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NOAA Technical Report OTES 03

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# Bias Correction Procedures for Airborne Laser Hydrography

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**U.S. DEPARTMENT OF COMMERCE**
**Malcolm Baldrige, Secretary**

**National Oceanic and Atmospheric Administration**
John V. Byrne, Administrator

Ocean Technology and Engineering Services
M.E. Ringenbach, Director

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# ABSTRACT

Of the many error sources associated with airborne laser hydrography, one of the potentially most serious is the effect of the scattering of the optical beam into a cone of continually increasing angle, i.e., of underwater light propagation. Depending on the entry nadir angle of the beam and the optical properties of the water, one of two opposing effects -- multiple scattering and geometric "undercutting" -- will dominate and result in either a deep or shallow depth measurement bias, respectively. The magnitude of this bias can greatly exceed international hydrographic accuracy standards, and hence bias correctors must be calculated and applied to the raw depths in post-flight data processing to attain the required accuracy for the overall system. The magnitudes of the bias correctors depend not only on the water and flight parameters, but also on the basic design of the receiver electronics. This report describes results obtained for several typical systems,* outlines the procedures required to calculate a set of bias correctors for any given system, and includes a cookbook approach for the necessary post-flight data processing algorithms.



* Portions of this work were sponsored by the Naval Ocean Research and Development Activity, Code 302, NSTL Station, Mississippi, 39529.

## SPECIFIC RESULTS

### Introduction

The basic premise of airborne laser hydrography is that the water depth, D, can be determined by measuring the round-trip transit time, T, for a short-duration light pulse which travels to the bottom and back to the surface along a slanted path which makes a known angle, $\phi$,from the vertical as in Fig. 1. From this simple ray model, the depth is calculated to be $D = (c_w T\cos\phi)/2$, where $c_w$ is the speed of light in water.

This model does not take into consideration the spreading of the beam in the water caused by scattering from entrained organic and inorganic particulate materials (Fig. 2). It can be seen that two competing effects exist which will cause a net bias in the measured slant range: a path lengthening due to multiple scattering and a path shortening due to energy returning early from the "undercutting" region. The magnitudes of these effects depend strongly on the beam entry nadir angle and the optical properties of the water. Because simple geometric arguments imply that the magnitudes could easily exceed the ±1 foot (30 cm) error budget, it its very important that the propagation-induced biases be accurately calculated. If the predicted biases do exceed an acceptable magnitude, they can, at least conceptually, be applied to field data as bias correctors to maintain system performance within the error budget.

### Impulse Response Functions

A Monte Carlo simulation has been conducted (Guenther and Thomas 1981a) to determine the impulse response functions (IRFs) at an airborne receiver for the underwater return (including scattering and absorption effects on propagation) as a function of nadir angle, depth, and optical properties of the water. The existence of undercutting is illustrated in Fig. 3 which depicts results for sample energy density distributions at the bottom. Examples of typical impulse response functions (scaled to a 20-m depth) are shown in Fig. 4. In the "key" blocks, AD denotes the optical depth, and WØ is the single-scattering albedo. The round-trip time for the unscattered reference path, measured from the earliest possible return for a vertical path, is

$$t_R = 2D\ (\sec \phi\ - 1)/c_w. \qquad (1)$$

This is denoted "REF" on the plots.

Depth measurement biases are defined from this reference time; i.e., if the pulse location time is $t_B$, the depth measurement bias for an impulse input is $B = c_w \cos\phi\ (t_B\ -\ t_R)/2$. In the limiting case where the depth scaled impulse response is quite long compared to the incident pulse (typically for deep water with significant scattering), the bottom return pulse will look very much like the impulse response, and pulse location algorithms applied to these impulse responses will yield a set of fairly realistic biases.

Fractional thresholds have been determined to be the optimum linear pulse location algorithms (Guenther and Thomas 1981b). Sample biases calculated from the IRFs in this way are presented in Fig. 5, where the notation in the "key" blocks indicates the scattering "phase function," air nadir angle, detector threshold fraction (as a percentage of the peak), and single-scattering albedo, respectively. A complete set of these biases is listed for reference in Appendix B of Guenther and Thomas 1981a. Under certain circumstances (such as high nadir angles) the bias magnitudes exceed, sometimes significantly, the acceptable error budget of ± 1 foot (30 cm) to a depth of 20 m.

## Realistic Bottom Return Signatures

Generally speaking, however, biases calculated from actual system input pulses will differ considerably from the above because typical impulse responses are not extremely long compared to a typical 7-ns incident laser pulse. The actual "input" pulses arriving at an aircraft receiver can be calculated by convolving the depth scaled impulse responses with the incident pulse from the laser transmitter. Typical biases for linear, depth-specific input pulses have been calculated for fractional threshold detectors by digitally convolving the depth-scaled impulse responses with an incident laser "source" pulse of triangular shape having a half-width of 7 ns. (This pulse shape is an excellent representation of the output pulse from the state-of-the-art HALS/AVCO* blue-green laser, as seen in Fig. 6). For the bias calculation, the source pulse is used for the surface return as described in detail in a later section titled "Processing". The results are tabulated in Appendix A, and sample plots are illustrated in Figs. 7 and 8 which demonstrate the effect of physical depth and the ancillary parameters on the biases for the same parameter sets as in Fig. 5.

It can be seen in Fig. 7 that at a 5-m depth, where the impulse response functions (IRFs) are generally narrow compared to the source pulse width, the biases are reasonably small because the convolution is very similar to the source pulse. For a 20-m depth, however, the IRFs are roughly of the same size as the source pulse, and the convolution differs significantly from the source pulse. The resulting biases (Figs. 8a, b) become quite large and require correction. Note the very important result that for air nadir angles of 25° and less the dependence of the bias on the phase function and single-scattering albedo (both unknown quantities from an airborne platform) as well as the threshold fraction is minimal, and precise values of these inputs are not required to maintain the bias estimate within ±10 cm. This is no longer the case, however, at 35° (Fig. 8b) where the biases are larger and exhibit a greater dependence on the input parameters.

## Effects of Non-Linear Processing

Bias results presented to this point have been calculated for an input signal which is processed linearly and located with a fractional threshold detector. In practice, because of the extremely large dynamic range inherent in incoming pulse amplitudes (as much as five decades), some form of amplitude compression will generally be required in the receiver hardware. Any form of

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*The AVCO Everett Research Laboratory, Inc., is presently building a Hydrographic Airborne Laser Sounder (HALS) system for the U.S. Navy.

non-linear signal processing has the potential to alter the biases significantly from those already presented. The most commonly used compression technique, logarithmic amplification, causes an extreme alteration in the shape of the leading edge of the pulse (Fig. 9) and a correspondingly large change in depth measurement biases resulting from locators applied to these distorted pulses.

This is illustrated in Figs. 10 through 13 where biases calculated for the HALS system are plotted for the same water optical properties as in Figs. 5, 7, and 8. Note that these biases differ significantly from the former. The HALS system incorporates logarithmic amplification for amplitude compression and a so-called "constant fraction discriminator" analog circuit for locating the pulse. The "delay" noted in the figures refers to a circuit parameter which serves roughly the same purpose as the threshold fraction for linear pulse location. As can be seen in Figs. 10 through 13, this combination has the unfortunate property of yielding biases sensitive to the peak signal-to-background ratio ($P_m/B$) as well as to the nadir angle, the delay, and the physical depth. Typical biases for the HALS system are tabulated in Appendix B.

It is clear, then, that bias correction for an airborne laser hydrography system depends not only on the transfer function of the water column, but also on the shape and duration of the incident pulse and on the transfer function of the receiver electronics. An explicit set of generalized bias correctors cannot be calculated for propagation-induced depth measurement errors until all of these things are completely defined. With this clearer understanding of the scope of the problem, we can now step back and take a broader look at the required procedures from a generic point of view.

## GENERAL PROCEDURES

### Input

The basic starting point is the set of impulse response functions (scaled to the vertical depth transit time, $D/c_w$) which describe the transfer function of the water column for various combinations of air nadir angle and water optical properties. In order to scale these functions into nanoseconds for any given depth (in meters), D, the normalized abscissae values must be multiplied by $D/c_w$ = 4.44D. The derivation of these functions by Monte Carlo computer simulation techniques is described in detail in Guenther and Thomas 1981a. Because of their importance, these functions are archived in four different ways: 1) on two ASCII disk files named ONEPRO.AS1 and ONEPRO.AS2 on the ADP Network Services, Inc. DEC-10 computer system; 2) on a magnetic tape cartridge for the Tektronix 4051 desk-top minicomputer; 3) as a printed paper output; and 4) on file 1 of a 9-track ASCII universal computer tape named PROP1.

The convolution of these functions with a given "source" pulse has been accomplished in a Fortran program on the ADP system called SMPD.FOR. This program is documented in Appendix C along with instructions on how to modify the code defining the source pulse (which is currently a 7-ns halfwidth symmetric triangle). The depth-scaled convolutions or "input" pulses for a 7-ns triangle source pulse are stored on an ADP ASCII disk file named SMPALL.EIR, on a 4051 tape cartridge, and on file 2 of the 9-track tape PROP1.

## Bias Calculation

For a given set of depth-specific input pulses parameterized on air nadir angle and water optical properties, the next step in calculating bias correctors for these circumstances is the modeling of the system receiver electronics including all the various non-linear processing and pulse location estimation procedures as well as bandwidth limitations. When the appropriate transfer functions have operated on the input signals, the apparent depth is then calculated from the time interval between the detection locations of the surface return and bottom return pulses. The source pulse (appropriately modified by the receiver electronics) may be used directly as the surface return pulse or, if desired, modified slightly before processing to include the effect of surface waves. The "input" pulse, modified by the electronics, is the bottom return pulse. (It should be noted that it might be desirable to use different pulse location techniques on the two pulses and correct for the resulting additional bias. Depending on the wind speed and air nadir angle, the "surface" return may come from a reflection at the air-water interface, or it may be the result of backscattering from the water beneath the interface. The latter effect will cause a shallow bias in measured depths whose magnitude depends on the pulse location procedure -- the nearer to the start of the "surface" pulse, the smaller the bias. Thus, while it may be desirable to have the bottom pulse located at, say, the 50% value, the surface pulse may need to be located at the 20% value to control the size of the interface/volume bias. Locating the two pulses at different levels causes an additional bias which depends only on the shape of the interface return and which can be easily removed with a pre-calculated ad hoc corrector.)

The bias calculation is then made according to the timing diagram shown in Fig. 14. The bottom pulse location time, $t_B$, and the "reference" time, $t_R$, can be measured from any consistent starting time such as the earliest possible return for a vertical path. The surface pulse location time, $t_S$, is measured from the start of that pulse (where it would be located if it were a "delta" function). The time associated with the true slant range, $t_D$, and the time associated with the apparent slant range measure, $t_A$, can be seen in Fig. 14 to be related by the expression

$$t_D = t_S + t_A + t_R - t_B. \qquad (2)$$

The slant range bias time, $t_E$, is then

$$t_E = t_A - t_D = t_B - t_R - t_S, \qquad (3)$$

and the associated depth measurement bias will be

$$B = (c_w t_E \cos\phi)/2. \qquad (4)$$

To calculate the bias time, $t_E$, one obtains $t_B - t_R$ from the processed bottom return "input" pulse and $t_S$ from the processed surface return "source" pulse. It is important to note that for non-linear processing such as in the HALS system, the signal strength of the surface return may have an effect on the bias calculation, and a table of values for $t_S$ parameterized on surface signal strength may be necessary.

Biases must be calculated for all combinations of physical depth, receiver parameters, pulse location algorithms, and relevant water optical properties (potentially: phase function, optical depth, and single-scattering albedo). This constitutes a very large data base. The next step is to examine this data base and compare the contents to a maximum permissable level - say ±15 cm. If all biases are smaller than this for the full range of desired operating conditions (an unlikely circumstance), then no bias correction is required, and the effort is completed. If biases exceed ±15 cm, several major decisions are required - such as how to obtain quantitative values from field data for the necessary defining parameters and how to handle and apply the bias correctors once they are calculated. These questions are discussed in the next section.

## Estimation of Input Parameters From Field Data

The application of a bias predictor as a bias corrector to field data implies adequate quantitative knowledge of all of the previously named variables upon which the biases are parameterized. This may include signal strengths, and it most certainly includes water optical properties. The operating scenario for an airborne laser hydrography system does not include any surface truth; hence any knowledge of water optical properties needed for bias estimation/correction must be obtained by the airborne system during its bathymetric profiling operations. This imposes a severe limitation on the parameters which can be obtained and the accuracy to which they can be measured. This in turn impacts the bounds of the operating parameters within which the system must be flown to maintain the ability to estimate the bias correctors to within about 10 cm.

Generally speaking, the phase function cannot be estimated from the air. The Monte Carlo simulations were conducted for two bounding phase functions (Petzold 1972): the so-called "NAVY" function for which the scattering was very strongly forward (37% within 1° and 76% within 10°) and the so-called "NOS" function for which the distribution was slightly broader (23% within 1° and 66% within 10°). Fortunately, the effect of these changes in phase function on the impulse response and resulting biases is sufficiently small that an average value can be used and the dependency removed; thus the phase function is not required.

The direct effect of the single-scattering albedo, $w_0$, on the impulse responses and subsequent biases is also small enough that an ad hoc average value of 0.8 can be used. There is, however, another need for $w_0$: the determination of the beam attenuation coefficient, $\alpha$, from the diffuse attenuation coefficient, K.

K is the only important parameter which can be easily extracted from the lidar returns. The log slope of the volume backscatter curve following the surface return pulse should be roughly equal to -2K, and hence its value can readily be determined from each recorded pulse. The biases, however, are parameterized on optical depth, $\alpha D$, which involves $\alpha$, not K. The relationship between $\alpha$ and K (Fig. 15) is a strong one which depends on a single parameter, the single-scattering albedo, $w_0$. (Guenther and Thomas 1981a). Even if K were known precisely, which it will not be, uncertainty in $w_0$ would cause an uncertainty in $\alpha$ and hence in the optical depth, $\alpha D$. Two approaches to the problem are possible: 1) try to estimate $w_0$ from airborne data, or 2) assume $w_0 = 0.8$ and restrict operational parameters such that the attendant errors caused by poor knowledge of $\alpha D$ are acceptable within the error budget. (Primarily this will mean restricting the nadir angle, because the bias versus optical depth plots become increasingly steep as the nadir angle increases).

It is theoretically possible to estimate $w_0$ from airborne data as follows. The peak signal strength of the volume backscatter return is proportional to the quantity $\sigma_\pi/K$ where $\sigma_\pi$ is the backscatter coefficient (at 180°) per unit solid angle. As seen in Fig. 16, a plot of $\sigma_\pi/K$ vs $w_0$ (which was obtained by using $\sigma_\pi$, $\alpha$, and $w_0$ values from Petzold 1972) provides a smooth, monotonic function. Thus, if an accurate quantitative estimate of $\sigma_\pi/K$ could be determined from an inversion of the signal equation by measuring the peak volume backscatter power, then the relationship described in Fig. 16 could be used to estimate $w_0$.

This procedure has never been attempted, and it is questionable whether the numerous parameters in the signal equation can be known to sufficient precision to permit an accurate estimate of $\sigma_\pi/K$. The range of interest in $w_0$

for coastal waters if roughly between 0.6 and 0.9, and $\sigma_{\pi}$ /K varies by only a factor of 2 over that range. Hence, $\sigma_{\pi}$/K would have to be determinable to within roughly 20% to predict $w_0$ to the nearest tenth. We regretfully do not believe this is practical.

The second and remaining option of selecting $w_0$ = 0.8 as a rough mean value leads (from Fig. 15) to the relationship $\alpha \sim 3.8$ KD, which implies the optical depth, $\alpha$D, can be estimated from the apparent measured depth, D, and the estimated value of K using the expression $\alpha$ D ~ 3.8 KD. If $w_0$ actually varies between 0.6 and 0.9, $\alpha$/K varies between 2.2 and 6.3. Thus, our estimate of $\alpha$D is basically good to a little better than a factor of 2, and changes in bias correctors over that range of optical depth for a given parameter set must be less than about 10 cm for that parameter set to be operationally acceptable.

## Application of Bias Correctors

A final required decision involves the practical handling of the large data base of bias correctors. It is expected that roughly 1080 correctors are required to provide coverage of all necessary combinations and resolutions of the input variables. These correctors could be utilized directly in matrix form with a table look-up procedure, or a multivariate (possibly non-linear) regression program could be used to fit the data and generate a formal expression which describes the results. The former is conceptually simpler but does not lend itself well to interpolation and would require considerably more computer time in operational use. The latter requires an additional development effort, but readily permits interpolation and would be fast computationally. Because of the importance of processing speed in the operational data reduction software, it is felt that the best approach is to develop a set of formal equations which fit the tabulated values.

# DATA PROCESSING

The post-flight data processing converts the raw lidar pulses and ancillary flight data into a set of depths at specified locations. The exact procedures implemented will be system dependent to a certain extent, but those involved with the calculation of the depths and their correction for propagation-induced biases can be listed generically to indicate the required parameters and the magnitude of the effort.

## Inputs

The data needed to calculate an apparent depth and a propagation-induced bias corrector are as follows:

1) the lidar return waveform;
2) the air nadir beam entry angle, $\theta$, corrected for aircraft roll and pitch;
3) surface and bottom return pulse location algorithm parameters, $p_i$, (such as fractional thresholds or CFD delays);
4) a table or equation of bias correctors, B, parameterized on physical depth, D, nadir angle, $\theta$, optical depth, $\alpha D$, pulse location algorithm, $p_i$, and other items such as signal-to-background ratio, as needed; and
5) a table or equation of bias corrector modifiers, $B_s$, parameterized on surface return strength or signal-to-background ratio, as needed.

## Calculations

A typical set of processing steps might occur as follows.

1) From the waveform, estimate surface and bottom peak signal strengths or signal-to-background ratios, as required (SSS, SSB).
2) Estimate K from -1/2 x log slope of volume backscatter curve between the surface and bottom returns.
3) Process the waveform prior to pulse location: this might include such things as low pass filtering, background subtraction, etc.
4) Apply pulse location algorithms to the waveform to obtain surface and bottom return location times $t_S$ and $t_B$; this process may include a tracking loop based on previous detections and statistics as well as rules limiting or expanding the search regions.

5) Using Snell's Law, calculate the water nadir angle, $\phi$, from the air nadir angle, $\theta$; calculate the apparent depth, D', from $D' = \frac{1}{2}c_w(t_B - t_S) \cos \phi$, where $c_w/2 = 2.22$ m/ns is half the speed of light in water.

6) Estimate the optical depth as $\alpha' D' \cong 3.8\ KD'$.

7) Given D', $\theta$, $\alpha'D'$, pulse location parameters $p_i$, and bottom signal strength measure SSB, use tables or regression equation to calculate the bias corrrector B (D', $\theta$, $\alpha'D'$, $p_i$, SSB).

8) Based on surface signal strength measure, SSS, use tables or regression equation to calculate bias modifer $B_S(p_i, SSS)$ as necessary.

9) Calculate the corrected depth estimate $D'' = D' - B - B_S$.

10) Apply the wave corrector, W (separately calculated from altitude information), to obtain the best estimate of the mean water depth: $D = D'' - W$.

11) Apply statistical editing procedures (see Appendix D) to remove suspect pulses.

12) Apply tide corrector, T, to convert depths to "mean low water": $D_{MLW} = D - T$.

## Conclusions

Steps 1, 2, 6, 7, and 8 involve the correction of propagation-induced biases as modified by the system electronics. Under many circumstances, as seen in the first section, these correctors are required to permit an airborne lidar system to meet international hydrographic accuracy standards. They must be developed for any given system by following the guidelines in the second section. This is not a simple task, and it should be undertaken as soon as the basic system design is solidified.

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Guenther, G.C., and Thomas, R.W.L., 1981b: Error Analysis of Pulse Location Estimates for Simulated Bathymetric Lidar Returns. NOAA Technical Report OTES 01, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C., 51 pp.

Petzold, T.J., 1972: Volume Scattering Functions for Selected Ocean Waters. SIO Ref. 72-78, Scripps Institution of Oceanography, San Diego, California, 79 pp.

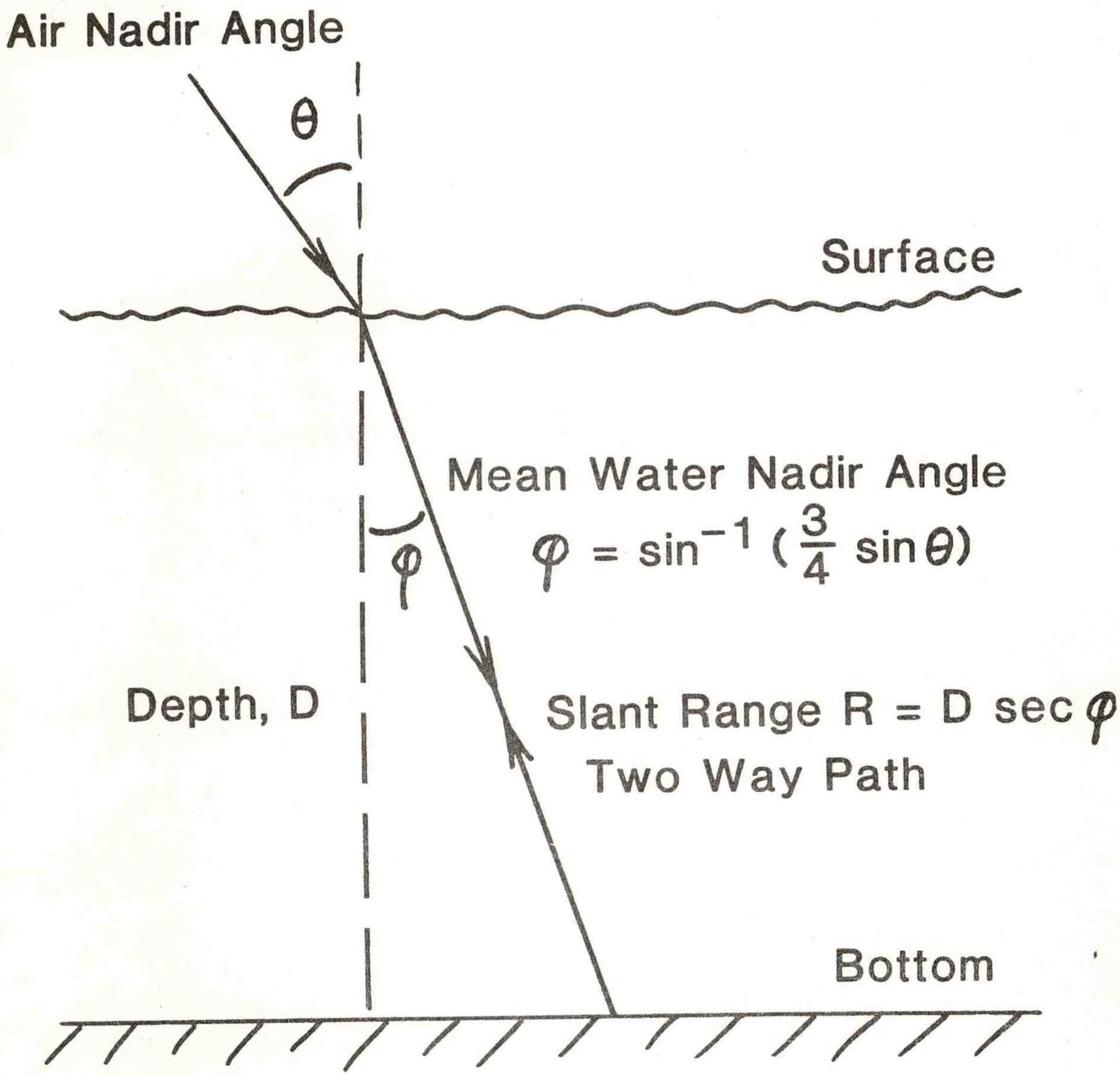



Figure 1. Geometry for Ray Model

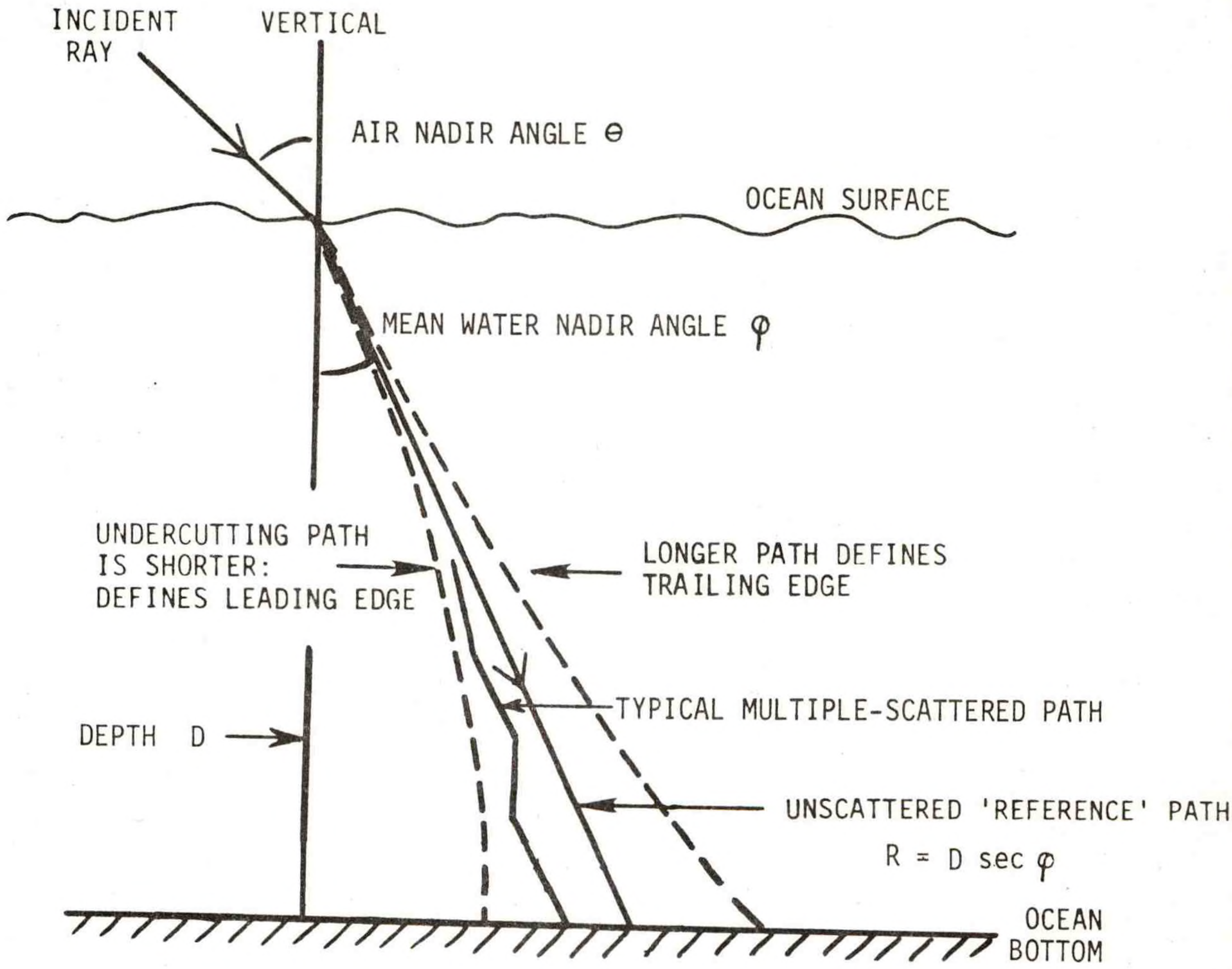



**FIGURE 2. GEOMETRICAL RELATIONSHIPS AFFECTING IMPULSE RESPONSE FUNCTION**

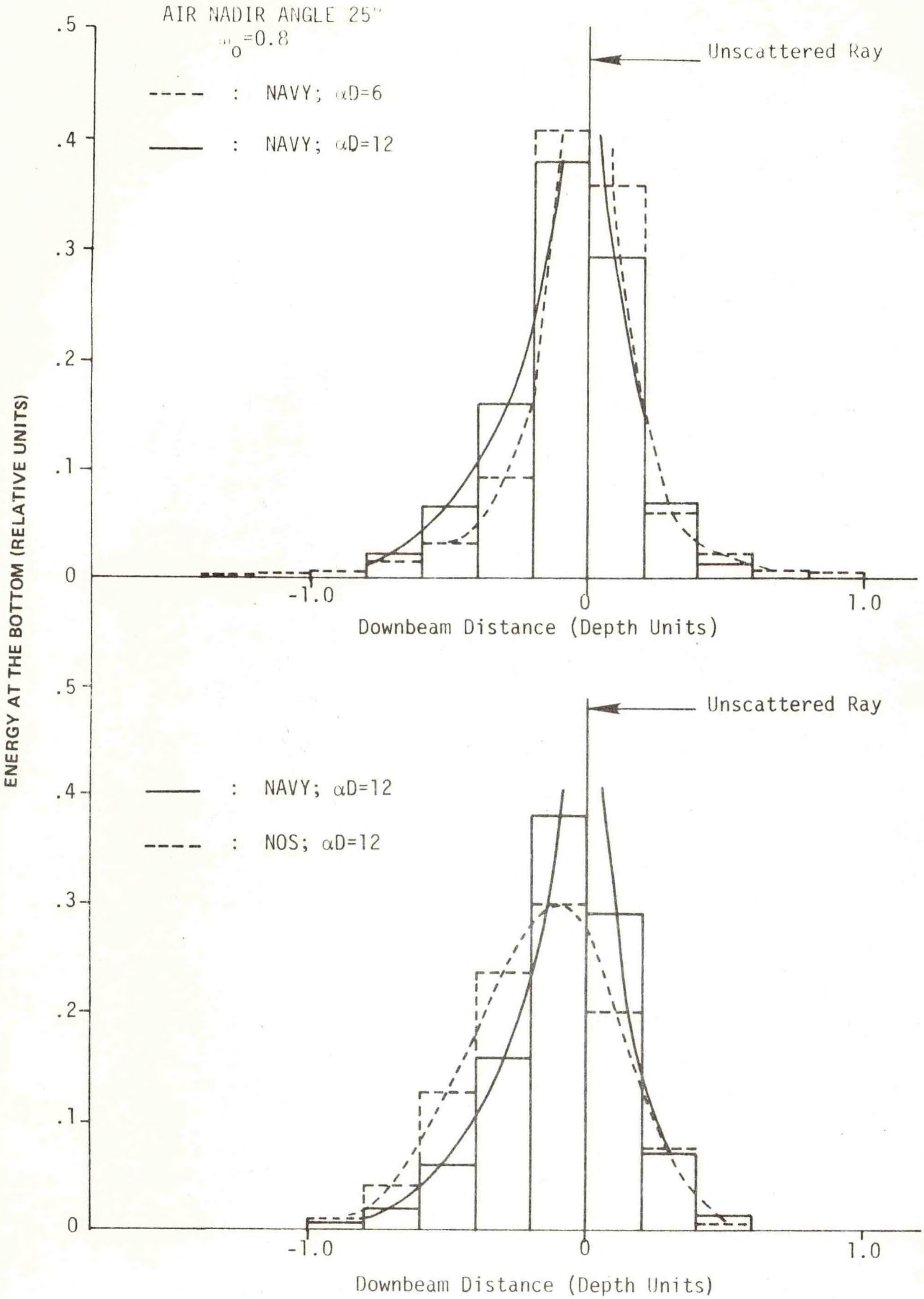



FIGURE 3. SPATIAL DISTRIBUTION OF PULSE ENERGY AT THE BOTTOM

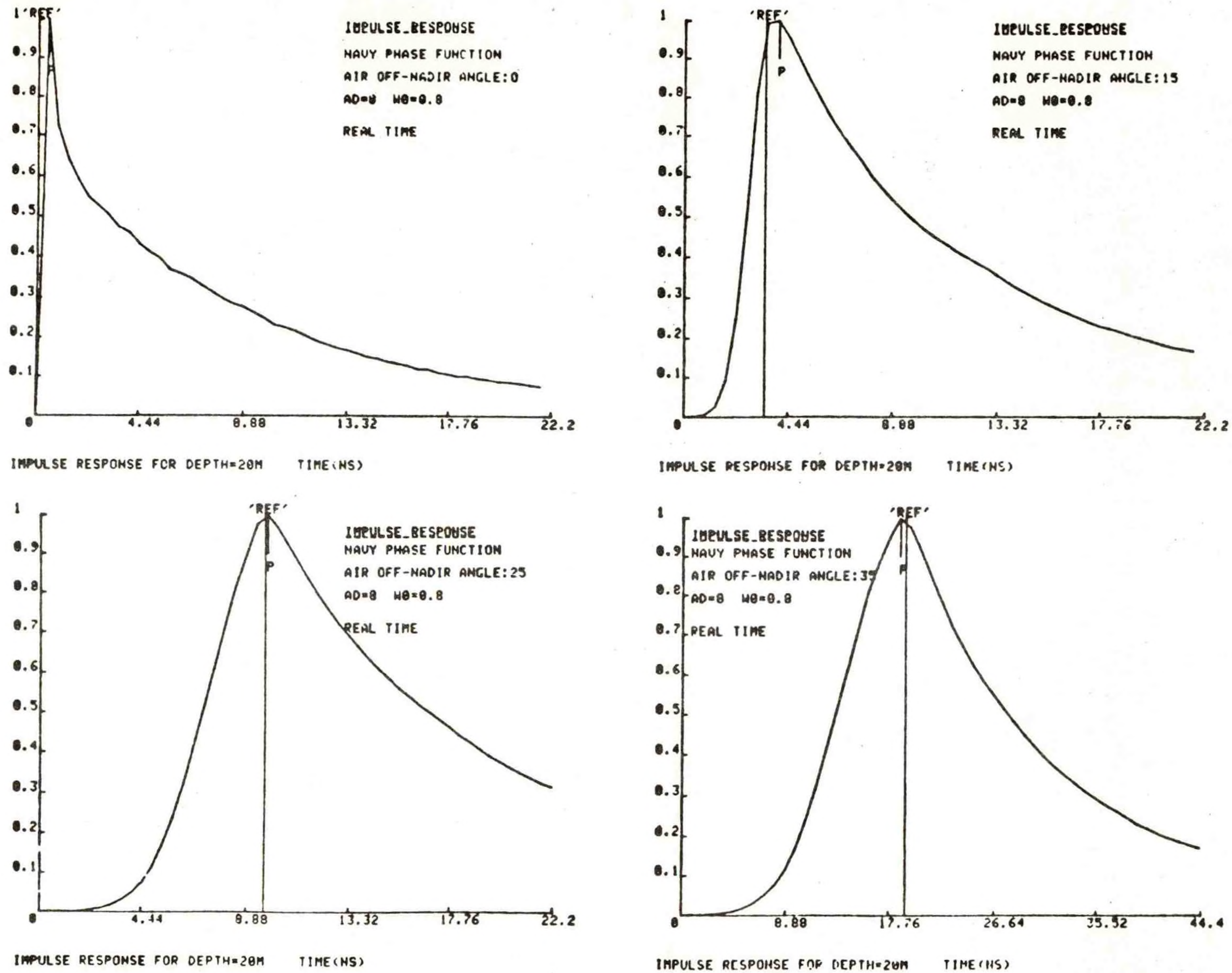
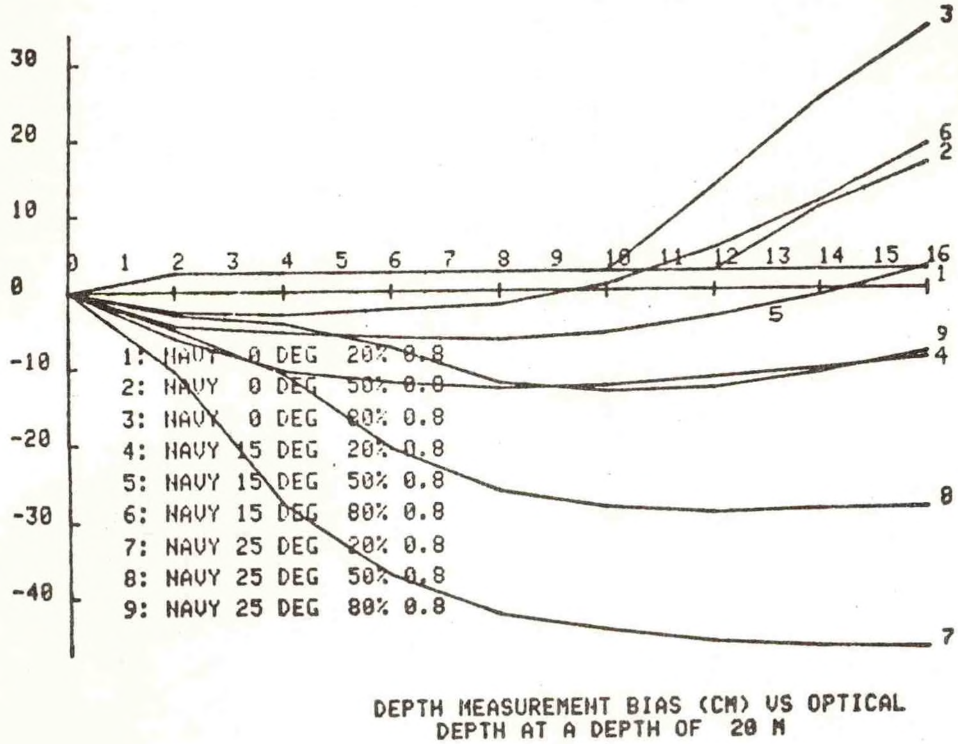



Figure 4. Typical Impulse Response Functions at an Airborne Receiver



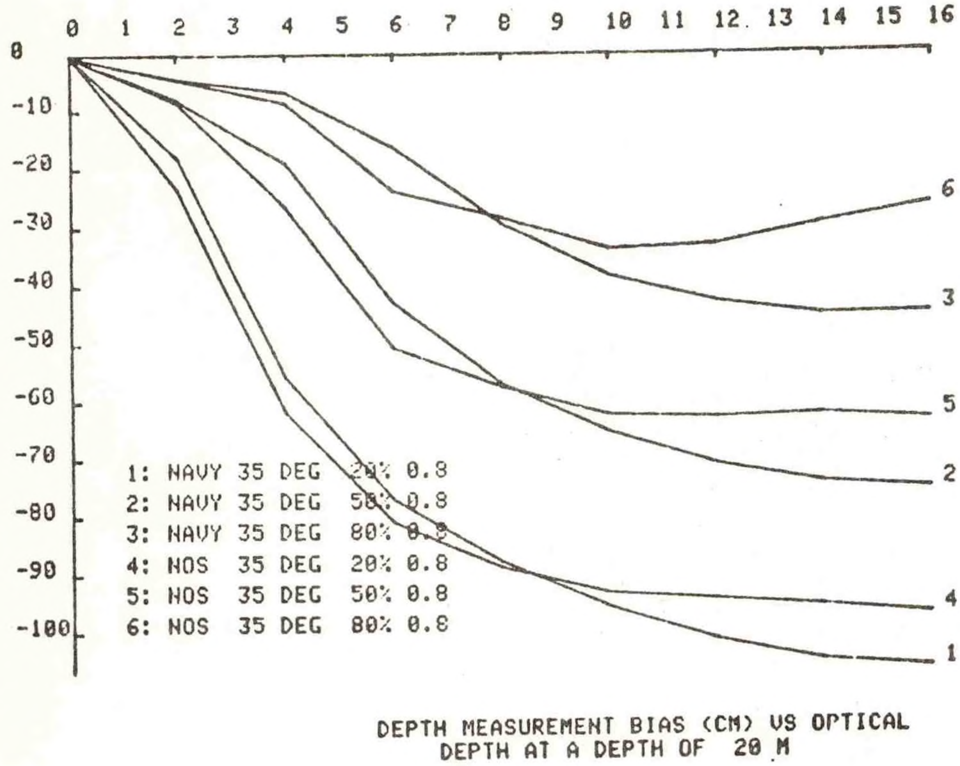




Figure 5. Biases Calculated From Impulse Responses

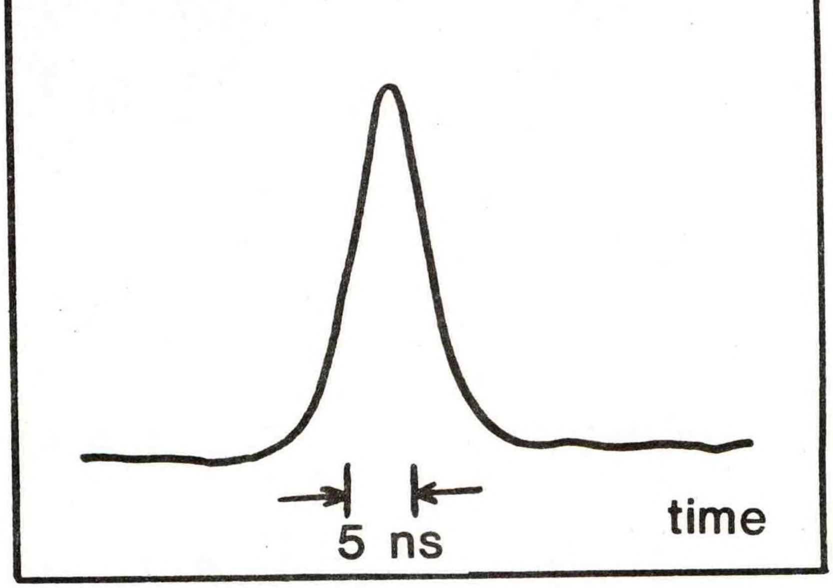



Figure 6. Typical Pulse from HALS/AVCO doubled Nd:YAG Laser

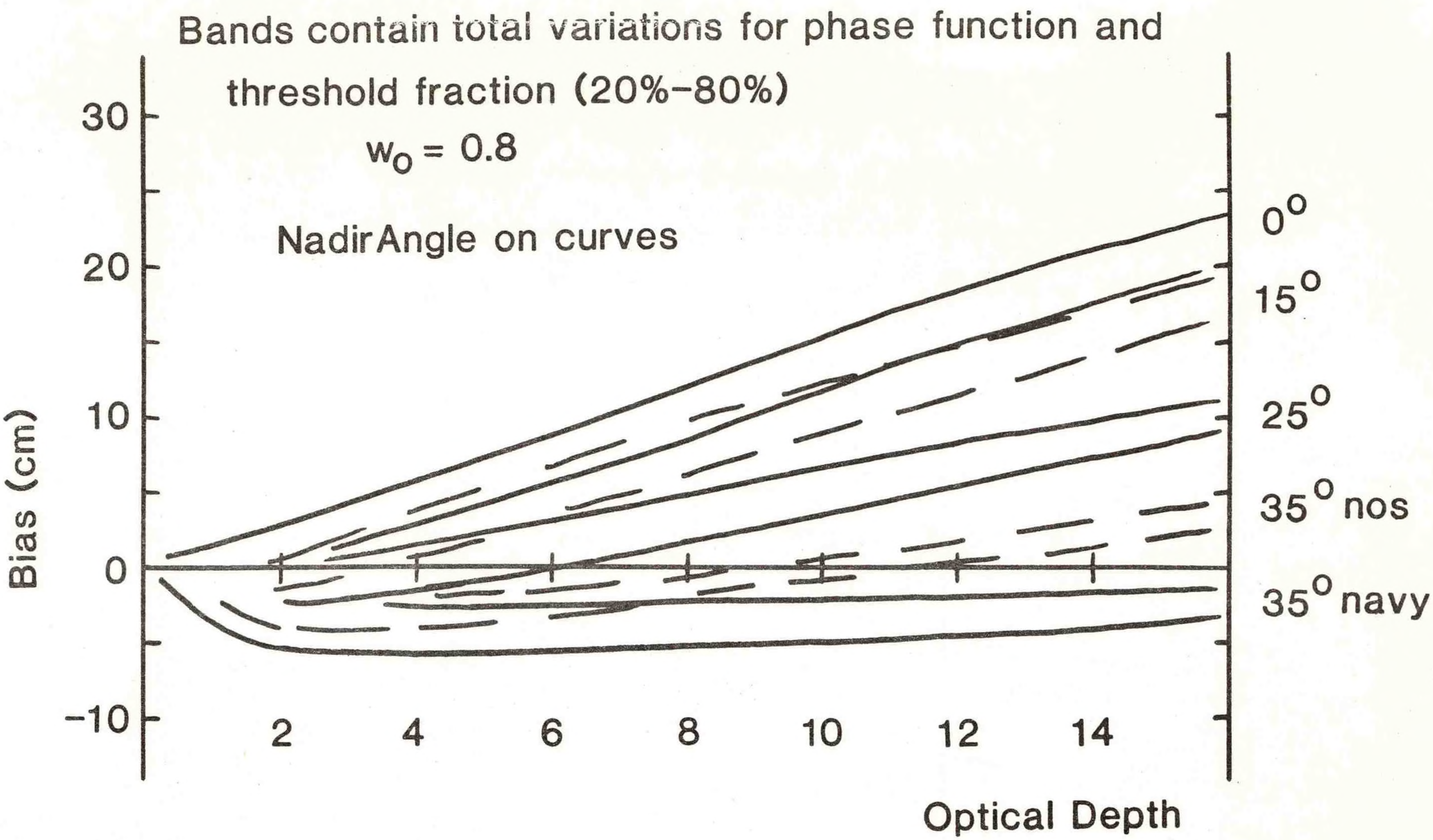



Figure 7. Biases For Linear Fractional Thresholds on Environmental Response Functions for 5-m Depth

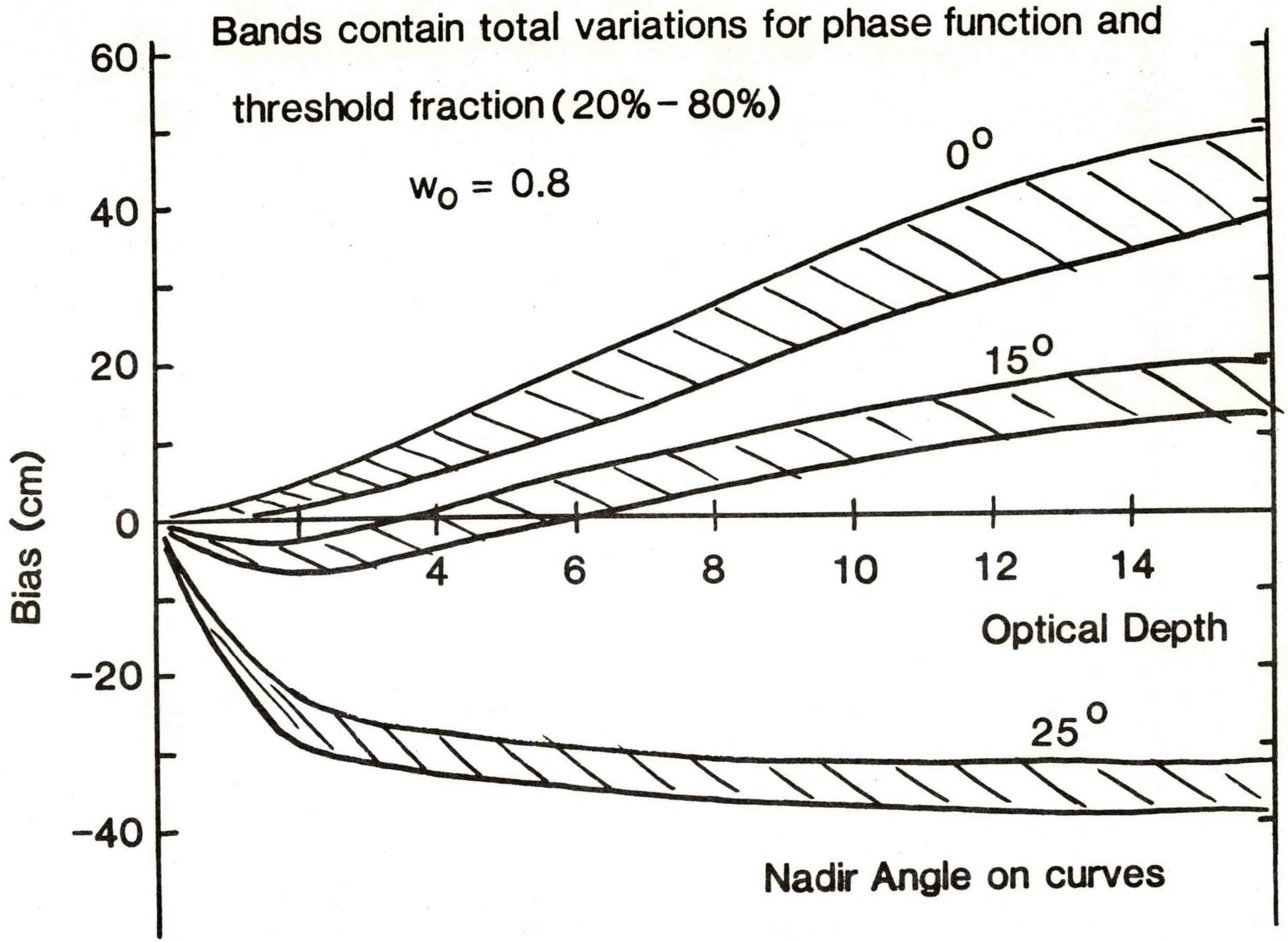



Figure 8a. Biases for Linear Fractional Thresholds on Environmental Response Functions for 20-m Depth

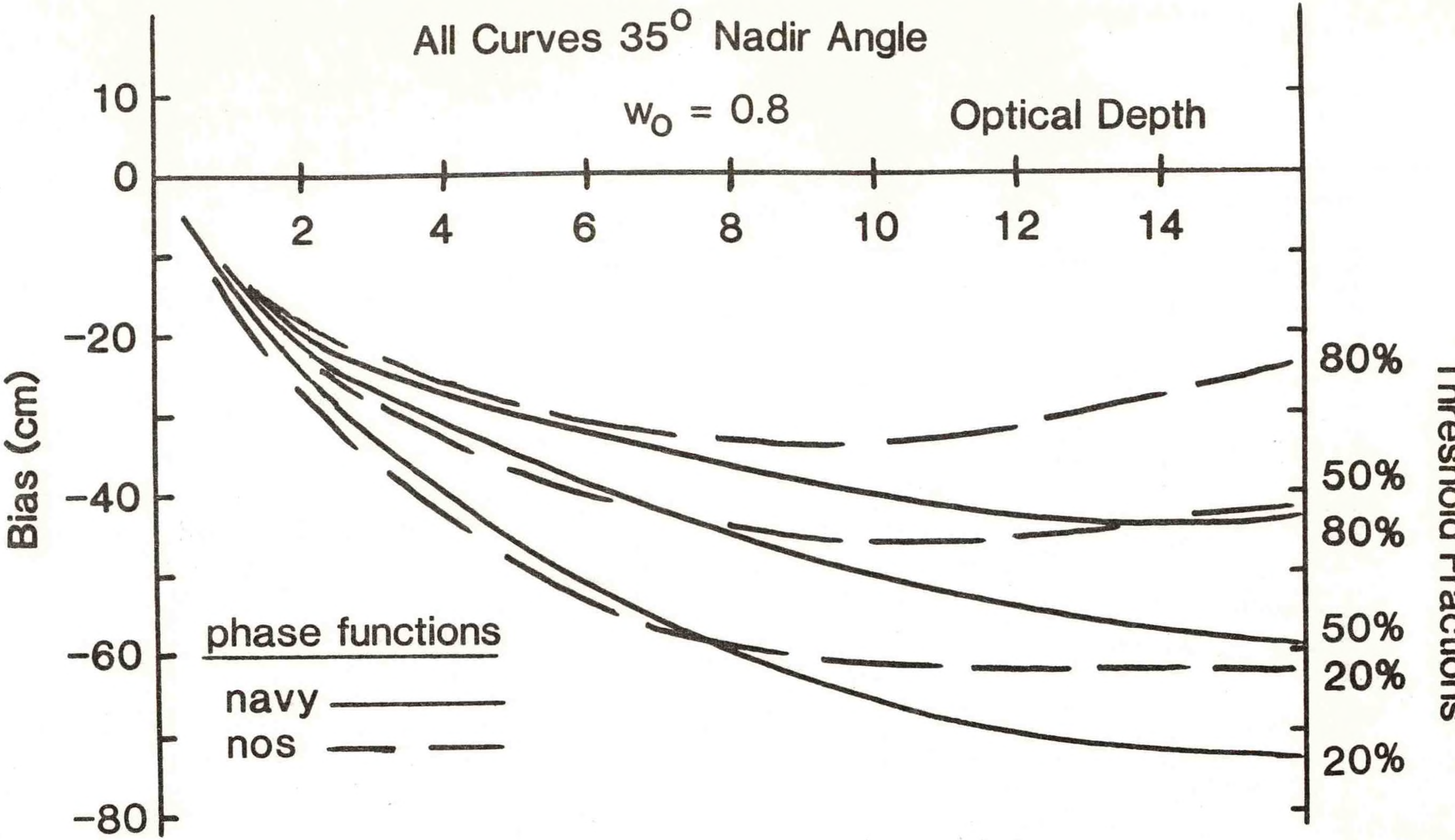



Figure 8b. Biases for Linear Fractional Thresholds on Environmental Response Functions for 20-m Depth

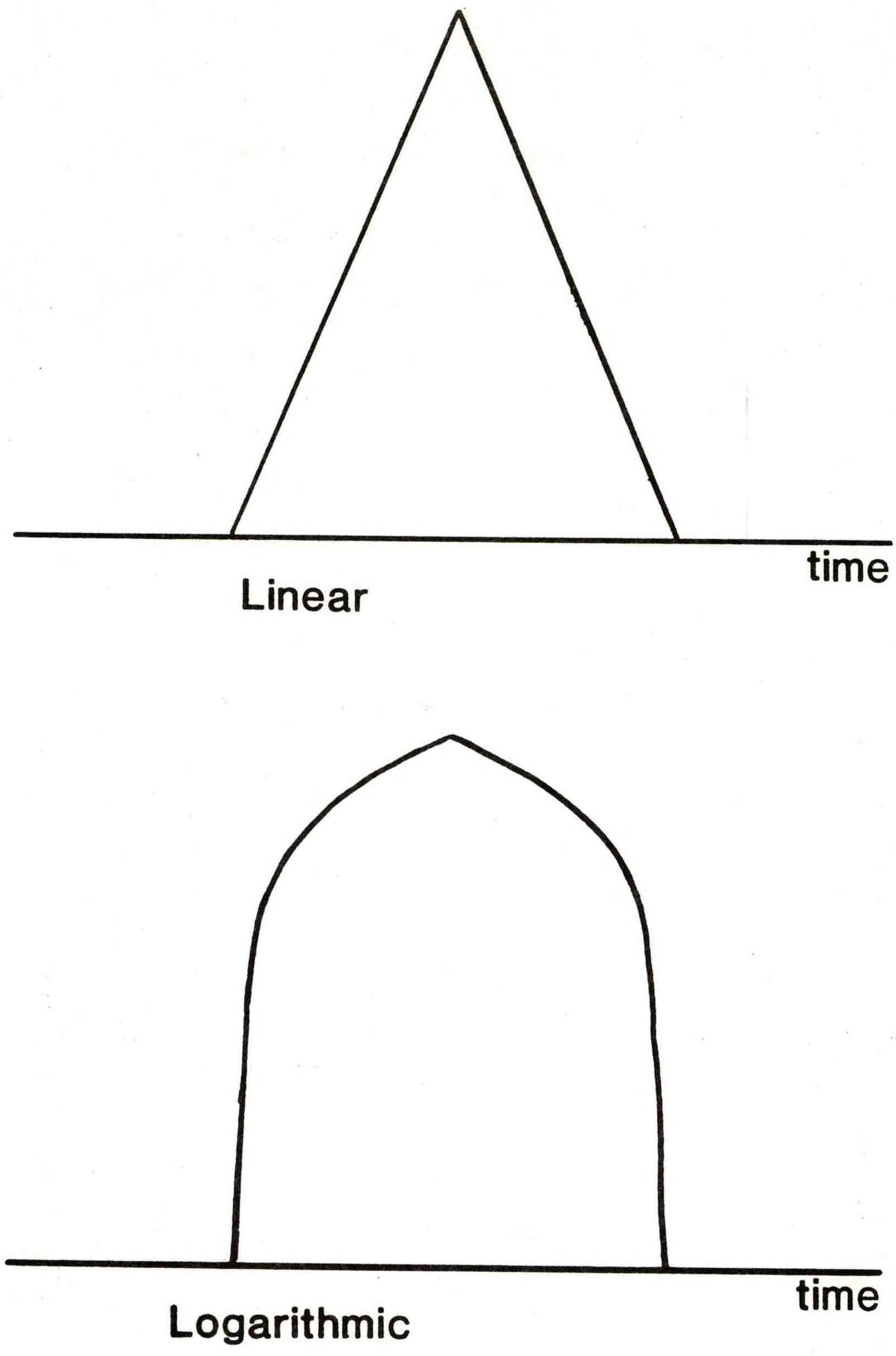



Figure 9. Distortion of Input Pulse by Logarithmic Amplification

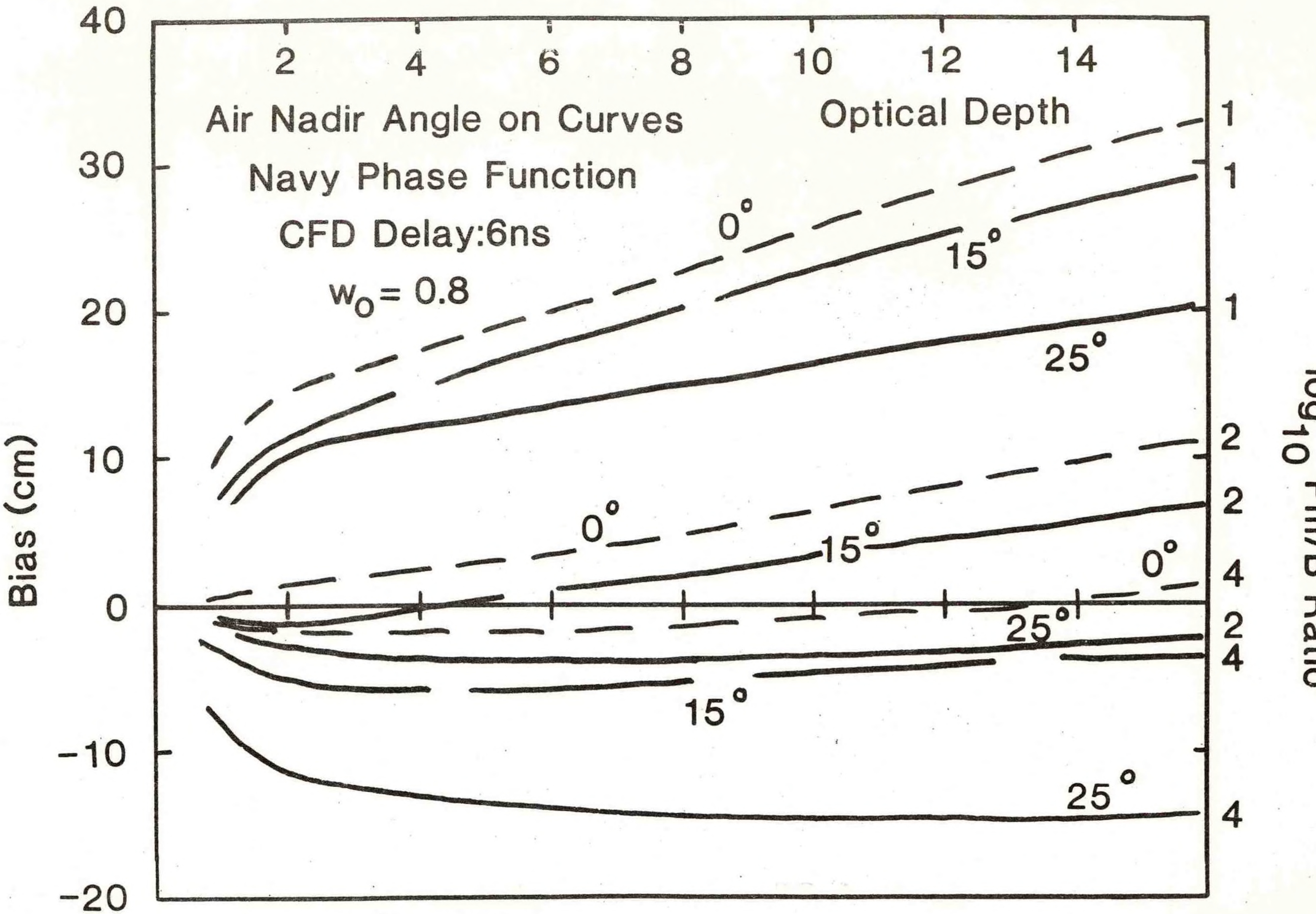



Figure 10. Biases for HALS System at 5–m Depth

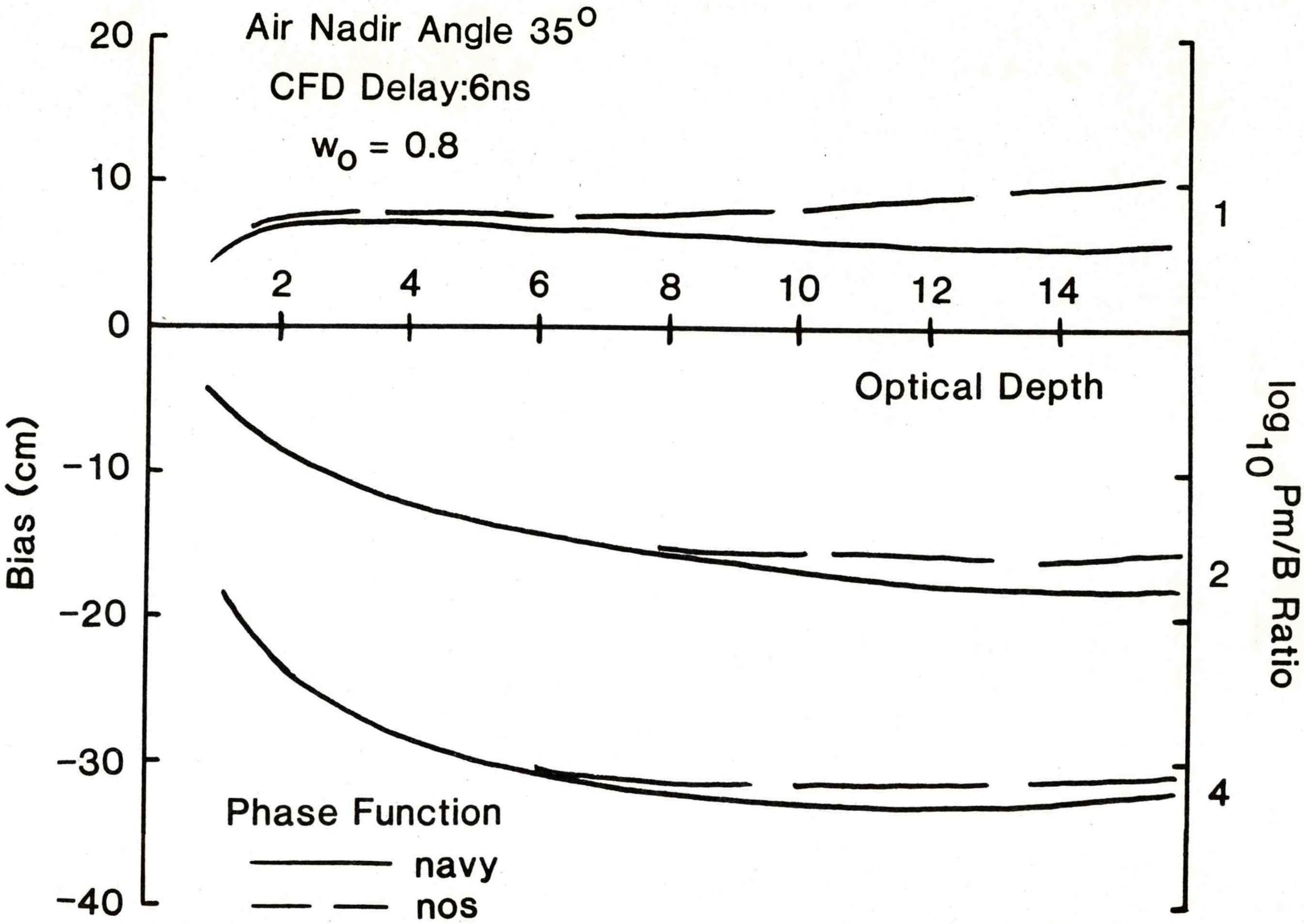



Figure 11. Biases for HALS System at 5-m Depth

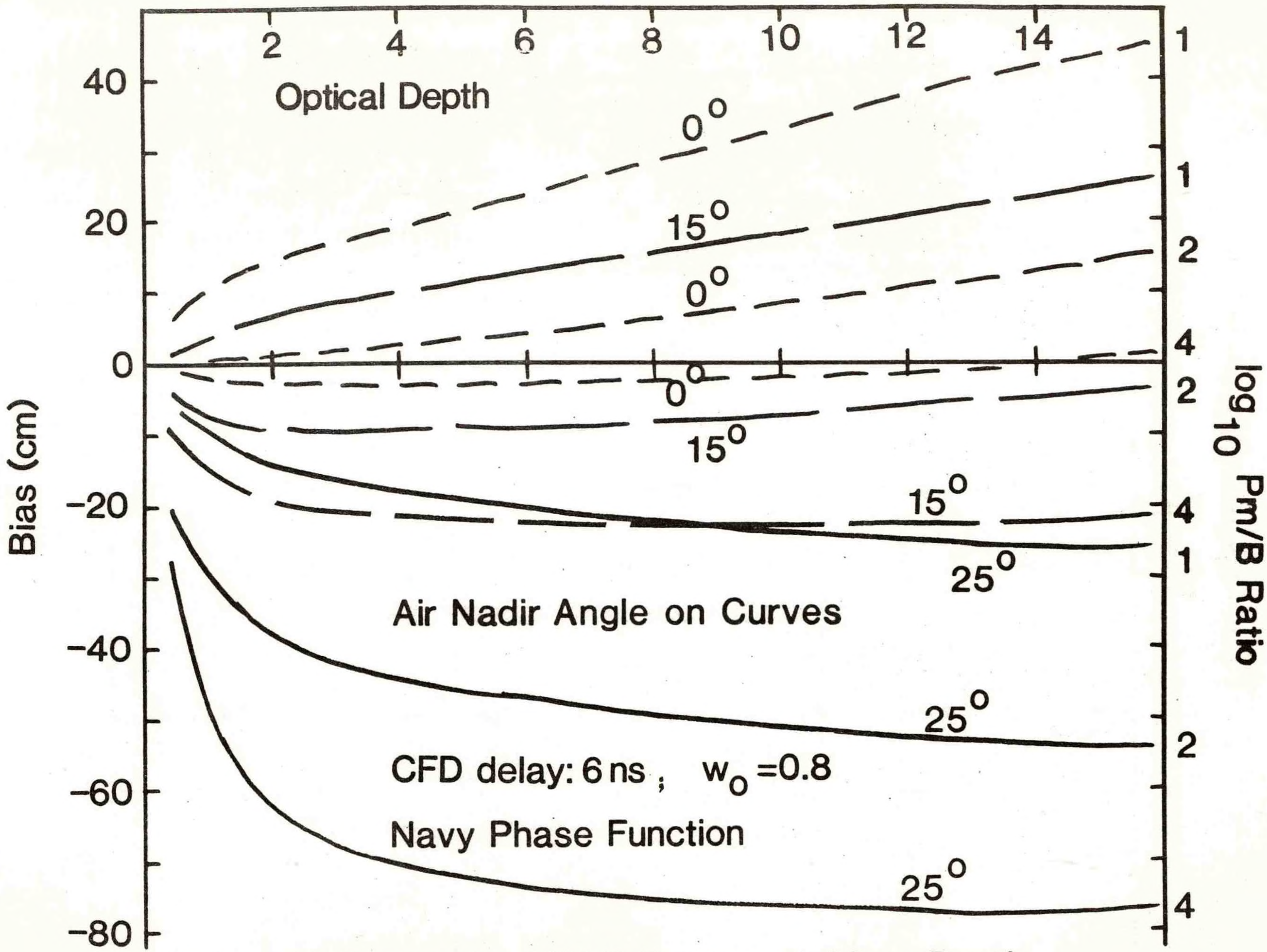


Figure 12. Biases for HALS System at 20-m Depth

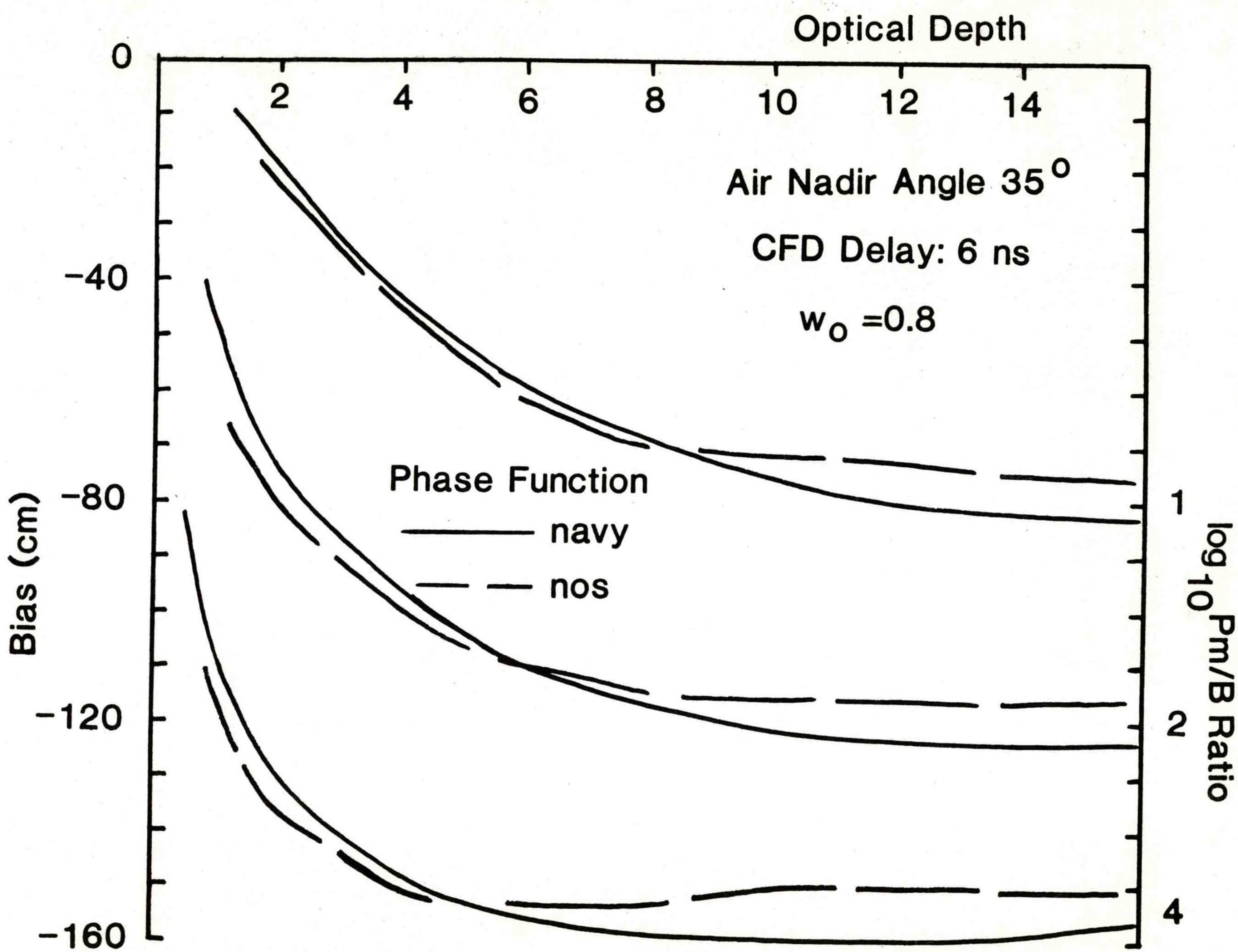


Figure 13. Biases for HALS System at 20–m Depth

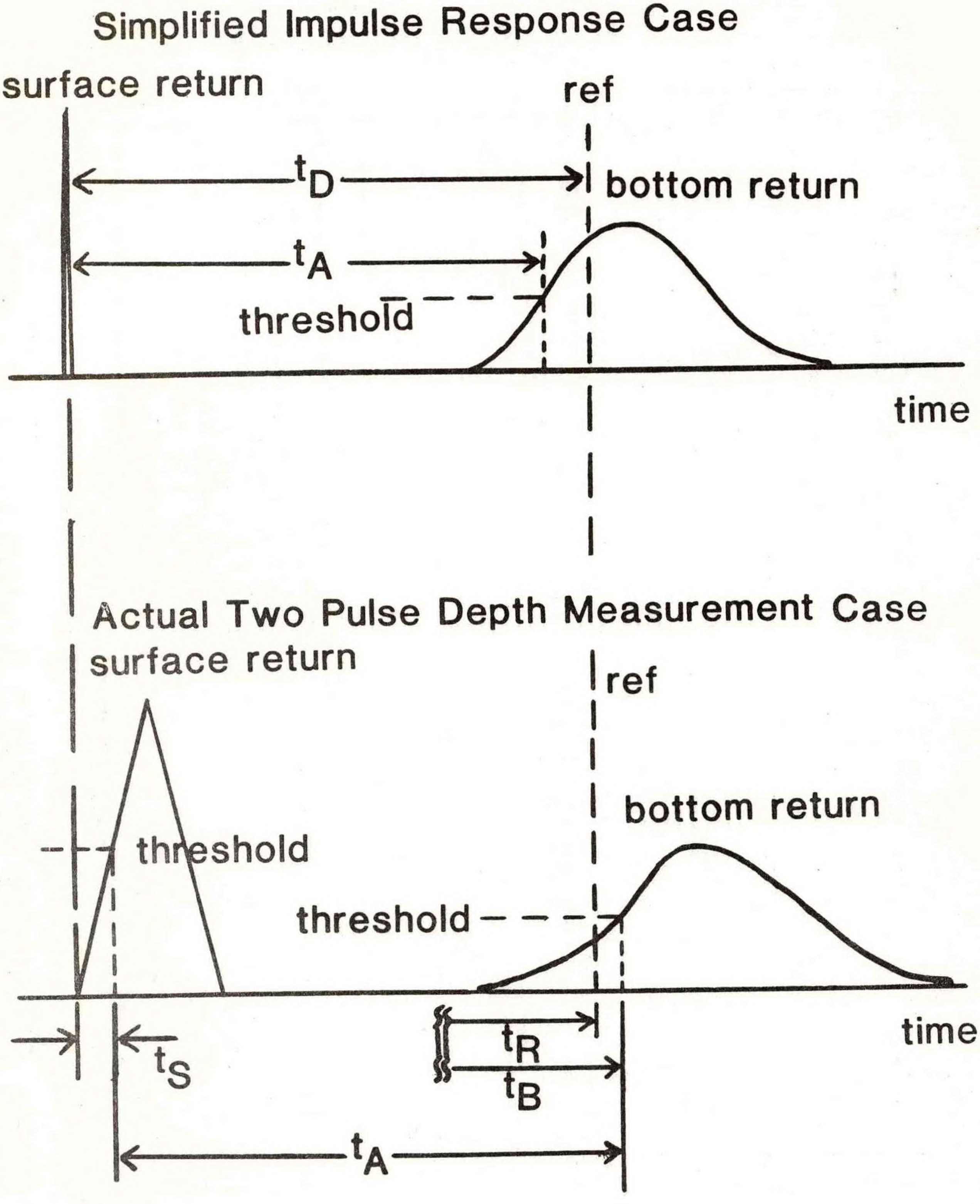



Figure 14. Timing Diagram for Bias Calculation

FIGURE 15.

NORMALIZED ATTENUATION COEFFICIENTS AS FUNCTION OF ALBEDO OF SINGLE SCATTERING

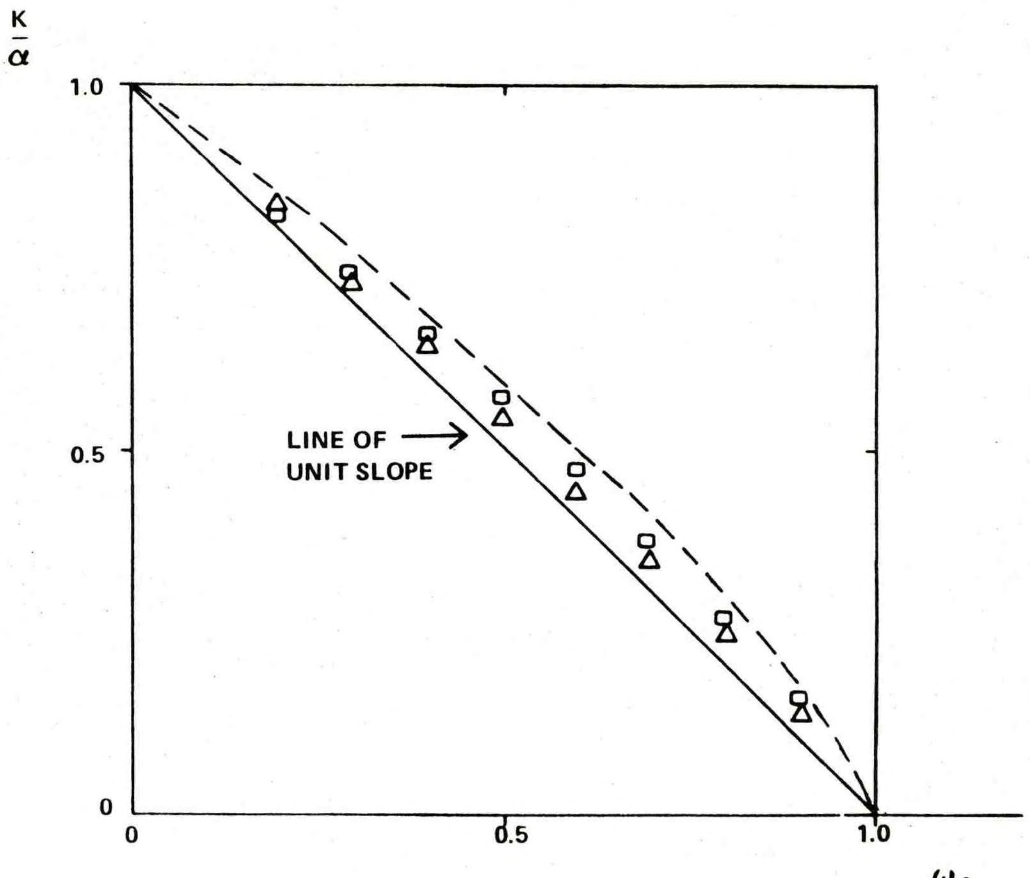
NADIR

Δ "NAVY" WATER (CLEAN)

□ "NOS" WATER (DIRTY)

ALL RESULTS AVERAGED OVER $\alpha D$ BETWEEN 0 AND 10

– – – TIMOFEYEVA $[0.23\,(1-\omega_o)]^{\omega_o/2}$



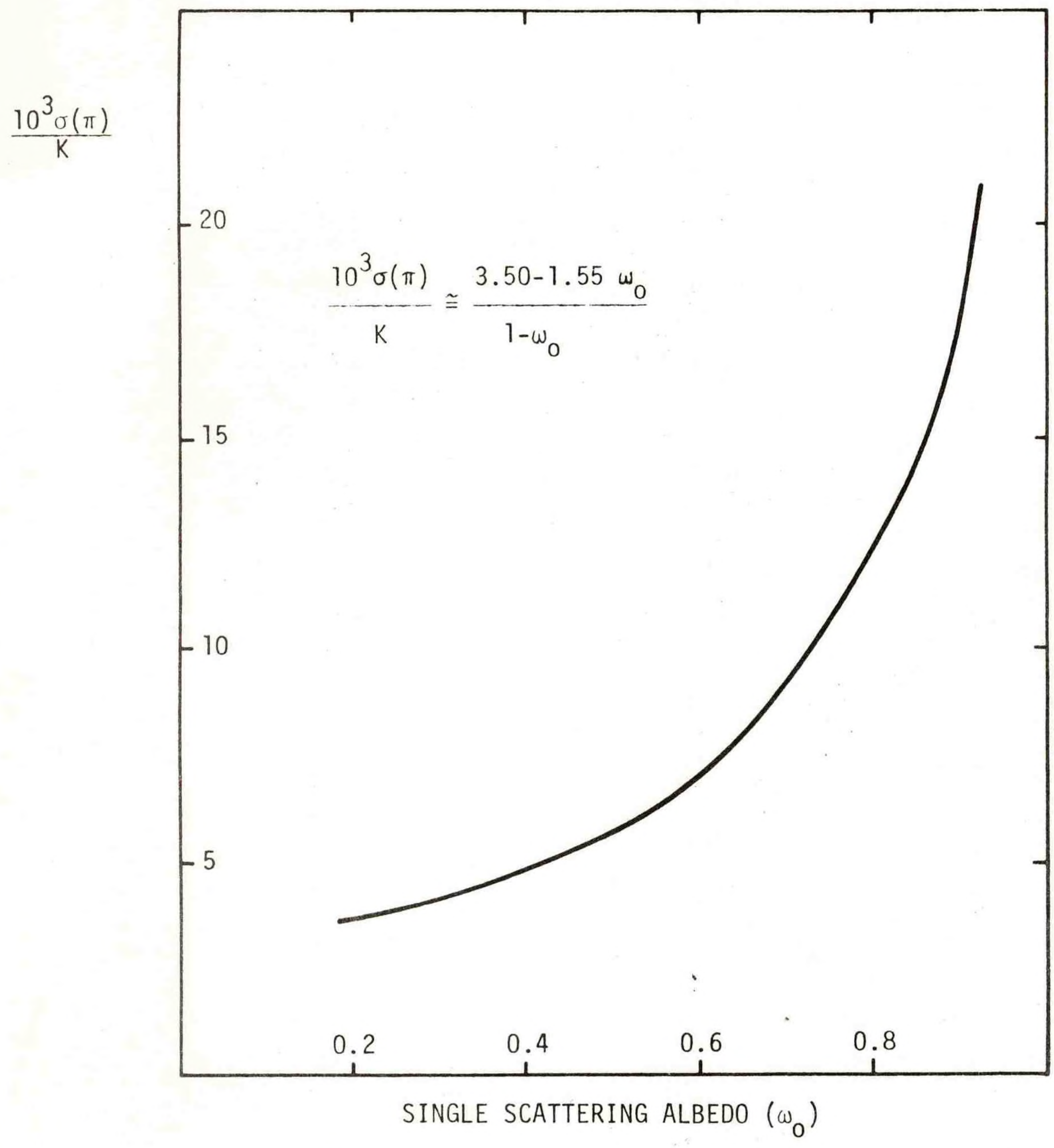



**FIGURE 16. RATIO OF VOLUME SCATTERING FUNCTION AT 180° TO DIFFUSE ATTENUATION COEFFICIENT AS FUNCTION OF SINGLE-SCATTERING ALBEDO**

# Appendix A

Depth-specific biases calculated from linear fractional threshold pulse locators applied to environmental response functions.

convolution summary for navy water

zenith angle of entry=    0.00 degrees        DEPTH=  10.00 METERS

bias in .1 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 0.177 | 0.379 | 0.635 | 0.993 | 1.569 | 2.554 | 4.213 | 5.748 |
| 0.80 | 0.157 | 0.328 | 0.532 | 0.787 | 1.159 | 1.714 | 2.521 | 3.713 |
| 0.70 | 0.136 | 0.280 | 0.444 | 0.628 | 0.880 | 1.210 | 1.621 | 2.129 |
| 0.60 | 0.116 | 0.235 | 0.366 | 0.500 | 0.678 | 0.883 | 1.102 | 1.321 |
| 0.50 | 0.096 | 0.193 | 0.296 | 0.395 | 0.521 | 0.654 | 0.774 | 0.861 |
| 0.40 | 0.076 | 0.152 | 0.231 | 0.304 | 0.392 | 0.479 | 0.550 | 0.554 |
| 0.30 | 0.057 | 0.112 | 0.171 | 0.224 | 0.278 | 0.329 | 0.384 | 0.318 |
| 0.20 | 0.037 | 0.073 | 0.113 | 0.150 | 0.171 | 0.184 | 0.251 | 0.141 |

bias in 1 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 0.572 | 1.475 | 3.023 | 5.075 | 7.602 | 10.366 | 13.151 | 15.944 |
| 0.80 | 0.493 | 1.208 | 2.322 | 4.034 | 5.826 | 7.942 | 10.173 | 12.145 |
| 0.70 | 0.419 | 0.979 | 1.779 | 2.925 | 4.447 | 5.952 | 7.584 | 8.951 |
| 0.60 | 0.348 | 0.783 | 1.350 | 2.093 | 3.214 | 4.379 | 5.408 | 6.303 |
| 0.50 | 0.281 | 0.612 | 1.008 | 1.488 | 2.184 | 2.965 | 3.834 | 4.189 |
| 0.40 | 0.216 | 0.461 | 0.732 | 1.037 | 1.453 | 1.885 | 2.345 | 2.308 |
| 0.30 | 0.154 | 0.324 | 0.507 | 0.694 | 0.918 | 1.136 | 1.424 | 1.146 |
| 0.20 | 0.095 | 0.200 | 0.313 | 0.422 | 0.511 | 0.570 | 0.815 | 0.482 |

bias in 10 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 3.312 | 7.215 | 11.617 | 16.213 | 20.897 | 25.518 | 30.002 | 34.365 |
| 0.80 | 2.893 | 6.184 | 9.797 | 13.536 | 17.415 | 21.175 | 24.798 | 28.064 |
| 0.70 | 2.477 | 5.184 | 8.098 | 11.106 | 14.309 | 17.317 | 20.170 | 22.506 |
| 0.60 | 2.073 | 4.283 | 6.581 | 8.921 | 11.525 | 13.866 | 16.094 | 17.485 |
| 0.50 | 1.679 | 3.457 | 5.170 | 6.951 | 9.029 | 10.790 | 12.460 | 13.054 |
| 0.40 | 1.296 | 2.663 | 3.929 | 5.189 | 6.750 | 8.057 | 9.283 | 9.116 |
| 0.30 | 0.921 | 1.897 | 2.835 | 3.670 | 4.678 | 5.591 | 6.517 | 5.667 |
| 0.20 | 0.554 | 1.172 | 1.786 | 2.309 | 2.834 | 3.237 | 4.107 | 2.914 |

bias in 20 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 4.469 | 9.387 | 14.719 | 20.050 | 25.371 | 30.539 | 35.563 | 40.366 |
| 0.80 | 3.918 | 8.078 | 12.465 | 16.859 | 21.275 | 25.515 | 29.552 | 33.166 |
| 0.70 | 3.374 | 6.831 | 10.408 | 13.937 | 17.598 | 21.046 | 24.240 | 26.809 |
| 0.60 | 2.836 | 5.685 | 8.494 | 11.254 | 14.266 | 17.001 | 19.489 | 21.029 |
| 0.50 | 2.303 | 4.620 | 6.738 | 8.829 | 11.234 | 13.348 | 15.219 | 15.809 |
| 0.40 | 1.773 | 3.589 | 5.164 | 6.655 | 8.453 | 10.062 | 11.440 | 11.198 |
| 0.30 | 1.243 | 2.579 | 3.761 | 4.760 | 5.926 | 7.037 | 8.075 | 7.202 |
| 0.20 | 0.718 | 1.589 | 2.402 | 3.037 | 3.626 | 4.104 | 5.088 | 4.001 |

convolution summary for navy water

zenith angle of entry= 0.00 degrees DEPTH= 10.00 METERS

bias in 50 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 4.360 | 9.537 | 15.490 | 21.454 | 27.376 | 33.086 | 38.676 | 44.059 |
| 0.80 | 3.813 | 8.055 | 12.907 | 17.772 | 22.619 | 27.280 | 31.710 | 35.628 |
| 0.70 | 3.260 | 6.717 | 10.567 | 14.421 | 18.378 | 22.151 | 25.625 | 28.389 |
| 0.60 | 2.698 | 5.514 | 8.434 | 11.378 | 14.576 | 17.544 | 20.248 | 21.862 |
| 0.50 | 2.131 | 4.425 | 6.536 | 8.700 | 11.179 | 13.478 | 15.487 | 16.023 |
| 0.40 | 1.558 | 3.417 | 4.878 | 6.355 | 8.139 | 9.892 | 11.338 | 10.863 |
| 0.30 | 0.980 | 2.384 | 3.514 | 4.408 | 5.512 | 6.694 | 7.736 | 6.498 |
| 0.20 | 0.396 | 1.334 | 2.135 | 2.784 | 3.255 | 3.785 | 4.647 | 3.295 |

bias in 80 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 2.054 | 6.123 | 11.745 | 18.002 | 25.069 | 31.973 | 38.806 | 45.315 |
| 0.80 | 1.722 | 4.832 | 9.254 | 13.991 | 19.298 | 24.716 | 29.943 | 34.613 |
| 0.70 | 1.381 | 3.721 | 7.089 | 10.740 | 14.630 | 18.666 | 22.612 | 25.765 |
| 0.60 | 1.031 | 2.817 | 5.187 | 7.874 | 10.919 | 13.742 | 16.529 | 18.255 |
| 0.50 | 0.673 | 2.083 | 3.598 | 5.478 | 7.741 | 9.828 | 11.727 | 12.284 |
| 0.40 | 0.305 | 1.470 | 2.357 | 3.519 | 5.028 | 6.510 | 7.858 | 7.440 |
| 0.30 | -0.071 | 0.827 | 1.530 | 2.111 | 2.915 | 3.753 | 4.735 | 3.578 |
| 0.20 | -0.458 | 0.156 | 0.667 | 1.129 | 1.410 | 1.645 | 2.377 | 1.280 |

results for bias in peak (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 1.575 | 11.025 | 23.625 | 33.075 | 42.525 | 51.975 | 61.425 | 67.725 |
| 0.80 | 1.575 | 7.875 | 20.475 | 26.775 | 36.225 | 42.525 | 48.825 | 55.125 |
| 0.70 | 1.575 | 7.875 | 14.175 | 20.475 | 26.775 | 33.075 | 39.375 | 42.525 |
| 0.60 | 1.575 | 4.725 | 11.025 | 14.175 | 20.475 | 26.775 | 29.925 | 33.075 |
| 0.50 | 1.575 | 1.575 | 4.725 | 11.025 | 14.175 | 17.325 | 20.475 | 23.625 |
| 0.40 | 1.575 | 1.575 | 4.725 | 4.725 | 11.025 | 11.025 | 14.175 | 14.175 |
| 0.30 | 1.575 | 1.575 | 1.575 | 1.575 | 4.725 | 7.875 | 7.875 | 7.875 |
| 0.20 | 1.575 | 1.575 | 1.575 | 1.575 | 1.575 | 1.575 | 4.725 | 1.575 |

rise time from one percent point to peak (ns)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 7.082 | 7.842 | 8.824 | 9.482 | 10.097 | 10.692 | 11.284 | 11.596 |
| 0.80 | 7.089 | 7.586 | 8.607 | 9.014 | 9.695 | 10.067 | 10.429 | 10.813 |
| 0.70 | 7.096 | 7.606 | 8.095 | 8.553 | 8.978 | 9.404 | 9.819 | 9.977 |
| 0.60 | 7.102 | 7.343 | 7.853 | 8.067 | 8.527 | 8.984 | 9.172 | 9.373 |
| 0.50 | 7.108 | 7.079 | 7.323 | 7.841 | 8.059 | 8.269 | 8.472 | 8.721 |
| 0.40 | 7.114 | 7.092 | 7.348 | 7.321 | 7.844 | 7.805 | 8.045 | 8.048 |
| 0.30 | 7.119 | 7.104 | 7.088 | 7.071 | 7.331 | 7.592 | 7.566 | 7.591 |
| 0.20 | 7.125 | 7.115 | 7.105 | 7.095 | 7.088 | 7.082 | 7.341 | 7.090 |

convolution summary for navy water

zenith angle of entry= 15.00 degrees DEPTH= 10.00 METERS

bias in .1 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -8.268 | -8.491 | -8.313 | -7.964 | -7.241 | -6.151 | -5.018 | -4.085 |
| 0.80 | -8.242 | -8.544 | -8.525 | -8.252 | -7.824 | -7.200 | -6.535 | -5.653 |
| 0.70 | -8.212 | -8.522 | -8.767 | -8.568 | -8.188 | -7.839 | -7.562 | -7.186 |
| 0.60 | -8.177 | -8.408 | -8.899 | -8.949 | -8.439 | -8.233 | -8.127 | -8.016 |
| 0.50 | -8.139 | -8.340 | -8.914 | -9.160 | -8.763 | -8.633 | -8.371 | -8.642 |
| 0.40 | -8.096 | -8.274 | -8.781 | -9.215 | -8.801 | -8.972 | -8.339 | -9.457 |
| 0.30 | -8.049 | -8.188 | -8.408 | -9.076 | -8.472 | -8.876 | -7.978 | -10.209 |
| 0.20 | -7.996 | -8.088 | -8.259 | -8.571 | -8.223 | -8.236 | -7.014 | -10.853 |

bias in 1 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -4.881 | -3.880 | -2.543 | -1.158 | 0.761 | 2.769 | 4.707 | 6.808 |
| 0.80 | -4.972 | -4.191 | -3.048 | -2.063 | -0.631 | 0.920 | 2.296 | 3.761 |
| 0.70 | -5.057 | -4.455 | -3.648 | -2.737 | -1.779 | -0.558 | 0.428 | 1.267 |
| 0.60 | -5.138 | -4.679 | -4.128 | -3.490 | -2.583 | -1.797 | -1.207 | -0.599 |
| 0.50 | -5.214 | -4.870 | -4.510 | -4.144 | -3.331 | -2.650 | -2.244 | -2.046 |
| 0.40 | -5.288 | -5.032 | -4.814 | -4.647 | -4.022 | -3.432 | -2.736 | -3.140 |
| 0.30 | -5.357 | -5.173 | -5.058 | -5.033 | -4.513 | -3.933 | -2.726 | -4.684 |
| 0.20 | -5.420 | -5.303 | -5.251 | -5.317 | -4.854 | -3.839 | -2.186 | -6.731 |

bias in 10 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -0.765 | 2.980 | 6.690 | 10.377 | 14.316 | 18.163 | 21.771 | 25.288 |
| 0.80 | -1.206 | 2.045 | 5.171 | 8.161 | 11.362 | 14.501 | 17.223 | 19.888 |
| 0.70 | -1.638 | 1.136 | 3.739 | 6.138 | 8.791 | 11.400 | 13.368 | 15.303 |
| 0.60 | -2.072 | 0.278 | 2.443 | 4.258 | 6.477 | 8.721 | 10.093 | 11.447 |
| 0.50 | -2.509 | -0.546 | 1.160 | 2.562 | 4.419 | 6.284 | 7.385 | 8.234 |
| 0.40 | -2.952 | -1.388 | -0.026 | 0.874 | 2.588 | 4.102 | 5.339 | 5.523 |
| 0.30 | -3.404 | -2.212 | -1.211 | -0.709 | 0.826 | 2.252 | 4.140 | 2.835 |
| 0.20 | -3.850 | -3.052 | -2.389 | -2.286 | -0.779 | 0.915 | 4.491 | -0.474 |

bias in 20 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 0.314 | 5.103 | 9.724 | 14.195 | 18.792 | 23.230 | 27.359 | 31.360 |
| 0.80 | -0.244 | 3.926 | 7.797 | 11.440 | 15.199 | 18.839 | 22.005 | 25.074 |
| 0.70 | -0.796 | 2.768 | 6.008 | 8.932 | 12.044 | 15.079 | 17.430 | 19.671 |
| 0.60 | -1.357 | 1.660 | 4.339 | 6.615 | 9.227 | 11.798 | 13.498 | 15.055 |
| 0.50 | -1.930 | 0.573 | 2.734 | 4.451 | 6.677 | 8.853 | 10.180 | 11.187 |
| 0.40 | -2.525 | -0.495 | 1.215 | 2.356 | 4.340 | 6.198 | 7.632 | 7.870 |
| 0.30 | -3.136 | -1.554 | -0.308 | 0.330 | 2.149 | 3.911 | 6.397 | 4.675 |
| 0.20 | -3.724 | -2.671 | -1.806 | -1.641 | 0.110 | 2.311 | 7.410 | 0.895 |

convolution summary for navy water

zenith angle of entry= 15.00 degrees DEPTH= 10.00 METERS

bias in 50 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 0.020 | 5.293 | 10.575 | 15.740 | 20.954 | 25.983 | 30.690 | 35.224 |
| 0.80 | -0.561 | 3.923 | 8.303 | 12.479 | 16.675 | 20.763 | 24.336 | 27.779 |
| 0.70 | -1.135 | 2.642 | 6.222 | 9.527 | 12.943 | 16.310 | 18.983 | 21.448 |
| 0.60 | -1.727 | 1.405 | 4.283 | 6.815 | 9.632 | 12.457 | 14.376 | 16.088 |
| 0.50 | -2.338 | 0.222 | 2.491 | 4.346 | 6.659 | 9.032 | 10.479 | 11.612 |
| 0.40 | -2.973 | -0.887 | 0.809 | 2.021 | 3.981 | 5.980 | 7.400 | 7.888 |
| 0.30 | -3.634 | -1.985 | -0.803 | -0.160 | 1.533 | 3.337 | 5.623 | 4.549 |
| 0.20 | -4.231 | -3.163 | -2.330 | -2.149 | -0.661 | 1.520 | 5.980 | 0.696 |

bias in 80 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -2.372 | 2.005 | 7.085 | 12.704 | 18.985 | 25.267 | 31.186 | 36.663 |
| 0.80 | -2.776 | 0.796 | 4.832 | 9.065 | 13.751 | 18.569 | 22.912 | 27.167 |
| 0.70 | -3.156 | -0.299 | 2.868 | 6.026 | 9.558 | 13.232 | 16.321 | 19.211 |
| 0.60 | -3.554 | -1.300 | 1.122 | 3.406 | 6.151 | 9.022 | 11.068 | 12.926 |
| 0.50 | -3.976 | -2.214 | -0.421 | 1.171 | 3.306 | 5.549 | 6.992 | 8.118 |
| 0.40 | -4.424 | -2.998 | -1.764 | -0.829 | 0.907 | 2.662 | 4.018 | 4.409 |
| 0.30 | -4.902 | -3.726 | -2.981 | -2.552 | -1.167 | 0.314 | 2.301 | 1.214 |
| 0.20 | -5.261 | -4.545 | -3.997 | -3.909 | -2.870 | -1.089 | 2.359 | -2.404 |

results for bias in peak (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 0.966 | 10.235 | 19.504 | 28.774 | 38.043 | 47.312 | 53.492 | 53.492 |
| 0.80 | -2.124 | 7.145 | 13.325 | 22.594 | 28.774 | 34.953 | 41.133 | 47.312 |
| 0.70 | -2.124 | 4.055 | 10.235 | 16.414 | 22.594 | 28.774 | 31.863 | 34.953 |
| 0.60 | -2.124 | 0.966 | 7.145 | 10.235 | 16.414 | 19.504 | 22.594 | 25.684 |
| 0.50 | -2.124 | 0.966 | 4.055 | 7.145 | 10.235 | 16.414 | 16.414 | 19.504 |
| 0.40 | -2.124 | -2.124 | 0.966 | 4.055 | 7.145 | 10.235 | 13.325 | 13.325 |
| 0.30 | -2.124 | -2.124 | -2.124 | 0.966 | 0.966 | 4.055 | 10.235 | 7.145 |
| 0.20 | -5.214 | -2.124 | -2.124 | -2.124 | -2.124 | 0.966 | 10.235 | 0.966 |

rise time from one percent point to peak (ns)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 7.523 | 8.272 | 8.991 | 9.705 | 10.372 | 11.030 | 11.414 | 11.224 |
| 0.80 | 7.251 | 8.020 | 8.477 | 9.227 | 9.658 | 10.077 | 10.512 | 10.940 |
| 0.70 | 7.259 | 7.764 | 8.251 | 8.729 | 9.202 | 9.651 | 9.842 | 10.046 |
| 0.60 | 7.266 | 7.505 | 8.015 | 8.237 | 8.715 | 8.923 | 9.150 | 9.375 |
| 0.50 | 7.273 | 7.522 | 7.769 | 8.016 | 8.222 | 8.721 | 8.684 | 8.946 |
| 0.40 | 7.280 | 7.256 | 7.517 | 7.782 | 8.005 | 8.232 | 8.448 | 8.485 |
| 0.30 | 7.286 | 7.269 | 7.259 | 7.537 | 7.489 | 7.717 | 8.168 | 8.065 |
| 0.20 | 7.012 | 7.281 | 7.276 | 7.282 | 7.240 | 7.428 | 8.119 | 7.690 |

convolution summary for navy water

zenith angle of entry= 25.00 degrees DEPTH= 10.00 METERS

bias in .1 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -21.721 | -25.178 | -26.723 | -27.664 | -27.704 | -27.463 | -27.082 | -26.474 |
| 0.80 | -21.169 | -24.763 | -26.567 | -27.954 | -28.226 | -28.438 | -28.665 | -28.456 |
| 0.70 | -20.508 | -24.171 | -26.334 | -28.037 | -28.521 | -29.133 | -30.040 | -29.928 |
| 0.60 | -20.046 | -23.418 | -25.955 | -27.884 | -28.513 | -29.562 | -31.329 | -31.132 |
| 0.50 | -19.434 | -22.782 | -25.320 | -27.413 | -28.066 | -29.689 | -31.967 | -31.288 |
| 0.40 | -18.565 | -21.836 | -24.248 | -26.475 | -26.738 | -29.161 | -31.974 | -29.817 |
| 0.30 | -17.352 | -20.426 | -22.886 | -25.539 | -24.761 | -27.537 | -30.977 | -26.442 |
| 0.20 | -15.895 | -18.987 | -20.830 | -23.905 | -21.227 | -24.044 | -28.505 | -22.917 |

bias in 1 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -11.318 | -14.161 | -15.259 | -15.822 | -15.523 | -15.024 | -14.408 | -13.766 |
| 0.80 | -10.888 | -13.917 | -15.298 | -16.349 | -16.427 | -16.461 | -16.459 | -16.238 |
| 0.70 | -10.342 | -13.552 | -15.172 | -16.614 | -17.005 | -17.555 | -18.191 | -18.309 |
| 0.60 | -9.625 | -13.021 | -14.909 | -16.625 | -17.196 | -18.200 | -19.759 | -19.988 |
| 0.50 | -8.943 | -12.246 | -14.442 | -16.362 | -16.957 | -18.459 | -20.540 | -20.564 |
| 0.40 | -8.272 | -11.469 | -13.670 | -15.744 | -16.077 | -18.014 | -20.566 | -19.999 |
| 0.30 | -7.367 | -10.211 | -12.304 | -14.825 | -14.433 | -16.793 | -19.710 | -17.858 |
| 0.20 | -6.227 | -8.546 | -10.536 | -13.492 | -11.718 | -14.337 | -17.673 | -15.373 |

bias in 10 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -3.565 | -2.955 | -2.035 | -0.689 | 0.955 | 2.613 | 4.222 | 5.594 |
| 0.80 | -3.671 | -3.273 | -2.797 | -2.132 | -0.947 | 0.033 | 0.883 | 1.707 |
| 0.70 | -3.778 | -3.535 | -3.367 | -3.242 | -2.614 | -2.294 | -2.201 | -1.877 |
| 0.60 | -3.887 | -3.745 | -3.776 | -4.039 | -3.753 | -4.085 | -4.662 | -4.723 |
| 0.50 | -4.001 | -3.916 | -4.050 | -4.644 | -4.485 | -5.376 | -6.236 | -6.539 |
| 0.40 | -4.126 | -4.050 | -4.241 | -4.987 | -4.748 | -5.976 | -6.899 | -7.617 |
| 0.30 | -4.261 | -4.189 | -4.304 | -5.120 | -4.549 | -5.949 | -6.923 | -8.740 |
| 0.20 | -4.404 | -4.336 | -4.333 | -5.091 | -4.062 | -5.470 | -7.070 | -10.690 |

bias in 20 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -2.415 | -0.627 | 1.345 | 3.567 | 5.823 | 7.915 | 9.843 | 11.456 |
| 0.80 | -2.669 | -1.242 | 0.182 | 1.608 | 3.364 | 4.808 | 5.979 | 7.047 |
| 0.70 | -2.928 | -1.797 | -0.820 | 0.002 | 1.142 | 1.858 | 2.243 | 2.862 |
| 0.60 | -3.189 | -2.298 | -1.640 | -1.328 | -0.580 | -0.615 | -0.867 | -0.638 |
| 0.50 | -3.454 | -2.764 | -2.311 | -2.373 | -1.853 | -2.502 | -2.959 | -3.018 |
| 0.40 | -3.726 | -3.184 | -2.897 | -3.201 | -2.660 | -3.836 | -4.149 | -4.701 |
| 0.30 | -4.007 | -3.597 | -3.345 | -3.822 | -3.059 | -4.600 | -4.674 | -6.561 |
| 0.20 | -4.298 | -4.015 | -3.760 | -4.264 | -3.162 | -4.913 | -5.451 | -9.202 |

convolution summary for navy water

zenith angle of entry= 25.00 degrees DEPTH= 10.00 METERS

bias in 50 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -2.777 | -0.364 | 2.430 | 5.484 | 8.339 | 10.791 | 12.923 | 14.702 |
| 0.80 | -3.077 | -1.179 | 0.849 | 2.972 | 5.289 | 7.146 | 8.583 | 9.873 |
| 0.70 | -3.374 | -1.930 | -0.494 | 0.846 | 2.431 | 3.479 | 4.120 | 4.977 |
| 0.60 | -3.670 | -2.598 | -1.626 | -0.914 | 0.141 | 0.293 | 0.207 | 0.662 |
| 0.50 | -3.967 | -3.194 | -2.569 | -2.373 | -1.649 | -2.269 | -2.567 | -2.348 |
| 0.40 | -4.268 | -3.683 | -3.379 | -3.513 | -2.905 | -4.155 | -4.320 | -4.483 |
| 0.30 | -4.572 | -4.152 | -3.938 | -4.391 | -3.606 | -5.413 | -5.363 | -6.754 |
| 0.20 | -4.880 | -4.608 | -4.424 | -5.012 | -3.806 | -5.968 | -6.592 | -9.911 |

bias in 80 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -5.074 | -3.142 | -0.037 | 3.847 | 7.452 | 10.260 | 12.451 | 14.159 |
| 0.80 | -5.233 | -3.910 | -1.826 | 0.763 | 3.748 | 6.140 | 7.943 | 9.425 |
| 0.70 | -5.381 | -4.570 | -3.273 | -1.713 | 0.219 | 1.699 | 2.709 | 3.829 |
| 0.60 | -5.518 | -5.105 | -4.393 | -3.657 | -2.455 | -2.093 | -1.939 | -1.408 |
| 0.50 | -5.642 | -5.518 | -5.239 | -5.150 | -4.424 | -4.951 | -5.063 | -5.032 |
| 0.40 | -5.756 | -5.740 | -5.884 | -6.188 | -5.711 | -6.851 | -6.957 | -7.593 |
| 0.30 | -5.859 | -5.906 | -6.126 | -6.842 | -6.285 | -7.878 | -8.026 | -10.044 |
| 0.20 | -5.951 | -6.018 | -6.212 | -7.092 | -6.220 | -7.908 | -9.173 | -12.725 |

results for bias in peak (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -2.548 | 6.412 | 12.385 | 18.359 | 18.359 | 18.359 | 18.359 | 18.359 |
| 0.80 | -2.548 | 3.425 | 9.399 | 15.372 | 18.359 | 18.359 | 18.359 | 18.359 |
| 0.70 | -2.548 | 0.438 | 6.412 | 9.399 | 15.372 | 18.359 | 18.359 | 18.359 |
| 0.60 | -2.548 | 0.438 | 3.425 | 6.412 | 9.399 | 9.399 | 12.385 | 12.385 |
| 0.50 | -2.548 | -2.548 | 0.438 | 3.425 | 3.425 | 6.412 | 6.412 | 6.412 |
| 0.40 | -2.548 | -2.548 | -2.548 | 0.438 | 0.438 | 0.438 | 3.425 | 3.425 |
| 0.30 | -2.548 | -2.548 | -2.548 | -2.548 | 0.438 | -2.548 | 0.438 | -2.548 |
| 0.20 | -2.548 | -2.548 | -2.548 | -2.548 | -2.548 | -2.548 | -2.548 | -11.509 |

rise time from one percent point to peak (ns)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 7.815 | 8.922 | 9.585 | 10.197 | 10.169 | 10.123 | 10.065 | 10.005 |
| 0.80 | 7.775 | 8.619 | 9.308 | 9.967 | 10.254 | 10.257 | 10.257 | 10.236 |
| 0.70 | 7.724 | 8.305 | 9.016 | 9.432 | 10.028 | 10.360 | 10.419 | 10.431 |
| 0.60 | 7.656 | 8.255 | 8.712 | 9.153 | 9.486 | 9.580 | 10.006 | 10.028 |
| 0.50 | 7.592 | 7.902 | 8.388 | 8.848 | 8.904 | 9.325 | 9.520 | 9.522 |
| 0.40 | 7.530 | 7.829 | 8.036 | 8.510 | 8.541 | 8.723 | 9.242 | 9.189 |
| 0.30 | 7.445 | 7.711 | 7.908 | 8.144 | 8.387 | 8.328 | 8.682 | 8.428 |
| 0.20 | 7.338 | 7.555 | 7.742 | 8.019 | 7.853 | 8.098 | 8.411 | 7.355 |

convolution summary for navy water

zenith angle of entry= 35.00 degrees DEPTH= 10.00 METERS

bias in .1 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -47.332 | -57.453 | -62.218 | -64.017 | -64.989 | -65.476 | -65.150 | -64.468 |
| 0.80 | -45.891 | -56.431 | -62.019 | -64.433 | -66.044 | -67.010 | -67.169 | -67.206 |
| 0.70 | -44.890 | -54.917 | -61.527 | -64.546 | -66.847 | -68.220 | -68.403 | -69.220 |
| 0.60 | -43.589 | -53.472 | -60.539 | -64.357 | -67.476 | -69.938 | -69.741 | -71.332 |
| 0.50 | -41.808 | -51.117 | -59.022 | -63.844 | -67.889 | -71.669 | -70.437 | -72.608 |
| 0.40 | -40.260 | -48.628 | -56.851 | -62.941 | -67.854 | -72.987 | -70.038 | -72.796 |
| 0.30 | -38.111 | -45.299 | -53.254 | -60.591 | -66.745 | -73.553 | -67.310 | -69.885 |
| 0.20 | -35.229 | -41.430 | -47.800 | -54.988 | -63.039 | -70.369 | -58.180 | -58.375 |

bias in 1 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -29.655 | -37.963 | -42.974 | -45.843 | -47.327 | -48.279 | -48.300 | -47.743 |
| 0.80 | -28.493 | -37.125 | -42.576 | -46.021 | -48.370 | -50.050 | -50.789 | -50.992 |
| 0.70 | -27.462 | -36.141 | -41.900 | -45.864 | -49.009 | -51.440 | -52.951 | -53.858 |
| 0.60 | -26.117 | -34.800 | -41.002 | -45.339 | -49.305 | -52.917 | -54.365 | -55.756 |
| 0.50 | -24.253 | -32.959 | -39.593 | -44.311 | -49.178 | -54.118 | -54.934 | -57.032 |
| 0.40 | -22.306 | -31.056 | -37.420 | -42.496 | -48.238 | -54.822 | -53.972 | -55.667 |
| 0.30 | -19.349 | -28.158 | -34.863 | -40.187 | -45.737 | -53.944 | -49.368 | -50.156 |
| 0.20 | -15.361 | -24.080 | -30.767 | -36.281 | -40.736 | -48.167 | -40.411 | -40.399 |

bias in 10 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -11.080 | -16.425 | -20.402 | -22.845 | -24.200 | -24.721 | -24.479 | -23.533 |
| 0.80 | -10.693 | -15.881 | -20.334 | -23.404 | -25.547 | -27.288 | -28.253 | -28.385 |
| 0.70 | -10.297 | -15.118 | -19.978 | -23.453 | -26.393 | -29.206 | -30.943 | -31.954 |
| 0.60 | -9.898 | -14.149 | -19.196 | -23.000 | -26.719 | -30.525 | -32.797 | -34.397 |
| 0.50 | -9.488 | -12.942 | -17.915 | -21.930 | -26.403 | -31.507 | -33.456 | -35.503 |
| 0.40 | -9.072 | -11.774 | -16.161 | -20.293 | -25.250 | -31.652 | -32.344 | -34.166 |
| 0.30 | -8.674 | -10.691 | -14.029 | -17.610 | -22.565 | -29.726 | -28.210 | -28.703 |
| 0.20 | -8.305 | -9.576 | -11.519 | -14.108 | -17.013 | -22.760 | -20.778 | -19.281 |

bias in 20 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -9.384 | -12.358 | -14.926 | -16.789 | -17.740 | -17.912 | -17.373 | -16.118 |
| 0.80 | -9.247 | -12.177 | -15.153 | -17.640 | -19.458 | -20.948 | -21.747 | -21.711 |
| 0.70 | -9.104 | -11.841 | -15.108 | -17.945 | -20.618 | -23.191 | -24.908 | -25.782 |
| 0.60 | -8.957 | -11.411 | -14.721 | -17.752 | -21.106 | -24.790 | -27.002 | -28.548 |
| 0.50 | -8.786 | -10.899 | -14.083 | -17.035 | -20.886 | -25.786 | -27.830 | -29.989 |
| 0.40 | -8.586 | -10.339 | -13.175 | -15.791 | -19.656 | -25.820 | -26.870 | -28.840 |
| 0.30 | -8.387 | -9.754 | -12.010 | -14.110 | -17.103 | -23.633 | -23.166 | -23.903 |
| 0.20 | -8.192 | -9.098 | -10.580 | -12.010 | -12.283 | -16.522 | -18.201 | -16.911 |

convolution summary for navy water

zenith angle of entry= 35.00 degrees DEPTH= 10.00 METERS

bias in 50 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -9.688 | -11.151 | -12.191 | -12.807 | -12.901 | -12.351 | -11.183 | -9.348 |
| 0.80 | -9.696 | -11.406 | -12.996 | -14.378 | -15.540 | -16.445 | -16.899 | -16.547 |
| 0.70 | -9.686 | -11.463 | -13.565 | -15.339 | -17.330 | -19.501 | -21.043 | -21.679 |
| 0.60 | -9.658 | -11.420 | -13.746 | -15.778 | -18.371 | -21.673 | -23.776 | -25.266 |
| 0.50 | -9.560 | -11.274 | -13.677 | -15.706 | -18.676 | -23.011 | -25.112 | -27.312 |
| 0.40 | -9.373 | -11.027 | -13.340 | -15.202 | -18.026 | -23.251 | -24.632 | -27.162 |
| 0.30 | -9.152 | -10.637 | -12.707 | -14.264 | -15.973 | -21.192 | -21.942 | -23.973 |
| 0.20 | -8.895 | -10.009 | -11.603 | -12.812 | -11.990 | -14.315 | -18.002 | -18.494 |

bias in 80 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -10.969 | -11.869 | -11.913 | -11.481 | -10.598 | -9.163 | -7.146 | -4.565 |
| 0.80 | -10.980 | -12.332 | -13.128 | -13.761 | -14.237 | -14.561 | -14.570 | -13.847 |
| 0.70 | -10.965 | -12.493 | -14.052 | -15.222 | -16.776 | -18.548 | -19.870 | -20.287 |
| 0.60 | -10.924 | -12.527 | -14.451 | -16.074 | -18.293 | -21.384 | -23.353 | -24.745 |
| 0.50 | -10.766 | -12.428 | -14.563 | -16.276 | -18.952 | -23.083 | -25.249 | -27.520 |
| 0.40 | -10.462 | -12.195 | -14.355 | -15.944 | -18.560 | -23.572 | -25.199 | -28.041 |
| 0.30 | -10.105 | -11.751 | -13.784 | -15.084 | -16.626 | -21.695 | -22.842 | -25.212 |
| 0.20 | -9.692 | -10.935 | -12.555 | -13.656 | -12.721 | -15.055 | -19.372 | -19.569 |

results for bias in peak (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -4.169 | 0.342 | 4.853 | 4.853 | 9.364 | 13.875 | 18.386 | 22.898 |
| 0.80 | -4.169 | -4.169 | 0.342 | 0.342 | 4.853 | 4.853 | 4.853 | 9.364 |
| 0.70 | -4.169 | -4.169 | 0.342 | 0.342 | 0.342 | 0.342 | -4.169 | -4.169 |
| 0.60 | -4.169 | -4.169 | -4.169 | -4.169 | -4.169 | -4.169 | -8.680 | -8.680 |
| 0.50 | -8.680 | -4.169 | -4.169 | -4.169 | -4.169 | -8.680 | -8.680 | -13.191 |
| 0.40 | -8.680 | -4.169 | -4.169 | -4.169 | -4.169 | -8.680 | -13.191 | -13.191 |
| 0.30 | -8.680 | -8.680 | -8.680 | -4.169 | -4.169 | -8.680 | -8.680 | -13.191 |
| 0.20 | -8.680 | -8.680 | -8.680 | -8.680 | -4.169 | -4.169 | -13.191 | -8.680 |

rise time from one percent point to peak (ns)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 9.504 | 10.767 | 11.705 | 11.988 | 12.578 | 13.117 | 13.563 | 13.953 |
| 0.80 | 9.389 | 10.240 | 11.221 | 11.561 | 12.237 | 12.402 | 12.475 | 12.939 |
| 0.70 | 9.288 | 10.143 | 11.155 | 11.545 | 11.855 | 12.095 | 11.799 | 11.888 |
| 0.60 | 9.155 | 10.011 | 10.622 | 11.049 | 11.440 | 11.796 | 11.494 | 11.631 |
| 0.50 | 8.527 | 9.829 | 10.483 | 10.948 | 11.427 | 11.470 | 11.550 | 11.312 |
| 0.40 | 8.335 | 9.642 | 10.269 | 10.769 | 11.335 | 11.539 | 11.011 | 11.178 |
| 0.30 | 8.044 | 8.912 | 9.573 | 10.542 | 11.088 | 11.453 | 11.002 | 10.635 |
| 0.20 | 7.651 | 8.510 | 9.169 | 9.712 | 10.596 | 11.328 | 9.675 | 10.118 |

convolution summary for NOS water

zenith angle of entry= 35.00 degrees DEPTH= 10.00 METERS

bias in .1 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -49.426 | -57.993 | -61.691 | -62.708 | -62.227 | -61.352 | -60.471 | -59.511 |
| 0.80 | -48.342 | -57.001 | -61.332 | -63.178 | -63.182 | -63.121 | -63.069 | -63.467 |
| 0.70 | -46.886 | -55.400 | -60.477 | -63.242 | -63.534 | -64.316 | -65.416 | -67.446 |
| 0.60 | -45.418 | -53.633 | -59.131 | -62.784 | -63.321 | -65.315 | -67.756 | -71.575 |
| 0.50 | -44.048 | -50.846 | -57.354 | -61.379 | -62.407 | -65.505 | -70.483 | -75.099 |
| 0.40 | -42.097 | -47.909 | -54.262 | -58.506 | -60.163 | -64.731 | -72.791 | -77.179 |
| 0.30 | -40.071 | -44.209 | -49.788 | -53.583 | -56.904 | -63.054 | -74.945 | -77.479 |
| 0.20 | -36.860 | -39.671 | -43.956 | -45.823 | -50.555 | -59.430 | -75.643 | -74.724 |

bias in 1 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -31.490 | -38.541 | -43.126 | -44.830 | -44.626 | -43.680 | -42.888 | -41.793 |
| 0.80 | -30.556 | -37.485 | -42.739 | -45.354 | -46.105 | -46.061 | -46.179 | -46.576 |
| 0.70 | -29.346 | -36.427 | -41.877 | -45.286 | -46.912 | -47.825 | -48.849 | -51.135 |
| 0.60 | -27.992 | -34.862 | -40.717 | -44.495 | -46.958 | -48.828 | -50.901 | -56.867 |
| 0.50 | -26.447 | -32.694 | -38.727 | -42.540 | -46.133 | -48.990 | -53.449 | -64.118 |
| 0.40 | -24.102 | -30.193 | -36.077 | -39.753 | -44.248 | -48.310 | -56.165 | -69.335 |
| 0.30 | -21.429 | -26.707 | -32.293 | -35.432 | -40.559 | -46.565 | -59.257 | -71.986 |
| 0.20 | -17.371 | -21.839 | -27.145 | -29.271 | -34.252 | -43.930 | -61.681 | -72.274 |

bias in 10 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -11.941 | -16.562 | -20.386 | -21.017 | -20.446 | -18.968 | -17.153 | -15.321 |
| 0.80 | -11.495 | -16.035 | -20.595 | -22.279 | -23.172 | -22.732 | -22.237 | -22.295 |
| 0.70 | -11.017 | -15.281 | -20.332 | -22.783 | -24.945 | -25.350 | -25.793 | -28.019 |
| 0.60 | -10.515 | -14.206 | -19.568 | -22.466 | -25.774 | -27.045 | -28.614 | -33.970 |
| 0.50 | -10.004 | -12.813 | -18.103 | -21.171 | -25.749 | -27.820 | -31.134 | -42.312 |
| 0.40 | -9.471 | -11.501 | -16.020 | -19.002 | -24.653 | -27.762 | -34.268 | -54.309 |
| 0.30 | -8.951 | -10.257 | -13.446 | -15.670 | -21.941 | -27.014 | -38.502 | -66.221 |
| 0.20 | -8.469 | -9.085 | -10.879 | -11.974 | -16.781 | -25.581 | -43.425 | -69.813 |

bias in 20 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -9.833 | -12.005 | -14.506 | -14.427 | -13.442 | -11.558 | -9.170 | -6.705 |
| 0.80 | -9.674 | -11.867 | -15.103 | -16.152 | -16.745 | -16.058 | -15.098 | -14.787 |
| 0.70 | -9.491 | -11.581 | -15.236 | -17.067 | -19.019 | -19.232 | -19.350 | -21.225 |
| 0.60 | -9.289 | -11.077 | -14.895 | -17.183 | -20.385 | -21.401 | -22.568 | -27.521 |
| 0.50 | -9.076 | -10.444 | -14.084 | -16.439 | -20.821 | -22.534 | -25.407 | -36.202 |
| 0.40 | -8.816 | -9.791 | -12.880 | -14.929 | -20.073 | -22.868 | -28.726 | -48.227 |
| 0.30 | -8.545 | -9.122 | -11.373 | -13.121 | -18.087 | -22.668 | -33.223 | -62.472 |
| 0.20 | -8.284 | -8.484 | -9.833 | -11.162 | -14.579 | -22.029 | -38.502 | -68.894 |

convolution summary for NOS water

zenith angle of entry= 35.00 degrees DEPTH= 10.00 METERS

bias in 50 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -9.819 | -10.131 | -10.911 | -9.443 | -7.431 | -4.742 | -0.995 | 2.679 |
| 0.80 | -9.856 | -10.512 | -12.300 | -12.177 | -12.029 | -10.841 | -9.051 | -7.947 |
| 0.70 | -9.854 | -10.759 | -13.159 | -13.988 | -15.434 | -15.233 | -14.744 | -15.893 |
| 0.60 | -9.817 | -10.726 | -13.578 | -15.038 | -17.722 | -18.287 | -18.890 | -23.032 |
| 0.50 | -9.749 | -10.524 | -13.438 | -15.278 | -19.064 | -20.220 | -22.371 | -32.311 |
| 0.40 | -9.552 | -10.197 | -12.908 | -14.903 | -19.258 | -21.256 | -26.211 | -45.751 |
| 0.30 | -9.288 | -9.786 | -12.033 | -13.989 | -18.219 | -21.761 | -31.192 | -60.625 |
| 0.20 | -8.985 | -9.252 | -10.896 | -12.550 | -15.596 | -21.823 | -37.311 | -67.704 |

bias in 80 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -11.058 | -10.532 | -9.879 | -7.023 | -3.759 | -0.091 | 5.340 | 10.529 |
| 0.80 | -11.117 | -11.197 | -11.997 | -10.885 | -9.890 | -8.196 | -5.346 | -3.339 |
| 0.70 | -11.127 | -11.733 | -13.402 | -13.586 | -14.509 | -13.885 | -12.833 | -13.227 |
| 0.60 | -11.090 | -11.861 | -14.280 | -15.321 | -17.748 | -17.933 | -18.104 | -21.451 |
| 0.50 | -11.011 | -11.773 | -14.431 | -16.086 | -19.831 | -20.563 | -22.305 | -31.092 |
| 0.40 | -10.718 | -11.529 | -14.131 | -16.111 | -20.580 | -22.179 | -26.631 | -44.541 |
| 0.30 | -10.316 | -11.164 | -13.410 | -15.370 | -19.926 | -23.209 | -32.133 | -64.530 |
| 0.20 | -9.847 | -10.540 | -12.288 | -13.758 | -17.354 | -23.745 | -38.676 | -70.174 |

results for bias in peak (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -4.169 | 0.342 | 9.364 | 13.875 | 18.386 | 27.409 | 36.431 | 40.942 |
| 0.80 | -4.169 | 0.342 | 4.853 | 4.853 | 9.364 | 13.875 | 18.386 | 22.898 |
| 0.70 | -4.169 | 0.342 | 0.342 | 0.342 | 4.853 | 4.853 | 4.853 | 9.364 |
| 0.60 | -4.169 | -4.169 | -4.169 | 0.342 | -4.169 | -4.169 | 0.342 | -4.169 |
| 0.50 | -4.169 | -4.169 | -4.169 | -4.169 | -8.680 | -4.169 | -8.680 | -13.191 |
| 0.40 | -8.680 | -4.169 | -4.169 | -4.169 | -8.680 | -8.680 | -13.191 | -31.236 |
| 0.30 | -8.680 | -4.169 | -4.169 | -8.680 | -8.680 | -13.191 | -17.703 | -44.769 |
| 0.20 | -8.680 | -8.680 | -8.680 | -8.680 | -8.680 | -13.191 | -26.725 | -71.836 |

rise time from one percent point to peak (ns)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 9.685 | 10.824 | 12.164 | 12.777 | 13.201 | 13.997 | 14.808 | 15.144 |
| 0.80 | 9.593 | 10.720 | 11.682 | 11.940 | 12.458 | 12.898 | 13.354 | 13.838 |
| 0.70 | 9.473 | 10.616 | 11.153 | 11.488 | 12.093 | 12.183 | 12.284 | 12.953 |
| 0.60 | 9.340 | 10.017 | 10.594 | 11.410 | 11.209 | 11.393 | 12.042 | 12.185 |
| 0.50 | 9.188 | 9.803 | 10.398 | 10.773 | 10.683 | 11.409 | 11.404 | 12.010 |
| 0.40 | 8.512 | 9.557 | 10.137 | 10.499 | 10.497 | 10.897 | 11.227 | 10.747 |
| 0.30 | 8.249 | 9.213 | 9.764 | 9.629 | 10.134 | 10.281 | 11.087 | 9.674 |
| 0.20 | 7.849 | 8.289 | 8.812 | 9.022 | 9.512 | 10.021 | 10.437 | 7.036 |

convolution summary for navy water

zenith angle of entry= 0.00 degrees DEPTH= 20.00 METERS

bias in .1 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 0.241 | 0.497 | 0.790 | 1.141 | 1.627 | 2.366 | 3.462 | 5.115 |
| 0.80 | 0.214 | 0.437 | 0.683 | 0.953 | 1.308 | 1.794 | 2.438 | 3.292 |
| 0.70 | 0.187 | 0.378 | 0.583 | 0.791 | 1.057 | 1.384 | 1.764 | 2.204 |
| 0.60 | 0.160 | 0.321 | 0.491 | 0.649 | 0.851 | 1.078 | 1.296 | 1.526 |
| 0.50 | 0.133 | 0.266 | 0.404 | 0.522 | 0.672 | 0.838 | 0.950 | 1.069 |
| 0.40 | 0.107 | 0.212 | 0.321 | 0.407 | 0.511 | 0.639 | 0.681 | 0.716 |
| 0.30 | 0.080 | 0.158 | 0.239 | 0.301 | 0.360 | 0.456 | 0.466 | 0.417 |
| 0.20 | 0.053 | 0.105 | 0.158 | 0.199 | 0.215 | 0.269 | 0.295 | 0.181 |

bias in 1 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 0.545 | 1.344 | 2.647 | 4.766 | 7.672 | 10.810 | 13.787 | 17.046 |
| 0.80 | 0.473 | 1.120 | 2.096 | 3.561 | 5.927 | 8.329 | 10.962 | 13.343 |
| 0.70 | 0.402 | 0.925 | 1.647 | 2.649 | 4.208 | 6.385 | 8.124 | 9.979 |
| 0.60 | 0.334 | 0.751 | 1.280 | 1.954 | 2.980 | 4.256 | 5.763 | 7.096 |
| 0.50 | 0.270 | 0.597 | 0.980 | 1.425 | 2.083 | 2.823 | 3.600 | 4.171 |
| 0.40 | 0.210 | 0.453 | 0.729 | 1.018 | 1.415 | 1.842 | 2.248 | 2.269 |
| 0.30 | 0.152 | 0.319 | 0.512 | 0.696 | 0.905 | 1.132 | 1.378 | 1.121 |
| 0.20 | 0.095 | 0.200 | 0.315 | 0.426 | 0.503 | 0.583 | 0.793 | 0.452 |

bias in 10 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 3.106 | 7.182 | 12.264 | 17.763 | 23.345 | 28.556 | 33.264 | 37.437 |
| 0.80 | 2.685 | 6.108 | 10.319 | 14.969 | 19.867 | 24.415 | 28.562 | 32.211 |
| 0.70 | 2.274 | 5.142 | 8.448 | 12.190 | 16.393 | 20.232 | 23.796 | 26.722 |
| 0.60 | 1.872 | 4.216 | 6.758 | 9.763 | 13.182 | 16.207 | 19.144 | 21.118 |
| 0.50 | 1.493 | 3.347 | 5.317 | 7.448 | 10.213 | 12.468 | 14.751 | 15.690 |
| 0.40 | 1.152 | 2.524 | 4.009 | 5.549 | 7.429 | 9.144 | 10.754 | 10.646 |
| 0.30 | 0.817 | 1.743 | 2.806 | 3.884 | 5.071 | 6.025 | 7.391 | 6.217 |
| 0.20 | 0.488 | 1.068 | 1.694 | 2.352 | 2.922 | 3.215 | 4.701 | 2.831 |

bias in 20 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 4.362 | 9.732 | 16.086 | 22.549 | 28.787 | 34.426 | 39.432 | 43.769 |
| 0.80 | 3.789 | 8.319 | 13.579 | 19.130 | 24.750 | 29.809 | 34.371 | 38.287 |
| 0.70 | 3.218 | 7.037 | 11.269 | 15.873 | 20.807 | 25.112 | 29.100 | 32.369 |
| 0.60 | 2.650 | 5.790 | 9.088 | 12.756 | 16.996 | 20.491 | 23.803 | 26.102 |
| 0.50 | 2.109 | 4.657 | 7.192 | 9.899 | 13.286 | 16.051 | 18.623 | 19.785 |
| 0.40 | 1.621 | 3.541 | 5.457 | 7.423 | 9.865 | 11.944 | 13.857 | 13.731 |
| 0.30 | 1.130 | 2.441 | 3.879 | 5.217 | 6.819 | 8.101 | 9.674 | 8.315 |
| 0.20 | 0.644 | 1.479 | 2.340 | 3.187 | 4.019 | 4.557 | 6.111 | 4.066 |

convolution summary for navy water

zenith angle of entry= 0.00 degrees DEPTH= 20.00 METERS

bias in 50 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 4.489 | 10.502 | 17.852 | 24.955 | 31.580 | 37.331 | 42.294 | 46.450 |
| 0.80 | 3.841 | 8.862 | 14.935 | 21.132 | 27.223 | 32.566 | 37.185 | 41.065 |
| 0.70 | 3.181 | 7.372 | 12.189 | 17.372 | 22.824 | 27.529 | 31.724 | 35.005 |
| 0.60 | 2.497 | 5.984 | 9.666 | 13.742 | 18.456 | 22.426 | 26.016 | 28.386 |
| 0.50 | 1.859 | 4.779 | 7.471 | 10.422 | 14.192 | 17.359 | 20.205 | 21.446 |
| 0.40 | 1.343 | 3.530 | 5.566 | 7.601 | 10.225 | 12.586 | 14.742 | 14.680 |
| 0.30 | 0.821 | 2.223 | 3.862 | 5.200 | 6.755 | 8.175 | 9.880 | 8.755 |
| 0.20 | 0.293 | 1.176 | 2.076 | 2.979 | 3.815 | 4.320 | 5.736 | 4.471 |

bias in 80 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 2.087 | 7.017 | 14.136 | 22.531 | 29.999 | 35.892 | 40.623 | 44.465 |
| 0.80 | 1.607 | 5.529 | 11.284 | 17.948 | 25.024 | 30.930 | 35.666 | 39.331 |
| 0.70 | 1.109 | 4.267 | 8.623 | 13.661 | 19.764 | 25.247 | 29.929 | 33.358 |
| 0.60 | 0.591 | 3.151 | 6.279 | 10.092 | 14.745 | 19.263 | 23.493 | 26.094 |
| 0.50 | 0.140 | 2.294 | 4.374 | 6.942 | 10.513 | 13.655 | 16.776 | 18.133 |
| 0.40 | -0.125 | 1.371 | 2.871 | 4.454 | 6.747 | 9.049 | 11.074 | 10.906 |
| 0.30 | -0.397 | 0.380 | 1.633 | 2.575 | 3.725 | 4.980 | 6.512 | 5.163 |
| 0.20 | -0.676 | -0.220 | 0.275 | 0.958 | 1.523 | 1.945 | 2.938 | 1.656 |

results for bias in peak (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 3.750 | 18.750 | 28.750 | 38.750 | 48.750 | 53.750 | 58.750 | 58.750 |
| 0.80 | 3.750 | 13.750 | 23.750 | 33.750 | 38.750 | 48.750 | 53.750 | 53.750 |
| 0.70 | 3.750 | 8.750 | 18.750 | 28.750 | 33.750 | 38.750 | 43.750 | 48.750 |
| 0.60 | 3.750 | 3.750 | 13.750 | 23.750 | 28.750 | 33.750 | 38.750 | 43.750 |
| 0.50 | -1.250 | 3.750 | 8.750 | 13.750 | 23.750 | 28.750 | 33.750 | 33.750 |
| 0.40 | -1.250 | 3.750 | 3.750 | 8.750 | 13.750 | 18.750 | 23.750 | 23.750 |
| 0.30 | -1.250 | 3.750 | 3.750 | 3.750 | 8.750 | 8.750 | 13.750 | 13.750 |
| 0.20 | -1.250 | -1.250 | 3.750 | 3.750 | 3.750 | 3.750 | 3.750 | 3.750 |

rise time from one percent point to peak (ns)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 7.278 | 8.540 | 9.313 | 10.014 | 10.644 | 10.810 | 10.990 | 10.700 |
| 0.80 | 7.284 | 8.116 | 8.918 | 9.676 | 9.911 | 10.586 | 10.796 | 10.585 |
| 0.70 | 7.291 | 7.689 | 8.513 | 9.313 | 9.619 | 9.870 | 10.160 | 10.439 |
| 0.60 | 7.297 | 7.260 | 8.101 | 8.930 | 9.284 | 9.615 | 9.925 | 10.251 |
| 0.50 | 6.858 | 7.273 | 7.684 | 8.089 | 8.919 | 9.298 | 9.673 | 9.622 |
| 0.40 | 6.863 | 7.286 | 7.262 | 7.680 | 8.089 | 8.496 | 8.904 | 8.902 |
| 0.30 | 6.868 | 7.298 | 7.281 | 7.264 | 7.690 | 7.670 | 8.093 | 8.116 |
| 0.20 | 6.873 | 6.864 | 7.298 | 7.289 | 7.282 | 7.275 | 7.256 | 7.286 |

convolution summary for navy water

zenith angle of entry= 15.00 degrees DEPTH= 20.00 METERS

bias in .1 percent point (CENTIMETERS)

| alpha*d= / albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -18.448 | -19.842 | -20.218 | -20.141 | -19.665 | -18.970 | -18.291 | -17.457 |
| 0.80 | -18.145 | -19.738 | -20.252 | -20.338 | -20.042 | -19.589 | -19.305 | -18.875 |
| 0.70 | -17.762 | -19.573 | -20.234 | -20.458 | -20.279 | -20.019 | -19.986 | -19.808 |
| 0.60 | -17.263 | -19.322 | -20.142 | -20.484 | -20.365 | -20.303 | -20.344 | -20.403 |
| 0.50 | -16.576 | -18.955 | -19.971 | -20.410 | -20.286 | -20.437 | -20.356 | -20.746 |
| 0.40 | -16.060 | -18.356 | -19.665 | -20.213 | -20.004 | -20.395 | -19.859 | -20.922 |
| 0.30 | -15.616 | -17.343 | -19.129 | -19.837 | -19.400 | -20.017 | -18.238 | -21.002 |
| 0.20 | -14.736 | -15.997 | -18.027 | -19.081 | -18.043 | -18.708 | -15.360 | -20.989 |

bias in 1 percent point (CENTIMETERS)

| alpha*d= / albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -10.937 | -11.029 | -10.633 | -9.810 | -8.387 | -6.849 | -5.770 | -4.584 |
| 0.80 | -10.906 | -11.097 | -10.911 | -10.395 | -9.360 | -8.120 | -7.091 | -6.387 |
| 0.70 | -10.870 | -11.122 | -11.126 | -10.860 | -10.107 | -9.238 | -8.704 | -8.051 |
| 0.60 | -10.831 | -11.107 | -11.253 | -11.186 | -10.632 | -10.096 | -9.799 | -9.540 |
| 0.50 | -10.788 | -11.063 | -11.313 | -11.391 | -10.958 | -10.698 | -10.366 | -10.582 |
| 0.40 | -10.743 | -10.969 | -11.284 | -11.474 | -11.103 | -11.031 | -10.310 | -11.490 |
| 0.30 | -10.694 | -10.859 | -11.177 | -11.433 | -11.062 | -10.950 | -9.358 | -13.326 |
| 0.20 | -10.634 | -10.743 | -10.992 | -11.252 | -10.847 | -10.034 | -6.965 | -16.099 |

bias in 10 percent point (CENTIMETERS)

| alpha*d= / albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -4.959 | -1.607 | 1.560 | 4.436 | 7.402 | 10.194 | 12.398 | 14.475 |
| 0.80 | -5.380 | -2.402 | 0.447 | 2.844 | 5.645 | 8.025 | 9.991 | 11.592 |
| 0.70 | -5.806 | -3.165 | -0.797 | 1.329 | 3.727 | 6.073 | 7.483 | 8.820 |
| 0.60 | -6.240 | -3.906 | -1.930 | -0.206 | 2.003 | 4.007 | 5.321 | 6.273 |
| 0.50 | -6.684 | -4.732 | -3.042 | -1.776 | 0.390 | 2.065 | 3.243 | 3.835 |
| 0.40 | -7.141 | -5.534 | -4.109 | -3.289 | -1.351 | 0.271 | 1.752 | 1.466 |
| 0.30 | -7.599 | -6.357 | -5.322 | -4.882 | -2.982 | -1.307 | 1.055 | -1.689 |
| 0.20 | -8.030 | -7.221 | -6.526 | -6.486 | -4.606 | -2.014 | 1.442 | -6.440 |

bias in 20 percent point (CENTIMETERS)

| alpha*d= / albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -3.608 | 0.971 | 4.957 | 8.466 | 11.904 | 14.841 | 17.388 | 19.431 |
| 0.80 | -4.156 | -0.092 | 3.529 | 6.600 | 9.751 | 12.644 | 14.673 | 16.504 |
| 0.70 | -4.722 | -1.129 | 2.024 | 4.652 | 7.661 | 10.301 | 12.035 | 13.534 |
| 0.60 | -5.309 | -2.151 | 0.542 | 2.793 | 5.470 | 8.002 | 9.404 | 10.575 |
| 0.50 | -5.920 | -3.301 | -0.960 | 0.767 | 3.389 | 5.593 | 7.025 | 7.791 |
| 0.40 | -6.562 | -4.353 | -2.442 | -1.263 | 1.218 | 3.258 | 4.967 | 4.799 |
| 0.30 | -7.214 | -5.470 | -4.050 | -3.435 | -0.961 | 1.093 | 3.825 | 1.187 |
| 0.20 | -7.823 | -6.684 | -5.677 | -5.581 | -3.193 | -0.290 | 4.244 | -4.069 |

convolution summary for navy water

zenith angle of entry= 15.00 degrees DEPTH= 20.00 METERS

bias in 50 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -3.950 | 1.166 | 5.508 | 9.167 | 12.539 | 15.321 | 17.534 | 19.392 |
| 0.80 | -4.515 | -0.019 | 3.960 | 7.216 | 10.469 | 13.193 | 15.175 | 16.792 |
| 0.70 | -5.111 | -1.193 | 2.251 | 5.146 | 8.257 | 10.950 | 12.612 | 14.127 |
| 0.60 | -5.742 | -2.368 | 0.651 | 3.067 | 5.983 | 8.559 | 10.042 | 11.234 |
| 0.50 | -6.422 | -3.650 | -1.050 | 0.875 | 3.688 | 6.068 | 7.522 | 8.290 |
| 0.40 | -7.145 | -4.734 | -2.728 | -1.405 | 1.269 | 3.543 | 5.471 | 5.087 |
| 0.30 | -7.857 | -5.932 | -4.455 | -3.823 | -1.164 | 1.265 | 4.889 | 1.113 |
| 0.20 | -8.405 | -7.294 | -6.181 | -6.053 | -3.623 | 0.060 | 7.027 | -4.485 |

bias in 80 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -6.752 | -2.515 | 1.549 | 5.228 | 8.882 | 11.972 | 14.415 | 16.517 |
| 0.80 | -7.127 | -3.584 | 0.030 | 3.334 | 6.712 | 9.607 | 11.851 | 13.645 |
| 0.70 | -7.532 | -4.595 | -1.541 | 1.208 | 4.359 | 7.273 | 9.052 | 10.678 |
| 0.60 | -7.971 | -5.522 | -2.955 | -0.758 | 2.100 | 4.663 | 6.329 | 7.661 |
| 0.50 | -8.449 | -6.580 | -4.489 | -2.748 | -0.176 | 2.188 | 3.698 | 4.531 |
| 0.40 | -8.974 | -7.300 | -5.821 | -4.781 | -2.386 | -0.338 | 1.497 | 1.336 |
| 0.30 | -9.457 | -8.122 | -7.148 | -6.770 | -4.583 | -2.407 | 0.635 | -2.496 |
| 0.20 | -9.654 | -9.097 | -8.324 | -8.306 | -6.589 | -3.373 | 1.861 | -8.009 |

results for bias in peak (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -5.131 | 4.678 | 14.486 | 19.391 | 24.295 | 24.295 | 29.200 | 29.200 |
| 0.80 | -5.131 | 4.678 | 9.582 | 14.486 | 19.391 | 24.295 | 24.295 | 29.200 |
| 0.70 | -5.131 | -0.227 | 9.582 | 9.582 | 14.486 | 19.391 | 24.295 | 24.295 |
| 0.60 | -5.131 | -0.227 | 4.678 | 9.582 | 14.486 | 14.486 | 19.391 | 19.391 |
| 0.50 | -5.131 | -0.227 | -0.227 | 4.678 | 9.582 | 14.486 | 14.486 | 14.486 |
| 0.40 | -5.131 | -5.131 | -0.227 | -0.227 | 4.678 | 9.582 | 9.582 | 9.582 |
| 0.30 | -10.036 | -5.131 | -5.131 | -0.227 | -0.227 | 4.678 | 9.582 | 4.678 |
| 0.20 | -10.036 | -5.131 | -5.131 | -5.131 | -5.131 | -0.227 | 9.582 | -0.227 |

rise time from one percent point to peak (ns)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 7.519 | 8.416 | 9.269 | 9.639 | 9.955 | 9.815 | 10.162 | 10.055 |
| 0.80 | 7.516 | 8.422 | 8.850 | 9.248 | 9.598 | 9.931 | 9.837 | 10.218 |
| 0.70 | 7.513 | 7.980 | 8.870 | 8.845 | 9.222 | 9.587 | 9.983 | 9.924 |
| 0.60 | 7.509 | 7.979 | 8.437 | 8.875 | 9.269 | 9.221 | 9.638 | 9.615 |
| 0.50 | 7.506 | 7.975 | 7.998 | 8.449 | 8.854 | 9.275 | 9.245 | 9.265 |
| 0.40 | 7.502 | 7.522 | 7.995 | 8.012 | 8.423 | 8.861 | 8.796 | 8.903 |
| 0.30 | 7.053 | 7.512 | 7.541 | 8.009 | 7.975 | 8.409 | 8.709 | 8.624 |
| 0.20 | 7.047 | 7.502 | 7.524 | 7.548 | 7.511 | 7.882 | 8.493 | 8.431 |

convolution summary for navy water

zenith angle of entry= 25.00 degrees DEPTH= 20.00 METERS

bias in .1 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -58.459 | -65.662 | -68.622 | -70.513 | -71.018 | -71.154 | -71.484 | -71.010 |
| 0.80 | -57.652 | -64.744 | -68.067 | -70.379 | -71.037 | -71.614 | -72.449 | -72.104 |
| 0.70 | -56.640 | -63.487 | -67.548 | -70.043 | -70.873 | -71.944 | -73.659 | -72.883 |
| 0.60 | -55.335 | -62.429 | -66.761 | -69.404 | -70.338 | -72.050 | -74.882 | -73.435 |
| 0.50 | -53.797 | -60.868 | -65.503 | -68.293 | -69.018 | -71.749 | -75.541 | -72.603 |
| 0.40 | -52.828 | -58.514 | -63.388 | -67.192 | -66.877 | -70.587 | -75.467 | -69.657 |
| 0.30 | -51.626 | -56.156 | -60.996 | -65.405 | -62.638 | -67.607 | -73.825 | -61.799 |
| 0.20 | -50.096 | -53.004 | -57.119 | -62.653 | -55.268 | -62.404 | -67.861 | -49.182 |

bias in 1 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -42.015 | -47.529 | -51.275 | -53.778 | -54.840 | -55.518 | -55.896 | -55.594 |
| 0.80 | -41.345 | -46.612 | -50.401 | -53.411 | -54.600 | -55.927 | -57.059 | -57.039 |
| 0.70 | -40.616 | -45.477 | -49.472 | -52.811 | -54.216 | -56.109 | -58.112 | -58.170 |
| 0.60 | -40.062 | -44.494 | -48.488 | -51.879 | -53.440 | -55.915 | -58.915 | -58.678 |
| 0.50 | -39.563 | -43.451 | -47.155 | -50.460 | -51.932 | -55.031 | -59.240 | -57.886 |
| 0.40 | -39.033 | -42.178 | -45.307 | -48.929 | -49.254 | -53.387 | -58.653 | -53.941 |
| 0.30 | -38.469 | -40.621 | -43.637 | -47.117 | -45.153 | -49.851 | -56.056 | -47.029 |
| 0.20 | -37.870 | -39.443 | -41.329 | -44.965 | -39.545 | -44.746 | -50.188 | -36.333 |

bias in 10 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -26.394 | -30.129 | -32.836 | -35.248 | -36.382 | -37.002 | -37.281 | -37.272 |
| 0.80 | -26.019 | -29.510 | -32.280 | -34.809 | -36.147 | -37.194 | -38.125 | -38.478 |
| 0.70 | -25.625 | -28.807 | -31.610 | -34.181 | -35.686 | -37.182 | -38.944 | -39.545 |
| 0.60 | -25.212 | -28.039 | -30.802 | -33.325 | -34.871 | -36.877 | -39.495 | -40.052 |
| 0.50 | -24.778 | -27.361 | -29.820 | -32.372 | -33.514 | -36.134 | -39.526 | -39.412 |
| 0.40 | -24.322 | -26.606 | -28.615 | -31.305 | -31.661 | -34.718 | -38.610 | -36.638 |
| 0.30 | -23.841 | -25.765 | -27.381 | -30.003 | -28.844 | -32.500 | -36.255 | -31.930 |
| 0.20 | -23.365 | -24.837 | -26.038 | -28.433 | -25.197 | -30.072 | -31.702 | -28.877 |

bias in 20 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -25.303 | -28.194 | -30.401 | -32.325 | -33.309 | -33.855 | -34.087 | -34.105 |
| 0.80 | -25.021 | -27.730 | -29.926 | -31.943 | -33.112 | -34.037 | -34.759 | -35.059 |
| 0.70 | -24.733 | -27.219 | -29.368 | -31.404 | -32.715 | -34.032 | -35.349 | -35.919 |
| 0.60 | -24.439 | -26.644 | -28.715 | -30.726 | -32.007 | -33.761 | -35.768 | -36.414 |
| 0.50 | -24.141 | -26.018 | -27.956 | -30.002 | -30.863 | -33.108 | -35.767 | -35.919 |
| 0.40 | -23.839 | -25.423 | -27.074 | -29.129 | -29.435 | -31.892 | -35.025 | -33.992 |
| 0.30 | -23.532 | -24.799 | -26.016 | -28.101 | -27.324 | -30.161 | -33.103 | -30.735 |
| 0.20 | -23.223 | -24.155 | -24.965 | -26.894 | -24.507 | -28.334 | -29.746 | -28.594 |

convolution summary for navy water

zenith angle of entry=   25.00 degrees      DEPTH=  20.00 METERS

bias in 50 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -27.726 | -30.718 | -32.977 | -34.778 | -35.664 | -36.161 | -36.370 | -36.392 |
| 0.80 | -27.404 | -30.264 | -32.476 | -34.430 | -35.484 | -36.323 | -36.986 | -37.276 |
| 0.70 | -27.077 | -29.774 | -31.896 | -33.946 | -35.131 | -36.311 | -37.534 | -38.052 |
| 0.60 | -26.745 | -29.212 | -31.233 | -33.320 | -34.487 | -36.057 | -37.901 | -38.457 |
| 0.50 | -26.409 | -28.568 | -30.482 | -32.551 | -33.471 | -35.463 | -37.882 | -38.039 |
| 0.40 | -26.070 | -27.888 | -29.637 | -31.646 | -31.968 | -34.378 | -37.167 | -36.186 |
| 0.30 | -25.728 | -27.178 | -28.572 | -30.617 | -29.844 | -32.727 | -35.381 | -32.841 |
| 0.20 | -25.383 | -26.451 | -27.384 | -29.472 | -26.767 | -30.832 | -32.154 | -29.793 |

bias in 80 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -29.367 | -32.471 | -34.758 | -36.710 | -37.687 | -38.210 | -38.428 | -38.483 |
| 0.80 | -29.038 | -32.013 | -34.241 | -36.315 | -37.483 | -38.351 | -39.024 | -39.372 |
| 0.70 | -28.704 | -31.529 | -33.656 | -35.786 | -37.102 | -38.314 | -39.543 | -40.161 |
| 0.60 | -28.368 | -30.961 | -33.002 | -35.123 | -36.383 | -38.034 | -39.870 | -40.579 |
| 0.50 | -28.010 | -30.286 | -32.226 | -34.337 | -35.299 | -37.409 | -39.800 | -40.163 |
| 0.40 | -27.646 | -29.586 | -31.387 | -33.439 | -33.761 | -36.265 | -39.053 | -38.292 |
| 0.30 | -27.283 | -28.867 | -30.268 | -32.402 | -31.584 | -34.611 | -37.260 | -34.549 |
| 0.20 | -26.921 | -28.129 | -29.040 | -31.247 | -28.383 | -32.812 | -33.772 | -30.753 |

results for bias in peak (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -19.509 | -24.250 | -24.250 | -24.250 | -28.991 | -28.991 | -28.991 | -28.991 |
| 0.80 | -19.509 | -24.250 | -24.250 | -24.250 | -28.991 | -28.991 | -28.991 | -28.991 |
| 0.70 | -19.509 | -24.250 | -24.250 | -24.250 | -28.991 | -28.991 | -28.991 | -28.991 |
| 0.60 | -19.509 | -19.509 | -24.250 | -24.250 | -24.250 | -28.991 | -28.991 | -28.991 |
| 0.50 | -19.509 | -19.509 | -24.250 | -24.250 | -24.250 | -28.991 | -28.991 | -28.991 |
| 0.40 | -19.509 | -19.509 | -24.250 | -24.250 | -24.250 | -24.250 | -28.991 | -28.991 |
| 0.30 | -19.509 | -19.509 | -19.509 | -24.250 | -24.250 | -24.250 | -28.991 | -28.991 |
| 0.20 | -19.509 | -19.509 | -19.509 | -24.250 | -19.509 | -24.250 | -24.250 | -28.991 |

rise time from one percent point to peak (ns)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 9.103 | 9.175 | 9.527 | 9.761 | 9.416 | 9.480 | 9.515 | 9.487 |
| 0.80 | 9.040 | 9.089 | 9.445 | 9.727 | 9.394 | 9.518 | 9.624 | 9.622 |
| 0.70 | 8.972 | 8.983 | 9.358 | 9.671 | 9.358 | 9.535 | 9.723 | 9.728 |
| 0.60 | 8.920 | 9.335 | 9.265 | 9.583 | 9.729 | 9.517 | 9.798 | 9.776 |
| 0.50 | 8.873 | 9.237 | 9.140 | 9.450 | 9.588 | 9.434 | 9.829 | 9.702 |
| 0.40 | 8.823 | 9.118 | 8.967 | 9.307 | 9.337 | 9.725 | 9.774 | 9.332 |
| 0.30 | 8.770 | 8.972 | 9.255 | 9.137 | 8.953 | 9.393 | 9.530 | 8.684 |
| 0.20 | 8.714 | 8.862 | 9.039 | 8.935 | 8.871 | 8.915 | 9.425 | 7.681 |

convolution summary for navy water

zenith angle of entry= 35.00 degrees DEPTH= 20.00 METERS

bias in .1 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -108.016 | -129.929 | -139.385 | -143.242 | -144.351 | -144.740 | -144.132 | -143.205 |
| 0.80 | -105.080 | -127.617 | -138.693 | -143.511 | -145.449 | -146.833 | -146.433 | -146.369 |
| 0.70 | -100.957 | -125.401 | -137.328 | -143.516 | -146.788 | -149.830 | -149.193 | -150.574 |
| 0.60 | -98.037 | -121.885 | -135.795 | -143.218 | -148.336 | -152.617 | -150.870 | -153.427 |
| 0.50 | -93.859 | -117.127 | -133.256 | -142.432 | -149.339 | -155.484 | -151.633 | -155.677 |
| 0.40 | -89.897 | -110.435 | -128.245 | -140.610 | -149.209 | -159.512 | -150.948 | -156.745 |
| 0.30 | -85.384 | -102.018 | -121.299 | -136.336 | -146.327 | -160.894 | -145.680 | -152.311 |
| 0.20 | -79.894 | -91.974 | -108.636 | -126.817 | -140.309 | -155.516 | -130.599 | -132.476 |

bias in 1 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -74.153 | -94.405 | -106.656 | -112.783 | -115.887 | -117.505 | -117.534 | -116.758 |
| 0.80 | -72.180 | -91.766 | -105.381 | -112.620 | -117.065 | -119.745 | -121.236 | -121.696 |
| 0.70 | -69.708 | -89.154 | -103.254 | -111.778 | -117.861 | -122.534 | -124.409 | -126.021 |
| 0.60 | -66.488 | -85.493 | -100.401 | -110.197 | -118.276 | -125.005 | -126.420 | -129.206 |
| 0.50 | -63.258 | -81.455 | -96.713 | -108.032 | -118.156 | -127.367 | -127.221 | -131.814 |
| 0.40 | -59.066 | -76.573 | -91.129 | -103.792 | -116.831 | -129.387 | -125.738 | -129.885 |
| 0.30 | -53.573 | -70.772 | -83.975 | -97.229 | -112.105 | -128.506 | -117.408 | -118.351 |
| 0.20 | -45.552 | -62.678 | -75.353 | -87.197 | -100.986 | -118.242 | -96.051 | -94.988 |

bias in 10 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -34.188 | -53.374 | -65.094 | -72.230 | -76.784 | -79.155 | -79.716 | -78.861 |
| 0.80 | -31.915 | -51.317 | -63.616 | -71.783 | -77.880 | -82.205 | -84.905 | -85.721 |
| 0.70 | -29.098 | -48.638 | -61.699 | -70.737 | -78.221 | -84.598 | -88.382 | -90.590 |
| 0.60 | -26.154 | -45.050 | -59.143 | -68.839 | -77.733 | -86.240 | -90.613 | -94.287 |
| 0.50 | -24.269 | -41.220 | -55.331 | -65.769 | -76.226 | -87.348 | -90.972 | -95.188 |
| 0.40 | -22.254 | -35.758 | -50.450 | -61.307 | -72.948 | -87.217 | -87.631 | -90.249 |
| 0.30 | -20.078 | -29.520 | -43.381 | -54.775 | -67.043 | -83.235 | -77.651 | -77.000 |
| 0.20 | -17.816 | -23.594 | -33.237 | -43.972 | -55.944 | -68.918 | -58.753 | -52.576 |

bias in 20 percent point (CENTIMETERS)

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -25.464 | -41.334 | -52.356 | -59.608 | -64.076 | -66.416 | -66.894 | -65.684 |
| 0.80 | -24.145 | -39.268 | -51.090 | -59.307 | -65.380 | -69.726 | -72.602 | -73.406 |
| 0.70 | -23.028 | -36.608 | -49.293 | -58.211 | -65.748 | -72.263 | -76.534 | -78.790 |
| 0.60 | -21.914 | -33.322 | -46.645 | -56.144 | -65.088 | -73.843 | -78.805 | -82.556 |
| 0.50 | -20.817 | -30.276 | -42.751 | -52.745 | -63.233 | -74.668 | -79.026 | -83.289 |
| 0.40 | -19.737 | -26.683 | -38.022 | -48.134 | -59.683 | -73.957 | -75.708 | -78.198 |
| 0.30 | -18.641 | -23.353 | -31.680 | -41.071 | -53.000 | -69.051 | -65.824 | -64.219 |
| 0.20 | -17.609 | -20.618 | -24.842 | -31.341 | -40.912 | -53.313 | -47.561 | -41.415 |

convolution summary for navy water

zenith angle of entry= 35.00 degrees DEPTH= 20.00 METERS

bias in 50 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -22.934 | -31.141 | -38.999 | -44.776 | -48.362 | -49.612 | -49.154 | -46.719 |
| 0.80 | -22.352 | -30.023 | -38.253 | -44.989 | -50.410 | -54.302 | -56.716 | -56.957 |
| 0.70 | -21.762 | -28.726 | -36.981 | -44.285 | -51.205 | -57.419 | -61.664 | -63.878 |
| 0.60 | -21.170 | -27.292 | -35.239 | -42.585 | -50.617 | -59.144 | -64.559 | -68.168 |
| 0.50 | -20.580 | -25.758 | -32.970 | -39.783 | -48.573 | -59.685 | -64.932 | -69.229 |
| 0.40 | -19.962 | -24.144 | -30.212 | -35.902 | -44.630 | -58.122 | -61.649 | -64.465 |
| 0.30 | -19.203 | -22.497 | -27.083 | -31.262 | -37.600 | -51.999 | -52.955 | -51.393 |
| 0.20 | -18.432 | -20.706 | -23.704 | -26.099 | -26.266 | -34.884 | -41.981 | -35.550 |

bias in 80 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -21.919 | -26.499 | -31.453 | -34.750 | -36.367 | -35.609 | -33.324 | -28.916 |
| 0.80 | -21.629 | -26.084 | -31.573 | -35.968 | -39.959 | -42.413 | -43.721 | -42.826 |
| 0.70 | -21.331 | -25.514 | -31.255 | -36.224 | -41.770 | -46.822 | -50.404 | -51.905 |
| 0.60 | -21.032 | -24.807 | -30.395 | -35.477 | -41.842 | -49.433 | -54.263 | -57.614 |
| 0.50 | -20.738 | -23.991 | -29.059 | -33.735 | -40.339 | -50.304 | -55.267 | -59.912 |
| 0.40 | -20.390 | -23.100 | -27.332 | -31.154 | -36.732 | -48.540 | -52.893 | -56.583 |
| 0.30 | -19.796 | -22.164 | -25.343 | -27.781 | -30.303 | -41.759 | -46.528 | -46.345 |
| 0.20 | -19.186 | -20.892 | -23.072 | -24.564 | -21.068 | -25.166 | -39.777 | -34.990 |

results for bias in peak (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -9.466 | -9.466 | -9.466 | -0.444 | -0.444 | 8.578 | 17.601 | 26.623 |
| 0.80 | -9.466 | -9.466 | -9.466 | -9.466 | -9.466 | -9.466 | -9.466 | -0.444 |
| 0.70 | -9.466 | -9.466 | -9.466 | -9.466 | -9.466 | -18.488 | -18.488 | -18.488 |
| 0.60 | -9.466 | -9.466 | -9.466 | -9.466 | -18.488 | -18.488 | -27.511 | -27.511 |
| 0.50 | -9.466 | -9.466 | -9.466 | -9.466 | -18.488 | -18.488 | -27.511 | -27.511 |
| 0.40 | -18.488 | -9.466 | -9.466 | -9.466 | -18.488 | -18.488 | -27.511 | -36.533 |
| 0.30 | -18.488 | -9.466 | -9.466 | -9.466 | -9.466 | -18.488 | -27.511 | -27.511 |
| 0.20 | -18.488 | -18.488 | -18.488 | -9.466 | -0.444 | -0.444 | -27.511 | -18.488 |

rise time from one percent point to peak (ns)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 13.366 | 15.361 | 16.568 | 18.061 | 18.367 | 19.415 | 20.307 | 21.119 |
| 0.80 | 13.172 | 15.101 | 16.443 | 17.156 | 17.594 | 17.858 | 18.005 | 18.939 |
| 0.70 | 12.928 | 14.844 | 16.233 | 17.073 | 17.672 | 17.244 | 17.429 | 17.587 |
| 0.60 | 12.611 | 14.483 | 15.952 | 16.917 | 16.824 | 17.487 | 16.738 | 17.012 |
| 0.50 | 12.293 | 14.085 | 15.589 | 16.704 | 16.812 | 17.720 | 16.817 | 17.269 |
| 0.40 | 10.991 | 13.604 | 15.039 | 16.286 | 16.682 | 17.919 | 16.671 | 16.190 |
| 0.30 | 10.450 | 13.033 | 14.334 | 15.640 | 17.105 | 17.832 | 15.850 | 15.943 |
| 0.20 | 9.659 | 11.347 | 12.595 | 14.651 | 16.899 | 18.599 | 13.746 | 14.530 |

convolution summary for NOS water

zenith angle of entry= 35.00 degrees DEPTH= 20.00 METERS

bias in .1 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -113.335 | -131.492 | -137.764 | -139.719 | -137.774 | -136.091 | -134.832 | -134.155 |
| 0.80 | -109.905 | -129.049 | -136.691 | -140.473 | -139.412 | -139.181 | -139.144 | -140.751 |
| 0.70 | -107.025 | -126.303 | -135.316 | -140.286 | -139.537 | -141.623 | -143.684 | -146.700 |
| 0.60 | -102.607 | -122.398 | -132.834 | -138.747 | -138.068 | -142.877 | -148.148 | -153.479 |
| 0.50 | -98.539 | -116.718 | -128.124 | -135.778 | -135.653 | -143.092 | -152.860 | -158.986 |
| 0.40 | -93.810 | -108.831 | -122.641 | -130.366 | -131.471 | -141.989 | -156.875 | -161.451 |
| 0.30 | -89.313 | -99.290 | -113.357 | -120.496 | -124.277 | -138.053 | -161.308 | -161.180 |
| 0.20 | -83.246 | -89.269 | -98.814 | -103.894 | -112.210 | -130.761 | -161.671 | -155.283 |

bias in 1 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -78.703 | -96.684 | -107.203 | -110.521 | -110.538 | -109.359 | -108.363 | -106.765 |
| 0.80 | -76.234 | -93.692 | -105.814 | -110.930 | -112.779 | -112.943 | -113.498 | -114.687 |
| 0.70 | -73.583 | -90.496 | -103.223 | -110.192 | -113.368 | -115.362 | -117.481 | -122.512 |
| 0.60 | -70.955 | -86.414 | -99.789 | -108.266 | -112.337 | -116.360 | -121.182 | -131.882 |
| 0.50 | -67.329 | -81.384 | -94.872 | -103.838 | -109.593 | -115.969 | -125.619 | -141.369 |
| 0.40 | -63.201 | -75.078 | -88.325 | -96.530 | -105.032 | -113.848 | -130.452 | -146.138 |
| 0.30 | -57.468 | -67.853 | -79.634 | -85.784 | -96.726 | -109.430 | -136.094 | -146.444 |
| 0.20 | -49.419 | -57.403 | -67.825 | -72.007 | -82.082 | -102.244 | -139.479 | -145.684 |

bias in 10 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -38.847 | -55.286 | -66.751 | -70.858 | -71.431 | -69.866 | -68.432 | -66.061 |
| 0.80 | -36.119 | -52.806 | -65.478 | -71.204 | -74.525 | -74.655 | -75.310 | -76.512 |
| 0.70 | -33.486 | -49.932 | -63.037 | -70.324 | -75.852 | -77.625 | -79.707 | -85.414 |
| 0.60 | -30.216 | -45.947 | -60.025 | -67.878 | -75.522 | -78.873 | -83.324 | -95.961 |
| 0.50 | -26.309 | -41.375 | -55.418 | -63.194 | -73.152 | -78.613 | -87.176 | -112.315 |
| 0.40 | -23.954 | -35.249 | -49.532 | -56.787 | -68.844 | -76.904 | -92.452 | -132.203 |
| 0.30 | -21.396 | -28.238 | -41.593 | -47.619 | -61.190 | -73.378 | -99.091 | -141.148 |
| 0.20 | -18.692 | -22.679 | -30.834 | -35.110 | -48.643 | -68.704 | -106.896 | -141.793 |

bias in 20 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -28.714 | -42.902 | -54.167 | -57.843 | -58.311 | -56.252 | -53.830 | -50.713 |
| 0.80 | -26.914 | -40.780 | -53.181 | -58.568 | -61.829 | -61.743 | -61.952 | -62.943 |
| 0.70 | -24.920 | -38.003 | -51.180 | -57.907 | -63.765 | -65.374 | -67.185 | -72.571 |
| 0.60 | -23.476 | -34.288 | -48.356 | -55.592 | -63.962 | -67.053 | -70.794 | -83.428 |
| 0.50 | -22.070 | -30.705 | -44.026 | -51.252 | -62.158 | -67.111 | -74.719 | -100.272 |
| 0.40 | -20.697 | -26.593 | -38.441 | -44.925 | -58.300 | -65.796 | -80.083 | -124.153 |
| 0.30 | -19.329 | -22.894 | -31.235 | -35.969 | -50.958 | -62.999 | -88.059 | -140.144 |
| 0.20 | -18.023 | -19.981 | -23.977 | -26.307 | -38.720 | -59.008 | -96.406 | -141.919 |

convolution summary for NOS water

zenith angle of entry= 35.00 degrees DEPTH= 20.00 METERS

bias in 50 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -24.484 | -31.764 | -39.938 | -41.230 | -40.733 | -37.273 | -31.703 | -25.559 |
| 0.80 | -23.741 | -30.568 | -39.980 | -43.203 | -46.106 | -45.271 | -43.698 | -43.162 |
| 0.70 | -22.963 | -29.105 | -38.952 | -43.517 | -49.376 | -50.375 | -50.924 | -55.200 |
| 0.60 | -22.166 | -27.426 | -37.010 | -42.112 | -50.797 | -53.189 | -55.650 | -66.395 |
| 0.50 | -21.364 | -25.611 | -34.285 | -39.095 | -50.196 | -54.159 | -59.901 | -83.398 |
| 0.40 | -20.575 | -23.711 | -30.815 | -34.728 | -47.410 | -53.831 | -65.722 | -113.932 |
| 0.30 | -19.679 | -21.834 | -26.918 | -29.896 | -41.921 | -52.457 | -74.732 | -138.788 |
| 0.20 | -18.729 | -20.121 | -23.157 | -25.263 | -33.463 | -50.642 | -85.831 | -142.604 |

bias in 80 percent point (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -22.748 | -26.128 | -30.778 | -28.561 | -25.977 | -20.180 | -9.417 | 1.712 |
| 0.80 | -22.413 | -25.807 | -32.191 | -32.540 | -34.047 | -32.054 | -27.470 | -23.922 |
| 0.70 | -22.011 | -25.273 | -32.408 | -34.436 | -39.279 | -39.506 | -38.039 | -40.497 |
| 0.60 | -21.584 | -24.545 | -31.856 | -34.548 | -42.380 | -43.905 | -44.609 | -53.022 |
| 0.50 | -21.158 | -23.663 | -30.385 | -33.307 | -43.280 | -46.133 | -49.882 | -70.631 |
| 0.40 | -20.751 | -22.681 | -28.112 | -30.890 | -42.241 | -47.004 | -56.180 | -98.498 |
| 0.30 | -20.135 | -21.607 | -25.477 | -27.627 | -38.279 | -46.729 | -66.130 | -140.082 |
| 0.20 | -19.406 | -20.622 | -22.898 | -24.167 | -31.439 | -46.160 | -79.414 | -143.774 |

results for bias in peak (CENTIMETERS)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -9.466 | -9.466 | -0.444 | 8.578 | 17.601 | 35.645 | 53.690 | 71.734 |
| 0.80 | -9.466 | -9.466 | -9.466 | -0.444 | -0.444 | 8.578 | 17.601 | 26.623 |
| 0.70 | -9.466 | -9.466 | -9.466 | -9.466 | -9.466 | -9.466 | -0.444 | -0.444 |
| 0.60 | -9.466 | -9.466 | -9.466 | -9.466 | -18.488 | -18.488 | -9.466 | -18.488 |
| 0.50 | -9.466 | -9.466 | -9.466 | -9.466 | -18.488 | -18.488 | -18.488 | -36.533 |
| 0.40 | -9.466 | -9.466 | -9.466 | -9.466 | -18.488 | -27.511 | -27.511 | -63.600 |
| 0.30 | -18.488 | -9.466 | -9.466 | -9.466 | -18.488 | -27.511 | -36.533 | -135.778 |
| 0.20 | -18.488 | -9.466 | -9.466 | -18.488 | -18.488 | -27.511 | -54.577 | -144.800 |

rise time from one percent point to peak (ns)

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 13.814 | 15.586 | 17.511 | 18.727 | 19.617 | 21.279 | 22.959 | 24.579 |
| 0.80 | 13.571 | 15.291 | 16.485 | 17.878 | 18.061 | 18.966 | 19.909 | 20.915 |
| 0.70 | 13.310 | 14.976 | 16.230 | 16.917 | 17.230 | 17.426 | 18.524 | 19.019 |
| 0.60 | 13.051 | 14.574 | 15.892 | 16.727 | 16.239 | 16.636 | 17.999 | 18.165 |
| 0.50 | 12.694 | 14.078 | 15.407 | 16.291 | 15.969 | 16.597 | 17.548 | 17.322 |
| 0.40 | 12.297 | 13.457 | 14.762 | 15.571 | 15.519 | 15.499 | 17.135 | 15.125 |
| 0.30 | 10.833 | 12.745 | 13.906 | 14.512 | 14.701 | 15.064 | 16.802 | 8.044 |
| 0.20 | 10.040 | 11.716 | 12.743 | 12.266 | 13.258 | 14.356 | 15.358 | 7.080 |

## Appendix B

Depth-specific biases calculated for the HALS system.

convolution summary for navy water

zenith angle of entry= 0.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 2.252 | 2.702 | 3.236 | 3.750 | 4.377 | 5.251 | 6.360 | 7.004 |
| 0.80 | 2.206 | 2.591 | 3.051 | 3.494 | 3.992 | 4.626 | 5.363 | 6.347 |
| 0.70 | 2.160 | 2.485 | 2.862 | 3.257 | 3.659 | 4.134 | 4.608 | 5.207 |
| 0.60 | 2.115 | 2.383 | 2.689 | 3.014 | 3.362 | 3.720 | 4.035 | 4.396 |
| 0.50 | 2.071 | 2.287 | 2.528 | 2.777 | 3.074 | 3.353 | 3.571 | 3.764 |
| 0.40 | 2.027 | 2.194 | 2.378 | 2.566 | 2.774 | 2.984 | 3.182 | 3.206 |
| 0.30 | 1.984 | 2.105 | 2.238 | 2.375 | 2.500 | 2.610 | 2.797 | 2.623 |
| 0.20 | 1.942 | 2.020 | 2.106 | 2.198 | 2.246 | 2.262 | 2.475 | 2.190 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 9.570 | 12.684 | 16.004 | 19.451 | 22.995 | 26.424 | 29.742 | 32.885 |
| 0.80 | 9.237 | 11.915 | 14.705 | 17.608 | 20.646 | 23.511 | 26.267 | 28.782 |
| 0.70 | 8.911 | 11.131 | 13.437 | 15.850 | 18.466 | 20.795 | 23.017 | 24.926 |
| 0.60 | 8.586 | 10.406 | 12.292 | 14.202 | 16.364 | 18.272 | 19.992 | 21.272 |
| 0.50 | 8.270 | 9.726 | 11.188 | 12.685 | 14.450 | 15.871 | 17.221 | 17.826 |
| 0.40 | 7.964 | 9.083 | 10.174 | 11.287 | 12.634 | 13.693 | 14.738 | 14.664 |
| 0.30 | 7.668 | 8.461 | 9.259 | 10.008 | 10.913 | 11.689 | 12.491 | 11.811 |
| 0.20 | 7.381 | 7.875 | 8.396 | 8.859 | 9.320 | 9.634 | 10.490 | 9.382 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 15.672 | 20.196 | 24.906 | 29.581 | 34.277 | 38.787 | 43.132 | 47.303 |
| 0.80 | 15.159 | 19.031 | 22.964 | 26.858 | 30.824 | 34.618 | 38.196 | 41.407 |
| 0.70 | 14.665 | 17.892 | 21.133 | 24.321 | 27.648 | 30.744 | 33.630 | 35.957 |
| 0.60 | 14.187 | 16.833 | 19.438 | 21.975 | 24.724 | 27.189 | 29.471 | 30.915 |
| 0.50 | 13.725 | 15.835 | 17.836 | 19.796 | 22.029 | 23.938 | 25.685 | 26.268 |
| 0.40 | 13.277 | 14.872 | 16.387 | 17.805 | 19.511 | 20.969 | 22.262 | 22.098 |
| 0.30 | 12.841 | 13.972 | 15.051 | 16.033 | 17.161 | 18.196 | 19.195 | 18.370 |
| 0.20 | 12.381 | 13.127 | 13.829 | 14.409 | 14.995 | 15.445 | 16.445 | 15.217 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 11.574 | 17.183 | 22.900 | 28.513 | 34.040 | 39.279 | 47.967 | 54.242 |
| 0.80 | 10.920 | 15.690 | 20.456 | 25.093 | 29.664 | 34.018 | 38.103 | 45.014 |
| 0.70 | 10.293 | 14.267 | 18.182 | 21.921 | 25.697 | 29.210 | 32.481 | 35.070 |
| 0.60 | 9.690 | 12.927 | 16.031 | 18.991 | 22.088 | 24.892 | 27.436 | 28.977 |
| 0.50 | 9.109 | 11.670 | 14.056 | 16.311 | 18.797 | 20.980 | 22.873 | 23.445 |
| 0.40 | 8.546 | 10.476 | 12.256 | 13.895 | 15.785 | 17.448 | 18.857 | 18.501 |
| 0.30 | 8.006 | 9.367 | 10.611 | 11.757 | 13.015 | 14.194 | 15.306 | 14.094 |
| 0.20 | 7.491 | 8.333 | 9.132 | 9.848 | 10.449 | 10.972 | 12.130 | 10.445 |

convolution summary for navy water

zenith angle of entry= 0.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 0.087 | 0.846 | 1.518 | 2.148 | 2.869 | 3.645 | 4.452 | 5.598 |
| 0.80 | -0.013 | 0.673 | 1.277 | 1.819 | 2.392 | 3.075 | 3.672 | 4.322 |
| 0.70 | -0.208 | 0.497 | 1.034 | 1.504 | 1.985 | 2.488 | 3.003 | 3.478 |
| 0.60 | -0.379 | 0.320 | 0.788 | 1.194 | 1.612 | 2.003 | 2.349 | 2.684 |
| 0.50 | -0.530 | 0.141 | 0.537 | 0.882 | 1.245 | 1.561 | 1.812 | 1.983 |
| 0.40 | -0.664 | -0.088 | 0.282 | 0.566 | 0.867 | 1.121 | 1.325 | 1.330 |
| 0.30 | -0.783 | -0.428 | 0.027 | 0.248 | 0.465 | 0.647 | 0.852 | 0.642 |
| 0.20 | -0.890 | -0.693 | -0.446 | -0.164 | 0.031 | 0.094 | 0.371 | -0.074 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 1.404 | 2.528 | 3.886 | 5.584 | 7.624 | 9.900 | 12.252 | 14.596 |
| 0.80 | 1.280 | 2.242 | 3.348 | 4.626 | 6.264 | 8.012 | 9.817 | 11.606 |
| 0.70 | 1.155 | 1.974 | 2.859 | 3.844 | 5.060 | 6.416 | 7.735 | 9.009 |
| 0.60 | 1.031 | 1.718 | 2.410 | 3.174 | 4.084 | 5.025 | 6.006 | 6.759 |
| 0.50 | 0.907 | 1.471 | 2.019 | 2.577 | 3.275 | 3.916 | 4.535 | 4.879 |
| 0.40 | 0.782 | 1.229 | 1.654 | 2.066 | 2.551 | 3.004 | 3.430 | 3.408 |
| 0.30 | 0.657 | 0.989 | 1.310 | 1.607 | 1.921 | 2.190 | 2.528 | 2.207 |
| 0.20 | 0.531 | 0.750 | 0.971 | 1.170 | 1.324 | 1.416 | 1.793 | 1.273 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 2.047 | 3.372 | 5.169 | 7.341 | 9.890 | 12.629 | 15.408 | 18.181 |
| 0.80 | 1.903 | 3.027 | 4.452 | 6.103 | 8.145 | 10.294 | 12.456 | 14.543 |
| 0.70 | 1.761 | 2.706 | 3.798 | 5.084 | 6.625 | 8.277 | 9.909 | 11.365 |
| 0.60 | 1.621 | 2.404 | 3.215 | 4.197 | 5.368 | 6.538 | 7.740 | 8.618 |
| 0.50 | 1.481 | 2.117 | 2.747 | 3.400 | 4.310 | 5.130 | 5.911 | 6.299 |
| 0.40 | 1.341 | 1.840 | 2.319 | 2.791 | 3.355 | 3.947 | 4.496 | 4.453 |
| 0.30 | 1.202 | 1.570 | 1.926 | 2.256 | 2.615 | 2.933 | 3.321 | 2.955 |
| 0.20 | 1.063 | 1.303 | 1.545 | 1.762 | 1.933 | 2.045 | 2.458 | 1.894 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 1.934 | 3.519 | 5.415 | 7.888 | 10.721 | 13.726 | 16.776 | 19.801 |
| 0.80 | 1.768 | 3.097 | 4.622 | 6.508 | 8.723 | 11.094 | 13.472 | 15.742 |
| 0.70 | 1.604 | 2.697 | 3.928 | 5.281 | 7.047 | 8.819 | 10.621 | 12.194 |
| 0.60 | 1.440 | 2.331 | 3.301 | 4.314 | 5.558 | 6.913 | 8.184 | 9.136 |
| 0.50 | 1.278 | 2.002 | 2.726 | 3.489 | 4.399 | 5.271 | 6.171 | 6.587 |
| 0.40 | 1.116 | 1.685 | 2.217 | 2.758 | 3.416 | 4.009 | 4.567 | 4.503 |
| 0.30 | 0.955 | 1.374 | 1.768 | 2.130 | 2.526 | 2.912 | 3.353 | 2.919 |
| 0.20 | 0.794 | 1.068 | 1.336 | 1.576 | 1.760 | 1.889 | 2.329 | 1.717 |

convolution summary for navy water

zenith angle of entry= 0.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -2.236 | -2.167 | -2.063 | -1.902 | -1.612 | -0.987 | 0.291 | 1.113 |
| 0.80 | -2.242 | -2.186 | -2.107 | -1.996 | -1.819 | -1.516 | -0.967 | 0.105 |
| 0.70 | -2.248 | -2.203 | -2.143 | -2.067 | -1.953 | -1.787 | -1.557 | -1.220 |
| 0.60 | -2.254 | -2.218 | -2.173 | -2.120 | -2.045 | -1.949 | -1.840 | -1.715 |
| 0.50 | -2.259 | -2.232 | -2.199 | -2.162 | -2.112 | -2.055 | -2.000 | -1.957 |
| 0.40 | -2.265 | -2.244 | -2.221 | -2.196 | -2.164 | -2.131 | -2.100 | -2.099 |
| 0.30 | -2.270 | -2.255 | -2.239 | -2.223 | -2.205 | -2.188 | -2.166 | -2.189 |
| 0.20 | -2.275 | -2.266 | -2.256 | -2.246 | -2.239 | -2.235 | -2.214 | -2.244 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -2.532 | -2.332 | -2.024 | -1.520 | -0.544 | 0.770 | 1.904 | 2.983 |
| 0.80 | -2.550 | -2.388 | -2.156 | -1.817 | -1.252 | -0.248 | 0.785 | 1.683 |
| 0.70 | -2.568 | -2.437 | -2.263 | -2.032 | -1.679 | -1.150 | -0.376 | 0.404 |
| 0.60 | -2.584 | -2.481 | -2.352 | -2.194 | -1.965 | -1.672 | -1.323 | -0.919 |
| 0.50 | -2.601 | -2.521 | -2.427 | -2.319 | -2.168 | -2.001 | -1.828 | -1.701 |
| 0.40 | -2.616 | -2.557 | -2.490 | -2.417 | -2.322 | -2.226 | -2.131 | -2.131 |
| 0.30 | -2.631 | -2.590 | -2.544 | -2.497 | -2.443 | -2.393 | -2.327 | -2.393 |
| 0.20 | -2.646 | -2.620 | -2.591 | -2.563 | -2.541 | -2.528 | -2.466 | -2.552 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -1.601 | -1.398 | -1.101 | -0.648 | 0.127 | 1.451 | 2.652 | 3.881 |
| 0.80 | -1.620 | -1.454 | -1.227 | -0.912 | -0.425 | 0.389 | 1.456 | 2.402 |
| 0.70 | -1.638 | -1.504 | -1.332 | -1.111 | -0.792 | -0.349 | 0.249 | 1.046 |
| 0.60 | -1.656 | -1.549 | -1.420 | -1.267 | -1.052 | -0.791 | -0.494 | -0.178 |
| 0.50 | -1.673 | -1.590 | -1.496 | -1.389 | -1.245 | -1.088 | -0.931 | -0.823 |
| 0.40 | -1.690 | -1.628 | -1.560 | -1.488 | -1.395 | -1.301 | -1.210 | -1.212 |
| 0.30 | -1.706 | -1.662 | -1.616 | -1.569 | -1.515 | -1.464 | -1.401 | -1.463 |
| 0.20 | -1.721 | -1.694 | -1.665 | -1.637 | -1.614 | -1.600 | -1.539 | -1.622 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -2.393 | -2.100 | -1.664 | -0.963 | 0.405 | 1.805 | 3.116 | 4.429 |
| 0.80 | -2.421 | -2.182 | -1.853 | -1.381 | -0.580 | 0.692 | 1.795 | 2.810 |
| 0.70 | -2.449 | -2.255 | -2.008 | -1.687 | -1.203 | -0.429 | 0.534 | 1.352 |
| 0.60 | -2.475 | -2.321 | -2.137 | -1.917 | -1.603 | -1.207 | -0.733 | -0.119 |
| 0.50 | -2.500 | -2.380 | -2.246 | -2.097 | -1.891 | -1.662 | -1.427 | -1.266 |
| 0.40 | -2.524 | -2.435 | -2.340 | -2.239 | -2.109 | -1.975 | -1.846 | -1.852 |
| 0.30 | -2.548 | -2.485 | -2.420 | -2.355 | -2.281 | -2.209 | -2.121 | -2.210 |
| 0.20 | -2.571 | -2.532 | -2.491 | -2.452 | -2.421 | -2.399 | -2.318 | -2.431 |

convolution summary for navy water

zenith angle of entry= 15.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 0.7

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -3.224 | -3.375 | -3.558 | -3.673 | -3.659 | -3.605 | -3.552 | -3.471 |
| 0.80 | -3.224 | -3.345 | -3.526 | -3.664 | -3.743 | -3.752 | -3.858 | -3.822 |
| 0.70 | -3.227 | -3.314 | -3.486 | -3.634 | -3.720 | -3.879 | -4.155 | -4.252 |
| 0.60 | -3.233 | -3.286 | -3.439 | -3.581 | -3.635 | -3.863 | -4.185 | -4.439 |
| 0.50 | -3.243 | -3.262 | -3.390 | -3.512 | -3.545 | -3.674 | -3.825 | -4.468 |
| 0.40 | -3.257 | -3.247 | -3.344 | -3.442 | -3.427 | -3.518 | -3.373 | -4.553 |
| 0.30 | -3.276 | -3.244 | -3.309 | -3.390 | -3.303 | -3.212 | -2.715 | -5.120 |
| 0.20 | -3.299 | -3.259 | -3.293 | -3.371 | -3.199 | -2.610 | -1.623 | -6.198 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 3.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 5.414 | 8.304 | 10.983 | 13.473 | 16.164 | 18.744 | 21.180 | 23.557 |
| 0.80 | 5.073 | 7.613 | 9.905 | 12.033 | 14.381 | 16.589 | 18.436 | 20.295 |
| 0.70 | 4.716 | 6.923 | 8.920 | 10.687 | 12.649 | 14.641 | 15.986 | 17.383 |
| 0.60 | 4.352 | 6.258 | 7.989 | 9.351 | 11.151 | 12.797 | 13.860 | 14.801 |
| 0.50 | 3.988 | 5.604 | 7.005 | 8.114 | 9.642 | 11.149 | 11.990 | 12.572 |
| 0.40 | 3.622 | 4.949 | 6.066 | 6.798 | 8.292 | 9.489 | 10.549 | 10.576 |
| 0.30 | 3.251 | 4.250 | 5.129 | 5.515 | 6.914 | 8.108 | 9.668 | 8.372 |
| 0.20 | 2.876 | 3.550 | 4.125 | 4.194 | 5.594 | 7.063 | 9.832 | 5.389 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 6.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 11.387 | 15.689 | 19.681 | 23.476 | 27.399 | 31.104 | 34.554 | 37.927 |
| 0.80 | 10.867 | 14.640 | 18.077 | 21.231 | 24.492 | 27.631 | 30.324 | 32.916 |
| 0.70 | 10.354 | 13.608 | 16.508 | 19.084 | 21.847 | 24.548 | 26.545 | 28.476 |
| 0.60 | 9.845 | 12.615 | 15.053 | 17.072 | 19.428 | 21.761 | 23.218 | 24.625 |
| 0.50 | 9.336 | 11.629 | 13.606 | 15.174 | 17.202 | 19.196 | 20.370 | 21.294 |
| 0.40 | 8.821 | 10.643 | 12.233 | 13.279 | 15.143 | 16.834 | 18.184 | 18.345 |
| 0.30 | 8.275 | 9.676 | 10.837 | 11.429 | 13.154 | 14.773 | 17.008 | 15.428 |
| 0.20 | 7.737 | 8.695 | 9.463 | 9.601 | 11.272 | 13.255 | 17.855 | 11.880 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 10.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 7.483 | 12.884 | 17.927 | 25.911 | 31.658 | 38.479 | 46.703 | 57.760 |
| 0.80 | 6.819 | 11.527 | 15.781 | 19.664 | 26.937 | 31.557 | 36.258 | 41.728 |
| 0.70 | 6.170 | 10.198 | 13.780 | 16.910 | 20.126 | 26.602 | 29.469 | 32.440 |
| 0.60 | 5.531 | 8.921 | 11.870 | 14.340 | 17.015 | 19.671 | 24.586 | 26.285 |
| 0.50 | 4.898 | 7.684 | 10.052 | 11.898 | 14.184 | 16.427 | 17.789 | 18.762 |
| 0.40 | 4.261 | 6.463 | 8.322 | 9.566 | 11.564 | 13.470 | 14.889 | 15.192 |
| 0.30 | 3.636 | 5.280 | 6.617 | 7.312 | 9.136 | 10.872 | 13.157 | 11.867 |
| 0.20 | 3.021 | 4.096 | 4.968 | 5.138 | 6.871 | 8.897 | 13.477 | 8.038 |

convolution summary for navy water

zenith angle of entry= 15.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 0.7

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -6.121 | -6.364 | -6.458 | -6.394 | -6.162 | -5.866 | -5.568 | -5.213 |
| 0.80 | -6.095 | -6.346 | -6.496 | -6.513 | -6.371 | -6.189 | -6.068 | -5.889 |
| 0.70 | -6.068 | -6.312 | -6.507 | -6.588 | -6.508 | -6.418 | -6.411 | -6.342 |
| 0.60 | -6.040 | -6.264 | -6.489 | -6.618 | -6.574 | -6.570 | -6.612 | -6.650 |
| 0.50 | -6.012 | -6.203 | -6.442 | -6.600 | -6.564 | -6.647 | -6.639 | -7.050 |
| 0.40 | -5.984 | -6.132 | -6.366 | -6.538 | -6.475 | -6.622 | -6.416 | -7.516 |
| 0.30 | -5.956 | -6.054 | -6.262 | -6.437 | -6.311 | -6.423 | -5.818 | -8.174 |
| 0.20 | -5.927 | -5.980 | -6.136 | -6.303 | -6.088 | -5.870 | -4.524 | -9.000 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 3.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -3.681 | -2.973 | -2.011 | -0.820 | 0.595 | 2.194 | 3.686 | 5.289 |
| 0.80 | -3.757 | -3.183 | -2.456 | -1.552 | -0.426 | 0.770 | 1.896 | 2.935 |
| 0.70 | -3.829 | -3.369 | -2.832 | -2.207 | -1.253 | -0.352 | 0.330 | 1.048 |
| 0.60 | -3.901 | -3.534 | -3.152 | -2.740 | -2.019 | -1.251 | -0.814 | -0.407 |
| 0.50 | -3.971 | -3.682 | -3.423 | -3.176 | -2.601 | -2.077 | -1.656 | -1.520 |
| 0.40 | -4.041 | -3.813 | -3.654 | -3.543 | -3.046 | -2.659 | -2.087 | -2.543 |
| 0.30 | -4.110 | -3.935 | -3.853 | -3.855 | -3.382 | -2.953 | -1.983 | -3.747 |
| 0.20 | -4.177 | -4.056 | -4.022 | -4.114 | -3.630 | -2.805 | -1.221 | -5.746 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 6.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -2.887 | -1.770 | -0.387 | 1.165 | 3.067 | 5.044 | 6.999 | 8.993 |
| 0.80 | -3.009 | -2.078 | -0.999 | 0.220 | 1.691 | 3.280 | 4.662 | 6.082 |
| 0.70 | -3.129 | -2.359 | -1.527 | -0.623 | 0.561 | 1.790 | 2.756 | 3.689 |
| 0.60 | -3.249 | -2.618 | -1.989 | -1.361 | -0.391 | 0.566 | 1.195 | 1.790 |
| 0.50 | -3.369 | -2.858 | -2.396 | -1.986 | -1.211 | -0.464 | 0.068 | 0.332 |
| 0.40 | -3.494 | -3.082 | -2.759 | -2.533 | -1.870 | -1.299 | -0.618 | -0.939 |
| 0.30 | -3.629 | -3.297 | -3.091 | -3.023 | -2.408 | -1.813 | -0.723 | -2.396 |
| 0.20 | -3.756 | -3.524 | -3.397 | -3.462 | -2.847 | -1.848 | -0.126 | -4.599 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 10.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -2.980 | -1.616 | 0.009 | 1.817 | 3.969 | 6.226 | 8.436 | 10.668 |
| 0.80 | -3.123 | -2.002 | -0.687 | 0.694 | 2.395 | 4.170 | 5.765 | 7.353 |
| 0.70 | -3.261 | -2.350 | -1.321 | -0.272 | 1.049 | 2.469 | 3.553 | 4.629 |
| 0.60 | -3.395 | -2.665 | -1.899 | -1.125 | -0.062 | 1.021 | 1.768 | 2.459 |
| 0.50 | -3.525 | -2.951 | -2.400 | -1.898 | -1.000 | -0.173 | 0.412 | 0.741 |
| 0.40 | -3.652 | -3.211 | -2.838 | -2.562 | -1.816 | -1.131 | -0.420 | -0.682 |
| 0.30 | -3.777 | -3.452 | -3.224 | -3.136 | -2.478 | -1.800 | -0.620 | -2.307 |
| 0.20 | -3.896 | -3.683 | -3.563 | -3.621 | -2.999 | -1.937 | -0.069 | -4.613 |

convolution summary for navy water

zenith angle of entry= 15.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -11.615 | -12.536 | -12.846 | -12.835 | -12.622 | -12.287 | -12.000 | -11.610 |
| 0.80 | -11.438 | -12.454 | -12.860 | -12.986 | -12.836 | -12.605 | -12.486 | -12.265 |
| 0.70 | -11.223 | -12.332 | -12.829 | -13.154 | -13.018 | -12.831 | -12.823 | -12.720 |
| 0.60 | -10.953 | -12.160 | -12.749 | -13.159 | -13.114 | -13.041 | -13.124 | -13.186 |
| 0.50 | -10.597 | -11.921 | -12.608 | -12.954 | -12.928 | -13.201 | -13.101 | -13.554 |
| 0.40 | -10.087 | -11.577 | -12.386 | -12.760 | -12.701 | -13.109 | -12.703 | -13.530 |
| 0.30 | -9.666 | -11.043 | -12.039 | -12.434 | -12.281 | -12.785 | -11.927 | -13.033 |
| 0.20 | -9.326 | -10.046 | -11.433 | -11.874 | -11.520 | -12.159 | -9.835 | -12.561 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -9.708 | -10.299 | -10.428 | -10.221 | -9.736 | -9.133 | -8.534 | -7.833 |
| 0.80 | -9.612 | -10.262 | -10.517 | -10.469 | -10.143 | -9.717 | -9.397 | -8.985 |
| 0.70 | -9.500 | -10.191 | -10.563 | -10.674 | -10.433 | -10.161 | -10.038 | -9.823 |
| 0.60 | -9.371 | -10.080 | -10.536 | -10.785 | -10.615 | -10.482 | -10.460 | -10.439 |
| 0.50 | -9.219 | -9.923 | -10.448 | -10.784 | -10.639 | -10.716 | -10.615 | -10.915 |
| 0.40 | -9.033 | -9.709 | -10.293 | -10.653 | -10.469 | -10.764 | -10.340 | -11.193 |
| 0.30 | -8.793 | -9.419 | -10.047 | -10.390 | -10.149 | -10.500 | -9.583 | -11.371 |
| 0.20 | -8.453 | -9.015 | -9.658 | -10.002 | -9.622 | -9.838 | -8.196 | -11.443 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -9.300 | -9.829 | -9.840 | -9.489 | -8.869 | -8.137 | -7.408 | -6.588 |
| 0.80 | -9.215 | -9.816 | -9.990 | -9.827 | -9.370 | -8.838 | -8.414 | -7.908 |
| 0.70 | -9.116 | -9.758 | -10.077 | -10.084 | -9.756 | -9.386 | -9.188 | -8.904 |
| 0.60 | -9.003 | -9.644 | -10.100 | -10.245 | -10.016 | -9.816 | -9.737 | -9.661 |
| 0.50 | -8.870 | -9.501 | -10.050 | -10.304 | -10.114 | -10.115 | -9.987 | -10.223 |
| 0.40 | -8.713 | -9.306 | -9.906 | -10.252 | -10.029 | -10.235 | -9.788 | -10.596 |
| 0.30 | -8.522 | -9.044 | -9.625 | -10.056 | -9.714 | -10.074 | -9.041 | -10.911 |
| 0.20 | -8.274 | -8.697 | -9.260 | -9.624 | -9.208 | -9.382 | -7.733 | -11.159 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -9.287 | -9.643 | -9.552 | -9.142 | -8.435 | -7.594 | -6.749 | -5.864 |
| 0.80 | -9.217 | -9.661 | -9.722 | -9.504 | -9.003 | -8.403 | -7.903 | -7.308 |
| 0.70 | -9.133 | -9.643 | -9.836 | -9.783 | -9.431 | -9.021 | -8.775 | -8.447 |
| 0.60 | -9.031 | -9.586 | -9.893 | -9.975 | -9.721 | -9.489 | -9.381 | -9.277 |
| 0.50 | -8.905 | -9.482 | -9.887 | -10.073 | -9.862 | -9.819 | -9.677 | -9.875 |
| 0.40 | -8.744 | -9.320 | -9.807 | -10.068 | -9.840 | -9.982 | -9.564 | -10.309 |
| 0.30 | -8.530 | -9.083 | -9.636 | -9.944 | -9.638 | -9.886 | -8.903 | -10.686 |
| 0.20 | -8.214 | -8.730 | -9.321 | -9.660 | -9.219 | -9.323 | -7.479 | -10.967 |

convolution summary for navy water

zenith angle of entry= 25.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 0.7

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -21.841 | -27.667 | -30.273 | -30.676 | -30.695 | -30.615 | -30.708 | -30.421 |
| 0.80 | -21.478 | -27.027 | -30.126 | -30.737 | -30.772 | -30.859 | -31.576 | -30.887 |
| 0.70 | -21.056 | -25.661 | -29.796 | -30.745 | -30.805 | -31.413 | -32.578 | -31.849 |
| 0.60 | -20.564 | -24.419 | -28.922 | -30.652 | -30.729 | -31.895 | -33.263 | -32.252 |
| 0.50 | -19.986 | -23.240 | -27.489 | -30.336 | -30.354 | -32.102 | -33.695 | -31.727 |
| 0.40 | -19.305 | -21.709 | -25.544 | -29.256 | -28.727 | -31.790 | -33.884 | -28.897 |
| 0.30 | -18.802 | -20.830 | -23.666 | -27.165 | -24.861 | -30.316 | -33.437 | -24.435 |
| 0.20 | -18.472 | -19.563 | -21.305 | -24.930 | -19.550 | -23.222 | -29.491 | -14.629 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 3.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 2.330 | 1.858 | 1.386 | 1.162 | 1.556 | 2.107 | 2.881 | 3.556 |
| 0.80 | 2.325 | 1.850 | 1.247 | 0.634 | 0.705 | 0.779 | 0.910 | 1.053 |
| 0.70 | 2.316 | 1.870 | 1.198 | 0.307 | 0.101 | -0.318 | -0.828 | -1.088 |
| 0.60 | 2.299 | 1.911 | 1.247 | 0.164 | -0.182 | -0.998 | -2.064 | -2.635 |
| 0.50 | 2.273 | 1.965 | 1.368 | 0.194 | -0.129 | -1.242 | -2.765 | -3.440 |
| 0.40 | 2.237 | 2.022 | 1.540 | 0.385 | 0.298 | -0.994 | -2.722 | -3.600 |
| 0.30 | 2.187 | 2.065 | 1.755 | 0.709 | 1.091 | -0.224 | -2.019 | -3.804 |
| 0.20 | 2.123 | 2.078 | 1.965 | 1.112 | 1.937 | 0.860 | -1.463 | -4.932 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 6.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 8.256 | 9.421 | 10.622 | 11.978 | 13.658 | 15.376 | 17.148 | 18.643 |
| 0.80 | 8.060 | 8.981 | 9.780 | 10.583 | 11.728 | 12.741 | 13.629 | 14.473 |
| 0.70 | 7.855 | 8.588 | 9.091 | 9.403 | 10.118 | 10.471 | 10.572 | 10.914 |
| 0.60 | 7.651 | 8.236 | 8.531 | 8.474 | 8.888 | 8.619 | 8.164 | 8.157 |
| 0.50 | 7.445 | 7.900 | 8.076 | 7.725 | 8.046 | 7.220 | 6.499 | 6.267 |
| 0.40 | 7.237 | 7.586 | 7.686 | 7.155 | 7.558 | 6.342 | 5.704 | 5.085 |
| 0.30 | 7.023 | 7.286 | 7.389 | 6.766 | 7.470 | 5.990 | 5.500 | 3.703 |
| 0.20 | 6.804 | 6.987 | 7.135 | 6.521 | 7.625 | 6.019 | 5.046 | 1.497 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 10.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 54.827 | 58.006 | 67.337 | 83.136 | 114.969 | 169.883 | 289.077 | 628.486 |
| 0.80 | 53.769 | 53.977 | 57.761 | 63.516 | 76.760 | 91.196 | 106.826 | 126.004 |
| 0.70 | 52.932 | 50.933 | 51.043 | 51.197 | 56.619 | 58.817 | 58.359 | 60.721 |
| 0.60 | 52.333 | 48.755 | 46.382 | 43.104 | 45.012 | 41.806 | 37.072 | 36.502 |
| 0.50 | 52.003 | 47.385 | 43.377 | 37.813 | 38.440 | 32.004 | 26.492 | 25.406 |
| 0.40 | 51.990 | 46.830 | 41.883 | 34.674 | 35.822 | 26.601 | 21.647 | 20.147 |
| 0.30 | 52.365 | 47.164 | 41.980 | 33.469 | 37.407 | 24.745 | 20.363 | 16.706 |
| 0.20 | 53.231 | 48.597 | 43.937 | 34.359 | 44.566 | 26.815 | 20.060 | 11.765 |

convolution summary for navy water

zenith angle of entry= 25.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 0.7

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -24.243 | -30.053 | -31.650 | -32.180 | -32.067 | -31.805 | -31.899 | -31.193 |
| 0.80 | -23.693 | -29.354 | -31.543 | -32.396 | -32.343 | -32.422 | -32.853 | -32.415 |
| 0.70 | -22.943 | -27.845 | -31.189 | -32.507 | -32.518 | -32.900 | -33.560 | -33.145 |
| 0.60 | -21.932 | -27.026 | -30.736 | -32.475 | -32.504 | -33.227 | -34.391 | -33.487 |
| 0.50 | -21.544 | -24.972 | -30.043 | -32.178 | -32.051 | -33.367 | -35.229 | -33.344 |
| 0.40 | -21.064 | -24.039 | -27.761 | -31.048 | -30.619 | -33.183 | -35.574 | -31.410 |
| 0.30 | -20.437 | -22.316 | -25.721 | -29.698 | -27.582 | -32.012 | -35.151 | -26.707 |
| 0.20 | -19.551 | -21.167 | -23.464 | -27.054 | -22.520 | -27.194 | -30.750 | -18.646 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 3.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -10.446 | -13.910 | -15.716 | -16.640 | -16.812 | -16.667 | -16.333 | -15.931 |
| 0.80 | -9.972 | -13.509 | -15.556 | -16.869 | -17.334 | -17.697 | -17.972 | -17.925 |
| 0.70 | -9.412 | -13.049 | -15.244 | -16.871 | -17.596 | -18.443 | -19.358 | -19.556 |
| 0.60 | -8.734 | -12.445 | -14.747 | -16.621 | -17.504 | -18.830 | -20.524 | -20.786 |
| 0.50 | -7.883 | -11.636 | -13.997 | -16.179 | -16.941 | -18.753 | -21.104 | -21.027 |
| 0.40 | -7.147 | -10.525 | -13.019 | -15.439 | -15.837 | -18.007 | -20.910 | -19.973 |
| 0.30 | -6.413 | -9.222 | -11.615 | -14.283 | -13.843 | -16.271 | -19.667 | -17.415 |
| 0.20 | -5.587 | -7.379 | -9.511 | -12.647 | -10.840 | -13.459 | -17.268 | -14.716 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 6.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -8.533 | -11.389 | -12.693 | -13.318 | -13.146 | -12.717 | -12.117 | -11.526 |
| 0.80 | -8.110 | -11.115 | -12.679 | -13.735 | -13.899 | -14.005 | -14.056 | -13.908 |
| 0.70 | -7.612 | -10.729 | -12.516 | -13.928 | -14.383 | -15.007 | -15.741 | -15.925 |
| 0.60 | -7.015 | -10.194 | -12.184 | -13.890 | -14.513 | -15.631 | -17.108 | -17.408 |
| 0.50 | -6.478 | -9.507 | -11.642 | -13.596 | -14.218 | -15.787 | -17.831 | -17.942 |
| 0.40 | -5.973 | -8.655 | -10.810 | -12.991 | -13.329 | -15.319 | -17.799 | -17.317 |
| 0.30 | -5.439 | -7.479 | -9.531 | -12.066 | -11.688 | -14.004 | -16.858 | -15.400 |
| 0.20 | -4.880 | -6.173 | -7.744 | -10.615 | -9.100 | -11.555 | -14.923 | -13.761 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 10.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -3.291 | -7.329 | -8.602 | -8.977 | -8.519 | -7.800 | -6.844 | -5.918 |
| 0.80 | -2.507 | -7.086 | -8.739 | -9.619 | -9.576 | -9.501 | -9.393 | -9.119 |
| 0.70 | -1.504 | -6.692 | -8.692 | -10.007 | -10.310 | -13.808 | -14.446 | -14.552 |
| 0.60 | -0.183 | -6.093 | -8.437 | -10.142 | -10.651 | -14.692 | -15.995 | -16.255 |
| 0.50 | 1.631 | -5.199 | -7.914 | -10.007 | -10.541 | -15.077 | -16.910 | -17.040 |
| 0.40 | 4.278 | -3.817 | -7.008 | -9.547 | -9.811 | -14.833 | -17.055 | -16.654 |
| 0.30 | 8.517 | -1.542 | -5.407 | -8.653 | -8.090 | -13.742 | -16.299 | -15.204 |
| 0.20 | 16.453 | 2.825 | -2.305 | -7.019 | -4.160 | -8.366 | -14.702 | -13.695 |

convolution summary for navy water

zenith angle of entry= 25.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -36.515 | -38.879 | -39.417 | -39.331 | -39.052 | -38.776 | -38.793 | -38.286 |
| 0.80 | -36.162 | -38.740 | -39.474 | -39.534 | -39.323 | -39.252 | -39.518 | -39.130 |
| 0.70 | -35.549 | -38.522 | -39.491 | -39.675 | -39.525 | -39.631 | -40.516 | -39.671 |
| 0.60 | -33.972 | -38.165 | -39.449 | -39.744 | -39.610 | -39.893 | -41.444 | -40.002 |
| 0.50 | -31.995 | -37.532 | -39.308 | -39.723 | -39.499 | -40.112 | -41.930 | -39.771 |
| 0.40 | -29.769 | -36.662 | -38.986 | -39.598 | -39.010 | -39.760 | -42.180 | -38.988 |
| 0.30 | -27.571 | -35.470 | -38.218 | -39.360 | -37.253 | -38.999 | -42.250 | -36.457 |
| 0.20 | -26.235 | -30.245 | -36.324 | -38.987 | -33.531 | -36.373 | -42.024 | -29.215 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -25.838 | -30.316 | -32.174 | -32.954 | -33.013 | -32.862 | -32.742 | -32.282 |
| 0.80 | -25.213 | -29.815 | -32.012 | -33.138 | -33.351 | -33.557 | -33.913 | -33.634 |
| 0.70 | -24.574 | -29.125 | -31.678 | -33.169 | -33.543 | -34.142 | -35.084 | -34.782 |
| 0.60 | -23.853 | -28.242 | -31.164 | -33.006 | -33.481 | -34.527 | -36.061 | -35.522 |
| 0.50 | -23.016 | -27.212 | -30.365 | -32.575 | -33.004 | -34.580 | -36.658 | -35.438 |
| 0.40 | -22.079 | -25.814 | -29.067 | -31.741 | -31.751 | -34.041 | -36.766 | -34.036 |
| 0.30 | -20.987 | -24.286 | -27.275 | -30.454 | -29.324 | -32.425 | -36.026 | -30.329 |
| 0.20 | -19.461 | -22.348 | -24.854 | -28.317 | -25.108 | -28.662 | -32.986 | -25.069 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -24.397 | -28.353 | -30.196 | -31.032 | -31.124 | -30.969 | -30.778 | -30.323 |
| 0.80 | -23.870 | -27.867 | -30.040 | -31.230 | -31.508 | -31.751 | -32.087 | -31.844 |
| 0.70 | -23.287 | -27.276 | -29.730 | -31.258 | -31.721 | -32.394 | -33.310 | -33.124 |
| 0.60 | -22.631 | -26.543 | -29.219 | -31.073 | -31.652 | -32.806 | -34.348 | -33.959 |
| 0.50 | -21.874 | -25.606 | -28.423 | -30.615 | -31.147 | -32.848 | -34.971 | -33.957 |
| 0.40 | -21.014 | -24.424 | -27.266 | -29.827 | -29.938 | -32.268 | -35.017 | -32.608 |
| 0.30 | -19.961 | -23.073 | -25.711 | -28.564 | -27.603 | -30.592 | -34.073 | -29.037 |
| 0.20 | -18.480 | -21.323 | -23.590 | -26.758 | -23.817 | -27.056 | -31.175 | -24.441 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -23.938 | -27.600 | -29.345 | -30.119 | -30.161 | -29.965 | -29.716 | -29.228 |
| 0.80 | -23.434 | -27.184 | -29.221 | -30.358 | -30.601 | -30.814 | -31.109 | -30.856 |
| 0.70 | -22.869 | -26.638 | -28.938 | -30.427 | -30.866 | -31.537 | -32.439 | -32.273 |
| 0.60 | -22.248 | -25.922 | -28.452 | -30.289 | -30.845 | -32.018 | -33.530 | -33.188 |
| 0.50 | -21.561 | -25.053 | -27.735 | -29.887 | -30.396 | -32.114 | -34.214 | -33.260 |
| 0.40 | -20.754 | -24.010 | -26.685 | -29.129 | -29.252 | -31.581 | -34.286 | -32.001 |
| 0.30 | -19.740 | -22.690 | -25.181 | -27.933 | -27.047 | -29.970 | -33.344 | -28.511 |
| 0.20 | -18.316 | -21.070 | -23.227 | -26.259 | -23.414 | -26.578 | -30.572 | -24.244 |

convolution summary for navy water

zenith angle of entry= 35.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 0.7

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -85.148 | -84.342 | -84.190 | -83.282 | -83.181 | -81.820 | -79.714 | -79.105 |
| 0.80 | -85.044 | -84.389 | -84.325 | -83.490 | -83.653 | -82.875 | -79.774 | -79.331 |
| 0.70 | -84.810 | -84.427 | -84.453 | -83.730 | -84.101 | -83.855 | -79.768 | -79.616 |
| 0.60 | -84.553 | -84.439 | -84.566 | -84.006 | -84.498 | -85.515 | -79.750 | -80.023 |
| 0.50 | -84.463 | -84.407 | -85.022 | -84.304 | -85.849 | -88.196 | -79.790 | -82.111 |
| 0.40 | -84.334 | -84.304 | -85.071 | -84.711 | -86.586 | -90.538 | -79.941 | -83.466 |
| 0.30 | -84.154 | -84.080 | -84.505 | -86.156 | -86.448 | -92.768 | -80.751 | -84.432 |
| 0.20 | -83.898 | -83.641 | -83.960 | -87.031 | -84.450 | -93.874 | -81.817 | -86.632 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 3.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -6.470 | -16.377 | -23.301 | -27.333 | -29.794 | -31.170 | -31.859 | -31.807 |
| 0.80 | -5.692 | -14.935 | -22.261 | -26.912 | -30.088 | -32.424 | -33.804 | -34.372 |
| 0.70 | -4.882 | -12.994 | -21.197 | -26.267 | -30.155 | -33.385 | -35.127 | -36.326 |
| 0.60 | -4.091 | -11.236 | -19.531 | -25.272 | -29.994 | -34.184 | -36.024 | -37.953 |
| 0.50 | -3.560 | -8.778 | -17.056 | -23.553 | -29.512 | -34.904 | -36.166 | -38.303 |
| 0.40 | -3.046 | -7.026 | -13.839 | -20.928 | -28.351 | -35.344 | -34.609 | -35.974 |
| 0.30 | -2.559 | -5.116 | -9.932 | -16.552 | -25.785 | -34.541 | -29.413 | -29.129 |
| 0.20 | -2.109 | -3.492 | -6.223 | -10.045 | -19.917 | -29.064 | -17.371 | -15.008 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 6.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 0.383 | -4.143 | -8.177 | -11.045 | -12.781 | -13.733 | -13.841 | -13.200 |
| 0.80 | 0.687 | -3.564 | -7.932 | -11.283 | -13.829 | -15.717 | -16.800 | -17.112 |
| 0.70 | 0.996 | -2.866 | -7.409 | -11.124 | -14.389 | -17.261 | -19.182 | -20.194 |
| 0.60 | 1.306 | -2.165 | -6.655 | -10.532 | -14.474 | -18.462 | -20.628 | -22.378 |
| 0.50 | 1.598 | -1.366 | -5.557 | -9.401 | -13.984 | -19.200 | -21.069 | -23.248 |
| 0.40 | 1.867 | -0.489 | -4.052 | -7.531 | -12.539 | -19.185 | -19.860 | -21.544 |
| 0.30 | 2.127 | 0.436 | -2.295 | -5.306 | -9.711 | -17.061 | -15.518 | -15.858 |
| 0.20 | 2.372 | 1.364 | -0.478 | -2.334 | -4.293 | -9.886 | -8.892 | -7.170 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 10.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -2.634 | -5.330 | -7.518 | -9.171 | -10.060 | -10.258 | -9.775 | -8.622 |
| 0.80 | -2.552 | -5.305 | -8.011 | -10.232 | -11.916 | -13.346 | -14.113 | -14.075 |
| 0.70 | -2.455 | -5.140 | -8.213 | -10.815 | -13.318 | -15.771 | -17.427 | -18.282 |
| 0.60 | -2.345 | -4.841 | -8.085 | -10.936 | -14.121 | -17.654 | -19.781 | -21.329 |
| 0.50 | -2.223 | -4.414 | -7.593 | -10.574 | -14.270 | -18.963 | -20.866 | -23.125 |
| 0.40 | -2.094 | -3.868 | -6.848 | -9.672 | -13.506 | -19.319 | -20.240 | -22.577 |
| 0.30 | -1.964 | -3.229 | -5.761 | -8.070 | -11.264 | -17.494 | -16.900 | -18.553 |
| 0.20 | -1.839 | -2.635 | -4.330 | -5.976 | -6.715 | -10.760 | -11.602 | -11.446 |

convolution summary for navy water

zenith angle of entry= 35.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 0.7

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -85.162 | -84.353 | -84.214 | -83.346 | -83.262 | -82.003 | -79.784 | -79.207 |
| 0.80 | -85.055 | -84.399 | -84.346 | -83.548 | -83.719 | -83.008 | -79.862 | -79.452 |
| 0.70 | -84.821 | -84.434 | -84.470 | -83.779 | -84.152 | -83.939 | -79.879 | -79.746 |
| 0.60 | -84.555 | -84.445 | -84.584 | -84.045 | -84.536 | -85.788 | -79.882 | -80.519 |
| 0.50 | -84.464 | -84.412 | -85.094 | -84.332 | -86.012 | -88.275 | -79.929 | -82.446 |
| 0.40 | -84.335 | -84.307 | -85.126 | -84.840 | -86.706 | -90.699 | -80.056 | -83.608 |
| 0.30 | -84.154 | -84.083 | -84.511 | -86.213 | -86.565 | -92.815 | -81.088 | -84.477 |
| 0.20 | -83.899 | -83.643 | -83.965 | -87.053 | -84.475 | -93.891 | -81.885 | -86.650 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 3.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -32.880 | -42.945 | -48.394 | -51.336 | -52.586 | -53.334 | -53.324 | -52.977 |
| 0.80 | -31.232 | -41.897 | -47.980 | -51.449 | -53.304 | -54.855 | -55.457 | -55.655 |
| 0.70 | -29.794 | -40.457 | -47.250 | -51.258 | -53.874 | -56.255 | -57.063 | -57.779 |
| 0.60 | -27.854 | -39.031 | -46.009 | -50.695 | -54.433 | -57.575 | -58.197 | -59.821 |
| 0.50 | -25.553 | -37.086 | -44.234 | -49.527 | -54.668 | -59.148 | -58.951 | -61.135 |
| 0.40 | -22.696 | -34.461 | -42.107 | -47.961 | -54.158 | -60.644 | -58.180 | -60.565 |
| 0.30 | -19.236 | -30.580 | -39.043 | -45.107 | -52.323 | -60.761 | -53.808 | -55.094 |
| 0.20 | -14.384 | -25.248 | -34.322 | -41.138 | -47.158 | -56.426 | -43.585 | -44.596 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 6.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -26.337 | -35.457 | -40.855 | -43.926 | -45.667 | -46.678 | -46.820 | -46.444 |
| 0.80 | -25.182 | -34.437 | -40.367 | -43.975 | -46.431 | -48.180 | -49.136 | -49.454 |
| 0.70 | -23.927 | -33.282 | -39.553 | -43.631 | -46.903 | -49.586 | -50.968 | -51.880 |
| 0.60 | -22.398 | -31.823 | -38.408 | -42.969 | -47.093 | -50.812 | -52.231 | -53.842 |
| 0.50 | -20.523 | -29.943 | -36.861 | -41.838 | -46.893 | -51.933 | -52.752 | -54.839 |
| 0.40 | -18.269 | -27.724 | -34.626 | -40.045 | -45.937 | -52.672 | -51.628 | -53.410 |
| 0.30 | -15.288 | -24.673 | -31.726 | -37.456 | -43.340 | -51.882 | -46.783 | -47.467 |
| 0.20 | -11.591 | -20.262 | -27.213 | -33.308 | -38.279 | -46.301 | -37.551 | -37.223 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 10.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -24.918 | -33.132 | -38.040 | -41.031 | -42.654 | -43.597 | -43.720 | -43.268 |
| 0.80 | -23.960 | -32.308 | -37.695 | -41.182 | -43.505 | -45.386 | -46.333 | -46.624 |
| 0.70 | -22.838 | -31.243 | -37.071 | -40.961 | -44.071 | -46.811 | -48.294 | -49.287 |
| 0.60 | -21.480 | -29.907 | -36.068 | -40.339 | -44.295 | -48.019 | -49.743 | -51.324 |
| 0.50 | -19.917 | -28.344 | -34.603 | -39.221 | -44.053 | -49.140 | -50.299 | -52.288 |
| 0.40 | -17.945 | -26.301 | -32.716 | -37.655 | -43.040 | -49.753 | -49.077 | -50.910 |
| 0.30 | -15.385 | -23.648 | -29.977 | -35.251 | -40.599 | -48.576 | -44.395 | -45.292 |
| 0.20 | -11.902 | -19.781 | -25.902 | -31.444 | -35.715 | -42.643 | -35.930 | -35.511 |

convolution summary for navy water

zenith angle of entry= 35.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -86.111 | -86.526 | -87.069 | -85.995 | -86.242 | -84.533 | -83.841 | -83.086 |
| 0.80 | -85.904 | -86.477 | -87.292 | -86.477 | -87.149 | -86.642 | -84.111 | -83.607 |
| 0.70 | -85.586 | -86.355 | -87.462 | -86.877 | -87.801 | -87.970 | -84.270 | -84.041 |
| 0.60 | -85.099 | -86.101 | -87.563 | -87.247 | -88.306 | -88.938 | -84.369 | -84.515 |
| 0.50 | -84.546 | -85.593 | -87.558 | -87.587 | -88.681 | -91.994 | -84.447 | -86.371 |
| 0.40 | -84.397 | -84.573 | -87.338 | -87.874 | -88.884 | -93.291 | -84.491 | -87.243 |
| 0.30 | -84.196 | -84.287 | -86.533 | -88.065 | -88.802 | -94.370 | -84.366 | -87.550 |
| 0.20 | -83.922 | -83.782 | -84.326 | -88.093 | -88.058 | -94.914 | -83.803 | -87.511 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -61.769 | -70.727 | -73.966 | -74.738 | -74.831 | -74.672 | -74.033 | -73.388 |
| 0.80 | -60.307 | -70.157 | -74.016 | -75.111 | -75.660 | -75.820 | -75.282 | -75.116 |
| 0.70 | -58.306 | -69.300 | -73.895 | -75.406 | -76.522 | -77.260 | -76.200 | -76.681 |
| 0.60 | -56.298 | -67.976 | -73.505 | -75.645 | -77.534 | -78.963 | -77.014 | -78.341 |
| 0.50 | -53.542 | -66.194 | -72.700 | -75.802 | -78.344 | -80.837 | -77.521 | -79.760 |
| 0.40 | -50.939 | -63.479 | -71.263 | -75.759 | -78.703 | -83.094 | -77.496 | -80.734 |
| 0.30 | -48.051 | -59.351 | -68.745 | -75.136 | -78.156 | -84.410 | -76.060 | -80.371 |
| 0.20 | -45.078 | -52.894 | -63.246 | -72.421 | -75.827 | -83.585 | -70.712 | -75.067 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -54.565 | -65.256 | -69.386 | -70.816 | -71.227 | -71.351 | -70.860 | -70.292 |
| 0.80 | -52.908 | -64.426 | -69.294 | -71.169 | -72.118 | -72.646 | -72.399 | -72.337 |
| 0.70 | -51.250 | -63.254 | -68.979 | -71.376 | -72.950 | -73.972 | -73.534 | -74.083 |
| 0.60 | -49.354 | -61.588 | -68.326 | -71.452 | -73.749 | -75.567 | -74.366 | -75.790 |
| 0.50 | -47.288 | -59.372 | -67.177 | -71.340 | -74.418 | -77.498 | -74.860 | -77.270 |
| 0.40 | -45.181 | -56.165 | -65.224 | -70.859 | -74.649 | -79.392 | -74.684 | -77.965 |
| 0.30 | -42.768 | -51.800 | -61.755 | -69.484 | -73.879 | -80.516 | -72.795 | -76.473 |
| 0.20 | -39.969 | -46.679 | -55.395 | -65.311 | -71.170 | -78.820 | -65.420 | -67.880 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -51.995 | -62.403 | -66.846 | -68.601 | -69.167 | -69.415 | -69.038 | -68.500 |
| 0.80 | -50.650 | -61.489 | -66.684 | -68.903 | -70.030 | -70.742 | -70.661 | -70.649 |
| 0.70 | -49.104 | -60.273 | -66.268 | -69.034 | -70.836 | -72.113 | -71.936 | -72.548 |
| 0.60 | -47.429 | -58.641 | -65.487 | -68.992 | -71.588 | -73.651 | -72.851 | -74.285 |
| 0.50 | -45.691 | -56.427 | -64.201 | -68.700 | -72.163 | -75.466 | -73.365 | -75.778 |
| 0.40 | -43.677 | -53.449 | -62.101 | -67.955 | -72.254 | -77.246 | -73.104 | -76.279 |
| 0.30 | -41.511 | -49.651 | -58.624 | -66.157 | -71.265 | -78.060 | -70.895 | -74.096 |
| 0.20 | -38.767 | -45.184 | -52.637 | -61.432 | -68.124 | -75.744 | -62.986 | -64.266 |

convolution summary for NOS water

zenith angle of entry= 35.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -84.478 | -85.720 | -83.709 | -80.064 | -76.645 | -74.885 | -74.362 | -75.203 |
| 0.80 | -84.490 | -86.048 | -83.574 | -81.069 | -76.466 | -75.442 | -75.528 | -77.955 |
| 0.70 | -84.489 | -86.193 | -83.369 | -81.483 | -75.536 | -77.353 | -79.097 | -79.179 |
| 0.60 | -84.478 | -86.166 | -83.090 | -81.546 | -75.209 | -78.512 | -82.593 | -79.344 |
| 0.50 | -84.457 | -85.951 | -82.735 | -81.369 | -74.583 | -79.155 | -86.172 | -78.277 |
| 0.40 | -84.427 | -85.516 | -82.301 | -80.985 | -73.012 | -79.542 | -87.517 | -74.048 |
| 0.30 | -84.390 | -84.886 | -81.765 | -80.387 | -70.458 | -79.731 | -87.989 | -70.916 |
| 0.20 | -84.344 | -84.564 | -81.066 | -79.927 | -66.346 | -79.626 | -88.201 | -70.526 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -8.002 | -17.493 | -24.393 | -27.158 | -27.828 | -27.433 | -27.883 | -27.778 |
| 0.80 | -7.144 | -16.089 | -23.371 | -26.879 | -28.650 | -28.975 | -29.884 | -30.900 |
| 0.70 | -6.214 | -14.052 | -21.839 | -26.157 | -28.807 | -29.853 | -31.236 | -34.513 |
| 0.60 | -5.222 | -11.840 | -20.015 | -24.733 | -28.223 | -30.133 | -32.906 | -39.413 |
| 0.50 | -4.184 | -9.162 | -17.169 | -21.932 | -26.637 | -29.785 | -34.707 | -47.183 |
| 0.40 | -3.515 | -6.949 | -13.561 | -17.799 | -24.331 | -28.692 | -37.312 | -57.674 |
| 0.30 | -2.884 | -4.728 | -9.191 | -12.272 | -20.166 | -26.620 | -40.165 | -62.889 |
| 0.20 | -2.303 | -3.119 | -5.389 | -6.698 | -13.008 | -24.022 | -43.034 | -64.191 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -0.385 | -4.319 | -8.482 | -9.757 | -9.702 | -8.614 | -7.628 | -6.596 |
| 0.80 | -0.025 | -3.715 | -8.445 | -10.504 | -11.659 | -11.483 | -11.462 | -11.930 |
| 0.70 | 0.362 | -2.928 | -7.953 | -10.637 | -13.023 | -13.643 | -14.361 | -16.724 |
| 0.60 | 0.767 | -2.098 | -7.053 | -10.085 | -13.629 | -14.953 | -16.534 | -22.338 |
| 0.50 | 1.178 | -1.126 | -5.727 | -8.662 | -13.383 | -15.459 | -18.949 | -30.383 |
| 0.40 | 1.578 | -0.060 | -3.849 | -6.427 | -12.023 | -15.288 | -21.894 | -42.136 |
| 0.30 | 1.928 | 1.018 | -1.764 | -3.614 | -9.456 | -14.556 | -25.865 | -54.118 |
| 0.20 | 2.256 | 1.920 | 0.303 | -0.996 | -5.052 | -13.333 | -30.771 | -58.770 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -2.933 | -4.743 | -6.910 | -6.801 | -5.815 | -4.059 | -2.022 | 0.002 |
| 0.80 | -2.859 | -4.795 | -7.691 | -8.633 | -9.100 | -8.410 | -7.525 | -7.335 |
| 0.70 | -2.748 | -4.658 | -8.093 | -9.813 | -11.542 | -11.727 | -11.813 | -13.663 |
| 0.60 | -2.607 | -4.321 | -8.018 | -10.280 | -13.239 | -14.145 | -15.269 | -20.132 |
| 0.50 | -2.444 | -3.807 | -7.435 | -10.002 | -14.070 | -15.557 | -18.430 | -28.873 |
| 0.40 | -2.264 | -3.149 | -6.479 | -8.934 | -13.856 | -16.165 | -22.016 | -41.313 |
| 0.30 | -2.080 | -2.538 | -5.119 | -7.127 | -12.220 | -16.181 | -26.637 | -55.231 |
| 0.20 | -1.906 | -2.003 | -3.510 | -5.160 | -8.866 | -15.767 | -32.401 | -62.040 |

convolution summary for NOS water

zenith angle of entry= 35.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 0.7

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -84.481 | -85.764 | -83.744 | -80.277 | -76.950 | -74.983 | -74.496 | -75.266 |
| 0.80 | -84.493 | -86.082 | -83.610 | -81.235 | -76.832 | -75.522 | -75.892 | -78.152 |
| 0.70 | -84.492 | -86.219 | -83.405 | -81.613 | -75.956 | -77.646 | -79.219 | -79.326 |
| 0.60 | -84.480 | -86.187 | -83.125 | -81.657 | -75.311 | -78.681 | -82.840 | -79.583 |
| 0.50 | -84.458 | -85.967 | -82.767 | -81.458 | -74.730 | -79.264 | -86.254 | -79.359 |
| 0.40 | -84.428 | -85.527 | -82.326 | -81.051 | -73.303 | -79.613 | -87.561 | -77.209 |
| 0.30 | -84.391 | -84.893 | -81.781 | -80.422 | -70.554 | -79.778 | -88.025 | -74.601 |
| 0.20 | -84.344 | -84.564 | -81.073 | -79.929 | -66.409 | -79.655 | -88.230 | -73.349 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 3.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -35.041 | -43.663 | -48.416 | -50.314 | -50.139 | -49.323 | -48.960 | -48.293 |
| 0.80 | -33.935 | -42.569 | -47.875 | -50.636 | -51.231 | -51.285 | -51.573 | -52.106 |
| 0.70 | -32.397 | -40.998 | -46.856 | -50.378 | -51.613 | -52.482 | -53.521 | -56.178 |
| 0.60 | -30.497 | -39.143 | -45.104 | -49.262 | -51.258 | -53.052 | -55.755 | -61.304 |
| 0.50 | -28.332 | -36.663 | -42.978 | -47.424 | -49.948 | -52.959 | -57.941 | -66.653 |
| 0.40 | -25.417 | -33.379 | -39.765 | -43.908 | -47.638 | -52.067 | -60.628 | -69.949 |
| 0.30 | -21.606 | -28.596 | -35.426 | -39.051 | -43.506 | -49.977 | -62.724 | -70.828 |
| 0.20 | -16.557 | -21.979 | -28.688 | -30.988 | -36.212 | -46.566 | -64.135 | -70.661 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 6.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -28.356 | -36.141 | -41.166 | -43.106 | -43.094 | -42.386 | -41.988 | -41.222 |
| 0.80 | -27.309 | -35.014 | -40.629 | -43.399 | -44.399 | -44.469 | -44.830 | -45.469 |
| 0.70 | -26.021 | -33.675 | -39.598 | -43.125 | -45.015 | -45.926 | -47.039 | -49.693 |
| 0.60 | -24.548 | -31.957 | -38.130 | -42.134 | -44.827 | -46.653 | -49.046 | -55.103 |
| 0.50 | -22.728 | -29.683 | -36.024 | -40.100 | -43.689 | -46.636 | -51.301 | -62.321 |
| 0.40 | -20.347 | -26.866 | -33.119 | -36.931 | -41.544 | -45.819 | -54.064 | -67.743 |
| 0.30 | -17.265 | -23.105 | -29.150 | -32.333 | -37.641 | -44.018 | -56.982 | -69.811 |
| 0.20 | -12.995 | -17.970 | -23.803 | -26.259 | -31.383 | -40.975 | -59.324 | -70.077 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 10.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -26.716 | -33.590 | -38.254 | -40.012 | -39.931 | -39.038 | -38.480 | -37.595 |
| 0.80 | -25.763 | -32.701 | -37.907 | -40.501 | -41.488 | -41.466 | -41.701 | -42.256 |
| 0.70 | -24.699 | -31.518 | -37.122 | -40.370 | -42.303 | -43.097 | -44.125 | -46.707 |
| 0.60 | -23.413 | -29.930 | -35.825 | -39.485 | -42.351 | -44.032 | -46.280 | -52.196 |
| 0.50 | -21.784 | -28.007 | -33.902 | -37.742 | -41.538 | -44.205 | -48.547 | -59.998 |
| 0.40 | -19.769 | -25.418 | -31.304 | -34.841 | -39.533 | -43.549 | -51.444 | -66.724 |
| 0.30 | -17.084 | -22.132 | -27.767 | -30.735 | -36.020 | -42.080 | -54.797 | -69.554 |
| 0.20 | -13.434 | -17.660 | -22.994 | -25.392 | -30.256 | -39.310 | -57.661 | -70.187 |

convolution summary for NOS water

zenith angle of entry= 35.00 degrees DEPTH= 10.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -85.416 | -87.627 | -86.058 | -83.881 | -80.052 | -79.220 | -78.763 | -79.364 |
| 0.80 | -85.287 | -87.647 | -85.538 | -84.047 | -80.288 | -79.879 | -80.010 | -82.303 |
| 0.70 | -85.092 | -87.568 | -84.557 | -84.074 | -79.968 | -81.803 | -83.676 | -83.926 |
| 0.60 | -84.834 | -87.360 | -84.320 | -83.961 | -79.655 | -82.940 | -86.587 | -84.431 |
| 0.50 | -84.569 | -86.976 | -83.984 | -83.682 | -79.109 | -83.506 | -88.083 | -84.475 |
| 0.40 | -84.506 | -86.344 | -83.504 | -83.155 | -77.816 | -83.809 | -88.694 | -84.014 |
| 0.30 | -84.438 | -85.441 | -82.775 | -82.149 | -74.745 | -83.880 | -89.029 | -83.038 |
| 0.20 | -84.367 | -84.708 | -81.650 | -80.267 | -70.732 | -83.442 | -89.328 | -81.932 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -63.963 | -70.940 | -72.603 | -72.515 | -71.097 | -70.095 | -69.230 | -69.062 |
| 0.80 | -62.719 | -70.386 | -72.359 | -73.128 | -71.664 | -71.446 | -71.340 | -72.034 |
| 0.70 | -61.365 | -69.466 | -71.769 | -73.369 | -71.748 | -72.722 | -73.851 | -75.203 |
| 0.60 | -59.393 | -67.893 | -70.950 | -73.157 | -71.300 | -73.604 | -76.238 | -78.007 |
| 0.50 | -56.837 | -65.691 | -69.552 | -72.204 | -70.239 | -73.998 | -79.142 | -79.520 |
| 0.40 | -53.414 | -62.141 | -67.043 | -70.312 | -68.273 | -73.796 | -81.733 | -79.796 |
| 0.30 | -49.817 | -56.940 | -63.099 | -66.288 | -65.139 | -72.571 | -83.375 | -79.162 |
| 0.20 | -46.903 | -49.922 | -56.271 | -59.124 | -59.847 | -69.324 | -83.322 | -77.368 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -57.066 | -65.684 | -68.432 | -68.951 | -68.018 | -67.085 | -66.245 | -65.894 |
| 0.80 | -55.724 | -64.842 | -68.097 | -69.426 | -68.717 | -68.582 | -68.521 | -69.156 |
| 0.70 | -54.001 | -63.578 | -67.395 | -69.530 | -68.867 | -69.731 | -70.783 | -72.516 |
| 0.60 | -51.927 | -61.634 | -66.200 | -69.136 | -68.412 | -70.492 | -73.275 | -75.727 |
| 0.50 | -49.701 | -58.941 | -64.422 | -67.963 | -67.242 | -70.752 | -75.781 | -78.045 |
| 0.40 | -47.220 | -55.063 | -61.544 | -65.474 | -65.118 | -70.308 | -78.185 | -78.952 |
| 0.30 | -44.775 | -50.089 | -57.011 | -60.862 | -61.661 | -68.756 | -79.798 | -78.570 |
| 0.20 | -41.848 | -44.679 | -49.729 | -52.408 | -55.982 | -65.030 | -79.705 | -76.562 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -54.377 | -62.910 | -66.067 | -66.853 | -66.104 | -65.217 | -64.453 | -64.007 |
| 0.80 | -53.028 | -61.968 | -65.706 | -67.328 | -66.917 | -66.816 | -66.760 | -67.376 |
| 0.70 | -51.520 | -60.633 | -64.968 | -67.393 | -67.146 | -68.015 | -69.022 | -70.850 |
| 0.60 | -49.768 | -58.733 | -63.764 | -66.911 | -66.738 | -68.773 | -71.471 | -74.325 |
| 0.50 | -47.734 | -56.074 | -61.864 | -65.591 | -65.582 | -68.985 | -73.935 | -77.089 |
| 0.40 | -45.719 | -52.457 | -59.016 | -63.008 | -63.509 | -68.469 | -76.284 | -78.384 |
| 0.30 | -43.402 | -48.058 | -54.588 | -58.332 | -60.078 | -66.812 | -78.055 | -78.294 |
| 0.20 | -40.618 | -43.220 | -47.792 | -50.408 | -54.387 | -63.240 | -78.305 | -76.510 |

convolution summary for navy water

zenith angle of entry= 0.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 2.158 | 2.500 | 2.849 | 3.185 | 3.540 | 3.950 | 4.400 | 4.780 |
| 0.80 | 2.120 | 2.422 | 2.731 | 3.018 | 3.328 | 3.678 | 4.037 | 4.369 |
| 0.70 | 2.083 | 2.345 | 2.614 | 2.854 | 3.123 | 3.418 | 3.690 | 3.955 |
| 0.60 | 2.045 | 2.268 | 2.498 | 2.694 | 2.923 | 3.168 | 3.356 | 3.568 |
| 0.50 | 2.008 | 2.192 | 2.383 | 2.539 | 2.726 | 2.927 | 3.038 | 3.184 |
| 0.40 | 1.970 | 2.117 | 2.269 | 2.390 | 2.530 | 2.691 | 2.743 | 2.789 |
| 0.30 | 1.932 | 2.041 | 2.156 | 2.246 | 2.332 | 2.450 | 2.481 | 2.400 |
| 0.20 | 1.895 | 1.967 | 2.043 | 2.106 | 2.133 | 2.190 | 2.254 | 2.076 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 9.306 | 12.201 | 15.607 | 19.438 | 23.468 | 27.364 | 31.099 | 34.802 |
| 0.80 | 9.007 | 11.454 | 14.391 | 17.523 | 20.925 | 24.386 | 27.518 | 30.507 |
| 0.70 | 8.710 | 10.762 | 13.178 | 15.732 | 18.794 | 21.393 | 24.124 | 26.318 |
| 0.60 | 8.408 | 10.112 | 11.996 | 14.166 | 16.503 | 18.823 | 20.734 | 22.330 |
| 0.50 | 8.121 | 9.499 | 10.954 | 12.588 | 14.552 | 16.150 | 17.767 | 18.647 |
| 0.40 | 7.851 | 8.910 | 10.015 | 11.190 | 12.635 | 13.909 | 15.070 | 14.970 |
| 0.30 | 7.592 | 8.325 | 9.149 | 9.973 | 10.859 | 11.584 | 12.744 | 11.604 |
| 0.20 | 7.343 | 7.794 | 8.306 | 8.860 | 9.279 | 9.471 | 10.681 | 8.971 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 15.566 | 20.302 | 25.603 | 31.213 | 36.922 | 42.273 | 47.161 | 51.514 |
| 0.80 | 15.076 | 19.068 | 23.515 | 28.282 | 33.309 | 37.965 | 42.291 | 46.127 |
| 0.70 | 14.566 | 17.909 | 21.576 | 25.548 | 29.905 | 33.731 | 37.382 | 40.498 |
| 0.60 | 14.069 | 16.832 | 19.798 | 22.898 | 26.537 | 29.686 | 32.590 | 34.758 |
| 0.50 | 13.593 | 15.829 | 18.081 | 20.536 | 23.417 | 25.822 | 28.075 | 29.119 |
| 0.40 | 13.142 | 14.864 | 16.559 | 18.327 | 20.526 | 22.252 | 24.004 | 23.871 |
| 0.30 | 12.705 | 13.898 | 15.179 | 16.380 | 17.766 | 18.949 | 20.422 | 19.138 |
| 0.20 | 12.282 | 13.023 | 13.823 | 14.599 | 15.305 | 15.717 | 17.239 | 15.291 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 11.811 | 17.887 | 24.255 | 30.512 | 36.492 | 41.847 | 46.588 | 50.695 |
| 0.80 | 11.148 | 16.354 | 21.762 | 27.163 | 32.590 | 37.435 | 41.785 | 45.519 |
| 0.70 | 10.503 | 14.897 | 19.399 | 23.932 | 28.730 | 32.921 | 36.755 | 39.873 |
| 0.60 | 9.873 | 13.448 | 17.098 | 20.807 | 24.967 | 28.411 | 31.621 | 33.793 |
| 0.50 | 9.255 | 12.100 | 15.000 | 17.822 | 21.216 | 24.021 | 26.546 | 27.619 |
| 0.40 | 8.670 | 10.831 | 12.976 | 15.129 | 17.637 | 19.852 | 21.726 | 21.642 |
| 0.30 | 8.109 | 9.621 | 11.162 | 12.598 | 14.278 | 15.779 | 17.310 | 16.111 |
| 0.20 | 7.572 | 8.498 | 9.486 | 10.362 | 11.139 | 11.717 | 13.363 | 11.419 |

convolution summary for navy water

zenith angle of entry= 0.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -2.682 | -0.290 | 0.815 | 1.669 | 2.362 | 2.986 | 3.577 | 4.126 |
| 0.80 | -2.801 | -1.119 | 0.447 | 1.265 | 1.953 | 2.547 | 3.064 | 3.511 |
| 0.70 | -2.906 | -1.809 | 0.056 | 0.818 | 1.503 | 2.073 | 2.531 | 2.912 |
| 0.60 | -3.001 | -2.265 | -0.353 | 0.329 | 0.997 | 1.545 | 1.944 | 2.276 |
| 0.50 | -3.084 | -2.585 | -1.615 | -0.190 | 0.426 | 0.943 | 1.270 | 1.528 |
| 0.40 | -3.155 | -2.829 | -2.308 | -1.508 | -0.213 | 0.255 | 0.509 | 0.574 |
| 0.30 | -3.220 | -3.021 | -2.732 | -2.389 | -1.891 | -1.004 | -0.306 | -1.187 |
| 0.20 | -3.280 | -3.167 | -3.026 | -2.871 | -2.757 | -2.606 | -2.221 | -2.842 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 0.372 | 1.908 | 3.482 | 5.201 | 7.267 | 9.815 | 12.254 | 14.870 |
| 0.80 | 0.195 | 1.546 | 2.911 | 4.319 | 5.951 | 7.931 | 9.964 | 11.957 |
| 0.70 | 0.017 | 1.190 | 2.358 | 3.502 | 4.836 | 6.262 | 7.782 | 9.389 |
| 0.60 | -0.164 | 0.839 | 1.822 | 2.758 | 3.827 | 4.908 | 5.908 | 6.875 |
| 0.50 | -0.344 | 0.495 | 1.302 | 2.053 | 2.917 | 3.707 | 4.397 | 4.881 |
| 0.40 | -0.517 | 0.146 | 0.796 | 1.381 | 2.042 | 2.642 | 3.109 | 3.145 |
| 0.30 | -0.692 | -0.209 | 0.294 | 0.734 | 1.171 | 1.587 | 1.992 | 1.552 |
| 0.20 | -0.868 | -0.549 | -0.219 | 0.088 | 0.290 | 0.462 | 0.966 | 0.145 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 1.282 | 3.015 | 4.906 | 7.248 | 10.044 | 13.143 | 16.248 | 19.319 |
| 0.80 | 1.087 | 2.596 | 4.194 | 6.041 | 8.257 | 10.806 | 13.283 | 15.811 |
| 0.70 | 0.890 | 2.191 | 3.528 | 4.924 | 6.737 | 8.628 | 10.594 | 12.445 |
| 0.60 | 0.692 | 1.796 | 2.900 | 4.006 | 5.368 | 6.795 | 8.142 | 9.379 |
| 0.50 | 0.496 | 1.413 | 2.305 | 3.169 | 4.198 | 5.173 | 6.123 | 6.731 |
| 0.40 | 0.308 | 1.028 | 1.737 | 2.396 | 3.160 | 3.845 | 4.440 | 4.467 |
| 0.30 | 0.118 | 0.640 | 1.184 | 1.669 | 2.167 | 2.621 | 3.115 | 2.620 |
| 0.20 | -0.075 | 0.270 | 0.625 | 0.956 | 1.192 | 1.370 | 1.944 | 1.068 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | 1.194 | 3.181 | 5.370 | 8.027 | 11.209 | 14.641 | 17.998 | 21.292 |
| 0.80 | 0.966 | 2.700 | 4.507 | 6.644 | 9.159 | 12.001 | 14.760 | 17.457 |
| 0.70 | 0.736 | 2.235 | 3.743 | 5.364 | 7.409 | 9.545 | 11.735 | 13.758 |
| 0.60 | 0.504 | 1.778 | 3.025 | 4.269 | 5.851 | 7.442 | 8.970 | 10.345 |
| 0.50 | 0.274 | 1.334 | 2.343 | 3.313 | 4.470 | 5.608 | 6.674 | 7.327 |
| 0.40 | 0.051 | 0.887 | 1.690 | 2.429 | 3.289 | 4.058 | 4.730 | 4.753 |
| 0.30 | -0.185 | 0.436 | 1.053 | 1.595 | 2.161 | 2.679 | 3.223 | 2.699 |
| 0.20 | -0.410 | 0.000 | 0.410 | 0.776 | 1.049 | 1.264 | 1.885 | 0.965 |

convolution summary for navy water

zenith angle of entry= 0.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 0.7

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -4.173 | -4.132 | -4.070 | -3.980 | -3.835 | -3.565 | -2.983 | -1.340 |
| 0.80 | -4.177 | -4.143 | -4.095 | -4.030 | -3.933 | -3.777 | -3.523 | -3.103 |
| 0.70 | -4.181 | -4.153 | -4.116 | -4.070 | -4.003 | -3.909 | -3.785 | -3.624 |
| 0.60 | -4.184 | -4.162 | -4.134 | -4.102 | -4.056 | -3.998 | -3.936 | -3.864 |
| 0.50 | -4.188 | -4.170 | -4.149 | -4.127 | -4.096 | -4.060 | -4.030 | -4.001 |
| 0.40 | -4.191 | -4.178 | -4.163 | -4.148 | -4.129 | -4.106 | -4.092 | -4.087 |
| 0.30 | -4.194 | -4.185 | -4.174 | -4.165 | -4.155 | -4.141 | -4.134 | -4.144 |
| 0.20 | -4.197 | -4.191 | -4.185 | -4.179 | -4.176 | -4.170 | -4.162 | -4.179 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 3.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -4.447 | -4.250 | -3.957 | -3.522 | -2.806 | -1.430 | 0.385 | 1.870 |
| 0.80 | -4.465 | -4.303 | -4.075 | -3.764 | -3.288 | -2.515 | -1.223 | 0.170 |
| 0.70 | -4.483 | -4.351 | -4.175 | -3.953 | -3.629 | -3.171 | -2.557 | -1.717 |
| 0.60 | -4.500 | -4.394 | -4.261 | -4.105 | -3.882 | -3.602 | -3.297 | -2.938 |
| 0.50 | -4.517 | -4.433 | -4.334 | -4.226 | -4.076 | -3.903 | -3.751 | -3.608 |
| 0.40 | -4.532 | -4.470 | -4.398 | -4.324 | -4.229 | -4.123 | -4.045 | -4.028 |
| 0.30 | -4.547 | -4.504 | -4.454 | -4.405 | -4.353 | -4.295 | -4.241 | -4.303 |
| 0.20 | -4.562 | -4.535 | -4.504 | -4.474 | -4.455 | -4.436 | -4.380 | -4.473 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 6.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -3.109 | -2.887 | -2.570 | -2.117 | -1.421 | -0.241 | 1.555 | 3.124 |
| 0.80 | -3.130 | -2.946 | -2.697 | -2.365 | -1.883 | -1.162 | -0.090 | 1.332 |
| 0.70 | -3.151 | -3.000 | -2.807 | -2.566 | -2.226 | -1.775 | -1.206 | -0.486 |
| 0.60 | -3.171 | -3.049 | -2.902 | -2.729 | -2.489 | -2.204 | -1.897 | -1.560 |
| 0.50 | -3.190 | -3.094 | -2.984 | -2.862 | -2.697 | -2.516 | -2.352 | -2.213 |
| 0.40 | -3.208 | -3.136 | -3.055 | -2.972 | -2.865 | -2.752 | -2.661 | -2.648 |
| 0.30 | -3.226 | -3.176 | -3.119 | -3.064 | -3.003 | -2.940 | -2.876 | -2.944 |
| 0.20 | -3.243 | -3.211 | -3.177 | -3.143 | -3.118 | -3.098 | -3.032 | -3.133 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 10.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -3.098 | -2.816 | -2.432 | -1.896 | -1.080 | 0.352 | 2.253 | 3.891 |
| 0.80 | -3.127 | -2.890 | -2.587 | -2.191 | -1.624 | -0.787 | 0.532 | 2.015 |
| 0.70 | -3.155 | -2.959 | -2.721 | -2.432 | -2.030 | -1.505 | -0.844 | -0.017 |
| 0.60 | -3.182 | -3.022 | -2.839 | -2.630 | -2.343 | -2.010 | -1.650 | -1.264 |
| 0.50 | -3.208 | -3.081 | -2.942 | -2.794 | -2.594 | -2.381 | -2.185 | -2.028 |
| 0.40 | -3.233 | -3.137 | -3.034 | -2.931 | -2.798 | -2.663 | -2.552 | -2.540 |
| 0.30 | -3.258 | -3.190 | -3.117 | -3.048 | -2.970 | -2.891 | -2.814 | -2.893 |
| 0.20 | -3.283 | -3.239 | -3.193 | -3.151 | -3.118 | -3.090 | -3.010 | -3.127 |

convolution summary for navy water

zenith angle of entry= 15.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 0.7

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -12.064 | -17.422 | -18.978 | -21.479 | -22.157 | -22.230 | -22.472 | -22.433 |
| 0.80 | -11.471 | -16.317 | -18.770 | -21.030 | -21.940 | -22.142 | -22.538 | -22.563 |
| 0.70 | -10.730 | -13.958 | -18.461 | -20.185 | -21.474 | -21.919 | -22.449 | -22.591 |
| 0.60 | -9.789 | -13.437 | -17.924 | -18.911 | -20.394 | -21.475 | -22.088 | -22.497 |
| 0.50 | -9.106 | -12.690 | -16.471 | -18.484 | -18.778 | -20.568 | -21.021 | -22.148 |
| 0.40 | -8.955 | -11.566 | -13.668 | -17.377 | -17.842 | -18.889 | -18.669 | -21.140 |
| 0.30 | -8.811 | -9.780 | -12.532 | -13.597 | -13.855 | -18.232 | -16.565 | -18.905 |
| 0.20 | -8.673 | -8.938 | -10.354 | -11.731 | -11.982 | -16.105 | -12.312 | -18.411 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 3.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 1.004 | 3.224 | 5.291 | 7.089 | 9.411 | 11.370 | 13.289 | 15.142 |
| 0.80 | 0.718 | 2.694 | 4.602 | 6.072 | 7.911 | 9.865 | 11.141 | 12.412 |
| 0.70 | 0.421 | 2.179 | 3.773 | 5.141 | 6.670 | 8.249 | 9.398 | 10.247 |
| 0.60 | 0.111 | 1.668 | 3.004 | 4.144 | 5.614 | 6.833 | 7.646 | 8.301 |
| 0.50 | -0.214 | 1.144 | 2.257 | 3.085 | 4.658 | 5.637 | 6.432 | 6.706 |
| 0.40 | -0.592 | 0.608 | 1.515 | 2.060 | 3.494 | 4.617 | 5.694 | 5.247 |
| 0.30 | -0.969 | 0.029 | 0.739 | 1.008 | 2.386 | 3.730 | 5.414 | 2.766 |
| 0.20 | -1.336 | -0.653 | -0.106 | -0.101 | 1.268 | 3.566 | 5.588 | -1.215 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 6.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 7.354 | 11.366 | 14.837 | 17.904 | 21.127 | 23.884 | 26.304 | 28.342 |
| 0.80 | 6.868 | 10.456 | 13.518 | 16.282 | 19.110 | 21.751 | 23.695 | 25.524 |
| 0.70 | 6.373 | 9.499 | 12.245 | 14.562 | 17.181 | 19.632 | 21.222 | 22.553 |
| 0.60 | 5.863 | 8.563 | 11.014 | 12.856 | 15.347 | 17.488 | 18.781 | 19.880 |
| 0.50 | 5.299 | 7.624 | 9.661 | 11.193 | 13.432 | 15.442 | 16.676 | 17.304 |
| 0.40 | 4.732 | 6.693 | 8.317 | 9.362 | 11.616 | 13.317 | 14.973 | 14.727 |
| 0.30 | 4.163 | 5.712 | 6.959 | 7.489 | 9.705 | 11.569 | 13.987 | 11.444 |
| 0.20 | 3.600 | 4.628 | 5.516 | 5.586 | 7.750 | 10.496 | 14.340 | 6.450 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 10.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | 3.289 | 7.962 | 11.883 | 15.197 | 18.348 | 21.105 | 23.274 | 25.238 |
| 0.80 | 2.701 | 6.927 | 10.485 | 13.375 | 16.408 | 18.971 | 20.949 | 22.520 |
| 0.70 | 2.106 | 5.890 | 8.981 | 11.584 | 14.363 | 16.861 | 18.421 | 19.841 |
| 0.60 | 1.502 | 4.750 | 7.515 | 9.685 | 12.325 | 14.669 | 16.050 | 17.108 |
| 0.50 | 0.878 | 3.615 | 6.049 | 7.715 | 10.290 | 12.394 | 13.718 | 14.434 |
| 0.40 | 0.213 | 2.487 | 4.436 | 5.699 | 8.125 | 10.141 | 11.920 | 11.617 |
| 0.30 | -0.443 | 1.332 | 2.805 | 3.457 | 5.996 | 8.063 | 11.191 | 7.968 |
| 0.20 | -1.089 | 0.084 | 1.127 | 1.233 | 3.672 | 6.839 | 12.396 | 2.635 |

convolution summary for navy water

zenith angle of entry= 15.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 0.7

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -17.631 | -20.690 | -22.521 | -23.024 | -23.177 | -23.078 | -23.141 | -23.033 |
| 0.80 | -16.862 | -19.966 | -22.306 | -22.960 | -23.163 | -23.121 | -23.277 | -23.224 |
| 0.70 | -14.536 | -18.957 | -21.982 | -22.822 | -23.067 | -23.104 | -23.317 | -23.340 |
| 0.60 | -13.803 | -18.713 | -21.468 | -22.566 | -22.831 | -23.016 | -23.218 | -23.375 |
| 0.50 | -13.460 | -18.310 | -20.607 | -22.115 | -22.336 | -22.829 | -22.866 | -23.262 |
| 0.40 | -13.071 | -17.250 | -18.971 | -21.300 | -21.212 | -22.454 | -21.830 | -22.845 |
| 0.30 | -12.625 | -13.804 | -18.447 | -19.675 | -18.783 | -21.496 | -18.611 | -21.948 |
| 0.20 | -12.105 | -13.012 | -14.028 | -18.304 | -17.060 | -18.691 | -15.090 | -20.927 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 3.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -9.662 | -10.306 | -10.355 | -9.909 | -9.132 | -8.238 | -7.374 | -6.436 |
| 0.80 | -9.577 | -10.269 | -10.535 | -10.325 | -9.680 | -9.033 | -8.556 | -8.006 |
| 0.70 | -9.484 | -10.166 | -10.644 | -10.669 | -10.114 | -9.663 | -9.481 | -9.188 |
| 0.60 | -9.383 | -10.003 | -10.649 | -10.868 | -10.463 | -10.187 | -10.113 | -10.066 |
| 0.50 | -9.274 | -9.850 | -10.557 | -10.927 | -10.586 | -10.602 | -10.383 | -10.899 |
| 0.40 | -9.156 | -9.644 | -10.317 | -10.827 | -10.471 | -10.702 | -9.912 | -11.680 |
| 0.30 | -9.026 | -9.407 | -9.945 | -10.525 | -10.056 | -10.232 | -8.770 | -13.018 |
| 0.20 | -8.878 | -9.145 | -9.571 | -9.944 | -9.568 | -9.044 | -6.705 | -15.337 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 6.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -8.524 | -8.432 | -7.896 | -7.016 | -5.677 | -4.202 | -2.923 | -1.694 |
| 0.80 | -8.515 | -8.544 | -8.221 | -7.619 | -6.573 | -5.434 | -4.522 | -3.610 |
| 0.70 | -8.500 | -8.616 | -8.493 | -8.133 | -7.311 | -6.449 | -5.942 | -5.358 |
| 0.60 | -8.477 | -8.647 | -8.686 | -8.534 | -7.875 | -7.289 | -6.981 | -6.719 |
| 0.50 | -8.447 | -8.647 | -8.818 | -8.831 | -8.269 | -7.929 | -7.562 | -7.767 |
| 0.40 | -8.407 | -8.595 | -8.875 | -9.062 | -8.495 | -8.313 | -7.524 | -8.799 |
| 0.30 | -8.354 | -8.515 | -8.824 | -9.156 | -8.543 | -8.237 | -6.665 | -10.628 |
| 0.20 | -8.279 | -8.409 | -8.683 | -9.055 | -8.408 | -7.330 | -4.798 | -13.588 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 10.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -8.587 | -8.165 | -7.323 | -6.182 | -4.588 | -2.986 | -1.577 | -0.203 |
| 0.80 | -8.615 | -8.353 | -7.755 | -6.918 | -5.641 | -4.287 | -3.262 | -2.290 |
| 0.70 | -8.636 | -8.502 | -8.135 | -7.568 | -6.536 | -5.472 | -4.814 | -4.102 |
| 0.60 | -8.648 | -8.610 | -8.438 | -8.110 | -7.260 | -6.481 | -6.050 | -5.678 |
| 0.50 | -8.651 | -8.685 | -8.678 | -8.551 | -7.820 | -7.298 | -6.828 | -6.932 |
| 0.40 | -8.644 | -8.707 | -8.840 | -8.903 | -8.217 | -7.864 | -6.978 | -8.167 |
| 0.30 | -8.621 | -8.696 | -8.935 | -9.188 | -8.435 | -7.975 | -6.252 | -10.152 |
| 0.20 | -8.576 | -8.652 | -8.895 | -9.288 | -8.460 | -7.241 | -4.371 | -13.359 |

convolution summary for navy water

zenith angle of entry= 15.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 0.7

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -27.138 | -28.788 | -30.978 | -31.193 | -30.997 | -29.947 | -29.704 | -28.697 |
| 0.80 | -26.747 | -28.640 | -30.920 | -31.363 | -31.279 | -30.462 | -30.599 | -29.900 |
| 0.70 | -26.219 | -28.425 | -30.724 | -31.444 | -31.415 | -30.718 | -30.997 | -30.700 |
| 0.60 | -25.442 | -28.117 | -30.230 | -31.395 | -31.357 | -30.802 | -31.004 | -31.028 |
| 0.50 | -24.116 | -27.676 | -28.880 | -31.122 | -30.973 | -30.727 | -30.431 | -30.890 |
| 0.40 | -23.615 | -26.992 | -28.407 | -30.222 | -29.624 | -30.449 | -28.629 | -29.665 |
| 0.30 | -23.252 | -25.786 | -27.760 | -28.493 | -28.254 | -29.617 | -27.475 | -28.128 |
| 0.20 | -22.780 | -23.698 | -26.594 | -27.428 | -26.945 | -28.365 | -23.432 | -26.429 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 3.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -20.716 | -22.863 | -23.825 | -24.095 | -23.918 | -23.474 | -23.210 | -22.787 |
| 0.80 | -20.345 | -22.615 | -23.726 | -24.181 | -24.135 | -23.829 | -23.806 | -23.550 |
| 0.70 | -19.909 | -22.292 | -23.549 | -24.169 | -24.218 | -24.067 | -24.223 | -24.134 |
| 0.60 | -19.515 | -21.873 | -23.264 | -24.021 | -24.111 | -24.182 | -24.363 | -24.521 |
| 0.50 | -19.081 | -21.340 | -22.864 | -23.707 | -23.764 | -24.145 | -24.091 | -24.639 |
| 0.40 | -18.560 | -20.616 | -22.305 | -23.184 | -23.122 | -23.894 | -23.203 | -24.401 |
| 0.30 | -17.883 | -19.651 | -21.528 | -22.394 | -22.105 | -23.229 | -21.314 | -23.811 |
| 0.20 | -16.868 | -18.544 | -20.339 | -21.179 | -20.484 | -21.592 | -18.090 | -23.005 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 6.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -19.920 | -21.708 | -22.482 | -22.612 | -22.284 | -21.725 | -21.323 | -20.797 |
| 0.80 | -19.622 | -21.514 | -22.440 | -22.766 | -22.590 | -22.194 | -22.068 | -21.746 |
| 0.70 | -19.277 | -21.250 | -22.323 | -22.824 | -22.757 | -22.534 | -22.620 | -22.488 |
| 0.60 | -18.864 | -20.901 | -22.105 | -22.749 | -22.734 | -22.743 | -22.878 | -23.012 |
| 0.50 | -18.401 | -20.453 | -21.781 | -22.519 | -22.476 | -22.790 | -22.708 | -23.267 |
| 0.40 | -17.882 | -19.844 | -21.310 | -22.098 | -21.940 | -22.614 | -21.907 | -23.210 |
| 0.30 | -17.203 | -18.994 | -20.640 | -21.439 | -21.061 | -22.018 | -20.164 | -22.875 |
| 0.20 | -16.189 | -17.844 | -19.606 | -20.416 | -19.663 | -20.515 | -17.136 | -22.349 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 10.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -19.676 | -21.272 | -21.897 | -21.912 | -21.474 | -20.832 | -20.336 | -19.736 |
| 0.80 | -19.405 | -21.116 | -21.903 | -22.121 | -21.845 | -21.374 | -21.173 | -20.798 |
| 0.70 | -19.088 | -20.893 | -21.836 | -22.238 | -22.078 | -21.785 | -21.811 | -21.637 |
| 0.60 | -18.707 | -20.588 | -21.672 | -22.227 | -22.126 | -22.066 | -22.156 | -22.252 |
| 0.50 | -18.300 | -20.188 | -21.406 | -22.068 | -21.946 | -22.187 | -22.071 | -22.602 |
| 0.40 | -17.818 | -19.630 | -20.998 | -21.728 | -21.494 | -22.086 | -21.352 | -22.667 |
| 0.30 | -17.180 | -18.841 | -20.400 | -21.160 | -20.706 | -21.566 | -19.653 | -22.496 |
| 0.20 | -16.220 | -17.784 | -19.449 | -20.243 | -19.407 | -20.130 | -16.708 | -22.151 |

convolution summary for navy water

zenith angle of entry= 25.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -90.965 | -89.345 | -89.340 | -87.645 | -85.072 | -84.598 | -84.871 | -83.909 |
| 0.80 | -90.967 | -89.406 | -89.521 | -88.178 | -86.175 | -84.883 | -86.168 | -84.207 |
| 0.70 | -90.959 | -89.456 | -89.738 | -88.595 | -86.937 | -85.222 | -87.304 | -84.230 |
| 0.60 | -90.913 | -89.482 | -90.840 | -88.925 | -87.385 | -85.709 | -87.939 | -83.870 |
| 0.50 | -90.788 | -89.467 | -91.844 | -89.209 | -87.496 | -85.393 | -88.436 | -82.657 |
| 0.40 | -90.525 | -89.384 | -92.551 | -89.523 | -87.082 | -84.909 | -89.026 | -79.930 |
| 0.30 | -90.018 | -89.192 | -93.059 | -90.582 | -85.045 | -84.462 | -89.830 | -77.691 |
| 0.20 | -89.684 | -88.808 | -93.428 | -92.262 | -83.962 | -81.896 | -92.217 | -73.846 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -20.343 | -24.462 | -27.877 | -30.522 | -31.937 | -32.682 | -33.027 | -32.977 |
| 0.80 | -19.831 | -23.834 | -27.217 | -29.967 | -31.642 | -32.905 | -33.979 | -34.362 |
| 0.70 | -19.368 | -23.201 | -26.396 | -29.141 | -31.063 | -32.894 | -35.109 | -35.729 |
| 0.60 | -19.012 | -22.474 | -25.364 | -28.329 | -30.032 | -32.537 | -35.864 | -36.329 |
| 0.50 | -18.641 | -21.632 | -24.114 | -27.311 | -28.481 | -31.625 | -35.966 | -35.480 |
| 0.40 | -18.253 | -20.653 | -23.034 | -25.972 | -26.418 | -29.775 | -34.899 | -32.009 |
| 0.30 | -17.847 | -19.507 | -21.669 | -24.245 | -23.171 | -27.309 | -32.095 | -25.955 |
| 0.20 | -17.421 | -18.706 | -19.915 | -22.820 | -18.916 | -24.166 | -26.206 | -22.284 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -14.416 | -17.624 | -20.308 | -22.307 | -23.346 | -24.033 | -24.331 | -24.337 |
| 0.80 | -14.054 | -17.138 | -19.712 | -21.939 | -23.090 | -24.252 | -25.147 | -25.476 |
| 0.70 | -13.676 | -16.598 | -18.990 | -21.416 | -22.684 | -24.242 | -25.855 | -26.416 |
| 0.60 | -13.354 | -15.997 | -18.165 | -20.715 | -21.996 | -23.906 | -26.330 | -26.876 |
| 0.50 | -13.048 | -15.327 | -17.378 | -19.809 | -20.876 | -23.084 | -26.345 | -26.350 |
| 0.40 | -12.735 | -14.588 | -16.447 | -18.668 | -19.065 | -21.876 | -25.525 | -23.977 |
| 0.30 | -12.416 | -13.776 | -15.335 | -17.525 | -16.682 | -19.961 | -23.194 | -20.189 |
| 0.20 | -12.090 | -13.068 | -14.011 | -16.267 | -13.386 | -17.653 | -19.392 | -17.551 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -19.537 | -22.775 | -25.401 | -27.281 | -28.286 | -28.903 | -29.169 | -29.175 |
| 0.80 | -19.166 | -22.291 | -24.845 | -26.933 | -28.057 | -29.101 | -29.909 | -30.210 |
| 0.70 | -18.778 | -21.752 | -24.175 | -26.440 | -27.634 | -29.092 | -30.554 | -31.073 |
| 0.60 | -18.372 | -21.149 | -23.369 | -25.780 | -26.983 | -28.787 | -30.987 | -31.498 |
| 0.60 | -18.044 | -20.477 | -22.530 | -24.931 | -25.929 | -28.045 | -30.996 | -31.015 |
| 0.40 | -17.720 | -19.729 | -21.603 | -23.871 | -24.237 | -26.861 | -30.234 | -28.791 |
| 0.30 | -17.387 | -18.902 | -20.490 | -22.674 | -21.813 | -25.061 | -28.078 | -25.026 |
| 0.20 | -17.044 | -18.080 | -19.158 | -21.430 | -18.373 | -22.799 | -24.390 | -22.281 |

convolution summary for navy water

zenith angle of entry= 25.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 0.7

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -90.995 | -89.370 | -89.378 | -87.799 | -85.574 | -84.710 | -84.962 | -84.088 |
| 0.80 | -90.993 | -89.427 | -89.551 | -88.287 | -86.506 | -84.975 | -86.566 | -84.379 |
| 0.70 | -90.982 | -89.474 | -89.760 | -88.672 | -87.163 | -85.749 | -87.586 | -84.428 |
| 0.60 | -90.933 | -89.497 | -90.928 | -88.979 | -87.549 | -86.148 | -88.170 | -84.145 |
| 0.50 | -90.805 | -89.479 | -91.892 | -89.246 | -87.627 | -85.832 | -88.623 | -83.161 |
| 0.40 | -90.540 | -89.394 | -92.577 | -89.545 | -87.200 | -84.981 | -89.146 | -80.080 |
| 0.30 | -90.030 | -89.201 | -93.071 | -90.626 | -85.156 | -84.538 | -90.032 | -77.892 |
| 0.20 | -89.685 | -88.815 | -93.433 | -92.274 | -83.979 | -82.138 | -92.246 | -73.872 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 3.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -42.650 | -49.494 | -53.775 | -56.339 | -57.305 | -57.798 | -58.194 | -57.721 |
| 0.80 | -42.015 | -48.300 | -52.848 | -56.013 | -57.178 | -58.318 | -59.505 | -59.273 |
| 0.70 | -41.346 | -47.175 | -51.918 | -55.437 | -56.815 | -58.637 | -60.740 | -60.502 |
| 0.60 | -40.638 | -45.944 | -50.717 | -54.482 | -56.028 | -58.603 | -61.752 | -61.063 |
| 0.50 | -39.888 | -44.419 | -49.024 | -52.908 | -54.412 | -57.878 | -62.323 | -60.190 |
| 0.40 | -39.090 | -42.748 | -47.026 | -51.161 | -51.477 | -56.160 | -61.861 | -55.931 |
| 0.30 | -38.308 | -41.283 | -44.755 | -48.755 | -46.777 | -52.200 | -59.326 | -47.169 |
| 0.20 | -37.694 | -39.621 | -42.094 | -46.411 | -39.837 | -45.893 | -52.659 | -35.333 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 6.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -38.652 | -44.035 | -47.834 | -50.445 | -51.653 | -52.315 | -52.675 | -52.411 |
| 0.80 | -38.059 | -43.158 | -47.007 | -50.023 | -51.417 | -52.682 | -53.803 | -53.805 |
| 0.70 | -37.441 | -42.140 | -46.092 | -49.369 | -50.943 | -52.831 | -54.894 | -54.987 |
| 0.60 | -36.878 | -41.155 | -45.012 | -48.413 | -50.054 | -52.610 | -55.779 | -55.540 |
| 0.50 | -36.328 | -40.071 | -43.669 | -47.062 | -48.480 | -51.729 | -56.134 | -54.634 |
| 0.40 | -35.770 | -38.867 | -41.984 | -45.503 | -45.865 | -49.923 | -55.420 | -50.722 |
| 0.30 | -35.204 | -37.533 | -40.214 | -43.647 | -41.874 | -46.444 | -52.677 | -43.908 |
| 0.20 | -34.630 | -36.259 | -38.040 | -41.602 | -36.239 | -41.428 | -46.776 | -32.357 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 10.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -38.158 | -43.155 | -46.685 | -49.287 | -50.490 | -51.090 | -51.408 | -51.206 |
| 0.80 | -37.600 | -42.316 | -45.989 | -48.854 | -50.265 | -51.398 | -52.506 | -52.563 |
| 0.70 | -37.056 | -41.456 | -45.137 | -48.192 | -49.782 | -51.506 | -53.566 | -53.740 |
| 0.60 | -36.542 | -40.539 | -44.091 | -47.237 | -48.890 | -51.279 | -54.405 | -54.288 |
| 0.50 | -36.020 | -39.513 | -42.800 | -46.040 | -47.327 | -50.487 | -54.705 | -53.398 |
| 0.40 | -35.489 | -38.376 | -41.314 | -44.585 | -44.949 | -48.722 | -53.937 | -49.801 |
| 0.30 | -34.950 | -37.141 | -39.629 | -42.808 | -41.248 | -45.536 | -51.214 | -43.470 |
| 0.20 | -34.404 | -35.965 | -37.569 | -40.930 | -35.967 | -40.954 | -45.783 | -32.887 |

convolution summary for navy water

zenith angle of entry= 25.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 0.7

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -92.575 | -92.333 | -92.913 | -91.265 | -89.718 | -89.391 | -89.554 | -88.732 |
| 0.80 | -92.459 | -92.270 | -93.065 | -91.750 | -89.982 | -89.631 | -90.588 | -89.092 |
| 0.70 | -92.324 | -92.157 | -93.250 | -92.049 | -90.449 | -89.785 | -91.739 | -89.278 |
| 0.60 | -92.150 | -91.945 | -93.438 | -92.197 | -90.498 | -89.958 | -92.333 | -89.207 |
| 0.50 | -91.905 | -91.544 | -93.605 | -92.233 | -89.885 | -89.674 | -92.722 | -88.657 |
| 0.40 | -91.534 | -90.751 | -93.730 | -92.263 | -89.496 | -89.291 | -93.034 | -85.626 |
| 0.30 | -90.932 | -89.688 | -93.797 | -92.484 | -88.644 | -88.447 | -93.294 | -81.383 |
| 0.20 | -89.864 | -89.256 | -93.807 | -92.986 | -84.793 | -85.157 | -93.397 | -74.970 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 3.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -71.497 | -76.985 | -79.113 | -79.495 | -79.305 | -79.074 | -79.482 | -78.701 |
| 0.80 | -70.599 | -76.377 | -78.965 | -79.639 | -79.509 | -79.637 | -80.550 | -79.695 |
| 0.70 | -69.481 | -75.750 | -78.720 | -79.672 | -79.606 | -80.104 | -81.721 | -80.401 |
| 0.60 | -68.009 | -74.894 | -78.303 | -79.543 | -79.453 | -80.356 | -82.780 | -80.541 |
| 0.50 | -66.176 | -73.650 | -77.564 | -79.181 | -78.793 | -80.219 | -83.481 | -79.694 |
| 0.40 | -63.957 | -71.671 | -76.242 | -78.494 | -77.067 | -79.389 | -83.805 | -76.867 |
| 0.30 | -60.979 | -69.116 | -74.302 | -77.308 | -73.620 | -77.095 | -83.510 | -70.321 |
| 0.20 | -57.194 | -64.813 | -70.532 | -75.489 | -66.107 | -72.236 | -80.555 | -55.300 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 6.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -65.116 | -71.680 | -74.434 | -75.527 | -75.694 | -75.643 | -76.068 | -75.361 |
| 0.80 | -64.094 | -70.925 | -74.095 | -75.538 | -75.821 | -76.229 | -77.265 | -76.563 |
| 0.70 | -62.899 | -69.997 | -73.610 | -75.379 | -75.786 | -76.692 | -78.436 | -77.467 |
| 0.60 | -61.458 | -68.853 | -72.898 | -74.995 | -75.416 | -76.900 | -79.444 | -77.741 |
| 0.50 | -59.875 | -67.341 | -71.819 | -74.316 | -74.462 | -76.636 | -80.134 | -76.857 |
| 0.40 | -58.033 | -65.291 | -70.155 | -73.235 | -72.434 | -75.498 | -80.289 | -73.802 |
| 0.30 | -55.837 | -62.556 | -67.685 | -71.642 | -68.400 | -72.896 | -79.380 | -66.527 |
| 0.20 | -53.829 | -58.668 | -63.680 | -69.405 | -60.776 | -67.567 | -74.893 | -52.795 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 10.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -63.284 | -69.772 | -72.652 | -73.911 | -74.185 | -74.206 | -74.591 | -73.988 |
| 0.80 | -62.258 | -69.027 | -72.260 | -73.871 | -74.269 | -74.740 | -75.770 | -75.161 |
| 0.70 | -61.058 | -68.105 | -71.713 | -73.665 | -74.189 | -75.166 | -76.946 | -76.119 |
| 0.60 | -59.783 | -66.933 | -70.930 | -73.230 | -73.784 | -75.344 | -77.946 | -76.443 |
| 0.50 | -58.297 | -65.406 | -69.805 | -72.482 | -72.782 | -75.041 | -78.587 | -75.580 |
| 0.40 | -56.492 | -63.437 | -68.173 | -71.325 | -70.684 | -73.902 | -78.640 | -72.566 |
| 0.30 | -54.771 | -60.731 | -65.659 | -69.677 | -66.709 | -71.299 | -77.543 | -65.266 |
| 0.20 | -52.884 | -57.055 | -61.771 | -67.426 | -59.336 | -66.077 | -72.736 | -52.149 |

convolution summary for navy water

zenith angle of entry= 35.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 0.7

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -196.499 | -196.538 | -196.571 | -196.598 | -196.605 | -196.653 | -196.957 | -197.690 |
| 0.80 | -196.501 | -196.539 | -196.554 | -196.596 | -196.588 | -196.591 | -197.010 | -197.954 |
| 0.70 | -196.504 | -196.541 | -196.538 | -196.595 | -196.566 | -196.529 | -197.105 | -198.093 |
| 0.60 | -196.509 | -196.546 | -196.522 | -196.592 | -196.541 | -196.476 | -197.270 | -198.136 |
| 0.50 | -196.516 | -196.556 | -196.508 | -196.585 | -196.514 | -196.439 | -197.526 | -198.143 |
| 0.40 | -196.526 | -196.573 | -196.497 | -196.573 | -196.487 | -196.416 | -197.831 | -198.144 |
| 0.30 | -196.541 | -196.605 | -196.489 | -196.556 | -196.462 | -196.403 | -198.051 | -198.144 |
| 0.20 | -196.564 | -196.669 | -196.486 | -196.538 | -196.439 | -196.394 | -198.131 | -198.144 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 3.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -76.441 | -100.456 | -112.033 | -114.520 | -114.582 | -115.092 | -113.852 | -112.917 |
| 0.80 | -74.974 | -95.917 | -111.841 | -115.526 | -116.640 | -117.506 | -116.804 | -116.641 |
| 0.70 | -73.236 | -92.600 | -111.121 | -116.514 | -118.726 | -119.933 | -118.972 | -119.813 |
| 0.60 | -71.136 | -87.512 | -109.034 | -117.623 | -120.928 | -123.036 | -120.690 | -122.903 |
| 0.50 | -68.539 | -83.427 | -103.168 | -118.916 | -124.256 | -128.570 | -122.002 | -127.503 |
| 0.40 | -66.719 | -78.212 | -94.327 | -120.279 | -128.067 | -134.503 | -122.979 | -130.281 |
| 0.30 | -64.691 | -74.016 | -85.597 | -116.757 | -130.488 | -139.495 | -120.389 | -129.873 |
| 0.20 | -61.979 | -68.462 | -78.876 | -89.725 | -131.450 | -143.059 | -91.459 | -97.721 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 6.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -20.986 | -46.127 | -60.928 | -69.456 | -74.252 | -77.494 | -78.569 | -78.535 |
| 0.80 | -17.971 | -42.888 | -59.202 | -68.657 | -74.778 | -79.278 | -81.832 | -83.105 |
| 0.70 | -15.904 | -39.190 | -56.543 | -67.188 | -74.845 | -80.799 | -84.758 | -86.974 |
| 0.60 | -14.050 | -34.237 | -52.636 | -64.755 | -74.412 | -82.721 | -86.624 | -89.609 |
| 0.50 | -12.118 | -28.713 | -47.941 | -61.301 | -73.212 | -84.567 | -86.933 | -90.621 |
| 0.40 | -10.123 | -22.518 | -40.984 | -56.591 | -70.698 | -85.767 | -83.430 | -86.266 |
| 0.30 | -8.182 | -16.046 | -31.321 | -48.333 | -65.883 | -83.979 | -71.770 | -71.851 |
| 0.20 | -7.009 | -11.524 | -18.937 | -32.163 | -55.642 | -72.500 | -47.038 | -40.505 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 10.0

| alpha*d= albedo | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| 0.90 | -20.626 | -36.147 | -47.602 | -55.598 | -60.588 | -63.705 | -64.837 | -64.501 |
| 0.80 | -19.406 | -34.084 | -46.219 | -54.973 | -61.346 | -66.098 | -69.154 | -70.373 |
| 0.70 | -18.113 | -31.516 | -44.202 | -53.589 | -61.377 | -68.002 | -72.429 | -74.813 |
| 0.60 | -16.743 | -28.915 | -41.302 | -51.220 | -60.588 | -69.482 | -74.366 | -78.003 |
| 0.50 | -15.295 | -25.861 | -37.812 | -47.772 | -58.670 | -70.404 | -74.473 | -78.486 |
| 0.40 | -13.767 | -21.936 | -33.373 | -43.229 | -55.415 | -70.080 | -70.903 | -73.336 |
| 0.30 | -12.435 | -18.758 | -27.808 | -36.727 | -48.701 | -65.861 | -60.494 | -59.066 |
| 0.20 | -11.491 | -15.211 | -20.781 | -27.663 | -36.971 | -50.986 | -42.353 | -37.089 |

convolution summary for navy water

zenith angle of entry= 35.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -196.499 | -196.538 | -196.571 | -196.598 | -196.605 | -196.653 | -196.957 | -197.690 |
| 0.80 | -196.501 | -196.539 | -196.554 | -196.596 | -196.588 | -196.591 | -197.010 | -197.954 |
| 0.70 | -196.504 | -196.541 | -196.538 | -196.595 | -196.566 | -196.529 | -197.105 | -198.093 |
| 0.60 | -196.509 | -196.546 | -196.522 | -196.592 | -196.541 | -196.476 | -197.270 | -198.136 |
| 0.50 | -196.516 | -196.556 | -196.508 | -196.585 | -196.513 | -196.439 | -197.526 | -198.143 |
| 0.40 | -196.526 | -196.573 | -196.497 | -196.573 | -196.487 | -196.416 | -197.831 | -198.144 |
| 0.30 | -196.541 | -196.605 | -196.489 | -196.556 | -196.462 | -196.403 | -198.051 | -198.144 |
| 0.20 | -196.564 | -196.669 | -196.486 | -196.538 | -196.439 | -196.394 | -198.131 | -198.144 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -99.898 | -126.562 | -133.070 | -135.440 | -135.676 | -135.673 | -134.561 | -133.171 |
| 0.80 | -95.106 | -124.947 | -133.113 | -136.122 | -137.186 | -137.727 | -137.116 | -136.965 |
| 0.70 | -92.810 | -122.104 | -132.738 | -136.697 | -138.595 | -139.684 | -138.781 | -139.671 |
| 0.60 | -89.680 | -119.318 | -131.716 | -137.251 | -139.958 | -143.429 | -139.959 | -143.615 |
| 0.50 | -85.695 | -111.959 | -130.494 | -137.821 | -142.159 | -147.271 | -141.092 | -146.702 |
| 0.40 | -83.209 | -102.151 | -128.301 | -138.354 | -143.533 | -151.546 | -140.947 | -148.314 |
| 0.30 | -79.730 | -93.013 | -121.062 | -138.573 | -142.954 | -154.918 | -138.540 | -147.669 |
| 0.20 | -75.654 | -84.803 | -97.820 | -137.238 | -139.554 | -154.571 | -125.508 | -141.199 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -78.584 | -99.973 | -112.182 | -117.299 | -119.695 | -121.057 | -120.818 | -119.965 |
| 0.80 | -76.109 | -97.311 | -111.093 | -117.358 | -121.044 | -123.330 | -123.892 | -124.100 |
| 0.70 | -72.860 | -94.373 | -109.190 | -116.899 | -122.186 | -125.468 | -126.391 | -128.046 |
| 0.60 | -69.169 | -90.263 | -106.433 | -116.002 | -123.149 | -128.520 | -128.618 | -131.588 |
| 0.50 | -64.240 | -86.209 | -102.675 | -114.383 | -123.791 | -131.795 | -129.739 | -134.080 |
| 0.40 | -58.438 | -80.905 | -96.813 | -111.000 | -123.534 | -134.773 | -128.709 | -133.847 |
| 0.30 | -50.884 | -74.425 | -89.046 | -104.314 | -120.742 | -136.137 | -121.767 | -124.571 |
| 0.20 | -40.812 | -63.028 | -79.959 | -93.331 | -111.540 | -129.561 | -99.259 | -100.165 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -67.984 | -89.578 | -102.176 | -108.853 | -111.742 | -113.762 | -113.929 | -113.201 |
| 0.80 | -65.452 | -86.824 | -100.871 | -108.613 | -112.916 | -116.234 | -117.468 | -117.923 |
| 0.70 | -62.683 | -83.614 | -98.847 | -107.813 | -113.811 | -118.437 | -120.114 | -121.817 |
| 0.60 | -59.347 | -80.026 | -95.734 | -106.263 | -114.345 | -120.716 | -122.241 | -125.405 |
| 0.50 | -55.514 | -75.468 | -91.573 | -103.480 | -114.317 | -123.597 | -123.245 | -127.550 |
| 0.40 | -50.751 | -70.387 | -85.832 | -99.371 | -112.955 | -126.062 | -121.452 | -125.851 |
| 0.30 | -44.869 | -63.823 | -78.772 | -92.296 | -108.710 | -125.861 | -112.622 | -113.792 |
| 0.20 | -36.939 | -54.834 | -69.250 | -81.951 | -97.586 | -116.295 | -90.211 | -89.537 |

convolution summary for navy water

zenith angle of entry= 35.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -196.499 | -196.537 | -196.568 | -196.595 | -196.602 | -196.650 | -196.955 | -197.689 |
| 0.80 | -196.501 | -196.538 | -196.551 | -196.593 | -196.583 | -196.587 | -197.008 | -197.954 |
| 0.70 | -196.504 | -196.540 | -196.535 | -196.592 | -196.561 | -196.523 | -197.103 | -198.093 |
| 0.60 | -196.509 | -196.546 | -196.519 | -196.589 | -196.534 | -196.468 | -197.268 | -198.136 |
| 0.50 | -196.516 | -196.555 | -196.506 | -196.581 | -196.506 | -196.427 | -197.525 | -198.143 |
| 0.40 | -196.526 | -196.573 | -196.495 | -196.569 | -196.480 | -196.401 | -197.831 | -198.144 |
| 0.30 | -196.541 | -196.604 | -196.488 | -196.553 | -196.457 | -196.386 | -198.051 | -198.144 |
| 0.20 | -196.564 | -196.669 | -196.486 | -196.536 | -196.437 | -196.382 | -198.131 | -198.144 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -149.880 | -160.297 | -164.677 | -164.914 | -165.184 | -164.399 | -162.596 | -160.852 |
| 0.80 | -148.423 | -159.261 | -164.739 | -165.323 | -166.328 | -166.121 | -164.076 | -163.185 |
| 0.70 | -146.934 | -158.002 | -164.608 | -165.693 | -167.649 | -168.754 | -164.982 | -165.016 |
| 0.60 | -144.841 | -156.857 | -164.192 | -166.048 | -169.661 | -172.375 | -165.569 | -166.845 |
| 0.50 | -141.435 | -155.123 | -163.298 | -166.347 | -171.069 | -175.799 | -165.926 | -169.529 |
| 0.40 | -137.574 | -152.138 | -161.468 | -166.435 | -171.542 | -180.501 | -165.884 | -171.310 |
| 0.30 | -128.433 | -147.634 | -157.791 | -165.918 | -170.185 | -183.269 | -164.517 | -171.458 |
| 0.20 | -104.308 | -140.430 | -153.105 | -163.611 | -165.523 | -183.190 | -157.580 | -168.250 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -134.459 | -150.764 | -156.778 | -157.933 | -158.250 | -157.737 | -156.226 | -154.797 |
| 0.80 | -131.837 | -149.674 | -156.737 | -158.422 | -159.621 | -159.719 | -158.130 | -157.549 |
| 0.70 | -128.350 | -148.123 | -156.396 | -158.832 | -161.047 | -162.120 | -159.437 | -159.907 |
| 0.60 | -123.873 | -145.798 | -155.610 | -159.185 | -162.708 | -165.573 | -160.371 | -162.532 |
| 0.50 | -118.321 | -142.412 | -154.079 | -159.423 | -164.164 | -169.362 | -160.962 | -165.188 |
| 0.40 | -111.481 | -137.696 | -151.487 | -159.318 | -164.700 | -173.644 | -160.889 | -166.821 |
| 0.30 | -103.680 | -130.039 | -147.162 | -158.227 | -163.310 | -176.432 | -158.806 | -166.411 |
| 0.20 | -95.970 | -116.707 | -137.946 | -153.756 | -158.812 | -175.402 | -149.493 | -159.367 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -124.979 | -143.861 | -151.167 | -153.208 | -153.782 | -153.613 | -152.385 | -151.162 |
| 0.80 | -121.800 | -142.341 | -150.934 | -153.645 | -155.184 | -155.687 | -154.523 | -154.154 |
| 0.70 | -117.943 | -140.240 | -150.316 | -153.946 | -156.636 | -158.179 | -156.095 | -156.892 |
| 0.60 | -112.811 | -137.438 | -149.131 | -154.112 | -158.191 | -161.341 | -157.266 | -159.765 |
| 0.50 | -106.956 | -133.633 | -147.133 | -154.041 | -159.488 | -165.098 | -158.016 | -162.311 |
| 0.40 | -100.368 | -128.084 | -143.904 | -153.410 | -159.890 | -169.198 | -157.714 | -163.809 |
| 0.30 | -93.712 | -119.739 | -138.224 | -151.328 | -158.283 | -171.772 | -154.644 | -162.222 |
| 0.20 | -87.474 | -104.727 | -127.647 | -145.075 | -153.146 | -169.667 | -143.123 | -150.550 |

convolution summary for NOS water

zenith angle of entry= 35.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -196.622 | -196.493 | -196.557 | -196.645 | -196.583 | -164.278 | -163.529 | -169.086 |
| 0.80 | -196.640 | -196.495 | -196.578 | -196.677 | -196.602 | -168.290 | -169.477 | -170.885 |
| 0.70 | -196.663 | -196.500 | -196.614 | -196.726 | -196.631 | -169.724 | -171.401 | -175.647 |
| 0.60 | -196.693 | -196.510 | -196.674 | -196.802 | -196.675 | -170.557 | -176.175 | -176.866 |
| 0.50 | -196.732 | -196.527 | -196.773 | -196.923 | -196.745 | -171.762 | -177.158 | -177.350 |
| 0.40 | -196.786 | -196.557 | -196.940 | -197.117 | -196.859 | -174.328 | -177.544 | -177.600 |
| 0.30 | -196.868 | -196.618 | -197.220 | -197.414 | -197.051 | -175.252 | -177.729 | -177.743 |
| 0.20 | -197.003 | -196.757 | -197.637 | -197.793 | -197.375 | -175.608 | -177.823 | -177.825 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -80.084 | -102.900 | -109.696 | -111.275 | -110.283 | -109.085 | -107.965 | -106.692 |
| 0.80 | -77.468 | -100.001 | -108.398 | -111.759 | -110.756 | -110.774 | -110.895 | -111.641 |
| 0.70 | -75.979 | -94.450 | -105.698 | -111.833 | -110.388 | -111.912 | -113.835 | -118.780 |
| 0.60 | -74.455 | -89.437 | -102.353 | -111.155 | -108.850 | -112.387 | -118.932 | -127.223 |
| 0.50 | -72.644 | -83.519 | -95.877 | -108.291 | -105.042 | -111.939 | -123.452 | -133.442 |
| 0.40 | -70.459 | -76.772 | -88.146 | -99.780 | -100.224 | -109.912 | -128.288 | -136.082 |
| 0.30 | -67.922 | -70.651 | -77.594 | -84.762 | -89.996 | -104.036 | -129.632 | -136.684 |
| 0.20 | -66.016 | -60.626 | -63.749 | -65.363 | -71.253 | -94.218 | -127.293 | -136.429 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -25.919 | -49.238 | -62.794 | -69.523 | -70.631 | -70.140 | -70.880 | -70.524 |
| 0.80 | -23.249 | -45.390 | -60.793 | -68.834 | -71.623 | -72.574 | -74.789 | -76.893 |
| 0.70 | -19.912 | -41.294 | -57.762 | -66.982 | -71.466 | -74.222 | -77.577 | -83.860 |
| 0.60 | -16.530 | -35.426 | -52.936 | -63.095 | -70.114 | -74.477 | -80.009 | -94.087 |
| 0.50 | -14.228 | -29.380 | -47.277 | -57.766 | -66.930 | -73.130 | -83.887 | -109.670 |
| 0.40 | -11.819 | -22.312 | -39.441 | -49.030 | -60.939 | -70.227 | -88.457 | -124.375 |
| 0.30 | -9.329 | -15.478 | -29.139 | -36.451 | -51.889 | -65.731 | -94.506 | -130.119 |
| 0.20 | -7.461 | -10.563 | -16.880 | -21.316 | -36.953 | -59.299 | -99.214 | -131.114 |

CFD BIASES IN CENTIMETERS FOR PM/B= 1.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -23.700 | -37.732 | -49.603 | -54.922 | -56.167 | -55.222 | -55.325 | -54.567 |
| 0.80 | -21.783 | -35.507 | -48.159 | -54.788 | -58.262 | -58.782 | -60.397 | -62.545 |
| 0.70 | -20.293 | -32.648 | -46.019 | -53.467 | -59.259 | -61.312 | -63.999 | -70.172 |
| 0.60 | -18.680 | -29.414 | -42.782 | -50.533 | -58.667 | -62.313 | -66.748 | -80.430 |
| 0.50 | -16.947 | -25.854 | -38.409 | -46.049 | -56.522 | -61.878 | -70.506 | -96.700 |
| 0.40 | -15.103 | -21.469 | -33.128 | -39.365 | -52.348 | -60.028 | -75.552 | -118.227 |
| 0.30 | -13.156 | -17.834 | -26.712 | -31.394 | -45.134 | -56.931 | -82.787 | -130.586 |
| 0.20 | -11.851 | -13.973 | -19.407 | -22.343 | -33.955 | -53.033 | -90.324 | -134.641 |

convolution summary for NOS water

zenith angle of entry= 35.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -196.622 | -196.493 | -196.557 | -196.645 | -196.583 | -164.498 | -163.701 | -169.106 |
| 0.80 | -196.640 | -196.495 | -196.578 | -196.677 | -196.602 | -168.361 | -169.504 | -170.894 |
| 0.70 | -196.663 | -196.500 | -196.614 | -196.726 | -196.631 | -169.760 | -171.518 | -175.681 |
| 0.60 | -196.693 | -196.510 | -196.674 | -196.802 | -196.675 | -170.577 | -176.216 | -176.895 |
| 0.50 | -196.732 | -196.527 | -196.773 | -196.923 | -196.745 | -171.856 | -177.196 | -177.378 |
| 0.40 | -196.786 | -196.557 | -196.940 | -197.117 | -196.859 | -174.369 | -177.588 | -177.621 |
| 0.30 | -196.868 | -196.618 | -197.220 | -197.414 | -197.051 | -175.274 | -177.779 | -177.751 |
| 0.20 | -197.003 | -196.757 | -197.637 | -197.793 | -197.375 | -175.618 | -177.869 | -177.826 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -105.752 | -127.100 | -130.143 | -130.527 | -129.192 | -127.736 | -125.999 | -125.136 |
| 0.80 | -102.210 | -125.522 | -129.590 | -131.128 | -129.980 | -129.878 | -129.595 | -130.509 |
| 0.70 | -98.207 | -122.218 | -128.464 | -131.306 | -129.927 | -131.448 | -133.944 | -137.393 |
| 0.60 | -93.886 | -118.993 | -126.372 | -130.844 | -128.923 | -133.180 | -138.658 | -143.479 |
| 0.50 | -90.803 | -111.203 | -122.062 | -129.404 | -126.459 | -133.477 | -144.281 | -147.336 |
| 0.40 | -86.382 | -101.009 | -117.124 | -125.431 | -121.455 | -131.716 | -148.160 | -148.444 |
| 0.30 | -83.540 | -91.414 | -104.127 | -115.205 | -114.812 | -128.481 | -150.397 | -147.479 |
| 0.20 | -79.587 | -82.478 | -89.791 | -94.190 | -103.335 | -120.031 | -149.524 | -145.283 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -82.999 | -102.328 | -111.928 | -115.094 | -114.777 | -113.544 | -112.537 | -111.182 |
| 0.80 | -80.422 | -99.208 | -110.453 | -115.411 | -116.005 | -116.154 | -116.504 | -117.769 |
| 0.70 | -77.989 | -95.869 | -107.776 | -114.888 | -116.138 | -118.282 | -120.633 | -125.002 |
| 0.60 | -74.739 | -91.312 | -104.591 | -113.063 | -115.061 | -119.265 | -124.390 | -133.528 |
| 0.50 | -70.256 | -86.068 | -99.213 | -108.746 | -112.352 | -118.787 | -129.178 | -141.228 |
| 0.40 | -64.261 | -79.360 | -92.313 | -101.360 | -107.050 | -116.360 | -134.084 | -145.097 |
| 0.30 | -56.466 | -70.225 | -82.956 | -89.333 | -98.555 | -112.129 | -138.616 | -145.142 |
| 0.20 | -45.454 | -56.299 | -69.531 | -74.740 | -83.914 | -104.174 | -139.990 | -142.648 |

CFD BIASES IN CENTIMETERS FOR PM/B= 100.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -72.514 | -91.809 | -102.818 | -107.312 | -107.455 | -106.230 | -105.514 | -104.084 |
| 0.80 | -70.058 | -88.961 | -101.285 | -107.416 | -108.953 | -109.223 | -109.956 | -111.177 |
| 0.70 | -67.086 | -85.082 | -98.762 | -106.446 | -109.190 | -111.097 | -113.641 | -118.811 |
| 0.60 | -63.993 | -80.885 | -94.824 | -103.829 | -108.053 | -111.837 | -117.363 | -128.204 |
| 0.50 | -60.127 | -75.356 | -89.713 | -99.225 | -105.096 | -111.252 | -121.384 | -137.805 |
| 0.40 | -55.334 | -68.971 | -82.572 | -91.243 | -99.904 | -109.055 | -126.448 | -143.918 |
| 0.30 | -48.844 | -60.750 | -73.387 | -80.119 | -91.079 | -104.494 | -131.180 | -145.163 |
| 0.20 | -40.383 | -49.390 | -60.842 | -65.041 | -75.687 | -97.316 | -133.954 | -144.010 |

convolution summary for NOS water

zenith angle of entry= 35.00 degrees DEPTH= 20.00 METERS

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 0.7

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -196.622 | -196.492 | -196.555 | -196.644 | -196.583 | -169.144 | -168.385 | -170.019 |
| 0.80 | -196.640 | -196.494 | -196.576 | -196.676 | -196.602 | -170.168 | -170.445 | -174.097 |
| 0.70 | -196.663 | -196.499 | -196.612 | -196.724 | -196.630 | -170.779 | -175.733 | -177.163 |
| 0.60 | -196.692 | -196.509 | -196.672 | -196.801 | -196.675 | -173.420 | -177.605 | -177.870 |
| 0.50 | -196.731 | -196.526 | -196.772 | -196.922 | -196.745 | -175.623 | -178.113 | -178.132 |
| 0.40 | -196.786 | -196.557 | -196.940 | -197.117 | -196.859 | -176.351 | -178.310 | -178.210 |
| 0.30 | -196.868 | -196.618 | -197.220 | -197.414 | -197.051 | -176.515 | -178.392 | -178.118 |
| 0.20 | -197.003 | -196.757 | -197.637 | -197.793 | -197.375 | -176.297 | -178.413 | -177.892 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 3.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -152.073 | -161.288 | -162.692 | -160.822 | -156.212 | -153.774 | -152.069 | -153.039 |
| 0.80 | -150.875 | -160.376 | -162.109 | -161.730 | -156.650 | -156.066 | -156.250 | -157.850 |
| 0.70 | -149.189 | -158.680 | -160.978 | -161.957 | -156.323 | -157.828 | -161.396 | -163.374 |
| 0.60 | -147.962 | -157.097 | -159.009 | -161.423 | -155.202 | -159.778 | -166.465 | -166.203 |
| 0.50 | -146.141 | -154.828 | -156.955 | -159.740 | -152.942 | -161.018 | -171.936 | -167.187 |
| 0.40 | -142.998 | -150.365 | -154.067 | -156.877 | -148.499 | -161.213 | -174.955 | -166.319 |
| 0.30 | -138.226 | -144.770 | -148.194 | -151.511 | -142.905 | -159.674 | -176.595 | -163.479 |
| 0.20 | -111.639 | -133.062 | -138.312 | -139.047 | -133.174 | -155.687 | -176.857 | -158.632 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 6.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -138.533 | -151.433 | -154.349 | -153.615 | -150.200 | -147.966 | -146.289 | -146.586 |
| 0.80 | -136.431 | -150.361 | -153.640 | -154.552 | -150.889 | -150.392 | -150.403 | -151.982 |
| 0.70 | -133.655 | -148.649 | -152.353 | -154.792 | -150.668 | -152.353 | -155.163 | -157.651 |
| 0.60 | -130.271 | -145.879 | -150.652 | -154.163 | -149.488 | -154.045 | -160.289 | -161.417 |
| 0.50 | -125.112 | -141.691 | -147.966 | -152.289 | -147.057 | -154.859 | -165.923 | -164.026 |
| 0.40 | -118.429 | -135.154 | -143.260 | -148.796 | -142.634 | -154.524 | -170.379 | -163.688 |
| 0.30 | -108.922 | -124.906 | -135.780 | -141.096 | -136.548 | -152.208 | -172.777 | -160.548 |
| 0.20 | -98.553 | -108.954 | -122.402 | -126.880 | -125.605 | -146.748 | -172.799 | -156.892 |

CFD BIASES IN CENTIMETERS FOR PM/B= 10000.0 AND DELTA(NS)= 10.0

| alpha*d= | 2.000 | 4.000 | 6.000 | 8.000 | 10.000 | 12.000 | 14.000 | 16.000 |
|---|---|---|---|---|---|---|---|---|
| albedo | | | | | | | | |
| 0.90 | -129.366 | -144.802 | -149.020 | -149.248 | -146.427 | -144.366 | -142.830 | -142.816 |
| 0.80 | -127.063 | -143.279 | -148.175 | -150.030 | -147.251 | -146.871 | -146.910 | -148.536 |
| 0.70 | -124.043 | -140.971 | -146.789 | -150.107 | -147.068 | -148.986 | -151.494 | -154.313 |
| 0.60 | -119.962 | -137.616 | -144.636 | -149.231 | -145.810 | -150.442 | -156.225 | -159.361 |
| 0.50 | -114.265 | -132.856 | -141.275 | -146.975 | -143.266 | -150.986 | -161.683 | -162.317 |
| 0.40 | -106.399 | -125.722 | -136.025 | -142.479 | -138.856 | -150.350 | -166.832 | -162.828 |
| 0.30 | -98.434 | -114.478 | -127.579 | -133.809 | -132.151 | -147.664 | -169.592 | -161.120 |
| 0.20 | -91.173 | -98.869 | -112.888 | -118.677 | -120.842 | -140.965 | -169.636 | -157.349 |

Appendix C

Program SMPD.FOR documentation

# APPENDIX C
## DOCUMENTATION FOR THE PROGRAM, "SMPD"

This section documents the computer program, SMPD, which is a post-processor to the radiative transfer simulation program, ONEPRO. The objectives of the program are as follow:

1) generate the temporal response at the receiver of a bathymetric lidar system for the bottom return from a given depth and for a specified source pulse description;

2) analyze the generated temporal response using emulations of realistic system electronics and compute the depth-specific depth estimate biases;

3) produce summary printouts of the computed biases as a function of depth and the inherent water parameters; and

4) archive the results on disk files for subsequent reference.

The impulse response function (IRF) generated by the simulation program is the receiver response for impulse input to the water column, and for given inherent water parameters it can be scaled to any depth. The temporal response at the receiver for a finite input pulse is referred to here as the "environmental response function" (ERF), and it is specific for the individual depth at which it is calculated.

Figure C1 presents the logical flow description for SMPD. The IRF is read from disk and the associated time bin computed for the specific depth being treated. The source pulse, described in the coding, is then convolved digitally over the depth-scaled IRF to produce the ERF. Two types of algorithms are applied to the ERF for depth bias estimation:

1) a linear fractional threshold technique in which we determine the time at which the ERF rises to a given fraction of its peak height, $P_m$; and

2) a constant fraction discriminator (CFD) appropriate to the operation of the U.S. Navy's Hydrographic Airborne Laser Sounder (HALS).

Figure C2 details the determination of the ERF. There are two slightly different treatments depending on whether the source pulse is longer or shorter than the IRF. For large depths, the IRF will generally be longer as shown on the left-hand side. In this case, the source pulse is sampled within the time bins appropriate to the description of the IRF, and the resultant ERF has an associated time bin which is the same as that for the IRF. For small depths, however, the source pulse is longer than the IRF and, in this case, the IRF is extrapolated to the end of the source pulse by assuming an exponential decay. The resultant ERF, in this case, has a duration equal to that of the source pulse.

The ERF is always assigned 50 time bins for its description. It follows that, for small depths, the IRF must be resampled since the time bins for its description are shorter than those for the ERF.

Figure C3 presents an overview of the data flow structure for the program together with the names assigned to the input and output files. Two files of IRFs may be input, one for the 'NAVY' phase function and the other for the 'NOS' phase function. Four output disk files are produced:

1) a file of all ERFs generated;

2) a file with a subset of all the computed biases;

3) a file of the biases in "summary page" format; and

4) a file of computed peak power, also in "summary page" format.

The last two files are routinely dumped on the line printer.

Following this section is a complete listing of the SMPD.FOR file containing all the Fortran code of the program. We will now discuss critical sections that the user may wish to modify.

1. Changing the Shape of the Source Pulse.

   The routine, CNV, beginning on line 2310, integrates the source pulse into time bins prior to convolving over the IRF to form the ERF. The method of obtaining the integration is to estimate the total integral of the source pulse, SINT, up to time, T, (lines 2810 thru 2840) and then to take the differences of these integrals estimated for all sampling bin boundaries for computing the integral over individual bins.

The parameter, TWID, defined in the data statement on line 2510, is the total width of the pulse in nanoseconds. The computations currently assume that the pulse is a symmetric triangle and, if the shape is to be retained but with a different base width, then only this line needs to be modified.

In order to facilitate the computation of the integral of the source pulse up to time, T, we compute the total integral, TINT, of the pulse in line 2760 assuming that the peak input power is unity per nanosecond. The quantity, C, computed in line 2600, is the number of centimeters of travel of light in water during the entry of the entire leading edge, and is defined here for convenience in calculating the biases. For assymetric triangular pulses, only the integral and the value of C need to be changed.

The program, STATS, beginning on line 490, estimates the biases for both linear fractional thresholds (LFTs) and the constant fraction discriminator (CFD). The biases depend on the detection algorithm performance over both the surface return (assumed to be identical to the source pulse) and the bottom return, represented by the ERF. Since the leading edge of the source pulse is linear in the present application, the effect of the LFT detection algorithms can be represented simply by the terms involving the parameter, C, in lines 900 and 930. Lines 890 and 900 compute the bias for a fractional threshold (centimeters of travel of light in water), while lines 920 and 930 estimate the duration of the leading edge of the ERF from the 0.1 percent point to the peak (the rise time). For a non-linear leading edge, the term, -C*TST(KK-2), in line 900 should be replaced by the number of centimeters of travel of light in water prior to reading the fractional threshold, TST(KK-2), in the leading edge of the source pulse. Also, the term, +0.999*C, in line 930 should be replaced by the number of centimeters of travel of light in the time from the 0.1 percent threshold to the peak of the source pulse.

It should be noted that for non-linear leading edges, the bias estimates for the CFD detectors will also be subject to modification, but these modifications will be much more complicated than those for the LFT and outside the scope of this document.

2. Changing the Depths for Which Results are to be Generated.

The depths in meters are specified in line 140, and the index, KD, of the loop beginning on line 320 controls which depths are to be employed. In this particular example, results were required for the first and second elements of the DEPTH array, namely, 5 and 10 meters.

3. Selection of the Phase Function and Beam Entry Nadir Angle.

This selection is controlled by the parameter, I, of the loop beginning on line 210. The values of the nadir angle (in air) and the phase functions associated with given values of I are as follow:

| I | Phase Function | Zenith Angle (Degrees) |
|---|---|---|
| 1 | NAVY | 0 |
| 2 | NAVY | 15 |
| 3 | NAVY | 25 |
| 4 | NAVY | 35 |
| 5 | NAVY | 45 |
| 6 | NOS | 0 |
| 7 | NOS | 15 |
| 8 | NOS | 25 |
| 9 | NOS | 35 |
| 10 | NOS | 45 |

The program is structured so that these parameters can be selected by merely choosing the range of values of I in the loop beginning on line 210.

## Program "SMPD"

```
C      THIS PROGRAM READS THE ARCHIVED CONVOLUTION RESULTS FROM
C      ONEPRO.BIN AND ONEPRO.ARN AND PROCESSES THEM USING THE
C      STATS CODE. THE RESULTS FOR DEPTH BIASES ARE WRITTEN ON
C      STANDARD SUMMARY PAGES.
       COMMON/BLK1/CIN(6),TSAMP(8 ,32,3),TDIST(8 ,32,50),stepr,RAD,IARC
      1,TSCALE(10),RSAMP(8 ,32,8),RDIST(8 ,32,100),G,A,B,C,BA,BB,BC,G1,ag
      1,ind,TPATH,IX,R,NMAX,PI,TPI,THO,CZ1,ntor,KP,t,d1,tor(8),frac(8)
      1,ISRCE,ITYPE,X1(5,100),Y1(5,100),X(5,100),S11(100,5),NK(5),NUMK(5)
      1,KIND,NUM,NKK,nalb,ALB(10),ZW(10),CR,SR,CZ0,TTH,CR1,TMAX,IP(5),IS
       DIMENSION TEMP(8,8)
       DIMENSION PMOB(3),DELTA(4)
       DIMENSION DEPTH(5)
       DATA PMOB/1.,100.,10000./,DELTA/0.7,3.0,6.0,10.0/
       DATA KDT/1/,DEPTH/5.,10.,15.,20.,40./
       opEN(UNIT=9,ACCESS='SEQIN',FILE='onepro.ARN',DEVICE='DSK')
       opEN(UNIT=7,ACCESS='SEQIN',FILE='onepro.BIN',DEVICE='DSK')
       OPEN(UNIT=8,ACCESS='SEQOUT',FILE='SMPALL.BAS',DEVICE='DSK')
       OPEN(UNIT=6,ACCESS='SEQOUT',FILE='ONEPRO.OU1',DEVICE='DSK')
       OPEN(UNIT=10,ACCESS='SEQOUT',FILE='SMPALL.EIR',DEVICE='DSK')
       OPEN(UNIT=11,ACCESS='SEQOUT',FILE='POWER.OUT',DEVICE='DSK')
       ilast=0
       DO 1 I=1,10
       A=0.005
       KK=MOD(I-1,5)+1
       IF(KK.GE.4)A=0.01
       KF=7
       IF(I.GT.5)KF=9
c      skip record blocks if appropriate
     3 IL=ILAST+1
       DO 4 K=IL,I
     4 cALL REDARC(ZEN,IALPHA,TEMP,KF)
     5 Ilast=I
       DO 1 KD=1,5
       D=DEPTH(KD)
       DO 2 L=1,NTOR
       I3=4*L-1
       CALL CNV(I3,D,IALPHA,ZEN)
       CALL STATS(I3,D,PMOB,DELTA)
     2 CONTINUE
C      OUTPUT THE SUMMARY PAGE
       CALL SMPAGE(ZEN,IALPHA,D,PMOB,DELTA)
     1 CONTINUE
       CLOSE(UNIT=9,ACCESS='SEQIN',FILE='onepro.ARN',DEVICE='DSK')
       CLOSE(UNIT=7,ACCESS='SEQIN',FILE='onepro.BIN',DEVICE='DSK')
       CLOSE(UNIT=6,ACCESS='SEQOUT',FILE='ONEPRO.OU1',DEVICE='DSK')
       CLOSE(UNIT=8,ACCESS='SEQOUT',FILE='SMPALL.BAS',DEVICE='DSK')
       CLOSE(UNIT=10,ACCESS='SEQOUT',FILE='SMPALL.EIR',DEVICE='DSK')
       CLOSE(UNIT=11,ACCESS='SEQOUT',FILE='POWER.OUT',DEVICE='DSK')
       stop
       END
       subroutine stats(i3,D,PMOB,DELTA)
c      this routine computes summary parameters for the receiver signal.
c      the input parameter, i3, is the second index of the tdist array
c      in which the temporal result is stored.
C          D        = DEPTH (METERS)
C          PMOB     = VECTOR OF VALUES OF BOTTOM SIGNAL PEAK/BACKGROUND
C          DELTA    = CFD TIME DELAY (NANOSECONDS)
       COMMON/BLK1/CIN(6),TSAMP(8 ,32,3),TDIST(8 ,32,50),stepr,RAD,IARC
      1,TSCALE(10),RSAMP(8 ,32,8),RDIST(8 ,32,100),G,A,B,C,BA,BB,BC,G1,ag
      1,ind,TPATH,IX,R,NMAX,PI,TPI,THO,CZ1,ntor,KP,t,d1,tor(8),frac(8)
```

```
     1,ISRCE,ITYPE,X1(5,100),Y1(5,100),X(5,100),S11(100,5),NK(5),NUMK(5)
     1,KIND,NUM,NKK,nalb,ALB(10),ZW(10),CR,SR,CZO,TTH,CR1,TMAx,IP(5),IS
      dimension tst(7),PMOB(3),DELTA(4),IST(4),FFR(4),SS(50)
      data tst/0.001,0.01,0.01,0.1,0.2,0.5,0.8/
      DO 5 I=1,4
      IST(I)=1+INT(DELTA(I)/BB)
      IF(IST(I).LT.2)IST(I)=2
    5 FFR(I)=DELTA(I)/BB-FLOAT(IST(I)-1)
C         BB=BIN WIDTH(NS)
C         B =BIN WIDTH(CMS)
      BAS=(200./CR-200.)*D
      i4=i3+1
      ir=i3/4+1
      TMULT=B
      do 1 i=1,nalb
c     compute the peak value and its position
      pk=0.
      ipos=0
      do 2 k=1,49
      if(tdist(i,i3,K).le.pk)go to 2
      pk=tdist(i,i3,K)
      ipos=k
    2 continue
      tdist(i,i4,1)=(float(ipos)-0.5)*tmult-BAS-C
      tdist(i,i4,2)=pK/BB
c     compute biases for forward looking threshold detectors
      base=bas
      kk=2
      TEST=TST(1)*PK
      do 3 k=2,50
    4 IF(tdist(i,i3,K).lt.test)go to 3
      kk=kk+1
      tdist(i,i4,kk)=(float(k)-0.5+(test-tdist(i,i3,K))
     1/(tdist(i,i3,K)-tdist(i,i3,K-1)))*tmult-baSE-C*TST(KK-2)
      if(kk.eq.9)go to 10
      IF(KK.EQ.4)TDIST(I,I4,4)=(TDIST(I,I4,1)-TDIST(I,I4,4)
     1+0.999*C)/22.5
      test=tst(kk-1)*pk
      GO TO 4
    3 continue
C       COMPUTE THE CFD RELATED BIASES
   10 KPOS=10
      DO 6 KA=1,3
      DO 7 K=1,49
      SS(K)=TDIST(I,I3,K)*PMOB(KA)/PK
      IF(SS(K).GT.0.0001)SS(K)=ALOG(SS(K)+1.)
    7 CONTINUE
      DO 6 KJ=1,4
      II=IST(KJ)-1
      KPOS=KPOS+1
      FF=0.
      DO 8 K=II,49
      FLAST=FF
      KPREV=K-IST(KJ)+1
      IF(KPREV.GT.0)GO TO 9
      FF=-0.2*SS(K)
      GO TO 8
    9 FF=-0.2*SS(K)+SS(KPREV)
      IF(KPREV.EQ.1)KPREV=2
      FF=FF-FFR(KJ)*(SS(KPREV)-SS(KPREV-1))
```

```
      IF(FF.GT.0.)GO TO 6
    8 CONTINUE
    6 TDIST(I,I4,KPOS)=(FLOAT(K)-0.5-FF/(FF-FLAST))*TMULT-BAS
     1-22.5*DELTA(KJ)
    1 continue
      return
      end
      subroutine smpaGE(ZEN,IALPHA,D,PMOB,DELTA)
c     this program publisnes a summary page of the sampled convolution
c     the input parameters are as follows.
C        ZEN       = ZENITH ANGLE OF ENTRY (DEGREES)
c        ialpha    = 4 character descriptor of scattering function type
c                    e.g. navy, nos,  kb etc
C        D         = DEPTH (METERS)
C        PMOB      = VECTOR OF VALUES OF BOTTOM SIGNAL PEAK/BACKGROUND
C        DELTA     = CFD TIME DELAY (NANOSECONDS)
      COMMON/BLK1/CIN(6),TSAMP(8 ,32,3),TDIST(8 ,32,50),stepr,RAD,IARC
     1,TSCALE(10),RSAMP(8 ,32,8),RDIST(8 ,32,100),G,A,B,C,BA,BB,BC,G1,ag
     1,ind,TPATH,IX,R,NMAX,PI,TPI,THO,CZ1,ntor,KP,t,di,tor(8),frac(8)
     1,ISRCE,ITYPE,X1(5,100),Y1(5,100),X(5,100),S11(100,5),NK(5),NUMK(5)
     1,KIND,NUM,NKK,nalb,ALB(10),ZW(10),CR,SR,CZ0,TTH,CR1,TMAx,IP(5),IS
      DIMENSION KV(20),TEST(8),PMOB(3),DELTA(3),ITT(5)
      DATA KV/3,5,6,7,8,9,1,4,11,12,13,14,15,16,17,18,19,20,21,22/
      DATA TEST/0.1,1.0,10.0,20.0,50.0,80.0,100.0,0.0/
      DATA ITT/3,7,15,23,31/
      FR=CR/2.
      nt=4*ntor
      DO 6 KJK=1,2
      KUNIT=16-5*KJK
      L=0
      DO 1 KK=1,5
      IF(KJK.EQ.2)Write(6,100)IALPHA,ZEN,D
      IF(KJK.EQ.1)Write(11,99)IALPHA,ZEN,D
      do 1 LL=1,4
      L=L+1
      K=KV(L)
      IF(KJK.EQ.1)K=2
      if(k.eq.1)write(6,101)
      if(k.eq.2)write(11,102)
      if(k.eq.3)write(6,103)
      if(k.eq.4)write(6,104)
      if(k.eq.5)write(6,105)
      if(k.eq.6)write(6,106)
      if(k.eq.7)write(6,107)
      if(k.eq.8)write(6,108)
      if(k.eq.9)write(6,109)
      IF(KK.GE.3)WRITE(6,113)PMOB(KK-2),DELTA(LL)
      write(KUNIT,110)(tor(i),i=1,ntor)
      do 2 j=1,nalb
      IF(K.EQ.2.OR.K.EQ.4)GO TO 4
      DO 3 I=4,NT,4
    3 TDIST(J,I,K)=TDIST(J,I,K)*FR
    4 IF(K.EQ.2)write(11,111)alb(j),(tdist(j,i,k),i=4,nt,4)
      IF(K.EQ.2)GO TO 2
      IF(K.NE.2)write(6,112)alb(j),(tdist(j,i,k),i=4,nt,4)
      IF(J.NE.1.AND.MOD(J,2).NE.0)GO TO 2
      IF(J.EQ.8)GO TO 2
      IF(J.NE.1)GO TO 5
      IF(KK.GE.3)WRITE(8,90)IALPA,D,ZEN,PMOB(KK-2),DELTA(LL)
     1,ALB(1),(ALB(M),M=2,6,2)
```

```
      IF(KK.LT.3)WRITE(8,90)IALPHA,D,ZEN,TEST(L)
     1,ALB(1),(ALB(M),M=2,6,2)
    5 WRITE(8,91)TDIST(J,4,K),(TDIST(J,I,K),I=8,NT,8)
      IF(KK*LL.NE.1)GO TO 2
      WRITE(10,114)IALPHA,D,ZEN,ALB(J),BB,TOR(1),(TOR(M),M=2,8,2)
      DO 12 IK=1,5
      I=ITT(IK)
   12 WRITE(10,115)(TDIST(J,I,M),M=1,50)
    2 continue
      IF(K.EQ.2)GO TO 6
    1 continue
    6 CONTINUE
   90 FORMAT(A4,9F8.2)
   91 FORMAT(8(1PE10.3))
  100 format('1convolution summary for ',a4,' water'
     1/'0zenith angle of entry=',f8.2,' degrees',6X,'DEPTH=',
     2F7.2,' METERS')
   99 format('0convolution summary for ',a4,' water'
     1/'0zenith angle of entry=',f8.2,' degrees',6X,'DEPTH=',
     2F7.2,' METERS')
  101 format('0results for bias in peak (CENTIMETERS)')
  102 format('0results for peak power per depth transit time (arbitrary
     1units)')
  103 format('0bias in .1 percent point (CENTIMETERS)')
  104 format('0rise time from one percent point to peak (ns)')
  105 format('0bias in 1 percent point (CENTIMETERS)')
  106 format('0bias in 10 percent point (CENTIMETERS)')
  107 format('0bias in 20 percent point (CENTIMETERS)')
  108 format('0bias in 50 percent point (CENTIMETERS)')
  109 format('0bias in 80 percent point (CENTIMETERS)')
  110 format('0alpha*d=',8f12.3/' albedo')
  111 format(' ' f5.2,7x,8(1x,e11.4))
  112 FORMAT(' ',F5.2,7X,8(F8.3,4X))
  113 FORMAT('0CFD BIASES IN CENTIMETERS FOR PM/B=',F8.1,'   AND
     1 DELTA(NS)=',F7.1)
  114 FORMAT(A4,9F8.4)
  115 FORMAT(50(1PE10.3))
      return
      end
      subroutine REDARC(zen,ialpha,temp,KF)
C     THIS PROGRAM READS THE ONEPRO.BIN AND ONEPRO.ARN FILES FROM DISK
C     THE INPUT PARAMETER, KF, IS THE LOGICAL FILE NUMBER FOR INPUT
c     the OUTput arguments are as follow.
C        ZEN     = ZENITH ANGLE OF ENTRY (DEGREES)
c        ialpha  = 4 character descriptor of scattering function type
c                  e.g. navy, nos,  kb etc
c        temp(i,j)= k*d estimate for ith o.t. and jth albedo
      COMMON/BLK1/CIN(6),TSAMP(8 ,32,3),TDIST(8 ,32,50),stepr,RAD,IARC
     1,TSCALE(10),RSAMP(8 ,32,8),RDIST(8 ,32,100),G,A,B,C,BA,BB,BC,G1,ag
     1,ind,TPATH,IX,R,NMAX,PI,TPI,THO,CZ1,ntor,KP,t,d1,tor(8),frac(8)
     1,ISRCE,ITYPE,X1(5,100),Y1(5,100),X(5,100),S11(100,5),NK(5),NUMK(5)
     1,KIND,NUM,NKK,nalb,ALB(10),ZW(10),CR,SR,CZ0,TTH,CR1,TMAx,IP(5),IS
      dimension temp(8,8)
  100 format(a4)
      READ(KF)zen,ntor,nalb,is,nmax,(tor(i),i=1,ntor),(alb(i),
     1i=1,nalb),((temp(i,j),j=1,nalb),i=1,ntor)
      READ(KF,100)ialpha
      do 2 l=1,ntor
      l2=l*4-2
      do 2 i=1,nalb
```

```
      2 READ(KF)(tdist(1,I2,k),k=1,50)
        SR=SIN(ZEN/57.295)/1.33
        CR=SQRT(1.-SR*SR)
        return
        end
        SUBROUTINE CNV(I3,D,IALPHA,ZEN)
C       THIS ROUTINE PERFORMS A CONVOLUTION OF THE SOURCE PULSE PROFILE
C       OVER THE IMPULSE RESPONSE FUNCTION.
C       THE INPUT PARAMETERS ARE AS FOLLOW:
C          I3        = INDEX OF THE TDIST ARRAY WHERE THE IMPULSE RESPONSE
C                        FUNCTION IS STORED AND REPLACED
C          D         = DEPTH IN METERS
C       THE OUTPUT RESULT FOR THE CONVOLUTION IS PLACED IN THE TDIST
C       ARRAY IN THE I4 LOCATION. ALSO, WE COMPUTE:
C          B         = NUMBER OF CMS OF TRAVEL OF LIGHT PER BIN WIDTH
C          C         = NUMBER OF CMS OF TRAVEL OF LIGHT IN THE LEADING
C                        EDGE OF THE SOURCE PULSE
C        NOTE: TWID IS THE FULL WIDTH OF THE SOURCE PULSE IN NANOSECONDS
C       AND CC IS THE VELOCITY OF LIGHT IN WATER IN CMS/NANOSECOND
        COMMON/BLK1/CIN(6),TSAMP(8 ,32,3),TDIST(8 ,32,50),stepr,RAD,IARC
       1,TSCALE(10),RSAMP(8 ,32,8),RDIST(8 ,32,100),G,A,B,C,BA,BB,BC,G1,ag
       1,ind,TPATH,IX,R,NMAX,PI,TPI,THO,CZ1,ntor,KP,t,d1,tor(8),frac(8)
       1,ISRCE,ITYPE,X1(5,100),Y1(5,100),X(5,100),S11(100,5),NK(5),NUMK(5)
       1,KIND,NUM,NKK,nalb,ALB(10),ZW(10),CR,SR,CZO,TTH,CR1,TMAx,IP(5),IS
        DIMENSION TEMP(50,8)
        DATA TWID/14./,CC/22.5/
C       COMPUTE THE WIDTH OF THE IMPULSE RESPONSE FUNCTION IN NANOSECONDS
C       FOR THE GIVEN DEPTH
        DWID=A*D*5000./CC
        I0=I3/4+1
        I2=I3-1
        I1=I2-1
        I4=I3+1
C       COMPUTE THE NUMBER OF CMS OF TRAVEL OF LIGHT IN THE LEADING EDGE
C       OF THE SOURCE PULSE
        C=TWID*CC/2.
        IF(DWID.LE.TWID)GO TO 1
C       THE SOURCE PULSE IS NARROWER THAN THE IMPULSE RESPONSE, SO DUMP
C       THE IMPULSE RESPONSE FUNCTION INTO THE I2 ARRAY AND INTEGRATE THE
C       THE SOURCE PULSE INTO THE I1 ARRAY
C       B AND BB ARE THE BIN WIDTH IN CMS AND NANOSECONDS, RESPECTIVELY
        B=A*D*100.
        BB=B/CC
C       COMPUTE THE NUMBER OF BINS FOR WHICH THE SOURCE PULSE IS NON-ZERO
        NN=1+INT(TWID/BB)
        DO 2 I=1,NALB
        DO 2 K=1,50
        TDIST(I,I1,K)=0.
      2 TEMP(K,I)=TDIST(I,I2,K)
C       CONSTRUCT THE SOURCE PULSE FUNCTION
      8 TT=0.5*TWID
C       COMPUTE THE INTEGRAL OF THE SOURCE PULSE ASSUMING UNIT PEAK
        TINT=TT*TT
        I=1
        SLINT=0.
        DO 4 K=1,NN
        T=BB*FLOAT(K)
C       THE NEXT 4 STATEMENTS COMPUTE THE INTEGRATED SOURCE PULSE
C       PRIOR TO TIME, T, ASSUMING THAT THE PEAK RATE IS UNITY.
C       FOR A DIFFERENT SOURCE SHAPE, THEY MUST BE REPLACED.
```

```
      SINT=T*T/2.
      IF(T.LE.TT)GO TO 5
      SINT=TINT-0.5*(TWID-T)**2
      IF(K.EQ.NN)SINT=TINT
    5 TDIST(I,I1,K)=(SINT-SLINT)/TINT
    4 SLINT=SINT
      IF(NALB.EQ.1)GO TO 6
      DO 7 I=2,NALB
      DO 7 K=1,NN
    7 TDIST(I,I1,K)=TDIST(1,I1,K)
      GO TO 6
C     THE SOURCE PULSE IS BROADER THAN THE IMPULSE RESPONSE FUNCTION
    1 BB=TWID/50.
      DT=DWID/50.
      B=BB*CC
C     SAMPLE THE IMPULSE RESPONSE FUNCTION IN THE FIRST NN BINS
      NN=INT(DWID/BB)
      TT=DT
      K=1
      F=1.
      DO 9 L=1,NN
      KK=1
      T=BB*FLOAT(L)
   10 DO 11 I=1,NALB
      IF(KK.GT.1)TEMP(L,I)=TEMP(L,I)+F*TDIST(I,I2,K)
      IF(KK.EQ.1)TEMP(L,I)=F*TDIST(I,I2,K)
   11 CONTINUE
      IF(TT.LT.T)GO TO 12
      F=1.-F
      GO TO 9
   12 K=K+1
      KK=KK+1
      IF(K.EQ.50)GO TO 9
      F=1.
      TT=TT+DT
      IF(TT.LE.T)GO TO 10
      F=F+(T-TT)/DT
      GO TO 10
    9 CONTINUE
      IF(NN.GE.50)GO TO 8
      NM=NN+1
C     FILL OUT THE IRF ASSUMING AN EXPONENTIAL DECAY
      DO 13 I=1,NALB
      RATIO=TEMP(NN-3,I)/TEMP(NN-1,I)
      RATIO=SQRT(RATIO)
      TEMP(NN,I)=TEMP(NN-1,I)/RATIO
       DO 13 K=NM,50
   13 TEMP(K,I)=TEMP(K-1,I)/RATIO
C     PERFORM THE CONVOLUTION ON THE I1 AND I2 ELEMENTS
      NN=50
      GO TO 8
    6 DO 14 I=1,NALB
      DO 15 M=1,50
      TDIST(I,I3,M)=0.
      DO 15 LM=1,M
   15 TDIST(I,I3,M)=TDIST(I,I3,M)+TEMP(LM,I)*TDIST(I,I1,1+M-LM)
   14 CONTINUE
      RETURN
  100 FORMAT(' IMPULSE RESPONSE',(/' ',10E11.4))
  101 FORMAT(' SOURCE',(/' ',10E11.4))
```

```
      102 FORMAT('OERF FOR ',A4,' WATER',4X,
         1'ALPHA*D=',F6.2,4X,'ALBEDO=',F6.2,4X,'ZEN(DEG)=',F6.2,'   D(M)=',
         2F6.2,'   TBIN(NS)=',F7.4/(' ',10E11.4))
          END
```

FIGURE C1. LOGIC FLOW DIAGRAM FOR PROGRAM "SMPD"

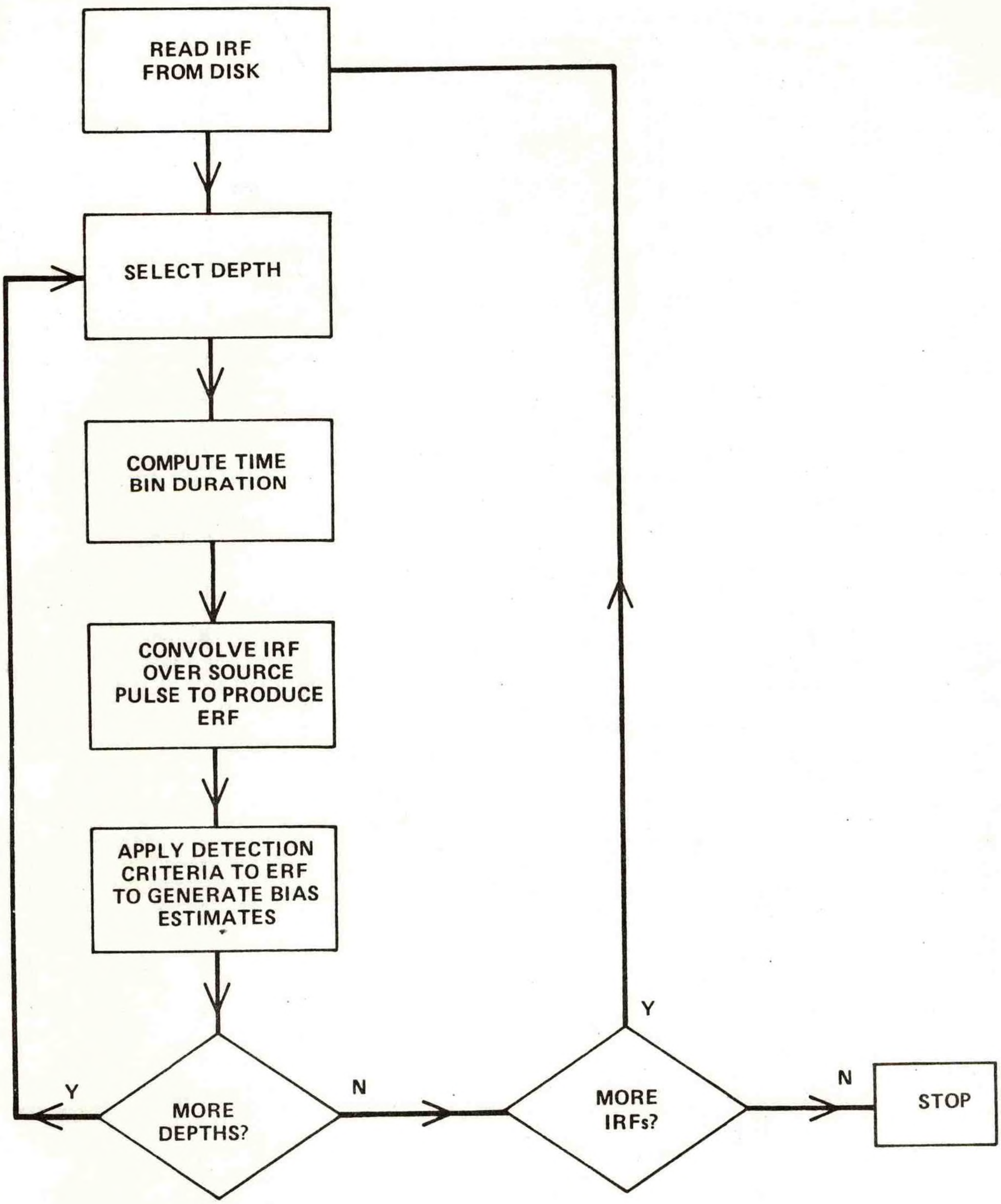


FIGURE C2. ILLUSTRATION OF PROCEDURE TO GENERATE ENVIRONMENTAL RESPONSE FUNCTION

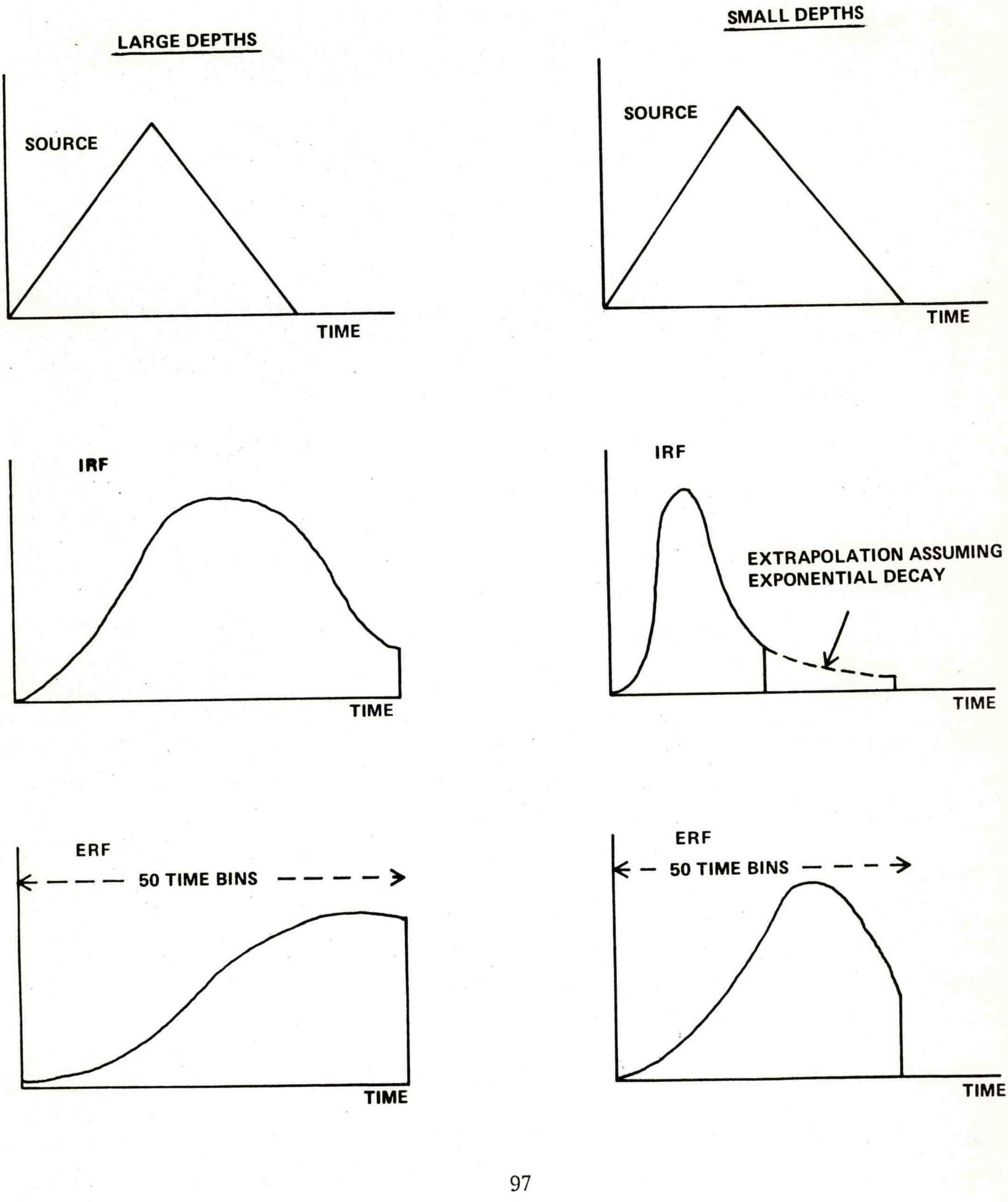
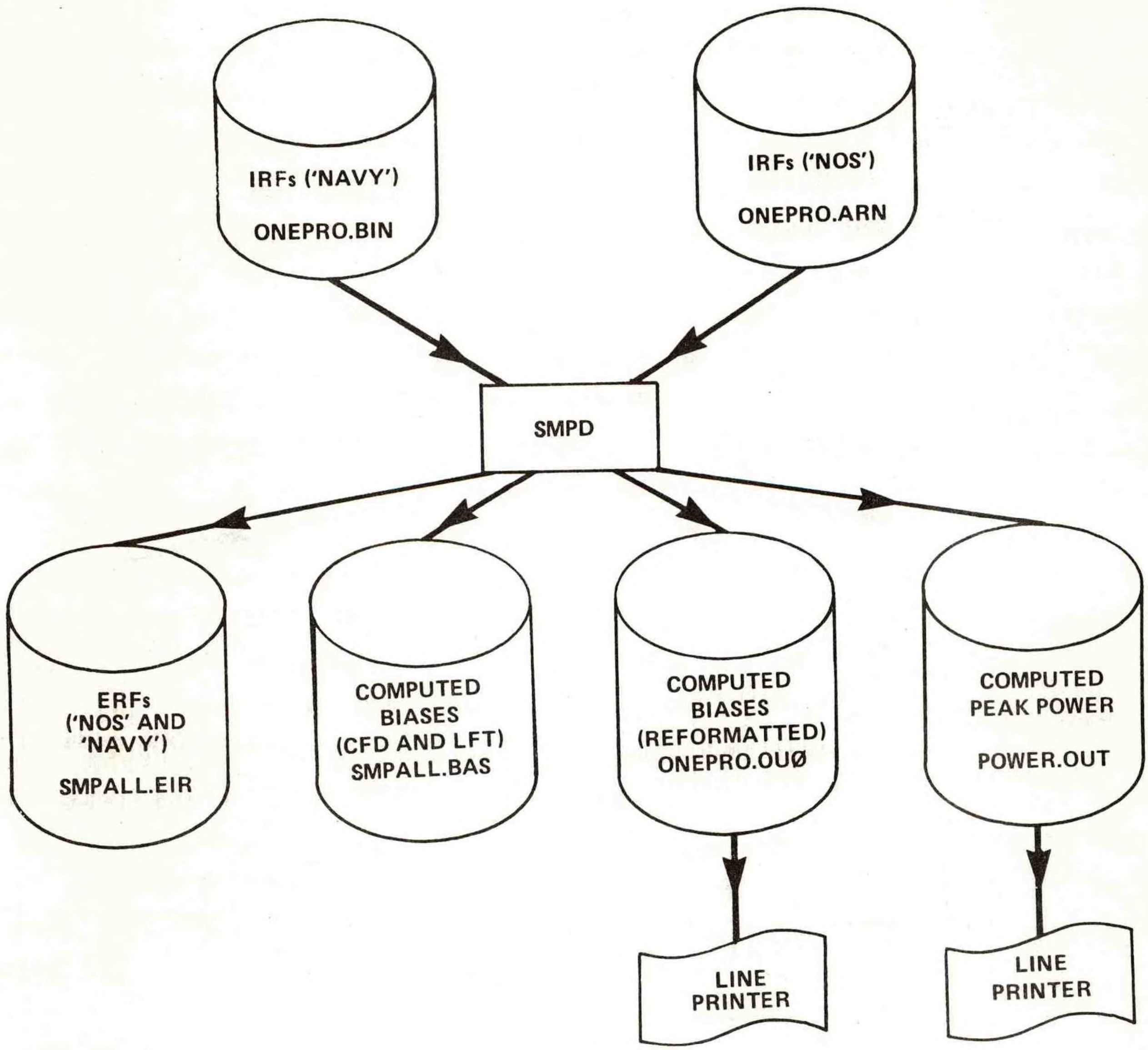


FIGURE C3. DATA FLOW DIAGRAM FOR PROGRAM "SMPD"




IRF = IMPULSE RESPONSE FUNCTION (DEPTH NORMALIZED)
ERF = ENVIRONMENTAL RESPONSE FUNCTION
CFD = CONSTANT FRACTION DISCRIMINATOR
LFT = LINEAR FRACTIONAL THRESHOLD

# Appendix D

## Data Quality Indicators

## APPENDIX D
## DATA QUALITY INDICATORS

The determination of depth measurements from airborne lidar return waveforms is conceptually simple: measure the time between the surface return an the bottom return and, knowing the nadir angle and the speed of light in water, calculate the depth. Measuring the time between the surface and bottom returns from a noisey waveform to sufficient accuracy is the problem. Lidar bathymetry returns are typically long compared to the accuracy requirment, and carefully selected sophisticated data processing procedures are required to obtain acceptable results. This cannot be significantly altered by going to a shorter laser source pulse width because the impulse response function of the water column (which can be quite long depending on depth, nadir angle, and optical properties) will then dominate.

Each particular hardware configuration will have its own inherent data processing requirements and problems, but a set of basic generic procedures is outlined here, and examples of data quality edits are specified. These procedures involve transformations on the raw waveforms, pulse identification and location, and a number of quality checks which, if failed, will result in the flagging or editing of the results out of the data base. Ultimate data quality depends first on the hardware; no amount of processing can salvage accurate depth measurements from a poorly designed or improperly operated system. The quality of the data from the hardware will determine the extent to which the various procedures need to be applied.

The processor must be very intelligent; indeed, it must emulate the thought processes of a trained data technician. It must be able to recognize a number of possible fatal flaws, and it must be able to make judgements based on non-parametric statistics and correlations from multiple inputs.

The following procedures are listed exactly in the order in which they would be applied. Notation: in the following text, the symbols a, b, and n are considered to be selectable constants. SS means signal strength; an added S means surface, and B means bottom. The standard deviation about a mean value $\mu$ is denoted as $\sigma$. "A" stands for altitude and D for depth.

1. Edit on lack of sufficient data;

e.g., lost or unacceptable values for position, aircraft attitude, scanner azimuth, etc.

2 Edit on fault indicators;

e.g., laser misfire, excessive roll or pitch, etc.

3. Preliminary waveform processing:

Non-linear transforms;
e.g., exponentiate a previously logged signal.
Special system-dependent noise suppression techniques;
e.g., removal of false pulses, deep-water subtraction ala AOL, etc.
Low-pass filter smoothing;
various weighting functions possible.

4. Pulse detection/identification:

Tracking algorithm with selectable width, number of consecutive "misses", and expanding search strategy;

Pulse identification logic such as stongest pulse or last pulse above a threshold;

Pulse shape or shape criteria for recognition;

Protocol for handling inflections such as differencing or deconvolution;

5. Single waveform properties:

Utilize widths or shapes to identify problems such as interface vs. volume return at surface or a merged surface/bottom return in shallow water;

Examine minimum and maximum SSS and SSB for acceptibility;

Cull out "strange" returns.

6. Edits on pulse properties compared to neighbors;

   e.g., edit pulses with SSB differing from an n-point running mean by more than $a + b\sigma$ or $a + b\sqrt{\mu}$, etc.

7. Edits on ancillary data;

   e.g., altimeter data corrected for scanner effects differing from an n-point running mean by more than some $\Delta A_{max}$.

8. Depth determining algorithm:

   digital or analog;
   linear or non-linear;

   fixed threshold, linear fractional threshold (threshold fraction), peak detector, centroid detector, correlation detector, or CFD detector;

   Separate techniques may be used for surface and bottom as long as a corresponding algorithm bias corrector relationship is known.

9. Wave correction:

   variable data span used for determination of surface plane

10. Edits on determined depths compared to neighbors;

    e.g., depths differing from the mean, $\mu$, of an n-point running average by more than $a + b\sigma$; or

    a block of data with the standard deviation exceeding some predetermined value.

11. Edits on combinations of factors:

e.g., edit if $\Delta D > a$ <u>and</u> $\Delta A > b$ or if sign ( $\Delta A$) = sign ( $\Delta D$).

12. Filters on determined depths;

e.g., HALS griding.

13. Overlapped data cross checks;

e.g., edit if $\Delta D > a$ and $\Delta$ position < b.

This is a shopping list of typical procedures many of which were used successfuly with AOL data. Data processing software must be designed to be flexible enough to permit the development of these kinds of interactions with the data during the shakedown flights.

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