ACIX

Atmospheric **C**orrection

Inter-comparison e**X**ercise

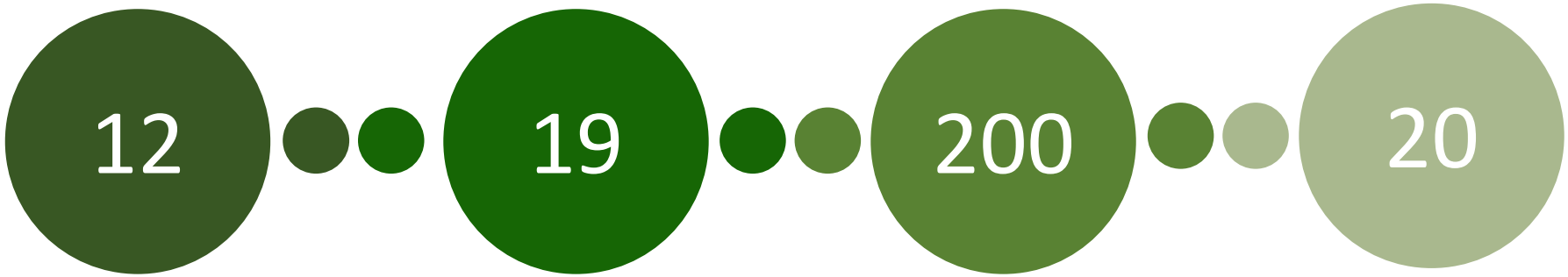
WHY?

Free and open access policy to **Sentinel-2** and **Landsat-8** imagery has stimulated the development and operational use of **AC processors** for generating Bottom-of-Atmosphere (BOA) products

The objective was to point out:

- **Strengths & Weaknesses**
- **Commonalities & Differences**

How?



Teams
from various Space Agencies, R&D Companies, Research Institutes and Universities

Study Sites
spread worldwide based on the AERONET stations

Image Scenes
processed acquired by Sentinel-2 and Landsat-8

Months
to complete the exercise and publish the results in a scientific journal

How?

Definition of the inter-comparison protocol

Coordinators & Participants
discussed all the major points and defined the inter-comparison procedure.

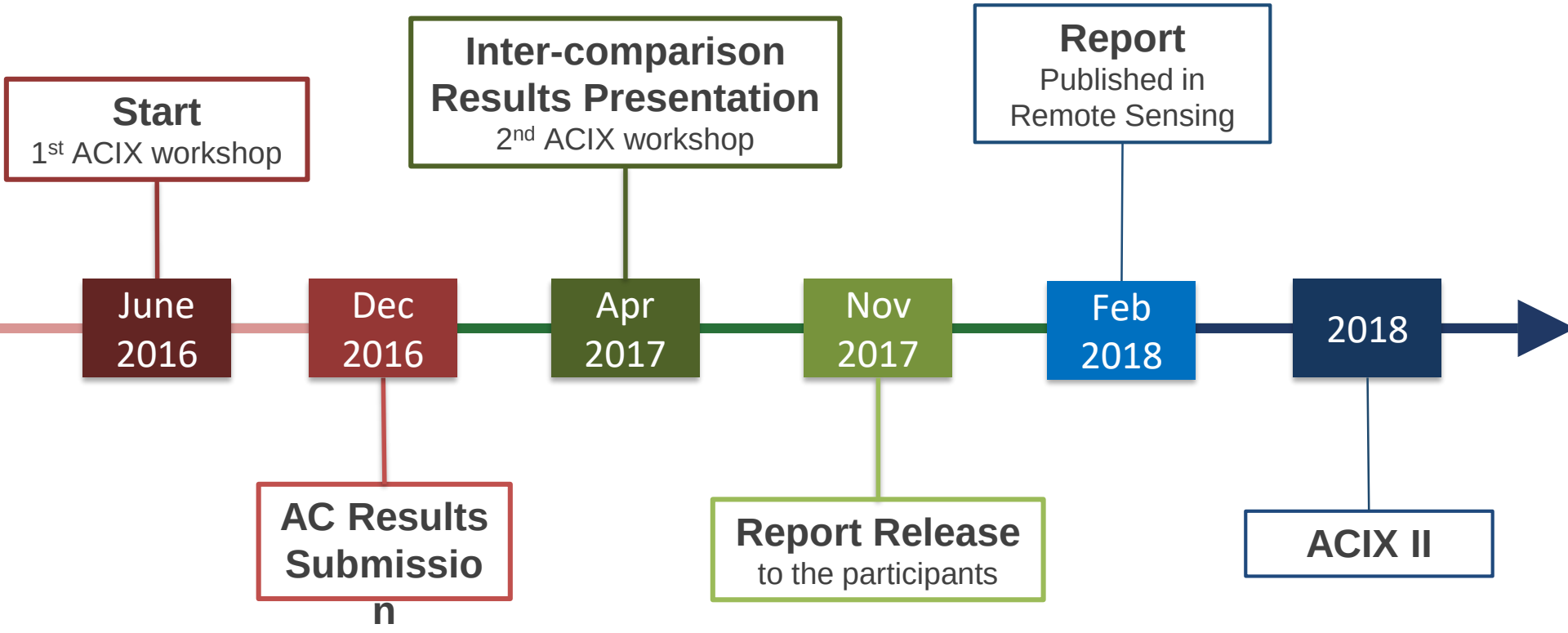
Application of the AC processors

Participants
applied their AC schemes on a set of test sites keeping the processing parameters constant. The results were submitted for analysis to ACIX coordinators.

Analysis of the results

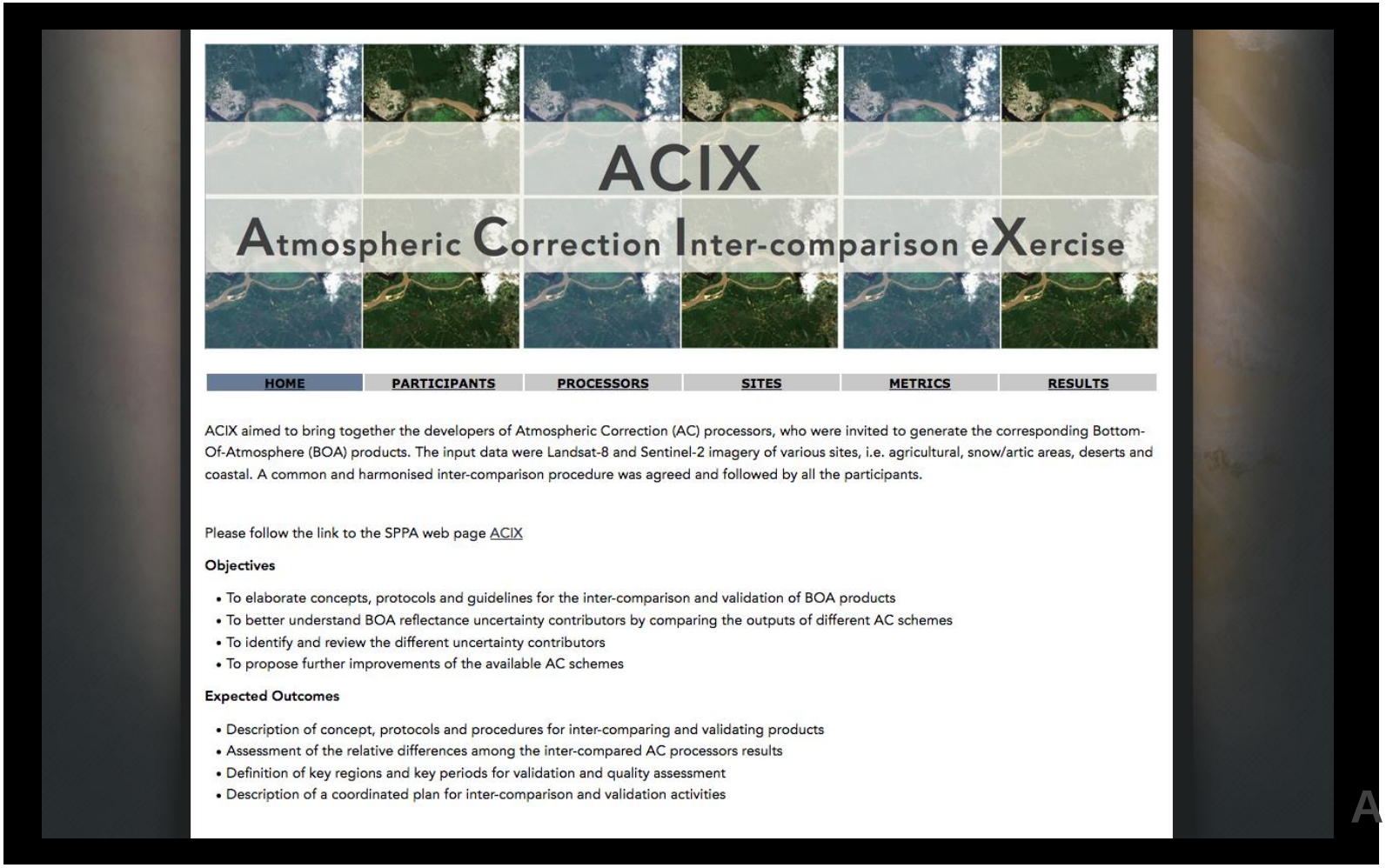
Coordinators
processed the AC results and assessed the inter-comparison metrics. The results presented and discussed with the participants.

When?


Start
1st ACIX workshop
Inter-comparison Results Presentation
2nd ACIX workshop
Report
Published in Remote Sensing
June 2016
Dec 2016
Apr 2017
Nov 2017
Feb 2018
2018
AC Results Submissio n
Report Release
to the participants
ACIX II

RESULTS PUBLICATION

http://calvalportal.ceos.org/projects/acix



RESULTS PUBLICATION

https://www.mdpi.com/2072-4292/10/2/352

remote sensing

MDPI

Article

Atmospheric Correction Inter-Comparison Exercise

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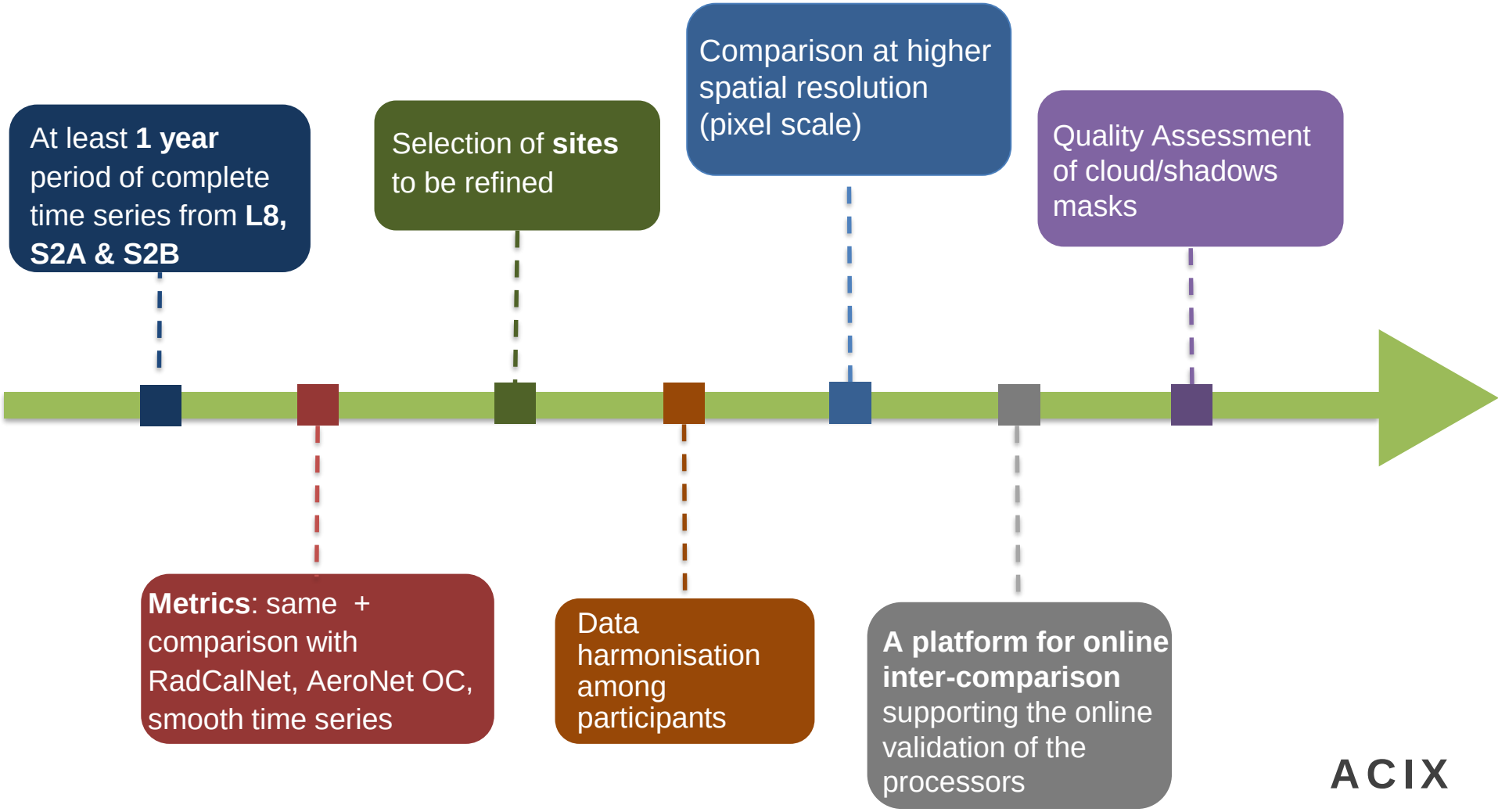
Abstract: The Atmospheric Correction Inter-comparison eXercise (ACIX) is an international initiative with the aim to analyse the Surface Reflectance (SR) products of various state-of-the-art atmospheric correction (AC) processors. The Aerosol Optical Thickness (AOT) and Water Vapour (WV) are also examined in ACIX as additional outputs of AC processing. In this paper, the general ACIX framework is discussed; special mention is made of the motivation to initiate the experiment, the inter-comparison protocol, and the principal results. ACIX is free and open and every developer was welcome to participate. Eventually, 12 participants applied their approaches to various Landsat-8 and Sentinel-2 image datasets acquired over sites around the world. The current results diverge depending on the sensors, products, and sites, indicating their strengths and weaknesses. Indeed, this first implementation of processor inter-comparison was proven to be a good lesson for the developers to learn the advantages and limitations of their approaches. Various algorithm improvements are expected, if not already implemented, and the enhanced performances are yet to be assessed in future ACIX experiments.

Doxani, G.; Vermote, E.; Roger, J.-C.; Gascon, F.; Adriaensen, S.; Frantz, D.; Hagolle, O.; Hollstein, A.; Kirches, G.; Li, F.; Louis, J.; Mangin, A.; Pahlevan, N.; Pflug, B.; Vanhellemont, Q. Atmospheric Correction Inter-Comparison Exercise. *Remote Sens*. **2018**, 10, 352

Way Forward



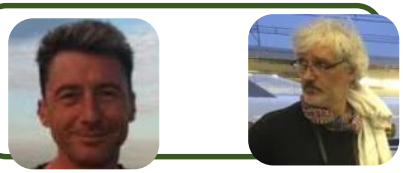
ACIX

WAY FORWARD

ACIX II

CMIX

Ferran Gascon Georgia Doxani



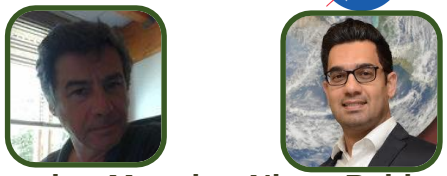
Eric Vermote Jean-Claude Roger

Atmospheric Correction Inter-comparison

Processors over LAND

Processors over WATER

Task Co-ordinators



Antoine Mangin Nima Pahlevan

Cloud Masking Inter-comparison

Task Co-ordinators

Carsten Brockmann

Sergii Skakun

How?

Definition of the inter-comparison protocol

Coordinators & Participants
discussed all the major points and defined the inter-comparison procedure.

Application of the AC processors

Participants
are applying their AC schemes on a set of test sites keeping the processing parameters constant. The results will be submitted for analysis to ACIX coordinators.

Analysis of the results

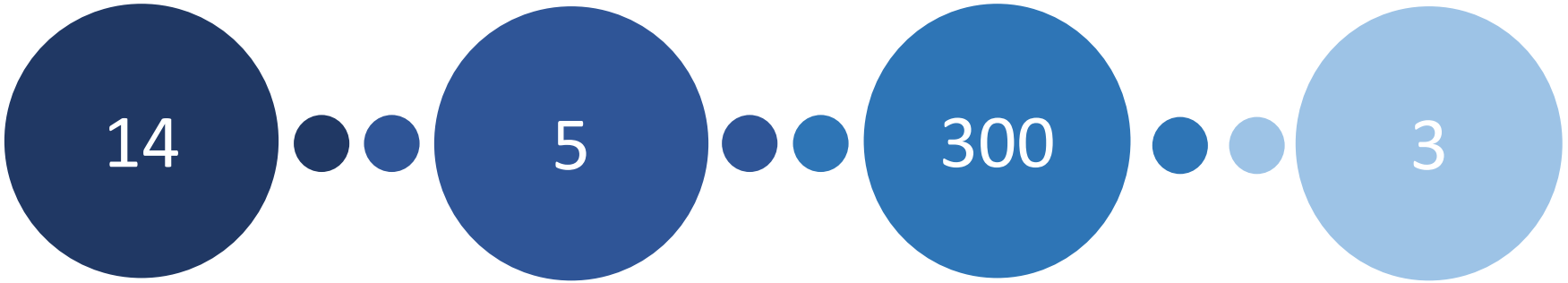
Coordinators
will process the AC results and assess the inter-comparison metrics. The results will be presented and discussed with the participants.


CMIX

ACIX-
Land

ACIX-Aqua

How?



Teams
from various Space Agencies, R&D Companies, Research Institutes and Universities

Validation Datasets
L8Biome (USGS), S2 Hollstein, S2/L8 PixBox, GSFC: LC8/S2A/S2B, CESBIO

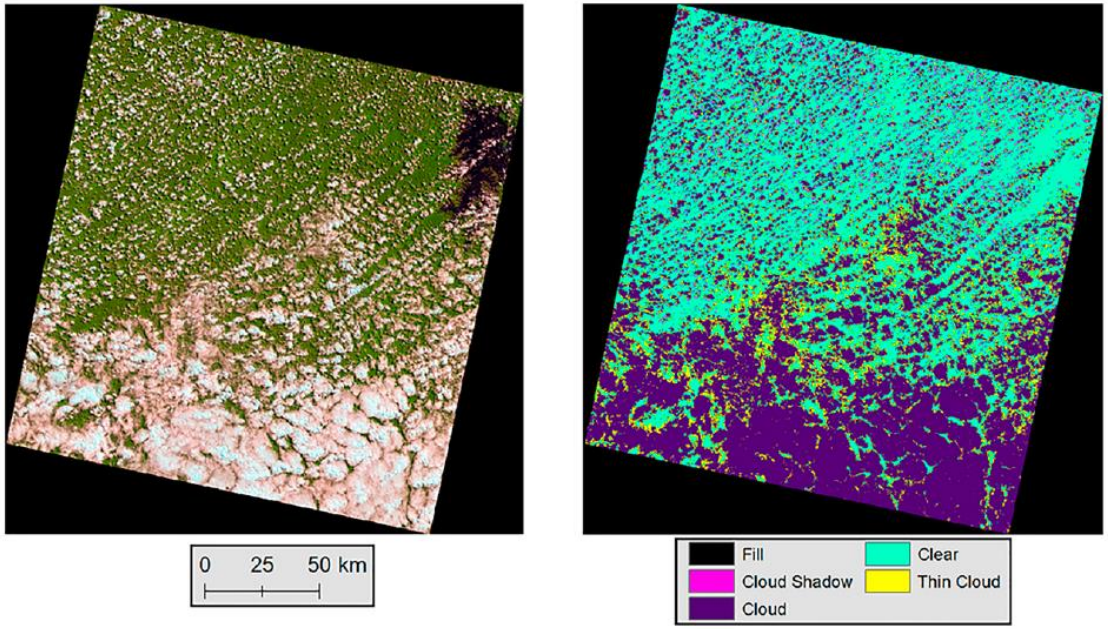
Image Scenes
to be processed acquired by Sentinel-2A, -2B and Landsat-8

Months
for the participants to submit their results

How?

L8Biome (Foga et al. 2016)

- 96 LC8 scenes, semi-random sampling with Biome stratification
- Photo-interpretation with See5.0
- All pixels are labelled (clear, cloud, cloud shadow, thin cloud).



How?

S2 (Hollstein et al. 2016)

- 108 Sentinel-2 scenes
- Photointerpretation
- Selected polygons are labeled manually
- Classes: *clear sky, cloud, cloud shadow, cirrus, water, snow*

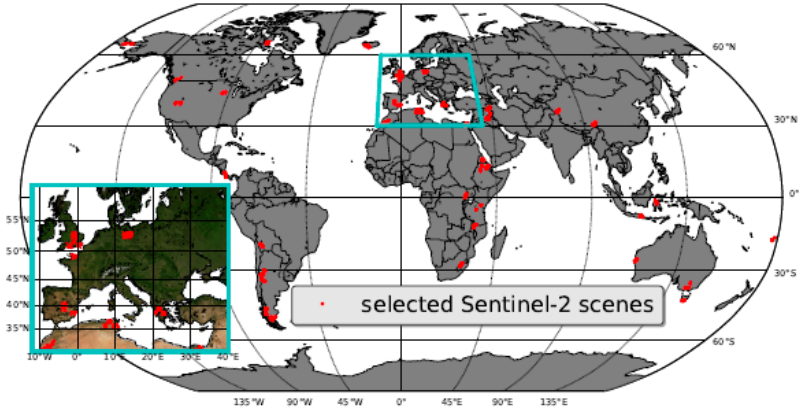
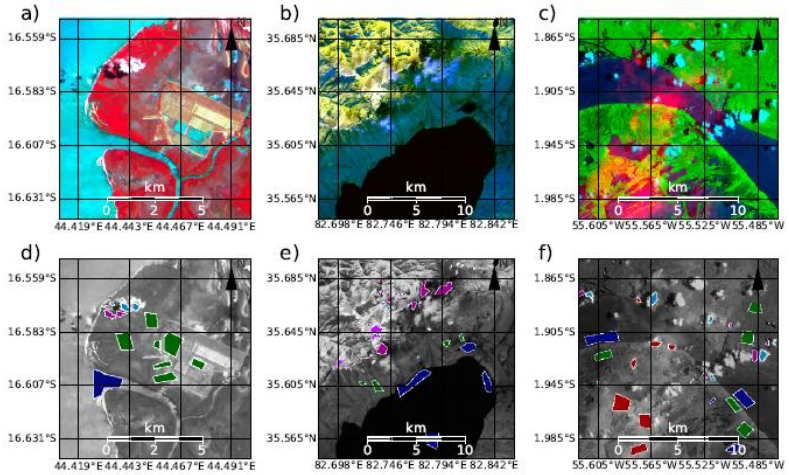


Figure 2. Global distribution of selected Sentinel-2 scenes which are included in the database.



How?

S2/L8: PixBox data set

Database to store manually classified pixels.

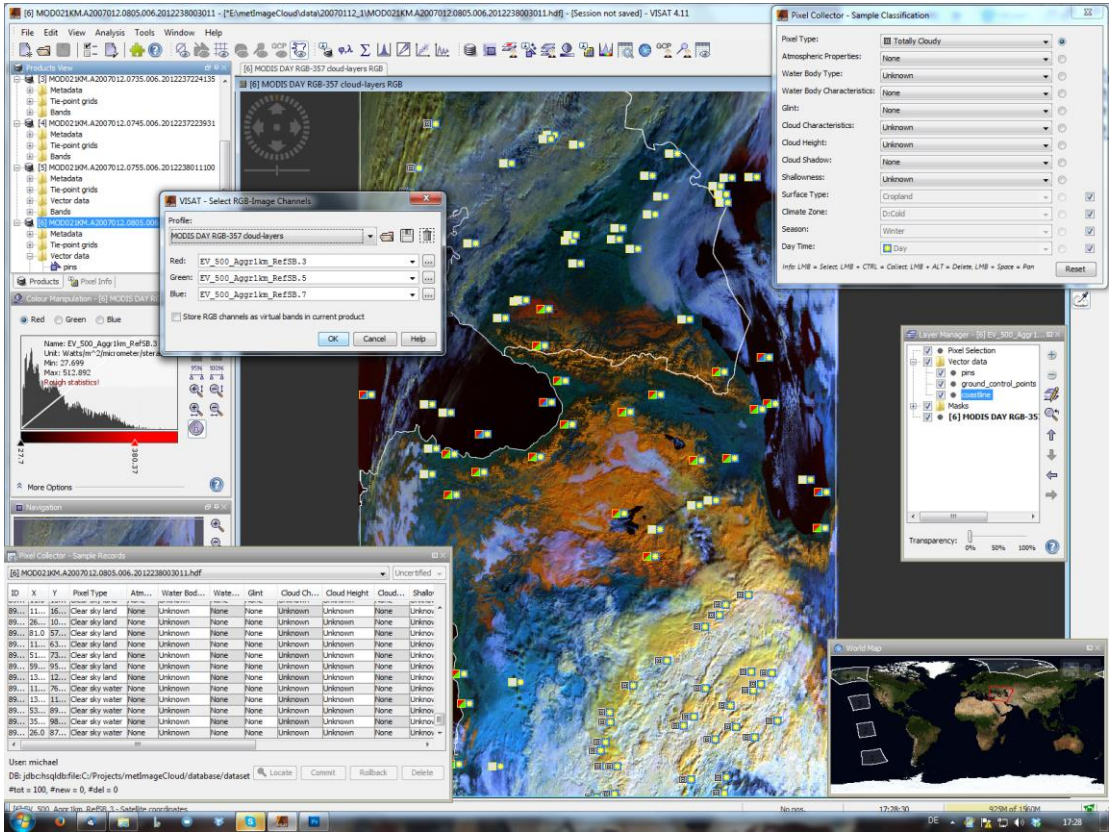
Pixel collection supported by dedicated SNAP tool.

S2 collection:

29 products

L8 collection:

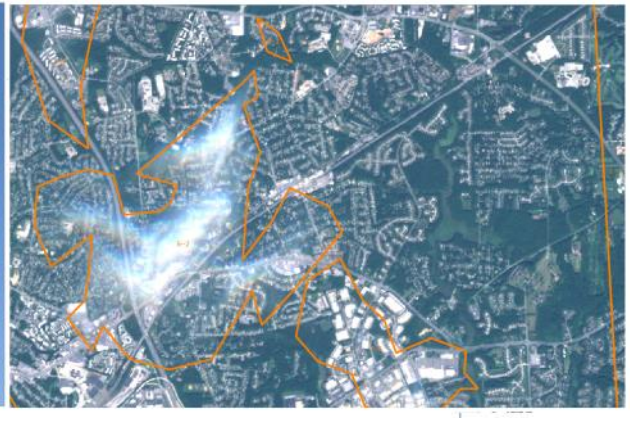
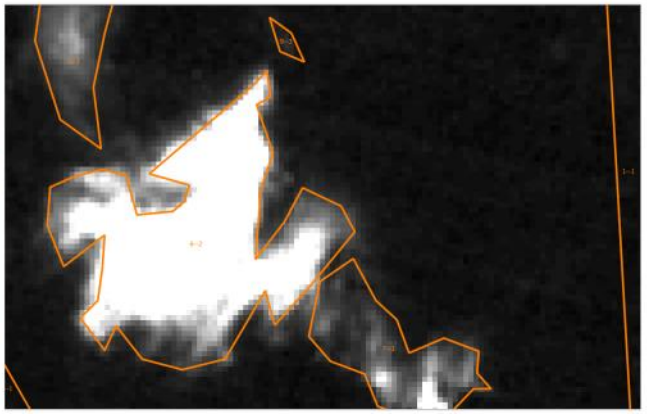
11 products



How?

GSFC: LC8/S2A/S2B

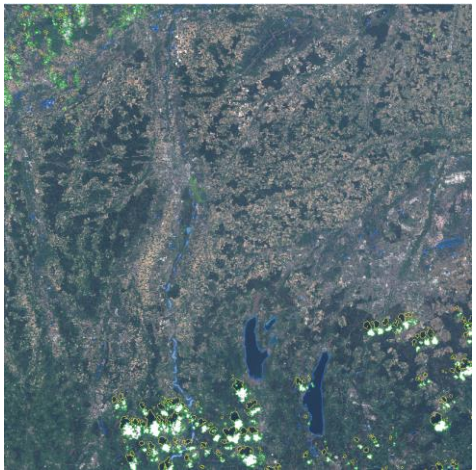
- Around 25 scenes labelled.
- Manually labeled polygons assisted by ground photos of sky.
- The same area over GSFC (also Aeronet measurements available), but varying conditions and time period.

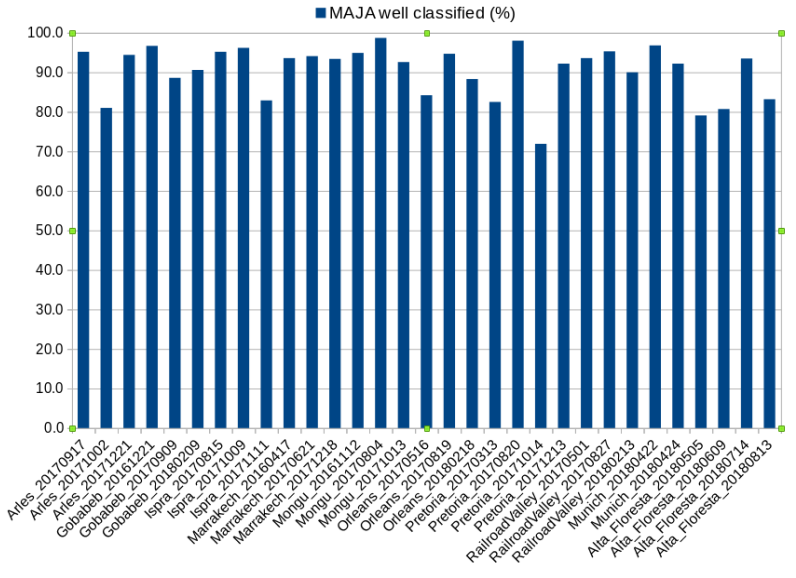




How?

CESBIO

- 31 fully classified images using active learning method (Active Learning for Cloud Detection)
  - Manually supervised and iterative
  - Manual reference points added where first iterations not satisfying
  - Valid/Invalid pixels (an invisible cloud except in cirrus band is valid)
- Data and software are available, can be used to generate reference for ACIX-2 scenes
  - Would save processing for users
  - <2 hours of work per image





How?

IDEALLY

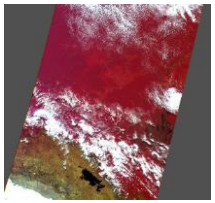
we would get a physical measure like cloud optical thickness or “impact on reflectance“, spectrally resolved

REALISTICALLY

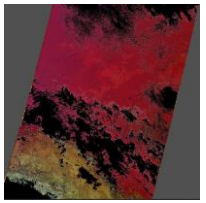
we follow the ‘traditional‘ approach: CM as an absolute indication on cloudiness

Binary mask for different levels of cloudy/ clear:
proposed classes: Clear, Cloud, Cloud shadows, Thin/(semi)-transparent

RGB



Cloud Mask

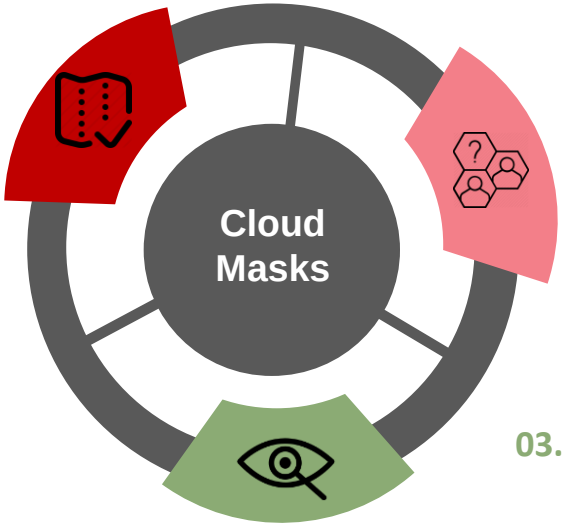


How?

01. Per pixel validation

Confusion matrix & OA, PA, UA

Class	Clear	Cloud	Cloud Shadow	Thin/(semi)-transparent	Row Total	UA
Clear						
Cloud						
Cloud Shadow						
Thin/(semi)-transparent						
Column Total						
PA						OA



02. Per object validation

Oversegmentation, undersegmentation, edge-location, fragmentation and shape

03. Visual inspection

potentially study an impact on SR, especially with transparent/cirrus clouds

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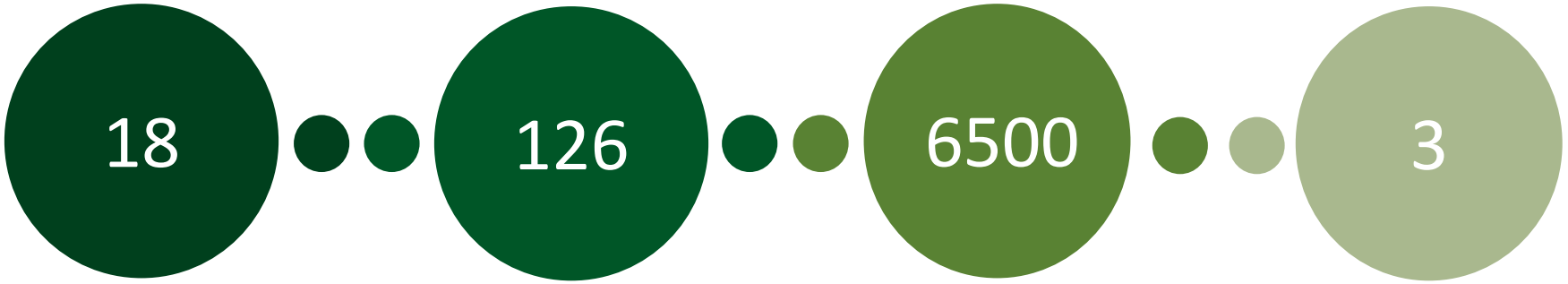
ACIX-Aqua

How?



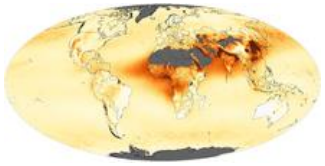
Teams
from various Space Agencies, R&D Companies, Research Institutes and Universities

Study Sites
spread globally based on the AERONET stations (location & measurements availability)

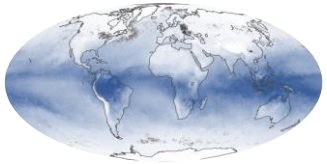
Image Scenes
to be processed acquired by Sentinel-2A, -2B and Landsat-8

Months
for the participants to submit their results

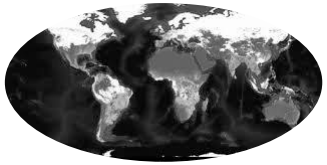
WHAT?



Aerosol Optical Thickness



Water Vapour



Surface Reflectance

How?

Estimated AOT(/WV) vs AERONET measurements

Estimated AOT (/WV) & compared to Level 1.5 (cloud screened) AERONET data

1. Interpolate AERONET values @ λ=550 nm using Angstrom Exponent
2. Average AERONET values over time period within ±15 min from AOT retrieved values (L-8/S-2A, -2B overpass)
3. Average AOT values over an image subset of 9 km x 9 km centred on the AERONET Sunphotometer station

Statistics and Plots

No. of samples

R^2 (Coefficient variation)

r (Pearson's correlation coef.)

A (Accuracy)

P (Precision)

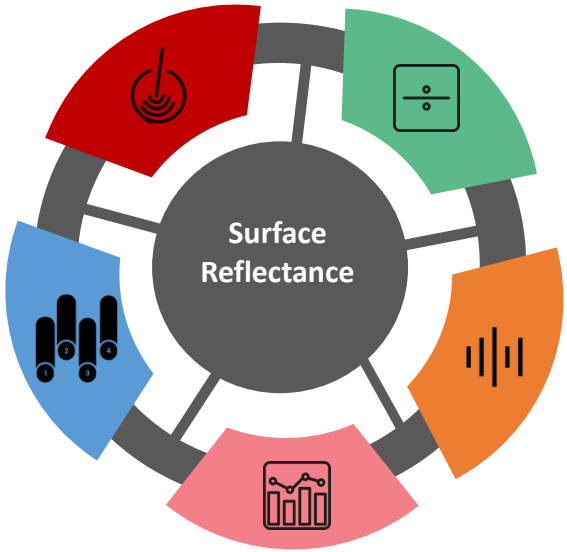
U (Uncertainty)

Max AOT_{550} difference

How?

01. Ground based validation

- **RadCalNet** [La Crau (France), Gobabeb (Namibia)], SR are provided by CNES in the same angular conditions as L-8, S-2A & -2B
- **DLR campaign measurements** from Lake Stechlin (Germany) at 4th May 2018



02. Indices

NDVI, NDWI and EVI based on the SR products. Similar directional effects are in the visible and near infrared bands, and therefore by estimating their ratio the effect is reduced.

03. Noise Estimation

Assuming that there is a linear SR variation between two consecutive acquisition days; for three successive observations the statistical difference between, the center measurement and the linear interpolation between the two extremes quantifies the "noise" :

$$Noise(y) = \sqrt{\frac{\sum_{i=1}^{n-2}\left(y_{i+1} - \frac{y_{i+2}-y_i}{d_{i+2}-d_i}\,(d_{i+1}-d_i) - y_i\right)^2}{N-2}}$$

04. AERONET corrected data

AC data generated by 6S radiative transfer model using AERONET data. AOT, aerosol model and column water vapour will be derived from AERONET sunphotometer measurements and will be used in the radiative transfer model in order to perform the AC of TOA reflectance.

05. SR inter-comparison

Plotting the SR time series per date, band and AC approach.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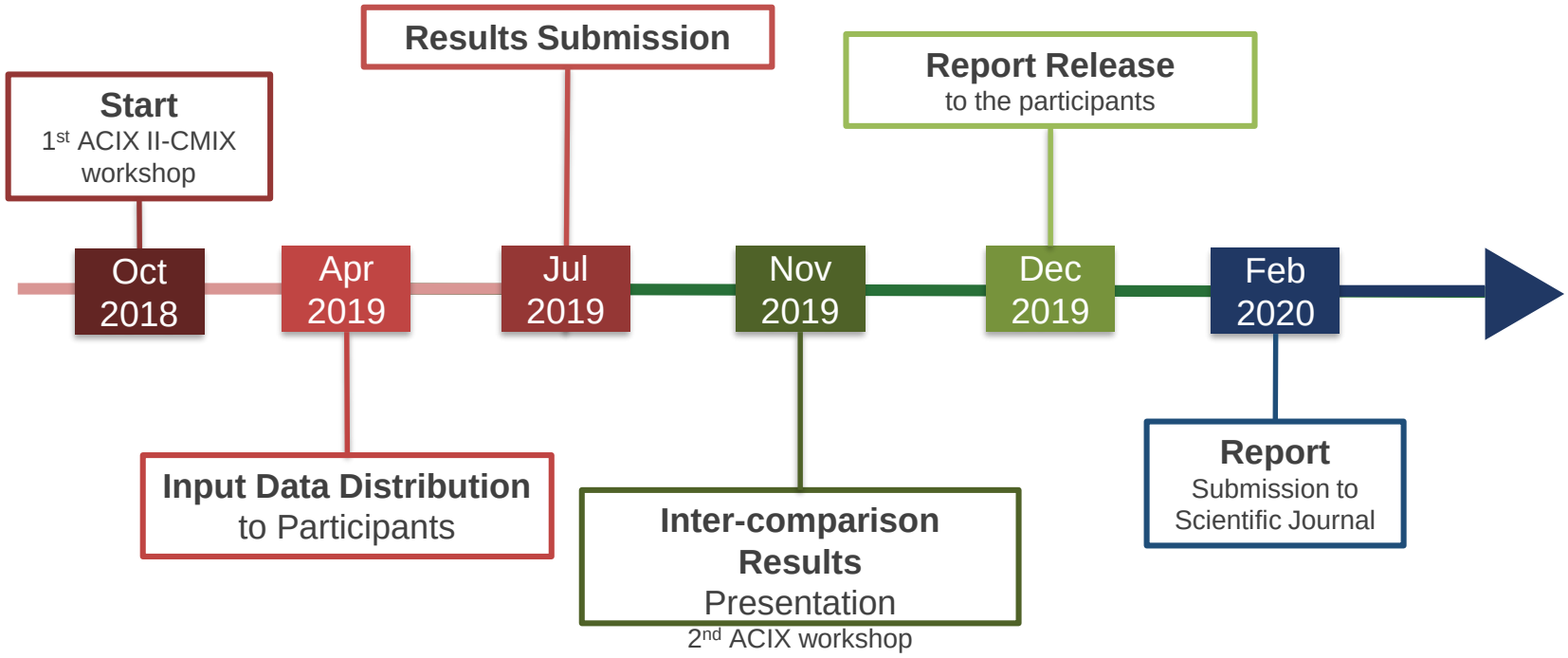
When?


Start
1st ACIX II-CMIX workshop
Results Submission
Report Release
to the participants
Oct 2018
Apr 2019
Jul 2019
Nov 2019
Dec 2019
Feb 2020
Input Data Distribution
to Participants
Inter-comparison Results
Presentation
2nd ACIX workshop
Report
Submission to Scientific Journal

CMIX

ACIX-
Land


ACIX-Aqua

How?

12

Teams
from various Space Agencies, R&D Companies, Research Institutes and Universities

15

In-situ data Providers
Together with
≅ 20 AERONET OC sites

4400

Image Scenes
to be processed acquired by Sentinel-2A, -2B and Landsat-8

3

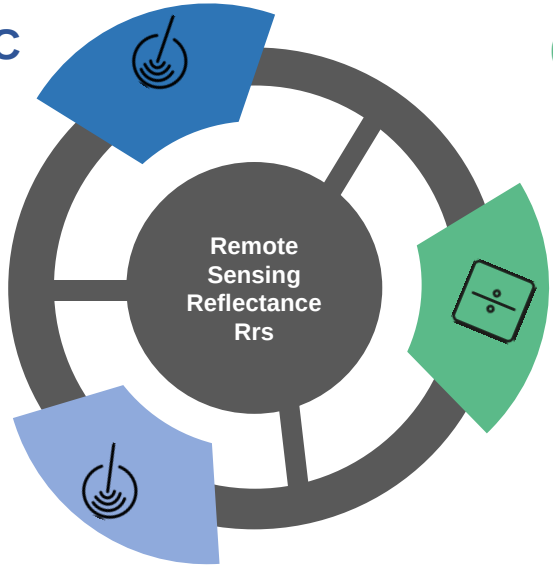
Months
for the coordinators to inter-compare the results

How?

01. Validation with AERONET-OC Rrs (Phase I)

Match-up Analyses (N ~ 1200)

- Time-diff threshold: +/1 hour
- Avoid adjacency effects due to the structure
- Band shifting/adjustment needed



02. Validation with field-based Rrs (Phase II)

Match-up Analyses (N ~ 3200)

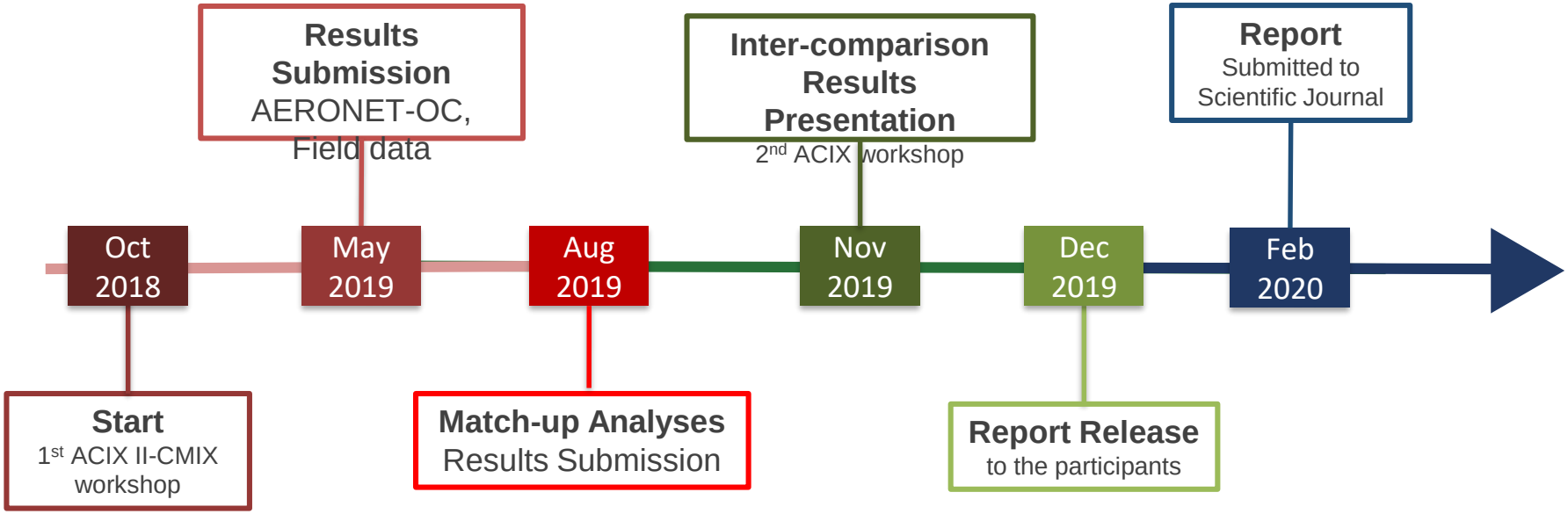
- Time-diff threshold: Variable
- Resample hyperspectral data

03. Performance metrics

- Measures for Rrs reported as a function of site characteristics (e.g., water types, solar zenith angles):
  Mean/Median percentage difference
  Mean/Median absolute difference
  RMSE / NRMSE, R^2, Linear regression, Accounting for negative retrievals
- Measures for Rrs: reported for a subset of high-fidelity in situ data, i.e., AERONET-OC, in-water field radiometric data within < +/-30min overpass, above-water radiometric data collected under clear skies within < +/-30min overpass
- and, the entire dataset (excluding suspicious data and/or outliers)

- Spider/Taylor diagram to report the overall performance of each processor

WHEN?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Thank you!

https://earth.esa.int/web/sppa/meetings-workshops/hosted-and-co-sponsored-meetings/acix-ii-cmix