ESSL Testbed

Operations Plan 2016

Version of 1 June 2016

6 – 10 June, 13 – 17 June, 27 June – 1 July, and 4 – 8 July 2016
ESSL Research and Training Centre
Wiener Neustadt, Austria

The ESSL Testbed 2016 is organized is supprted by

ZAMG Zentralanstalt für Meteorologie und Geodynamik

Deutscher Wetterdienst Wetter und Klima aus einer Hand DWD

Federal Office of Meteorology and Climatology MeteoSwiss

WIENER NEUSTADT

eumetcal

VAISALA

EUMETSAT

NIEDERÖSTERREICH HINEIN INS LEBEN.

Pieter Groenemeijer

with contributions from:

Thomas Hengstebeck
Paul James
Marco Arpagaus
Susanne Theis
Uli Blahak
Alois Holzer
Tomas Pucik

European Severe Storms Laboratory – Science and Training
Bräunlichgasse 6a / 6
2700 Wiener Neustadt, Austria

Tel: +49 151 59031839 or +43 2622 23622
Fax: +49 8153 965999911
e-mail: testbed@essl.org

Testbed website:

http://essl.org/testbed

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1 Introduction and goals

1.1 ESSL Testbed Concept

The ESSL Testbed evaluates tools to forecast and nowcast convective high-impact weather and provides forecaster training to meteorologists. Within the Testbed, occurrences of high-impact weather across Europe will be investigated during one or more annual test periods of a number of subsequent weeks. In 2015, the Testbed is in full operation during the weeks starting 6 June, 10 June, 27 June and 4 July.

The Testbed's concrete aims are...

1. to assess the ability of new diagnostic products based on satellite measurements, numerical weather prediction, radar and standard weather observations to correctly indentify (upcoming) severe weather events (e.g. via subjective and objective verification procedures).
2. to obtain feedback from forecasters regarding these products, both with respect to their performance and to operational needs and constraints. This feedback helps the product developers to refine and optimize them, thereby accelerating their successful operational deployment.
3. to familiarize the forecasters of the European National (Hydro-)meteorological Services with the best use of the new products.
4. to enhance the forecasters' overall skills in forecasting of convective high-impact weather, by providing training by internationally known forecasting experts who teach scientifically-motivated forecasting techniques. The training is performed through remote learning in cooperation with EUMETCAL and "hands on" at the ESSL Training Centre.

An overall aim in the Testbed is to ***stimulate interaction between and among developers and forecasters*** which benefits the forecasting and warning process at European National Meteorological Services. The participants therefore include the persons from the following groups:

- weather forecasters from forecasting agencies worldwide and especially from Europe's National (Hydro-)Meteorological Institutes
- researchers/developers from these agencies and from international organizations such as EUMETSAT
- renowned experts on forecasting techniques

The Testbed is loosely modelled after its US counterpart, the Hazardous Weather Testbed Spring Experiment, an annual programme in which several branches of the National Oceanographic and Atmospheric Administration (NOAA) cooperate, including the Storm Prediction Center (SPC) and the National Severe Storms Laboratory (NSSL).

1.2 Facilities

Fig 1. The ESSL Training Centre in Wiener Neustadt, Austria

The ESSL Testbed is located in the ESSL Training Center in Wiener Neustadt, a historical imperial city 45 km south of Vienna and 60 km southeast of the Vienna International Airport. The main train station of Wiener Neustadt with frequent trains to Vienna and other Central European Destinations is only 300 m away, thus within walking distance.

The Testbed Centre is housed on the first floor of an Art Deco Style house (Fig. 1) near the town center of Wiener Neustadt. The Testbed and briefing rooms are situated on 150 m² including the secretariat and break rooms.

2 Operations

2.1 Overview

The operations include the following three fundamental components:

1. **Forecasting**
2. **Verification**
3. **Evaluation**

Within the forecasting activities, participants operationally use the experimental forecast products to generate a forecast. After the period for which the forecast was valid has passed, they are verified against observations. Finally, the use of the experimental forecast products is evaluated. Below, these activities are described in more detail.

In addition, there are presentations by experts on a forecasting topic or developers of the nowcast and forecast products under evaluation.

Within each daily online session, remote participants will receive a briefing of the forecasting, verification and evaluation efforts and are asked to provide feedback and questions. Subsequently, the "lecture of the day" will be transmitted online.

The daily Testbed programme is shown in the Tables 2 and 3, below.

Programme on Mondays

On-site registration: 13:00 – 14:00 local time.

Time (local, UTC)		Activity	Description
14:00	1200	**Welcome Presentation**	Presentation of organizational and local matters. Introduction Round.
14:15	1215	**Introduction to the Testbed**	Presentation of the concept of the ESSL Testbed.
14:30	1230	**Introduction to forecasting**	Brief introduction to scientifc and ingredients-based forecasting. Concepts of moisture, instability and lift. Importance of wind shear to the storm type.
15:30	1330	Break	
15:45	1345	**Introduction to forecast products with hands-on exercise**	Introduction to the products used and evaluated during the Testbed and to the data interface.
18:30	1630	**Discussion**	Discussion of the exercise, questions about the products
19:00	1700	End	

Programme Tuesday – Friday*

Time (local, UTC)		Activity	Description
09:00	0845	**Verification**	Subjective verification of yesterday‘s experimental convective forecasts compared to ESWD severe weather reports, satellite and radar data. On Tuesday, verification session is skipped and programme starts with forecast operations.
09:20	0720	**Forecast operations**	The participants will be split into two groups, each dealing with a particular forecast period. Street Room: Day 1 forecast Experimental probabilistic convective forecast for the present day. Mountain Room: Day 2 forecast Experimental probabilistic convective forecast for day 2.
Part of programme with remote participation			
11:00	0900	**Weather briefing**	Discussion of the current weather and the forecasts that were made. Subjective evaluation with remote participants: summarizing new insights, preliminary findings, and issues needing further examination.
followed by		**Expert presentation**	Presentation on forecasting by developers of forecast tools or forecasting experts.
12:30		Lunch break	
14:00	1200	**Forecast tool evaluation**	Participants jointly discuss forecast tool performance, answer questions by their respective developers
followed by….		**Forecast operations**	Street Room: Nowcasting Short-range forecast and issuance of experimental watches for 2 hours at 13, 14 and 15 UTC. Mountain Room: Day 3 - 5 forecast Experimental probabilistic convective forecast for day 3 - 5. After the finished day 3 - 5 forecast the team can also switch to nowcast-mode. If the weather situation is unusually calm, the programme for both teams will be altered: Studies of past severe weather situations, or severe weather forecasting training by an expert.
1730	1530	end	End of forecast operations.

* On Friday the programme ends at 13:00 after a final weather briefing and product evaluation session. On-site participants are asked not to leave before 13:00, as this disturbs the programme. There is no expert presentation on Friday.

Experimental convective forecasts

On a daily basis, participants will prepare experimental forecasts for severe weather. These forecasts differ in time range, validity time period, domain, and quantities to be forecast. They range from Nowcasts, that have a validity time of two hours starting at the moment the forecasts issuance, to Day 5 forecasts, that deal with the weather occurring four days ahead. The forecasts will be issued using a program with which areas can designated in which a particular probability of severe weather or lightning is expected. In addition, a short(!) text to explain the motivation for the forecast should be given.

Type	**Deadlines (UTC)**	**Validity (UTC)**	**Forecast type** The percentages refer to the probability of one or more events within 40 km of a point	**Domain**
Nowcast	1300 (1500 CEST) 1400 (1600 CEST) 1500 (1700 CEST)	1300 – 1500 1400 – 1600 1500 – 1700	warning with indication of expected severe weather type	selected sub-domain
Day 1	0855 (1055 CEST)	0900 – 0600 (next day)	thunder 15 % thunder 50 % level 1 (> 5% severe) level 2 (> 15% severe) level 3 (> 15 % extreme)	selected sub-domain
Day 2	0800 (1000 CEST)	0600 (next day) – 0600 (day + 2)	thunder 15 % thunder 50 % level 1 (> 5% severe) level 2 (> 15% severe) level 3 (> 15 % extreme)	selected sub-domain
Day 3	0855 (1055 CEST), on Mondays: 1300 (1500 CEST)	0600 (day + 2) – 0600 (day + 3)	level 1 (> 5% severe) level 2 (> 15% severe) level 3 (> 15 % extreme)	Europe
Day 4		0600 (day + 3) – 0600 (day + 4)		Europe
Day 5		0600 (day + 4) – 0600 (day + 5)		Europe

Table 4. Forecasts at the testbed.

The forecasts are issued at fixed times and deal with a particular forecast domain. In the case of the Day 3, Day 4, and Day 5 forecasts, the domain is Europe, whereas the Nowcasts and Day1 and Day 2 forecasts are issued for a sub-domain that is decided based on the pre-conceived likelihood of severe weather occurring within that sub-domain. The subdomains can be seen in Figure 2. An example of a forecast is given in Fig. 3.

Many of the predictands of the various forecasts relate to the probabilities of severe weather and extreme weather, which for the ESSL Testbed are defined as in Table 5.

Severe weather	**Extremely severe weather**
• hail 2.0 cm or larger in diameter • wind gusts 25 m/s or higher • any tornado • rainfall causing significant damage	• hail with 5.0 cm diameter or larger • wind gusts 32 m/s or higher • tornado F2 or higher
The quantities to be forecast in the Day 1-5 forecasts are the probabilities that lightning / severe / extreme weather occurs within a radius of 40 km of any given point.	

Table 5. ESSL Testbed criteria for severe weather.

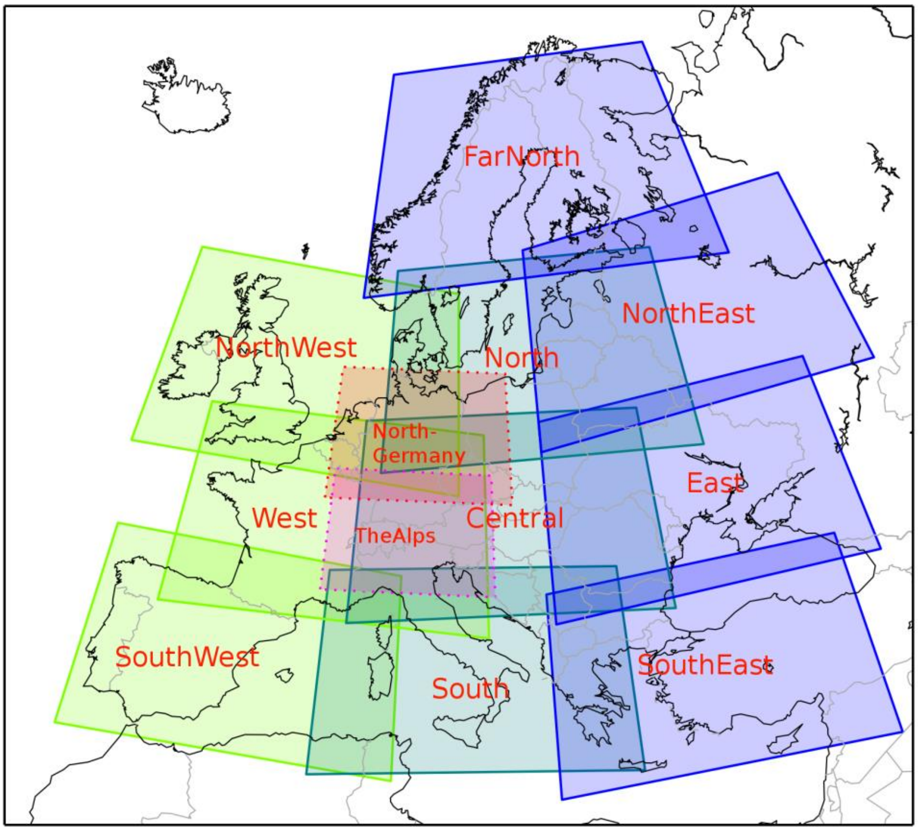


Fig. 2. The full ESSL Testbed domain (EU) and subdomains for which forecasts are to be made. The domains

NorthGermany and Alps are to display COSMO and DWD nowcast products in detail; no forecasts or nowcasts are to be made for those domains.

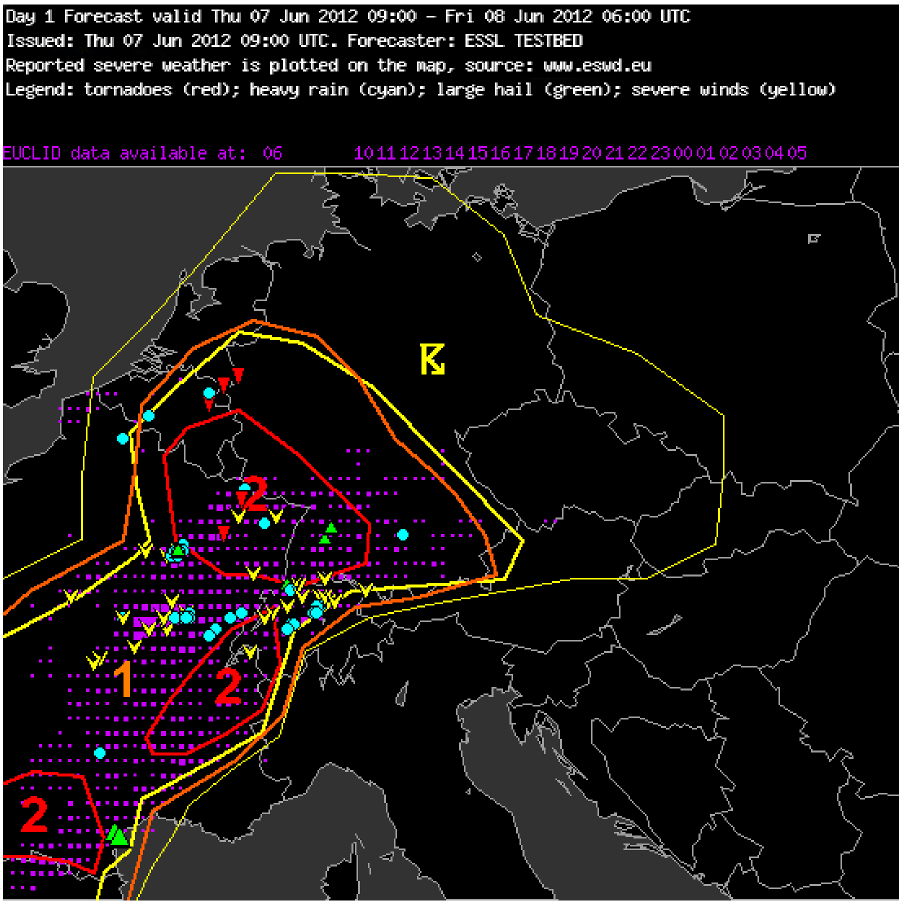


Fig. 3: Day 1 forecast map showing the areas drawn to depict low (15 – 50 %) thunderstorm probability (inside the thin yellow contour) and high (> 50%) thunderstorm probability (inside the thick yellow line), as well as a level 1 and 2 of severe weather threat (see the text and Tables 1 and 2 for definitions). The map also shows the data to verify the forecast, i.e. the observed severe weather reports from the European Severe Weather Database: heavy rain (blue circles), tornadoes (red triangles), yellow V's (severe wind > 25 m/s), and large (>= 2 cm) hail (green triangles), as well as lightning detected by the EUCLID network (purple).

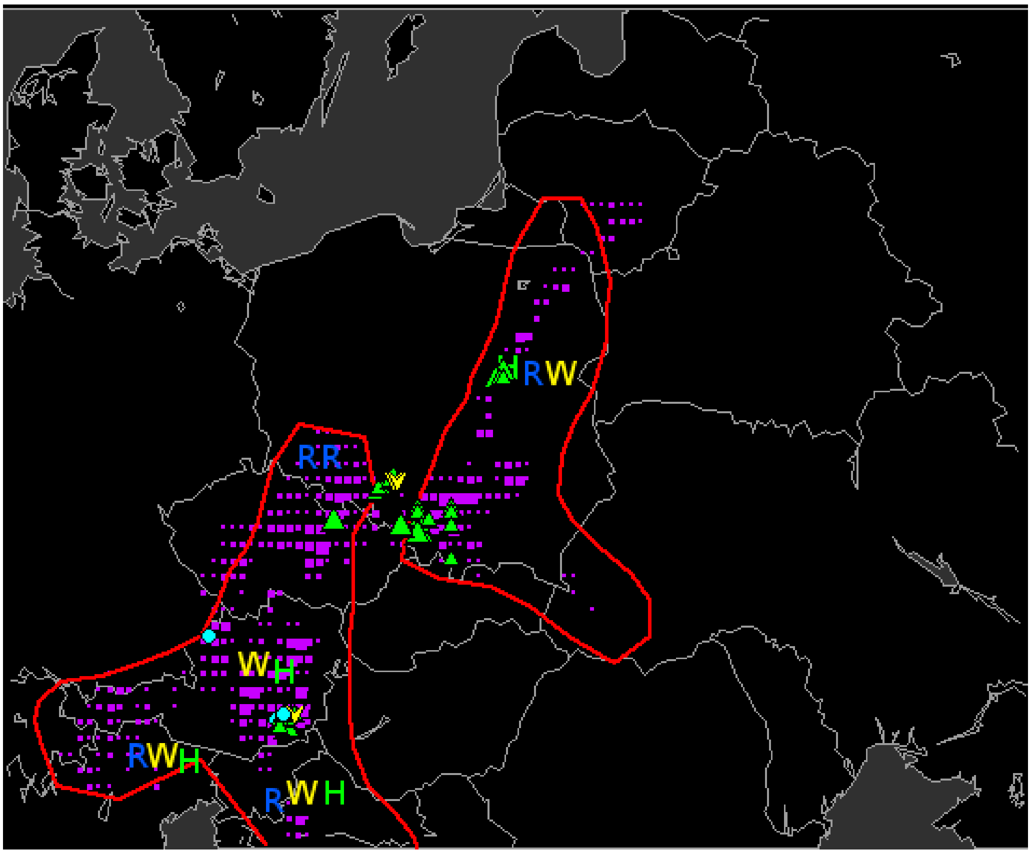


Fig. 4: Nowcast map with verification data. The map shows areas outlined by red contours within which thunderstorms are expected within the next two hours. The characters W, H, and R indicate that the main threat would be for wind, hail and extreme rainfall, respectively. The symbols, as in Fig. 3.a., denote the occurrence of such phenomena according to reports entered into the ESWD.

Nowcasts

During the afternoon session, starting at 14:45 local time, one or both of the Testbed teams will work on issuing severe weather warnings for smaller areas within the domain of the day. These are supposed to be warnings for severe weather issued two hours ahead of time.

Climatology

In case almost no convection is expected across the entire domain, the time slots for forecasting the current weather are used for studying historical cases, or for forecaster training sessions.

Fig 5. shows the coverage of high-impact weather during the Testbed period in previous years. The average number of monthly reports is approximately 1000. Considering that the domain covers the entire European continent (except for Islands and the extreme eastern parts), the weather is usually interesting enough somewhere over Europe.

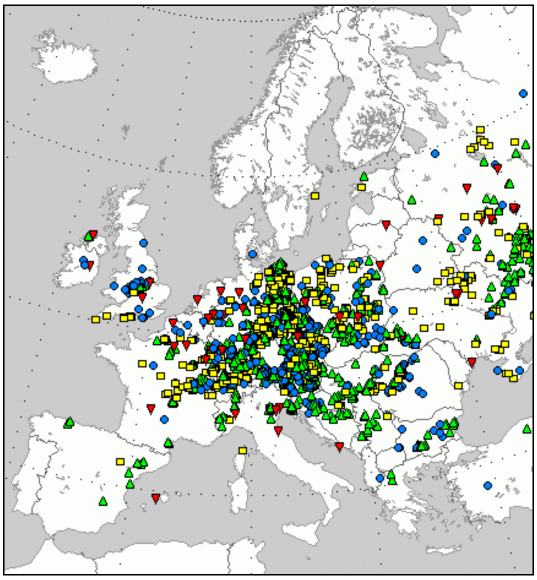


Fig. 5. Severe weather coverage during the Testbed period in 2012; yellow rectangles: severe wind gusts, red triangles: tornadoes, blue circles: flash floods, green triangles: large hail (source: ESWD, www.eswd.eu).

2.2 Forecast verification

During the *verification* slots, the forecasts will be verified subjectively against observed high-impact weather as collected in the European Severe Weather Database (ESSL) and against lightning data. Areas outside of the lightning detection network will be validated using satellite imagery as a proxy for the occurrence of convection. The outcome of the verification procedure is to establish how much forecast and observations differed and to identify possible causes. Such causes may be poor guidance by particular data, poor interpretation of the available data or other reasons.

2.3 Evaluation and reporting

In the evaluation sessions, the value of the individual products to the forecast will be assessed. These assessments result from discussions within the group of participants. At 14:00, typically, a plenary discussion will be held. In addition, participants are asked to report on the performance of a particular forecast-supporting product. There are three ways in which the feedback is collected:

Questionnaires

Questionnaires have been developed for each forecast-supporting product, in collaboration with the responsible researcher/developer. The answers given to these questions will be filled in during the evaluation session, at least once per group per week, but, preferably even more frequently. It is very important to document any feedback. The collected answers will be sent to the researcher/developer after the conclusion of the Testbed.

Testbed Blog

The Testbed blog is a web site (**www.essl.org/testbed/blog**) on which several texts with illustrations on the work at the Testbed will be posted on a daily basis, both by Testbed staff and participants. The posts discuss the forecasting, the products and their performance, as well as general impressions.

Direct communication with the developer

Almost every week some researchers/developers will be present at the Testbed. This gives the opportunity to directly interact, discuss and collect feedback on the forecast-supporting products.

2.4 Expert Presentations

The presentations 30 minutes in length (plus 15 minutes of question time) that will be disseminated online with support from EUMETCAL following the *Daily Briefing*, start approximately at 0930 UTC (1130 local time). The lecturers include experts on forecasting, modelling, remote-sensing or other relevant topics. They include scientists from European weather services and overseas, and from international organizations like EUMETSAT and ECMWF, as well as forecasters with a great expertise in the forecasting of convective high-impact weather. A list of speakers is available in **Appendix 2**. Since some changes occur, please visit the Testbed info page for the most current schedule: http://www.essl.org/testbed/info

2.5 Participation schedule

Testbed Groups

Participants to the Testbed consist of both forecasters and scientists/developers. Each Testbed week has up to 10 external participants, i.e. not including ESSL staff.

On-site and remote participation

It is recommended that participants first participate one week remotely, followed by a week on site at the ESSL Training Centre in Wiener Neustadt. All participants will, however, be able to take part in all online sessions. The online participation involves connecting to the Testbed through Saba Meeting teleconferencing system (provided by EUMETCAL) as well as participating in the Daily Briefing, and attending the *Lecture of the day.* These activities take place from 0900 UTC to approximately 1030 UTC. Participants of the first Testbed week will not have the possibility of prior remote participation, but are welcome to attend remotely later.

2.6 Standard tools at the Testbed

Testbed Data Interface

Data of all experimental products as well as conventional meteorological data are displayed through the Testbed Data Interface, which is a collection of intranet pages, that are accessed through a web browser: these pages include the *Multi-Model* and *Hi-Res Ensemble* pages that display output from several NWP models simultaneously, and the *Nowcast Display* page that allows the user to overlay several layers of satellite, radar, NWP, and observational data as well as various experimental products. For the 2016 Testbed, the data will be made available to remote participants through the internet and to the general public after the Testbed has ended. The web page to access is www.essl.org/testbed/data. Participants will receive a valid username and password to gain access from their home institution for the duration of the Testbed.

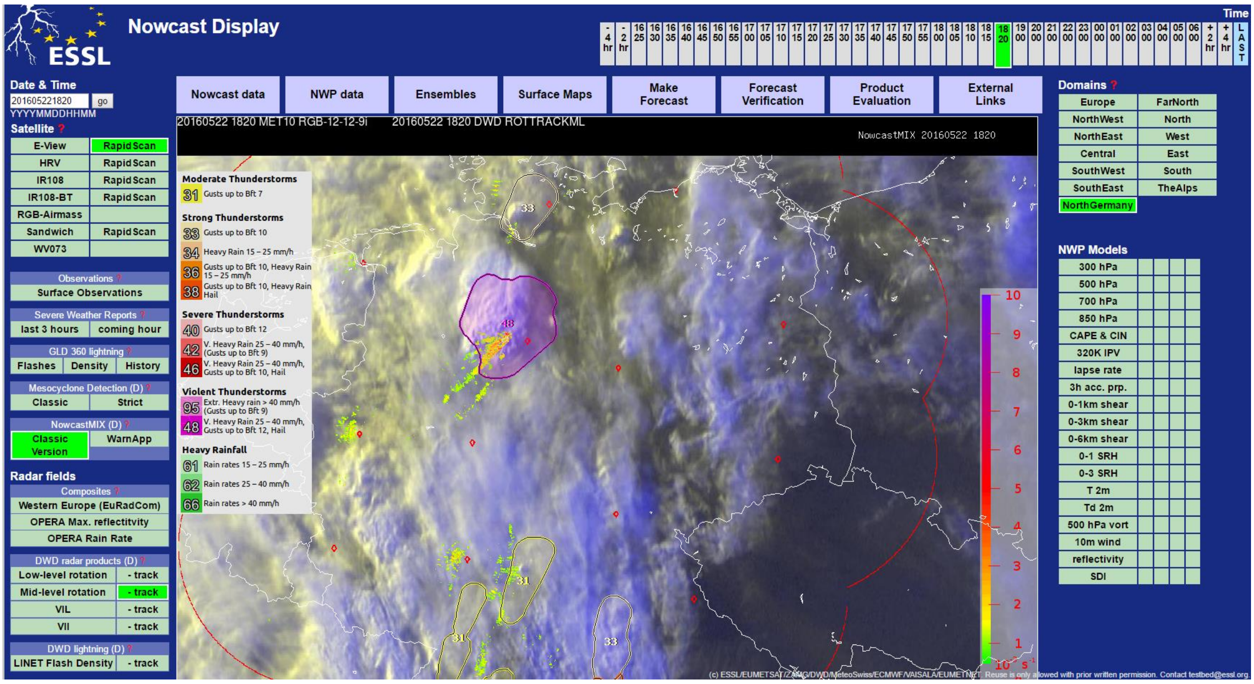


Fig. 6. Nowcast Display

Testbed Participant Page

On a dedicated web page, background information on the experimental products and techniques, beyond the information contained in this Operations Plan is gathered. The web page to access is www.essl.org/testbed/info.

Workstations and printing

ESSL's Research and Training Centre is equipped with 5 workstations that the participants will use to access the Testbed Data Interface. One of the pages of the Testbed Data Interface provides maps of surface observations, that can be printed in A3 format and analysed using provided colour pencils.

Available Standard Meteorological Data

In addition to the experimental products described in the following sections, the following "standard" meteorological is available through the Testbed Data Interface:

2.6.1.1 NWP

Global:

- ECWMF IFS, provided by ZAMG
- GFS (source: NCEP)

Regional:

- ICON-EU* (source: DWD)
- ALARO5 (source: ZAMG)

Convection-permitting

- COSMO-DE* (source: DWD)
- COSMO-1* (source: MeteoSwiss)

Convection-permitting-ensembles

- COSMO-DE-EPS* (source: DWD)
- COSMO-1* (source: MeteoSwiss)

* part of the evaluation programme

2.6.1.2 Satellite

From Meteosat 9 (available every 15 minutes):

- E-View, High Resolution Visible, IR-10.8, IR-10.8 (color enhanced), Airmass-RGB, WV-7.3

From Meteosat 8 RapidScan service (available every 5 minutes):

- E-View, High Resolution Visible, IR-10.8, IR-10.8 (color enhanced)

From these products, a “Sandwich Product” is created, both from Meteosat 9 and from MeteoSat8 RapidScan data.

Radar imagery

- The European radar composite OPERA is made available by ZAMG through an agreement with EUMETNET
- The West-European radar composite EuRadCom is provided by DWD

Observations

- Severe weather observations are available from the European Severe Weather Database.
- SYNOP and METAR surface observations of Europe
- Radiosonde data are available on the internet through the University of Wyoming and the University of Oklahoma

Lightning data

- The GLD360 product by VAISALA
- LINET lightning density product by DWD

3 Forecast-supporting products

A wide range of tools that support the forecaster in early operational or pre-operational stage (Forecast-Supporting Products) are evaluated at the ESSL Testbed. For example, new versions or configurations of numerical weather prediction models, new techniques to extract information from satellite, radar and other remote sensing data. This includes new visualizations and ways to combine different types of meteorological data relevant to the prediction of high-impact weather. The products up for evaluation in 2016 are listed in Table 2, and described in the sections that follow.

Forecast-supporting Product	Developer	Description
3.1 Mesocyclone Detection Algorithm	DWD	Radar-based algorithm to detect and assign severity levels to mesocyclones, based on Doppler velocity data from radars in the German national radar network
3.2 VIL (-Track)	DWD	Radar-derived vertically integrated liquid product.
3.3 VII (-Track)	DWD	Radar-derived vertically integrated ice product.
3.4 Rotation (-Track)	DWD	Doppler-radar-derived shear/rotation at several levels, and corresponding tracks.
3.5 Lightning density	DWD	LINET lightning density product
3.6 NowCastMIX	DWD	Grid-based system combining nowcast data from multiple sources using fuzzy logic
3.6 GLD360	VAISALA	Global Lightning Detection network
3.7 COSMO-1 and COSMO-E (experimental setup)	MeteoSwiss	COSMO-1 is a very high-resolution (1 km) convection-permitting model run every 3 hours out to +33 hours. COSMO-E is a convection-permitting ensemble for the Alpine region and surroundings, run twice a day to + 120 hours. Various visualizations are available.
3.8 COSMO-DE and COSMO-DE-EPS	DWD	COSMO-DE: Convection-permitting model for Germany and (wide) surroundings. COSMO-DE-EPS: Convection-permitting 20-member ensemble for Germany and (wide) surroundings. Both are Run 8 times a day out to 27 hours, and once per day out to 48 hours at 03 UTC.
3.9 Lightning potential index in COSMO-DE	DWD	A parameter forecasting lightning activity
3.10 European Severe Weather Database	ESSL and partners	Database of severe weather events filled with reports in near real-time

Table 6. Forecast-supporting products.

3.1 Mesocyclone Detection Algorithm

Thomas Hengstebeck (DWD)

Data basis

In the 5 min scan strategy of the DWD radar network 10 sweeps corresponding to 10 elevations ranging from 0.5° to 25° build up a 3D-volume for each radar site. The quality controlled basic data of this volume scan are provided as input for the MDA (Hengstebeck et al., 2011). The quality control includes the removal of spoke and ring artefacts, a clutter removal (static and dynamic clutter), an attenuation correction, the interpolation of “holes” within the reflectivity data and a speckle remover. A dual-PRF unfolding error correction is applied to the radial velocity data. The MDA uses the radial wind (Doppler wind) information of a volume as detection basis. The further classification of a detected mesocyclone, i.e. the severity estimation, is based on both radial wind and reflectivity information. A detected mesocyclone cell is assigned a time stamp corresponding to the time of the scan begin, the so-called reference time, which is 0, 5, 10, 15, etc. min after the full hour. The scanning of all 10 sweeps of the volume scan takes ca. 4.5 min.

Description of Algorithm

General remarks

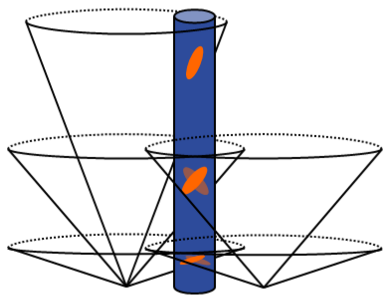
A mesocyclone (often found in connection with the updraft in supercells) is an atmospheric vortex field, which can be described by a so-called “Rankine Combined Vortex“-model (Zrnic et al., 1985). Here, one distinguishes between an outer and inner region of rotation. In the outer region, the rotation smoothly merges into the overall wind field. However, the inner region is characterized by rigid rotation and shows constant and high values of azimuthal shear. This region of high azimuthal shear – in the Doppler wind data visible as central part of the typical rotation dipole - is the signature that is searched for by the automatic mesocyclone detection algorithm. The algorithm follows the approach described in (Zrnic et al., 1985).

Pattern Vectors and Features

A so-called "pattern vector"-method is used for identifying regions of high azimuthal shear, i.e. in each radial wind sweep one tries to find contiguous azimuthal sequences of pixels with high azimuthal shear. The found pattern vectors are filtered with respect to the values of azimuthal shear and specific angular momentum and are grouped to so-called features (spatially correlated pattern vectors). The features are filtered according to symmetry criteria: Since a feature ideally resembles a complete rotation signature, it should have roughly equal extensions in range and azimuth directions. The "pattern vector-feature"-search is performed for each sweep of each volume (all radar stations) yielding a list of geo-referenced features (i.e. features with latitude / longitude coordinate pairs).

Mesocyclone-Objects

Within the above described list vertically aligned features, i.e. features with similar latitude / longitude coordinates, are searched for. A group of such features resembles a so-called mesocyclone-object (see Figure), which is classified as mesocyclone-cell with related severity level after validation. (In NinJo an upside down triangle symbol with color coding of severity index is visualized).



A vertically aligned group of geo-referenced features (orange patches) forms a mesocyclone object (depicted as blue cylinder).

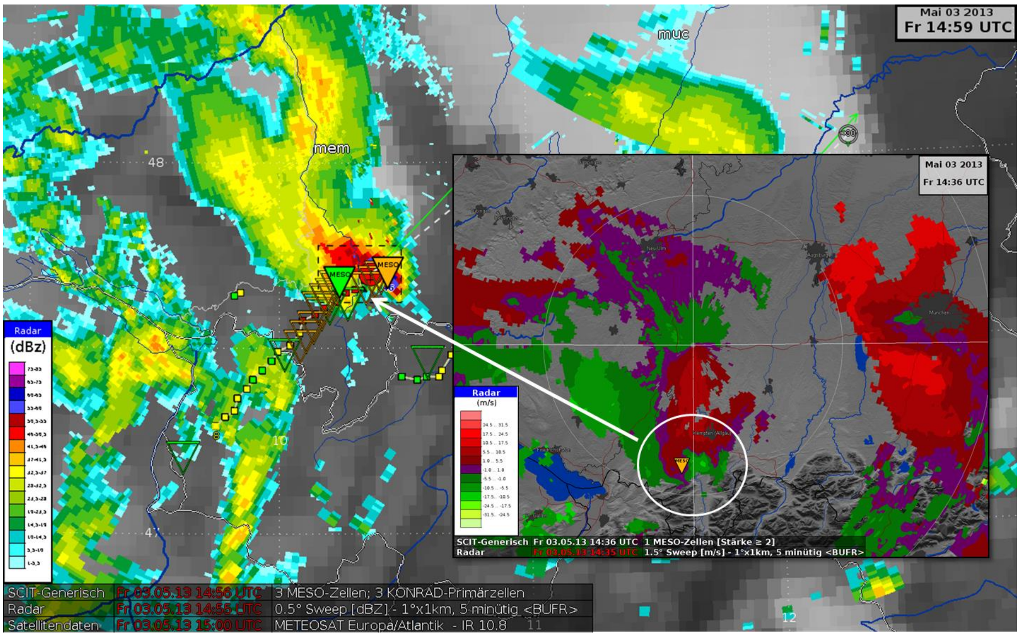
Properties of the region of the detected mesocyclonic rotation like mean / max. reflectivity, cell-based VIL (vertically integrated liquid water), VIL density, height of lowermost detected rotation signature over ground, total height of rotational column and echo top height as well as max. rotational shear, max specific angular momentum and max. rotational velocity are calculated.

The severity level is determined by applying thresholds to these cell-characteristics (also called attributes). The thresholds given in table A1 are used, which put emphasize on the geometry of detection and the strength of the rotation. Basic thresholds on reflectivity related attributes are used as well. The thresholds for severity level 3 approximately follow the guide values given in the online resource “Radar Signatures for Severe Convective Weather” (see last entry in literature list).

The severity levels 1-5 imply mesocyclonic rotation with increasing strength and clearness. Severity-level 1 rather serves for test / tuning purposes, but may also give hints to early stages of rotation. The latitude / longitude-coordinate-pair of the mesocyclone-cell is determined as shear weighted mean of the lowest 3 km of the mesocyclone object.

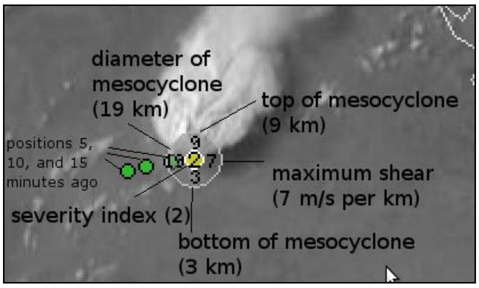
Mesocyclone Cell Attributes			Severity-Level 1	2	3	4	5
Reflectivity	*Max. Reflectivity [dBZ]*	≥	10				
	Avg. Reflectivity [dBZ]	≥	10				
	VIL [kg m⁻²]	>	0				
	Echo Top Height [km]	>	2				
	VIL Density [g cm⁻³]	>	1				
Geometry of detection	*No. of features*	≥	1	1	2	2	2
	Height agl [km]	≤	5				
	Diameter d [km]	≥	3	3	5	5	5
	Meso-Height h [km]	>	1	2	3	6	8
Rotational Strength	*Rotational velocity [m/s]*	>	10 ⊗	15 ⊗	15 ⊗	20 ⊗	25 ⊗
	Max. Shear [m/s / km]	>	5	10	10	20	30
	*Max. Mom. [m/s * km]*	>	0				

Table A1: Strict thresholds for severity estimation. The "or"-symbol (⊗) in the rotational strength thresholds has the following meaning: E.g. for severity level 3 values of max. shear or rotational velocity must exceed the given thresholds of 15 m/s and 10 m/s/km, respectively.



Example of mesocyclone detections visualised by means of the NinJo workstation system at DWD. This weather case is addressed in the next two sections as well (VIL and rotation products).

For the ESSL Testbed, the algorithm has been integrated into the Nowcast Display. The figure explains which parameters are shown. Since the 2015 ESSL Testbed a further attribute has been added on top of the “top of mesocyclone” number. Here, the maximum rotational velocity is shown.



Visualisation of a mesocyclone detection in the Testbed Nowcast Display. On top of the “top of mesocyclone” a further number – the maximum rotational velocity - is displayed in the Nowcast Display since 2015.

In the Mesocyclone Detection menu of the Nowcast Display the user can choose between the options “All” (show all mesocyclone detections), “Intensity ≥ 2” (show detections with severity ≥ 2) and “Features ≥ 2“ (show detections where at least 2 features were detected). Choosing the last option will supress weak detections relying on just a single feature.

Hengstebeck, T., D. Heizenreder, P. Joe and P. Lang (2011): The Mesocyclone Detection Algorithm of DWD*, 6th European Conference on Severe Storms, 3-7 October 2011, Palma de Mallorca, Spain.*

Zrnic, D.S., D.W. Burgess and L.D. Hennington (1985): Automatic Detection of Mesocyclonic Shear with Doppler Radar, *J. Atmos. Oceanic Technol., **2**, 425–438.*

Bureau of Meteorology, Commonwealth of Australia 2010: *Radar Signatures for Severe Convective Weather*,

URL: http://ftp.comet.ucar.edu/msanchez/W_modulos/radar/severe_signatures/print_supercell.htm

The source of the Radar Signatures for Severe Convective Weather is the Commonwealth of Australia, Bureau of Meteorology, via the University Corporation for Atmospheric Research (UCAR) COMET MetEd Website at http://www.meted.ucar.edu, and has been fully funded by the Bureau of Meteorology. ©2010, the Commonwealth of Australia, Bureau of Meteorology. All Rights Reserved.

3.2 Vertically integrated liquid water (VIL) and VIL-Track

Thomas Hengstebeck (DWD)

Data basis

The quality controlled 3D-reflectivity data are used as input (see section 3.1).

Description of Algorithm

For the VIL calculation the following formula is used (Greene et al., 1972):

$VIL = \Sigma_i\ 3.44 \times 10^{-6}\ [(Z_i + Z_{i+1})/2]^{4/7}\ \Delta h_i$

Here, the sum is carried out over different height layers. Z_i and Z_{i+1} are the reflectivity at the bottom and top of the i-th layer with the thickness Δh_i. The units are as follows:

$[Z] = mm^6/m^3$

$[\Delta h] = m$

$[VIL] = kg/m^2$ or mm

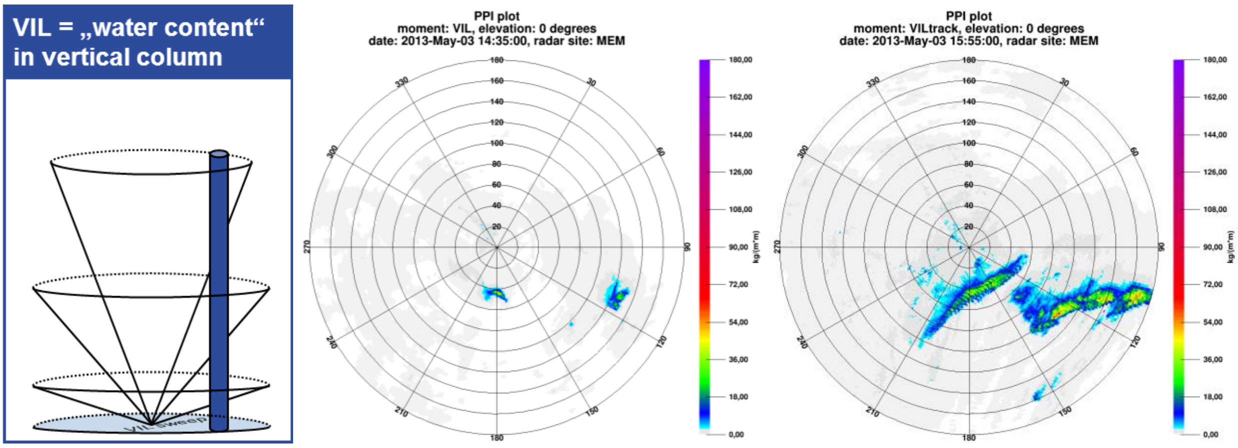
Above given formula indirectly contains a Z-R relation, the water equivalent is derived under the assumption of a Marshall Palmer drop size distribution. Details can be found in (Greene et al., 1972).

The VIL product at DWD is generated as Germany composite using the 3D-reflectivity volumes of all DWD radar stations (flatmap composite with 1950 x 1200 pixels, horizontal pixel size: 553.50 m - 699.67 m, vertical pixel size: 1000 m). For a given grid-cell of the composite a VIL value is calculated by integrating exactly vertical using above given equation. The reflectivities Z_i are taken from the intersected sweep data taking into account all sweeps of all radar stations which intersect with a vertical column above the grid-cell.

A so-called VIL Track is created by accumulating VIL composite products from a certain time interval, which should be chosen large enough to visualize tracks of moving cells. Currently, this time is set to 3 hours. In the accumulation procedure each pixel of the VIL Track composite is assigned the maximum value of all VIL values for this pixel in the corresponding VIL composite products.

Interpretation guidelines

VIL can be used for a classification of storm severity (Kitzmiller et al. 1995). VIL values exceed 10 kg/m^2 in convective events (thunderstorms); the higher the VIL, the more severe the storm. NowcastMix uses the VIL product as one of its input data sets. The VIL Track product is useful for depicting paths of moving cells. In case of cell splits two divergent VIL paths can be observed. It should be noted that VIL overestimates the “water content” when hail is present (especially water coated hail).



Left: VIL value calculation for a single pixel of a polar VIL sweep coordinate grid (actually a flatmap Germany composite grid is used, however the principle of the VIL calculation is unchanged). Observational data at DWD contains 10 sweeps for each radar site. Here, 3 sweeps are depicted for illustration purposes. Middle: VIL product as derived from observational data (see label for details). Right: Corresponding VIL Track.

In the VIL formula, as given above, the reflectivities are always interpreted as belonging to liquid hydrometeors. However, this overestimation pronounces severe storms, which make VIL a kind of “storm severity indicator”. In the VII (vertically integrated ice) product as described in the next section one tries to lift the lower integration limit in order to catch just the frozen hydrometeors, so that VII may be better suited to imply the presence of hail.

There are unavoidable geometrical influences, which should be taken into account when interpreting VIL values: In the vicinity of a certain radar site (< ca. 20 km) precipitation in larger heights is not captured by this site (so called cone-of-silence). The nearest radar sites are providing coverage filling the cone-of-silence. However, deterioration in vertical resolution may still occur, so that possibly too low VIL values are observed. On the other hand, for a location within the VIL composite, where the nearest radar site is situated at large distance (> ca.100 km) the spatial resolution of the radar scan is limited and precipitation close to ground may not be captured (overshooting precipitation). Furthermore, if vertical gradients of reflectivity are present the VIL algorithm produces positively biased values (overestimation) especially at large radar ranges. All these effects are mainly noticeable at the composite’s border regions and within the composite in case of single radar site’s data outages.

Greene, D.R. and R.A. Clark (1972): Vertically Integrated liquid Water - A New Analysis Tool*, Monthly Weather Review, **100**, 548–552.*

Kitzmiller, D.H., W.E. McGovern and R.F. Saffle (1995): *The WSR-88D severe weather potential algorithm, Weather and Forecasting, **10,** 141–159.*

Brown, R. A. and V. T. Wood, 1999: *Development of New WSR-88D Scanning Strategies for Convective Situations*, Final Report, NSSL, Norman, OK, fig. 17.

3.3 Vertically integrated ice (VII) and VII-Track

Thomas Hengstebeck (DWD)

Data basis

The quality controlled 3D-reflectivity data are used as input (see section 3.1). Furthermore, data from the COSMO-DE model with information about the height of the 0°C-layer h_0 is used.

Description of Algorithm

The algorithm works analogue to the VIL algorithm with the exception that the vertical integration is performed beginning at the -10°C-layer height h_{-10}, which is estimated from h_0 (COSMO-DE output) as follows:

$h_{-10} = h_0 + 1330$ m (assuming a temperature gradient of 7.5 K / 1000 m for convective situations)

REMARK: Actually, the calculation of VII involves a different factor (2.11 instead of 3.44 in the VIL equation) to account for the density of ice. However, this altered factor is *not* used. The only difference between VII and VIL is the lower integration limit. Thus, differences in the two products can unambiguously be traced back to the h_{-10} height.

Interpretation guidelines

The same considerations as for the VIL algorithm apply here. Additionally, uncertainties of h_0 (COSMO-DE model) influence the VII-product.

R. M. Mosier et al. (2011), Radar Nowcasting of Cloud-to-Ground Lightning over Houston, *Texas, Wea. Forecasting*, **26**.

3.4 Rotation and Rotation-Track

Thomas Hengstebeck (DWD)

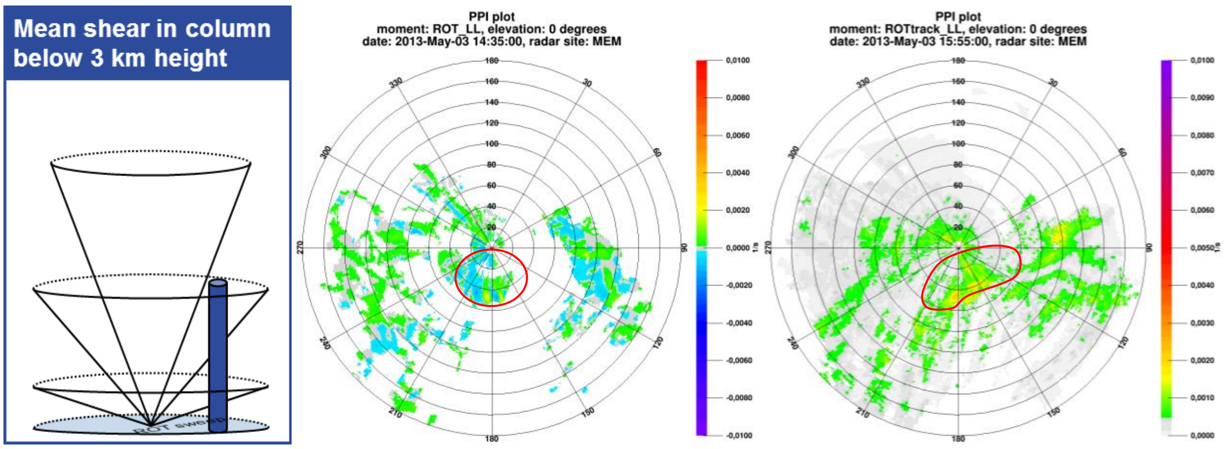
Data basis

The quality controlled 3D reflectivity and radial velocity radar data are used as input (see section 3.1).

Description of Algorithm

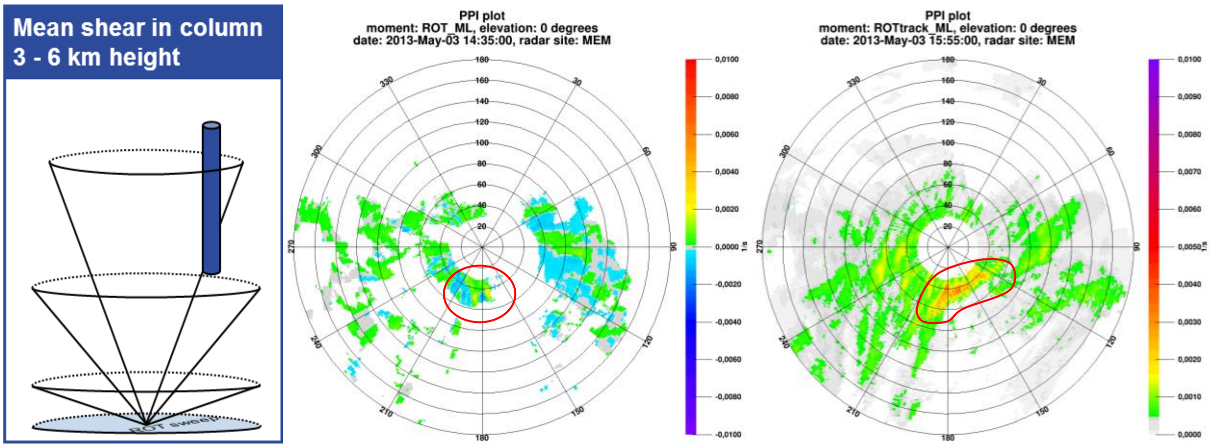
The rotation product is meant for visualising the azimuthal shear connected with rotation in meso-(anti)cyclones. The data processing for the rotation algorithm starts by applying a smoothing filter to each radial velocity sweep of the 3D Doppler volume. Subsequently, the azimuthal shear is calculated pixelwise averaging over 3 azimuthally adjacent range bins.

The resulting 3D-volume of azimuthal shear sweeps is then further processed (see also the figures below). In analogy to the VIL product, a flatmap Germany composite is used (the same format as described in section 3.2 for the VIL-product). Each pixel (grid-cell) within this composite is assigned a value corresponding to the average azimuthal shear in the vertical column above the pixel. For the low level (LL) rotation product the column extends from 0 to 3 km above ground level (agl). In case of the mid level (ML) rotation product the column is ranging from 3 to 6 km height agl. A minimum reflectivity of 5 dBZ is necessary for a shear value to enter the averaging procedure.



Left: low level rotation (ROT-LL) value calculation for a single pixel of a polar "ROT" sweep coordinate grid (actually a flatmap Germany composite grid is used, however the principle of the ROT calculation is unchanged). Middle: ROT-LL sweep from observational data (see figure label for details). Right: ROT-LL Track (time interval for accumulation is 3 hours). Compare also figure

in section 3.1 (mesocyclone detection). In this weather case, the rotation is more restricted to higher atmospheric layers as can be seen from the ROT-ML product (next figure).



Left: mid level rotation (ROT-ML) value calculation for a single pixel of a polar "ROT" sweep coordinate grid. Middle: ROT-ML sweep from observational data (see figure label for details). Right: ROT-ML Track (time interval for accumulation is 3 hours).

Both LL and ML rotation products show positive (cyclonic) and negative (anti-cyclonic) shear. The related track products are obtained by pixelwise accumulating the maxima from the LL and ML rotation products of the last 3 hours (which corresponds to 36 composite products due to the 5 min scan strategy), so that only positive shear is picked up.

The rotation and rotation track products are inspired by (Smith et al., 2004). However, it was found that picking up the maximum value in the column leads to noisy rotation products, so that finally the mean value was preferred.

In case of the track composite products only positive azimuthal shear is evaluated. The more frequently occurring cyclonic vortices are represented by an area of positive shear (centre of rotation) flanked on two sides by negative shear values (regions where the rigid rotation of the inner core merges into surrounding wind field). Accumulating both positive and negative shear values (by investigation of absolute value) would result in a complicated picture showing two negative rotation tracks beside each positive rotation track and vice versa.

Interpretation guidelines

Rotation and rotation track products should be used in addition to the mesocyclone detection as verification check. Moving rotating cells are expected to produce tracks of high azimuthal shear visible in the rotation track product. The low level and mid level rotation track products can help to distinguish between close to ground (implication for possible occurrence of tornadoes) and mid level atmospheric rotation.

A discussion of non-mesocyclonic signatures can be found in (Miller et al., 2012). Here it is stated that "significant vertical shear near the surface can cause false high azimuthal shear values very close to the radar" (Miller et al., 2012, p. 577) and that "bands of high azimuthal shear values associated with linear meteorological phenomena like outflow boundaries and bow echoes also appear in the rotation track fields" (Miller et al., 2012, p. 580).

Smith, T.M. and K.L. Elmore (2004): The Use of Radial Velocity Derivatives to Diagnose Rotation and Divergence, *11th Conference on Aviation, Range, and Aerospace Meteorology, 2004.*

Miller, M.L., V. Lakshmanan and T. Smith (2012): An Automated Method for Depicting Mesocyclone Paths and Intensities, *Weather and Forecasting, 2012*

3.5 Lightning density and lightning density track

Kathrin Wapler (DWD)

Data basis

Lightning stroke data measured by the Lightning detection NETwork (LINET, Betz et al. 2008) are used.

Description of the product

Lightning strokes are mapped on a grid with a spatial resolution of 1 km. The grid is similar to that of the VIL and VII products. The lightning density product shows the number of lightning strokes per km² for a 5 minute interval. The lightning density labelled 12:00 UTC contains the strokes that occurred between 12:00:00 and 12:04:59 UTC. This time slot is chosen to be comparable to the 3D volume radar data based products (see Section….).

A so-called lighting density track is created by accumulating the lightning density products from a certain interval. Currently, this time is set to 3 hours. Each pixel of the lightning density track product is assigned the total of all lightning density values for this pixel in the corresponding lightning density products. The lightning density track labelled 12:00 UTC contains the strokes that occurred between 09:05:00 and 12:04:59 UTC.

Interpretation guideline / product assessment

The products may be used for nowcasting as well as verification purposes. Intense convective storms tend to have higher lightning stroke densities. A so-called lightning jump, i.e. a rapid increase in the lightning stroke rate of a storm, has in many cases shown to be a precursor of severe weather (e.g. gusts, hail or tornadoes).

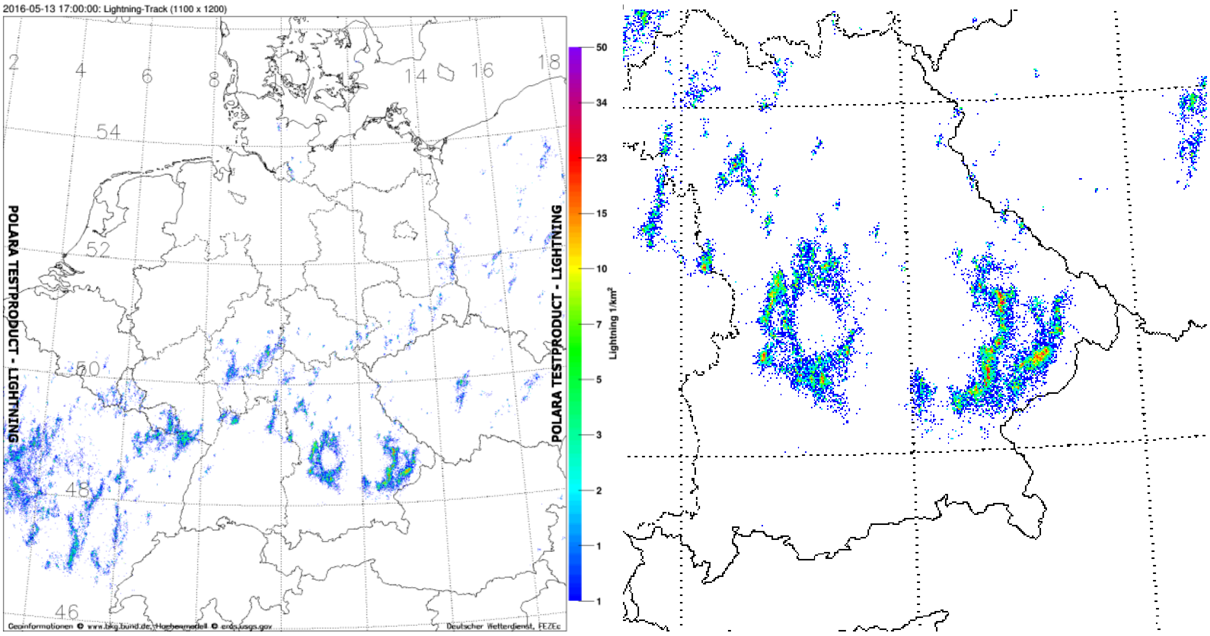


Figure: Example of lightning density track for 13 May 2016 17:00 UTC. Whole domain of the product (left) and zoom into the area of interest (right). Note: the color bar is logarithmic (unfortunately, the double "1" at the lower end of the color bar cannot be avoided).

3.6 NowcastMix

Paul James (DWD)

The GermanWeather Service's AutoWARN system integrates various meteorological data and products in a warning decision support process, generating real-time warning proposals for assessment and possible modification by the duty forecasters. These warnings finally issued by the forecaster are then exported to a system generating textual and graphical warning products for dissemination to customers. On very short, nowcasting timescales, several systems are continuously monitored. These include the radar-based storm-cell identification and tracking methods, KONRAD and CellMOS; 3D radar volume scans yielding vertically integrated liquid water (VIL) composites; precise lightning strike locations; the precipitation prediction system, RadVOR-OP as well as synoptic reports and the latest high resolution numerical analysis and forecast data. These systems provide a huge body of valuable data on rapidly developing mesoscale weather events.

However, without some form of pre-processing, the forecasters could become overwhelmed with information, especially during major, widespread summer convective outbreaks. NowCastMIX thus processes all available nowcast data together in an integrated grid-based analysis, providing a generic, optimal warning solution with a 5-minute update cycle, combining inputs using a fuzzy logic approach.

The method includes optimized estimates for the storm cell motion vectors by combining raw cell tracking inputs from the KONRAD and CellMOS systems with vector fields derived from comparing consecutive radar images. Finally, the resulting gridded warning fields are spatially filtered to provide regionally-optimized warning levels for differing thunderstorm severities which can be managed adequately by the duty forecasters. NowCastMIX thus delivers an ongoing real-time synthesis of the various nowcasting and forecast model system inputs to provide consolidated sets of most-probable short-term forecasts. More information is given in James et al. (2011).

NowcastMIX at the Testbed 2016

The NowcastMIX is available in two different visualizations. One is the ‘classic’ version that uses DWD’s internal warning levels and the associated color scheme. It is provided to forecasters as part of DWD’s AutoWARN system. An example is show in the figure below.

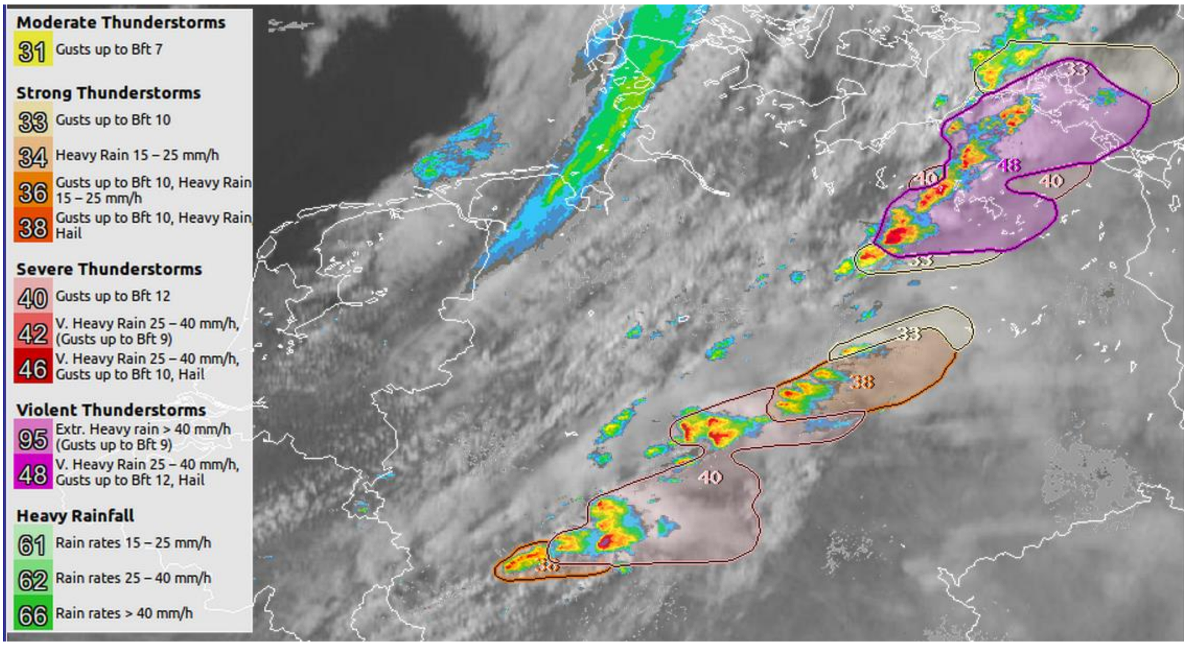


Figure. The “classic” visualization of DWD’s NowcastMIX product.

The other version is one developed for DWD’s app “WarnWetter”, that provides the general public with warning information. The polygons are similar to the classic product, but do not have a spatial filtering and fewer overlap within warning groups. The only distinction is within the severity levels indicated by a yellow, orange, red or violet colour. This means that severe thunderstorms are depicted sharper and smaller because of the lack of clustering. However, thinner filaments and residual polygons arise whenever two or more polygons overlap.

3.7 Vaisala GLD360

In 2009, Vaisala launched the Global Lightning Dataset GLD360. GLD360 data is produced by a Vaisala owned and operated lightning detection network that provides uniform, high quality lightning information across the globe. Data delivered includes CG stroke and cloud lightning information – and it can be delivered to the customer in real time.

Patented sensor algorithms and extreme sensitivity give GLD360 sensors the ability to detect lightning at distances up to 9,000 km. Each GLD360 sensor provides both direction and time-of-arrival information. Scientific studies have shown that lightning networks using a combination of direction and time-of-arrival sensor information provide significant detection efficiency and redundancy improvements over lightning networks using time-of-arrival sensor information alone. Through its GLD360 offering Vaisala provides the highest quality global lightning data in the market:

- Location Accuracy (LA): The median cloud-to-ground lightning stroke location accuracy 2-5 km
- Detection Efficiency (DE): 70% for cloud-to-ground flashes and >5% for cloud flashes with near uniform coverage around the globe (ref. the DE map in the Figure 1 below).
- Polarity & Peak Amplitude (kA): Unique to the GLD360 is the ability to provide polarity & peak amplitude (kA), which is typically the reserve of precision networks. The GLD360 polarity classification is greater than 90% and peak current estimates are accurate to within 25 % of the peak current value.

To ensure GLD360 provides the high level of network performance described above, validation studies have been performed in North America, Europe, and are now ongoing in South America. The results of these studies show that GLD360 has a CG flash detection efficiency of 70% or greater and a median CG stroke location accuracy of 2-5 km in all three regions.

Long-range severe weather detection has traditionally been limited by data gaps, leading to situations where people have late or no warnings. GLD360 is the only severe weather data set that has no data gaps and provides a nearly uniform, global coverage. GLD360 routinely detects over 1.5 million lightning events across the world each day.

As your global window, the GLD360 provides immediate access to a world-wide lightning dataset, anywhere around the globe. Vaisala thus has a unique offering that supports:

- Ability to detect and characterize lightning in areas of the world where meteorological observations may be partially lacking or absent.
- Lightning as a radar proxy or radar complement where weather radar information is limited or nonexistent.
- The ability to extend the range of lightning being assimilated into weather models and enhance the foresight of advancing weather systems.

- Quality lightning warnings on a truly global scale.

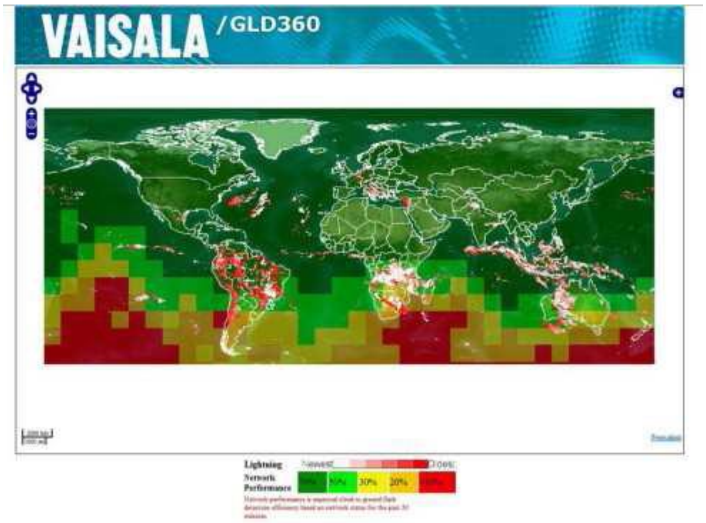


Figure: The global detection efficiency map for GLD360.

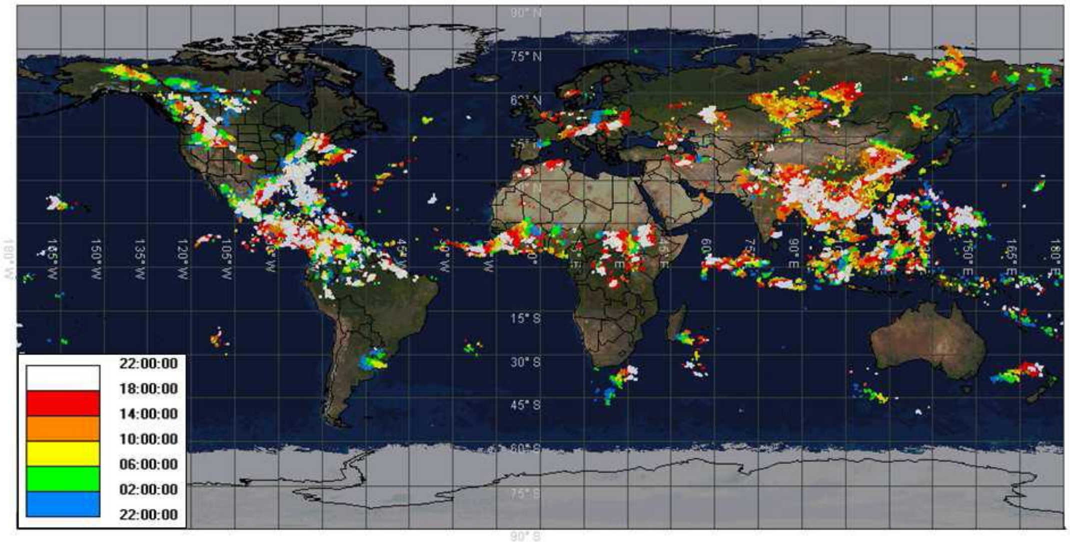
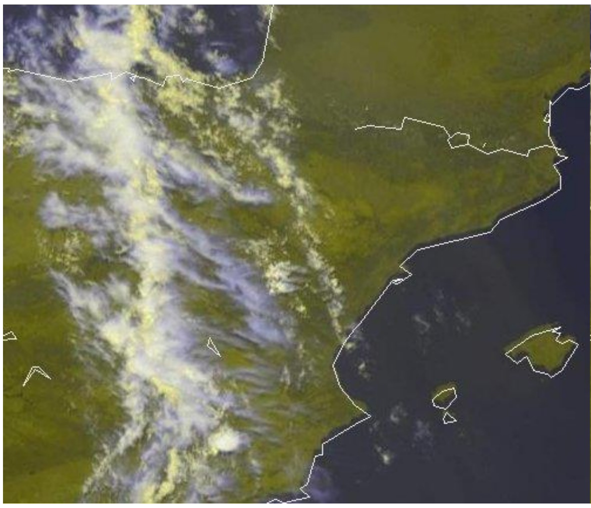
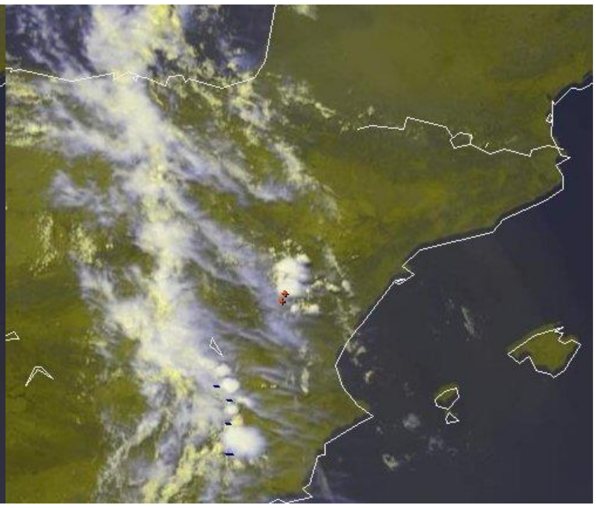


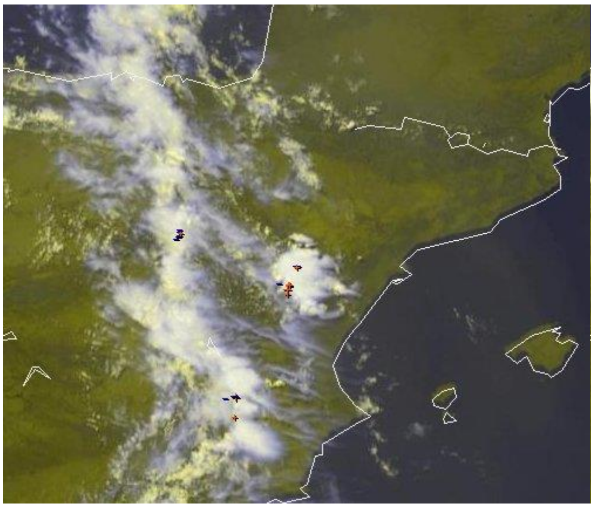
Figure: Global image showing more than two million lightning events reported by GLD360 on 22-23 June 2011. Colors show age of lightning events in 4-hour intervals starting on 22 June at 22:00 and ending on 23 June at 22:00.



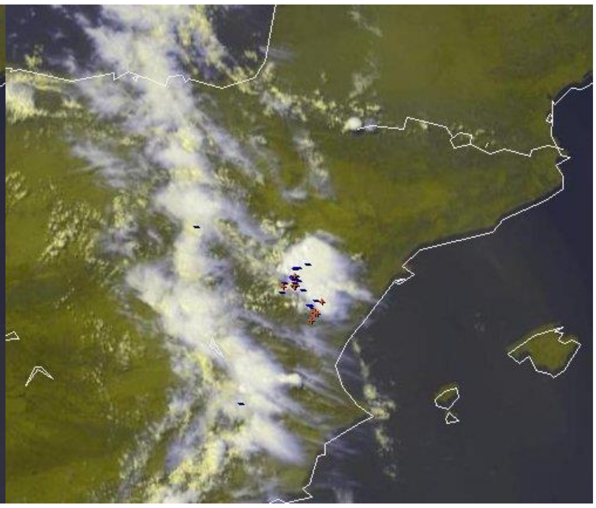
1230 UTC



1300 UTC



1330 UTC



1400 UTC

E-View satellite imagery (source: EUMETSAT/ZAMG/ESSL) with GLD360 overlay on 27 June 2012.

3.8 COSMO-DE and COSMO-DE-EPS

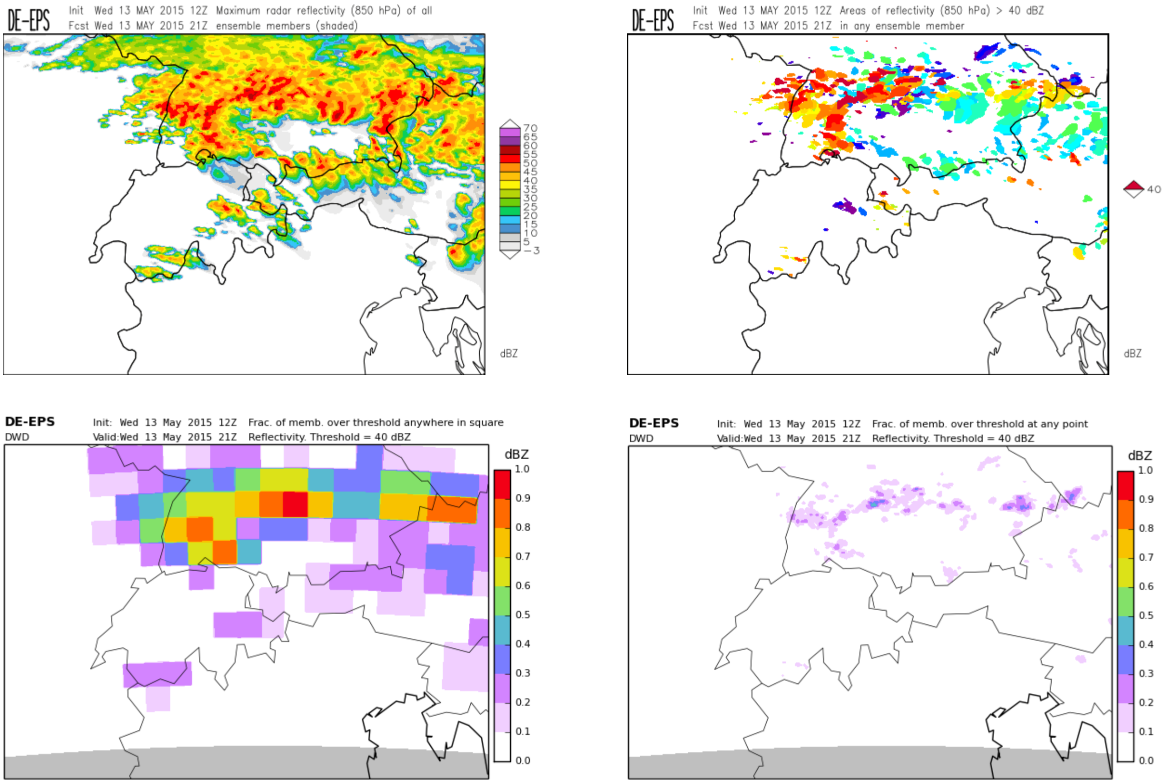
DWD (Susanne Theis, Lars Wiegand, Detlev Majewski, Ulrich Blahak and others) / Pieter Groenemeijer (ESSL)

COSMO-DE-EPS is an ensemble of the German Weather Service's high-resolution, convection permitting model COSMO-DE (COnsortium for Small-scale MOdelling - DEutschland). Different initial and boundary conditions of the ensemble members are ...from four different COSMO runs at 7 km which are in turn driven by different global NWP models (ECMWF IFS, DWD ICON, NCEP GFS and JMA GSM). Additionally, the ensemble members use varying model physics parameters and varying soil moisture initializations.

Visualizations of the ensemble

Visualization of large volumes of ensemble data is a challenge. For example, in plotting the average and standard deviation of forecast quantities much information is lost. For a field like radar reflectivity such a display would not make much sense. In past years, ESSL has evaluated several visualization of high-resolution ensemble data. For several parameters the methods where by the most extreme value of any ensemble member at each location was plotted was compared to plotting contours of ensemble members exceeding a threshold and the pointwise probability of exceedance. As a logical next step, a 'probability of exceedance' will now be computed using the methods described by Ben Bouallègue and Theis (2013). These products called 'fuzzy' and 'upscaled'. The fuzzy method is a smoothing method that enlarges the ensemble sample size by including neighbouring forecasts and the upscaled method modifies the reference area of probabilities. At the Testbed, we will collect forecaster feedback on these products and compared them with the traditional pointwise or local probabilities.

At the 2013 Testbed it was noted that small-scale variations in convective parameters such as CAPE (Convective Available Potential Energy) and CIN are simulated by the COSMO-DE and COSMO-DE-EPS models, and that these may be relevant for the development and life cycle of convective storms. At the 2016 Testbed, we will visualize the distribution of CIN and CAPE and investigate whether they can benefit forecasting convective storms by characterizing the pre-convective environment more accurately than coarser models.



Five different visualizations of the same parameter in the same model ensemble. Which visualization is most useful? How does this depend on which parameter we are considering?

Particular model fields

There are several ways to characterize whether simulated convective storms are prone to produce large hail, some of which have also been tested at NOAA's Hazardous Weather Testbed. A candidate quantity that can be made available easily by DWD is the total integrated graupel (total graupel). At the Testbed, we will perform a subjective assessment of whether this parameter, preferably treated in an ensemble sense, can be used to indicate the probability of large hail with up to 27 hours lead time (i.e. the forecast time of the COSMO-DE model). In addition, several new radar products have been developed at DWD that can, in principle, be simulated by a convection-permitting model like COSMO-DE, the rotation and rotation track products. We will perform an initial comparison of vertically integrated liquid and compare those directly that to the values derived from radar measurements. We will investigate whether the information that is thus obtains supports storm forecasting beyond the information from measures such as (simulated) reflectivity. Secondly, COSMO is able to compute rotation in thunderstorm updraughts. We will compare these to the new radar-derived rotation and rotation-track products.

General assessment of model performance

As at previous Testbeds, the ESSL team and the participants will monitor the overall performance of the COSMO-DE and COSMO-DE-EPS models, and will provide related feedback. Points of attention will include any tendencies to under- or overforecast convective initiation, the storm life cycle and secondary initiation of storms.

3.9 Lightning Potential Index (LPI) from COSMO-DE

Ulrich Blahak, Deutscher Wetterdienst

The LPI from the COSMO-model generally follows Yair et al. (2010) and Lynn and Yair (2010). The concept behind this index is to detect regions of potential charge separation within explicitly simulated convective cells in the model. It is based on the observation that charge separation is correlated with the simultaneous presence of updrafts, supercooled liquid water, graupel and other frozen hydrometeor types („cloud ice“, „snow“), which indicates active riming in an updraft environment. Unlike other indices, it does not consider the storm’s environmental conditions.

The formula of the LPI as implemented in the COSMO-model is given in Figure 1. It is a vertical colmn integral of the squared updraft speed w over the layer between 0°C and -20°C, weighted by a function ε that depends on the simultaneous presence of supercooled liquid water q_L with graupel q_g and it’s precursors (cloud ice q_i and snow q_s in case of COSMO). ε is a nested combination of the ratio of the geometric and arithmetic mean of two quantities and this ratio is depicted in Figure 2 for q_L and q_F. Its maximum is 1 if both are equal and goes to 0 if one of them goes to 0. Altogether, ε reaches it’s maximum of 1 if the contents of all hydrometeors are equal and becomes 0 if either no supercooled liquid is present or if graupel is 0 or if cloud ice and snow are 0. The filter function g (see Figure 3) masks out heights where w < 0.5 m/s.

$$\mathrm{LPI} = f_1\, f_2\, \frac{1}{H_{-20^\circ\mathrm{C}} - H_{0^\circ\mathrm{C}}} \int_{H_{0^\circ\mathrm{C}}}^{H_{-20^\circ\mathrm{C}}} \boxed{\epsilon}\, w^2\, g_{(w)}\, dz$$

$$\epsilon = \frac{2\sqrt{q_L\, q_F}}{q_L + q_F}$$

$$q_L = q_c + q_r$$

$$q_F = \frac{q_g}{2}\left[\frac{2\sqrt{q_i\, q_g}}{q_i + q_g} + \frac{2\sqrt{q_s\, q_g}}{q_s + q_g}\right]$$

Figure 1: Formal definition of the LPI. z is height, w vertical velocity, H_X denote heights of 0 and -20°C levels, f_1, f_2 and g are weighting functions (see Figure 2), q_x denote model hydrometeor contents: c = cloud water, r = rain water, I = cloud ice, s = snow, g = graupel.

f_1 and f_2 are additional spatial filter functions in the horizontal (see Figure 3). f_1 demands that the majority of grid columns in a certain neighbourhood exhibit a column maximum w_{max} > 1.1 m/s. f_2 filters out false LPI signals in a stable environment, which, for example, can occur in deep lenticular clouds associated with moist large-amplitude orographic lee waves. g and f_1 have already been proposed in the original literature and f_2 has been added by the author or the present paper.

The unit of LPI is J/kg. Figure 4 shows an example of the operational 12 UTC COSMO-DE run from February 9, 2016, for 16:45 UTC. The observed radar reflectivity (EX-Composite, semi-transparent colors), simulated precipitation rate (contour lines of 1 and 10 mm/h), simulated LPI (filled color contours) and observed flashes within +/- 7.5 min ("+" and "-" signs, colors denote the observ. time) are shown on the left, whereas the LPI and observed flashes alone are shown on the right for clarity. In this case (a cold front passage), the area with LPI > 0 reasonably well corresponds to the area of observed flashes.

First longer-term statistical comparisons of the space-time cumulative distribution functions of COSMO-DE derived LPI and the observed flash rate (FLR) in Figure 5 suggest that the flash rate can be estimated from LPI by the simple linear relation

$$FLR = 0.01 * LPI$$

if FLR is in 1/(km^2 min) and LPI in J/kg. Note that this relation may have to be revised if, for example, the model grid spacing or the cloud microphysics parameterization is changed.

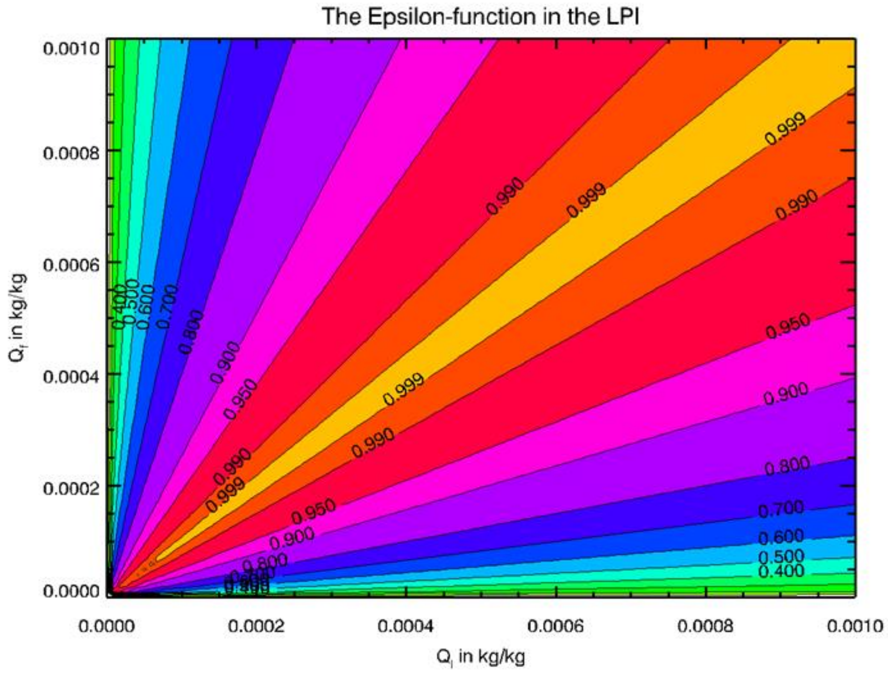


Figure 2. The ratio of the geometric to the arithmetic mean of two quantities q_L and q_F, which is the basis of the ε-function in the LPI.

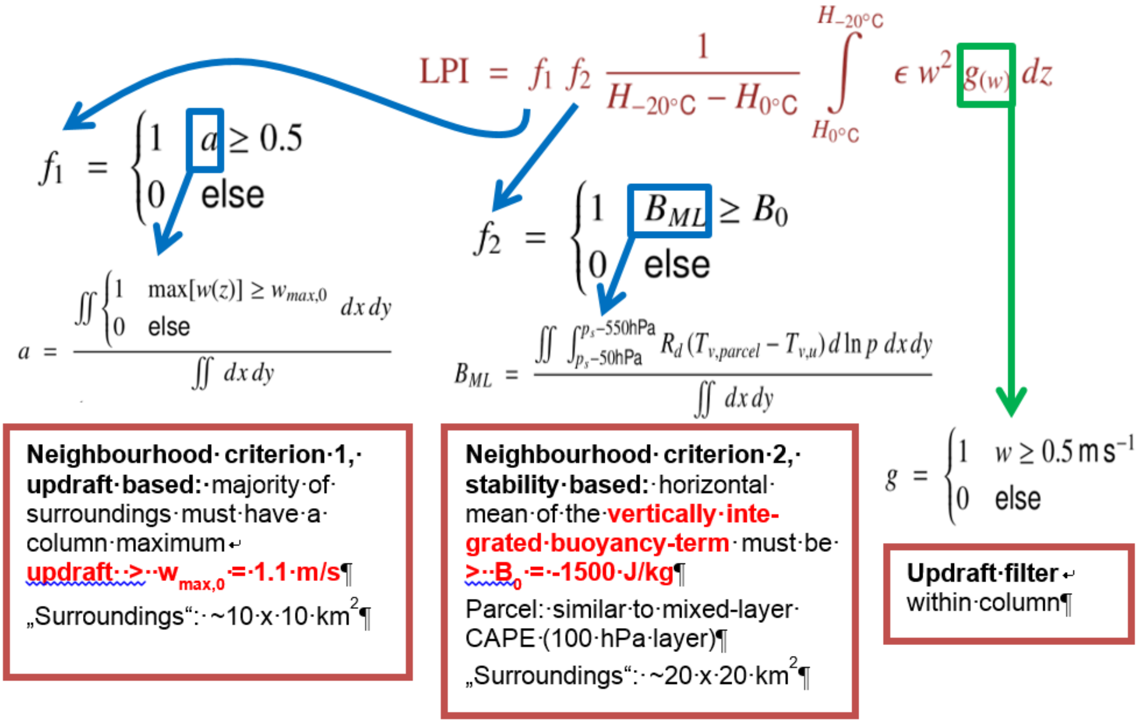


Figure 3. The filter functions f_1, f_2 and g.

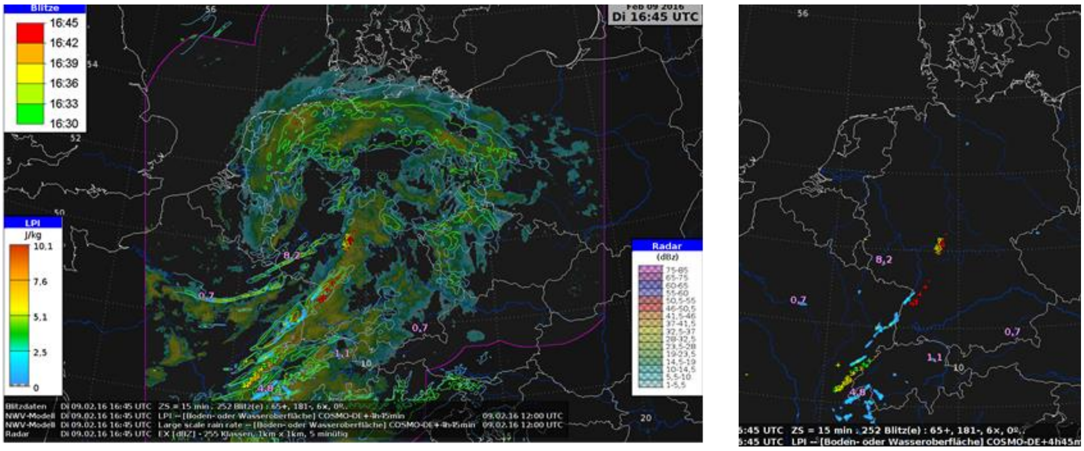


Figure 4: COSMO-DE Feb. 9, 2016, 16:45 UTC, LPI (filled contours), precipitation rate (line contours 1 and 10 mm/h), observed strikes ("+","-" signs), observed radar composite (semi-transparent colors). Right: same scene but only LPI and observed strikes.

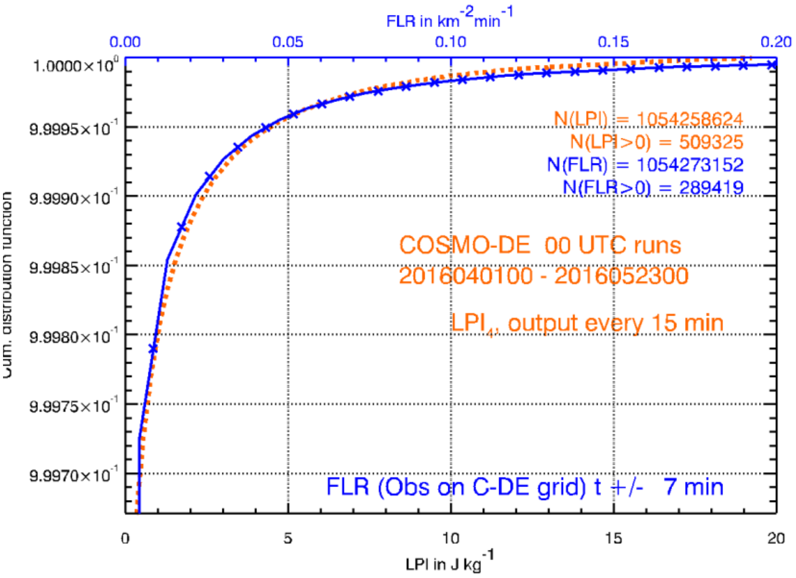


Figure 5: Space-time cumulative distribution function of COSMO-DE LPI (orange, lower abscissa) and observed FLR on COSMO-DE-grid (blue, upper abscissa) for each operational 00 UTC run from 1.4. to 23.5. 2016. The relative abscissa scaling of LPI and FLR by the factor 0.01 has been chosen "by eye" so that both cumulative distributions approximately match.

3.10 COSMO-1 and COSMO-E:

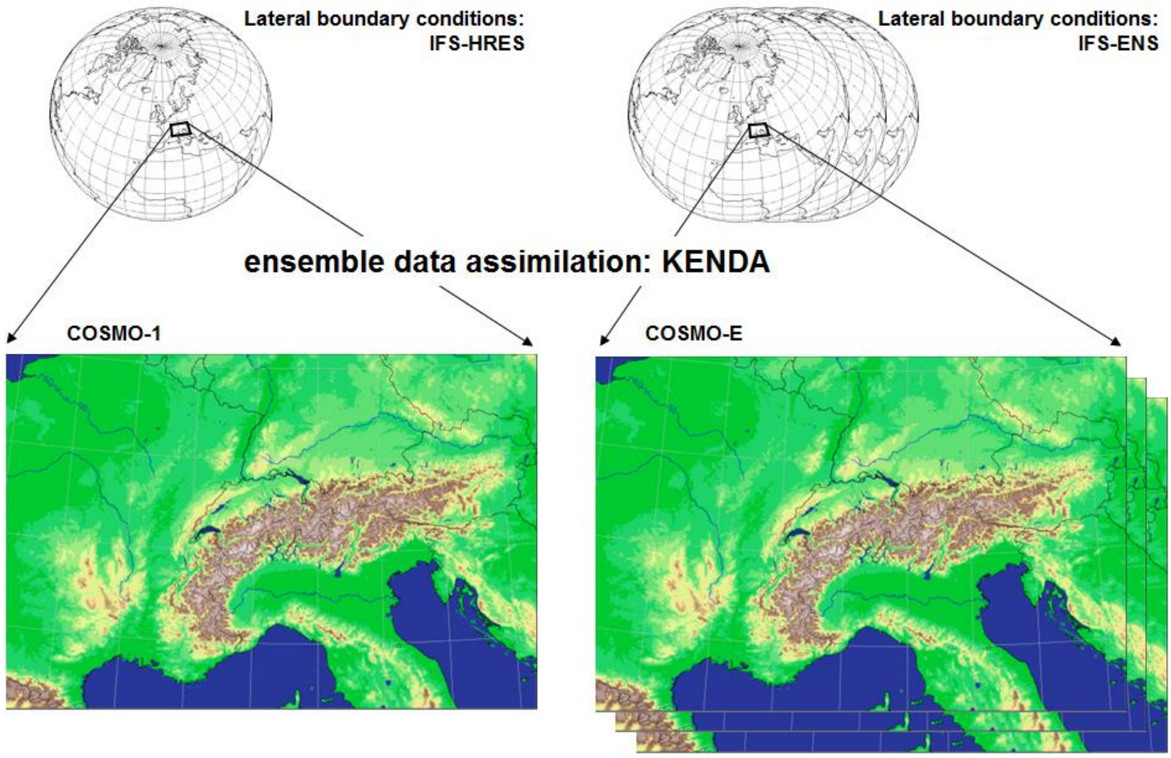
MeteoSwiss (Marco Arpagaus / COSMO-NExT development team)

COSMO-1

- Deterministic forecast with very high spatial resolution (1.1 km mesh-size) for Alpine area
- Initial conditions (ICs) from a continuous 1 km nudging assimilation cycle
- Lateral boundary conditions (LBCs) from ECMWF IFS-HRES;
  Forecasts are initialised every 3 hours, with a lead-time of +33 hours

COSMO-E

- Ensemble forecasts with convection-permitting resolution (2.2 km mesh-size) for Alpine area
- 20 members plus control run
- Initial conditions (ICs) and IC perturbations from KENDA (see below)
- Lateral boundary conditions (LBC) and LBC perturbations from ECMWF IFS-ENS
- Stochastically Perturbed Physics Tendencies (SPPT) to represent parameterization uncertainties
- Forecasts are initialised at 00 UTC and 12 UTC, with a lead-time of +120 hours



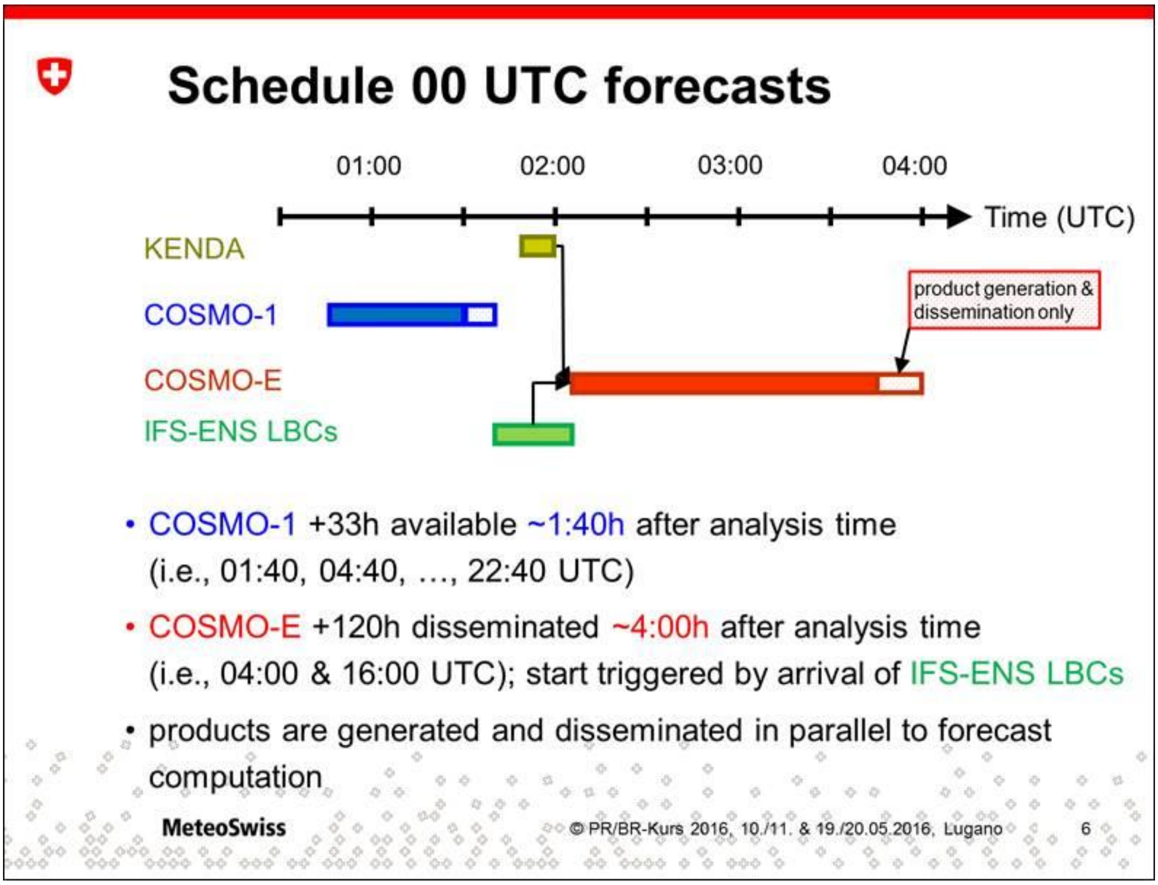
KENDA (Km-scale Ensemble Data Assimilation) Facts

- New ensemble data assimilation system based on the Local Ensemble Transform Kalman Filter (LETKF)
- Quasi-optimal and flow-dependent combination of observations and model forecasts based on error statistics
- Provides ensemble initial conditions for COSMO-E.
- Assimilated information: Conventional observations such as TEMPS, SYNOP, AMDAR, WINDPROFILER, SHIPS, and BUOYS.

COSMO: Model Setup for COSMO-1 / COSMO-E

- COSMO V5.0 with many extensions; GPU / CPU-version
- Runge-Kutta, 10s / 20s time-step
- parameterisations
  - radiation (Ritter & Geleyn)
  - turbulence and surface layer transfer (Raschendorfer)
  - microphysics (Doms & Seifert; rain, snow, graupel)
  - shallow convection (adapted from Tiedtke)
  - soil (TERRA, Schrodin & Heise)

The production scheme of the COSMO-1 and COSMO-E models is visualized in the following figure:



Differences between COSMO-DE-EPS and COSMO-DE

Besides the obvious differences in mesh-size (1.1 km for COSMO-1, 2.2 km for COSMO-E and 2.8 km for COSMO-DE-EPS and COSMO-DE) and domain-size, the four models are all based on COSMO and hence fairly similar in the model setup. The biggest differences certainly are the different initial (COSMO-E uses a KENDA analysis, whereas COSMO-1 still uses a nudging assimilation scheme similar to the one employed for COSMO-DE) and lateral boundary conditions (COSMO-E and COSMO-1 use the IFS-ENS and IFS-HRES, respectively) and a newer set of external parameters. For the two ensemble systems, an additional important difference is that COSMO-E uses an SPPT (Stochastically Perturbed Physics Tendencies) scheme to represent model error, whereas the COSMO-DE-EPS uses varying model physics parameters ("perturbed parameters").

Visualizations at the ESSL Testbed 2016

The visualisations of COSMO-E and COSMO-1 provided at the ESSL Testbed 2016 are a "one-to-one copy" of the visualisation for the respective DWD models COSMO-DE-EPS and COSMO-DE, respectively.

General assessment of model performance

Besides the general assessment of COSMO-E and COSMO-1 analogously to the one of COSMO-DE-EPS and COSMO-DE, respectively, we are also interested to learn after what typical lead-time the use of the coarser ensemble predictions system COSMO-E is preferable over the use of the high-resolution but deterministic model COSMO-1, and how the COSMO-E and COSMO-1 models compare to their “twin models” COSMO-DE-EPS and COSMO-DE, respectively

3.11 European Severe Weather Database, ESWD

Pieter Groenemeijer, Thilo Kühne, Alois Holzer (ESSL)

The ESWD (Groenemeijer et al, 2004, 2009; Dotzek et al, 2009) is a dataset of severe weather reports managed by ESSL. The dataset is fed by observations from cooperating National (Hydro-)Meteorological Services, networks of voluntary observers, the general public and by ESSL itself. The following categories of severe weather are included in the ESWD at this time:

- straight-line wind gusts (v > 25 m s-1)
- tornadoes
- large hail (diameter > 2 cm; or layer > 2 cm)
- heavy precipitation
- damaging lightning strikes
- and several others

The ESWD database can be run in a *Nowcast mode* that features a map showing the reports in real-time as they are reported by its various sources. At the Testbed, the ESWD’s usefulness for both nowcasting and forecast verification purposes will be evaluated.

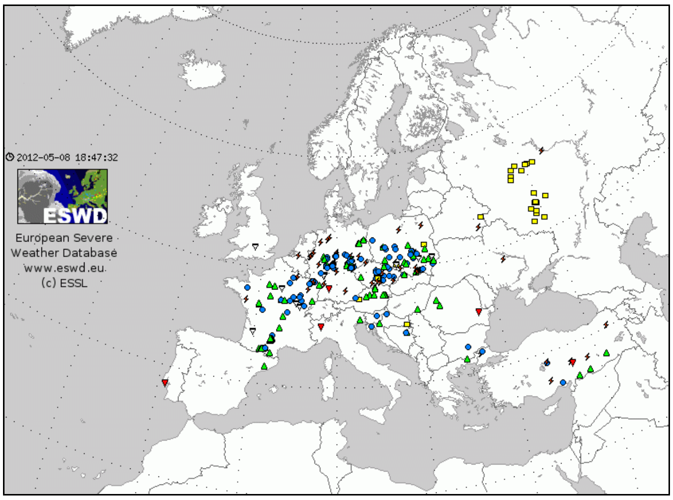


Figure: Example ESWD database display with several rain (blue), hail (green), tornado (red) and severe wind reports (yellow) plotted.

Appendix 1: List of on-site participants

As of 23 May 2016

Week 1: 6 – 10 June

Luca Nisi – MeteoSwiss, Switzerland
Anna Wieczorek – DWD, Germany
Josef Kantuzer – DWD, Germany
Marlies Kriegler – AustroControl, Austria
Lucia Hirtl-Wielke – AustroControl, Austria
Vaclav Smolka – CHMI, Czechia
Setfan Kisenhofer – ZAMG, Austria
Marcus Beyer – DWD, Germany
Rich Thompson – SPC/NOAA, USA
Alois Holzer – ESSL
Pieter Groenemeijer – ESSL
Tomas Pucik – ESSL

Week 2: 13 – 17 June

Marco van den Berge – KNMI, Netherlands
Maile Meius – EEA, Estonia
Tuomo Bergman – FMI, Finland
Jari Tuovinen – FMI, Finland
Peter Hartmann – DWD, Germany
Paul Brüser – DWD, Germany
Susanne Drechsel – ZAMG, Austria
Mike Coniglio, NSSL/NOAA, USA
Christoph Gatzen, ESTOFEX
Alois Holzer – ESSL
Pieter Groenemeijer – ESSL
Tomas Pucik – ESSL

Week 3: 27 June - 1 July

Margarida Goncalves, IPMA, Portugal
Stefan Dlhos – SHMU, Slovakia
Bodo Erhardt – DWD, Germany
Gunther Kolar – AustroControl, Austria
Ricardo Tavares – IPMA, Portugal
Michou Baart de la Faille, KNMI – Netherlands
Christian Ortner – ZAMG, Austria
Jason Selzler – VAISALA, USA
Abel Flores – MeteoCat, Catalonia, Spain
Ulrich Blahak – DWD, Germany
Charles Doswell – USA
Alois Holzer – ESSL
Pieter Groenemeijer – ESSL
Tomas Pucik – ESSL
Thilo Kühne – ESSL
Lars Tijssen - ESSL

Week 4: 4 - 8 July

Petra Mikus – DHMZ, Croatia
Virmantas Smatas – LVGMC, Lithuania
Kathrin Wapler – DWD, Germany
Joel Rominger – SRF, Switzerland
Helge Tuschy– DWD, Germany
Michael Tiefgraber – DWD, Germany
Christian Herold – DWD, Germany
Ines Wiegand – DWD, Germany
Harold Brooks – NSSL, USA
Alois Holzer – ESSL
Pieter Groenemeijer – ESSL
Tomas Pucik – ESSL
Thilo Kühne – ESSL
Lars Tijssen - ESSL

Appendix 2: Expert Lectures

Expert lectures are daily returning lectures (Tue-Thu, 30 minutes plus 15 minute question time) on a specific topic, starting after the Daily Briefing at 11:00 l.t. / 0900 UTC has ended, approximately between 11:30 and 11:45 l.t. (0930-0945 UTC). They are intended both for the audience on site and for remote participants who can follow the presentation through the Saba Meeting teleconferencing software.

Day		**Speaker**	**Topic**
Tuesday	7 June	Thomas Hengstebeck	DWD Radar products
Wednesday	8 June	Marcus Beyer	Ingredients-based Forecasting at DWD
Thursday	9 June	Rich Thompson	Anticipating Convective Mode
Tuesday	14 June	Paul James	NowcastMIX
Wednesday	15 June	Chrostoph Gatzen	Severe Wind Forecasting
Thursday	16 June	Mike Coniglio	Derechoes
Tuesday	28 June	Tomas Pucik	Storm Forecast Parameters
Wednesday	29 June	Ulrich Blahak	COSMO-DE(-EPS)
Thursday	30 June	Chuck Doswell	Doing meaningful surface analyses
Tuesday	5 July	Kathrin Wapler	DWD lightning detection products
Wednesday	6 July	Marco Arpagaus	COSMO-E and COSMO-1
Thursday	7 July	Harold Brooks	Forecast Verification