CONSORTIUM FOR SMALL SCALE MODELING

AWARE: Appraisal of "Challenging WeAther" FoREcasts

DWD: C. Marsigli, M. Hoff, G.Pante, **MCH:** D. Cattani, **HNMS:** F. Gofa, D. Boucouvala, **IMGW-PIB:** A. Mazur, J. Linkowska, G. Duniec, **RHM**: A. Bundel, A.Muraviev, E.Tatarinovich, **ARPAE:** M.S. Tesini

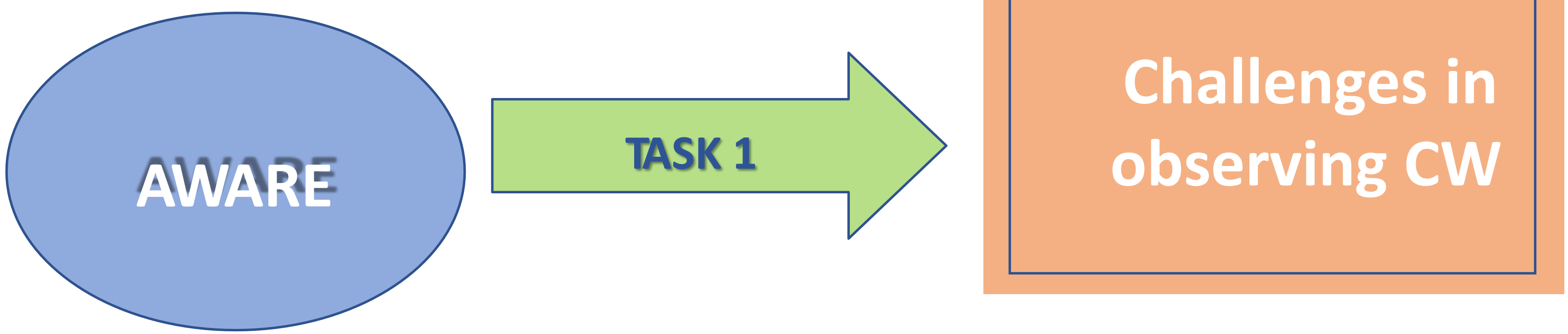
Project Period: 2019-2021

http://www.cosmo-model.org/content/tasks/priorityProjects/aware/default.htm

Focus of the study is to provide COSMO Community with an overview of forecast methods and forecast evaluation approaches that are linked to high impact weather.

Project Extension requested:

- **Short prolongation is proposed** to complete Tasks and provide the related deliverables. The requested extension is until the **end of December 2021**.
- Delays in **Tasks 1.2, 2.3, 3.3. 4.1, and 4.4**. The delays are due to partial unavailability of some contributors due to health issues and other constraints.
- Consolidation of the outcomes of the project tasks will be made during the extension period to provide the **Executive Summary** of the project. Final project **technical report** will be delivered at the new deadline.
- The deliverable reports are available on the PP AWARE web page on the COSMO web site (http://www.cosmo-model.org/content/tasks/priorityProjects/aware/default.htm).
- Unused FTEs from the main project period will be relocated to the extension period of the project. **No additional FTEs are requested. The total resources are equivalent to 0.45 FTE.**



Task 1.1 Overview of CW/HIW observational data sources characteristics
Review of non conventional observations and their use in verification

STATUS: Completed , presented during ICCARUS

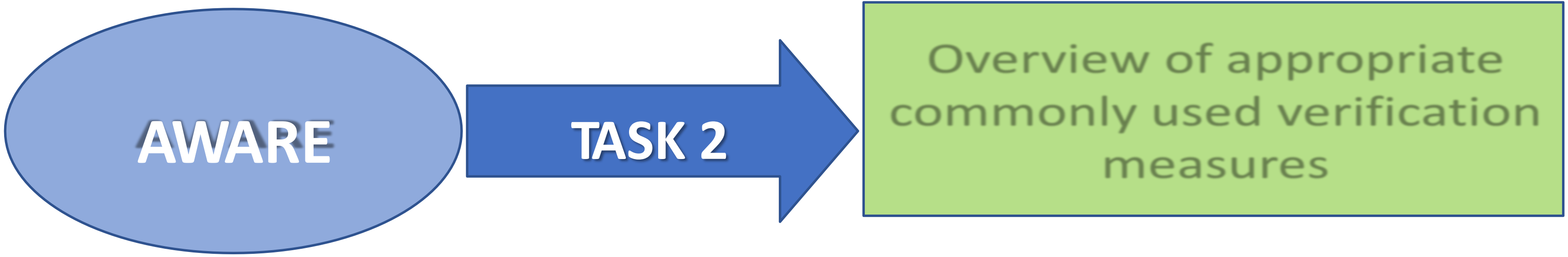
Final report was prepared based based also on paper (https://nhess.copernicus.org/articles/21/1297/2021/nhess-21-1297-2021.html)

Task 1.2. Approaches to introduce observation uncertainty - 0.05 FTEs
for observation uncertainty (e.g., CRPS adapted for observation ensemble).

FTEs remaining: 0.02 A. Bundel

STATUS: Task delayed

Practical implementation: spatial scores using the radar precipitation data and nowcasting zero step data as reference are planned. Extension without additional FTEs is required to finish the task by the end of year 2021.



Task 2.1 Survey for assessment of proper verification of phenomena 0.35FTEs
Comparison and judgment whether continuous or discrete methods may/should be applied.
STATUS: Completed. Pending Revision of Report: with applicability of recommended methods and suggestions for parameters to account for flash rate derived from forecast data.

Task 2.2 Role of SEEPS and EDI-SEDI for the evaluation of extreme precipitation forecasts - 0.25FTEs
STATUS: Completed. *Final Report available on COSMO web*

Task 2.3 Extreme Value Theory (EVT) approach- Fitting precipitation object characteristics to different distributions - 0.3FTEs
FTEs remaining: 0.0
STATUS: Completed. Pending Final Report. *To be submitted by the end of project extension.*

Task 2.3 Extreme Value Theory (EVT) approach - Fitting precipitation object characteristics to different distributions

Verification of large contiguous precipitation areas using Generalized Pareto distribution

<u>Results</u>

Anatoly Muraviev, Anastasia Bundel
RHM

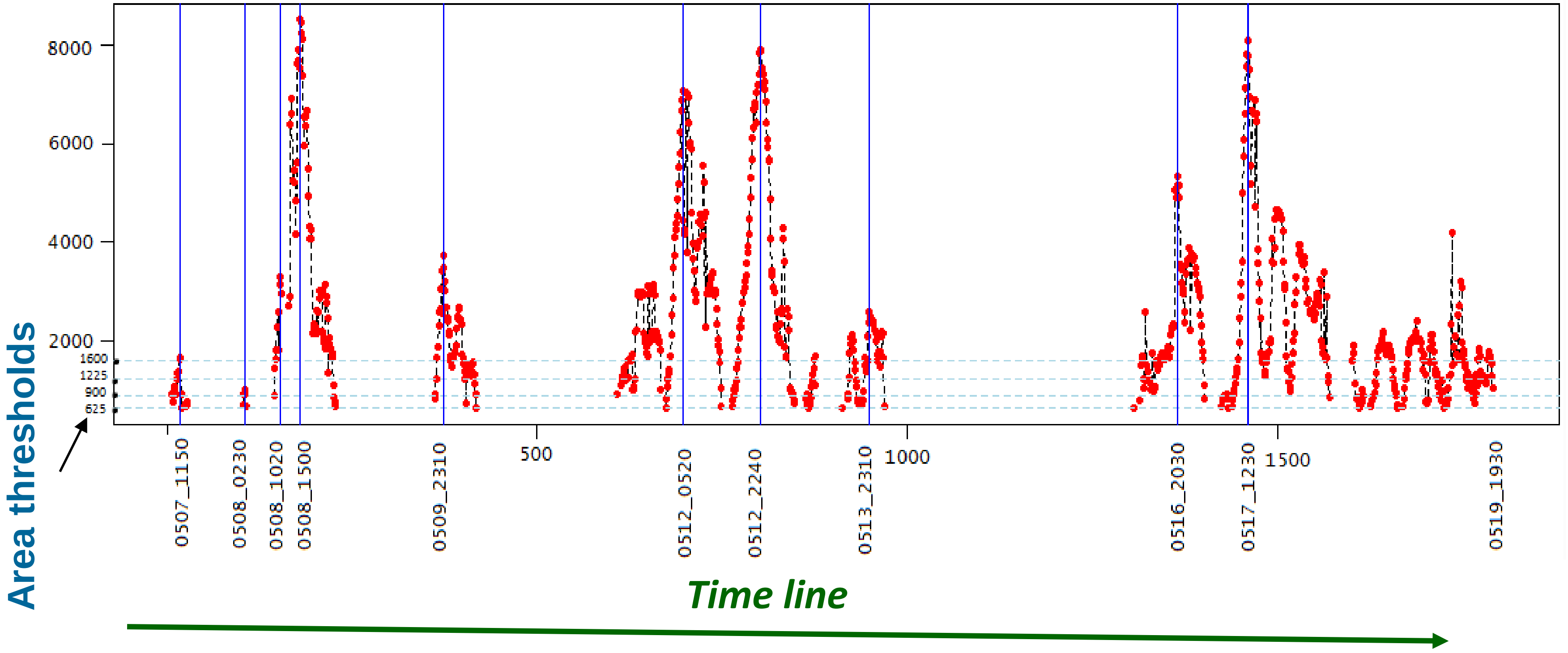
FTE 0.3, Start 09.2019 – End 08.2020

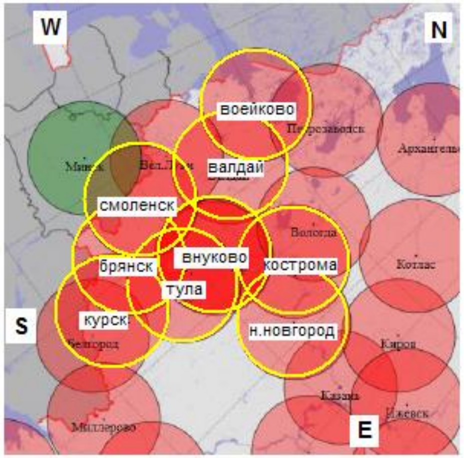
Finished. Report under preparation

Peaks over threshold (PoT) model for the area size

Maximum areas of objects in Kursk radar fields from 5 to 19 May 2017.

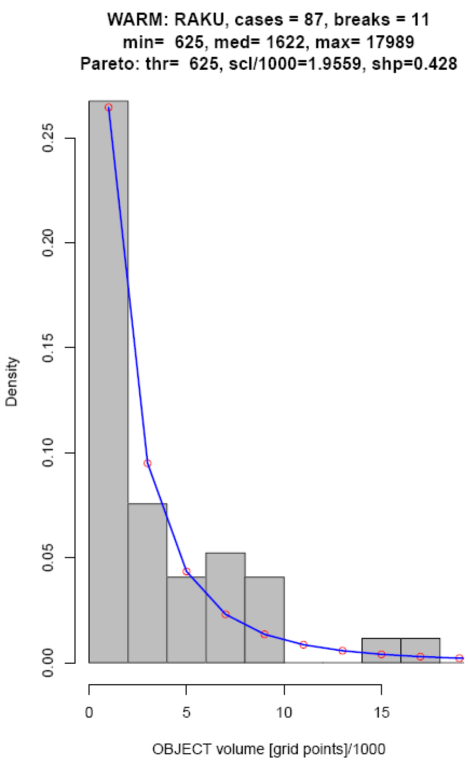
Blue lines indicate times of maximum areas within a precipitation situation for area threshold of 625 contiguous grid points

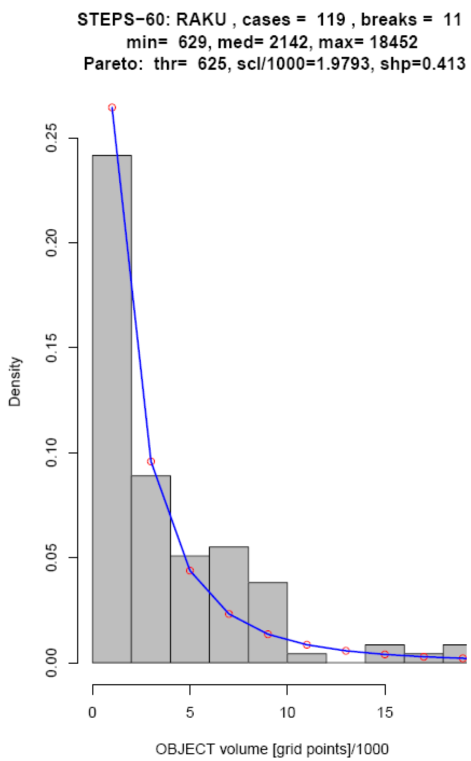




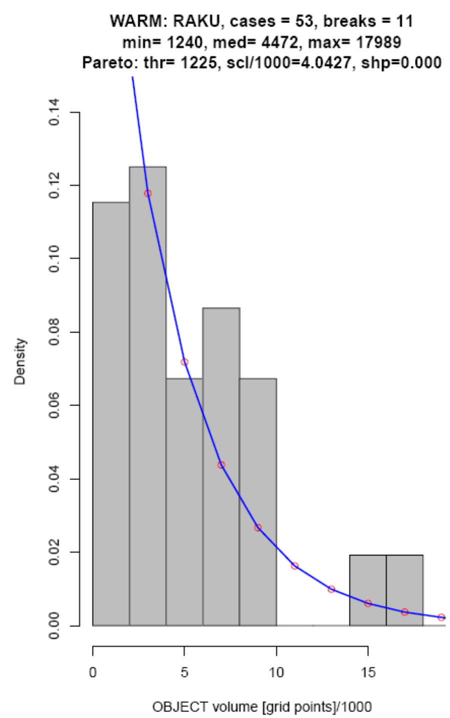
Radars under study: Yellow circles

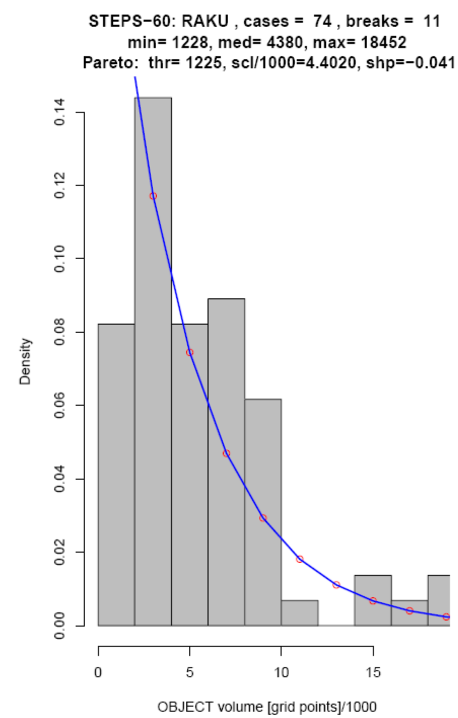
Fitting the distribution of precipitation object areas (histograms) to Generalized Pareto distribution (blue line), warm period, Kursk radar, lead time 60 min





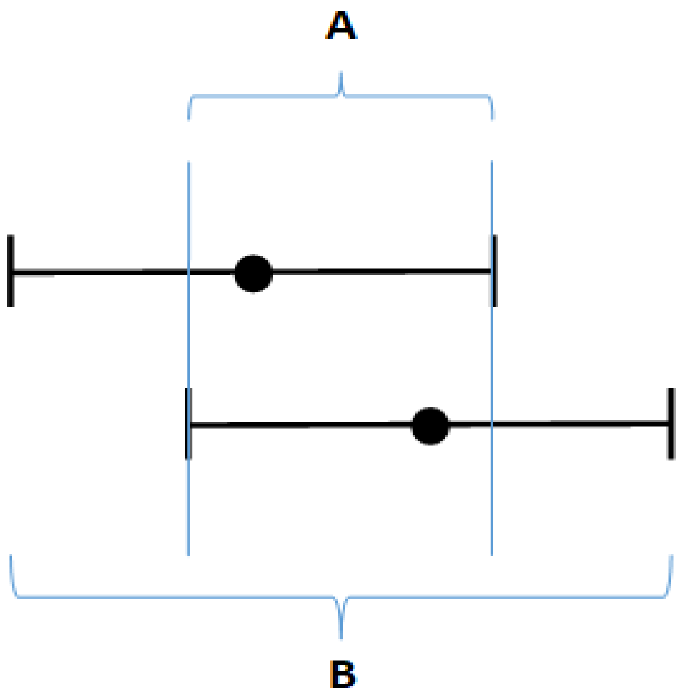
For area threshold of
625 grid points (~50*50 km)





For area threshold of
1225 grid points (~70*70 km)

A measure of STEPS quality: intersection ratio of confidence intervals of Generalized Pareto parameters estimates (σ and ξ) in STEPS and in observations (radars)



intersection ratio (IR) = A/B

Ideal intersection ratio = 100%

IR >= 50% : choosen empirically as a useful skill level

The intersection ratio gives a diagnostic estimate of model ability to reproduce vast contiguous precipitation areas (or other extremes)

Summary table with shape (ξ) parameter intersection ratio, %

Negative ξ indicates β-distribution, zero ξ: exponential distribution, and positive ξ: Pareto itself.

Positive shape parameter ξ indicates heavy tail in the Pareto distribution, the higher ξ, the heavier the tail (probability of largest precip areas here)

(+/-) indicate ξ sign in the observations/forecast distribution pairs,

0 indicates ξ in the interval [-0.1, 0.1]

*** : not enough cases

A desirable quality of a forecast system is to reproduce the sign of shape parameter

RADAR		*CI intersection (%).* SHAPE							
		Warm period				*Cold period*			
	Lead\ Thresh	625	900	1225	1600	625	900	1225	1600
RAKU	30	84 (+ +)	74 (+ +)	55 (0 +)	69 (- -)	78 (+ +)	47 (0 +)	79 (0 0)	90 (0 0)
	60	85 (+ +)	76 (+ +)	76 (0 0)	60 (- -)	68 (+ +)	44 (0 +)	78 (0 0)	64 (0 -)
	90	83 (+ +)	76 (+ +)	73 (0 0)	39 (- -)	54 (+ +)	33 (0 +)	50 (0 +)	97 (0 0)
	120	80 (+ +)	72 (+ +)	73 (0 0)	47 (- -)	54 (+ +)	23 (0 +)	45 (- +)	82 (0 0)
RATL	30	74 (+ +)	41 (0 +)	78 (0 0)	48 (+ 0)	78 (+ +)	87 (+ +)	91 (+ +)	38 (0 +)
	60	72 (+ +)	36 (0 +)	79 (0 0)	47 (+ 0)	69 (+ +)	71 (+ +)	87 (+ +)	81 (0 0)
	90	66 (+ +)	32 (0 +)	48 (0 +)	46 (+ 0)	67 (+ +)	69 (+ +)	82 (+ +)	95 (0 0)
	120	65 (+ +)	34 (0 +)	44 (0 +)	43 (+ 0)	68 (+ +)	73 (+ +)	83 (+ +)	85 (0 0)
RAVO	30	78 (+ +)	40 (0 +)	79 (0 0)	74 (0 0)	76 (+ +)	71 (+ +)	73 (+ +)	80 (+ +)
	60	76 (+ +)	36 (0 +)	78 (0 0)	69 (0 0)	72 (+ +)	67 (+ +)	65 (+ +)	71 (+ +)
	90	77 (+ +)	38 (0 +)	82 (0 0)	73 (0 0)	66 (+ +)	63 (+ +)	60 (+ +)	65 (+ +)
	120	69 (+ +)	34 (0 +)	42 (0 +)	76 (0 0)	64 (+ +)	60 (+ +)	58 (+ +)	60 (+ +)
RUDB	30	93 (+ +)	91 (+ +)	94 (+ +)	90 (+ +)	72 (+ +)	72 (+ +)	65 (+ +)	37 (0 +)
	60	91 (+ +)	92 (+ +)	95 (+ +)	88 (+ +)	60 (+ +)	64 (+ +)	60 (+ +)	37 (0 +)
	90	92 (+ +)	94 (+ +)	96 (+ +)	89 (+ +)	56 (+ +)	57 (+ +)	54 (+ +)	33 (0 +)
	120	89 (+ +)	92 (+ +)	94 (+ +)	89 (+ +)	55 (+ +)	56 (+ +)	52 (+ +)	32 (0 +)
RUDK	30	80 (+ +)	79 (+ +)	38 (0 +)	83 (0 0)	75 (+ +)	70 (+ +)	72 (+ +)	***
	60	75 (+ +)	74 (+ +)	39 (0 +)	79 (0 0)	64 (+ +)	64 (+ +)	61 (+ +)	***
	90	76 (+ +)	74 (+ +)	43 (0 +)	72 (0 0)	60 (+ +)	57 (+ +)	52 (+ +)	***
	120	74 (+ +)	73 (+ +)	41 (0 +)	79 (0 0)	56 (+ +)	53 (+ +)	49 (+ +)	***
RUDL	30	80 (+ +)	76 (+ +)	78 (+ +)	41 (0 +)	72 (+ +)	71 (+ +)	72 (+ +)	79 (+ +)
	60	76 (+ +)	73 (+ +)	73 (+ +)	36 (0 +)	64 (+ +)	63 (+ +)	60 (+ +)	63 (+ +)
	90	73 (+ +)	69 (+ +)	70 (+ +)	36 (0 +)	62 (+ +)	61 (+ +)	59 (+ +)	67 (+ +)
	120	74 (+ +)	70 (+ +)	69 (+ +)	28 (0 +)	59 (+ +)	57 (+ +)	55 (+ +)	58 (+ +)

Summary

Object-based verification of RHM nowcasting system is performed. The verification period is May-Sep 2017 and Nov-March2017-2018, for seven radars in Central Russia.

The ability of the system to forecast contiguous precipitation areas greater than a certain threshold (peaks over threshold method) is assessed. Several thresholds were studied.

Generalized Pareto distribution is used to assess precipitation areas in distribution tails according to the shape parameter. The best fit of Pareto distribution corresponds to the area threshold of 625 points (~50*50 km).

A measure of STEPS quality is introduced: intersection ratio of confidence intervals of Generalized Pareto parameters (σ and ξ) estimates in STEPS and in observations (radars). It gives a diagnostic estimate of model ability to reproduce vast contiguous precipitation areas (or other extremes).

A paper "Evaluation of radar nowcasting of large precipitation areas using the Generalized Pareto distribution **under preparation"**

AWARE → TASK 3 → **Verification applications with spatial methods**

Task 3.1 Verification of forecasts of intense convective phenomena - 0.5FTEs
Report on the verification approach, recommendations and considerati
STATUS: ***Completed,*** ***Pending Report Revision*** with the analysis on thermodynamical indices. *First draft report available on COSMO web*

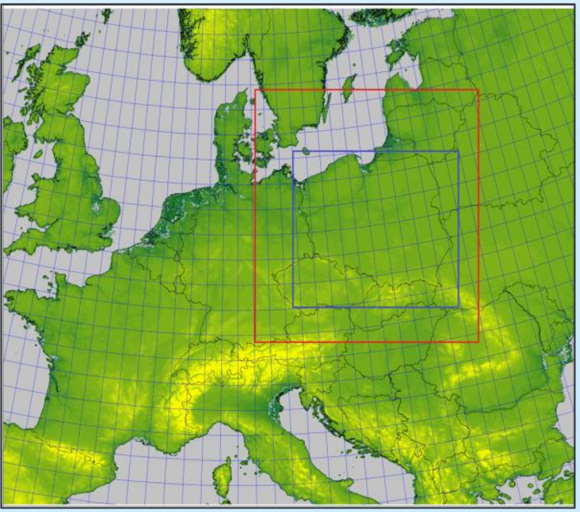
Task 3.2 Lightning potential index (LPI) in mountain regions
Integration in the operational chain of COSMO-1, and COSMO-E, Tests of the flash conversion rate LPI to flash numbers
STATUS: ***Completed.*** *Final Report available on COSMO web*

Task 3.5 LPI verification and correlation of convective events with microphysical and thermodynamical indices - 0.3FTEs
STATUS: ***Completed, Pending Final Report.*** *To be submitted until Sept 2021*

Flashrate verification – parameterisations

Four parameterisations of lightning intensity used

1. CAPE-based with cloud top/bottom temperatures correction
2. Lightning Potential Index (LPI) (cf. U. Blahak, X.Lapillonne, D. Cattani)
3. ~Combination of the two above (cf. P. Lopez, D. Cattani)
4. Graupel flux at -15°C level/total ice mass (cf. J. Wilkinson)



1)

$$W = 0.3 \cdot \sqrt{2 \cdot CAPE}$$

$$FR = \left(\frac{W}{14.66}\right)^{4.54}$$

$$\text{if} \quad CTT > -15°C \quad FR = FR \cdot \left[\max\left(\frac{-CTT}{15}, 0.01\right)\right]$$

$$\text{if} \quad CBT < -5°C \quad FR = FR \cdot \left[\max\left(\frac{CBT+15}{10}, 0.01\right)\right]$$

2)

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

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

$$q_L = q_c + q_r$$

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

3)

$$f_T = \alpha\, Q_R \sqrt{CAPE}\, \min(z_{base}, 1.8)^2$$

$$Q_R = \int_{z0}^{z-25} q_{graup}\,(q_{cond} + q_{snow})\,\bar{\rho}\, dz$$

Zbase - the convective cloud base height

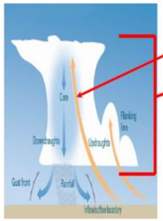
4) Met Office

McCaul et al (2009) Lightning parametrization
(Weather and Forecasting)

$$F = 0.95F_1 + 0.05F_2$$

$$F_1 = 0.042 w q_g(-15°C)$$

$$F_2 = \int \rho(q_i + q_s + q_g)dz$$



In words
Number of lightning flashes is:
- 95% due to the upward flux of graupel (soft hail) at -15 Celsius level; and
- 5% due to the total ice mass (ice+snow+graupel) in the column.

Institute of Meteorology and Water Management – National Research Institute;
COSMO General Meeting 2021

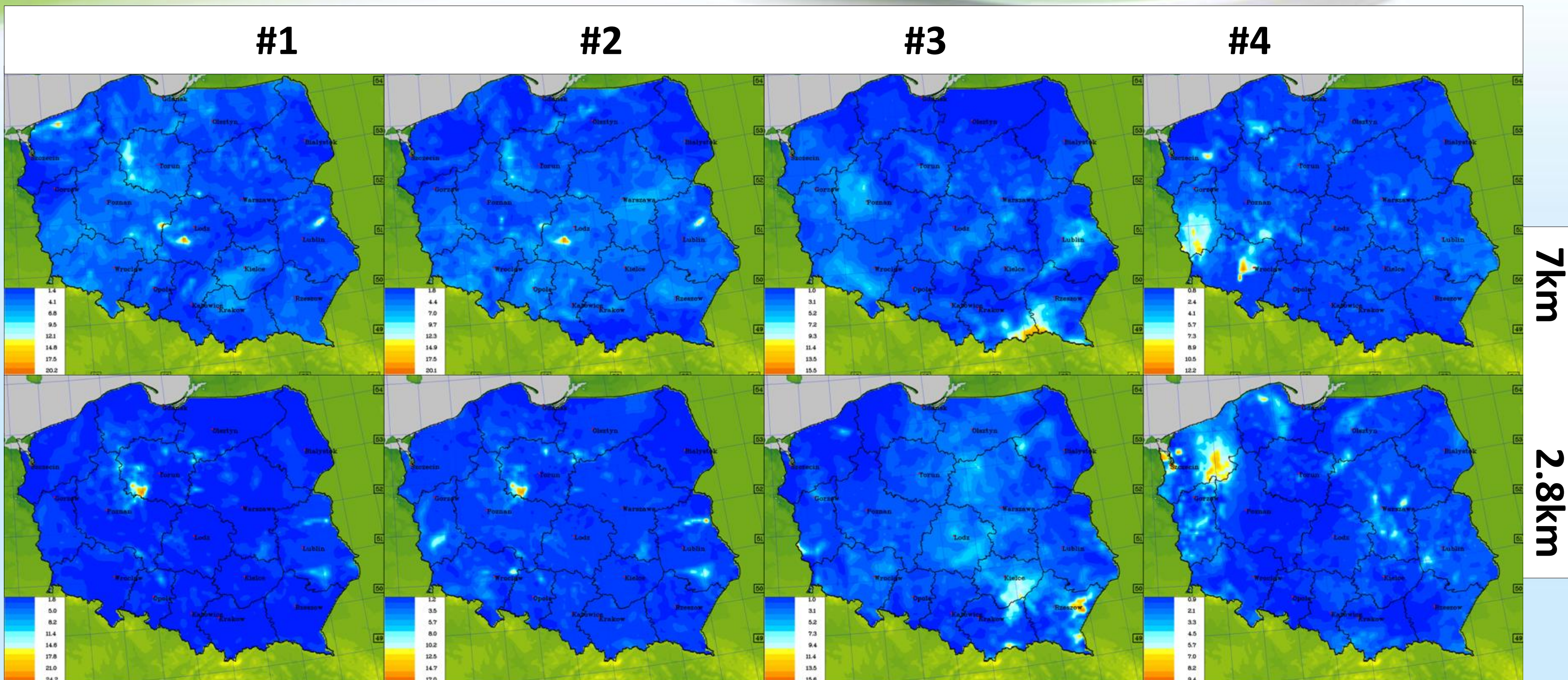
Andrzej Mazur,
Joanna Linkowska

Flashrate discrete verification – parameterisations (summer 2020)

	7km resolution						
Par.	**EQS**	**FAR**	**FBI**	**PFD**	**POD**	**SUC**	**THS**
#1	0.051	0.830	1.911	0.118	0.198	0.170	0.093
#2	0.056	0.853	2.730	0.159	0.264	0.147	0.103
#3	0.030	0.906	3.495	0.155	0.219	0.094	0.068
#4	0.030	0.883	2.720	0.174	0.237	0.117	0.083

	2.8km resolution						
Par.	**EQS**	**FAR**	**FBI**	**PFD**	**POD**	**SUC**	**THS**
#1	0.084	0.823	2.337	0.126	0.386	0.176	0.140
#2	0.095	0.798	1.607	0.098	0.343	0.203	0.145
#3	0.075	0.837	2. 435	0.161	0.429	0.163	0.127
#4	0.067	0.863	2.645	0.134	0.375	0.137	0.110

Flashrate continuous verification – parameterisations (summer 2020)



RMSE, mean values

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Icons production pipeline

New methodology

Data4web 4.0 in production since 27.04.2021

LPI $[J/kg]$ → Conversion → **LD** $\left[\frac{Flashes}{km^2h}\right]$ → Data4web

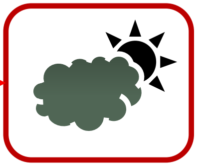
One instantaneous value per hour on --:00

Value with a validity on one hour

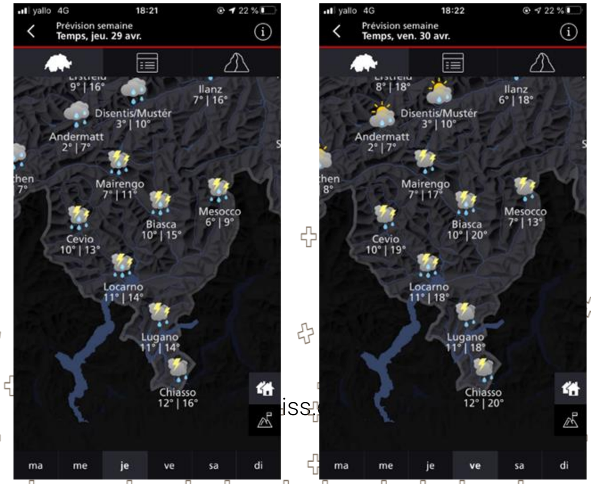
Prediction

Probability > threshold

Probability < threshold



Data4web 4.0 in production since 27.04.2021



Daniel Cattani, **Benoît Pasquier, Luca Schwaller**, Lionel Moret, Mathieu Schaer

Lightning Potential Index (LPI)

LPI at each gridpoint: $LPI = f_1 f_2 \frac{1}{H_{-20°C} - H_{0°C}} \int_{H_{0°C}}^{H_{-20°C}} \epsilon \, \omega^2 \, g_{(\omega)} \, dz$

f_1 Neighborhood maximal **updraft based** filter, ≠ 0 if the majority of the neighbour grid cells (~10×10km2) have a maximal updraft velocity exceeding 1.1 ms^{-1}

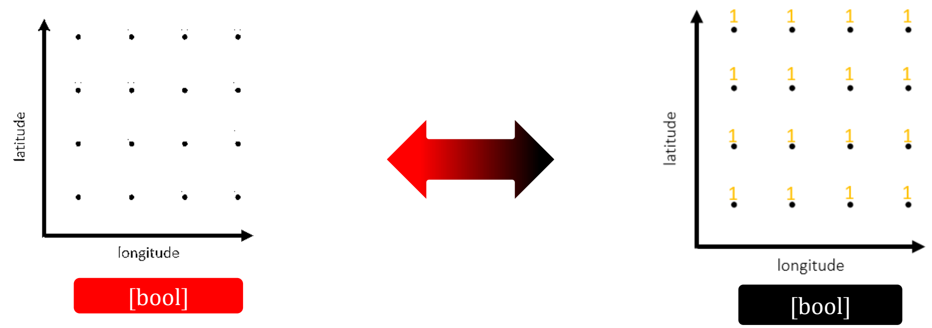
f_2 A neighborhood column **stability based** filter for pruning LPI with regard to graupel formation regions of intense orographic wave related clouds, where lightning activity does not develop.
≠ 0 if the neighbour (~20×20km2) grid cells all have an average of the vertically integrated buoyancy of more than −1500 Jkg^{-1}

$g_{(\omega)}$ Velocity based filter function within the column, , ≠ 0 if $\omega < 0.5$ ms^{-1}

Observations – LPI comparison

Instantaneous value of LPI at every hour that is above a threshold

Gridpoints where there is at least one flash during one hour



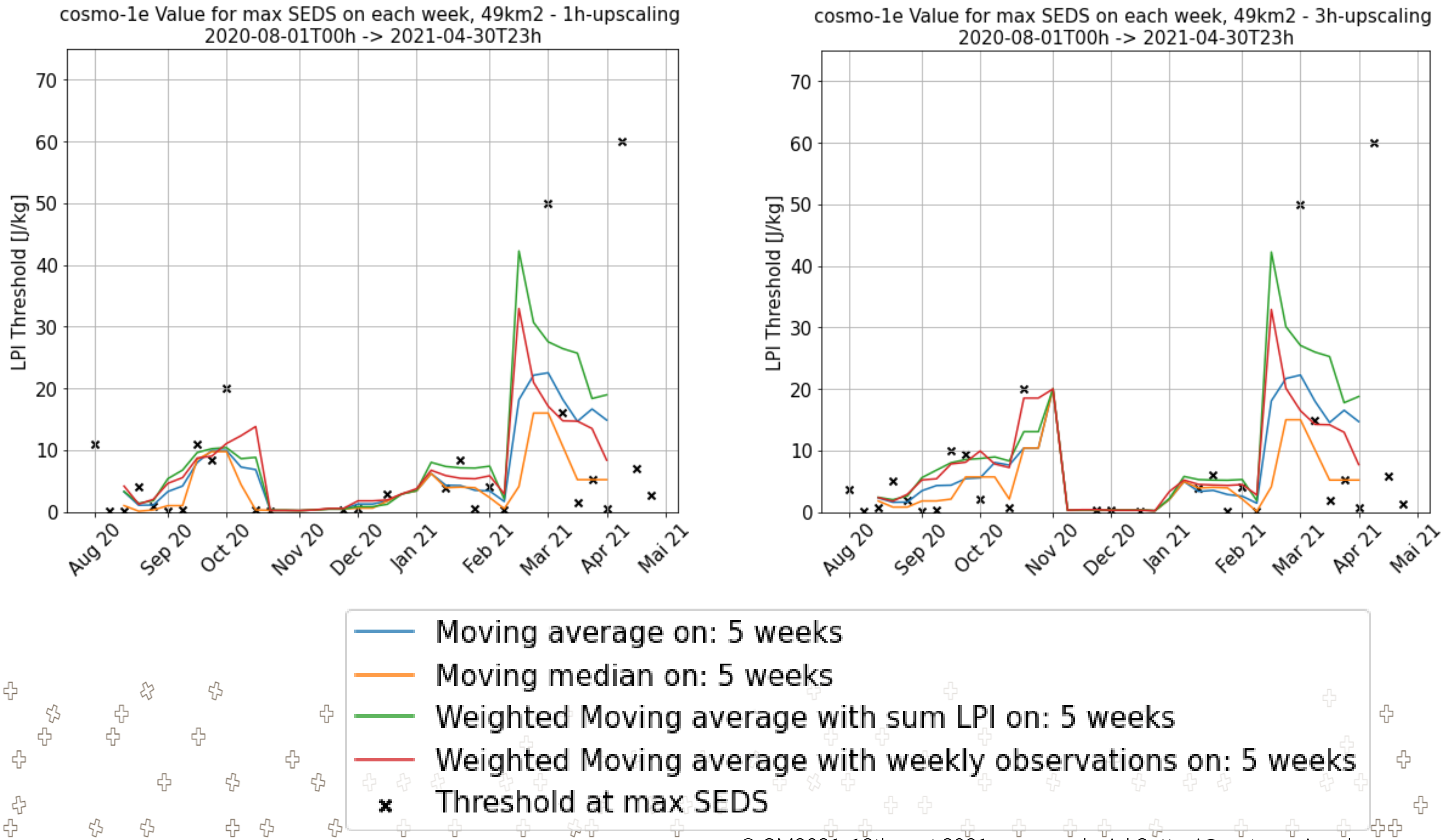
$$SEDS = \frac{\ln q - \ln H}{\ln p + \ln H}$$

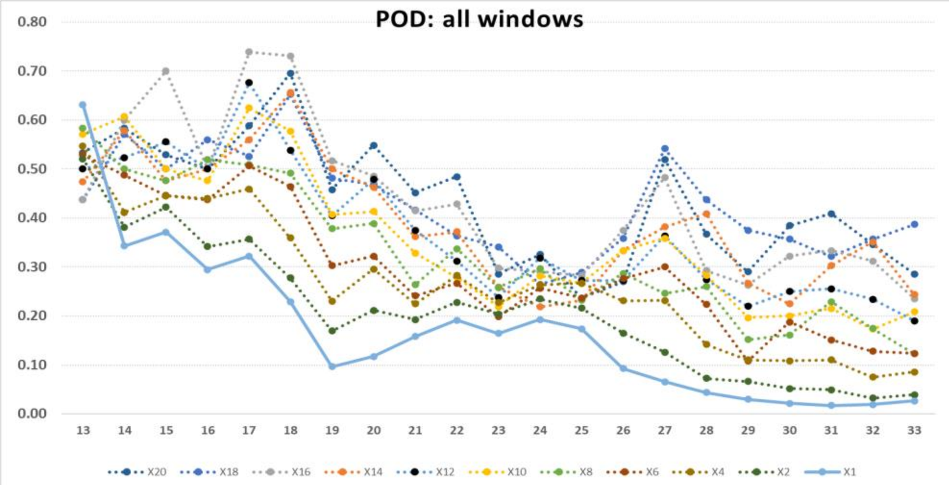
Observations\Predictions	Flash	No Flash
Flash	True Positives (HIT)	False Negatives (MISS)
No Flash	False Positives (False alarm)	True Negatives (correct rejection)

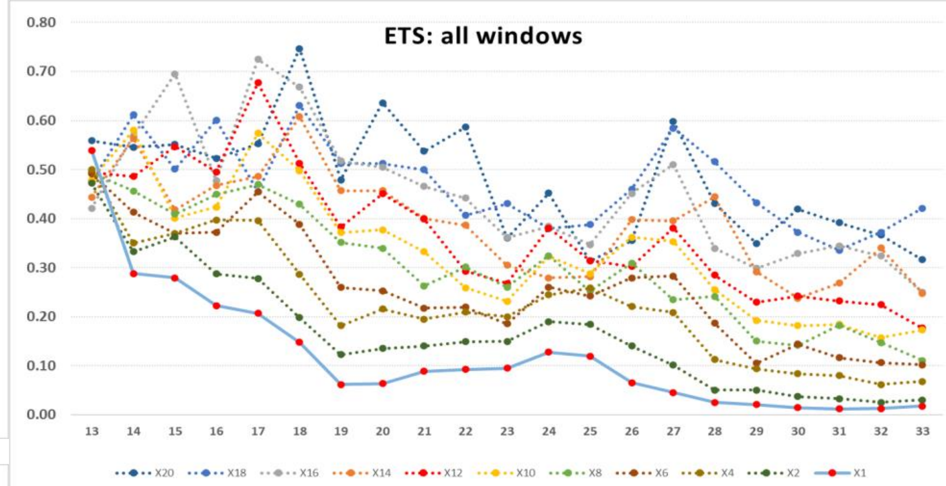
p = (*hits+misses*)/*total* is the base rate (climatology),
q = (*hits+false alarms*)/*total* is the frequency with which the event is forecast,
H = the probability of detection.

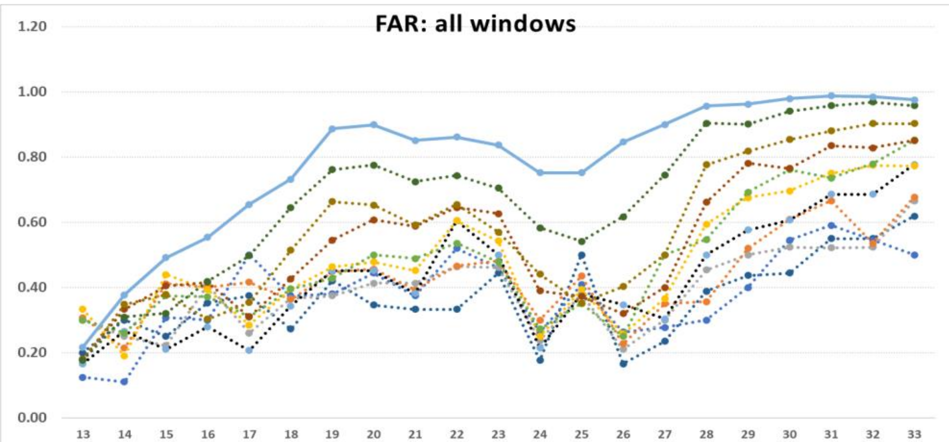
Scores 0 for a hedged forecast and 1 for a perfect forecast.

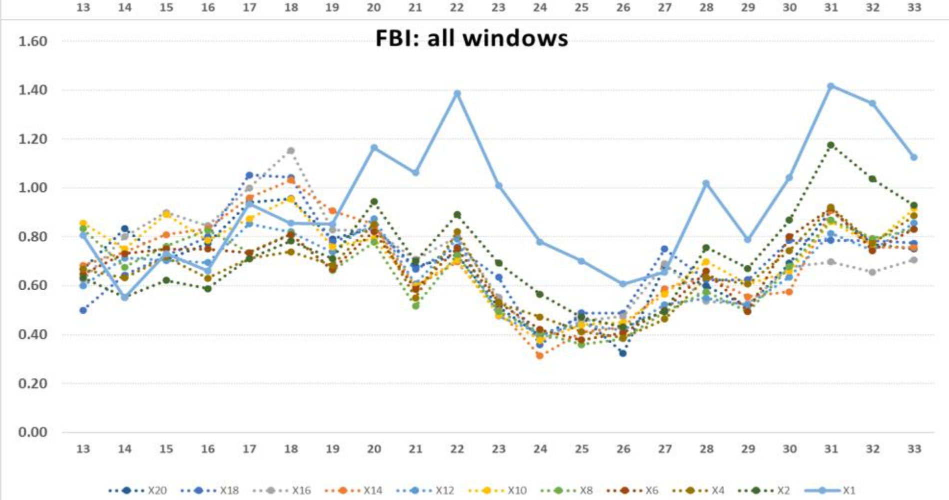
Results: weekly values, COSMO-1E











Test Case III

Even original resolution exhibits skill

POD: skill reduces with lead time

FAR: For resolution >10x0.04~40km skill steadily good

FBI: small underestimation in all upscaled grids

ETS: performance increases linearly with window size. For windows higher than 40km good forecast skill

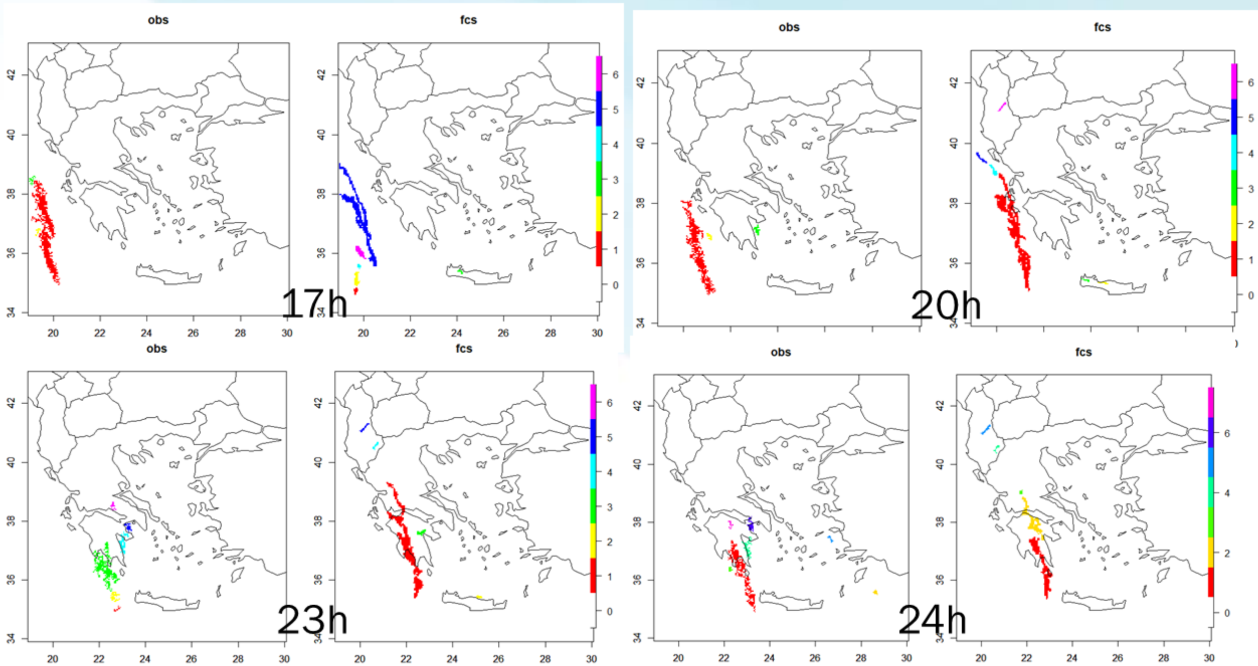
LPI verification and correlation of convective events with microphysical and thermodynamical indices

F. Gofa, D. Boucouvala

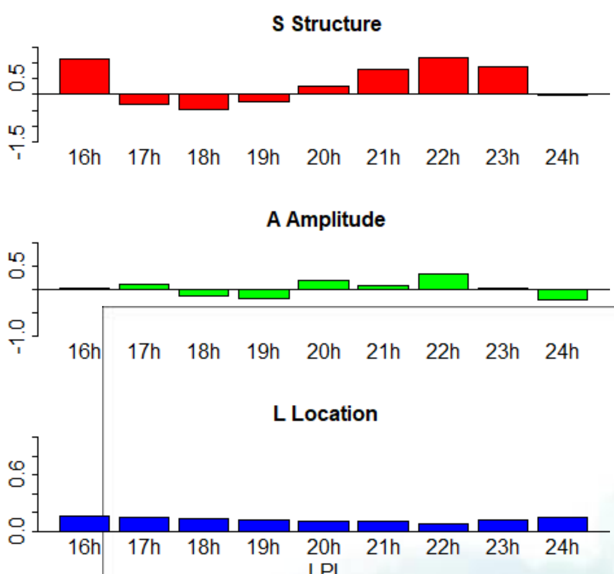
ΕΘΝΙΚΗ ΜΕΤΕΩΡΟΛΟΓΙΚΗ ΥΠΗΡΕΣΙΑ
HELLENIC NATIONAL METEOROLOGICAL SERVICE

Test Case III

F. Gofa, D. Boucouvala, J. Samos



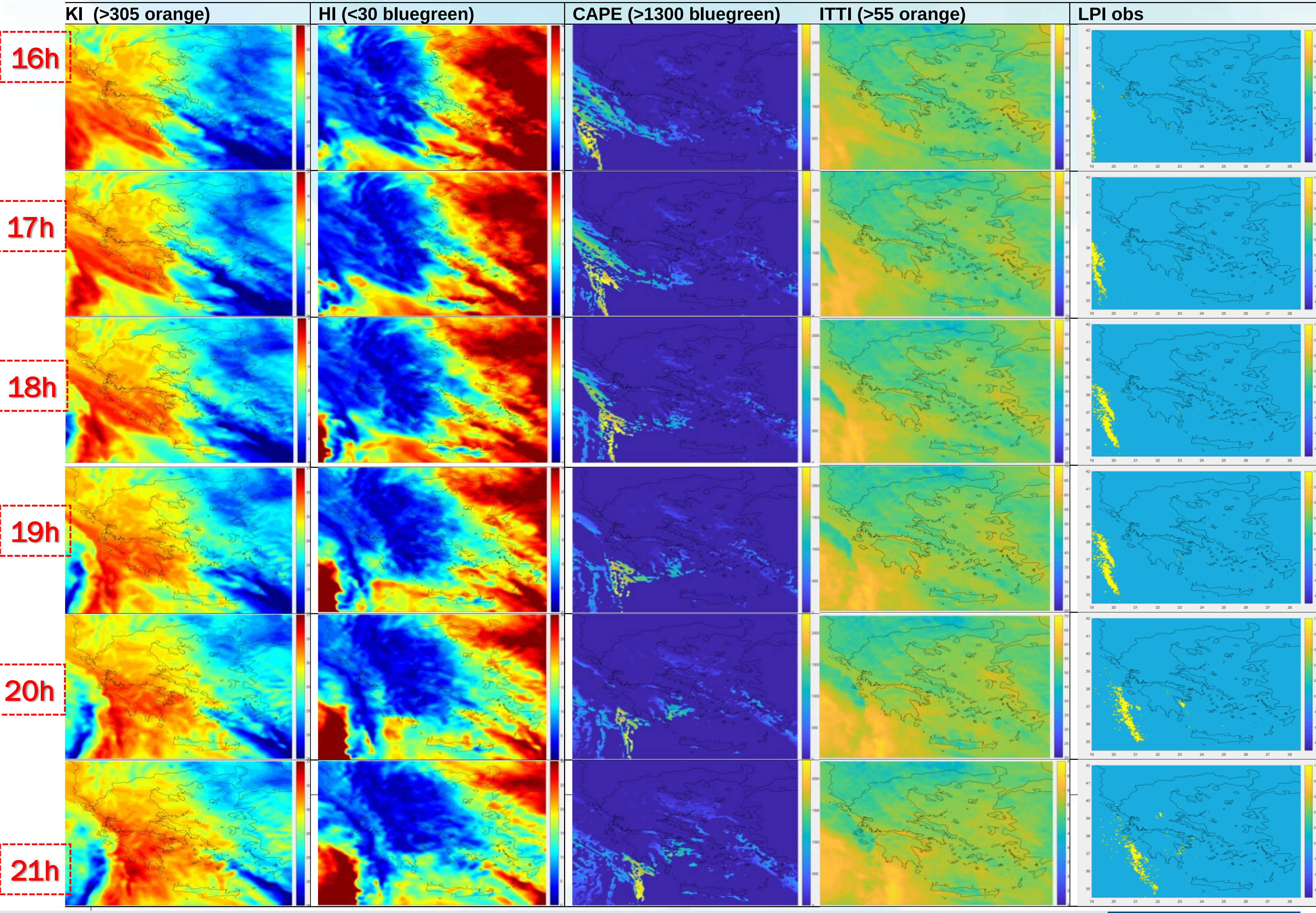
24/11/19 Observed and forecasted objects during the passage of the front



The **S values** are variable with time model predicting more widespread objects in the beginning and around the end of the forecast time.

The **A absolute values** are less than 0.5 and the total LPI is satisfactorily predicted (slightly over forecasted mainly 20-23h).

The **L parameter** is low (around 0.2) and shows good agreement on the location of objects in respect to the observed.



Test Case III: Thermodyamical indices vs. obs lightning

ΕΘΝΙΚΗ ΜΕΤΕΩΡΟΛΟΓΙΚΗ ΥΠΗΡΕΣΙΑ
HELLENIC NATIONAL METEOROLOGICAL SERVICE

AWARE → TASK 3 → Verification applications with spatial methods

Task 3.4 DIST methodology tuned on high-threshold events for flash floods forecast evaluation - 0.1FTEs

Verification of average values of precipitation over catchment areas to investigate the ability of models in reproducing different amounts of precipitation.

STATUS: ***Completed.*** *Final Report available on COSMO web*

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Task 3.6 Work on the comparative verification of NWC and NWP results using spatial verification methods as part of the SINFONY project at DWD 0.16FTEs

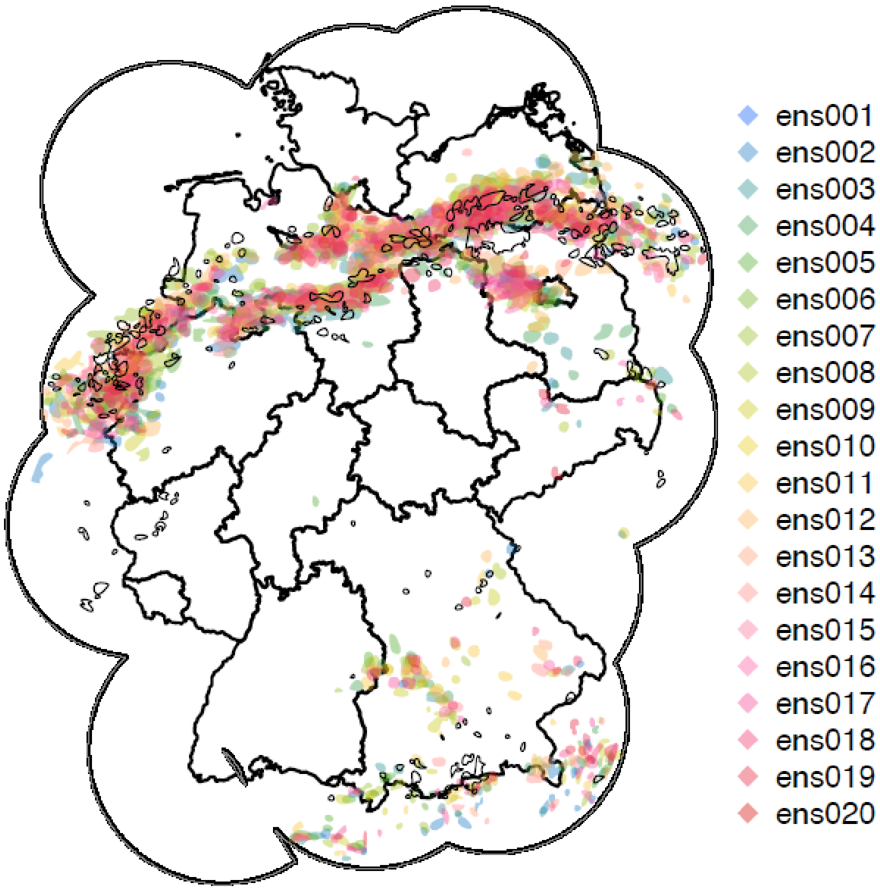
STATUS: ***Completed.*** *Final Report available on COSMO web*

SINFONY project

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

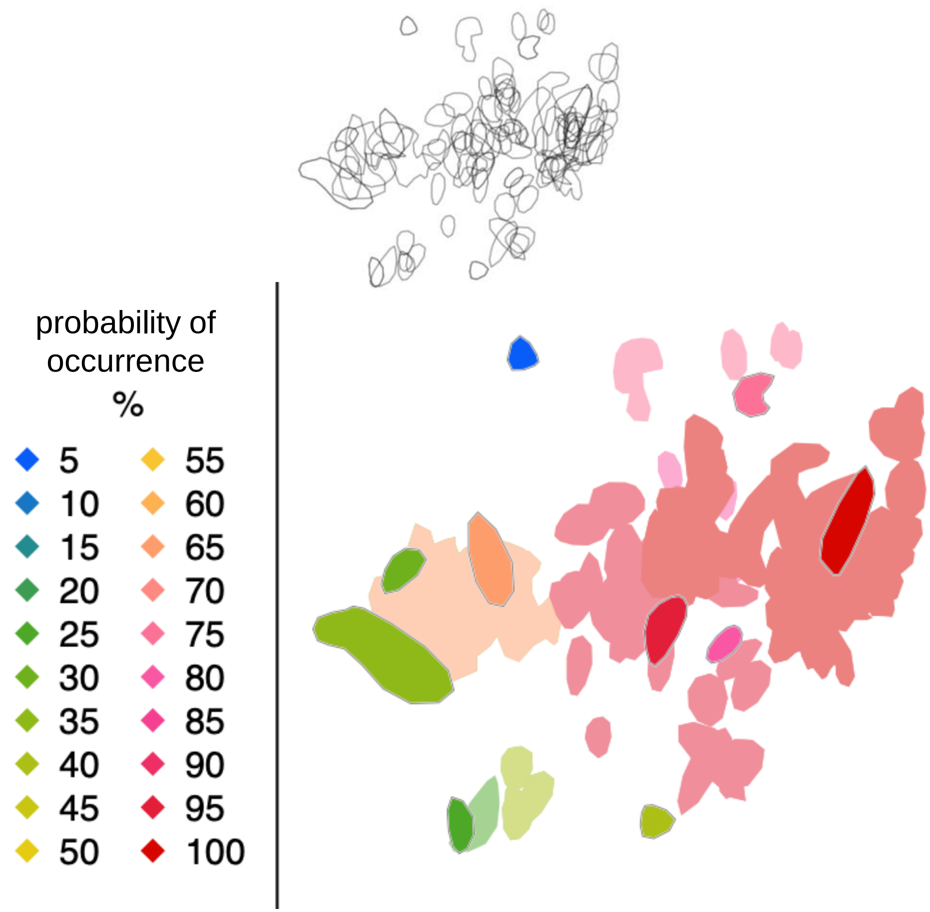
- Seamless INtegrated FOrecastiNg sYstem
- Here: „seamless“ = „from minutes to hours“
- Aim: Development of a coupled probabilistic system consisting of precipitation nowcasting and short-range numerical weather prediction (+12 h) on the convective scale

- SINFONY-RUC (Rapid Update Cycle)
  - Hourly initialization of ICON-D2-EPS (20+1 members) + 8 hours lead time
  - 2-moment microphysics
  - Running since June 2021
- Object-based verification of features from KONRAD3D cell detection tool of observed radar reflectivities and from model equivalents (EMVORADO forward operator)
  - Reflectivity objects as polygons with several properties, e.g., position, size, intensity, …



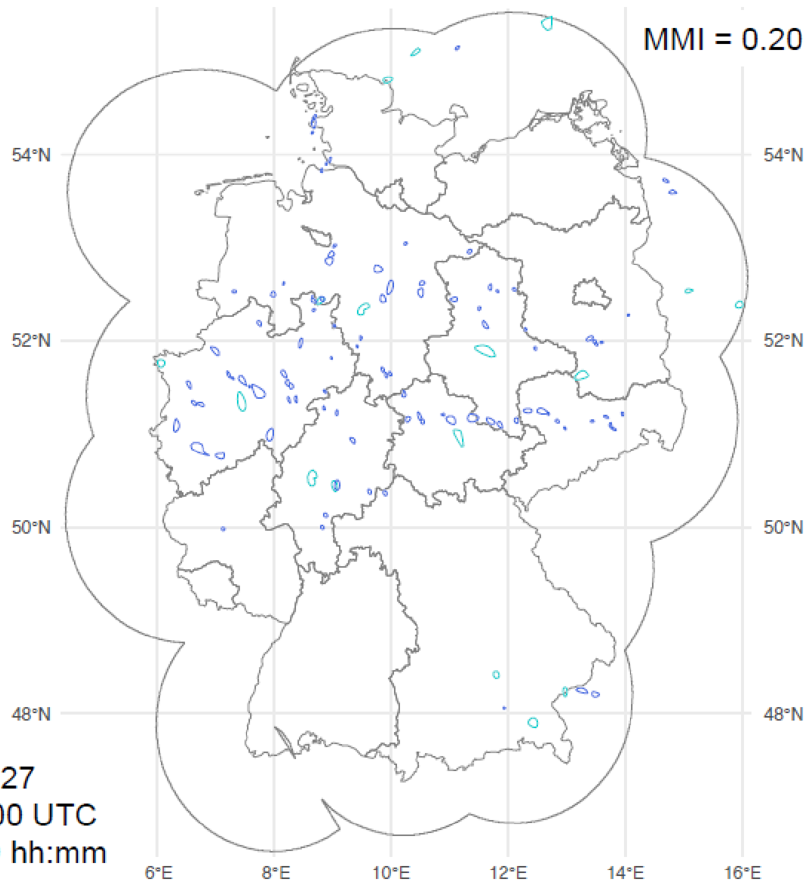
Pseudomember (Johnson et al., WAF, 2020)

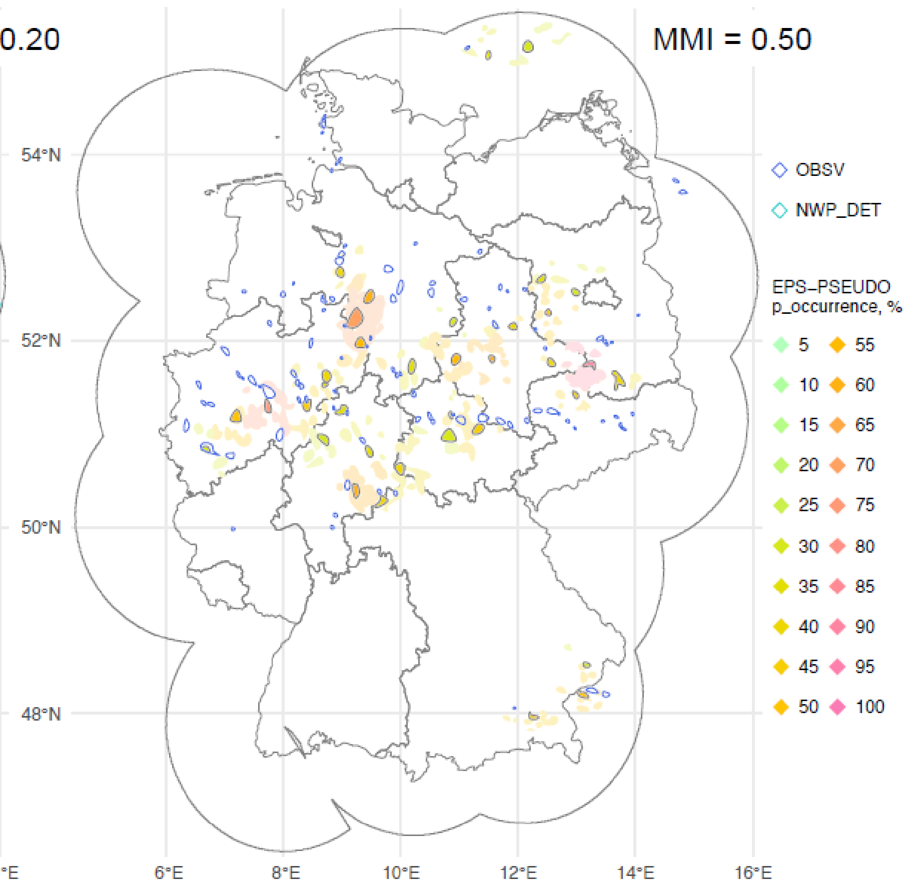
- ➔ Selection of the locally most representative objects from the ensemble
- ➔ Each pseudomember object has a probability of occurrence, i.e., the percentage of ensemble members with similar objects
- ➔ Use unified area of „matching“ objects from other members to define uncertainty regions



Example: pseudomember objects with p ≥ 30%

Deutscher Wetterdienst
Wetter und Klima aus einer Hand





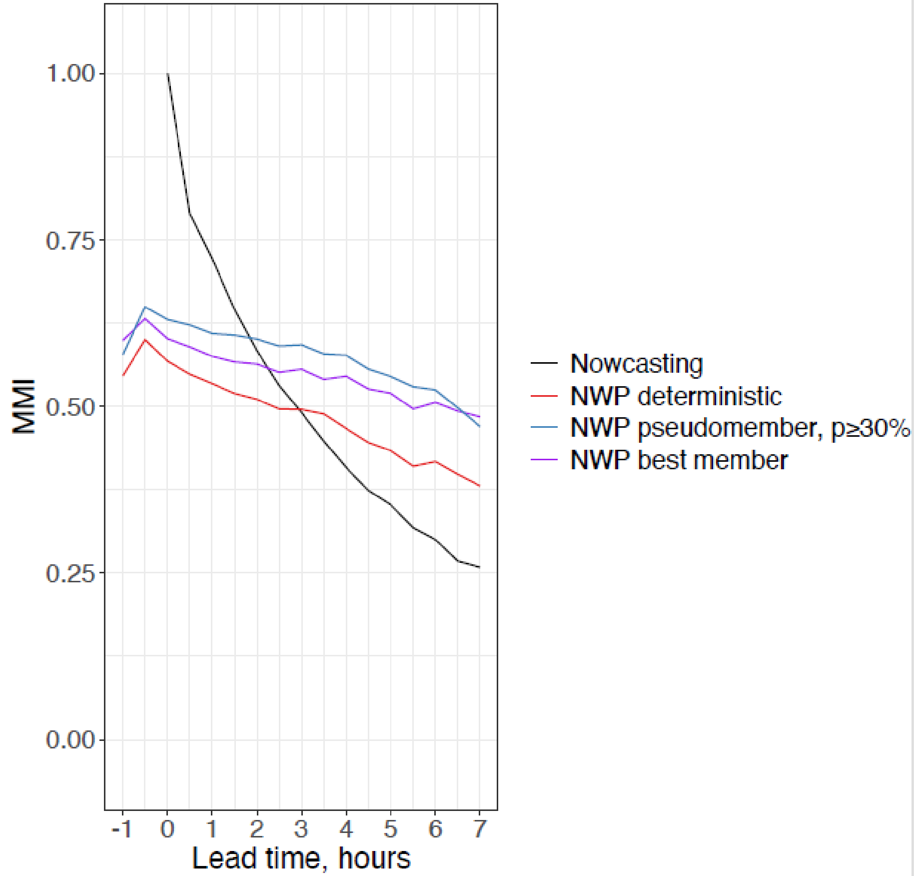
20210827
init 10:00 UTC
+ 05:00 hh:mm

SINFONY

Local beats global

- Pseudomember: a-priori selection of locally most representative objects only based on ensemble forecasts
- „Best member“: a-posteriori selection; use observations to evaluate which member is globally the best at each time step
- Pseudomember has higher MMI than the best member selection!

SINFONY ref.: 27 May - 25 Jun 2016, hourly init. 12-16 UTC



AWARE → TASK 4 → **Overview of forecast methods, representation and user-oriented products linked to HIW**

Task 4.1. Postprocessing vs. direct model output for HIW – 0.5FTEs

Studying literature, internet search to understand the state-of-the art in fog/visibility modelling, and in postprocessing methods to predict fog/visibility and convection related CW and the overview of these methods

STATUS: Pending Final Reports:

Task 4.2 Improving existing post-processing methods – 0.12FTEs (initially planned 0.25 FTEs, but 0.13 FTEs for year 2020-2021 moved to MILEPOST)

Report on the quality of various forecasts methods, advantages and disadvantages; conclusions (recommendations) of hind-cast evaluation, esp. of ANN vs. MLR and ALSR; recommendations for future and operational use

FTEs remaining: 0.0

STATUS: Completed. *Final Report available on COSMO web*

AWARE

TASK 4

Overview of forecast methods, representation and user-oriented products linked to HIW

Task 4.3 QPF evaluation approaches – 0.1 FTEs
An overview of all the products provided to the end-user (forecaster or hydrologist)
STATUS:* *Completed. *Final Report available on COSMO web*

Task 4.4. Representing and communicating HIW forecast for decision making – 0.3 FTE (0.2 RHM, 0.1 NMA)
Overview of approaches to communicating high impact weather to different categories of users. Feedback from users. Examples of representing HIW forecasts.
FTEs remaining: 0.11 RHM, ~~0.1 NMA~~
STATUS: Pending Final Report. A.Bundel is preparing the report “Preparing and communicating warnings based on high-resolution NWP in the cities, international experience and Moscow applications”. ***Extension to complete the reports until 2021.***
NMA contribution is cancelled.

Postprocessing model data for fog forecast

Julia Khlestova, Marina Shatunova,

Ekaterina Tatarinovich, Gdaly Rivin

Hydrometeorological Centre of Russia, 11-13, B. Predtechensky per., Moscow, 123242, Russia

23th COSMO General Meeting
13/09/2021

What is the “fog forecast” means?

FOG

intensity

vertical extent

horizontal visibility range (VIS)

time of formation and duration

$$VIS = \frac{ln\left(\frac{1}{\varepsilon}\right)}{\beta_\lambda}$$

β_λ – volumetric attenuation radiation coefficient

λ – wavelength (=550 nm usually)

ε – eye contrast threshold (=0.05 or 0.02 usually)

Directions of fog forecast development

a) Empirical ratios

↓

$\beta = f(k_1, k_2, k_3 \ldots)$

k_i – meteorological parameters (air temperature, dew point temperature, wind speed, relative humidity).

(Zverev A.S., 1977)

Base: measurements

b) Machine learning methods

↓

$\beta = f(k_1, k_2, k_3 \ldots)$

k_i – meteorological parameters (air temperature, dew point temperature, wind speed, air pressure, relative humidity).

(Abdulkareem et al., 2019; Zhu et al., 2017; Oguz and Pekin, 2019)

Base: measurements or NWP results

c) NWP forecast (or postprocessing)

↓

$$\beta_\lambda = \int_0^\infty Q_{ext,\lambda} n(r) r^2 dr$$

or need the parametrization of β

(Kunkel B.A., 1984; Wilkinson et al. 2013; Creighton et al., 2014)

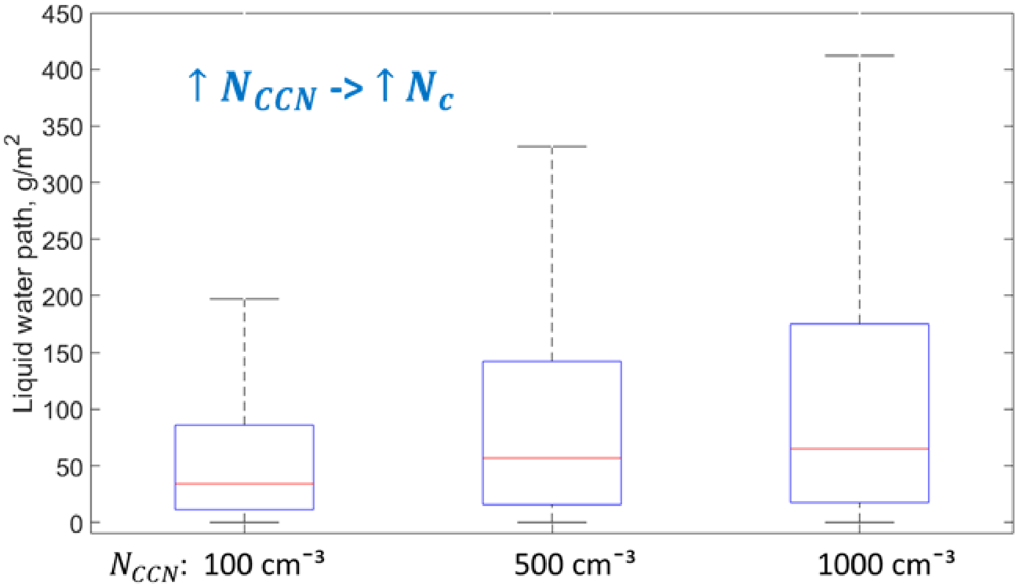
Base: NWP results

Impact of two-moment microphysics

- Low-level cloudiness
- Liquid water clouds mostly

Model: COSMO v.5.08
Grid step: 1 km
Microphysics: 2-moment (2797)
Convection: shallow (type 3)
Aerosol-cloud-radiation interaction:

- CLOUDRAD scheme (Hu & Stamnes, 1993; Fu et al., 1996 ;1998) with additions.
- $N_{CCN} = 100$, 500 and 1000 cm^{-3}



CLOUDRAD&2MOM can use aerosol fields from chemical-transport models for more realistic aerosol effect

↓

Additional information about aerosol typification, solubility and anthropogenic impact

$$\beta = a_6 Q C^{a_7} N_c^{a_8}$$

(Trautmann and Bott, 2002)

Conclusions

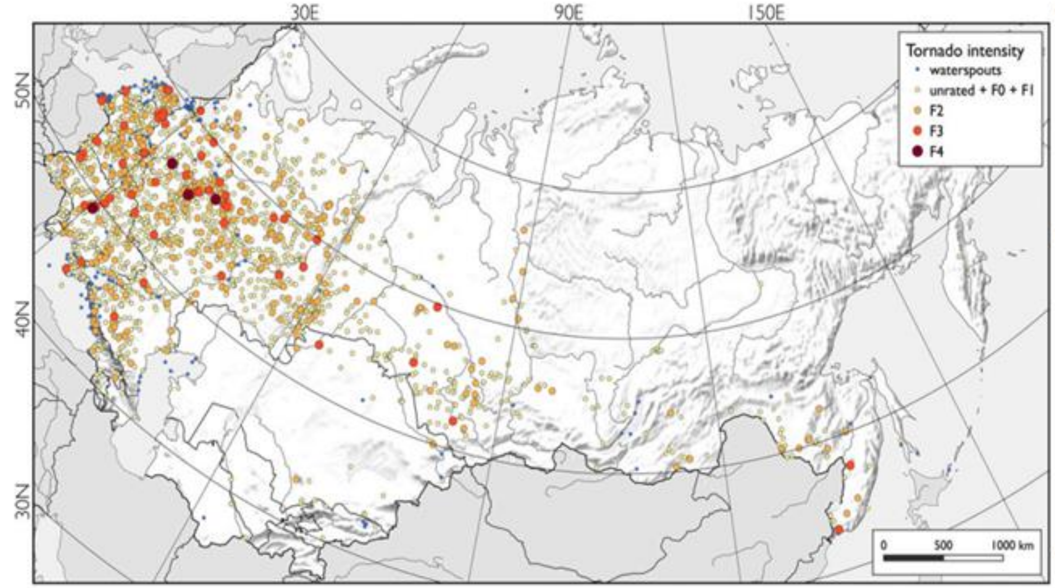
- The NWP fog forecast is preferable because it has not only fog intensity, but includes also the fog vertical extent, moment of fog formation and duration
- The microphysical approach of horizontal visibility range calculation is better than meteorological approach
- The two-moment microphysics allows expanding the range of horizontal visibility due to accounting for the geographical location and the level of aerosol pollution
- The visibility forecast using ICON results needs the analysis of all liquid and ice water sources (schemes) in the model

Tornado hazard prediction with COSMO-Ru Parameters and indices

Denis Zakharchenko & Denis Blinov

dozentmi7@mail.ru

Tornado occurrence in Russia



*Spatial distribution of Tornadoes, observed over Northern Eurasia in 979-2016 [Chernokulsky et al, Monthly Weather Reviews, 2020 DOI:*10.1175/MWR-D-19-0251.1*]*

- Previous estimates of Tornado occurrence frequency in Russia [Snitkovsky, 1987] turned out to be severly undervalued.
- Recent research [Chernokulsky et al, 2020] showed that on average Russia experiences about 100-150 tornadoes per year. During some years the number can rise up to 350.
- About 10% of these tornadoes become significant (EF-2 or higher) and can cause serious damage and human deaths or injuries.

Tornado Season 2021 in Russia

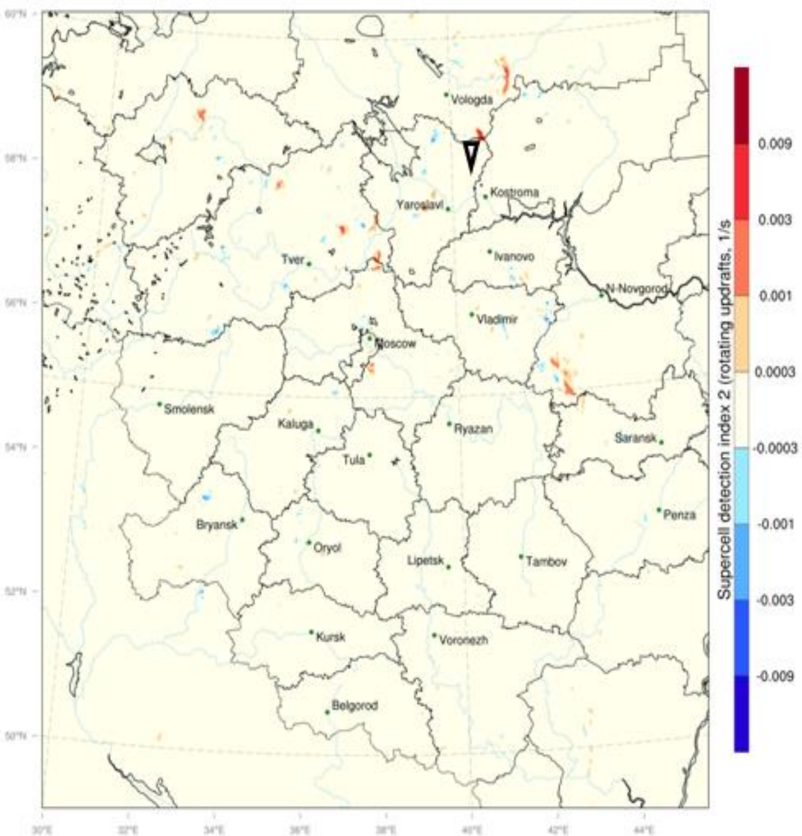
- According to the European Severe Weather Database (ESWD), 85 tornado records took place in Russia in 2021.
- The most damaging outbreaks on the European part of Russia in 2021 were recorded on May 15 and August 2.

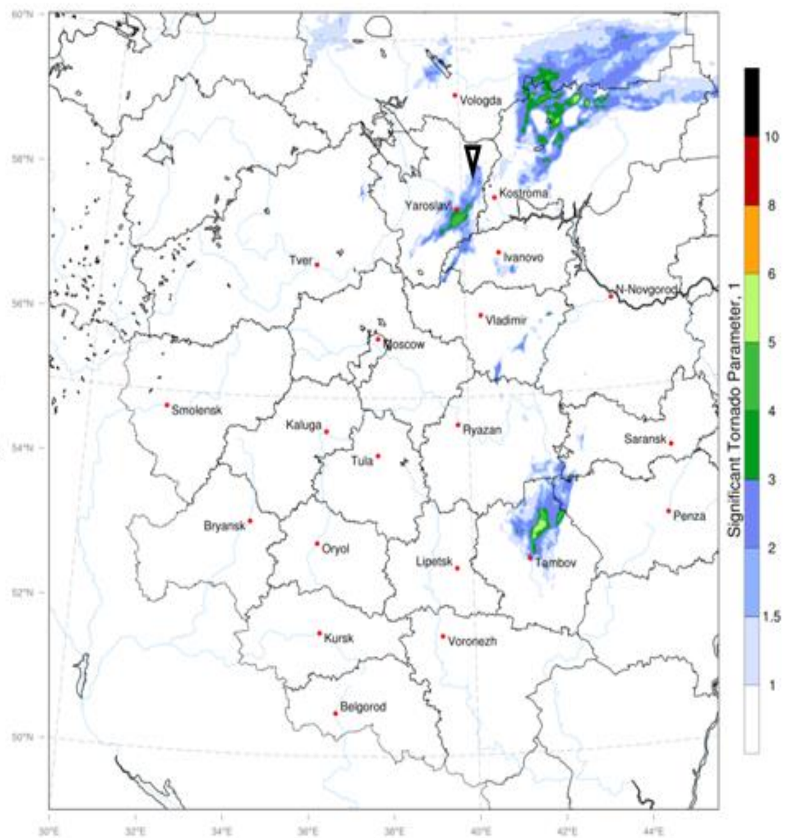
The COSMO-Ru Setup

The experiments were performed using global ICON 13km-grid initial and boundary data and downscaling to 1km-grid domains.

Case 1. The May 15 Tornado outbreak and Derecho

- 13:00 UTC COSMO-Ru (2.2 km) Supercell Detection index 2 & Significant Tornado Parameter.





Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet)
Hydrometeorological Research Centre of Russian Federation

Conclusions

- The comparison between simulated Significant Tornado Parameter values and the Supercell Detection index values in some cases can help exclude false alarms in Tornado risk prediction

- Experiments performed with COSMO-Ru with 1km spatial grid resolution show more distinct supercell and mesoscale convective systems compared to COSMO-Ru 2.2 km

Related publications & conference presentations

- Marsigli, Chiara & Ebert, Elizabeth & Ashrit, Raghavendra & Casati, Barbara & Chen, Jing & Coelho, Caio & Dorninger, Manfred & Gilleland, Eric & Haiden, Thomas & Landman, Stephanie & Mittermaier, Marion. (2020). Observations for high-impact weather and their use in verification. 10.5194/nhess-2020-362.

- Object based verification of radar-reflectivities on the convective scale
G. Pante, M. Hoff, and U. Blahak. Deutscher Wetterdienst, Offenbach, Germany. Presented in ICCARUS 2021

- Verification of Intense Precipitation over diverse climatological areas Boucouvala D.1, Gofa F. 1 and Kolyvas C.1. HNMS. Paper submitted and will be presented in COMECAP 2021.

- Muraviev et al. a paper “Evaluation of radar nowcasting of large precipitation areas using the Generalized Pareto distribution under preparation

PP-AWARE continuation (phase II)

I. Stressing of observations role in HIW

ü**new obs types use in the evaluation of forecasted phenomena (severe convection, fog).**

<u>Obs Types:</u>

- *Remote sensing derived non-conventional observations.* Use of satellite products (e.g. cloud oprical thickness, brightness temp, LWR, SWR) to evaluate characteristics of convection, NWC-SAF products for fog verification
- *Crowd-sourced data:* third party and citizen met stations, smart phones, web & social media etc. usefulness for NWP predictions and evaluation

ü**observation uncertainty and impact on score**

Thank You

II. Verification scheme for convection permitting ensemble forecasts

ü**object-based approaches:** methodology and criteria for reduction/summarizing of object information, metrics for performance evaluation, visualisation

ü**build of a robust common verification framework for sensitivity tests**

III. Impact-based warnings issuing and evaluation

IV. ………………..

Not resources available yet, to be discussed after the end of current phase