Verification and Case studies

Overview of activities

Flora Gofa

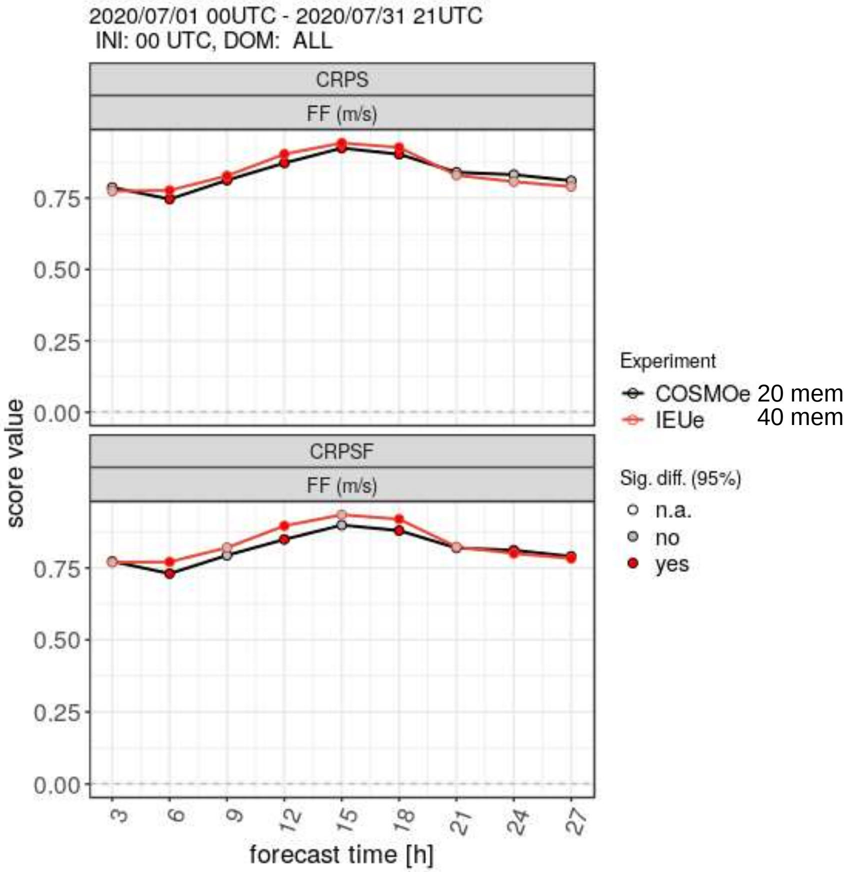
Status of PPCARMA: Amalia Iriza-Burca

COSMO Common verification: D. Boucouvala, A. Kirshanov, N. Vela


Software
PPCARMA
NWP Test Suite
Verification Applications
Common Plots (CP)
High Impact Weather
(AWARE)
WG5 activities

II Feedback File Verification

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

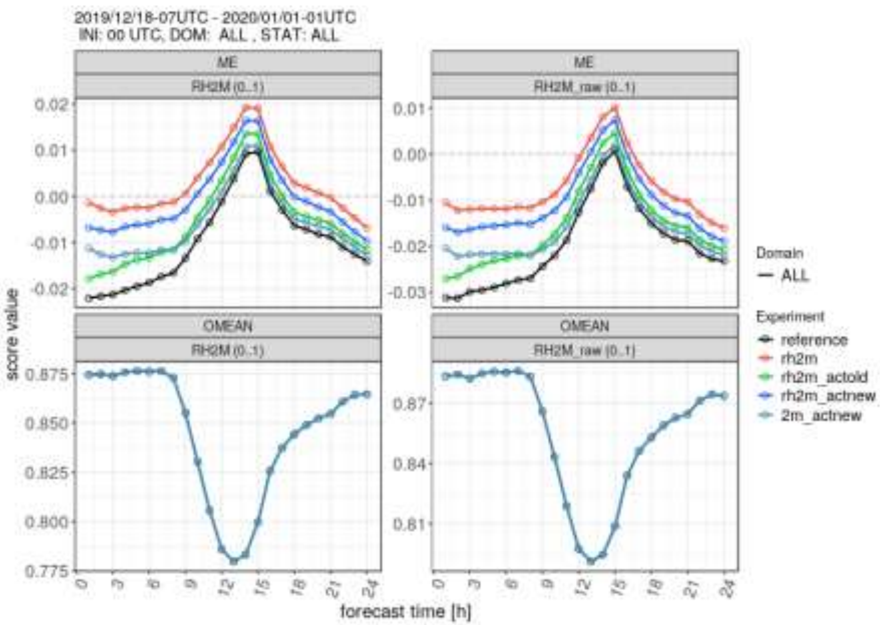


Fair CRSP (CRPSF)

- CRPS is increasingly biased for ensembles with fewer members
- CRPSF corrects for finite number of ensemble
- CRPSF = CRPS for infinite number of ensemble members
- Allows fair comparison of differently sized EPS
- Now part of the SYNOP EPS verification

II Feedback File Verification

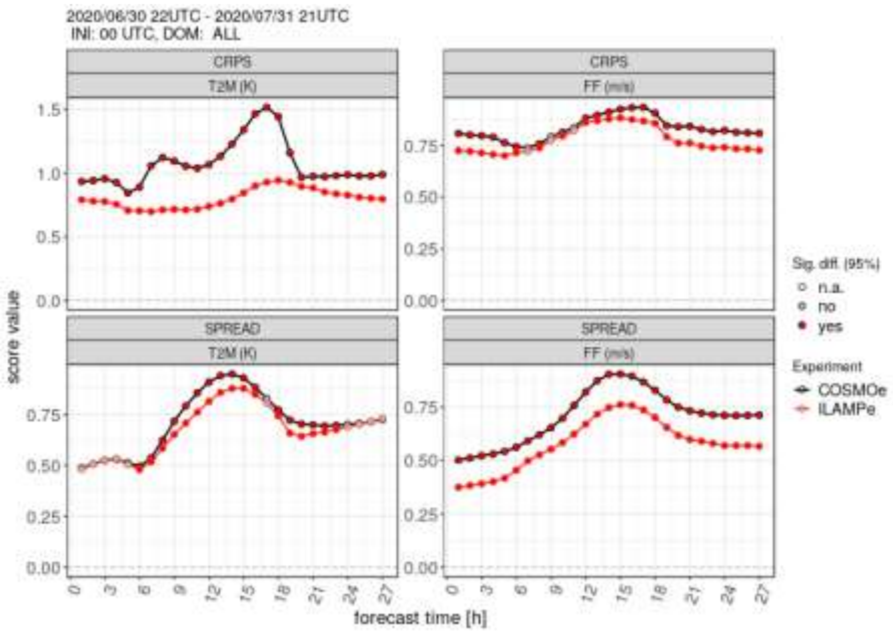
Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Biased Observations

- Observations might be subject to bias correction
- By default the verification uses bias corrected observations only
- The actually used bias correction is contained in the feedback file
- Now the verification can be performed against the raw observation too
- Namelist key *useObsBias*
- Implemented for SYNOP det. and EPS

II Feedback File Verification

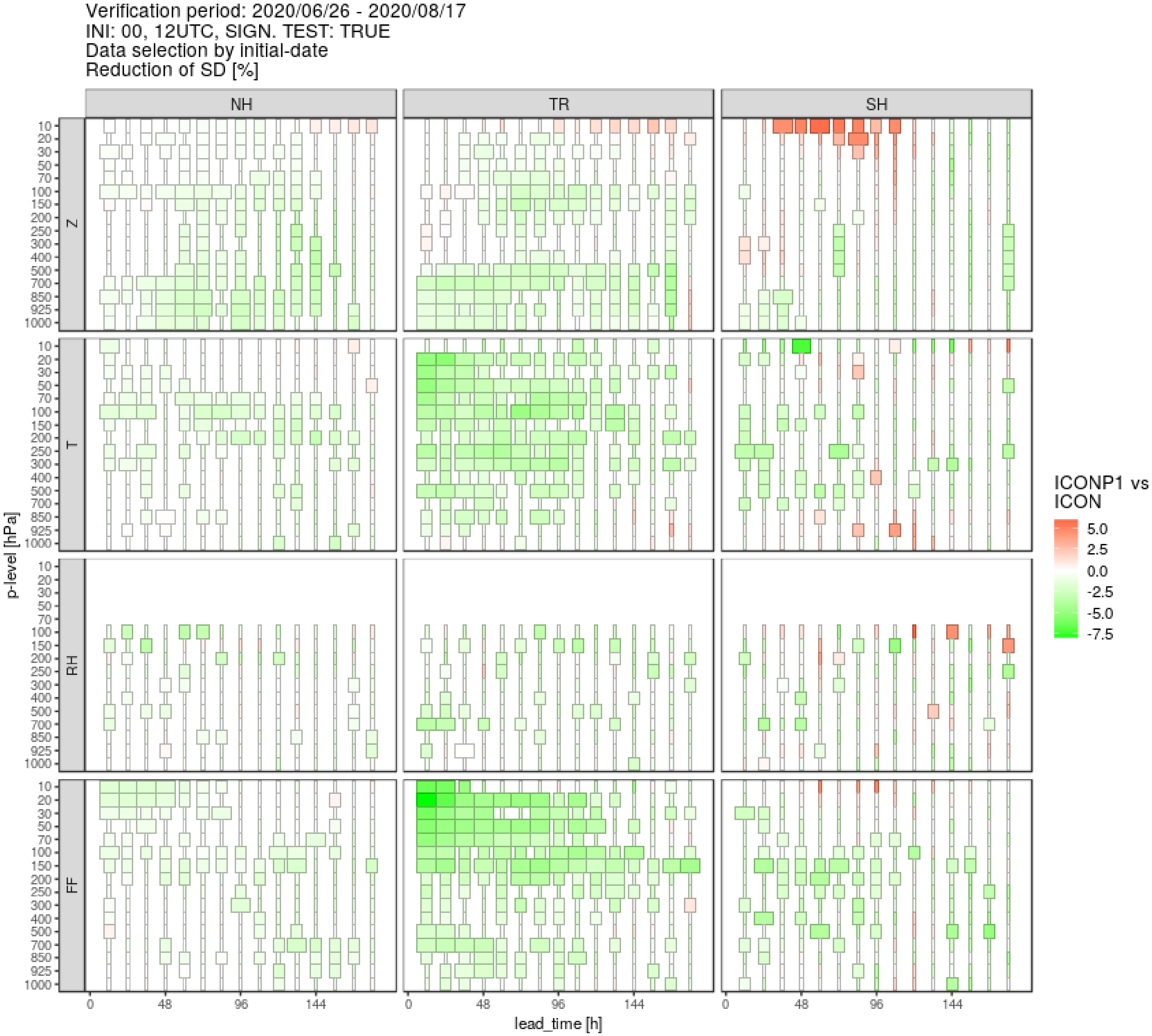


Significance Test SYNOP EPS

- t-test on 95% c.l.
- Implemented for ensemble scores (CRPS, SPREAD, etc.)
- Not available for probabilistic scores (Brier, econ. value etc. or reliability diag.)

II Feedback File Verification

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Significance Visualization I

- Visually highlight significanct results
- Box width depends on significance test outcome
- Small box if no run shows sig. differences between experiments
- Widest possible box if all runs show a sign. difference

Spatial Verification Efforts at DWD

Felix Fundel on behalf of Michael Hoff

Deutscher Wetterdienst

FE 15 – Predictability & Verification

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Email: Michael.Hoff@dwd.de

II. Approach

- **Review of existing neighborhood/spatial verification methods for deterministic and ensemble forecasts**
  - Deterministic
    - methods & scores from Ebert 2008 (incl. single member verification)
    - neighborhood contingency table after Stein & Stoop 2019
    - reliability and ROC diagrams based on neighborhood fractions ***new***
  - Ensemble
    - Scores based on neighborhood ensemble probabilities (E-FSS, etc.) (Schwartz et al. 2010)
    - time fuzzyness (Duc et al. 2012,2013) planned for future
- **Developing R package**
  - R-package currently in test mode internally. Medium-term distribution possible.
  - Namelist control (xml)
  - Reading capability for common data formats (grib, Rdata, Radolan; easy-to-add more by S3-class)
  - Aggregation functionality (important for routine verification)
  - Alignment observation/forecast data from different experiments/models
  - Interactive visualization of scores via R-shiny server
  - *No pre-processing (e.g. regridding, restructuring) provided (too complex)*

II. Approach - Methodology

Namelist for Parameter & Verification → **R-Neighborhood Verification Tool (RNVT)**
(R-package)

- 1 score file/ step as *.rds
- data.table format
- Incl. all necessary information for later aggregation
- Parallelized over individual time steps

↓

Namelist for aggregation → **Aggregation (part of R-package)**

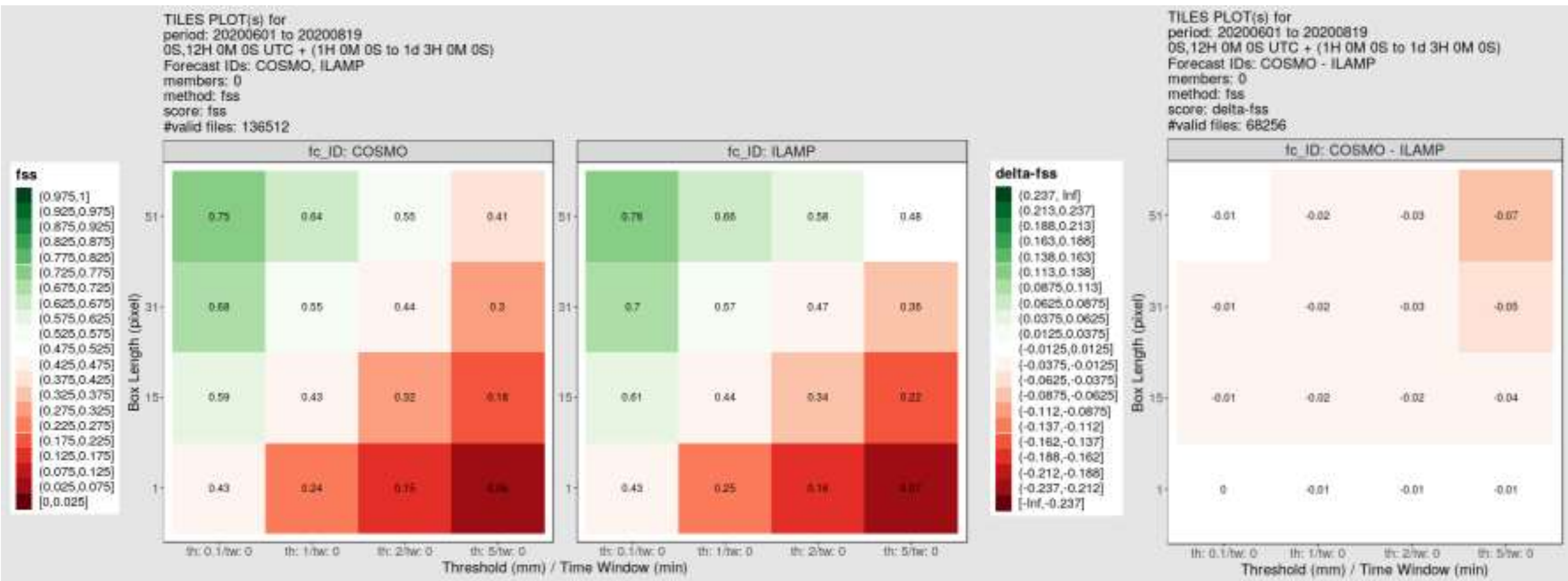
- 1 aggregated score file for chosen period as *.rds
- data.table format

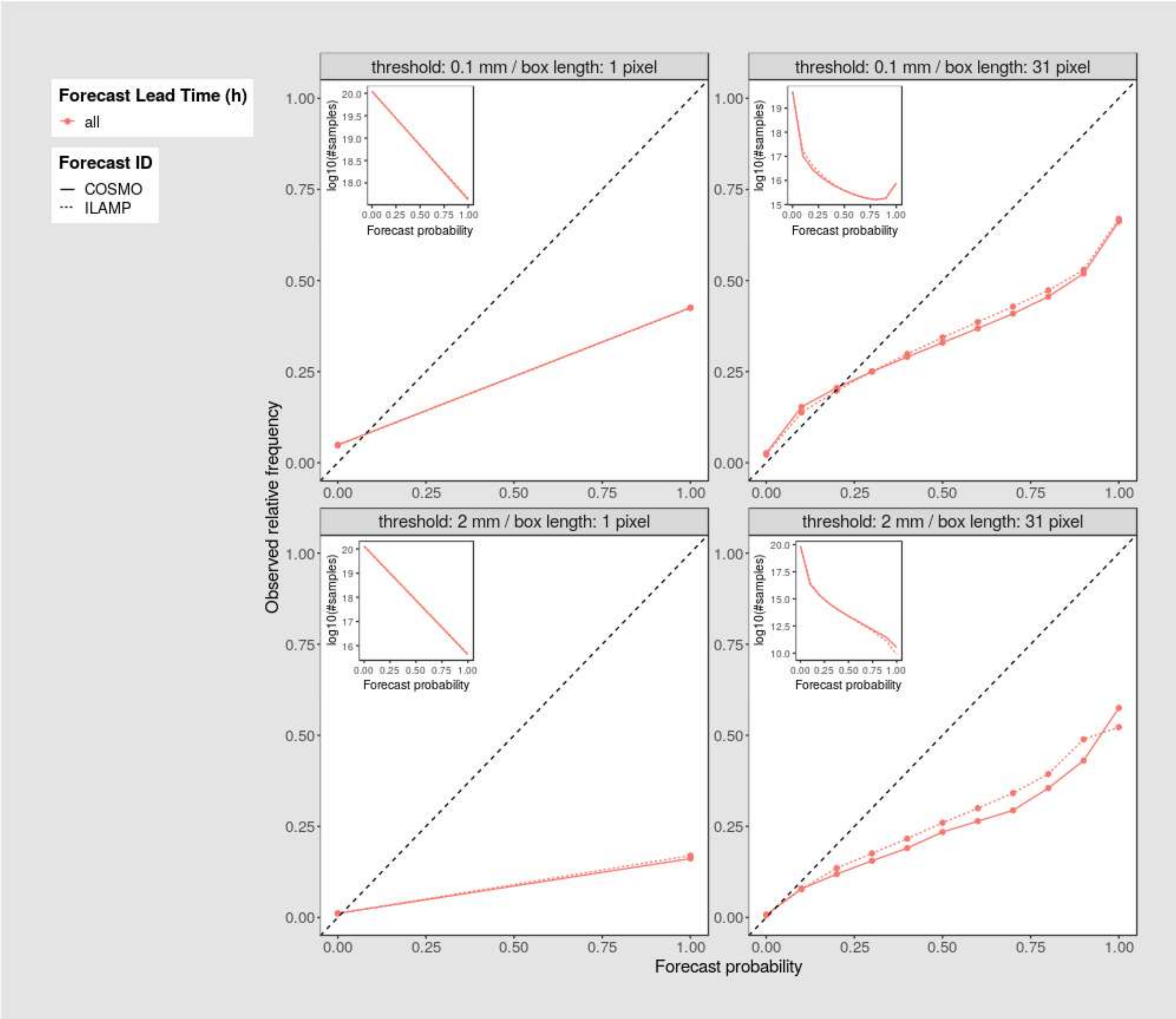
↓

Shiny-server interactive visualization

III. Results – Tiles Plots

FSS for COSMO-D2 vs. ICON-D2 (DET) for JJA period





1 pixel ≈ 2.2 km

ighborhood
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his
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classical one
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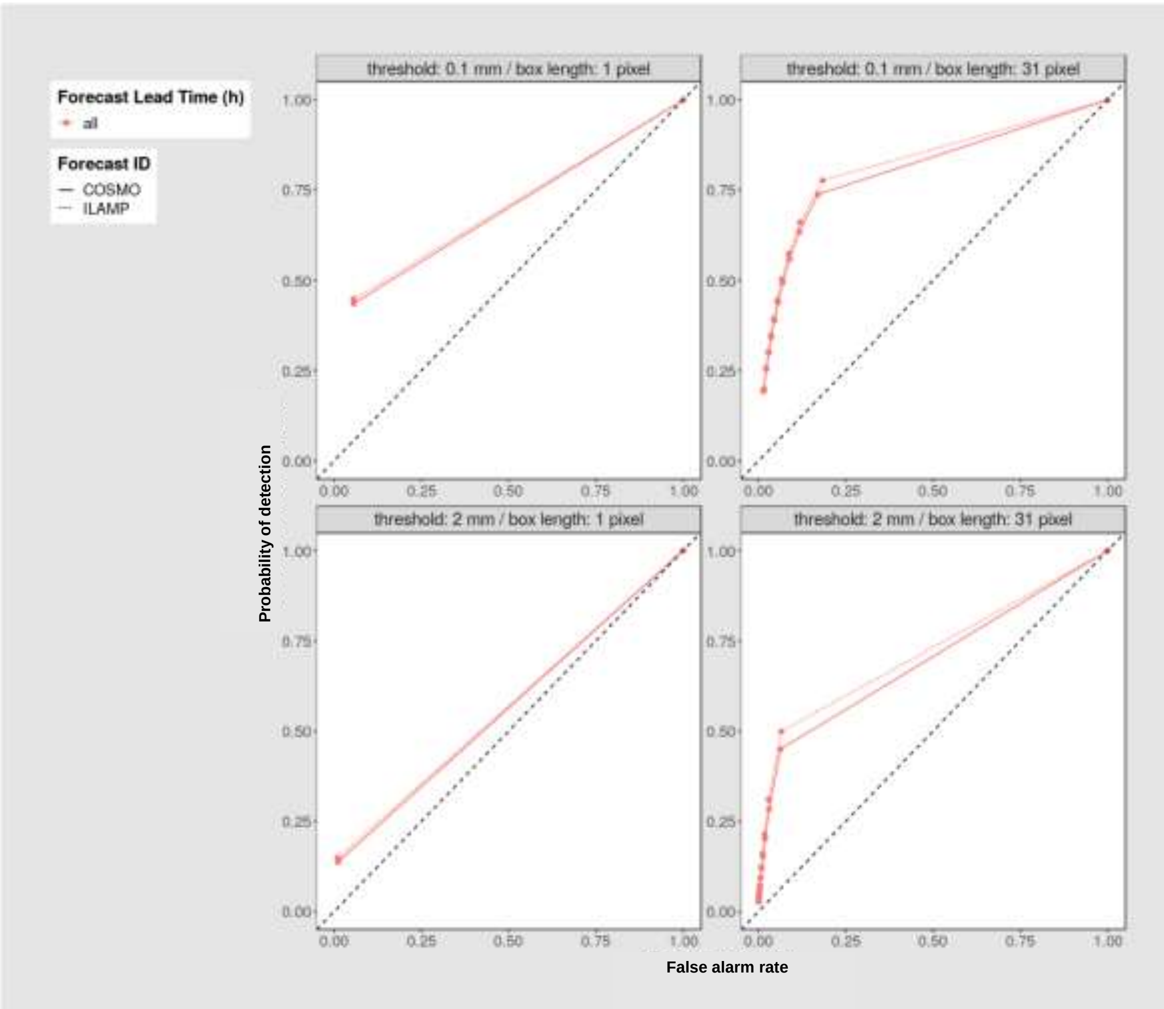
III. Results – Reliability Plots

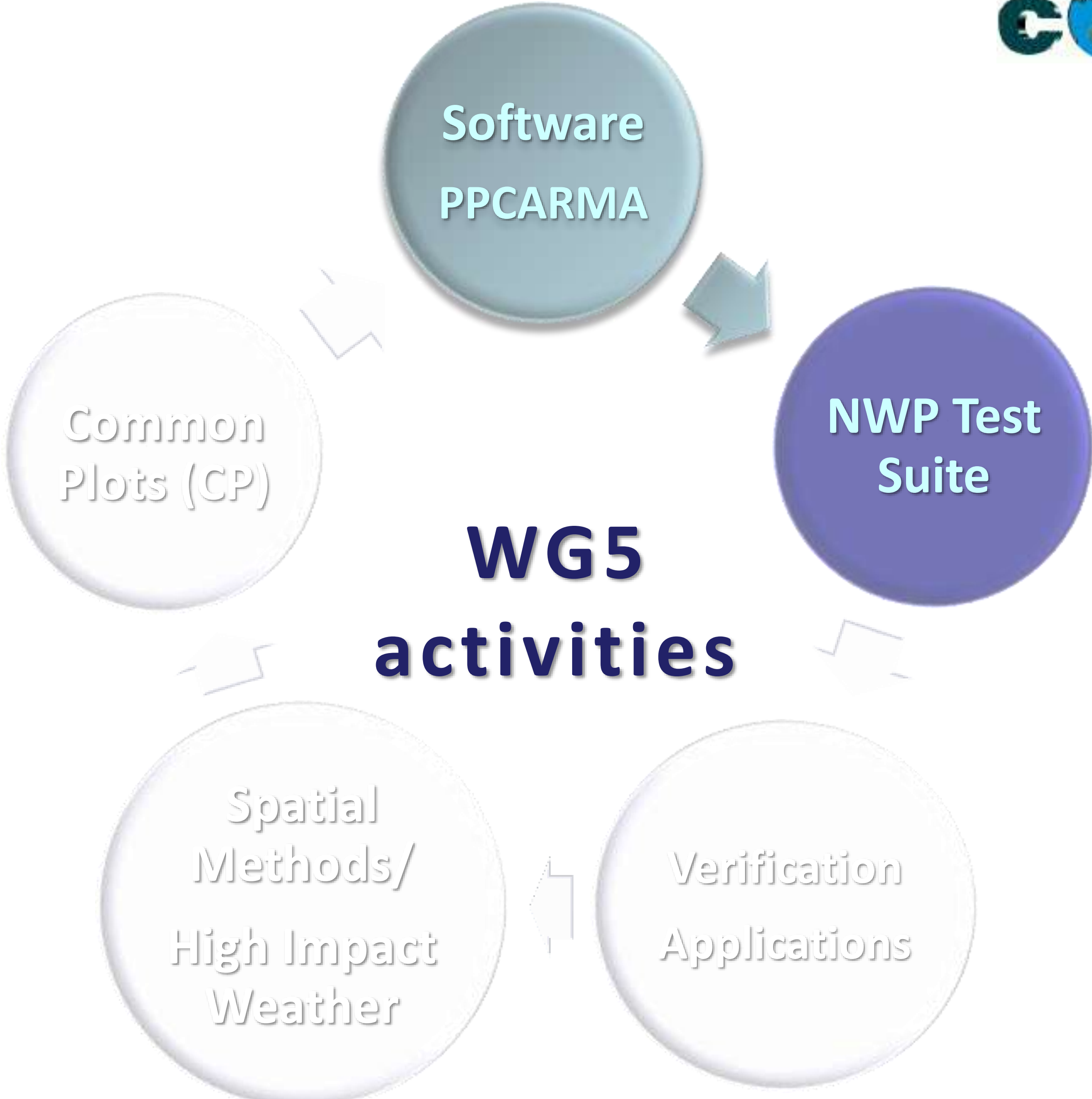
COSMO-D2 vs. ICON-D2 (DET) for JJA period

1 pixel ≈ 2.2 km



Note that neighborhood fractions are a result of a smoothing process which decreases the number of high „probabilities“. Therefore, this neighborhood fractions ROC diagram is not the same as the classical one based on ensemble probabilities.

ROC-area for ICON-D2 higher than COSMO-D2


Software
PPCARMA
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WG5 activities
Verification Applications
Spatial Methods/
High Impact Weather
Common Plots (CP)

NWP Test Suite (COSMOv5.06)

MODEL OUTPUT VERIFICATION

A. Iriza-Burca (NMA)

- **surface continuous parameters**
  - ➔ T2M, TD2M, FF, N, PS
  - ➔ BIAS (ME), RMSE, SD, R^2, TCC (tendency correlation), LEN (# of observations used), OMEAN and FMEAN (observed and forecast mean);

- **upper air verification** (TEMP based)
  - ➔ T, TD, RH, FF and DD for selected pressure levels (250., 500., 700., 850., 925., 1000.)
  - ➔ BIAS, MAE, RMSE. SD, etc.

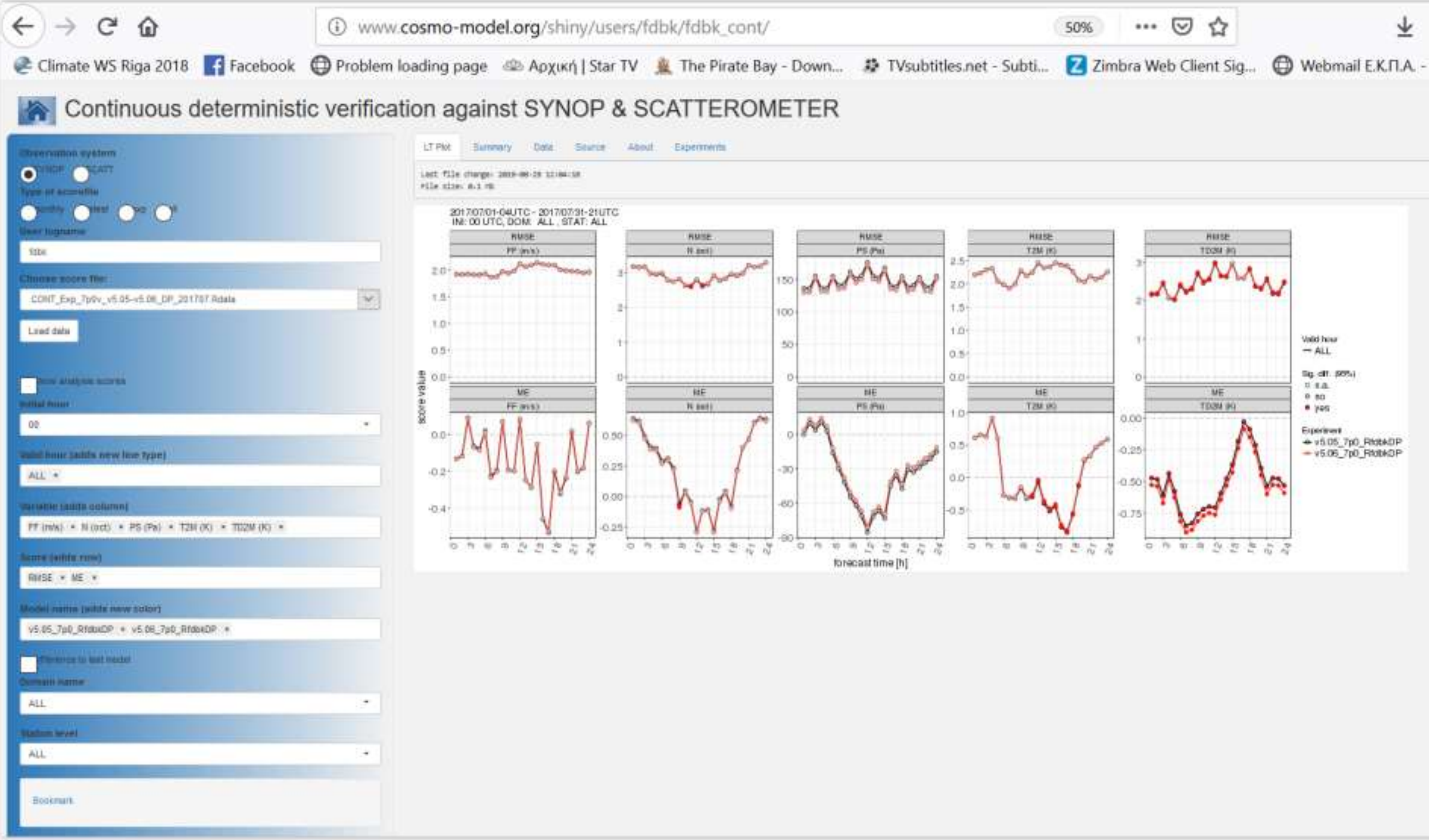
- **precipitation verification** (6h, 12h)
  - ➔ for selected thresholds (greater than 0.2, 0.4, 0.6, 0.8, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 25, 30)
  - ➔ ETS, FBI, Performance diagrams, etc.

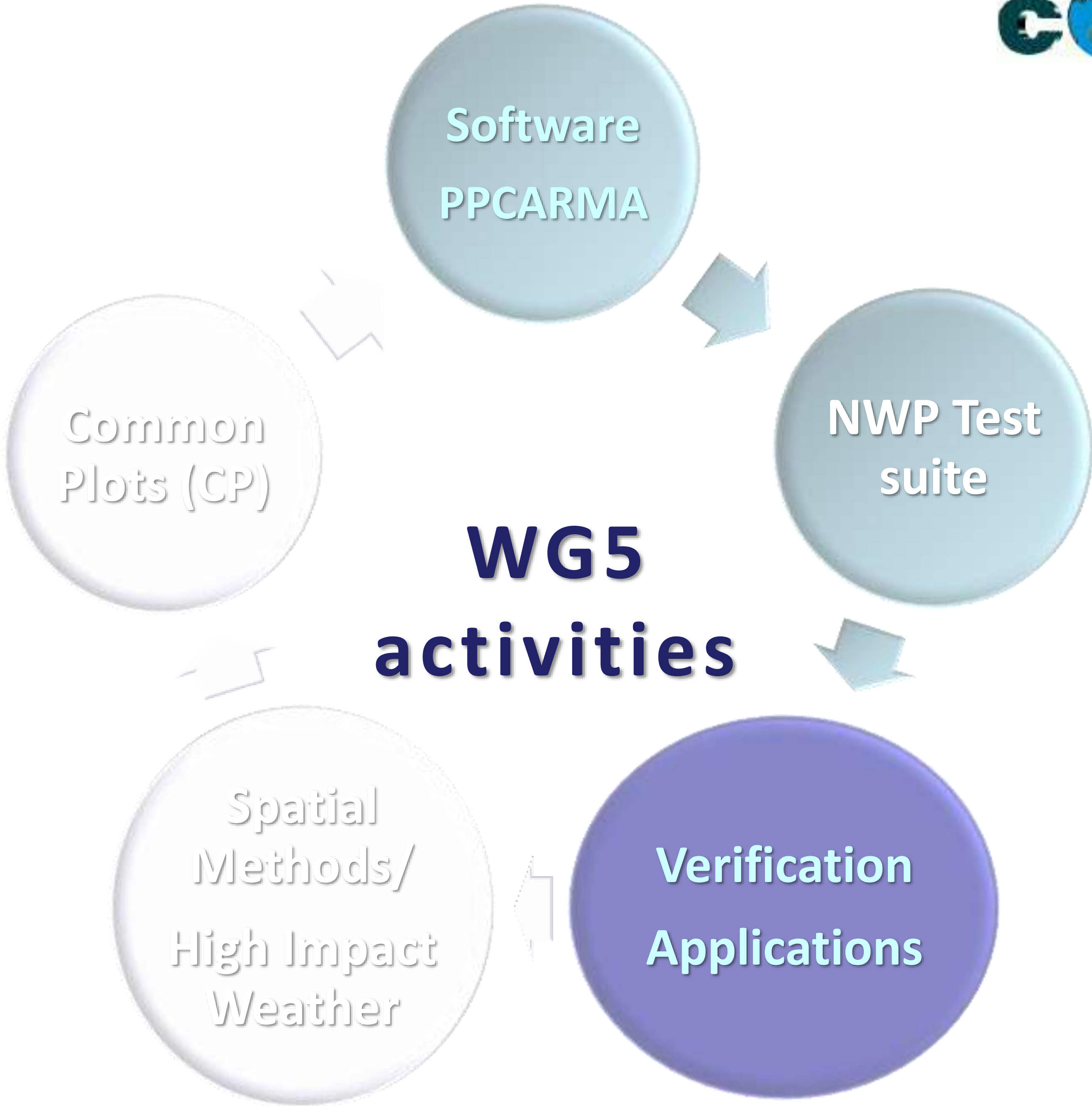
  ➔ **TP regribbed as accumulated fields of up to 255 hours (~10days) cumulation interval in grib1, hindcast files were split in three 10-day periods + 1 day.**

✓ **Report "Numerical Weather Prediction Meteorological Test Suite: COSMO 5.06 vs. 5.05_1" available on the COSMO website**

NWP Test Suite (COSMOv5.06)

http://www.cosmo-model.org/shiny/users/fdbk/




Software
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Common Plots (CP)

Verification highlights of the new MeteoSwiss models COSMO-1E and COSMO-2E

COSMO GM 2020 WG5 2020-09-07

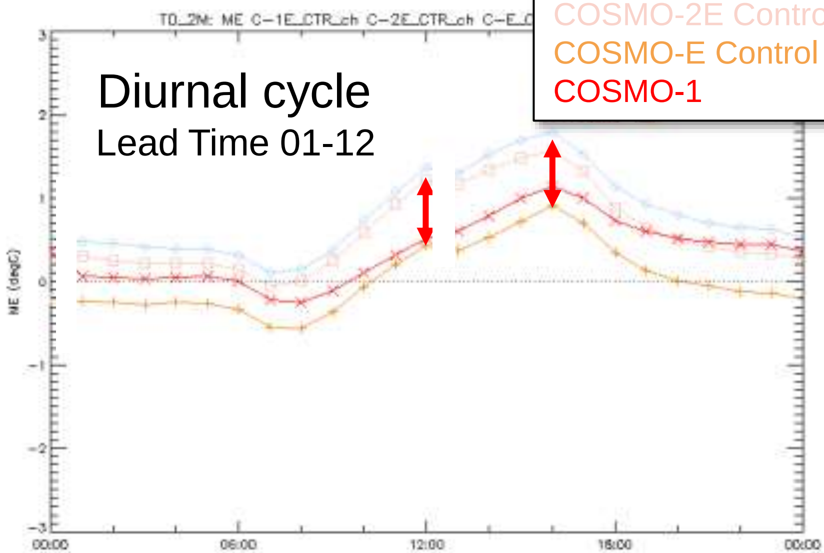
Pirmin Kaufmann, Andreas Pauling, and Marco Arpagaus

Problem (!): Td2m in March 2020

Bias T_d 2 m

Diurnal cycle

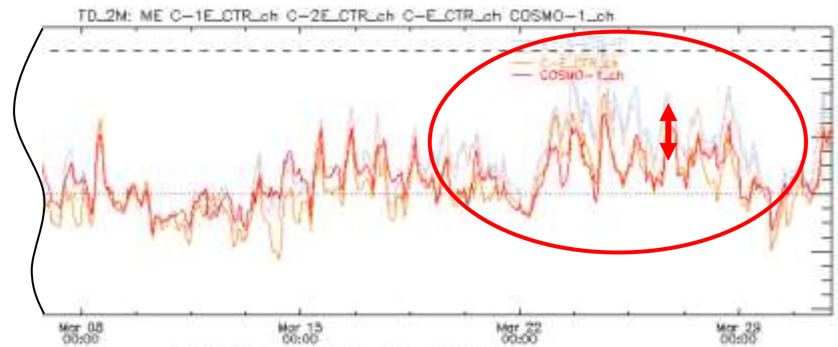
Lead Time 01-12



COSMO-1E Control
COSMO-2E Control
COSMO-E Control
COSMO-1

Daytime

Time series



Time

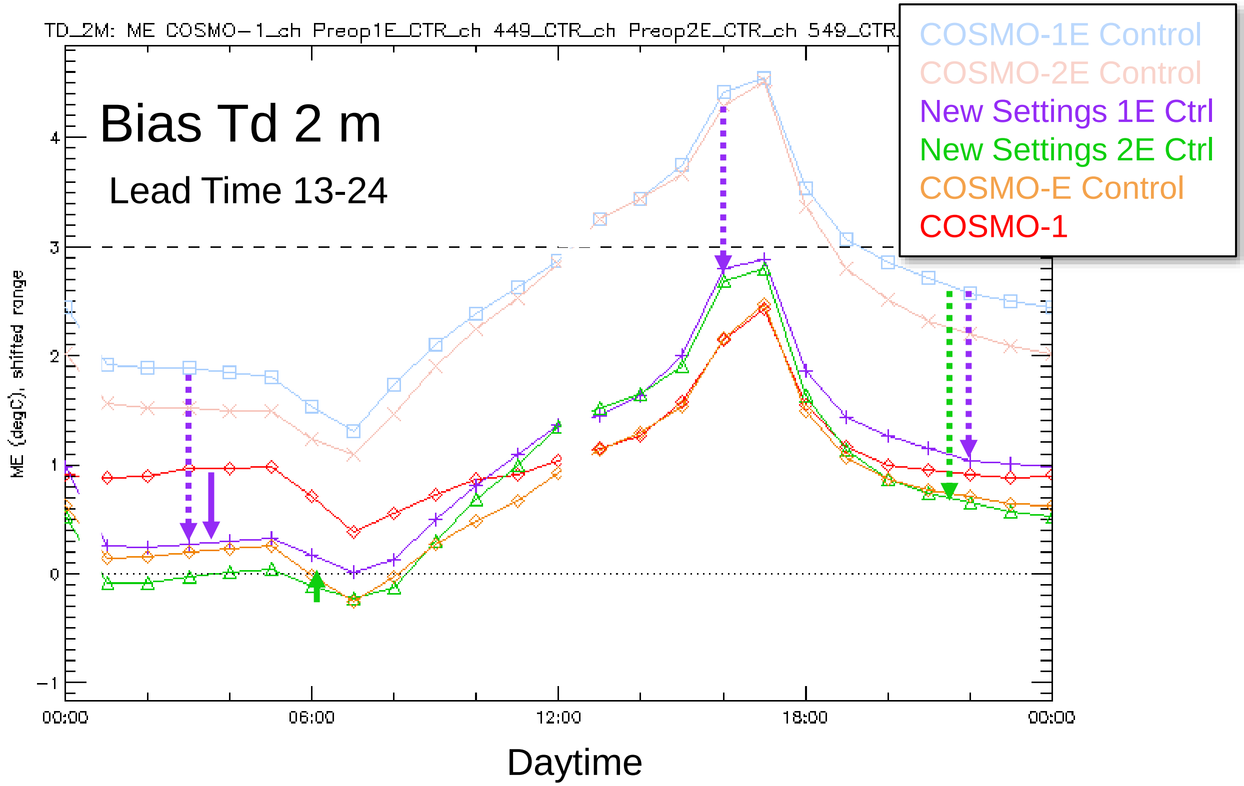
Schulz & Vogel: main changes

- improved bare soil evaporation
  - less evaporation for medium-wet to wet soil conditions, thereby leading to smaller Td2m and larger T2m values as well as to a larger diurnal temperature range
  - more evaporation for medium-dry to dry soil conditions, thereby leading to larger Td2m and smaller T2m values as well as to a smaller diurnal temperature range
- skin layer temperature (new; to simulate vegetation canopy effect)
- interception reservoir activated (new)
- a few more smaller changes; *still unsatisfactory: plant transpiration*

Jan-Peter Schulz and Gerd Vogel («Improving the Processes in the Land Surface Scheme TERRA: Bare Soil Evaporation and Skin Temperature", Atmosphere 2020, 11, 513;

2 m Dewpoint Spring 2020 (15 d)

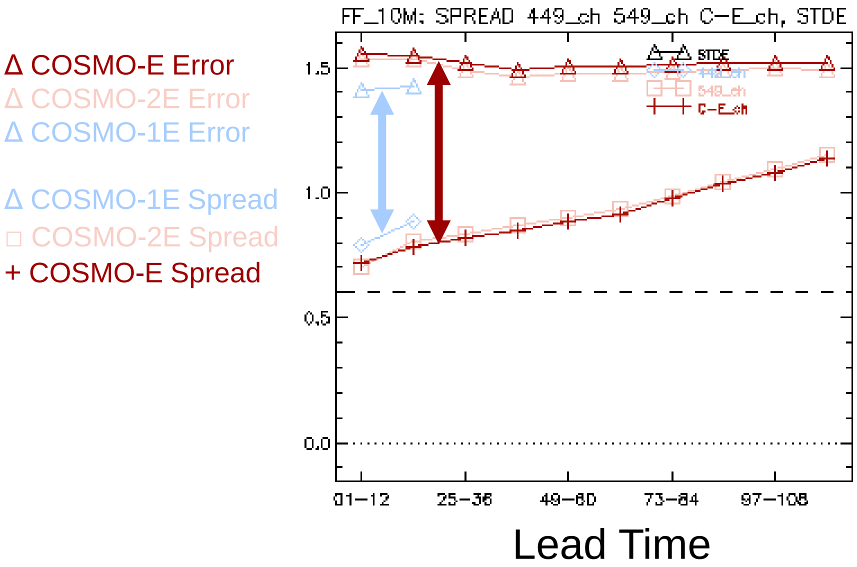
T_d bias almost back to normal (afternoon) or even improved (night, morning)



Spread / Error Relation

The spread/error relation for the 1.1 km model COSMO-1E is similar for most parameters and for some even better than for the 2.2 km models COSMO-2E and COSMO-E

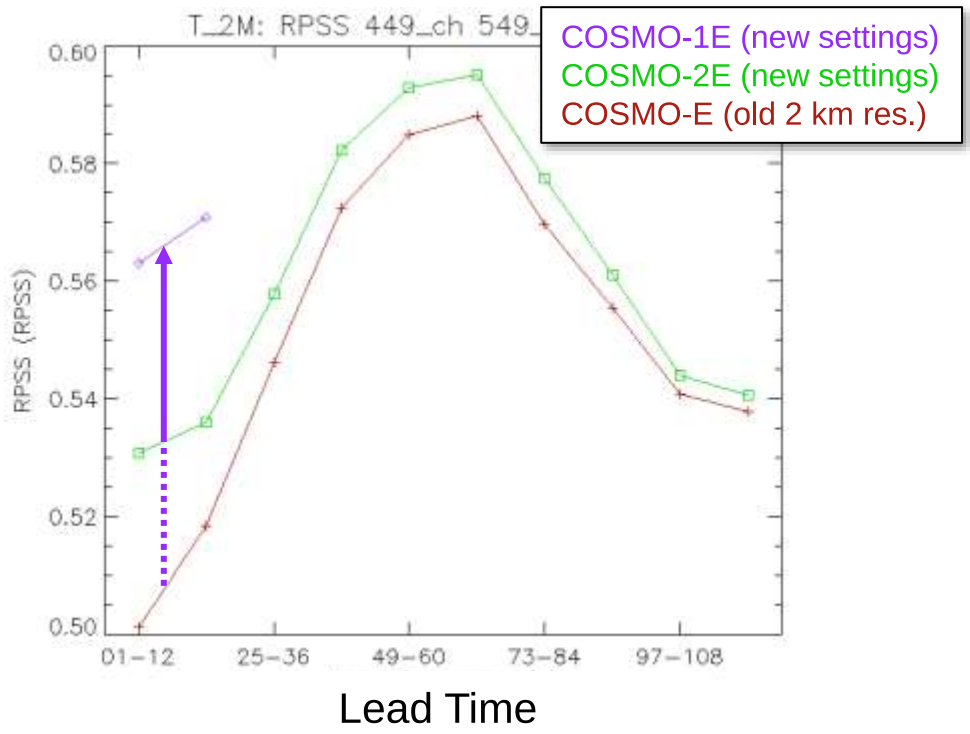
Example: wind speed, summer 2019



Ranked Probability Skill Score RPSS

The RPSS of COSMO-1E is better for most parameters and most seasons

Example: RPSS T2m, Autumn 2019

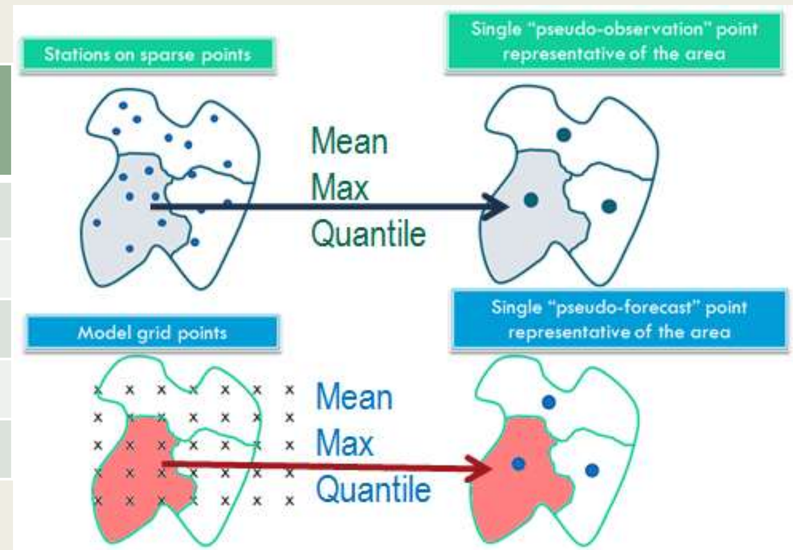


■ Maria Stefania Tesini

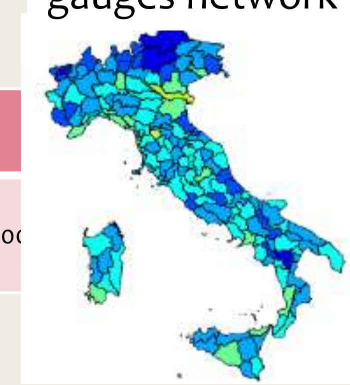
User oriented verification

- Observed and forecast precipitation, aggregated on the catchment areas used for Civil Protection purposes, have been divided into classes

CLASSES FOR MEAN PRECIPITATION	MEAN AMOUNT IN 24h (mm)
NO PRECIPITATION	<0.2
NON SIGNIFICANT	0.2 – 5
LIGHT	5-20
MODERATE	20-45
HEAVY	>45



DPCN rain-gauges network

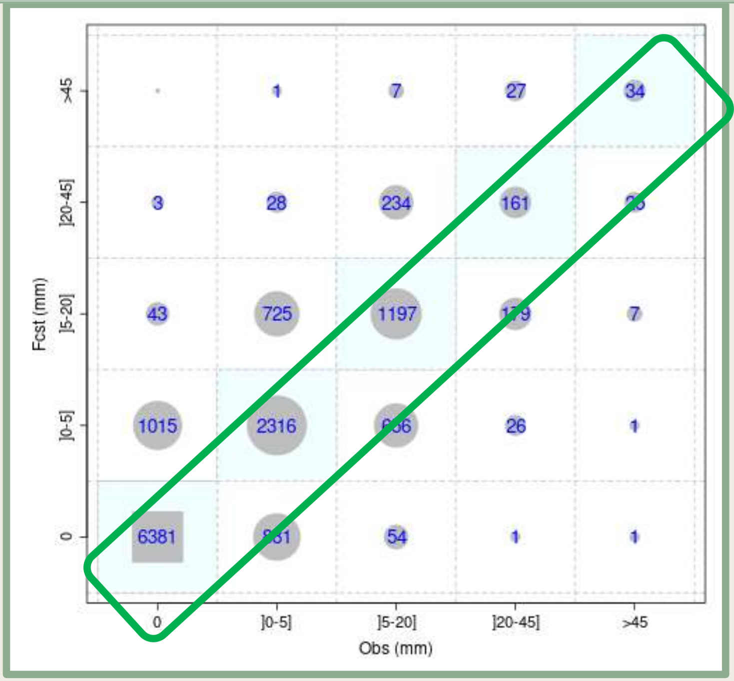


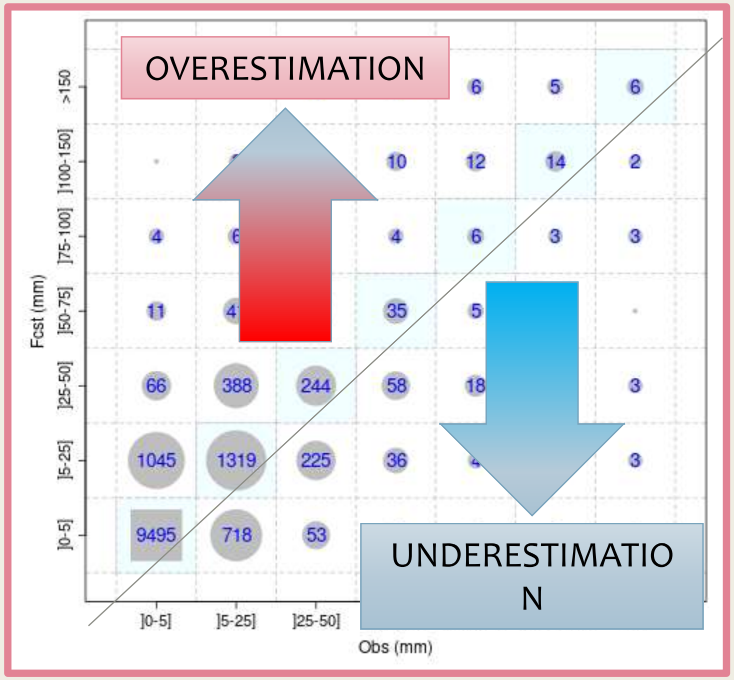
CLASSES FOR MAX PRECIPITATION						
MAX AMOUNT IN 24h (mm)	0.2 -5	5-25	25-50	50-75	75-100	10

Visual verification with “bubble plots”

- Bubble plot is a sort of the scatter plot, in which the data points are replaced with bubbles. The sizes of the bubbles are determined by the number of events.
  (The square symbol is used for the most populated category to preserve the proportions of the other bubbles)
- The advantage of this approach is that the nature of the forecast errors can more easily be diagnosed

✓ CORRECT FORECASTS LIE ON THE DIAGONAL





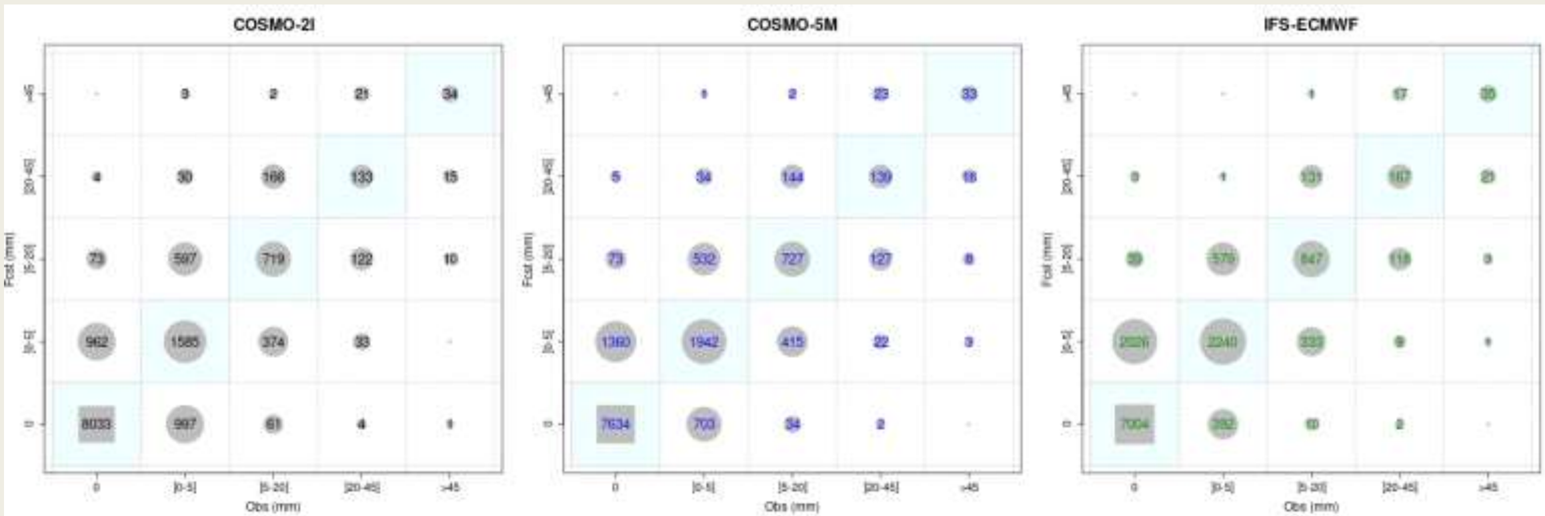
arpae
agenzia prevenzione ambiente energia emilia-romagna

Verification Practices in Arpae

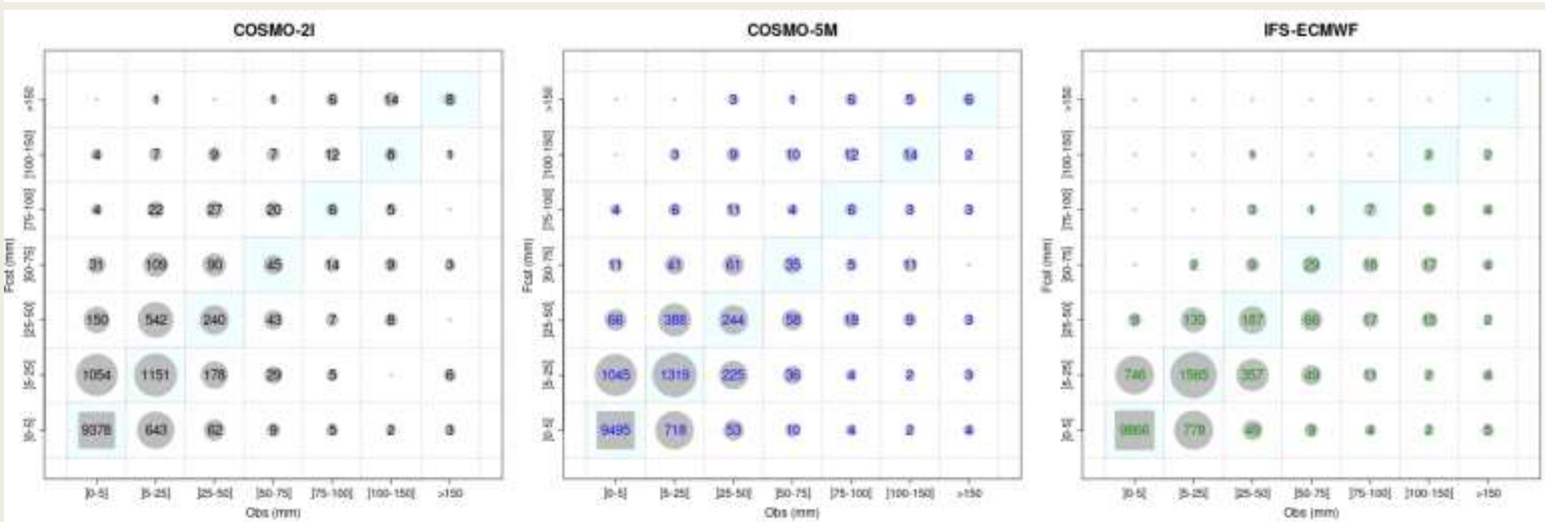
- Maria Stefania Tesini

MAM2020

MEAN



MAX



- **Answers the question:** *What was the accuracy of the forecast in predicting the correct category, relative to that of random chance?*
- **Range:** -1 to 1, 0 indicates no skill. Perfect score: 1

Gerrity score - $GS = \frac{1}{N}\sum_{i=1}^{K}\sum_{j=1}^{K} n(F_i, O_j)\, s_{ij}$

where s_{ij} are elements of a scoring matrix given by

$$s_{ii} = \frac{1}{K-1}\left(\sum_{r=1}^{i-1} a_r^{-1} + \sum_{r=i}^{K-1} a_r\right) \quad (i = j, \text{ diagonal}),$$

$$s_{ij} = s_{ji} = \frac{1}{K-1}\left(\sum_{r=1}^{i-1} a_r^{-1} - (j-i) + \sum_{r=j}^{K-1} a_r\right) \quad (i \neq j, \text{ off-diagonal})$$

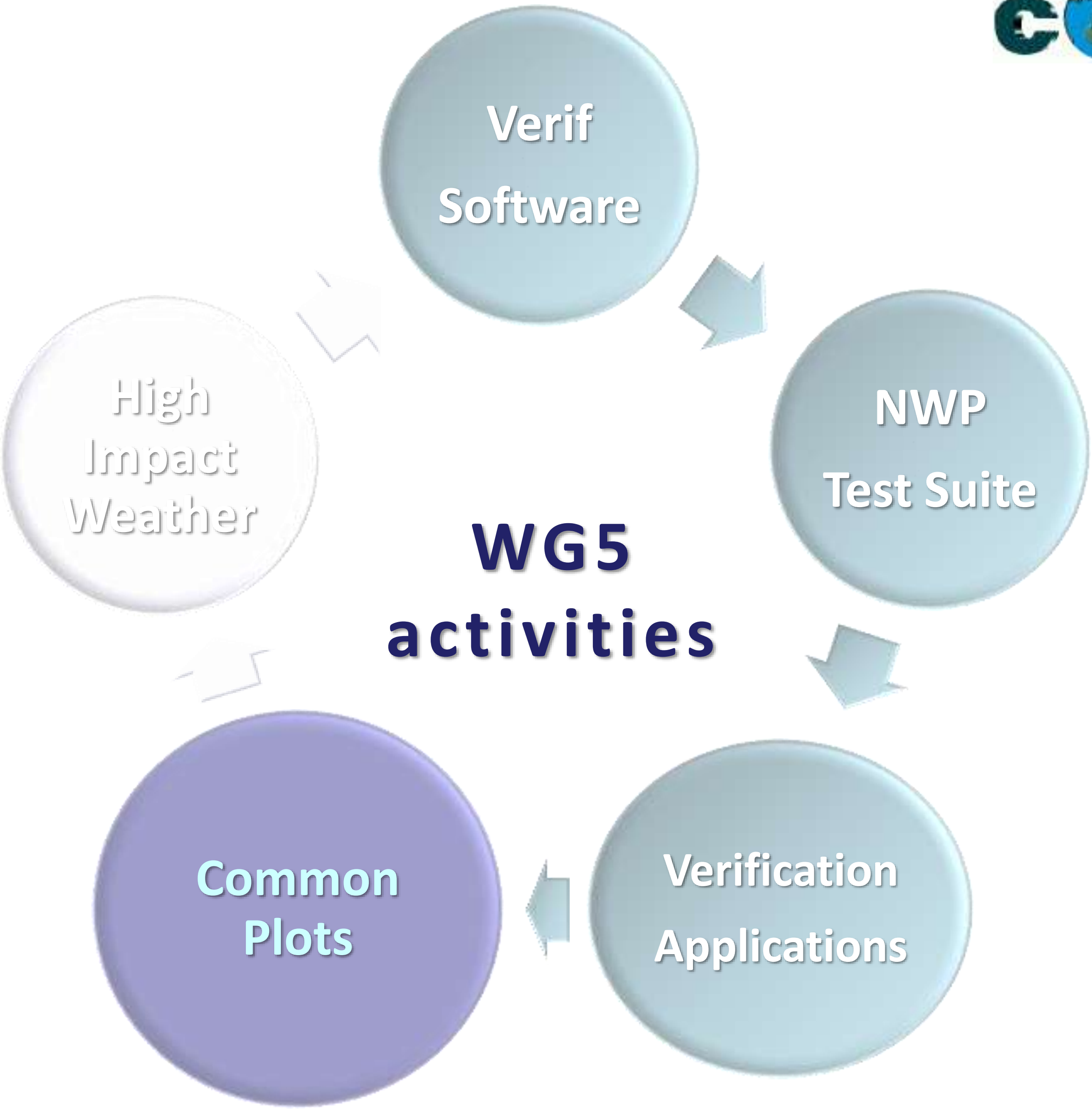
$$a_i = \left(1 - \sum_{r=1}^{i} p_r\right) \Big/ \sum_{r=1}^{i} p_r$$

with the sample probabilities (observed frequencies) given by $p_i = N(O_i) / N$)

QPF: GS trend

MEAN

MAX



Verif
Software
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Test Suite
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activities

Coarse Det / Fine Det / EPS

Service	model	type	IC/BC	DA	cycles	fct range	Mbs	Plans for 2020-2021
DWD	ICON-EU	det	VAE-EnKF/ICON	ICON-EDA	00UTC /3h	120/30h		status confirmed
DWD	ICON-EU-EPS	eps	VAE-EnKF/ICON	ICON-EDA	00UTC /3h	120/30h	40	status confirmed
DWD	ICON-D2	det	ICON-EU	KENDA LHN	00UTC /3h	27h	1	oper in 2020
DWD	ICON-D2-EPS	det	ICON-EU-EPS	KENDA LHN	00UTC /3h	27h	20	oper in 2020
DWD	COSMO-DE	det	ICON-EU	KENDA,LHN	00UTC /3h	27h	1	cease in 2020
DWD	COSMO-D2-EPS	eps	ICON-EU	KENDA,LHN	00UTC /3h	27h	20	cease in 2020
MCH	COSMO-1E	eps	KENDA-1/IFS-HRES	KENDA + LHN	00UTC /3h	33	11	oper Aug 2020
MCH	COSMO-7	det	COSMO-7 Analysis Cycle /IFS-HRES	Nudging + LHN	00,06,12UTC	72		shutdown Oct 2020
MCH	ICON							no plans
COMET	COSMO-ME	det	KENDA 7km/IFS	KENDA 7km	00,06,12,18 UTC	72		status confirmed
COMET	COSMO-ME-EPS	eps	KENDA 7km/IFSENS	KENDA 7km	00,12UTC	72	20	status confirmed
COMET	COSMO-IT	det	KENDA 2.2 km/IFS	KENDA 2.2km	00,06,12,18 UTC	30-48		status confirmed
COMET	COSMOIT-EPS	eps	KENDA 2.2 km/IFSENS	KENDA 2.2km	00,12UTC	48	20	status confirmed
COMET	ICON-IT	det	ICON-KENDA 2.2 KM/IFS	ICON-KENDA 2.2km	00,12 UTC	48		status confirmed
IMGW	COSMO-PL7	det	DAC/ICON	Nudging	00,06,12,18 UTC	86		status confirmed
IMGW	COSMO-CE PL2.8	det	COSMO-PL7	Nudging	00,06,12,18 UTC	48		status confirmed
IMGW	COSMO-PL2.8-TLE	eps	COSMO-PL7	No	00,06,12,18 UTC	36	20	status confirmed
IMGW	ICON-PL	det	ICON	No	00, 12UTC	48		Upgrade to ICT 2019 distribution
RHM	COSMO-RU7	det	ICON	Nudging	00,06,12,18 UTC	78		status confirmed
RHM	COSMO-RU6-ENA	det	ICON	Nudging	00,06,12,18 UTC	120/78		not oper
RHM	COSMO-RU13	det	ICON	No	00,06,12,18 UTC	99/78		status confirmed
RHM	COSMO-RU2cfo	det	COSMO-Ru7	Nudging	00,06,12,18 UTC	42		status confirmed
RHM	COSMO-RU2sfo	det	COSMO	Nudging	00,06,12,18 UTC	42		status confirmed
RHM	COSMO-RU2vfo	det	COSMO	Nudging	00,06,12,18 UTC	42		status confirmed
RHM	COSMO-RU	det	COSMO	Nudging	00,06,12,18 UTC	36		status confirmed
RHM	COSMO-RU2-ETR	det	COSMO-RU6-ENA	Nudging	00,06,12,18 UTC	48		not oper
RHM	ICON-RU	det	ICON		00,12UTC	120/48		test phase

Service	model	type	IC/BC	DA	cycles	fct range	Mbs	Plans for 2020-2021
IMS	ICON-IL-ICON	det	ICON-IN/ICON	No	00,12 UTC	78		oper Nov. 2020
IMS	ICON-IL-IFS	det	ICON-IN/IFS	No	00,12 UTC	78		test phase
IMS	COSMO-IL-RUC	det	IFS	Nudging	hourly	12		pre-oper
IMS	COSMO-IL-ENS	det	IFS	Nudging	00,12 UTC	78	20	oper Nov 2020
IMS	COSMO-IL-CAMS	det	IFS	Nudging	00,12 UTC	78		test phase
IMS	COSMO-IL-IFS	det	IFS	Nudging	00,06,12,18 UTC	90		oper
NMA	COSMO-RO7	det	ICON	Nudging	00,06,12,18 UTC	78/48/174/48		status confirmed
NMA	COSMO-RO3	det	COSMO-RO7	Nudging	00,06,12,18 UTC	30/18/84/30		status confirmed
NMA	ICON-RO2p8	det	ICON	NO	00,12UTC	78		testing phase
HNMS	COSMO-GR4	det	IFS	NO	00-12UTC	72		status confirmed
HNMS	COSMO-GR1	det	COSMO-GR7	NO	00-12UTC	48		status confirmed
HNMS	ICON-GR	det	IFS	NO	00UTC	48		status confirmed
Arpae SIMC	COSMO-5M	det	LETKF –COMET /IFS-ECMWF	NO	00-12UTC	72		status confirmed
Arpae SIMC	COSMO-2I	det	COSMO-5M	KENDA (40 members)	00-12UTC	48		status confirmed
Arpae SIMC	COSMO-2I RUC	det	COSMO-5M	KENDA (40 members)	00UTC /3h	18		status confirmed
Arpae SIMC	COSMO-2I-EPS	eps	KENDA/COSMO-ME-EPS	KENDA (40 members)	00-12UTC	51	20	pre-oper phase
Arpae SIMC	ICON							test phase

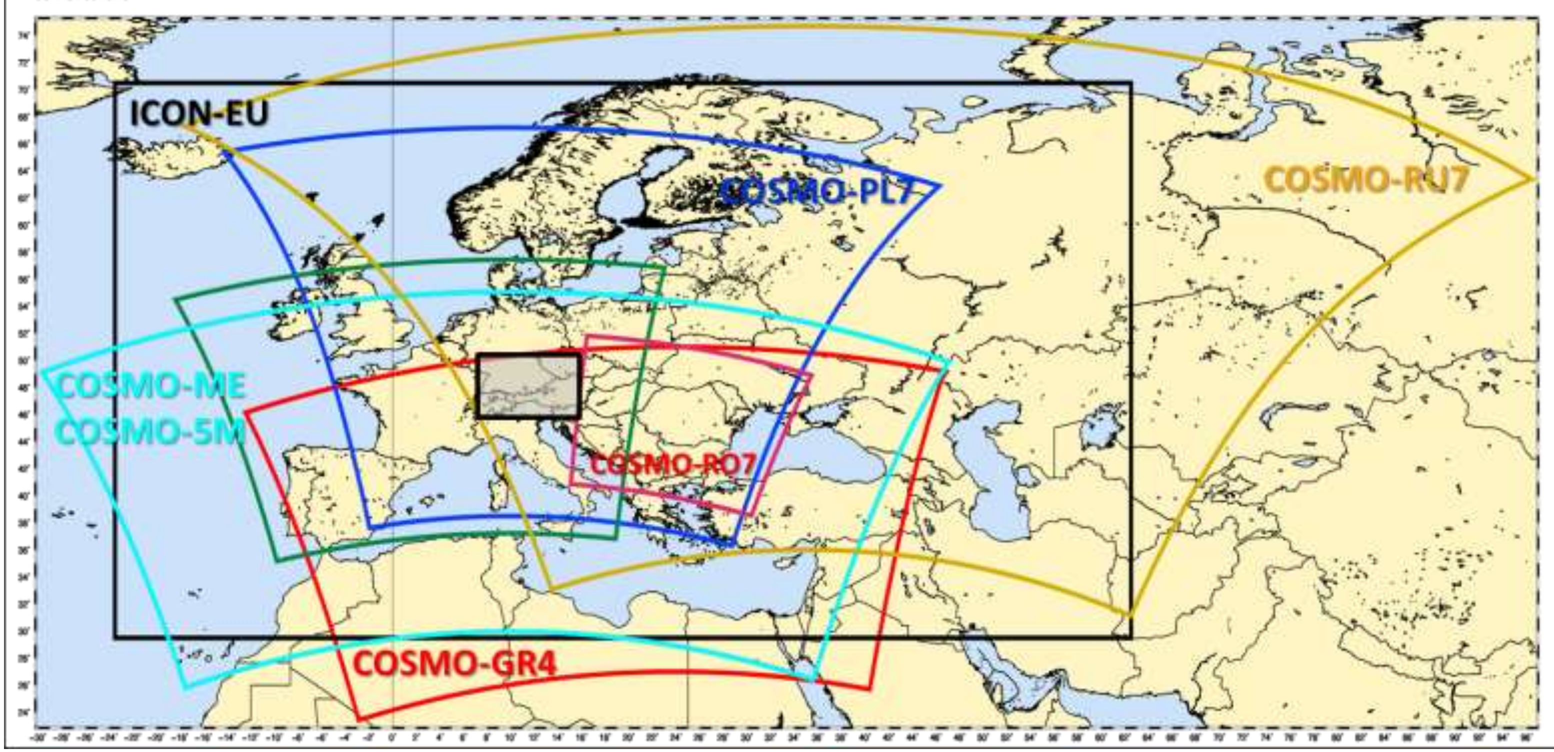
Model Information: updated Aug2020

COSMO / ICON-LAM
2020-2021

Service	model	type	dlon,dlat	IC/BC	DA	cycles	fct range	Mbs	Plans for 2020-2021
DWD	ICON-EU	det	0.0625	VAE-EnKF/ICON	ICON-EDA	00UTC /3h	120/30h		status confirmed
DWD	ICON-EU-EPS	eps	0.0625	VAE-EnKF/ICON	ICON-EDA	00UTC /3h	120/30h	40	status confirmed
DWD	ICON-D2	det	0.02	ICON-EU	KENDA LHN	00UTC /3h	27h	1	oper in 2020
DWD	ICON-D2-EPS	det	0.02	ICON-EU-EPS	KENDA LHN	00UTC /3h	27h	20	oper in 2020
DWD	COSMO-DE	det	0.02	ICON-EU	KENDA,LHN	00UTC /3h	27h	1	cease in 2020
DWD	COSMO-D2-EPS	eps	0.02	ICON-EU	KENDA,LHN	00UTC /3h	27h	20	cease in 2020
MCH	COSMO-1E	eps	0.01	KENDA-1/IFS-HRES	KENDA + LHN	00UTC /3h	33	11	oper Aug 2020
MCH	COSMO-7	det	0.06	COSMO-7 Analysis Cycle /IFS-HRES	Nudging + LHN	00,06,12UTC	72		shutdown Oct 2020
MCH	ICON								no plans
COMET	COSMO-ME	det	0.045	KENDA 7km/IFS	KENDA 7km	00,06,12,18 UTC	72		status confirmed
COMET	COSMO-ME-EPS	eps	0.0625	KENDA 7km/IFSENS	KENDA 7km	00,12UTC	72	20	status confirmed
COMET	COSMO-IT	det	0.02	KENDA 2.2 km/IFS	KENDA 2.2km	00,06,12,18 UTC	30-48		status confirmed
COMET	COSMOIT-EPS	eps	0.02	KENDA 2.2 km/IFSENS	KENDA 2.2km	00,12UTC	48	20	status confirmed
COMET	ICON-IT	det	0.02	ICON-KENDA 2.2 KM/IFS	ICON-KENDA 2.2km	00,12 UTC	48		status confirmed
IMGW	COSMO-PL7	det	0.0625	DAC/ICON	Nudging	00,06,12,18 UTC	86		status confirmed
IMGW	COSMO-CE PL2.8	det	0.025	COSMO-PL7	Nudging	00,06,12,18 UTC	48		status confirmed
IMGW	COSMO-PL2.8-TLE	eps	0.025	COSMO-PL7	No	00,06,12,18 UTC	36	20	status confirmed
IMGW	ICON-PL	det	2.5km / R2B10	ICON	No	00, 12UTC	48		Upgrade to ICT 2019 distribution
RHM	COSMO-RU7	det	0.0625	ICON	Nudging	00,06,12,18 UTC	78		status confirmed
RHM	COSMO-RU6-ENA	det	0.06	ICON	Nudging	00,06,12,18 UTC	120/78		not oper
RHM	COSMO-RU13	det	0.12	ICON	No	00,06,12,18 UTC	99/78		status confirmed
RHM	COSMO-RU2cfo	det	0.02	COSMO-Ru7	Nudging	00,06,12,18 UTC	42		status confirmed
RHM	COSMO-RU2sfo	det	0.02	COSMO	Nudging	00,06,12,18 UTC	42		status confirmed
RHM	COSMO-RU2vfo	det	0.02	COSMO	Nudging	00,06,12,18 UTC	42		status confirmed
RHM	COSMO-RU	det	0.01	COSMO	Nudging	00,06,12,18 UTC	36		status confirmed
RHM	COSMO-RU2-ETR	det	0.02	COSMO-RU6-ENA	Nudging	00,06,12,18 UTC	48		not oper
RHM	ICON-RU	det		ICON		00,12UTC	120/48		test phase

ICON-LAM:DWD, CoMET, IMGW-PIB, HNMS, IMS, RHM?,NMA?, Apra-E?

IMS	ICON-IL-ICON	det	0.025	ICON-IN/ICON	No	00,12 UTC	78		oper Nov. 2020
IMS	ICON-IL-IFS	det	0.025	ICON-IN/IFS	No	00,12 UTC	78		test phase
IMS	COSMO-IL-RUC	det	0.025	IFS	Nudging	hourly	12		pre-oper
IMS	COSMO-IL-ENS	det	0.025	IFS	Nudging	00,12 UTC	78	20	oper Nov 2020
IMS	COSMO-IL-CAMS	det	0.025	IFS	Nudging	00,12 UTC	78		test phase
IMS	COSMO-IL-IFS	det	0.025	IFS	Nudging	00,06,12,18 UTC	90		oper
NMA	COSMO-RO7	det	0.0625	ICON	Nudging	00,06,12,18 UTC	78/48/174 /48		status confirmed
NMA	COSMO-RO3	det	0.025	COSMO-RO7	Nudging	00,06,12,18 UTC	30/18/84/ 30		status confirmed
NMA	ICON-RO2p8	det	0.025	ICON	NO	00,12UTC	78		testing phase
HNMS	COSMO-GR4	det	0.04	IFS	NO	00-12UTC	72		status confirmed
HNMS	COSMO-GR1	det	0.01	COSMO-GR7	NO	00-12UTC	48		status confirmed
HNMS	ICON-GR	det	0.025	IFS	NO	00UTC	48		status confirmed
Arpae SIMC	COSMO-5M	det	0.045	LETKF –COMET /IFS-ECMWF	NO	00-12UTC	72		status confirmed
Arpae SIMC	COSMO-2I	det	0.02	COSMO-5M	KENDA (40 members)	00-12UTC	48		status confirmed
Arpae SIMC	COSMO-2I RUC	det	0.02	COSMO-5M	KENDA (40 members)	00UTC /3h	18		status confirmed
Arpae SIMC	COSMO-2I-EPS	eps	0.02	KENDA/COSMO-ME-EPS	KENDA (40 members)	00-12UTC	51	20	pre-oper phase
Arpae SIMC	ICON								test phase



ComA models

COSMO and one ICON-LAM

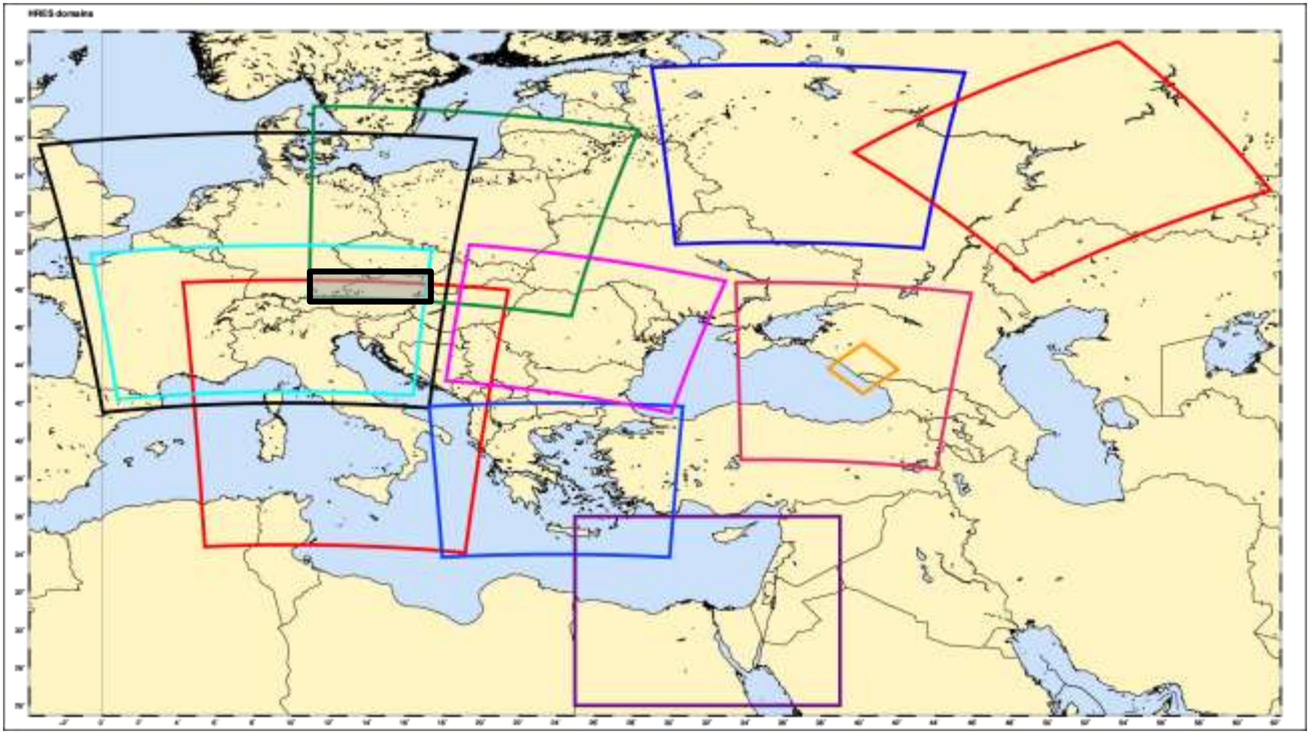
ICON-EU, COSMO-ME, COSMO-PL,

COSM-RU7, COSMO-GR4, COSMO-5M

Driving Md: ECMWF-IFS, ICON

Long term trend

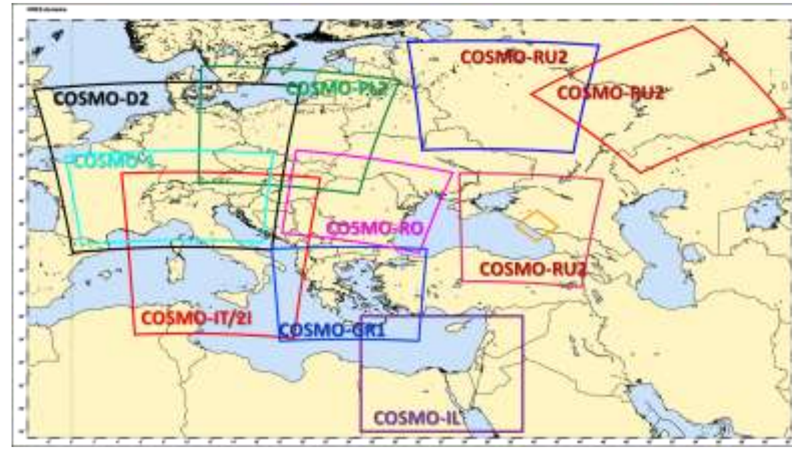
Num	Service	model	IC/BC	DA	cycles	fct range	Plans for 2020-2021
1	DWD	**ICON-EU**	VAE-EnKF/ICON	ICON-EDA	00UTC /3h	120/30h	**status confirmed**
2	COMET	**COSMO-ME**	KENDA 7km/IFS	KENDA 7km	00,06,12, 18UTC	72	**status confirmed**
3	IMGW	**COSMO-PL7**	DAC/ ICON	Nudging	00,06,12, 18UTC	86	**status confirmed**
4	RHM	**COSMO-RU7**	ICON	Nudging	00,06,12, 18UTC	78	**status confirmed**
	RHM	ICON-RU	ICON		00,12UTC	120/48	**test phase**
	NMA	**COSMO-RO7**	ICON	Nudging	00,06,12, 18UTC	78/48/17 4/48	**status confirmed**
5	HNMS	**COSMO-GR4**	IFS	NO	00-12UTC	72	**status confirmed**
6	Arpae SIMC	**COSMO-5M**	LETKF –COMET /IFS-ECMWF	NO	00-12UTC	72	**status confirmed**



ComA-2 models

~~COSMO-D2~~, ICON-D2,
COSMO-PL2.8, ICON-PL,
COSMO-IT, ICON-IT
COSMO-2I
~~COSMO-1~~, COSMO-!E
4 COSMO - 3 ICON-LAM
Spatial Verification: FSS, POD, FAR

Num	Service	model	type	dlon,dlat	IC/BC	DA	cycles	fct range	Plans for 2020-2021
1	DWD	ICON-D2	det	0.02	ICON-EU	KENDA LHN	00UTC /3h	27h	oper in 2020
2	MCH	COSMO-1E	eps	0.01	KENDA-1/IFS-HRES	KENDA + LHN	00UTC /3h	33	oper Aug 2020
3	COMET	COSMO-IT	det	0.02	KENDA 2.2 km/IFS	KENDA 2.2km	00,06,12, 18UTC	30-48	status confirmed
4	COMET	ICON-IT	det	0.02	ICON-KENDA 2.2 KM/IFS	ICON-KENDA 2.2km	00,12 UTC	48	status confirmed
5	IMGW	COSMO-CE PL2.8	det	0.025	COSMO-PL7	Nudging	00,06,12, 18UTC	48	status confirmed
6	IMGW	ICON-PL	det	2.5km / R2B10	ICON	No	00, 12UTC	48	Upgrade to ICT 2019 distrib
7	RHM	COSMO-RU2cfo	det	0.02	COSMO-Ru7	Nudging	00,06,12, 18UTC	42	status confirmed
	RHM	COSMO-RU2sfo	det	0.02	COSMO	Nudging	00,06,12, 18UTC	42	status confirmed
	RHM	COSMO-RU2vfo	det	0.02	COSMO	Nudging	00,06,12, 18UTC	42	status confirmed
8	RHM	COSMO-RU	det	0.01	COSMO	Nudging	00,06,12, 18UTC	36	status confirmed
9	IMS	ICON-IL-ICON	det	0.025	ICON-IN/ICON	No	00,12 UTC	78	oper Nov. 2020
	IMS	ICON-IL-IFS	det	0.025	ICON-IN/IFS	No	00,12 UTC	78	test phase
	IMS	COSMO-IL-IFS	det	0.025	IFS	Nudging	00,06,12, 18UTC	90	oper
10	NMA	COSMO-RO3	det	0.025	COSMO-RO7	Nudging	00,06,12, 18UTC	30/18/84 /30	status confirmed
11	NMA	ICON-RO2p8	det	0.025	ICON	NO	00,12UTC	78	testing phase
12	HNMS	COSMO-GR1	det	0.01	COSMO-GR7	NO	00-12UTC	48	status confirmed
13	HNMS	ICON-GR	det	0.025	IFS	NO	00UTC	48	status confirmed
14	Arpae SIMC	COSMO-2I	det	0.02	COSMO-5M	KENDA (40 members)	00-12UTC	48	status confirmed
	Arpae SIMC	ICON							test phase



No-ComA models

COSMO and ICON-LAM (~14 models)

1-2.5km res

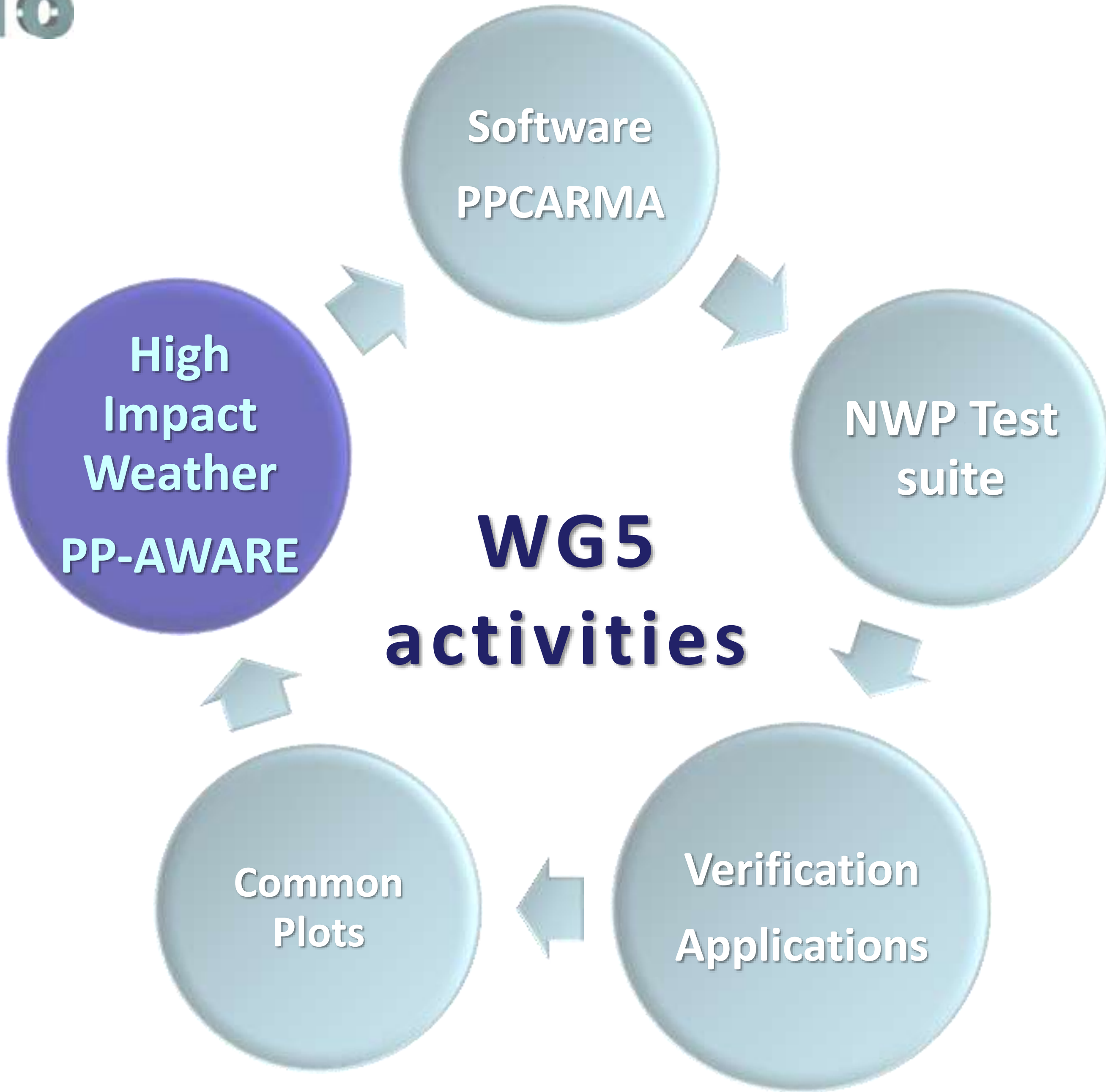
Various areas but both COSMO/ICON-LAM for some domains

Common Plots 2020-2021

Key Questions

A. Models: COSMO/ICON-LAM
B. Comparable resolution(s)
C. Model domain(s)
D. (Common) Verification Software
E. Decision on guidelines
F. Responsible person

- ❑ **MEC/Rfdbk is not installed-used in every service as expected. PP-CARMA is extended, will include also ICON-LAM FFs for verif**
- ❑ **Use both VERSUS and Rfdbk, save in appropriate text format, adaptation of Common Plots scripts**


Software
PPCARMA
NWP Test
suite
Verification
Applications
Common
Plots
High
Impact
Weather
PP-AWARE
WG5
activities

Status of activities: PP-AWARE

Appraisal of "Challenging WeAther" FoREcasts
WG5 &WG4 (collaboration with WG7), Duration: Sept 2019 – Aug 2021
PL. F. Gofa and A. Bundel

Crucial Points

- Various subTasks have been delayed to start
- Almost all efforts concentrated to phenomena connected to convection
- Some small modifications of Task content has been approved (Task 1.1, 3.1). One subtask (4.5) was deleted
- Pending intermediate and few final reports
- Project outcomes will be presented in Int. Verif. Methods Wrks (Nov. 2020)
- Visibility: Application (July 2020) for endorsement by WMO HiWeather International Project: decision is pending

Status of activities: PP-AWARE

PP-AWARE: Appraisal of "Challenging WeAther" FoREcasts

***WG5 &WG4 (collaboration with WG7)*, Duration: Sept 2019 – Aug 2021**

Task 1. Challenges in observing CW/HIW (WG5 and WG4 related)

Question: How well high-impact weather is represented in the observations, including biases and random errors, and their sensitivity to observation density?

HIW phenomena studied: visibility range (fog), thunderstorms (w. lightning), intense precipitation.

Task 1.1 Overview of CW/HIW observational data sources characteristics

Review of available sources, estimation methodologies, and associated error.

End: ~~30082020~~ 30112020 Delayed in report preparation

Additional work on non conventional observations for HIW is added (Chiara Marsigli,DWD) through the WMO Verification Group activity

Task 1.2 Approaches to introduce observation uncertainty

Analysis of observation uncertainty contribution to verification scores focused on HIW forecasts. Anastasia Bundel, RHM. **End: ~~30082020~~ 30112020 Delayed completion**

Status of activities: PP-AWARE

PLs: Flora Gofa and Anastasia Bundel **Duration: Sept 2019 – Aug 2021**

Task 2: Overview of appropriate verification measures for HIW

Question: How well high-impact weather forecast quality is represented with commonly used verification measures? What is the most appropriate verification approach?

HIW phenomena studied: intense precipitation, thunderstorm (lightning activity, visibility range).

Task 2.1 Survey for assessment of proper verification of phenomena – continuous vs. discrete verification (occurrence vs. specific values).

Andrzej Mazur, Joanna Linkowska, IMGW-PIB **End:** ~~30052019~~ **30112020** **Delayed**

Task 2.2 Role of SEEPS and EDI-SEDI for the evaluation of extreme precipitation forecasts

Flora Gofa, Dimitra Boucouvala, HNMS **Start:** Dec 2019 **COMPLETED** **(final report expected)**

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

Anatoly Muraviev, RHM **End:** ~~30082020~~ **31122020** **ONGOING** **Extended**

Done or to be done

Survey on (basic) methods applicable to the problem:

1. Neighborhood-based approaches *)
2. Coverage–Distance–Intensity (CDI) verification*)
3. **SAL (Structure/Amplitude/Location) Verification**)**
4. **FSS (Fraction Skill Score) verification***)**
5. **Standard evaluation at the grid scale**
6. **Categorical analysis (Contingency tables and predictands)**
7. **Cross- (space-lag) correlation approach and verification**

*) Wilkinson, 2017: A technique for verification of convection-permitting NWP model deterministic forecasts of lightning activity. Wea. Forecasting, 32, 97–115

**) Wernli *et al.*, 2008, SAL – a Novel Quality Measure for the Verification of Quantitative Precipitation Forecasts, Mon.Wea.Rev.136(11):4470–4487,https://doi.org/10.1175/2008MWR2415.1

***) Blaylock and Horel, 2020: Comparison of Lightning Forecasts from the High-Resolution Rapid Refresh Model to Geostationary Lightning Mapper Observations, Wea. Forecasting 35, 402-416

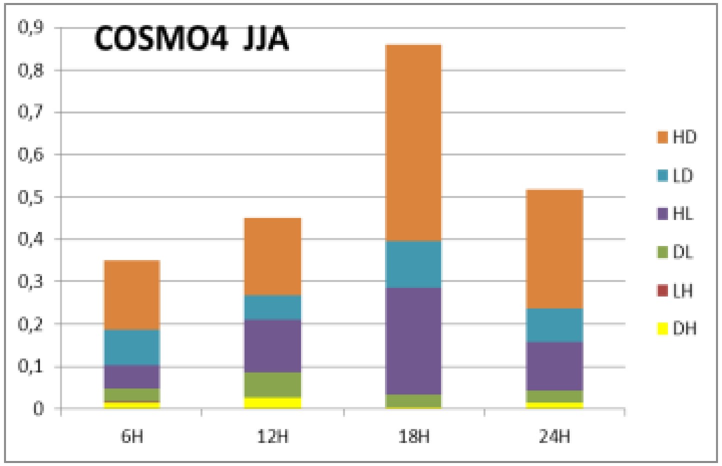
Stable Equitable Error in Probability Space

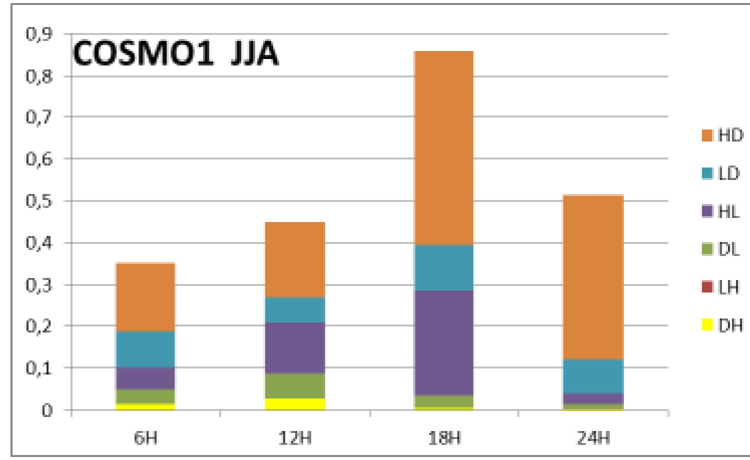
- A score based on climatology.
- Measures the ability of a forecast to discriminate between 3 categories: ‘dry’, ‘light’, and ‘heavy’ precipitation. Thresholds for each category and climatological probabilities need to be defined.
- The threshold (TH1) between **dry and light** category is constant (0.2mm).
- The threshold defining the boundary **between the ‘light’ and ‘heavy**’ categories (TH2) **varies systematically** and is defined by local climatology for **each station and month**.
- Climatological probabilities are: for dry p1, for light p2, for heavy p3
- A 3x3 scoring matrix Rodwell et al. (2010) with the assumptions p3=p2/2 and p1+p2+p3=1 is constructred as a function of p1 only.

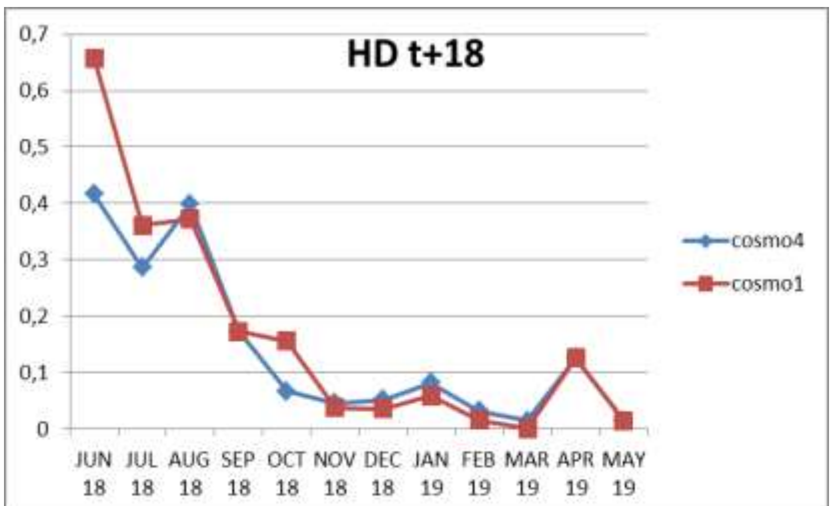
D.Boucouvala, F.Gofa, C.Kolyvas HNMS)

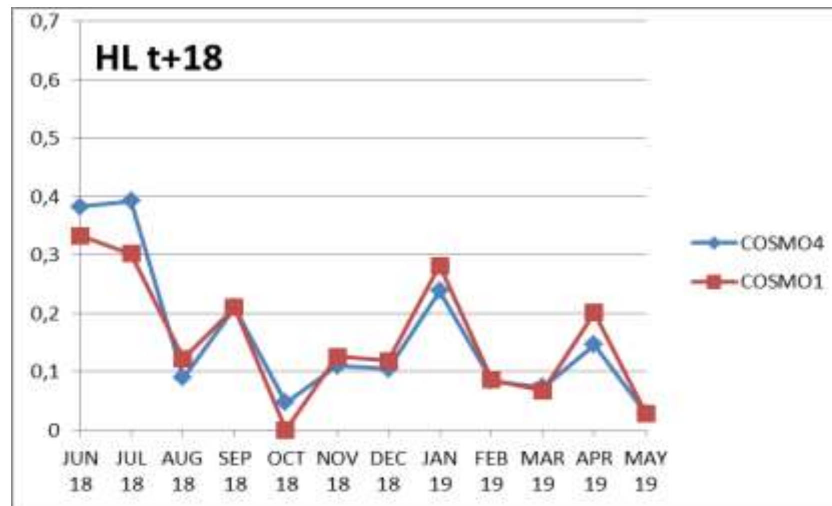
SEEPS seasonal results (for all stations) for COSMO4, COSMO1.
Colors exhibit different score contributions from each SEEPS matrix element: *(e.g. HD: Heavy obs/ Dry forecast)*

HD
LD
HL
DL
LH
DH









SEEPS=**HD+HL**+DH+DL

SEEPS HD (Heavy OBS, Dry FCS) component (**best is 0**). Higher values in the summer-> SEEPS main component is HD. COSMO1 worse in JJA

SEEPS HL (Heavy OBS, Light FCS) component (**best is 0**) .January high values -> SEEPS January main component is HL.

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

Anatoly Muraviev, RHM

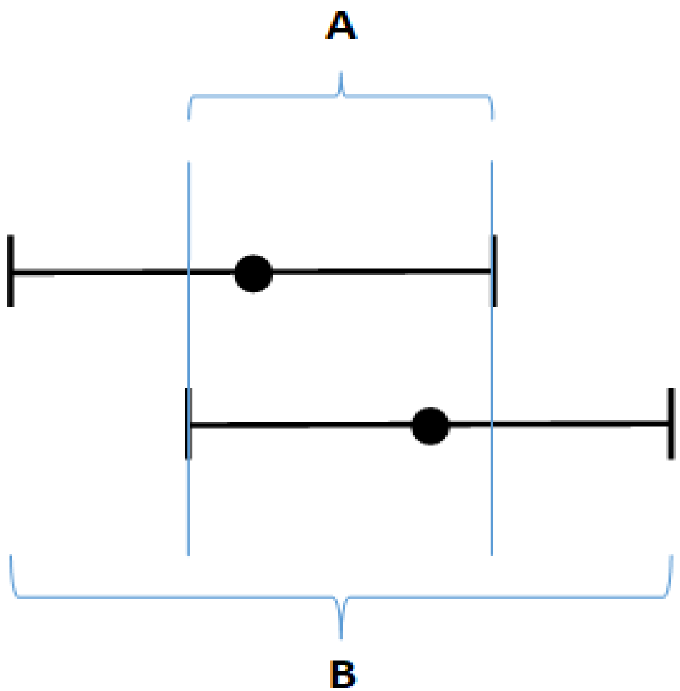
FTE 0.3, Start 09.2019 – End 08.2020

Report under preparation. Extension until 31.12.2020 is required

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

- The method analyses **the largest precipitation objects** (predicted by STEPS nowcasting system implemented at RHM) using Peaks over threshold (PoT) approach
- **The largest objects (peaks) are fitted to Generalized Pareto (GP) distribution** using the GMLE (Generalized Maximum Likelihood Estimation)
- Two parameters defining GP are found: scale (σ), and shape (ξ) along with the confidence intervals

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 = A/B

Ideal intersection ratio = 1, meaning ideal simulation of the observed distribution of extreme value by the model

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

STEPS Intersection ratio (%) in warm and cold period, precip > 1 mm/h, scale parameter σ, Kursk radar

Lead time, min	625	900	1225	1600	625	900	1225	1600
Lead time, min	Warm period				Cold period			
30 min	80	74	61	71	75	68	74	51
60 min	83	77	80	79	50	63	73	28
90 min	83	73	84	70	23	38	67	54
120 min	79	68	79	75	21	20	52	70

The higher the numbers in the table, the better!
STEPS is better in warm period for predicting vast precipitation areas of precipitation greater than 1 mm/h for this radar

Status of activities: PP-AWARE

Task 3: Verification applications (with a focus on spatial methods) to

Question: Can spatial verification methods contribute to the proper evaluation of HIW phenomena and in what way?

HIW phenomena studied: intense precipitation, thunderstorm (lightning activity LPI

Task 3.1 Verification of forecasts of intense convective phenomena (thunderstorms w. lightning) ~~and visibility range (fog)~~. Joanna Linkowska, IMGW-PIB**, End** 08.2021 **ONGOING**

Task 3.2 Lightning potential index (LPI) in mountain regions. Daniel Cattani, MCH, **, End** 08.2021 **ONGOING**

Task 3.3. CRA (Contiguous rain area) and FSS analysis on intense precipitation Anastasia Bundel, RHM, **End:** ~~30082020~~ **31082021** **DELAYED**

Task 3.4 DIST methodology tuned on high-threshold events for flash floods Maria Stefania Tesini, Arpae-SIMC, **End**: Aug 2020, **COMPLETED**

Task 3.5 LPI verification and correlation of convective events with microphysical and thermodynamical indices. Dimitra Boucouvala, F. Gofa, HNMS, **End**: Aug 2021 **ONGOING**

Task 3.6 Work on the comparative verification of NWC and NWP results using spatial verif methods as part of the SINFONY project at DWD. Michael Hoff, DWD **End**: Feb 2021 **ONGOING**

Andrzej Mazur, Joanna Linkowska
Institute of Meteorology and Water Management – National Research Institute

Verification of forecasts of intense convective phenomena

Done (1)

Observations: lightnings (C2G, C2C) from the Polish lightning detection network PERUN, covering Poland + parts of neighbouring countries

Forecast: CAPE-based FLR (Flash Rates) as follows:

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

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

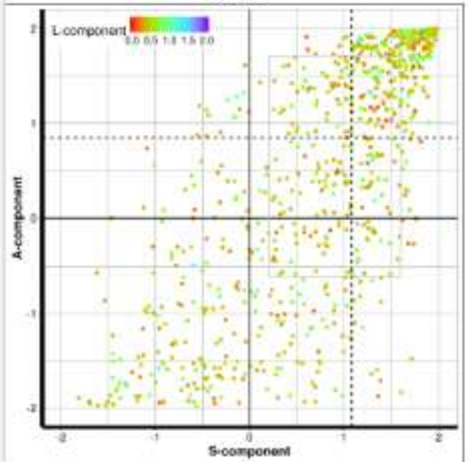
$$if \quad CTT > -15°C \quad FR = FR \cdot \left[\max\left(\frac{-CTT}{15}, 0.01\right)\right]$$

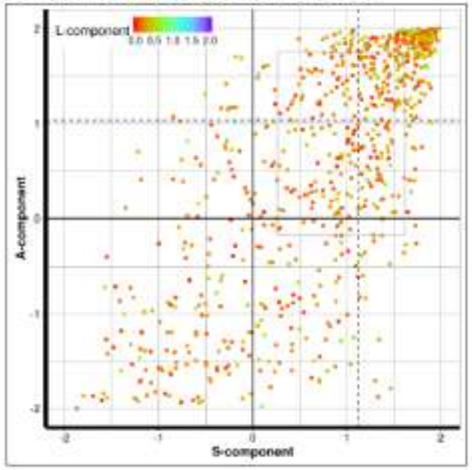
$$if \quad CBT < -5°C \quad FR = FR \cdot \left[\max\left(\frac{CBT + 15}{10}, 0.01\right)\right]$$

Archive observations vs. forecasts (2011-2017)

Examples (1)

SAL | SAL with cross-correlation



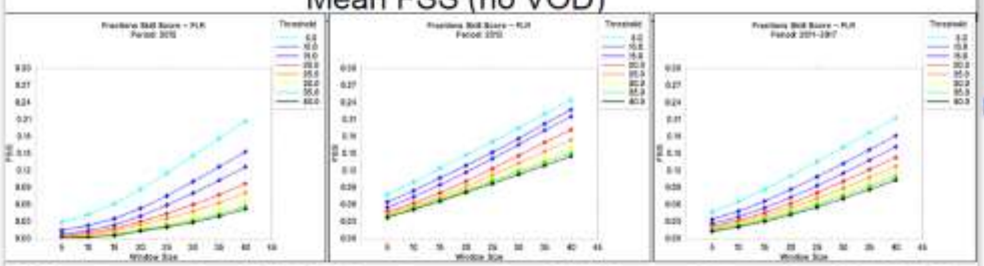


All selected cases (2011-2017)

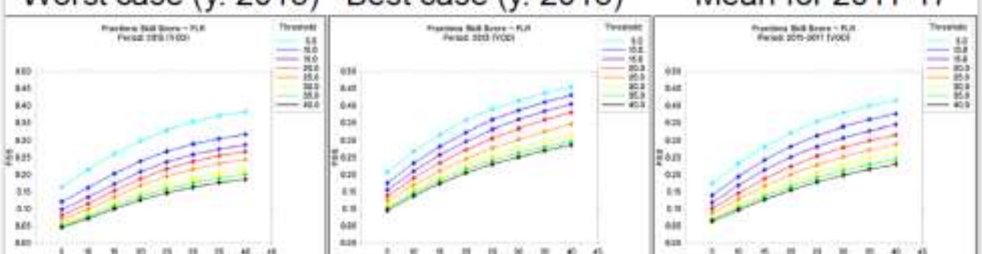
Dotted lines denote the median Structure- and Amplitude-component scores, resp.
The box corresponds to the 25 and 75 quartiles of S (*x*-axis) and A (*y*-axis) components.

Examples (1)

Mean FSS (no VOD)

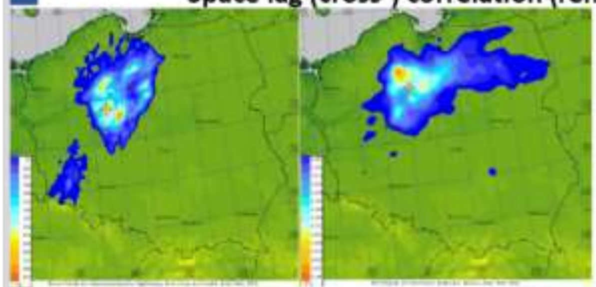


Worst case (y. 2015) | Best case (y. 2013) | Mean for 2011-17



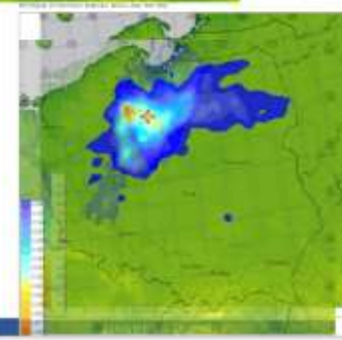
Mean FSS with VOD

Space lag (cross-) correlation (reminder)



Calculate coordinates of "centres of mass" for both distribution patterns (obs. vs. fcst)

Compute vector of displacement of fcst to obs. as a difference of the two above



Verification applications (spatial) to HIW - LPI in mountain regions (Task 3.2)

Daniel Cattani, André-Charles Letestu, Mathieu Schaer

Indices available

IFS ENS

Average lightning flash density

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

$$Q_R = \int_{z(0^\circ C)}^{z(-25^\circ C)} q_{graup} \, (q_{cond} + q_{snow}) \rho(z) \, dz$$

- Microphysics by hydrometeor amounts
- Convection by CAPE, height cloud base

Ecmwf Newletter 155

COSMO ens

LPI, lightning potential index, converted in lightning flash density

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

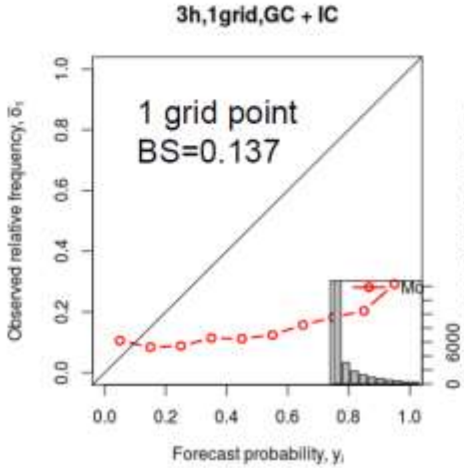
$$\varepsilon = 2(Q_s Q_l)^{0.5} / (Q_s + Q_l), \qquad Q_i = q_g \left[\left((q_s q_g)^{0.5} / (q_s + q_g) \right) + \left((q_i q_g)^{0.5} / (q_i + q_g) \right) \right]$$

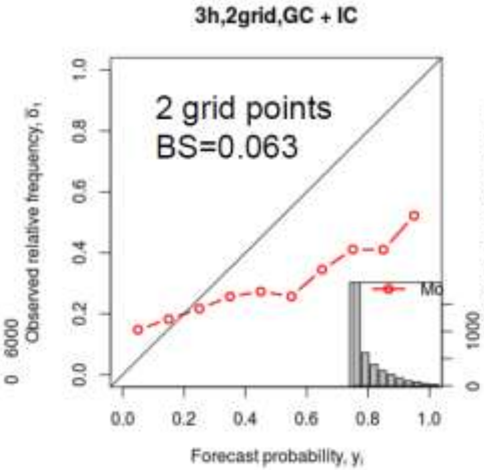
-Microphysics by hydrometeor amounts

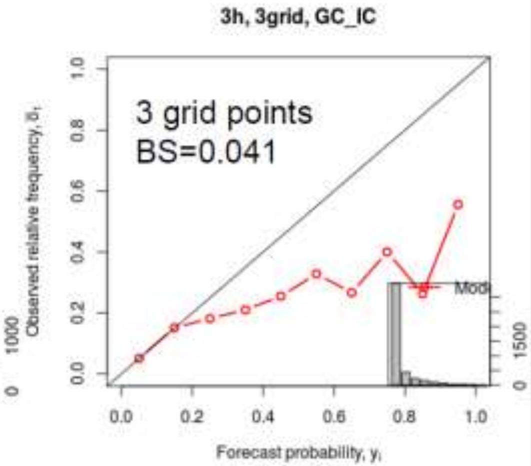
-Convection by vertical velocity ω

Jonas Jucker (Master Thesis MeteoSwiss 2019)

Scale resolution

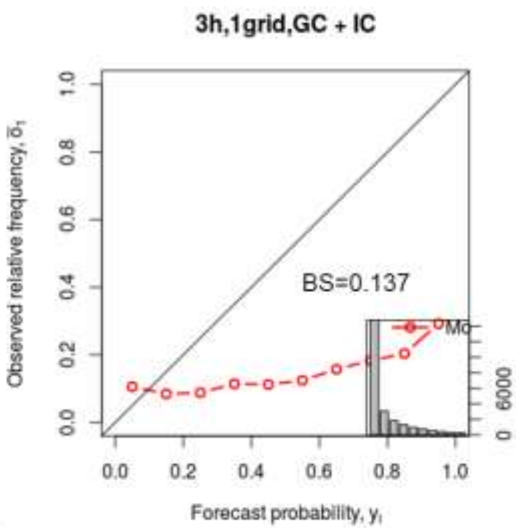


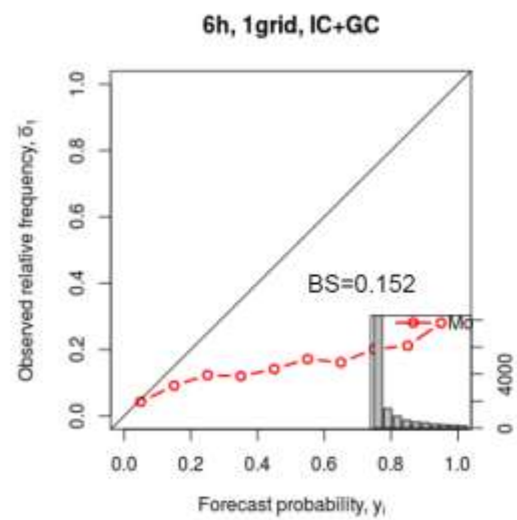




Threshold used very low → density ≥1 flash/100km^2

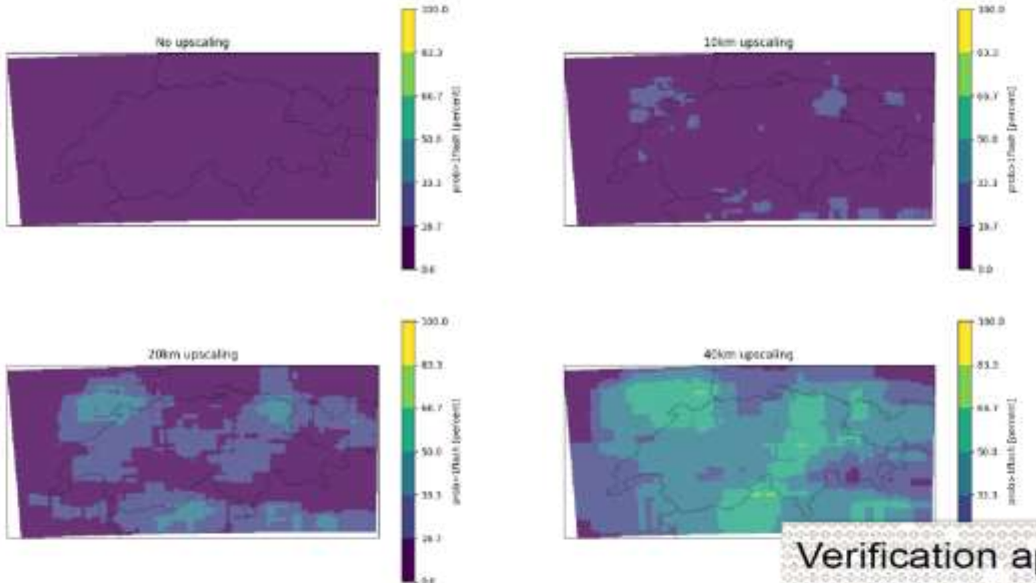
Time aggregation

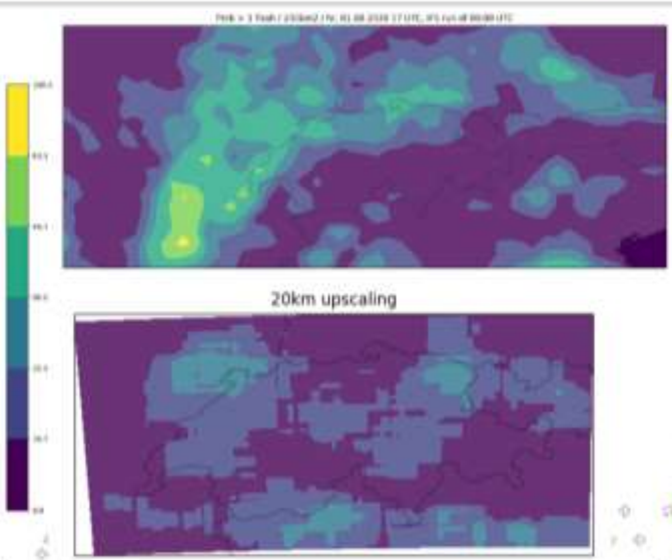


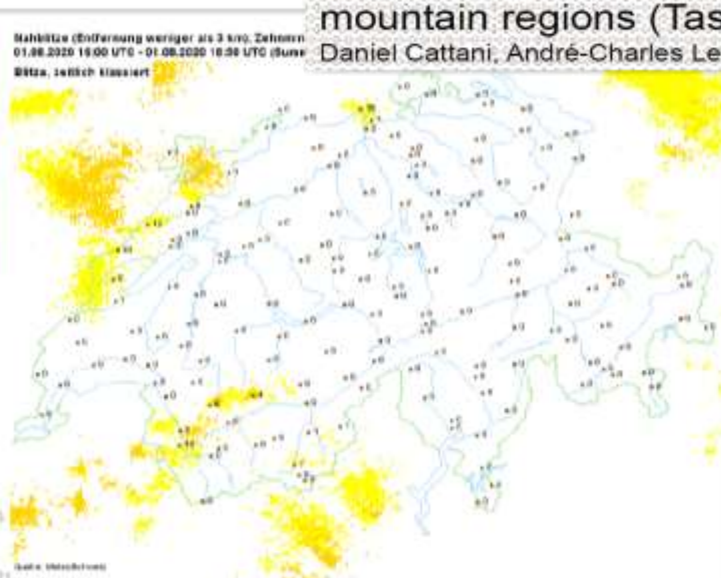


1st August COSMO 2E

COSMO 2E run 00UTC, val 17UTC, prob of flash density ≥ 1 flash / km² /h







Verification applications (spatial) to HIW - LPI in mountain regions (Task 3.2)

Daniel Cattani, André-Charles Letestu, Mathieu Schaer

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Task 3.6:
Verification applications (spatial) to HIW - Comparative verification of NWC and NWP using spatial verification methods (SINFONY)

Today:
Extension of object-based verification of NWC and NWP towards “gridded objects” and ensemble forecasts

AWARE report

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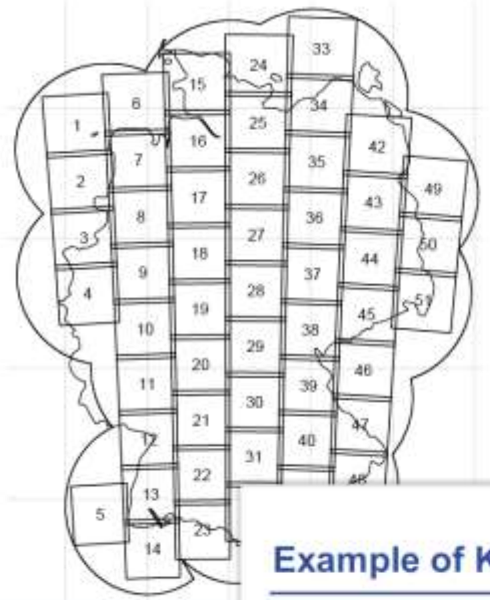
Tel.: +49 (0) 69 / 80 62 -3146

SINFONY

Introduction of “gridded objects”

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

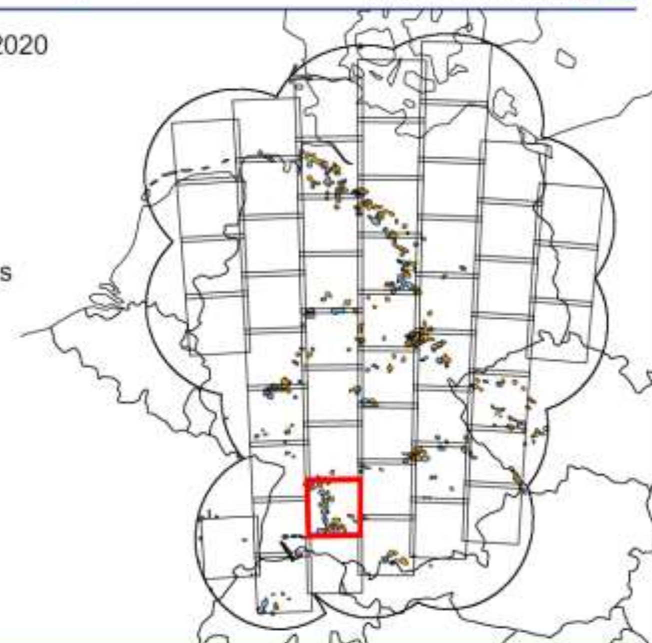
- ➔ For **small-scale convective events** it is unnecessary to compare all objects all over Germany with each other
- ➔ Divide region of German radar composite into **51 grid boxes** with edge lengths of about 100 km and assign objects according to their **centroid position**
- ➔ **Overlap of 10%** of the boxes allows objects to belong to more than one box *(better more overlap? tests ongoing!)*
- ➔ Calculation of **MMI for each box** separately
- ➔ **MMI for entire domain** can be calculated additionally



Example of KONRAD3D objects

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- ➔ Preliminary data for 3 June 2020
  - ➔ Observation 13:05
  - ➔ Nowcast for 13:35
  - ➔ Observation 13:35
- ➔ Divide domain into grid boxes
  - ➔ **“Gridded objects”**

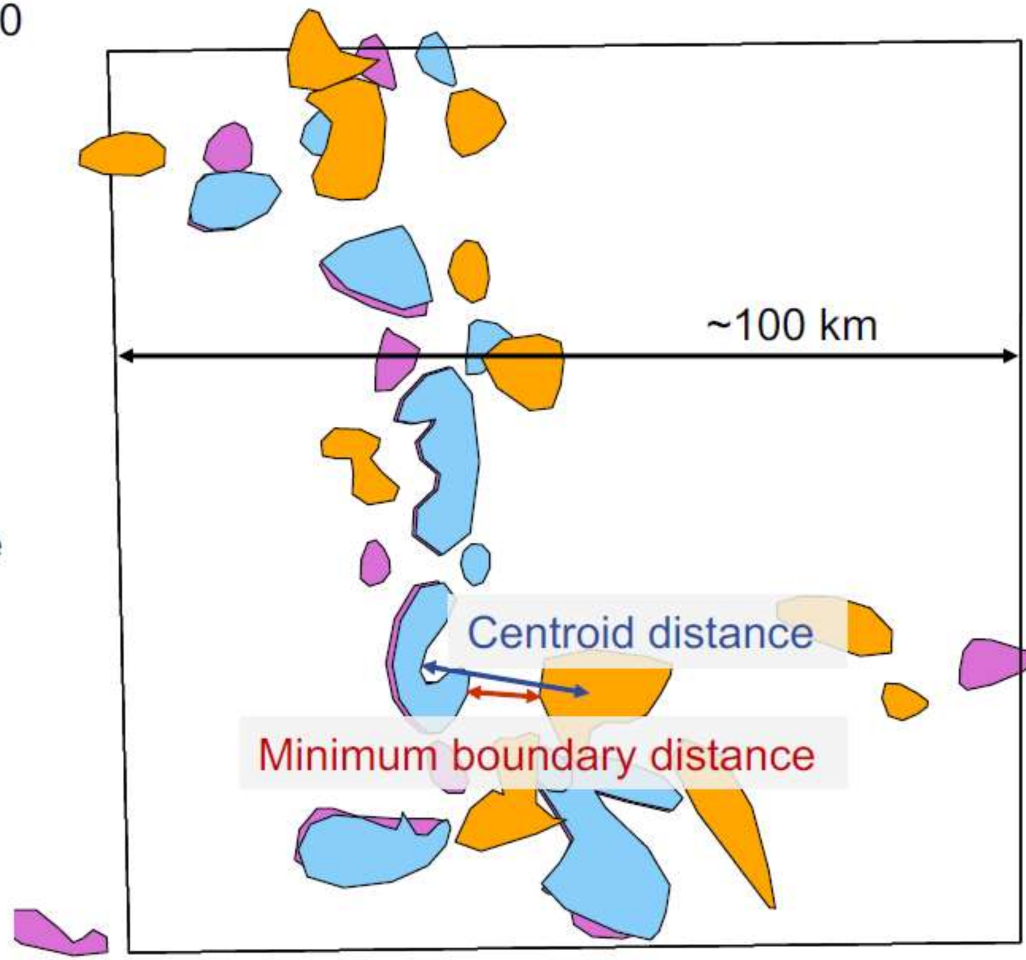


Example of KONRAD3D objects

- Preliminary data for 3 June 2020
  - Observation 13:05
  - Nowcast for 13:35
  - Observation 13:35

- Attributes of interest
  - Centroid distance
  - Minimum boundary distance
  - Area ratio
  - Intersection area ratio

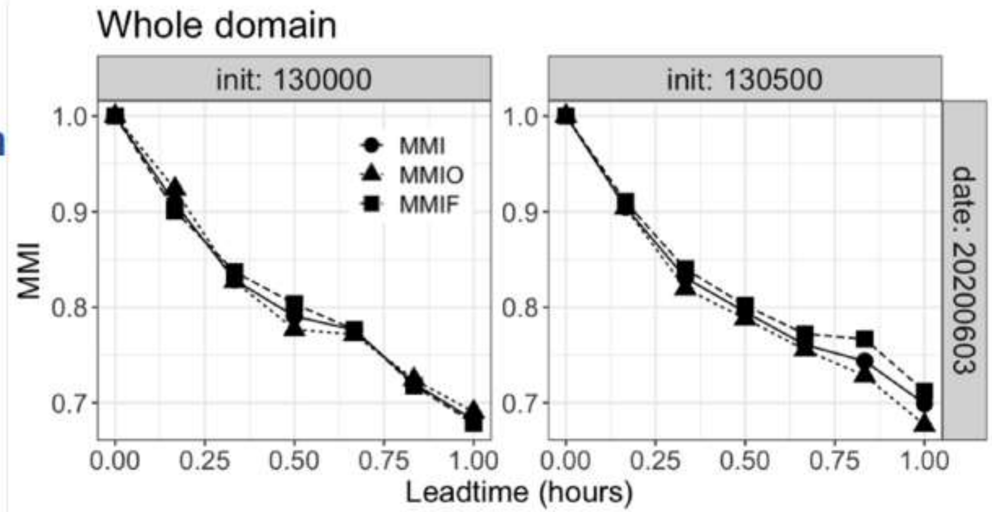
- Compare all nowcasted with all observed objects

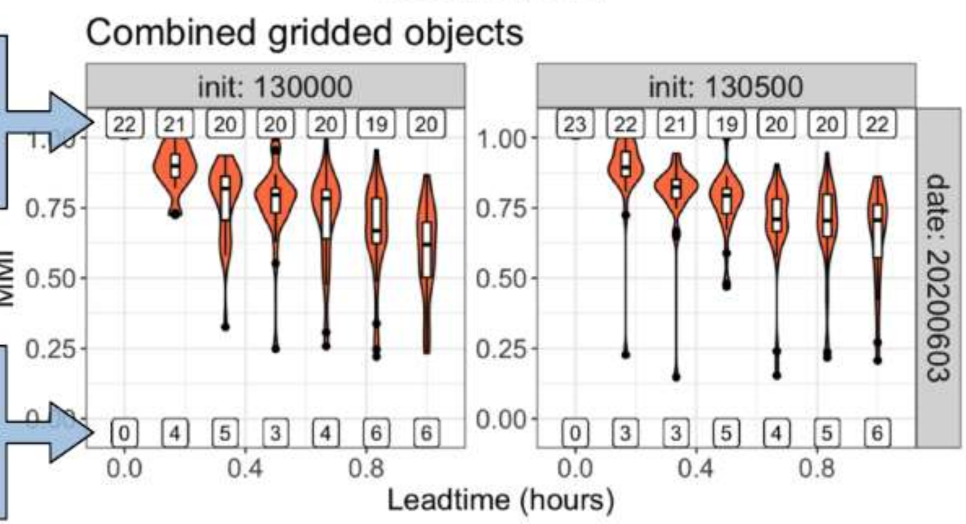


Visualisation

- Extended R-Shiny application **plots single grid boxes separately** or the **entire domain**

- Additionally a **combined violin-/box-plot** shows the probability density and the distribution of the scores of all grid boxes





number of boxes with 0 objects in both the observations and forecasts 👍

number of boxes with 0 objects in either the observations or the forecasts 👎

PP AWARE Task 4: Overview of forecast methods, representation and user-oriented products linked to HIW

- Task 4.1. Postprocessing vs. direct model output (DMO) for HIW.

  - Overview of model methods to predict fogs is prepared (E. Tatariniovich); Overview of postprocessing methods to predict fogs is under preparation;

  - Supercell detection index (SDI) and Significant Tornado Parameter (STP) for **detecting areas with a high probability of tornado formation (D.Zakharchenko)**, experiments with high-resolution COSMO and ICON-LAM forecasts
- Task 4.2 Improving existing post-processing methods **Intermediate report is under preparation. After approval of MILEPOST, this task will be shifted to MILEPOST**
- Task 4.3 QPF evaluation approaches. **Finished. The report is prepared**
- Task 4.4. Representing and communicating HIW forecast for decision making. **A document "How to provide high-resolution NWP output for adverse weather forecasting" is being prepared by RHM. NMA contribution is delayed**
- Task 4.5 Product generation and calibration of convection-permitting ensemble is **Cancelled** because of the lack of resources. 0.1 FTEs shifted to Task 1.1.3. Review of non conventional observations and their use in verification

Task 4.2. Improving existing post-processing methods (IMGW)

Improving existing post-processing methods: Use of MLR, A/R-LS and/or ANN techniques

Introduction (2)

Various methods of post-processing

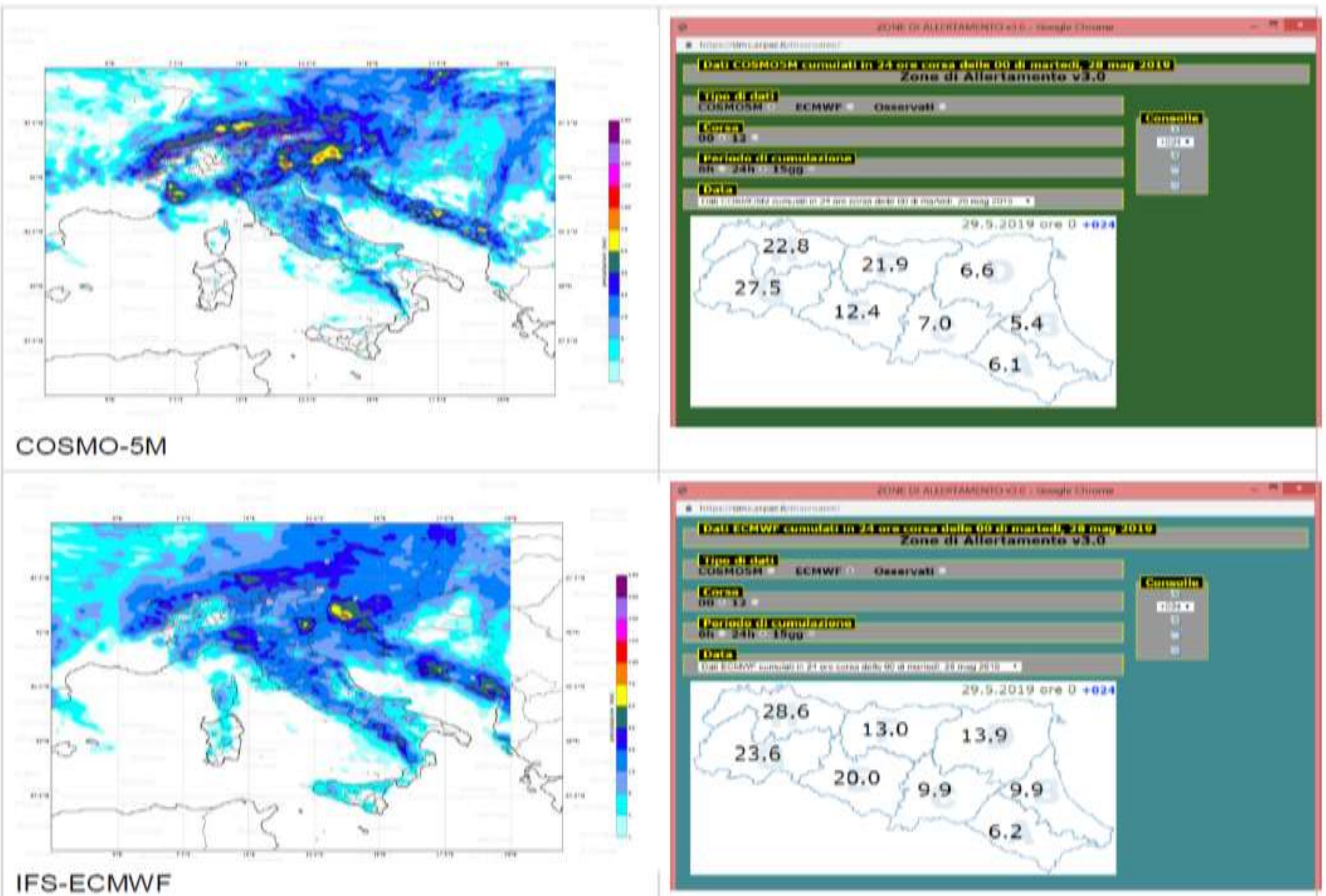
1. Multi-Linear Regression (MLR) – class of LMS method with multidimensional input data vector, yet constant over time

2. Adaptive/Recursive least mean squares (LMS)

3. ANN – transferring the problem from EPS- to deterministic forecasts

Various set-ups of post-processing of various methods have been tested over the seven-years period.

Task 4.3 QPF evaluation approaches (ARPAE-SIMC, M.S. Tesini)

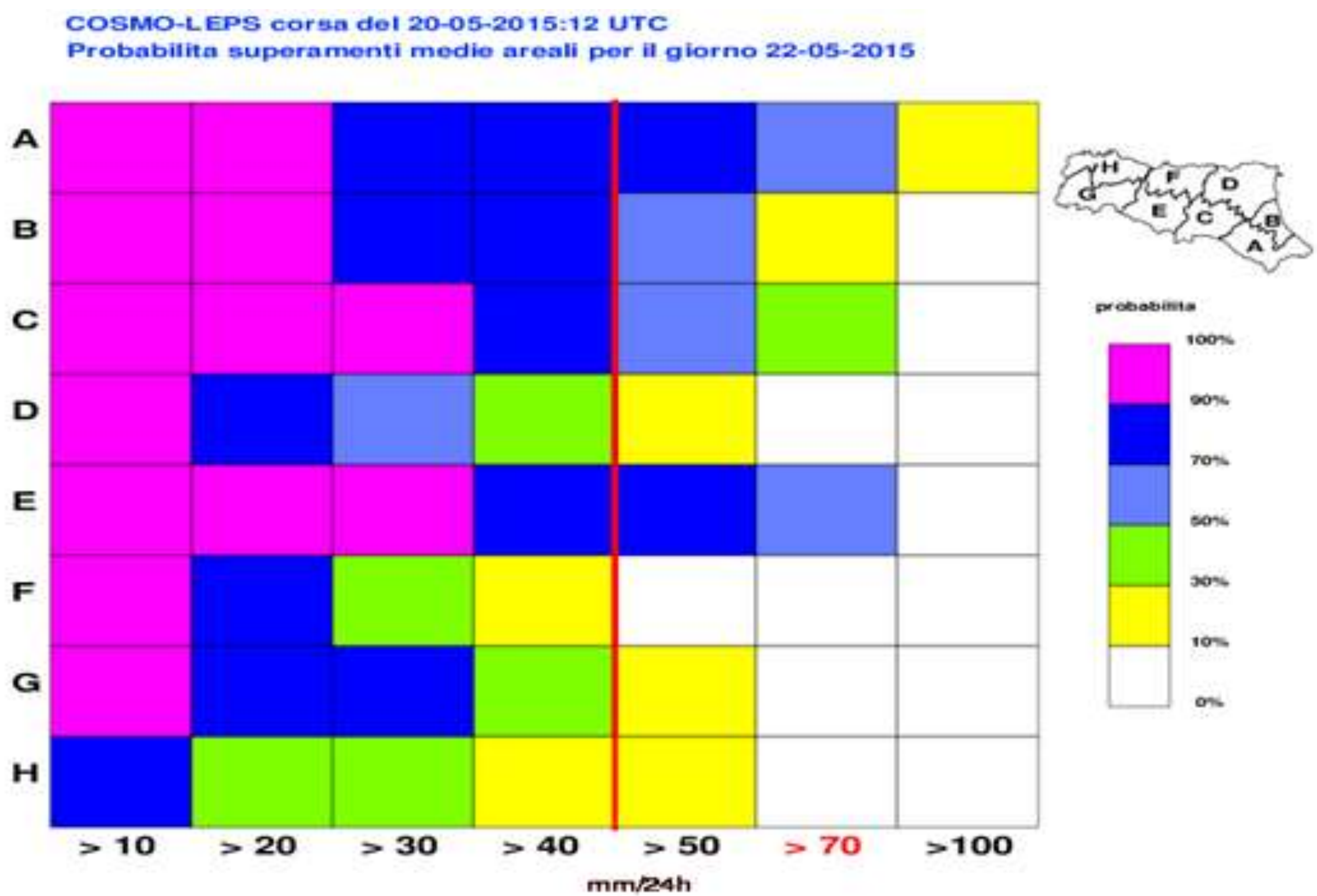


Example of total precipitation field and corresponding average value on Emilia-Romagna catchment areas of COSMO-5M (top) and IFS-ECMWF (bottom)

For each model, it is possible to visualize the estimated average precipitation over each catchment area by step of 6 or 24 hours for the available period of forecast

WG4

Probability of exceeding for increasing thresholds of the average areal precipitation based on the COMSO system (indicated by colors). In the table, rows represent the catchment area of the Emilia-Romagna region, while columns the threshold (mm/24)

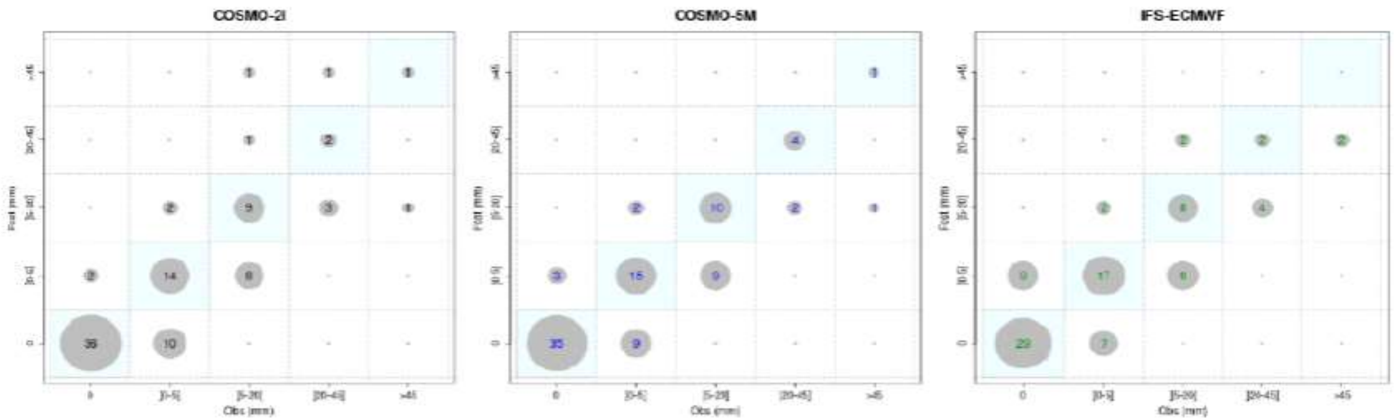


The thresholds on probability are not used to issue alert, but they help forecaster to assess confidence in one modeling chain or another

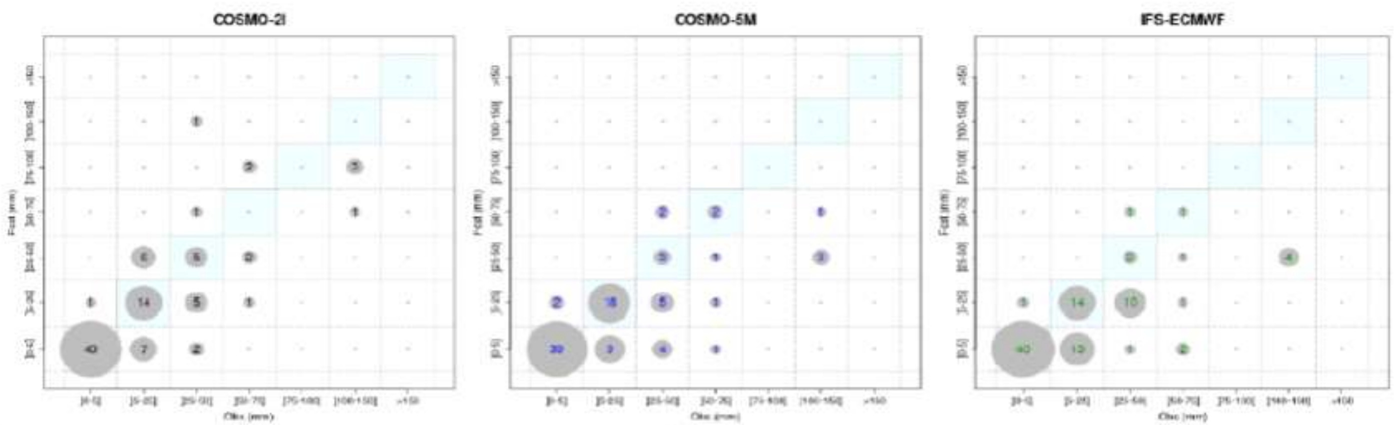
Validation

Emil-E run 00 UTC - cumulata in 24 ore a +48

MEDIA



MASSIMO



Example of “bubbles plot” relative to an area of the Emilia-Romagna region, as presented in the Arpae seasonal report for MAM2019. In the top panel are displayed the charts for mean value, in the bottom panel those for maximum for the three models (COSMO-2I, COSMO-5M,IFS-ECMWF from left to right)

Task 4.4. Representing and communicating HIW forecast for decision making, RHM

- I. Rozinkina: a document is being prepared: "**How to provide high-res NWP for adverse weather forecasting" (additional 0.1 FTE according to the STC decision)**
- **It will summarize the Russian experience in providing forecasters responsible for warnings with NWP output from different COSMO-Ru configurations.** The recommendations should take into account many factors: different geographical areas (moderate, subtropical, plane and mountain), grid steps, events (e.g., different NWP products are required to forecast storm wind due to mesoscale convective systems at the front and due to bora)

Contents of the document

- **Typical geographical conditions and corresponding HIW events**
- **Official guidelines to issuing warnings in the weather service (how often, which lead times, which economy sector, etc.)**
- **Procedure of HIW forecast issuing: the role of automated and human forecast in decision-making, …)**
- **Role of NWP: which products for different HIW classes**
- **Requirements of forecasters to NWP product form depending on the lead time and spatial scale**
- **Examples of HIW development on different domains**
- **Examples of NWP products**
  - charts, meteograms, maps, and their combinations for different HIW
  - Processed NWP: convective indices, etc.
- **Forecast reliability**
  - Typical errors in interpretation of NWP, pitfalls, etc.
  - Taking into account verification results: Common verification – which variables are most reliable, differences among COSMO countries.
  - Success-failure cases analysis as a feedback from forecasters
  - Communicating verification results to forecasters

Re-forecast of the Piedmont major flood of 1994 by COSMO-2I-EPS

Pincini G., <u>Cerenzia I.,</u> Paccagnella T., Cesari D., Gastaldo T., Minguzzi E.

Arpae-Emilia Romagna, Bologna

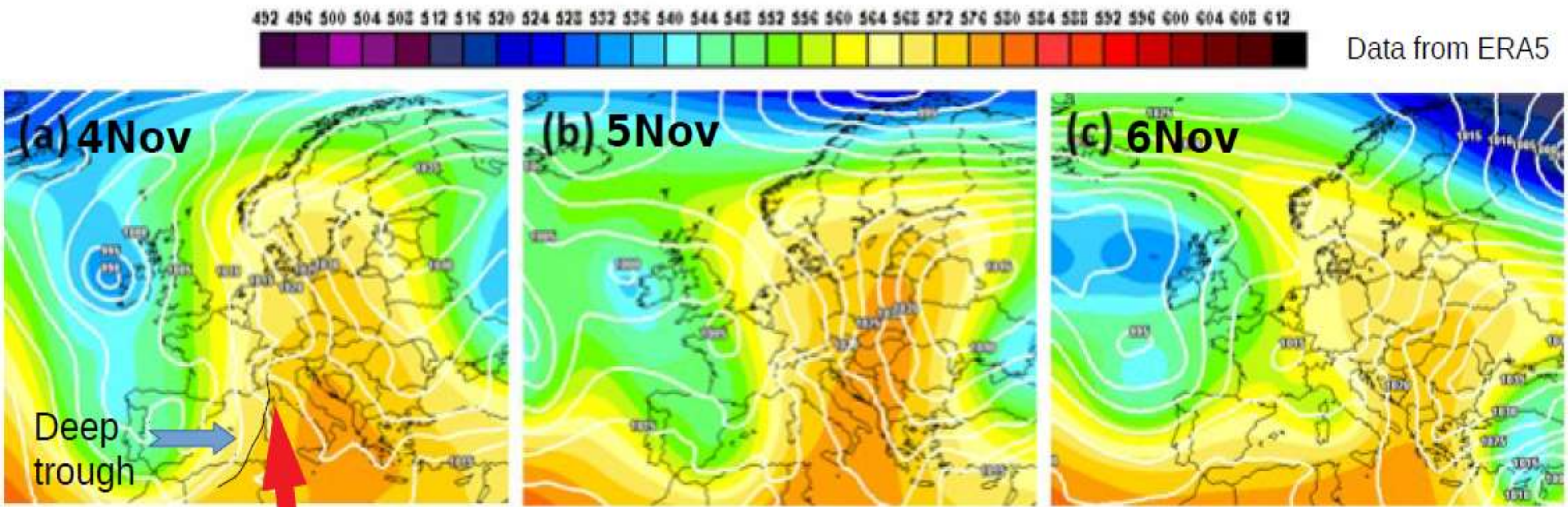
COSMO CONSORTIUM FOR SMALL SCALE MODELLING

arpae agenzia prevenzione ambiente energia emilia-romagna

Synoptic situation

Geop500hPa 04-06 November 1994

Data from ERA5



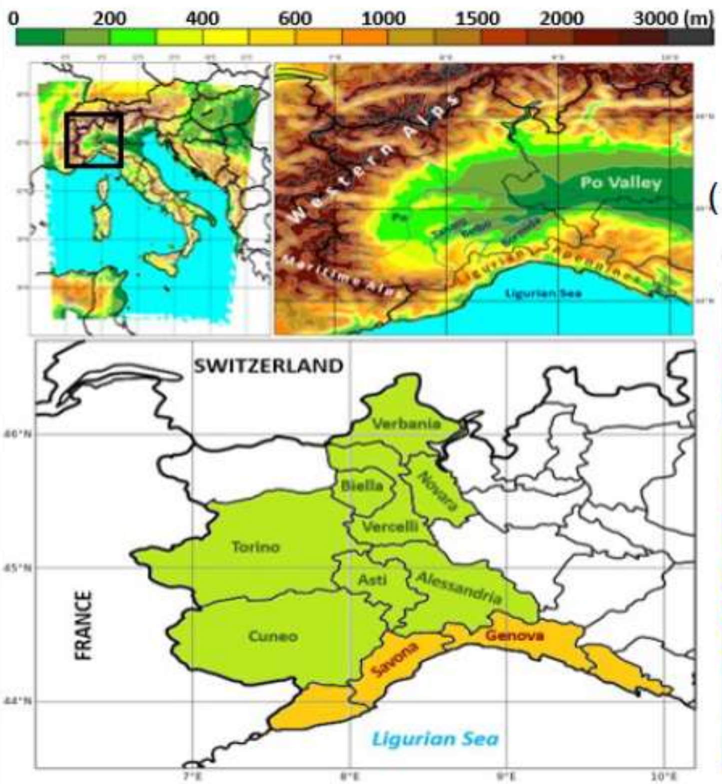
Warm moist air from Mediterranean Sea

Slowly-evolving synoptic situation

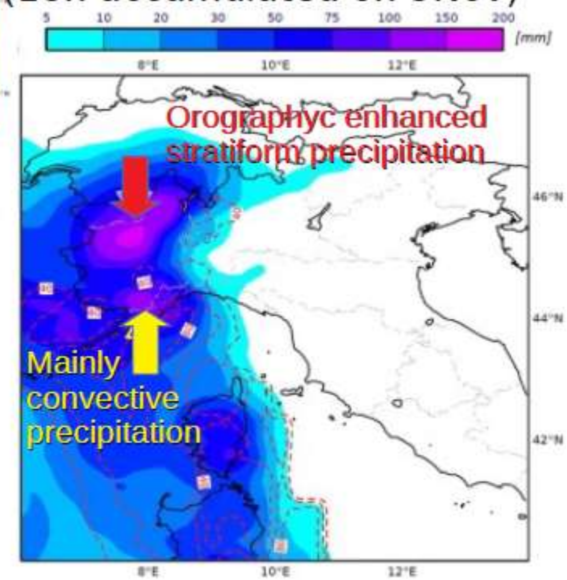
Autumnal case: high thermal contrast

WG4

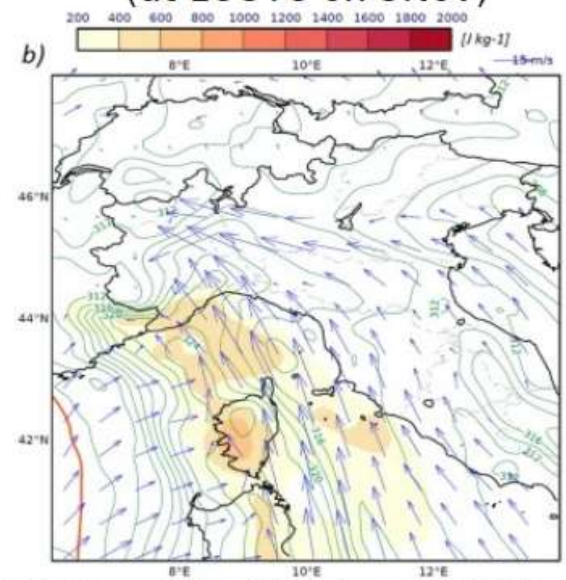
Flow interaction with the orography



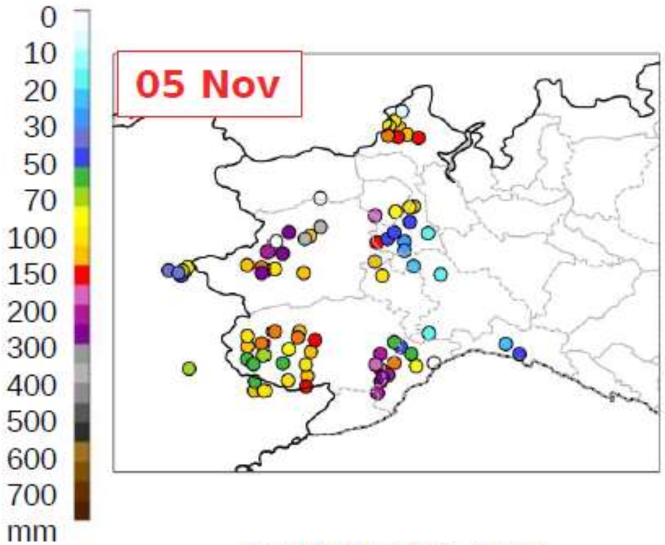
Tot. Prec
(18h accumulated on 5Nov)



UV at 925hPa, CAPE
(at 18UTC on 5Nov)

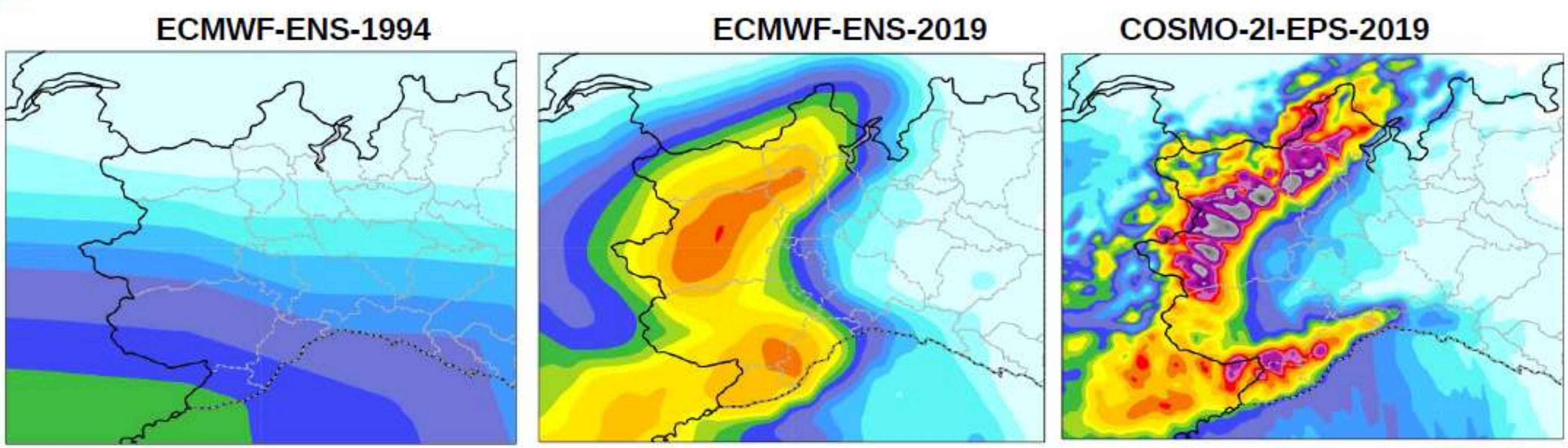


Data from ERA5, Grazzini et al. 2020



Conclusions

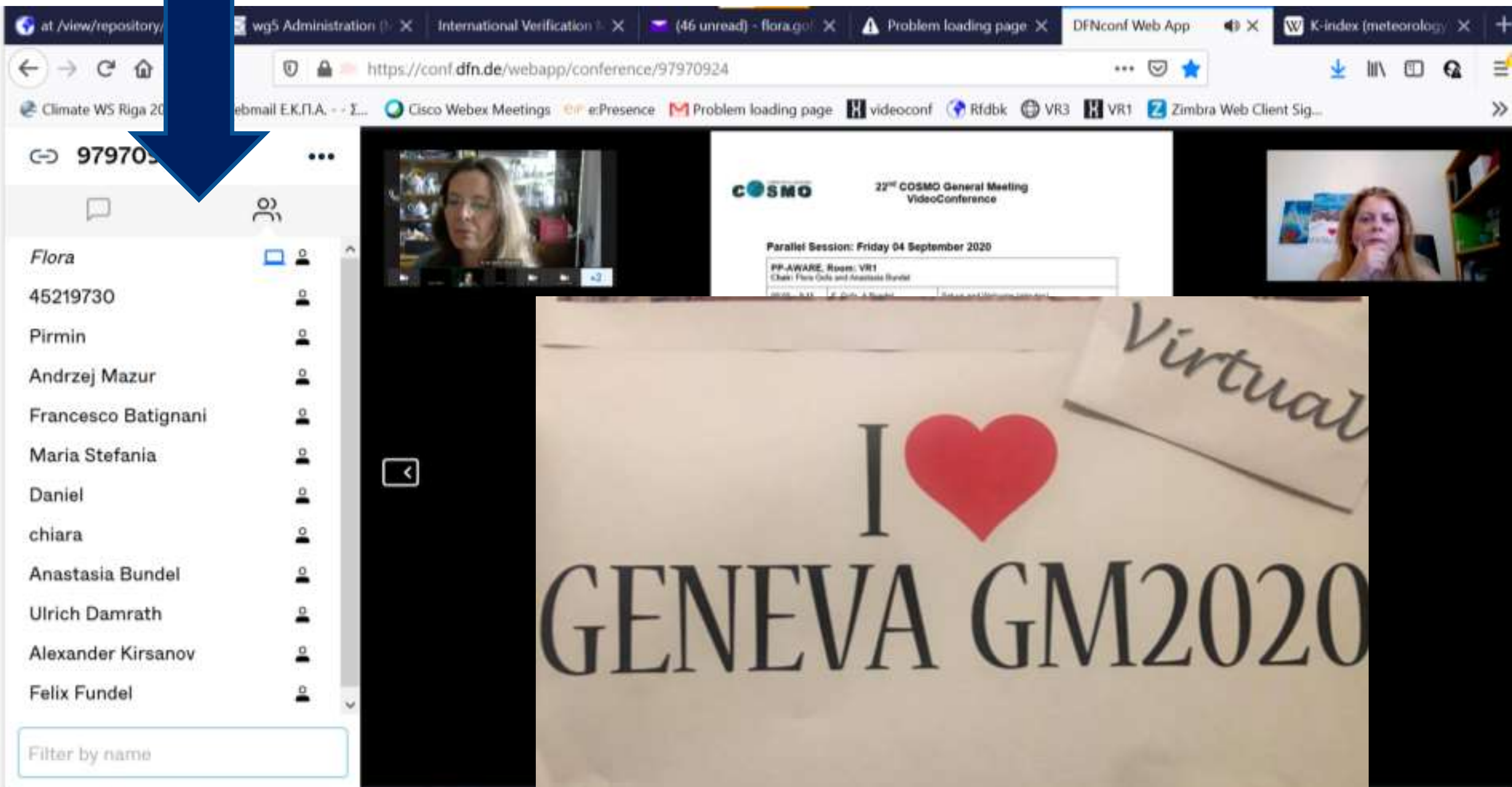
- Impressive improvements along the years in the ability to forecast the intensity/location in advance (resolution, physics, perturbation techniques..)
- Km-scale resolution models are pivotal for having the chance to reproduce convective events over complex orography
- Predictability issues moves to the small scale
- Ensemble spread as an index of predictability and of potential occurrence of extreme events (alternatively to 90° percentile)



PP C2I Task 5.6

- Survey draft for Forecasters' feedback about the ICON-LAM NWP written and the comments from WG4 members received
- Now the comments from the participants of PP C2I task 6.3 are expected along with the information about the planned start of survey distribution among the forecasters in different institutes
- It is decided to begin distributing the survey even before DA is established, mentioning this and other model details in the corresponding file

WG5 Contributions



Thank You