Regional Cooperation for
Limited Area Modeling in Central Europe

LACE
nwp central europe

LAM-EPS activities in LACE

Martin Belluš with contributions of
RC LACE partners

DHMZ SHMU ARSO METEO Slovenia OMSZ IMGW ZAMG ROMANIA ANM

Operational ensembles

Three independent LAM-EPS became operational:

- **A-LAEF**
  Common RC LACE EPS with 4.8 km horizontal resolution based on ALARO-1 physics.
- **C-LAEF**
  Austrian convection-permitting EPS with 2.5 km horizontal resolution utilizing AROME model.

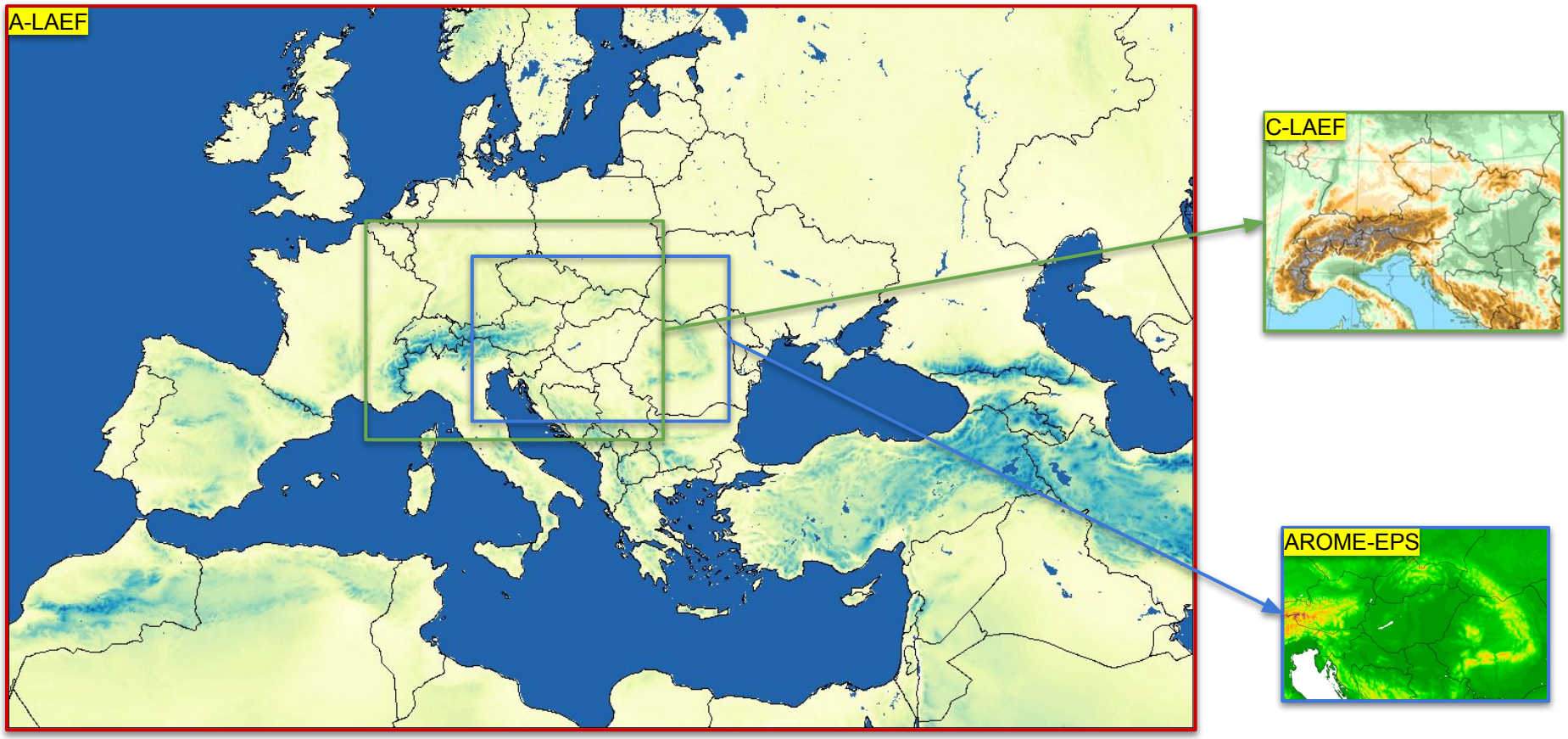
ECMWF HPCF

- **AROME-EPS**
  Hungarian convection-permitting EPS with 2.5 km horizontal resolution utilizing AROME model.

local HPC

Operational ensembles

Three independent LAM-EPS became operational:



Operational ensembles

	A-LAEF	C-LAEF	AROME-EPS
CMC	ALARO	AROME	AROME
Code version	cy40	cy40	cy40
Horizontal resolution	4.8 km	2.5 km	2.5 km
Vertical levels	60	90	60
Runs per day	2	4	1
Forecast length	+72h (00/12 UTC)	+60h (00 UTC), +48h (12 UTC), +6h (06/18 UTC)	+48h (00 UTC)
Members	16+1	16+1	10+1
Assimilation cycle	yes (12h)	yes (6h)	not yet
IC perturbation	ESDA [surface], blending (Phase I) / ENS BlendVar (Phase II) [upper-air]	ESDA [surface], EDA, Ensemble-JK [upper-air]	downscaling (AROME-EDA is being tested)
Model perturbation	ALARO-1 multi-physics + surface stochastic physics (SPPT)	hybrid stochastic scheme with a combination of parameter and tendency perturbations	-
LBC perturbation	ECMWF ENS (c903)	ECMWF ENS	ECMWF ENS

A-LAEF operational suite

A-LAEF suite modifications since last year:

- The suite was moved to the **ecgb-vecf virtual machine**.
- New **admin family** was added containing 2 tasks for easy switch between the computational clusters (cca/ccb) and/or tcwork file systems (sc1/sc2).
- New task was added to **mirror the necessary files** (binaries, namelists, clim files, ...current 12h first guesses) between the sc1/sc2 file systems. It uses rsync for an incremental file transfer, therefore unmodified files are not unnecessarily copied between STHOSTs.
- New task to convert **FA files to GRIBs** was added and the list of post-processed fields has been slightly changed to meet requirements (but this is still opened).

A-LAEF operational suite

A-LAEF suite modifications since last year:

- Start of the 00/12 suite has been shifted to **00:30 UTC** and **12:30 UTC** respectively (suite was switched to the time-lagged coupling mode). Outputs are available in “real-time” (24h forecast at 01:40/13:40 UTC).
- The **local ECPDS dissemination** stream was implemented instead of MARS database for the IFS ENS input parameters (to generate LBCs).
- **Manual pages** have been added for each ecFlow task.
- **ECPDS dissemination of GRIB files** to member’s destination was implemented (SK).
- **Technical documentation** of A-LAEF TC2 suite was prepared.

A-LAEF operational suite

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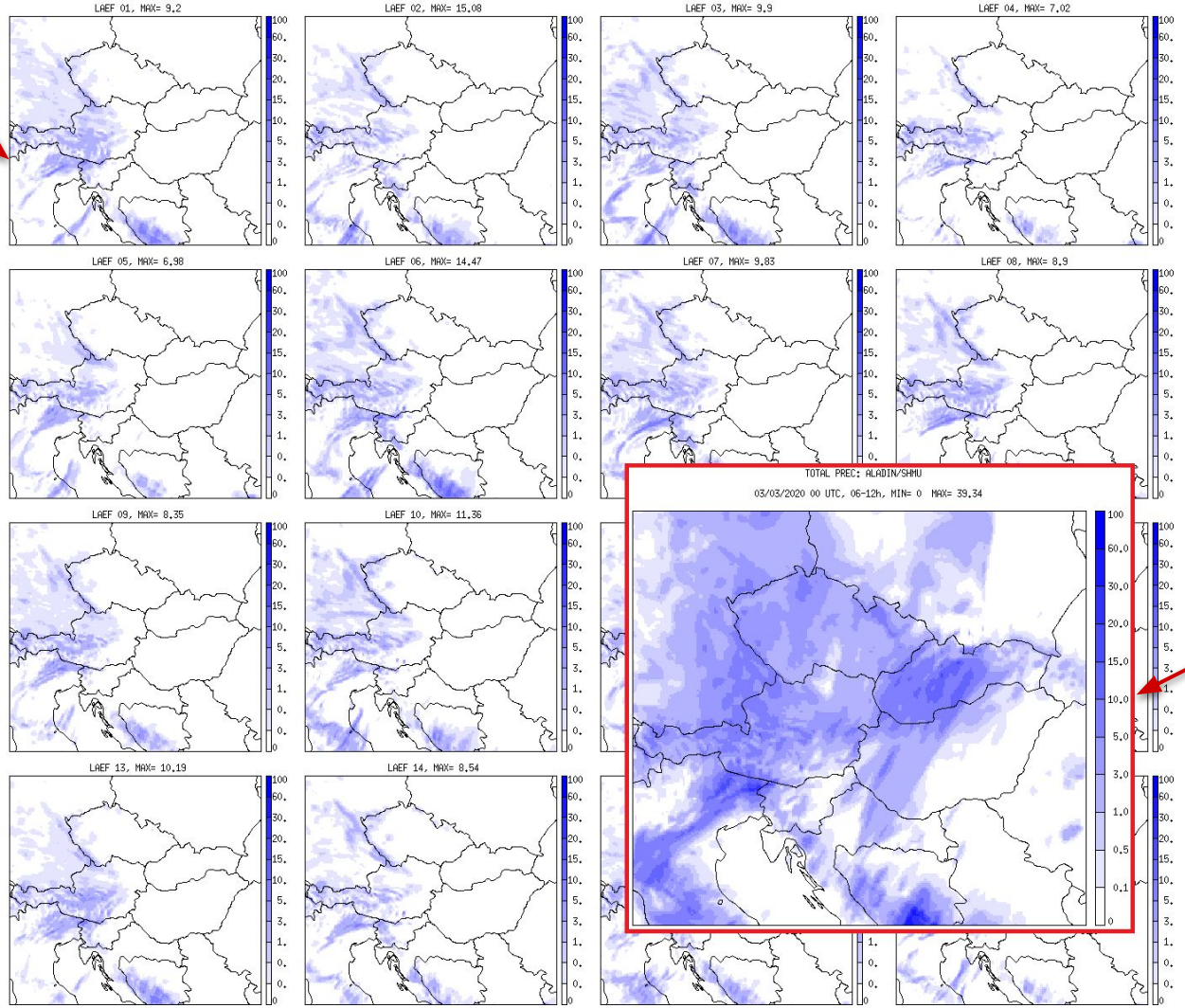
A-LAEF operational suite

Coupling:

- Not trivial preparation of LBCs from ECMWF global gribs.
- Processing data on native CO grid (to avoid downscaling and several spatial interpolations).
- Configuration 903 was implemented (cy46).
- During test period the data retrieved from MARS database were used.
- The switch for ECPDS stream was planned since October 2019.
- The refactored ECPDS management tool already contains all needed parameters since the end of February.
- An issue was introduced by switching to ECPDS inputs: A-LAEF precipitation forecasts were suddenly deteriorated.

A-LAEF operational suite

A-LAEF

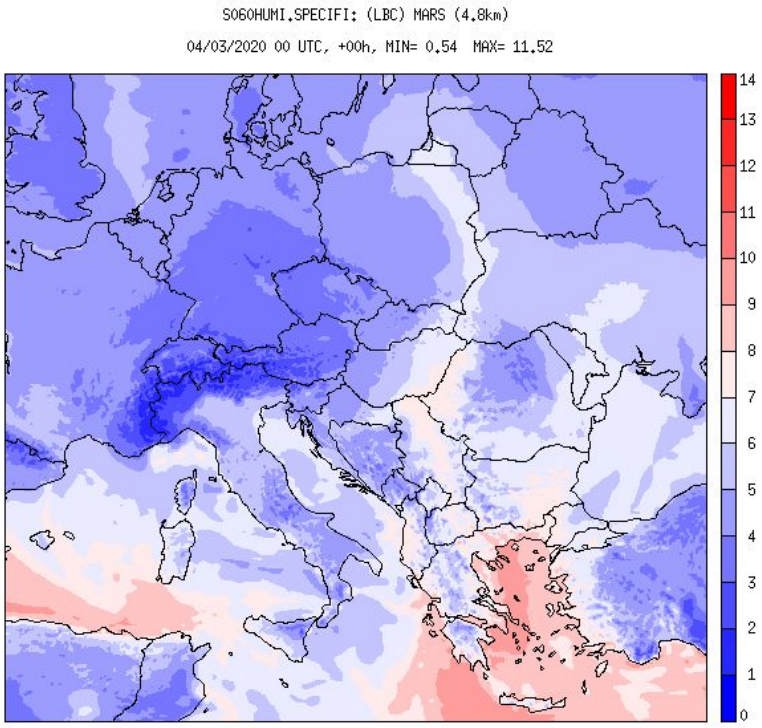


ALADIN SHMU

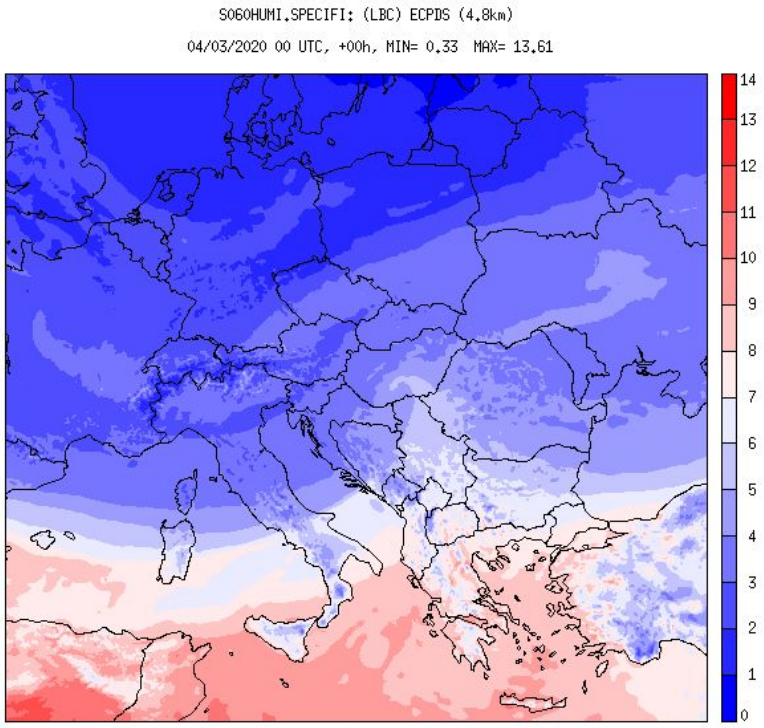
A-LAEF operational suite

Specific humidity at the model levels wasn't correct:

MARS



ECPDS

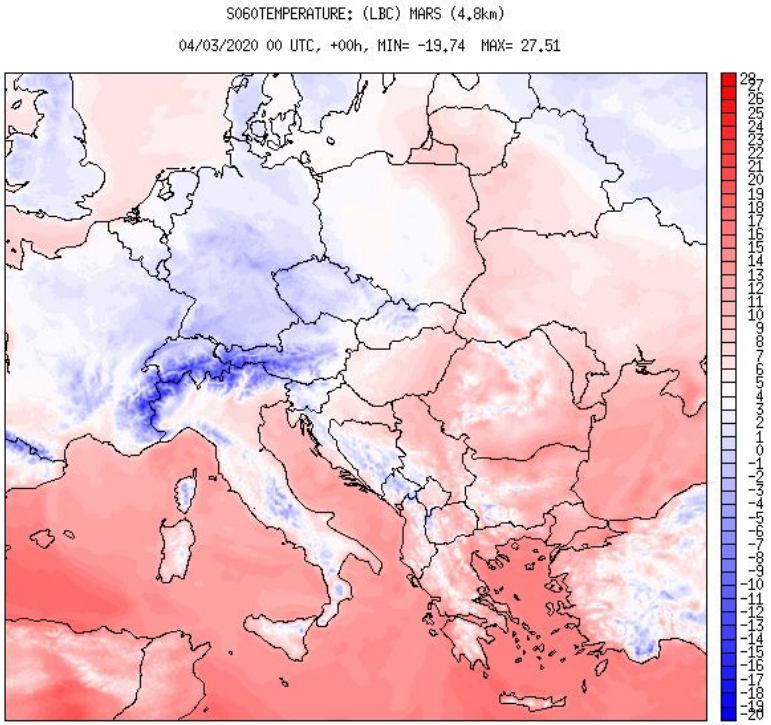


Specific humidity at the lowest model level in LBCs obtained from MARS input fields (left) and ECPDS (right).

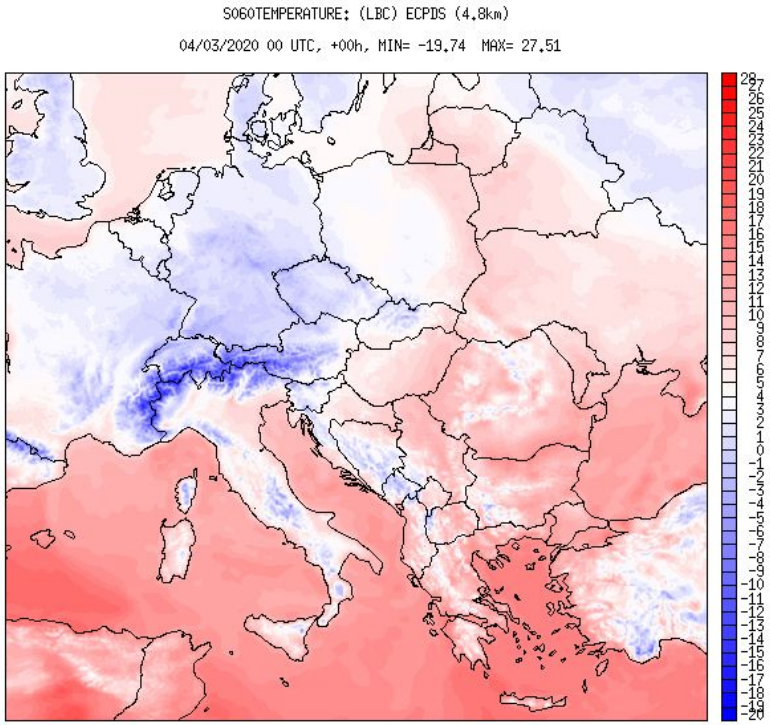
A-LAEF operational suite

The other fields seemed to be OK, but...

MARS

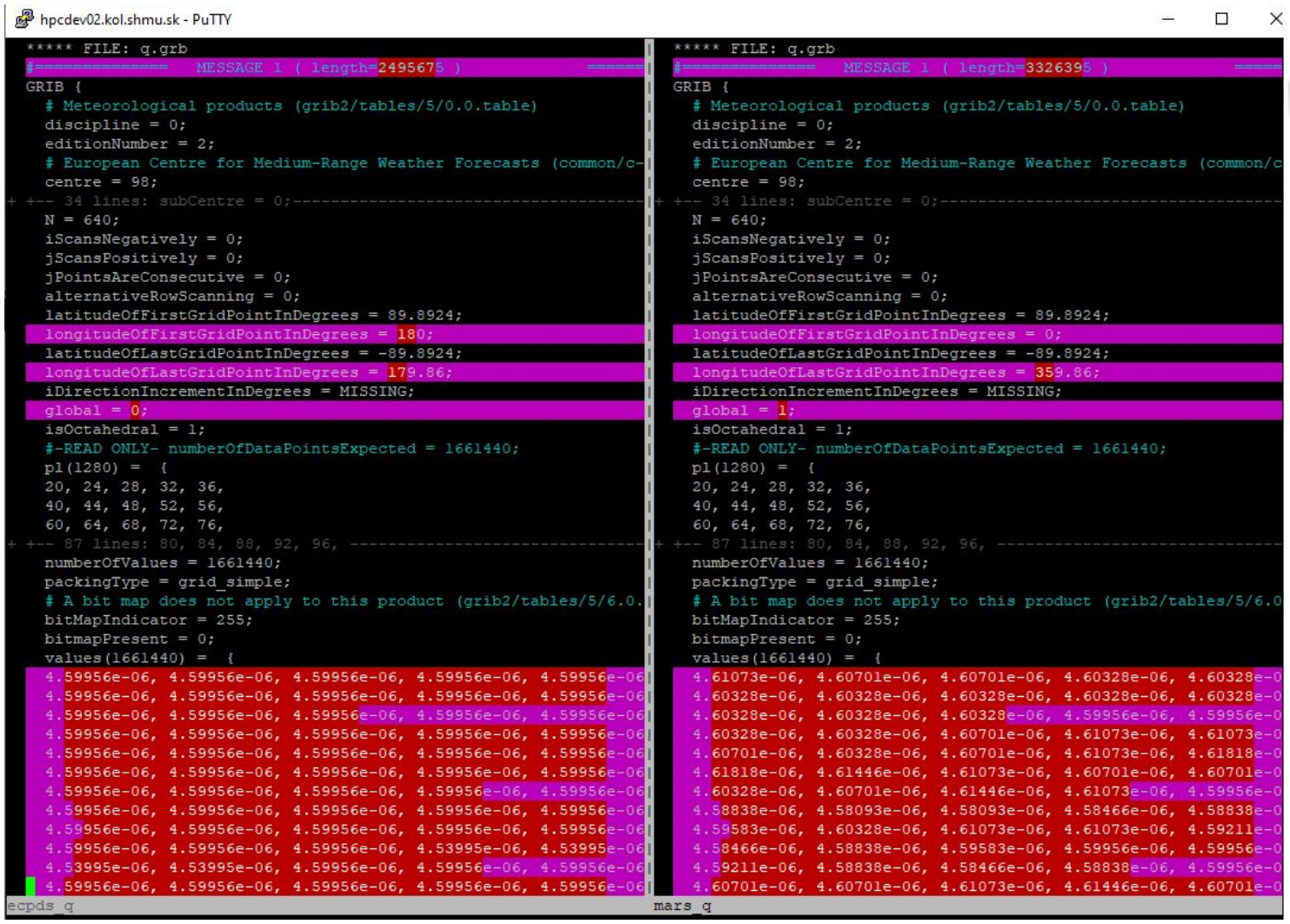


ECPDS



Temperature at the lowest model level in LBCs obtained from MARS input fields (left) and ECPDS (right).

A-LAEF operational suite



A-LAEF operational suite

assimilation

driving model

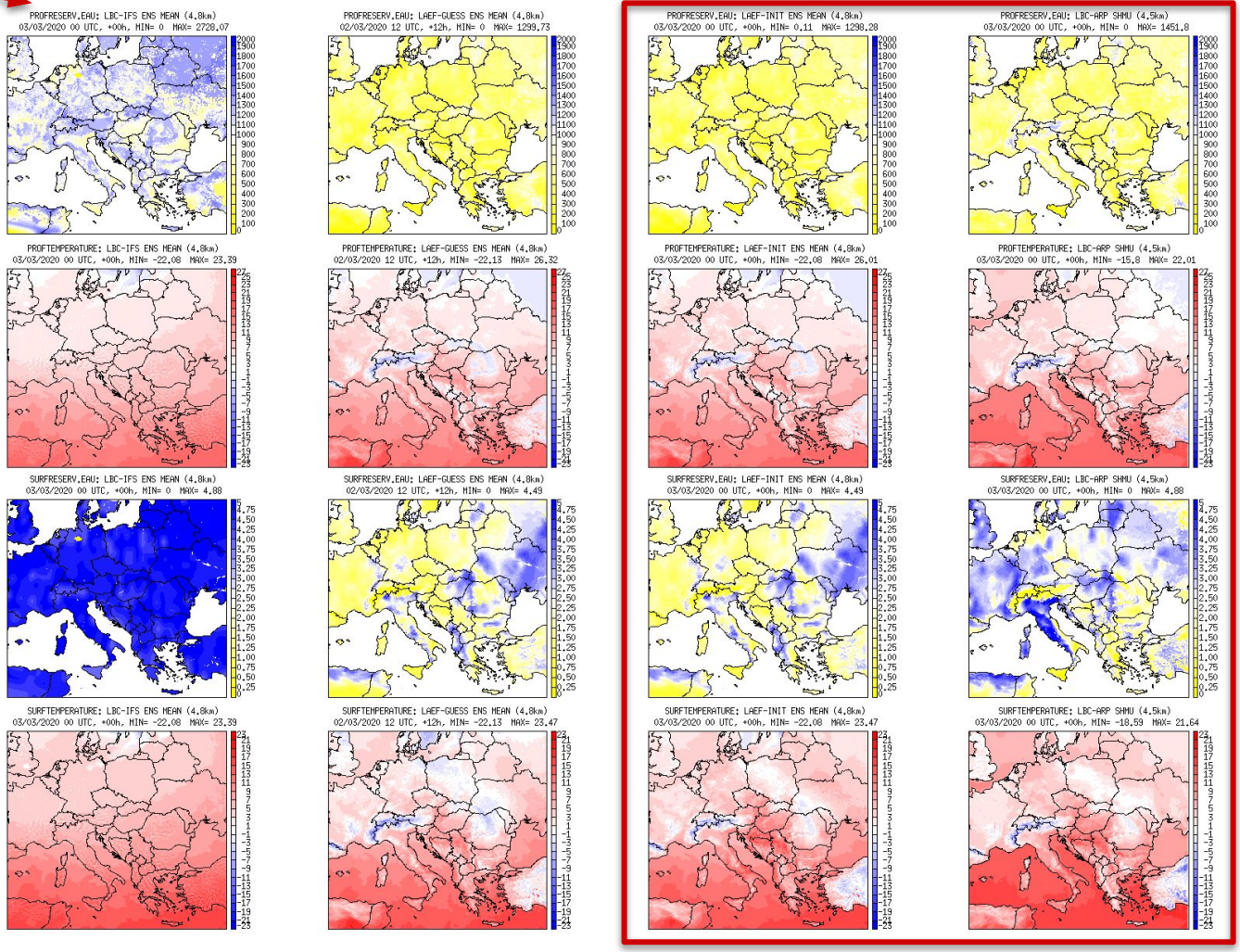
ECMWF ENS | first guess | INIT | ARPEGE

soil moisture

soil temperature

surface moisture

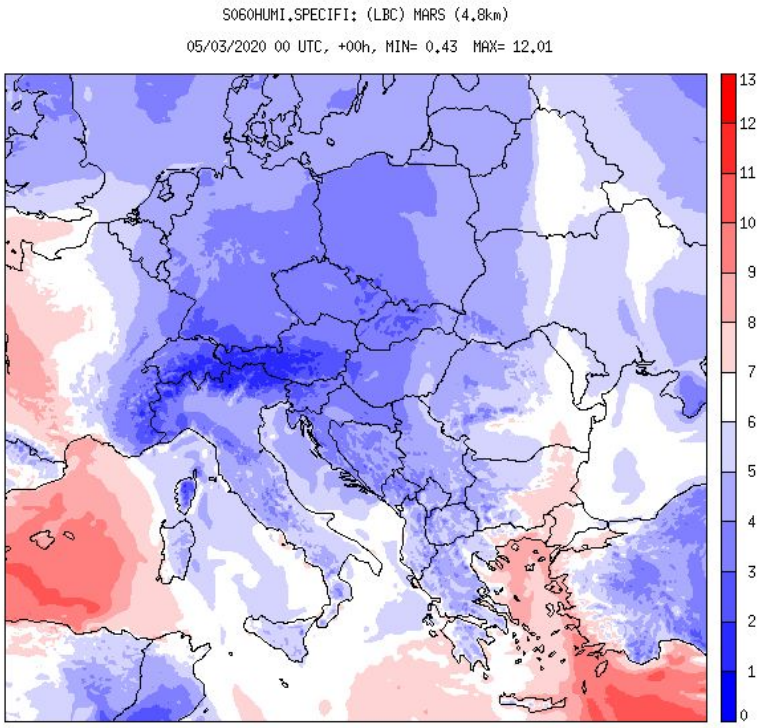
surface temperature



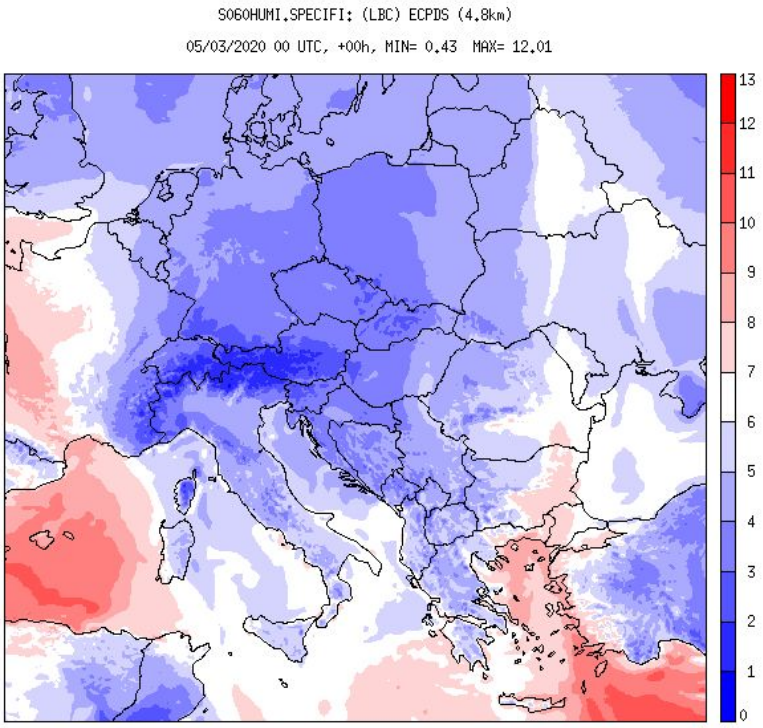
A-LAEF operational suite

Problem solved when all ECPDS fields were coded with 16 bits per value:

MARS



ECPDS



Specific humidity at the lowest model level in LBCs obtained from MARS input fields (left) and ECPDS (right).

A-LAEF operational suite

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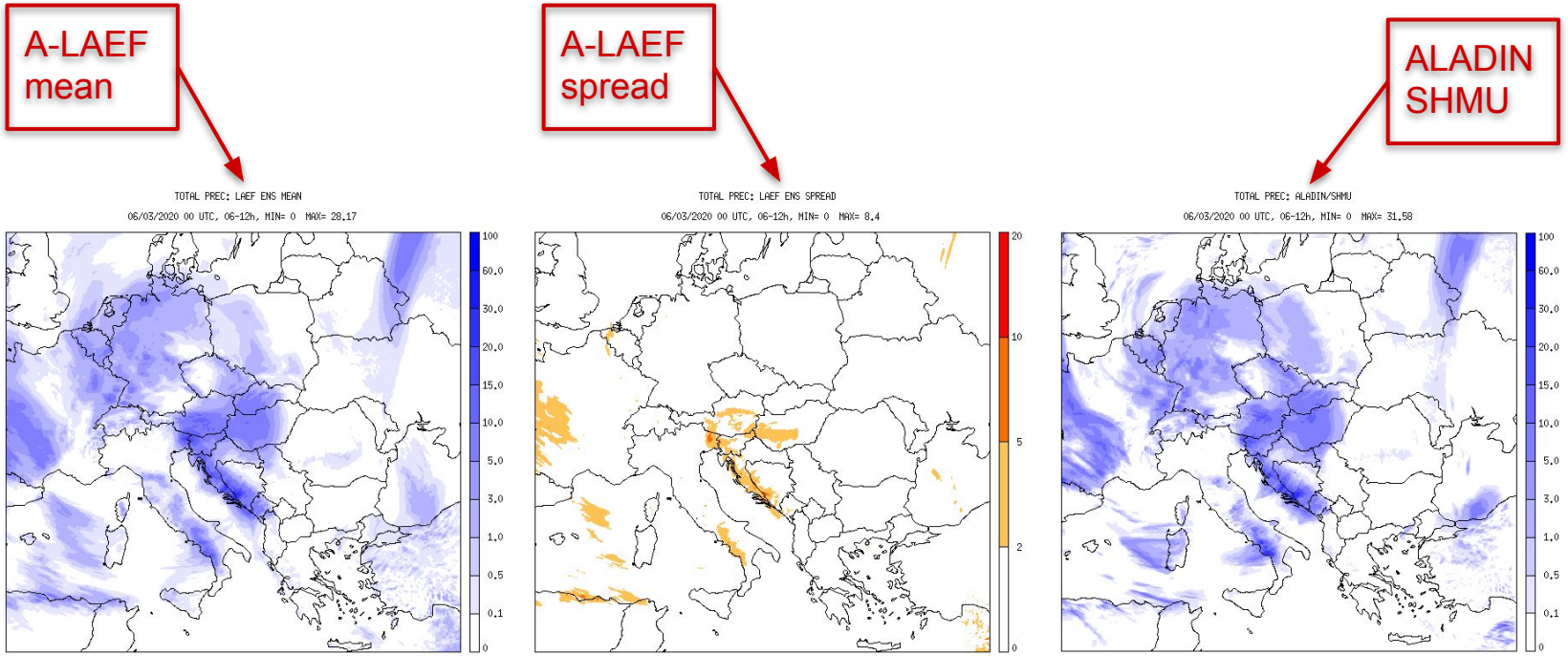
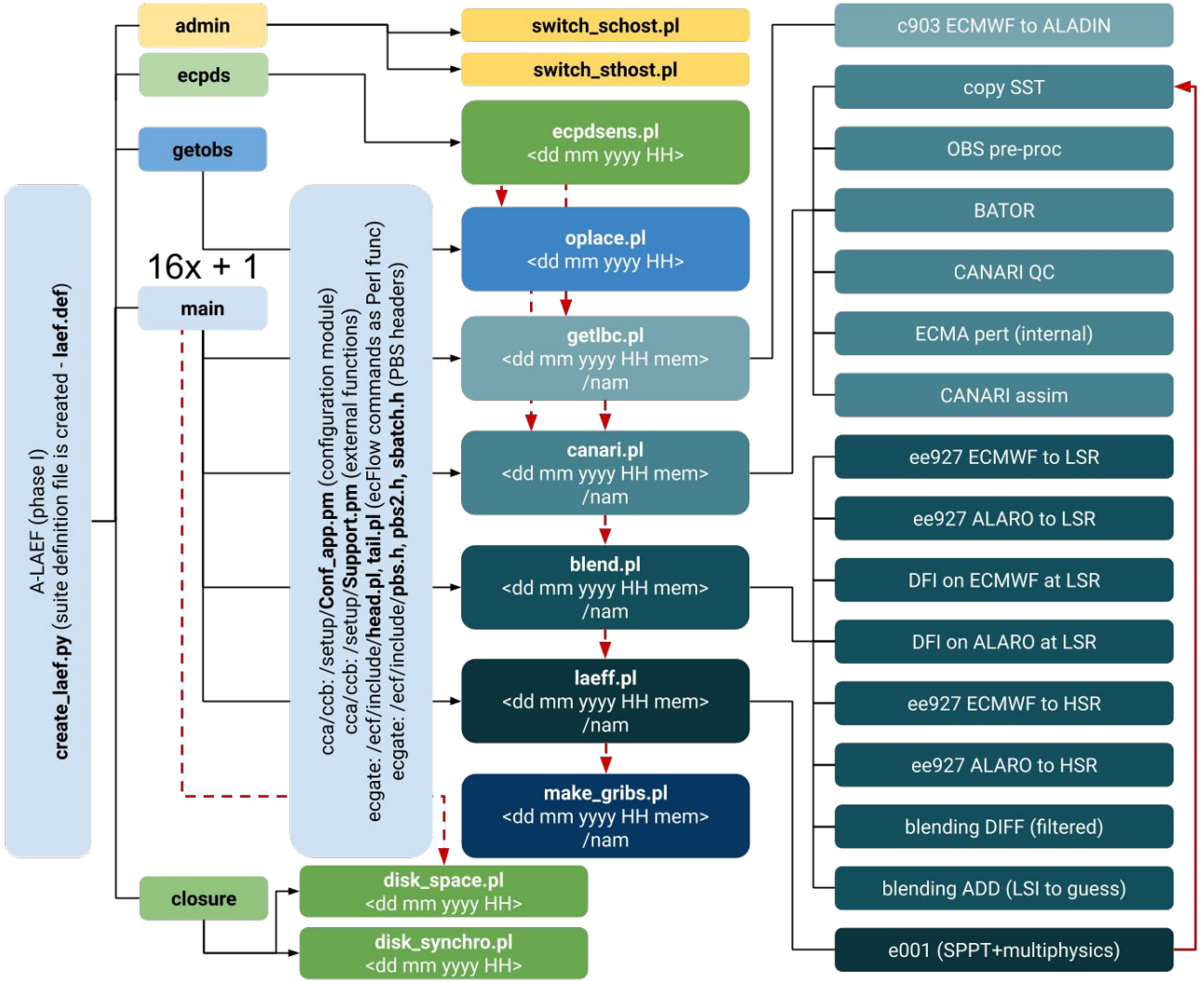
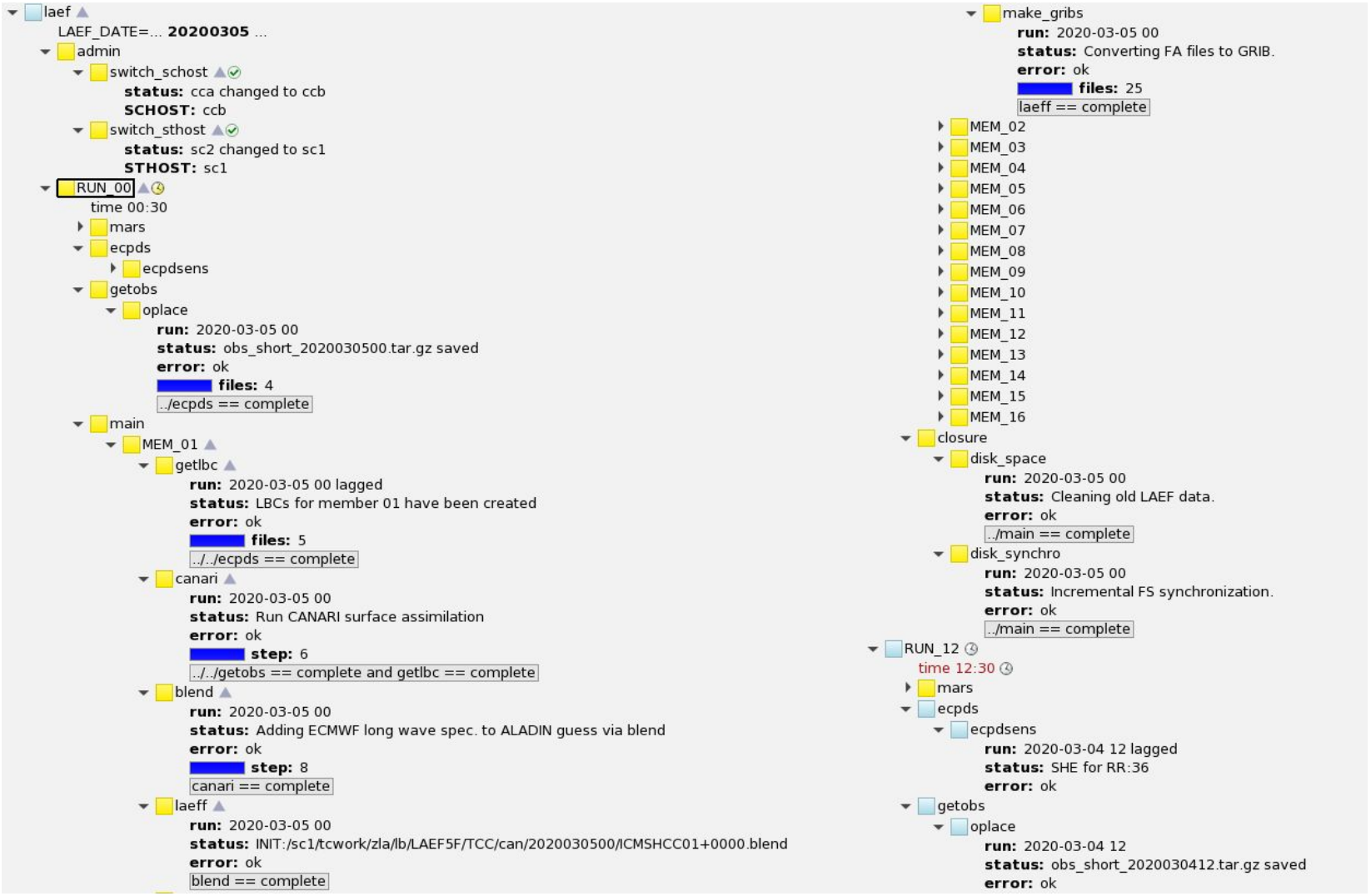


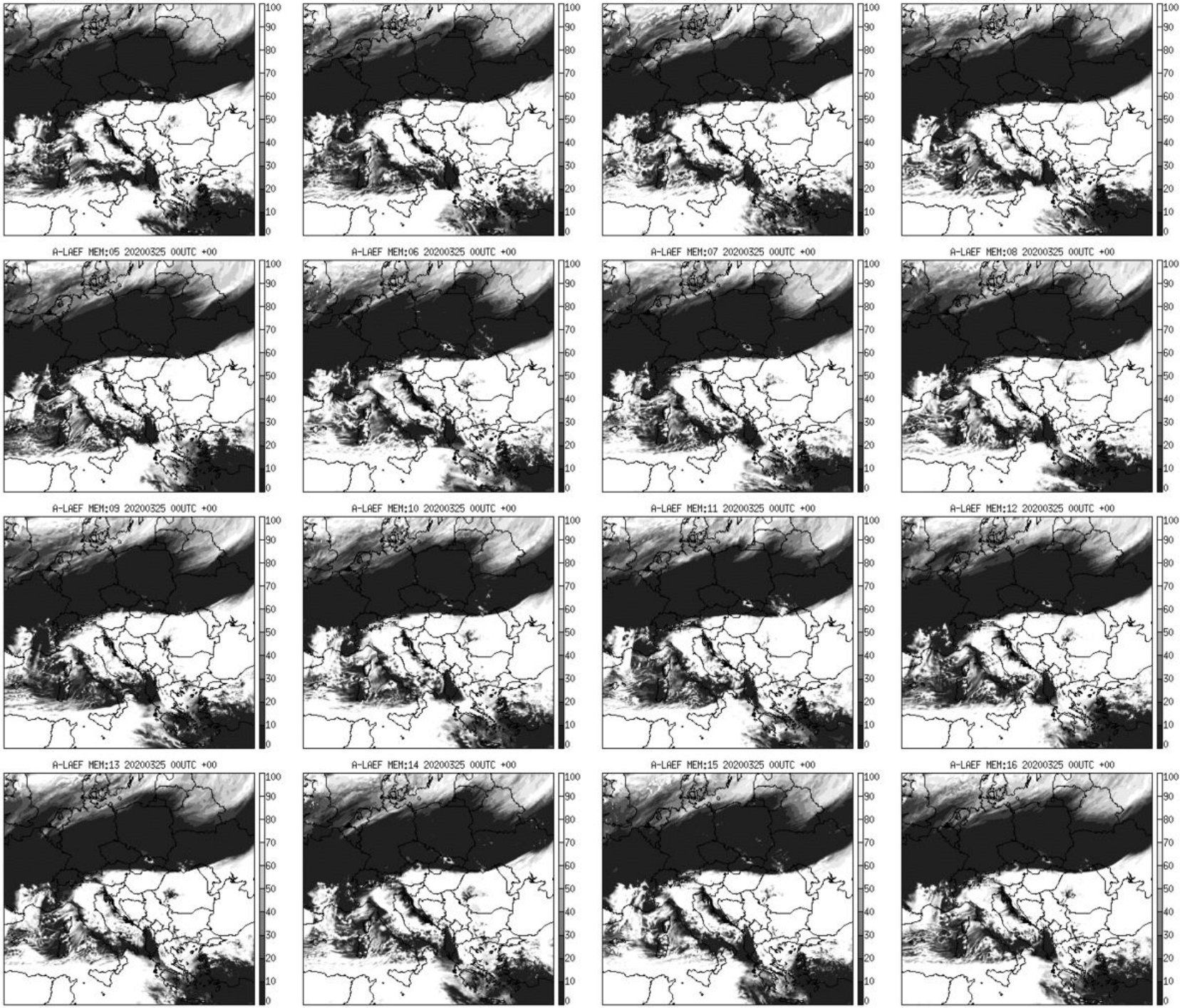
Precipitation forecast verified against the reference ALADIN/SHMU coupled to ARPEGE.

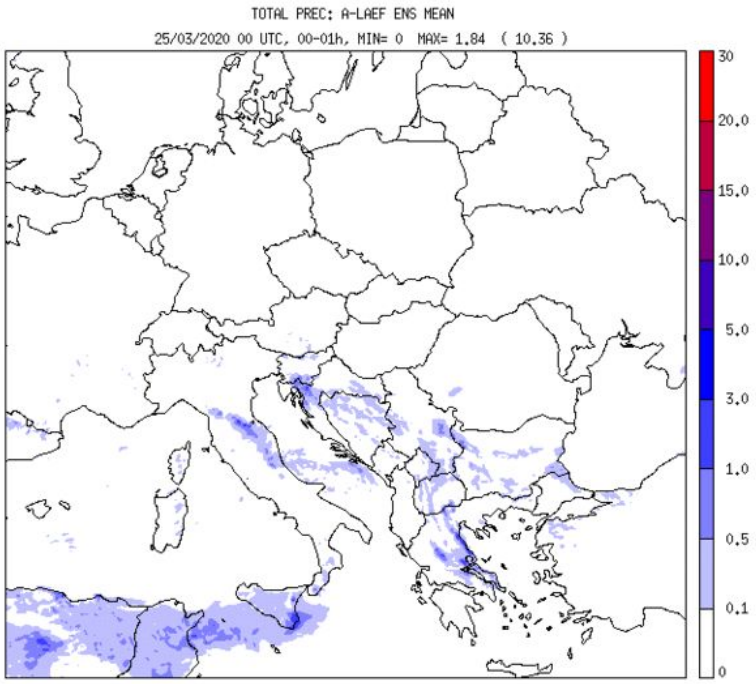
A-LAEF operational suite

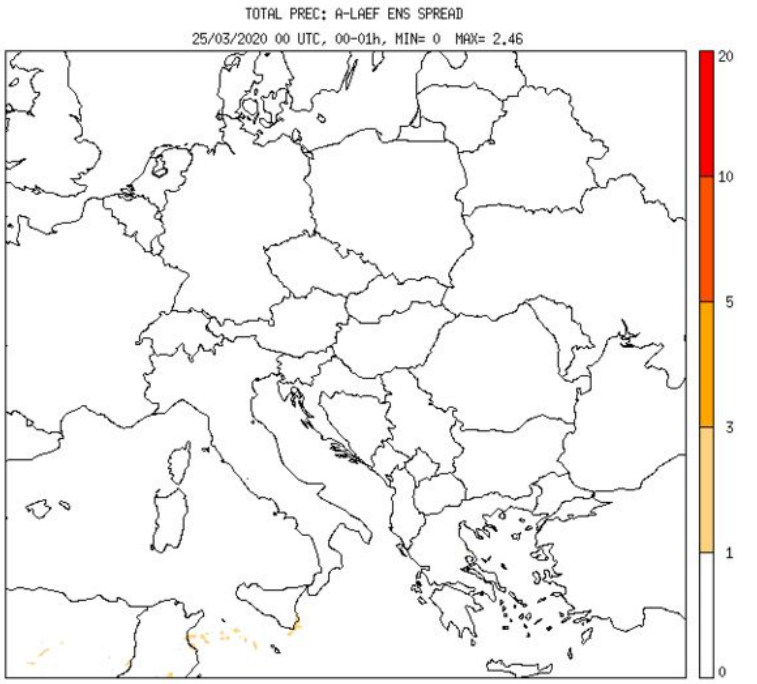


A-LAEF operational suite




A-LAEF MEM:01 20200325 00UTC +00
A-LAEF MEM:02 20200325 00UTC +00
A-LAEF MEM:03 20200325 00UTC +00
A-LAEF MEM:04 20200325 00UTC +00
A-LAEF MEM:05 20200325 00UTC +00
A-LAEF MEM:06 20200325 00UTC +00
A-LAEF MEM:07 20200325 00UTC +00
A-LAEF MEM:08 20200325 00UTC +00
A-LAEF MEM:09 20200325 00UTC +00
A-LAEF MEM:10 20200325 00UTC +00
A-LAEF MEM:11 20200325 00UTC +00
A-LAEF MEM:12 20200325 00UTC +00
A-LAEF MEM:13 20200325 00UTC +00
A-LAEF MEM:14 20200325 00UTC +00
A-LAEF MEM:15 20200325 00UTC +00
A-LAEF MEM:16 20200325 00UTC +00
100
90
80
70
60
50
40
30
20
10
0


TOTAL PREC: A-LAEF ENS MEAN
25/03/2020 00 UTC, 00-01h, MIN= 0 MAX= 1.84 (10.36)
30
20.0
15.0
10.0
5.0
3.0
1.0
0.5
0.1
0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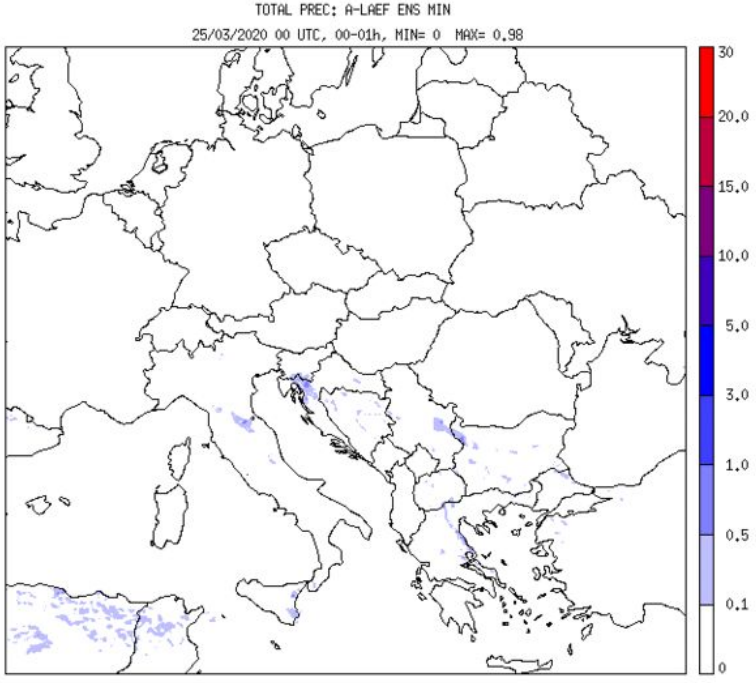
20
10
5
3
1
0


TOTAL PREC: A-LAEF ENS MIN
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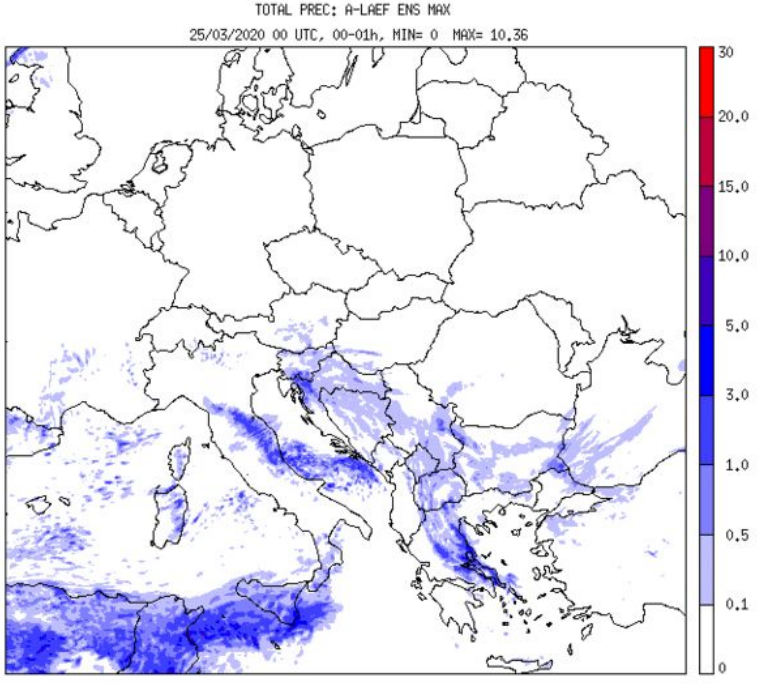
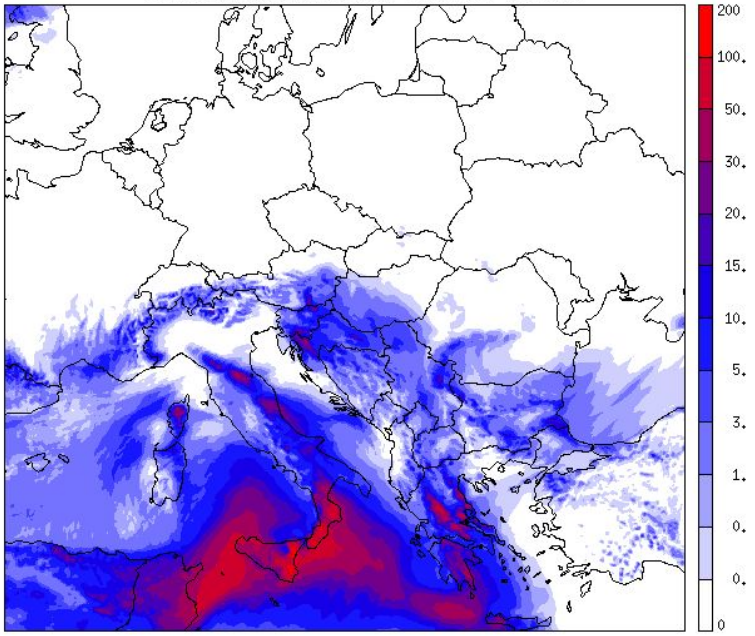
15.0
10.0
5.0
3.0
1.0
0.5
0.1
0


TOTAL PREC: A-LAEF ENS MAX
25/03/2020 00 UTC, 00-01h, MIN= 0 MAX= 10.36
30
20.0
15.0
10.0
5.0
3.0
1.0
0.5
0.1
0

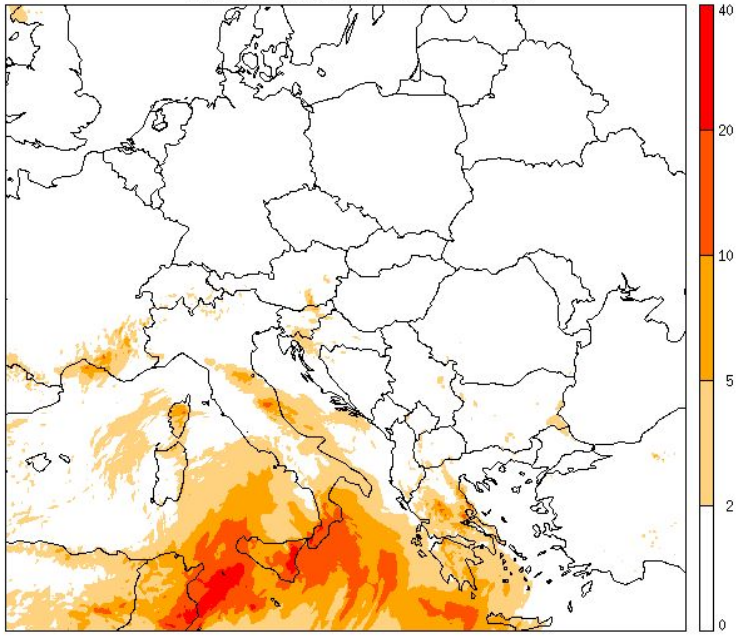
TOTAL PREC: A-LAEF ENS MEAN

25/03/2020 00 UTC, 00-24h, MIN= 0 MAX= 145.25 (209.78)



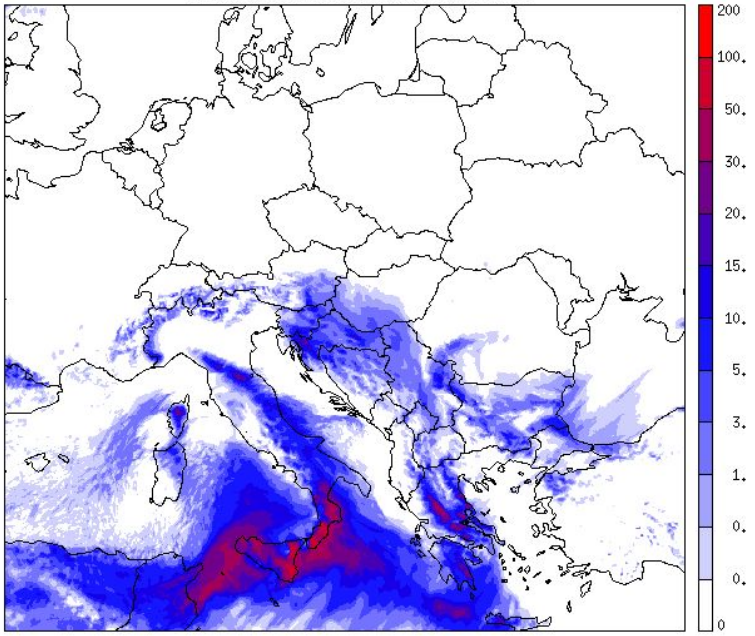
TOTAL PREC: A-LAEF ENS SPREAD

25/03/2020 00 UTC, 00-24h, MIN= 0 MAX= 39.41



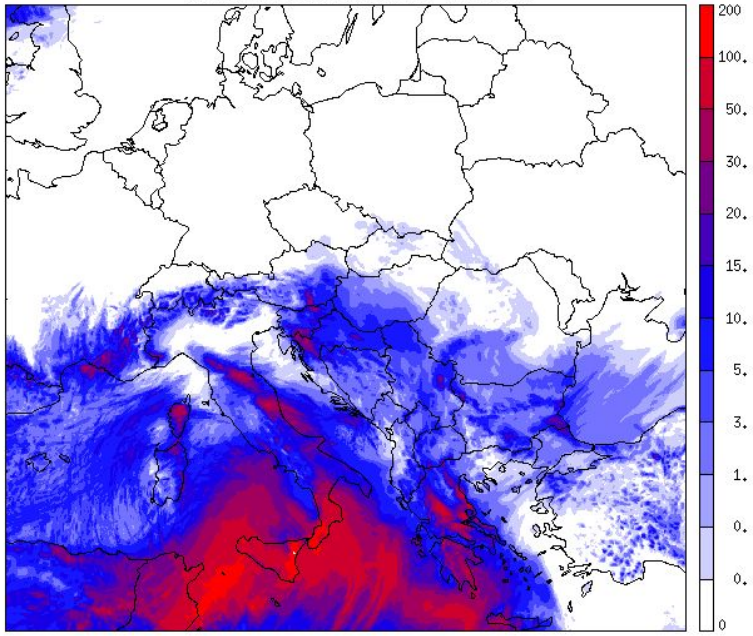
TOTAL PREC: A-LAEF ENS MIN

25/03/2020 00 UTC, 00-24h, MIN= 0 MAX= 84.99



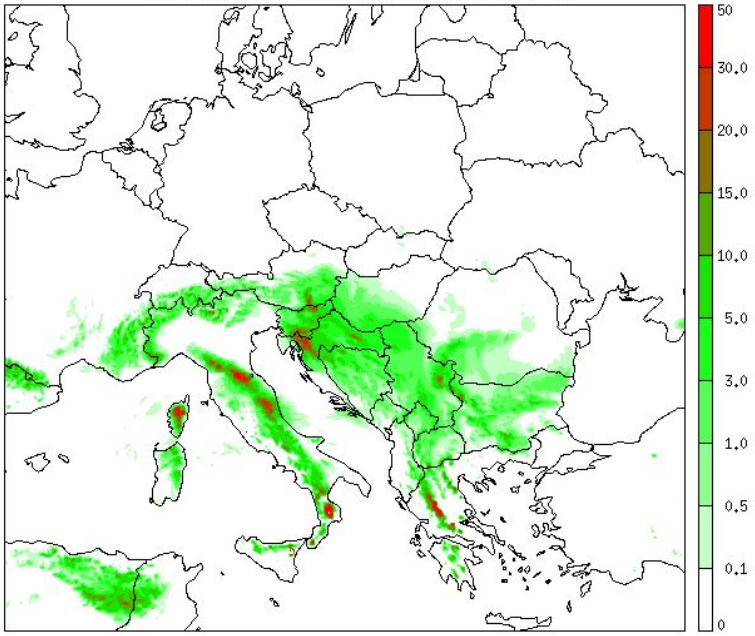
TOTAL PREC: A-LAEF ENS MAX

25/03/2020 00 UTC, 00-24h, MIN= 0 MAX= 209.78



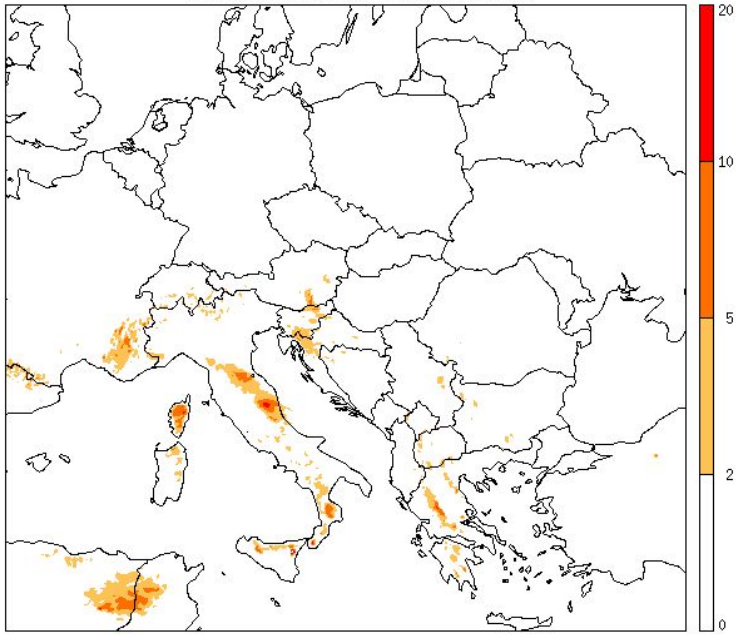
TOTAL SNOW: A-LAEF ENS MEAN

25/03/2020 00 UTC, 00-24h, MIN= 0 MAX= 91.58 (142.52)



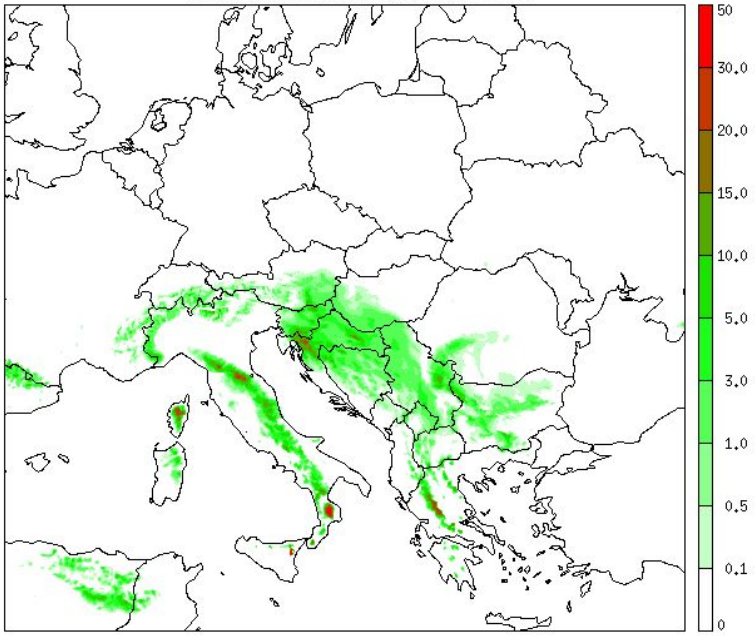
TOTAL SNOW: A-LAEF ENS SPREAD

25/03/2020 00 UTC, 00-24h, MIN= 0 MAX= 25.98



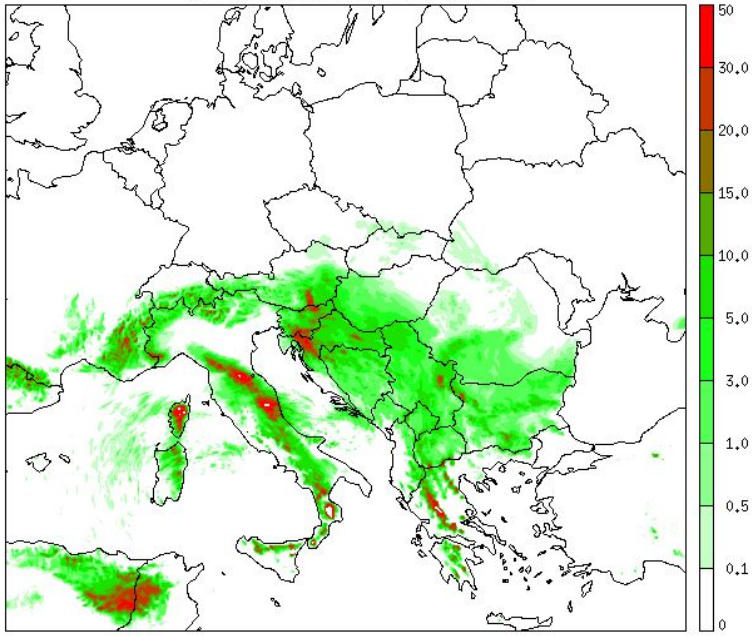
TOTAL SNOW: A-LAEF ENS MIN

25/03/2020 00 UTC, 00-24h, MIN= 0 MAX= 58.25



TOTAL SNOW: A-LAEF ENS MAX

25/03/2020 00 UTC, 00-24h, MIN= 0 MAX= 142.52



A-LAEF extreme weather case studies

Heavy rainfall events:

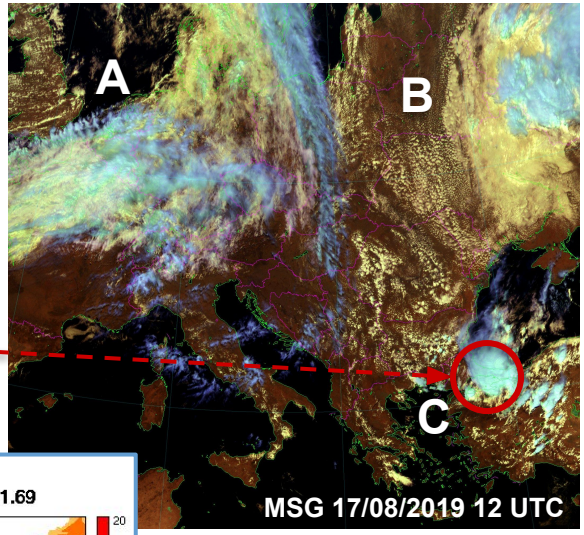
- Turkey - **Flash floods of 17 August 2019**

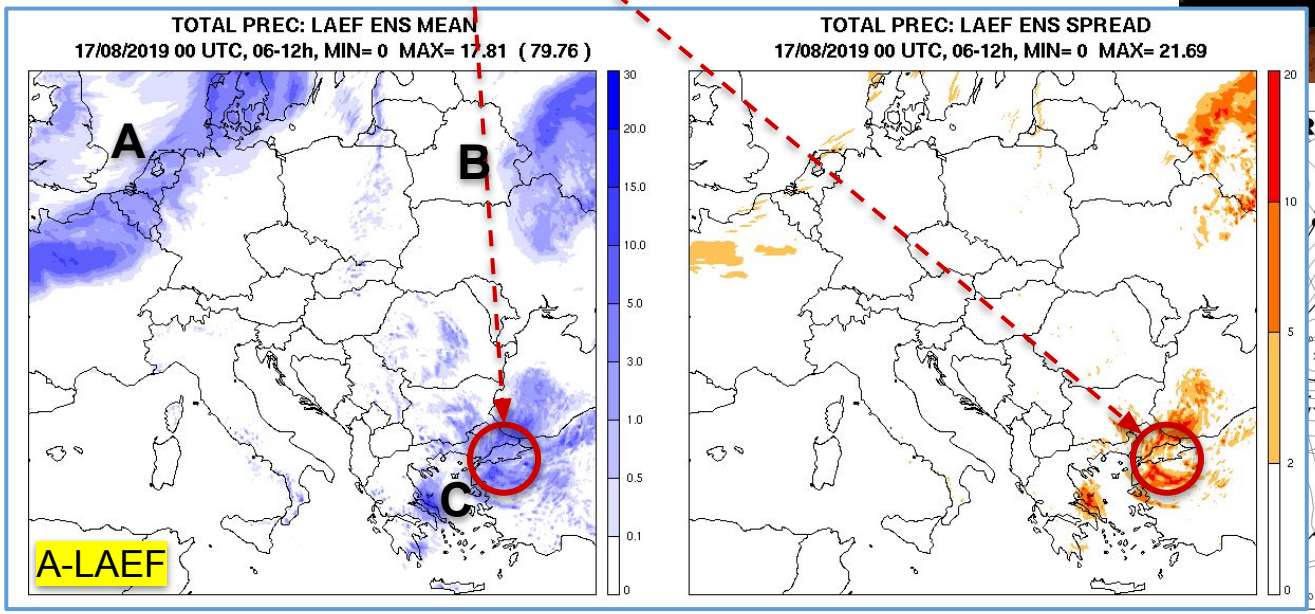
Heavy rainfall affected several districts of Istanbul (particularly Fatih, Kartal and Bakirkoy) on 17 August causing widespread flash floods. According to media reports, one person died in Fatih District, some houses have been damaged and several streets were flooded leading to significant transport disruptions.

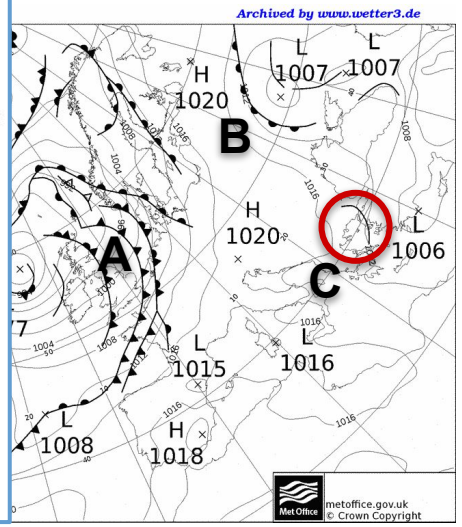
A-LAEF extreme weather case studies

A, **B**: synoptic scale systems

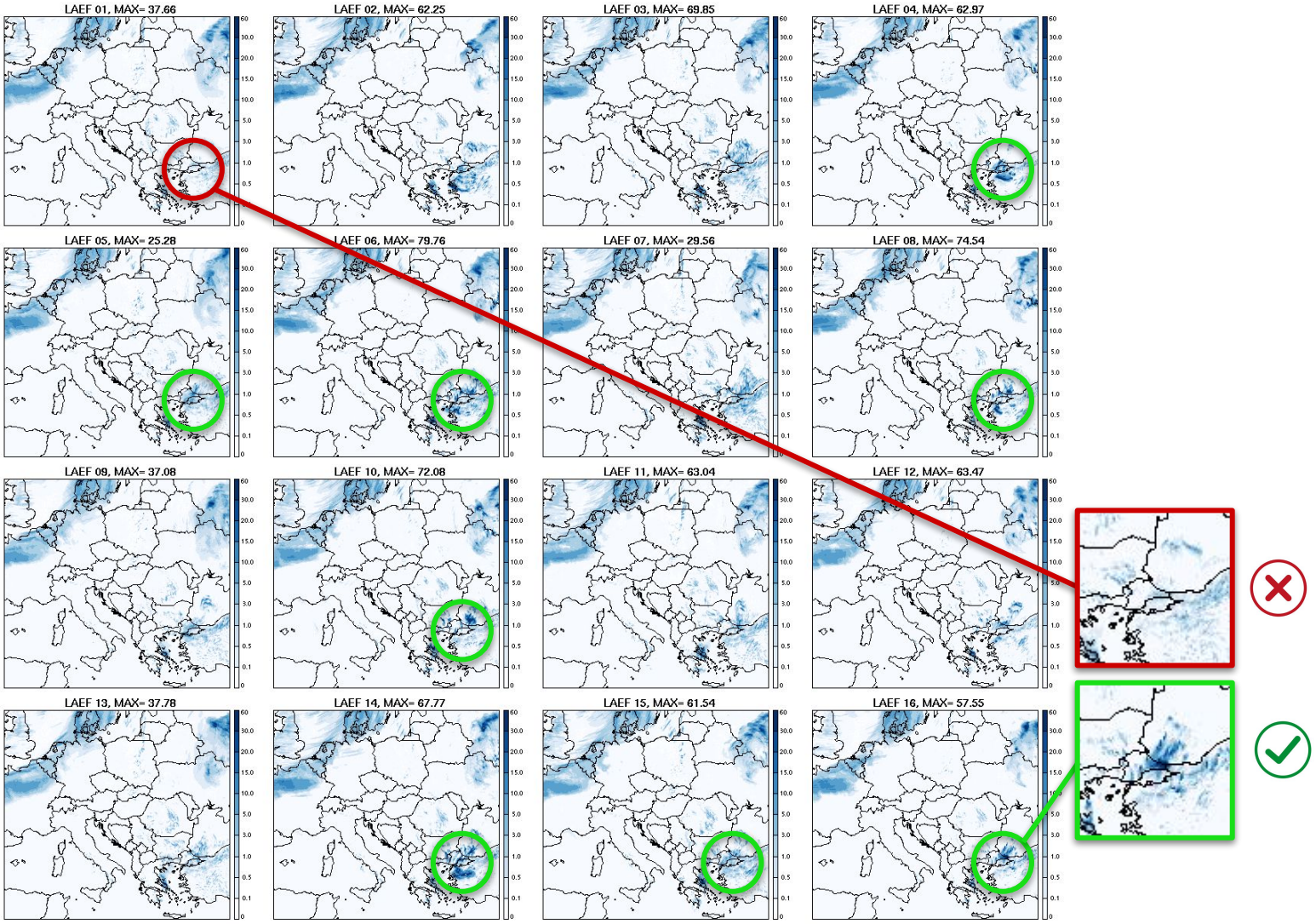
C: mesoscale convective system (MCS)







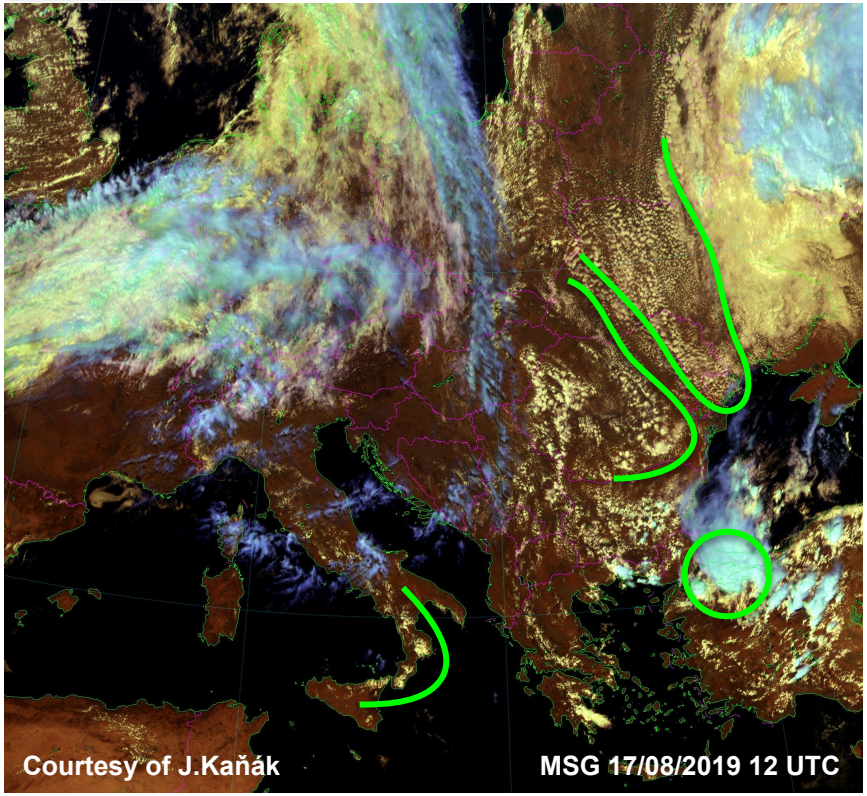
A-LAEF extreme weather case studies



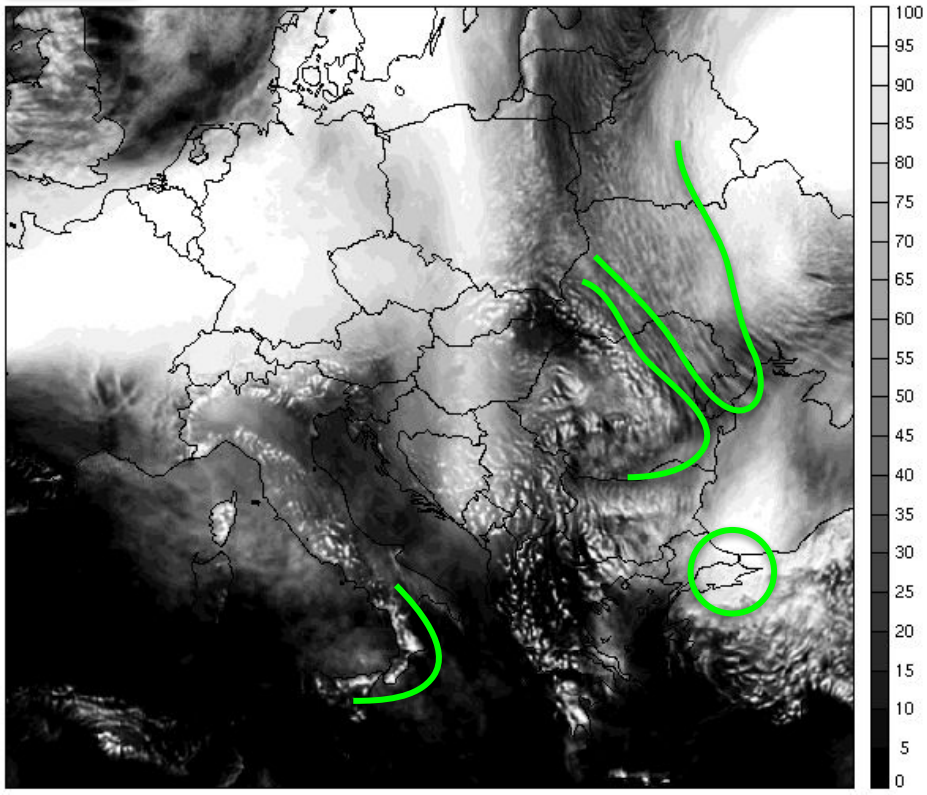
A-LAEF extreme weather case studies

Cloud physics:

REALITY



A-LAEF



A-LAEF extreme weather case studies

Heavy rainfall events:

- Central Europe - **Night storm of 24 August 2019**

During the night hours the southwestern part of Slovakia was hit by strong thunderstorms. The total number of lightning strikes was about 15,000 with about 15 to 50 millimeters of rain. The thunderbolts also hit the 30-meters flagpole situated in front of Slovak Parliament.

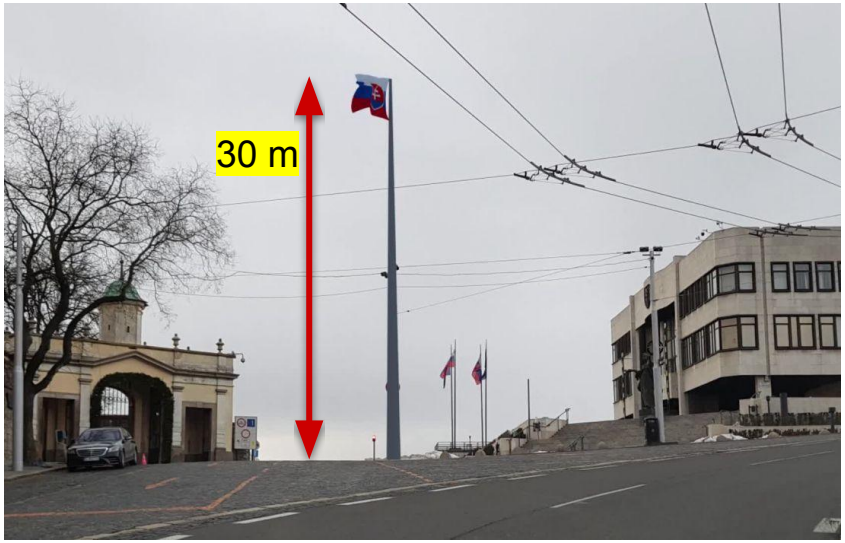
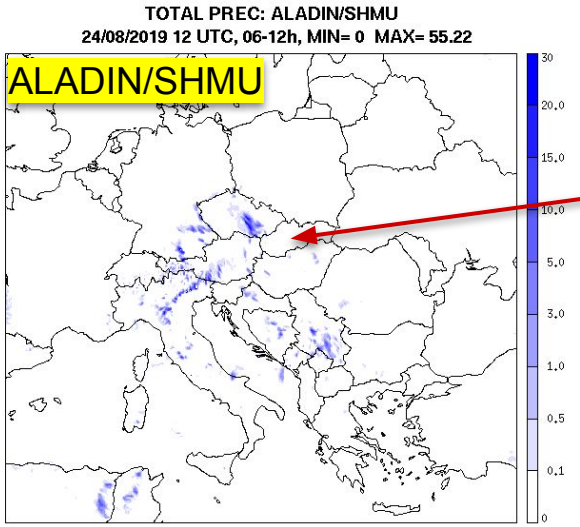


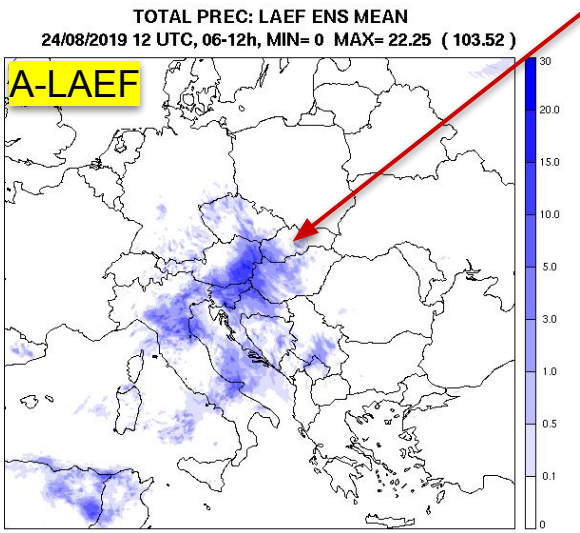
Photo: Adam Kováč, 2019.08.24/25, Bratislava

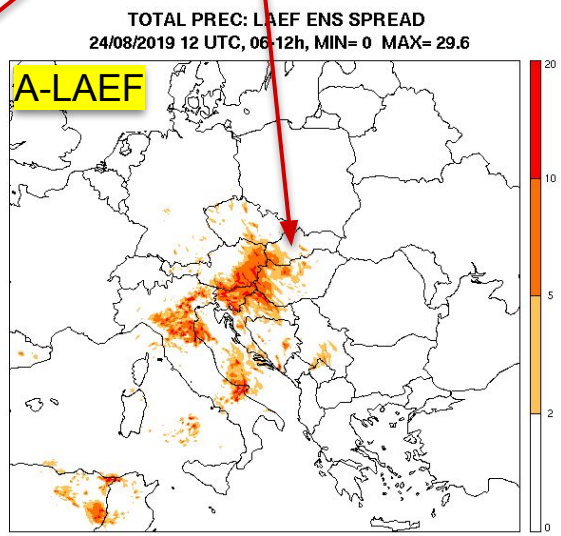
A-LAEF extreme weather case studies

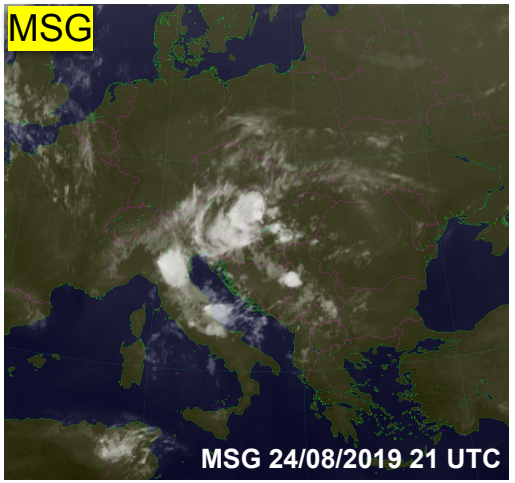


The deterministic ALADIN/SHMU forecast from August 24, 12 UTC was completely missing this convective precipitation event during the night hours.

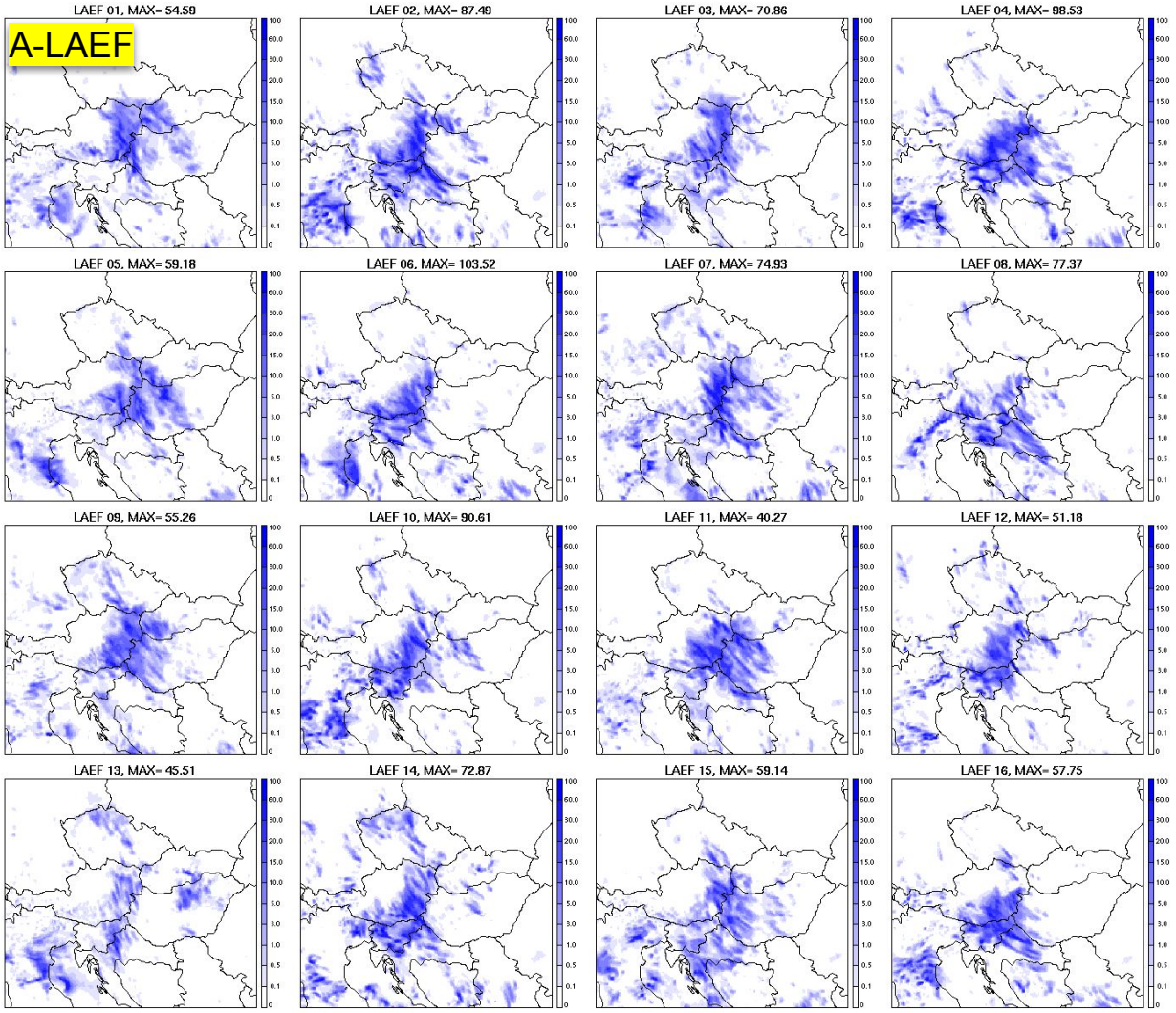
A-LAEF ensemble for the same network time captured the case nicely.

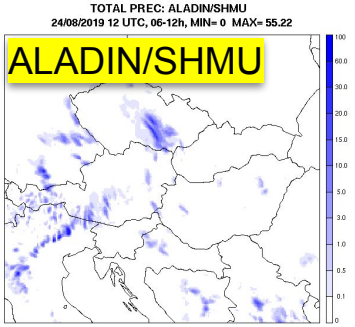


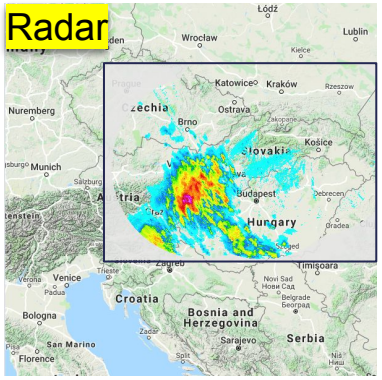


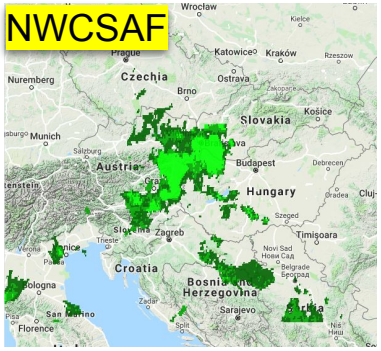


A-LAEF extreme weather case studies









A-LAEF extreme weather case studies

Strong wind events:

- Central Europe - **Storm Petra of 4 February 2020**

The center of deep cyclone was located over the central part of Slovakia, which led to extremely strong and gusty wind especially at south-west. In Bratislava and Nitra maximum wind gusts about 28-29 m/s were recorded. At the small Carpathian ridge it was 33 m/s, elsewhere mostly in the interval 25-30 m/s. It was for the first time in history when the highest warning level (3rd) was issued for capital city Bratislava. Similar situation was in eastern part of Austria and north-western part of Hungary.

OGIMET synop based Daily summary by state

Day before: (2020/02/03) 12:00 UTC

02/04/2020 12:00 UTC

SLOVAKIA

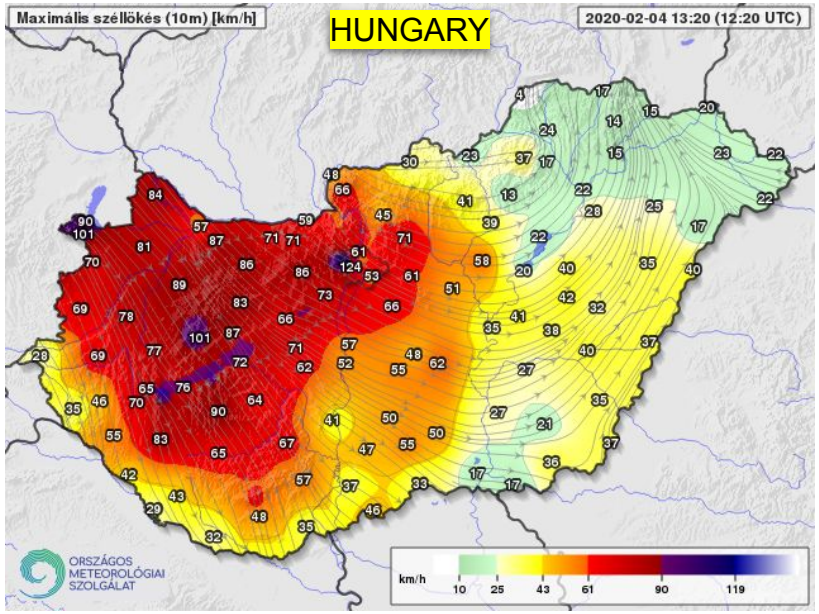
Station	Temperature (C) Max	Min	Med	Td. Med (C)	Hr. Med (%)	Wind (km/h) Dir.	Int.	Gust	Pres. s.lev (Hp)	Prec. (mm)	TotCl Oct	Low Cl Oct	Sun D-1 (h)	Vis Km	Snow Dep. (cm)	Daily weather summary
Malacky	9.6	5.2	7.4	3.5	76.9	WSW	23.1	100.9	1008.3	4.0	7.7	5.9	---	17.7	----	
Maly Javornik	5.2	1.6	4.2	2.5	89.2	W	39.5	----	----	7.0	---	---	0.0	16.1	----	
Bratislava-koliba	8.2	4.8	6.7	3.2	79.4	W	18.0	93.7	1007.3	4.0	7.8	6.3	0.0	41.7	----	
Bratislava Ivanka	9.7	5.9	7.8	3.7	76.0	W	26.3	100.9	1007.4	6.0	7.2	4.6	0.0	39.5	----	
Jaslovske Bohunice	9.1	5.3	6.9	3.9	81.9	WSW	26.7	79.3	1006.7	13.0	---	---	2.3	----	----	
Piestany	9.2	5.5	7.1	3.8	80.6	WSW	18.9	86.5	1006.8	15.0	7.0	5.1	0.1	32.7	----	
Zilina / Hricov	7.2	3.3	5.4	3.4	87.6	WSW	13.1	36.0	1005.6	26.0	7.7	7.1	0.0	17.4	----	
Nitra	9.8	5.8	7.4	4.1	80.7	WNW	22.2	104.5	1006.6	14.0	7.1	5.4	0.0	16.3	----	
Mochovce	8.4	4.6	6.3	4.0	86.5	WNW	14.7	75.6	1007.0	17.0	---	---	0.0	----	----	
Hurbanovo	10.3	6.3	8.1	4.1	76.8	W	16.8	79.3	1007.9	4.0	7.8	6.3	0.0	44.2	----	
Prievidza	8.5	5.0	6.1	5.1	93.8	SW	14.3	43.2	1006.2	24.0	7.3	6.1	0.0	10.5	----	
Dudince	8.9	4.6	6.7	4.8	88.6	W	10.7	75.6	1007.2	17.0	7.5	7.3	---	18.3	----	
Ziar Nad Hronom	9.1	4.1	6.1	4.1	87.4	W	9.0	----	1006.5	20.0	---	---	0.7	13.8	----	
Sliac	7.7	1.0	4.8	2.9	88.5	NW	8.4	----	1006.4	24.0	7.5	7.4	0.0	10.1	----	
Chopok	-3.2	-5.8	-4.7	-5.3	95.4	WNW	51.9	100.9	784.1	12.0	---	---	---	0.0	107	
Liesek	5.1	0.4	2.9	1.6	91.7	WSW	15.6	----	----	11.0	7.4	6.9	---	19.7	----	
Lucenec	9.4	4.1	5.7	4.0	89.9	WSW	9.5	----	1006.0	15.0	6.3	6.3	0.2	21.7	----	
Lomnicky Stit	-5.3	-9.5	-8.0	-8.7	94.4	WNW	27.8	111.7	722.1	34.0	---	---	0.0	0.0	132	
Strbske Pleso	0.4	-1.2	-0.8	-0.8	99.6	NNW	7.8	28.8	853.7	35.0	---	8.0	0.0	0.3	40	
Poprad / Tatry	6.7	0.4	2.8	1.0	89.4	WSW	23.6	57.6	----	5.2	6.1	5.3	3.1	27.6	----	
Telgart	4.5	-0.3	1.3	0.0	92.1	WSW	26.0	57.6	899.4	13.0	4.9	4.5	---	9.9	0	
Poprad-Ganovce	6.5	0.2	2.5	0.3	86.8	WNW	17.4	----	----	3.0	---	---	---	----	----	
Presov	10.4	0.9	4.7	1.7	83.9	SW	11.1	----	1005.3	6.3	6.6	6.5	---	17.8	----	
Kojsovska Hola	3.4	-2.5	-0.6	-1.8	92.7	W	13.5	----	861.9	5.0	---	---	2.4	11.8	----	
Kosice	11.2	-1.2	4.0	2.1	89.2	SSW	11.4	----	1005.9	10.2	4.8	4.5	2.9	17.5	----	
Stropkov, Tisinec	9.1	2.7	4.3	3.4	95.3	NNE	5.4	----	1005.5	15.9	7.5	7.1	---	21.0	----	
Milhostov	11.4	0.8	4.8	3.2	91.5	E	7.7	----	1005.9	8.3	6.3	6.2	1.4	17.9	----	
Kamenica Nad Ciro...	9.8	3.7	5.5	3.2	86.7	SSE	8.0	----	1005.7	8.9	7.3	7.3	3.3	16.0	----	
Summary	7.2	2.0	4.1	2.0	87.6	W	15.1	77.0	1006.5	13.5	6.9	6.2	0.8	18.4	70	

A-LAEF extreme weather case studies

Strong wind events:

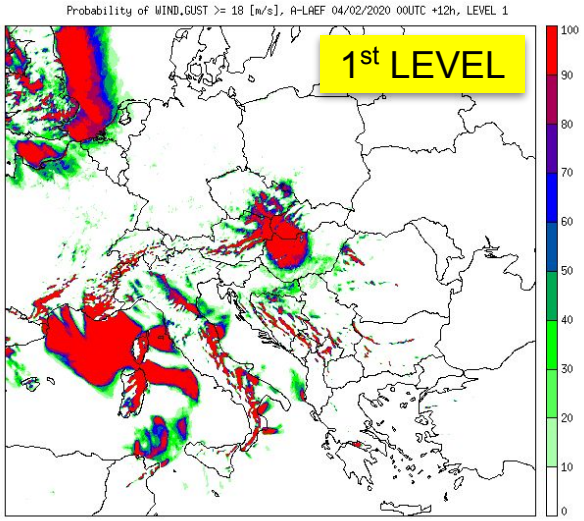
- Central Europe - **Storm Petra of 4 February 2020**

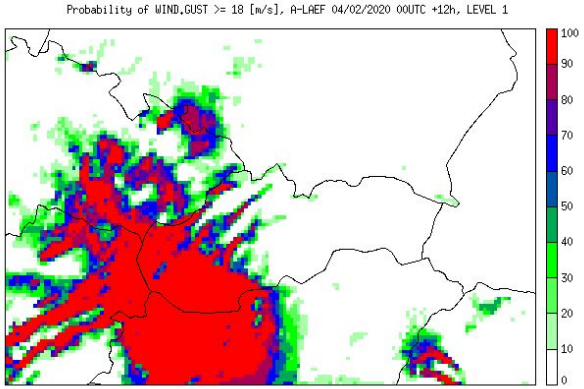
The center of deep cyclone was located over the central part of Slovakia, which led to extremely strong and gusty wind especially at south-west. In Bratislava and Nitra maximum wind gusts about 28-29 m/s were recorded. At the small Carpathian ridge it was 33 m/s, elsewhere mostly in the interval 25-30 m/s. It was for the first time in history when the highest warning level (3rd) was issued for capital city Bratislava. Similar situation was in eastern part of Austria and north-western part of Hungary.



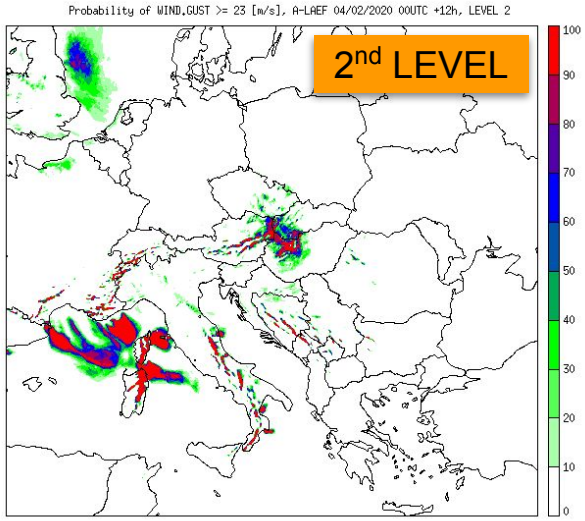
A-LAEF extreme weather case studies

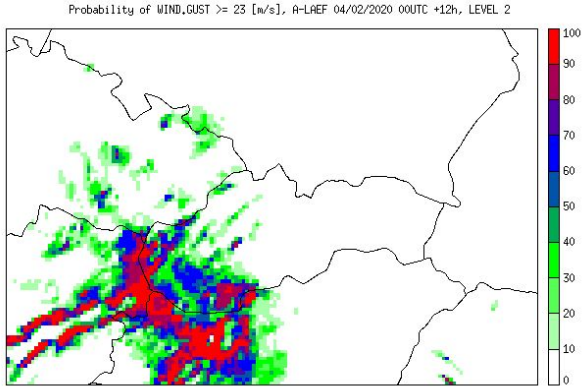
wind gusts >= 18 m/s



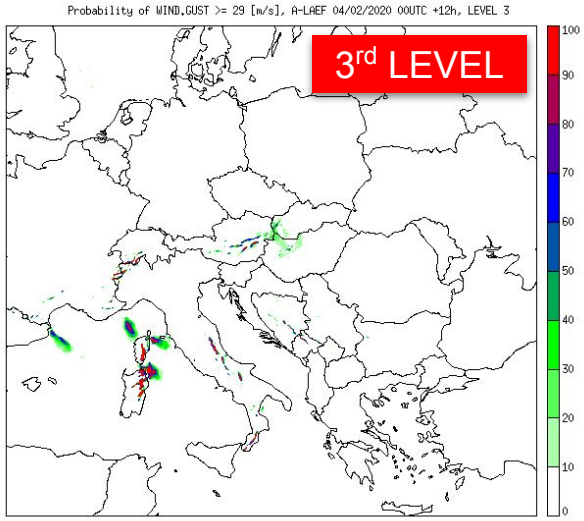


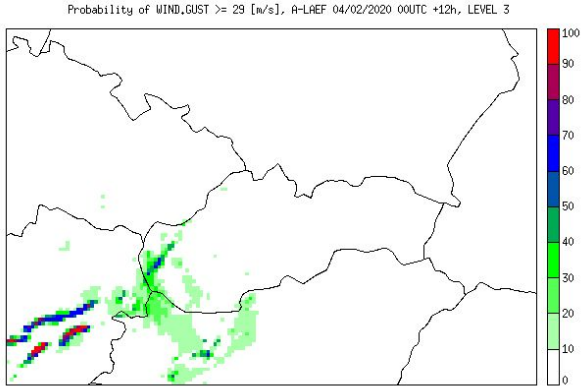
wind gusts >= 23 m/s





wind gusts >= 29 m/s

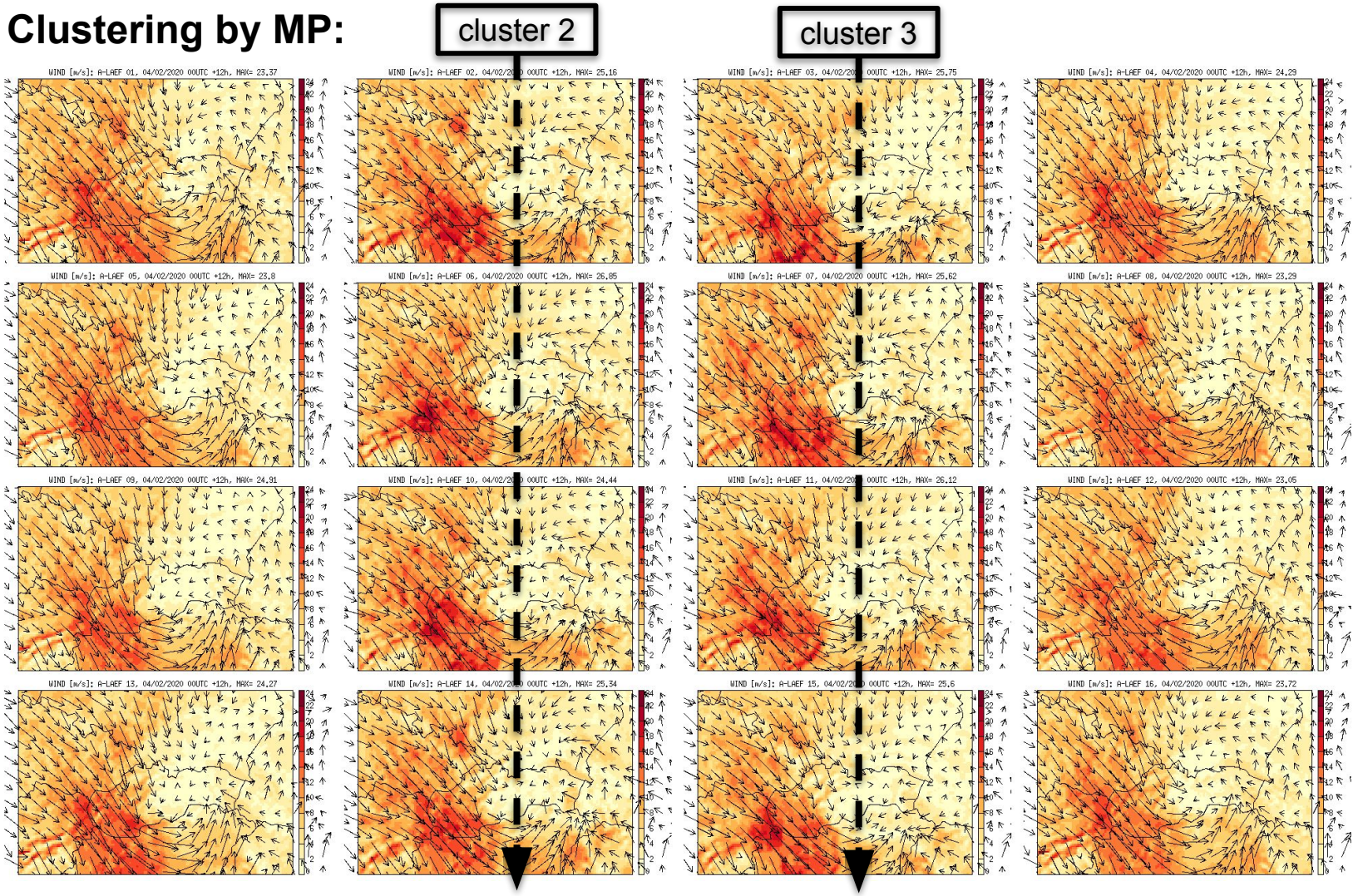




A-LAEF probability maps for wind gusts with different thresholds.

A-LAEF extreme weather case studies

Clustering by MP:



A-LAEF extreme weather case studies

Clustering by MP:

ALARO-1 default	cluster 2	cluster 3
CGMIXLEN='EL0'	CGMIXLEN='EL3'	CGMIXLEN='EL3'
CGTURS='MD2'	CGTURS='QNSE'	CGTURS='QNSE'
LPRGML=.T.	LPRGML=.F.	LPRGML=.F.
LCVGQM=.T.	LCVGQM=.T.	LCVGQM=.F.
LENTCH=.T.	LENTCH=.T.	LENTCH=.F.
LSCMF=.T.	LSCMF=.T.	LSCMF=.F.
C3TKEFREE=1.183	C3TKEFREE=1.39	C3TKEFREE=1.39
C_EPSILON=0.871	C_EPSILON=0.798	C_EPSILON=0.798
ETKE_OLAM=0.29	ETKE_OLAM=0.324	ETKE_OLAM=0.324
NUPTKE=0.5265	NUPTKE=0.504	NUPTKE=0.504
LXRCDEV=.T.	LXRCDEV=.T.	LXRCDEV=.F.

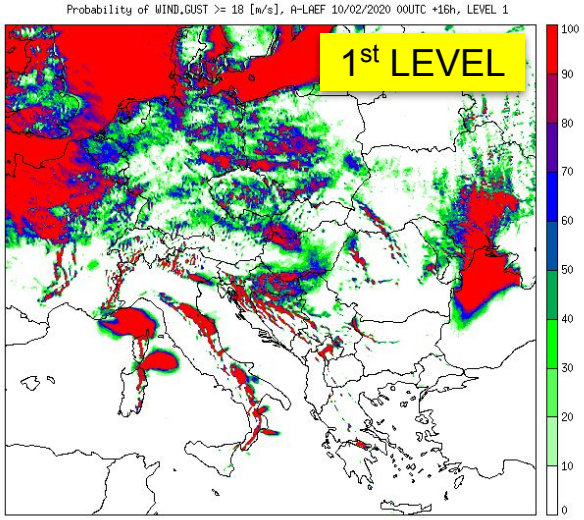
A-LAEF extreme weather case studies

Strong wind events:

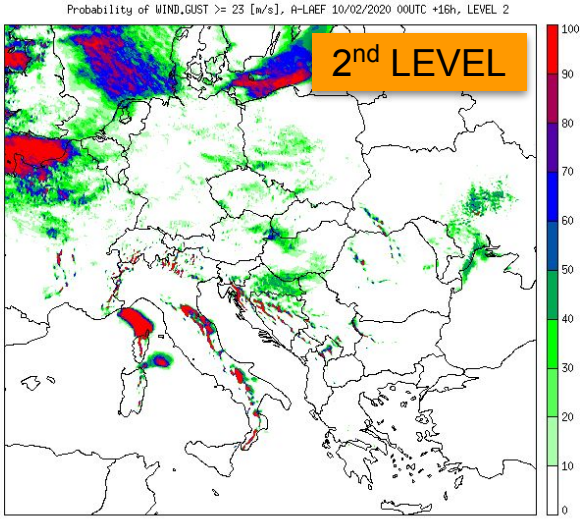
- Central Europe - **Windstorm of 10 February 2020**

Another strong wind situation during cold front passage just one week later. This time wind gusts were over-predicted by deterministic model. The highest warning level for strong wind was issued again, even though the reality was not that bad. This was subsequently confirmed by A-LAEF ensemble, were the threshold for level 3 was not reached (unfortunately, A-LAEF forecast was not available to the forecasters yet).

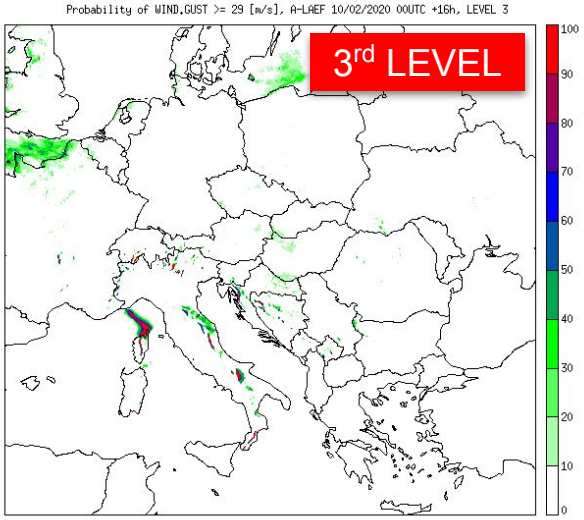
wind gusts >= 18 m/s



wind gusts >= 23 m/s



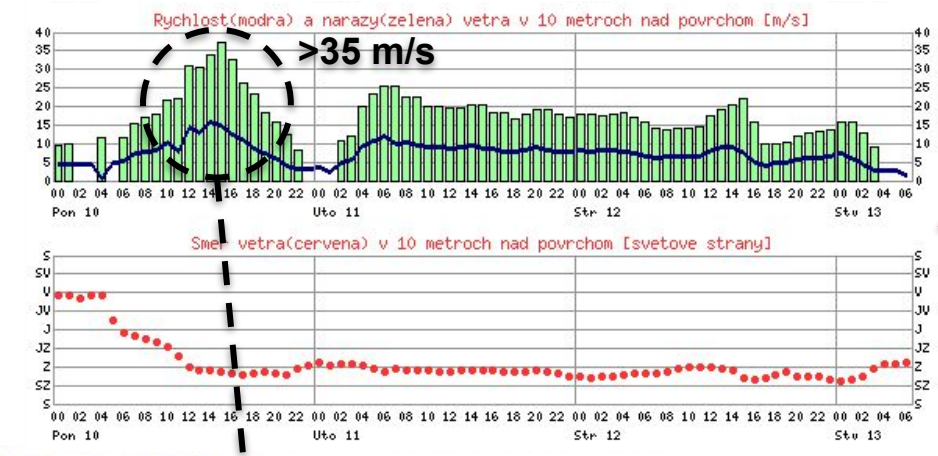
wind gusts >= 29 m/s



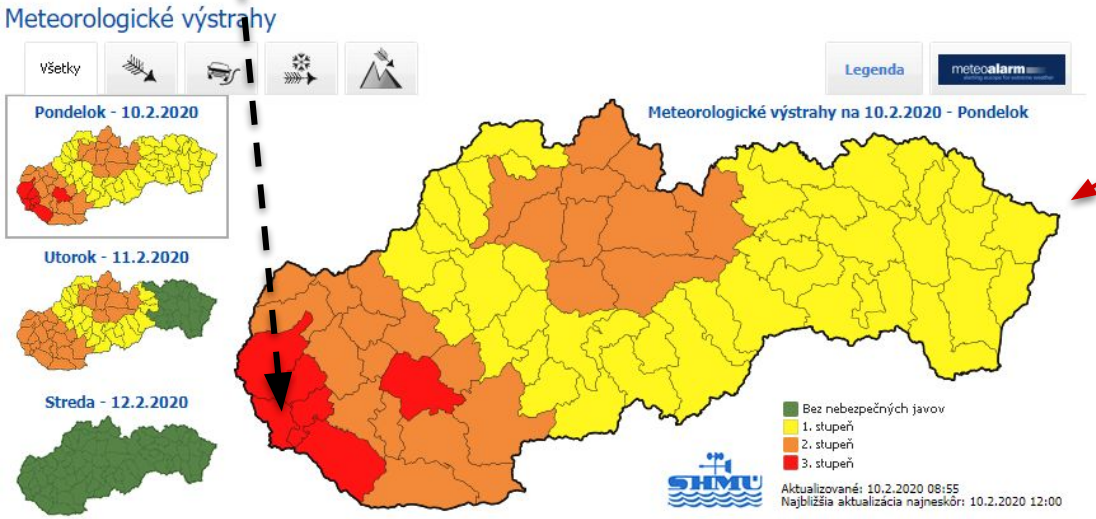
A-LAEF probability maps for wind gusts with different thresholds.

A-LAEF extreme weather case studies

One deterministic forecast is not enough!



ALADIN
SHMU



METEO
ALARM

Publications

Published papers:

- Belluš, M., F. Weidle, C. Wittmann, Y. Wang, S. Taşku, and M. Tudor, 2019: "Aire Limitée Adaptation dynamique Développement InterNational – Limited Area Ensemble Forecasting (ALADIN-LAEF)", Adv. Sci. Res., 16, 63–68, https://doi.org/10.5194/asr-16-63-2019
- Wang, Y., M. Belluš, F. Weidle, et al., 2019: "Impact of land surface stochastic physics in ALADIN-LAEF", Quarterly Journal of the Royal Meteorological Society, 1–19, https://doi.org/10.1002/qj.3623
- Keresturi E., Y. Wang, F. Meier, F. Weidle, Ch. Wittmann, A. Atencia, 2019: "Improving initial condition perturbations in a convection permitting ensemble prediction system", Quarterly Journal of the Royal Meteorological Society, DOI: 10.1002/qj.3473
- Wastl C., Y. Wang, A. Atencia and C. Wittmann, 2019: "Independent perturbations for physics parametrization tendencies in a convection-permitting ensemble (pSPPT)", Geosci. Model Dev., 12, 261-273, DOI: 10.5194/gmd-12-261-2019

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Publications

Published papers:

- Wastl C., Y. Wang, A. Atencia, C. Wittmann, 2019: "A hybrid stochastically perturbed parametrization scheme in a convection permitting ensemble", Mon. Wea. Rev., 147, 2217-2230. doi: https://doi.org/10.1175/MWR-D-18-0415.1
- Wastl C., Y. Wang, C. Wittmann: "A comparison of different stochastically perturbed parametrization tendencies schemes", Meteorologische Zeitrschrift, DOI: 10.1127/metz/2019/0988
- Plenković, I. O., I. Schicker, M. Dabernig, K. Horvath: "Analog-based post-processing of the ALADIN-LAEF ensemble predictions in complex terrain", accepted for publication in Quarterly Journal of the Royal Meteorological Society

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Stay reports:

- Iris Odak Plenković, 2019: Work on analog-based post-processing method, Report on stay at ZAMG, 04/02~01/03, 2019, Vienna, Austria
- Endi Keresturi, 2019: Adding lagged deterministic forecasts to a convection-permitting EPS, Report on stay at ZAMG, 24/06~19/07, 2019, Vienna, Austria
- Iris Odak Plenković, 2019: Work on analog-based post-processing method, Report on stay at ZAMG, 11/11~06/12, 2019, Vienna, Austria

Annual report:

- Martin Belluš, 2020: Working Area Predictability Progress Report 2019

What's next?

Operations:

- Commencing of the **operational utilization** of A-LAEF (and local convection-permitting systems).
- Providing the quality **probabilistic products** to the end users.

R&D topics:

- Implementation of **new random number generator** (SPG) suitable for LAM EPS environment.
- Investigation of the possibilities of **stochastic perturbation of fluxes** instead of tendencies (in order to preserve the energy balance in perturbed model).
- Computation of **flow-dependent B-matrix** using the operational A-LAEF forecasts.

What's next?

R&D topics:

- Implementation of A-LAEF Phase II configuration involving **ENS BlendVar** (in order to enhance the simulation of upper-air ICs uncertainty).
- Continuation work on **analog-based post-processing** method utilizing ensemble data and extending the method to the spatial grid.
- **Calibration of precipitation** and post-processing over the river catchments for the hydrological models.
- Updating of ensemble **verification tools** (LAEF verification package, HARP).

Thank you for your attention!