
A-LAEF (ALARO-Limited Area Ensemble Forecasting)

M. Belluš - martin.bellus@shmu.sk, M. Derková

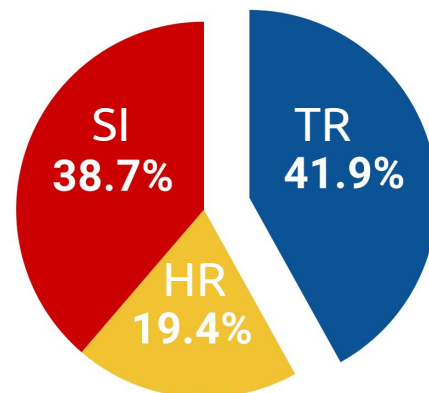
Outlook

- A-LAEF TC2 suite at ECMWF HPCF
- Uncertainty simulation
- Operational products
- Objective verification
- Case studies
- What's next?

A-LAEF

TC2 suite at ECMWF HPCF

- common high resolution EPS for LACE consortium
- operational since July 2020 (2 runs per day, 00/12 UTC)
- running reliably without any major issues:
 - 9 issues due to missing obsoul files in OPLACE (or unavailable FTP server)
 - since May 2021 backup GTS data via SVK ("saved" A-LAEF suite 4 times)
- surface/levels multi-GRIB files disseminated to:
 - SI, SK, RO, CZ, TR (via ECPDS)
 - HR (processing A-LAEF outputs at ECMWF)
 - PL (pushed via SHMU)
- availability by ~03:45 UTC and ~15:45 UTC (LACE domain)
- SBUs for the operations are contributed by SI, HR and TR



2021

Technical documentation:

https://www.rclace.eu/media/files/Predictability/project/A_LAEF_suite_description_02_2021.pdf

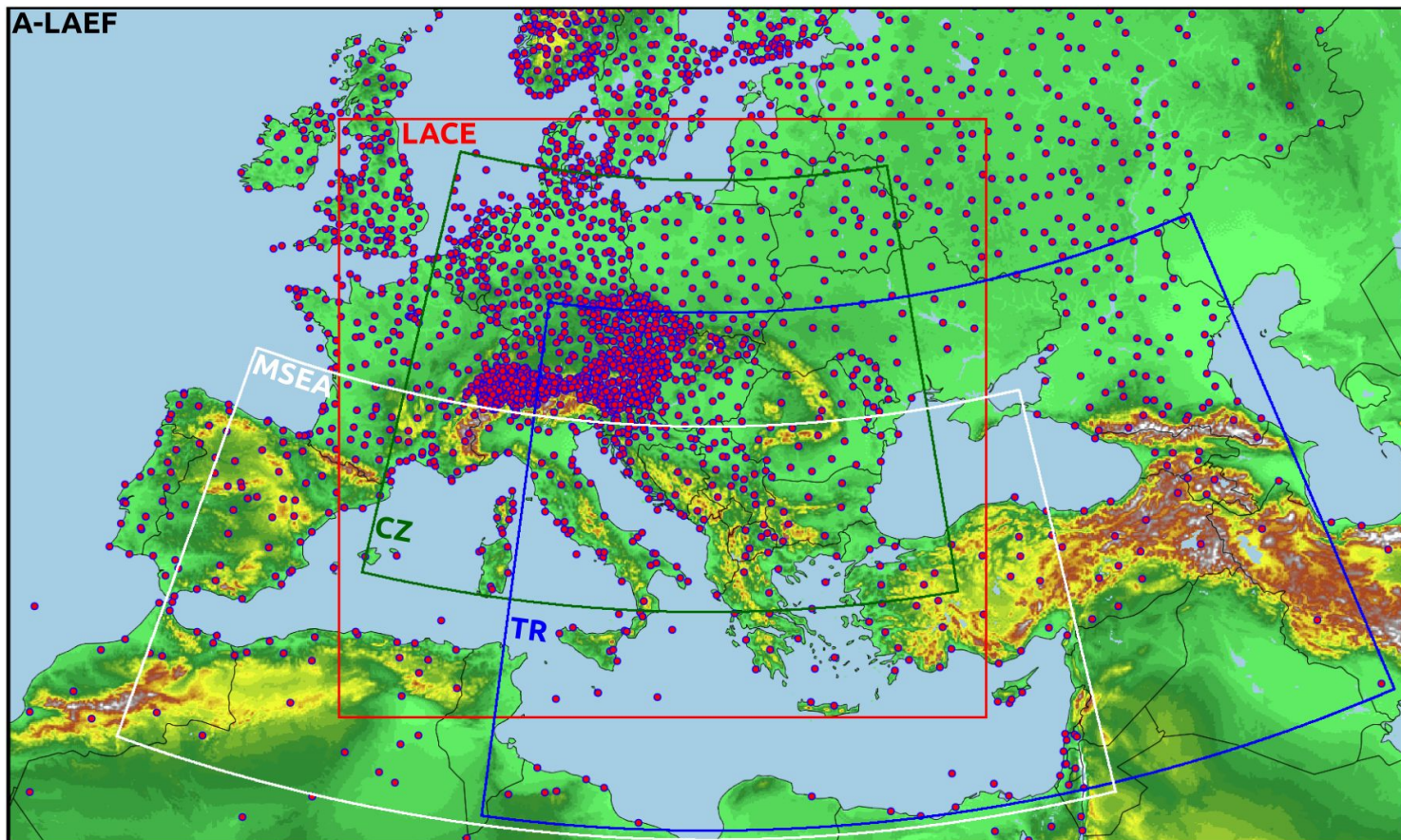
A-LAEF

setup

Code version	cy40t1
Horizontal resolution	4.8 km
Vertical levels	60
Number of grid points	1250x750
Grid	linear
Time step	180s
Forecast length	72 h (00/12 UTC)
Members	16+1
IC perturbation	ESDA [surface] spectral blending by DFI [upper-air]
Model perturbation	ALARO-1 multi-physics + surface SPPT
LBC perturbation	ECMWF ENS (c903)

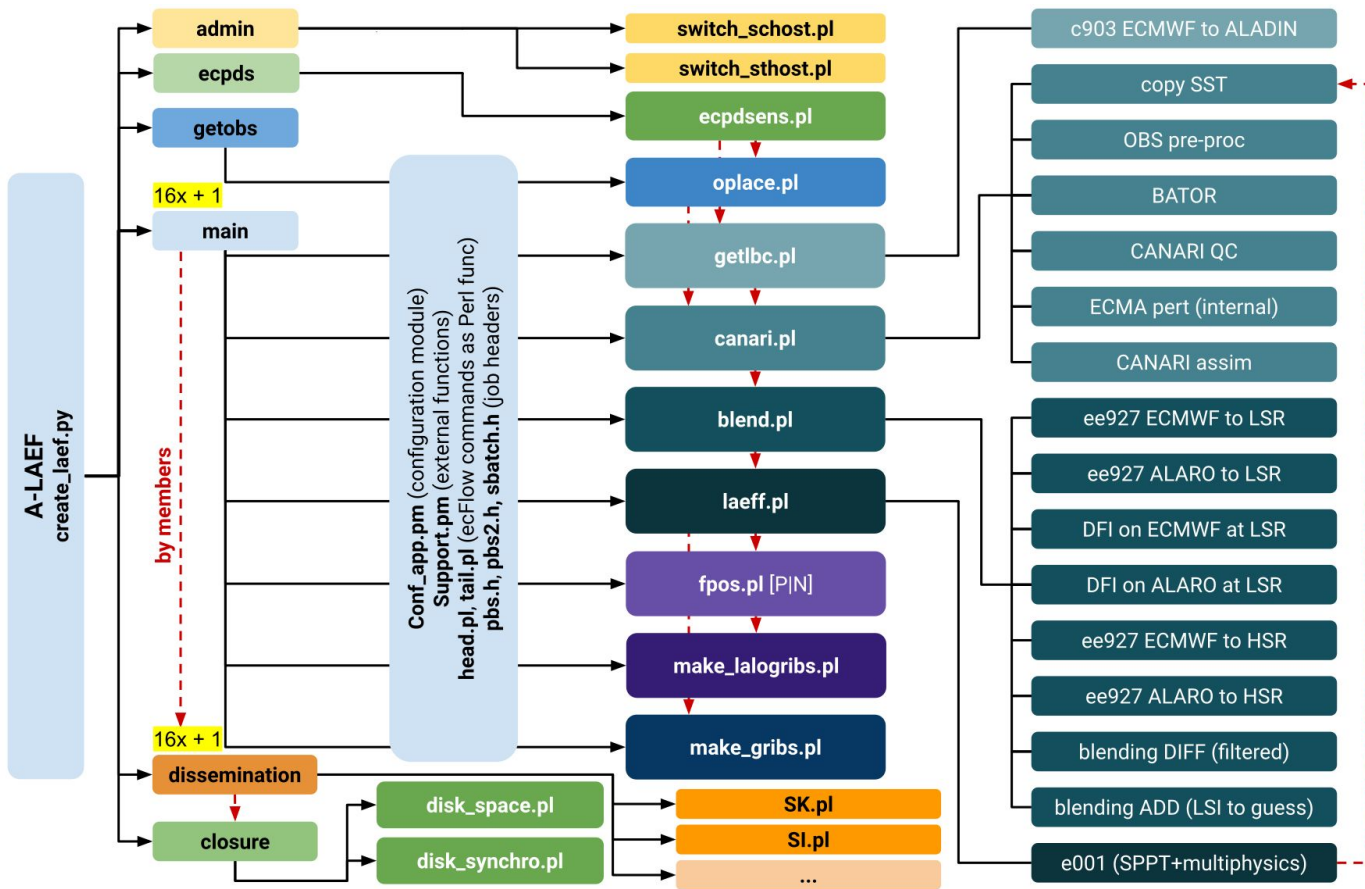
A-LAEF

e001 domain (with OBS) and postprocessing subdomains (LACE - Lambert, CZ/TR/MSEA - latlon)



A-LAEF

suite scheme and task dependencies



A-LAEF

(a portion of) suite in ecFlow UI

ecFlowUI (5.7.0) - (menu: user)

File Panels Refresh Servers Tools Help

2_laief_tc 2-03s d=3s

2_laief tc > laef > RUN_00 > main > MEM_00 > blend

2_laief tc > laef > RUN_00 > main > MEM_00 > blend

Info Manual Script Job Job status Output Why Triggers V= Variables Edit Node log Zombies Suite filter

File: /c:/t/work/2laief/ECF/laef/RUN_00/main/MEM_00/blend.1 Size: 10 KB
Source: served by cca-log@51799 (took 0.3 s) at 2022-06-10 11:41:47

```

=> started at: 01:09:20

[1] Convert ECMWF file to low spectral resolution (via ee927):
+ OK: [BC_LAEF_00_5km+000] input file ready
+ OK: [BC_LAEF_00_5km+000] input file truncation [NSMAX=374, NMEMAX=624]
+ OK: input clim file truncation [NSMAX=374, NMEMAX=624]
+ OK: target clim file truncation [NSMAX=43, NMEMAX=72]
+ OK: namelist was fully modified
+ OK: [ARL20220610-00] target file truncation [NSMAX=43, NMEMAX=72]
=> ARL20220610-00 is READY
---> [time spent: 00:00:26]

[2] Convert ALADIN file to low spectral resolution (via ee927):
+ OK: [ICMSHCC00+0000] input file ready
+ OK: [ICMSHCC00+0000] input file truncation [NSMAX=374, NMEMAX=624]
+ OK: input clim file truncation [NSMAX=374, NMEMAX=624]
+ OK: target clim file truncation [NSMAX=43, NMEMAX=72]
+ OK: namelist was fully modified
+ OK: [ALL20220610-00] target file truncation [NSMAX=43, NMEMAX=72]
=> ALL20220610-00 is READY
---> [time spent: 00:00:26]

[3] Run DFI on ECMWF file with low spectral resolution (via e001):
+ OK: [ARL20220610-00] input file ready
+ OK: LBCs for constant coupling ready
+ OK: namelist was fully modified
=> ARF20220610-00 is READY
---> [time spent: 00:02:17]

[4] Run DFI on ALADIN file with low spectral resolution (via e001):
+ OK: [ALL20220610-00] input file ready
+ OK: LBCs for constant coupling ready
+ OK: namelist was fully modified
=> ALF20220610-00 is READY
---> [time spent: 00:02:19]

[5] Convert filtered ECMWF file to high spectral resolution (via ee927):

```

LAEF_DATE=... 20220610 ...

- admin
 - switch_sghost
 - switch_sthost
- RUN_00
 - time 00:15 # free
 - mars
 - ecpcds
 - ecpcdsens
 - getobs
 - oplace
 - main
 - MEM_00
 - getbcb
 - run: 2022-06-10 00 lagged
 - status: LBCs for member 00 have been created
 - msg: files: 13
 - ./ecpcds == complete
 - canari
 - run: 2022-06-10 00
 - status: Run CANARI surface assimilation
 - msg: step: 6
 - ./getobs == complete and getbcb == complete
 - blend
 - run: 2022-06-10 00
 - status: Adding ECMWF long wave spec. to ALADIN guess via blend
 - msg: step: 8
 - canari == complete
 - laeff
 - fpos_P
 - fpos_N
 - make_gribs
 - make_lalognbs
 - MEM_01
 - MEM_02
 - MEM_03
 - MEM_04
 - MEM_05
 - MEM_06
 - MEM_07

Uncertainty simulation

in A-LAEF system

- **initial conditions uncertainty**

a) ensemble of surface data assimilation (ESDA)
[perturbed T2m and RH2m OBS, perturbed first guess]

b) upper-air spectral blending by DFI
[combination of GM and LAM uncertainty]

- **lateral boundary conditions uncertainty**

perturbations inherited from the first 16 members of ECMWF ENS
[via standard coupling]

- **numerical model uncertainty**

a) ALARO-1 multi-physics
[4 clusters with different setup of micro-physics, deep and shallow convection, radiation and turbulence; control run with the default ALARO-1 physics configuration]

b) stochastic physics for surface prognostic fields
[stochastic perturbation of physics tendencies (SPPT) for 7 surface prognostic fields: surface temperature, surface liquid water content, surface frozen water content, snow albedo, snow reservoir water content, snow density and water intercepted by vegetation; control run without SPPT]

ESDA:

$$\Delta T_s = \Delta T_{2m}$$

$$\Delta T_p = \frac{1}{2\pi} \Delta T_{2m}$$

$$\Delta W_s = \alpha_s^T \Delta T_{2m} + \alpha_s^H \Delta H_{2m}$$

$$\Delta W_p = \alpha_p^T \Delta T_{2m} + \alpha_p^H \Delta H_{2m}$$

BLENDING:

$$IC_{blend}^n = a_{breed}^n + \{ \overline{(a_{sv}^n)_{trunc}} - \overline{(a_{breed}^n)_{trunc}} \}$$

$$IC_{blend}^n = LS^n + a_{breed}^n$$

SPPT + MP:

$$\frac{\partial e_j}{\partial t} = A(e_j, t) + P'(e_j, t)$$

$$P'_j(e_j, t) = (1 + r_j(\lambda, \varphi, t)_{D,T}) P_j(e_j, t)$$

Uncertainty simulation

ALARO-1 multi-physics clusters

cluster 1: 01, 05, 09, 13	
LAB12	F
LCVGQM	F
LCVGQD	F
LENTCH	F
LSCMF	F
LSMGCDEV	T
LXRCDEV	F

microphysics and
deep convection

cluster 2: 02, 06, 10, 14	
CGMIXLEN	EL3
CGTURS	QNSE
LPRGML	F
C3TKEFREE	1.39
C_EPSILON	0.798
ETKE_OLAM	0.324
NUPTKE	0.504

turbulence

turbulence,
microphysics and
deep convection

cluster 3: 03, 07, 11, 15	
CGMIXLEN	EL3
CGTURS	QNSE
LCVGQM	F
LCVGQD	F
LENTCH	F
LPRGML	F
LSCMF	F
LSMGCDEV	T
LXRCDEV	F
C3TKEFREE	1.39
C_EPSILON	0.798
ETKE_OLAM	0.324
NUPTKE	0.504

cluster 4: 04, 08, 12, 16	
LAB12	T
LCVGQM	T
LENTCH	T
LSCMF	T
LXRCDEV	T
CGMIXLEN	EL0
CGTURS	MD2
LPRGML	T
C3TKEFREE	1.183
C_EPSILON	0.871
ETKE_OLAM	0.29
NUPTKE	0.5265

ALARO-1 reference

A-LAEF

references

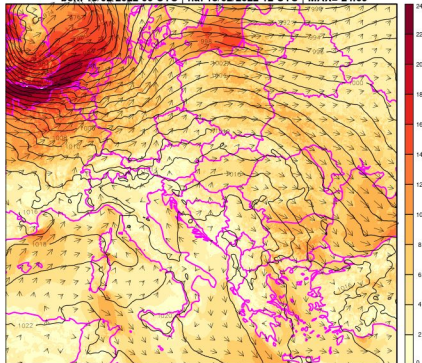
- Belluš, M., Y. Wang & F. Meier**, 2016: Perturbing surface initial conditions in a regional ensemble prediction system. *Mon. Wea. Rev.*, **144**, 3377–3390.
- Belluš, M., F. Weidle, C. Wittmann, Y. Wang, S. Taşku & M. Tudor**, 2019: Aire Limitée Adaptation dynamique Développement InterNational – Limited Area Ensemble Forecasting (ALADIN-LAEF). *Adv. Sci. Res.*, **16**, 63–68.
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- Derková, M. & M. Belluš**, 2007: Various applications of the blending by digital filter technique in the ALADIN numerical weather prediction system. *Meteorologický časopis*, **10**, 27–36.
- Simon, A., M. Belluš, K. Čatlošová, M. Derková, M. Dian, M. Imrišek et al.**, 2021: Numerical simulations of 7 June 2020 convective precipitation over Slovakia using deterministic, probabilistic and convection-permitting approaches. *IDŮJÁRÁS*, **125**, 571–607.
- Wang, Y., M. Belluš, C. Wittmann, M. Steinheimer, F. Weidle, A. Kann et al.**, 2011: The Central European limited-area ensemble forecasting system ALADIN-LAEF. *Q. J. R. Meteorol. Soc.*, **137**, 483–502.
- Wang, Y., M. Belluš, F. Weidle, C. Wittmann, J. Tang, F. Meier et al.**, 2019: Impact of land surface stochastic physics in ALADIN-LAEF. *Q. J. R. Meteorol. Soc.*, **145**, 1–19.
- Wang, Y., M. Belluš, J.-F. Geleyn, X. Ma, W. Tian & F. Weidle**, 2014: A new method for generating initial perturbations in regional ensemble prediction system: blending. *Mon. Wea. Rev.*, **142**, 2043–2059.
- Belluš, M., M. Tudor & X. Abellan**, 2022: The mesoscale ensemble prediction system A-LAEF. *ECMWF Newsletter*, **172**, (accepted)

Operational products

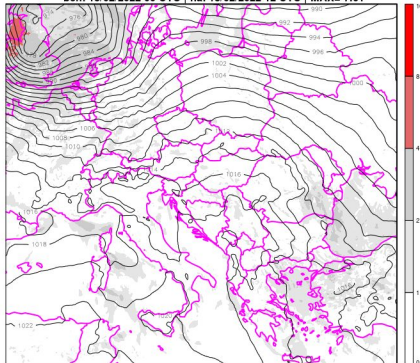
SHMU and RC LACE (maps)

Storm Eunice (18 Feb 2022) - "Record-breaking gusts hit UK and Ireland..." [The Guardian]

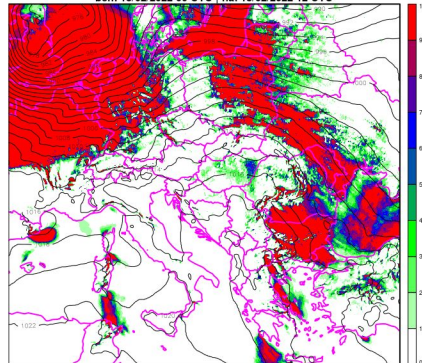
[A-LAEF] RYCHLOST VETRA [m/s] (ans.PRIEMER) + TLAK (kontrol.beh)
beh: 18/02/2022 00 UTC | na: 18/02/2022 12 UTC | MAX= 24.69



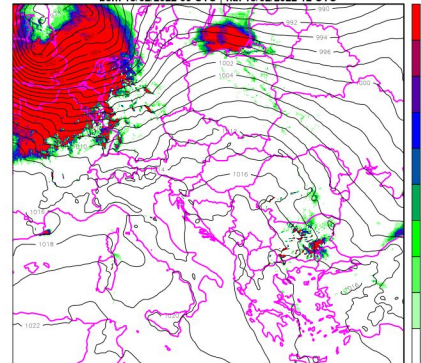
[A-LAEF] RYCHLOST VETRA [m/s] (ans.ROZPTYL) + TLAK (kontrol.beh)
beh: 18/02/2022 00 UTC | na: 18/02/2022 12 UTC | MAX= 7.61



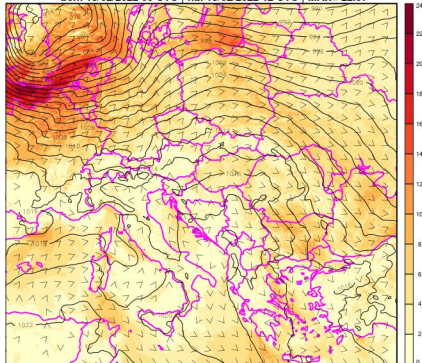
[A-LAEF] Pravdepodobnost [%] NARAZOV VETRA >= 12 [m/s] + TLAK (kontrol.beh)
beh: 18/02/2022 00 UTC | na: 18/02/2022 12 UTC



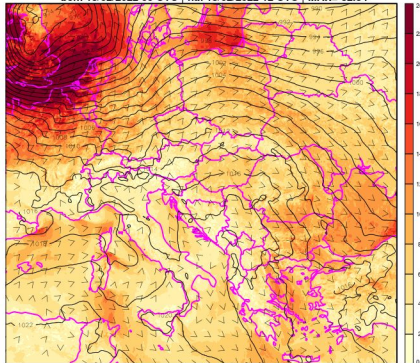
[A-LAEF] Pravdepodobnost [%] NARAZOV VETRA >= 18 [m/s] + TLAK (kontrol.beh)
beh: 18/02/2022 00 UTC | na: 18/02/2022 12 UTC



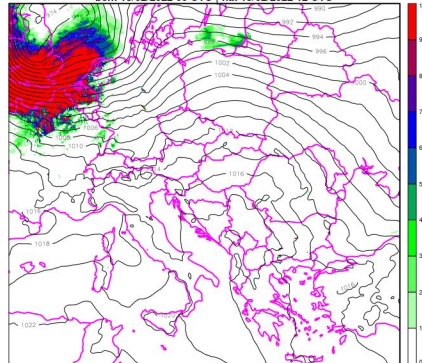
[A-LAEF] RYCHLOST VETRA [m/s] (ans.MINIMUM) + TLAK (kontrol.beh)
beh: 18/02/2022 00 UTC | na: 18/02/2022 12 UTC | MAX= 22.57



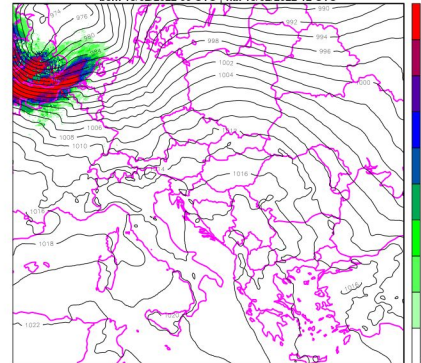
[A-LAEF] RYCHLOST VETRA [m/s] (ans.MAXIMUM) + TLAK (kontrol.beh)
beh: 18/02/2022 00 UTC | na: 18/02/2022 12 UTC | MAX= 32.54



[A-LAEF] Pravdepodobnost [%] NARAZOV VETRA >= 23 [m/s] + TLAK (kontrol.beh)
beh: 18/02/2022 00 UTC | na: 18/02/2022 12 UTC



[A-LAEF] Pravdepodobnost [%] NARAZOV VETRA >= 29 [m/s] + TLAK (kontrol.beh)
beh: 18/02/2022 00 UTC | na: 18/02/2022 12 UTC

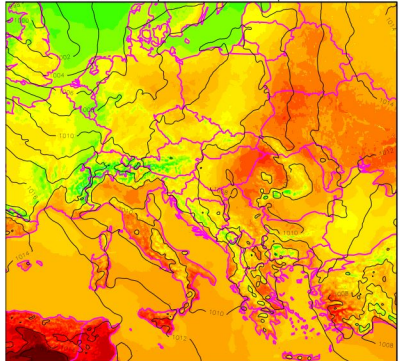


Operational products

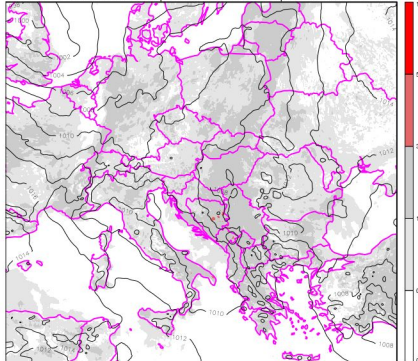
SHMU and RC LACE (maps)

Just a normal weather (8 June 2022)

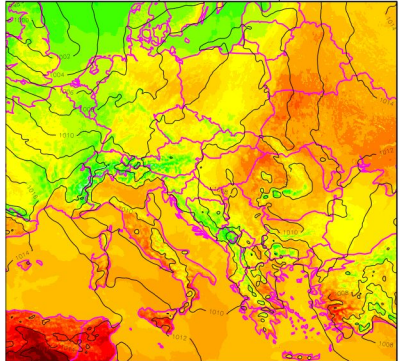
[A-LAEF] TEPLOTA [C] (ans.PRIEMER) + TLAK (kontrol.beh)
 beh: 08/06/2022 00 UTC | na: 08/06/2022 12 UTC | MIN= 0.35 MAX= 40.57



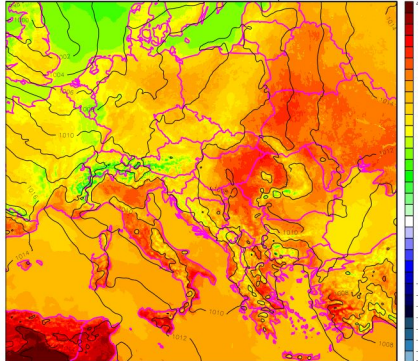
[A-LAEF] TEPLOTA [C] (ans.ROZPTYL) + TLAK (kontrol.beh)
 beh: 08/06/2022 00 UTC | na: 08/06/2022 12 UTC | MIN= 0.03 MAX= 3.64



[A-LAEF] TEPLOTA [C] (ans.MINIMUM) + TLAK (kontrol.beh)
 beh: 08/06/2022 00 UTC | na: 08/06/2022 12 UTC | MIN= -0.63 MAX= 39.5

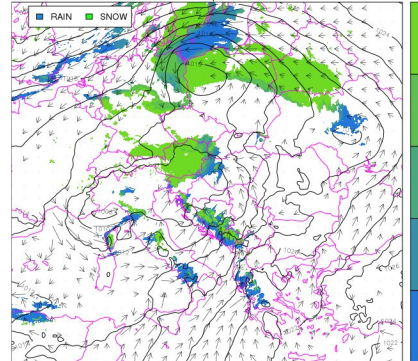


[A-LAEF] TEPLOTA [C] (ans.MAXIMUM) + TLAK (kontrol.beh)
 beh: 08/06/2022 00 UTC | na: 08/06/2022 12 UTC | MIN= 1.27 MAX= 42.42

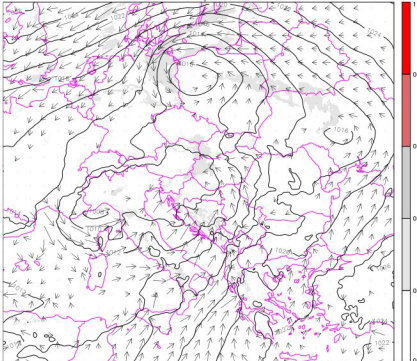


Precipitation phase (6 Jan 2021)

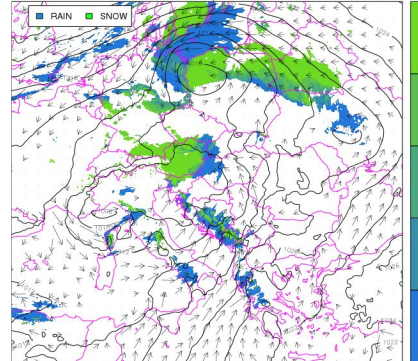
[A-LAEF] SKUP.ZRAZOK [mm] (ans.PRIEMER) + VIETOR a TLAK (kontrol.beh)
 beh: 06/01/2021 00 UTC | na: 06/01/2021 03-06 UTC



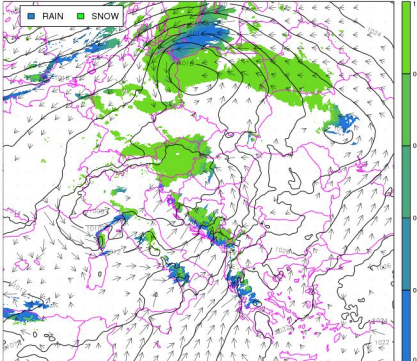
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 beh: 06/01/2021 00 UTC | na: 06/01/2021 03-06 UTC



[A-LAEF] SKUP.ZRAZOK [mm] (ans.MINIMUM) + VIETOR a TLAK (kontrol.beh)
 beh: 06/01/2021 00 UTC | na: 06/01/2021 03-06 UTC



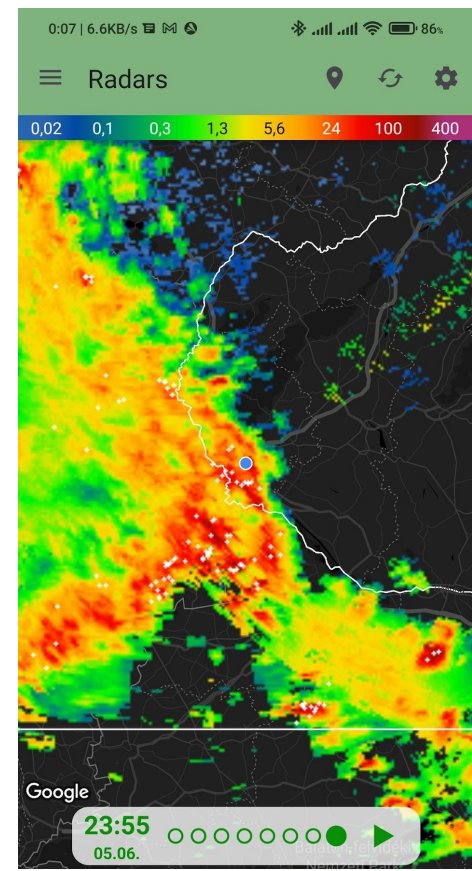
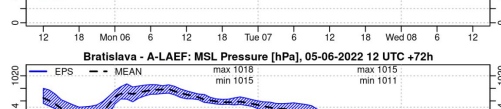
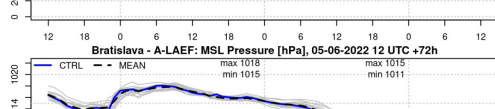
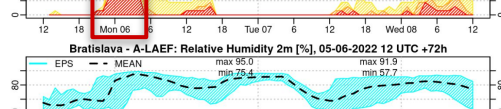
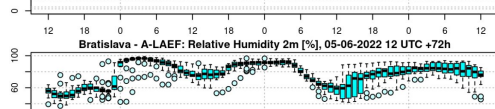
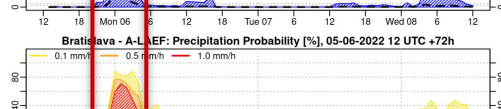
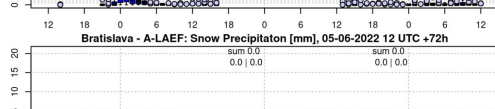
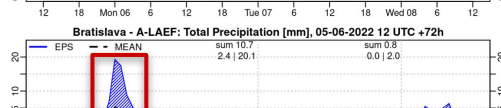
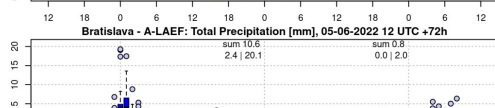
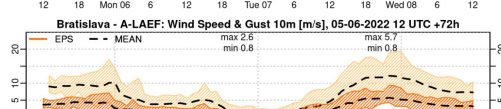
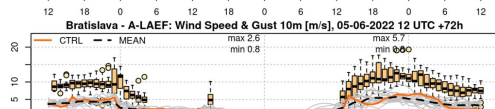
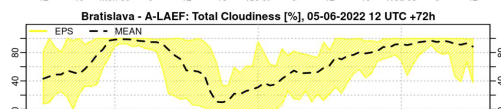
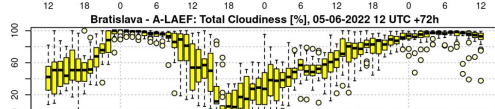
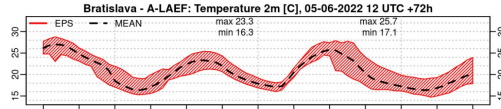
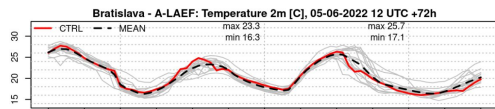
[A-LAEF] SKUP.ZRAZOK [mm] (ans.MAXIMUM) + VIETOR a TLAK (kontrol.beh)
 beh: 06/01/2021 00 UTC | na: 06/01/2021 03-06 UTC



Operational products

SHMU and RC LACE (epsgrams)

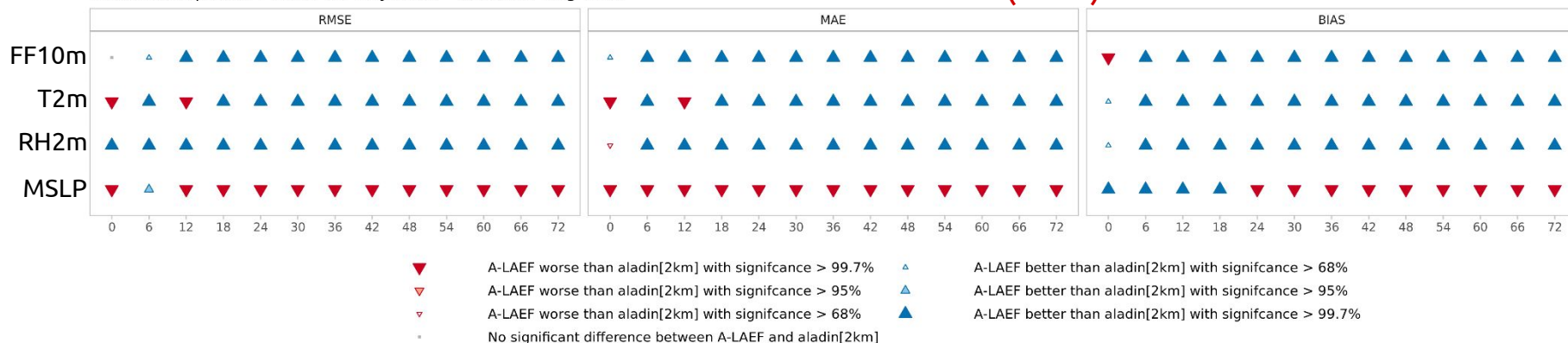
Night storm on cold front (6 June 2022)



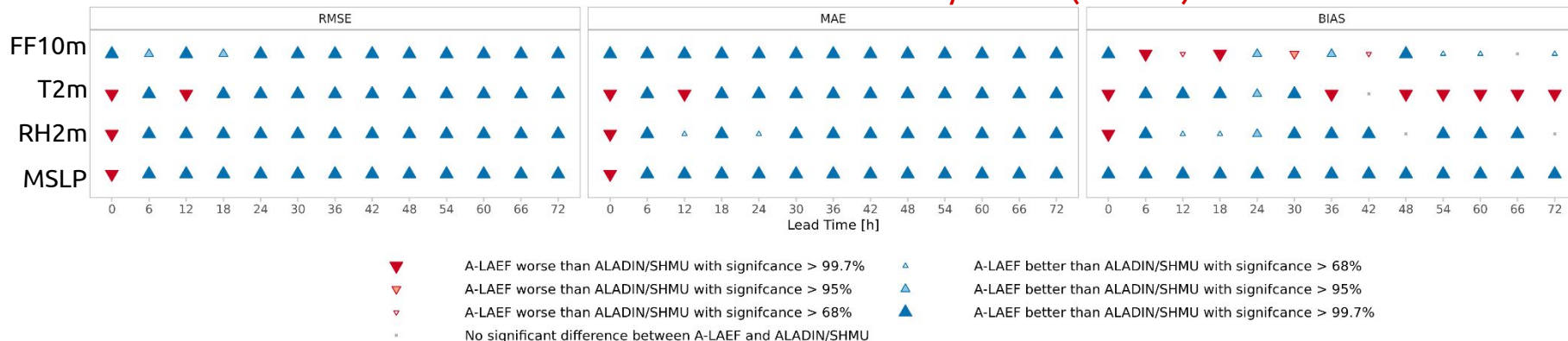
Objective verification (HARP)

A-LAEF (4.8 km) vs. det. ALADIN/SHMU oper (4.5 km) and ALARO NH (2 km) - **May-August 2021** [96 SK stations]

Verification period : 00:00 01 May 2021 - 00:00 31 Aug 2021 **A-LAEF vs. ALARO NH (2 km)**



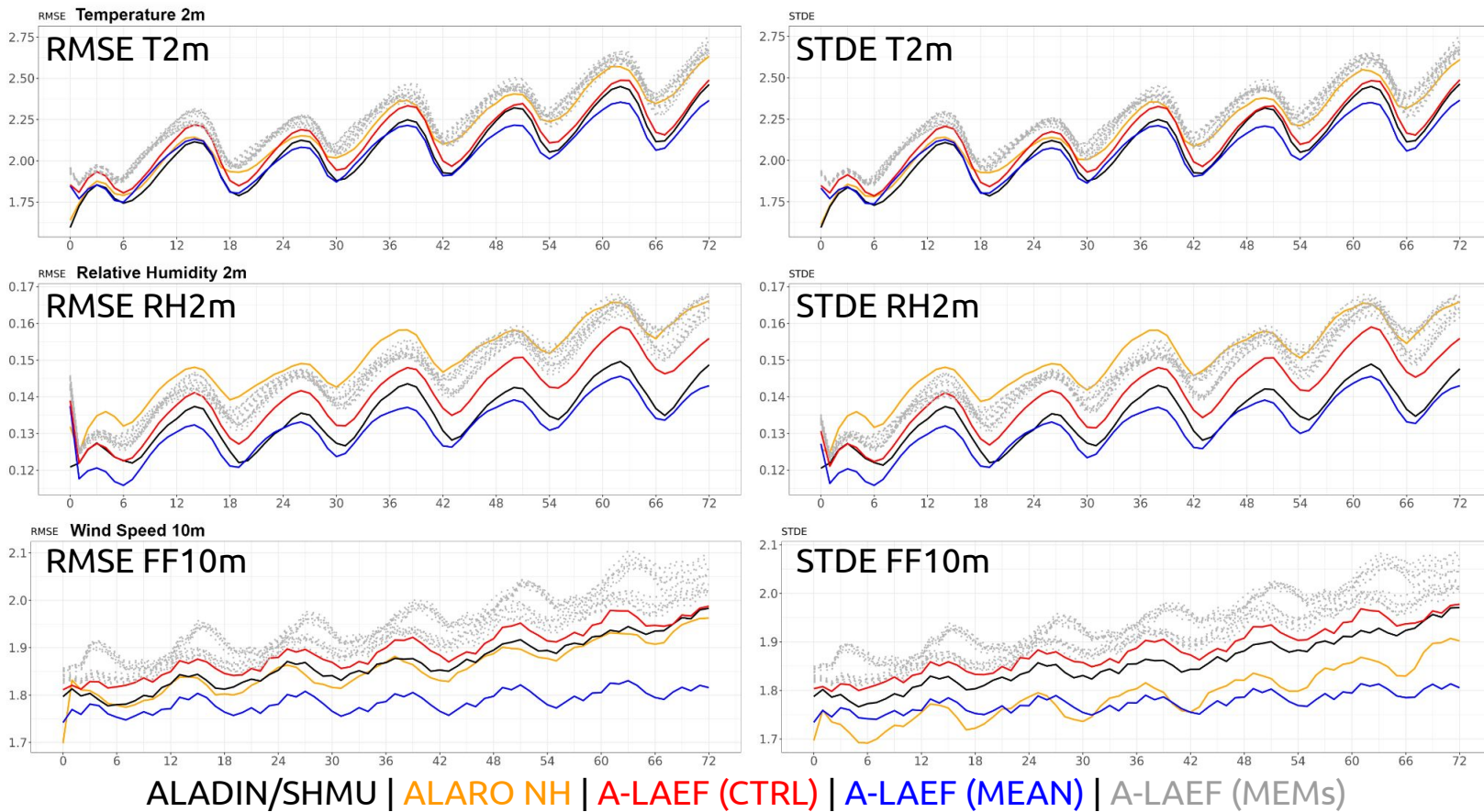
Verification period : 00:00 01 May 2021 - 00:00 31 Aug 2021 **A-LAEF vs. ALADIN/SHMU (4.5 km)**



Objective verification (HARP)

A-LAEF (4.8 km) vs. det. ALADIN/SHMU oper (4.5 km) and ALARO NH (2 km) - 11 months in 2021 [96 SK stations]

January - November 2021



Objective verification (custom R scripts)

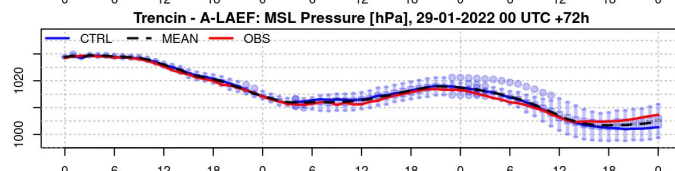
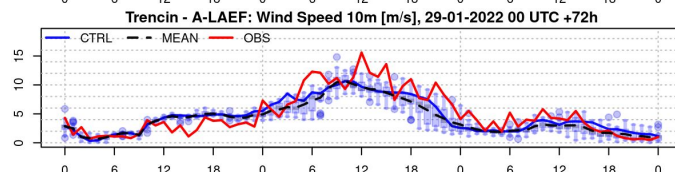
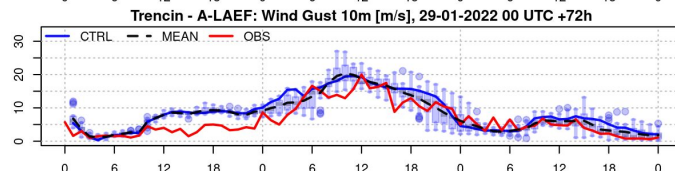
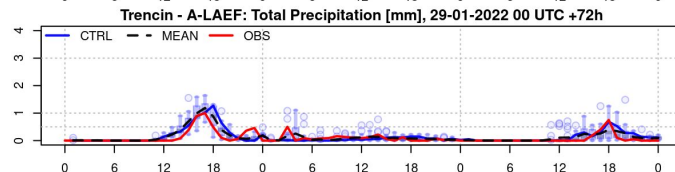
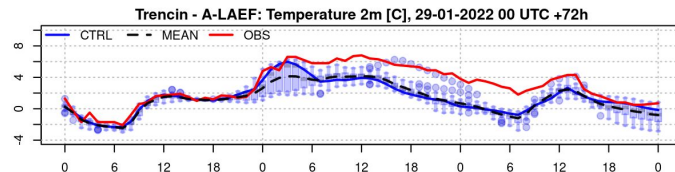
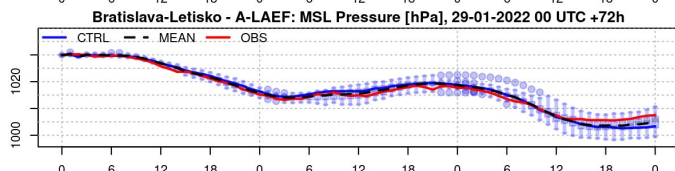
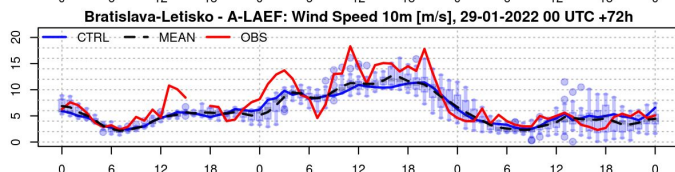
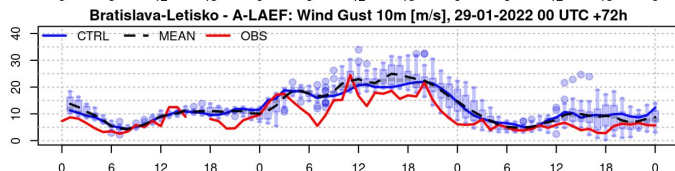
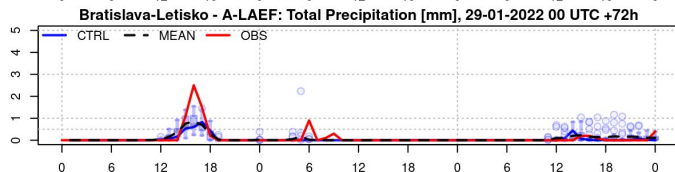
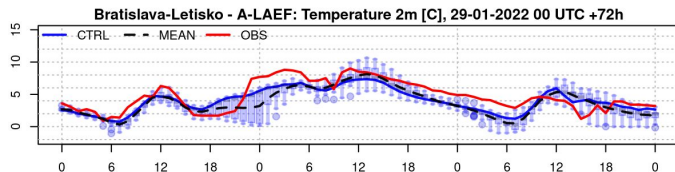
A-LAEF vs AWS

Extreme wind
(30 Jan 2022)

Precipitation →

Wind gust →

Wind speed →



Objective verification ("okometricky")

A-LAEF vs INCA vs ALADIN/SHMU oper vs ALARO NH

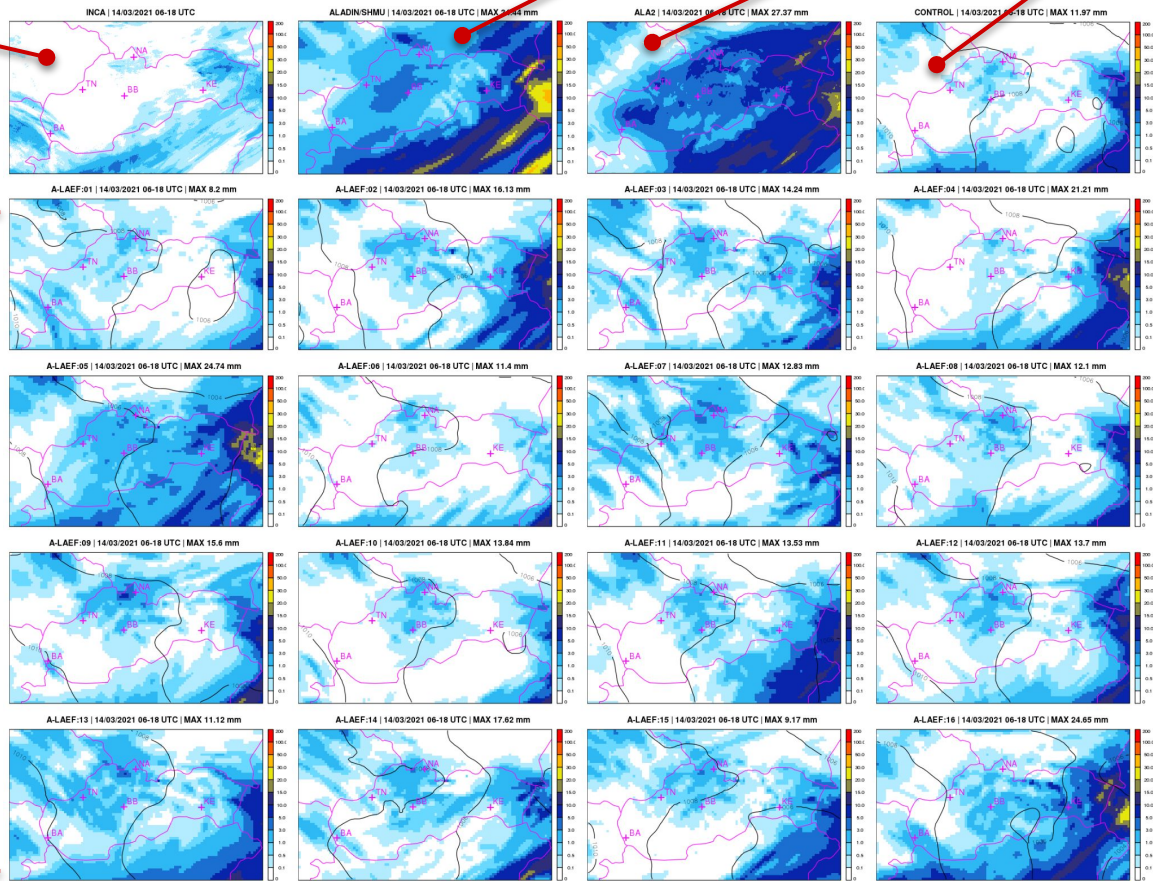
ALADIN oper

ALARO NH

A-LAEF CTRL

Overestimated precipitation*
(14 March 2021)
accum: 12 hrs
*) by deterministic models

INCA



A-LAEF members

Objective verification ("okometricky")

A-LAEF vs INCA vs ALADIN/SHMU oper vs ALARO NH

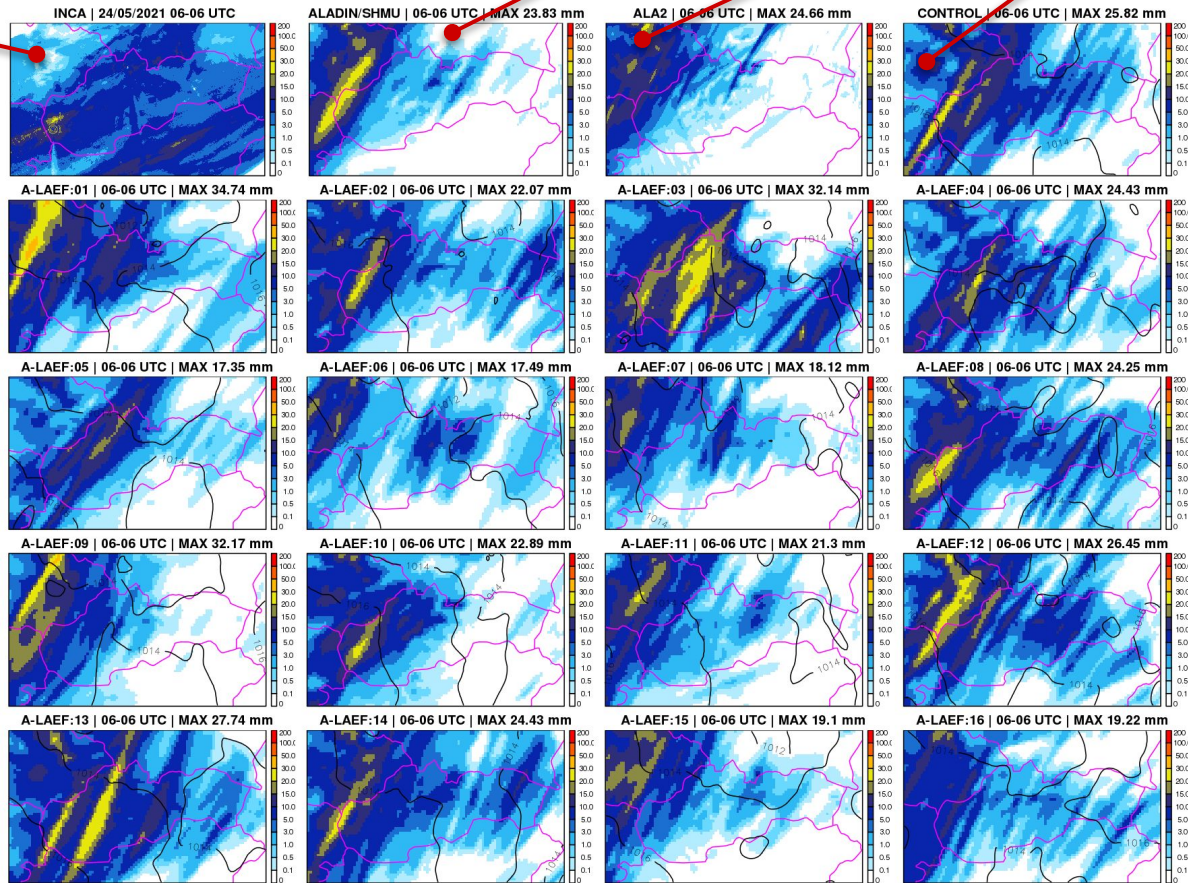
ALADIN oper

ALARO NH

A-LAEF CTRL

Underestimated precipitation*
(24 May 2021)
accum: 24 hrs
*) by deterministic models

INCA



A-LAEF members

Case study (Italy)

Record rainfall in Italy 4 Oct 2021

Description:

A European precipitation intensity record was broken in Northern Italy (Liguria region), where more than 740 mm of rain fell within a 12-hour period, causing floods and landslides. During this event, 178 mm of rainfall was measured in just 1 hour in Urbe Vara Superiore, and over 900 mm in 24 hours in Rossiglione.

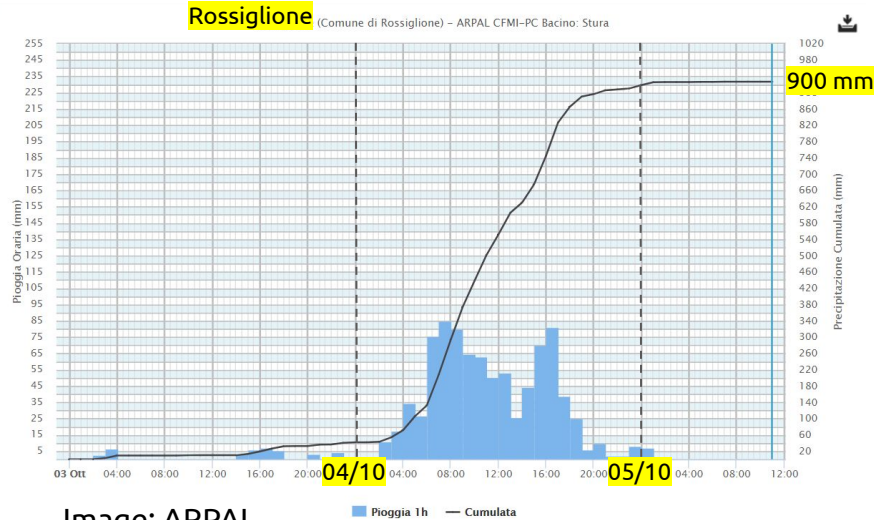


Photo: President of Liguria Giovanni Toti

Case study (Italy)

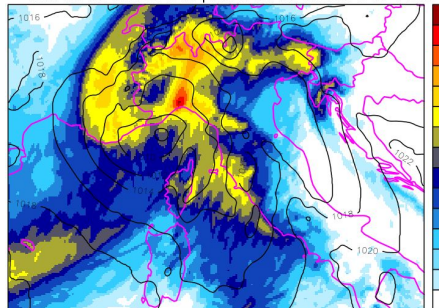
Record rainfall in Italy 4 Oct 2021 - A-LAEF precipitation forecast (24-h accum.) - 48 h ahead

ENS MEAN, SPREAD, MIN and MAX

Probabilities for thresholds 50, 100, 150 and 200 mm

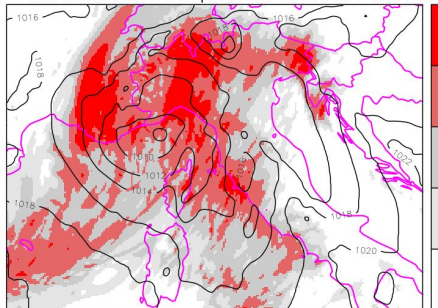
[A-LAEF] PREC [mm] (ENS MEAN) | MAX= 207

run: 03/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



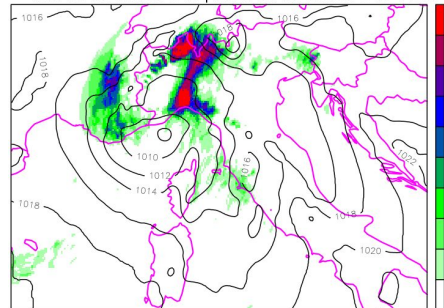
[A-LAEF] PREC [mm] (ENS SPREAD) | MAX= 103.42

run: 03/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



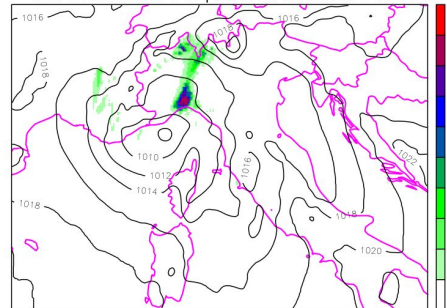
[A-LAEF] PREC Probability [%] >= 50 [mm] + MSLP [hPa]

run: 03/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



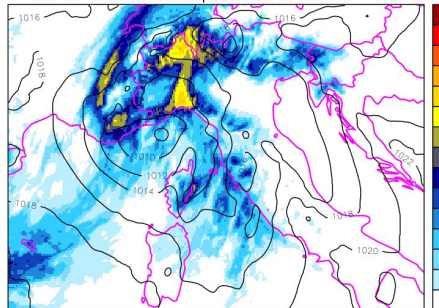
[A-LAEF] PREC Probability [%] >= 100 [mm] + MSLP [hPa]

run: 03/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



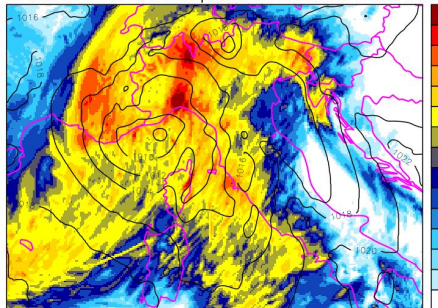
[A-LAEF] PREC [mm] (ENS MIN) | MAX= 75.8

run: 03/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



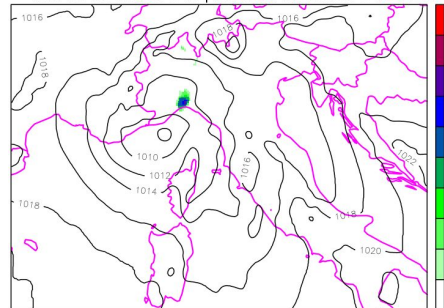
[A-LAEF] PREC [mm] (ENS MAX) | MAX= 458.49

run: 03/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



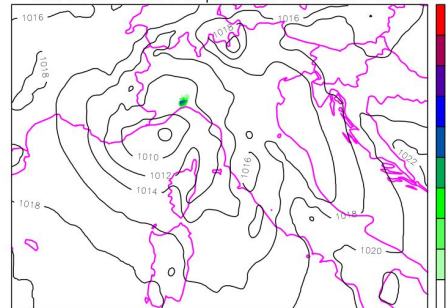
[A-LAEF] PREC Probability [%] >= 150 [mm] + MSLP [hPa]

run: 03/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



[A-LAEF] PREC Probability [%] >= 200 [mm] + MSLP [hPa]

run: 03/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



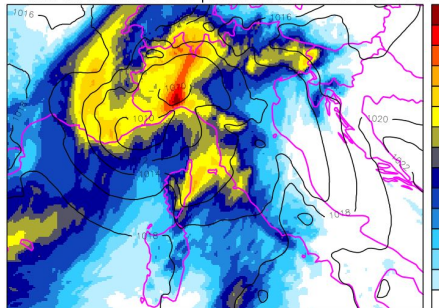
Case study (Italy)

Record rainfall in Italy 4 Oct 2021 - A-LAEF precipitation forecast (24-h accum.) - 24 h ahead

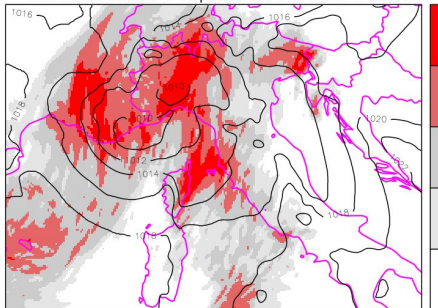
ENS MEAN, SPREAD, MIN and MAX

Probabilities for thresholds 50, 100, 150 and 200 mm

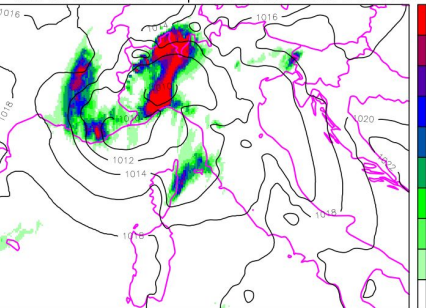
[A-LAEF] PREC [mm] (ENS MEAN) | MAX= 241.9
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



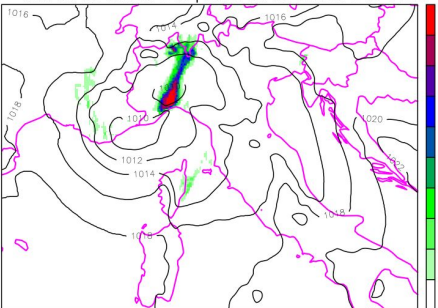
[A-LAEF] PREC [mm] (ENS SPREAD) | MAX= 102.36
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



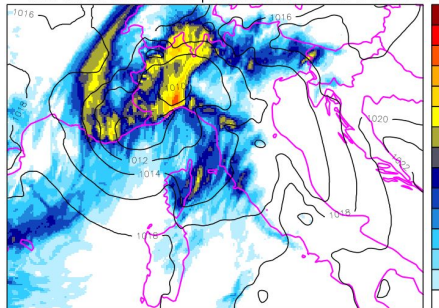
[A-LAEF] PREC Probability [%] >= 50 [mm] + MSLP [hPa]
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



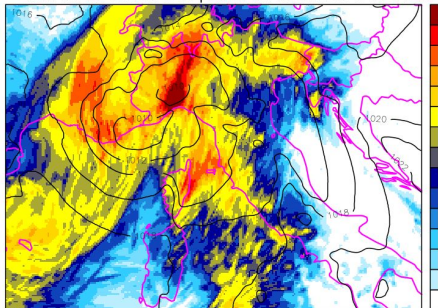
[A-LAEF] PREC Probability [%] >= 100 [mm] + MSLP [hPa]
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



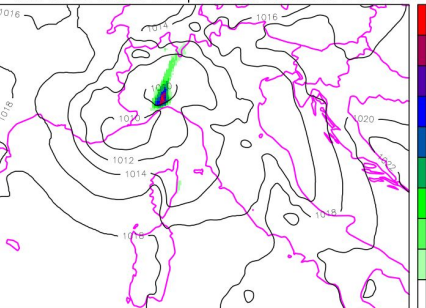
[A-LAEF] PREC [mm] (ENS MIN) | MAX= 138.22
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



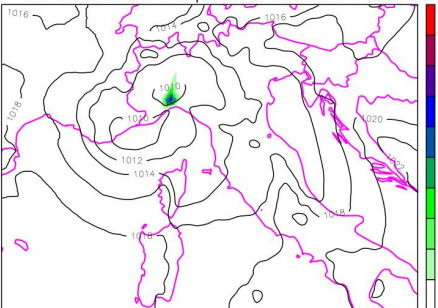
[A-LAEF] PREC [mm] (ENS MAX) | MAX= 501.46
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



[A-LAEF] PREC Probability [%] >= 150 [mm] + MSLP [hPa]
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



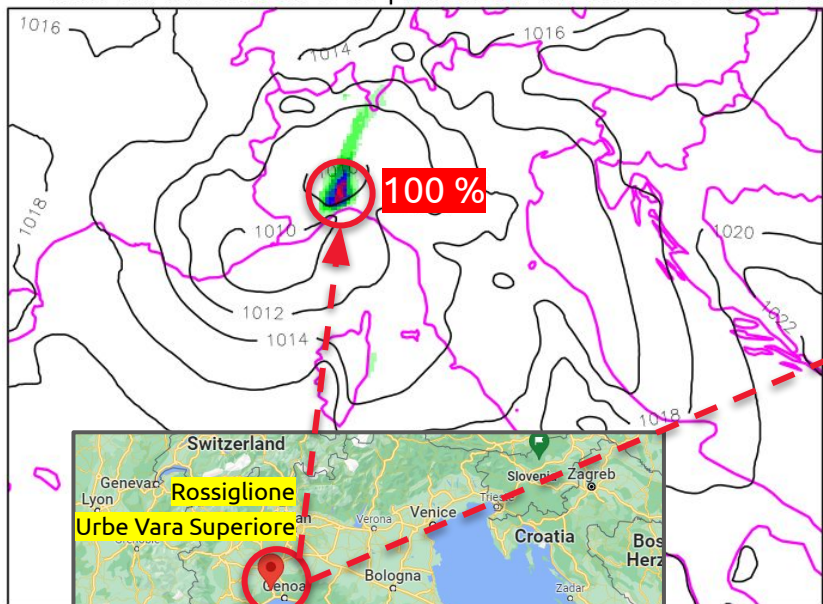
[A-LAEF] PREC Probability [%] >= 200 [mm] + MSLP [hPa]
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



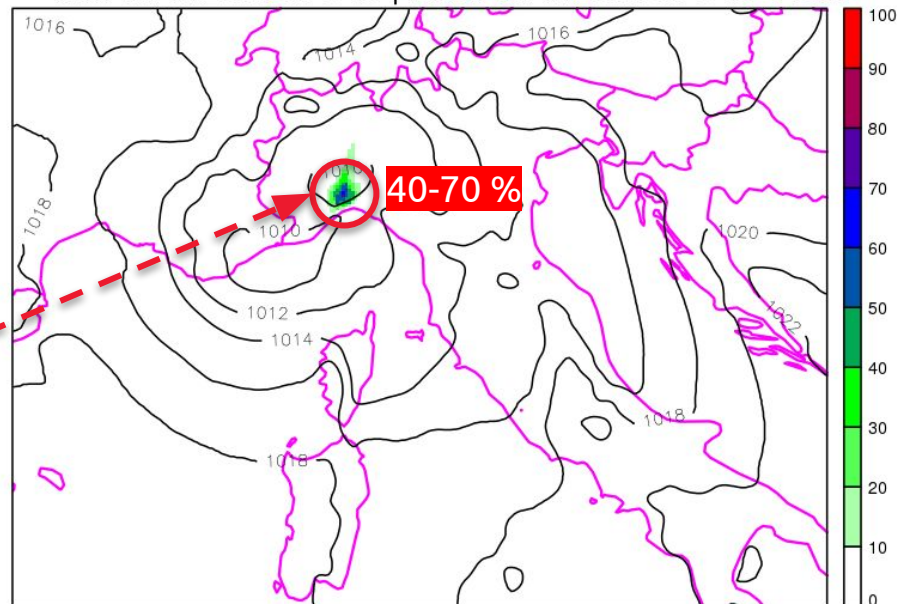
Case study (Italy)

Record rainfall in Italy 4 Oct 2021 - A-LAEF probabilities for thresholds 150 and 200 mm / 24 h

[A-LAEF] PREC Probability [%] \geq 150 [mm] + MSLP [hPa]
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



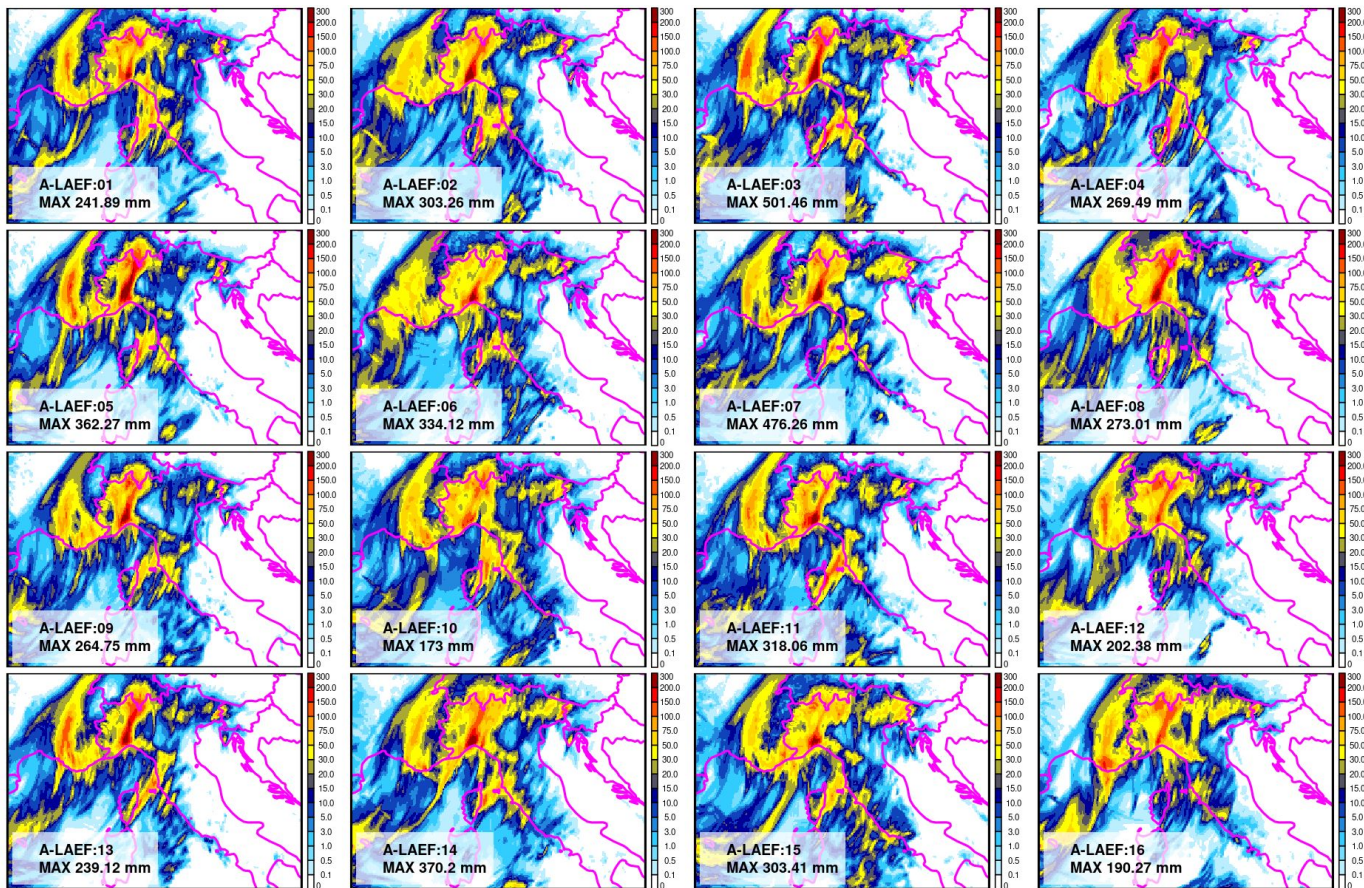
[A-LAEF] PREC Probability [%] \geq 200 [mm] + MSLP [hPa]
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



...perfect localization of precipitation maximum with high probabilities for extreme thresholds

Case study (Italy)

Record rainfall in Italy 4 Oct 2021 - A-LAEF precipitation forecast (24-h accum.) - 16 pert. MEMs



member 03
501 mm/24 h

...variability
in extremes

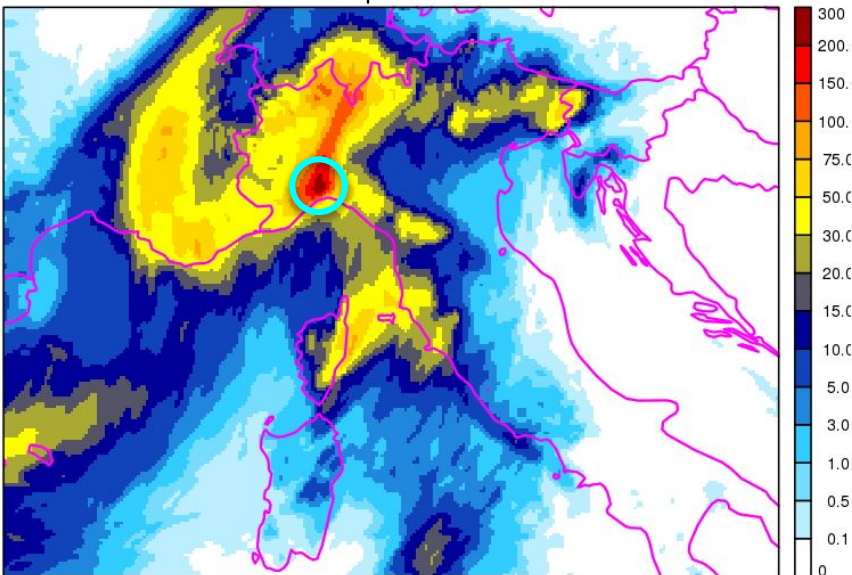
Case study (Italy)

Record rainfall in Italy 4 Oct 2021 - **A-LAEF ENS MEAN** vs. **ALADIN/SHMU deterministic (oper)**

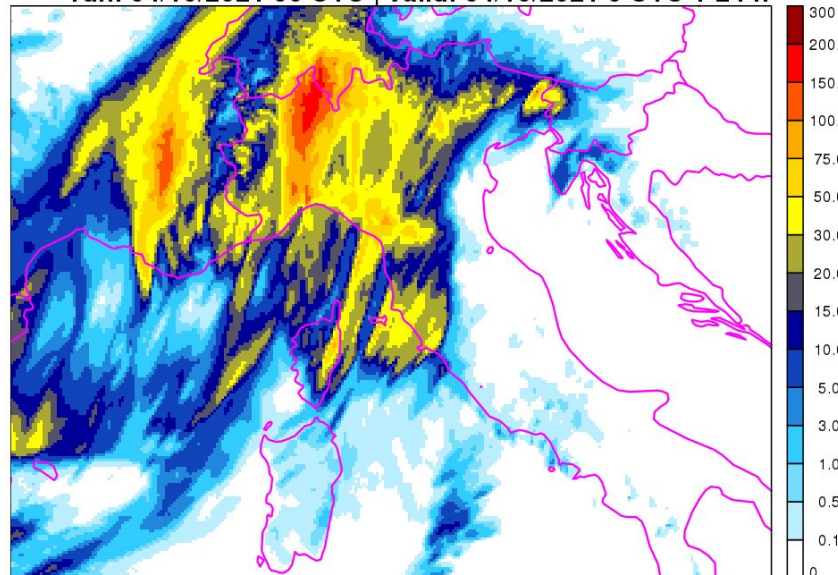
A-LAEF ENS MEAN (242 mm)

ALADIN/SHMU (198 mm)

[A-LAEF] PREC [mm] (ENS MEAN) | MAX= 241.9
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



[ALADIN/SHMU] PREC [mm] | MAX= 197.96
run: 04/10/2021 00 UTC | valid: 04/10/2021 0 UTC + 24 h



...less and at wrong location

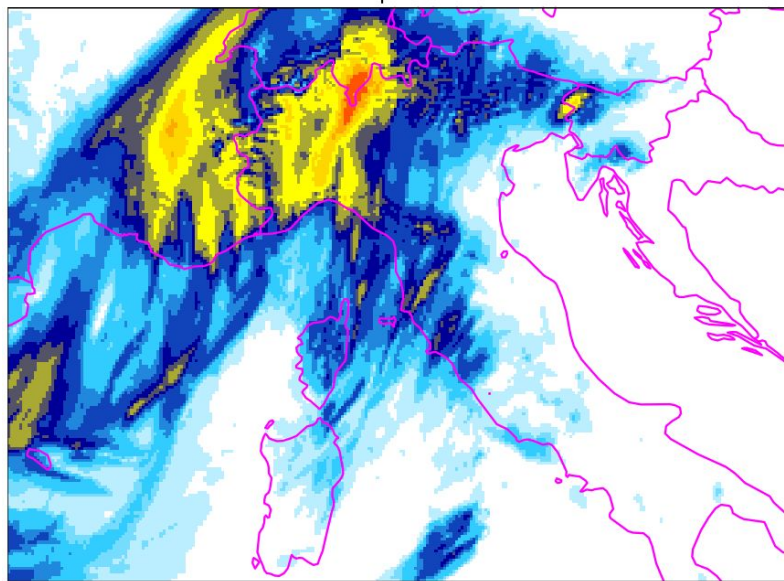
Case study (Italy)

Record rainfall in Italy 4 Oct 2021 - **A-LAEF** - coupling matters, and so the perturbations (**CTRL**)

A-LAEF CTRL coupled to **cy47r2**

[A-LAEF cy47r2] PREC [mm] | MAX= 134.91

run: 04/10/2021 00 UTC | valid: 04/10/2021 0 UTC + 24 h



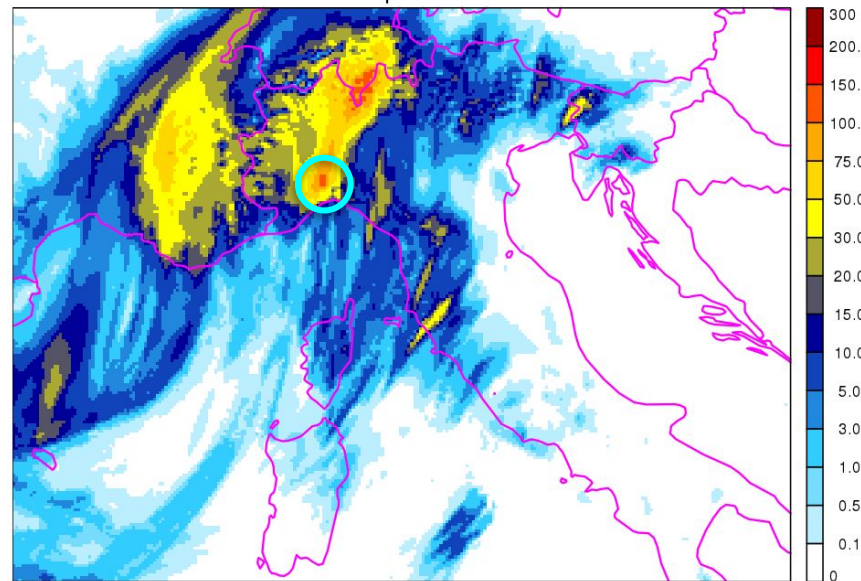
(operational on 4 Oct 2021)

...and still, the correct location of extreme values in ensemble mean (!)

A-LAEF CTRL coupled to **cy47r3**

[A-LAEF cy47r3] PREC [mm] | MAX= 127.87

run: 04/10/2021 00 UTC | valid: 04/10/2021 0 UTC + 24 h



(operational since 12 Oct 2021)

...slight improvement against cy47r2 (for CTRL)

Case study (Italy)

Record rainfall in Italy 4 Oct 2021 - A-LAEF - cy47r2 versus cy47r3 coupling (**CTRL**)

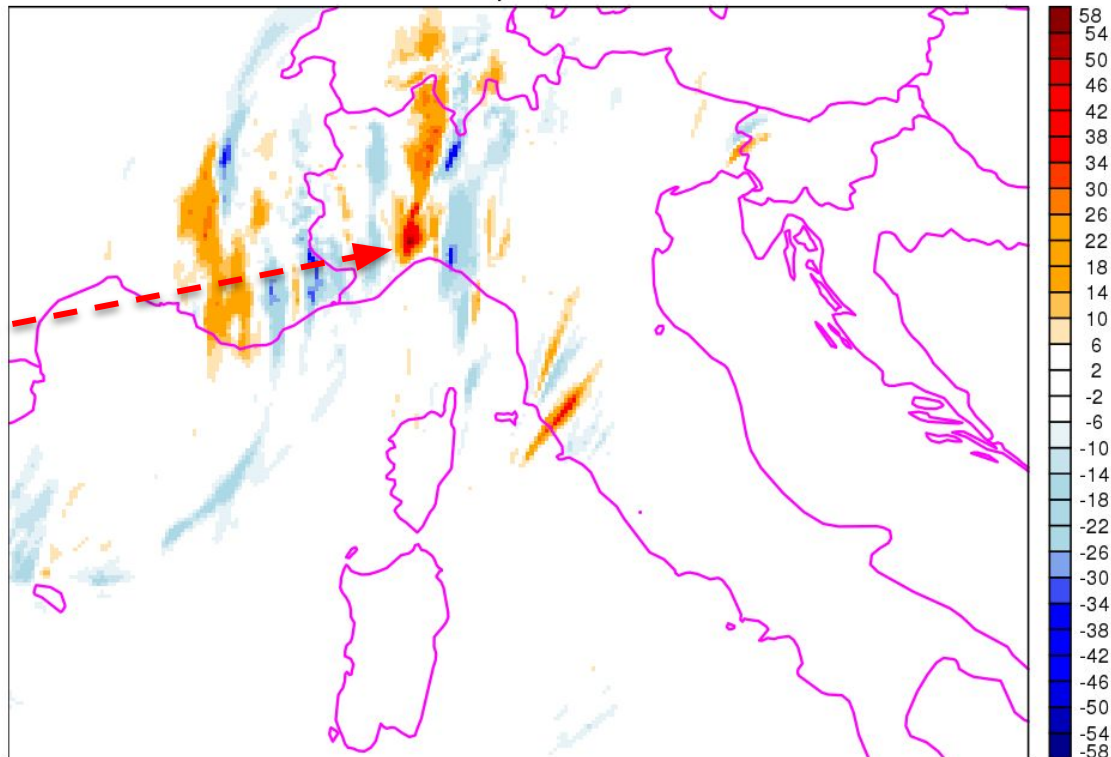
Difference in A-LAEF CTRL precipitation forecast coupled to **cy47r3 - cy47r2** (24 h accum.)

Location of record values



...enhancement in new cycle

[A-LAEF cy47r3-cy47r2] PREC [mm] | MIN= -42.19 MAX= 54.86
run: 04/10/2021 00 UTC | valid: 04/10/2021 0 UTC + 24 h



Case study (Italy)

Record rainfall in Italy 4 Oct 2021 - A-LAEF precipitation forecast (24-h accum.) - **cy47r2** vs **cy47r3**

ENS MEAN, SPREAD, MIN and MAX (**cy47r2**)

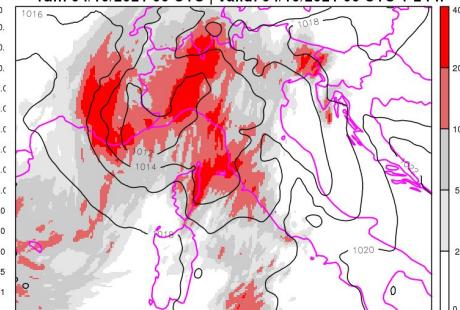
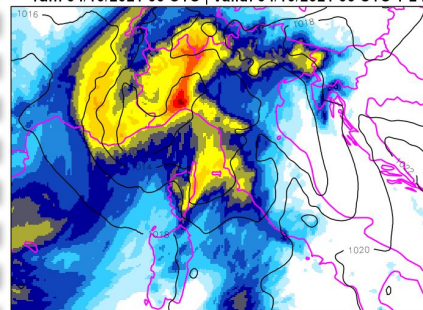
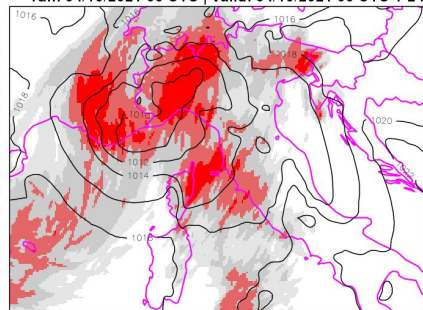
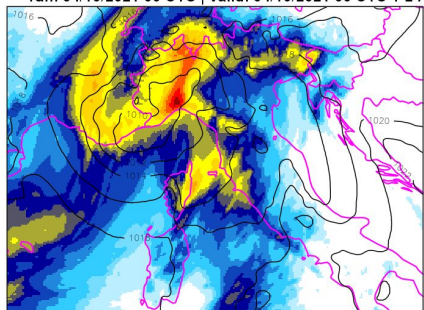
ENS MEAN, SPREAD, MIN and MAX (**cy47r3**)

[A-LAEF] PREC [mm] (ENS MEAN) | MAX= 230.59
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h

[A-LAEF] PREC [mm] (ENS SPREAD) | MAX= 110.58
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h

[A-LAEF] PREC [mm] (ENS MEAN) | MAX= 224.59
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h

[A-LAEF] PREC [mm] (ENS SPREAD) | MAX= 109.33
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h

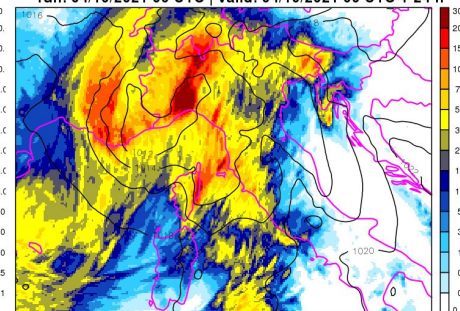
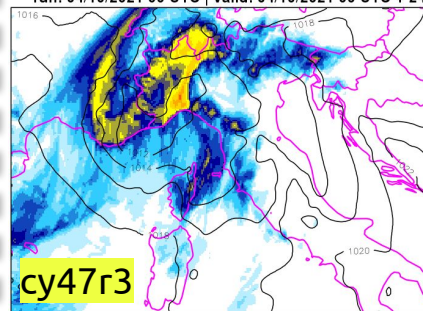
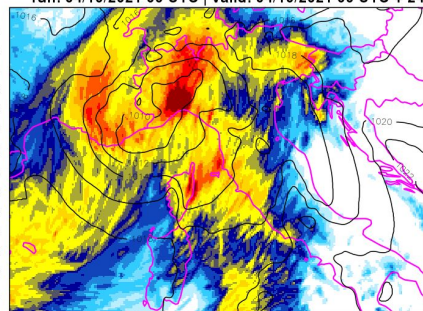
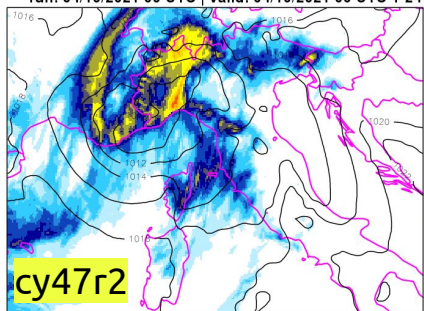


[A-LAEF] PREC [mm] (ENS MIN) | MAX= 128.4
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h

[A-LAEF] PREC [mm] (ENS MAX) | MAX= 533.56
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h

[A-LAEF] PREC [mm] (ENS MIN) | MAX= 104.83
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h

[A-LAEF] PREC [mm] (ENS MAX) | MAX= 495.2
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



...ENS statistical scores are very similar in terms of MEAN, SPREAD, MIN and MAX

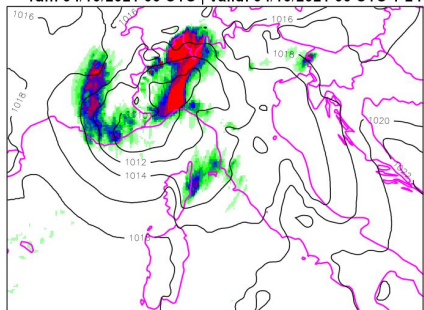
Case study (Italy)

Record rainfall in Italy 4 Oct 2021 - A-LAEF precipitation forecast (24-h accum.) - cy47r2 vs cy47r3

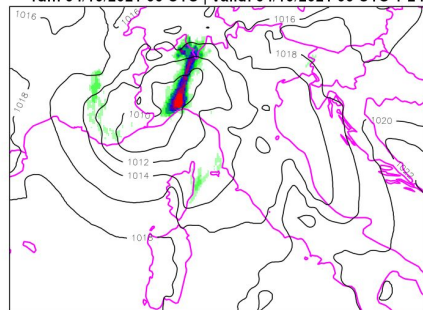
Probabilities for thresholds 50, 100, 150 and 200 mm

Probabilities for thresholds 50, 100, 150 and 200 mm

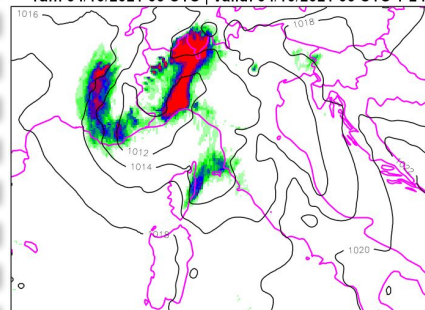
[A-LAEF] PREC Probability [%] >= 50 [mm] + MSLP [hPa]
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



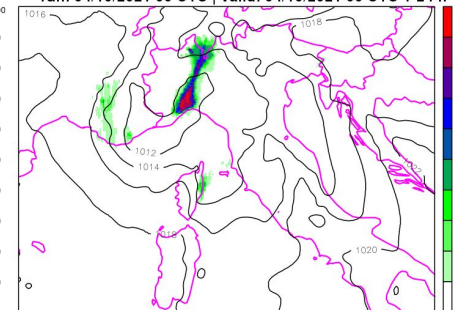
[A-LAEF] PREC Probability [%] >= 100 [mm] + MSLP [hPa]
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



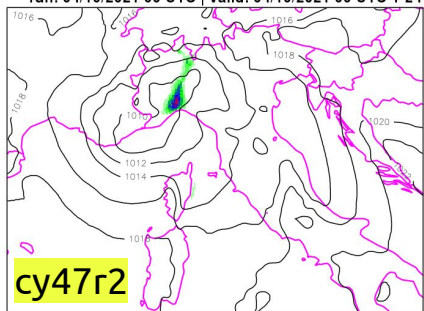
[A-LAEF] PREC Probability [%] >= 50 [mm] + MSLP [hPa]
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



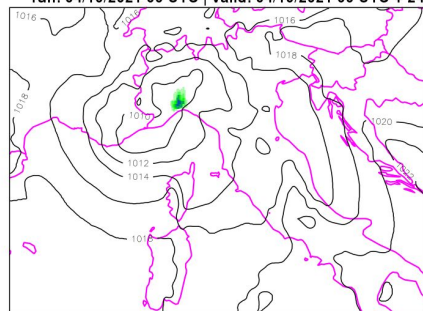
[A-LAEF] PREC Probability [%] >= 100 [mm] + MSLP [hPa]
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



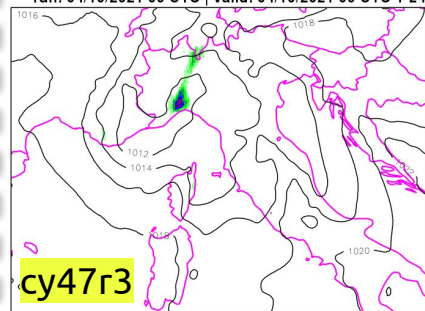
[A-LAEF] PREC Probability [%] >= 150 [mm] + MSLP [hPa]
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



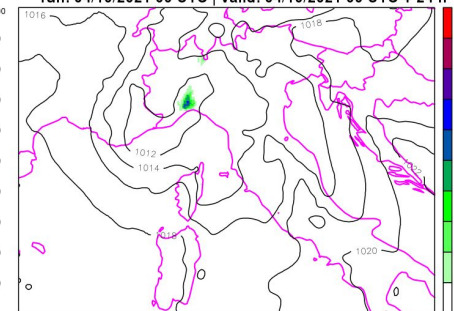
[A-LAEF] PREC Probability [%] >= 200 [mm] + MSLP [hPa]
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



[A-LAEF] PREC Probability [%] >= 150 [mm] + MSLP [hPa]
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



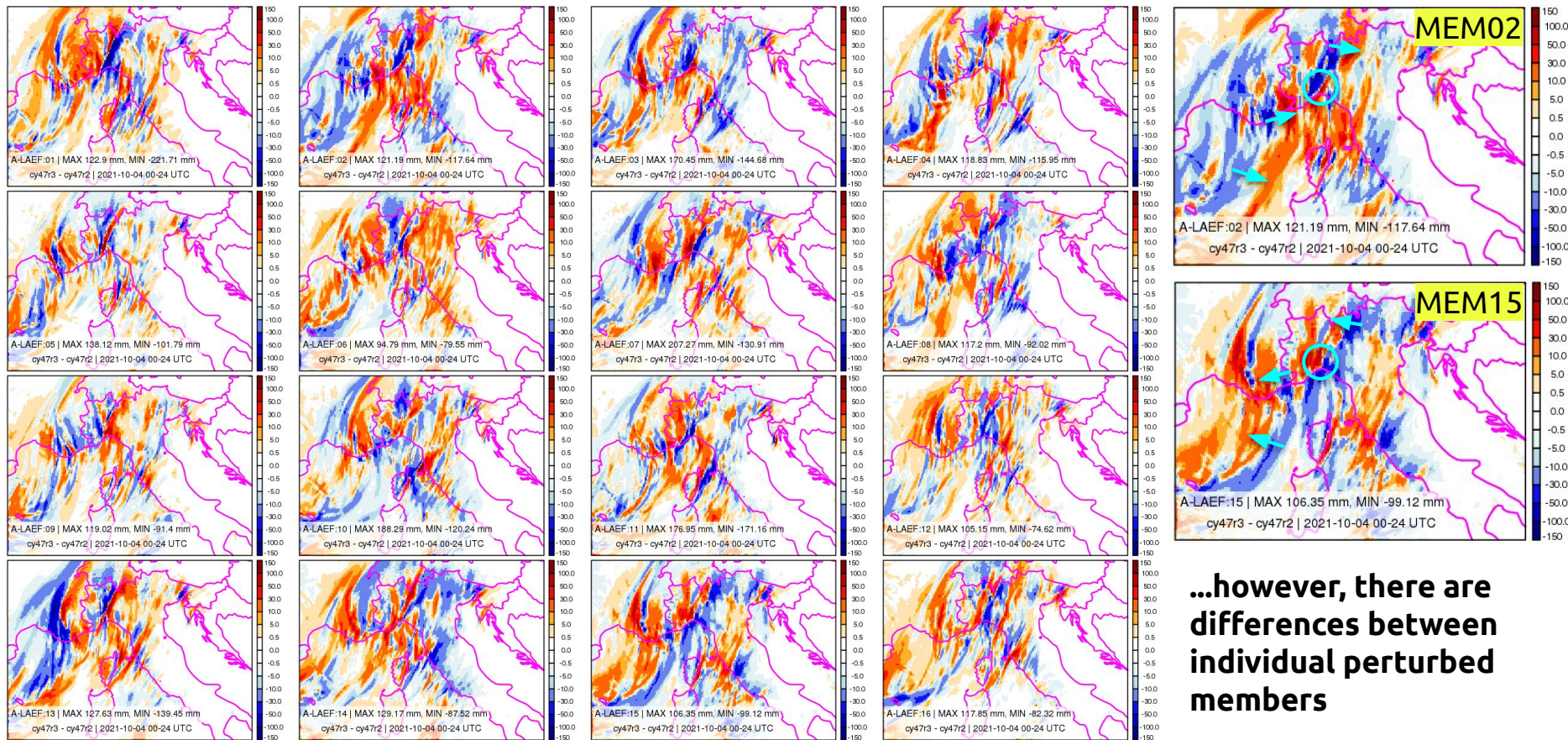
[A-LAEF] PREC Probability [%] >= 200 [mm] + MSLP [hPa]
run: 04/10/2021 00 UTC | valid: 04/10/2021 00 UTC + 24 h



...even the probabilities are equal to each other with the exactly same localization of extremes

Case study (Italy)

Record rainfall in Italy 4 Oct 2021 - **A-LAEF precipitation forecast (24-h accum.)** - **cy47r3** - **cy47r2**



Case study (Germany)

Catastrophic floods in Germany 13-15 July 2021

Description:

After several episodes of heavy rain, a cyclonic weather system (Bernd) caused persistent or recurring heavy rainfall between 13 and 15 of July 2021 in Germany. The west of Rhineland-Palatinate and the southern half of North Rhine-Westphalia were largely affected. As a result, small rivers expanded locally and flash floods formed. In addition to immense property damage, over 160 people lost their lives.

A-LAEF ensemble successfully captured the precipitation event, with well localized patterns (even with unusually high probabilities of extreme precipitation amounts).



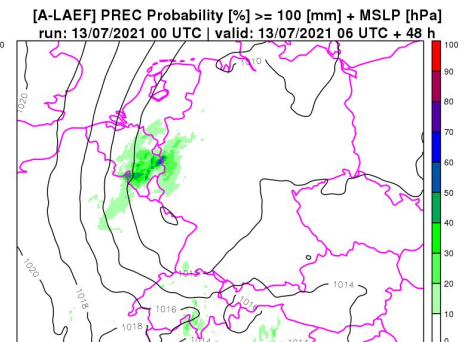
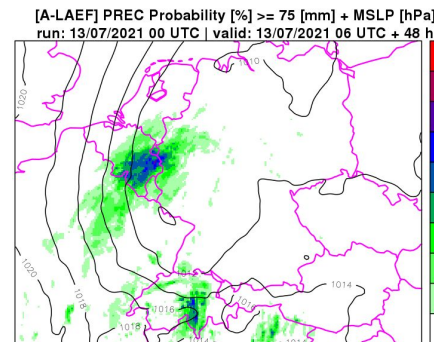
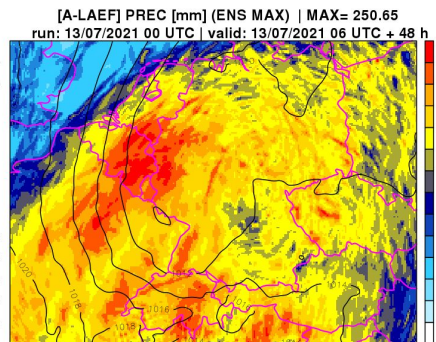
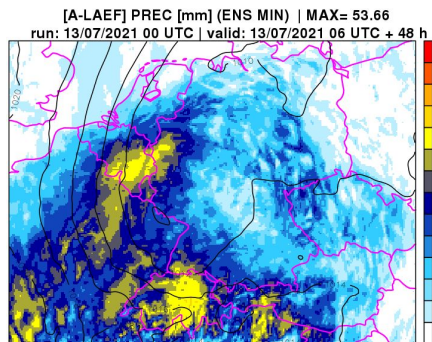
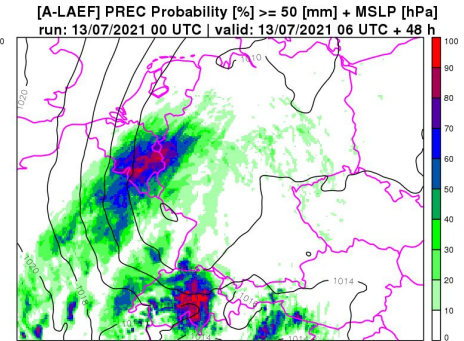
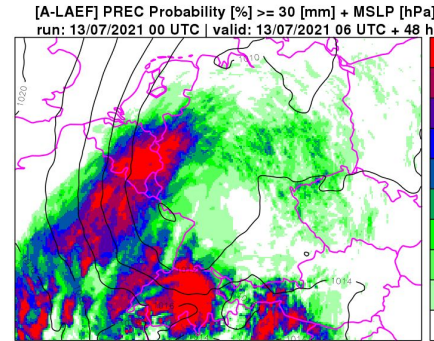
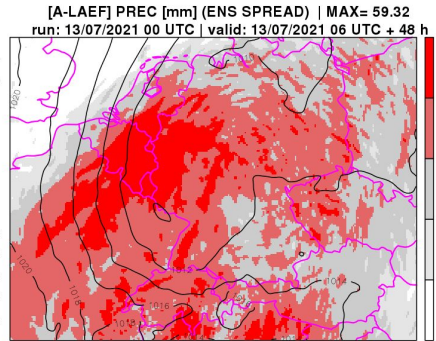
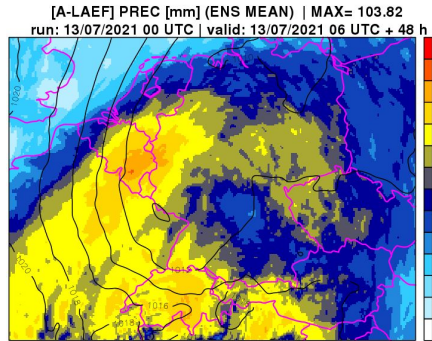
source: TASR/Rhein-Erft-Kreis via AP

Case study (Germany)

Catastrophic floods in Germany 13-15 July 2021 - **A-LAEF precipitation forecast (48-h accum.)**

ENS MEAN, SPREAD, MIN and MAX

Probabilities for thresholds 30, 50, 75 and 100 mm

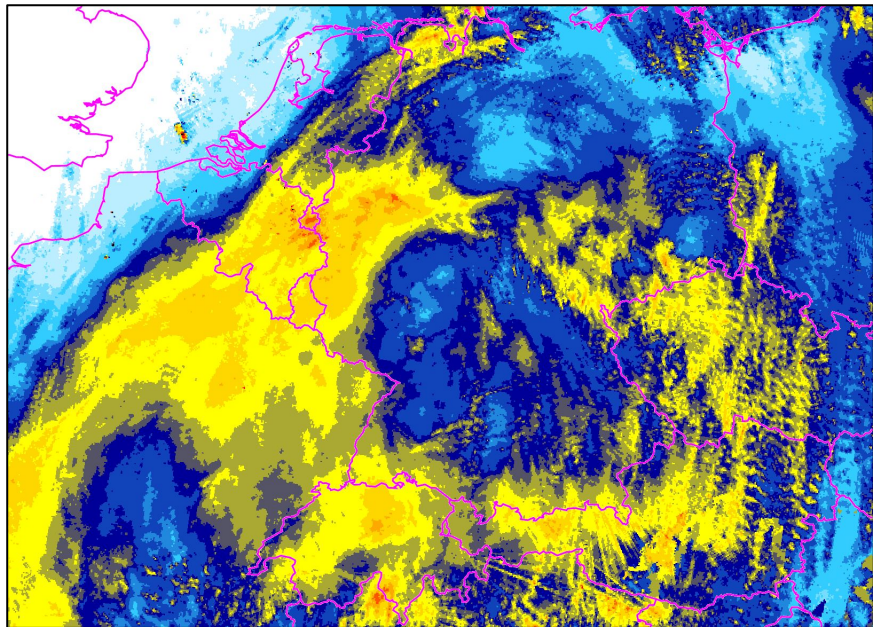


Case study (Germany)

Catastrophic floods in Germany 13-15 July 2021 - **RADAR vs. ENS MEAN (48-h accum.)**

48-hourly precipitation accumulation (13 July 06 UTC ~ 15 July 06 UTC)

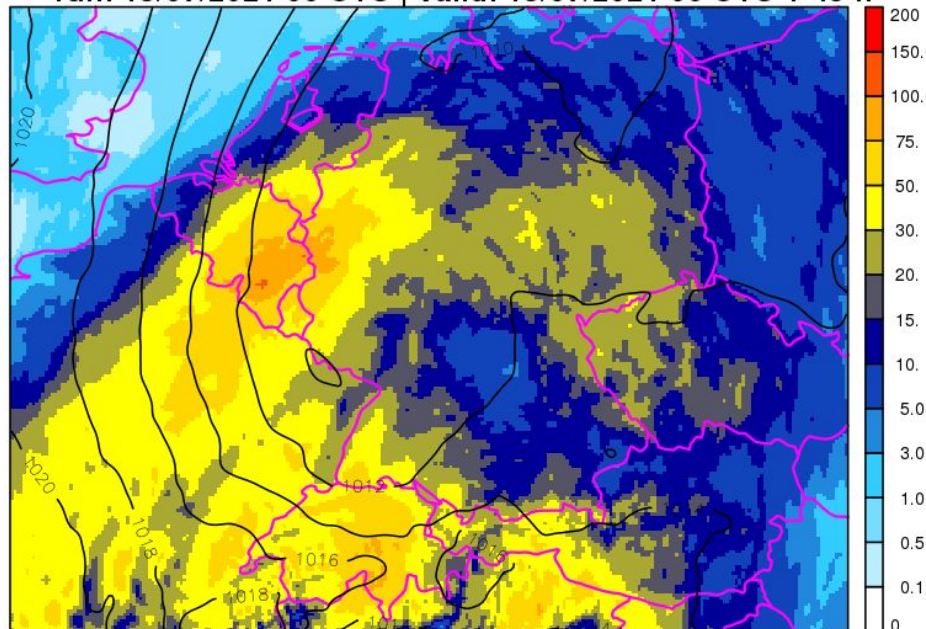
RADAR precipitation estimate (OPERA)



Courtesy of L. Okon, SHMU

* without AT radar network

[A-LAEF] PREC [mm] (ENS MEAN) | MAX= 103.82
run: 13/07/2021 00 UTC | valid: 13/07/2021 06 UTC + 48 h

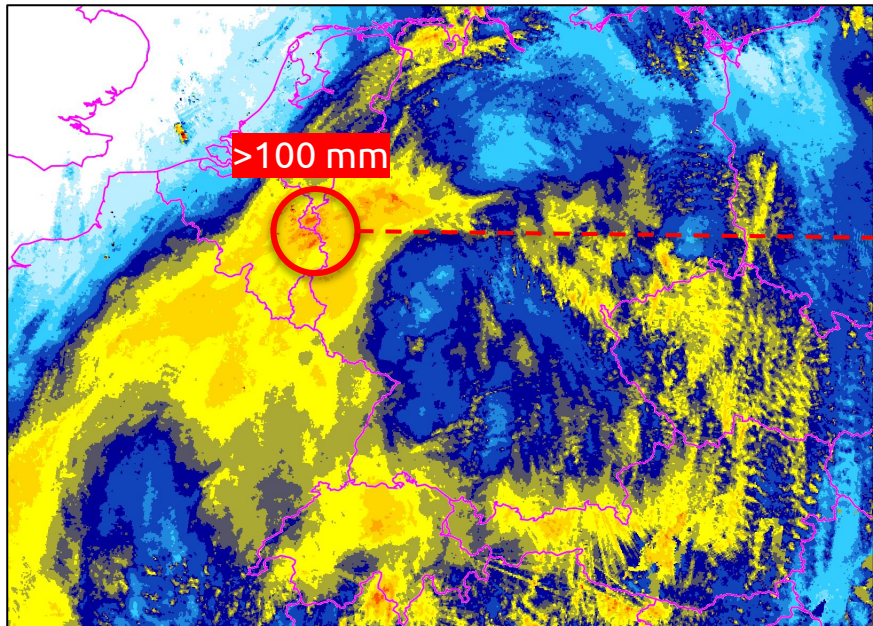


Case study (Germany)

Catastrophic floods in Germany 13-15 July 2021 - **RADAR vs. probability of ≥ 100 mm (48-h accum.)**

48-hourly precipitation accumulation (13 July 06 UTC ~ 15 July 06 UTC)

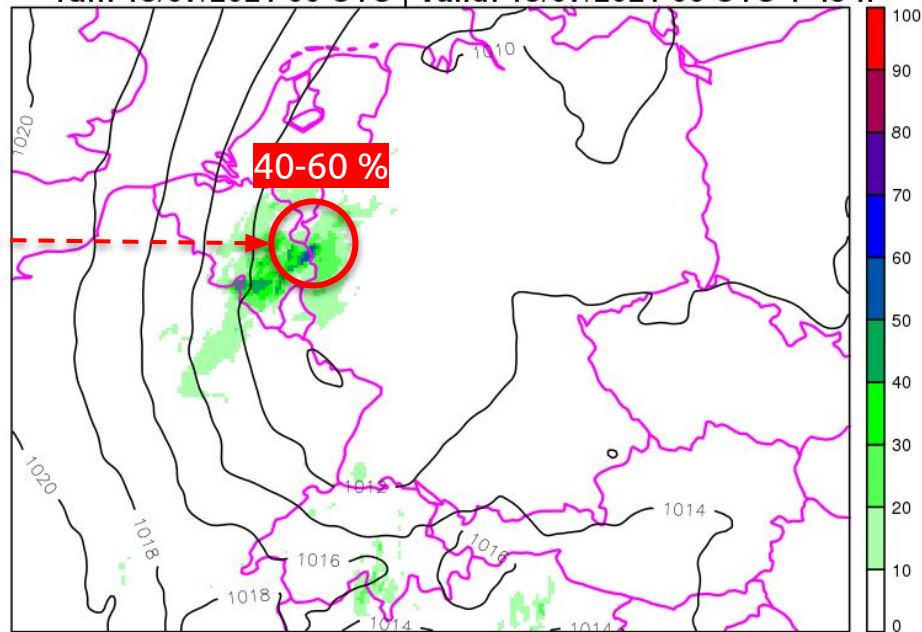
RADAR precipitation estimate (OPERA)



Courtesy of L. Okon, SHMU

* without AT radar network

[A-LAEF] PREC Probability [%] ≥ 100 [mm] + MSLP [hPa]
run: 13/07/2021 00 UTC | valid: 13/07/2021 06 UTC + 48 h



What's next?

Planned work

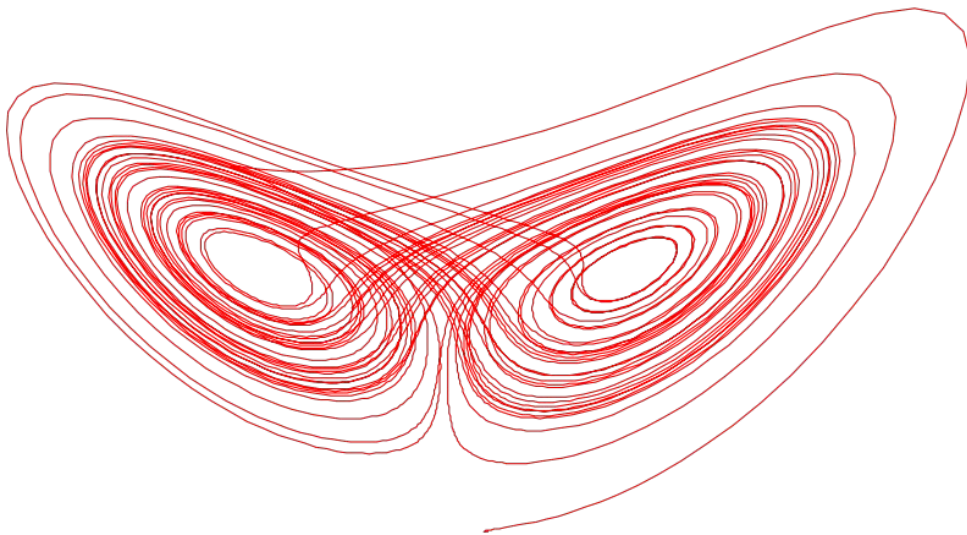
Short term:

- migration to ATOS in Bologna
- upgrade to cy43t2 (or cy46t1)
- LBC creation for local convection-permitting EPS coupling (LACE domain)
- operational implementation of ENS BlendVar

Long term:

- stochastic perturbation of fluxes instead of tendencies
- use of other perturbation techniques?
- higher resolution and/or more members?
- single precision?
- keep domain size as large as possible

Thank you!



(my eyes at the end of the day)