Testing a WRF-based modelling chain for operational forecasting under different data assimilation inputs

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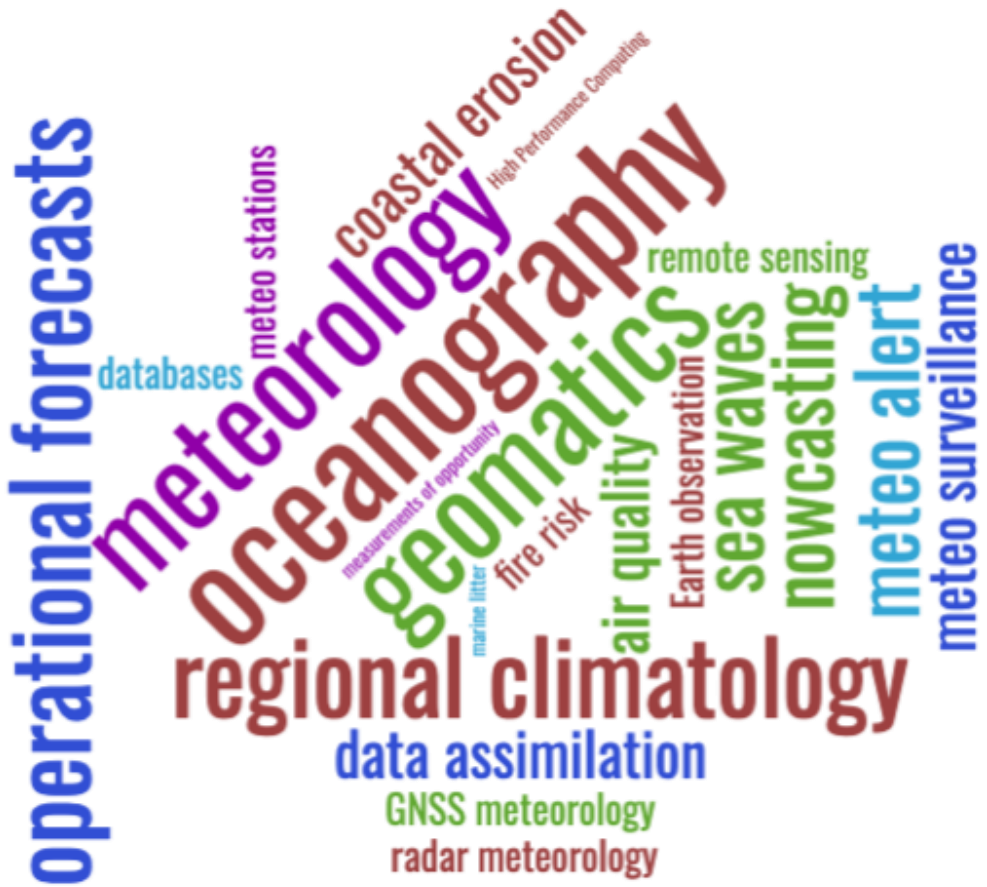

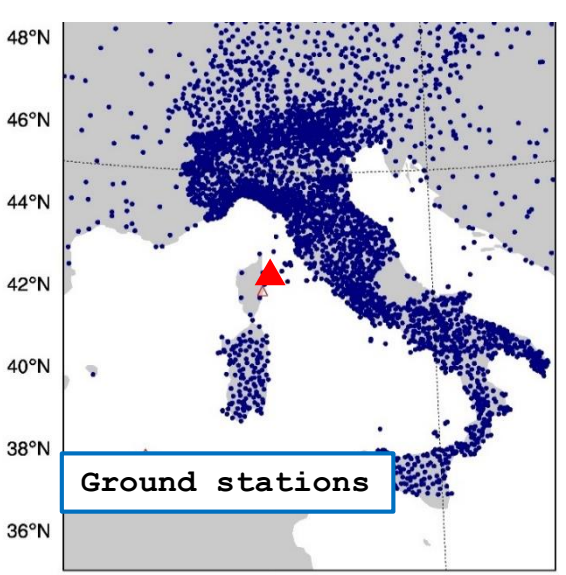
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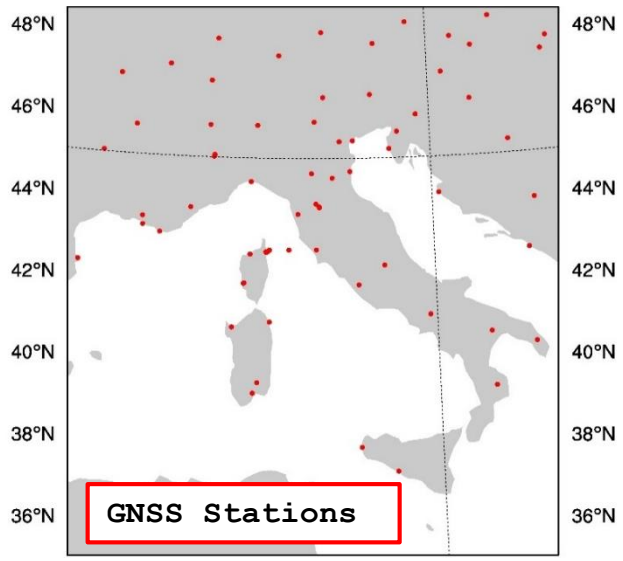
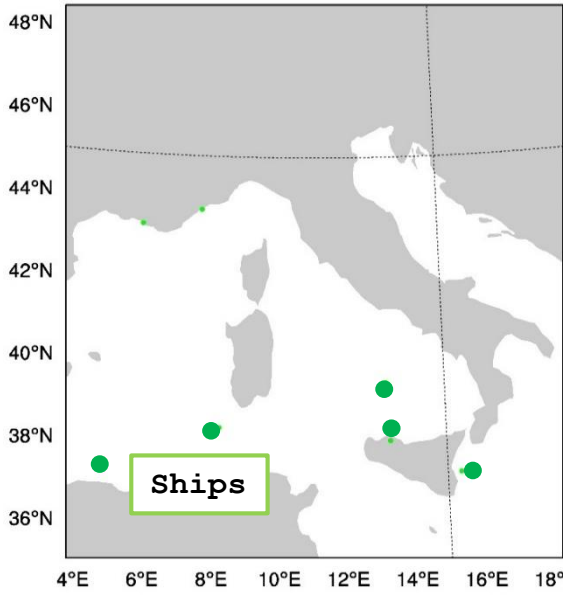
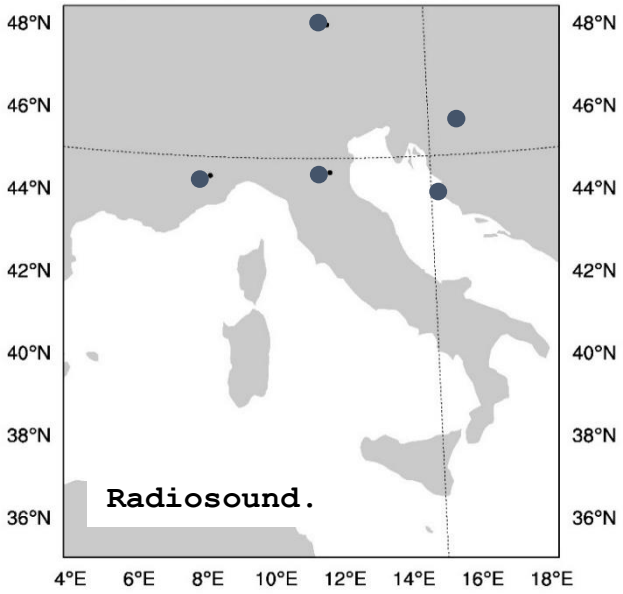
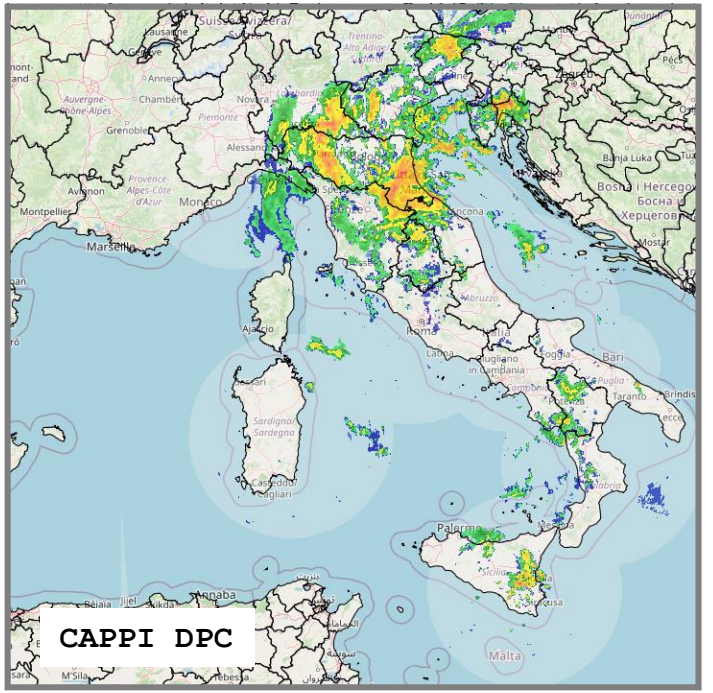

GNSS Stations


Ships

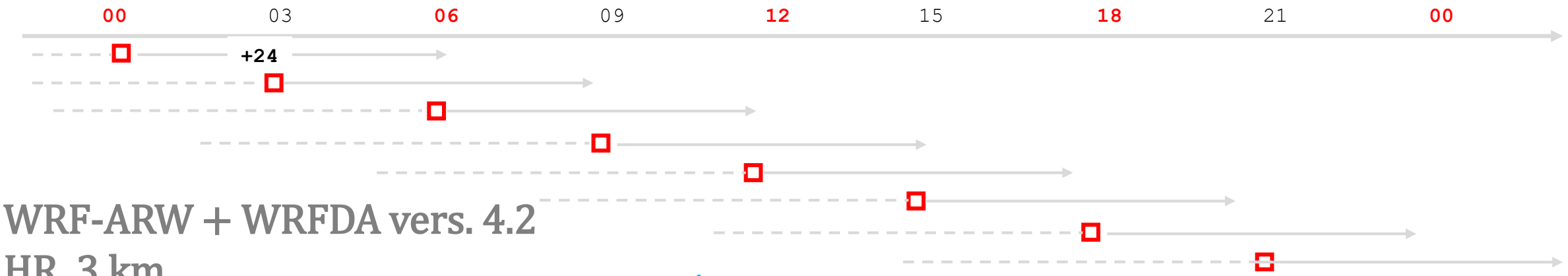

Radiosound.


CAPPI DPC

General architecture of the LaMMA RUC

IFS
0.12 deg

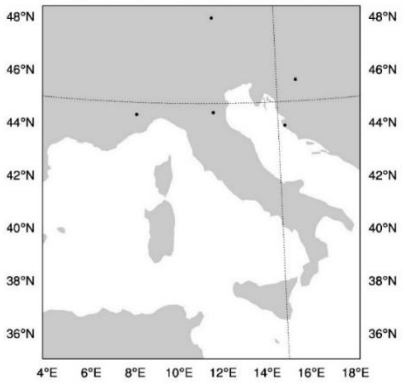
8 daily run every 3 hours with hourly assimilation starting from the most updated initial conditions



WRF-ARW + WRFDA vers. 4.2
HR 3 km
50 model levels

3Dvar →

$$J(x) = \frac{1}{2} \cdot \{[(x - x_b)^T \mathbf{B}^{-1}(x - x_b)] + [y_0 - H(x)]^T \cdot \mathbf{R}^{-1} \cdot [y_0 - H(x)]\}$$



B	→ background error
R	→ measurement error
H	→ measurement operator
x_b	→ first guess or background state
y_0	→ measurement

BE → NMC method
on 3 years of data
and difference 6h

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Atmospheric Event: SEP. 15, 2022

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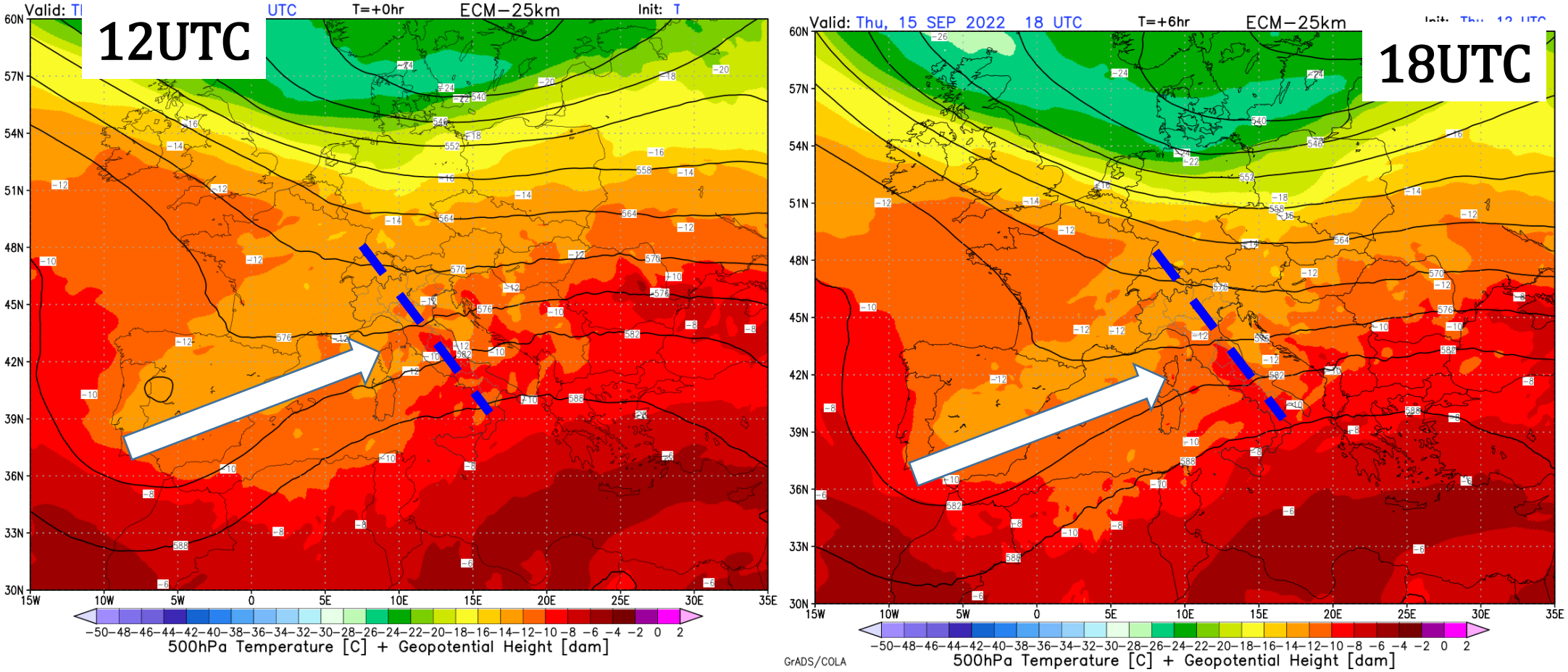
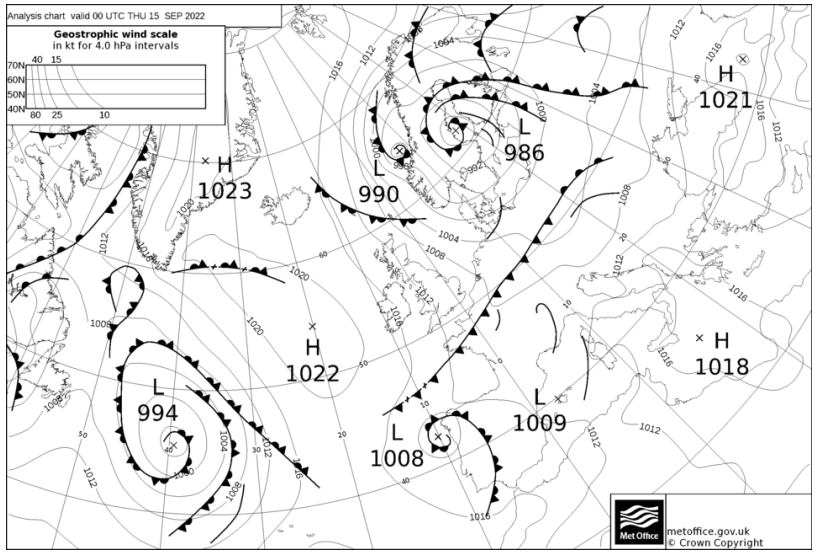
500hPa



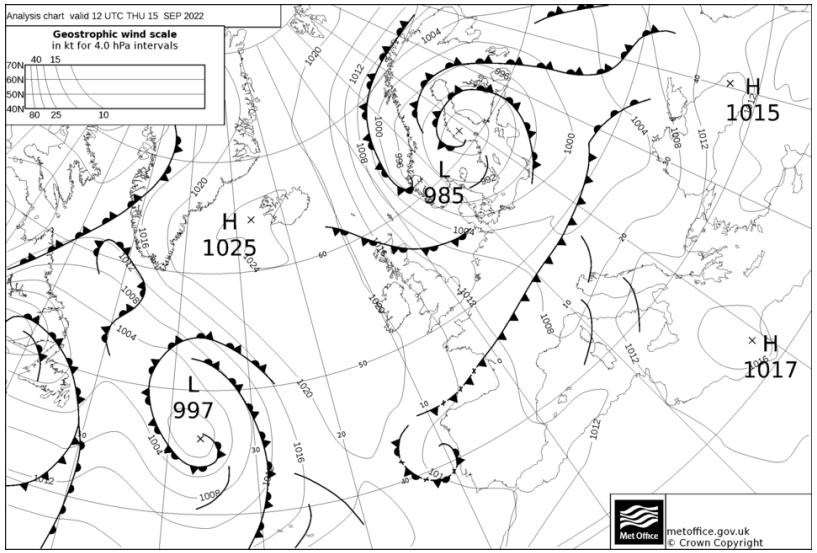
A flow of moist air with zonal and orthogonal characteristics to the central Apennines mountain range generated a typical V-shape storm system in central-eastern Italy

synoptic scale description of the case of study

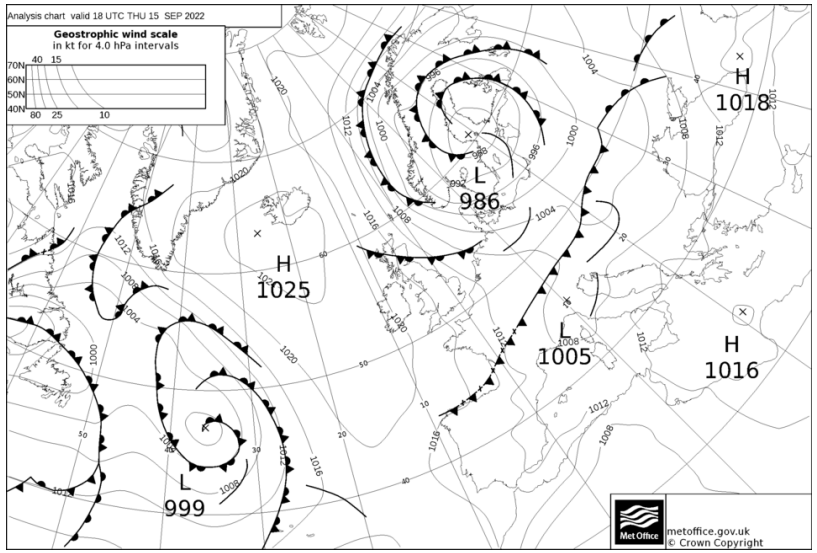
00UTC



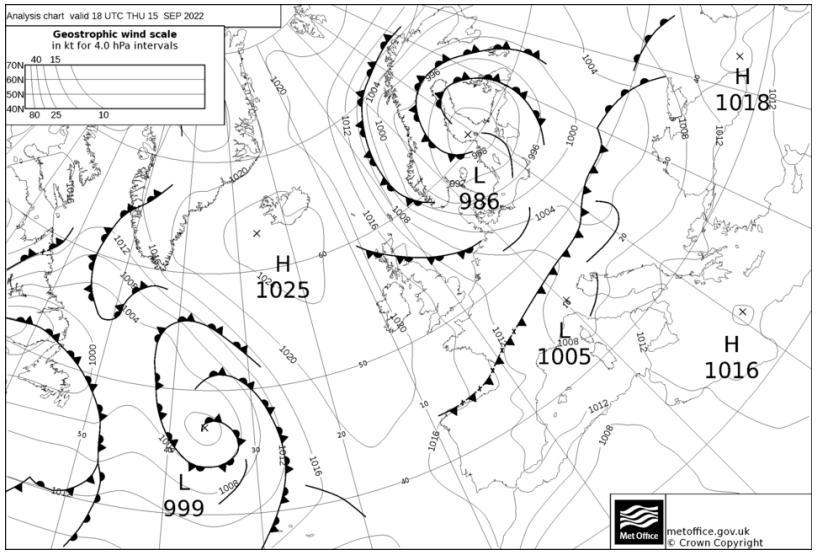
06UTC



12UTC



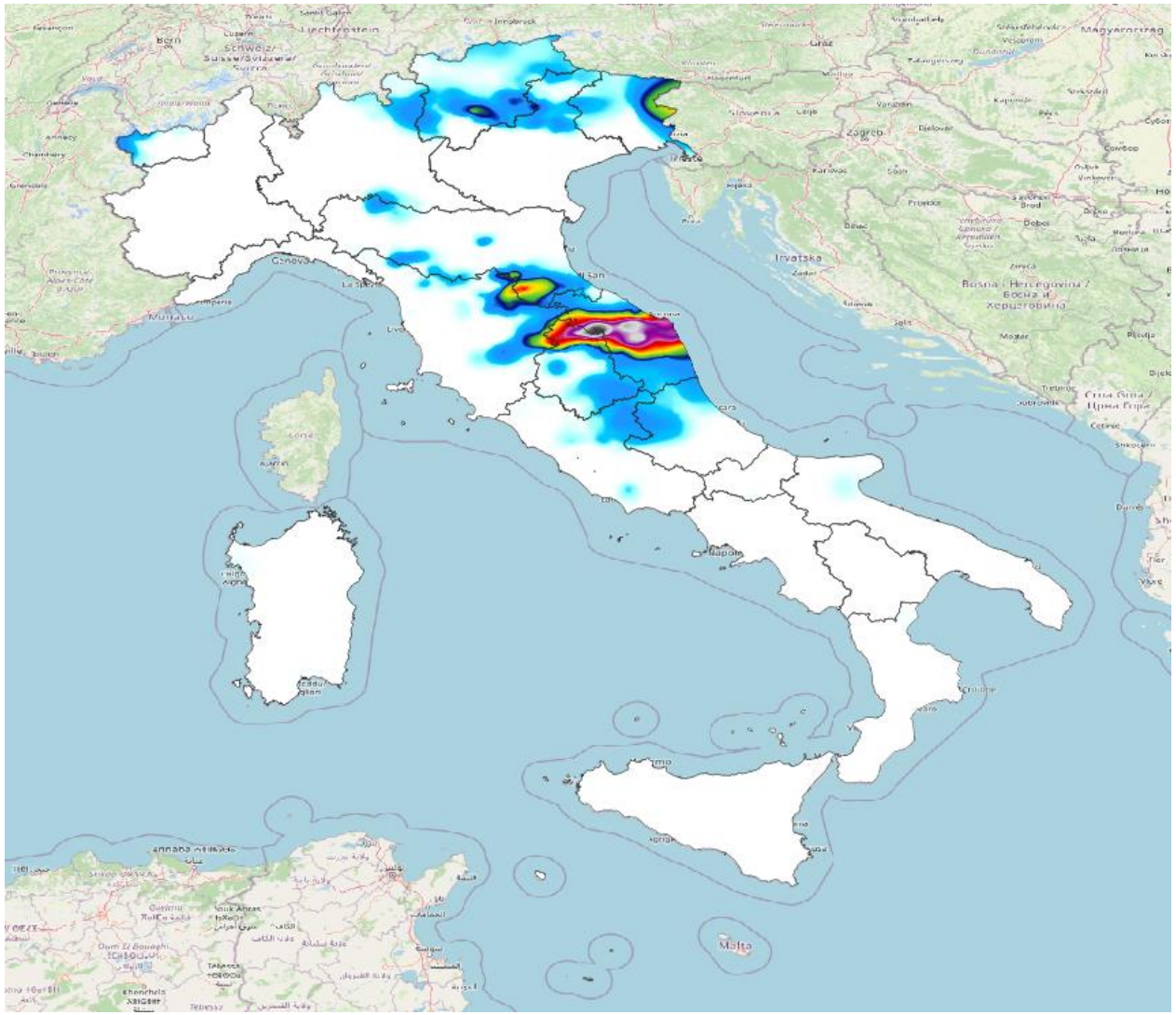
18UTC

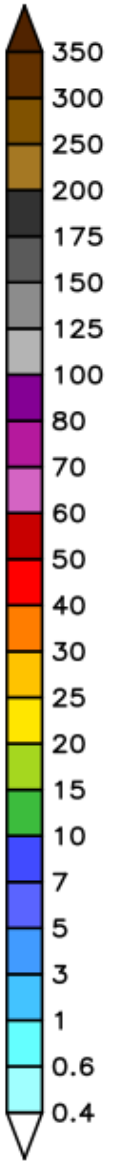


total precipitation cumulated in the previous 6h, SEP 15, 2022 at 21UTC

An intense convective precipitation, very localized in space and time, caused victims and extensive damage. Very localized rainfall amounts exceeding 200 mm were recorded in few hours.

We will focus on the forecast of the total precipitation cumulated during the 6-hour on interval time 3pm to 9pm. at 15th september





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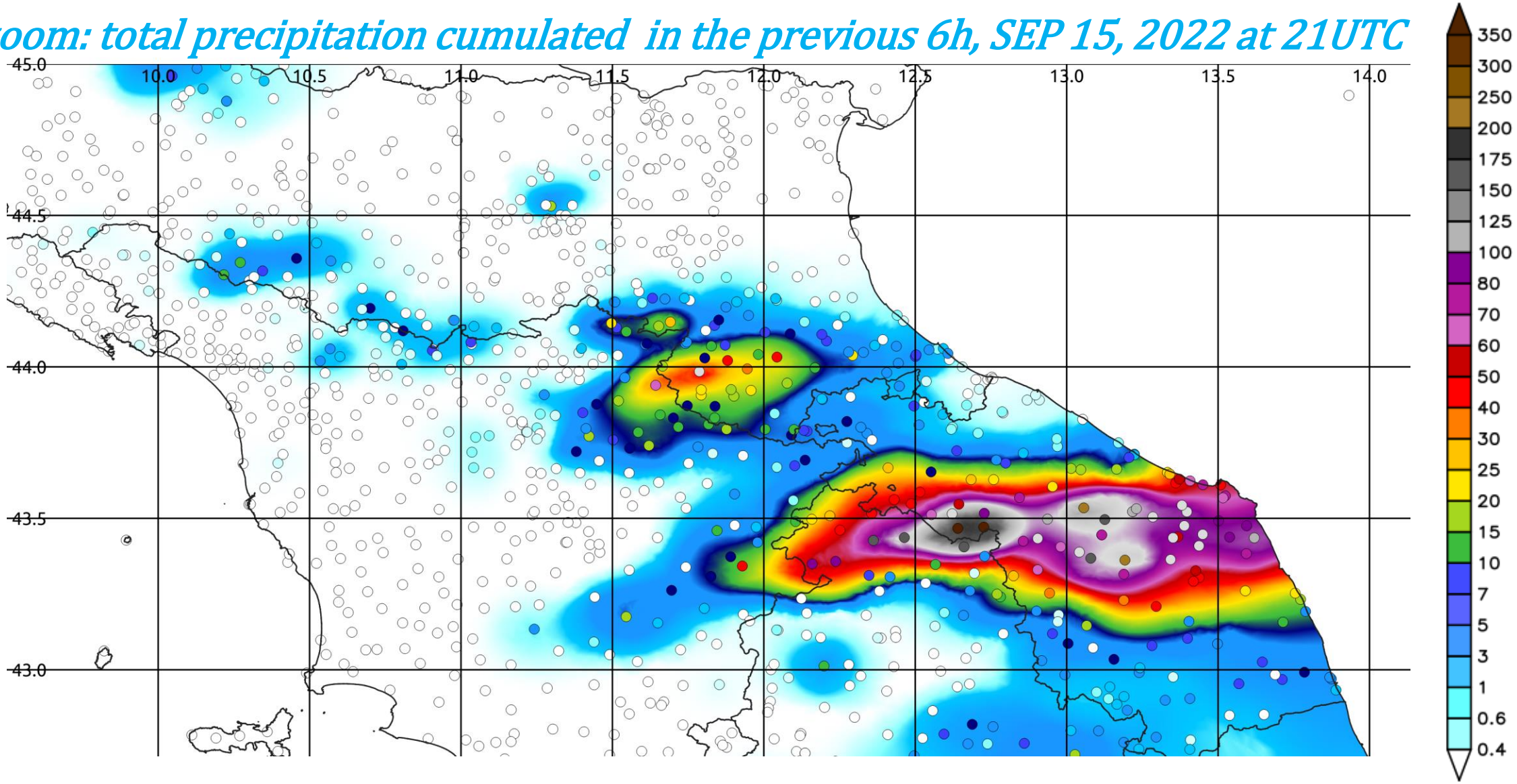
zoom: total precipitation cumulated in the previous 6h, SEP 15, 2022 at 21UTC



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Focus on alert areas of the Italian civil defence department (DPCN)

for the purposes of this work we focused attention on the areal rainfall in the **63 alert areas** of central-southern Italy of the DPCN

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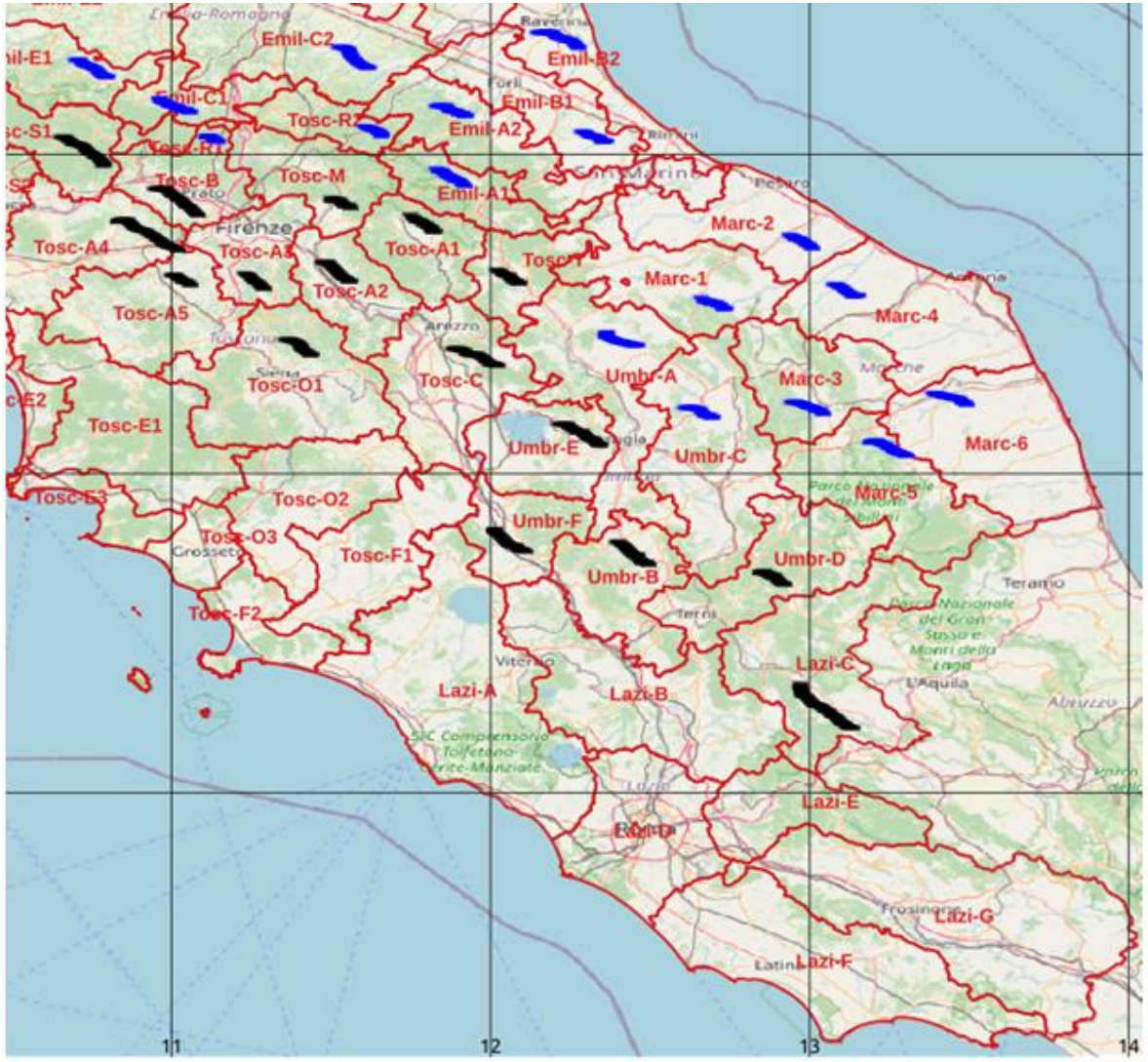
Focus on the effects of zonal and orthogonal flow to the Apennine chain

UPWIND Areas

- Tosc-A1
- Tosc-A2
- Tosc-A3
- Tosc-A4
- Tosc-A5
- Tosc-B
- Tosc-C
- Tosc-M
- Tosc-O1
- Tosc-S1
- Tosc-T
- Umbr-B
- UMB-D
- Umbr-E
- Umbr-F
- Lazi-B
- Lazi-C



LEEWARD Areas

- Emil-A1
- Emil-A2
- Emil-B1
- Emil-B2
- Emil-C1
- Emil-C2
- Emil-E1
- Marc-1
- Marc-2
- Marc-3
- Marc-4
- Marc-5
- Marc-6
- Tosc-R1
- Tosc-R2
- Umbr-A

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Areal Mean Rain Cumulated By Rain gauges

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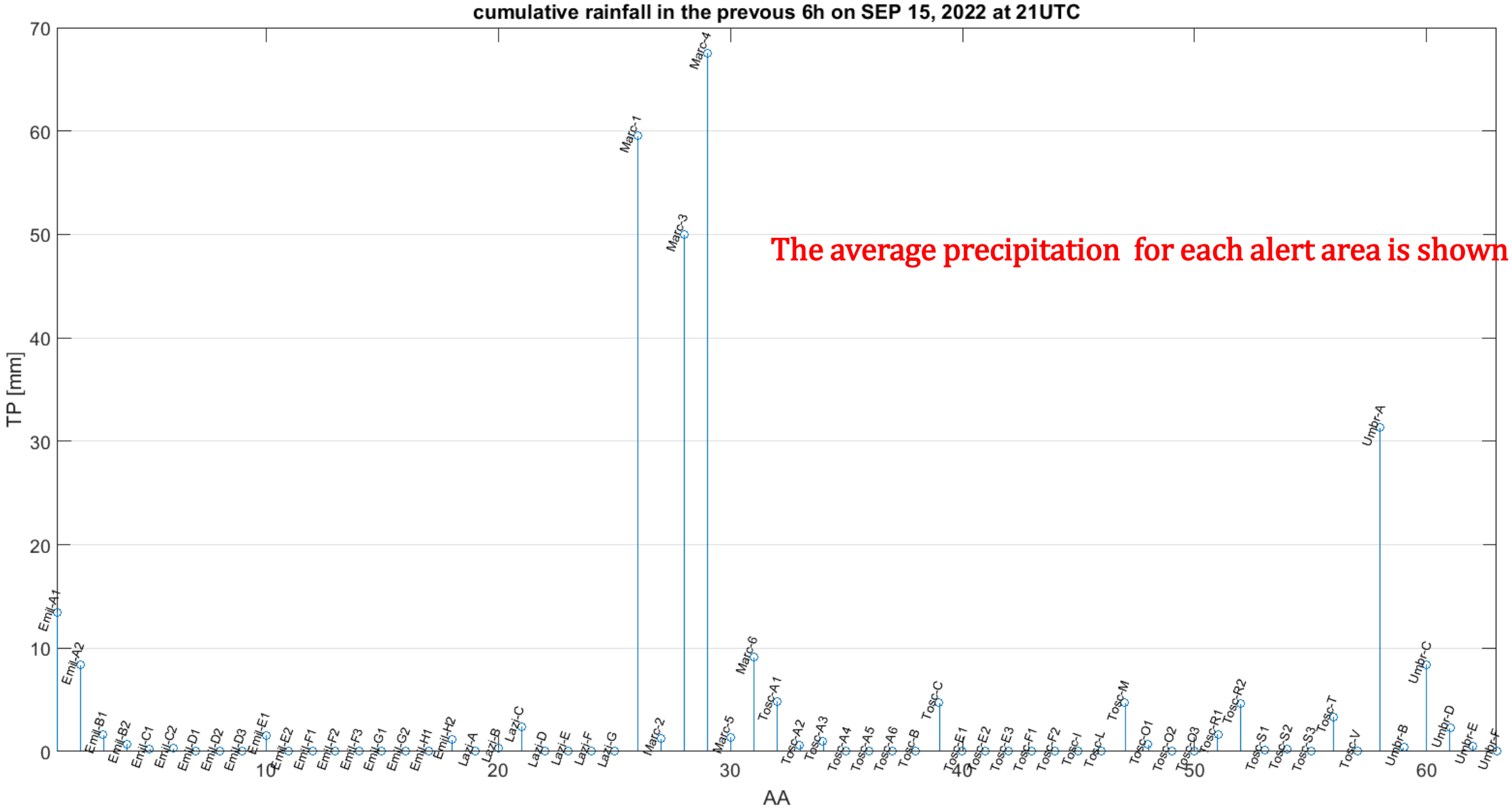
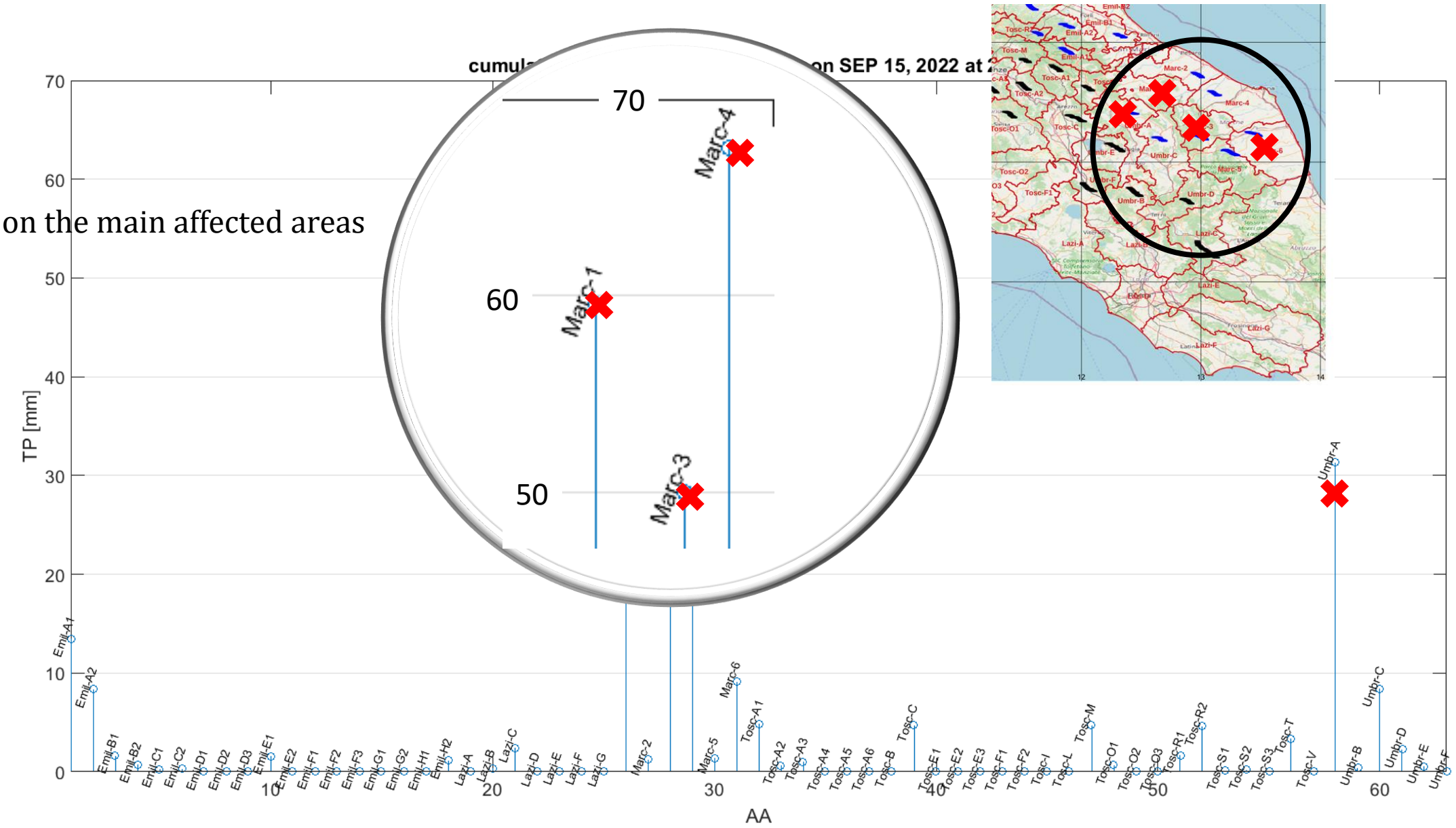


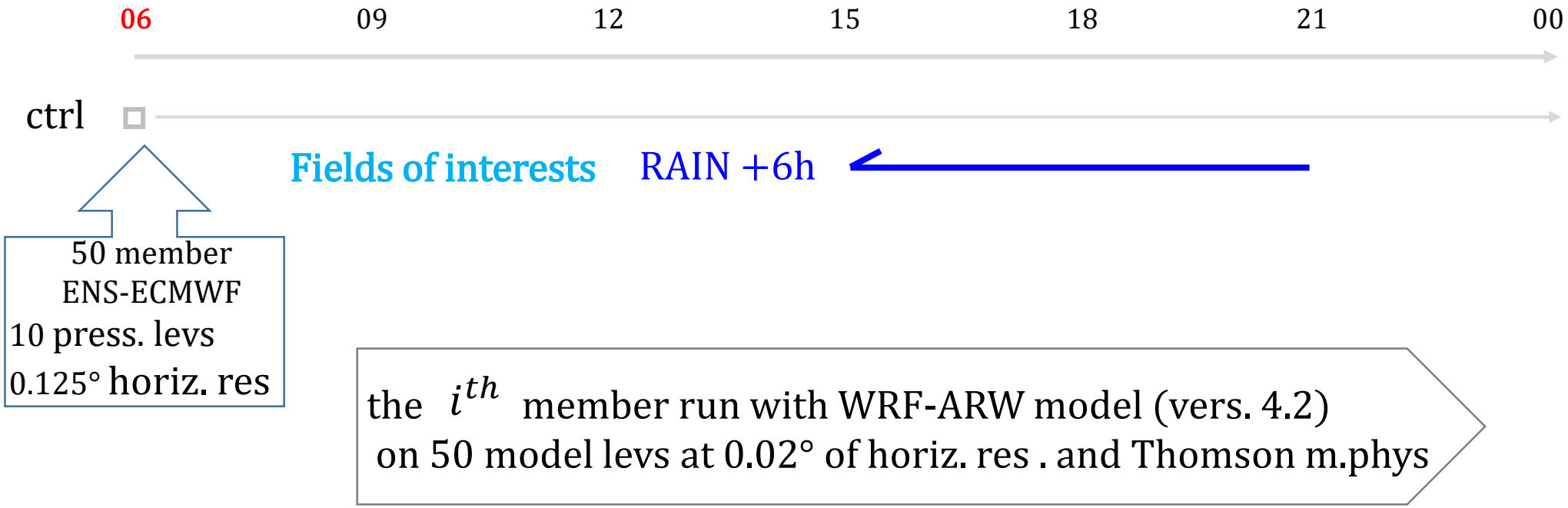
The average precipitation for each alert area is shown here

Areal Mean Rain Cumulated By Rain gauges

a zoom on the main affected areas

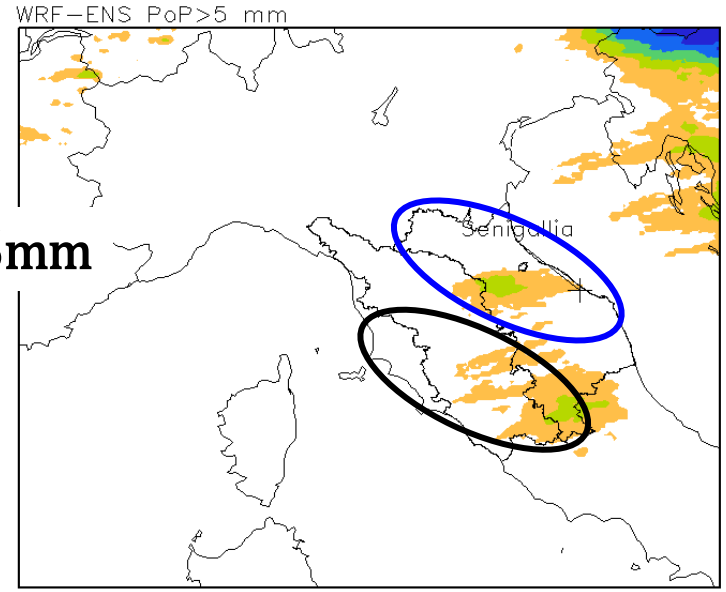


General architecture of the ensemble in semi-operational mode

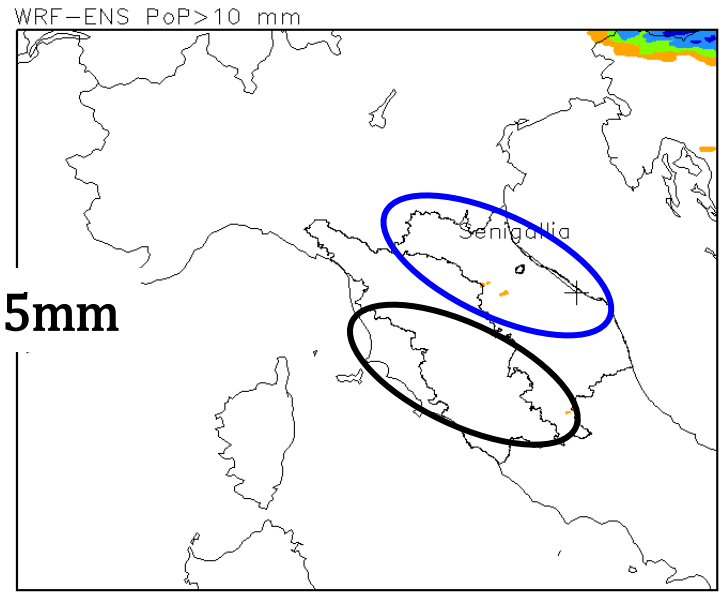


let's therefore start from the architecture of the ensemble: we initialized the WRF-ARW model version 4.2 with the 50 members of the ECMWF ENSAMBLE on the Italian domain. The ensemble members are provided at 10 pressure levels and at a horizontal resolution of 0.125° with a time step of 3h. Mesoscale runs with WRF were performed for 24 hours, on 50 model levels at a resolution of 3 km.

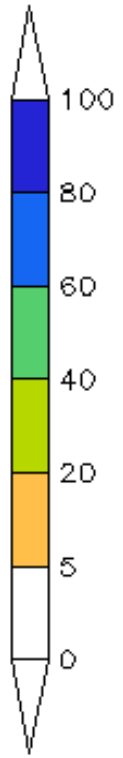
Probability of Precipitation for 50th Ensemble Members



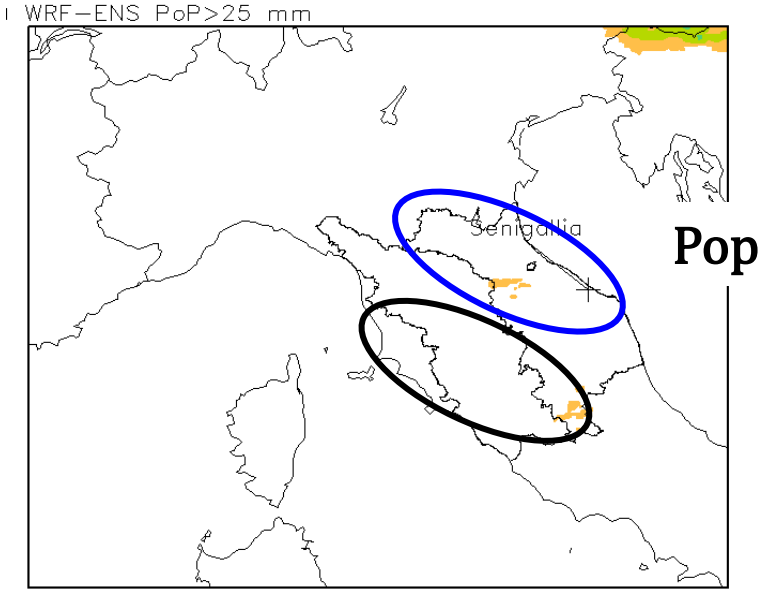
Pop >5mm



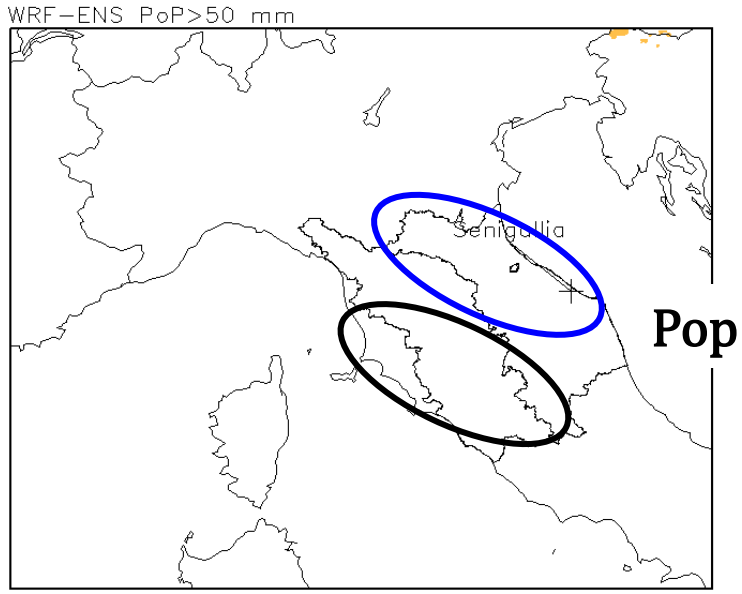
Pop >25mm



%



Pop >10mm



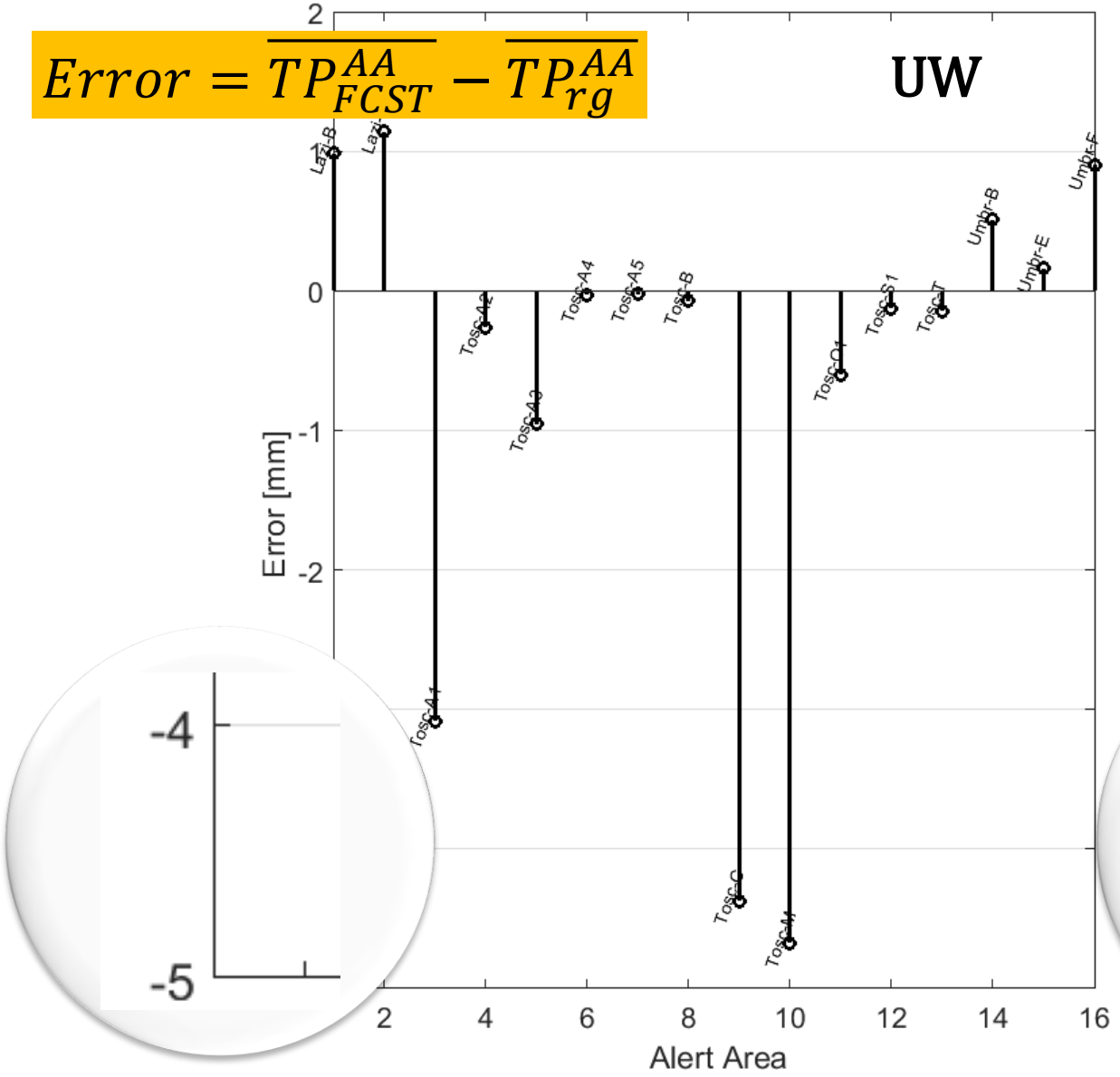
Pop >50mm

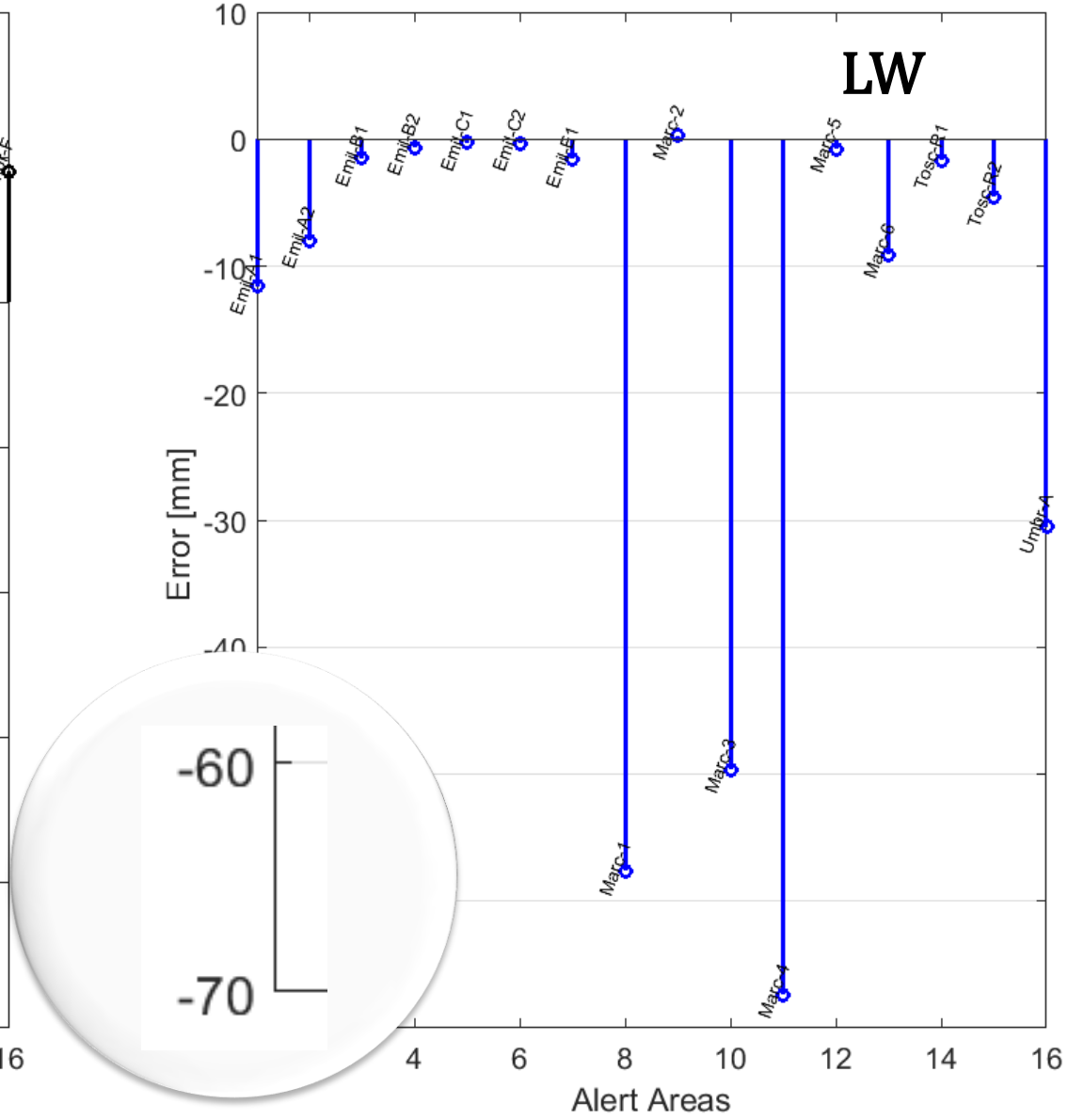
UPWIND

LEEWARD

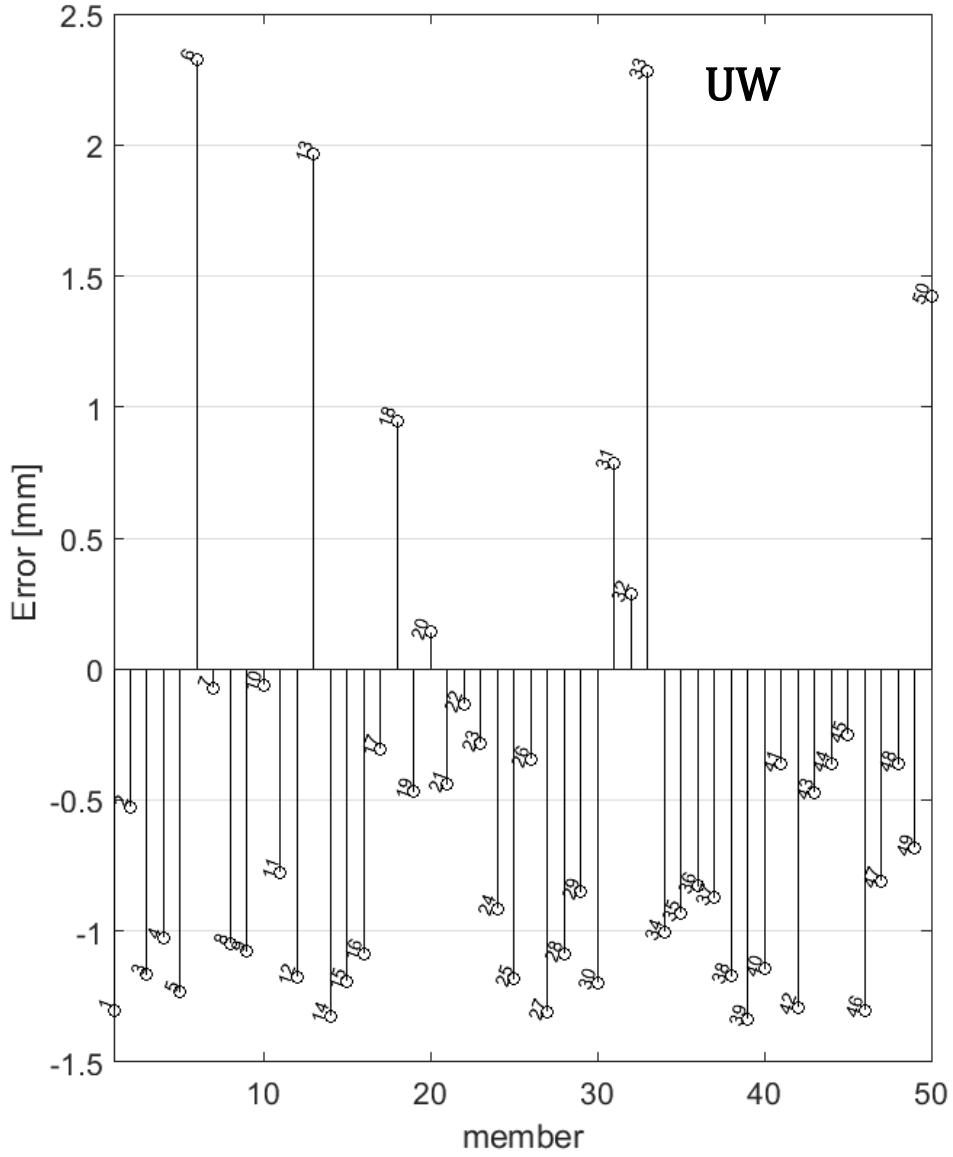
Alert Areas Mean values of Ensemble Average of Error

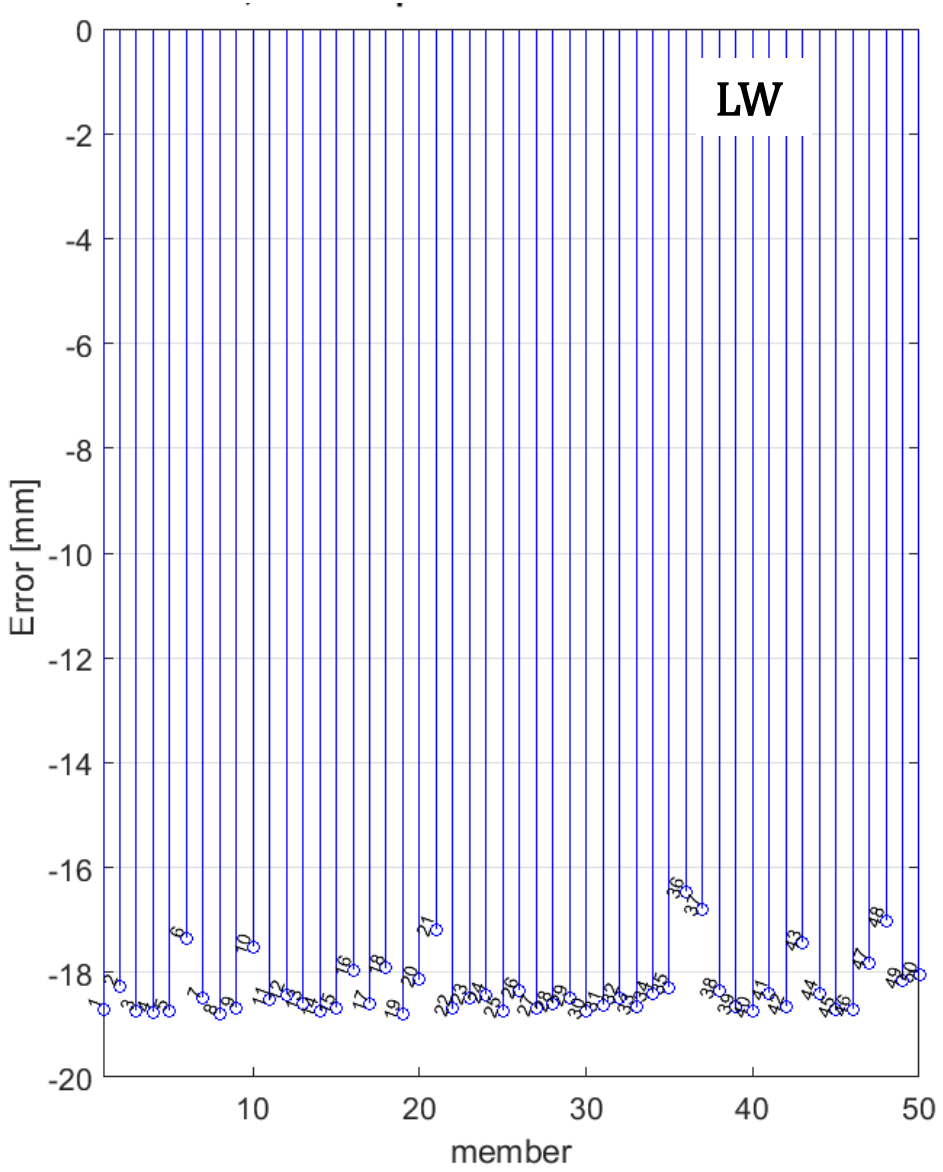
$$Error = \overline{TP_{FCST}^{AA}} - \overline{TP_{rg}^{AA}}$$



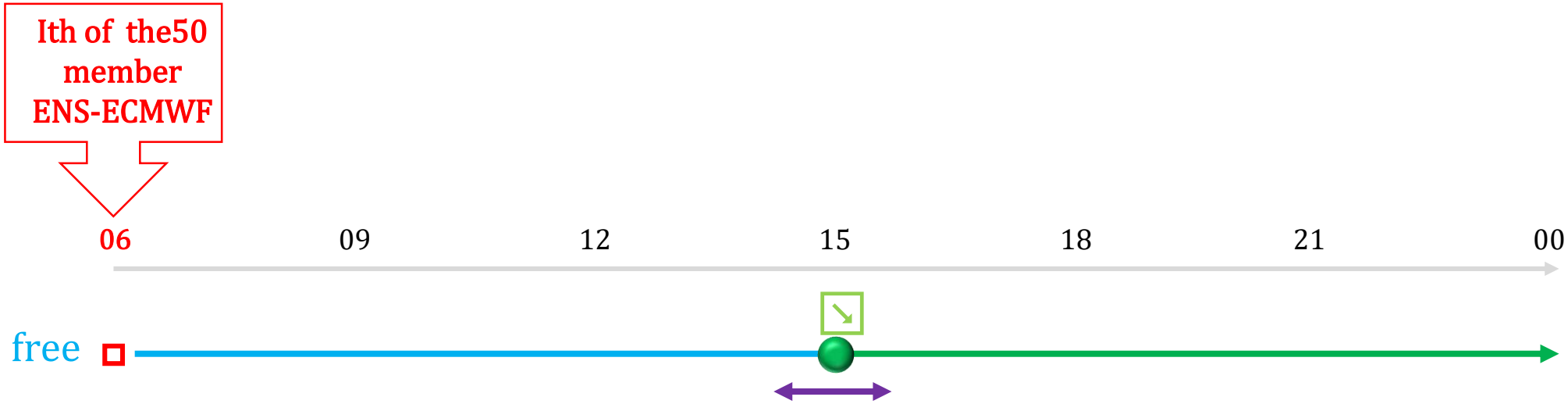


Upwind /Leeward total Area mean Error for each Ensemble member





architecture for test on WRFDA, SEP. 15, 2022

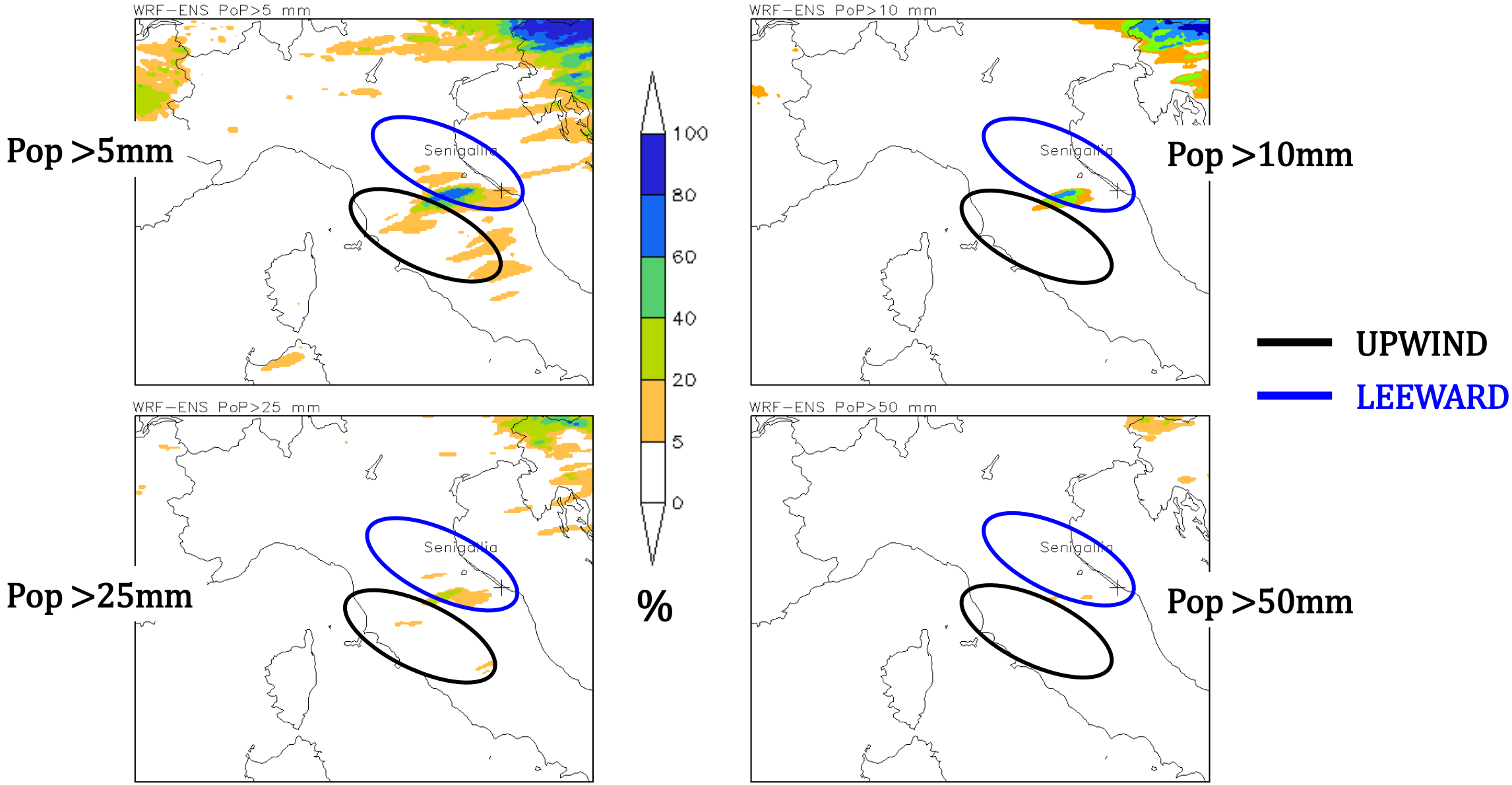


DFI

3DVar ±15’

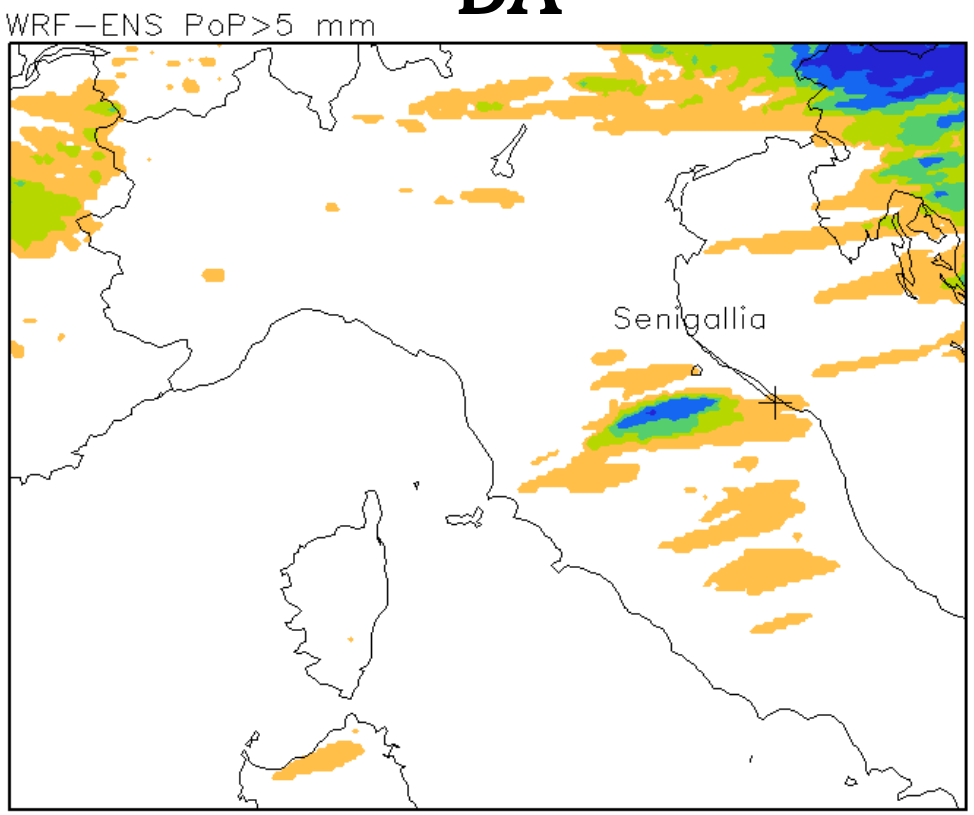
- Automatic weather stations (ground stations. GS)
- GNSS (GPS,GLONASS,Galileo and Beidou)
- Radiosound
- Ship weather stations
- CAPPI Radar by Dipartiment of Civiles Defence (DPCN)

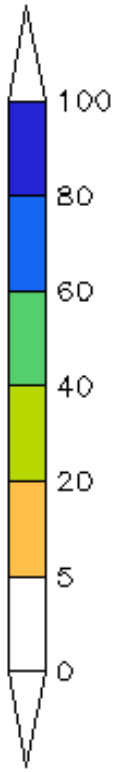
Probability of Precipitation for 50th Ensemble Members with DA



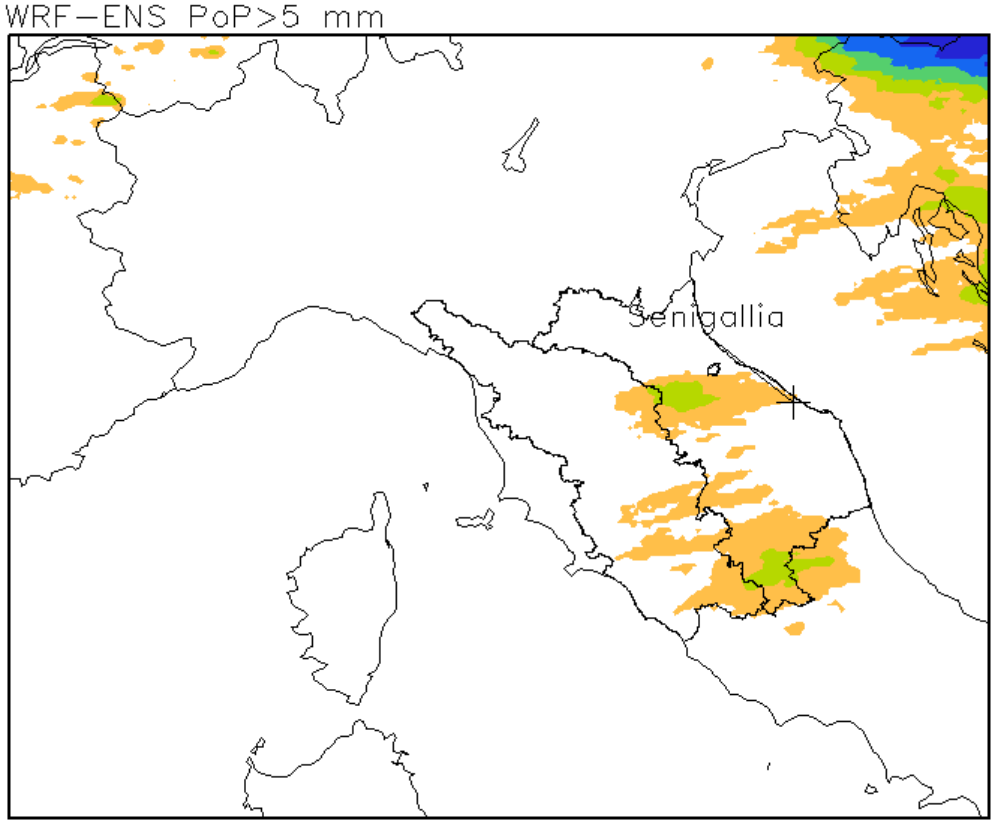
Comparison to evaluate localization skill of PoP

DA





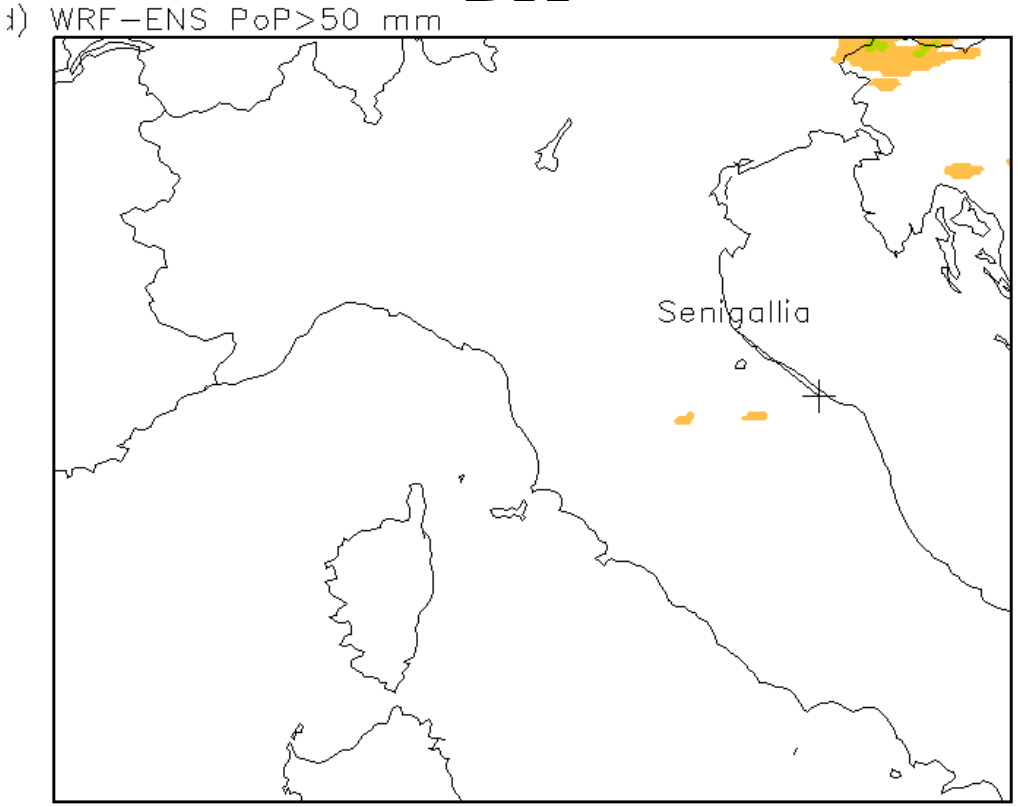
No DA

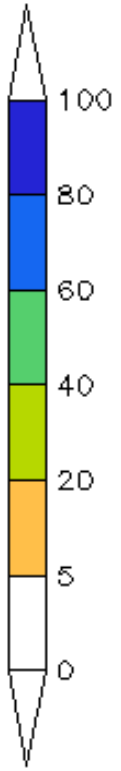


PoP > 5mm

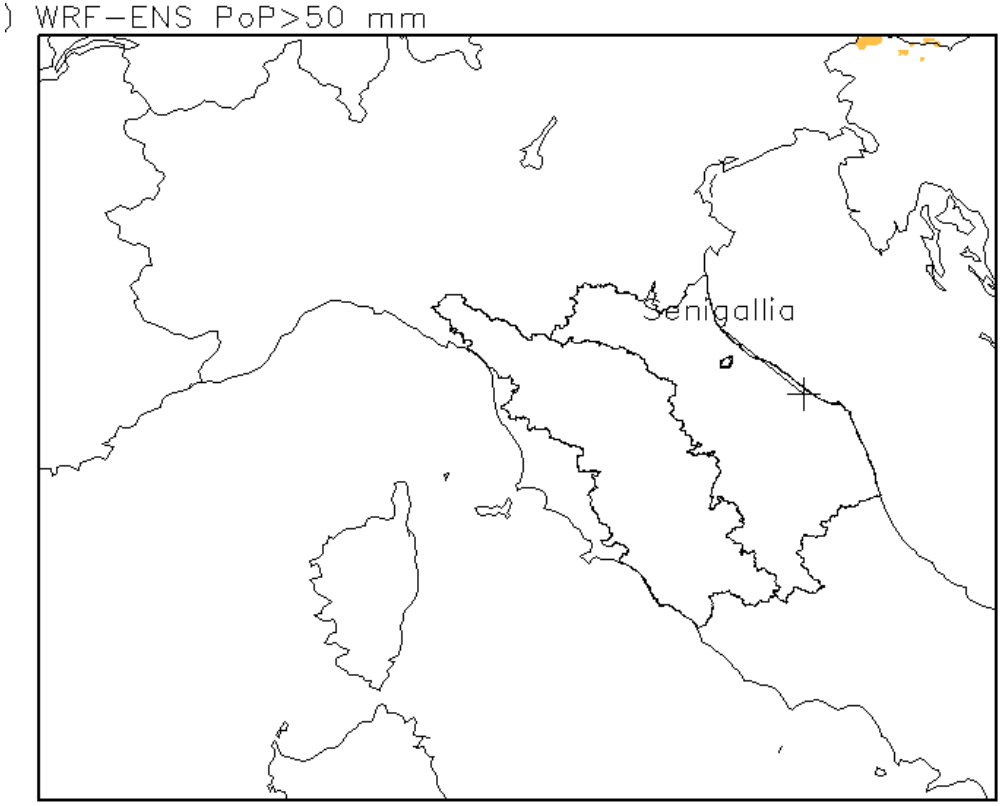
comparison to evaluate the skill to predict cumulative rainfall

DA





ctrl



PoP > 50mm

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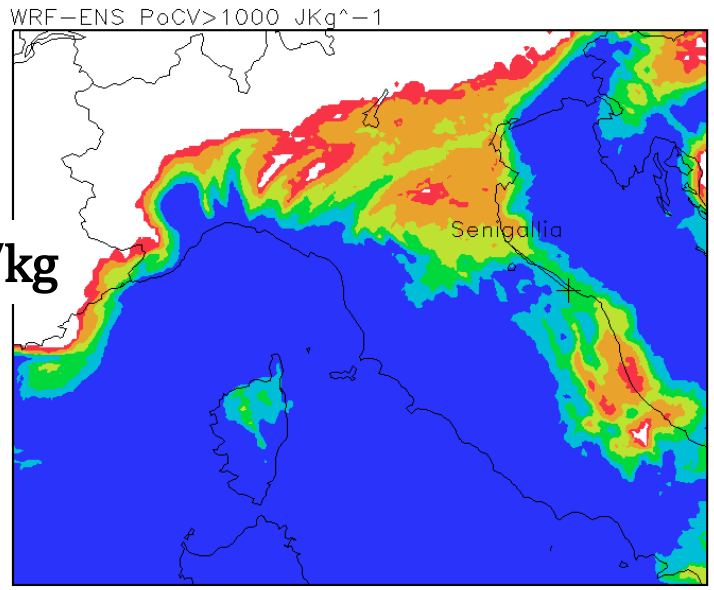
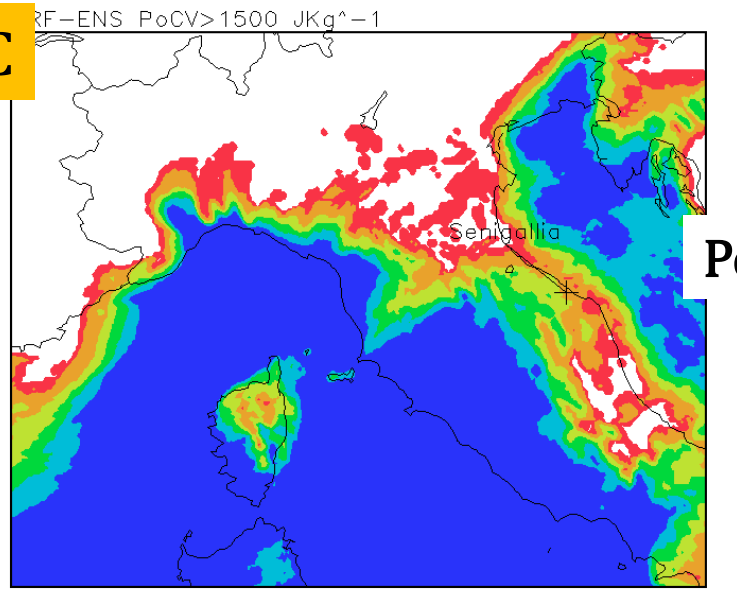
Probability of CAPE Value for 50th Ensemble Members

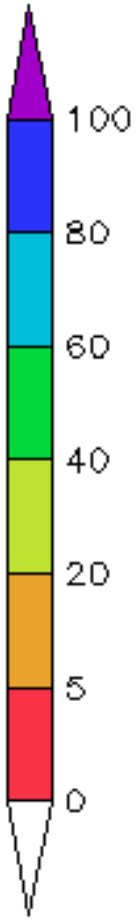
15UTC

PoC >1000 J/kg

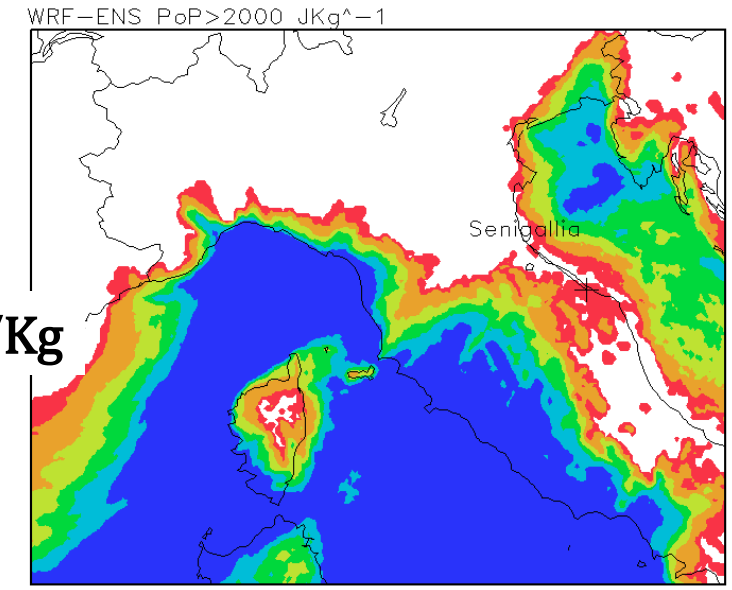


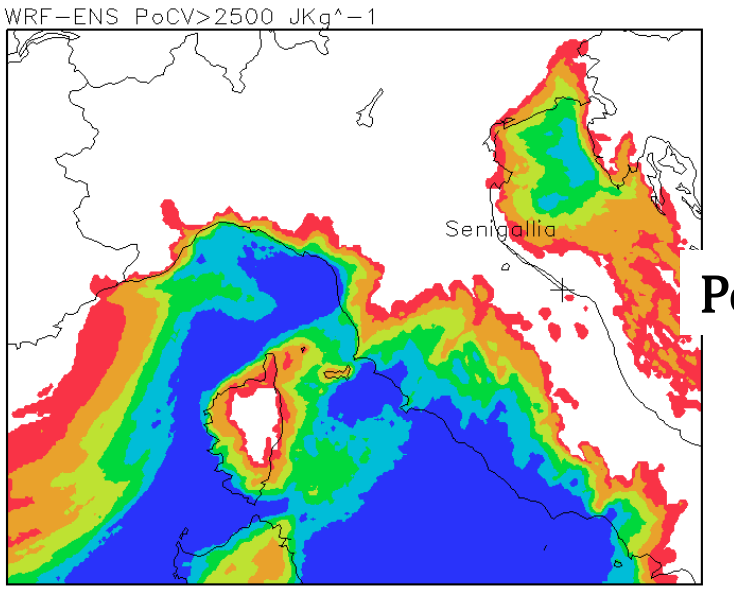


PoC >1500 J/Kg



PoC >2000 J/Kg





PoC>2500 J/Kg

conclusion

It is well known how dramatically global forecasts and consequently regional ones have improved in the last decades, however further steps are needed to support civil protection and more generally societal needs in a number of critical cases, increased by the contest of climate change.

Observations (local and remote) are increasing as well as their real-time availability and they represent a treasure to drive/constraint model runs also at small scales through DA approaches.

In very critical operational cases this can make the difference between foreseeing or not-foreseeing a potential risk, increasing the reliability of forecasts, adding value also to ensemble approaches. The control on the input observations is however a critical point, as the higher is the impact of a measurement assimilation the higher is the sensitivity to the measurement errors or to information overweighting.