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A multi-model, multi-analysis study to asses the capability of the CRA analysis for QPF spatial verification in the MesoVICT framework

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Contribution to MesoVICT

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MesoVICT:

2nd phase of the ICP spatial forecast methods intercomparison project focusing: "***on the application, capability and enhancement of spatial methods to forecasts over complex terrain, both for deterministic and ensemble forecasts***".

Aim of the ISPRA work:

- Investigate pros and cons in applying the **Contiguous Rain Area** (CRA) **analysis** to verify high-resolution QPFs over a Central Europe region, characterized by complex terrain due to the simultaneous presence of the Alps (i.e., *complex orography*) and the Mediterranean Sea (i.e., *lack of observations*, *coastlines*).
- Verify whether the use of **"complex" criteria is a strong/mandatory requirement** when deploying feature-based methods over such region, or it is only necessary when there are strong differences in terms of rainfall structure and details between QPFs and the corresponding gridded observation fields.
- Intercompare results obtained by using **different LAMs** (w. different spatial resolutions) and **different observational analysis**.

Methodology

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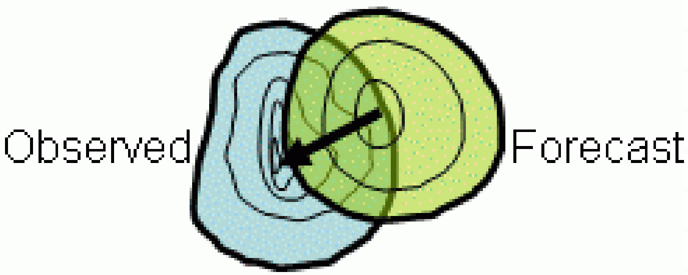
Methodology:

CRA analysis (Ebert and McBride, 2000; Grams et al., 2006) using "traditional" pattern matching criteria (max CORR; min MSE) and imposing some additional checks/constraints



- Max **shifting value** (search distance):
  ca. ±1.0° / ±1.5° in both LON & LAT
- Check on **No. of effective grid points** (**N_{eff}**):
  the smaller N_{eff} is, the greater the min CORR is to have a statistical significant shift → considering only **statistical significant shifts**
- Check on % of precipitation out of the verification domain (**domain jumping**)
- Check on ratio between "max forecast after best shift" and "max forecast before the best shift"
- A (final) **eyeball comparison** of the "best shift" against the "intermediate matches" found during the CRA application (obtained through minim. MSE or maxim. CORR) to visually detect the **suspicious** results and distinguish from the **more robust/reliable** results

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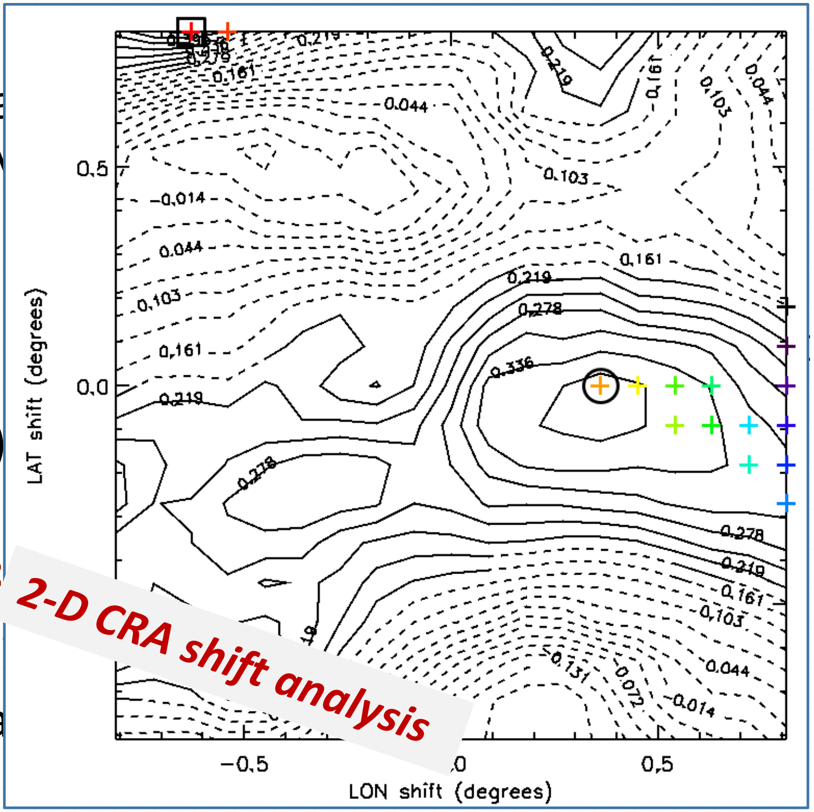

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NWP models and obs. analyses

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NWP models:

- COSMO-2 from MeteoSwiss, mapped on 8-km VERA grid
- GEM-LAM from Envir. Canada, mapped on 8-km VERA grid
- Low-res (@ 10 km) and hi-res (@ 7.5 km) BOLAM from ISPRA, mapped on an *ad hoc* 10-km verification grid
- Hi-res (@ 2.5 km) non-hydr. MOLOCH from ISPRA, mapped on an *ad hoc* 10-km verification grid

Precipitation analyses:

- 8-km VERA analysis (at 3 and 12 hours)
- 10-km Barnes obj. analysis (at 24 hours)

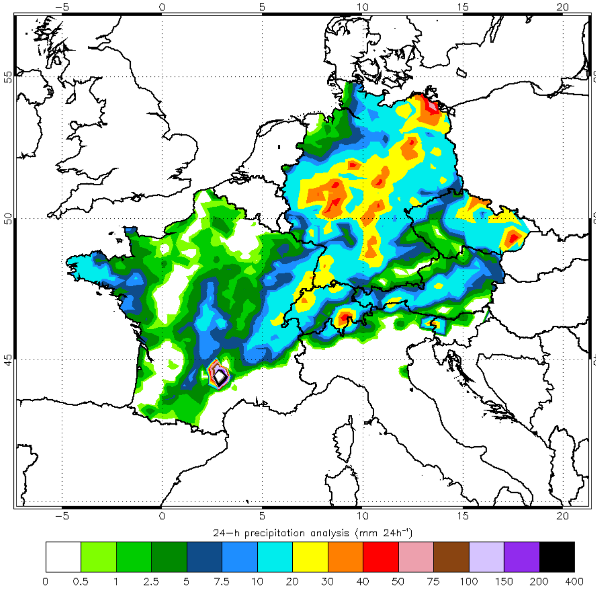
Case studies presented:

- Case 1: 20-22 JUN 2007 – mandatory
- Case 3: 25–28 SEP 2007 – core case
- Extra case: 22–25 NOV 2007 – tier 3 case

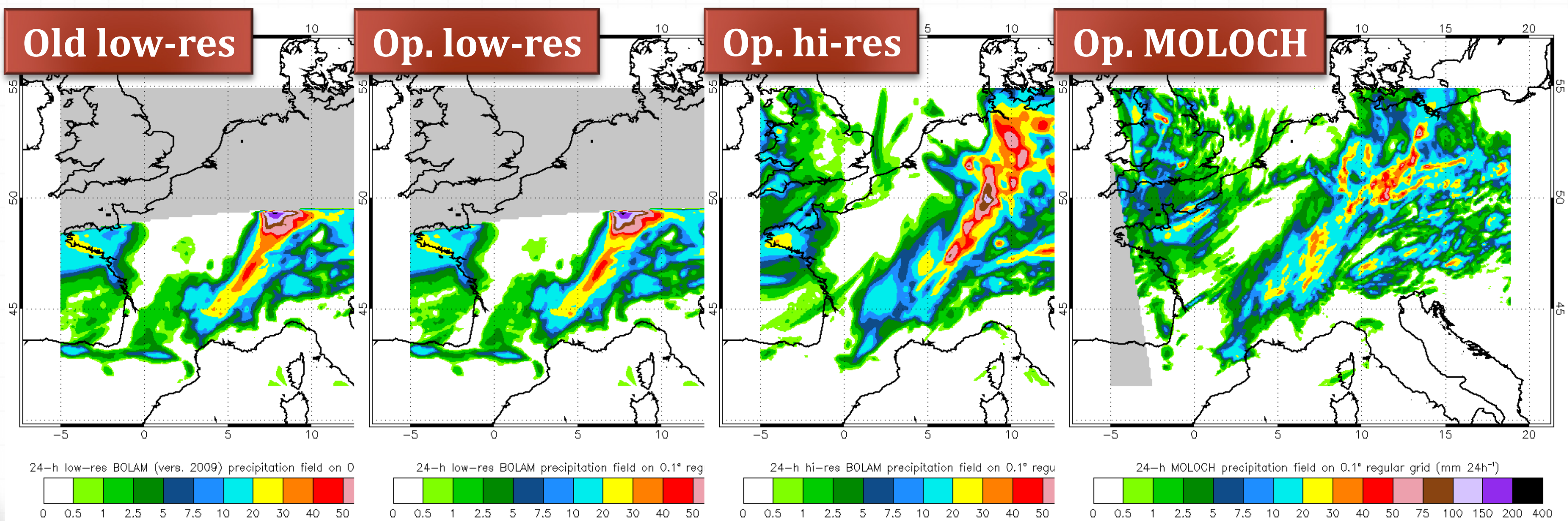
Rainfall thresholds:

0.5, 5.0, 10.0 and 20.0 mm

20–22 June 2007 (core case/mandatory)

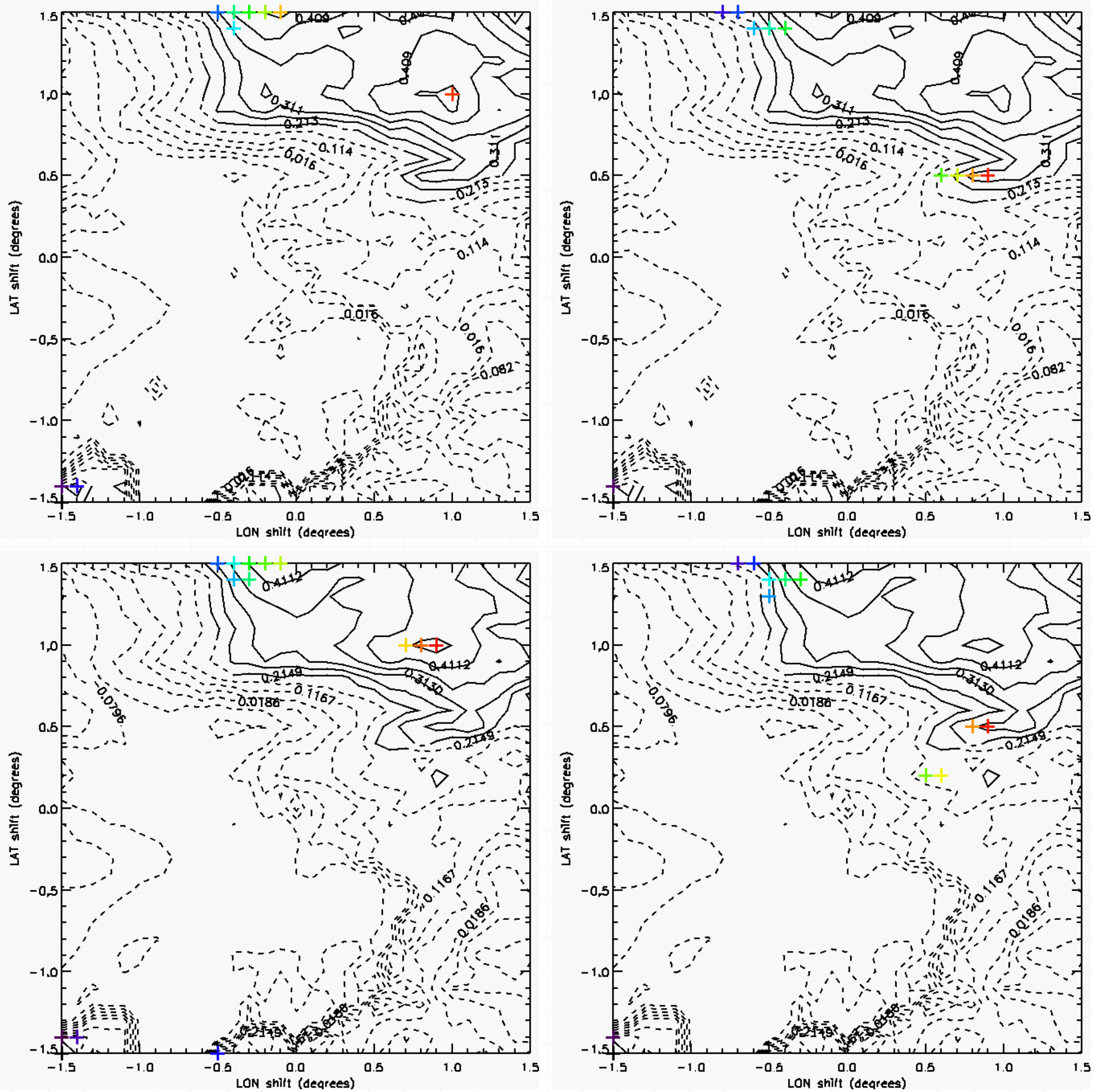


- ✓ Convective events, started in the evening of 20 JUN
- ✓ 24-h heavy precipitation mainly recorded on **21 JUN** in Southern Swiss, Germany, Slovenia and Hungary
- ✓ 3 configs. of BOLAM with similar horiz. grid size (10km & 7.8km / remapped @10km) but different domains (***obs. rain band not completely forecast***) and/or parameterizations (incl. convection)
- ✓ 1 config. of convection-permitting MOLOCH with a higher native horiz. grid size (remapped @10km)



21 JUN: old low-res (top panels) vs. oper. low-res (bottom panels) BOLAM

CORR

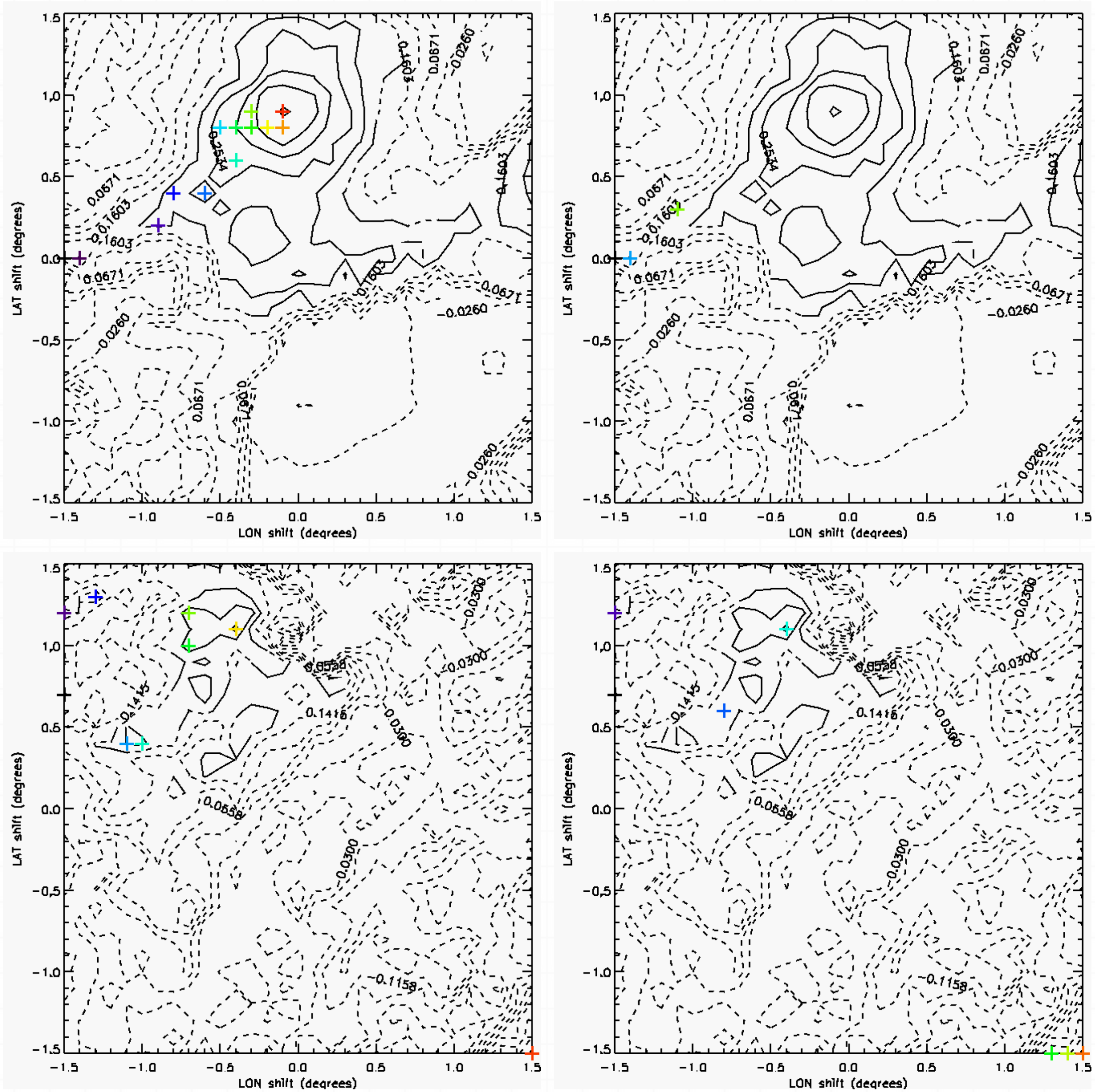


MSE

10 mm $24h^{-1}$

21 JUN: hi-res BOLAM (top panels) vs. MOLOCH (bottom panels)

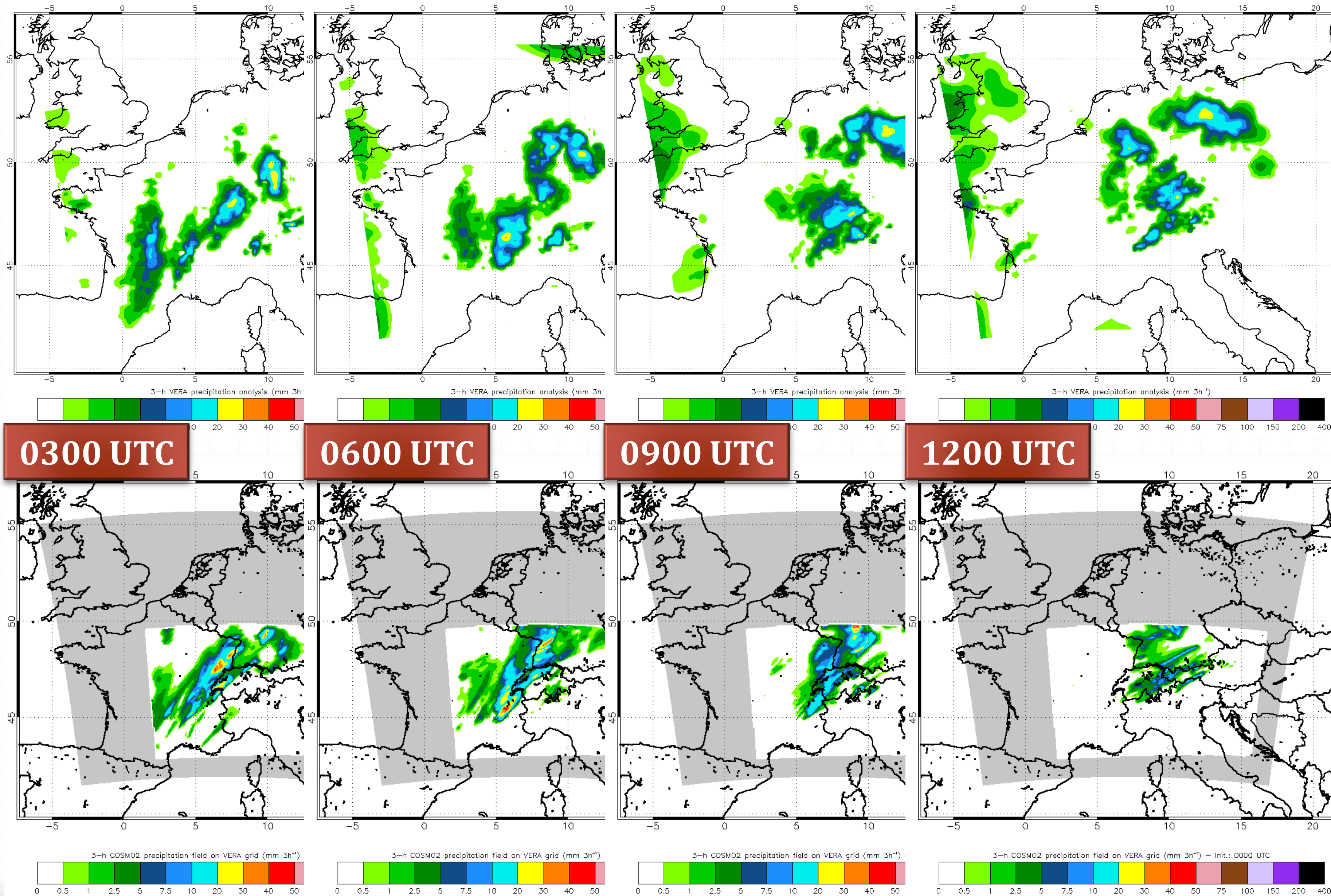
CORR



MSE

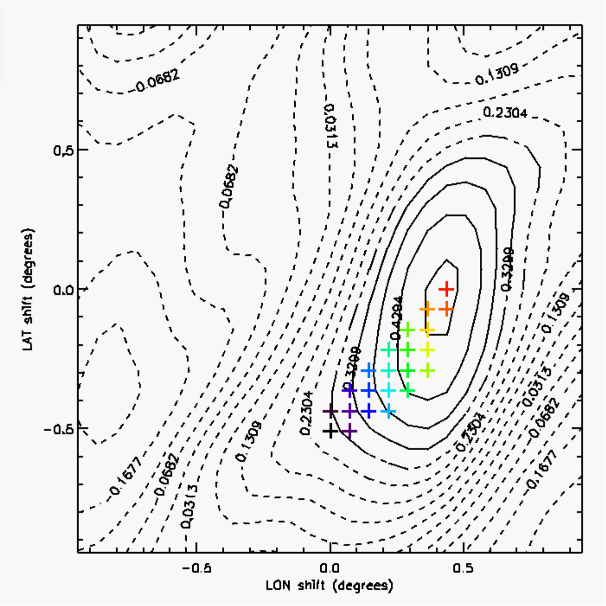
10 mm 24h^{-1}

21 JUN: 3-h VERA analyses vs.COSMO-2 forecasts

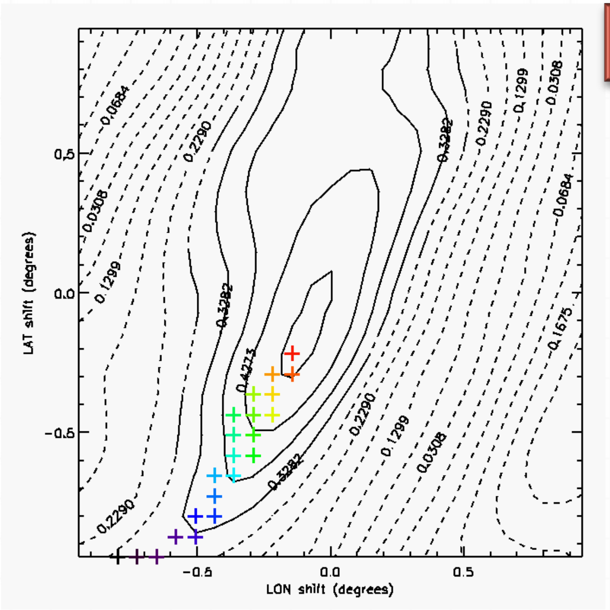


21 JUN: 3-h VERA analyses vs.COSMO-2 forecasts

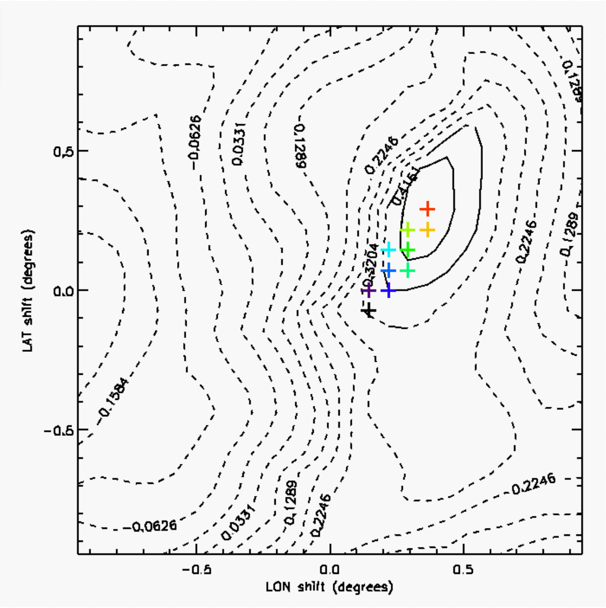
0300 UTC



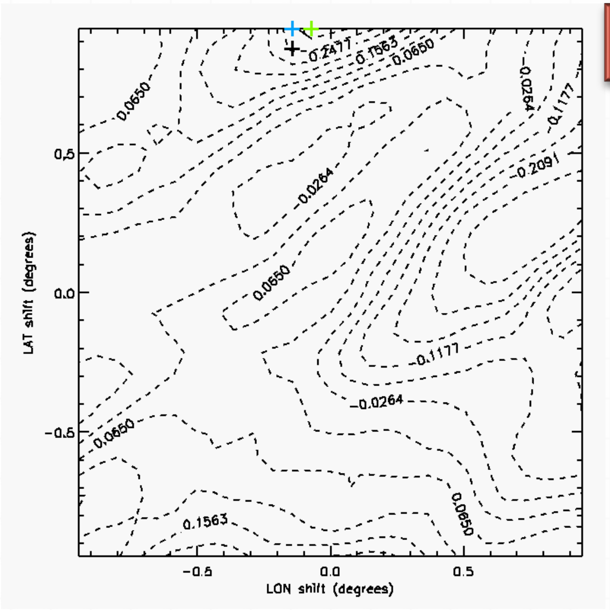
0600 UTC



0900 UTC

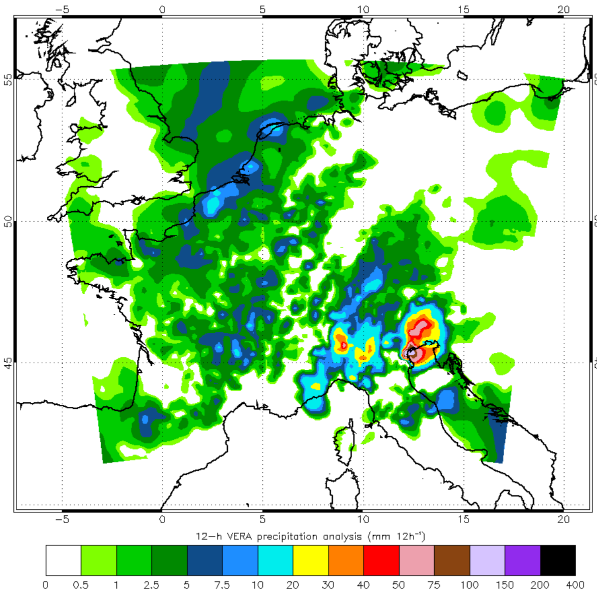


1200 UTC

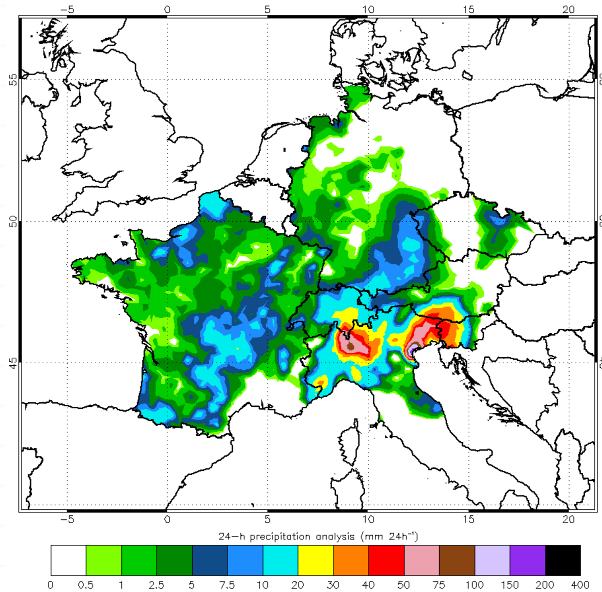


25–28 September 2007 (core case)

12-h VERA analysis
26 SEP at 1800 UTC

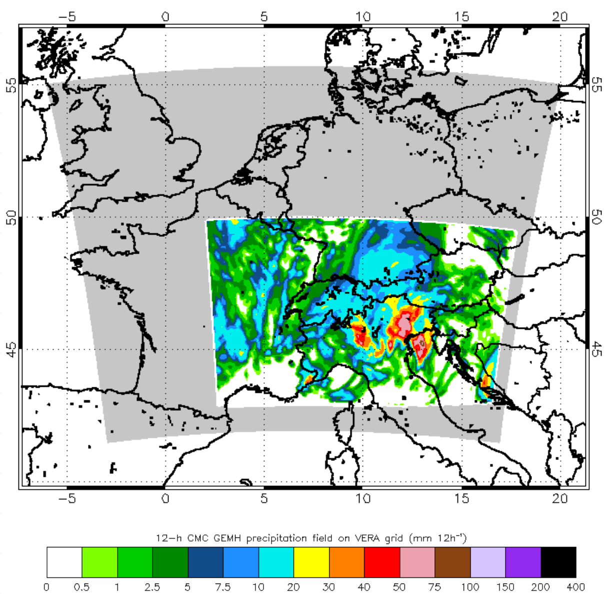


24-h Barnes analysis
26 SEP



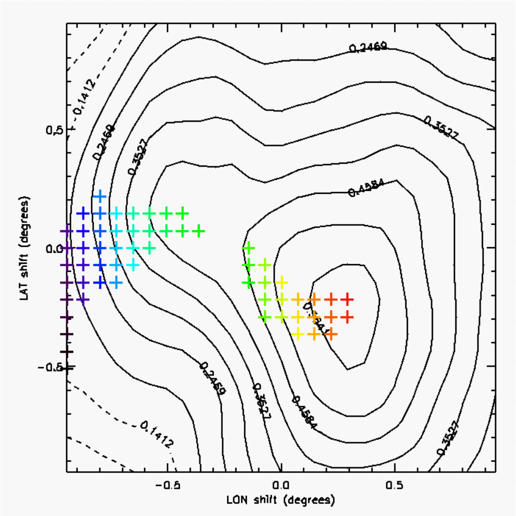
- ✓ A cold air outbreak into the Mediterranean caused a cyclone development in the Gulf of Genoa on 25 September and, as a consequence, warm and moist air was advected towards the Alps from the South (Dorninger et al., 2013)
- ✓ Heavy precipitations recorded in the Po valley, in the Apennines, in the North-eastern Italy and in several areas of Germany in the following days
- ✓ A flooding occurred in the Venice Lagoon: sea level reached a peak of around 100 cm (e.g., at the Punta della Salute and at Lido Diga Nord tide gauges)

26 SEP: 12-h acc. GEM-LAM at 1800 UTC



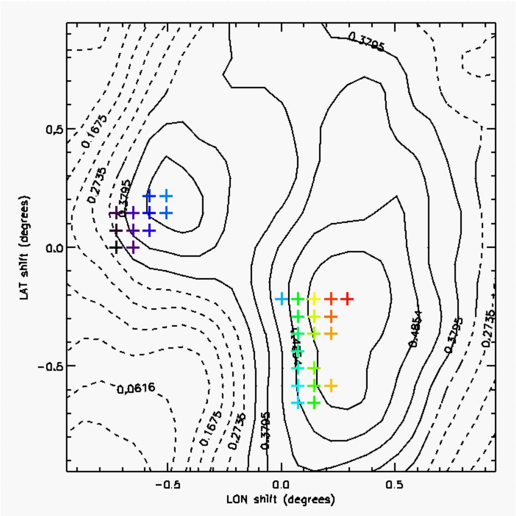
0.5 mm $12h^{-1}$

$[E, N]_{sh}$ =[0.29°, –0.22°]



5.0 mm $12h^{-1}$

$[E, N]_{sh}$ =[0.29°, –0.22°]

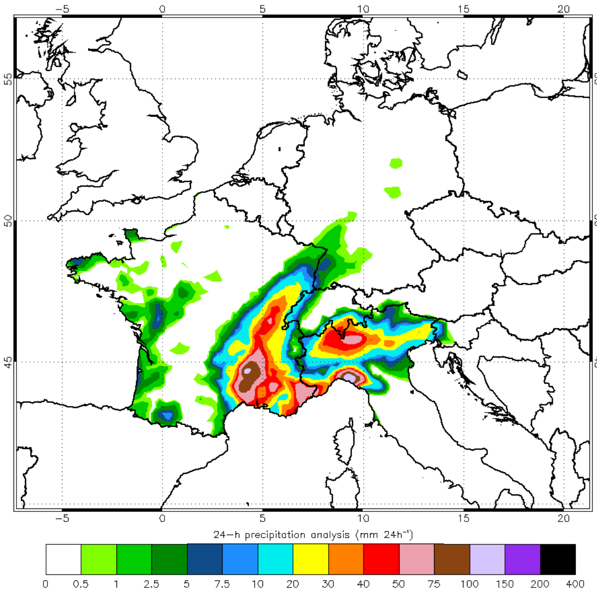


≥ 10.0 mm $12h^{-1}$

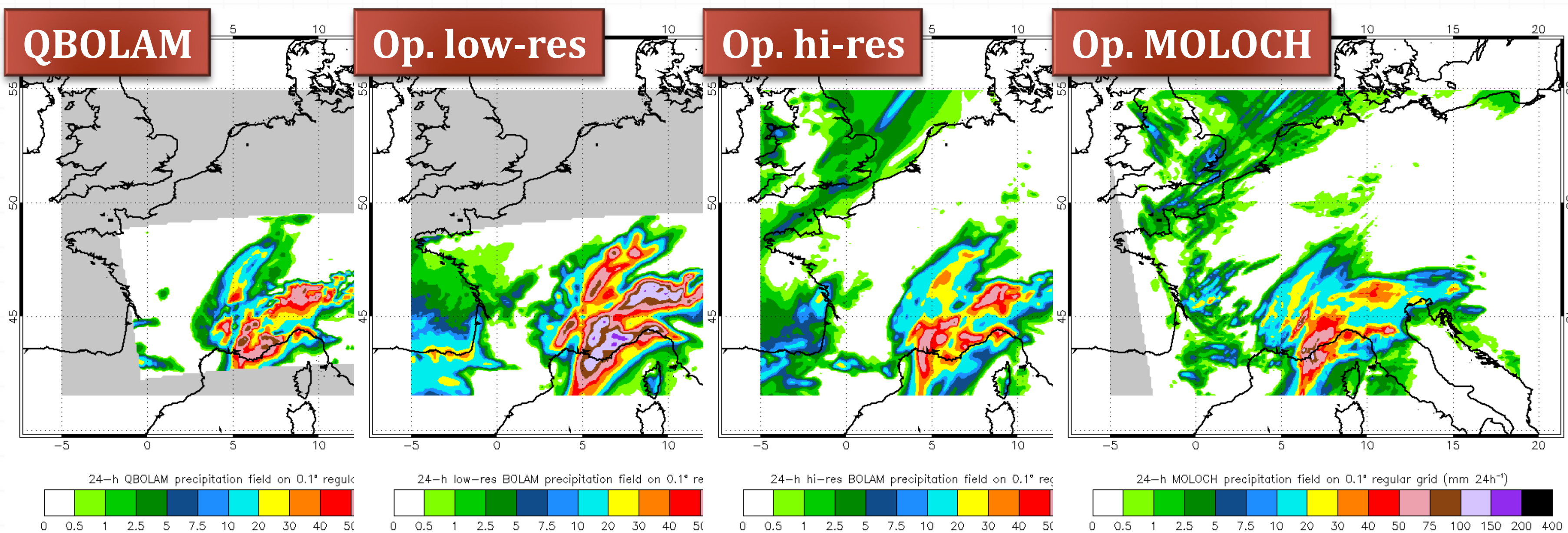
No stat. sign. shift,

CORR too low wrt N_{eff}

22–25 November 2007 (tier 3 case)

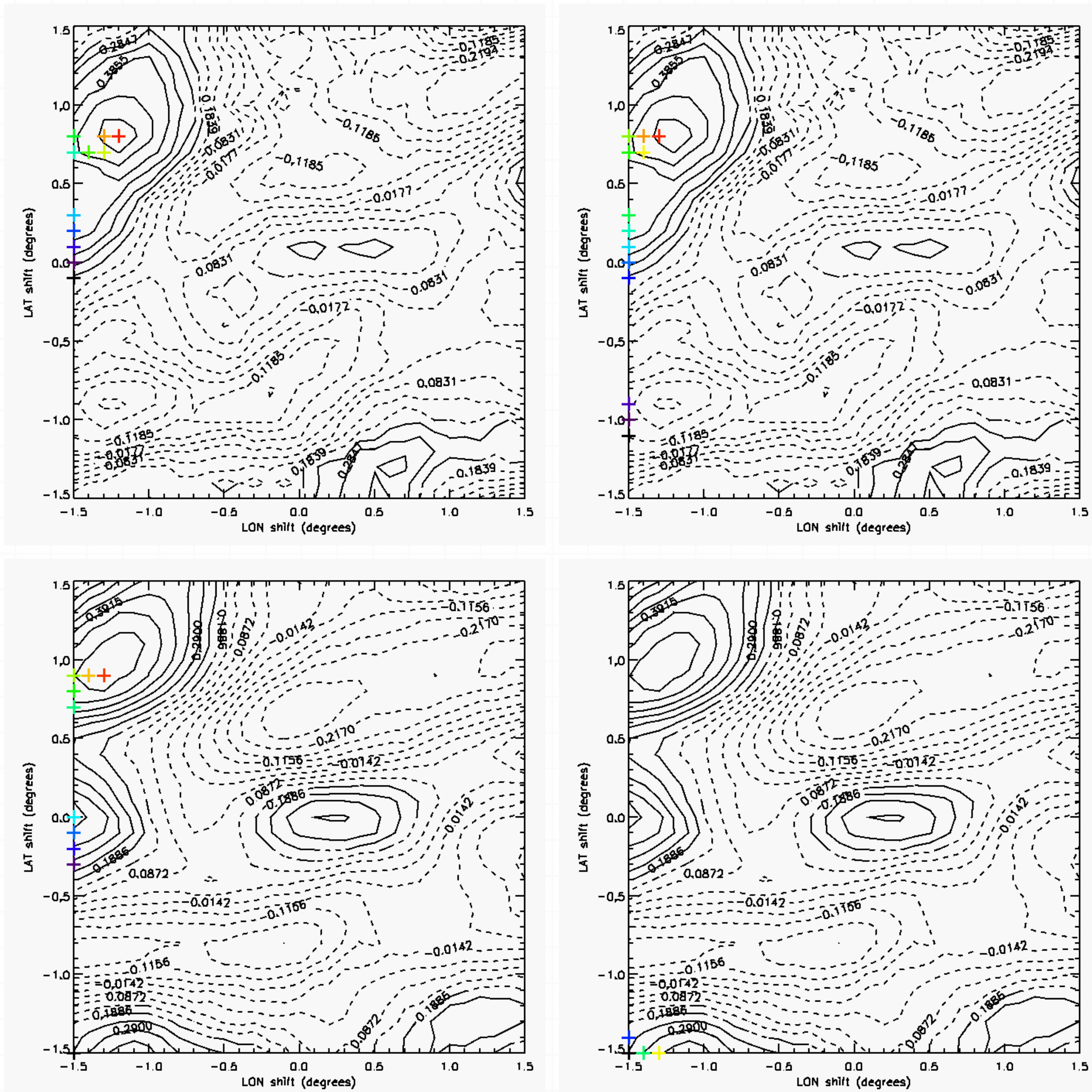


- ✓ 24-h Barnes rainfall analysis on **22 NOV** (from 0000 UTC) *vs.* BOLAM (3 configs.) and MOLOCH forecasts
- ✓ Max precipitation recorded in France (Massif Central/ Cévennes-Vivarais) and in Italy (Liguria, Tuscany and north-eastern Italy): two of the regions in the NW MED area usually affected by HPEs [*hydro-met target sites for the WMO-endorsed **HyMeX** programme*]
- ✓ The observed rain band and maxima are completely forecast inside the 4 model domains



22 NOV: QBOLAM (top panels) vs. oper. low-res BOLAM (bottom panels)

CORR

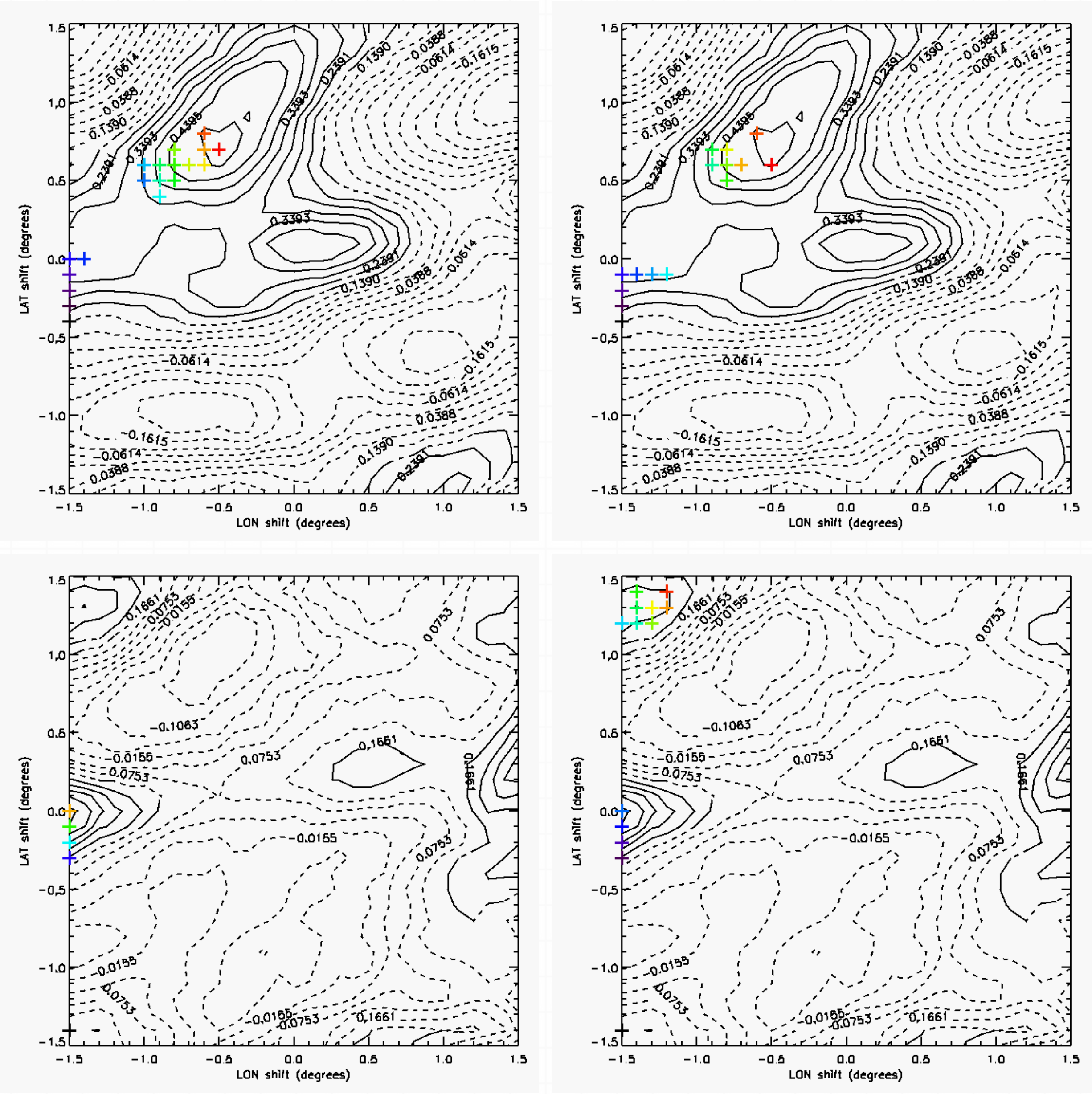


MSE

10 mm $24h^{-1}$

22 NOV: hi-res BOLAM (top panels) vs. MOLOCH (bottom panels)

CORR

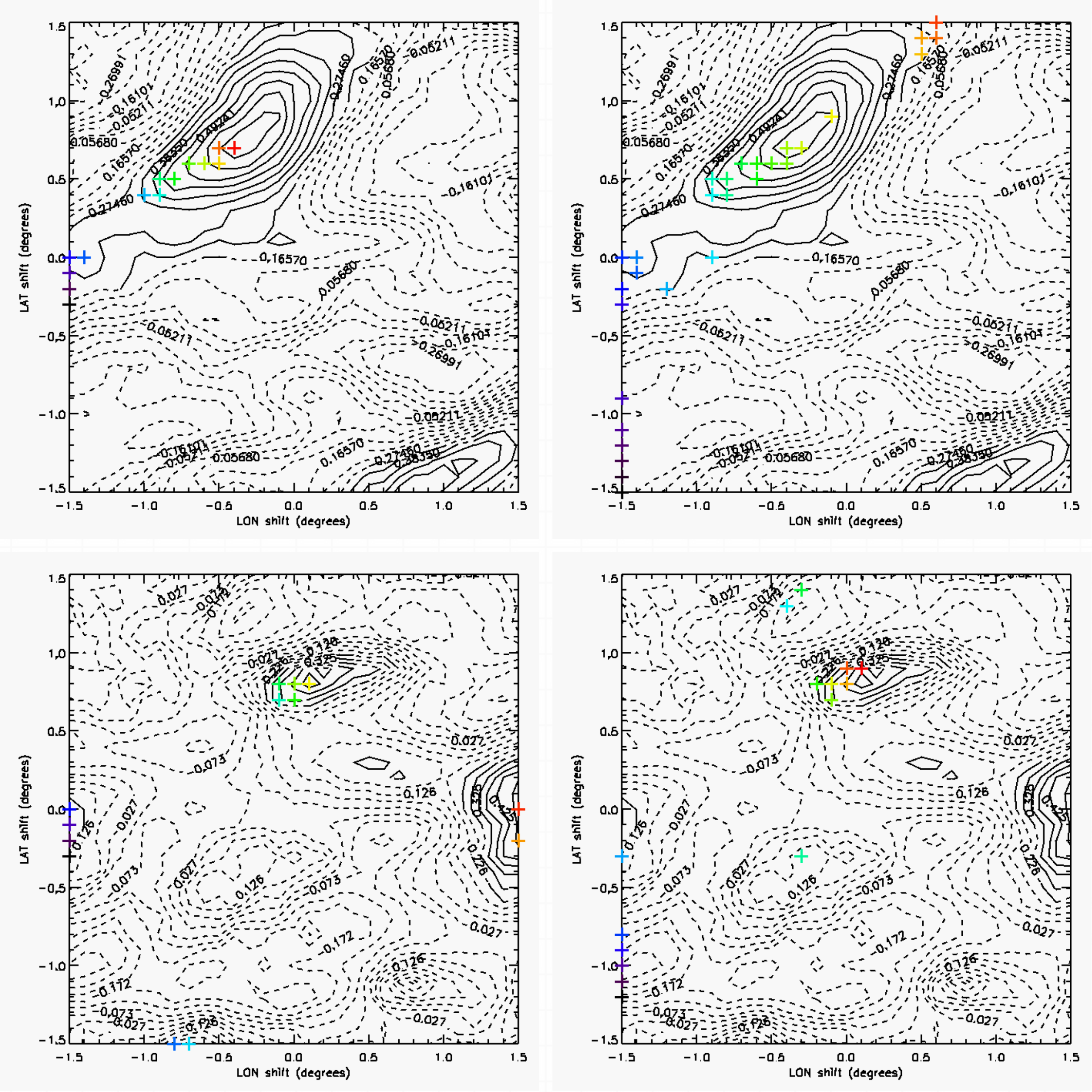


MSE

10 mm $24h^{-1}$

22 NOV: hi-res BOLAM (top panels) vs. MOLOCH (bottom panels)

CORR



MSE

20 mm 24h^{-1}

Conclusions

- ✓ In general, results confirms that CRA tends to provide more robust and reliable results when using the CORR maximization as pattern matching criterion.
- ✓ Min MSE should be avoid or used in conjunction with either max CORR or other additional constraints or check (e.g., % of grid points out of the verif. domain), to discriminate the CRA results.
- ✓ Results can be influenced by the difference in resolution (spatial scales resolved) between observation and forecast fields, even if comparison is performed on a coarser verification grid, especially when considering higher entity threshold and/or convective events.
- ✓ Verification at short accumulation time could be problematic since either entities are defined over a reduced number of grid points or results are associated to erroneously matches.
- ✓ The CRA could be sensitive to lack of information in the observed entity (e.g., over MED sea when using as “truth” the Barnes analysis) and/or in the forecast entity (e.g., when the rainfall band under investigation is partially observed outside the model domain), since it could be conditioned by the “domain jumping” issue.
- ✓ The 2-D CRA shift analysis is valuable diagram/tool to investigate and compare the intermediate results and discriminate whether the best shift is reliable or not.

Relevant references

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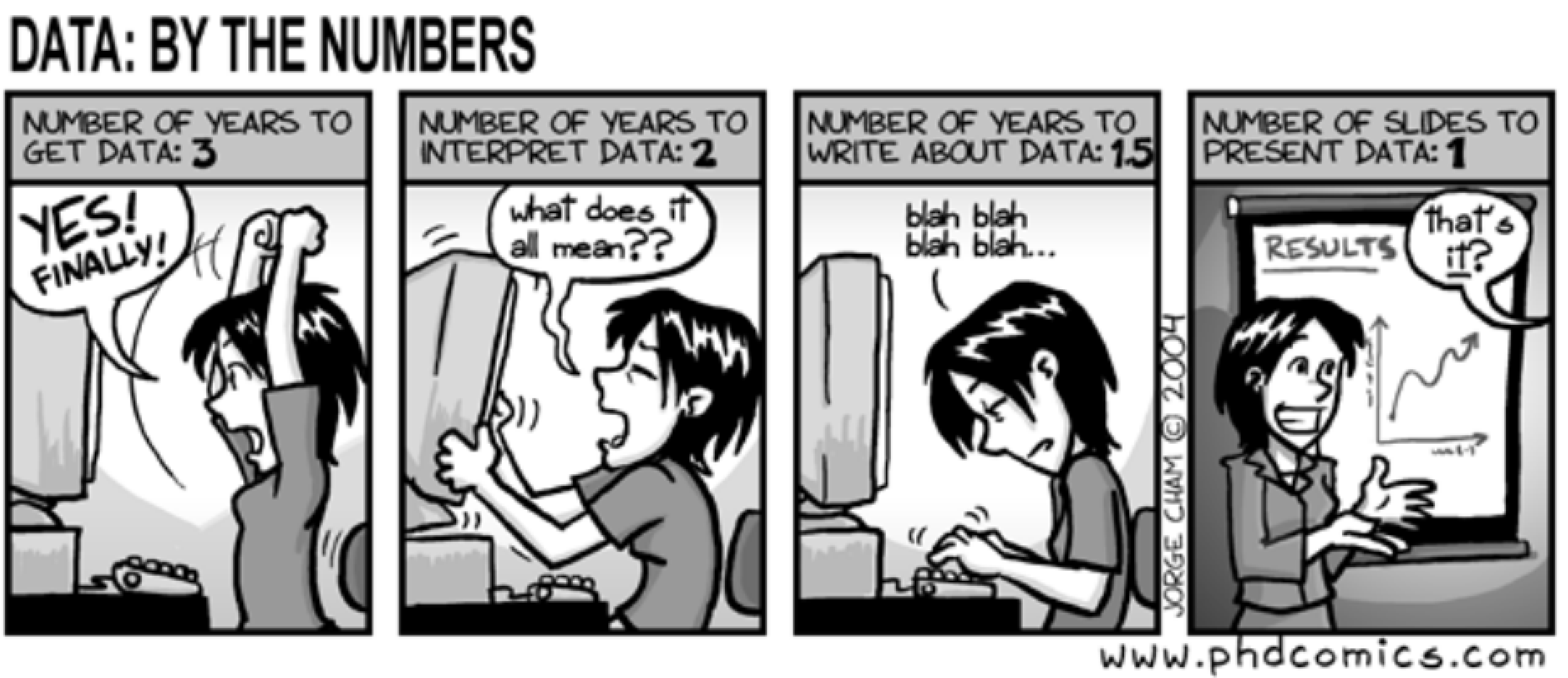
Thanks for your kind attention!



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