Improving initial condition perturbations in a convection-permitting EPS

Autors: Endi Keresturi, Yong Wang, Florian Meier, Florian Weidle, Christoph Wittmann and Aitor Atencia

Motivation

- Include large scale information (perturbations) from a global model (EPS)
  - Better treatment of large scales
    - Limited domains, less effective DA systems, etc.
- Mismatching perturbations coming from the driving model with those generated by a limited area model (LAM)
  - LBC perturbations vs IC perturbations
  - Concern raised by many authors (Wang *et al.*, 2014; Caron, 2013; Brousseau *et al.*, 2011...)
  - Excessive spread (Caron, 2013), better precipitation forecasts (Kühnlein *et al.*, 2014)

State of the art

- Wang *et al.* (2014)
  - ALADIN-LAEF coupled to ECMWF-EPS
  - Digital filter blending method
- Caron (2013)
  - Regional 1.5 km EPS coupled to regional 24 km EPS
  - Selective scale ETKF

State of the art

- Include global model information directly to a limited area variational assimilation
  - Proposed by Guidard and Ficher (2008)
  - *Jk* blending method

Theoretical background – *Jk* 3D-Var

- Cost function:

$$J(x) = \underbrace{\frac{1}{2}(x - x_b)^T B^{-1}(x - x_b)}_{J_b} + \underbrace{\frac{1}{2}(y - Hx)^T R^{-1}(y - Hx)}_{J_o}$$

- Cost function in *Jk* blending method:

$$J(x) = J_b + J_o + \underbrace{\frac{1}{2}(x - x_{ls})^T V^{-1}(x - x_{ls})}_{J_k} = J_b + J_o + J_k$$

Idea

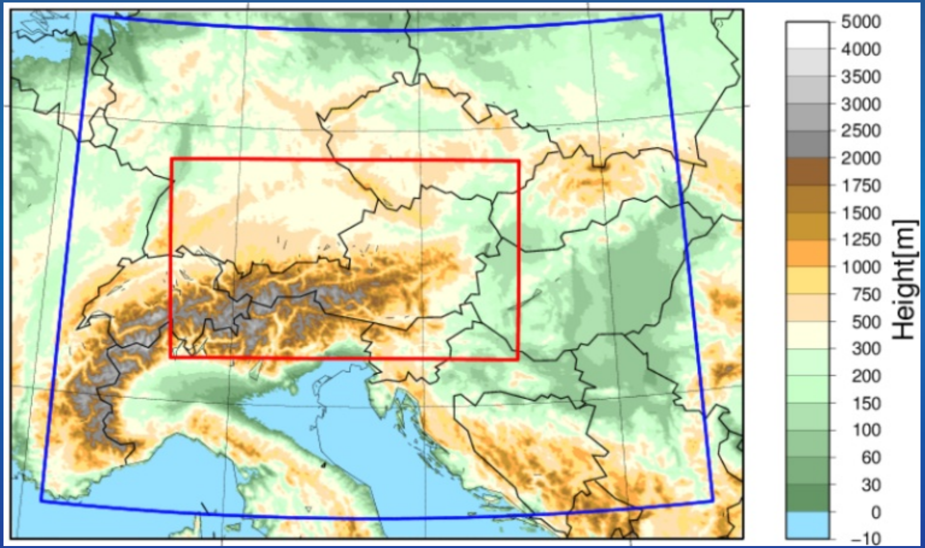
- Global model large scale perturbations as a new information in 3D-Var of a convection-permitting ensemble
- Ensemble *Jk* method
  - Small scale perturbation – 3D-Var EDA
  - Large scale perturbations – *Jk*
- Final analysis
  - Perturbed small and large scales
  - Perturbation consistent with LBC perturbations

Model setup and experiments

- LAM: 17 member AROME-EPS (2.5L90)
  - IC perturbations:
    - **REF**: 3D-Var EDA with random observation perturbation
    - **JK**: REF + *Jk*
  - LBC perturbations: ECMWF-EPS
- Driving model: ECMWF-EPS
  - IC perturbations: 4D-Var EDA + singular vectors
  - Model perturbations: stochastics physics

Model setup and experiments

- No surface or model perturbations
- Verification
  - Surface observations, INCA and GFS/ECMWF HRES analyses
  - July – August 2016, 12 UTC runs
  - Bootstraping



V-matrix calculation

- Climatological
  - Ensemble method
- 16 ECMWF-EPS members (+000 h)
- Two times per day for two weeks in January, April, July and October
  - Annual variability

Scale selection

- Truncation of *Jk* term
  - Wave number for which horizontal error variance spectra, between LAM and global model, starts to diverge

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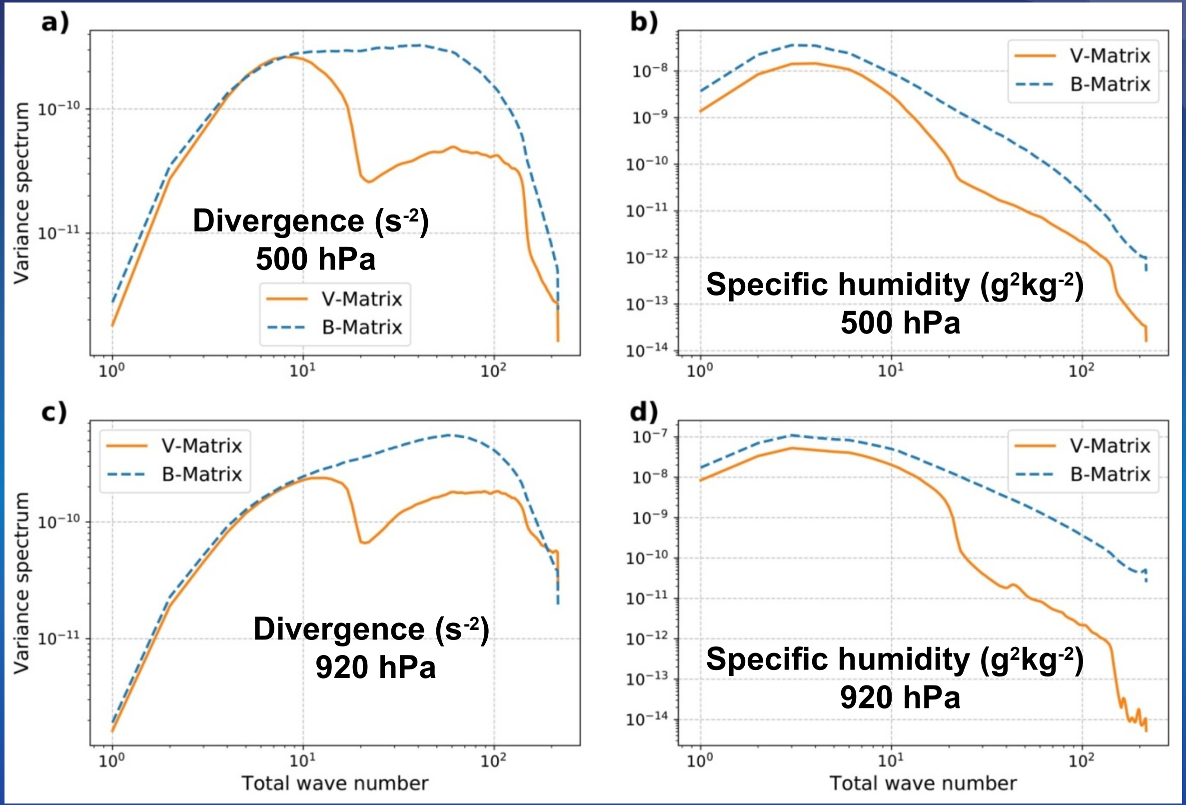
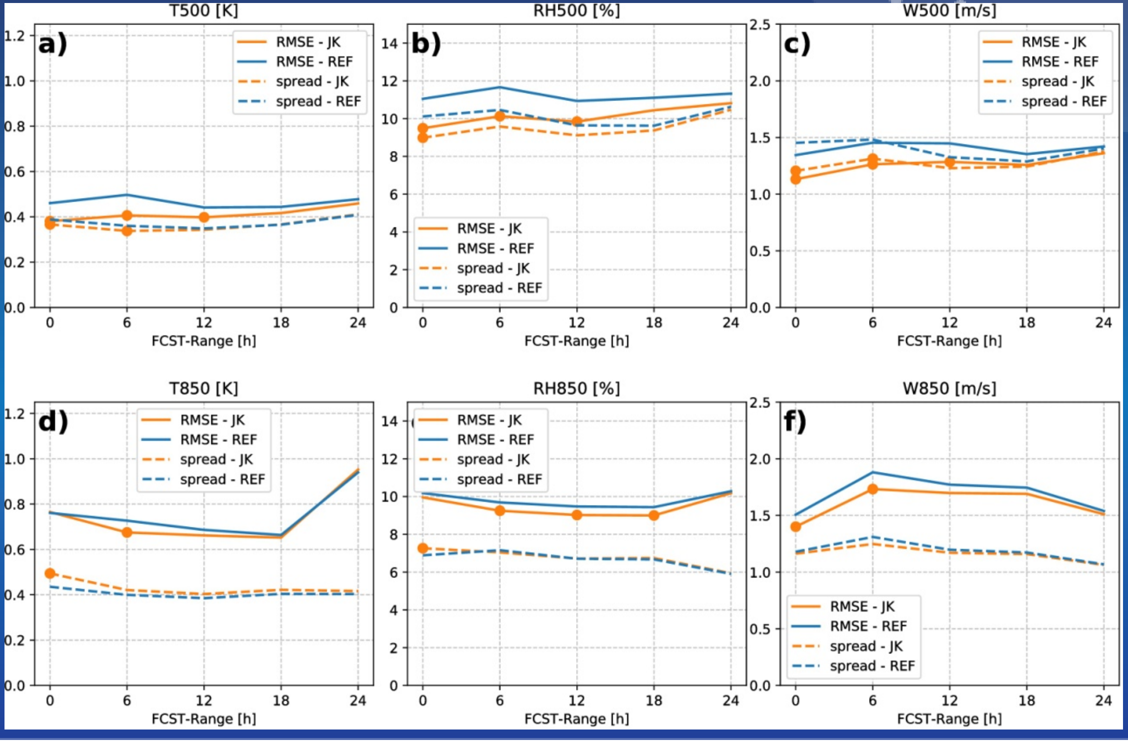


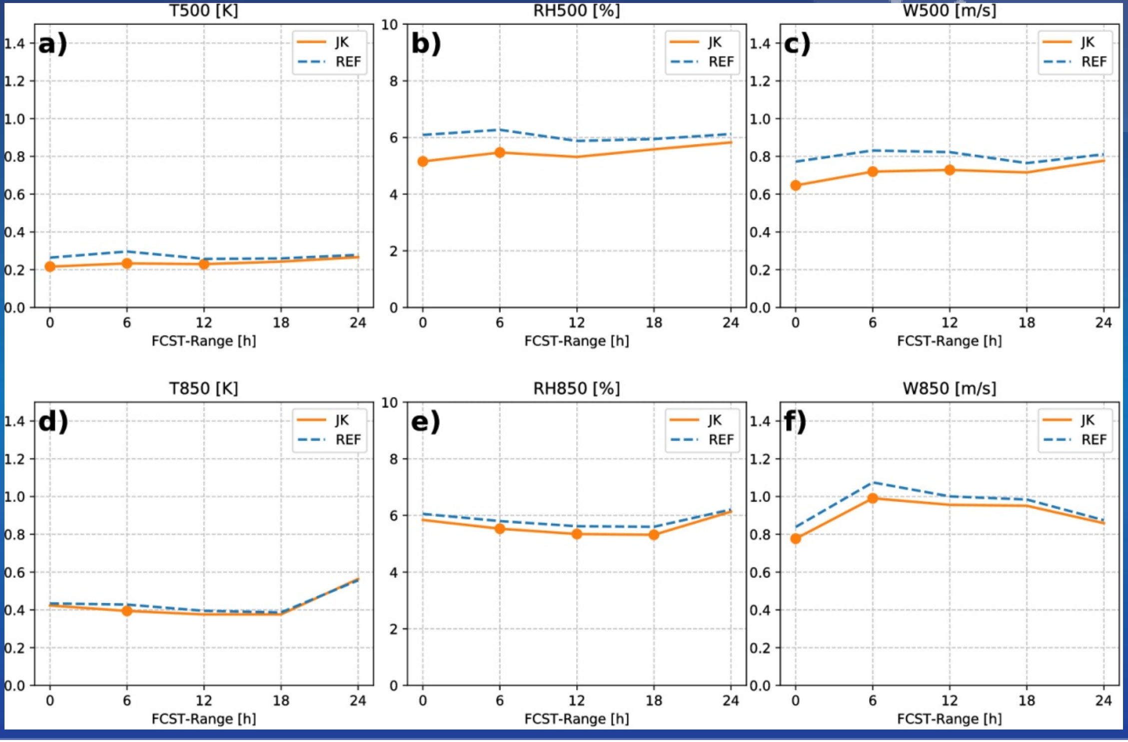
Results – upper air

- RMSE and SPREAD on 500 and 850 hPa



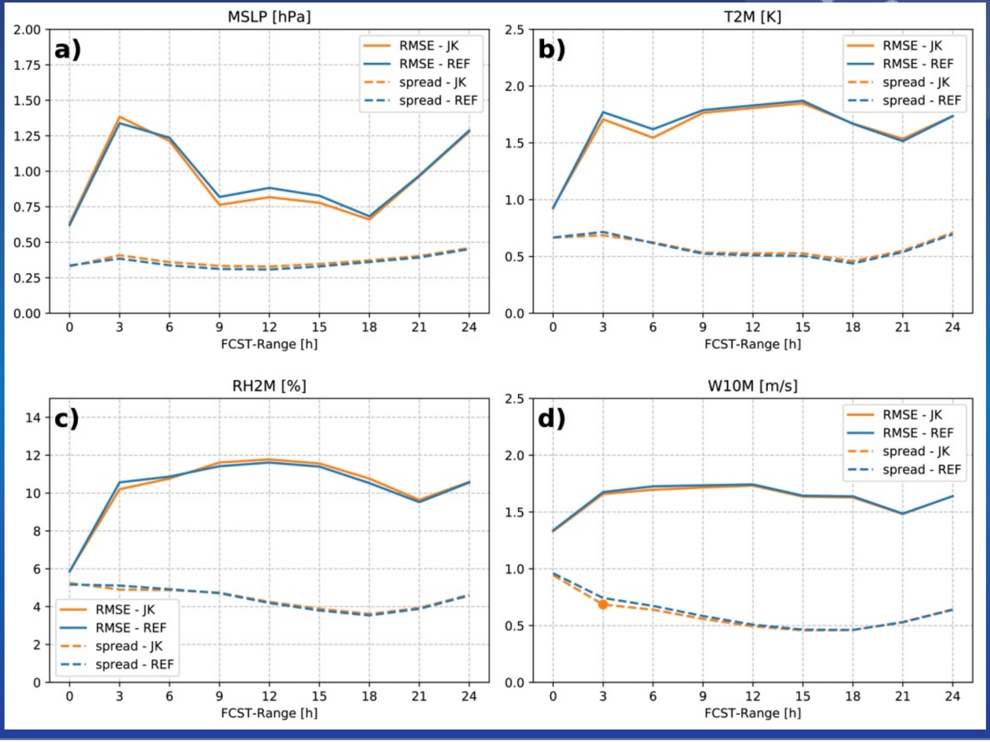
Results – upper air

- CRPS on
  500 and 850 hPa



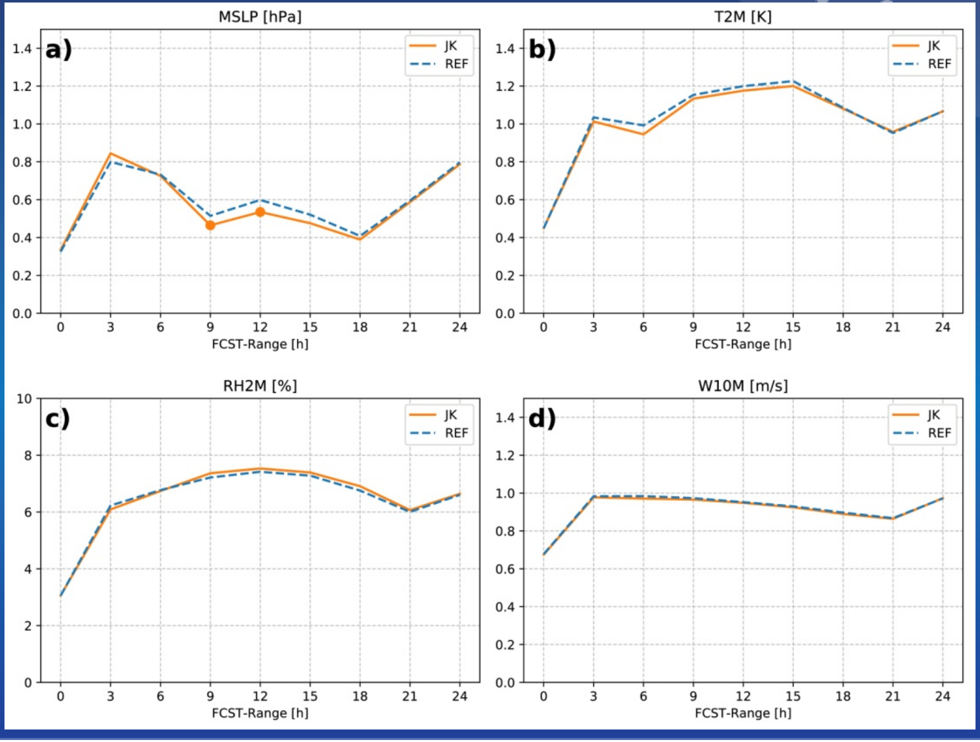
Results – surface

- RMSE and SPREAD

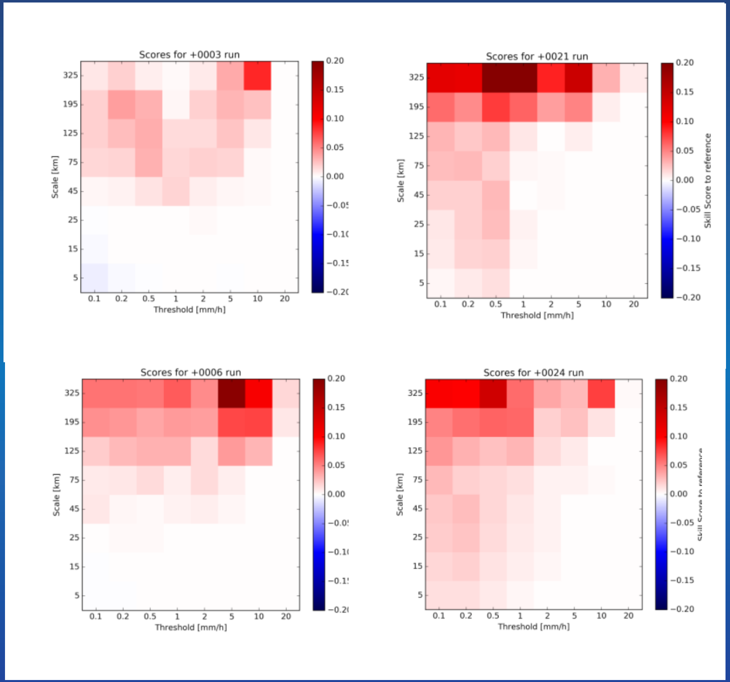


Results – surface

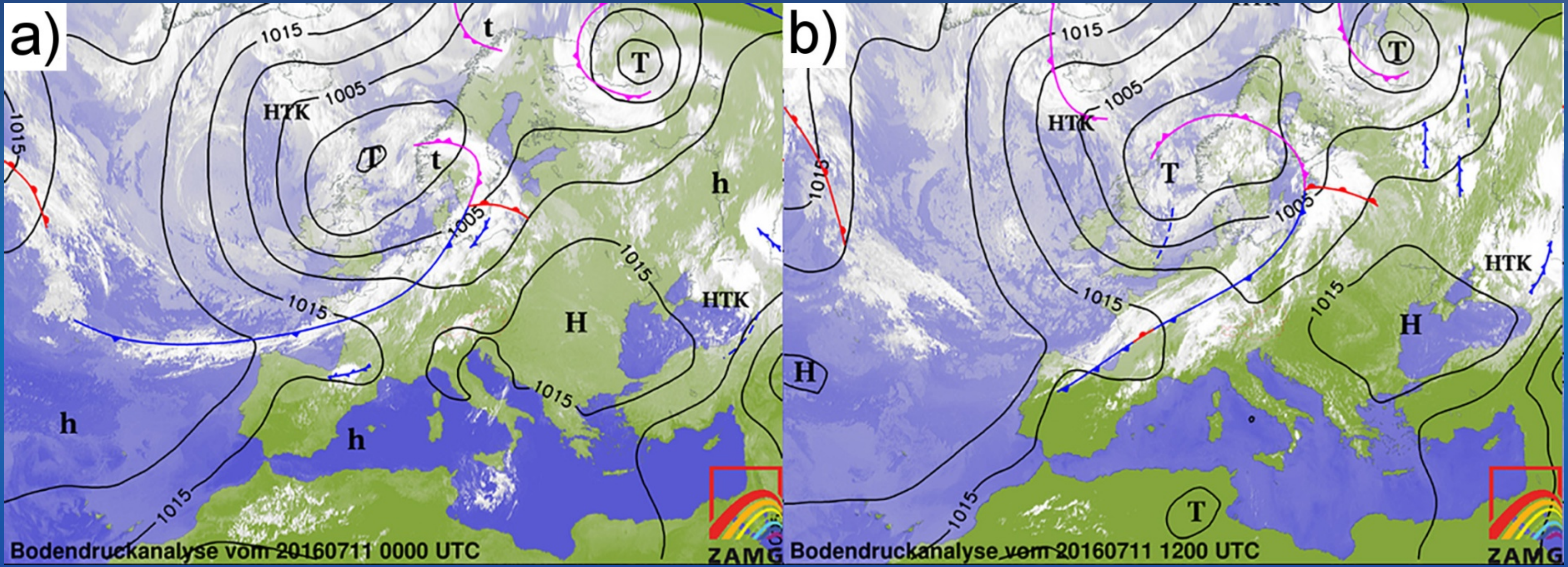
- CRPS



FSS – precipitation



Case study – 11 July 2016



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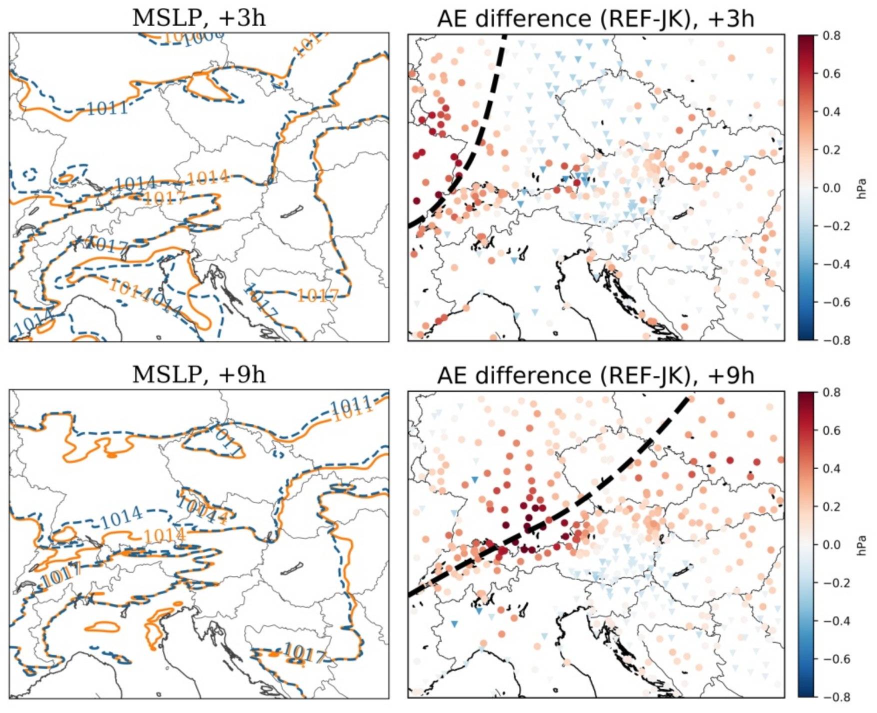

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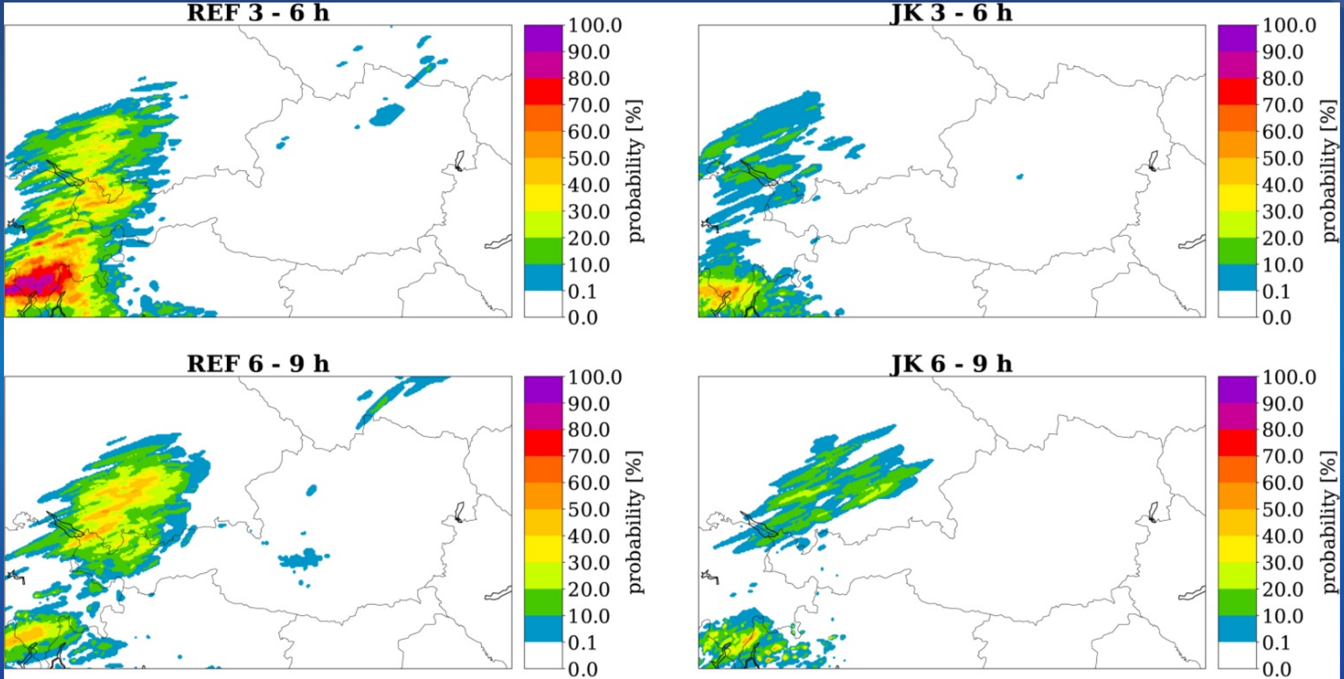

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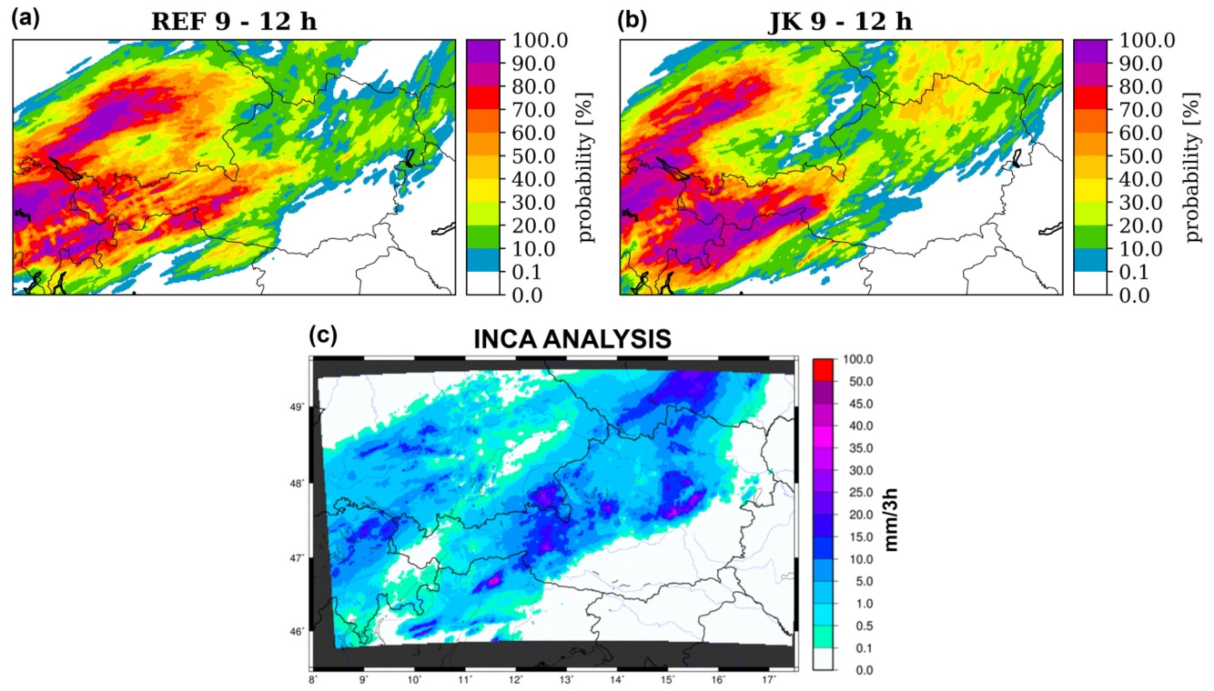

Conclusion

- Global model perturbations included into convection-permitting EPS
- Positive impact on upper air variables
- Positive impact on surface pressure and precipitation
- Better match between IC and LBC perturbations -> reduction of excessive spread
    - Keresturi, E, Wang, Y, Meier, F, Weidle, F, Wittmann, C, Atencia, A. Improving initial condition perturbations in a convection-permitting ensemble prediction system. *Q J R Meteorol Soc.* 2019; 1– 20. https://doi.org/10.1002/qj.3473

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