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LBC perturbations for a convection-permitting COSMO ensemble system

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Introduction

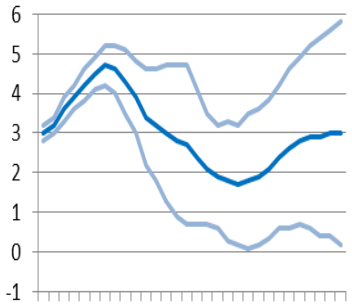
- 3 major uncertainty sources in LAM:
  - lateral boundary conditions (LBCs)
  - initial conditions
  - model physics
- Investigate 3 different methods to perturb the LBC
  - Downscale global EPS
  - Downscale global EPS perturbations
  - Downscale global climatological perturbations (Torn et al., 2006)
- Results shall give a hint which method(s) to use in a future COSMO-E (EPS and EDA) system at MeteoSwiss

COSMO-E Configuration

- Operational MeteoSwiss COSMO-2 setup (2.2km, no deep convection scheme)
- Nested directly into ECMWF EPS (32km/20km) and ECMWF DET (16km/10km) model
- 21 ensemble members, integrated out to +120h
- All members started from same operational COSMO-2 analysis
- No physics perturbations
- No obs assimilation

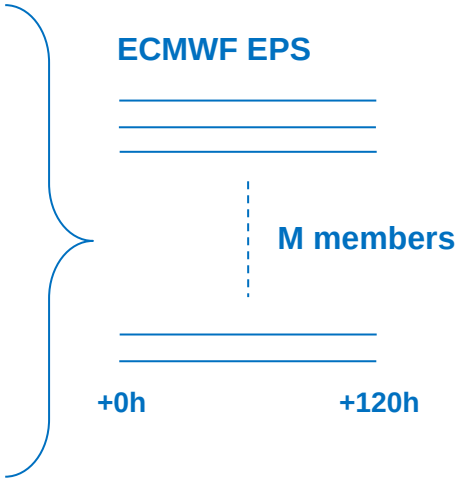
LBC Perturbation Methods

Method 1
«Downscale EPS»

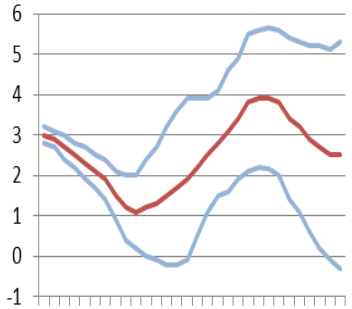


EPS
$\overline{EPS}$
EPS

$$X^m_{ijk} = \overline{EPS}_{ijk} + \Delta EPS^m_{ijk}$$



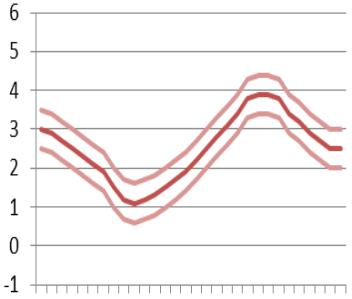
Method 2
«Downscale
EPS Perturbations»



EPS
DET
EPS

$$X^m_{ijk} = DET_{ijk} + \Delta EPS^m_{ijk}$$

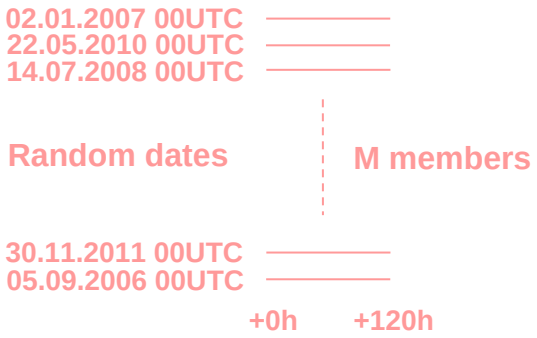
Method 3
«Downscale Clim.
Perturbations»



CLIM
DET
CLIM

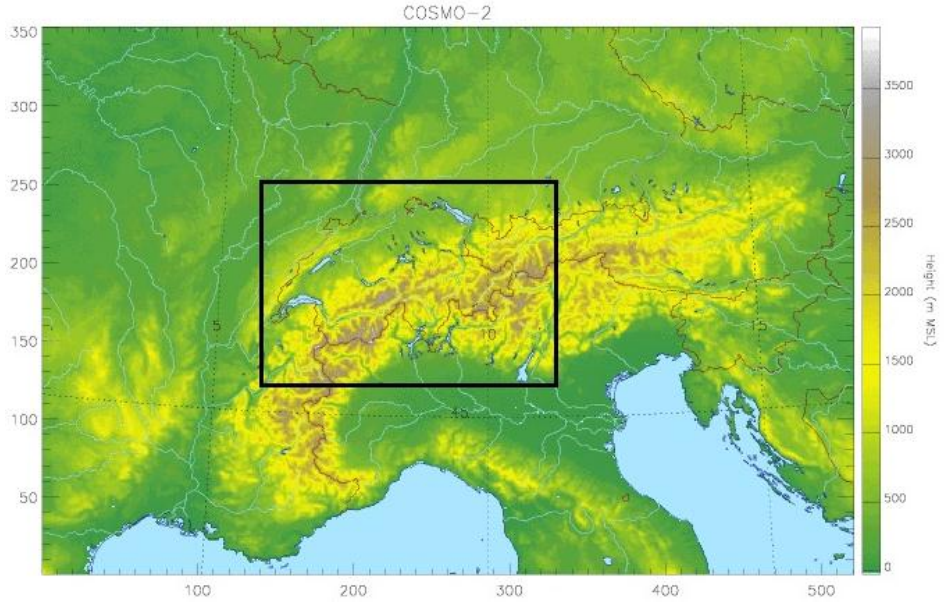
$$X^m_{ijk} = DET_{ijk} + \alpha \cdot \Delta CLIM^m_{ijk}$$

Climatological ensemble:
ECMWF analysis time series



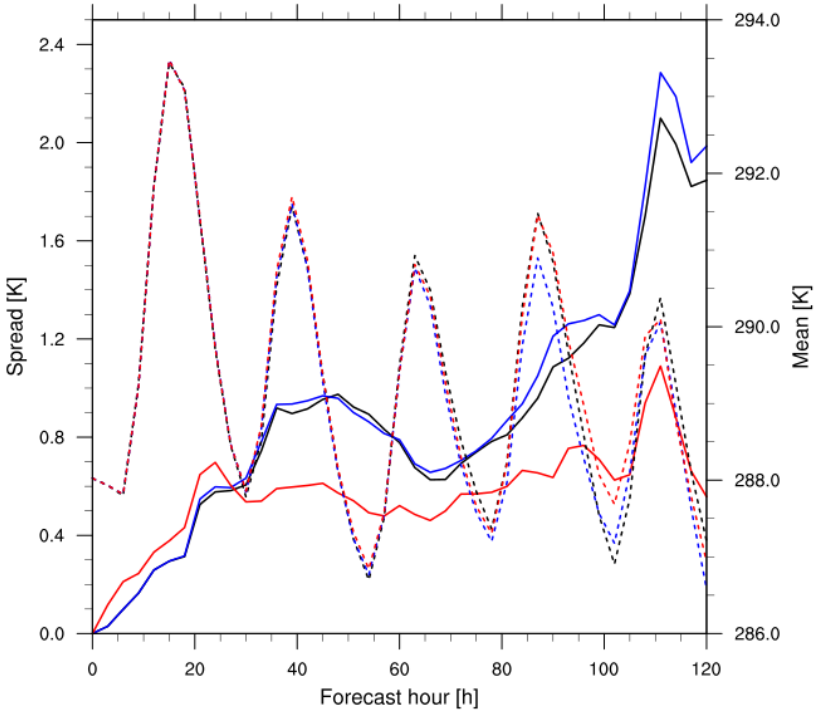
Ensemble Assessment

- Results are based on 4 case studies:
  - 2 summer cases (low advection, convection)
  - 2 autumn cases (high advection, large scale forcing)
- Compare temporal and spatial evolution of ensemble mean and spread of different methods

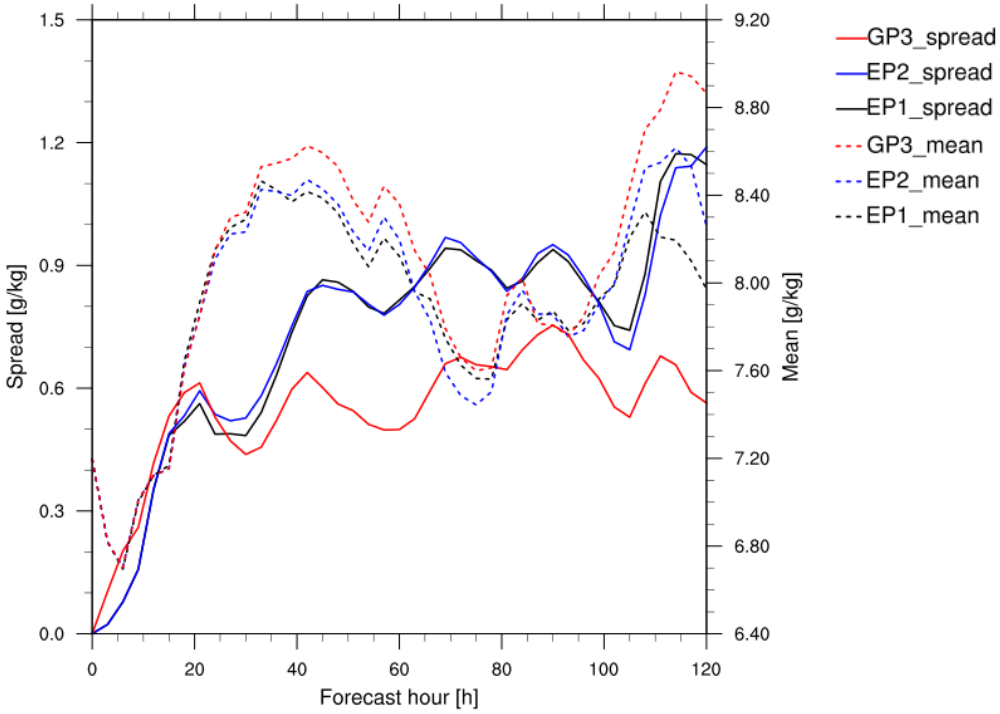


Temporal Evolution

Temperature

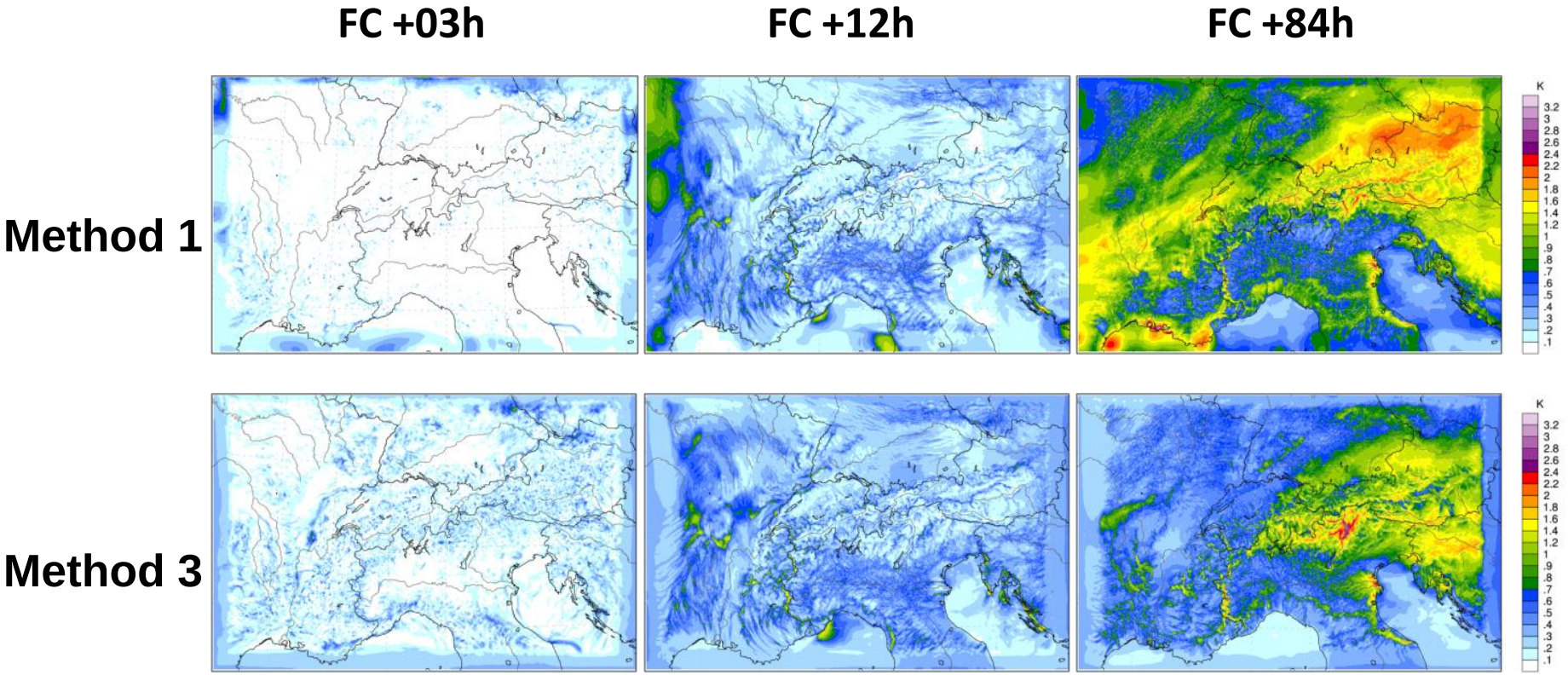


Specific humidity



Mean and spread, averaged over SWISS domain,
z = 0m-1500m (case 1)

Spatial Evolution



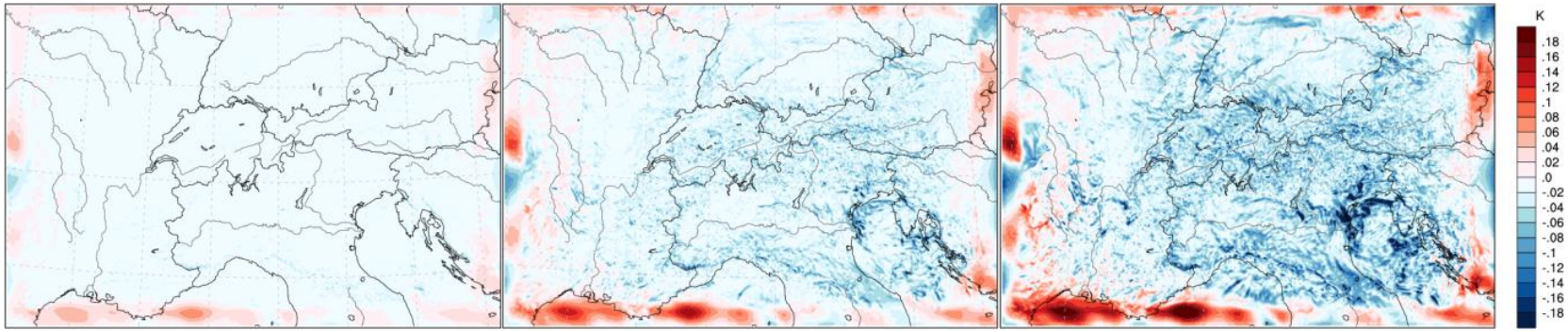
Temperature spread at 500m (case 1)

Can Method 3 be used for EDA?

- Torn et al. (2006) used method 3 for EDA in an idealized, regional ($\Delta x \approx 100$km) model environment
- How does it compare to method 1 in a high-resolution model in real case studies?

FC +01h **FC +02h** **FC +03**

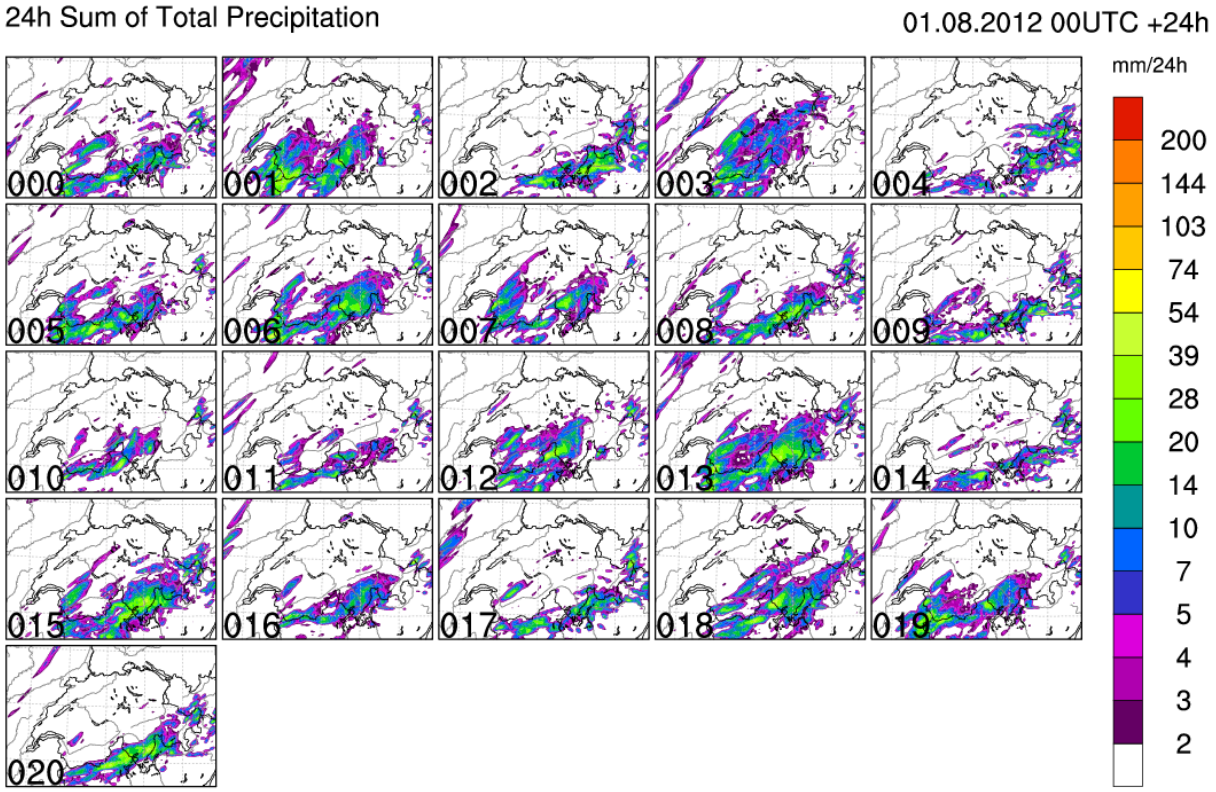
M1-M3



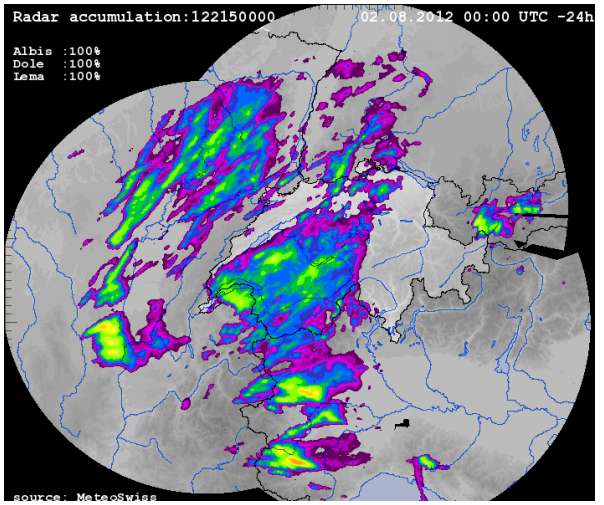
- Differences in spread, at +03h: < 0.07 K

Further results

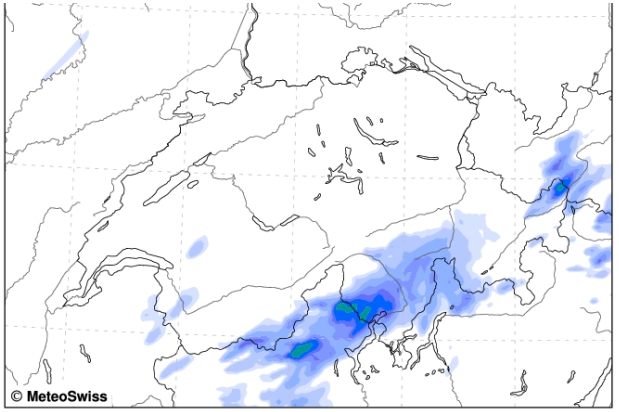
- Influence of COSMO-E strongest near surface
  - Upper level mainly downscaling of global model
- No significant model imbalances found (analysis of surface pressure tendencies)
- Sufficient to perturb T, U, V, QV (no large differences with additional perturbation of QI, QC, PP)
- Ensemble results are realistic in comparison with obs.



COSMO-E



Observation



COSMO-2

Conclusions

- **Generally small differences between EP1 and EP2 up to 40h**
- **Method 3 seems suitable for data assimilation, but**
  - **not flow-dependent**
  - **initially faster growth of spread**
    -> stronger gravity & sound waves?

- *Only four case studies -> to make general conclusions more cases have to be calculated*

Outlook

- Use method 2 for EPS and EDA:
  - Flow-dependent pert.
  - High-res. and more frequently updated ensemble mean than using only global EPS (4x vs. 2x per day)
  - If underdispersive: Use scaled perturbations to enhance ensemble spread
- Potential use of method 3:
  - Only for EDA
  - Advantageous if more members are required than provided by global EPS