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More spread needed! — LBCs? Model errors beyond SPPT?

Spread-error relations for the new high-resolution NWP ensemble prediction system COSMO-E

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Conclusions

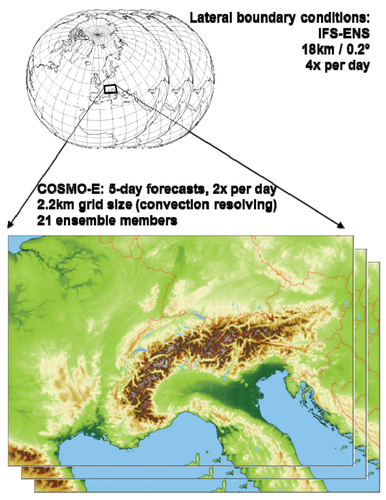
- COSMO-E is moderately overconfident / underdispersive.
- Lack of ensemble spread is most pronounced for winter or strong synoptic forcing, for the lower troposphere, for short lead-times, and for humidity and temperature.
- For longer lead-times and the upper troposphere the ensemble spread matches the forecast error fairly well.
- Stochastic Perturbation of Physical Tendencies (SPPT) scheme significantly increases the ensemble spread especially in the lower troposphere in summer; impact of SPPT on forecast errors (BIAS, STDE, and RMSE) is small but mostly reducing errors.
- Largest contribution to SPPT is from the PBL / turbulence parameterization scheme.

Outlook & Questions

- How can the ensemble spread be further increased, especially in the lower troposphere and for strong synoptic forcing?
- Are lateral boundary conditions from IFS-ENS underdispersive, especially for short lead-times?
- How should processes be perturbed that are explicitly simulated by the model (i.e., not through a parameterization scheme, like, e.g., convection) as models become higher resolved (and hence more explicit)?

COSMO-E, operational at MeteoSwiss since May 2016

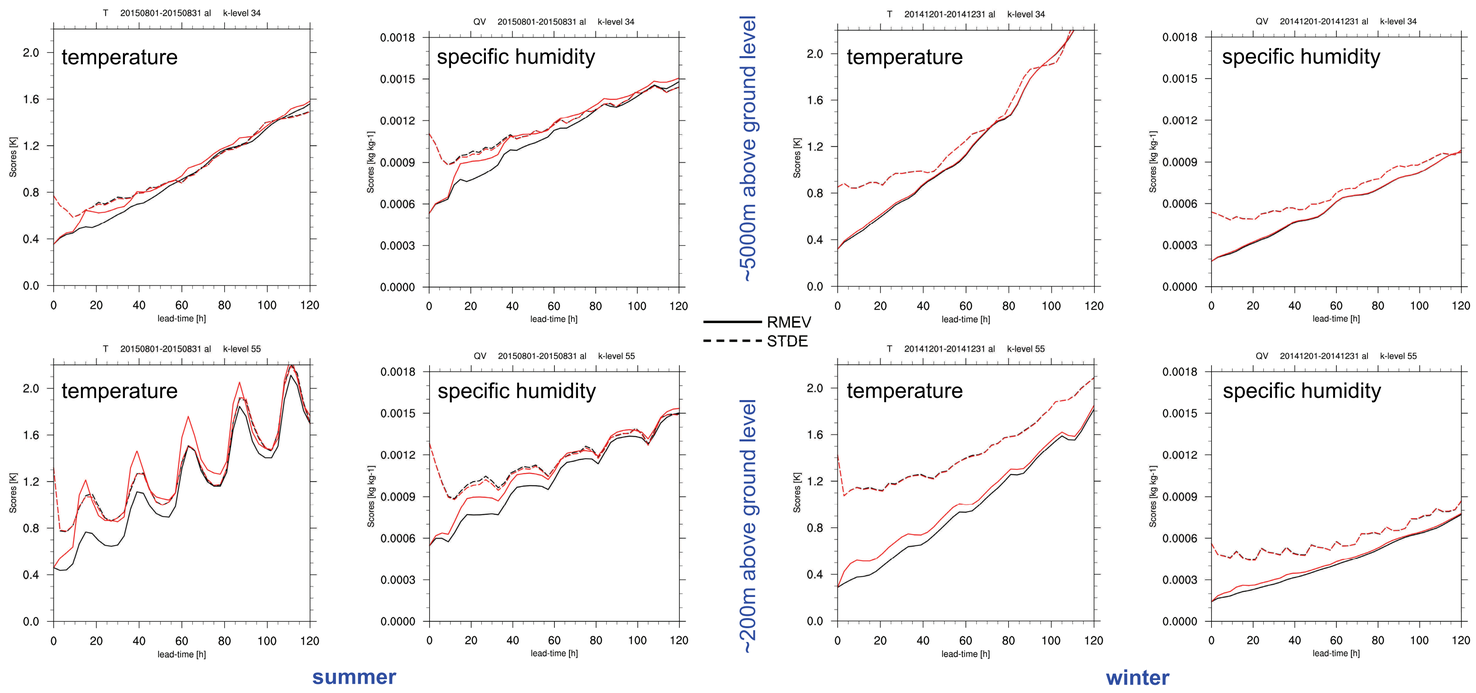
- High-resolution NWP ensemble prediction system for the Alpine area
  - convection-resolving resolution (2.2km mesh-size); 21 members; runs twice a day up to +120h
  - Initial conditions (ICs) from ensemble data assimilation system (LETKF)
  - Lateral boundary conditions (LBCs) from IFS-ENS
- Perturbations
  - ICs: from ensemble data assimilation (LETKF; first 20 out of 40 members)
  - LBCs: from IFS-ENS (ctrl plus first 20 out of 50 members)
  - Model errors: Stochastic Perturbation of Physical Tendencies (SPPT)



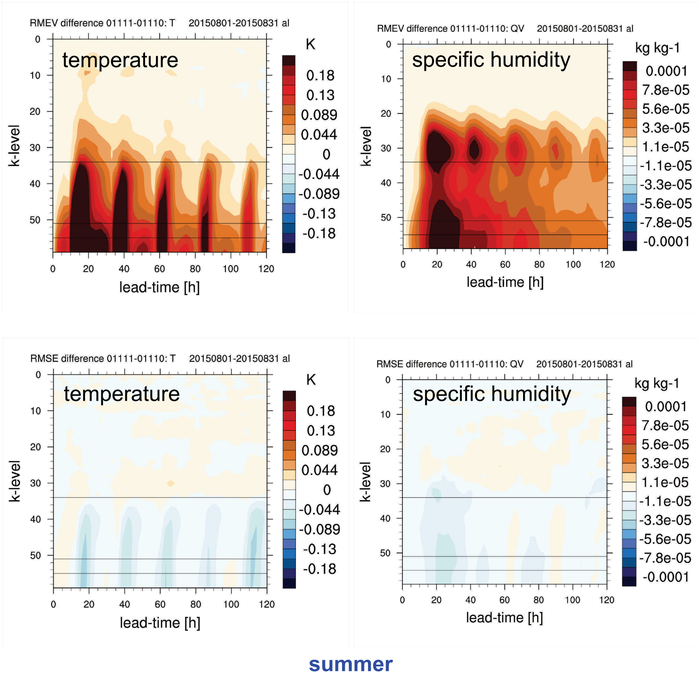
SPPT experiments

- COSMO-E, setup as used for operations (left), except for the initial conditions: ICs and IC perturbations for the atmosphere from downscaled IFS-ENS. For the soil, ICs from a deterministic COSMO-E analysis based on the nudging scheme; no IC perturbations for the soil.
- SPPT switched off vs SPPT switched on. SPPT settings (same as used for operations):
  - random numbers with σ=1.0 but limited to ±0.8
  - spatial / temporal correlation length: 5° / 6hrs
  - no tapering in the boundary layer

SPPT experiments for Aug 2015 and Dec 2014

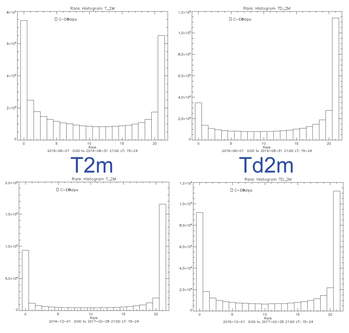


Domain averaged spread (RMEV, full line) and error (STDE, dashed line) as a function of lead-time for temperature and specific humidity against a deterministic analysis for two COSMO-E experiments with the SPPT scheme switched off (black) and on (red). Top (bottom) row shows scores for a model level in the upper troposphere (lower troposphere), left (right) two columns scores for summer (winter).



Difference of domain averaged spread (ΔRMEV, top row) and full error (ΔRMSE, bottom row) as a function of lead-time and model level for temperature and specific humidity against a deterministic analysis for COSMO-E experiments with the SPPT scheme switched on and off, respectively.

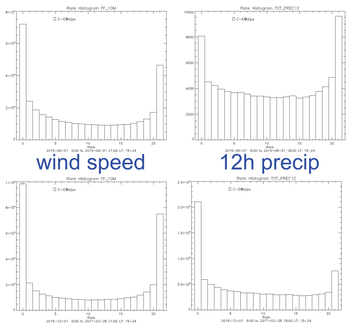
Seasonal verification for JJA 2016 and DJF 2016/2017



JJA 2016

Rank histograms for 2m temperature (far left), 2m dew point temperature (left), 10m wind speed (right), and 12h precipitation sum (far right) against surface observations (no observation error included) averaged over the full domain and the lead-time interval +15h to +24h. Top (bottom) row shows rank histograms for JJA 2016 (DJF 2016/2017).

DJF 2016/2017



Ongoing work

- Case studies for different large-scale forcing situations (Klasa et al., 2017a).
- Sensitivity studies with modified perturbations at the lateral boundaries (Klasa et al., 2017b).
- Operational implementation of optimised selection of lateral boundary conditions (Westerhuis, 2016).

References

Klasa, C., Arpagaus, M., Walser, A., and Wernli, H., 2017a: "An evaluation of the convection-permitting ensemble COSMO-E for three contrasting precipitation events in Switzerland", *submitted to QJRMS*
Klasa, C., Arpagaus, M., Walser, A., and Wernli, H., 2017b: "Scale dependency of model and boundary condition error" (tentative title), *in preparation*
Westerhuis, S., 2016: "Ensemble member selection for COSMO-E initial and boundary conditions", Master thesis, *downloadable from http://www.gl.ethz.ch/people/person-detail.html?persid=171208*

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