Numerical Weather Prediction at MeteoSwiss

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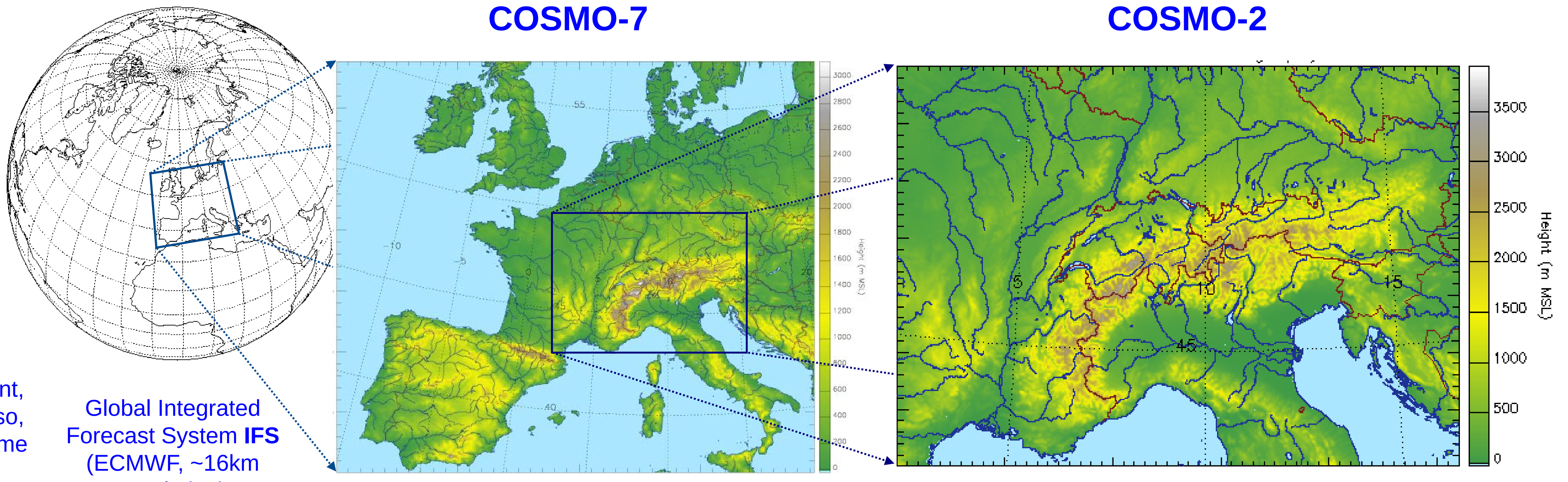
Swiss implementation of the COSMO-Model

- **Prognostic variables**
  pressure, 3 wind components, temperature, specific humidity, cloud water, cloud ice, rain, snow, turbulent kinetic energy (TKE), COSMO-2: also graupel
- **Coordinates** general terrain-following height-based vertical levels, Lorenz staggering; Arakawa-C, rotated Lat/Lon horizontal grid
- **Dynamics** 2-timelevel 3rd order Runge-Kutta
- **Physics**
  bulk microphysics for atmospheric water content, multilayer soil module, radiation, turbulence, sso, COSMO-7: Tiedtke mass flux convection scheme
  COSMO-2: explicit deep convection
- **Computers**
  2 Cray XE6 (production / backup & development) at Swiss National Supercomputing Centre, CSCS
  144 / 336 AMD 2.1 GHz MagnyCour processors with 1728 / 4032 computational cores
  Together, the systems can reach a peak performance of 50 TFlops.
- **Time to solution**
  27 minutes for 33h COSMO-2
  Effective performance 450 Gflops (5% of peak)

COSMO-7 COSMO-2



Global Integrated Forecast System **IFS** (ECMWF, ~16km resolution)

COSMO-7 domain (maximum height at 3140m).

COSMO-2 domain (maximum height of 3944m).

Mesh size	3/50°, **~6.6km**	1/50°, **~2.2km**
Domain	393 x 338 x 60 = 7'970'040 grid points	520 x 350 x 60 = 10'920'000 grid points
Forecasts	+72h at 00, 06 and 12 UTC	+33h at 00, 06, 09, 12, 15, 18, 21 UTC, +45h at 03 UTC
Boundary conditions	Hourly update from IFS	Hourly update from COSMO-7
Initial conditions	Newtonian relaxation (nudging) to surface and upper air observations, intermittent cycle of 3h assimilation	Same as COSMO-7, but with use of radar data over Switzerland (latent heat nudging)

KENDA: LETKF Experiments

Daniel Leuenberger

KENDA

- Kilometric ENsemble-based Data Assimilation (KENDA) using the Local Ensemble Transform Kalman Filter (LETKF, Hunt et al., 2007, Reich et al., 2011). Will replace current nudging scheme
- MeteoSwiss limited-area ensemble prediction system for Alpine domain based on COSMO with 2.2 km mesh size
- Hourly update cycle, 40 members
- LBC from ECMWF-ENS and ECMWF-HIRES

EXPERIMENTS

- Analysis period: 5.6.2014, 00UTC – 15.6.2014 ,00UTC
- LETKF
  - Adaptive multiplicative covariance inflation and localisation
- LETKF_RTPP
  - Additional use of relaxation to prior perturbations (RTPP, Whitaker and Hamill, 2012) to account for model error
- LETKF_RTPP_W_SO
  - Additional soil moisture perturbations to account for low-level model error
- All experiments use the same conventional observations (TEMP, AIREP, WIND-PROF and SYNOP, p_s only) and the same LBC

RESULTS

- Innovation statistics has been calculated against TEMP observations of 21 radiosonde stations (Figure 1)
- RTPP increases spread in all variables across whole atmosphere and decrease low-level first guess wind RMSE
- Soil moisture perturbations further increase spread and decrease first guess RMSE, particularly in wind and humidity
- Encouraging results with potential for further improvements

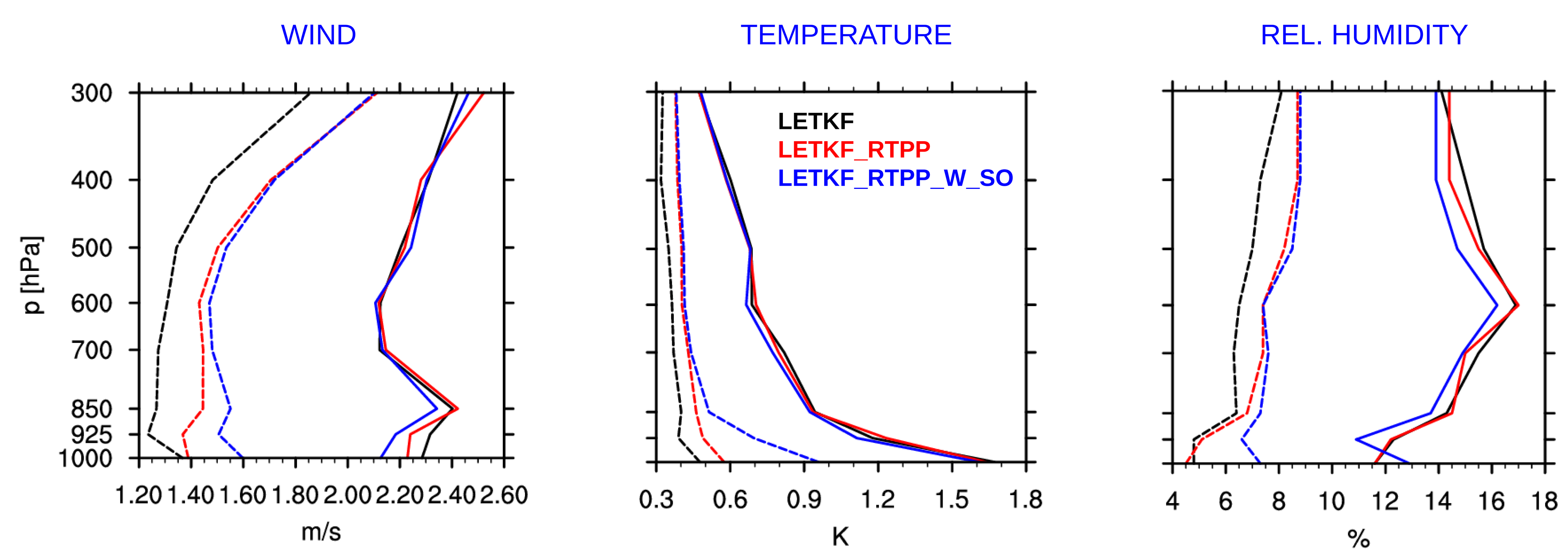


Figure 1) Ensemble mean first guess RMSE (solid) against TEMP obs and ensemble first guess spread (dashed)

References

Hunt, B. et al., 2007: Efficient data assimilation for spatiotemporal chaos: A local ensemble transform Kalman filter. *Physica D*, **230**: 112-126
Reich, H. et al., 2011: LETKF for the non-hydrostatic regional model COSMO-DE, *COSMO Newsletter*, **11**, available from www.cosmo-model.org
Whitaker J. and Hamill, T., 2013: Evaluating Methods to Account for System Errors in Ensemble Data Assimilation, *Mon.Wea.Rev.*, **140**, 3078-3089

Outlook

- Assimilate Td2m and T2m to decrease low-level temperature errors
- Add radar sfc rain rates to assimilation using Latent Heat Nudging (LHN)
- Run deterministic analysis with 1.1km mesh size

Neighborhood verification with radar and satellite measurements

Thomas Leutert, Daniel Leuenberger, Francis Schubiger

Goal: insight of the diurnal convection in high spatial and temporal resolution over the Alps

- **Observations (measurements):**
  - **CombiPrecip**: **hourly precipitation** estimates from the radar composit of the 4 swiss radars and 450 raingauges by spatio-temporal co-kriging
    pixel resolution: 1 km
  - **METEOSAT-8 data**: infrared 10.8µm channel of MSG SEVIRI -> **brightness temperature**
    pixel resolution: 5 km
- **Models** (COSMO-1 **[1.1km], COSMO-2 [2.2km], COSMO-7 [6.6km]):**
  00 UTC forecast up to +24h
  - **Precipitation:** 1h- and 3h-sums
  - **brightness temperature:** LMSynSat product (from NWP-SAF; RTTOV version 7)
- **Period:** Summer 2014
- **Neighborhood methods:**
  - Fractions Skill Score [FSS]
    -> see results in the third column
  - Upscaling [UP with ETS]
- **Mean diurnal cycle**:
  -> see results in the fourth column

Brightness Temperature
mean over all 24h for Summer 2014

- The convection-permitting models COSMO-1 and COSMO-2 give better scores than COSMO-7.
- COSMO-1 gives the best FSS values for all scales and thresholds < 240 K, i.e. for high (deep convective) clouds.

Precipitation sums
3-hourly sums up to +24h for Summer 2014

- High precipitation amounts (5 and 10 mm/3h) show the best scores in COSMO-1.

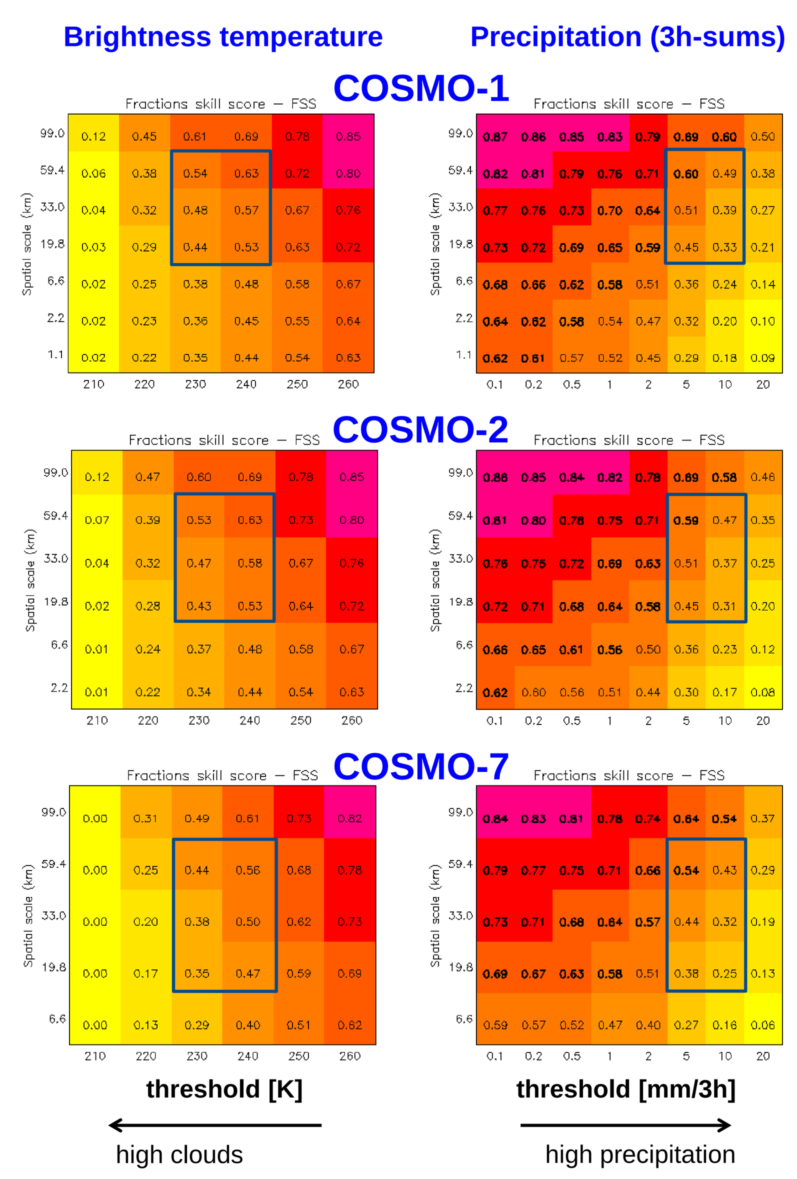
Diurnal cycle for June 2014

- COSMO-1 and COSMO-2 are much better in timing and amplitude than COSMO-7, however overestimation of clouds and precipitation during night and morning.

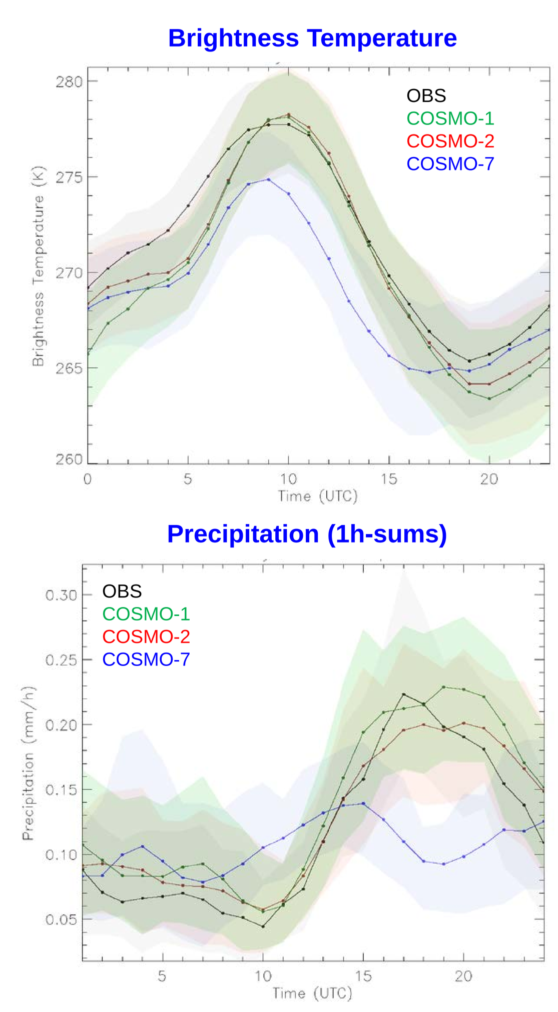
Summary:
Brightness temperature of:
- **SEVIRI 10.8 µm channel of METEOSAT and**
- **COSMO simulated LMSynSat**

can well serve as proxy for convective clouds, and has the potential to complement precipitation for the spatial verification of convective processes.

Fractions Skill Score in Summer 2014



Mean diurnal cycle June 2014



shaded area represents the range between the 10th and 90th percentile of a 100 days bootstrapping