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Numerical Weather Prediction at MeteoSwiss

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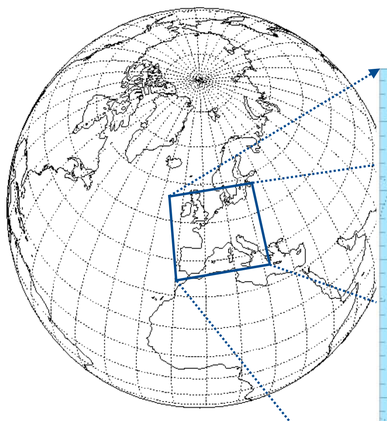
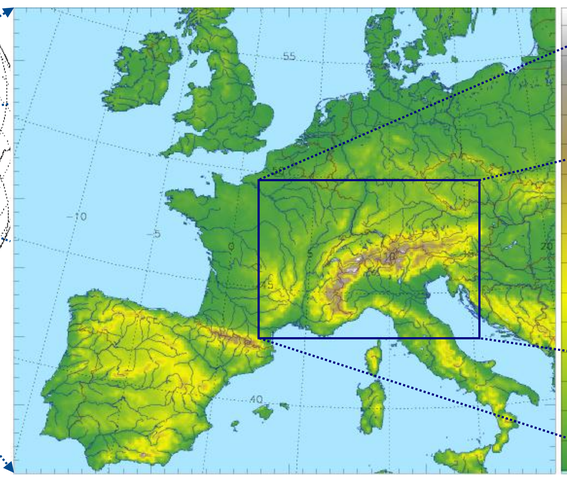
Swiss implementation of the COSMO-Model

- **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 processing 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)



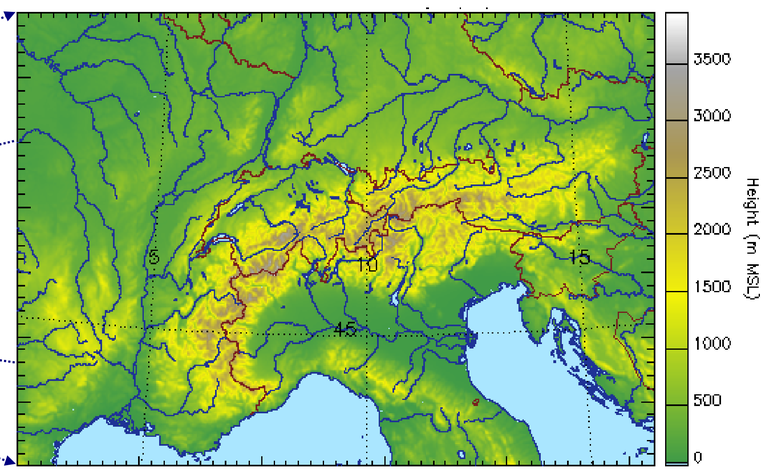
Global Integrated Forecast System **IFS** (ECMWF, ~16km resolution)

COSMO-7



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

COSMO-2



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)

COSMO-E: Experiments with SPPT

André Walser, Daliah Maurer

COSMO-E

- MeteoSwiss limited-area ensemble prediction system for Alpine domain based on COSMO; operational in 2016
- Convection-permitting resolution (2.2 km mesh size)
- 21 members with 120h forecast range
- Driven by IFS-ENS
- Initial condition (IC) perturbations from ensemble based data assimilation cycle (LETKF)

Experimental setup with SPPT

- SPPT: stochastic perturbation of physics tendencies
- Implemented into COSMO by Torrisi based on Buizza et al. (1999) and Palmer et al. (2009)
- 2D random-pattern to perturb physics tendencies for U, V, T, and QV with correlations in time and space (Fig. 1)
- No IC perturbations yet (IC: COSMO-2 analysis)

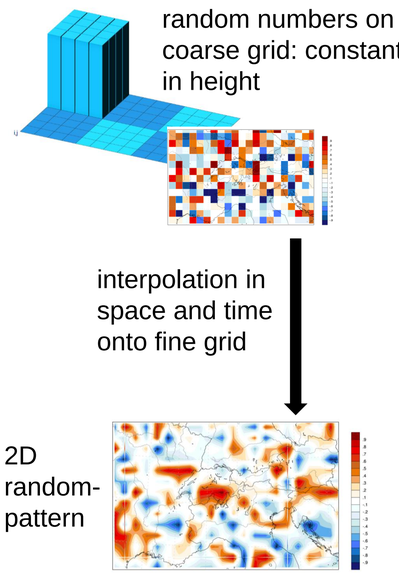


Figure 1) Procedure to generate 2D random-pattern on model grid

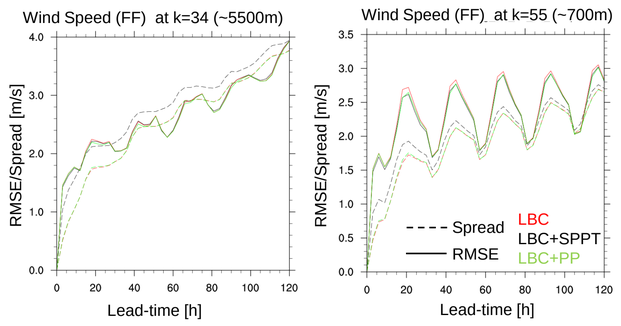


Figure 2) RMSE against analysis versus ensemble spread averaged over domain and time period for wind speed at (left) ~5500m and (right) ~700m above ground

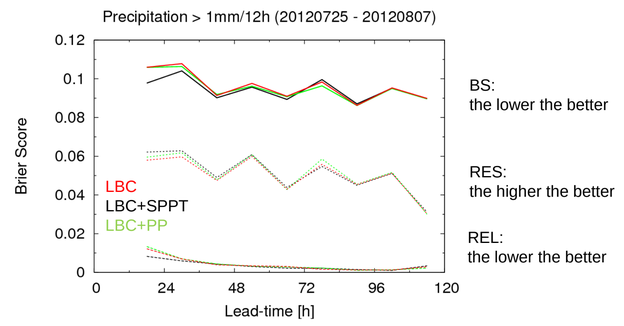


Figure 3) Brier Score (BS), Resolution (RES) and Reliability (REL) against SYNOP observations

Verification

- 25.07.-07.08.2012 (00 UTC runs)
- 3 setups:
  LBC perturbations only
  LBC+SPPT perturbations
  LBC+PP perturbations
  PP are parameter perturbations used for COSMO-DE-EPS
- Focus on lead-times beyond 24h due to lack of IC perturbations

Results

- The model runs stable even if no tapering for perturbation is applied at low model levels
- Nevertheless, spread near surface clearly too small, but rather too large in upper-air (Fig. 2)
- Comparison with LBC perturbations only and parameter perturbations (PP) experiments show similar results, but impact of SPPT is larger and scores slightly better as compared to PP (Fig. 2 and 3)
- SPPT does not degrade quality of members (in terms of bias and STDE), except for large space and time correlation and largest random numbers

References

Palmer, T.N., et al., 2009: Stochastic Parametrization and Model Uncertainty. Technical Memorandum ECMWF.
Buizza, R., et al., 1999: Stochastic representation of model uncertainties in the ECMWF Ensemble Prediction System. Q. J. R. Meteorol. Soc., 125, 2887–2908.

Outlook

- Future development aims at generation of more spread near surface without increasing upper-air spread
- Add IC perturbations from ensemble based data assimilation cycle (LETKF)

COSMO-1: New external parameters

Jean-Marie Bettems, Martina Messmer

COSMO-1

- MeteoSwiss deterministic forecasts for Alpine domain based on COSMO; operational in 2016.
- Very high resolution (1.1 km mesh size).
- Rapid update cycle of short range forecasts (8x 24h); on demand mode.

New external parameters: motivation, status

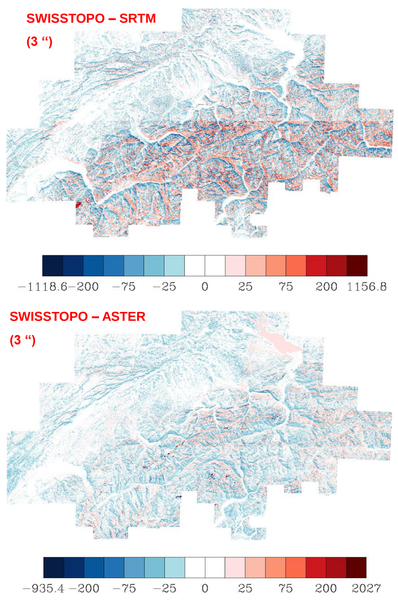
- High resolution topography is critical for a good representation of near surface weather over the Alps.
- State of the art and high resolution information on land use and soil texture are required for a faithful representation of observed high spatial heterogeneities.
- Software implementation is ready, tuning and sensitivity study are pending.

	GLOBE	ASTER	SRTM	SWISSTOPO
Resolution	30 arc-sec (~1km)	1 arc-sec (~30m)	3 arc-sec (~90m)	25 meters
Lat range	90° N – 90° S	83° N – 83° S	60° N – 58° S	whole CH
Projection	WGS84	WGS84	WGS84	CH-1903
Method	Patchwork of multiple data	Satellite / stereoscopic IR	Space Shuttle / radar	

Table 1) Digital Elevation Model : GLOBE is the COSMO default, ASTER and SRTM are candidates for new high resolution data sets, SWISSTOPO is used as reference.

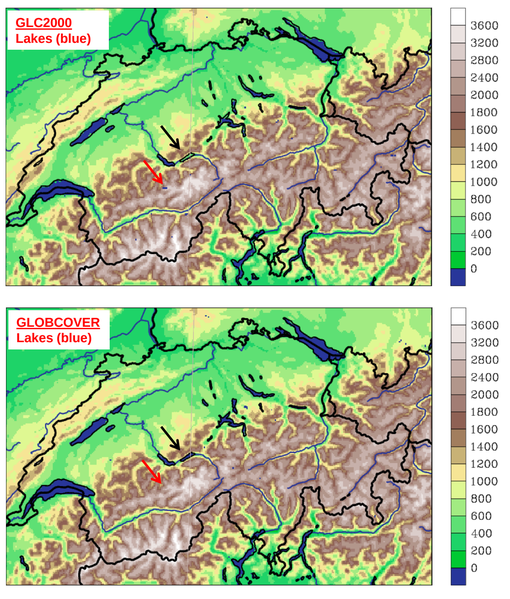
Topography

- Two high resolution data sets are evaluated (see Table 1).
- Federal Office of Topography data (SWISSTOPO) are used as reference.
- ASTER is more accurate than SRTM over Swiss Alps, as seen below.



Land use: lakes

- GLC2000 is the COSMO land use default, GLOBCOVER is considered as alternative.
- Lakes derived from GLOBCOVER are much more accurate: spurious lakes disappear (red arrow), real lakes are correctly filled up (black arrow).



Soil texture, glaciers

- FAO is the COSMO soil texture default, Harmonized World Soil data (HWSD) is considered as alternative.
- Finer and more realistic soil structures are observed with HWSD.
- Glaciers derived from HWSD are much more accurate (although they partly represent rock).