Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

ETH zürich

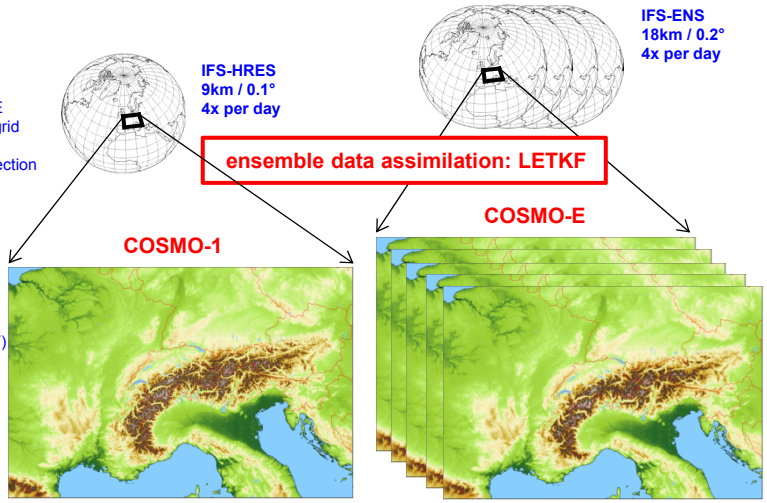
C2SM Center for Climate Systems Modeling

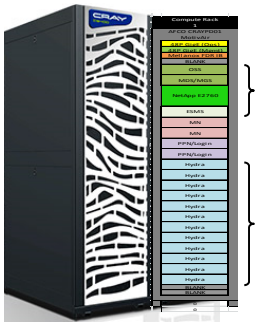
CSCS
Centro Svizzero di Calcolo Scientifico
Swiss National Supercomputing Centre

Numerical Weather Prediction at MeteoSwiss

Philippe Steiner
Federal Office of Meteorology and Climatology MeteoSwiss, Zurich, Switzerland

- **Prognostic variables**
  pressure, 3 wind components, temperature, specific humidity, cloud water, cloud ice, graupel, rain, snow, turbulent kinetic energy (TKE), 4 different pollen species
- **Coordinates** general terrain-following height-based vertical levels (SLEVE for COSMO-1), Lorenz staggering; Arakawa-C, rotated Lat/Lon horizontal grid
- **Dynamics** 2-timelevel 3rd order Runge-Kutta, Bott 2nd order for tracer advection
- **Physics**
  bulk microphysics for atmospheric water content, multilayer soil module, radiation, turbulence
  COSMO-E: - shallow Tiedtke mass flux convection scheme
  - model uncertainty: SPPT
- **Computers**
  2 CS Storm from Cray Hybrid system
  12 computational nodes per rack
  (using 50% of rack space) with:
  - 8 dual GPU cards (Tesla K80)
  - 2 Intel Haswell (2.6GHZ, 12-core)
- **Time to solution**
  ~1:40h after analysis time (AT) for +33h COSMO-1
  ~4h after (AT) for +120h disseminated COSMO-E





Mesh size	1/100°, **~1.1km**, Δt = 10 s	1/50°, **~2.2km**; 20 + 1 ensemble members
Domain	1158 x 774 x 80 = 71'703'360 grid points	582 x 390 x 60 = 13'618'800 grid points
Forecasts	+33h at 00, 06, 09, 12, 15, 18, 21 UTC +45h at 03 UTC	+120h at 00 and 12 UTC
Boundary conditions	Hourly update from IFS-HRES (0.1°)	Perturbations: IFS-ENS 18 & 06 UTC: • IFS-ENS control for control • IFS-ENS members 1-20 (out of 50)
Initial conditions	Newtonian relaxation (nudging) to surface and upper air observations, intermittent cycle of 3h assimilation 2017: LETKF (downscaling from 2.2km)	LETKF intermittent 1h assimilation cycle • LETKF mean for control member • 20 out of 40 members from LETKF

Member selection for COSMO-E initial and boundary conditions

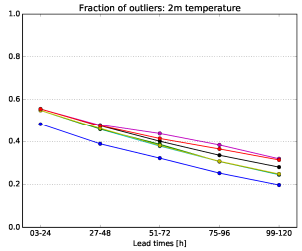
Stephanie Westerhuis, André Walser, Oliver Fuhrer

Questions:
- Is it possible to increase the COSMO-E forecast quality by using a smarter selection method than just using the first 20 perturbed LETKF and IFS-ENS members?
- How big is the difference in forecast quality between using best and the worst choice?

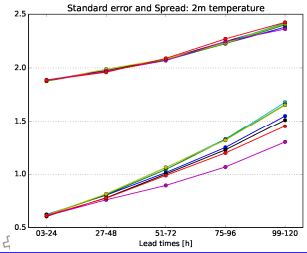
Method:
- Goal: Keep the "shape of the PDF"
- Problem: multidimensionality (grid-points, variables)
- reduce phase space and «make» it one-dimensional by standardization (normalization and scaling)
- similar approach used as in COSMO-LEPS clustering:
  - 3 variables: wind, temperature, humidity on model levels ~850, 700, 500 hPa at time steps +48 and +96h
  - Representative Member (RM) for every cluster

Experiments for LBCs:
- 19 forecasts (00 UTC) with strong synoptic forcing for +120h
- Control + 50 perturbed members driven by IFS-ENS
- Analyses from LETKF members 1-40 (+1-10 for members 41-50)
- Verification against SYNOP stations for COSMO-E model domain for 7 LBC selection configurations (all includes the control in addition):
  - full: all 50 perturbed members
  - rand: first 20 IFS-ENS members
  - clust_point: 20 RMs, point-wise standardization
  - clust_area: 20 RMs, area-wise standardization
  - clust_clima: 20 RMs, point-wise standarization using 30d
  - closet: 20 members with smallest distance to ensemble mean
  - leftest: 20 driest members
- full: proxy for the best selection
- closest & leftest: proxies for worst selection

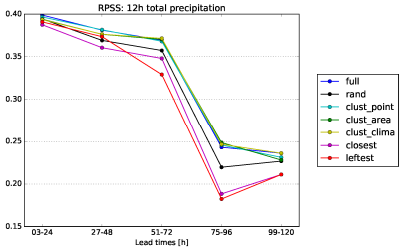
Outliers for T2m
- clustering reduces the outliers as compared to random choice by ~10% for day 5
- worst selection shows ~35% more outliers than clustering for day 5



Spread-Error for T2m
- heavily underdispersive for near-surface fields
- clustering helps to increase spread (even larger than full!)



Rank Probability Skill Score (RPSS) for 12h precipitation sums
- clustering comparable to full
- random choice ~5-10% lower score
- worst choice ~25% lower scores



Conclusions:
- sophisticated member selection like clustering for LBCs can improve COSMO-E forecasts significantly
- clustering is able to increase the spread for near-surface variables (most welcome!)
- random member choice can result in significantly worse forecasts with bad luck
- results insensitive to standardization method for clustering
- results sensitive to clustering time steps which allows an optimization for the preferred lead-time (not shown)
- benefit of sophisticated member selection for COSMO-E IC limited (not shown), probably due to the much smaller variety (i.e. spread) to chose from as compared to LBCs

MeteoSwiss
Operation Center 1
CH-8058 Zurich-Airport
T +41 58 460 91 11 www.meteoswiss.ch