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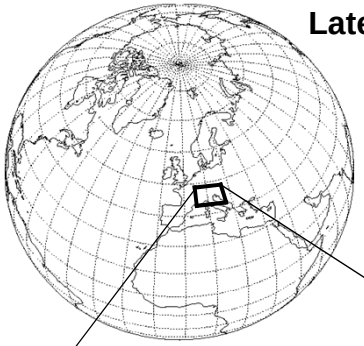
Eidgenössisches Departement des Innern EDI
Bundesamt für Meteorologie und Klimatologie MeteoSchweiz

Progress in setting up KENDA at MeteoSwiss

Daniel Leuenberger, Simon Förster and André Walser
MeteoSwiss

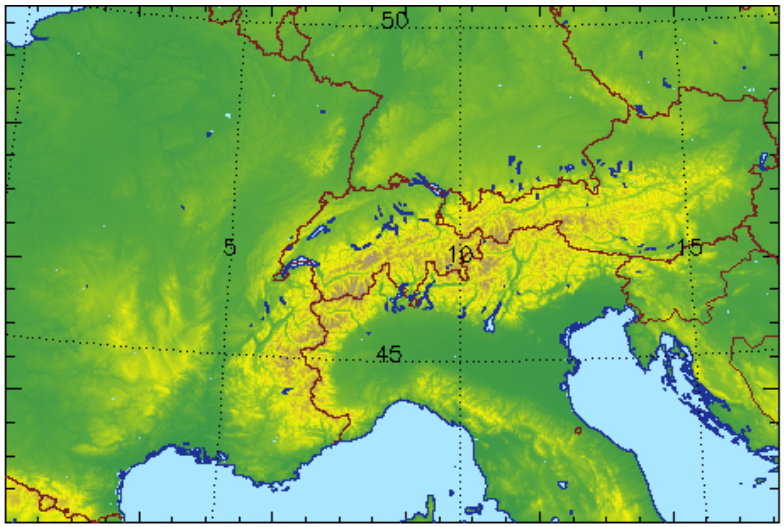
7.9.2015, COSMO General Meeting, Wroclaw, Poland

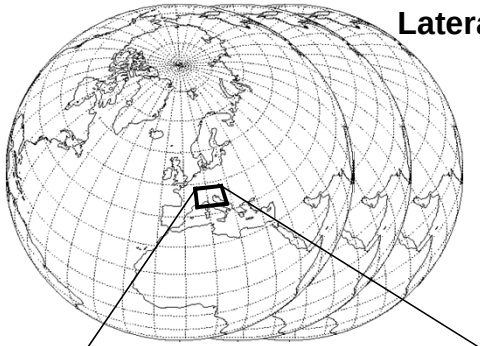
Next Generation MCH NWP System



Lateral boundary conditions:
IFS-HRES
8-10km
4x per day

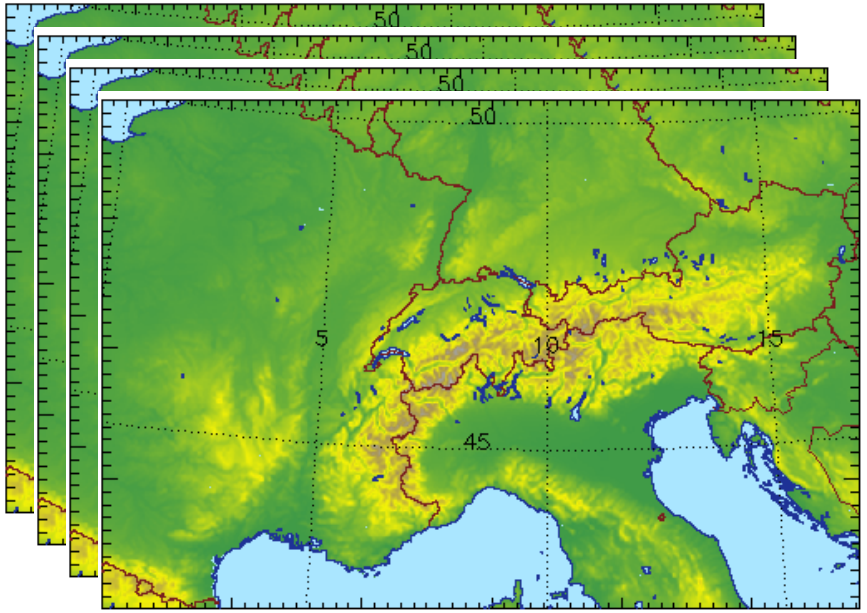
COSMO-1: 24h forecasts, 8x per day
1.1km grid size (convection permitting)





Lateral boundary conditions:
IFS-ENS
20km
4x per day

COSMO-E: 5 day forecasts, 2x per day
2.2km grid size (convection permitting)
21 ensemble members



Outline

- Introduction
- Experimental Setup
- KENDA Performance
  - Analysis
  - Deterministic forecasts
  - Ensemble forecasts
- Experiment with soil moisture perturbations
- Deterministic 1.1km analysis
- Summary and Outlook

Introduction

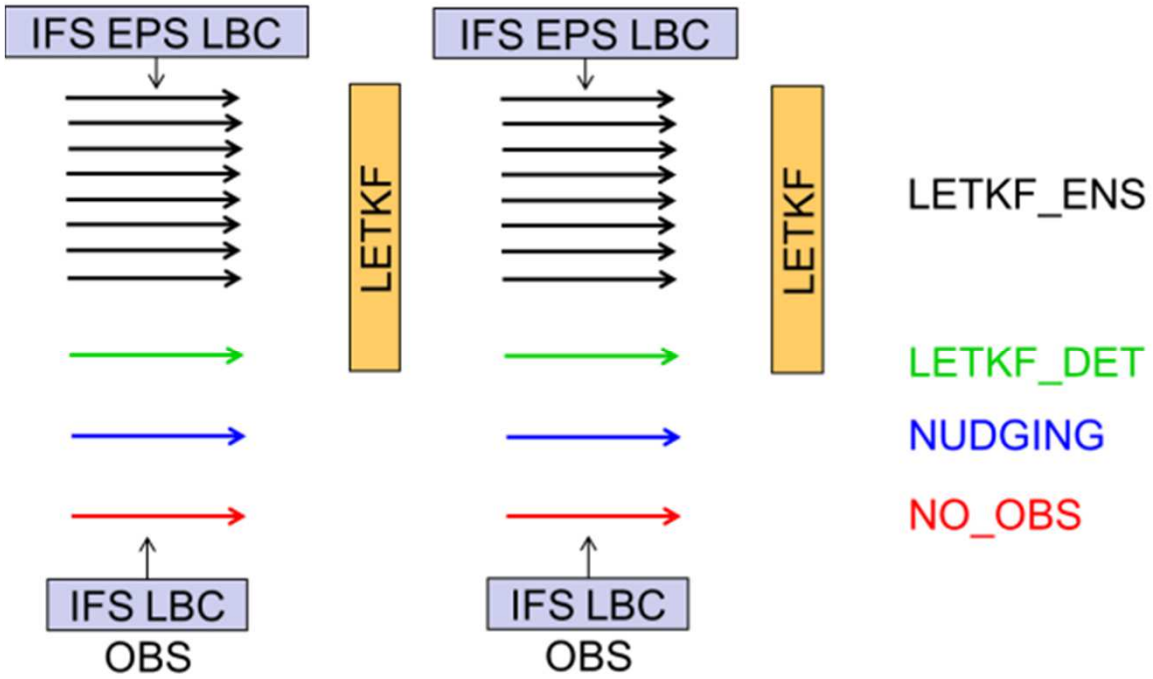
- Use of KENDA for
  - IC perturbations for COSMO-E
  - IC for deterministic COSMO-1

- Real-time assimilation cycle running since 11.1.2015
  - 40 ensemble members + deterministic analysis
  - 2.2km grid length

- Test forecasts (March and April 2015)
  - Deterministic 2.2km forecasts, comparison with nudging
  - COSMO-E ensemble forecasts, comparison with IC perturbations downscaled from ECMWF-EPS

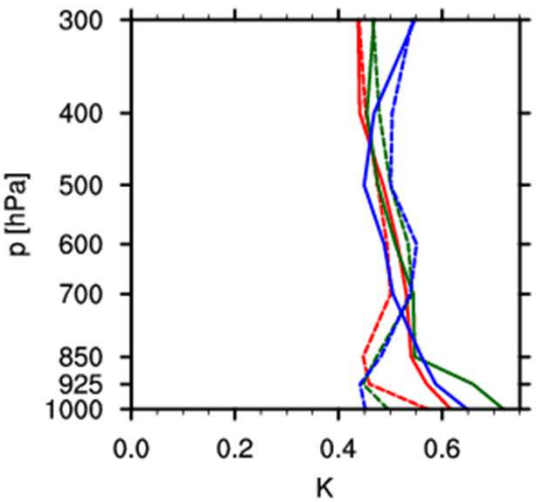
Real-time LETKF Assimilation Cycle

Analysis	Forecast	Type
LETKF	LETKF_ENS	Ensemble (40 members)
LETKF_DET	LETKF_DET	Deterministic
NUDGING	NUDGING	Deterministic
NO-OBS	NO-OBS	Deterministic

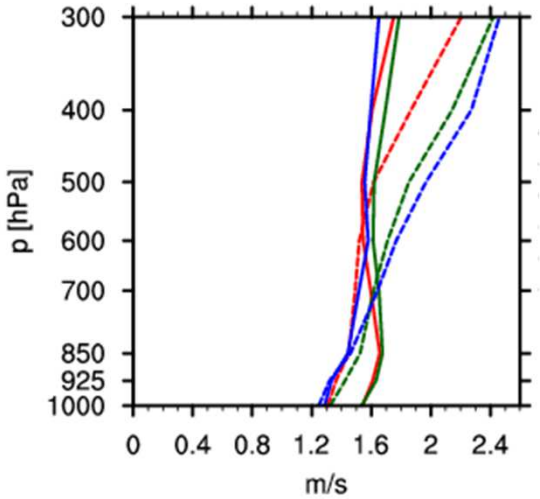


Seasonal LETKF Spread-Skill Relation

Temperature (AIREP)

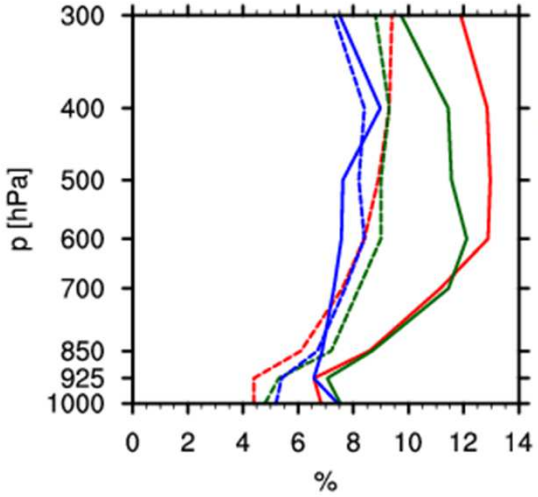


Wind speed (AIREP)

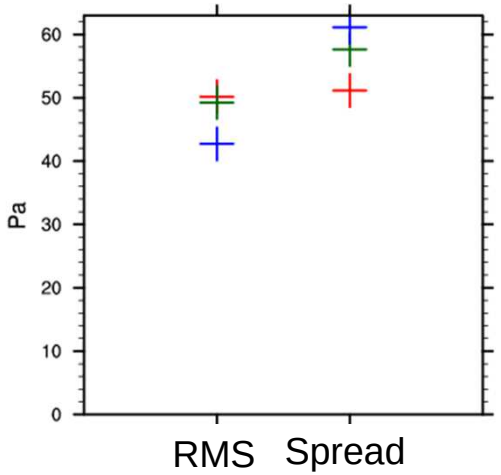


---- Spread
— RMS

Humidity (TEMP)



Ps (SYNOP)



Winter (JF)
Spring (MAM)
Summer (JJA)

Obs error is taken into account in RMS !

Deterministic Forecast Verification

SYNOP

Parameter	ME	STDE
Surf. Pres.	☑	☑
T 2m	☑	☑
Td 2m	◐	☒
DD 10m	☑	☑
FF 10m	☑	☑

Radiosondes (PBL)

Parameter	ME	STDE
T	◐	☑
RH	◐	☒
DD	☑	☑
FF	☑	☑

Combiprecip

Better Frequency Bias
Very similar FSS

- March and April 2015
- Benchmark: nudging analysis
- Cooler and moister than nudging (too cool and too moist)
- Especially during night time
- Generally better than nudging at daytime, slightly worse during night

Ensemble Forecast Verification

- March and April 2015
- Focus on first 6 forecast hours
- Comparison against COSMO-E started from downscaled IFS-ENS analysis

Median Verification

Parameter	ME	STDE
Surf. Pres.	☑	☑
T 2m	☑	☑
Td 2m	☑	☒
DD 10m	☑	☑
FF 10m	☑	☑

Probabilistic Verification

Parameter	RPS(S)	Outliers	Spread/ Error	Resolution Thrs1	Resolution Thrs2
T 2m	☑	☑	☑	☑	☑
Td 2m	☑	☑	☑	☒	☑
ff 10m	☑	☑	☑	☑	☑
Prec 12h	☑	☑	☒	☑	☑
Prec 1h	☑	☑	☑	☑	☑
Gusts	☑	☑	☑	☑	☑

- Reduces spin-up, particularly Td 2m and FF 10m bias

Deterministic Forecast Verification

SYNOP

Parameter	ME	STDE
Surf. Pres.	☑	☑
T 2m	!	☒
Td 2m	☑	☒
DD 10m	☑	☑
FF 10m	!	☑

Radiosondes (PBL)

Parameter	ME	STDE
T	☑	☑
RH	☑	☑
DD	☑	☒
FF	☑	☑

Combiprecip

Better Frequency Bias for thr<0.5mm/3h

Strong underestimation for larger thr

Significant lower FSS than in nudging

- 22.5. – 1.7.2015
- Benchmark: nudging analysis
- Cooler than nudging (too cool) at 2m above ground

Ensemble Forecast Verification

- 22.5.-1.7.2015
- Focus on first 6 forecast hours
- Comparison against COSMO-E started from downscaled IFS-ENS analysis

Median Verification

Parameter	ME	STDE
Surf. Pres.	☑	☑
T 2m	!	☑
Td 2m	☑	☑
DD 10m	☑	☑
FF 10m	☑	☑

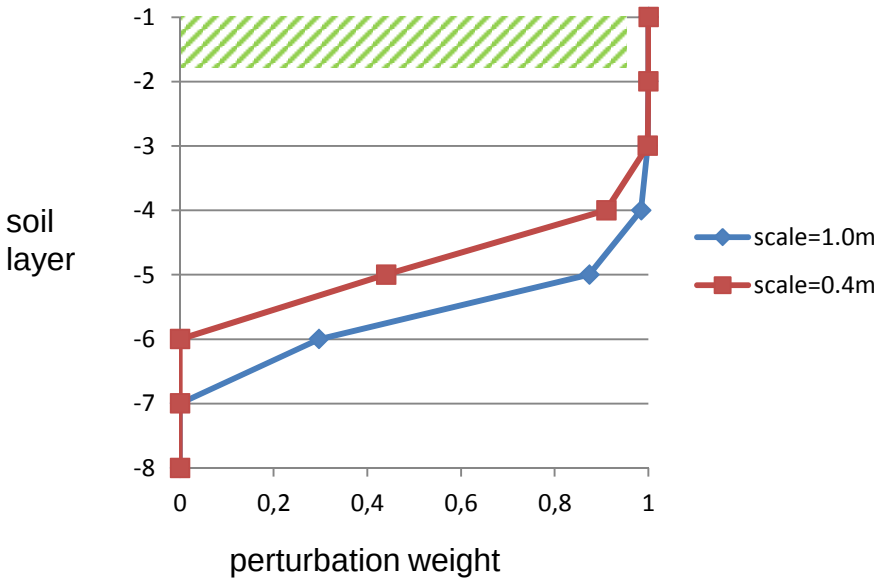
Probabilistic Verification

Parameter	RPS(S)	Outliers	Spread/ Error	Resolution Thrs1	Resolution Thrs2
T 2m	☑	☒	☑	☑	
Td 2m	☒	☒	☒	☑	
ff 10m	☑	☑	☑	☑	☑
Prec 12h	☒	☑	☑	☒	☑
Prec 1h	☑	☑	☑	☑	☑
Gusts	☑	☑	☑	☑	☑

- Still problems in humidity and temperature
- Results not well understood, needs more investigation

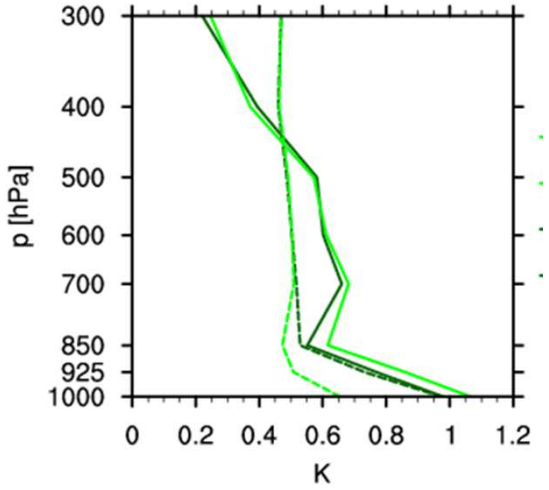
Soil moisture perturbations

- Test soil moisture perturbations in LETKF to increase low-level spread
- Horizontal correlation lengths: 10km and 100km
- Perturbation amplitude (stddev) 0.002 (SMI Units)
- Scale in vertical Gaspari-Cohn-Function: 1m

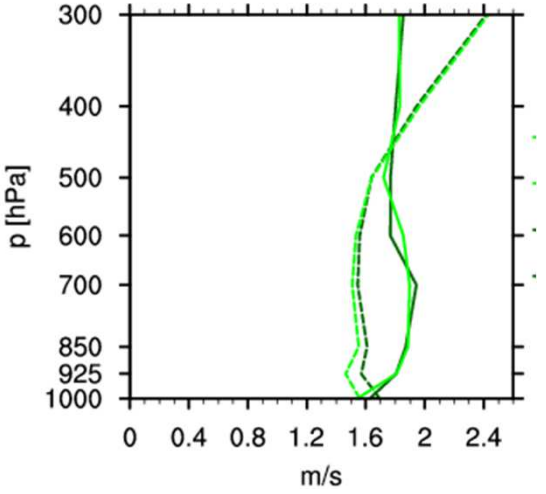


Effect on LETKF Performance

Temperature (TEMP)

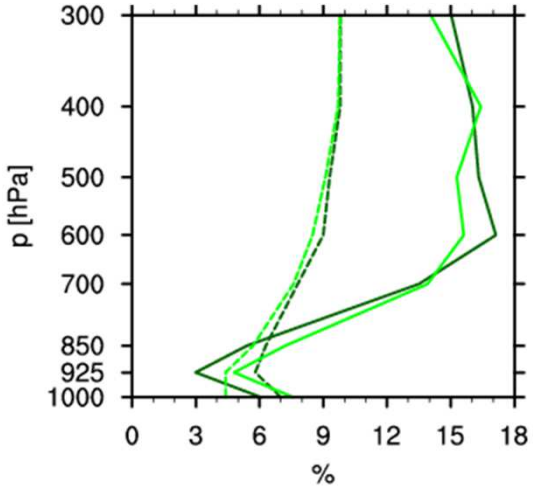


Wind speed (TEMP)

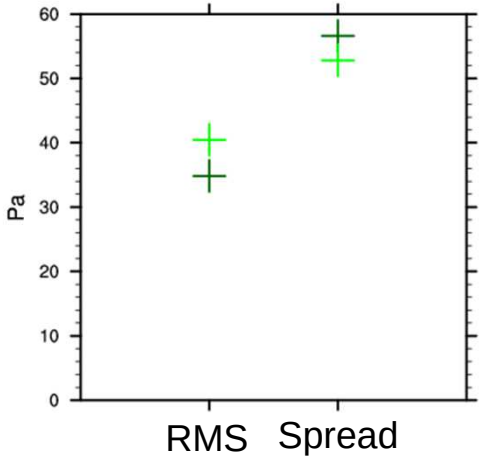


---- Spread
— RMS

Humidity (TEMP)



Ps (SYNOP)



w/o soil pert.
with soil pert.

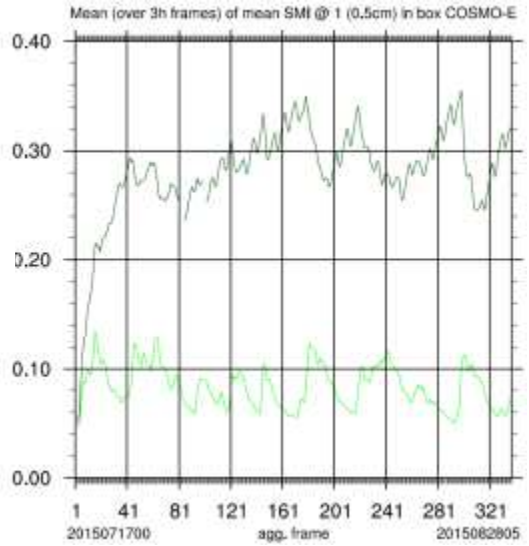
Obs error is taken into account in RMS !

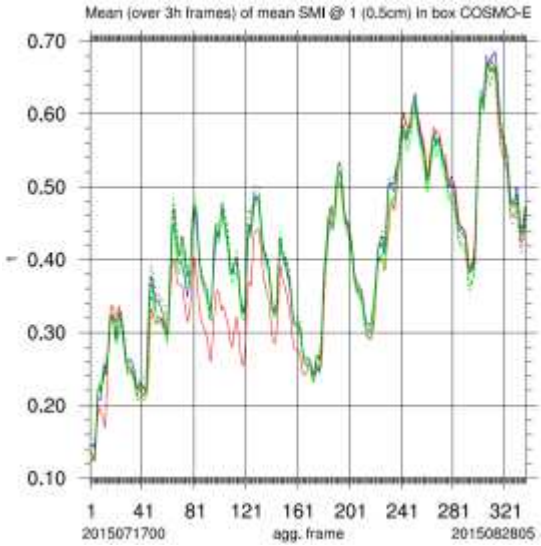
Effect on Soil Moisture Index (SMI)

SMI Spread

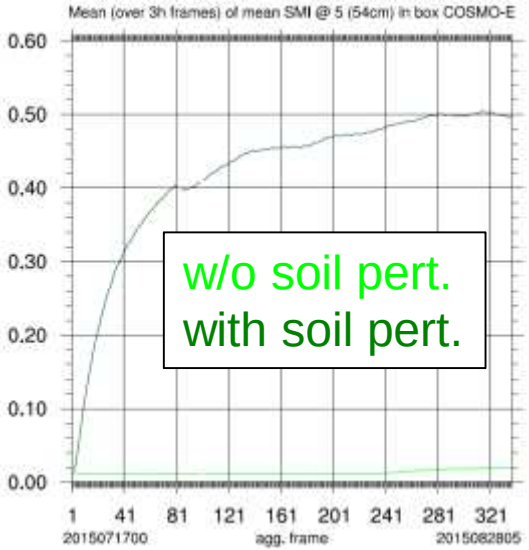
SMI

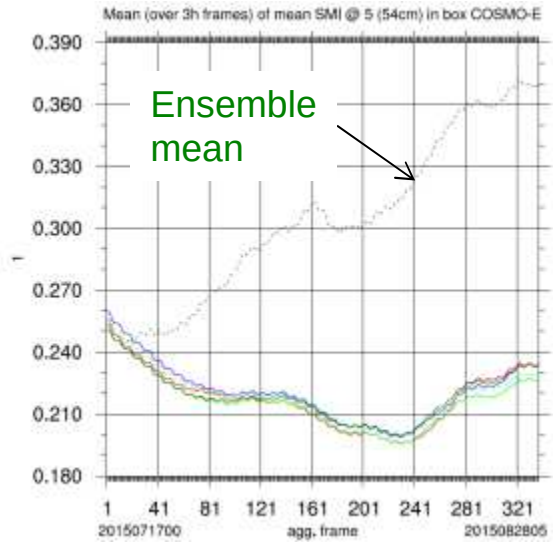
0.5cm





54cm





Soil layer	Pert. weight	Spread unpert.	Spread pert.
1 (0.5cm)	0.999	0.08	0.30
2 (2.0cm)	0.999	0.08	0.30
3 (6.0cm)	0.998	0.08	0.35
4 (18cm)	0.984	0.05	0.45
5 (54cm)	0.873	0.01	0.50
6 (162cm)	0.296	0.005	>0.35
7 (486cm)	0.000	0.005	>0.35
8 (1458cm)	0.000	0.005	>0.35

Spread probably too large, especially in lower layers

Drift in SMI in lower layers unacceptable!

Adapt perturbations

COSMO-1 Analysis

- Deterministic LETKF Analysis with 1.1km grid length (ensemble with 2.2km)
- Update equation for deterministic forecast

$$\boldsymbol{x}_{\boldsymbol{d}}^{\boldsymbol{a}} = \boldsymbol{x}_{\boldsymbol{d}}^{\boldsymbol{f}} + \underbrace{\boldsymbol{K}\left(\boldsymbol{y} - \boldsymbol{H}\left(\boldsymbol{x}_{\boldsymbol{d}}^{\boldsymbol{f}}\right)\right)}$$

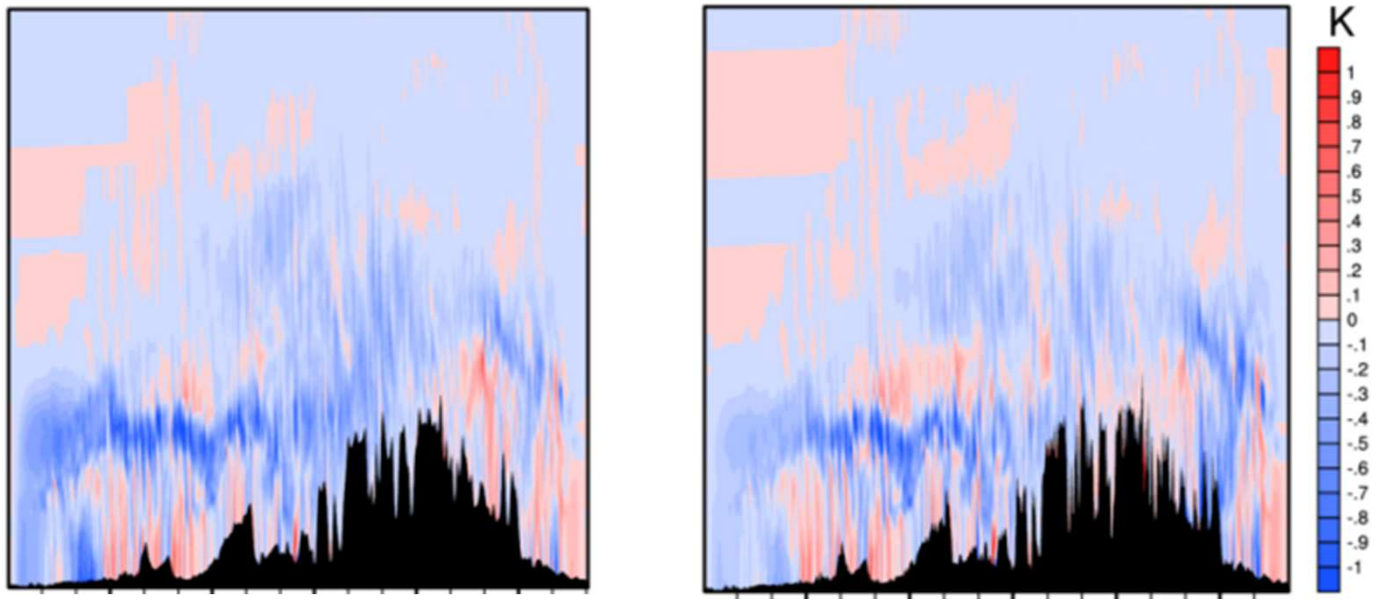
Interpolation to 1.1km

- Real-time assimilation cycle runs since 28.08.2015

COSMO-1 Analysis

- First test update result from 28.5.2015, 13UTC:

Temperature Analysis increment (det ana – det fg)

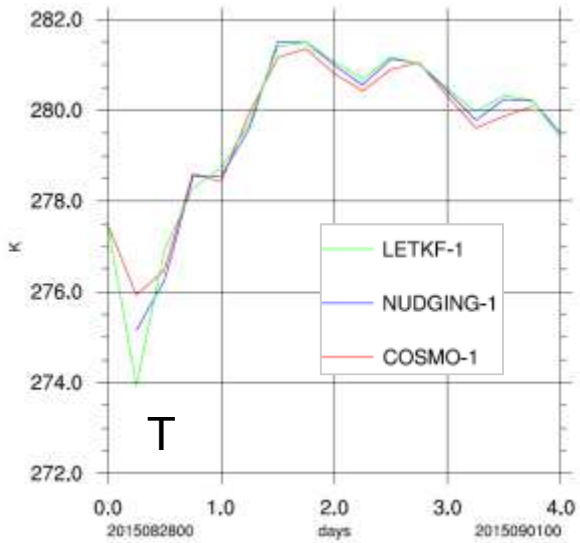


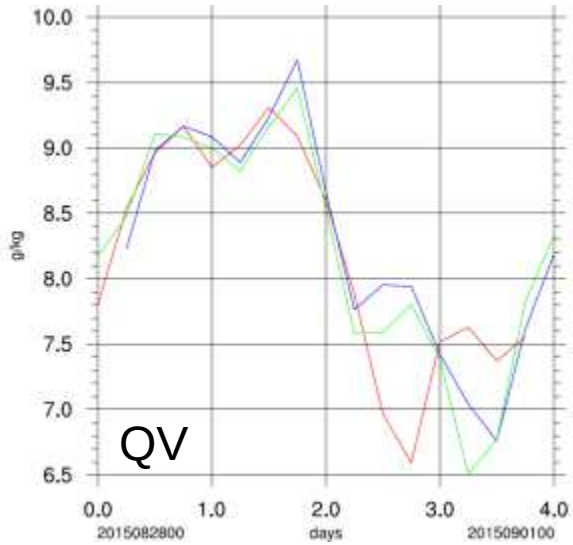
2.2km, 60 Level

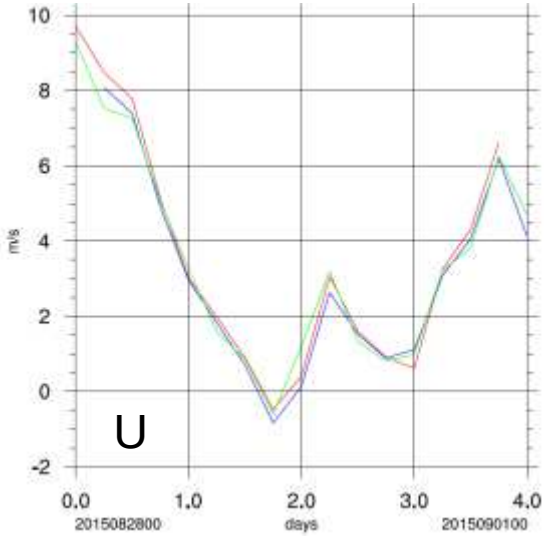
1.1km, 80Level

COSMO-1 Analysis

Evolution of domain-average T, QV and U averaged between 0 and 3200m agl







First 4 days of experiment look similar to Nudging and COSMO-1 experiments

Summary

- Real-time KENDA assimilation cycle runs very stably since mid-January 2015
- Verification results from first months are encouraging
- Deterministic 2.2km analysis performance similar to nudging
- COSMO-E forecasts started from KENDA compare mostly favourably to those downscaled from IFS-ENS (reduced spin-up effect)
- Approaching to meet benchmark, but some problems in PBL humidity and temperature, still lack of spread there
- Soil moisture perturbations in LETKF need further tuning, make sure to avoid soil moisture drifts in data assimilation cycle!

Outlook

- KENDA for COSMO-E: preopr: Nov 2015, opr: Spring 2016
- KENDA for COSMO-1: preopr: ? , opr: ?
- Todo until preoperational:
  - Investigation of RH and T problems in PBL
- Todo until operational
  - Assimilation of TD_2M (and possibly: T_2M)
    Internship of Tobias Necker (LMU Munich, Nov 2015 – January 2016)
  - Improvement of soil moisture perturbations
  - Further tuning (use SPPT in addition to RTPP)
  - Use of grib2 in COSMO and LETKF