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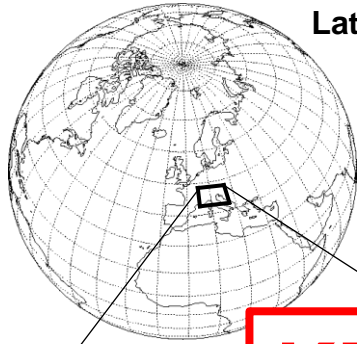
Towards operational Ensemble Data Assimilation at the Convective Scale

Daniel Leuenberger, MeteoSwiss

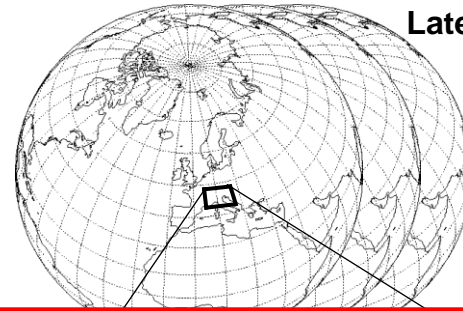
3.3.2015, COSMO User Seminar, DWD, Offenbach



Next Generation MCH NWP System



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

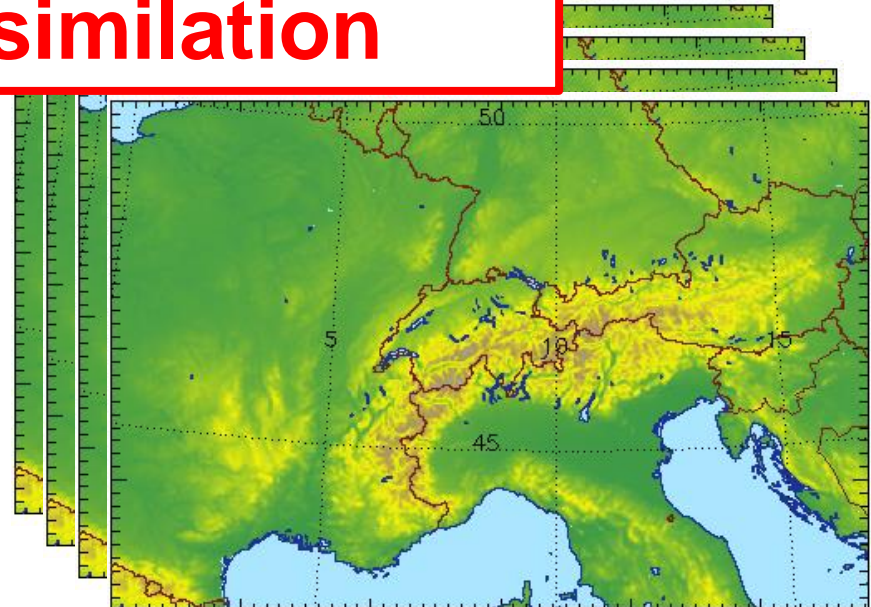
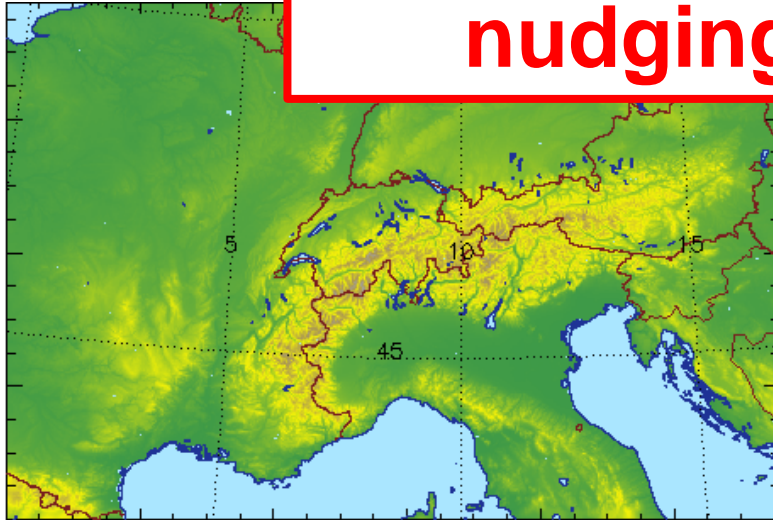


Lateral boundary conditions:
IFS-ENS
20km
4x per day

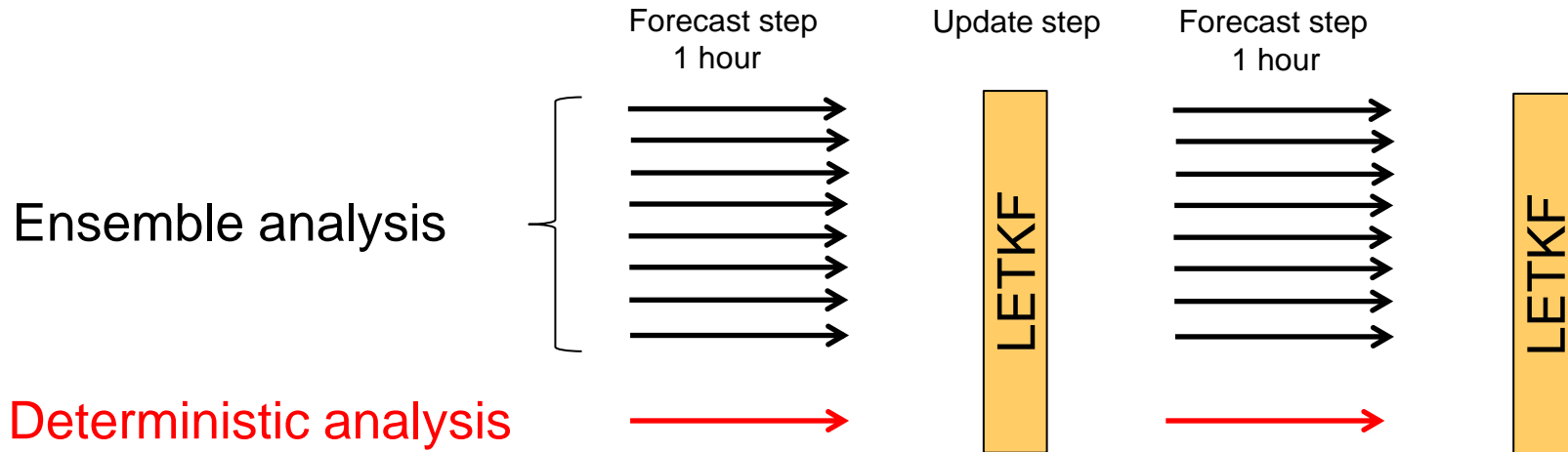
KENDA Assimilation System
Shall replace the current nudging assimilation

COSMO-1: 24h
1.1km grid size

day (tting)



KENDA Assimilation System



Update ensemble mean

$$\bar{x}^a = \bar{x}^f + K(y - H(\bar{x}^f))$$

Update deterministic analysis

$$x_d^a = x_d^f + K(y - H(x_d^f))$$

Is yet at same grid as ensemble members

But will be on COSMO-1 grid in future to initialize COSMO-1 forecasts



KENDA Experiments

- **Summer Experiment**
 - 5.-15.06.2014
 - Tested several configurations with different LETKF options
- **Real-time, continuous analysis cycle**
 - started at 11.01.2015, ongoing
 - Using most promising configuration from summer experiment
 - Including Radar Data Assimilation with Latent Heat Nudging
- **Winter Experiment**
 - 21.01. – 12.02.2015

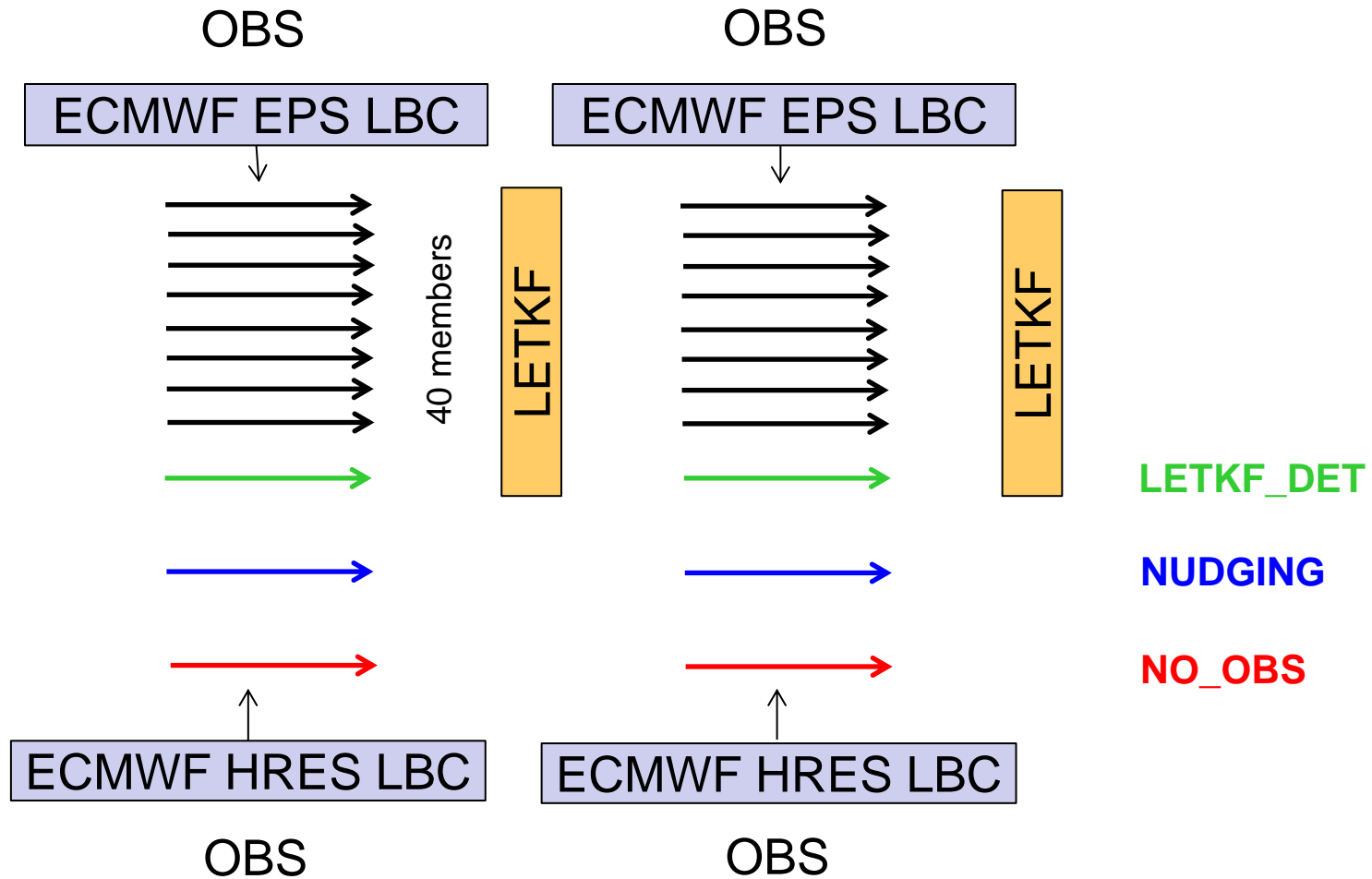


Experimental Setup

- 1h update cycles
- **LETKF**
 - 40 members + deterministic analysis (**LETKF_DET**)
 - Adaptive covariance inflation and localisation
 - RTPP scheme to increase spread
 - Soil moisture perturbations
- **NUDGING**
 - As operational COSMO-2 analysis but without assimilation of RH_2m
- **NO_OBS**
 - Cycle without assimilation of observations. Analysis is only constrained by driving model



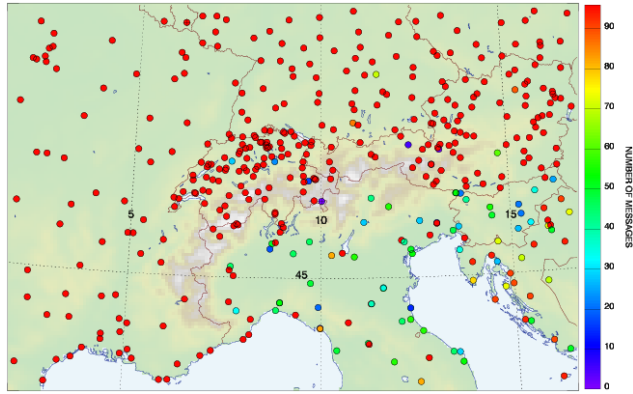
Experimental Setup



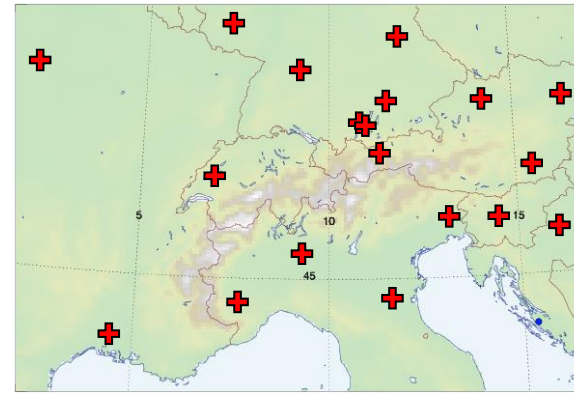


Assimilated Observations

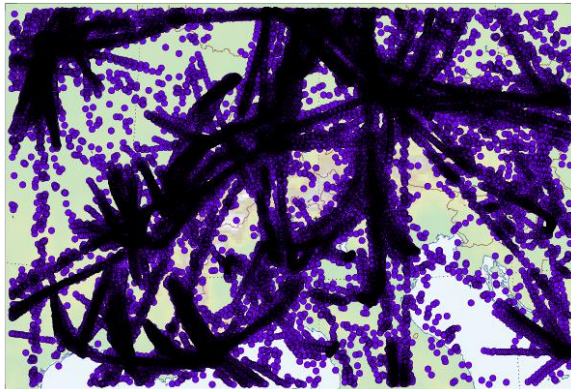
SYNOP



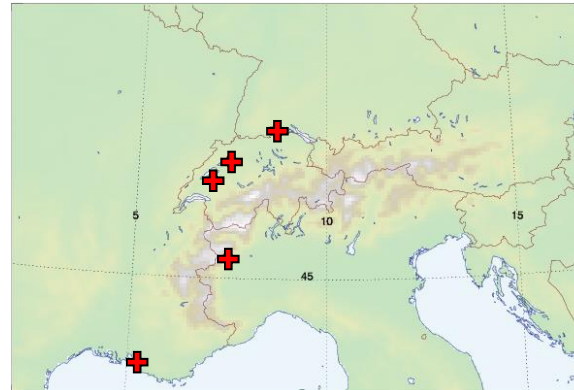
TEMP



AIREP



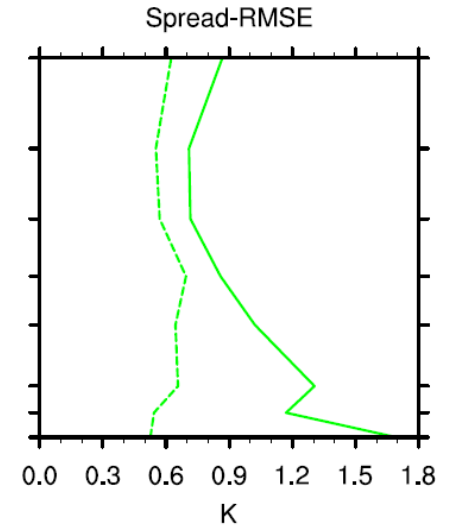
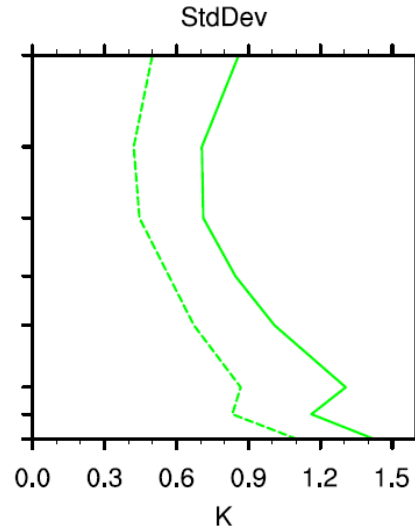
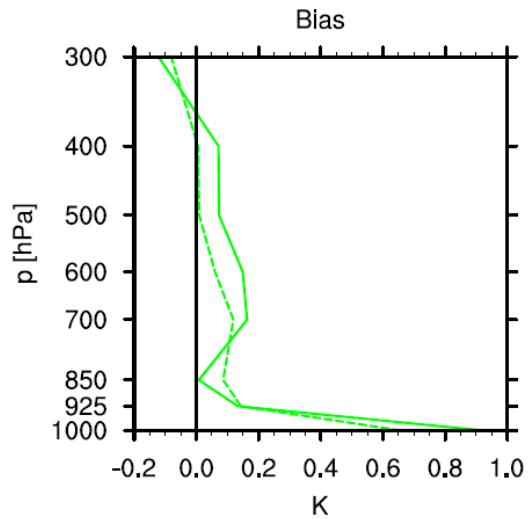
WINDPROFILER



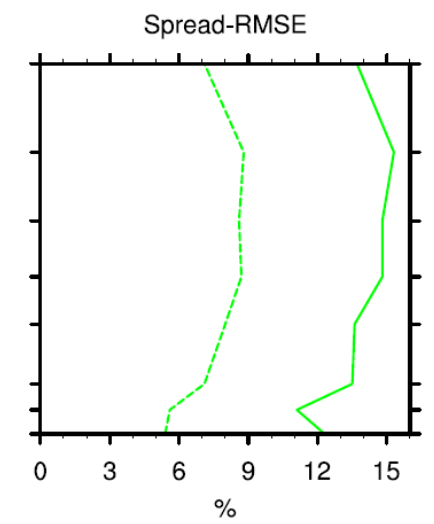
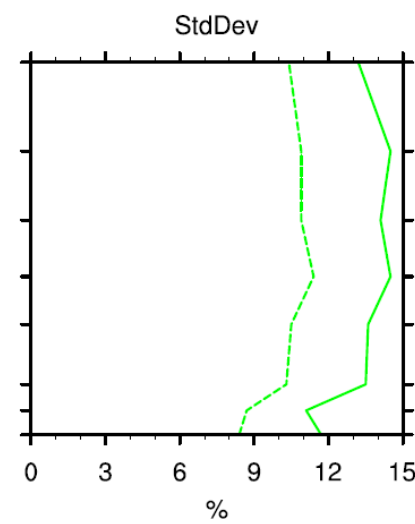
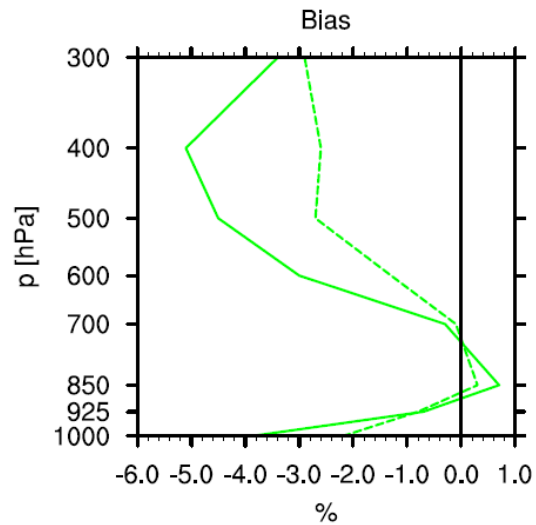


LETKF Sanity Check

T



RH





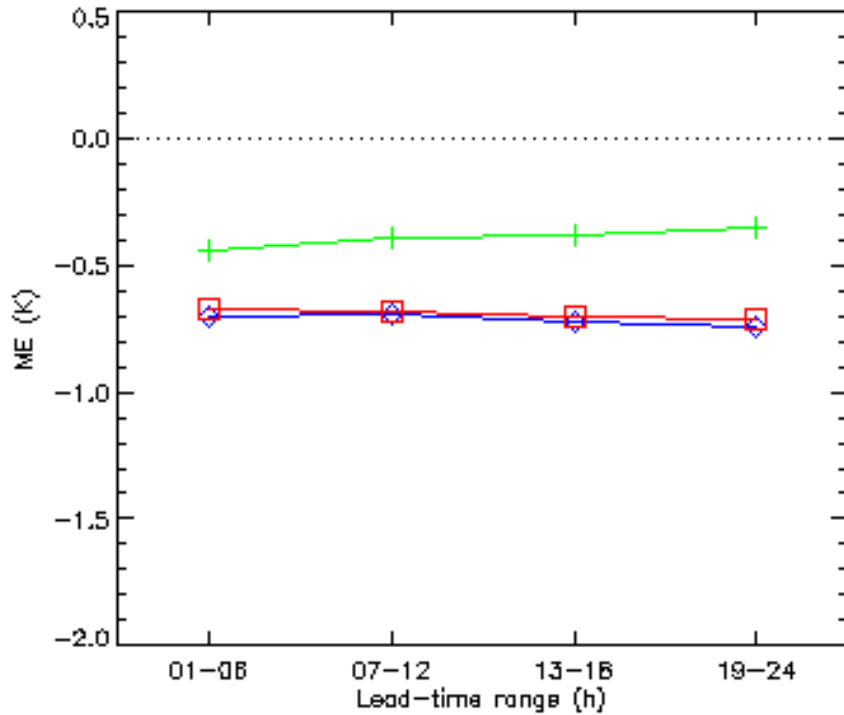
Verification Results

- Deterministic forecasts started every six hours from all deterministic analyses
- 92 forecasts in summer, 40 forecasts in winter
- Integrated out to +24h
- Objective verification against
 - Swiss SYNOP surface observations
 - Radiosonde observations on whole model domain
 - Gridded QPE estimated from combined radar-gauge obs Switzerland only

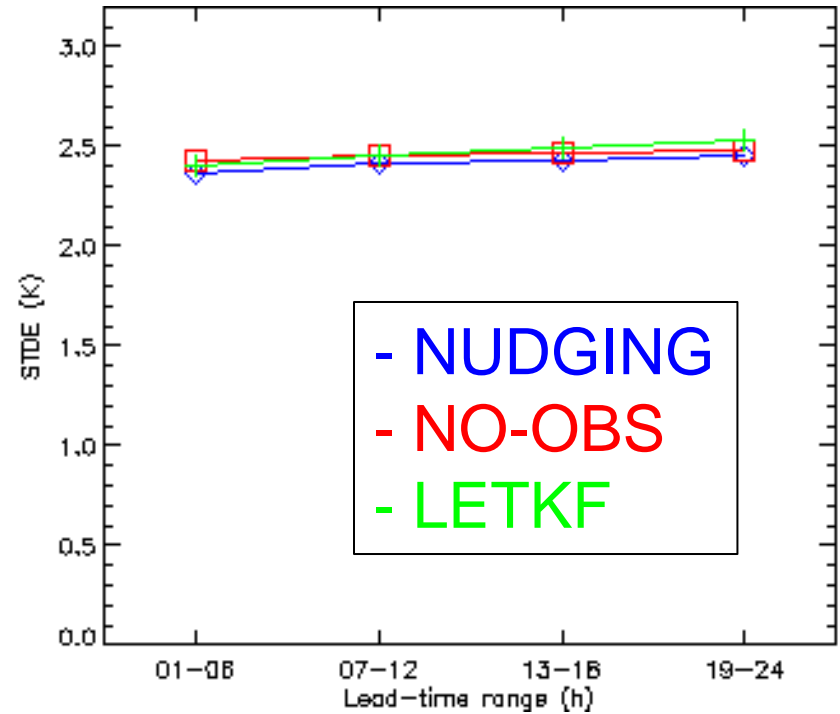


2m-Temperature

BIAS



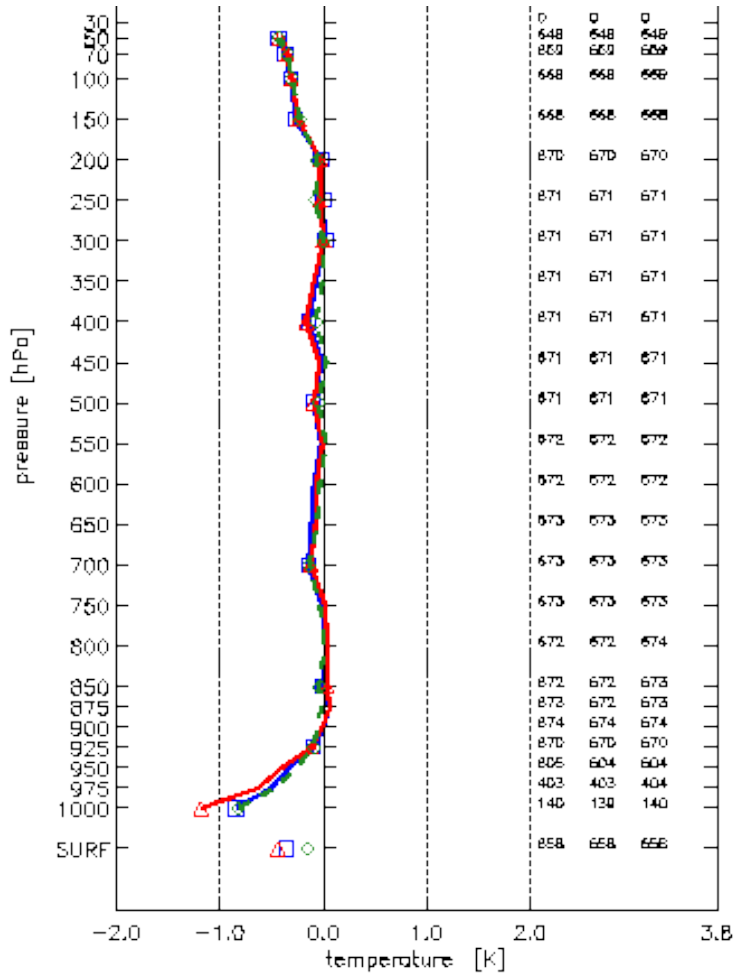
STD DEV



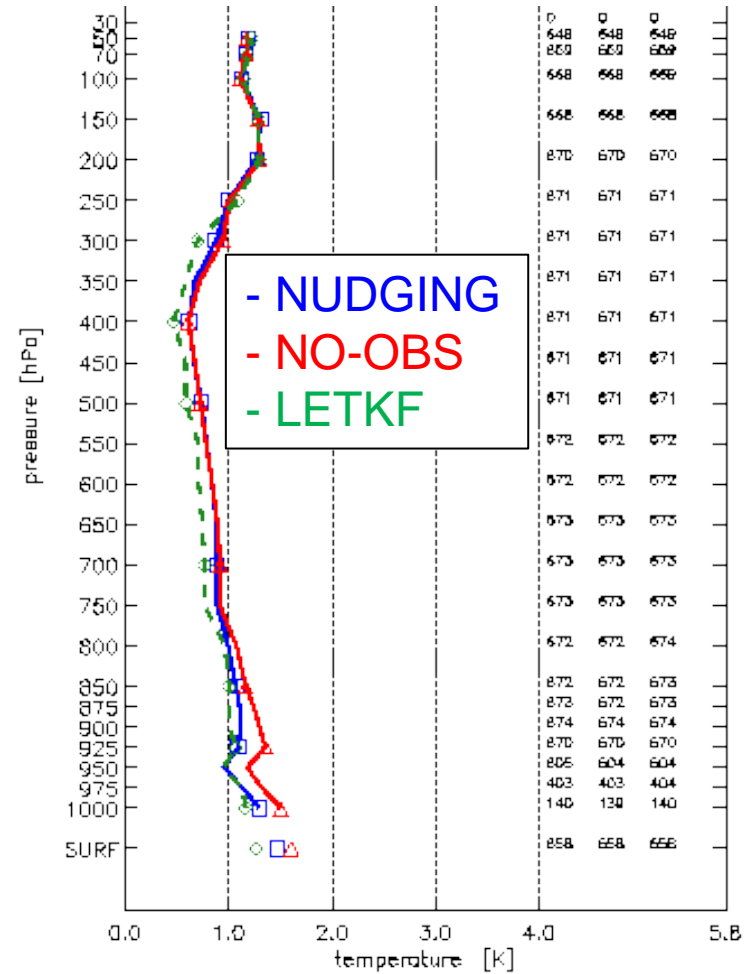


Temperature Analysis

BIAS



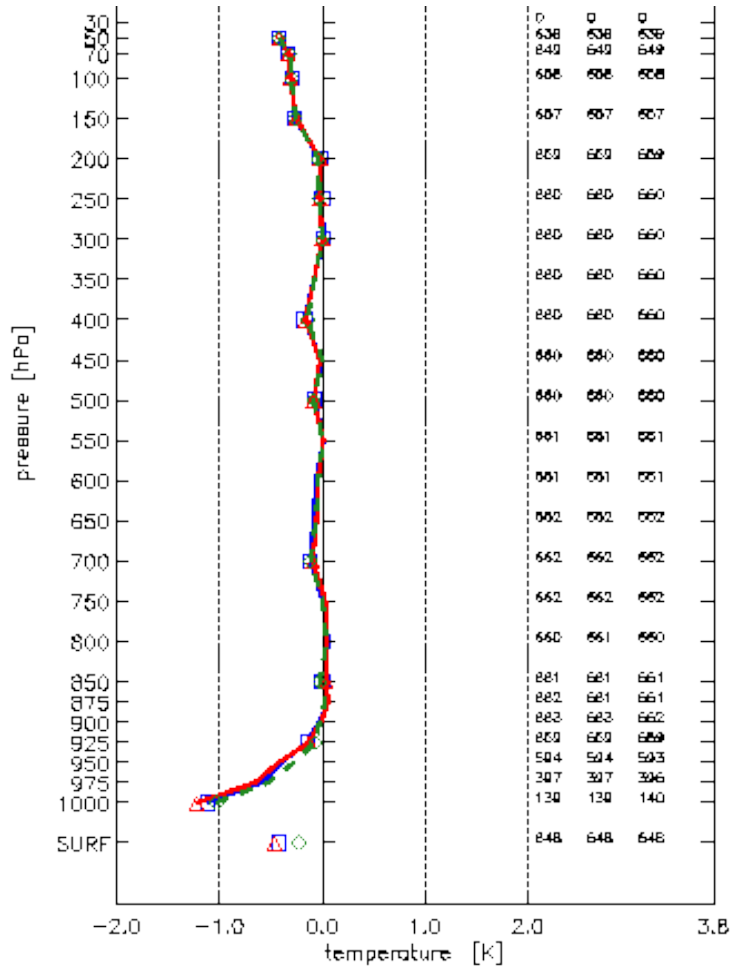
STD DEV



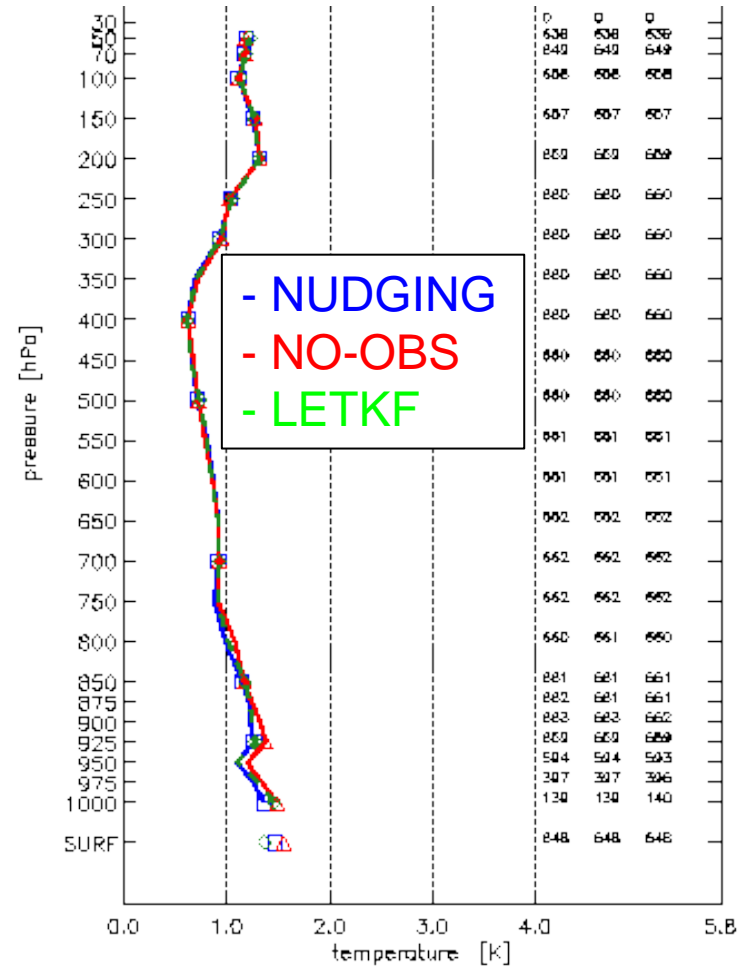


Temperature Forecasts (+06h)

BIAS



STD DEV





Comparison LETKF_DET vs NUDGING

Winter 2015

Variable	BIAS	STD DEV
Ps	Green	Grey
T_2M	Green	Grey
TD_2M	Green	Grey
WS_10M	Green	Grey
T	Grey	Grey
RH	Grey	Grey
WS	Grey	Grey
WD	Grey	Grey

Summer 2014

Variable	BIAS	STD DEV
Ps	Red	Grey
T_2M	Red	Grey
TD_2M	Green	Green
WS_10M	Green	Grey
T	Grey	Grey
RH	Red	Green
WS	Grey	Grey
WD	Grey	Grey

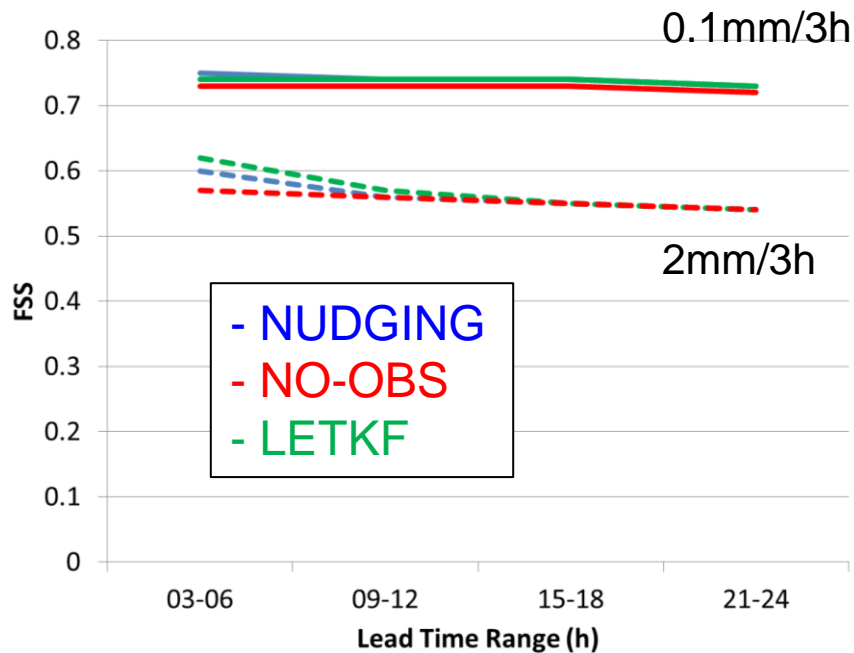
LETKF_DET better than NUDGING LETKF_DET worse than NUDGING LETKF_DET equal to NUDGING



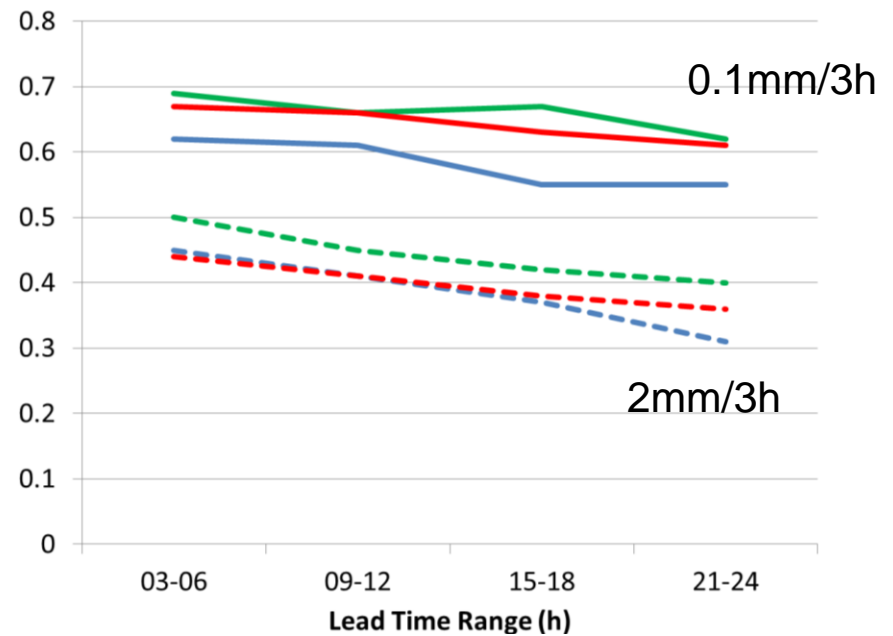
Precipitation Verification

- Fraction Skill Score for a scale of 30x30km
- Reference: QPE from radar-gauge combination
- 3h accumulations

Winter 2015



Summer 2014





COSMO-E Forecasts

- Compare COSMO-E ensemble forecasts initialized from KENDA against downscaled forecasts (winter experiment)

Variable	BIAS	STD DEV
Ps	Green	Grey
T_2M	Red	Green
TD_2M	Red	Red
WS_10M	Green	Green

- Soil considerably drier in LETKF ensemble than in deterministic and nudging analysis. Caused by LETKF soil perturbations?
- Reset soil to NUDGING soil in ensemble and switched off perturbations



Summary

- LETKF runs stably in a real-time configuration for almost 2 months now
- Forecasts started from LETKF_DET are of comparable quality to those started from NUDGING (small differences)
- COSMO-E forecasts benefit from KENDA IC perturbations during first forecast hours (STDDEV), but still drier and colder BIAS than downscaled COSMO-E
- Observations seem to have small impact on forecast quality, reasons to be investigated



Outlook

- Continue real-time assimilation cycle, further diagnosis and tuning of LETKF
- Use COSMO-1 setup for deterministic analysis
- Test alternative methods to increase spread
 - Stochastic Physics Perturbation Tendencies (SPPT)
 - Relaxation to prior spread (RTPS, Whitaker et al., 2012)



Thank you for your attention