Overview on Status of KENDA

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PP KENDA: overview

• Task 1: General issues in the convective scale, to decide on LETKF
  (e.g. occurrence and effects of non-Gaussianity in COSMO-DE-EPS)

• Task 2: Implementation of LETKF system
  → MEC (Model Equivalent Calculator) for feedback files (verification)

• Task 3: Main development (tuning, refinement, testing) of LETKF,
  comparison with nudging (using conventional obs)
  – Stochastic Perturbation of Physics Tendencies (Torrisi, CNMCA)
  – Stochastic Pattern Generator (Tsyrulkov, Gayfullin, HMC)

• Task 4: Use of additional (high-resolution) observations
MEC (Model Equivalent Calculator)

- first version disseminated for testing + use
  - with documentation, test cases for deterministic and ensemble forecasts
  - for verification of conventional obs

- some pending issues
  - verification of time-accumulated quantities
  - need to use same model domain / resolution for first creation of feedback file and for forecasts for which model equivalents are computed
  - technical

- future: extend to non-conventional obs
LETKF, high-resolution obs

3-D radar radial velocity and reflectivity
- obs operator implemented, superobbing, thinning,
- tuning, sensitivity tests with LETKF, impact studies

GPS slant path delay (Bender, DWD)
- obs operator implemented, technically ready for DA experiments
- work continues (IAFE-DWD, +3y)

Use of cloud top height (CTH) derived from satellite (SEVIRI) data
- obs operator implemented, LETKF single-obs experiments
- sensitivity tests and impact studies for low-stratus periods

Use of direct satellite radiances for assimilation of cloud information
- first DA exp. over several days: benefit for f.g. simulated radiances
- A. Perianez left DWD in Nov. 2014; new IAFE 4y will start in late 2015

Raman lidar (qv-profile) & microwave radiometer (T-profile) delay (Haefele, MCH)
- innovation statistics of obs at Payerne with COSMO-2 forecasts
LETKF: use of radar reflectivity sensitivity test (single case)

**CONV + RADAR−3D** with different LETKF cycling frequencies: 5, 15, 30, 60 min.

- 1-hour LETKF update rate better than higher update rates
- better to use radar obs at full hours and throw away obs in between

Why?
- system flooded with radar obs → influence of other obs reduced?
- obs error mis-specified, correlations neglected?
- too few ensemble members, LETKF over-confident?
- noise? does not yet level off completely after 5 or 15 min.
LETKF: use of radar **reflectivity** → *Theresa Bick et al.*
impact study  (7 day period)

7 days: 22 – 29 May 2014

- mean FSS (precip) over **19** forecasts
- std dev.

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- [ ] rather large, long-lived positive impact from use of radar reflectivity in LETKF
- [ ] use of radar reflectivity in LETKF slightly better than LHN in first 4 hours

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Overview on Status of KENDA
COSMO GM, Wroclaw, 07 – 10 Sept. 2015

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LETKF: use of radar reflectivity impact study (7 day period)

7 days, 19 forecasts:
22 – 29 May 2014

**Use of radar Z in LETKF gives slightly better score, but worse bias than LHN**
LETKF: use of radar reflectivity impact study (7 day period)

Surface verification (RMSE):
- slight benefit from use of radar Z in LETKF, but LETKF + LHN is better
LETKF: use of radar reflectivity impact study (7 day period)

- **LETKF**: use of radar reflectivity impact study (7 day period)

**Upper-air verification (analysis / f.g. RMSE):**
- Use of radar Z in LETKF improves 1-h wind forecast

- **Wind [m/s]**
  - Analysis
  - First guess (+1h)

- **Temperature [K]**
  - Analysis
  - First guess (+1h)

**Graphs:**
- 7 days, 19 forecasts: 22 – 29 May 2014
1-hrly LETKF cycling over 5 days (1 – 6 June 2011)

**RMSE of first guess (1-hr forecast)**

against Radar radial velocity

against radiosonde + aircraft wind speed
**LETKF: use of radar data**

**status summary, further steps**

**radar radial velocity** (5-day period)
- (small) positive impact on 1-hr forecast of upper-air wind

**radar reflectivity** (7-day period)
- (small) positive impact on 1-hr forecast of upper-air wind
- long-lasting positive impact on precip, slightly better than LHN
- small positive impact in surface verification, not as good as LHN

**further steps**
- quality control
- balance impact of precip vs. non-precip obs / (4-D) radar vs. conventional obs
- thinning / superobbing, obs errors, localization, Gaussianity (variable transform?)
- more test periods
Overview on Status of KENDA COSMO GM, Wroclaw, 07 – 10 Sept. 2015

LETKF: use of **satellite cloud top height data** application to low stratus period

upper-air verification for 83 hours cycled assimilation starting 12 Nov. 2011, 12 UTC

Bias: OBS - FG

assimilation of conventional obs only
assimilation of conventional + cloud obs

→ cold and strong moist bias in mid-levels !
Why ?
LETKF: use of satellite cloud top height data application to low stratus period

→ mid-level moisture increment in low-stratus situation! Why?

→ problems caused by incorrect cloud top height in NWCSAF cloud top height product
LETKF: use of **satellite cloud top height data** application to low stratus period

pre-processing to merge satellite and radiosonde cloud top height information (cloud analysis):

*use nearby radiosondes within the same cloud type to determine quality flag*

→ discard data flagged as ‘inconsistent’
→ applied to new experiment
LETKF: use of **satellite cloud top height data**
application to low stratus period

results of new experiment with rigid quality control:
upper-air verification for several 6-h forecasts from 13 – 15 Nov. 2011

→ no detrimental effect of cloud assimilation any more
→ but sometimes a lot of cloud data are discarded by new QC
LETKF: use of satellite cloud top height data
application to low stratus period

Correlation coefficient for total cloud cover

FSS for cloud cover of 15-h forecast

new experiment with rigid quality control

→ long-lasting small (?) benefit in some cases

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LETKF: use of **satellite cloud top height data** application to low stratus period

results of (new experiment with rigid quality control: total cloud cover of first guess fields (1-h forecast) after 24 hours of cycling

- **satellite obs**
- **conventional only**
- **conventional + cloud**

13 Nov 2011, 12:00 UTC

→ better match with observed cloud cover
status

- problem with mid-tropospheric cold / moist bias solved; with new QC, less data are used in LETKF
- some positive impact on cloud cover remains

further steps

- quality control
- balance impact of cloudy (which may be flagged by QC) vs. cloud-free obs (which are never flagged)
- localization (dep. on observed cloud ?), thinning / superobbing, obs errors
- alternative use of Optimal Cloud Analysis (Watts et al., 2011) , which can detect multi-layer clouds ?
- more test periods, other weather types
MeteoSwiss: summary + outlook

- 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 not applied!)
- COSMO-1 deterministic analysis under development

- COSMO-E plans to use KENDA IC when going operational in Spring 2016, (COSMO-1 will first use nudging IC)
LETKF: main development + testing
comparison to Nudging + LHN

surface verification (RMSE) of 0-UTC forecast runs, 28 days (18.05. – 15.06. 2014)

- LETKF: smaller errors, particularly pressure and humidity
- (also slightly smaller error for 10-m wind, neutral for cloud cover)
DWD: \textbf{LETKF outperforms nudging}, in particular if both \textbf{combined with LHN}, in test periods

most critical criterion for operationability fulfilled \textbf{(still more periods required)}

(also encouraging results on use of KENDA for IC of COSMO-DE-EPS
(possibly in combination with other perturbations))

\textbf{MeteoSwiss:} mostly only \textbf{neutral} results for deterministic forecast

→ possible reasons for different performance:
  \begin{itemize}
    \item model configuration + model domain (smaller at MCH!),
    \item test period (summer period with little advection vs. spring),
    \item lateral boundary conditions (ICON-LETKF vs. ECMWF),
    \item soil state, soil moisture perturbations, etc.
  \end{itemize}
LETKF: main development + testing
remaining problems

- explicit soil moisture perturbations:

![Graph showing soil layer 5: ensemble mean, deterministic run, and ensemble spread over time.]

**Soil layer 5 (27 – 81 cm)**
- **drift (bias)** of mean of perturbed ensemble vs. unperturbed det.
- **spread** becomes (too) large
  (no problems for soil layers 1 - 3)
• explicit soil moisture perturbations:
  
  - spread: (small) perturbations are added at each hour to existing perturbed values → perturbations accumulate
    → possible solution: re-scaling of perturbations
  
  - bias: non-linear response of model to soil moisture perturbations
    → different feedback for positive resp. negative perturbations, particularly near soil field capacity (FC) & plant wilting point (PWP)
    → symmetric limiter to perturbations near FC & PWP
    → re-centering of ensemble mean to (unperturbed) deterministic soil moisture
LetKF: main development + testing
remaining problems

• explicit soil moisture perturbations: bias (drift), too large spread
  → solutions: symmetric limiter, re-scaling & re-centering of soil perturbations

• upper-air humidity verifies slightly worse, mainly in PBL
  → should be investigated (sampling noise in LETKF cross-covariance ?)
  → tolerable, considering benefits for other variables (precip !) (DWD)

• LETKF less able than nudging to correct (temperature, humidity) model biases
  → inherent, difficult to solve in LETKF
  → needs improvement of model itself

• technical issues:
  → robustness: creation of new ens members if few have crashed
  → continuous online estimation of observation errors (weather dependent)