Status of KENDA-O

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Mikhail Tsyrulnikov, Dmitri Gayfullin (HMC)

PP KENDA-O : Km-Scale Ensemble-Based Data Assimilation for the use of High-Resolution Observations

- Task 1: further development of LETKF scheme
  - mainly with conventional obs only
  - includes work towards operationalization
  - link to EPS
- Task 2: extended use of observations (high-resolution obs)
- Task 3: lower boundary: soil moisture analysis using satellite soil moisture data
- Task 4: adaptation to ICON-regional, hybrid methods (also particle filters)

KENDA-O overview
Task 1 (+ 3)

MeteoSwiss

- **KENDA** provides the IC for **operational COSMO-E** since 19 May 2016
- further tests on SPPT and soil moisture perturbations
- next year: work on KENDA for COSMO-1 , screen-level obs
  → *talk by Daniel Leuenberger*

DWD

- reference paper on KENDA: Schraff et al. 2016, QJRMS (doi:10.1002/qj.2748)
- comparison to nudging in winter period: neutral
- some sensitivity tests (e.g. SPPT: mixed impact)
- **KENDA** run in **pre-operational suite** since May 2016
  for deterministic + EPS forecasts
  → *talk by Hendrik Reich*

COMET

- KENDA/DACE code: adapted to include required capabilities of COMET system and run in a **parallel suite**
- sensitivity tests on treatment of humidity and localisation
- soil moisture assimilation (Task 3)

→ *talk by Francesca Marcucci*

ARPAE-SIM

- start **pre-operational suite** with KENDA-IC for 2.2 km EPS soon (Oct.?)

HMC : stochastic pattern generator: refined, accelerated, cleaned

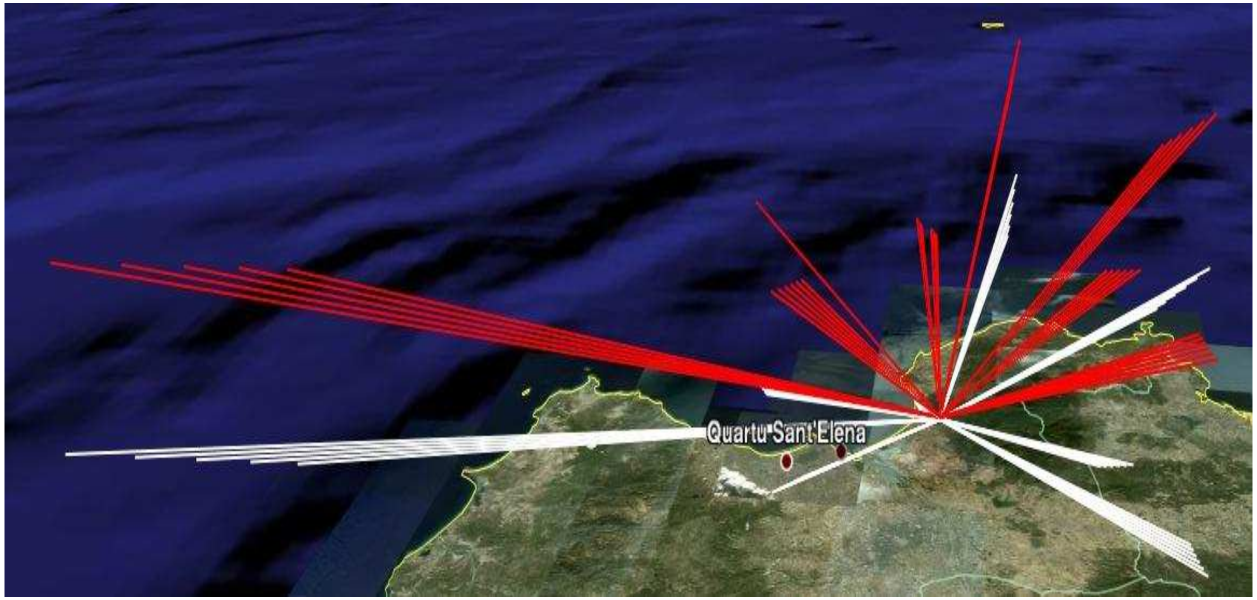
→ *talk by Mikhail Tsyrulnikov*

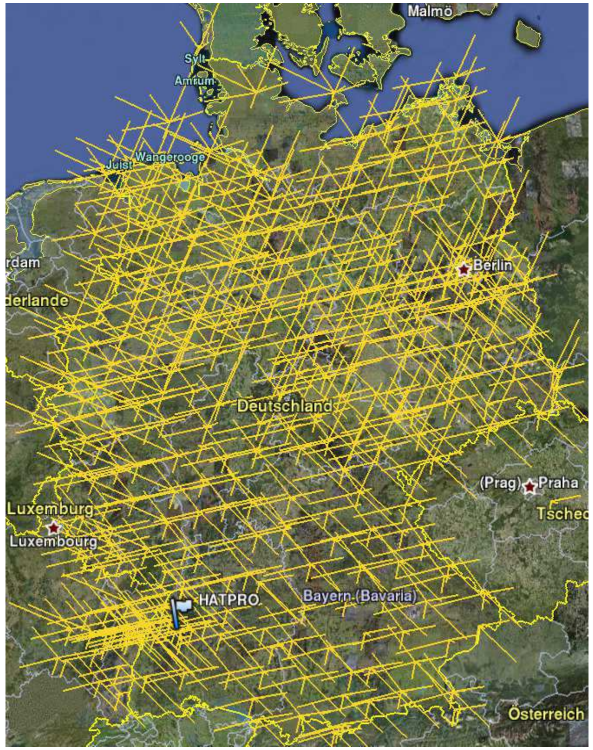
KENDA-O overview, Task 2 (high-res. obs): GNSS Slant Total Delay (STD)

Deutscher Wetterdienst

→ GNSS (GPS) Slant Path Delay : **humidity** integrated over path from ground station to GNSS (GPS) satellite, all weather obs

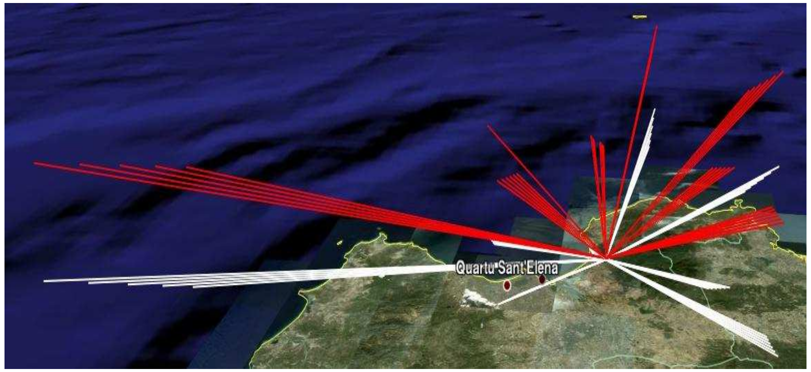
(45) GPS obs from 1 station / 9 satellites in 15 min.



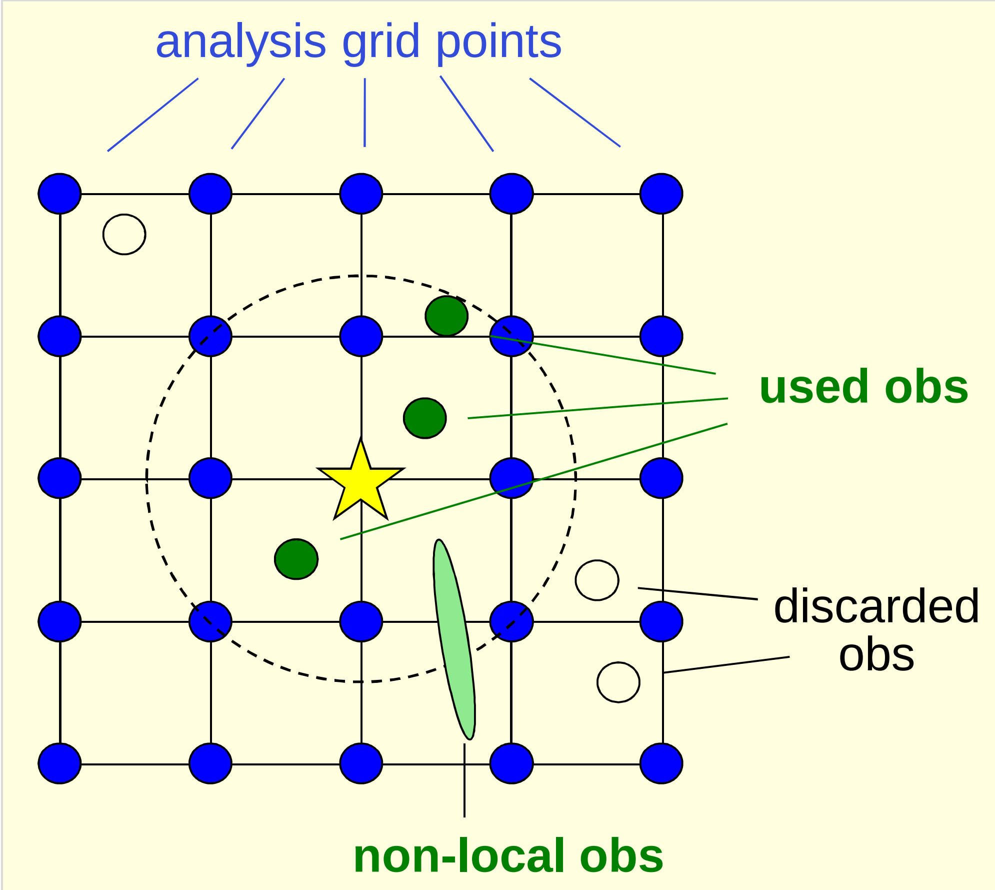


→ many stations → 3-D information on humidity, but !
→ at 5° (7°), path reaches height of 10 km at ~ 100 (80) km distance
→ vert. + horiz. non-local obs (not point measurements)
→ 1-week data assimilation test

Slant Total Delay :
humidity integrated over path
from ground station to satellite



elevation angles 90° - 5



→ vert. + horiz. non-local obs

→ difficult to use in LETKF:

explicit localization (doing separate analysis at every analysis grid point, select only obs in vicinity and scale $\mathbf{R}^{-1}$)

high-resolution obs:
GNSS-STD, first trial for use in KENDA

Deutscher Wetterdienst

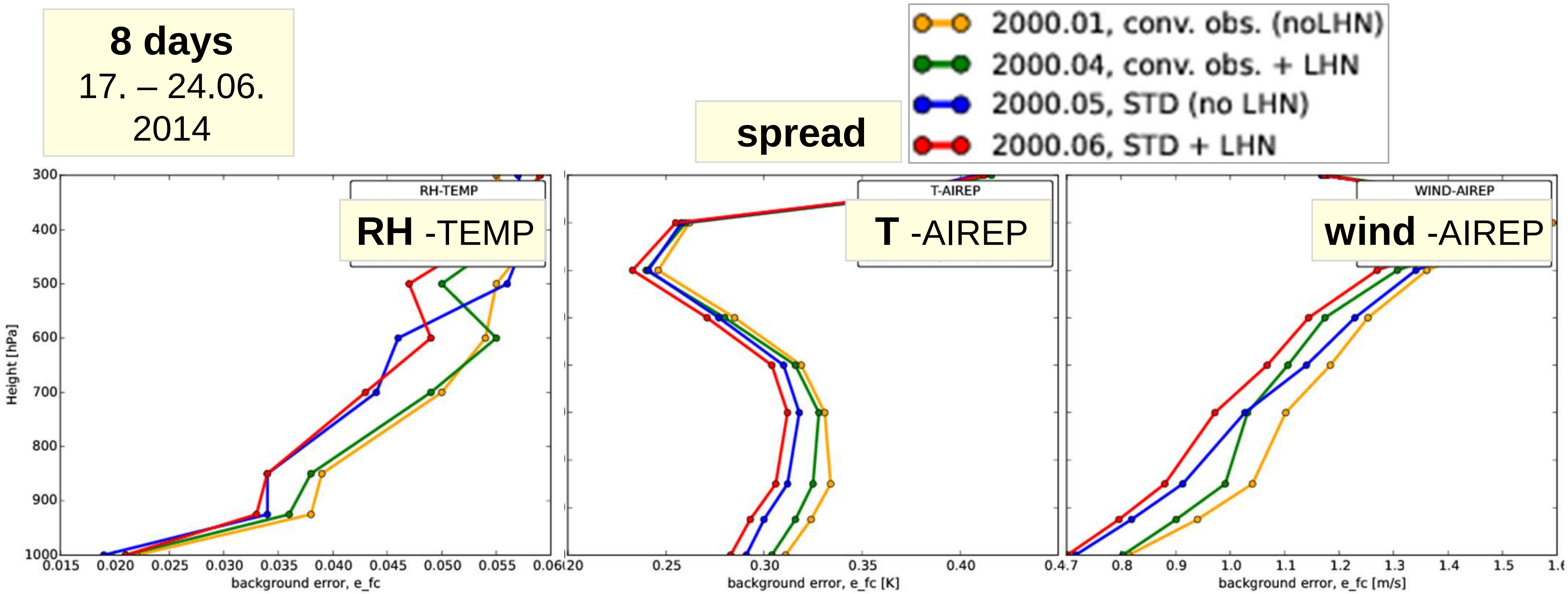
DWD

LETKF settings:

- STD localised 1000 m above the GNSS station
- vertical localisation length : 125 hPa ≈ 1000 m (v_loc = 0.15)
- horizontal localisation length : 30 km (h_loc = 30)

8 days
17. – 24.06.
2014

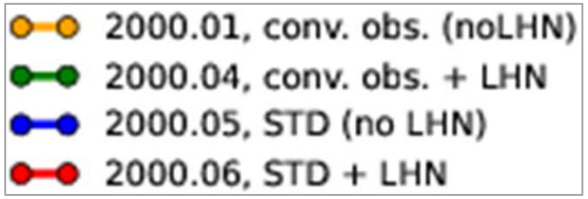
spread

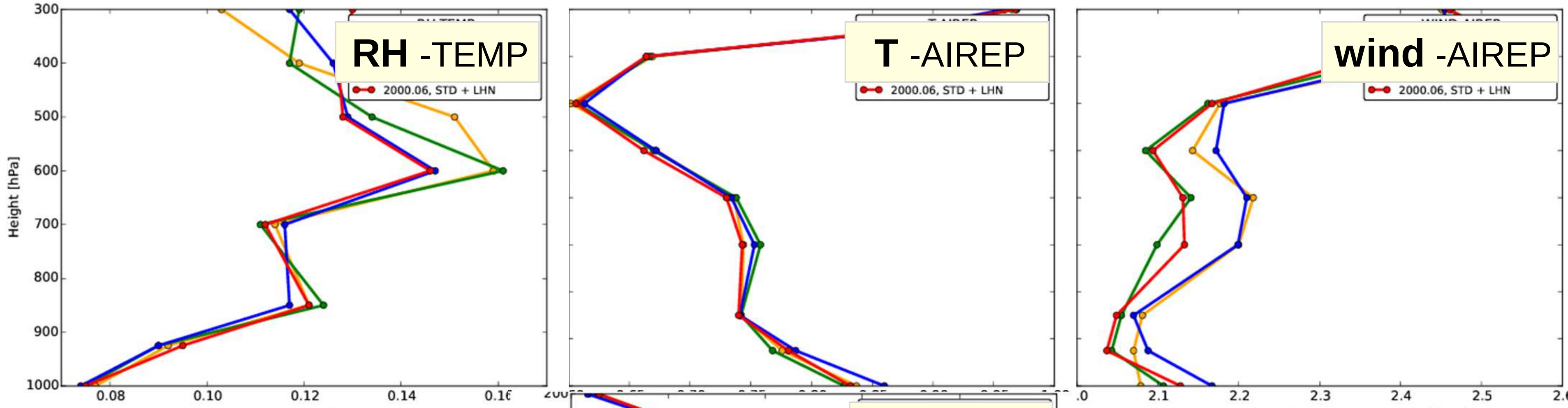


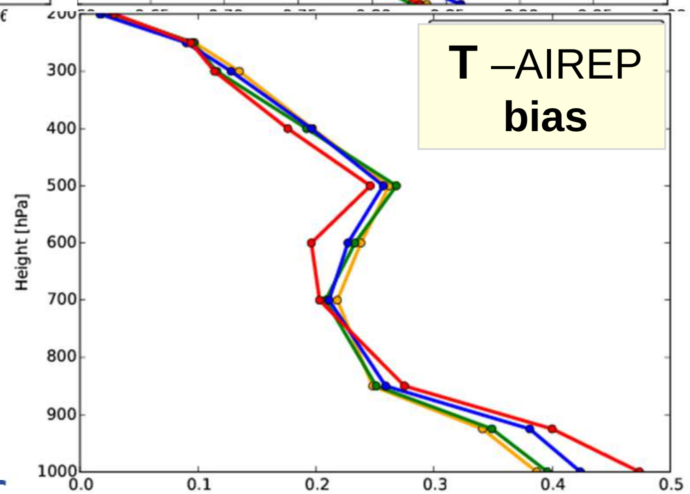
✓ spread reduced particularly in lower atmosphere

8 days
17. – 24.06.
2014

std dev







- ✓ low level degraded
- ✓ upper levels improved

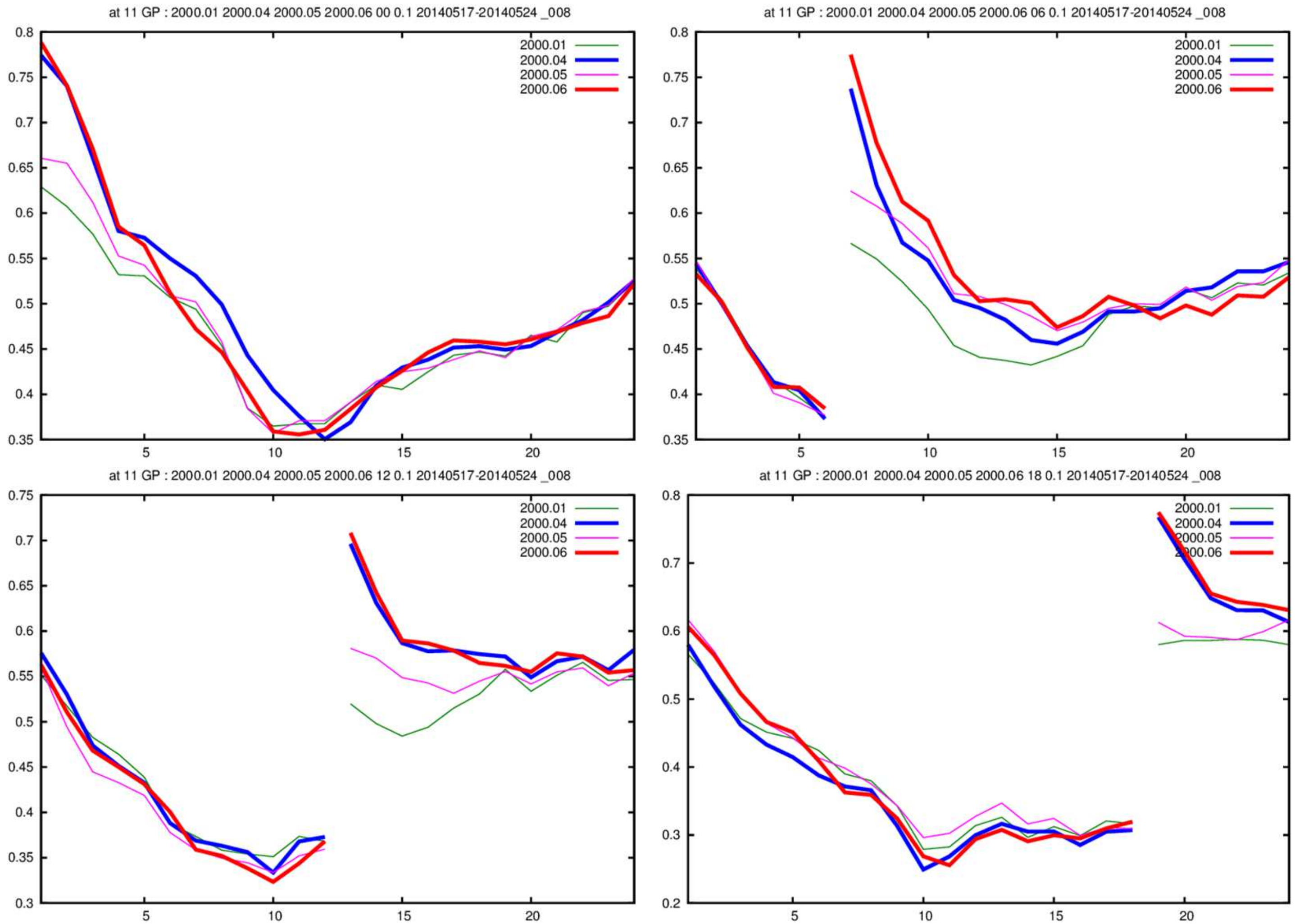
high-resolution obs:
GNSS-STD, first trial for use in KENDA

8 days
17 – 24 May 2014

1-hrly precip
FSS (30 km)

0.1 mm/h

CONV only
CONV + GNSS
CONV + LHN
CONV + LHN + GNSS



✓ 0.1 mm/h : slightly worse for 0-UTC runs, slightly better for 6-, 18-UTC runs

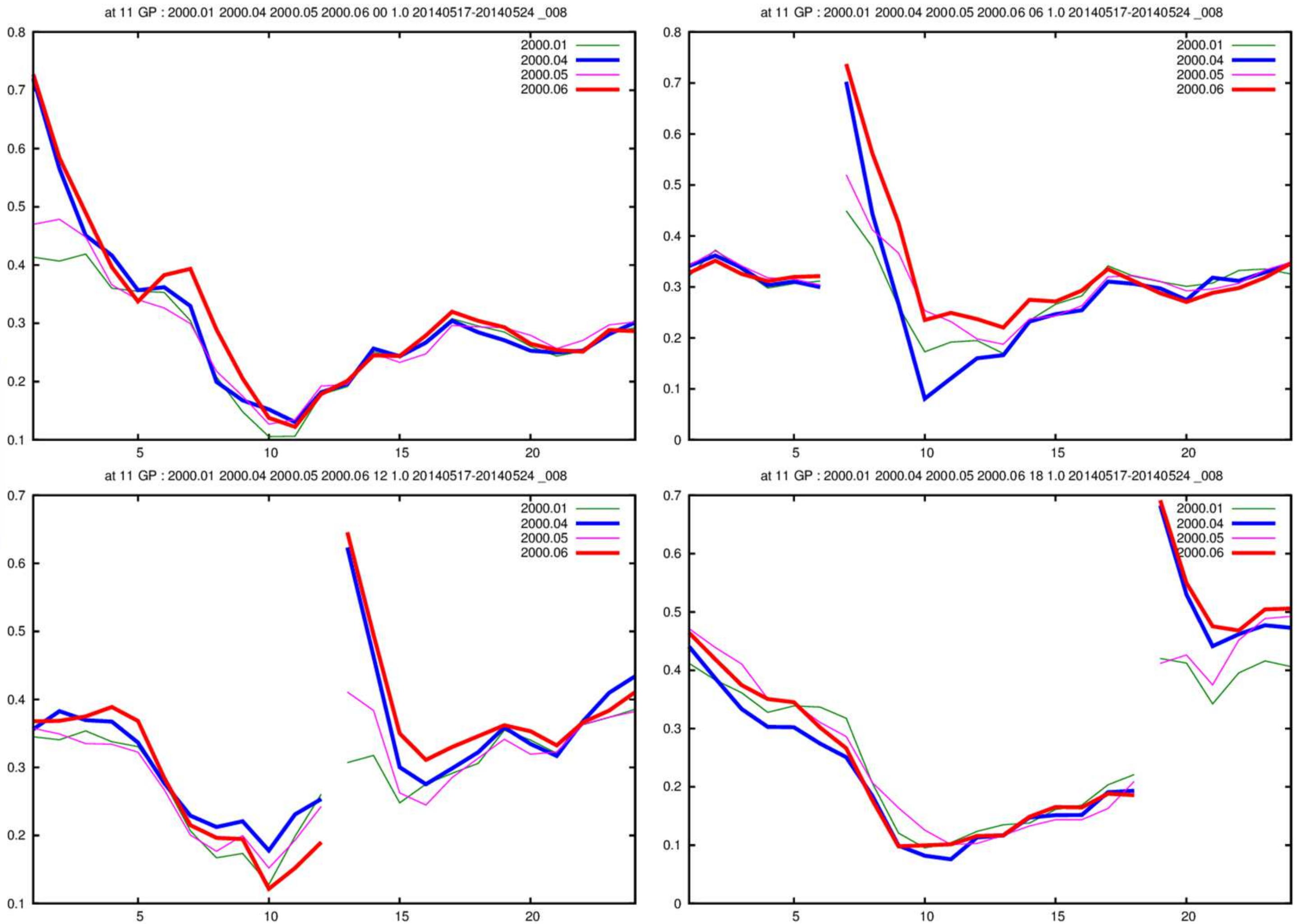
high-resolution obs:
GNSS-STD, first trial for use in KENDA

8 days
17 – 24 May 2014

1-hrly precip
FSS (30 km)

1 mm/h

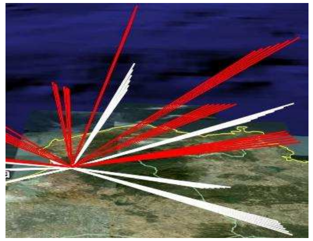
CONV only
CONV + GNSS
CONV + LHN
CONV + LHN + GNSS



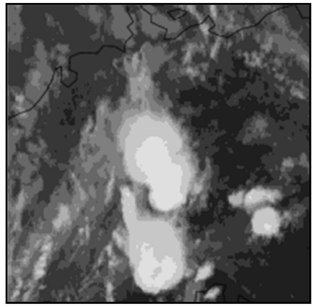
✓ 1 mm/h : slightly better for 0-, 6-, 18-UTC runs

KENDA-O overview, Task 2:
High-res obs, in the context of convection

Deutscher Wetterdienst

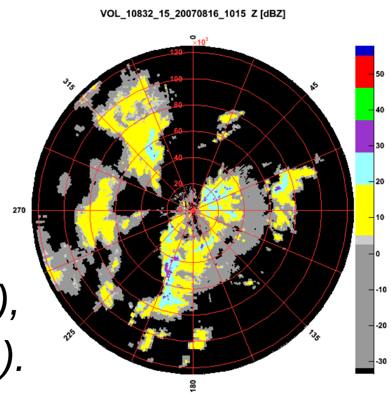


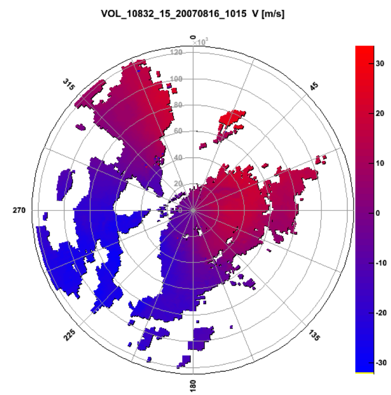
- pre-convective environment: no clouds
  → GNSS **Slant Total Delay** : *Michael Bender*



- developing convection: clouds
  → cloud top height from satellite data (Meteosat / SEVIRI)
  no resources
  → **cloudy SEVIRI** radiances (**IR** window + **WV** channels)
  all-sky approach for WV: *Axel Hutt* *(Florian Harnisch, HErZ)*
  work on cloud-dependent obs errors + bias correction
  very preliminary assimilation experiments with mixed impact

- mature convection: precipitation
  → **radar**: 3-dim. **reflectivity**
  3-dim. **radial velocity**
  → *Therea Bick left* → *Axel Seiffert*
  Elisabeth Bauernschubert (DWD/IAFE),
  Virginia Poli (ARPAE): (1 week DA exp).



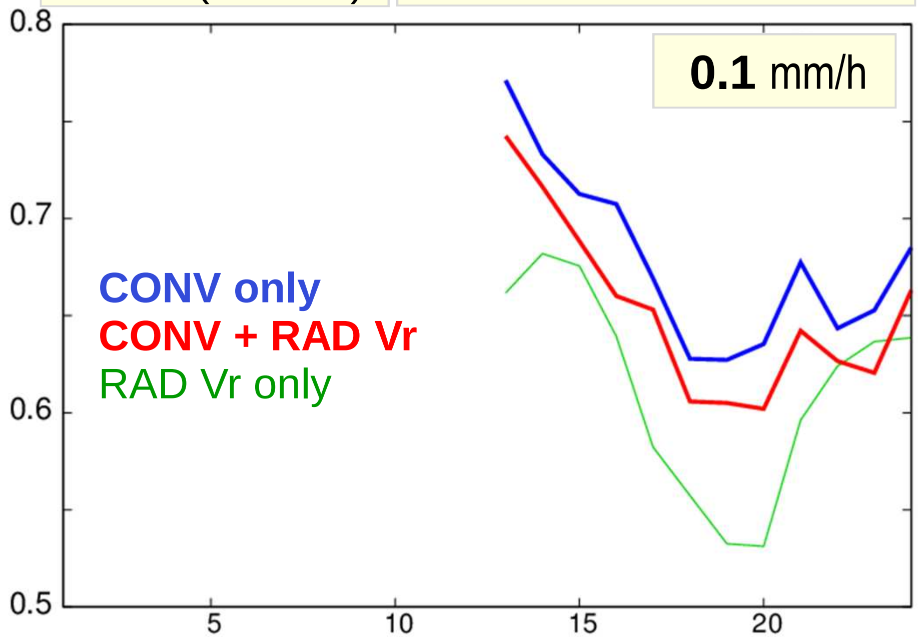


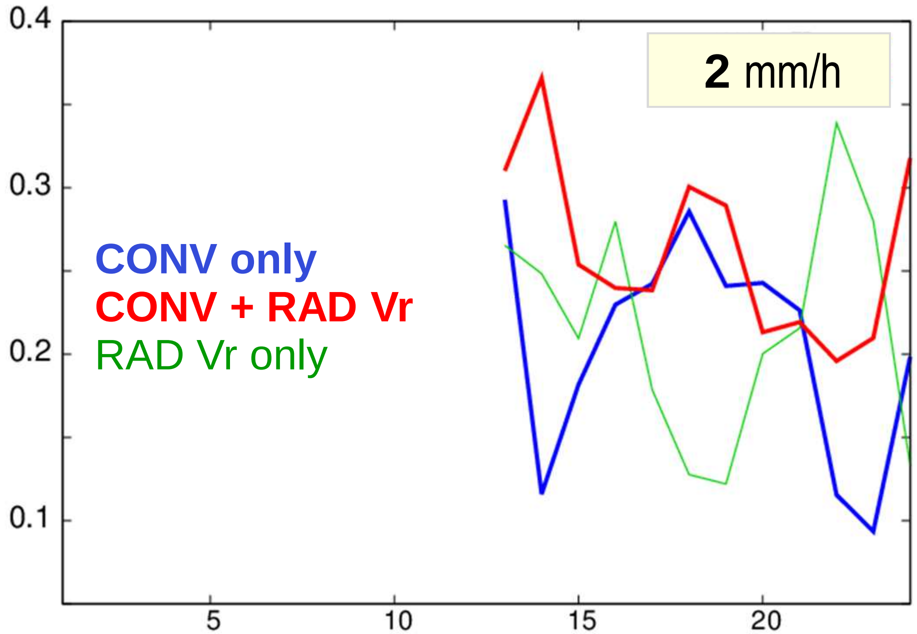
8 days
21 – 29 May 2014

- only 1 radar used (Boostedt in Northern Germany)
- obs error 5 m/s, superobbing 10 km, h-loc 16 km

1-hrly precip
FSS (30 km)

12-UTC forecast runs





preliminary tuning experiments (4 radars used)

✓ moderate sensitivity, optimal values: obs error 3 m/s (better than 5 m/s),
superobbing 10 km (5 km, 20 km), horizontal localisation 32 km (16 km)

✓ generally positive impact on first few hours of forecasts (upper-air + surface verif)

Task 2

- GNSS slant total delay
- SEVIRI WV all-sky for cloud info
- radar reflectivity + radial velocity
- screen-level obs: sensitivity tests with 2-m humidity by T. Necker (COSMO money)
- Mode-S : test at DWD will start soon (based on positive results by H. Lange)
- ground-based remote sensing
- at DWD possibly 2 additional positions (IVS): VIR/NIR SEVIRI , assimilation of objects

Task 4

- KENDA for ICON: start 2017, see later
- non-Gaussianity: Promising research ongoing with
  - hybrid LETK-PF applied to the COSMO model (Sylvain Robert, ETH)
  - hybrid VarEnKF-PF applied to ICON (Roland Potthast)

requirements for operationalisation of KENDA (late 2016, or 1st half 2017)

- data base (software update ongoing, hardware update needed?)
- test reduced soil moisture perturbations: still need positive / neutral impact
- winter period with pre-operational configuration (LBC!), keep an eye on wind gusts
- (desired, but (presumably) not mandatory: improve surface pressure / balance)
- desired: Mode-S aircraft

outlook: KENDA for ICON

- Task, starting 2017: port KENDA from COSMO to **ICON-regional**

  → consider hybrid (4-D) EnVar

  some advantages:

  - very positive experience with (3-D) EnVar for global ICON;
    KENDA 4-D LETKF: large improvement for EPS, not for deterministic
  - certain advantages of VAR (localisation, variational bias correction & QC,…) and hybrid approach (hybrid B)
  - further code unification with global DA at DWD
  - nudging not available any more for ICON-regional:
    → capability to use KENDA analysis code without need to run ensemble:
    3DVar, or use global ensemble for ensemble perturbations in EnVar

  some disadvantages:

  - limited 4-D capability , need to interpolate, lot of I/O
  - increased oomplexity, need of tangent linear / adjoint obs operators

outlook: KENDA for ICON

- implement MEC-based LETKF for COSMO (Reich, Oct. 16)
  → allows to test 4-D aspect of LETKF (only conventional obs)
- implement MEC-based LETKF for ICON-EU with COSMO obs operators
  → code changes: grid point assignment, (vertical grid, variables?), hydrostatic balancing (and other balancing?)
  (Rhodin, Schraff, Nov. 16 +)
- capsulate DACE data structures and implement global obs operators into ICON
  (Rhodin, Anlauf, Nov. 16 +)
- implement OCSMO obs operator functionality into DACE global obs operator environment (Schraff, Rhodin)
- tangent linear + adjoint for obs operators (also radar etc)
- re-write ‘cdfin’ reading routines ?