Task 2: extended use of observations: ongoing

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- ✓ **radar radial winds**: in parallel suite
- ✓ **radar reflectivity**: promising results
- ✓ **GPS slant total delay**:
  - (error-free) bias correction & blacklisting of stations important
  - small positive impact on precip, upper-air wind, 2-m temperature + humidity, cloud
- ✓ **SEVIRI WV, clear-sky**: bias correction important, small consistent positive impact
- ✓ **T2M, RH2M**: preparatory work; more resources in 2019
- ✓ **Mode-S aircraft** : operational
- ✓ **Raman lidar** (T-, q- profiles): first case study with positive impact

in WG1:

- ✓ **SEVIRI VIS**: first impact experiments, slightly improved cloud, precip, T2M, surface pressure, upper-air fields, etc.

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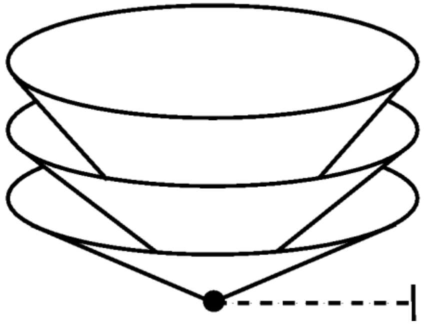
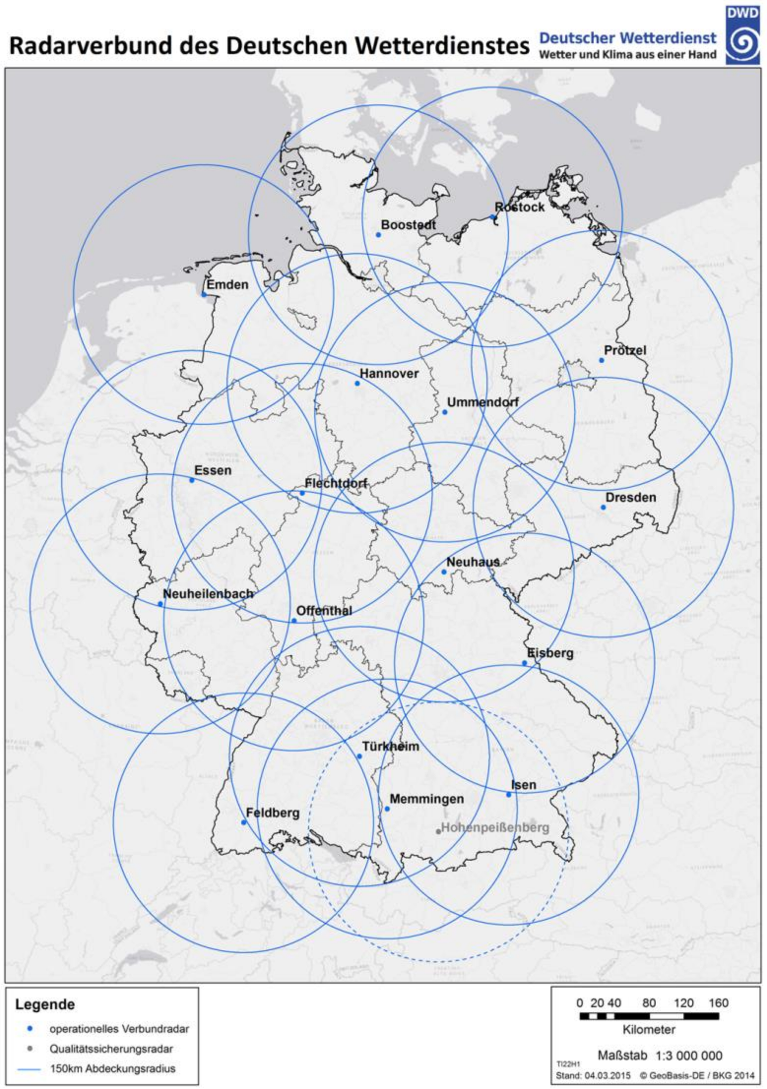
Deutscher Wetterdienst

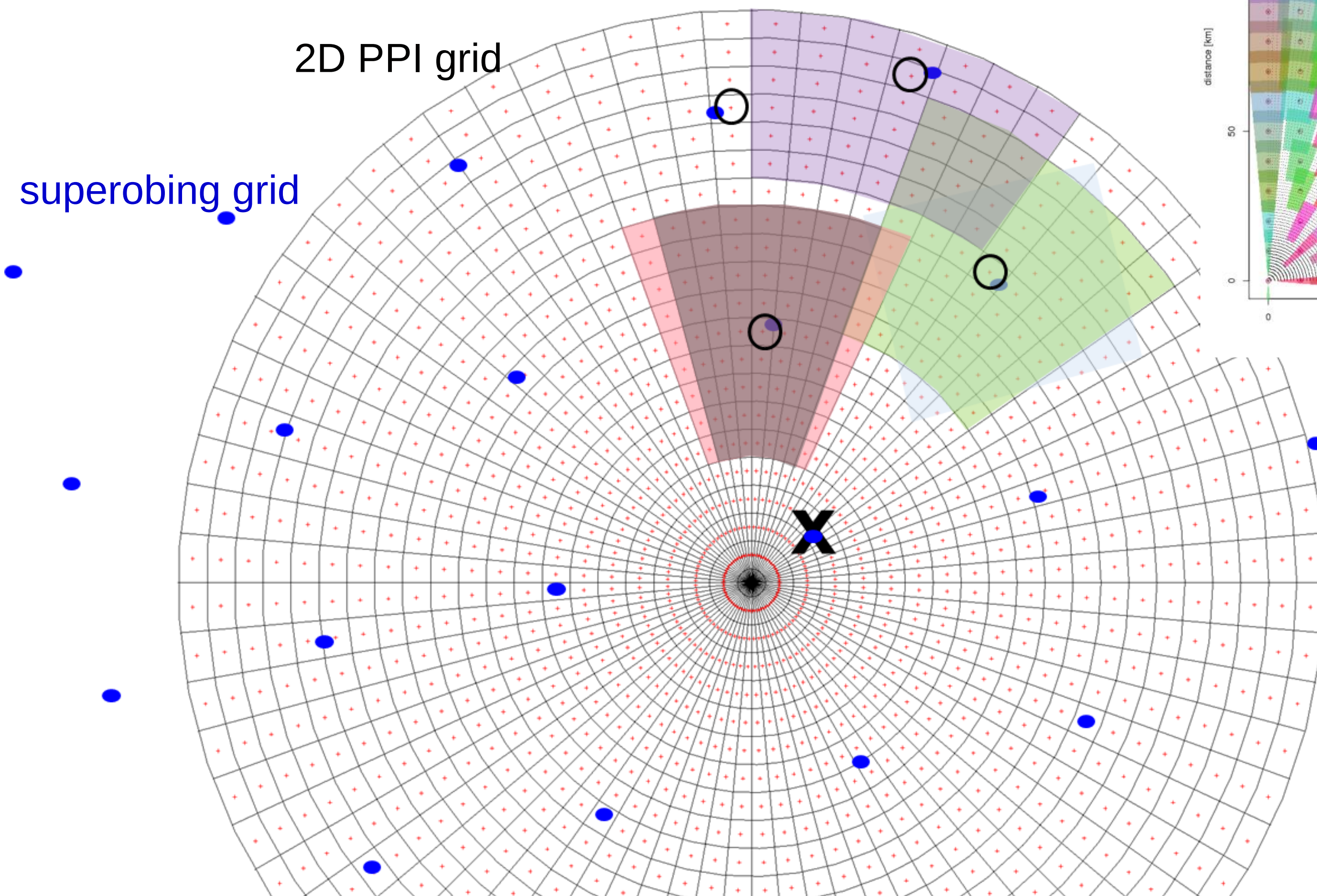
radar network of DWD:

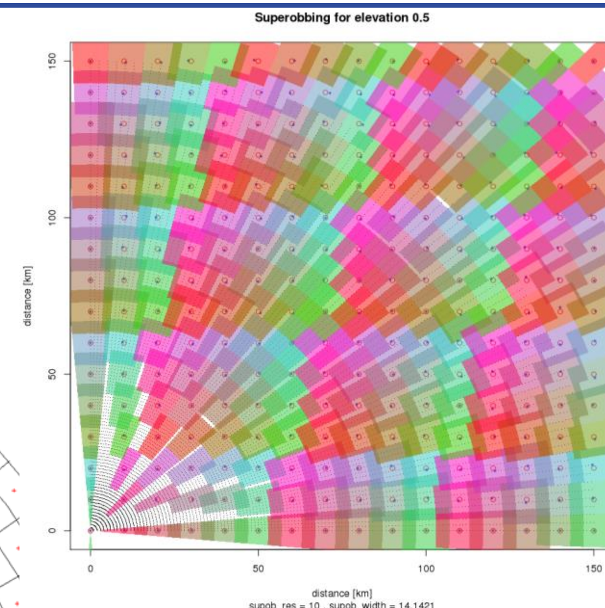
- 17 polarimetric Doppler C-Band radars
- reflectivity (Z) + radial wind (Vr)
- resolution: 5 min. ; 1° x 1 km
  10 elevations (between 0.5° and 25°)





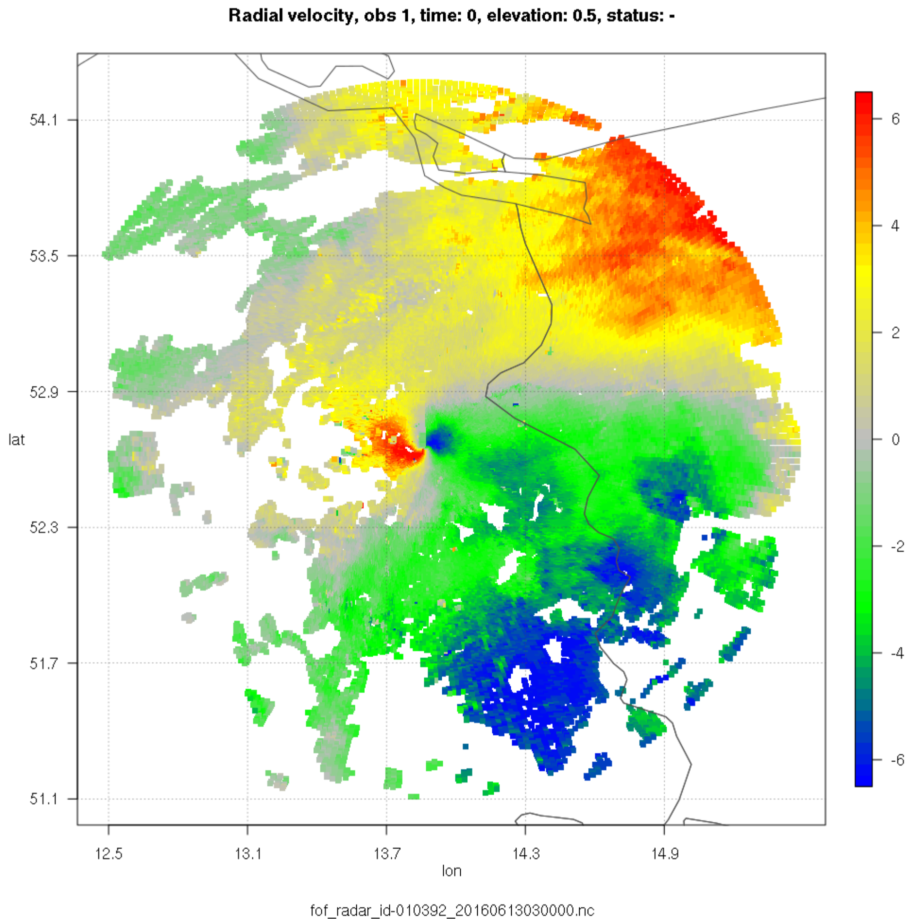
- superobbing for each elevation and radar station
- average over each wedge



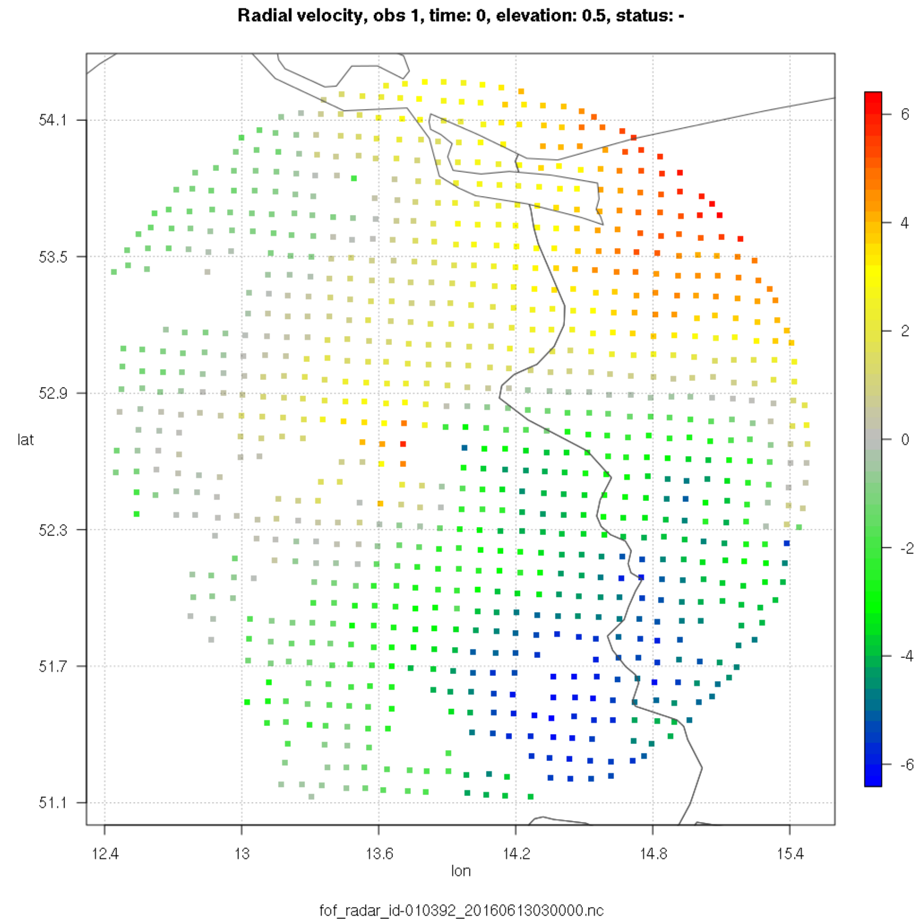


Task 2.1: radar radial velocity (Vr) superobbing

without superobbing



with superobbing (here 10 km)



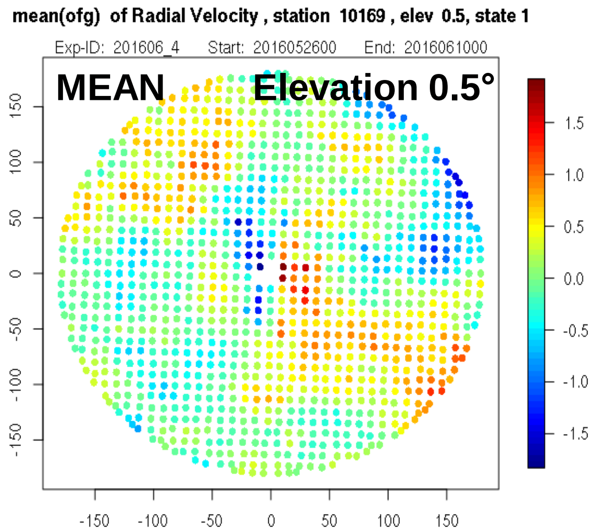
Why superobbing?

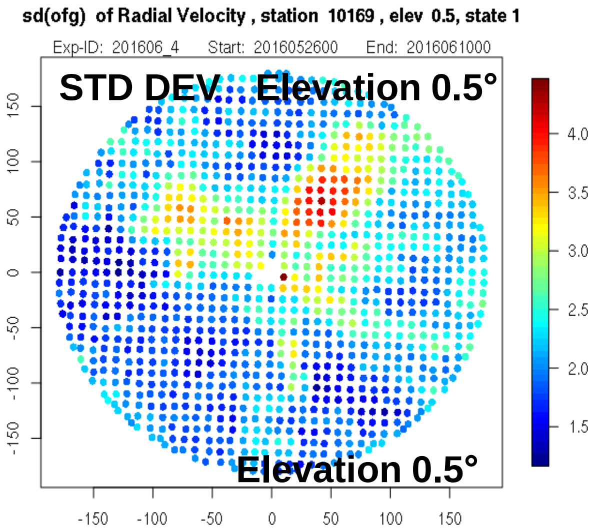
- **efficiency** (less memory, computing time, …)
- spatial resolution of obs should be ≤ effective resolution of model
- a too large number of high resolution data might result in an **imbalance between this high-res data and conventional observations** with regard to the influence in the data assimilation process
- LETKF implementation does not yet account for **obs error correlations**

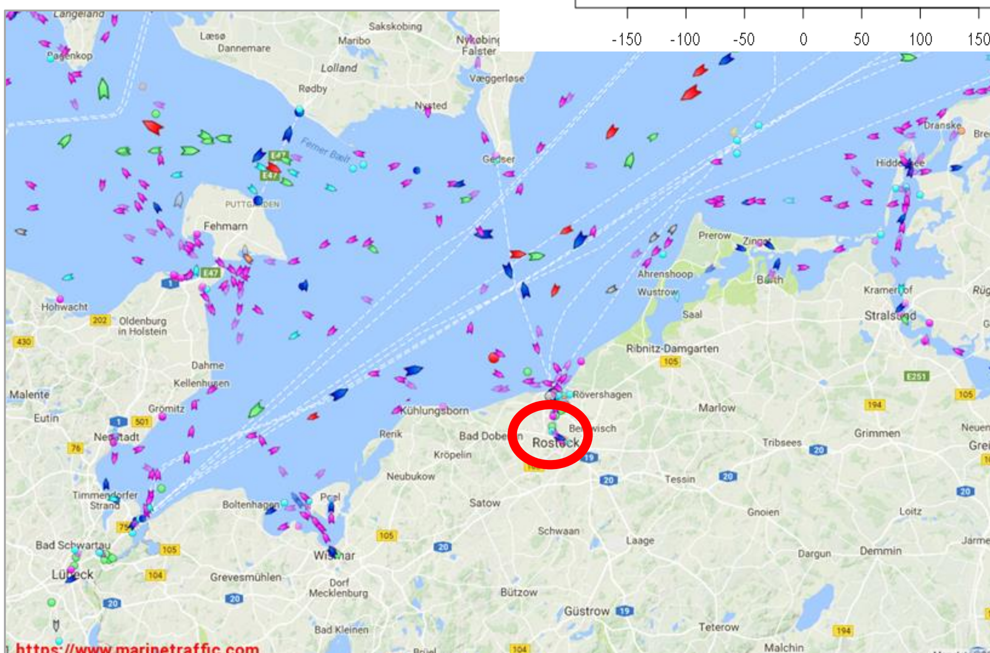
Task 2.1: radar radial velocity (Vr)
observation errors

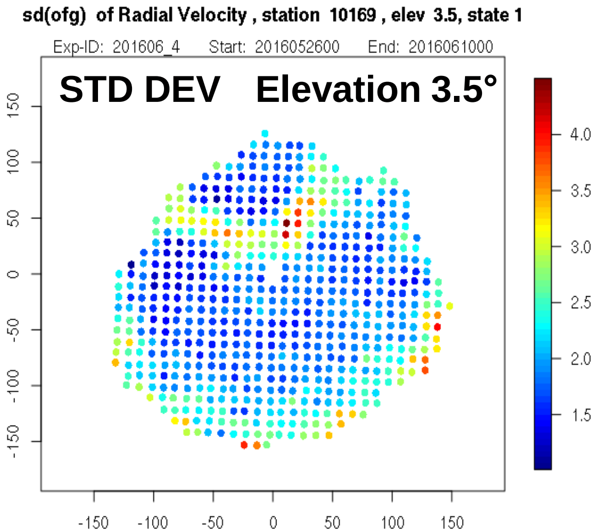
obs – first guess statistics:

→ influence of ships
(radar Rostok)









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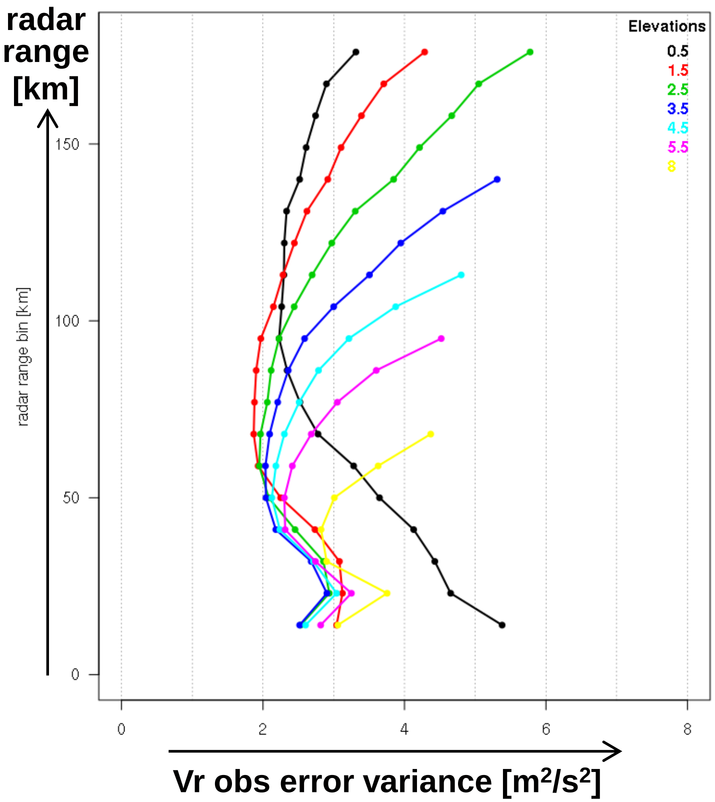
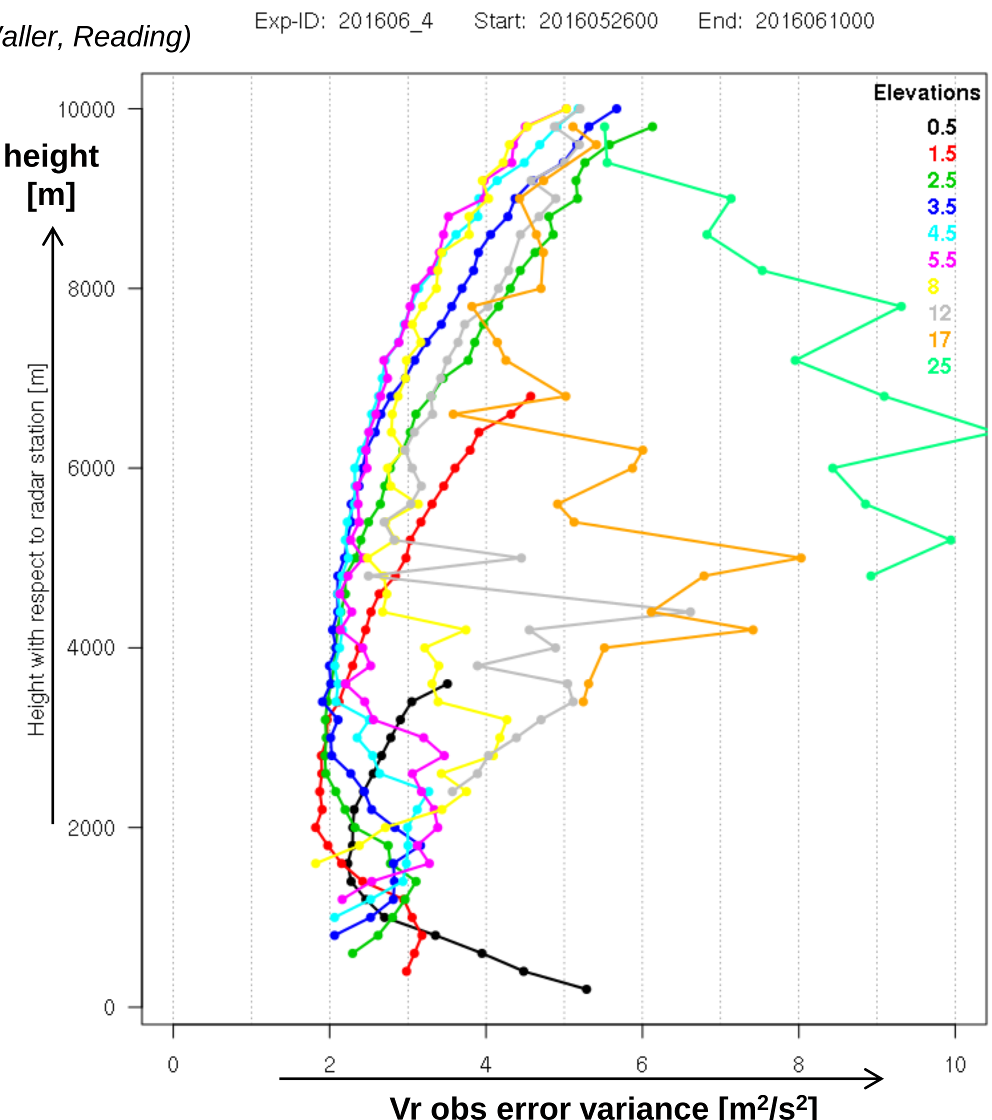
Desroziers statistics

(collaboration w. J. Waller, Reading)

to estimate obs error
(for R-Matrix in LETKF)

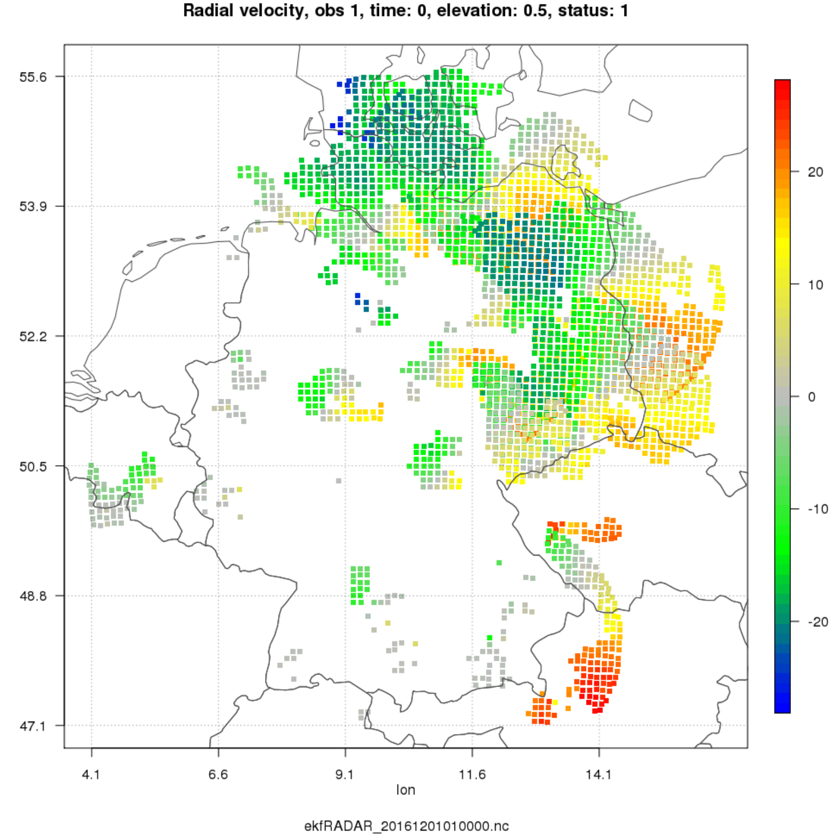
$$E[(obs - fg)(obs - ana)]$$





- 26 May – 30 June 2016 (severe **convective events**)
- forecasts every 6 hrs (0, 6, 12, 18 UTC)
- reference exp.: conv. obs **with Mode-S + LHN**

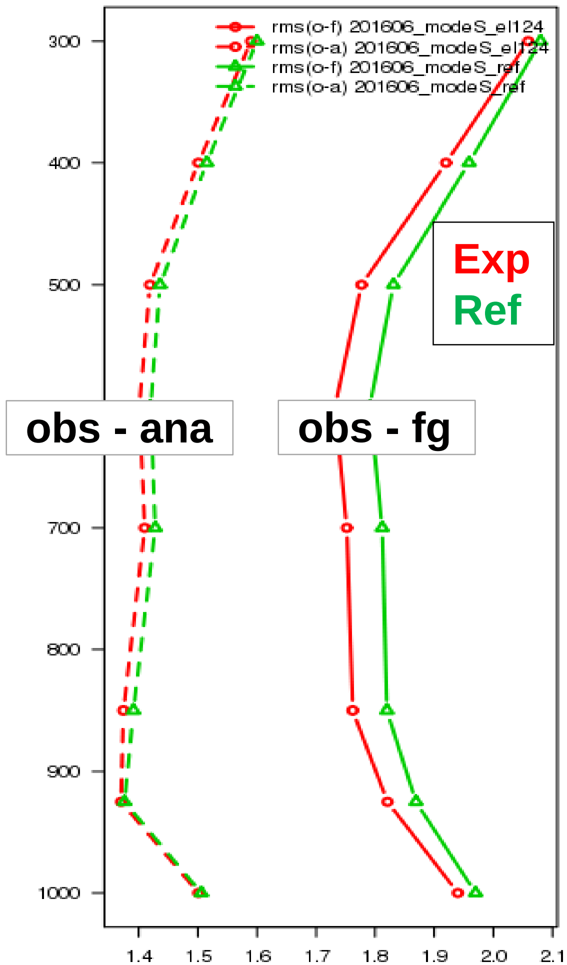
example
→ data available only in 'rainy' areas



from previous sensitivity experiments:

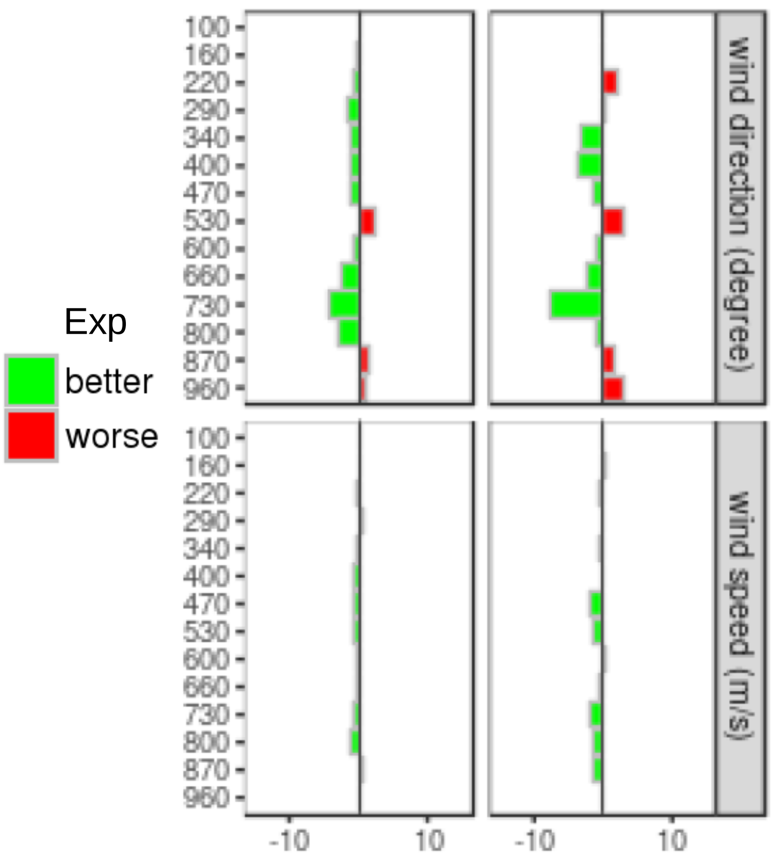
- „**temporal thinning**": only radial winds from 1 scan per hour (i.e. at analysis time)
- use of **lower elevations** only (elevations 1, 2, 4, i.e. 0.5°, 1.5°, 3.5°)

wind RMSE vs. **TEMP, AMDAR + WProf**



✓ clear positive impact on 1-h forecast

radiosonde verif (+6, 12, 18, 24h)

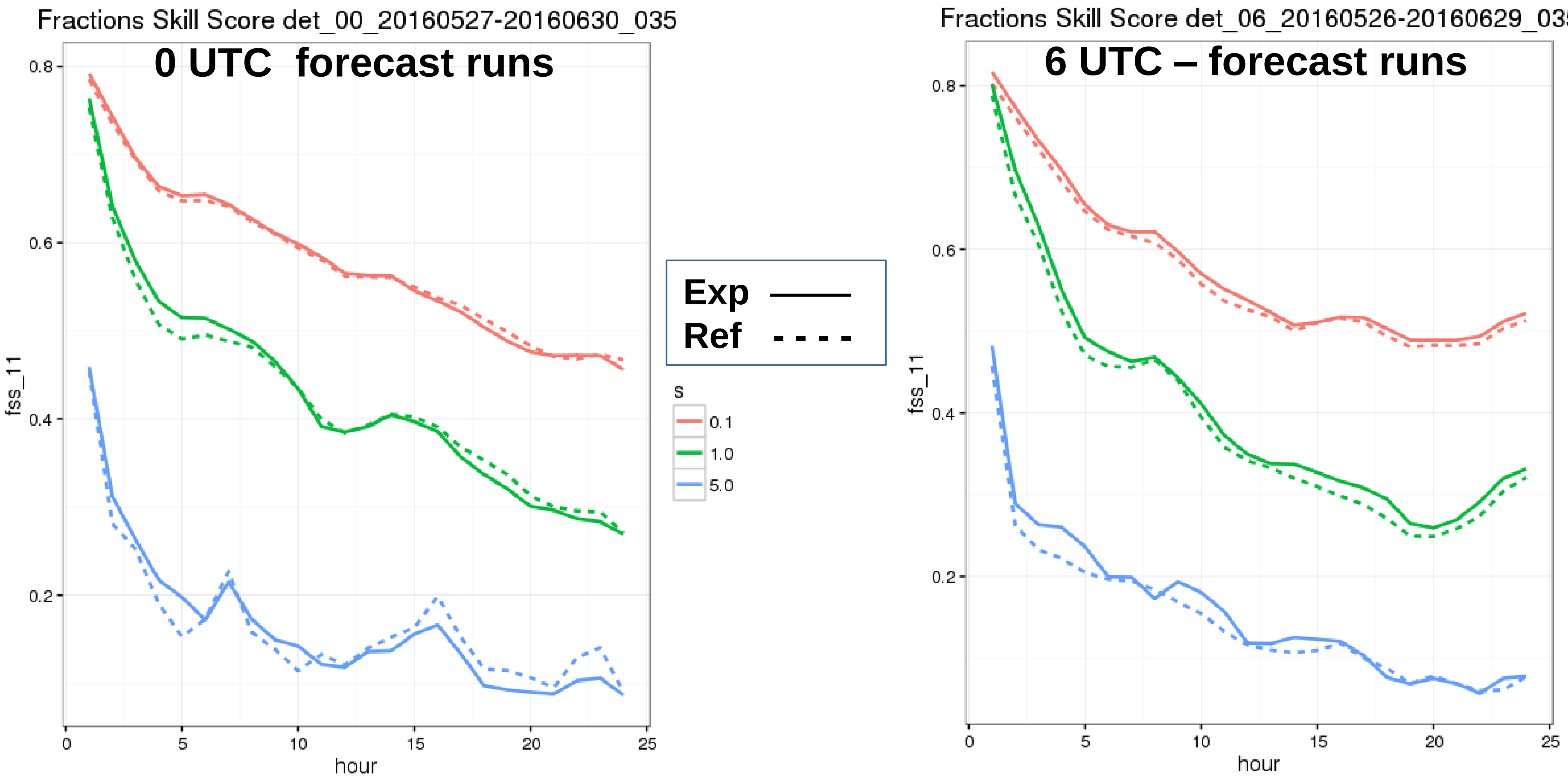


✓ small positive impact at ≥ 6 hrs

Task 2.1: radar radial velocity (Vr) impact experiments

Deutscher Wetterdienst

FSS (fraction skill score: perfect = 1) for **1-h precip**
11 g.pt. (30 km) ; thresholds: 0.1, 1.0 und 5.0 mm/h



✓ (small) positive impact on 6-UTC forecast runs, ~ neutral in 0-, 12-, 18- UTC runs

Task 2.1: radar radial velocity (Vr)
conclusions

- **obs errors** depend on elevation and height / range
- **superobbing** (10 km), **vertical** (elevat. 0.5°, 1.5°, 3.5°) **+ temporal thinning** (1 h) beneficial
- **positive impact on precipitation only small** (in summer),
  larger without simultaneous use of Mode-S (in Exp. & Ref.)

  → operational use of radar Vr could increase obs redundancy in the DA system,
  might mitigate outage of Mode-S (pot. larger impact in areas w/o Mode-S)
- positive impact on wind, especially in first forecast hours → useful towards nowcasting
- neutral (or very small positive) impact in **winter**
- still challenge: radial wind **data quality (control)**
  increase of computational **cost**: COSMO 5 – 10%, LETKF up to 50%

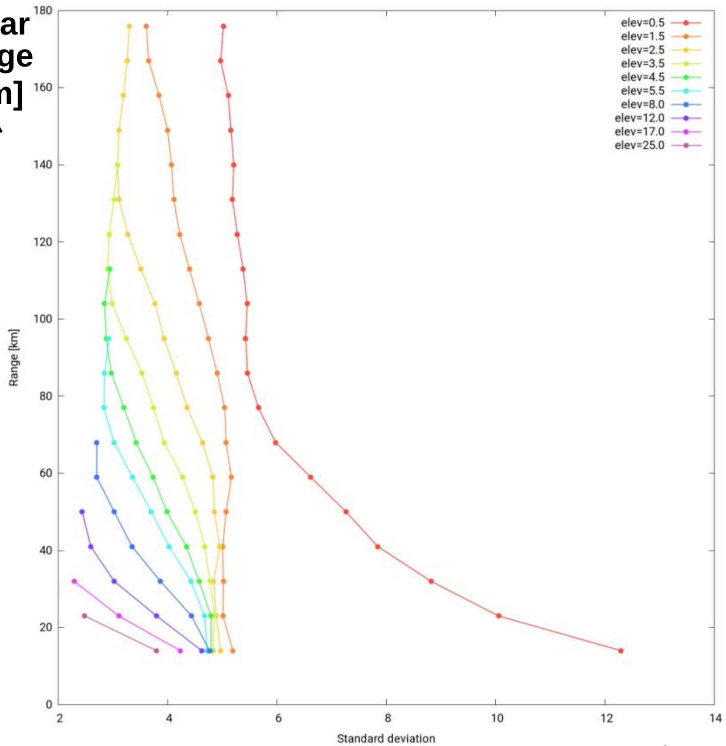
- all experiments with COSMO-DE (2.8 km) so far,
  experiment with COSMO-D2 (2.2 km) for convective period being set up
- **radar Vr in parallel suite for COSMO-D2 since 12 June 2018,**
  with neutral impact in the dry summer so far

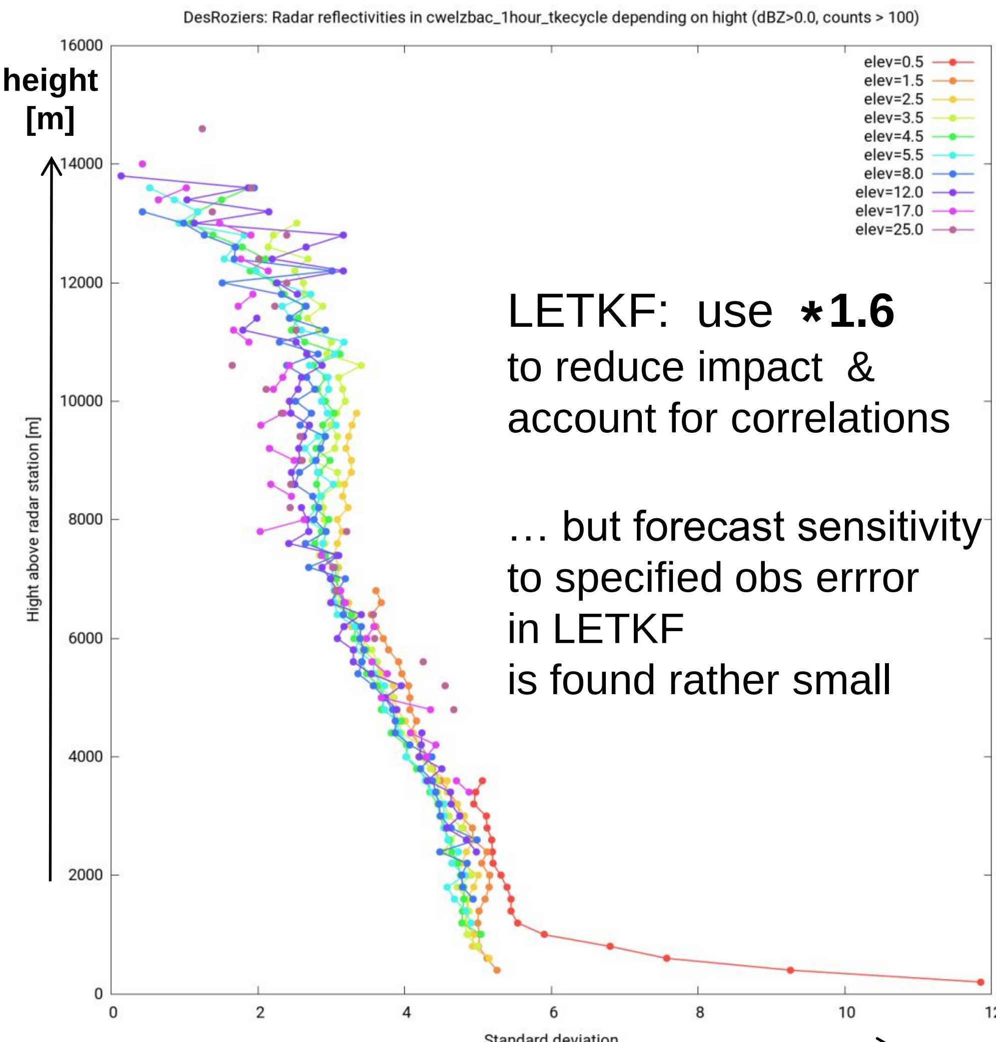
Task 2.1: radar reflectivity (Z) observation errors

Desroziers statistics

to estimate obs error
(for R-Matrix in LETKF)

$$E[(obs - fg)(obs - ana)]$$





LETKF: use ***1.6**
to reduce impact &
account for correlations

… but forecast sensitivity
to specified obs errror
in LETKF
is found rather small

Task 2.1: radar reflectivity (Z) (+ radial velocity Vr) impact experiments

- 27 May – 10 June 2016 (severe **convective events**)
- forecasts every 6 hrs (0, 6, 12, 18 UTC)
- reference exp.: conventional obs **with Mode-S**
- operational LETKF settings !
  (adapt. mult. cov. inflation, RTPP, additive cov. inflation,…)


(source: http://strangesounds.org)

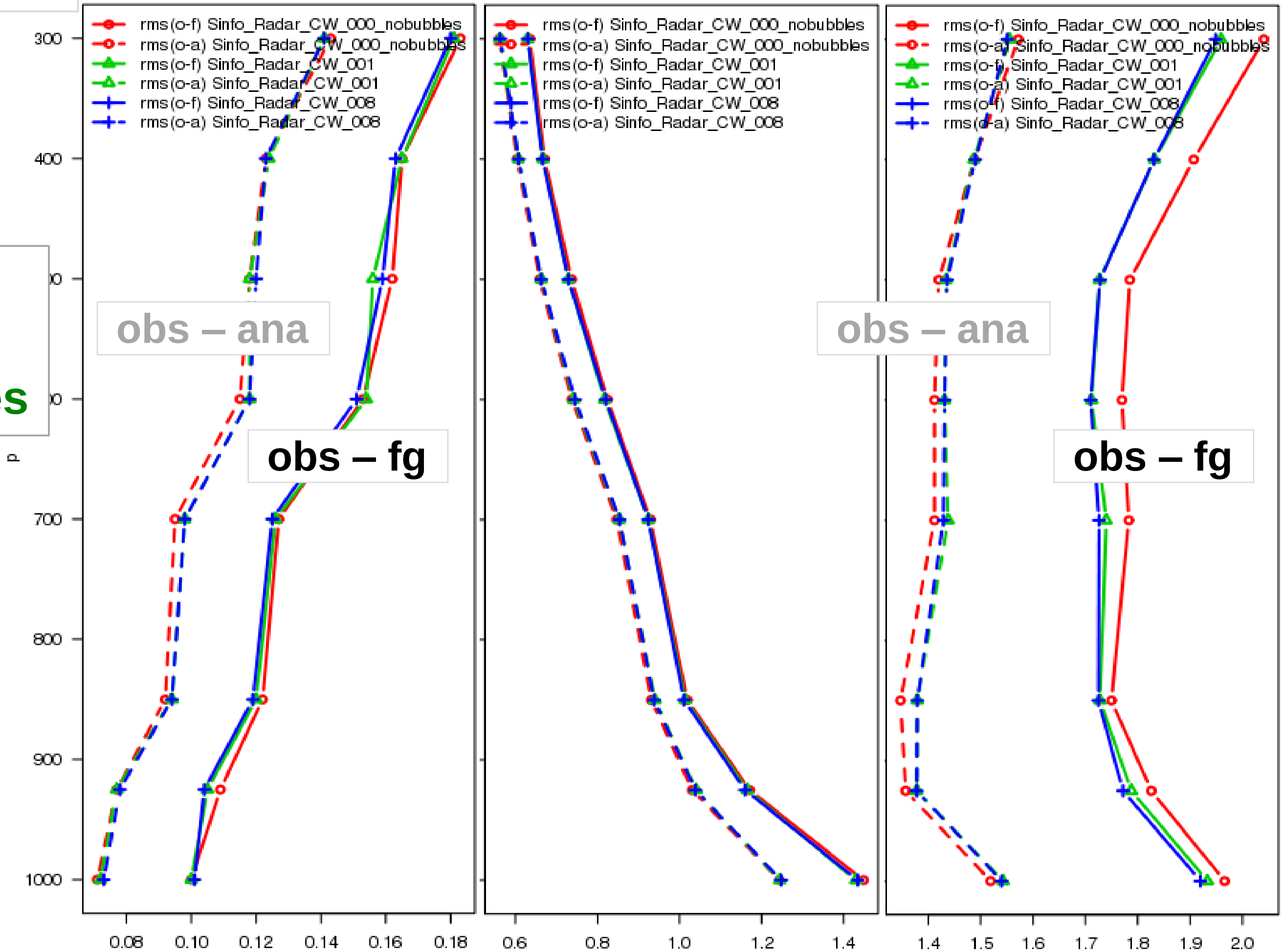
from previous sensitivity experiments:

- modified model settings !
  - max. turb length scale: 500 m (instead of 150 m)
    → more turbulent mixing
  - TKE cycling
- „**temporal thinning**“: (Z , Vr) data from only 1 scan per hour (i.e. at analysis time)
- “**warm bubbles**” introduced in model states (as initial trigger for convection)
  ‘where’ convective precip cells are observed, but not simulated by the ensemble

RMSE of **1-h** forecast
vs. TEMP, AMDAR, WindProf

no radar
3D radar Z
3D radar Z with bubbles

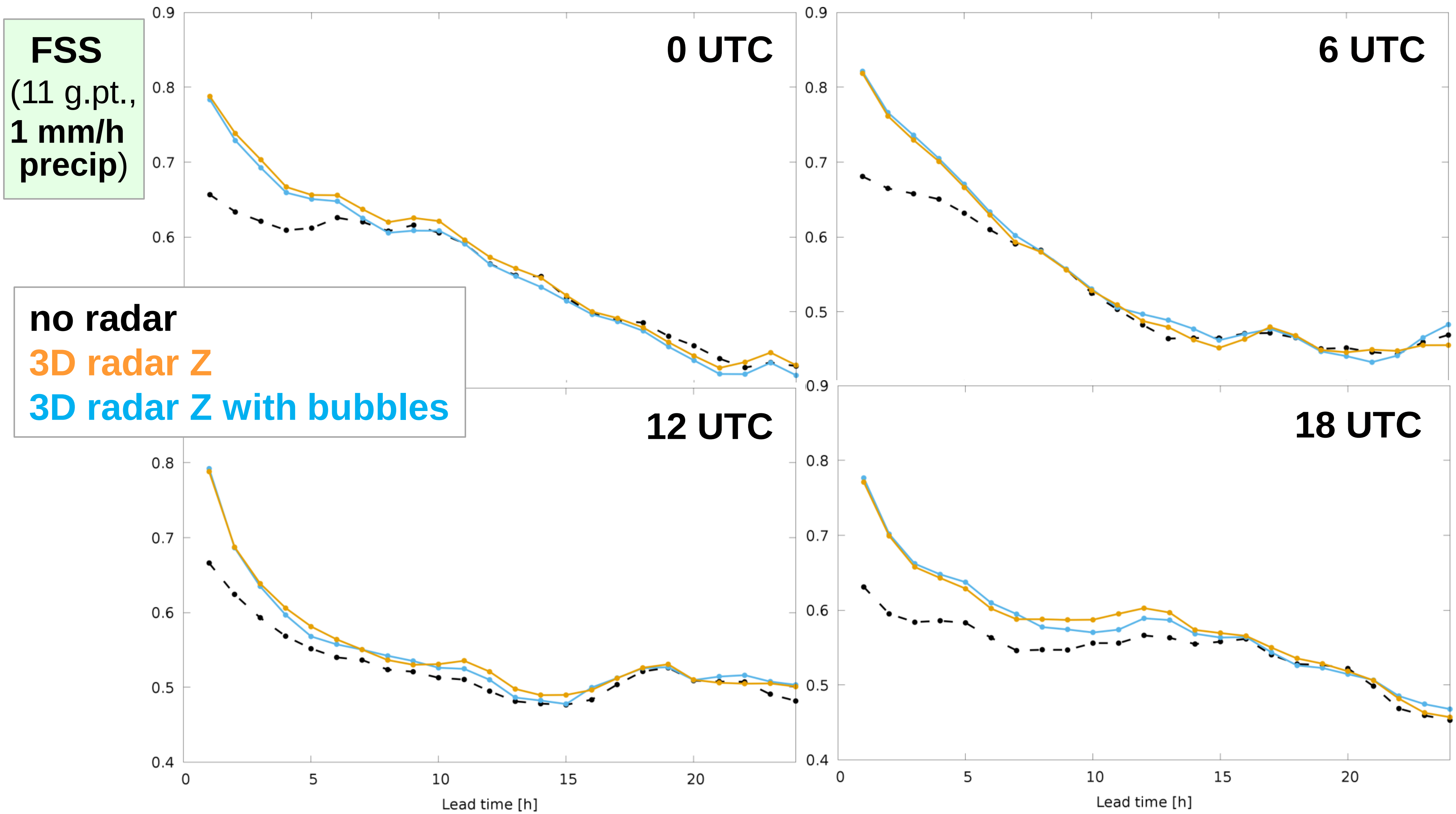
RH **T** **wind**



✓ 3D radar Z in LETKF improves wind + humidity

Task 2.1: radar reflectivity (Z) (+ radial velocity Vr)
impact experiments

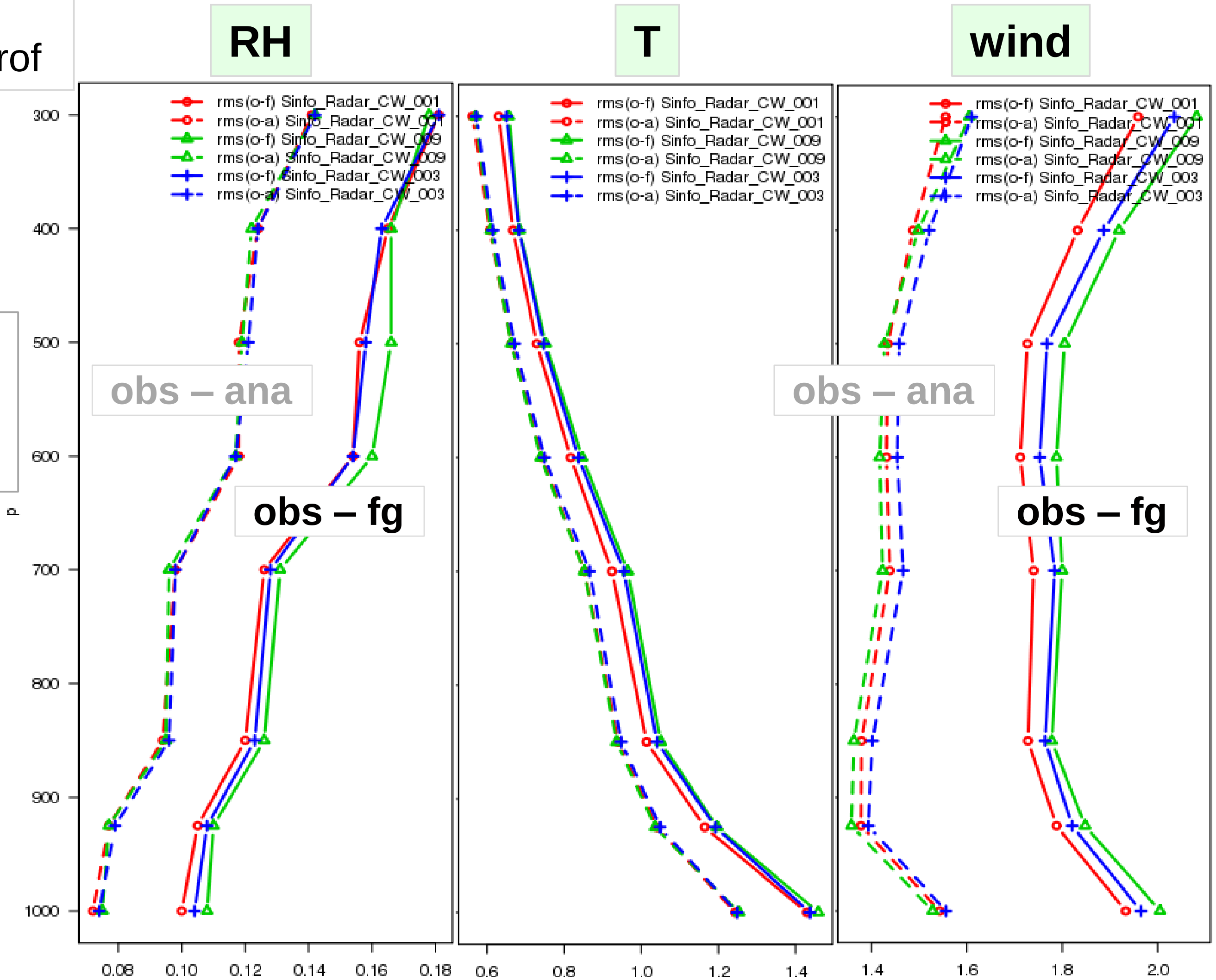
Deutscher Wetterdienst



- ✓ 3D radar Z: clear and sometimes long-lasting positive impact
- ✓ warm bubbles improve DA cycle (not shown), but not the forecast

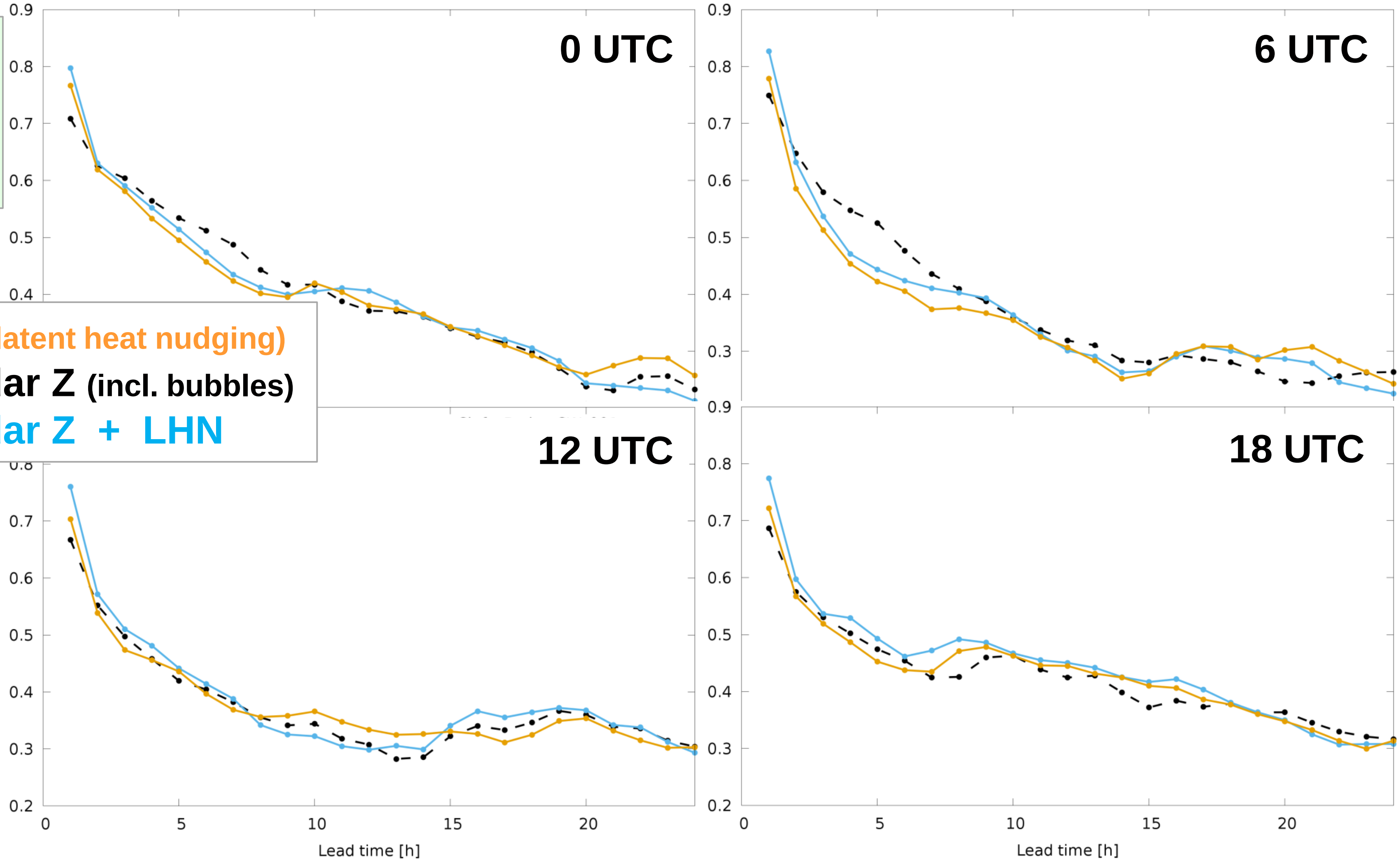
RMSE of **1-h** forecast
vs. TEMP, AMDAR, WindProf

LHN (latent heat nudging)
3D radar Z (incl. bubbles)
3D radar Z + LHN



✓ 3D radar Z in LETKF better than LHN (and better than combination)

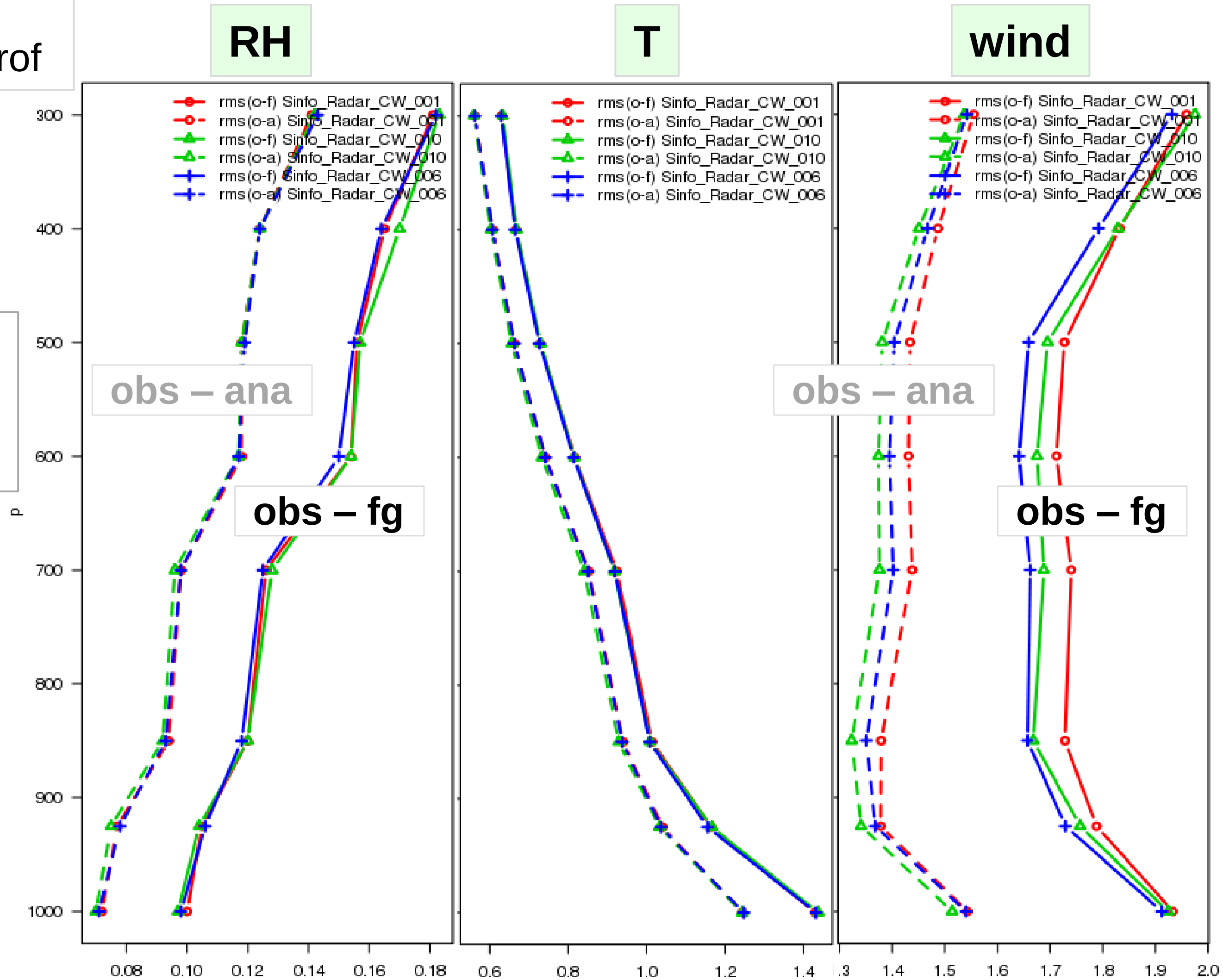
FSS
(11 g.pt.,
1 mm/h precip)



- ✓ 3D radar Z in LETKF slightly better than LHN for 0-, 6-UTC runs
- ✓ combination radar Z + LHN slightly better in 18-UTC runs

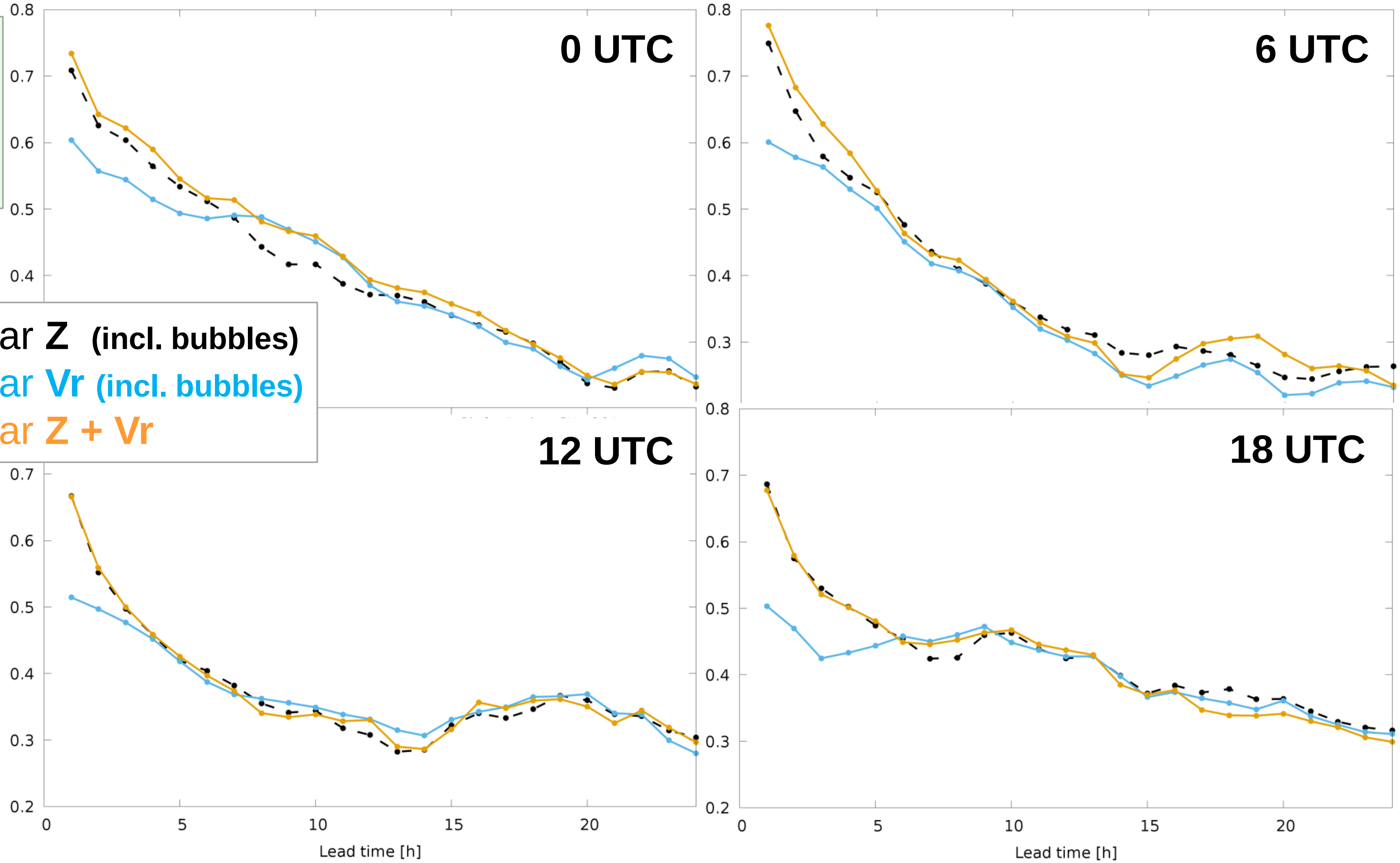
RMSE of **1-h** forecast
vs. TEMP, AMDAR, WindProf

3D radar **Z** **(incl. bubbles)**
3D radar **Vr** **(incl. bubbles)**
3D radar **Z + Vr**



✓ wind improved by radar Vr, best for combination for Vr + Z

FSS
(11 g.pt.,
1 mm/h precip)



- ✓ clear improvement by 3D radar Z up to 6 hrs (longer for low thresholds)
- ✓ combination radar Z + Vr slightly better in 0-UTC runs

Task 2.1: radar reflectivity (Z) (+ radial velocity Vr)
summary

- **obs errors** depend on elevation and height / range
- **superobbing** (10 km) **+ temporal thinning** (1 h) beneficial
- **warm bubbles:** minor forecast impact (not shown,
  (despite positive impact in previous experiments with RTPS)
- **3D radar Z in LETKF slightly better than LHN** overall (upper-air first guess, precip),
  no additional gain by combination (Z + LHN)
- 3D radar Vr (incl. bubbles) improves upper-air wind and slightly precip (not shown);
  3D radar Vr + Z (compared to Z) improves precip very slightly and upper-air wind clearly
- no additional gain by assimilation of radar Z with fuzziness (with approach similar to FSS,
  or use of nowcast objects)

further steps

- investigate role of model errors in idealised setup
- further tests (with operational model settings (tur_len = 150 m), COSMO-D2)
  sensitivity tests, winter experiments
- combine use of 3D radar Z from German radar
  with LHN of surface precip from foreign radars

Task 2.1: radar reflectivity volumes in LETKF at ARPAE-SIMC

Virginia Poli[1], Thomas Gastaldo[1,2], Chiara Marsigli[1], Pier Paolo Alberoni[1], Tiziana Paccagnella[1]

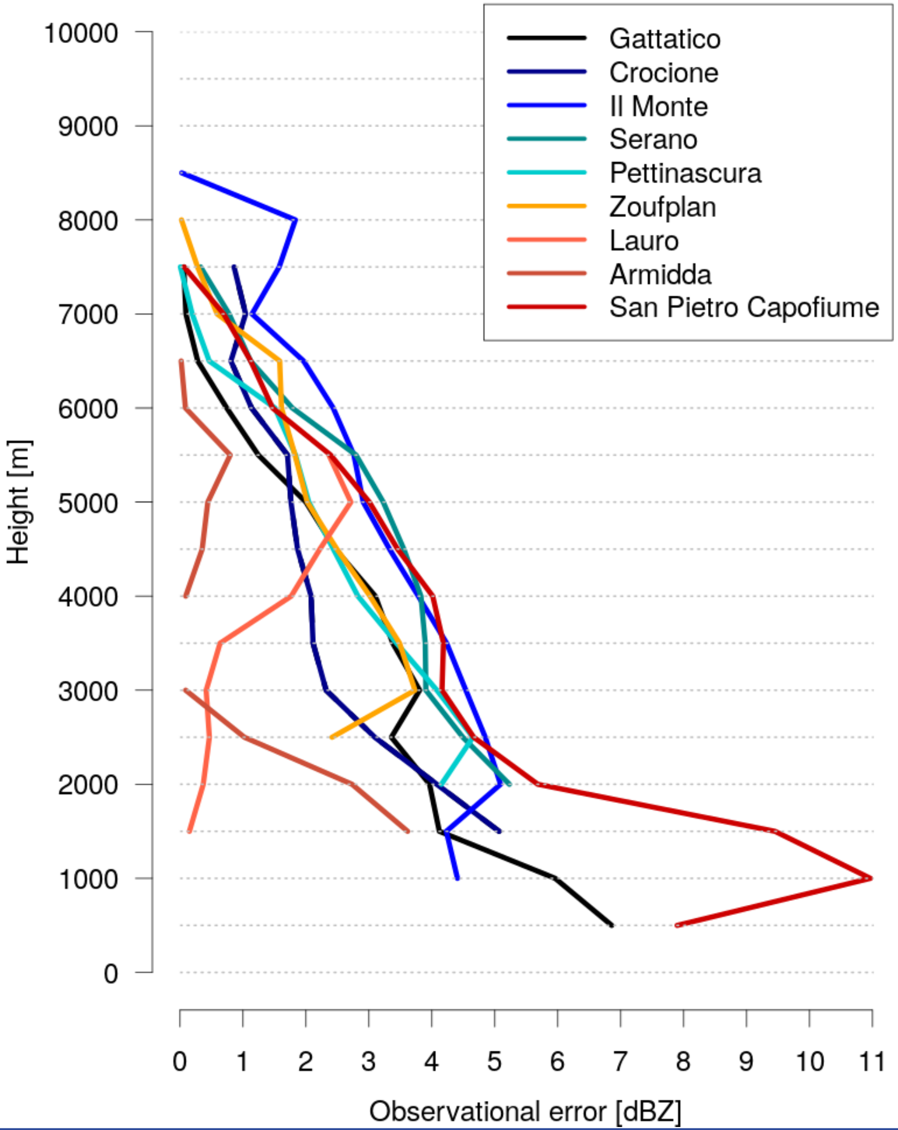
[1] *Arpae Emilia-Romagna, Hydro-Meteo-Climate Service (SIMC), Bologna, Italy*
[2] *University of Bologna, Bologna, Italy*

The work was focused on:

- estimation of reflectivity **observation error** specific for each radar of **Italian** radar network
- **impact** of assimilation of reflectivity volumes:
  - default observational error
  - specific error for each radar

Task 2.1: radar reflectivity: observation error specific for each radar of Italian radar network

arpae emilia-romagna



as default, an error of **10 dBZ** is used for every radar, but due to:

- complex orography
- inhomogeneity in acquisition strategy
- inhomogeneity from instrumental point of view

Desroziers statistics is applied **separately for each radar** to calculate radar error

mean values for each radar range **from 3.0 to 7.7 dBZ**

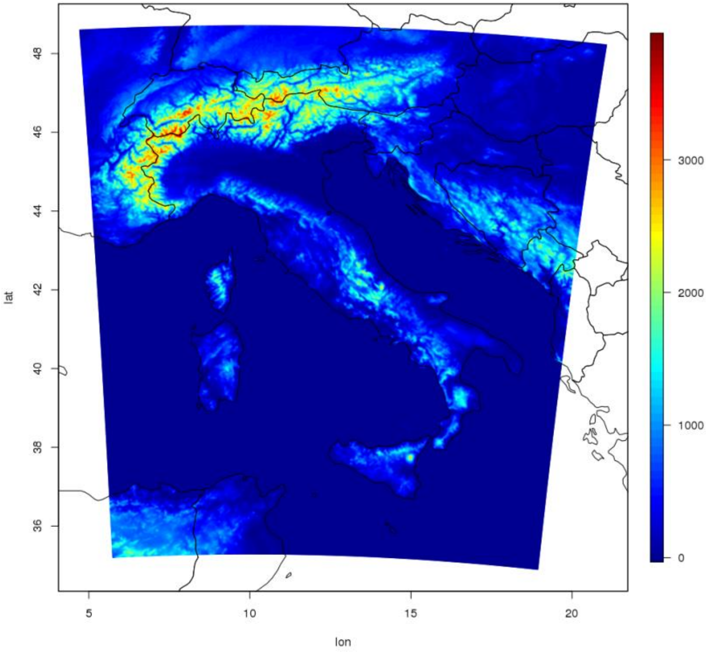
Task 2.1: radar reflectivity impact experiment

experimental period: **3 – 6 Feb. 2017** ,

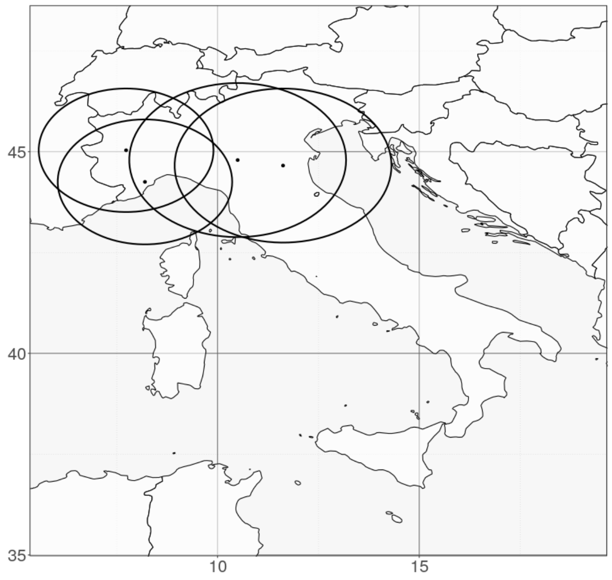
8 daily **deterministic** forecasts evaluated,

KENDA run with 3 different configurations

COSMO integration domain



areas covered by used radars



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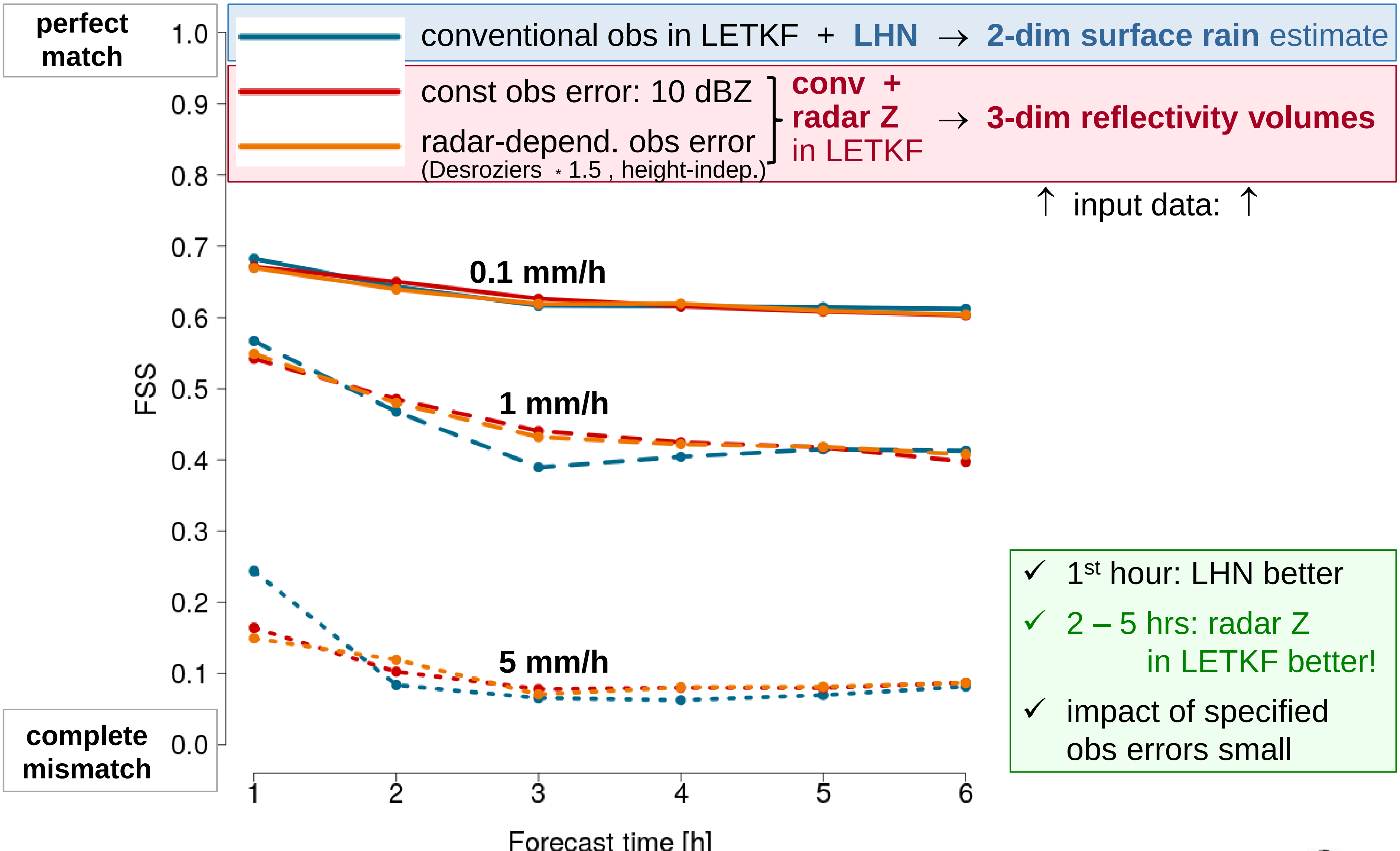
Task 2.1: radar reflectivity impact experiment



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Klaus Stephan
Deutscher Wetterdienst

- developments for ICON-EU have shown that **grid point search** (which is applied in the operational setup of LHN for COSMO) **is not essential**

  (without g.pt. search, a climatological latent heat profile is used also if precip is present at nearby grid pts)

→ test without grid point search for COSMO-DE for August 2017,

with **revised climatological profile**: Gaussian in the vertical

		operational (approx.)	revised	
z_max	(height of maximum)	3500 m	3000 m	→ similar
std	(width of Gaussian)	z_max / 4	z_max / 4	→ similar
tt_max	(**amplitude**)	0.0015 K/s	0.009 K/s	→ **much larger**

→ much larger trigger to initiate missing convective precip
(where convective has been produced, the climatological profile is not used any more)

→ will be tested further (e.g. in winter: ~ neutral)

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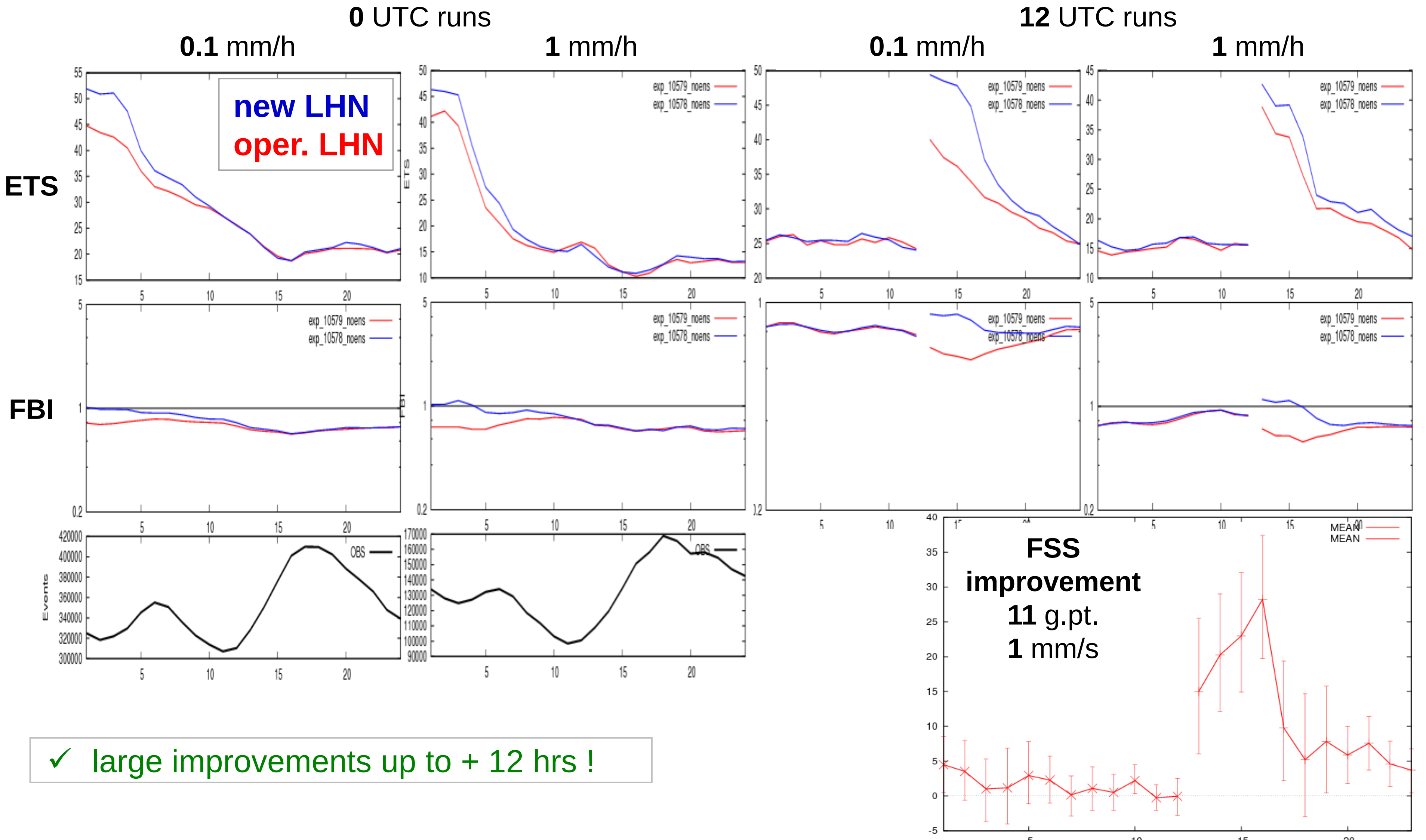
WG1: Latent heat nudging

impact exp. for August 2017



✓ large improvements up to + 12 hrs !

WG1: Latent heat nudging
impact exp. for August 2017

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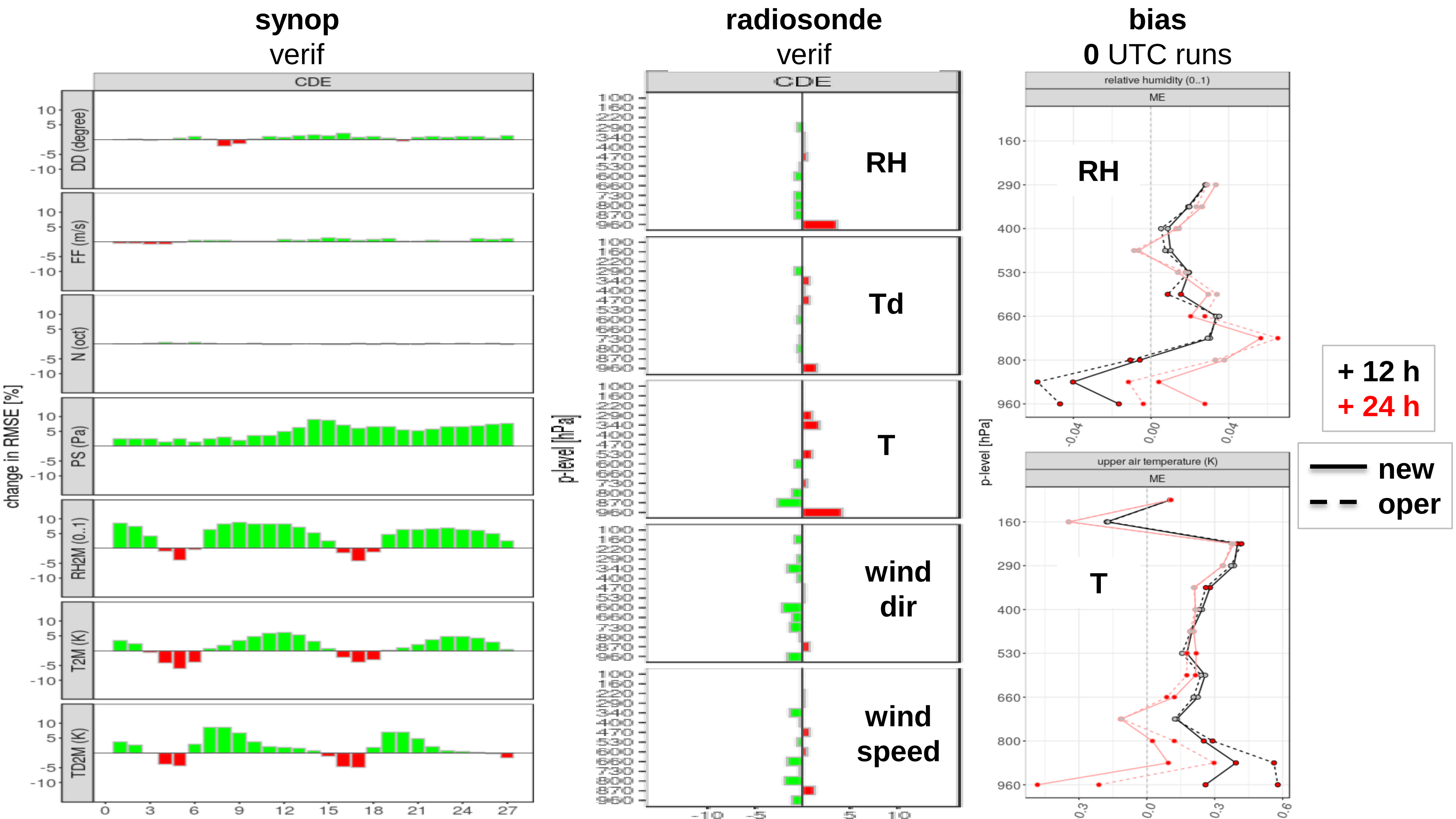

✓ improved ps, T2m, RH2M; colder + drier in PBL due to enhanced convection

→ will be tested further (e.g. in winter: ~ neutral)

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Lilo Bach et al.
Deutscher Wetterdienst

- SEVIRI channel in the visible spectral range (0.6 µm) → only at daytime !
- observation operator MFASIS (Scheck et. al, 2016)
- 5km x 3km Pixel (over COSMO-DE domain)
- superobbing 18km x 18km

Why assimilate them?

- information on cloud cover
- brightness contrast useful to identify **low** clouds (compared to IR)
- transparency of thin cirrus (which shine relatively bright in IR)

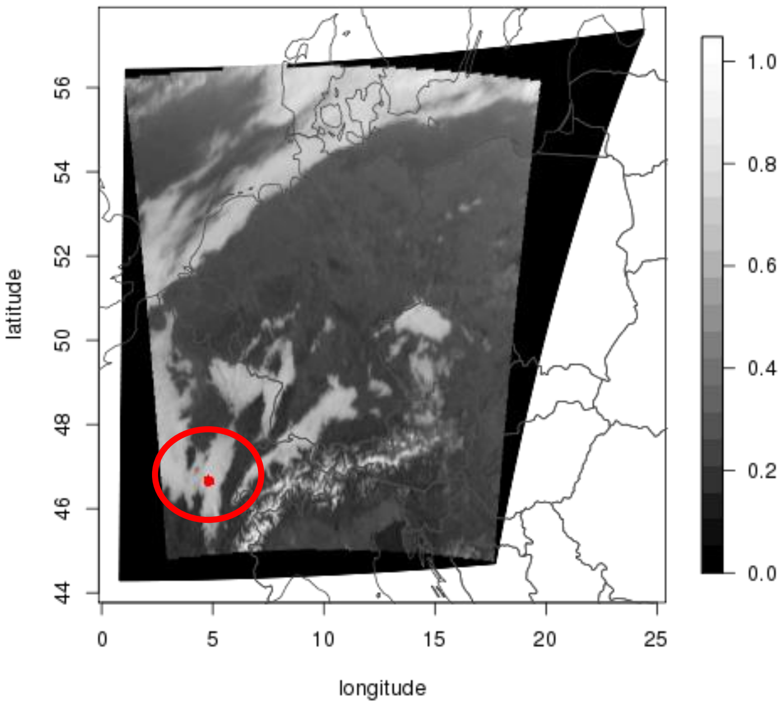
What do we want to improve?

- clouds / cloud cover
- moisture fields
- convective precipitation
- surface variables

low stratus

WG1: SEVIRI-VIS: single observation experiment

low stratus case (Dec 2016)

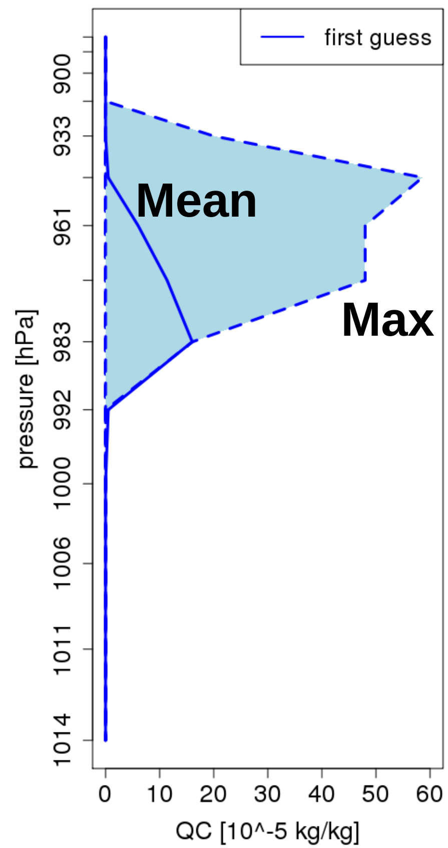


2 experiments:

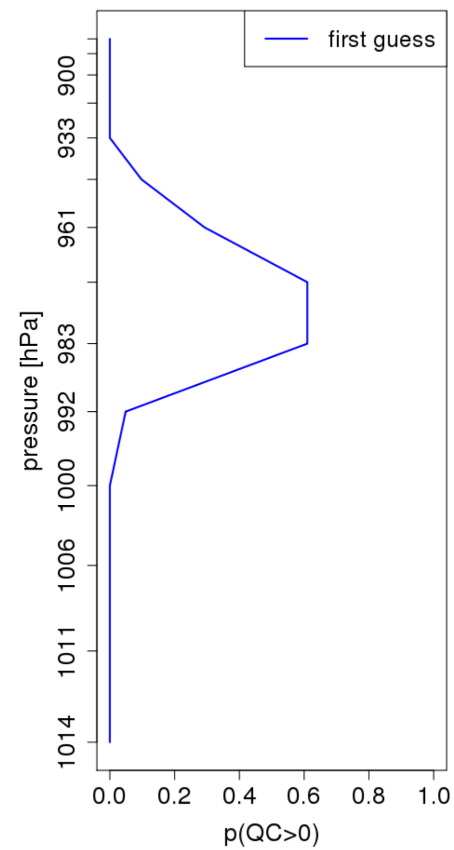
- locate at 950 hPa
  + narrow vertical localization
- no vertical localization

Do we have cloud water in the first guess ensemble members?

cloud water



probability of cloud
(grid-scale liquid)



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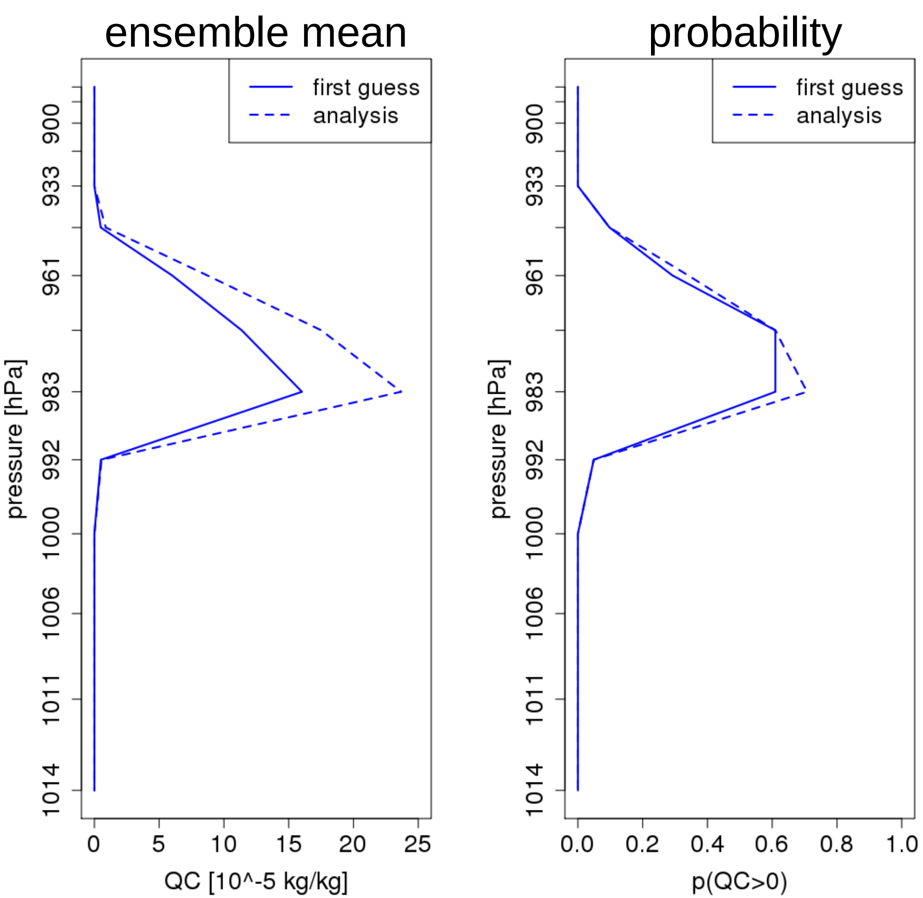
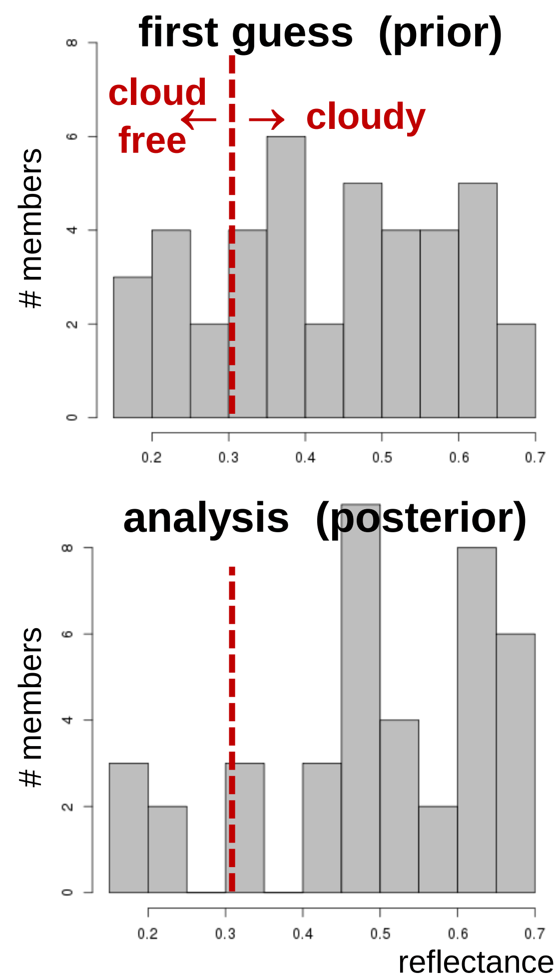
WG1: SEVIRI-VIS, single-obs exp.: can we generate cloud water?

LETKF improves both
the ensemble mean & (slightly) the probability
of grid-scale cloud water



change of reflectance distribution ?
(also sensitive to sub-grid scale cloud)



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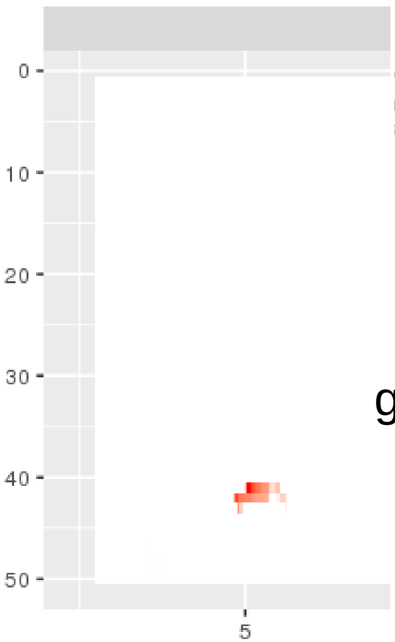
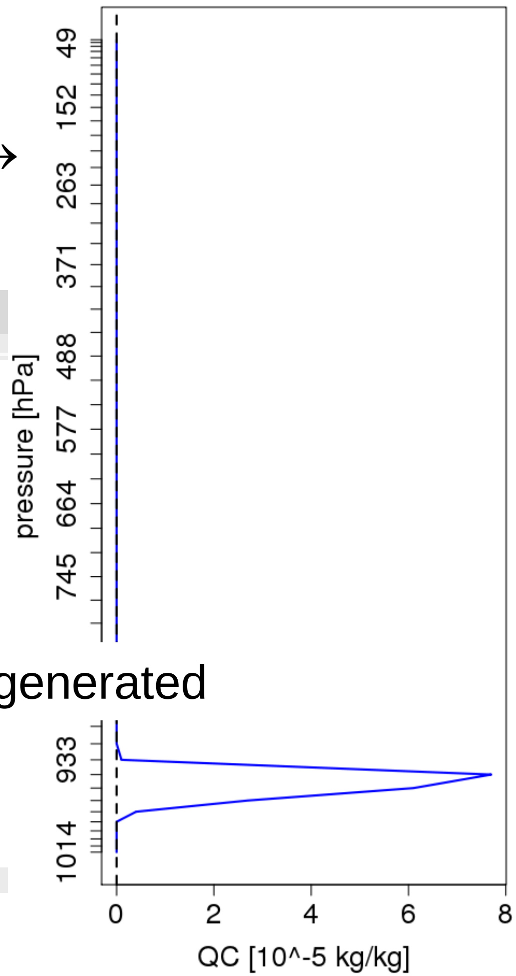
WG1: SEVIRI-VIS, single-obs exp.: analysis increments **with** vertical localisation

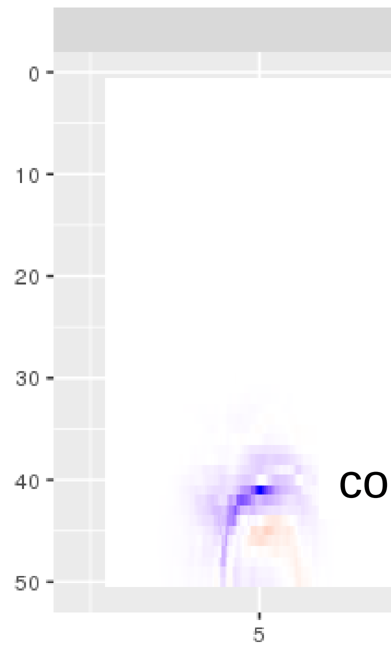
cloud water → ↓

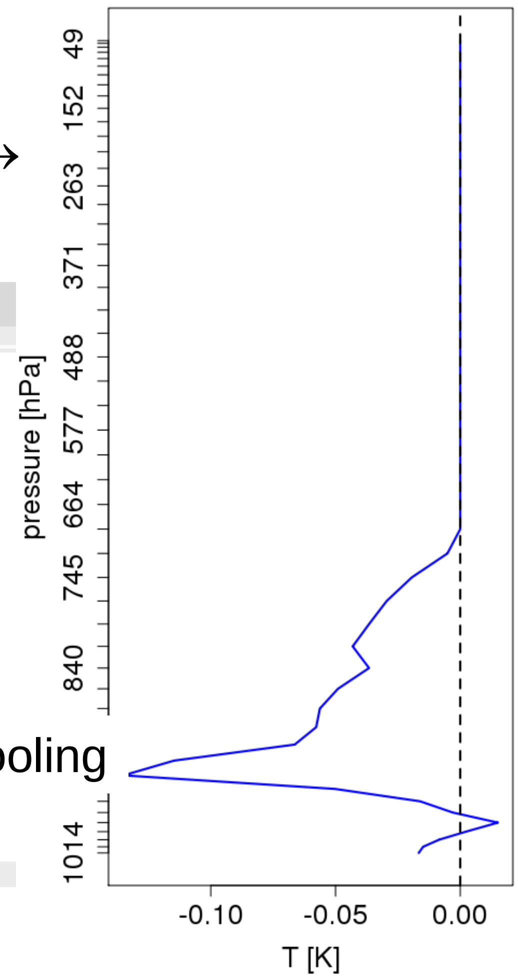




generated

temperature → ↓





cooling

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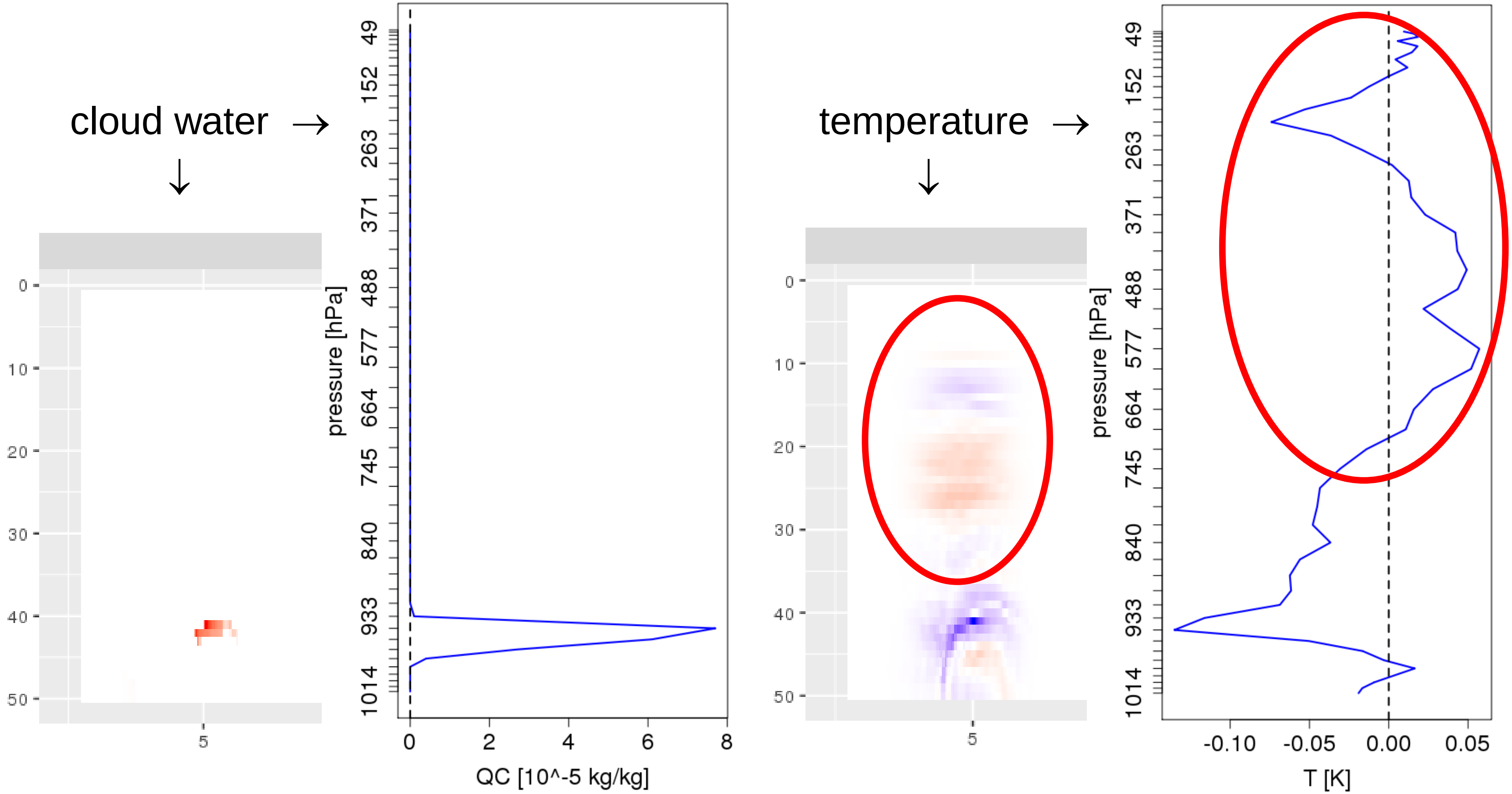
WG1: SEVIRI-VIS, single-obs exp.: analysis increments **without** vertical localisation



✓ mid-/upper-tropospheric temperature analysis increments likely spurious

→ need for vertical localization !

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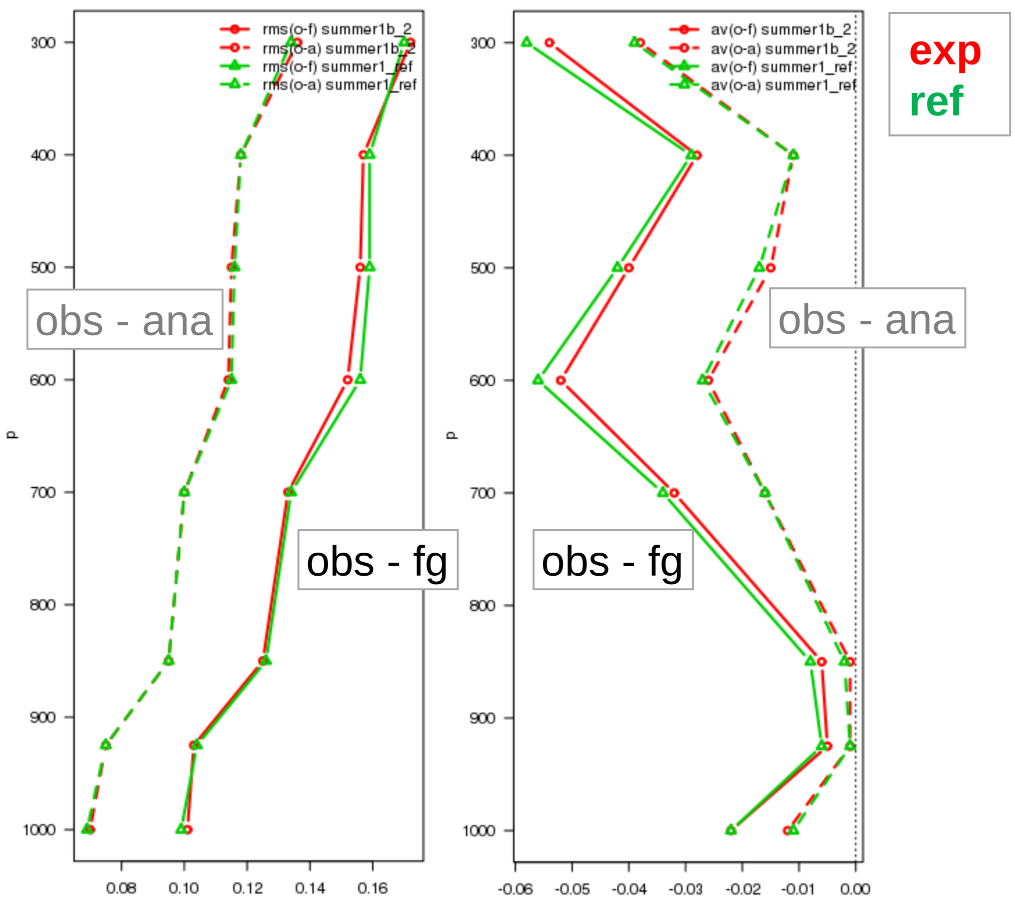
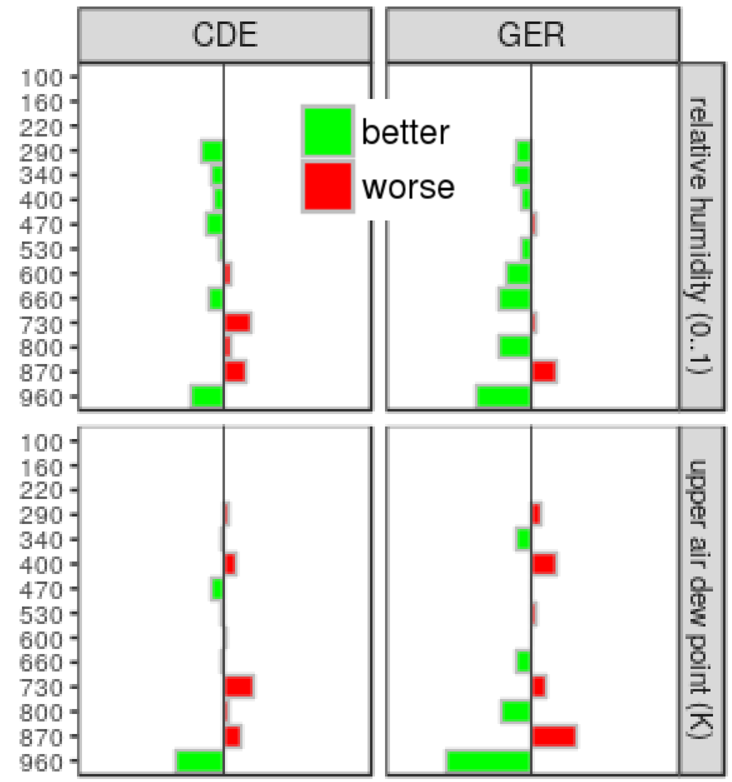
long period: 26 May – 13 June 2016

RMSE BIAS



reduction of RMSE
6-, 12-, 18-, 24-h forecasts
started from 0(!), 6, 12, 18 UTC



✓ upper air relative humidity: rmse and moist bias slightly reduced

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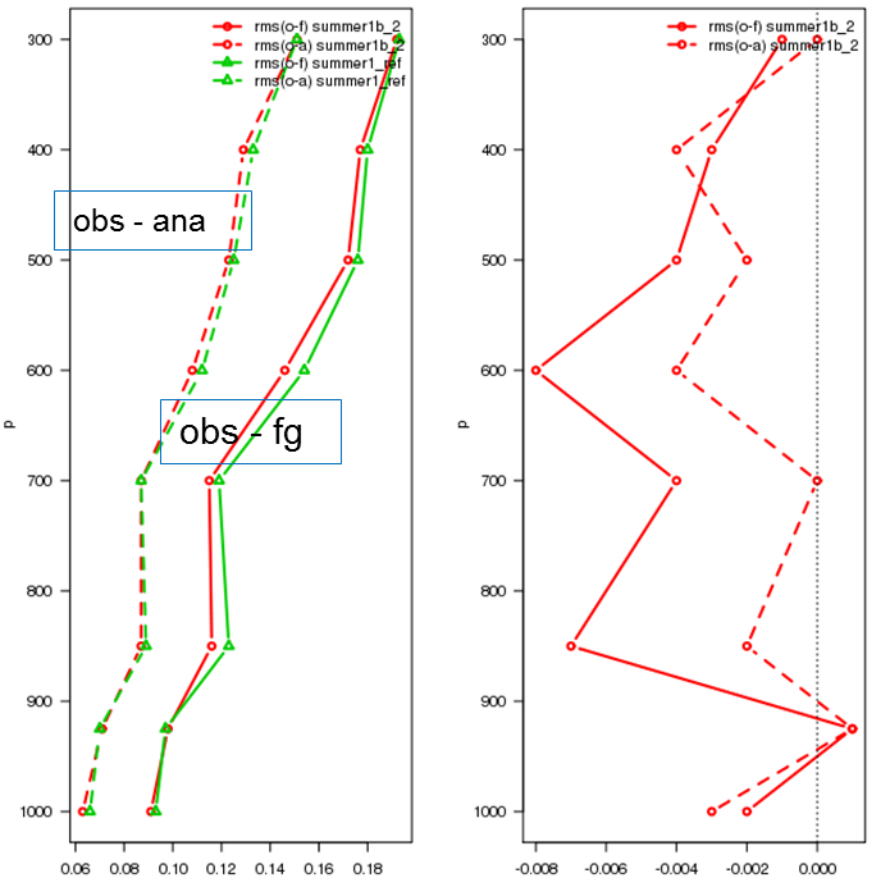
WG1: SEVIRI-VIS, impact experiment: Can we improve the moisture fields?

Deutscher Wetterdienst

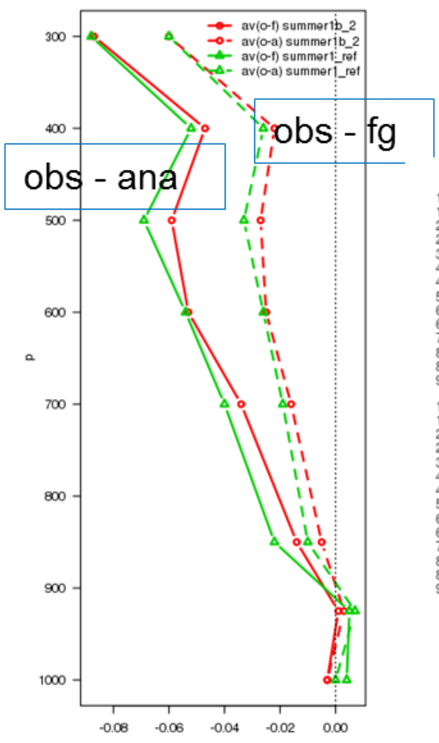
DWD

short period with mainly deep convective (high) cloud: 26 – 31 May 2016

RMSE

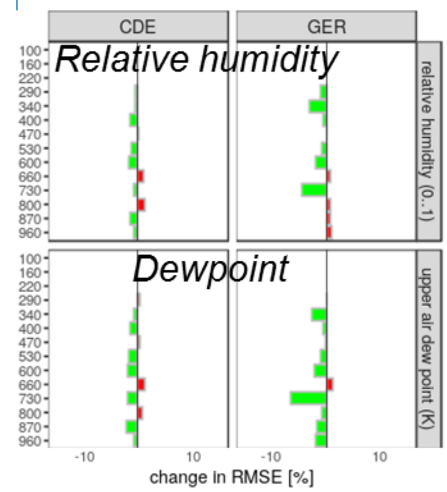


BIAS



exp
ref

RMSE FORECASTS



✓ upper air relative humidity: rmse and moist bias (clearly) reduced

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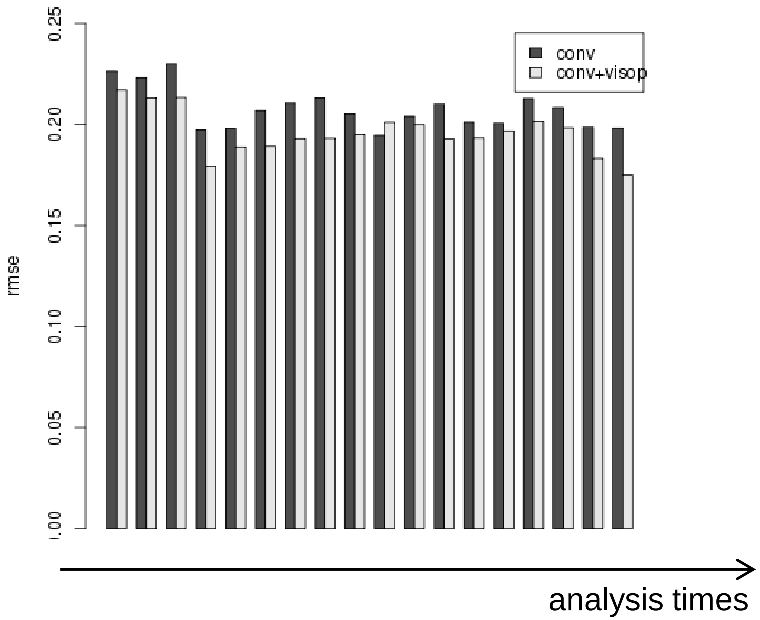
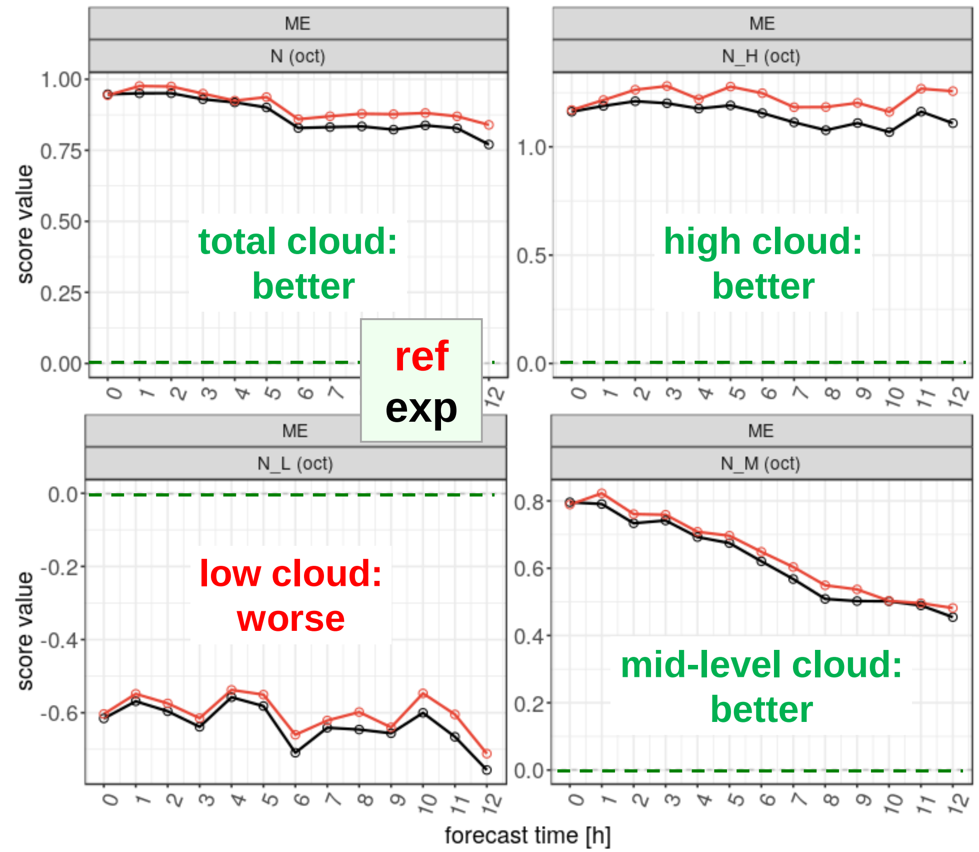
31 May – 13 June 2016

RMSE (against SEVIRI) of
first guess reflectance



bias (against SYNOP) of cloud cover for
forecasts started at 0(!), 6, 12, 18 UTC



- ✓ improved first guess reflectance
- ✓ cloud reduced,
  bias mostly improved in forecasts

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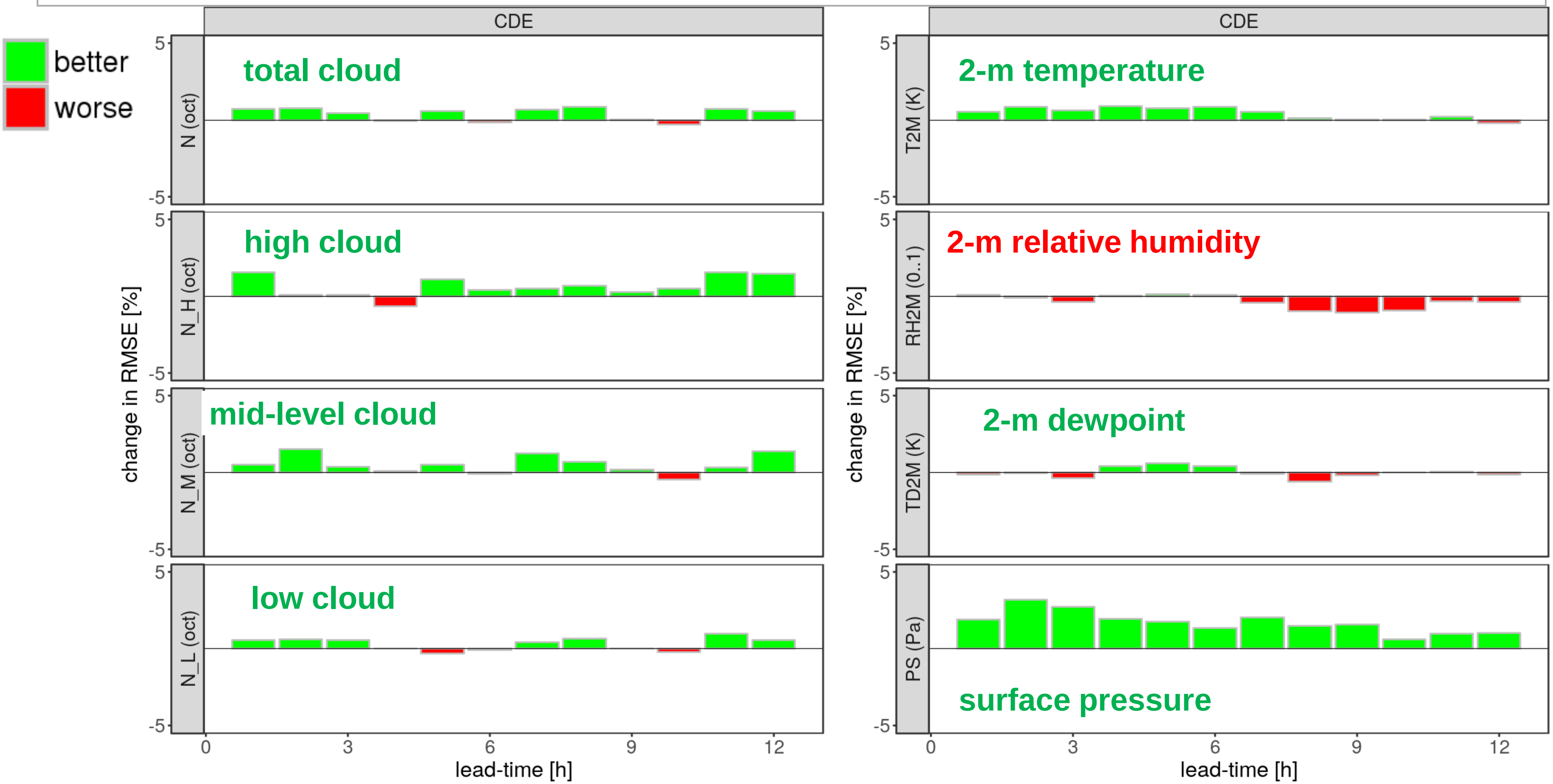
WG1: SEVIRI-VIS, impact experiment: Can we improve **cloud cover**?

Deutscher Wetterdienst
DWD

31 May – 13 June 2016

reduction of RMSE [%] (against SYNOP) for forecasts started at 0(!), 6, 12, 18 UTC



✓ small (!) improvements not only for cloud cover (except for 2-m humidity)

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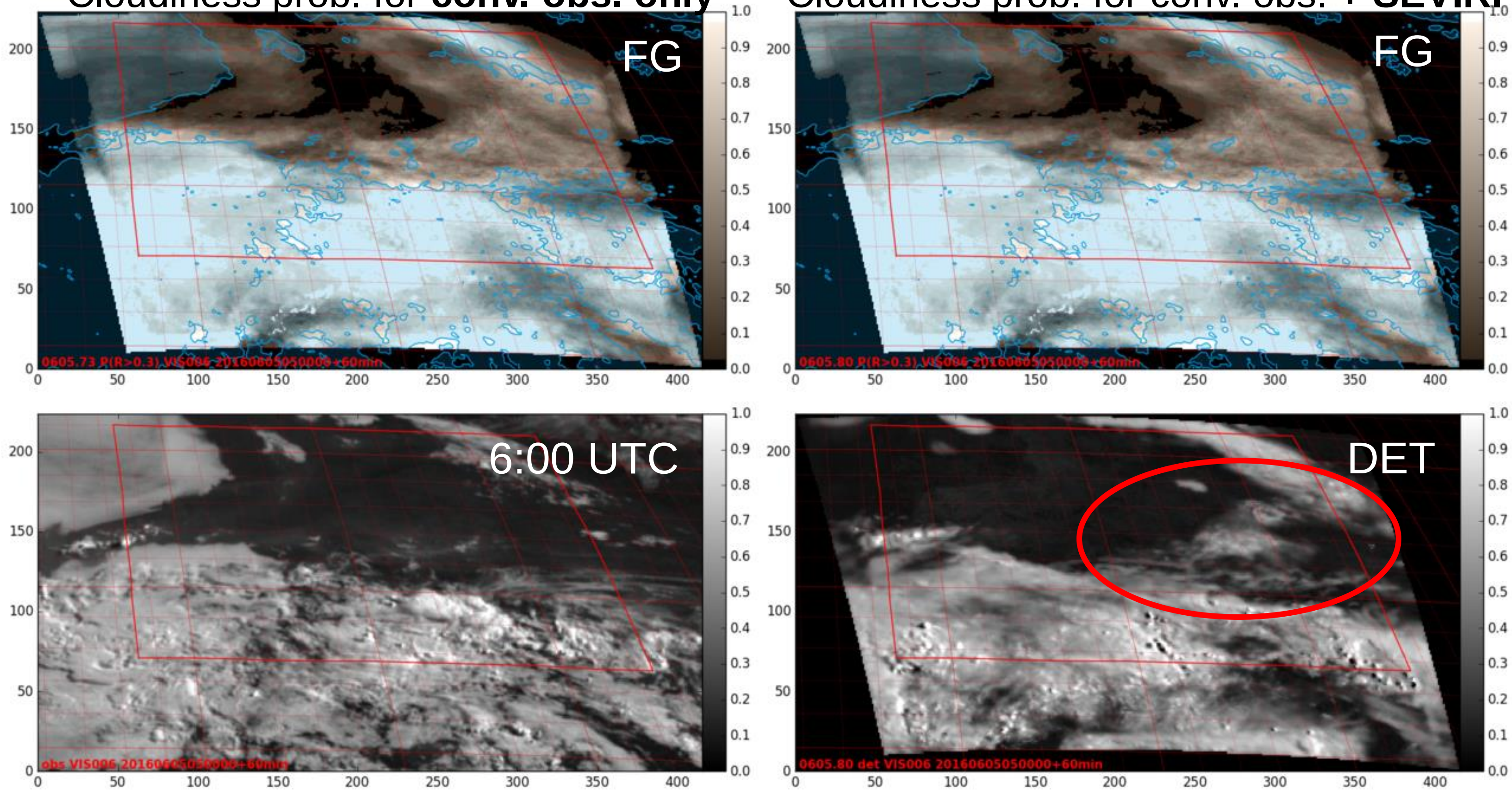
WG1: SEVIRI-VIS, impact experiment: Can we improve **cloud cover**?

case study: excessive cloud in first guess when first VIS data are available in the morning

Cloudiness prob. for **conv. obs. only** | Cloudiness prob. for conv. obs. **+ SEVIRI**



SEVIRI 0.6mu observation | det. member (conv. obs. + SEVIRI)

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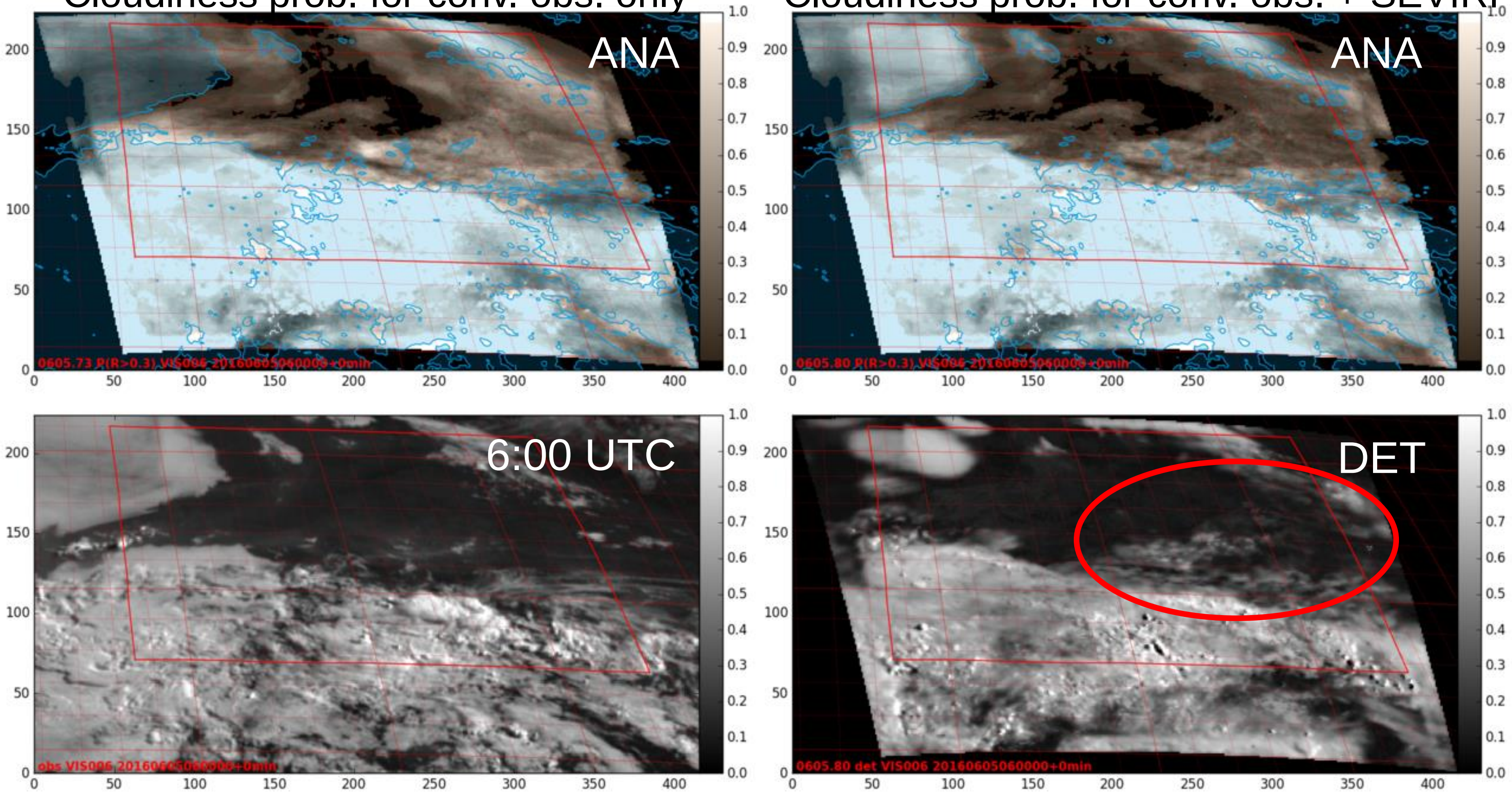
WG1: SEVIRI-VIS, impact experiment: Can we improve **cloud cover**?

Deutscher Wetterdienst

Cloudiness prob. for conv. obs. only | Cloudiness prob. for conv. obs. + SEVIRI



SEVIRI 0.6mu observation | det. member (conv. obs. + SEVIRI)

✓ spurious cloud is reduced in the analysis (both ensemble + det run)

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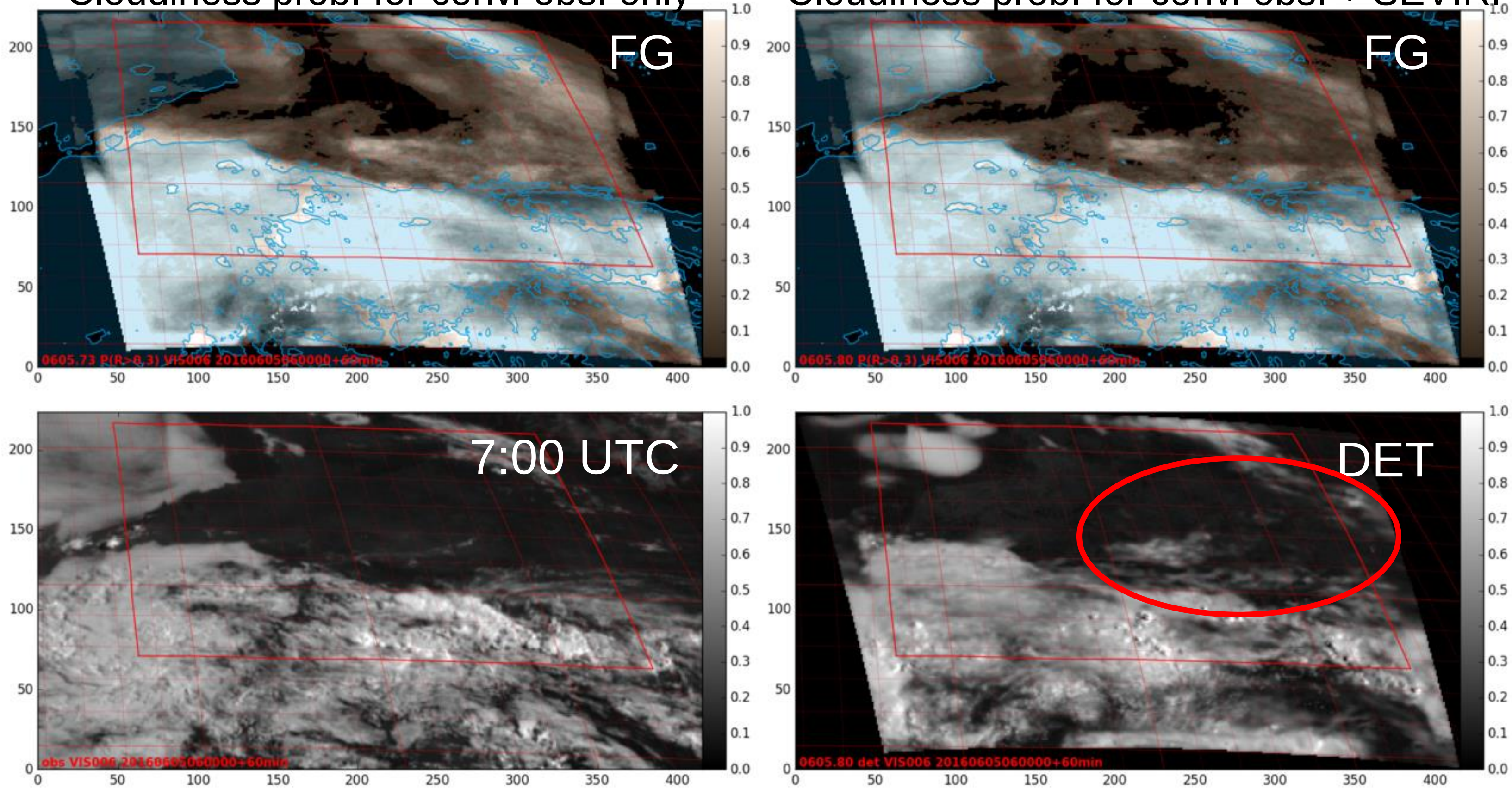
Cloudiness prob. for conv. obs. only | Cloudiness prob. for conv. obs. + SEVIRI



SEVIRI 0.6mu observation | det. member (conv. obs. + SEVIRI)

✓ reduction of spurious cloud is maintained in subsequent 1-h forecast

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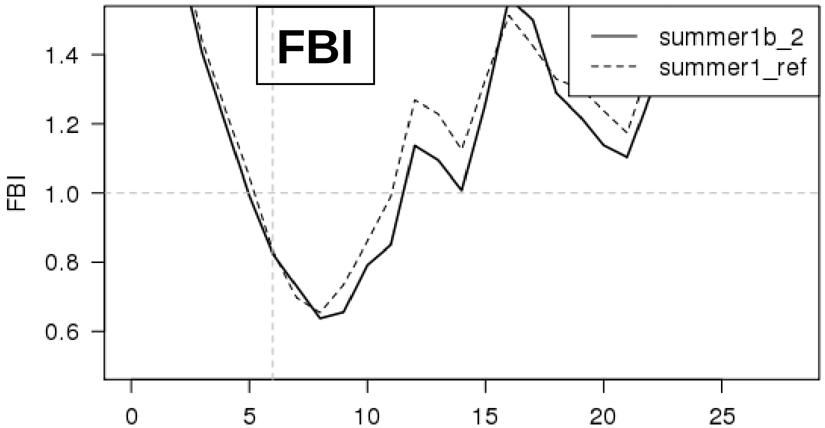
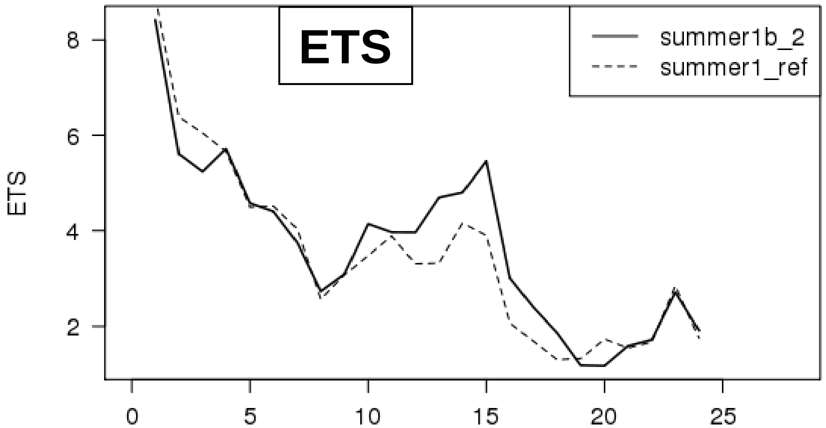
WG1: SEVIRI-VIS, impact experiment: Can we improve **precipitation**?

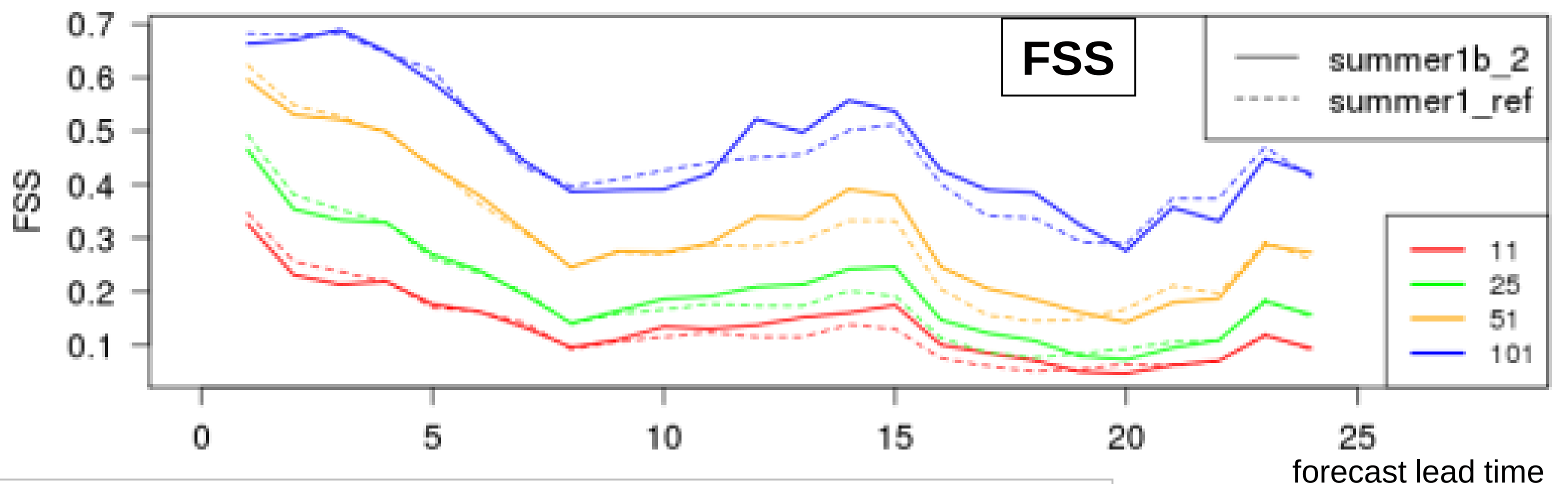
Deutscher Wetterdienst

31 May – 13 June 2016, 12-UTC runs only!

5 mm/h







- ✓ slight reduction of precip, frequency bias mostly slightly improved
- ✓ FSS / ETS in first ~ 4 hours slightly degraded, but improved later on !

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