KENDA developments at DWD

Christoph Schraff and many colleagues

Deutscher Wetterdienst

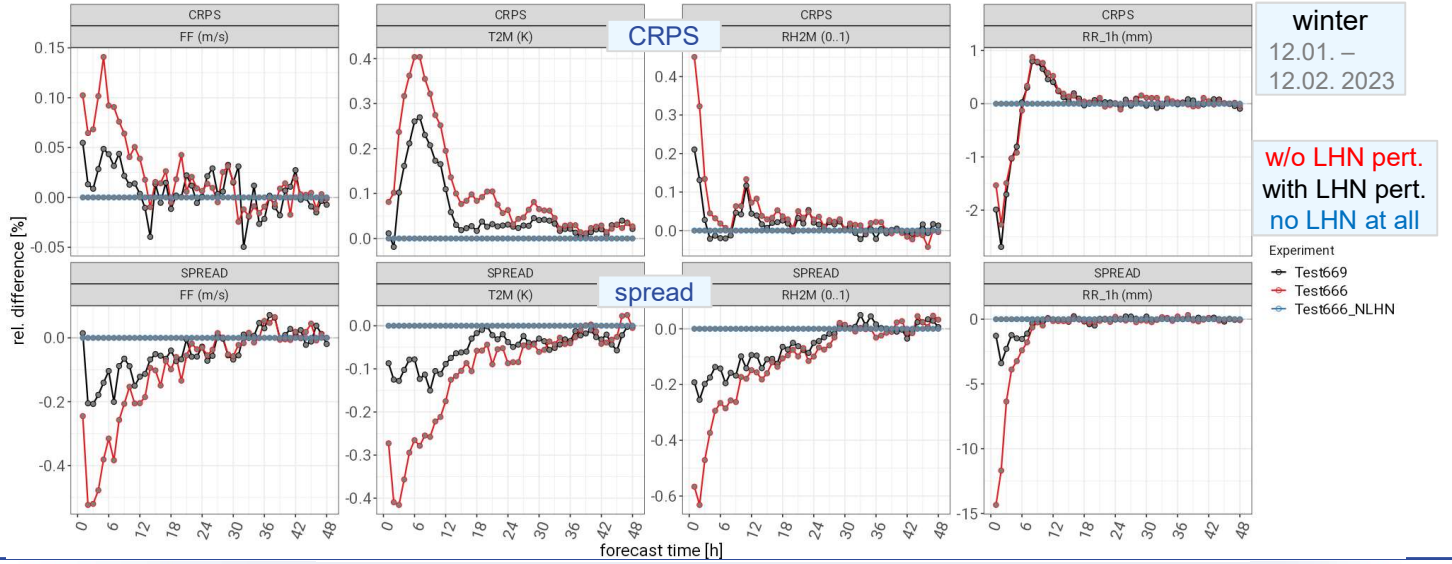
… a selection (incl. operational changes):

- perturbation of LHN parameters in the forecasts
- Radar: obs errors for reflectivity / use of French radars
- SEVIRI IR WV operational, work on bias correction
- revised 10-m wind assimilation and adaptive parameter tuning
- ICOS towers (+ RASS)
- removal of ‘bias ’ of near-saturated humidity obs

perturbation of 4 LHN parameters *(Günther Zängl, Klaus Stephan)*

- ensemble perturbations of (physics +) 4 LHN parameters introduced in 09/2024 were restricted to DA cycle
- LHN is applied up to ~30min of forecast (depending on data availability)

→ continue LHN perturbations in forecast to avoid discontinuities of LHN parameters

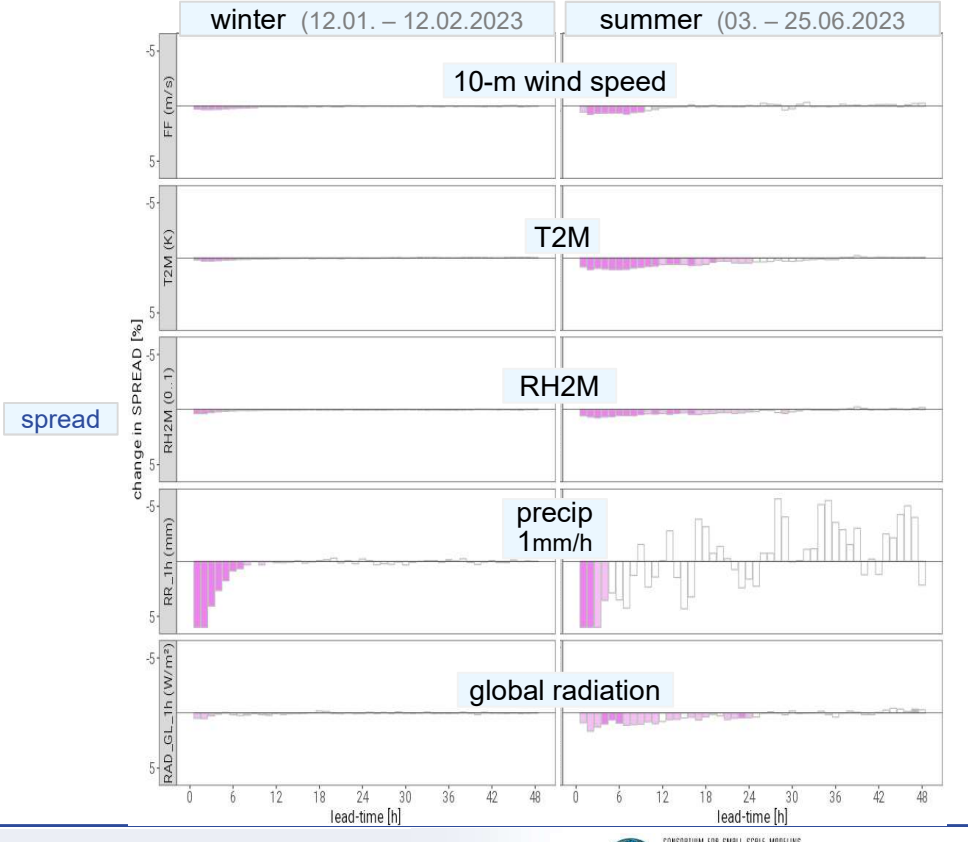


Task 1.1: Refinements on reference KENDA

Deutscher Wetterdienst

perturbation of 4 LHN parameters
continued in forecast

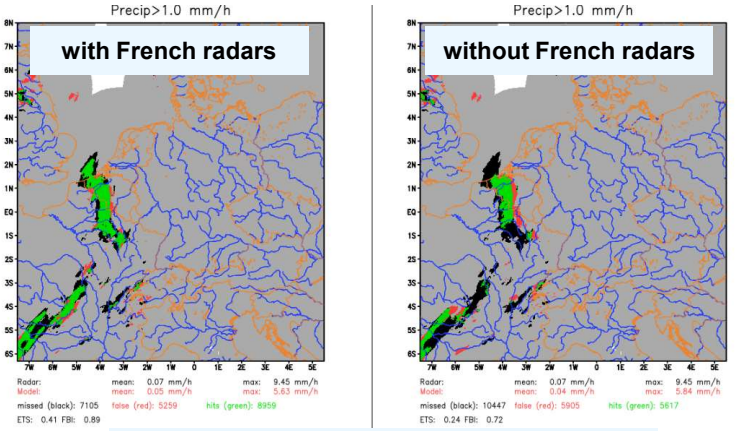
- improves ensemble spread of precipitation in first few forecast hours
- … and in summer slight increase of spread for T2M, RH2M, surface radiation
- operational since Jan. 2024



Task 2.1: **3-D radar** reflectivity + radial velocity

- Sinfony-RUC:
  - adjustment to 2-moment microphysics, tuning EMVORADO *(Alberto de Lozar, …)*
  - use of Nowcasting radar data in 1st hour via LHN not yet beneficial (further tuning required) *(Klaus Stephan)*
- ICON-D2:
  - observation errors for radar reflectivity *(Klaus Stephan)* :
    10 dBZ replaced by values used in Sinfony-RUC: 7 dBZ near surface to 4 dBZ above 500 hPa
    → neutral impact, operational since 9 July 2024
- ICON-D2 + RUC: work on use of foreign radars *(Klaus Stephan)* :
  - very heterogeneous data / scan strategies
    → evaluate country-wise
  - start with (17) French (C-band) radars (Z + Vr):
    → positive impact on precip (particularly w/o LHN)
    → very slight positive impact in TEMP + SYNOP verif
    (irrespective of LHN)

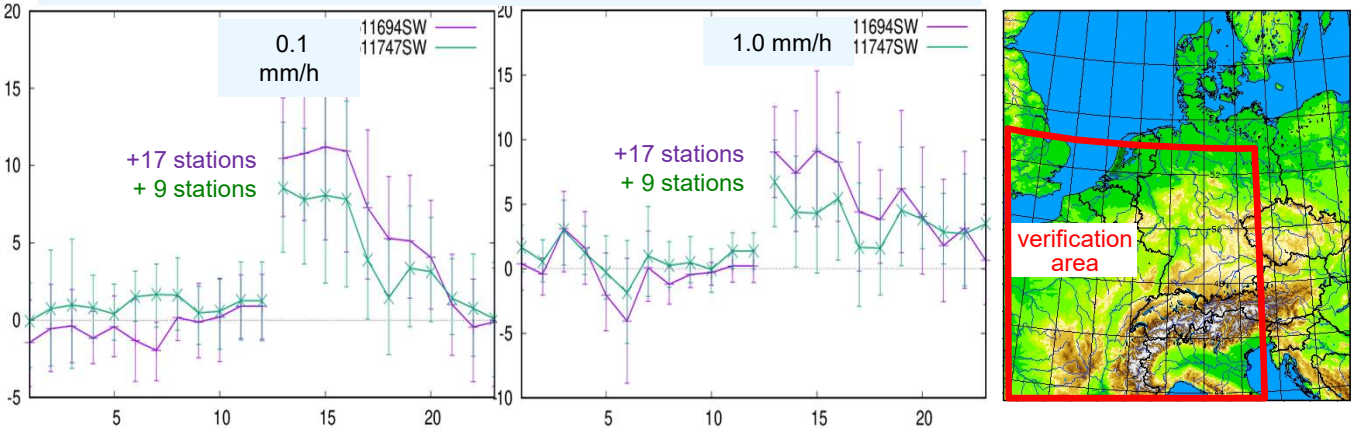
(RUC: April / May 2023; ID2: June 2023)



Example 22.04.2023 10 UTC (vv +1h)
ICON-RUC Setup without LHN

– 17 stations within model domain: costs too large (reading of fdbk files, to be checked)
→ use only 9 stations actively: → 20 % less data, but 50 % cost reduction
(cost: ~1 min per 3-hr cycle, at (non-parallel) pre-reading of fdbk files in LETKF → optimizable?)

ICON-D2 with LHN: rel. change of FSS 23 km, 12 UTC, 5 June – 1 July 2023



✓ in ICON-D2 operational since 22 May 2024

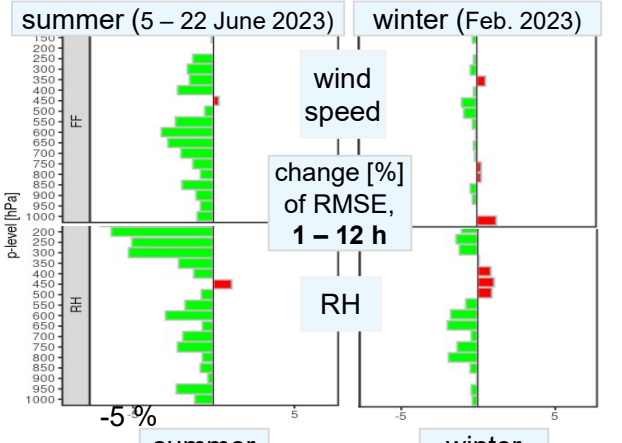
✓ in Sinfony-RUC suite

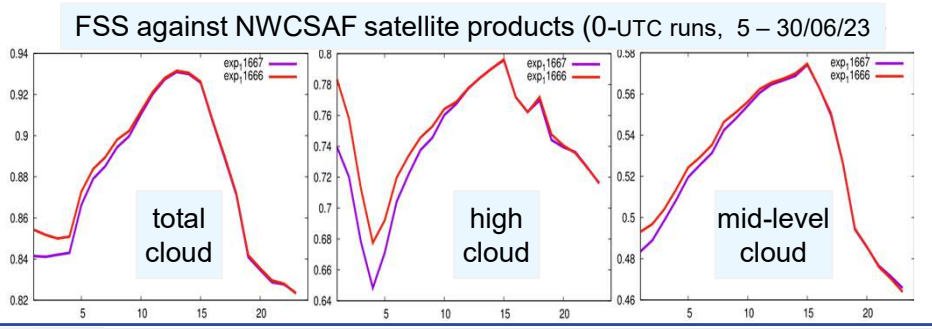
SEVIRI WV channels (added to VIS)

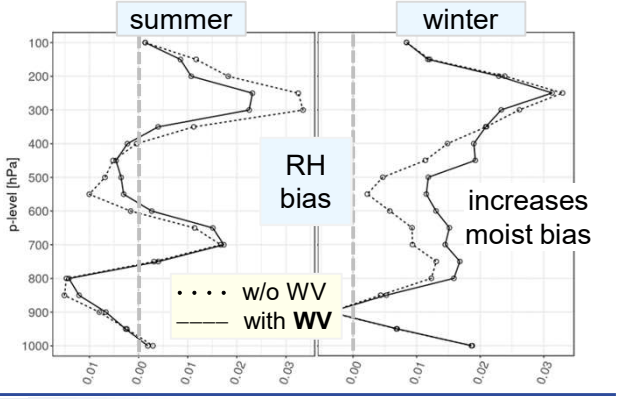
- ‘final’ exp. with then operational NWP environment

  (05/23: Mode-S in ICON → impact on ICON-D2 via LBC:
  RMSE, spread, spread-skill reduced (2 – 5%))

  - summer: positive impact not only on cloud + upper-level humidity, but also on wind (precip: ~ neutral)
  - winter: cloud positive, otherwise small impacts
    increased mid-tropospheric moist bias







Task 2.3: all-sky (cloudy) SEVIRI **IR WV** radiances

- extra cost ok
- parallel suite autumn 2023: no negative impact on humidity biases, generally small impact

✓ SEVIRI WV operational in ICON-D2 & in SINFONY RUC since 29 Nov 2023

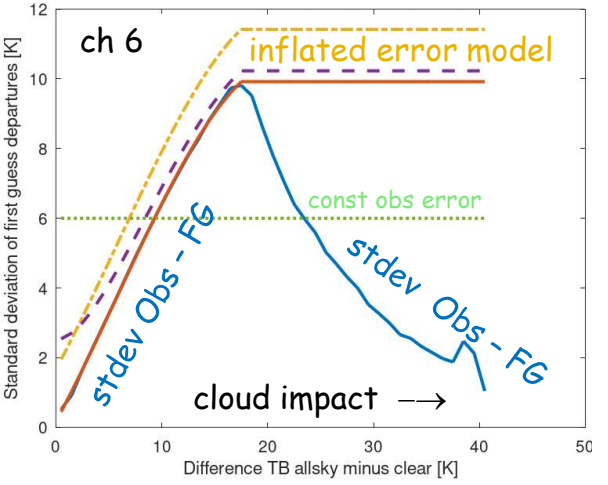
✓ first time internationally: use of operational all-sky IR data assimilation

- paper in preparation
- next steps:
  - preparation of FCI @ MTG: delayed (no data available until few weeks ago), started recently (first implement and test setup analogous to SEVIRI)
  - further visible + near IR channels of FCI

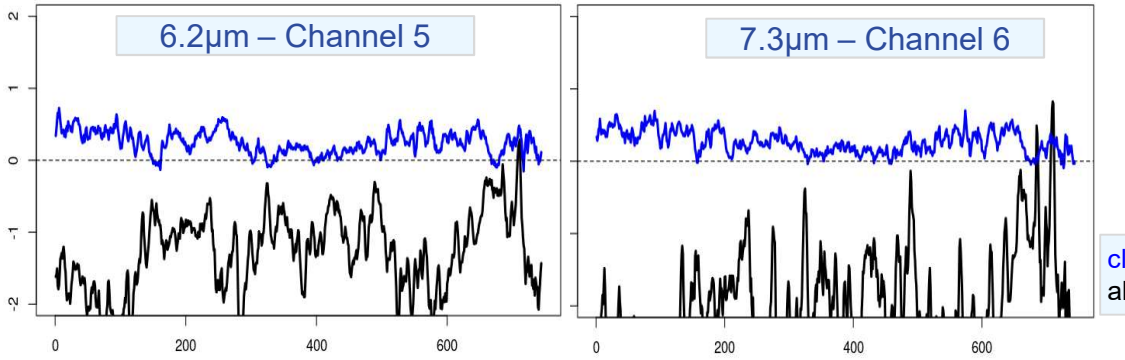
Task 2.3: all-sky (cloudy) SEVIRI **IR WV** radiances

Deutscher Wetterdienst

- so far – no bias correction for SEVIRI …
  - obs error of 2 K assigned to clear-sky obs = 2 K >> stdev(O – FG)
  - → low weight given to clear-sky data (WV)



- clear-sky biases in a experiment with passive SEVIRI data (4 weeks August 2022)

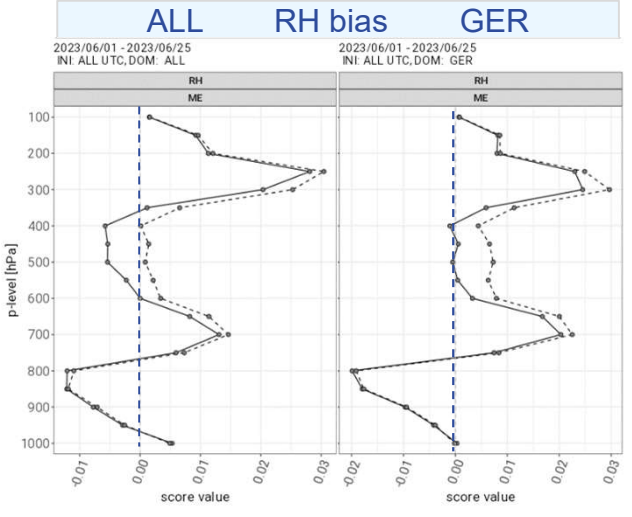


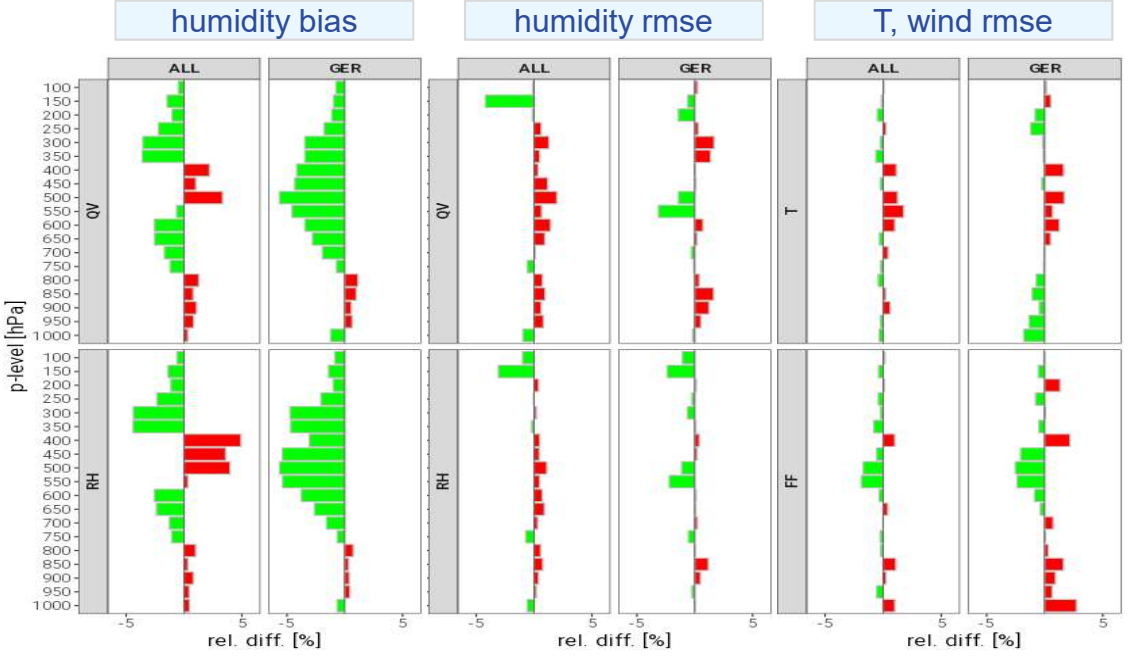
→ *average clear-sky bias: + 0.25 K* → *average clear-sky bias: + 0.27K*

→ assimilation experiment with constant bias correction of – 0.25 / – 0.27 K for channels 5 / 6 (applied all-sky)
(→ bias correction makes the obs 'drier'), no changes of other settings (e.g. obs error)

Task 2.3: all-sky (cloudy) SEVIRI **IR WV** radiances

- 1 – 12 h forecasts verified against radiosondes



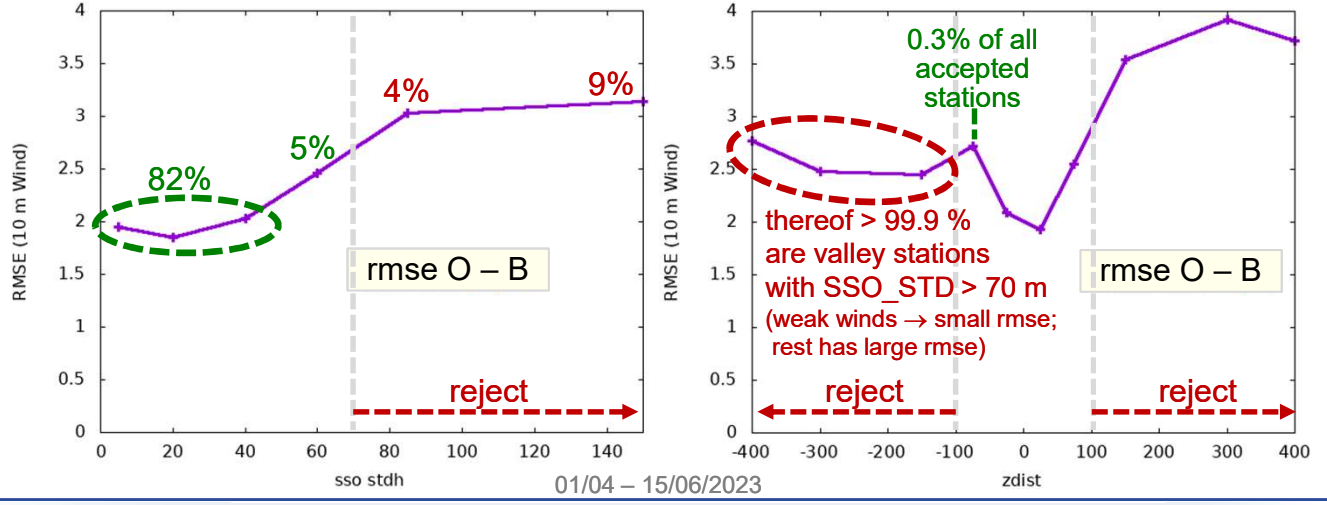


- wet bias reduced (also obs_err_stat), but RMSE neutral to slightly worse

revised criteria for station selection for 10-m wind assimilation

(Hendrik Reich, Christoph Schraff, Klaus Stephan, Günther Zängl et al.)

- until Jan. 2024: use only stations ≤ 100 m altitude
- now: SSO standard deviation ≤ 70 m (as in global ICON setup) (rejects ~13 %)
  & distance station height vs model orography ≤ 100 m (< 1% additionally)



01/04 – 15/06/2023

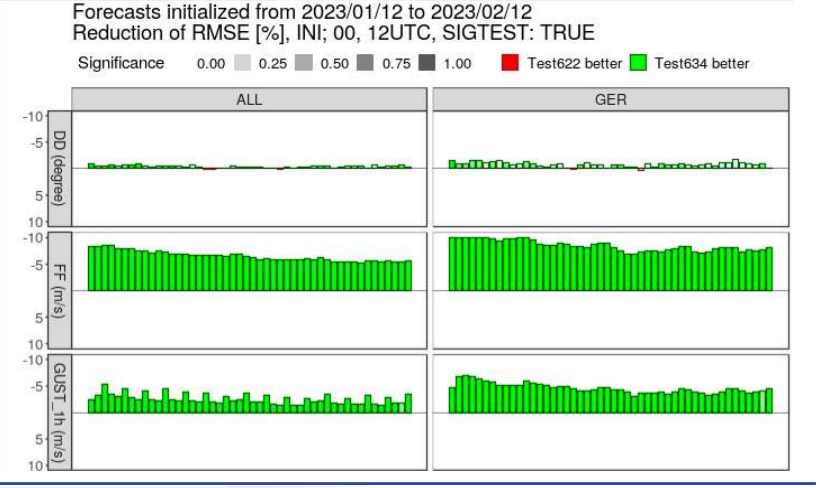
Task 2.5: Screen-level obs: **10-m wind**

- revised criteria for station selection for 10-m wind assimilation
- reduced obs errors : 3.6 m/s → 2.0 m/s (~ rmse O – B)

→ neutral impact for upper-air wind, slightly positive for 10-m wind in first hour(s)

- allows for introduction of adaptive surface friction (as in global ICON, Günther Zängl),
  (using wind analysis increments at lowest model level (~10m a.g.) as predictor field):
  - adaptive adjustment of vegetation roughness length
  - adaptive SSO blocking tendency at lowest model level

→ major improvement of 10-m wind speeds + gusts
(winter + summer)



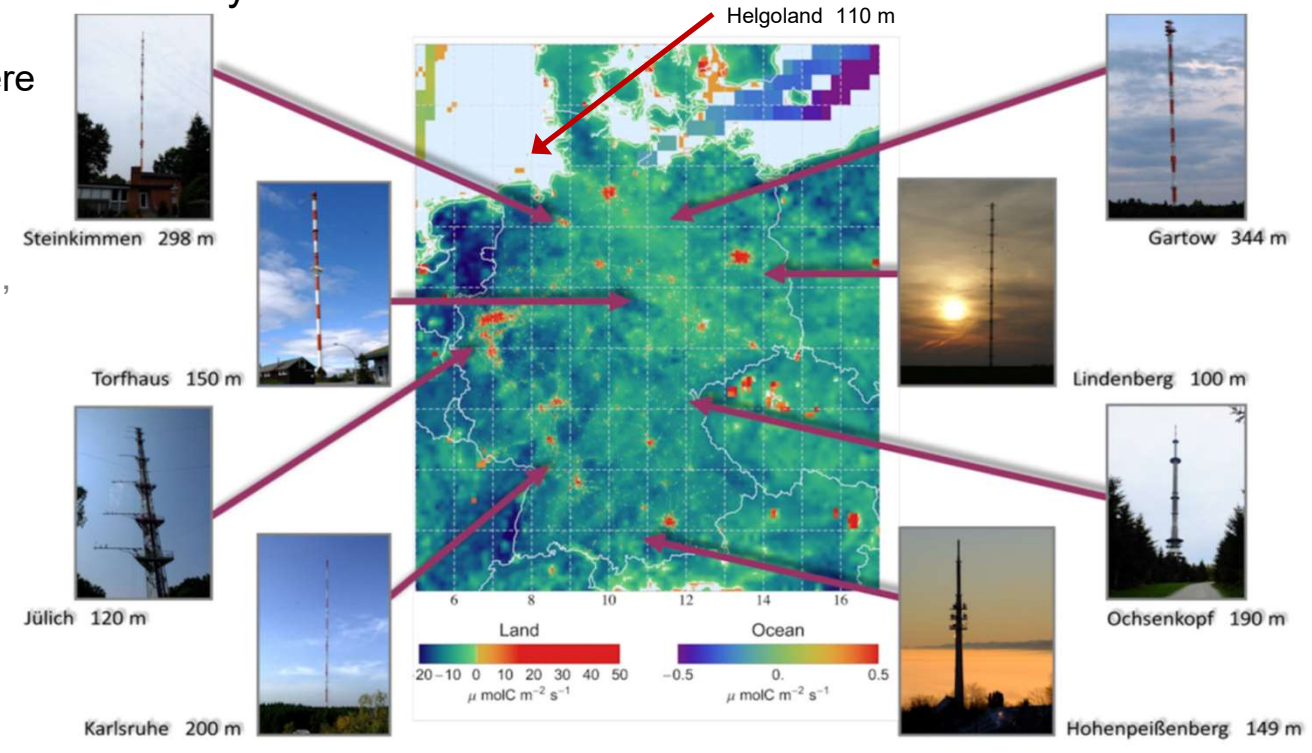
- operational since Jan. 2024

Task 2.6: PBL profiler obs: ICOS towers

ICOS: Integrated Carbon Observation System

- ecosystem, ocean, atmosphere (greenhouse gases)
- 9 towers in Germany

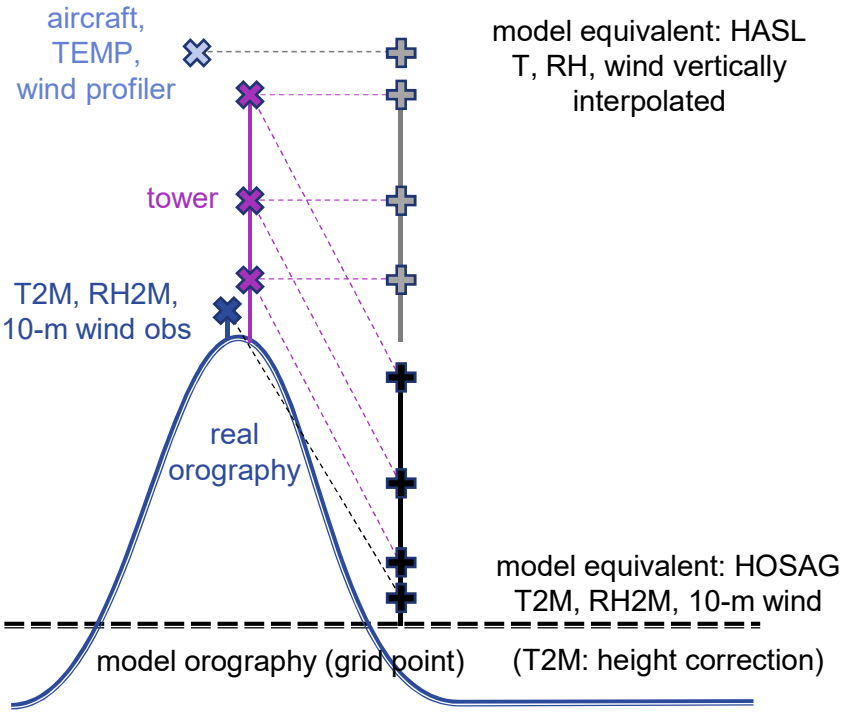
  (within ICON-D2: Cabauw NL, Ispra IT, 1 CZ, 3 FR (no access to data yet))
- heterogeneous architectures, max. heights 98 – 341 m (min. heights 10 – 60 m)
- T, RH on 2 – 6 levels, wind on 1 – 5 levels



Task 2.6: PBL profiler obs: ICOS towers

observation operator

- model equivalent computed at ‘correct’ (i.e. same as observation)
  - height above sea level “HASL”
  - height of sensor above ground “HOSAG”
- monitoring: both observation operators applied to each tower observation
- ICON tower network Germany:
  - 2 mountain stations: OXK dh = +137m
HPB dh = + 91 m
  - 2 ‘hill’ stations: HEL dh = + 43 m
GAT dh = + 32 m
  - 5 ‘flatland’ stations: -3 ≤ dh ≤ + 13 m
  - no valley station



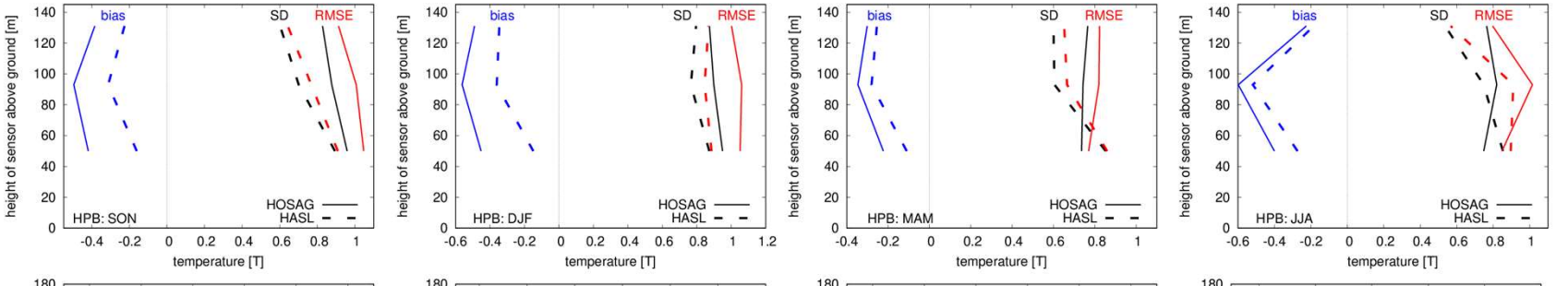
Task 2.6: PBL profiler obs: ICOS towers

observation operator: monitoring

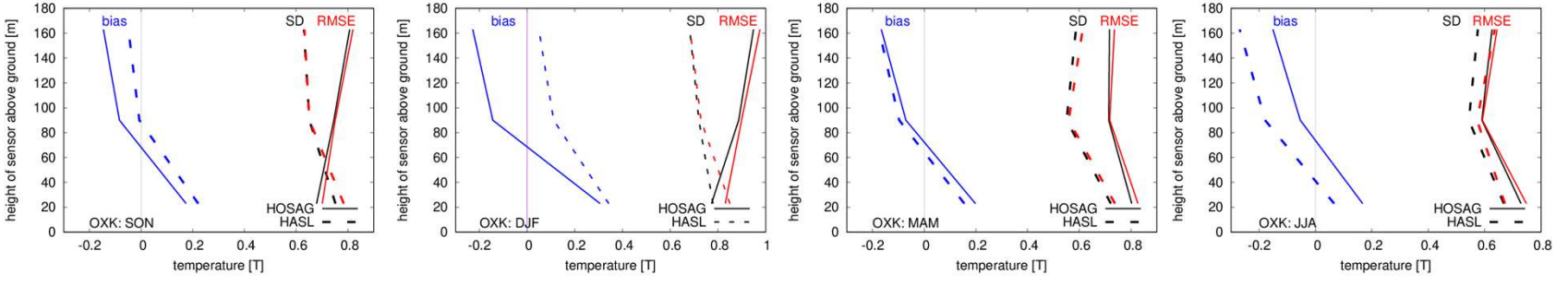
temperature

autumn (SON 23) | winter (DJF 24) | spring (MAM 24) | summer (JJA 24)

HPB

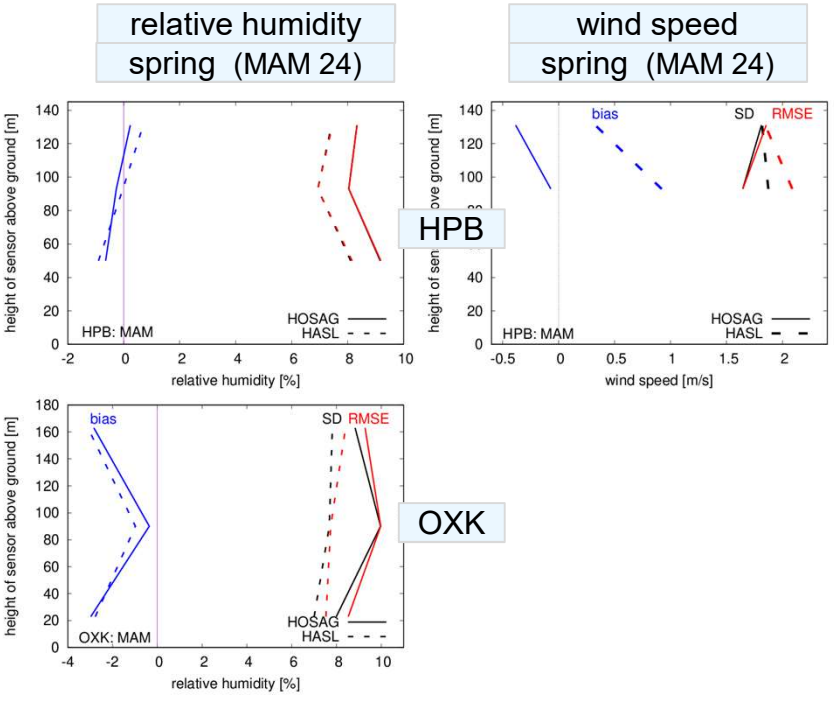


OXK



Task 2.6: PBL profiler obs: ICOS towers

- Observation operator
  - T: HASL always (equal or) better
  - RH: HASL always better
  - wind: 4 (+2) HASL, 1 HOSAG better

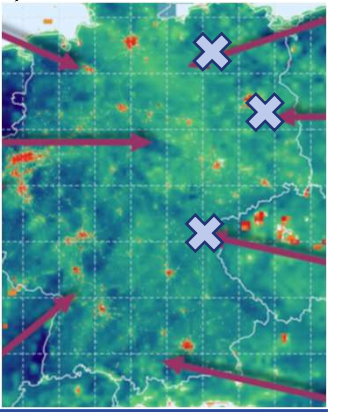


Task 2.6: PBL profiler obs: ICOS towers

Deutscher Wetterdienst

- blacklisting:
  - T: 97 % good (34/35) , -0.3 K ≤ obs bias ≤ 0.5K, RMSE 0.45 – 0.8 K mostly
  - RH: 83 % good (29/35) , obs bias ≤ 4%, RMSE 4 – 9 %
  - wind: 18 % good (5/28) , obs bias < 0.8 m/s RMSE 1.2 – 2.2 m/s
    (1 – 2 levels from 4 towers ok;
    rejected winds: negative wind speed bias > 1 m/s (or large bias U, V)

- assimilation experiments (o.a.): 16 days winter (25.02. – 11.03.24), limited advection, w. low stratus
  20 days summer (15.05. – 03.06.24), little advection, w. convection
  - **ref**erence: ICON-D2 operational setup as in summer 2024
  - **tower** (9 ICOS + 2 nuclear plants (1 T, 2 wind obs))
  - tower + **RASS** (3 / 2 stations, T-profiles up to ~ 2 – 2.5 km,
    blacklisted below 925 / 900 hPa, (T stdev 0.7 – 0.9 K)
    constant bias correction -0.5 or -0.6 K to reduce biases 0.6 – 1.1 K)



- obs error (tower, RASS): like radiosondes, except T1000: 1.1 → 0.85 K

Task 2.6: PBL profiler obs: ICOS towers / RASS

Deutscher Wetterdienst

‘PILOT’ verification
(i.e. against tower,
RASS, wind profiler)

RMSE
+ 1h forecasts

T

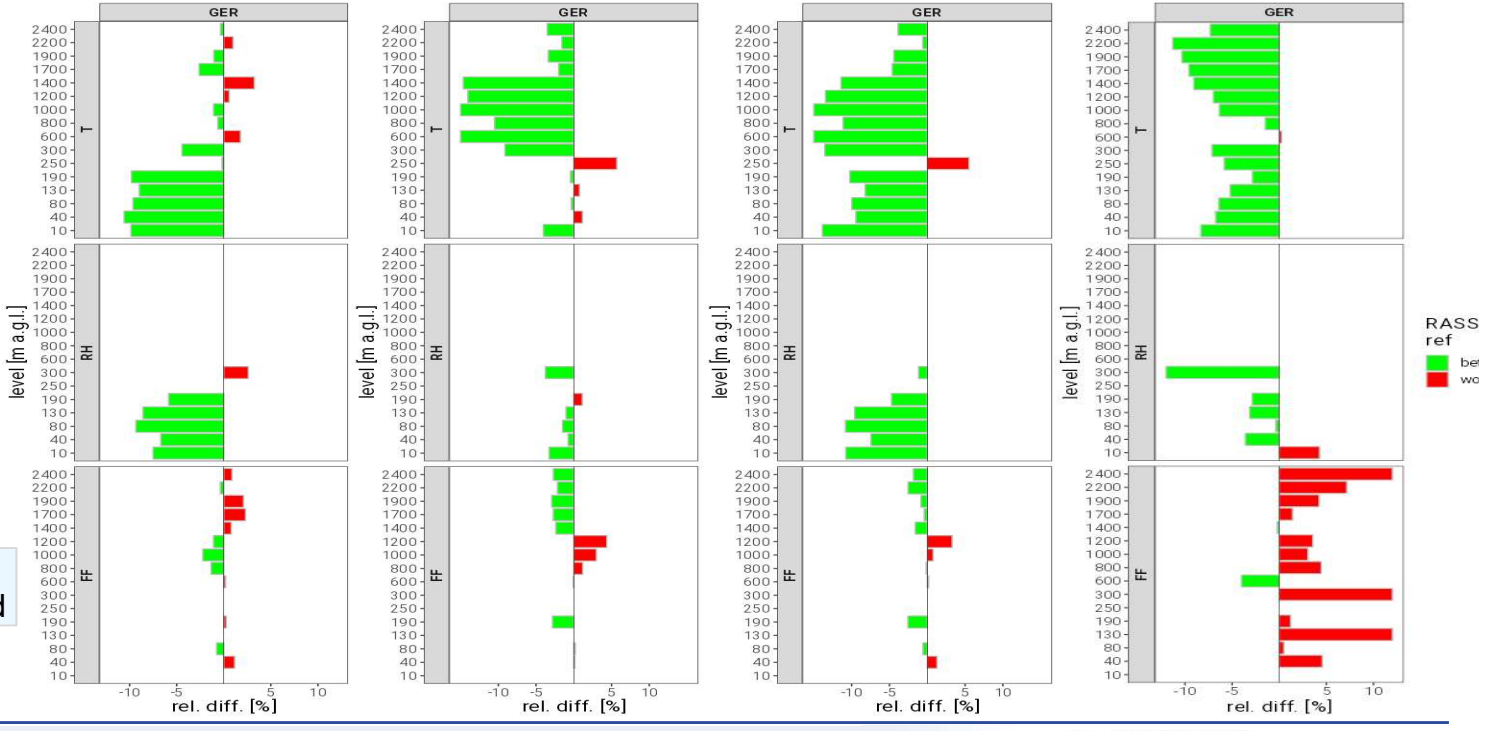
RH

wind speed

winter (24.02. – 11.03.24)

summer (15.05 – 03.06.24)

tower vs. ref | RASS+tower vs. tower | RASS+tower vs. ref | RASS+tower vs. ref



Task 2.6: PBL profiler obs: ICOS towers / RASS

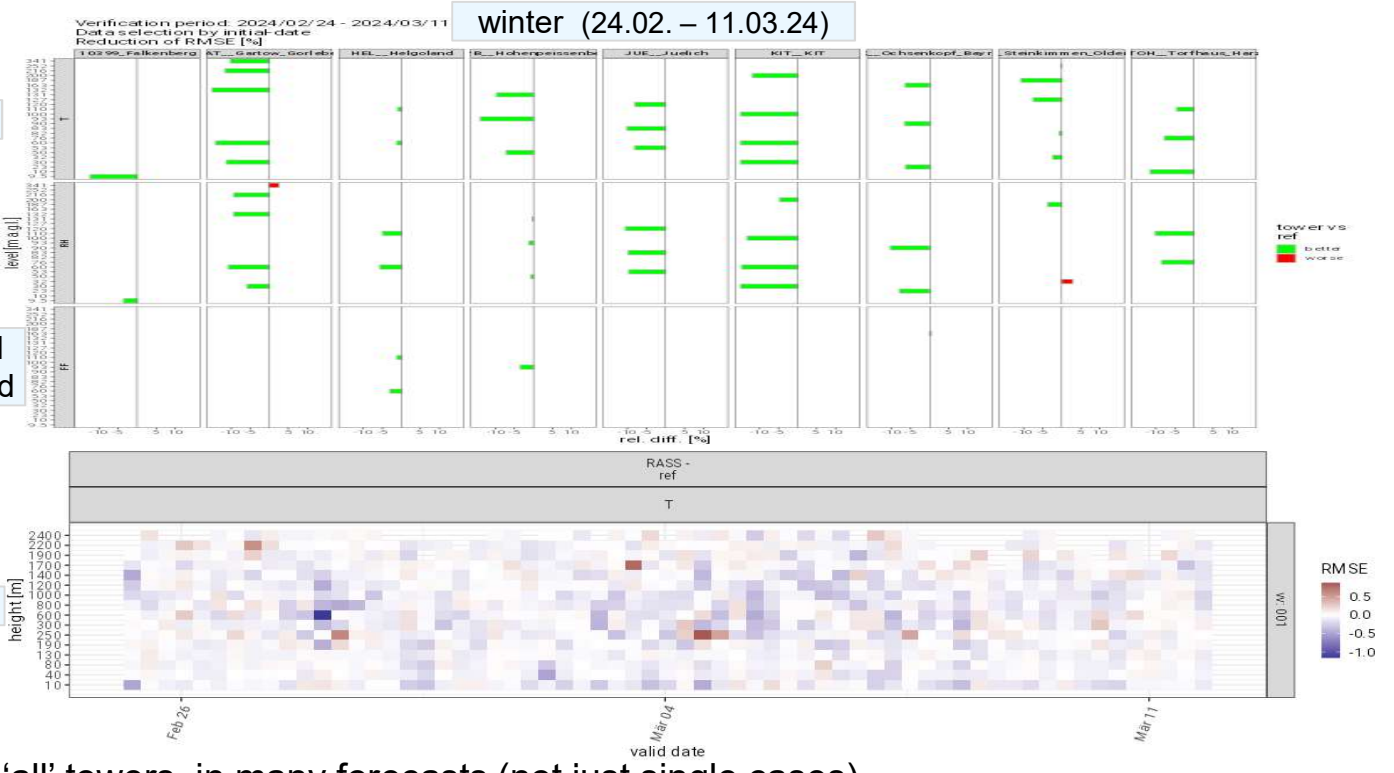
Deutscher Wetterdienst

‘PILOT’ verification
(i.e. against tower,
RASS, wind profiler)

tower vs. ref
for single towers

RMSE
+ 1h forecasts

RASS+tower vs. ref
time series of impact



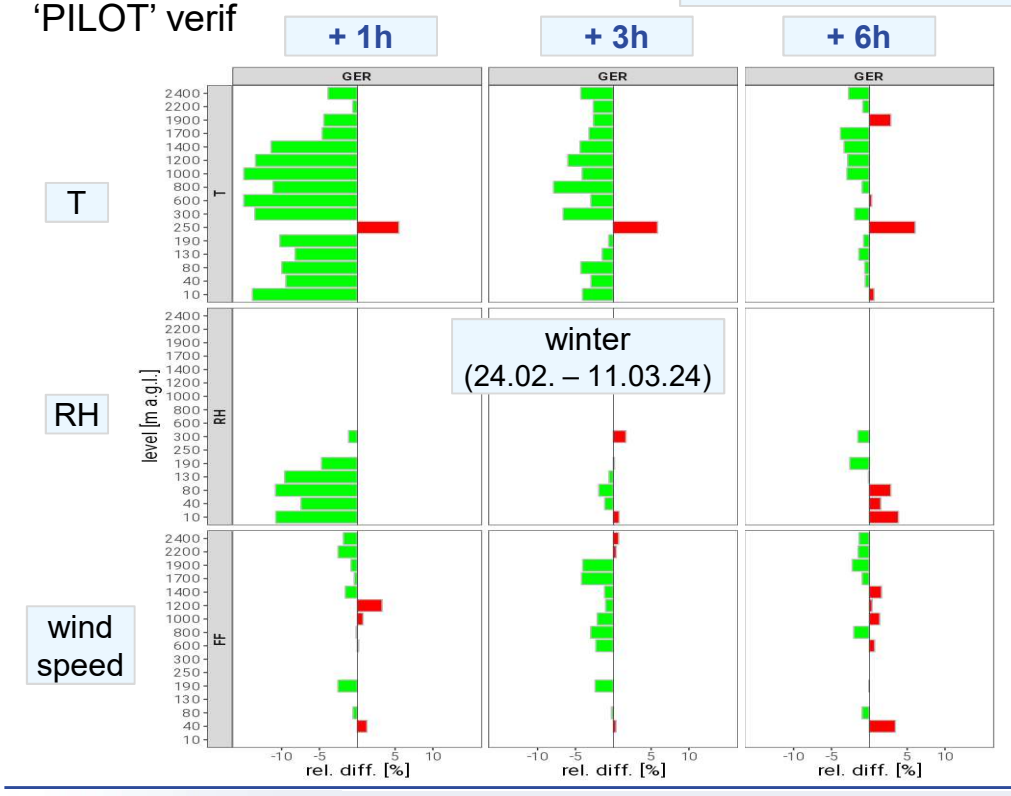
- positive impact seen from ‘all’ towers, in many forecasts (not just single cases)

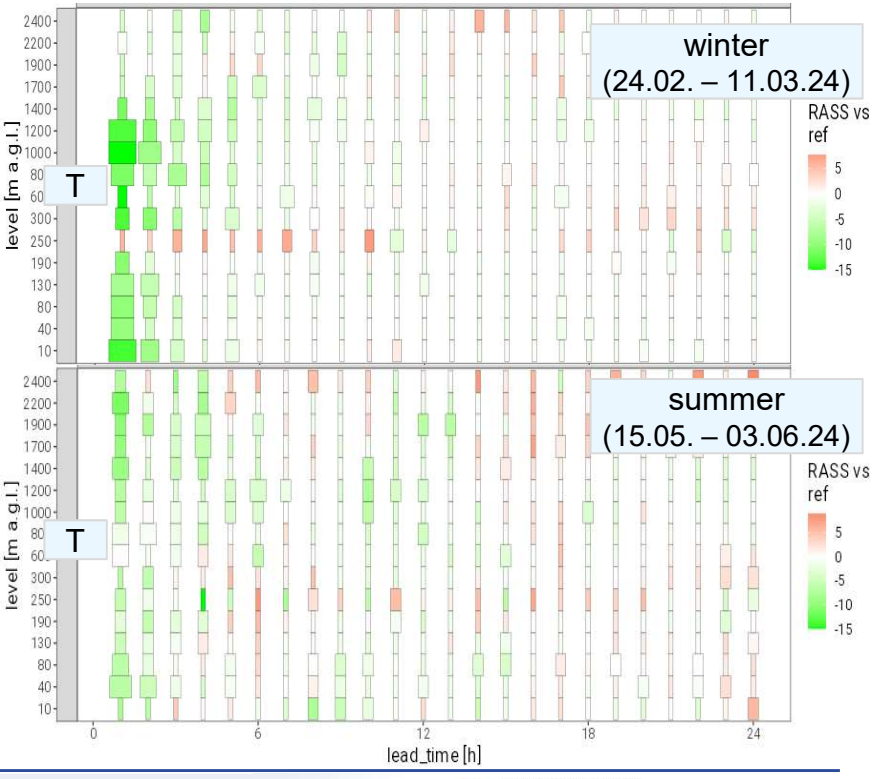
Task 2.6: PBL profiler obs: ICOS towers / RASS

Deutscher Wetterdienst

RASS+tower vs. ref: RMSE

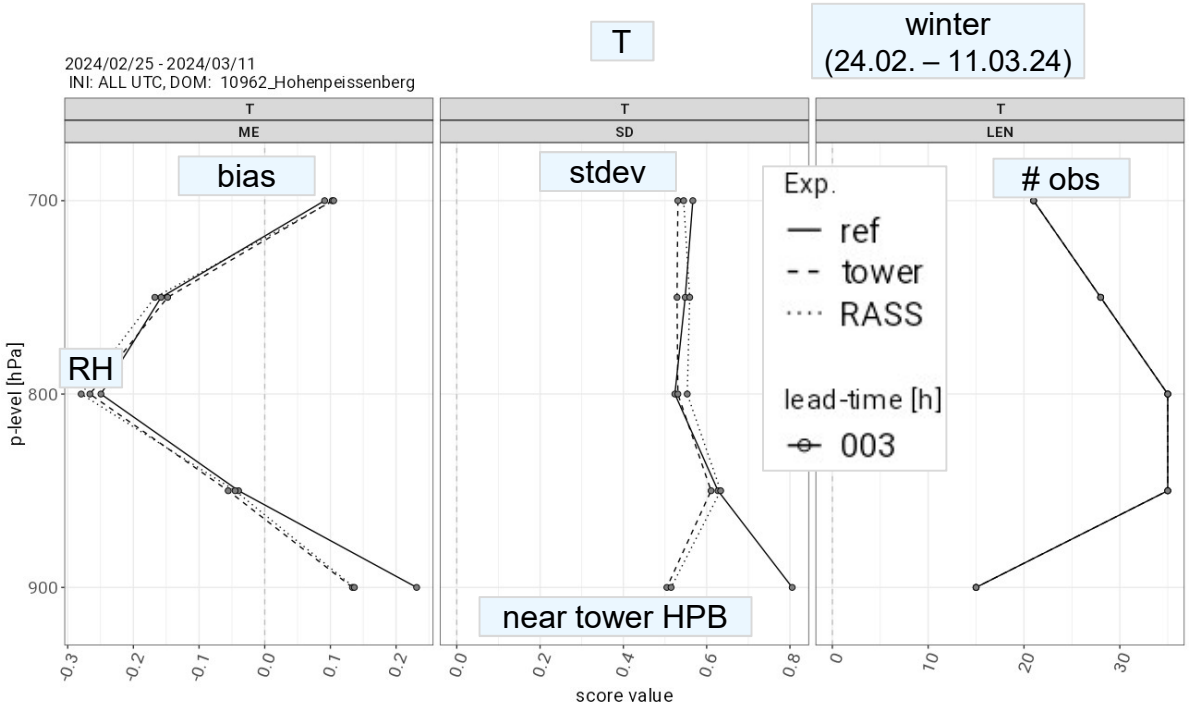
'PILOT' verif

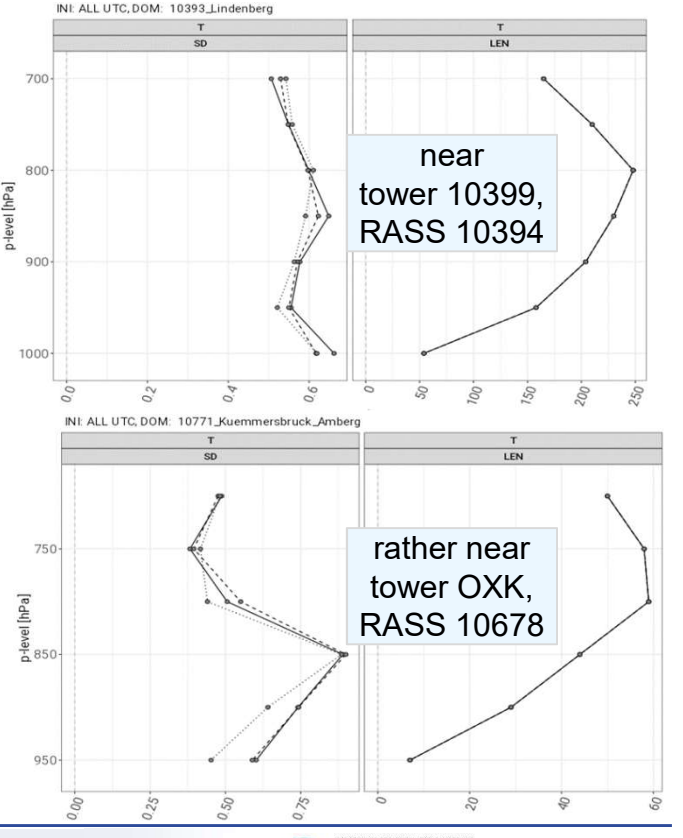




Task 2.6: PBL profiler obs: ICOS towers / RASS

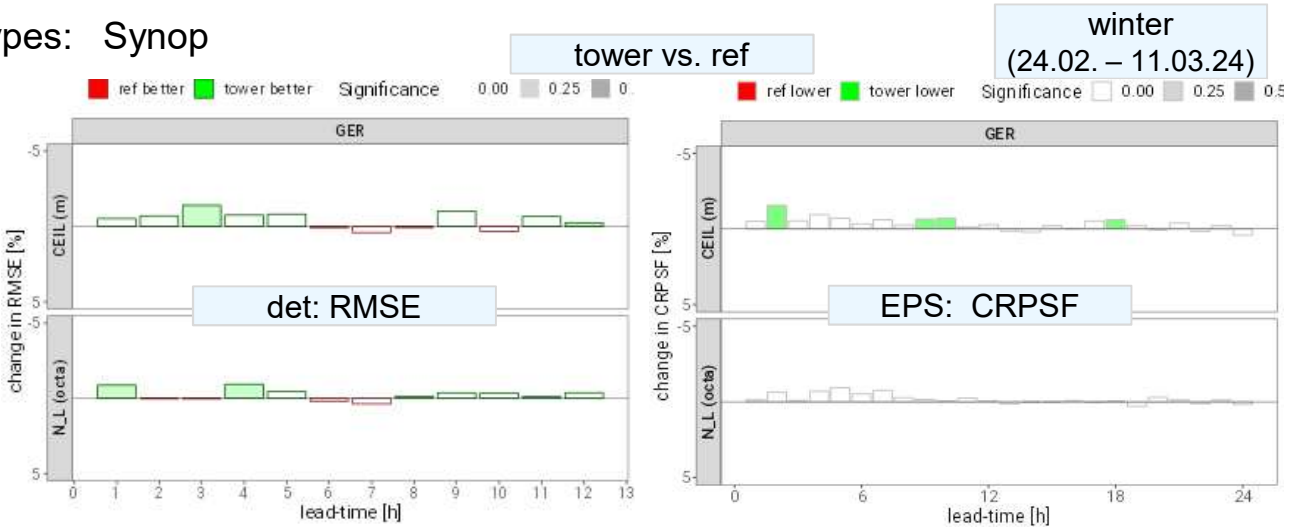
verification against other obs types: single radiosondes





Task 2.6: PBL profiler obs: ICOS towers / RASS

verification against other obs types: Synop



Summary of results:

- large positive impact vs. tower T + RH & RASS T in first hour, decreasing rapidly within 6 hrs, possible negative impact on wind in summer to be investigated
- difficult to see impact vs. other obs (some indication of benefit vs. TEMP), evaluation to be continued

Removal of 'bias correction' of near-saturated humidity obs

(Christoph Schraff, Hendrik Reich)

- 'bias correction' feature in KENDA / COSMO obs operators:
  set observed relative humidity > 96% to 100%

- introduced in context of observation nudging > 20 years ago,
  when (particularly) radiosondes were known to report > ~97% rarely

- today:
  - radiosondes + Synops report > 96% frequently
  - no continuous forcing of model fields by LETKF

  → no reason for this correction, no such correction in (global) EnVar

  → remove it ('bug fix')

Removal of 'bias correction' of near-saturated humidity obs

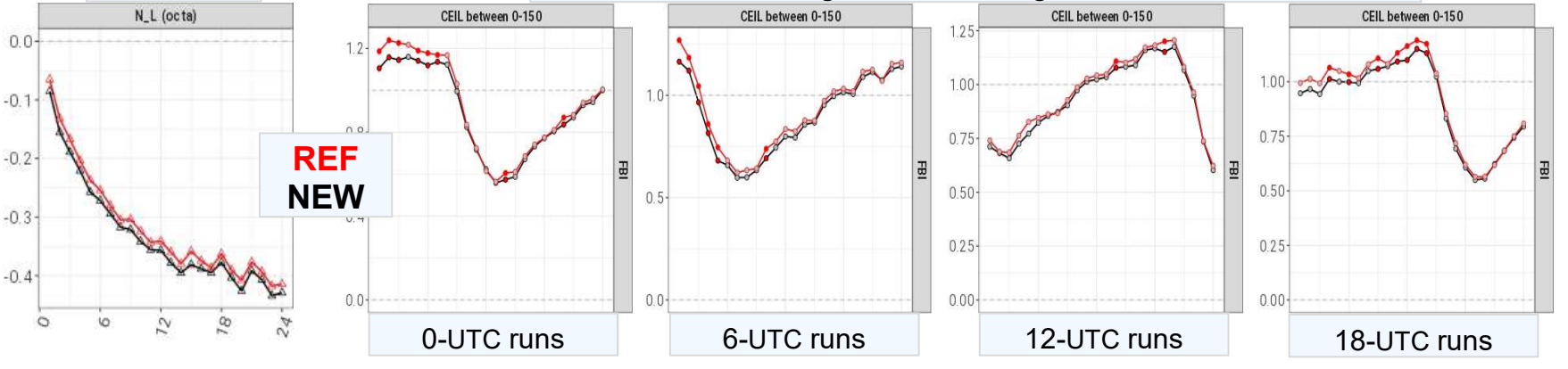
- tested in summer + winter
- impact on bias of independent obs

winter (20.01. – 09.02.2023)

FBI

low cloud

cloud ceiling 0 – 150 m a.g. (German stations)



→ occurrence of very low cloud ceiling (~fog) at night in winter slightly reduced (improved)

Removal of 'bias correction' of near-saturated humidity obs

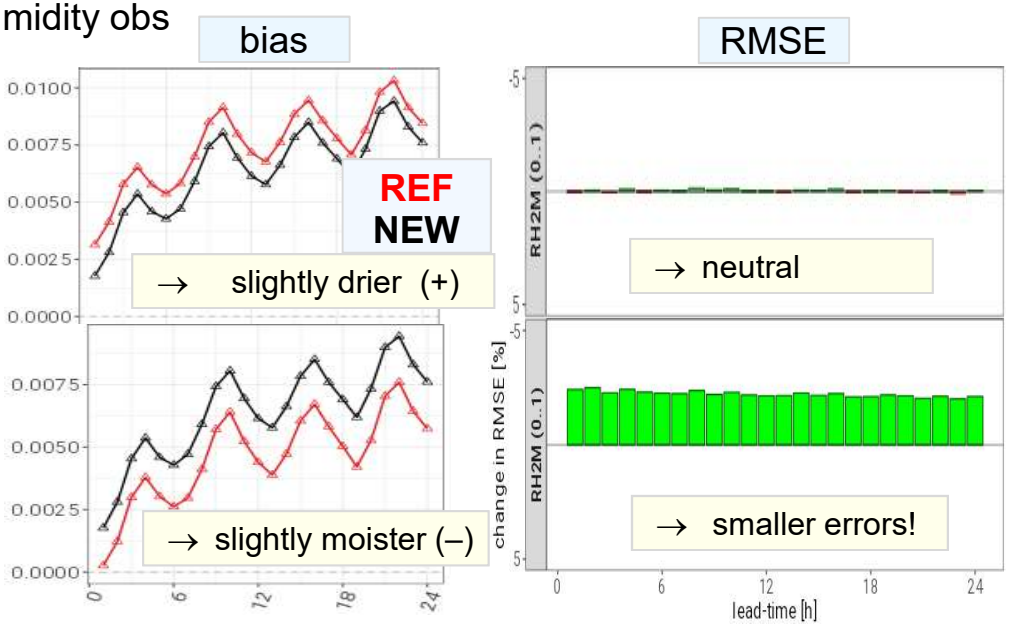
- impact on RH2M

  verif against same obs for both exp.
  (here: original obs)

  → indicates changes in model state

  verif against own obs
  (REF vs. bias-corr. obs,
  NEW vs. original obs)

  → what we see in our standard verif

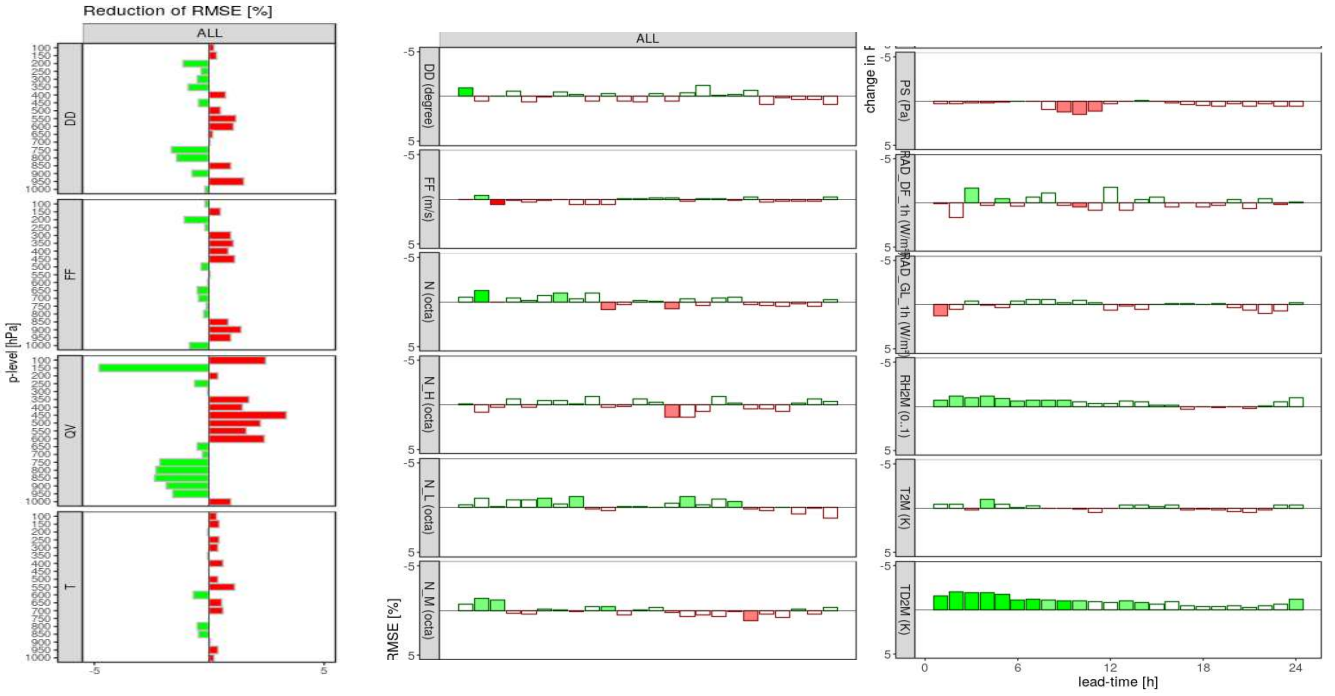


- neutral impact on forecast fields / forecast quality (~ positive for very low cloud ceiling at night in winter)
- (2-m) humidity errors in standard verification reduced due to more consistent data used for verification
- operational since 22 May 2024 (rhtsat = 0.96 → 1.0)

(Michael Bender)

impact of **ZTD** in 4-week (NUMEX) experiment in summer 2023 (4 – 30 June)

(incl. use of high-res. Mode-S in ref!)



- → Synop: improved 2-m humidity, slightly improved low cloud
- → improved boundary layer humidity but degradation above
- → further tuning experiments needed (vertical localization, height assignment) for ZTD,

  even more for STD