KENDA developments at DWD

Christoph Schraff et many al.

Deutscher Wetterdienst

KENDAscope: KENDA from Surface to Cloud Observations Progressive Extension
(Sept. 2020 – Aug. 2025)

- Task 1: algorithmic developments (operational KENDA; (C)EnVar)
- Task 2: observations (from surface to clouds)
  - 2.1 Radar (Z + Vr)
  - 2.2 ground-based GNSS ZTD + STD
  - 2.3 all-sky IR WV + VIS radiances
  - 2.4 MTG IRS
  - 2.5 screen-level obs (T2M, RH2M; 10-m wind)
  - 2.6 PBL profiling obs (wind lidar, MW radiometer, Raman lidar, drones, towers)
- Task 3: soil / surface

Task 1.1: Refinements on reference KENDA

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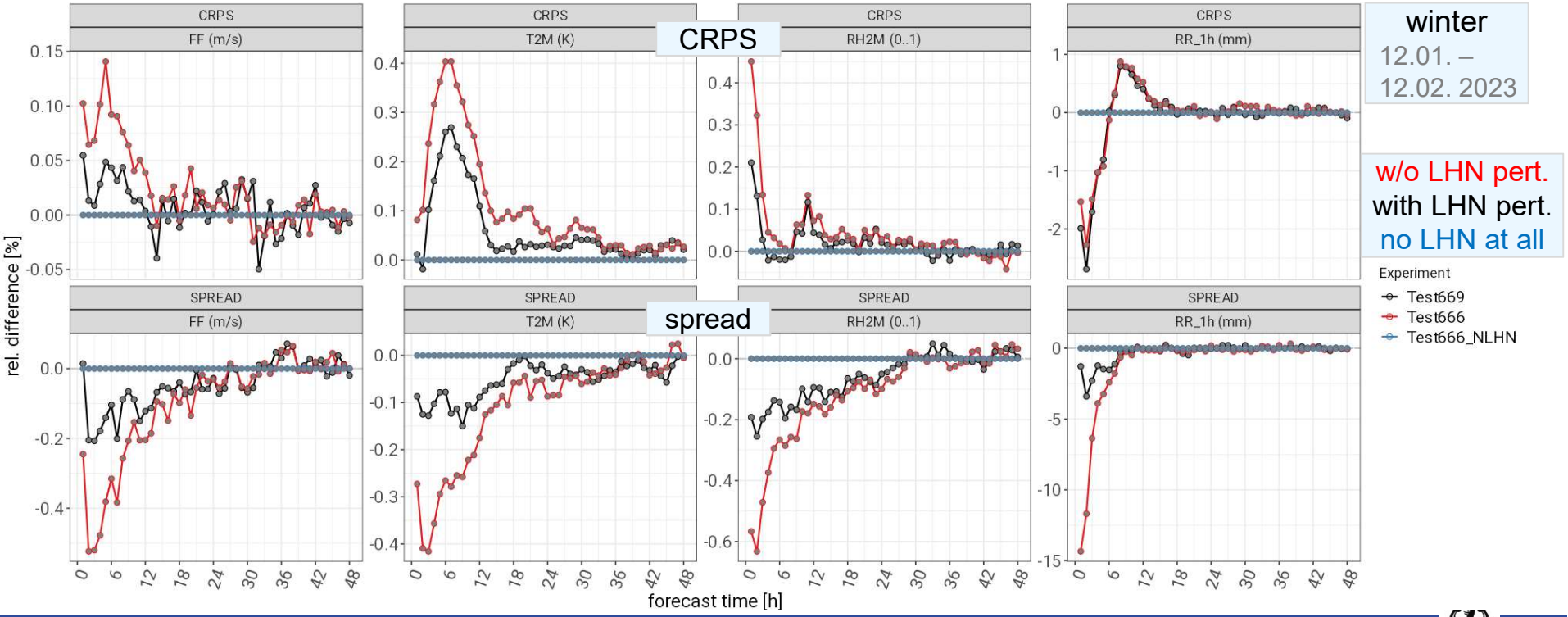
perturbation of 4 LHN parameters *(Günther Zängl, Klaus Stephan)*

- ensemble perturbations of (physics +) 4 LHN parameters introduced in September 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

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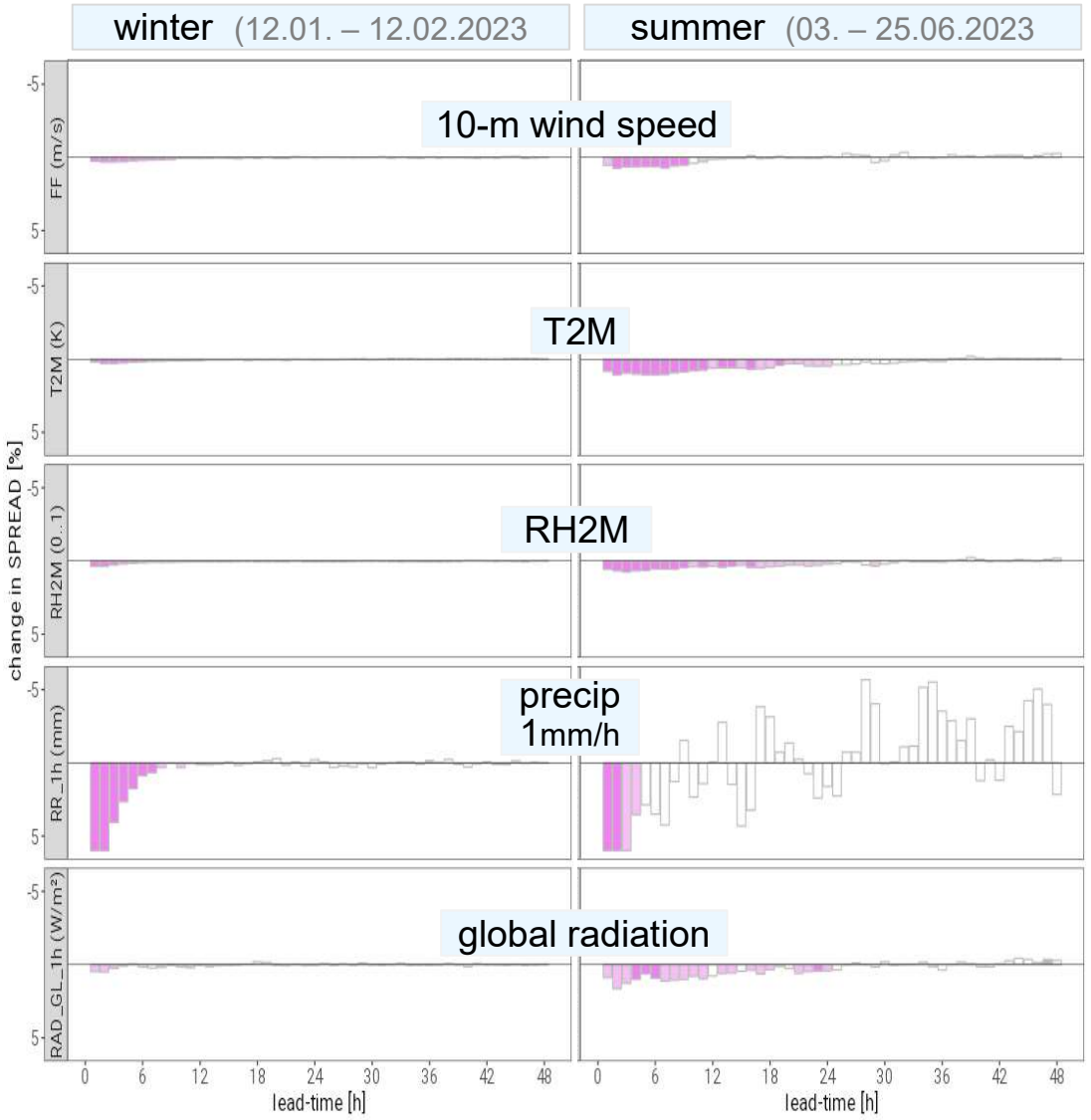
perturbation of 4 LHN parameters continued in forecast

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

spread

- operational since Jan. 2024



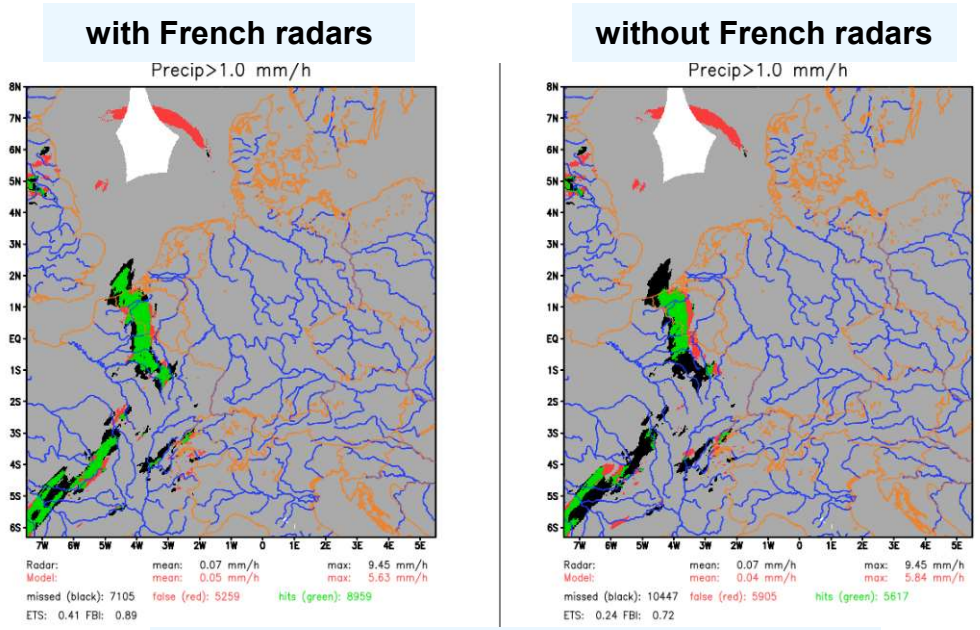
technical work

- 'code redesign': DACE-2: re-write of analysis code for generalized states
  - applicable to (a.o.)
    - atmosphere (with extended control vector (hydrometeors) for use of radar + all-sky satellite obs in (En-)VAR), with modified interface for all obs types, incl. EMVORADO)
    - ocean (ESM-W), ocean waves
    - surface / soil
    - green house gases (ITMS project)
  - more developer friendly, user friendly
  - more modular, flexible, possibly performant (fortan 2003 (+ parts of 2008))
  - docu / user guide should be developed on the way
  - start with MEC
  - work is progressing … but will take time

- Sinfony-RUC: – adjustment to 2-moment microphysics, tuning EMVORADO (*Alberto de Lozar, …* (→ talk *Jana Mendrok*))
  – use of Nowcasting radar data in first hour via LHN not yet successful (further tuning required) *(Klaus Stephan)*

- work on use of foreign radars (in ICON-D2 + RUC) *(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)

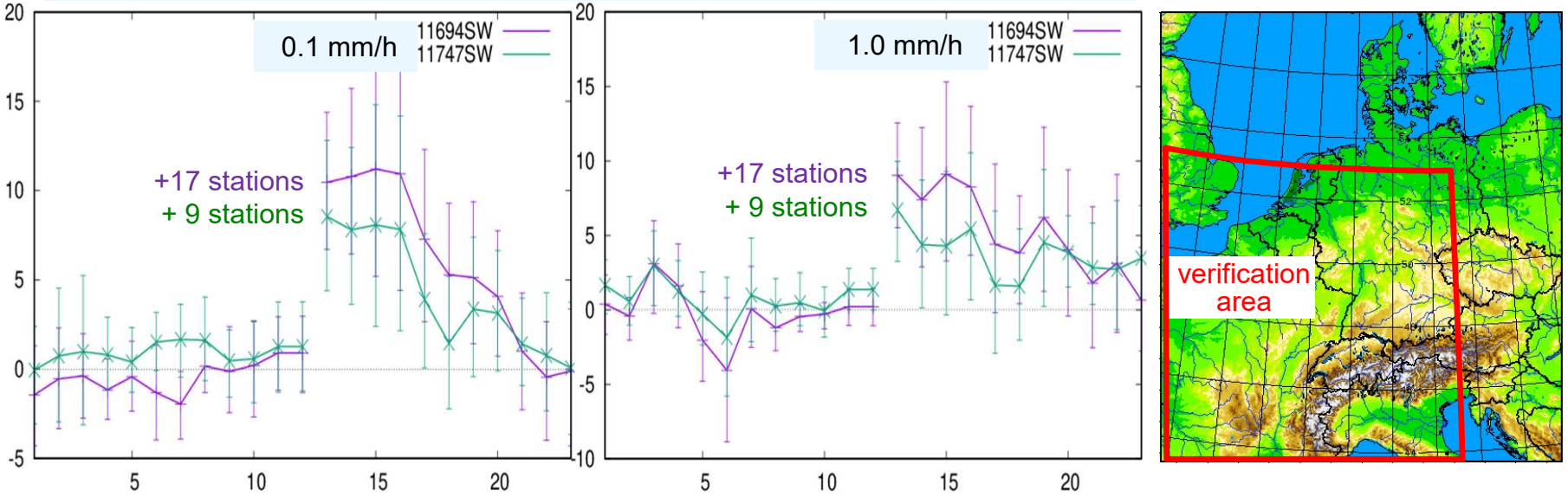
  (RUC: April / May 2023; ID2: June 2023)



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

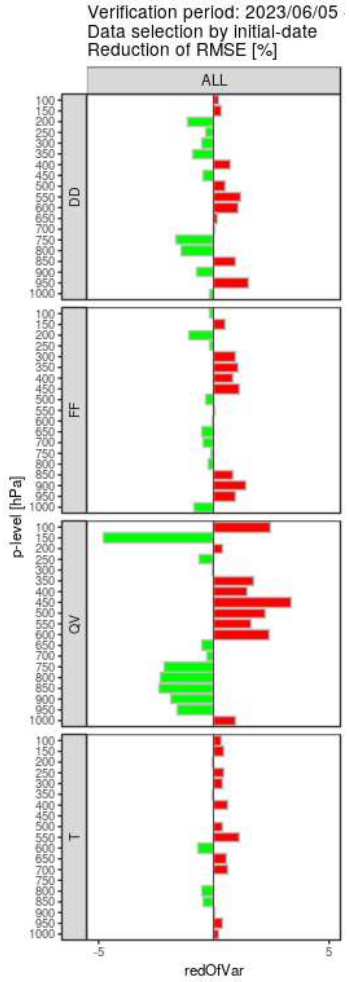


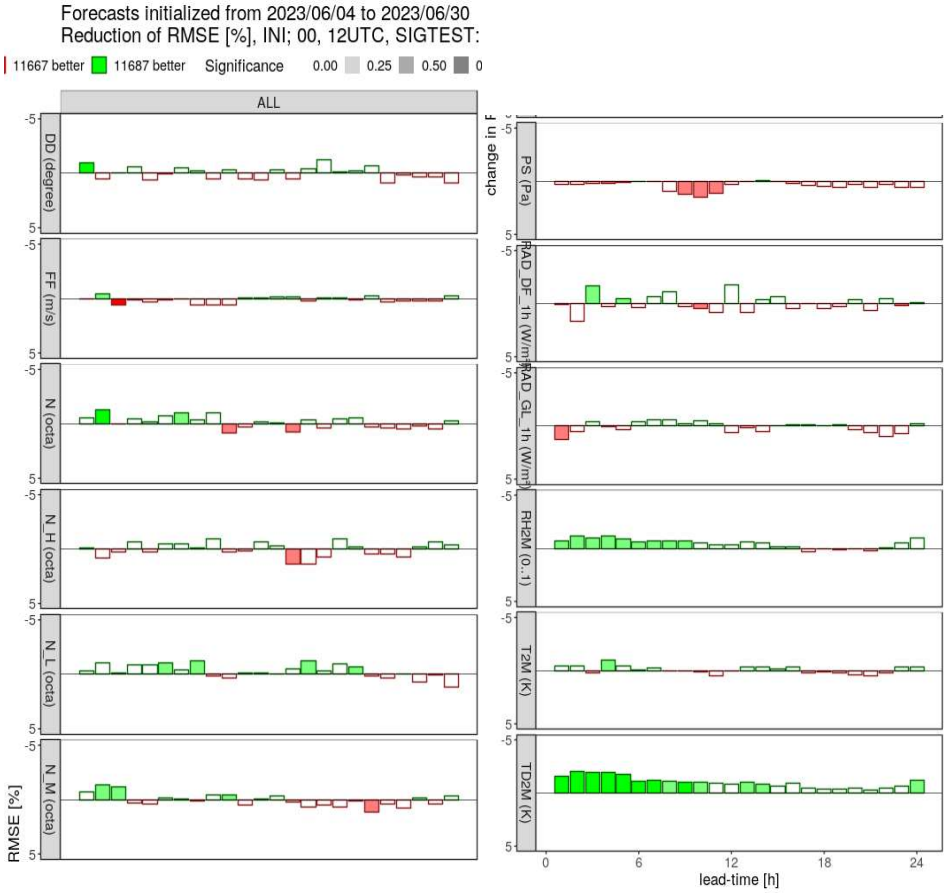
✓ in **ICON-D2** pre-operational suite since 26 Jan. 2024

✓ in Sinfony-RUC suite

(Michael Bender, DWD)

impact of **ZTD** in 4-week (NUMEX) experiment in summer 2023
(incl. use of high-res. Mode-S in ref!)





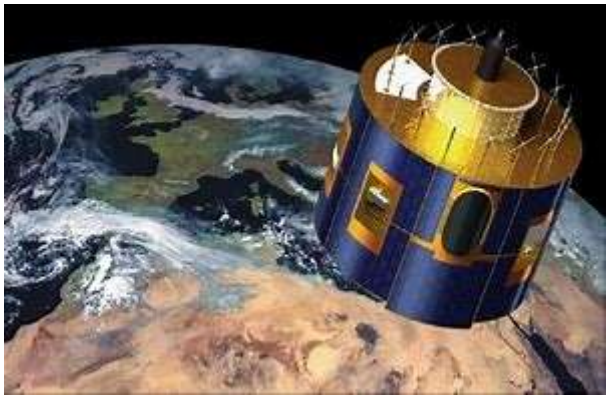
→ Synop: improved 2-m humidity, slightly improved low cloud

→ improved boundary layer humidity but degradation above

→ further tuning experiments needed (vertical localization, height assignment) for ZTD,

even more for STD

SEVIRI WV channels (added to VIS) *(Annika Schomburg et al)*



- presented previously (ICCARUS / COSMO GM 2023):
  method + settings (e.g. localisation, obs errors)
  + good results from assimilation of IR WV alone

- assimilation of SEVIRI visible channel (VIS)
  operational in March 2023

→ need to find suitable settings for assimilation of VIS + WV together

→ revised suitable settings for VIS assimilation

- horizontal localisation 35 km → 25 km
- superobbing → thinning
- no vertical localisation → broad (0.3 ln(p)) localisation around 800 hPa

→ positive impact of WV and / or VIS on cloud + upper-tropospheric humidity (Aug. 2022)

→ '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%))
bad impact of WV in first 3 – 6 hrs (upper-air) (GM 23) → error found in exp. setup ☺

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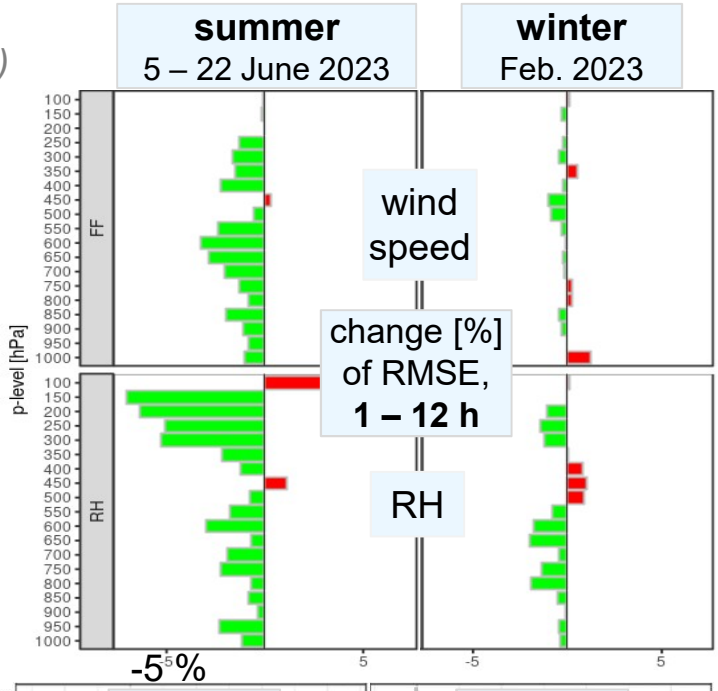
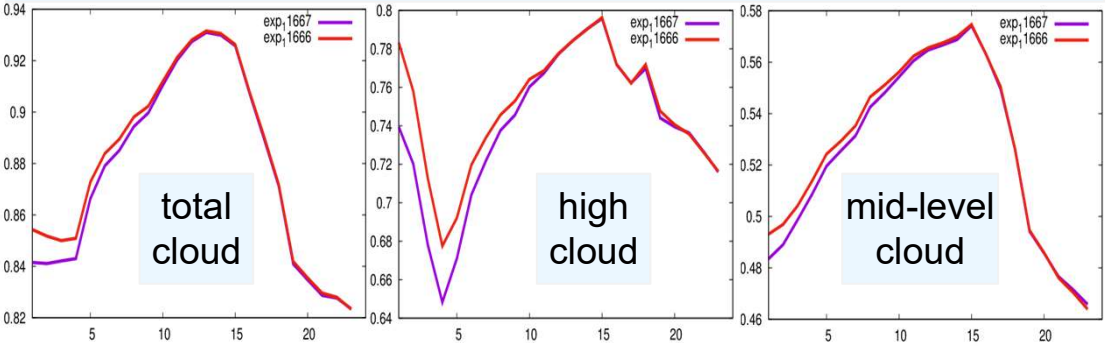
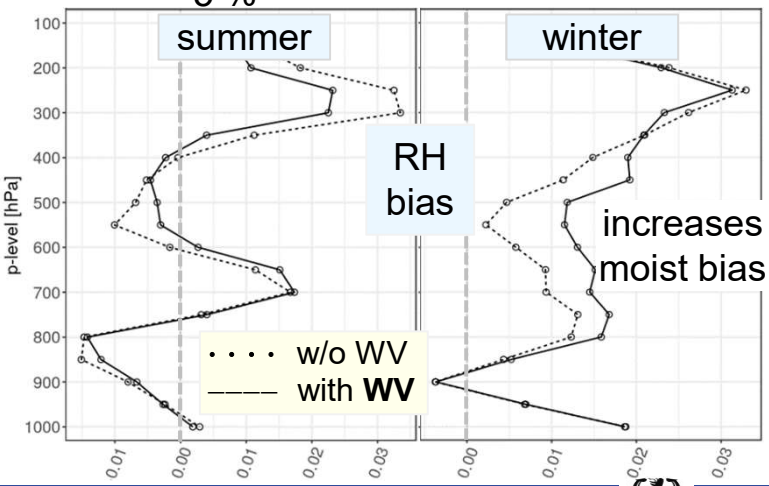
SEVIRI WV channels (added to VIS) *(Annika Schomburg)*

- 'final' exp. with then operational NWP environment
  - 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



FSS against NWCSAF satellite products (0-UTC runs, 5 – 30/06/23





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

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

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

- future steps
  - preparation for **FCI @MTG**
  - further visible + near IR channels

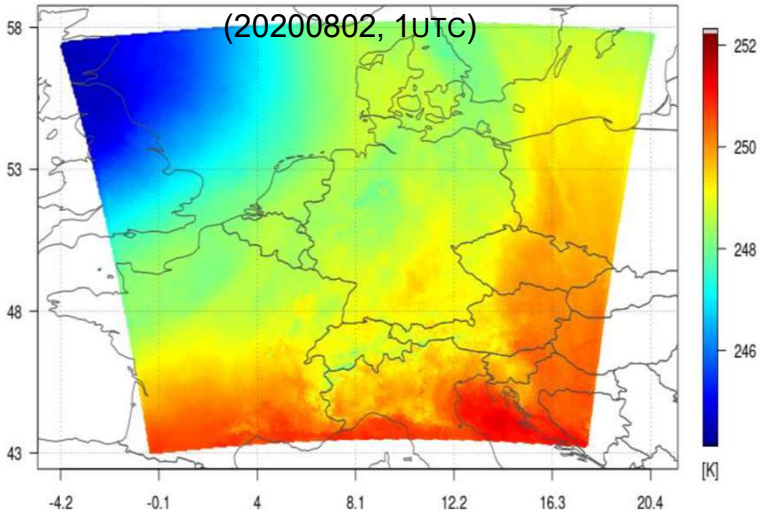
DWD: clear-sky assimilation of IRS

(Mahdiyeh Mousavi, Christina Köpken-Watts)

→ temperature + humidity profile information

- simulated ‚obs' (with RadSim) into fdbk file
- technical test in KENDA successful
  (bias correction,
  non-diagonal obs error covariance matrix **R**
  with inter-channel correlations not yet available,
  but needed for meaningful experiments)

simulated IRS obs – channel 59
(20200802, 1UTC)



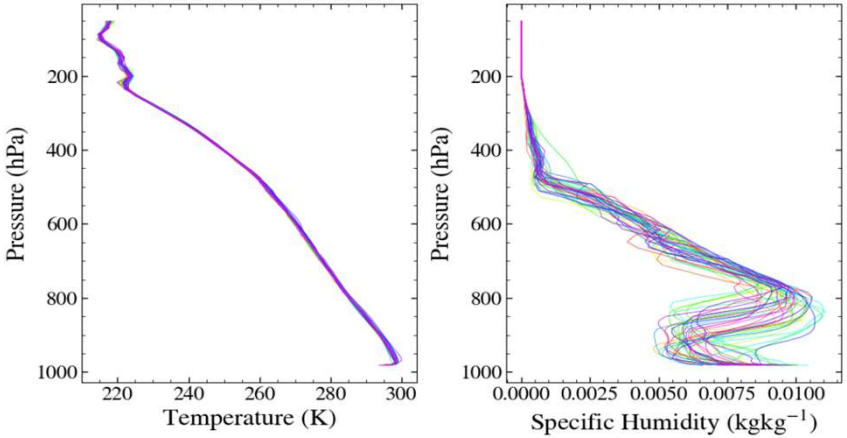
- ICON-LAM has a significant land contribution → use of IRS observation over land
  - ✓ improvement of land surface emissivity → employing IR emissivity atlas
  - ✓ improvement of model skin temperature → skin temperature retrieval from surface surface sensitive observations
    (by inversion of the radiative transfer eqn.)

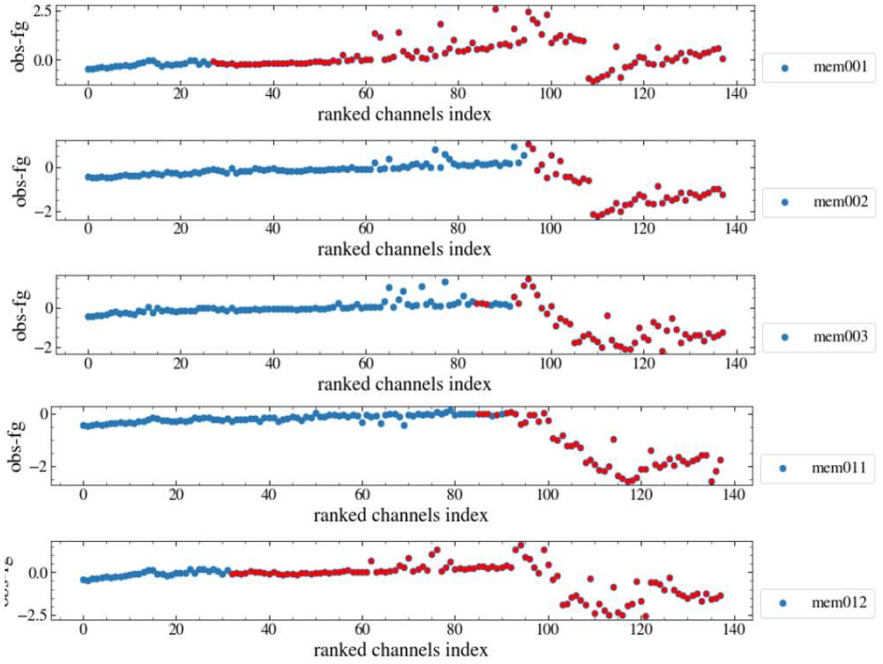
- also important: slant radiative transfer, 4D-EnVar (for indirect wind info), horiz. obs error correlations

- cloud detection by CADS software using McNally and Watts scheme
  - criteria depend (heavily) on O-B for series of channels
  - ICON-global model fields are used to extend the ICON-LAM model top for this

- cloud detection results of ensemble members often vastly different

temperature + humidity profiles
of ensemble members on one spot



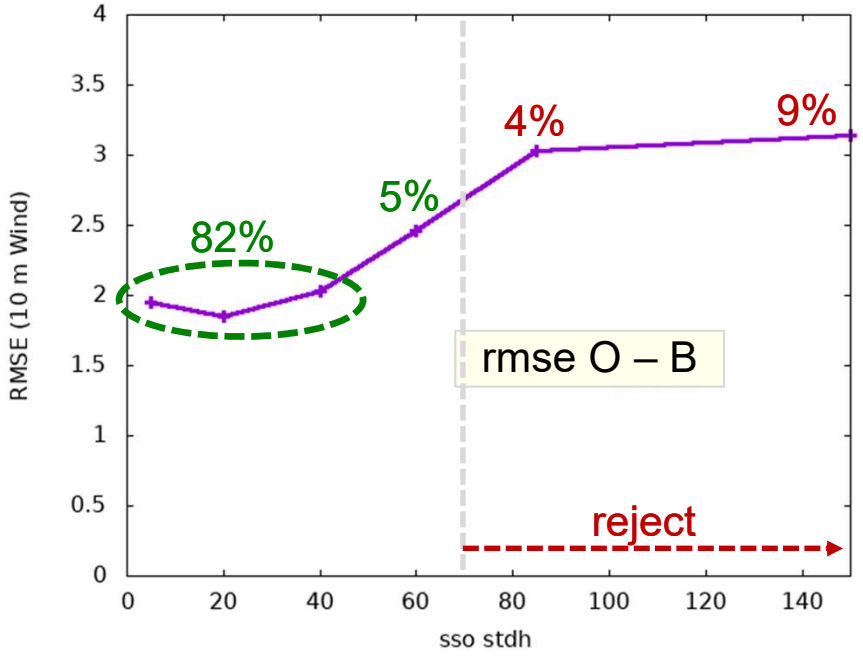


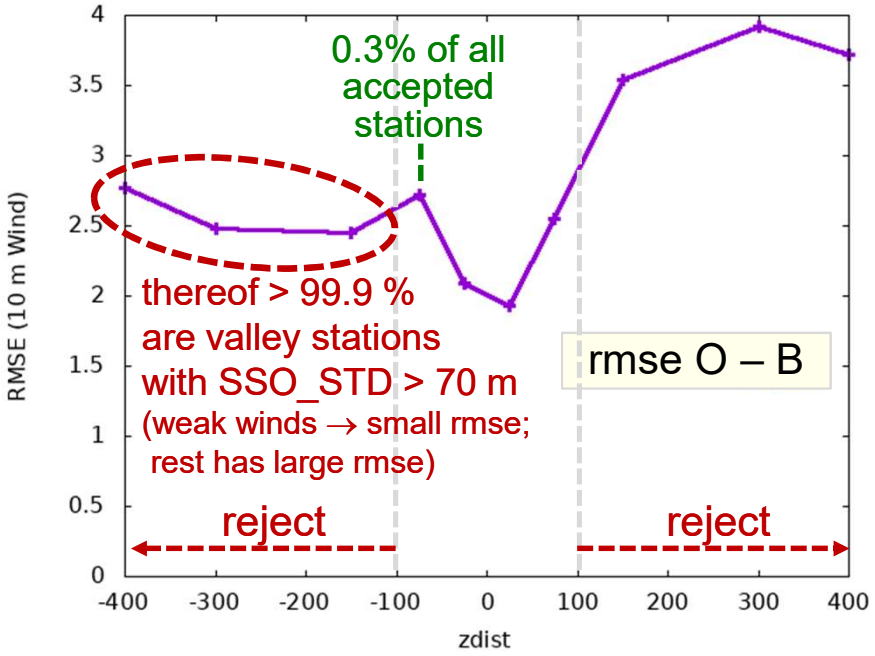
- which observations qualify as being clear of clouds? → where most ens. members agree
- adjust the obs error based on the ensemble members' agreement on cloudiness(?)
- future: thinning based on cloud detection, adaptive bias correction

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)





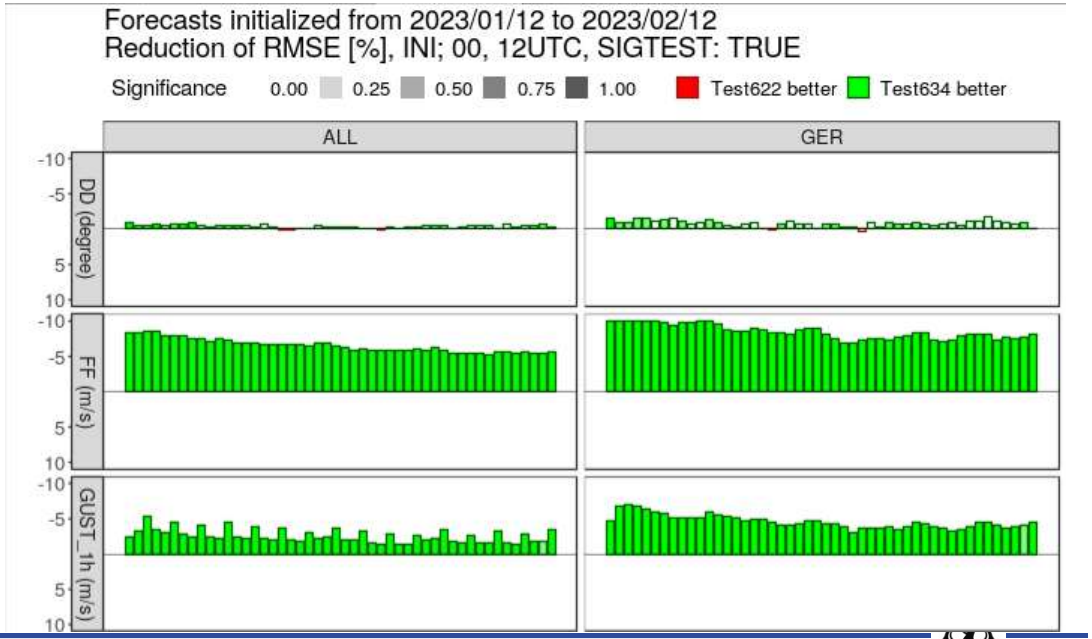
01/04 – 15/06/2023

- 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 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.s.) 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

Namelist settings

- icon_dace

```
&rules
comment = 'set wind observations above 5000m passive'
zlim = 5000 10000 ! above 5000m

&cosmo_obs
altopsu(1) = 5000.! max height for single level wind obs
zlimv10(1) = 70.
doromx(1) = 100.
```

- LETKF

```
&OBSERR obstype='SYNOP' quantity='u10m'
table='extern' scale=1.0
err= 2.00 2.00 2.00 2.00 2.00
2.25 2.48,2.48 2.48 2.48
2.48,2.48 2.48 2.48 2.48 /
```