Assimilation of all-sky SEVIRI data and other news on KENDA

Christoph Schraff

- SEVIRI **VIS** *(Lilo Bach, T. Deppisch, L. Scheck, R. Faulwetter, C. Schraff, a.o., DWD)*
- SEVIRI **WV** *(Annika Schomburg, C. Schraff, K. Stephan, a.o., DWD)*
- Other news on KENDA

- VIS: sensitive to: – high / mid-level / low cloud cover
  – cloud properties (cloud water mass (TQC_DIA, TQI_DIA), optical properties → effective radius)

  → info on: – cloud yes / no
  – cloud optical thickness

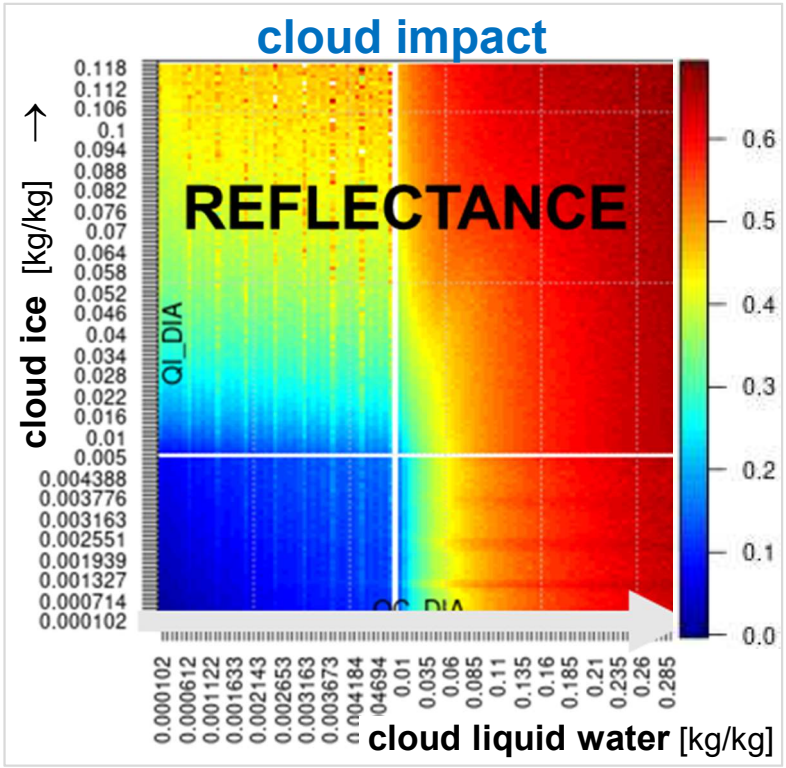
  (no info: at night, on cloud top height)

- MFASIS → RTTOV (input incl. optical thickness, effective radii, sfc. albedo, …)

- QC: snow cover, (Saharan) dust, volcanic ash, etc.

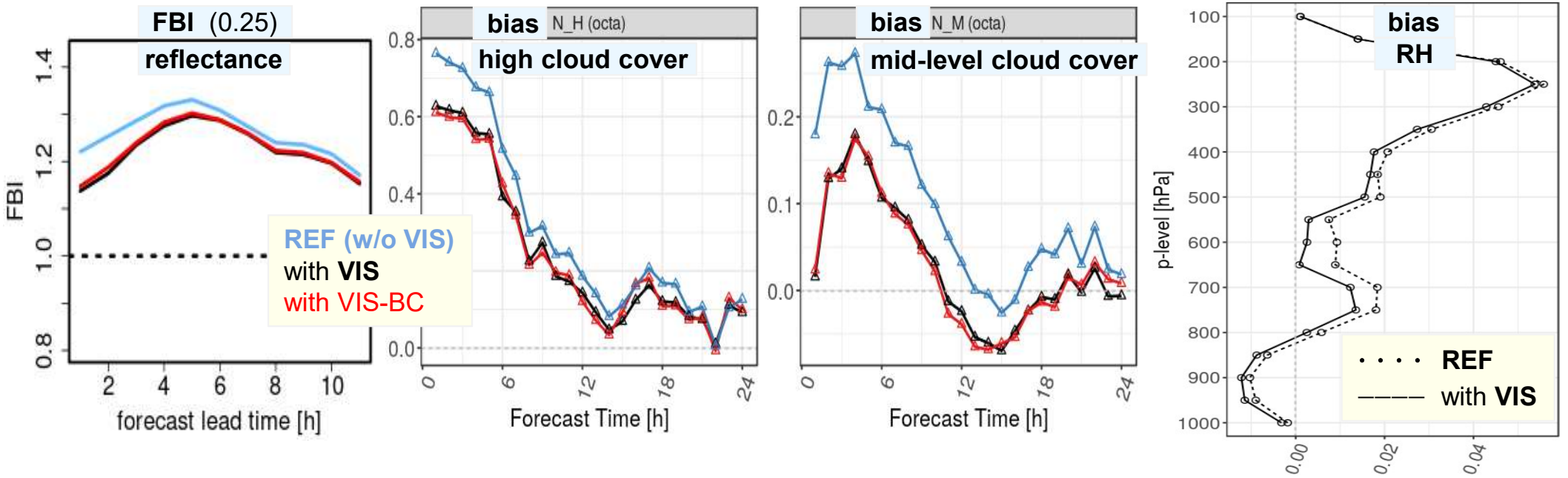
- obs calibration (vs. moon, Modis): factor 1.08
  (bias correction not applied due to small impact in DA cycle)

- obs error: inflated for large innovations



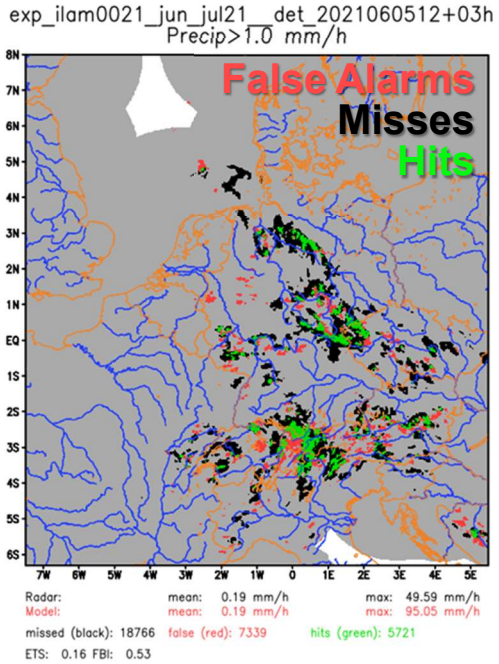
impact on forecast bias in ICON-D2 (June 2021)

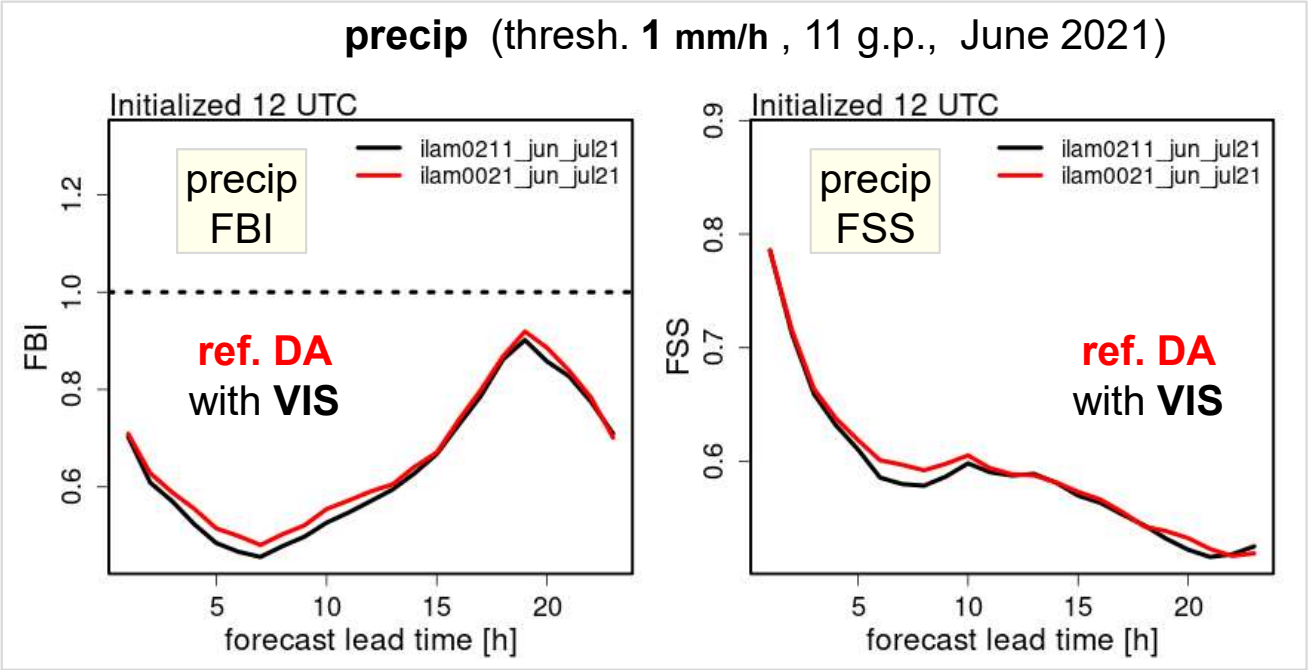
- cloud cover: positive bias (Synop high + mid-level, reflectance FBI cloud y/n) reduced
  (low cloud: small bias, small impact from VIS on bias)



- tropospheric humidity: reduced by VIS (bias positive at high level, negative in PBL)
- (no impact from histogram-based bias correction)
- rmse for cloud cover & surface global radiation reduced

- by reducing humidity / clouds, VIS tends to reduce precipitation events which are already underestimated



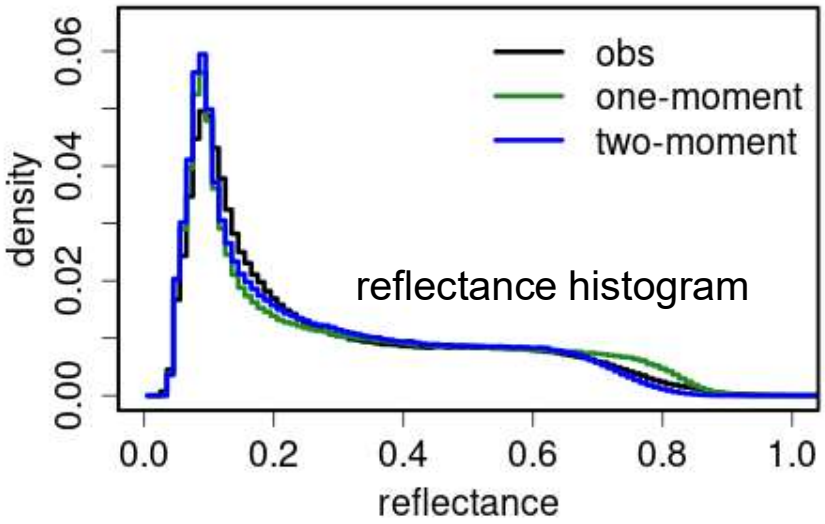


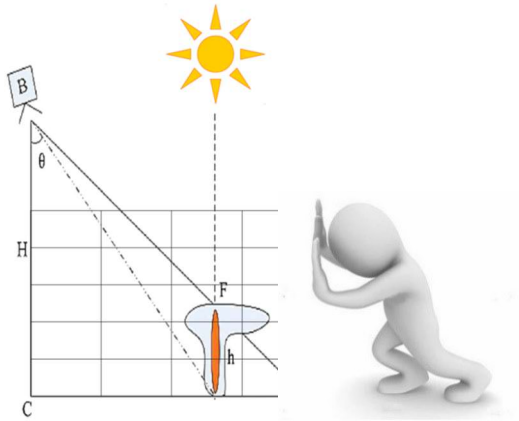
- interaction DA – model physics: ICON-D2 needs too much cloud / humidity / instability to produce convective precip

→ no solution without reduction of model biases

refinement of model & obs operator *(G. Zängl, A. de Lozar, Leonhard Scheck, a.o.)*

ICON





MFASIS

- interaction DA – model physics … experts !

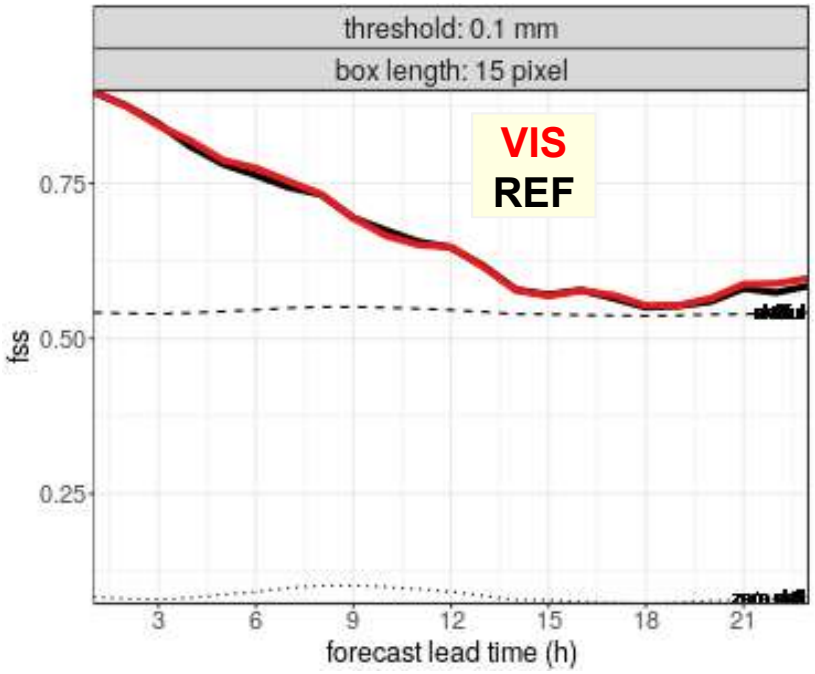
  (for one-moment microphysics in ICON-D2 and particularly two-moment microphysics in Sinfony-RUC)

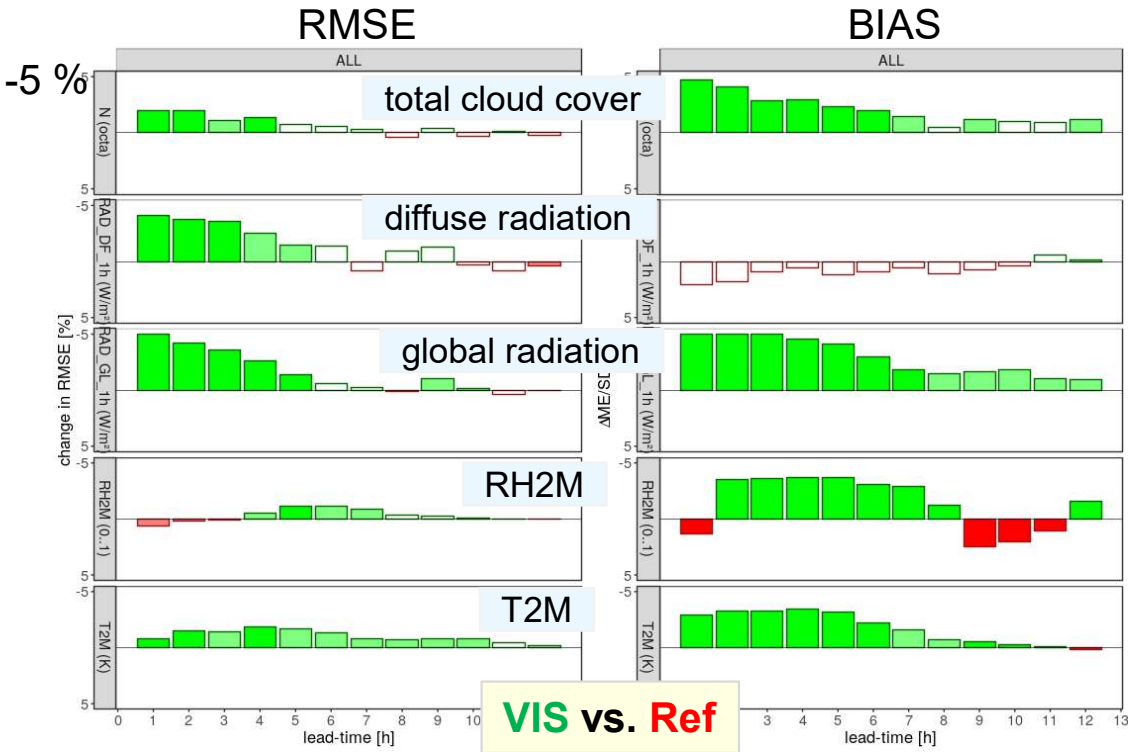
- account for latent heating from sub grid-scale condensation in the prognostic grid-scale variables

  → more instability, convection, precip (at ~ same RH), slightly reduces cloud & precip model biases

  operational since Oct. 2022

- experiment, ICON with LH of sub-grid cloud condensation, 12 May – 11 June 2022
  (incl. new Mode-S)
  - positive impact on cloud, radiation, 2-m temperature + humidity; upper-air neutral
  - precip neutral, no increase of negative bias





SEVIRI VIS (visible channel)

- **operational** in ICON-D2 since 15 March 2023:
  - ✓ first time at DWD / COSMO: use of all-sky cloudy satellite data
  - ✓ first time NWP at any NWS: use of **visible** channel data

- in Sinfony-RUC since Oct. 2022 (2-moment microphysics, towards nowcasting)
- monitoring of SEVIRI VIS set up in global DA system

all-sky SEVIRI IR **WV** (water vapour channels)

(Annika Schomburg a.o.)

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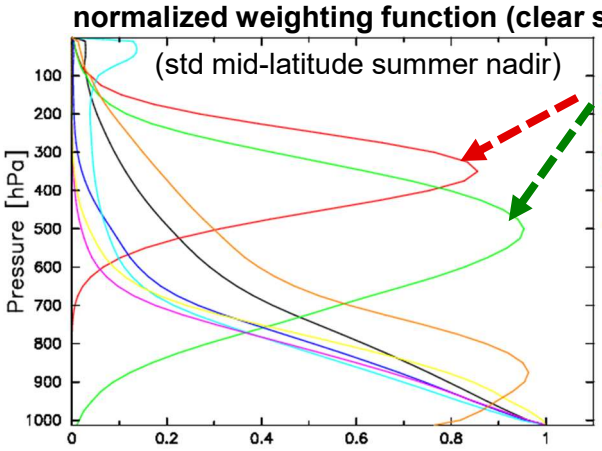
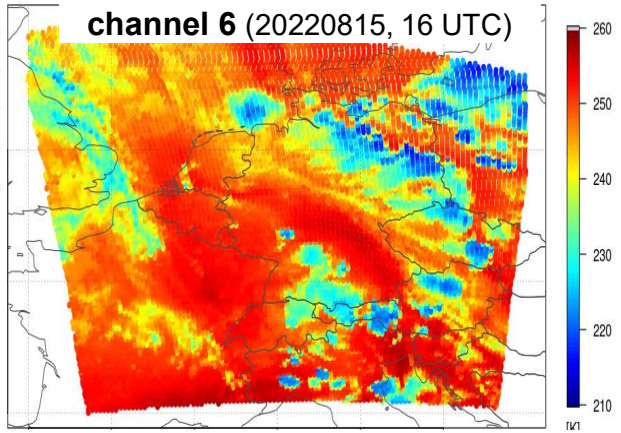
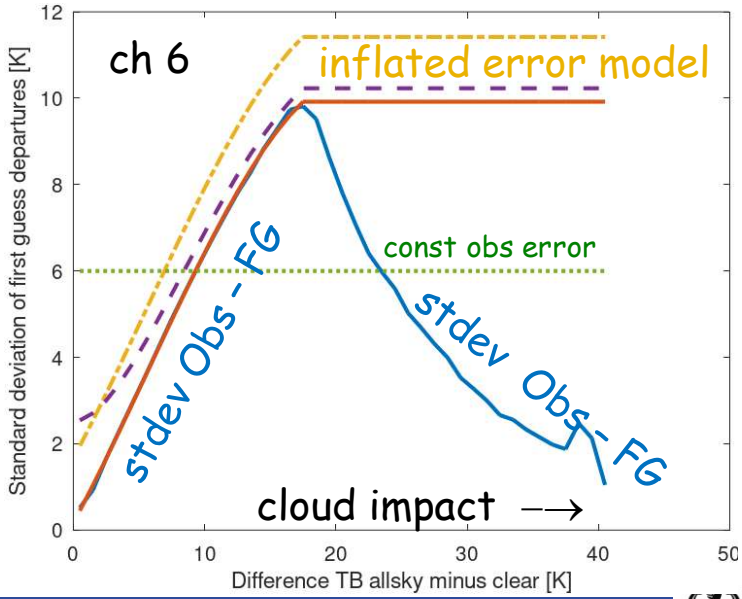
- info on WV + **clouds**
  in mid- to upper troposphere





- what has been tested:
  - different obs error models
  - different height assignment methods
    (based on Jacobians and transmission)
  - vertical localization (0.3, 0.25, 0.15))
  - horizontal localizations (35km, 25km, 12.5km)
  - superobbing, different thinning distances
  - small benefit from analysing / updating cloud ice
  - …



- VIS operational → need to combine WV + VIS

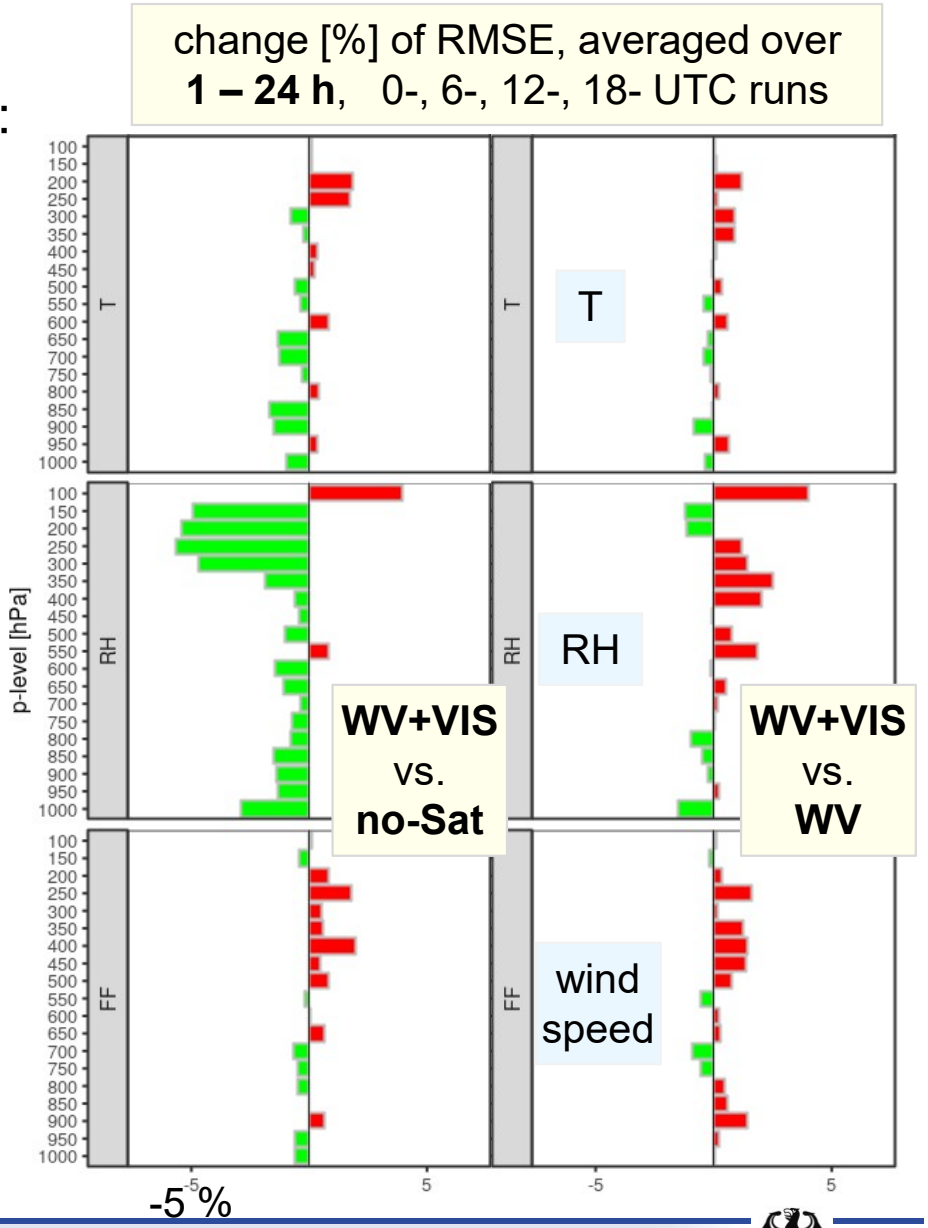
- for combined use of WV + VIS
  need to change settings for VIS DA (tuning):

  best results with thinning 4 x 2 grid pts,
  25 km horiz. localisation for all channels
  (instead of superobbing 4 x 2 g.p, / 35 km for VIS)

- 1 – 22 June 2021:
  positive impact on humidity

  but WV + VIS worse than WV above 500 hPa

  VIS (w/o vertical localisation) appear to
  negatively affect impact of WV at high levels



all-sky SEVIRI IR WV

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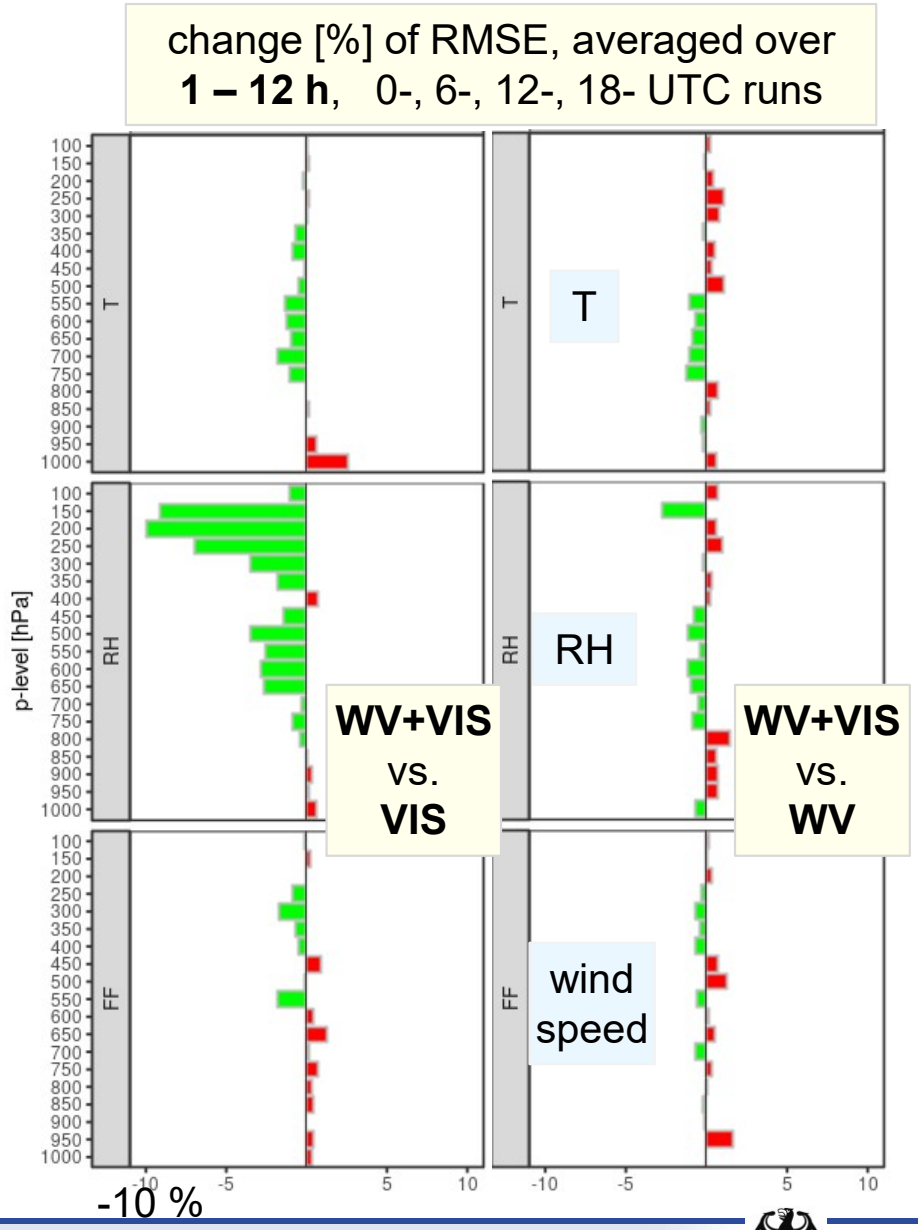
- tuning experiments (June 21) for combined use of WV + VIS:

  vertical localisation for VIS fixed at 800 hPa

- 15 Aug. – 12 Sept. 2022 →
  (new Mode-S, ICON w. LH from subgrid-scale condens.
  operational VIS (superobbing …) = ref)

  WV + VIS as good as WV !



all-sky SEVIRI IR WV

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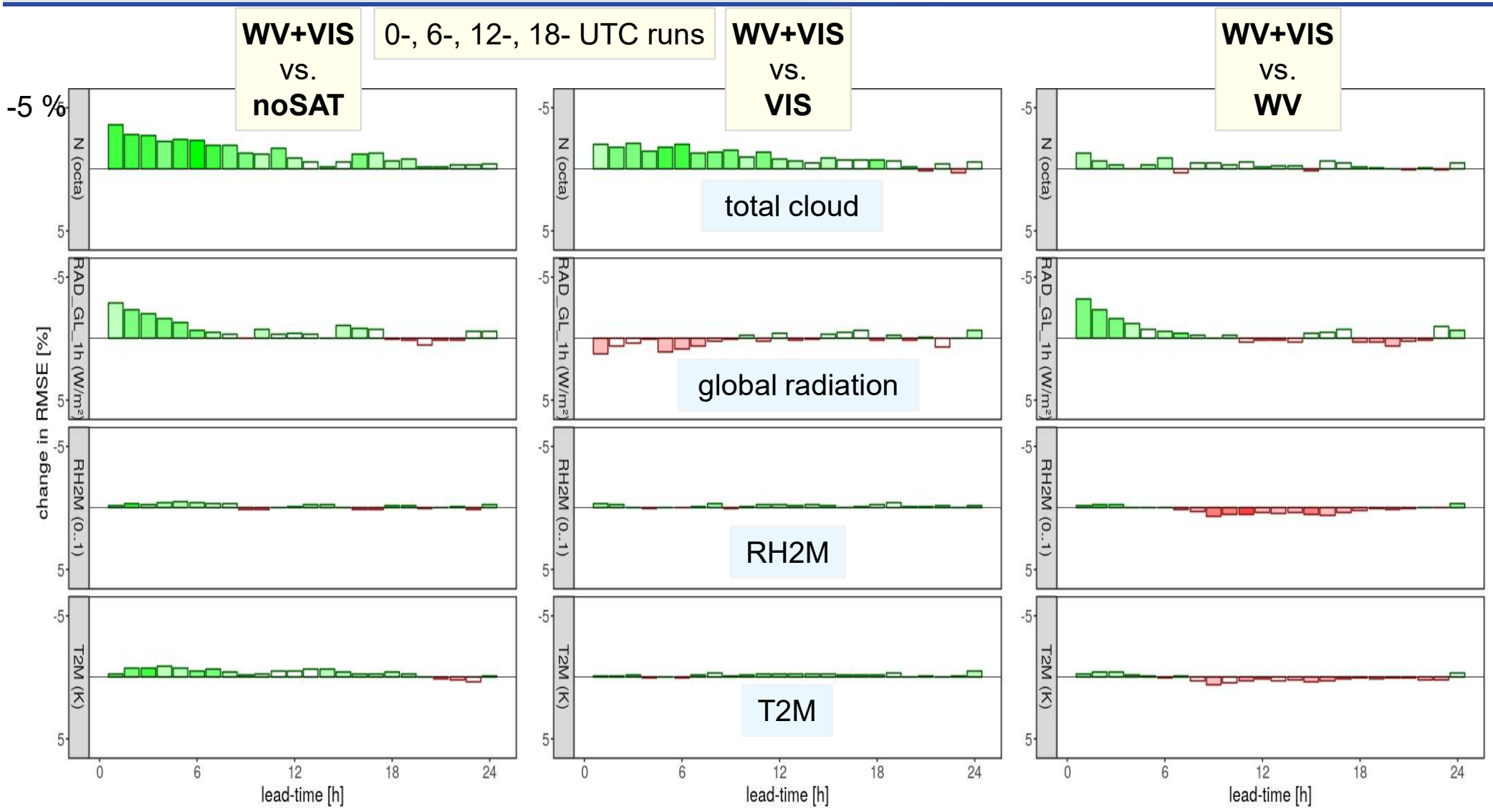

- extra benefit VIS: surface radiation
- extra benefit WV: upper-level QV + total cloud cover (high cloud slightly worse in new exp.)

all-sky SEVIRI IR WV

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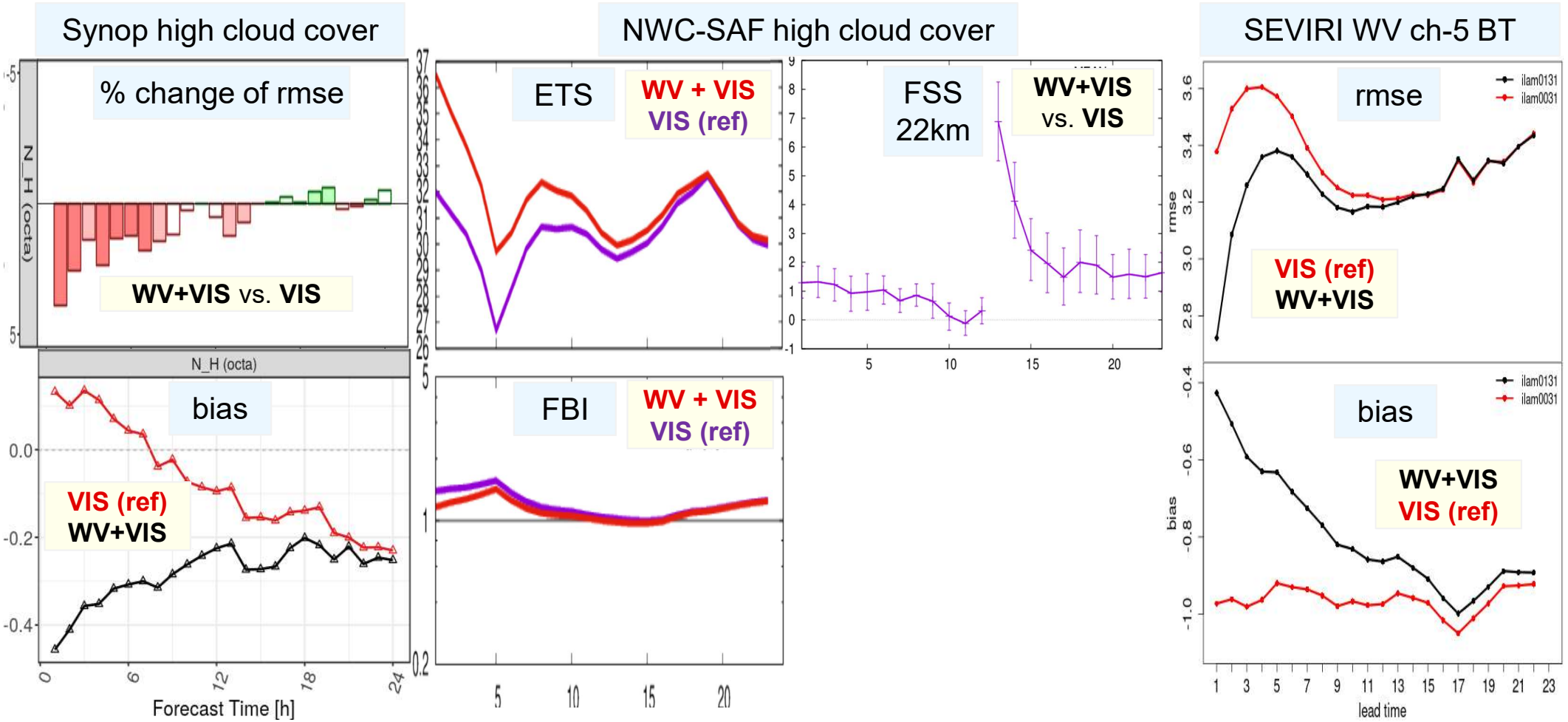

- vs. Synop high cloud: WV introduce underestimation of high cloud, negative impact
- vs. Satellite-derived NWC-SAF high cloud, SEVIRI brightness temperature (ch5 + ch6): WV reduce overestimation of high cloud, clear significant positive impact

all-sky SEVIRI IR WV

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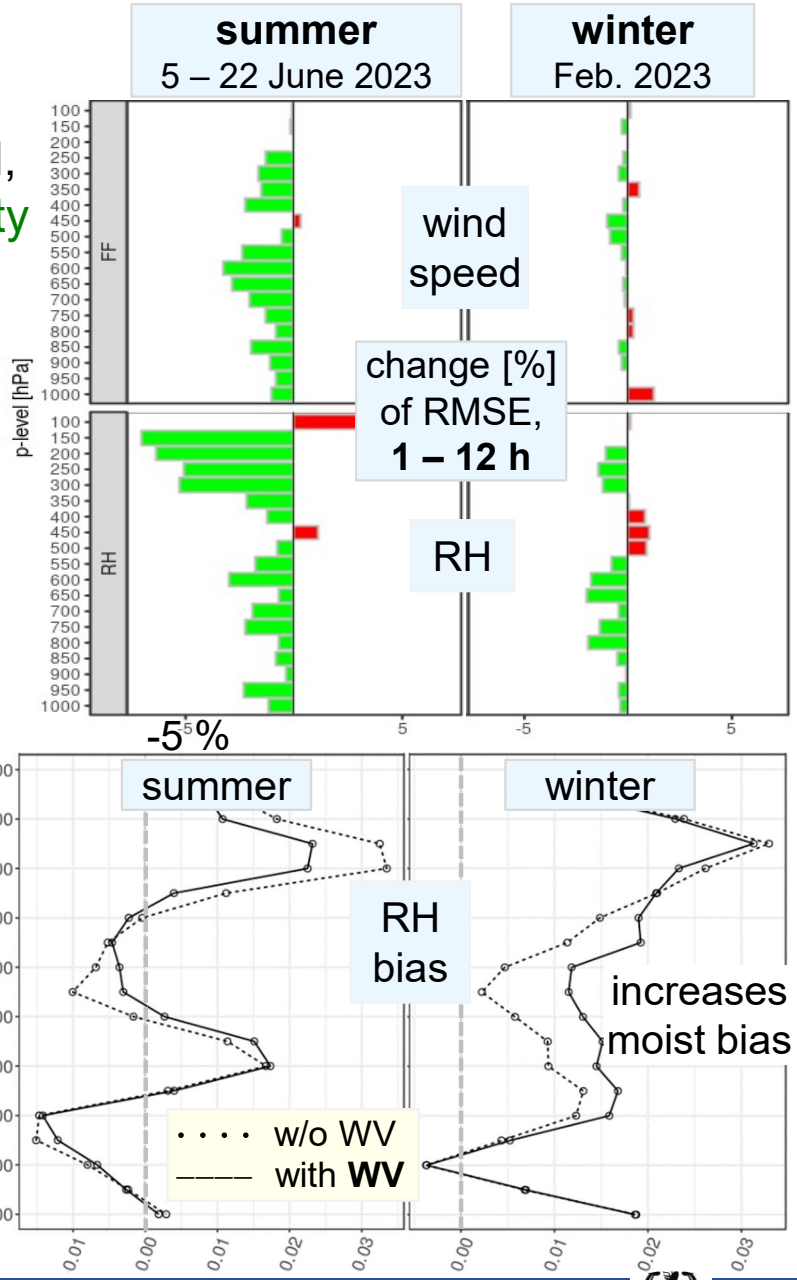
- SEVIRI WV channels (added to VIS): summary
  - suitable settings for combined use of WV + VIS found, positive impact on cloud + upper-tropospheric humidity
    (precip: ~ neutral)
  - 'final' exp. with current operational NWP environment
    (Mode-S in ICON-global/-EU since May 2023
    → impact on ICON-D2 via LBC: reduction of RMSE, spread, spread-skill (2 – 5%))

    preliminary (!) results:
    - summer: positive impact also on wind
    - winter: cloud positive, otherwise small impacts
      increased mid-tropospheric moist bias
  - introduce WV in parallel suite soon?
- further steps VIS + WV channels
  - preparation for VIS & WV of FCI @MTG
  - further visible + near IR channels



some other news on KENDA: observations

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- preparation of (clear-sky) MTG IRS data (clear sky, above clouds)
  - cloud detection, skin temperature T_s retrieval from very low peaking channels

- GPS ZTD & (low-elevation) STD:
  - first exp. with ICON-D2 (after porting from COSMO, much technical work)
  - positive impact from ZTD (RH, T); STD degrades wind, T, improves precip slightly
  - STD: need to work on improved obs error specification (station-dep., adaptive, …), bias correction, localisation, obs error correlations, …

- direct assimilation of 3-D radar reflectivity (+ radial wind):
  - MeteoSwiss, CNMCA & ARPAE (IT): work on use in ICON-LAM
  - DWD: first tests with reflectivity from French radars: positive impact

- ground-based remote sensing: wind lidar, Raman lidar (MeteoSwiss), MWR
  - some small benefits, but often difficult to obtain conclusive results from 1 – 2 devices, tuning severely hampered

- EnVar (deterministic analysis / forecast; ensemble $\mathbf{B}$) :
  - runs technically in a preliminary version, for conventional obs only (with LHN)
  - 2-week comparison to LETKF: slightly better in radiosonde verif.
  - much development needed for use of radar reflectivitiy (+ SEVIRI VIS), activities started

- no resources in past year for 4D-EnVar (global) and Particle Filter

- code redesign / re-write of analysis code for generalized states (control vector)
  (incl. hydrometeors, ocean, surface / soil, greenhouse gases, …)

- perturbations of physics + LHN parameters in LETKF DA cycle (ICON-D2):
  - operational since 6 Sept. 2023

other news on KENDA

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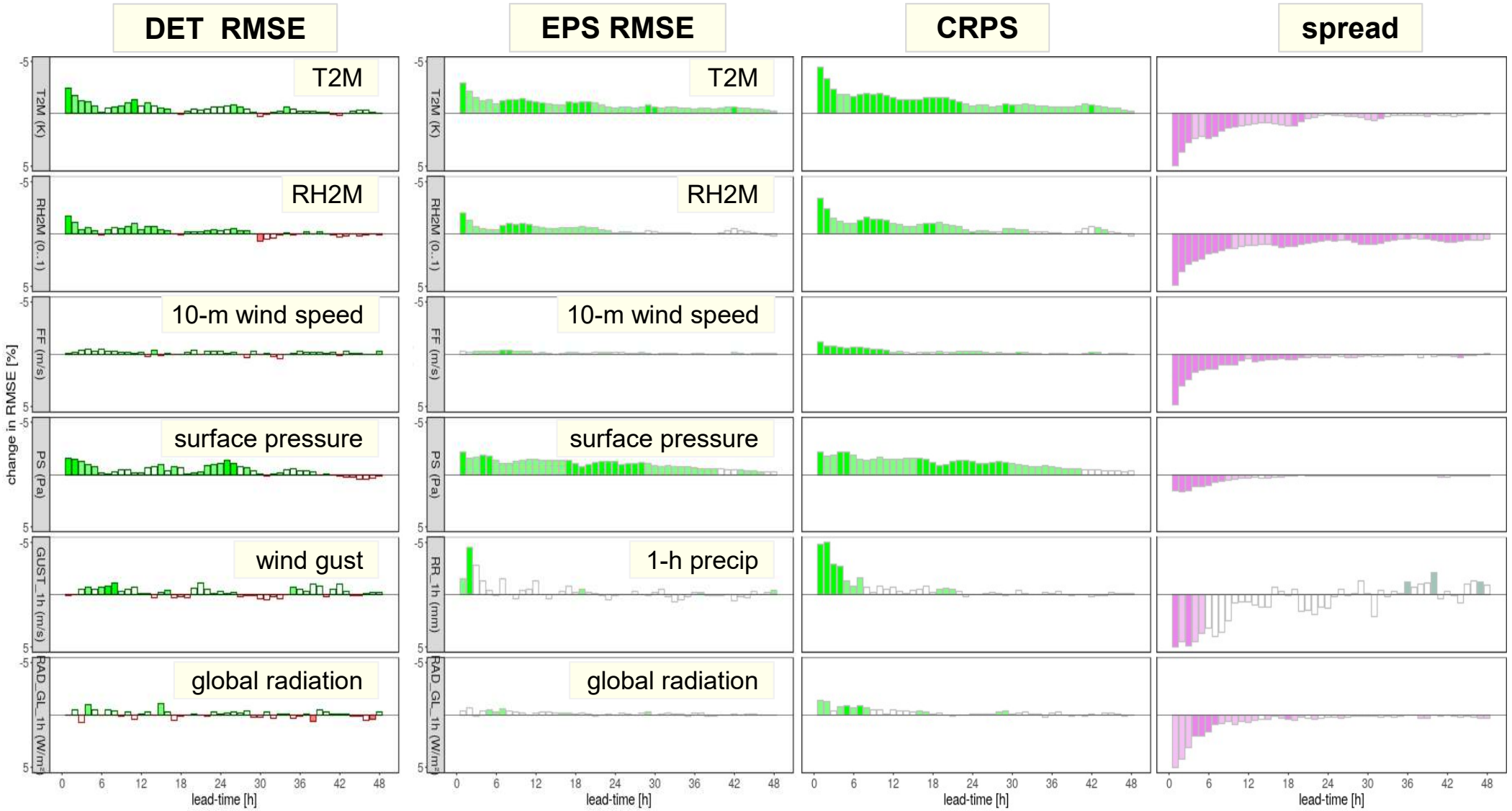
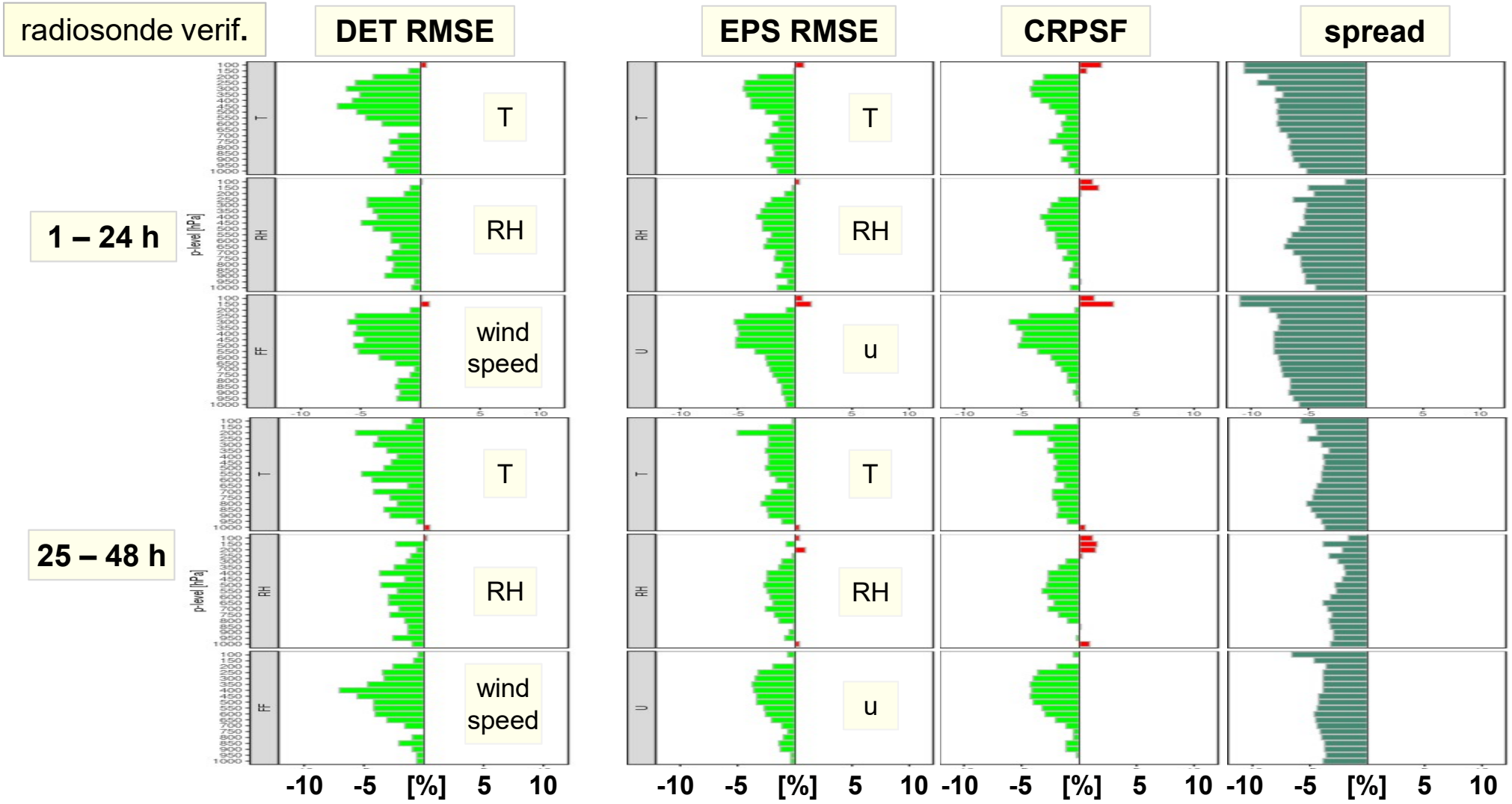
parameter perturbations in DA cycle, parallel suite 21/07 – 22/08/2023, Synop verif.



- positive impact generally similar, up to +48 h

bestu kveðjur til Reykjavíkur

impact of adding **Mode-S in global DA** (operational since May 2023) on ICON-D2 parallel suite April 2023



- very large + long-lasting reduction of errors & CRPS (2 – 6 %; Synop verif 1 – 2 %), of spread (4 – 8 %) & spread / skill ratio (2 – 5 %)