Operational all-sky assimilation of SEVIRI water-vapour radiances in the convection-resolving ICON-D2 of DWD

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Outline

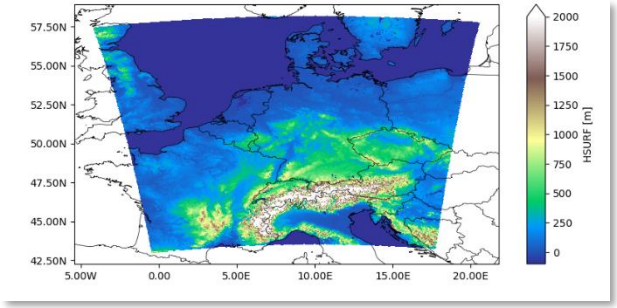
- Overview of DWD high resolution models
- Characteristics of used SEVIRI channels
- All-sky assimilation of SEVIRI visible channel
- All-sky assimilation of SEVIRI water vapour channels
  - Setup
  - Assimilation impact
- Transition to FCI
- Summary & outlook

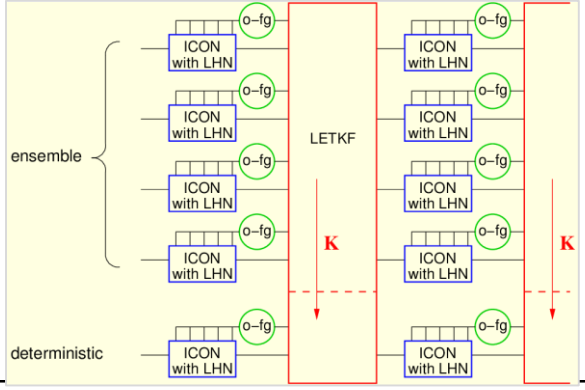
DWD regional limited area models

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

ICON-D2 model & EPS

- ~2.2 km grid spacing, 65 vertical levels
- 72h forecasts: every 3hours, 20 members





ICON-D2 - RUC system

- ~2.2 km grid spacing, 65 vertical levels
- 14h forecasts: every hour, 20 members
- 2-moment physics

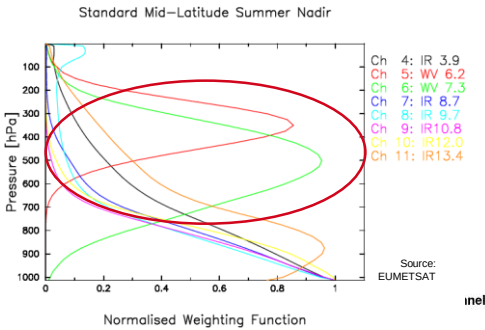
Data assimilation system

- Ensemble Kalman Filter (LETKF);
- 40 members
- Hourly cycling
- **Control vector: includes cloud water & ice**
- Observations:
  - Radiosondes: T, RH, u/v
  - Synop: ps, u/v, T2m, RH2m
  - AIREP, MODE-S
  - Radar 3D-reflectivity & radial winds
  - Radar Latent Heat Nudging
  - Geostationary radiances SEVIRI
    - 0.6 µm (VIS) all-sky
    - 6.2 µm (IR-WV) all-sky
    - 7.3 µm (IR-WV) all-sky

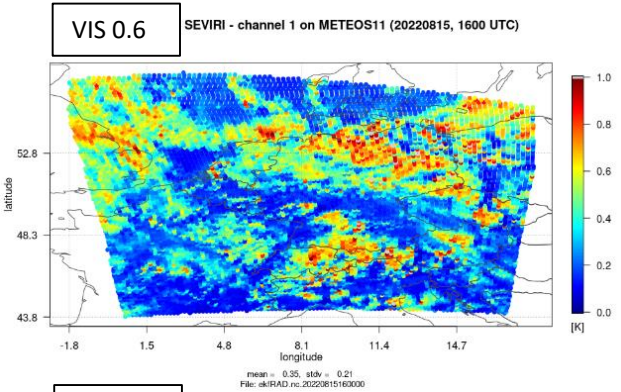
SEVIRI channel characteristics

WV and VIS channels provide complementary information on

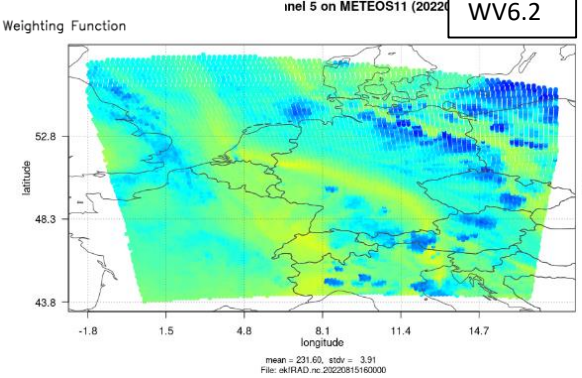
- Humidity profile
- High and low levels clouds



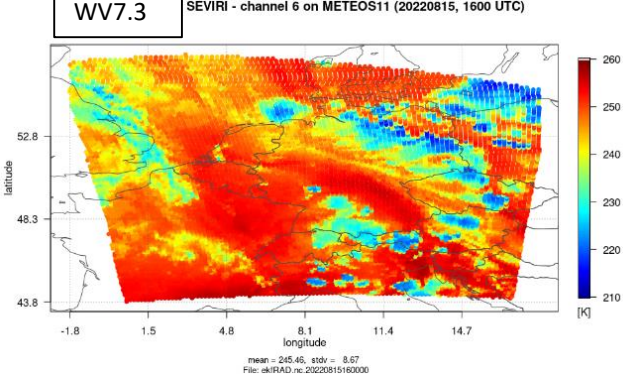
VIS 0.6



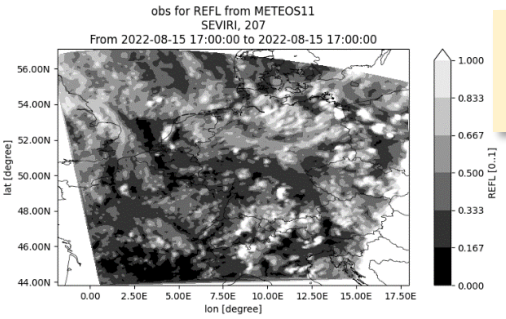
WV6.2



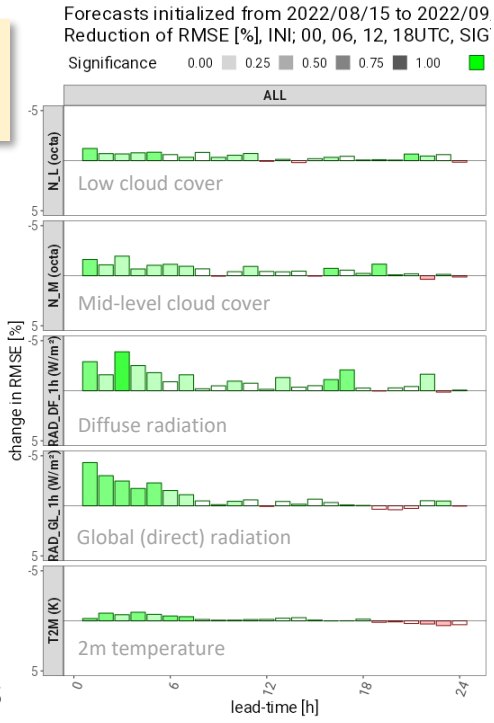
WV7.3



SEVIRI-VIS all-sky assimilation



In ICON-D2 operations since 15 March 2023



- 0.6 µm reflectance; RTTOV-MFASIS v13.2
- Sensitive to
  - Vertically integrated cloud water and cloud ice content
  - Particle size of water droplets, ice cristals
- QC screens out aerosol, snow, mountain areas
- DA settings: see presentation at ITSC-24 (thinning, height assignment, localization, observation error model…)

Improved cloud cover, surface radiation and T2m

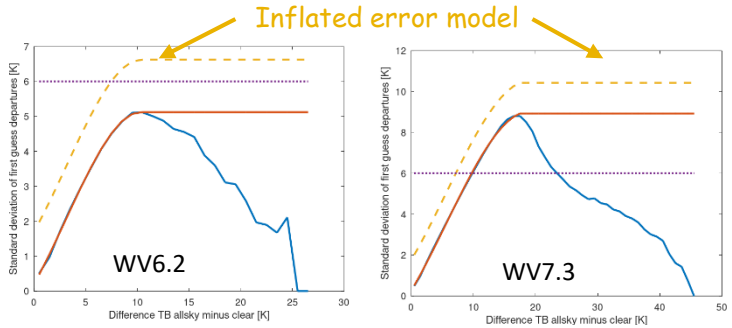
(Liselotte.Bach@dwd.de)

Settings for SEVIRI-WV assimilation

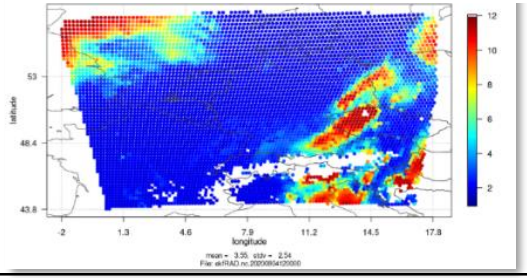
Chosen settings after extensive testing:

In ICON-D2 operations since 29 November 2023

- Height assignment:
  - WV channels: at transmission=0.5
  - VIS channel: 800hPa
- Vertical localization: 0.3 in ln p
- Horizontal localization: 25km
- Thinning to 12km in both directions (4x2 pixels)
- Observation error model:
  - WV: based on cloud impact (Okamoto 2014) with inflation
  - VIS: adaptive observation inflation based on Minamide&Zhang (2017)

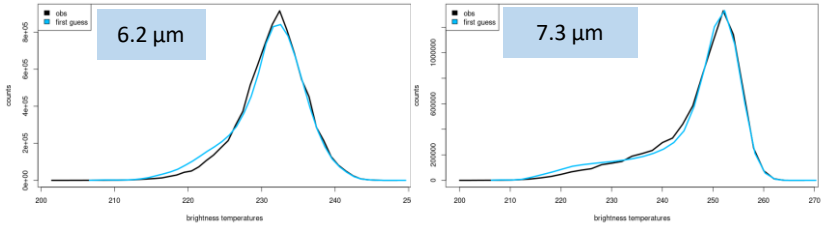


Example of resulting OBS errors (7.3 µm)

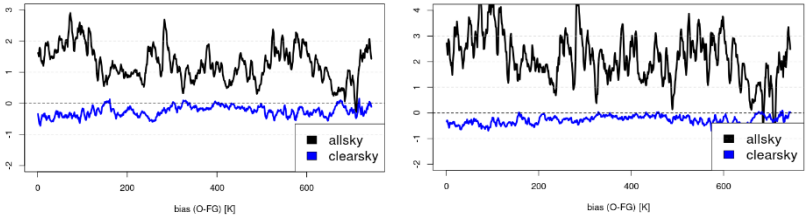


Bias correction

TB distributions



Bias time series of OBS-FG



Testing of predictor-based bias correction correction ongoing with transition to FCI

Histograms of OBS and FG

- generally match very well
- show overestimation of cold TBs in FG

Timeseries OBS-FG

- clear-sky bias varying between zero and small negative values

Test with constant bias correction:

- positive impact on FG
- but mixed results in forecasts

➢ currently no bias correction applied

Assimilation: Evaluation of OBS-FG

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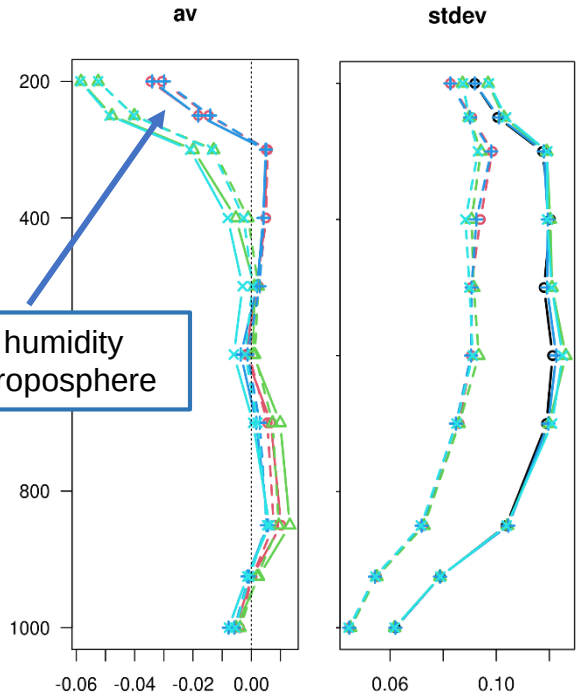
Verification OBS-FG, OBS-AN
radiosonde relative humidity

Experiment: 4 weeks (summer 2022)

NO SAT (cntl)
VIS only
WV only
VIS + WV



reduced moist humidity
bias in upper troposphere

improved
stdv(OBS-FG)

FG : solid
ANA: dashed

Forecast impact: Upper air verification

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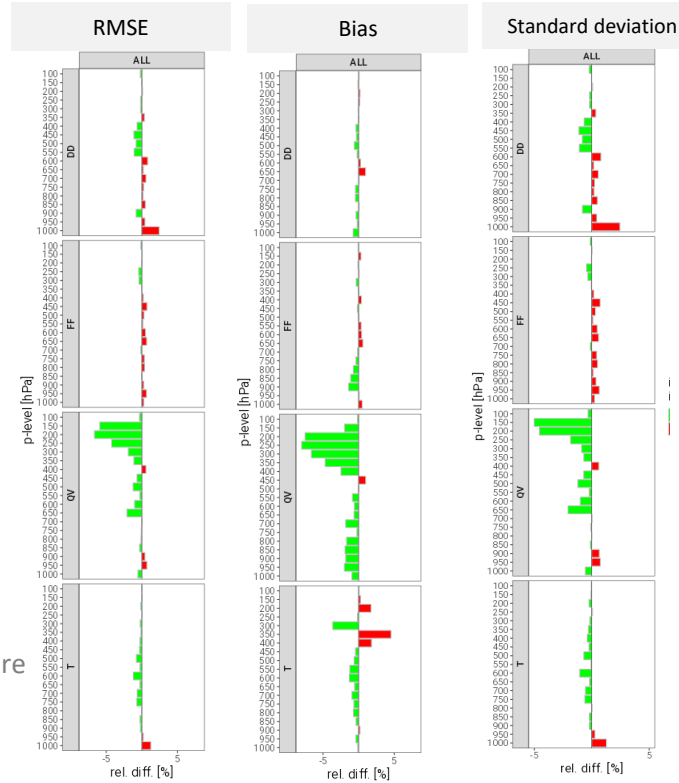
Wetter und Klima aus einer Hand

Experiment: 4 weeks (summer 2022)



Wind direction

Wind speed

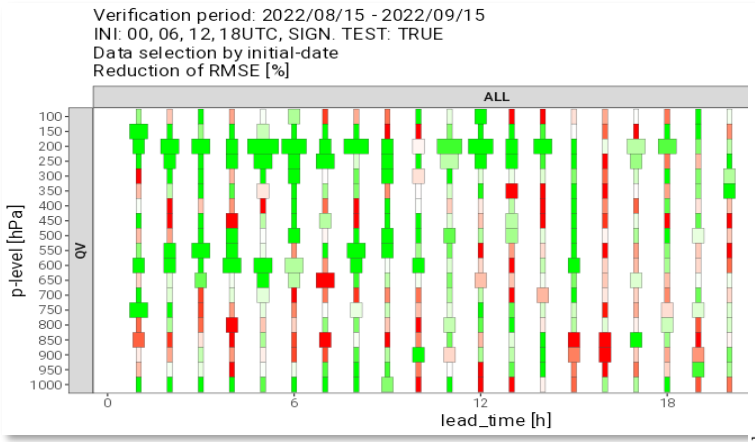
Specific humidity

Temperature

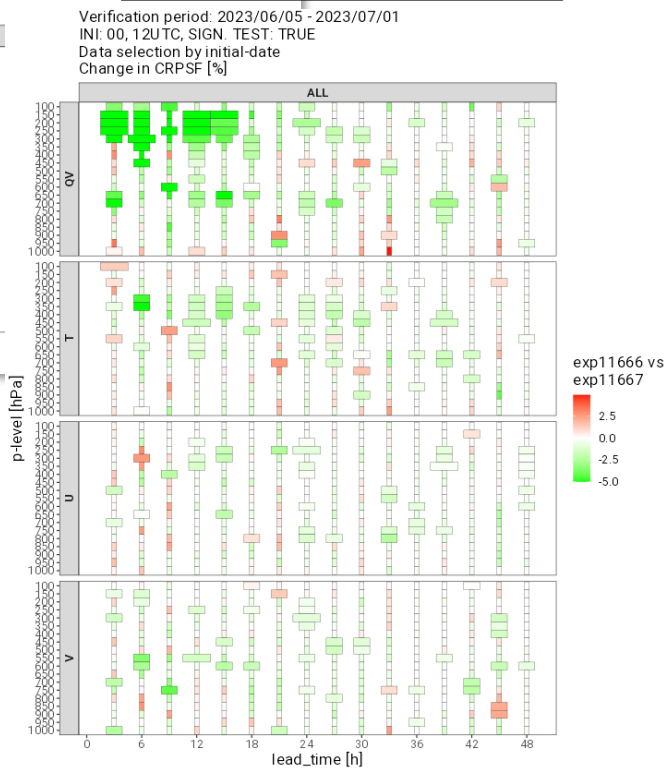
Impact of SEVIRI WV all-sky relative to reference using SEVIRI VIS

green: WV all-sky better
red: WV all-sky worse

Forecast impact: 0 - 24h vs radiosondes



Impact on ensemble



- Positive forecast impact on humidity lasts for more than 12-15 hours
- Positive forecast impact on humidity also in ensemble CRPSF

Impact on clouds and surface variables

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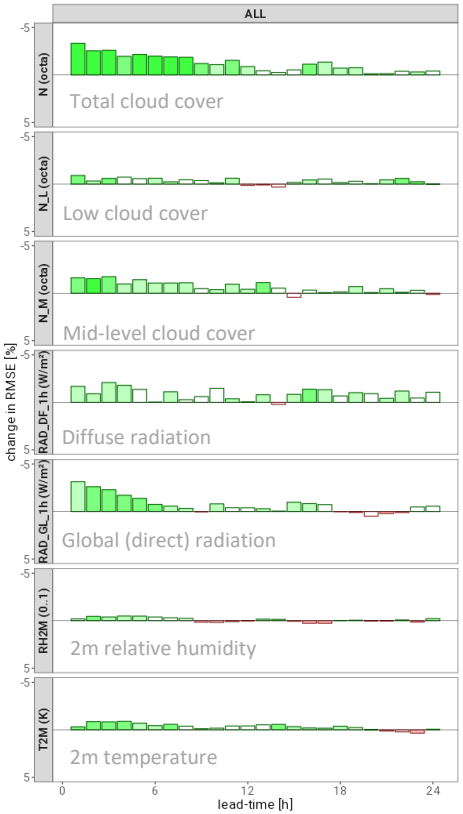
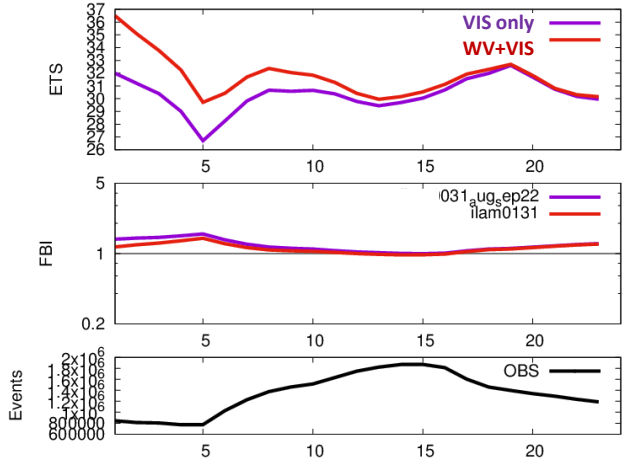
Wetter und Klima aus einer Hand

Verification vs SYNOPs



- "VIS+WV" experiment versus "VIS only" (4 weeks, summer 2022)

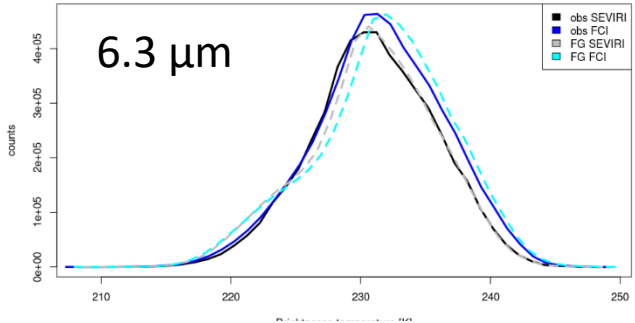
Verification vs NWC SAF high clouds

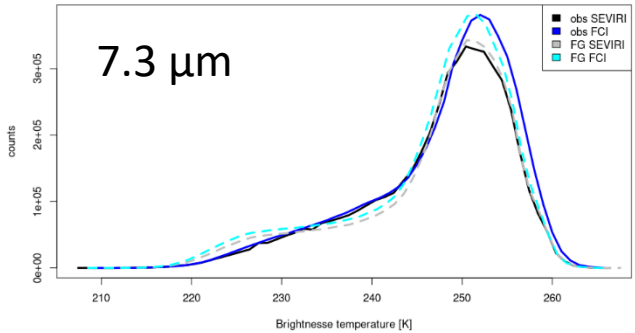


- *Cloud cover improved for 12-18 hours, esp. for high and mid-levels clouds*
- *Improvement in radiation, T2m*

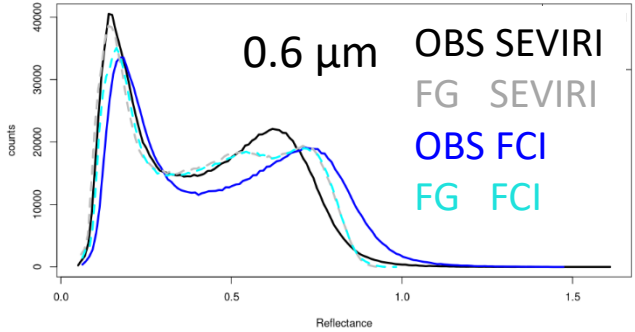
Transition to FCI / MTG

Brightness temperatures





Reflectances

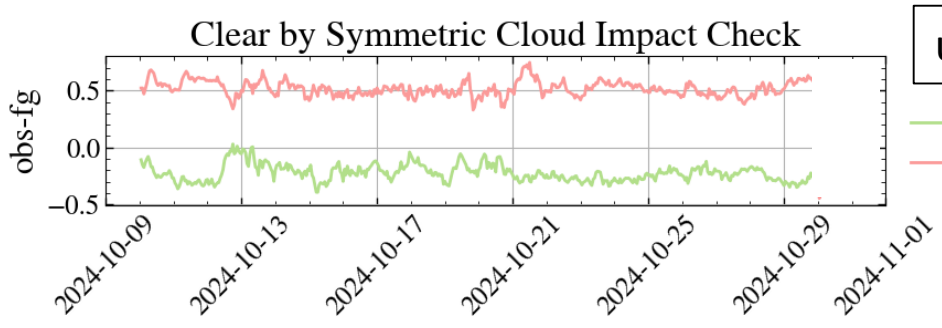


Differences in fit of OBS and FG:

- Larger clear-sky biases, esp. for WV channels
- Changes in reflectance histogram

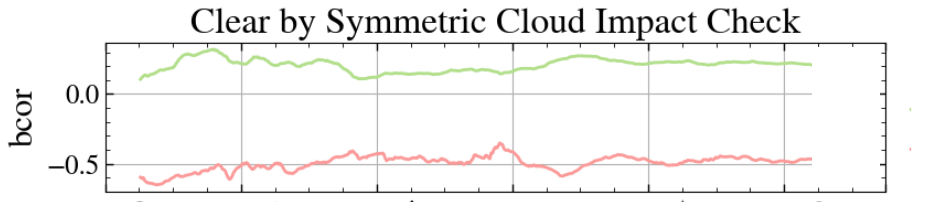
- Differences in SRF between SEVIRI and FCI
- Resolution difference

Online bias correction for FCI

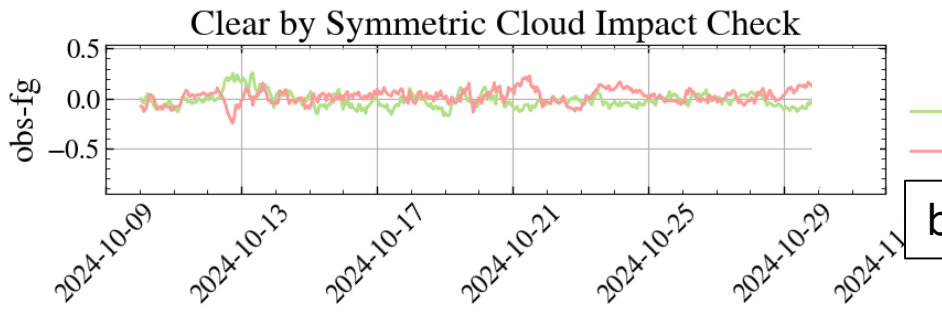


uncorrected OBS-FG

WV6.2
WV7.3



Predictor based bias correction computed for clear-sky scenes



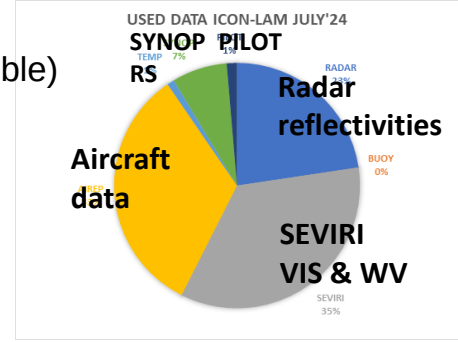
WV6.2
WV7.3

bias corrected OBS-FG

Summary & outlook

- Operational all-sky assimilation of SEVIRI : 0.6 µm, 6.2 µm, 7.3 µm
  - since 2023 in convection-resolving IDON-D2 and RUC systems
  - used now for regional reanalysis (data set for AI model training)

- Positive forecast impact for 15-18h (deterministic & ensemble)
  - tropospheric moisture & cloud cover
  - radiative fluxes and surface temperature
- Precipitation shows only very little sensitivity to SEVIRI all-sky radiance/reflectance assimilation



- Ongoing work: Assimilation trials for transition to FCI and bias correction
  Refinement of observation error model
- Next step: Extension of visible assimilation to additional frequencies

- Preparation for IRS in clear-sky mode ongoing

Thank you for your attention!