Developments in satellite radiance assimilation at DWD since ITSC-22

Christina Köpken-Watts, Robin Faulwetter, Olaf Stiller, Anne Walter,
Michael Bender, Silke May, Annika Schomburg, Liselotte Bach,
Thomas Deppisch, Christina Stumpf, Leonhard Scheck,
Christoph Schraff, Roland Potthast

Deutscher Wetterdienst (DWD)
Germany

Christina.Koepken-Watts@dwd.de

Outline

- Global ICON / EnVar
  - Overview of operational upgrades since ITSC - 22
  - Upcoming upgrades
  - Current developments

- High-resolution ICON-LAM / LETKF
  - Overview of operational upgrades since ITSC - 22
  - All-sky developments
    - Visible reflectances
    - IR

- Challenges

Deterministic ICON:
@ 13 km Global
@ 6.5 km Europe
(two-way nesting)

+ ICON-Ensemble:
40 members @ 40/20km

Global ICON / EnVar

Christina.Koepken-Watts@dwd.de

Global ICON / EnVar: Operational upgrades

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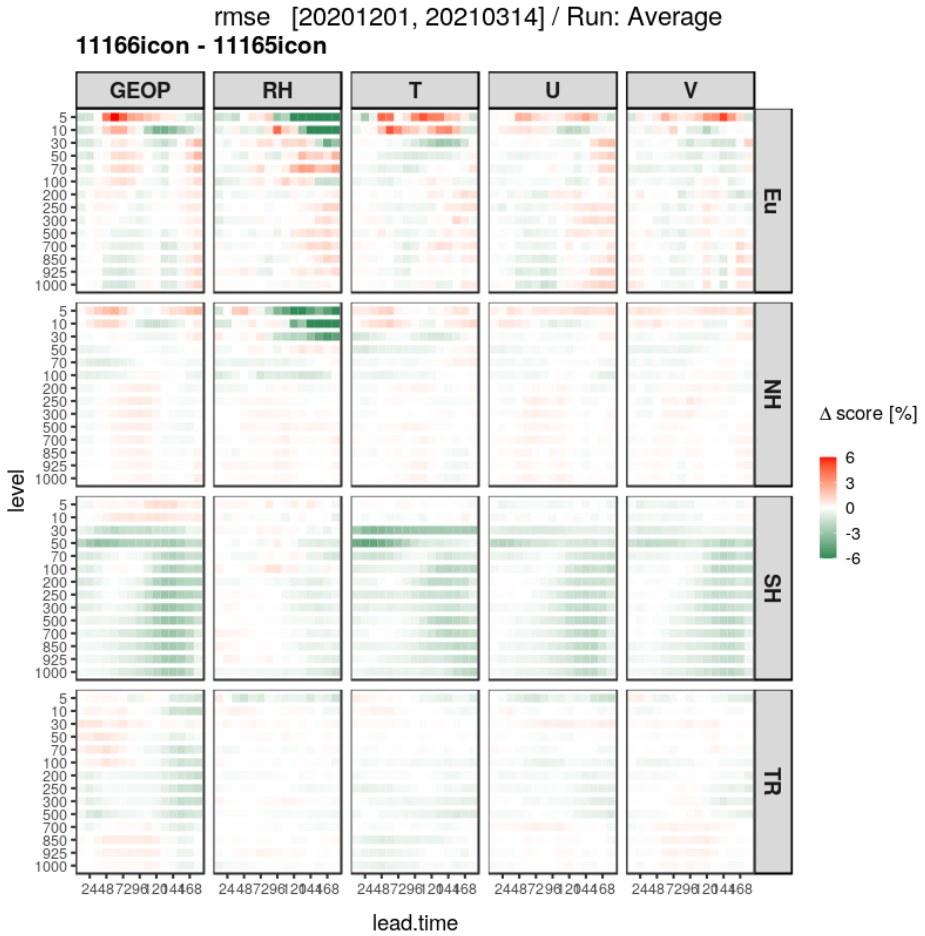
- Oct 2019 SSMI/S WV channels over land
  Tuning update of IASI error covariances
- Feb 2020 Assimilation of SAPHIR WV channels
- April 2020 GNSS-RO ZTD
- May 2020 Aeolus HLOS winds (Mie and Rayleigh)
- June 2020 GOES-17 ABI, WV channels
  SEVIRI CSR: move to ASR product
  RS descent data
- Sep 2020 **Migration to NEC vector computer (**ICON, ICON-EPS, ICON-ART)
- Sep 2020 Additional RO data (COSMIC-2, FY-3D, KOMPSAT-5, PAZ)

- April 2021 **ICON upgrade: ecRad radiation**, CAMEL emissivity, glacier snow albedo
  Sahara dust properties; overall model & radiance bias retuning
- June 2021 GOES-CSR, change to EUMETCast data and ASR product

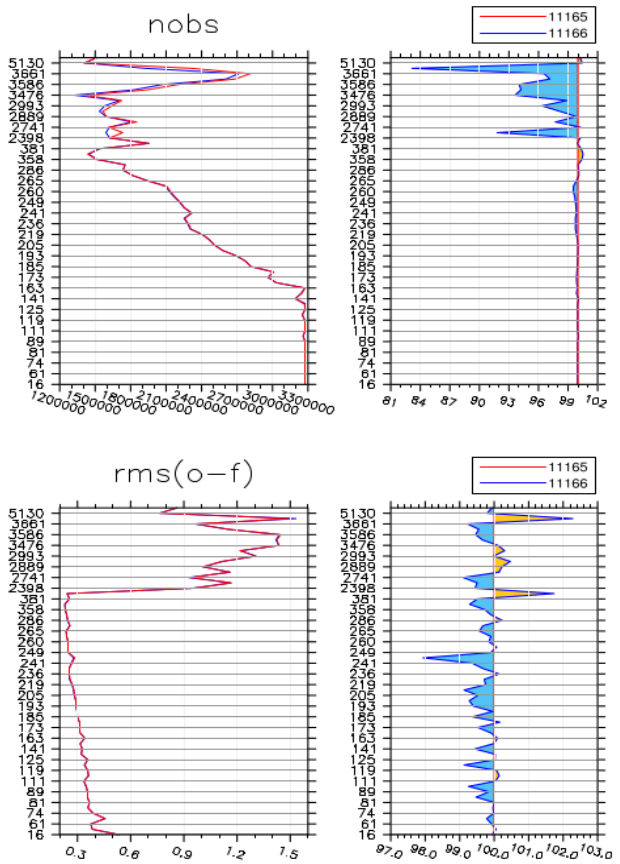
Global ICON / EnVar: Upcoming upgrades

(1) RTTOV – 13 & new coefficients (LBLRTM 12.8, v13 predictors, 54L)

- RTTOV – 13 implemented & optimized (NEC)
- Experiments ongoing (Nov 2020 – March 2021)



OBS-FG statistics: IASI
relative change vs control



Control:
- RTTOV-12, v7 predictors, 54L

Impact:
- SH positive
- NH overall neutral
- TR neutral to positive
- OBS-FG fits neutral to positive

But also:
- Reduction in number of used IASI WV channels
- Larger changes in GOES WV -> investigation ongoing

Further tuning ongoing
- Special bias correction inialization setup

Global ICON / EnVar: Upcoming upgrades

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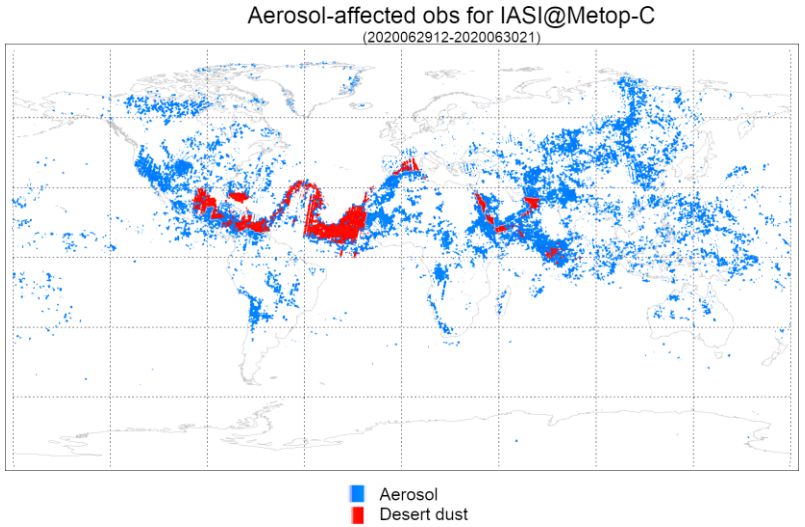
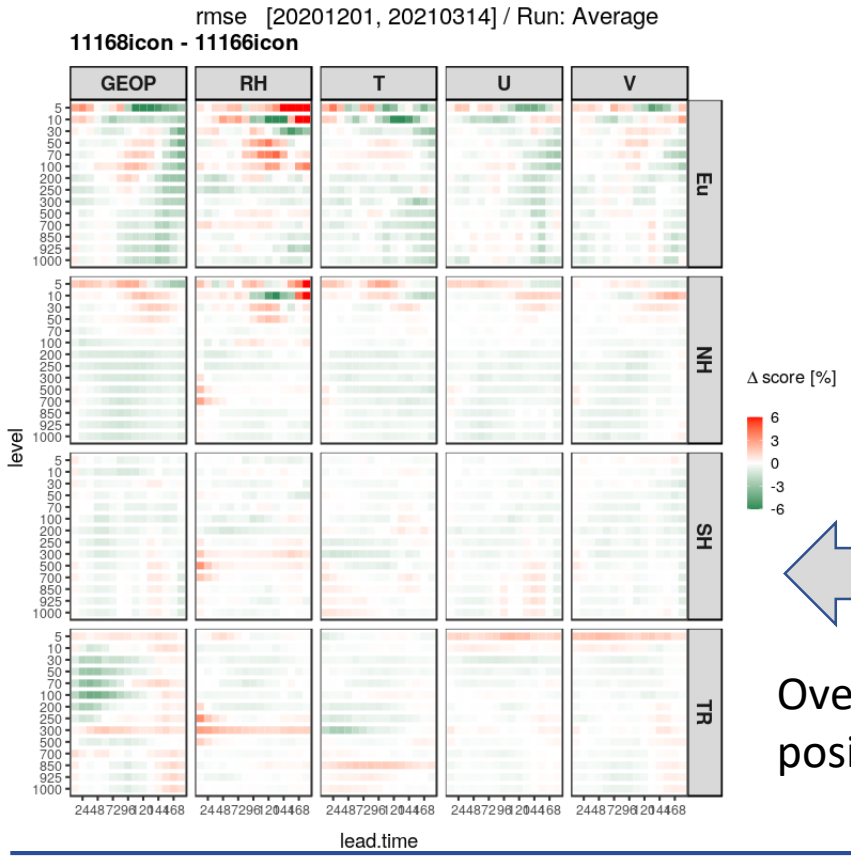
(2) Update of hyperspectral IR cloud + aerosol detection:

- CADS v3 implemented + tested





(3) Update to assimilation of MW humidity channels @183 GHz

a. Addition of MWHS-2

b. Retuned QC → improved data coverage

c. Constrained bias correction for 183 ± 1, ±3 GHz

Overall positive impact

Global ICON / EnVar: Current developments

- Implementation of all-sky RT:
  - Code adaptations to generalize DA - code
  - Followed by RTTOV-SCATT implementation

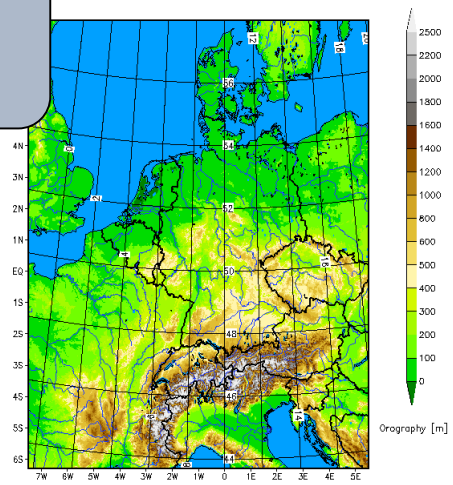
- Data over land:
  - Low peaking MW channels (land, snow, ice)

- Hyperspectral sounders
  - CrIS, preparation for IRS starting

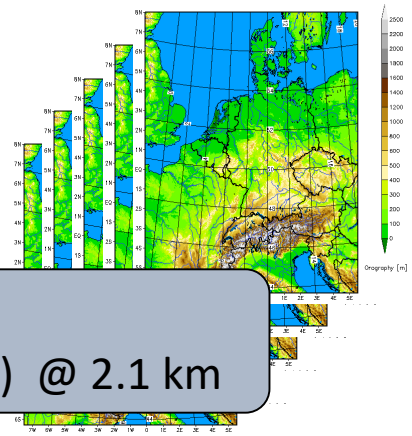
- Improvement of RT setup and biases:
  - Use of up-to-date O_3 and CO_2 – profiles

- Improved understanding of ensemble system impacts
  - Ensemble - FSOI statistics (poster 1p.16, O. Stiller)

ICON – D2
deterministic
@ 2.1 km



High-resolution ICON-LAM / LETKF



+ ICON – D2 ensemble
40/20 members (DA/FCST) @ 2.1 km

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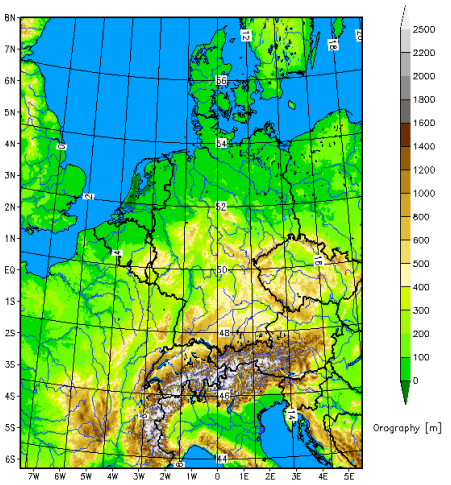
ICON-LAM / LETKF: Upgrades & developments

- March 2020 Radar 3D-radial velocities
- June 2020 Radar 3D-reflectivities (forward operator EMVORADO)
- Sep 2020 **Migration to NEC vector computer**
- Feb 2021 **ICON-LAM replaces COSMO** (ICON-D2, ICON-D2-EPS)
- April 2021 **ecRad**, CAMEL surface emissivity etc. (as in ICON)

- May 2021 Start of pre-operations for **SINFONY - RUC NWP**
  - part of new merged NWC + RUC NWP forecasting
  - 1h assimilation cycle, hourly forecasts up to 12h



Current satellite developments for SINFONY & ICON - LAM:

- Preparation of VIS reflectance assimilation for pre-operational setup
- Testing of IR all-sky assimilation
- Key focus: improved very short-range forecasts of:
  - Cloud cover, cloud position, optical thickness
  - Radiation, 2m – variables
  - Precipitation

ICON – LAM: Assimilation of visible reflectances

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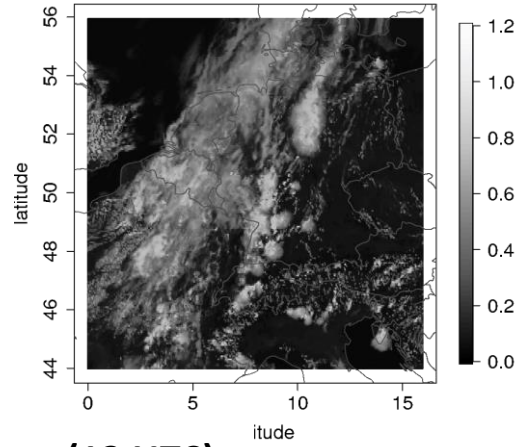
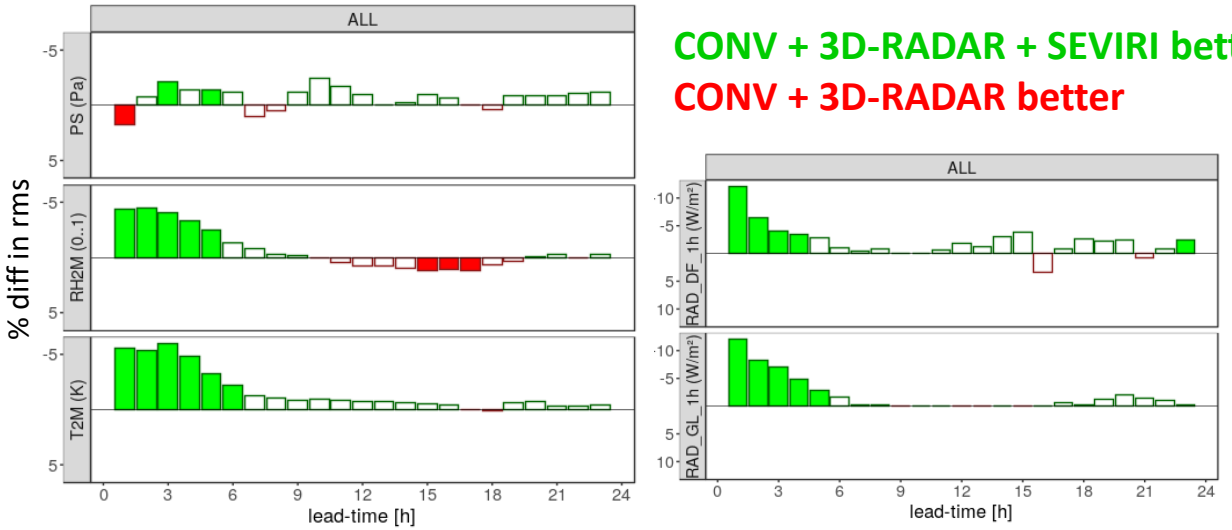
Ensemble experiment: 2 – 30 August 2020

- Uses MFASIS (RTTOV) operator
- Control: Conventional data, radar (radial winds + 3D reflectivities) + LHN
- Exp: Control + SEVIRI VIS (6-17 UTC)

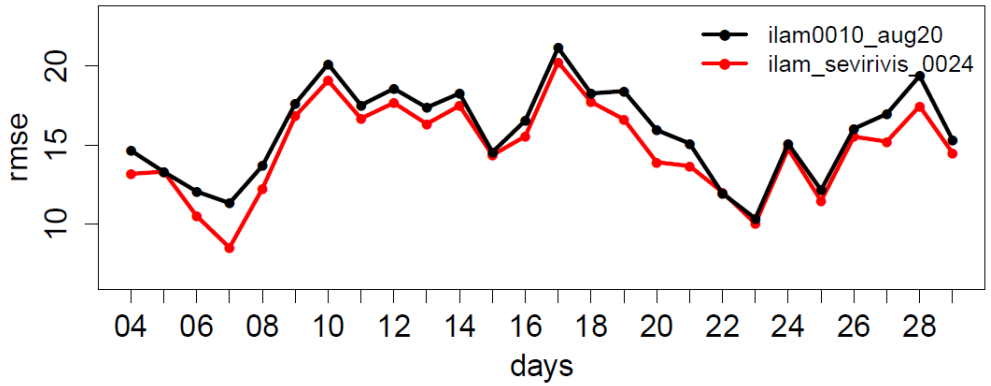




CONV + 3D-RADAR + SEVIRI better

CONV + 3D-RADAR better

RMS (OBS – FG) for SEVIRI 10.8 µm (12 UTC)



- Assimilation of reflectance improves forecasts of clouds, radiation, precipitation, T2m, RH2m for 6 – 10 h forecasts
- Upper air verification neutral to slightly positive

➢ Setup in preparation for inclusion into SINFONY – RUC pre-operational phase, development of bias correction

→ for more details see poster 2p.01, L. Bach + T. Deppisch (for MFASIS developments: presentation 2.05, L. Scheck)

Model evaluation & tuning using VIS and IR

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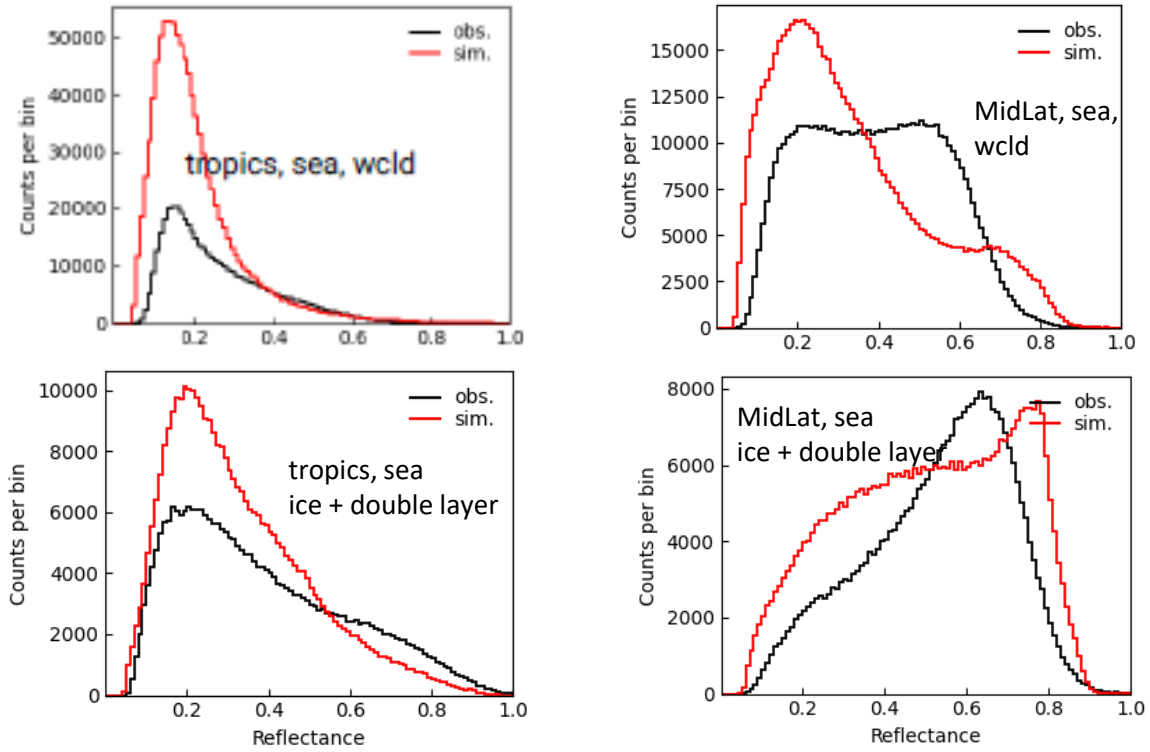
Aim:

- Consistency between model and RT assumptions and parameters
- Minimize biases
- Better understand characteristics of differences to set up bias correction and OBS errors

Example 1: ICON global
Ongoing evaluation with
SEVIRI - VIS reflectances



Example for stratification of satistics

also looking at

- symmetric sampling
- geometry
- use of IR + VIS
- ....
- See also poster 3p.16, C. Stumpf

Christina.Koepken-Watts@dwd.de

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Aim:

- Consistency between model and RT assumptions and parameters
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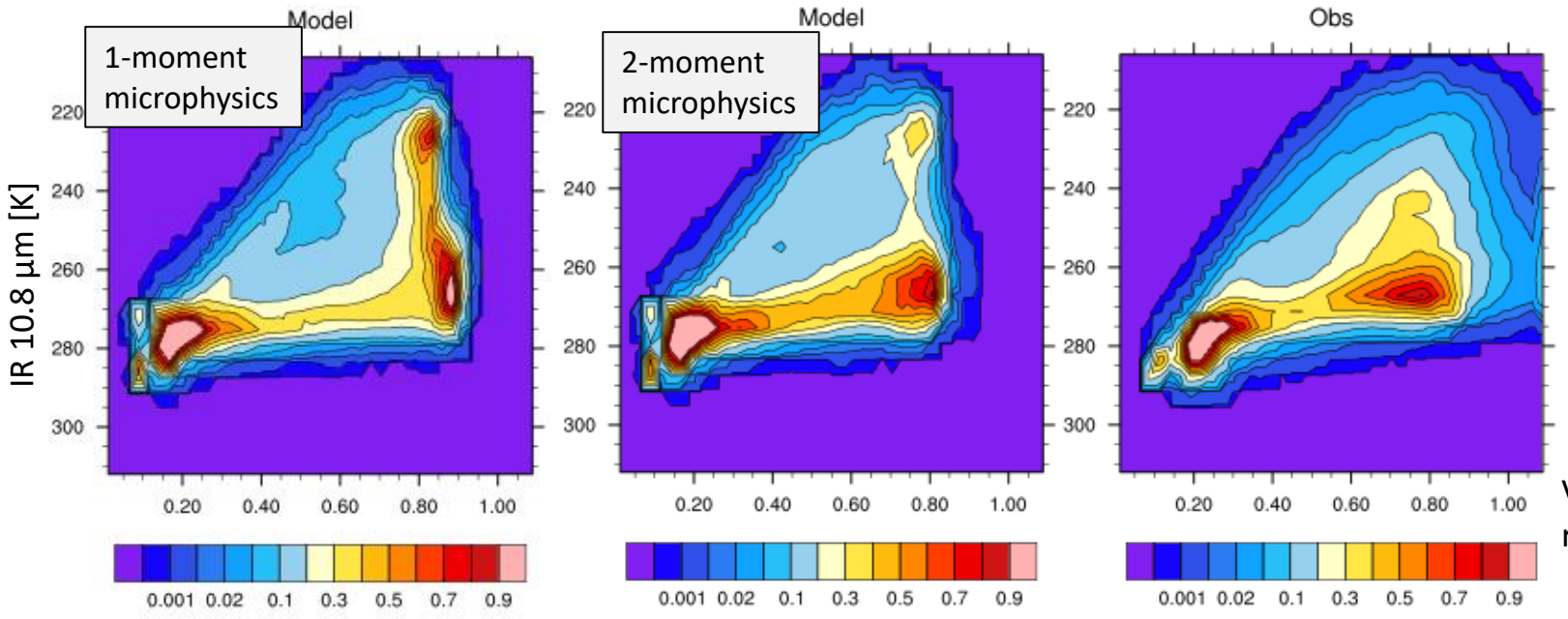
Example 2: ICON - LAM
Comparison of 1- and 2-moment cloud microphysics to SEVIRI - VIS and IR observations

(Jan 2019, detailed tuning still to be done)



Courtesy:
Vera Maurer
Alberto de Lozar

ICON – LAM: IR all-sky assimilation

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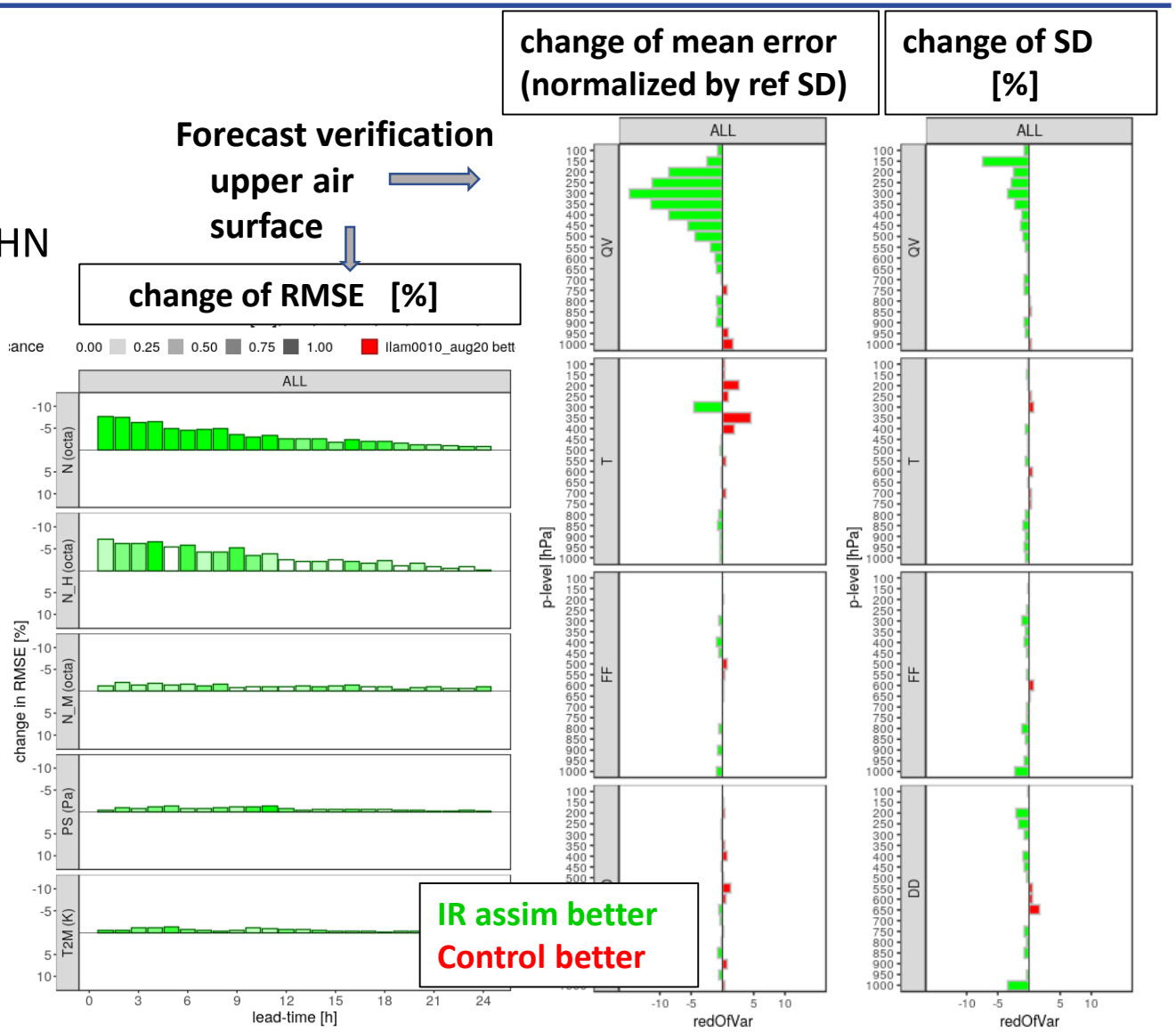
Ensemble experiment: 3 - 26 August 2020

- All-sky assimilation of: SEVIRI 6.25 µm, 7.35 µm
- Control: conventional data,
  radar (radial winds + 3D reflectivities) + LHN
- Exp: Control + WV channels (every 4th pixel)
  simple OBS error (σ_{OBS} = 6 K)
  → focus on cloud signal



- Very positive impact in LETKF on clouds and humidity
  neutral for other parameters

- Ongoing work:
- Tuning of the implemented OBS error model (as function of symmetric cloud impact parameter)
- Combination with VIS assimilation

Christina.Koepken-Watts@dwd.de

Challenges

(1) All-sky assimilation
- Analysis of cloud parameters (esp. convective scale NWP)
- Consistency between model physics & forward model
- Use of model physics variables (cloud parameters, r_{eff} (2-moment scheme), cloud inhomogeneity)

(2) Biases
- Bias tuning (esp. following major model & data usage changes)
- Use of setup with reduced satellite data to allow efficient anchorage with other data
- Bias correction for cloudy radiances & reflectances

(3) Technical & DA aspects:
- Slant path, satellite footprint / model averaging (high-resolution NWP)
- Horizontal error correlations

(4) Improved assimilation over land, ice, snow
- Emissivity, Tskin issues
- Improved model background values

(5) Implementation of all available & preparation for future instruments
- Limited by number of staff