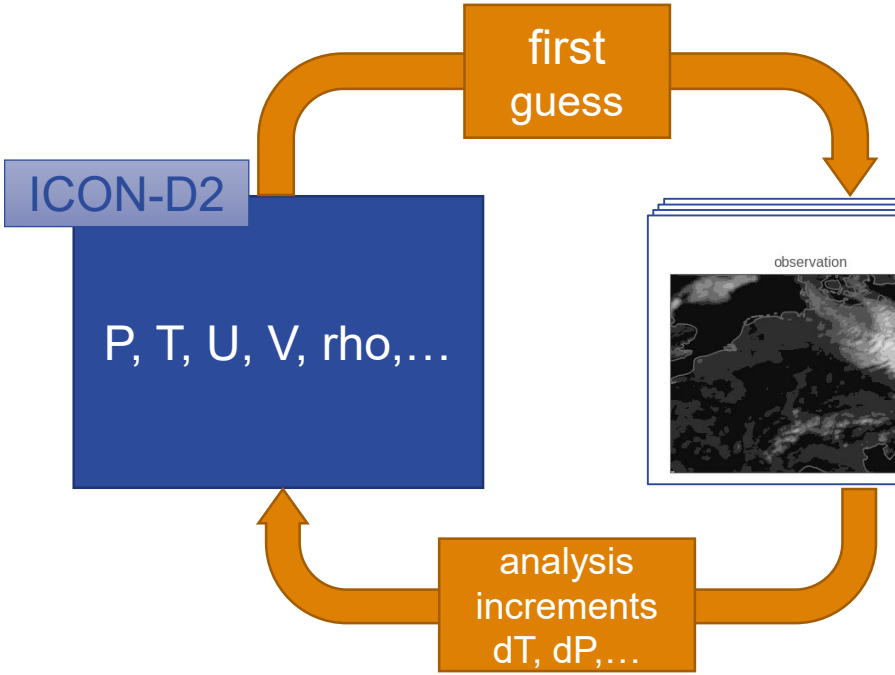
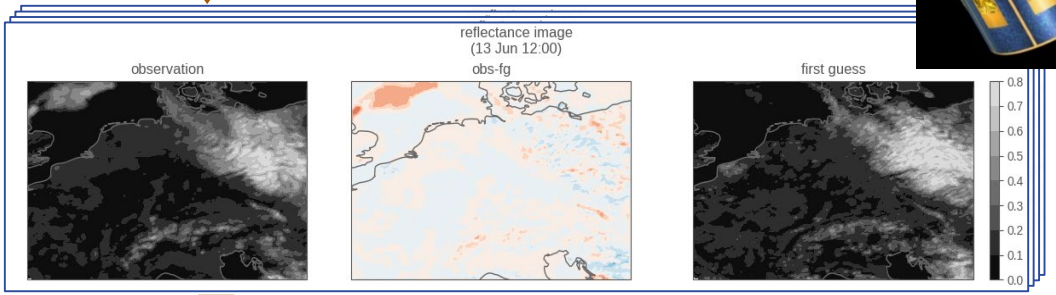
Studying the Interaction between NWP Models and Data Assimilation with **O**bserving **S**ystem **S**imulation **E**xperiments

Thomas Deppisch, Lilo Bach, Annika Schomburg,
Christoph Schraff, Christina Köpken-Watts

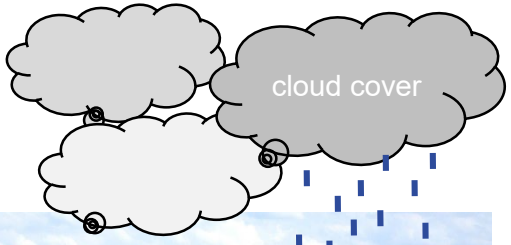
assimilating SEVIRI data

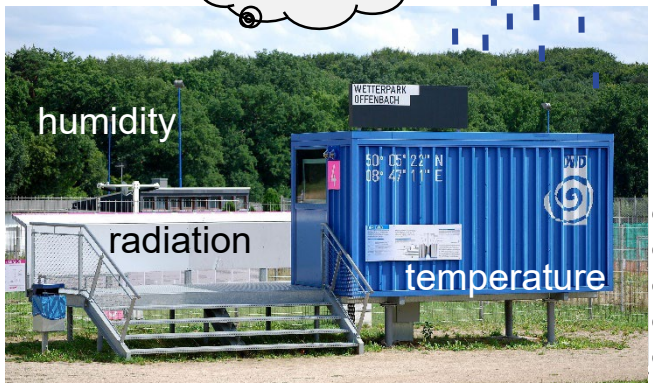




- DA cycle for the regional model (ICON-LAM @ 2.1 km): LETKF step every hour
  - increments of T, U, V, P, QV, QC
- operational: conventional, 3d radar reflectivities and radial winds, latent heat nudging, (all-sky SEVIRI VIS / WV)
- Do we get plausible increments from observations? (→ ensemble correlations)

SEVIRI VIS vs. model biases





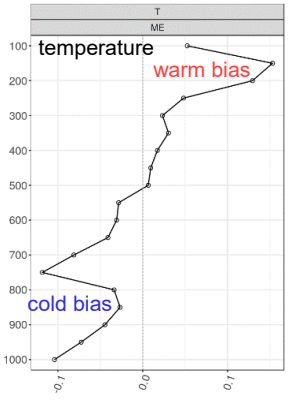
known *features* of ICON-D2

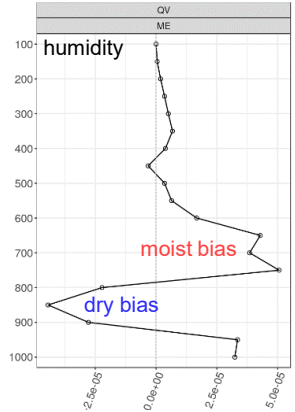
- ➔ clouds are optically too thick
- ➔ dry bias around boundary layer
- ➔ cold + moist bias at the ground

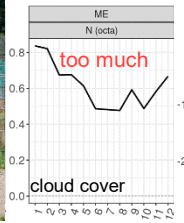
DA experiments with SEVIRI VIS

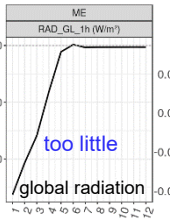
- ➔ reduces some bias
- ➔ degrades precipitation forecasts
- ➔ solution: model adjustments (sub-grid scale clouds)

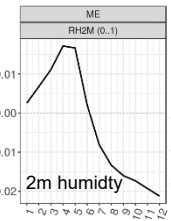
operational verification
forecast started at 12 UTC
September 2022

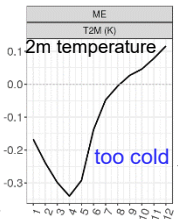


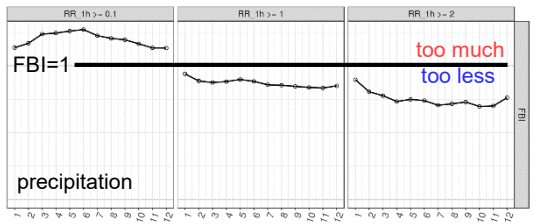




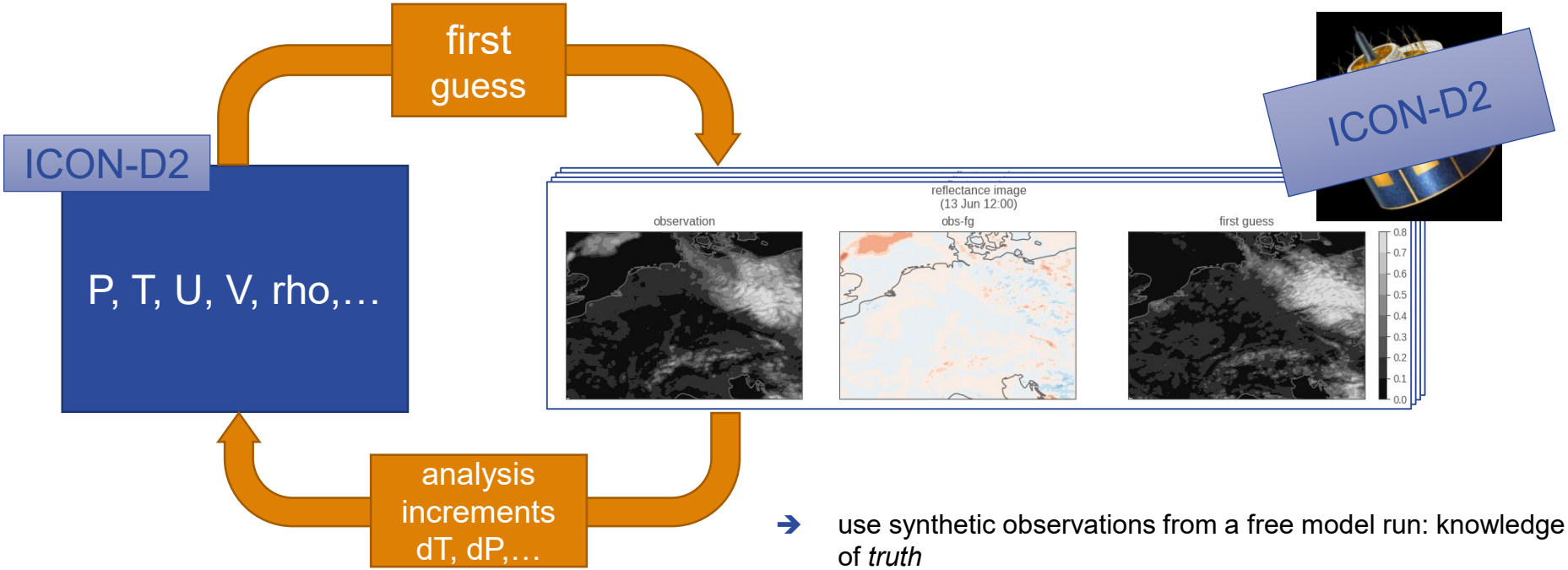






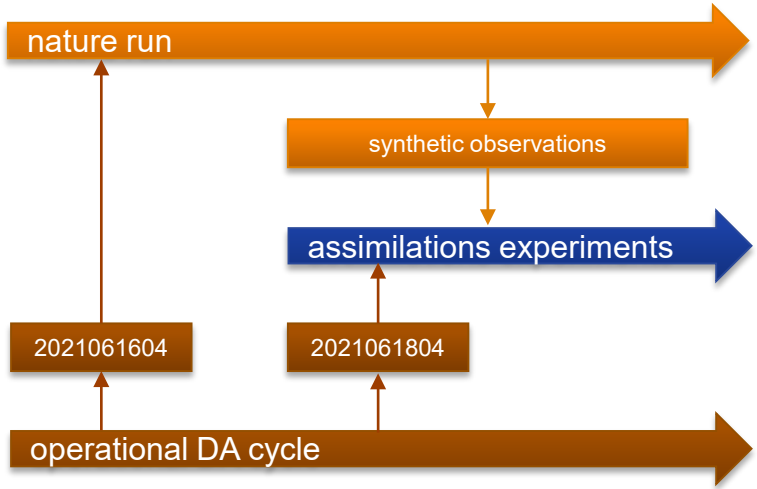


using OSSEs as a sandbox



- ➔ use synthetic observations from a free model run: knowledge of *truth*
- ➔ allows for verification in model space + observation space
- ➔ goal: reproduce observed biases in a controlled environment

case study: 18th June 25th June 2021



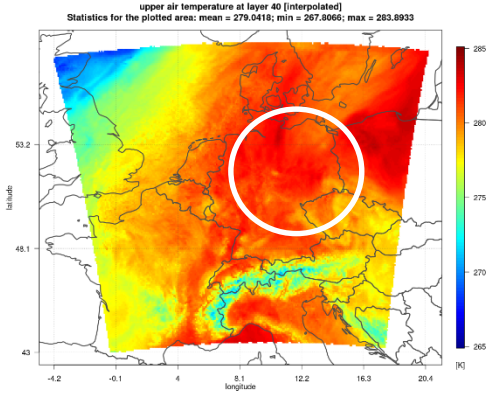
- initial conditions
  - different for nature run and assimilation experiments
- boundary conditions: ICON-EU
  - same for nature run und assimilation experiments
- observational data:
  - 3d radar reflectivities and radial winds (EMVORADO)
  - latent heat nudging (LHN, precipitation fields from nature run)
  - conventional data (radio sondes, SYNOP stations, air planes,…)
  - SEVIRI: VIS, WV (RTTOV/MFASIS)
- "perfect model" and "(almost) perfect observations" make a perfect forecast?!

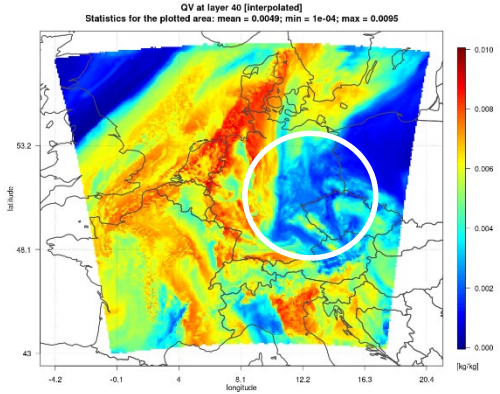
work in progress

initial conditions

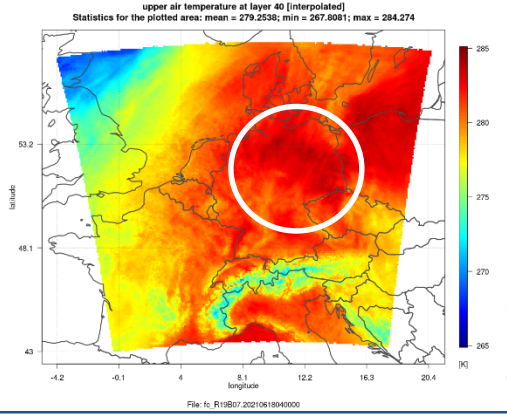
model layer 40:
~710 hPa

nature run

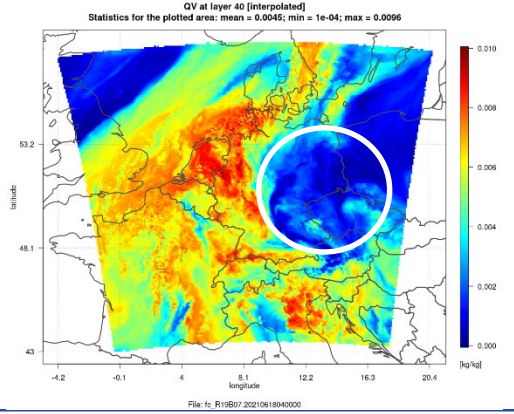




assimilation

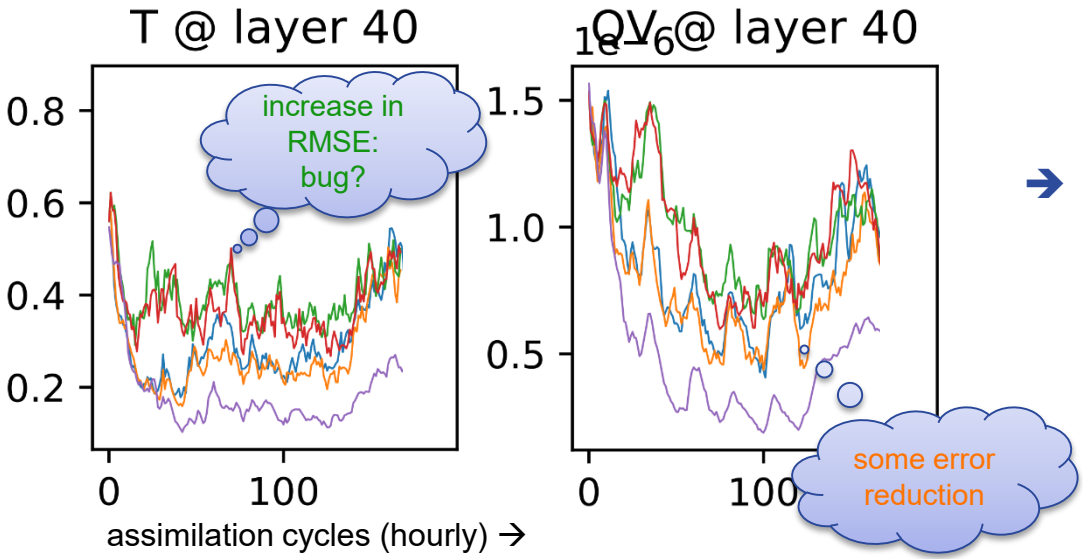


temperature:
~0.2 K warmer
than nature run



humidity:
dryer than nature run

temperature and humidity

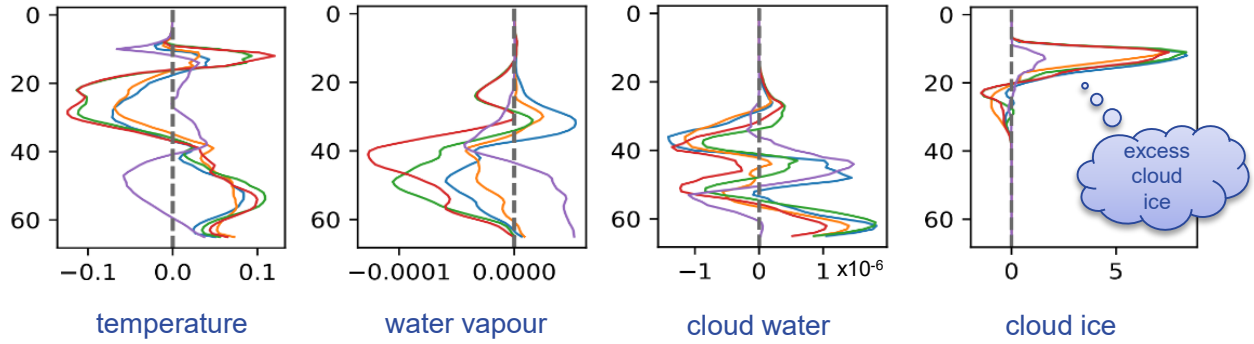


- left: RMSE of humidity (QV) and temperature (T) of first guess fields compared to the nature run at model layer 40 (~710 hPa)
- experiments:
  - operational
  - operational+VIS
  - operational+WV
  - operational+VIS+WV
  - control (no assimilation)

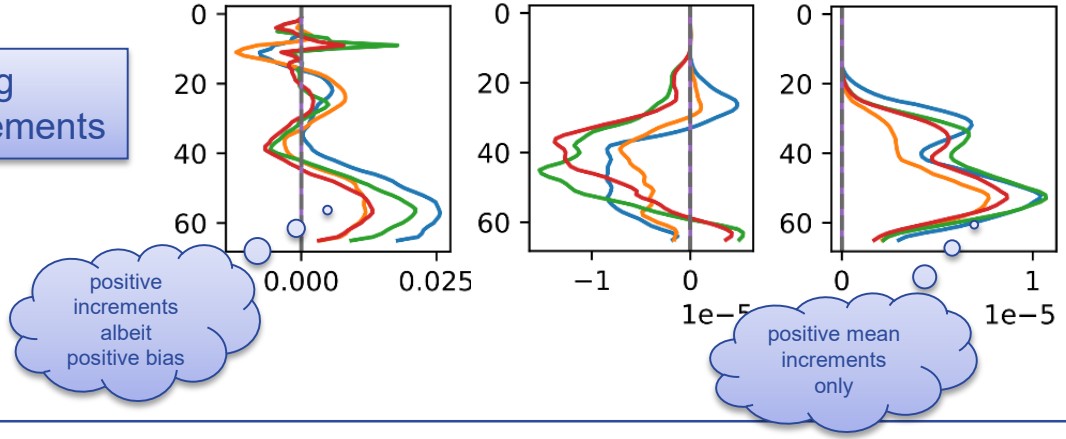
model profiles vs. analysis increments

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

average deviation of the model profiles from the nature run



corresponding analysis increments

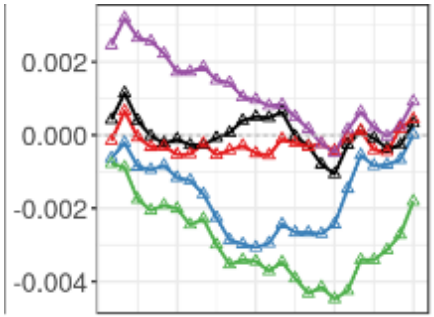


operational
operational+VIS
operational+WV
operational+VIS+WV
control (no assimilation)

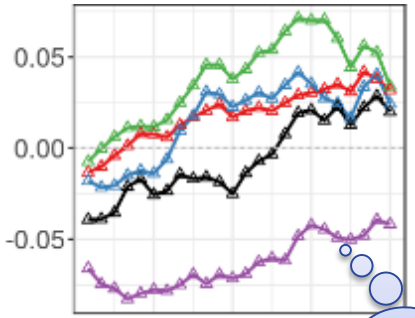
forecast verification: SYNOP / radio sondes

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

2m humidity bias



2m temperature bias

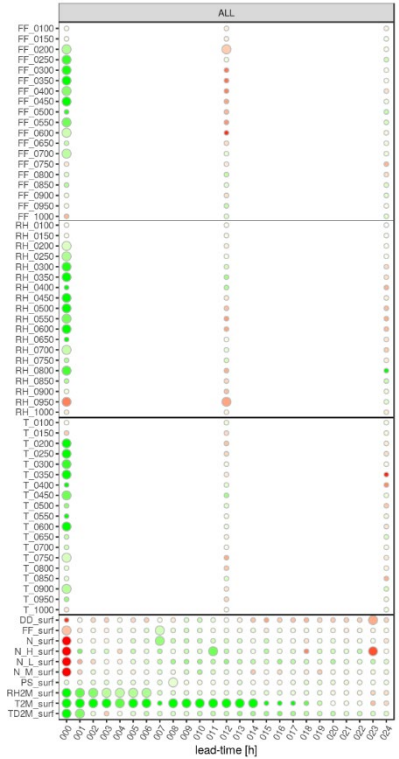


lead time (24 h) →

all forecasts become warmer over time

- above: forecast verification against (synthetic) SYNOP stations
  - operational
  - operational+VIS
  - operational+WV
  - operational+VIS+WV
  - control (no assimilation)

- right: reduction of RMSE (<15%) against (synthetic) radio sonde observations:
  operational system better
  control run better



summary and outlook

OSSES as new part of our development tool box

- ➔ The interplay of model physics and data assimilation can be investigated in a controlled environment.
- ➔ OSSEs allow to verify against model fields: new insights in the context of indirect observations (radar data / all-sky satellite data).
- ➔ The interpretation may not be straight forward.

results so far

- ➔ Excess of high ice clouds in the model may be due to radar data assimilation.
- ➔ Additional assimilation of visible SEVIRI data has a mostly positive impact compared to the operational setup (perfect forward operator and perfect model physics).

plans for the future

- ➔ further investigations on satellite data (SEVIRI WV)
- ➔ experiments with two-moment microphysics
- ➔ comparison to experiments with real data
- ➔ impact studies for European radar stations
- ➔ collaboration with universities (Munich, Cologne)