# Assimilation of 3D radar information at convective scales at Deutscher Wetterdienst (DWD)

## 9th International Symposium on Data Assimilation (ISDA)

## 16-20 Oct 2023

**Kobra Khosravian,** Klaus Stephan, Alberto De Lozar, Lisa Neef, Jana Mendrok, Yuefei Zeng, Sven Ulbrich and Ulrich Blahak

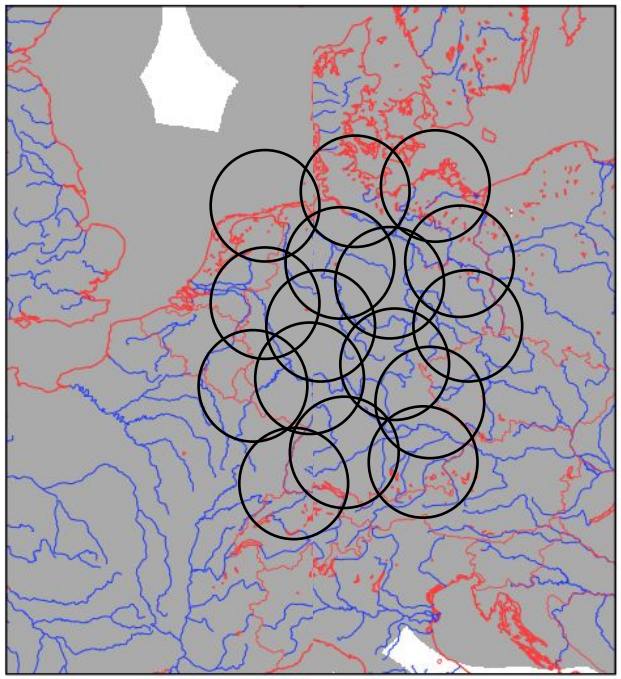
# Short introduction of radar data assimilation in ICON-LAM



## 2 ways of radar data assimilation at DWD

➢ **2D rain rate composites via LHN:**

- Adjust dynamically model state during model integration
- Independent of data assimilation algorithm (LETKF)
- No restriction by other observation
- Including OPERA composite



- ❑ **Circles:** radar network for 3D radar data assimilation
- ❑ **Grey area:** 2D rain rate composite assimilation via LHN (ICON-D2 domain)

➢ **3D radar data assimilation (DBZH and VRAD):**

- Using forward operator „EMVORADO“
- Constraining of radar data by other observation via LETKF
- Using correlation of model ensemble to update all model variable
- Applied only for German radar network
- Using OPERA data in progress
- Operational in ICON-D2 parallel routine since Jun 2020

# Short range NWP (SRNWP) system at DWD

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DWD

## ICON-D2

- Same (D2) model domain
- 1-mom microphysics parameterization in ICON-LAM
- Hourly assimilation of 3D radar data + LHN + conventional observation (radio sounding (TEMP), Aircraft (AIREP), SYNOP stations, wind profile, BUOY) + SEVIRI VIS channel using LETKF
- Continues assimilation cycle
- Longer cut off time (assimilation of about 98% of observation)
- Start forecast cycle every 3 h with lead-time of 48 h

## ICON-RUC

- Same (D2) model domain
- **2-mom microphysics parameterization in ICON-LAM**
- Hourly assimilation of 3D radar data + LHN + conventional observation (radio sounding (TEMP), Aircraft (AIREP), SYNOP stations, wind profile, BUOY) + SEVIRI VIS channel using LETKF
- **New assimilation cycle starting at 3 UTC branching from ICON-D2**
- **Shorter cut-off time (assimilation of less conventional data)**
- **Hourly new forecast cycle with a lead-time of 14 h**

# 6h forecast verification of reflectivity and precipitation over Germany - From 02 until 09 Dec 2022

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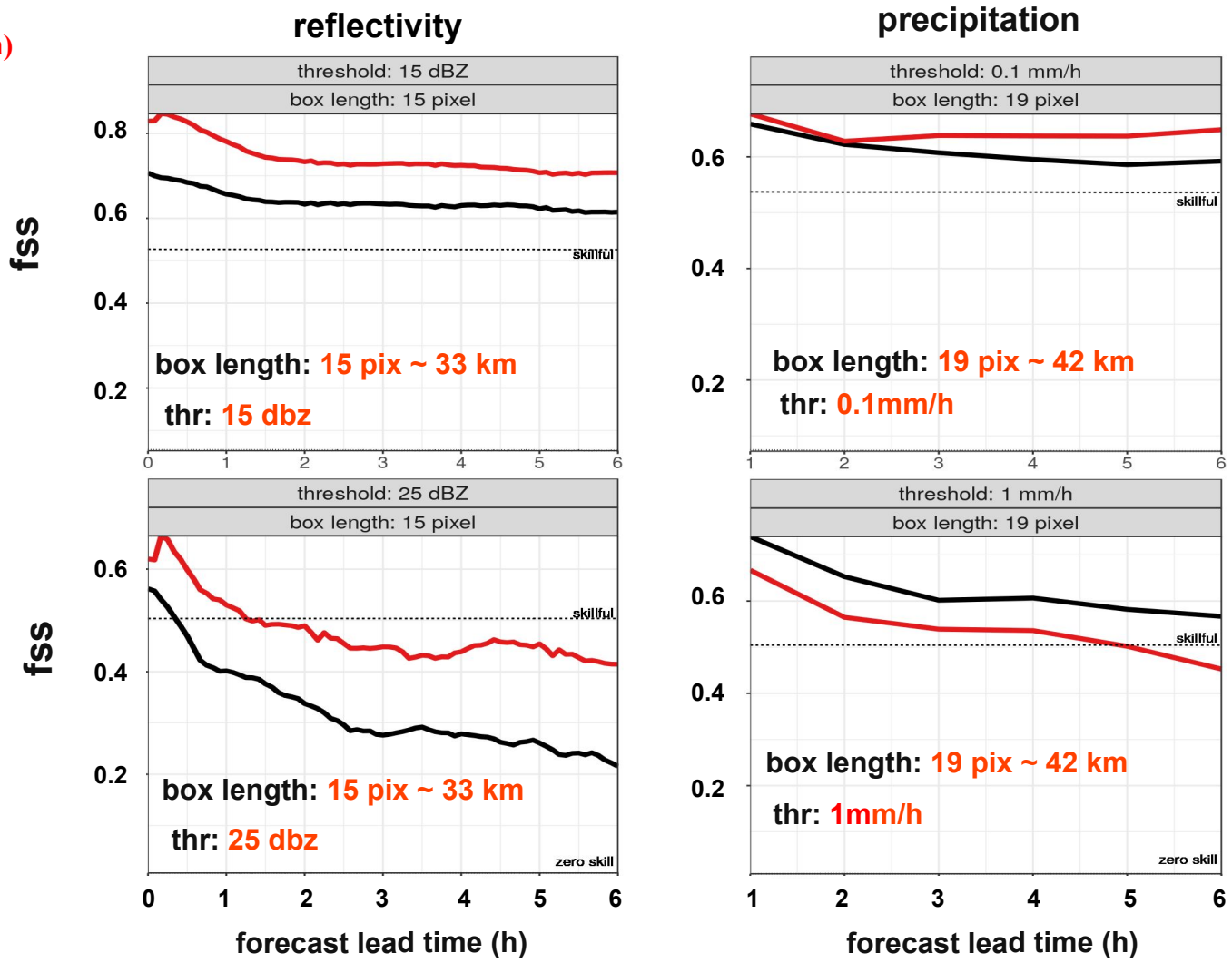
ICON-D2 (1-mom)
ICON-RUC (2-mom)

## Sum scores over all initial times (3h interval)



# Ongoing investigations conducted by the radar assimilation group at DWD



- Starting the test phase for the integration of the European radar network (OPERA) into the KENDA assimilation cycle → **K. Stephan**
- Further investigation and improvement of targeted covariance inflation (TCI) → **K. Vobig**
- Assimilation of radar objects → **L. Neef**
- Investigating polarimetric radar data to enhance the forward model (EMVORADO) output and integrate it into the assimilation system → **J. Mendrok, K. Khosravian**
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# Precipitation verification (1 mm/h)
## case study: 22 Apr 2023 at 10 UTC (1h forecast)

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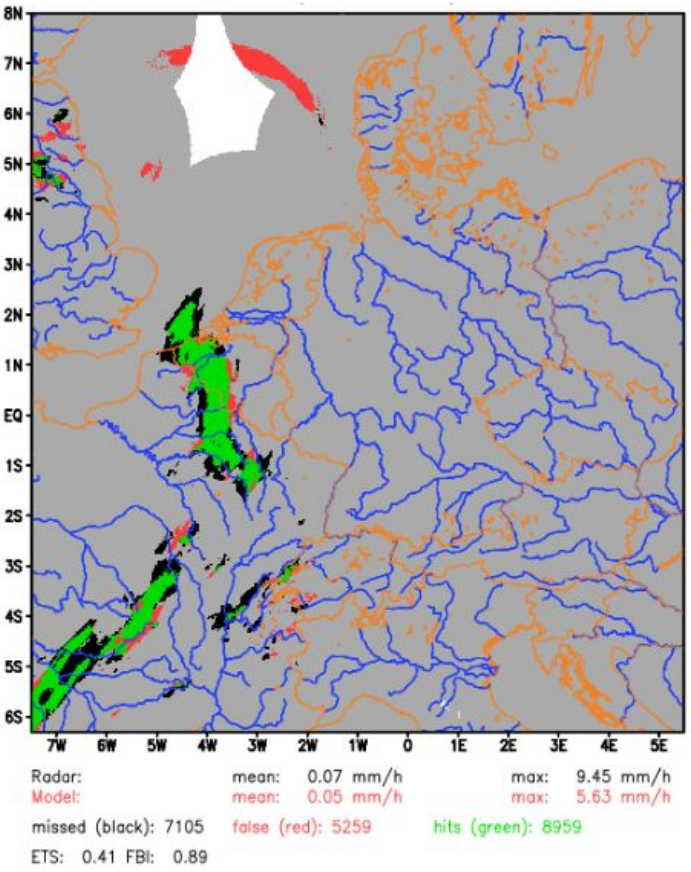
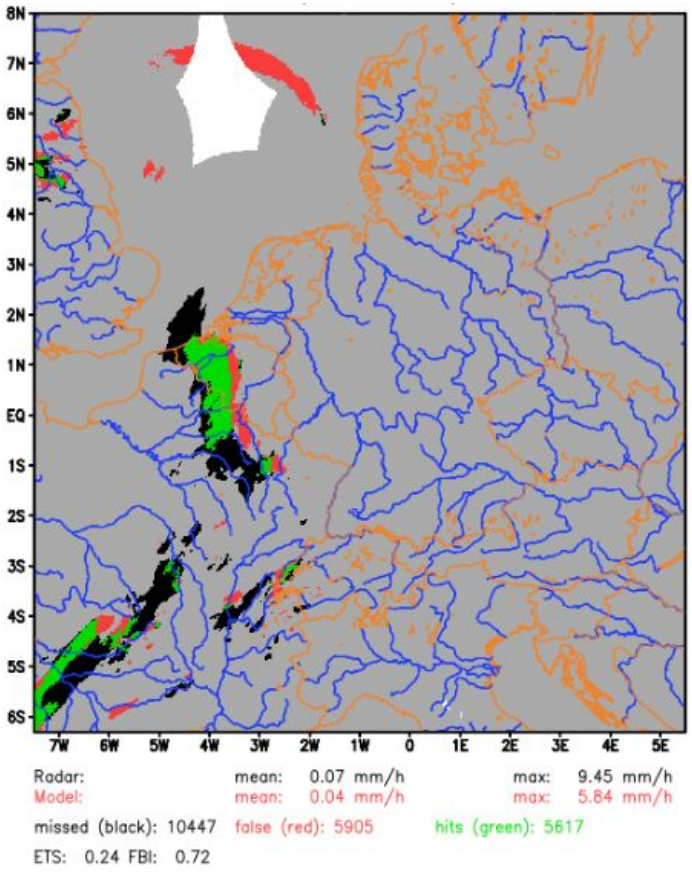
Hits
Misses
False alarms

**French + German radar**




**only German radar**




Good improvement due to French data, up to 3h forecast

From K. Stephan

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# Assimilation of radar objects

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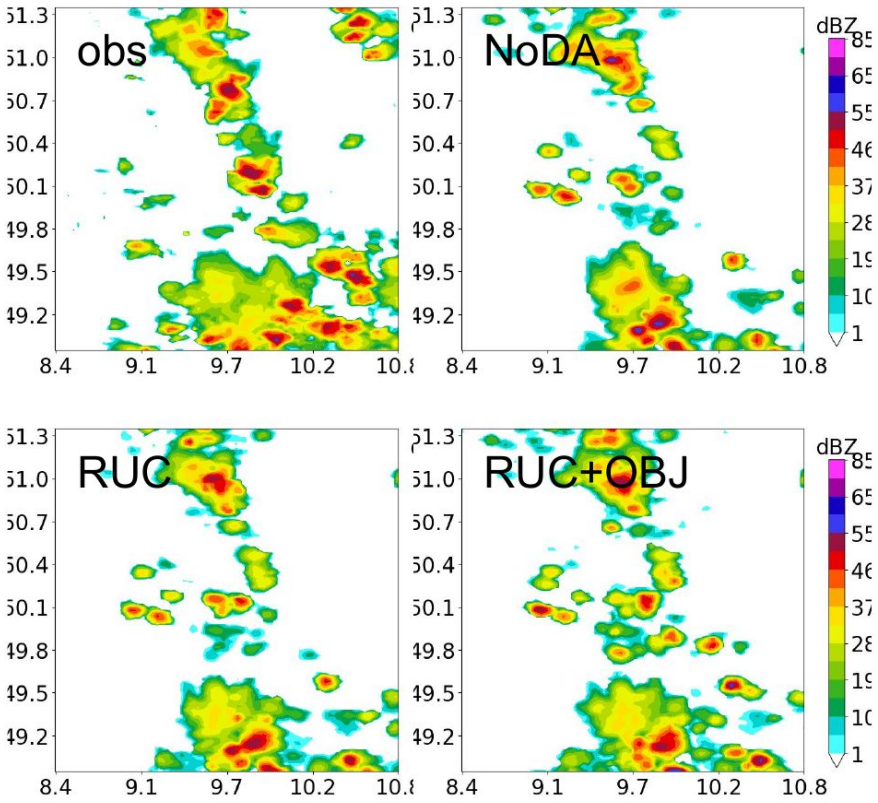
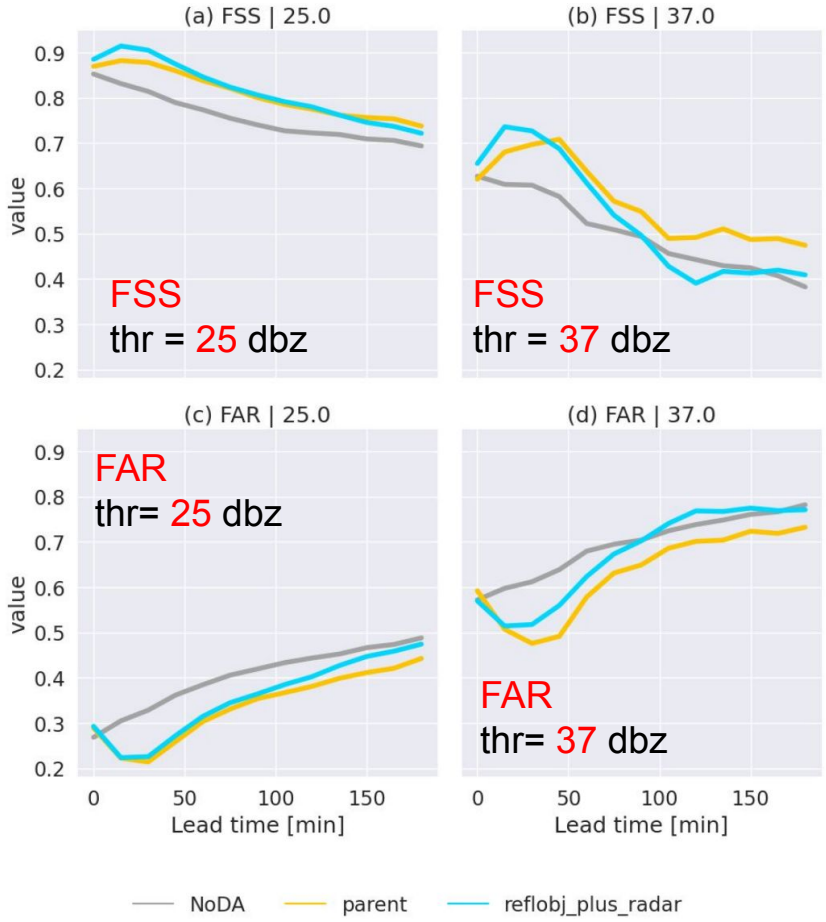
dBZ composite 30 min after update




**Reflectivity Verification**
**aggregation over 16 h forecast in July 2021**




**From L. Neef**

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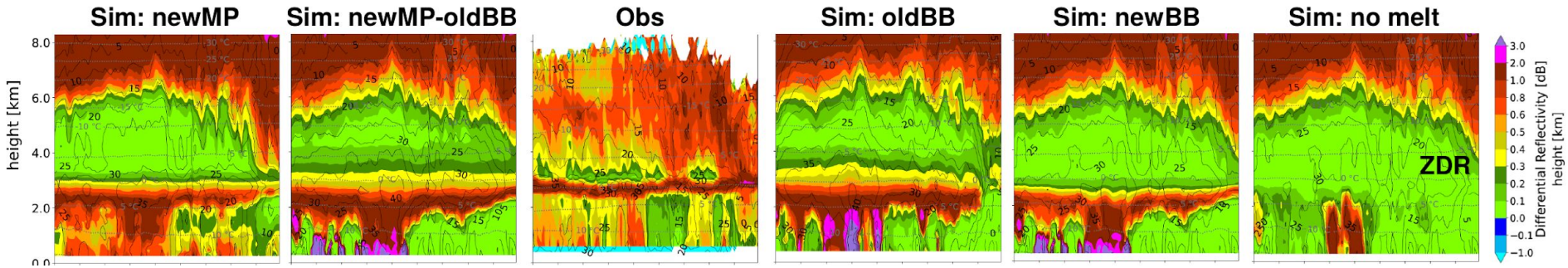
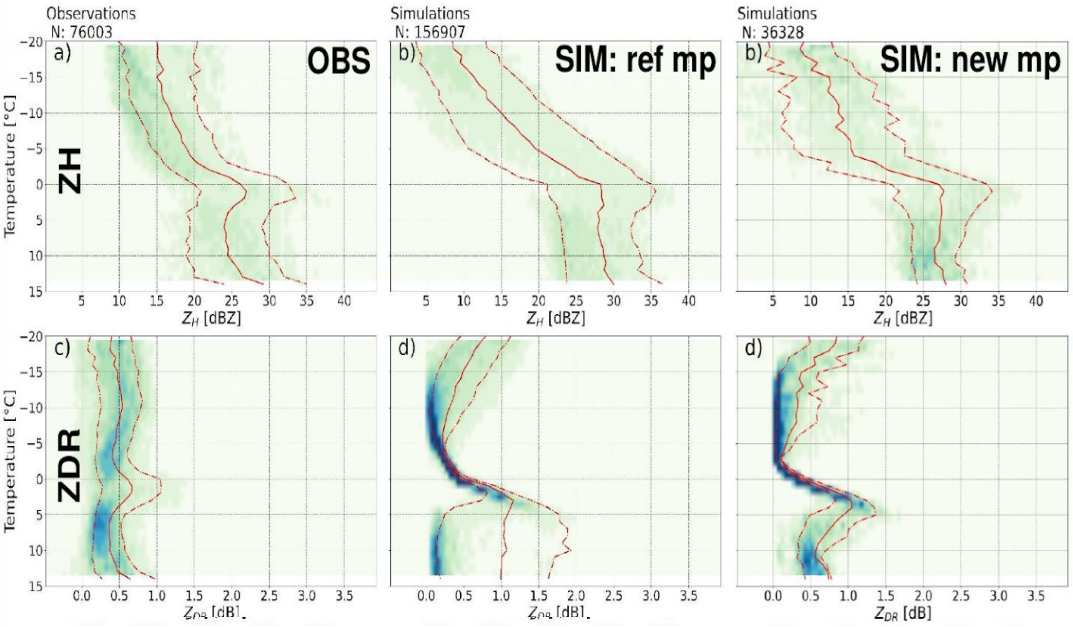
# Investigating polarimetric radar data






- **above-ML slope reduced**
- **clear brightband top**
- **offset reduced in and below ML**

**→ graupel size & amount strongly reduced**

- **flatter profile in DGL**, increase at lower T
- low-T ZDR still too high → too large cloud ice?
- aggregation layer ZDR still too low
- **excessive ZDR below ML strongly reduced**
- ZDR-max & avg. below-ML ZDR still too high
- ZDR-max still too far down
- brightband bottom still smeared out

**From J. Mendrok**

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  - Reduced collision efficiency of graupel by 50%
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- **Dynamic melting layer instead of fixed melting layer in EMVORADO**

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  **New scheme**: assume wet growth only at such grid points where model state suggests it to be physically plausible (supercooled liquid + "large enough" particles)
- **Turning off the attenuation correction in EMVORADO**

# Radar reflectivity composite plots
## over German radar network from radar elevation of 0.5°

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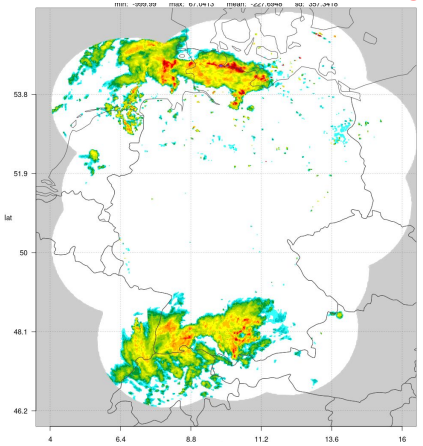
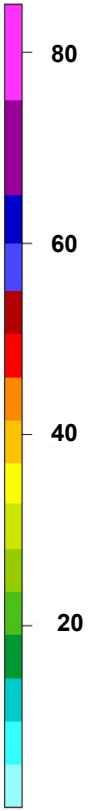
Wetter und Klima aus einer Hand

DWD

**17 Aug 2022 at 21 UTC**

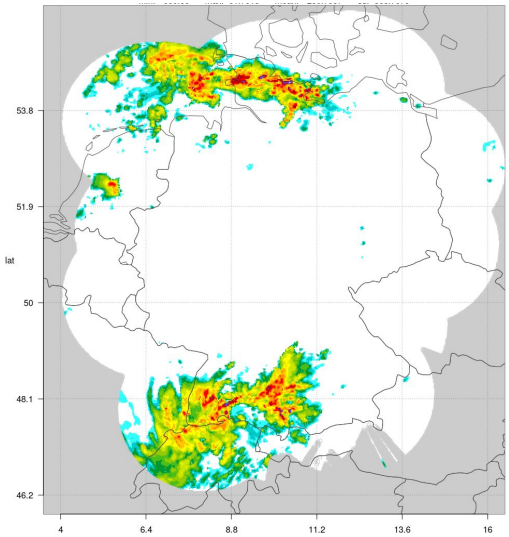
**observed reflectivity**



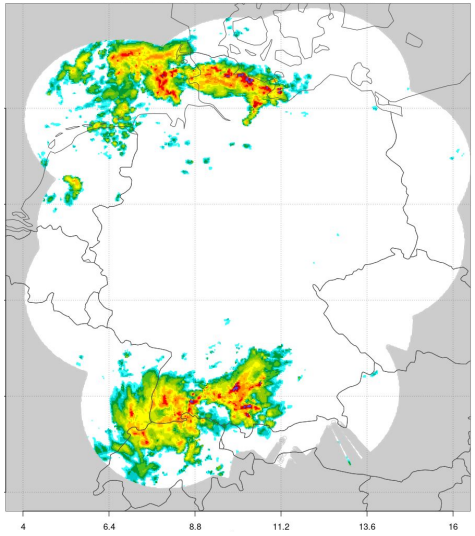



**simulated reflectivity**

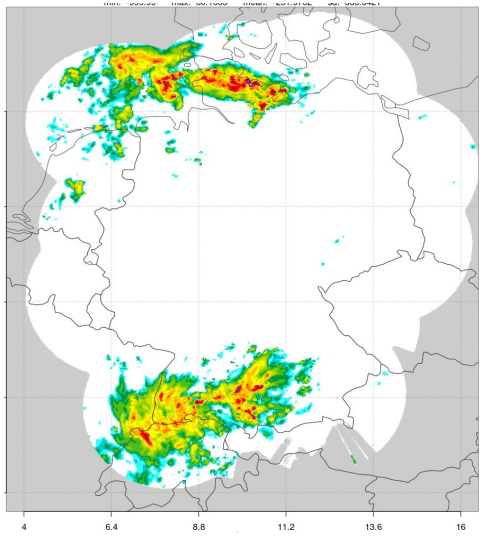
**old setting**



**less sticky**



**dynamical meliting layer**



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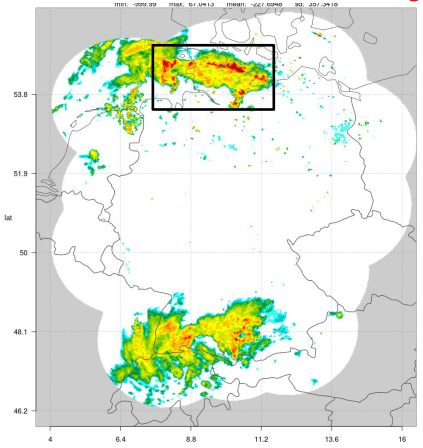


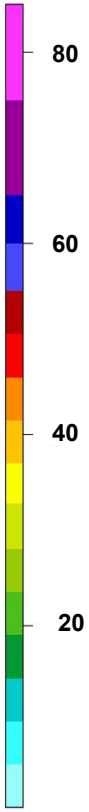


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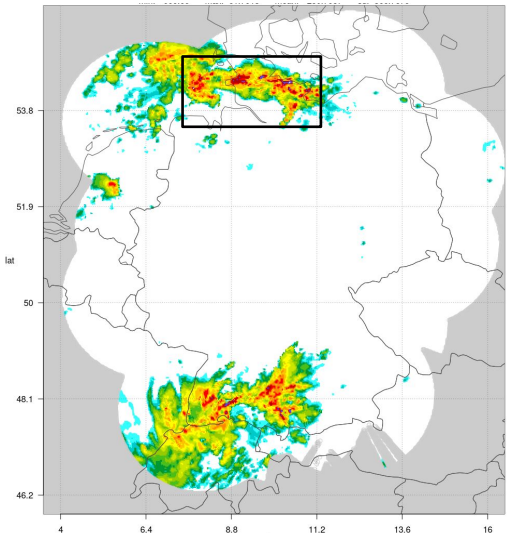


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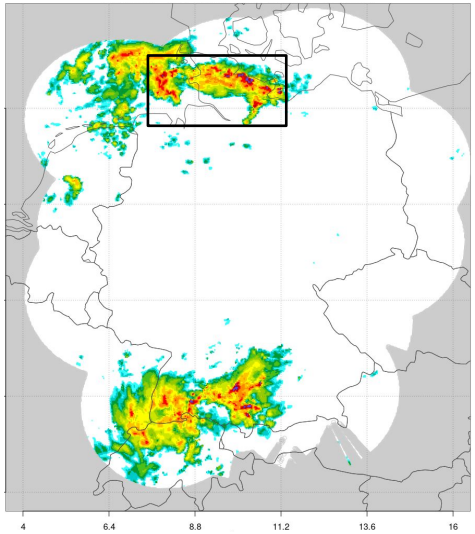


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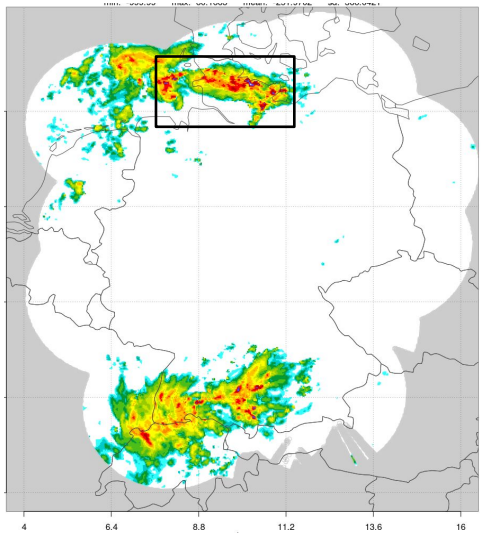

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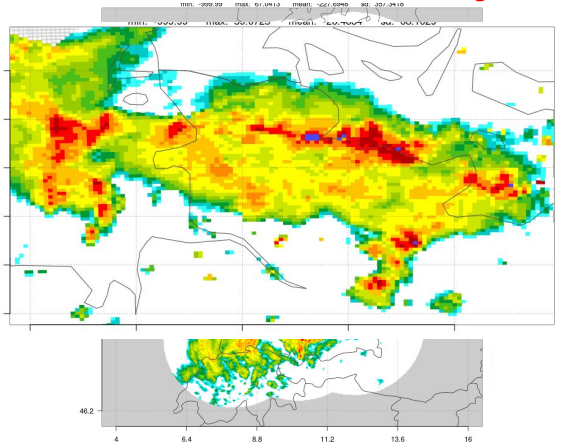

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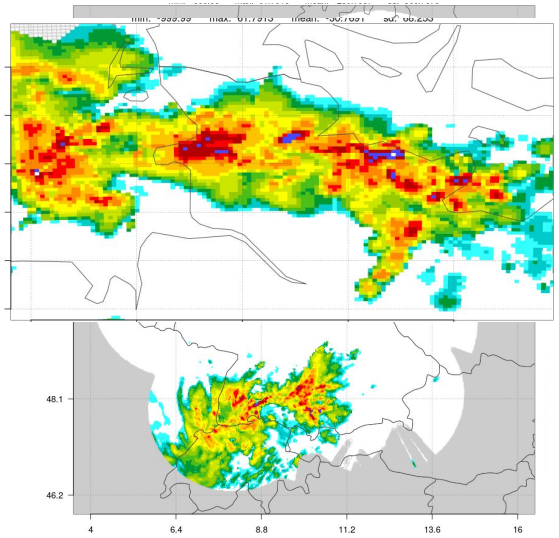
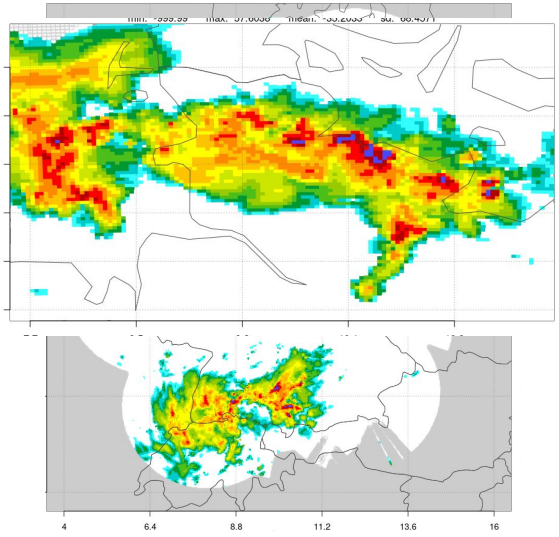


**less sticky**



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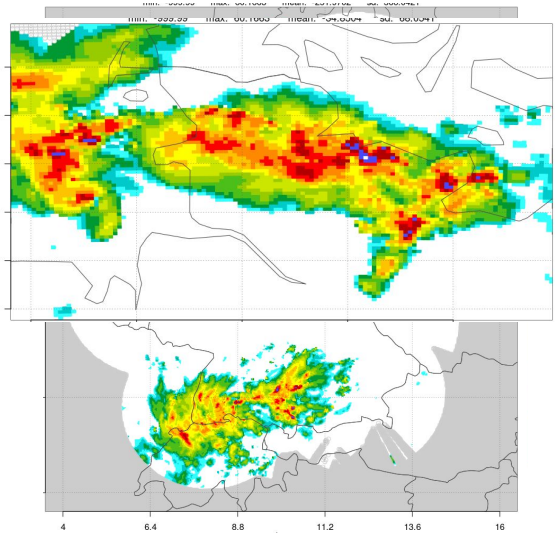

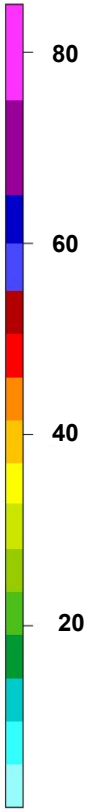

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## over German radar network from radar elevation of 0.5°

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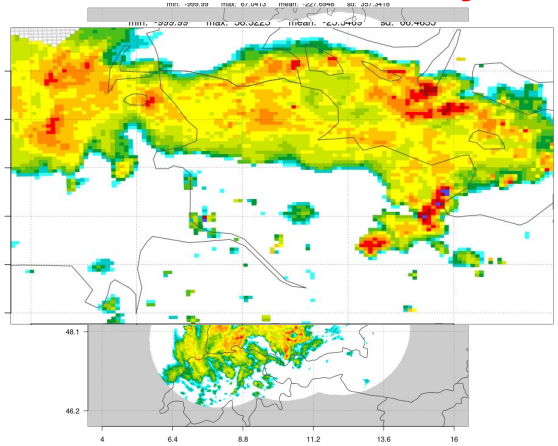
**17 Aug 2022 at 21 UTC**

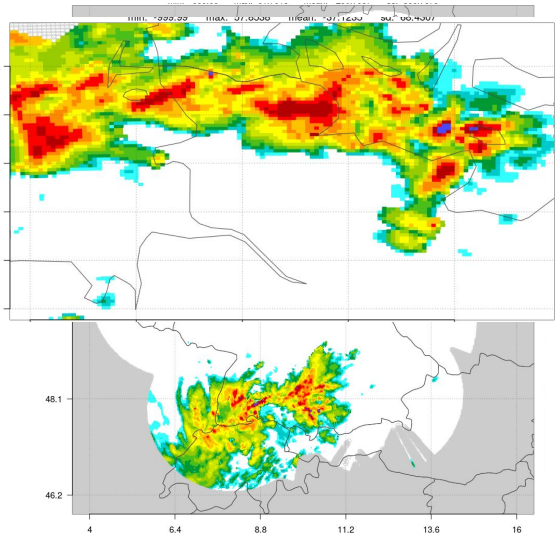
**After 1 hours (1h forecast)**

**observed reflectivity**




**simulated reflectivity**

**old setting**

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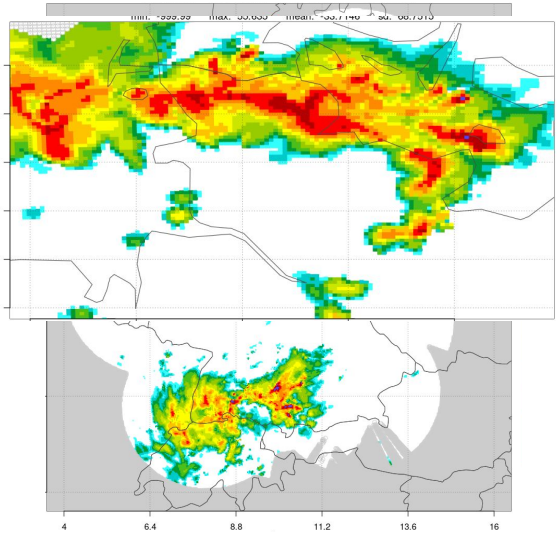
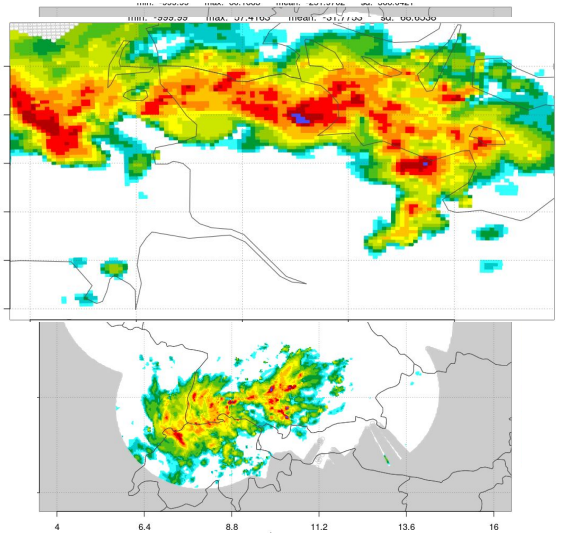
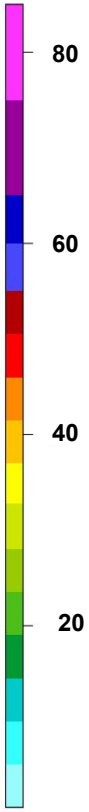



**dynamical meliting layer**



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  **New scheme**: assume wet growth only at such grid points where model state suggests it to be physically plausible (supercooled liquid + "large enough" particles)
- **Turning off the attenuation correction in EMVORADO**

Winter exp
**Dec 2022**

Summer exp
**Aug-Sep 2022**

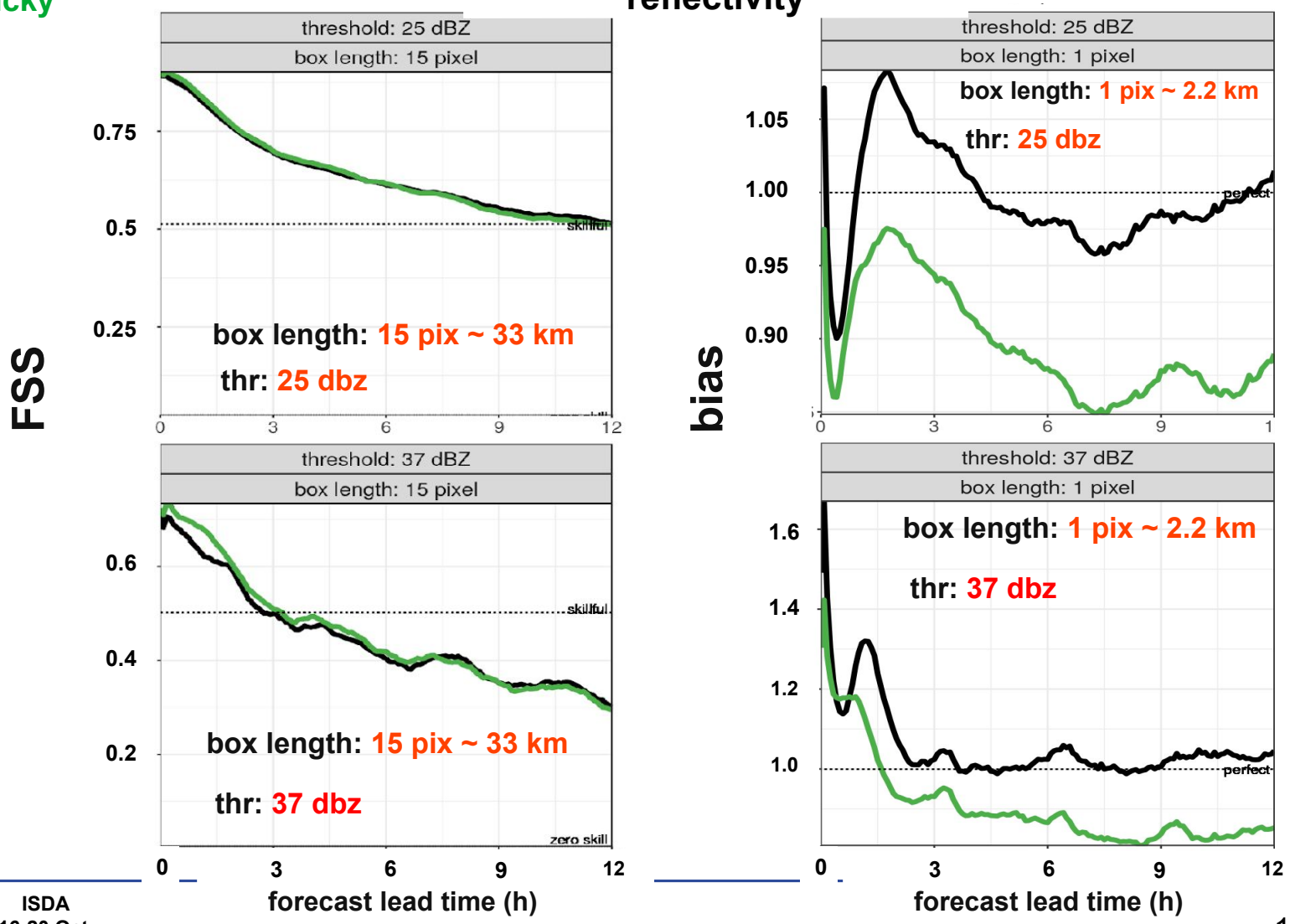
# Reflectivity verification_FSS and bias over Germany - from 16 Aug to 4 sep 2022

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

**old setting**
**new less sticky**

**Sum scores over all initial times (3h interval)**

**reflectivity**



# Reflectivity verification_FSS and bias over Germany - from 16 to 29 Aug 2022

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

DWD

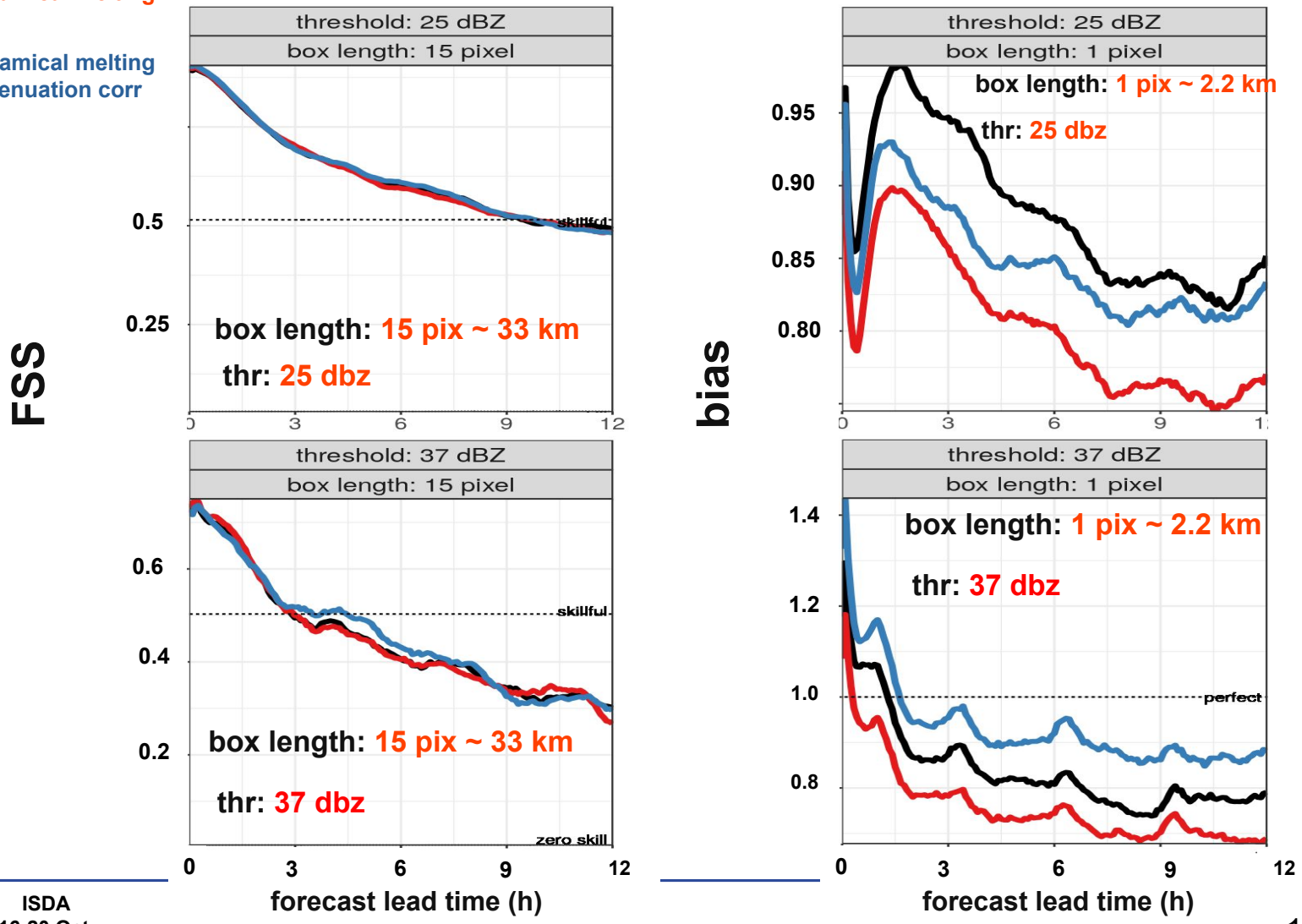
less sticky

less sticky+ dynamical melting layer

less sticky+ dynamical melting layer without attenuation corr

## Sum scores over all initial times (3h interval)

## reflectivity



# Summary and outlook



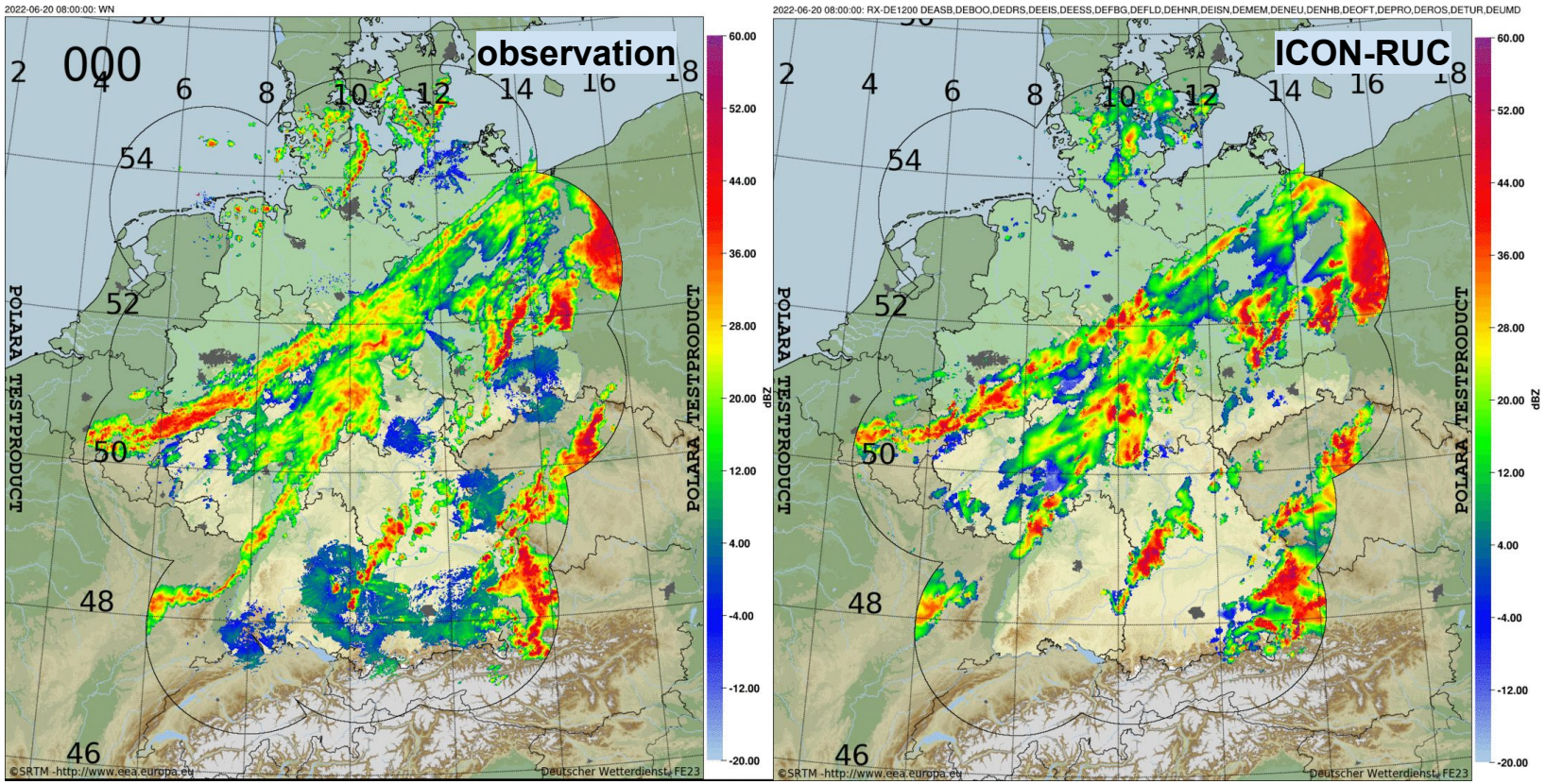
## Summary

- Radar data assimilation significantly improves reflectivity and precipitation verification.
- The integration of the European radar network into the assimilation system significantly enhances the ability to detect missed cells in convective events.
- The new configurations in 2-mom microphysics and EMVORADO can potentially reduce overestimations in higher reflectivity and enhance the ability to capture the structure of convective cells more effectively.

## Outlook

- Continuing to integrate additional radar data from the OPERA network while enhancing their configuration within the KENDA system.
- Continuing the investigation of the new configurations in 2-mom ICON microphysics and EMVORADO.
- Continuing the investigation of the radar polarimetric variables to enhance EMVORADO and integrate them into the assimilation system.
- Continuing the investigation of object assimilation and enhancement of TCI.

## case study: 20 Jun 2022 at 8 UTC

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**Tel. +49-69-8062-3186**
**Email kobra.khosravian@dwd.de**

# Thank you for your attention