Assimilation of Lightning and Reflectivity Texture Fraction in ICON-LAM

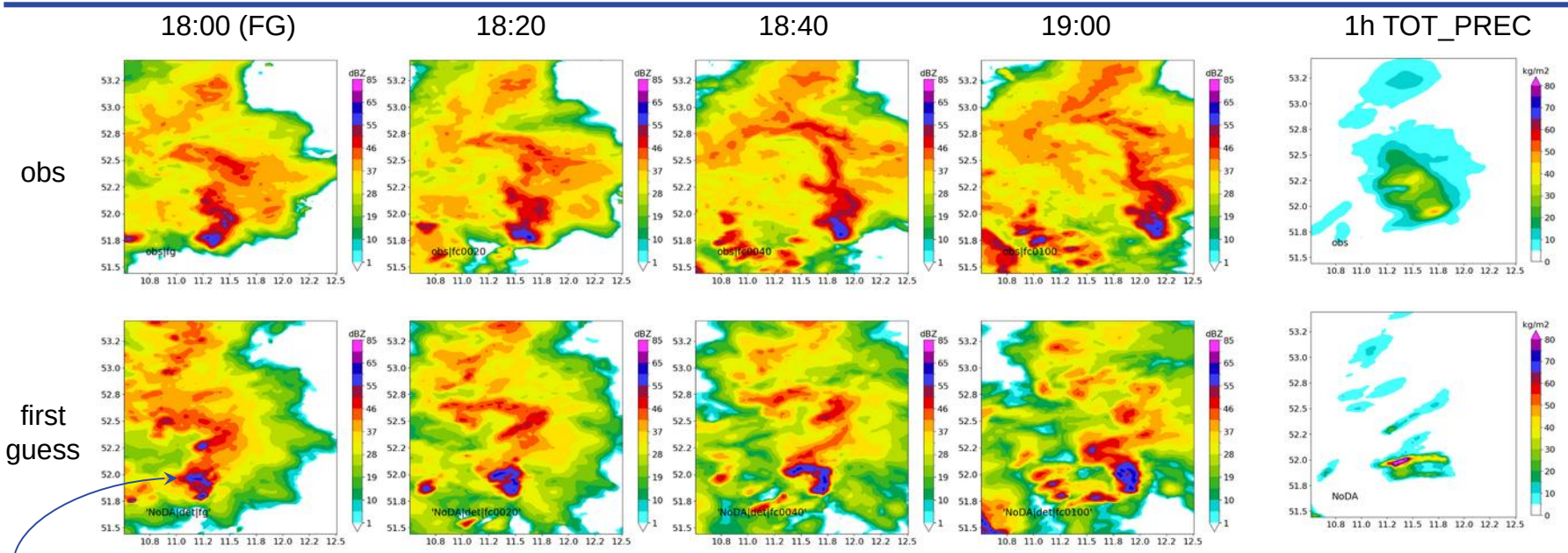
Lisa Neef

Ulrich Blahak, Klaus Stephan, Christian Welzbacher (+ many others)

Convective-scale Data Assimilation

example:
2023062218
cell 897

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



let's update **T, QV, U, V, P,** and **hydrometeors** here in order to

correct the convective cells we have

improve the evolution of cells

improve the conditions that lead to more convection

Convective-scale Data Assimilation

example:
2023062218
cell 897

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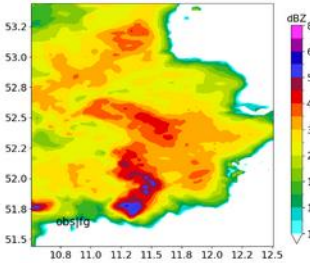
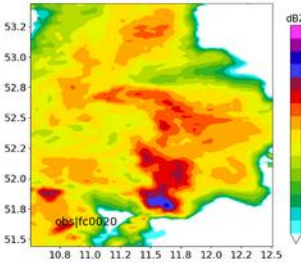
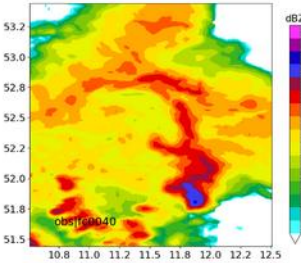
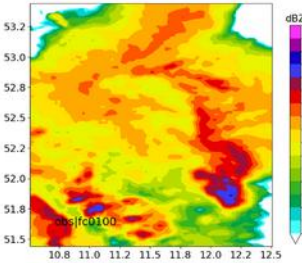
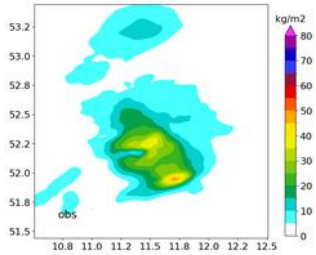
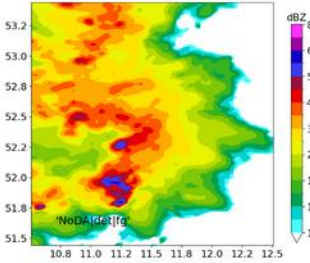
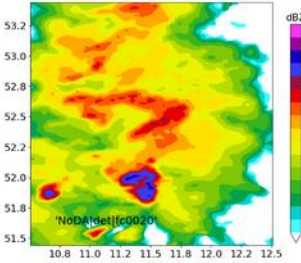
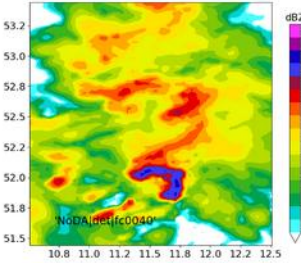
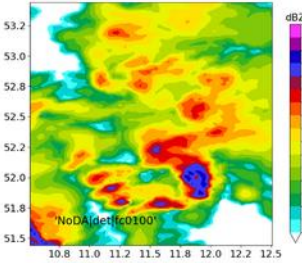
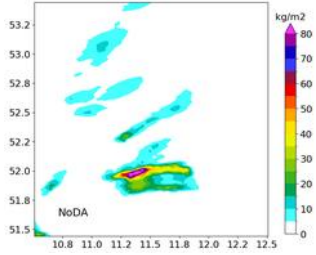
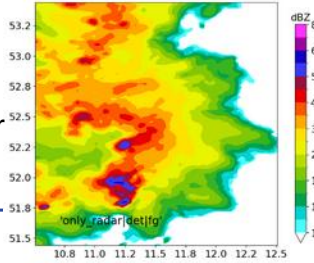
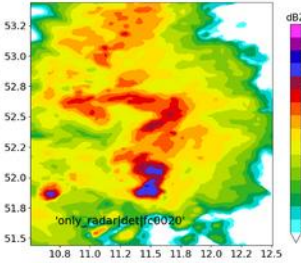
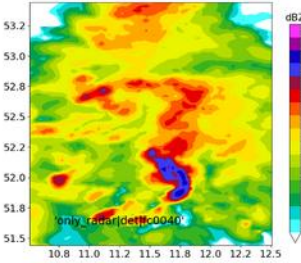
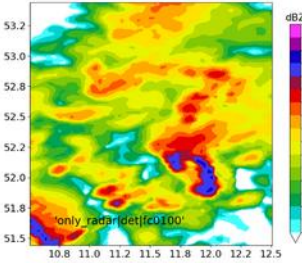
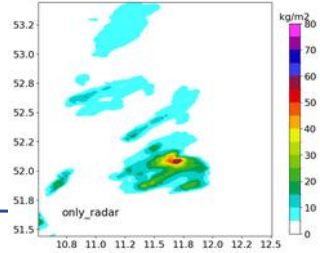
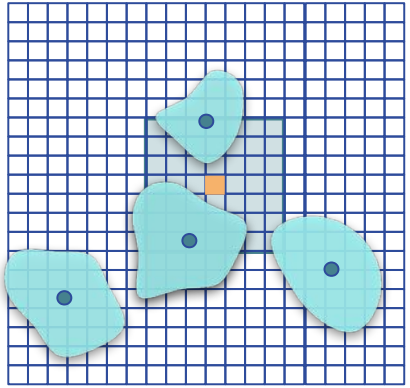
	18:00 (FG)	18:20	18:40	19:00	1h TOT_PREC
obs					
first guess					
DA of 3D radar					

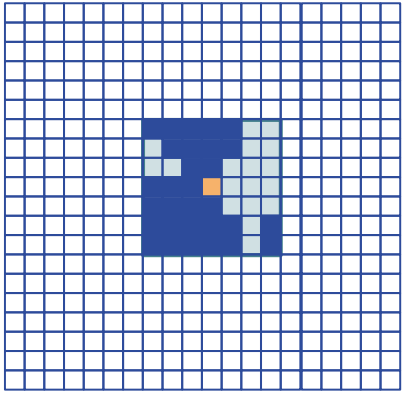
Fractions Skill Score

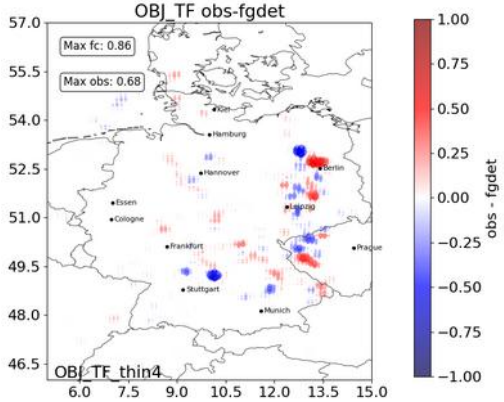
set a threshold (e.g. in dBZ) & neighborhood on gridboxes

What fraction of points in the box exceed a threshold?

Take diff between obs and model







$$\mathrm{FBS} = \frac{1}{N}\sum_i\sum_j \left(F^{ij}_{\mathrm{obs}} - F^{ij}_{\mathrm{mod}}\right)^2$$

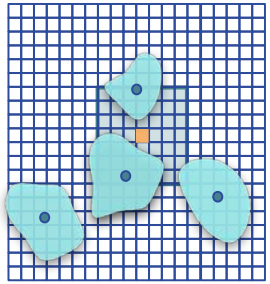
$$\mathrm{FSS} = 1 - \frac{\mathrm{FBS}}{\mathrm{FBS}_{\mathrm{ref}}}$$

Now what if we assimilate **the FSS?**

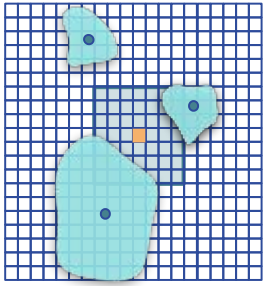
Texture Fraction as a DA Variable

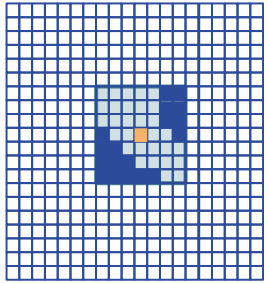
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Observation



Model Equivalent





apply to **reflectivity composites** → RTF

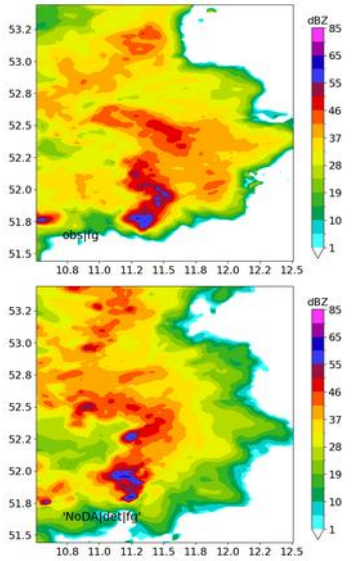
apply to **lightning flashrate** → LTF

Reflectivity Texture Fraction

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

obs

model

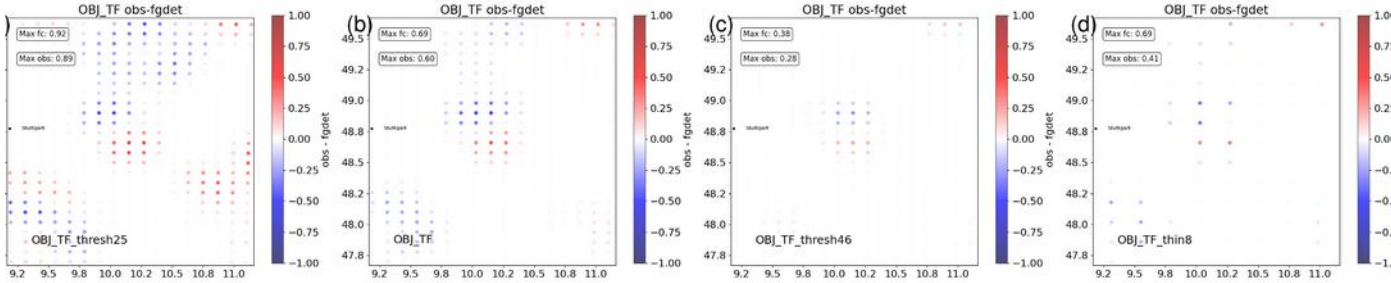


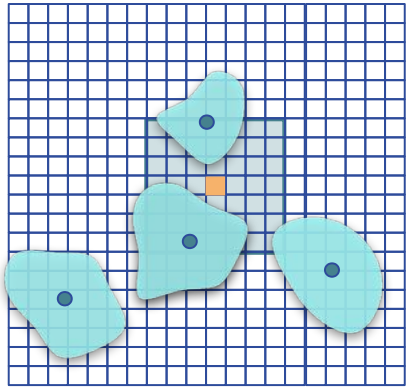
RTF thresh 25dBZ

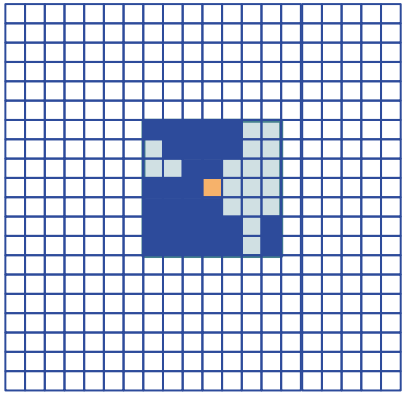
RTF thresh 37dBZ

RTF thresh 46dBZ

RTF thresh 27dBZ, larger box



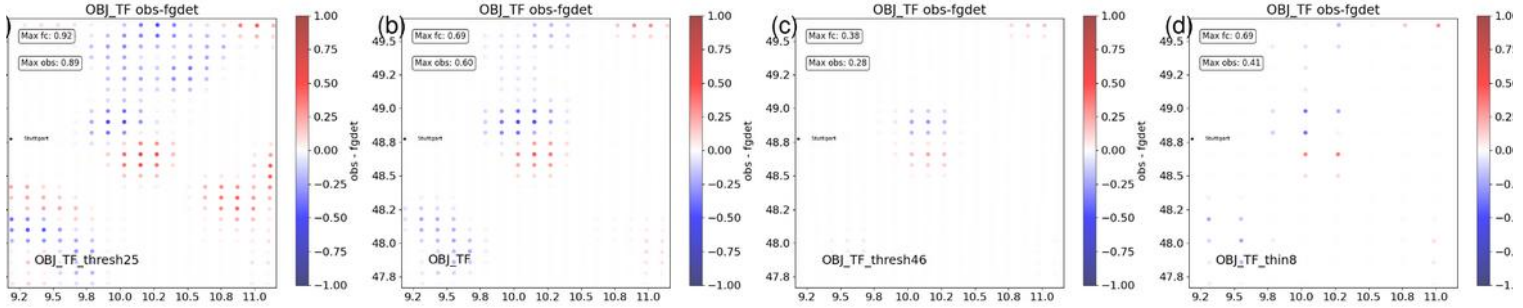




Reflectivity Texture Fraction DA

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

obs-model diffs



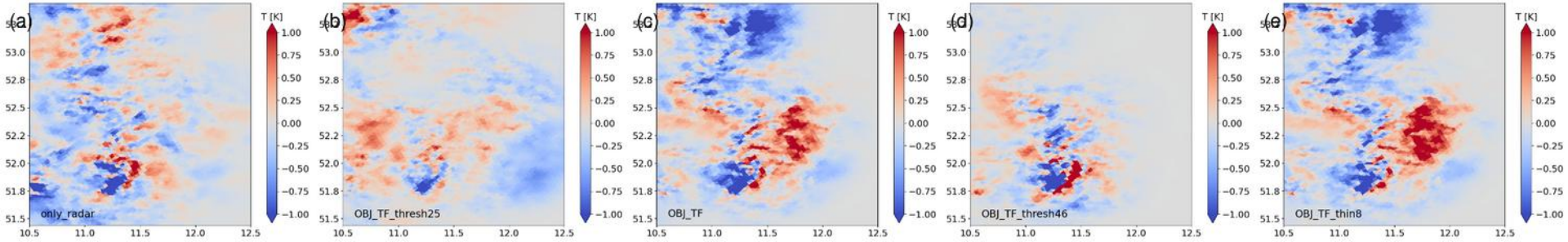
RTF thresh 25dBZ

RTF thresh 37dBZ

RTF thresh 46dBZ

RTF thresh 37dBZ, larger box

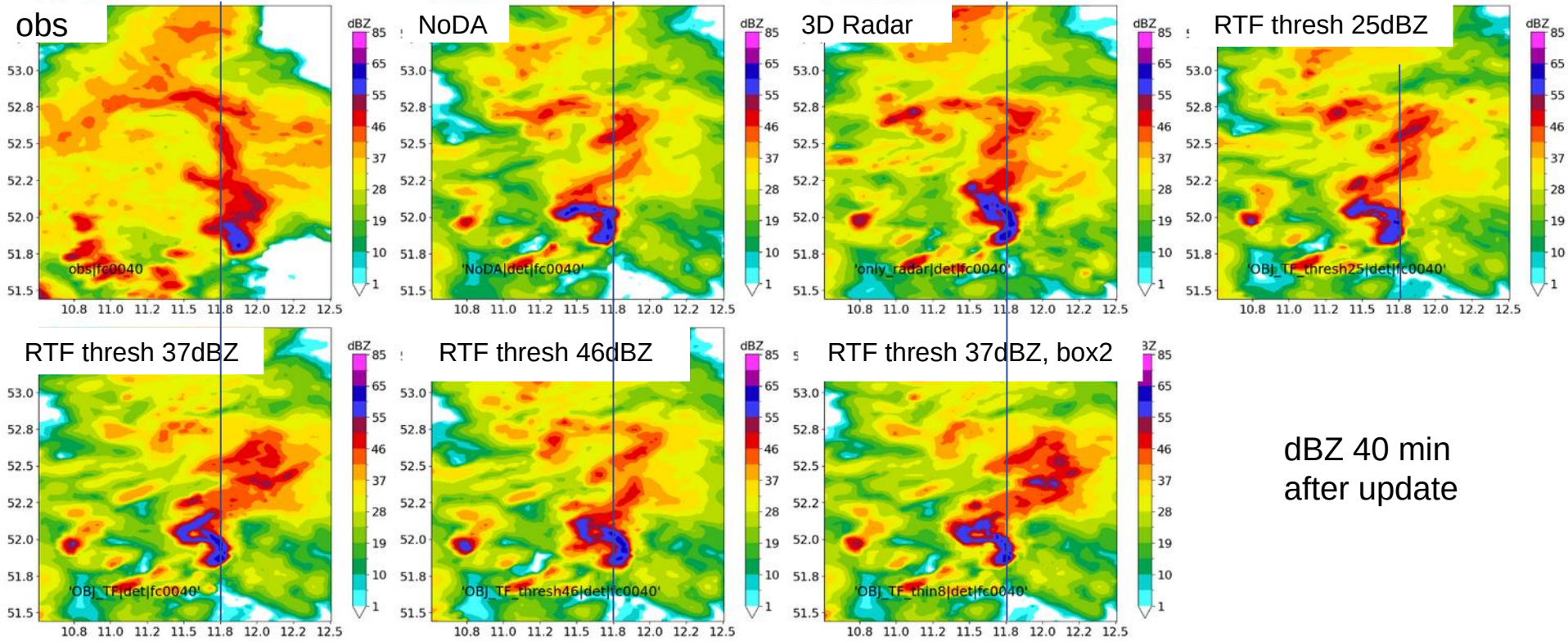
temp increments



SINFONY

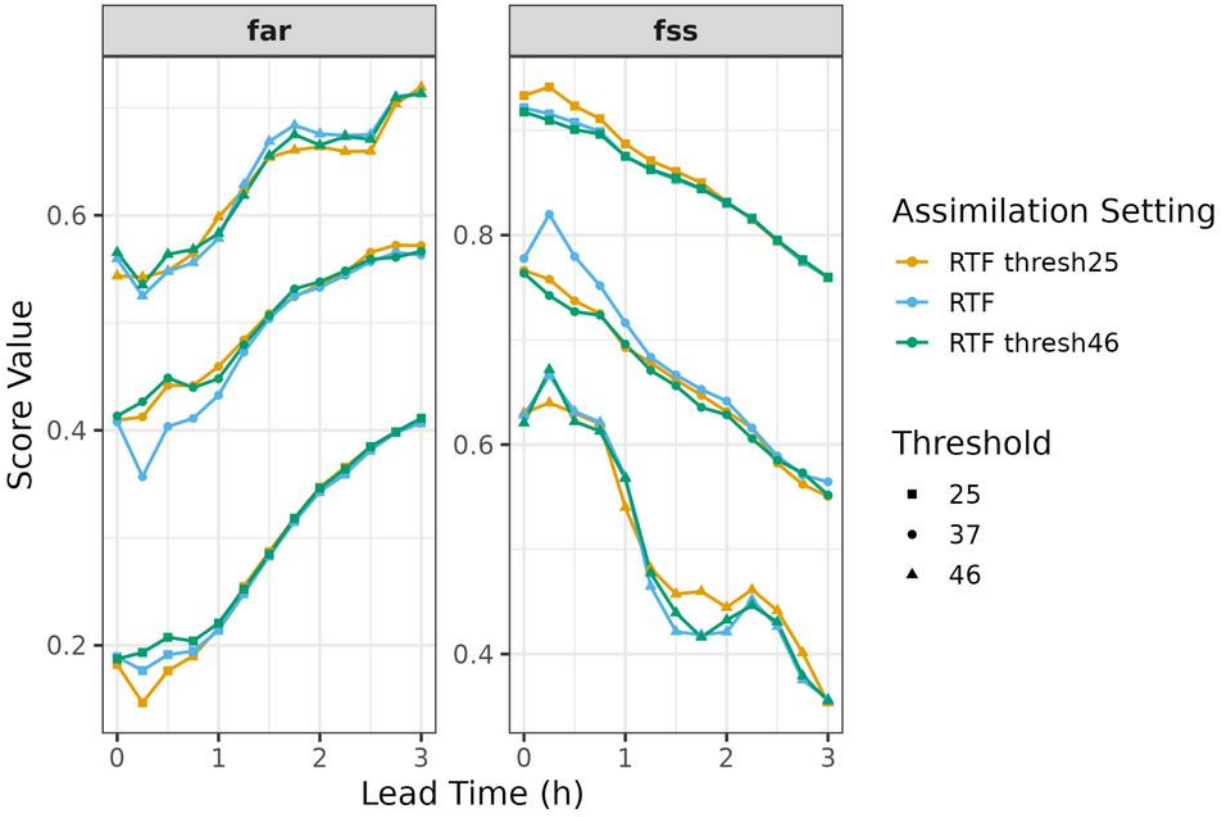
Reflectivity Texture Fraction DA

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



dBZ 40 min
after update

Texture Fraction DA in multiple cases



False alarms go down (and FSS goes up) **at the scales where we define the texture fraction**.

Lightning Texture Fraction

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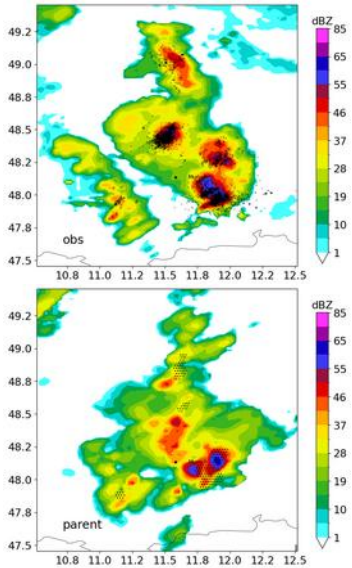
Wetter und Klima aus einer Hand

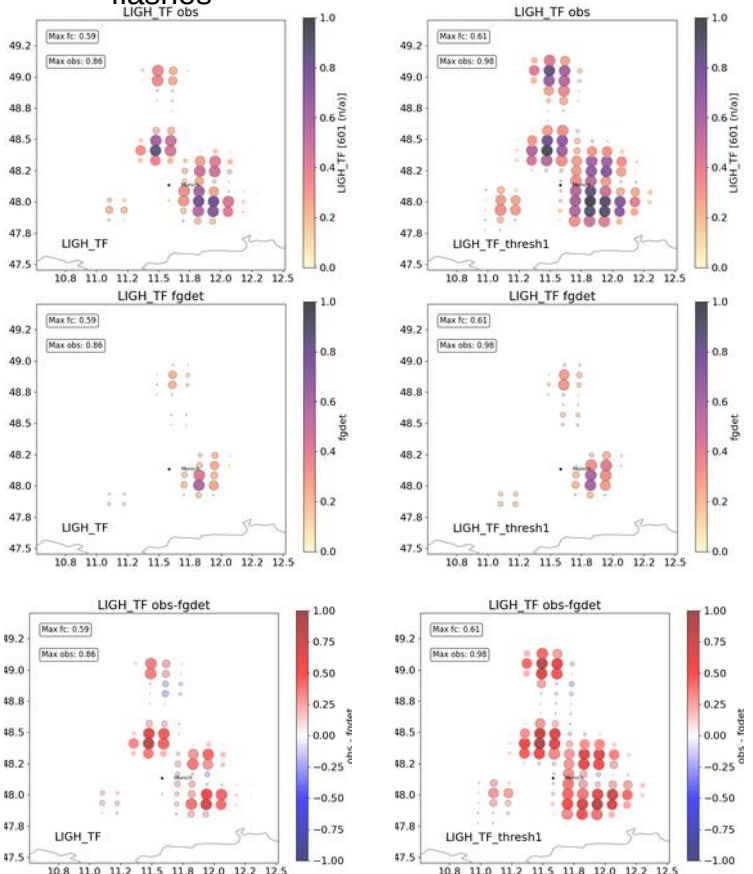
LTF thresh 15 flashes

LTF thresh 1 flash

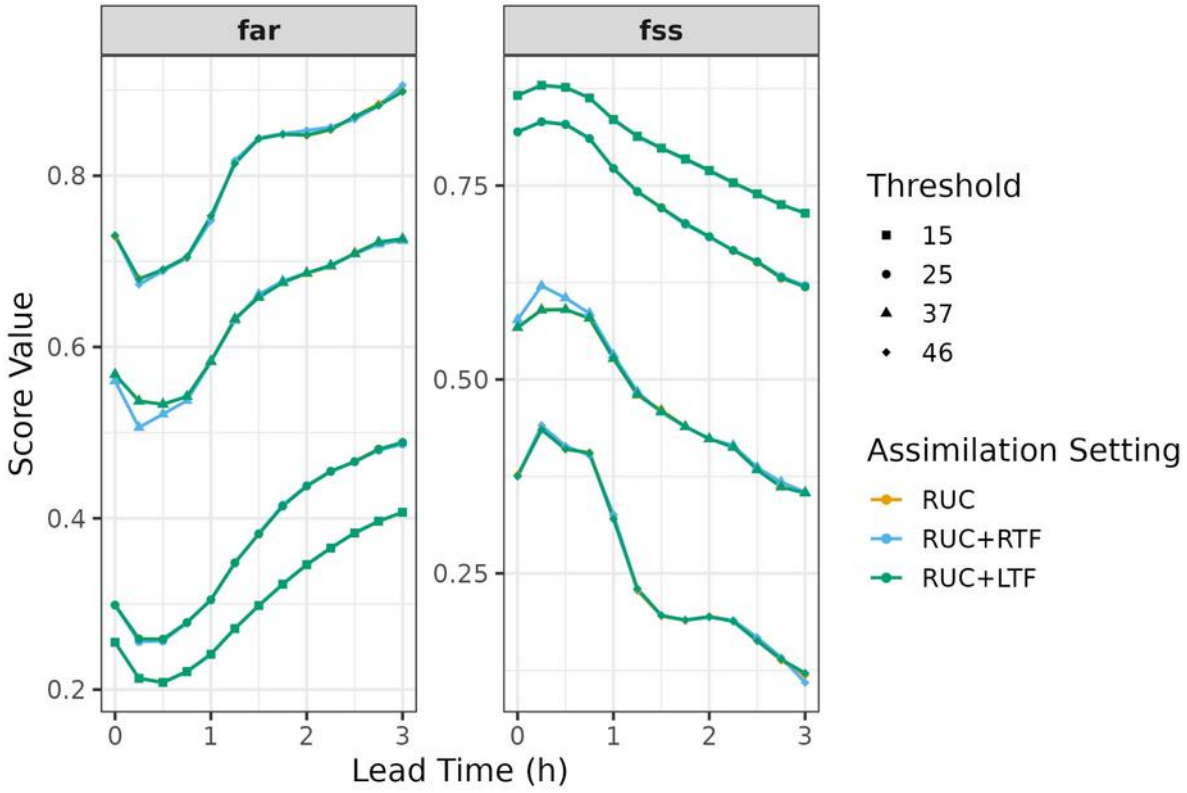
obs

model





Texture Fraction DA in the SINFONY-RUC



In the full Rapid Update Cycle, adding RTF improves scores for the first 40-60 min.

LTF not so much…

Convective-scale Data Assimilation

We are trying to **correct convective processes** over the next few hours by doing an **instantaneous adjustment** of the environment in which convection takes place.

Zero-spread where no model equivalent	Limited to the space spanned by the ensemble	Nonlinear observation operators	Zero-spread where no model equivalent

Summary

We are trying to correct convective processes over the next few hours by doing an instantaneous adjustment of the environment in which convection takes place.

Casting precipitation-related observations as **texture fraction** can give the DA an extra push that targets the thresholds and scales that we want.

But:

- v difficult to get impact beyond 30 min
- non-linearity of obs operator is a problem
- payoff questionable in system that is already highly constrained

More Qs? Contact me!

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extras

The DWD Rapid Update Cycle

- ICON-LAM D2
- hourly assimilation with LETKF
  - conventional obs
  - radar scans
  - SEVIRI visual and IR
- 2-moment microphysics
- hydrometeor updates
- hourly 14-h forecasts