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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Towards the assimilation of objects based on radar reflectivities on the convective scale with KENDA

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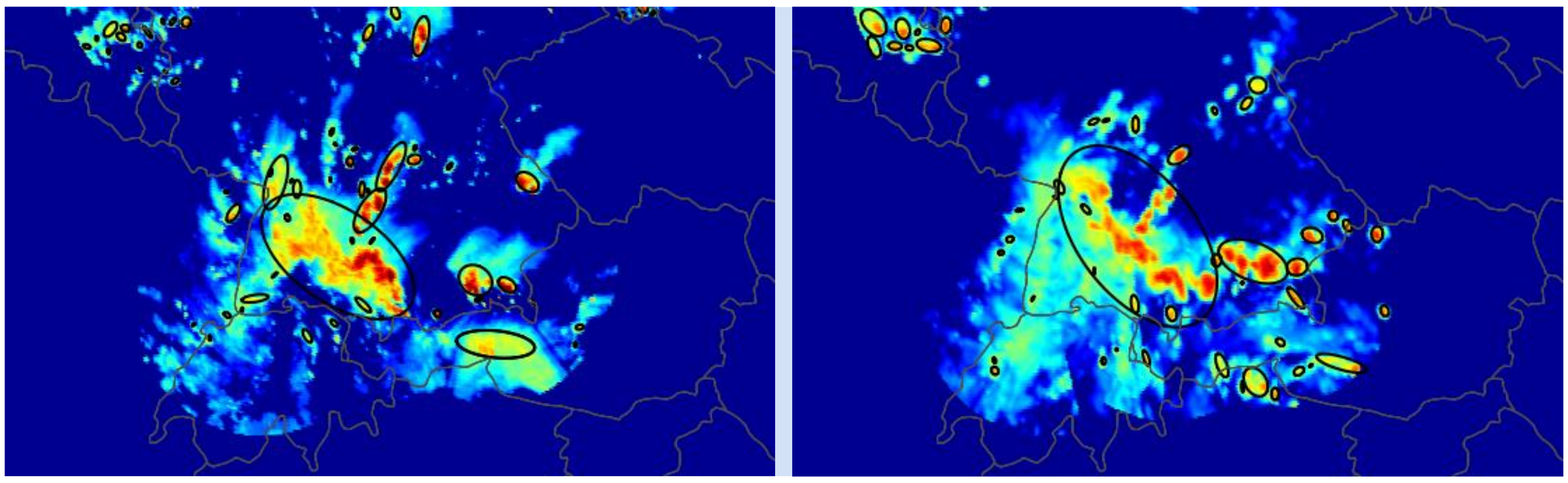

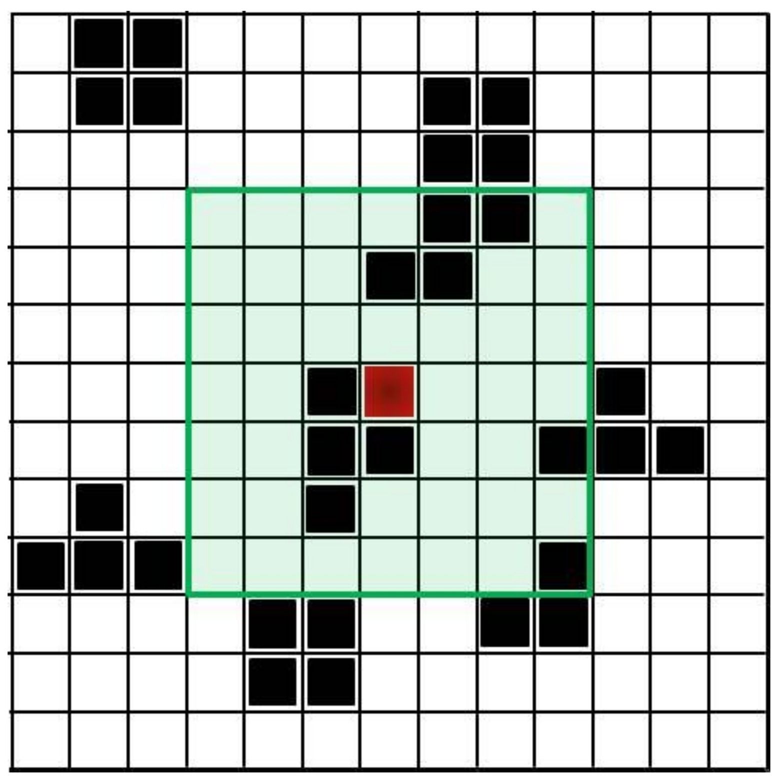

Fig. 1: Sketch of the idea of texture assimilation.

At Deutscher Wetterdienst the development of an ensemble-based seamless integrated forecasting system SINFONY for convective-scale weather prediction has been initialized with

- *Forecast ranges of 6 to 12 hours integrating predictions from Nowcasting with NWP*
- *Assimilation of new remote sensing data, where one component are objects derived from 3D radar reflectivities*

COSMO-KENDA

In March 2017 the Kalman filter for convective-scale data assimilation, which has been developed for the Consortium for Small-scale Modelling (COSMO) model, has become operational at DWD (Schraff2016, Fig. 3)

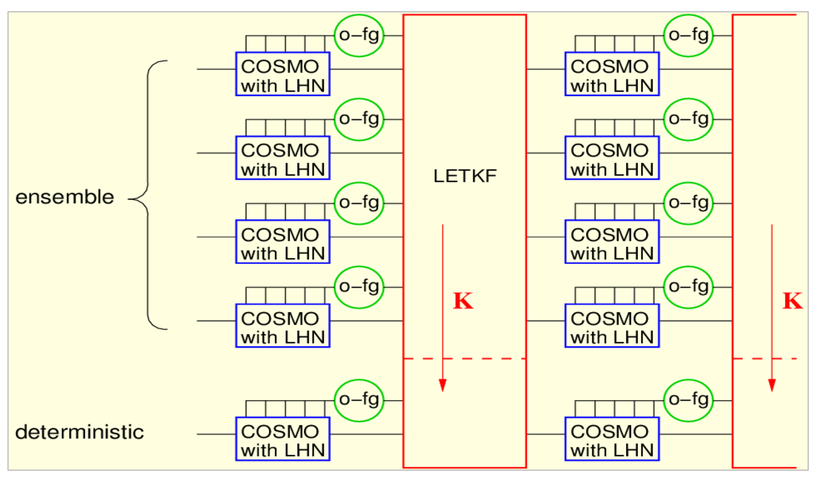

Fig. 3: COSMO-KENDA system.

The Kilometre-scale ENsemble Data Assimilation system *KENDA* renders the assimilation of any type of observation, given a corresponding forward operator, possible. Therefore KENDA allows to assimilate data based on objects and texture in a natural way.

Radar data assimilation

In combination with the Efficient Modular VOlume scanning RADar Operator *EMVORADO* (Zeng2016, Bick2016), the direct assimilation of 3D radar data (reflectivity, radial wind) is possible. Reduction techniques such as thinning and superobing are used to reduce

- Vast amount of data
- Representativity error
- Observation error correlation
- Impact of the double penalty problem.

Radar objects

A different view on radar reflectivities is given by the concept of objects which might be defined as

- Areas of connected grid points fulfilling certain conditions (e.g. thresholding and connection criteria to describe cores of convective cells)
- Numbers parametrizing gridded areas geometrically, as e.g. given by the Nowcasting-Tool Konrad3D (M.Werner, DWD), see Fig. 2).

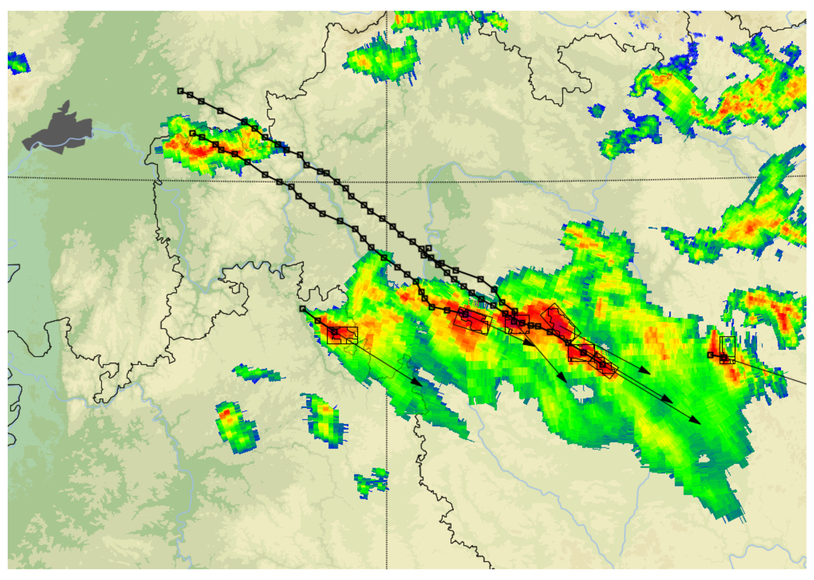

Fig. 2: Example of radar reflectivity objects as obtained from Nowcasting (Konrad 3D) including cell-tracks.

Direct assimilation of individual objects compared to pure radar reflectivities may lead to

- Reduction of the amount of data
- Avoidance of the double penalty problem.

However, this requires to

- Find a proper matching algorithm
- Develop techniques to facilitate the application of a LETKF („fail objects", harmonization of the ensemble).

Nonetheless it would be desirable to assimilate attributes of objects to

- Connect NWP and Nowcasting
- Potentially improve the skill of the system with regard to convection
- Access scale-dependent information encoded in radar objects.

Assimilation of texture/features

In this approach we aim to assimilate 2D textural information obtained from a certain horizontal scale. In Fig. 1 a sketch of the idea is shown

- Black squares indicate that corresponding pixel fulfills a desired constraint (e.g. exceedance of an adaptive threshold in a reflectivity composite, part of an object of size X)
- At the red square the average number of black squares in the green box is used as a texture observation.

The term texture can be understood by considering that the distribution of the derived texture observations (e.g. red square in Fig. 1) is freely selectable. Therefore, by using overlapping regions, the texture may be scanned and assimilated. It is important to note that in this approach

- The localization radius and the scale are to be linked
- The vertical localization and localization radius have to be carefully tested
- Double counting of data may happen
- Some information might not be used (e.g. data below threshold).

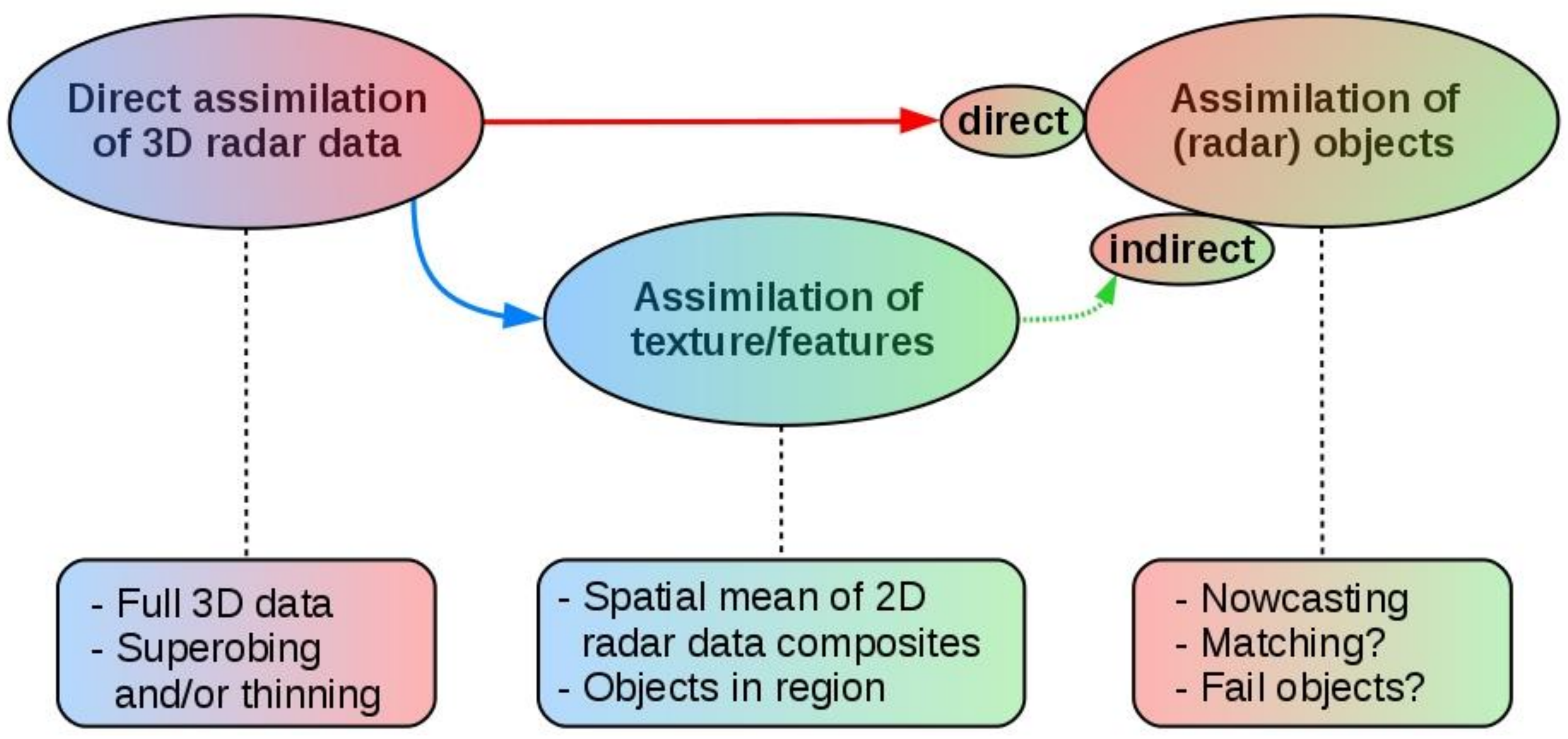

Fig. 6: The road to the assimilation of (radar) objects.

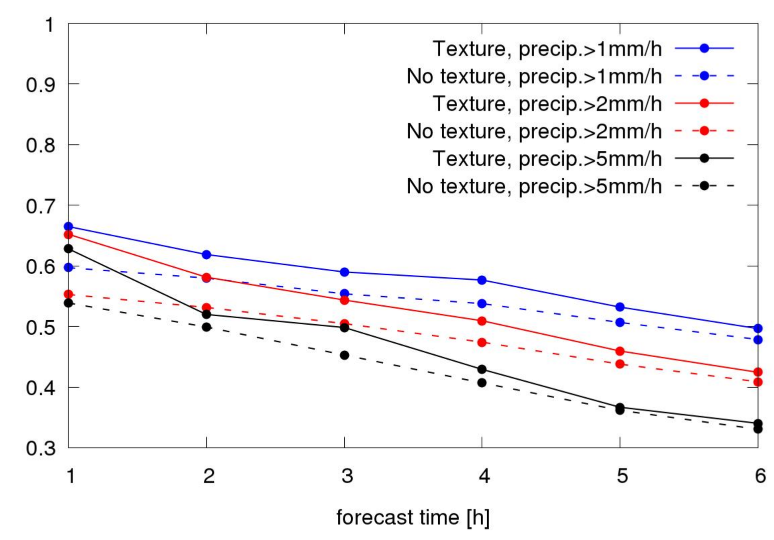

Fig.4: FSS (25 grid points) for precipitation of ensemble with and without texture (T=30dbZ, scale=7) assimilation [7 days, 17 UTC runs].

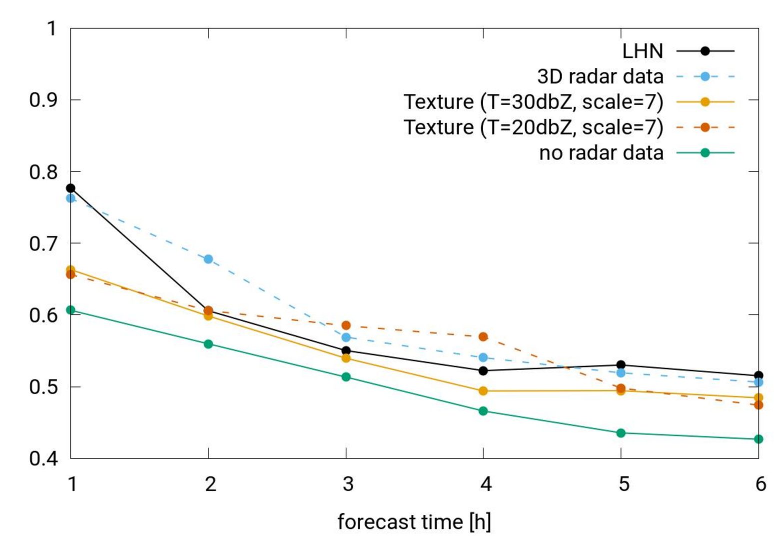

Fig.7: FSS (25 grid points) for precipitation>2mm/h of deterministic forecasts [4 days, 17 UTC runs].

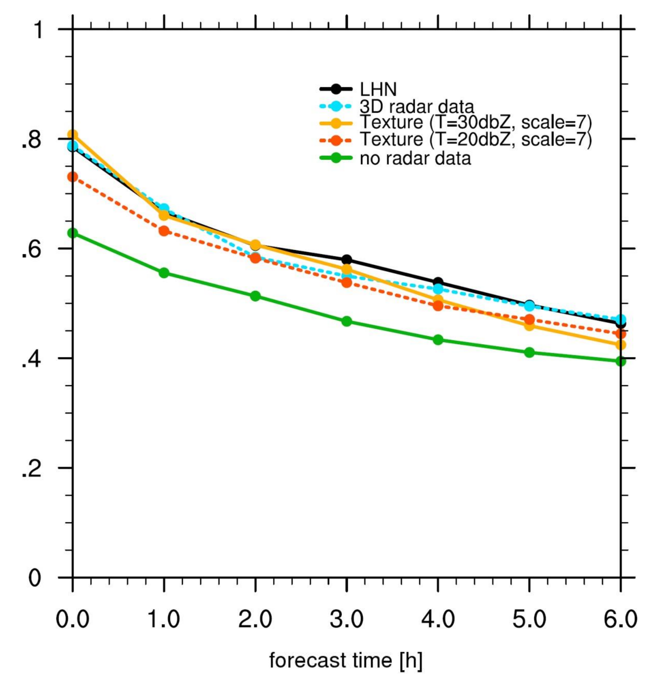

Fig.5: FSS (21 grid points) of deterministic forecasts for reflectivity>30 dbZ [4 days, hourly between 10-18 UTC].

Stephan2008: K. Stephan et al, Q.J.R. Meteorol. Soc. **134**:1315-1326 (2008) „Assimilation of radar-derived rain rates into the convective-scale model COSMO-DE at DWD"
Schraff2016: C. Schraff et al, Q.J.R. Meteorol. Soc. **142**: 1453-1472 (2016) „Kilometre-scale ensemble data assimilation for the COSMO model (KENDA)"
Zeng2016: Y. Zeng et al, Q.J.R. Meteorol. Soc., **142**: 3234-3256 (2016) „An efficient modular volume-scanning radar forward operator for NWP models: description and coupling to the COSMO model"
Bick2016: T. Bick et al, Q.J.R. Meteorol. Soc., **142**: 1490-1504 (2016), „Assimilation of 3D Radar Reflectivities with an Ensemble Kalman Filter on the Convective Scale"

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