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DWD

# The Impact of Data Assimilation Length Scales On Analysis and Prediction of Convective Storms


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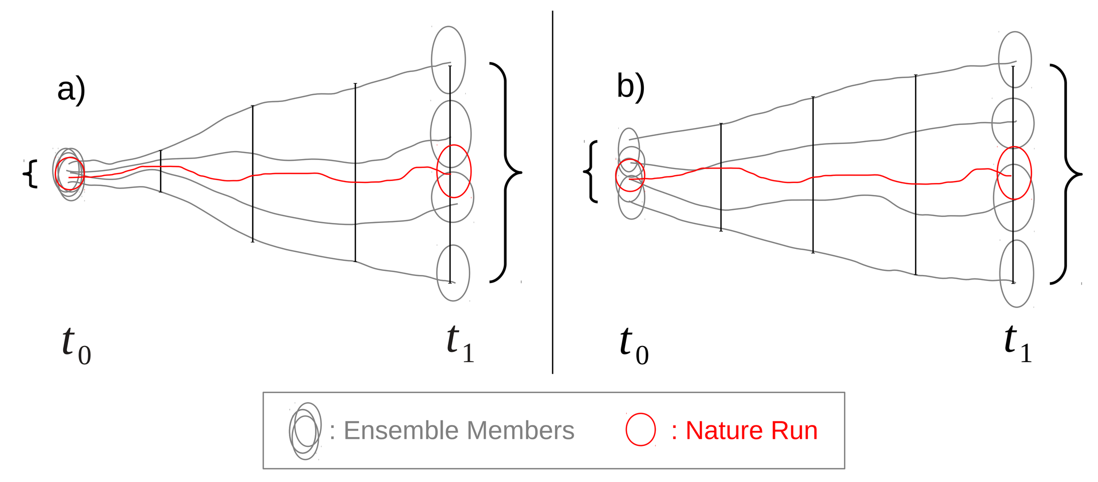
## 1 LIMITED PREDICTABILITY

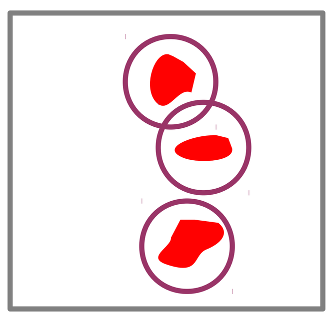
due to nonlinear error growth in time $t$:




Is an ensemble forecast (a) from a fine analysis *more precise than* (b) from a coarse analysis?

## 2 ANALYSIS SCHEMES

**Nature Run:** *convective system* consisting of multiple *convective cells*



**a) Fine Analysis L8:** linear combination of forecast members whose *single convective cells* fit the observations *locally*

**b) Coarse Ana. L32SOCG20:** linear combination of forecast members whose larger scale *convective systems* fit the observations roughly, on a coarser scale

## 3 CONVECTIVE SETUP

**Nature Run and Ensemble (COSMO):**

- 400 x 400 km, $\Delta x = 2$ km
  periodic lateral BC
- Random storm positions, triggered by noise and radiative forcing
- CAPE = 2200 J/kg
- storm lifetimes $\geq$ 6 hours

**Simulated Doppler-Radar Observations:**

- $U$-wind, masked to Reflectivity
- Reflectivity, no-Reflectivity

## 4 LETKF-SETUP

**DWD implementation [2] in KENDA**
(Kilometer-scale ENsemble Data Assimilation)

- 50 Ensemble Members
- Localization of obs. error cov. matrix $\mathbf{R}$
- Analysis grid on model resolution, optionally coarsened analysis grid with interpolation of analysis weights afterwards
- Hydrostatic relaxation of increments

## 5 LENGTH SCALES OF THE ANALYSIS SCHEMES

| | |
|---|---|
| Localization Radius | $r_{Loc,h}$ |
| Observation Resolution | $\Delta x_{obs}$ |
| Analysis Grid Resolution | $\Delta x_{ana}$ |
| Assimilation Interval | $\Delta t_{ass}$ |
| Covariance Localization | L8, L32 |
| SuperObservation | SO |
| CoarseGrid (Analysis) | CG |
| Cycling Interval Minutes | (5), 20 |

| Experiment: | $r_{Loc,h}$ (km) | $\Delta x_{obs}$ (km) | $\Delta x_{ana}$ (km) | $\Delta t_{ass}$ (min) |
|---|---|---|---|---|
| **L8** | 8 | 2 | 2 | 5 |
| L8SO | 8 | 8 | 2 | 5 |
| L8SOCG | 8 | 8 | 8 | 5 |
| L8SOCG20 | 8 | 8 | 8 | 20 |
| L32 | 32 | 2 | 2 | 5 |
| L32SO | 32 | 8 | 2 | 5 |
| L32SOCG | 32 | 8 | 8 | 5 |
| **L32SOCG20** | 32 | 8 | 8 | 20 |

## 6 ANALYSIS AND FORECAST ENSEMBLE PRECISION

L32SOCG20 allows errors on small scales:

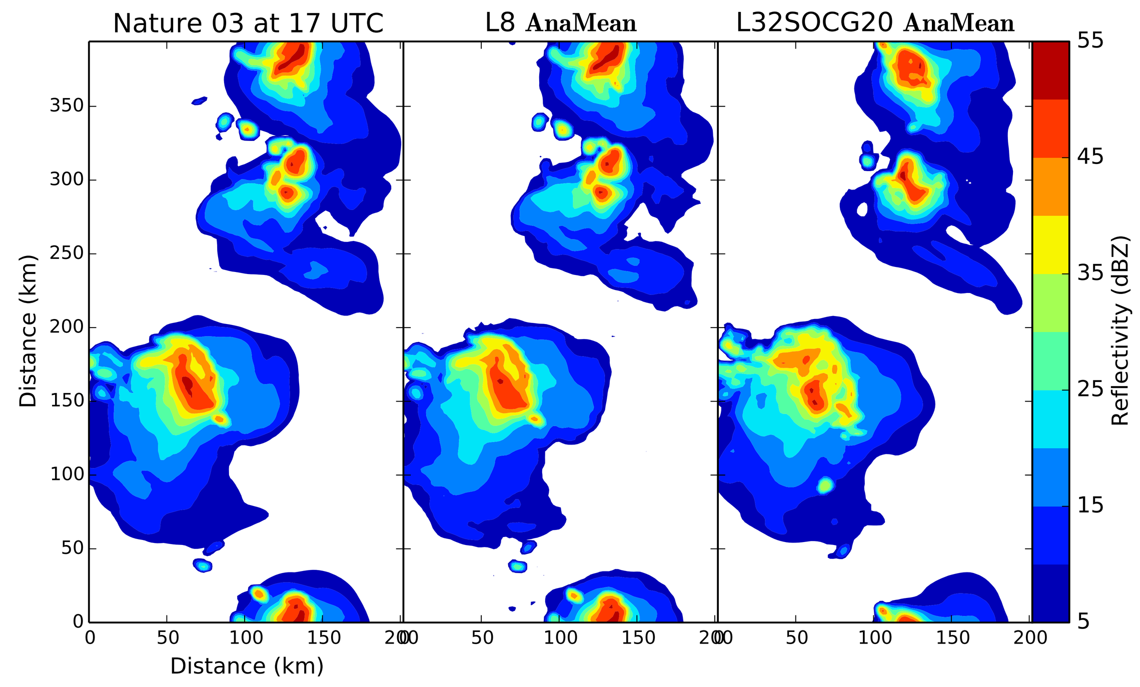



**Figure 1:** Nature Run and Analysis Ensemble Means of L8 and L32SOCG20 after 3 hrs of cycled LETKF assimilation (last analysis)

L8 spreads rapidly due to dynamical imbalances:

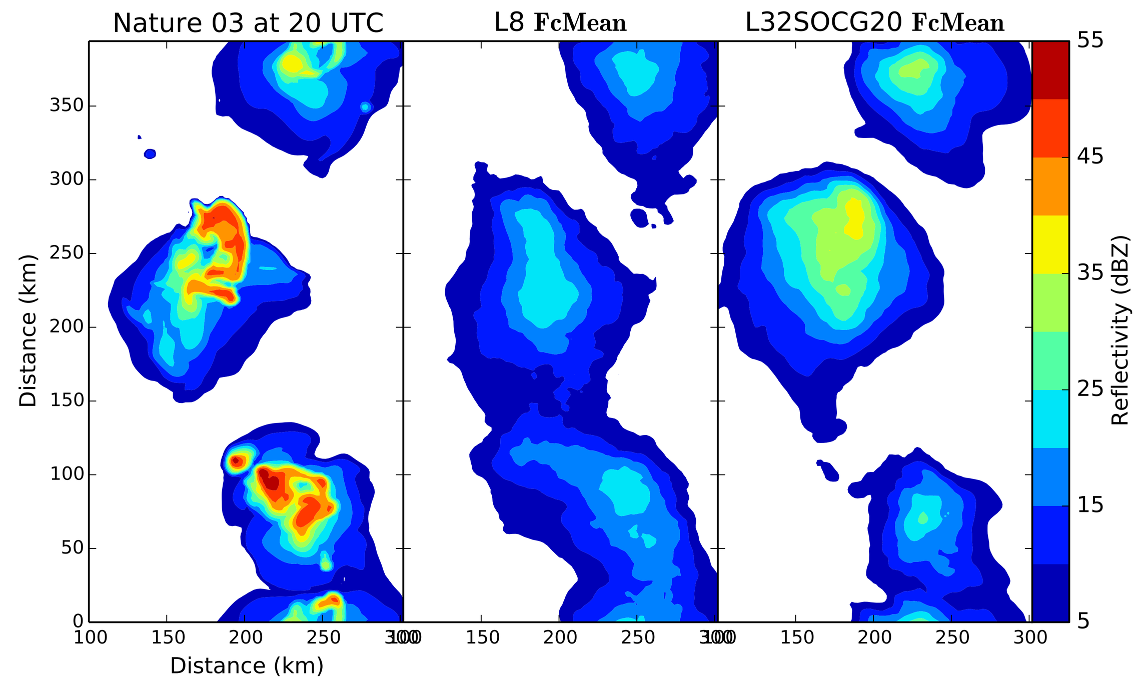
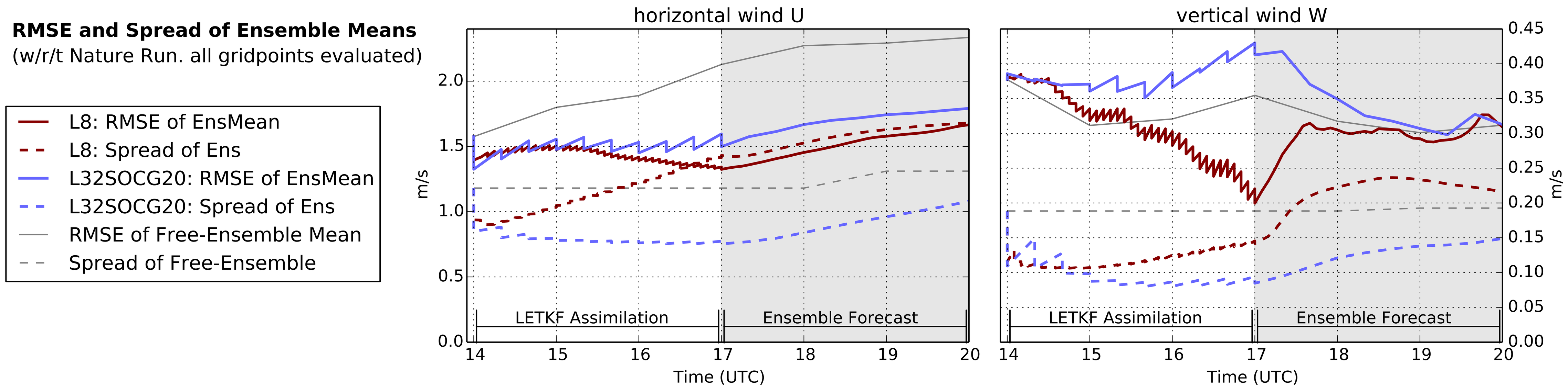



**Figure 2:** Nature Run and Forecast Ensemble Means of L8 and L32SOCG20 after 3 hrs of free ensemble forecast (initialized from last analysis)

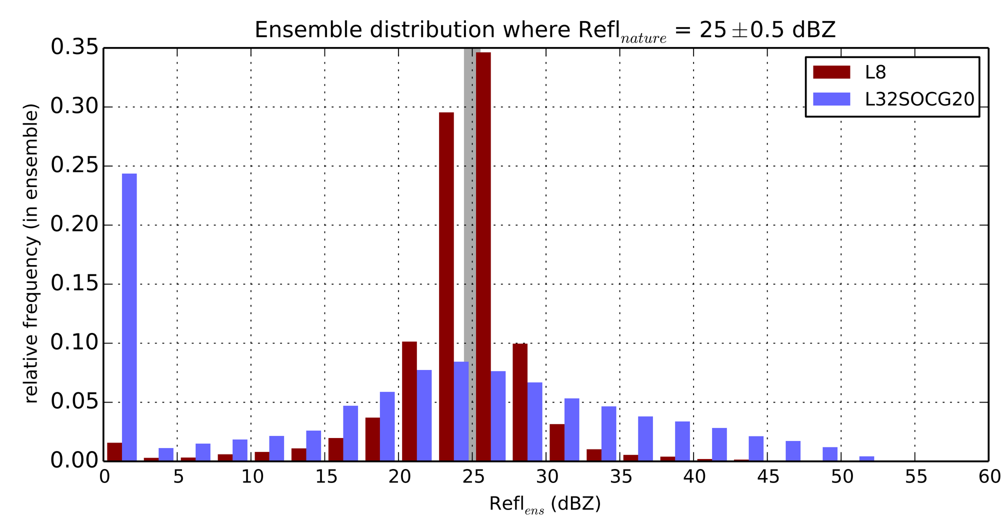
## 7 ANALYSIS AND FORECAST RMSE

High resolution analysis L8 gives major improvement in the analysis of *W* since the field is dominated by fine-scale updraft structures, but the advantage in precision is lost within 1-3 hrs of forecast:




## 8 ANALYSIS DISTRIBUTIONS

Strongly non-Gaussian rain-distribution of coarse analysis approximates climatology:




Analysis ensemble values at precipitation cores of the Nature Run at 17 UTC (last analysis, cf. Fig. 1)

## 9 CONCLUSIONS

For convective forecasts beyond 3 hrs, the highest possible analysis precision might not be necessary or helpful due to

- limited intrinsic and practical predictability
- dynamical imbalances due to rigorous filter convergence, causing spurious convection

## REFERENCES


[1] H. Lange and G. C. Craig (2014): The Impact of Data Assimilation Length Scales on Analysis and Prediction of Convective Storms. Submitted to MWR.

[2] Hunt, B. R., Kostelich, E. J., and Szunyogh, I. (2007): Efficient Data Assimilation for Spatiotemporal Chaos: A Local Ensemble Transform Kalman Filter. Physica D, 203:112-126

[3] Aksoy, A., Dowell, D. C., and Snyder, C. (2009). A Multicase Comparative Assessment of the EnKF for Assimilation of Radar Observations. Part I: Storm-Scale Analyses. MWR, 137:1805-1824.