LETKF: Precision and Predictability

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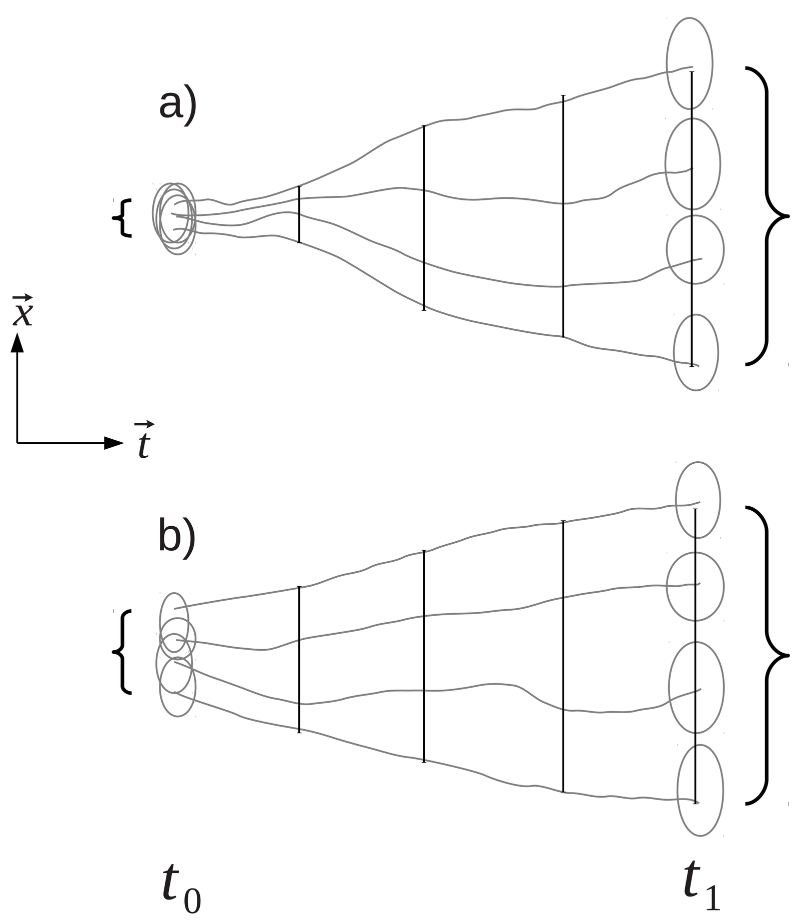
1) Limited Predictability

due to nonlinear error growth in time t:

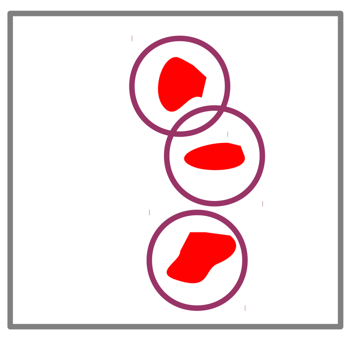


Question:

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

2) Analysis Precision

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



a) Fine Analysis R4:
linear combination of forecast members whose *single convective cells* fit the observations locally well

b) Coarse Analysis R16:
linear combination of forecast members whose larger scale *convective systems* fit the observations roughly, on a coarser scale

Idealized 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 ∼ 6 hours

Simulated Doppler-Radar Observations:

- U-wind (∼ radial wind)
- Reflectivity, 0-dBZ-Reflectivity

LETKF-Setup

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

- 50 Ensemble Members
- Localization of obs. error cov. matrix **R**
- Analysis grid on model resolution, optionally coarsed analysis grid with interpolation of analysis weights afterwards
- Hydrostatic relaxation of increments

2a) Fine Analysis R4

Filter settings for fine analysis:

1. High-resolution (2 km) radar-observations
2. 4-km **R**-localization length scale (cutoff at 14 km), fine analysis grid
3. **R**-inflation factor 4
4. 5 minute assimilation interval

Fine analysis properties:

- Collapse of ensemble onto observed storms
- No spurious clouds
- Small error and variance

2b) Coarse Analysis R16

Filter settings for coarse analysis:

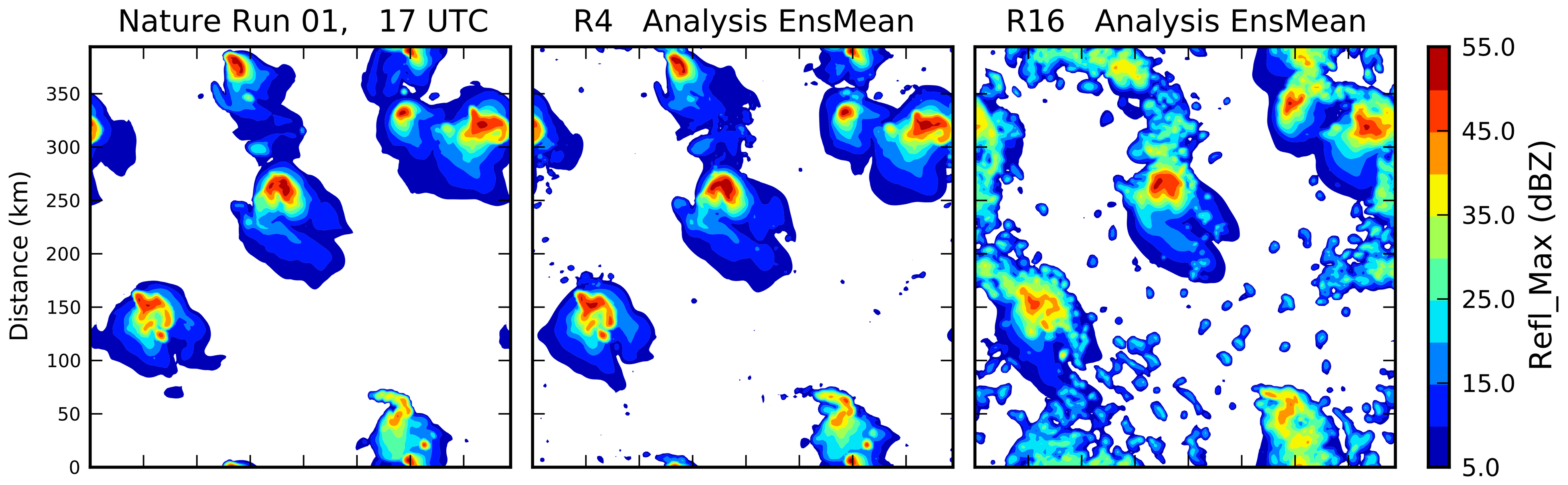
1. Coarse-grained (8 km) radar-observations
2. 16-km **R**-localization length scale (cutoff at 58 km), coarse analysis grid
3. **R**-inflation factor 16
4. 20 minute assimilation interval

Coarse analysis properties:

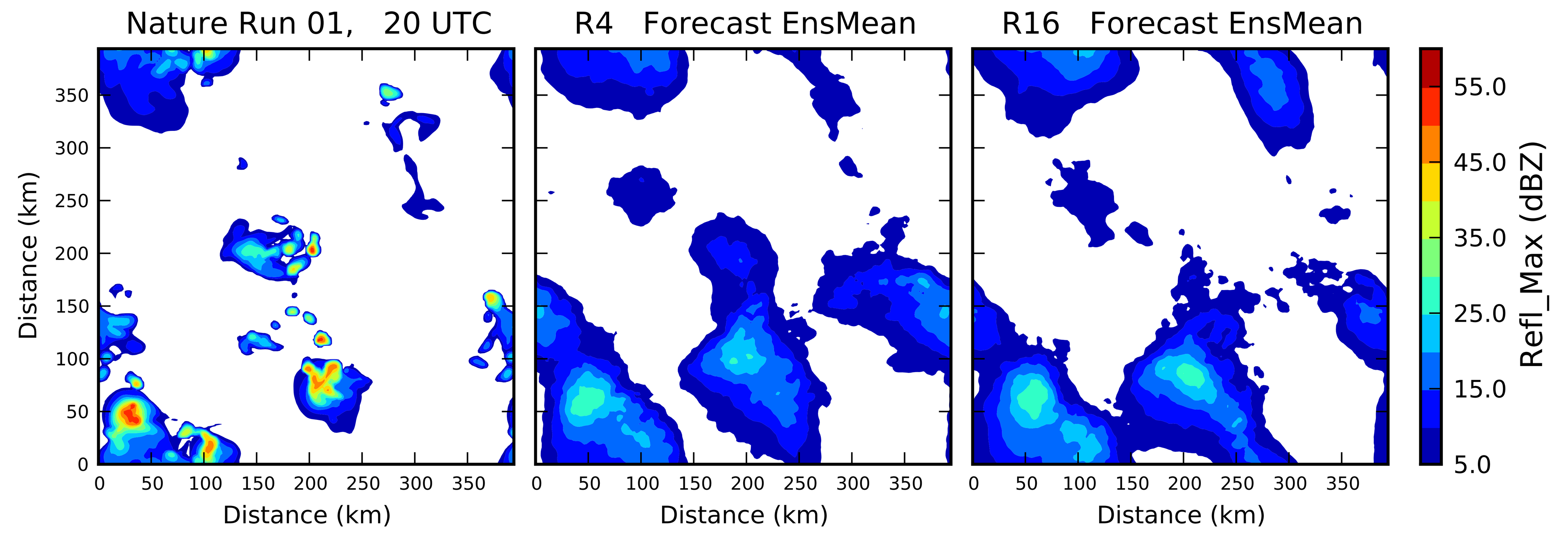
- Position of storms roughly correct
- Spurious clouds allowed
- Larger error and variance

3) Results: Nature vs. Analysis and Forecast Ensemble Means

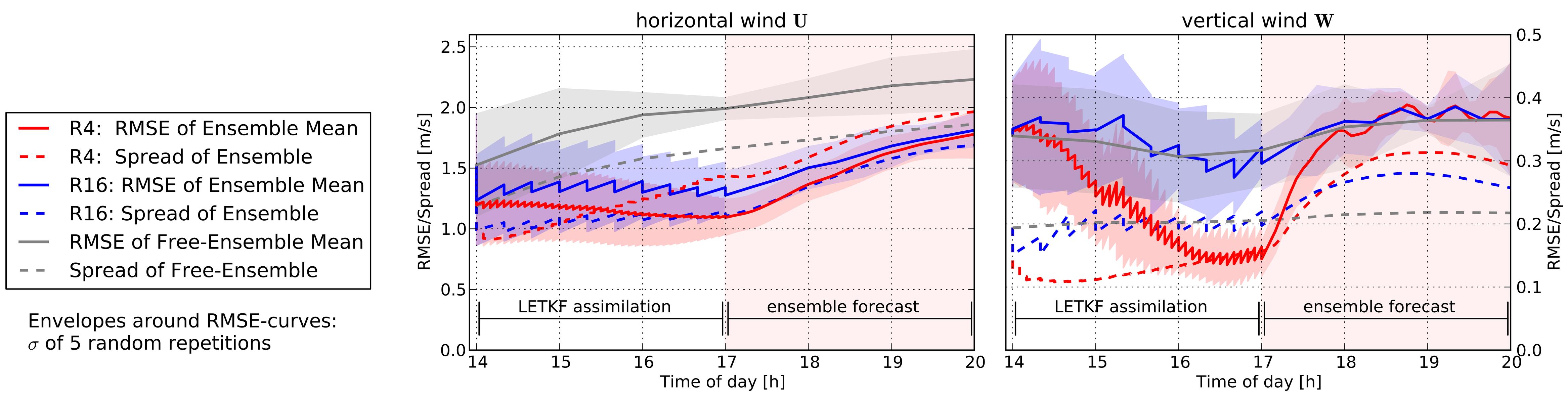
After 3 hours of cycled LETKF-assimilation (14 - 17 UTC):



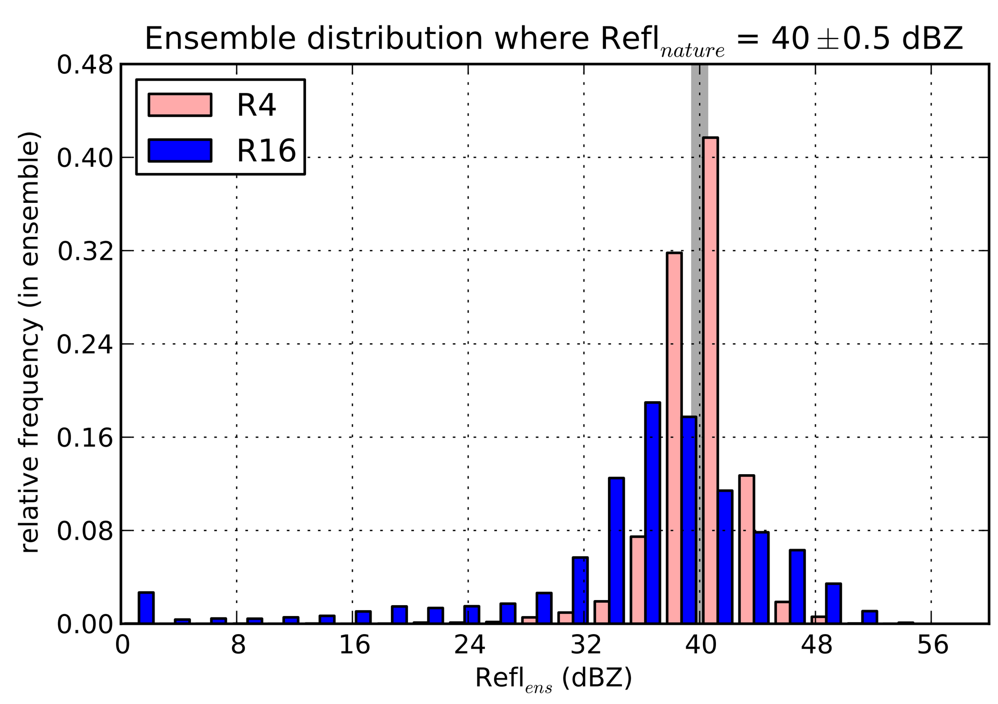
Followed by 3 hours of ensemble forecast (17 - 20 UTC):



4) Analysis and Forecast RMSE



5) Analysis Distributions



Analysis ensemble values in precipitation cores of the Nature Run 01 at 17 UTC (cf. Box 3)

6) Conclusions

- Analysis precision advantage of R4 is lost within 1-3 hours compared to R16
- **For convective forecasts beyond 3 hours, the highest possible analysis precision might not be necessary or helpful due to the limited predictability**

References

[1] H. Lange and G. C. Craig (2013): On the Benefits of a High-Resolution Analysis for Convective Data Assimilation of Radar Observations using a Local Ensemble Kalman Filter. In prep. for 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