COSMO-KENDA for idealized Radar-OSSES, MODE-S and COSMO-MUC

Heiner Lange, George C. Craig, Tijana Janjic-Pfander

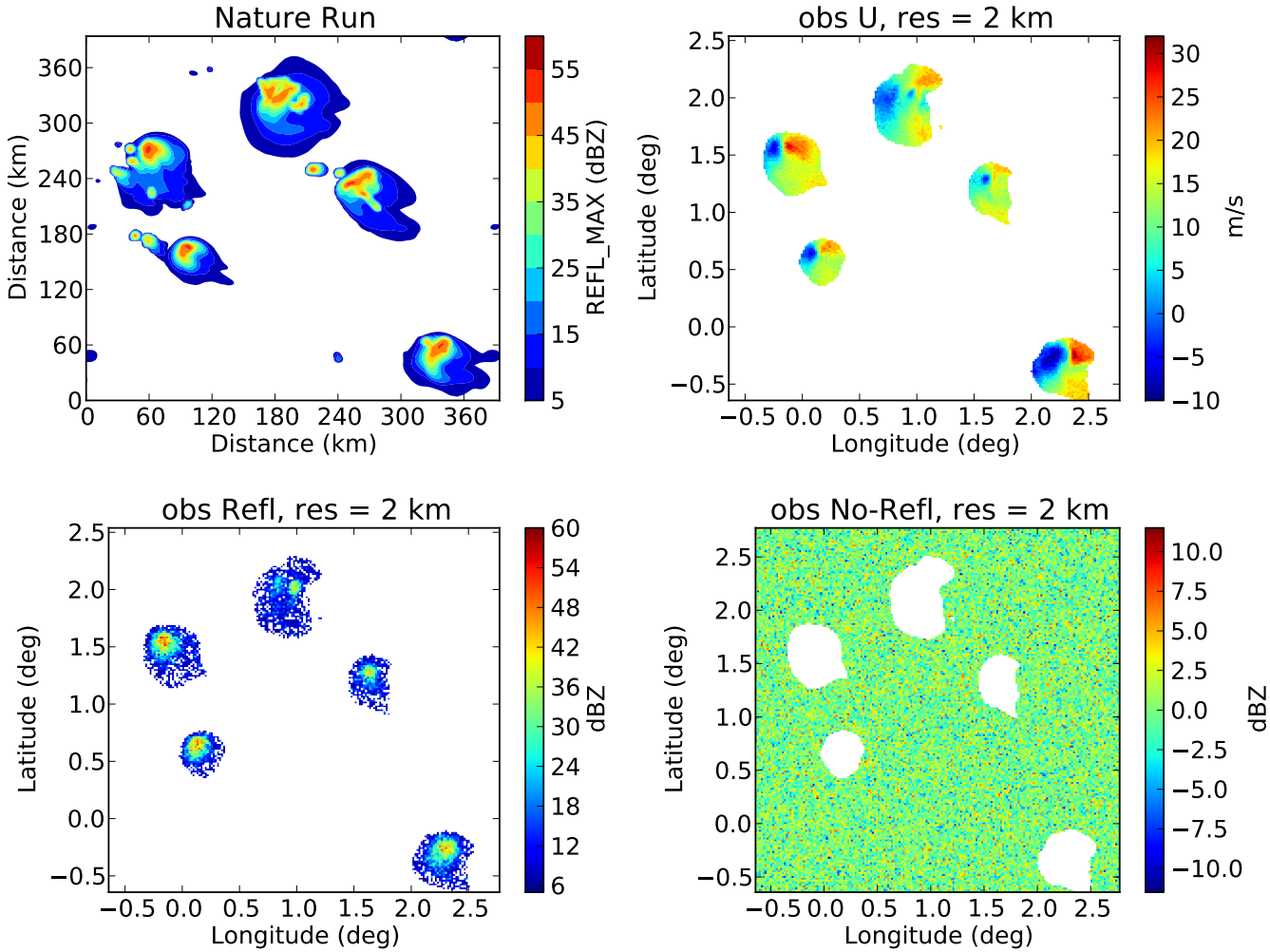
Hans-Ertel-Centre for Weather Research, Data Assimilation Branch

KENDA Workshop at ISDA Munich, 26.02.2014

Outline

Synthetic Observations

t = 14:00, $z_{synthobs}$ = 11500.0 m



LETKF-Setup

Assimilation setup

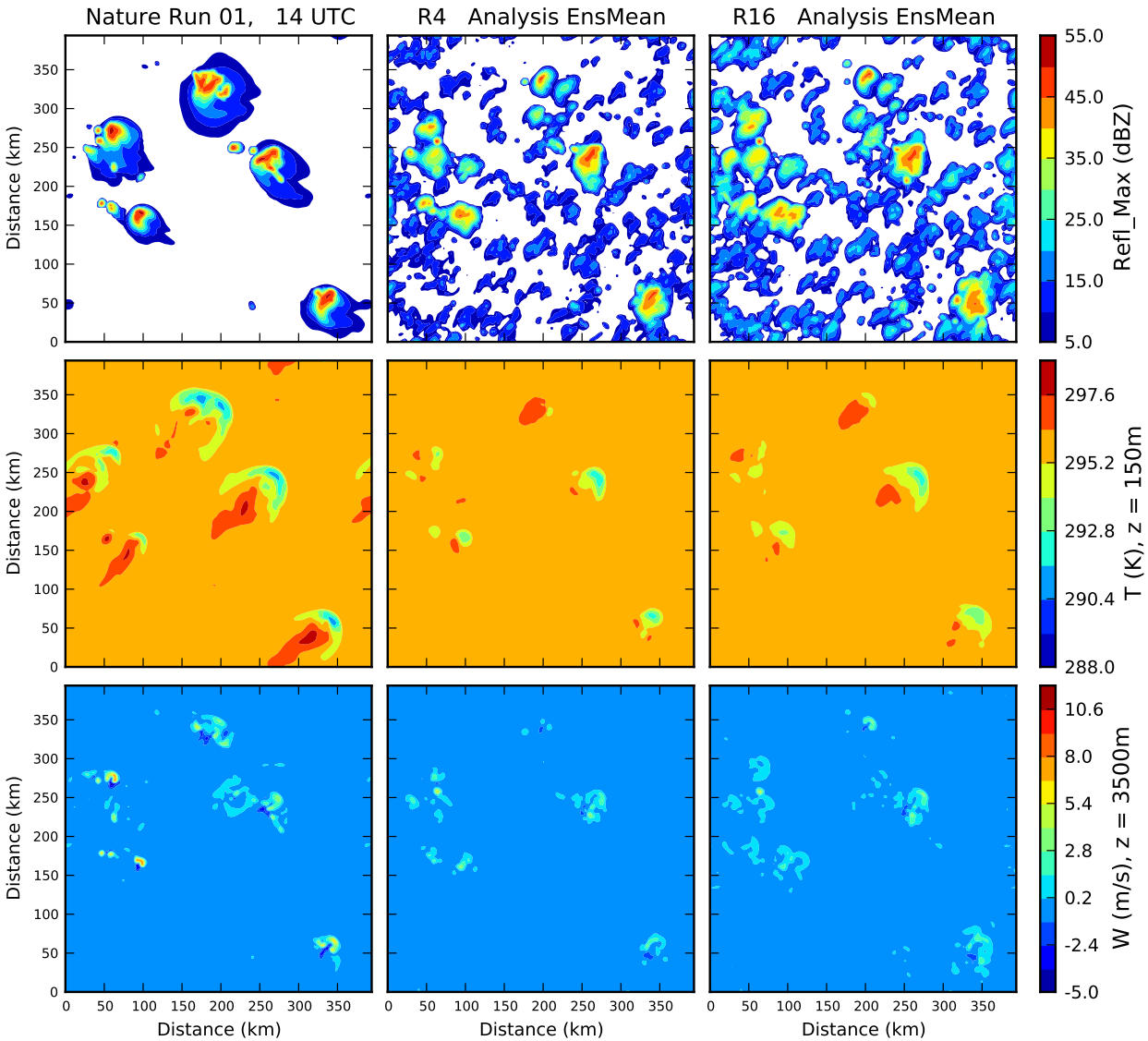
- 50 member ensemble (perfect model)
- simulated observations of *radial wind* and *(no)-reflectivity*
- periodic LETKF-solution
- `Python`-cycling environment

LETKF-Setup

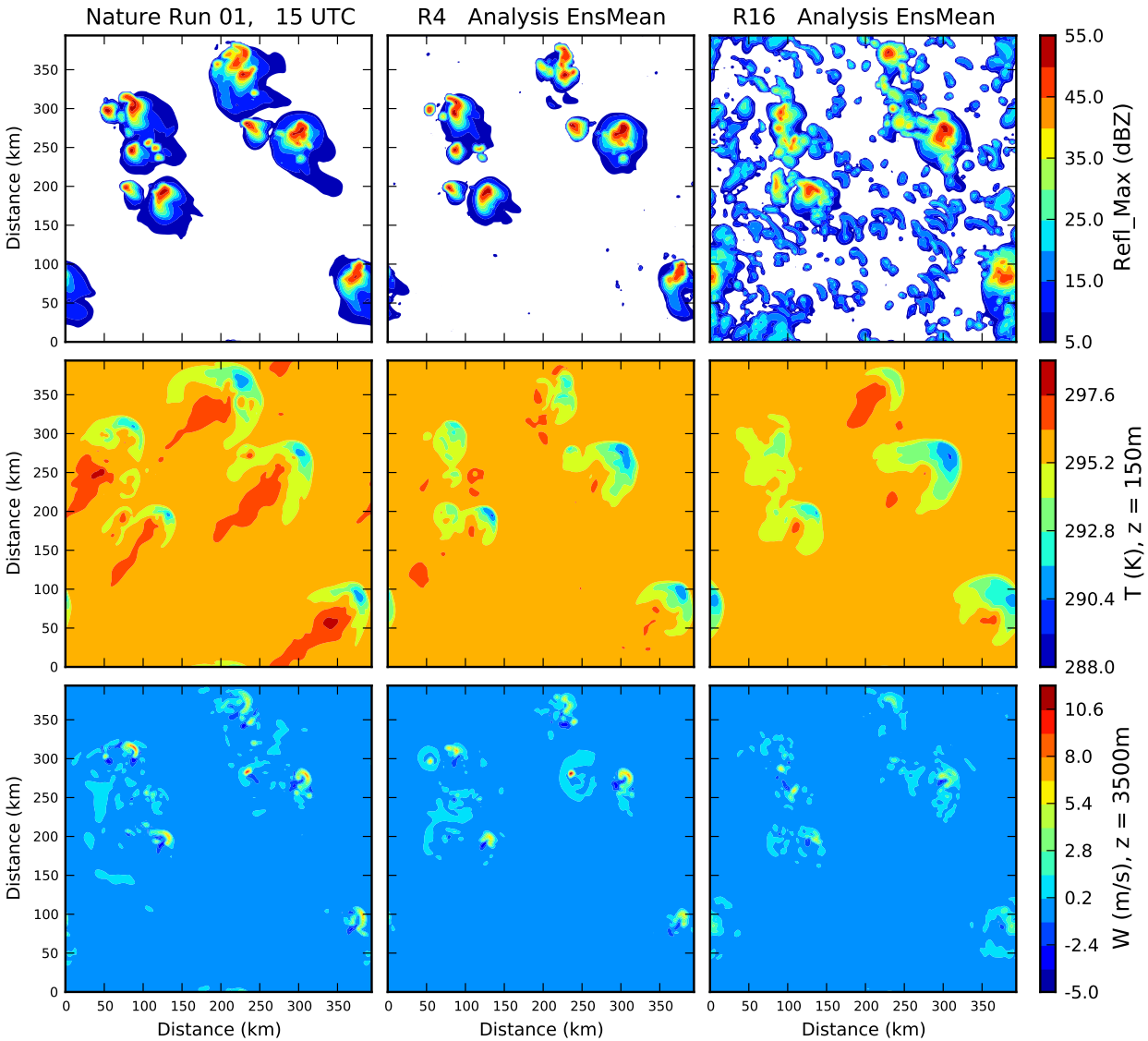
Assimilation setup

- 50 member ensemble (perfect model)
- simulated observations of *radial wind* and *(no)-reflectivity*
- periodic LETKF-solution
- `Python`-cycling environment
- 3 hours cycled assimilation
- 3 hours ensemble forecast

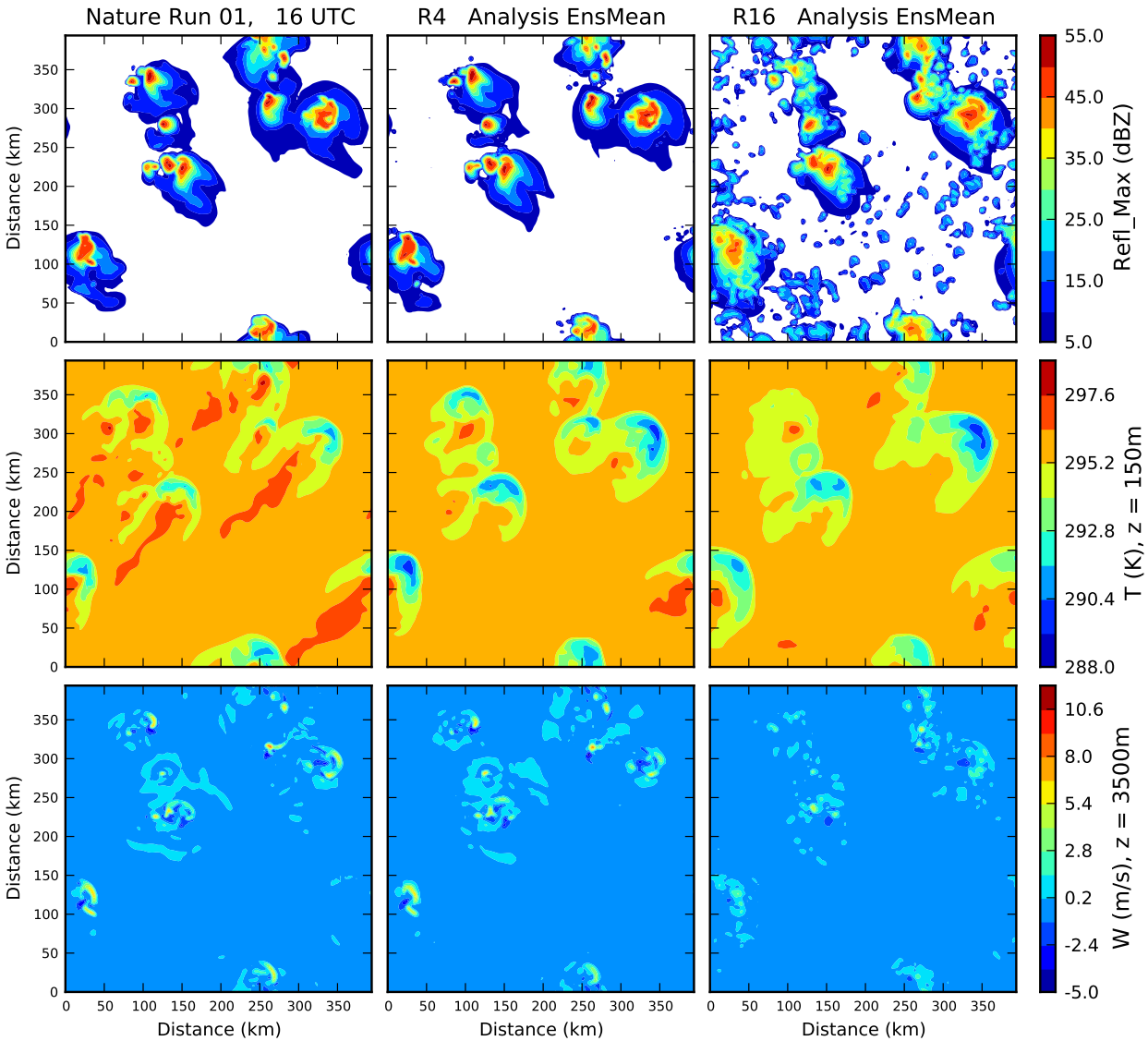
Assimilation Results: Nature vs. Analysis Ensemble Means



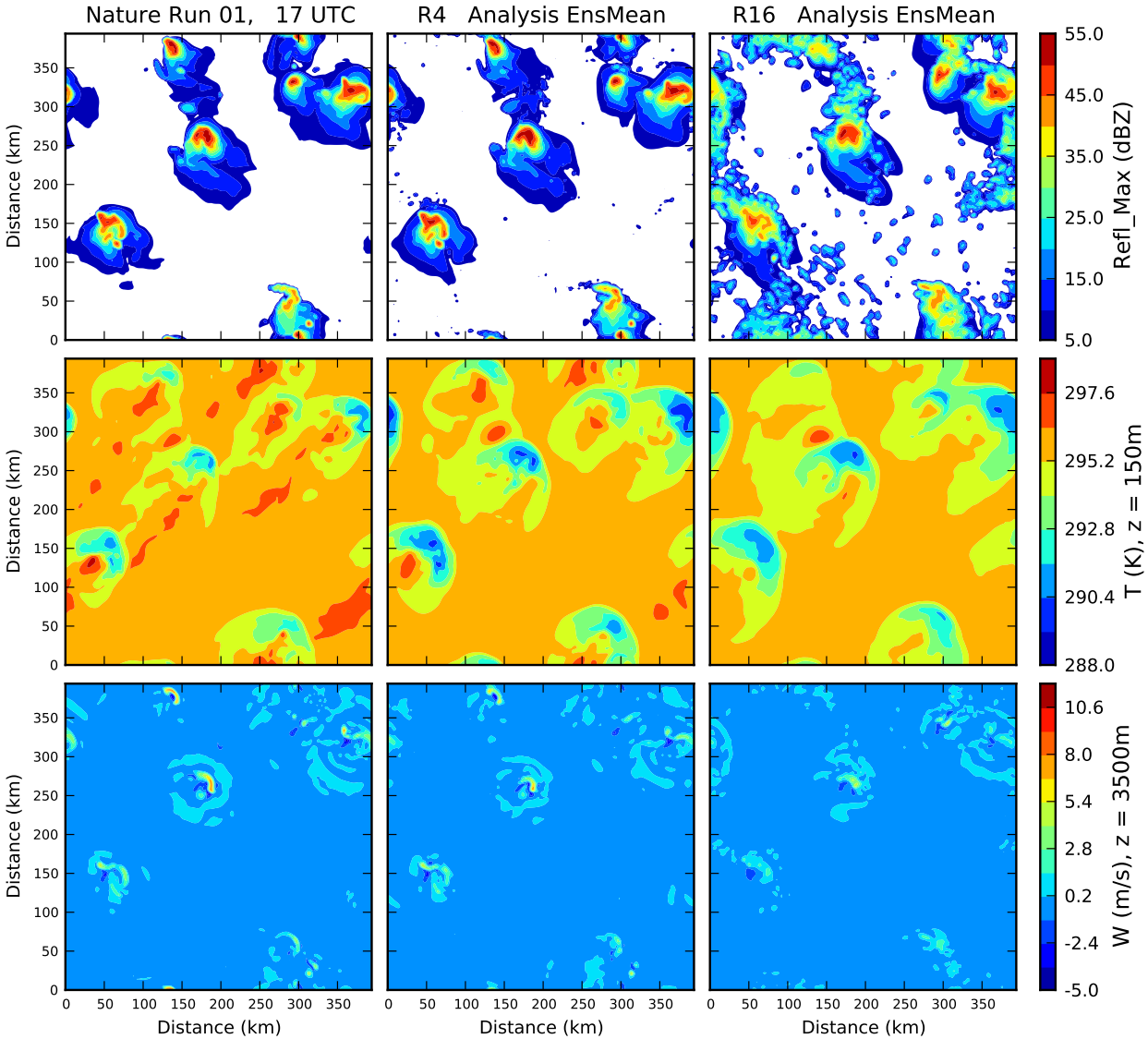
Assimilation Results: Nature vs. Analysis Ensemble Means



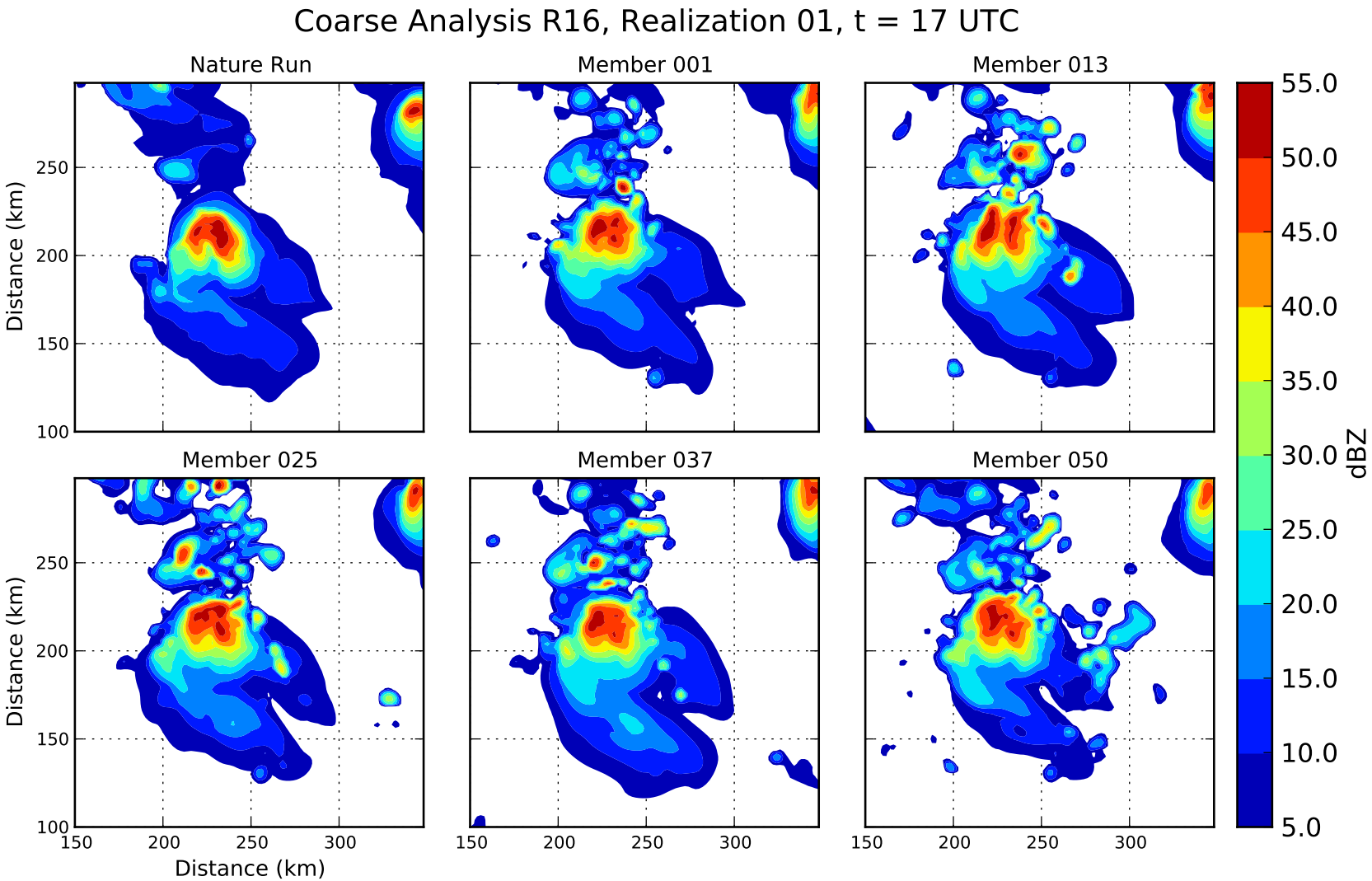
Assimilation Results: Nature vs. Analysis Ensemble Means



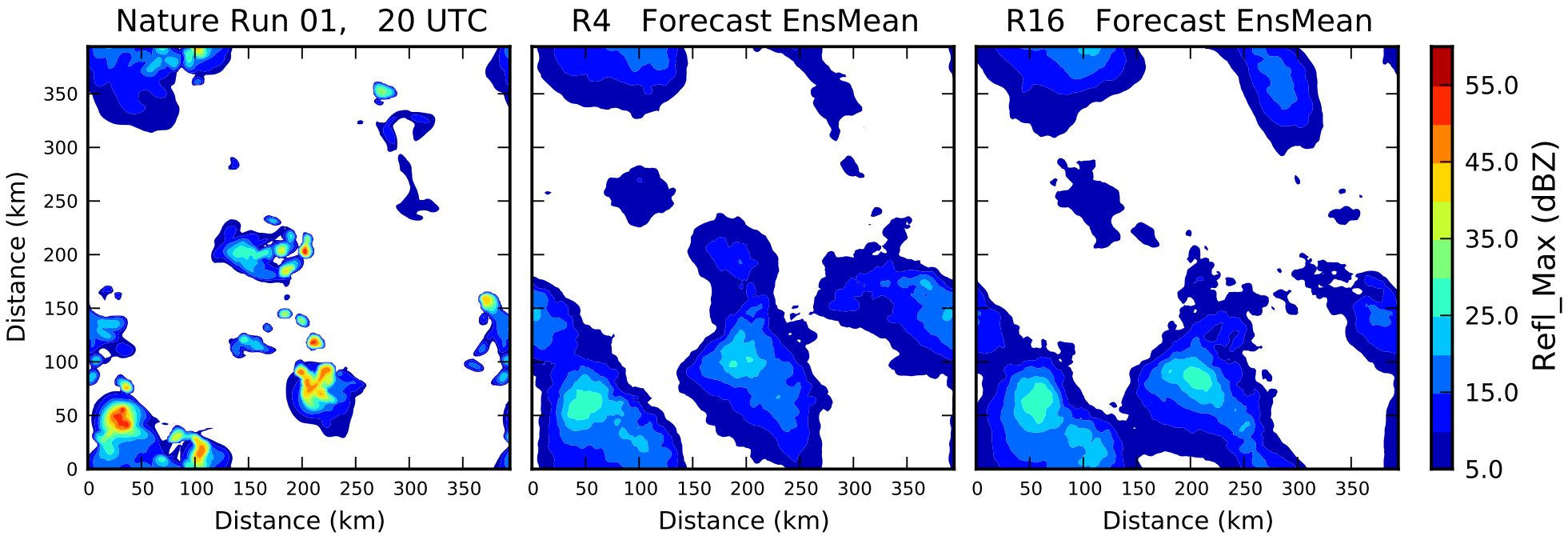
Assimilation Results: Nature vs. Analysis Ensemble Means



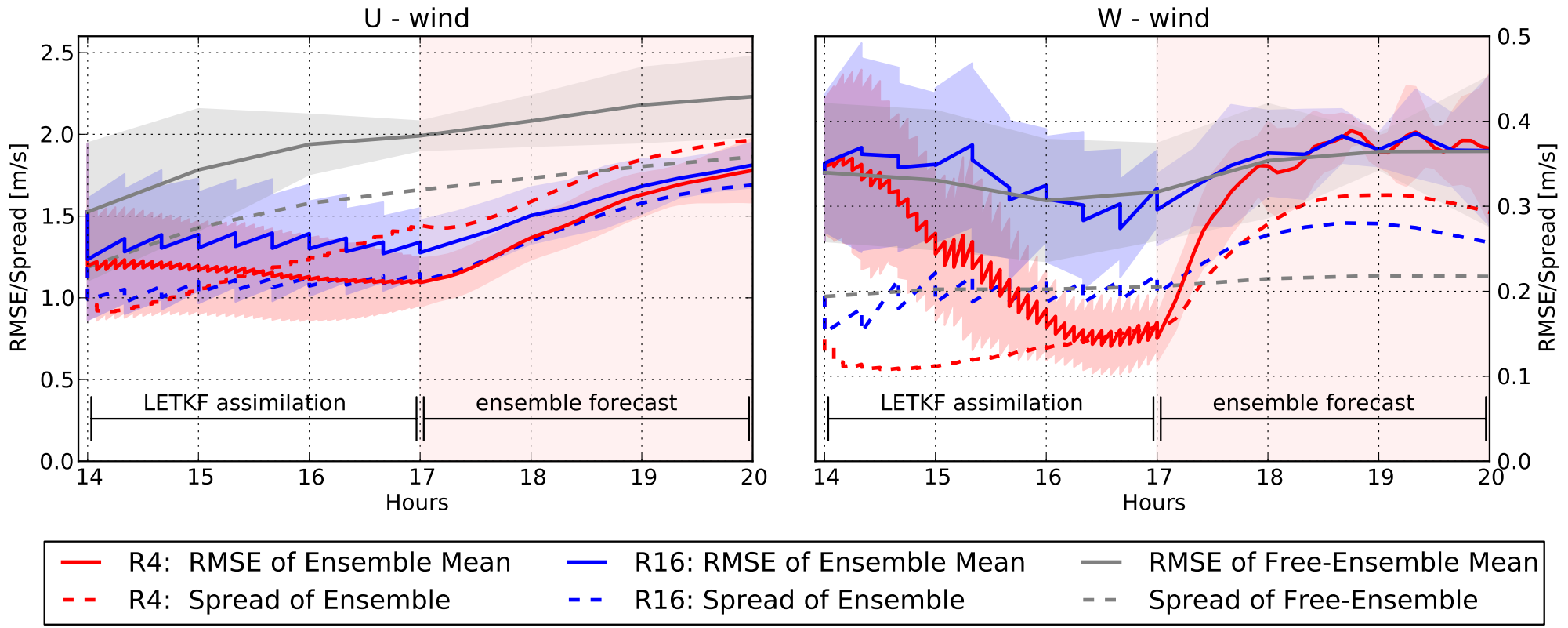
Analysis Members R16



Forecast Results: Nature vs. Forecast Ensemble Means



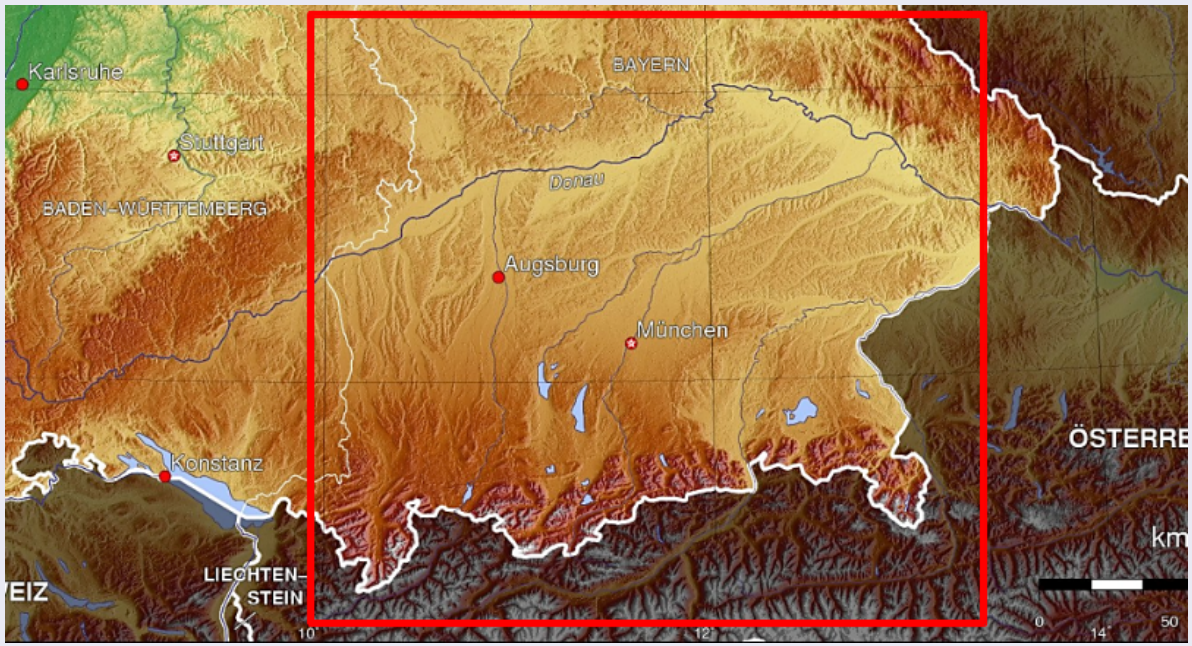
RMSE-Statistics: U, W



COSMO-MUC

COSMO-MUC Development: *Ingo Soelch* (DLR Oberpfaffenhofen)

COSMO-MUC Domain:



COSMO-MUC

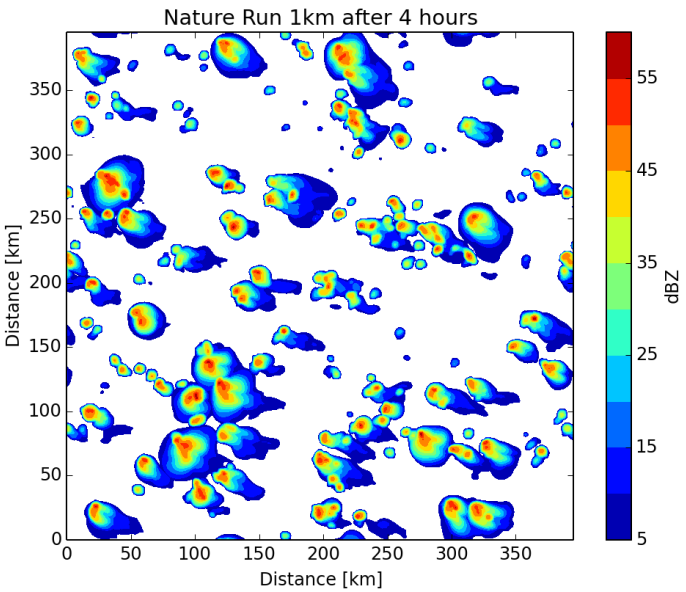
COSMO-MUC: Convective Forecasts for Munich Airport

- resolution $\Delta x = 1$ km resolves finer orography
- representation of even more non-linear physics
- *challenge for highly resolved and balanced Data Assimilation*

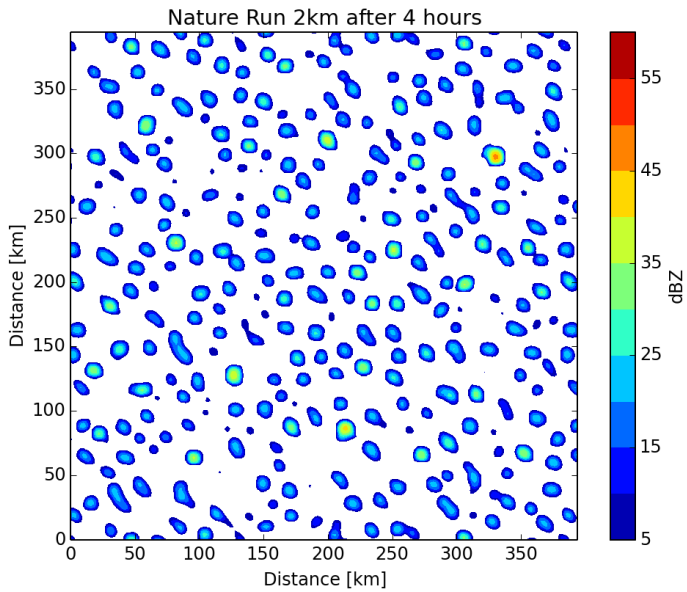
1 km Physics vs. 2 km Physics

Faster spin-up and smaller updraft structures with $\Delta x = 1$ km:

$\Delta x = 1$ km, 4 hours



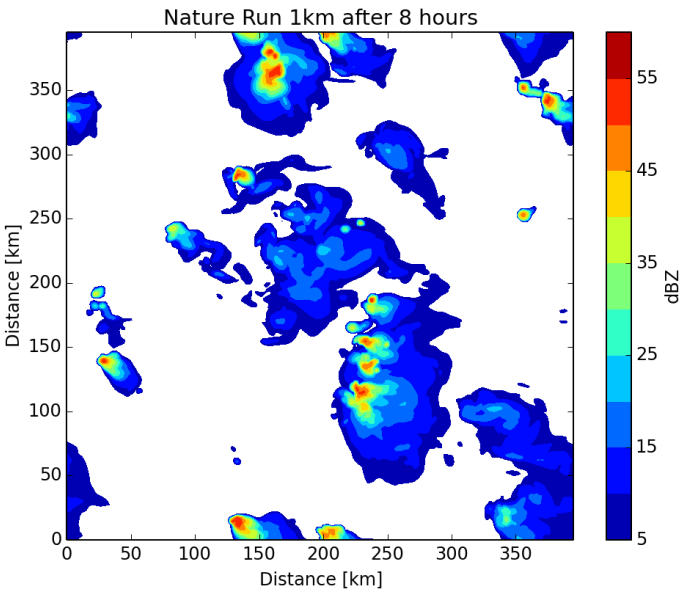
$\Delta x = 2$ km, 4 hours



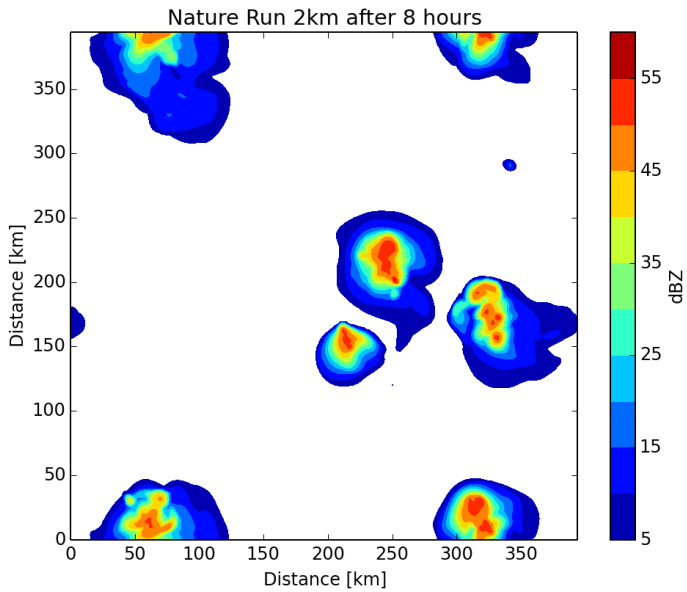
1 km Physics vs. 2 km Physics

Faster spin-up and smaller updraft structures with $\Delta x = 1$ km:

$\Delta x = 1$ km, 8 hours



$\Delta x = 2$ km, 8 hours



Constraints on energy and balance in LETKF

Problems:

Analysis increments from localized LETKF may cause

- biases (e.g. QR due to positivity-post-processing)
- imbalances ($\frac{dp}{dz}$)
- dynamical inconsistencies (p' and W)

Evaluation and solutions

- constrain preservation of total humid mass in LETKF
- compare analysis states with spun-up model state for
  - hydrostatic balance
  - vertical accelerations and pressure perturbations
  - spectral energy components and gravity waves

COSMO-MUC Data Assimilation

COSMO-MUC with **Nudging** (Ingo Soelch at DLR)

- 1 deterministic forecast
- model state variables are drawn towards observations

COSMO-MUC-**KENDA** (Heiner Lange, PhD)

- ensemble data assimilation system with ≈ 50 members
- LETKF setup as in COSMO-DE

COSMO-MUC Ensemble

COSMO-MUC Ensemble (working on testcases) needs

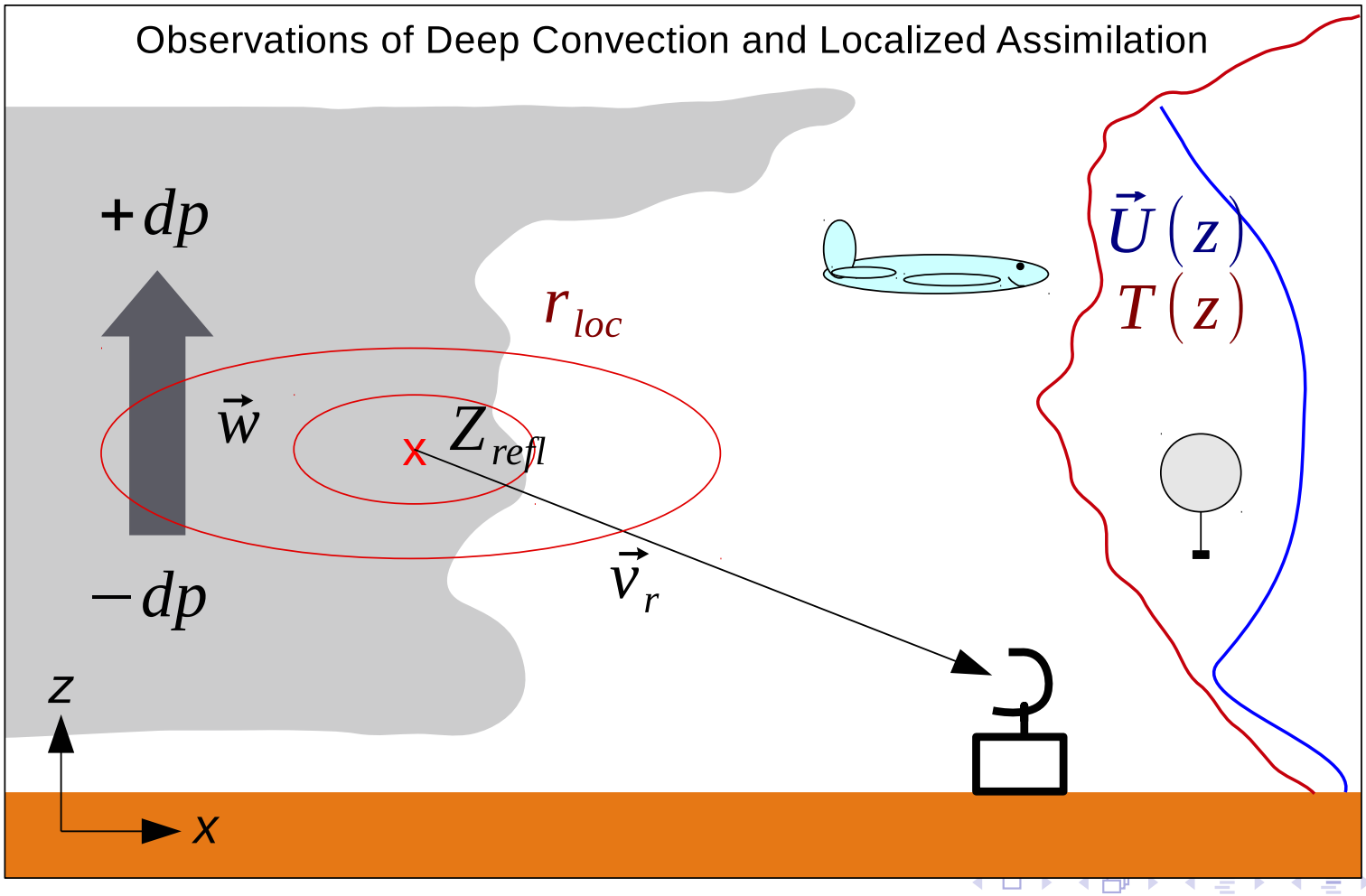
Boundary Conditions

possible sources:

- COSMO-DE-KENDA
- COSMO-DE-EPS
- GME ensemble
- ECMWF ensemble

$\rightarrow$ *huge data amount with rapid updates!*

Localized Convective Assimilation



Localization and SuperObservations

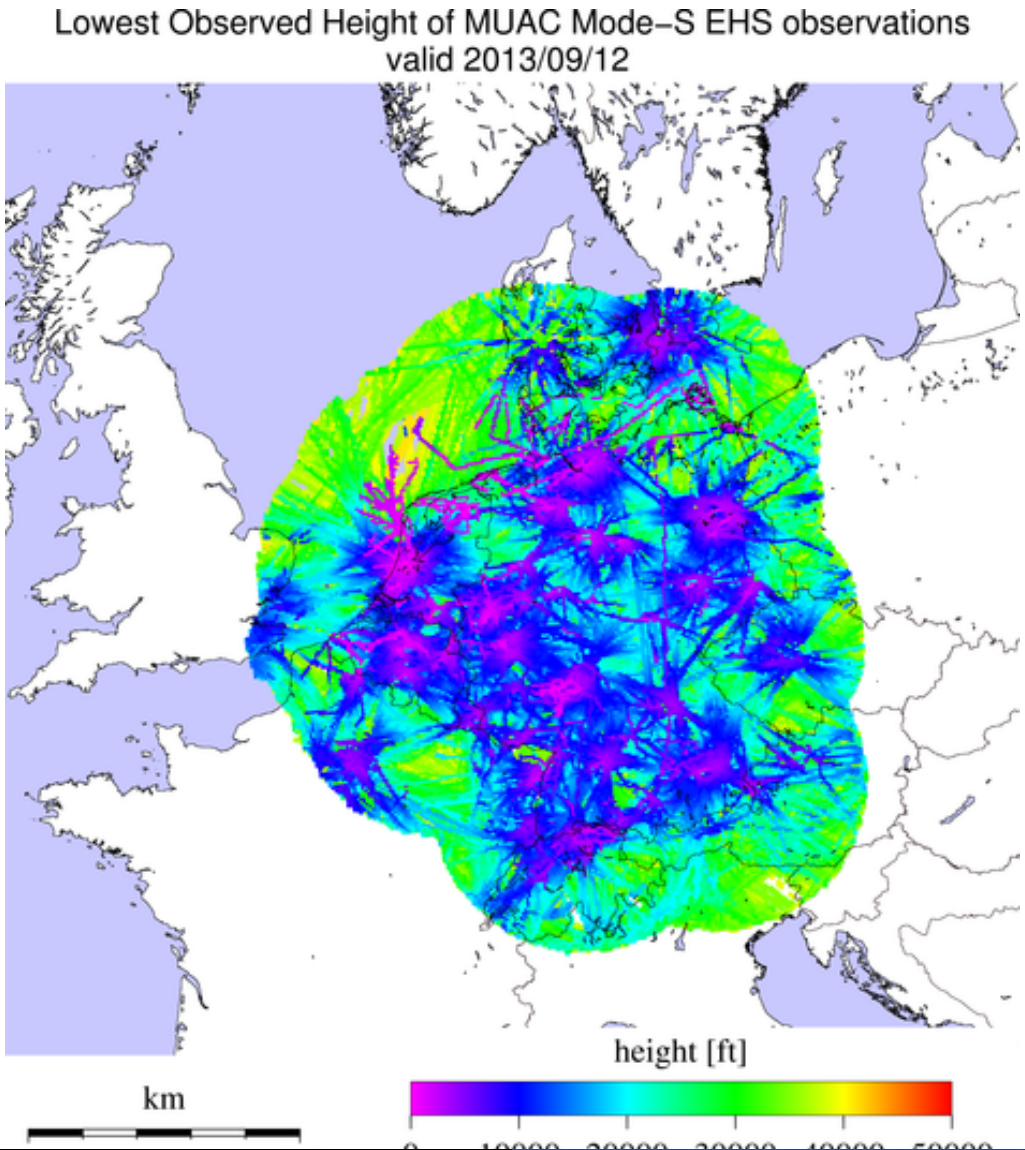
Localization

- short localization lengths for radar observations
- long localization lengths for conventional observations
- adaptive localization?

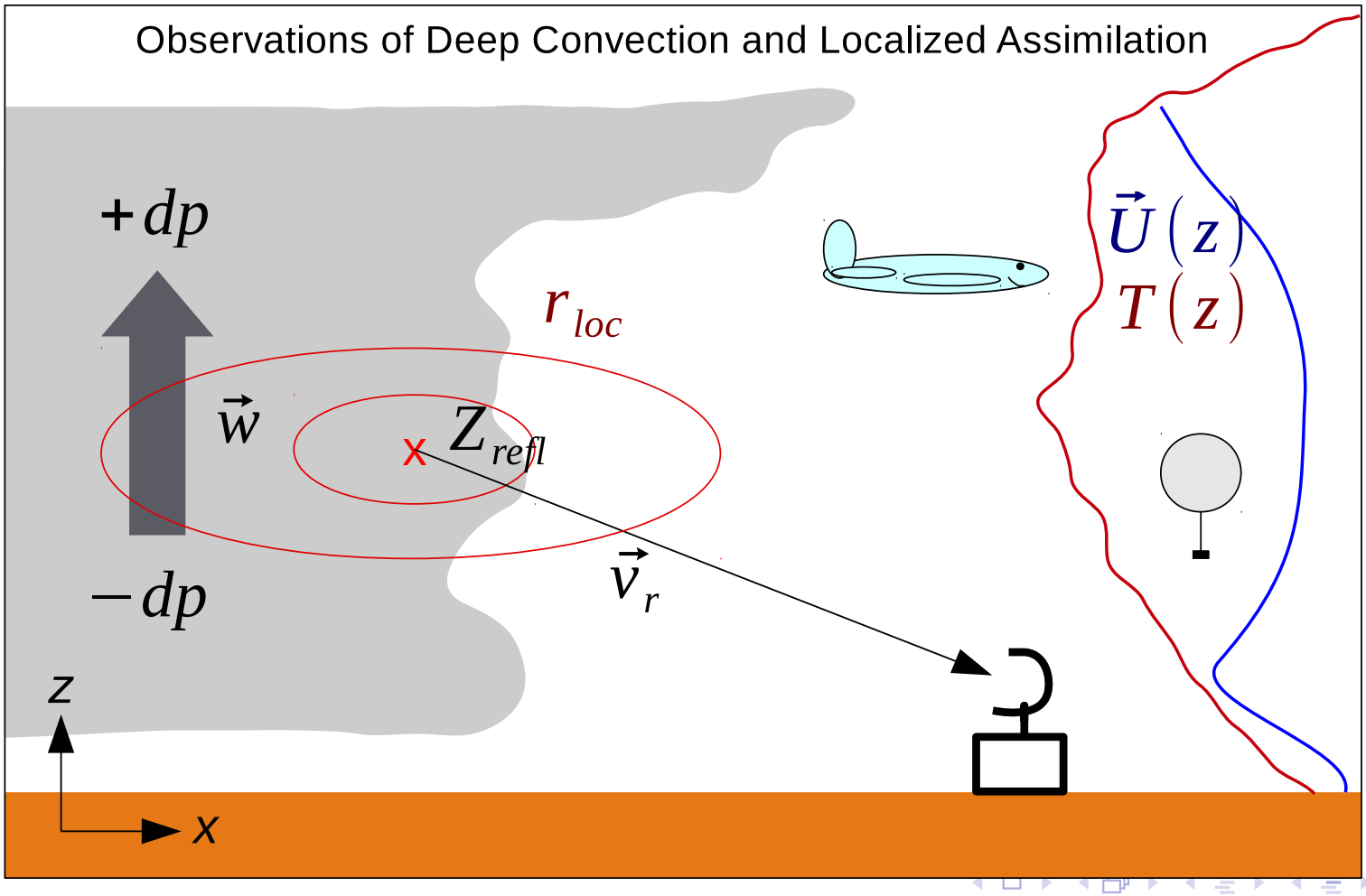
Observation treatment

- adapt observation error in **R** to ensemble spread
- *thinning* and *superobservations* for
  - MODE-S
  - radar observations

MODE-S


Lowest Observed Height of MUAC Mode−S EHS observations
valid 2013/09/12
height [ft]
km

Localized Convective Assimilation



Nature Run and Ensemble

COSMO model setup

Domain: 198 x 198 x 50 gridpoints
periodic lateral boundaries conditions

Resolution: 2 km horizontally

Initial state: Horizontally homogenous sounding,
CAPE $= 2200 \frac{\mathrm{J}}{\mathrm{kg}}$,
random white noise on T (0.02 K) and W (0.02 $\frac{\mathrm{m}}{\mathrm{s}}$)
in the boundary layer

Model: Full COSMO physics with active radiation scheme

Forecast: 8 hour spinup until convection evolves:

- long-lived cells, lifetime $\geq$ 6 h
- horizontal position *fully random* in ensemble