Test of deterministic assimilation in NHM-LETKF

Le Duc[1], Kazuo Saito[2], and Tadashi Fujita[3]

[1]Japan Agency for Marine-Earth Science and Technology

[2]Meteorological Research Institute / Japan Meteorological Agency

[3]Numerical Prediction Division / Japan Meteorological Agency

Motivation

EnKF $$\overline{x_a} = \overline{x_f} + K\left[y - \overline{H(x_f)}\right]$$

Using a limited ensemble member (about 50-100 members), the average operator tends to smooth out the short range forecasts, thus removing small scale processes in the analysis. This feature of EnKF may spoil the forecast characteristic when applying for deterministic forecasts.

Deterministic assimilation in EnKF

EnKF $$\overline{x_a} = \overline{x_f} + K\left[y - \overline{H(x_f)}\right]$$

DET $$x_a = x_f + K\left[y - H(x_f)\right]$$

Therefore a natural way to include a deterministic assimilation into EnKF is using DET with the Kalman gain from EnKF. This is equivalent to the use of ensemble forecasts in estimating the background error covariance in DET.

It can be considered as a special case of hybrid method that assigns the weight 1.0 for the ensemble B matrix.

Practical consideration

EnKF $$\overline{x_a} = \overline{x_f} + K\left[y - \overline{H(x_f)}\right]$$

DET $$x_a = x_f + K\left[y - H(x_f)\right]$$

Implementation (2 ways):

- Embed deterministic part in EnKF so that K can be used on-the-fly.
- Re-center ensemble forecasts in EnKF around the deterministic forecast then run EnKF with $H(x_f)$ in place of $\overline{H(x_f)}$ -> we can run the deterministic part at a higher resolution by interpolating forecast perturbations to this resolution.

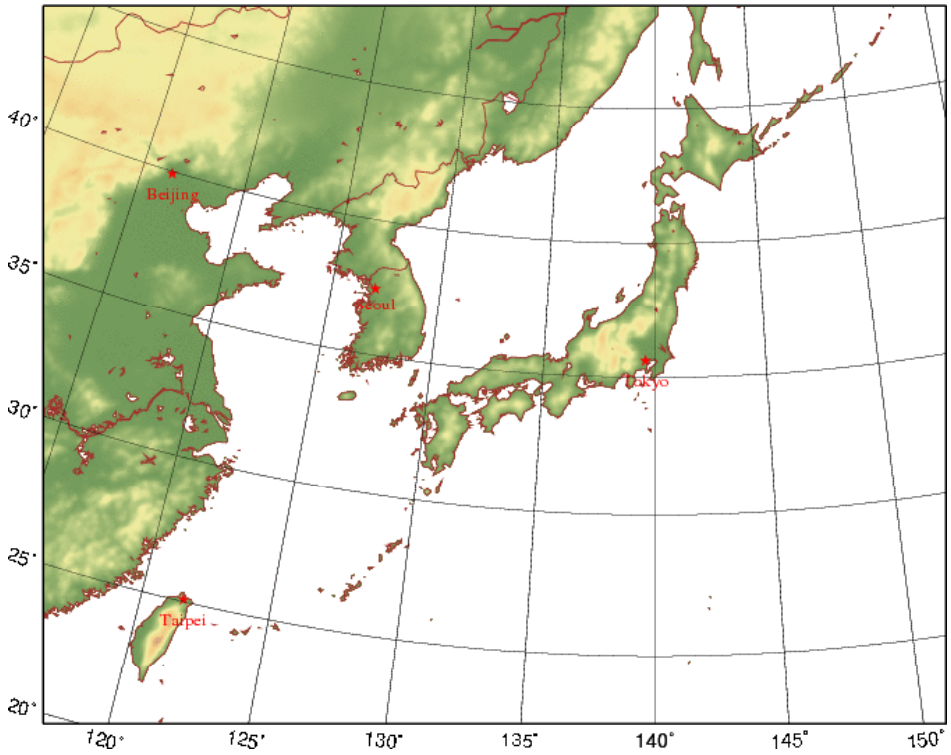
The ensemble and deterministic part must use the same observation dataset.

NHM-LETKF

- The NHM-LETKF system originally developed at JMA
- Driving model: JMA-NHM
- Control variables: u, v, t, qv, ps, and gt
- Assimilation method: 4D-LETKF, supporting adaptive inflation, adaptive vertical localisation (precipitation water and radiances), and outer loop as options.
- Observations: the same observation types and quality control programs as JNoVA

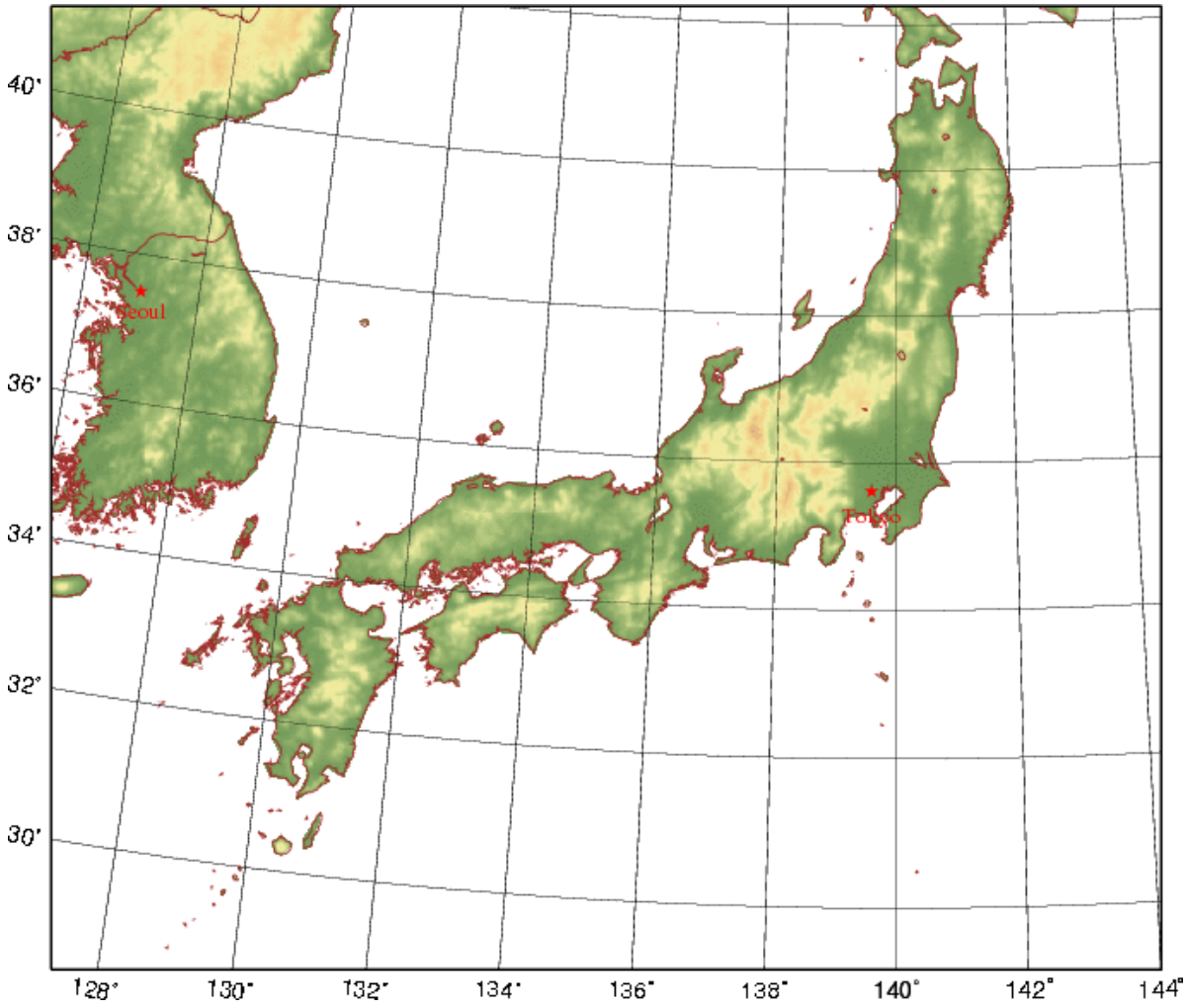
Experiment 1: Niigata-Fukushima heavy rainfall

- Time: 12UTC-26/07/2011 to 15UTC-28/07/2011
- Cycle: 3 hours
- Domain: 361x289 horizontal grid points, 50 levels, a resolution of 10 km
- Ensemble: 50 members
- Boundary conditions: GSM forecasts
- Boundary perturbations: JMA's one-week EPS
- SST perturbations
- Observations: the same as using by JNoVA except precipitation analyses and radar reflectivities

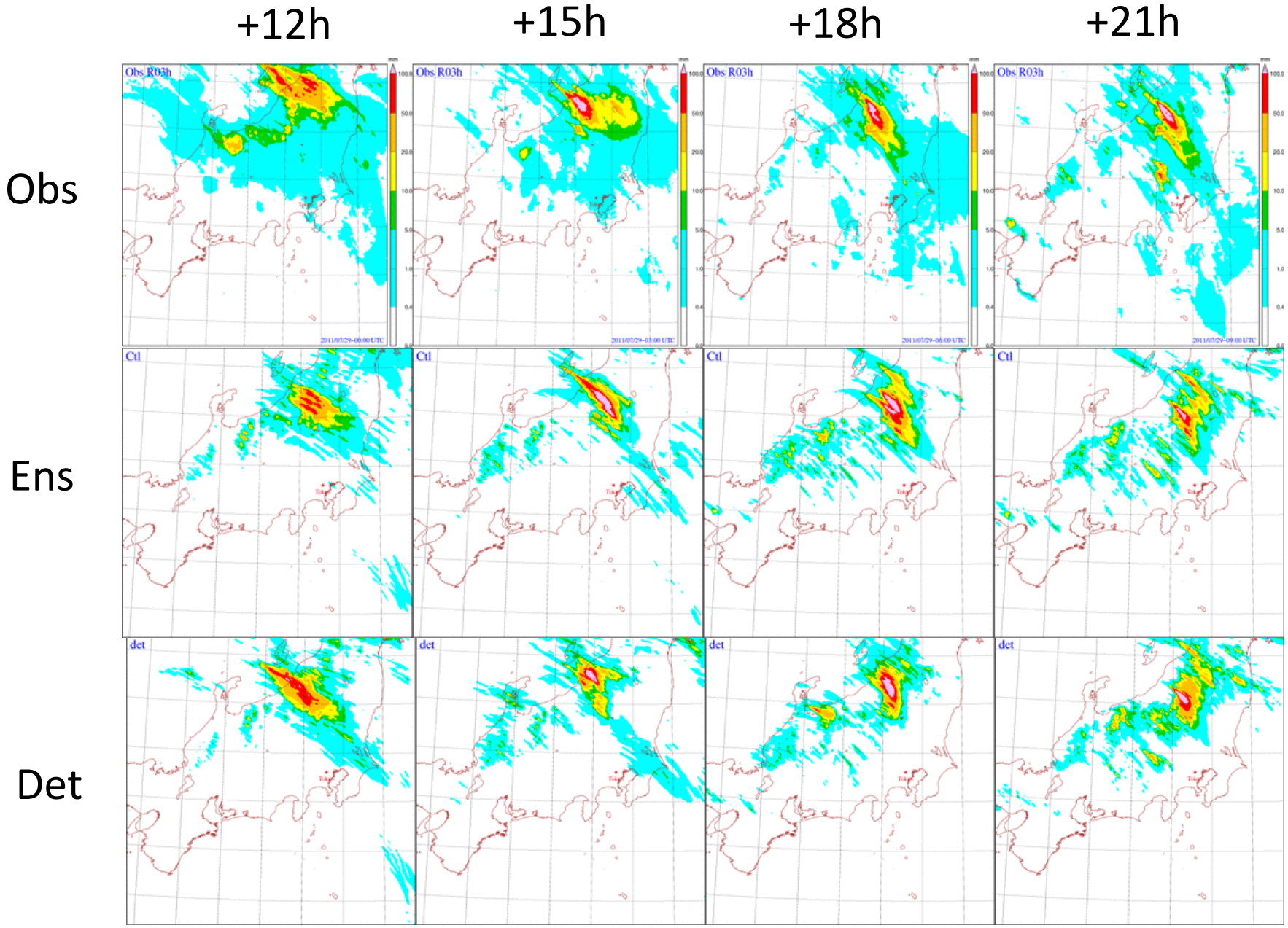


Experiment 1: Downscaling experiments

- Domain: 1637x1429 horizontal grid points, 60 levels, a resolution of 1 km
- Forecast range: 30 hours (12UTC-28/07/2011 to 18UTC-29/07/2011)
- Initial condition: NHM-LETKF ensemble and deterministic analyses
- Boundary condition: GSM forecasts
- No cumulus parameterization

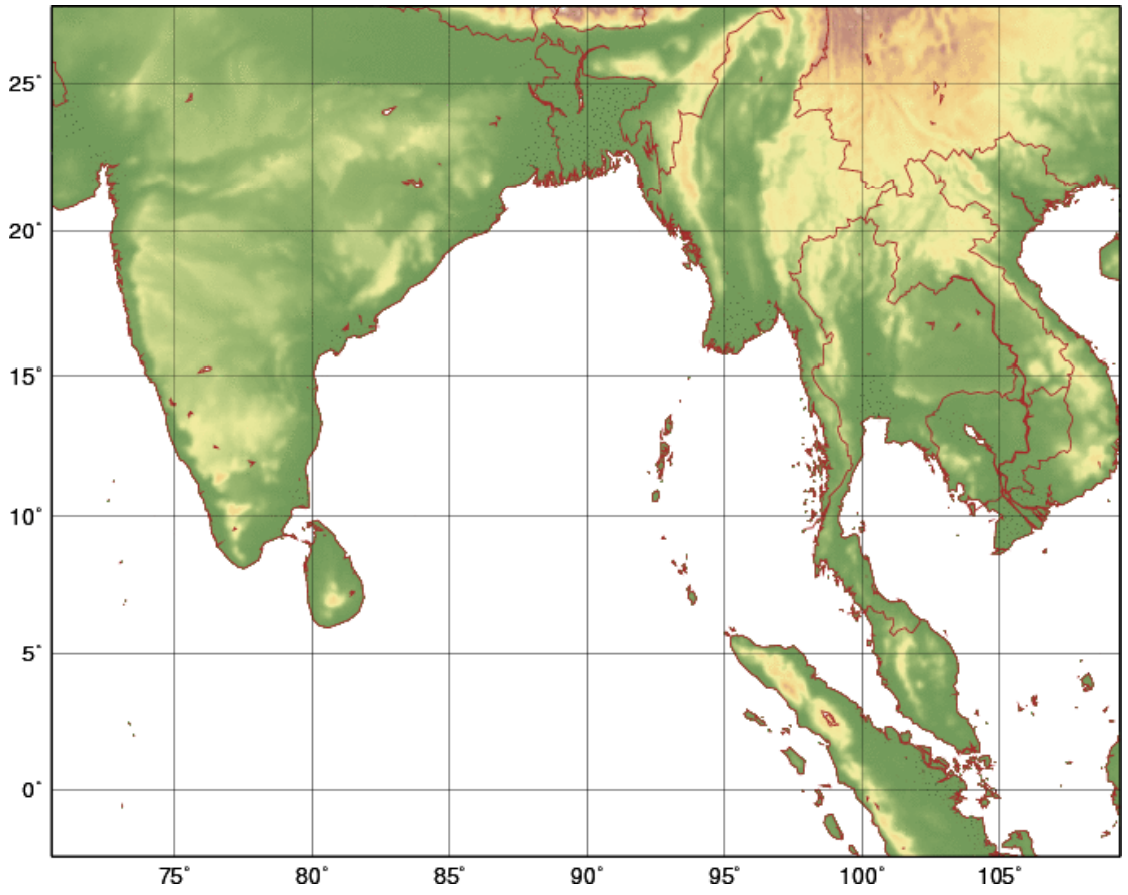


Downscaling results



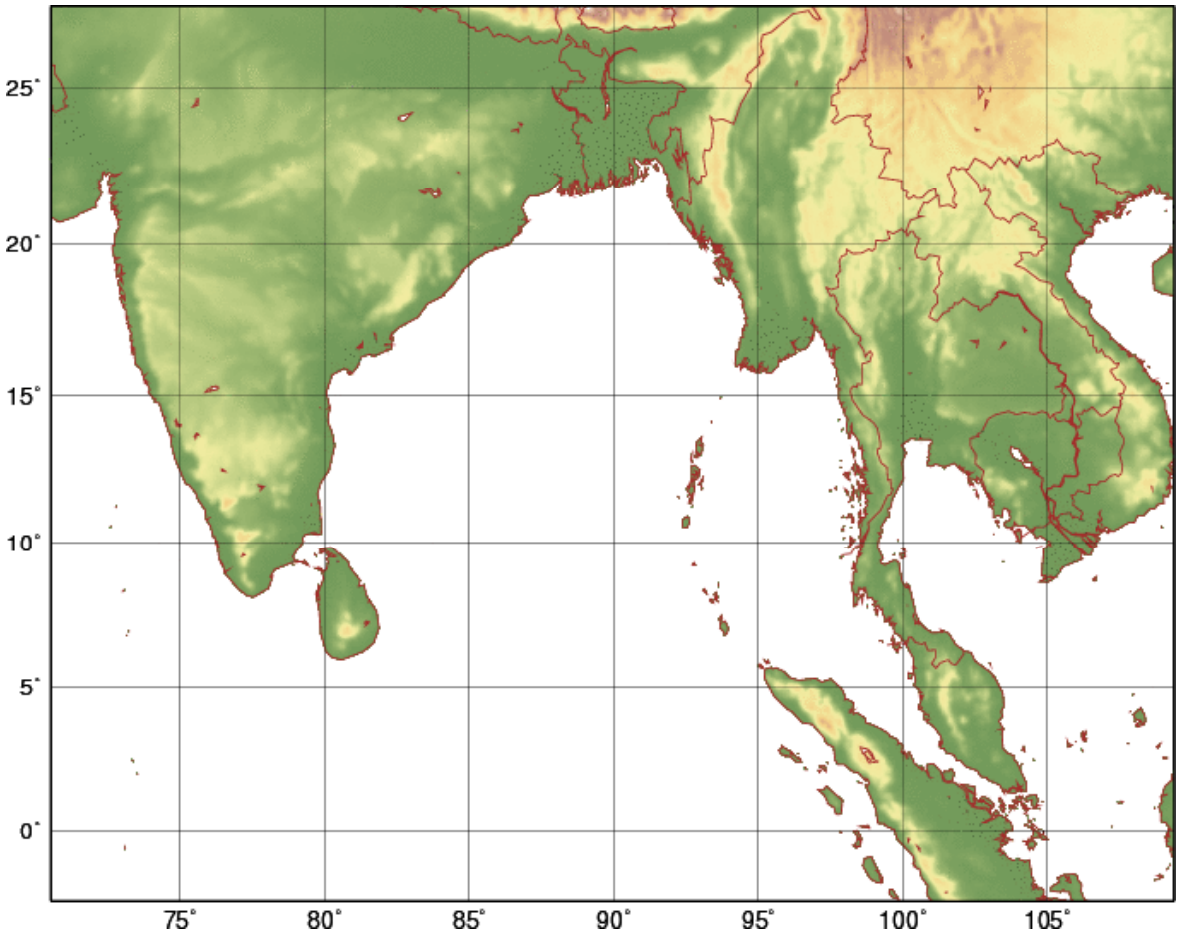
Experiment 2: Nargis tropical cyclone

- Time: 12UTC-28/04/2008 to 12UTC-30/04/2008
- Cycle: 3 hours
- Domain: 201x161 horizontal grid points, 40 levels, a resolution of 20 km
- Ensemble: 50 members
- Boundary conditions: GSM forecasts
- Boundary perturbations: JMA's one-week EPS
- SST perturbations
- Observations: conventional data, TC advisories

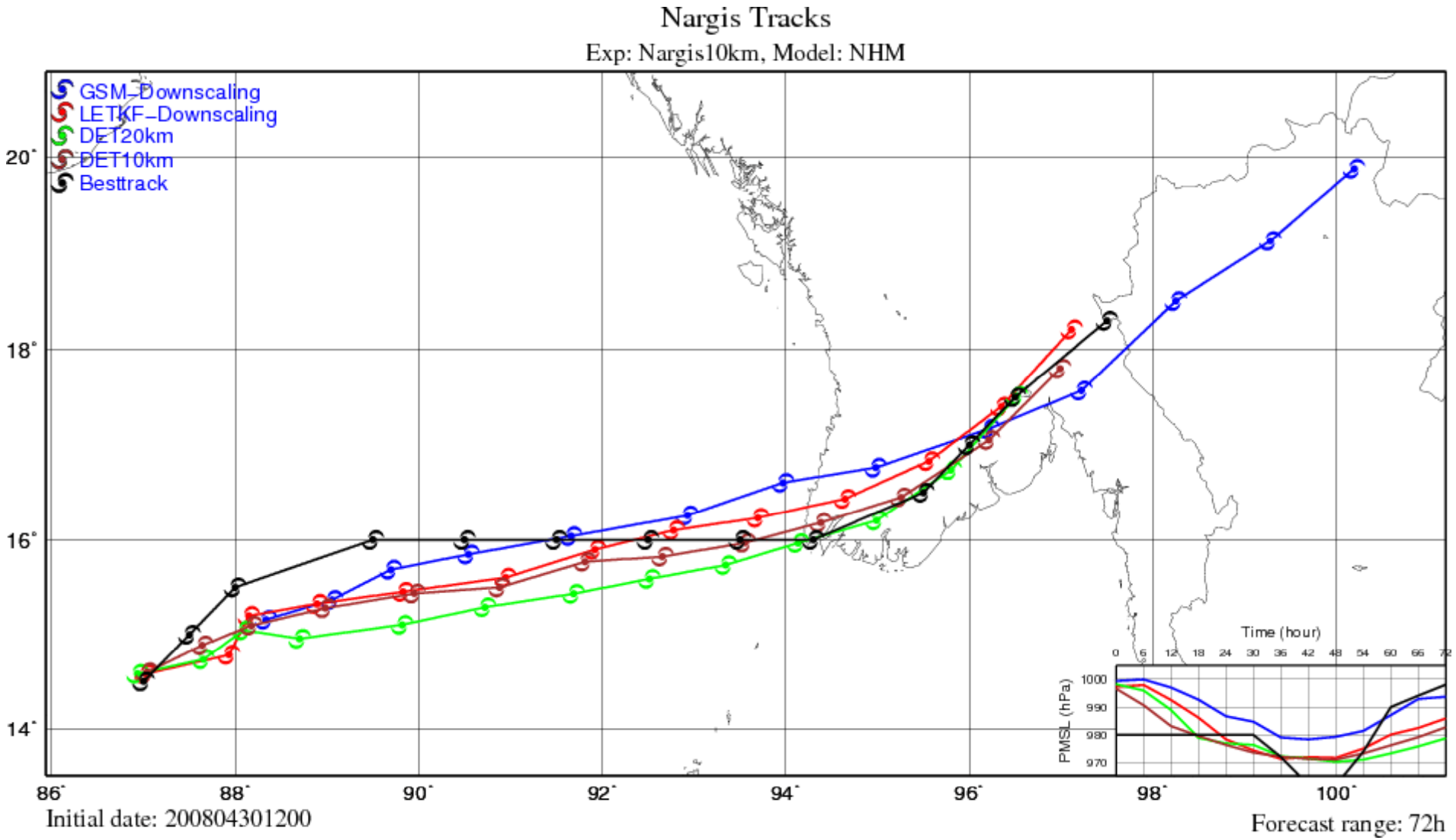


Experiment 2: Downscaling experiments

- Domain: 401x321 horizontal grid points, 50 levels, a resolution of 10 km
- Forecast range: 72 hours (12UTC-30/04/2008 to 12UTC-03/05/2008)
- Initial condition: NHM-LETKF ensemble and deterministic (DET20km and DET10km) analyses
- Boundary condition: GSM forecasts



Downscaling results



Summary

- The deterministic assimilation was implemented in NHM-LETKF. The forecasts with the deterministic analyses are slightly better than the one with the conventional LETKF analysis.

- The deterministic part that uses a finer resolution than the ensemble part in LETKF slightly improves the final analysis. This is needed to be verified in other cases.