Atmospheric uncertainty associated with typhoon genesis estimated in ensemble reanalysis ALERA

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ALERA
AFES-LETKF data assimilation system (ALEDAS)

Observation

AFES

spatio-temporally inhomogeneous

Ensemble

Guess

Analysis

Predicts atmospheric flows

Finds optimal analysis
ALERA

AFES-LETKF experimental reanalysis

Miyoshi et al. 2007, SOLA

- all observations used in JMA NWP but for satellite radiances
- T159L48 (about 83 km mesh, 48 levels), 40 ensemble members
- available from the Earth Simulator Center
  http://www.jamstec.go.jp/esc/afes/alera/ (OPeNDAP)
Analysis ensemble spread

- an estimate of flow-dependent analysis error
- bred vectors corrected by observation
- indicates growing perturbations like BV or SV
- enables investigation of dynamical uncertainty with analysis unlike BV or SV
Precursory signals of typhoon genesis
Extract dynamical uncertainty

- The analysis ensemble spread contains information on observation density and dynamical uncertainty.
- Normalize ensemble spread by the standard deviation of the analysis ensemble spread in time.
- Uncertainty in regions with rich observation stands out in the normalized ensemble spread.
ET of Typhoon 0504

GOES 9 IR
JMA/Kochi Univ

ALERA
(u,v) 850 hPa & u850 sprd

2005-06-09 0UTC
Comparison with OLR

The analysis ensemble spread of $u_{850}$ hPa

- is similar to OLR
- not always large at low OLR regions
- could be useful information for forecasters
Typhoons in reanalyses
Typhoons in global analysis

- Central pressure not low enough
- Large analysis error
- Will T-PARC data improve analysis?
CDAS vs JMA best track

JRA-25 vs JMA best track

Higher resolution
w/ bogus

w/o bogus
ALERA vs JMA best track

JRA-25 vs JMA best track

typhoon central pressure hPa 2005-6

JMA best track

w/o bogus

w/ bogus
ALERA vs JMA best track

\[ w/o \ u > 25 \text{ m/s} \]

\[ r_{25} \geq 166 \text{km} \]
ALERA vs JMA best track

ensemble mean

Larger spread for intense typhoons

ensemble spread
ALERA first guess vs JMA best track

ensemble mean

ensemble spread
Typhoons in ALERA

- Central pressure is represented fairly well in ALERA ensemble mean w/o bogus
- Small, intense core is difficult to resolve
- Analysis ensemble spread increases with depth
Coarse models cannot represent the central pressure
Observations near the centre have representativeness error
Bias correction methods
Observations near TC centre

- may be obtained by chance
- one of the goals of T-PARC
- unresolvable by a moderate resolution GCM
- representativeness error to DA
- could be rejected during QC
Case study

• Typhoon Shan Shan in 2006
• From 12 UTC 13 to 12 UTC 18 Sep 2006
• Central pressure of JMA best track is used as observation substitutes
Shan Shan

15JST 17 September 2006

Tornado events

ALERA ensemble mean
JMA best track
ALER IA (u,v) and u sprd 850 hPa

12 UTC
Bias correction methods

• Bogus-based: Replace the observed value with the minimum pressure used in the bogus generation (Onogi 1998)

• Ensemble-based: Reduce the first-guess ensemble mean slp by 2 x ensemble spread
Bogus based $p_{c\min}$ correction

- 18 UTC 13 Sep 2006
- 127.6E, 20.3N
- $r_b = 448$ km, $p_b = 1008$ hPa
- Best track: 950 hPa
- Corrected: 999 hPa

Assumed Fujita (1952)'s pressure distribution and gradient wind balance
Ensemble based $p_c_{\text{min}}$ correction

Ensemble mean

Typhoon central pressure hPa 2005-6

Ensemble spread

Typhoon central pressure hPa 2005-6

$2\sigma$
Positive increment to weaken typhoon

Large spread near typhoon centre

Reduced spread

Negative increment near centre
bogus based correction

ALERA
2006091318  T0613 Shanshan  2006091812

JMA best track

ALERA

positional error 141 km
18UTC 13 Sep 2006

NB. model horizontal resolution is 80 km
Ensemble prediction of tornado potential

$\text{EHI} > 0.5 \text{ J/kg m}^2/\text{s}^2$

Initial time 12UTC 15 Sep 2006

FT=42h  12UTC 17 Sep

FT=48h  18UTC 17 Sep

FT=54h  6UTC 17 Sep

AFES T159L48M40
EHI in Kyushu and Shikoku
Bias correction

- is required to assimilate into a model with insufficient resolution
- can correct location and intensity of TC and reduce analysis error
- could be formulated w/ or w/o an assumption of the TC structure
- using ensemble spread could be extended to other phenomena
Conclusions

- Analysis ensemble spread contains precursory signals of typhoon genesis.
- ALERA represents typhoons well w/o bogus.
- Observations near the typhoon centre can improve the intensity and position of analysis if representativeness error is corrected.
- Ensemble-based correction
ALERA2

- Updated AFES and LETKF
- Larger ensemble size (T119L48M64)
- PREPBUFR and NOAA daily 1/4° SST from UCAR
- Two streams: from June 2003 and from January 2008
  - IPY, PALAU and summer and winter T-PARC OSE's