Atmospheric uncertainty associated with typhoon genesis estimated in ensemble reanalysis ALERA

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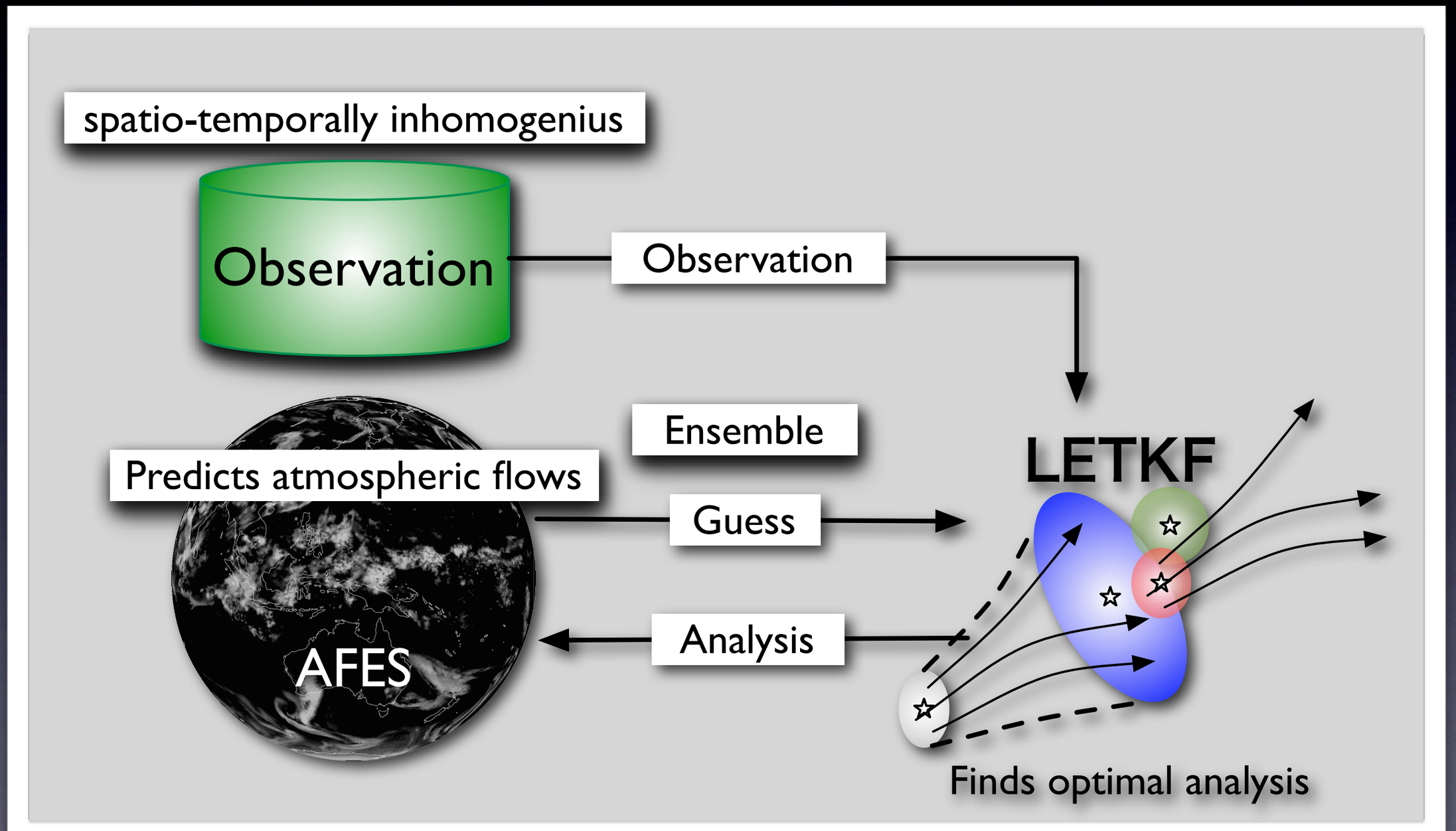
EARTH SIMULATOR

Contents

- Experimental ensemble reanalysis ALERA
- Precursory signals of typhoon genesis
- Typhoons in reanalyses
- Bias correction methods for observations near the typhoon centre

ALERA

AFES-LETKF data assimilation system (ALEDAS)



ALERA

AFES-LETKF experimental reanalysis

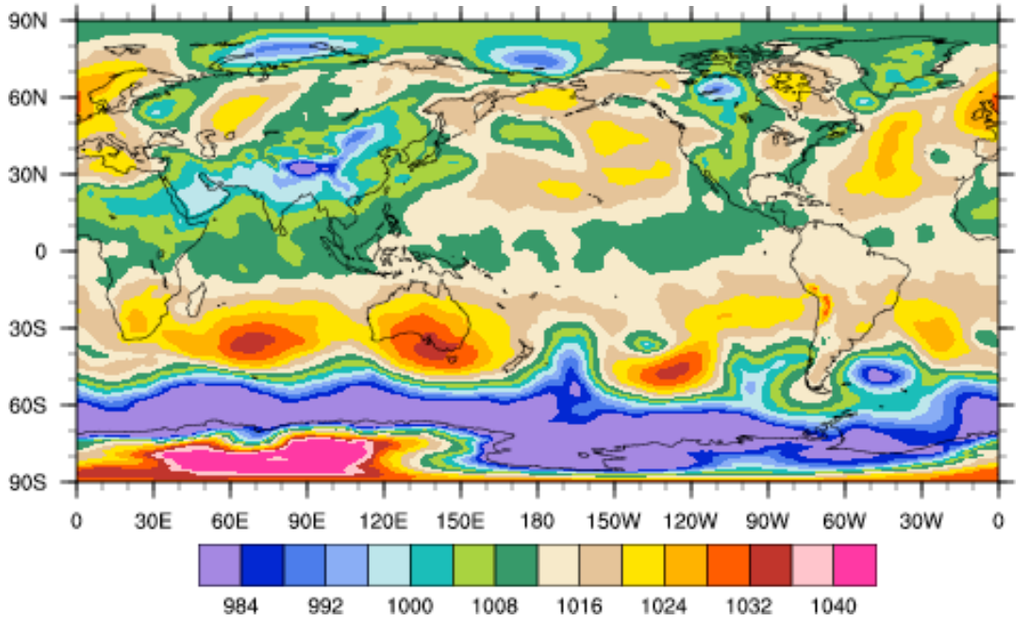
Miyoshi et al. 2007, *SOLA*

- 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)

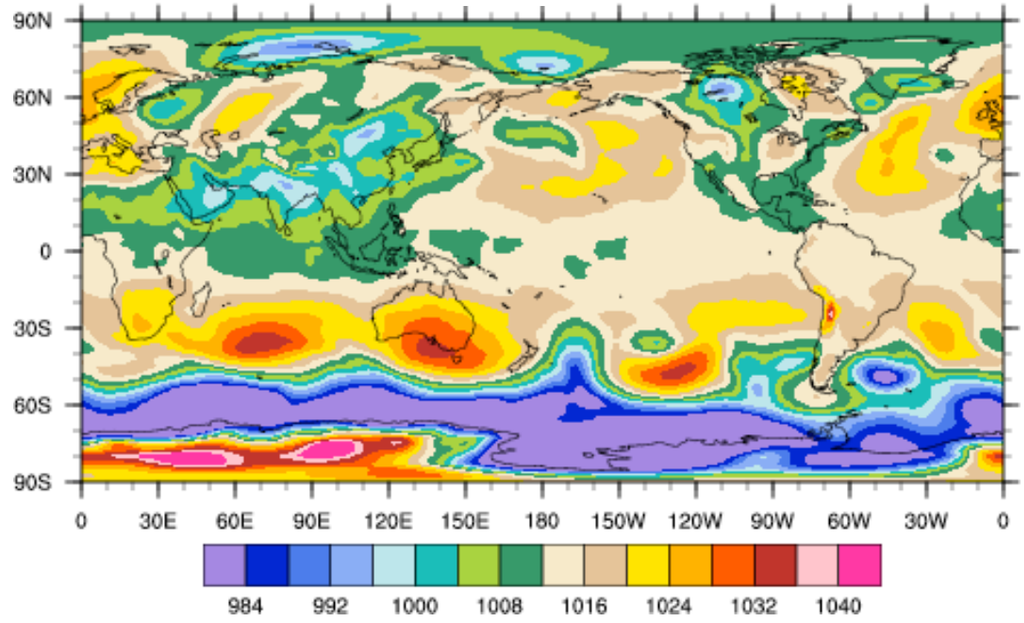
ALERA

SLP hPa

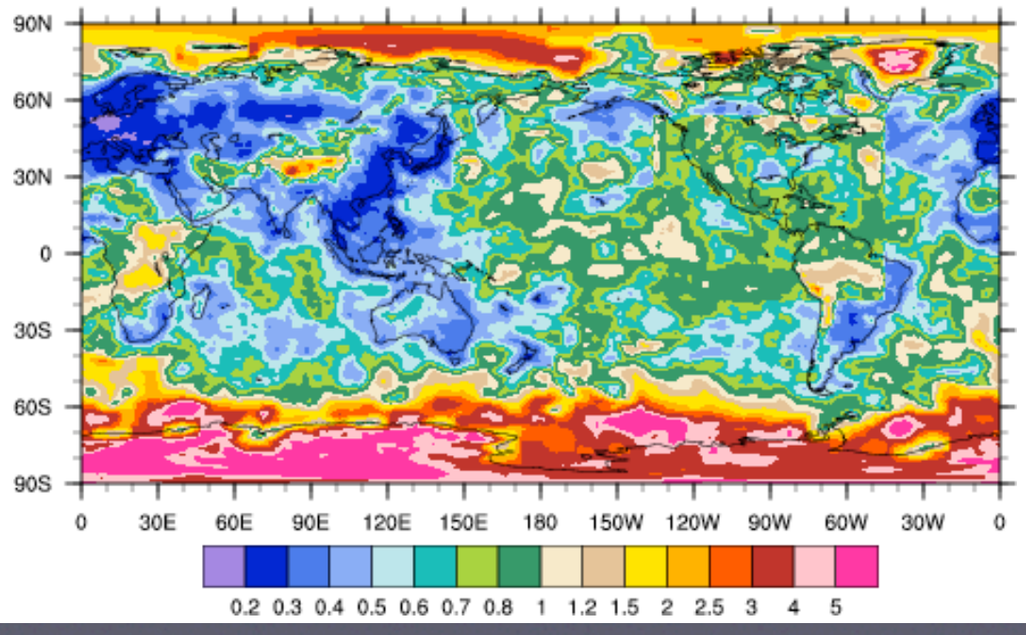
ALERA ensemble mean



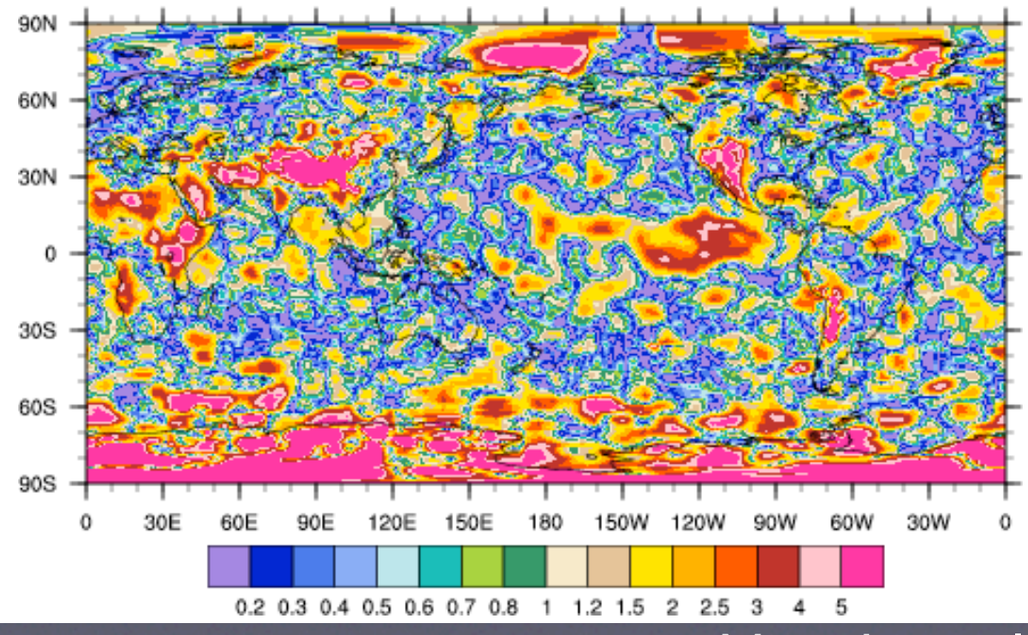
CDAS



ALERA ensemble spread



|ALERA-CDAS|

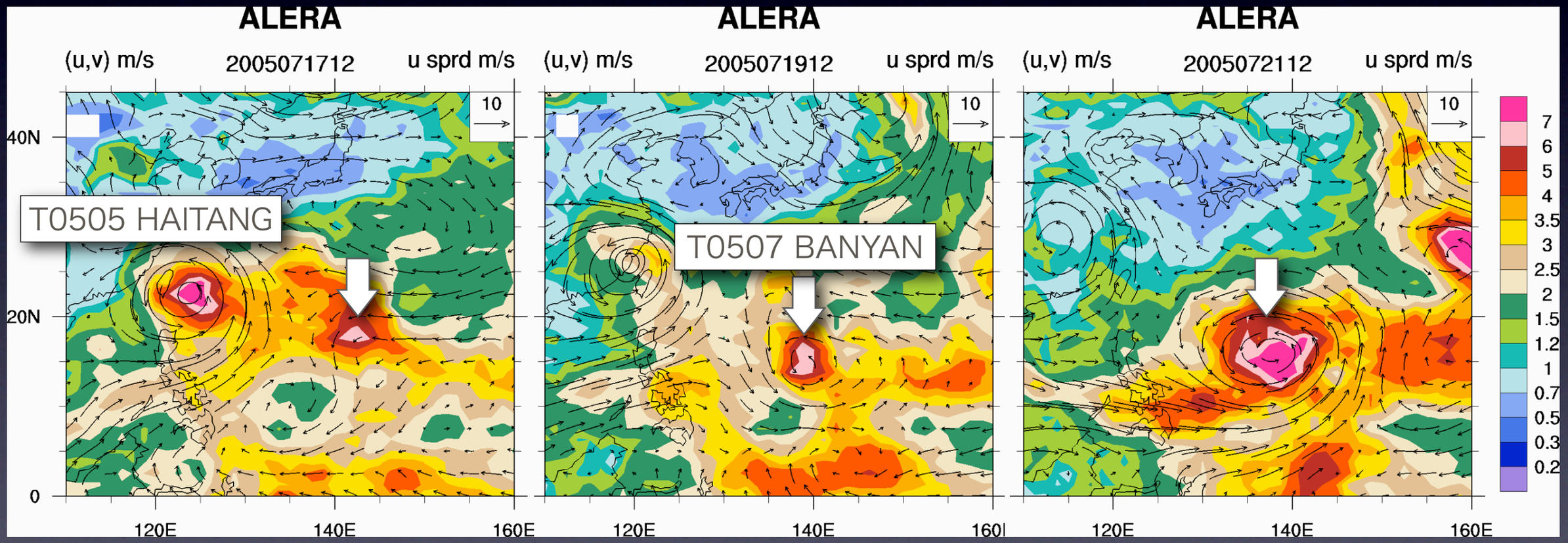


Miyoshi et al 2007

Analysis ensemble spread

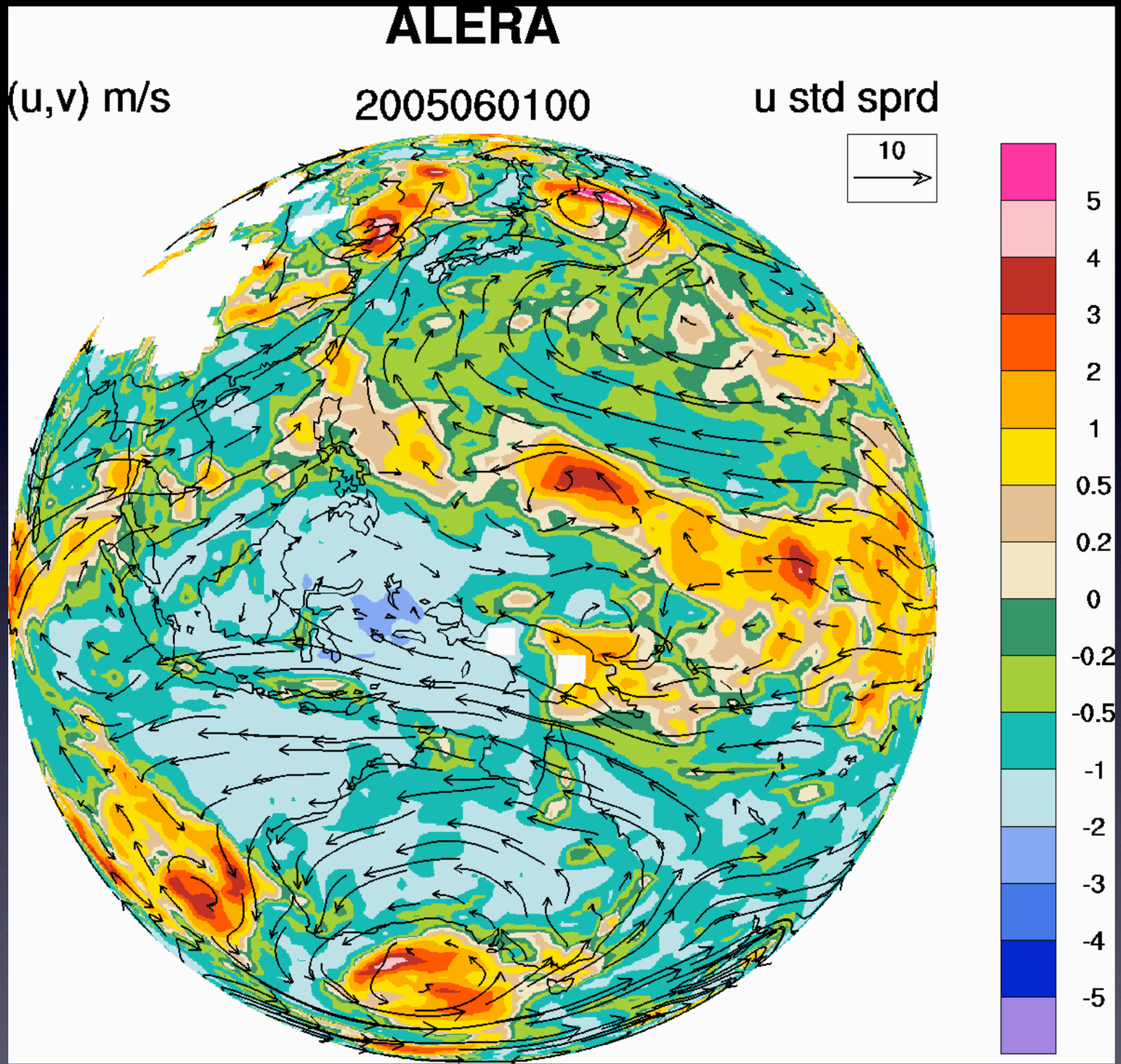
- an estimate of flow-dependent analysis error
- bred vectors corrected by observation
- indicates growing perturbations like BV or SV
- enables investigation of dynamical uncertainty with analysis unlike BV or SV

Precursory signals of typhoon genesis



Extract dynamical uncertainty

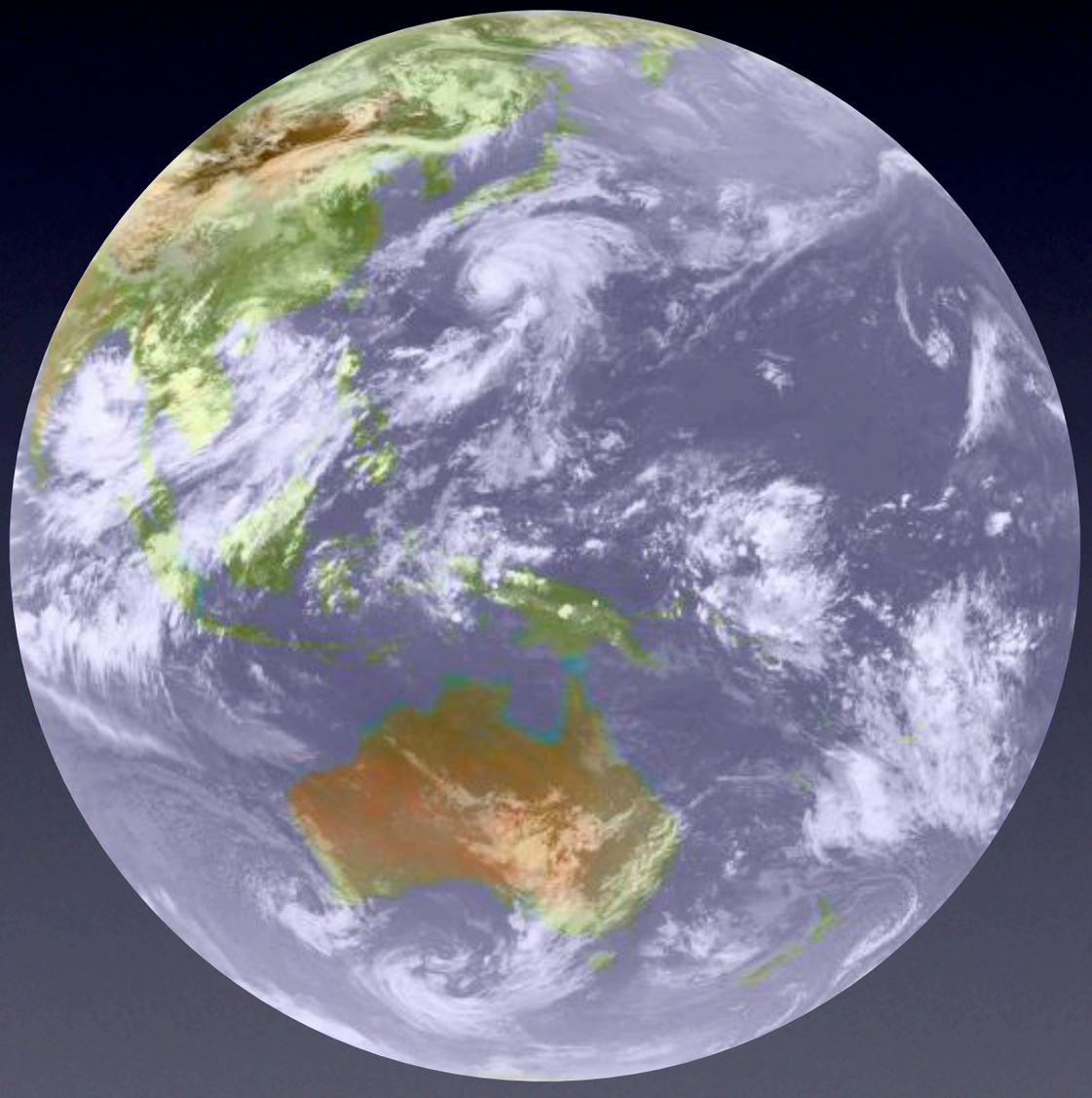
- The analysis ensemble spread contains information on observation density and dynamical uncertainty
- Normalize ensemble spread by the standard deviation of the analysis ensemble spread *in time*
- Uncertainty in regions with rich observation stands out in the normalized ensemble spread


ALERA
(u,v) m/s
2005060100
u std sprd
10
5
4
3
2
1
0.5
0.2
0
-0.2
-0.5
-1
-2
-3
-4
-5

ET of Typhoon 0504

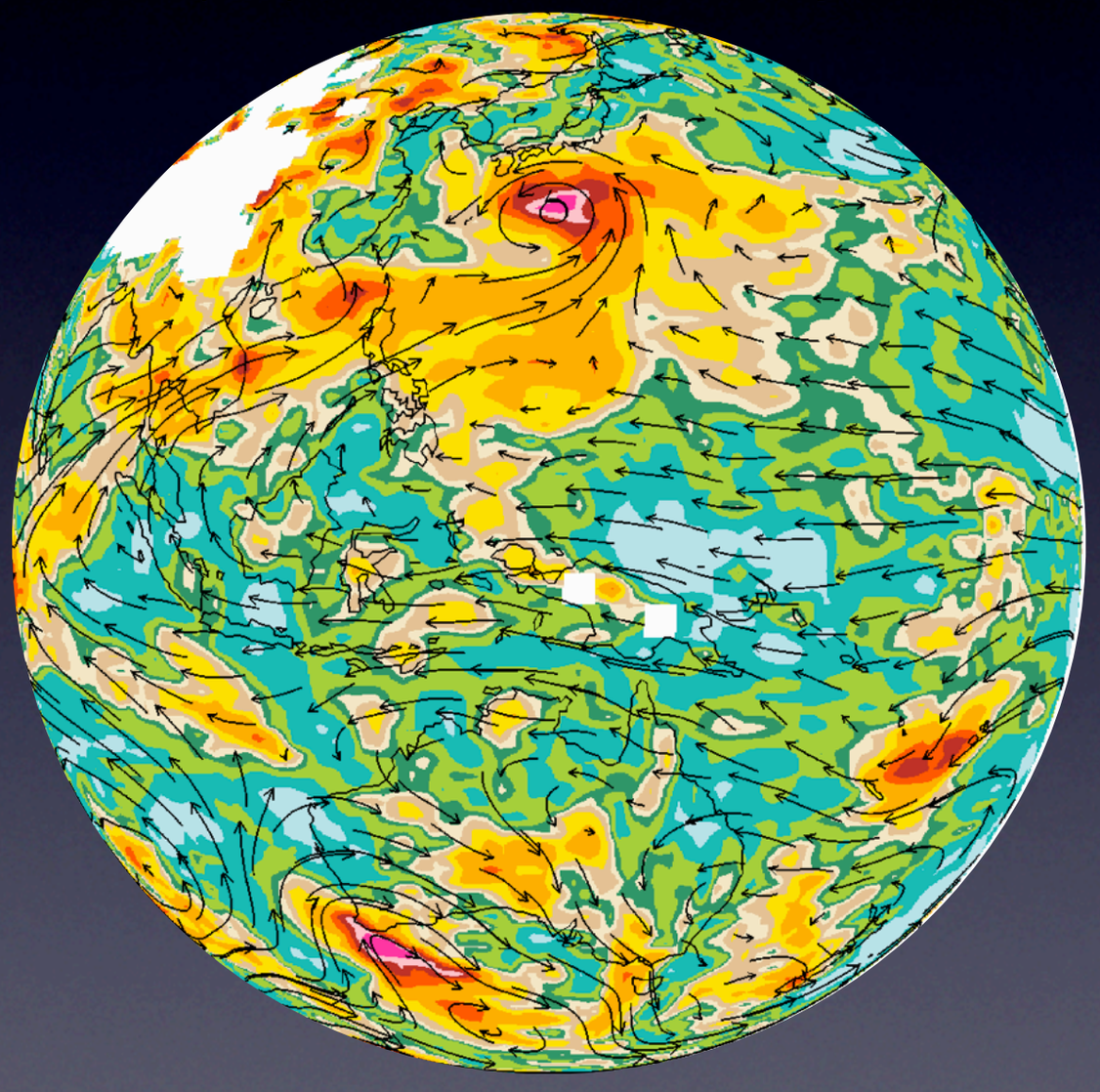
GOES 9 IR

JMA/Kochi Univ



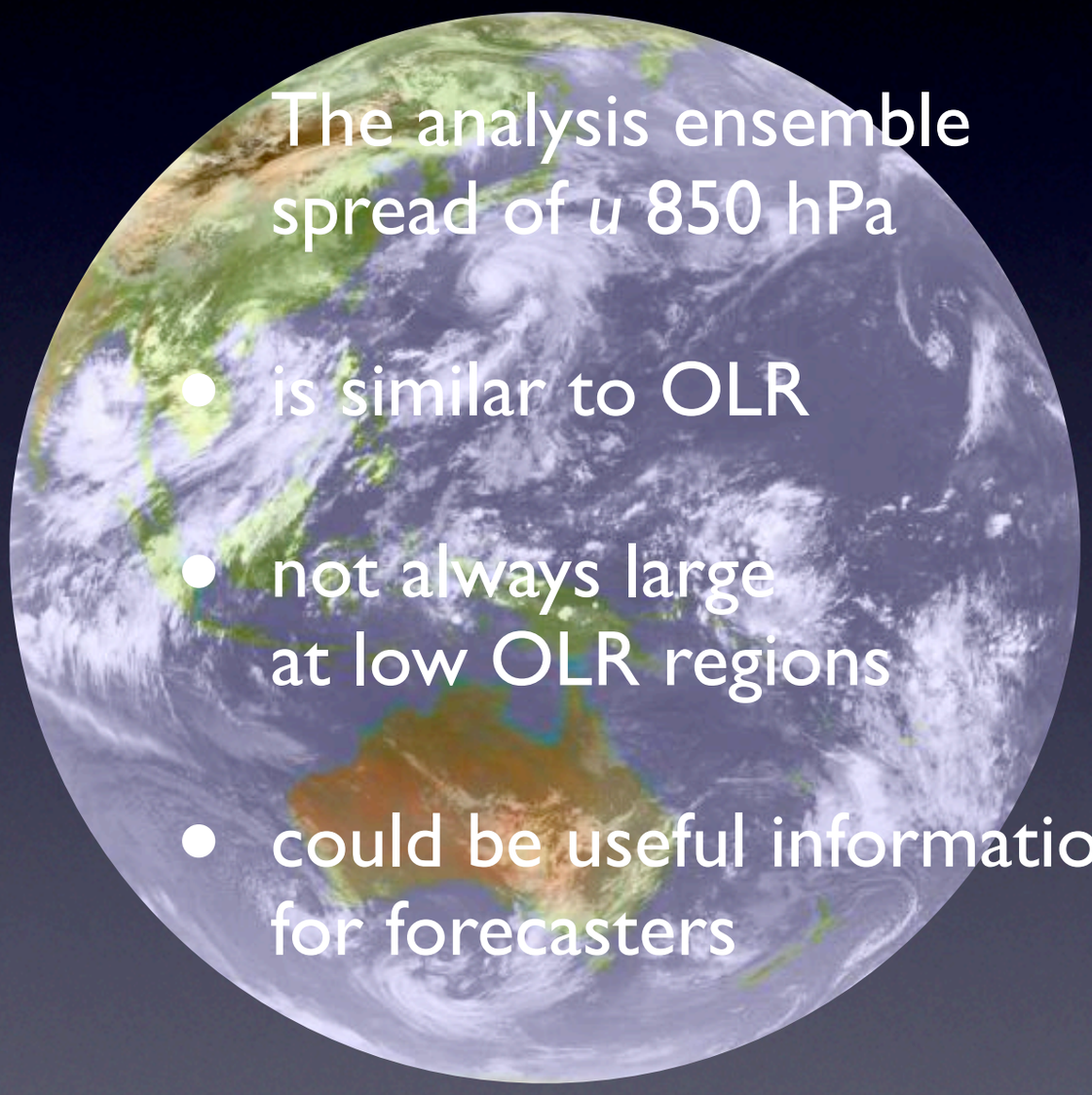
ALERA

(u,v) 850 hPa & u850 sprd



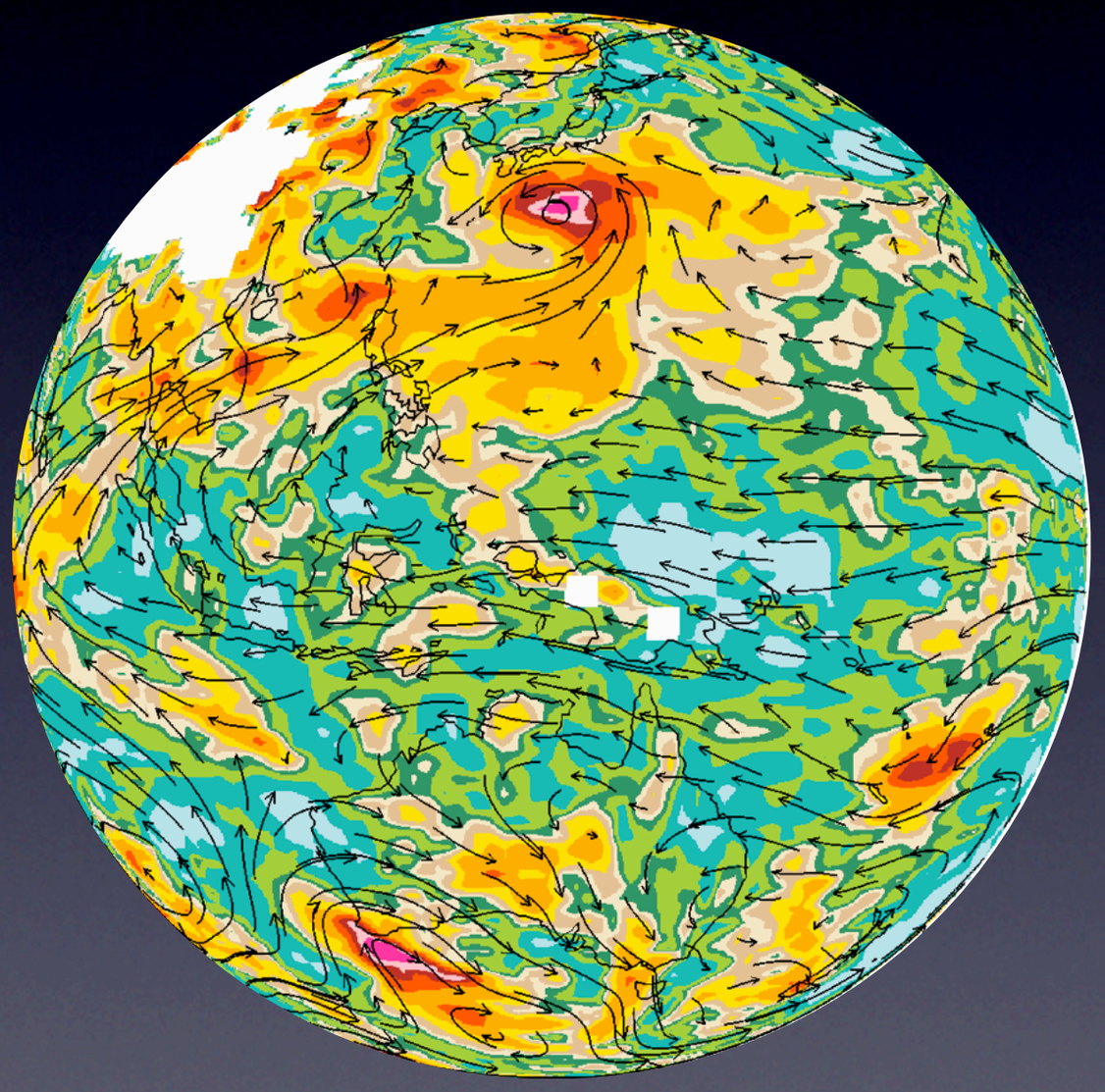
2005-06-09 0UTC

Comparison with OLR



The analysis ensemble spread of *u* 850 hPa

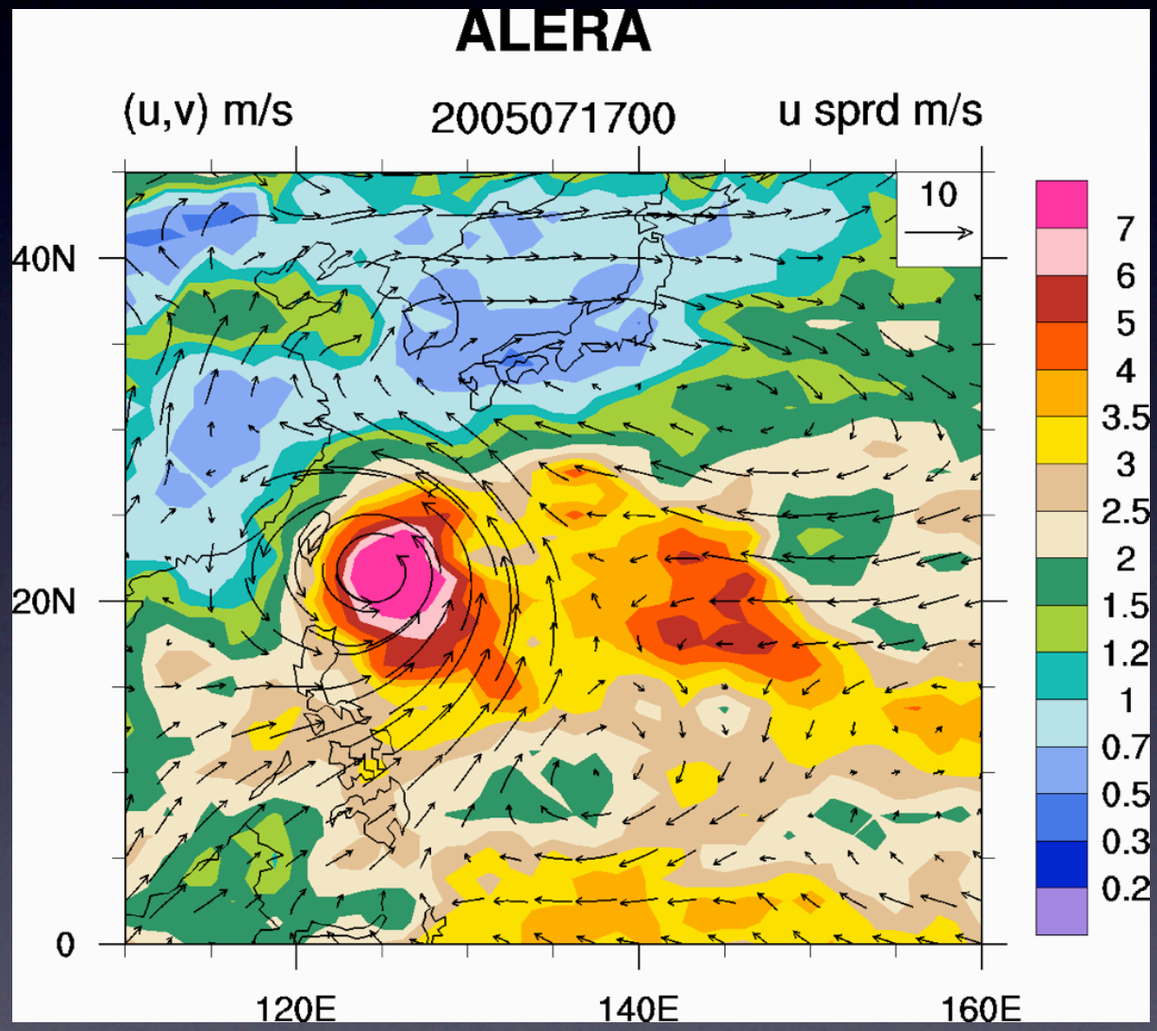
- is similar to OLR
- not always large at low OLR regions
- could be useful information for forecasters



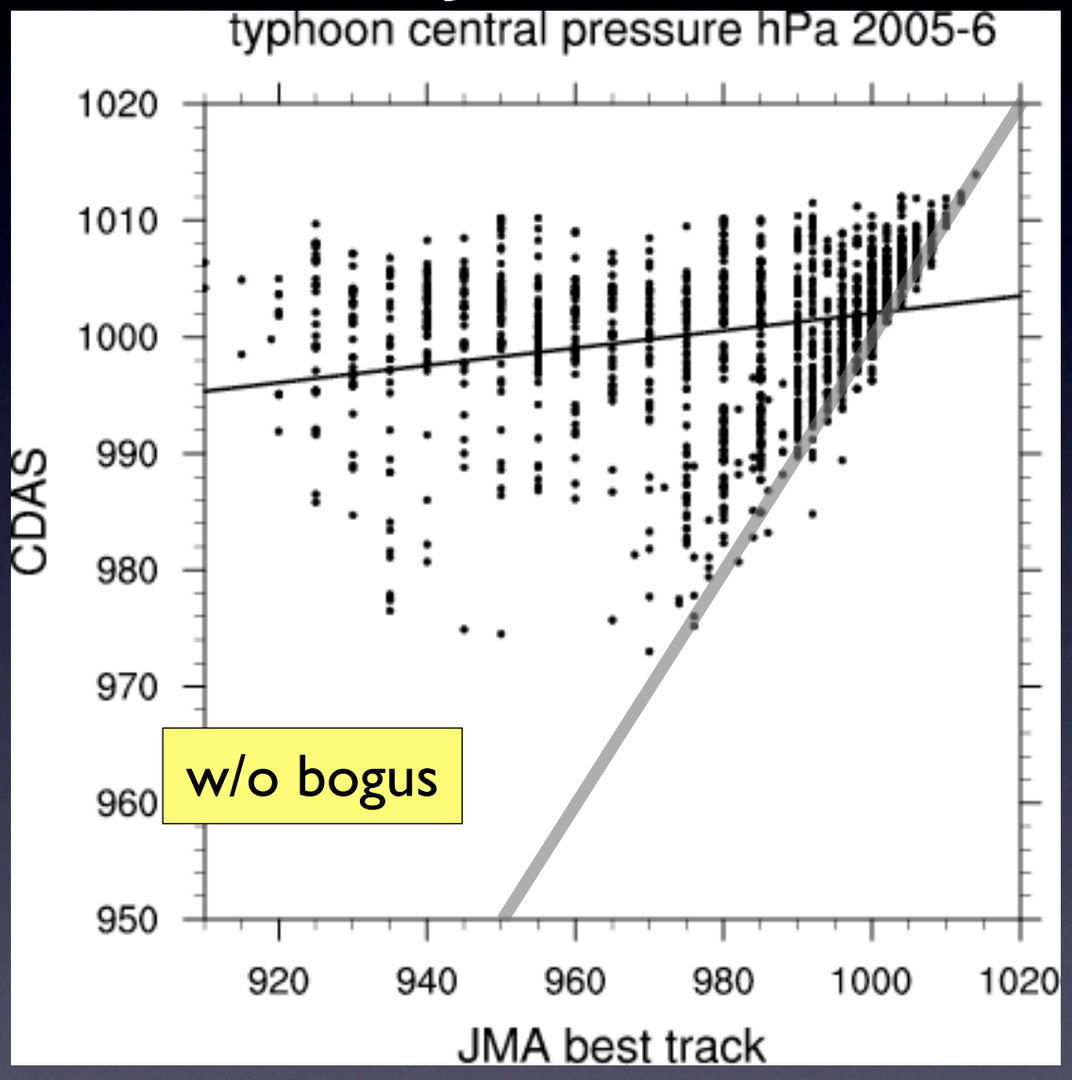
Typhoons in reanalyses

Typhoons in global analysis

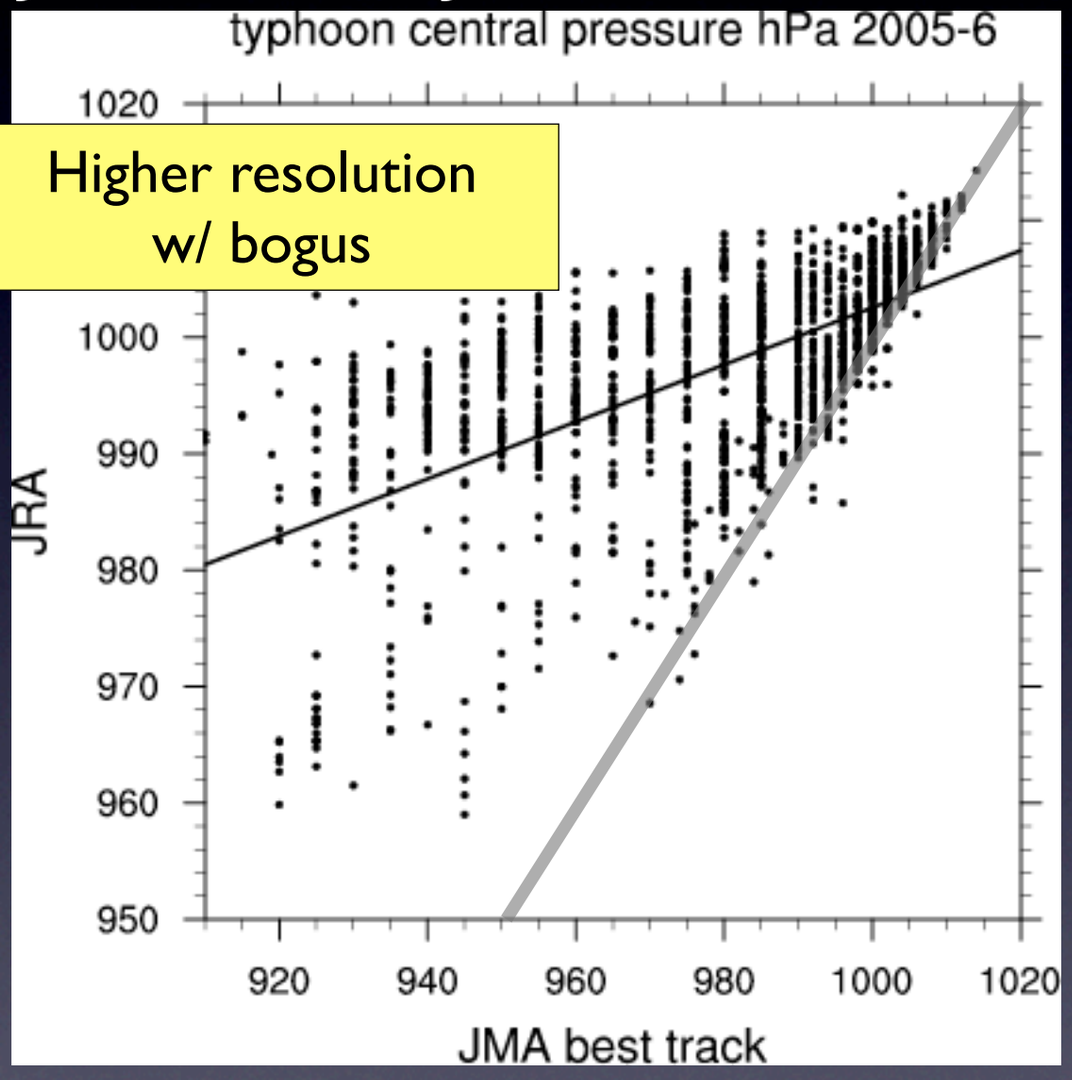
- Central pressure not low enough
- Large analysis error
- Will T-PARC data improve analysis?



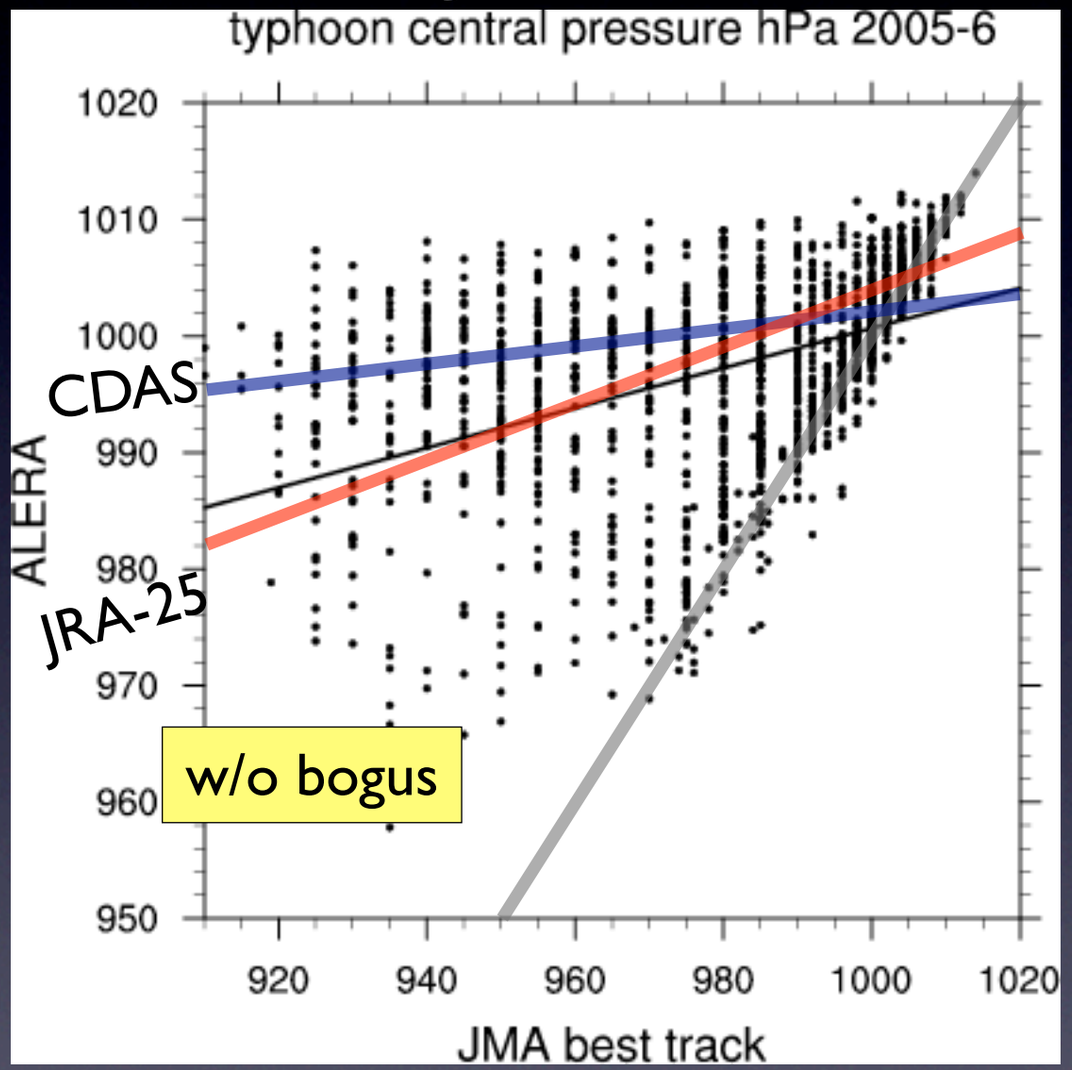
CDAS vs JMA best track



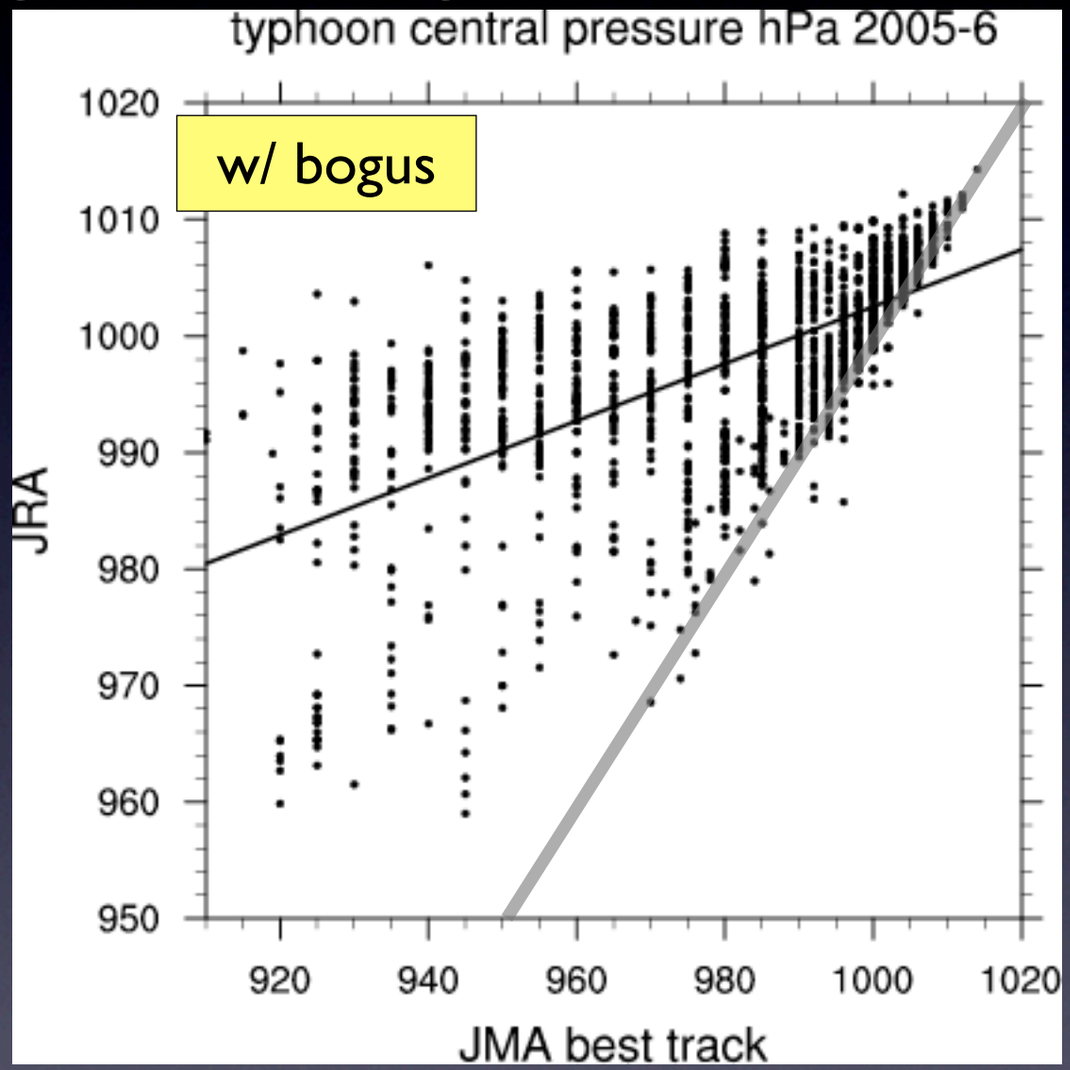
JRA-25 vs JMA best track



ALERA vs JMA best track

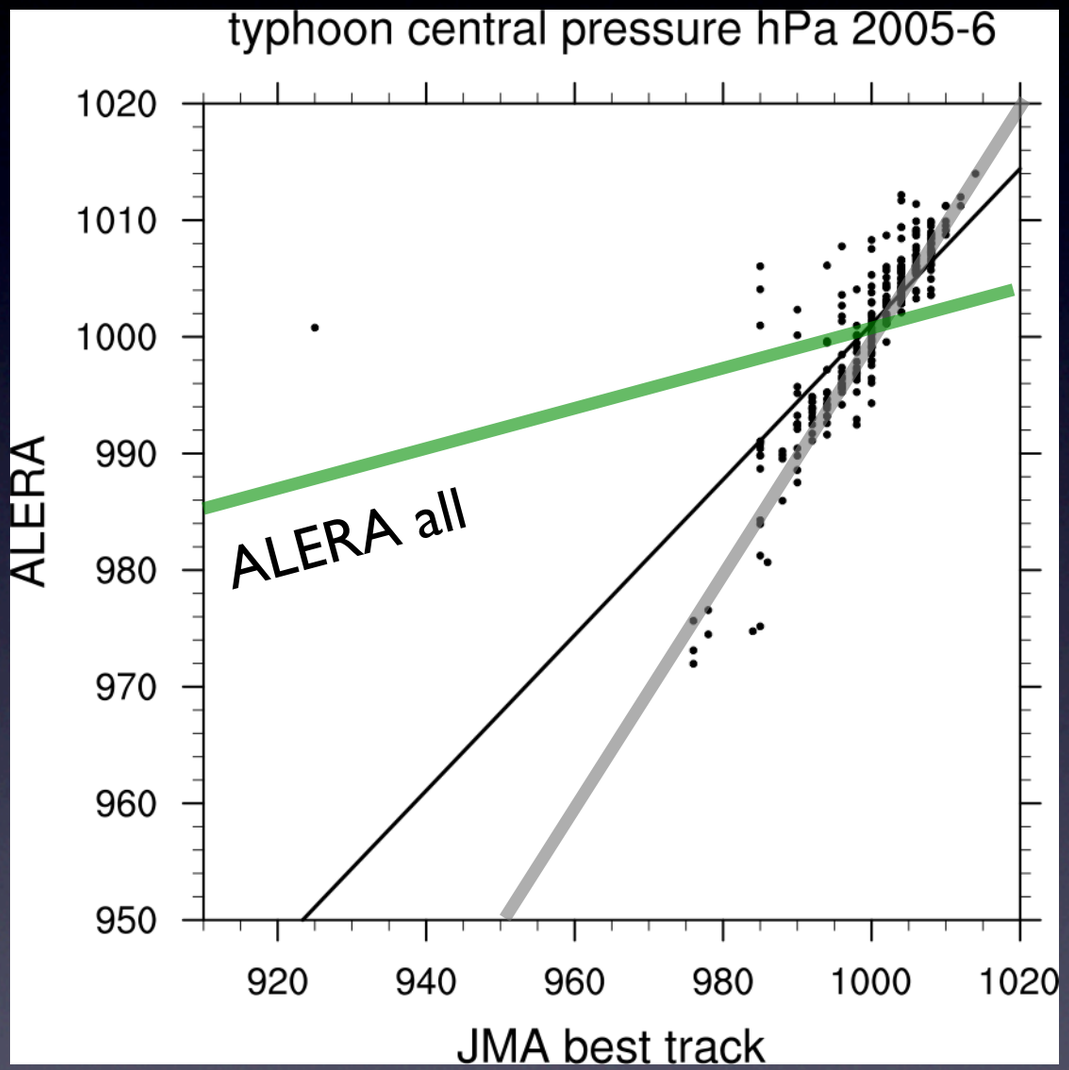


JRA-25 vs JMA best track

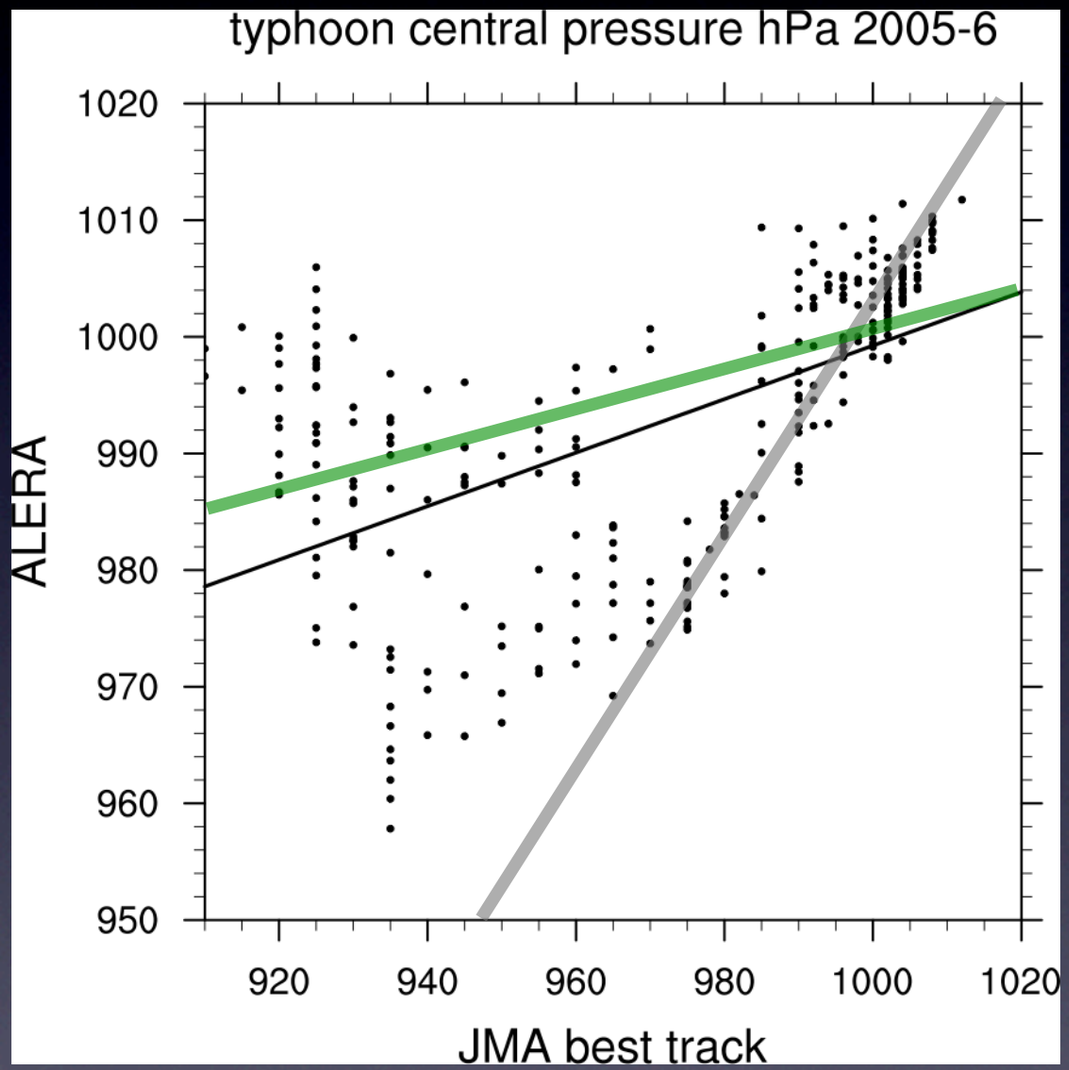


ALERA vs JMA best track

w/o *u* > 25 m/s

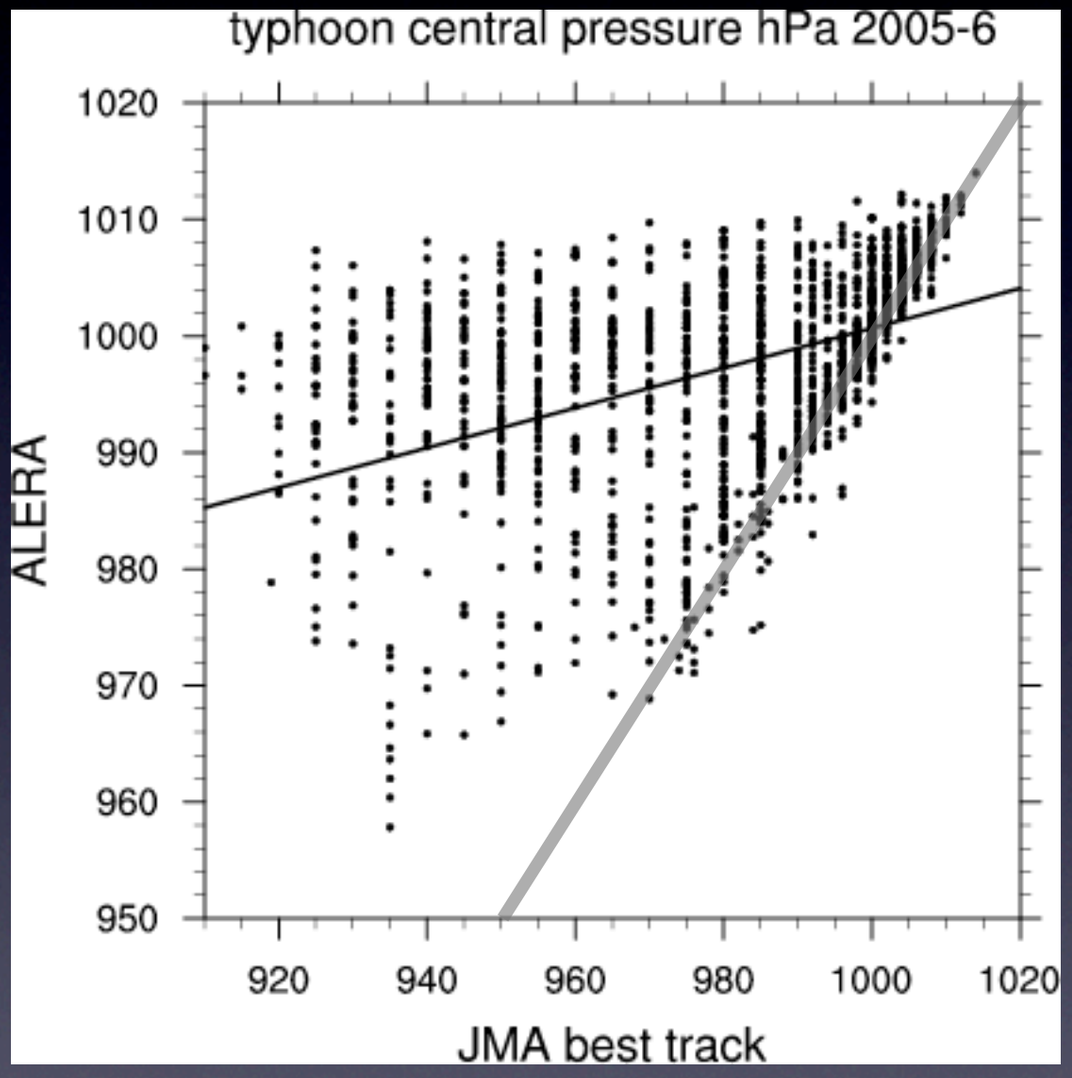


r25 ≥ 166km



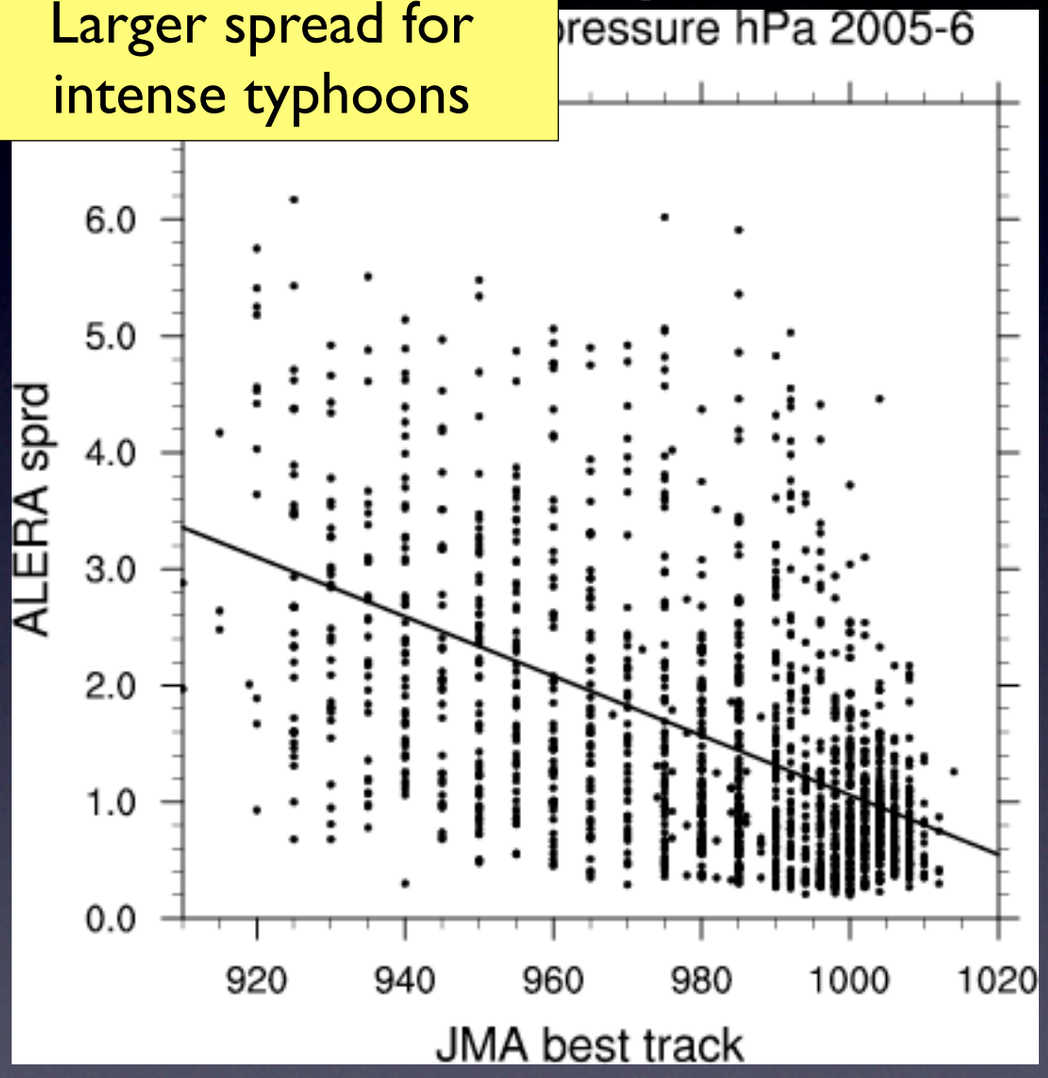
ALERA vs JMA best track

ensemble mean



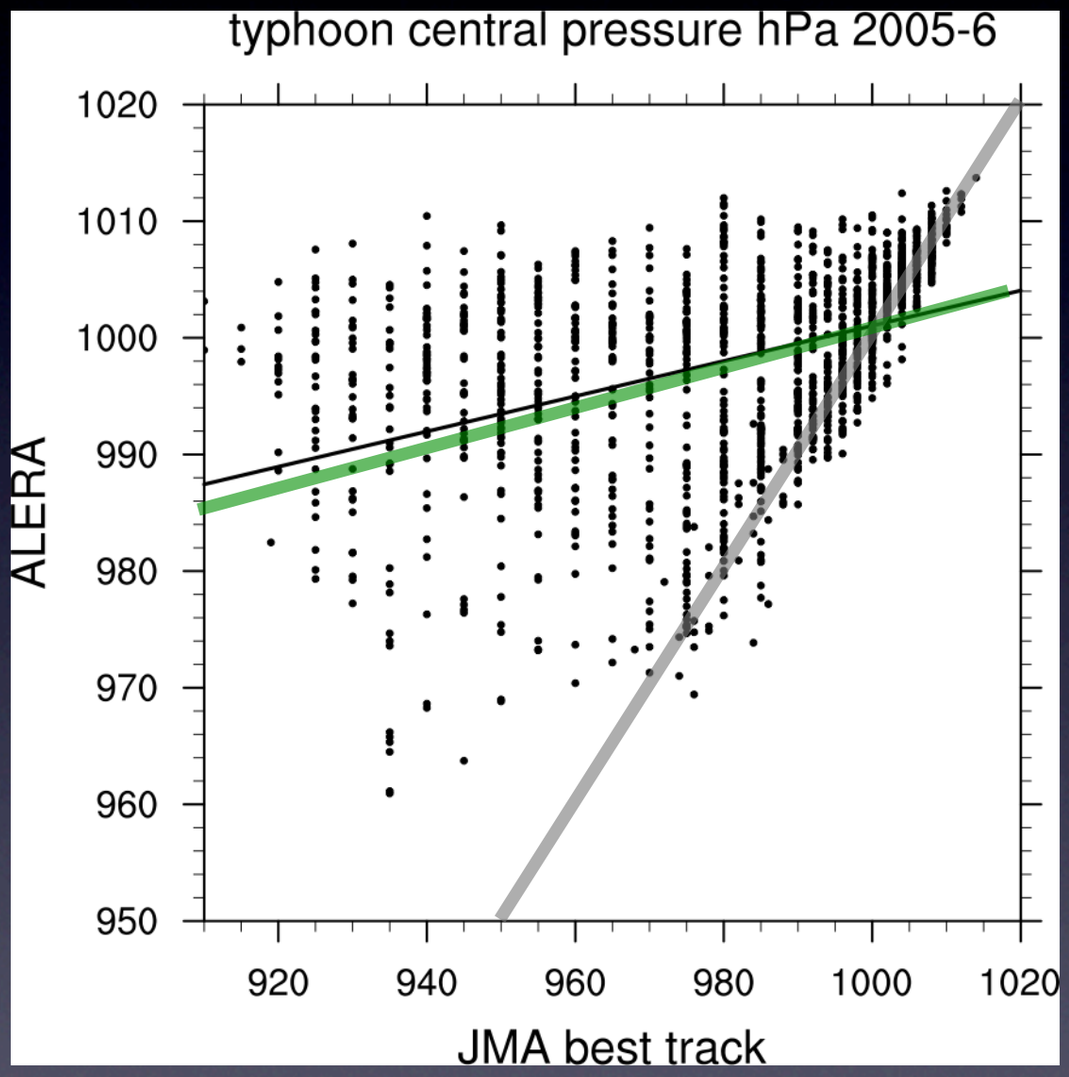
ensemble spread

Larger spread for intense typhoons

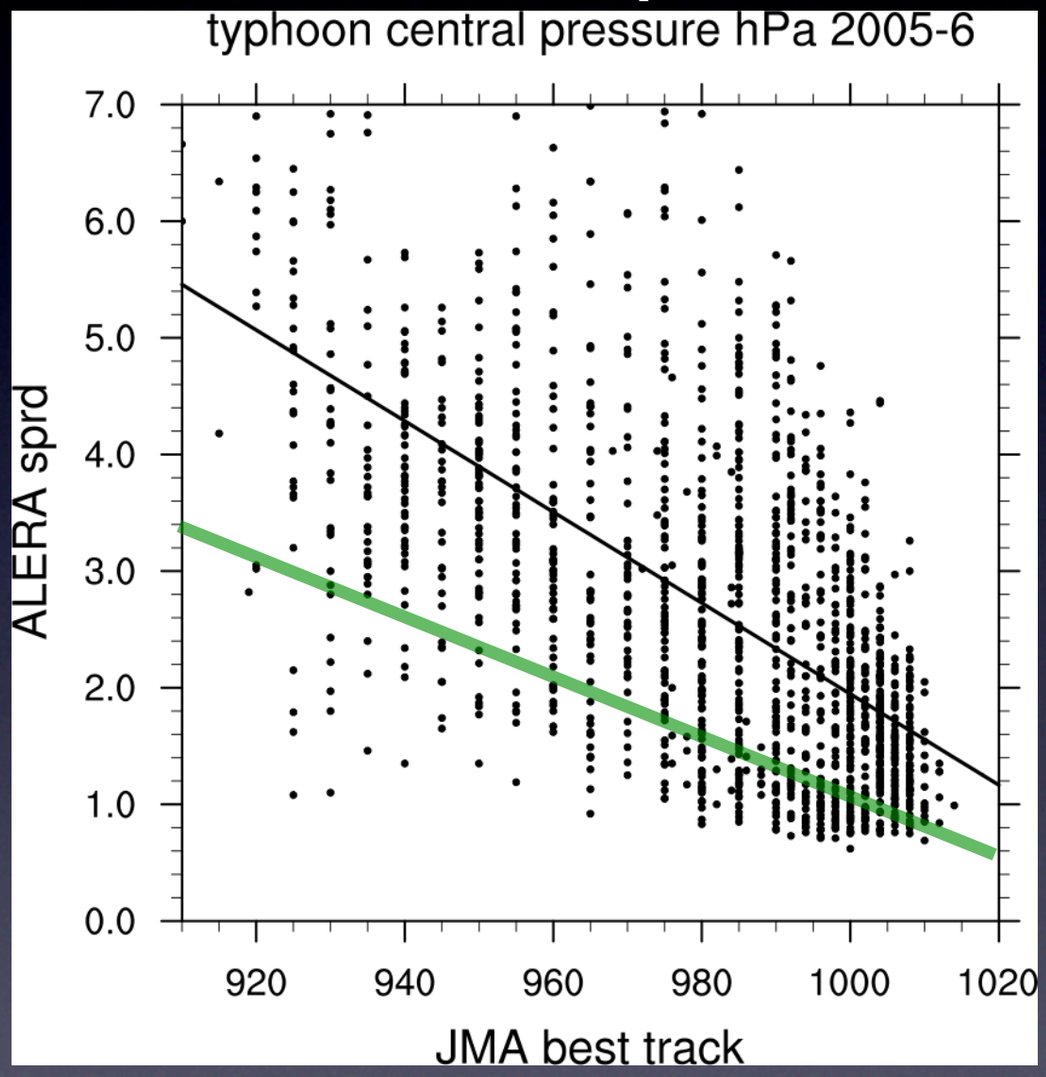


ALERA first guess vs JMA best track

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

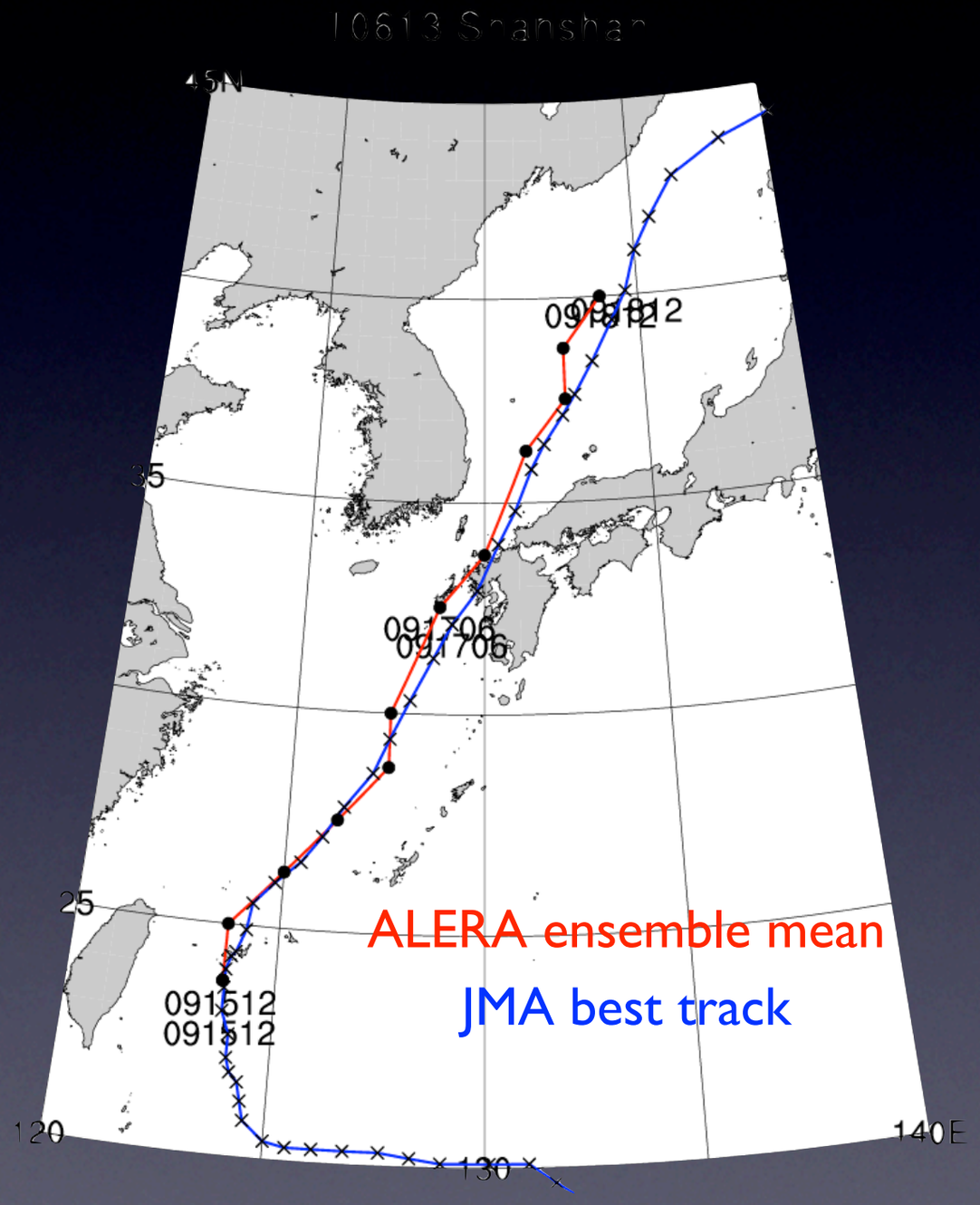
- may be obtained by chance
- one of the goals of T-PARC
- unresolvable by a moderate resolution GCM
- representativeness error to DA
- could be rejected during QC

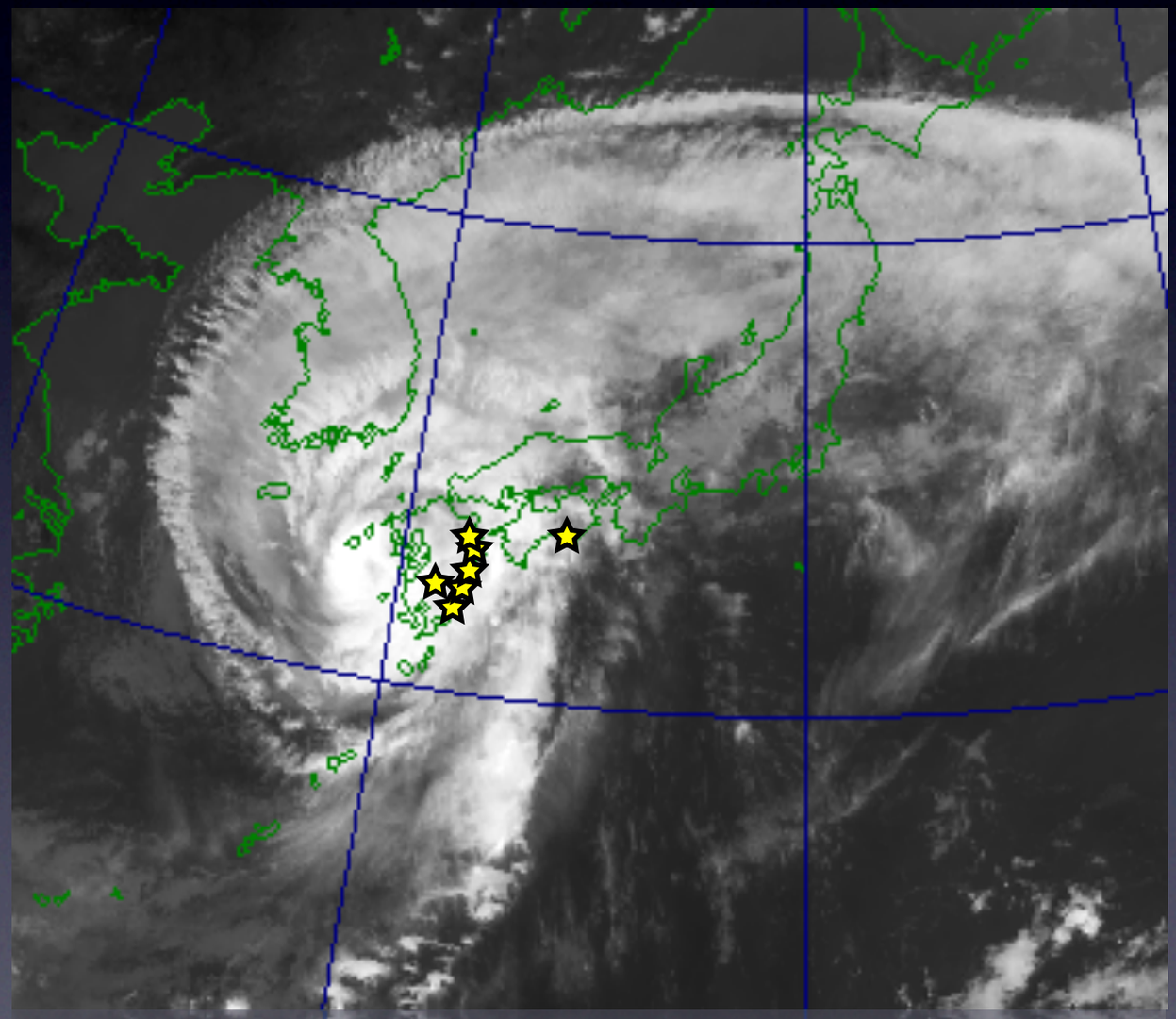
Case study

- Typhoon Shan Shan in 2006
- From 12 UTC 13 to 12 UTC18 Sep 2006
- Central pressure of JMA best track is used as observation substitutes

Shan Shan

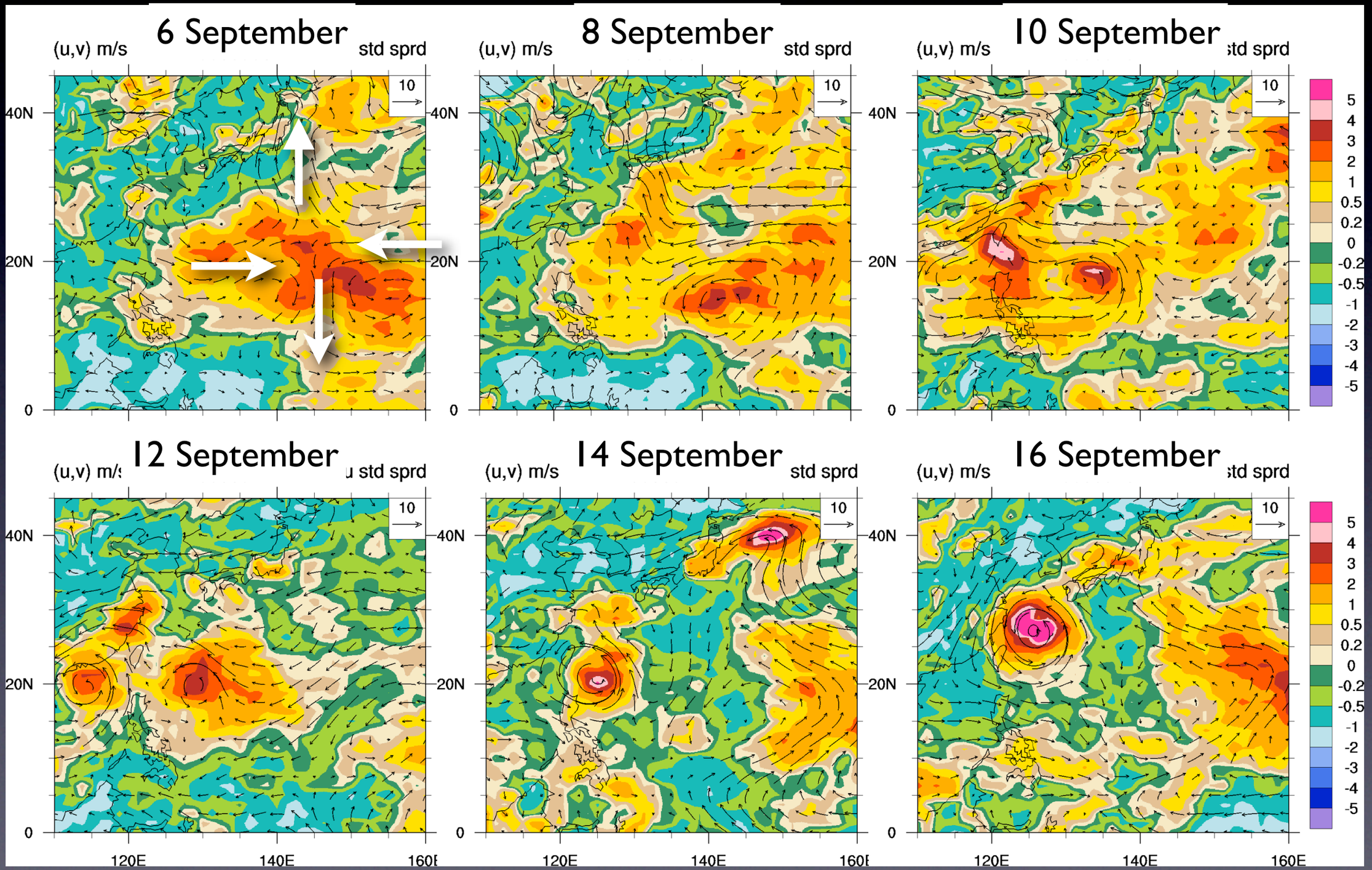
15JST 17 September 2006





Tornado events

ALERA (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 $p_{\mathrm{c\,min}}$ correction

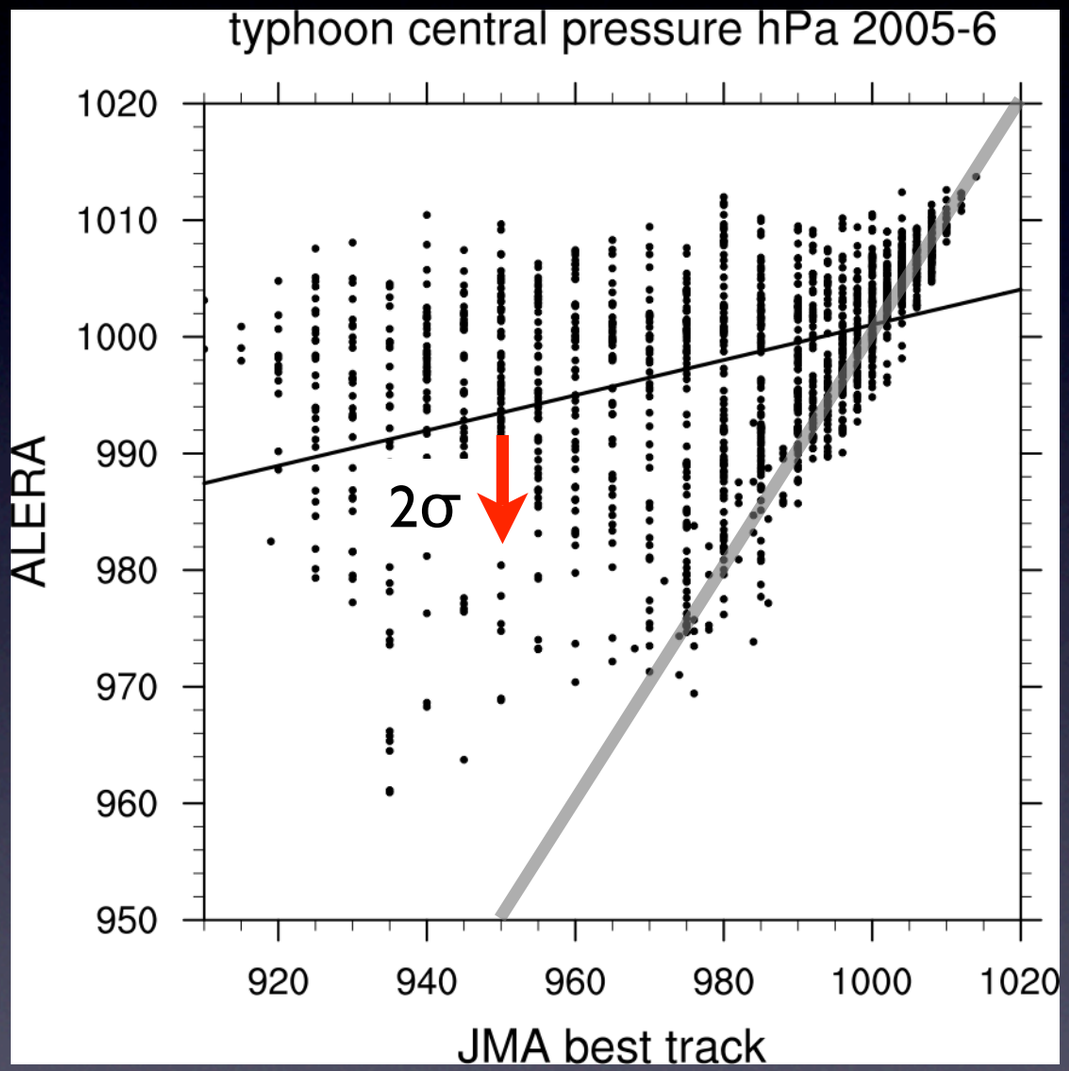
- 18 UTC 13 Sep 2006
- 127.6E, 20.3N
- r_{b} = 448 km, p_{b} = 1008 hPa
- Best track: 950 hPa
- Corrected: 999 hPa

$$p_{\mathrm{c\,min}} = p_{\mathrm{b}} - \rho\left(\frac{v_{15}^2}{r_{15}} + f v_{15}\right) \times \frac{r_{0\,\mathrm{min}}^2}{r_{15}}\left[1 + \left(\frac{r_{15}}{r_{0\,\mathrm{min}}}\right)^2\right]^{3/2} \times \left\{1 - \left[1 + \left(\frac{r_{\mathrm{b}}}{r_{0\,\mathrm{min}}}\right)^2\right]^{-1/2}\right.$$

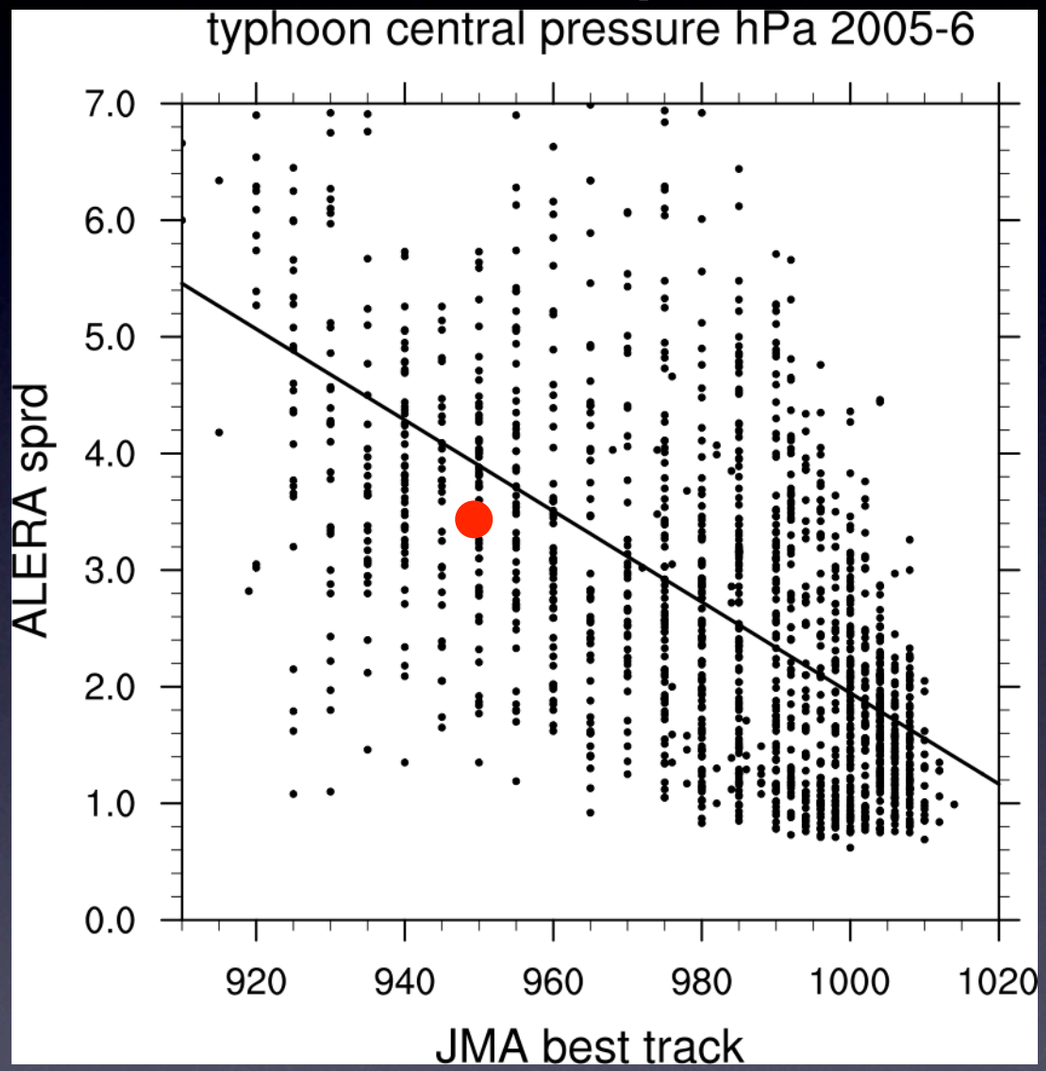
Assumed Fujita (1952)'s pressure distribution and gradient wind balance

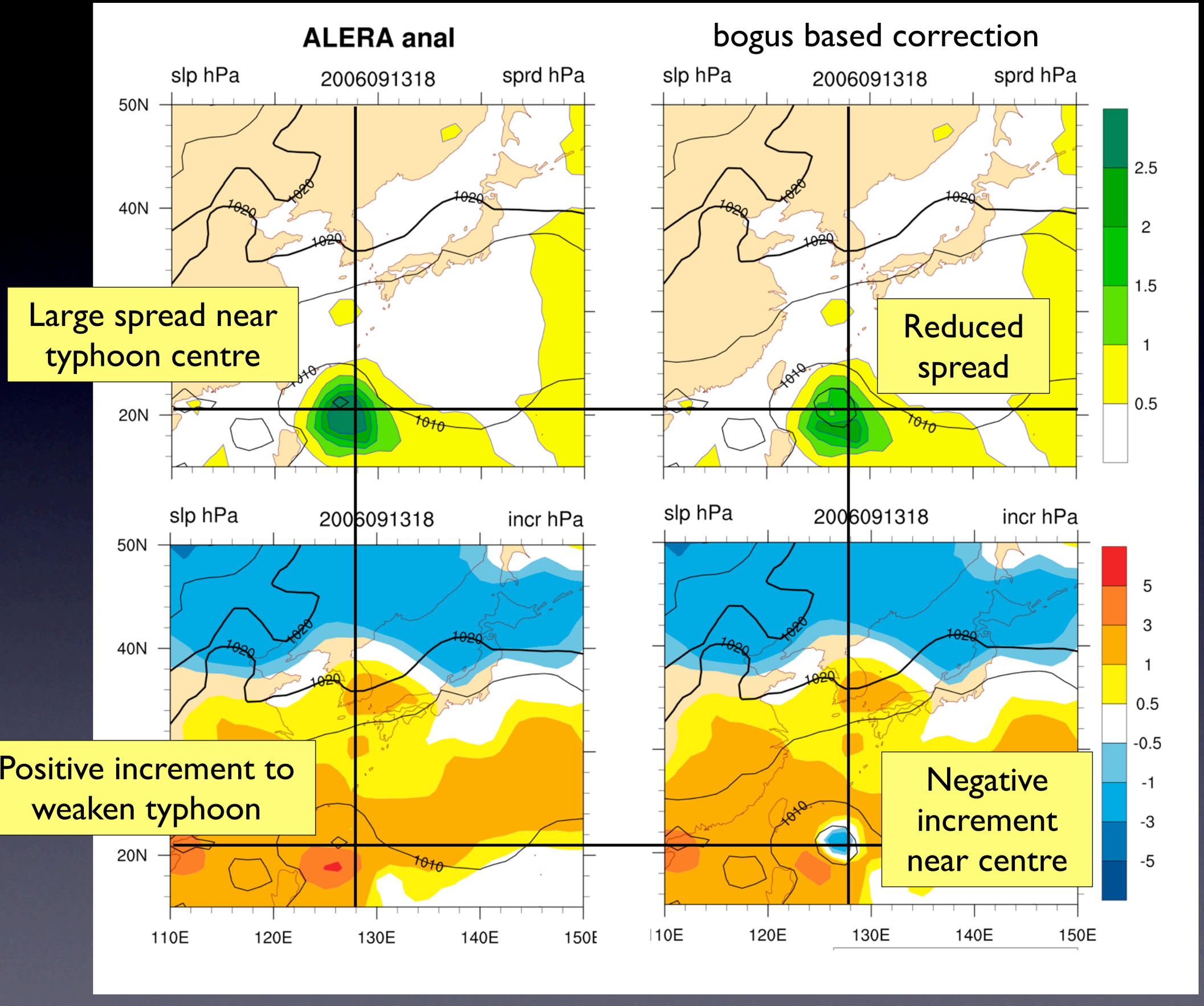
Ensemble based $p_{c\ min}$ correction

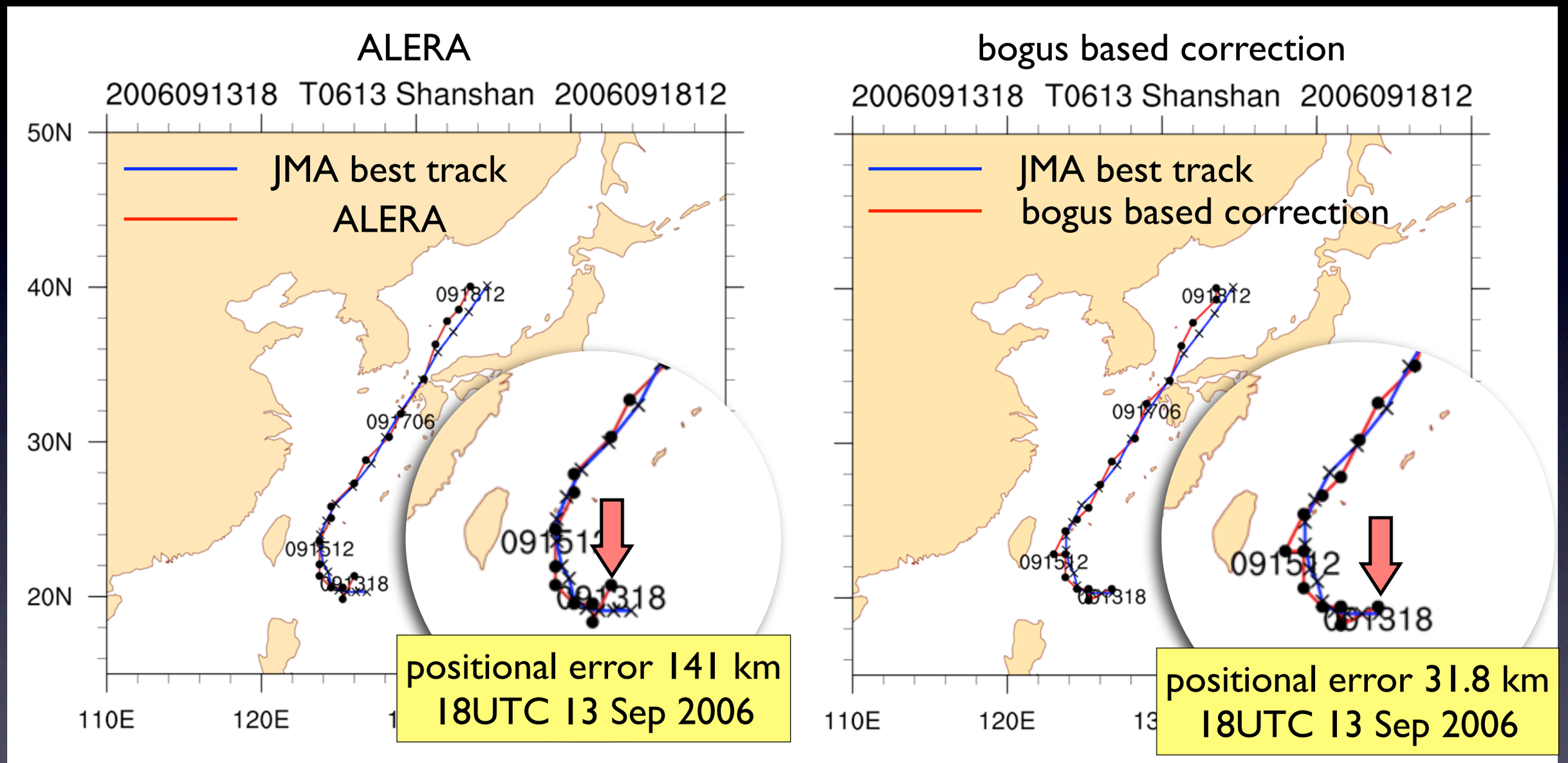
ensemble mean



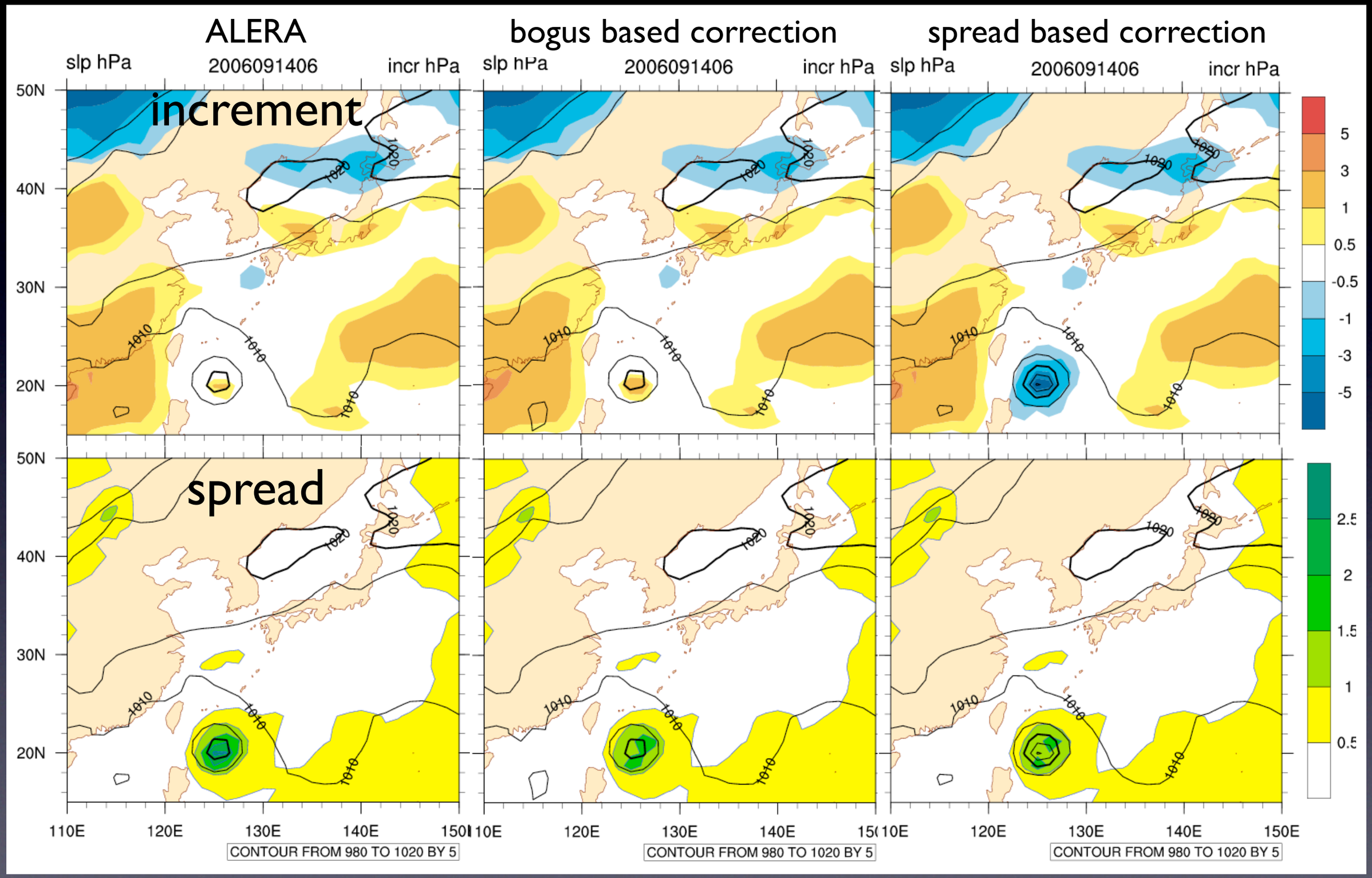
ensemble spread

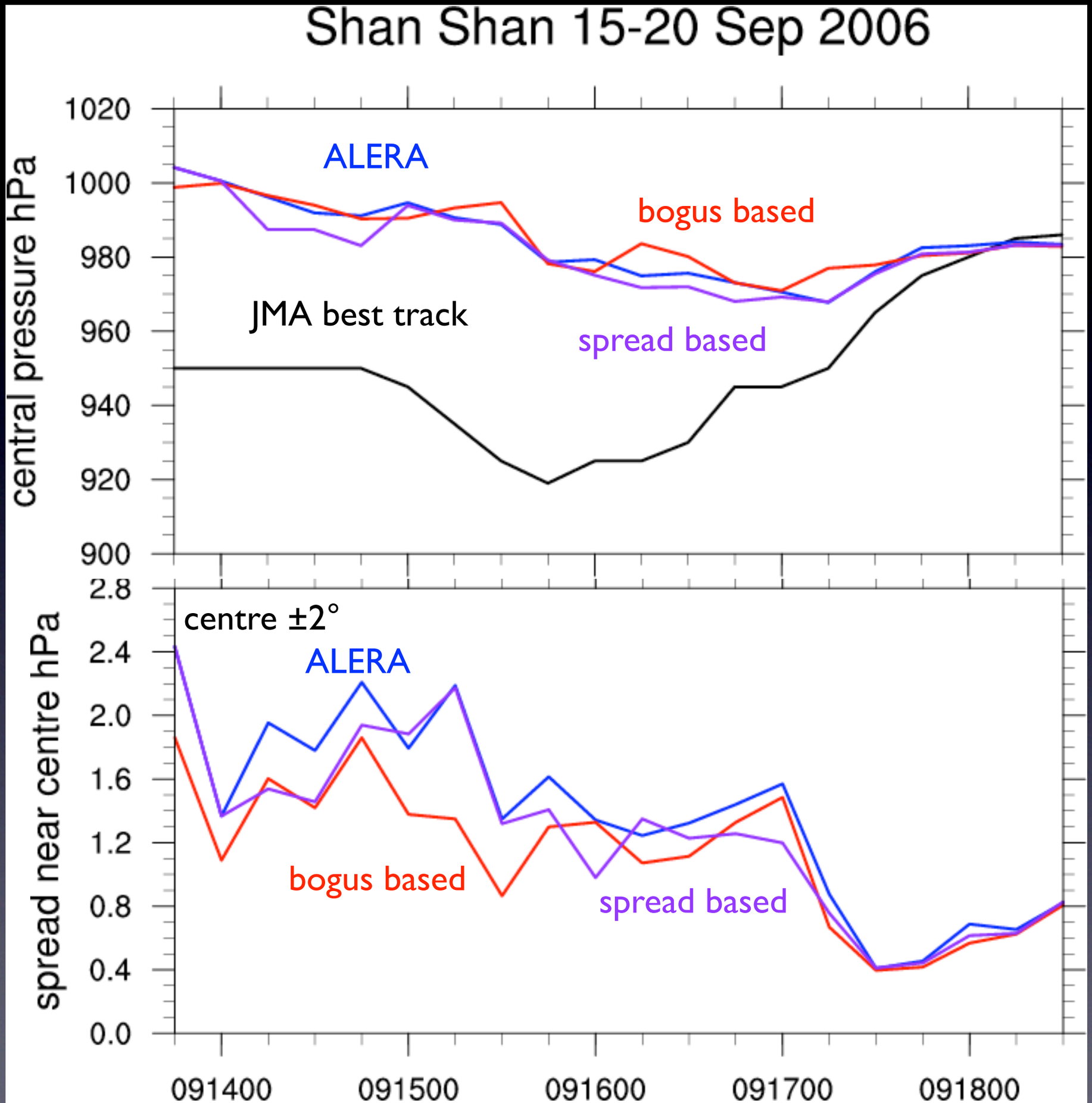



ALERA anal
bogus based correction
slp hPa
2006091318
sprd hPa
slp hPa
2006091318
incr hPa
50N
40N
20N
110E
120E
130E
140E
150E
1020
1010
2.5
2
1.5
1
0.5
5
3
1
0.5
-0.5
-1
-3
-5
Large spread near typhoon centre
Reduced spread
Positive increment to weaken typhoon
Negative increment near centre



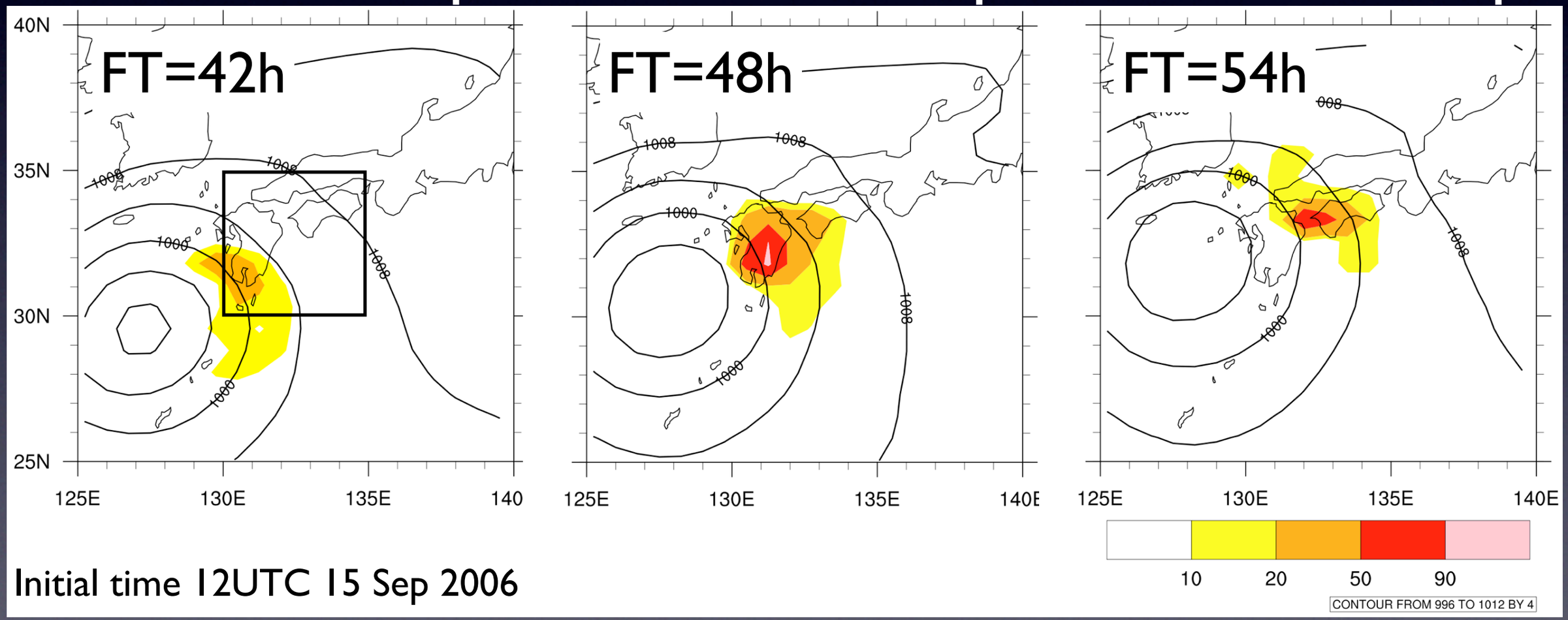
NB. model horizontal resolution is 80 km


ALERA
bogus based correction
spread based correction
slp hPa
2006091406
incr hPa
increment
spread
50N
40N
30N
20N
110E
120E
130E
140E
150E
1010
1020
1030
5
3
1
0.5
-0.5
-1
-3
-5
2.5
2
1.5
1
0.5
CONTOUR FROM 980 TO 1020 BY 5


Shan Shan 15-20 Sep 2006
central pressure hPa
1020
1000
980
960
940
920
900
ALERA
bogus based
JMA best track
spread based
spread near centre hPa
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0.0
centre ±2°
ALERA
bogus based
spread based
091400
091500
091600
091700
091800

Ensemble prediction of tornado potential

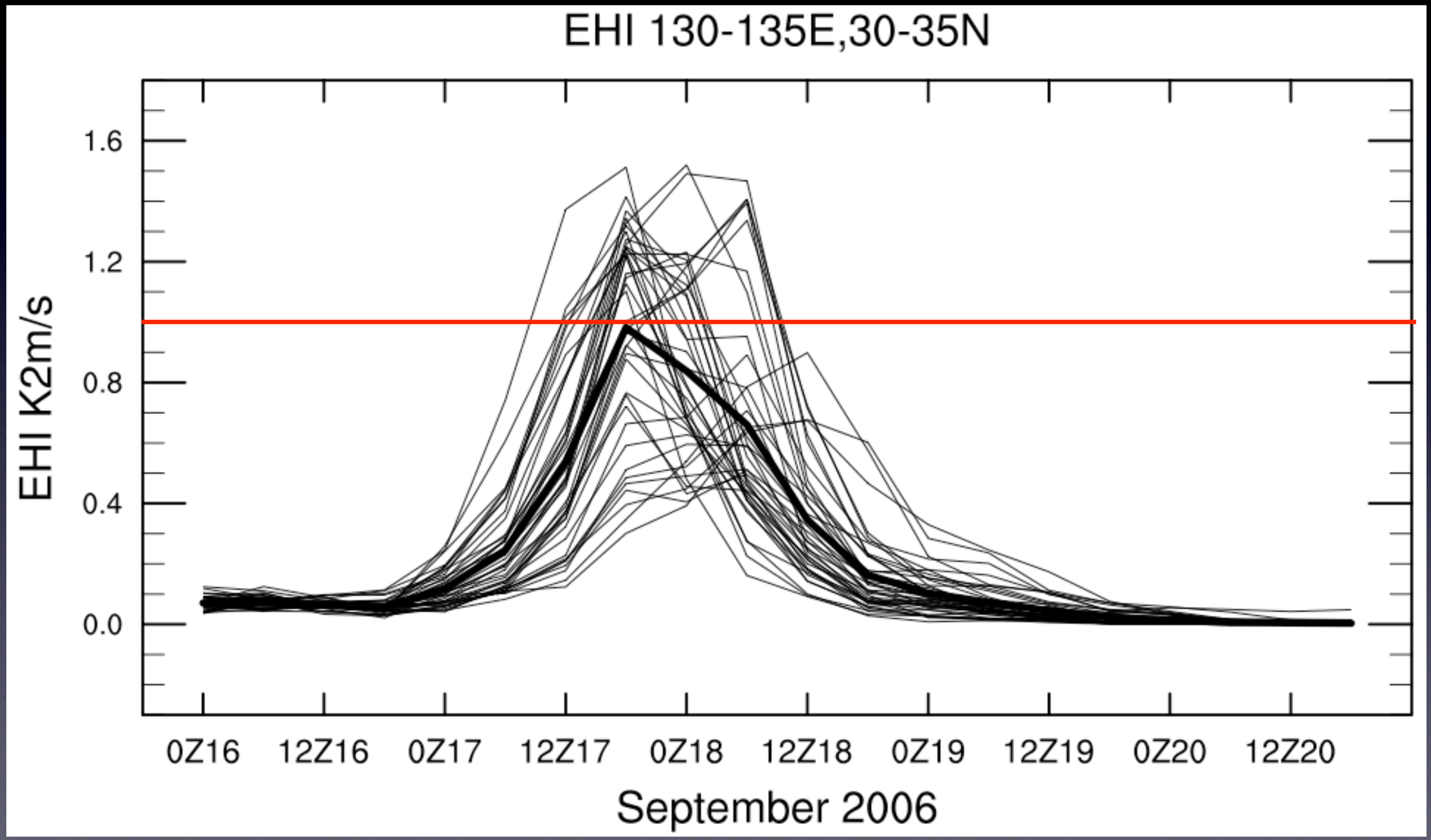
EHI > 0.5 J/kg m^2/s^2



Initial time 12UTC 15 Sep 2006

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 winterT-PARC OSE's