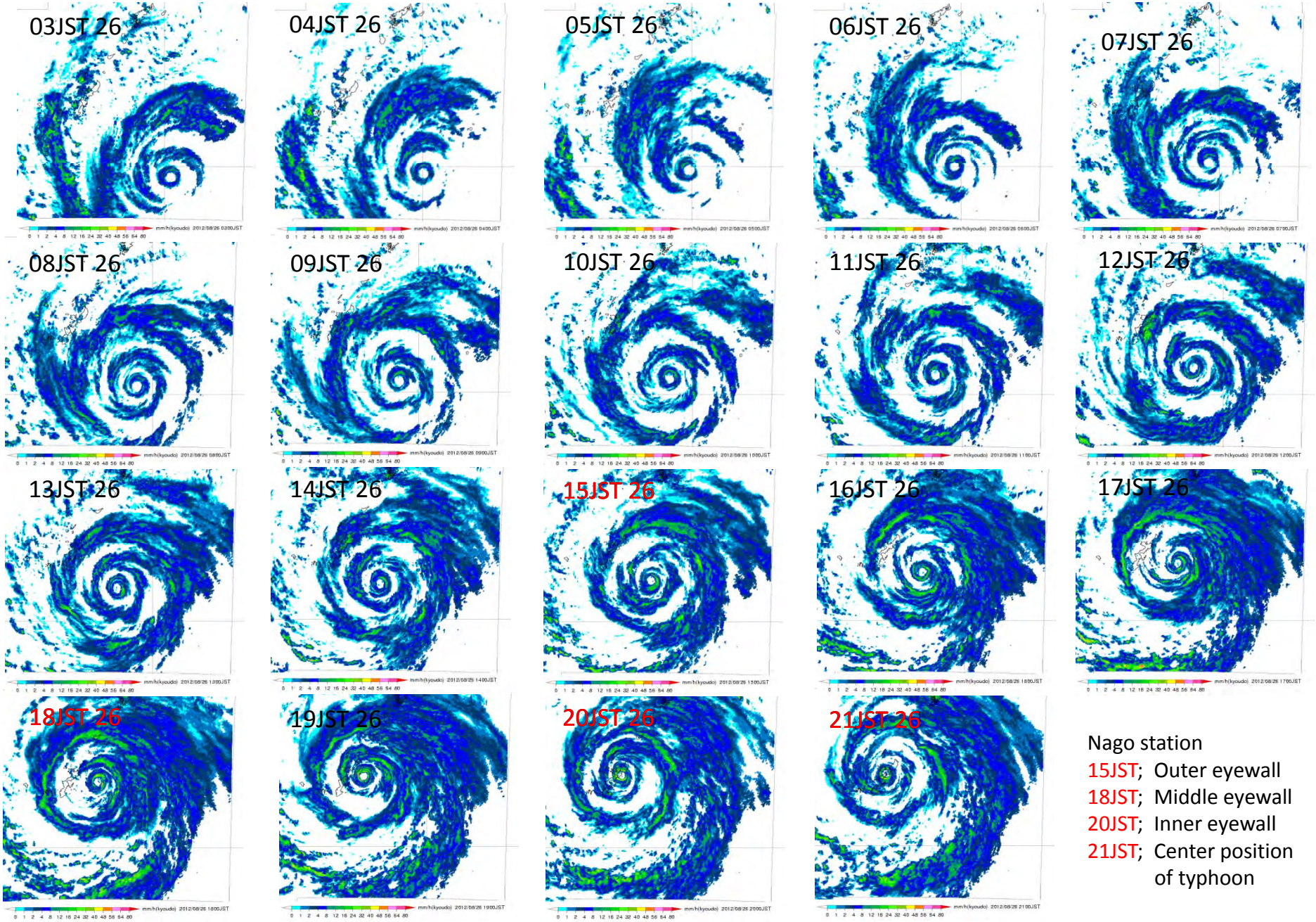
“The 3rd Research meeting of Ultrahigh Precision Meso-Scale Weather Prediction”
Thu. 21 Mar. 2013

Triple eyewall experiment of the 2012 typhoon “Bolaven” using cloud resolving ensemble forecast

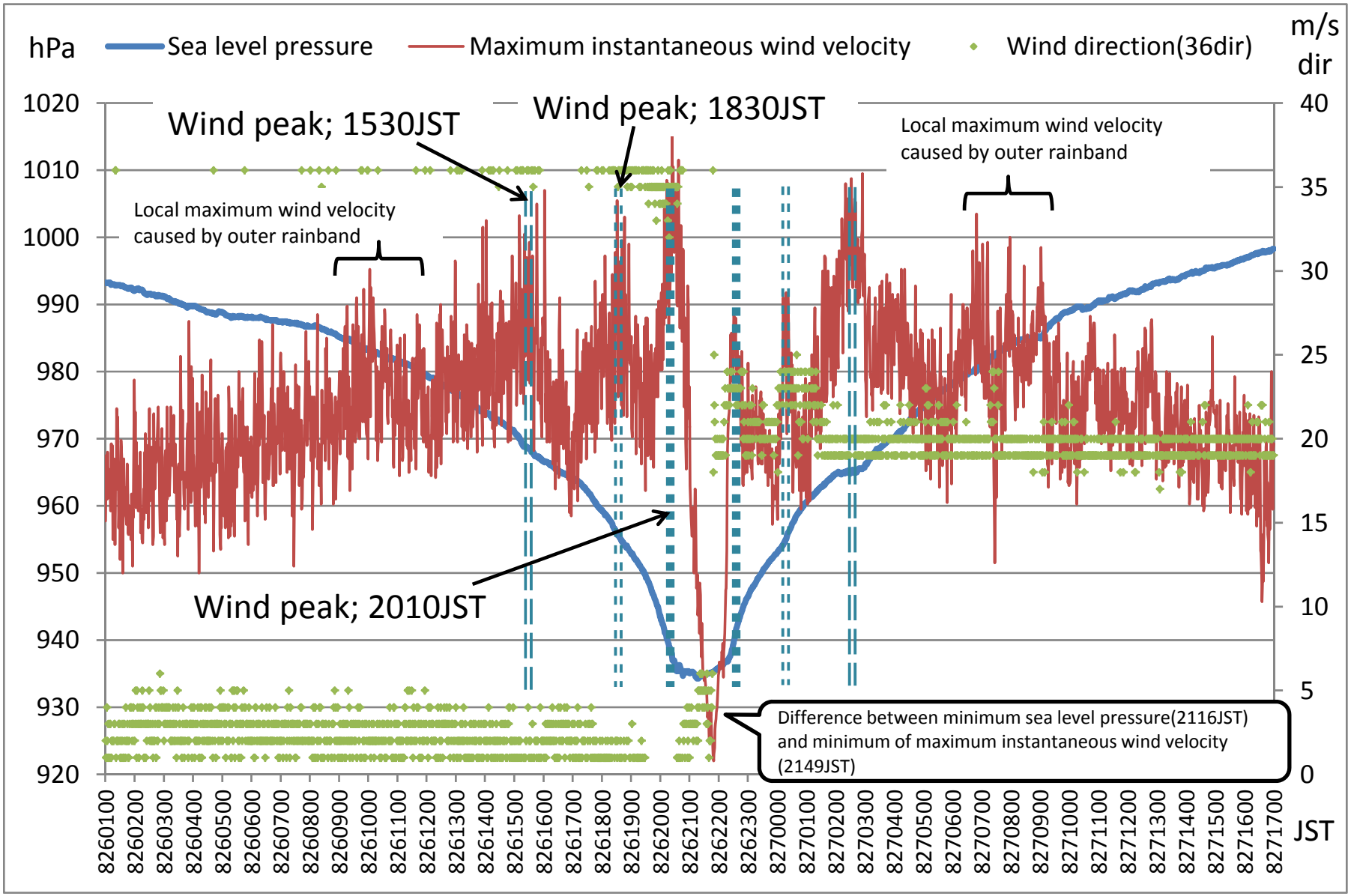
Seiji ORIGUCHI, Kazuo SAITO, Hiromu SEKO, Wataru MASHIKO (MRI)
Tohru KURODA (JAMSTEC)

JMA's Radar image (RISS)

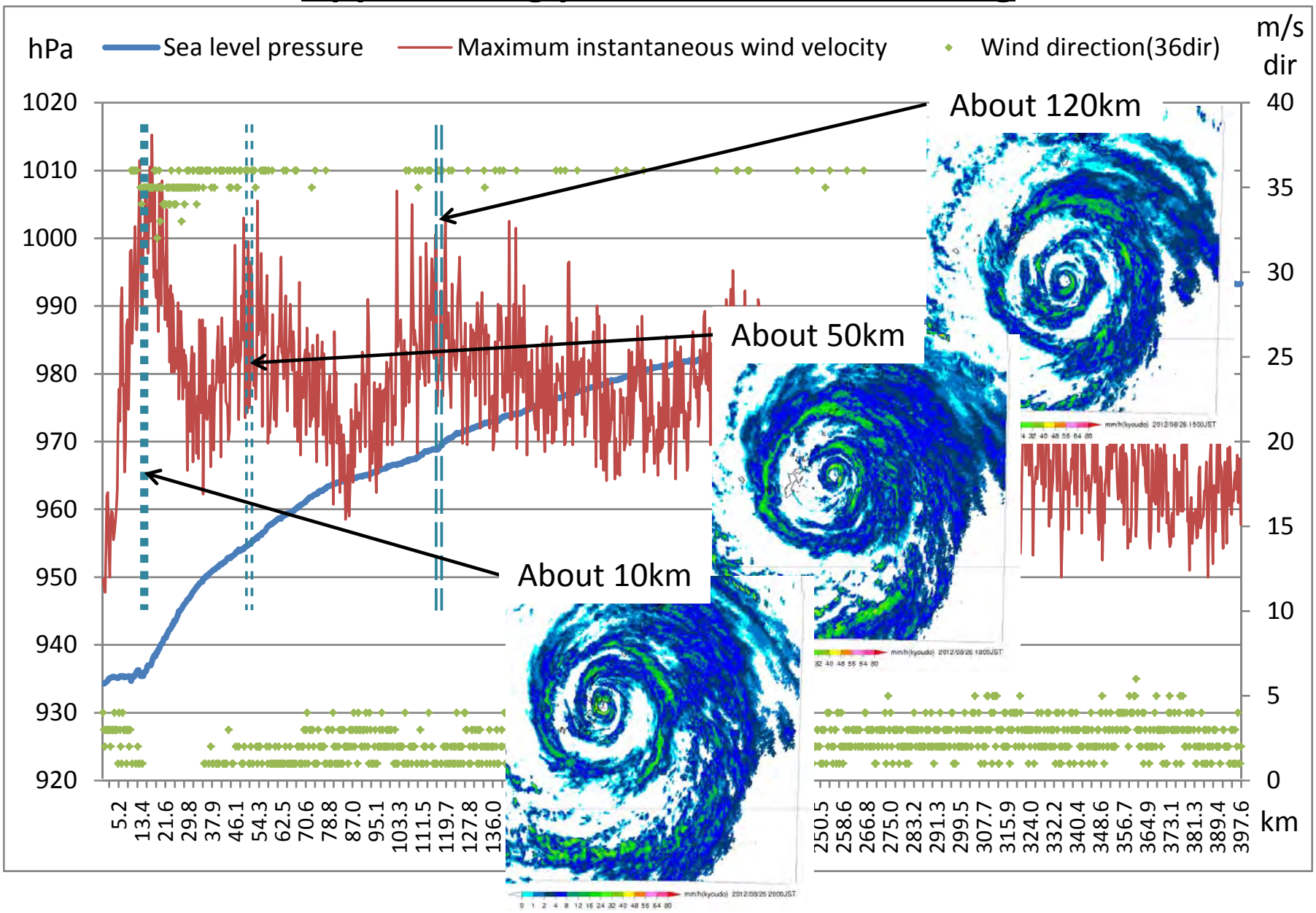


Nago station
15JST; Outer eyewall
18JST; Middle eyewall
20JST; Inner eyewall
21JST; Center position of typhoon

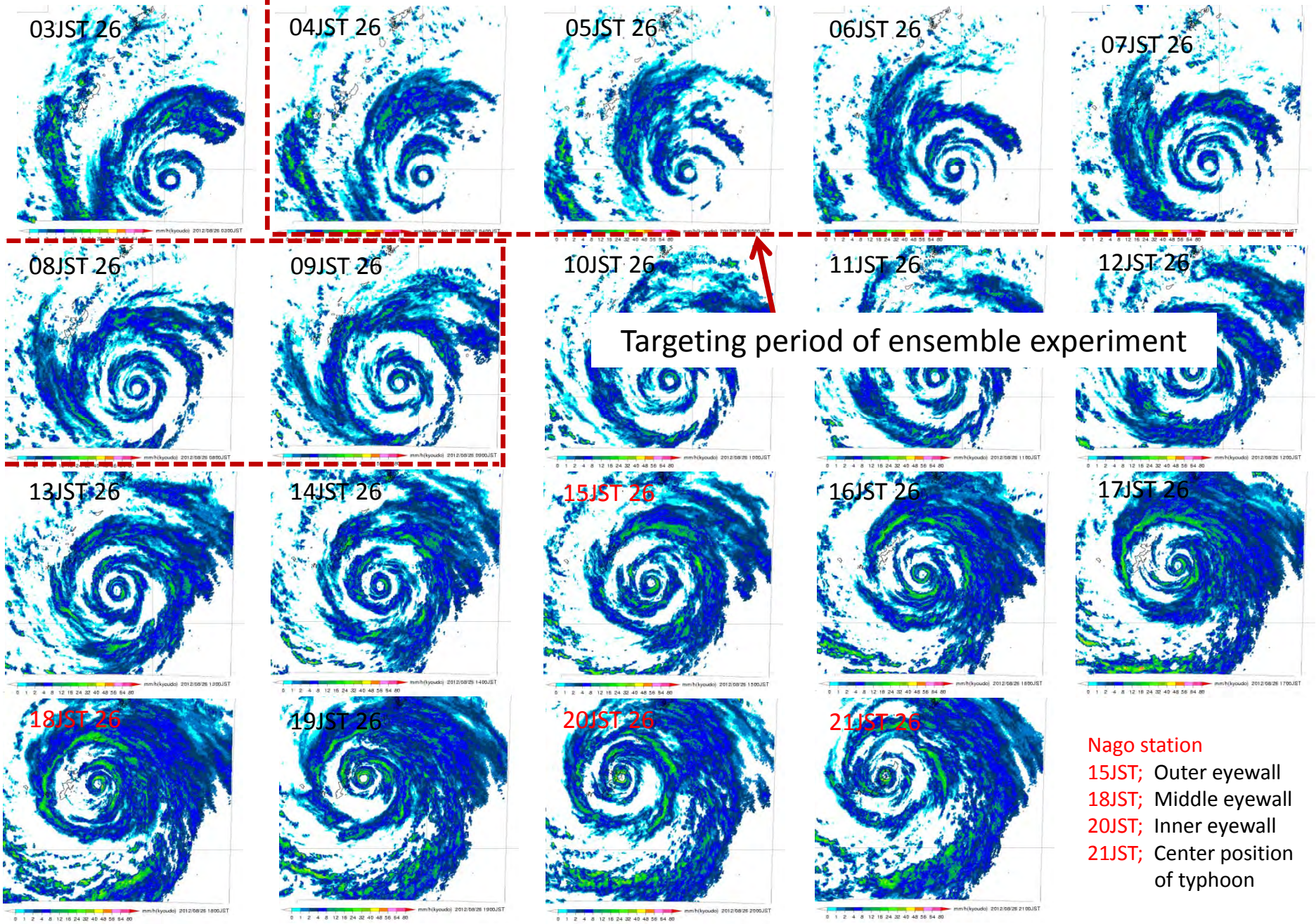
Surface observation data (Nago station)
26 – 27 Aug 2012



Surface observation data (Nago station)
Approaching period, ～21JST 26 Aug



JMA's Radar image (RISS)



Nago station

15JST; Outer eyewall

18JST; Middle eyewall

20JST; Inner eyewall

21JST; Center position of typhoon

Ensemble experiment under the changed physical conditions

3
- Case1
  10km（789x251）→ 2km（400x400）
  [10km: 2mom3iceCMF+KF, MYNN3,　2km: 2mom3iceCMF, MYNN3]

2
- Case2
  5km（789x251）→ 1km（800x800）
  [5km: 2mom3iceCMF, MYNN3,　1km: 2mom3iceCMF, deardorff]

1
- Case3
  5km（789x251）→ 1km（800x800）
  [5km: 2mom3iceCMF+KF, MYNN3,　1km: 2mom3iceCMF, deardorff]

5
- Case4
  2km（800x800）
  [2km: 2mom3iceCMF, MYNN3]

4
- Case5
  2km（800x800）
  [2km: 2mom3iceCMF, deardorff]

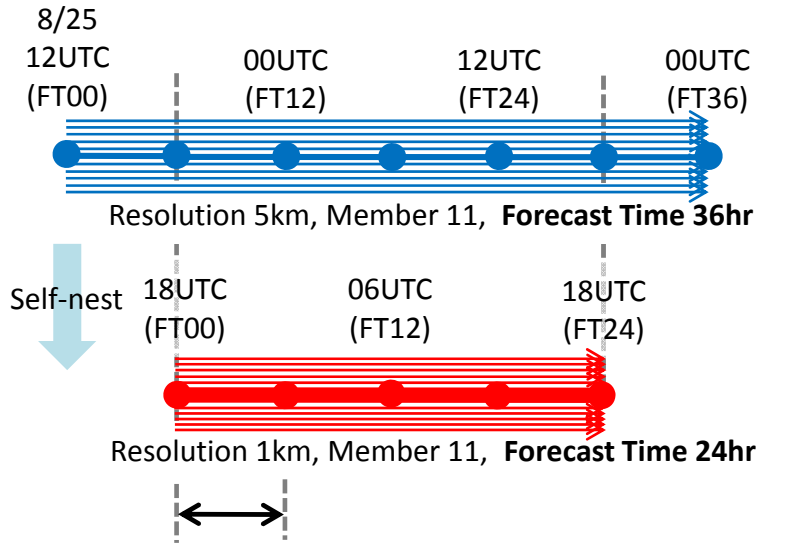
?
- Case6
  2km（1800x1440）→ 500m（3000x3000）
  [2km: 2mom3iceCMF, deardorff,　500m: 2mom3iceCMF, deardorff]

Experimental conditions of Case3

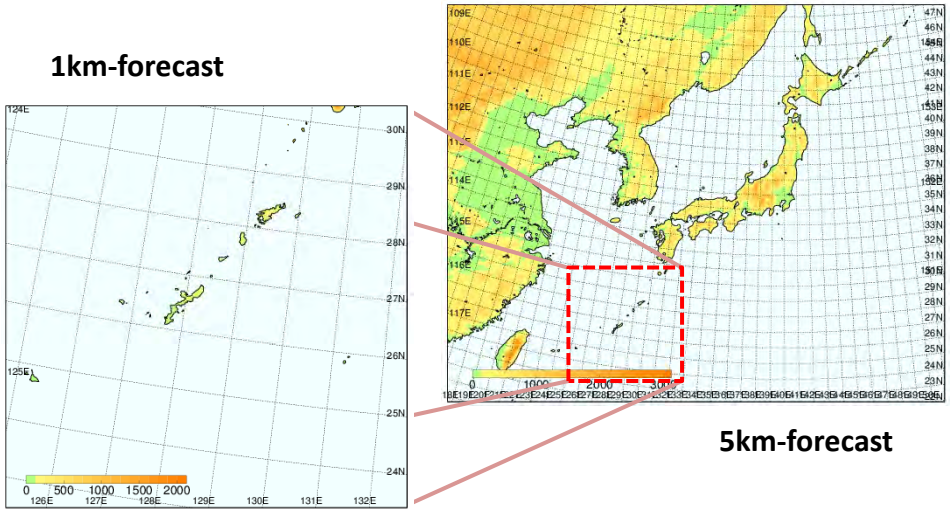
＜Model settings＞

	5km-forecast	1km-forecast
Model	JMA-NHM	
Resolution・Grid size	5km・721x577x50	1km・800x800x60
Time step	24(sec)	4(sec)
Initial condition (CNTL)	Meso analysis (NHM-4DVAR) Resolution 5km (Inner-loop 15km, Increment method 5km, Window 3hr)	FT=06 of 5km forecast
Boundary condition (CNTL)	GSM forecast (interval 1hr)	5km forecast (interval 1hr)
Initial condition (ENS)	Meso analysis + perturbation of JMA 1 week forecast	FT=06 of 5km forecast
Boundary condition (ENS)	GSM forecast + perturbation of JMA 1 week forecast	5km forecast (interval 1hr)
Member	11(CNTL+ENS)	
Treatment of density	Full compressibility	
Basic equations	Elasticity・Nonhydrostatic・Solution of HE-VI	
Cloud microphysics・Convective scheme	2-moment 3-ice bulk method ＋Kain-Fritsch scheme	2-moment 3-ice bulk method
Layer・Turbulent scheme	MYNN Level3	Deardorff(1980)

＜Ensemble forecast＞



＜Model domain＞



Reproducible criteria of multiple eyes?

・There aren’t objective(numerical) evaluation method or common indicator between researchers.

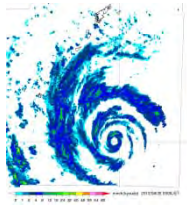
・Therefore, we think the following 2 criteria.

●We don’t decide by shape of precipitation distribution of the short time. We judge by shape of updrafts or water substances(**Qc+Qr**+Qi+Qs+Qg) between 1km and 5km AGL, and if ring shape of updrafts or water substances keeps about 6 hours, we define as eyewall structure.

●Even when a part of ring changes spiral or it cuts off for the short time, if ring shape of updrafts or water substances keeps overall between 1km and 5km AGL, we define as eyewall structure.

Precipitation 1hr(prec1)・Water substance(tw=lw+iw)・Updraft(w)　FT=03

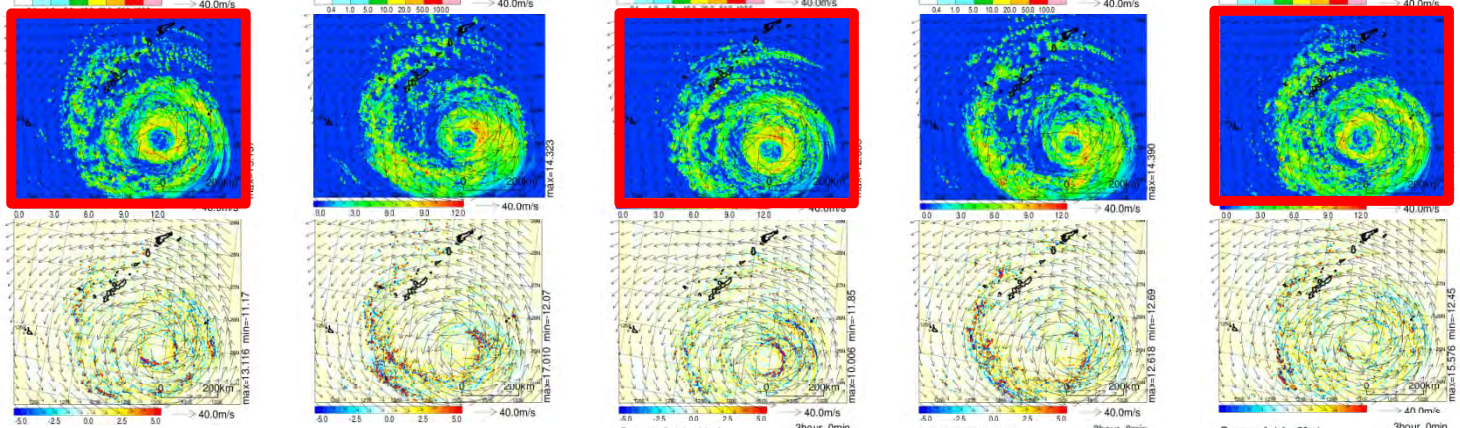
Radar



Surface(Nago) and Radar observation
➔ Radius of eyewall;
About 10km, About 50km, About 120km

1km Ensemble forecast
Inner eyewall ➔ weak
About 10km
Middle eyewall ➔ strong
About 50km
Outer eyewall ➔ moderate
About 120km

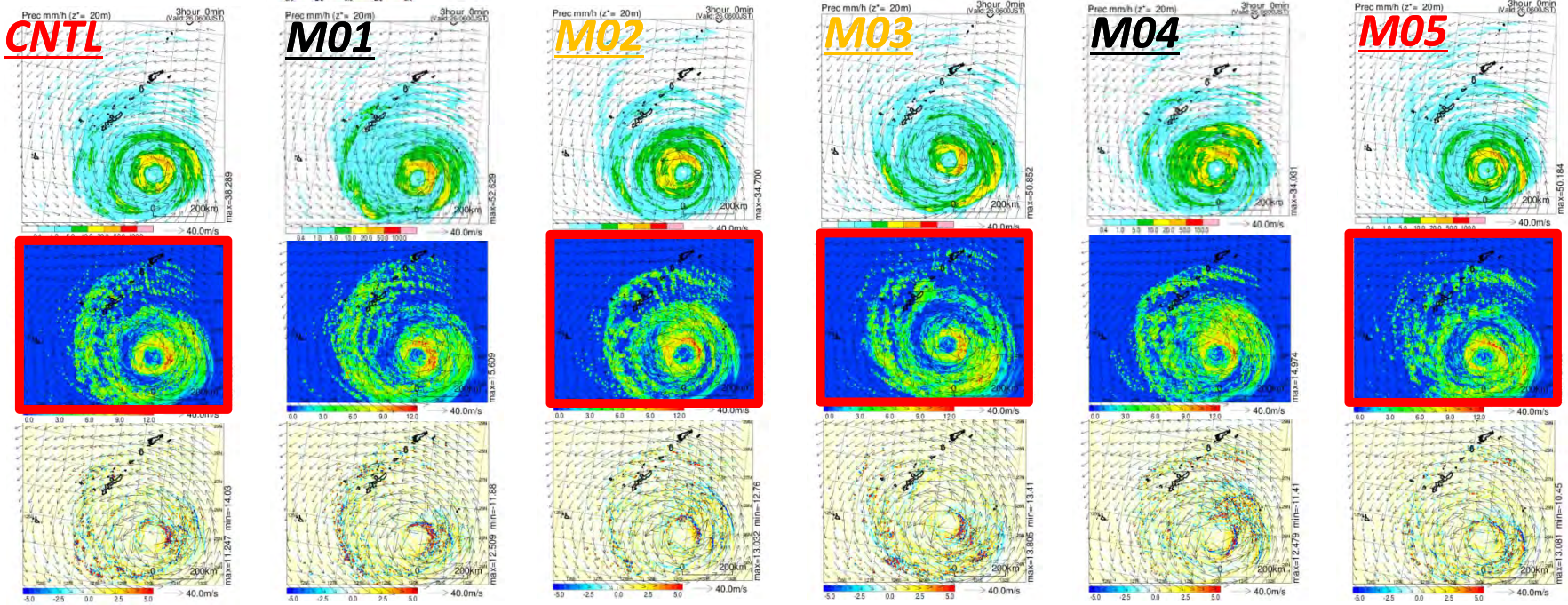
P01　**P02**　**P03**　**P04**　**P05**　Surf



Z*=3.72km

Z*=3.87km

CNTL　**M01**　**M02**　**M03**　**M04**　**M05**　Surf



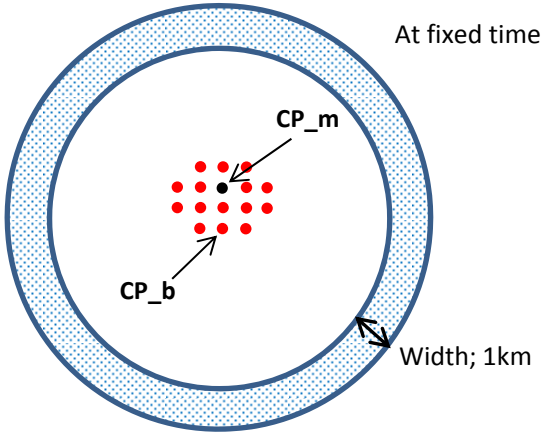
Z*=3.72km

Z*=3.87km

Analysis method of triple eyewall ～Estimation of center position～

● Braun's method 2002

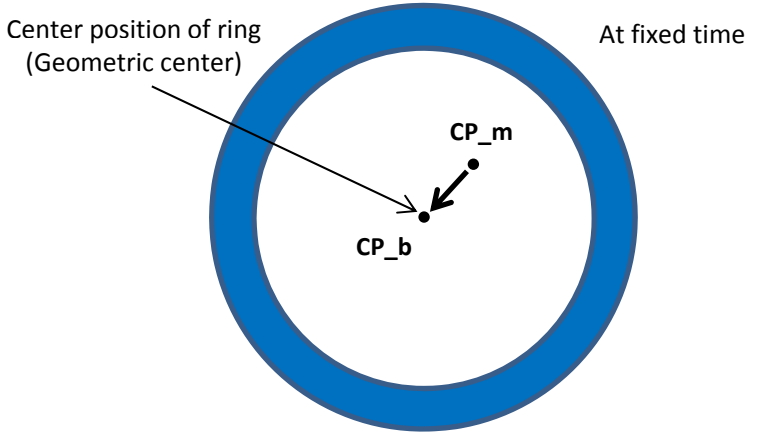
CP_m; Position decided by minimum surface pressure(Psea_m)
CP_b; Position decided by Braun's method

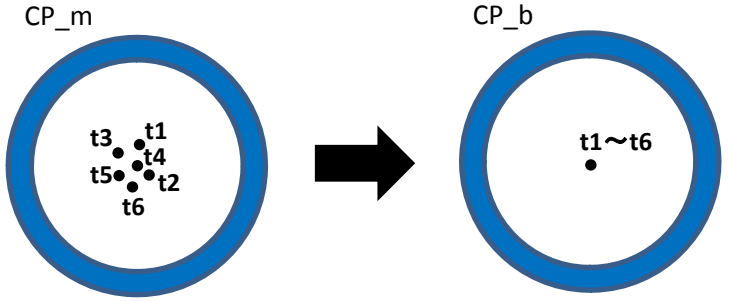


$$Sp = \sum_{r=1(km)}^{100} Sr(Psea)$$

Sr; Standard deviation(Psea) in ring of radius r and width 1km

①Calculation of Sp at neighborhood position
②CP_b decided by position of minimum value of Sp





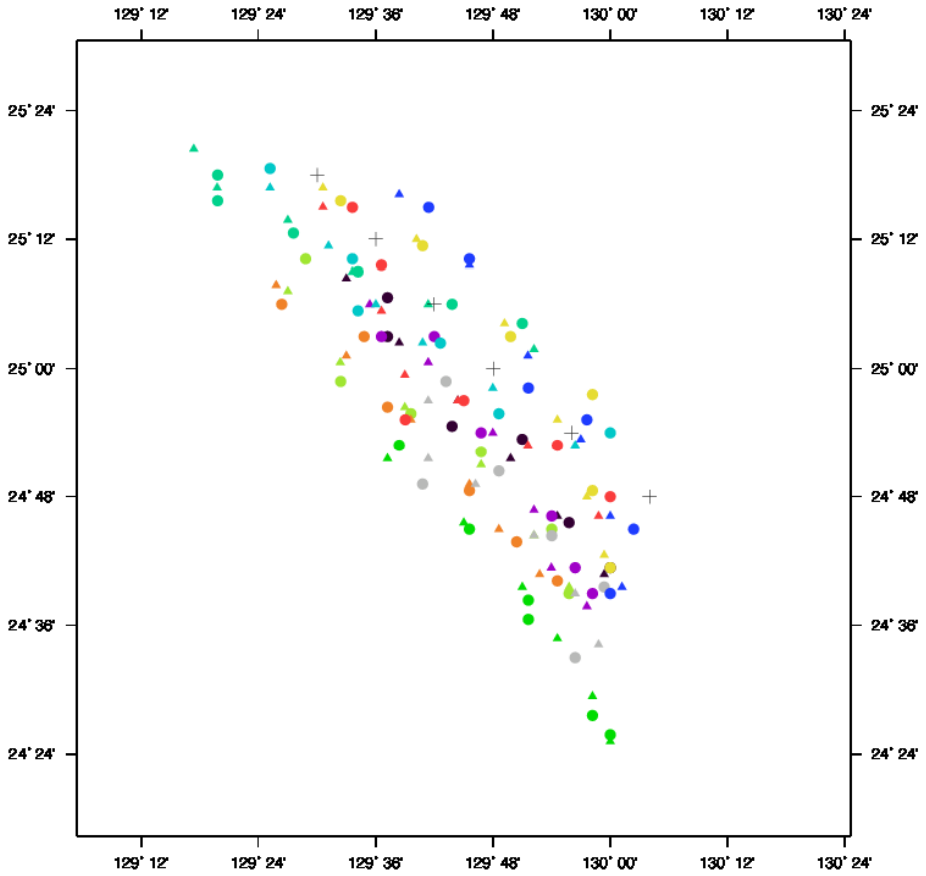
Ring's oscillation occurs for each forecast time

Ring is fixed for each forecast time.
Consistency with temperature and wind

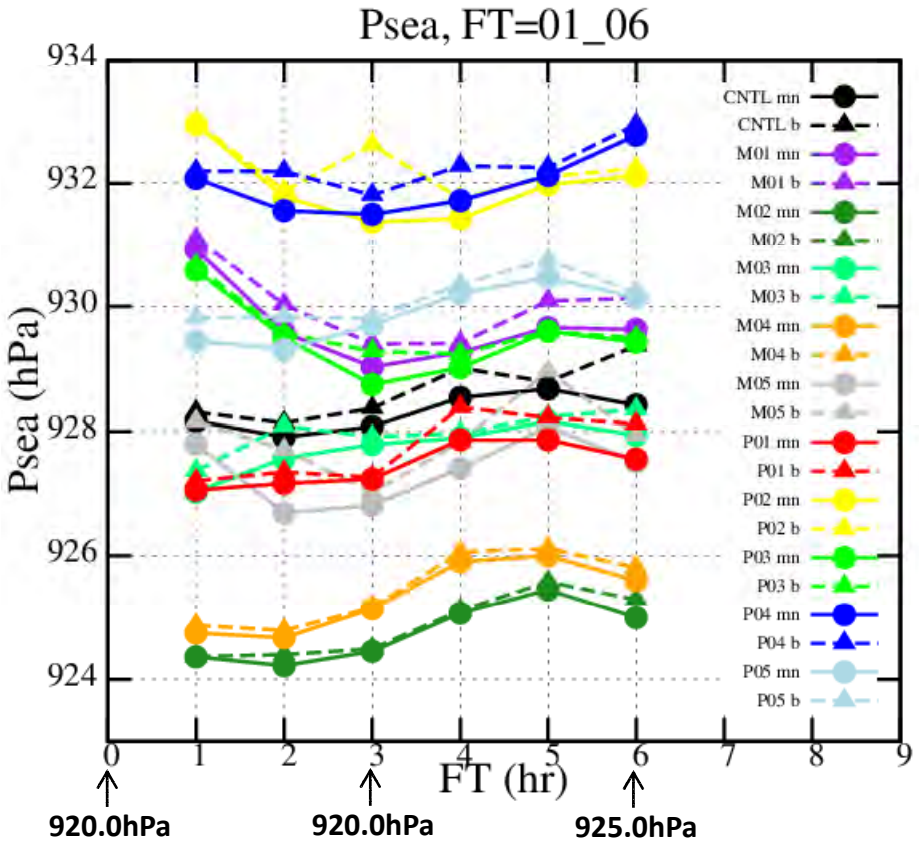
Results depend on the determining method of the center position, therefore we decided optimum position from Braun's method 2002.

Analysis results of triple eyewall ～Estimation of center position～

Comparison of CP_m and CP_b for FT=01～06 (11member)



Comparison of Psea_m and Psea_b for FT=01～06 (11member)

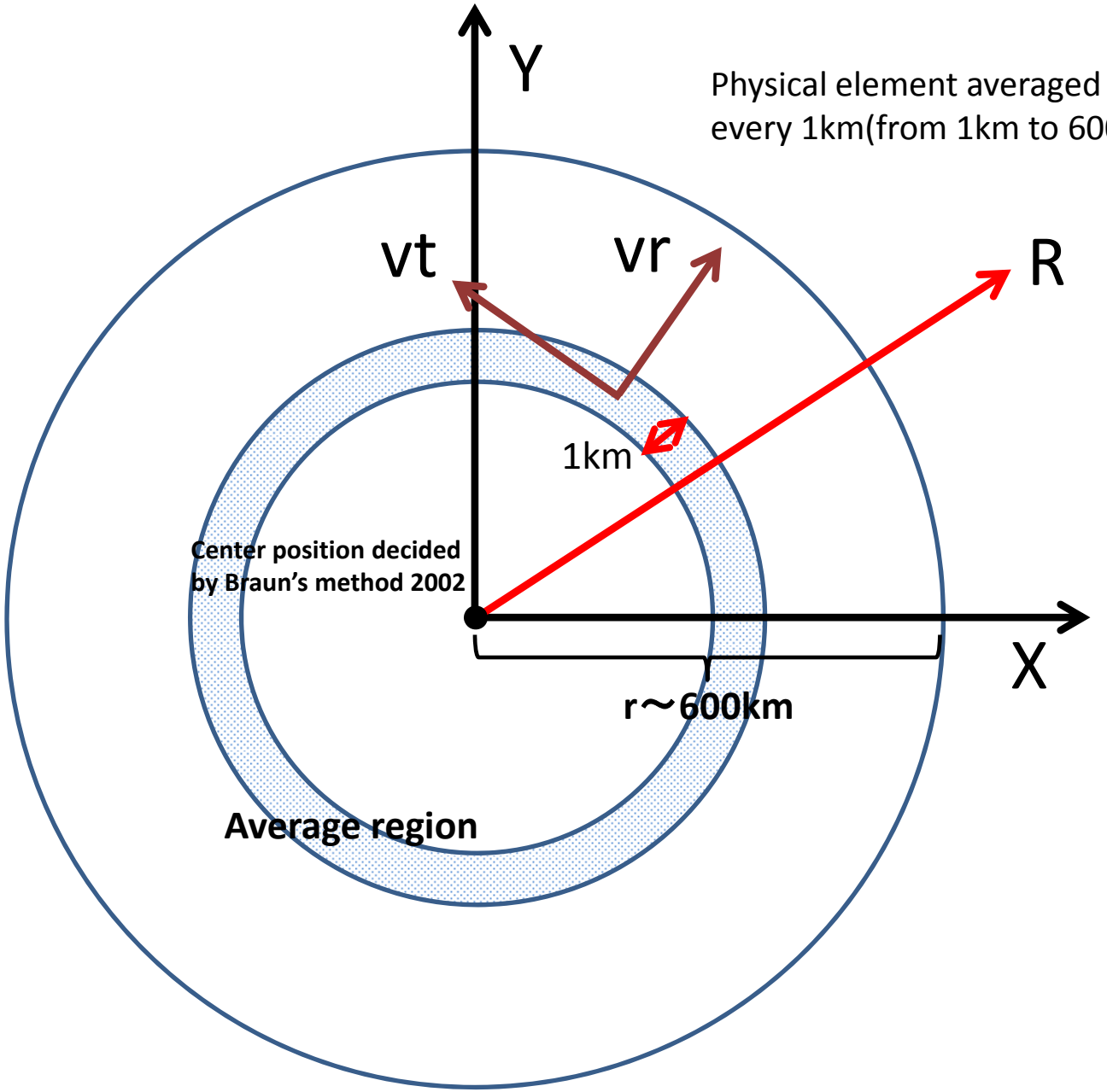


Different about maximum 6km between CP_m and CP_b

⬇

Radius of inner eyewall is about 10km. So, if we don't correct center position by Braun's method 2002, we can't get accurate analysis results.

Analysis method of triple eyewall ～Averaged physical element～



Physical element averaged in the ring region of radius every 1km(from 1km to 600km) and width 1km.

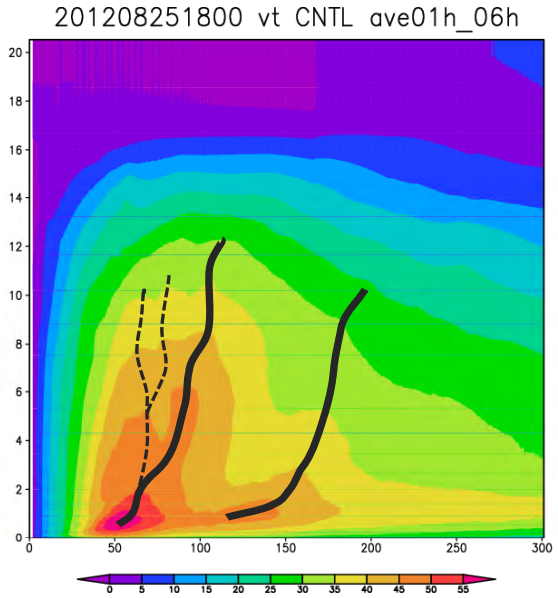
- ⟨**vt**m⟩t
- ⟨**vr**m⟩t
- ⟨**vel**m⟩t=⟨(Vt+Vr)$^{1/2}$|m⟩t
- ⟨**w**m⟩t
- ⟨**t**m⟩t
- ⟨**lw**m⟩t=⟨(Qc+Qr)|m⟩t
- ⟨**iw**m⟩t=⟨(Qi+Qs+Qg)|m⟩t

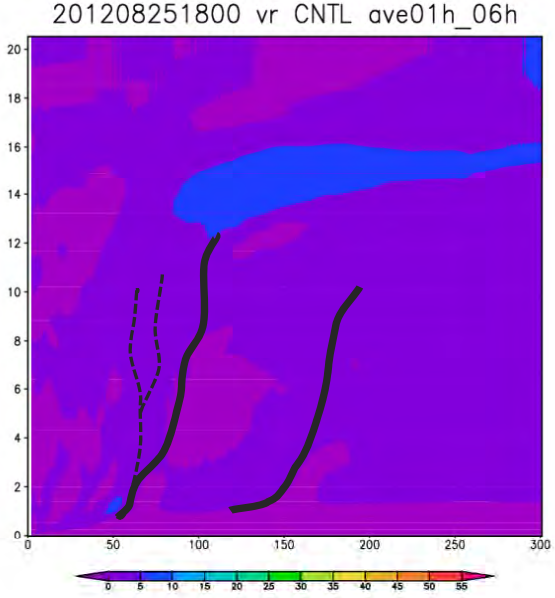
*m : Spatial average of *

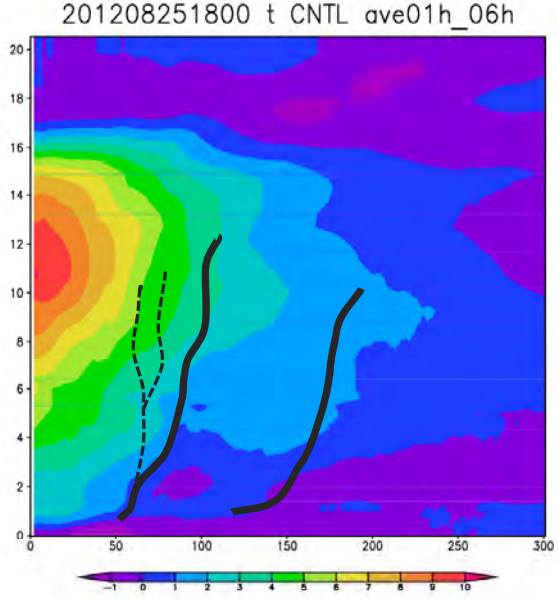
⟨*⟩t : Temporal average of *

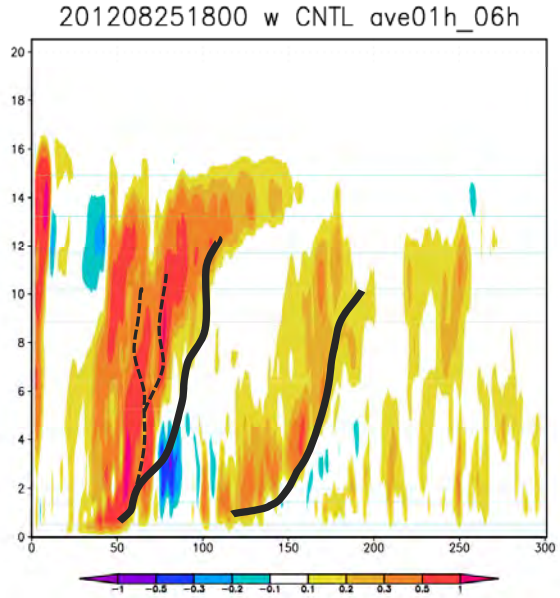
Analysis results of triple eyewall ～Averaged physical element～

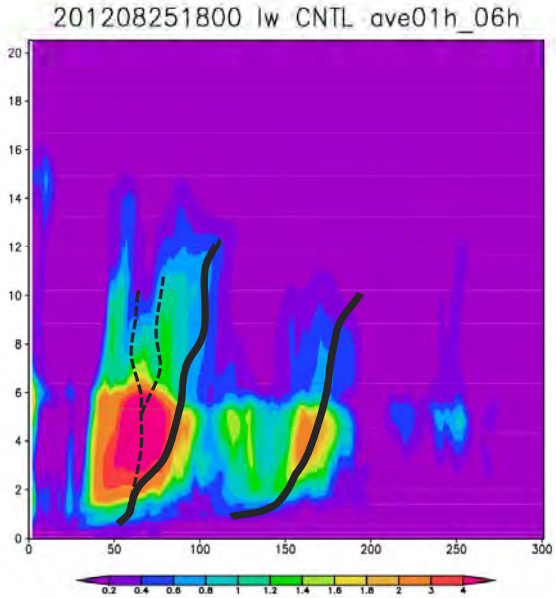
Tangential velocity〈vtm〉t・Radial velocity〈vrm〉t・Updraft〈wm〉t・liquid water〈lwm〉t・Solid water〈iwm〉t average 6hr *CNTL*

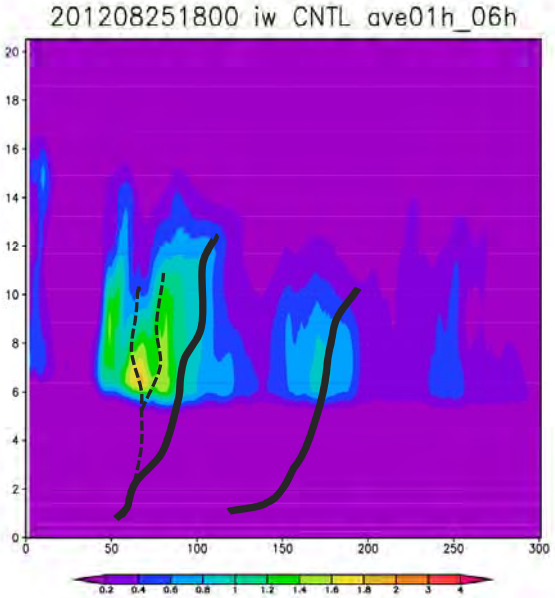






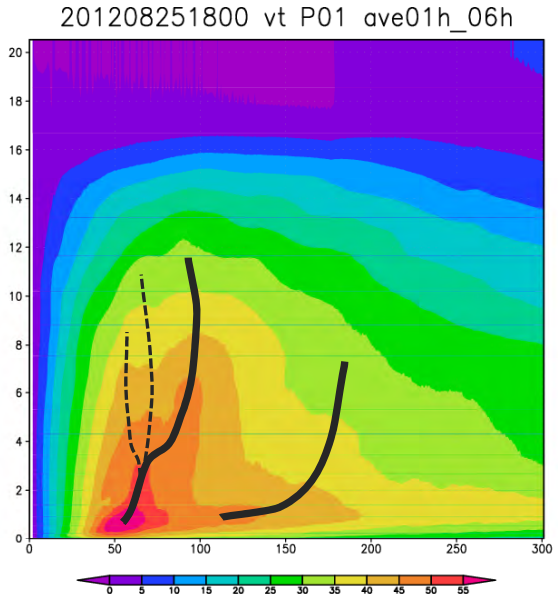


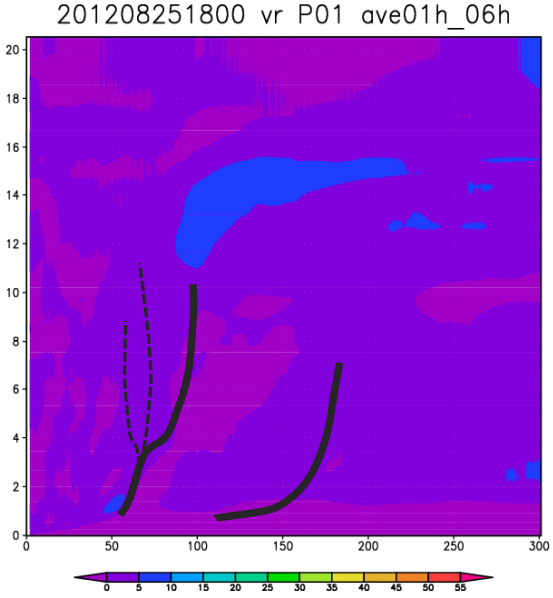


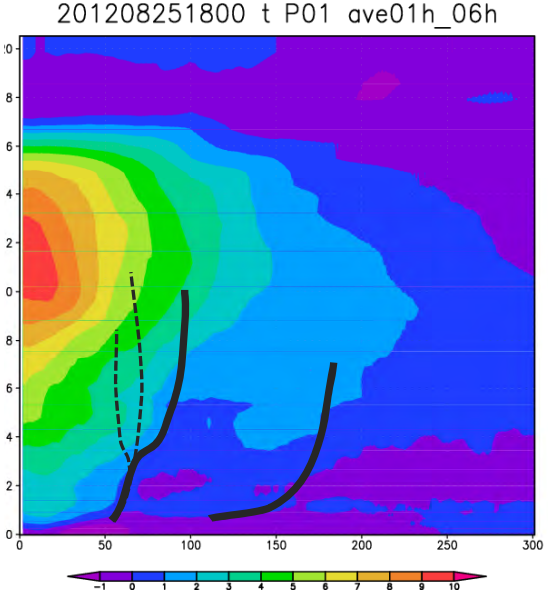


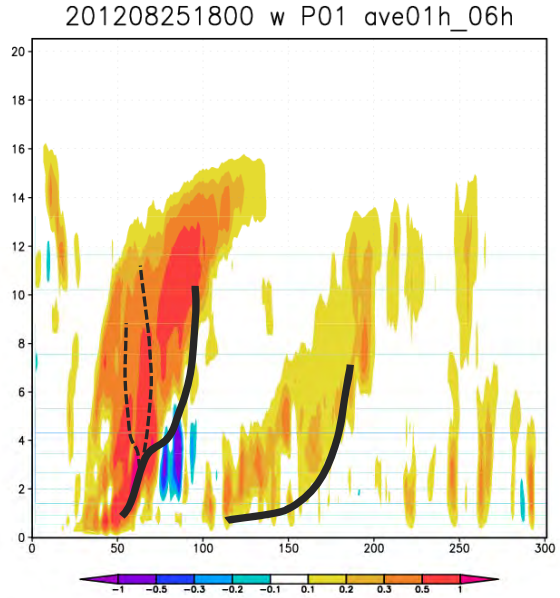
Analysis results of triple eyewall ～Averaged physical element～

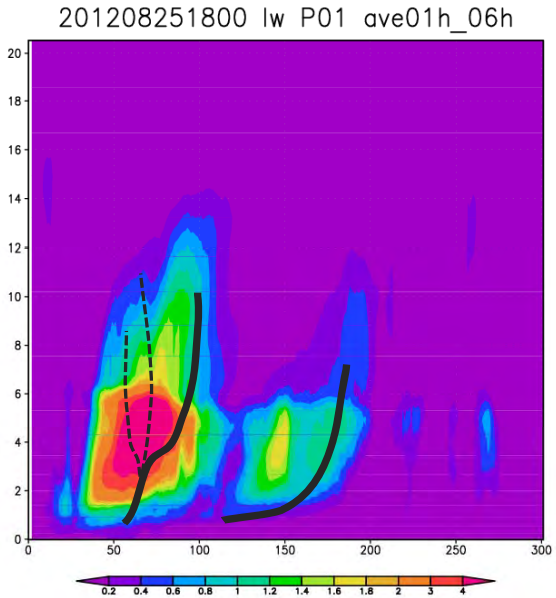
Tangential velocity〈vtm〉t・Radial velocity〈vrm〉t・Updraft〈wm〉t・liquid water〈lwm〉t・Solid water〈iwm〉t average 6hr *P01*

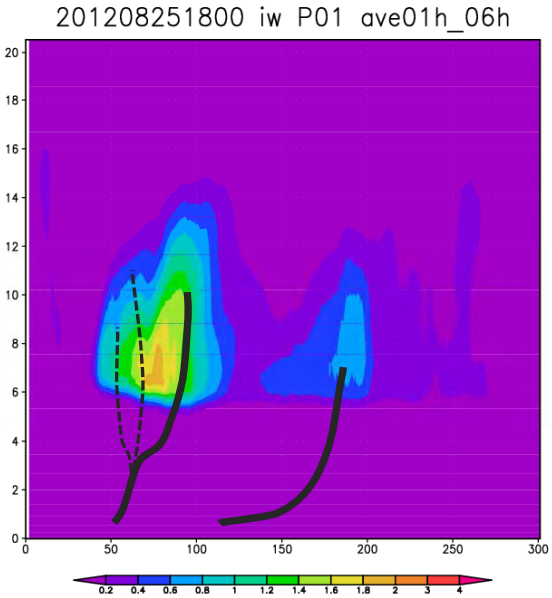






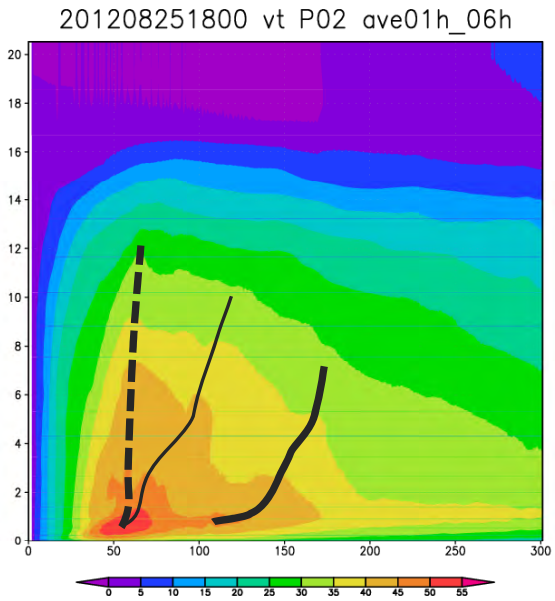


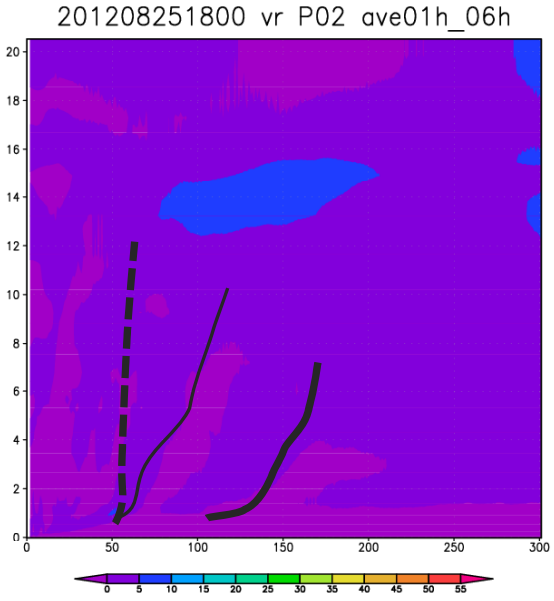


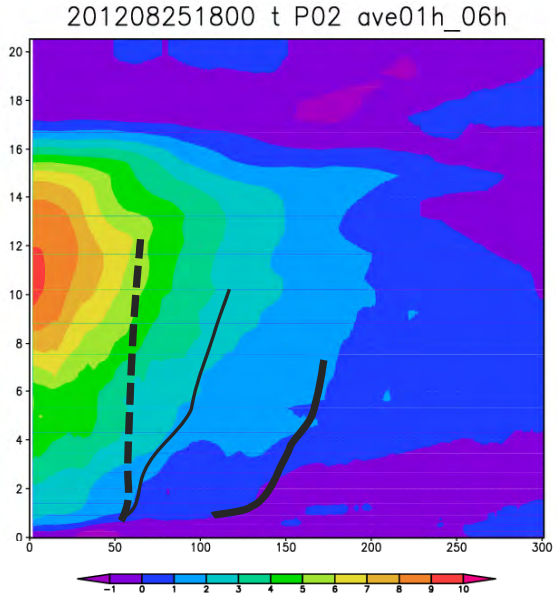


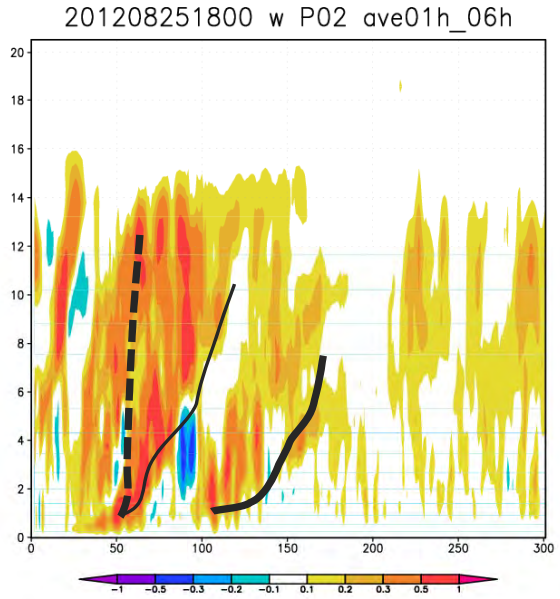
Analysis results of triple eyewall ～Averaged physical element～

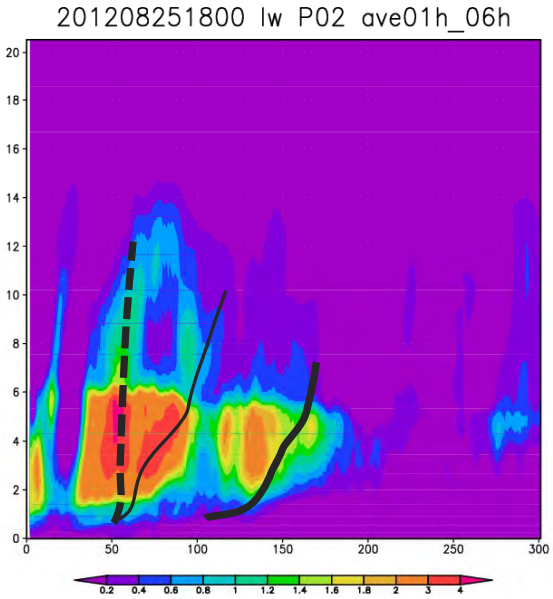
Tangential velocity〈vtm〉t・Radial velocity〈vrm〉t・Updraft〈wm〉t・liquid water〈lwm〉t・Solid water〈iwm〉t average 6hr *P02*

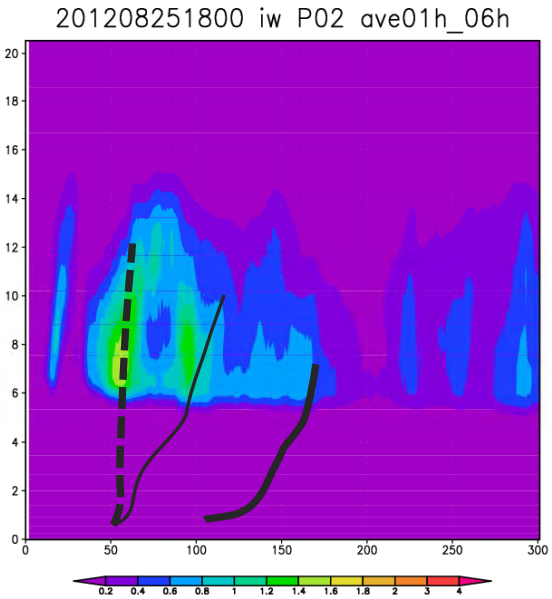






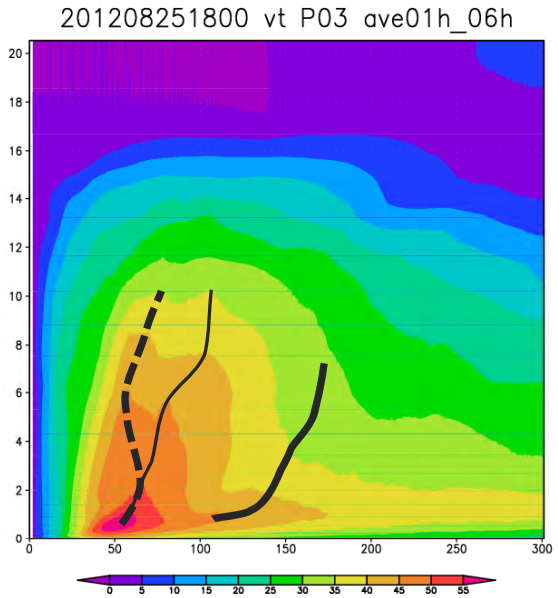


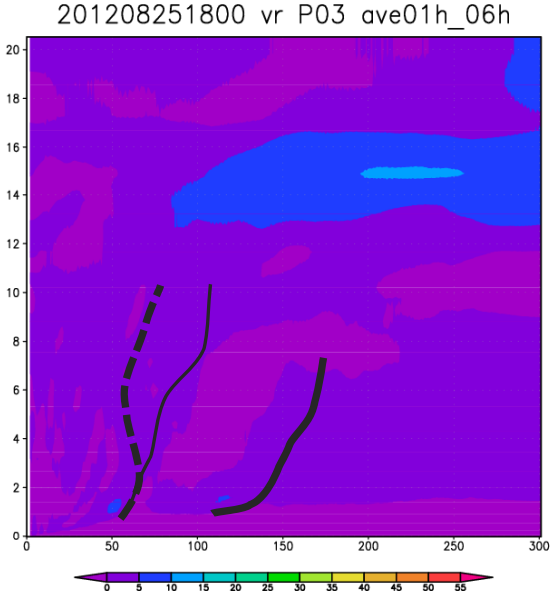


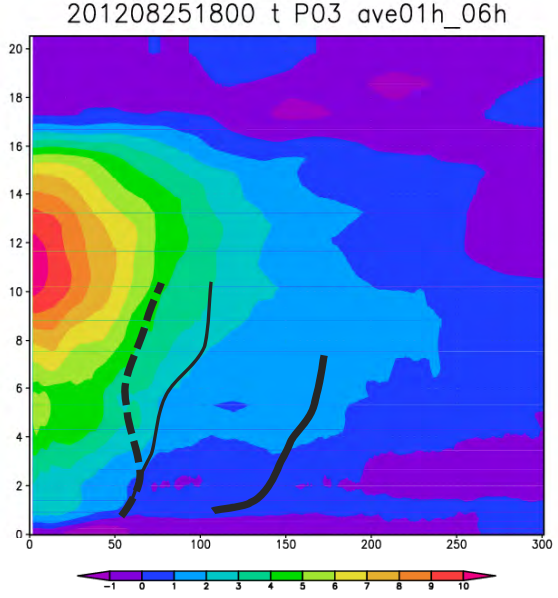


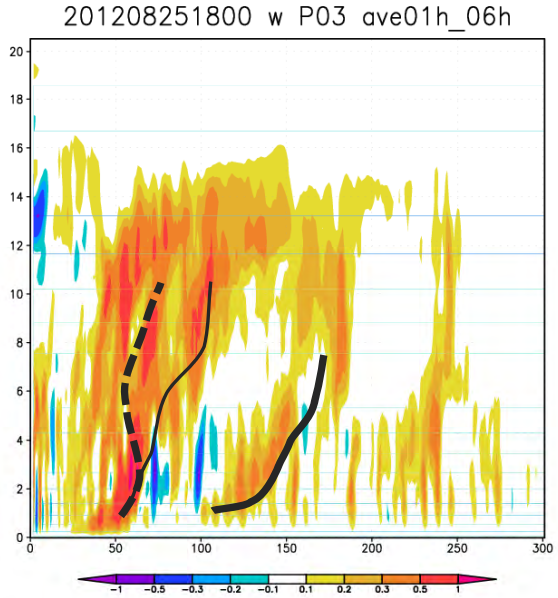
Analysis results of triple eyewall ～Averaged physical element～

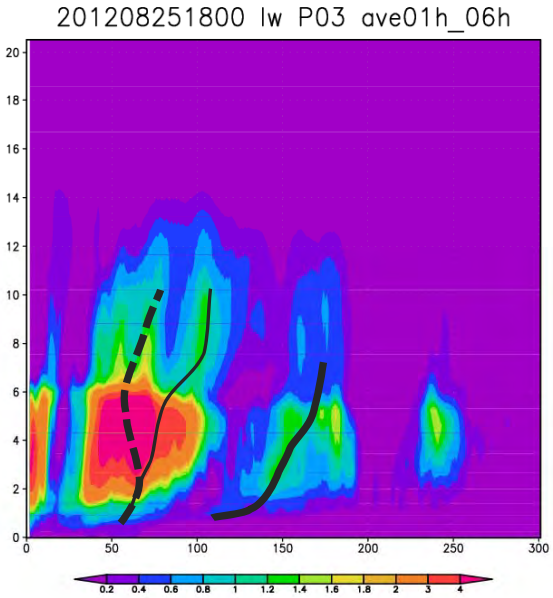
Tangential velocity〈vtm〉t・Radial velocity〈vrm〉t・Updraft〈wm〉t・liquid water〈lwm〉t・Solid water〈iwm〉t average 6hr *P03*

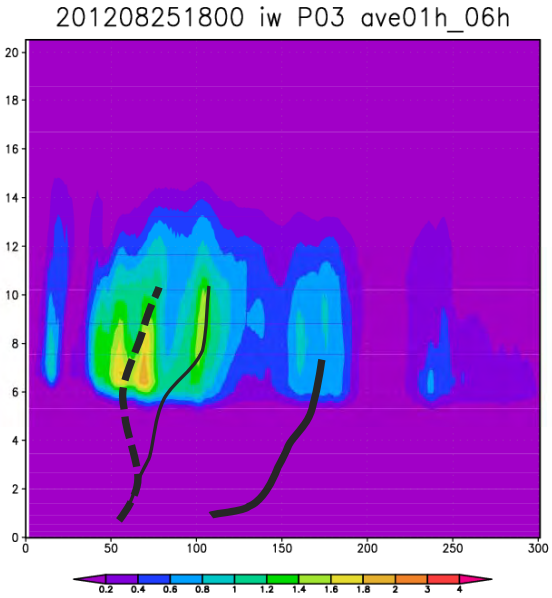






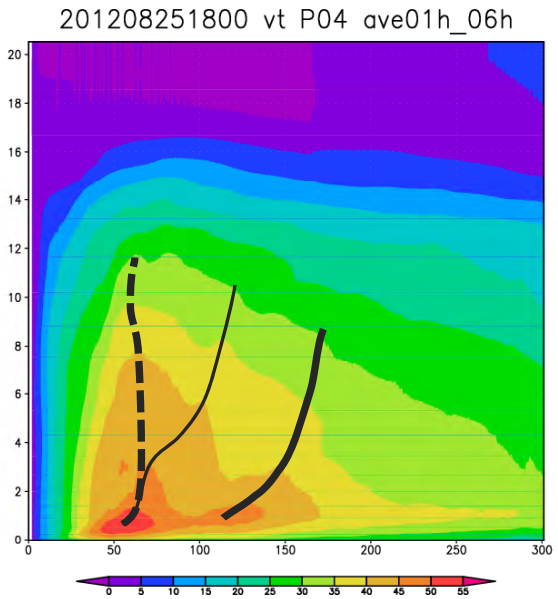


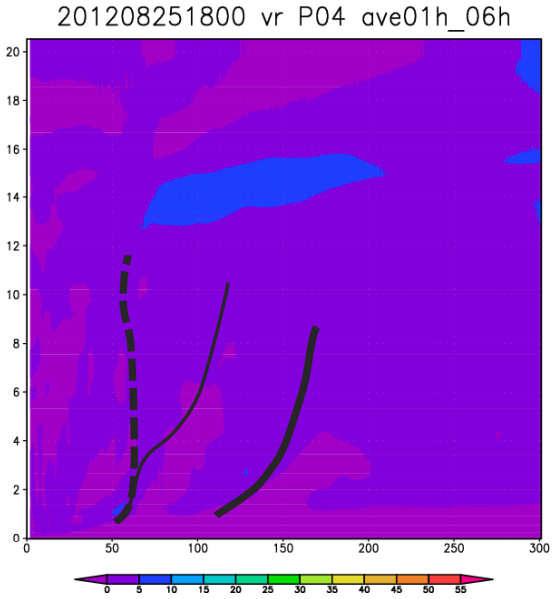


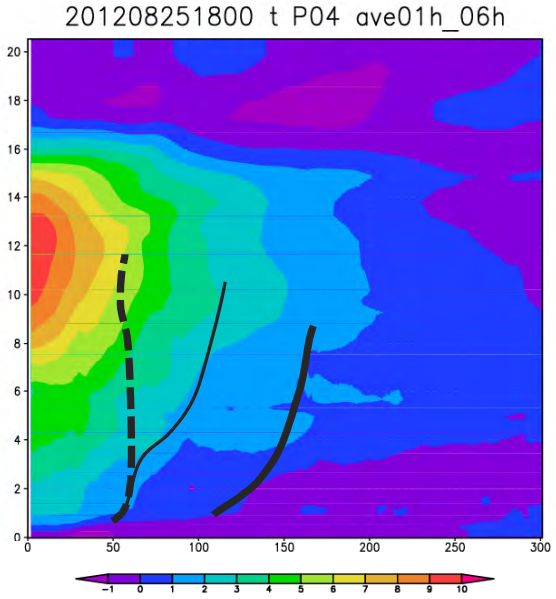


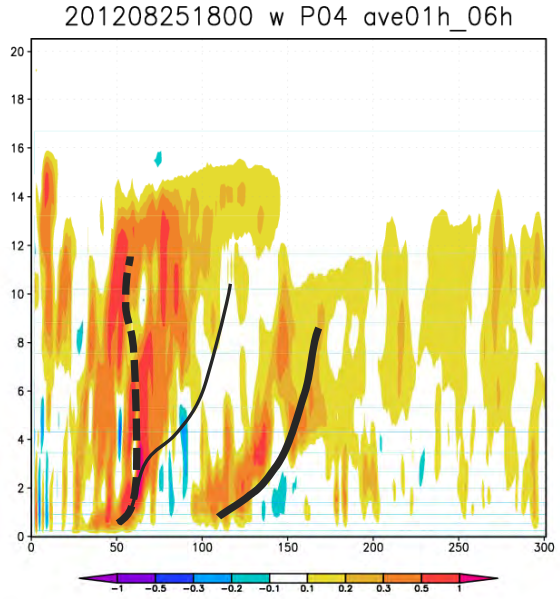
Analysis results of triple eyewall ～Averaged physical element～

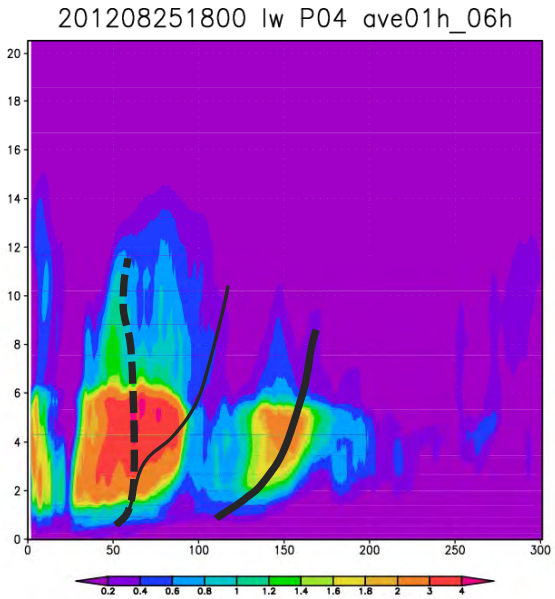
Tangential velocity〈vtm〉t・Radial velocity〈vrm〉t・Updraft〈wm〉t・liquid water〈lwm〉t・Solid water〈iwm〉t average 6hr *P04*

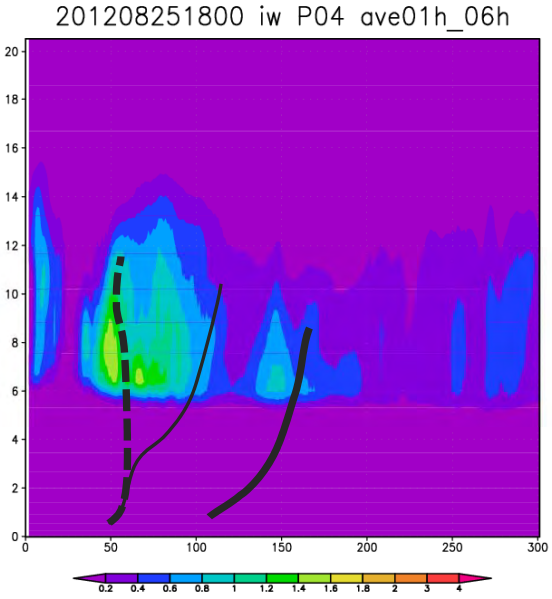






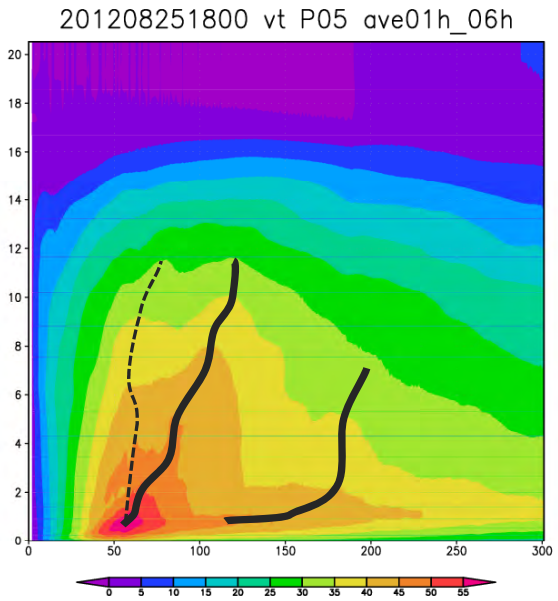


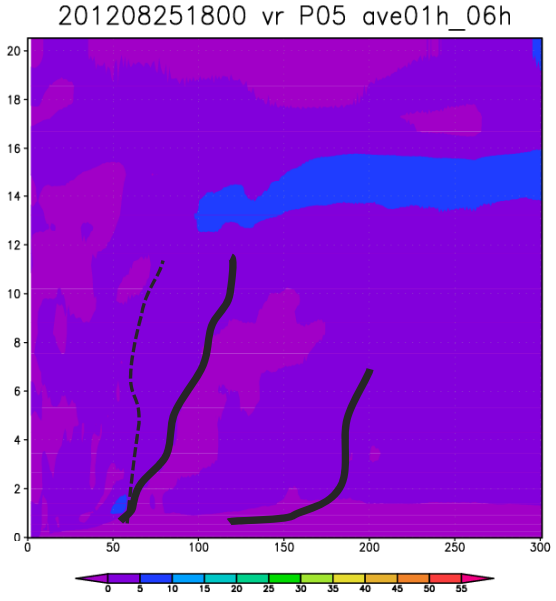


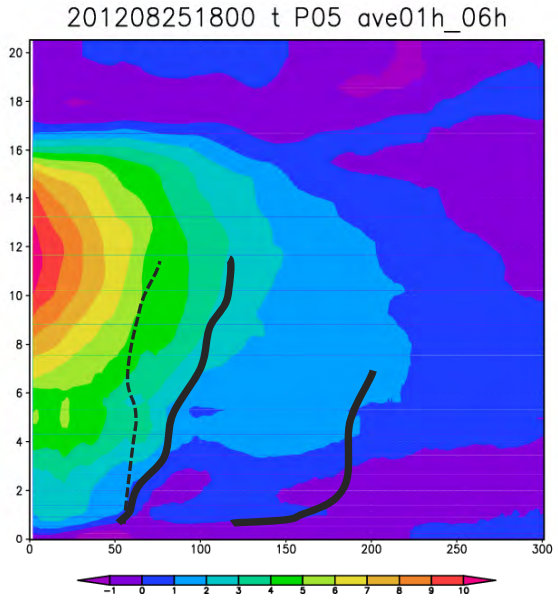


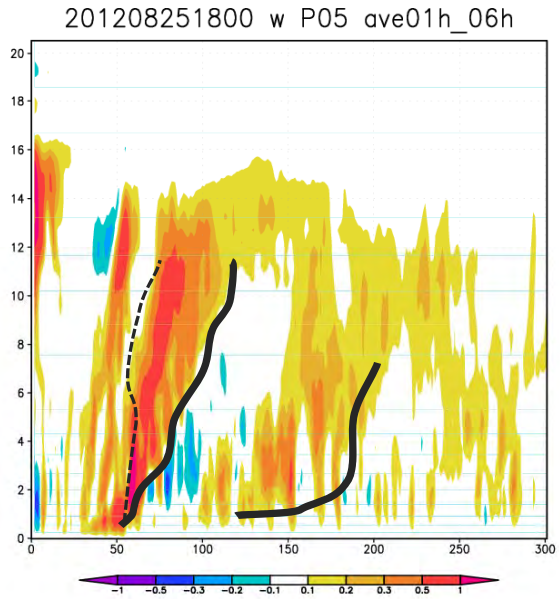
Analysis results of triple eyewall ～Averaged physical element～

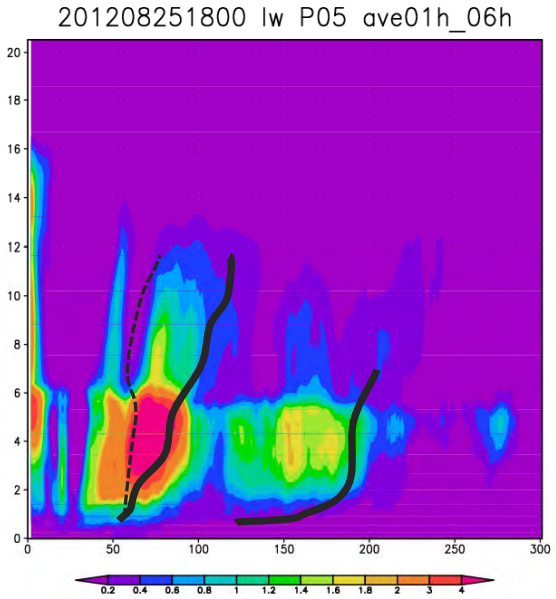
Tangential velocity〈vtm〉t・Radial velocity〈vrm〉t・Updraft〈wm〉t・liquid water〈lwm〉t・Solid water〈iwm〉t average 6hr *P05*

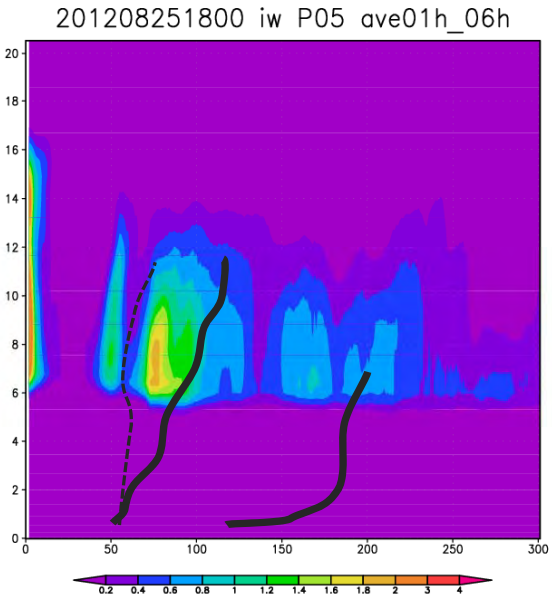






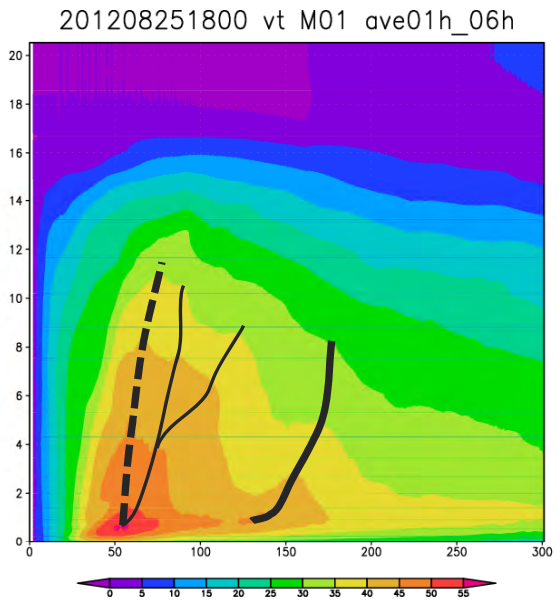


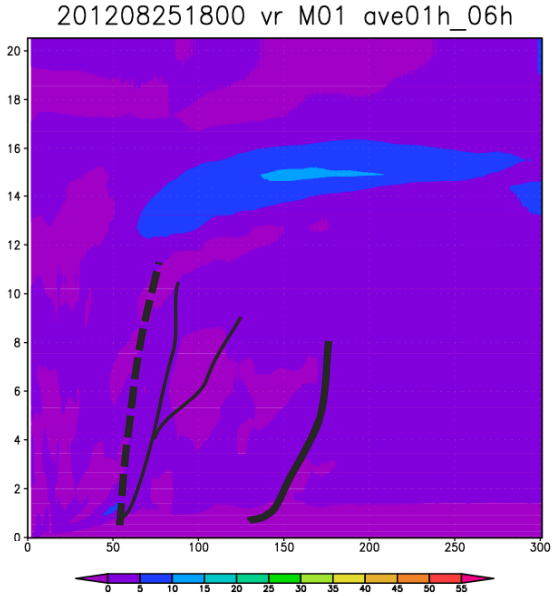


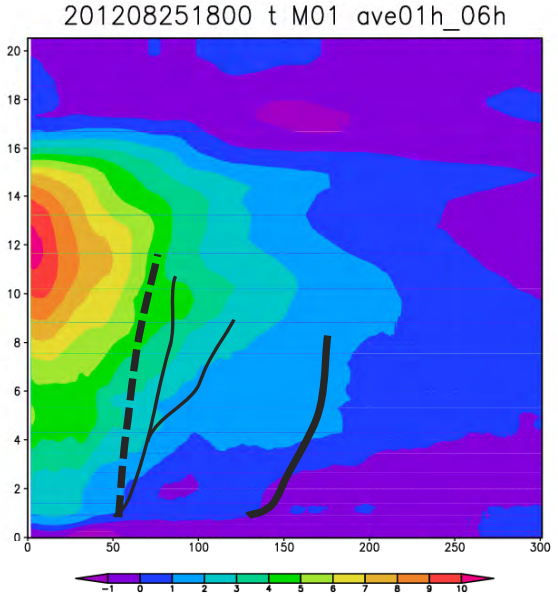


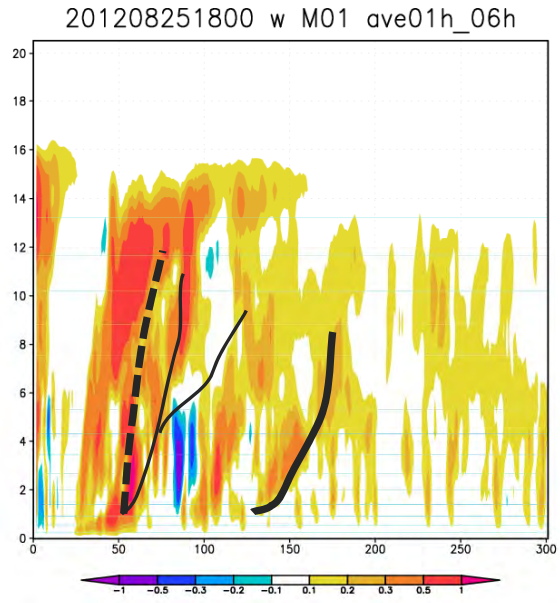
Analysis results of triple eyewall ～Averaged physical element～

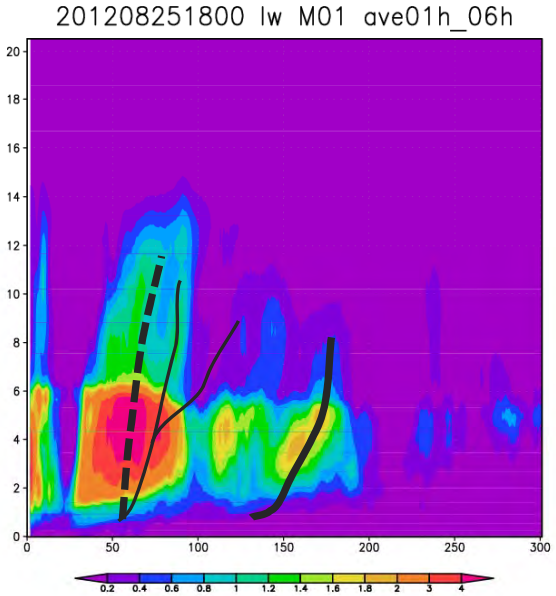
Tangential velocity〈vtm〉t・Radial velocity〈vrm〉t・Updraft〈wm〉t・liquid water〈lwm〉t・Solid water〈iwm〉t average 6hr *M01*

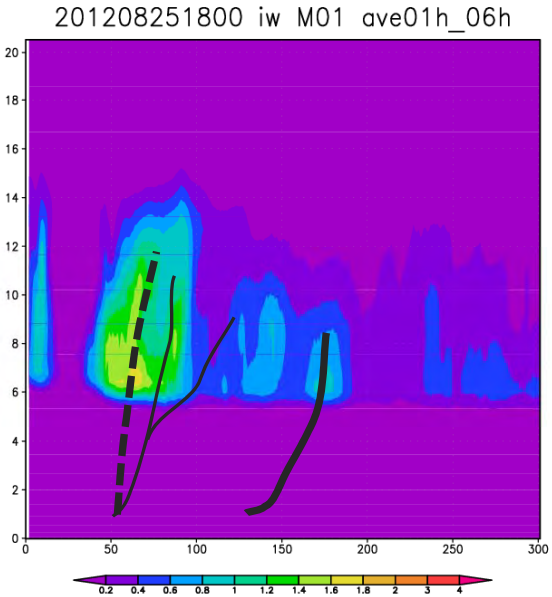






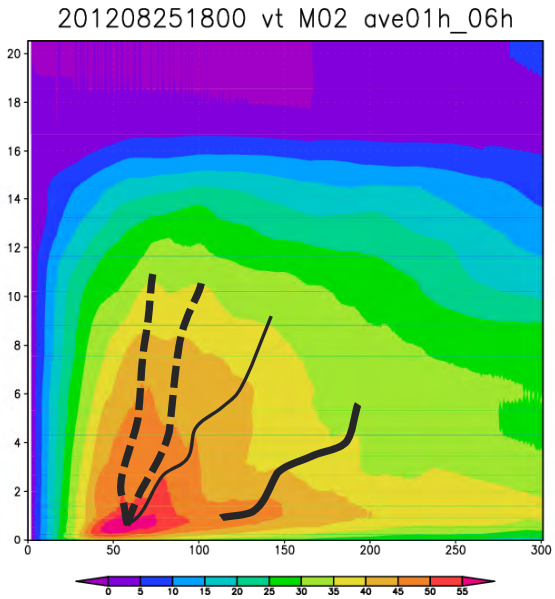


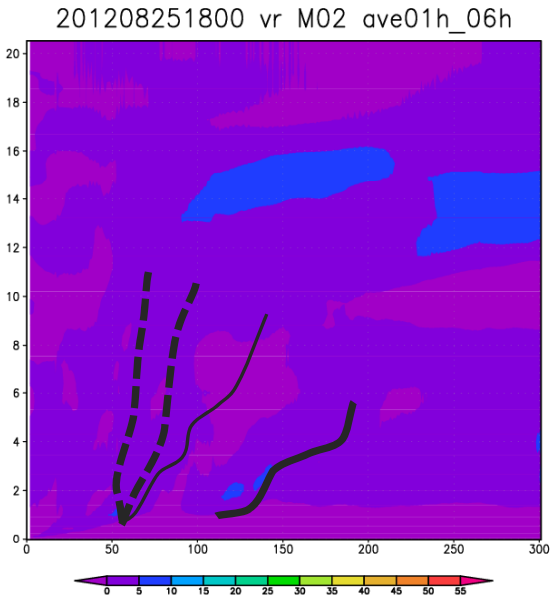


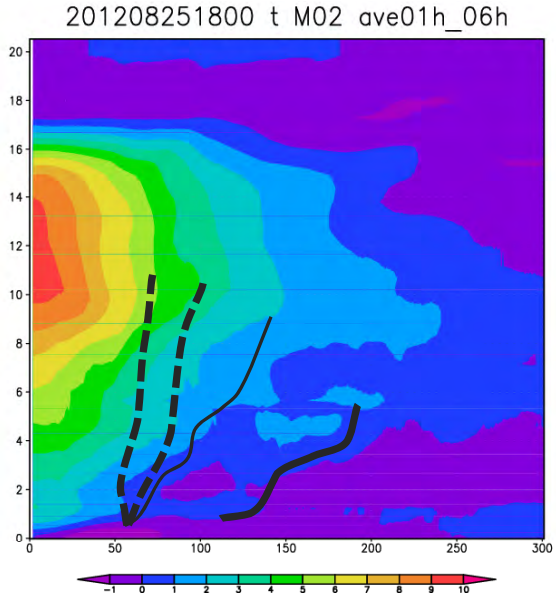


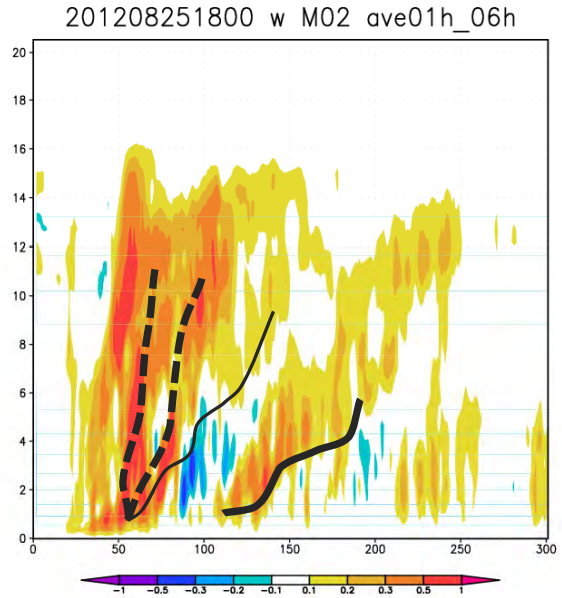
Analysis results of triple eyewall ～Averaged physical element～

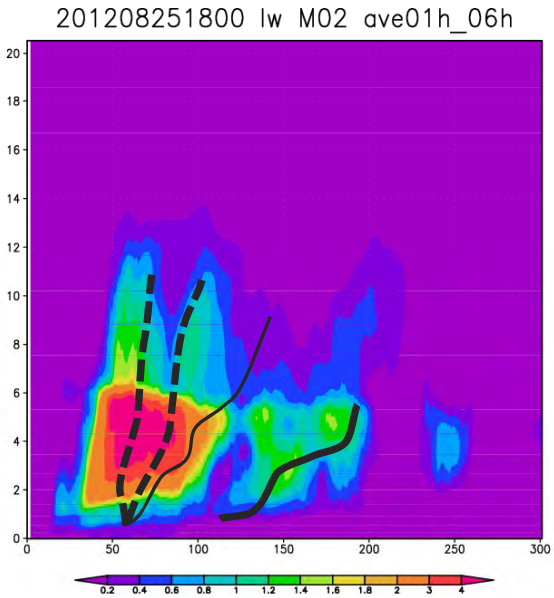
Tangential velocity〈vtm〉t・Radial velocity〈vrm〉t・Updraft〈wm〉t・liquid water〈lwm〉t・Solid water〈iwm〉t average 6hr *M02*

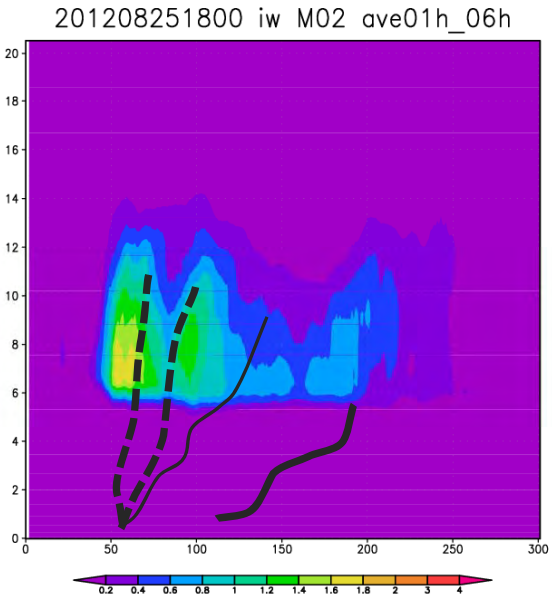






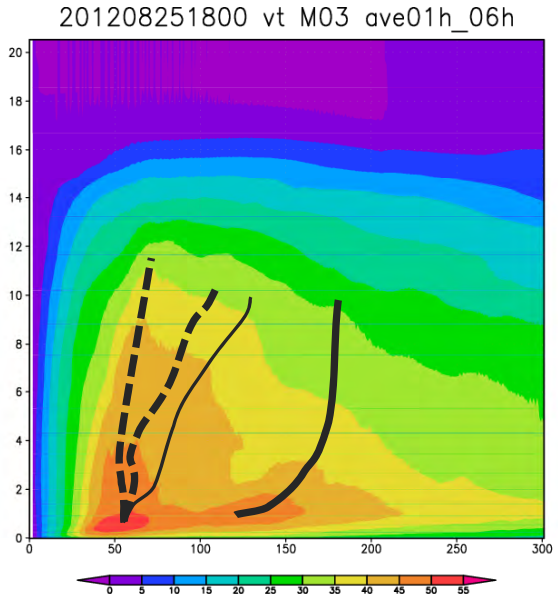


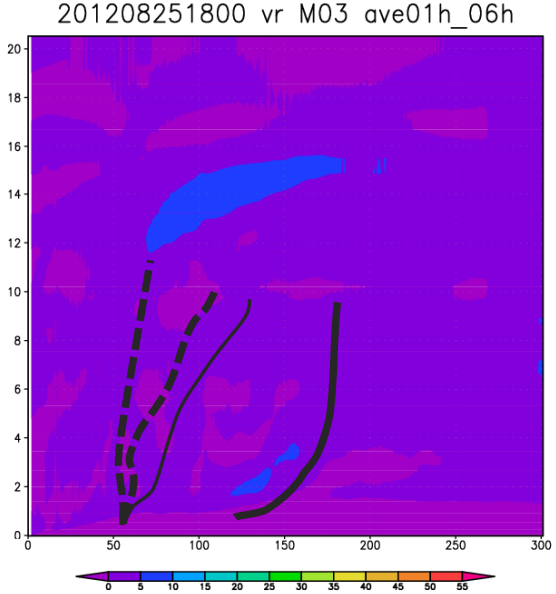


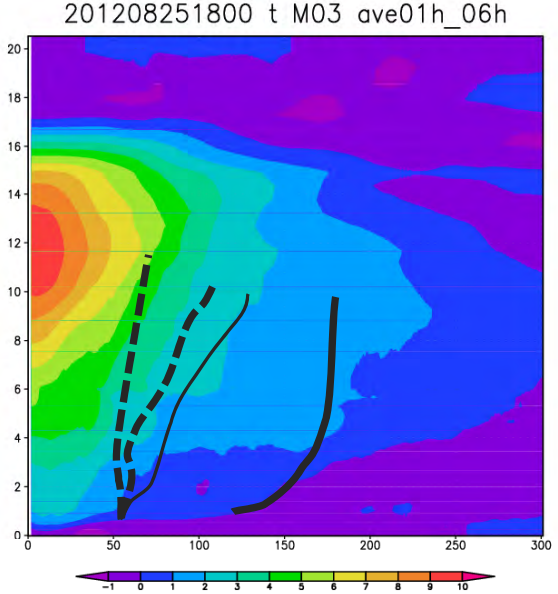


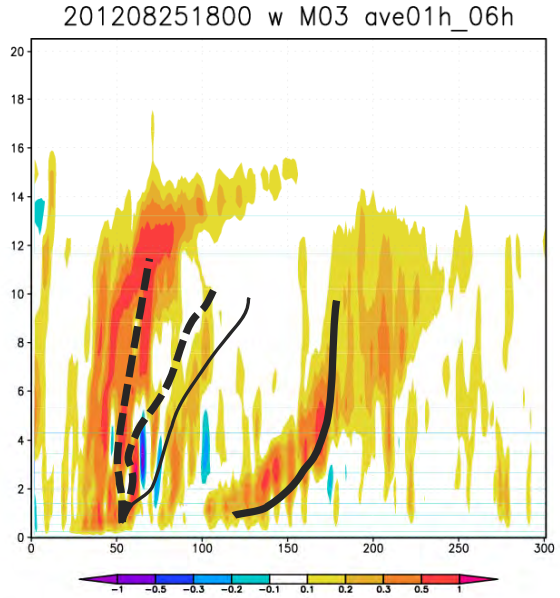
Analysis results of triple eyewall ～Averaged physical element～

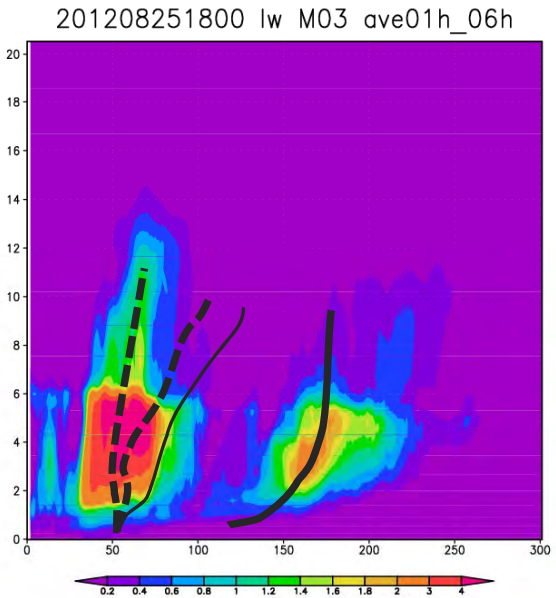
Tangential velocity〈vtm〉t・Radial velocity〈vrm〉t・Updraft〈wm〉t・liquid water〈lwm〉t・Solid water〈iwm〉t average 6hr *M03*

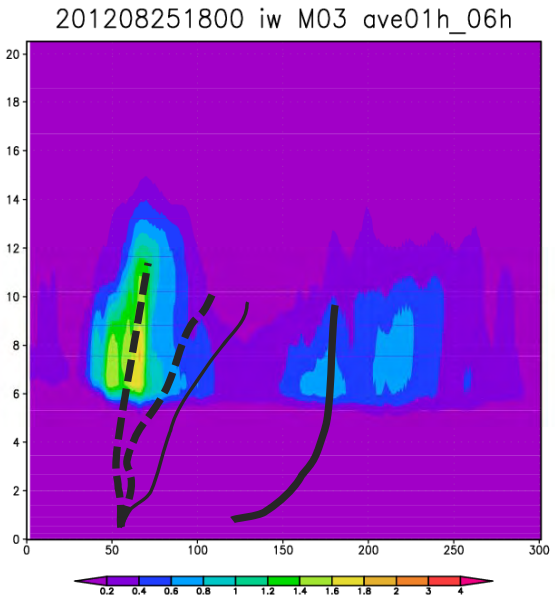






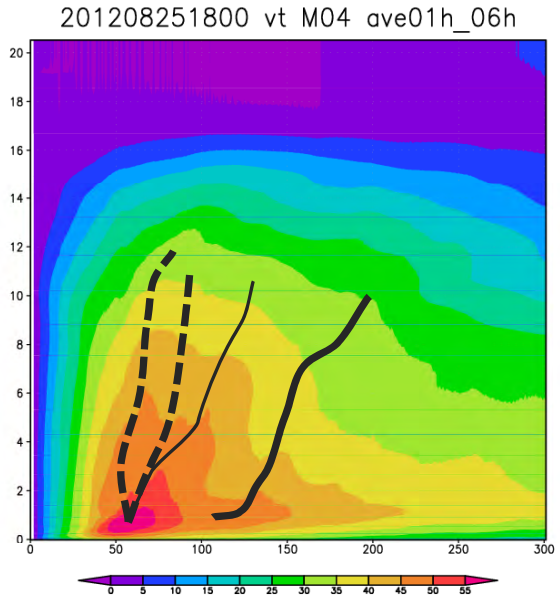


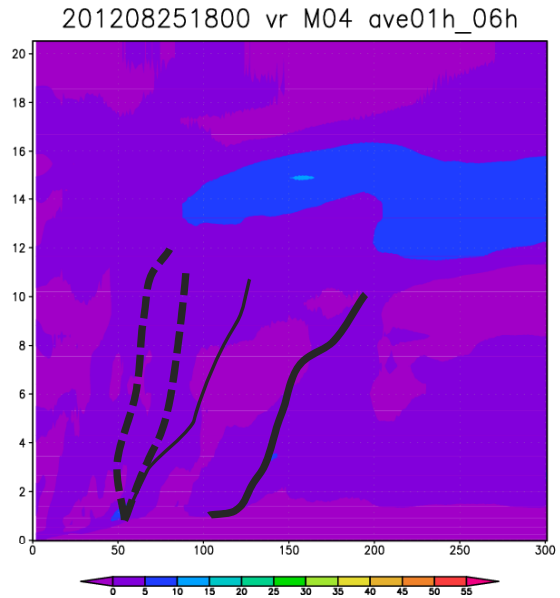


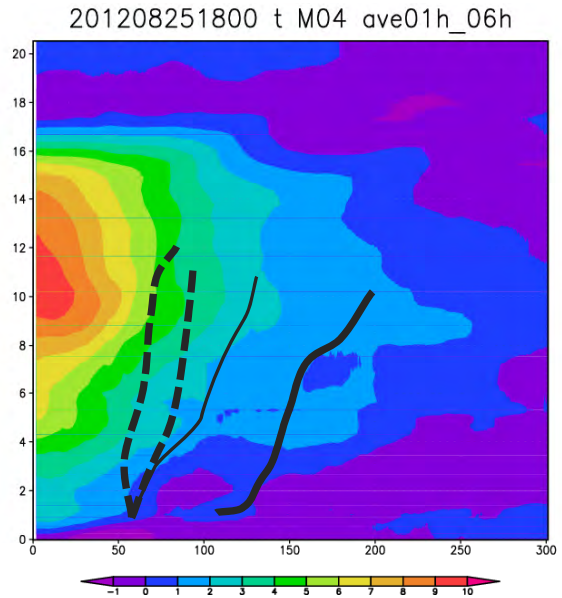


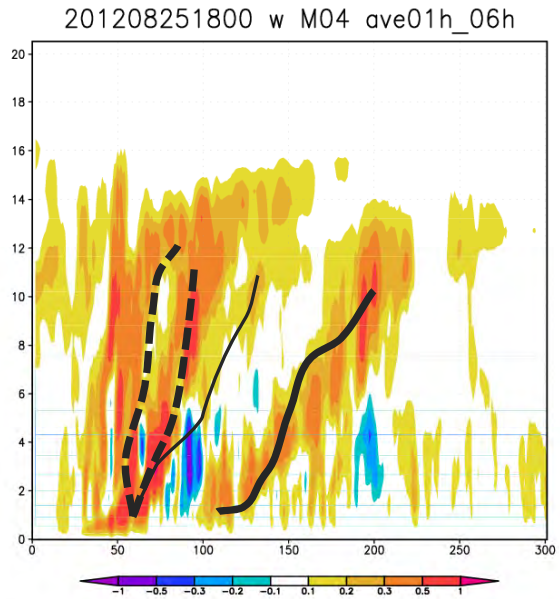
Analysis results of triple eyewall ～Averaged physical element～

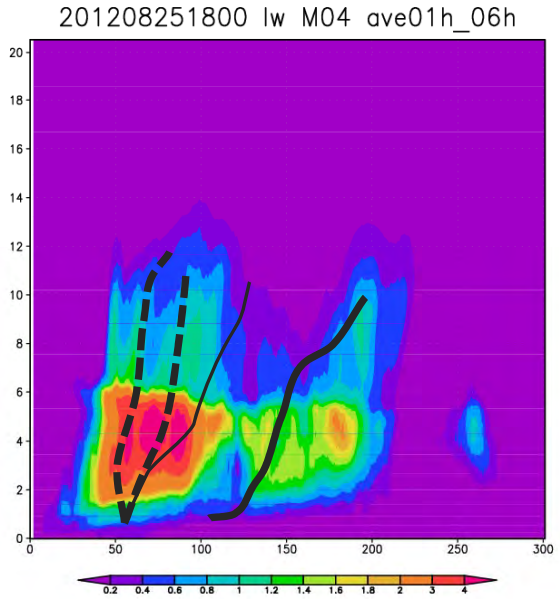
Tangential velocity〈vtm〉t・Radial velocity〈vrm〉t・Updraft〈wm〉t・liquid water〈lwm〉t・Solid water〈iwm〉t average 6hr *M04*

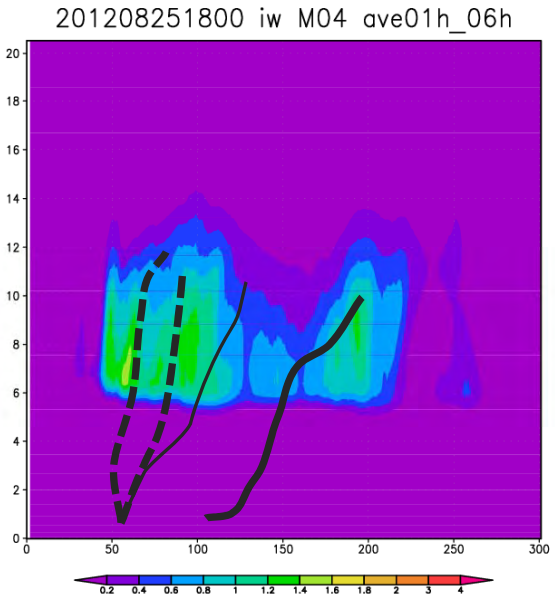






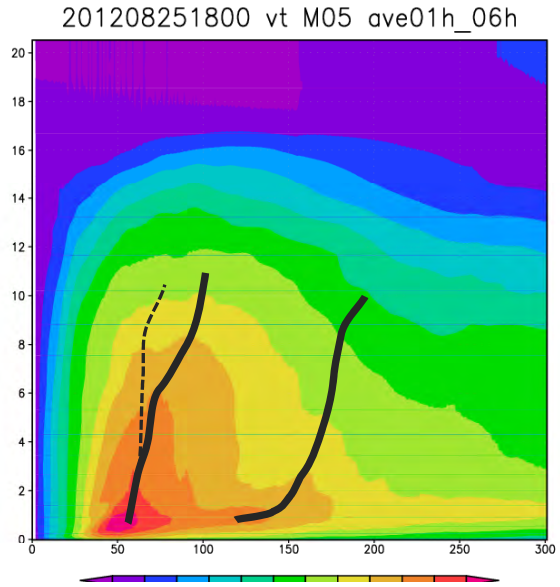


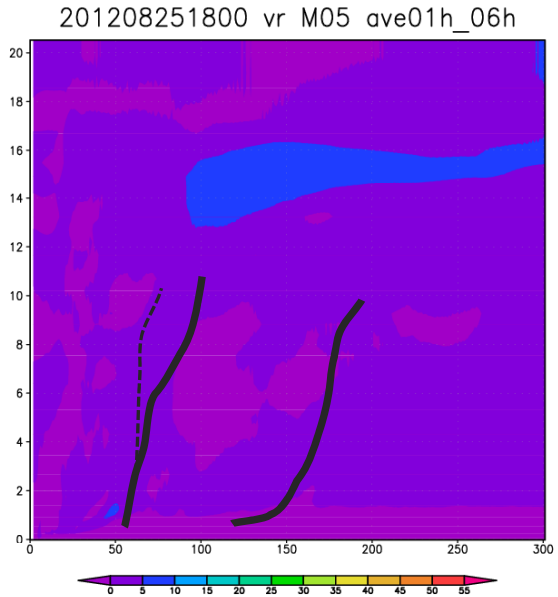


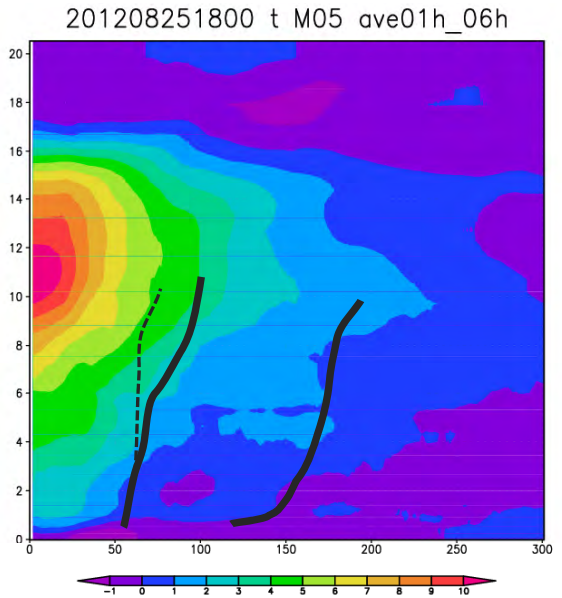


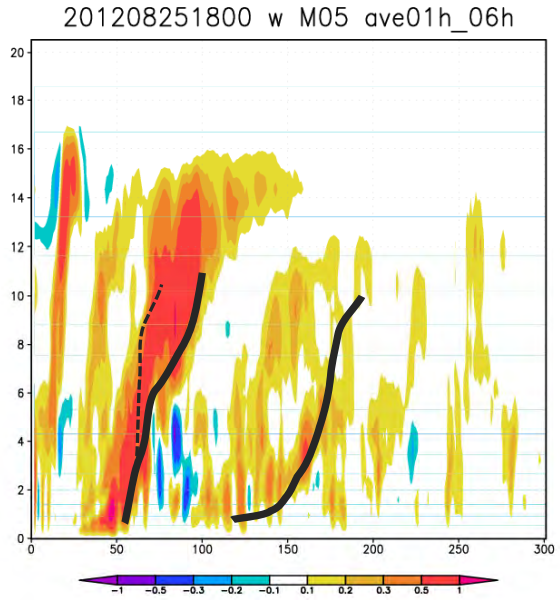
Analysis results of triple eyewall ～Averaged physical element～

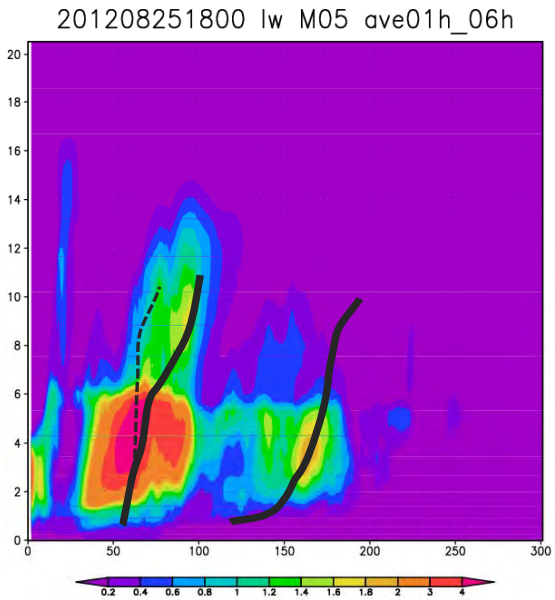
Tangential velocity〈vtm〉t・Radial velocity〈vrm〉t・Updraft〈wm〉t・liquid water〈lwm〉t・Solid water〈iwm〉t average 6hr *M05*

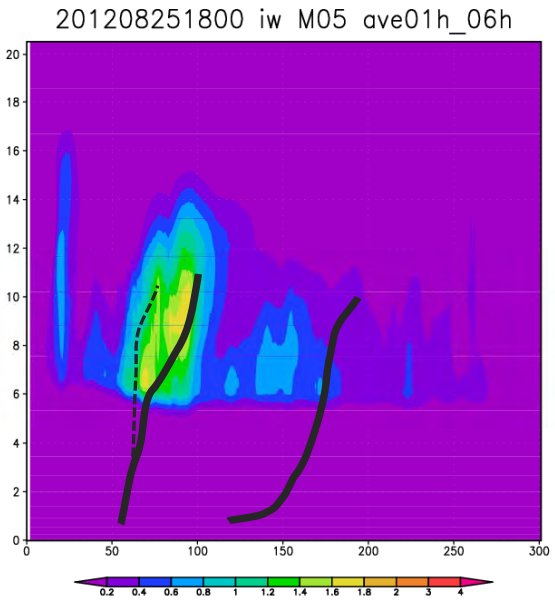




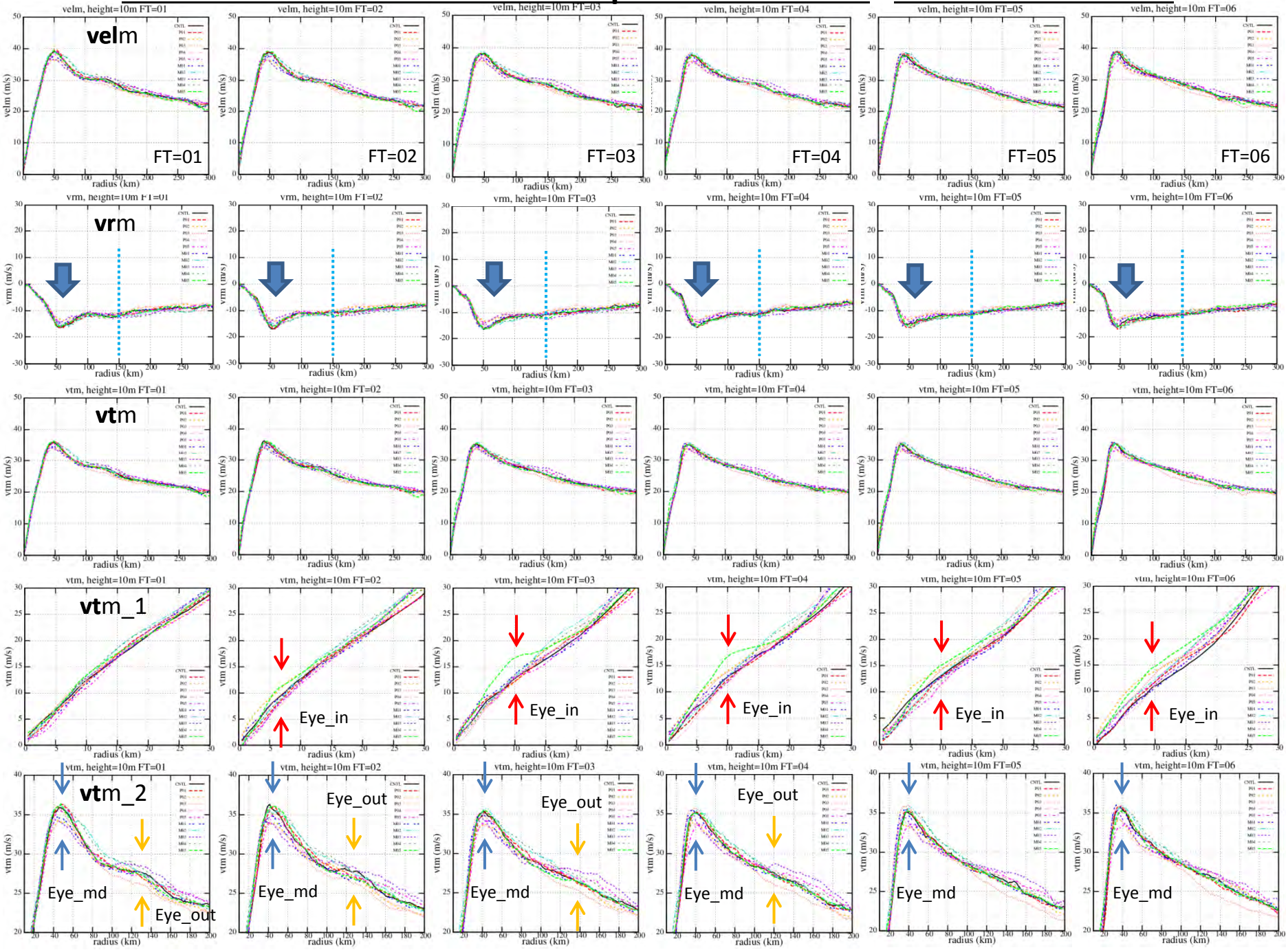






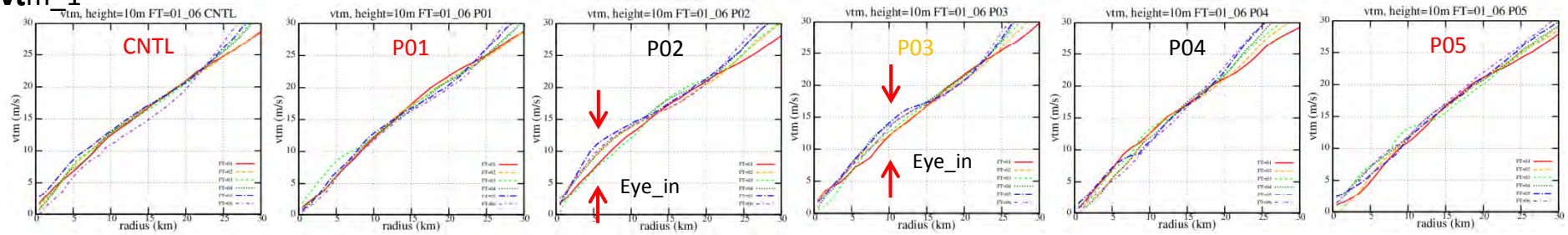


Radius of local maximum wind speed at 10m AGL Each forecast time

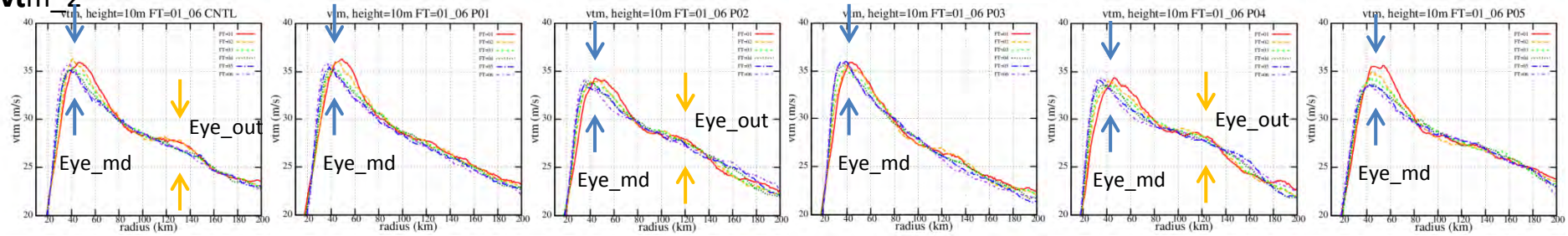


Radius of local maximum wind speed at 10m AGL Each member

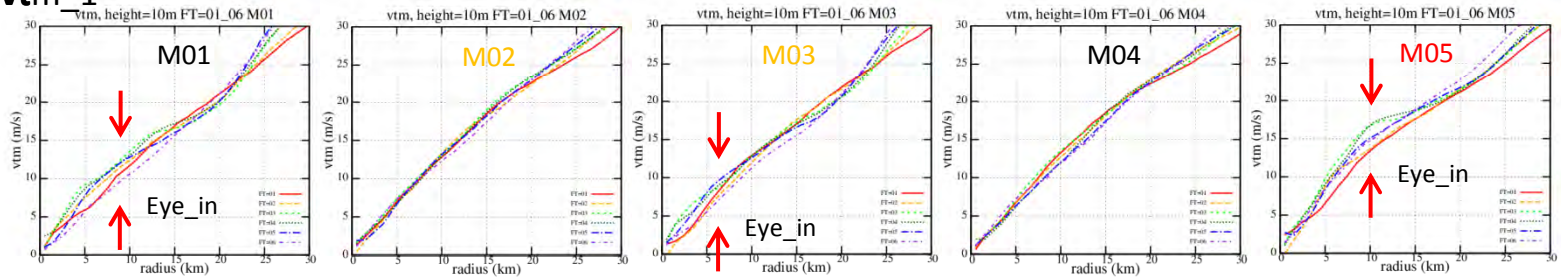
vtm_1



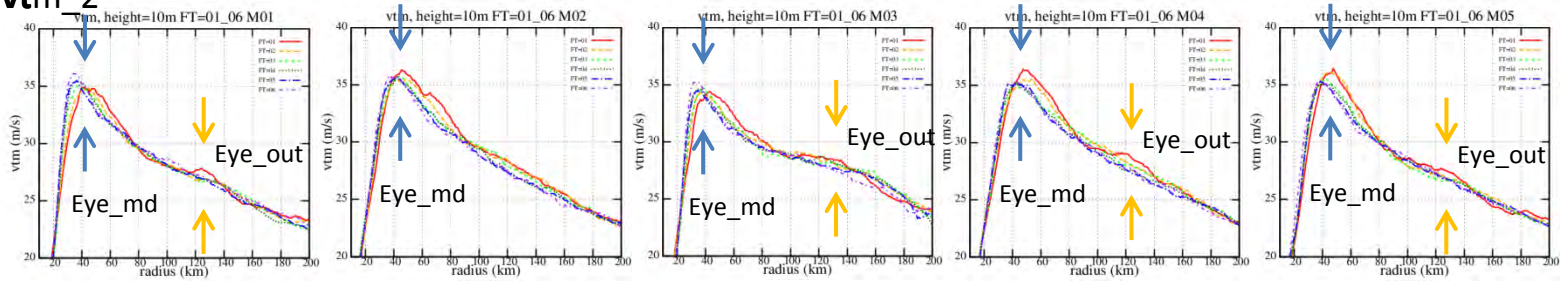
vtm_2



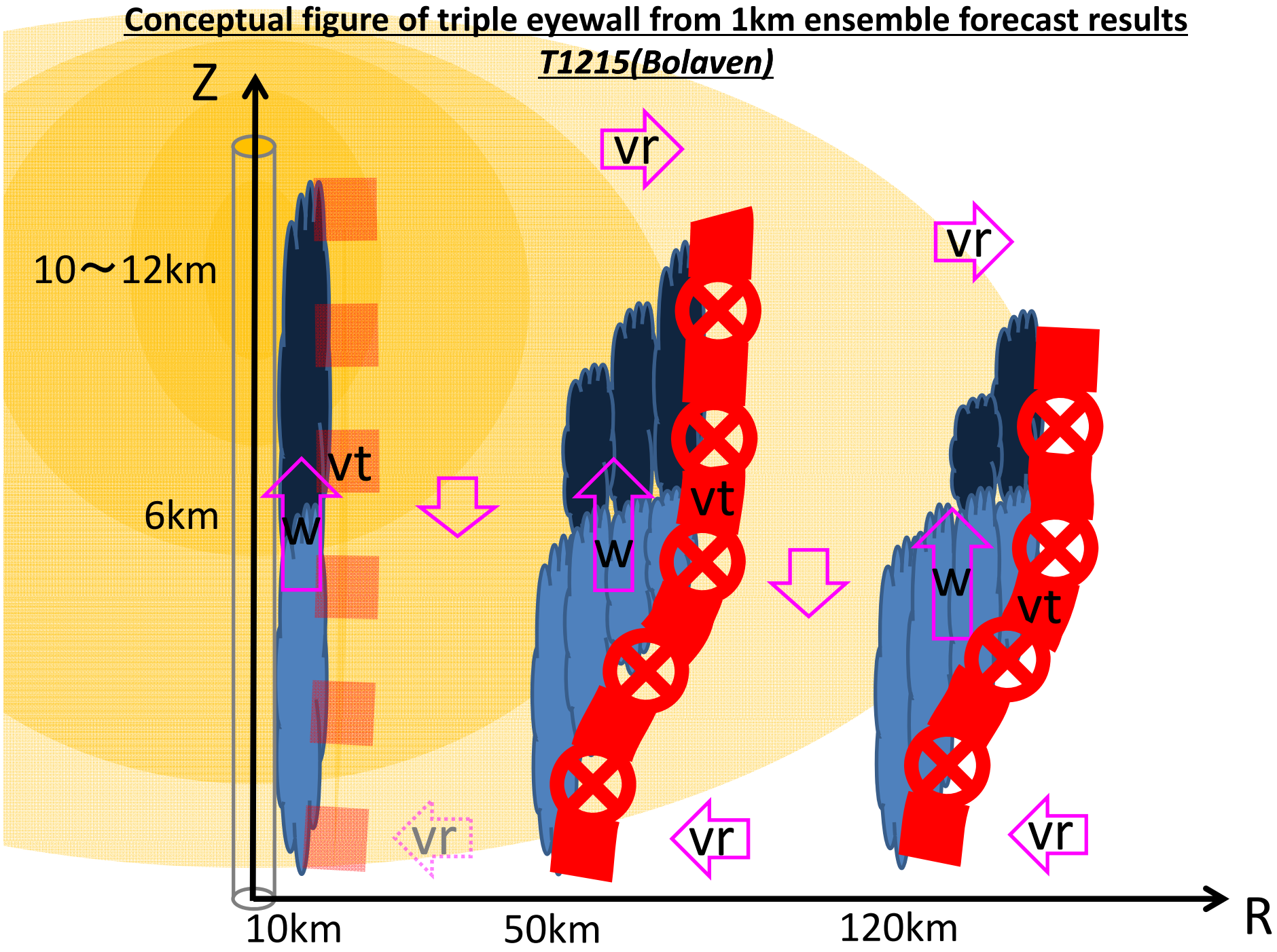
vtm_1



vtm_2



As forecast time passed, the radius of local maximum wind speed(Eye_md) is reduced.


Conceptual figure of triple eyewall from 1km ensemble forecast results
T1215(Bolaven)
Z
10～12km
6km
vr
vt
w
vr
vt
w
vr
w
vt
vr
vr
vr
10km
50km
120km
R

Future Plan

●We will continue the experiment of Case6 (2km 1800x1440 → 500m 3000x3000).

➔If 2km or 500m forecast results have high reproducibility about triple eyewall, we will investigate results.