Tropical Cyclone Formations in the South China Sea (SCS) associated with the Strong Northeasterly Monsoons

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Outline

1. Characteristics of TC formation in the SCS

   Climatology - SCS vs western North Pacific (WNP)

   Environments – Formation vs. non-Formation Cases

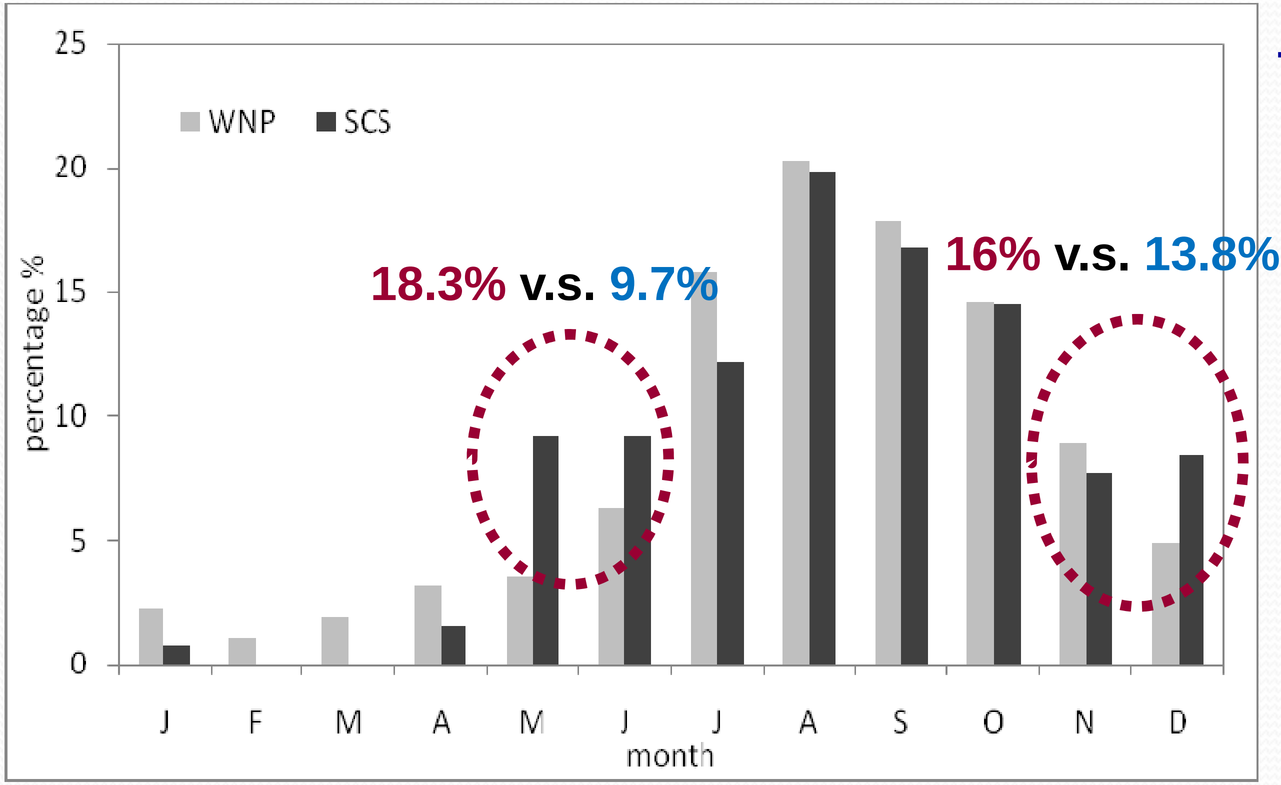
2. Simulations of formation and non-formation cases

3. Sensitivity tests of environmental forcing on the development of pre-TC and non-formation cases

4. Conclusions

TC formations in the SCS (1972-2005)

Monthly Variation (WNP vs SCS)



Total TC Number
WNP: 865
SCS: 131

TC Formation:
Vmax ~ 25 kt

- ✓**Percentages of TC formation during May-June and Nov-Dec in the SCS are higher than those in the WNP.**
- ✓**The SCS is relatively more favorable for TC formation during the early (May-Jun) and late (Nov-Dec) seasons.**

Formation Cases

131
TC formations in the SCS during 1972-2005

22
in late season (Nov-Jan)

11
semi-stationary (formations)

11
Westward

Non-formation Cases

(Surface closed isobar ≧ 24 h)

42
Non-development In late season

33
Non-formations

Life span 68 h

9
Track on landmass

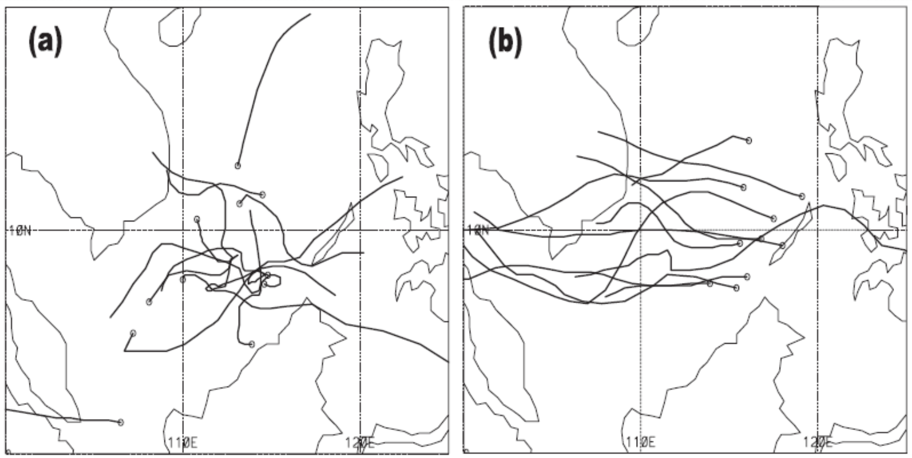
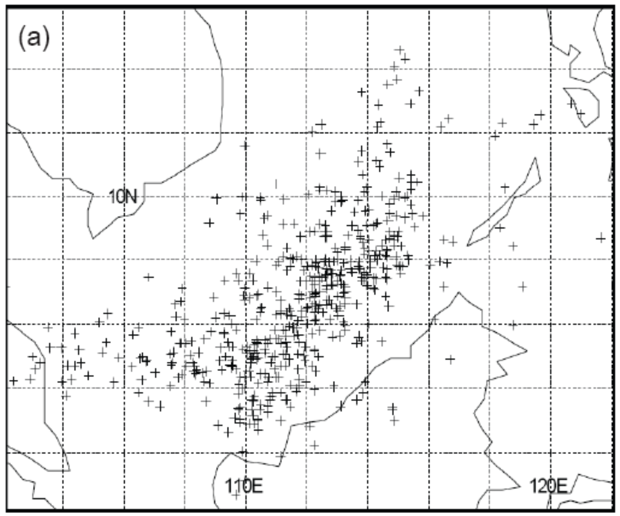


FIG. 3. The JTWC best tracks and initial positions (circles) of (a) 11 semistationary and (b) 11 westward-moving formation cases.



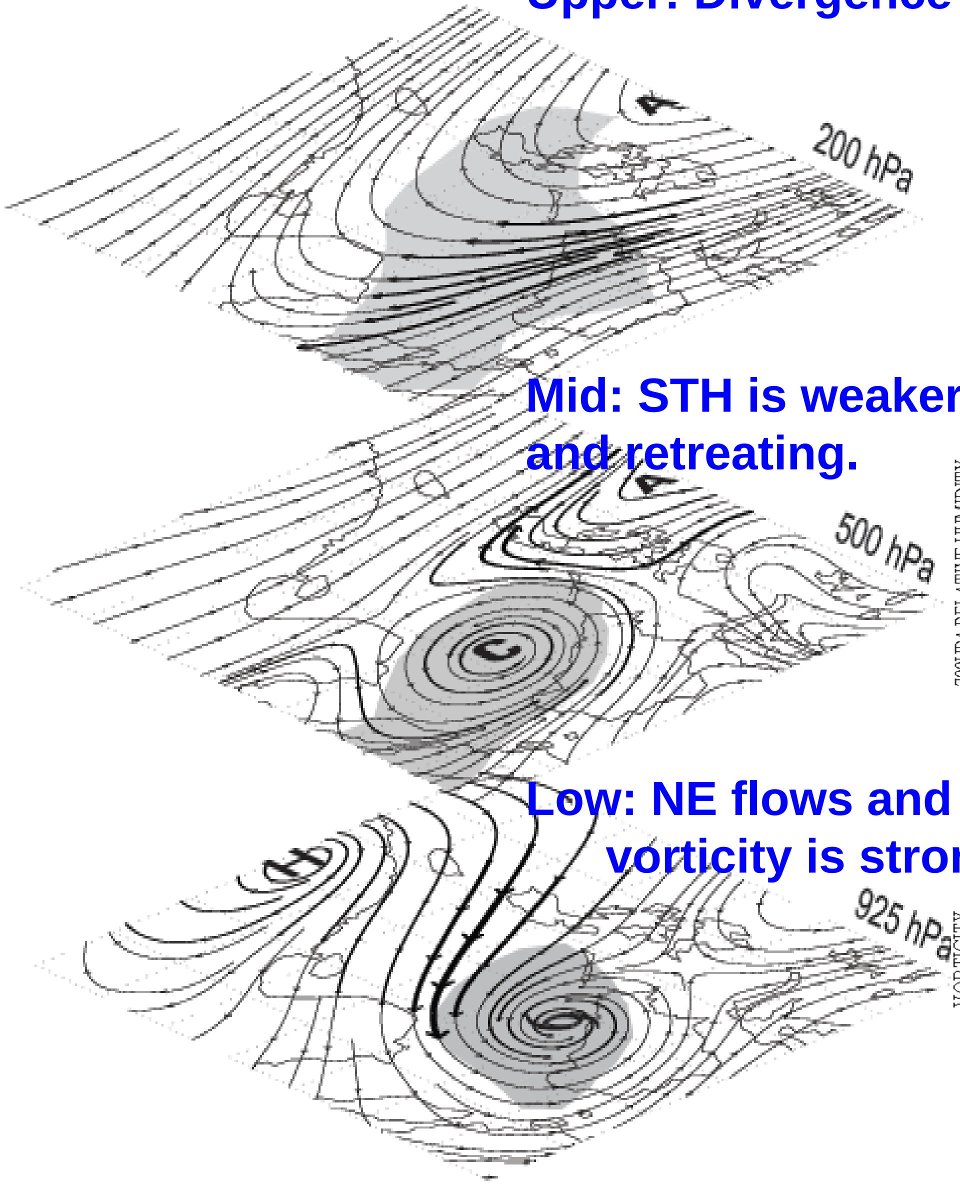
Composite Results (formation vs. non-formation)

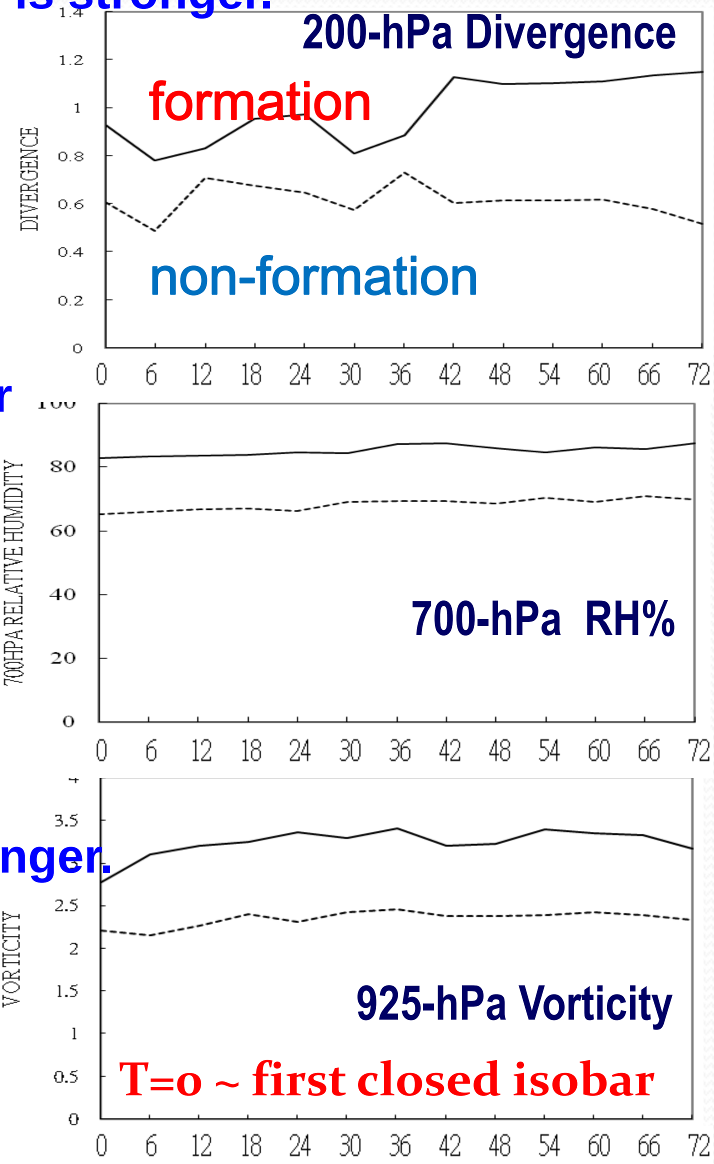
For the formation case

Upper: Divergence is stronger.

Mid: STH is weaker and retreating.

Low: NE flows and vorticity is stronger.

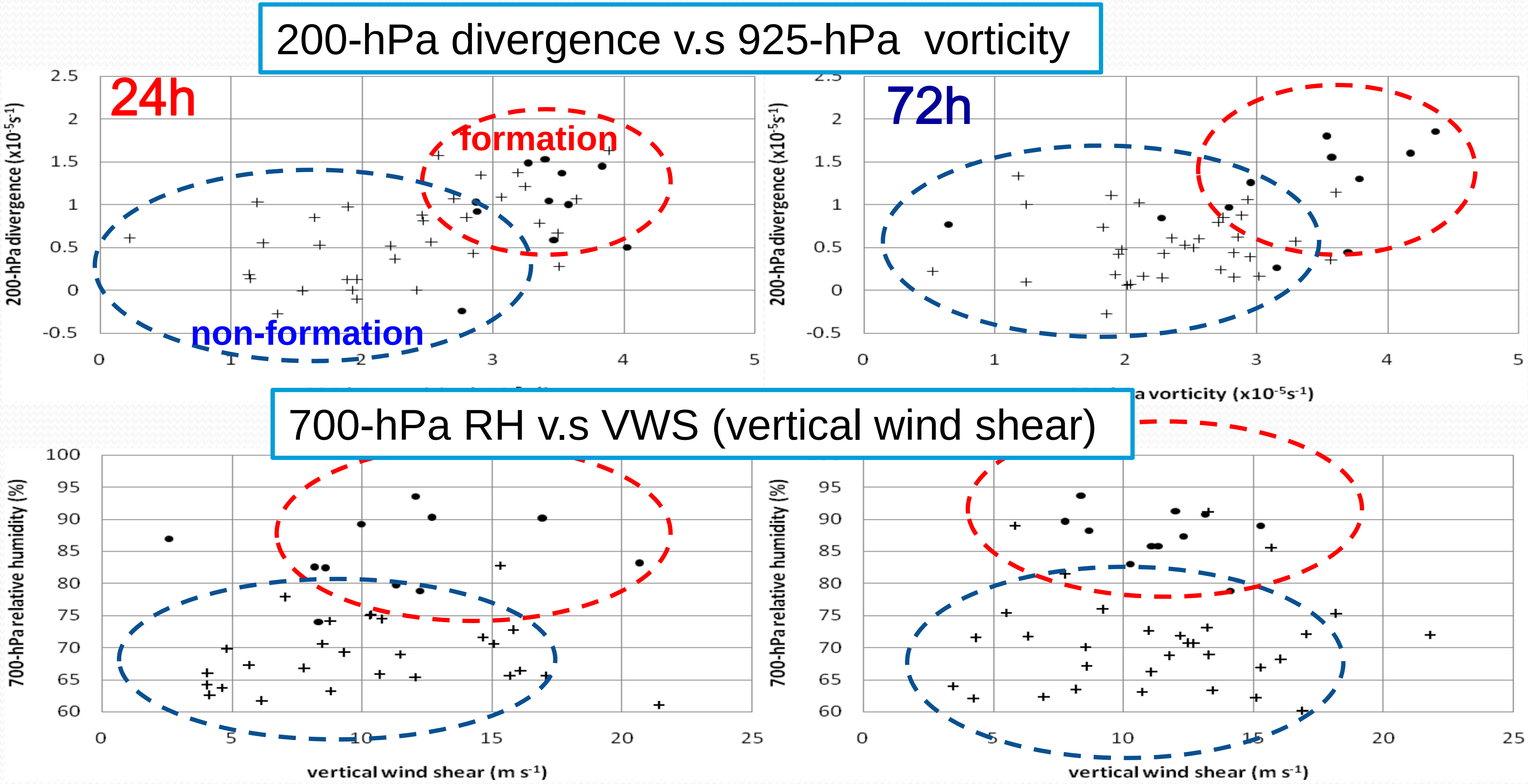




T=o ~ first closed isobar

Scatter Plots

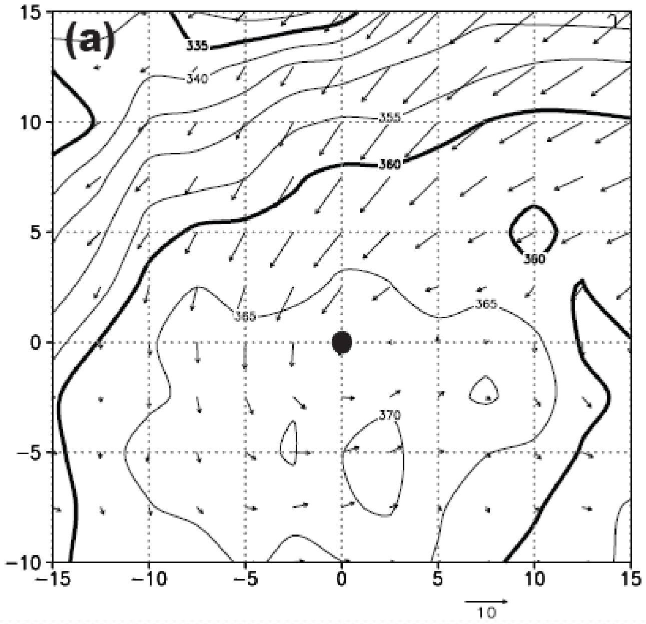
Dots: formation **Cross: non-formation**



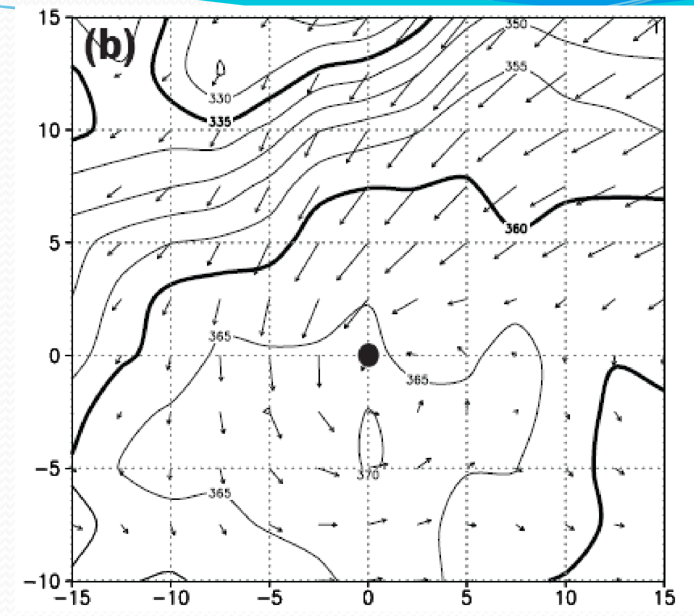
T=0 ~ first closed isobar

1000-hPa Θ_e and winds (formation composite)

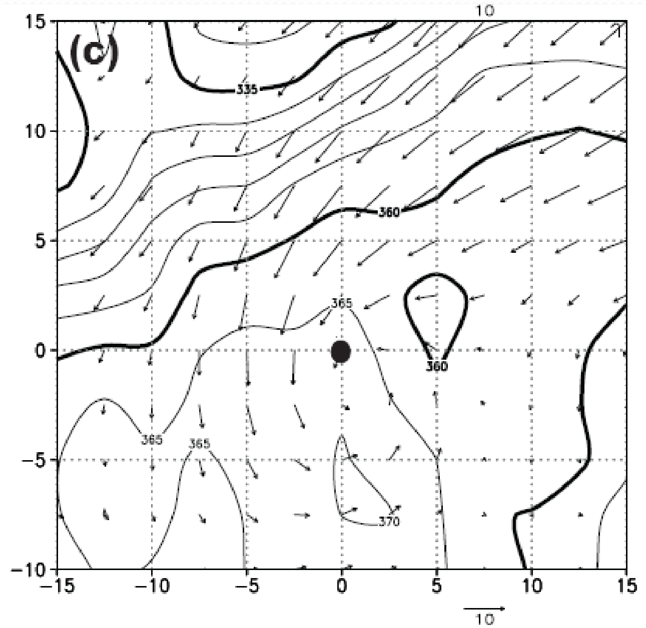
0 h



24 h



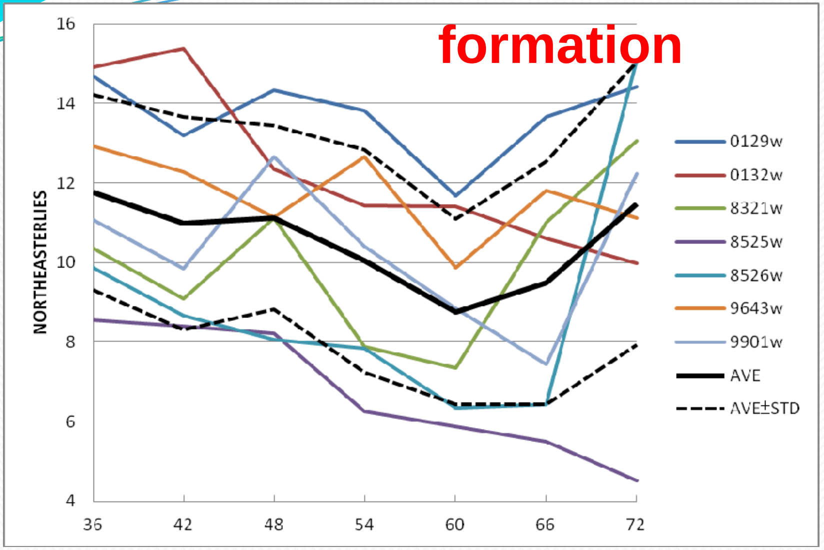
48 h

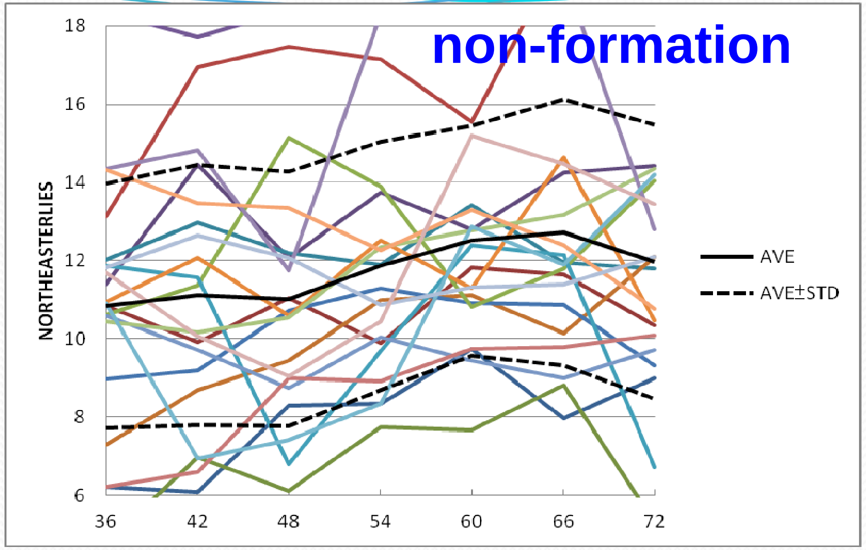


changes of baroclinic zone

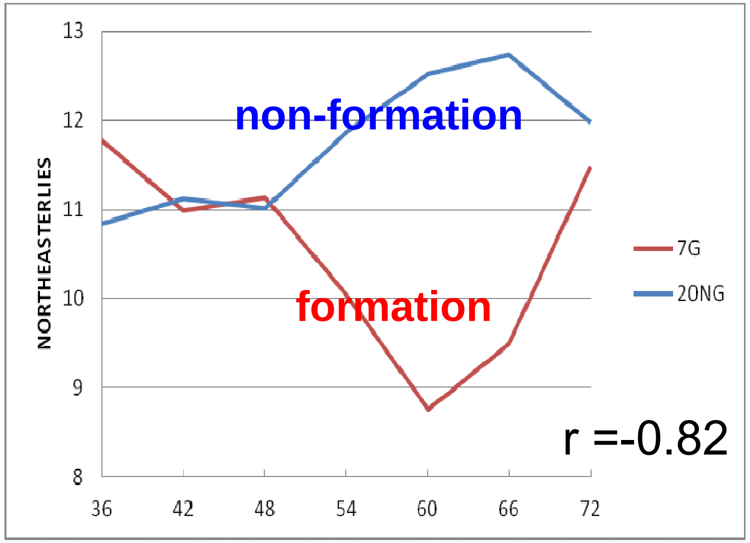
Thick lines – 335K and 365K

Time series of upstream NE wind speed for each case

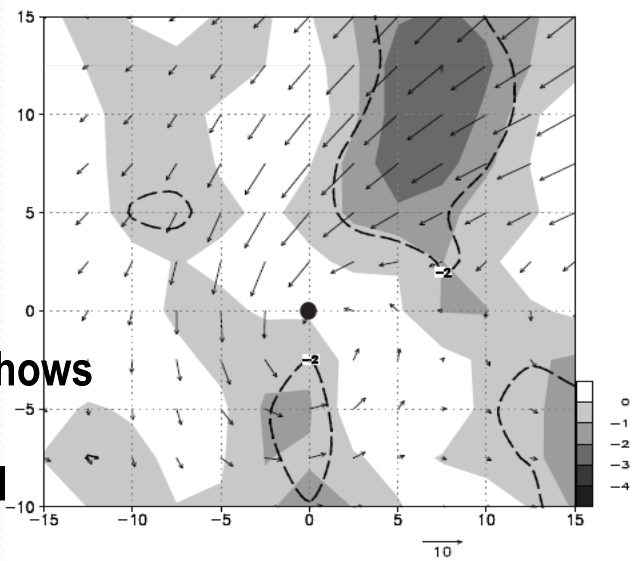




Changes of upstream NE flows are similar for 7 formations & 20 non-formation, respectively



The diff. of 1000-hPa wind speed changes from 24 h to 48 h



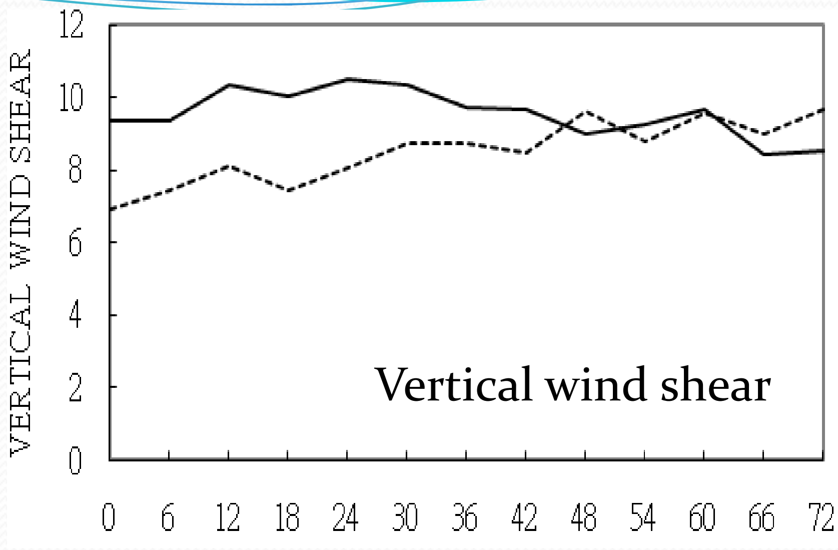
Dashed curve shows area with 95% confidence level

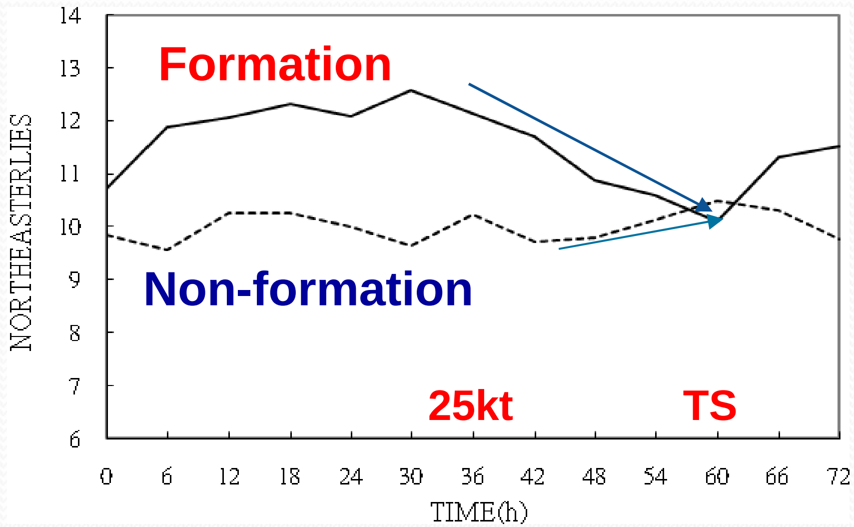
Summary I

During the mid-developing phase

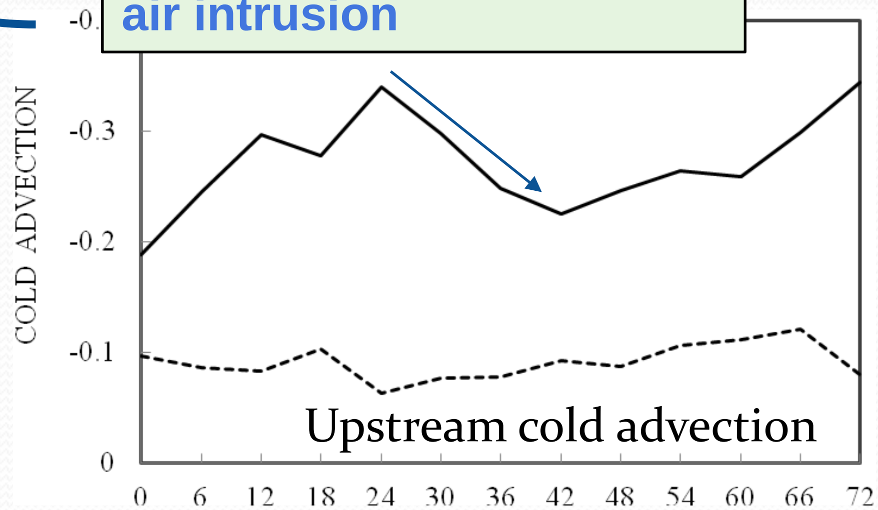
The weakening of upstream NE flows

decreases the VWS





reduces the cold and dry air intrusion



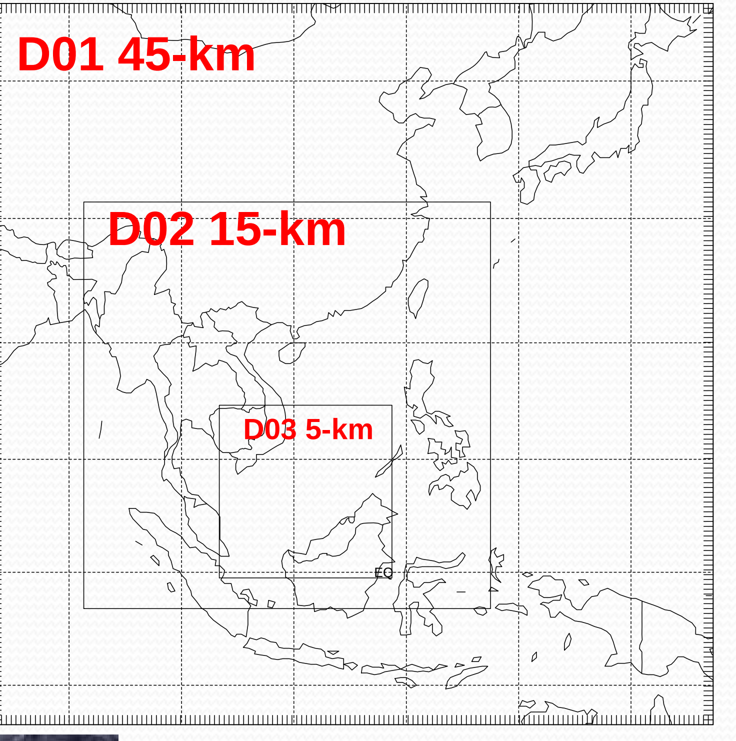
- **The persistent monsoonal NE flows** lead to positive shear vorticity over the equatorial SCS.
- **The weakening of the upstream NE flows** also contributes to the **decrease of the VWS and the cold and dry air intrusion** thus is favorable for the further development of the incipient vortex.

-Lin and Lee, 2011, MWR

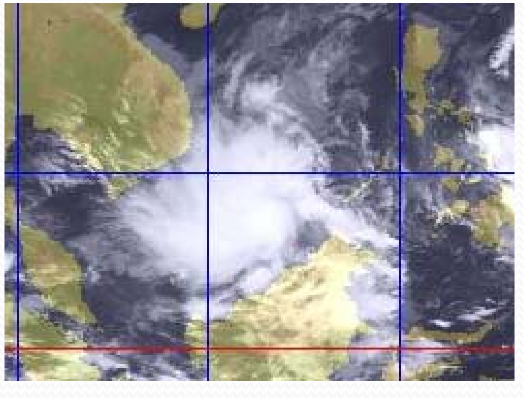
Simulations of formation & non-formation cases

WRF Model Setup

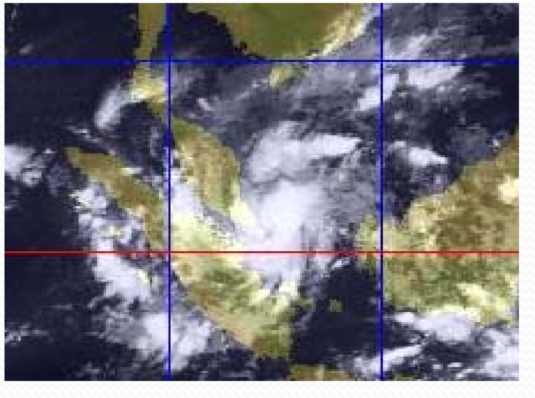
- Cumulus scheme : Kain and Fritsch on the 15- and 45-km
- PBL scheme : YSU
- Cloud microphysics scheme : WSM6
- Initial time :
  - 24 hrs before the 1st closed isobar for non-formation cases
  - 42 hrs before 25 kt of 0129w
  - 36 hrs before 25 kt of Vamei
- Initial field : NCEP FNL 1° × 1°, except Vamei (ECMWF Adv. 1.125° × 1.125°)



TS 29w (2001)

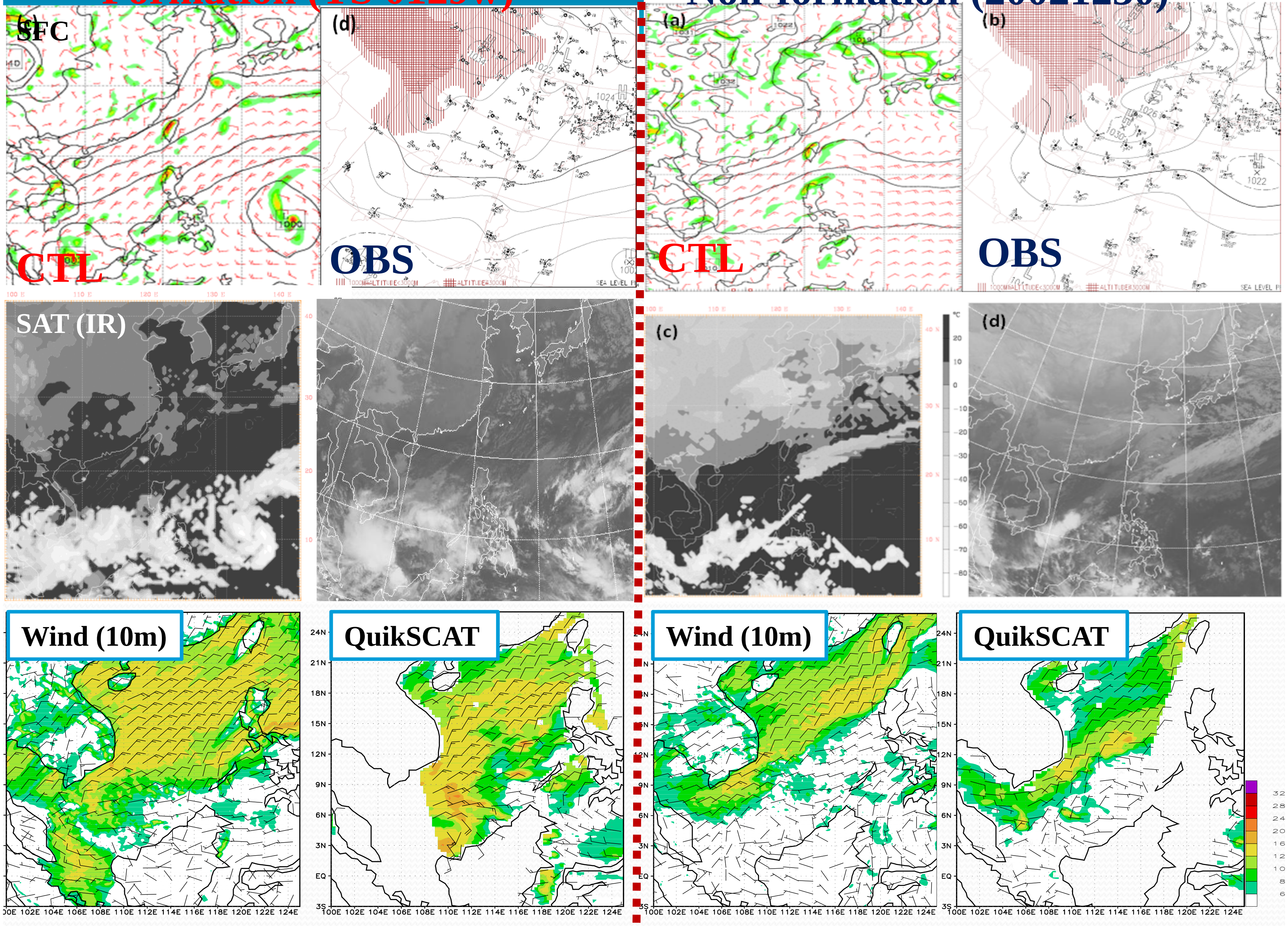


TY Vamei (2001)

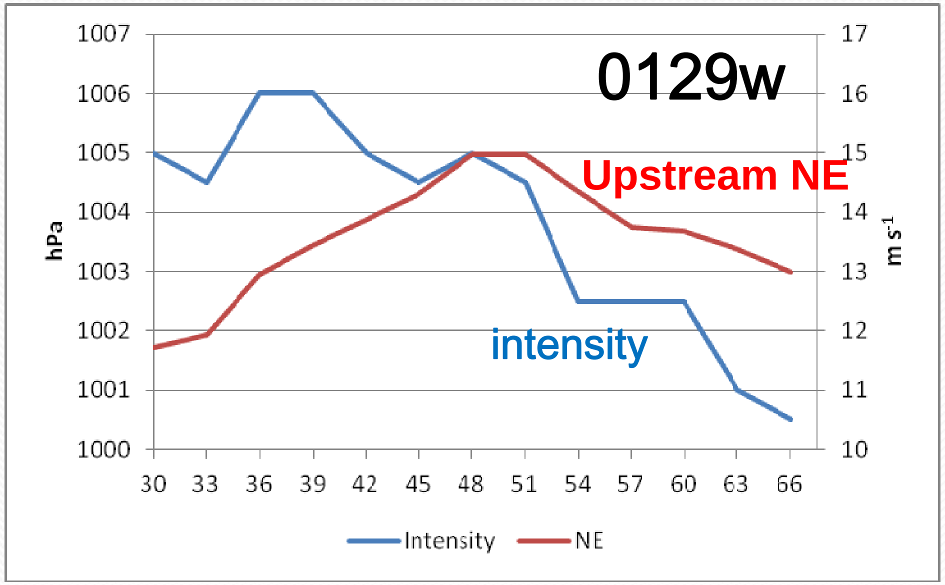


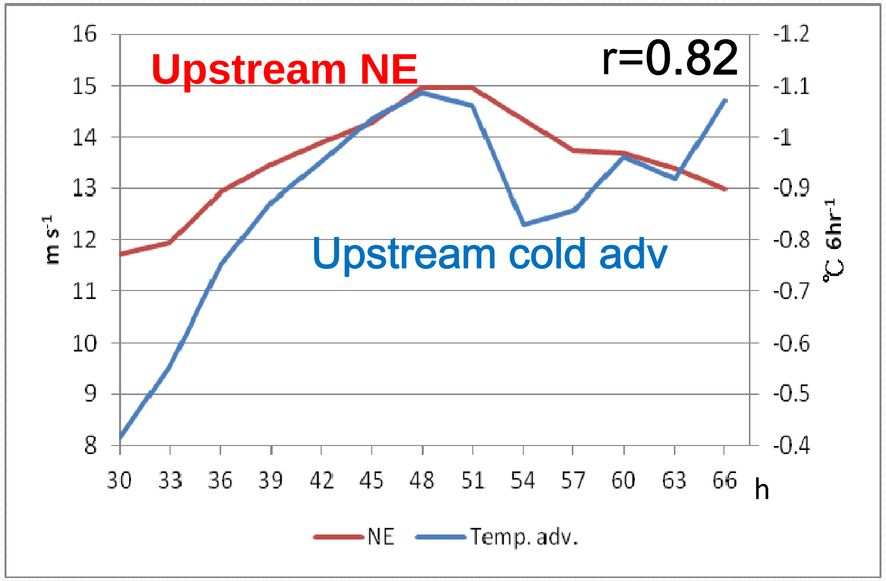
Formation (TS 0129w)

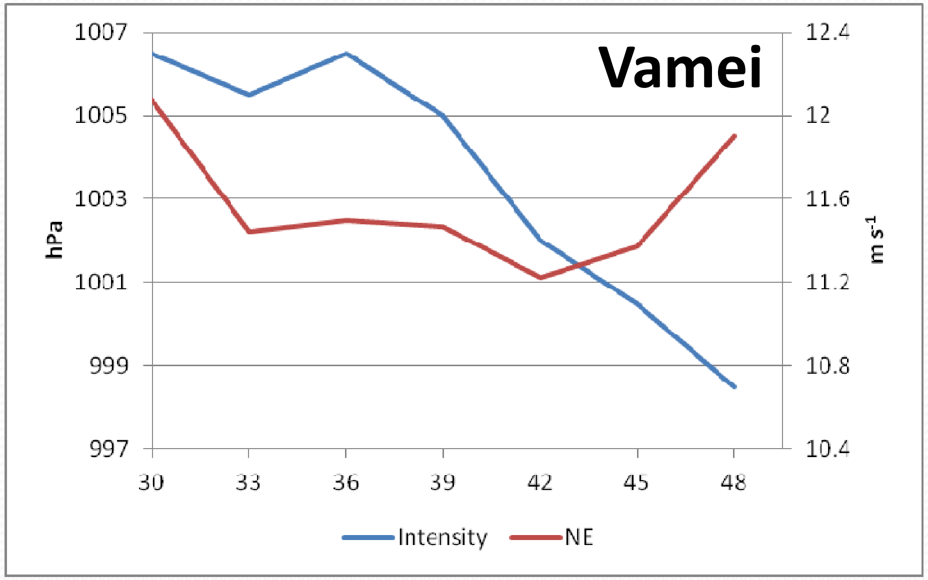
Non-formation (20021230)

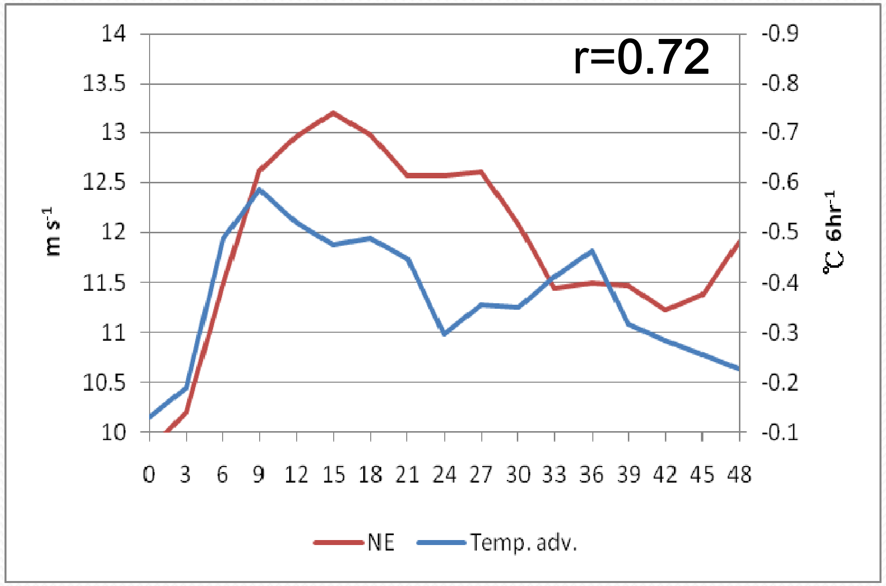


Formation cases – Intensity, NE flows and cold adv.

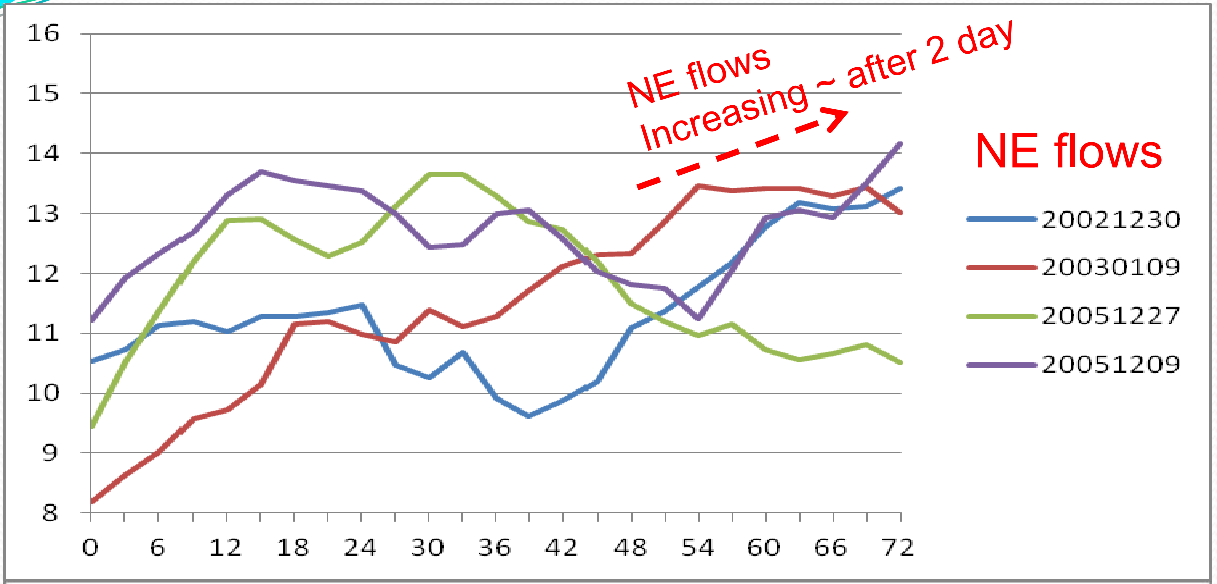


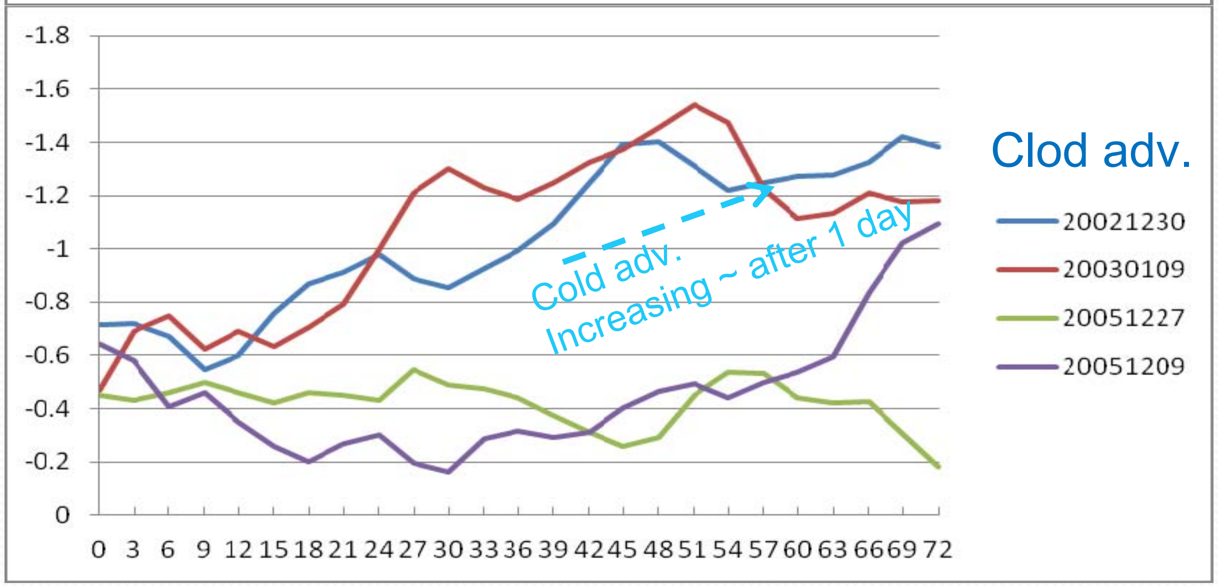






Non-formation cases





Simulation results are consistent with composite results.

The changes of upstream NE flows and cold advection appear to be important to the development of pre-TC disturbance and TC formation →

Sensitivity tests

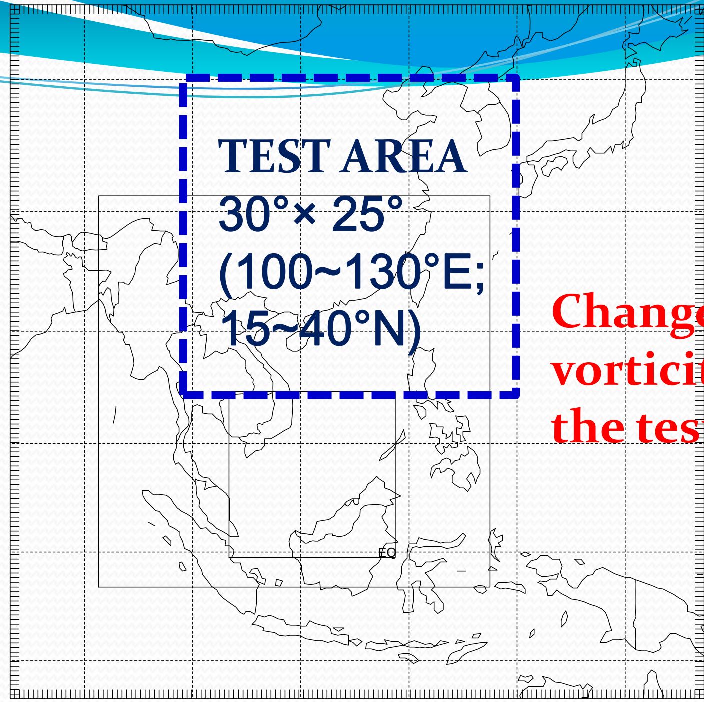
What is the effect of initial large-scale anti-cyclonic vorticity to TC formation?

How does the intensifying or weakening of upstream NE flows affect TC formations?

Sensitivity test

Change the initial field to change the environmental forcing

Change the environmental forcing during the mid-developing phase (nudging)

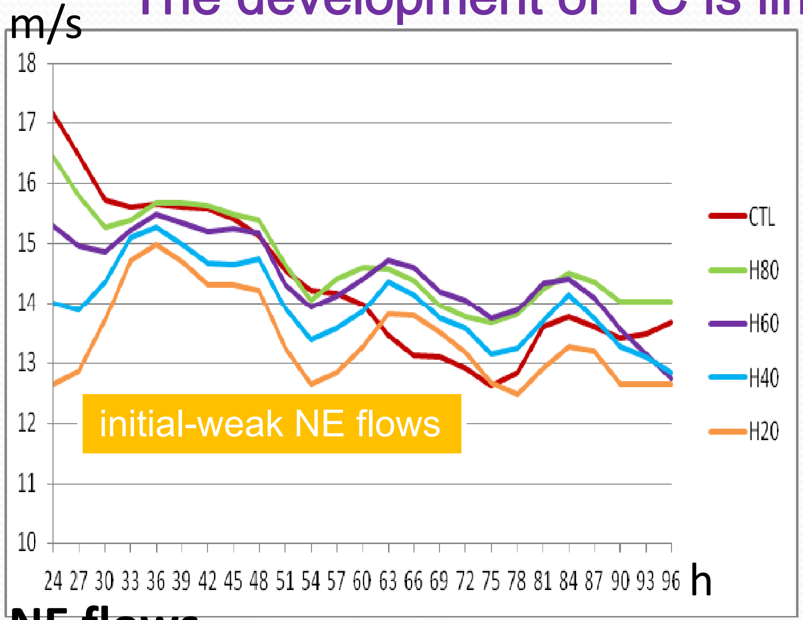


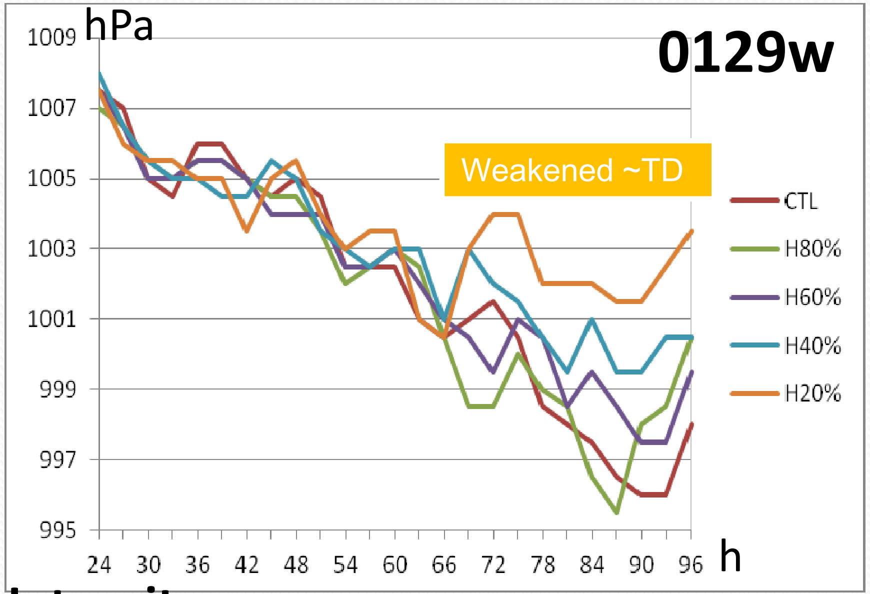
Change the vorticity of the test area

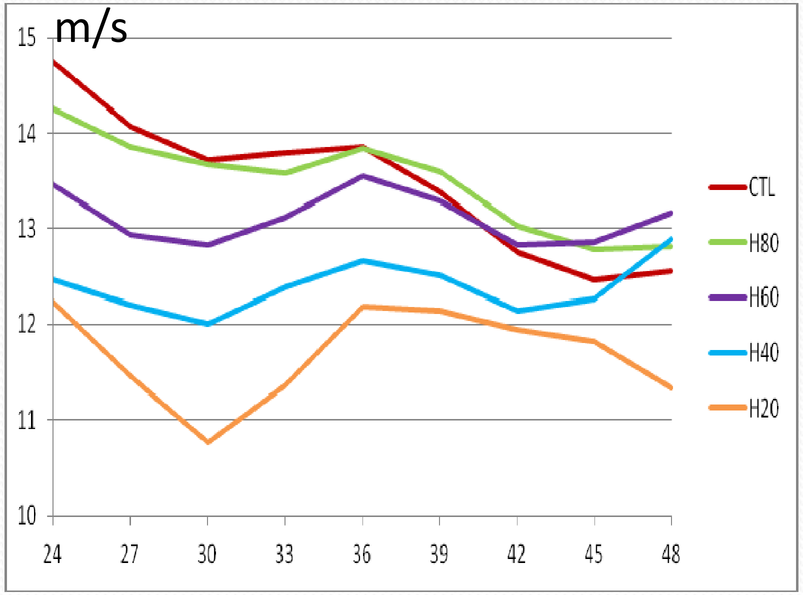
Change intensity of H	formation	Non-formation
Decrease ini. 20%	H80	80% of original vort
Decrease ini 40%	H60	
Decrease ini 60%	H40	
Decrease ini 80%	H20	
Nudging Decrease **20%**		H80
Nudging Decrease **40%**		H60
Nudging increase **20%**	H120	
Nudging increase **40%**	H140	
Nudging increase **80%**	H180(Vamei)	

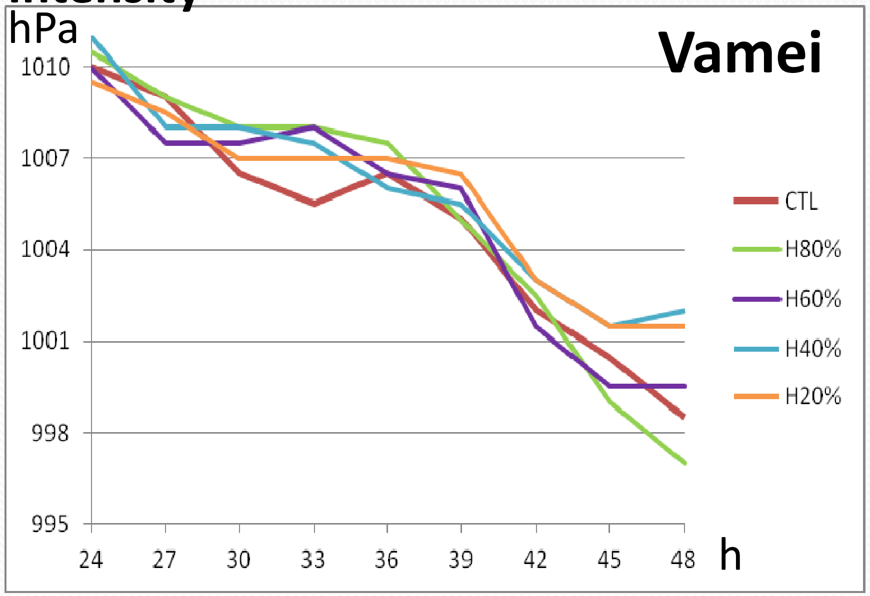
Changing the initial field to change NE flows

The development of TC is limited by initial-weaker NE flows









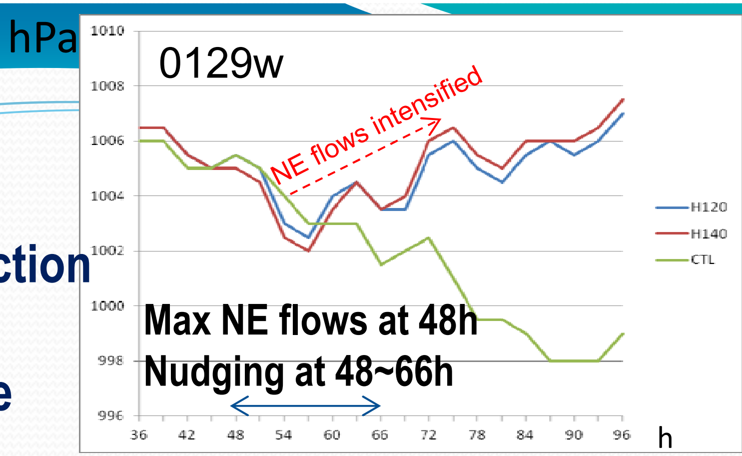
formation

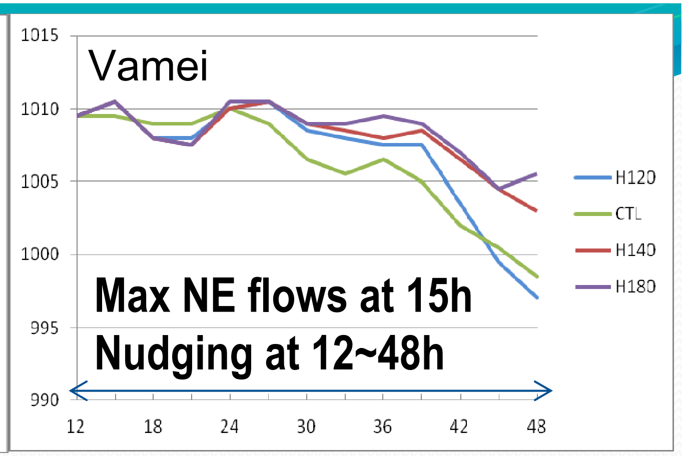
Stronger NE flows

→ stronger cold advection intrusion

→decrease convective instability

→become non-formation





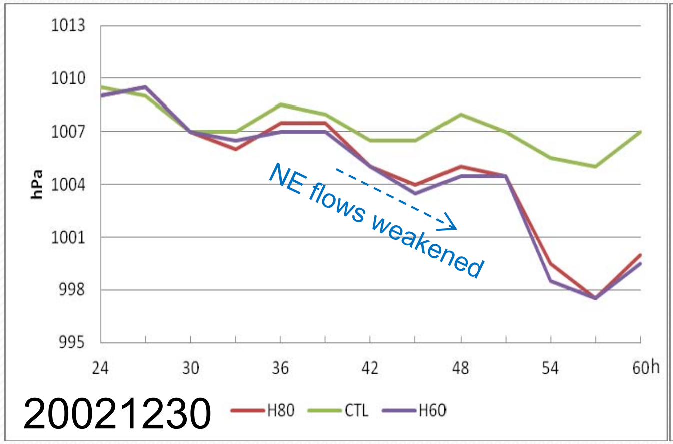
non-formation

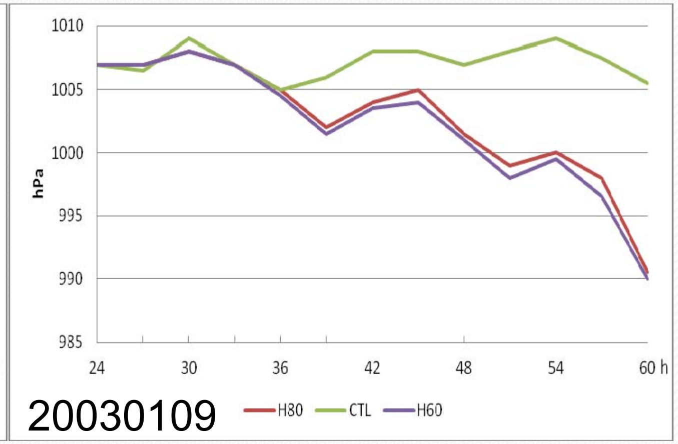
Weaker NE flows

→ weaker cold advection intrusion

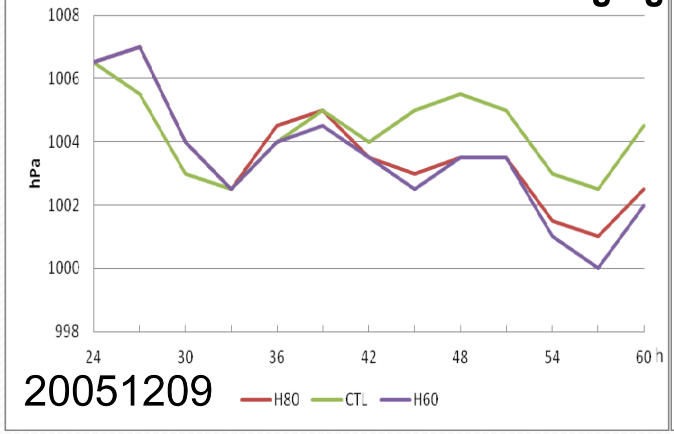
→ increase convective instability

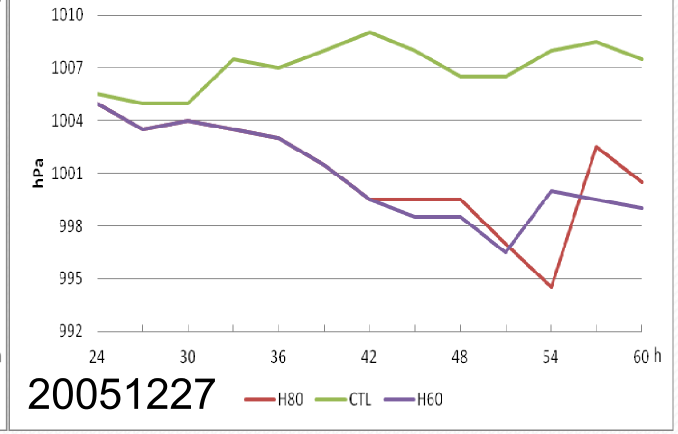
→ become formation





Nudging at 36~72h

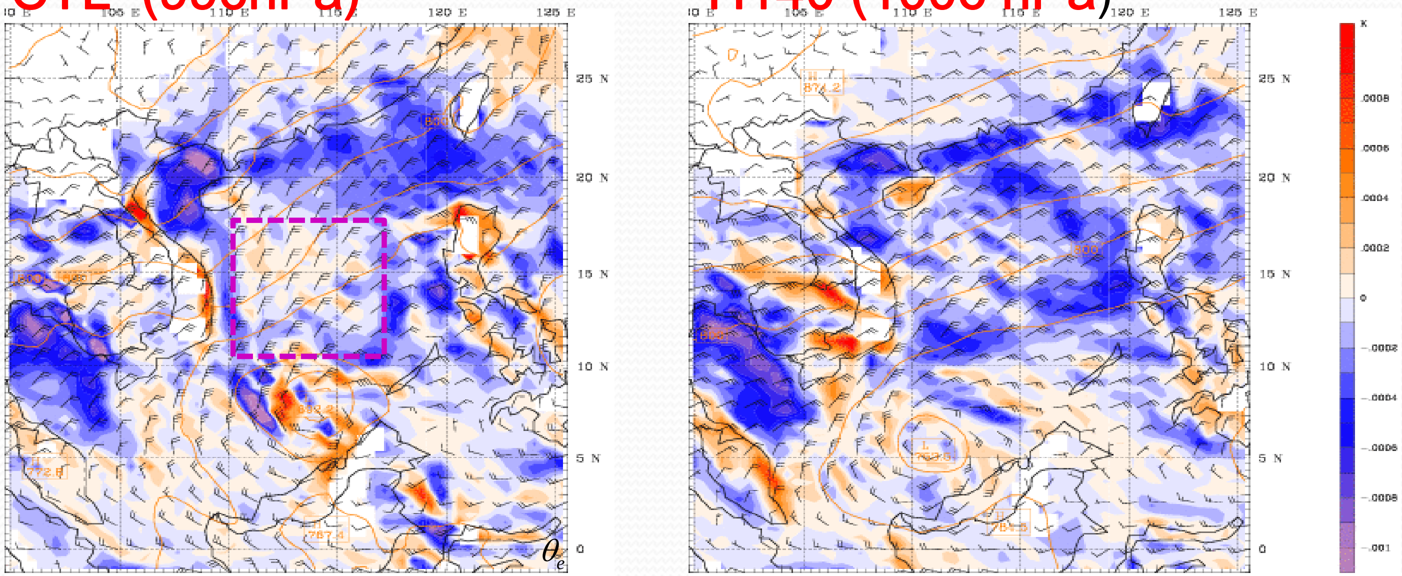




Formation case (0129w)

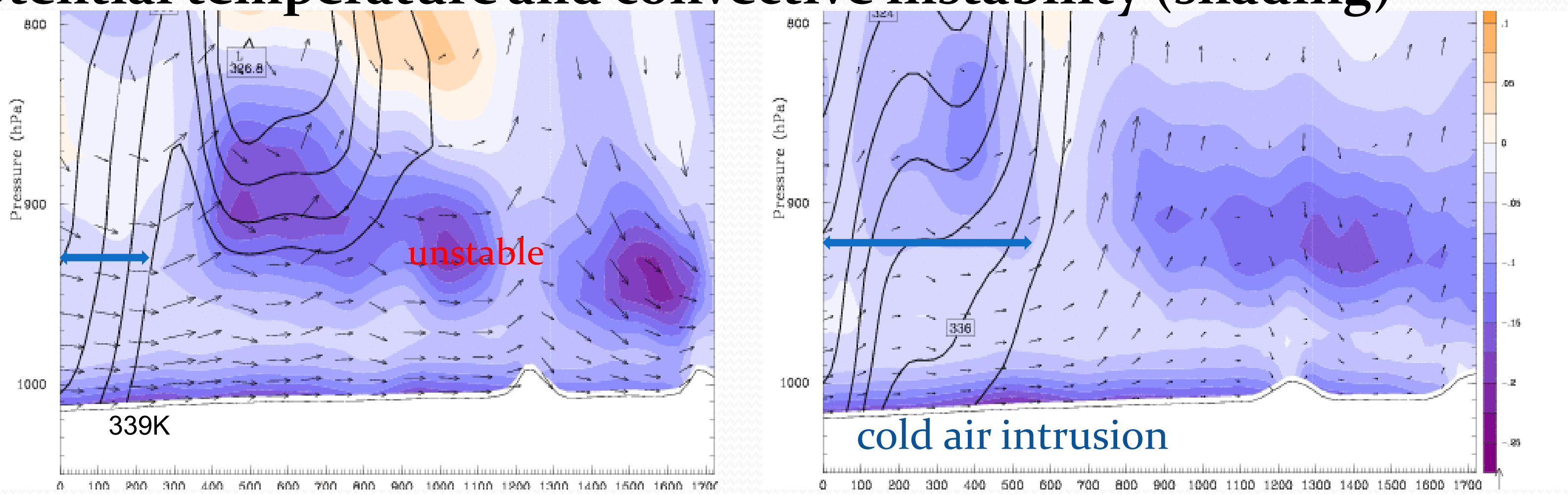
925-hPa

$-V\cdot\nabla\theta_e$



Potential temperature and convective instability (shading)

$-\frac{\partial\theta_e}{\partial p}$



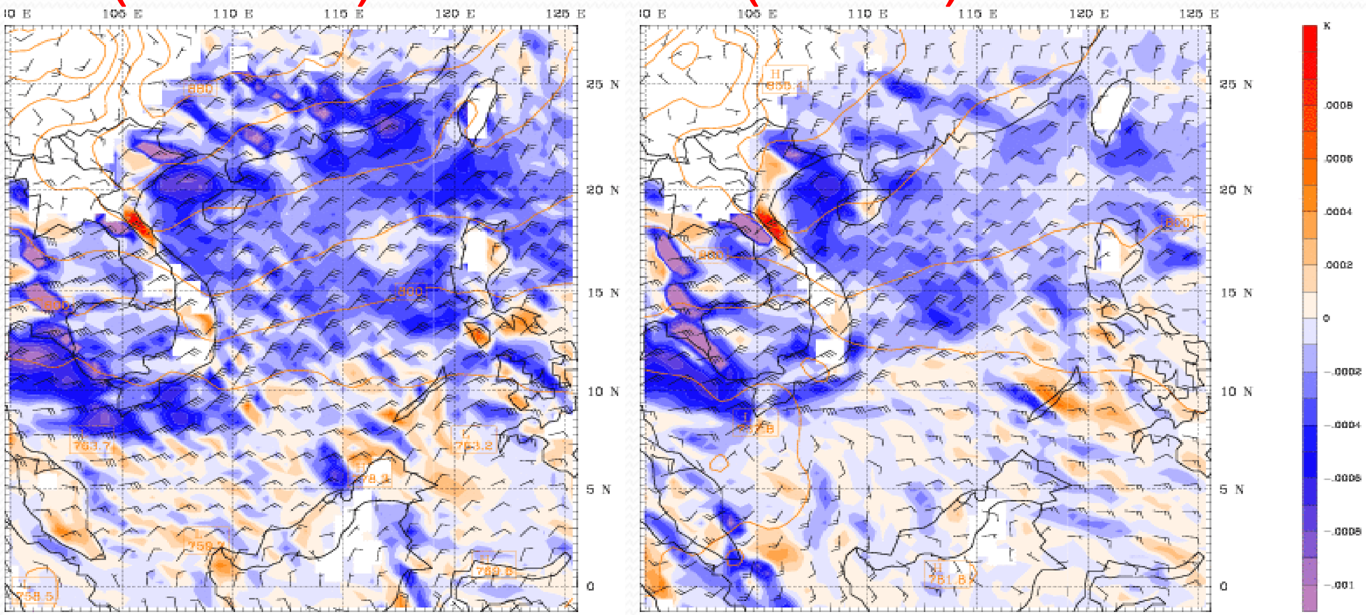
(Along 118.5E, 20 - 5N)

Non-formation (20021230)

CTL (1006 hPa) H60 (997hPa)

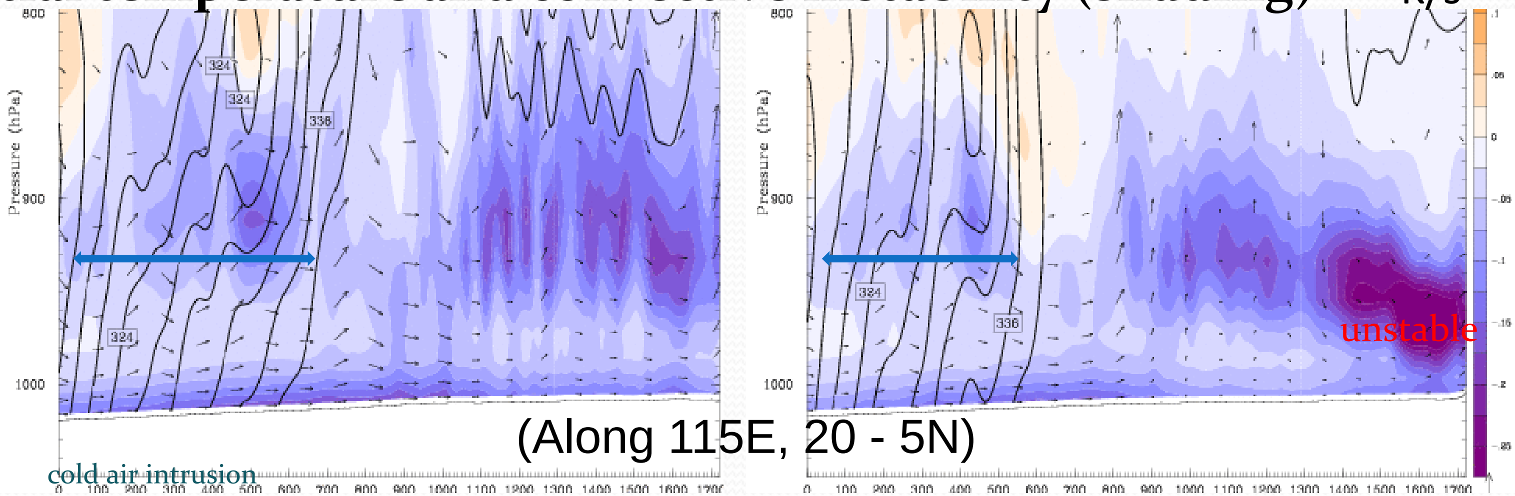
925-hPa

$$-V\cdot\nabla\theta_e$$



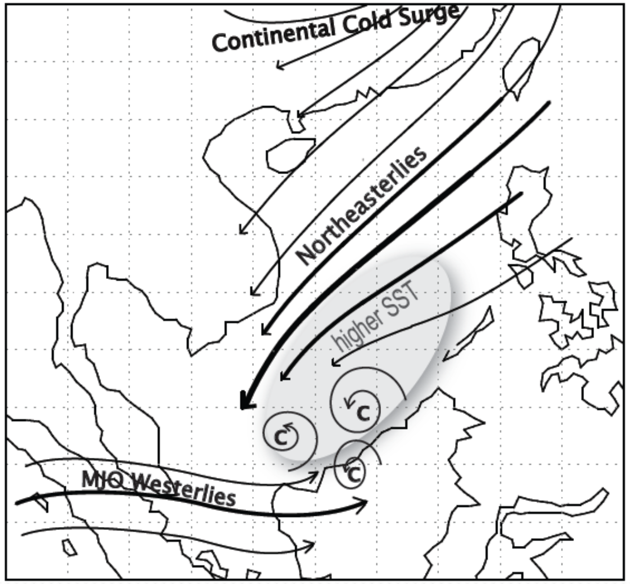
Potential temperature and convective instability (shading)

$$-\frac{\partial\theta_e}{\partial p}$$



Conclusions

Large-scale background cyclonic vorticity



- Observations

  A weakening in the upstream NE flows for the formation cases

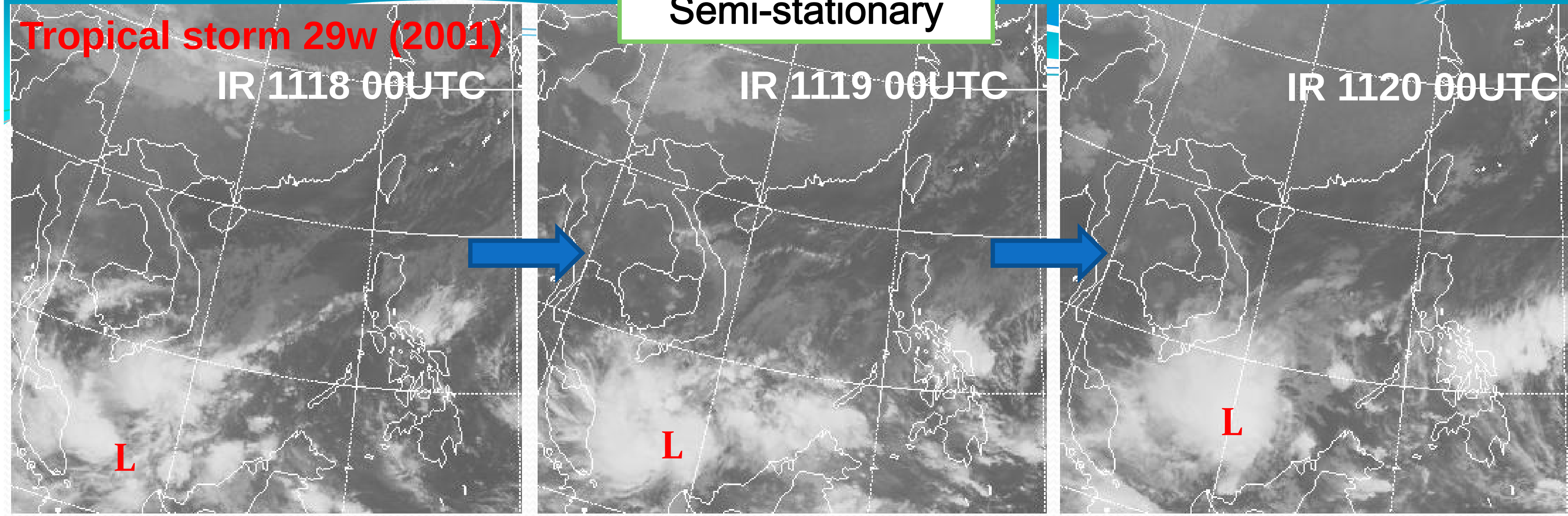
  - Decreases the VWS & reduce the cold and dry air intrusion → avoid stabilizing effect

- The role of the strong NE flows

  - The development of the vortex is limited by initial-weaker NE flows accompanying with weaker shear vorticity.
  - The changes of the upstream NE flows during the mid-developing phase of the vortex affect the further development of the vortex (TC formation).
  - The results of sensitive tests are consistent with our hypothesis.

Thank for your attention!!

Semi-stationary



Westward-moving