Is a necessary condition of barotropic instability for a normal mode satisfied in Typhoon Sinlaku?

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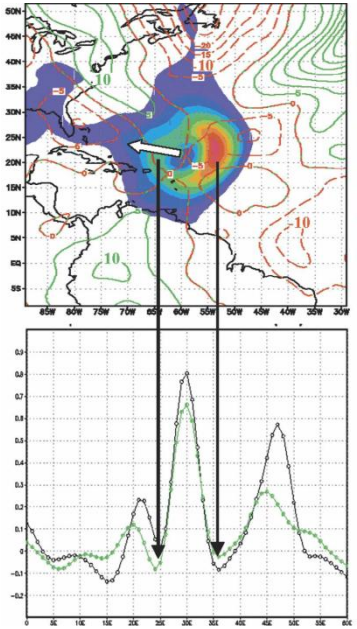
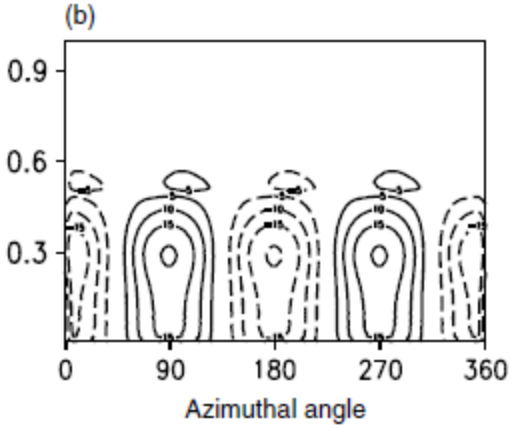
Previous Studies on a barotropic instability in TCs

Peng and Reynolds (2006):
They suggested that the fast growing perturbation appears in the area where the PV (vorticity) gradient changes sign.



Peng et al. (2008):
They conducted a normal mode analysis in the vicinity of a TC and found a barotropically growing mode.



What I did

I looked into the initial condition of non-perturbed (control) run of ECMWF and NCEP and drew figures of vorticity and the radial gradient of the vorticity

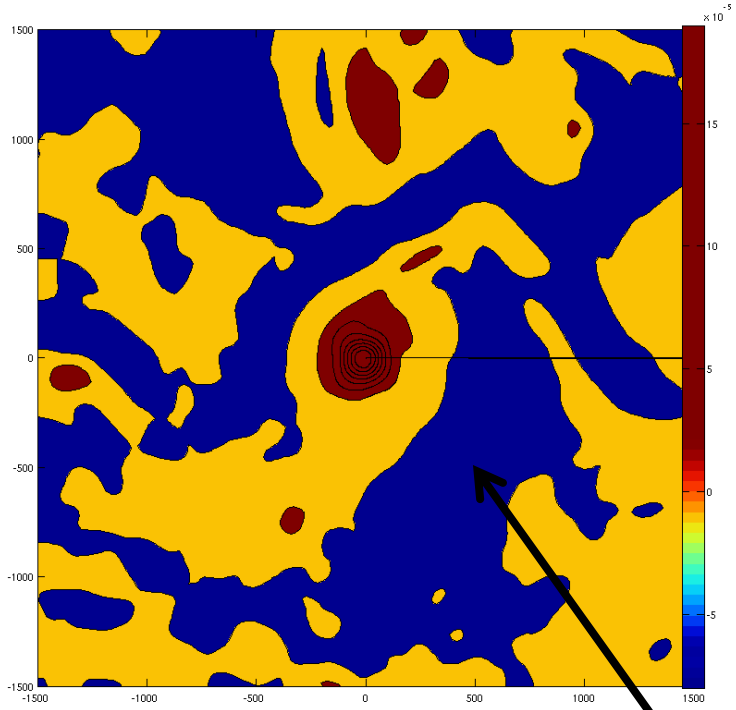
As a first step, I picked up 00UTC of 09/10 (before-recurvature stage of Typhoon Sinlaku)

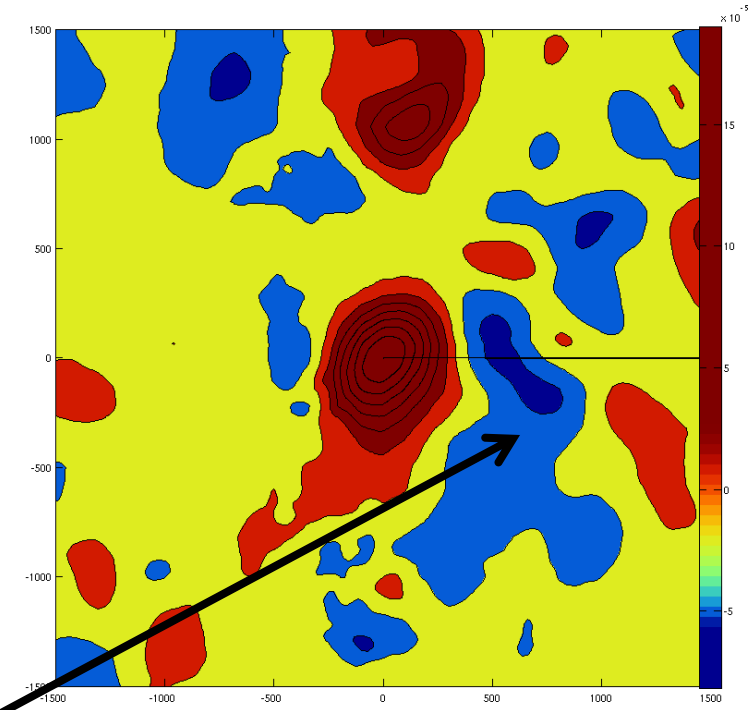
I focused on one vertical level, 500 hPa, where seems to determine the advection flow.

Vorticity

ECMWF

NCEP



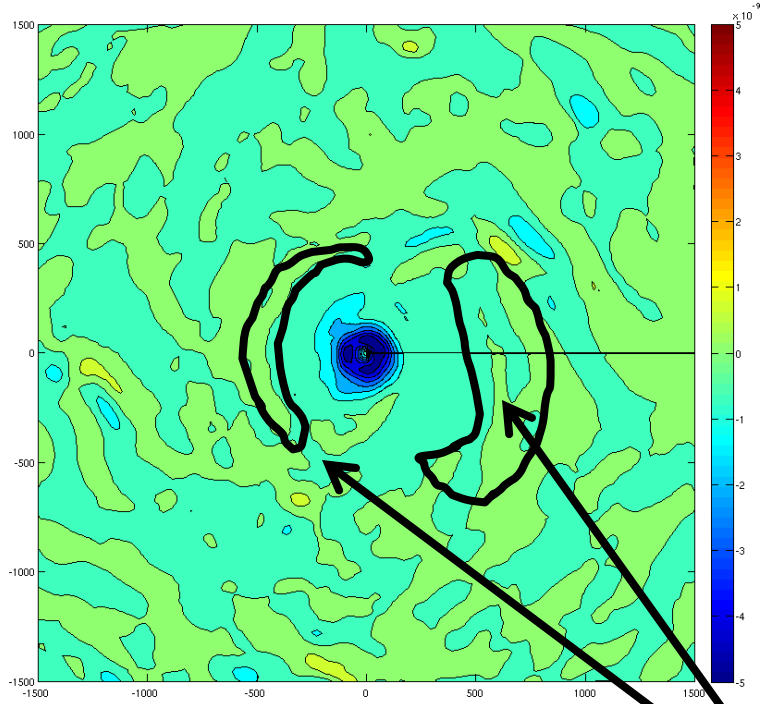


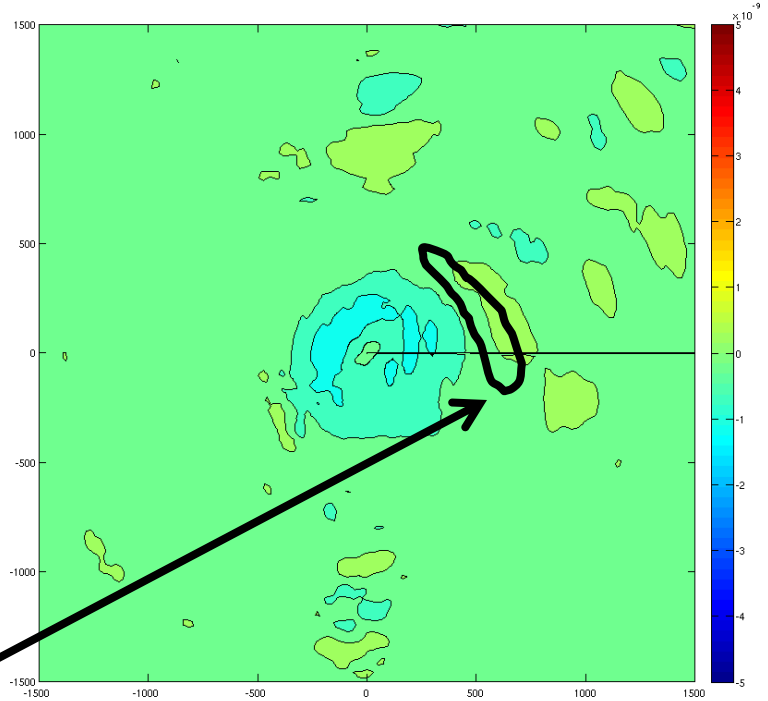
Negative vorticity

Vorticity Gradient

ECMWF

NCEP

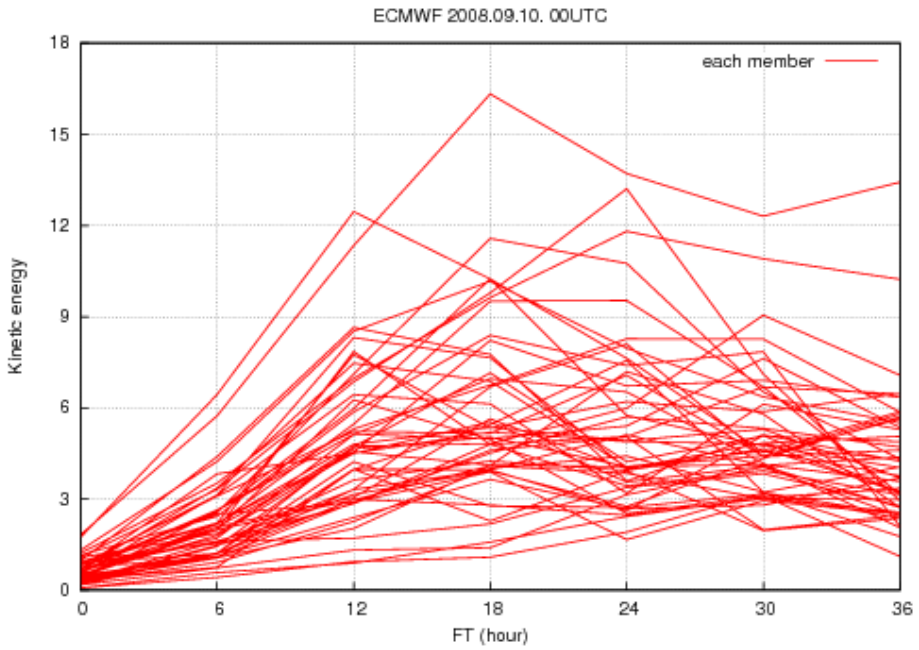




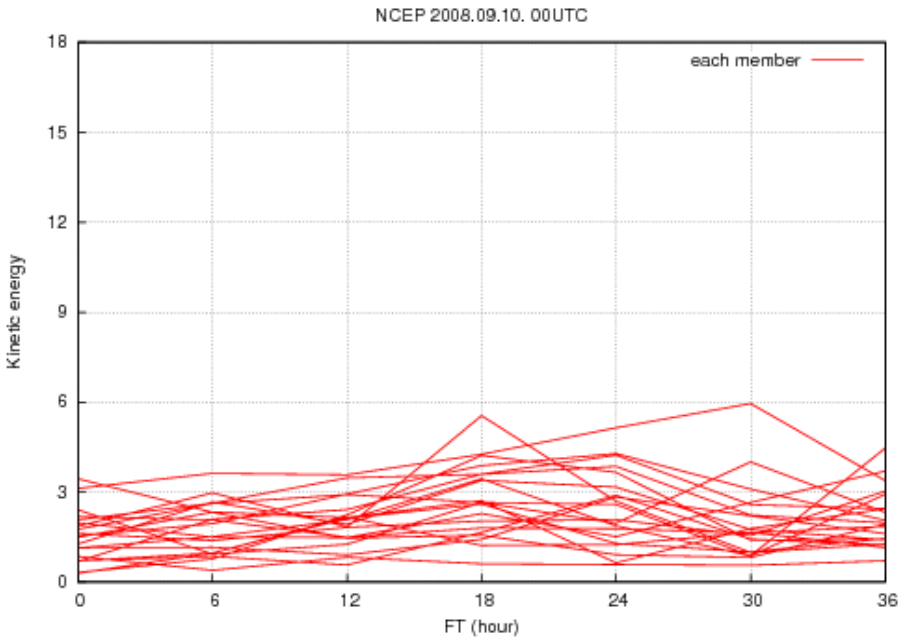
Vorticity gradient changes sign

Growth of kinetic energy (asymm)

ECMWF (50 members)



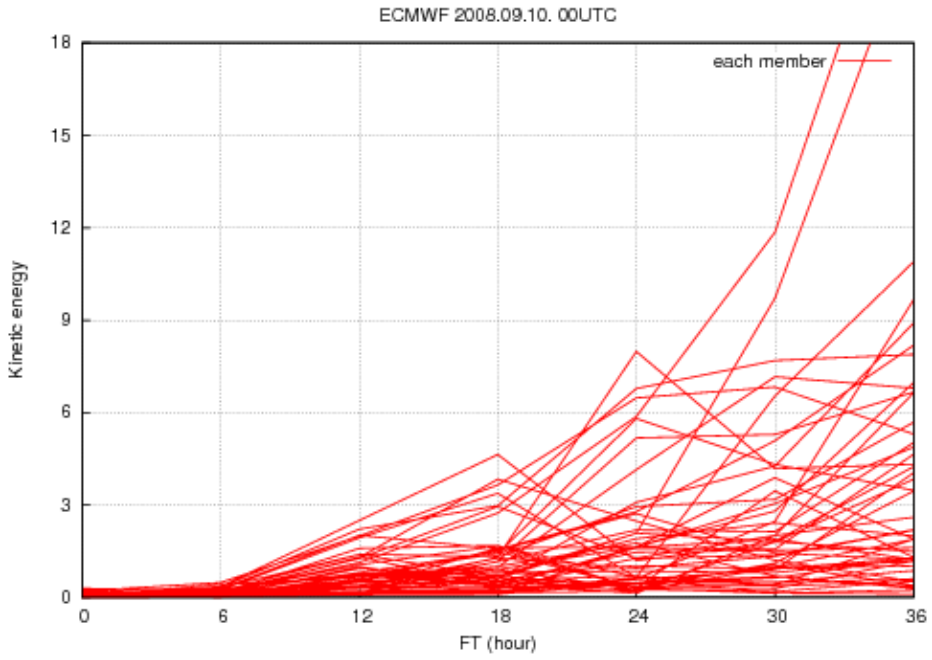
NCEP (20 members)



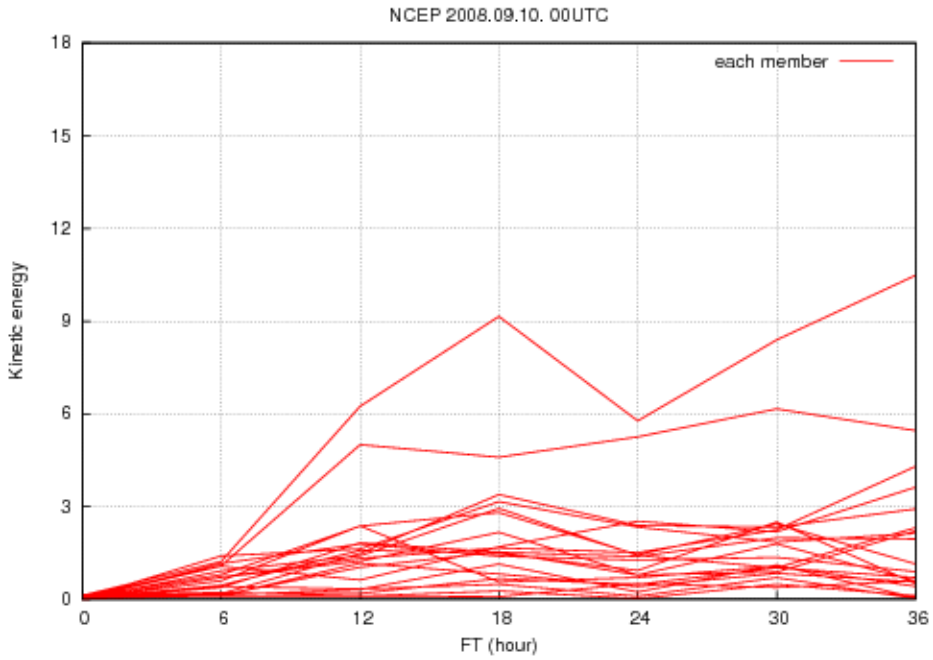
1. The growth rate of ECMWF is much larger than NCEP.
2. The growth of ECMWF is up to 12 to 18 hours.
3. Though it is not growing, it is not decaying in NCEP… why??
4. The initial amplitudes of NCEP are larger than ECMWF

Growth of kinetic energy (symm)

ECMWF (50 members)



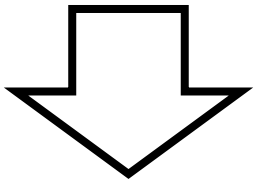
NCEP (20 members)



Correlated to the growth of asymmetric component as seen in a barotropic instability of a normal mode???

Discussion

1. It is found that a necessary condition of barotropic instability is somewhat satisfied.
2. Peng (2008) shows a solution of a normal mode which grows exponentially with time in the vicinity of a TC.



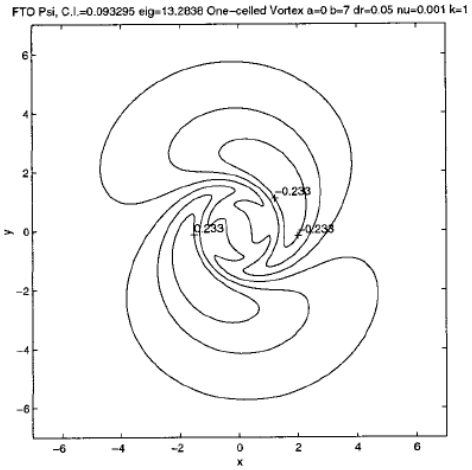
Can we say based on these 2 facts that a SV captures a normal mode-like barotropic instability?

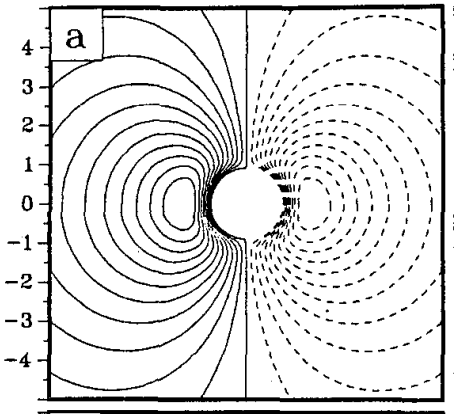
Discussion 2

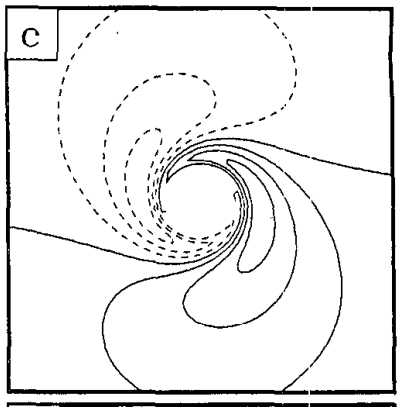
I would say no.

One reason is the characteristic of highly sheared tangential wind in TCs. How the radially same phase speed like the normal mode is sustained in such highly sheared environment.

Assuming tangentially advected perturbations like Nolan and Farrell (1999) seems to be more realistic in the highly sheared environment.







Against-shear stage

Neutral stage

Along-shear stage

time

Question?

Do SVs capture a normal mode-like barotropic instability against an initial condition which satisfies the necessary condition of instability?