Recent Advancements in the Understanding of Typhoon Inner-Core Structures and its Implication for Typhoon Vortex Initialization

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A number of previous studies suggest that inner-core processes could play a significant role in the evolution of TC structure.

- The structure and evolution of vortex-Rossby wave / eyewall meso vortices depend on the symmetric PV structure in the inner-core region.
- Eyewall mixing occurred associated with vortex-Rossby wave contributes to subsequent TC structure and intensity changes.

If smoothed initial conditions are provided, a vortex spinup will introduce a delay or incorrect timing/magnitude of the triggering of vortex Rossby waves or eyewall mixing events.  

(Elsberry 2002)
Case Study: Typhoon Rusa (2002)

Mashiko (2005)
Case Study: Hurricane Bonnie (1998)

Vorticity
Vertical motion
Asymmetric flow

Braun et al. (2006)
Some recent studies suggest that wavenumber-one asymmetries in precipitation in the inner-core region and vertical tilt of TC vortices are attributable to environmental vertical wind shear, and their amplitudes depend on the TC strength as well as shear magnitude.
Environmental shear can be a significant contributor to wind and rainfall asymmetries.
Case Study: Typhoon Songda (2004)

RMW~30km

Radar_Composit

Radar_Composit

RMW~200km

MSM analysis

9h integration at a very high resolution of 667 m

hard to spin up the vortex well in a short term even with a very high resolution model

Not rare case!
Case Study: Typhoon Rusa (2002)

- Shallower than observed
- Developing spuriously
- Steady in intensity

Graph showing time-lapse of atmospheric pressure with annotations.
Case Study: Hurricane Bonnie (1998)

Vertical motion

 waktu (h)

Braun et al. (2006)
At present, a feasible option to prepare a realistic typhoon inner-core structure in the initial fields for high resolution models is to use a TC bogusing method.

In the ongoing study, a revised version of JMA TC bogusing procedure, which is best-tuned to high resolution models, will be sought.
Distinctive aspects of JMA TC bogusing method

- Mass fields are specified ahead of wind ones.
- MSLP profile is the cornerstone of the method.
- 3-D mass fields are constructed based on an analytical function which contains some arbitrary parameters.
Issues to be tackled in the current method

- The arbitrary parameters are best tuned to the models of tens-of-kilometer resolution.
- MSLP profile is basically determined from gale-force wind radius and central pressure, therefore, detailed inner-core structures such as RMW are not always correctly specified.
- Vortex tilt is not explicitly considered.
Possible ways to resolve the listed issues

- To reexamine the validity of current setting of the parameters and best tune them to high resolution models making use of observational data
- To replace the formula for MSLP profile with another one which has more degree of freedom, so that the information on RMW can be utilized in the bogusing procedure
- To explore the specification method of inner-core asymmetries including vortex tilt
Data collected so far for the study

- **Observational data**
  - **Period:** 2004-2007
  - **Surface:** SYNOP, METAR, SHIP, BUOY
  - **Upper:** TEMP, PILOT

- **Best track data**
  - **Period:** 2004-2007
  - **Region:** NW Pacific, NE Pacific, Atlantic

- **Global analyses**
  - **Period:** 2004 (not all), 2005 (not all)
Verification of Analysis against Sonde etc.

Geopotential Height

Wind

RMS Error (m)

Vertical Level in Pressure

RMS Error (m/s)
## Verification of Bogus Data against Sonde etc.

in the near-core area

<table>
<thead>
<tr>
<th>Level</th>
<th>GPH (m)</th>
<th>Wind (m/s)</th>
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<tr>
<td></td>
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Summary

- Previous studies suggest that a high resolution model is needed to obtain accurate forecasts of TC inner-core structures (such as detailed wind and rainfall distributions in the near-core region) and their evolutions.
- According to our numerical experiences, conventional observational network is not enough to provide initial TC fields suited for high resolution models, and an ad hoc procedure such as bogusing one is needed to avoid the spin-up problem arising from the use of smoothed initial conditions.