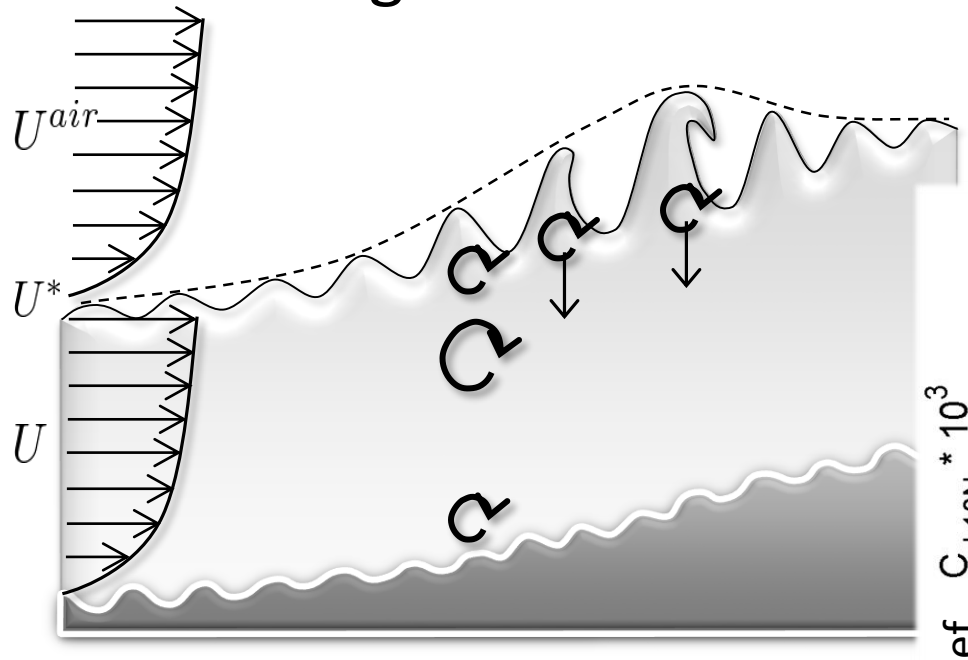
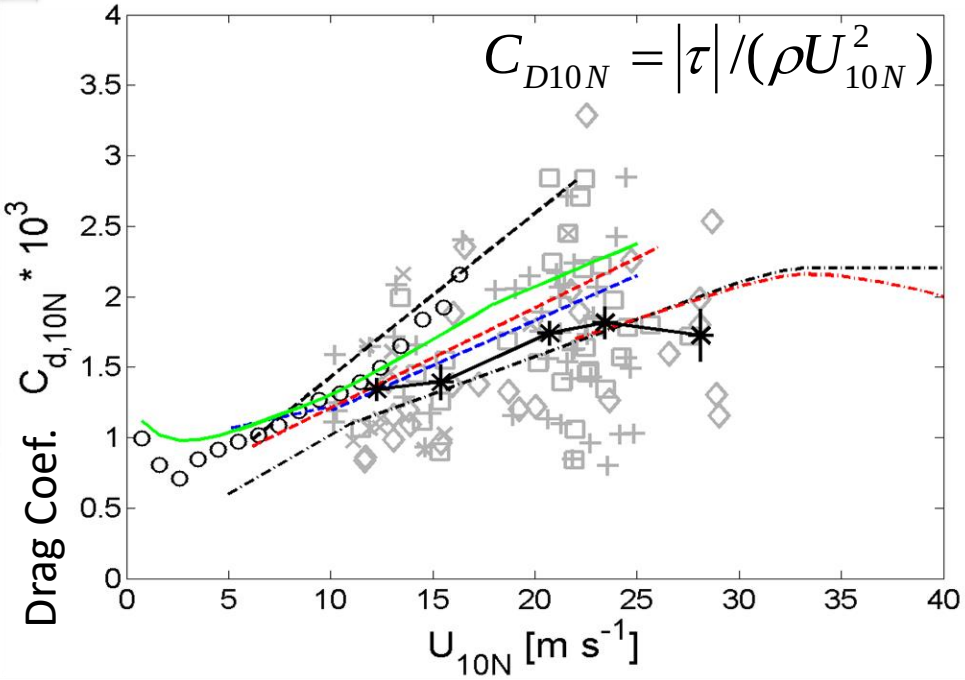
# Impact of estimation methods of drag coefficient at sea surface on typhoon Haiyan using high-resolution air-sea-wave coupled model


| | |
|---|---|
| Kanazawa Univ. | Junichi Ninomiya |
| Kyoto Univ. | Nobuhito Mori |
| Kyoto Univ. | Tetsuya Takemi |

# Motivation

- To examine the sensitivity of parameterization of drag coefficient on super typhoon using high resolution modeling.



# Drag Coefficient (Roughness) bulk formulas

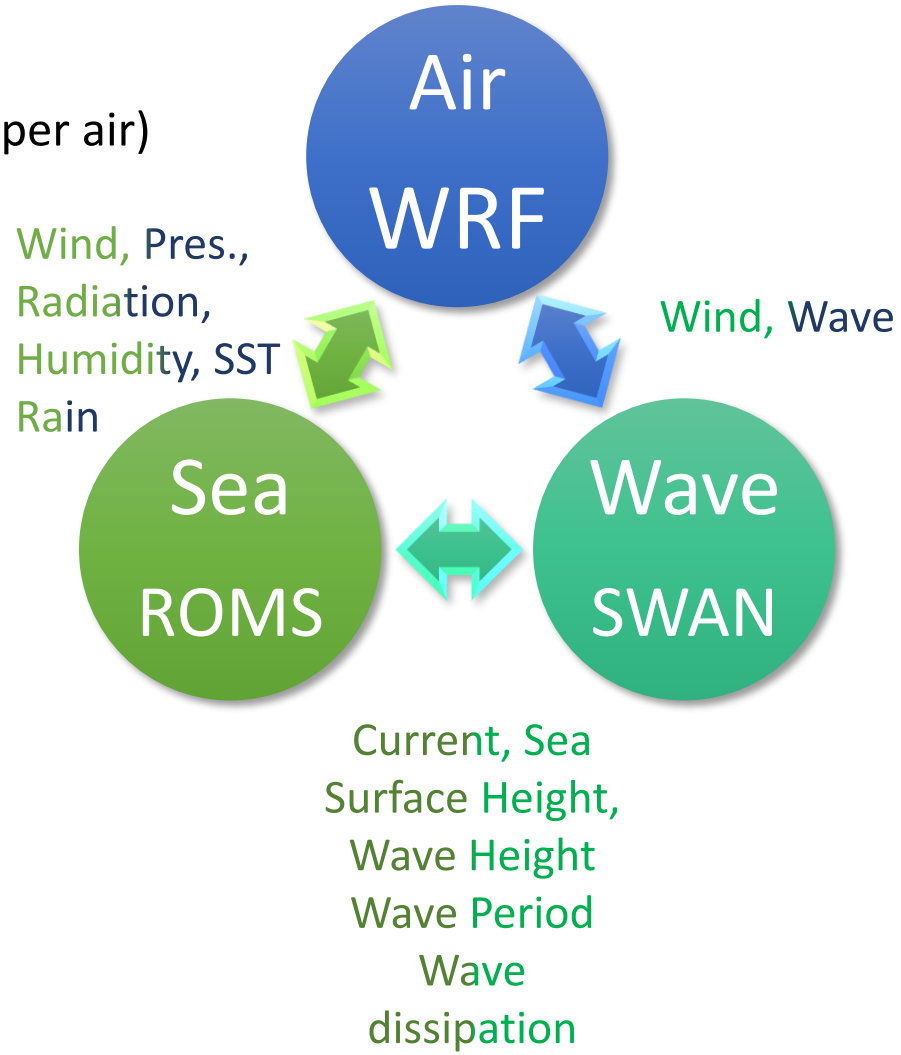
- Wind dependent formula (Charnock)
  - $z_0 = \frac{0.018 u_*^2}{g} + \frac{0.11\nu}{u_*}$
- Wave dependent formula (Taylor and Yelland)
  - $z_0 = 1200 H_s \left(\frac{H_s}{L_p}\right)^{4.5} + \frac{0.11\nu}{u_*}$

- Drag limitation
  - $z_0 = \min(z_0, 2.85 \times 10^{-2})$ <-> $C_d = \min(C_d, 2.4 \times 10^{-3})$

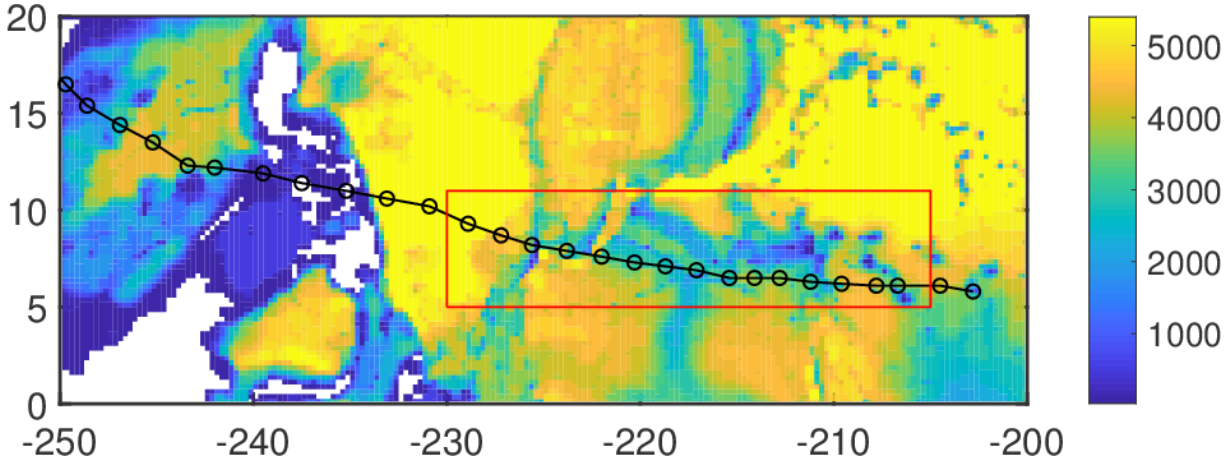
# Model Setup

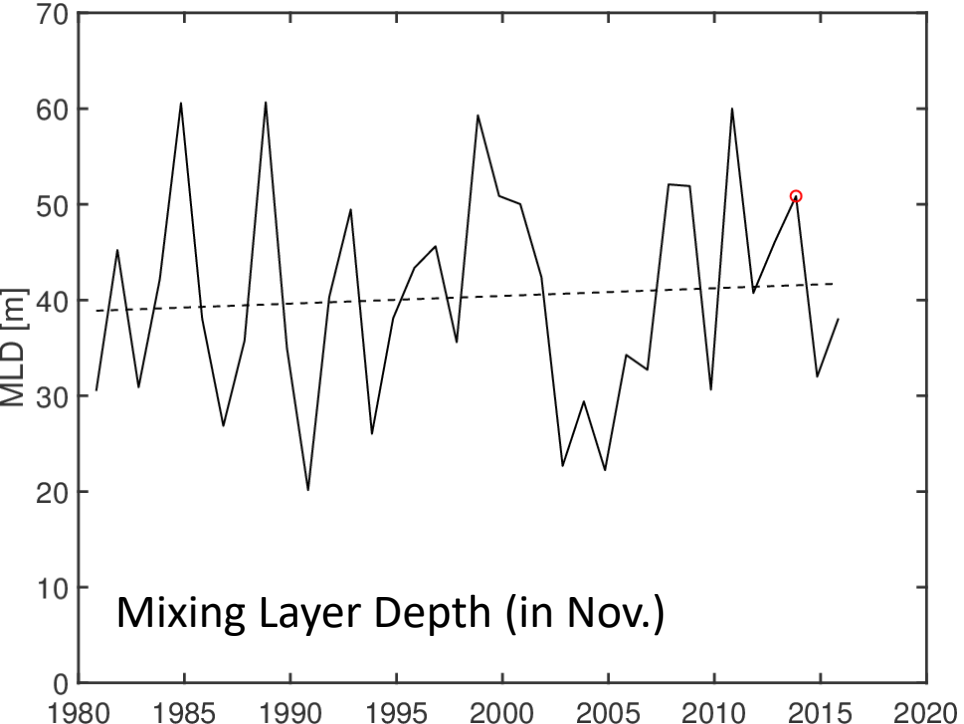
- Initial and boundary condition
  - WRF
    - NCEP FNL (Spectral nudging for upper air)
      - 1 deg., 6 hour
    - MGDSST (under WRF run only)
      - 0.25 deg., daily
  - ROMS
    - SODA v3.4.2
      - 1/4 deg., 5 day
  - SWAN
    - WW3 (NOAA Reanalysis)
      - 1/2 deg., 3 hour
  - Topography
    - GEBCO (Ocean:-100 ~ -2000)
  - Initial TY Bogus

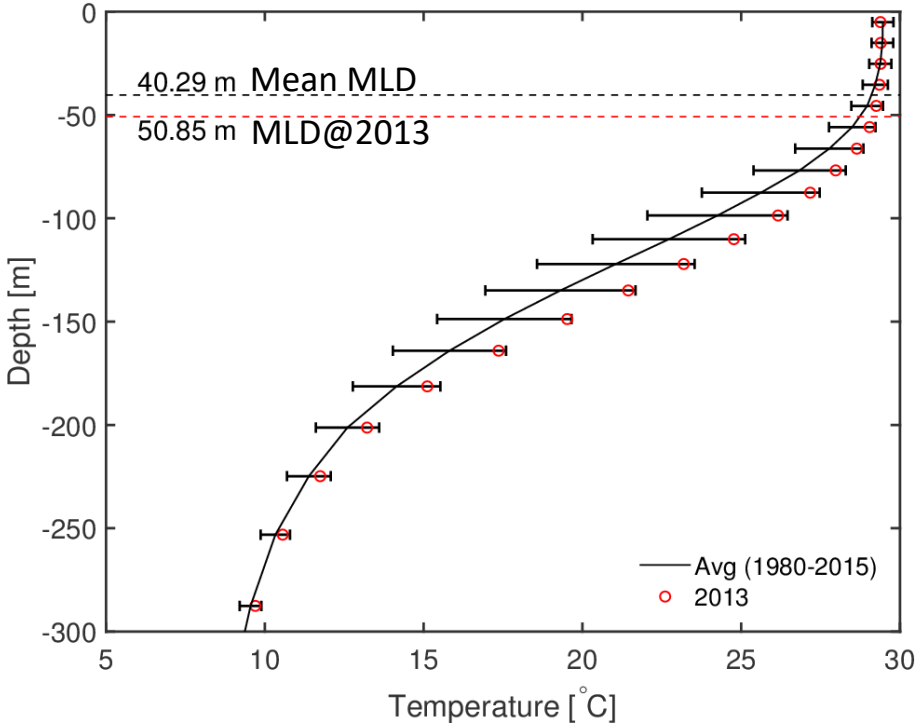
COAWST (Warner et al., 2008)



# Monthly Averaged Temperature of SODA

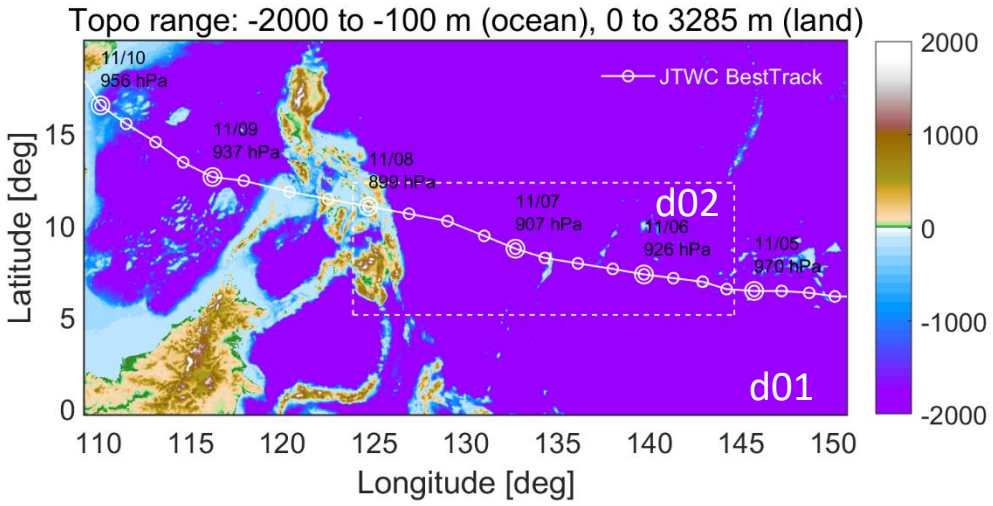


# Model Setup for TC Haiyan

- Period
  - Nov. 5th, 2013 – Nov. 10th 5 days
    - Coupling Interval: 600 s
- Domain




| Model | Resolution | Horizontal Grids | Vertical Grids Directions etc. | Dt [s] |
|---|---|---|---|---|
| WRF D01 | 3 km | 1334x667 | 56 | 10 |
| WRF D02 | 1 km | 2002x703 | 56 | 10/3 |
| ROMS | 3 km | 1334x667 | 40 | 10 |
| SWAN | 3 km | 1334x667 | Dir.: 24<br>Freq.: 24<br>(0.05-0.5Hz) | 300 |

# Simulation Cases

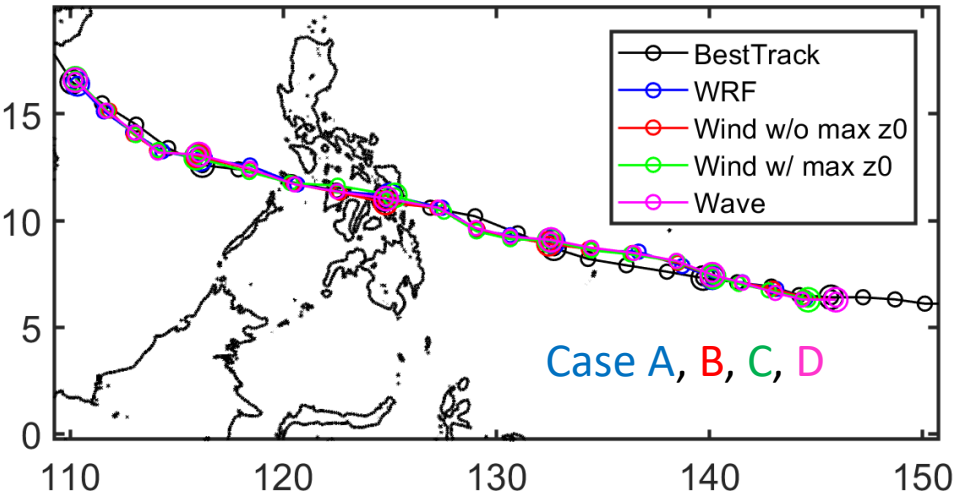
A) WRF
   - WRF 2 domain run using MGDSST.
   - Roughness (z0) is NOT limited.

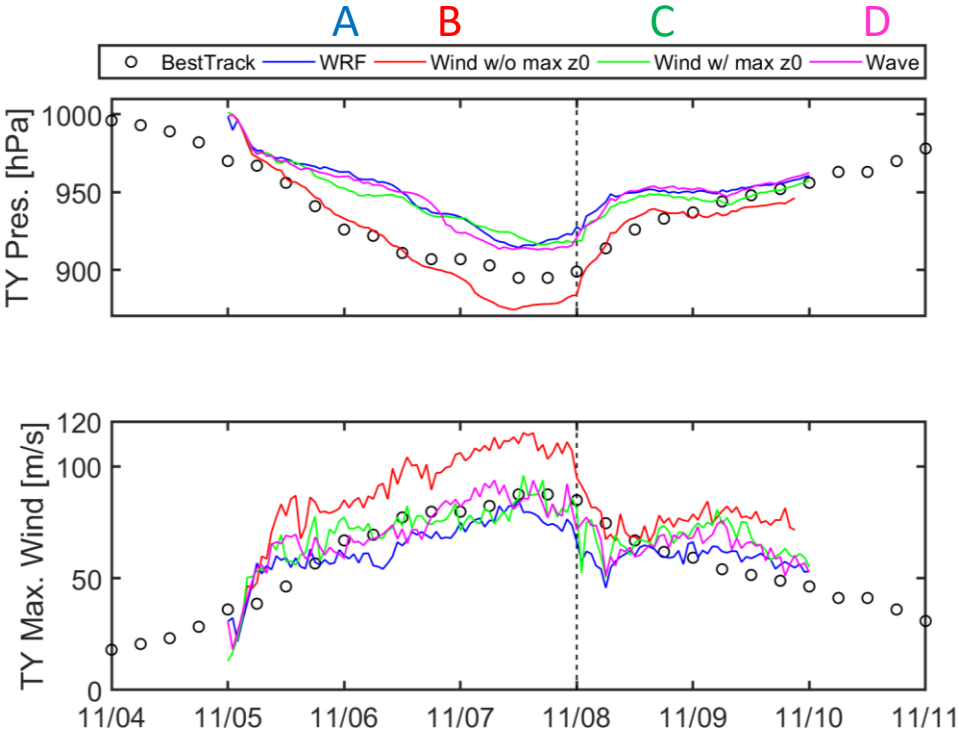
B) Wind w/o max z0
   - Full coupled run with Charnock formula.
   - Roughness is NOT limited.

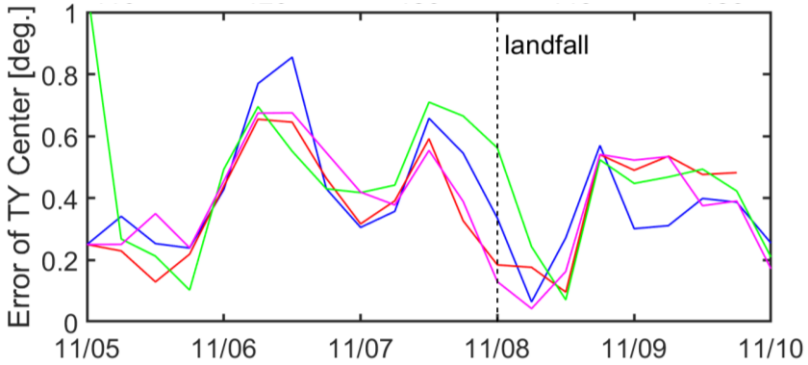
C) Wind w/ max z0
   - Full coupled run with Charnock formula.
   - $z0 <= 2.85 \times 10^{-3}$.

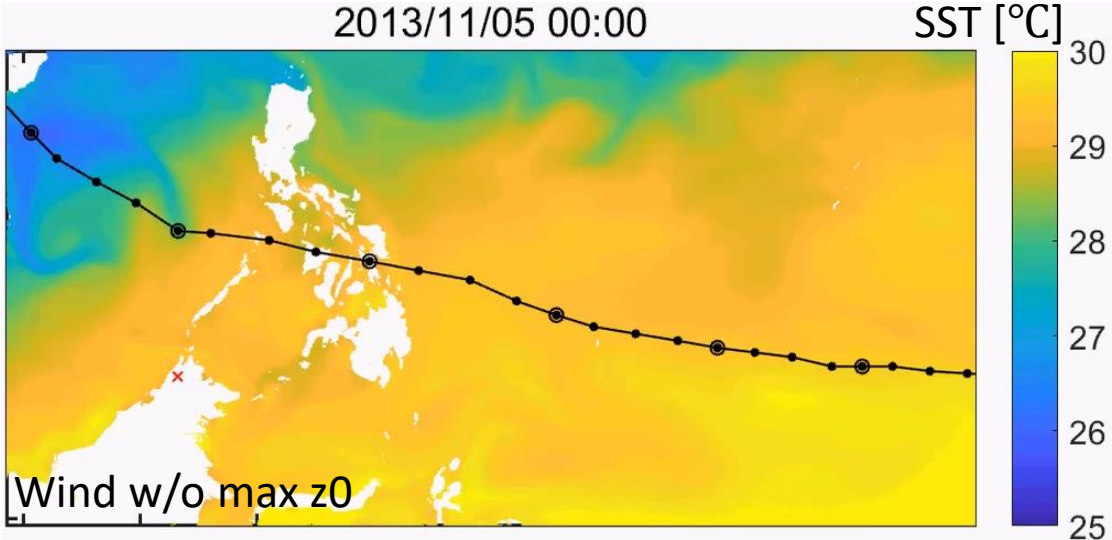
D) Wave
   - Full coupled run with Taylor-Yelland formula (wave slope).
   - $z0 <= 2.85 \times 10^{-3}$.

# Characteristics of TY



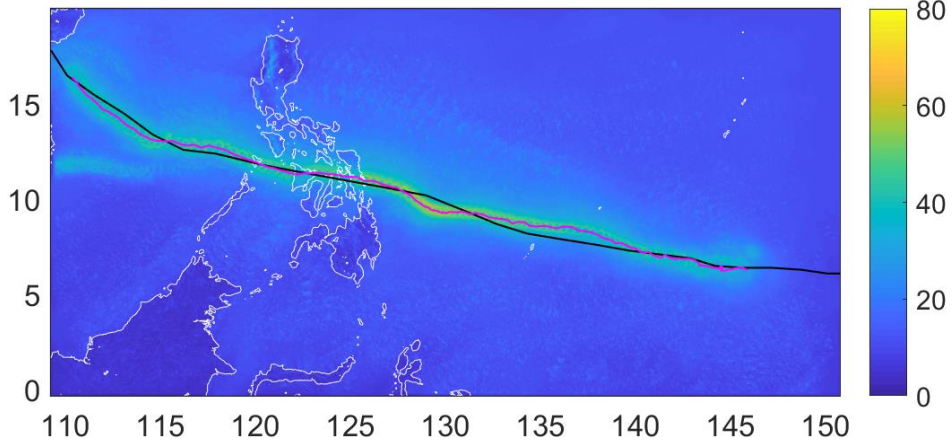



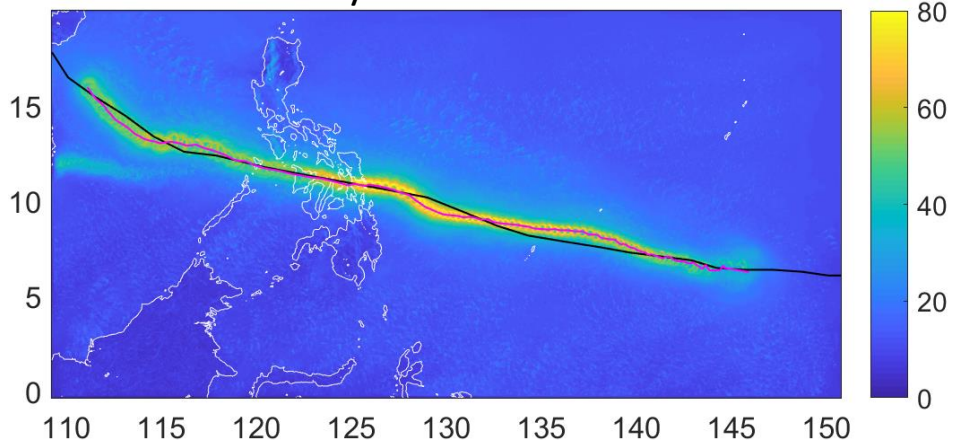
Black: BestTrack
Red: Simulation

# Max. Wind Speed

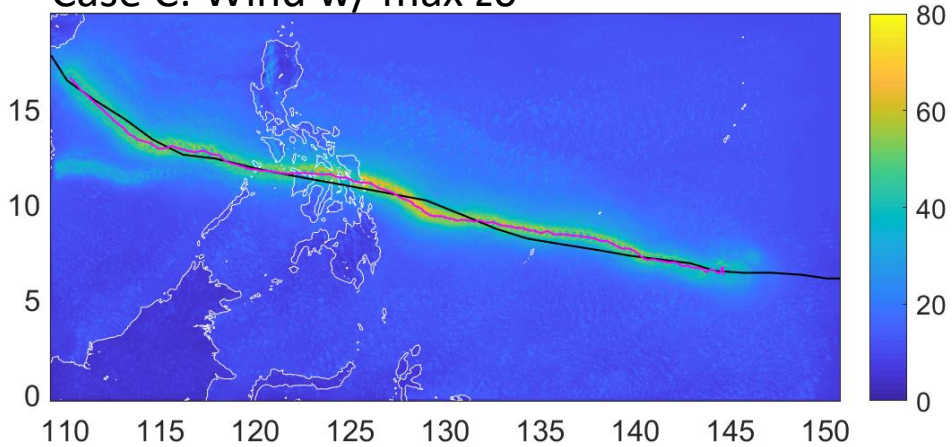
Case A: WRF



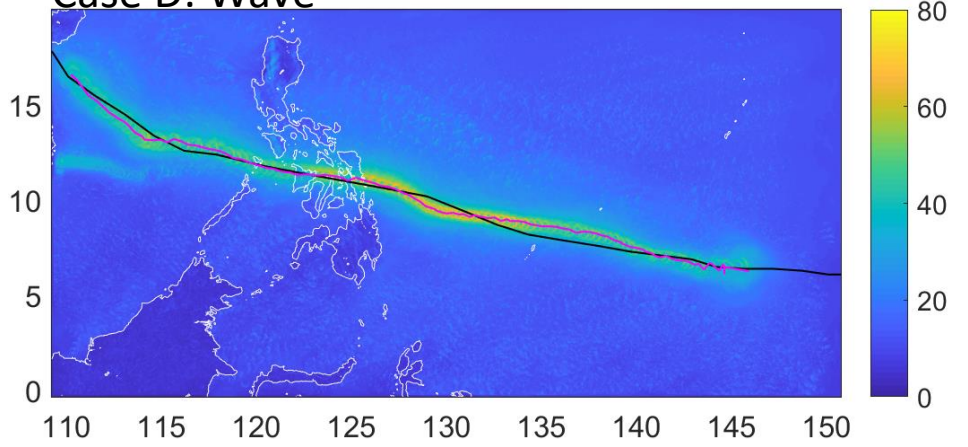

Case B: Wind w/o max z0




Case C: Wind w/ max z0

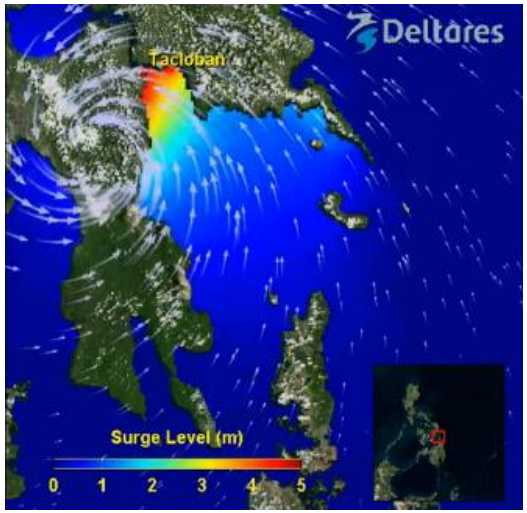



Case D: Wave

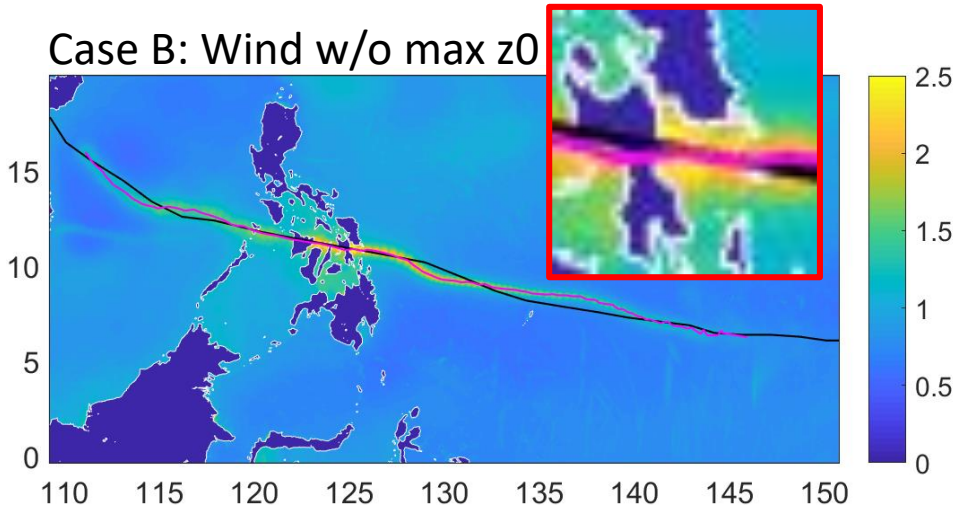


Black: BestTrack
Red: Simulation

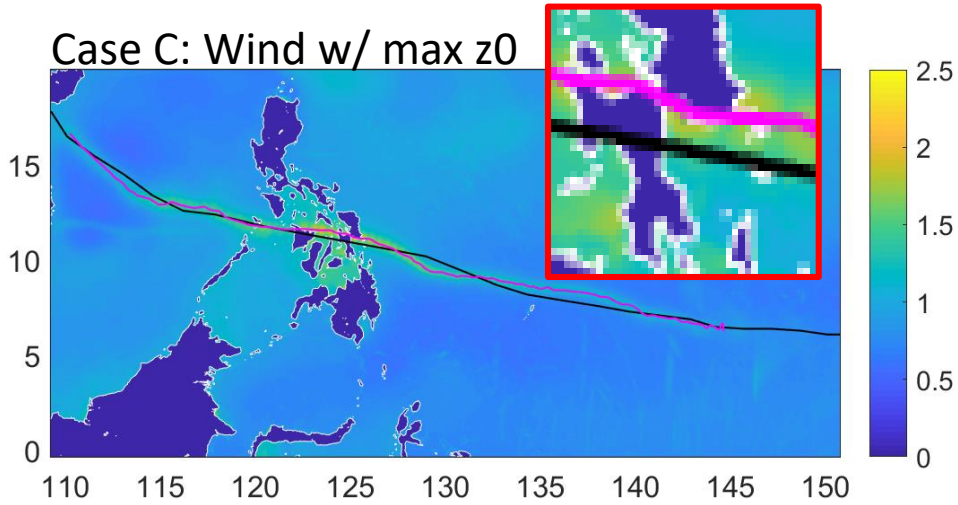
# Max. Storm Surge



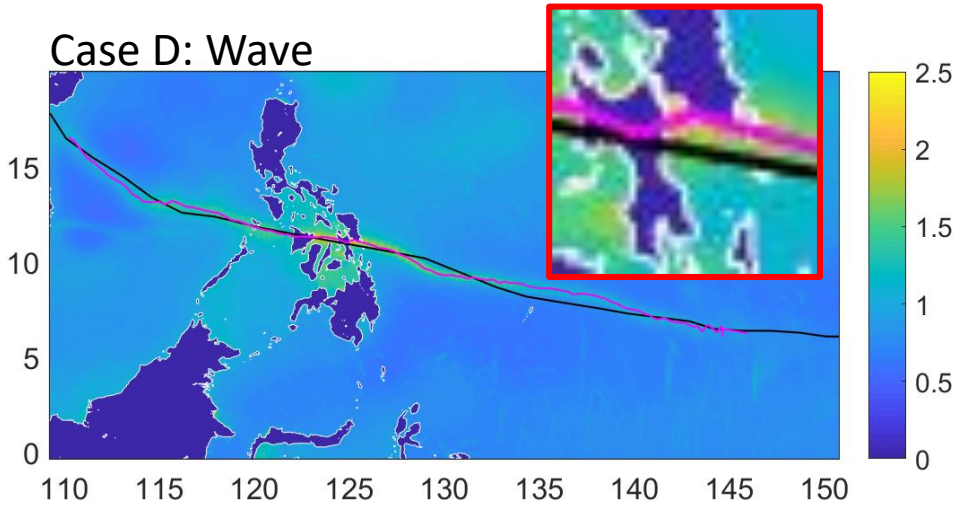

Case B: Wind w/o max z0




Case C: Wind w/ max z0



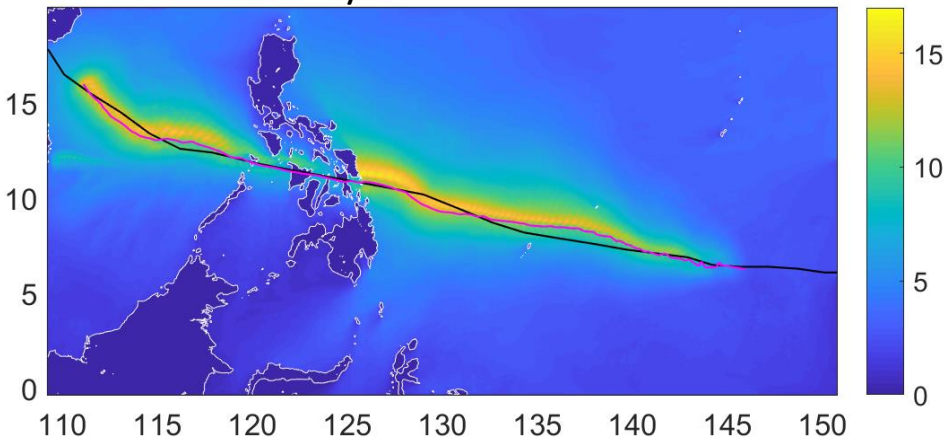

Case D: Wave



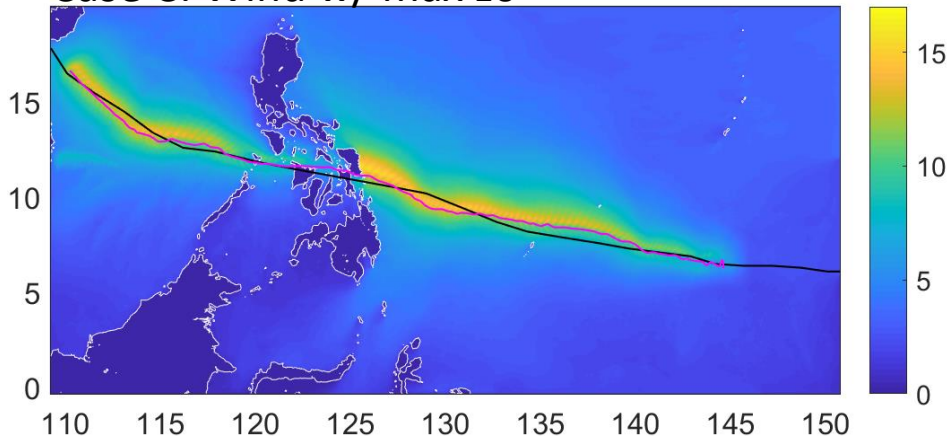
Black: BestTrack
Red: Simulation

# Max. Significant Wave Height

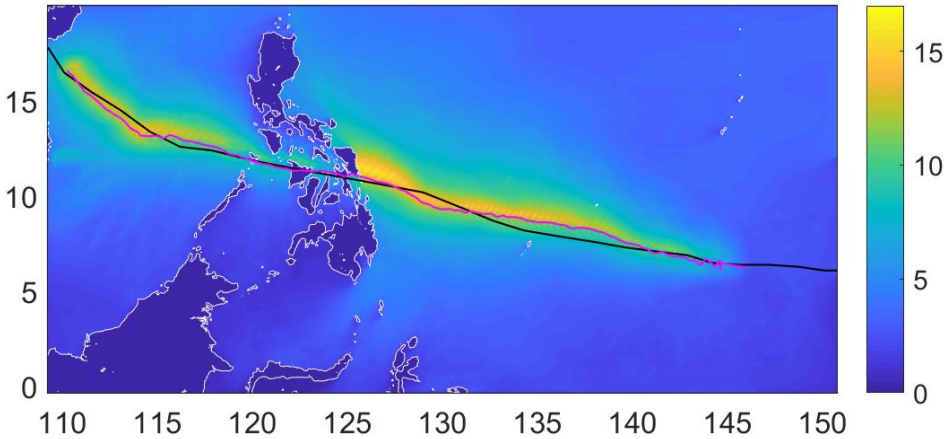
Case B: Wind w/o max z0




Case C: Wind w/ max z0




Case D: Wave

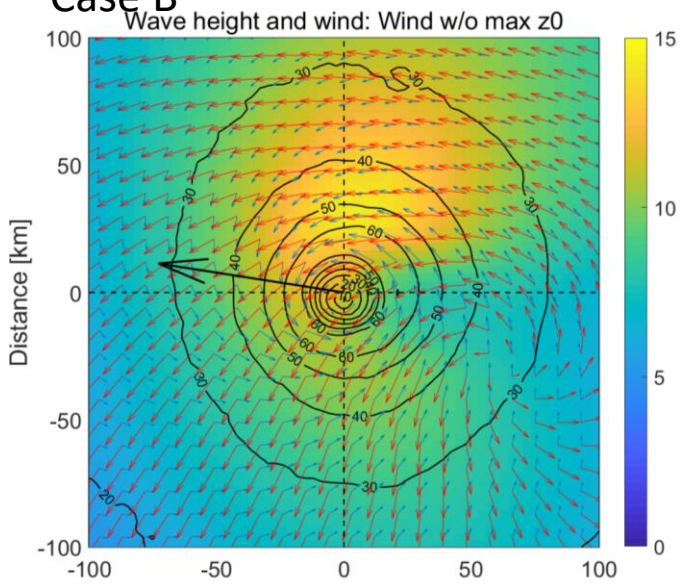


# Wave Height around TY

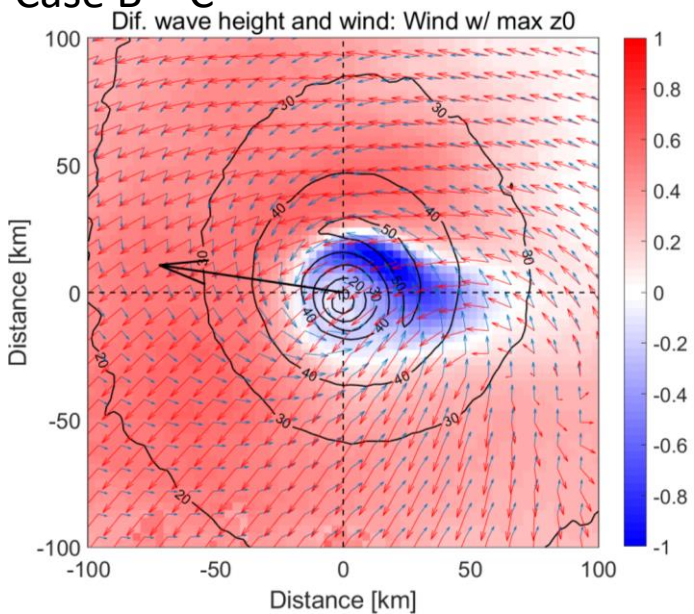
Time:
20191106 120000 –
20191107 120000

Line: wind speed
Color: wave height
Blue vec.: wind dir.
Red vec.: wave dir.

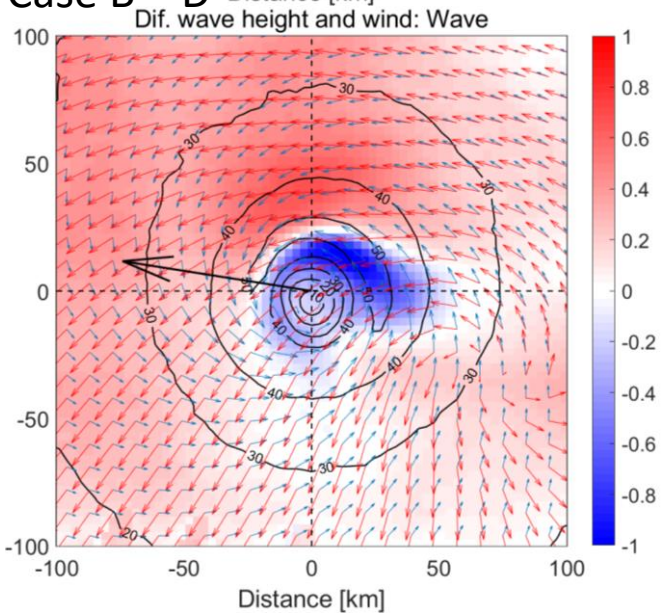
Case B




Case B – C

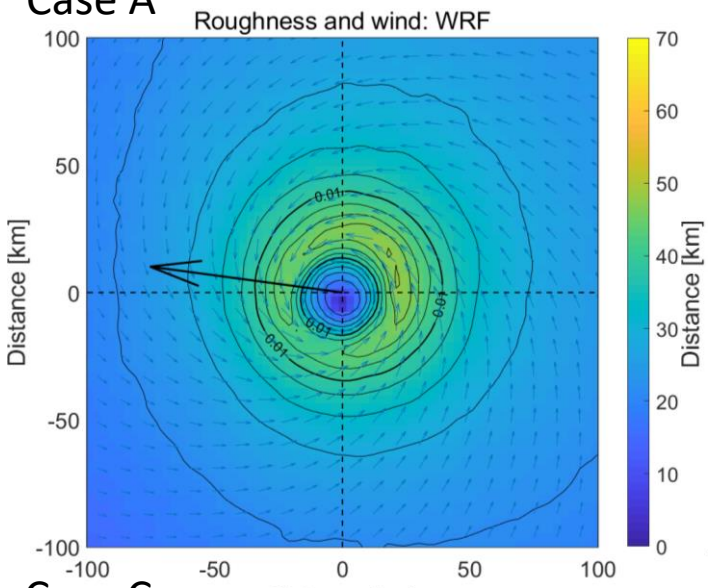



Case B – D

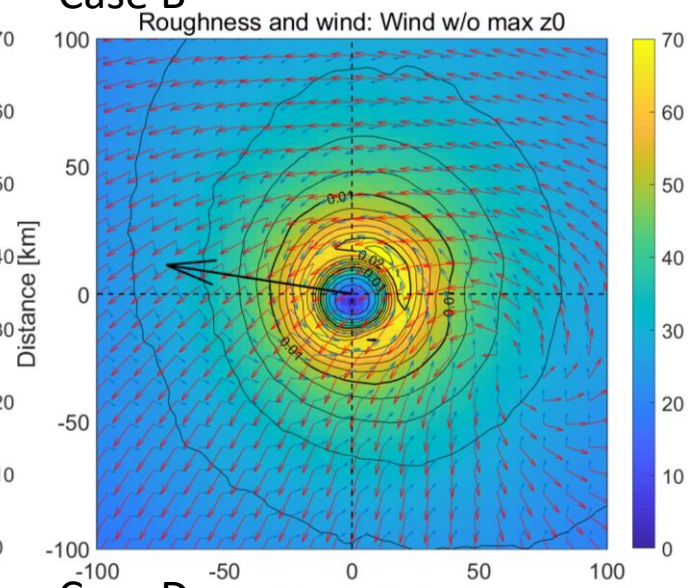


# Roughness around TY

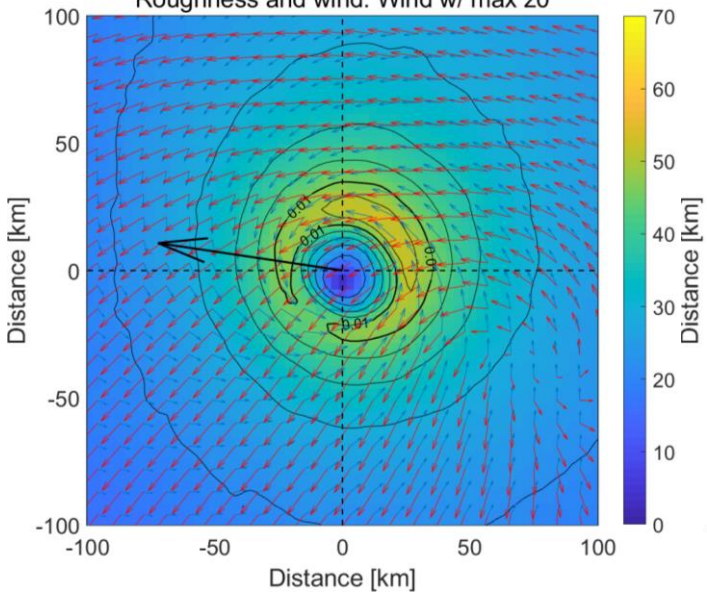
Case A



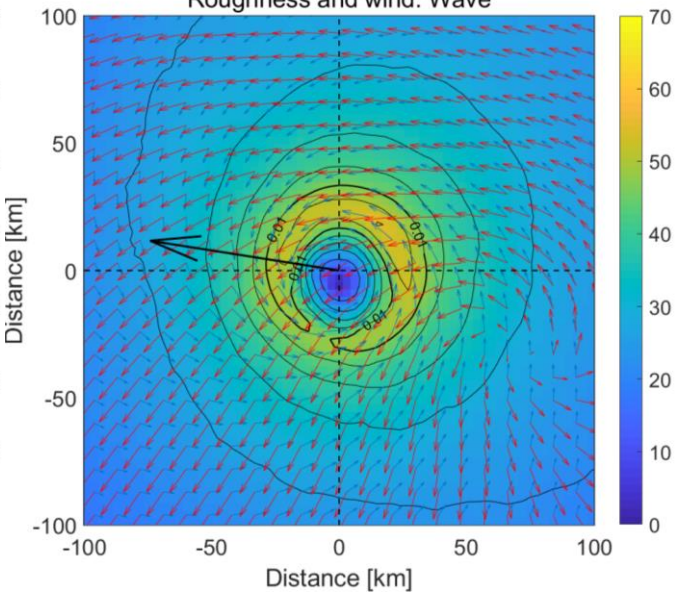

Case B




Case C




Case D




Time:
20191106 120000 –
20191107 120000

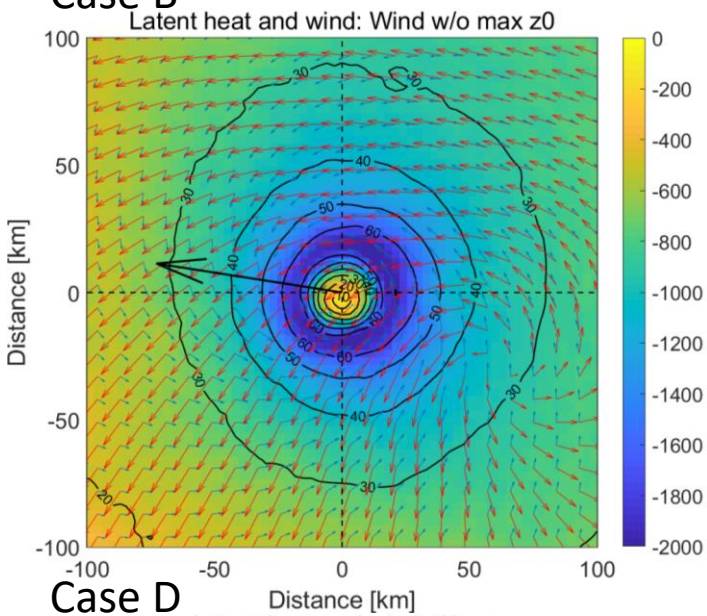
Line: z0 (interval 0.002)
Color: wind speed
Blue vec.: wind dir.
Red vec.: wave dir.

# Latent Heat Flux around TY

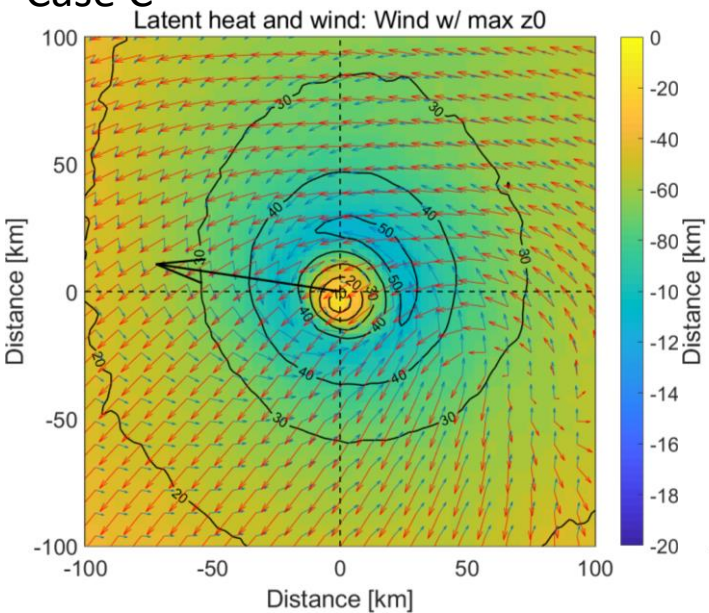
Time:
20191106 120000 –
20191107 120000

Line: wind speed
Color: upward latent heat flux
Blue vec.: wind dir.
Red vec.: wave dir.

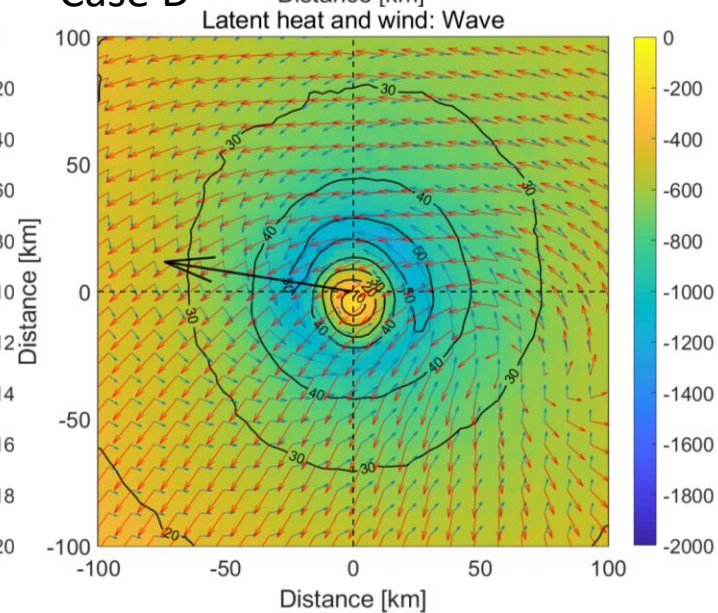
Case B




Case C



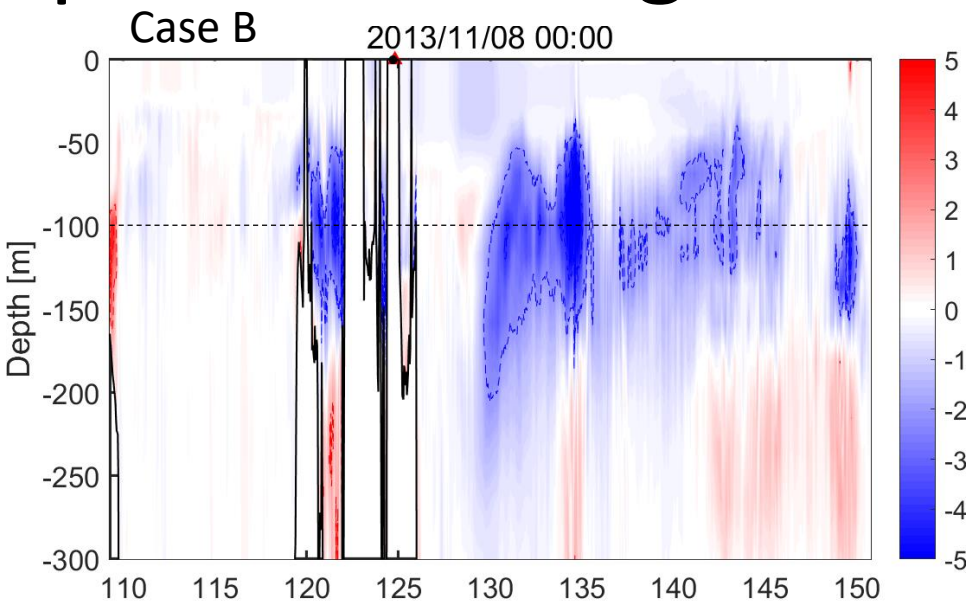

Case D

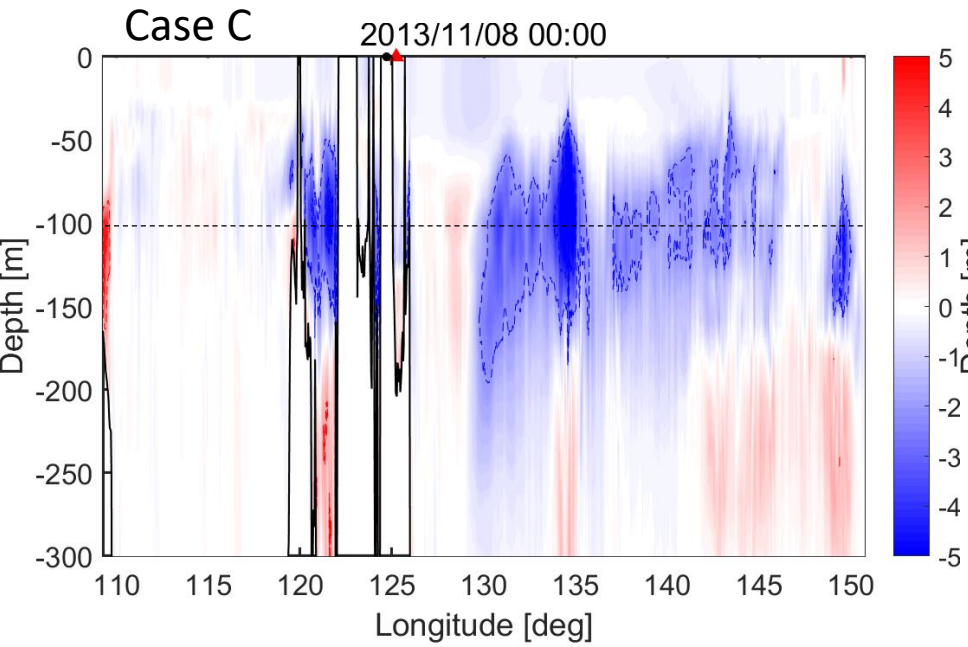


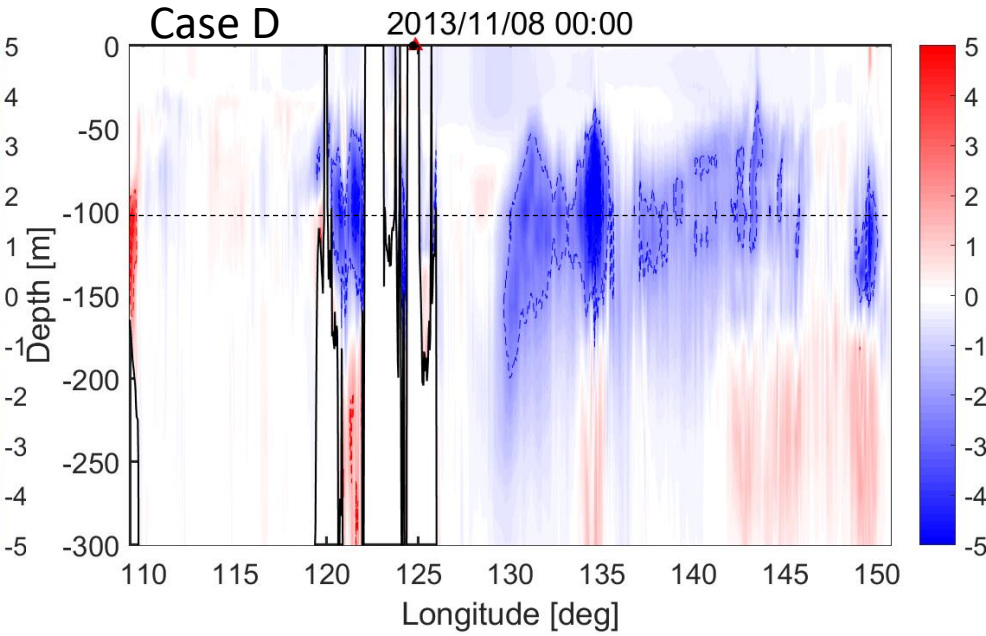
# Change of Water Temperature along Track

Difference of water temperature along TY track.
20131108 00:00 – 20131105 00:00

Black line: bottom
Black circle: TY center (at 125°E)



# Conclusions

- We carried out simulations with different drag coefficient using high resolution model.

- Typhoon characteristics
  - Full coupled run without roughness limitation had good agreement with typhoon pressure of Best Track but it overestimated wind.
  - Full coupled run with roughness limitation estimated weak typhoon but it had good agreement with wind speed of Best Track.
  - The track errors estimated every simulation were within 1 degree.
- Impact of drag limitation
  - Typhoon intensity, latent heat flux
- Impact of wave information
  - No significant impact on typhoon and ocean, wave response

- However, this study is only a case study. The characteristics of HAIYAN have high strength and linear track. If these characteristics change, results are expected to change.
  (e.g. please check my ppt or text at waveworkshop 2013)