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Introduction

• Air-sea interaction plays an important role in TC development
  • Ocean provides energy for TC
  • The TC-induced cold wake acts as a break to prevent over-intensification

• The TC-ocean coupled effect becomes more essential when there are ocean eddies

• The air-sea interaction is generally believed to have larger impact on TC intensity, but less impact on TC track

• In the eddy-rich WNP, few studies have focus on the TC ensemble prediction using a high-resolution coupled model.

Investigate the TC-ocean interaction in typhoon Fanapi (2010) using high-resolution coupled ensemble forecast
Experiment setup

WRF-LETKF DA system (Yang et al. 2013, Lin et al. 2016)

- Advanced Research WRF (ARW) V3.6.1
  - Nested domain 12/4/1.33(no DA) km, 36 layers

- Observations:
  - sound, ground station, airep, buoy, AMV, JTWC’s MSLP, dropsonde (ITOP), synthetic wind profile (to spin-up vortex)

- Experiments:
  - 0000UTC 15-0000UTC 16
  - 36 members
  - 6-h LETKF analysis cycling
  - 3-day ensfcst

B: Bogus assimilation

3-day ensemble forecast

UA: WRF only
AO: UMCM (WRF + HYCOM 4km res.)
IC: HYCOM global anal.
University of Miami Coupled Model (UMCM)

Unified Air-Sea Interface

\[ (\tau_{ax}, \tau_{ay}) = (\tau_{wx}, \tau_{wy}) + (\tau_{tx}, \tau_{ty}) \]
\[ (\tau_{cx}, \tau_{cy}) = \text{wave dissipation} \]

University of Miami Wave Model (Donelan et al. 2012)

Chen et al. (2013)
Uncoupled (UA) forecast result

5~10 knots higher
Difference between UA & AO

- Track difference: 40 km after 72h, 20 km std.
- Size difference: 25 km after 72h, 20 km std.
- MSLP difference: 16 hPa after 72h, 10 hPa std.
- MWS difference: 10 m/s after 72h, 8 m/s std.

Contribute to 20% operational forecast uncertainty

TCs become too weak!!
Track difference in zonal and meridional direction

Distance between UA & AO

- No significant bias in zonal dir.
- 23 km northward bias in 3 day forecast

Ensemble members
- Diff. in mean forecast
- Ens. forecast mean (solid)
- Ensemble spread (dashed)
Large displacement VS. Small displacement

Diff. in meridional direction

850-200 hPa vertical wind shear
Why does the track ensemble from AO deflect to the north?

Characteristics of the TCs with larger northward track deflection after coupled with ocean.

- Large vertical shear in the environment
- Fast moving speed
- Smaller size and weaker intensity
Why AO deflect to the north? (1) height of TC development

Small difference between UA and AO in environmental flow
Why AO deflect to the north? (2) beta effect

Bender et al. (1993): Air-sea interaction has weaken the TC at all radius that will alters the orientation of beta gyres and thus affects the beta drift.

Westward tracks turn more to the north.

After coupled with ocean, TC become smaller.
Coupled effect increases intensity variability in TC simulation

With ocean coupled, MSLP become 10 hPa different
Summary

• As pointed out in previous studies, the TC-ocean coupled effect has a strong impact on TC development. (TC become smaller, weaker and more asymmetry)

• Results show that the coupled effect can modulate the TC track. (contribute to 20% operational forecast uncertainty)
  • (1) Interaction between TC and environmental flow; (2) Beta effect

• Impact of air-sea interaction on TC development:
  - Ocean provides energy for TC
  - The TC-induced cold wake acts as a break to prevent over-intensification
  - Modulate how TC interacts with its environment

• The coupled effect seems to degrade the performance of TC intensity forecast. However, the atmosphere-ocean conditions are not well coupled initially: over-intensified TC (from uncoupled model) + cold eddy!

A more balanced coupled states should be constructed through coupled DA!!
Thank you!!