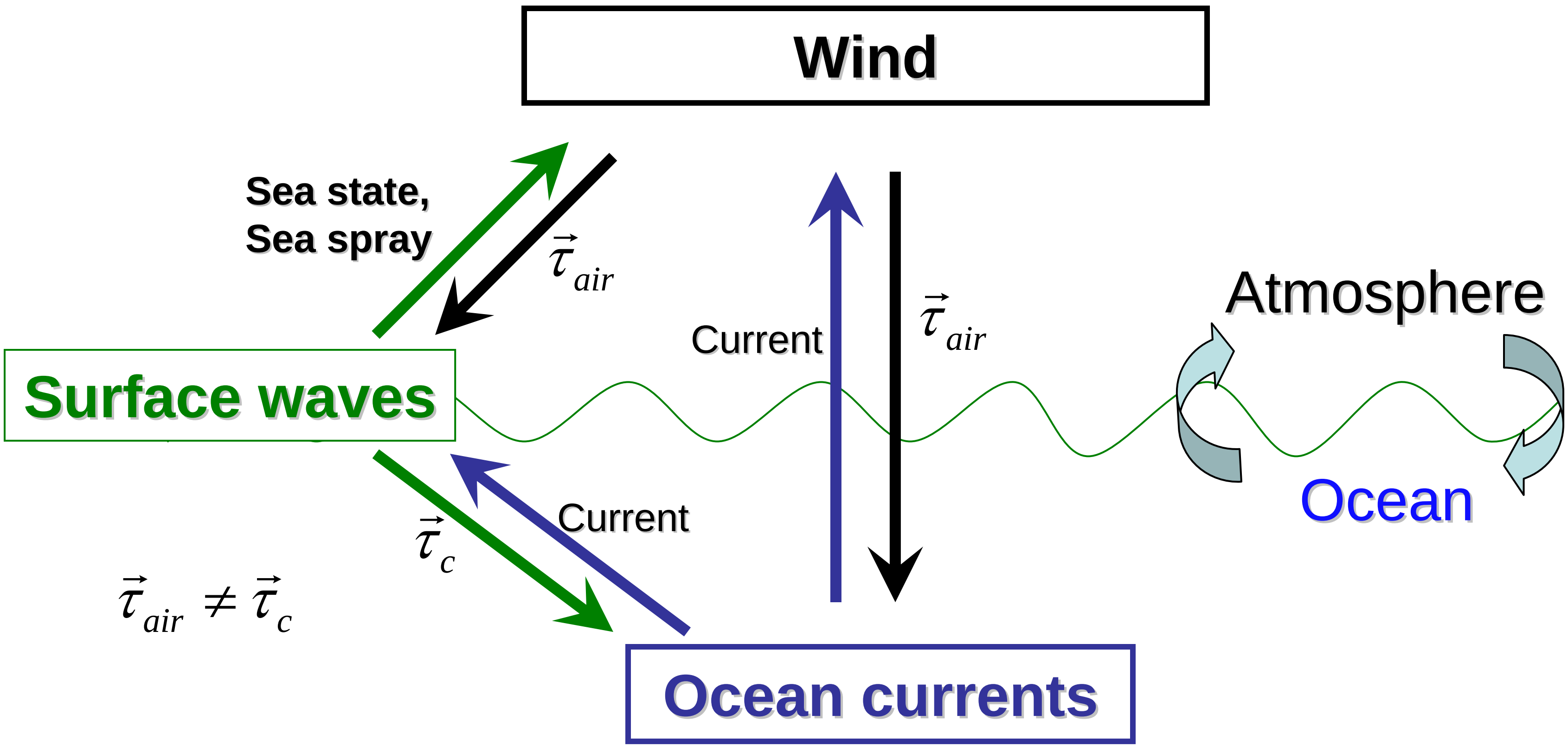
Modeling of Wind-Wave-Current Coupled Processes in Hurricanes

Isaac Ginis
Yalin Fan
Tetsu Hara
Biju Thomas

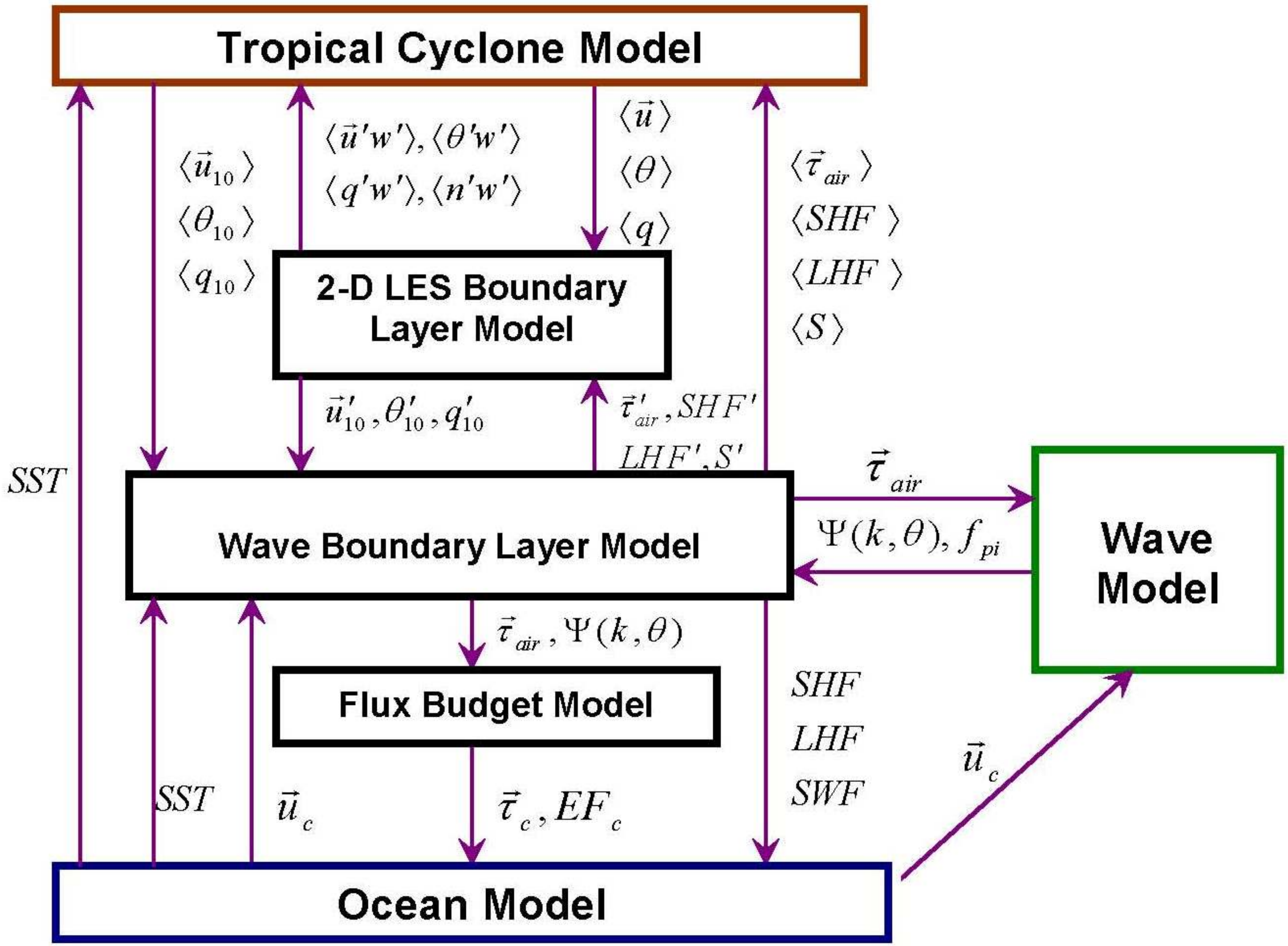
Graduate School of Oceanography
University of Rhode Island

62nd Interdepartmental Hurricane Conference

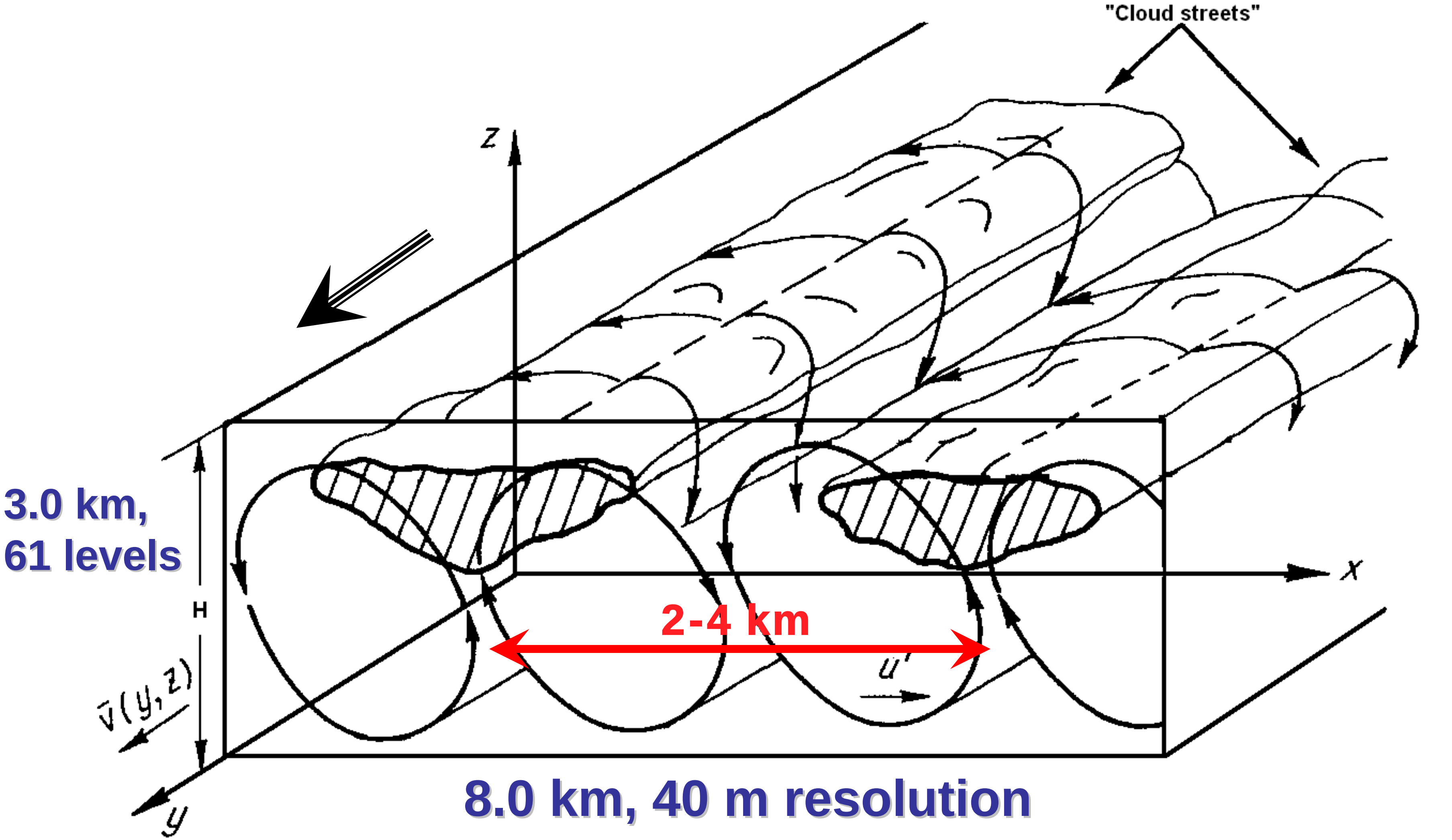
Wind-Wave-Current Interaction



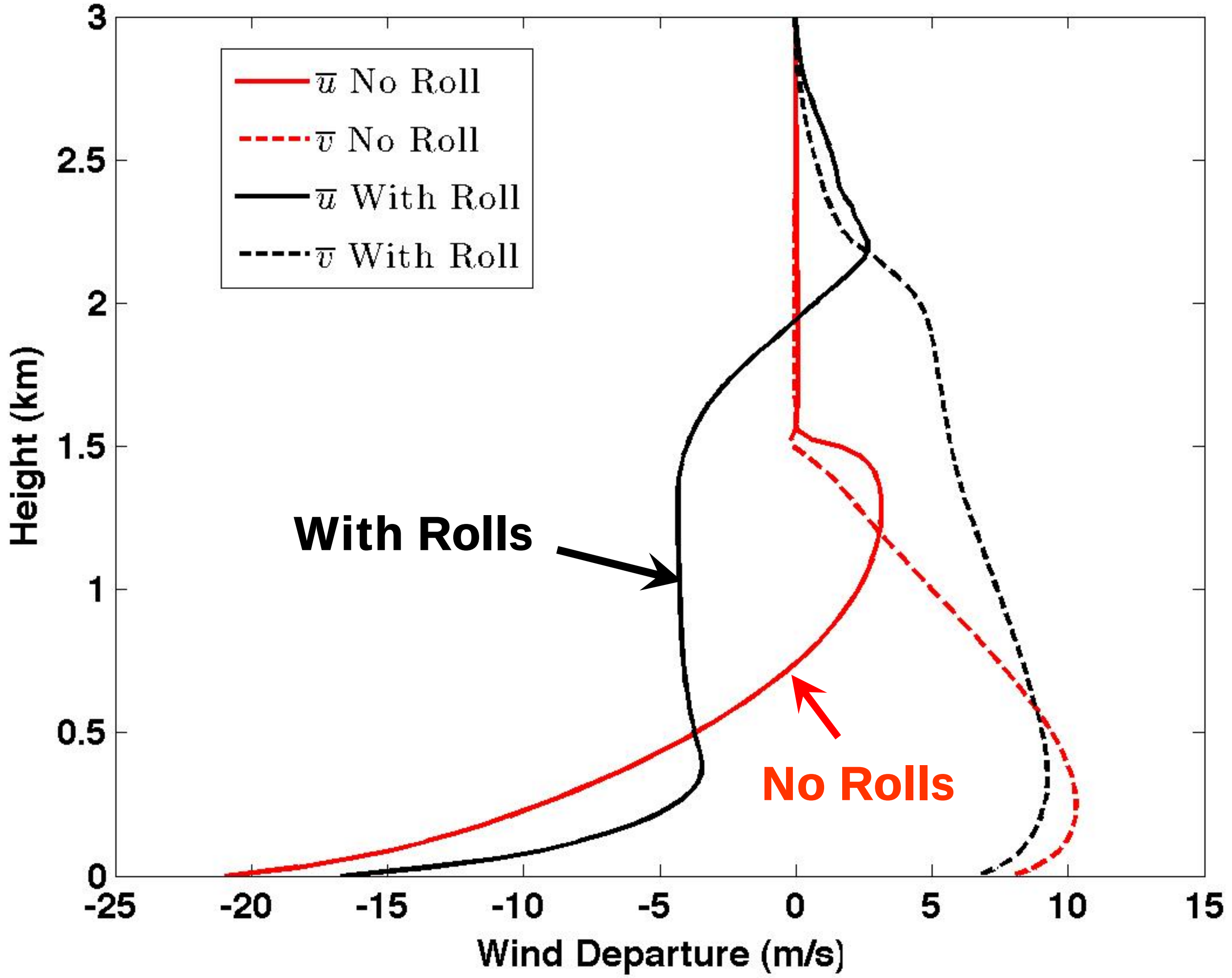
Key Air- Sea Physical Processes in the Coupled Tropical Cyclone-Ocean System



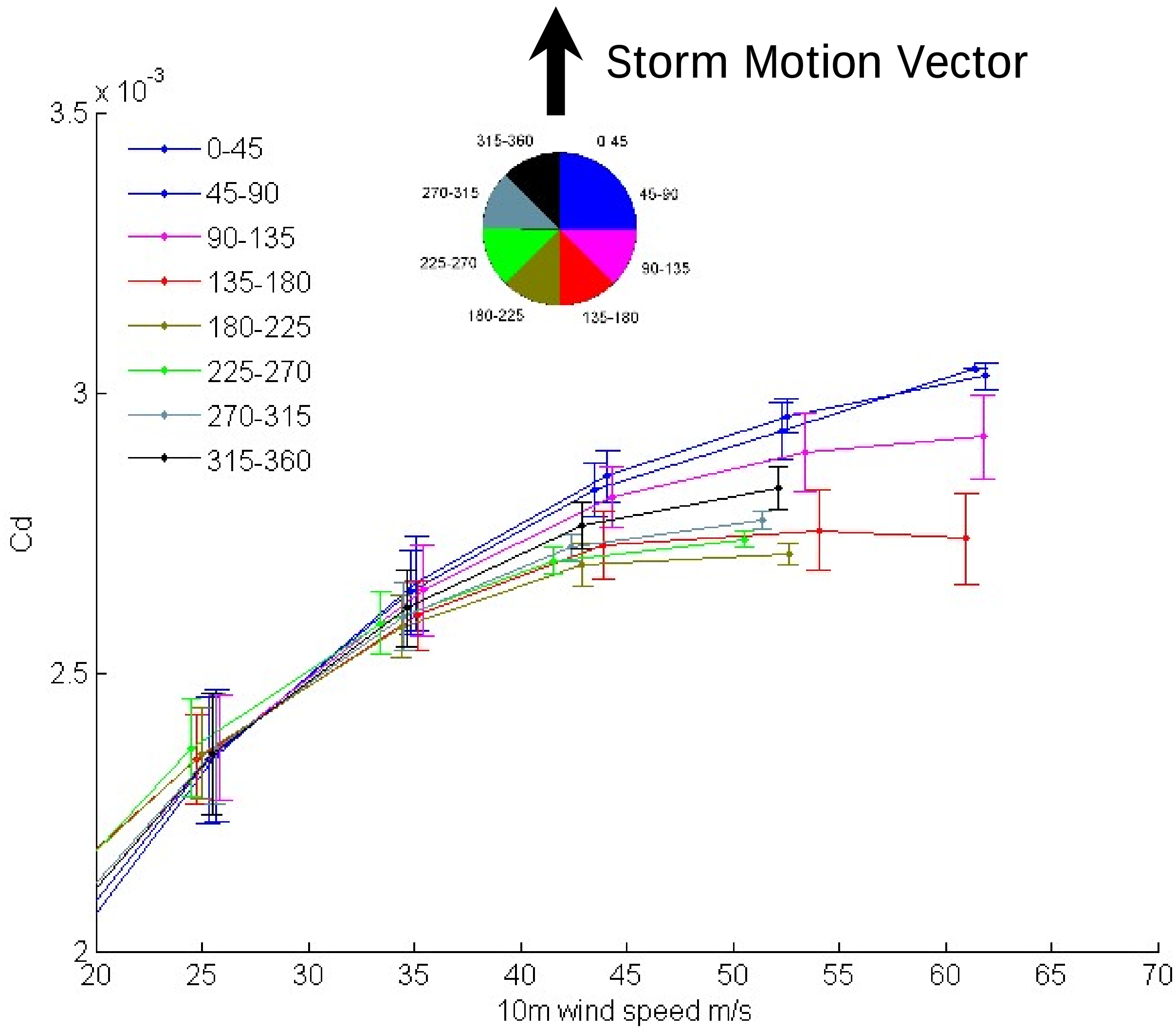
2D LES BL Model for Roll Vortices



2D LES BL Model for Roll Vortices

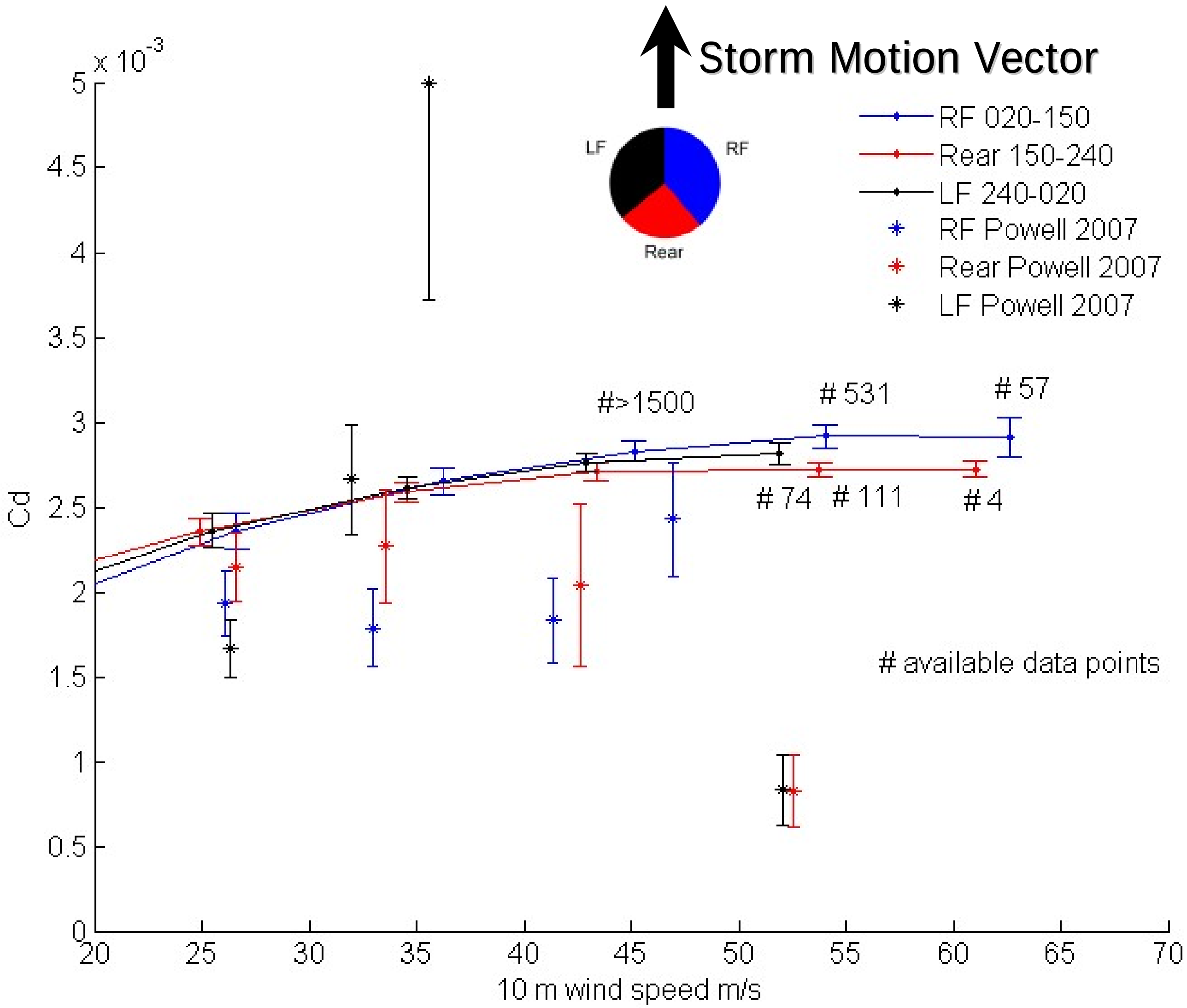


Wave BL Model: Drag Coefficient Sea State Dependence



Noel (2007), Helene and Florence (2006), Katrina, Rita, Emily, Dennis (2005), Ivan and Frances (2004), and Isabel and Fabien (2003)

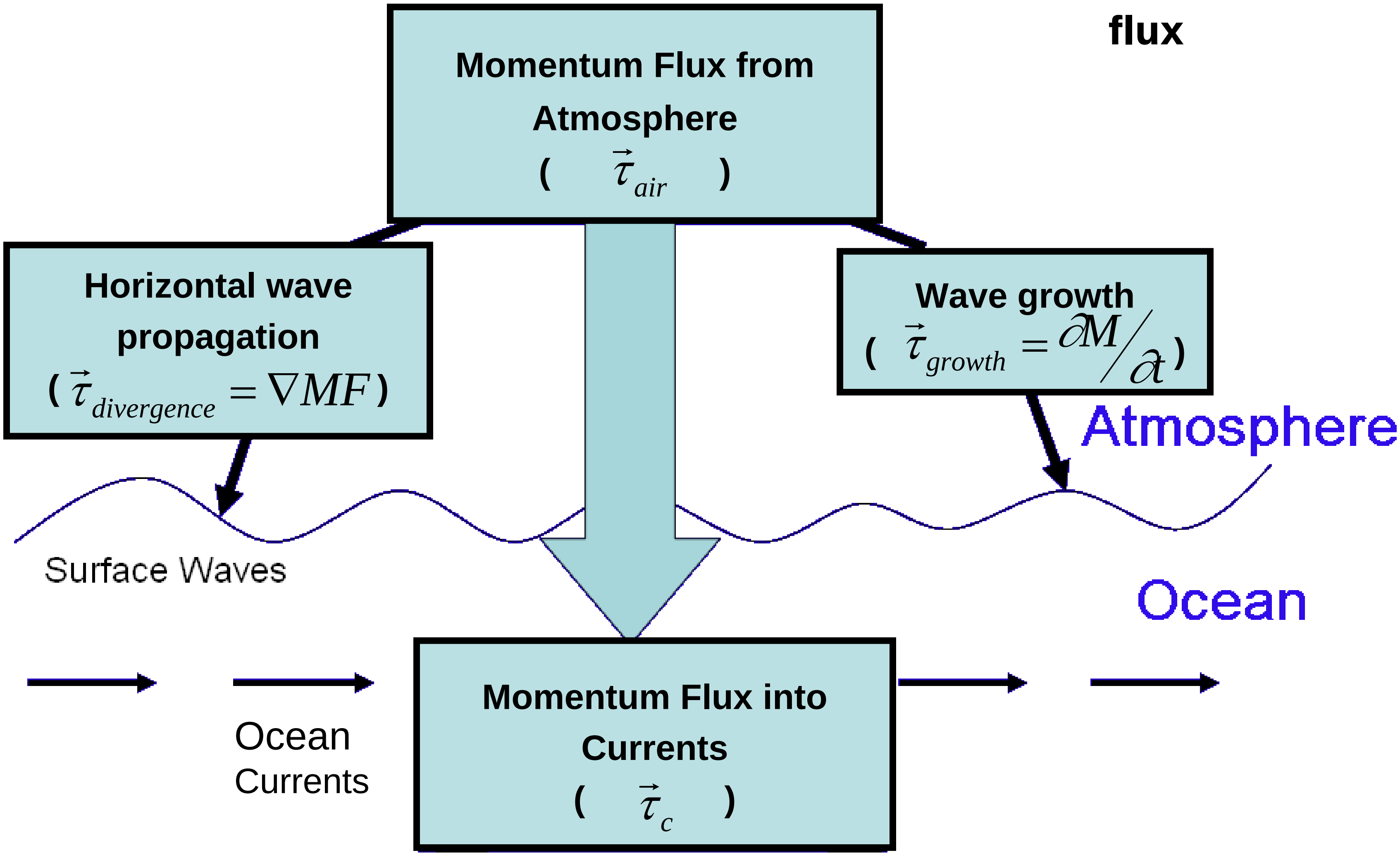
Wave BL Model: Drag Coefficient Sea State Dependence



Flux Budget Model

$$\vec{\tau}_{air} = \vec{\tau}_c + \left(\vec{\tau}_{growth} + \vec{\tau}_{divergence}\right)$$

M - total momentum
MF - total momentum flux

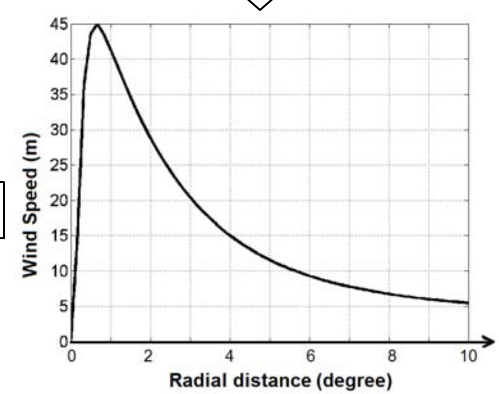


Flux Budget Model

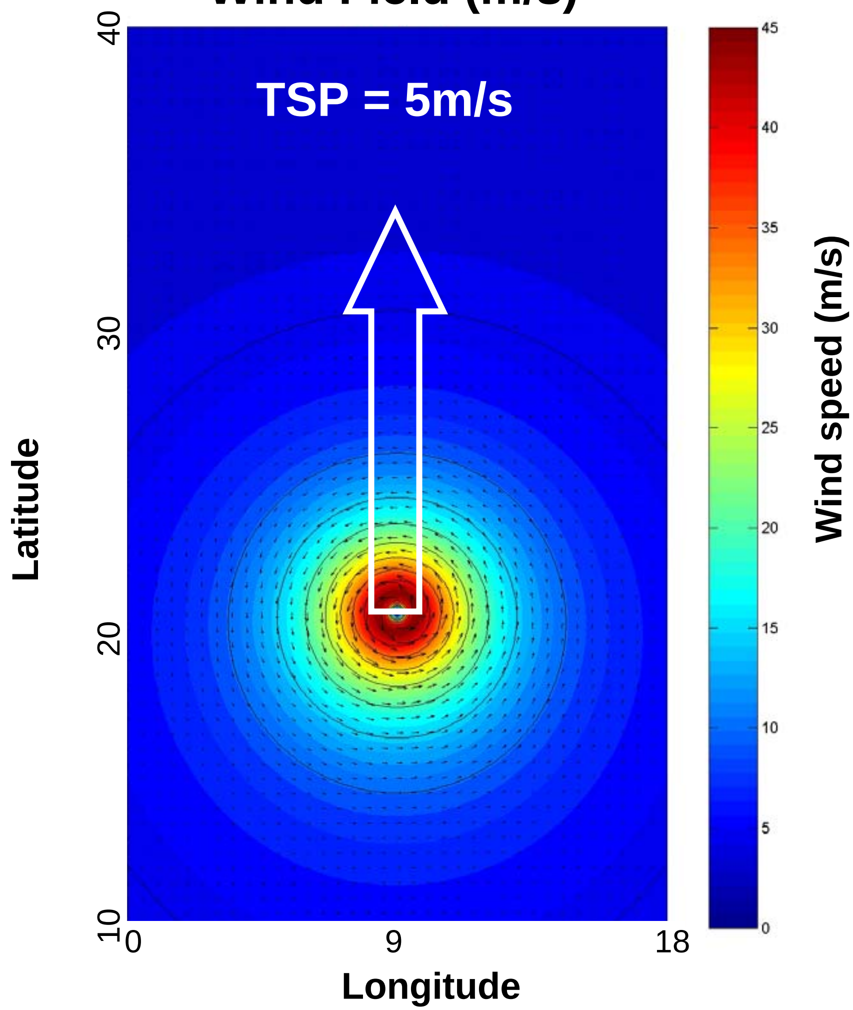
- **Idealized Hurricane experiments**

Holland Hurricane Wind Model

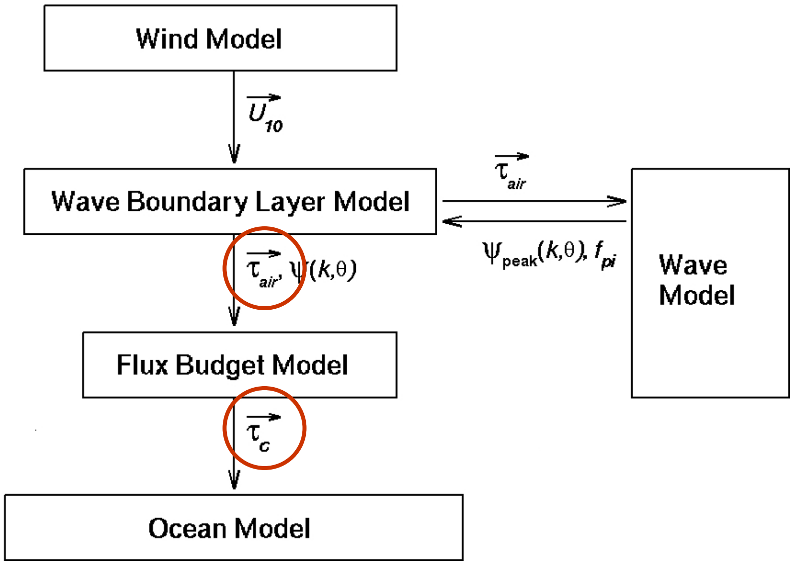
Input parameters:
Maximum wind speed (MWS)
Radius of MWS (RMW)
Central & environmental sea-level pressure

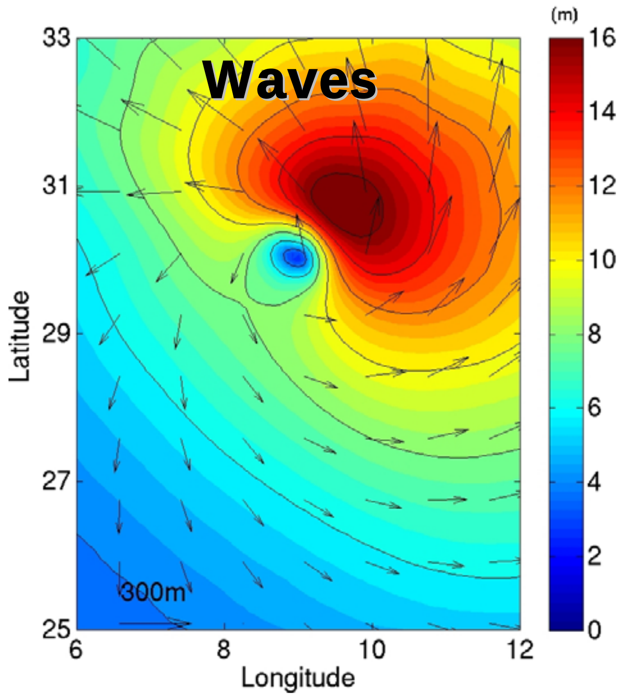


Wind Field (m/s)

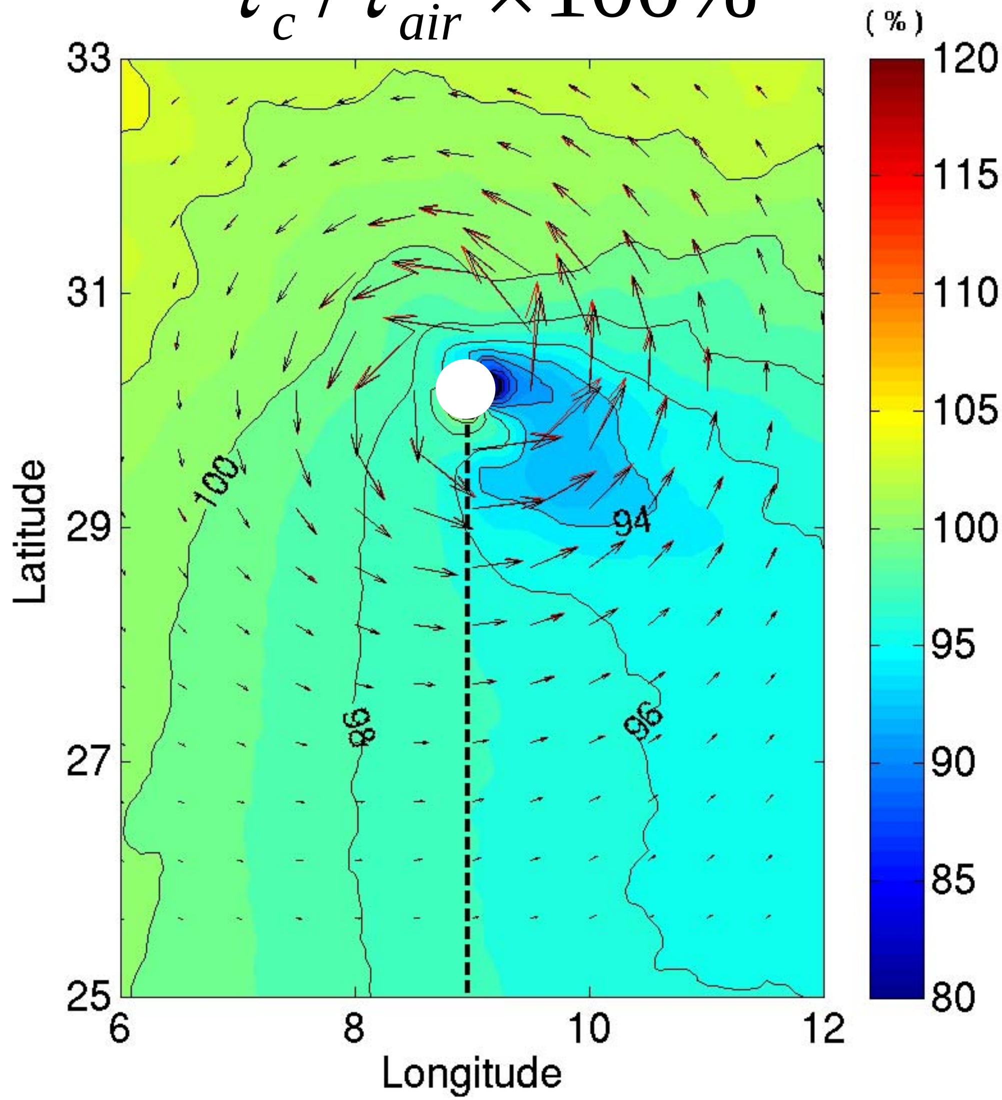


Flux Budget Model

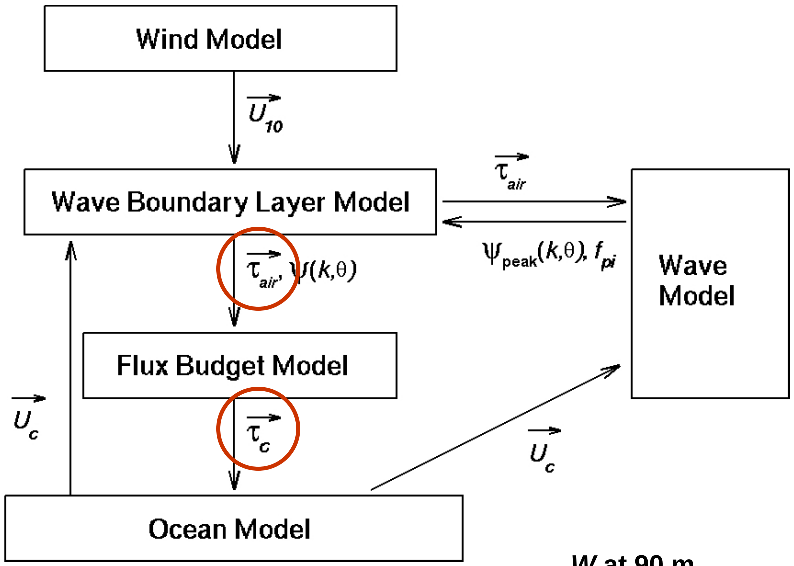


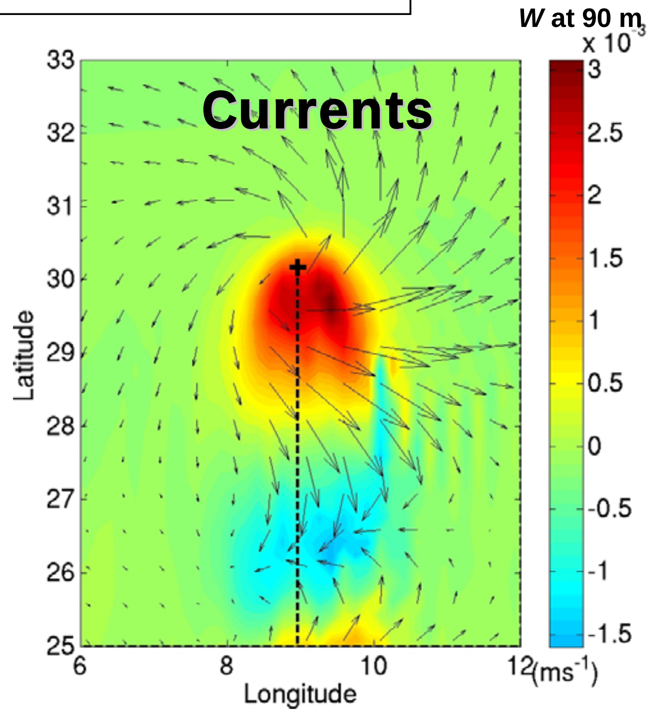


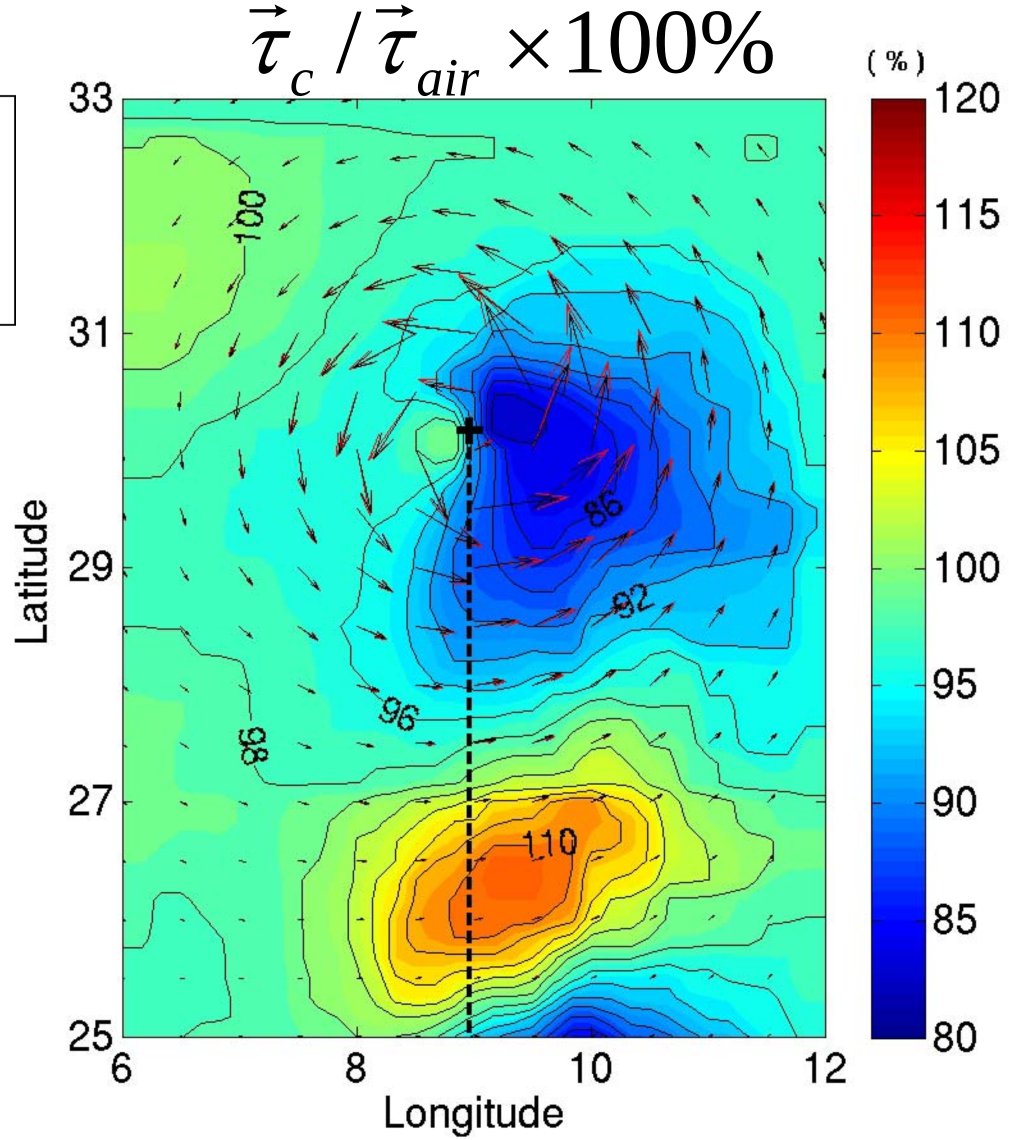
$$\vec{\tau}_c / \vec{\tau}_{air} \times 100\%$$



Wind-wave-current Interaction



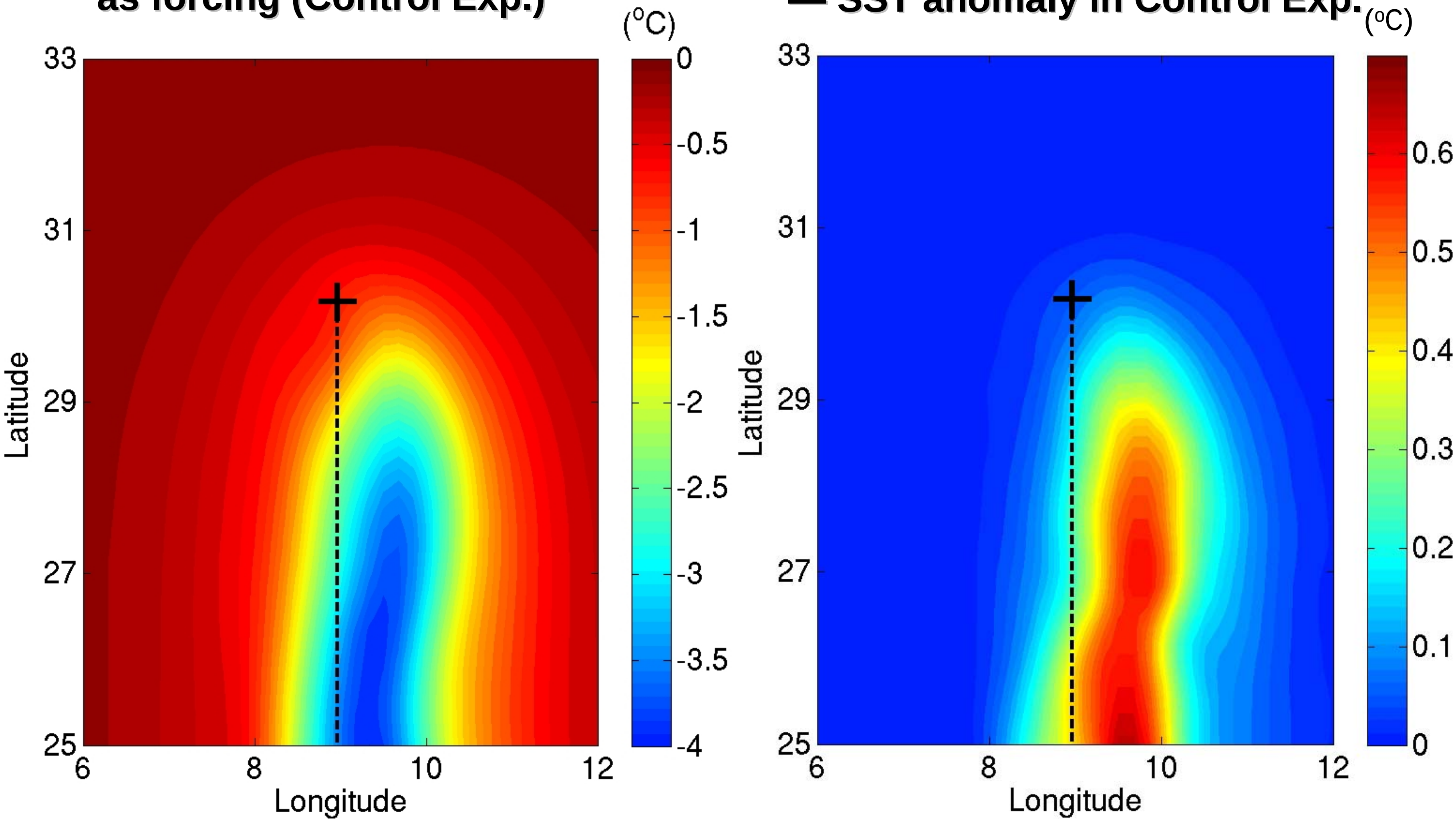




Impact Wind-Wave-Current Interaction on Ocean Cooling

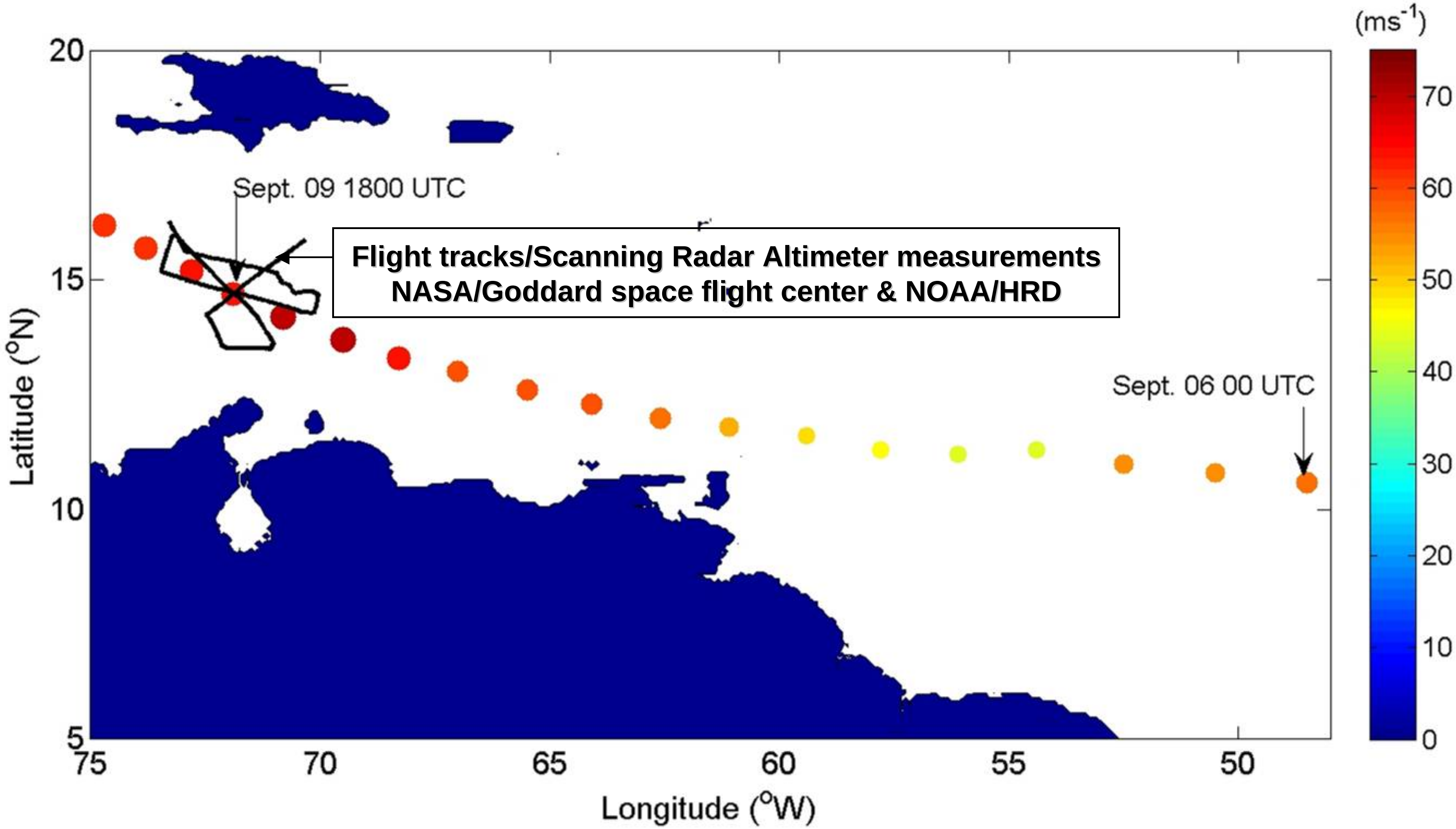
SST anomaly when $\vec{\tau}_{air}$ as forcing (Control Exp.)

SST anomaly in Fully Coupled Exp. — SST anomaly in Control Exp.



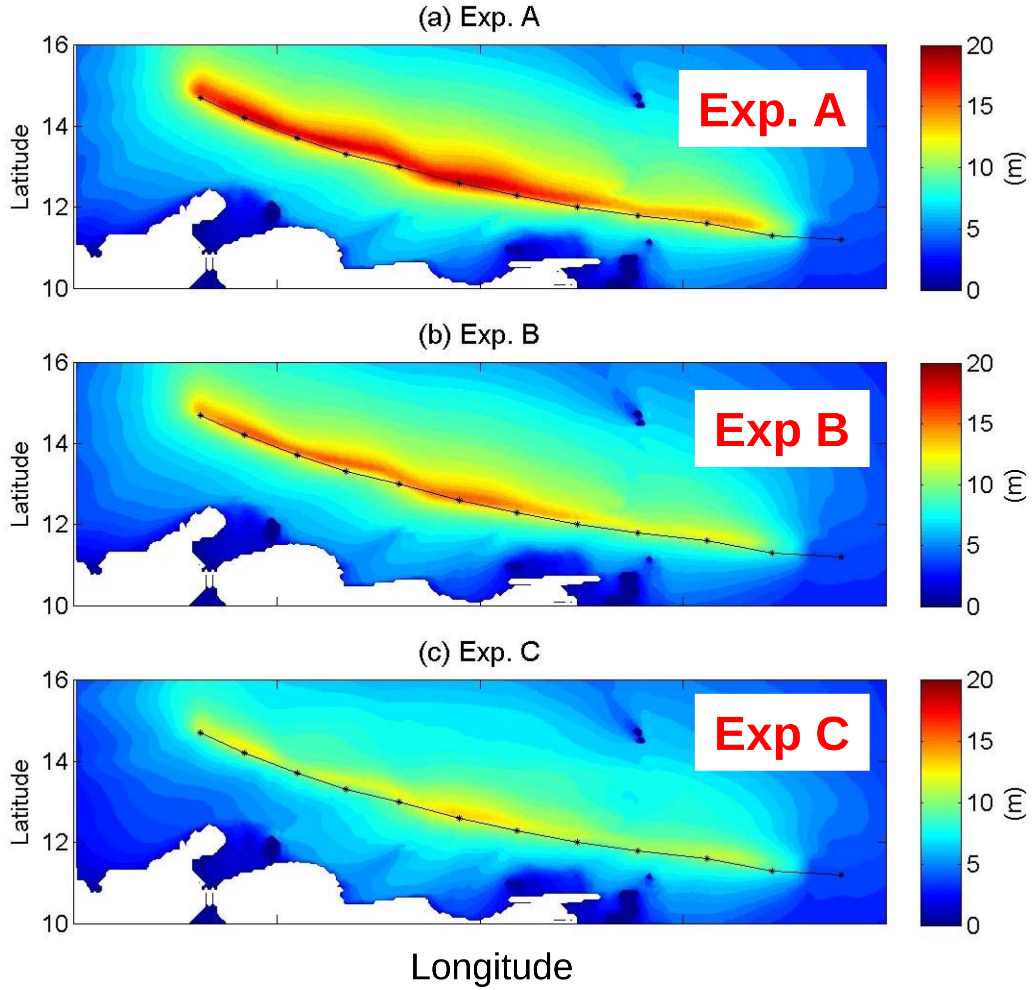
Impact Wind-Wave-Current Interaction on Waves

- **Hurricane Ivan (2005) track and reconnaissance flight tracks**



Impact Wind-Wave-Current Interaction on Waves

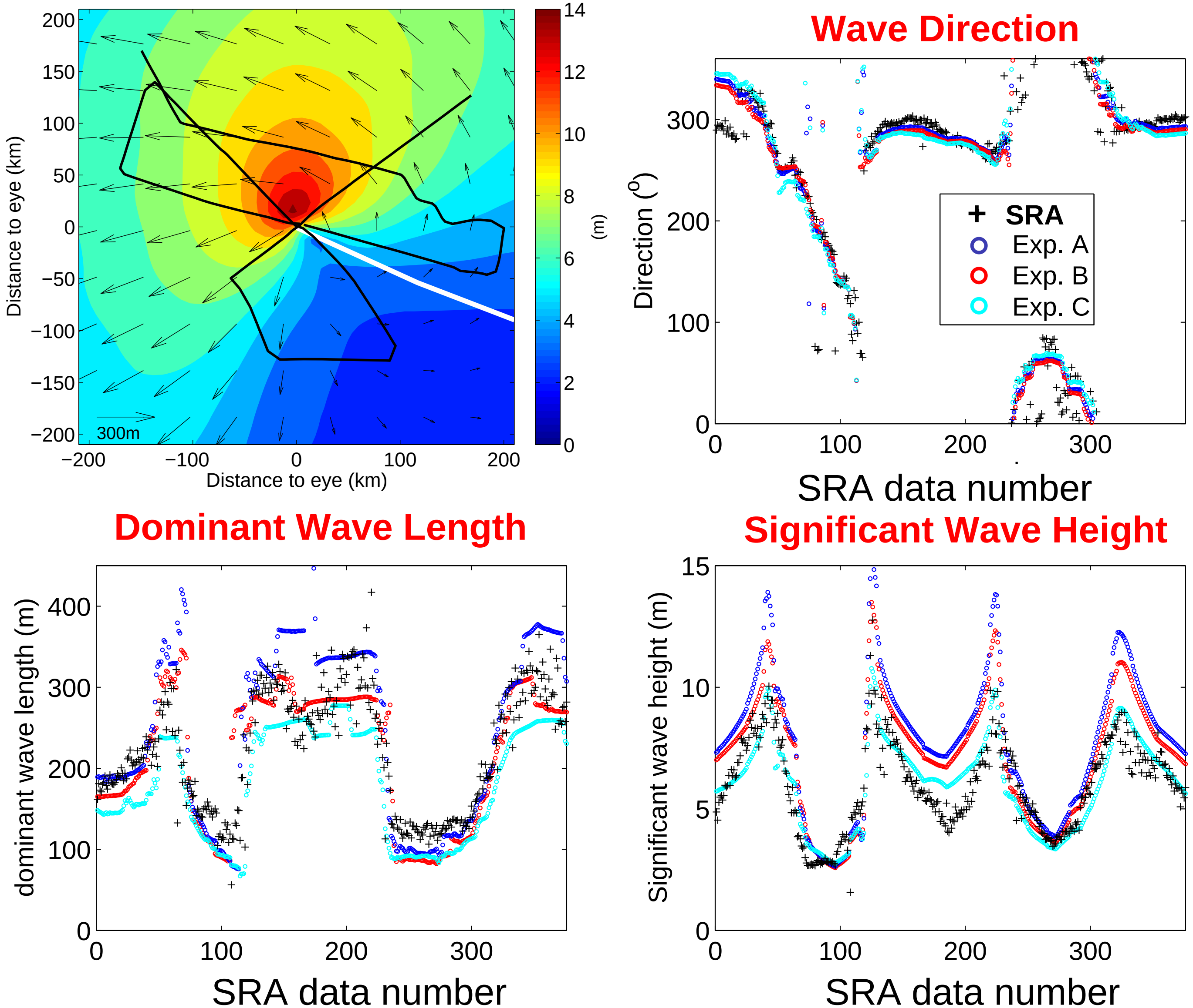
❖ **Significant Wave Height Swaths**



Exp. A: **WAVEWATCH III wave model (operational model)**
Exp. B: **Coupled wind-wave model**
Exp. C: **Coupled wind-wave-current model**

Impact Wind-Wave-Current Interaction on Waves

Wave parameters comparison between model and SRA (Courtesy of Ed Walsh)



Air-Sea Coupling Strategies for Tropical Models

- In the TC model, the parameterizations of the air-sea heat and momentum explicitly include the a) *sea state dependence*, b) *SST* and c) ocean current effects.

- The wave model is forced by a) *the sea-state dependent momentum flux* and b) includes the *ocean current effects*.

- The ocean model is forced by a) *the sea-state dependent momentum* and *energy fluxes* calculated from the air-sea flux budget.