ARE THIRD GENERATION WAVE MODELS ABLE TO PROVIDE ACCURATE STRESS ESTIMATES FOR HURRICANE PREDICTIONS?

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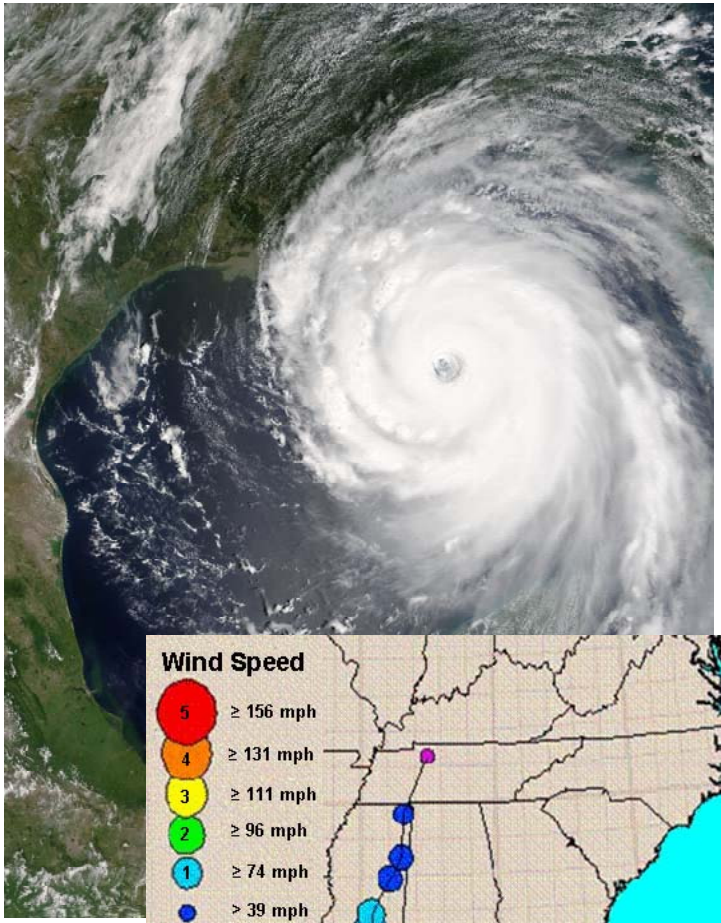
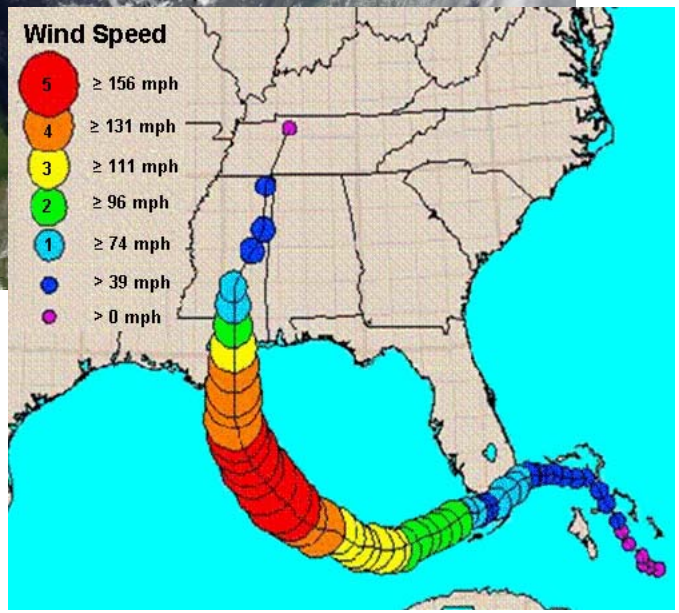
Hurricane Katrina, 2005

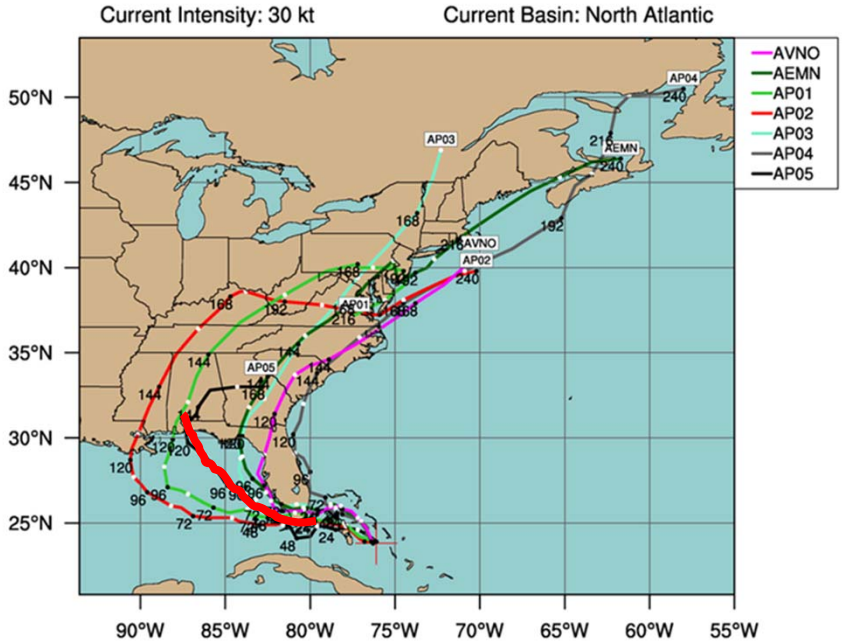




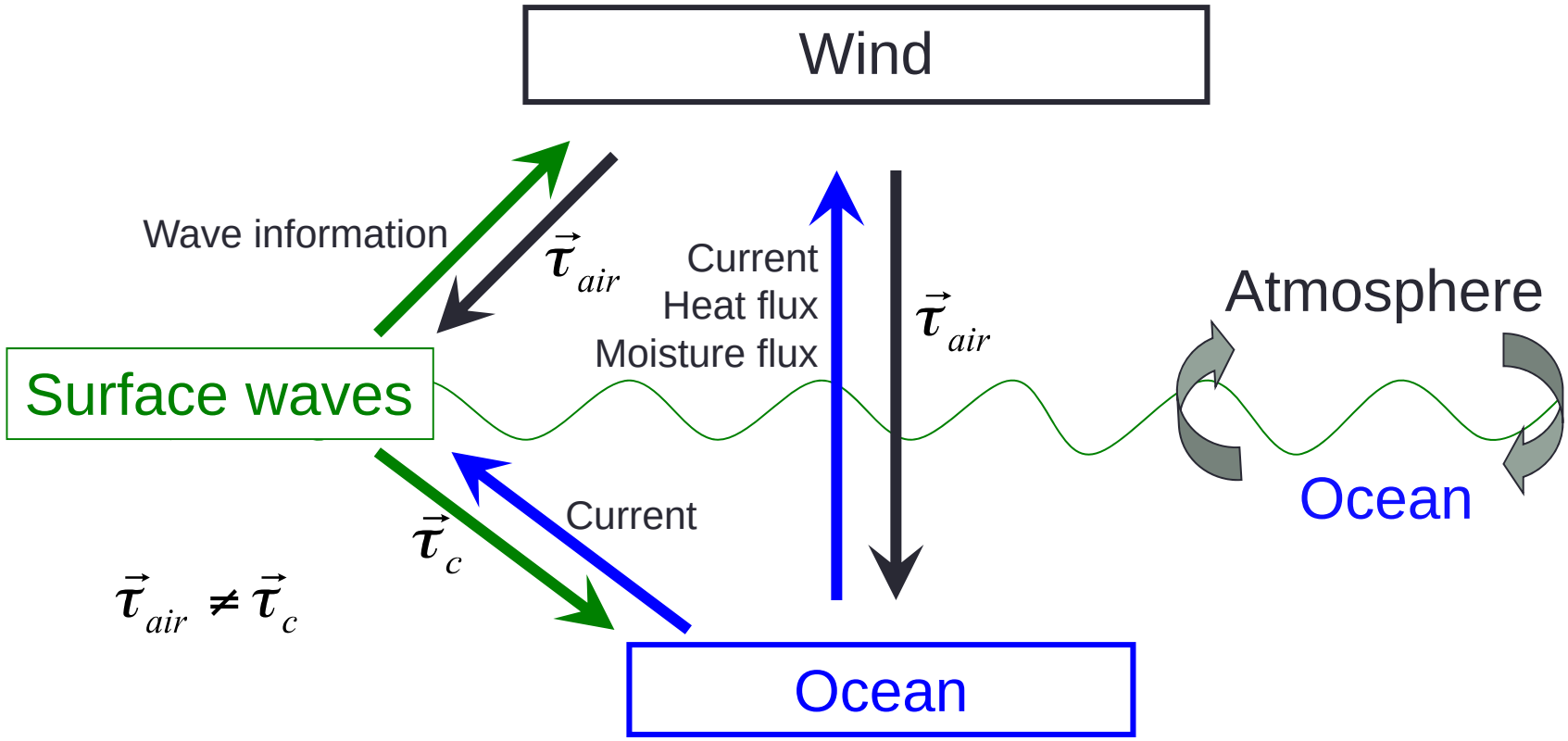
- Peak strength – Category 5
- Landfall – Category 4
- Fatalities – 1,245 – 1,836
- Damage - $108 billion

Tropical Depression Twelve (AL12)

NCEP GFS Ensemble track guidance valid 0600 UTC, 24 August 2005

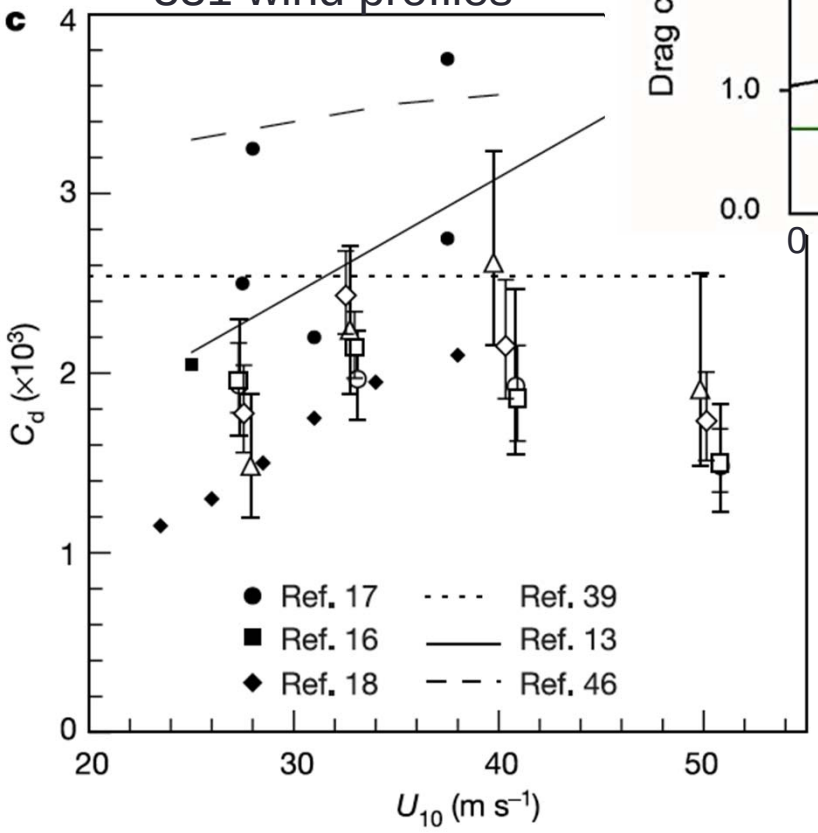


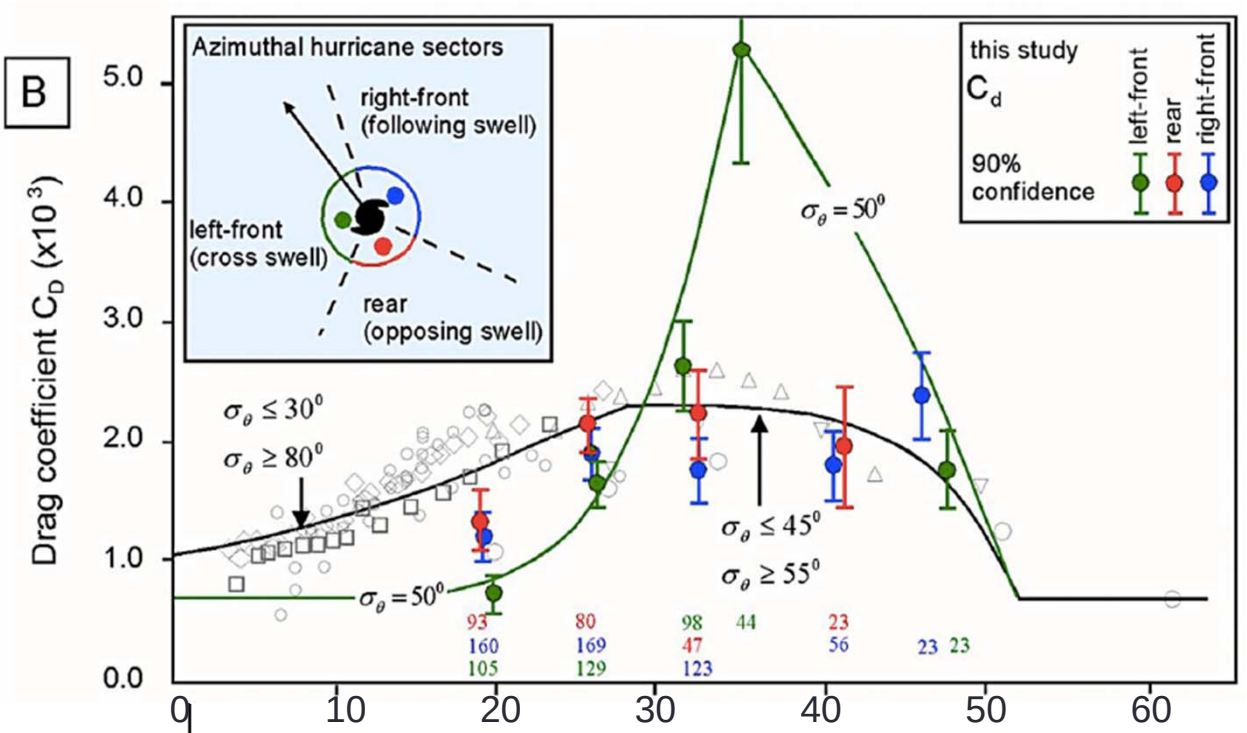
Wind-Wave-Current Interaction in Tropical Cyclones



Drag Measurements in Hurricanes

Powell et. al. (2003)
331 wind profiles





Holthuijsen et. al. (2012), 1149 wind profiles

- Drag is sea state dependent
- Swells affect C_d in hurricanes

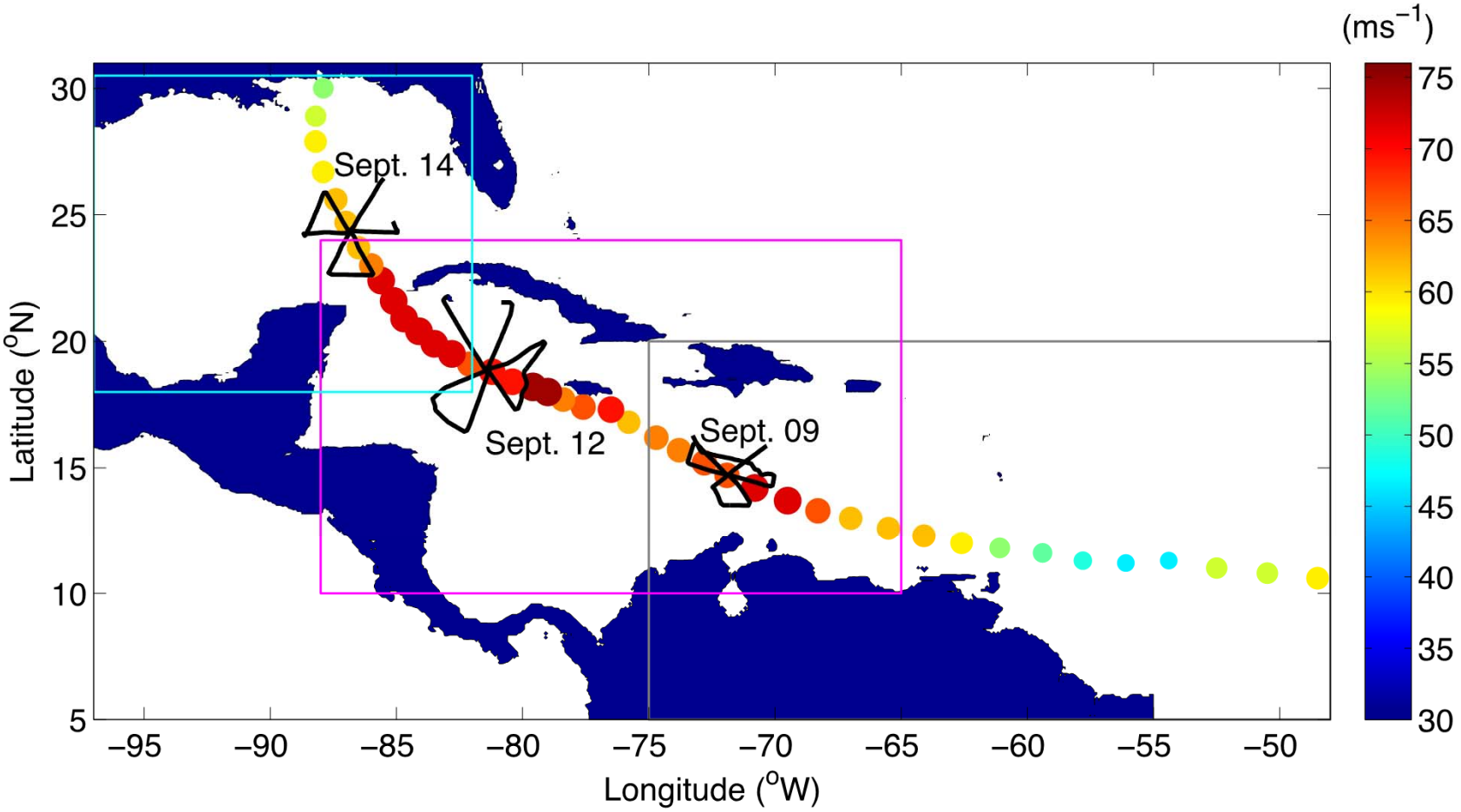
Are third generation wave models able to provide accurate stress estimates for hurricane predictions?

- Third generation wave models are proven capable of simulating wave parameters under hurricanes (Phadke et al 2003, Moon et al 2003, Xu et al 2007, Fan et al 2009b, Allard et al. 2014)

- Fully coupled Atmosphere-wave-ocean model is suggested for accurate hurricane predictions as well as corresponding ocean responses (Chen et al 2007, Fan et al 2009a, Liu et al 2011, Chen et al 2013)

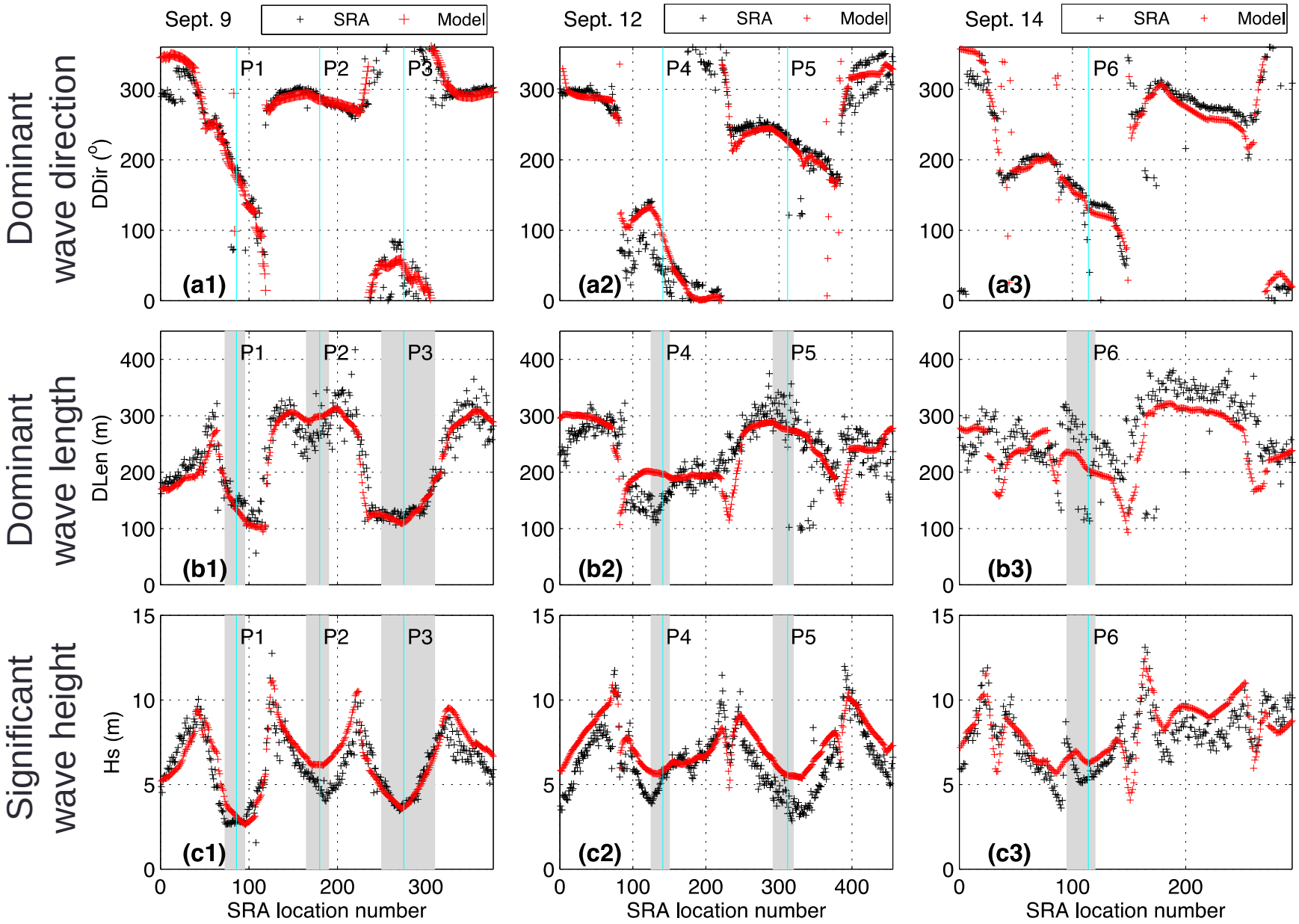
- Does third generation wave models give reasonable wave spectrum for stress calculations?

Model Domain and Measurements in Hurricane Ivan, 2004

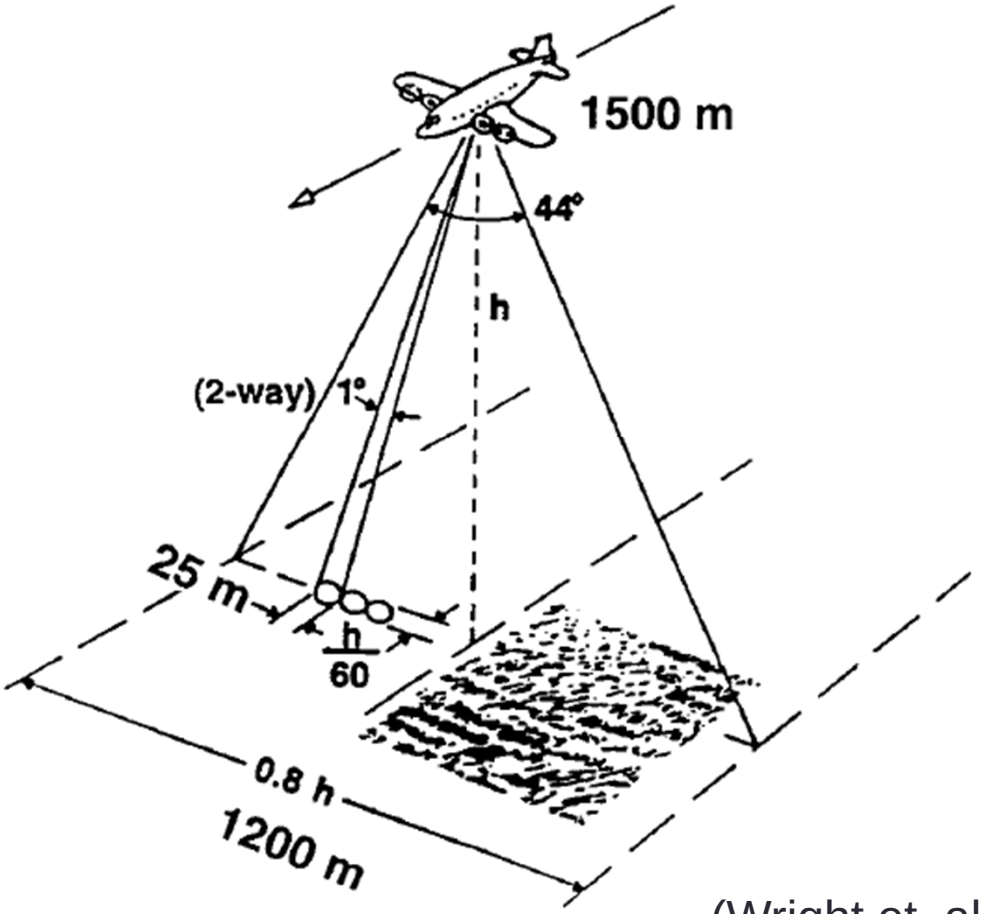


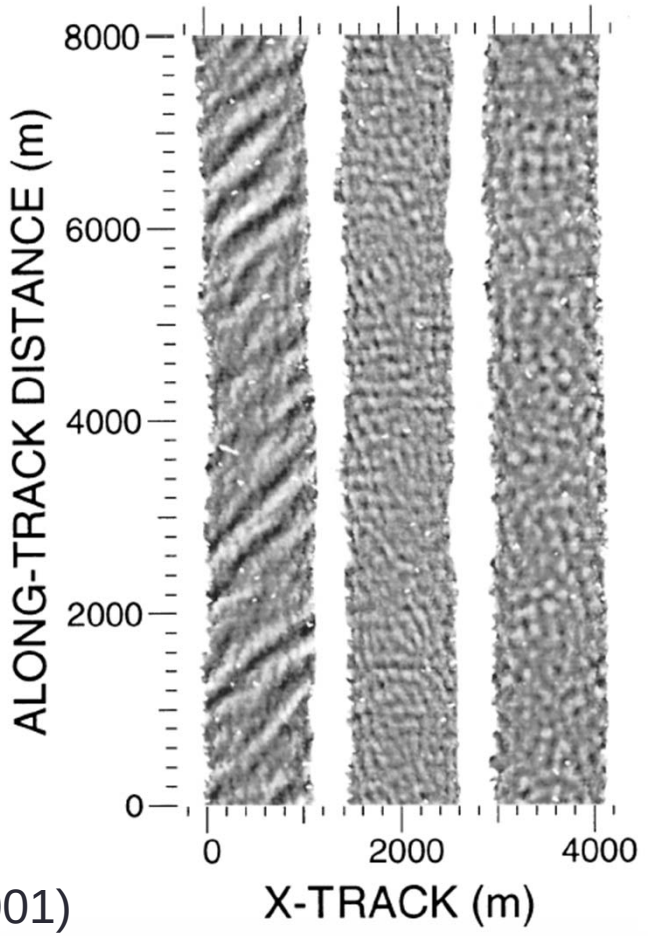
- WAVEWATCH III, ST4 Source Term Package (Ardhuin et. al. 2010)
- Hurricane Research Division (HRD) wind; HYCOM currents

Model & Data comparison



Scanning Radar Altimeter (SRA) Spectra





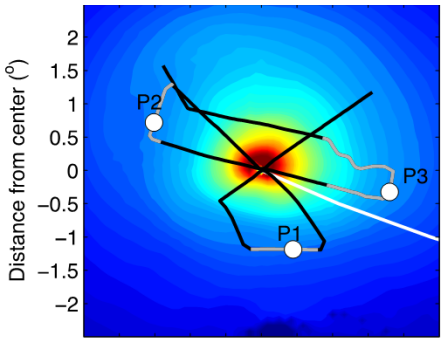
(Wright et. al. 2001)

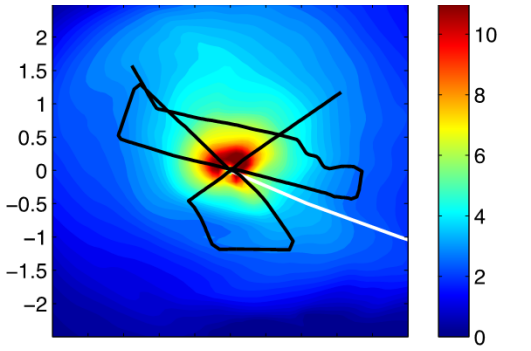
SRA resolve waves equal or longer than 50m (~ 0.17 Hz)

Drag Coefficient (C_d) Comparison (Donelan et. al. 2006)

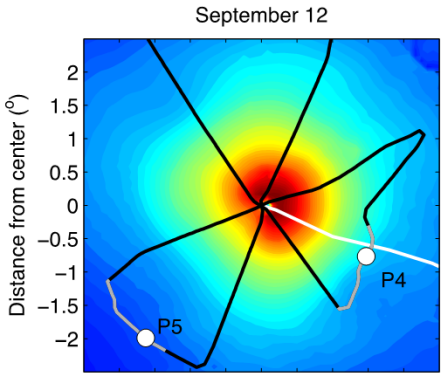
Real WWIII spectra | WWIII spectra with diagnostic tail

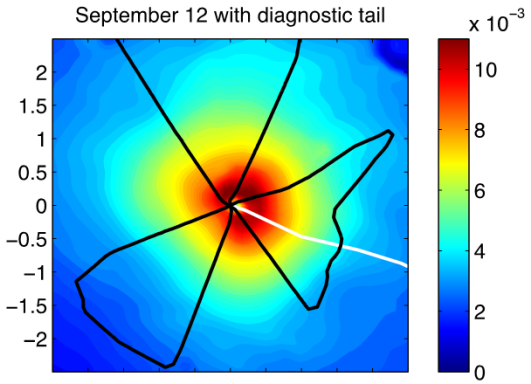
Sept. 9



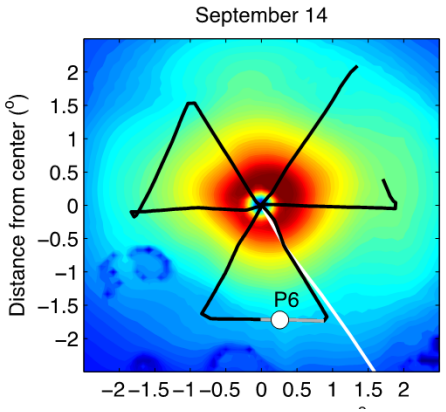


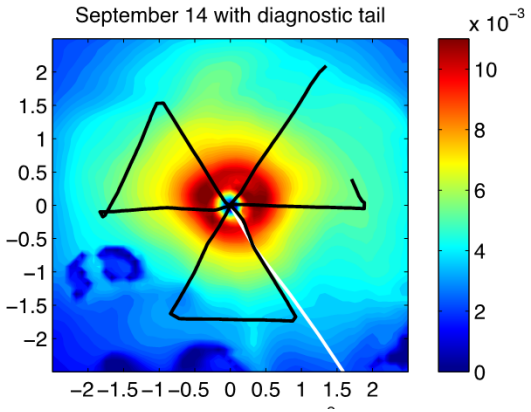
Sept. 12





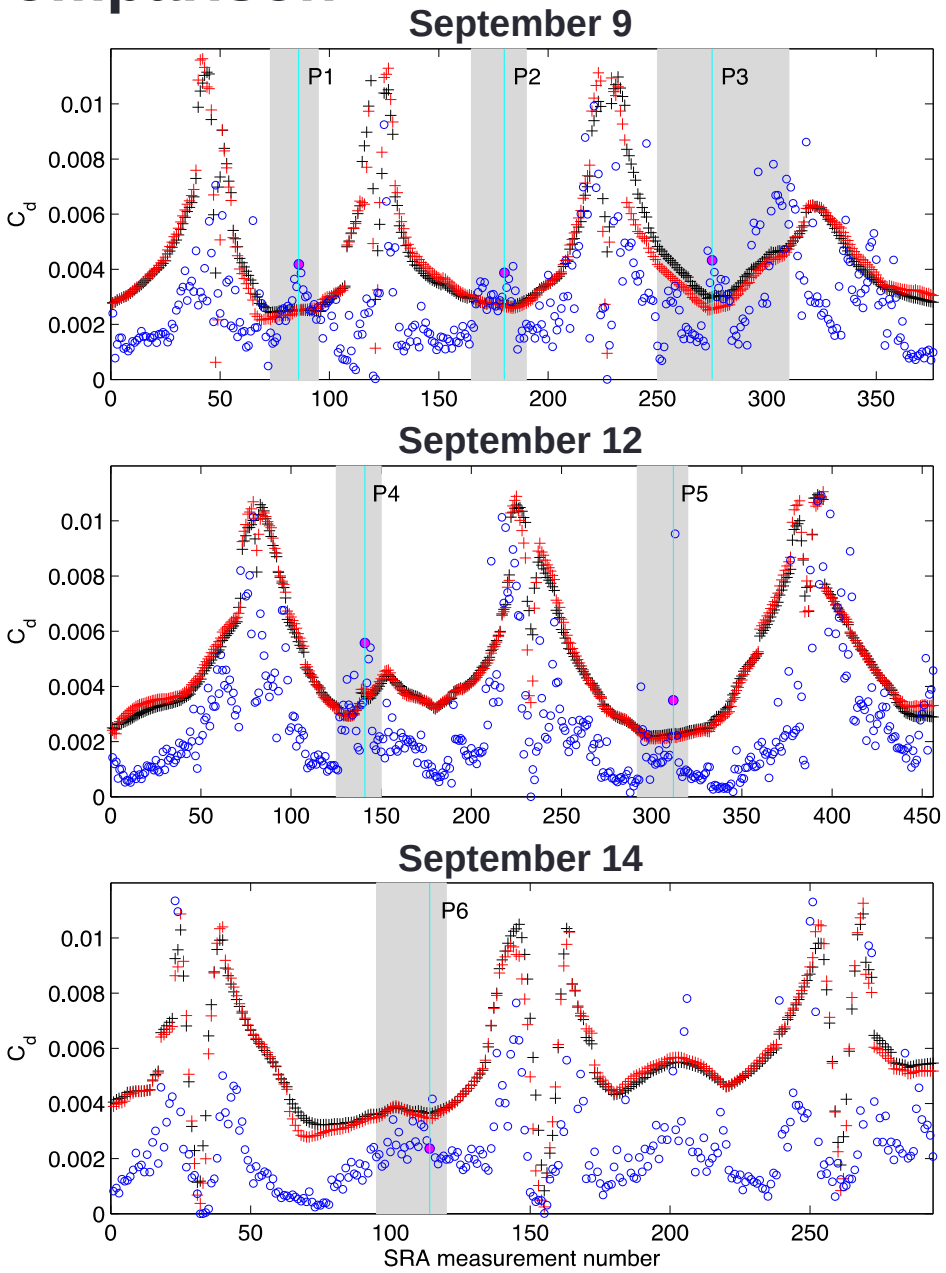
Sept. 14





Drag Coefficient (C_d) Comparison

+	WWIII spectra
+	WWIII spectra with diagnostic tail
o	SRA spectra with diagnostic tail



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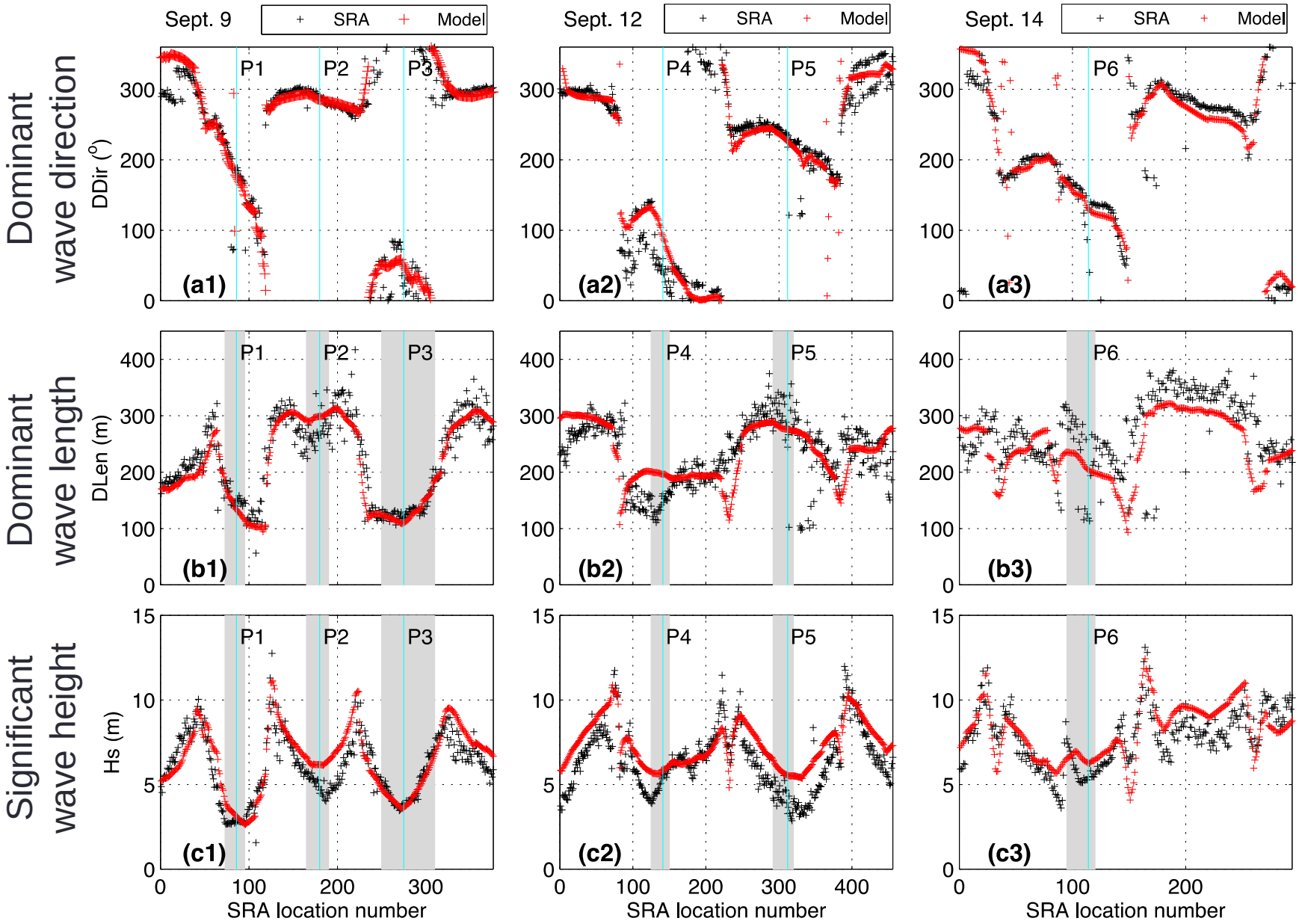

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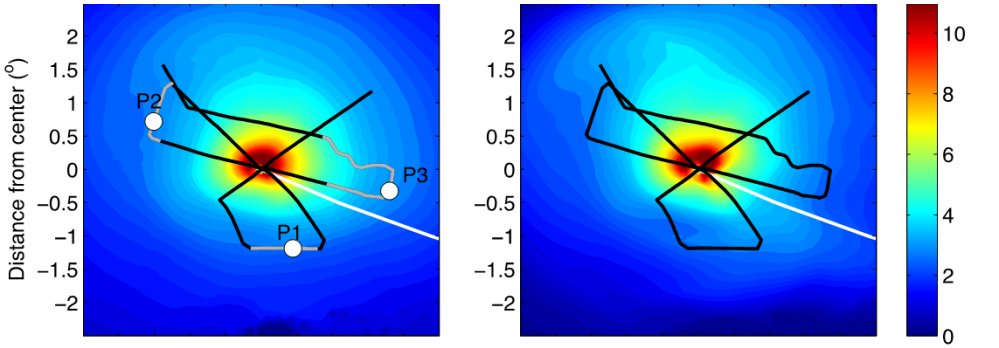

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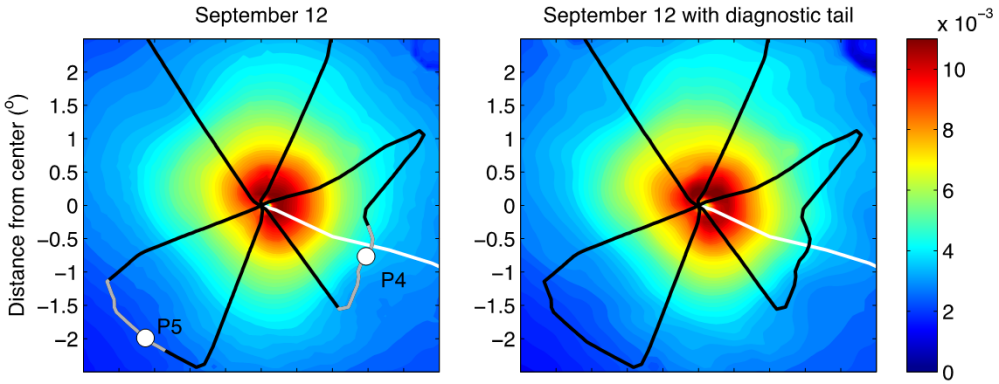

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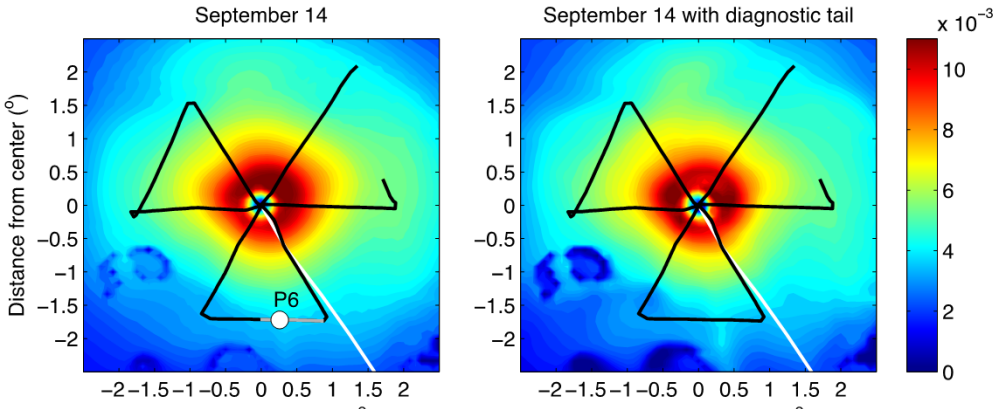

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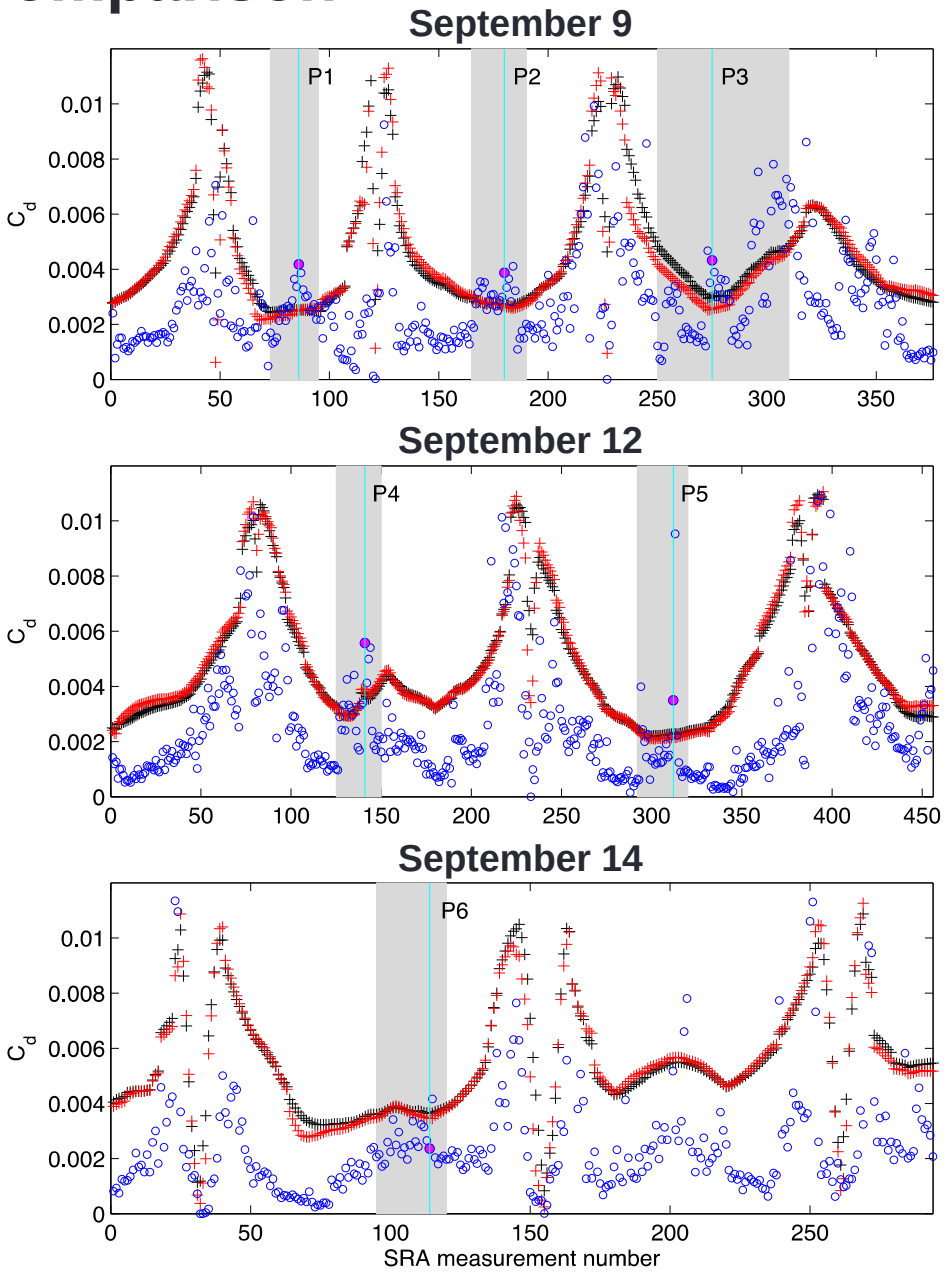


Spectra Comparisons

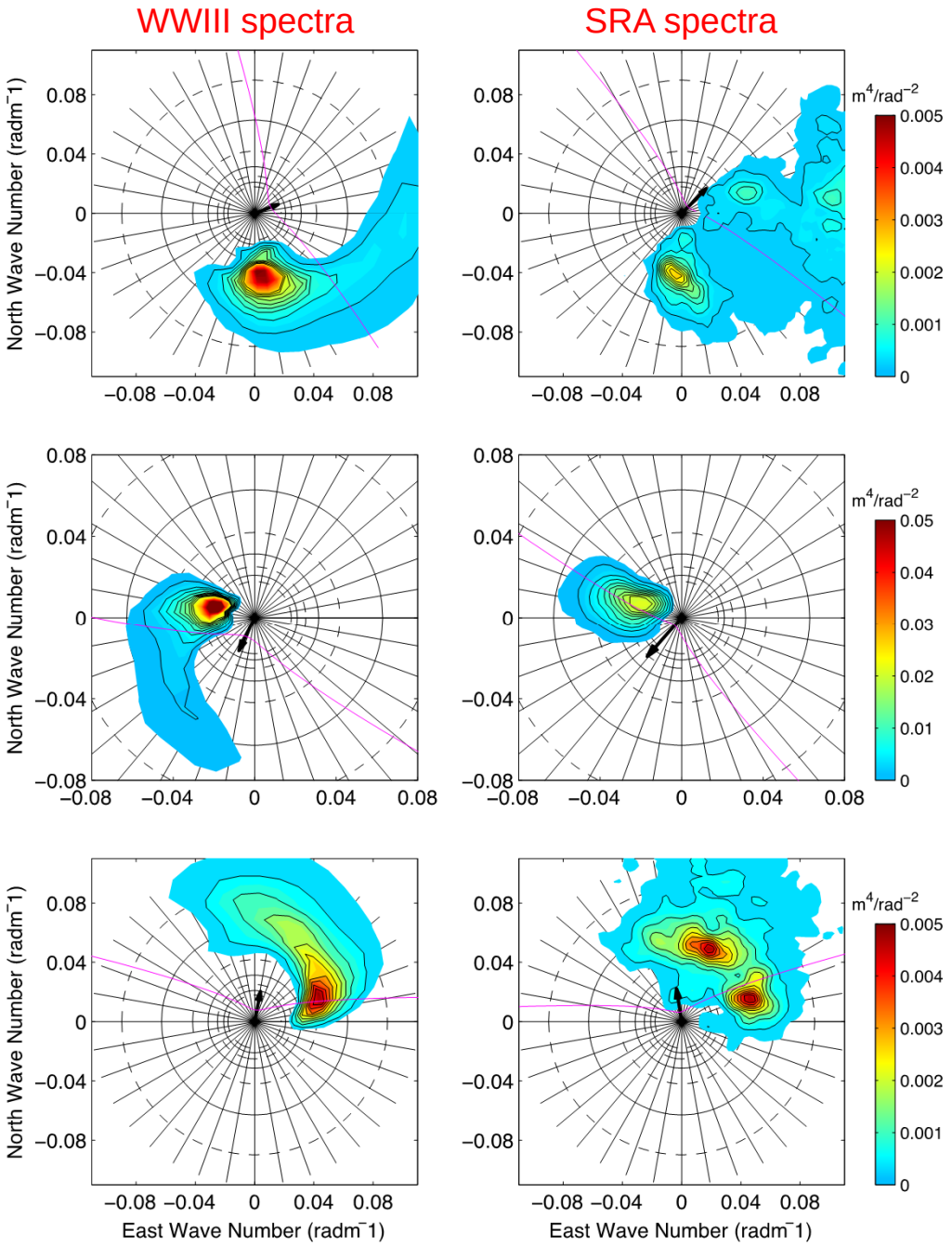
Purple line gives

$U_p/c = 1$

c – phase speed

$U_p – 1.7U_{10\_wave}$

(Tracy et. al. 2007)



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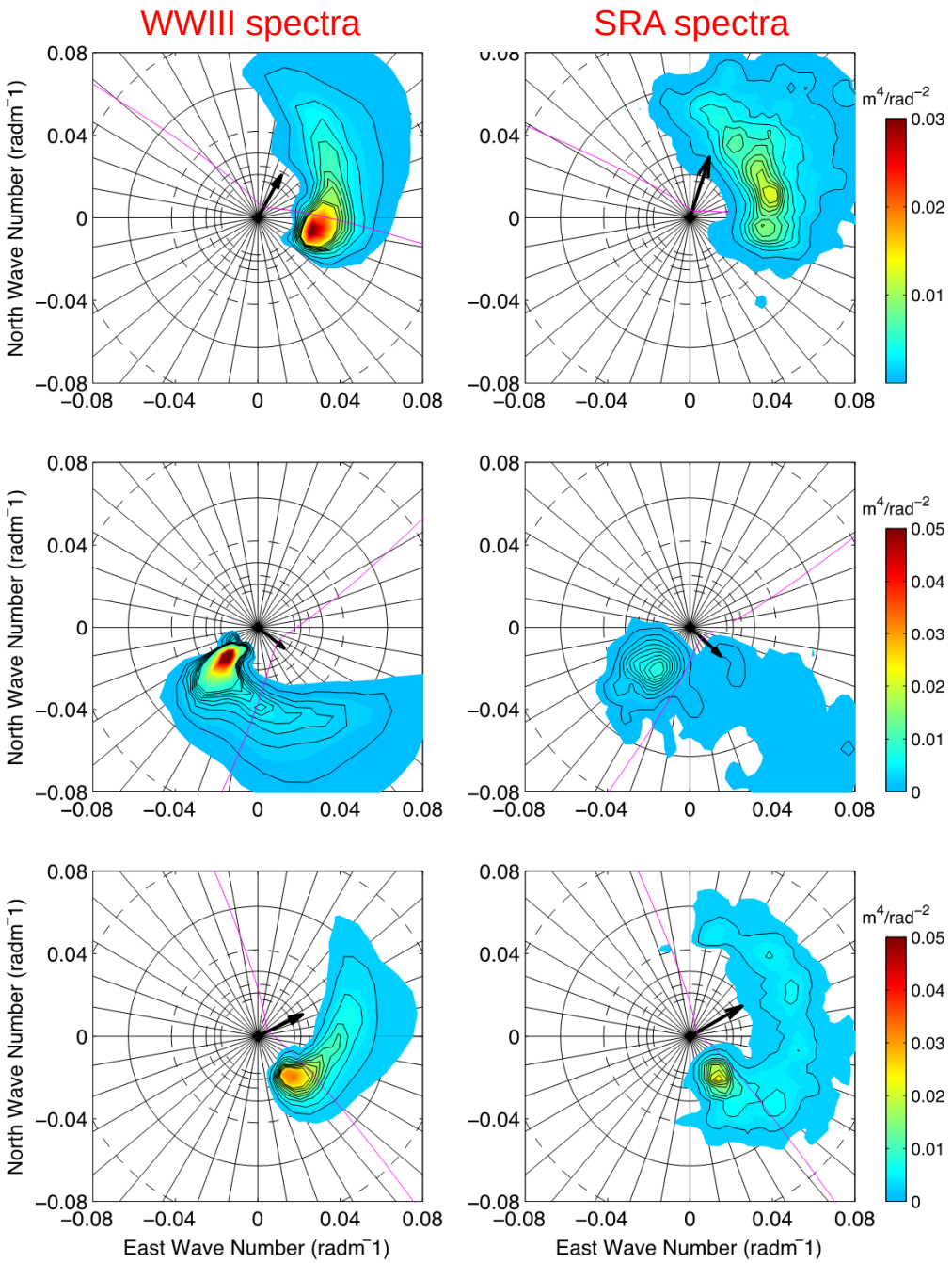


Effect of Wind Sea Spectra Shape

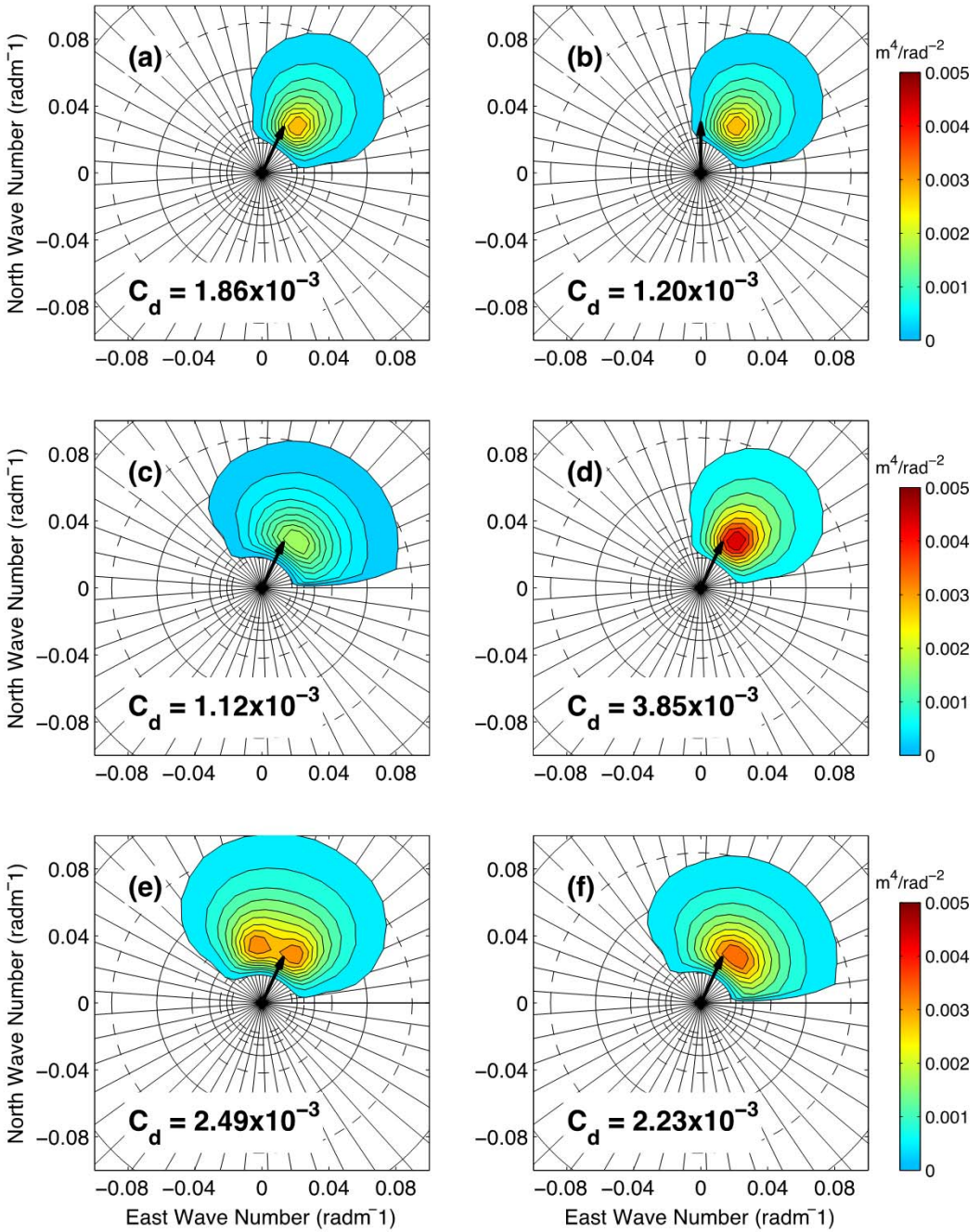
Parametric Spectra
Donelan et. al. (1985)

Wind Speed = 20 m/s

❖ Factors that decrease C_d
Increase wind – wave angle
Increase directional spreading

❖ Factors that increase C_d
Increase wind sea energy

❖ Multi-peak spectrum produce higher C_d



Discussion / Conclusion

- WAVEWATCH III is not capable of providing sensible stress calculations in the left - rear quadrants of the hurricane.
- HRD wind do not represent fine structure of wind field
- Source function not for high wind condition
- Model dissipation to low for swells & too high for wind sea
- Wind sea part is more problematic