

Evaluation of SWAN and WW3 in hurricane conditions

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WW3 development group call
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1. Spatial resolution sensitivity in SWAN and WW3 under real (Hurricane Bob, 1991) and idealized hurricanes
2. Evaluation of WW3 (ST2 and ST4) and SWAN under Hurricane Ivan (2004)

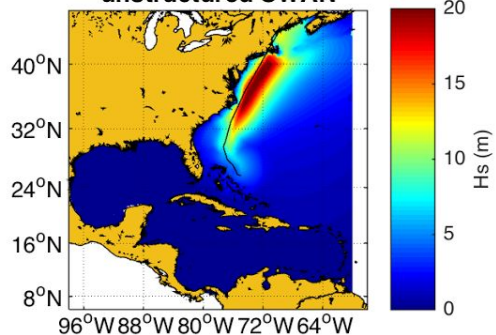
Spatial resolution sensitivity in SWAN and WW3 wave models

Motivation

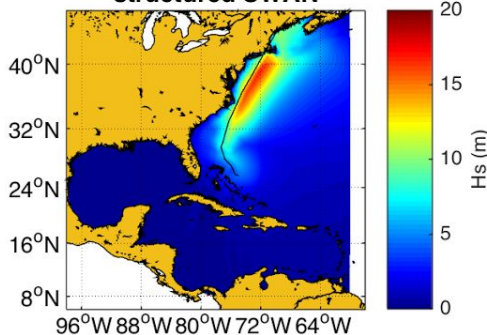
Hurricane Bob (1991) simulations with unstructured and structured SWAN systems

Swath of Maximum SWH

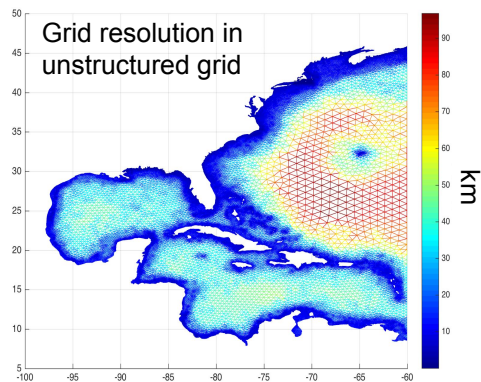
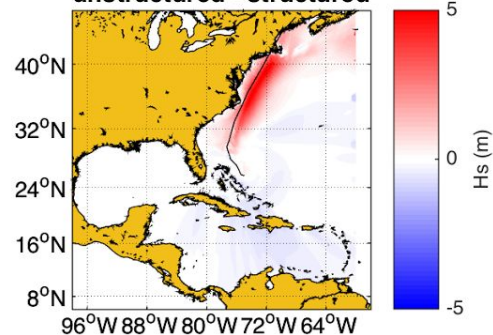
unstructured SWAN



structured SWAN



unstructured - structured



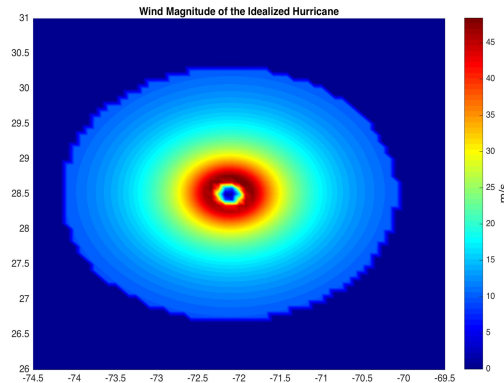
1/12 degree

Resolution Experiments with an Idealized Hurricane

Exp. Name	Control	Coarse Res.1	Coarse Res.2	Fine Res. 1	Fine Res. 2
Grid Resolution	1/12 degree	1/3 degree	1/6 degree	1/24 degree	1/36 degree

Parameters used in Holland profile for idealized hurricane winds:

Radius of Maximum Wind	Maximum Wind Magnitude	Translation Speed
25km	~50m/s	3m/s (westward)



Model settings in SWAN and WW3

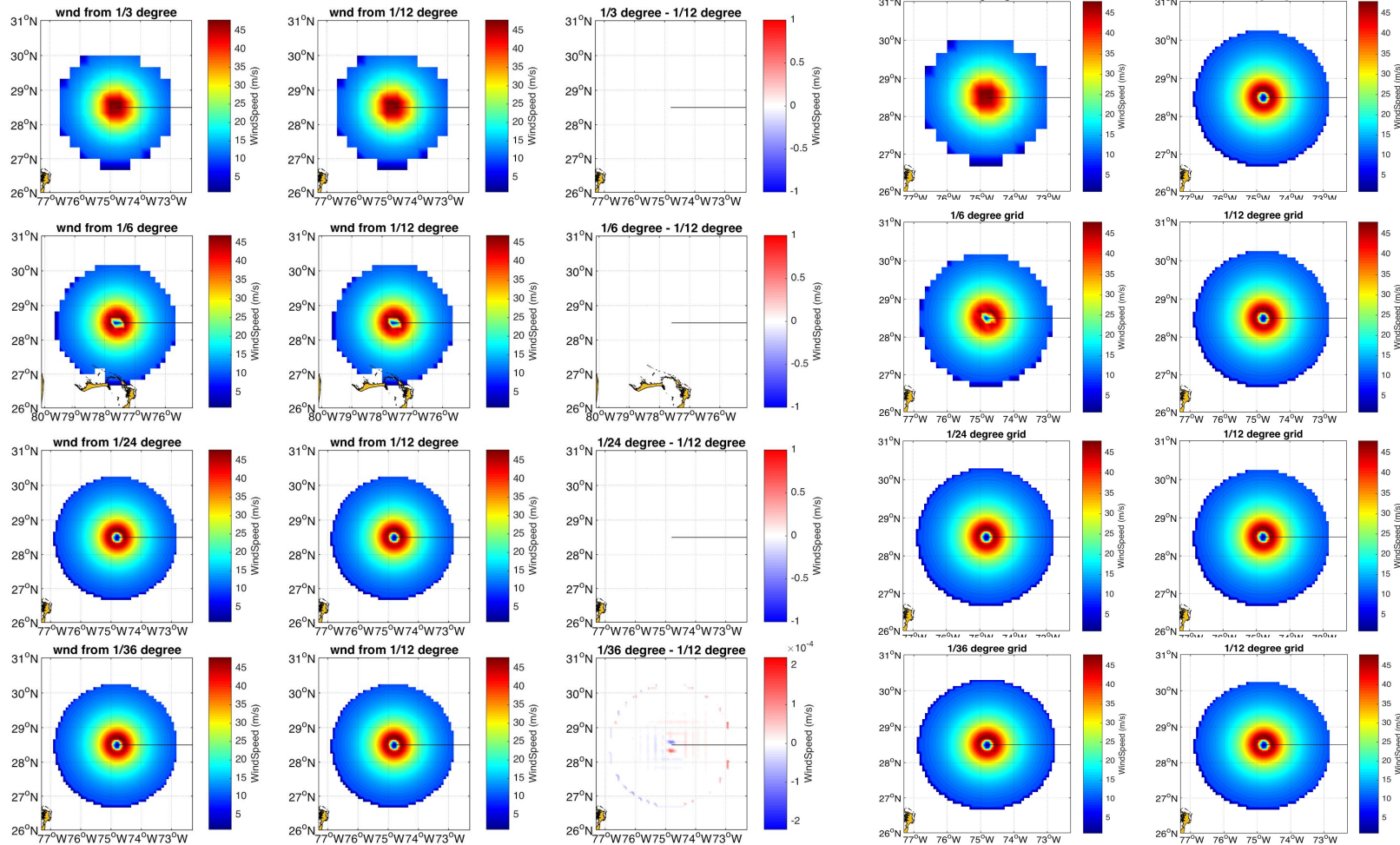
	SWAN (v41.01)	WW3 (v5.16)
# of Frequency bin	40 (0.0285 ~ 1.1726 with logarithmic increment factor of 1.1)	
# of Direction bin	36	
Wind input term	Komen (Cd capped at 0.0020)	ST2
Dissp. from white capping		(FLX3: Cd capped at 0.0025)
Dissp. from bottom friction	Madsen (Kn=0.05)	JONSWAP default
Dissp. from surface breaking	Battjes and Janssen (Same alpha and gamma parameters)	
Quadruplets & Triad	On and use default respectively	
Propagation Scheme	first order, Backward Space, Backward Time (BSBT) scheme	3rd order UQ + GSE averaging default

Results of the experiments

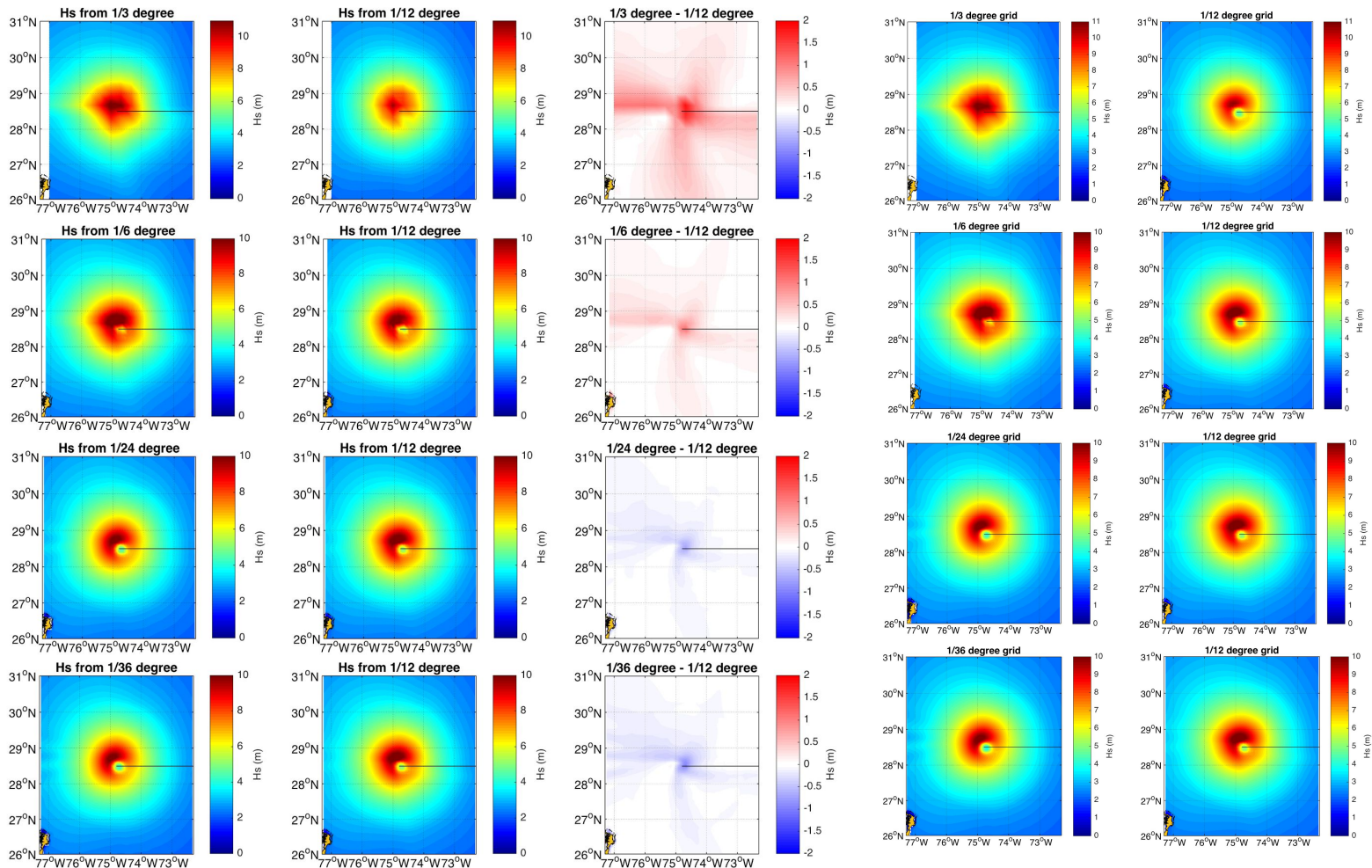
Results will be shown in two ways:

1. Snapshots at 24th hour of simulation (after reaching quasi-steady state)
2. Swaths of maximum significant wave height

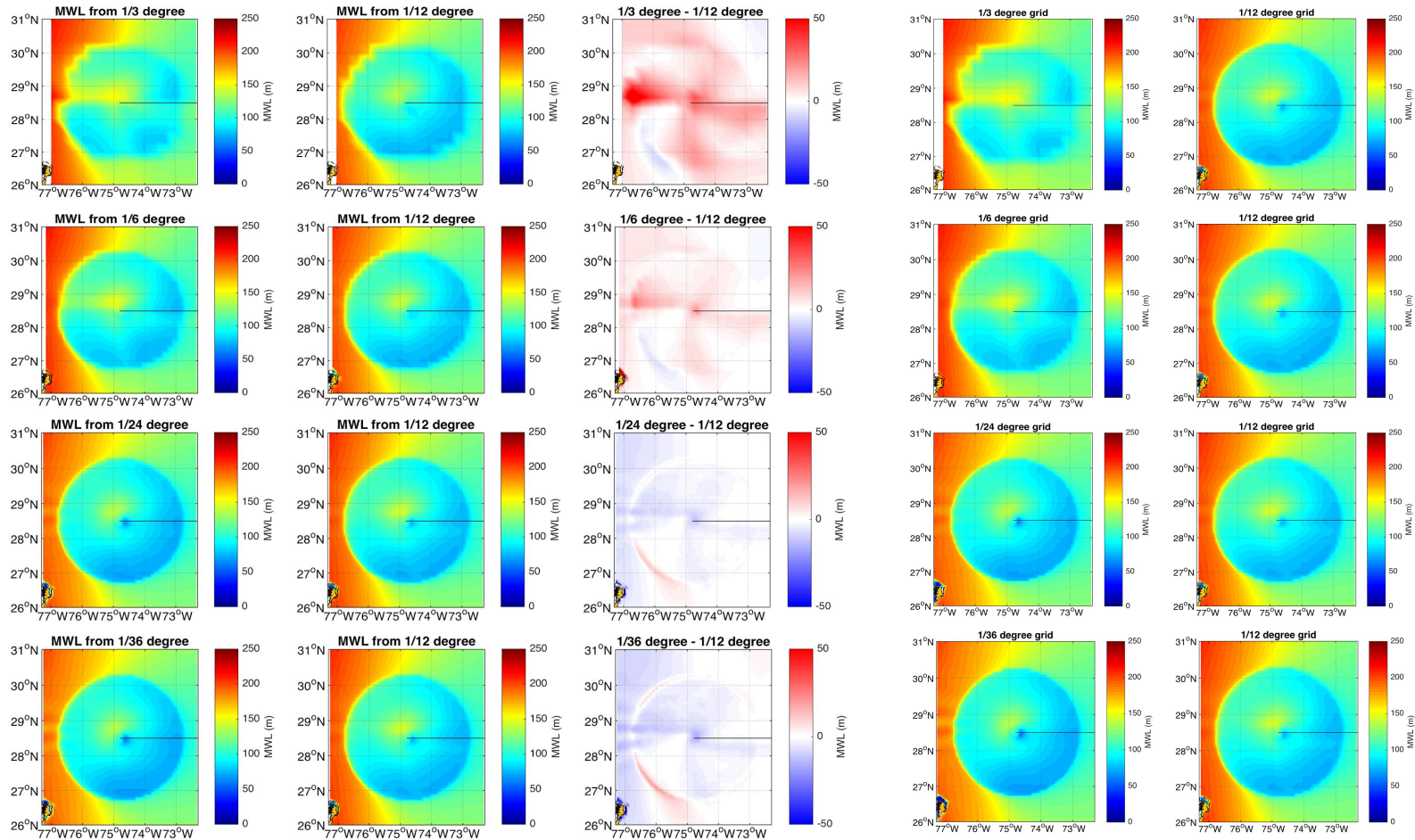
SWAN: Wind Magnitude



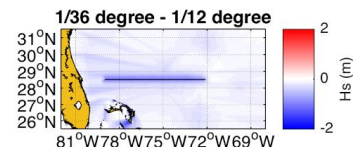
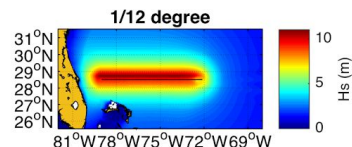
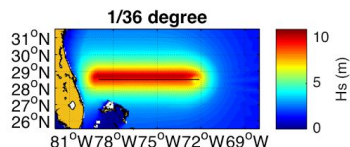
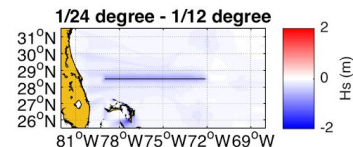
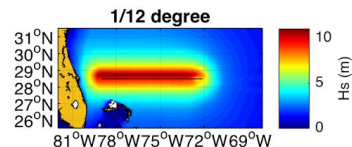
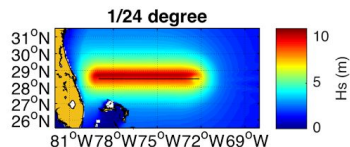
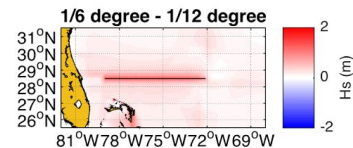
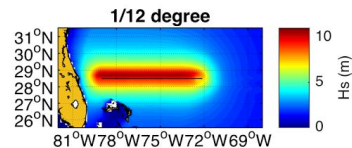
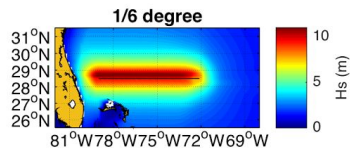
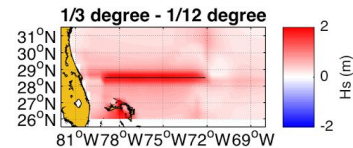
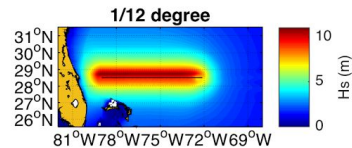
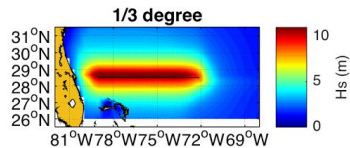
SWAN: Significant Wave Height



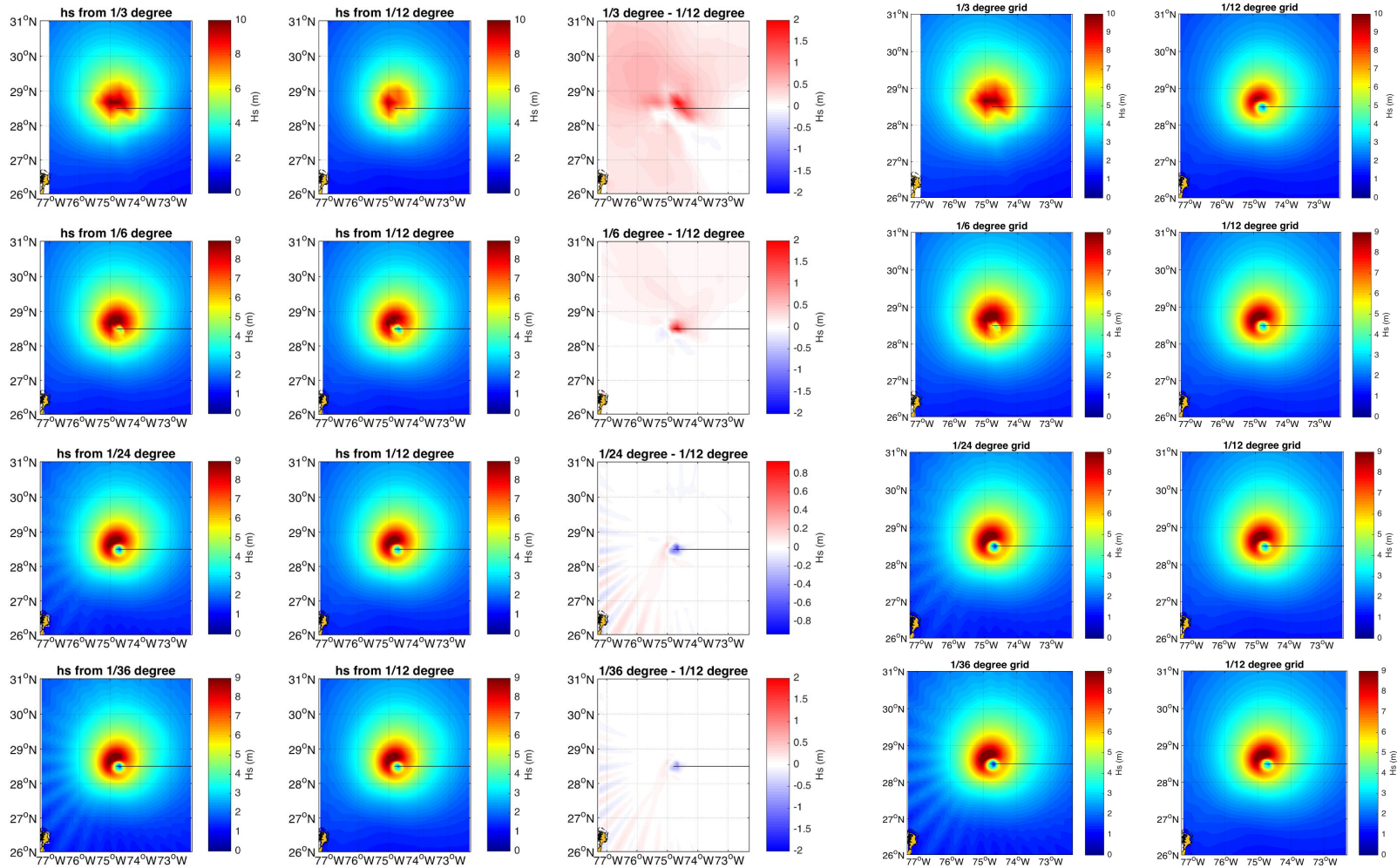
SWAN: Mean Wave Length



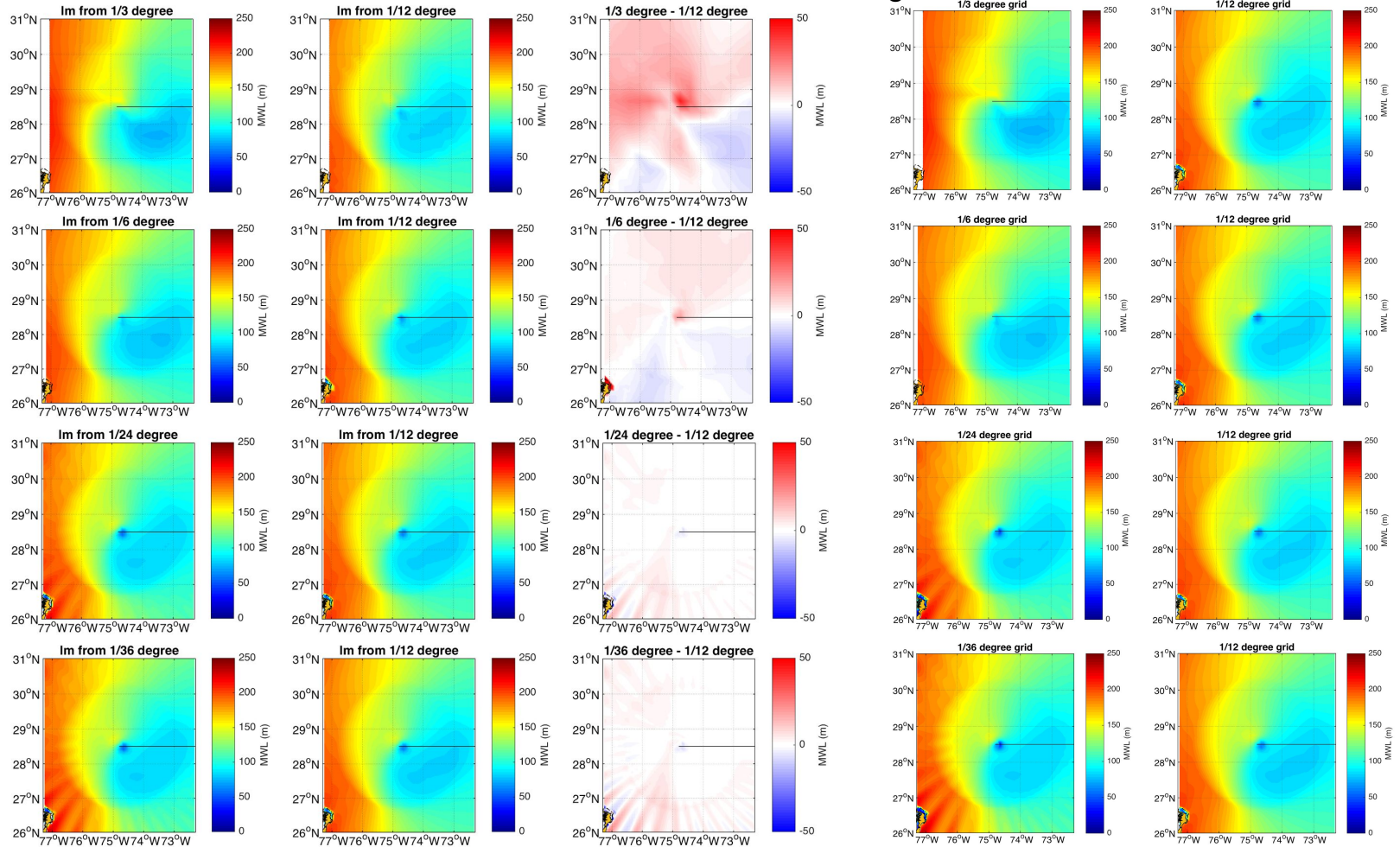
SWAN: Swath of maximum SWH



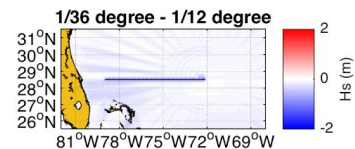
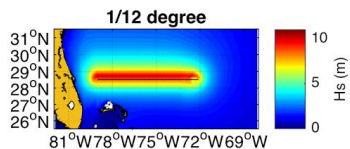
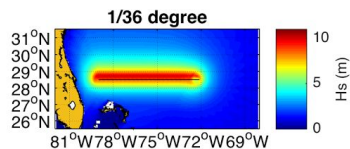
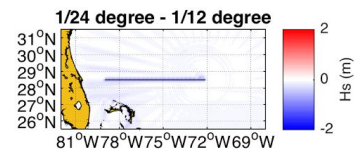
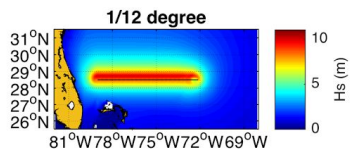
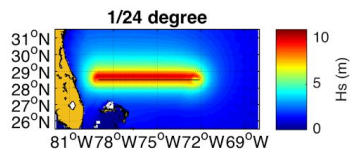
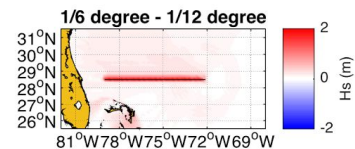
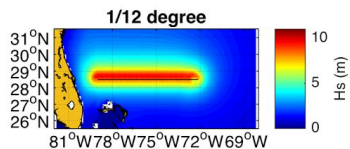
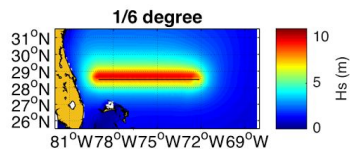
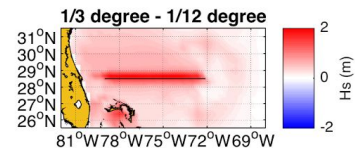
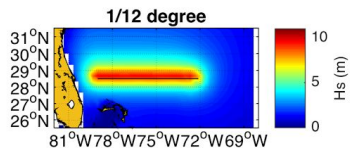
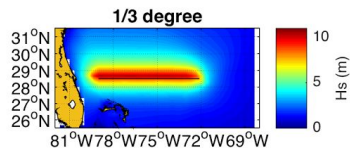
WW3: Significant Wave Height



WW3: Mean Wave Length



WW3: Swath of maximum SWH



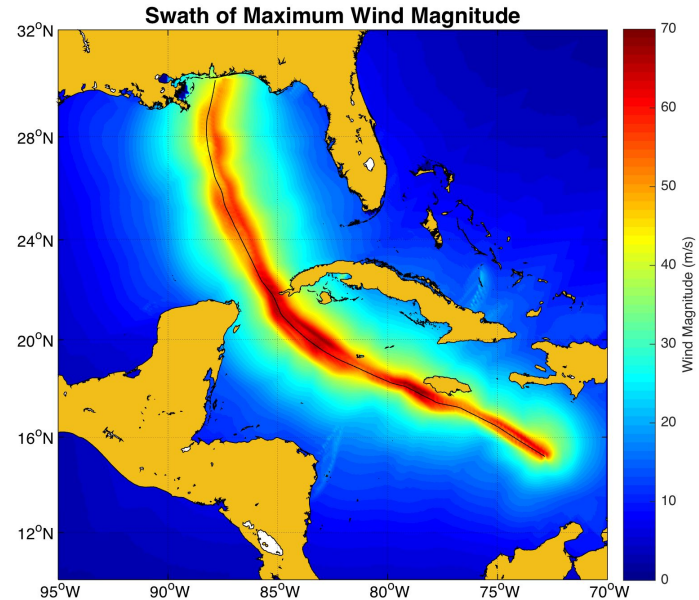
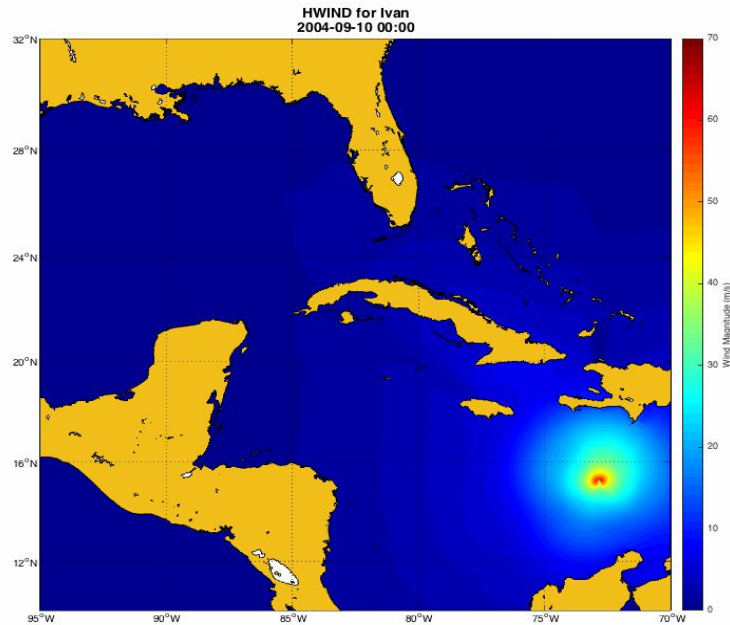
Summary of spatial resolution experiments

- Both SWAN and WW3 results with coarse resolutions ($> 1/12$ degree) significantly overestimate the SWH and overestimate the mean wave length. SWAN is more affected by the coarse resolution.
- Even the $1/12$ degree resolution overestimate the SWH in a small area inside the eye.
- The idealized experiments with a relatively slow moving hurricane show up to 2 m difference of SWH. With the faster moving Hurricane Bob (1991), the difference is up to 5 m. More careful investigations with different conditions (storm intensity, size, speed) are needed.

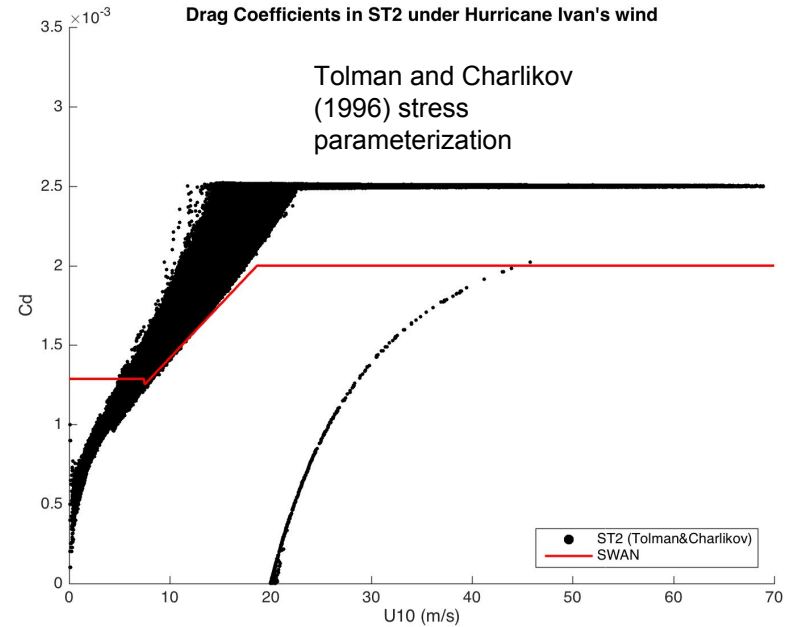
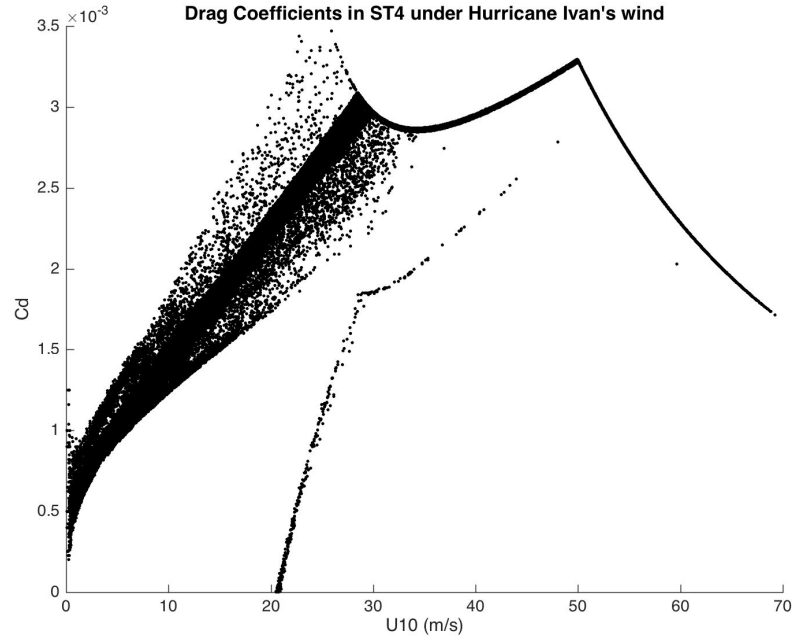
Comparison between WW3 (ST4 and ST2) and SWAN under Hurricane Ivan (2004)

Wind forcing

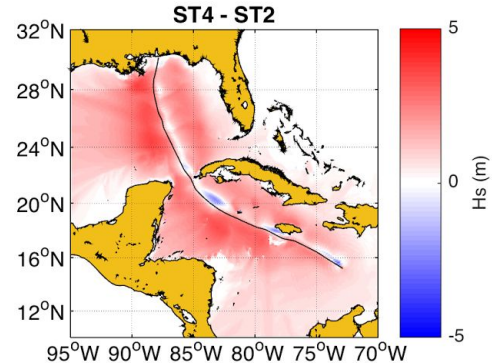
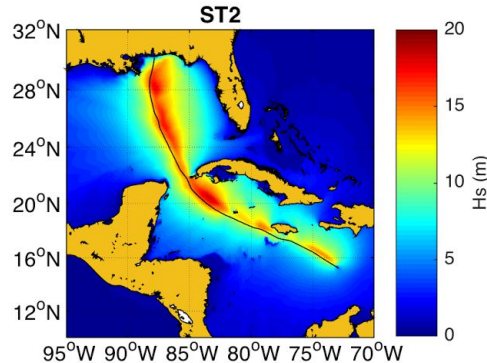
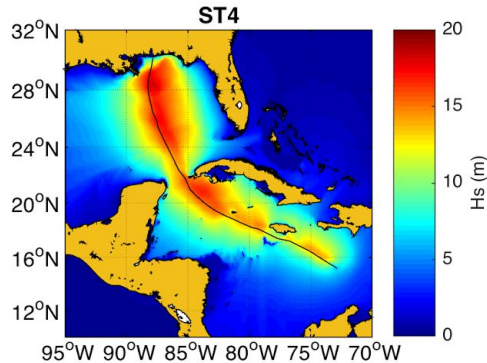
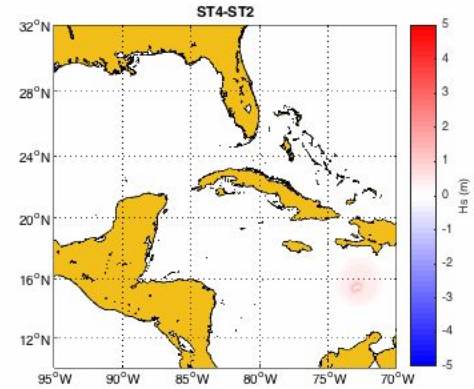
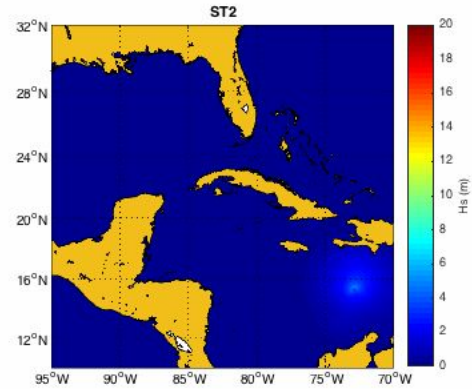
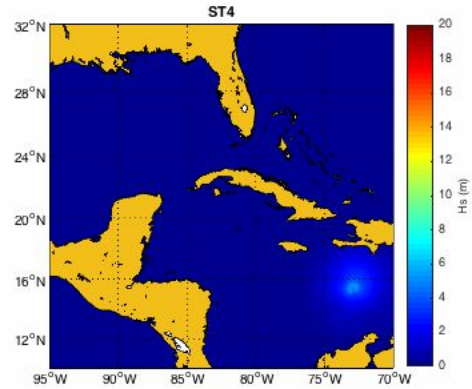
Observational wind product: H*Wind
(time and spatial interpolation as in Fan et al. 2009)



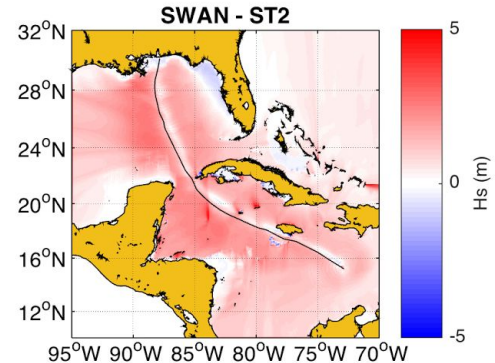
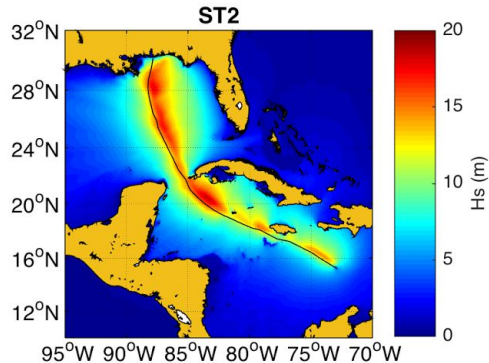
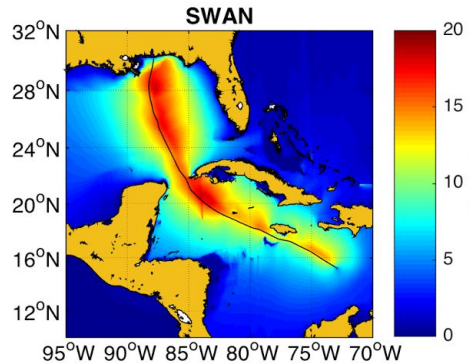
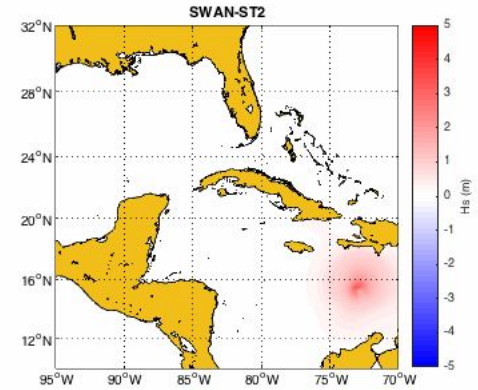
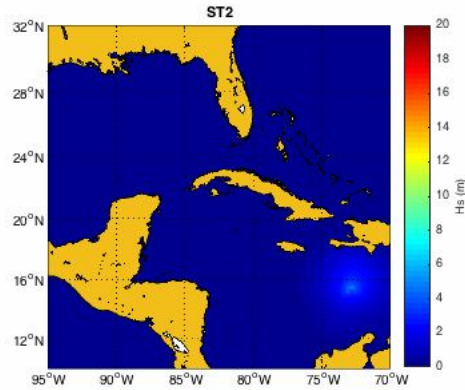
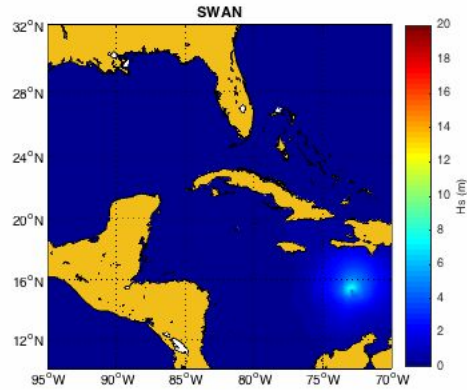
Drag coefficients in ST4, ST2 and SWAN



ST4 vs. ST2 Significant Wave Height



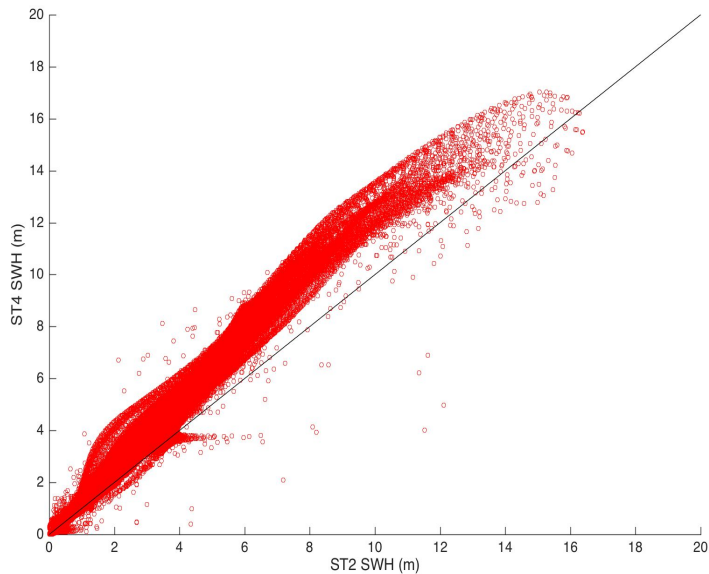
SWAN vs. ST2 Significant Wave Height



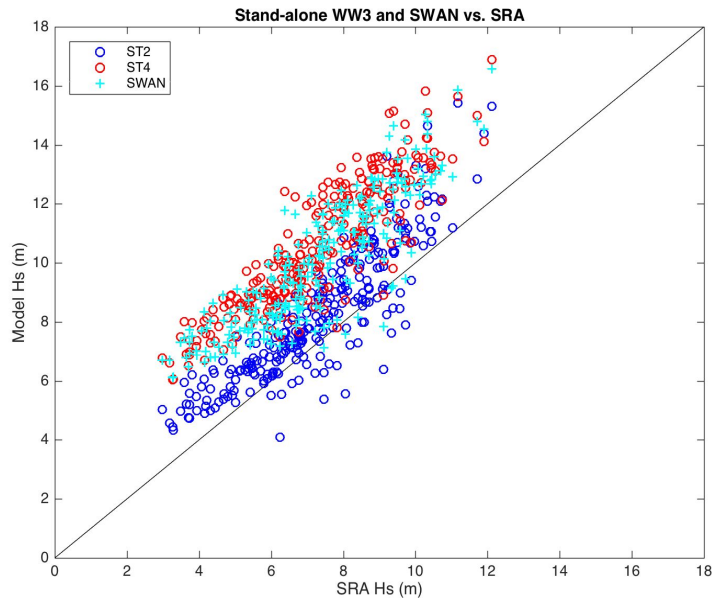
Intra-, Inter-model Comparisons and Validations

Against Scanning Radar Altimeter (SRA)

ST2 vs. ST4

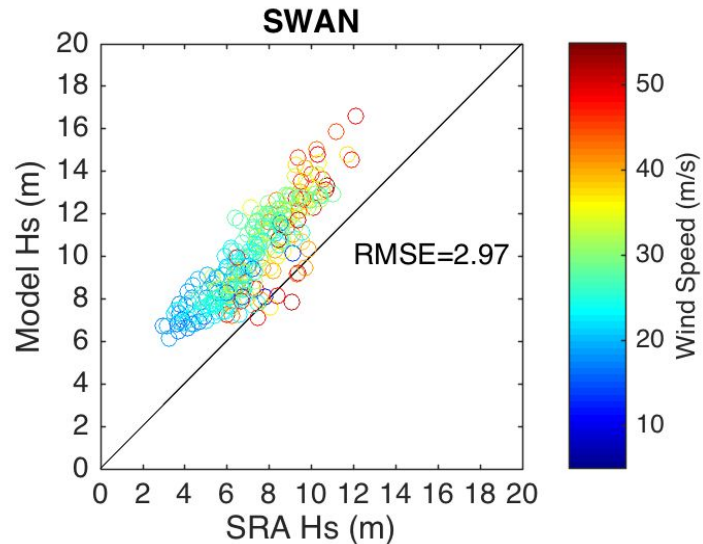
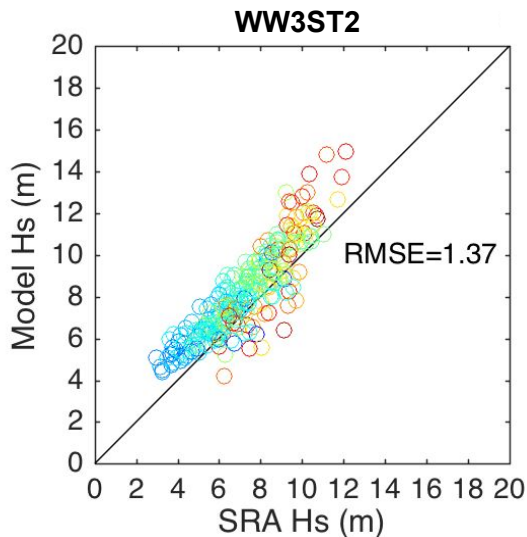
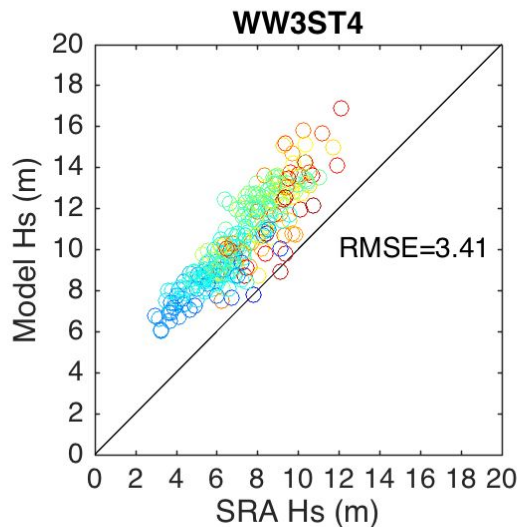


ST2, ST4, SWAN vs SRA

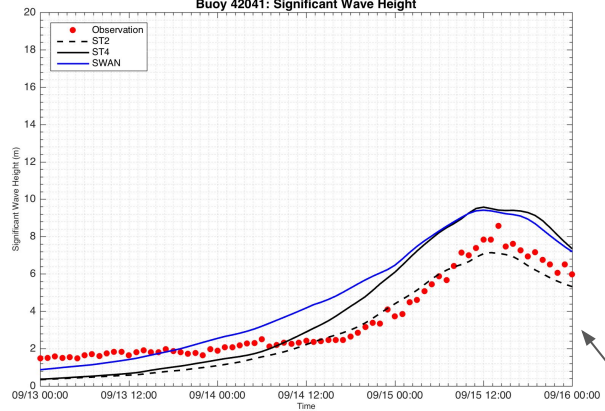
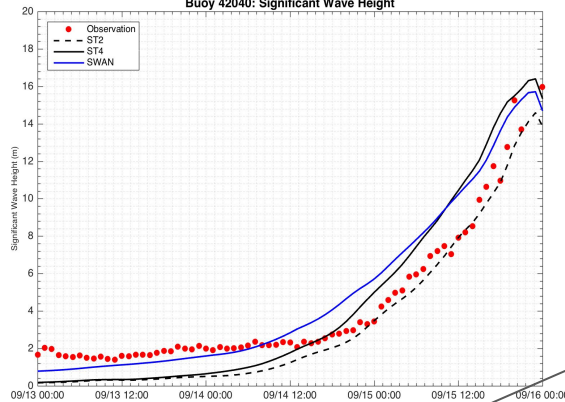
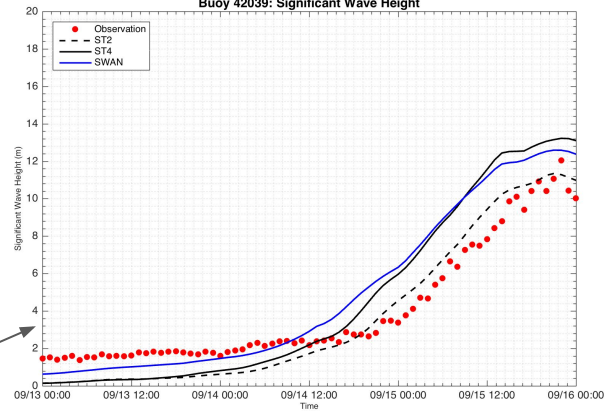
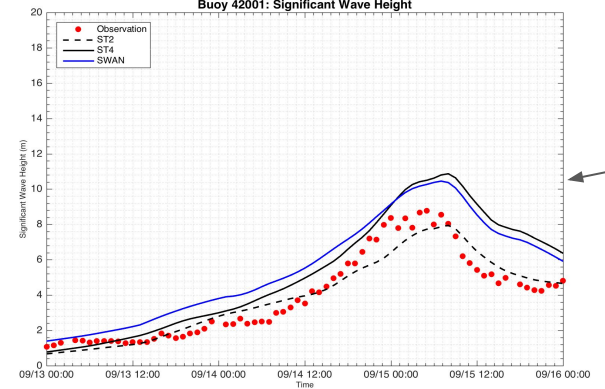
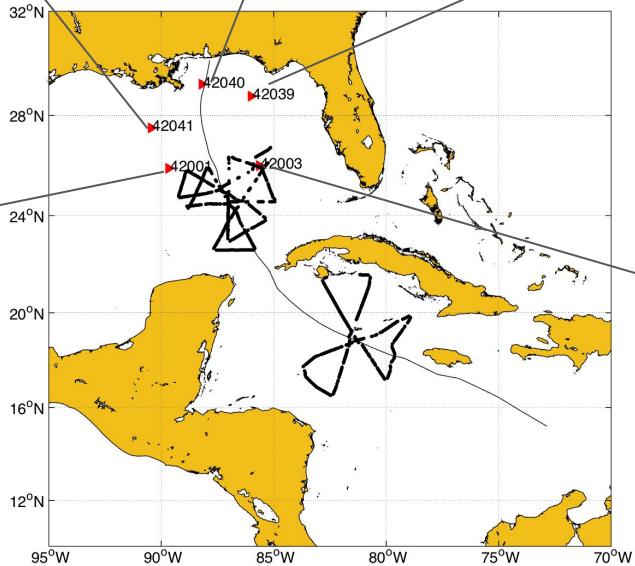
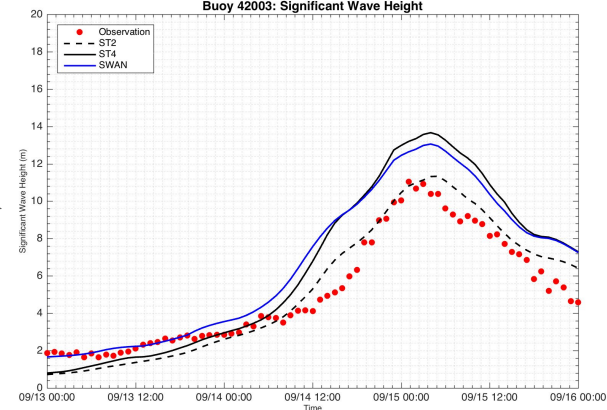


Intra-, Inter-model Comparisons and Validations

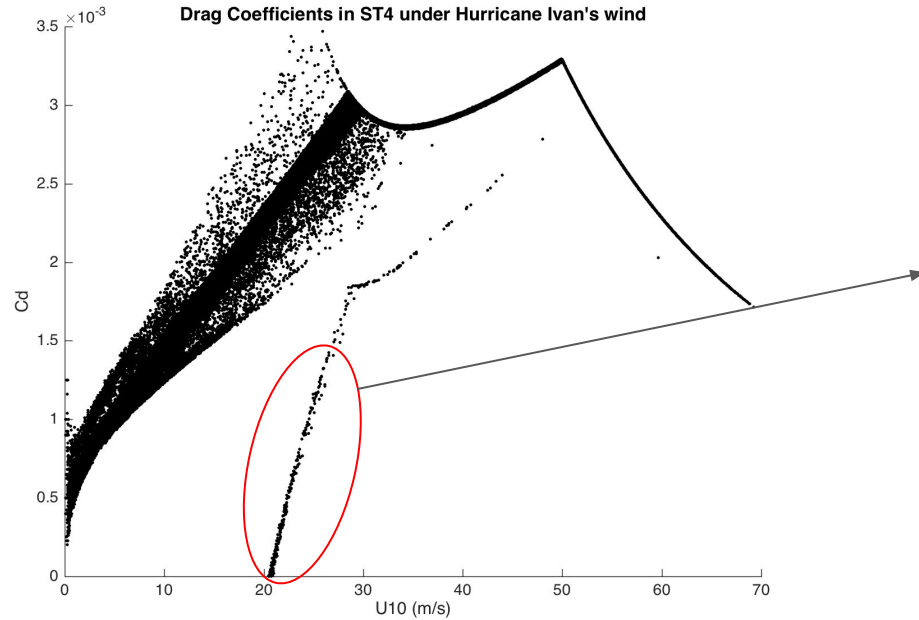
Against Scanning Radar Altimeter (SRA)



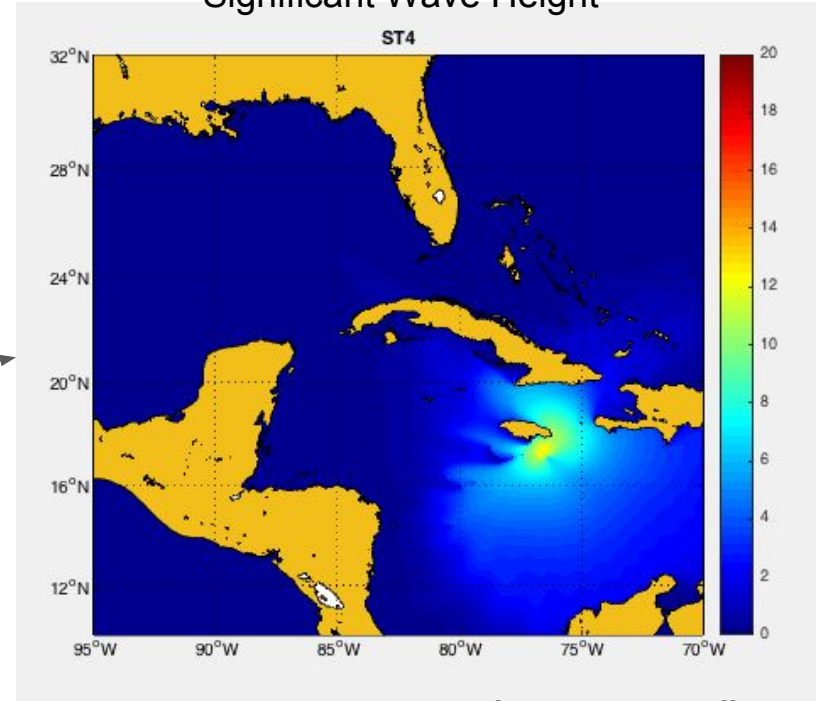
RMSE: Root Mean Square Error

Buoy 42041: Significant Wave Height**Buoy 42040: Significant Wave Height****Buoy 42039: Significant Wave Height****Buoy 42001: Significant Wave Height****Buoy 42003: Significant Wave Height**

Locations of the small drag coefficient for wind >20 m/s in ST4



Significant Wave Height



red triangles indicate locations of small drag coefficient circled out in the left panel.

Summary of Hurricane Ivan experiments

- WW3 (ST2 with Tolman and Charlikov stress) slightly overestimates the SWH (We have confirmed the results of Fan et al. (2009). The same paper shows that including ocean currents reduces the model error.
- WW3 (ST4) significantly overestimates the SWH except near the storm center. The drag coefficient of ST4 is higher than the Tolman and Charlikov parameterization for wind speed 20-55 m/s.
- SWAN also significantly overestimates the SWH except near the storm center, even if the drag coefficient is lower (capped at 0.002).