



Supplement of

Hurricane impacts in the United States East Coast offshore wind energy lease areas

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This document contains:

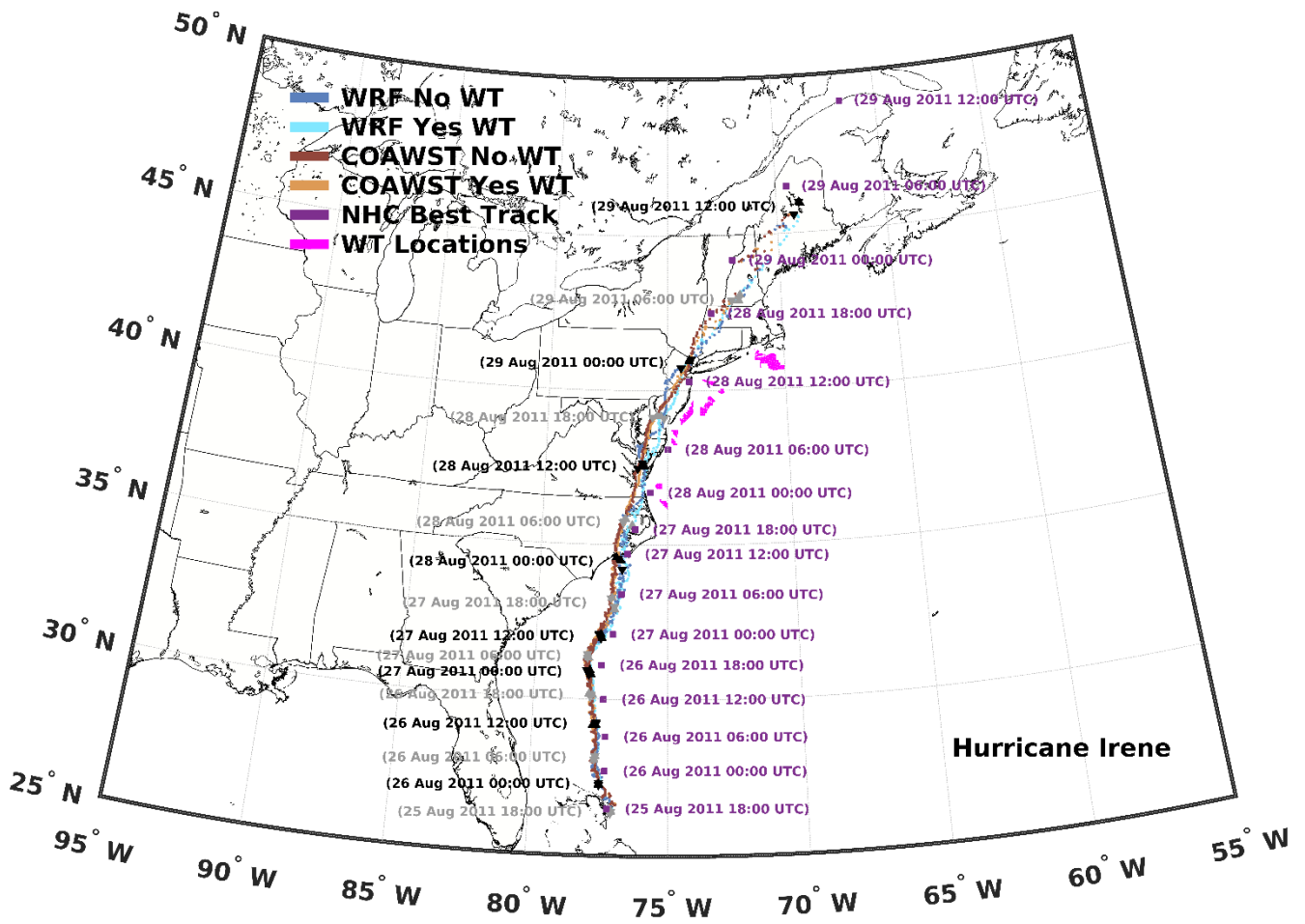
- Further details of the NDBC buoy measurements.
- Table S1: Additional details about the NHC best tracks for Hurricane Irene and Hurricane Sandy within d02.
- Figs. S1 and S2: Details of storm tracking for Hurricane Irene and Hurricane Sandy within the outer model domain.
- 5 • Fig. S3 and Table S2: Information flow between the COAWST model components.
- Fig. S4: Simulated precipitation during two 10 min periods, with contours of HH WS at 25, 35, and 45 m s⁻¹ and R₁₈ radii.
- Figs. S5-S11: Time series of WS and WG, SST, SLP, and Hs from observations on NDBC buoys and as simulated with WRF and COAWST for Hurricanes Irene and Sandy without the action of WTs.
- 10 • Fig. S12: Mean simulated CF and time series of the CF for LA clusters A, B, C, and D for simulations with the WFP active.
- Fig. S13: Mean simulated HH WS and time series of the fraction of WT grid cells with HH WS > 25 m s⁻¹ for LA clusters A, B, C, and D for simulations with the WFP active.
- Fig. S14: Mean simulated HH WS and time series of the fraction of WT grid cells with HH WS > 25 m s⁻¹ for LA
15 clusters A, B, C, and D for simulations without the WFP active.
- Fig. S15: Spatial depiction of the mean difference in CF from the simulations, WRF minus COAWST, for Hurricanes Irene and Sandy.
- Fig. S16: Time series of simulated 10 m WS close to the hurricane center.
- 20 From <https://zenodo.org/records/14895862> (Thompson et al., 2025), the reader can obtain:
 - Time lapse videos of HH WS and CF based on simulations with WRF and COAWST (without and with WFP active) for Hurricanes Irene and Sandy.
 - The header file for the COAWST simulations, an initial (non-restart) WRF namelist.input file, an initial (non-restart) ROMS ocean.in file, and initial (non-restart) SWAN swan.in files. For more information about the files,
25 refer to <https://github.com/DOI-USGS/COAWST> (United States Geological Survey, 2019).

Further details of the NDBC buoy measurements:

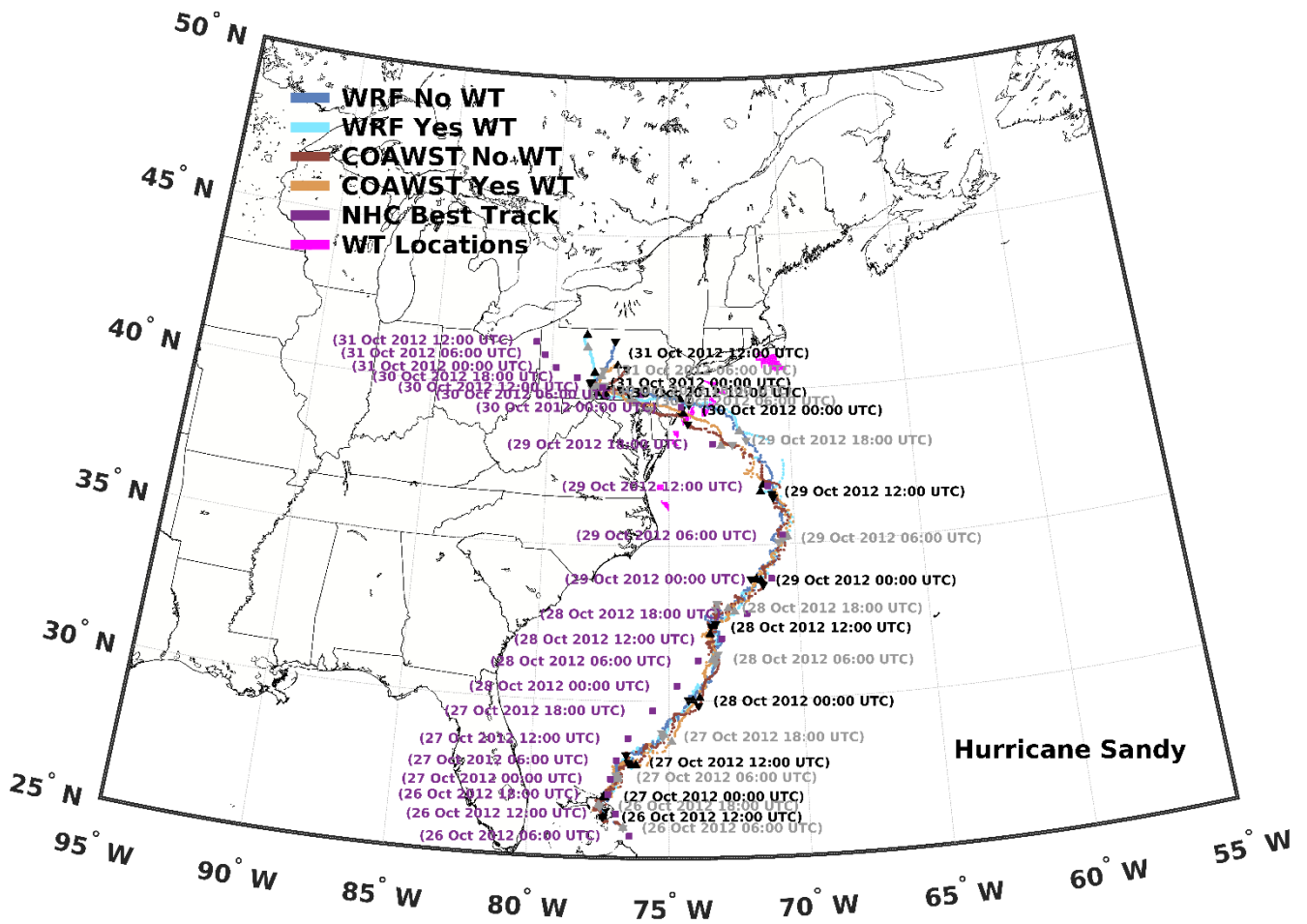
The mixture of 3 m foam and 3 m discus buoys have anemometer heights of 4.1 or 3.8 m above site elevation (site elevation is sea level), barometer elevations of 3.4, 2.7, or 2.4 m above sea level, sea temperature depths of 1.5 or 2 m below the water
30 line, and water depths from 24 to 4501 m. Note that buoy 41036, a 3 m discus buoy, was disestablished in 2015 and its heights, elevations, and depths are not included in the previous discussion. Each of the buoys provide both continuous winds data and standard meteorological data. Continuous winds data include a 10 min average WS value every 10 min and a maximum 5 s peak WG once an hour (with the hour starting/ending at 50 min past the top of the hour), with the time of occurrence noted. Standard meteorological data include SST, SLP, and Hs (“the average of the highest one-third of all of the
35 wave heights during the 20 min sampling period”), each provided at 50 min past the top of the hour.

45 **Table S1: The date and time that correspond to the numbered locations for Hurricanes Irene and Sandy shown in Fig. 1.**

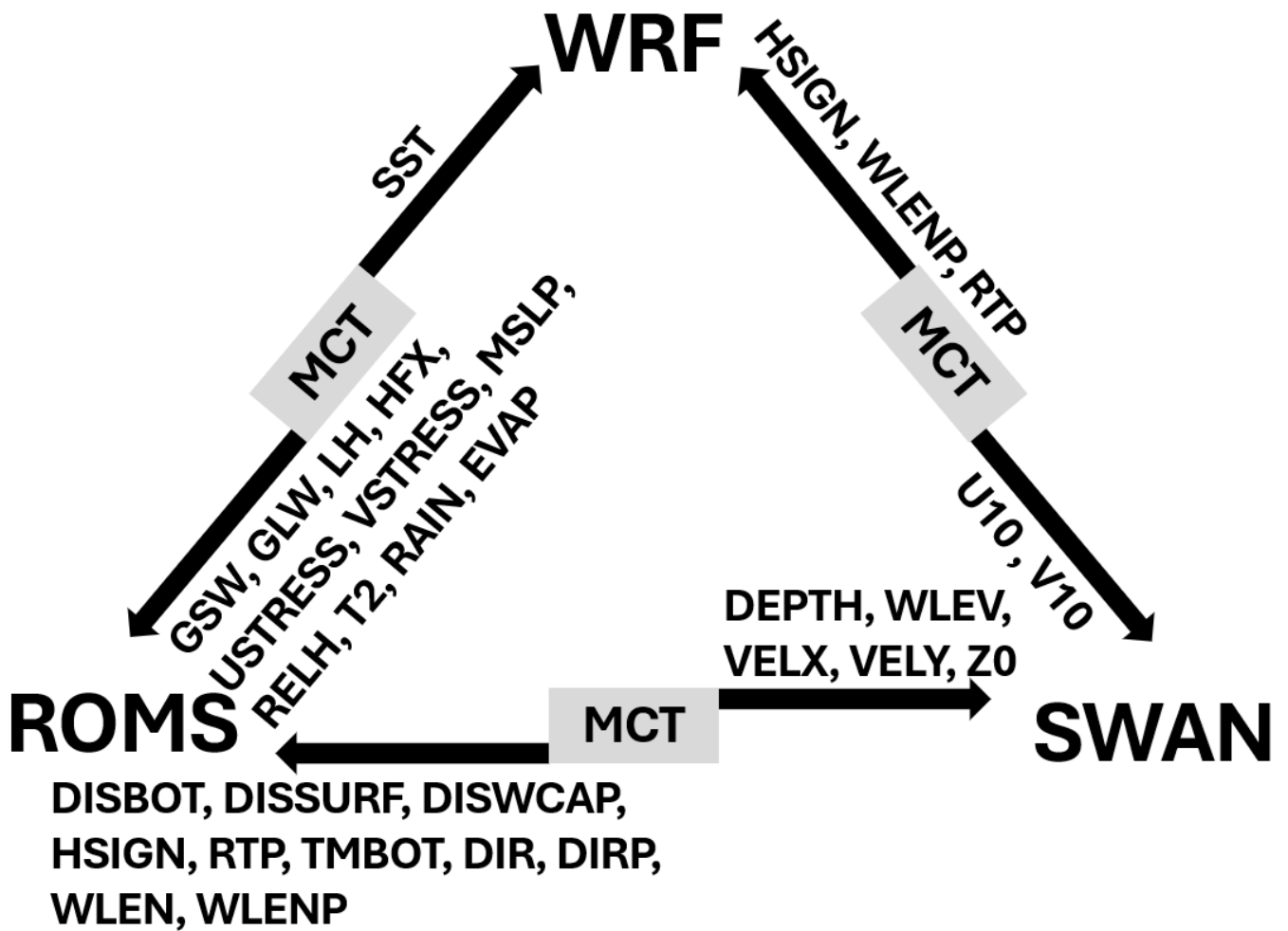
Location	Irene: Date and Time (UTC)	Sandy: Date and Time (UTC)
1	27 Aug 2011 18:00	29 Oct 2012 00:00
2	28 Aug 2011 00:00	29 Oct 2012 06:00
3	28 Aug 2011 06:00	29 Oct 2012 12:00
3a	28 Aug 2011 09:35 (landfall at Brigantine Island, NJ)	-
4	28 Aug 2011 12:00	29 Oct 2012 18:00
4a	28 Aug 2011 13:00 (landfall at Coney Island, NY)	29 Oct 2012 21:00 (downgraded to extratropical)
4b	-	29 Oct 2012 23:30 (landfall at Brigantine Island, NJ)
5	28 Aug 2011 18:00	30 Oct 2012 00:00
6	29 Aug 2011 00:00	30 Oct 2012 06:00
7	-	30 Oct 2012 12:00
8	-	30 Oct 2012 18:00
9	-	31 Oct 2012 00:00
10	-	31 Oct 2012 06:00
11	-	31 Oct 2012 12:00
12	-	31 Oct 2012 18:00



50 Figure S1: Track of Hurricane Irene within the outer domain from the WRF and COAWST simulations derived from the minimum sea level pressure (SLP) every 10 min, along with the corresponding National Hurricane Center (NHC) best track locations every 6 h. Hurricane Irene is tracked from 25 August 2011 18:00 UTC through 29 August 2011 12:00 UTC. Also shown (in magenta) are the locations of the wind turbines (WTs) in the offshore lease areas (LAs) considered herein.



55 Figure S2: Track of Hurricane Sandy within the outer domain from the WRF and COAWST simulations derived from the minimum sea level pressure (SLP) every 10 min, along with the corresponding National Hurricane Center (NHC) best track locations every 6 h. Hurricane Sandy is tracked from 26 October 2012 00:00 UTC through 31 October 2012 12:00 UTC. Also shown (in magenta) are the locations of the wind turbines (WTs) in the offshore lease areas (LAs) considered herein.

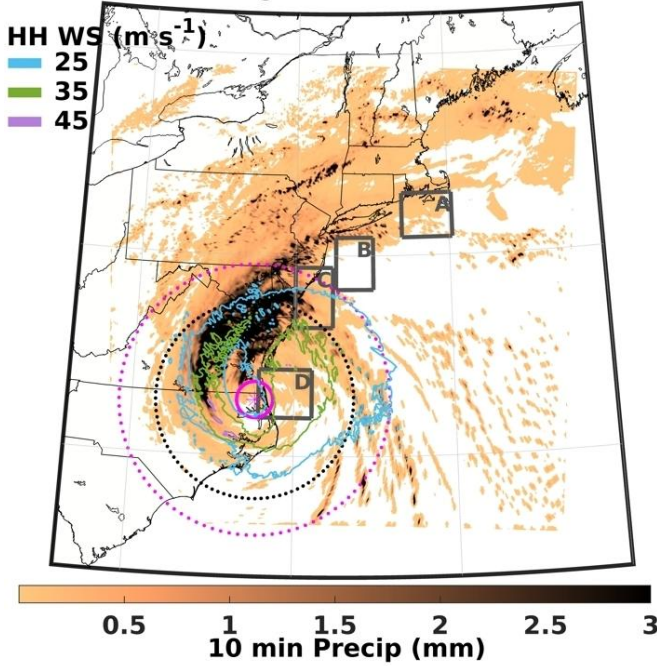


60 Figure S3: Schematic of complete flow between the COAWST model components. See Table S2 for additional details.

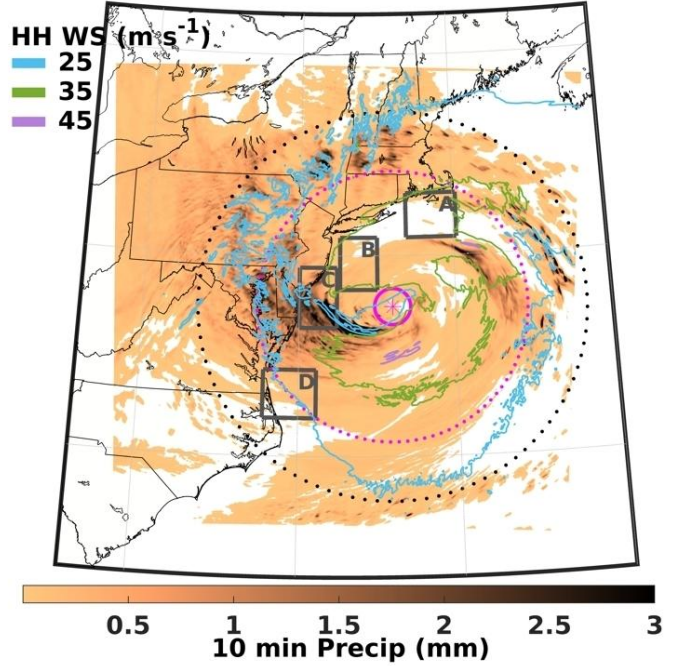
Table S2: Definitions used to describe the complete information flow between the COAWST model components in Fig S3.

Name	Abbreviation	Units
depth below mean sea level	DEPTH	m
mean wave direction	DIR	rad
peak wave direction	DIRP	rad
energy dissipation due to bottom friction	DISBOT	W m ⁻²
energy dissipation due to surf breaking	DISSURF	W m ⁻²
energy dissipation due to white-capping	DISWCAP	W m ⁻²
evaporation rate	EVAP	kg m ⁻² s ⁻¹
downward long wave flux at ground surface	GLW	W m ⁻²
net short wave flux at ground surface	GSW	W m ⁻²
upward heat flux at the surface	HFX	W m ⁻²
significant wave height	HSIGN	m
latent heat flux at the surface	LH	W m ⁻²
mean sea level pressure	MSLP	mb
rainfall rate	RAIN	kg m ⁻² s ⁻¹
relative humidity	RELH	-
relative peak period	RTP	s
sea surface temperature	SST	K
temperature at 2 m	T2	°C
near bottom wave period	TMBOT	s
x-wind component at 10 m	U10	m s ⁻¹
surface u-stress	USTRESS	N m ⁻²
y-wind component at 10 m	V10	m s ⁻¹
current velocity component in x direction	VELX	m s ⁻¹
current velocity component in y direction	VELY	m s ⁻¹
surface v-stress	VSTRESS	N m ⁻²
mean wave length	WLEN	m
peak wave length	WLENP	m
water level	WLEV	m
roughness length	Z0	m

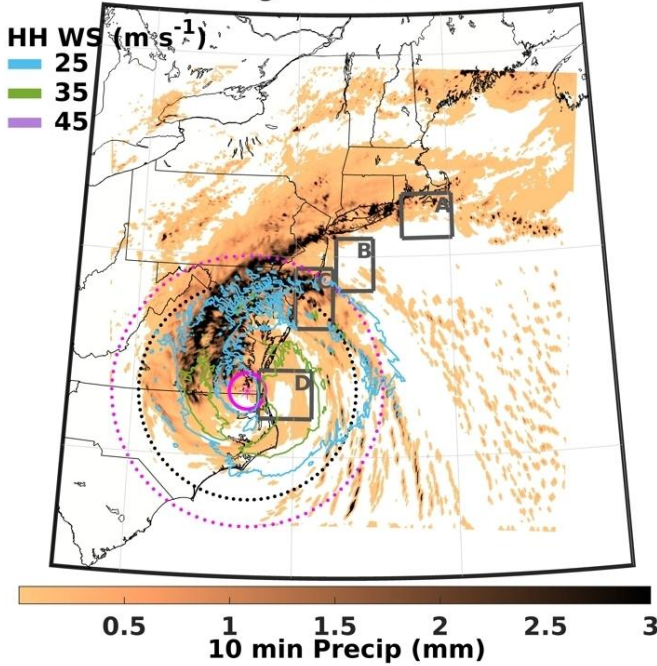
(a) Hurricane Irene - WRF - No WT:
28 Aug 2011 09:00 UTC



(c) Hurricane Sandy - WRF - No WT:
29 Oct 2012 19:00 UTC



(b) Hurricane Irene - COAWST - No WT:
28 Aug 2011 09:00 UTC



(d) Hurricane Sandy - COAWST - No WT:
29 Oct 2012 19:00 UTC

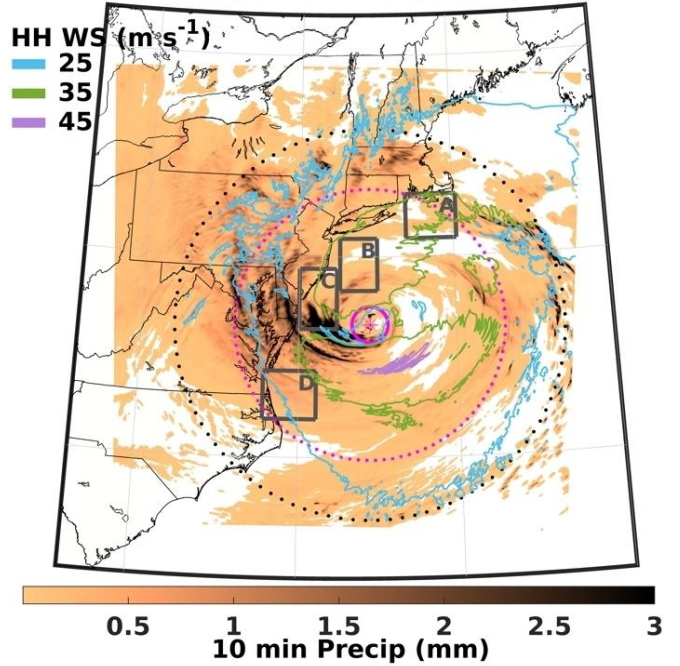


Figure S4: Simulated precipitation from (a, c) WRF and (b, d) COAWST during two example 10 min periods (background color) and contours of hub-height wind speed (HH WS) at 25, 35, and 45 m s^{-1} for (a, b) 28 August 2011 09:00 UTC and (c, d) 29 October 2012 19:00 UTC when the hurricanes are close to wind turbine (WT) lease areas (LAs). Magenta rings mark 50 km and 375 km from the minimum sea level pressure (SLP). The black rings mark the mean outermost radii of 18 m s^{-1} WSs at 10 m (R_{18}) of (a) 274 km, (b) 301 km, (c) 539 km, and (d) 541 km. For legibility, the colorbar is truncated. Maximum 10 min precipitation in any grid cell is (a) 14.0 mm, (b) 13.8 mm, (c) 18.4 mm, and (d) 16.8 mm.

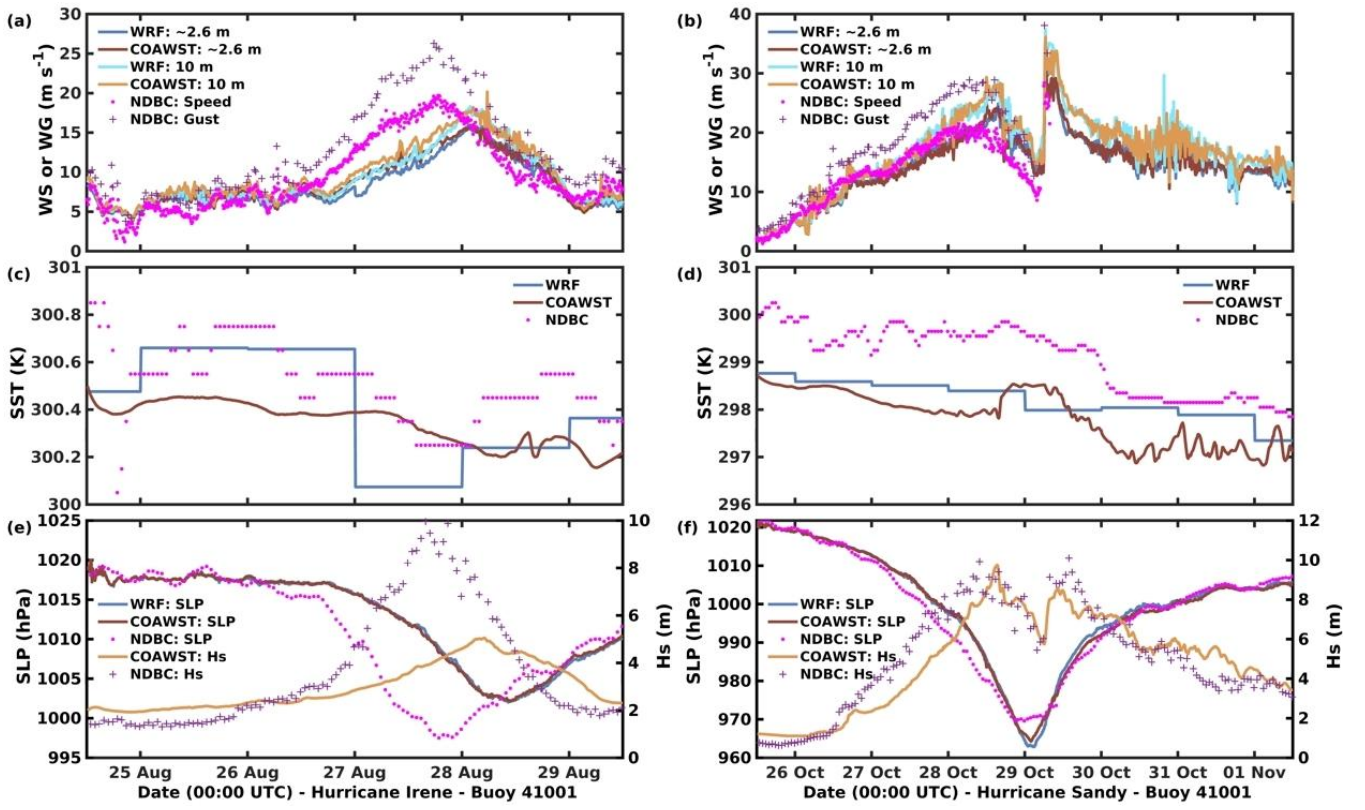


Figure S5: Time series of (a, b) wind speed (WS) and wind gust (WG), (c, d) sea surface temperature (SST), and (e, f) sea level pressure (SLP) and significant wave height (Hs) from observations and simulations (WRF and COAWST without wind turbines [WTs]) for Hurricane Irene (a, c, and e) and Hurricane Sandy (b, d, and f) at buoy 41001 (see location in main text Fig. 2a).

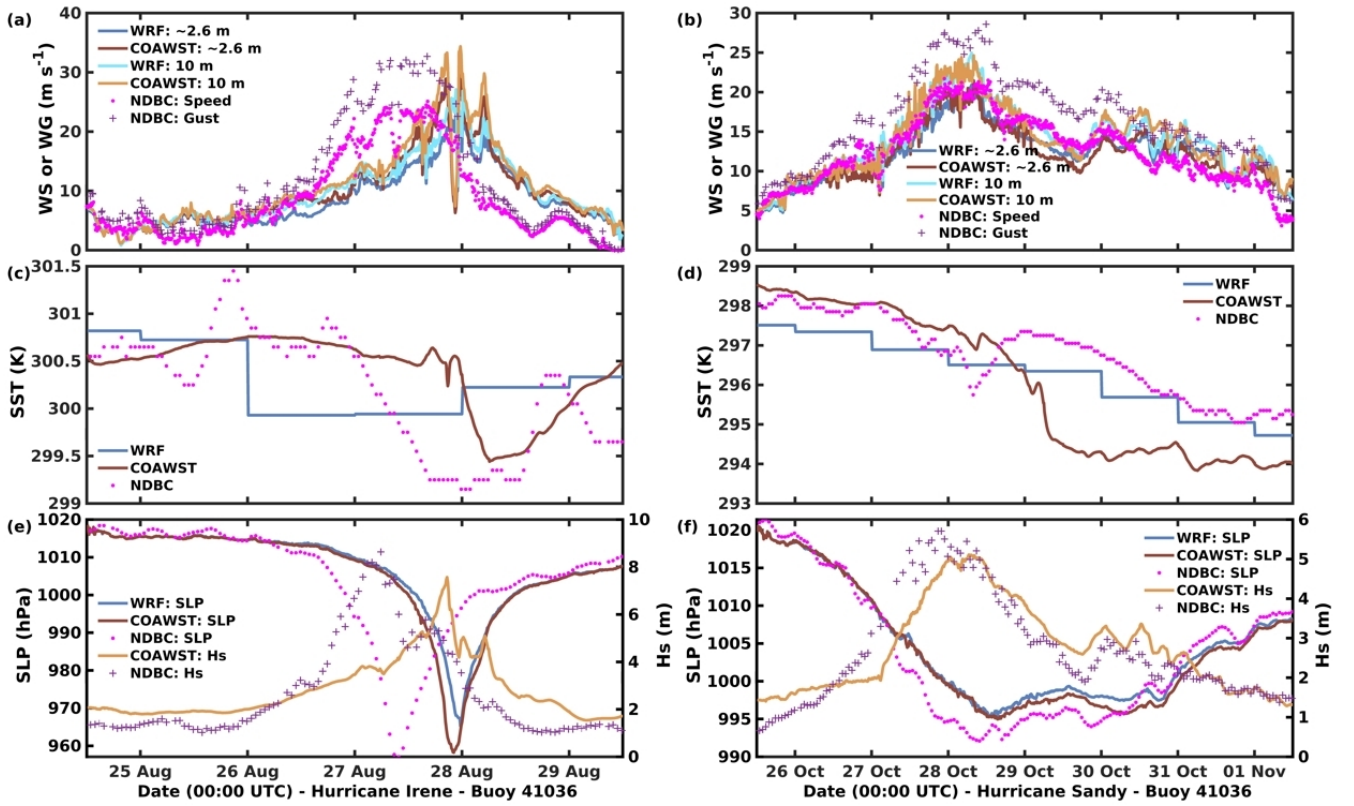


Figure S6: Time series of (a, b) wind speed (WS) and wind gust (WG), (c, d) sea surface temperature (SST), and (e, f) sea level pressure (SLP) and significant wave height (Hs) from observations and simulations (WRF and COAWST without wind turbines [WTs]) for Hurricane Irene (a, c, and e) and Hurricane Sandy (b, d, and f) at buoy 41036 (see location in main text Fig. 2a).

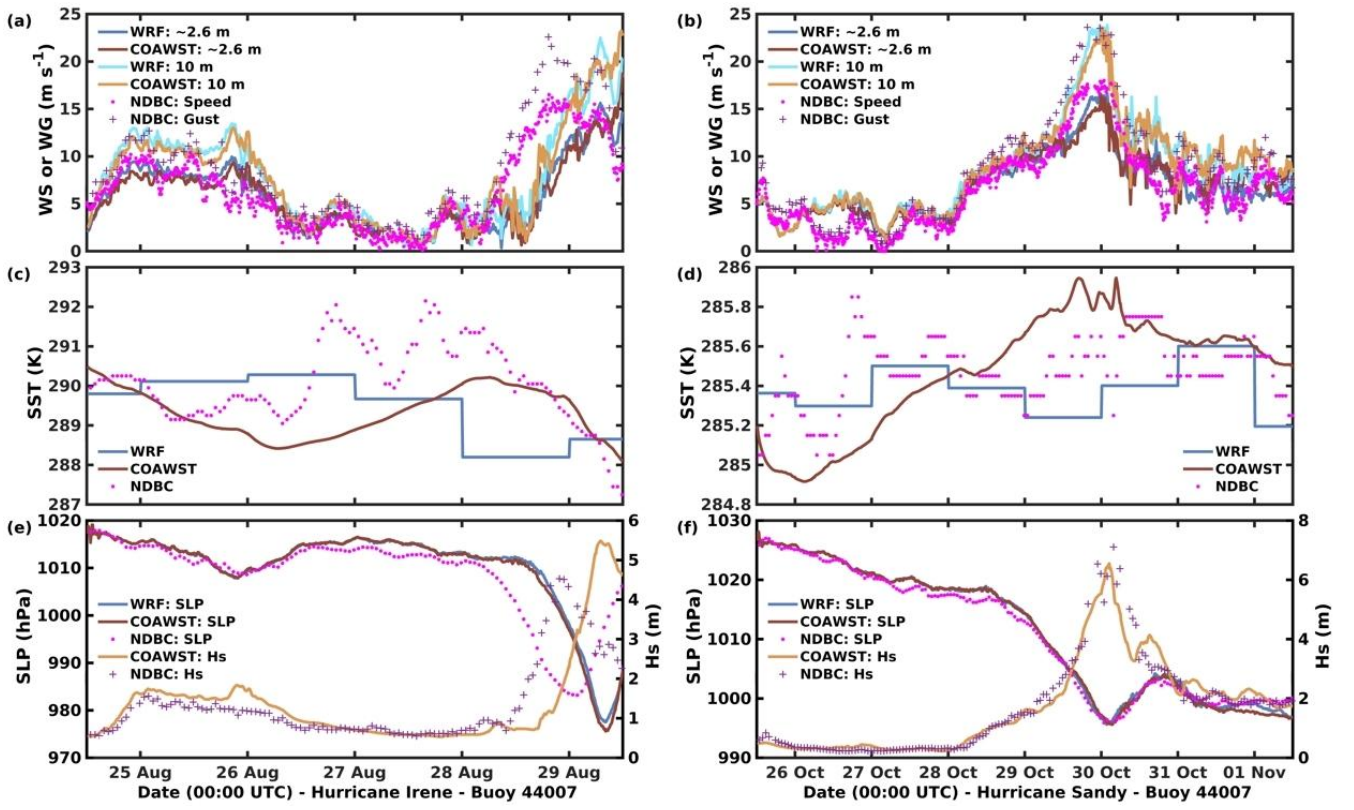


Figure S7: Time series of (a, b) wind speed (WS) and wind gust (WG), (c, d) sea surface temperature (SST), and (e, f) sea level pressure (SLP) and significant wave height (Hs) from observations and simulations (WRF and COAWST without wind turbines [WTs]) for Hurricane Irene (a, c, and e) and Hurricane Sandy (b, d, and f) at buoy 44007 (see location in main text Fig. 2a).

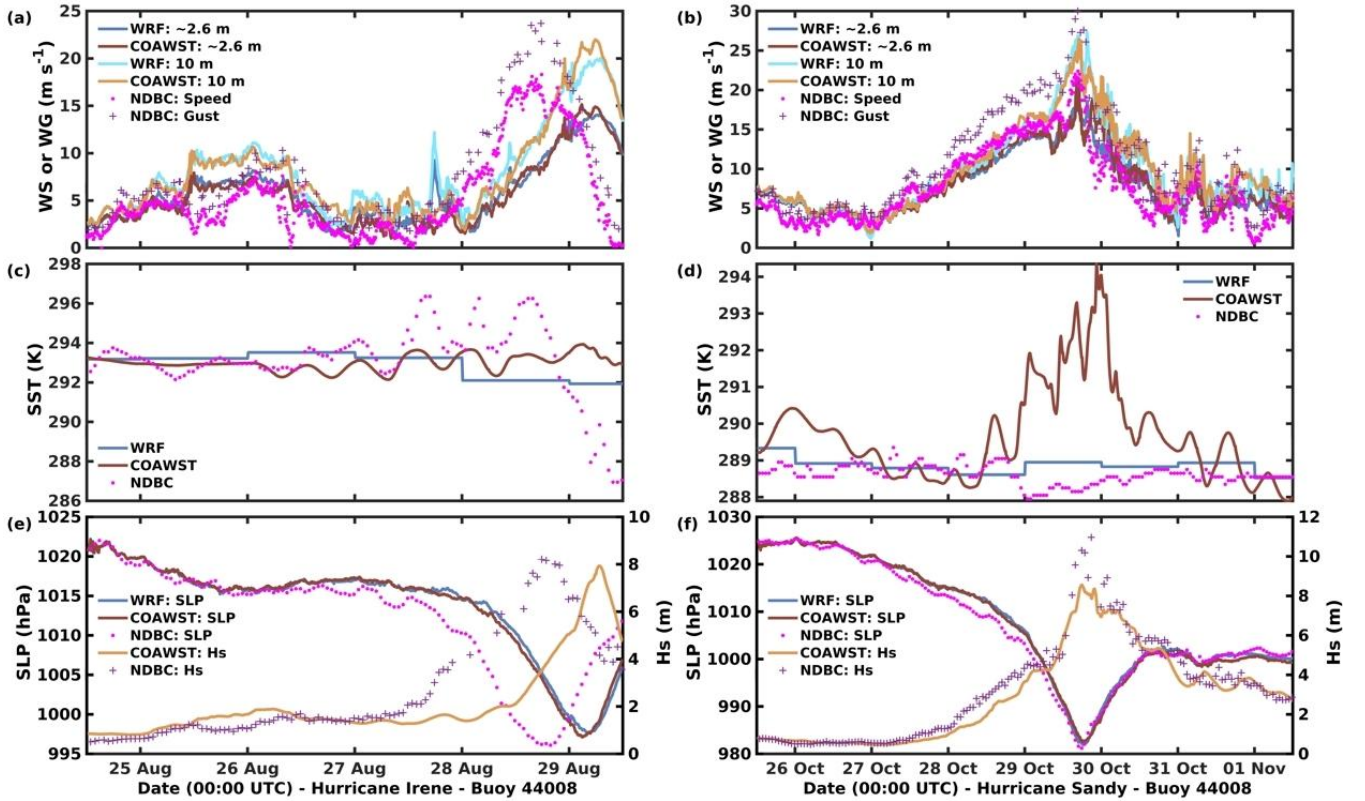
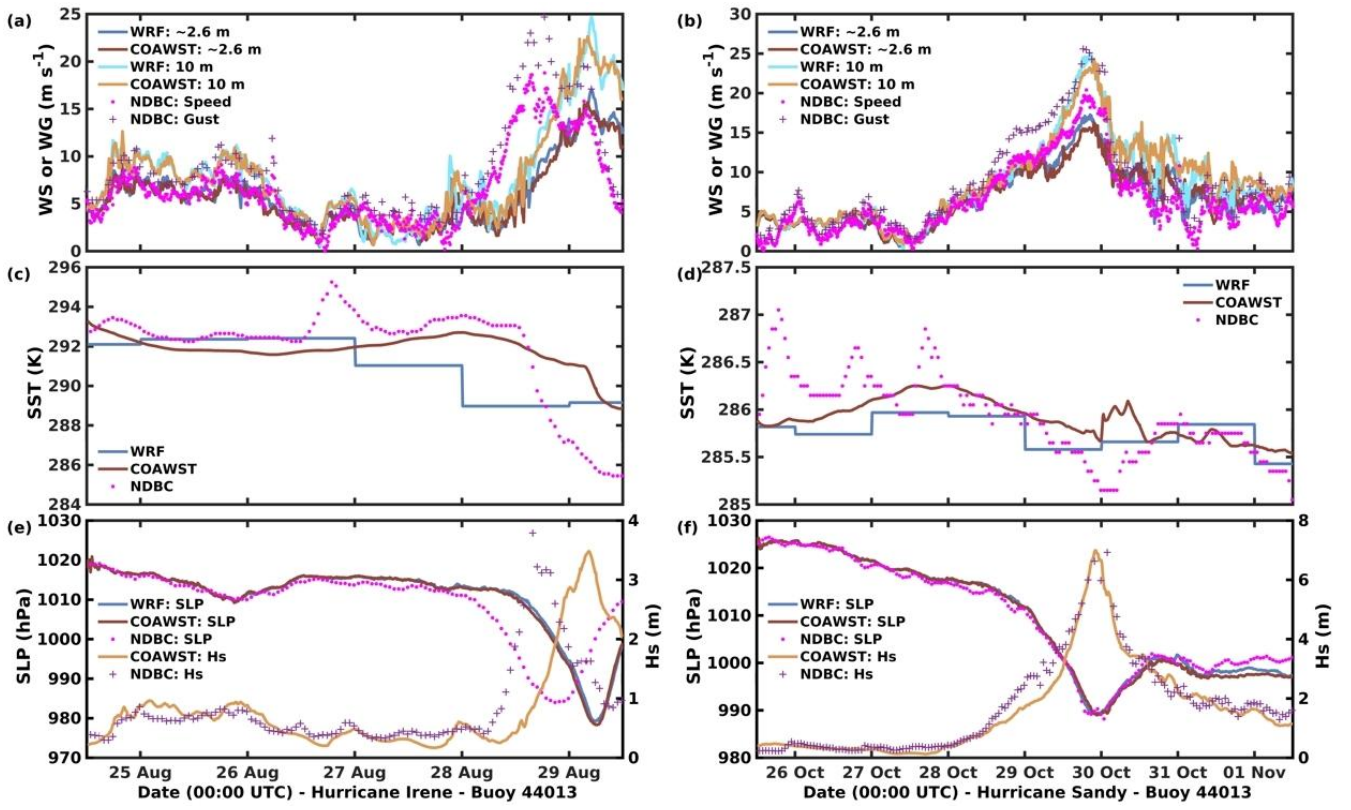
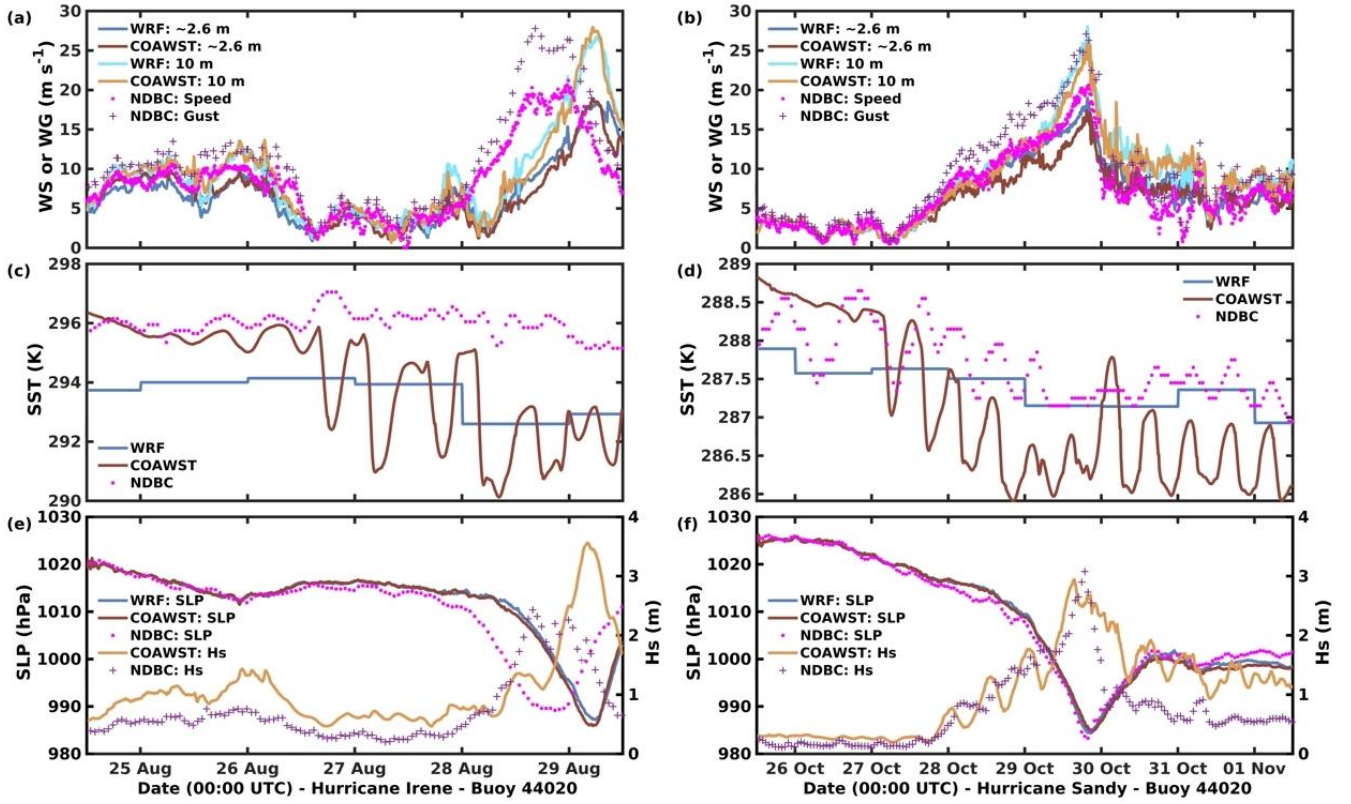


Figure S8: Time series of (a, b) wind speed (WS) and wind gust (WG), (c, d) sea surface temperature (SST), and (e, f) sea level pressure (SLP) and significant wave height (Hs) from observations and simulations (WRF and COAWST without wind turbines [WTs]) for Hurricane Irene (a, c, and e) and Hurricane Sandy (b, d, and f) at buoy 44008 (see location in main text Fig. 2a).



95 Figure S9: Time series of (a, b) wind speed (WS) and wind gust (WG), (c, d) sea surface temperature (SST), and (e, f) sea level pressure (SLP) and significant wave height (Hs) from observations and simulations (WRF and COAWST without wind turbines [WTs]) for Hurricane Irene (a, c, and e) and Hurricane Sandy (b, d, and f) at buoy 44013 (see location in main text Fig. 2a).



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Figure S10: Time series of (a, b) wind speed (WS) and wind gust (WG), (c, d) sea surface temperature (SST), and (e, f) sea level pressure (SLP) and significant wave height (Hs) from observations and simulations (WRF and COAWST without wind turbines [WTs]) for Hurricane Irene (a, c, and e) and Hurricane Sandy (b, d, and f) at buoy 44020 (see location in main text Fig. 2a).

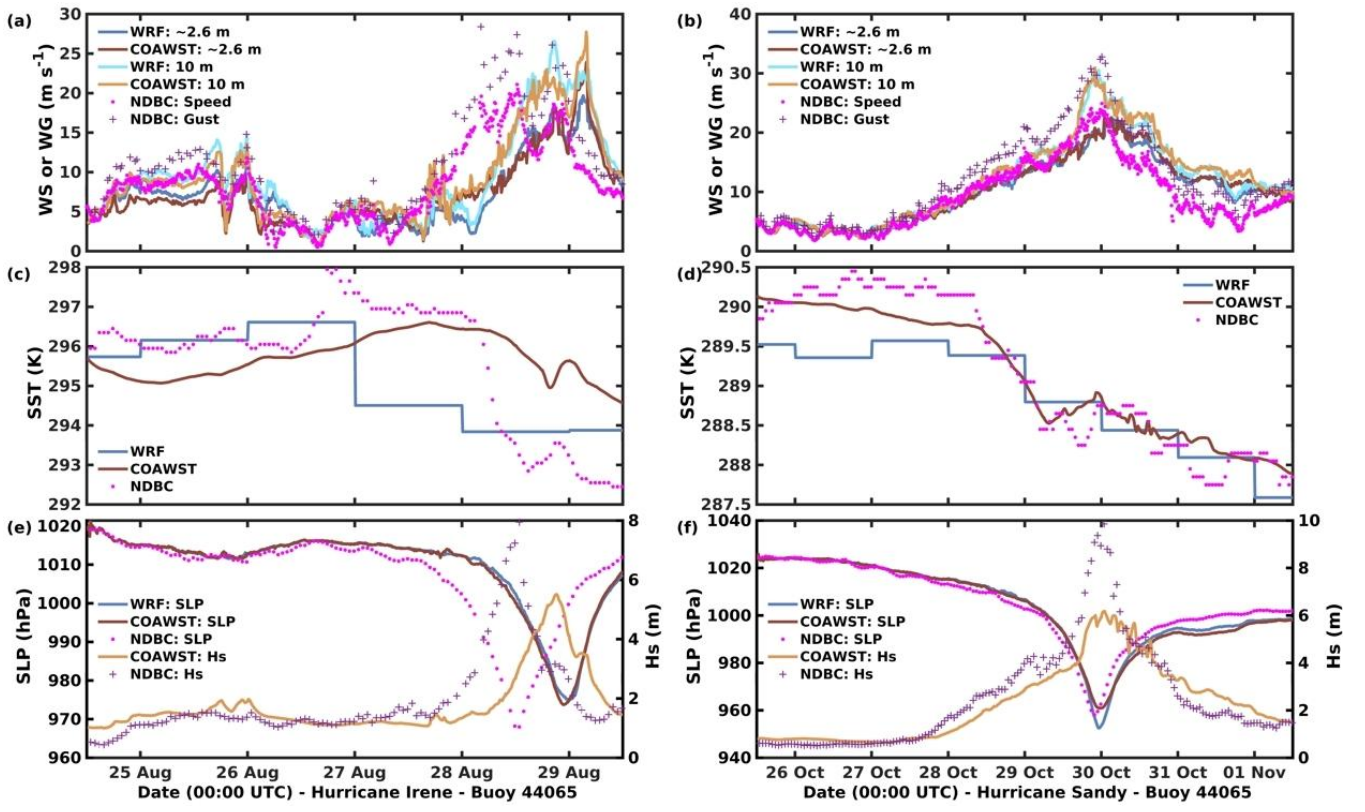
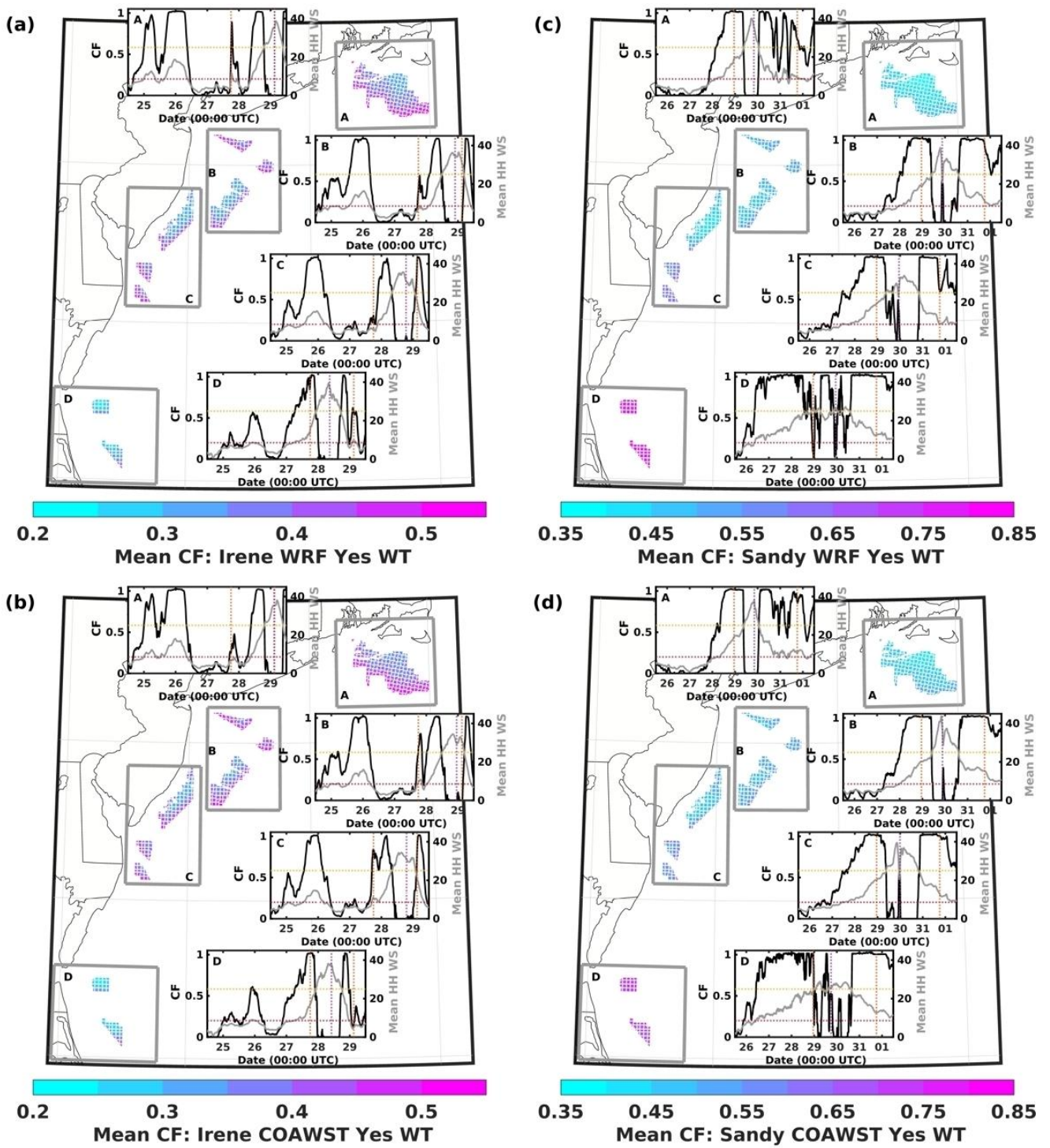


Figure S11: Time series of (a, b) wind speed (WS) and wind gust (WG), (c, d) sea surface temperature (SST), and (e, f) sea level pressure (SLP) and significant wave height (Hs) from observations and simulations (WRF and COAWST without wind turbines [WTs]) for Hurricane Irene (a, c, and e) and Hurricane Sandy (b, d, and f) at buoy 44065 (see location in main text Fig. 2a).



110 Figure S12: Mean capacity factor (CF) from (a, c) WRF simulations and (b, d) COAWST simulations for (a, b) Hurricane Irene and (c, d) Hurricane Sandy. Also shown are time series of the CF and mean hub-height wind speed (HH WS) for the four lease area (LA) clusters. Orange dashed lines indicate the start and end time of storm tracking within d02. The purple dashed line represents the time when the location of the minimum sea level pressure (SLP) is closest to the cluster center. The red dashed line indicates CF = 0.2 and the yellow line indicates HH WS = 25 m s⁻¹.

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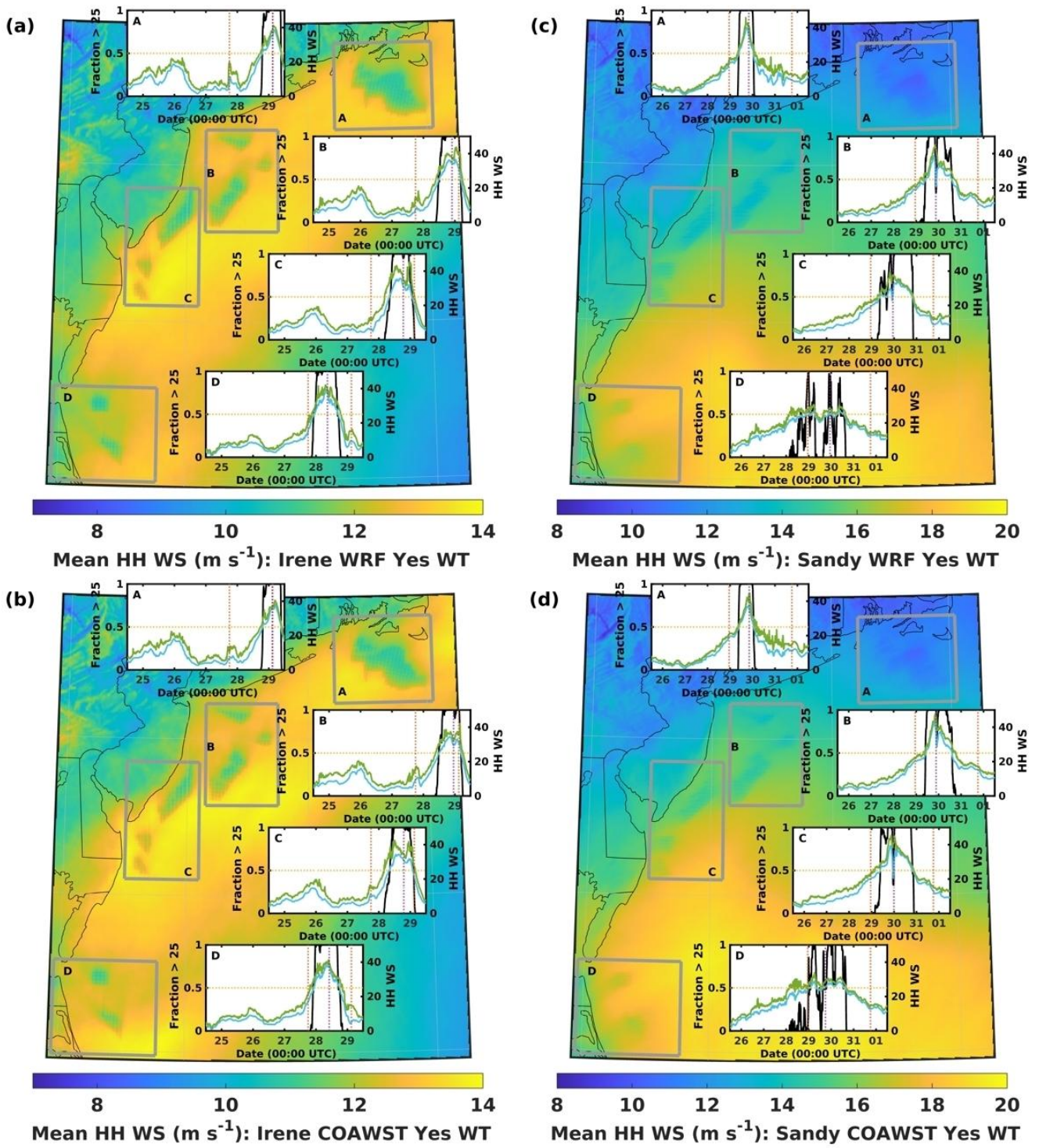


Figure S13: Mean simulated hub-height wind speed (HH WS) with the wind farm parameterization (WFP) active from (a, c) WRF and (b, d) COAWST for (a, b) Hurricane Irene and (c, d) Hurricane Sandy. The time series show the fraction of wind turbine (WT) grid cells with HH WS $> 25 \text{ m s}^{-1}$ (left axis, black) plus the mean (blue) and maximum (green) HH WS in those grid cells (right axis). Orange dashed lines indicate the start and end time of storm tracking within d02. The purple dashed line represents the time when the location of the minimum sea level pressure (SLP) is closest to the lease area (LA) cluster center. The yellow line indicates HH WS = 25 m s^{-1} .

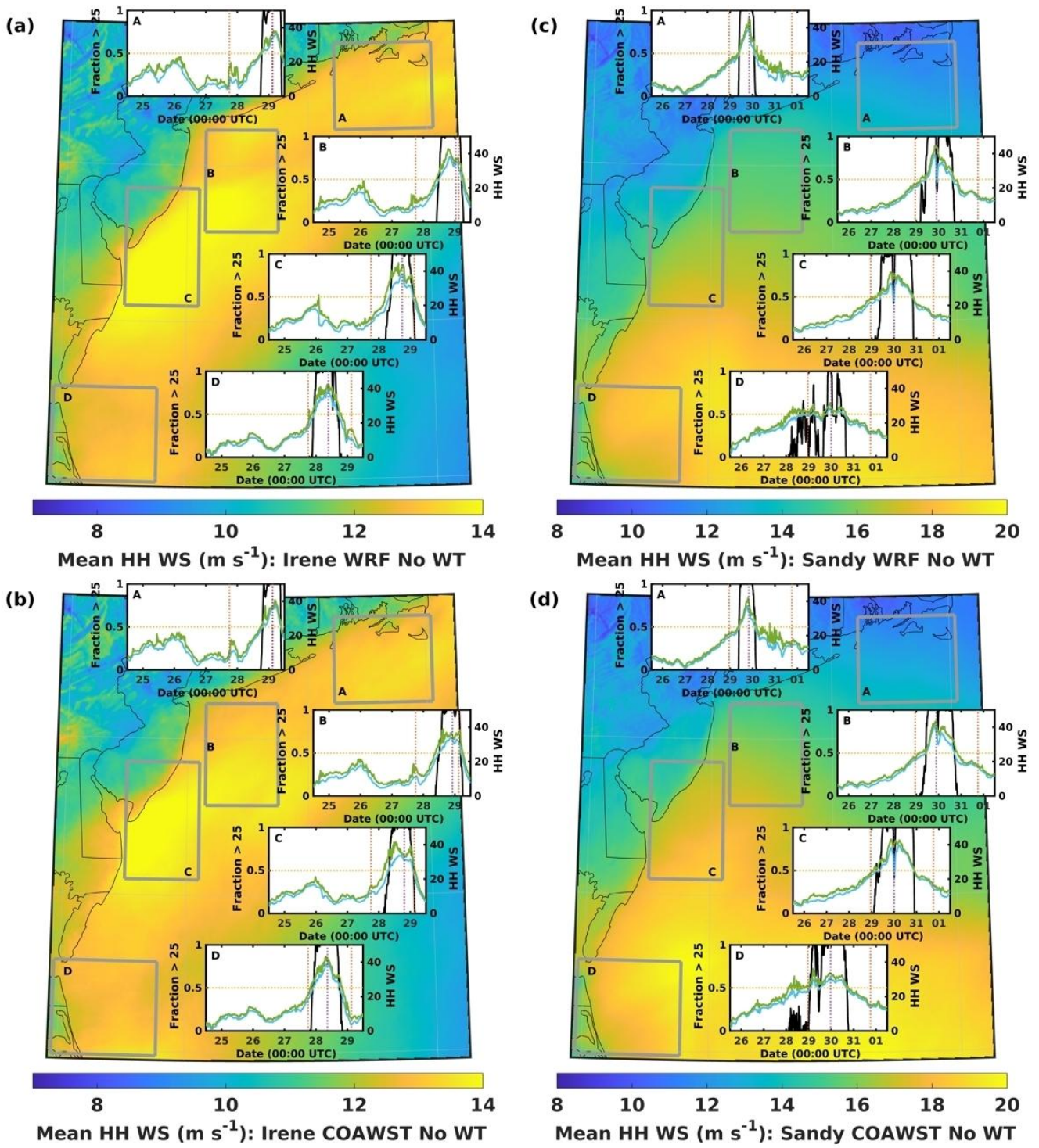


Figure S14: Mean simulated hub-height wind speed (HH WS) without the wind farm parameterization (WFP) active from (a, c) WRF and (b, d) COAWST for (a, b) Hurricane Irene and (c, d) Hurricane Sandy. The time series show the fraction of wind turbine (WT) grid cells with HH WS $> 25 \text{ m s}^{-1}$ (left axis, black) plus the mean (blue) and maximum (green) HH WS in those grid cells (right axis). Orange dashed lines indicate the start and end time of storm tracking within d02. The purple dashed line represents the time when the minimum sea level pressure (SLP) is closest to the lease area (LA) cluster center. The yellow line indicates HH WS = 25 m s^{-1} .

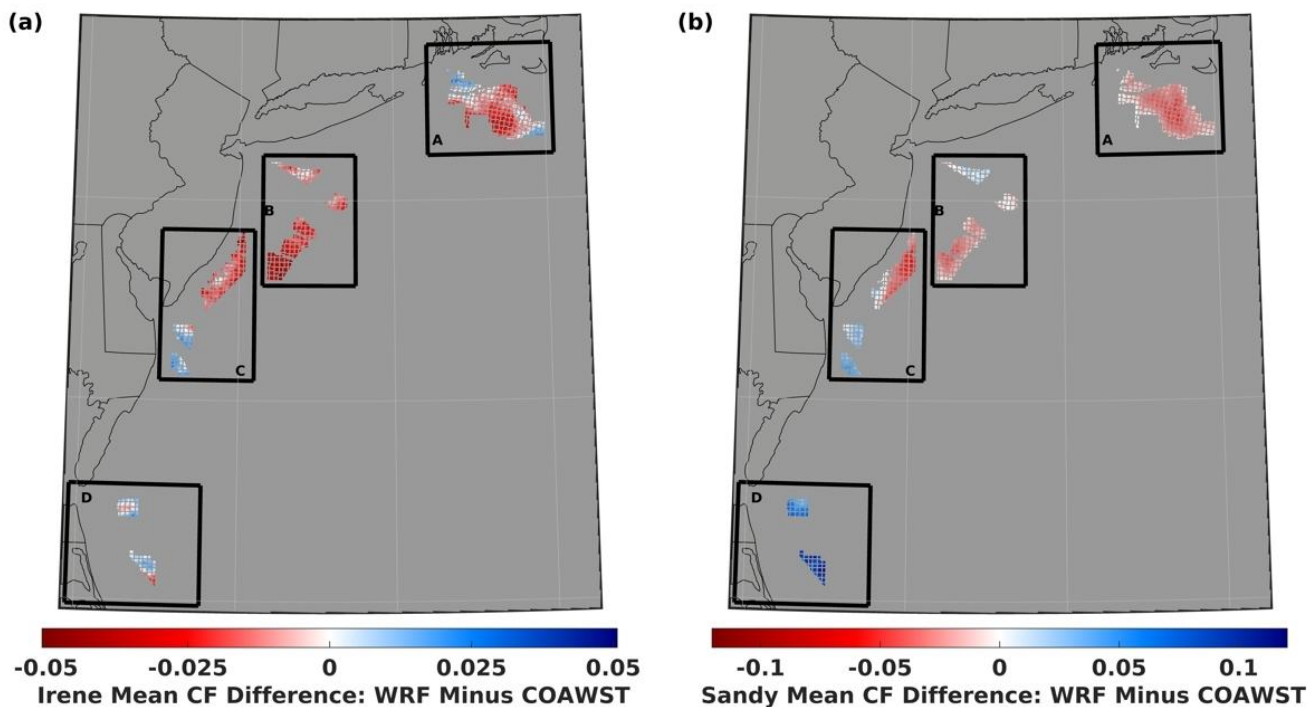


Figure S15: Mean difference in capacity factor (CF) from the simulations, WRF minus COAWST, for Hurricanes (a) Irene and (b) Sandy.

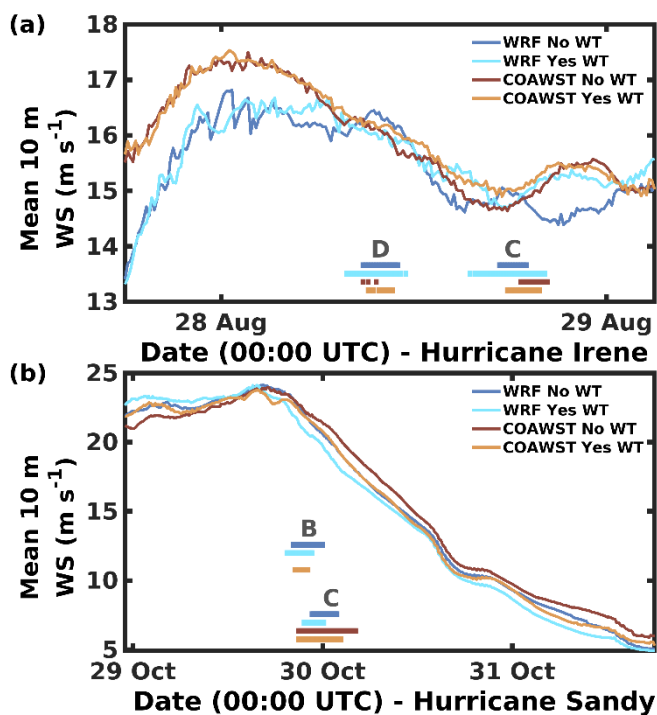


Figure S16: Time series of the mean 10 m wind speed (WS) from 50 to 375 km from the minimum sea level pressure (SLP) location for Hurricanes (a) Irene and (b) Sandy. The colored horizontal lines and labels denote times when the minimum SLP is within 100 km of the center of the specified lease area (LA) cluster centroid.