

NWS 13: NetCDF Wind/Pressure Inputs for ADCIRC

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Summary

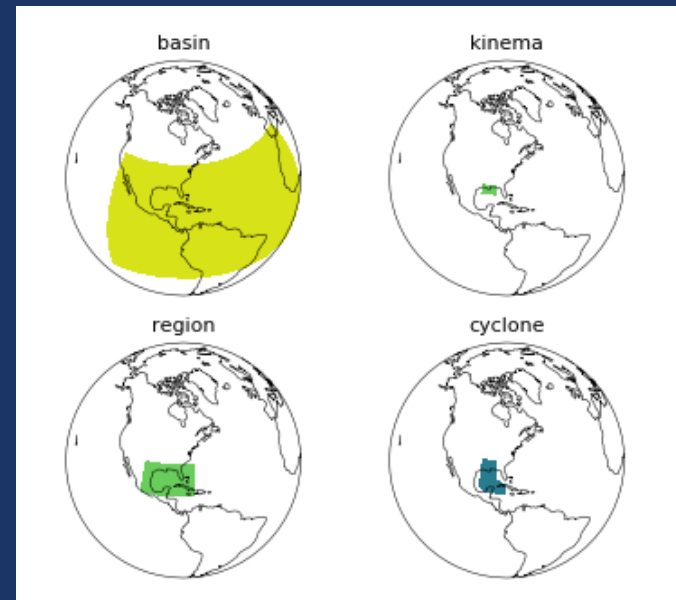
- Motivation
- NetCDF Structure/Schema
- Implementation
- Examples
- Application

Basic Needs

- Self-describing
- Efficient
- Multi-grid
- Replicate NWS12 features and more
- Single-file, wind/pressure/all-grids
- Common & community supported format

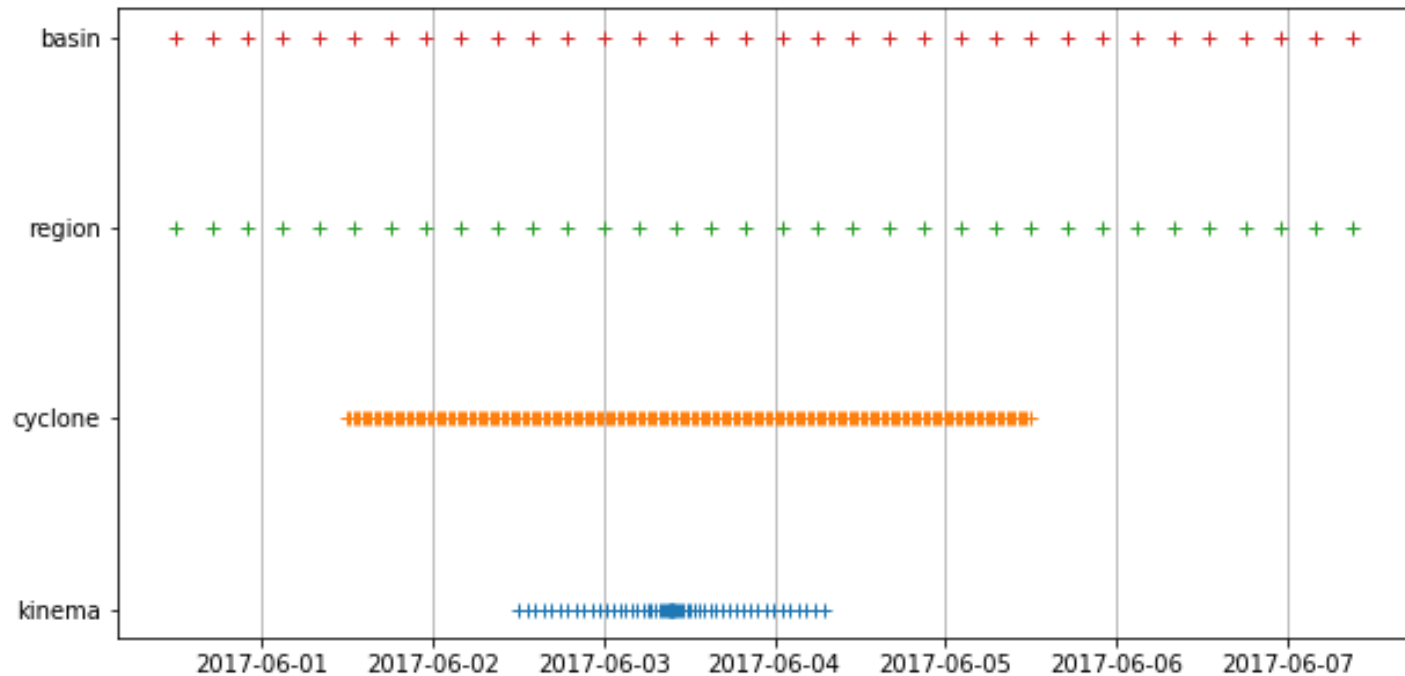
Additional Motivation

- Moving storm-centered grids
- Grids that can change size
- Curvilinear grids
- Arbitrary # of grid overlays
- New ADCIRC NWS interp code
- Arbitrary & irregular timesteps



Example of grid domains for multiple independent wind/pressure overlays.

Additional Motivation



Example of independent time-stepping for each overlay, including individual start/stop and non-regular timestep intervals.

Future-proofing Attempts

- Multi-resolution representation of tropical cyclone wind fields
- Be able to introduce additional meteorological parameters using the same format/NWS input
 - Possibility to include wind stresses
 - Alternative reference heights

NWS 13 NetCDF Schema

NetCDF4 File:

Group(s) – 1 group per grid or overlay

Variables – U10/V10, PSFC

Dimensions – time, yi, xi

Attributes – grid rank/priority

NWS 13 NetCDF Schema

Global Attributes:

group_order: space separated list of group names reflecting their appropriate rank/order

conventions: should include “OWI-NWS13”

(Climate Forecast conventions (CF) seemingly don't support NC groups)

NWS 13 NetCDF Schema

Group Attributes:

rank: integer representing the order of overlay/precedence in application to nodes

NWS 13 NetCDF Schema

Group Dimensions:

time – length of time dimension

yi – number of rows in spatial grid description

xi – number of columns in spatial grid description

NWS 13 NetCDF Schema

Group Variables:

U10 (time, yi, xi), U-component of 10m WS (m/s)

V10 (time, yi, xi), V-component of 10m WS (m/s)

PSFC (time, yi, xi), Surface Pressure (mb)

lon (yi, xi) or (time, yi, xi), Longitude in Decimal Degrees

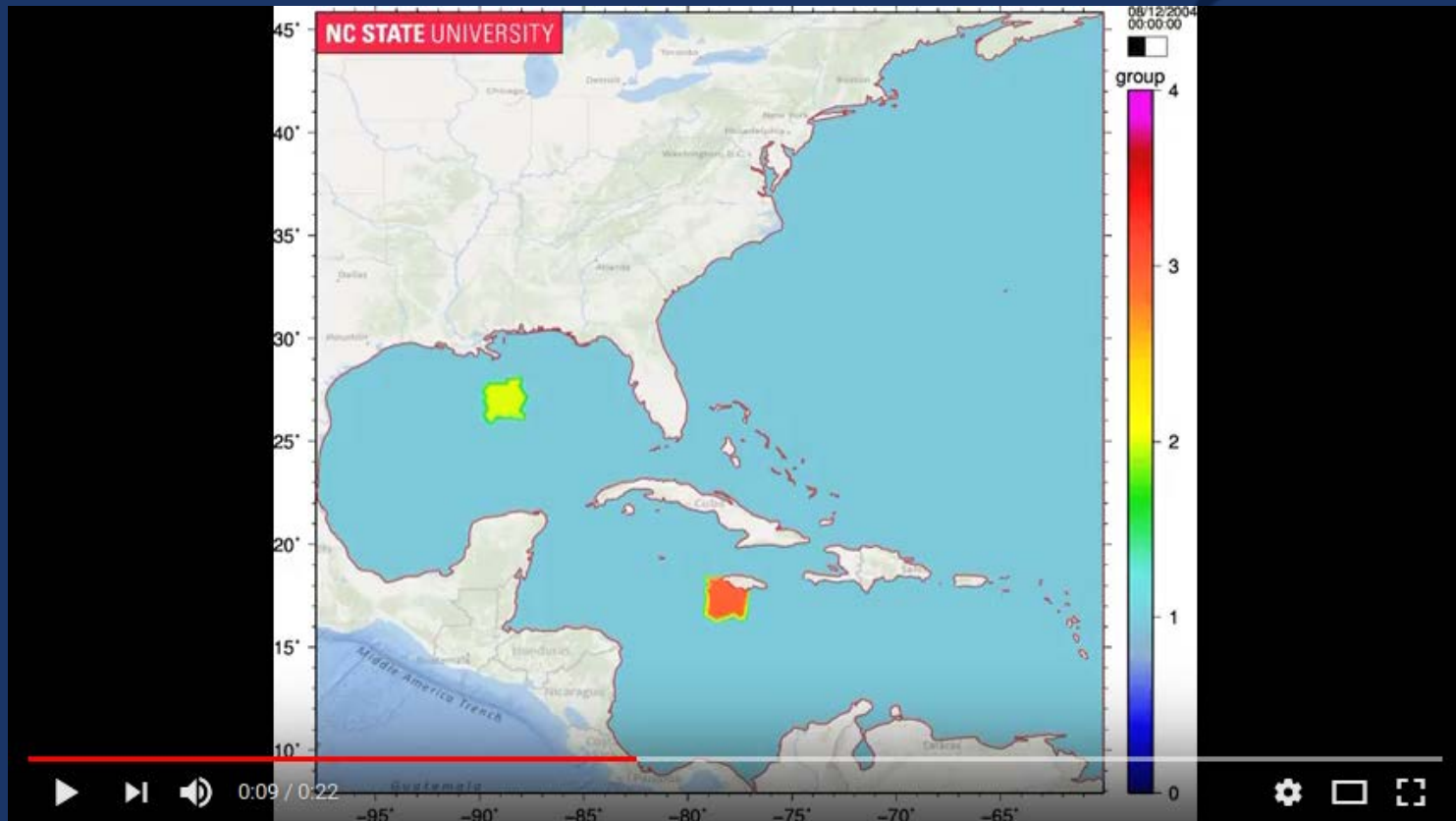
lat (yi, xi) or (time, yi, xi), Latitude in Decimal Degrees

time (time), Datetime-number with units specified

Schema Notes

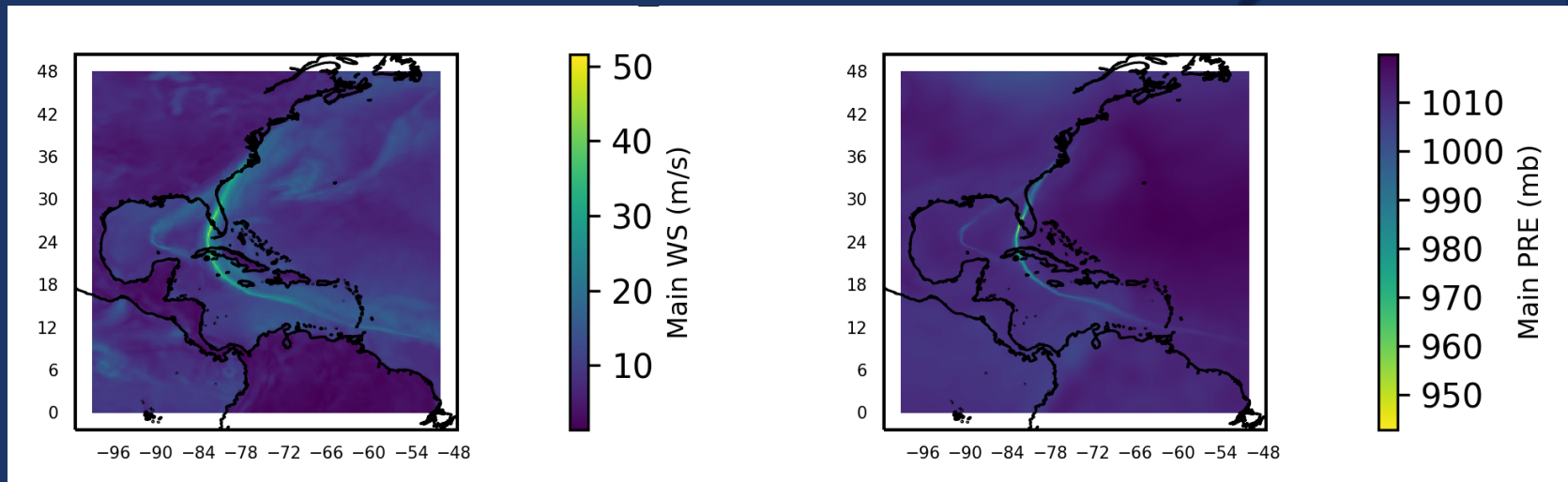
- Decoupling the y_i/x_i dimensions from lat/lon allows lat and lon to be 2-d arrays by depending on both dimensions
- Regular grids and Curvilinear grids
- Non-evenly spaced grids (our raw tropical model output has higher resolution in the core than in the far field)
- Grids that change spatial resolution or position in time (but have consistent y_i/x_i array size)
- Each group/sub-grid can define the timesteps independently, including start and stop times
- Fill Value (and NetCDF packing/compression)

ADCIRC Implementation



Multiple grids applied to nodes on relatively coarse mesh
<https://youtu.be/4brhCdsjqeU>

Example: Charley 2004



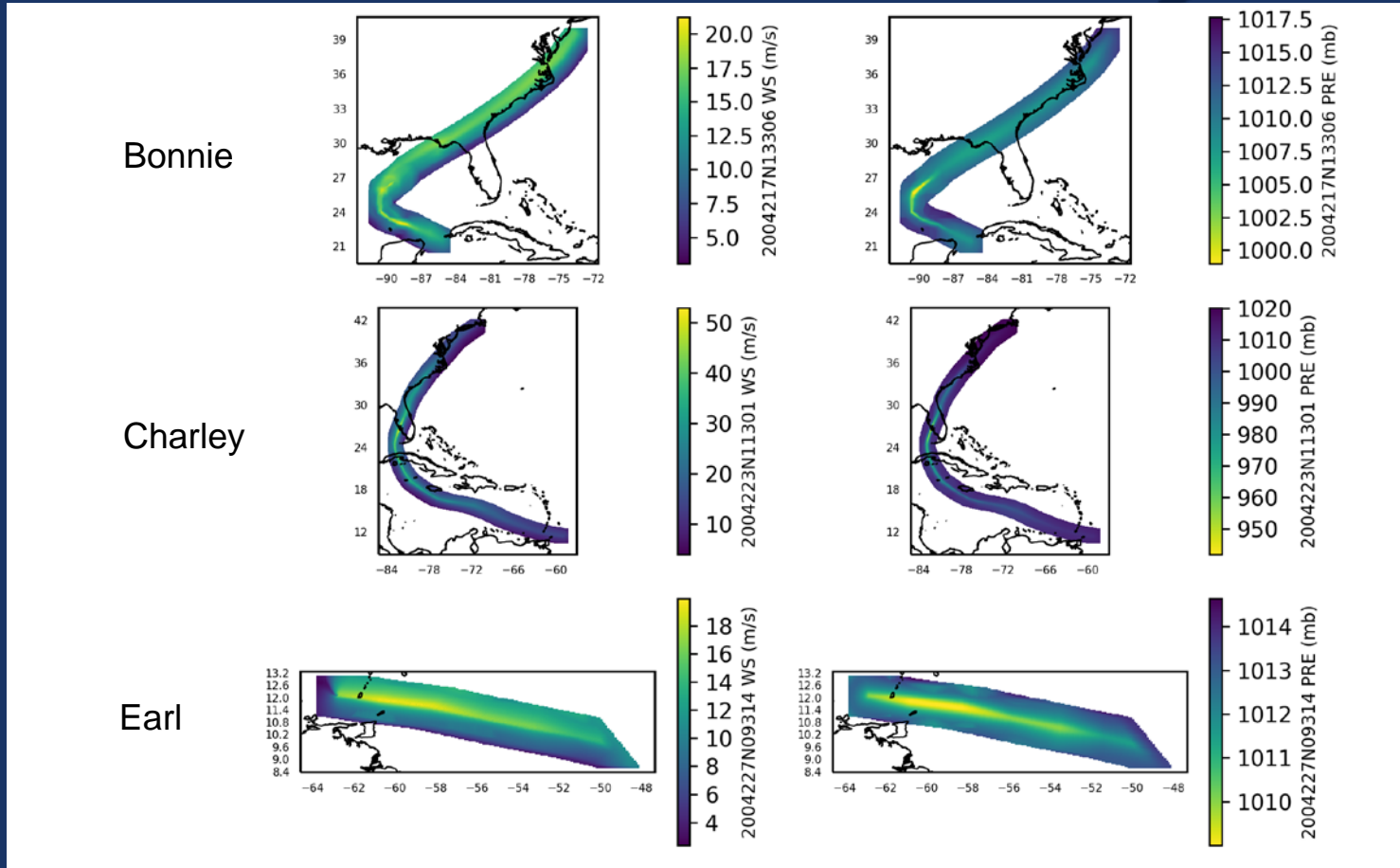
Max wind speed, left, (and minimum pressure, right) over “Main” basin scale grid for the duration of the Charley (2004) Hurricane.

Test file*: http://s3.amazonaws.com/owi-nws13/Charley_2004_Test.nc

* We don't consider this quality controlled or validated science quality data

Headers/Structure: http://s3.amazonaws.com/owi-nws13/Charley_2004_Test.nc.cdl

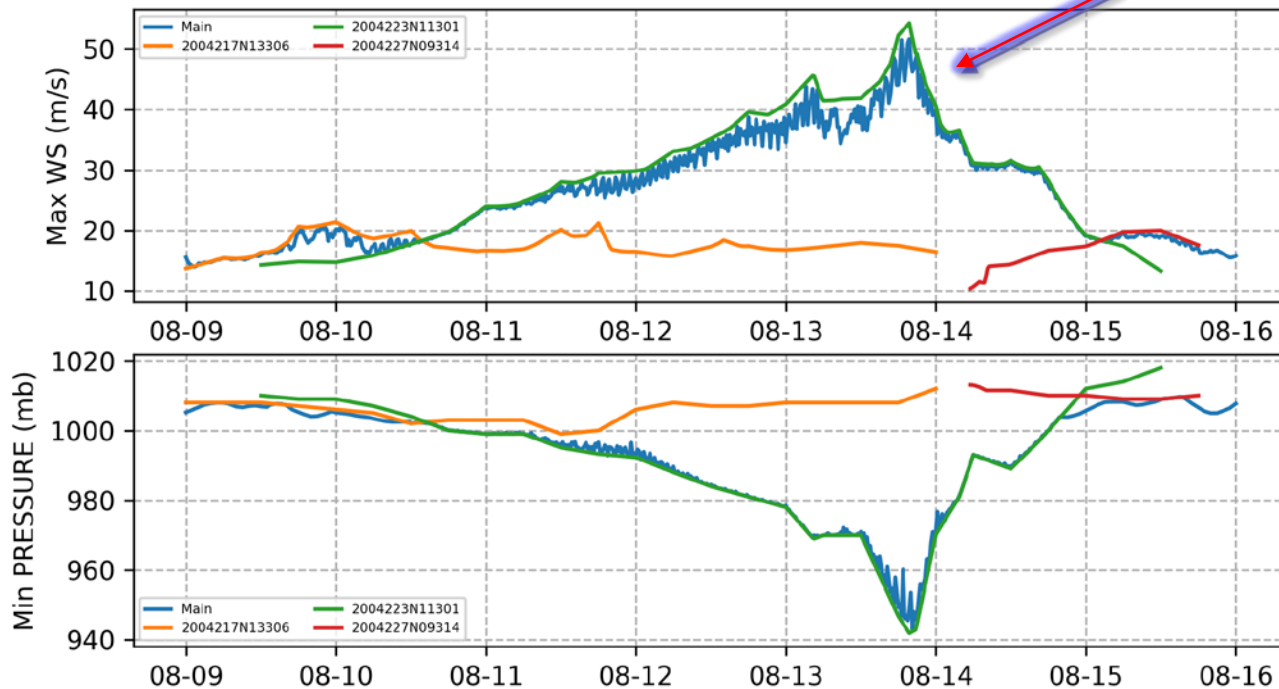
Example: Charley 2004



Max wind speed, left, (and minimum pressure, right) for Charley and the 2 tropical systems that coincide with the Charley time period (+ model spinup).

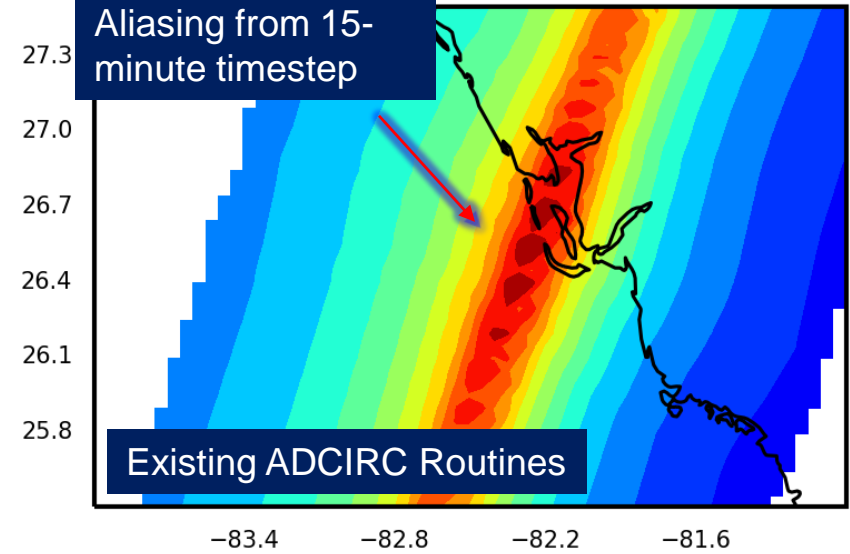
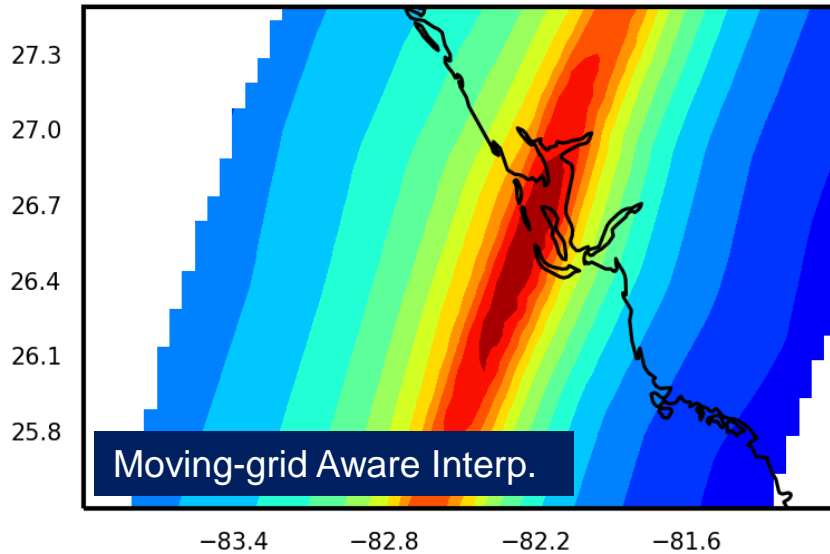
Example: Charley 2004

Note the aliasing of the max wind speeds due to the spatial resolution of the large scale grid



Time evolution of maximum wind speed (top) and minimum surface pressure (bottom) by sub-grid/overlay for Charley example file.

Example: Charley 2004

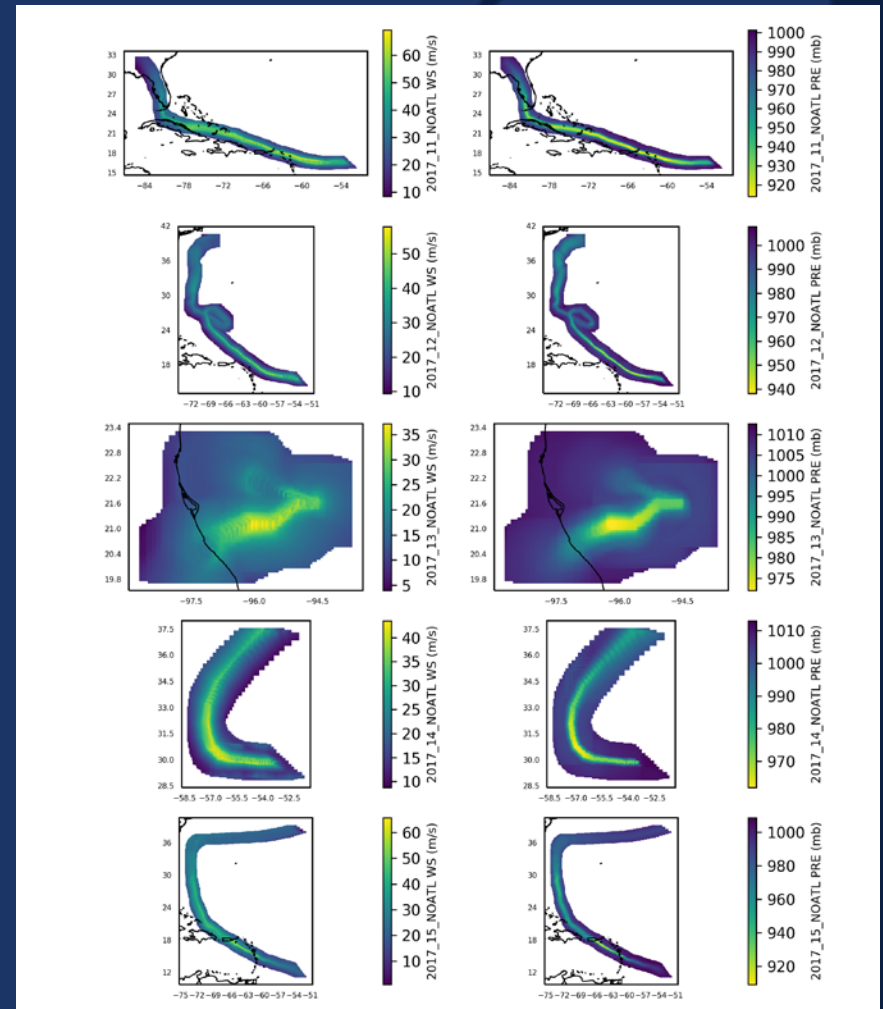
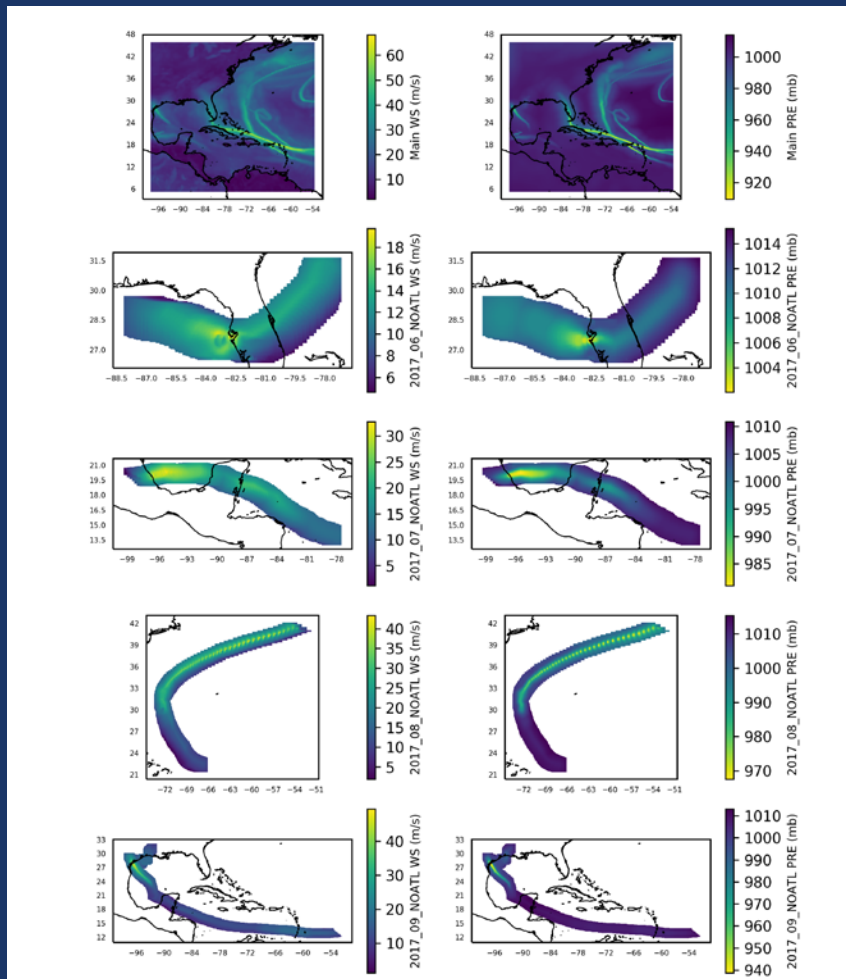


Max wind speed plots showing the impact of intelligent moving-grid aware interpolation routines (left) compared to a fixed 15-minute timestep (right) from fast moving Hurricane Charley (2004) as it makes landfall in Florida.

Production Example

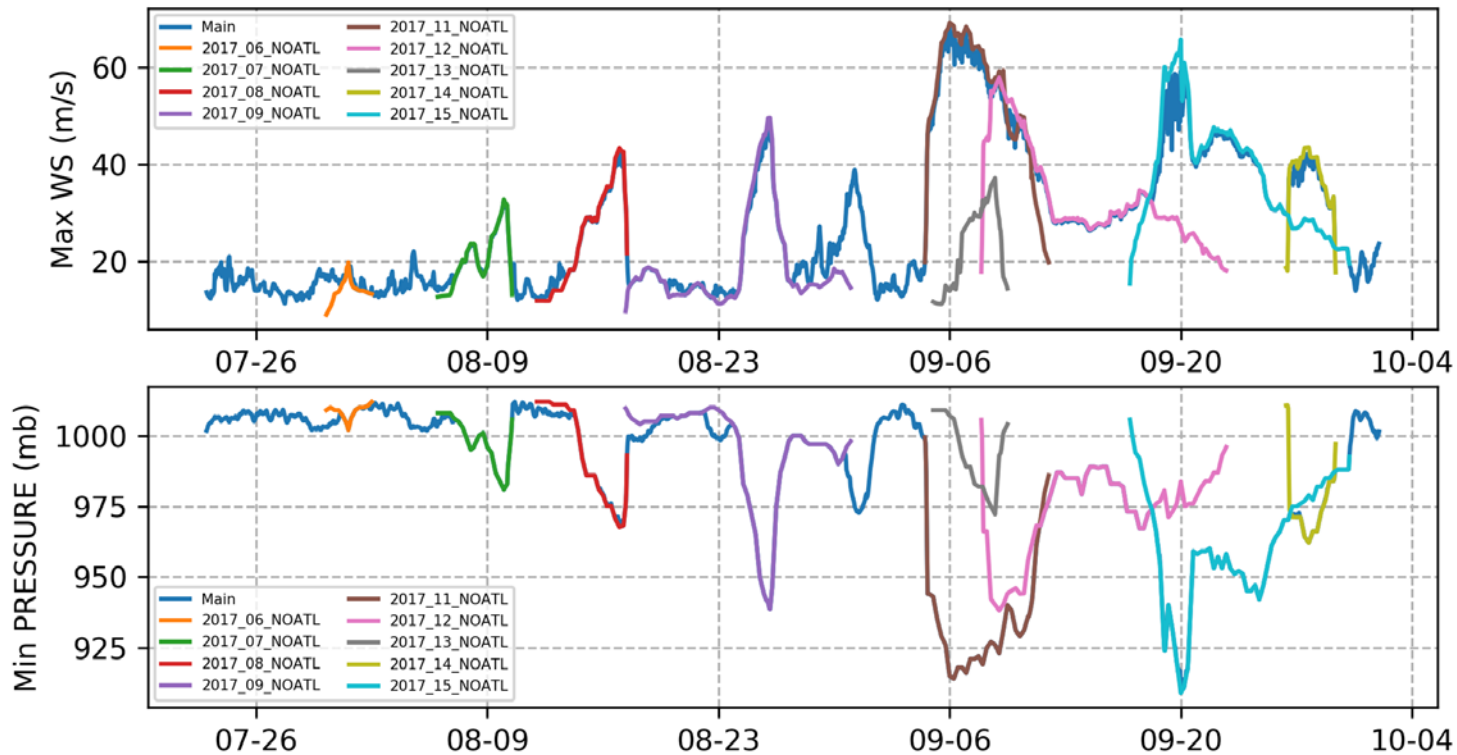
- Operational and tropical storm Wind/Wave/Hydro hindcast of the Caribbean and US East Coast
- 900+ Tropical Cyclones, 1924–2017
- 300+ Analyzed by meteorologists in the areas of interest
- Blended back into a corrected, and morphed, synoptic field
- Modified version of the NOAA HSOFS mesh (“HSOFSR”) that eliminates a lot of high resolution overland areas – we are concerned with offshore areas

Production Example: 2017 Hurricane Season



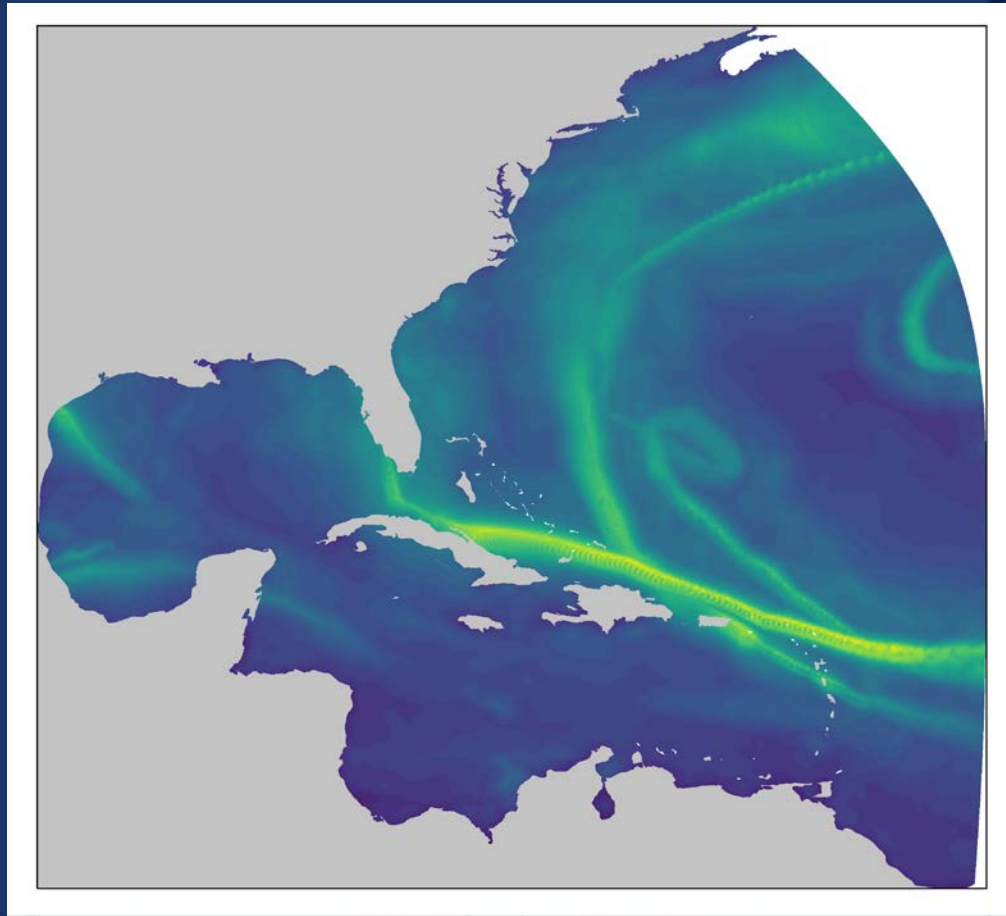
Max wind speed (and minimum pressure) for 2017 Hurricane Season (+ model spinup) basin-scale and storm centered grids.

Production Example: 2017 Hurricane Season



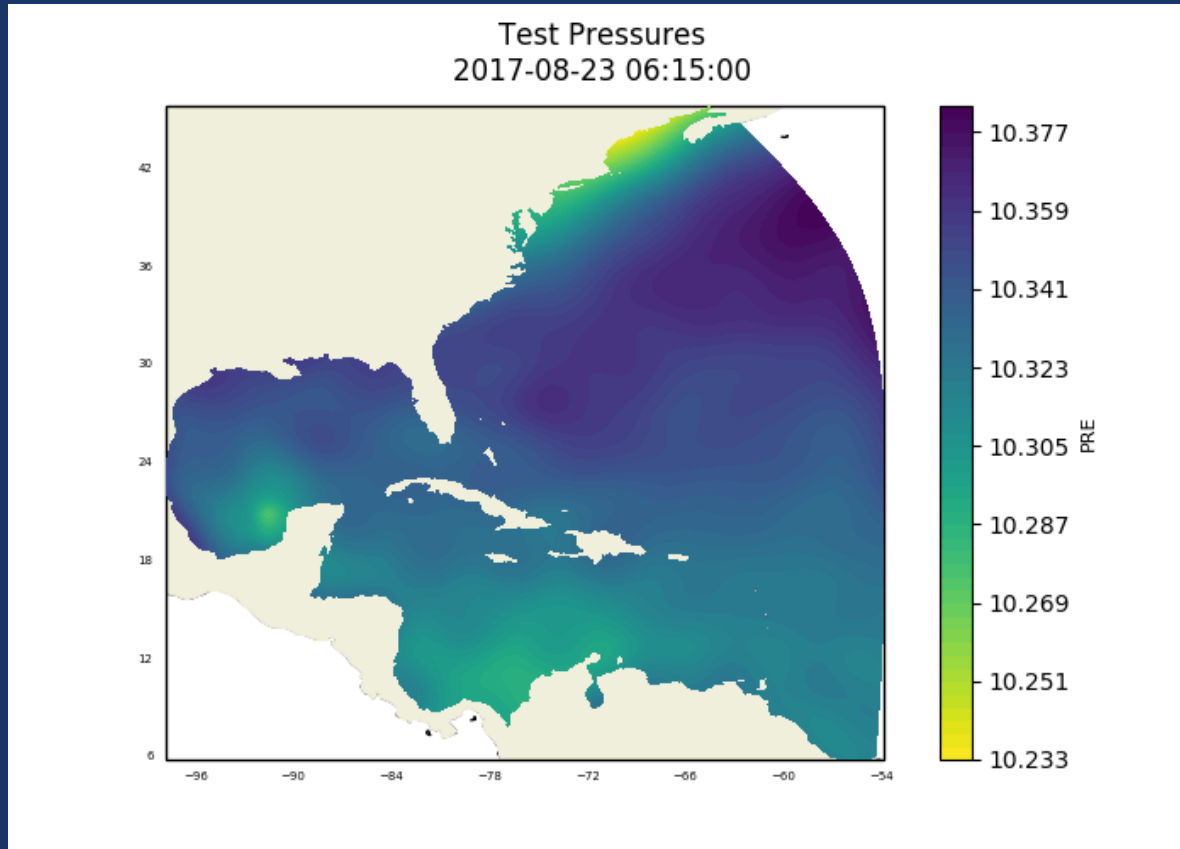
Max wind speed (top) and minimum surface pressure (bottom) by sub-grid/overlay for the 2017 Hurricane Season storms.

Production Example: 2017 Hurricane Season



Max wind speed as applied to OWI HSOF SR ADCIRC mesh. (Intelligent moving-grid interpolation had not yet been implemented.)

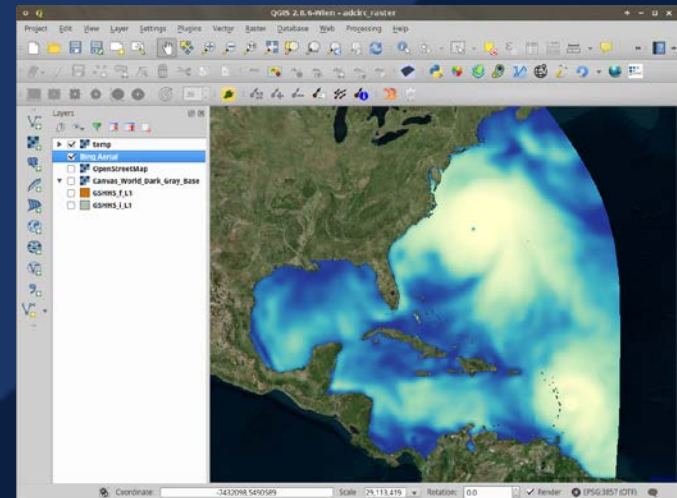
Production Example: 2017 Hurricane Season



Surface pressure animation of 2017 tropical cyclones starting as Hurricane Harvey moves into the US Gulf of Mexico from the Yucatan.

Future

- Quantify improvements in ADCIRC skill for fast moving storms (Charley 2004, etc.)
- ADCIRC speed/timing tests
- Tools to plot/qc NWS-13, GIS plugins
- Tools to convert wind inputs into NWS-13 formatted files
- Python/Julia/Fortran tools to interface with NWS-13 implicitly leveraging the rank-based overlays
- Ice inputs
- 3D meteorological data
- WaveWatchIII



Global ADCIRC Met Output Timestep in QGIS

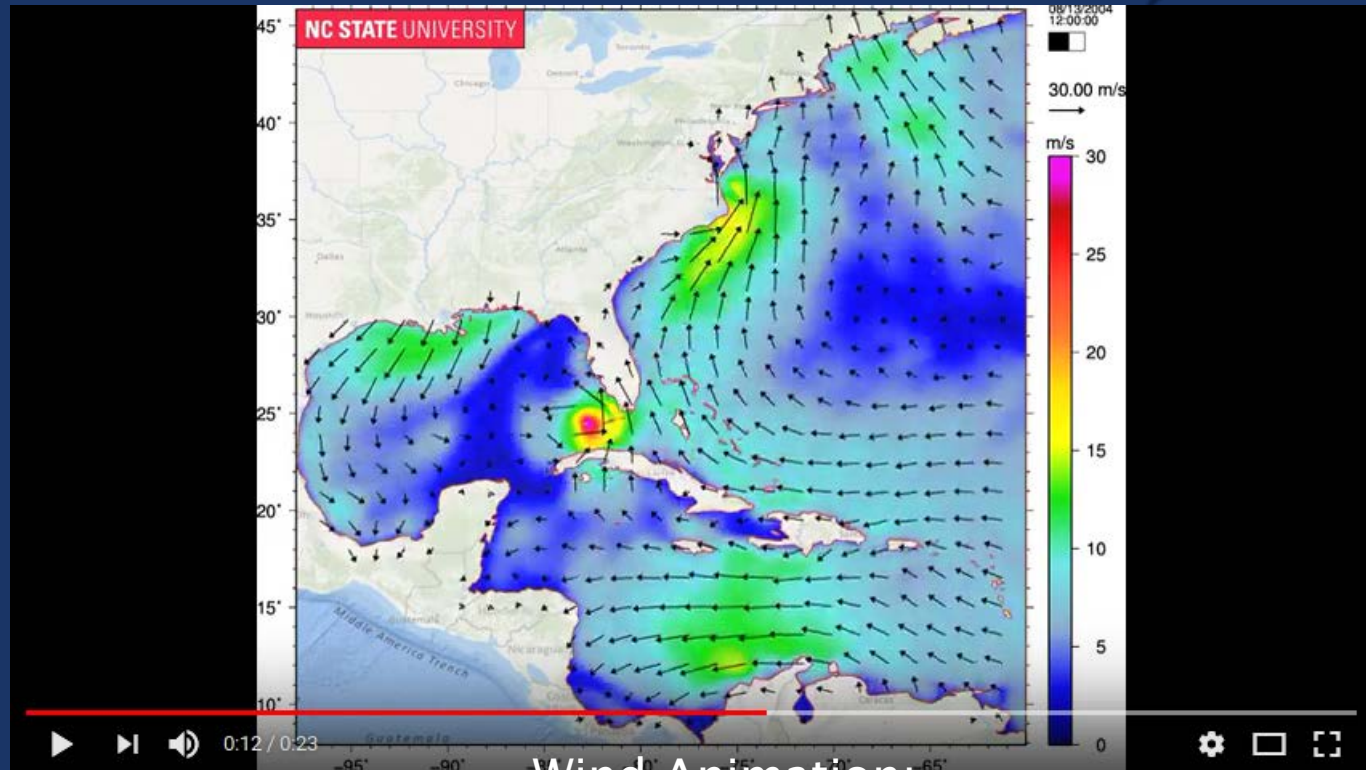
Resources

- Example file, Charley (2004)*
http://s3.amazonaws.com/owi-nws13/Charley_2004_Test.nc
- Example headers/structure as text file
http://s3.amazonaws.com/owi-nws13/Charley_2004_Test.nc.cdl
- Alex Crosby, Oceanweather Inc., Stamford CT (alexc@oceanweather.com)
<http://www.oceanweather.com>
- Casey Dietrich, NC State University Coastal & Computational Hydraulics Team
<https://ccht.ccee.ncsu.edu/>
- Unidata NetCDF (C and Fortran Libs)
<https://www.unidata.ucar.edu/software/netcdf/>
- Python NetCDF Packages:
<https://github.com/Unidata/netcdf4-python>
<https://github.com/pydata/xarray>

Suggestions

- Keep the spatial and temporal resolutions to only what is required
- Add sub-grids, more complex time dimensions, and complex lat/lon grid definitions only as necessary by sub-grid/group
- In most cases 1-hourly specified--if you have a moving-grid overlay and can rely on the built-in moving-aware interpolation
- Avoid discontinuities between overlays/grids
- Best case: the lowest rank grid should just be a less resolved version of exact same higher resolution fields that will be overlaid
- Lowest rank grid should probably cover the entire domain/mesh, and the entire model run time period

Example: Charley 2004



Wind Animation:

<https://youtu.be/jmKrbTZjrGk>

Wind and Surface Elevation Animation:

<https://youtu.be/VwA5zlczOtc>