NWS 13:
NetCDF Replacement for NWS12 Met Inputs and Application

2020 ADCIRC User's Group Meeting

Thanks to Zach Cobell and Casey Dietrich

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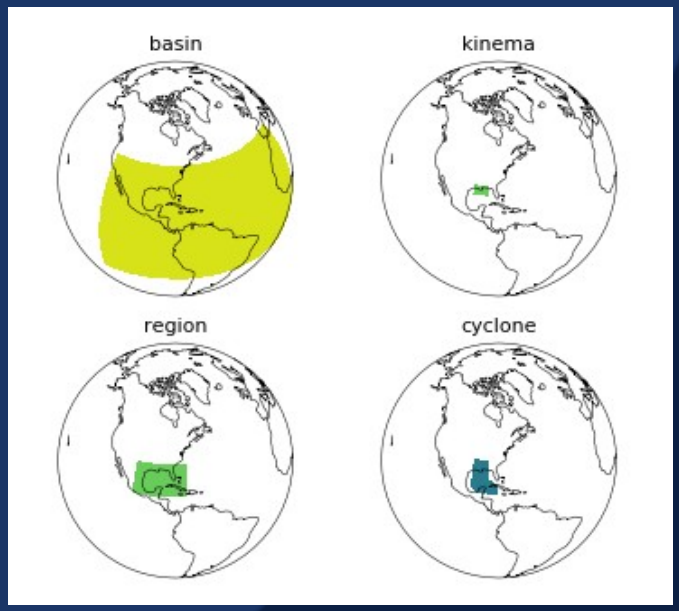
Motivation

A major source of error in ADCIRC can come from the accuracy and representation of the wind and pressure fields.

Additional Motivation

- Replicate NWS12 features and more
- Single-file, wind/pressure/all-grids
- Multiple grid overlays
- 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.

Future-proofing Attempts

- Multi-resolution representation of tropical cyclone wind fields
- Be able to introduce additional meteorological parameters using the same format/NWS input
- Other gridded inputs: Ice drag? Wave stresses? Rainfall?

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)

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

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 of
"minutes from YYYY-mm-dd HH:MM:SS"

clon/clat *(time)*, optional storm center coordinates for Powell drag

Fort.15

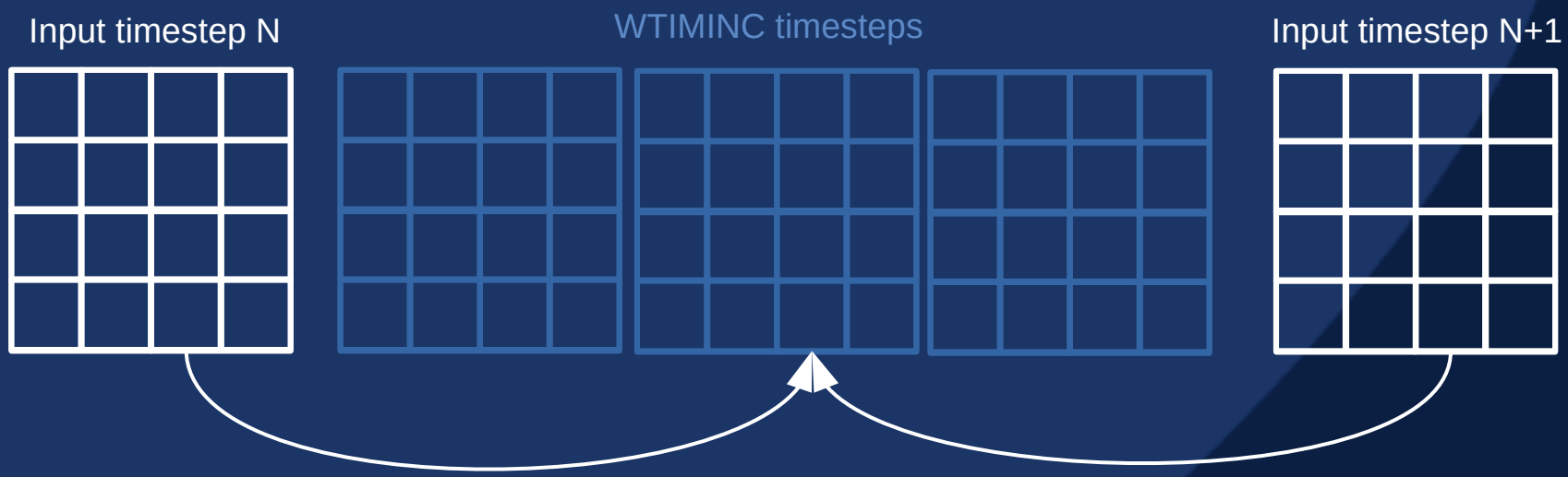
WTIMINC: configurable grid-to-mesh interpolation timestep

&owiWindNetcdf Fort.15 namelist

- NWS13ColdStartString: required cold start time of simulation
- NWS13WindMultiplier: optional wind speed multiplier
- NWS13File: optional file name for netCDF file (fort.22.nc default)
- NWS13GroupForPowell: optional group to use for Powell drag

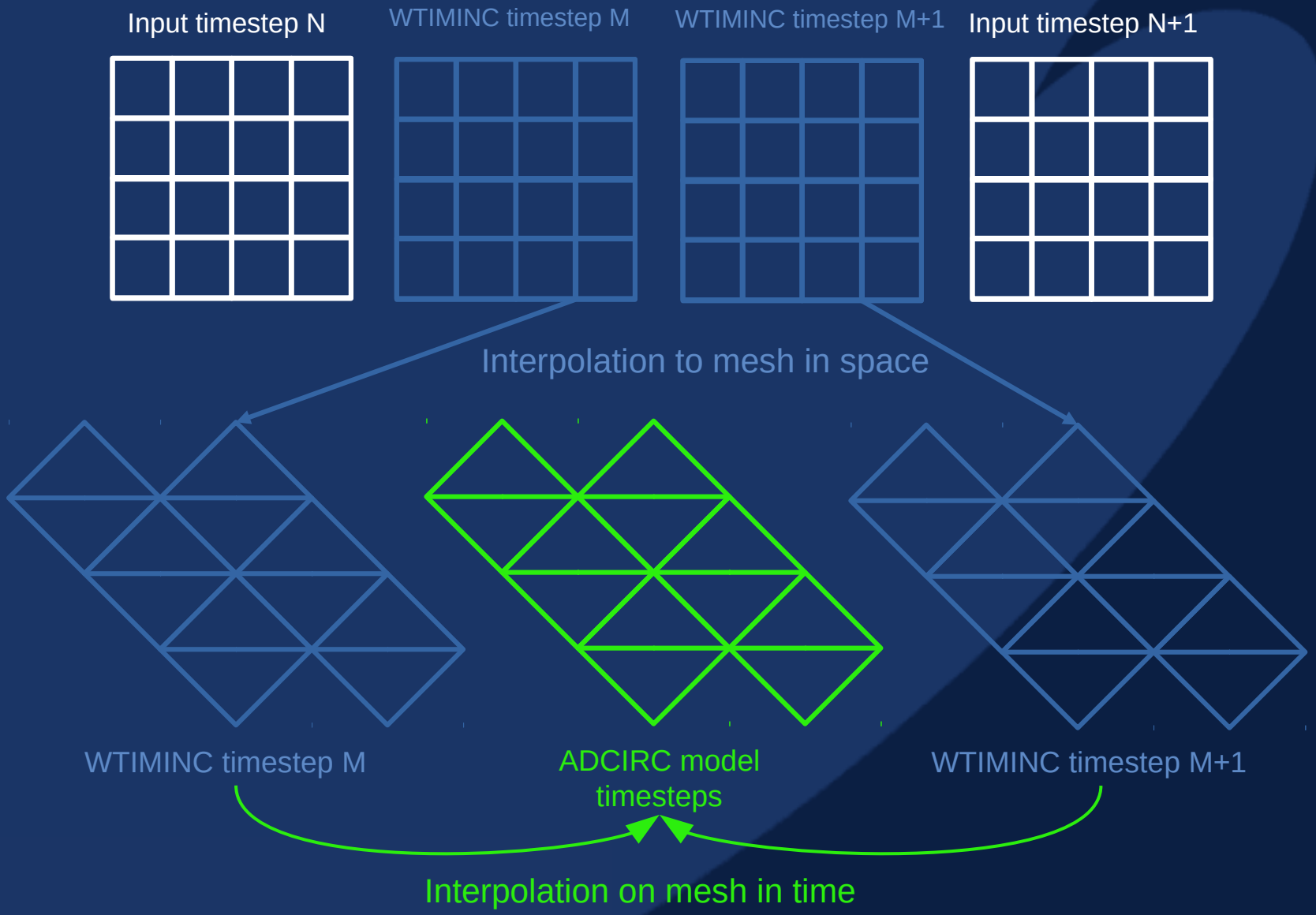
```
&owiWindNetcdf NWS13File='fort.22.nc' NWS13ColdStartString='20000706.000000' /
```

Interpolation Procedure

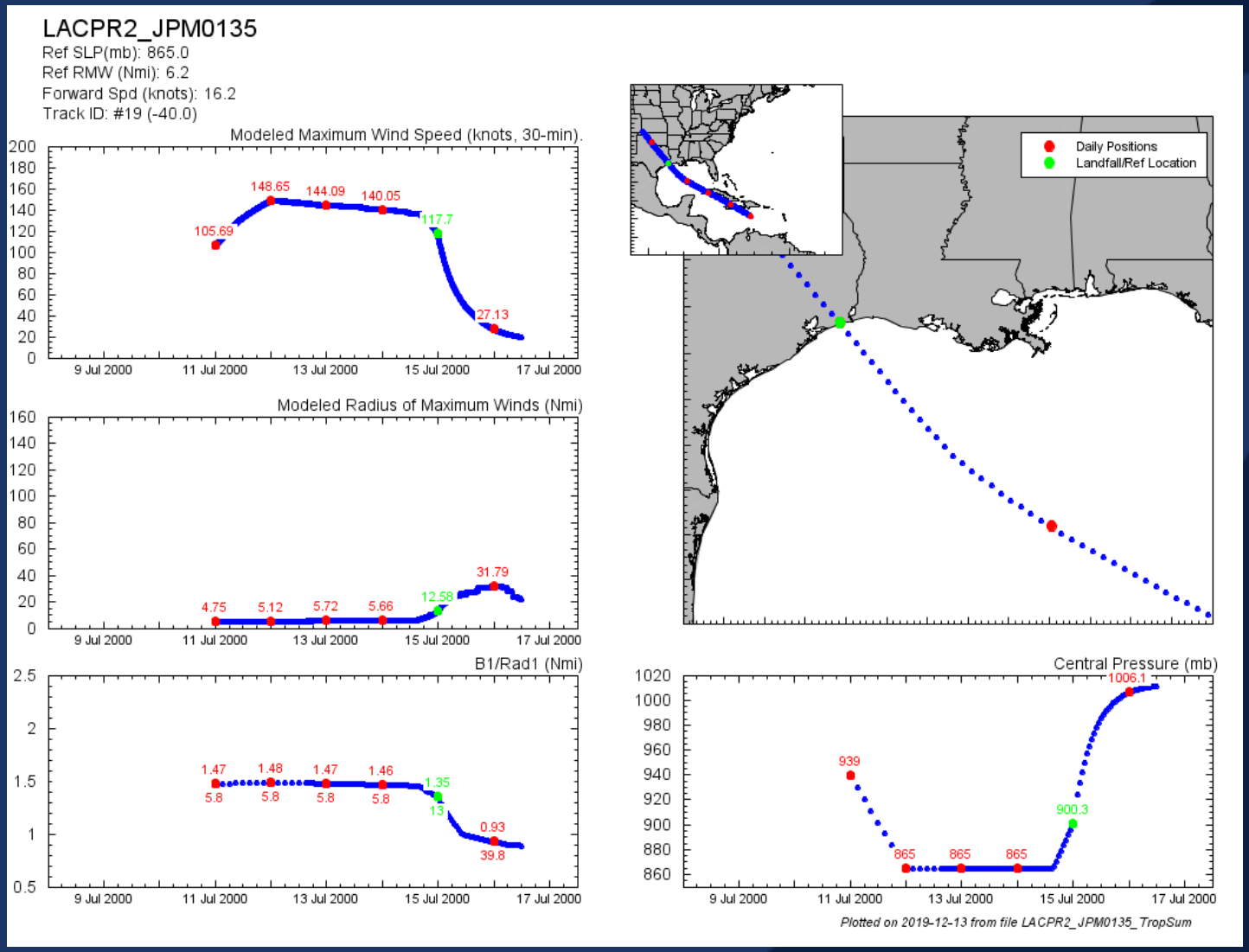


Interpolation on input grid(s) in time and space

Interpolation Procedure

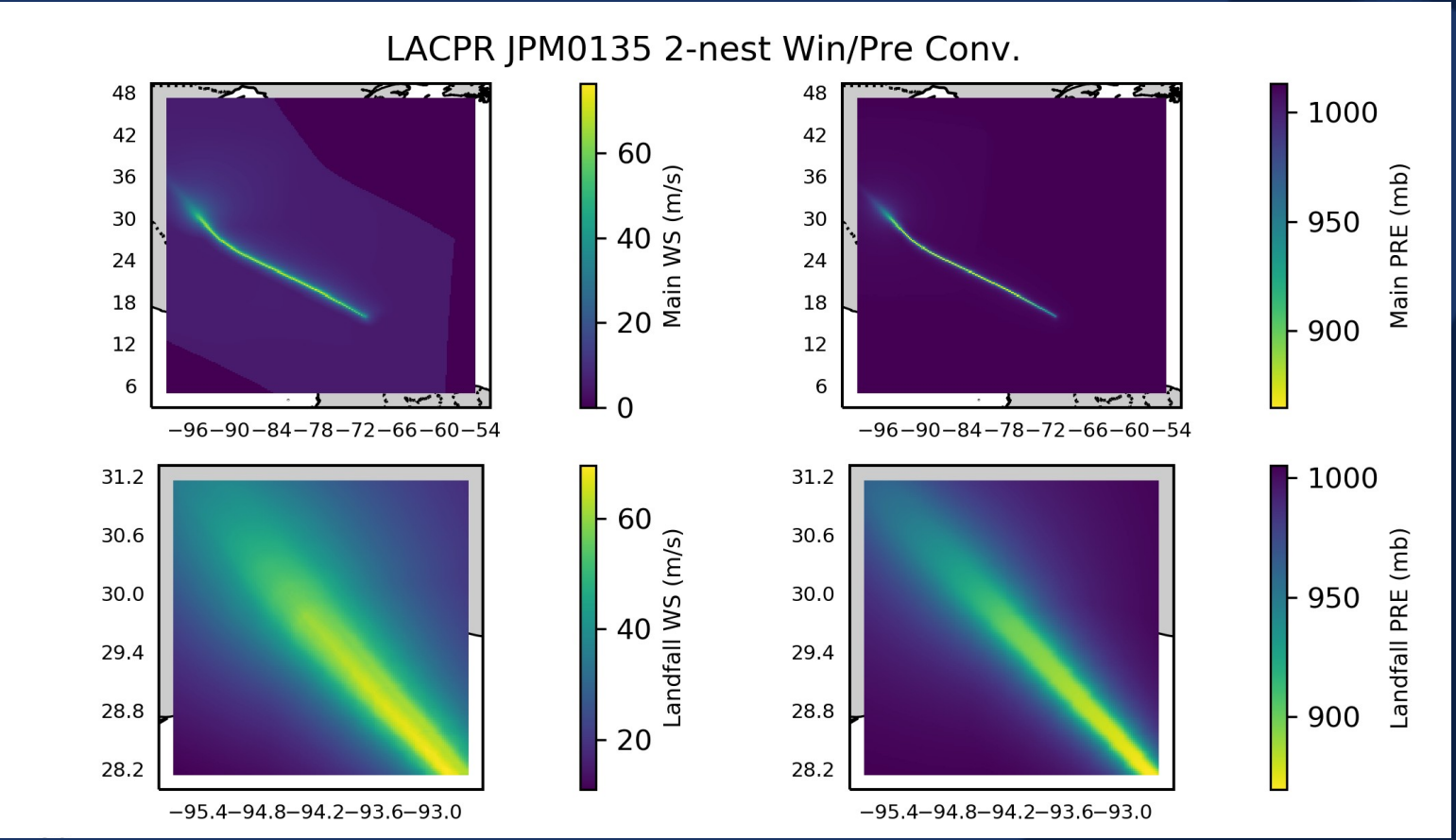


LACPR JPM Storm Example: NWS12 vs NWS13



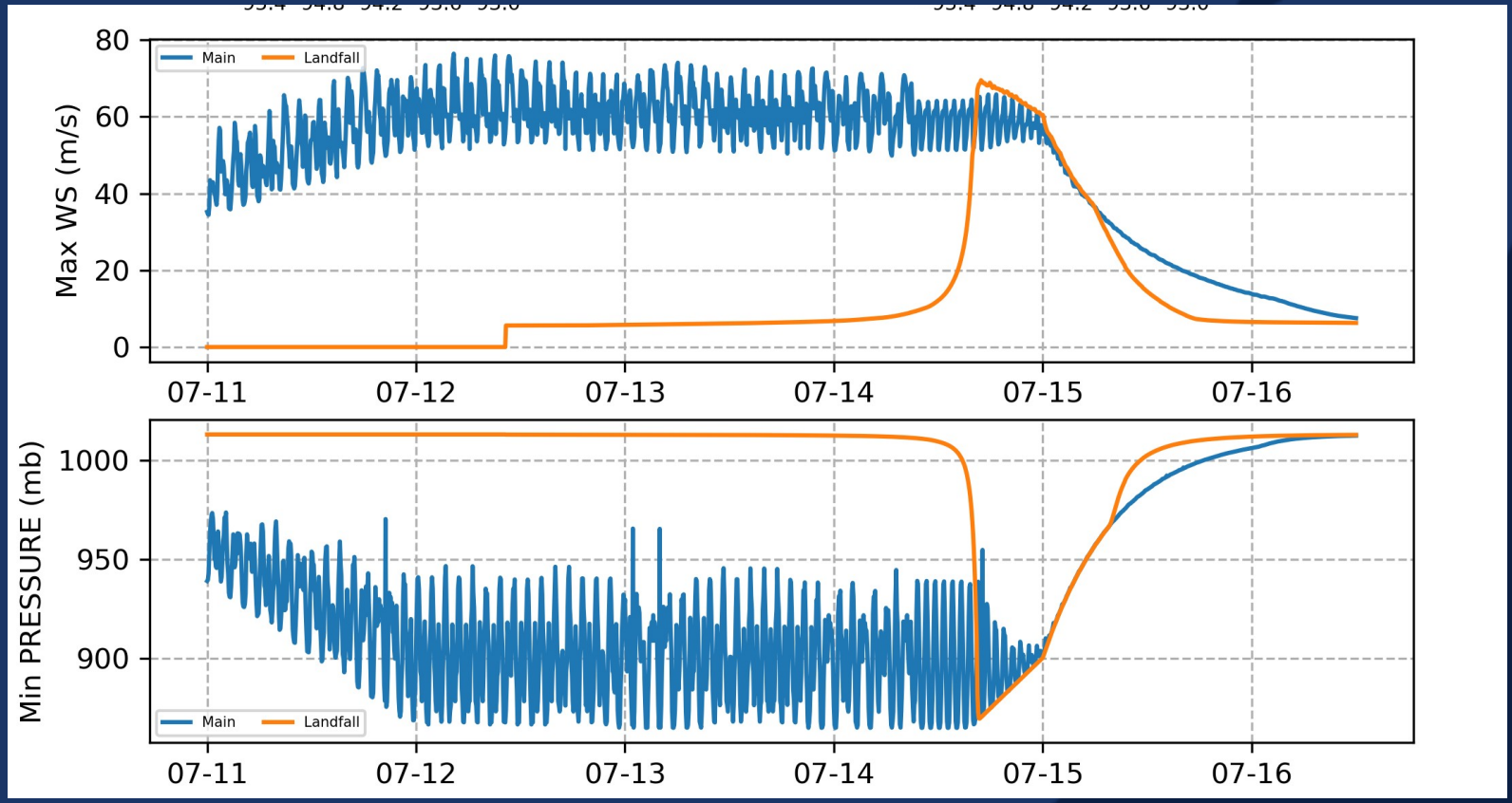
Diagnostic information for synthetic JPM storm 135, demonstrating relatively tight, intense, and fast moving storm.

LACPR JPM Storm Example: NWS12



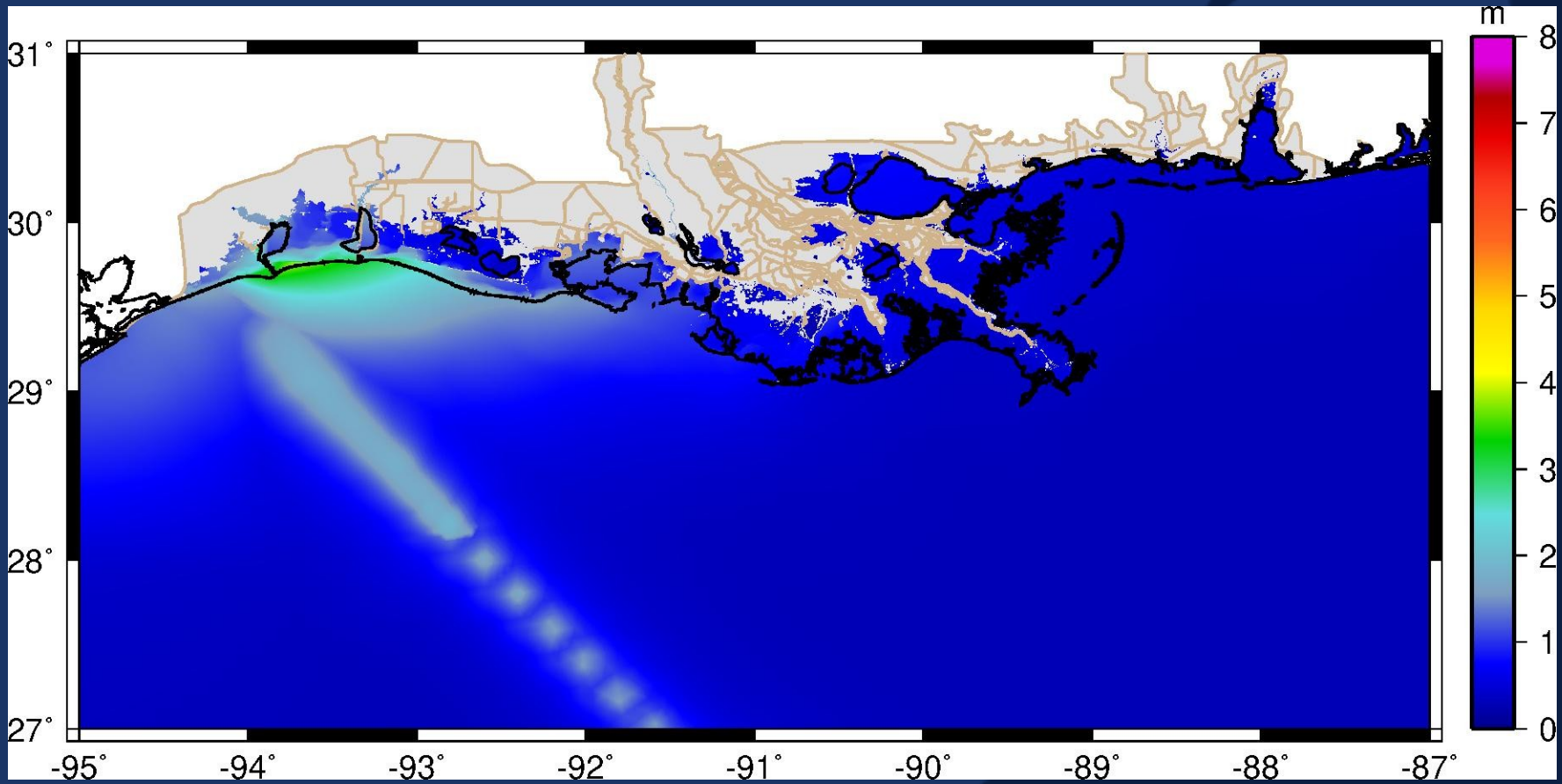
NWS 12 max wind speed (left) and min pressure (right) inputs on basin-wide (top) and landfall (bottom), 5 minute input timestep

LACPR JPM Storm Example: NWS12



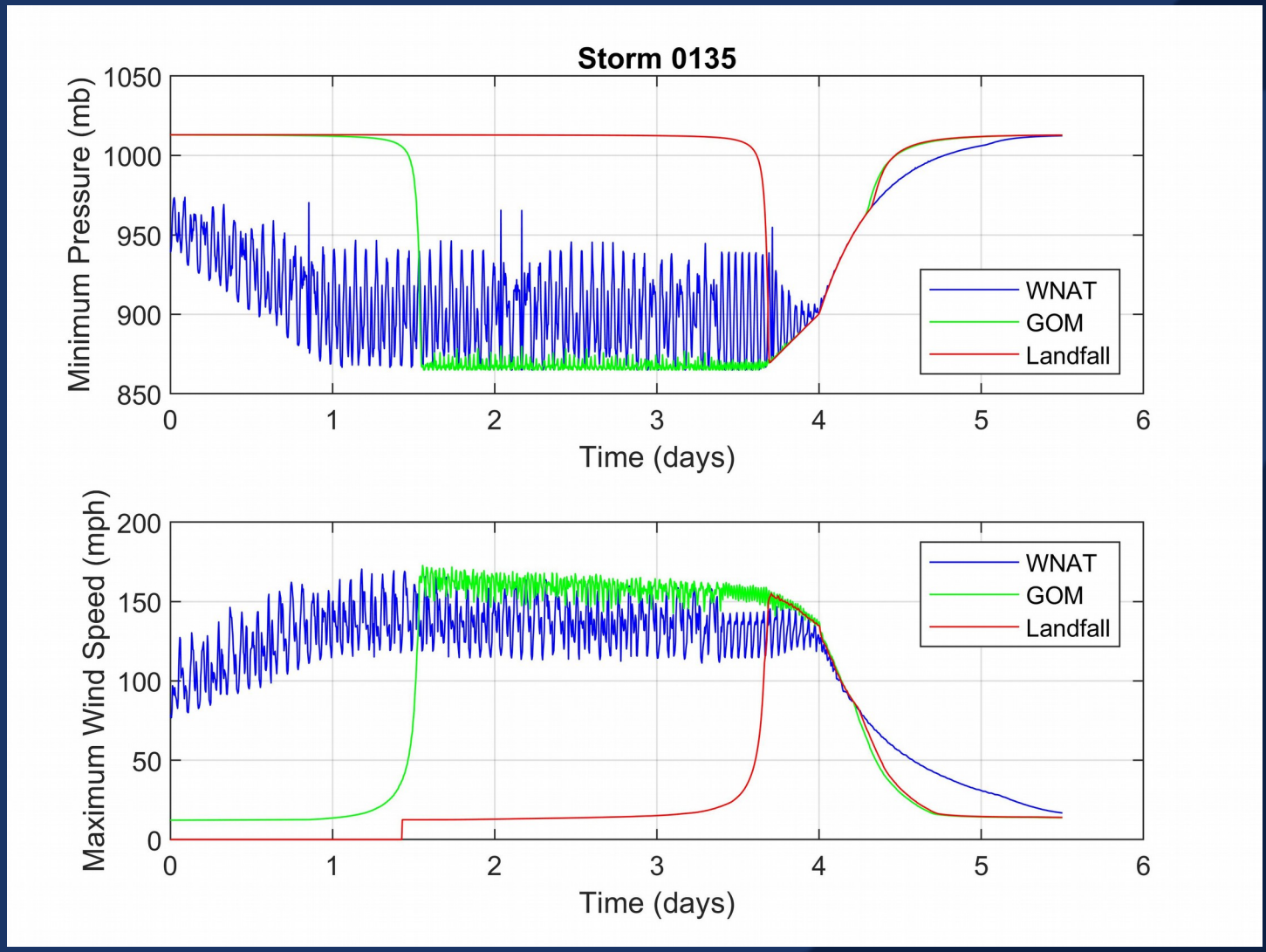
Time evolution of max wind speed (top) and min pressure (bottom) by sub-grid/overlay for JPM 135 as NWS12 files with 5 minute input timestep

LACPR JPM Storm Example: NWS12



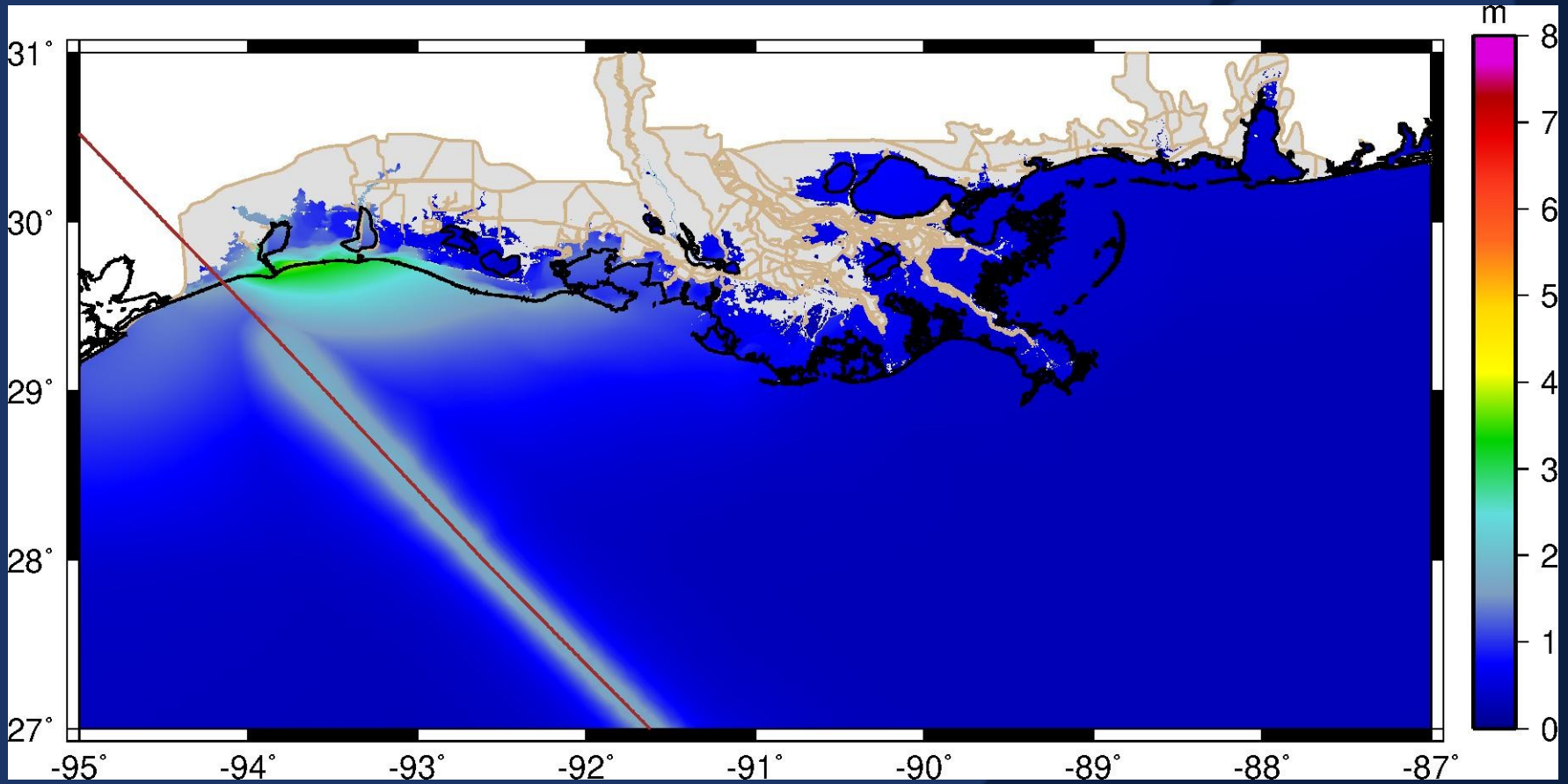
Max water level for JPM 135 from 2-grid NWS12 files with 5 minute input timestep

LACPR JPM Storm Example: NWS12



Time evolution of min pressure (top) and max wind speed (bottom) by sub-grid/overlay (including a 3rd Gulf of Mexico domain (GOM, green)) for JPM 135 as NWS12 files with 5 minute input timestep

LACPR JPM Storm Example: NWS12



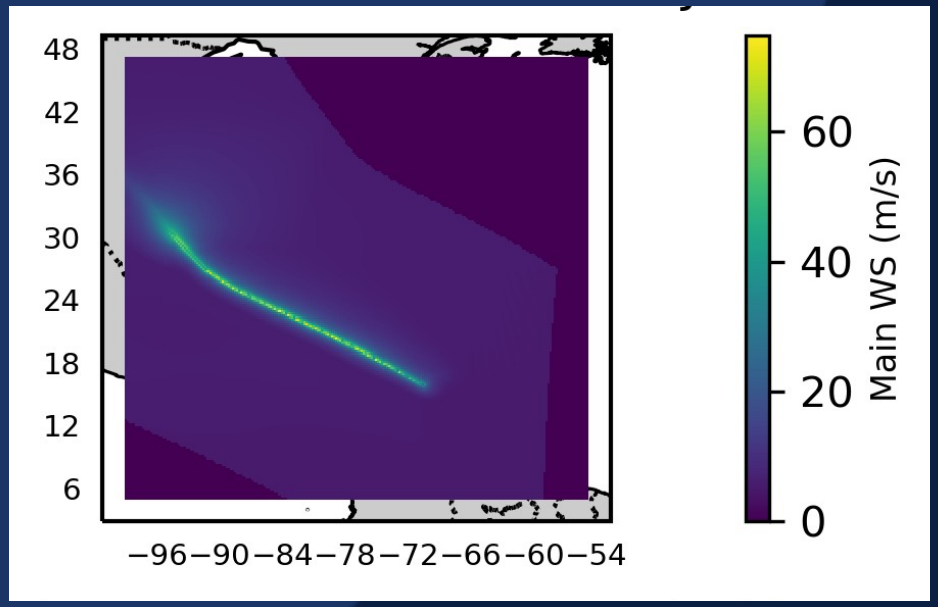
Max water level for JPM 135 from 3-grid NWS12 files with 5 minute input timestep

NWS13 Main Grid

```
group: Main {
  dimensions:
        yi = 211 ;
        xi = 221 ;
        time = 133 ;
  variables:
        float lon(yi, xi) ;
                lon:_FillValue = NaNf ;
                lon:units = "degrees_east" ;
                lon:standard_name = "longitude" ;
                lon:axis = "X" ;
                lon:coordinates = "time lat lon" ;
        float lat(yi, xi) ;
                lat:_FillValue = NaNf ;
                lat:units = "degrees_north" ;
                lat:standard_name = "latitude" ;
                lat:axis = "Y" ;
                lat:coordinates = "time lat lon" ;
        int64 time(time) ;
                time:units = "minutes since 1990-01-01T01:00:00" ;
                time:calendar = "proleptic_gregorian" ;
        float U10(time, yi, xi) ;
                U10:_FillValue = NaNf ;
                U10:units = "m s-1" ;
                U10:coordinates = "time lat lon" ;
        float V10(time, yi, xi) ;
                V10:_FillValue = NaNf ;
                V10:units = "m s-1" ;
                V10:coordinates = "time lat lon" ;
        float PSFC(time, yi, xi) ;
                PSFC:_FillValue = NaNf ;
                PSFC:units = "mb" ;
                PSFC:coordinates = "time lat lon" ;

  // group attributes:
                :rank = 1 ;
  } // group Main
```

- Rank 1
- Files must have a fixed grid
- Should cover full mesh
- Fixed in time

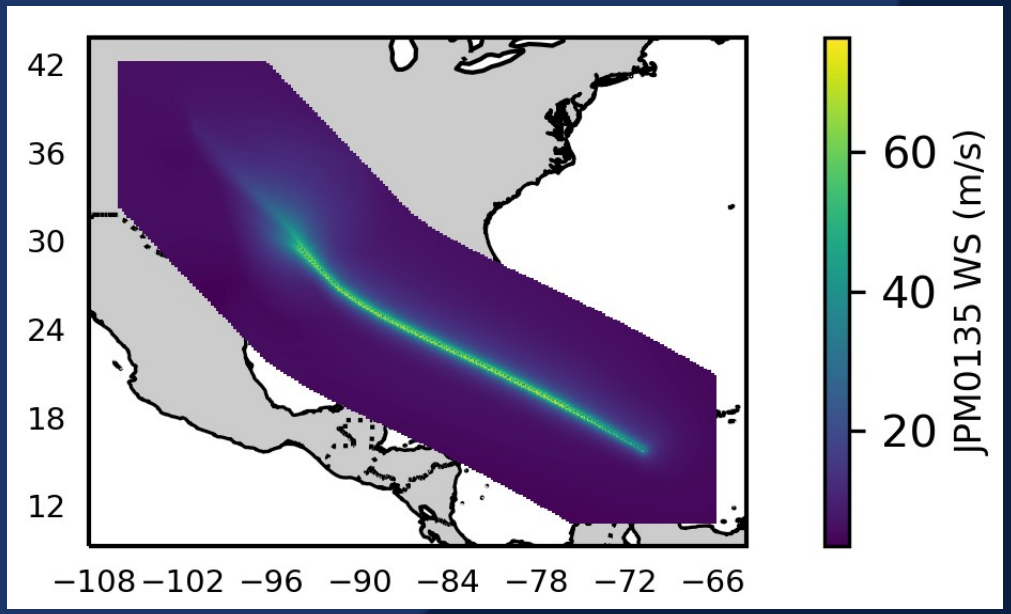


Max wind speed on “Main” mesh-wide input grid

NWS13 Moving Grid Storm Overlay

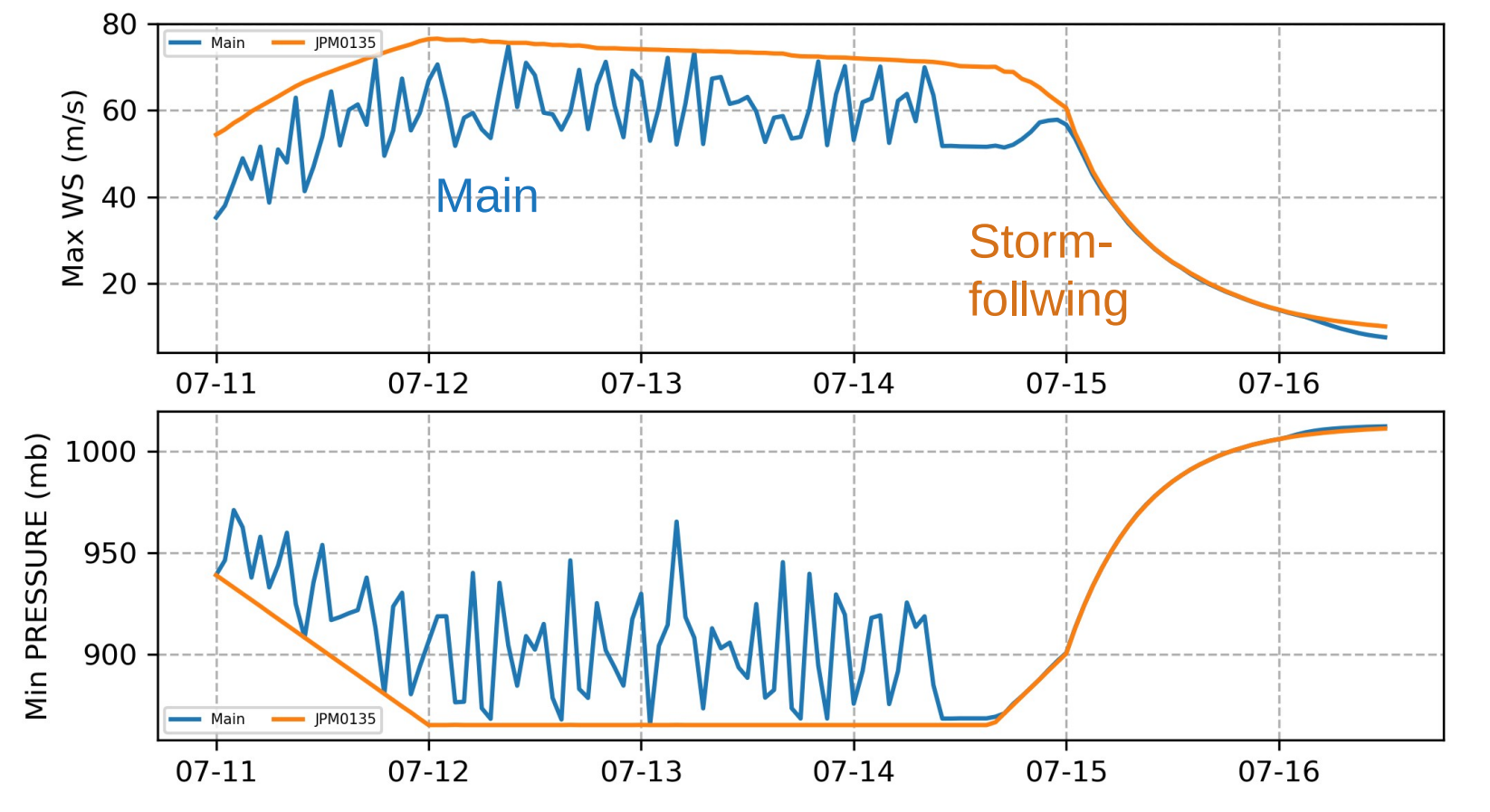
```
group: JPM0135 {
  dimensions:
        time = 133 ;
        yi = 501 ;
        xi = 501 ;
  variables:
        int64 time(time) ;
              time:units = "minutes since 1990-01-01T01:00:00" ;
              time:calendar = "proleptic_gregorian" ;
        float lat(time, yi, xi) ;
              lat:_FillValue = NaNf ;
              lat:units = "degrees_north" ;
              lat:standard_name = "latitude" ;
              lat:axis = "Y" ;
              lat:coordinates = "time lat lon" ;
        float lon(time, yi, xi) ;
              lon:_FillValue = NaNf ;
              lon:units = "degrees_east" ;
              lon:standard_name = "longitude" ;
              lon:axis = "X" ;
              lon:coordinates = "time lat lon" ;
        float U10(time, yi, xi) ;
              U10:_FillValue = NaNf ;
              U10:units = "m s-1" ;
              U10:coordinates = "time lat lon" ;
        float V10(time, yi, xi) ;
              V10:_FillValue = NaNf ;
              V10:units = "m s-1" ;
              V10:coordinates = "time lat lon" ;
        float PSFC(time, yi, xi) ;
              PSFC:_FillValue = NaNf ;
              PSFC:units = "mb" ;
              PSFC:coordinates = "time lat lon" ;

  // group attributes:
              :rank = 2 ;
  } // group JPM0135
```



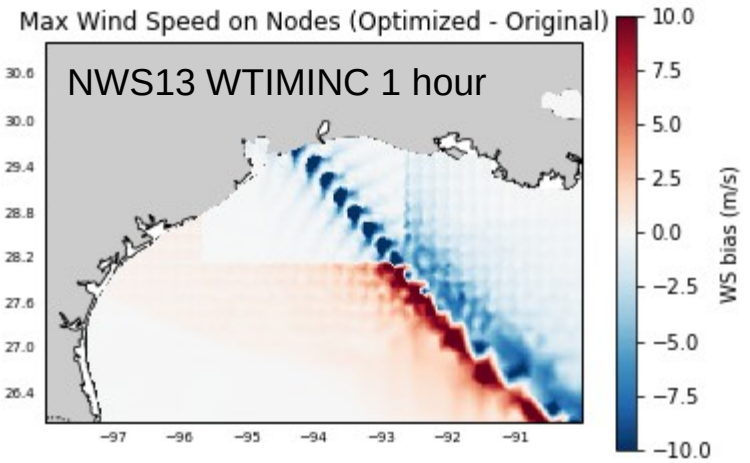
Max wind speed for the storm-following input grid

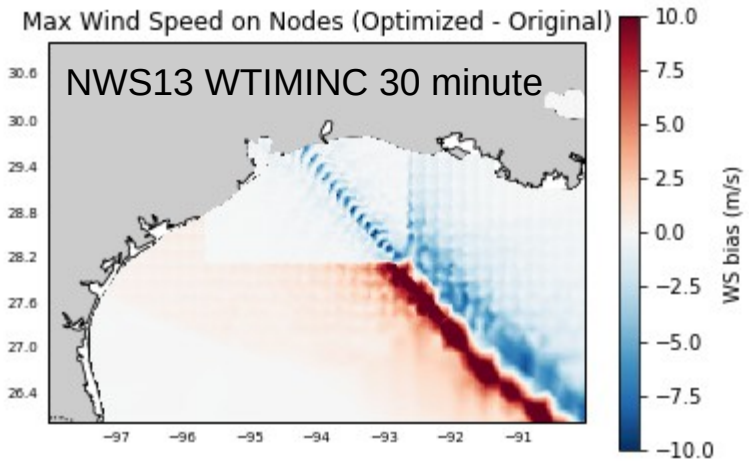
Moving Grid Storm Overlay

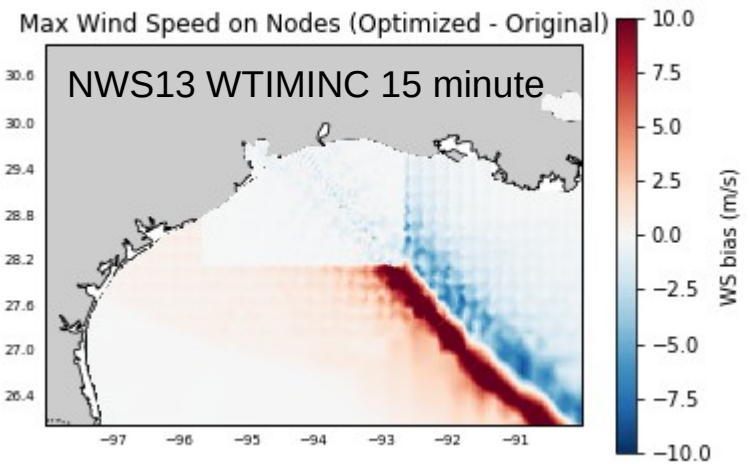


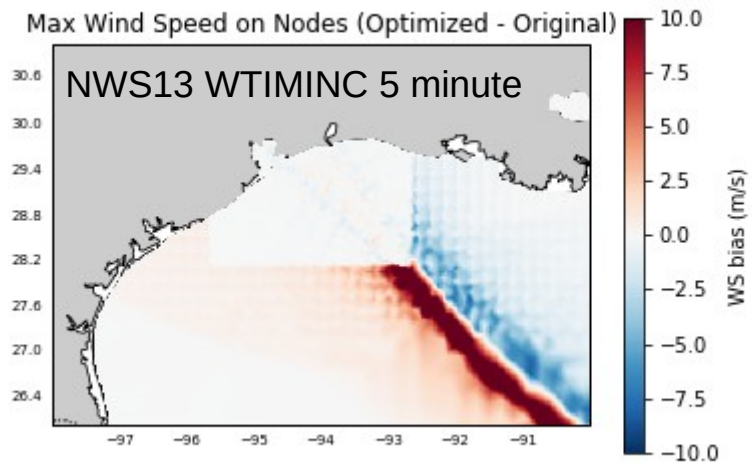
Time evolution of maximum wind speed (top) and minimum surface pressure (bottom) by sub-grid/overlay for JPM 135, 1-hour input timestep

Max Wind Speed on Mesh









Difference between the NWS 12 (5 min input timestep) and 13 (1 hour input timestep) max wind speed representations interpolated by ADCIRC on to a mesh for various WTIMINC in the NWS-13 cases.

File Sizes

NWS 13 Files:

1.3G	LACPR2_JPM0135.nc	(5 minute timestep)
709M	LACPR2_JPM0135_Optimized_60min.nc	(1 hour timestep)
8.7G	LACPR2_JPM0135_withMovingCenter.nc	(5 minute timestep)

NWS 12 Files:

354M	LACPR2_JPM0135_LandFallDomain.pre	(5 minute timestep)
707M	LACPR2_JPM0135_LandFallDomain.win	(5 minute timestep)
327M	LACPR2_JPM0135_StormCenter_60min.pre	(1 hour timestep)
653M	LACPR2_JPM0135_StormCenter_60min.win	(1 hour timestep)
3.8G	LACPR2_JPM0135_StormCenter.pre	(5 minute timestep)
7.6G	LACPR2_JPM0135_StormCenter.win	(5 minute timestep)
61M	LACPR2_JPM0135_WNATDomain_60min.pre	(1 hour timestep)
122M	LACPR2_JPM0135_WNATDomain_60min.win	(1 hour timestep)
723M	LACPR2_JPM0135_WNATDomain.pre	(5 minute timestep)
1.5G	LACPR2_JPM0135_WNATDomain.win	(5 minute timestep)

Progress

- Pull request to `master` opened from `nws13` branch with conflicts resolved (Hopefully in v55)
- ADCIRC speed/timing tests, data access optimization
- ADCIRC CI Test Case based on Katrina 2D, (also working on WIKI!!!)

Future

- Provide as default for JPM/synthetic storm work
- Possibly provide an operational global forecast NWS13 file
- Implement as output option in the PBL model

Questions?

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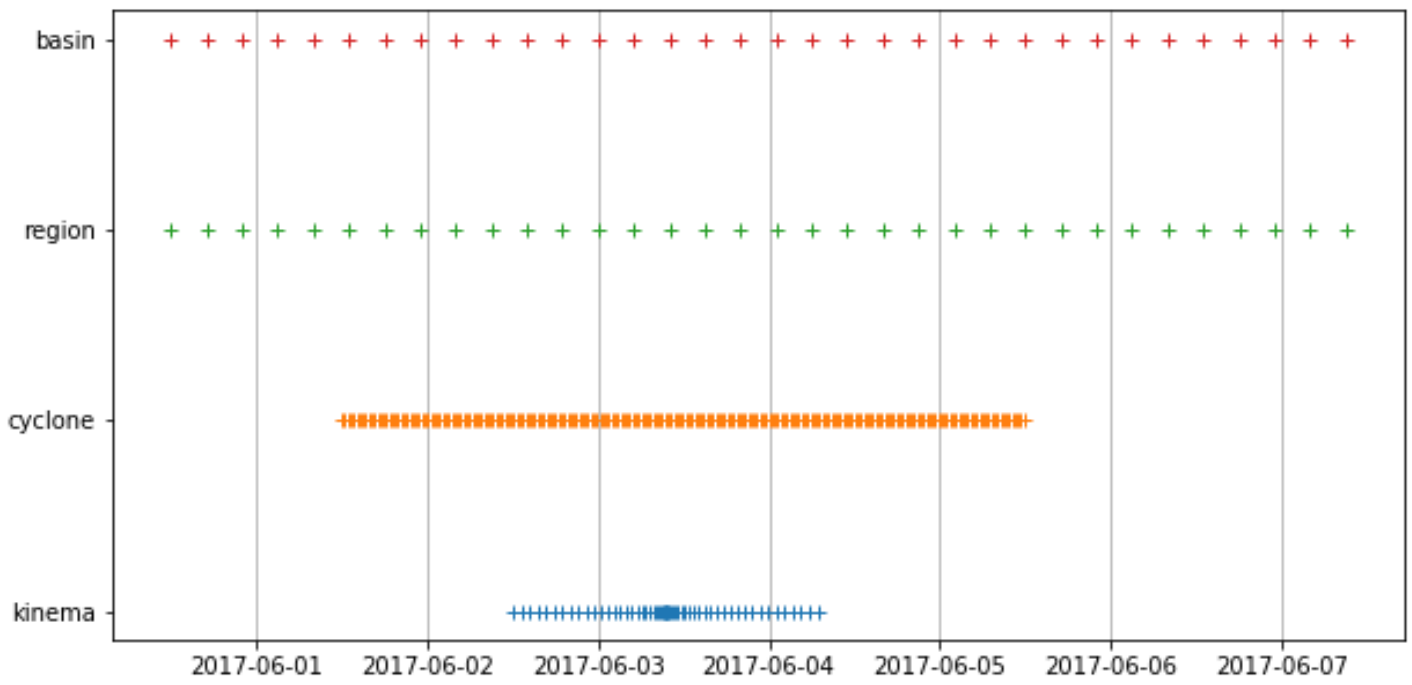
Additional Motivation



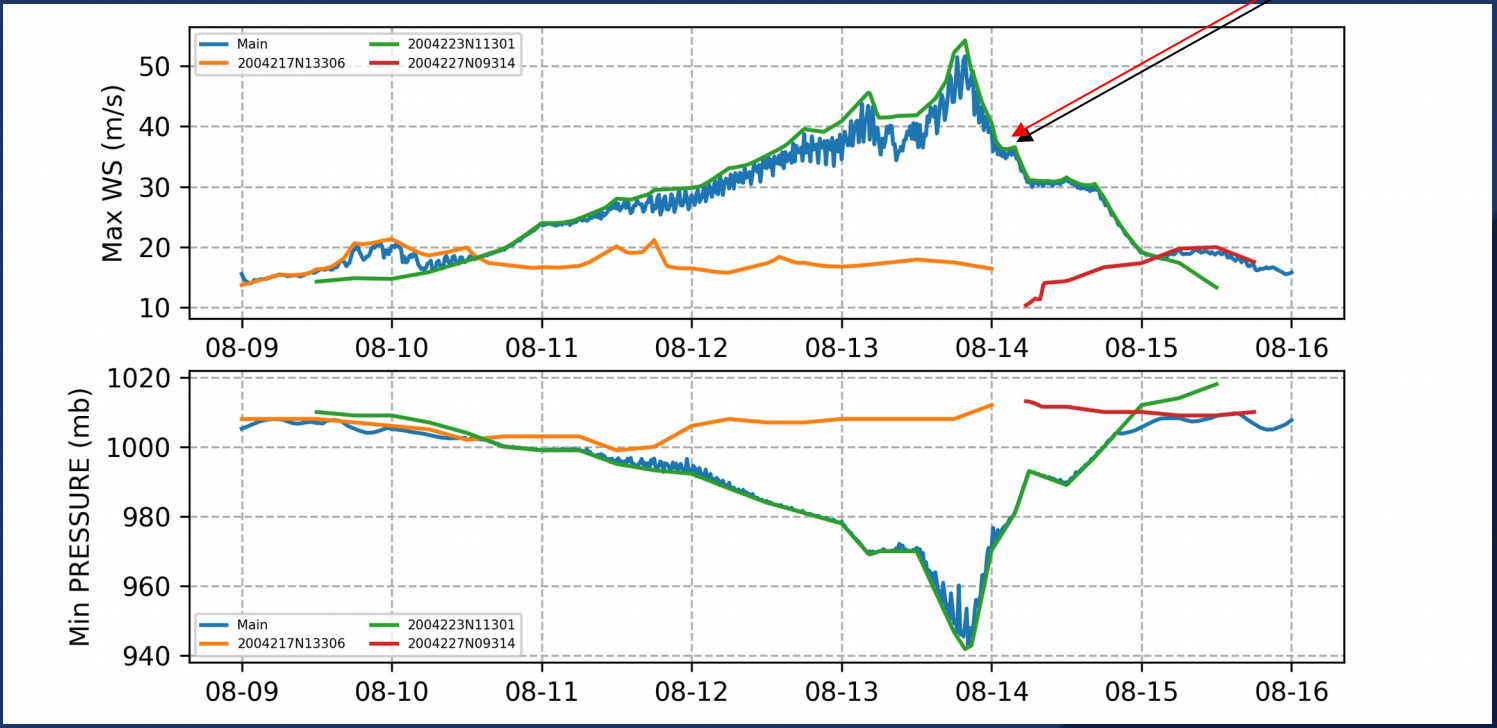
Example of independent time-stepping for each overlay, including individual start/stop and non-regular timestep intervals.

Schema Notes

- Decoupling the yi/xi 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 yi/xi array size)
- Each group/sub-grid can define the timesteps independently, including start and stop times
- Fill Value (and NetCDF packing/compression)

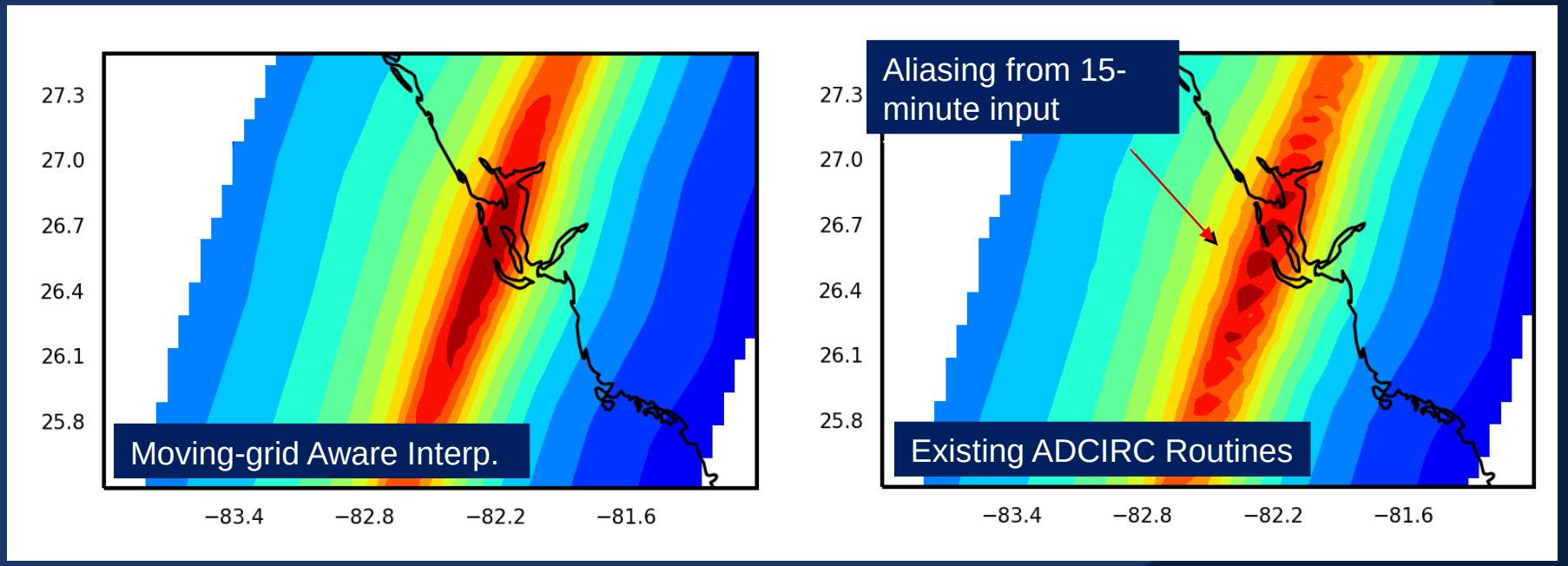
Another Example: Charley 2004

Note the aliasing of the max **input** 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.

Another 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.