Idealized Hurricane: SST 26°C

Time series output in WRF:
The time-series output in WRF records atmospheric quantities at a given location for every time step of the simulation. For the hurricane simulations, the time series output records the three wind speed components and height at every time step.

- UU: u-wind/zonal component.
- VV: v-wind/meridional component.
- WW: w-wind/vertical component.
- PH: height above the surface.

The naming convention for a time series output file is as follows:
`name.d##.XX`

- `name`: name for each time series location (specified by the user)
- `d##`: domain for time series output
- `XX`: variable in time series ouput

For example, the file `hi118.d05.UU` contains the time series output for the u-velocity component in domain 05 of the simulation at location `hi118` specified by the user.

The time series output files have a specific format. The first line in each file has the following convention:

```
name  domain_ID  timeSeries_ID (lat,lon) grid_indices:(index_x,index_y)  actual_lat_lon:(lat,lon)
```

The `name` of each time series location is specified by the user and should match the name of the file. The `domain_ID` is the domain number for the time series output. The `timeSeries_ID` is the time series location within the `tslist` file (i.e., irrelevant for end user). Given that our simulations are idealized, the values for `(lat,lon)` are zero. The `grid_indices` represent the grid cell for the time series output within the domain.

The rest of the lines in each file follow this convention:

```
time  var_z1  var_z2  var_z3  var_z4  var_z5  var_z6  …
```

The first column (`time`) represents the time since initialization in hours. The high-resolution domain (i.e., d05) is initialized after 7 days and 5 hours of simulation (~173 hr). The remaining columns (`var_zi`) provide the output for each variable at increasing vertical levels in the domain. The vertical levels for each output are provided in the `name.d##.PH` files. For this hurricane simulation, data are output for the following vertical levels: z = [0 21 43 66 91 117 144 172 202 233] m above the surface. Note that the height coordinate changes slightly with every time step given that the vertical coordinate in WRF is a function of hydrostatic pressure.

The file `tslist_d04_d05.txt` provides the names and locations ((i,j) grid point in d05) for each time series output file.

Location of time-series output in LES domains:
The time series output for the highest resolution domain ($\mathrm{d05}$: $\Delta x = 55.55\ \mathrm{m}$) are distributed at different radial and azimuthal locations from the center of the hurricane (Figure 1). Also, as shown in Figure 1, time-series output for each radial location for an azimuth angle $\theta = 90$ deg includes data for each grid cell surrounding the desired radial location (9x9 grid).

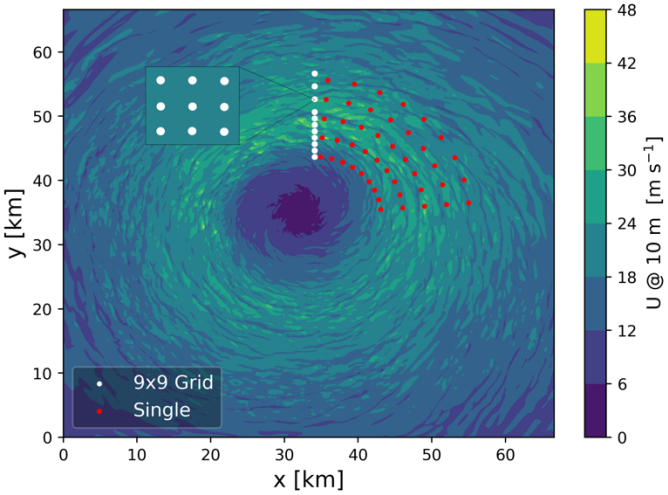

Figure 1. Plan view of the instantaneous horizontal velocity at 10 m above the surface for d05. The white dots represent 9x9 grids of time-series output. The red dots represent single time-series output locations.

<u>9x9 grid:</u>
Time series output for the 9x9 grids is at the following approximate radial locations r = [9 10 11 12 13 14 15 16 18 20 22] km from the center of the hurricane.
Time-series output for the 9x9 grids corresponds to the files: `hi[000-098].d05.*`
The files are named in ascending order as a function of their radial location relative to the center of the hurricane. In this way, files `hi[000-008].d05.*` correspond to the 9x9 grid centered at a radial location of 9 km from the center of the hurricane.

<u>Single locations:</u>
Time series output for the single locations is at the following radial r = [9 12 15 18 21] km and azimuthal θ = [5 15 25 35 45 55 65 75 85] deg locations from the center of the hurricane.
Time-series output for the 9x9 grids corresponds to the files: `hi[099-143].d05.*`
The files are named such that all azimuthal angles for a given radial location are grouped together. For example, files `hi[099-107].d05.*` contain output for all azimuthal locations at r = 9km.

Hurricane characteristics:

Turbulence spins up rapidly throughout the high-resolution LES domain (Figure 2). Small-scale turbulence develops rapidly after initialization close and far away from the center of the hurricane. Five minutes after initialization, turbulence spectra become self-similar thought the domain.

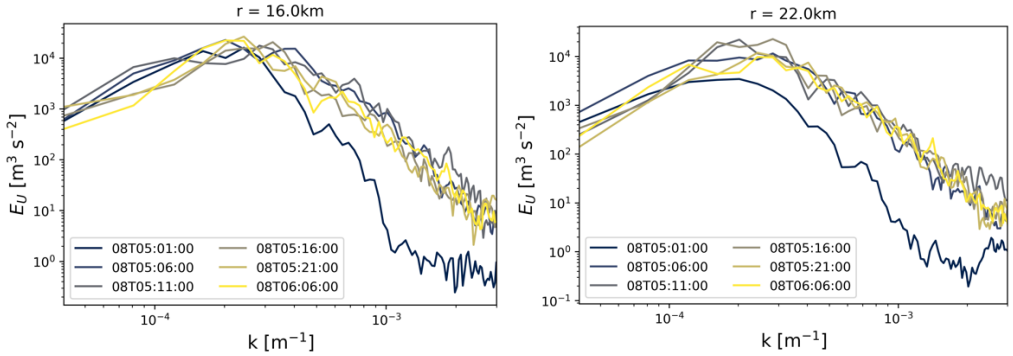

Figure 2. Temporal evolution of turbulence spectra of the horizontal velocity at 10 m for r = 16km (left) and r = 22km (right).

The sustained 1-minute winds at 10 m recorded in d05 suggest this is a Category-1 hurricane (Figure 3). Maximum 1-min wind speed remains within the 33 – 42 m/s range throughout the simulation time in d05.

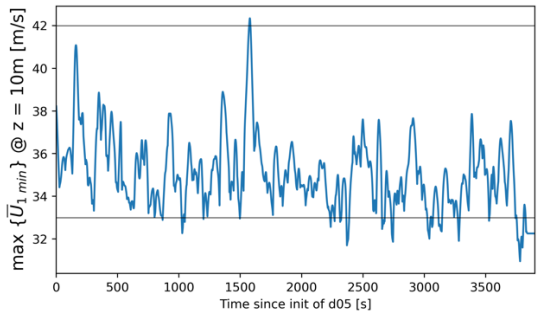

Figure 3: Maximum 1-min averaged wind speed at 10 m above the surface estimated using the time series output. The horizontal, black lines represent the lower and upper bound for a Category-1 hurricane in the Saffir-Simpson scale.

On average, the hurricane eyewall is at 14 km from the center of the hurricane (Figure 4).

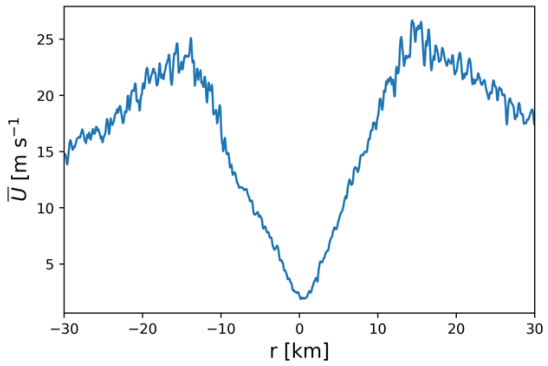

Figure 4. Radial distribution of time-averaged horizontal wind speed at 10 m for d05.

Additional files:

The hurricane in d05 shifts over time (Figure 5), therefore the relative radial location between each time-series output and the center of the hurricane varies throughout the simulation. The hurricane center is displaced 3.3km to the south-east of the domain throughout the simulation. An additional file named `center.txt` provides the (x, y) location for the center of the hurricane at every time step within d05.

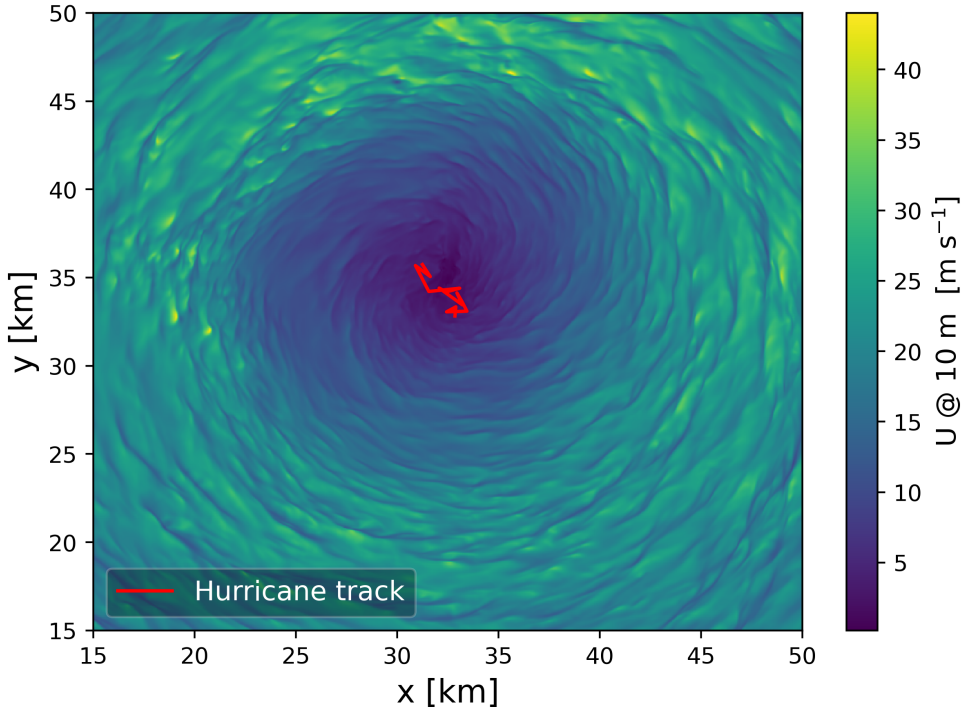

Figure 5. Plan view of horizontal wind speed at 10 m. The red, solid line shows the hurricane track in 5-minute time increments throughout the simulation.