User's Guide

FAST Version of Risk Model

May 2022

The FAST version of the MIT Tropical Cyclone Risk Model was developed from the model described in Emanuel et al. (2006) and (2008) except that it uses the CHIPS emulator called FAST (Emanuel 2017) instead of the actual CHIPS model. This FAST version is freely available and open source.

The main program is coded in FORTRAN while the scripts that contain the control parameters and which control the program itself as well as input and output are coded as LINUX scripts. The program reads input data from various files which reside in the main directory and various subdirectories. Two of the scripts require Octave (or MATLAB) to be installed. If NETCDF output is desired and you are using Octave instead of MATLAB, you must install and configure an Octave add-on available at Octave Forge - The 'netcdf' package (sourceforge.io) .

Setup

First compile the main program, *wrtfastn.f* . We use Portland Fortran and compile with

pgf95 -tp p7 -pc 64 -fast -Mipa=fast -Mconcur -o wrtfastn wrtfastn.f

Now check that the sub-directories *data, climdata*, and *polyfiles* are present; each directory should have some files in it.

The directory *data* has subdirectories named for the global climate models. Each of those has subdirectories named for the particular model "flavor". Each of those in turn has subdirectories for each year.

The subdirectory *climdata* has climatological data, bathymetry, and surface drag coefficients. Normally, there will be no need to change anything in this subdirectory.

The subdirectory *polyfiles* contains ascii files with various line segments that can be used as filters for the track sets. Each row contains a longitude-latitude pair for the beginning and ending points of the line segment.

The main directory should also contain the following ascii files: *Models.txt* and *gen{bas}.in* files, where '*bas*' is a two-letter basin identifier. It should also contain a number of Octave/MATLAB scripts.

The *gen{bas}.in* files provide large random samples of historical genesis points that can be used in place of the standard random seeing algorithm, if desired.

Models.txt is an ascii file that contains necessary information for the reanalyses and models to be downscaled, including the model lat-long grid and frequency calibrations specific to the model. Note that some of the older models/reanalyses include basin-specific calibration factors; these are not usually reliable and it is recommended that the event sets be calibrated after generation by comparing with historical data. In any event, it will not usually be necessary to alter this file.

The Octave/MATLAB scripts perform various functions and should not need to be altered.

Configuring ***masterwrtfast{n}***

The script *masterwrtfast1* is supplied as the main controlling script of the routines. You can duplicate it as many times as you like (*masterwrtfast2, masterwrtfast3*, ….) but in each file the first line (e.g. *filenum=2*) should match the number in the master file name. Each file needs to be given permission to execute. This way, you can run many different simulations simultaneously, especially if you have multiple processors.

The program is controlled through the set of parameters above the dashed line. Each of these is described within the file itself. Note that *modellist, flavorlist*, and *basinlist* may contain more than one entry (separated by spaces), in which case the algorithm will cycle through the entries. also note that it is possible to do multiple sets of years for the same model and flavor. To achieve this, repeat the entry in the flavorlist once for each set of years, and enter the appropriate beginning and ending years (separated by spaces) in the *yearb* and *yeare* fields.

If you have not installed the NETCDF add-on in Octave, be sure to set *write2netcdf* to *n*.

Running the algorithm

Just run the script *masterwrtfast{n}* in the background, as you would any other LINUX script. The script supplied runs 100 North Atlantic tracks per year from 1979 to 2020 downscaled from ERA5 reanalyses. (This is the only dataset initially supplied with this release.) On a reasonably fast desktop it should take 5-10 minutes to run.

Output

The program creates a number of both mandatory and optional subdirectories and files as it is running:

Mandatory output: (Note: None of the files described here should be erased while the program is running)

ASCII output:

A subdirectory tree is created of the *form Model/Flavor/Year/Name/Basin/*, e.g. *era5/reanal/1979/Test/AL/*. Within each of these is a set of *n* ascii files, where *n* is the number of tracks per year. These have all been zipped into a single file called *hurr.zip*. When unzipped, each file contains rows separated by 2 hours of simulated time, with the columns containing:

- Month
- Day of the month
- Greenwich Mean Time (hours, 24 hour clock)
- Latitude (degrees)

- Longitude (degrees east of the Greenwich meridian)
- Maximum 1 minute wind speed at 10 m altitude (knots). **This is the maximum of the circular component of the wind; no translation speed has been added.** (We recommend adding 60% of the translation velocity vector to the circular wind vector to derive surface-relative 1 minute average winds at 10 m altitude.)
- Surface central pressure (hPa or millibars). Note: Ambient pressure is always assumed to be 1005 hPa
- Radius of maximum winds (kilometers)
- Magnitude (m/s) of the 250 hPa-850 hPa shear of the horizontal ambient winds
- Potential intensity (knots)
- Zonal component of environmental 850 hPa wind (m/s) interpolated to storm center
- Meridional component of environmental 850 hPa wind (m/s) interpolated to storm center
- Environmental temperature (K) interpolated to storm center
- Environmental relative humidity (%) interpolated to storm center
- Last two columns are reserved for secondary eyewall variables, missing from the FAST simulator and set equal to zero here.

Octave/MATLAB output

The program creates a subdirectory called *matlab_binaries/model/* (e.g. *matlab_binaries/ERA5/*) within which it deposits a matlab binary for each year as well as a single matlab binary containing all the years. The variable stored in these files are described in detail in the *Readme_matlab_scripts* document that accompanies the analysis scripts described below.

There is an extensive set of binary scripts that have been developed to read and process the matlab/binary output. These are described in separate documentation. Note that these are necessary to produce rain output, which is all done as a post-processing step. These scripts have not been made Octave compatible but probably could be with a little work. The rain scripts are computationally intensive and make full use of Matlab's matrix operators; they are probably unworkably slow in Octave.

Production.log

Each run creates an entry at the end of a *production.log* ascii file that is created the first time the algorithm is run. The entry has the date and time followed by a brief description that is entered in the *pname* field of the *masterwrtfast{n}* file.

Optional output:

The output can be written to *.csv* files and/or *netcdf* files depending on settings in the master file. This output is deposited in the subdirectories *csv_files* and/or *netcdf_files*. The output format is described in detail in the files *Readme_csv_FAST.pdf* and *Readme_netcdf_FAST.pdf*.

Note

If you repeat a run that has identical *name1, model, flavor*, and *basin* fields but a different set of years, the original concatenated Octave/Matlab file will be overwritten. In that case, assign a new name before running. If, on the other hand, you specify more than one set of years in the yearb and yeare fields of the master script, the original file will not be overwritten. For example:

```
#
modellist="era5"       # List of models or reanalyses used
#
flavorlist="reanal reanal"   # List of "flavors" (e.g. 'reanal', '20th') used
#                                    # Can be all the same if multiple periods desired
#     Line below: Set yearb to year range for CMIP3 files (e.g. yearb=1981_2000)
yearb=(1979 2000) # Beginning years: One set for each flavor in flavorlist; no commas!
yeare=(1990 2020) # Ending years: no commas!
```

This will produce two concatenated files; one for the years 1979:1990 and one for 2000:2020. Note that to accomplish this, *reanal* is specified twice in the flavorlist.

References

Emanuel, K., 2017: A fast intensity simulator for tropical cyclone risk analysis. *Nat Hazards*, https://doi.org/10.1007/s11069-017-2890-7.

——, R. Sundararajan, and J. Williams, 2008: Hurricanes and global warming: Results from downscaling IPCC AR4 simulations. *Bull Amer Meteor Soc*, **89**, 347–367.

Emanuel, K. A., S. Ravela, E. Vivant, and C. Risi, 2006: A statistical-deterministic approach to hurricane risk assessment. *Bull Amer Meteor Soc*, **19**, 299–314.