NHC Ensemble-based Sensitivity Code Readme

This document provides a description of the enclosed code, that can be used to compute ensemble-based sensitivity from gridded ensemble forecast data. The enclosed set of code is written in conda python and is designed to work with any grib files that contain forecast data on a lat/lon grid. Most of the settings for this program are set within a configuration/parameter file, while the date, storm, and parameter file itself are set at the command line. Furthermore, the code is designed to work for a variety of models and computing locations. Those differences related to various locations and models is also isolated to the individual i/o module, which has common routine names, but does all of the model/location specific differences inside of it and is transparent to the rest of the code.

The code itself consists of four distinct stages, all of which are controled by run_NHC_sens.py

1. Data staging and preparation (model and platform specific)
2. Computing forecast metrics (fcst_metrics_tc.py)
3. Compute forecast fields to compute sensitivity to (compute_tc_fields.py)
4. Compute sensitivity and generate maps (nhc_sens.py)

In order to generate sensitivity output, the user should run the following code from the unix command line, which is the command for the Hurricane Laura forecast initialized 0000 UTC 22 August 2020:

python run_NHC_sens.py –init 2020082200 –storm laura13l –param ecmwf_teton.py,

where the –init argument is the forecast initialization date in yyyymmddhh format, –storm is the TC name, including both the name, TC number, and the basin. The TC number and basin are necessary as the code parses the storm text string to figure out the basin and TC number. Finally, –param is the path to the paramter/configuration file, that contains a number of configuration options that are meant to be static from one initialization time/storm to another, but still gives the user the option to change how the code executes, or how the plots look. Most of the configuration options have default values, though some MUST be set within the file for the code to work. The tables below list the individual parameter/configuration options available and the default values, where appropriate.

The outcome of running this code is a set of output directories that include the graphical and gridded sensitivity output. The format of these directory is:

{html_dir}/{storm}_{yyyymmddhh}/{metric}/sens/{field}, where storm is the name of the TC (same as –storm line above), yyyymmddhh is the initialization date (same as –init line above), metric is the name of each forecast metric, where each forecast metric has its own directory. For example, the integrated track metric (the default metric of the code) is named f120_intmajtrack. Positive values of the metric are indicative of a TC that will end up further along and/or i to the right of the ensemble-mean track. The advantage of using this position metric is that it does not require specifying a particular lead time and takes into account the temporal correlation of forecast tracks (i.e., members that are further west early in the forecast will end up further west later on). The user can specify additional metrics to compute sensitivity for using the metrics configuration option.

Within each forecast metric directory are two sub-directories, one is called sens, which are the sensitivity plots/grids on a fixed domain, while the other are the plots/grids on a storm-centered grid. Within each of these directories is a set of subdirectories that represent individual forecast fields that you are computing the sensitivity to. The forecast hour in each file's name is the forecast lead time that you are computing the sensitivity to (i.e., a file starting with 202008200_f036 is the sensitivity of the metric to the 36 h forecast fields.). The table below gives the list of fields for which the sensitivity of TC track/position forecasts are computed and what they represent:

Parameter Name	Description
usteer	Zonal component of the steering flow. By default, this is designated as the average wind between 300-850 hPa (vortex removed), but this can be changed in the configuration file.
vsteer	Meridional component of the steering flow. By default, this is designated as the average wind between 300-850 hPa (vortex removed), but this can be changed in the configuration file.
masteer	Major axis winds are the wind component that is in the direction of greatest track variability for that particular case (positive values are either along and/or right of track). In most situations, the sensitivity to the major axis wind is the most useful for sensitivity calculations because it most closely relates to variability in subsequent TC position, which is not often in the Cartesian directions.
pv250hPa	250 hPa potential vorticity
h500	500 hPa height

Table 1: Configuration options for the model subset.

Parameter Name	Type	Description
model_src	string	Name of the model being used in the sensitivity calculation. This is mainly used in plot titles, so the user can set to whatever they want. No default value.
io_module	string	Name of the module to use for obtaining and reading the grib and ATCF file. Each platform and model will have its own module. This value MUST be set by the user.
num_ens	integer	Number of perturbation ensemble members (i.e., ECMWF has 50 perturbed members, GEFS has 30). No default value, so it must be set.
fcst_hour_int	integer	Forecast hour interval for computing forecast fields for sensitivity calculations in hours. Default: 12 h
fcst_hour_max	integer	Last forecast hour to compute forecast fields for sensitvity calculations in hours. Default 120 h

Table 2: Configuration options for the local subset.

Parameter Name	Type	Description
atcf_dir	string	Path to raw ATCF forecast data on local server. No default value
model_dir	string	Path to raw model data on local server. No default value
work_dir	string	Path to work directory where sensitivity calculations are carried out No default value.
output_dir	string	Path to directory to save certain output of the sensitivity calculations, if desired. No default value.
script_dir	string	Path to python scripts and modules (i.e., where this code is located.) No default value.
html_dir	string	Path to directory where output figures will be placed. No default value.
outgrid_dir	string	Path to directory where gridded sensitivity output will be placed. No default value.

Table 3: Configuration options for the vitals_plot subset.

Parameter Name	Type	Description
trackfile	string	Name of figure that shows the TC track forecast. Default: track.png
intfile	string	Name of figure that shows the TC intensity forecast. Default: intensity.png
forecast_hour_max	string	Maximum forecast hour for track and intensity plots. Default: 120 hours
grid_interval	float	Latitude and Longitude line grid interval in degrees. Default: 5°.

Table 4: Configuration options for the metric subset.

Parameter Name	Type	Description
metric_hours	float	Vector list of forecast hours to compute forecast metrics. No default value
int_track_fhr1	float	Initial forecast hour to use for integrated track metric. Default: 24 h
int_track_fhr1	float	Final forecast hour to use for integrated track metric. Default: 120 h
kinetic_energy_metric	logical	True to calculate area-average kinetic energy metric. Default: False

Table 5: Configuration options for the field subset.

Parameter Name	Type	Description
calc_steer_circ	logical	True to compute the circulation/vorticity from the steering wind. Default: False
calc_pv250hPa	logical	True to compute PV on the 250 hPa surface. Default: True
calc_the700hPa	logical	True to compute 700 hPa equivalent potential temperature. Default: False
calc_q500-850hPa	logical	True to compute the integrated water vapor between 500 and 850 hPa. Default: False
min_lat	float	Minimum latitude to compute forecast fields over. Default: 0.0
max_lat	float	Maximum latitude to compute forecast fields over. Default: 65.0
min_lon	float	Minimum longitude to compute forecast fields over. Default: -180.0
max_lon	float	Maximum longitude to compute forecast fields over. Default: -10.0

Table 6: Configuration options for the sens subset. This set of parameters set the display options for the sensitivity plots.

Parameter Name	Type	Description
metrics	string	List of names of forecast metrics to compute the sensitivity to. Default: none
min_lat	float	Minimum latitude for sensitivity plots. Default: 8.0, also set in run_NHC_sens.py based on basin.
max_lat	float	Maximum latitude for sensitivity plots. Default: 65.0, also set in run_NHC_sens.py based on basin.
min_lon	float	Minimum longitude for sensitivity plots. Default: -140.0, also set in run_NHC_sens.py based on basin.
max_lon	float	Maximum longitude for sensitivity plots. Default: -20.0, also set in run_NHC_sens.py based on basin.
grid_interval	float	Latitude and Longitude line grid interval in degrees. Default: 10°.
barb_interval	integer	Number of grid points in between each wind barb in the plot. Default: 6 grid points
dropsonde_file	string	Full path to file of dropsonde locations. Default: none
drop_mark_size	integer	Marker size of dropsonde locations in plot. Default: 6
drop_mark_color	string	Dropsonde marker color in plot. Default: black
drop_mark_type	string	Dropsonde marker in plot. Default: +
rawinsonde_file	string	Full path to file of rawinsonde locations. Default: none
rawin_mark_size	integer	Marker size of rawinsonde locations in plot. Default: 6
rawin_mark_color	string	Rawinsonde marker color in plot. Default: gray
range_rings	logical	True to plot range rings from the predicted TC center. Default: True
ring_values	floats	List of range ring radii for plot in km. Default:
output_sens	logical	True to create netCDF file that contains gridded sensitivity fields that can be used in AWIPS or traveling salesman. Default: True
nhc_sens	logical	True to create NHC version of the gridded netCDF file, which means that it includes a variable that is the absolute value of sensitivity (for traveling salesman software). Default: False