OFCL/WW3 Documentation

1 Revision History

Date	Who	What
8 August 2011	Buck Sampson	OFCL/WW3 for NHC

2 Introduction

The OFCL/WW3 algorithm is a method to ensure consistency between the official NHC forecast and the significant wave heights output by WAVEWATCH III. This is done by generating wind fields from the official observed and forecast tropical cyclone structure. Then, the GFS surface wind fields for the same forecast times (with its TC circulation removed) are used as background fields outside the area defined by the official forecast circulation. These modified fields are then used in the NCEP WAVEWATCH III (version 2.23) to generate the wave height fields.

The OFCL/WW3 software consists of two separable algorithms: The algorithms to create wind fields from the official forecast (in the ~/tessa directory), and the WAVEWATCH III (in the ~/ww3 directory). Both are initiated by cron entries and scripts within the ~/tessa directory. This is done twice for each storm (a preliminary run and a final run), twice a day (00 and 12 UTC). The preliminary run is done at approximately + 3 hours using 12-hour old GFS data and the final run is done at approximately +8 hours using the current GFS run. The cron times can be further adjusted to fit NHC operations with little effort.

The algorithm to generate surface wind fields in the ~/tessa directory or "tessa" (short for Delaunay tessellation) starts with NHC generated storm files (adeck and bdeck) from the Automated Tropical Cyclone Forecasting System (ATCF) and background surface winds from GFS, and generates a set of hourly grids to be used in WAVEWATCH III. This process is completed for each Atlantic storm in the active list. An active list is currently obtained from NRL, though this should eventually be generated at NHC. The GFS background fields are GRIB files, and are currently also obtained from NRL. In the future, these GFS files should really be supplied from within NHC vice NRL. Even more preferable would be to replace the entire wind fields generated here by those from the TAFB unit, but that will be left for later.

The WAVEWATCH III algorithm in the ~/ww3 directory takes only the surface wind input grids from the wind generation algorithm. It runs on a .25 degree grid, the domain of which covers most of the western Atlantic. The WAVEWATCH is run once for each storm in the current storm list. Once the model runs to completion (the last forecast period of the OFCL forecast), the significant wave height fields are converted to GRIB files for display in AWIPS and AWIPS-2. A version of the Marchok tc tracker is

also run on the output, and ATCF files with highest seas and significant wave height are then created. These ATCF files can be used to rapidly investigate OFCL/WW3 runs.

3 References

Sampson, C. R., P. A. Wittmann, and H. L. Tolman, 2010: Consistent tropical cyclone wind and wave forecasts for the U.S. Navy. **Wea. Forecasting, 25,** 1293-1306.

Sampson, C. R., and A. J. Schrader, 2000: The Automated Tropical Cyclone Forecasting System (Version 3.2). **Bull. Amer. Meteor. Soc., 81**, 1231-1240.

Tolman, H. L., J. H. G. M. Alves, and Y. Y. Chao, 2005: Operational forecasting of wind-generated waves by Hurricane Isabel at NCEP. **Wea. Forecasting, 20,** 544-557.

Tolman, 2002g: User manual and system documentation of WAVEWATCH-III version 2.22. NOAA / NWS / NCEP / MMAB Technical Note 222, 133 pp.

NRL, 2011: ATCF Tropical Cyclone Database. Available online at: http://www.nrlmry.navy.mil/atcf_web/docs/database/new/database.html

4 Software Description

The software is composed of cron entries, shell scripts and FORTRAN programs. The cron entries are under the user “wave” on “compute2.nhc.noaa.gov”. Under the home directory of wave, there are two directories: “tessa” and “ww3”. In the tessa/scripts directory the three scripts “tws_00.sh”, “tws_12.sh”, and “tws.sh” orchestrate the entire OFCL/WW3 process. The scripts make decisions about what storms to run and for what initial time (00Z or 12Z). The tws.sh script calls the script “tessa.sh” to generate wind fields, and then executes “ww3.sh” over in the ww3/job directory. The ww3.sh script is the driver for the WAVEWATCH III model. The tessa.sh script is rather complex (probably overly complex), and its flow is shown in the figures below. It takes approximately 5 minutes to generate wind fields for a 120-h forecast, and another hour to run the WAVEWATCH III through the ww3.sh script. The ww3.sh script sets up the domains and input for WAVEWATCH III. See the WAVEWATCH III manual for more information on domains, input files and output files.

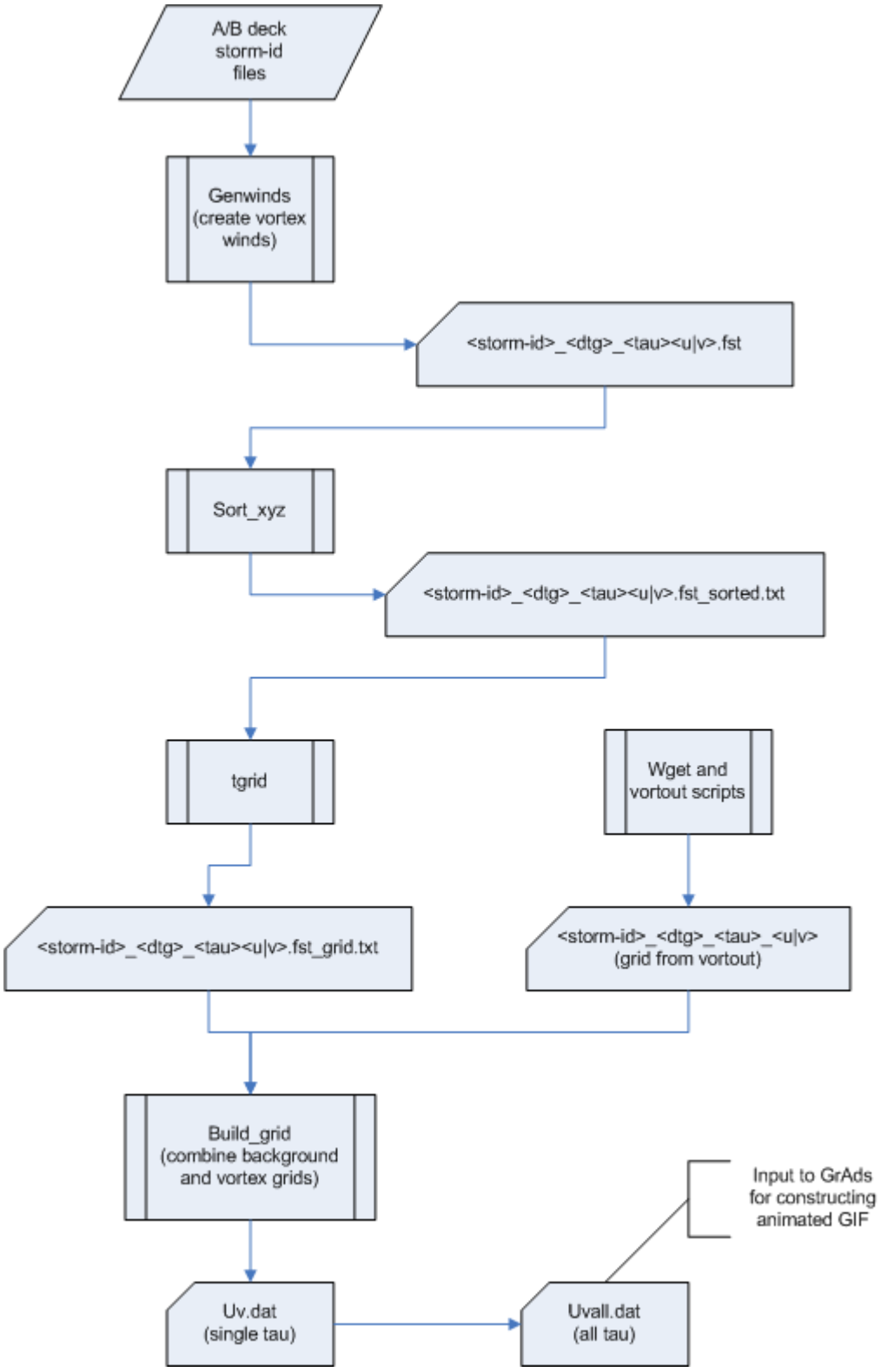

Figure 1. Tessa scripts/programs to generate winds for WAVEWATCH III

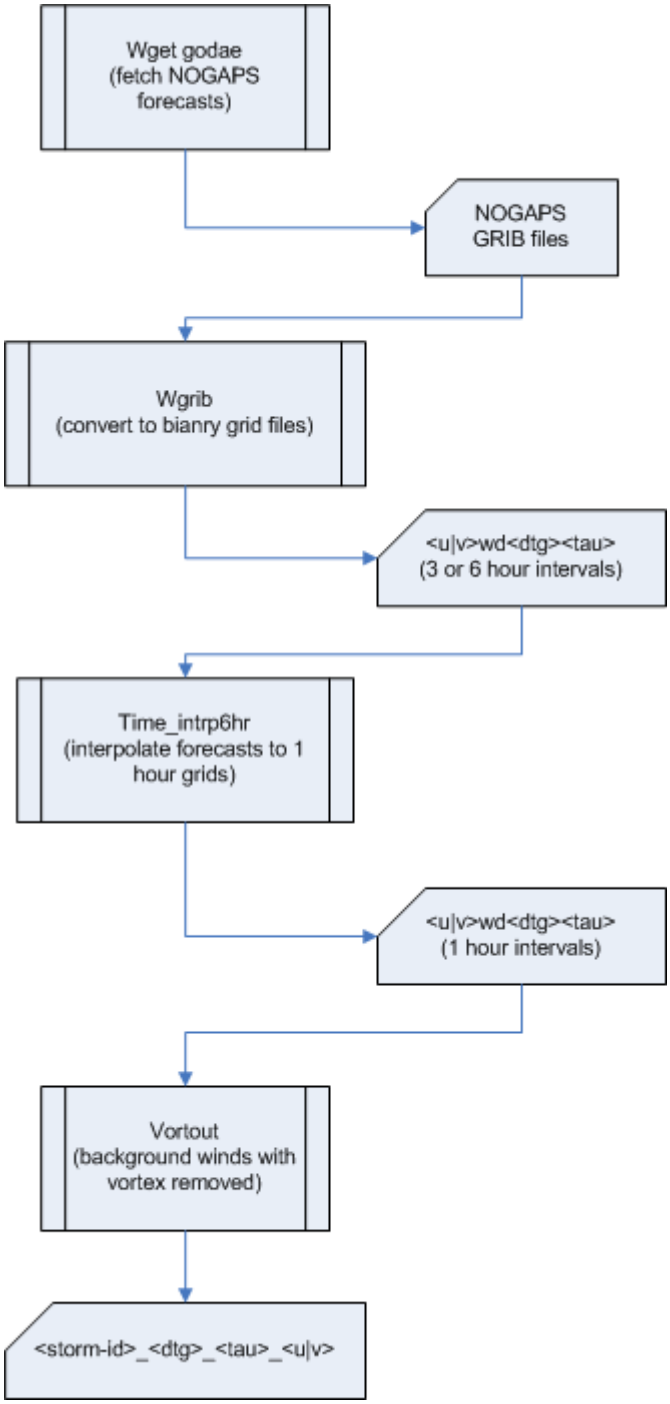

Figure 2. Tessa scripts and programs to obtain background fields and take the vortex out

4.1 Tessa Scripts and Programs (~/tessa/scripts and ~/tessa/bin)

Parameters or components of filenames are designated here with angle brackets "<>". Within angle brackets, multiple choices are separated by vertical bar "|", e.g., wind components U or V, "<u|v>". The following table lists all parameters that are used as inputs or may be seen in filenames.

Parameter	Description	Example
<storm-id>	composed of 2-letter basin, 2-digit storm number, 4-digit year	wp272008; io012009
<dtg>	date-time group, 4-digit year, 2-digit month, 2-digit day, 2-digit hour. Usually designates start time for forecast.	2009041506
<tau>	3-digit time in hours. Time of forecast after the <dtg>	006
<basin>	2-letter code for ocean basin	io, wp, al, ep, cp, sh

tws_00.sh. No arguments. Runs the 00 UTC tessa.sh and ww3.sh
tws_12.sh No arguments. Runs the 12 UTC tessa.sh and ww3.sh
tws.sh argument list: "<hour> <basin>
tessa.sh. argument list: "<storm-id> <dtg> <end tau> [model] [server]". [model] is either "nogaps" or "gfs". [server] is either "godae" or "xx". Example: tessa.sh io012009 2009041500 72 nogaps godae
do_genwinds.sh. Run from tessa.sh. Runs the genwinds software
wget_godae.sh. Run from tessa.sh. Uses godae server to fetch NOGAPS or GFS model grids in GRIB format. Then de-gribs the files, and finally interpolates between the forecast times and creates grids at one hour intervals.
do_vortout.sh. Run from tessa.sh. Removes vortex from the hourly grids.
genwinds. Input a-deck and b-deck. Output u,v and atcf winds files. These are text files with names <storm-id>_<dtg>_<tau>[uv].fst. The atcf file variant mimics a SCT input. Each row in the output is one point in the vortex prediction; so the output is not a regular grid and will not fill the entire background space.
vortout. Input de-grib'ed NOGAPS file and a-deck and b-deck files. Output file with name <storm-id>_<dtg>_<tau>_[uv]; output files are ASCII, entire grid, one grid point per row, represents NOGAPS input with a-deck vortex removed. Uses a-deck and b-deck to create a vortex wind grid, then removes from the NOGAPS wind field.
sort_xyz: reads cyclone wind forecasts from a-deck files, sorts on latitude-longitude, removes forecasts that are duplicate (nearly same lat-long).
tgrid: creates a grid file by Delaunay tessellation (interpolation) from the output of sort_xyz. The grid file is regularly spaced coverage of the vortex area only.
build_grid: uses output from tgrid to interpolate the vortex to the regional grid that is used by the background fields.
wnd_to_ww3: creates wind field file over span of times that is used as input to Wave Watch III.

4.2 Directories under ~/tessa

Directory	Contents	Notes
bin	compiled programs from src	
scripts	shell scripts that run the entire process	
src	fortran source code	includes Makefiles
data	subdirectories will contain wind forecast files in GRIB format	files obtained from GODAE or ISIS or CAVU
output	ASCII .fst files for U,V at each TAU	also some binary grid files
storms	A-deck and B-deck files for each storm	files obtained from NRL server
tmp	debug outputs and other temporary files	
etc	contains subdirectory for region and analysis time that contains binary file wind.ww3	
test	contains copies of data, output and storms directories for at least one tropical cyclone. The storms and data files are sufficient to run tessa offline, and the output directory can be compared to your test run for verification.	
Tc_tracker	Modified Marchok tracker code	Tracks 12-ft seas and max seas

4.3 Tessa Input (in ~/tessa)

Essential input files.

Storm-id is a two-letter code plus two-digit code plus four-digit year; e.g., wp272008 is Western Pacific, 27th storm of the year, year 2008.

DTG stands for date-time group. It is 4-digit year plus 2-digit month plus 2-digit day plus 2-digit hour; e.g., 2009041500. When tessa software is run, the input DTG typically represents the current watch time. Therefore, every 6 or 12 hours the DTG input will change and a new set of input and output files will be generated

File	Description	Location
a<storm-id>.dat	a-deck storm fixes. Updated as new fixes and predictions are made, but the file is cumulative over the lifetime of the storm.	storms directory
b<storm-id>.dat	b-deck storm fixes (BEST). Same comments as above.	storms directory
GRIB files of u,v	Files are obtained from godae, cavu	data/winds/nogaps/<DTG>

File	Description	Location
wind fields at surface. Analysis plus forecast files.	or ISIS	or data/winds/gfs/<DTG>
Stormlist.current	List of storms on which to run OFCL/WW3	storms directory

4.4 Tessa Output (in ~/tessa)

Temporary files are found in the "temp dir" (subdirectory tmp/<storm-id>_<dtg>). However, there are other temporary files in the output directory and

File	Description	Location
<u|v>wd<dtg><tau>	binary grid (long*lat, real*4) of surface wind field forecast at TAU hours. Created by wgrib and time_intrp programs from forecast GRIB files. Input to vortout.	data/winds/nogaps/<dtg>
wind.ww3	binary. Contains all U,V wind fields for all TAU, and also has some parameters at start of file.	etc/winds/<basin>/<dtg>
wind.ww3	(duplicate file)	storms/<storm-id>
UGRD<dtg><tau>	copy of ucmp.dat	temp directory
VGRD<dtg><tau>	copy of vcmp.dat	temp directory
<u|v>cmp.dat	created by program build_grid	
<storm-id>_<dtg>_ <tau><u|v>.fst	Input to sort_xyz. Output from genwinds. Interpolated background?	output dir, then copied to temp dir and also storms/<storm-id>
<storm-id>_<dtg>_ <tau><u|v>.fst_sorted.txt	outut of program sort_xyz. Input to tgrid.	temp directory
<storm-id>_<dtg>_ <tau><u|v>.fst_grid.txt	output of program tgrid. Input to build_grid	temp directory
uv.dat	grads data file. Binary. Created in build_grid by interpolating file from tgrid to the regional grid.	temp directory
uvall.dat	concatenation of all uv.dat files (one for each tau)	temp directory
uv.gs	input to grads to generate GIF	temp directory
cbarn.gs	input to grads to draw a colorbar on the GIF	temp directory
backu, backv	temp copy of background winds for each tau	temp directory
<storm-id>_<dtg>_	background winds for each tau,	output directory

<tau>_<u|v>	output by vortout. Vortex is removed. Text format, one degree grid. Input to build_grid.	
<storm-id>.uv.<dtg>_ animation.gif	output by grads, shows the cyclone over time against the background forecast from NOGAPS or GFS.	storms/<storm-id>

wind.ww3 – created by program wnd_to_ww3. Reads binary files UGRD<DTG><TAU> and VGRD<DTG><TAU>

4.5 WW3 Scripts and Programs (~/ww3/scripts and ~/ww3/bin)

scripts/ww3.sh. argument list: "<storm-id> <dtg> <end tau>
scripts/grib.sh. argument list: "<storm-id> <dtg> <end tau>

Again, see WAVEWATCH III Users Manual for more information.

4.6 Directories under ~/ww3

Directory	Contents	Notes
bin	compiled programs from src	
jobs	shell scripts that run the WAVEWATCH	
src	fortran source code	includes Makefiles
output	ASCII .fst files for U,V at each TAU	also some binary grid files
tmp	debug outputs and other temporary files	
etc	contains subdirectory for region and analysis time that contains binary file wind.ww3	
atcf	Adeck format 12-ft seas and max sea ht	
runs	Saved GRIB files for individual runs	

4.7 WAVEWATCH III Input (in ~/ww3)

Essential input files. See WAVEWATCH III Users Manual for more information on the many other files in this system.

File	Description	Location
wind.ww3	Surface wind file for a given dtg	etc/winds/al/<DTG>
restart?.ww3	Restart files	etc/restart/al/<DTG>
model_def.ww3	Grid definition for domain	etc/static/al

4.8 WAVEWATCH III Output (in ~/ww3)

Essential output files. See WAVEWATCH III Users Manual for more information on the many other files in this system.

File	Description	Location
<storm-id>.<DTG>.ww3.grib	GRIB file with sig wave hts	runs/
restart?.ww3	Restart files	etc/restart/al/<DTG>
OFWW.<storm-id>.<DTG>_ID	ATCF format 12-ft seas and max sea heiths	atcf/

5 Troubleshooting

Troubleshooting this software should be limited to maintenance of three datasets:

1) the stormlist.current file
This file contains a list of ATCF current storm ids and resides in the "~/tessa/storms" directory. At the time this document was written, the stormlist.current was obtained from NRL via wget. It should be replaced by something within NHC architecture to eliminate dependence on NRL websites.

2) the ATCF files (bdeck, adeck, forecast file)
These files are all in /atcf directory, which is updated by the operational ATCF at NHC. The files are used to determine whether the observations and forecasts are in sync with regard to date, and then used to generate wind for the official forecast. Finally, the adeck is used in removing the GFS vortex from the background GFS surface winds.

3) The GFS surface winds for all forecast times.
These GFS winds are stored in ~/tessa/data/winds/gfs/<yyyymmddhh>. They are grib files, and they currently come from a real-time server at NRL through a series of wget commands. As these files arrive late at NRL and the server is not operational, it is advised that a grib feed directly from within NHC replace the NRL feed.

6 Potential Future Improvements

Probably the easiest and most elegant improvement would be to replace the entire vortex creation, background removal, GFS data retrieval processes with a process to obtain and ingest the modified surface wind fields directly from TAFB. This would

require some effort, but it would enable the WW3 to produce a product that is entirely consistent with the TAFB surface winds. It would also greatly reduce possible interruptions in the OFCL/WW3 products since there would be limited input (just the TAFB surface winds). When the TAFB winds from AWIPS-2 become available in real-time, a process to replace the existing OFCL/WW3 process should be initiated.