

## **WRFv3.4.1+ Surface Drag Parameterization Sensitivity Test - Archive Overview**

This sensitivity test consisted of a year-long retrospective time period from 1 July 2011 – 29 June 2012, with a focus on assessing two new surface drag parameterization schemes (namelist option *topo\_wind*) available in the Weather Research and Forecasting (WRF) model version 3.4.1+. The parameterizations are associated with the Yonsei University (YSU) planetary boundary layer (PBL) scheme; the new parameterizations aim to address the high wind speed bias in WRF, namely over the plains and valleys. Three WRF configurations with the Advanced Research WRF (ARW) core were tested. The baseline configuration (*topo\_wind* = 0 option; REF) was run with the physics suite currently being used in the ARW High-Resolution Window (HIRESW) forecast system being run operationally at the National Centers for Environmental Prediction (NCEP). The second configuration was run with the *topo\_wind* = 1 option (TWIND1); the third configuration was run with the *topo\_wind* = 2 option (TWIND2). All three configurations were initialized every 36 h with a 48 h forecast integration; forecasts were generated on a 15-km and 5-km 2-way nested (*feedback* = 1) grid with output files written every 3 h. The initialization times included both 00 and 12 UTC for a total of 244 cases. The dates for which forecasts were generated are listed below.

<b>00 UTC Initialization</b>	<b>12 UTC Initialization</b>
July 2011: 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31	July 2011: 2, 5, 8, 11, 14, 17, 20, 23, 26, 29
August 2011: 3, 6, 9, 12, 15, 18, 21, 24, 27, 30	August 2011: 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31
September 2011: 2, 5, 8, 11, 14, 17, 20, 23, 26, 29	September 2011: 3, 6, 9, 12, 15, 18, 21, 24, 27, 30
October 2011: 2, 5, 8, 11, 14, 17, 20, 23, 26, 29	October 2011: 3, 6, 9, 12, 15, 18, 21, 24, 27, 30
November 2011: 1, 4, 7, 10, 13, 16, 19, 22, 25, 28	November 2011: 2, 5, 8, 11, 14, 17, 20, 23, 26, 29
December 2011: 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31	December 2011: 2, 5, 8, 11, 14, 17, 20, 23, 26, 29
January 2012: 3, 6, 9, 12, 15, 18, 21, 24, 27, 30	January 2012: 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31
February 2012: 2, 5, 8, 11, 14, 17, 20, 23, 26, 29	February 2012: 3, 6, 9, 12, 15, 18, 21, 24, 27
March 2012: 3, 6, 9, 12, 15, 18, 21, 24, 27, 30	March 2012: 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31
April 2012: 2, 5, 8, 11, 14, 17, 20, 23, 26, 29	April 2012: 3, 6, 9, 12, 15, 18, 21, 24, 27, 30
May 2012: 2, 5, 8, 11, 14, 17, 20, 23, 26, 29	May 2012: 3, 6, 9, 12, 15, 18, 21, 24, 27, 30
June 2012: 1, 4, 7, 10, 13, 16, 19, 22, 25, 28	June 2012: 2, 5, 8, 11, 14, 17, 20, 23, 26, 29

The archive resides on the NCAR High Performance Storage System (HPSS). The following paragraphs describe the overall directory structure of this archive.

## INPUT DATA:

**/RAPDMG/grib/GFS004:** Directory containing GFS forecast grids, which were used to generate the initial and lateral boundary conditions for the retrospective simulations; subdirectories are in **yyyymmdd** format, where *yyyy* corresponds to the year of the forecast cycle, *mm* corresponds to the month, *dd* corresponds to the day. Files in the subdirectories contain output for 00, 06, 12, and 18 UTC initializations with output every 3 hours and have the naming convention: **yyyymmdd\_ihh\_ffhr\_GFS004.grb2.gz**, where *yyyy* corresponds to the year of the forecast cycle, *mm* corresponds to the month, *dd* corresponds to the day, *hh* corresponds to the hour of the forecast initialization and *ffhr* corresponds to the forecast hour (available every 3 h from 000 to 192; this test only ran a 48 h forecast).

**/DTCRT/RefConfig/INPUT\_DATA:** Directory containing SST data used to generate the initial and lateral boundary conditions for the retrospective forecasts. The files are grouped into subdirectories named **yyyymmdd**, where *yyyy* corresponds to the year of the forecast cycle, *mm* corresponds to the month, *dd* corresponds to the day. Files in the subdirectories contain SST analysis grids with the naming convention: **navysst.tar.gz** (valid at 12 UTC daily).

## OUTPUT DATA:

**/DTCRT/RCv3.4/NOAA\_SFCDRAG:** Root directory for all output files, METViewer plots, code, scripts, and static files.

**static:** Subdirectory containing all time-independent namelists used to run the forecast system.

Tar files for **REF\_static.tar.gz**, **TWIND1\_static.tar.gz**, and **TWIND2\_static.tar.gz** contain namelists to run the WRF Pre-Processor (WPS), WRF, and the Unified Post-Processor (UPP) for the ARW dynamic core as well as the *geogrid* and *metgrid* TBL files, along with the Variable Tables used to run the *ungrib* program of WPS;

**met\_config.tar.gz** contains the configuration files for running the Model Evaluation Tools (MET).

**code:** Subdirectory containing all source codes and scripts used in the end-to-end system. The code used was WPS (v3.4.1), WRF (v3.4.1+, tag from the WRF repository, dated 11 November 2012), UPP v2.0, and MET. Scripts used to run individual steps of the process, workflow manager, and output log files are also located in this subdirectory. Due to a bug in processing virtual temperature in MET, the point verification was rerun; both the original version and bug fix version of MET are included.

**REF, TWIND1, and TWIND2:** The subdirectories under these three headings are as follows:

**yyyymmddhh:** Subdirectories contain output files for each forecast cycle, where *yyyy* corresponds to the year of the forecast cycle or initial time of the forecast, *mm*

corresponds to the month, *dd* corresponds to the day, and *hh* corresponds to the hour.

Under each data subdirectory and contain the following data:

**metprd:** Contains **metverif.d01.tar.gz** and **metverif.d02.tar.gz**, which have all the verification output files for the 15-km (d01) and 5-km (d02) domains. All of these files were produced by the MET (v4.0). The Point-Stat tool statistics files ("point\_stat\*.stat") contain surface and upper air point verification statistics. The Grid-Stat tool statistics files ("grid\_stat\*.stat") contain traditional statistics for 24-h and 3-h Quantitative Precipitation Forecasts (QPF). Also included are the **wrfpcp.d01.tar.gz** and **wrfpcp.d02.tar.gz** files that contain the NetCDF files with 3-h and 24-h precipitation accumulations that have been run through PCP-Combine for the 15-km (d01) and 5-km (d02) domains.

**nclprd:** Contains the files **images.d01.tar.gz** and **images.d02.tar.gz**, which have all the image files, generated with NCAR Command Language (NCL), for the forecasts from the 15-km (d01) and 5-km (d02) domains

**postprd:** Contains post-processed output files. All of these files were produced by the UPP and are in GRIB format. The **wrfprs.d01.tar.gz** and **wrfprs.d02.tar.gz** files contain the GRIB files with 3D grids on pressure surfaces and 2D grids (files used by DTC for verification and image generation), the **wrftwo.d01.tar.gz** and **wrftwo.d02.tar.gz** files contain the GRIB files with 2D grids, and the **WRFNAT.d01.tar.gz** and **WRFNAT.d02.tar.gz** files contain the GRIB files with the 3D grids on the model native vertical coordinates, all for the 15-km (d01) and 5-km (d02) domains

**wpsprd:** Contains final output from the WPS process *metgrid* (**met\*** files). WPS was ONLY run for the ARWref configuration and the output for the TWIND1 and TWIND2 configurations were used input files from the ARWref configuration.

**wrfprd:** Contains the raw WRF output files on the native grid (**wrfout\***). Output was generated every 3 h over the 48 h forecast with each forecast time (or valid time) written to a separate file. Additionally, this directory contains output files from *real* (**wrfinput\_d01** and **wrfbdy\_d01**).

Two additional subdirectories (**REFTWIND1** and **REFTWIND2**) contain the file

**nclprd/images.d01.tar.gz** and **nclprd/images.d02.tar.gz** with the images of the difference fields between ARWref and TWIND1 as well as ARWref and TWIND2 for the 15-km (d01) and 5-km (d02) domains.

**metv:** Contains all load and batch XMLS (**xml.tar.gz**) as well as vertical level, lead series, and select threshold series plots for all configurations (**all\_d01.tar.gz**, **all\_d02.tar.gz**), REF – TWIND1 (**reftwind1diff\_d01.tar.gz**, **reftwind1diff\_d02.tar.gz**), REF – TWIND2 (**reftwind2diff\_d01.tar.gz**, **reftwind2diff\_d02.tar.gz**), TWIND1 – TWIND2

(**twind1twind2diff\_d01.tar.gz, twind1twind2diff\_d02.tar.gz**) and d01 – d02  
(**refdiff\_d01\_d02.tar.gz, twind1diff\_d01\_d02.tar.gz, twind2diff\_d01\_d02.tar.gz**).

**RERUN\_MET:** Subdirectory containing reprocessed grid-to-point verification data (MET files and METViewer plots) due to a bug in processing virtual temperature in the *pb2nc* tool. Contains the following subdirectories with rerun MET output:

**REF, TWIND1, and TWIND2:** The subdirectories under these three headings are as follows:

**yyyymmddhh:** Subdirectories contain output files for each forecast cycle, where *yyyy* corresponds to the year of the forecast cycle or initial time of the forecast, *mm* corresponds to the month, *dd* corresponds to the day, and *hh* corresponds to the hour. Under each data subdirectory and contain the following data:

**metprd:** Contains **point\_stat.tar.gz**, which have all the verification output files for the 15-km (d01) and 5-km (d02) domains. All of these files were produced by the MET (v4.1 w/*pb2nc* fix). The Point-Stat tool statistics files ("point\_stat\*.stat") contain surface and upper air point verification statistics.

**metv:** Contains all load and batch XMLS (**xml.tar.gz**) as well as vertical level and lead series plots for all configurations (**all\_d01.tar.gz, all\_d02.tar.gz**), REF – TWIND1 (**reftwind1diff\_d01.tar.gz, reftwind1diff\_d02.tar.gz**), REF – TWIND2 (**reftwind2diff\_d01.tar.gz, reftwind2diff\_d02.tar.gz**), TWIND1 – TWIND2 (**twind1twind2diff\_d01.tar.gz, twind1twind2diff\_d02.tar.gz**) and d01 – d02 (**refdiff\_d01\_d02.tar.gz, twind1diff\_d01\_d02.tar.gz, twind2diff\_d01\_d02.tar.gz**).

#### **OBSERVATION DATA:**

**/DTCRT/RefConfig/OBS:** Root directory for all the observation files used for the forecast verification. The observation files are collected into subdirectories for each type named **NDAS\_03h** (point observations), **NESTED\_RC/ST2\_24h/15km** and **NESTED\_RC/ST2\_24h/5km** (gridded 24-h precipitation accumulations valid at 12 UTC for the 15- and 5-km domains, respectively), and **NESTED\_RC/ST2\_03h/15km** and **NESTED\_RC/ST2\_03h/5km** (gridded 3-h precipitation accumulations valid every 3 h for the 15- and 5-km domains, respectively). Each has subdirectories named **yyyymmdd**, where *yyyy* corresponds to the year, *mm* corresponds to the month, and *dd* corresponds to the day for which the observations are valid. The following types of files are archived under the observation subdirectory tree:

**ndas\_prepbuf.yyyymmdd.nc.tar.gz:** contains NDAS prepbuf files used for the surface and upper air point verification every 3 h.

**ST2mlyyyymmdd.15km.24h.nc.tar.gz** or **ST2mlyyyymmdd.5km.24h.nc.tar.gz**: contains Stage-II national multi-sensor hourly precipitation analysis data summer over a 24-h interval, valid at 12 UTC for the 15- and 5-km domains, respectively.

**ST2mlyyyymmdd.15km.03h.nc.tar.gz** or **ST2mlyyyymmdd.5km.03h.nc.tar.gz**: contains Stage-II national multi-sensor hourly precipitation analysis data summed over 3-h intervals for the 15- and 5-km domains, respectively.

Data with problems:

**Missing forecasts:**

Affected Cycle	Missing data	Reason
2011071712	WRF output	Missing SST input data
2011080112	WRF output	Missing SST input data
2011082400	WRF output	Missing SST input data
2011121712	WRF output	Missing GFS input data
2012011012	WRF output	Missing GFS input data
2012011612	WRF output	Missing GFS input data
2012012212	WRF output	Missing GFS input data
2012042000	WRF output	Missing GFS input data
2012042412	WRF output	Missing GFS input data
2012042600	WRF output	Missing GFS input data
2012050500	WRF output	Missing GFS input data
2012060400	WRF output	Missing SST input data

**Missing verification:**

Affected Cycle	Missing data	Reason
2011072500	Missing 3-h QPF verification for 18 – 21-h Missing 24-h QPF verification for 36-h	Missing ST2 analysis