How to use SRTM Topographical Data with RASP

RASP comes with a set of static geog data. It contains among other things terrain height in four resolutions, the finest being 30 arc seconds or approximately 1 km at the equator. Studies show that a model grid spacing of ~4 km or less is more accurate using higher resolution terrain data, especially for wind and wave forecasts. The instructions below show how to incorporate a high resolution terrain dataset into RASP. There is no need to (re)install anything concerning RASP: you can just add this to a working RASP-V3 model, test it, use it or easily return to your previously used terrain dataset. The grid calculation time is about the same.

- Go to http://dwtkns.com/srtm/ or to http://srtm.csi.cgiar.org/SELECTION/inputCoord.asp. Click on a tile to download it. Download all available GeoTiff tiles for the area of your nest domain or inner grid. Try to download a complete square or rectangle but it is not a problem if one or more (100% sea) tiles within it don't exist. Extract each of them in a separate directory.

Each tile contains 4 files: a .txt, .hdr, .tfw and .tif file. This latest SRTM version 4 has a resolution of 90m at the equator and is provided in 5 deg x 5 deg tiles. Their size is 6001x6001 pixels: in fact 5999x5999 pixels with an overlap of 1 pixel on each side (not 6000x6000 pixels as indicated in the text file). The overlap was checked by opening neighbouring .tif-files in a paint program. The total number of pixels over all tiles combined has a maximum of 99999, both horizontally and vertically. Therefore the maximum downloadable area for your nest domain or inner grid will be 16x16 tiles.

- The WRF preprocessing system (WPS) requires the static geographic data to be in binary format. This file is read by the geogrid program used to set up the WRF domain. Each SRTM tile must be converted to the WPS binary format via the command:

```
$ gdal_translate -of ENVI tilename.tif tilename.bil
```

The .hdr file is overwritten by a slightly different one and 2 new .bil and .bil.aux.xml files are created.

- To create the needed index file, use a text editor to copy and paste the following in a new file named "index".

```
type = continuous
signed = yes
projection = regular_ll
dx = 0.000833333333333
dy = 0.000833333333333
known_x = 1.0
known_y = 5999
known_lat = 45.0004168845861
known_lon = -5.00041608553147
wordsize = 2
endian = little
tile_x = 5999
tile_y = 5999
tile_z = 1
tile_bdr=1
row_order = top_bottom
missing_value = 32768
units = "meters MSL"
description = "SRTM 3-sec Topography height"
```

- Next change the known_lat and known_lon. There are two options here:

1.If you were able to download your most southwest (lower left) tile, open the .hdr file for this tile. Locate the known_lat and known_lon values and copy into your index file. For example you might find **"map info = {Geographic Lat/Lon, 1, 1, -5.00041608553147, 45.0004168845861, 0.000833333333333333, 0.000833333333333333,WGS-84}"** The first value is always known_lon and the second is known_lat.

2.If you were not able to download your most southwest or lower left tile, you obviously can't open its .hdr file to copy the values of known_lat and known_lon into your index file! You have to determine these values from the other .hdr files. Open multiple .hdr files for the tiles to the north and to the east of your non-existent extreme southwest (lower left) tile. You can see the values of known_lon and known_lat change following a regular pattern. Deduce the appropriate values.

- Rename all .bil files into "00001-ncols.00001-nrows" without an extension. Ncols and nrows are the number of columns and rows in the datafile. Start with the tile in the most southwest or lower left corner. The name of this tile will be "00001-05999.00001-05999". The name of the tile above this will be "00001-05999.06000-11998" and the name of the tile on the right is "06000-11998.00001-05999" etc. If a tile is not available just continue with the numbering as if it was there.

- Create a "topo_SRTM3S" directory in the RASP "geog" directory and copy the renamed .bil files/tiles and the created index file into this "topo_SRTM3S" directory.

- Now tell RASP about your new data. There are three options here:

1.If you were able to download a complete set of tiles for a square or rectangle with no missing (100% sea) tiles, open the "GEOGRID.TBL" file in the RASP "RUN.TABLES" directory. Add the following two lines under the section "**name = HGT_M**": immediately above the line with "**30s:average…" add interp_option = SRTM3S:average_gcell(4.0)+four_pt+average_4pt** and above the line with "30s:topo …" add **rel_path= SRTM3S:topo_SRTM3S/**

2.If you there were one or more tiles missing, you will need to create the missing tile(s) by downloading a tile in the neighbourhood which consists mostly of sea. Open the .tif file in a simple paint program and make all the land the color of the sea and save the file. The memory size of the tile will double but this is no problem. Convert the .tif into a .bil file and correctly rename it (or them), following the instructions above. I guess there is a better way to create a 6001x6001 pixel sea tile but it works. Open the "GEOGRID.TBL" file in the RASP "RUN.TABLES" directory. Then add the extra two lines in GEOGRID.TBL under "name = HGT_M" as above.

3.If there were one or more tiles missing, you can cover the missing area of your nest domain with the existing 30s resolution terrain data. This method is often used when there are no data values in the new data, for example when incorporating high resolution land use data for a specific area. In the SRTM data all voids were filled so there will not be any "no data" pixels/cells. Open the "GEOGRID.TBL" file in the RASP "RUN.TABLES" directory. Add the following lines above "name = HGT_M" and "priority = 1":

==========
name = HGT_M
priority = 2

```
        dest_type = continuous
        df_dx=SLPX
        df_dy=SLPY
        smooth_option = smth-desmth_special; smooth_passes=1
#       fill_missing=0.
        interp_option =     SRTM3S:average_gcell(4.0)+four_pt+average_4pt
        interp_option =          10m:four_pt
        rel_path=           SRTM3S:topo_SRTM3S/
        rel_path=                10m:topo_10m/
==============================
name = HGT_M
      priority = 1
```

Where the two 10m lines have to have the same resolution as your moad as specified in geog_data_res, see below. (If you run multiple regions you probably also need to specify the data they use under priority = 2.) Also add the following two lines under "name = HGT_M" and “priority = 1” at the right place each above the lines with 30s:

interp_option = SRTM3S:average_gcell(4.0)+four_pt+average_4pt, and
rel_path= SRTM3S:topo_30s/

And uncomment the following two lines:

```
#       df_dx=SLPX
#       df_dy=SLPY
```

- To use the new SRTM3S terrain data option, you must, for each region, alter the geog_data_res variable in *both* **namelist.wps** and **namelist.wps.template** in directory $BASEDIR/REGIONXYZ as follows. Note the current settings (or backup the file) in case you want undo the changes.

Change **geog_data_res = '10m', '2m',** to **geog_data_res = '10m', 'SRTM3S+2m',** or perhaps **geog_data_res = '2m', '30s',** to **geog_data_res = '2m', 'SRTM3S+30s’,** In this way it will use SRTM data and for all other variables 30s data.

Note that the first value sets the data used for the moad, the second sets the data used for the nest domain.

- Run "geogrid.exe" in the region directory. It takes takes noticably longer to do HGT_M and to generate the geo_em.d0x domain files. No errors should occur and it should finish with

*** Successful completion of program geogrid.exe ***

and the file geogrid.log should contain STRM (use grep!).

When the geo_em.d0x.nc files are created you can make a plot of the HGT_M variable for the domain on which the SRTM3S data is used by running **ncview geo_em.d02.nc** in the region directory. Click on 2d vars and check HGT_M to ensure there is no offsetting or incorrect mapping in locations. You may need to install ncview from your repository.

- runGM your region to test it. Add 'wrf=HGT' to your parameter_dolist if you like. Or run replot…

- To return to your previous setup reset the geog_data_res variables in both namelist.wps and namelist.wps.template and rerun geogrid.exe in that region directory.

- If you are really into high resolution model runs you can download 30m resolution tiles: http://dwtkns.com/srtm30m/. Their size is 3601x3601 pixels or in fact 3599x3599 pixels with a overlap of 1 pixel on each side. The overlap was checked by opening neighbouring .tif-files in KolourPaint. Follow the same steps above. Each SRTM tile must be converted to the Geotiff format first via the terminal command: "gdal_translate -of GTiff tilename.hgt tilename.tif". The first tile will be named "00001-03599.00001-03599". The name of the tile above is "00001-03599.03600-07198" and the name of the tile on the right is "03600-07198.00001-03599" etcetera. Use "SRTM1S" everywhere instead. In the index file dx and dy become "0.0002777777777777778" and known_y, tile_x and tile_x become "3599" and it will be "description = "SRTM 1-sec Topography height"".

- Perhaps you can also update your 30s topography data depending on the WRF version you are using. Since WRF 3.8 the HGT_M field is interpolated from the new 30-arc-second USGS GMTED2010 topography data. You can download topo_gmted2010_30s here: http://www2.mmm.ucar.edu/wrf/users/download/get_sources_wps_geog.html. To use the new dataset geog_data_res needs to be adjusted based on your new GEOGRID.TBL settings and don't forget to run geogrid.exe as explained above.

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