Climate-in-a-Box Workshop: WRF Tutorial

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Outline

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- WRF Setup
- WPS Architecture
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- WRFV3 Architecture
  - WRFV3 Executables
- Compiling WPS and WRFV3
- Running WPS and WRFV3
- Visualization
- WRF Case Study
WRF Description

- WRF – Weather Research and Forecasting Model
  - Research and Operational Applications
  - Regional Applications
  - Fully compressible, non-hydrostatic
  - Mass based terrain following coordinate system, η
  - Staggered Arakawa C-grid

- Contains options for Chemistry, Data Assimilation, Fire modeling, etc…
  - For the purposes of this tutorial, we are only building the standard WRF package
WRF Setup

- WPS – WRF Preprocessing System
  - Prepares input data into WRF for real-data simulations
  - Defines the domain area
  - Produces static fields such as terrain, land use, soil types, etc…
  - Interpolates the meteorological initialization data onto the WRF grid (horizontally)

- WRF model
  - Sets up vertical model levels
  - Numerically integrates the model
WPS Architecture

WRF Preprocessing System

- Geogrid.exe
- Ungrib.exe
- Metgrid.exe

WRF Geog Data

Grib data: NAM, RUC, GFS, etc…
WPS Executables

- **Geogrid.exe**
  - Defines the map projection, geographic location and dimensions of the domains
  - Provides static field information for terrestrial data

- **Ungrib.exe**
  - Read GRIB1 and GRIB2 formats (Gridded Binary Data)
  - Extracts met fields
  - Writes fields to intermediate format

- **Metgrid.exe**
  - Horizontally interpolates the met data to WRF grids
WRF Model Architecture

WPS → Real.exe → Wrf.exe
WRF Executables

- **Real.exe**
  - Vertically interpolates met fields to model levels
  - Creates initial and boundary conditions files for real-data cases

- **Wrf.exe**
  - Runs the WRF model simulation
  - Numerically integrates the model simulation
  - Outputs history and restart files
WRF Prerequisites

- Netcdf
- Libpng
- Zlib
- Jasper
- Ncl

Required to use GRIB2 format data
Compiling WRF

- WRFV3 must be compiled before WPS
- Steps to compiling WRFV3
  1. Copy over the WRFV3 tarball
     - `cp /cib/models/archives/WRFV3.1.TAR.gz .`
  2. Untar the WRFV3 tar file
     - `tar xvzf WRFV3.1.TAR.gz`
  3. Move to WRFV3 directory
  4. Configure the model
     - `./configure`
     - Choose option 7 (Linux x86_64 i486 i586 i686, ifort compiler with icc (dmpar))
     - Choose option 1 for nesting
Steps to compiling WRFV3

5. ./compile em_real >& compile.log & (for csh)
   ./compile em_real &> compile.log & (for bash)

Executables generated:

- main/real.exe
- main/wrf.exe
- main/nup.exe
- main/ndown.exe (does one-way nesting)
Compiling WPS

- WPS must be located on top level directory (along with WRFV3)

- Steps to compiling WPS
  1. Copy over the WPS tarball
     - `cp /cib/models/archives/WPSV3.1.TAR.gz .`
  2. Untar the WPS tar file
     - `tar xvzf WPSV3.1.TAR.gz`
  3. Move into the WPS directory
  4. Configure WPS
     - `./configure`
     - Choose option 4 (PC Linux x86_64, Intel compiler)
Compiling WPS cont...

- Steps to compiling WPS
  5. Edit the configure.wps file
     - Replace \(-L/usr/X11R6/lib\) with \(-L/usr/X11R6/lib64\)
     - Change the COMPRESS\_LIBS and COMPRESS\_INC paths
  6. Compile WPS
     - \./compile &> compile.log & (for csh)
     - \./compile &> compile.log & (for bash)

- Executables generated:
  - geogrid.exe
  - ungrib.exe
  - metgrid.exe
Running WPS

- Edit the namelist.wps
- Run geogrid.exe
  - ./geogrid.exe
  - Generates files: geo_em_dxx.nc
- Link the proper Vtable
  - ln -sf ungrib/Variable_Tables/Vtable.GFS Vtable
- Link the input GRIB data
  - ./link_grib.csh path_to_GRIB_data
  - Generates links: GRIBFILE.AAA, GRIBFILE.AAB. Etc…
Running WPS cont...

- Run ungrrib.exe
  - ./ungrrib.exe
  - Generates Files: FILE:2010-02-05_00, ...

- Run metgrid.exe
  - ./metgrid.exe
  - Generates Files: met_em.dxx.YYYY-MM-DD_HH:00:00.nc
Running WRF Model

- Move into WRFV3 run directory
  - `cd WRFV3/run`
- Edit the namelist.input file
  - Make sure that the values match the namelist.wps
- Link the files produced by metgrid.exe to the run directory
  - `ln -s ../../WPS/met_em* .`
- Edit the run_real.job script
  - Make sure the path is correct
Running WRF Model cont...

- Submit run_real.job
  - qsub run_real.job
  - Files produced:
    - wrfinput_dxx
    - wrfbdy_d01

- Edit the run_wrf.job script
  - Make sure paths are correct

- Submit run_wrf.job
  - qsub run_wrf.job
  - Files produced:
    - wrfout_dxx_......
Documentation on how to run/compile WRF can be found at:

- The CIB User’s Guide
  - http://modelingguru.nasa.gov/
- WRF Model Users Website –
  - http://www.mmm.ucar.edu/wrf/users
Setup WRF Simulation

- Hurricane Earl – Sep 2nd, 2010
- First step: Retrieve data to initialize WRF Model
  o [http://nomads.ncdc.noaa.gov/](http://nomads.ncdc.noaa.gov/)
  o Place data onto Nimbus
- Edit namelist.wps in WPS directory
- Use util/plotgrids.exe to examine domain configuration
- Edit namelist.input
WRF Case Study

- DC “Snowpocalypse” Event
  - February 5, 2010
  - Domain centered on Dulles International Airport (IAD)
  - 48 hour simulation
  - Triple Nested Domain
  - Horizontal Resolution 16, 4, 1 km
  - Horizontal Grid Size: (198x191), (301x285), (357x345)
  - 28 Vertical levels
  - Run with 48 cores
Run WRF Case Study

- Move to your outputdata location
- Copy over the WRF run directory into your output location:
- Change over to the run directory
- Workshop demo only runs single domain
- Edit/submit the run_wrf.job script
  - Executables already built
- Will produce wrfout files from Feb 5 00Z – 12Z
**Summary of Steps to Run Case Study**

- `cd /cib/outputdata/guestX`, where X = your number
- `cd run`
- Edit path on line 10 of `run_wrf.job` (Change X to your number)
- `qsub run_wrf.job`
- To run “Full” Case study replace this command for step 2:
  - `cp –R /cib/models/wrf/wrf3.1/Case_Study_demo/run .`
Visualization

- NCL sample script
  - plotVars.ncl

- Steps to run plotVars.ncl
  - Provide the file to be plotted
    f = addfile ("wrfout_d01_2010-02-07_00:00:00.nc", "r")
  - Provide the Variable to plot
    x = f -> QVAPOR
  - Provide the output file name
    wks = gsn_open_wks("ps","Qvapor_plot")

- To run:
  - ncl plotVars.ncl

- To view the image type:
  - display Qvapor_plot.ps
Sample Output