WRF & WPS: COMPILATION PROCESS

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INSTALLING STEPS

- ***Check system requirements***
- Installing libraries
- Obtain source code
- Compile WRF
- Compile WPS
- Download static geographical data & initial/BC datasets

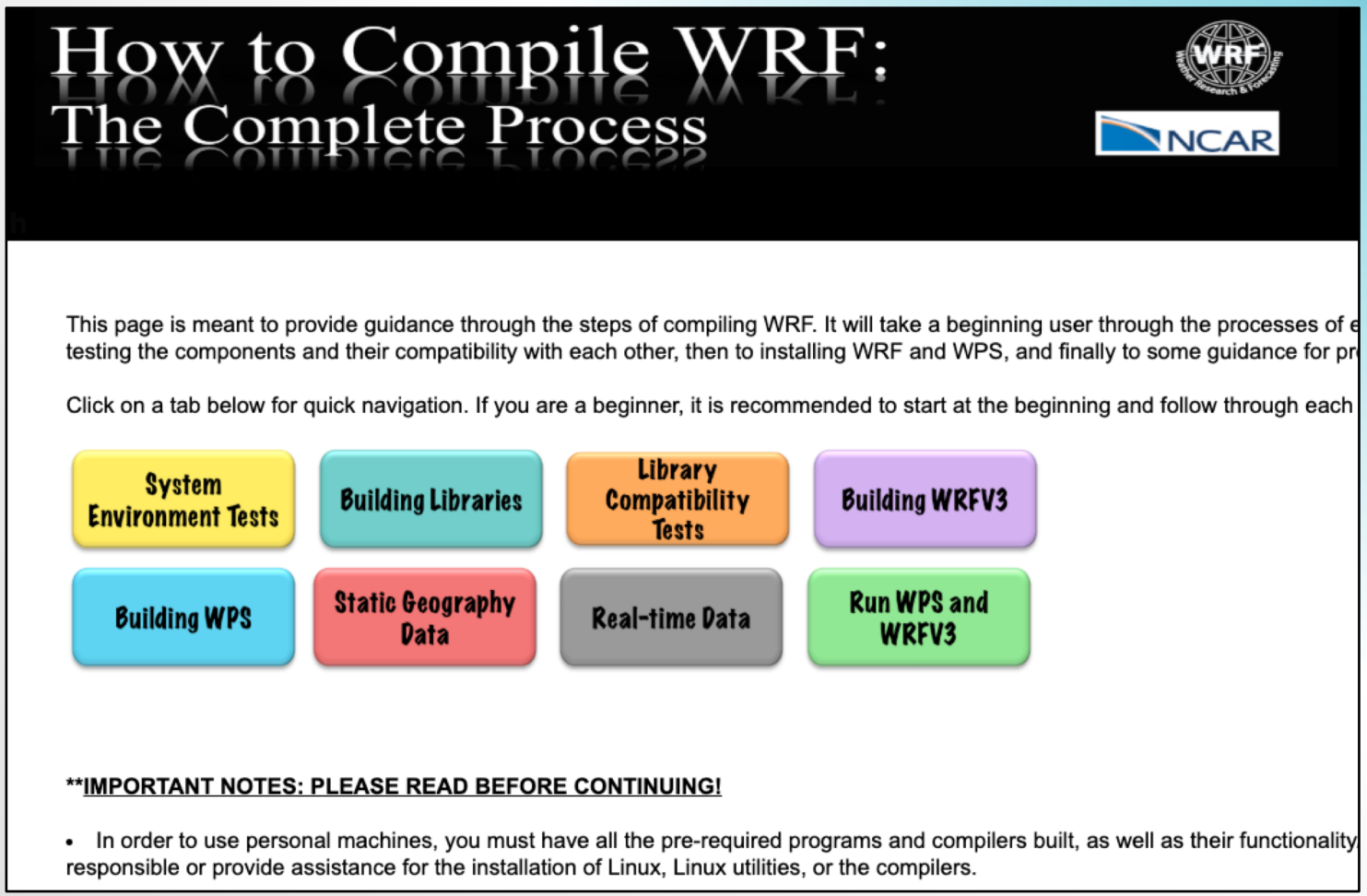
SYSTEM REQUIREMENTS

- On what kinds of systems will WRF run?
  - Generally any 32- or 64-bit hardware, running a UNIX-like operating system
  - You may also use dual-booting into a UNIX-like OS (e.g., Windows with Linux built parallel)
- Examples of acceptable systems:
  - Laptops, desktops, and clusters running Linux
  - Laptops and desktops running MacOS
  - Clusters running Unix-like: Linux, AIX

CHECK SYSTEM REQUIREMENTS

- Webpage:

http://www2.mmm.ucar.edu/wrf/OnLineTutorial/compilation_tutorial.php



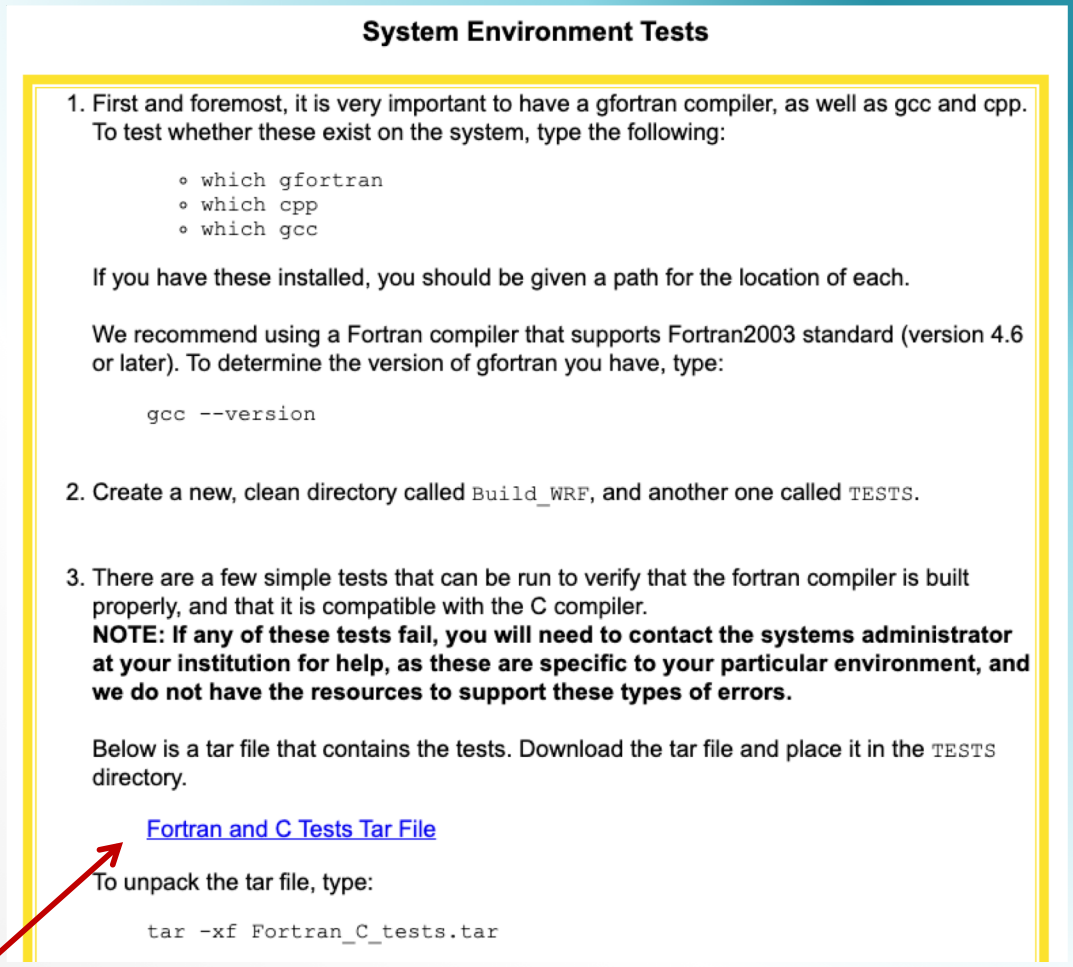
CHECK SYSTEM REQUIREMENTS

- It is mandatory to have a Fortran (e.g., gfortran) compiler, a C compiler, and cpp on your system. To test whether these exist on your system, type:
  - **`which gfortran`**
  - **`which cpp`**
  - **`which gcc`**
  - *If installed, you will be given a path for each*

- Fortran compiler should be a version that supports Fortran2003 standard (at least v4.6)
  - Check this by typing (csh e.g.):

```
gcc --version
```

- Tests available for checking that your fortran compiler is built properly, and that it is compatible with the C compiler.



System Environment Tests

1. First and foremost, it is very important to have a gfortran compiler, as well as gcc and cpp. To test whether these exist on the system, type the following:

   - `which gfortran`
   - `which cpp`
   - `which gcc`

   If you have these installed, you should be given a path for the location of each.

   We recommend using a Fortran compiler that supports Fortran2003 standard (version 4.6 or later). To determine the version of gfortran you have, type:

   ```
   gcc --version
   ```

2. Create a new, clean directory called `Build_WRF`, and another one called `TESTS`.

3. There are a few simple tests that can be run to verify that the fortran compiler is built properly, and that it is compatible with the C compiler.
   NOTE: If any of these tests fail, you will need to contact the systems administrator at your institution for help, as these are specific to your particular environment, and we do not have the resources to support these types of errors.

   Below is a tar file that contains the tests. Download the tar file and place it in the `TESTS` directory.

   Fortran and C Tests Tar File

   To unpack the tar file, type:

   ```
   tar -xf Fortran_C_tests.tar
   ```

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INSTALLING LIBRARIES

- NetCDF (needed by WRF and WPS)
  - netCDF Version 3 or 4
  - If using netCDF4 capabilities
    http://www2.mmm.ucar.edu/wrf/users/building_netcdf4.html
- Optional libraries for GRIB2 meteorological data support
  - JasPer (JPEG 2000 “lossy” compression library)
  - PNG (“lossless” compression library)
  - Zlib (compression library used by PNG)
- Optional MPI library (for building in parallel):
  - E.g., MPICH2 or OpenMPI

INSTALLING LIBRARIES

- Installation of these libraries (MPICH2, NetCDF, JasPer, zlib, and libpng) is NOT part of the WPS and WRF installation scripts

- Downloads for the libraries, with installation instructions, and library compatibility tests are also included on the compilation website

- **VERY IMPORTANT!**

  Make sure these libraries are installed using the same compilers as will be used to install WRF and WPS

BEFORE INSTALLING LIBRARIES: SET ENVIRONMENT VARIABLES

```
> setenv DIR directory-where-your-tar-files-are
> setenv CC gcc
> setenv CXX g++
> setenv FC gfortran
> setenv FCFLAGS -m64  # FCFLAGS may be needed on some systems
> setenv F77 gfortran
> setenv FFLAGS -m64          # FFLAGS may be needed on some systems
> setenv JASPERLIB $DIR/grib2/lib
> setenv JASPERINC $DIR/grib2/include
> setenv LDFLAGS -L$DIR/grib2/lib
> setenv CPPFLAGS -I$DIR/grib2/include
```

Keep these set until all libraries are built

INSTALLING LIBRARIES: NETCDF

```
> tar xzvf netcdf-4.1.3.tar.gz    # no '.gz' if downloaded to
                                  # most Macs

> cd netcdf-4.1.3

>./configure --prefix=$DIR/netcdf --disable-dap \
--disable-netcdf-4 --disable-shared

> make

> make install

> setenv PATH $DIR/netcdf/bin:$PATH

> setenv NETCDF $DIR/netcdf

> cd ..
```

INSTALLING LIBRARIES: MPICH2

In principle, any implementation of the MPI-2 standard should work with WRF; however, we have the most experience with MPICH

```
> tar xzvf mpich-3.0.4.tar.gz      # no '.gz' if downloaded to
                                   # most Macs
> cd mpich-3.0.4
> ./configure --prefix=$DIR/mpich
> make
> make install
> setenv PATH $DIR/mpich/bin:$PATH
> cd ..
```

INSTALLING LIBRARIES: ZLIB

```
> tar xzvf zlib-1.2.7.tar.gz          # no '.gz' if downloaded to
                                      # most Macs
> cd zlib-1.2.7
>./configure --prefix=$DIR/zlib
> make
> make install
> cd ..
```

INSTALLING LIBRARIES: LIBPNG

```
> tar xzvf libpng-1.2.50.tar.gz   # no '.gz' if downloaded to
                                  # most Macs
> cd libpng-1.2.50
>./configure --prefix=$DIR/libpng
> make
> make install
> cd ..
```

INSTALLING LIBRARIES: JASPER

```
> tar xzvf jasper-1.900.1.tar.gz  # no '.gz' if downloaded to
                                  # most Macs
> cd jasper-1.900.1
> ./configure --prefix=$DIR/jasper
> make
> make install
> cd ..
```

INSTALLING LIBRARIES: COMPATIBILITY

- Make sure libraries are compatible with compilers
- Test 1
  - Fortran + C + netCDF
- Test 2
  - Fortran + C + netCDF + MPI

Library Compatibility Tests

- Once the target machine is able to make small Fortran and C executables (what was verified in the System Environment Tests section), and after the NetCDF and MPI libraries are constructed (two of the libraries from the Building Libraries section), to emulate the WRF code's behavior, two additional small tests are required. We need to verify that the libraries are able to work with the compilers that are to be used for the WPS and WRF builds.
  NOTE: If any of these tests fail, you will need to contact the systems administrator at your institution for help, as these are specific to your particular environment, and we do not have the resources to support these types of errors.

  Below is a tar file that contans these tests. Download this tar file and place it in the `TESTS` directory, and then "cd" into the `TESTS` directory:

  Fortran_C_NETCDF_MPI_tests.tar

  To unpack the tar file, type:

  ```
  tar -xf Fortran_C_NETCDF_MPI_tests.tar
  ```

- There are 2 tests:

  1. **Test #1**: Fortran + C + NetCDF

     The NetCDF-only test requires the include file from the NETCDF package be in this directory. Copy the file here:

     ```
     cp ${NETCDF}/include/netcdf.inc .
     ```

INSTALLING STEPS

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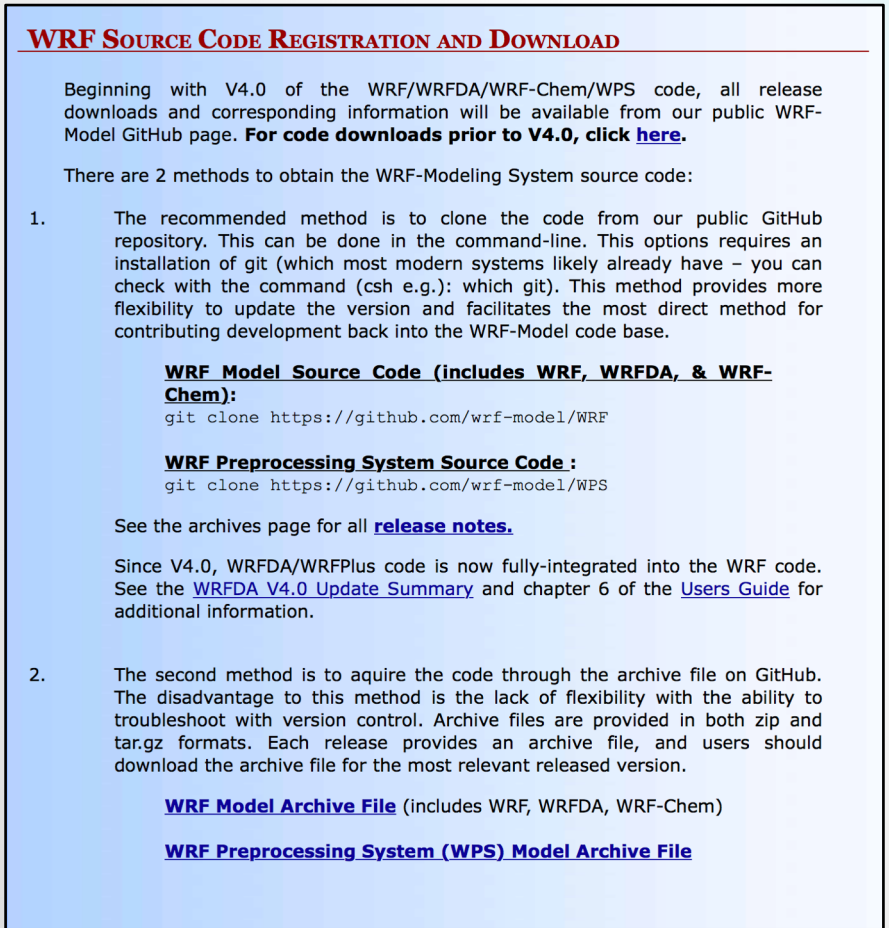
OBTAIN WRF & WPS CODE

- WRF & WPS source code from:

http://www2.mmm.ucar.edu/wrf/users/download/get_source.html

  - Click 'New User,' and then register, or
  - Click 'Returning User,' enter your email, and go to the information page.



WRF Source Code Registration and Download

Beginning with V4.0 of the WRF/WRFDA/WRF-Chem/WPS code, all release downloads and corresponding information will be available from our public WRF-Model GitHub page. **For code downloads prior to V4.0, click here.**

There are 2 methods to obtain the WRF-Modeling System source code:

1. The recommended method is to clone the code from our public GitHub repository. This can be done in the command-line. This options requires an installation of git (which most modern systems likely already have – you can check with the command (csh e.g.): which git). This method provides more flexibility to update the version and facilitates the most direct method for contributing development back into the WRF-Model code base.

   WRF Model Source Code (includes WRF, WRFDA, & WRF-Chem):
   `git clone https://github.com/wrf-model/WRF`

   WRF Preprocessing System Source Code :
   `git clone https://github.com/wrf-model/WPS`

   See the archives page for all **release notes.**

   Since V4.0, WRFDA/WRFPlus code is now fully-integrated into the WRF code. See the WRFDA V4.0 Update Summary and chapter 6 of the Users Guide for additional information.

2. The second method is to aquire the code through the archive file on GitHub. The disadvantage to this method is the lack of flexibility with the ability to troubleshoot with version control. Archive files are provided in both zip and tar.gz formats. Each release provides an archive file, and users should download the archive file for the most relevant released version.

   WRF Model Archive File (includes WRF, WRFDA, WRF-Chem)

   WRF Preprocessing System (WPS) Model Archive File

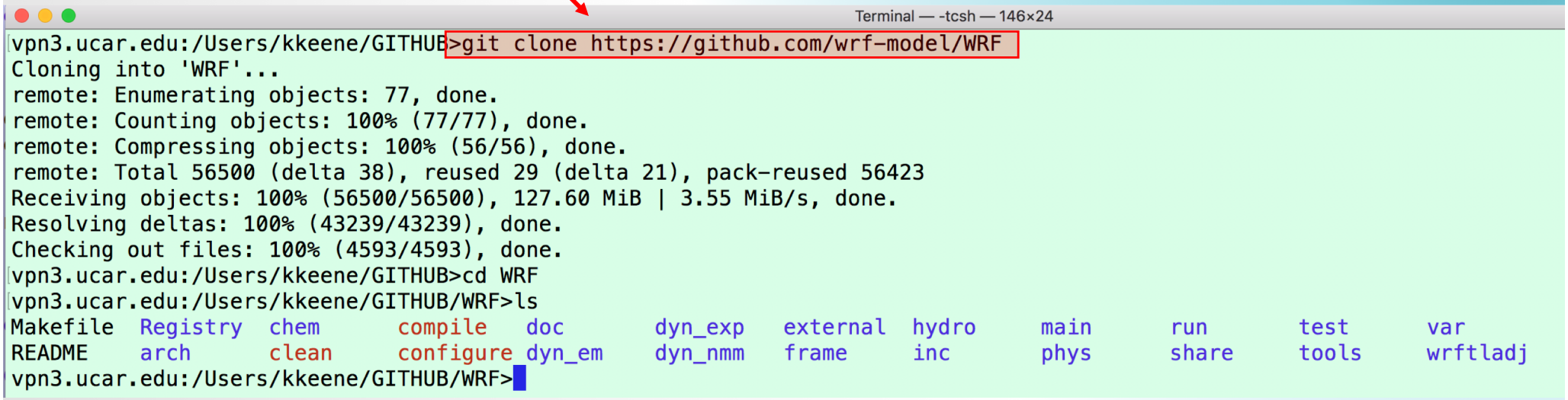
Code available from GitHub!

2 Methods to obtain code:

- Clone from Github
- Download archived tar file from GitHub

OBTAIN WRF & WPS CODE

- Cloning WRF from GitHub repository:



**Must have 'git' installed on your system!

INSTALLING STEPS

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CHOOSING A COMPILER

- Compile
  - WRF V4.0
  - dmpar/nesting
  - 4 processors

Compiler	Compile Time	Run Time
GNU 6.3.0 **FREE**	6.82 Mins	3.92 Mins
Intel 17.0.1	46.77 Mins	2.20 Min

- Run
  - Single domain
  - Small domain (75x70), 30km resolution
  - 12 hours
  - 8 processors

STEP 1: CONFIGURE FOR WRF

- Inside the WRF/ directory, type: **`./configure`**

```
$JASPERLIB or $JASPERINC not found in environment, configuring to build without grib2 I/O...
------------------------------------------------------------------------
Please select from among the following Linux x86_64 options:

  1. (serial)   2. (smpar)   3. (dmpar)   4. (dm+sm)   PGI (pgf90/gcc)
  5. (serial)   6. (smpar)   7. (dmpar)   8. (dm+sm)   PGI (pgf90/pgcc): SGI MPT
  9. (serial)  10. (smpar)  11. (dmpar)  12. (dm+sm)   PGI (pgf90/gcc): PGI accelerator
 13. (serial)  14. (smpar)  15. (dmpar)  16. (dm+sm)   INTEL (ifort/icc)
                                         17. (dm+sm)   INTEL (ifort/icc): Xeon Phi (MIC architecture)
 18. (serial)  19. (smpar)  20. (dmpar)  21. (dm+sm)   INTEL (ifort/icc): Xeon (SNB with AVX mods)
 22. (serial)  23. (smpar)  24. (dmpar)  25. (dm+sm)   INTEL (ifort/icc): SGI MPT
 26. (serial)  27. (smpar)  28. (dmpar)  29. (dm+sm)   INTEL (ifort/icc): IBM POE
 30. (serial)               31. (dmpar)                PATHSCALE (pathf90/pathcc)
 32. (serial)  33. (smpar)  34. (dmpar)  35. (dm+sm)   GNU (gfortran/gcc)
 36. (serial)  37. (smpar)  38. (dmpar)  39. (dm+sm)   IBM (xlf90_r/cc_r)
 40. (serial)  41. (smpar)  42. (dmpar)  43. (dm+sm)   PGI (ftn/gcc): Cray XC CLE
 44. (serial)  45. (smpar)  46. (dmpar)  47. (dm+sm)   CRAY CCE (ftn $(NOOMP)/cc): Cray XE and XC
 48. (serial)  49. (smpar)  50. (dmpar)  51. (dm+sm)   INTEL (ftn/icc): Cray XC
 52. (serial)  53. (smpar)  54. (dmpar)  55. (dm+sm)   PGI (pgf90/pgcc)
 56. (serial)  57. (smpar)  58. (dmpar)  59. (dm+sm)   PGI (pgf90/gcc): -f90=pgf90
 60. (serial)  61. (smpar)  62. (dmpar)  63. (dm+sm)   PGI (pgf90/pgcc): -f90=pgf90
 64. (serial)  65. (smpar)  66. (dmpar)  67. (dm+sm)   INTEL (ifort/icc): HSW/BDW
 68. (serial)  69. (smpar)  70. (dmpar)  71. (dm+sm)   INTEL (ifort/icc): KNL MIC
 72. (serial)  73. (smpar)  74. (dmpar)  75. (dm+sm)   FUJITSU (frtpx/fccpx): FX10/FX100 SPARC64 IXfx/Xlfx

Enter selection [1-75] : 34
------------------------------------------------------------------------
Compile for nesting? (1=basic, 2=preset moves, 3=vortex following) [default 1]:
```

  - Configuration output: `configure.wrf`

CONFIGURE OPTIONS FOR WRF

DEBUGGING OPTIONS

- `./configure -d`
  - No optimization
  - Extra debugging
- `./configure -D`
  - No optimization
  - Checks uninitialized variables, floating point traps, etc.
- `./configure -r8`
  - Double-precision
    - Works for GNU, Intel, & PGI compilers

PARALLEL COMPILE OPTION FOR WRF

- To build WRF with multiple compilers, set (csh e.g.):

```
setenv J "-j 2"
```

Before or after configure

# of Processors	Time to Compiler
1	17.25 Mins
2	9.95 Mins
3	8.05 Mins
4	6.82 Mins
5	6.32 Mins
6	6.12 Mins

Compiled with GNU V6.3.0

STEP 2: COMPILE WRF

- In the WRF/ directory, type:

```
./compile em_case >& log.compile
```

Where **em_case** is one of the following
(type **./compile** to see all options)

em_real (3d real case)

em_quarter_ss
em_b_wave
em_les
em_heldsuarez
em_tropical_cyclone
em_convrad

3d Ideal

em_hill2d_x
em_squall2d_x
em_squall2d_y
em_grav2d_x
em_seabreeze2d_x

2d Ideal

em_scm_xy (1d ideal)

Compilation should take ~30 mins

SUCCESSFUL COMPILATION

- If the compilation is successful, you should see these executables in **`WRF/main`** (non-zero size)**:**

Real data case:

`wrf.exe` – model executable

`real.exe` – real data initialization

`ndown.exe` – one-way nesting

`tc.exe` – for tc bogusing (can only be run serially)

Ideal case:

`wrf.exe` – model executable

`ideal.exe` – ideal case initialization

***Note: Each ideal case compile creates a different executable, but with the same name**

- These executables are linked to 2 different directories (**`WRF/run`** and **`WRF/test/em_real`**). You can go to either place to run WRF.

UNSUCCESSFUL COMPILATION

- Use your 'log.compile' file to search for errors!
  - Search for 'Error' with a capital 'E'
- Use our Frequently Asked Questions forum page for help
- Visit the wrfhelp Forum:
  http://forum.mmm.ucar.edu/
- Before recompiling:
  - Issue a '`clean -a`'
  - Reconfigure
    * If you need to make changes to the configure.wrf file, do this after issuing ./configure, and then save the edited file.
  - Recompile

INSTALLING STEPS

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STEP 1: CONFIGURE FOR WPS

- Inside the WPS/ directory, type:

  `./configure`

```
$JASPERLIB or $JASPERINC not found in environment. Using default values for library paths...
-----------------------------------------------------------------------
Please select from among the following supported platforms.

   1.  Linux x86_64, gfortran    (serial)
   2.  Linux x86_64, gfortran    (serial_NO_GRIB2)
   3.  Linux x86_64, gfortran    (dmpar)
   4.  Linux x86_64, gfortran    (dmpar_NO_GRIB2)
   5.  Linux x86_64, PGI compiler   (serial)
   6.  Linux x86_64, PGI compiler   (serial_NO_GRIB2)
   7.  Linux x86_64, PGI compiler   (dmpar)
   8.  Linux x86_64, PGI compiler   (dmpar_NO_GRIB2)
   9.  Linux x86_64, PGI compiler, SGI MPT   (serial)
  10.  Linux x86_64, PGI compiler, SGI MPT   (serial_NO_GRIB2)
  11.  Linux x86_64, PGI compiler, SGI MPT   (dmpar)
  12.  Linux x86_64, PGI compiler, SGI MPT   (dmpar_NO_GRIB2)
```

- Always choose a **serial** compile for WPS (even if you compile WRF with a parallel option)
  - Exception: You are using a VERY large domain

  *NOTE: if you do compile WPS in parallel, ungrib.exe must run serially

- Configuration output: `configure.wps`

STEP 2: COMPILE WPS

- In the WPS/ directory, type:

```
./compile >& log.compile
```

- Compilation should be quick.

- If successful, these executables should be in your WPS/ directory (linked from their source code directories):

```
geogrid.exe -> geogrid/src/geogrid.exe
ungrib.exe -> ungrib/src/ungrib.exe
metgrid.exe -> metgrid/src/metgrid.exe
```

UNSUCCESSFUL WPS COMPILATION

No `geogrid.exe` or `metgrid.exe`

- Make sure WRF compiled successfully.
  - WPS makes use of the external I/O libraries in the *`WRF/external/`* directory - The libraries are built when WRF is installed
- Check that you are using the same compiler (and version) as used to compile WRF.
- Check that you are using the same netCDF (and version) as used to build WRF.
- Have you changed the name or path of the WRF/ directory?
  - If so, you need to change the following line in the configure.wps file:

    `WRF_DIR = ../WRF`
  - Beginning V4.0: set WRF_DIR environment variable (prior to configure):

    `setenv WRF_DIR` *`path_to_WRF/`*`WRF`
  - Save the configure file and recompile

UNSUCCESSFUL WPS COMPILATION

No `ungrib.exe`

- Make sure jasper, zlib, and libpng libraries are correctly installed.
- Make sure that you are using the correct path and format for the following lines in the configure.wps file

```
COMPRESSION_LIBS = -L/${DIR}/UNGRIB_LIBRARIES/lib -ljasper -lpng -lz
COMPRESSION_INC = -I/${DIR}/UNGRIB_LIBRARIES/include
```

Save configure.wps and recompile

./CLEAN -A

- The ‘./clean –a’ command should be used when modifications have been made to the configure.wrf(wps) file, or any changes to the registry. If so, issue ‘clean –a’ prior to recompiling.

- Modifications to subroutines within the code will require a recompile, but **DO NOT** require a ‘clean –a’, nor a reconfigure. Simply recompile. This compilation should be much faster than a clean compile.

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DOWNLOAD STATIC GEOGRAPHICAL DATA

- From the WRF Download page:

http://www2.mmm.ucar.edu/wrf/users/download/get_sources_new.php

WRF Source Code Registration and Download

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1. The recommended method is to clone the code from our public GitHub repository. This can be done in the command-line. This options requires an installation of git (which most modern systems likely already have – you can check with the command (csh e.g.): which git). This method provides more flexibility to update the version and facilitates the most direct method for contributing development back into the WRF-Model code base.

   WRF Model Source Code (includes WRF, WRFDA, & WRF-Chem):
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   WRF Preprocessing System Source Code :
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   See the archives page for all **release notes.**

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   WRF Model Archive File (includes WRF, WRFDA, WRF-Chem)

   WRF Preprocessing System (WPS) Model Archive File

WPS Geographical Static Data To access the WPS Geographical Static Data Downloads page, click here.

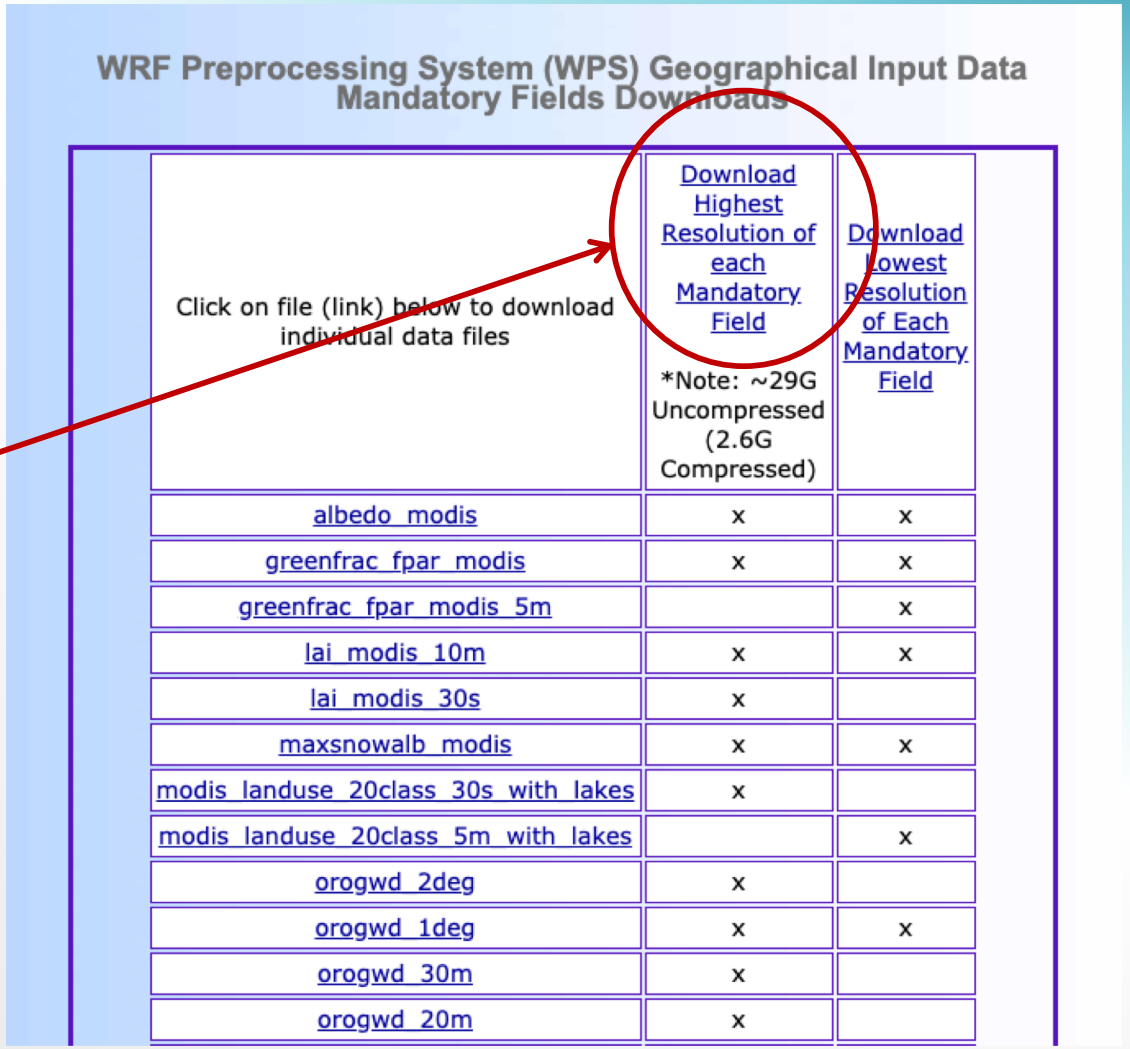
Click Here

DOWNLOAD STATIC GEOGRAPHICAL DATA

- Geographical Input and Data Download Page:
  http://www2.mmm.ucar.edu/wrf/users/download/get_sources_wps_geog.html

geog_high_res_mandatory.tar.gz
~ 29 GB when uncompressed

This is the one you want



WRF Preprocessing System (WPS) Geographical Input Data Mandatory Fields Downloads

Click on file (link) below to download individual data files	Download Highest Resolution of each Mandatory Field *Note: ~29G Uncompressed (2.6G Compressed)	Download Lowest Resolution of Each Mandatory Field
albedo_modis	x	x
greenfrac_fpar_modis	x	x
greenfrac_fpar_modis_5m		x
lai_modis_10m	x	x
lai_modis_30s	x	
maxsnowalb_modis	x	x
modis_landuse_20class_30s_with_lakes	x	
modis_landuse_20class_5m_with_lakes		x
orogwd_2deg	x	
orogwd_1deg	x	x
orogwd_30m	x	
orogwd_20m	x	

STATIC GEOGRAPHICAL DATA: OTHER OPTIONS

- Geographical Input and Data Download Page:

http://www2.mmm.ucar.edu/wrf/users/download/get_sources_wps_geog.html

WPS Geographical Input Data Mandatory for Specific Applications

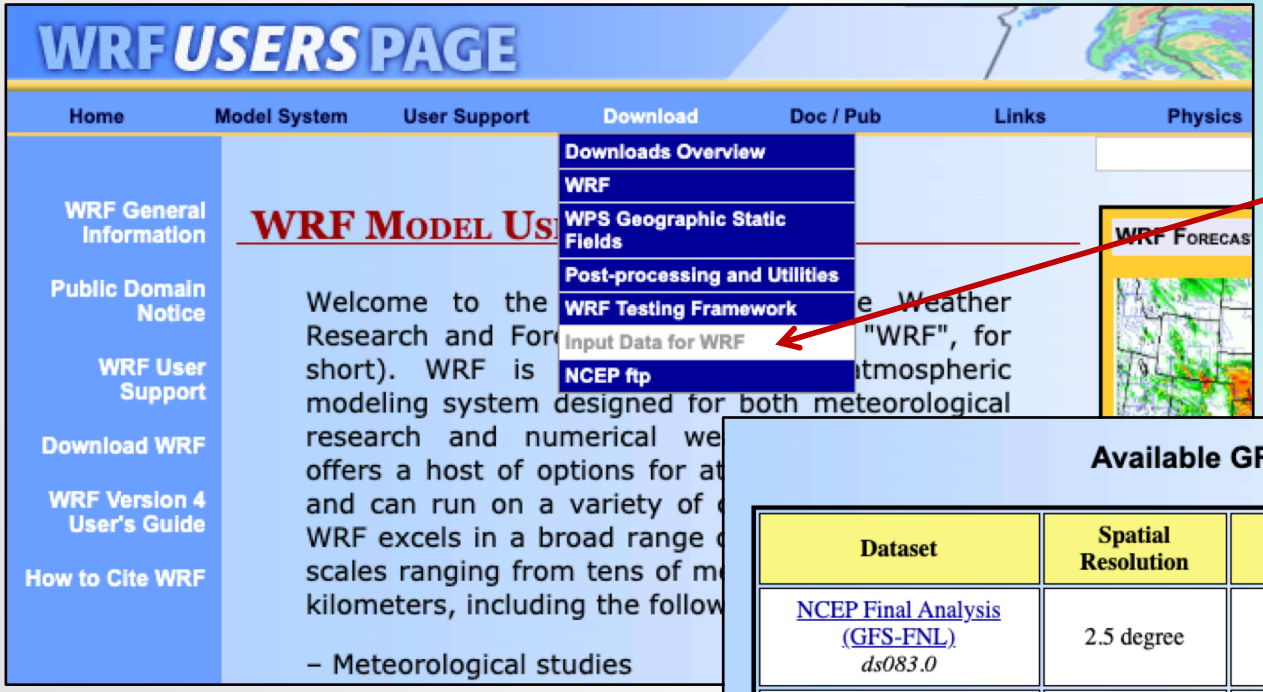
Click on file (link) below to download individual data files	Mandatory Use	Combined TAR Files
clayfrac_5m erod sandfrac_5m	Thompson MP Scheme *(mp_physics=28)* and chem	Thompson28 and Chem Tar File
crop groundwater soilgrids	NoahMP LSM *(sf_surface_physics=4)*	NoahMP Tar File
nlcd2011_can_ll_9s nlcd2011_imp_ll_9s nlcd2011_ll_9s	Pleim-Xiu LSM *(sf_surface_physics=7)* **U.S. Only**	Pleim-Xiu Tar File
NUDAPT44_1KM	Urban Physics *(sf_urban_physics=1, 2,*	

Optional WPS Geographical Input Data

Click on file (link) below to download individual data files	Optional Use	Combined TAR Files
albedo_ncep greenfrac landuse_30s_with_lakes maxsnowalb	Simulations Older than Year 2000	Older Than 2000 Tar File
bnu_soiltype_bot bnu_soiltype_top	Alternative Data Source for all LSM's	Alternative LSM Data Tar File
modis_landuse_20class_15s modis_landuse_20class_15s_with_lakes	Alternative High-resolution Data	
	Alternative High-	

DOWNLOAD DATASETS

- From the WRF Users' page: **http://www2.mmm.ucar.edu/wrf/users/**



Step 1: Click Download, then scroll down and click 'Input Data from NCAR'

Available GRIB Datasets from NCAR

Dataset	Spatial Resolution	Temporal Resolution	Temporal Availability	Vtable
NCEP Final Analysis (GFS-FNL) *ds083.0*	2.5 degree	12-hourly	1997-04-01 to 2007-06-30	Vtable.GFS
NCEP Final Analysis (GFS-FNL) *ds083.2*	1 degree	6-hourly	1999-07-30 to current	
NCEP GDAS Final Analysis *ds083.3*	0.25 degree	6-hourly	2015-07-08 to current	
NCEP GFS *ds084.1*	0.25 degree	3-hourly (for first 240 hrs) 12-hourly (hrs 240-384)	2015-01-15 to current	
NCEP/NCAR Reanalysis (NNRP) *ds090.0*	209 km	6-hourly	1948-01-01 to current	Vtable.NNRP
NCEP Climate Forecast System Reanalysis (CFSR) *ds093.0*	0.3, 0.5, 1.0, 1.9, & 2.5 degree	6-hourly	1979-01-01 to 2011-01-01	Vtable.CFSR_press_pgbh06

Step 2: Click the dataset you wish to use (for this example, we will use 'FNL from GFS')

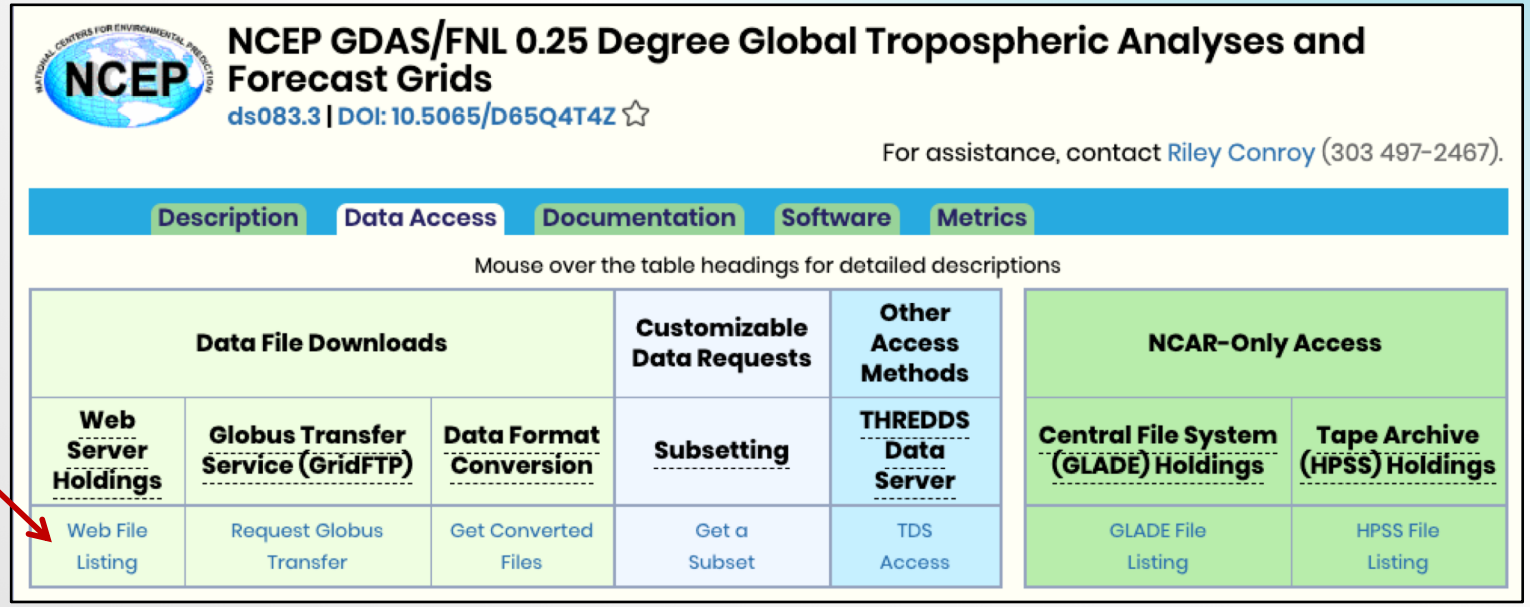
*Note: The NOMADS site has several types of useful data: http://nomads.ncdc.noaa.gov

DOWNLOAD DATASETS (CONT'D)

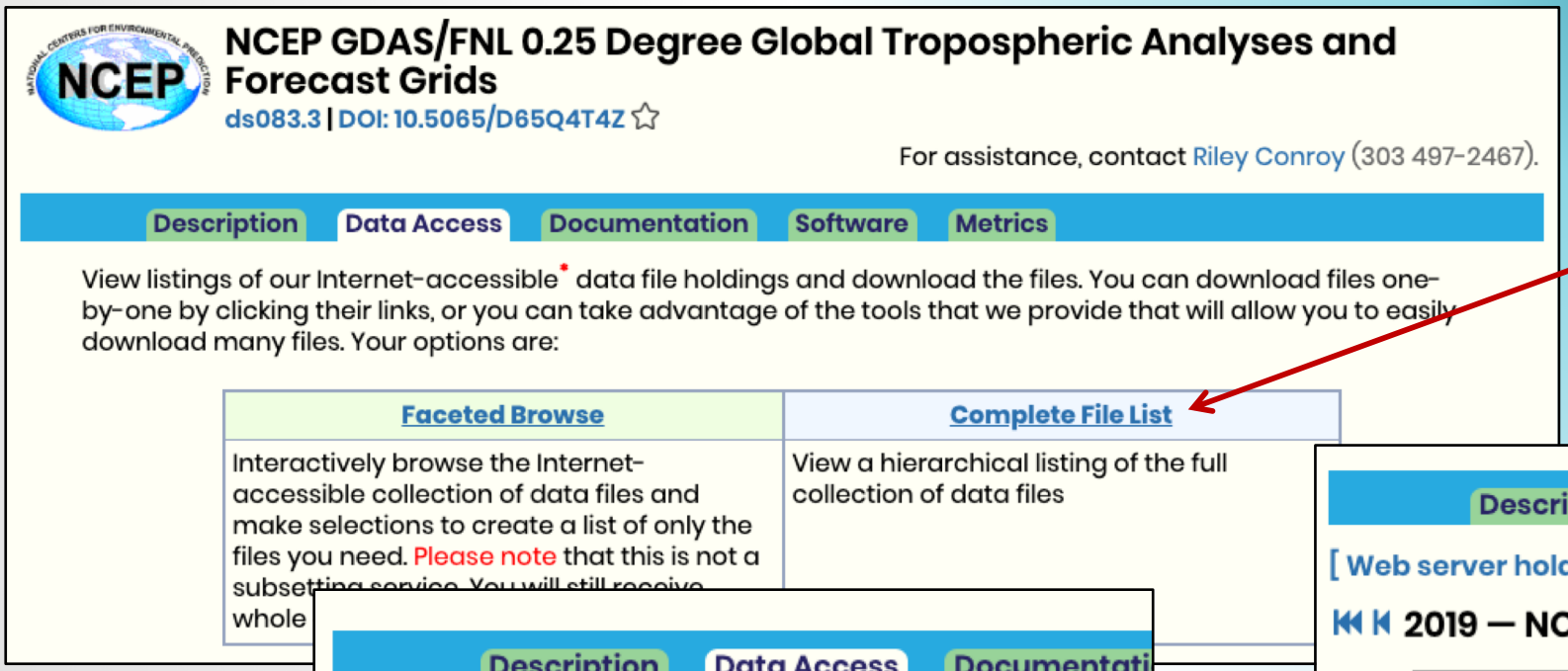
Step 3: Register, or sign-in (if you already have an account)

Step 4: Click 'Data Access'

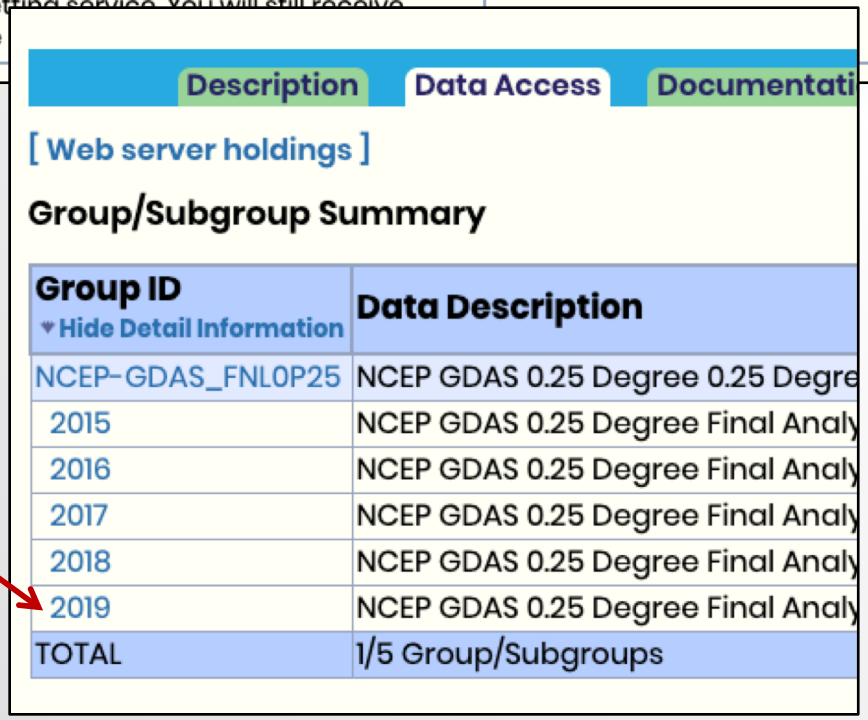
Step 5: Click 'Web File Listing' for the span of years you need



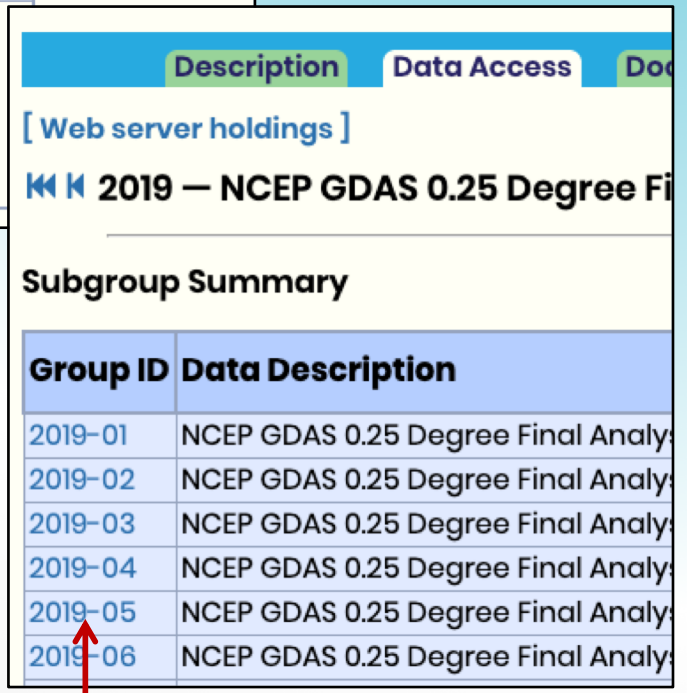
DOWNLOAD DATASETS (CONT'D)



Step 6: Click 'Complete File List'

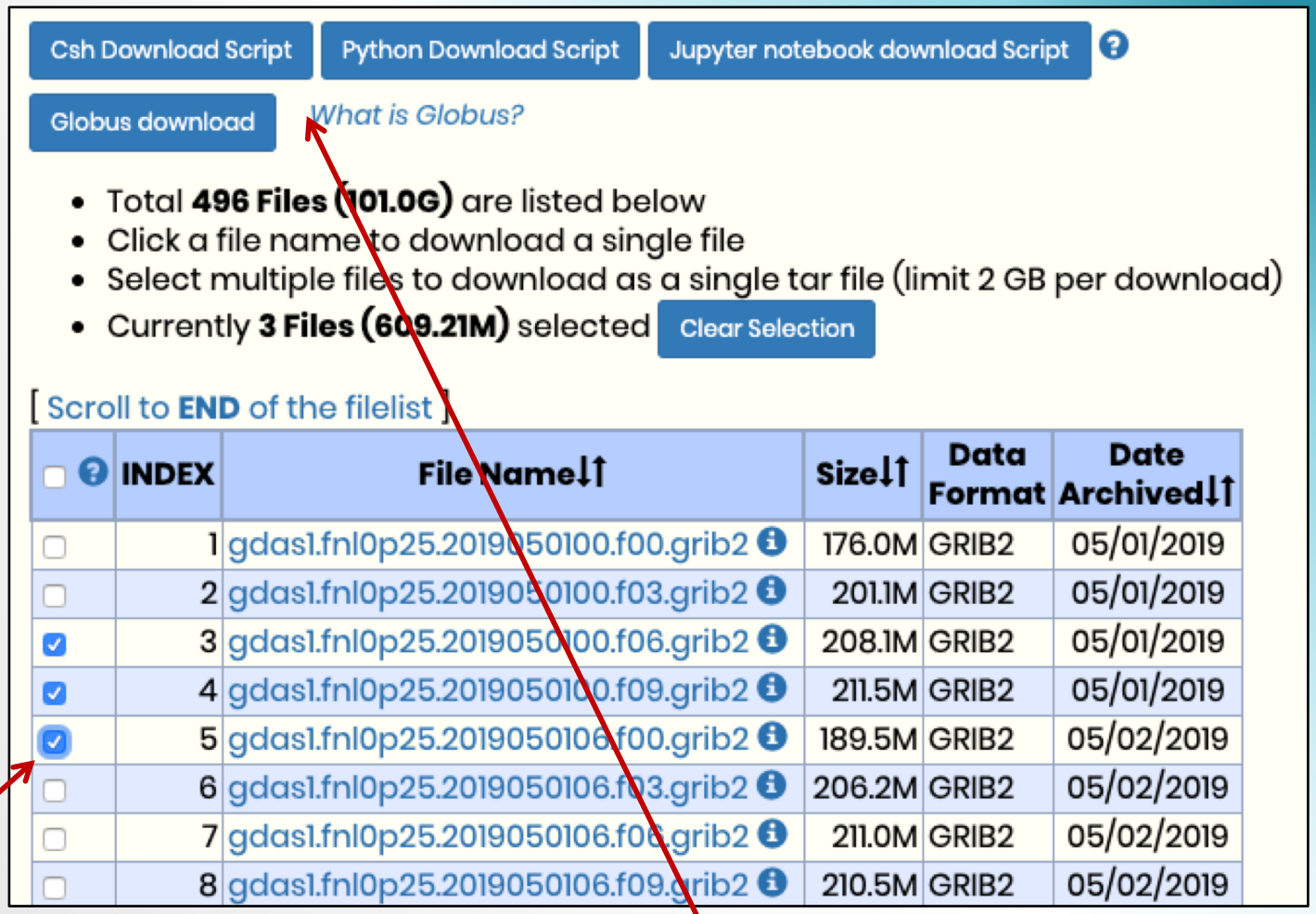


Step 7: Choose the year



Step 8: Choose the month

DOWNLOAD DATASETS (CONT'D)



Step 8: Choose a box for each time span that you need

Step 9: Once you have chosen all your times, choose a method to download the files

QUESTIONS?