COMPILING WRF & WPS

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PRESENTATION OUTLINE

1. Check system requirements
2. Install libraries
3. Obtain source code
4. Compile WRF
5. Compile WPS
6. Troubleshooting

WRF/WPS COMPILING PAGE

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Compiling WRF and WPS

This page provides guidance for compiling WRF and WPS using either a GNU/gfortran/gcc compiler or an intel compiler. **Follow the steps in order** for a successful compile.

Important

WRF User Support staff cannot help with errors that occur during system environment tests or during the process of installing libraries. If such errors should arise, please contact a systems administrator at your institution to assist. You may also find it useful to do a web search for the errors.

System Environment Tests

https://www2.mmm.ucar.edu/wrf/wrf_tutorial/compiling_tutorial/compiling_tutorial.html

CHECK SYSTEM REQUIREMENTS

Mandatory Requirements

- Fortran compiler (e.g., gfortran)
- C compiler/cpp
- gcc

Check if they exist on your system

```
> which gfortran
> which cpp
> which gcc
```

If installed, a path will be printed as output for the command

NOTE: You cannot compile newer versions of WRF with older compilers, or vice versa. Check the version:

```
> gcc --version
```

Test #1 - Fixed Format Fortran Test

Issue the following two commands from within the *tests* directory.

```
gfortran TEST_1_fortran_only_fixed.f

a.out
```

If successful, the following message should print to the screen:

```
SUCCESS test 1 fortran only fixed format
```

Test #2: Free Format Fortran

Issue the following two commands from within the *tests* directory.

```
gfortran TEST_2_fortran_only_free.f90

./a.out
```

If successful, the following message should print to the screen:

```
Assume Fortran 2003: has FLUSH, ALLOCATABLE, derived type, and ISO C Binding
SUCCESS test 2 fortran only free format
```

Test #3: C

Issue the following two commands from within the *tests* directory.

```
gcc TEST_3_c_only.c

./a.out
```

If successful, the following message should print to the screen:

```
SUCCESS test 3 c only
```

Test #4: Fortran Calling a C Function

gcc and gfortran have different defaults, so they are forced to both always use 64 bit [-m64] when combining them. Issue the following two commands from within the *tests* directory.

```
gcc -c -m64 TEST_4_fortran+c_c.c

gfortran -c -m64 TEST_4_fortran+c_f.f90

gfortran -m64 TEST_4_fortran+c_f.o TEST_4_fortran+c_c.o

./a.out
```

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

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Required Libraries

NetCDF (for WRF & WPS)

- NetCDF (v3 or v4)
- NetCDF-c and netCDF-fortran
- If using netCDF-4 capabilities, you must install HDF5 before installing netCDF
  - See *Notes on Building NetCDF4 for WRF*

Libraries for GRIB2 Meteorological Data

- *Only required for WPS versions prior to v4.4*
- JasPer (JPEG 2000 “lossy” compression library)
- PNG (“lossless” compression library)
- Zlib (compression library used by PNG)

“Optional” Libraries

- MPI: e.g., MPICH or OpenMPI – if planning to run with multiple processors
- HDF5 – if needing to use file compression

Set Paths in Environment Script

Environment Settings for a gfortran/GNU Compiler

```
export dir=/full-path-to-libs-directory/libs
export dir=/full-path-to-libs-directory/libs
export PATH=.:/$dir/netcdf/bin:/$dir/bin:${PATH}
export LD_LIBRARY_PATH=/$dir/lib:/$dir/netcdf/lib:/$dir/grib2/lib
export JASPERLIB=/$dir/grib2/lib
export JASPERINC=/$dir/grib2/include
export NETCDF=/$dir/netcdf
export CC=gcc
export CXX=g++
export FC=gfortran
export FCFLAGS=-m64
export F77=gfortran
export FFLAGS=-m64
export LDFLAGS=-L$dir/grib2/lib
export CPPFLAGS=-I$dir/grib2/include
```

Environment Settings for an Intel Compiler

```
export dir=/full-path-to-libs-directory/libs
export PATH=.:/$dir/netcdf/bin:/$dir/bin:${PATH}
export LD_LIBRARY_PATH=/$dir/lib:/$dir/netcdf/lib:/$dir/grib2/lib
export JASPERLIB=/$dir/grib2/lib
export JASPERINC=/$dir/grib2/include
export NETCDF=/$dir/netcdf
export CC=icc
export CXX=icpc
export CFLAGS='-O3 -xHost -ip -no-prec-div -static-intel'
export CXXFLAGS='-O3 -xHost -ip -no-prec-div -static-intel'
export F77=ifort
export FC=ifort
export F90=ifort
export FFLAGS='-O3 -xHost -ip -no-prec-div -static-intel'
export CPP='icc -E'
export CXXCPP='icpc -E'
export LDFLAGS=-L$dir/grib2/lib
export CPPFLAGS=-I$dir/grib2/include
```

Environment Scripts:

- e.g., **.cshrc, .bashrc, .tcshrc**
- Found in your home directory
- Issue “ls –a” to see files with a “.” in front of them

***Examples for compiling with GNU or Intel**

Ensures settings are in place every time you open a new terminal window!

Installing MPI

Install mpich

If planning to use more than a single processor when running WRF, it is necessary to install an MPI library. From inside the *libs* directory, issue the following commands:

```
wget https://www2.mmm.ucar.edu/wrf/OnLineTutorial/compile_tutorial/tar_files/mpich-3.0.4.tar.gz

tar -xf mpich-3.0.4.tar.gz

cd mpich-3.0.4

./configure --prefix=$dir

make 2>&1

make install

cd ..

rm -rf mpich*
```

Step-by-step instructions for installing remaining libraries (zlib, HDF5, netCDF-c, netCDF-fortran libpng, jasper) available from Compiling WRF and WPS

Library Compatibility Checks

Make sure libraries are compatible with compilers

Test 1

Fortran + C + netCDF

Test 2

Fortran + C + netCDF + MPI

Test #1: Fortran + C + netCDF

This test requires the *include* file from the netCDF package be in this directory. From the *tests* directory, copy the file "here":

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

Compile the Fortran and C codes for the purpose of this test (the -c option specifies no executable is to be built). Issue the following commands:

```
gfortran -c 01_fortran+c+netcdf_f.f

gcc -c 01_fortran+c+netcdf_c.c

gfortran 01_fortran+c+netcdf_f.o 01_fortran+c+netcdf_c.o -L${NETCDF}/lib -lnetcdff -lnetcdf

./a.out
```

If successful, the following message should print to the screen:

```
C function called by Fortran
Values are xx = 2.00 and ii = 1
SUCCESS test 1 fortran + c + netcdf
```

Test #2: Fortran + C + netCDF + MPI

From the *tests* directory, issue the following commands:

```
mpif90 -c 02_fortran+c+netcdf+mpi_f.f

mpicc -c 02_fortran+c+netcdf+mpi_c.c

mpif90 02_fortran+c+netcdf+mpi_f.o  02_fortran+c+netcdf+mpi_c.o  -L${NETCDF}/lib -lnetcdff -lnet
mpirun ./a.out
```

If successful, the following message should print to the screen:

```
C function called by Fortran
Values are xx = 2.00 and ii = 1
status = 2
SUCCESS test 2 fortran + c + netcdf + mpi
```

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Obtain WRF/WPS Source Code

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

Obtain Source Code from:

WRF Source Codes and Graphics Software

To DOWNLOAD, click one of the links below:

New User

Returning User

1. Choose ‘New User,’ and then register, or
2. Click ‘Returning User,’ enter your email, and go to the download page.

All code is stored in a GitHub repository, and can be obtained by:

- Cloning from GitHub
- Downloading archived tar file from GitHub

Cloning Source Code from GitHub

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

Clone WRF from GitHub repository *"wrf-model"*

```
cheyenne:/glade/scratch/kkeene>git clone --recurse-submodule https://git@github.com/wrf-model/WRF
Cloning into 'WRF'...
remote: Enumerating objects: 62656, done.
remote: Counting objects: 100% (250/250), done.
remote: Compressing objects: 100% (134/134), done.
remote: Total 62656 (delta 130), reused 189 (delta 116), pack-reused 62406
Receiving objects: 100% (62656/62656), 266.71 MiB | 22.74 MiB/s, done.
Resolving deltas: 100% (48594/48594), done.
Updating files: 100% (4758/4758), done.
Submodule 'phys/noahmp' (https://github.com/NCAR/noahmp) registered for path 'phys/noahmp'
Cloning into '/glade/scratch/kkeene/WRF/phys/noahmp'...
remote: Enumerating objects: 1149, done.
remote: Counting objects: 100% (285/285), done.
remote: Compressing objects: 100% (216/216), done.
remote: Total 1149 (delta 76), reused 245 (delta 62), pack-reused 864
Receiving objects: 100% (1149/1149), 7.23 MiB | 21.72 MiB/s, done.
Resolving deltas: 100% (377/377), done.
Submodule path 'phys/noahmp': checked out '3be0b2860dab167006a0b3c4822e234ca253c3df'
cheyenne:/glade/scratch/kkeene>
```

Clone WPS:

```
> git clone https://github.com/wrf-model/WPS
```

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Step 1: Configure for WRF

In the WRF directory, issue:

./configure

Configuration Output

configure.wrf

```
$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]:
```

Additional WRF Configuration Options

```
> ./configure -d
```

- No optimization
- Extra debugging

```
> ./configure -D
```

- No optimization
- Checks uninitialized variables

```
> ./configure -r8
```

- Double-precision
- *Works for GNU, Intel, and PGI compilers*

Step 2: Compile WRF

In the WRF/ directory, type

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

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

Real-data Case

em_real

2D Ideal Cases

em_hill2d_x
em_squall2d_x
em_squall2d_y
em_grav2d_x
em_seabreeze2d_x

3D Ideal Cases

em_quarter_ss
em_b_wave
em_les
em_heldsuarez
em_tropical_cyclone
em_convrad
em_fire

1D Ideal Case

em_scm_xy

Compilation will take ~10-50 mins

Compiling With Multiple Processors

To build WRF with multiple processors, add the ”j” variable to the compile command:

```
./compile em_real -j 6 >& compile.log
```

# of Processors	Time to Compile
1	38 Mins 43 Secs
2	25 Mins 4 Secs
3	21 Mins 48 Secs
4	20 Mins 14 Secs
5	19 Mins 16 Secs
6	19 Mins 10 Secs

*Compiled with GNU V10.1.0

Successful Compile

If compiling is successful, this message appears at the end of the compile log:

```
--->      Executables successfully built                  <---

-rwxr-xr-x 1 wrfhelp ncar 54128088 Jul 22 15:54 main/ndown.exe
-rwxr-xr-x 1 wrfhelp ncar 54180032 Jul 22 15:54 main/real.exe
-rwxr-xr-x 1 wrfhelp ncar 53464304 Jul 22 15:54 main/tc.exe
-rwxr-xr-x 1 wrfhelp ncar 60686816 Jul 22 15:52 main/wrf.exe
```

Real data case

wrf.exe – model executable
real.exe – real data initialization
ndown.exe – separate one-way nesting
tc.exe – for tropical cyclone bogusing

```
--->      Executables successfully built                  <---

-rwxr-xr-x 1 wrfhelp ncar 45136368 Nov  2 17:39 main/ideal.exe
-rwxr-xr-x 1 wrfhelp ncar 53253904 Nov  2 17:39 main/wrf.exe
```

Ideal case

wrf.exe - model executable
ideal.exe – ideal data initialization

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

These executables are linked to 2 different directories. You can run a real-data case in either directory. Idealized cases must be run in the appropriate em_*case* directory.

- WRF/run
- WRF/test/em_*case*

Choosing the Right Compiler

Compile

WRF V4.5.2
dmpar/basic nesting
6 processors

Compiler	Compile Time	Run Time
GNU/gcc 12.2.0	25 Mins	3.92 Mins
Intel 2023.2.1	37 Mins	2.20 Min

Run

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

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Step 1: Configure for WPS

Inside the WPS/ directory, type

```
> export WRF_DIR=path-to-top-level-WRF/WRF
> ./configure
```

Configuration Output

configure.wps

```
Will use NETCDF in dir:
/glade/u/apps/derecho/23.09/spack/opt/spack/netcdf/4.9.2/gcc/13.2.0/zywl
Using WRF I/O library in WRF build identified by $WRF_DIR: ../wrf
$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)
 13.  Linux x86_64, IA64 and Opteron    (serial)
 14.  Linux x86_64, IA64 and Opteron    (serial_NO_GRIB2)
 15.  Linux x86_64, IA64 and Opteron    (dmpar)
 16.  Linux x86_64, IA64 and Opteron    (dmpar_NO_GRIB2)
 17.  Linux x86_64, Intel oneAPI compilers    (serial)
 18.  Linux x86_64, Intel oneAPI compilers    (serial_NO_GRIB2)
 19.  Linux x86_64, Intel oneAPI compilers    (dmpar)
 20.  Linux x86_64, Intel oneAPI compilers    (dmpar_NO_GRIB2)
 21.  Linux x86_64, Intel Classic compilers    (serial)
 22.  Linux x86_64, Intel Classic compilers    (serial_NO_GRIB2)
 23.  Linux x86_64, Intel Classic compilers    (dmpar)
 24.  Linux x86_64, Intel Classic compilers    (dmpar_NO_GRIB2)
 25.  Linux x86_64, Intel Classic compilers, SGI MPT    (serial)
 26.  Linux x86_64, Intel Classic compilers, SGI MPT    (serial_NO_GRIB2)
 27.  Linux x86_64, Intel Classic compilers, SGI MPT    (dmpar)
 28.  Linux x86_64, Intel Classic compilers, SGI MPT    (dmpar_NO_GRIB2)
 29.  Linux x86_64, Intel Classic compilers, IBM POE    (serial)
 30.  Linux x86_64, Intel Classic compilers, IBM POE    (serial_NO_GRIB2)
 31.  Linux x86_64, Intel Classic compilers, IBM POE    (dmpar)
 32.  Linux x86_64, Intel Classic compilers, IBM POE    (dmpar_NO_GRIB2)
```

Choose a **serial** compile for WPS (even if WRF is compiled with a parallel option)

* Exception: You are using a VERY large domain (1000's x 1000's)

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

Configure WPS to Use Internal Compression Libraries

Feature available in WPSv4.4+

```
./configure --build-grib2-libs
```

Installs these compressions libraries for use with GRIB2 input

- `zlib`
- `libpng`
- `JasPer`

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
```

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Failed WRF Compile

Search for errors in the *compile.log*

- Search for ‘Error’ with a capital ‘E’
- Typically the first ‘Error’ in the file is the culprit

Visit the WRF & MPAS-A Support Forum

- See Frequently Asked Questions (FAQ)
- Search the forum to see if your issue has already been addressed – if not, post a new topic

Before Recompiling

- Issue the *./clean –a* command
- Reconfigure
  - If you need to make changes to the *configure.wrf* file, do that after issuing *./configure*, and then save the edited file
- Recompile

Failed WPS Compile:
No geogrid or metgrid

- Did WRF compile successfully?

  geogrid and metgrid use the external I/O libraries from WRF, which are built when WRF is installed

- Check that you are using the same compiler (& version) that was used to compile WRF

- Check that you are using the same version of netCDF that was used to compile WRF

Failed WPS Compile:
No ungrib

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

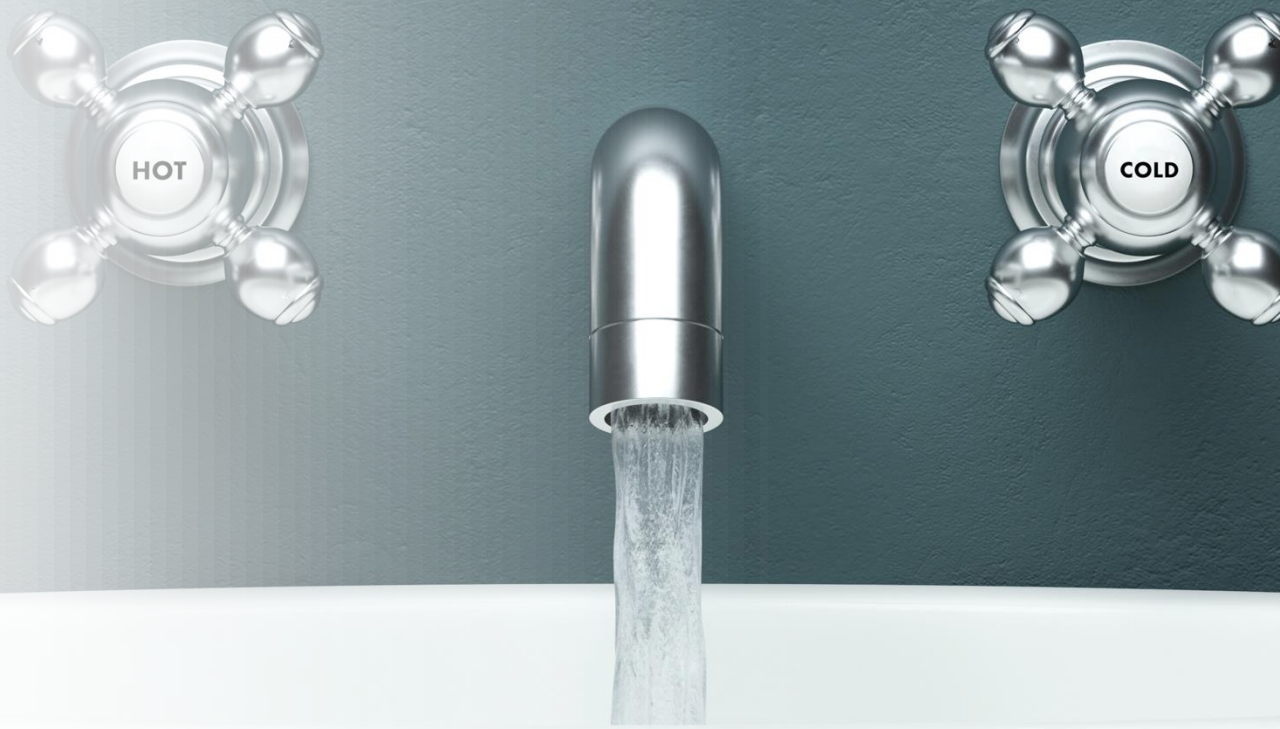
```
COMPRESSION_LIBS = -L/${DIR}/UNGRIB_LIBRARIES/lib -ljasper -lpng -lz
COMPRESSION_INC = -I/${DIR}/UNGRIB_LIBRARIES/include
```

- Alternatively, use the option to build these libraries internally

Using "*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.



THANK YOU!