Build JEDI environment with Singularity

The differences between singularity and Docker (https://cloud4scieng.org/singularity-a-container-system-for-hpc-applications/):

	Docker	Singularity
Permissions	the process inside the container is running with "root" privileges	user permissions inside the Singularity container are the same as outside the container
Filesystem	has no direct access to the host's file system except for those directories that are explicitly cross mounted into the container.	the process that the user is running sees the user's home directory, and the user's environment is shared seamlessly.
Image	Docker images come in layers, and they are assembled like layers of a cake to generate a running image	Singularity image is an actual file that you could put in entirety on your desktop, and move around as you would with any other file.

Step-by-step guide

Installation (You don't need to have Docker installed)

Please visit here to install the Singularity tools on your computer. (root privilege is needed)

Install the latest official release

It is critical to install the latest official release. http://singularity.lbl.gov/release-2-4, as of Oct. 2, 2017

Click here for instructions to install Singularity on Mac OS X.

Check the singularity version

```
[xinzhang@xzhang-qua ~]$ singularity --version
2.4-dist

# Please make sure you installed the latest 2.4 version
```

---

1. ## Check out the Singularity image

check out the singularity image

```
[xinzhang@localhost jedi]$ singularity pull shub://JCSDA/singularity
Progress |===================================| 100.0%
Done. Container is at: /home/xinzhang/jedi/JCSDA-singularity-master.simg
```

---

2. ## Running the Singularity image

running the singularity image

```
[xinzhang@localhost jedi]$ singularity shell -e JCSDA-singularity-master.simg   # -e option cleans all
environment before running container
Singularity: Invoking an interactive shell within container...

Singularity JCSDA-singularity-master.simg:~/jedi> cd


Singularity JCSDA-singularity-master.simg:~> pwd
/home/xinzhang
```

All the steps below are optional and depend on what you intend to use.

To work with the jedi-bundle, follow the instructions in the README of that repository once you have reached this point.

To exit the singularity container or vagrant at any time, type exit

3. ## Check out the GSI code and get case (T24) data

check out the GSI code

```
Singularity JCSDA-singularity-master.simg:~> mkdir -p ~/jedi/code


Singularity JCSDA-singularity-master.simg:~> cd ~/jedi/code

Singularity JCSDA-singularity-master.simg:~> git clone https://Your_UserName@bitbucket.org/jcsda/gsi-
vlab.git gsi   # Check out the GSI code, please replace Your_UserName with your bitbucket username

Singularity JCSDA-singularity-master.simg:~> cd gsi/

Singularity JCSDA-singularity-master.simg:~> git submodule init   # Check out the external repositories
Submodule 'fix' (git@bitbucket.org:jcsda/fix) registered for path 'fix'
Submodule 'libsrc' (git@bitbucket.org:jcsda/external-libs) registered for path 'libsrc'

Singularity JCSDA-singularity-master.simg:~> git submodule update   # Check out the external repositories
Cloning into 'fix'...
remote: Counting objects: 332, done.
remote: Compressing objects: 100% (235/235), done.
remote: Total 332 (delta 102), reused 320 (delta 96)
Receiving objects: 100% (332/332), 961.58 MiB | 357.00 KiB/s, done.
Resolving deltas: 100% (102/102), done.
Checking connectivity... done.
Submodule path 'fix': checked out 'd13e5a23dde538ceefedc39746b029878ee6ff60'
Cloning into 'libsrc'...
remote: Counting objects: 896, done.
remote: Compressing objects: 100% (630/630), done.
remote: Total 896 (delta 263), reused 890 (delta 260)
Receiving objects: 100% (896/896), 5.57 MiB | 1.59 MiB/s, done.
Resolving deltas: 100% (263/263), done.
Checking connectivity... done.
Submodule path 'libsrc': checked out '8fa69e1fd011b658de6cd2e9f08cf1ad77566f4f'

Singularity JCSDA-singularity-master.simg:~> cd fix/


Singularity JCSDA-singularity-master.simg:~> git checkout rev1
```

Get case (T24) data

```
Singularity JCSDA-singularity-master.simg:~> cd ~/jedi


Singularity JCSDA-singularity-master.simg:~> wget ftp://ftp.ucar.edu/pub/mmm/xinzhang/caseT24.tar.gz


Singularity JCSDA-singularity-master.simg:~> tar xvf caseT24.tar.gz


Singularity JCSDA-singularity-master.simg:~>$ rm caseT24.tar.gz


Singularity JCSDA-singularity-master.simg:~> ls -la
total 1163160
drwxrwxr-x. 5 xinzhang xinzhang         64 Oct  4 12:11 .
drwxrwxr-x. 4 xinzhang xinzhang         33 Oct  4 11:30 ..
drwxrwxr-x. 3 xinzhang xinzhang         17 Oct  4 11:30 code
drwxrwxr-x. 4 xinzhang xinzhang         36 Oct  3 13:34 data
drwxrwxr-x. 2 xinzhang xinzhang         32 Oct  3 13:55 test
```

List of Case (T24) Content

```
1) T24 background(size: 52M):

On Theia: /scratch3/BMC/wrfruc/mhu/jedi/casedata/T24_2016030406/gest24/
On Docker: ~/jedi/data/case/T24_2016030406/gest24

aircraft_t_bias.gdas.2016030400  sfcf05.gdas.2016030400  sigf04.gdas.2016030400
biascr.gdas.2016030400           sfcf06.gdas.2016030400  sigf05.gdas.2016030400
biascr_pc.gdas.2016030400        sfcf07.gdas.2016030400  sigf06.gdas.2016030400
radstat.gdas.2016030400          sfcf08.gdas.2016030400  sigf07.gdas.2016030400
sfcf03.gdas.2016030400           sfcf09.gdas.2016030400  sigf08.gdas.2016030400
sfcf04.gdas.2016030400           sigf03.gdas.2016030400  sigf09.gdas.2016030400


2) T24 ensemble forecast(size:178M):

On Theia:/scratch3/BMC/wrfruc/mhu/jedi/casedata/T24_2016030406/enst24
On Docker: ~/jedi/data/case/T24_2016030406/enst24

20 member, hourly output during 3-h to 09-h forecast initialized from 2016030400
  sfg_2016030400_fhr03s_mem020
  sfg_2016030400_fhr04s_mem020
  sfg_2016030400_fhr05s_mem020
  sfg_2016030400_fhr06s_mem020
  sfg_2016030400_fhr07s_mem020
  sfg_2016030400_fhr08s_mem020
  sfg_2016030400_fhr09s_mem020

3) Observations:
On Theia:/scratch3/BMC/wrfruc/mhu/jedi/casedata/T24_2016030406/obs
On Docker: ~/jedi/data/case/T24_2016030406/obs

3.1) Original observation file: 1bamua.gdas.2016030406, prepbufr.gdas.2016030406


3.2) Small observation file: 1bamua.gdas_picked, prepbufr_picked

List of observations in prepbufr_listobs.txt:
  header: number, level number, SID XOB YOB DHR TYP ELV SAID T29
  observation:POB QOB TOB ZOB UOB VOB PWO CAT PRSS
  obs quality: PQM QQM TQM ZQM WQM NUL PWQ
  obs error: POE QOE TOE NUL WOE NUL PWE

List of observations in 1bamua_listobs.txt:
  header: number, channel number, SAID FOVN YEAR MNTH DAYS HOUR MINU SECO CLAT CLON CLATH CLONH HOLS
  header 2: SAZA SOZA BEARAZ SOLAZI
  obs (channel):
```

---

4. Build GSI code and run GSI case

suppose you already checked out the GSI code as $HOME/jedi/code/gsi and have test case directory as $HOME/jedi/data.

Build GSI code and run GSI case

```
Singularity JCSDA-singularity-master.simg:~> cd ~

Singularity JCSDA-singularity-master.simg:~> mkdir -p ~/jedi/build/gsi   # Prepare the directory for GSI
building, out-of-source building

Singularity JCSDA-singularity-master.simg:~> cd ~/jedi/build/gsi     # Enter into directory for GSI
building

Singularity JCSDA-singularity-master.simg:~> export FC=mpif90

Singularity JCSDA-singularity-master.simg:~> cmake -DBUILD_CORELIBS=ON -DUSE_WRF=OFF -DBUILD_GLOBAL=ON ~
/jedi/code/gsi

Singularity JCSDA-singularity-master.simg:~> make -j`nproc`  # parallel compilation with the availble
cores

Singularity JCSDA-singularity-master.simg:~> ls -al bin/
total 44560
drwxr-xr-x. 2 root root       44 Sep 29 17:24 .
drwxr-xr-x. 9 1000 1001      251 Sep 29 17:17 ..
-rwxr-xr-x. 1 root root  8266248 Sep 29 17:24 enkf_gfs.x
-rwxr-xr-x. 1 root root 37358984 Sep 29 17:23 gsi_global.x

Singularity JCSDA-singularity-master.simg:~> cd /jedi/test

# Please modify following variables to reflect the correct PATHS in ./run_gsi_picked.csh
#####################################################
# set DATA = ~/jedi/test/$PSLOT
# set APRUN = "mpirun -np 2 "
# set CASEDIR  = ~/jedi/data/case/T24_2016030406
# set BASEGSI  = ~/jedi/code/gsi/
# set FIXcrtm  = ~/jedi/data/CRTM_2.2.3/
# set GSIEXEC = ~/jedi/build/gsi/bin/gsi_global.x
#####################################################

Singularity JCSDA-singularity-master.simg:~> ./run_gsi_picked.csh
```

Read Diag (O-B) information from GSI test case

```
After a successful GSI run, we can check the O-B for each observation by reading diagnosis files.

1) combine subdomain drag files to one drag file:
 > cd ~/jedi/test/testT24_picked
 > ls dir.*
 > cat dir.0000/conv_01 dir.0001/conv_01 > conv_ges
 > cat dir.0000/amsua_metop-b_01 dir.0001/amsua_metop-b_01 > amsua_metop-b_ges

2) compile read_diag utilities:
 > cd ~/jedi/code/gsi/util/Analysis_Utilities/read_diag


3) Edit makefile and change the variable "INCLD" to reflect the correct path of GSI code, for example :
   INCLD=   -I/home/xinzhang/jedi/build/gsi/include
 > make
Should generate three executables: read_diag_conv.exe read_diag_conv_ens.exe read_diag_rad.exe


3) read conventional observations:
> vi namelist.conv
It should be set up like this:
 &iosetup
  infilename='/home/xinzhang/jedi/test/testT24_picked/conv_ges',
  outfilename='./results_conv_ges',
 /
```

```
> ./read_diag_conv.exe
Now, we should see a text file: results_conv_ges.
The content of each column is listed below
    1-3: variable name,station ID,itype,
    4-7: obs relative time,latitude,longitude,pressure,
    8-14:iuse,observation,background, O-B (for wind, U and then V)

4) read radiance diag:

> vi namelist.rad
It should be set up like:
 &isotope
  infilename='/home/xinzhang/jedi/test/testT24_picked/amsua_metop-b_ges',
  outfilename='./results_amsua_metop-b_ges',
 /

> ./read_diag_rad.exe
Now, we should see a new text file: results_amsua_metop-b_ges
The content of this text file is listed below:

head information (number 1-26):
    1:observation latitude (degrees)
    2:observation longitude (degrees)
    3:model (guess) elevation at observation location
    4:observation time (hours relative to analysis time)
    5:sensor scan position
    6:satellite zenith angle (degrees)
    7:satellite azimuth angle (degrees)
    8:solar zenith angle (degrees)
    9:solar azimuth angle (degrees)
   10:sun glint angle (degrees) (sgagl)
   11:fractional coverage by water
   12:fractional coverage by land
   13:fractional coverage by ice
   14:fractional coverage by snow
   15:surface temperature over water (K)
   16:surface temperature over land (K)
   17:surface temperature over ice (K)
   18:surface temperature over snow (K)
   19:soil temperature (K)
   20:soil moisture OR graupel water path (if gmi .or. saphir)
   21:surface land type
   22:vegetation fraction OR scattering index from AMSU-A (if radmod%lcloud_fwd .and. sea)
   23:snow depth OR integrated CLWP (kg/m**2) from background (if radmod%lcloud_fwd .and. sea)
   24:surface wind speed (m/s)
   25:cloud fraction (%) OR if microwave:
      cloud liquid water (kg/m**2) OR
         cloud liquid water (kg/m**2) if(radmod%lcloud_fwd .and. sea)
         clw (kg/m**2) from retrievals if(gmi .or. amsr2)
   26:cloud top pressure (hPa) OR if microwave:
      total column precip. water (km/m**2) OR
         retrieved CLWP (kg/m**2) from simulated BT if((radmod%lcloud_fwd .and. sea) .or. gmi .or. amsr2)

channel information (loop through each channel with column list), for each column:
   1: observed brightness temperature (K)
   2: observed - simulated Tb with bias correction (K)
   3: observed - simulated Tb with no bias correction (K)
   4: inverse observation error
   5: quality control mark or event indicator
   6: surface emissivity
   7: stability index
   8: indicator of cloudy consistency (if lcloud_fwd) OR d(Tb)/d(Ts)
```

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5. ## Check out the OOPS code

check out the OOPS code

```
Singularity JCSDA-singularity-master.simg:~> cd ~/jedi/code


Singularity JCSDA-singularity-master.simg:~> git clone -b feature/ufo https://github.com/UCAR/oops.git
# Check out the oops code to oops directory
```

---

6. Build and test OOPS code

Build the OOPS code

```
Singularity JCSDA-singularity-master.simg:~> cd ~

Singularity JCSDA-singularity-master.simg:~> mkdir -p ~/jedi/build/oops   # Prepare the directory for
oops building, out-of-source building

Singularity JCSDA-singularity-master.simg:~> cd ~/jedi/build/oops

Singularity JCSDA-singularity-master.simg:~> ecbuild --build=release -
DLAPACK_LIBRARIES=$LAPACK_LIBRARIES ~/jedi/code/oops

Singularity JCSDA-singularity-master.simg:~> make -j`nproc`
...
...
[ 99%] Built target test_qg_4dvar_obsbias.x
[ 99%] Built target test_qg_3dfgat.x
Scanning dependencies of target test_qg_4densvar.x
[ 99%] Built target test_qg_4densvar.x
[ 99%] Linking CXX executable test_qg_increment
[ 99%] Built target test_qg_increment
[100%] Linking CXX executable test_qg_localization
[100%] Built target test_qg_localization

Singularity JCSDA-singularity-master.simg:~> ctest
...
...
108/108 Test #108: test_qg_dfi ......................   Passed    0.46 sec

100% tests passed, 0 tests failed out of 108

Label Time Summary:
boost         =   1.13 sec (53 tests)
executable    =   1.16 sec (56 tests)
fortran       =   0.04 sec (3 tests)
oops          =  23.89 sec (108 tests)
script        =  22.73 sec (52 tests)

Total Test time (real) =  23.94 sec
```

---

7. Download WRF and WPS

Download WPS/WRF

```
Singularity JCSDA-singularity-master.simg:~> cd ~/jedi/code

Singularity JCSDA-singularity-master.simg:~> wget http://www2.mmm.ucar.edu/wrf/src/WPSV3.9.1.TAR.gz

Singularity JCSDA-singularity-master.simg:~> tar xvf WPSV3.9.1.TAR.gz

Singularity JCSDA-singularity-master.simg:~> rm -f WPSV3.9.1.TAR.gz

Singularity JCSDA-singularity-master.simg:~> wget http://www2.mmm.ucar.edu/wrf/src/WRFV3.9.1.1.TAR.gz

Singularity JCSDA-singularity-master.simg:~> tar xvf WRFV3.9.1.1.TAR.gz

Singularity JCSDA-singularity-master.simg:~> rm -f WRFV3.9.1.1.TAR.gz

Singularity JCSDA-singularity-master.simg:~> ls -la
total 12
drwxrwxr-x.  6 xinzhang xinzhang   53 Oct  5 16:01 .
drwxrwxr-x. 13 xinzhang xinzhang  196 Oct  5 14:45 ..
drwxrwxr-x. 13 xinzhang xinzhang  243 Oct  5 14:29 gsi
drwxrwxr-x. 10 xinzhang xinzhang 4096 Oct  5 11:13 oops
drwxr-xr-x.  7 xinzhang xinzhang 4096 Aug 17 11:10 WPS
drwxr-xr-x. 17 xinzhang xinzhang 4096 Aug 28 15:01 WRFV3
```

---

8. Build WRF and WPS code

Build WRF and WPS code

```
Singularity JCSDA-singularity-master.simg:~> cd ~/jedi/code/WRFV3

Singularity JCSDA-singularity-master.simg:~> ./configure  # Select 34 for dmpar gnu

Singularity JCSDA-singularity-master.simg:~> vi configure.wrf   # Becasue WRF has problem to test mpi2
support, please add -DMPI2_SUPPORT after DM_CC = mpicc

Singularity JCSDA-singularity-master.simg:~> ./compile em_real  # For unknown reason,
module_ra_rrtmg_swf.f90 might fail to be compiled due to internal compiler error, typing "./compile
em_real" again usually can solve the problem.
...
...
========================================================================
build started:   Thu Oct  5 22:12:18 UTC 2017
build completed: Thu Oct 5 22:21:58 UTC 2017

--->                  Executables successfully built                  <---

-rwxr-xr-x. 1 root root 36472488 Oct  5 22:21 main/ndown.exe
-rwxr-xr-x. 1 root root 36346432 Oct  5 22:21 main/real.exe
-rwxr-xr-x. 1 root root 35944328 Oct  5 22:21 main/tc.exe
-rwxr-xr-x. 1 root root 40051304 Oct  5 22:21 main/wrf.exe

========================================================================


Singularity JCSDA-singularity-master.simg:~> cd ../WPS


Singularity JCSDA-singularity-master.simg:~> ./configure   # Select 3 for dmpar gfortran


Singularity JCSDA-singularity-master.simg:~> vi configure.wrf   # edit COMPRESSION_LIBS and
COMPRESSION_INC as following lines and remove -f90=gfortran from DM_FC and remove -cc=gcc from DM_CC
...
...
...
#
#   Settings for Linux x86_64, gfortran    (dmpar)
#
#
COMPRESSION_LIBS    = -L/usr/local/lib -ljasper -lpng -lz
COMPRESSION_INC     = -I/usr/local/include
FDEFS               = -DUSE_JPEG2000 -DUSE_PNG
SFC                 = gfortran
SCC                 = gcc
DM_FC               = mpif90
DM_CC               = mpicc
...
...
...


Singularity JCSDA-singularity-master.simg:~> ./compile


Singularity JCSDA-singularity-master.simg:~> ls -al *.exe
lrwxrwxrwx. 1 root root 23 Oct  6 16:02 geogrid.exe -> geogrid/src/geogrid.exe
lrwxrwxrwx. 1 root root 23 Oct  6 16:02 metgrid.exe -> metgrid/src/metgrid.exe
lrwxrwxrwx. 1 root root 21 Oct  6 16:02 ungrib.exe -> ungrib/src/ungrib.exe
```

---

9. Download MPAS code

Download MPAS code

```
Singularity JCSDA-singularity-master.simg:~> cd ~/jedi/code

Singularity JCSDA-singularity-master.simg:~> git clone -b v5.2 https://github.com/MPAS-Dev/MPAS-Release.
git
```

---

10. Build MPAS code

Build MPAS code

```
Singularity JCSDA-singularity-master.simg:~> cd ~/jedi/code/MPAS-Release

Singularity JCSDA-singularity-master.simg:~> vi ./src/core_atmosphere/physics/checkout_data_files.sh #
Replace the MPAS-Data address to https (see next line below)

Singularity JCSDA-singularity-master.simg:~> git diff
diff --git a/src/core_atmosphere/physics/checkout_data_files.sh b/src/core_atmosphere/physics
/checkout_data_files.sh
index e62b466..f2c3cba 100755
--- a/src/core_atmosphere/physics/checkout_data_files.sh
+++ b/src/core_atmosphere/physics/checkout_data_files.sh
@@ -56,7 +56,7 @@ fi
 which git
 if [ $? -eq 0 ]; then
    echo "*** trying git to obtain WRF physics tables ***"
-   git clone git://github.com/MPAS-Dev/MPAS-Data.git
+   git clone https://github.com/MPAS-Dev/MPAS-Data.git
    if [ $? -eq 0 ]; then
       mv MPAS-Data/atmosphere/physics_wrf/files/* physics_wrf/files
       rm -rf MPAS-Data

Singularity JCSDA-singularity-master.simg:~> make gfortran CORE=atmosphere
...
...
make[2]: Leaving directory '/home/xinzhang/jedi/code/MPAS-Release/src/core_atmosphere'
*****************************************************************************
MPAS was built with default double-precision reals.
Debugging is off.
Parallel version is on.
Papi libraries are off.
TAU Hooks are off.
MPAS was built without OpenMP support.
MPAS was built with .F files.
The native timer interface is being used
Using the PIO 1.x library.
*****************************************************************************
make[1]: Leaving directory '/home/xinzhang/jedi/code/MPAS-Release'
```

---

11. Test MPAS

Test MPAS

```
Singularity xinzhang8noaa-singularity-master.simg:~/jedi/code/MPAS-Release> wget ftp://ftp.ucar.edu/pub
/mmm/xinzhang/mpas_10242_case.tgz
Singularity xinzhang8noaa-singularity-master.simg:~/jedi/code/MPAS-Release> tar xvf mpas_10242_case.tgz

Singularity xinzhang8noaa-singularity-master.simg:~/jedi/code/MPAS-Release> mpirun -np 8
atmosphere_model # or mpirun -np 1 atmosphere_model

task 0 of 8 is running
task 1 of 8 is running
task 2 of 8 is running
task 3 of 8 is running
task 6 of 8 is running
task 7 of 8 is running
task 4 of 8 is running
task 5 of 8 is running
```

---

12. Check out the FV3 code

check out the FV3 code

```
Singularity JCSDA-singularity-master.simg:~> cd ~/jedi/code

Singularity JCSDA-singularity-master.simg:~> git clone https://Your_UserName@bitbucket.org/jcsda/comfv3.
git comfv3   # Check out the FV3 code, please replace Your_UserName with your bitbucket username

Singularity JCSDA-singularity-master.simg:~> cd comfv3

Singularity JCSDA-singularity-master.simg:~> git submodule init

Singularity JCSDA-singularity-master.simg:~> git submodule update

Singularity JCSDA-singularity-master.simg:~> git branch -a

Singularity JCSDA-singularity-master.simg:~> git checkout feature/gfortran_build

Singularity JCSDA-singularity-master.simg:~> cd FV3

Singularity JCSDA-singularity-master.simg:~> git checkout feature/gfortran_build

Singularity JCSDA-singularity-master.simg:~> cd ../NEMS

Singularity JCSDA-singularity-master.simg:~> git checkout feature/gfortran_build
```

---

13. Build the FV3 code

Build FV3 code

```
Singularity JCSDA-singularity-master.simg:~> cd ~/jedi/code/comfv3/release/v0/exp/

Singularity JCSDA-singularity-master.simg:~> ./build.sh macgnu
...
...
...
Elapsed time 66 seconds. Compiling HYDRO=Y 32BIT=N finished
+ cp /home/xinzhang/jedi/code/comfv3/release/v0/exp/../../../tests/fv3_1.exe ../NEMS/exe/fv3_gfs_hydro.
prod.64bit.x
+ rm /home/xinzhang/jedi/code/comfv3/release/v0/exp/../../../tests/fv3_1.exe
+ exit 0
```

14. Check out and build the CRTM V2.2.3 code

Checkout and Build CRTM V2.2.3

```
Singularity JCSDA-singularity-master.simg:~> cd ~/jedi/code
Singularity JCSDA-singularity-master.simg::~/jedi/code> git clone https://YourUserName@bitbucket.org
/jcsda/crtm-release.git crtm_v2.2.3 # please replace Your_UserName with your bitbucket username

Singularity JCSDA-singularity-master.simg::~/jedi/code> cd crtm_v2.2.3/

Singularity JCSDA-singularity-master.simg::~/jedi/code/crtm_v2.2.3> source config-setup/gfortran.setup

Singularity JCSDA-singularity-master.simg::~/jedi/code/crtm_v2.2.3>./configure --prefix=/home/`whoami`
/jedi/build/crtm

Singularity JCSDA-singularity-master.simg::~/jedi/code/crtm_v2.2.3> make

Singularity JCSDA-singularity-master.simg::~/jedi/code/crtm_v2.2.3> make check

Singularity JCSDA-singularity-master.simg::~/jedi/code/crtm_v2.2.3> make install
```

What's inside the JEDI docker image?

When you start a Singularity container instance from the xinzhang8noaa-singularity-master.simg, we already prepapre the **gnu version 7.2 compilers** and most of the necessary libraiestools for GSI, OOPS, WRF etc., all libraries are installed under **/usr/local**, which include

1. git
2. git flow
3. emacs
4. open-mpi v2.1.0
5. zlib v1.2.11
6. szip v2.1.1
7. jpeg v9b
8. png v1.4.19
9. jasper v1.900.2
10. hdf5 v1.8.17
11. freetype v2.5.5
12. netcdf-c v4.4.11
13. netcdf-fortran v4.4.4
14. lapack v3.7.0
15. parallel-netcdf v1.8.1
16. xerces-c v3.1.4
17. esmf v7.0.0
18. udunites-2 v2.2.24
19. nco v4.6.6
20. grib_api v1.21.0
21. cdo v1.8.2
22. boost v1.65.1
23. eigen3 v3.3.4
24. pio 1.7.1
25. ecbuild
26. eckit
27. fckit

The major NCEP libraries are also installed at :

1. /nwprod/lib/bacio/v2.0.1/libbacio_v2.0.1_4.a
2. /nwprod/lib/bacio/v2.0.1/libbacio_v2.0.1_8.a
3. /nwprod/lib/ip/v2.0.0/libip_v2.0.0_4.a
4. /nwprod/lib/ip/v2.0.0/libip_v2.0.0_8.a
5. /nwprod/lib/ip/v2.0.0/libip_v2.0.0_d.a
6. /nwprod/lib/sigio/v2.0.1/lib/libsigio_v2.0.1_4.a
7. /nwprod/lib/sigio/v2.0.1/libsigio_v2.0.1_4.a
8. /nwprod/lib/sp/v2.0.2/libsp_v2.0.2_4.a
9. /nwprod/lib/sp/v2.0.2/libsp_v2.0.2_8.a
10. /nwprod/lib/sp/v2.0.2/libsp_v2.0.2_d.a
11. /nwprod/lib/w3emc/v2.2.0/libw3emc_v2.2.0_4.a
12. /nwprod/lib/w3emc/v2.2.0/libw3emc_v2.2.0_8.a
13. /nwprod/lib/w3emc/v2.2.0/libw3emc_v2.2.0_d.a
14. /nwprod/lib/w3nco/v2.0.6/libw3nco_v2.0.6_4.a
15. /nwprod/lib/w3nco/v2.0.6/libw3nco_v2.0.6_8.a
16. /nwprod/lib/w3nco/v2.0.6/libw3nco_v2.0.6_d.a

1. Related articles

- Infrastructure Knowledge Base
- GNSSRO UFO Hackathon, August 21-27, 2018
- Running HOFX tests on the gnssro branch
- Install Singularity on Mac OS X
- Build JEDI environment with Singularity

1. **Build MPAS code**