2017 Joint DTC-EMC-JCSDA GSI-EnKF Tutorial
July 11-14, 2017,
NCWCP, College Park, MD

EnKF Fundamentals (1): Configuration and Run

Chunhua Zhou*

Kathryn Newman* and Ming Hu**

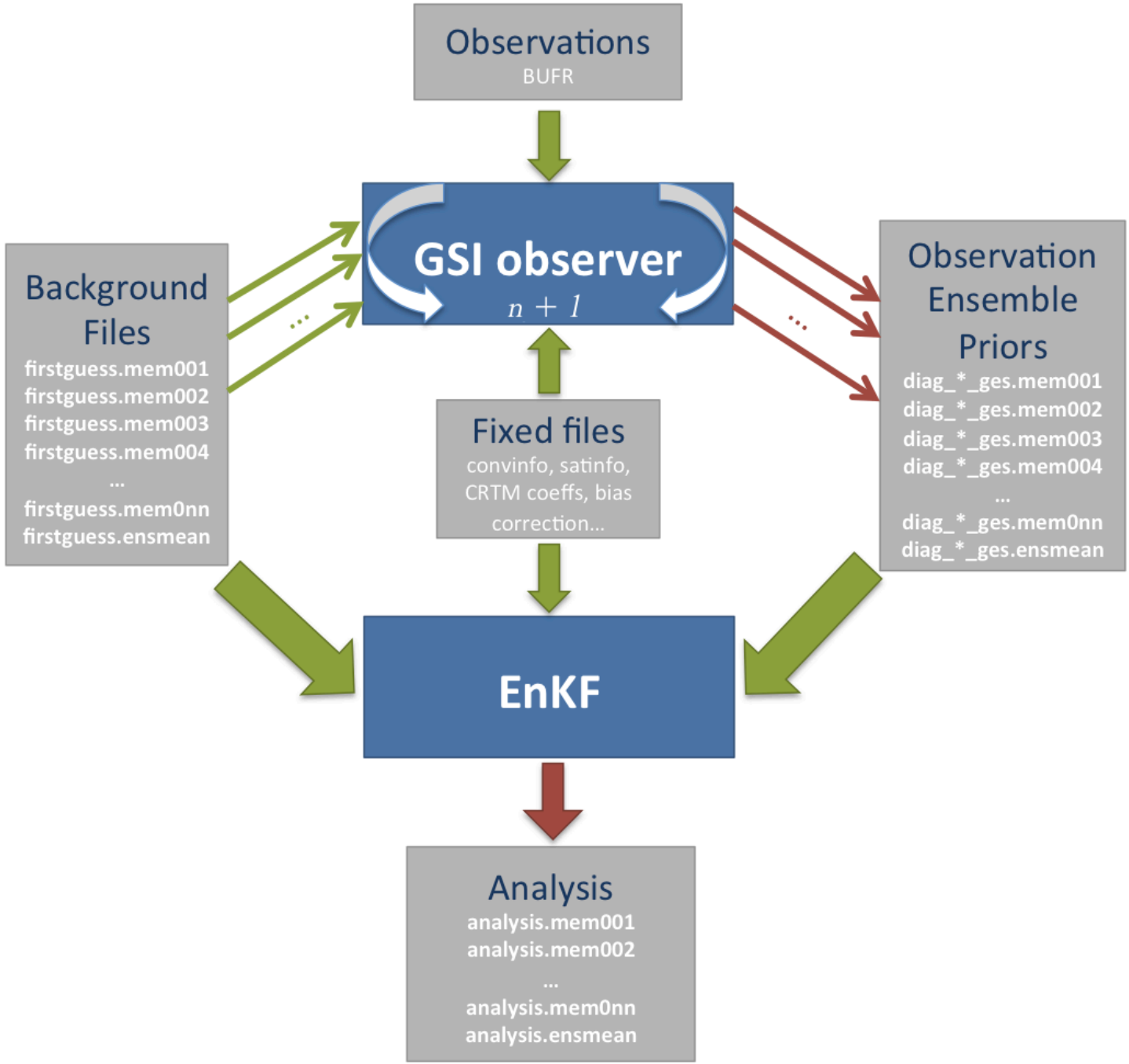
Developmental Testbed Center

*National Center for Atmospheric Research

**NOAA/ESRL/Global System Division

Outline

- **EnKF Fundamentals (1): Configuration and Run**
  - Input data required to run EnKF
  - Understanding GSI observer/EnKF run scripts
  - Running GSI observer and check results
  - Running regional EnKF and check results
  - Brief overview of running global GSI observer and EnKF
- EnKF Fundamentals (2): Diagnostics and Applications


Observations
BUFR
GSI observer
n + 1
Background Files
firstguess.mem001
firstguess.mem002
firstguess.mem003
firstguess.mem004
...
firstguess.mem0nn
firstguess.ensmean
Fixed files
convinfo, satinfo, CRTM coeffs, bias correction...
Observation Ensemble Priors
diag_*_ges.mem001
diag_*_ges.mem002
diag_*_ges.mem003
diag_*_ges.mem004
...
diag_*_ges.mem0nn
diag_*_ges.ensmean
EnKF
Analysis
analysis.mem001
analysis.mem002
...
analysis.mem0nn
analysis.ensmean

Before you run…

Obtain input data

Understand GSI observer and EnKF run scripts

Input data required to run EnKF

- **Ensemble mean and members**
  - Ensemble mean and members used as the background for the EnKF analysis:

```
firstguess.mem001
firstguess.mem002
        …
firstguess.ensmean
```

For regional EnKF

  - Ensemble members can be generated using methods such as:
    - Global/regional ensemble forecasts
    - Ensemble forecasts generated using multi-physics, multi-models, or adding random perturbations drawn from climatology
    - For cycling assimilation, using ensemble forecasts initialized from previous ensemble analyses generated by EnKF
  - This EnKF can use any of the following:
    - ARW forecast (NetCDF)
    - GFS forecast
- **Observation Innovation**
- **Fixed files**

Input data required to run EnKF

- Ensemble mean and members
- **Observation Innovation**
  - Need innovations of ensemble priors to all observations to run EnKF
  - Observation innovations of ensemble priors generated by running GSI observation forward operators w/ ensemble members as background

```
diag_conv_ges.mem001          diag_instrument_satellite_ges.mem001
…                             …
diag_conv_ges.ensmean         diag_instrument_satellite_ges.ensmean
```

  - Preparation of observations for EnKF assimilation done within GSI
    - Quality control
    - Selection of observation types for assimilation
    - Observation error tuning
    - Bias correction (for radiance assimilation)
- Fixed files

Input data required to run EnKF

- Ensemble mean and members
- Observation Innovation
- **Fixed files**
  - EnKF uses same fixed files as GSI to setup the analysis configurations
    - Observation control:
      - **convinfo** (conventional data)
      - **ozinfo** (ozone retrieval info file)
      - **satinfo** (satellite channel/usage info file)
    - Bias correction for satellite radiance assimilation:
      - **satbias_in** (satellite bias correction coefficient file)
    - For namelist parameter `readin_localization=.true.`
      - **hybens_info** (customized horizontal and vertical localization values varying by model level)
        - NAM, HWRF, Global files in /comGSIv3.6-EnKFv1.2/fix

Before you run…

Obtain input data

Understand GSI observer and EnKF run scripts

Two sample run scripts are provided:

- GSI observer
- EnKF

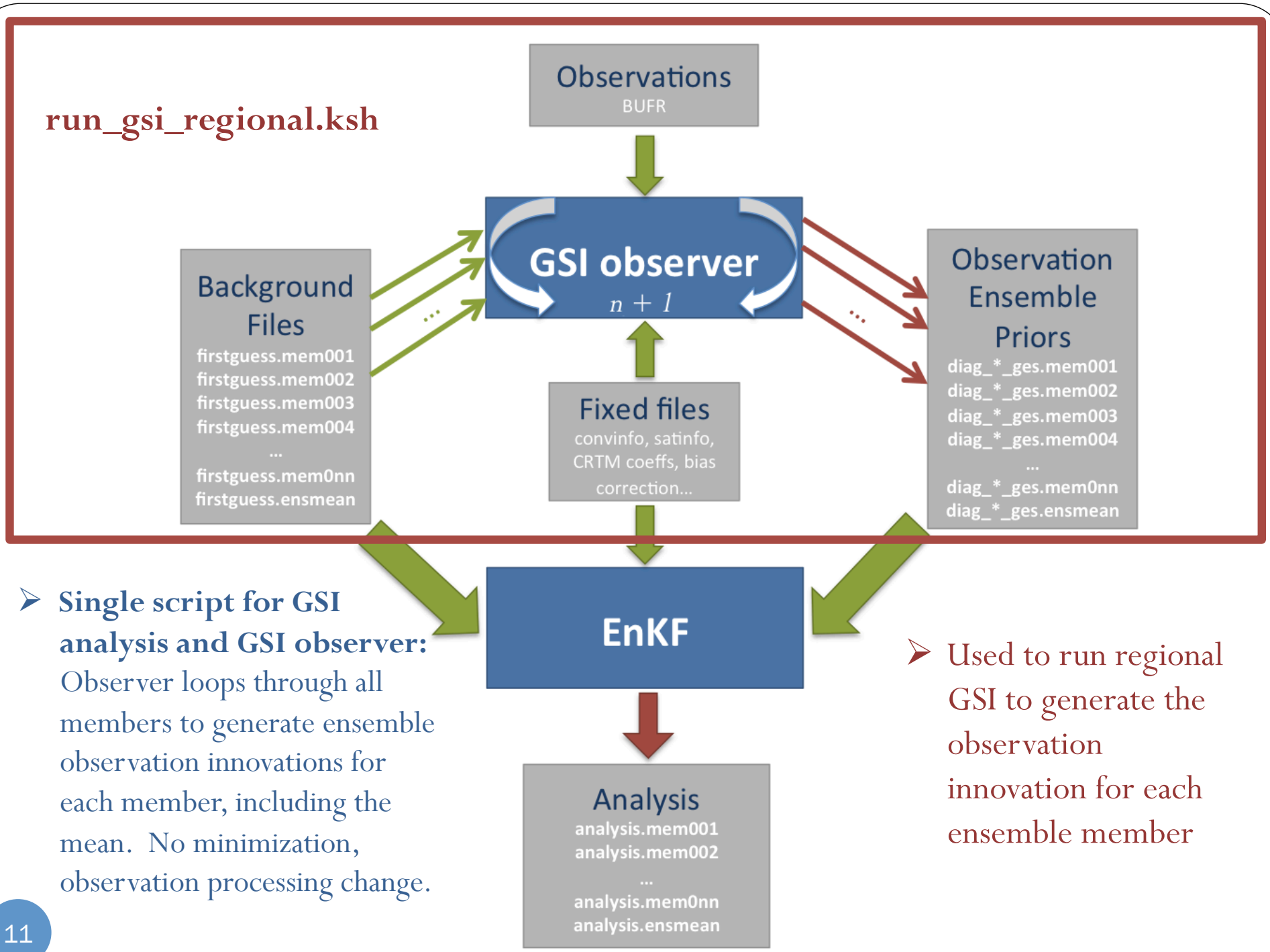
**The following covers scripts for regional cases – global case later!*

Understanding GSI Observer/EnKF Run Scripts:

Steps follow community GSI scripts close!

- GSI observer:
  - Computer resources
  - Analysis time
  - GSI observer run directory
  - Location and names of background files
  - Location and names of observation files
  - Location of the Fix files
  - Location of the CRTM coefficients
  - GSI executable
  - Observation data types used
  - … (run GSI observer and save results) …
- EnKF:
  - Computer resources
  - Analysis time
  - EnKF run directory
  - Location and names of ensemble priors (background)
  - Location and names of observation **innovation** files
  - Location of the Fix files
  - Location of the CRTM coefficients
  - EnKF executable
  - Ensemble parameters
  - Observation data types used
  - … (run EnKF and save results)

Set up GSI observer run



- **Single script for GSI analysis and GSI observer:** Observer loops through all members to generate ensemble observation innovations for each member, including the mean. No minimization, observation processing change.

- Used to run regional GSI to generate the observation innovation for each ensemble member

GSI observer run script

- Set experiment variables

```
###############################################
# case set up (users should change this part)
###############################################
#
# ANAL_TIME= analysis time  (YYYYMMDDHH)
# WORK_ROOT= working directory, where GSI runs
# PREPBURF = path of PreBUFR conventional obs
# BK_FILE  = path and name of background file
# OBS_ROOT = path of observations files
# FIX_ROOT = path of fix files
# GSI_EXE  = path and name of the gsi executable
  ANAL_TIME=2012102506
  WORK_ROOT=…/enkf/regional/gsidiag_arw
  OBS_ROOT=…/enkf/enkfdata/arw/obs
  PREPBUFR=${OBS_ROOT}/nam.t18z.prepbufr.tm00.nr
  BK_ROOT=…/enkf/enkfdata/arw/bk
  BK_FILE=${BK_ROOT}/firstguess.ensmean
  CRTM_ROOT=…/gsi/CRTM_2.2.3
  GSI_ROOT=…/enkf/code/comGSIv3.6_EnKFv1.2
  FIX_ROOT=${GSI_ROOT}/fix
  GSI_EXE=${GSI_ROOT}/run/gsi.exe
  GSI_NAMELIST=${GSI_ROOT}/run/comgsi_namelist.sh
```

Note: background set to ensemble mean

GSI observer run script

- Set experiment variables

```
#-----------------------------------------------
# bk_core= which WRF core is used as background (NMM or ARW)
# bkcv_option= which background error covariance and parameter will be used
#              (GLOBAL or NAM)
# if_clean = clean  : delete temporary files in working directory (default)
#            no     : leave running directory as is (this is for debug only)
  bk_core=ARW
  bkcv_option=NAM
  if_clean=clean
# if_observer = Yes  : only used as observation operator for enkf
# no_member     number of ensemble members
# BK_FILE_mem   path and base for ensemble members
  if_observer=Yes
  no_member=20
  BK_FILE_mem=${BK_ROOT}/firstguess.mem
```

Indicates this GSI run is for the generation of observation ensemble priors (Yes) vs. GSI analysis (No)

Path and name of ensembles (excluding member ID)

Number of ensemble members

GSI observer run script

- Generate a run directory for GSI/EnKF
- Copy the GSI/EnKF **executable** to the run directory.
- Copy/Link the **background file/ensemble files** to the run directory.
- Link **observations** to the run directory
- Link **fixed files** (statistic, control, and coefficient files) to the run directory
- Generate **namelist** for GSI

```
# Link to the prepbufr data
ln -s ${PREPBUFR} ./prepbufr
# ln -s ${OBS_ROOT}/gdas1.t${HH}z.sptrmm.tm00.bufr_d
tmirrbufr
# Link to the radiance data
srcobsfile[1]=${OBS_ROOT}/gdas1.t${HH}z.satwnd.tm00.bufr_d
gsiobsfile[1]=satwnd
srcobsfile[2]=${OBS_ROOT}/gdas1.t${HH}z.1bamua.tm00.bufr_d
gsiobsfile[2]=amsuabufr
. . .     . . .
```

```
if [ ${if_observer} = Yes ] ;
then
  nummiter=0
  if_read_obs_save='.true.'
  if_read_obs_skip='.false.'
else
  nummiter=2
  if_read_obs_save='.false.'
  if_read_obs_skip='.false.'
fi

# Build the GSI namelist on-the-fly
. $GSI_NAMELIST
cat << EOF > gsiparm.anl

 $comgsi_namelist

EOF
```

Namelist option to save ensemble obs processing

outer loops=0 to skip minimization iterations

Setting up data usage:

Detailed GSI usage/ tuning already covered in GSI portion!

- Link the observation files

```
ln -s ${PREPBUFR} ./prepbufr
. . .    . . .
```

- Set namelist section &*OBS_INPUT*

```
&OBS_INPUT
 dmesh(1)=120.0,dmesh(2)=60.0,dmesh(3)=60.0,dmesh(4)=60.0,dmesh(5)=120,time_window_max=1.5,
 dfile(01)='prepbufr',  dtype(01)='ps',     dplat(01)=' ',    dsis(01)='ps',         dval(01)=1.0,  dthin(01)=0,
 dfile(02)='prepbufr'   dtype(02)='t',      dplat(02)=' ',    dsis(02)='t',          dval(02)=1.0,  dthin(02)=0,
 dfile(03)='prepbufr',  dtype(03)='q',      dplat(03)=' ',    dsis(03)='q',          dval(03)=1.0,  dthin(03)=0,
 dfile(28)='amsuabufr', dtype(28)='amsua', dplat(28)='n15',  dsis(28)='amsua_n15',  dval(28)=10.0, dthin(28)=2,
 dfile(29)='amsuabufr', dtype(29)='amsua', dplat(29)='n16',  dsis(29)='amsua_n16',  dval(29)=0.0,  dthin(29)=2,
```

- Set *info* file

```
!otype    type   sub  iuse  twindow  numgrp  ngroup  nmiter  gross  ermax  ermin  var_b     var_pg  ithin  rmesh   pmesh
 ps        120     0     1      3.0       0       0       0    4.0    3.0    1.0    4.0  0.000300       0     0.      0.
 ps        180     0     1      3.0       0       0       0    4.0    3.0    1.0    4.0  0.000300       0     0.      0.
 ps        181     0     1      3.0       0       0       0    3.6    3.0    1.0    3.6  0.000300       0     0.      0.
 ps        183     0    -1      3.0       0       0       0    4.0    3.0    1.0    4.0  0.000300       0     0.      0.
 t         120     0     1      3.0       0       0       0    8.0    5.6    1.3    8.0  0.000001       0     0.      0.
 t         126     0    -1      3.0
 t         130     0     1      3.0
 t         131     0     1      3.0
 t         180     0     1      3.0
 t         181     0    -1      3.0
```

```
!sensor/instr/sat      chan  iuse  error   error_cld  ermax
 amsua_n15               2     1  2.000    13.500     4.500
 amsua_n15               3     1  2.000     7.100     4.500
 amsua_n15               4     1  0.600     1.300     2.500
 amsua_n15              14    -1  2.000     1.400     4.500
 amsua_n15              15     1  3.000    10.000     4.500
 hirs3_n17               1    -1  2.000     0.000     4.500
```

GSI observer: files to note while running:

- Once run script is configured and data are linked, run `wrf_enkf` exe

`amsua_n18.TauCoeff.bin`
`amsua_n18.SpcCoeff.bin`
`imgr_g11.SpcCoeff.bin`
	`imgr_g11.TauCoeff.bin`
	`ssmi_f15.SpcCoeff.bin`
	`ssmi_f15.TauCoeff.bin`
		CRTM coefficients that have been linked through run script

`obs_input.0001`
`obs_input.0003`
`obs_input.0005`
`obs_input.0007`
	`obs_input.0002`
	`obs_input.0004`
	`obs_input.0006`
	`obs_input.nnnn`
		Ensemble mean (*save=T, skip=F*), save all observation processing to this file. nnnn = different variable type.

`pe0001.obs_setup`
`pe0003.obs_setup`
`pe0005.obs_setup`
`pe0007.obs_setup`
	`pe0002.obs_setup`
	`pe0004.obs_setup`
	`pe0006.obs_setup`
	`pe0008.obs_setup`
		Ensemble members (*save=F, skip=T*), obs_input.nnnn read & pennnn.obs_setup (per processor) written for all obs

`pe0001.conv_01`
`pe0003.conv_01`
`pe0005.conv_01`
`pe0007.conv_01`
	`pe0002.conv_01`
	`pe0004.conv_01`
	`pe0006.conv_01`
	`pe0008.conv_01`
		Files generated after O-B, generated for each observation type (conv, sensor)

`stdout`
`stdout_mem001`
`stdout_mem003`
`stdout_mem005`
`stdout_mem007`
	
	`stdout_mem002`
	`stdout_mem004`
	`stdout_mem006`
	`stdout_mem008`
		Standard output for ensemble mean, each ensemble member

Run results: GSI observer

```
amsuabufr
amsubbufr
anavinfo
berror_stats
convinfo
diag_amsua_n15_ges.ensmean
diag_amsua_n15_ges.mem001
diag_amsua_n15_ges.mem002
diag_amsua_n15_ges.mem003
diag_amsua_n15_ges.mem004
diag_amsua_n15_ges.mem005
diag_conv_ges.ensmean
diag_conv_ges.mem001
diag_conv_ges.mem002
diag_conv_ges.mem003
diag_conv_ges.mem004
diag_conv_ges.mem005
diag_hirs4_n19_ges.ensmean
diag_hirs4_n19_ges.mem001
diag_hirs4_n19_ges.mem002
diag_hirs4_n19_ges.mem003
diag_hirs4_n19_ges.mem004
diag_hirs4_n19_ges.mem005
diag_mhs_n19_ges.ensmean
diag_mhs_n19_ges.mem001
diag_mhs_n19_ges.mem002
diag_mhs_n19_ges.mem003
diag_mhs_n19_ges.mem004
diag_mhs_n19_ges.mem005
errtable
fit_p1.2013091218
fit_q1.2013091218
fit_rad1.2013091218
fit_t1.2013091218
fit_w1.2013091218
fort.201
fort.202
fort.203
fort.204
fort.205
fort.206
fort.207
                    .bufrtable
fort.212
fort.213
fort.214
fort.215
fort.217
fort.218
fort.219
fort.220
fort.221
gpsrobufr
gsi.exe
gsiparm.anl
hirs3bufr
hirs4bufr
l2rwbufr
list_run_directory
list_run_directory_mem001
list_run_directory_mem002
list_run_directory_mem003
list_run_directory_mem004
list_run_directory_mem005
mhsbufr
ozinfo
pcpbias_out
pcpinfo
prepbufr
satinfo
sigf03
stdout
stdout.anl.2013091218
stdout_mem001
stdout_mem002
stdout_mem003
stdout_mem004
stdout_mem005
wrfanl.2013091218
wrf_inout
wrf_inout_ensmean
```

Diag files of conventional observations for ensemble mean and members

Run results: GSI observer

```
amsuabufr
amsubbufr
anavinfo
berror_stats
convinfo
diag_amsua_n15_ges.ensmean
diag_amsua_n15_ges.mem001
diag_amsua_n15_ges.mem002
diag_amsua_n15_ges.mem003
diag_amsua_n15_ges.mem004
diag_amsua_n15_ges.mem005
diag_conv_ges.ensmean
diag_conv_ges.mem001
diag_conv_ges.mem002
diag_conv_ges.mem003
diag_conv_ges.mem004
diag_conv_ges.mem005
diag_hirs4_n19_ges.ensmean
diag_hirs4_n19_ges.mem001
diag_hirs4_n19_ges.mem002
diag_hirs4_n19_ges.mem003
diag_hirs4_n19_ges.mem004
diag_hirs4_n19_ges.mem005
diag_mhs_n19_ges.ensmean
diag_mhs_n19_ges.mem001
diag_mhs_n19_ges.mem002
diag_mhs_n19_ges.mem003
diag_mhs_n19_ges.mem004
diag_mhs_n19_ges.mem005
errtable
fit_p1.2013091218
fit_q1.2013091218
fit_rad1.2013091218
fit_t1.2013091218
fit_w1.2013091218
fort.201
fort.202
fort.203
fort.204
fort.205
fort.206
fort.207
fort.208
fort.209
fort.214
fort.215
fort.217
fort.218
fort.219
fort.220
fort.221
gpsrobufr
gsi.exe
gsiparm.anl
hirs3bufr
hirs4bufr
l2rwbufr
list_run_directory
list_run_directory_mem001
list_run_directory_mem002
list_run_directory_mem003
list_run_directory_mem004
list_run_directory_mem005
mhsbufr
ozinfo
pcpbias_out
pcpinfo
prepbufr
prepobs_prep.bufrtable
stdout
stdout.anl.2013091218
stdout_mem001
stdout_mem002
stdout_mem003
stdout_mem004
stdout_mem005
wrfanl.2013091218
wrf_inout
wrf_inout_ensmean
```

Diag files of satellite radiance observations for ensemble mean and members

Run results: GSI observer

List of files in the run directory after the GSI observer finished for a particular ensemble member

```
amsuabufr
amsubbufr
anavinfo
diag_amsua_n15_ges.mem001
diag_amsua_n15_ges.mem002
diag_amsua_n15_ges.mem003
diag_amsua_n15_ges.mem004
diag_amsua_n15_ges.mem005
diag_conv_ges.ensmean
diag_conv_ges.mem001
diag_conv_ges.mem002
diag_conv_ges.mem003
diag_conv_ges.mem004
diag_conv_ges.mem005
diag_hirs4_n19_ges.ensmean
diag_hirs4_n19_ges.mem001
diag_hirs4_n19_ges.mem002
diag_hirs4_n19_ges.mem003
diag_hirs4_n19_ges.mem004
diag_hirs4_n19_ges.mem005
diag_mhs_n19_ges.ensmean
diag_mhs_n19_ges.mem001
diag_mhs_n19_ges.mem002
diag_mhs_n19_ges.mem003
diag_mhs_n19_ges.mem004
diag_mhs_n19_ges.mem005
errtable
fit_p1.2013091218
fit_q1.2013091218
fit_rad1.2013091218
fort.202
fort.203
fort.204
fort.205
fort.206
fort.207
fort.208
fort.209
fort.210
fort.211
fort.212
fort.213
fort.214
fort.215
fort.217
fort.218
fort.219
fort.220
fort.221
gpsrobufr
gsi.exe
gsiparm.anl
hirs3bufr
hirs4bufr
l2rwbufr
list_run_directory
list_run_directory_mem001
list_run_directory_mem002
list_run_directory_mem003
list_run_directory_mem004
list_run_directory_mem005
mhsbufr
ozinfo
pcpbias_out
pcpinfo
prepbufr
prepobs_prep.bufrtable

satbias_in
satbias_out
satinfo
sigf03
stdout
stdout.anl.2013091218
stdout_mem001
stdout_mem002
stdout_mem003
stdout_mem004
stdout_mem005
wrfanl.2013091218
wrf_inout
wrf_inout_ensmean
```

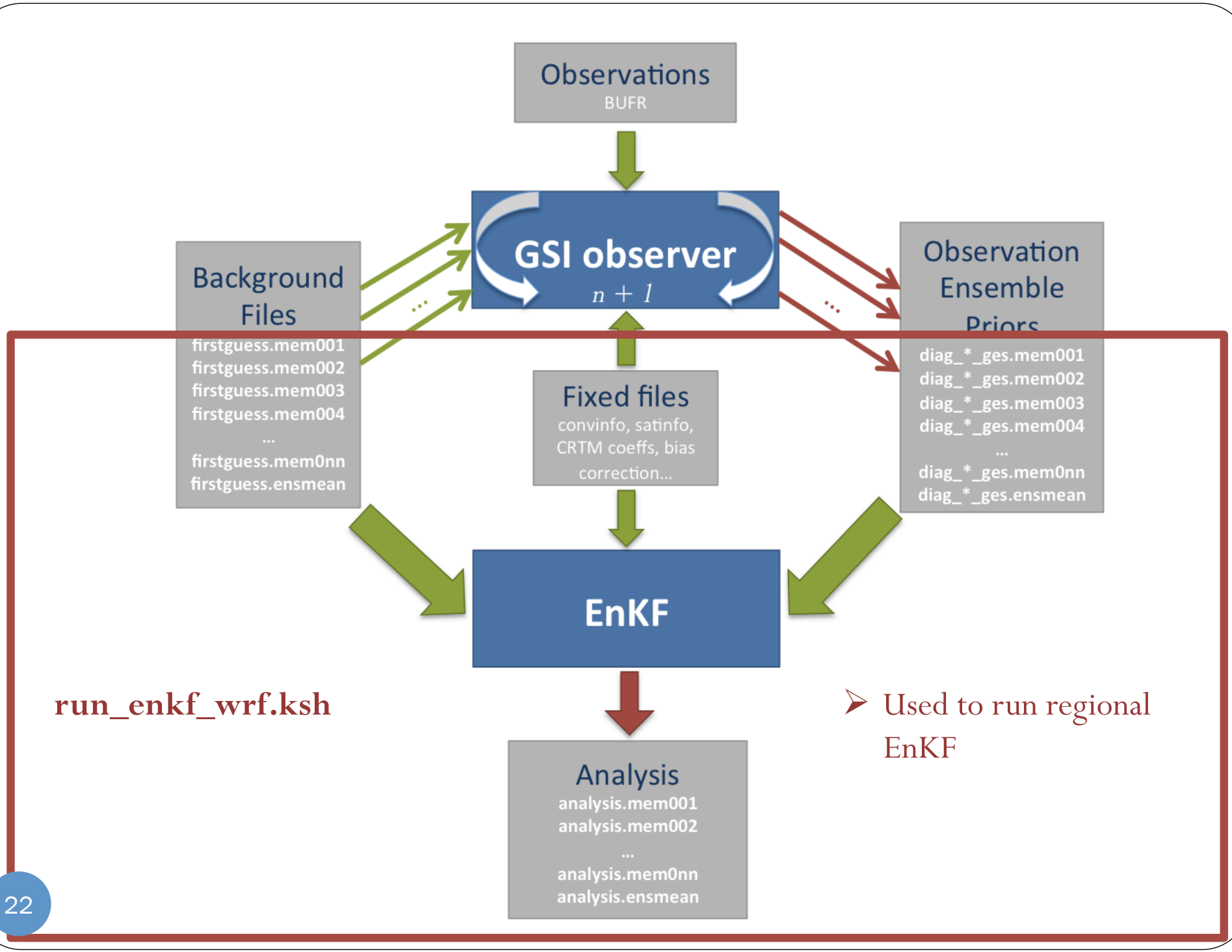
Run results: GSI observer

```
amsuabufr
amsubbufr
anavinfo
berror_stats
convinfo
diag_amsua_n15_ges.ensmean
diag_amsua_n15_ges.mem001
diag_amsua_n15_ges.mem002
diag_amsua_n15_ges.mem003
diag_amsua_n15_ges.mem004
diag_amsua_n15_ges.mem005
diag_conv_ges.ensmean
diag_conv_ges.mem001
diag_conv_ges.mem002
diag_conv_ges.mem003
diag_conv_ges.mem004
diag_conv_ges.mem005
diag_hirs4_n19_ges.ensmean
diag_hirs4_n19_ges.mem001
diag_hirs4_n19_ges.mem002
diag_hi
diag_hi
diag_mh
diag_mhs_n19_ges.mem001
diag_mhs_n19_ges.mem002
diag_mhs_n19_ges.mem003
diag_mhs_n19_ges.mem004
diag_mhs_n19_ges.mem005
errtable
fit_p1.2013091218
fit_q1.2013091218
fit_rad1.2013091218
fit_t1.2013091218
fit_w1.2013091218
fort.201
fort.202
fort.203
fort.204
fort.205
fort.206
fort.207
fort.208
fort.209
fort.210
fort.211
fort.212
fort.213
fort.214
fort.215
fort.221
gpsrobufr
gsi.exe
gsiparm.anl
hirs3bufr
hirs4bufr
l2rwbufr
list_run_directory
list_run_directory_mem001
list_run_directory_mem002
list_run_directory_mem003
list_run_directory_mem004
list_run_directory_mem005
mhsbufr
ozinfo
pcpbias_out
pcpinfo
prepbufr
prepobs_prep.bufrtable

satbias_in
satbias_out
satinfo
sigf03
stdout
stdout.anl.2013091218
stdout_mem001
stdout_mem002
stdout_mem003
stdout_mem004
stdout_mem005
wrfanl.2013091218
wrf_inout
wrf_inout_ensmean
```

Standard output from GSI observer run for a particular ensemble member

Set up EnKF run



run_enkf_wrf.ksh

- Used to run regional EnKF

EnKF run script

- Set experiment variables

- Closely matches GSI observer script … should setup based on options in GSI observer scripts

```
###################################################
# case set up (users should change this part)
###################################################
#
# ANAL_TIME= analysis time  (YYYYMMDDHH)
# WORK_ROOT= working directory, where GSI runs
# PREPBURF = path of PreBUFR conventional obs
# BK_FILE  = path and name of background file
# OBS_ROOT = path of observations files
# FIX_ROOT = path of fix files
# GSI_EXE  = path and name of the gsi executable

  ANAL_TIME=2013091218
  WORK_ROOT=/glade/scratch/${USER}/enkf/regional/enkf_arw
  diag_ROOT=/glade/scratch/${USER}/enkf/regional/gsidiag_arw
  BK_ROOT=/glade/p/work/${USER}/enkf/enkfdata/arw/bk
  BK_FILE=${BK_ROOT}/firstguess.ensmean
  GSI_ROOT=/glade/p/work/${UESR}/enkf/code/comGSIv3.6_EnKFv1.2
  FIX_ROOT=${GSI_ROOT}/fix
  ENKF_EXE=${GSI_ROOT}/src/enkf/wrf_enkf
  CRTM_ROOT=/glade/p/work/${USER}/gsi/CRTM_2.2.3
  ENKF_NAMELIST=${GSI_ROOT}/run/enkf_wrf_namelist.sh
```

GSI observer run directory

EnKF exe in GSI source code

Path to EnKF namelist

EnKF run script

Namelist tuning parameters discussed in 'EnKF Fundamentals (2): Diagnostics&Applications'

- Several values set in the run script populate the EnKF namelist (**enfk.nml**)

```
# ANAL_TIME= analysis time  (YYYYMMDDHH)
```

&nam_enkf
datestring: analysis time
datapath: path to data directory (./)

```
# ensemble parameters
#
  NMEM_ENKF=20
  BK_FILE_mem=${BK_ROOT}/wrfarw
  NLONS=111
  NLATS=111
  NLEVS=56
  IF_ARW=.true.
  IF_NMM=.false.
```

&nam_enkf
regional: true, perform regional analysis using either ARW or NMM
nlons: grid pts in longitude of model bk
nlats: grid pts in latitude of model bk
nlevs: vertical levels of model bk
nanls: number of ensemble members

&nam_wrf
arw: true, use WRF ARW

```
  list="conv amsua_n18 hirs4_n19"
#  list="conv amsua_n18 mhs_n19 hirs4_n19"
#
```

List of observation types that EnKF will use in analysis (based files generated from GSI observer)

EnKF run script

- Users can run simple EnKF cases without changing remainder of script.

```
# Given the analysis date, compute the date from which the
# first guess comes.  Extract cycle and set prefix and suffix
# for guess and observation data files
# gdate=`$ndate -06 $adate`
gdate=$ANAL_TIME
YYYYMMDD=`echo $adate | cut -c1-8`
HH=`echo $adate | cut -c9-10`

# Fixed files
# CONVINFO=${FIX_ROOT}/global_convinfo.txt
# SATINFO=${FIX_ROOT}/global_satinfo.txt
# SCANINFO=${FIX_ROOT}/global_scaninfo.txt
# OZINFO=${FIX_ROOT}/global_ozinfo.txt
CONVINFO=${diag_ROOT}/convinfo
SATINFO=${diag_ROOT}/satinfo
SCANINFO=${diag_ROOT}/scaninfo
OZINFO=${diag_ROOT}/ozinfo
# LOCINFO=${FIX_ROOT}/global_hybens_info.l64.txt

# Set up workdir
rm -rf $WORK_ROOT
mkdir -p $WORK_ROOT
cd $WORK_ROOT
```

Analysis time from which the first guess comes

Location of fixed files

Copied from observer directory

Can also set through namelist

Creates working directory for EnKF to run

Workdir cleaned before each run, save files from previous run!

EnKF run script

```
# Build the GSI namelist on-the-fly
. $ENKF_NAMELIST
cat << EOF > enkf.nml

 $enkf_namelist
EOF
```

Script: `enkf_wrf_namelist.sh` provided in run directory generates EnKF namelist in the working directory

```
# make analysis files
cp firstguess.ensmean analysis.ensmean
# get each member
imem=1
while [[ $imem -le $NMEM_ENKF ]]; do
   member="mem"`printf %03i $imem`
   cp firstguess.${member} analysis.${member}
   (( imem = $imem + 1 ))
done
```

Copy ensemble bk files to working directory and rename as analysis

```
###################################################
#  run  EnKF
###################################################
echo ' Run EnKF'

${RUN_COMMAND} ./enkf.x < enkf.nml > stdout 2>&1
```

Run EnKF – update analysis files

```
###################################################################
#  run time error check
###################################################################
error=$?
if [ ${error} -ne 0 ]; then
  echo "ERROR: ${ENKF_EXE} crashed  Exit status=${error}"
  exit ${error}
fi
```

Run results: EnKF

```
analysis.ensmean
analysis.mem001
analysis.mem002
analysis.mem003
analysis.mem004
analysis.mem005
convinfo
covinflate.dat
diag_amsua_n18_ges.ensmean
diag_amsua_n18_ges.mem001
diag_amsua_n18_ges.mem002
diag_amsua_n18_ges.mem003
diag_amsua_n18_ges.mem004
diag_amsua_n18_ges.mem005
diag_conv_ges.ensmean
diag_conv_ges.mem001
diag_conv_ges.mem002
diag_conv_ges.mem003
diag_conv_ges.mem004
diag_conv_ges.mem005
diag_gome_metop-a_ges.ensmean
diag_gome_metop-b_ges.ensmean
diag_hirs4_n19_ges.ensmean
diag_hirs4_n19_ges.mem001
diag_hirs4_n19_ges.mem002
diag_hirs4_n19_ges.mem003
diag_hirs4_n19_ges.mem004
diag_hirs4_n19_ges.mem005
diag_omi_aura_ges.ensmean
diag_sbuv2_n16_ges.ensmean
diag_sbuv2_n17_ges.ensmean
diag_sbuv2_n18_ges.ensmean
diag_sbuv2_n19_ges.ensmean
enkf.log
enkf.nml
enkf.x
firstguess.ensmean
firstguess.mem001
firstguess.mem002
firstguess.mem003
firstguess.mem004
firstguess.mem005
Ozinfo
satbias_in
satinfo
stdout
```

Binary diag files for conventional and GPSRO observations. Contains observations and their priors.

Run results: EnKF

```
analysis.ensmean
analysis.mem001
analysis.mem002
analysis.mem003
analysis.mem004
analysis.mem005
convinfo
covinflate.dat
diag_amsua_n18_ges.ensmean
diag_amsua_n18_ges.mem001
diag_amsua_n18_ges.mem002
diag_amsua_n18_ges.mem003
diag_amsua_n18_ges.mem004
diag_amsua_n18_ges.mem005
diag_conv_ges.ensmean
diag_conv_ges.mem001
diag_conv_ges.mem002
diag_conv_ges.mem003
diag_conv_ges.mem004
diag_conv_ges.mem005
diag_gome_metop-a_ges.ensmean
diag_gome_metop-b_ges.ensmean
diag_hirs4_n19_ges.ensmean
diag_hirs4_n19_ges.mem001
diag_hirs4_n19_ges.mem002
diag_hirs4_n19_ges.mem003
diag_hirs4_n19_ges.mem004
diag_hirs4_n19_ges.mem005
diag_omi_aura_ges.ensmean
diag_sbuv2_n16_ges.ensmean
diag_sbuv2_n17_ges.ensmean
diag_sbuv2_n18_ges.ensmean
diag_sbuv2_n19_ges.ensmean
enkf.log
enkf.nml
enkf.x
firstguess.ensmean
firstguess.mem001
firstguess.mem002
firstguess.mem003
firstguess.mem004
firstguess.mem005
Ozinfo
satbias_in
satinfo
stdout
```

Binary diag files for satellite radiance observations. Contains observations and their priors

Run results: EnKF

```
analysis.ensmean
analysis.mem001
analysis.mem002
analysis.mem003
analysis.mem004
analysis.mem005
convinfo
covinflate.dat
diag_amsua_n18_ges.ensmean
diag_amsua_n18_ges.mem001
diag_amsua_n18_ges.mem002
diag_amsua_n18_ges.mem003
diag_amsua_n18_ges.mem004
diag_amsua_n18_ges.mem005
diag_conv_ges.ensmean
diag_conv_ges.mem001
diag_conv_ges.mem002
diag_conv_ges.mem003
diag_conv_ges.mem004
diag_conv_ges.mem005
diag_gome_metop-a_ges.ensmean
diag_gome_metop-b_ges.ensmean
diag_hirs4_n19_ges.ensmean
diag_hirs4_n19_ges.mem001
diag_hirs4_n19_ges.mem002
diag_hirs4_n19_ges.mem003
diag_hirs4_n19_ges.mem004
diag_hirs4_n19_ges.mem005
```

Ensemble analysis (same format as bk)

```
diag_omi_aura_ges.ensmean
diag_sbuv2_n16_ges.ensmean
diag_sbuv2_n17_ges.ensmean
diag_sbuv2_n18_ges.ensmean
diag_sbuv2_n19_ges.ensmean
enkf.log
enkf.nml
enkf.x
firstguess.ensmean
firstguess.mem001
firstguess.mem002
firstguess.mem003
firstguess.mem004
firstguess.mem005
Ozinfo
satbias_in
satinfo
stdout
```

Run results: EnKF

```
analysis.ensmean
analysis.mem001
analysis.mem002
analysis.mem003
analysis.mem004
analysis.mem005
convinfo
covinflate.dat
diag_amsua_n18_ges.ensmean
diag_amsua_n18_ges.mem001
diag_amsua_n18_ges.mem002
diag_amsua_n18_ges.mem003
diag_amsua_n18_ges.mem004
diag_amsua_n18_ges.mem005
diag_conv_ges.ensmean
diag_conv_ges.mem001
diag_conv_ges.mem002
diag_conv_ges.mem003
diag_conv_ges.mem004
diag_conv_ges.mem005
diag_gome_metop-a_ges.ensmean
diag_gome_metop-b_ges.ensmean
diag_hirs4_n19_ges.ensmean
diag_hirs4_n19_ges.mem001
diag_hirs4_n19_ges.mem002
diag_hirs4_n19_ges.mem003
diag_hirs4_n19_ges.mem004
diag_hirs4_n19_ges.mem005
diag_omi_aura_ges.ensmean
diag_sbuv2_n16_ges.ensmean
diag_sbuv2_n17_ges.ensmean
diag_sbuv2_n18_ges.ensmean
diag_sbuv2_n19_ges.ensmean
enkf.log
enkf.nml
enkf.x
firstguess.ensmean
firstguess.mem001
firstguess.mem002
firstguess.mem003
firstguess.mem004
firstguess.mem005
Ozinfo
satbias_in
satinfo
stdout
```

Background ensemble members (mean)

Run results: EnKF

```
analysis.ensmean
analysis.mem001
analysis.mem002
analysis.mem003
analysis.mem004
analysis.mem005
convinfo
covinflate.dat
diag_amsua_n18_ges.ensmean
diag_amsua_n18_ges.mem001
diag_amsua_n18_ges.mem002
diag_amsua_n18_ges.mem003
diag_amsua_n18_ges.mem004
diag_amsua_n18_ges.mem005
diag_conv_ges.ensmean
diag_conv_ges.mem001
diag_conv_ges.mem002
diag_conv_ges.mem003
diag_conv_ges.mem004
diag_conv_ges.mem005
diag_gome_metop-a_ges.ensmean
diag_gome_metop-b_ges.ensmean
diag_hirs4_n19_ges.ensmean
diag_hirs4_n19_ges.mem001
diag_hirs4_n19_ges.mem002
diag_hirs4_n19_ges.mem003
diag_hirs4_n19_ges.mem004
diag_hirs4_n19_ges.mem005
```

3d multiplicative inflation factor fields

```
diag_omi_aura_ges.ensmean
diag_sbuv2_n16_ges.ensmean
diag_sbuv2_n17_ges.ensmean
diag_sbuv2_n18_ges.ensmean
diag_sbuv2_n19_ges.ensmean
enkf.log
enkf.nml
enkf.x
firstguess.ensmean
firstguess.mem001
firstguess.mem002
firstguess.mem003
firstguess.mem004
firstguess.mem005
Ozinfo
satbias_in
satinfo
stdout
```

EnKF namelist

EnKF executable

Run results: EnKF

```
analysis.ensmean
analysis.mem001
analysis.mem002
analysis.mem003
analysis.mem004
analysis.mem005
convinfo
covinflate.dat
diag_amsua_n18_ges.ensmean
diag_amsua_n18_ges.mem001
diag_amsua_n18_ges.mem002
diag_amsua_n18_ges.mem003
diag_amsua_n18_ges.mem004
diag_amsua_n18_ges.mem005
diag_conv_ges.ensmean
diag_conv_ges.mem001
diag_conv_ges.mem002
diag_conv_ges.mem003
diag_conv_ges.mem004
diag_conv_ges.mem005
diag_gome_metop-a_ges.ensmean
diag_gome_metop-b_ges.ensmean
diag_hirs4_n19_ges.ensmean
diag_hirs4_n19_ges.mem001
diag_hirs4_n19_ges.mem002
diag_hirs4_n19_ges.mem003
diag_hirs4_n19_ges.mem004
diag_hirs4_n19_ges.mem005
diag_omi_aura_ges.ensmean
diag_sbuv2_n16_ges.ensmean
diag_sbuv2_n17_ges.ensmean
diag_sbuv2_n18_ges.ensmean
diag_sbuv2_n19_ges.ensmean
enkf.log
enkf.nml
enkf.x
firstguess.ensmean
firstguess.mem001
firstguess.mem002
firstguess.mem003
firstguess.mem004
firstguess.mem005
Ozinfo
satbias_in
satinfo
stdout
```

Text file with standard output

Run results: EnKF

```
analysis.ensmean
analysis.mem001
analysis.mem002
analysis.mem003
analysis.mem004
analysis.mem005
convinfo
covinflate.dat
diag_amsua_n18_ges.ensmean
diag_amsua_n18_ges.mem001
diag_amsua_n18_ges.mem002
diag_amsua_n18_ges.mem003
diag_amsua_n18_ges.mem004
diag_amsua_n18_ges.mem005
diag_conv_ges.ensmean
diag_conv_ges.mem001
diag_conv_ges.mem002
diag_conv_ges.mem003
diag_conv_ges.mem004
diag_conv_ges.mem005
diag_gome_metop-a_ges.ensmean
diag_gome_metop-b_ges.ensmean
diag_hirs4_n19_ges.mem004
diag_hirs4_n19_ges.mem005
diag_omi_aura_ges.ensmean
diag_sbuv2_n16_ges.ensmean
diag_sbuv2_n17_ges.ensmean
diag_sbuv2_n18_ges.ensmean
diag_sbuv2_n19_ges.ensmean
enkf.log
enkf.nml
enkf.x
firstguess.ensmean
firstguess.mem001
firstguess.mem002
firstguess.mem003
firstguess.mem004
firstguess.mem005
Ozinfo
satbias_in
satinfo
stdout
```

Text file with standard output

Details on the EnKF diagnostics, interpretation and tuning options discussed in next talk!

Global GSI Observer & EnKF

Similar procedure to regional case (only cover notable differences)

Two sample run scripts are provided in the release:

- GSI observer (*run_gsi_global.ksh*)
- EnKF (*run_enkf_global.ksh*)

Global GSI observer run script

- Set experiment variables

```
ANAL_TIME=2014040512
GUESS_TIME=2014040506
GFSCASE=enkf_glb_t254
WORK_ROOT=./comGSIv3.6_EnKFv1.2/run/gsidiag_${GFS_CASE}
BK_ROOT=./casedata/enkf_glb_t254/bk
OBS_ROOT=./casedata/enkf_glb_t254/obs
PREPBUFR=${OBS_ROOT}/gdas1.t12z.prepbufr.nr
CRTM_ROOT=./CRTM_2.2.3
GSI_ROOT=./comGSIv3.6_EnKFv1.2/
FIX_ROOT=${GSI_ROOT}/fix
GSI_EXE=${GSI_ROOT}/run/gsi.exe
GSI_NAMELIST=${GSI_ROOT}/run/comgsi_namelist_gfs.sh
```

Case information

Choose valid GFS case

Location of GSI system

Separate GSI namelist for global applications

```
##############################################
if_observer=Yes
no_member=10
BK_FILE_mem=${BK_ROOT}/sfg_${GUESS_DATE}
```

background set to GFS ensemble mean

Global EnKF run script

- Set experiment variables

```
ANAL_TIME=2014040512
GUESS_TIME=2014040506
GFSCASE=enkf_glb_t254
WORK_ROOT=comGSIv3.6_EnKFv1.2/run/${GFSCASE}
DIAG_ROOT=comGSIv3.6_EnKFv1.2/run/${GFSCASE}-observer
BK_ROOT=data/global_case/enkf_glb_t254/bk
GSI_ROOT=comGSIv3.6_EnKFv1.2
OBS_ROOT=data/global_case/enkf_glb_t254/obs
FIX_ROOT=${GSI_ROOT}/fix
ENKF_EXE=${GSI_ROOT}/src/enkf/global_enkf
CRTM_ROOT=CRTM_2.2.3
ENKF_NAMELIST=${GSI_ROOT}/run/enkf_gfs_namelist.sh

. . .    . . .
```

Case information

Choose valid GFS case

Location of Global EnKF

Separate GSI namelist for global applications

Run EnKF results:

diag_conv_ges.ensmean	diag_conv_ges.mem001
diag_conv_ges.mem002	diag_conv_ges.mem003
diag_conv_ges.mem004	diag_conv_ges.mem005
sfg_2014040506_fhr06_ensmean	sfg_2014040506_fhr06_mem002
sfg_2014040506_fhr06_mem001	sfg_2014040506_fhr06_mem004
sfg_2014040506_fhr06_mem003	enkf.nml
sfg_2014040506_fhr06_mem005	convinfo
satbias_in	ozinfo
satinfo	stdout
covinflate.dat	
sanl_2014040506_mem001	sanl_2014040506_mem002
sanl_2014040506_mem003	sanl_2014040506_mem004
sanl_2014040506_mem005	

Diag* files from global observer

First guess files

Analysis files

Questions?

enkf-help@ucar.edu