

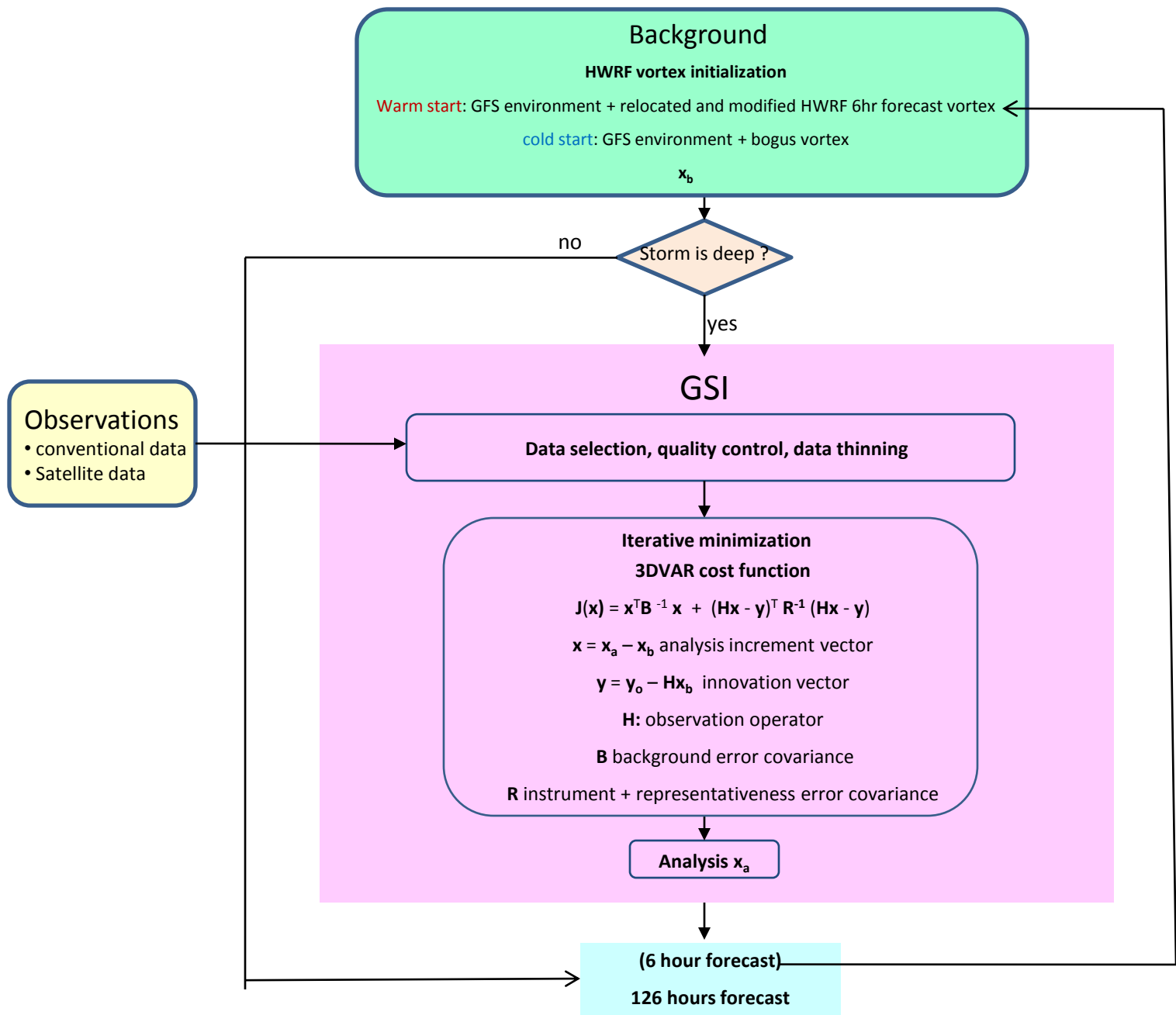
HWRF Initialization -GSI customization

Mingjing Tong
NOAA/NCEP/EMC

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Outline

- HWRF domains
- Background fields
- Analysis variables
- Background error statistics
- Observations
- GSI namelist
- GSI fix files
- GSI standard output
- Observation fitting statistics



HWRF domains

D01 (OUTER): 216x432 with resolution 0.18 deg.
Covers about 80x80 deg

4x: 420x820 with resolution of 0.06 deg. Covers
about 40x40 deg

Ghost: 210x409 with resolution of 0.06 deg.
Covers about 20x20 deg

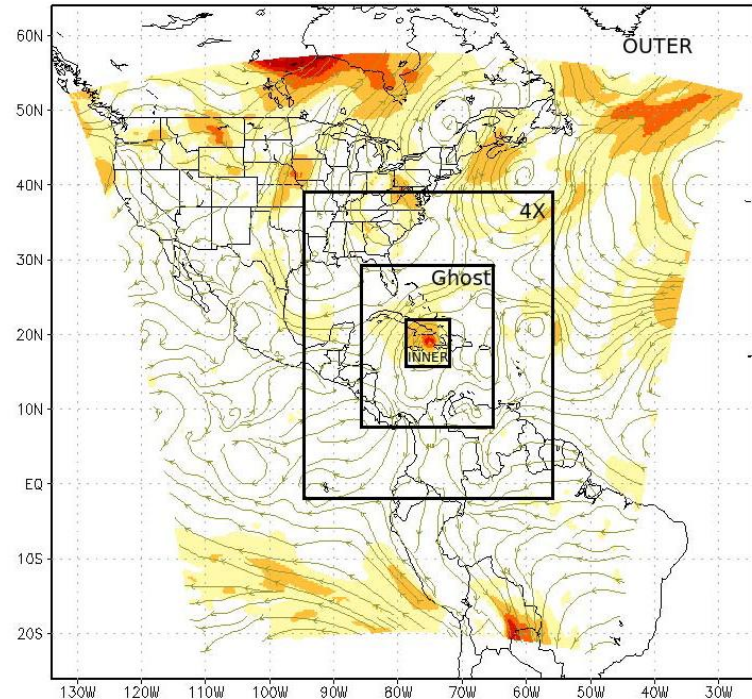
D02 (INNER): 61x100 with resolution of 0.06 deg.
Covers about 6x6 degree

Model forecast domains: D01 and D02

HWRF vortex initialization domain: 4x

GSI analysis domain: D01 and Ghost

* After GSI analysis, model fields in Ghost are interpolated to D02 and D01. For D01, a blending zone is added around the boundary of ghost domain, so that the model fields are gradually merged from ghost domain to D01.



Four HWRF domains (Fig 4.1 of HWRF USERS' GUIDE)

Background fields

- Define new domain center based on observed storm center
- Create new HWRF domains
- Interpolate GFS analysis to 4x domain and apply GFDL filter to remove hurricane vortex from GFS analysis
- Interpolate HWRF 6 hr forecast from D01 and D02 to 4x domain and apply GFDL filter to get hurricane vortex
- Vortex initialization – relocation, size correction, intensity correction and balance adjustment
- Background = Environment flow from GFS analysis + modified hurricane vortex
- Interpolate background fields from 4x domain to D01 and Ghost domain

Analysis variables

- GSI analysis variables
 - Analysis variables used for HWRF include streamfunction (ψ), unbalanced velocity potential (χ), unbalanced temperature (T), unbalanced surface pressure (P_s), normalized relative humidity, satellite bias correction coefficients
 - Balanced part of velocity potential, temperature and surface pressure (χ_b , T_b and P_{sb}) are calculated from ψ using pre-specified statistical balance relationship specified in the background error statistics file.
 - Currently ozone and cloud variables are not analyzed for HWRF
- Model variables currently updated
 - u , v , pd , $pint$, t , q

Background error statistics

- Isotropic background error covariance is used for HWRF
- Background error statistics are estimated in grid space with the NMC method.
- Error statistics (variance and correlation length scales) are latitude and height dependent
- Three sets of horizontal scales are used to achieve a 'fat-tailed' B spectrum through a linear combination of three recursive filters. A single recursive filter is used in the vertical direction.
- More information can be found in Wu et. al 2002 and GSI 2010 Tutorial - Background and Observation Error Estimation and Tuning by Wan-Shu Wu.

Wu, W.-S., D. F. Parrish, and R. J. Purser, 2002: Three-dimensional variational analysis with spatially inhomogeneous covariances. *Mon. Wea. Rev.*, 130, 2905–2916.

Observations – control data usage

1. Presence or lack of input data

cp \$datobs/\${prefixa}.prepbuf `./prepbuf` → conventional data

cp \$datobs/\${prefixa}.goesfv.\${suffix} `./gsnd1buf`
cp \$datobs/\${prefixa}.1bamua.\${suffix} `./amsuabuf`
cp \$datobs/\${prefixa}.1bamub.\${suffix} `./amsubbuf`
cp \$datobs/\${prefixa}.1bhrs3.\${suffix} `./hirs3buf`
cp \$datobs/\${prefixa}.1bhrs4.\${suffix} `./hirs4buf`
cp \$datobs/\${prefixa}.1bmhs.\${suffix} `./mhsbuf`
cp \$datobs/\${prefixa}.airsev.\${suffix} `./airsbuf`

→ satellite data

Observations – control data usage

2. GSI namelist

&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(04)='prepbufr', dtype(04)='uv', dplat(04)=' ', dsis(04)='uv', dval(04)=1.0, dthin(04)=0,  
dfile(05)='prepbufr', dtype(05)='spd', dplat(05)=' ', dsis(05)='spd', dval(05)=1.0, dthin(05)=0,
```

```
.....  
dfile(19)='hirs3bufr', dtype(19)='hirs3', dplat(19)='n17', dsis(19)='hirs3_n17', dval(19)=6.0, dthin(19)=1,  
dfile(20)='hirs4bufr', dtype(20)='hirs4', dplat(20)='n18', dsis(20)='hirs4_n18', dval(20)=0.0, dthin(20)=1,  
dfile(21)='hirs4bufr', dtype(21)='hirs4', dplat(21)='metop-a', dsis(21)='hirs4_metop-a', dval(21)=6.0, dthin(21)=1,
```

```
.....  
dfile(26)='airsbufr', dtype(26)='airs', dplat(26)='aqua', dsis(26)='airs281SUBSET_aqua', dval(26)=20.0, dthin(26)=1,  
dfile(27)='msubufr', dtype(27)='msu', dplat(27)='n14', dsis(27)='msu_n14', dval(27)=2.0, dthin(27)=2,  
dfile(28)='amsuabufr', dtype(28)='amsua', dplat(28)='n15', dsis(28)='amsua_n15', dval(28)=10.0, dthin(28)=2,
```

```
.....  
dfile(31)='amsuabufr', dtype(31)='amsua', dplat(31)='n18', dsis(31)='amsua_n18', dval(31)=10.0, dthin(31)=2,  
dfile(32)='amsuabufr', dtype(32)='amsua', dplat(32)='metop-a', dsis(32)='amsua_metop-a', dval(32)=10.0, dthin(32)=2,  
dfile(33)='airsbufr', dtype(33)='amsua', dplat(33)='aqua', dsis(33)='amsua_aqua', dval(33)=5.0, dthin(33)=2,  
dfile(34)='amsuabufr', dtype(34)='amsu', dplat(34)='n15', dsis(34)='amsu_n15', dval(34)=3.0, dthin(34)=3,
```

```
.....  
dfile(37)='mhsbufr', dtype(37)='mhs', dplat(37)='n18', dsis(37)='mhs_n18', dval(37)=3.0, dthin(37)=3,  
dfile(38)='mhsbufr', dtype(38)='mhs', dplat(38)='metop-a', dsis(38)='mhs_metop-a', dval(38)=3.0, dthin(38)=3,
```

Observations – control data usage

3. GSI info/fix files

- **convinfo** (for conventional data)

!otype	type	sub	iuse	twindow	numgrp	ngroup	nmiter	gross	ermax	ermin	var_b	var_pg	ithin	rmesh	pmesh	npred
ps	111	0	-1	1.5	0	0	0	5.0	3.0	1.0	10.0	0.000	0	0.	0.	0
ps	120	0	1	1.5	0	0	0	5.0	3.0	1.0	10.0	0.000	0	0.	0.	0
ps	132	0	-1	1.5	0	0	0	5.0	3.0	1.0	10.0	0.000	0	0.	0.	0

- **satinfo** (for satellite data)

sensor/instr/sat	chan	iuse	error	ermax	var_b	var_pg
amsua_n15	1	1	3.000	4.500	10.00	0.000
amsua_n15	2	1	2.000	4.500	10.00	0.000
amsua_n15	3	1	2.000	4.500	10.00	0.000
amsua_n15	4	1	0.600	2.500	10.00	0.000
amsua_n15	5	1	0.300	2.000	10.00	0.000
amsua_n15	6	1	0.230	2.000	10.00	0.000

Conventional Data

- Data currently assimilated (depends on analysis domain)
 - Radiosonde
 - Aircraft reports (AIREP/PIREP, RECCO , MDCRS-ACARS, TAMDAR , AMDAR)
 - Surface ship and buoy observation
 - Surface land observations
 - Pibal winds
 - Wind profilers
 - VAD wind
 - Dropsondes
 - JMA IR/visible winds
 - EUMETSAT IR/visible winds
 - GOES IR winds
 - GOES water vapor cloud top winds
 - MODIS IR and imager water vapor winds
- Conventional data (prebufr) within 150 km of the storm center are removed

Satellite Data

- Data currently assimilated (depends on analysis domain)
 - AMSU-A
 - NOAA 15 Channel 1-10, 12, 13, 15
 - NOAA 18 Channel 1-8, 10-13, 15
 - METOP-a Channel 1-6, 8-13, 15
 - AMSU-B/MHS
 - NOAA 15 Channel 1-3, 5
 - NOAA 18 Channel 1-5
 - METOP-a Channel 1-5
 - HIRS
 - NOAA 17 Channel 2-15
 - METOP-a Channel 2-15
 - AIRS
 - AQUA 148 Channels
 - GOES – 11, 12 sounders
 - sndrd1, sndrd2, sndrd3 and sndrd4 Channel 1-15

* Only clear sky radiance data are assimilated

GSI fix files

- background error covariance

```
cp $fixgsi/nam_nmmstat_na      ./berror_stats
```

- observation error table

```
cp $fixgsi/nam_errtable.r3dv   ./errtable
```

- Radiance coefficient used by CRTM

```
cp $fixcrtm/EmisCoeff.bin      ./EmisCoeff.bin
```

```
cp $fixcrtm/AerosolCoeff.bin   ./AerosolCoeff.bin
```

```
cp $fixcrtm/CloudCoeff.bin     ./CloudCoeff.bin
```

GSI fix files

- Observation data control file

```
cp $fixgsi/nam_regional_convinfo.txt ./convinfo
cp $fixgsi/nam_regional_satinfo.txt ./satinfo
cp $fixgsi/nam_global_pcpinfo.txt ./pcpinfo
cp $fixgsi/nam_global_ozinfo.txt ./ozinfo
```

* pcpinfo and ozinfo are not used, because ozone data and precipitation rate observations are not assimilated into HWRF

- Satellite bias correction coefficients

```
cp $fixgsi/nam_global_satangbias.txt ./satbias_angle
cp $datobs/gfs.t${CYCLE}z.abias ./satbias_in
```

* If the satellite bias correction coefficients output file (*.biascr) is not found from previous cycle, which means either previous cycle is a cold start or GSI analysis is not performed (for shallow or medium storm), the bias correction coefficients from GFS analysis are used as the first guess for HWRF analysis.

GSI namelist

&SETUP

miter=2,niter(1)=50,niter(2)=50,

* two outer loop with 50 iterations each

write_diag(1)=.true.,write_diag(2)=.false.,write_diag(3)=.true.,

* output innovation diagnostic information

gencode=78,qoption=2,

* use normalized relative humidity as analysis variable

ndat=59,

* number of data listed in &OBS_INPUT

oneobtest=.false.,retrieval=.false.,

nhr_assimilation=3,l_foto=.false.,

use_pbl=.false.,

GSI namelist

&GRIDOPTS

JCAP=\$JCAP,JCAP_B=\$JCAP_B,NLAT=\$NLAT,NLON=\$LONA,nsig=\$LEVS,

* analysis domain dimensions. It's okay if wrong values are given to NLAT, NLON and nsig. For HWRF, domain dimensions are read in from input background data

hybrid=.true.,wrf_nmm_regional=.true.,wrf_mass_regional=.false.,

* if run GSI for HWRF, need to be set to 'true'

&BKGERR

as=1.0,1.0,0.5,0.7,0.7,0.5,1.0,1.0,

vs=1.0

hzscl=0.373,0.746,1.50,

* background error variance and correlation length scale parameter

bw=0.,fstat=.true.,

&ANBKGERR

anisotropic=.false.,

* anisotropic background error covariance are not mature yet

GSI namelist

&JCOPTS

&STRONGOPTS

jcstrong=.false.,

* weak constraint and strong constraint has not been applied to HWRF yet.

&OBSQC

dfact=0.75,dfact1=3.0,noiqc=.false.

* Variational quality control is not used

&OBS_INPUT

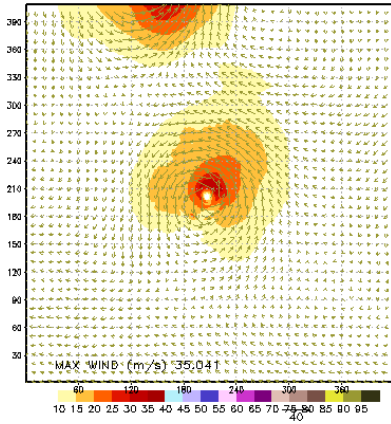
dmesh(1)=120.0,dmesh(2)=60.0,dmesh(3)=60.0,dmesh(4)=60.0,dmesh(5)
=120,time_window_max=1.5,

* dmesh – data thinning mesh size (km)

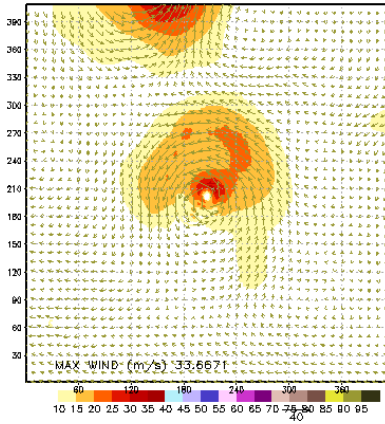
Impact of GSI analysis

Ghost domain

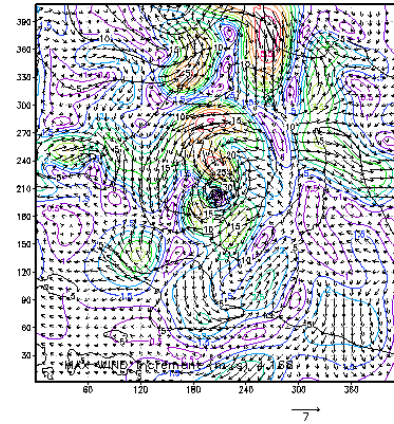
lev=11 hor wind vector and isotach (m/s)



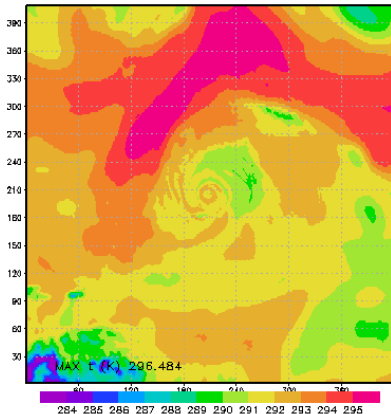
lev=11 hor wind vector and isotach (m/s)



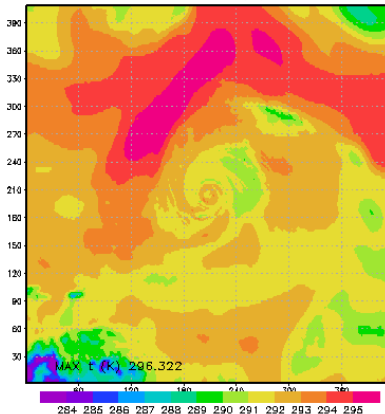
lev=11 wspd inc OPER



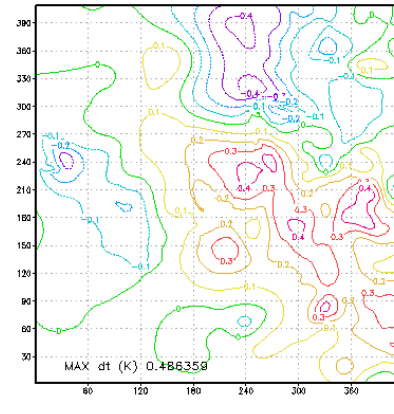
lev=11 t (K)



lev=11 t (K)



lev=11 T inc (K)OPER



guess

analysis

analysis- guess

* In current operational HWRF, GSI analysis has consistent positive impact only on track forecast, and the impact on intensity forecast is mixed. (Qingfu Liu 2010 HWRF tutorial)

Standard Output

Details in User’s Guide Section 4.1
Highlight several important points

Check Background Input

ZNW, RDX, RDY, MAPFAC_M, XLAT, XLONG, MUB, MU, PHB

```
0:  rmse_var=T
0:  ordering=XYZ
0:  WrfType,WRF_REAL= 104 104
0:  ndim1= 3
0:  staggering= N/A
0:  start_index= 1 1 1 -7269735
0:  end_index= 69 64 45 -7269735
0:  k,max,min,mid T= 1 309.9411316 264.5114136 289.7205811
0:  k,max,min,mid T= 2 310.6200562 269.5698547 295.0413208
0:  k,max,min,mid T= 3 311.5386047 272.4312744 296.7247009
0:  k,max,min,mid T= 43 486.2092896 436.1306763 461.4866943
0:  k,max,min,mid T= 44 498.1362000 456.4700012 478.7089233
0:  k,max,min,mid T= 45 510.0127563 472.5627441 494.7407227
```

Variable name in netcdf file

K	Maximum	Minimum	Central grid
1	309.9411316	264.5114136	289.7205811
2	310.6200562	269.5698547	295.0413208
3	311.5386047	272.4312744	296.7247009
43	486.2092896	436.1306763	461.4866943
44	498.1362000	456.4700012	478.7089233
45	510.0127563	472.5627441	494.7407227

QVAPOR, U, V, LANDMASK, XICE, SST,IVGTYP, ISLTYP, VEGFRA, SNOW, U10, V10, SMOIS, TSLB, TSK

Check Fix Files Input

convinfo

0:READ_CONVINFO:	ps	120	0	1	3.0	0	0	0	4.0	3.0	1.0	4.0
0:READ_CONVINFO:	ps	132	0	-1	3.0	0	0	0	4.0	3.0	1.0	4.0
0:READ_CONVINFO:	t	120	0	1	3.0	0	0	0	8.0	5.6	1.3	8.0
0:READ_CONVINFO:	t	180	0	1	3.0	0	0	0	7.0	5.6	1.3	7.0
0:READ_CONVINFO:	uv	220	0	1	3.0	0	0	0	8.0	6.0	1.4	8.0
0:READ_CONVINFO:	uv	280	0	1	3.0	0	0	0	6.0	6.1	1.4	6.0
0:READ_CONVINFO:	spd	283	0	1	3.0	0	0	0	8.0	6.1	1.4	8.0

CRTM coefficients

0: **Read_SpcCoeff_Binary**(INFORMATION) : FILE: ./hirs3_n16.SpcCoeff.bin;
0: SpcCoeff RELEASE.VERSION: 7.01 N_CHANNELS=19

0: **Read_TauCoeff_Binary**(INFORMATION) : FILE: ./hirs3_n16.TauCoeff.bin;
0: TauCoeff RELEASE.VERSION: 5.04 N_ORDERS=10 N_PREDICTORS= 6 N_ABSORBERS= 3
N_CHANNELS= 19 N_SENSORS= 1

0: Read_CloudCoeff_Binary(INFORMATION) : FILE: ./CloudCoeff.bin;
0: CloudCoeff RELEASE.VERSION: 2.02 N_FREQUENCIES(MW)= 31 N_FREQUENCIES(IR)= 701
N_RADII(MW)= 6 N_RADII(IR)= 6 N_TEMPERATURES= 5 N_DENSITIES= 3
N_LEGENDRE_TERMS=38 N_PHASE_ELEMENTS= 6

Check Observations Input

```
0: READ_OBS: read 1 ps ps using ntasks= 1 0 2 1
0: READ_OBS: read 2 t t using ntasks= 1 0 3 1
0: READ_OBS: read 3 q q using ntasks= 1 0 0 1
0: READ_OBS: read 4 uv uv using ntasks= 1 0 1 1
0: READ_OBS: read 5 spd spd using ntasks= 1 0 2 1
0: READ_OBS: read 7 dw dw using ntasks= 1 0 3 1
0: READ_OBS: read 8 sst sst using ntasks= 1 0 0 1
```

```
READ_PREPBUFR: messages/reports = 681 / 71658 nthread = 1
READ_PREPBUFR: file=prepbuftr type=t sis=t nread= 11452 ithin= 0 rmesh=120.000
isfcalc= 0 ndata= 11280 ntask= 1
READ_PREPBUFR: messages/reports = 681 / 71658 nthread = 1
READ_PREPBUFR: file=prepbuftr type=q sis=q nread= 11379 ithin= 0 rmesh=120.000
isfcalc= 0 ndata= 10186 ntask= 1
```

Observation distribution in an analysis using 4 processors

3:OBS_PARA: ps		291	508	1140	1561
3:OBS_PARA: t		484	887	1730	2729
3:OBS_PARA: q		464	868	1642	2568
3:OBS_PARA: uv		1146	2067	2766	5162
3:OBS_PARA: sst		0	0	47	0
3:OBS_PARA: pw		13	18	44	17
3:OBS_PARA: hirs3	n16	21	21	0	0
3:OBS_PARA: amsua	n15	179	189	149	224

Check outer loop and inner iteration

1st outer loop **Inner iteration**

```
0: grepcost J, Jb, Jo, Jc, Jl = 1 0 1.6048921E+04 0.0E+0 1.60489216E+04 0.0E+0 0.0E+0
0: grepgrad grad, reduction= 1 0 4.622906854790679176E+02 1.000000000000000000E+00
0: pcgsoi: cost, grad, step = 1 0 1.60489216E+04 4.6229068547E+02 1.4816403979E-02
0: pcgsoi: gnorm(1:2), b= 1.24089076555E+05 1.240890765553E+05 5.8063507409044E-01
0: stprat 0.518838814777991403E-01
0: stprat 0.246311812999037177E-15
0: Minimization iteration 1
0: grepcost J, Jb, Jo, Jc, Jl = 1 1 1.288246E+04 4.6915E+01 1.283555E+04 0.0E+0 0.0E+0
0: grepgrad grad, reduction= 1 1 3.522627947361617657E+02 7.619941430814570760E-01
0: pcgsoi: cost, grad, step = 1 1 1.288246824862E+04 3.522627947E+02 1.408558895E-02
0: pcgsoi: gnorm(1:2), b= 3.9226971306926E+04 3.9226971306926E+04 3.1611945544163E-01
0: stprat 0.364906062575707624
0: stprat 0.156431139151674278E-14224
```

2nd outer loop **Inner iteration**

```
0: Minimization iteration 2
0: grepcost J, Jb, Jo, Jc, Jl = 2 0 9.9610405E+03 8.5076644E+02 9.1102740E+03 0.0 0.0
0: grepgrad grad, reduction= 2 0 2.291813874420873560E+02 1.000000000000000000E+00
0: pcgsoi: cost, grad, step = 2 0 9.96104052193E+03 2.29181387442E+02 7.15279261E-03
0: pcgsoi: gnorm(1:2), b= 1.13035507282E+04 1.13035507282E+04 2.15206903713E-01
0: stprat 0.319264972580440953
0: stprat 0.577830902990640559E-14
0: Minimization iteration 1
0: grepcost J, Jb, Jo, Jc, Jl = 2 1 9.58534646E+03 8.7366356E+02 8.7116829E+03 0.0 0.0
0: grepgrad grad, reduction= 2 1 1.063181580364677217E+02 4.639039811351767240E-01
0: pcgsoi: cost, grad, step = 2 1 9.58534646763E+03 1.06318158036E+02 1.05074549E-02
0: pcgsoi: gnorm(1:2), b= 5.4234537548554E+03 5.4234537548554E+03 4.7980089488985E-01
0: stprat 0.410968433100896591
0: stprat 0.157538354385690312E-13
```

Check Analysis Result Output

```
0: ordering=XY
0: WrfType,WRF_REAL= 104 104
0: ndim1= 2
0: staggering= N/A
0: start_index= 1 1 1 -7269735
0: end_index1= 69 64 45 -7269735
0: k,max,min,mid T= 1 309.9584656 264.4796753 290.9471130
0: k,max,min,mid T= 2 310.6225281 269.6447144 296.2458191
0: k,max,min,mid T= 44 496.4794922 457.3758850 478.2719116
0: k,max,min,mid T= 45 509.2687378 475.0305481 494.7050171
0: rmse_var=T K Maximum Minimum Central grid
```

	K	Maximum	Minimum	Central grid
1	309.9584656	264.4796753	290.9471130	
2	310.6225281	269.6447144	296.2458191	
44	496.4794922	457.3758850	478.2719116	
45	509.2687378	475.0305481	494.7050171	

QVAPOR, U, V, SMOIS, XICE, SST, TSK



Variable name in netcdf file

Observation Fitting Statistic

Details in User’s Guide Section 4.5

Why need to check fitting statistic

- Data Analysis: adjust background fields based on observation data so that analysis fields fit the observation better.
- GSI has a series of **text files** to provide statistic information on how outer loop fields fit to the certain observation variable (fort.2*)
- GSI also has a series of **binary files** to save diagnostic information for each observation (diag*)

Statistic fitting files

File name	Variables in file	Ranges/units
fort.201 or fit_p1.analysis_time	fit of surface pressure data	mb
fort.202 or fit_w1.analysis_time	fit of wind data	m/s
fort.203 or fit_t1.analysis_time	fit of temperature data	K
fort.204 or fit_q1.analysis_time	fit of q data,	percent of guess $q_{\text{saturation}}$
fort.205	current fit of precipitation water data	mm
fort.206	fit of ozone observations from sbuv6_n14 (, _n16, _n17, _n18) and sbuv8_n16 (, _n17, _n18, _n19)	

File names are from fort.201 to fort.215 (or fit_*)
Each file is for one observation variable

Statistic fitting files (Continue)

File name	Variables in file	Ranges/units
fort.207 or fit_rad1.analysis_time	fit of satellite data including: amsua_n15(, n16, n17, n18, metop-a, aqua, n19), amsub_n15(, n16, n17,), hirs3_n16(, n17), hirs4_n18 (, metop-a, n19), mhs_n18(, metop-a, n19), hirs2_n14, iasi616_metop-a, airs281SUBSET_aqua, avhrr3_n16(, n17, n18), amsre_aqua, ssmi_f13(, f14, f15), ssmis_f16, msu_n14, sndr_g11(, g12, g13), imgr_g11(, g12, g13), sndrD1(, 2, 3, 4)_g11(, g12,g13),	Satellite radiance
fort.208	pcp_ssmi, pcp_tmi	
fort.209	Rw	Radar radial wind
fort.210	Dw	
fort.211	srw1, srw2	
fort.212	GPS RO	GPS RO
fort.213	fit of conventional sst data	C
fort.214	Tropical cyclone central pressure	
fort.215	Lagrangian data	

Example: fit_t1.2010050700 (fort.203)

current fit of temperature data, ranges in K

it	obs	type	styp	ptop	1000.0	900.0	800.0	600.0	400.0	300.0	250.0	200.0	150.0	100.0	50.0	0.0
				pbot	1200.0	999.9	899.9	799.9	599.9	399.9	299.9	249.9	199.9	149.9	99.9	2000.0
o-g 01	t	120	0000	count	44	180	214	381	405	200	93	147	247	334	396	3432
o-g 01	t	120	0000	bias	3.67	2.12	0.51	0.23	-0.33	-0.63	-0.66	-1.49	-0.45	-1.04	-1.21	-0.40
o-g 01	t	120	0000	rms	4.36	2.77	1.45	1.19	0.83	1.04	1.43	2.09	1.74	1.89	2.38	1.81
o-g 01	t	130	0000	count	0	0	0	0	0	0	3	12	2	0	0	18
o-g 01	t	130	0000	bias	0.00	0.00	0.00	0.00	0.00	0.00	-0.55	-0.50	2.33	0.00	0.00	-0.04
o-g 01	t	130	0000	rms	0.00	0.00	0.00	0.00	0.00	0.00	0.57	1.31	2.51	0.00	0.00	1.48
o-g 01	t	180	0000	count	714	79	0	0	0	0	0	0	0	0	0	793
o-g 01	t	180	0000	bias	2.65	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.38
o-g 01	t	180	0000	rms	3.66	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.51
o-g 01		all		count	758	259	214	381	405	200	96	159	249	334	396	4243
o-g 01		all		bias	2.70	1.46	0.51	0.23	-0.33	-0.63	-0.65	-1.41	-0.42	-1.04	-1.21	0.12
o-g 01		all		rms	3.70	2.47	1.45	1.19	0.83	1.04	1.41	2.04	1.74	1.89	2.38	2.23

O-B

current fit of temperature data, ranges in K

it	obs	type	styp	ptop	1000.0	900.0	800.0	600.0	400.0	300.0	250.0	200.0	150.0	100.0	50.0	0.0
				pbot	1200.0	999.9	899.9	799.9	599.9	399.9	299.9	249.9	199.9	149.9	99.9	2000.0
o-g 03	t	120	0000	count	44	180	214	381	405	200	93	147	247	334	396	3432
o-g 03	t	120	0000	bias	2.38	1.36	0.13	0.13	-0.07	-0.10	-0.03	-0.50	0.03	-0.24	-0.27	0.02
o-g 03	t	120	0000	rms	2.75	1.94	1.06	0.90	0.59	0.61	1.02	1.23	1.37	1.19	1.90	1.34
o-g 03	t	130	0000	count	0	0	0	0	0	0	3	12	2	0	0	18
o-g 03	t	130	0000	bias	0.00	0.00	0.00	0.00	0.00	0.00	-0.06	-0.04	1.70	0.00	0.00	0.29
o-g 03	t	130	0000	rms	0.00	0.00	0.00	0.00	0.00	0.00	0.26	1.08	1.87	0.00	0.00	1.24
o-g 03	t	180	0000	count	714	79	0	0	0	0	0	0	0	0	0	793
o-g 03	t	180	0000	bias	0.84	-0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74
o-g 03	t	180	0000	rms	2.34	1.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.27
o-g 03		all		count	758	259	214	381	405	200	96	159	249	334	396	4243
o-g 03		all		bias	0.93	0.88	0.13	0.13	-0.07	-0.10	-0.03	-0.46	0.04	-0.24	-0.27	0.16
o-g 03		all		rms	2.37	1.79	1.06	0.90	0.59	0.61	1.01	1.22	1.37	1.19	1.90	1.56

O-A

Results from test case using 2 outer loops with 10 inner iterations in each outer loop

Observation departure for each obs

- Diagnostic files:

```
diag_amsua_metop-a_anl.2010050700  diag_amsub_n16_anl.2010050700
diag_amsua_metop-a_ges.2010050700  diag_amsub_n16_ges.2010050700
diag_amsub_n17_anl.2010050700      diag_conv_anl.2010050700
Diag_amsub_n17_ges.2010050700      diag_conv_ges.2010050700
```

- To get these files, has to turn write_diag on:

write_diag(1)=.true.,write_diag(2)=.false.,write_diag(3)=.true.,

- To read this binary information:

- Code to read these files (/util/diag)

- read_diag_conv.f90 (diag_conv*)
- read_diag_rad.f90 (diag_amsub_n16* ...)

- see User’s Guide appendix A.2 for details