WRF-Var tools and WRF-Var verification package

Hui-Chuan Lin

Syed Rizvi Yong-Run Guo

22 July 2008 WRF-Var Users Tutorial

- WRF-Var diagnostics
- Verifications using WRF-Var
- WRF-Var tools

WRF-Var diagnostics

ASCII output files in the WRF-Var working directory

check_max_iv
cost_fn
filtered_obs (analysis_type="QC-OBS")
grad_fn
gts_omb_oma
jo
statistics
unpert_obs
pert_obs (omb_add_noise=true)
runtime.log or rsl.out.0000

check_max_iv

Information of observations that fail check_max_iv check

```
For outer iteration     1, Total Rejections for Synop follows:

Number of failed u-wind observations:         25 on    230
Number of failed v-wind observations:         30 on    230
Number of failed pressure observations:        5 on    230
Number of failed temperature observations:     0 on    230
Number of failed mixing ratio observations:     1 on    230
Finally Total Synop rejections     61 on   1150

Err_max failed:ID=47843FM-12 SYNOP Ix=  204 Ixf= 30 Err_max ratio = 1.3 for V     inv, error: 0.708141E+01 0.110000E+01
Err_max < 0 ==>        0.0 -4444440.0        5.0  for V     OBS ID: 98752FM-12 SYNOP  LA/LON/ELV:      9.93    125.51     46.00
```

```
&wrfvar1
   CHECK_MAX_IV_PRINT=true (default)

&wrfvar5
   CHECK_MAX_IV=true (default)
```

Check for observations with
innovations (O-B) larger than [factor × observation error]

factors are hard-wired in
var/da/da_control/da_control.f90

```
! Maximum error check factors:  inV > (Obs_error*factor) --> fails_error_max
   real, parameter :: max_error_t              = 5.0, &
                      max_error_uv             = 5.0, &
                      max_error_pw             = 5.0, &
                      max_error_ref            = 5.0, &
                      max_error_rh             = 5.0, &
                      max_error_q              = 5.0, &
                      max_error_p              = 5.0, &
                      max_error_tb             = 5.0, &
                      max_error_thickness      = 5.0, &
                      max_error_rv             = 5.0, &
                      max_error_rf             = 5.0, &
                      max_error_buv            = 500.0, &
                      max_error_bt             = 500.0, &
                      max_error_bq             = 500.0, &
                      max_error_slp            = 500.0
```

check_max_iv is written out in var/da/da_tools/da_max_error_qc.inc

cost_fn and grad_fn

&wrfvar11 CALCULATE_CG_COST_FN=false (default)

Outer Iter	EPS	Inner Iter	J	Jb	Jo	Jc	Je	Jp
1	0.100E-01	0	37293.267	0.000	37293.267	0.000	0.000	0.000
1	0.100E-01	61	29974.427	1093.616	28880.811	0.000	0.000	0.000

Outer Iter	EPS	Inner Iter	G	Gb	Go	Ge	Gp
1	0.100E-01	0	1619.534	0.000	1619.534	0.000	0.000
1	0.100E-01	61	12.931	46.768	48.511	0.000	0.000

b: background term
o: observation term
c: JcDFI term
e: alpha term
p: radiance variational bias correction term

&wrfvar11 CALCULATE_CG_COST_FN=true

Outer Iter	EPS	Inner Iter	J	Jb	Jo	Jc	Je	Jp
1	0.100E-01	0	37293.267	0.000	37293.267	0.000	0.000	0.000
1	0.100E-01	1	36140.373	1.014	36139.360	0.000	0.000	0.000
1	0.100E-01	2	35693.377	2.264	35691.114	0.000	0.000	0.000
1	0.100E-01	3	34953.968	6.881	34947.087	0.000	0.000	0.000
1	0.100E-01	4	34516.190	11.563	34504.627	0.000	0.000	0.000
					.			
					.			
					.			
1	0.100E-01	59	29976.227	1088.245	28887.982	0.000	0.000	0.000
1	0.100E-01	60	29975.699	1089.784	28885.915	0.000	0.000	0.000
1	0.100E-01	61	29974.427	1093.616	28880.811	0.000	0.000	0.000

cost_fn and grad_fn are written out in var/da/da_minimisation/da_calculate_j.inc

cost_fn and grad_fn are used in var/graphics/ncl/plot_cost_grad_fn.ncl

gts_omb_oma

complete point-by-point, detailed observation information

```
 synop      995
        1
        1        176556    21.51  -104.90    89973.8836463        3.3147587        1.2193668        2        1.1000000        0.1849281       -1.5412909
   -1.4225501         2         1.1000000        -1.6862257      295.5511624        2.5999150        2        2.0000000        1.3689324    89973.8836463
 -273.5464584         2       100.0000000      -236.6028635        0.0134689        0.0048657        0        0.0036749        0.0050584

 sound      121
        49
        1       4978897    16.26   -61.51     5000.0000000        3.1528830        0.0000000 -888888        2.7000000        0.0000000       -1.7396925
    0.0000000 -888888         2.7000000        0.0000000      204.6500000        0.0000000 -888888        1.0000000        0.0000000  -888888.0000000
    0.0000000 -888888  -888888.0000000        0.0000000
        55
        2        104220    68.70   -52.75    99500.0000000       -7.5305439        0.0000000 -888888        1.1000000        0.0000000        1.6861190
    0.0000000 -888888         1.1000000        0.0000000  -888888.0000000        0.0000000 -888888        1.0000000        0.0000000  -888888.0000000
    0.0000000 -888888  -888888.0000000        0.0000000
```

obstype number of obs
number of levels
obs index, level index, station id, lat, lon, pressure,
(O, O-B, qcflag, Oerr, O-A)u,
(O, O-B, qcflag, Oerr, O-A)v,
(O, O-B, qcflag, Oerr, O-A)t,
(O, O-B, qcflag, Oerr, O-A)p,
(O, O-B, qcflag, Oerr, O-A)q

listed variables of each observation type vary:

Synop: u, v, t, p, q
Metar: u, v, t, p, q
Ship: u, v, t, p, q
Geoamv: u, v
Polaramv: u, v
Gpspw: tpw
Sound: u, v, t, q
Sonde_sfc: u, v, t, p, q
Airep: u, v, t
Pilot: u, v
Satem: thickness
Qscat: u, v
Profiler: u, v
Buoy: u, v, t, p, q
Airsr: t, q
Gpsref: ref

- SATOB are separated as geoamv and polaramv in WRF-Var
- AMDAR and AIREP are grouped as airep in WRF-Var

gts_omb_oma is written out in var/da/da_obs_io/da_write_obs.inc

gts_omb_oma is used in
var/graphics/ncl/plotobs.ncl
var/da/da_verif_obs/da_verif_obs.f90

statistics

domain-wise O-B and O-A information

```
Diagnostics of OI for synop

   var             u (m/s)     n    k    v (m/s)     n    k    t (K)       n    k    p (Pa)      n    k    q (kg/kg)   n    k

 Number:               331                    332                    355                    330                    361
Minimum(n,k):       -5.4017  363    0      -5.4086  878    0      -9.7206  592    0   -390.7893  931    0 -0.4461E-02  719    0
Maximum(n,k):        5.0466  886    0       5.2878  630    0       7.7302  421    0    471.9343  944    0  0.5408E-02  787    0
Average     :       -0.8471                -0.1995                -1.1171                 20.4177             -0.2525E-03
   RMSE     :        2.3023                 2.1150                 3.1978                116.1518              0.8045E-03

 Diagnostics of AO for synop

   var             u (m/s)     n    k    v (m/s)     n    k    t (K)       n    k    p (Pa)      n    k    q (kg/kg)   n    k

 Number:               331                    332                    355                    330                    361
Minimum(n,k):       -4.2496  172    0      -5.0463  683    0      -8.9005  583    0   -472.9290  931    0 -0.4152E-02  719    0
Maximum(n,k):        5.5540  886    0       5.7990  630    0       8.8192  421    0    392.4096  944    0  0.5058E-02    1    0
Average     :       -0.0847                -0.0376                -0.4283                  1.1709             0.1625E-04
   RMSE     :        1.8650                 1.8093                 2.1990                101.3816              0.5958E-03

 Minimum of gridded analysis increments

 Lvl         u     i    j          v     i    j          t     i    j          p     i    j          q     i    j

   1     -1.8915   17   32     -1.9965   36   24     -5.2526   20   35   -314.7470   44    1 -0.1451E-02   18   32
   2     -1.9476   16   32     -2.0070   36   24     -3.0142   21   36   -311.2885   44    1 -0.1438E-02   18   33

 Maximum of gridded analysis increments

 Lvl         u     i    j          v     i    j          t     i    j          p     i    j          q     i    j

   1      1.3750   41    8      1.5739   28   12      3.2994   24   20    197.8351   28    2  0.1401E-02   39    8
   2      1.4844   40    8      1.6180   28   13      1.7471    7   20    195.5165   28    2  0.1591E-02   39    8

Mean of gridded analysis increments

 Lvl         u           v           t           p           q

   1     -0.0327      0.0632     -0.1477     17.4414 -0.1047E-03
   2     -0.0031      0.0736      0.0116     17.2543 -0.8066E-04

RMSE of gridded analysis increments

 Lvl         u           v           t           p           q

   1      0.7546      0.6040      1.3120     72.0441  0.4258E-03
   2      0.7995      0.6483      0.9169     71.2614  0.4476E-03
```

statistics is written out separately by each observation type with non-zero observation number

For example, var/da/da_sound/da_print_stats_sound.inc

da_oi_stats_sound.inc

da_ao_stats_sound.inc

var/da/da_synop/da_print_stats_synop.inc

da_oi_stats_synop.inc

da_ao_stats_synop.inc

jo

cost function of each observation type

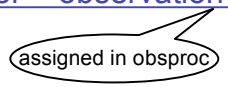
synop	obs,	Jo(actual)	=	1007	1709	475.29555	1.00000	448.89633	1.00000	214.58090	1.00000	169.59091	1.00000	39.54654	1.00000
metar	obs,	Jo(actual)	=	2551	4996	1142.22791	1.00000	1139.04835	1.00000	450.85222	1.00000	141.48881	1.00000	127.23786	1.00000
ships	obs,	Jo(actual)	=	270	739	295.61942	1.00000	328.81980	1.00000	38.63147	1.00000	76.05158	1.00000	10.88285	1.00000
geoamv	ob,	Jo(actual)	=	18216	35619	4375.80943	1.00000	4291.11244	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000
gpspw	obs,	Jo(actual)	=	113	94	42.19891	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000
sound	obs,	Jo(actual)	=	122	12507	1501.01081	1.00000	1417.89485	1.00000	2934.71994	1.00000	1412.34202	1.00000	0.00000	1.00000
sonde	obs,	Jo(actual)	=	122	12507	77.96908	1.00000	70.37029	1.00000	43.28542	1.00000	45.34806	1.00000	4.58217	1.00000
airep	obs,	Jo(actual)	=	1527	4506	699.19993	1.00000	655.45784	1.00000	776.57509	1.00000	0.00000	1.00000	0.00000	1.00000
pilot	obs,	Jo(actual)	=	112	5895	2582.21854	1.00000	2434.46137	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000
satem	obs,	Jo(actual)	=	204	2079	108.15758	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000
buoy	obs,	Jo(actual)	=	241	400	133.21166	1.00000	104.72975	1.00000	31.86149	1.00000	38.47701	1.00000	1.04651	1.00000

Sum of individual Jo (numbers in red boxes)
equals the printout value in rsl.out.0000

```
Final value of Jo    =    28880.81069
```

Blue boxes are observation error factor used in WRF-Var.

observation error = observation error × factor



factor = 1.0 when

```
&wrfvar4
   use_obs_errfac=false (default)
```

jo is written out in var/da/da_minimisation/da_get_var_diagnostics.inc

To apply observation error tuning factors:
prepare an ASCII errfac.dat (or an output from da_util/da_tune_obs_desroziers.f90)
and run WRF-Var with

```
&wrfvar4
   use_obs_errfac=true
```

errfac.dat is read in var/da/da_obs_io/da_read_errfac.inc

unpert_obs (y=H(x'(y_o)))

```
synop      990
         1
         1        1 -0.4190450E+00  0.2579359E-01  0.2115635E+00  0.1756130E+02 -0.4622692E-04 -0.9999999E+06 -0.9999999E+06

 sound     160
        46
         1        1 -0.5809316E+00 -0.3796593E+00  0.6811523E+00 -0.3070524E-03 -0.9999999E+06 -0.9999999E+06 -0.9999999E+06
         1        2 -0.7361224E+00 -0.3743801E+00 -0.8888880E+06 -0.8888880E+06 -0.9999999E+06 -0.9999999E+06 -0.9999999E+06
```

obstype obs number
level numer
obs index, level index,

listed variables of each observation type vary:

- Synop: u, v, t, p, q
- Metar: u, v, t, p, q
- Ship: u, v, t, p, q
- Geoamv: u, v
- Polaramv: u, v
- Gpspw: tpw
- Sound: u, v, t, q
- Sonde_sfc: u, v, t, p, q
- Airep: u, v, t
- Pilot: u, v
- Satem: thickness
- Qscat: u, v
- Profiler: u, v
- Buoy: u, v, t, p, q
- Airsr: t, q
- Gpsref: ref

unpert_obs is written out in var/da/da_obs_io/da_write_y.inc

pert_obs (y=H(x'(y_o+noise)))

unpert_obs and pert_obs, together with other files, are used in var/da/da_util/da_tune_obs_desroziers.f90

Reference: Desroziers, G. and S. Ivanov, 2001: Diagnosis and adaptive tuning of observation-error parameters in a variational assimilation. Q. J. R. Meteorol. Soc., 127, 1433-1452.

Observation error tuning

Data used in calculating tuning factors:

a collection of unpert_obs, jo and rsl.out.0000 from regular WRF-Var runs
a collection of rand_obs_error and pert_obs from perturbed WRF-Var runs

Steps:

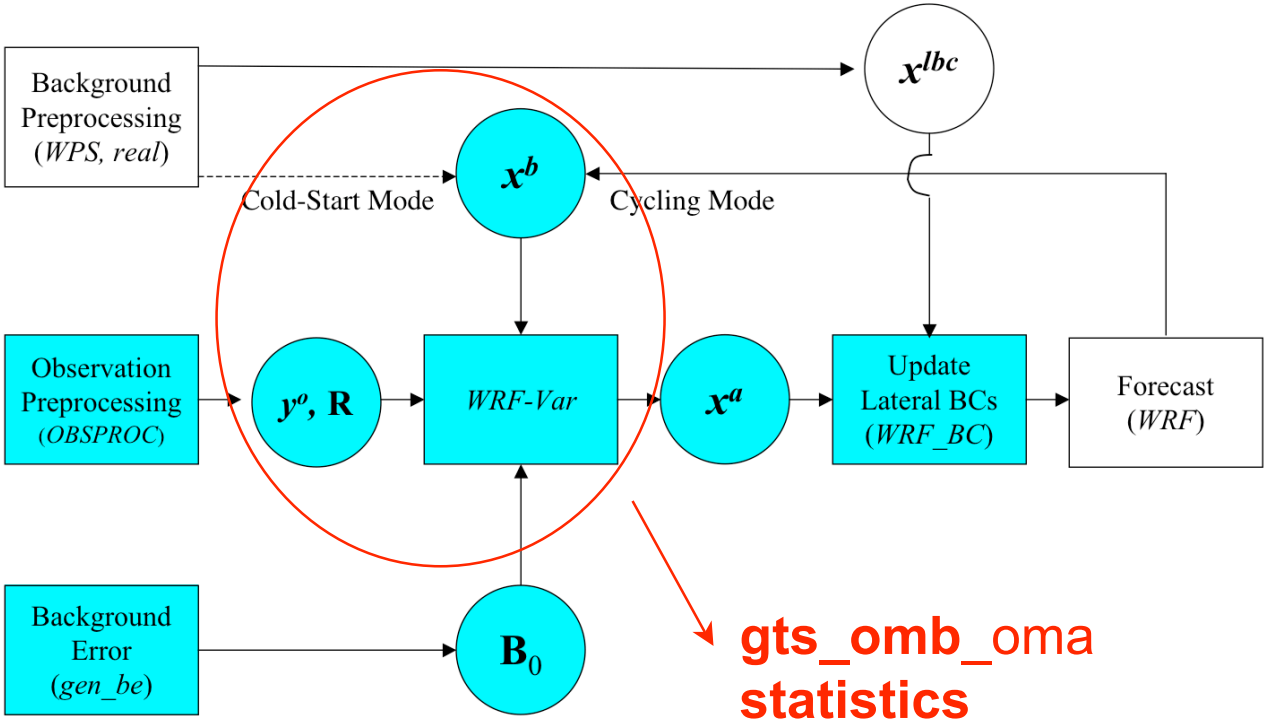
(1) a series of WRF-Var regular runs to collect unpert_obs [y = H(x'(y_o)) of each obs type], jo [Jo of each obs type], and rsl.out.0000 which contains the final total cost function (J, Jo, Jb) information

(2) a series of WRF-Var perturbed runs `(&wrfvar5 omb_add_noise = .true.)` to collect rand_obs_error [noise of each obs type] and pert_obs [yp = H(x'(y_o+noise)) of each obs type]

(3) run da_tune_obs_desroziers.exe to generated errfac.dat

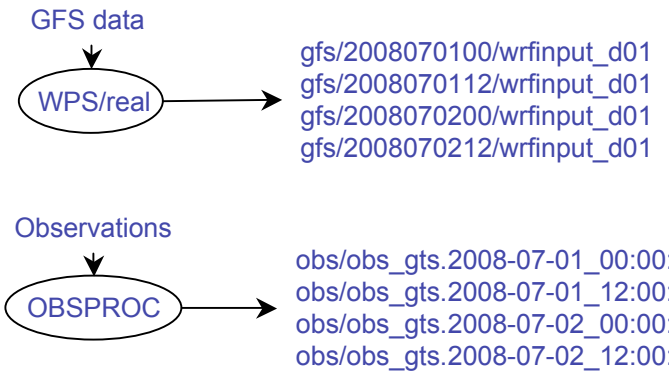
var/scripts/da_tune_obs_desroziers.ksh
var/da/da_util/da_tune_obs_desroziers.f90

How to do verification using WRF-Var?



- Verifying against observations
  (**all types that can be assimilated in WRF-Var**)
- Collecting O-B (observations minus background) information
- Same numbers of observations should be used for verifying analyses/forecasts from different experiments

Sample experiment scenario



wrf forecasts from 4 different initial times,
each wrfout contains, for example, 00h, 12h, 24h forecasts

EXP1 WRF-Var
Use_soundobs=true
Use_synopobs=false
wrfvar_output
(wrfinput_d01)

Exp1/wrfout_d01_ 2008-07-01_00:00:00
Exp1/wrfout_d01_ 2008-07-01_12:00:00
Exp1/wrfout_d01_ 2008-07-02_00:00:00
Exp1/wrfout_d01_ 2008-07-02_12:00:00

EXP2 WRF-Var
Use_soundobs=true
Use_synopobs=true
wrfvar_output
(wrfinput_d01)

Exp2/wrfout_d01_ 2008-07-01_00:00:00
Exp2/wrfout_d01_ 2008-07-01_12:00:00
Exp2/wrfout_d01_ 2008-07-02_00:00:00
Exp2/wrfout_d01_ 2008-07-02_12:00:00

EXP1 and EXP2 have different types of observations assimilated - testing impact of synop

How to do verification using WRF-Var?

Step 1: generate one set of observations to be used for verifying wrf forecasts

Pre-Step 2: split wrf output so that each file contains data from only one time.

wrfout_d01_2008-07-01_00:00:00 contains the following forecast times
Times =
"2008-07-01_00:00:00",
"2008-07-01_12:00:00",
"2008-07-02_00:00:00",

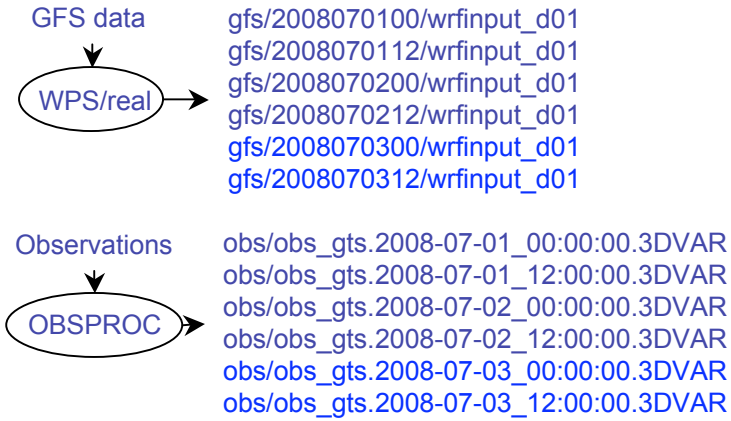
```
mkdir 2008070100
ncks  -d  Time,0,0  wrfout_d01_2008-07-01_00:00:00  2008070100/wrfout_d01_2008-07-01_00:00:00
ncks  -d  Time,1,1  wrfout_d01_2008-07-01_00:00:00  2008070100/wrfout_d01_2008-07-01_12:00:00
ncks  -d  Time,2,2  wrfout_d01_2008-07-01_00:00:00  2008070100/wrfout_d01_2008-07-02_00:00:00
```

Step 2: run WRF-Var with the observations from step 1 and with each forecast you want to verify as a first-guess to collect O-F (observation minus forecast) values, i.e. gts_omb_oma and statistics.

Step 3: graphics/visualization

How to do verification using WRF-Var?

Step 1: generate one set of observations to be used for verifying wrf forecasts



Run WRF-Var with the settings:

```
&wrfvar5    check_max_iv=true
&wrfvar6    ntmax=0
&wrfvar11   sfc_assi_options=2
&wrfvar17   analysis_type="QC-OBS"
```

Purpose: to write out good observations

with respect to the background used

WRF-Var does not actually do QC except for

(1) rejecting observations that fail check_max_iv check when check_max_iv = true

(2) rejecting surface observations with larger than 100m height difference between model and observation when sfc_assi_options = 1

(3) Rejecting observations below the lowest model level and above the highest model level

filtered_obs
(in the same format as obs_gts*.3DVAR) will be used in Step 2.

2008070100/filtered_obs
2008070112/filtered_obs
2008070200/filtered_obs
2008070212/filtered_obs
2008070300/filtered_obs
2008070312/filtered_obs

How to do verification using WRF-Var?

Step 2: run WRF-Var with the filtered observations from step 1 and with each forecast or analysis you want to verify as a first-guess to collect O-F (observation minus forecast) values, i.e. gts_omb_oma and statistics.

Initial time / Forecast valid time

Exp1/2008070100/wrfout_d01_ 2008-07-01_00:00:00
Exp1/2008070100/wrfout_d01_ 2008-07-01_12:00:00
Exp1/2008070100/wrfout_d01_ 2008-07-02_00:00:00
Exp1/2008070112/wrfout_d01_ 2008-07-01_12:00:00
Exp1/2008070112/wrfout_d01_ 2008-07-02_00:00:00
Exp1/2008070112/wrfout_d01_ 2008-07-02_12:00:00

Exp2/2008070100/wrfout_d01_ 2008-07-01_00:00:00
Exp2/2008070100/wrfout_d01_ 2008-07-01_12:00:00
Exp2/2008070100/wrfout_d01_ 2008-07-02_00:00:00
Exp2/2008070112/wrfout_d01_ 2008-07-01_12:00:00
Exp2/2008070112/wrfout_d01_ 2008-07-02_00:00:00
Exp2/2008070112/wrfout_d01_ 2008-07-02_12:00:00

2008070100/filtered_obs
2008070112/filtered_obs
2008070200/filtered_obs
2008070212/filtered_obs

Run WRF-Var with the settings:

```
&wrfvar5
    check_max_iv=false

&wrfvar6
    ntmax=0
```

(only O-B information is needed, no need to go through minimization)

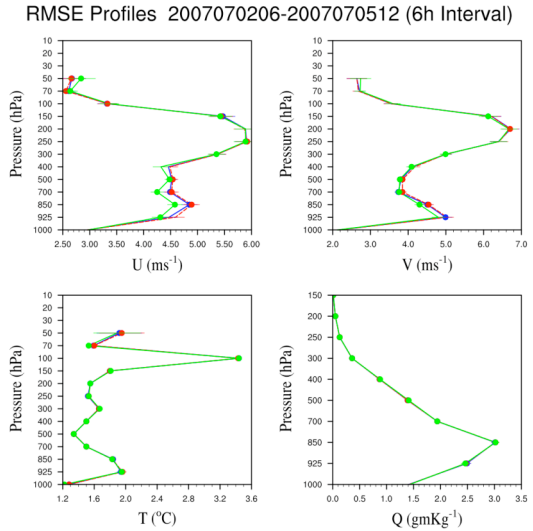
```
&wrfvar17
    analysis_type="VERIFY"
```

Lots of gts_omb_oma and/or statistics files to play with!

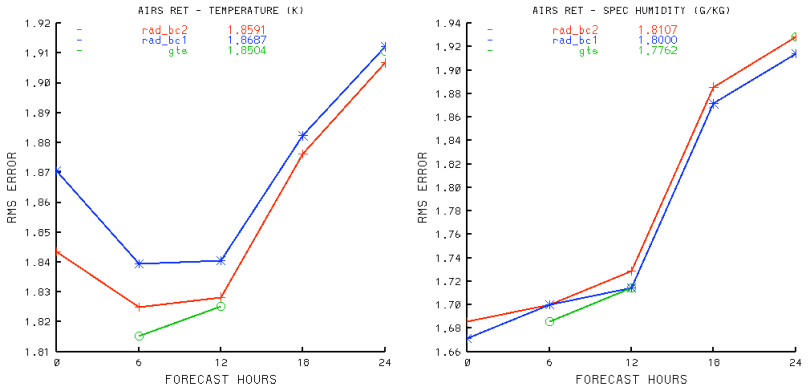
analysis_type="VERIFY" keeps observations below the lowest model level and above highest model level to ensure same observations are used for different experiments.

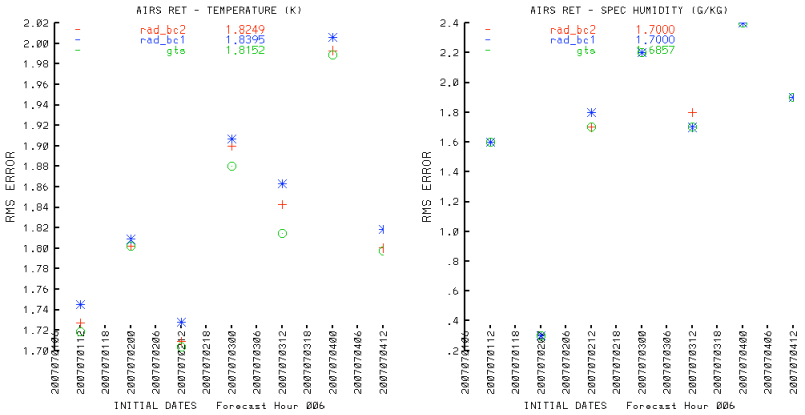
Step 3: graphics/visualization

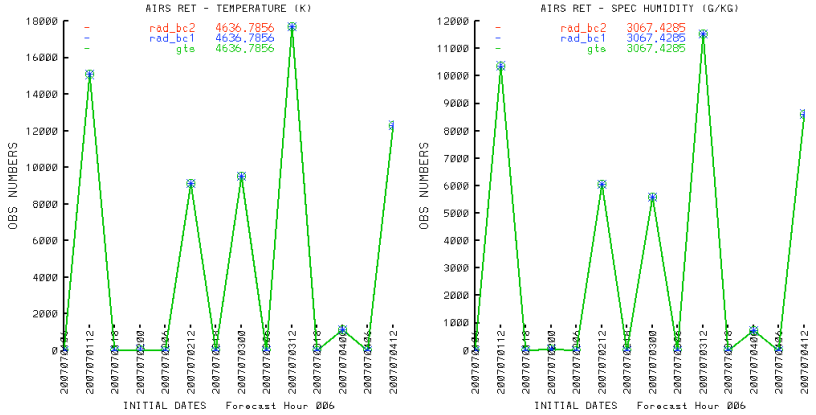
Presentation and manipulation of the large amount of gts_omb_oma and/or statistics files collected in Step 2



statistics files might be easier to handle than gts_omb_oma files, but no information in vertical if using statistics







WRF-Var Tools

Misc. plotting

var/graphics/ncl/WRF-Var_plot.ncl
WRF_contributed.ncl.test
(procedure WRF_map_c for setting map resources)
plot_cost_grad_fn.ncl
plotobs.ncl

Background Error Statistics plotting

var/graphics/ncl/gen_be/gen_be_corr_ps.ncl
gen_be_corr_yz.ncl
gen_be_corr_z.ncl
gen_be_global_evals.ncl
gen_be_global_evecs.ncl
gen_be_lengthscales.ncl

Pseudo single obs test plotting

var/scripts/da_plot_psot.ksh
var/graphics/ncl/psot_xy_auto.ncl
var/graphics/ncl/psot_xz_auto.ncl
var/graphics/ncl/psot_yz_auto.ncl

Verification plotting

var/scripts/da_verif_anal_plot.ksh
var/graphics/ncl/verif_anal_time_series.ncl
var/graphics/ncl/verif_anal_time_average.ncl
var/graphics/ncl/verif_anal_vert_profile.ncl

} for verification against grid analysis

var/scripts/da_verif_obs_plot.ksh
var/graphics/ncl/verif_obs_time_series.ncl
var/graphics/ncl/verif_obs_vert_profile.ncl
var/graphics/ncl/verif_obs_time_average.ncl
var/graphics/ncl/verif_obs_vert_profile_gpsref.ncl

} for verification against observations

AIRS Retrievals Decoder

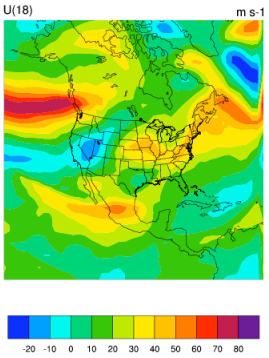
convertor/decode_l2_airs

var/graphics/ncl/**WRF-Var_plot.ncl**

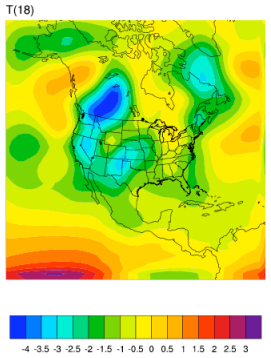
WRF_contributed.ncl.test
(procedure WRF_map_c for setting map resources)

Reads in WRF netCDF files: wrfinput_d01 and wrfvar_output

kl = 18
fg = first_guess->U
an = analysis->U
plot_data = an



kl = 18
fg = first_guess->T ;Theta-T0
an = analysis->T ;Theta-T0
plot_data = an - fg



Eta-level plots only

Alternative tools
WRF tutorial: Post-processing Tools (1): NCL by Cindy Bruyere
WRF tutorial: Post-processing Tools (3): RIP by Cindy Bruyere

var/graphics/ncl/**plot_cost_grad_fn.ncl**

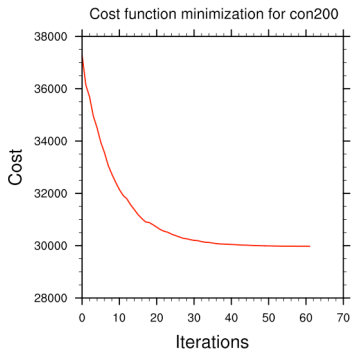
Reads in WRF-Var ASCII output: cost_fn and grad_fn

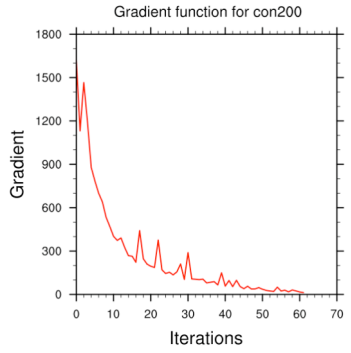
Run WRF-Var with

```
&wrfvar11
  CALCULATE_CG_COST_FN=true
```

to get cost function value of each iteration

However, `CALCULATE_CG_COST_FN=true` increases run-time significantly.
Default setting in Registry.wrfvar is `CALCULATE_CG_COST_FN=false`





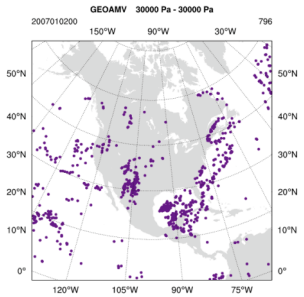
var/graphics/ncl/**plotobs.ncl**

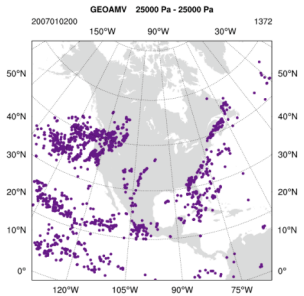
Reads in WRF-Var ASCII output: gts_omb_oma

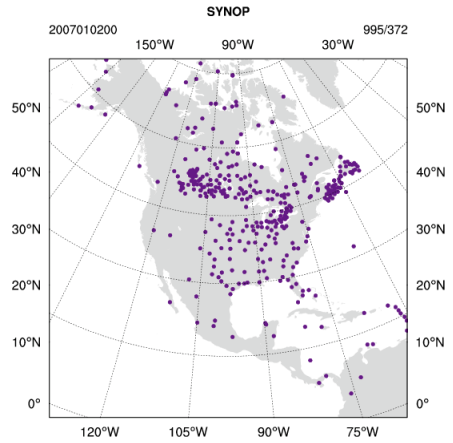
```
; method 1: set a 2-D array of bounded pressure levels in hPa
plevs  = (/ (/1005.,995./),(/930.,920./),(/855.,845/),(/705.,695./) /)
; plevs  = (/ (/1050.,0./),(/-999.,-999./) /)

; method 2: set a 1-D array of fixed pressure levels in hPa
; plevs  = (/ 1000., 850., 500., 300., 250., 200., 150., 100. /)

mapinfo_from_file = True
fname="wrfinput_d01"
; subdomain = True
subdomain = False
if ( subdomain ) then   ; subdomain needs to be a lat-lon box
  maxlat = 35.
  minlat = 25.
  maxlon = -75.
  minlon = -90.
end if
```

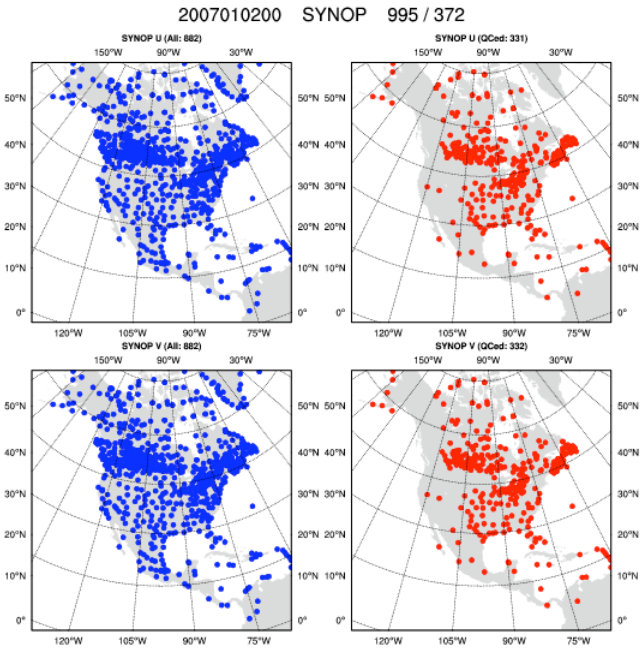


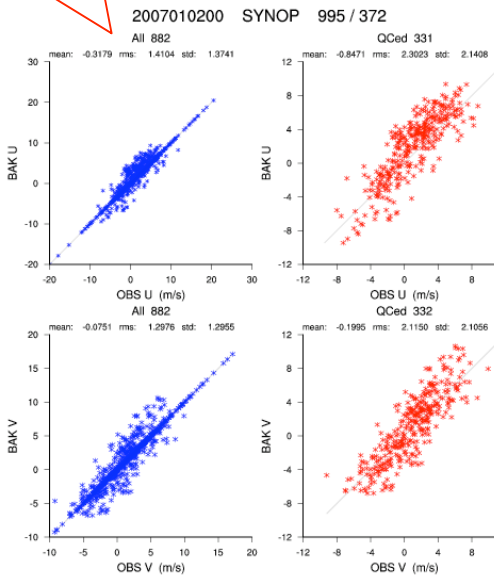


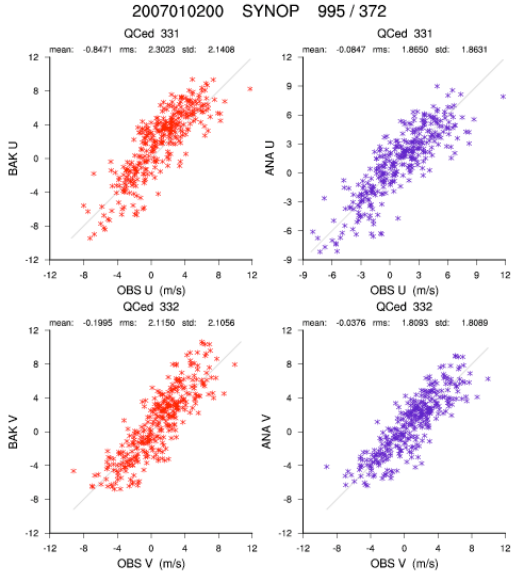


The information stored in gts_omb_oma is obs, omb, oma. Background value is calculated using obs - omb. Analysis value is calculated using obs - oma. In the case of a rejected obs, its omb is 0, which leads to obs = bak. All rejected observations show up on the scatter plots on the diagonal line. The shape of 'before QC' and 'after QC' scatter plots are the same, with 'before QC' having lower mean and rms values because of those obs=bak points.

I guess the 'QC' term used in the plots is somewhat misleading. Please refer to p.17 of this presentation about the meaning of "QC".







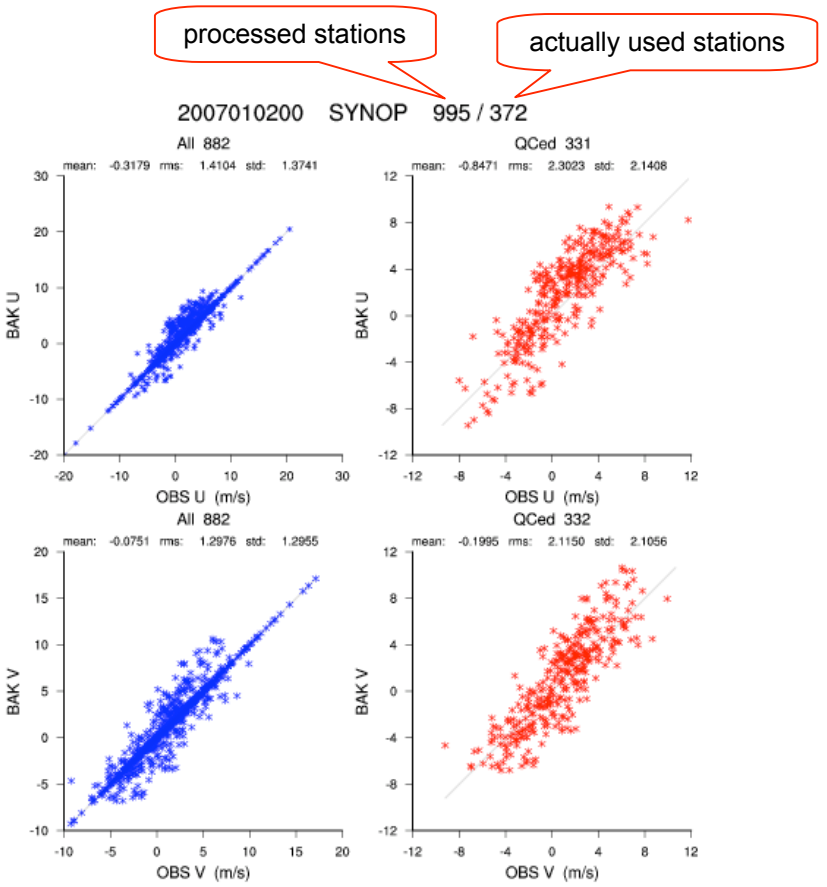
The information stored in gts_omb_oma is **obs**, **omb**, **oma**.

Background value is calculated using obs - omb.

Analysis value is calculated using obs - oma.

In the case of a rejected obs, its omb is set to be 0, which leads to obs = bak.

All rejected observations show up on the scatter plots on the diagonal line. The shape of 'before QC' and 'after QC' scatter plots are the same, with 'before QC' having lower mean and rms values because of those obs=bak points.



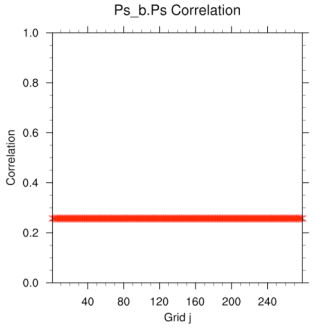
var/graphics/ncl/gen_be

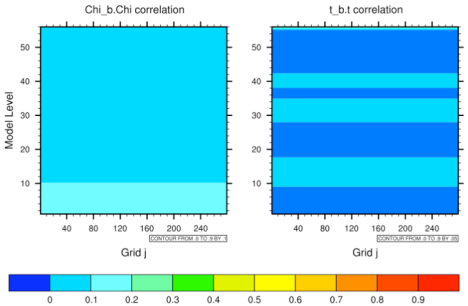
gen_be_corr_ps.ncl
gen_be_corr_yz.ncl
gen_be_corr_z.ncl

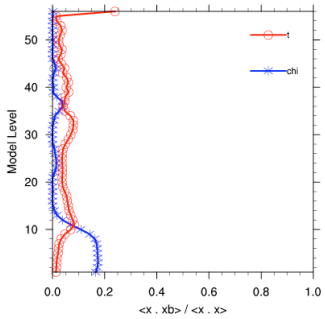
Reads in ASCII ps_u.ps.dat, chi_u.chi.dat, t_u.t.dat, ASCII output from gen_be/gen_be_cov2d.f90 and gen_be/gen_be_cov3d.f90

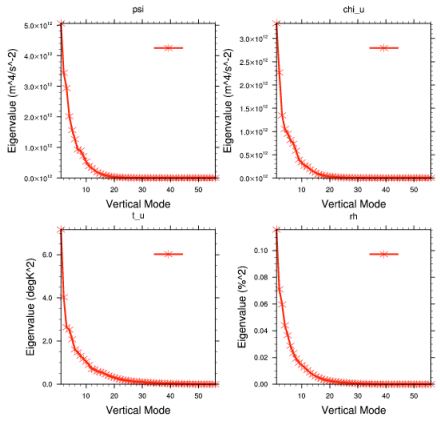
gen_be_global_evals.ncl
gen_be_global_evecs.ncl
gen_be_lengthscales.ncl

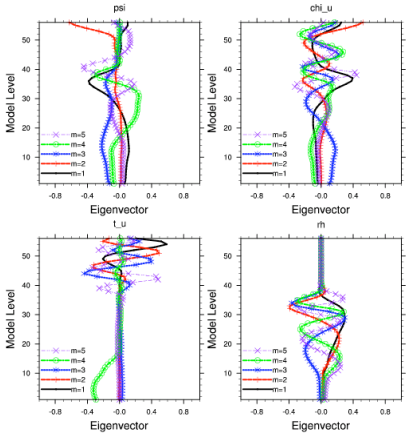
Reads in ASCII fort.1* output from gen_be/gen_be_diags_read.f90

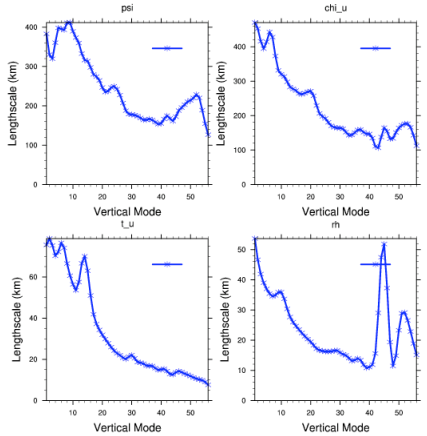








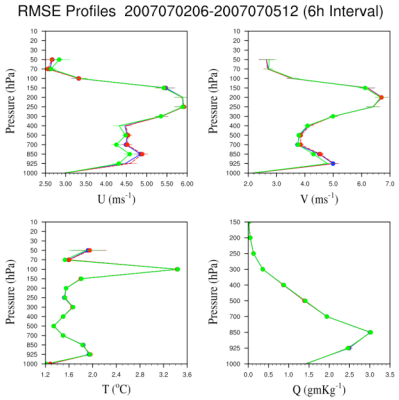


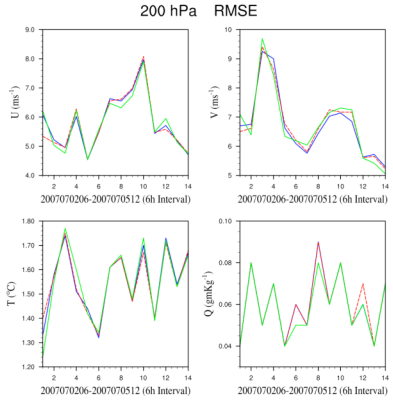


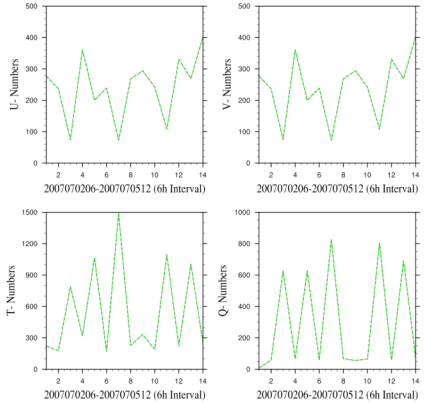
Var/scripts/da_verif_obs_plot.ksh
Var/graphics/ncl/verif_obs_time_series.ncl
Var/graphics/ncl/verif_obs_vert_profile.ncl
Var/graphics/ncl/verif_obs_time_average.ncl
Var/graphics/ncl/verif_obs_vert_profile_gpsref.ncl

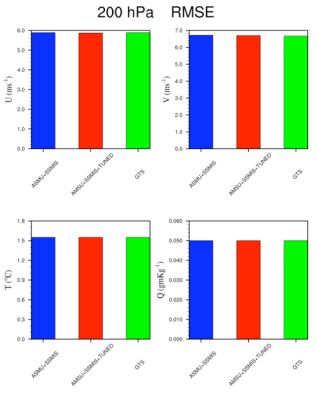
Var/scripts/da_verif_anal_plot.ksh
Var/graphics/ncl/verif_anal_time_series.ncl
Var/graphics/ncl/verif_anal_time_average.ncl
Var/graphics/ncl/verif_anal_vert_profile.ncl

U, V T, Q RMSE/BIAS/ABIAS on user-specified levels

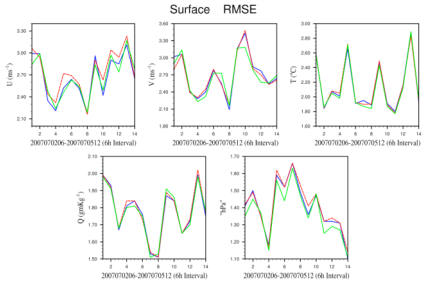


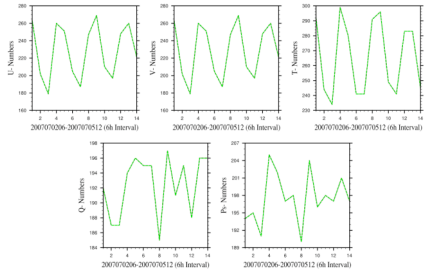


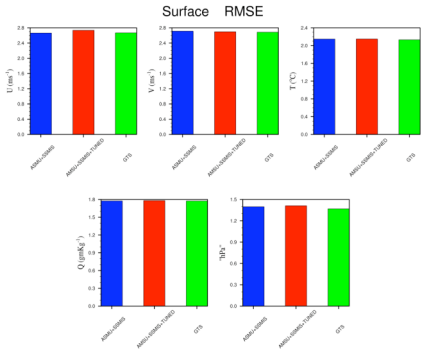




U, V T, Q, P RMSE/BIAS/ABIAS on surface level







AIRS Retrievals Decoder: var/convertor/decode_l2_airs

AIRS Retrieval (T and Q profiles)

Data (in HDF format) can be downloaded from
ftp://airspar1u.ecs.nasa.gov/ftp/data/s4pa/Aqua_AIRS_Level2/AIRX2RET.005

Visit NASA's web site for documentation
http://daac.gsfc.nasa.gov/AIRS/documentation/v5_docs/v5_docs_list.shtml

```
var/convertor/decode_l2_airs>ls -l
total 144
-rw-r--r--   1 hclin  users    1022 Mar 14 09:12 calc_rh.f90
-rw-r--r--   1 hclin  users   21445 Mar 14 09:12 decode_airs.f90
-rw-r--r--   1 hclin  users    7426 Mar 14 09:12 decode_l2_airs.README
-rw-r--r--   1 hclin  users    5573 Mar 14 09:12 geth_newdate.c
-rw-r--r--   1 hclin  users   17668 Mar 14 09:12 module_read_airs.f90
-rw-r--r--   1 hclin  users      30 Mar 14 09:12 qual_threshold.nl
-rw-r--r--   1 hclin  users      72 Mar 14 09:12 time_window.nl
```

decode_l2_airs.README contains important information about QC and installation. PLEASE READ!

Usage:
decode_airs.exe.v5 AIRS.2008.01.04.001.L2.RetStd.v5.2.2.0.G08064195538.hdf

Output:
soundings.little_r
soundings_polarday.little_r (containing non-validated PolarDay data)

Makefile

```
CC = gcc-3.3
FC = g95
FFLAGS = -ffree-form -fno-second-underscore
CFLAGS =

EXTERNAL = /sausage/hclin/extlib
JPEGLIB    = $(EXTERNAL)/jpeg-6b/lib
ZLIBLIB    = $(EXTERNAL)/zlib-1.2.3/lib
HDFEOS_LIB =  $(EXTERNAL)/hdfeos/lib
HDFLIB     =  $(EXTERNAL)/HDF4.2r1/lib
HDFEOS_INC =  $(EXTERNAL)/hdfeos/include
HDFINC     =  $(EXTERNAL)/HDF4.2r1/include

.IGNORE:
.SUFFIXES: .c .f90 .o

.c.o:
        rm -f $@
        $(CC) $(CFLAGS) -c $*.c

.f90.o:
        rm -f $@ $*.mod
        cp $< $*.f
        $(FC) $(FFLAGS) -c $*.f
        rm -f $*.f

all: decode_airs.exe

decode_airs.exe: decode_airs.o module_read_airs.o geth_newdate.o calc_rh.o
        $(FC) -o $@ decode_airs.o module_read_airs.o geth_newdate.o calc_rh.o \
          -L${HDFEOS_LIB} -L${HDFLIB} -I${HDFEOS_INC} -I${HDFINC} -lhdfeos \
          -lGctp -lmfhdf -ldf -L${ZLIBLIB} -lz -L${JPEGLIB} -ljpeg -lm

decode_airs.o: module_read_airs.o geth_newdate.o calc_rh.o

module_read_airs.o:

geth_newdate.o:

calc_rh.o:

clean:
        rm -f decode_airs.o module_read_airs.o geth_newdate.o calc_rh.o read_airs.mod

clobber:
        make clean; rm -f decode_airs.exe
```