# WRF-Var Namelist

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# What is a namelist?

- The Fortran namelist (namelist.input) file helps the user to configure a WRF-Var run without recompiling the code.

    – Specific Fortran 90 namelist format

| | |
|---|---|
| &namelistname | - start |
| … | |
| / | - end |

- Description of WRF-Var namelist variables are given in WRF User's Guide (Chapter 6).

# WRF-Var Namelist

- Default values of the namelist variables are defined by WRF-Var Registry (registry.wrfvar).

- Define namelist.input with non-default and desired variable values before running WRF-Var.

- When the WRF-Var is run, a namelist.output file will be produced with all values of namelist variables (default or/and from namelist.input).

# namelist.input ⟹ namelist.output

**namelist.input**

```
&wrfvar1
write_increments=true,
var4d=false,
multi_inc=0,
global=false,
/
&wrfvar2
/
&wrfvar3
ob_format=2,
num_fgat_time=1,
/
&wrfvar4
use_profilerobs=false,
use_satemobs=false,
use_gpspwobs=false,
use_gpsrefobs=false,
use_ssmiretrievalobs=true,
use_qscatobs=false,
/
```

**namelist.output**

```
&WRFVAR1
WRITE_INCREMENTS=T, WRFVAR_MEM_MODEL=0, VAR4D=F,
MULTI_INC=0, VAR4D_COUPLING=2, GLOBAL=F, PRINT_DETAI
L_AIREP=F, PRINT_DETAIL_RADAR=F, PRINT_DETAIL_RAD=F,
PRINT_DETAIL_XA=F, PRINT_DETAIL_XB=F, PRINT_DETAI
L_OBS=F, PRINT_DETAIL_F_OBS=F, PRINT_DETAIL_MAP=F,
PRINT_DETAIL_GRAD=F, PRINT_DETAIL_REGRESSION=F, PRI
NT_DETAIL_SPECTRAL=F, PRINT_DETAIL_TESTING=F,
PRINT_DETAIL_PARALLEL=F, PRINT_DETAIL_BE=F, PRINT_DETAIL
_TIMING=F, CHECK_MAX_IV_PRINT=T
 /
 &WRFVAR2
 ANALYSIS_ACCU=900, CALC_W_INCREMENT=F,
DT_CLOUD_MODEL=F, WRITE_QCW=F, WRITE_QRN=F,
WRITE_QCI=F, WRITE
_QSN=F, WRITE_QGR=F, WRITE_FILTERED_OBS=F
 /
 &WRFVAR3
 FG_FORMAT=1, OB_FORMAT=2, NUM_FGAT_TIME=1
 /
 &WRFVAR4
 USE_SYNOPOBS=T, USE_SHIPSOBS=T, USE_METAROBS=T,
USE_SOUNDOBS=T, USE_MTGIRSOBS=T, USE_PILOTOBS=T,
USE_
AIREPOBS=T, USE_GEOAMVOBS=T, USE_POLARAMVOBS=T,
USE_BOGUSOBS=F, USE_BUOYOBS=T, USE_PROFILEROBS=F,
USE_SATEMOBS=F, USE_GPSPWOBS=F, USE_GPSREFOBS=F,
USE_SSMIRETRIEVALOBS=T, USE_SSMITBOBS=F,
USE_SSMT1OBS=F, USE_SSMT2OBS=F, USE_QSCATOBS=F,
```

# Namelist - WRFVAR1

- Write_increments
  - .false. : Default
  - .true. : Output analysis increment file "analysis_increments" (analysis-background). The file is a binary file, generated every time you run WRF-Var by using a FORTRAN code given in
    *WRFVAR/da/da_setup_structures/da_write_increments.inc* .

```
-rw-r--r--      1 huishao  ncar     43271476 Jul  7 16:27 analysis_increments
lrwxrwxrwx      1 huishao  ncar           32 Jul  7 16:27 be.dat -> /ptmp/huishao/tutorial/be/be.dat
-rw-r--r--      1 huishao  ncar         1600 Jul  7 16:27 check_max_iv
-rw-r--r--      1 huishao  ncar          313 Jul  7 16:27 cost_fn
```

  ✓ You could still produce your own analysis increment file by extracting first guess from analysis files (both in netcdf format). The advantage of using this "analysis_increment" is to avoid spurious increments (because it is generated directly from the code without including the first guess).

# Namelist - WRFVAR1

- Print_detail_*
  - .false. : Default
  - .true. : Output extra diagnostics

Example: print_detail_grad=.true.

**Iteration 19**

**Iteration 0**

```
jo_geoamv          0.118917669698E+03
jo%geoamv_u        0.371704152820E+02
jo%geoamv_v        0.817472544158E+02
jo%total           0.120493680229E+03
…
Calculate grad_v(jo) iter=    0
  cv_jb.cv_jb =    0.00000000000000E+00
  cv_je.cv_je =    0.00000000000000E+00
  xhat.xhat =    0.00000000000000E+00
  j_grad.j_grad =    0.93533513206338E+02
Calculate grad_v(j) iter=    0
  cv_jb.cv_jb =    0.00000000000000E+00
  cv_je.cv_je =    0.00000000000000E+00
  xhat_jb.xhat_jb =    0.00000000000000E+00
  xhat_je.xhat_je =    0.00000000000000E+00
  cv_xhat_jp.cv_xhat_jp = 0.00000000000000E+00
  j_grad.j_grad =    0.93533513206338E+02
```

```
Inner iteration stopped after   19 iterations

  jo_geoamv          0.985110326458E+02
  jo%geoamv_u        0.292654551874E+02
  jo%geoamv_v        0.692455774585E+02
  jo%total           0.100697022398E+03
…
Calculate grad_v(jo) iter=    19
  cv_jb.cv_jb =    0.00000000000000E+00
  cv_je.cv_je =    0.00000000000000E+00
  xhat.xhat =    0.11886920460937E+02
  j_grad.j_grad =    0.12125274158977E+02
Calculate grad_v(j) iter=    19
  cv_jb.cv_jb =    0.00000000000000E+00
  cv_je.cv_je =    0.00000000000000E+00
  xhat_jb.xhat_jb =    0.11886920460937E+02
  xhat_je.xhat_je =    0.00000000000000E+00
  cv_xhat_jp.cv_xhat_jp = 0.00000000000000E+00
  j_grad.j_grad =    0.66566955863646E-02
```
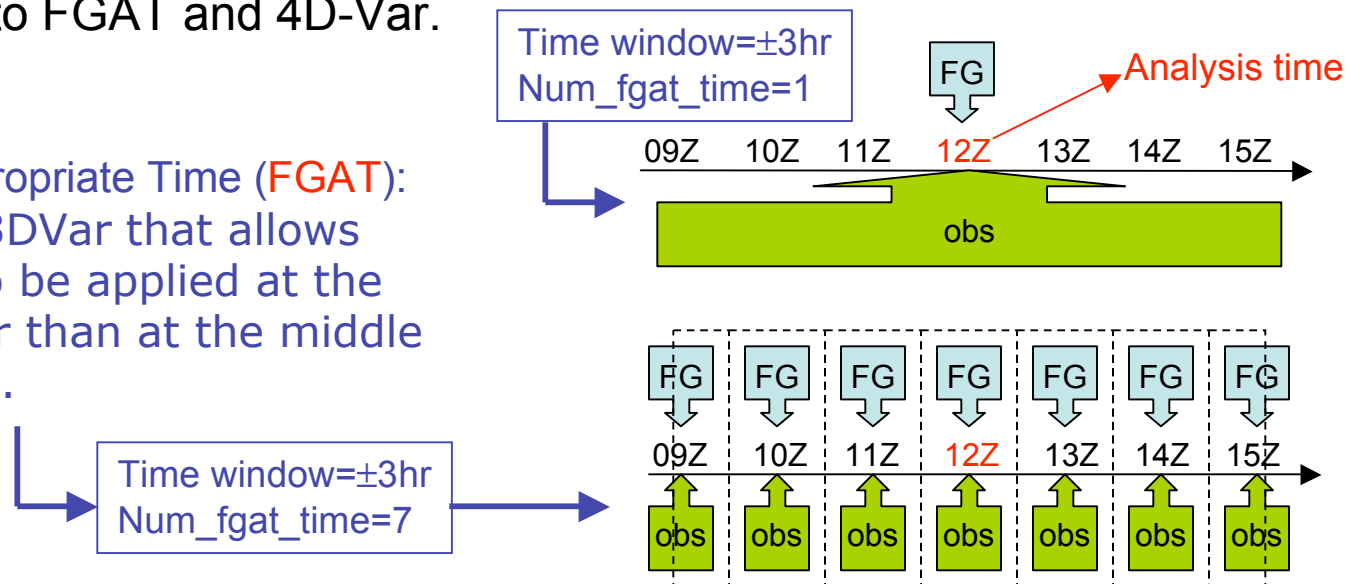
# Namelist - WRFVAR2

- Analysis_accu
  - 900 (Sec): Default.

  If |analysis time - first guess time| > Analysis_accu, WRF-Var will give a warning like "*Wrong xb time found???*".

- Write_filtered_obs
  - Not used.
  - Please refer to "analysis_type" for outputting filtered observation by WRF-Var (WRF-Var internal QC procedure).

# Namelist - WRFVAR3

- **Fg_format**: The format of the first guess of WRF-Var.
    - 1 = WRF-ARW: Default (recommended).
- **Ob_format**: The format of the conventional and satellite retrieval observation data going into WRF-Var.
    - 1 = BUFR (Please use this option with caution).
    - 2 = ASCII (ob.ascii): Default.
    - ✓ Both formats are supported by OBSPROC.
- **Num_fgat_time**: number of data time window (slot) used in WRF-Var.
    - 1 = 3DVAR: Default.
    - >1 apply to FGAT and 4D-Var.

✓ First-Guess at Appropriate Time (FGAT): An option in WRF-3DVar that allows the observations to be applied at the correct time, rather than at the middle of the time window.

# Namelist - WRFVAR4

- Use_obstype: Set to true to use particular observation types.
  - E.g, use_gpsrefobs=.true.: Assimilate GPS refractivity observations if any available in the data file.

- Use_obs_errfac: Option for using tuned observation error.
  - .false. : Default. At this moment, please use this option.
  - .true. : Use tuned observation error statistics (need to produce errfac.dat beforehand created by da_tune_obs_desrozier.f).

# Namelist - WRFVAR5

- Check_max_iv: Option for WRF-Var internal QC procedure, which is basically a maximum observation error check based on the innovations (Obs-Background).
    - .true. : default
    - .false: Use this option only if the observation data have been cleaned before going into WRF-Var.

- Put_rand_seed:
- Omb_set_rand:
- Omb_add_noise:

For observation error tuning.

# Namelist - WRFVAR5 (Cont.)

- **Obs_qc_pointer:**
  - 0 : Default, Good data.
  - ✓ For ASCII observation files generated by OBSPROC, QC flag value ranges from -88 to 88 (please refer to the latest QC flags from OBSPROC).
    - qc = -88      : Missing data
    - qc =   0      : Good data
    - qc = -77      : Outside of horizontal domain
    - qc = -15      : Wind direction <0 or > 360 degrees
    - qc = -14      : Negative wind speed vector norm
    - qc = -13      : Null wind speed vector norm
    - qc = -12      : Spike in the wind profile
    - qc = -11      : Null temperature or dew point
    - qc = -10      : Superadiabatic temperature
    - qc =  -9      : Spike in Temperature profile
    - qc =  -8      : Height higher than model lid's height
    - qc =  -5      : h,p or T from  standard atmosphere
    - qc =  -4      : h,p or T from background
    - qc =   1      : convective adjustement correction
    - qc =   2      : surface_correction
    - qc =   3      : Height recovery from hydrostaic + OBS
    - qc =   4      : Height recovery from reference + OBS
    - qc =  88      : Any other check

  - ✓ For PREBUFR observation files generated by OBSPROC, qc = 0 indicates the best quality (please refer to the latest QC flags from OBSPROC).
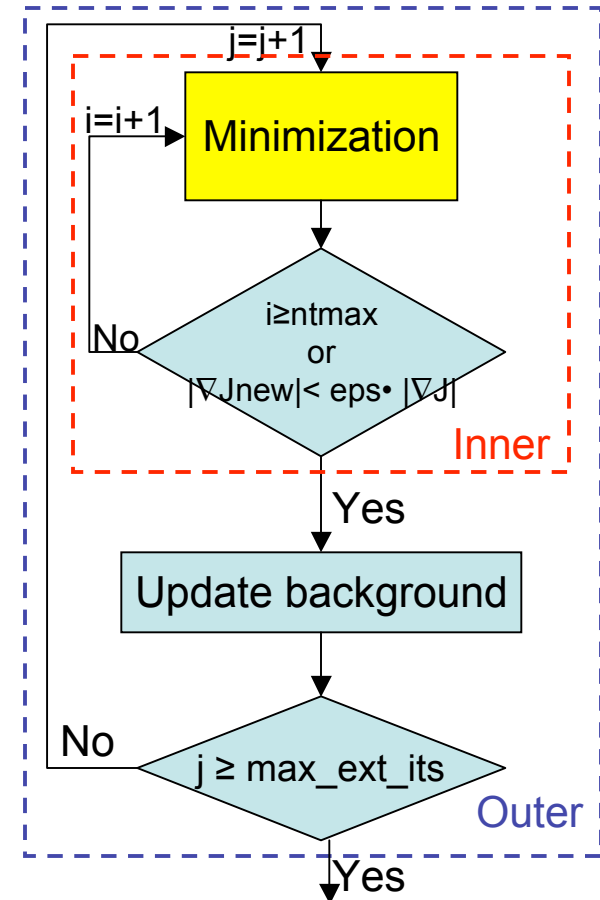
# Namelist - WRFVAR5 (Cont.)

- Max_obstype_input: Set to restrict the maximum number of observations used in each type.
  - The restriction is applied when the observations are read, and applies to the total number of observations across all processors before quality control.
  - E.g., max_sound_input=5000: the maximum number of radiosondes is 5000.
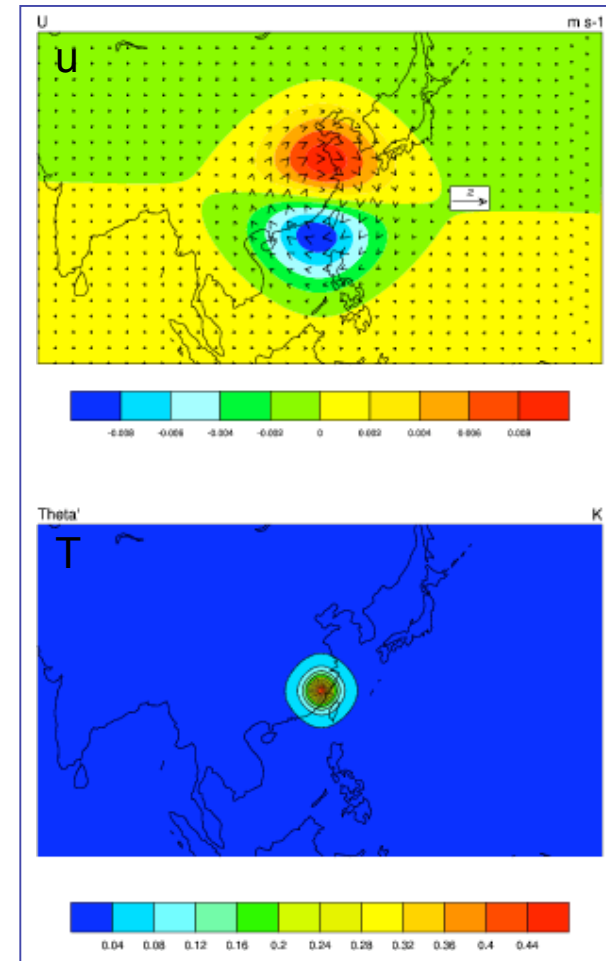
# Namelist - WRFVAR6

The following namelist variables are for
minimization options:

- Max_ext_its: Number of outer loops.
  - 1: Default. Only one outer loop.
  - Currently, maximum outer loop number is 10.

- Ntmax: Maximum number of iterations in an inner loop for the minimization in WRF-Var.
  - 200: Default. The minimization in the inner loop can not exceed 200.

- Eps: Value for minimization convergence criterion. It is an array with the dimension=max_ext_its.
  - 0.01(max_ext_its): The minimization is considered to converge when the norm of the cost function gradient is reduced at least 2 orders.

# Namelist - WRFVAR7

- **Rf_passes**: number of passes of recursive filter used in WRF-Var to define the horizontal correlation shape of background errors.

- **Var_scaling1(2,…5)**: The tuning factor of background error covariance for control variables.
  - ✓ Control variables:
    — 1: stream function
    — 2: unbalanced potential velocity
    — 3: unbalanced pressure
    — 4: pseudo relative humidity
    — 5: Unbalanced pressure

- **Len_scaling1(2,…5)**: The tuning factor of scale-length for control variables.



An example of pseudo single observation test (PSOT)

# Namelist - WRFVAR8

- Used for debugging purposes.

# Namelist - WRFVAR9

- Stdout : 6 (default). Unit number for standard output.
- Stderr : 0 (default). Unit number for error output.
- Warnings_are_fatal: .false.(default). If true, warning messages that would normally allow the program to continue are treated as fatal errors.

# Namelist - WRFVAR9 (Cont.)

The following namelist variables are for tracing:

Tracing gives additional diagnostics about program runs. It does not change results, but does slow the program down, so should be disabled in production environments.

- Trace_use: .true. (default). Use tracing function in WRF-Var if true.

- Trace_unit : Unit number for tracing output.

    - Units 9 and 10 are reserved for reading and writing namelist.input and namelist.output.

- Trace_pe : 0 (default). Currently, statistics are always calculated for all processors, and output by processor 0.

- Trace_all_pes: .false. (default). Trace is output for all pes. As above, this does not change processor statistics.

Trace Output

    * Calling Tree
    * Local routine timings
    * Overall routine timings
    * Memory usage

# Namelist - WRFVAR9 (Cont.)

• Trace_repeat_head & trace_repeat_body: 10 (default). The number of times any trace statement will produce output for any particular routine.

  ✓This stops the trace output being overwhelmed when a routine is called multiple times. Once this limit is reached a 'going quiet' message is written to the trace file, and no more output is produced from the routine, though statistics are still gathered.

• Trace_max_depth: Define the deepest level to which tracing writes output.

  - 30 : Default, which means effectively unlimited.

• Trace_memory: .true. (default). If true, calculate allocated memory using a mallinfo call.

  ✓On some platforms (Cray and Mac), mallinfo is not available and no memory monitoring can be done.

• Trace_csv: .true. (default). The tracing statistics are written to a xxxx.csv file in CSV format.

• Use_html: .true. (default). If true, the tracing and error reporting routines will use HTML tags.

---

Trace Output

  * Calling Tree
  * Local routine timings
  * Overall routine timings
  * Memory usage

→

Maximum memory usage for routines

| Routine | Max in any PE (kbytes) | Overall (kbytes) | Average per PE (kbytes) |
|---|---|---|---|
| da_transfer_xatoanalysis | 508076 | 15803513 | 493859 |
| da_transfer_xatowrf | 508076 | 15803513 | 493859 |
| da_write_increments | 508076 | 15803513 | 493859 |
| da_deallocate_observations | 506698 | 15761784 | 492555 |
| da_deallocate_y | 506392 | 15756018 | 492375 |

# Namelist - WRFVAR10

- Test_transforms:
  - .false. (default): Run data assimilation.
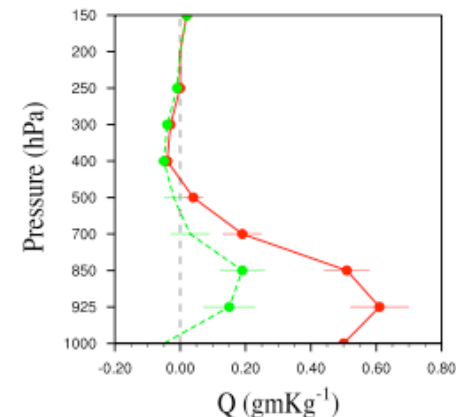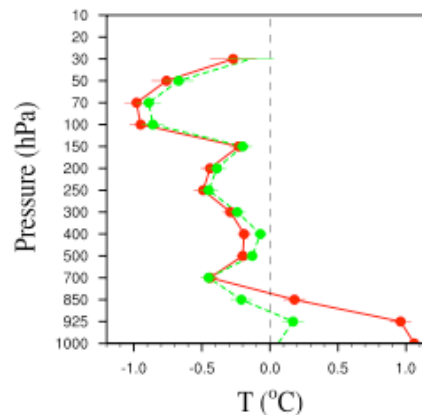  - .true.: Perform adjoint check for the code debugging.

# Namelist - WRFVAR11

- Cv_options_hum:
  - 1 (default): Please do not change.

- Check_rh:
  0 : No supersaturation check after minimization.
  1: With the supersaturation (rh> 100%) and minimum rh (rh<10%) check, and make the local adjustment of q.
  2 (default): With the supersaturation (rh> 95%) and minimum rh (rh<11%) check, and make the multi-level q adjustment under the constraint of integrated water vapor in column conserved.

# Namelist - WRFVAR11 (Cont.)

- Set_omb_rand_fac
- Seed_array1
- Seed_array2

For ensemble perturbation purpose.

- Sfc_assi_options:
  - 1 (default): The surface observations will be assimilated based on the lowest model level first guess (therefore, the innovation vector are modified).
  - 2: The surface observations will be assimilated based on surface similarity theory in PBL. Innovations are computed based on 10-m wind and 2-m temperature & moisture.

✓Please use this option with caution, since the results could be very sensitive.

# Namelist - WRFVAR11 (Cont.)

- Calculate_cg_cost_fn:
  - .false. : Only the initial and final cost functions are computed and output.
  - .true. : The cost functions are computed and output (cost_fn) at every iteration for diagnostic purpose.

  ✓ The conjugate gradient algorithm for the minimization does not require the computation of cost function at every iteration.

  ✓ The cost function gradient values will be output (grad_fn) at every iteration as well if this option is set true.

| Outer Iter | EPS | Inner Iter | J | Jb | Jo | Jc | Je | Jp |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.100E-01 | 0 | 11251.182 | 0.000 | 11251.182 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 19 | 8634.570 | 885.427 | 7749.143 | 0.000 | 0.000 | 0.000 |

| Outer Iter | EPS | Inner Iter | J | Jb | Jo | Jc | Je | Jp |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.100E-01 | 0 | 11251.182 | 0.000 | 11251.182 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 1 | 10384.156 | 41.768 | 10342.388 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 2 | 9633.557 | 184.109 | 9449.448 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 3 | 9245.700 | 327.121 | 8918.579 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 4 | 9014.861 | 453.787 | 8561.075 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 5 | 8872.989 | 559.714 | 8313.275 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 6 | 8777.974 | 652.105 | 8125.869 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 7 | 8720.998 | 721.735 | 7999.263 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 8 | 8689.342 | 768.464 | 7920.878 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 9 | 8665.605 | 810.136 | 7855.469 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 10 | 8654.051 | 833.590 | 7820.461 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 11 | 8646.376 | 851.091 | 7795.285 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 12 | 8641.869 | 862.515 | 7779.355 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 13 | 8638.219 | 872.853 | 7765.365 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 14 | 8636.669 | 877.707 | 7758.962 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 15 | 8635.794 | 880.667 | 7755.127 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 16 | 8635.176 | 882.929 | 7752.247 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 17 | 8634.861 | 884.169 | 7750.693 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 18 | 8634.686 | 884.909 | 7749.777 | 0.000 | 0.000 | 0.000 |
| 1 | 0.100E-01 | 19 | 8634.570 | 885.427 | 7749.143 | 0.000 | 0.000 | 0.000 |

The following namelist variables are related to Background Error (BE) computation and should be consistent to those in BE file (be.dat) computed from GEN_BE (**July 22: BE talk**).

# Namelist - WRFVAR11

- Lat_stats_option: .False. (default). Only set it true when be.dat is computed with i-dependence (approximately latitude-dependence) .

# Namelist - WRFVAR13

- Vert_corr: 2 (default). Please do not change it at this moment.
- Vert_evalue: 1 (default). Please do not change it at this moment.
- Max_vert_var1(2,…5): Maximum truncation value (percentage) used in the vertical    eigenvector decomposition in BE calculation.
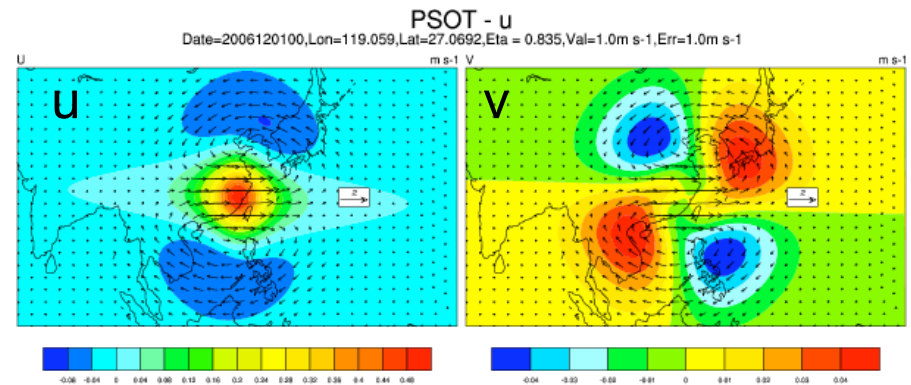
# Namelist - WRFVAR14

- Namelist options for radiance data assimilation (not supported).
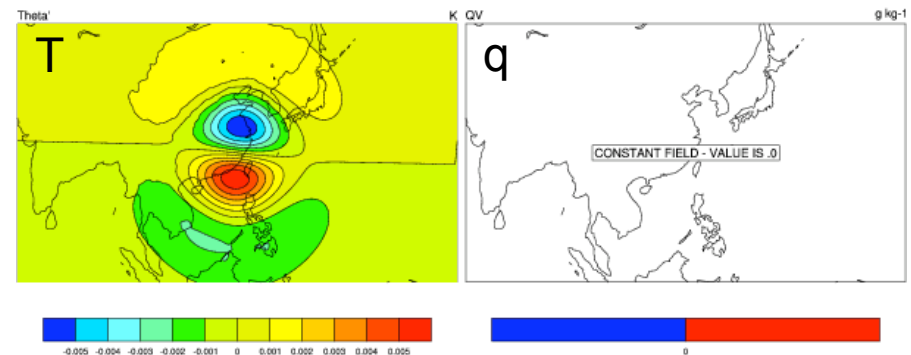
# Namelist - WRFVAR15

- **num_pseudo** = 0 (default),
  Set the number of pseudo observations. Currently only the value of 1
  is allowed, i.e. num_pseudo = 1 --- the SINGLE-OBS test.
- **pseudo_x** = 1.0 (default),
  Set the x-position (J) of the OBS in unit of grid-point.
- **pseudo_y** = 1.0 (default),
  Set the y-position (I) of the OBS in unit of grid-point.
- **pseudo_z** = 1.0 (default),
  Set the z-position (ZK) of OBS with the vertical level index.
  In MM5, the top level has z=1, and bottom level, z=kx.
- **pseudo_val** = 1.0 (default),
  Set the innovation of the OBS variable:
  u/v at m/s, p at Pa, t at degree,
  and q at kg/kg.
- **pseudo_err** = 1.0 (default),
  Set the OBS error of the OBS variable.

The namelist variables here are for pseudo single-observation test (**PSOT**) (**July 22: Single ob experiment talk**).



PSOT - u
Date=2006120100,Lon=119.059,Lat=27.0692,Eta = 0.835,Val=1.0m s-1,Err=1.0m s-1

# Namelist - WRFVAR19

- **pseudo_var** = 't' (default)
  Set the name of the OBS variable:
  'u' = X-direction component of wind,
  'v' = Y-direction component of wind,
  't' = Temperature,
  'p' = Pressure,
  'q' = Specific humidity,
  'pw' = Total precipitable water,
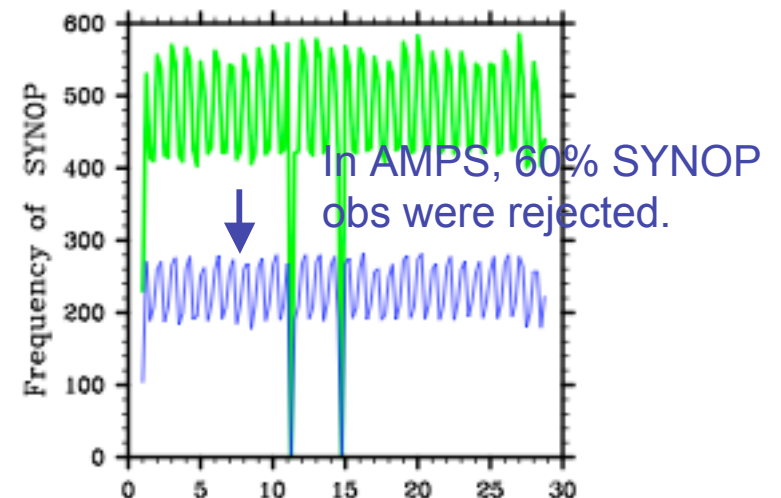  'ztd' = Zenith tropospheric delay,
  'ref' = Refractivity

# Namelist - WRFVAR16

- For hybrid WRF-Var/Ensemble data assimilation option (Not supported).

# Namelist - WRFVAR17

- Analysis_type: Indicate job type of WRF-Var.
  - 3D-VAR (default): Run 3D-Var data assimilation.
  - VERIFY: Run WRF-Var verification mode ( then Check_max_iv=.false. and ntmax=0 by default).
  - ✓ **July 22: WRF-Var tools Talk.**
  - QC-OBS: Run WRF-Var QC procedure.
  - ✓ By combined with Check_max_iv=.true. and ntmax=0, you can produce a WRF-Var filtered (QCed) observation data set (filtered_obs) without running the data assimilation.

➢ 1st screen/QC procedure performed by observation preprocessor (OBSPROC).
➢ 2nd screen/QC procedure performed in WRF-Var.
➢ Main impact of 2nd screen/QC is on surface observations*.
➢ Rejection rates will reduce with higher resolution, higher-order interpolation.

In AMPS, 60% SYNOP obs were rejected.

* Surface observation rejection here is mostly due to surface elevation check with sfc_assim_options=1. Such a rejection may be bypassed by using sfc_assim_options=2.

# Namelist - WRFVAR17

- Analysis_date: Specify the analysis time. It should be consistent with the first guess time (check analysis_accu).

# Namelist - WRFVAR21/22

- Time_window_min(max): Specify the lower (upper) time values of the assimilation time window.
  - These two values do not have any impact on the observation data (GTS) processed through OBSPROC, since OBSPROC already conducts time check and bundles the observation data within same time window into one file.
  - The radiance data do not go through OBSPROC currently and require the setup of these two variables.

# Namelist - WRFVAR23

- The namelist variables are related 4D-Var enhanced by adding a penalty term, JcDFI to control the high-frequency gravity waves using a digital filter (Not supported).