Observation Preprocessor for WRF-Var

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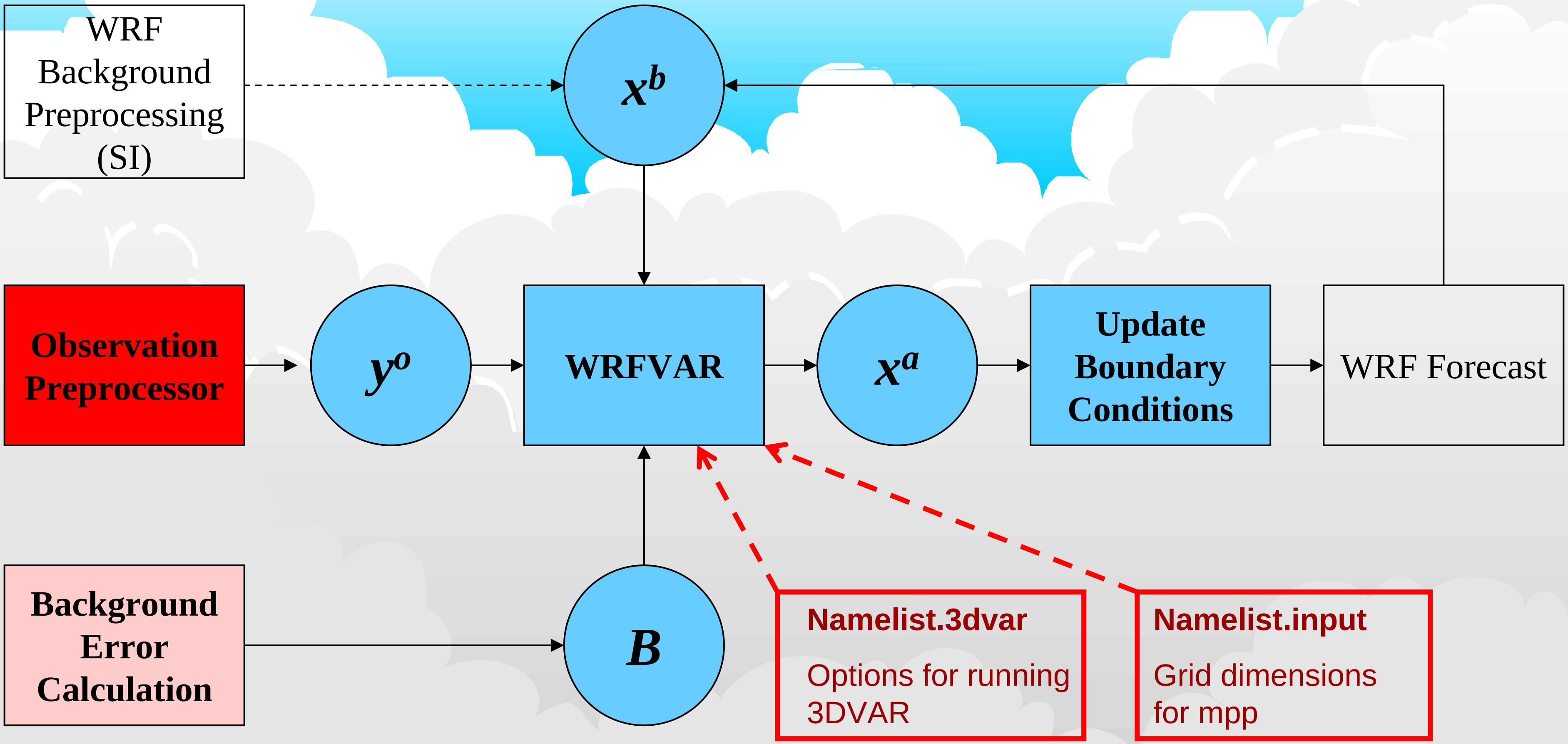
WRF-Var in the WRF Modeling System



The observations are one of the important input files for WRF-Var, no observations will be no data assimilation.

The data format of observations accepted by WRF-Var

1. **Official format: BUFR --- International WMO standard format**

   not fully tested in WRF-Var,

   ob_format = 1 in WRF-Var

2. **ASCII format --- for research and operational:**

   Current working format,

   ob_format = 2 in WRF-Var

   fully supported

   **** Radar OBS (Radial velocity and reflectivity) processing not included here (but the data file format provided below).**

Web sites for 3DVAR_OBSPROC

The 3DVAR OBS preprocessor program can be obtained from:

http://www.mmm.ucar.edu/wrf/WG4/wrfvar/wrfvar-tutorial.htm

Click "*b) The 3D-Var Observation Preprocessor (3DVAR_OBSPROC)*"

The presentation for this 3DVAR preprocessor can be found from:

http://www.mmm.ucar.edu/people/guo/individual_guo/OBSPROC/Slide1.html

The files inputted to and Outputted from 3DVAR_OBSPROC are ASCII files.

Advantages of ASCII format observations

- The ***input file*** to 3DVAR_OBSPROC is the MM5/LITTLE_R format.

  Anyone who is familiar with MM5 modeling system should be familiar with the MM5/LITTLE_R format.

  This is a report-based format, so all types of the observation data can be easily '*cat*'ted together to form a monolithic file.

  It is easily to read, edit,…. with an ASCII file.

- The ***output file*** from observation preprocessor, 3DVAR_OBSPROC program is still an ASCII file. It is easily manipulated for specific purposes of research, such as single point data tests, etc.

- Users' duty is just to convert their own observations in any format to the MM5/LITTLE_R format. Then that data can be processed by 3DVAR_OBSPROC, and assimilated with WRF-Var system.

Disadvantages of ASCII format observations

The size of the observation file is larger in compared with the WMO BUFR format file, not suitable for the remote sensing data, such as Radiance, etc.

Input OBS (LITTLE_R) file to preprocessor

- *OBS decoded file* in LITTLE_R format containing *Reports*
- *Report* containing *Records (header, data,…, and ending*) *and 3 tail integers* (3I7)
- *Record* containing *fields*
  - The *fields* in the *header record* (Fortran format in parenthesis)
  - The *fields* in the *data record* (Fortran format in parenthesis)
  - The *fields* in the *ending record*

No	Field	No	Filed	No	Field
1	Latitude (f20.5)	2	Longitude (f20.5)	3	ID (a40)
4	Name (a40)	5	Platform (a40)	6	Source (a40)
7	Elevation (f20.5)	8	Num_vld_fld (i10)	9	Num_error (i10)
10	Num_warning (i10)	11	Seq_num (i10)	12	Num_dupd (i10)
13	Is_sound (L10)	14	Bogus (L10)	15	Discard (L10)
16	Valid_time%sut (i10)	17	Valid_time%julian (i10)	18	Valid_time%date_char(a20)
19	Slp%data (f13.5)	20	Slp%qc (i7)	21	Ref_pres%data (f13.5)
22	Ref_pres%qc (i7)	23	Ground_t%data (f13.5)	24	Ground_t%qc (i7)
25	SST%data (f13.5)	26	SST%qc (i7)	27	Psfc%data (f13.5)
28	Psfc%qc (i7)	29	Precip%data (f13.5)	30	Precip%qc (i7)
31	T_max%data (f13.5)	32	T_max%qc (i7)	33	T_min%data (f13.5)
34	T_min%qc (i7)	35	T_min_night%data (f13.5)	36	T_min_night%qc (i7)
37	P_tend03%data (f13.5)	38	P_tend03%qc (i7)	39	P_tend24%data (f13.5)
40	P_tend24%qc (i7)	41	Cloud_cvr%data (f13.5)	42	Cloud_cvr%qc (i7)
43	Celling%data (f13.5)	44	Celling%qc (i7)	45	Pw%data (f13.5)
46	Pw%qc (i7)	47	Tb19v%data (f13.5)	48	Tb19v%qc (i7)
49	Tb19h%data (f13.5)	50	Tb19h%qc (i7)	51	Tb22v%data (f13.5)
52	Tb22v%qc (i7)	53	Tb37v%data (f13.5)	54	Tb37v%qc (i7)
55	Tb37h%data (f13.5)	56	Tb37h%qc (i7)	57	Tb85v%data (f13.5)
58	Tb85v%qc (i7)	59	Tb85h%data (f13.5)	60	Tb85h%qc

The fields in the data record (Fortran format in parenthesis)

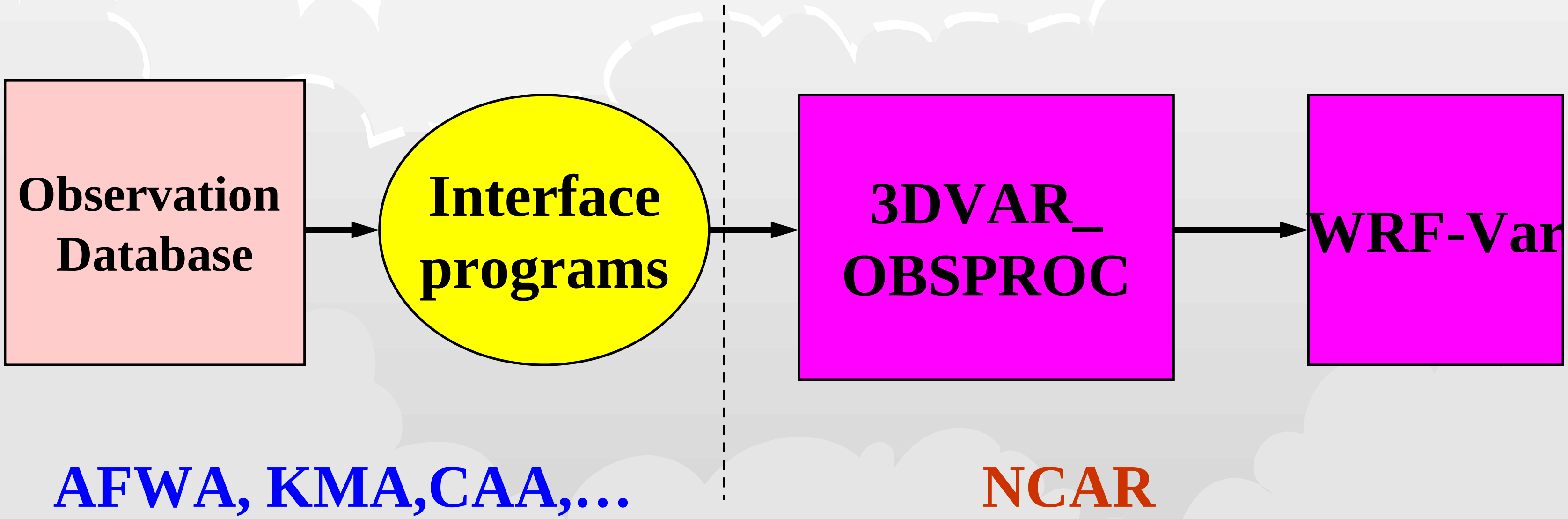
No	Field	No	Field
1	Pressure%data (f13.5)	2	Pressure%qc (i7)
3	Height%data 9f13.5)	4	Height%qc (i7)
5	Temperature%data (f13.5)	6	Temperature%qc (i7)
7	Dew_point%data (f13.5)	8	Dew_point%qc (i7)
9	Speed%data (f13.5)	10	Speed%qc (i7)
11	Direction%data (f13.5)	12	Direction%qc (i7)
13	U%data (f13.5)	14	U%qc (i7)
15	V%data (f13.5)	16	V%qc (i7)
17	RH%data (f13.5)	18	RH%qc (i7)
19	Thickness%data (f13.5)	20	Thickness%qc (i7)

The fields in the ending record

No	field	No	field	No	field	No	field
1	-777777.00000	2	0	3	-777777.00000	4	0
5	-888888.00000	6	0	7	-888888.00000	8	0
9	-888888.00000	10	0	11	-888888.00000	12	0
13	-888888.00000	14	0	15	-888888.00000	16	0
17	-888888.00000	18	0	19	-888888.00000	20	0

Interface programs in AFWA, KMA, CAA,..

- Interface programs to convert the data format from AFWA, KMA, CAA,… observation database to MM5/LITTLE_R format to provide the OBS file to WRF-Var OBS preprocessor



- In NCAR, MM5 Utility ***fetch.csh*** will obtain the OBS data file in LITTLE_R format from NCAR archive.

Why do we need the OBS preprocessor?

To prepare the OBS data file suitable for WRF-Var needs

- Clean out the unnecessary information for WRF-Var, and keep the necessary information for WRF-Var assimilation

  For example (Typhoon Sam case 1999081912Z),
  LITTLE_R obs file : 40425051 bytes,
  3DVAR obs file : 3934484 bytes)

- Save the OBS data processing time, *one OBS file* can be repeatedly used for multiple times of WRF-Var experiments.

- The output file from 3DVAR_OBSPROC is still to be an ACSII format for easy manipulation (read, check, and edit), especially for research purpose.

Tasks of the OBS preprocessor: 3DVAR_OBSPROC

1, To perform a time-windowed and, in case of regional application (domain_check_h = .TRUE.), geographically-filtered dump of the ingested observations

Currently, there is *no time-check for observation data in WRF-Var assimilation code*, so to select the observation data within a suitable time-window must be performed in 3DVAR_OBSPROC.

For the regional application with the IPROJ = 1 (Lambert conformal), 2 (Polar Stereographic), or 3 (Mercator), there is a geographic-filtered performed based on the model domain settings. For the global application with the IPROJ = 0, no geographic-filtered is performed.

Tasks of the OBS preprocessor: 3DVAR_OBSPROC (cont.)

2, To retrieve the pressure or height based on the observed information with the hydrostatic assumption

3, To remove the duplicate reports of observations

4, To re-order (from bottom to top) and merge the data reports with the same platform, time, and location based on the pressure.

5, To discard the data above the model top ($p<p_{top}$) in the upper-air observations (remove_above_lid = .TRUE.)

Tasks of the OBS preprocessor: 3DVAR_OBSPROC (cont.)

6, To assign the observation errors to the different types of observations

Observations errors

→ NCEP OBS error (Parrish and Derber 1992)

→US Air Force (AFWA) OBS error file

→Directly from the observation reports

7, To perform the vertical consistency check and super adiabatic check for the multi-level observations

Tasks of the OBS preprocessor: 3DVAR_OBSPROC (cont.)

8, To complete thinning with the SATOB, SSMI, and QSCAT data

The data points nearest to the model grid-points will be picked up for assimilation.

9, To write out the OBS files in ASCII format as the WRF-Var input

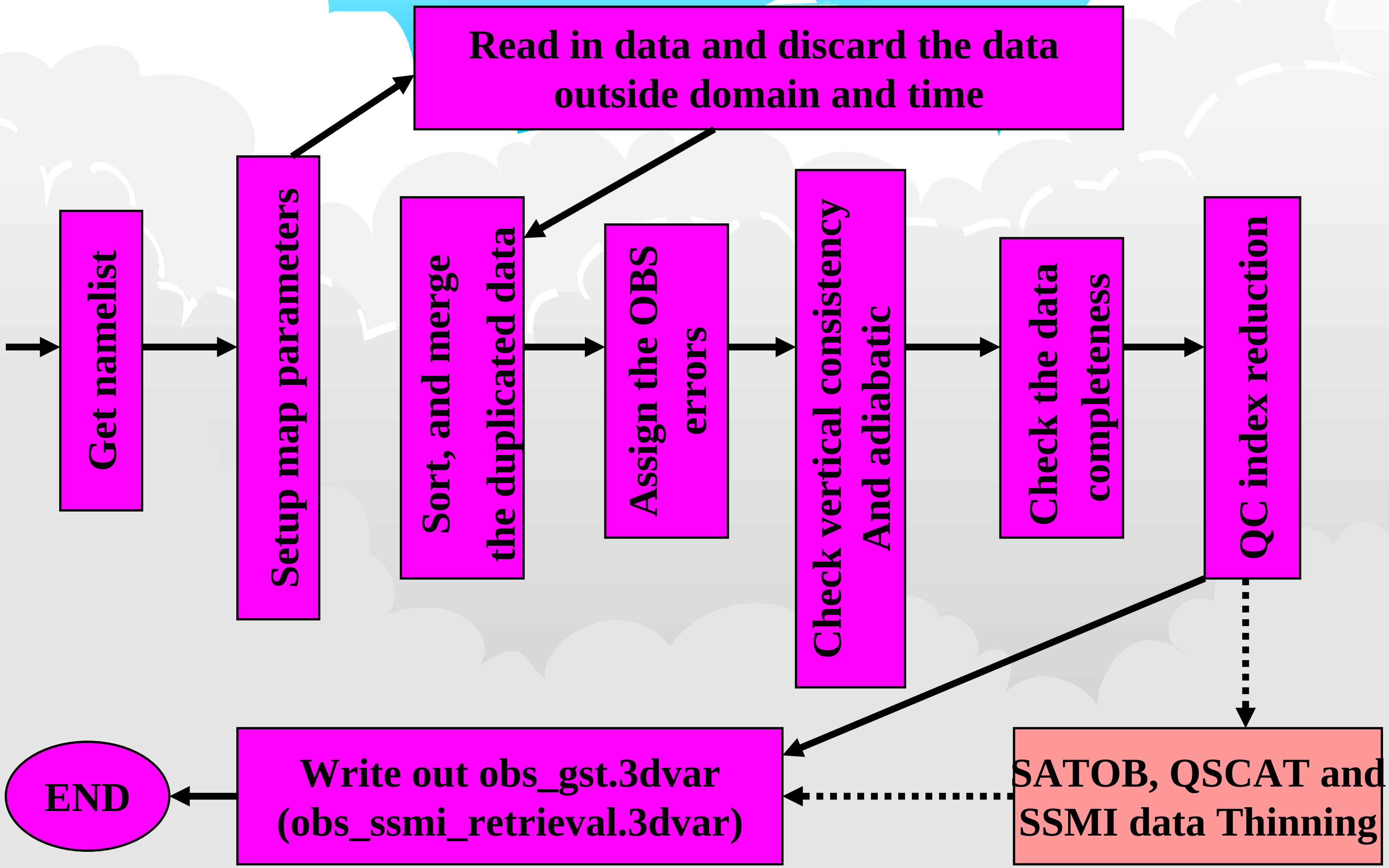
→ GTS data (*obs_gts.3dvar*): pressure, Wind, height, temperature, dewpoint, RH, etc.

→ SSMI data (*obs_ssmi_retrieval.3dvar*): PW and surface wind speed

10, To plot the distribution for each type of observations

→MAP_plot

Flow chart of OBS preprocessor



Types of observations to be processed

→18 types (SYNOP, SHIPS, METAR, TEMP, AIREP, PILOT, AMDAR, PROFL, SATOB, SATEM, SSMT1, SSMT2, SSMI, GPSPW, GPSZD, GPSRF, QSCAT, BOGUS)

(* Radar radial velocity and reflectivity)

WMO code for each type of observations

Name	WMO code	WMO code name
SYNOP	12, 14	SYNOP, SYNOP MOBIL
SHIP	13	SHIP
METAR	15, 16	METAR, SPECI
PILOT	32, 33, 34	PILOT, PILOT SHIP, PILOT MOBIL
SOUND	35, 36, 37, 38	TEMP, TEMP SHIP, TEMP DROP, TEMP MOBIL
AMDAR	42	AMDAR
SATEM	86	SATEM
SATOB	88	SATOB
AIREP	96, 97	AIREP
GPSPW	111	GPSPW (Ground-based GPS precipitable water)
GPSZD	114	GPSZD (Ground-based GPS Zenith Total Delay)
GPSRF	116	GPSRF (Space-based GPS Refractivity)
SSMT1	121	SSMT1
SSMT2	122	SSMT2
SSMI	125	SSMI
PROFL	132	WIND PROFILER
BOGUS	135	TCBOU (Typhoon bogus), BOGUS (other bogus)
QSCAT	281	Quik SCAT level-2B SeaWind
OTHER		UNKNOWN

Input and output files for OBS preprocessor

3 *Input files*

- OBS decoded file (Reports) in little_r format

  A report (F90 pointer linking structure)
  - header record (fields)
  - Level*1* data record (fields)

    …………………
  - Level*n* data record (fields)
  - Ending record (fields)
  - 3 Integers in format(3i7)

- Namelist file (*namelist.3dvar_obs*) (See: README.namelist)

  Record1: input file names
  Record2: analysis times
  Record3: Maximum number of observations allowed
  Record4: quality control switches
  Record5: print switches
  Record6: define the reference state: ptop, etc.
  Record7: Geographic parameters
  Record8: Domain settings

- AFWA OBS errors file: *obserr.txt* (provided by 3DVAR system)

Output files

1, Obs_gts.3dvar **and** ***obs_ssmi_retrieval.3dvar***

Header: the information for this OBS file and data format

Data : *header* record and *data* records for each of levels

- These are the OBS input file to WRF-Var program
- obs_ssmi_retrieval.3dvar needed only when SSMI retrieval data available
- These files can be used as input to MAP_plot to obtain the gmeta plot file with NCAR GRAPHICS

2, 3dvar_obs.out ---- a program execution log file

The printing out from the program execution. It can used to monitor the execution and to identify the troubles if any

3, Diagnostic files depended on the print switches in namelist

File: obs_gts.3dvar

```
TOTAL =   8169, MISS. =-888888.,
SYNOP =   1432, METAR =    164, SHIP  =     86, BUOY  =      0, TEMP  =    179, AMDAR =      0,
AIREP =    265, PILOT =      0, SATEM =      0, SATOB =   6043, GPSPW =      0, SSMT1 =      0,
SSMT2 =      0, TOVS  =      0, QSCAT =      0, PROFL =      0, OTHER =      0,
PHIC  =  28.50, XLONC = 116.00, TRUE1 =  10.00, TRUE2 =  45.00, XIM11 =   1.00, XJM11 =   1.00,
TS0   = 275.00, TLP   =  50.00, PTOP  =  7000., PS0   =100000.,
IXC   =     67, JXC   =     81, IPROJ =      1, IDD   =      1, MAXNES=     10,
NESTIX=     67,     67,     67,     67,     67,     67,     67,     67,     67,     67,
NESTJX=     81,     81,     81,     81,     81,     81,     81,     81,     81,     81,
NUMC  =      1,      1,      1,      1,      1,      1,      1,      1,      1,      1,
DIS   = 135.00,   0.00,   0.00,   0.00,   0.00,   0.00,   0.00,   0.00,   0.00,   0.00,
NESTI =      1,      1,      1,      1,      1,      1,      1,      1,      1,      1,
NESTJ =      1,      1,      1,      1,      1,      1,      1,      1,      1,      1,
INFO  = PLATFORM, DATE, NAME, LEVELS, LATITUDE, LONGITUDE, ELEVATION, ID.
SRFC  = SLP, PW (DATA,QC,ERROR).
EACH  = PRES, SPEED, DIR, HEIGHT, TEMP, DEW PT, HUMID (DATA,QC,ERROR)*LEVELS.
INFO_FMT = (A12,1X,A19,1X,A40,1X,I6,3(F12.3,11X),6X,A5)
SRFC_FMT = (F12.3,I4,F7.2,F12.3,I4,F7.2)
EACH_FMT = (3(F12.3,I4,F7.2),11X,3(F12.3,I4,F7.2),11X,1(F12.3,I4,F7.2)))
#------------------------------------------------------------------------------#
FM-35 TEMP   1999-08-19_11:00:00  AHMADABAD / INDIA                          17      23.070             72.630             55.000             42647
 -888888.000 -88 200.00 -888888.000 -88   0.20
  100000.000   0 100.00       3.000   0   1.10     225.000   0   5.00            53.000   0   7.00     305.550   0   1.00     298.550   0   1.00              65.984   0  15.00
   92500.000   0 100.00       3.000   0   1.10     220.000   0   5.00           745.000   0   7.48     300.550   0   1.00     295.550   0   1.00              73.714   0  12.60
   91600.000   0 100.00 -888888.000 -88   1.10 -888888.000 -88   5.00           830.000   0   7.54     300.150   0   1.00     295.150   0   1.00              73.653   0  12.30
   87300.000   0 100.00 -888888.000 -88   1.10 -888888.000 -88   5.00          1251.000   0   7.84     297.350   0   1.00     291.350   0   1.00              68.712   0  10.82
   85000.000   0 100.00       6.000   0   1.10     250.000   0   5.00          1498.000   0   8.00     295.350   0   1.00     290.750   0   1.00              74.809   0  10.00
   79200.000   0 100.00 -888888.000 -88   1.13 -888888.000 -88   5.00          2104.000   0   8.22     290.750   0   1.00     288.550   0   1.00              86.755   0  10.00
   78000.000   0 100.00 -888888.000 -88   1.18 -888888.000 -88   5.00          2238.000   0   8.27     292.950   0   1.00     281.950   0   1.00              48.599   0  10.00
   70700.000   0 100.00 -888888.000 -88   1.39 -888888.000 -88   5.00          3076.000   0   8.57     289.950   0   1.00     268.950   0   1.00              23.245   0  10.00
   70000.000   0 100.00       2.000   0   1.40      30.000   0   5.00          3168.000   0   8.60 -888888.000 -11   1.00 -888888.000 -11   1.00         -888888.000 -11  10.00
   61100.000   0 100.00 -888888.000 -88   1.76 -888888.000 -88   5.00          4312.000   3  10.01     282.350   0   1.00     271.350   0   1.00              45.937   0  10.00
   60000.000   0 100.00 -888888.000 -88   1.80 -888888.000 -88   5.00          4463.000   3  10.20     281.350   0   1.00     272.350   0   1.00              52.920   0  10.00
   57400.000   0 100.00 -888888.000 -88   1.90 -888888.000 -88   5.00          4828.000   3  10.66     279.150   0   1.00     274.150   0   1.00              70.188   0  10.00
   52700.000   0 100.00 -888888.000 -88   2.14 -888888.000 -88   5.00          5526.000   3  11.55     275.550   0   1.00     272.650   0   1.00              81.128   0  10.00
   50300.000   0 100.00 -888888.000 -88   2.28 -888888.000 -88   5.00          5902.000   3  12.04     273.350   0   1.00     269.650   0   1.00              76.187   0  10.00
   50200.000   0 100.00 -888888.000 -88   2.29 -888888.000 -88   5.00          5918.000   3  12.06     273.150   0   1.00     269.450   0   1.00              76.157   0  10.00
   50000.000   0 100.00       3.000   0   2.30      95.000   0   5.00          5950.000   0  12.10     272.850   0   1.00     269.250   0   1.00              76.682   0  10.00
   46900.000   0 100.00       2.000   0   2.42     100.000   0   5.00          6461.000   3  12.90     270.450   0   1.00     266.250   0   1.00              72.904   0  10.00
FM-35 TEMP   1999-08-19_11:00:00  BOMBAY / SANTACRUZ / INDIA                 25      19.120             72.850             14.000             430
…………………………………………………………
```

← # of observations

← Model domain information

← Data format

How to plot the OBS distribution?

- Go to the directory *3DVAR_OBSPROC/MAP_plot*
- Modify the shell script *Map.csh*
  - » To fill in *TIME_ANALYSIS*, etc., and *OBSDATA* file name
- Run shell script *Map.csh*
  - » You will have a gmeta file: *gmeta.${TIME_ANALYSIS}* to show the the distribution of observations contained in *OBSDATA* file.

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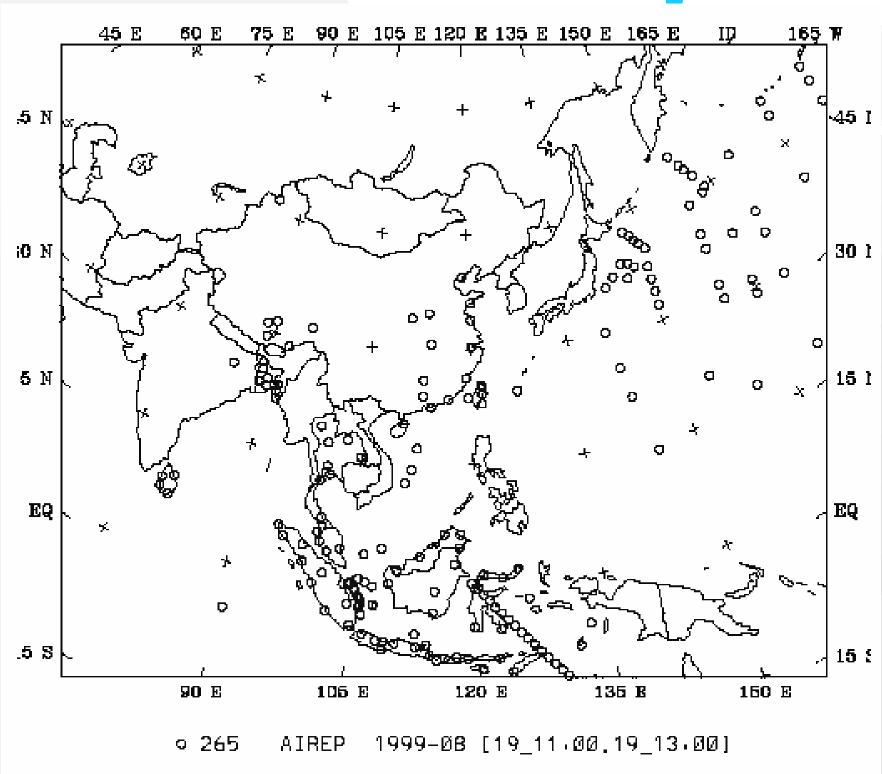
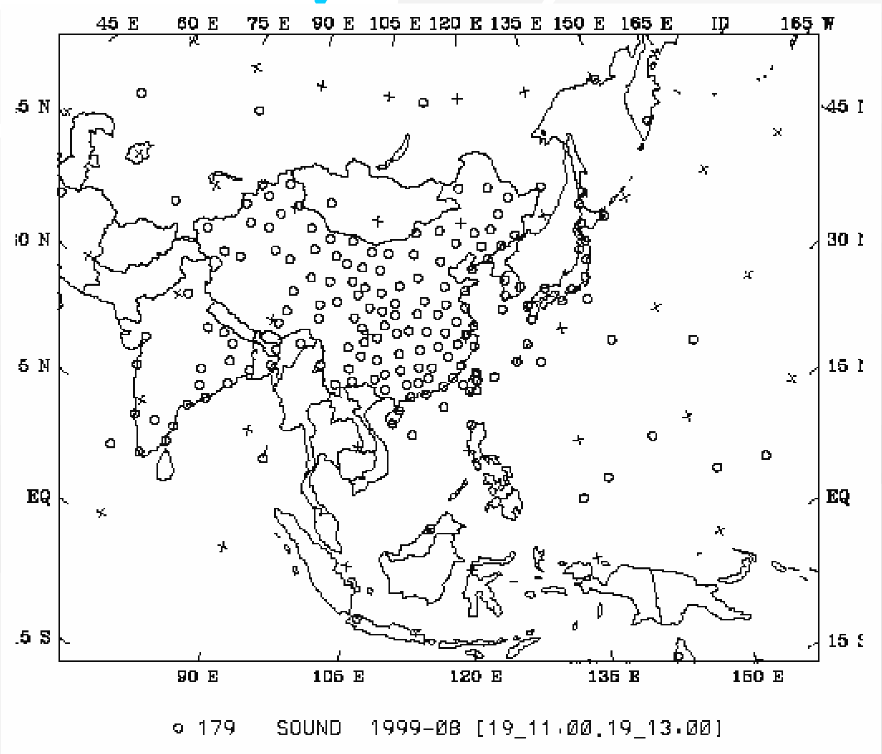
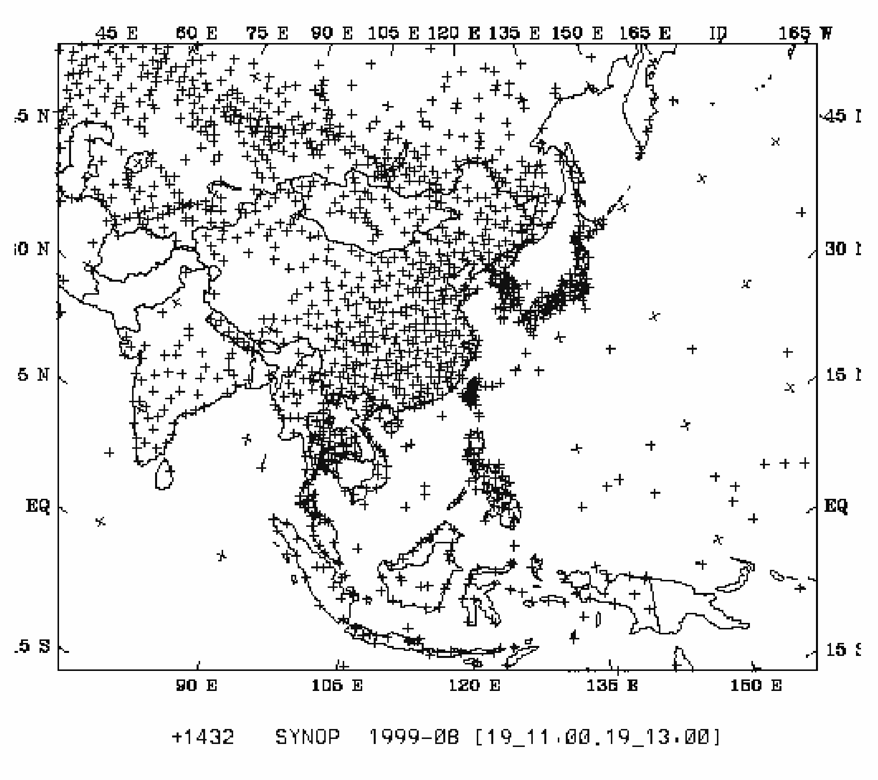
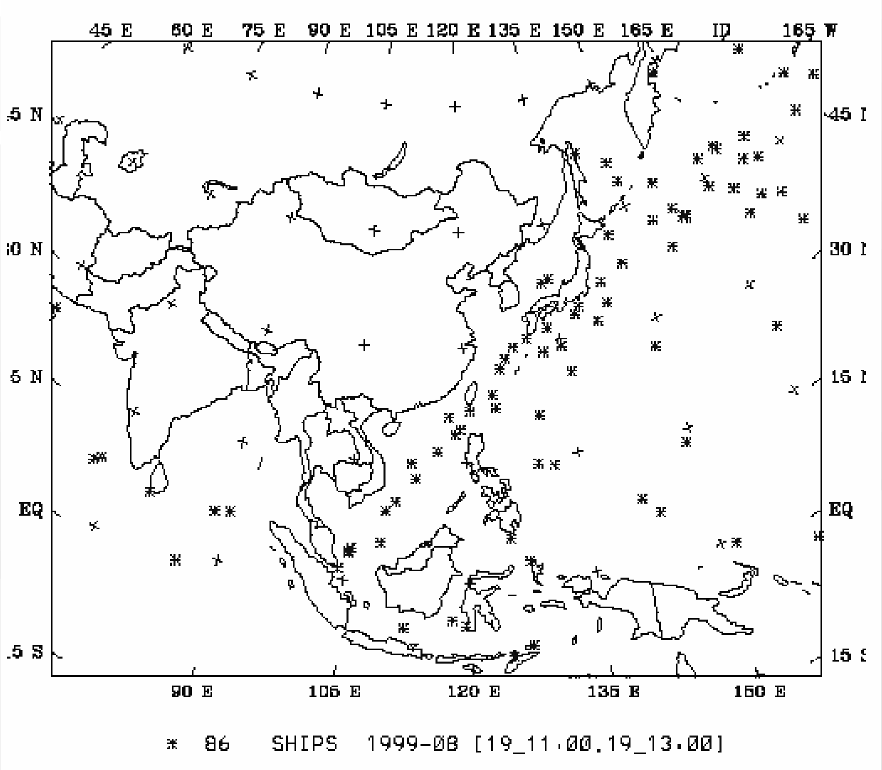
Distribution for each type of observations



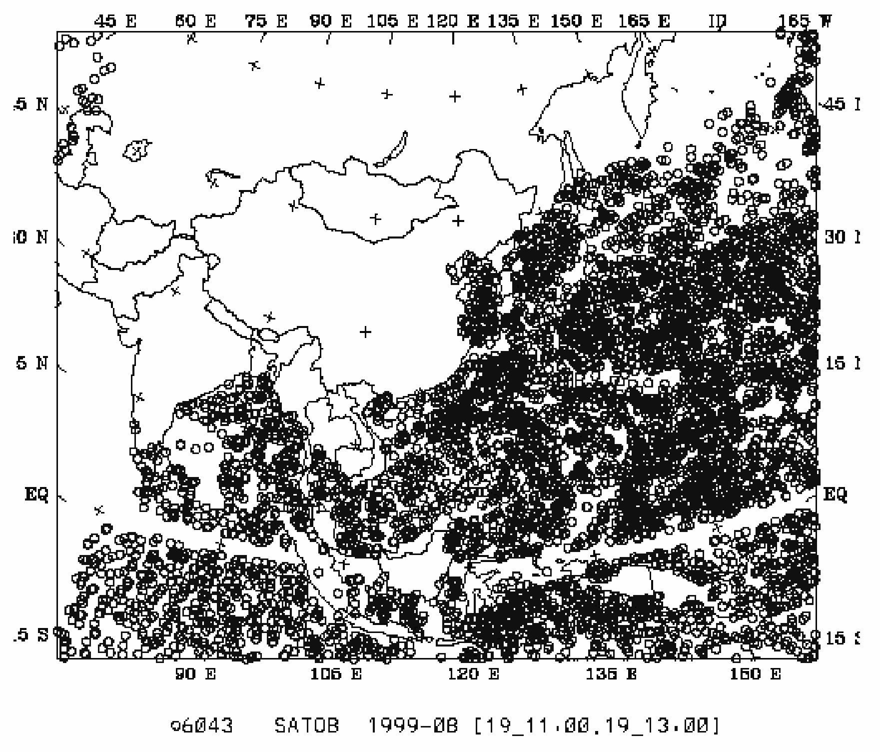


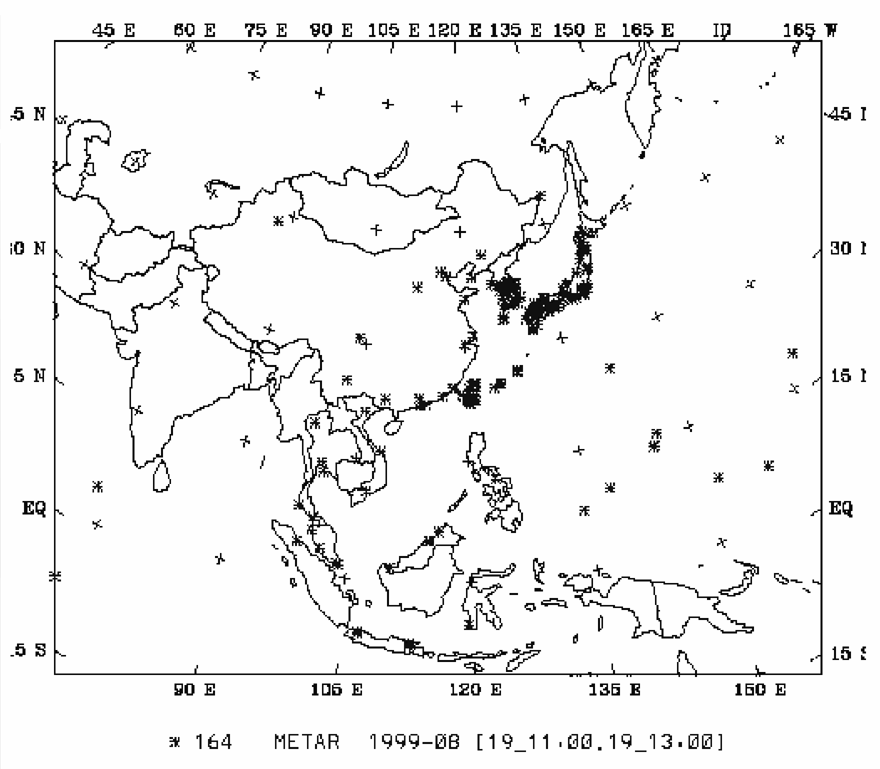
Distribution for each type of observations





Distribution for each type of observations





Radar data input file to WRFVar

TOTAL RADAR (14X, I3) – FMT = (A14,I3)

#--

Head record for specific Radar information (site, lat0, lon0, elv, date, # of data locations, max_levs)

– FMT = (A5,2X,A12,2(F8.3,2X),F8.1,2X,A19,2I6)

#--

Head record for the specific location (FM-128 RADAR, date, lat, lon, elv, levs)

-- FMT=(A12,3X,A19,2X,2(F12.3,2X),F8.1,2X,I6)

Data-level record (height<m>, Radial_V<m/s>, qc, err, Reflectivity<dbz>, qc, err)

Data-level record (height<m>, Radial_V<m/s>, qc, err, Reflectivity<dbz>, qc, err)

……………………………………………………………………………………

– FMT=(3X,F12.1,2(F12.3,I4,F12.3,2X))

Head record for specific Radar information (site, lat0, lon0, elv, date, # of data locations, max_levs)

#--

Head record for the specific location (FM-128 RADAR, date, lat, lon, elv, levs)

Data-level record (height<m>, Radial_V<m/s>, qc, err, Reflectivity<dbz>, qc, err)

Data-level record (height<m>, Radial_V<m/s>, qc, err, Reflectivity<dbz>, qc, err)

……………………………………………………………………………………

```
TOTAL RADAR =   2
#-----------------------------------------------------------------------------------#

RADAR        JINDO 126.328    34.471     499.0  2002-08-31_00:00:00  5706     9
#-----------------------------------------------------------------------------------#
FM-128 RADAR   2002-08-31_00:00:00       34.314       124.003     499.0       2
         3803.5       7.918   1       0.500       17.704   1       1.125
         7480.6 -888888.000 -88 -888888.000   -888888.000 -88 -888888.000
FM-128 RADAR   2002-08-31_00:00:00       34.360       124.002     499.0       2
         3795.2       7.125   1       0.500       18.214   1       1.160
         7467.1 -888888.000 -88 -888888.000   -888888.000 -88 -888888.000
FM-128 RADAR   2002-08-31_00:00:00       34.405       124.000     499.0       2
         3790.2       6.714   1       0.598       14.864   0       0.707
         7459.0 -888888.000 -88 -888888.000   -888888.000 -88 -888888.000
FM-128 RADAR   2002-08-31_00:00:00       35.275       123.974     499.0       2
         4325.9       4.118   0       0.500       16.650   0       3.959
         8315.9 -888888.000 -88 -888888.000   -888888.000 -88 -888888.000
.....................................................................................................................................

RADAR        JINDO 126.328    34.471     499.0  2002-08-31_00:00:00  5706     9
#-----------------------------------------------------------------------------------#
FM-128 RADAR   2002-08-31_00:00:00       34.314       124.003     499.0       2
         3803.5       7.918   1       0.500       17.704   1       1.125
         7480.6 -888888.000 -88 -888888.000   -888888.000 -88 -888888.000
FM-128 RADAR   2002-08-31_00:00:00       34.360       124.002     499.0       2
         3795.2       7.125   1       0.500       18.214   1       1.160
         7467.1 -888888.000 -88 -888888.000   -888888.000 -88 -888888.000
FM-128 RADAR   2002-08-31_00:00:00       34.405       124.000     499.0       2
         3790.2       6.714   1       0.598       14.864   0       0.707
         7459.0 -888888.000 -88 -888888.000   -888888.000 -88 -888888.000
FM-128 RADAR   2002-08-31_00:00:00       35.275       123.974     499.0       2
         4325.9       4.118   0       0.500       16.650   0       3.959
         8315.9 -888888.000 -88 -888888.000   -888888.000 -88 -888888.000
.....................................................................................................................................
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KMA Radar sites

References for Radar data assimilation with WRFVar

Xiao, Q., Y.-H. Kuo, J. Sun, W.-C. Lee, D. M. Barker, and Eunha Lim, 2006: An approach of radar reflectivity data assimilation and its assessment with inland QPF of Typhoon Rusa (2002) at landfall, *J. Appl. Meteor*., in press.

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Flow chart for preprocessing