How to get the observations for WRF 3DVAR

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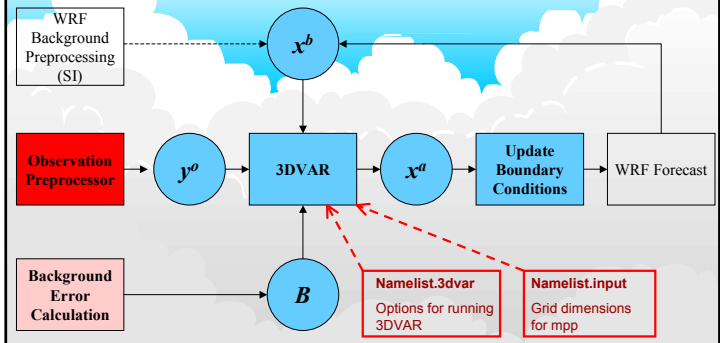
WRF 3DVAR in the WRF Modeling System



The observations are one of the important input files for WRF 3DVAR, no observations will be no data assimilation.

The data format of observations accepted by WRF 3DVAR

1. **Official format: BURF --- the operational OBS format**
2. **Format for research: ASCII (MM5/LITTLE_R) format**

Official format --- BURF

- Currently we do not have the conversion program available from other format of observation data to the BURF data file.
- NCEP provides the BURF format observations since May 1995. The data can be downloaded from NCAR Mass Storage System (MSS). The data inventory can be obtained through ftp.
- A data file from MSS includes the OBS for several days. You need to extract the files you needed. We haven't tried to use these data yet, here just provide a way to get the BURF data. Please feed back your experiences to get and use the BURF format observations.

Shell script to get the BURF OBS inventory

```
#
cat >! ftp.cmd << EOF1
Open ncardata.ucar.edu
user anonymous ${user-email-address}
cd datasets/ds609.2/inventories
get eta.inv
EOF1
#
ftp –n < ftp.cmd
#
```


A file "eta.inv" will be obtained after executed the ftp shell script. You can look at this file to find the BURF OBS files which you needed:

```
<20040507  ds609.2>
      To use the NCEP Eta 3D, SF, BUFR and PREC data from NCAR/SCD/DSS ds609.2 dataset,
      we recommend users to access the reorganized MSS vsns listed below.
      The complete tar lists can be found at
        ftp://ncardata.ucar.edu/datasets/ds609.2/inventories/TARLST/

      -SD:Starting day of the month,  ED:Ending day of the month,
      ------------------------------------------------------------------
      -              MSS SIZE                          UNIX TAR
      -/DSS/           (BYTE)  YYYY.MM  TYPE   SD-ED    SIZE (BYTE)
      ------------------------------------------------------------------
      ..................................................................
      G40455         609480704  1995.05  BUFR   1-31     608141312
      ..................................................................

      ..................................................................
      G41492        1331208192  2004.04  BUFR   01-05    1328283648
      G41493        1331208192  2004.04  BUFR   06-10    1328283648
      G41494        1331208192  2004.04  BUFR   11-15    1328283648
      G41495        1331208192  2004.04  BUFR   16-20    1328283648
      G41496        1331208192  2004.04  BUFR   21-25    1328283648
      G41497        1331208192  2004.04  BUFR   26-30    1328283648
      ------------------------------------------------------------------
      - Each /DSS/G* on MSS is a cosblocked unix tar file with a fixed block size of 32768 bytes.
      - For NCAR users who retrieve the G vsns themselves, the following commands will result
      - a plain unix tar file:
      -  msread -fBI Gvsn /DSS/Gvsn                -- (as a disk file)
      -  msexport -fBI -Mf -b32768 Gvsn output_media  -- (as a unix tar file on output_media)
      -
```


Format for research --- ASCII (MM5/LITTLE_R)

- Anyone familiar with MM5 modeling system should be familiar with the MM5/LITTLE_R format.
- It is easy to manipulate an ASCII format file, look, edit,….
- A 3DVAR OBS preprocessor program available to convert the LITTLE_R format OBS to a WRF 3DVAR ASCII OBS file. The users' duty is just to convert the OBS in any format to the LITTLE_R format.

  The 3DVAR OBS preprocessor program can be obtained from:

  http://www.mmm.ucar.edu/individual/guo/3DVAR_code_data.htm

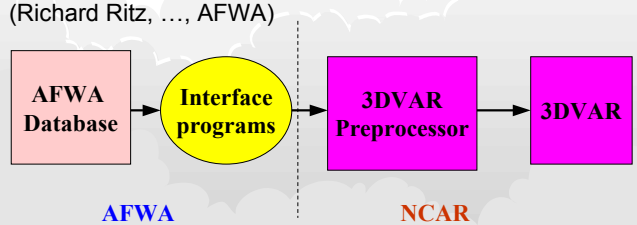
  Click "3DVAR Pre-processing Source Code".

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

  http://www.mmm.ucar.edu/individual/guo/OBSPROC/Slides1.html

Interface programs in AFWA

- Programs to convert the data format from AFWA observation database to MM5/LITTLE_R format to provide the OBS input file to 3DVAR OBS preprocessor (Richard Ritz, …, AFWA)



- 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 make the OBS data file suitable for 3DVAR needs

- Clean out the unnecessary information for 3dvar, and the necessary information for 3dvar

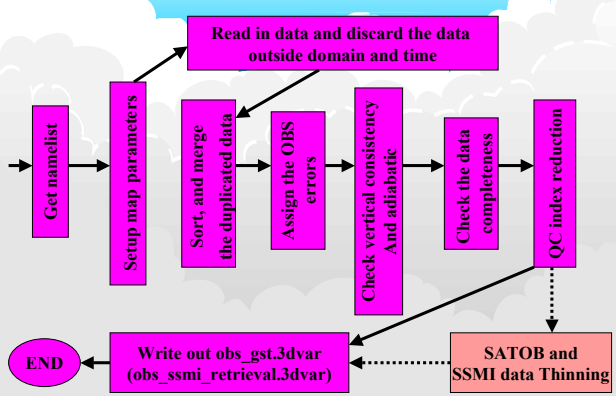
  For example (Sam case 1999081912Z),
  LITTLE_R obs file : 40425051 bytes,
  3DVAR obs file : 3934484 bytes)

- Save the OBS data processing time, the OBS file can be used for multiple times of 3DVAR experiments.
- Still to keep in ACSII format for easy manipulation (look, check, and edit), especially for research purpose.

Tasks of the 3DVAR preprocessor

- Remove the observations outside the time range and domain (horizontal and top)
- Retrieve the pressure or height based on the observed information with the hydrostatic assumption
- Re-order and merge the duplicate (time and location) data reports
- Assign the observation errors to the different types of observations
- Check the vertical consistency and super adiabatic for the multi-level observations
- Complete thinning with the SATOB, SSMI, and QSCAT data
- Write out OBS file in format for 3DVAR input
  → GTS data and SSMI data
- Plot the distribution for each type of observations →MAP_plot

Flow chart of OBS preprocessor



Types of observations to be processed
→14 types (SYNOP, SHIPS, METAR, TEMP , AIREP, PILOT , AMDAR, SATOB, SATEM, SSMT1, SSMT2, SSMI, GPSPW, QSCAT)

Observations errors
→ NCEP OBS error (Parrish and Derber 1992)
→US Air Force (AFWA) OBS error file
→Directly from the observation reports

MAP_plot
→Program to plot the distribution of each type of observations.

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
SSMT1	121	SSMT1
SSMT2	122	SSMT2
SSMI	125	SSMI
TOVS	131	TOVS
QSCAT	281	Quik SCAT level-2B SeaWind
OTHER		UNKNOWN

Input and output files for OBS preprocessor

4 (or 3) *Input files*

- First guess (MMINPUT/MMOUT)*
- 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*)
  - Record1: input file names
  - Record2: analysis times
  - Record3: Maximum number of observations allowed
  - Record4: quality control switches
  - Record5: print switches
  - Record6: user defined sub-domain (not used)
- AFWA OBS errors file: *obserr.txt* (provided by 3DVAR system)

Running 3dvar_obs without first guess as input

- Modify the Makefile to remove –DBKG from CPPFLAGS, and re-compile the program by type *make*;
- Copy namelist.3dvar_obs.sample1 to namelist.3dvar_obs, and edit it;

Namelist file (*namelist.3dvar_obs*)

- Record1: input file names
- Record2: analysis times
- Record3: Maximum number of observations allowed
- Record4: quality control switches
- Record5: print switches
- Record6: model reference state definition
- Record7: geographic parameter's definition
- Record8: model domains' definition

Output files

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 3DVAR 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

3dvar_obs.out

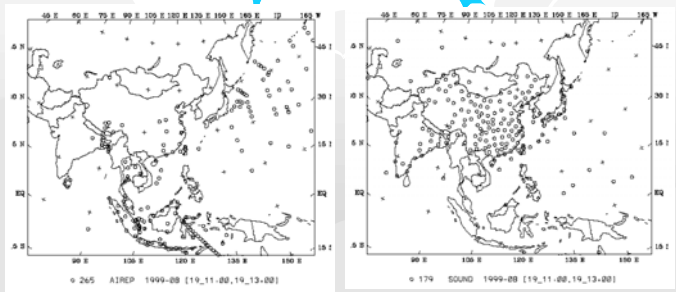
The printing out from the program execution. It can used to monitor the execution and to identify the troubles if any

Diagnostic files depended on the print switches in namelist

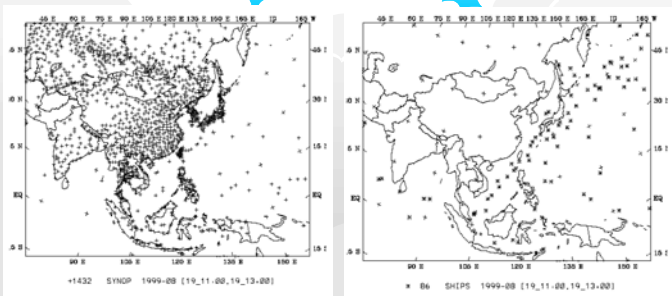
How to plot the OBS distribution?

- 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.

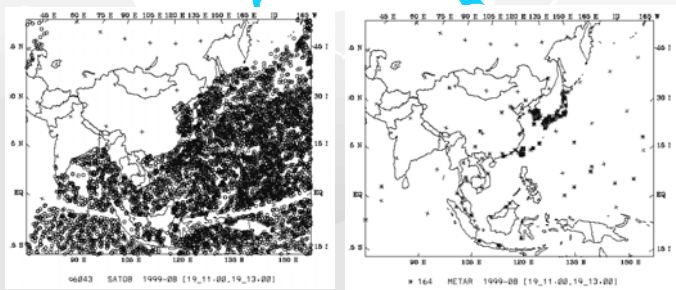
Distribution for each type of observations



Distribution for each type of observations



Distribution for each type of observations



A Three-Dimensional Variational (3DVAR) Data Assimilation System For The WRF Community

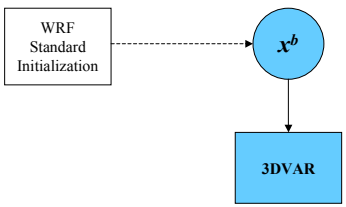
Dale Barker

Web Site: http://www.wrf-model.org/WG4

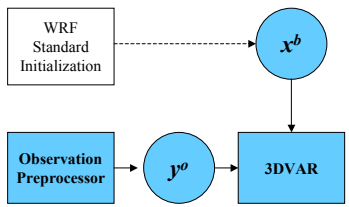
WRF 3DVAR in the WRF Modeling Systems

3DVAR

WRF 3DVAR in the WRF Modeling Systems



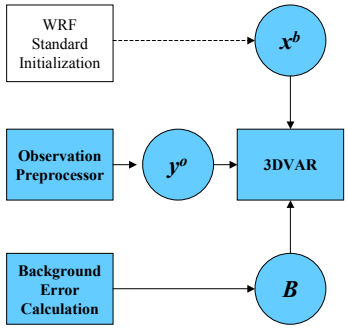
WRF 3DVAR in the WRF Modeling Systems



NCAR

Mesoscale and Microscale Meteorology

WRF 3DVAR in the WRF Modeling Systems



NCAR

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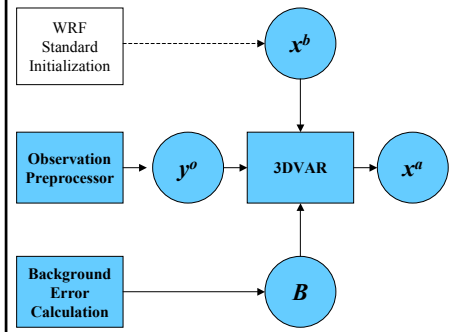

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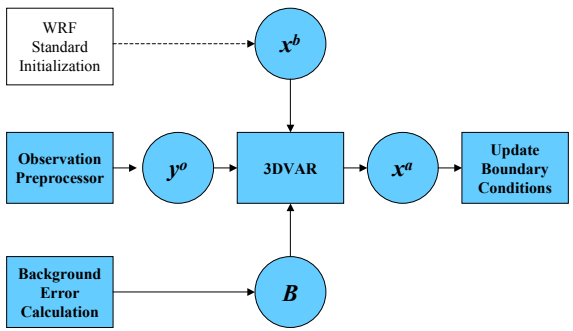

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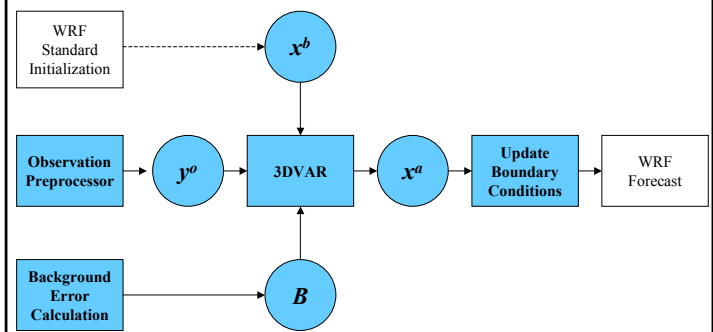
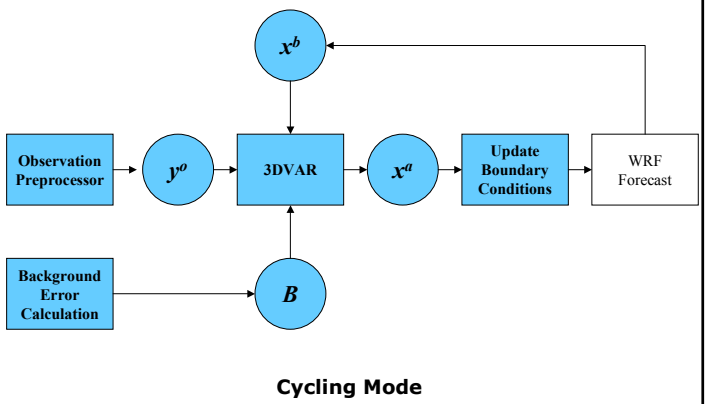


Cold-Start Mode

WRF 3DVAR in the WRF Modeling Systems



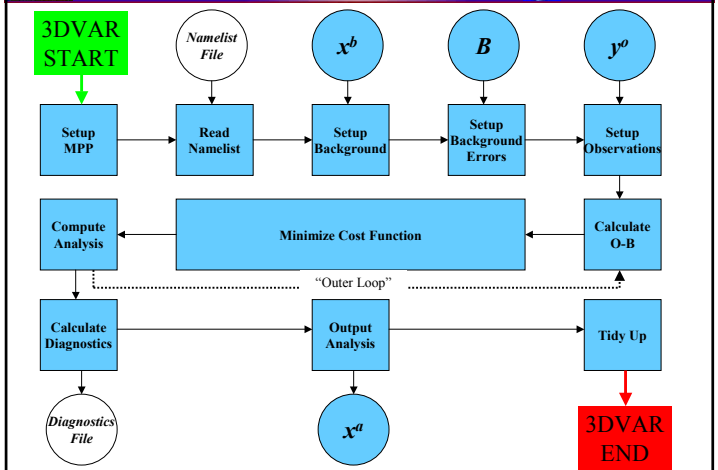
Cycling Mode

Input Data For 3DVAR System

a) First-Guess Forecast - Output from SI and real.

b) Observations – In BUFR format, or ASCII files in "3DVAR format" (little_r format input to observation preprocessor).

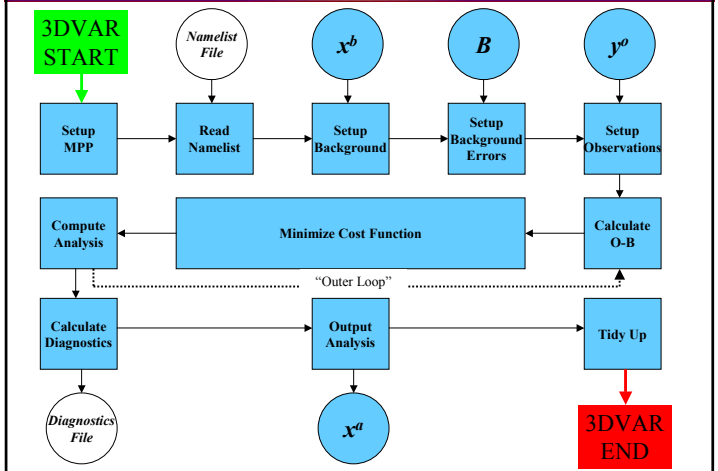
c) Background Error Statistics File – NCEP GDAS statistics, or MM5 format, containing non-standard data (e.g. eigenvectors, eigenvalues, regression coefficients, etc).



Setup MPP

a) Reads grid dimensions from "namelist.input" file.

b) Use WRF framework's distributed memory capability to initialize tile, memory, patch dimensions, etc.

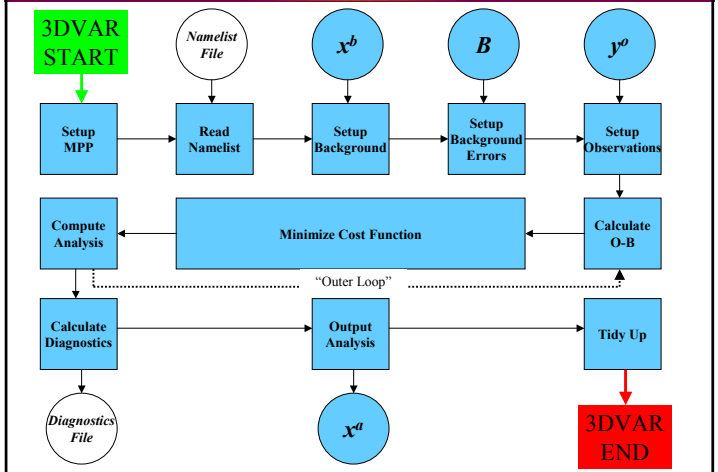


Read Namelist

a) Reads 3DVAR data assimilation options from "namelist.3dvar" file.

b) "Namelist.3dvar" file is created automatically at run-time by the script from which 3DVAR is run.

c) Performs consistency checks between namelist options.

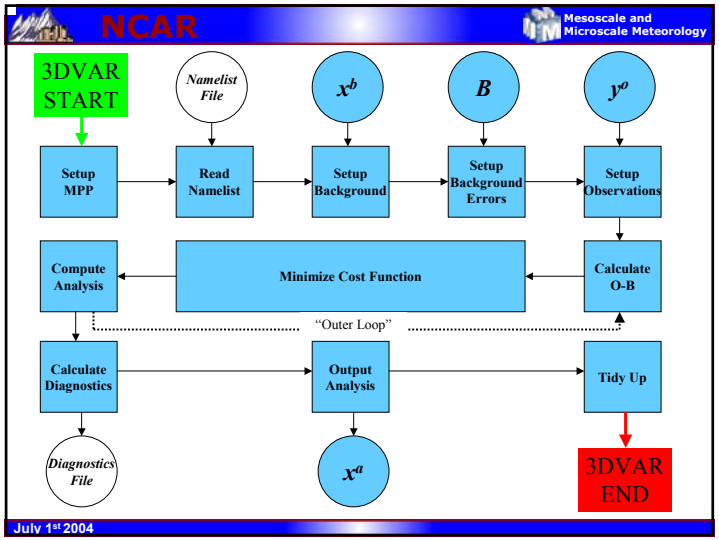


Setup First-Guess (Background)

a) Reads in the first-guess field in WRF "grid" derived data type.

b) Performs variable conversion and interpolation (unstaggered grid in 3D-Var).

c) Creates background FORTRAN 90 derived data type "xb" e.g. xb % mix, xb % u(:,:,:), ….



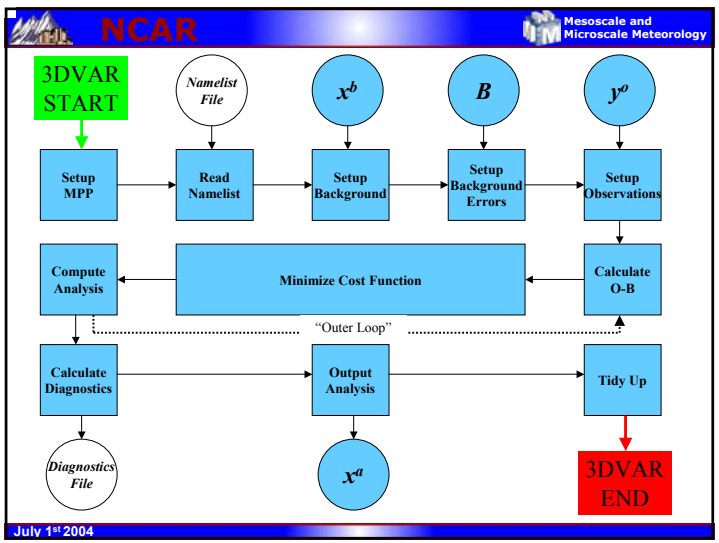
Setup Background Errors

a) **Reads in background error statistics.**

b) **Format depends on namelist option "cv_options" – 3 = WRF, 2 = MM5 control variables.**

c) **Extracts necessary quantities – eigenvectors, eigenvalues, lengthscales, regression coefficients, etc.**

d) **Creates background error FORTRAN 90 derived data type "be" e.g. be % v1 % evec(:,:), be % v2 % eval(:), etc, ….**

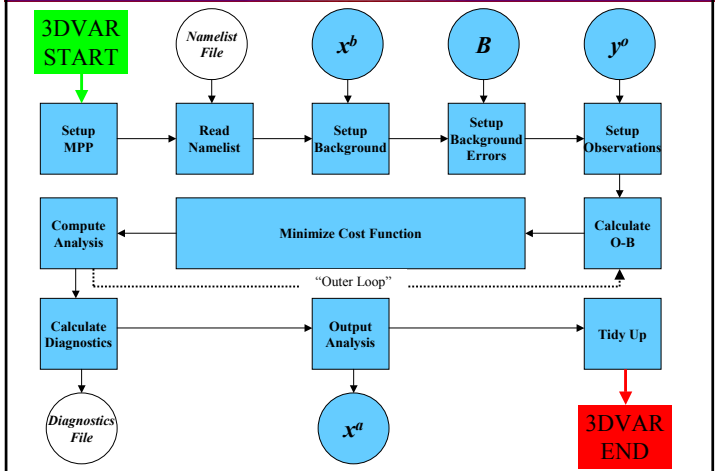


Setup Observations

a) **Reads in observations.**

b) **Format depends on namelist variable "ob_format" – 1 = BUFR, 2 = ASCII "3DVAR" format.**

c) **Creates observation FORTRAN 90 derived data type "ob" e.g. ob % num_gpspw, ob % metar(:), ob % sound(:) % u(:), etc, ….**

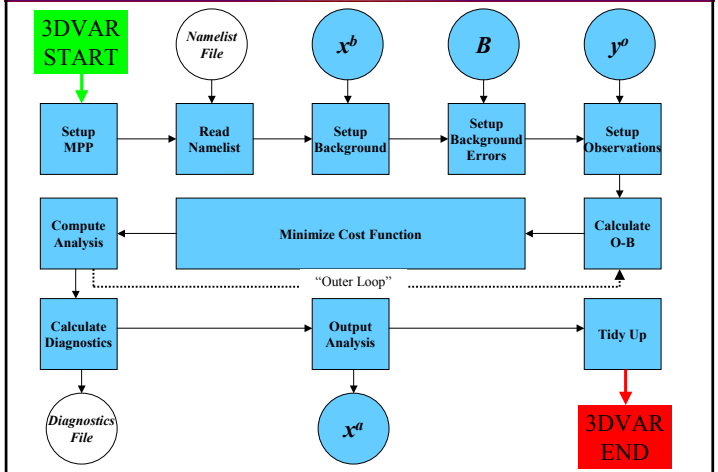


Calculate Innovation Vector (O-B)

a) Calculates "model equivalent" B of observation O through interpolation and change of variable.

b) Computes observation minus first guess (O-B) value.

c) Creates innovation vector FORTRAN 90 derived data type "iv" e.g. iv % metar(:), iv % qscat(:) % u, etc, ….



Minimize Cost Function

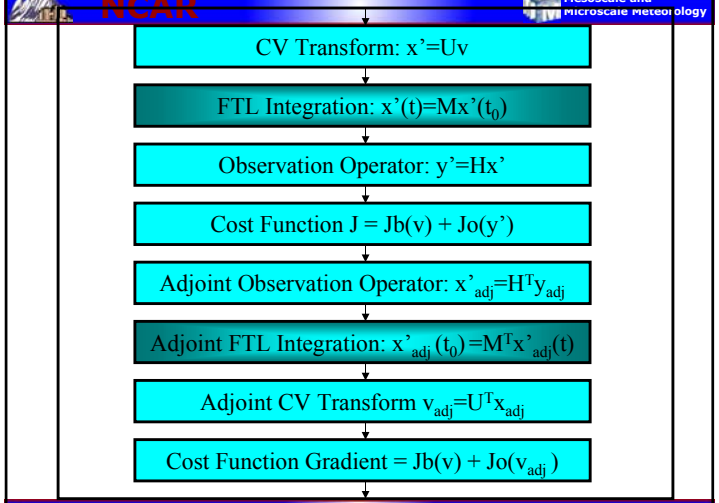
a) Initializes analysis increments to zero.

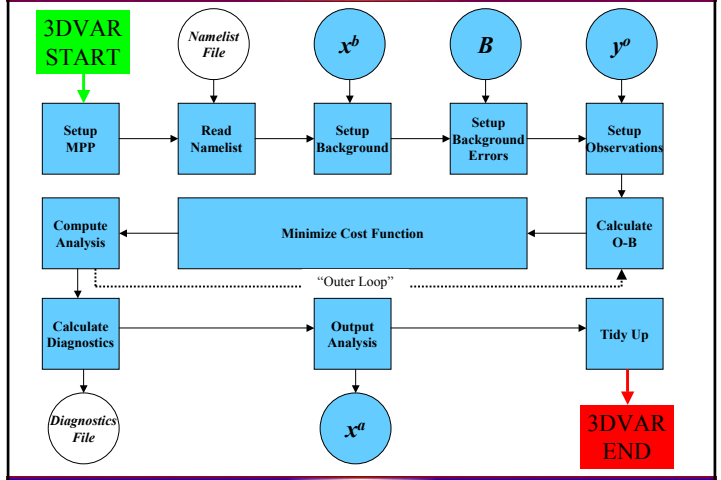
b) Computes cost function.

c) Computes gradient of cost function.

d) Uses cost function and gradient to calculate new value of control variable v

e) Iterate b) to d).



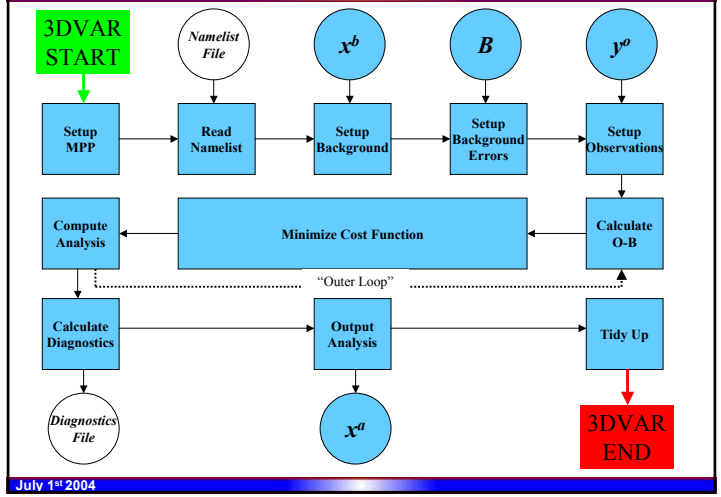


Compute Analysis

a) **Once 3DVAR has found a converged control variable, convert to model space analysis increments u', v' T, p', q'.**

b) **Calculate analysis = first-guess + analysis increment.**

c) **Performs consistency checks e.g. remove negative humidities from analysis.**



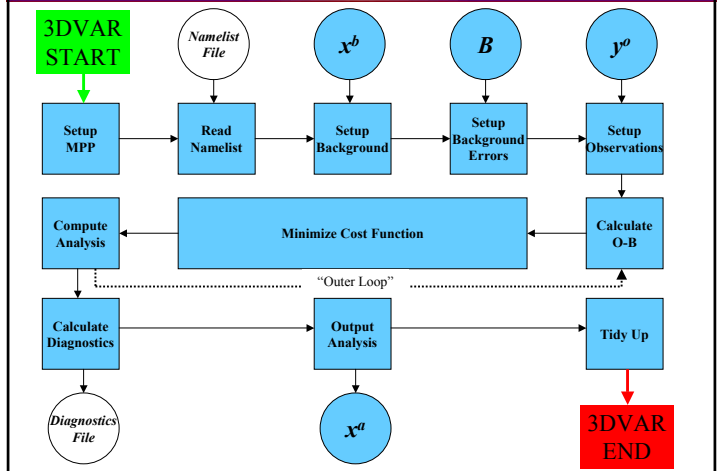
Compute Diagnostics

a) Compute O-B, O-A statistics for all observation types and variables.

b) Compute A-B (analysis increment) statistics for all model variables and levels.

c) Statistics include minimum, maximum (and their locations), mean and standard deviation.

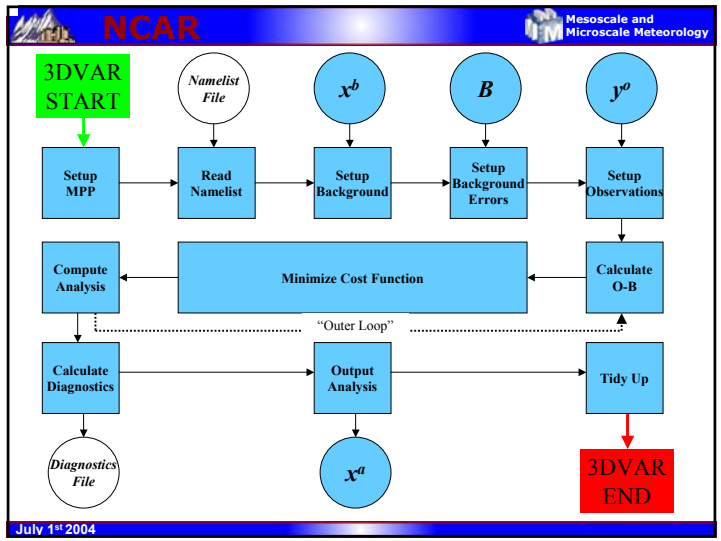
d) Also compute "specialist diagnostics" for error tuning.



Output Analysis

a) Convert 3D-Var analysis variables to WRF variables and grid.

b) Outputs analysis in WRF NETCDF native model format.

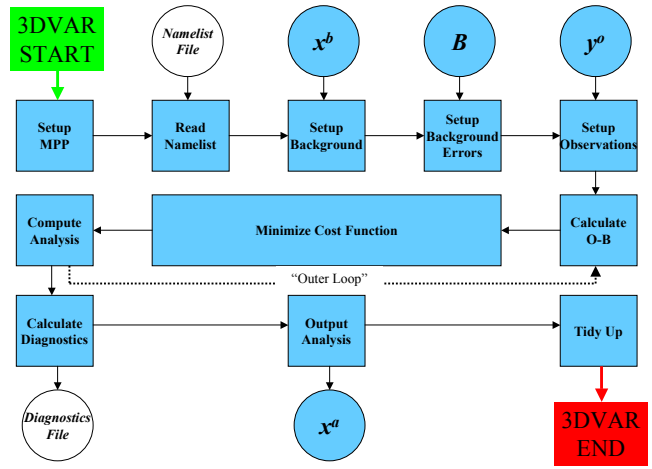


Tidy Up

a) Deallocate dynamically-allocated arrays, structures, etc.

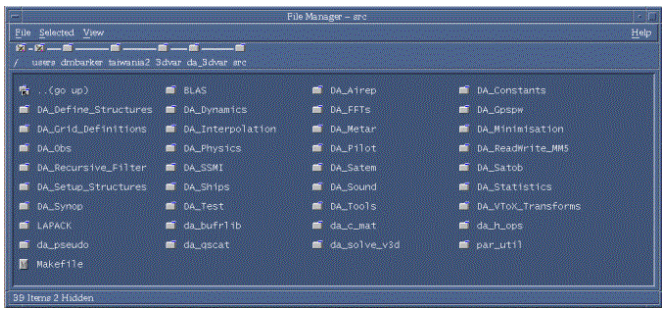
b) Timing information.

c) Clean end to 3DVAR.



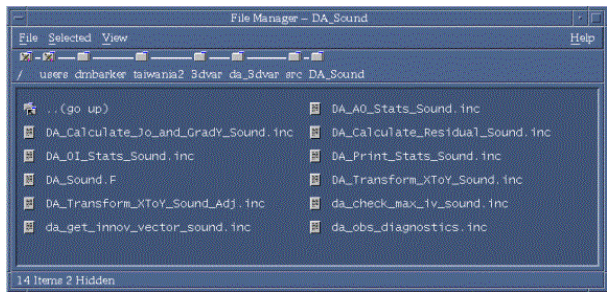
Source Code Organization 1

Example Directory *3dvar/da_3dvar/src:*



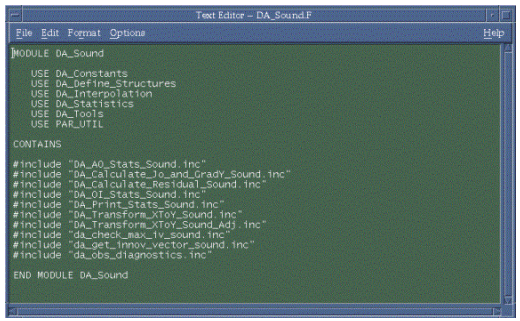
Source Code Organization 2

Example Directory *3dvar/da_3dvar/src/DA_Sound:*



Source Code Organization 3

Example FORTRAN 90 Module: 3*dvar/da_3dvar/src/DA_Sound/DA_Sound.F:*



Learning To Use 3DVAR

a) **Consult the documentation at http://www.wrf-model.org/WG4**

b) **Run through the Online 3DVAR Tutorial.**

c) **If still confused, ask questions - wrfhelp@ucar.edu.**