ARPS-3dvar Program

1. Introduction

The ARPS variational data assimilation program *3dvar* is designed to assimilate the observation data to ARPS model. The program takes an ARPS forecast as background, and surface data, multi-level data (sounding and profiler) and radar data as observations into a cost function. Through minimize the cost function to get the optimal initial condition for the ARPS model. The program can also use an analysis or forecast from another model that has been interpolated to the ARPS model coordinate by *ext2arps*. The user must specify the name and format of the forecast file and the names and data types of the input observation files in the namelist input file, `arps.input`. The current version can handle the data from single level (surface observations, aircraft, etc), vertical profile data (rawinsondes, wind profilers, etc), radar reflectivity and Doppler radar winds, same as the ADAS program. The 3dvar program can be followed by a cloud analysis package inherited from ADAS also.

2. Using the Program

2.1. Building the executable

Build the arps`3dvar` executable using `makearps`:

```
makearps arps3dvar
```

switches for optimization (`-opt` *n*), debug (`-d`), and I/O options can be specified in the makearps command as would be done for building any of the other executables in the ARPS model system.

2.2. Setting-up the Data

The arps 3dvar program uses the same dataset as ADAS. Prepare the data as you would to run ADAS. Specifically, convert surface, upper air and aircraft data into ASCII formatted files and run 88d2arps and/or nids2arps to prepare the radar data files. Satellite data are used in the cloud analysis. There are separate documents describing how to use radar pre-processing programs 88d2arps and/or nidsarps, and there is also a document about how to run the ADAS program.

The program also utilizes the expected-error ADAS table files in ASCII format for each data source that is read in. These are contained in the directory `./data/adas` and are named *source*`.adastab,` where *source* is the name of the data source. These files should be set-up with the same expected-error data that one would use for running ADAS. There is a separate help file describing the format of the data source error files.

2.3. Running the Program

Once the data and error tables are prepared, edit the namelists in the input file, `arps.input`. An additional list of the input variables and their default values can be found in the next page. To run the program, issue the following command from the ARPS top level directory:

```
bin/arps3dvar < input/arps.input >! arps3dvar.out
```

2.4. Output Files

The 3DVAR produces ARPS history-dump files. These files are named *runname*`.`*fmt*`000000` and *runname*`.`*fmt*`grdbas` where *runname* is the run name that is supplied in the input file, and *fmt* is the ARPS history dump format indicator (`bin`, `hdf`, `grb`, etc). These files can be used as input to plotting programs, as the initial field for the ARPS forecast model.

3. References

Gao, J., M. Xue, K. Brewster, F. Carr, and K. K. Droegemeier 2001: A Three-Dimensional Variational Data Assimilation Scheme for storm-scale model, Preprints, *14th Conference on Numerical Weather Prediction*, 30 July - 2 August 2001, American Meteorology Society. J72-J74.

Gao, J., M. Xue, K. Brewster, F. Carr, and K. K. Droegemeier 2002: New developments of a 3DVAR system for a nonhydrostatic NWP model, Preprints, *15th Conf. on Numerical Weather Prediction*, 12-16 August, Amer. Meteorol. Society. 339-342.

Gao, J., M. Xue, K. Brewster, and K. K. Droegemeier 2004: A Three-dimensional Variational Data Assimilation Method with recursive filter for Single-Doppler Radar, *J. Atmos. Oceanic. Technol.* **21**, 457-469.

Hu, M., M. Xue, J. Gao and K. Brewster, 2006: 3DVAR and Cloud analysis with WSR-88D Level-II Data for the Prediction of Fort Worth Tornadic Thunderstorms. Part II: Impact of radial velocity analysis via 3DVAR, *Mon. Wea. Rev.* 134, 699-721.

(Also check the references for ADAS)

4. Input Parameters

The table in the following details the additional input parameters for the 3DVAR program. Some input parameters for ARPS and ADAS program were documented in ARPS users guide.

3DVAR Adjustment Options

Parameter	Definition/Purpose	Options/Suggested Values
turn_chk	Gradient check option	1, check the gradient; 0, no gradient check.
turn_3ddda	3dvar analysis option	1, do the assimilation; 0, without analysis option
cntl_rh	3dvar analysis option	1, RH; 0, q.
maxin (ipass)	maxmum iteration number for each data pass	between 20 –60 is recommended
filt_type (ipass)	Indicate which type of recursive filter (anisotropic, or isotropic)	0 for isotropic; 1 for anisotropic. It is recommended 0 is selected for the first pass.
ipass_filt (ipass)	Number of passes for recursive filter (only valid for isotropic filter	1-3 is recommended

hradius	horizontal influence radius in (km), (multi-pass parameters)	For surface data, it can be 25-100km; for sounding data 100-300 km, and for radar data 6-10km.
nradius_z	vertical influence radius in grid points	suggested value: 4
turn_div	Option for 3D mass continuity equation	1, turn on; 0 switch off.
wei_div_h (ipass)	coefficient of horizontal divergent term	5.0E-3, or 5.0E-4 is recommended, if <0.0, mass continuity is turn off.
wei_div_v (ipass)	coefficient of vertical divergent term	Same as above, can be turn off.
turn_thermo	coefficient of horizontal divergent term	5.0E-3, or 5.0E-4 is recommended, if <0.0, mass continuity is turn off.
wei_thermo (ipass)	coefficient of thermal wind relationship	can be adjusted, temporarily set to 10E-2.

ADAS & 3DVAR Single-Level Data Specifications (&adas_sng)

Parameter	Definition/Purpose	Options/Suggested Values
nsngfil	Number of single-level data files. Single level data include surface data and pilot report data.	Data dependent. Typical: 1 or more *nsngfil* ≤ *mx_sng_file* (*mx_sng_file* is set in **adas.inc**)
sngfname (ifile)	Name of single-level data file Repeat for *nsngfil*s. character*132	Typical: *sngfname(1)*= 'jun08/951591500.lso'
sngtimchk (ifile)	Name of data file used for time consistency check of respective *sngfname* data. Dataset of the same type from a previous time period. Specify a dummy filename if no such data are available. character*132	Typical: *sngtimchk(1)*= 'jun08/951591400.lso'
srcsng (isrc)	Following are repeated for each data source in the single-level data file(s). Note that a single-level file can contain one or more sources. Largest index, *isrc*, used must be less than or equal to *nsrc_sng* (*nsrc_sng* is set in **adas.inc**). Name of data source. These must match the source name(s) in the data file(s). character*8	Typical: *srcsng(1)*='SA'
sngerrfil (isrc)	Name of file containing error specification table for each source. character*132	Typical: *sngerrfil(1)*= 'saoerr.adastab'

iusesng (isrc, ipass)	Integer switch indicating whether the data source should be used on each pass. A switch is required for each pass, i.e. *iusesng(1,1)*, *iusesng(1,2)*...	0: Do not use data from this source on this pass. 1: use data Example: *iusesng(1,1)*=0, *iusesng(1,2)*=1, *iusesng(1,3)*=0

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sngfname (ifile)	Name of single-level data file Repeat for *nsngfil*s. character*132	Typical: *sngfname(1)*= 'jun08/951591500.lso'
sngtimchk (ifile)	Name of data file used for time consistency check of respective *sngfname* data. Dataset of the same type from a previous time period. Specify a dummy filename if no such data are available. character*132	Typical: *sngtimchk(1)*= 'jun08/951591400.lso'

srcsng (isrc)	Following are repeated for each data source in the single-level data file(s). Note that a single-level file can contain one or more sources. Largest index, *isrc*, used must be less than or equal to *nsrc_sng* (*nsrc_sng* is set in **adas.inc**). Name of data source. These must match the source name(s) in the data file(s). character*8	Typical: *srcsng(1)*='SA'
sngerrfil (isrc)	Name of file containing error specification table for each source. character*132	Typical: *sngerrfil(1)*= 'saoerr.adastab'
iusesng (isrc, ipass)	Integer switch indicating whether the data source should be used on each pass. A switch is required for each pass, i.e. *iusesng(1,1)*, *iusesng(1,2)*...	0: Do not use data from this source on this pass. 1: use data Example: *iusesng(1,1)*=0, *iusesng(1,2)*=1, *iusesng(1,3)*=0

ADAS & 3DVAR Single-Level Data Specifications (&adas_sng)

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nsngfil	Number of single-level data files. Single level data include surface data and pilot report data.	Data dependent. Typical: 1 or more *nsngfil* ≤ *mx_sng_file* (*mx_sng_file* is set in **adas.inc**)
sngfname (ifile)	Name of single-level data file Repeat for *nsngfil*s. character*132	Typical: *sngfname(1)*= 'jun08/951591500.lso'

sngtimchk (ifile)	Name of data file used for time consistency check of respective *sngfname* data. Dataset of the same type from a previous time period. Specify a dummy filename if no such data are available. character*132	Typical: *sngtimchk(1)*= 'jun08/951591400.lso'
srcsng (isrc)	Following are repeated for each data source in the single-level data file(s). Note that a single-level file can contain one or more sources. Largest index, *isrc*, used must be less than or equal to *nsrc_sng* (*nsrc_sng* is set in **adas.inc**). Name of data source. These must match the source name(s) in the data file(s). character*8	Typical: *srcsng(1)*='SA'
sngerrfil (isrc)	Name of file containing error specification table for each source. character*132	Typical: *sngerrfil(1)*= 'saoerr.adastab'
iusesng (isrc, ipass)	Integer switch indicating whether the data source should be used on each pass. A switch is required for each pass, i.e. *iusesng(1,1)*, *iusesng(1,2)*...	0: Do not use data from this source on this pass. 1: use data Example: *iusesng(1,1)*=0, *iusesng(1,2)*=1, *iusesng(1,3)*=0

ADAS & 3DVAR Multiple-Level Data Specifications (&adas_ua)

Parameter	**Definition/Purpose**	**Options/Suggested Values**

nuafil	Number of multiple-level data files. Multiple level data include radiosonde data and profiler data.	Data dependent. Typical: 1 or more *nuafil* ≤ *mx_ua_file* (*mx_ua_file* is set in **adas.inc**)
uafname (ifile)	Name of multiple-level data file Repeat for *nuafils*. character*132	Typical: *uafname(1)*= 'jun08/951591500.snd'
srcua (isrc)	Following are repeated for each data source in the multiple-level data file(s). Note that a multiple-level file usually contains one source, but more than one file may have the same source. Largest index, *isrc*, used must be less than or equal to *nsrc_ua*. (*nsrc_ua* is set in **adas.inc**). Name of data source. character*8	Typical: *srcua(1)*="NWS RAOB'
uaerrfil (isrc)	Name of file containing error specification table for each source. character*132	Typical: *uaerrfil(1)*= 'snderr.adastab'
iuseua (isrc, ipass)	Integer switch indicating whether the data source should be used on each pass. A switch is required for each pass, i.e. *iuseua(1,1)*, *iuseua(1,2)*...	0: Do not use data from this source on this pass. 1: use data Data dependent Example: *iuseua(1,1)*=1, *iuseua(1,2)*=0, *iuseua(1,3)*=0

ADAS & 3DVAR Radar Data Specifications (&adas_radar)

Parameter	Definition/Purpose	Options/Suggested Values
nradfil	Number of remapped radar data files. Remapped radar data files are created by mapping raw data onto a regular grid, which need not match the final analysis grid.	Data dependent. Typical: 0 or more *nradffl* ≤ *mx_rad_file* (*mx_rad_file* is set in **adas.inc**)
radfname (ifile)	Name of radar data file(s) Repeat for nradfils. character*132	Typical: *radfname(1)*= 'KTLX.950507.1756'
srcrad (isrc)	Following are repeated for each data source in the radar data file(s). **Note**: that a radar data file contains one source, but more than one file may have the same source. Largest index, *isrc*, used must be less than or equal to *nsrc_rad* (*nsrc_rad* is set in **adas.inc**). Name of data source. character*8	Typical: *srcrad(1)*='88D-AII' *srcrad(2)*='NIDS'
raderrfil (isrc)	Name of file containing error specification table for each source. character*132	Typical: *raderrfil(1)*= 'data/adas/88derr.adastab' *raderrfil(2)*= 'data/adas/nidserr.adastab'

iuserad (isrc, ipass)	Integer switch indicating whether the radar data source should be used on each pass. A switch is required for each pass, i.e. *iuserad(1,1)*, *iuserad(1,2)*...	0: Do not use data from this source on this pass. 1: use data Data dependent Example: *iuserad(1,1)*=0, *iuserad(1,2)*=0, *iuserad(1,3)*=1