OBAN Class Homework Assignment from Xue
Distributed on November 11, 2014
Ming Xue

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Original document on ANALAB was written by Huang, Gustafsson and Robertson (2000), and can be found in file analab_docs.pdf.

The following is part of the document modified for use by the OBAN class by Ming Xue.

Brief documentation on ANALAB package.

An analysis package, ANALAB, written in Fortran 77, includes OI and several versions of variational method, for 2D analysis of surface meteorological fields.

The variational algorithms and some of the analysis experiments are described in Huang (2000).

Reference: Huang, X.-Y., 2000: Variational analysis using spatial filters. *Mon. Wea. Rev.*, **128,** 2588–2600.

We will first focus on the OI scheme.

You need to have access and be able to edit and run programs under Linux/Unix.

First, download the tar file of the ANALAB package from the link at our class website, and place it into a directory of the Unix machine (including OSCER Sooner) that you will use to run the package.

You can run ANALAB on a Linux machine or any Unix system that has g77 (GNU fortran-77) or a Fortran 90 compiler.

After saving analab.tar.gz into your work directory, do the following

```
gunzip analab.tar.gz
tar xvf analab.tar
cd analab
```

Take a look of the content of the directory:

```
README          ! a short description of ANALAB
analab_docs.pdf ! A more detailed documentation on
                ! ANALAB - you should read this document.
anaclean        ! script to clean ANALAB
anainstall      ! script to install ANALAB
exp             ! experiment directory
map             ! source code for graphics
```

```
src             ! source code for analysis
```

Now you are in the `analab` directory. Check script `anainstall`. The `OPTION` is currently set to linux, assuming you are using a Linux machine. If you want to install ANALAB on other computers, select other `OPTION` or create a new `OPTION` and set appropriate compiler name and options inside `anainstall` script. Then compile and build ANALAB by running

```
anainstall
```

If the installation is successful, you should see the following on your screen:

```
Installation is done. Go to one of the directories inside exp to
run experiments...
```

Otherwise, try `anaclean` then `anainstall` again.

There are two directories inside `exp`, for two different cases described in Huang (2002). For this home work assignment, you are asked to work on the 92030303 case only, although you are welcome to try the other case.

Go to `exp/92030303` directory, you should see the following:

```
nn060000.dat    ! coastline data (for graphics)
params.dat      ! namelist for analysis
92030303.obs    ! observations
map             ! a link to ../../map/map1.x (graphics executable)
analysis        ! a link to ../../src/analysis.x (analysis executable)
namexp.dat      ! namelist for graphics (contour)
namgeo.dat      ! namelist for graphics (geometry)
92030303.fgs    ! background (firstguess)
README
```

The experiments are performed by changing `params.dat.` The following shows example settings that are not necessarily used in your experiments.

```
&PARAMS
iy=92,im=03,id=03,ih=03     ! date of the observation data
ischeme=4,                  ! analysis scheme, 4 for OI
gscale=200000.,200000.      ! the length scale L (m) for P and T
igcut=4,jgcut=4,            ! filter span (*2=filter order)
sdevfg=1.,1.                ! sigma_b for P (mb) and T (C)
sdevob=1.,1.                ! sigma_r for P (mb) and T (C)
toleral=2,2                 ! tau_1 for P (mb) and T (C)
tolera2=3,4                 ! tau_2 for P (mb) and T (C)
idim=21,jdim=21             ! dimension of the analysis grid
latm=56.5,lonm=14.         ! analysis domain center (lat,lon,
degs)
```

```
dlon=0.6,dlat=0.3          ! analysis resolution
lfgs=.t.                   ! using the provided background
lplot=.t.                  ! plotting the results
/
```

Definitions for additional parameters and their default values can be found inside `params.dat` and in source code `src/analysis.f`.

After selecting the parameters, simply run command `analysis`. But you need to first make sure that your X-window DISPLAY parameter is set for the graphics to be displayed on your terminal (assuming your terminal supports X-window display, i.e., xterm works). If not set already, enter

```
setenv DISPLAY your_display_address:0.0
```

If you terminal does not support X-windows, you will get an error about display when the script tries to run 'gs POST' command – you can ignore it, and move onto the later step that converts the post-script output POST to PSF format.

Further, you may need to do the following in order to perform the OI analysis which requires more stack memory than the default on some computers. Do

```
unlimit stacksize
```

Then run the analysis program:

```
analysis
```

A Postscript graphics output file, `POST.ps` will be produced. It can be converted to PDF format file `POST.pdf` using the following command

```
ps2pdf POST.ps
```

You can use `xpdf` command to display the PDF file under X-Windows or view and print it on a PC or Mac.

The program also produces an ascii file, `92030303.EO1`. In the file, the observations are included together with quality control flags (0=correct, probably correct, 2=rejected, 3=missing), like the following:

```
COUNTRY STN LAT LON P T FLAG_P FLAG_T
```

By setting different quality control threshold values, we could get different flags. The original observation file, `92030303.obs`, has the following format:

```
COUNTRY STN LAT LON P T WIND_DIRECTION WIND_SPEED
```

where the wind data have not been used by ANALAB.

Required exercises:

1. Read and comment on OI analysis program and subroutines

Read the main driver program `src/analysis.f` and `src/OI.f` and all subroutines that are called to perform the OI analysis and add comments to the Fortran code to define all key variables/arrays, and the functions of all subroutines called by subroutine OI. Proceed your comments with !. Describe the method/algorithms of these functions outside the code.

Hand in a printout of your code and description of the functions/algorithms.

To save paper, you can try two column printing by formatting your Fortran source files into PS and PDF format first, using script `text2pdf` included in `analab` directory. Commands `nenscript` and `ps2pdf` are assumed to be available on your system.

```
cd src
../text2pdf *.f
```

will create PS and PDF versions of your *.f files. The PS files can be directly sent to a PS print using comment `lpr file.ps` if such a printer is available on your Linux machine. Otherwise, print the PDF files from a PC or Mac.

2. Perform OI analyses for the 92030303 case.

a) Length scale experiments

Perform OI analysis experiments using length scales L= 10, 50, 100, 200 and 500 km, where L is the length scale that appears in the Gaussian background error correlation model (see Huang 2000). Discuss the analysis results.

b) Test with a different background

In the default parameter settings, `lfgs=.true.`, we use the provided background field, `92030303.fgs`. You can set `lfgs=.false.`, in this case the average value of all observations is used as the background field.

For L= 10, 50, 100, 200 and 500 km and `lfgs=.false.`, perform an OI analysis and discuss the result.

c) Box structures tests

The default value of the box data selection method of the OI is `nbox`=1, i.e., only one

analysis box is used for which all observational data are used. When `lfgs=.false.`, `idim`=21, `jdim`=21, you can select values of `nbox` up to 9. In this case, we are using 9 analysis boxes.

Try nbox = 9 for L= 10, 50, 100, 200 and 500 km and discuss the differences among the analyses for different L and between `nbox`=1 and `nbox`=9. What is the reason for using box structures? What are the disadvantages of using boxes?

d) Single observation experiment

Make a backup copy of the observation file `92030303.obs`, then modify the file to keep only one observation record (preferable one that is not too close to the boundary - look at the lat/lon of that data for reference). Run analysis with and without background, for L=50, 200 and 500 km, using a single data selection box. Discuss your results.

Note: When no first guess/background is provided, the program uses the mean of all observations to specify the first guess value. For the single observation experiment, this first guess will then be equal to the single observation so that the analysis has no effect. For this case, I ask you to edit src/oibox.f file and add a few (e.g., 3) degrees/minibars to the first guess, i.e., modify the following two lines

```
valfgs(i) = valmean
fgs(i,j) = valmean
```

to read, e.g.,

```
valfgs(i) = valmean + 3.0
fgs(i,j) = valmean + 3.0
```

before running the single-obs experiments. Rerun `anainstall` to recompile first.

3. Read and comment on the 3DVAR analysis subroutines

Read 3DVAR analysis subroutines VAR, VAN and VAF and all subroutines that they call, and add comments to the Fortran code to define the functions of all subroutines. Proceed your comments with !. Describe the method/algorithms of these functions outside the code.

Hand in a printout of your code and description of the functions/algorithms. Again the use of paper saving format is encouraged.

4. Variational analysis

a) Tests with four variational schemes

With L=200 km, using the provided first guess background, perform analysis with the

standard variational analysis scheme (ischeme=1, VAR), variational analysis with no inversion of B (ischeme=2, VAN) and variational analysis using a filer (ischeme=3, VAF), and physical-space statistical analysis (ischeme=5, PSAS). Compare the results among themselves and with the OI solution. Which one should be most accurate?
Hint: VAR requires a larger step size. `alpha` =0.2 seems to work. It may require more iterations for the minimization to converge. For other variational schemes, `alpha`=0.002 seem to work well.

b). Tests with filter cutoff radius.

For ischeme=3, i.e., the VAF scheme, try filter cutoff radii `igcut=jgcut=1,4,8,` and discuss the results. `igcut` is the number of Gaussian filter coefficients kept on the left and right side. For example, when `igcut=1`, the filter involves only 3 grid points, one on the left, one on the right and one at the current point.

Hand in all of your plots with your discussions. The plots should include figure captions.

Hint: For your report, you can use ps2epsi command to convert the PS files to EPS files then insert the EPS files into a MS Word document. If you have a PC/Mac program such as Adobe Illustrator, it's even better. This is not required, however.

Finally, you are encouraged to study the analysis code, which gives you first hand knowledge of real analysis programs. The code is reasonably well documented.