ATSC 5010 – Physical Meteorology I Lab
Intro to IDL --- 3 Exercises today

→ map home drive on *Batcivet* (on *this computer* connect to \batcivet\{yourusername})

→ Start idl (applications→ idl)

1. *Parts of the desktop environment (command input, output log, variable watch…)*
2. *Determining current directory* `'CD, CURRENT=c & PRINT, c'`
3. *Your environment*
    a. *Setting your working directory: (window → preferences → idl)*
    b. *Setting your search path: (window → preferences → idl → paths)*

→ The idl command line (use of idl from command prompt vs. program/procedure mode)

→ Working with variables
1. *short (integer), longs, floats, double, string*
2. *assigning variables*
3. *system variables (constants): '!PI'*
4. *arrays, vectors & operations (DBLARR, DINDGEN) idl starts at 0!!!*
5. *'help' procedure, 'print' procedure*

→ Procedures and functions (use help/index to look at syntax)
1. *differences/similarities*
2. *calling procedures/calling functions, arguments versus keywords*
    a. *example functions:* `DINDGEN    COS    SMOOTH`
    b. *example procedures:* `PRINT    HELP`
3. *passing variables back and forth (arguments/keywords, returned values)*
4. *syntax*
5. *comments*

→Object Oriented Graphics
1. PLOT function
2. Using keywords
3. Methods (for saving, annotating, etc)

→ Writing procedures and functions
1. *syntax*
2. *passing variables back and forth*
3. *comments*

→ useful commands
1. *resetting idl session (.reset)*
2. *compiling procedure/function (.com)*
3. *running programs in memory (.run)*

Exercise #1:
Build a procedure, create variables with values, perform simple arithmetic operations, and plot the resulting functions.

→ Setup directory structure, map home drive on *Batcivet* (start→ utilities→ map drive)

Do everything in DOUBLE precision!

Functions/Procedures to use in Exercise #1:

System variable !PI	SIN
DINDGEN	.RESET
PLOT (with keyword overplot and properties yrange,	
xrange, xstyle, ystyle)	

1. setup a PROCEDURE, first line should read "PRO *procedure_name*" for procedure_name use: 'atsc5010_*yourlastname*_Lab1a'
2. Last line should read "END", just before end should read "RETURN"
3. Create a 10001-pt array called *time* whose minimum value is 0 and maximum value is 1
4. Create a <u>double precision</u> 10001-pt vector (array) whose minimum value is 0 and maximum value is 4*pi (think of this as a 2 Hz signal) (*use* **DINDGEN also use system variable !PI)**
5. From (4) create a sin function (variable) that is offset by 2 with an amplitude of 10 (ranges from -3 to +7)
6. Plot the variable from (5) as a function of your time variable in red
7. Use the method *yrange to* change the y-range of the plot to be from -10 to +10
8. Create a second double precision 10001-pt vector whose minimum is 0 and maximum value is 12*pi (….a 6 Hz signal)
9. From (8) create a sin function (variable) that is offset by -1 with an amplitude of 4 (ranges from -3 to 1)
10. Overplot the variable from (9) on the current plot in blue (do not erase the previous plot!)
11. Create a third sin function (variable) that is the sum of (5) and (9)
12. Overplot the variable from (11) in the same plotting window
13. Using the 'thick' method, increase the thickness of the overplot in (12) to be four times that as in the earlier line plots
14. Using 'xtitle' and 'ytitle' methods, add the title 'time (s)' for the abscissa and the title 'signal' for the ordinate.
15. Edit procedure for readability:
    a. add comments to describe what you are doing
    b. add blank lines, spaces etc for readability!
16. Name the procedure 'atsc5010_*lastname*_Lab1a.pro' and save it
17. compile and run the procedure

Exercise #2:

We will compare cloud parameters that were measured with different instruments and look at a few simple IDL statistical routines that can help us evaluate data.

The data that we are using today were collected in a convective cloud in SW England. The data are from a single penetration. We are using a ~100-second time series of 3 parameters:
- Vertical velocity (in m s^{-1})
- Liquid Water Content (in g m^{-3})
- Droplet Number Concentration (in # cm^{-3})

The data are located in the file 'atsc5010_Lab1.idlsav'. This is an *idl_save* file that was generated with the *save* procedure in IDL. The file can be opened using the *restore* procedure in IDL.

To access the file:
Use a web browser to navigate to my teaching page:
http://www.atmos.uwyo.edu/~jfrench/teaching.html
Right click on **'atsc5010_Lab1.idlsav'** and choose to download (and save to a location, your atsc5010 directory on your BAT home directory would be a good choice!).

Once you have the file downloaded such that you can access it, within IDL use the *restore* procedure to open the file. The restore command uses a single argument: the path+filename of the file you want to restore.

Once opened, you will notice there are 5 variables:
- LWC_CDP (liquid water content from the cloud droplet probe), it consists of a 1001 element vector,
- LWC_PVM (liquid water content from the particle volume monitor probe) also consisting of 1001 element vector,
- N_CDP (droplet number concentration from the cdp), 1001 element vector,
- N_FSSP (droplet number concentration from the forward scattering spectrometer probe), 1001 element vector, and
- WWIND (vertical air velocity), 2501 element vector.

All variables contain ~100 s of data. The 1001-element vectors contain data at 10 Hz (each point represent 1/10th of a second. The 2501-element vector (WWIND) contains 25 Hz data.

For this exercise you will build a procedure to generate several plots and explore routines in IDL that allow users to visualize and anlyze data

Do everything in DOUBLE precision!

Functions/Procedures to use:

DINDGEN	SMOOTH
LEGEND	TEXT
PLOT with	WHERE

     Keywords: DIMENSIONS, LAYOUT,
     CURRENT, OVERPLOT, NAME
     Properties: YRANGE, XRANGE, THICK,
     LINESTYLE, COLOR, TITLE, …

CORRELATE   LINFIT

1. setup a PROCEDURE, first line should read "PRO *procedure_name*" for procedure_name use: 'atsc5010_*yourlastname*_Lab1b'
2. Last line should read "END", just before end should read "RETURN"
3. In the first line (the line that starts with PRO), add 5 arguments, one for each variable that is in the save file. When you run the program you will need to run it from the command line and you will pass the variable into your procedure using these arguments. (This also means, of course, that you will have needed to restore the data file prior to running your procedure).
4. The King Air files at ~100 m/s; each 10 Hz point represents about 10 m of data, each 25 Hz point represents ~4 m of data. Assuming the center of the data arrays represents the center of the cloud, build two arrays (one for the 10 Hz data and another for the 25 Hz data) that represents the distance from the center of the cloud (in km). *Hint: for the 10 Hz data, the vector will be 1001 elements, the zeroth element should be -5.0, the 500th element should be 0, and the 1001st element should be +5.0.*
5. We are first going to generate 3 separate plots on the same plotting window. Each of these three plots will have some additional plots overlaid. The plotting window should be 1200 pixels wide by 900 pixels high. The plots should be arranged in a single column in 3 rows (the plots will be short and wide).

PLOT#1
6. The top plot will be the liquid water content. Plot the PVM liquid water content (in green, solid line) as a function of distance from the center of the cloud.
7. Overplot the CDP liquid water content (in red, solid line).
8. Force the yrange from 0 to 3 g/m3 and the xrange from -5 to +5 km. Add a plot title and titles for the x and y axes.
9. Add a legend on the left side.

PLOT#2
10. The middle plot will be number concentration. Plot the FSSP number concentration (in Cyan, solid line) as a function of distance from the center of the cloud.
11. Overplot the CDP number concentration in red.
12. Set the xrange as in previous plots. Add a plot title and titles for the axes.
13. Add a legend on the right side.

PLOT#3

14. The bottom plot will be vertical velocity. Plot the vertical velocity (in red, solid line) as a function of distance from the center of the cloud. Force the yrange from -10 to +20 m/s and the xrange as in previous plots. Add a plot title and titles for the x and y axes.
15. Use the SMOOTH function to produce a smoothed version of the vertical wind (smoothing to 1 second, 25 points). This is a very simple low-pass filter. Overplot the smoothed velocity in blue, with a slightly thicker line.
16. From the smoothed variable you created, use the WHERE function to determine the points where the vertical velocity is in excess of 12 m/s. Overplot those points in green with a slightly thicker line.
17. Add a thin, dashed line that runs the length of the plot and denotes 0 m/s.
18. Force the yrange from -10 to +20 m/s and the xrange as in previous plots.
19. Add a plot title and titles for the x and y axes.

NOW lets play a bit more with some of the data
20. In a separate graphics window that is 600 by 600 pixels, we will analyze/compare the liquid water content measurements. When comparing these, we want to ignore the "zero" points….So first we use the WHERE function (along with the logical operator AND) to determine the points for which both the CDP and PVM LWC's are greater than some threshold value, lets use 0.02 g/m3.
21. For those points that meet our threshold, plot the PVM liquid water content as a function of CDP liquid water using small red diamonds.
22. Force the both axes to run from 0 to 2.5 g/m3.
23. Overplot a solid black line that runs from [0,0] to [2.5,2.5]; the 1:1 line.
24. Use the LINFIT function to determine the bestfit line to the data. Overplot the best fit line in thick red.
25. Use the CORRELATE function to compute the correlation coefficient.
26. Use the TEXT function to write on the graph the value of the correlation coefficient.
27. Add appropriate graph title and axes titles.

28. Finally, on yet a third graphics window, repeat the above analysis on the droplet concentration.

Exercise #3:

Begin developing a library of physical constants that will be used throughout this course. The name of the procedure should be '*phycon.pro*'. This will be a procedure (not a function) that will define set of physical constants as *system variables*.

Note: the system variables/constants should be readonly (see help for DEFSYSV). Because of this, in the procedure before you set each variable, you should check to see if it exists. If it already exists, you should warn the user that the variable already exists:
(for a system variable named !foo)

Call DEFSYSV with the keyword EXISTS:
DEFSYSV, '!foo', EXISTS=alive
IF (alive NE 1) THEN BEGIN
  DEFSYSV, '!foo', *value,* 1
ENDIF ELSE Print, "warning: system variable !foo already exists."

Functions/Procedures to use in Exercise #2:
DEFSYSV   PRINT

Syntax to use in Exercise #2:
IF/THEN BEGIN/END

The procedure will look similar to this:
PRO phycon

{some short comments describing what this procedure is used for}
…
…
{Definitions of constants, think DEFSYSV}
...
...
RETURN
END

```
;Avogadro's Number [mol-1]
!Na    6.022 X 10^23

;Gravitational Acceleration [m/s^2]
!Grav 9.807

;Molecular Wgt of Dry Air [g/mol]
!Md    28.966

;Molecular Wgt of Water Vapor [g/mol]
!Mv    18.016

;Universal Gas Constant [J/mol/K]
!Rstar      8.3143

;Gas Constant for Dry Air [J/kg/K]
!Rd    287.04

;Gas Constant for Water Vapor [J/kg/K]
!Rv    461.5

;Specific Heat of Dry Air (Constant Pressure) [J/kg/K]
!Cpd  1005.0

;Specific Heat of Dry Air (Constant Volume) [J/kg/K]
!Cvd  718.0

;Specific Heat of Water Vapor (Constant Pressure) [J/kg/K]
!Cpv  1850.0

;Specific Heat of Water Vapor (Constant Volume) [J/kg/K]
!Cvv  1390.0

;Specific Heat of Liquid Water (@ 0 degrees C) [J/kg/K]
!Cw    4218.0

;Specific Heat of Ice (@ 0 degrees C) [J/kg/K]
!Ci    2107.0

;Absolute Temperature of 0 degrees C  [K]
!Tzero      273.15

;Latent Heat Vaporization at 0 degrees C
!Lv0  2.500 X 10^6

;Latent Heat Sublimation at 0 degrees C
!Liv0 2.834 X 10^6

;Saturation Vapor Pressure at 0 degrees C [Pa]
!es0   611.21
```