ATM 401/501 Name: _____

Lab #1: Intro NCAR Command Language (NCL) Lab

For today's class, we are going to learn how to edit a basic NCL script, which modifies a base script to create imagery from the Climate Forecast Center Reanalysis dataset. The end goal is for you to obtain the basic skills for mapmaking that can then be applied towards making additional graphics for class projects, undergraduate research, ect. All of the variables, functions, and graphical packages used today are available for free on NCL's webpage maintained by NCAR. If you want to learn about more advanced NCL skills, please visit their website: http://www.ncl.ucar.edu/

For today's lab, you will use:

- Basic Linux Commands (mainly copying files from one directory to another)
- NCL variables and functions (which you will learn about in this lab)
- Climate Forecast Center Reanalysis Data (located on our servers)

At the end of the lab, you will create a 500 hPa map over the Eastern United States, plotting vorticity, geopotential height, vertical velocity, and wind barbs. Most of you should have already taken Kevin's ATM 350 class and be familiar with the Unix/Linux environment. Let me know if you have any concerns before starting the lab.

Getting Started

1. Make sure your computer is on and in the Linux OS (should be RedHat)

   a. Log in using your username and password
   b. Wait till computer has fully loaded and open up a terminal typing:

      ssh –Y username@ash.atmos.albany.edu
      (username should be same as login)

2. Let's take a file from my directory and copy it to your director

   a. Create your own directory to store the script as well as an output directory:
      mkdir /nfs/lb13/ppapin/classes/atm401/ncl_lab/username
      mkdir /nfs/lb13/ppapin/classes/atm401/ncl_lab/username/output
      (where your username = login name)

   b. Use the following command: **cd /nfs/lb13/ppapin/classes/atm401/code**
   c. Use the following command to look at the contents of the directory: **ls**

      You should see the following script: **ncl_lab_atm401.ncl**

      We want to copy this file into your self-created directory. To do this, use the following command: **cp ncl_lab_atm401.ncl . ./ncl_lab/username**
      (where your username = login name)

d. You should now have a ncl script in your lab directory ready to edit as we will do in the next step.

Editing the NCL Script

3. Now we are going to start editing some basic things with the script. We will go through this together so nobody gets lost:

a. For editing the script you can use a basic Linux text editor. I'll show how to edit the script in **vi**, but if you feel more confortable using **Emacs** or some other text editor, feel free to use whatever you are more comfortable with.

i. Just an aside, but if you are a mac user, I highly recommend downloading TextWrangler (a free text editor that has advanced functionality for editing code)

b. To open the script in vi, simply enter this command in the terminal where that file is located:

vi ncl_lab_atm401.ncl

You should see something like this at the start of the script:

```
;***********************************************
; ncl_lab_atm401.ncl
;
; Author - Philippe Papin
; Date - 13 Feb 2014
;
; About - This program is a script that will
;         plot a series of variables in order to
;         make a map
;
;
;
;***********************************************
```

If you don't, let me know!

c. A lot of the program is already completed. Oftentimes, instead of making a new code from scratch, programmers will adopt pieces of code from previous scripts to make a new script (saving time rather than writing out the same format every time!)

For this code, I have left a lot of sections blank or with text fillers (denoted by the quotes "text_filler") so that we can cover each section of the script to see how it works.

To start off, to make sure we know how to use the basic commands of vi lets just change the name of the Author of the code (since you are editing it to make it your own!)

To make edits in vi, simply hit the **i key** (insert mode) to make edits. You can use the **arrow keys (up,down,left,right)** to navigate through the script. When you are finished making edits, hit the **escape key** once again to exit insert mode.

d. Now lets really get down to editing the details. The first section we will edit is below the header **DATE SECTION**. Note that these lines of code are **commented out** by the semicolon (;) meaning it won't be read by the ncl compiler. This is a nifty way to label portions of your code so you can remember what it does. I've added a lot of helpful labeling and description for deeper understanding of the code.

   Note below this header is where we will edit. Using the **i key** to enter insert mode, insert the following values into the specified functions

   syyyy = **1993**
   smm = **03**
   sdd = **13**
   shh =**12**

   eyyyy = **1993**
   emm = **03**
   edd = **13**
   ehh = **12**

   Here we have specified the start and end time of our code to search for CFSR data. Note that this is the same time period, which means it will only retrieve one time in the dataset.

   Exit insert mode (**escape**) when you are finished

e. Set output directory of image. Here we need to set the place we want to send the output image we will create. Below the header **OUTPUT SECTION** create your output directory path.

   imgoutdir = **"/nfs/lb13/ppapin/classes/atm401/ncl_lab/username/output/"**

   Where username is your own username (e.g. ppapin). The quotes are important because this tells the compiler that this is a **string** rather than a numerical input.

f. Next we are going to read in the data. Below the header **DATA SECTION** I have already read in a lot of the variables for you, but I have purposefully left one blank. Here we need to fill in the blanks going into insert mode.

filename_w = **"/cfsr/data/"+syyyy+"/w."+syyyy+".0p5.anl.nc"**

file_w = **addfile(filename_w,"r")**

w_500 = **file_w->w({sdate:edate},{500},:,:)**

This does three things. First, it sets the directory pathway where the CFSR data is located. Second, it adds the file path into the ncl script. Finally, the specific portion of the file we want is read in, noting the start and end date we set earlier, the height level we want (500 hPa), and the latitude and longitude (in this case the entire globe).

g. Adjusting the data to make it plotable. This portion of the script is where the major number crunching is done. In this case, we want to calculate vorticity from the zonal and meridional winds we read in earlier. Fortunately, ncl has a special function that calculates this variable on a global field.

Below the header **CALCULATE SECTION** we want to use this function to calculate vorticity

vor_500 = **uv2vrF_Wrap(u_500,v_500)**

After we also need to add a constant to put vorticity in units of 10^{-5} s^{-1}

vor_500 = **vor_500 * 10^5**

Finally lets change the units of zonal and meridional wind from ms-1 to knots. To do this multiple by a constant 1.9438.

u_500 = **u_500 * 1.9438**
v_500 = **v_500 * 1.9438**

h. Now we have reaches the resource section. This is where you set the vast majority of options to adjust how the plot looks. There are literally thousands of options here, but we are only going to edit a few so you can get a hang of the most important components.

Below the header **RESOURCE SECTION** lets fill in the following missing resources

res@mpMinLatF = **20.**
res@mpMaxLatF = **60.**
res@mpMinLonF = **-110.**
res@mpMaxLonF = **-60.**

These resources limit the size of the domain plotted (in lat/lon coordinates)

w_500res@cnLineColor = **"pickacolor"**

This resource picks the color of the contour for vertical velocity. Feel free to use a color of your choosing from the choices available on the NCL website: http://www.ncl.ucar.edu/Document/Graphics/named_colors.shtml

i. Its plotting time. The last portion of the code sets the variables that will be used to plot the data you have read into the script.

Below the header **PLOT SECTION** lets fill in the following missing variables

plot_w = **gsn_csm_contour(wks,w_500(j,:,:),w_500res)**

This creates contours for the vertical velocity based upon the resources set above (including the color you choose). However, since we are overlaying a lot of different fields, we also need to ensure we overlay this variable as well

overlay(plot_map, plot_w)

j. Ok! that's all the editing we are going to do today. To save your script, use the vi commands **:wq** (make sure you are out of insert mode) to save and quit the vi program.

Running the Script

4. Now comes the moment of truth! We will now run the ncl compiler which will run the script. This process is simple, in the directory where you script is located us this linux command:

ncl ncl_lab_atm401.ncl

If your code runs successfully, you should see something like this below:

```
Copyright (C) 1995-2013 - All Rights Reserved
 University Corporation for Atmospheric Research
 NCAR Command Language Version 6.1.2
 The use of this software is governed by a License Agreement.
 See http://www.ncl.ucar.edu/ for more details.
(0)     reading in files from year: 1993
(0)     Reading in Variables
(0)     Now Creating Image For: 1200 UTC 13 Mar 1993
(0)     Figure 0 is finished!
(0)     Figures are finished
Mon Feb 17 18:46:37 UTC 2014
```

If you do, congrats! You code ran and produced an image, which we will soon view! However if you get a bunch of errors like this:

```
Copyright (C) 1995-2013 - All Rights Reserved
 University Corporation for Atmospheric Research
 NCAR Command Language Version 6.1.2
 The use of this software is governed by a License Agreement.
 See http://www.ncl.ucar.edu/ for more details.
fatal:syntax error: line 152 in file ncl_lab_atm401.ncl
before or near ; enter starting year

    syyyy =                ; enter starting year
^

fatal:syntax error: line 153 in file ncl_lab_atm401.ncl
before or near ; enter starting month

    smm =                  ; enter starting month
^

fatal:syntax error: line 154 in file ncl_lab_atm401.ncl
before or near ; enter starting day

    sdd =                  ; enter starting day
^
```

That means you missed some of the missing variables I have placed in the code, and it's not time to troubleshoot where things went wrong. Don't worry, I'll be coming around to help those of you that are experiencing this and other errors throughout the exercise.

Viewing the Image

5. The last step in today's lab is viewing the image you created and making sure its what we think it should be. To do this you will have to access your output directory where you sent the image. From your home directory use the linux command:

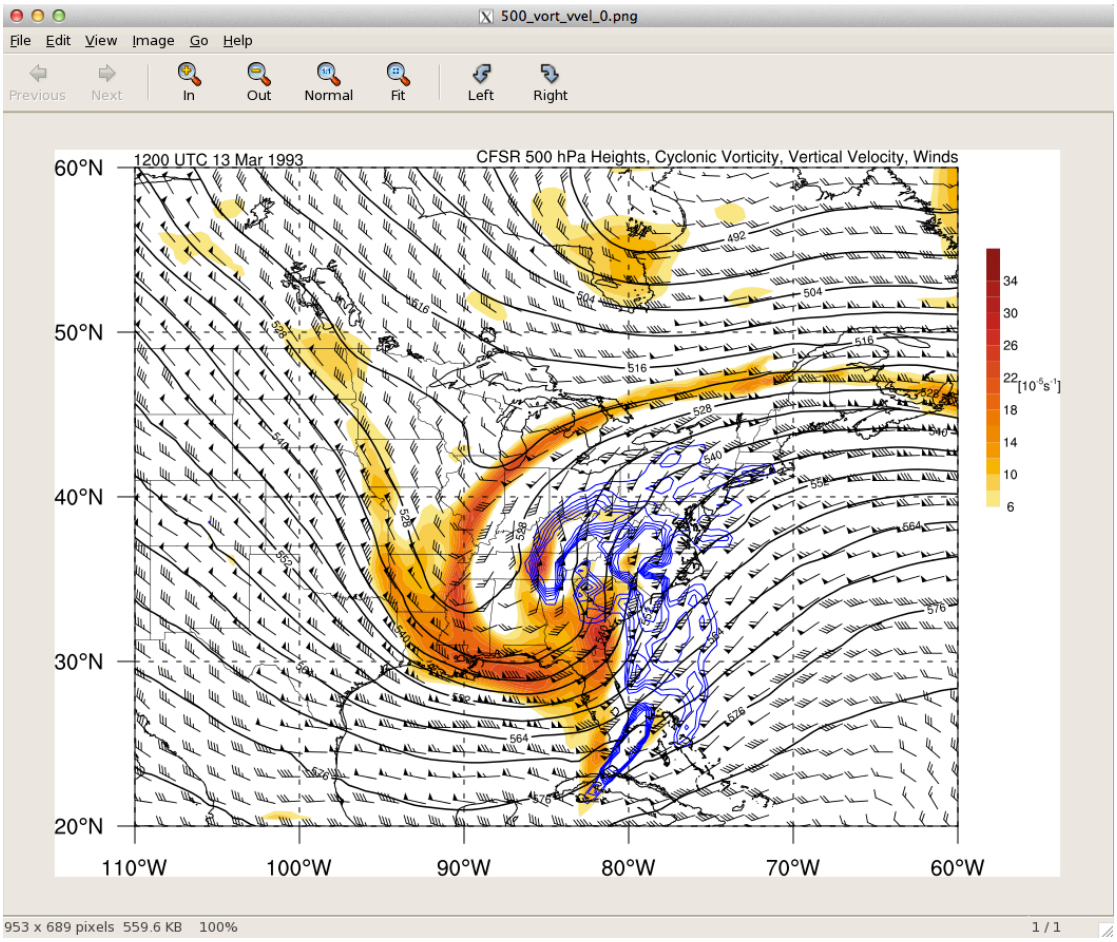
   cd /nfs/lb13/ppapin/classes/atm401/ncl_lab/output/username

   Again where your username is replaced with your login name (e.g. ppapin)

6. Once in this directory, lets view the image you have created. To do this we are going to invoke a image viewing program that uses the X-terminal (X11)

   eog 500_vort_vvel_0.png

When the x11 terminal opens up, you should see an image that looks like this



Note my color of the vertical velocity is blue, but yours might be a different color based on the color you choose in the lab. If you are seeing this image though, congrats, you have successfully created an image with an NCL script.

Now obviously there are quite a few other steps and settings you can make, and horizontal plots are only one of the many different types of plots available in NCL (again see the website for more information) but this lab should give you an idea of the basic structure of an NCL script that is used to make imagery. My hope is that with this initial script you will be able to adjust it accordingly to plot a multitude of other variables that are available in the CFSR dataset.