Atmospheric Sciences 528: Atmospheric Data Analysis
Dr. Jared Marquis (Fall 2024)
Assignment #2: Successive Corrections
Due: 25 October 2024 at 11:59PM
100 pts

1. Perform a three pass Cressman analysis of the geopotential heights in the data set given to you earlier. Use all 135 stations in the data set. The parameters you used in your previous assignment are the same here:
   a. Polar Stereographic Projection Parameters

      $\varphi_0 = 60°N$

      $\lambda_0 = 115°W$

      $m = 1 / 15000000$

   b. Analysis Grid Parameters

      $x_0=18.90cm$

      $y_0=-6.30cm$

      $\Delta x=\Delta y=1.27cm$

   The Cressman weight function is given by

$$w(d_{ik}, R) = \begin{cases} \frac{R^2-d_{ik}^2}{R^2+d_{ik}^2} & d_{ik} \leq R \\ \\ 0 & d_{ik} > R \end{cases}$$

   where d_{ik} is the distance between the i^{th} analysis point and the k^{th} observation point and R is the radius of influence. In this assignment use $R_1 = 4\ d_{min}$, $R_2 = 2.5\ d_{min}$, and $R_3 = 1.5\ d_{min}$, where R_j is the radius of influence of the j^{th} analysis pass and d_{min} is the average distance between the nearest rawinsondes in your data set (to be calculated).

   Not that you are not given a background field, so you will generate one in your first pass that is used to get the subsequent passes. Thus, your first pass analysis values at the grid points are generated using:

$$f_A^1(\vec{r_i}) = \frac{\sum_{k=1}^{K_i} w(d_{ik}) f_O(\vec{r_k})}{\sum_{k=1}^{K_i} w(d_{ik})}$$

   For subsequent passes, analysis values are computed using:

$$f_A^j(\vec{r_i}) = f_A^{j-1}(\vec{r_i}) + \frac{\sum_{k=1}^{K_i} w(d_{ik})[f_O(\vec{r_k}) - f_A^{j-1}(\vec{r_k})]}{\sum_{k=1}^{K_i} w(d_{ik})}$$

where $j \geq 2$. Note that this is the same as a Barnes analysis, except the Cressman weight function is being used here.

In order to perform passes two and three, you need to estimate the analysis values from the previous analysis pass at the observation stations. Use bilinear interpolation for this (you are expected to code this and not use a "canned" routine). Some observation stations are outside of your analysis domain. For these, use a Cressman analysis to estimate the analysis values at the observation stations. When you perform these Cressman analyses:

- Use the radius of influence that was used to obtain the analysis values at the analysis grid points.
- Weight the analysis values at the grid points, not the observation values at the observation locations.

If no analysis points are within the radius of influence, simply set the values there to "not-a-number" or NaN.

2. Compute the differences between analyses (analysis 2 - analysis 1, analysis 3 - analysis 1, analysis 3 - analysis 2).

3. Compute the root mean square differences between the analyses and observations fro each analysis pass. These are calculated using:

$$\Delta^j_{rms} = \sqrt{\frac{\sum\limits_{k=1}^{K}[f_O(\vec{r_k}) - f^j_A(\vec{r_k})]^2}{K}}$$

where K is the total number of observations.

4. Contour your analyses and difference fields.

5. You should link your github repository to the course's blackboard site. Within this repository, you should have:
   a. Your code
   b. Text files containing your analyses and number of observations considered during the analysis.
   c. 4 contour plots (2 analyses and 2 indicating the number of obs used at each analysis point for the two different radii of influence).
   d. Answers to the following questions:
      i. Describe the general features that you see in your contoured analyses.

ii. Describe the differences that you see in your contoured analyses. Does one analysis seem to be smoother than the other? If so, what would cause this?

iii. What happens as you increase the number of successive correction passes? Is this desirable? Why or why not?