Atmospheric Sciences 528: Atmospheric Data Analysis
Dr. Jared Marquis (Fall 2024)
Assignment #3: Statistical Objective Analysis
Due: 15 November 2024 at 11:59PM
100 pts

1. Perform a univariate statistical objective analysis of the height data you have been using all semester on the grid that you have been using all semester:
   a. Polar Stereographic Projection Parameters

      $\varphi_0 = 60°N$

      $\lambda_0 = 115°W$

      $m = 1 / 15000000$

   b. Analysis Grid Parameters

      $x_0=18.90cm$

      $y_0=-6.30cm$

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

   You need a background field to perform this analysis. We will use one obtained from a one-pass Barnes analysis of the observation values. This analysis is performed similar to the one you did for the first successive corrections pass - i.e.,

$$w(d_{ik}) = exp(\frac{-d_{ik}^2}{K_d})$$

   except, the weights will be determined using the following weight function:

   where $K_d = 10.8844524\ cm^2$. Use $r_e=12.7775892\ cm$ as your radius of influence.

2. The analysis equation is given by:

$$f_A(\vec{r_i}) = f_B(\vec{r_i}) + \sum_{k=1}^{K} w_{ik}[f_O(\vec{r_k}) - f_B(\vec{r_k})]$$

   where the weights w_{ik} are given by:

$$\sum_{l=1}^{K} w_{ik}\rho_{kl} = \rho_{ik}$$

   where ρ_{kl} is the background error correlation between the k^{th} and l^{th} observation stations and ρ_{ki} is the background error correlation between the k^{th} observation station and the i^{th} gridpoint (the gridpoint at which we are determining the weights). Note that this simplified form of the statistical objective analysis assumes that the observations are perfect (observation error covariances and variances are zero) and that $E_B\underline{\underline{\sigma}}_B^{-1} = I$, where I is the identity matrix (it assumes that the background error standard deviation is homogeneous). In matrix form, the above equation is:

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$$\begin{bmatrix} \rho_{11} & \rho_{12} & \cdots & \rho_{1K} \\ \rho_{21} & \rho_{22} & \cdots & \rho_{2K} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{K1} & \rho_{K2} & \cdots & \rho_{KK} \end{bmatrix} \begin{bmatrix} w_{i1} \\ w_{i2} \\ \vdots \\ w_{iK} \end{bmatrix} = \begin{bmatrix} \rho_{i1} \\ \rho_{i2} \\ \vdots \\ \rho_{iK} \end{bmatrix}$$

3. To compute the correlations, use the Schlatter (1975) model

$$\rho(s) = 0.95 exp[-1.24 s^2]$$

where *s* is the distance *on the Earth* between two points in 1000s of km. [You can use the Cartesian distance on your grid if you adjust the range factor *b = 1.24* to your grid (i.e., *b' = xxx cm-2*).] Use the image scale factor valid at *40°N* so that this value is constant over your analysis domain. Note that when *s = 0*, this equation produces *0.95* while it really should produce *1*. Catch this situation in your code so that it produces *1* when *s = 0*.

4. Perform 3 analyses using:
   a. N = 2 (use the 2 closest stations)
   b. N = 4 (use the 4 closest stations)
   c. N = 10 (use the 10 closest stations)

5. You should link your github repository to the course's blackboard site. Within this repository, you should have:
   a. Your code
   b. The analyses (raw values and plotted)
   c. The analysis increment fields (raw values and plotted)
   d. Analysis difference (analysis value minus observation value) at each station (raw values – note this will require a forward interpolation of the analysis values … use the same bilinear interpolation for observation stations within the grid and one pass Barnes scheme for observation stations outside the grid to perform this forward interpolation.)
   e. Computed RMS differences between analysis values and observations at the observation stations.
   f. 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 points considered for the analysis? Is this desirable? Why or why not?