

SIO 217B Atmospheric and Climate Sciences II

Exercise #5

- Write down an equation for calculating the horizontal divergence of the wind field in spherical coordinates. Split $\partial/\partial\phi$ ($v \cos\phi$) into separate terms.
 - What does the tangent term physically represent?
 - Download the files containing u_{10-m} and v_{10-m} for 1993 March 14 00Z. Using a centered finite difference method, calculate the divergence of the wind field (units are s^{-1}). For more convenient numbers, multiply divergence by 10^5 . Plot contours of divergence in the domain 20-50°N, 270-310°E using intervals of 2 (actually 2×10^{-5}). To check your results, download the file containing divergence in the lowest model layer for 1993 March 14 00Z. If possible, add the data to the same plot using a different color (divide by 10 to obtain similar units). There will not be exact agreement due to the differing sources for divergence values.
- Plot contours of calculated divergence overlaid by wind vectors in the domain 20-50°N, 270-310°E, using every other wind vector if necessary to reduce crowding. Check to see if the areas of divergence (positive values) and convergence (negative values) are consistent with the wind vectors.
- Download the file containing SLP data for 1993 March 14 00Z. Calculate geostrophic wind from the SLP data as in Exercise #4. For convenience, assume density has a uniform value of 1.2 kg m^{-3} . Calculate the horizontal divergence of the geostrophic wind field. Plot contours of divergence overlaid by geostrophic wind vectors in the domain 20-50°N, 270-310°E using the same contour interval as in the previous plot.
 - Why is horizontal divergence of the geostrophic wind field so small?
- Divergence is difficult to accurately calculate from wind observations since it is determined by small spatial differences in the magnitude and direction of atmospheric flow. Small errors in the wind measurements can thus result in large errors in calculated divergence. Such a problem is not apparent in the downloaded model analyses, however, because the model adjusts and interpolates the assimilated wind observations so that they are dynamically consistent (at least from the model point of view). To mimic real observations, I have separately multiplied u_{10-m} and v_{10-m} for each grid box by a random number drawn from a normal distribution with a mean of 1.0 and a standard deviation of 0.3 (i.e., introducing approximately $\pm 30\%$ errors). Download the files containing u_{10-m} and v_{10-m} with “errors” for 1993 March 14 00Z, and plot them in the domain 20-50°N, 270-310°E. If possible, add the “non-error” wind vectors to the same plot using a different color. Note that the errors in the wind vectors at each grid box have little impact on the large scale structure of the wind field.

5. Calculate the horizontal divergence of the 10-m wind field with “errors”, and plot it in the domain $20\text{-}50^\circ\text{N}$, $270\text{-}310^\circ\text{E}$. If possible, add the “non-error” divergence to the same plot using a different color. Although the gross features of the divergence field are still present, note that there are now relatively large and obvious errors in divergence at various locations.