This assignment involves an examination of several diagnostics for vertical motion as applied to a strong cyclone that moved through the central US this week. In preparation for your upcoming case studies, your plots should be presentation quality. This means, for example, that the contours should be smooth (but with skip = 0 for all contour plots), the titles clear and succinct with all the proper information, the color schemes neat and not messy, etc. Use an appropriate garea and projection, along with the following parameters for all plots in this assignment:

```
gdfile = $MODELDATA/09100612_eta.gem
gdattim = f00
```

**1. The traditional QG omega equation**

a) Create a four-panel plot containing the following fields (hand in the plot and the script). In each panel, omit the zero contour, contour positive values with a solid line, and contour negative values with a dashed line. For negative omega, only plot the positive values.

- **Upper left**: Horizontal temperature advection at 700 mb
- **Upper right**: Negative Laplacian of temperature advection at 700 mb
- **Lower left**: Differential geostrophic vorticity advection between 850 mb and 500 mb
- **Lower right**: Negative omega at 700 mb (color fills) and 700-mb heights (contours)

b) Address the following questions. Qualitatively, what are some differences between the temperature advection and the Laplacian of temperature advection?† Are there regions in which cancellation occurred between the two terms in the traditional QG omega equation? Where? Is the forecasted upward vertical motion (negative omega) successfully diagnosed by using the two terms from the traditional QG omega equation? If there are differences, what may be causing the differences?

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† Note: These two fields do not have the same scale. Thus, do not compare magnitudes here.
2. The Trenberth formulation and Q-vectors

a) Create a four-panel plot containing the following fields (hand in the plot and the script). In each panel, omit the zero contour, contour positive values with a solid line, and contour negative values with a dashed line. For color fills, only plot the positive values.

- **Upper left**: Positive geostrophic relative vorticity at 700 mb (color fills) and 900–500-mb thickness (contours)
- **Upper right**: Positive geostrophic relative vorticity advection by the 900–500-mb thermal wind at 700 mb (color fills)
- **Lower left**: Q-vectors (arrows) and Q-vector convergence (color fills) at 700 mb
- **Lower right**: Negative omega at 700 mb (color fills) and 700-mb heights (contours)

b) Compare the plot of relative vorticity advection by the thermal wind with the vertical motion field. Describe how well the vorticity advection field matches up with the model forecast vertical velocity. What term(s) have been neglected in the Trenberth form of the QG omega equation that should be considered in this situation?

c) Compare the Q-vector convergence field with the vertical velocity field. Describe how well the Q-vector convergence and upward vertical motion correspond, and, in particular, make note of locations where the two fields do not correspond all that well. Why does Q-vector convergence not completely account for the plotted upward vertical motion?