EAS372 Assignment 2 (15%) Due: 21 March, 2017

Interpreted in the simplest terms, the quasigeostrophic model suggests that positive vorticity advection (PVA) and positive temperature advection (PTA) correlate with falling isobaric height (i.e. deepening of a low pressure system) and with ascending vertical motion. This assignment, effectively a case study, is intended to demonstrate the validity of the paradigm. To that end, by monitoring the CMC RDPS progs please choose a time and location **P** for which strong ascent at the 500 hPa level is evident (preferably choose a point away from the immediate influence of mountains, i.e. well east of the Rockies). Be sure, having fixed on a "case", to store all the charts you may need for the tasks below. (Note: "omega" is designated ϖ in this file to clearly differentiate it from w.)

Task A: Based on the RDPS 0h prog (upper-left panel of the black-and-white charts at weather.gc.ca/model_forecast/index_e.html), estimate the rate of vorticity advection at the 500 hPa level at your "**P**", approximating this as $-\mathcal{U}\,\partial\zeta/\partial s$ (in the natural coordinate system). Then, assuming the time tendency in ζ can be neglected, use the quasi-geostrophic vorticity equation[1]

$$\frac{\partial \zeta}{\partial t} = 0 = -\mathcal{U}\,\frac{\partial \zeta}{\partial s} + f_0\,\frac{\partial \varpi}{\partial p} \tag{1}$$

to infer $\partial\varpi/\partial p$ at **P**. Compare this estimate for $\partial\varpi/\partial p$ with an "actual value"

$$\frac{\Delta\varpi}{\Delta p} = \frac{\varpi_{700} - \varpi_{500}}{p_{700} - p_{500}} \tag{2}$$

deduced from the RDPS 0h progs for ϖ at 500 hPa and 700 hPa (be sure to use the same units for both estimates). RDPS fields may be accessed via Vizaweb (colour fields), or via weather.gc.ca/model_forecast/index_e.html (colour 4-panel chart, or black-and-white chart). Note: patterns of ϖ are generally quite "noisy", and the uncertainty in your evaluation of $\Delta\varpi/\Delta p$ using Eq. (2), an uncertainty which you should estimate, will be quite large[2].

[1]Here the term in $v_g\,\partial f/\partial y$ has been neglected.

[2]Recall that when adding or substracting quantities, the absolute uncertainties add; but when multiplying or dividing, one adds the *fractional* uncertainties.

Task B: The QG vertical velocity (w) equation may be written in qualitative form as a proportionality

$$[\,\overline{w}_{\rm nbr} - w_{\rm P}\,] \propto \nabla \cdot \mathbf{Q} \,, \tag{3}$$

where the left hand side "compares" vertical velocity $w_{\rm P}$ at a point **P** with the average value $\overline{w}_{\rm nbr}$ nearby, and the right hand side is the divergence of the "**Q**-vector." According to this formula, wherever **Q**-vectors are *convergent* (i.e. $\nabla \cdot \mathbf{Q} < 0$) a local maximum in vertical velocity can be expected (i.e. $w_{\rm P} > \overline{w}_{\rm nbr}$).

Demonstrate whether the pattern of vertical motion is (or is not) qualitatively consistent with the pattern of the **Q**-vectors in the region of your chosen point **P**, based on the **Q**-vector plots available at `www.atmo.arizona.edu/~tgalarneau/realtime/qg_diag/Qvect700-NorAmer/res3.html`). (Note: these **Q**-vectors are based on the GFS model. Be sure to navigate to the correct Frame No., i.e. that which gives you **Q**-vectors from the 0h GFS prog for your chosen date and time; for instance if your chosen time is 12Z the final 8 digits should be 1200V000.)

Format: Please submit your report as a PDF file, double spaced with font size 12 pt; the page limit is **four**, not counting figures and tables. Attach each of the charts that underpin your report (height and vorticity at 500 hPa; omega at 700 and 500 hPa; **Q**-vectors at 700 hPa). These images may be cropped to focus on the area of interest, and should preferably be integrated into your PDF; however if your software does not permit that step, please submit them as images, each with a suitable title (instructor will integrate them into a single PDF).