ATM 401 **Spring 2010**

Due: 11 Mar 2010

Problem Set #1: Sutcliffe Development Theory

1. Overview:

Use archived GEMPAK plots from Tom Galarneau's Real-Time QG Analysis and Forecast Diagnostics webpage located at:

http://www.atmos.albany.edu/student/nmetz/atm401/PS1loops.html

to analyze, diagnose, and interpret the evolution of the 24–25 Feb 2010 anticyclone in the lee of the Rockies and the 25–27 Feb 2010 East Coast cyclone based on the application of Sutcliffe development theory.

The Sutcliffe development equation can be expressed as:

$$-\vec{\nabla}_p \bullet \vec{V}_0 = -\frac{2}{f_0}(\vec{V}_t \bullet \vec{\nabla}_p \zeta_0) - \frac{1}{f_0}(\vec{V}_t \bullet \vec{\nabla}_p \zeta_T) - \frac{1}{f_0}(\vec{V}_t \bullet \vec{\nabla}_p f)$$

LHS **Term A** **Term B** **Term C**

2. Definitions:

Thermal wind: $\vec{V}_t = \frac{g}{f_0}\hat{k} \times \vec{\nabla} Z$ where Z is 1000–500-hPa thickness and $\hat{k}$ is a unit vector.

Thermal vorticity: $\zeta_T = \zeta_{g500} - \zeta_{g1000}$ where ζ_g is geostrophic relative vorticity.

Coriolis parameter: $f = 2\Omega \sin\phi$; $f_0 = 10^{-4} s^{-1}$

LHS = 1000-hPa horizontal convergence

Symbols:
g = gravity
$\vec{\nabla}_p$ = horizontal gradient operator on a pressure surface
ϕ = latitude

Subscripts:
0 = 1000 hPa
g = geostrophic
t = thermal wind
T = thermal vorticity

3. Questions:

Loops from 1200 UTC 19 February to 0600 UTC 1 March 2010 of:

1) 1000-hPa geostrophic relative vorticity.
2) 1000–500-hPa thermal vorticity.
3) Term A of the Sutcliffe development equation.
4) Term B of the Sutcliffe development equation.
5) Term C of the Sutcliffe development equation.
6) The total Sutcliffe forcing [sum of terms on the RHS of the Sutcliffe development equation (A+B+C)].

are located at the above website. For the purposes of analysis **T=0 h** for the anticyclone in the lee of the Rockies is 0000 UTC 24 February, while **T=0 h** for the east-coast cyclone is 1200 UTC 25 February.

1. Write a **succinct** discussion of the synoptic pattern at **T=0 h** based on number 1 and 2 above.

2. Based on Sutcliffe development theory, how do you expect the 1000-hPa cyclone and anticyclone to move over the next 12 hours (**T=12 h**)? Explain your reasoning.

3. How well does the theory predict the observed 12-h cyclone and anticyclone movement?

4. Based on Sutcliffe development theory, how do you expect the intensity of the 1000-hPa cyclone and anticyclone to change over the next 12 hours (**T=12 h**)? Explain your reasoning.

5. How well does the theory predict the observed 12-h cyclone and anticyclone intensity change?

6. How does the magnitude of forcing for 1000-hPa convergence from term B compare to that from term C for the cyclone and anticyclone?

7. Discuss the physical implications of the total Sutcliffe forcing for 1000-hPa convergence for the cyclone and anticyclone. Where does Sutcliffe development theory succeed and where does it fail? Explain