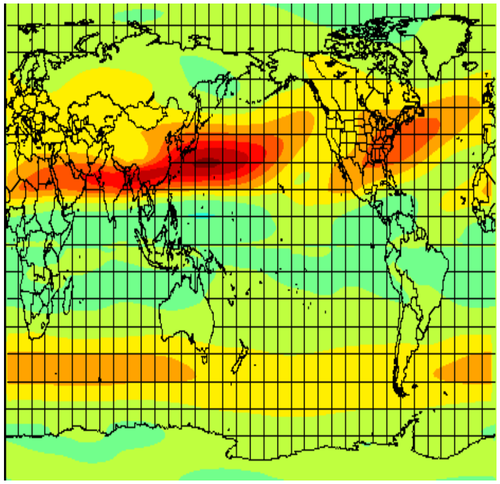
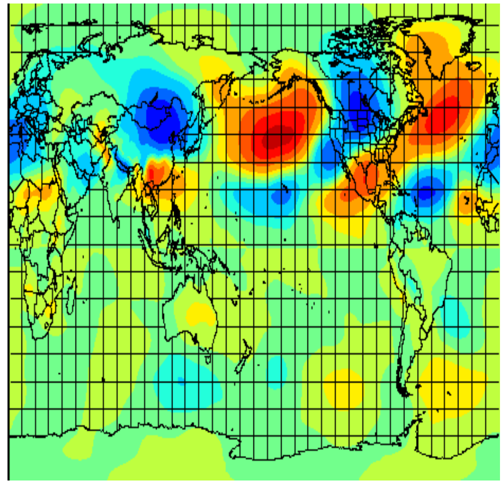
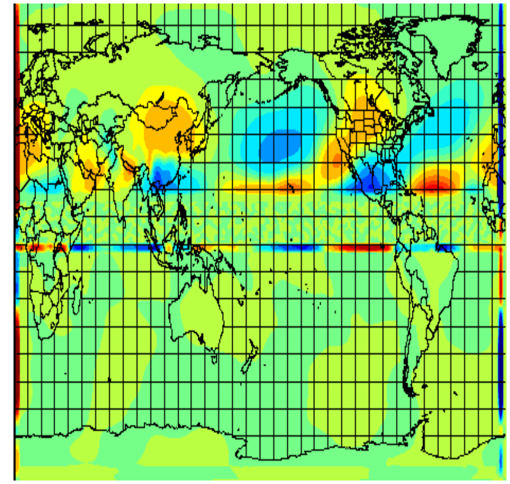


Average of **Zonal Wind at 500hPa** [m/s], for January computed over 1960-1999, from HadGEM2



Average of **Meridional Wind at 500hPa** [m/s], for January, computed over 1960-1999, from HadGEM2



Average of **Divergence at 500hPa** [10-6 s-1], for January, computed over 1960-1999, from HadGEM2

Example of maps prepared from the HadGEM2 AOGCM simulations using the geostrophic approximation (i.e. wind recontructed from the pressure gradient). Note that grid points near the equator are excluded from the final products (i.e. winds, divergence and vorticity from the predictors list).
We can see that the divergence (right panel) is strongly correlated with the meridional component features of the wind (middle panel, see further explanations in the following slides).

The divergence divergence of the geostrophic wind can be written as:

$$div_h \mathbf{v}_g = \left(\frac{\partial u_g}{\partial x} + \frac{\partial v_g}{\partial y} \right) = -\frac{\partial}{\partial x}\left(\frac{1}{\rho f} \frac{\partial p}{\partial y} \right) + \frac{\partial}{\partial y}\left(\frac{1}{\rho f} \frac{\partial p}{\partial x} \right)$$

$$= \frac{1}{\rho f}\left\{ -\frac{\partial^2 p}{\partial x \partial y} + \frac{\partial^2 p}{\partial y \partial x} \right\} - \frac{1}{\rho f^2} \frac{\partial p}{\partial x} \frac{\partial f}{\partial y}$$

We have neglected some horizontal gradients in density as being small. Hence we have deduced that:

$$div_h \mathbf{v}_g = 0 - \frac{v_g}{f} \frac{\partial f}{\partial y}.$$

Now $\frac{1}{f} \frac{\partial f}{\partial y} = \frac{1}{2\Omega \sin\phi} \frac{1}{a} \frac{\partial}{\partial \phi} 2\Omega \sin\phi = \frac{1}{a} \cot\phi$.

At 45°N $\frac{1}{a} \cot\phi = \frac{1}{6.4 \times 10^6 m} = 10^{-7} m^{-1}$, so that

$$div_h \mathbf{v}_g \sim 10 ms^{-1} 10^{-7} m^{-1} = 10^{-6} ms^{-1}.$$

Source: Choux (2005)

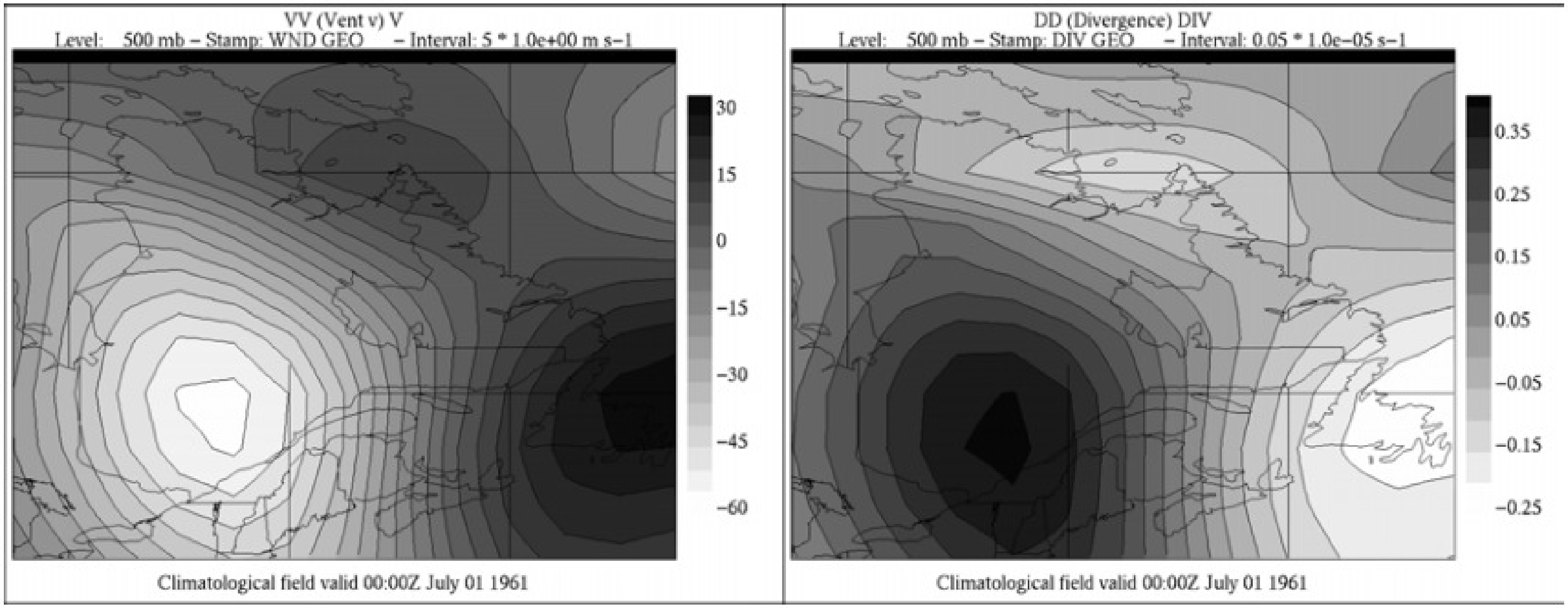


Figure 2.1 Geostrophic meridional wind (left panel) and divergence (right panel) fields at 500hPa, over the province of Quebec in eastern Canada, for July 1st 1961.

As noted before (i.e. previous slide) and in Holton (1992), the divergence of geostrophic wind is proportional to the meridional (V) component of the same wind, i.e.

$$\vec{\nabla}_H . \vec{V}_g = -\frac{\beta}{f} v_g$$

As shown Choux (1995), the geostrophic and meridional wind are strongly correlated. As shown in Fig. 2.1 (using NCEP 500-hPa geopotential height to reconstruct the geostrophic wind), the max./min. divergence of the wind and the min./max. of the V component of the wind (geostrophic), reached at the same location, are of approximately proportional. The proportionality factor between the two variables would be of order of 10-7 m-1, which is good agreement with typical dimensions of : β (10^{-11} m^{-1}.s^{-1}) and f (10^{-4} s^{-1}).

<u>REFERENCES or further reading:</u>

Choux M., **2005**: “Development of new predictor variables for the statistical downscaling of precipitation”, Degree Master of Engineering, Department of Civil Engineering and Applied Mechanics, McGill University. 72 pp.

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