Angular momentum as the sole forcing of polar lows

Torsten Linders, University of Gothenburg
Oslo Polar Low Workshop, May 2012

Introductory excuses

I am an oceanographer cheating in the field of meteorology

Introductory excuses

This is not work in progress...
This is work I am contemplating
thinking about starting with.

Any suggestions or objections are most welcome!

Summary

- The intensity of polar lows can be entirely explained by converging angular momentum.
- The role of the sea surface heat fluxes is to maintain the convergence by creating convection.

Motivation

- It could be argued that polar lows get their intensity from the sea surface heatfluxes. This has been done by Kerry Emanuel and followers, including myself...

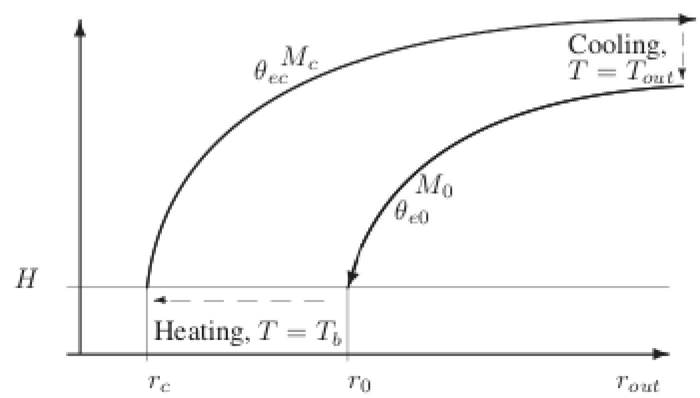


Figure 6. Schematic illustration of the Carnot circuit. Adopted from Emanuel (1986b). Note that the ascent and the descent take place along surfaces of constant angular momentum, M, and constant equivalent potential temperature, θ_e.

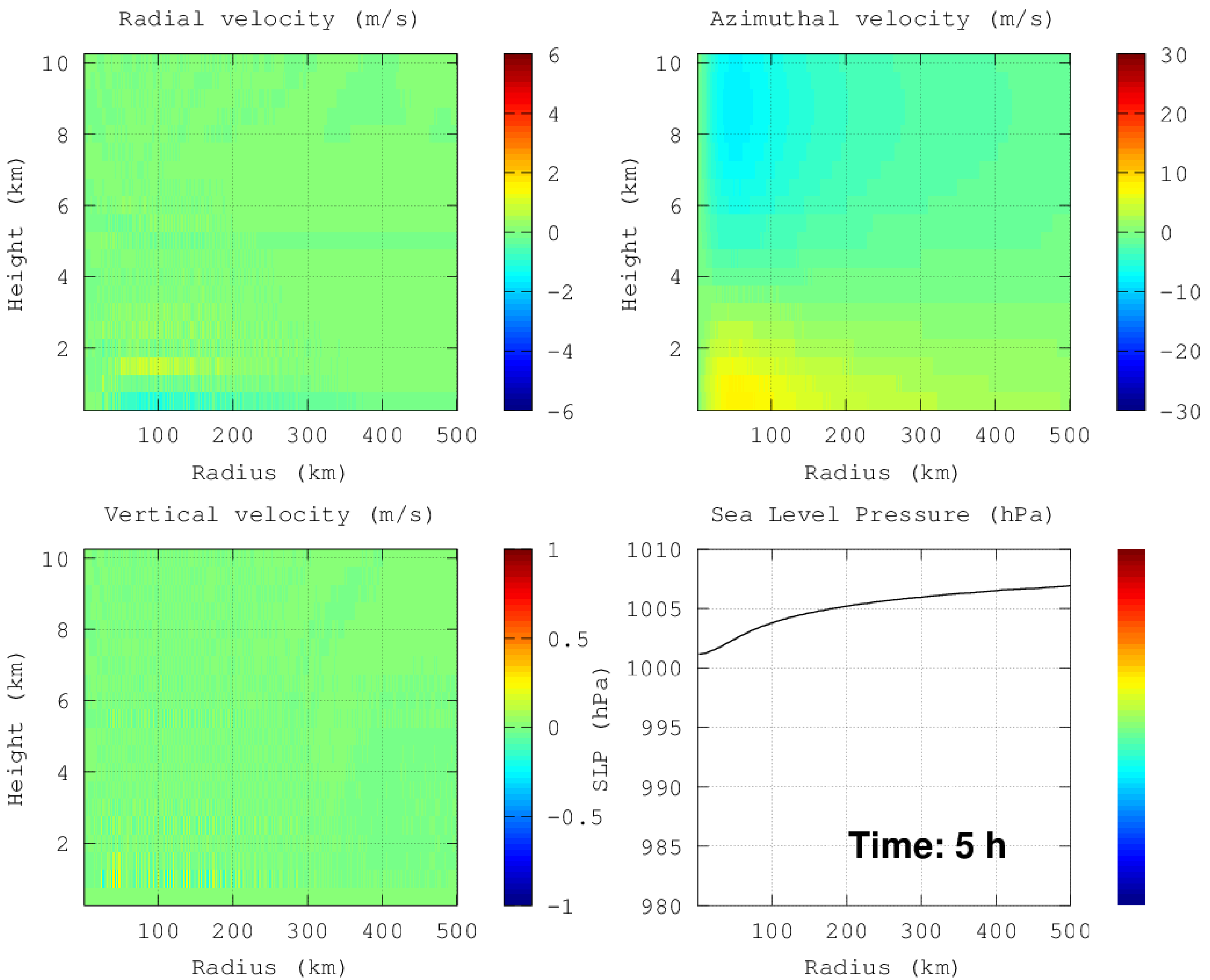
My framework

- The axis-symetric and non-hudrostatic model of Emanuel and Rotunno (1989), modified by Craig (1995). δr = 2 km, δz = 500 m.
- The model is initialized with sounding from Bjørnøya December 1982 and a weak low level vortex. The SST is 6 ºC.

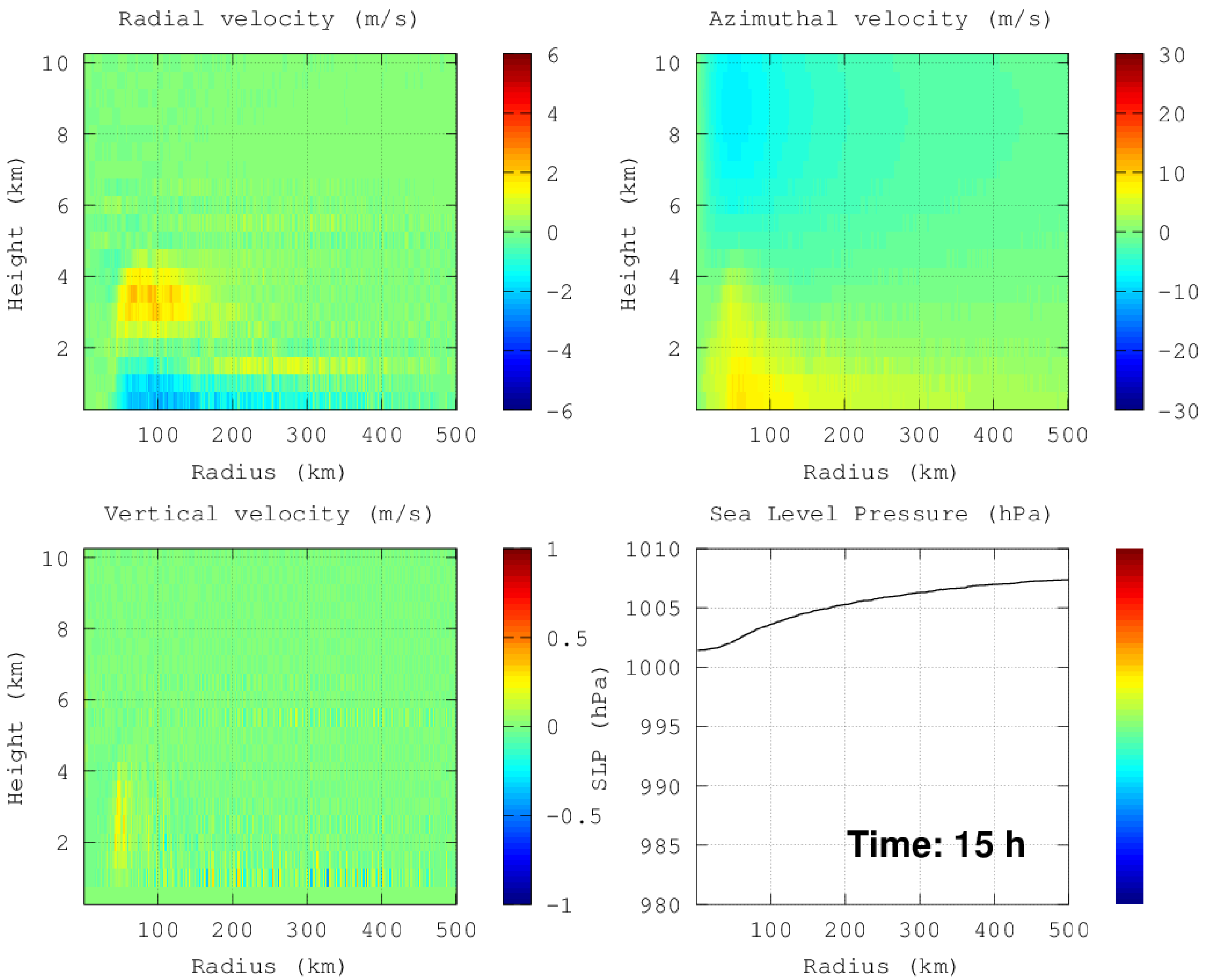
Not in my framework

- Baroclinic instability.
- Observations of the real world.

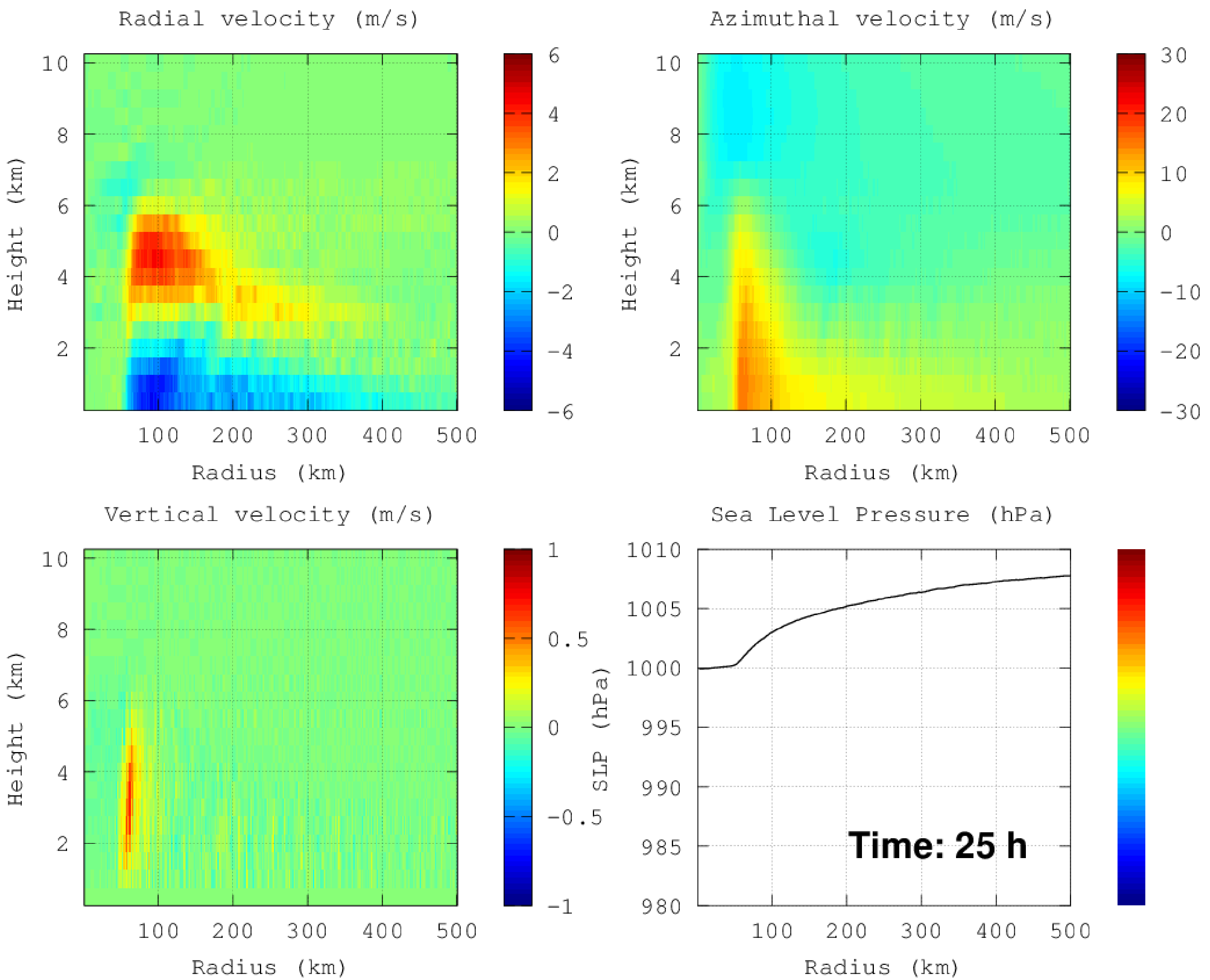
Polar low simulation



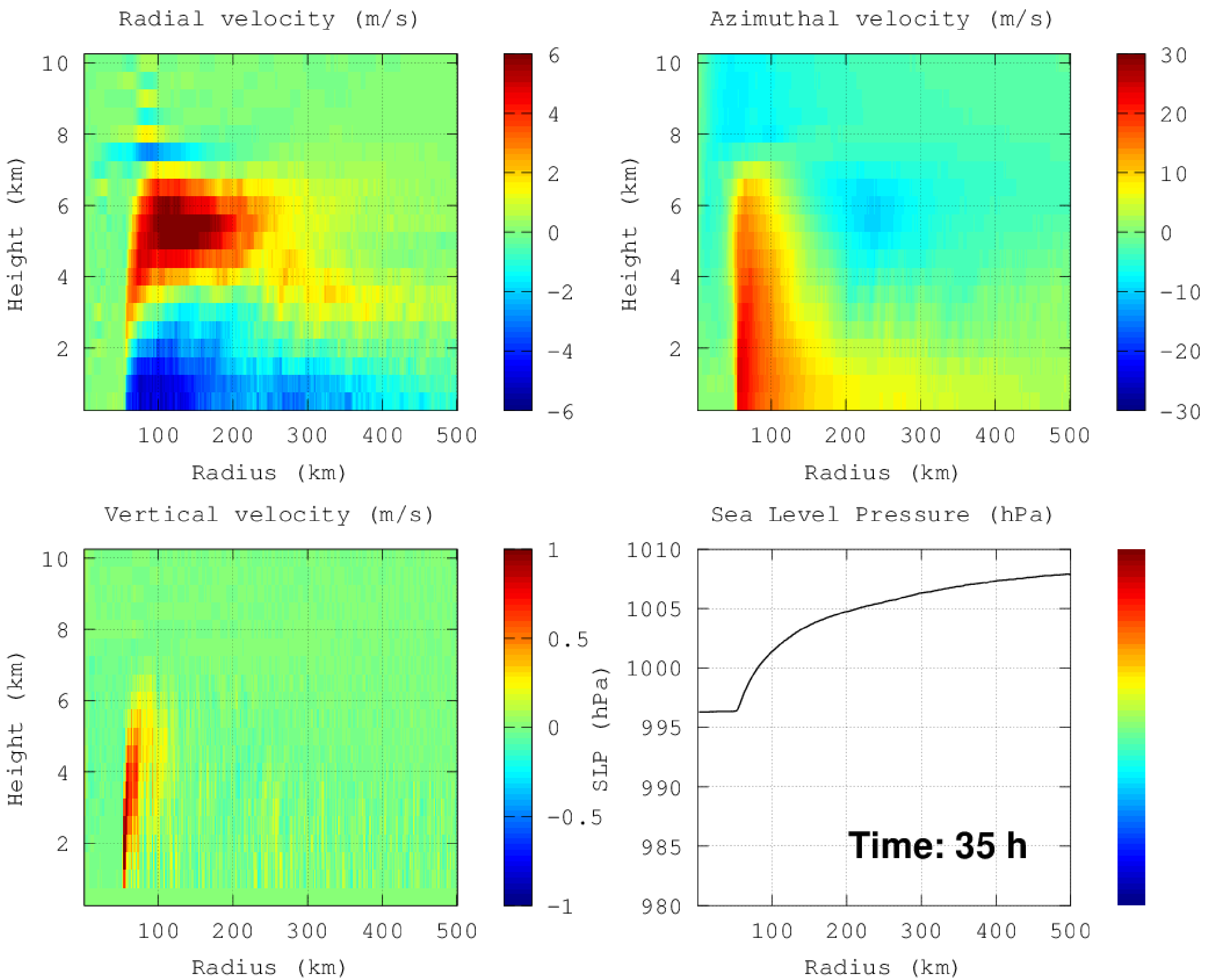
Polar low simulation



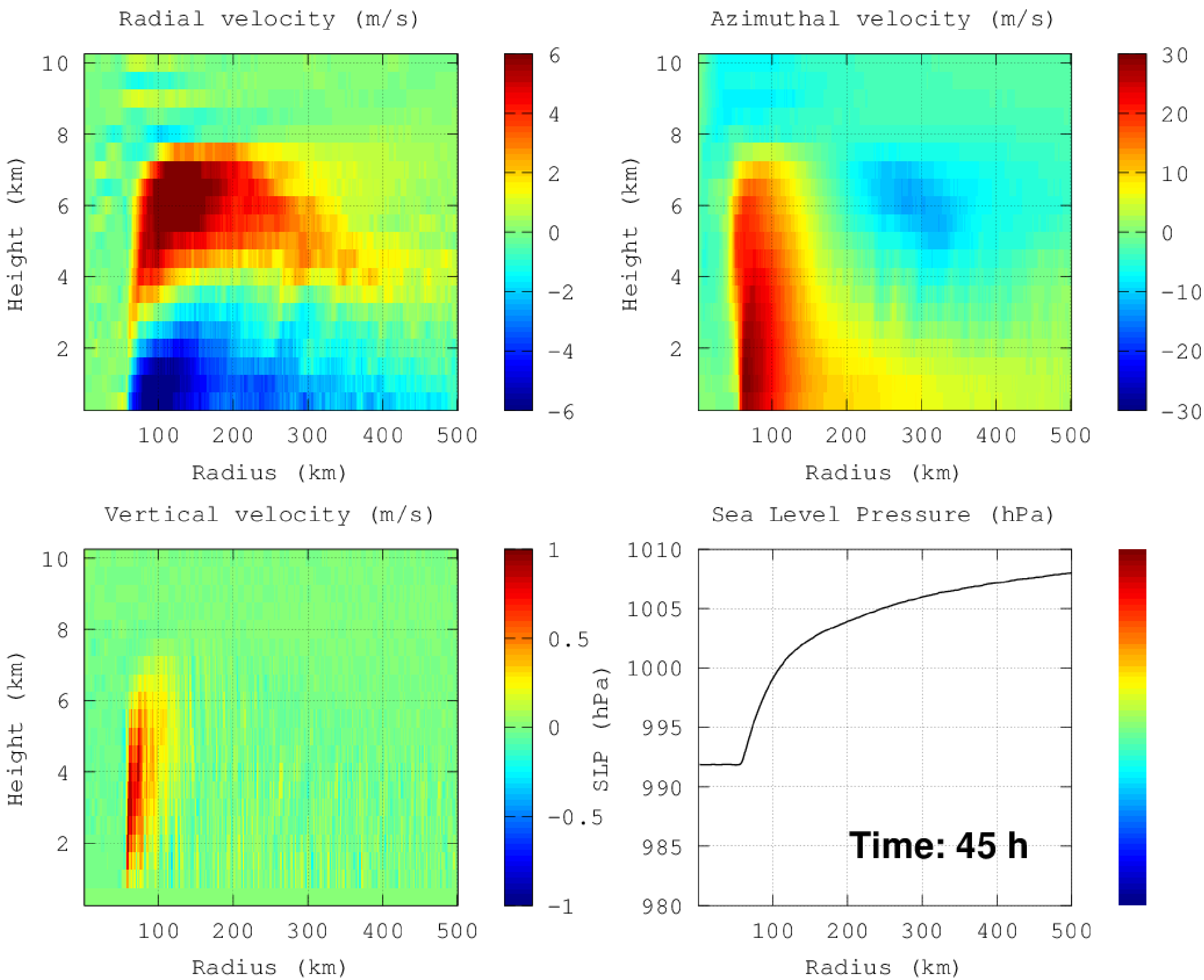
Polar low simulation



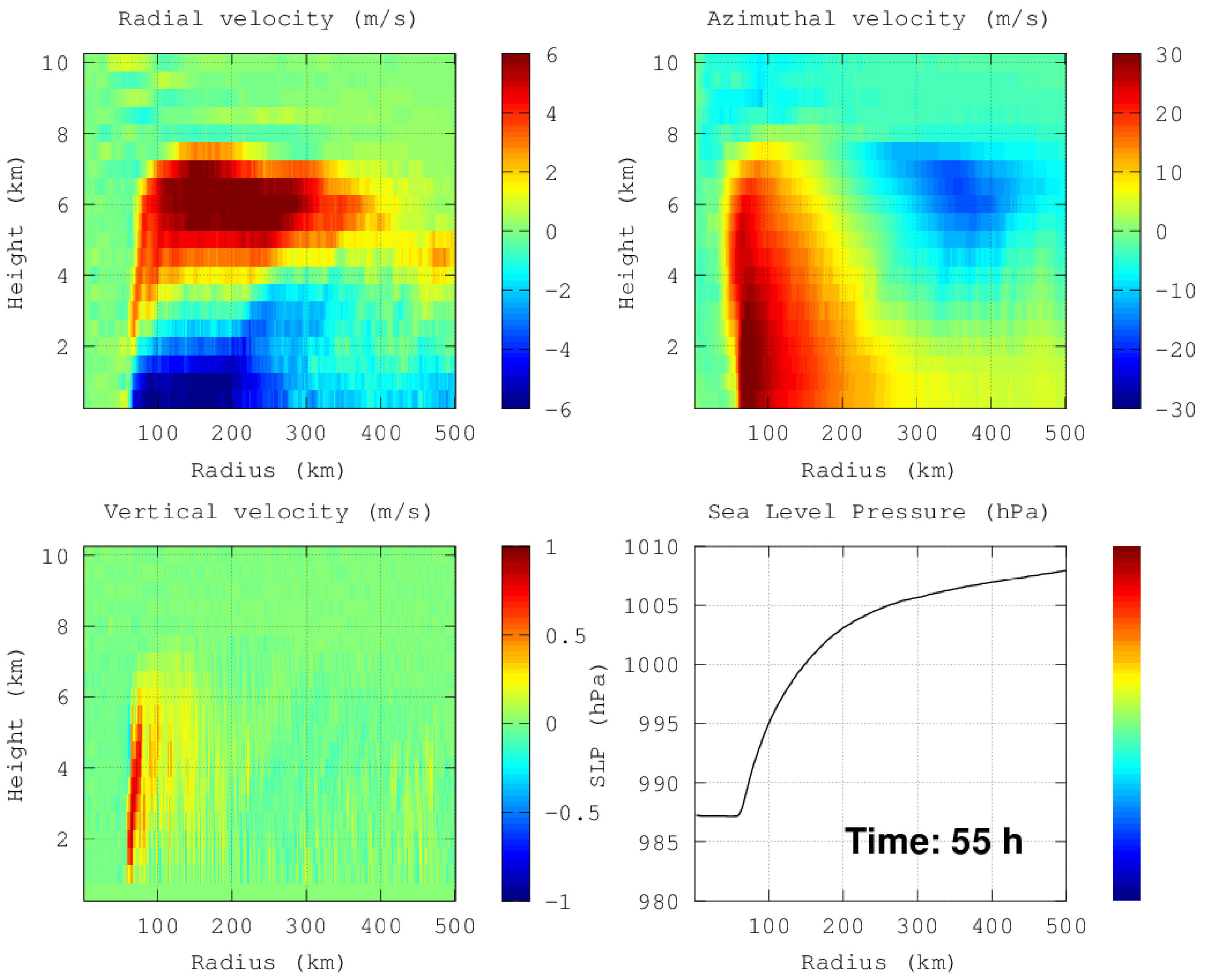
Polar low simulation



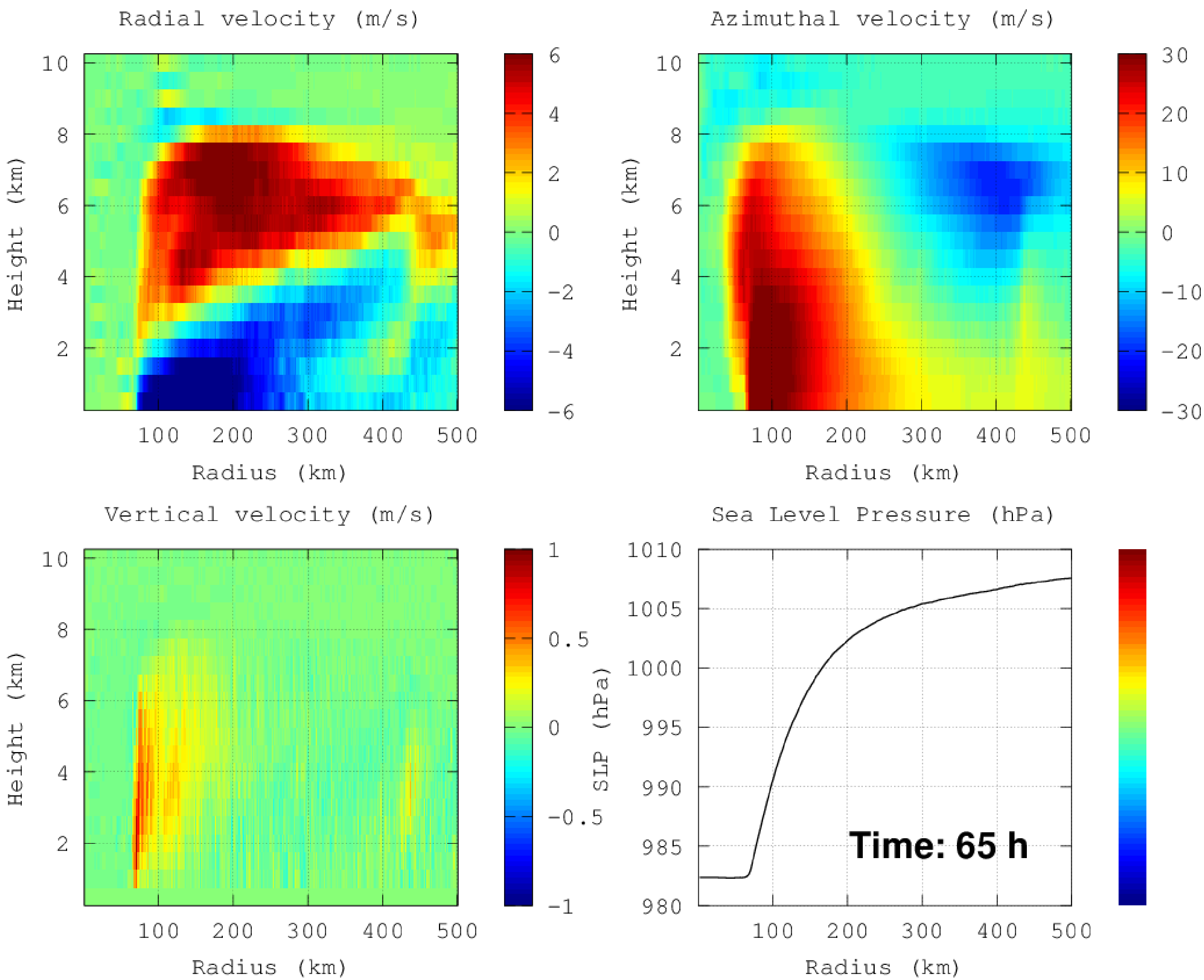
Polar low simulation



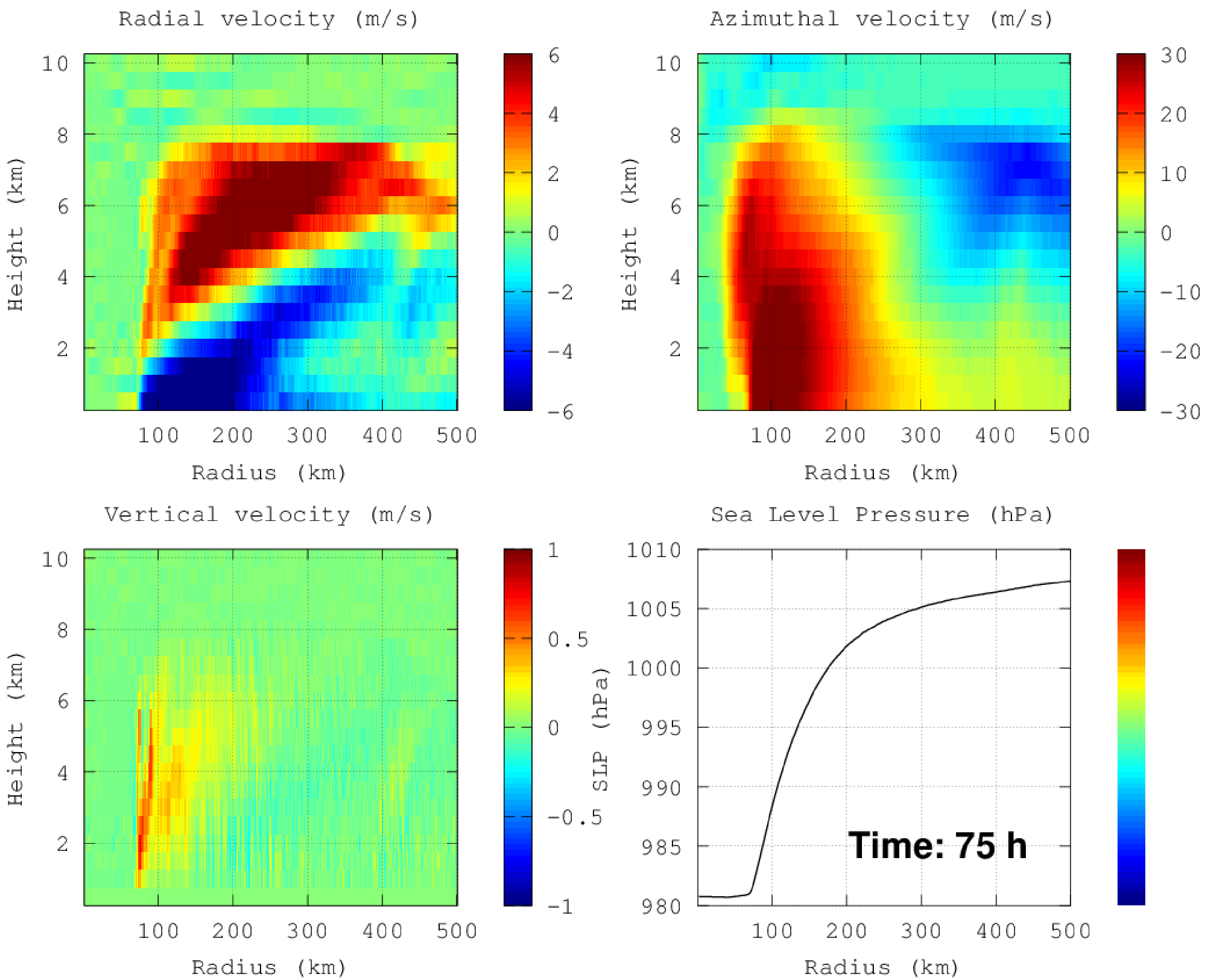
Polar low simulation



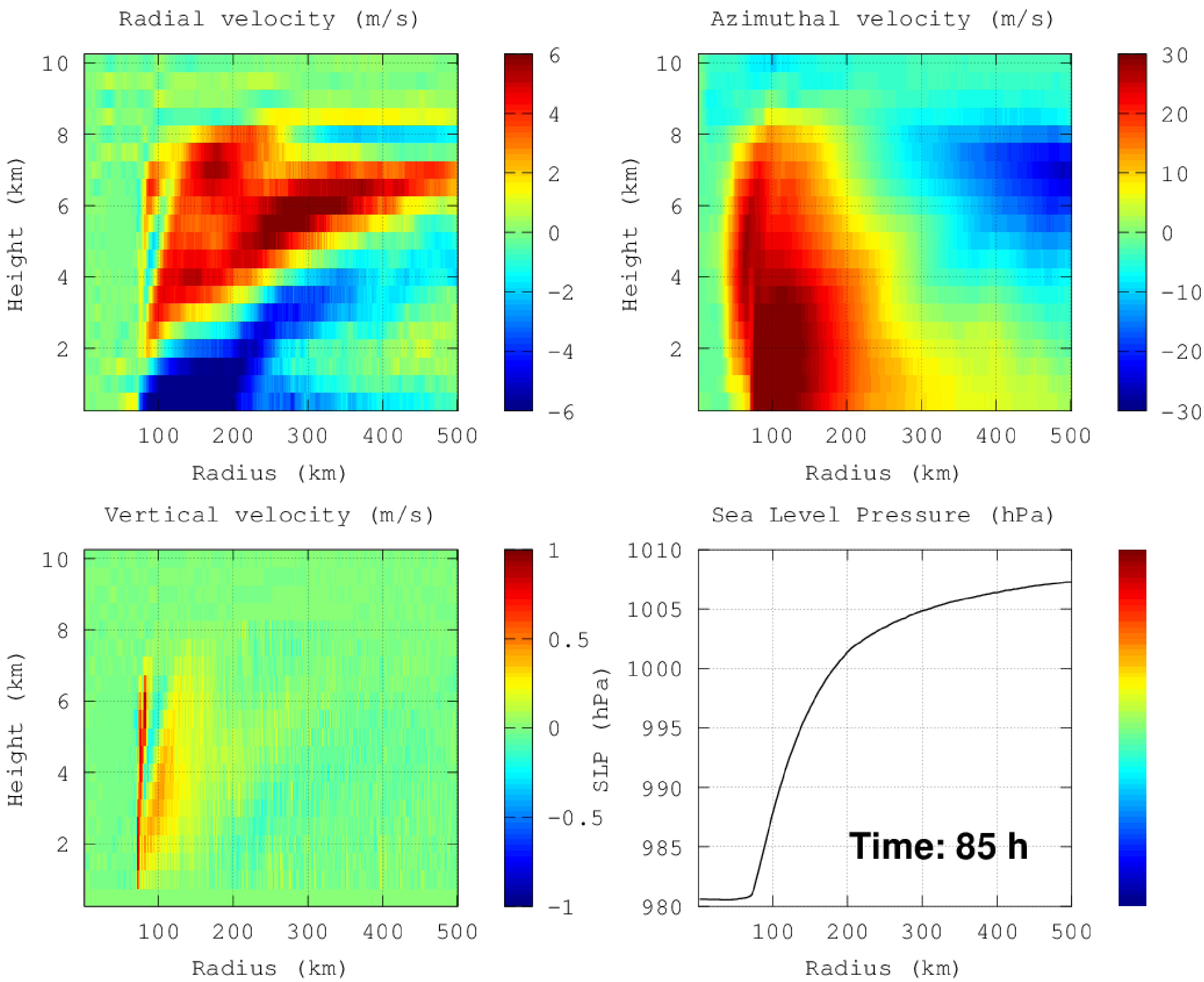
Polar low simulation



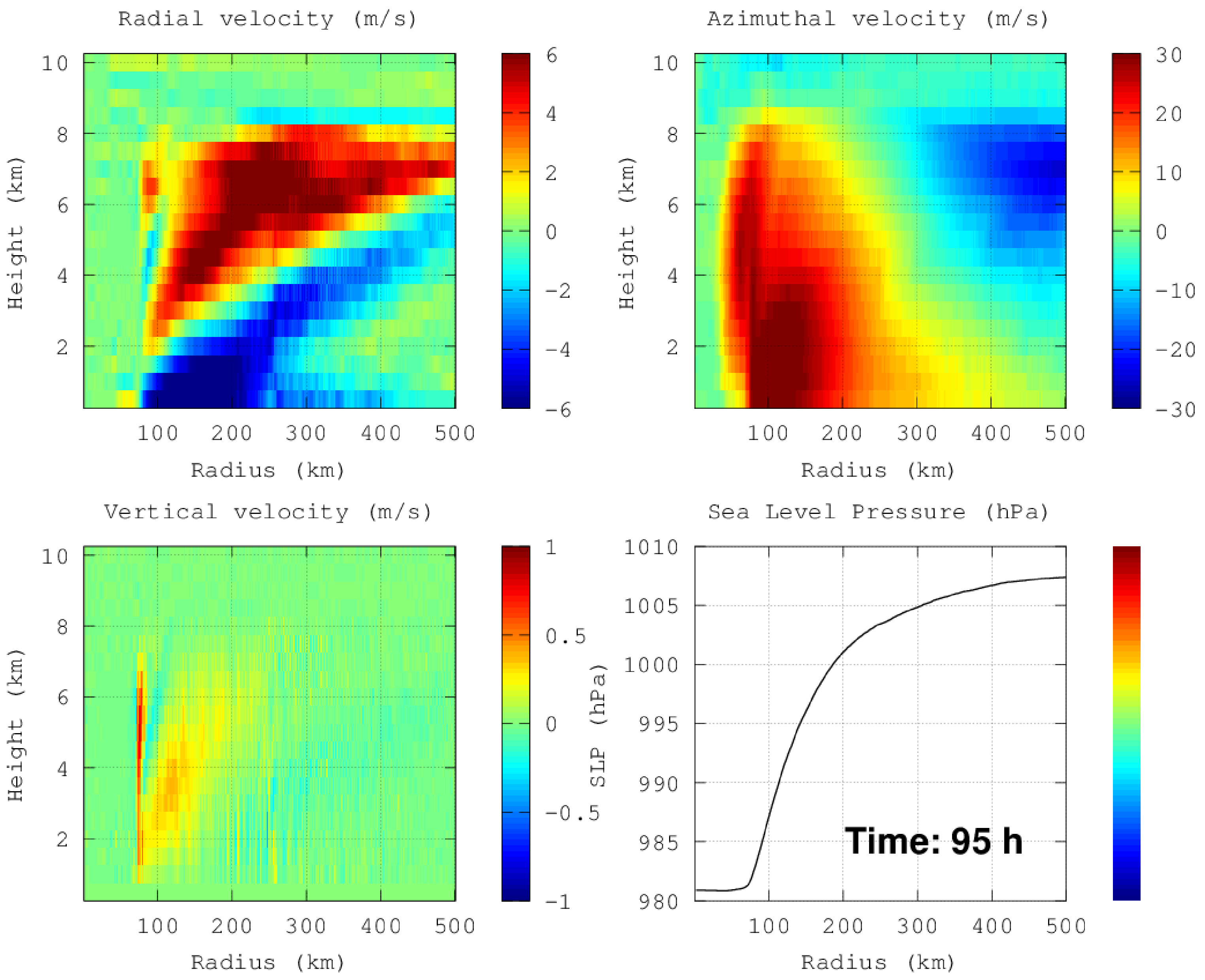
Polar low simulation



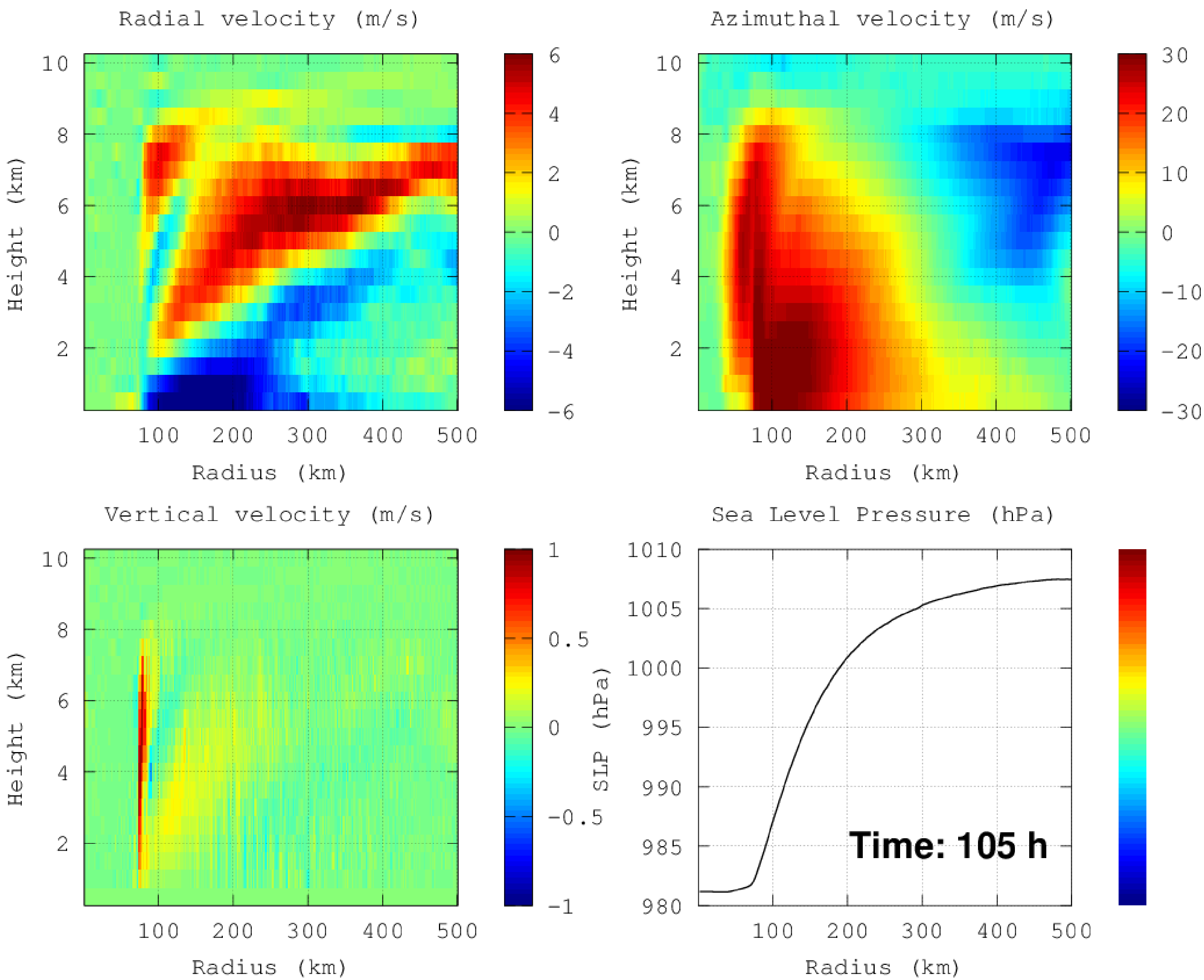
Polar low simulation



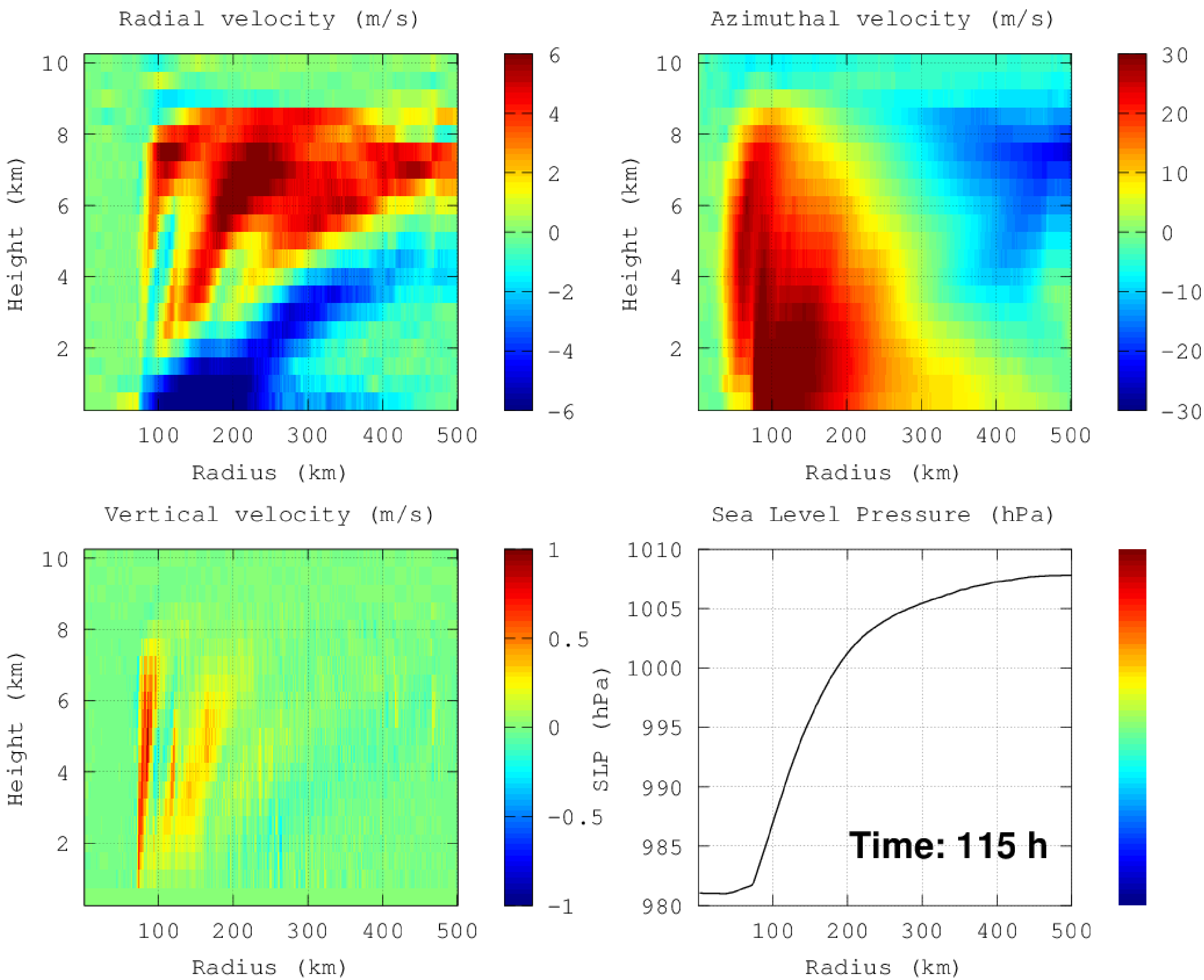
Polar low simulation



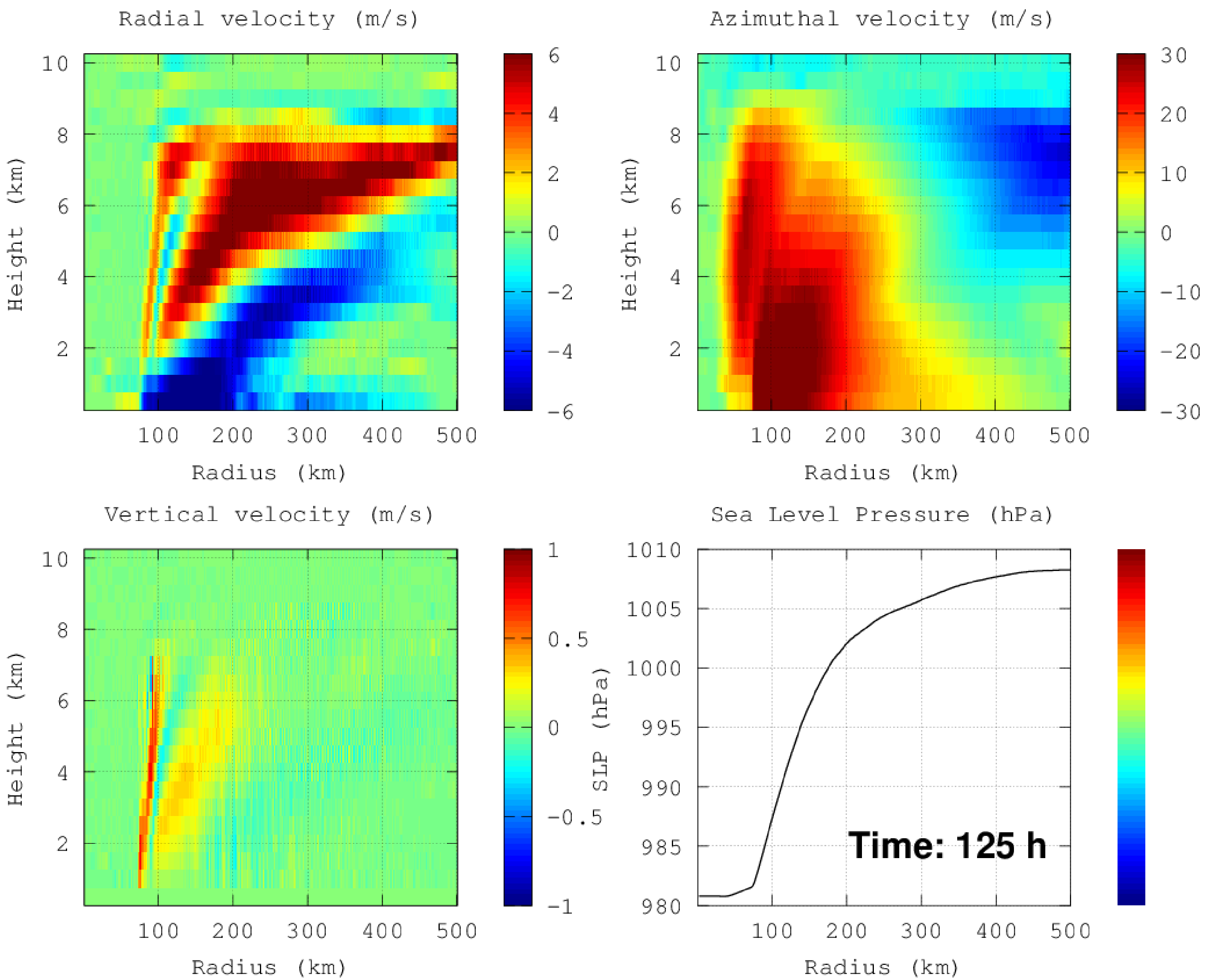
Polar low simulation



Polar low simulation



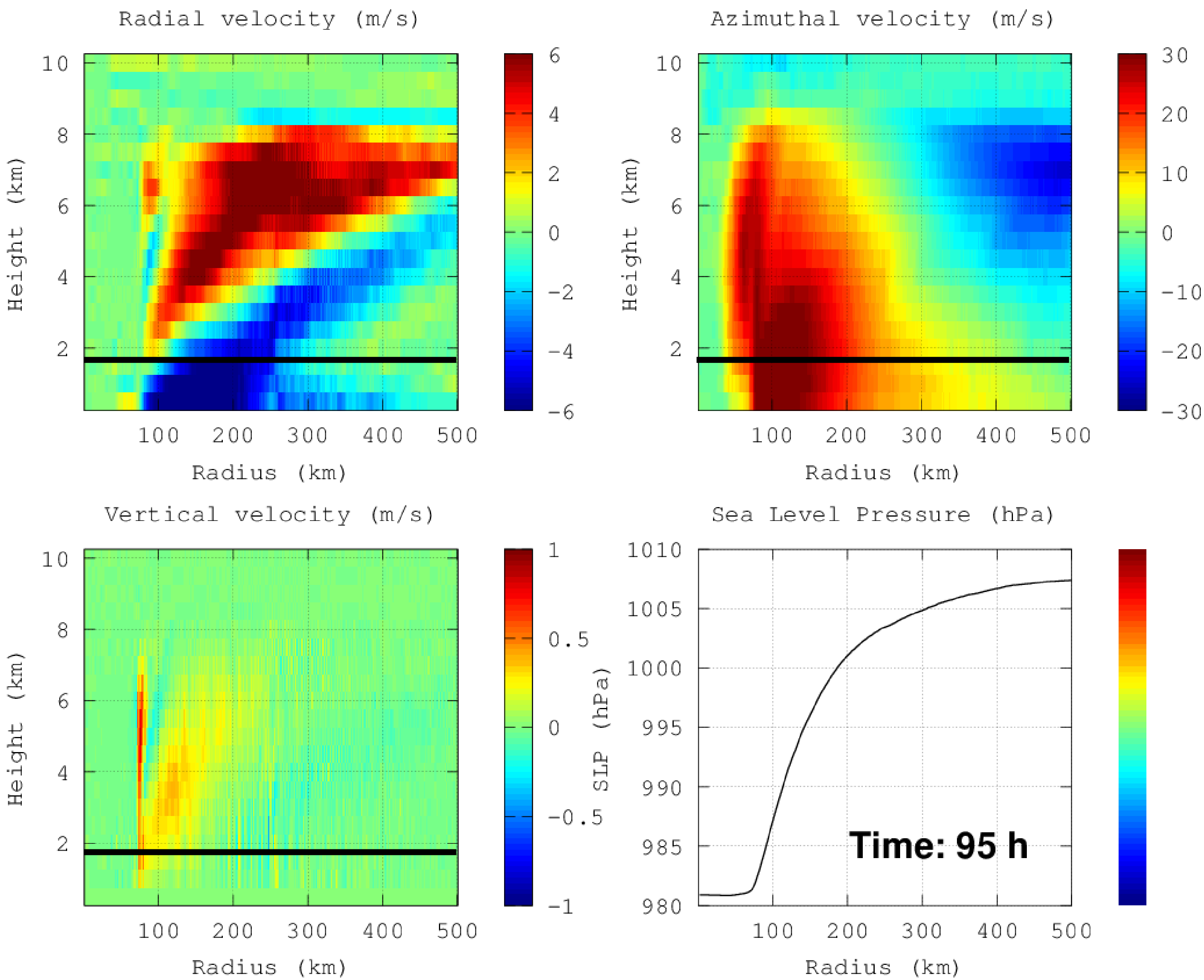
Polar low simulation



Boundary layer stream line

- Let us look at an average stream line in the boundary layer.
- We assume that the stream line is horizontal (and goes towards the centre, i.e. in negative radial direction).
- We look at forces generating radial acceleration.

Boundary layer stream line



Boundary layer stream line

- Balance between friction, pressure gradient and the gradient of kinetic energy

$$F = -\frac{1}{\rho}\frac{\partial p}{\partial r} - \frac{1}{2}\frac{\partial V^2}{\partial r}$$

- The friction is overcome by work done by the converging angular momentum (hypothesis)

$$F = \frac{W_M}{\delta r}$$

Boundary layer stream line

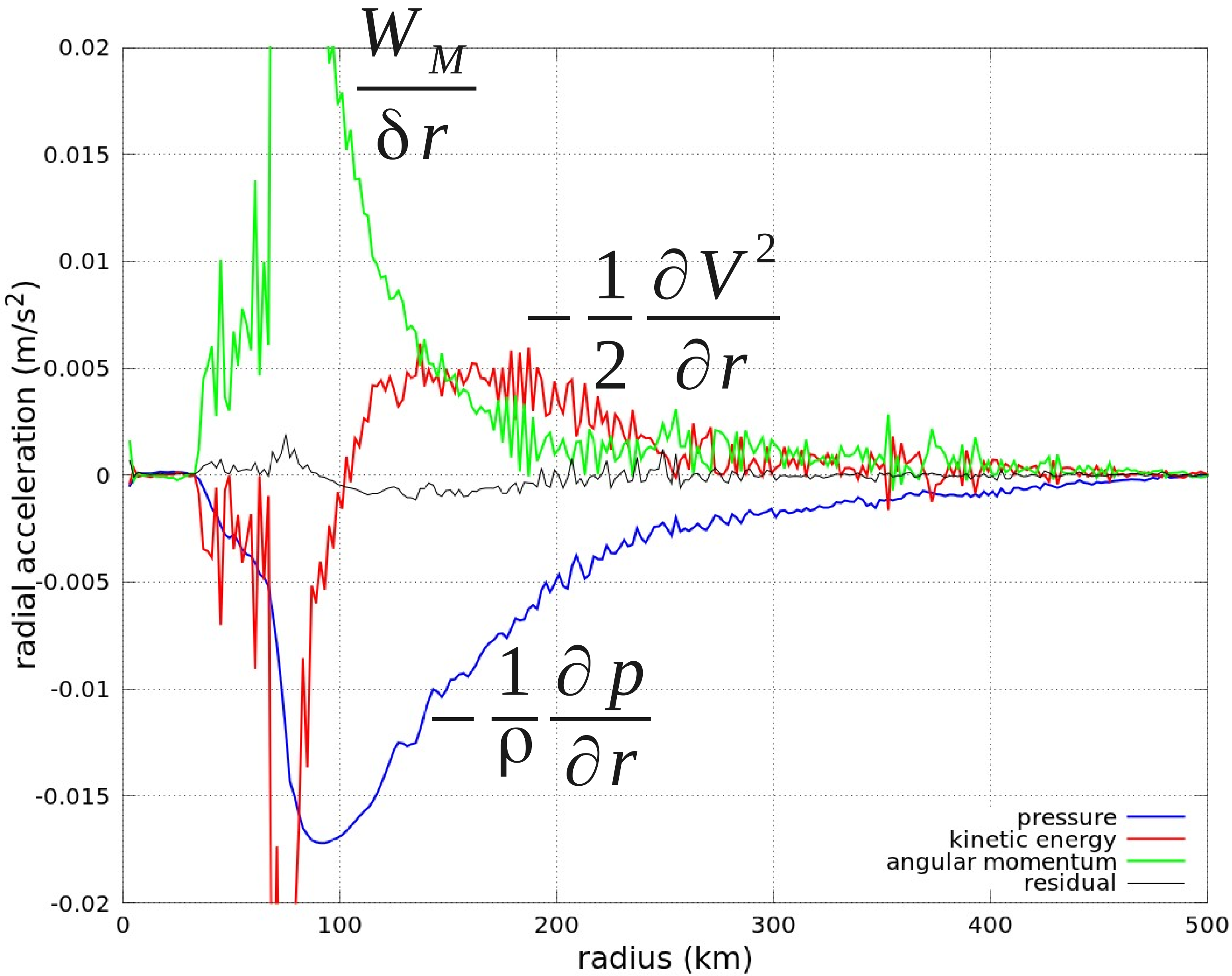
- Angular momentum defiend as

$$M = rV + \frac{1}{2} f r^2$$

- Work done by the converging angular momentum, calculated as the kinetic energy needed to increase M_i (at r_i) to M_{i+1}

$$W_M = \frac{1}{2}\left[\frac{M_{i+1}^2 - M_i^2}{r_i^2} + f\left(M_i - M_{i+1}\right)\right]$$

Boundary layer stream line



Summary

- The intensity of polar lows can be entirely explained by converging angular momentum.
- The role of the sea surface heat fluxes is to maintain the convergence by creating convection.

End of presentation

- Questions?
- Suggestions?
- Objections?