Atmospheric Dynamics Curiosities

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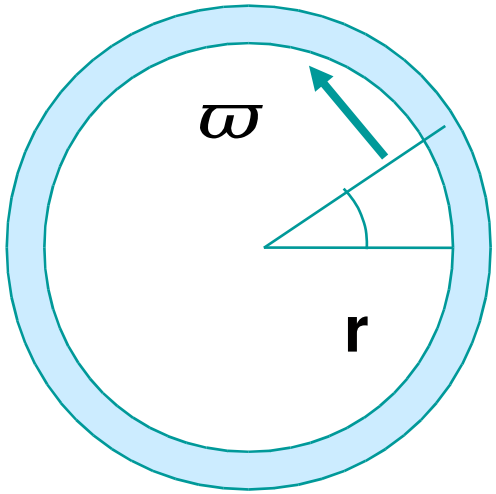
Main structure of course

- Expressing Newton's laws for a fluid on a rotating sphere
- Consequence of scale (Rossby Number) gives geostrophic and higher approximations for wind in terms of pressure (or geopotential)
- Variation of wind with height
  - In free atmosphere – "thermal" wind
  - In boundary layer, eddy friction, and Ekmann spiral
- Circulations in the tropics (introduced via "dishpan" results)
- Notions of vorticity, divergence, and potential vorticity
- Use of those concepts in
  - Rossby waves (2-D and 3-D)
  - Cyclone waves

Conservation of angular momentum

View from Pole star



ϖ **Is angular velocity of ring**

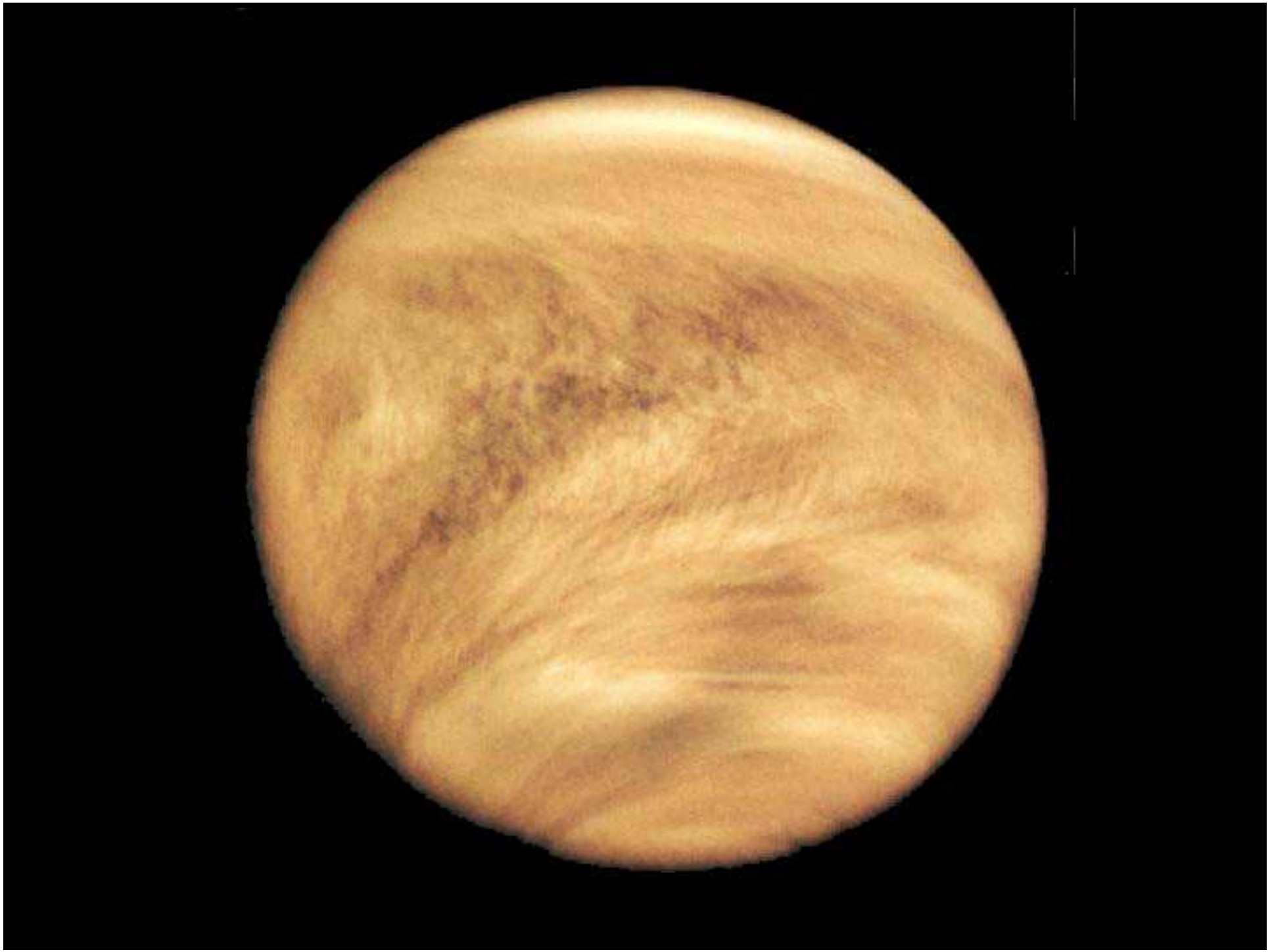
$$\varpi m r^2 = const \qquad \varpi r^2 = const$$

$$\varpi = \Omega + \frac{u}{r} \qquad r = (a+z)\cos\varphi$$

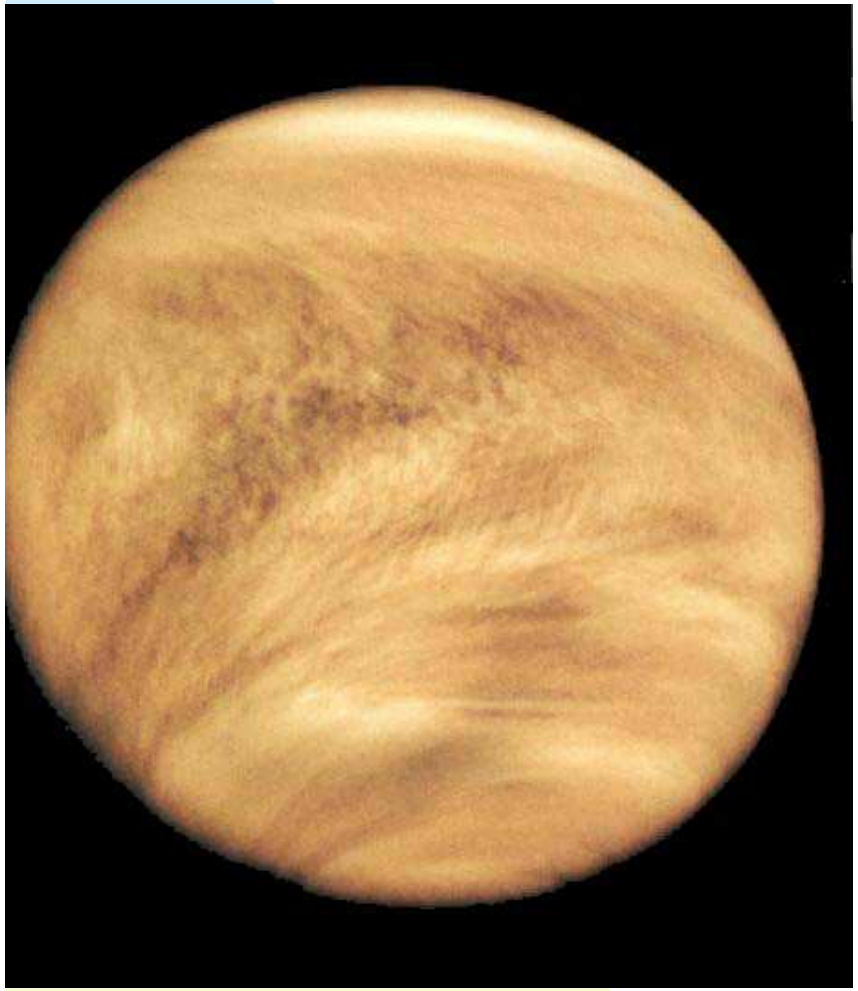
$$\left[\Omega + \frac{u}{(a+z)\cos\varphi}\right](a+z)^2\cos^2\varphi = const$$

See also Tut. Q 9.3

$$(u + (a+z)\Omega\cos\varphi)(a+z)\cos\varphi = \text{const}$$



Venus



- Radius: 6052 km
- Surface Gravity 8.9 m/s^2
- Rotation Period: 243 Earth Days (retrograde)
- Orbit Period: 225 Earth Days
- Length of Solar Day: 113 Earth Days
- Surface Temperature: 465°C
- Surface Pressure: 90 bar

Super-rotation

Atmosphere rotates with a period of 4 days!

From:
Mayr, Harris (1983): Quasi-axisymmetric circulation and superrotation in planetary atmospheres.
Astronomy and Astrophysics 121, 124-136.

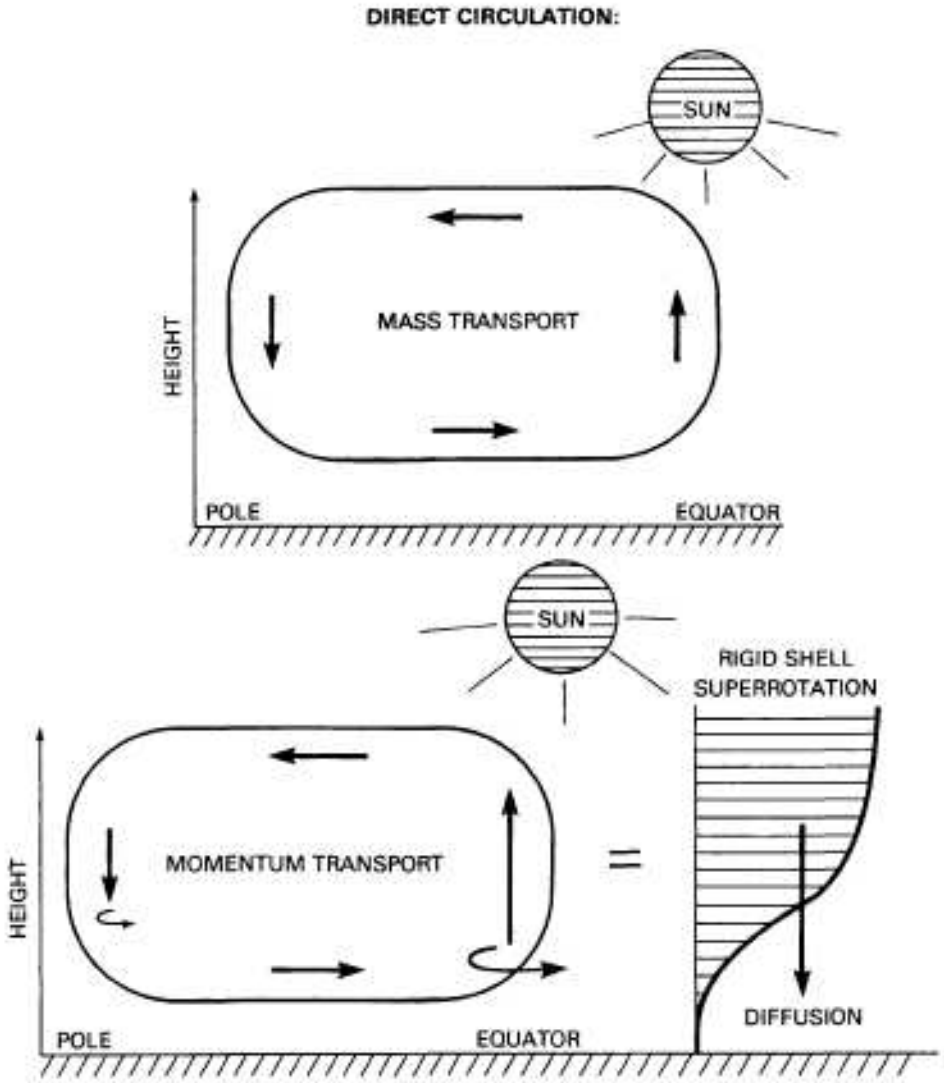
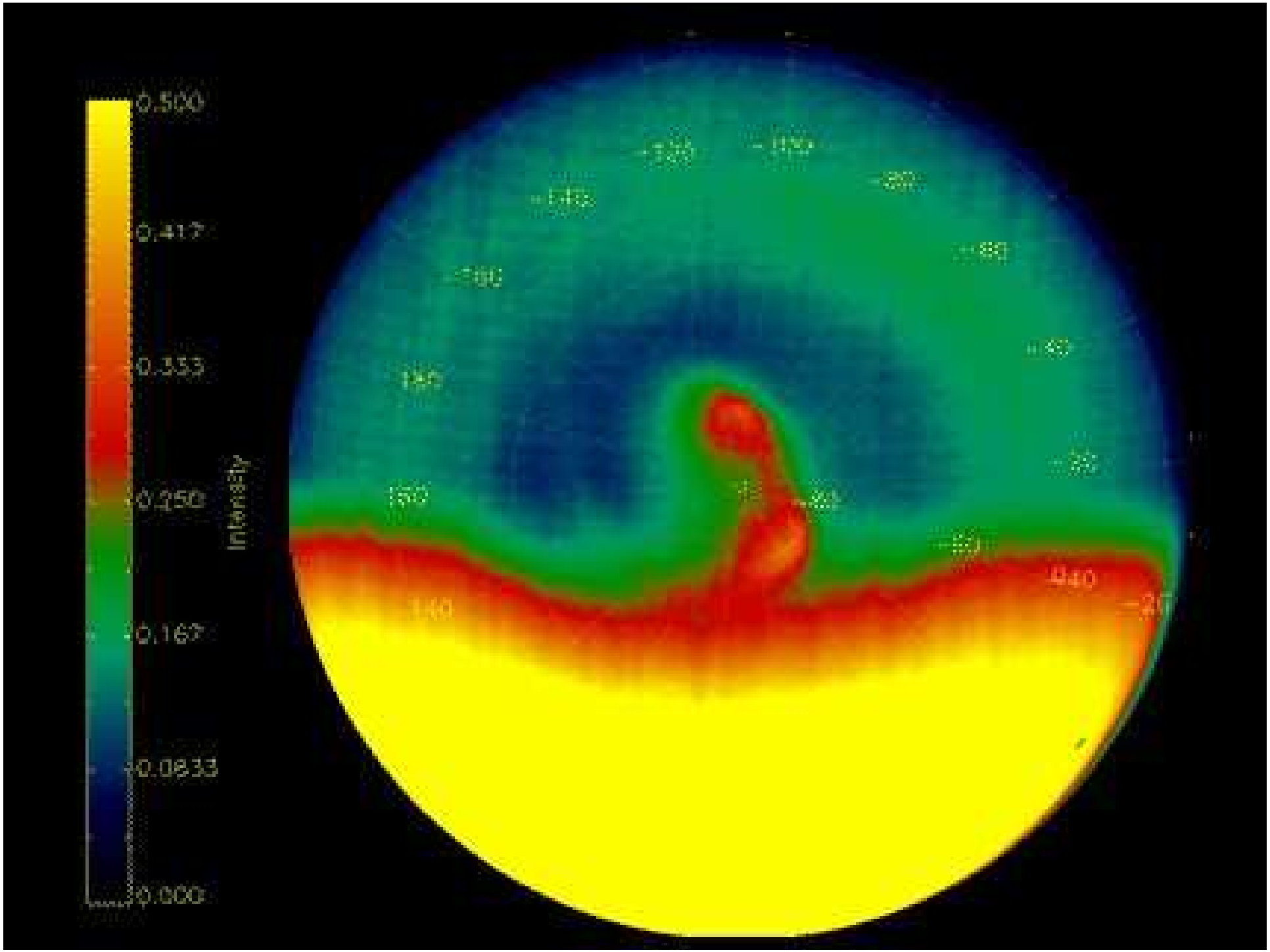


Fig. 1. Schematic illustration of the mass (top)- and momentum (bottom)-budgets for the direct circulation producing the rigid shell component of superrotation which is observed on virtually every planet in our solar system. The balance is established between upward transport of momentum by convection (more being carried upwards at low latitudes than is carried downwards at high latitudes) and diffusion


0.500
0.417
0.333
0.250
0.167
0.0833
0.000
Intensity

More Info: Venus Express

http://www.esa.int/SPECIALS/Venus_Express

esa Venus Express

European Space Agency

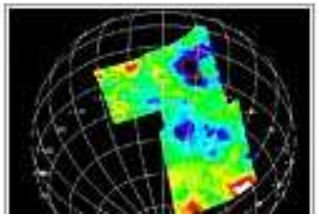
ESA | Venus Express | ESA Science

- Europe goes to Venus
  - Tribute to the cryptic planet
  - Penetrating an impenetrable world
  - Past missions to Venus
- About Venus Express
  - Venus Express mission facts
  - Venus Express objectives
  - The spacecraft
  - Orbiter instruments
  - The launcher
  - Operating Venus Express
- About Venus
  - Venusian geography
  - The surface
  - Acid clouds and lightning

The planetary adventure continues - Mars Express and Venus Express operations extended

27 February 2007 ESA's Mars Express and Venus Express missions, to explore our nearest neighbour planets Mars and Venus respectively, will continue to operate until early-May 2009. The decision was unanimously taken by ESA's Science Programme Committee last Friday.

Full story



Hot stuff on Venus! Venus Express sees right down to the hell-hot surface

14 December 2006 Thanks to ESA's Venus Express data, scientists obtained the first large-area temperature

- VOI highlights and press conference

- ESApod: Venus Express

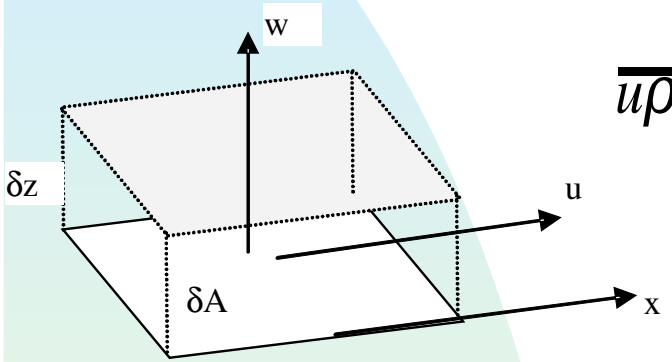
- Where is Venus Express now?

- Winning postcards

Eddy friction

Mean $\bar{s} = \frac{1}{2Q}\int_{t_o-Q}^{t_o+Q} s\,dt$

eddy $s' \equiv s - \bar{s}$



$$\overline{u\rho w} = \rho\overline{\left(\bar{u}+u'\right)\left(\bar{w}+w'\right)} = \rho\overline{\left(\bar{u}\,\bar{w}+u'\,\bar{w}+\bar{u}\,w'+u'\,w'\right)}$$

$$= \rho\left(\bar{u}\,.\,\bar{w}\right) + \rho\left(\overline{u'\,w'}\right)$$

Upward flux of x-mom^t due to the eddies = $\tau_{xz} = \rho\left(\overline{u'\,w'}\right)$

Accel due to the eddies = $-\frac{1}{\rho}\frac{\partial \tau}{\partial z}$

Introduce eddy diffusion coeff. $\tau_{xz} = -\rho K \frac{\partial \bar{u}}{\partial z}$

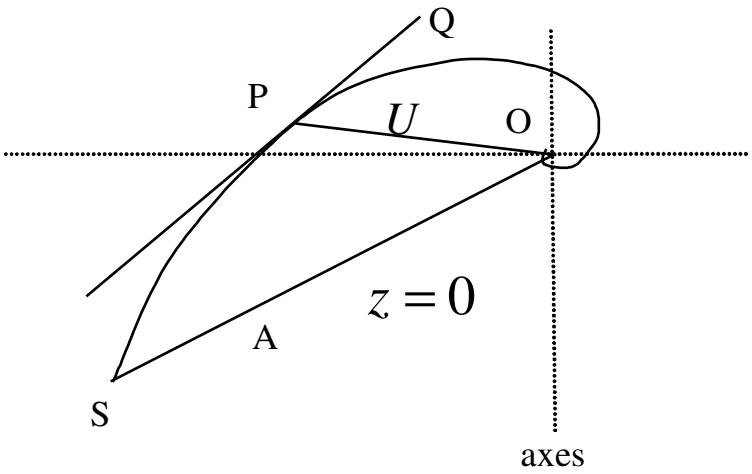
Ekmann Spiral

- Steady unaccelerated flow
- Uniform geostrophic wind in vertical and horizonal
- Variations of density small in bottom km

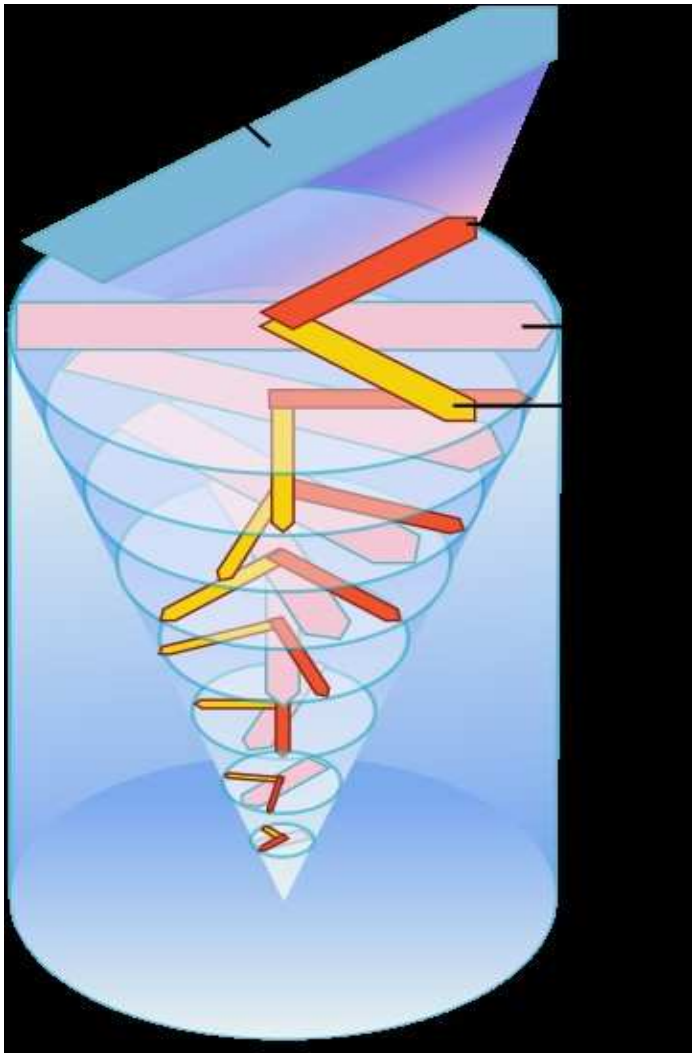
$$fk \wedge \bar{v}_h = -\frac{1}{\rho} \nabla_h p + K \left(\frac{\partial^2 \bar{v}_h}{\partial z^2} \right)$$

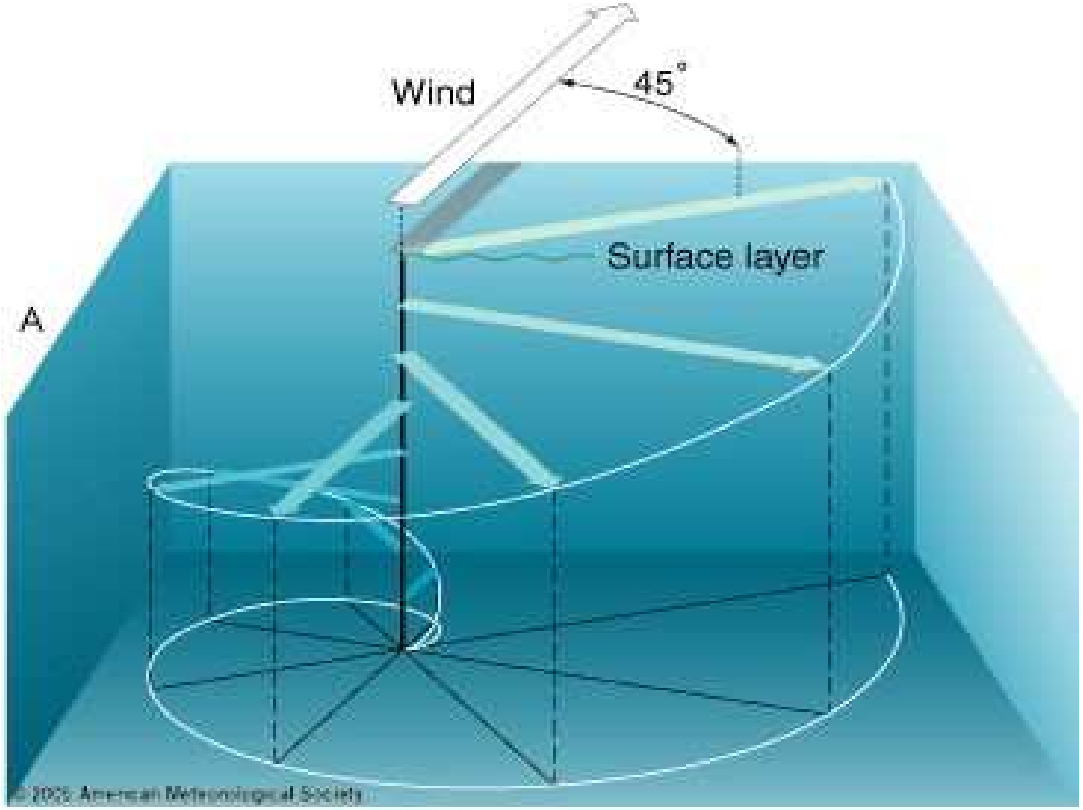
$$fk \wedge v_a = + K \left(\frac{\partial^2 v_a}{\partial z^2} \right)$$

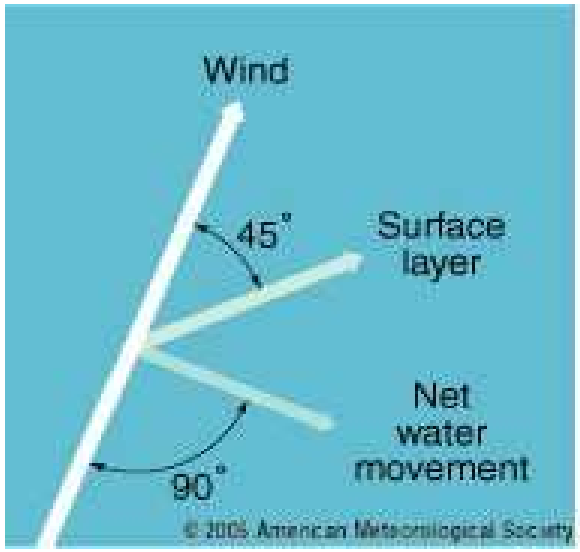
Shape of ageostrophic component



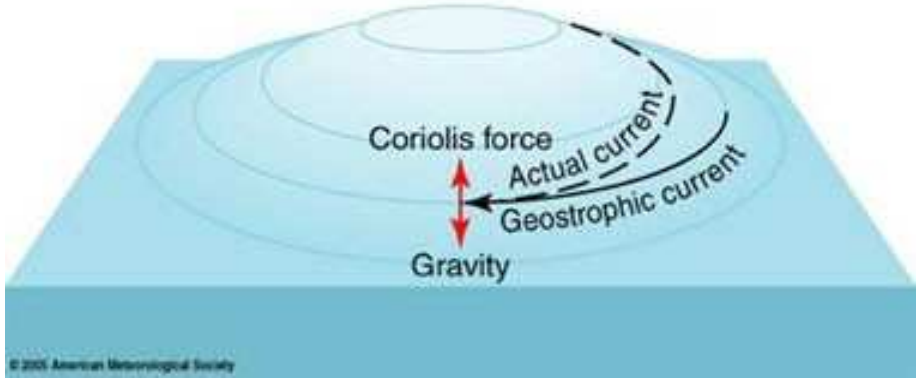
Ekman-Spiral in the Ocean

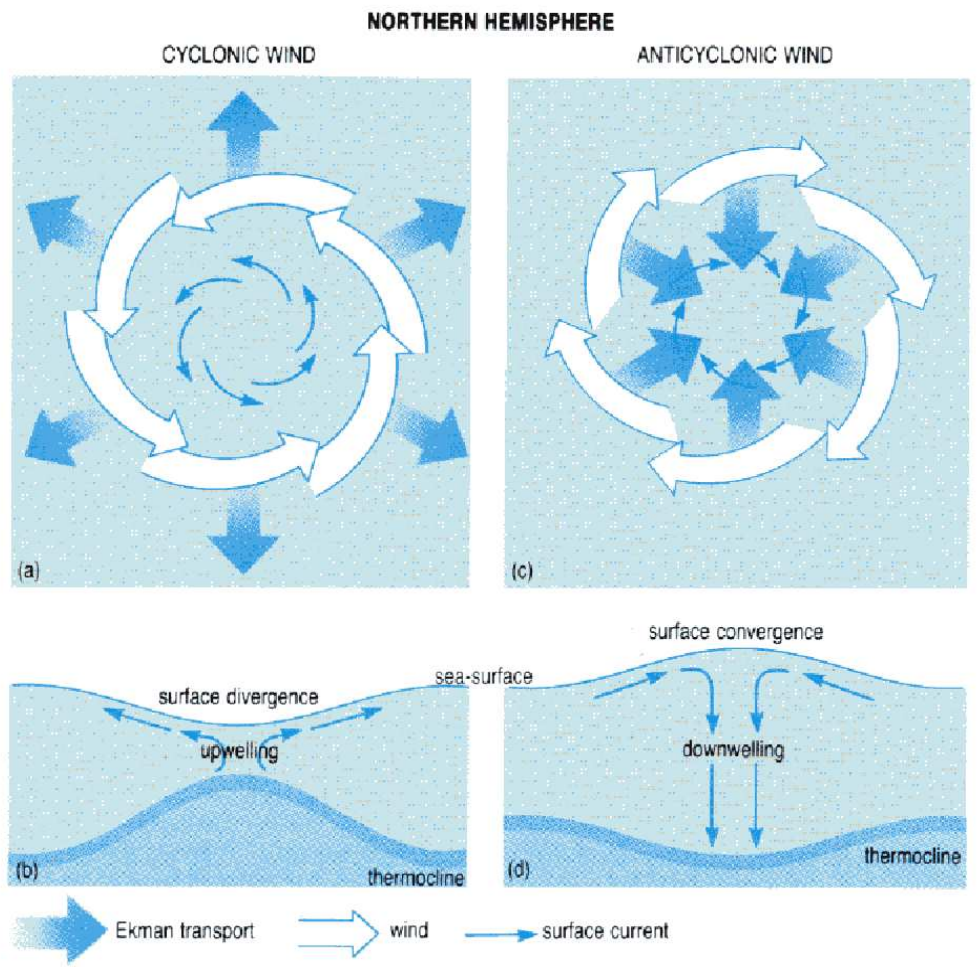




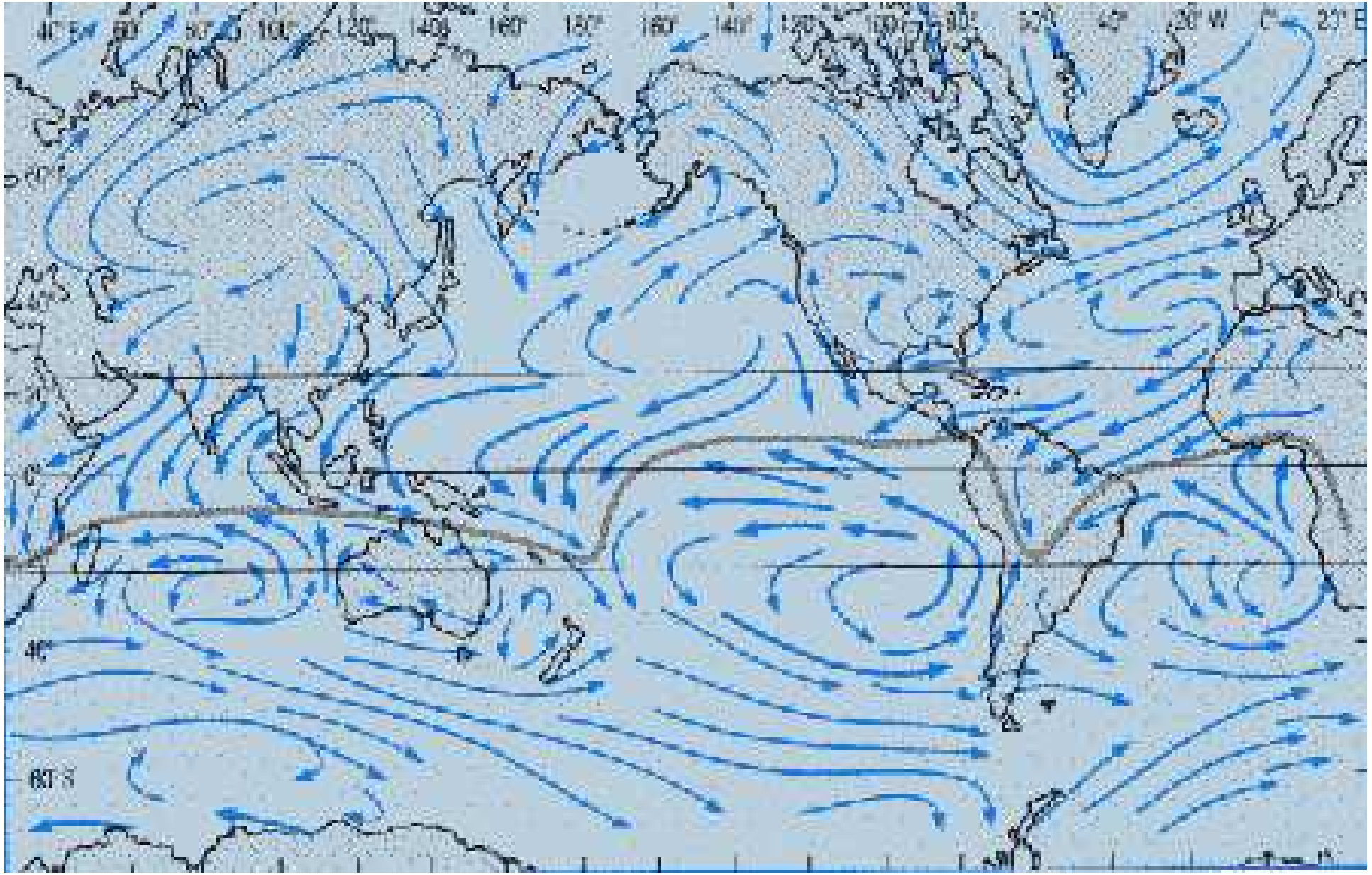


Oceanic Gyres

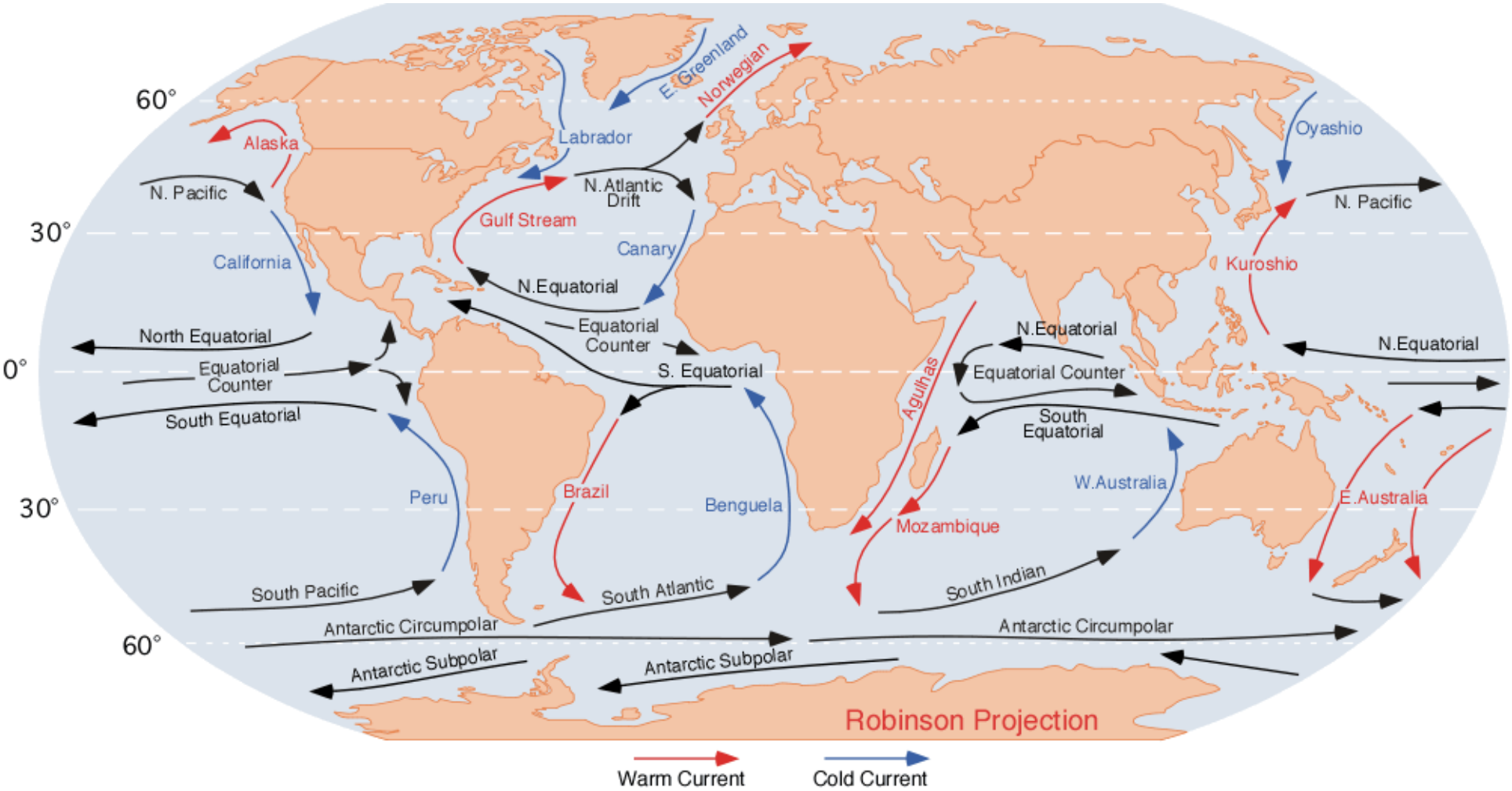




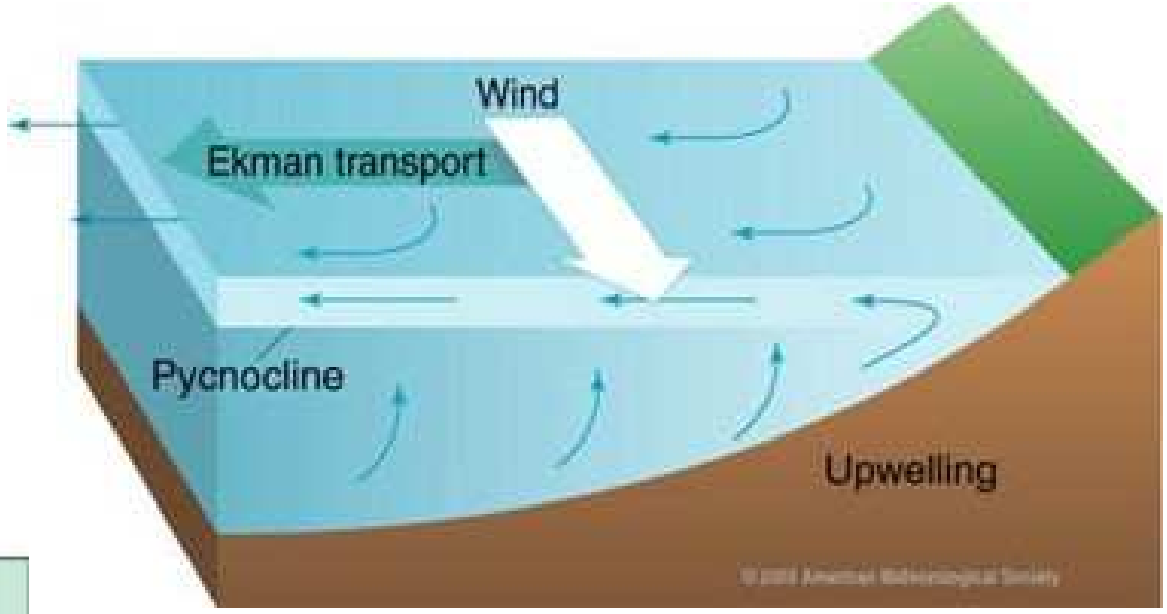
Wind

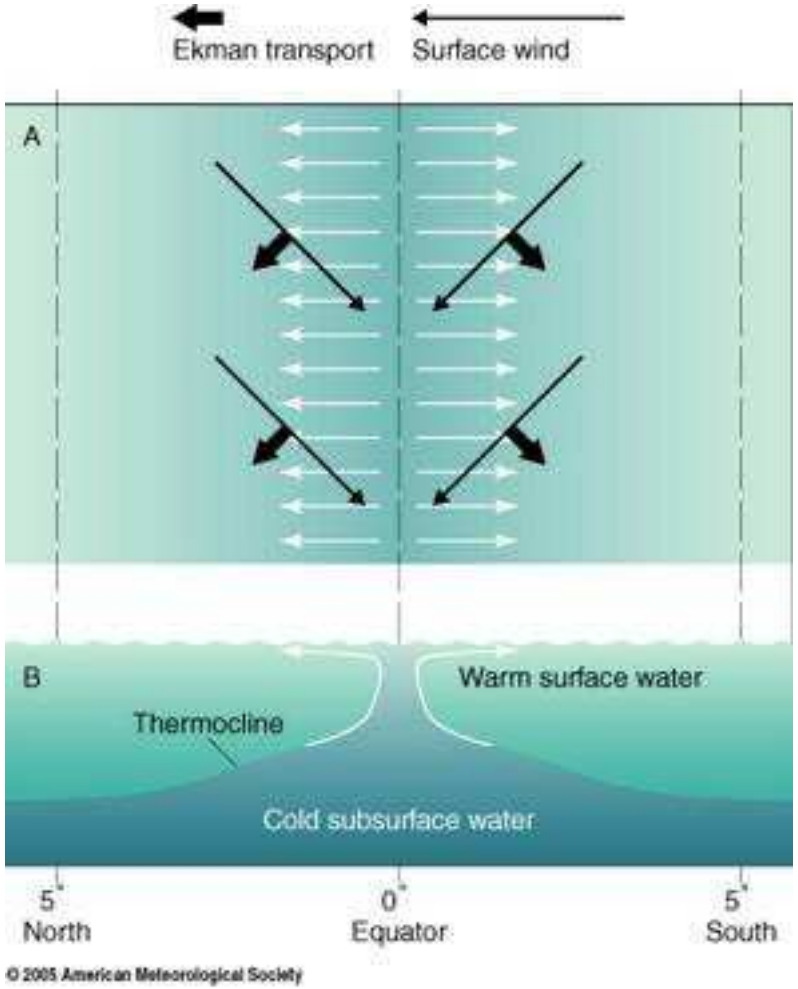


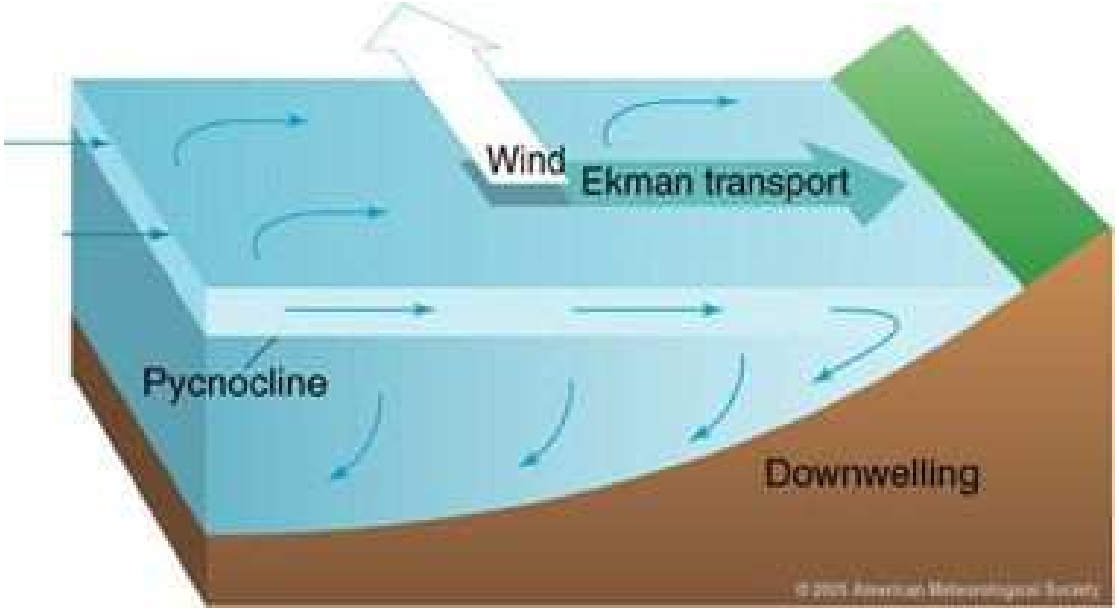
Ocean surface currents



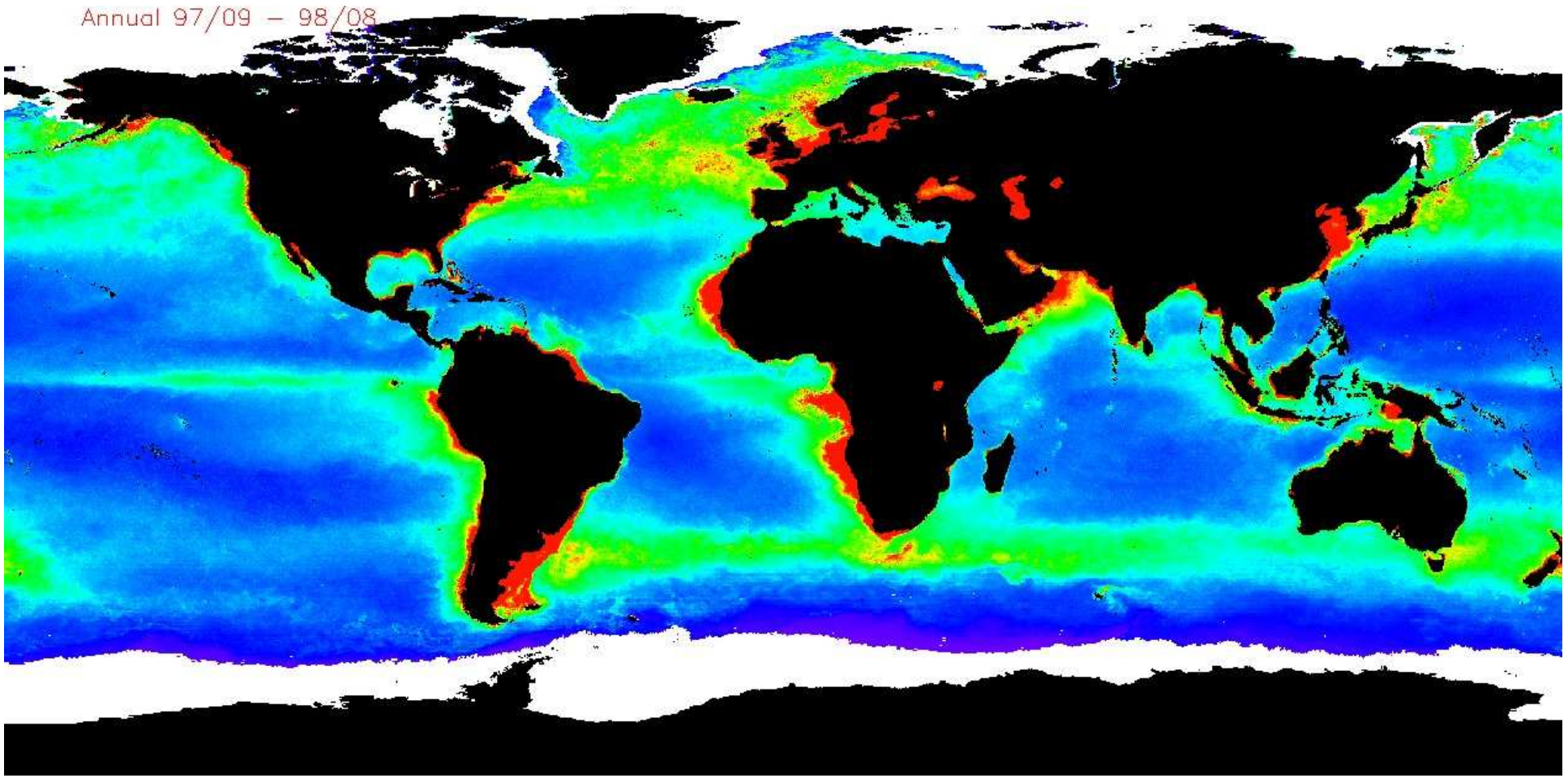
Currents and Upwelling



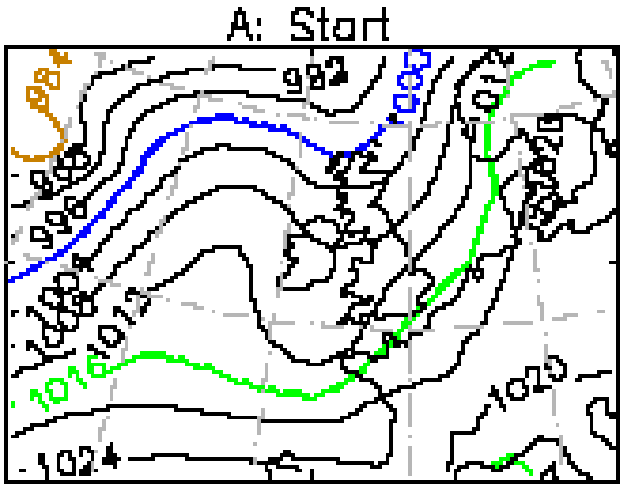


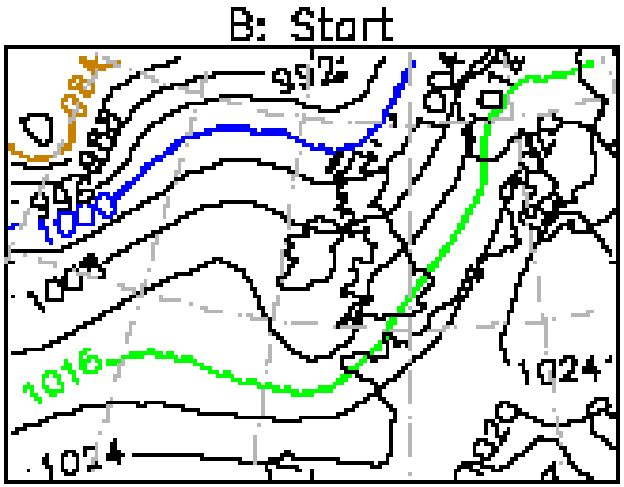


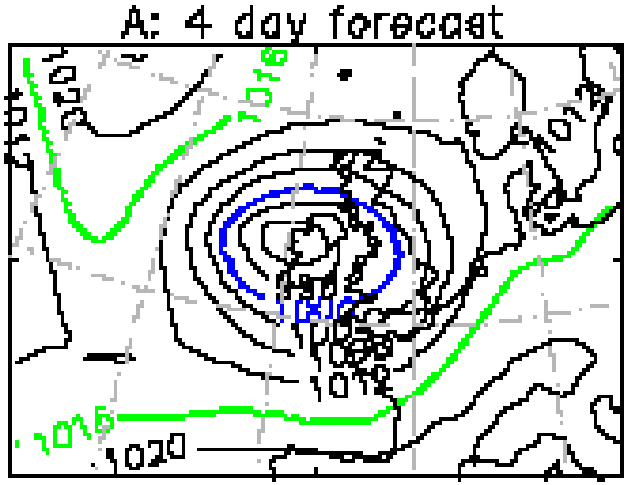
Primary Productivity

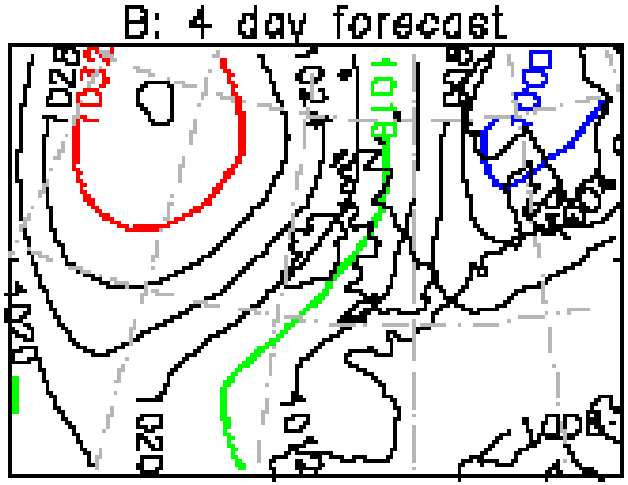


Unpredictable Weather?

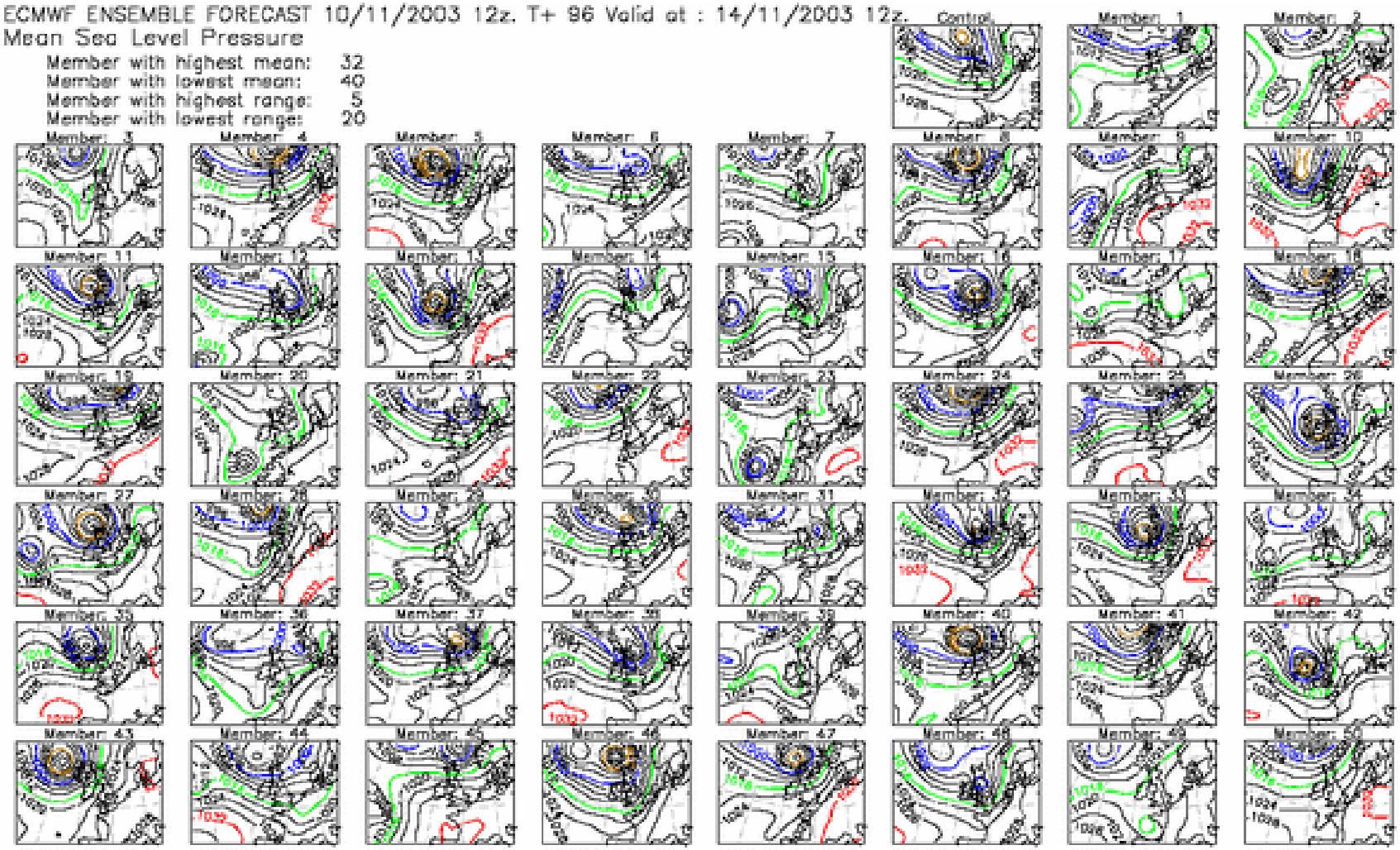




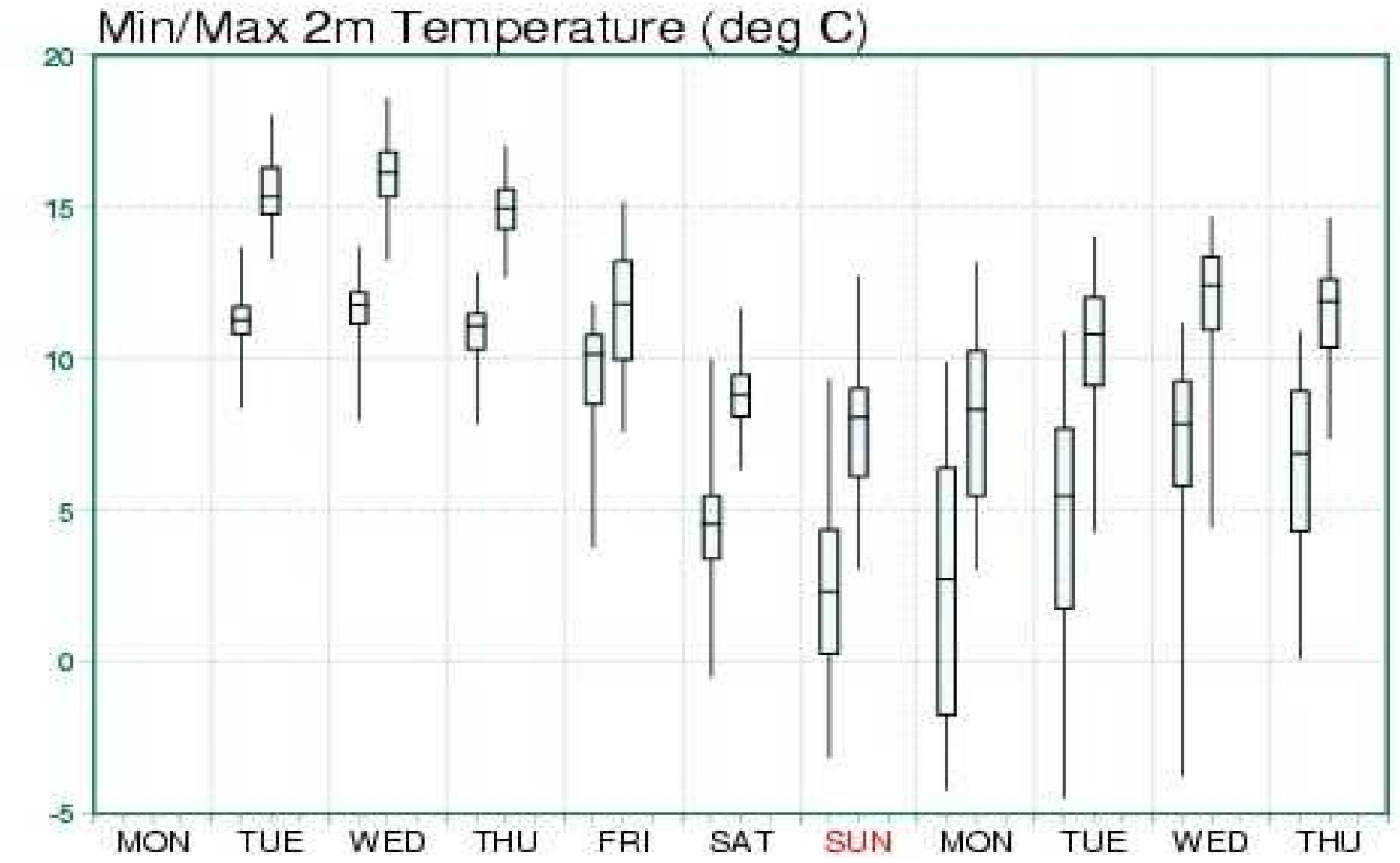


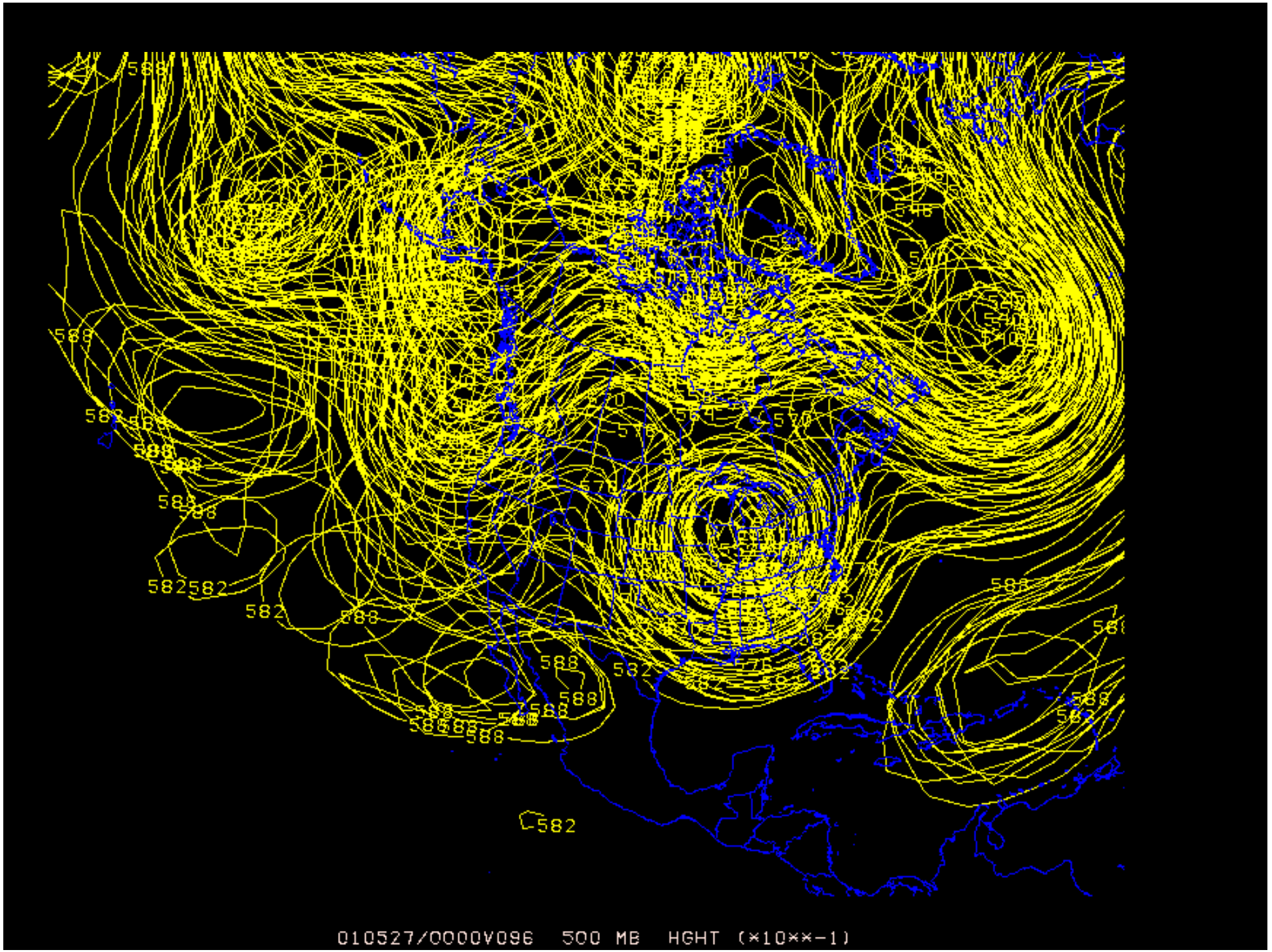


Ensemble Forecasts



Probability




010527/0000V096 500 MB HGHT (×10××-1)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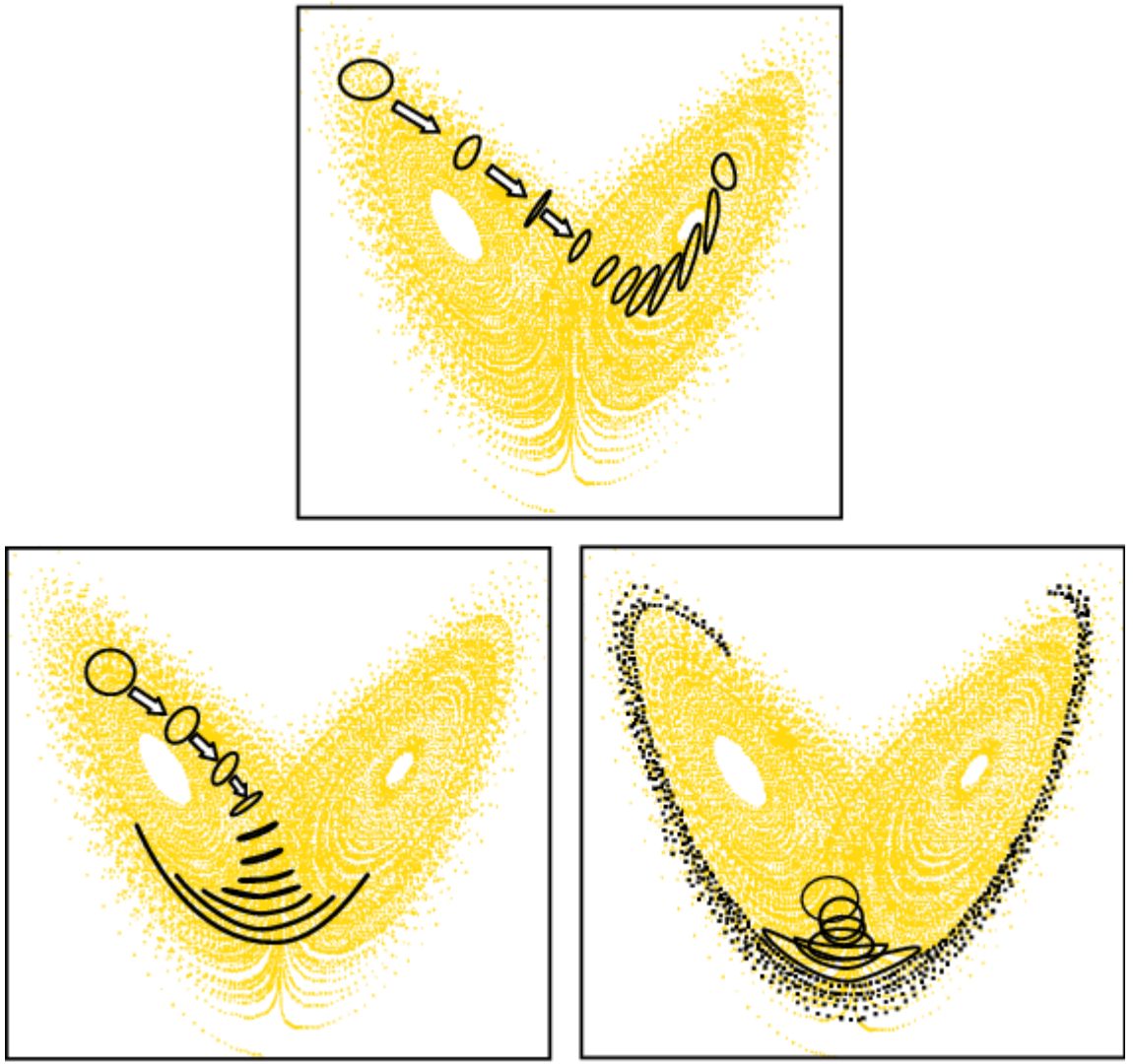
010527/0000V096 ENS 500 MB MEAN HGHT AND SPREAD

Lorenz Ensemble



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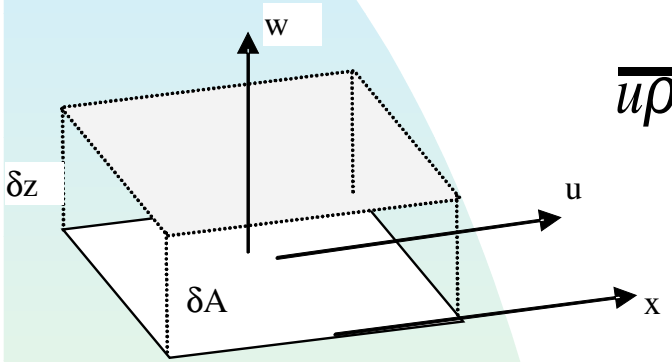

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Eddy flux measurements