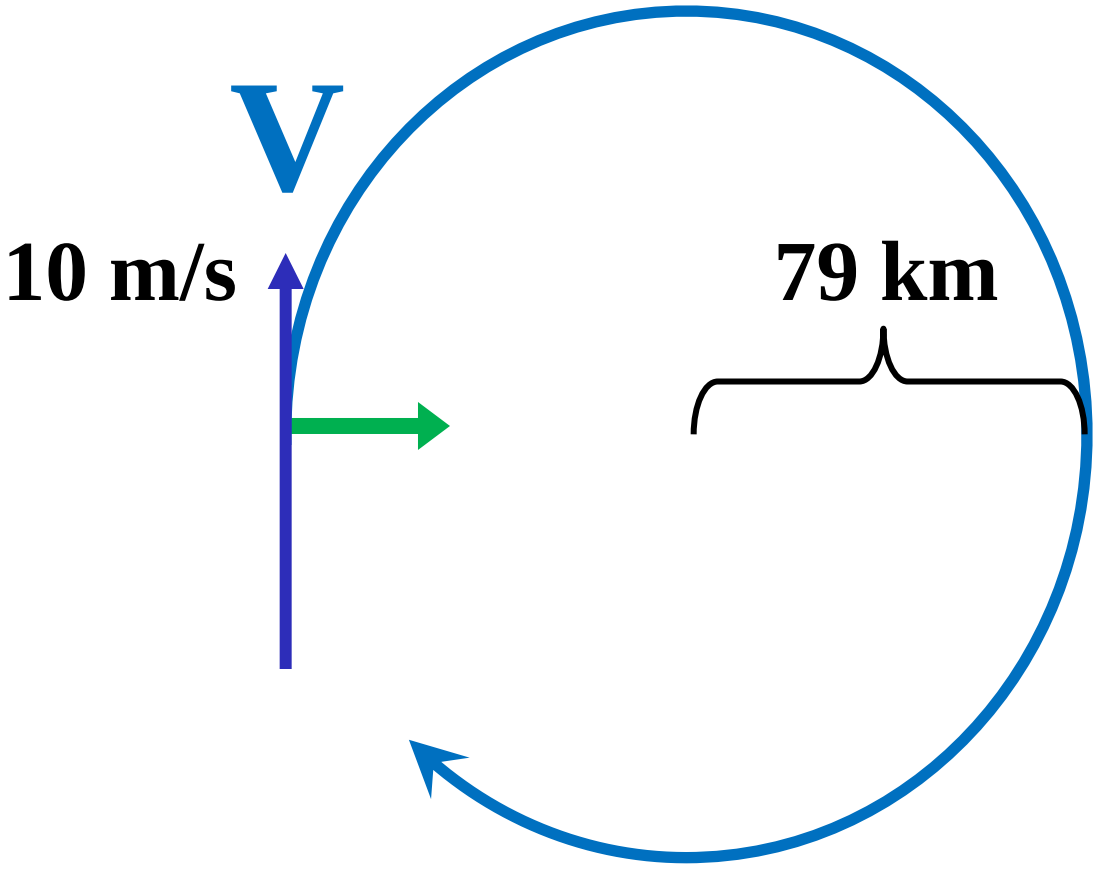
Dynamic meteorology without tears

Part III: Some consequences of the Coriolis Effect

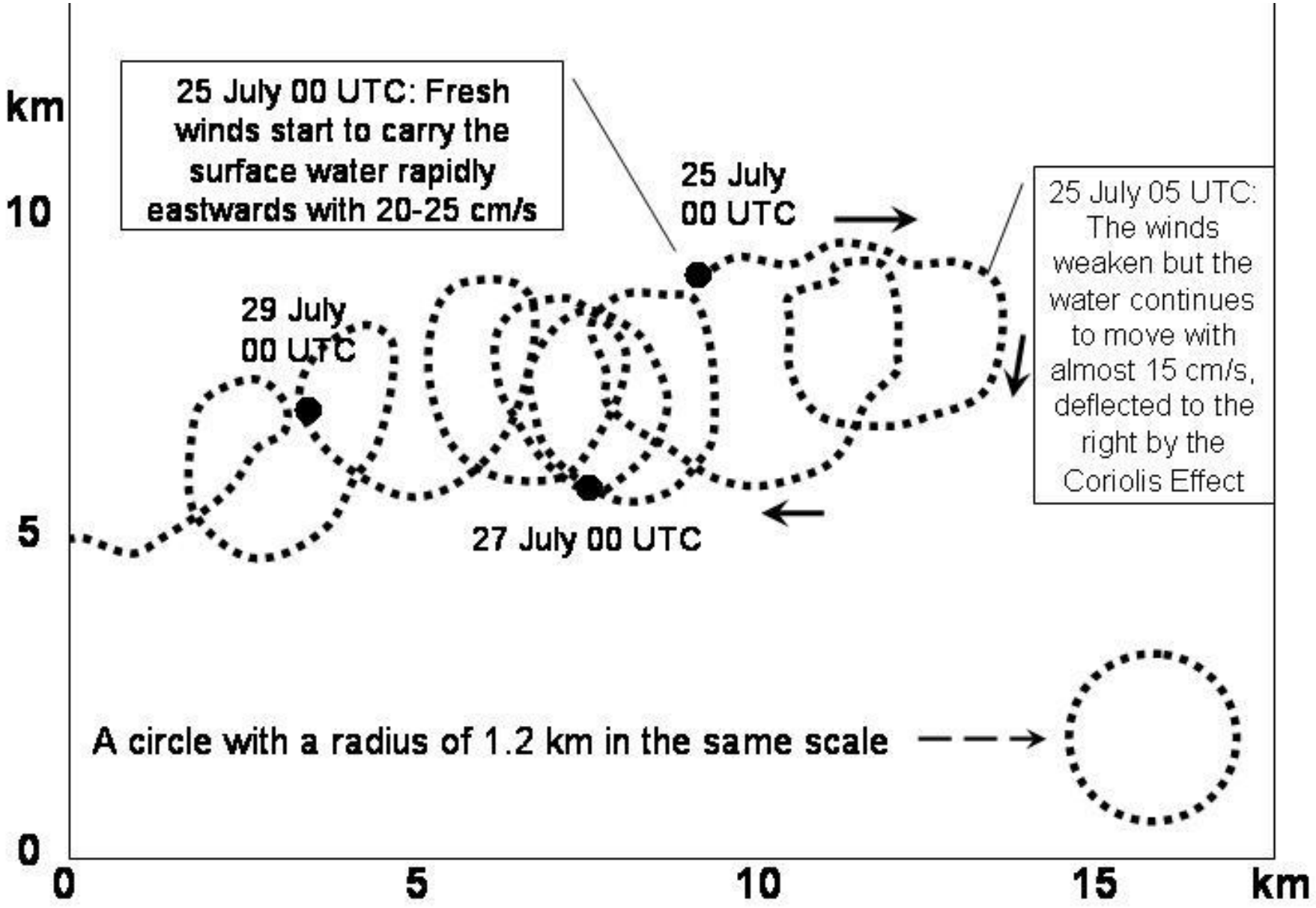
The Coriolis effect



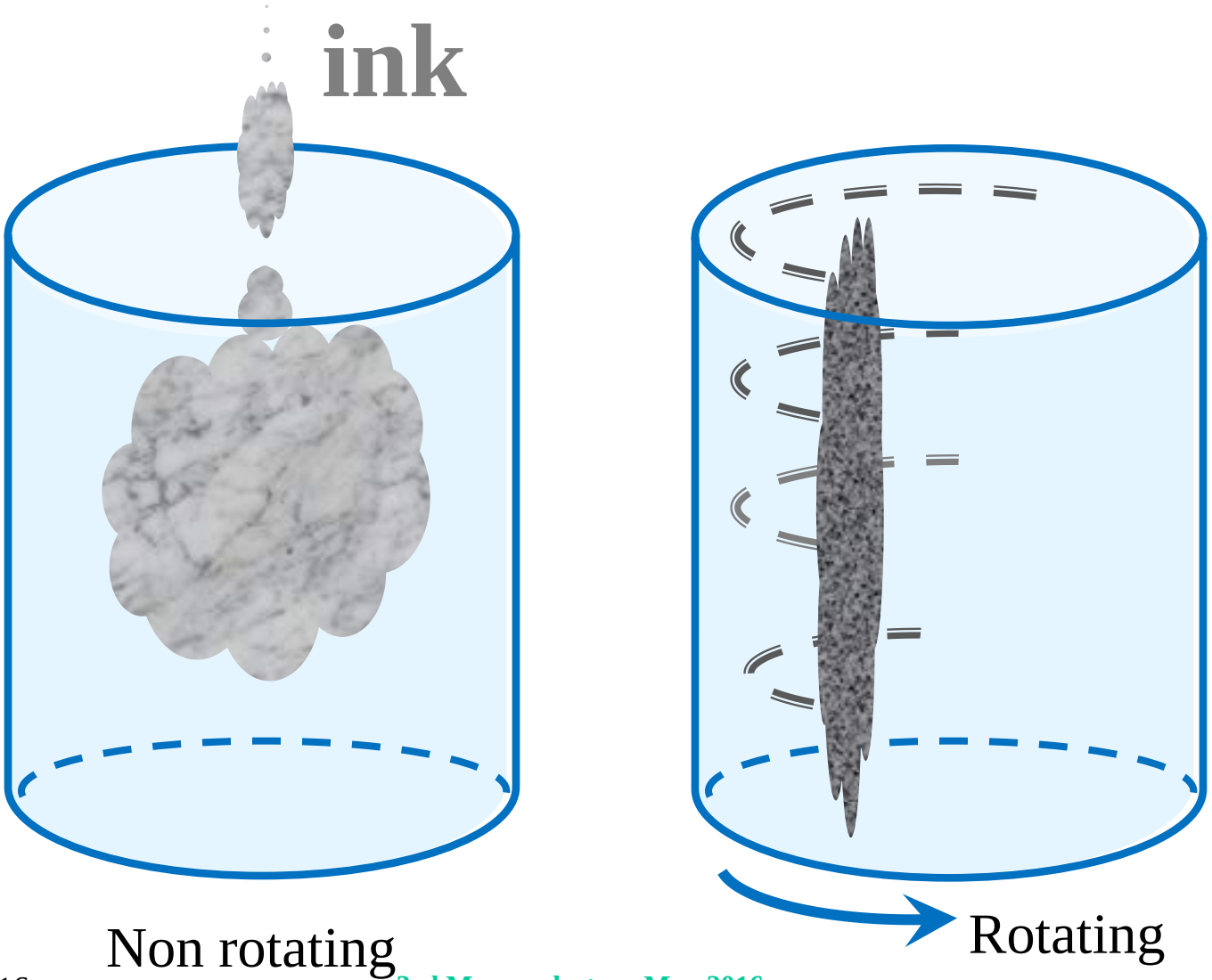
A 10 m/s frictionless motion of an object only affected by the Coriolis force, will at latitude 60°N result in an approximate circular motion with a radius of about 79 km

The Coriolis effect

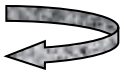
1. Inertia circle motion in oceans



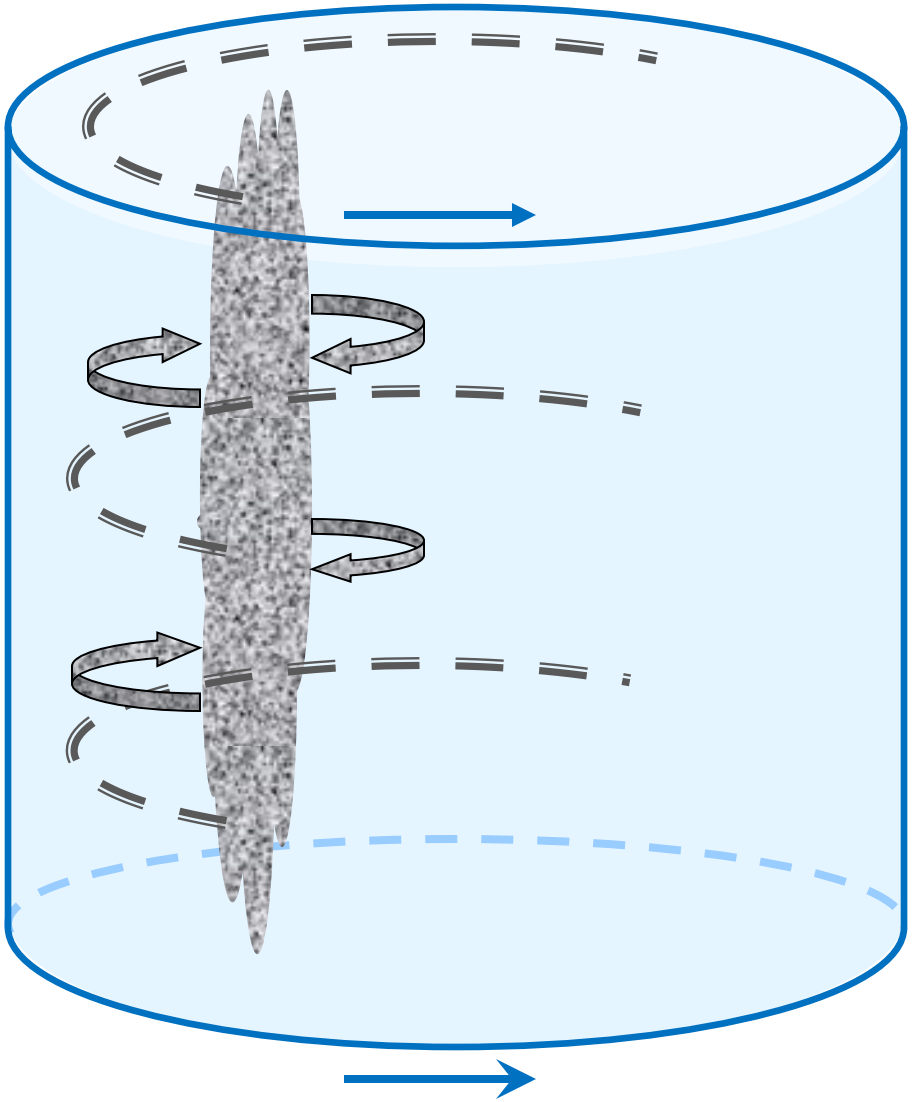
2. Taylor columns (Inertia circles in a water tank)



Whenever a water parcel tries to move away it is brought back by the Coriolis force in an "inertia circle"

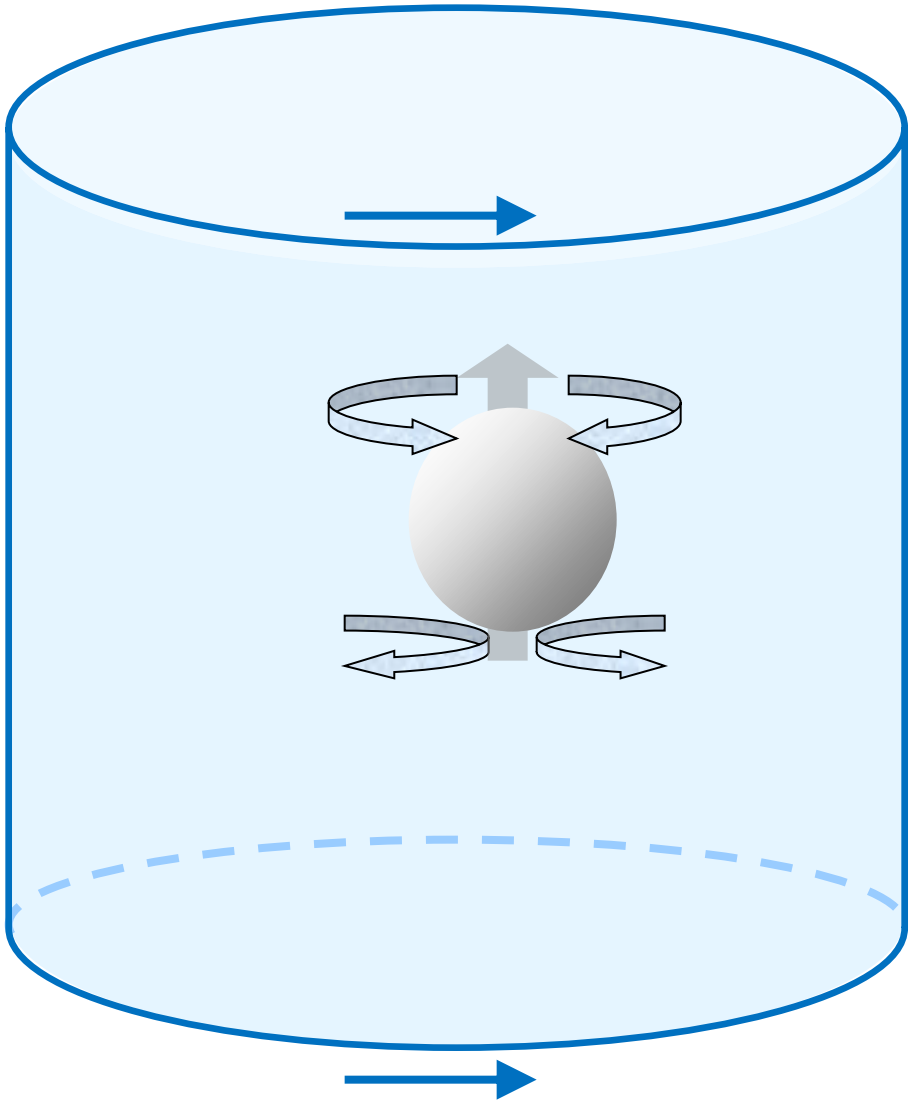


Any motion "away" has a component perpendicular to the axis of rotation and is therefore subjected to the Coriolis effect



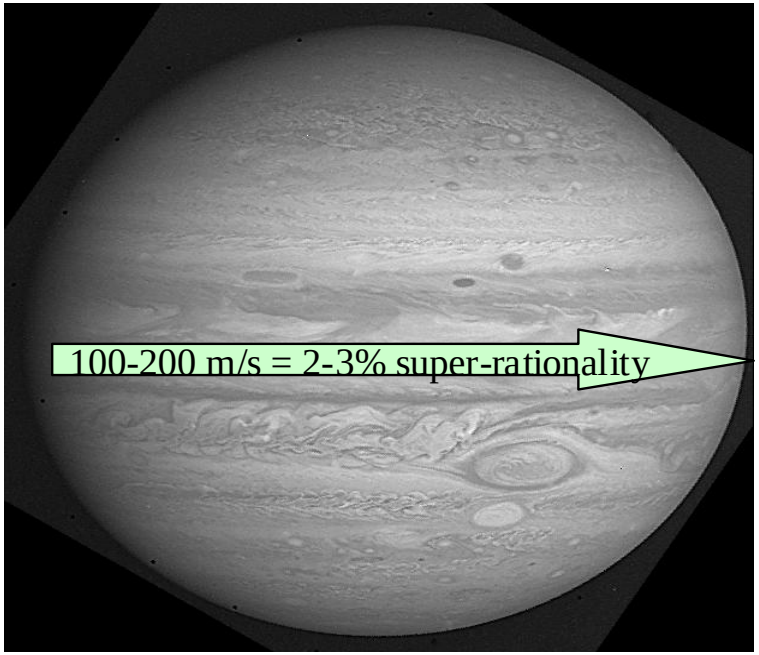
When the water above the ping-pong ball tries to move away it is brought back by the Coriolis force in an "inertia circle"

When the water below the ping-pong ball tries to move in behind it is brought back by the Coriolis force in an "inertia circle"

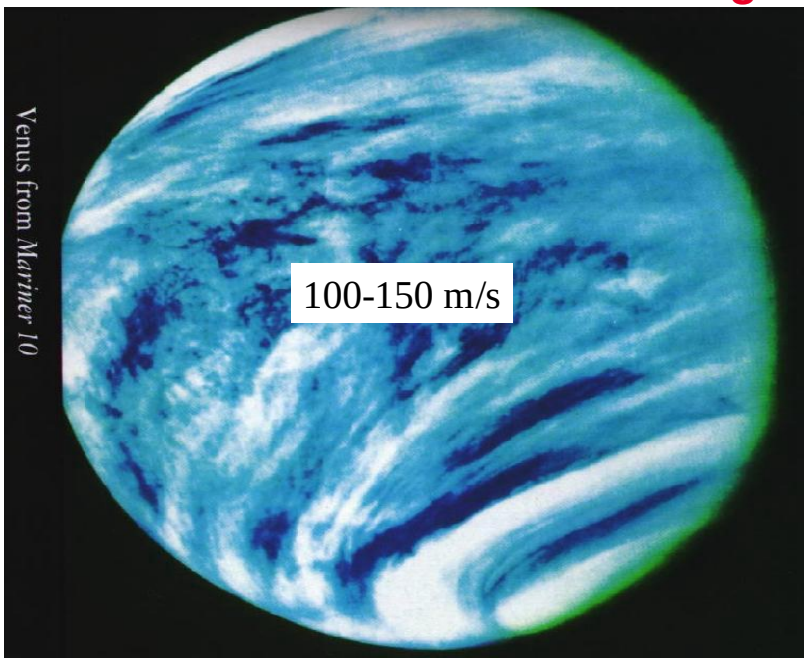


3. Winds on our and other planets

The equatorial jet circulation on Jupiter

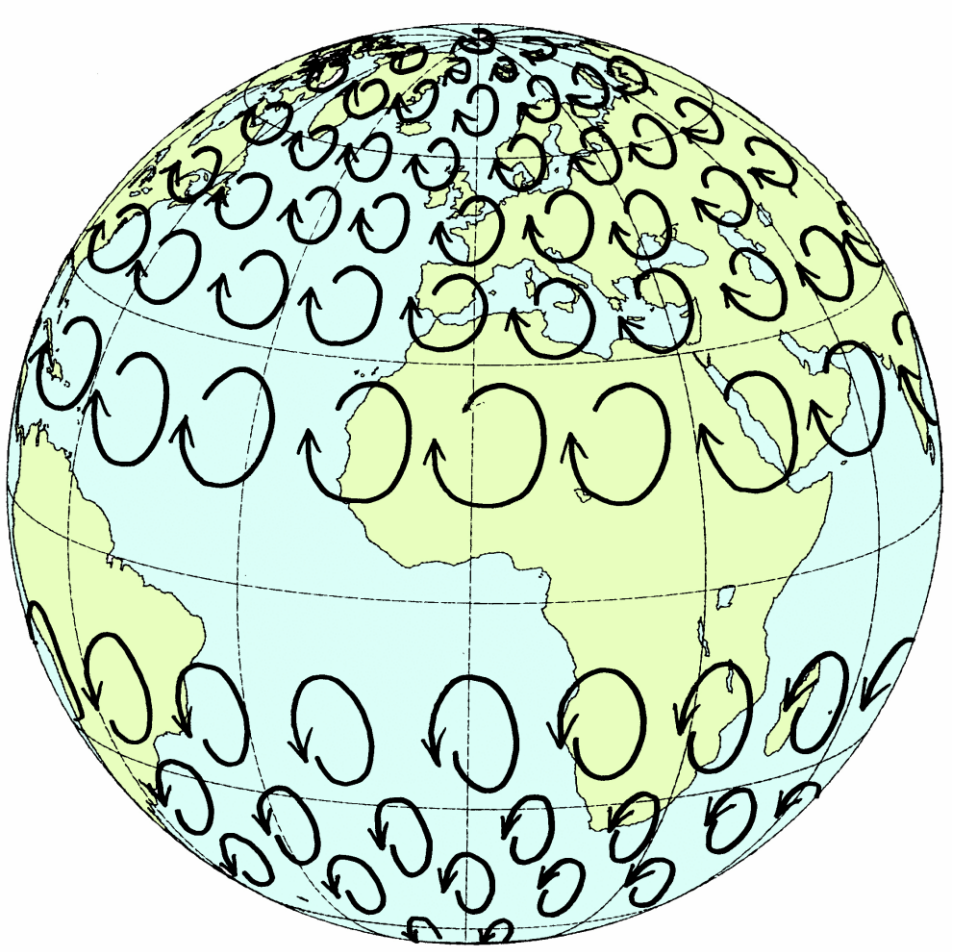


The hurricanes on the slow rotating Venus



Possible misunderstandings are that the winds on Jupiter are strong because it rotates rapidly, and the winds on Venus are weak because it rotates slowly – *but the opposite is true*

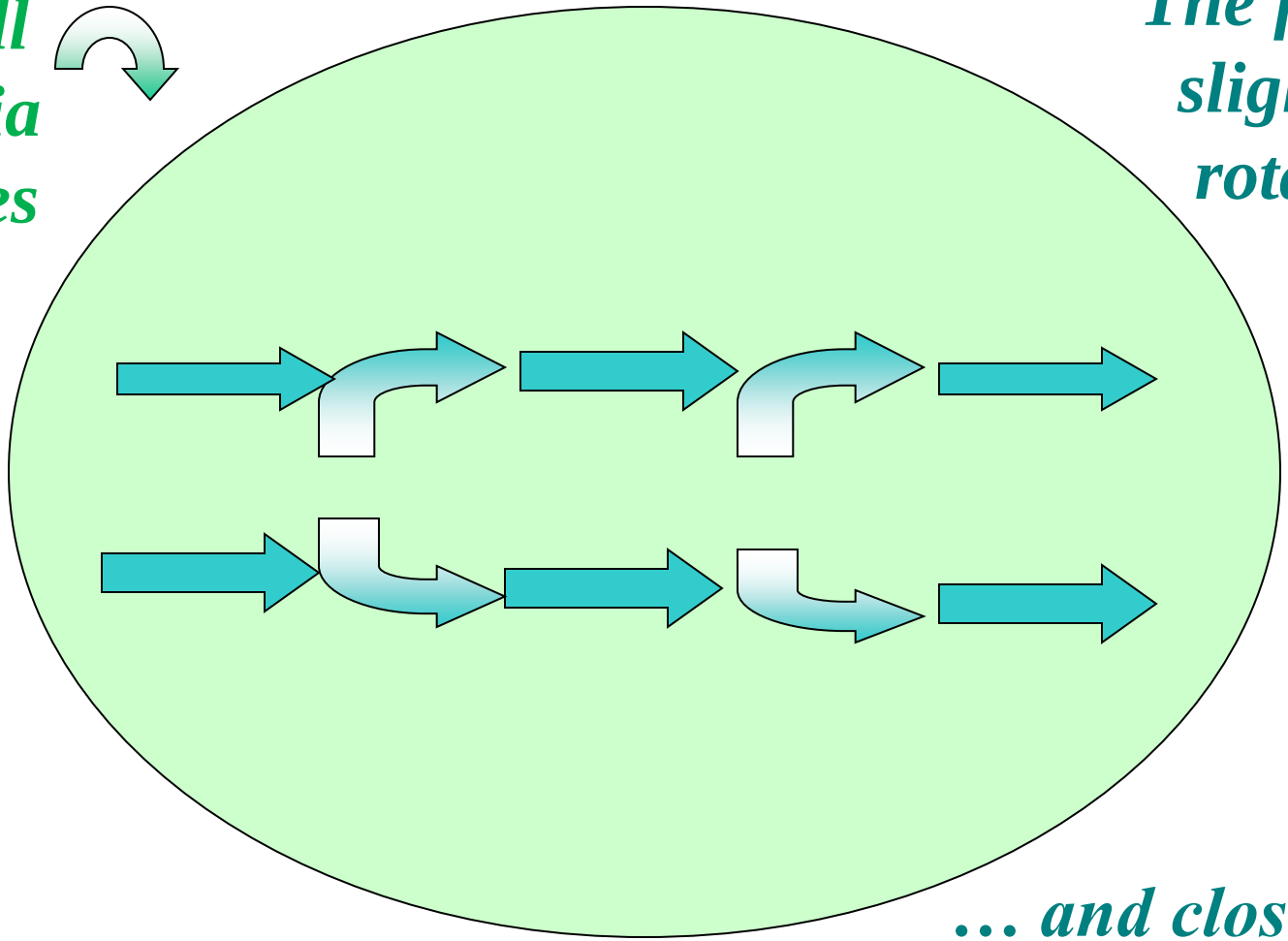
The rotation of the earth exerts a constraining effect on the motion over its surface



Inertia circles for approx. 30 m/s

High rotation - strong Coriolis force

Small inertia circles



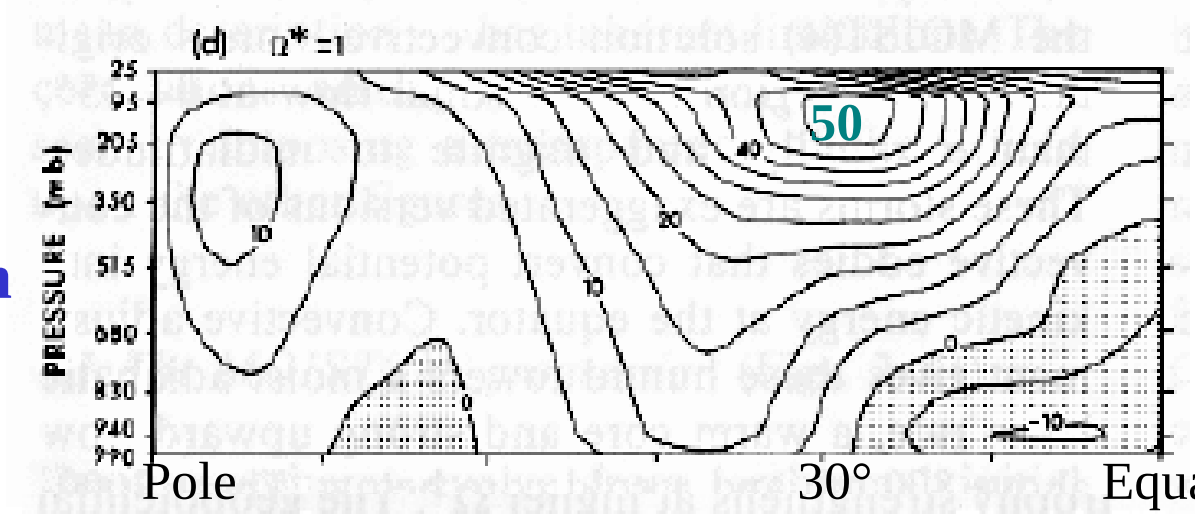
The flow is only slightly super rotational ...

… and closer to the equator

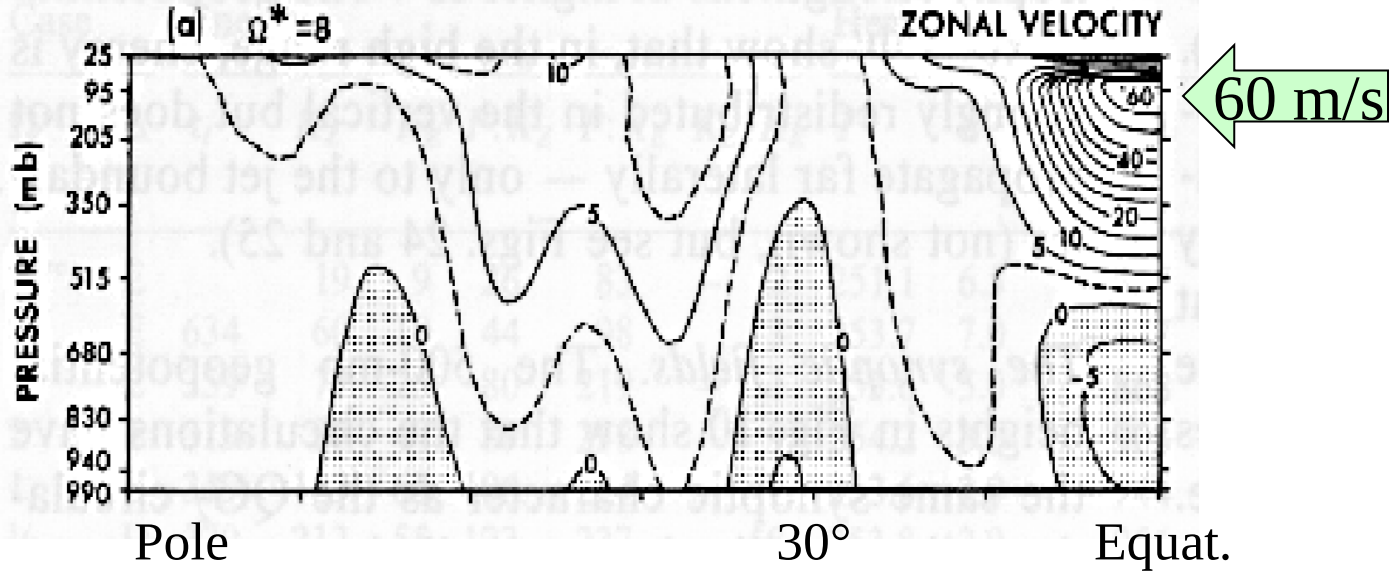
P-G. William's computer simulations

Ω=1

The earth

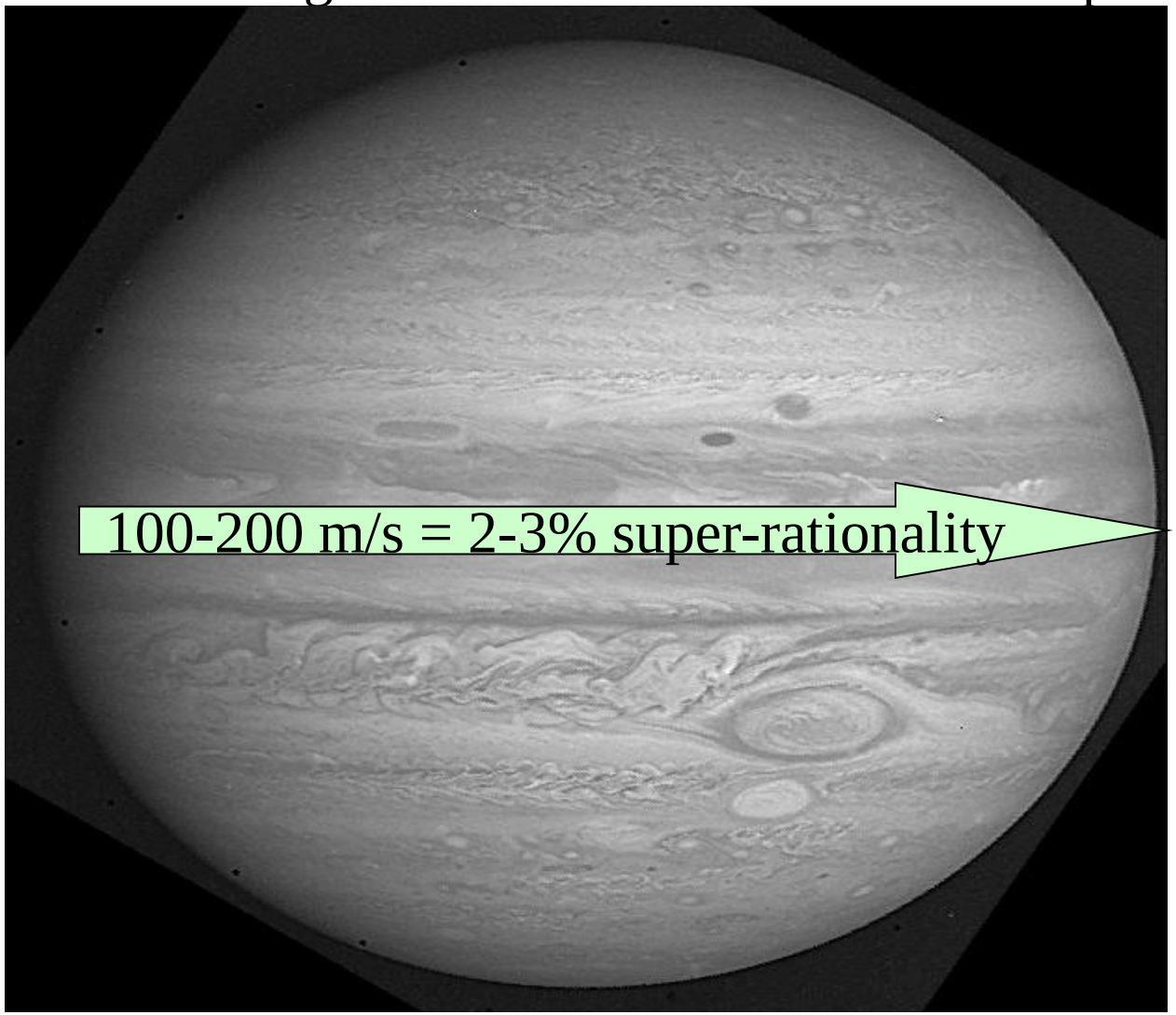


Ω=8

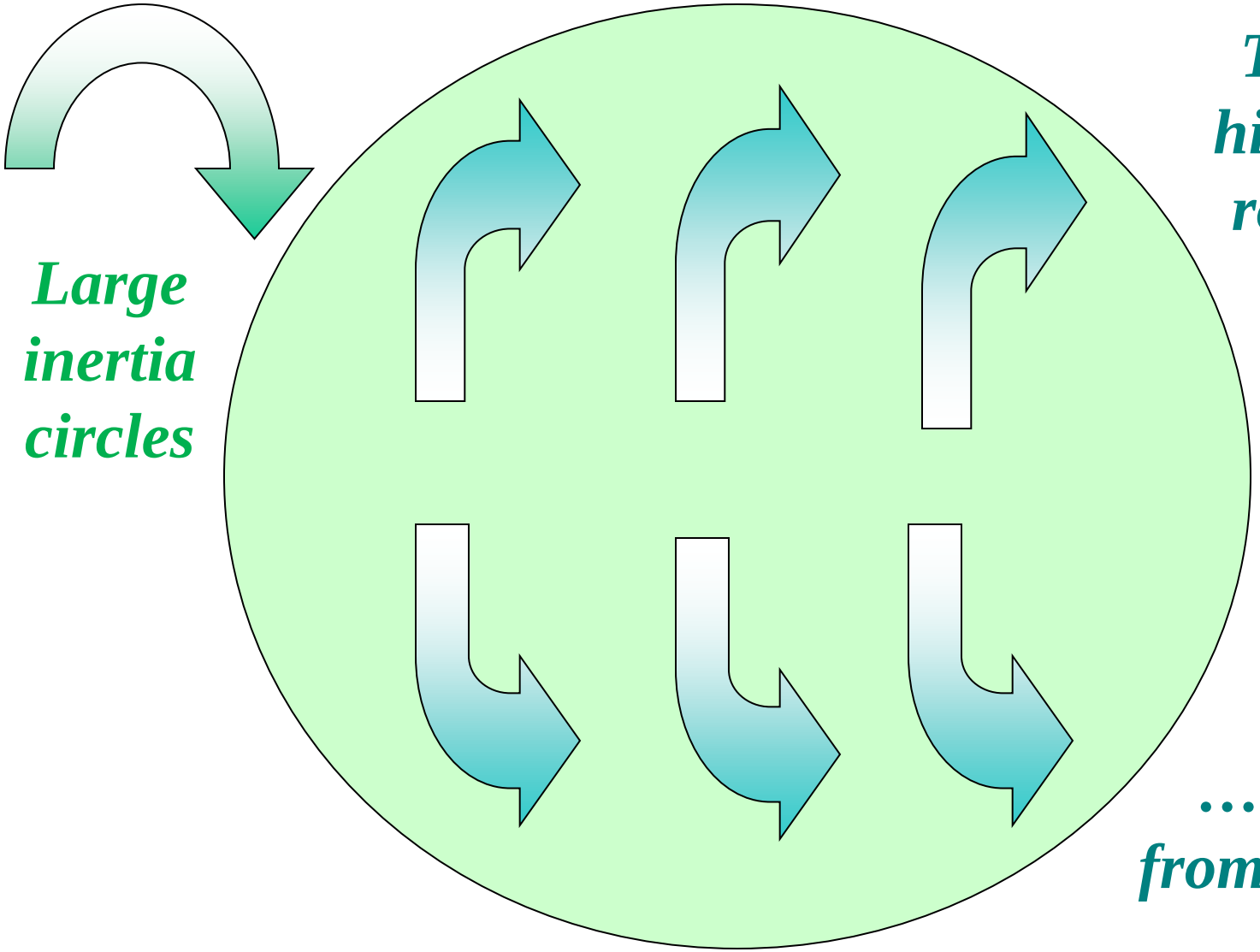


The relatively “weak” equatorial jet stream on Jupiter

Its absolute strengths derives from the size of the planet



Slow rotation - weak Coriolis force



Large inertia circles

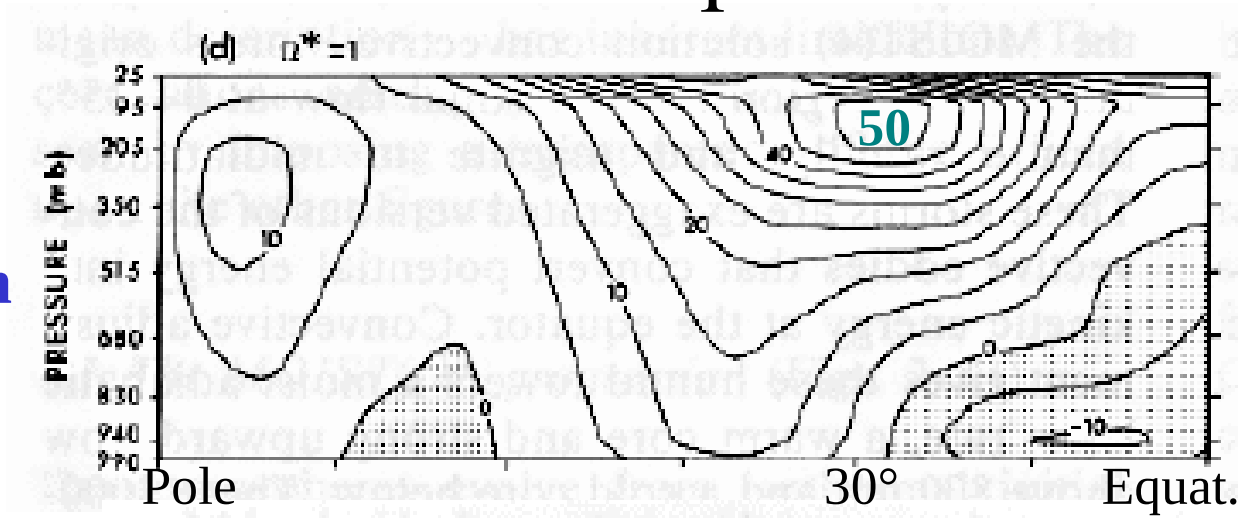
The flow is highly super rotational...

… and away from the equator

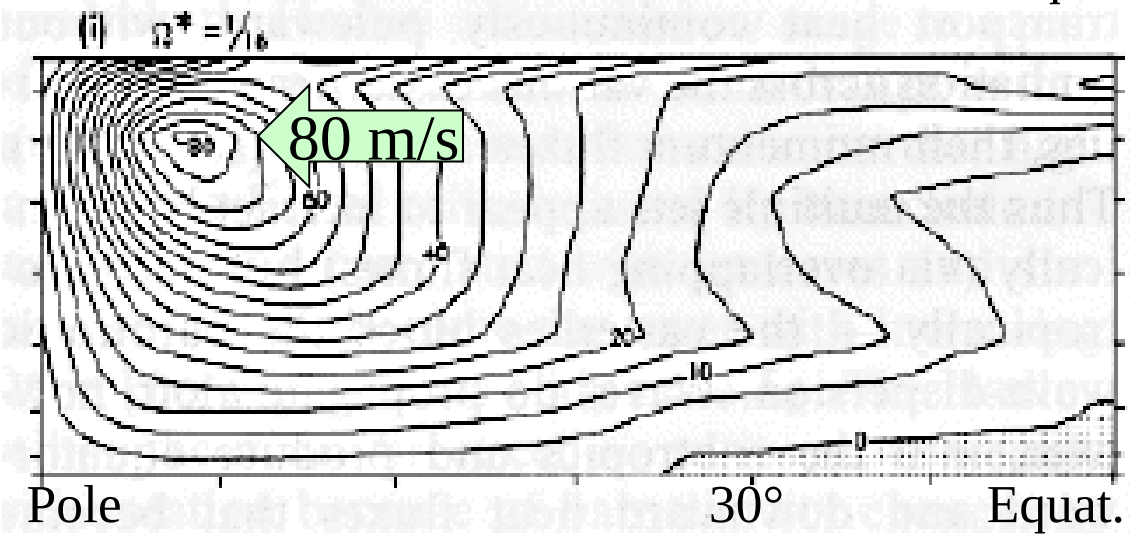
P-G. William's computer simulations

Ω=1

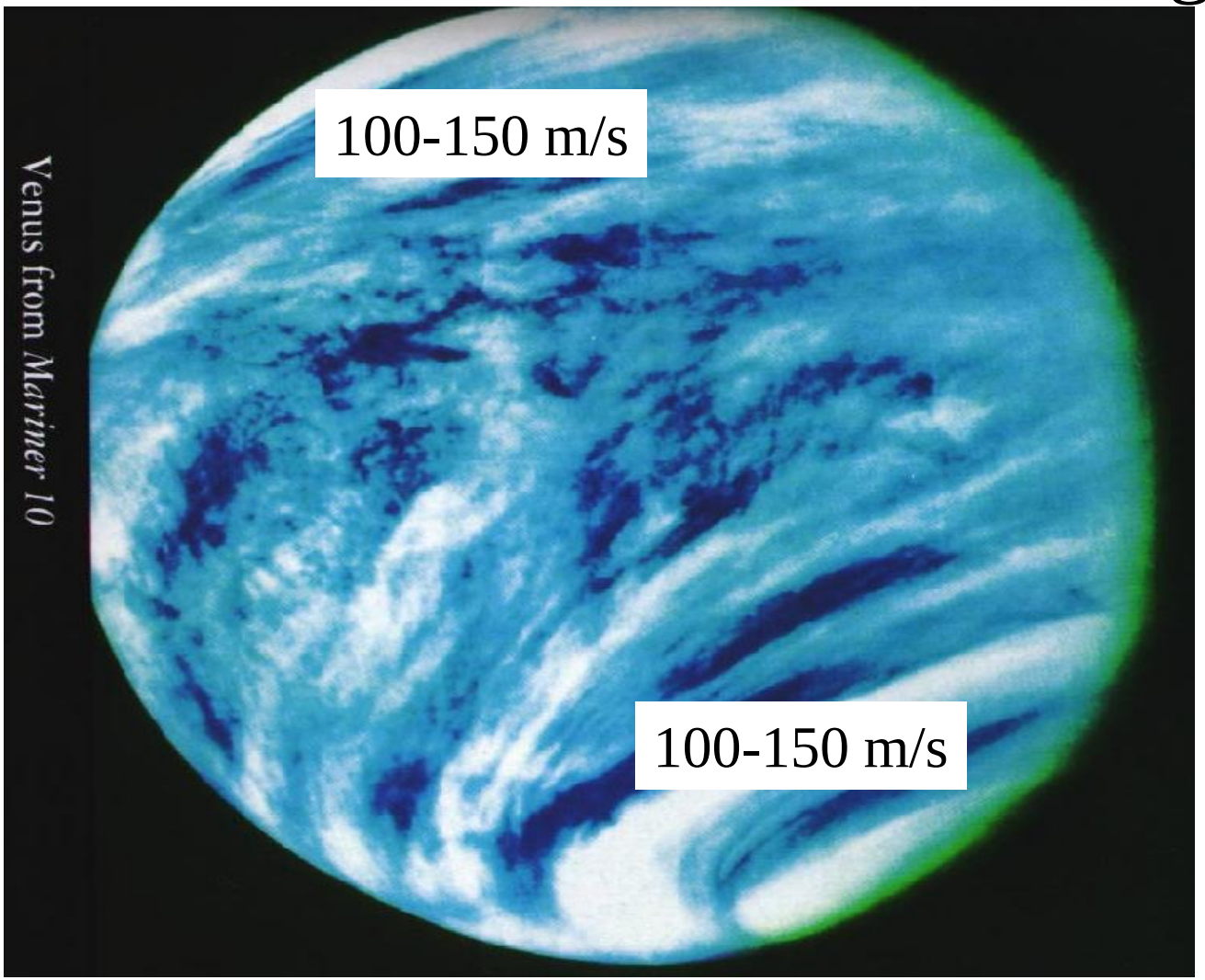
The earth



Ω=1/16

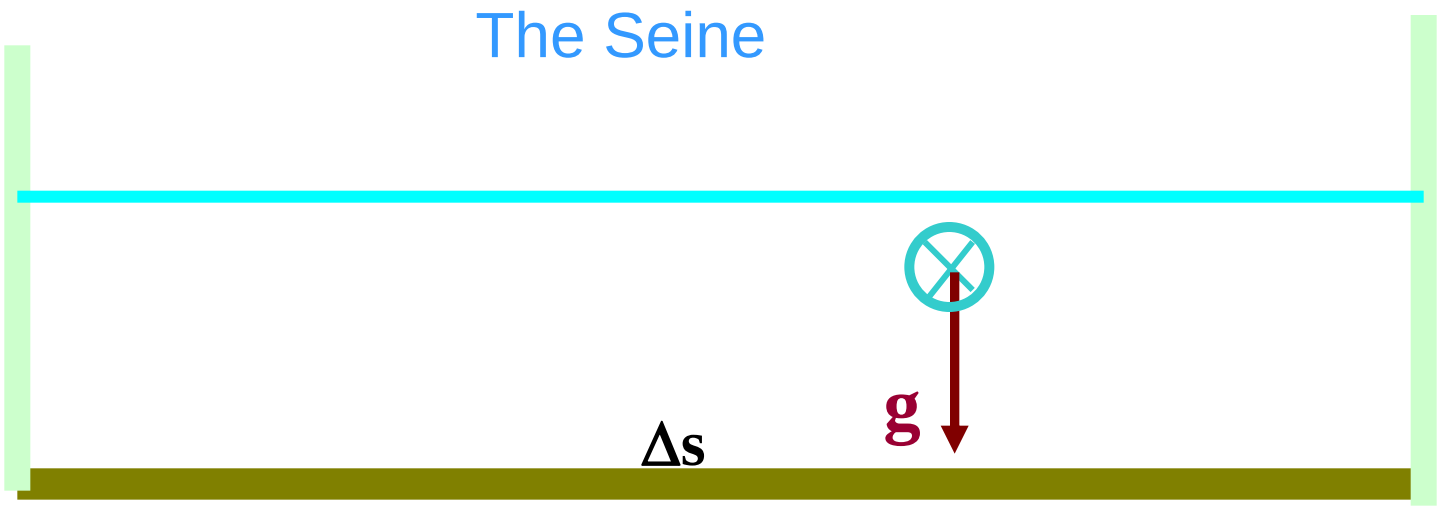


The hurricane winds on the slow rotating Venus

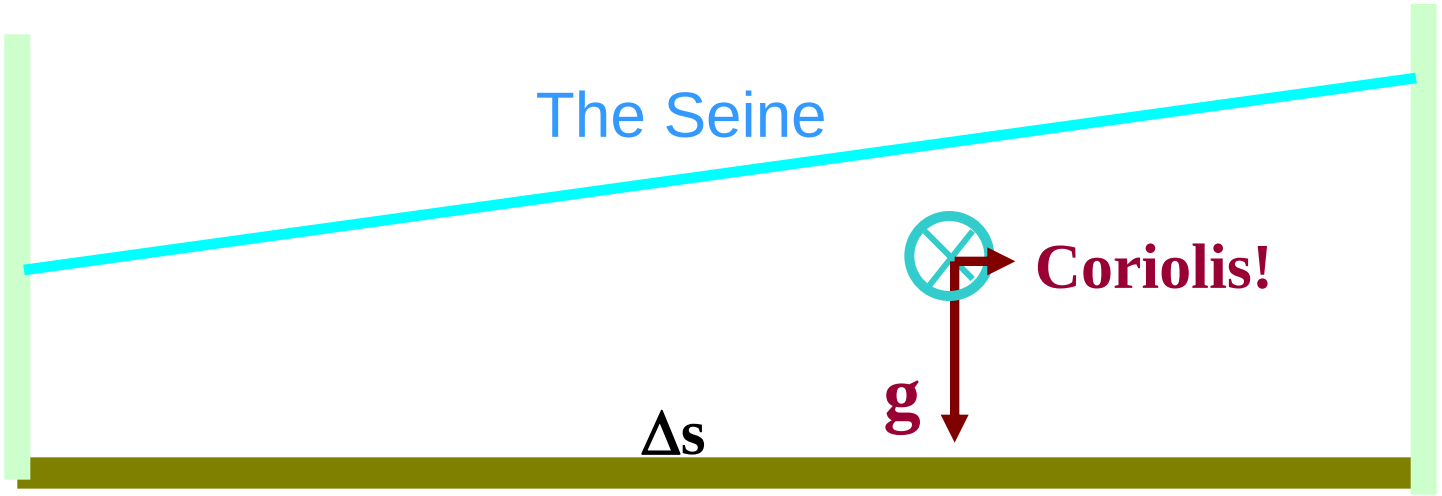


4. The geostrophic wind

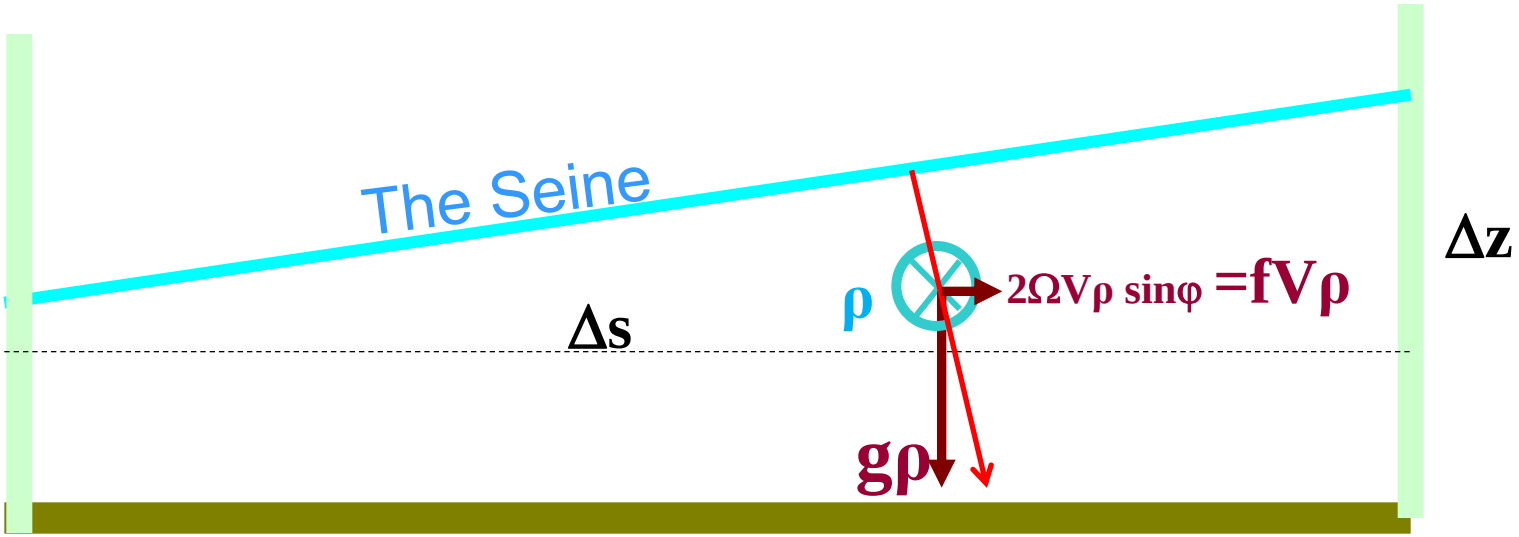
How the French Academy in 1859 derived the geostrophic equation without being aware of it!



The water in the Seine would be deflected to the right hand bank of the river – perhaps flooding Paris??

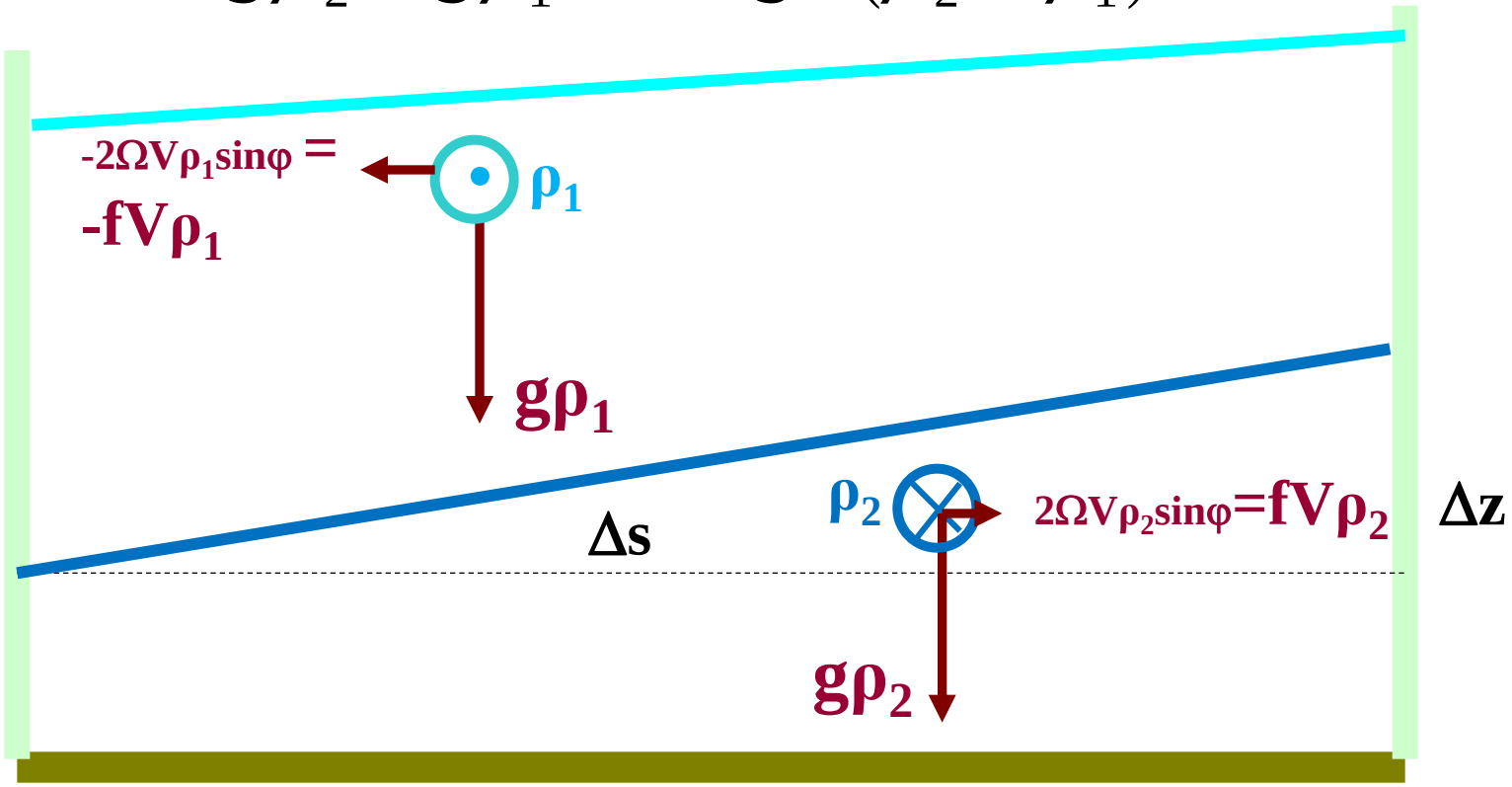


$$\frac{\Delta z}{\Delta s} = \frac{fV\rho}{g\rho} \Rightarrow V = \frac{g}{f}\frac{\Delta z}{\Delta s}$$

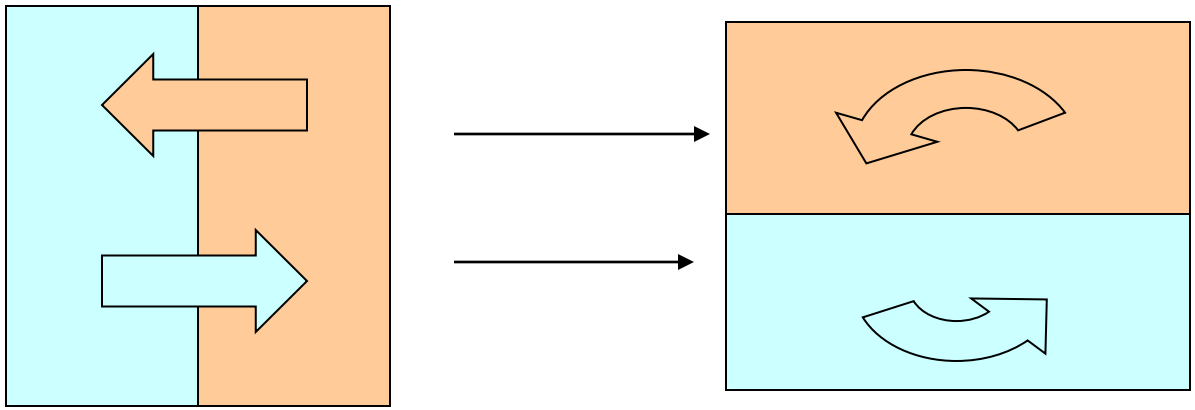


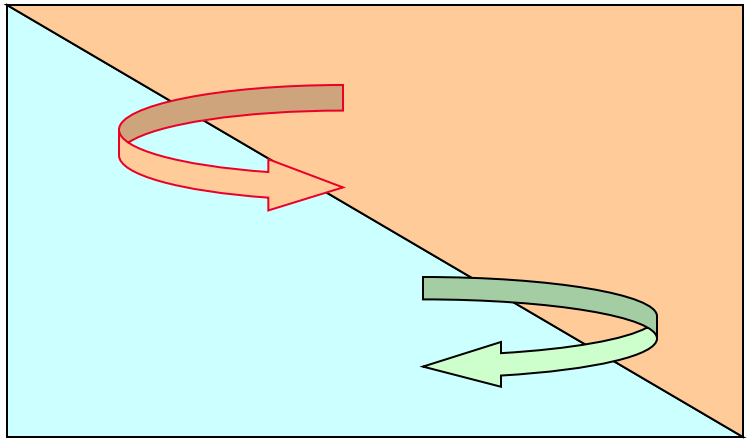
5. Sloping weather fronts (stratified fluid)

$$\frac{\Delta z}{\Delta s} = \frac{fV_2\rho_2 - fV_1\rho_1}{g\rho_2 - g\rho_1} \approx \frac{\overline{\rho} f}{g} \frac{(V_2 - V_1)}{(\rho_2 - \rho_1)} = \tan\alpha$$



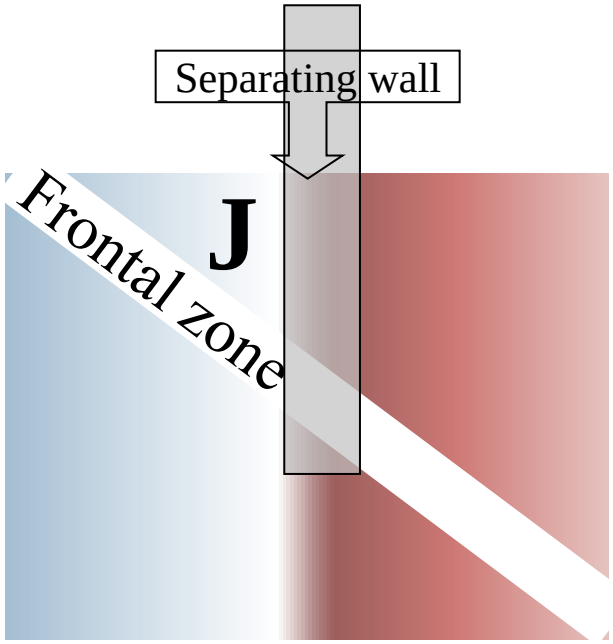
The slope of frontal surfaces (Margules equation)





With rotation the Coriolis force tries to turn back the air...

Margules's formula



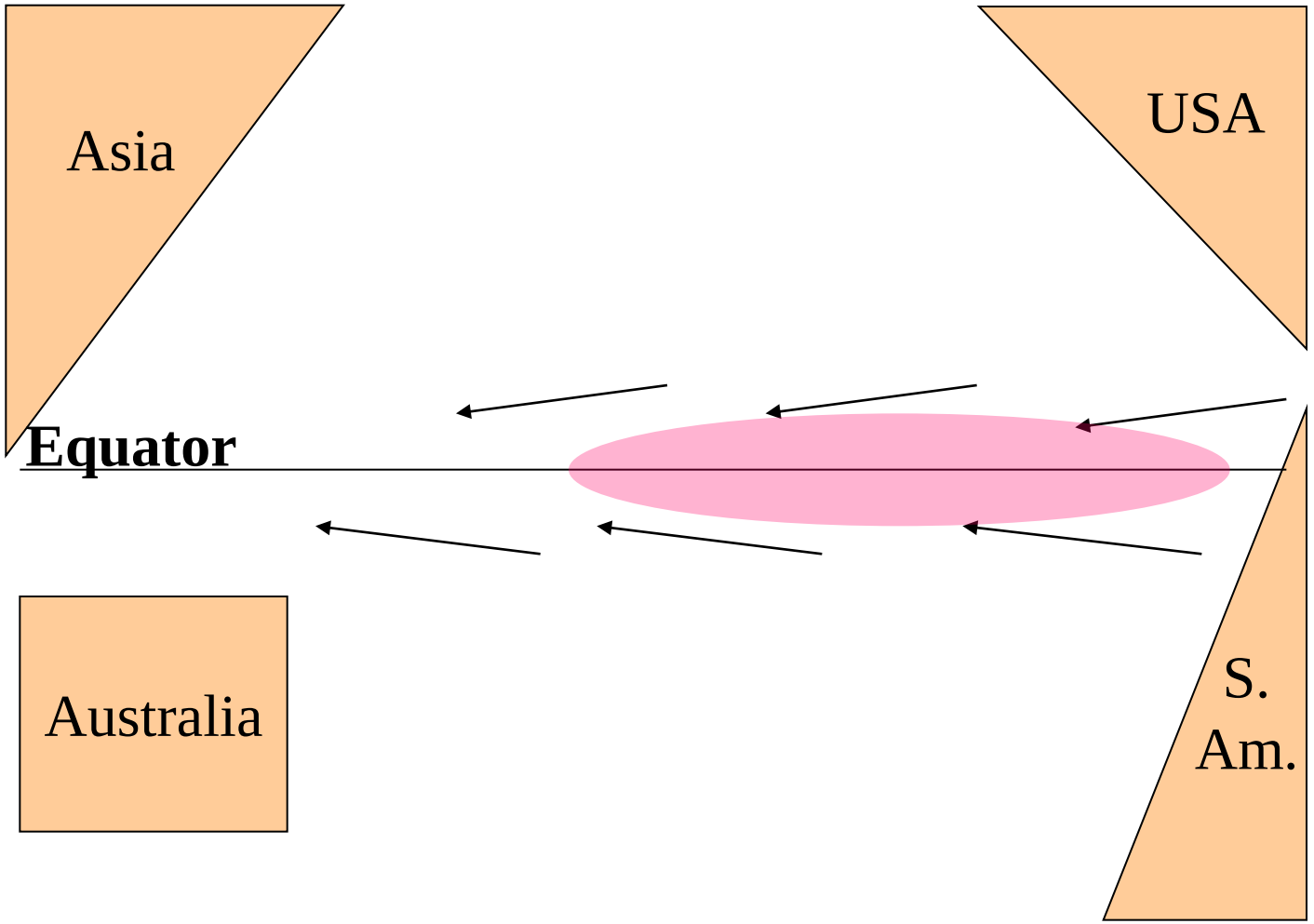
Max Margules 1856-1920

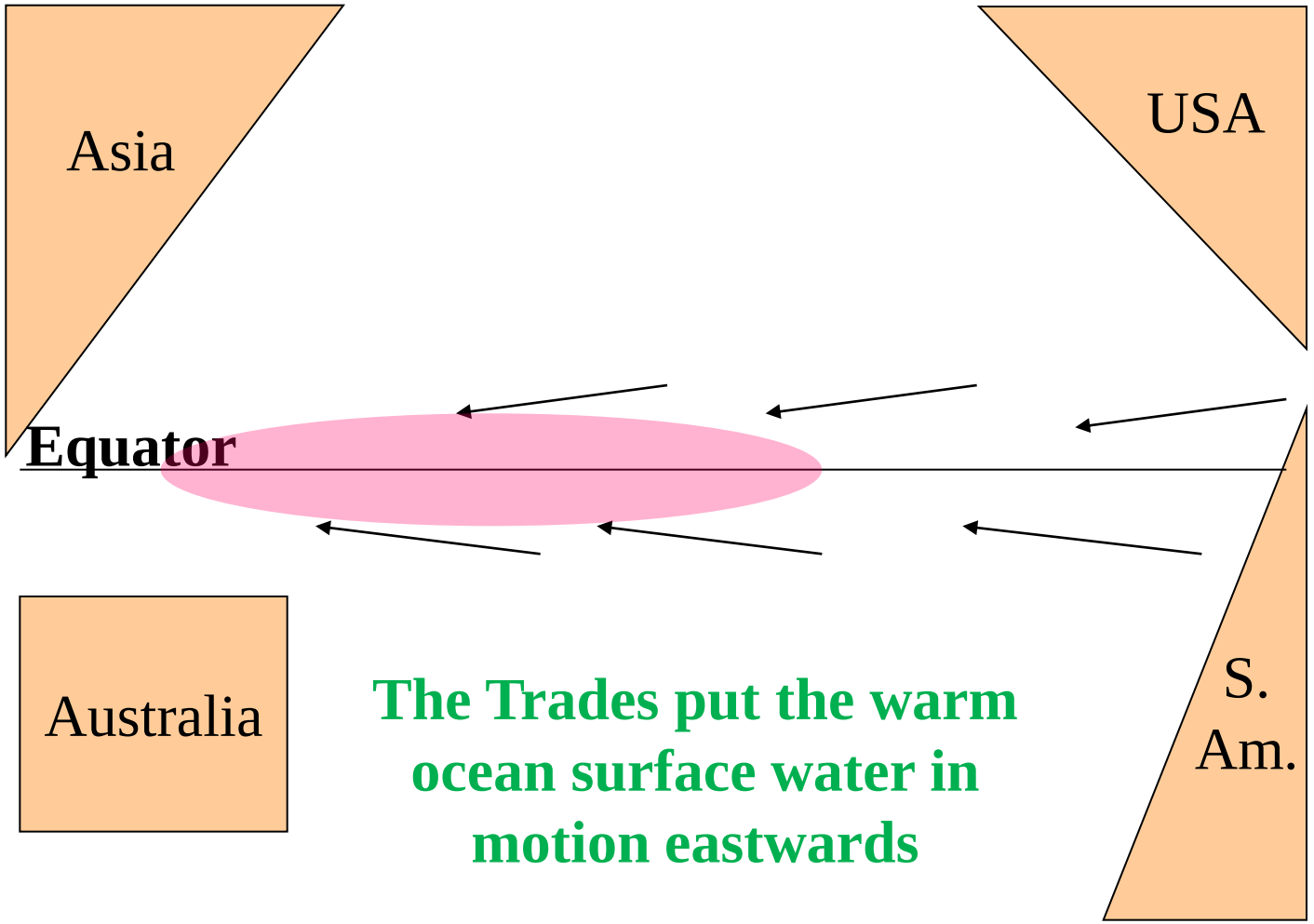
Rotating box with liquid or gas

The density differences try to equalize, the Coriolis effect tries to restore

$$\tan\alpha \approx \frac{g}{f}\frac{\bar{T}\left(V_c - V_w\right)}{\left(T_w - T_c\right)}$$

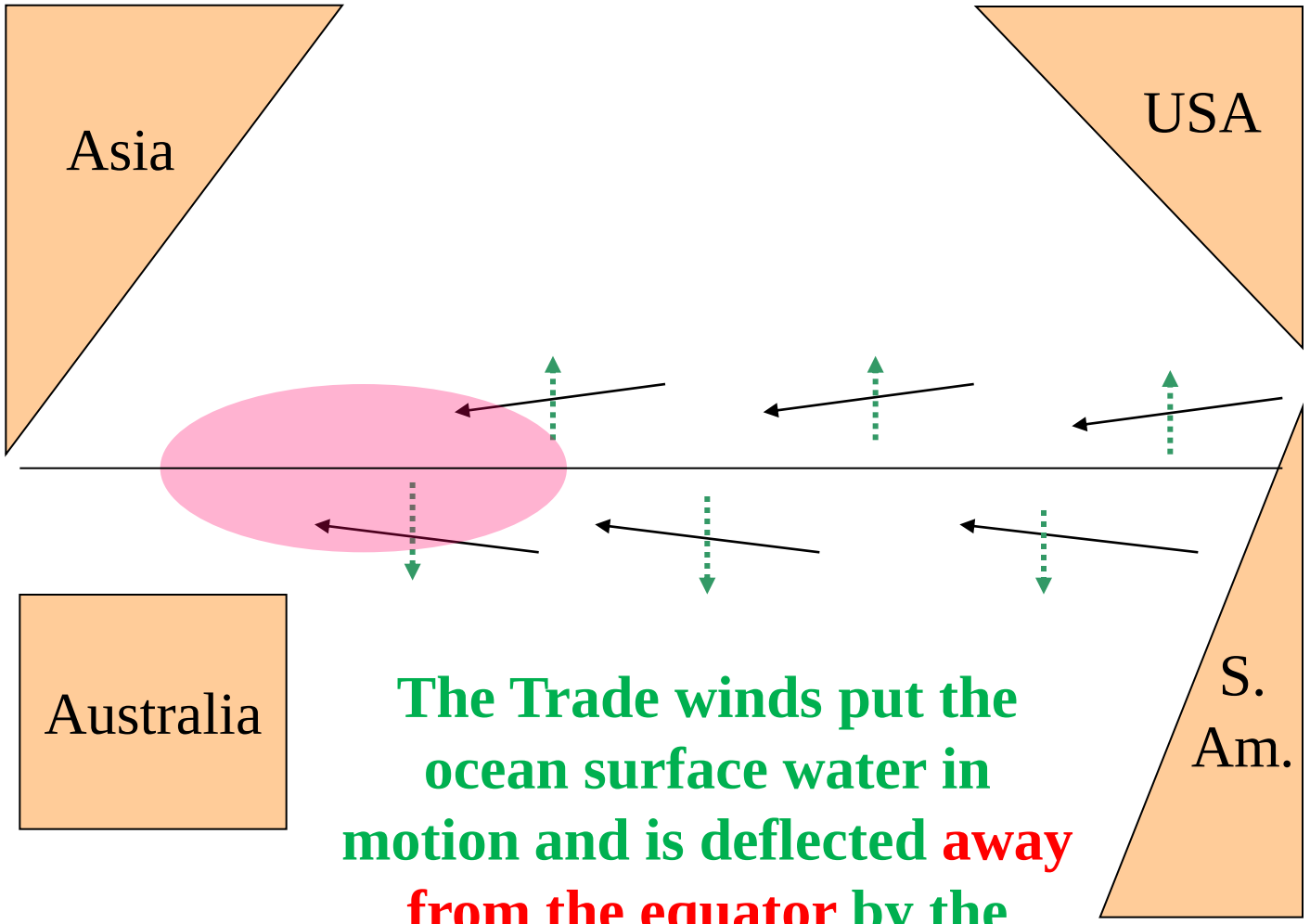
6. El Niño and la Niña





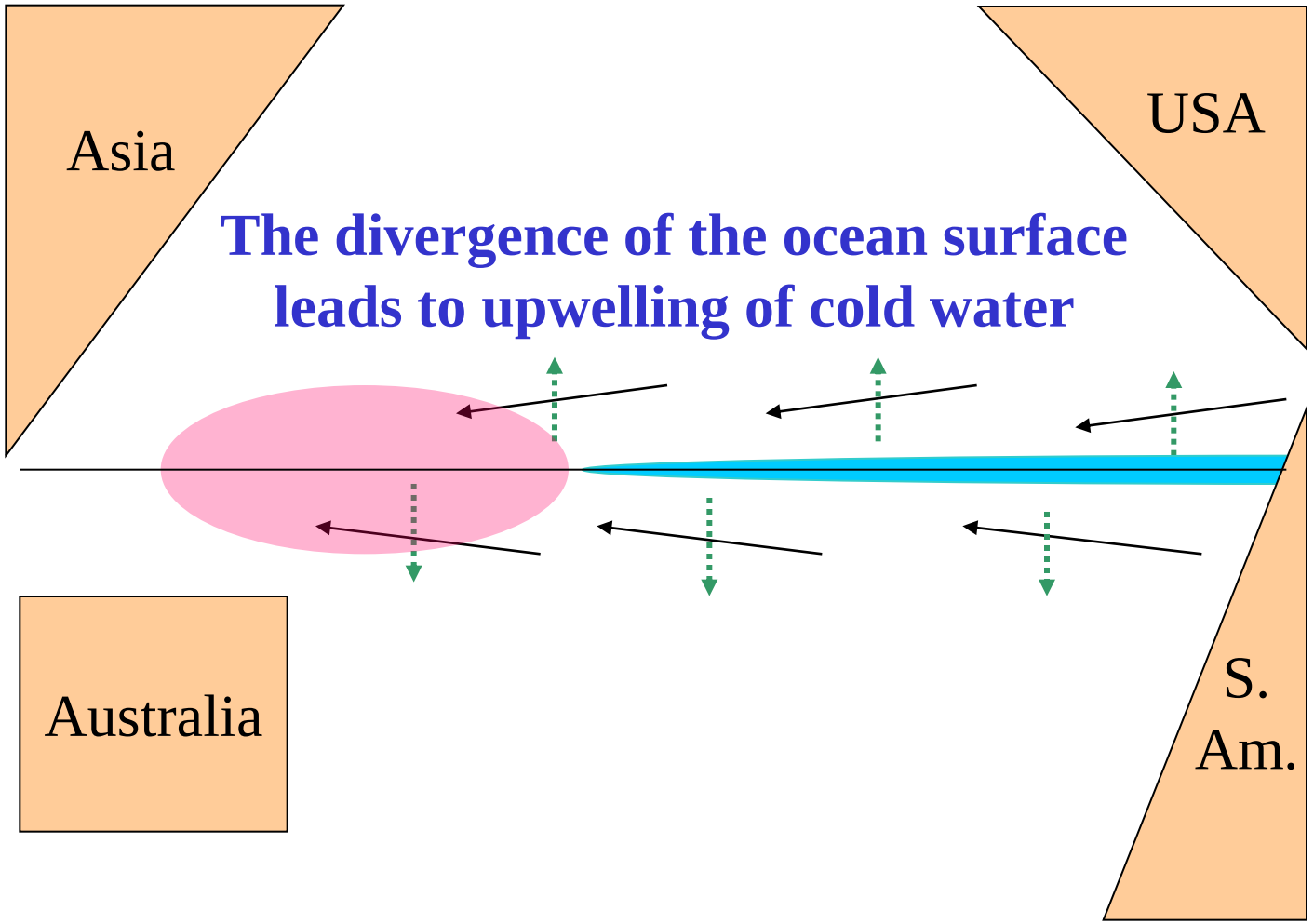
The Trades put the warm ocean surface water in motion eastwards

Divergent ocean water at the equator

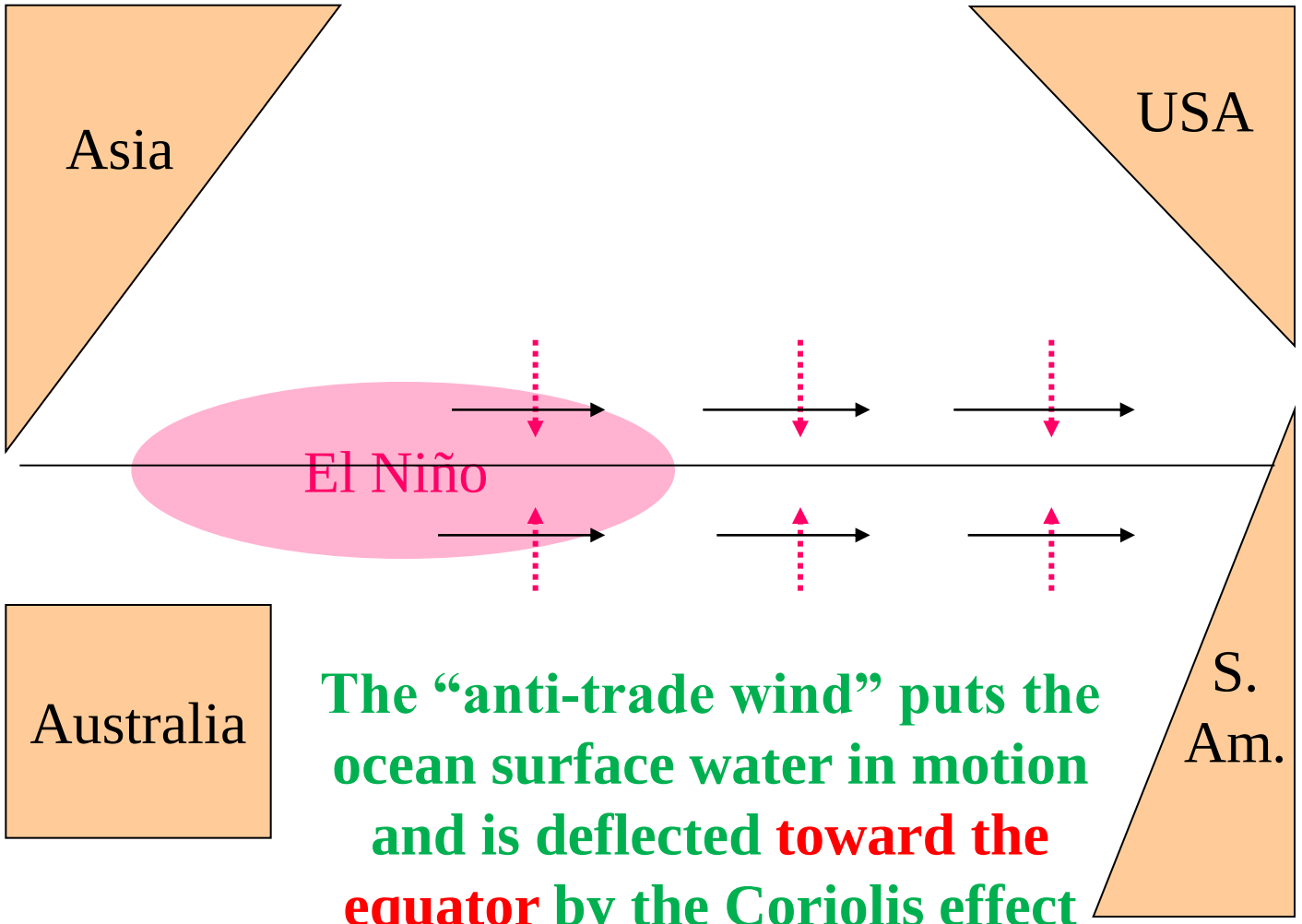


The Trade winds put the ocean surface water in motion and is deflected away from the equator by the Coriolis effect

The cold equator during La Niña

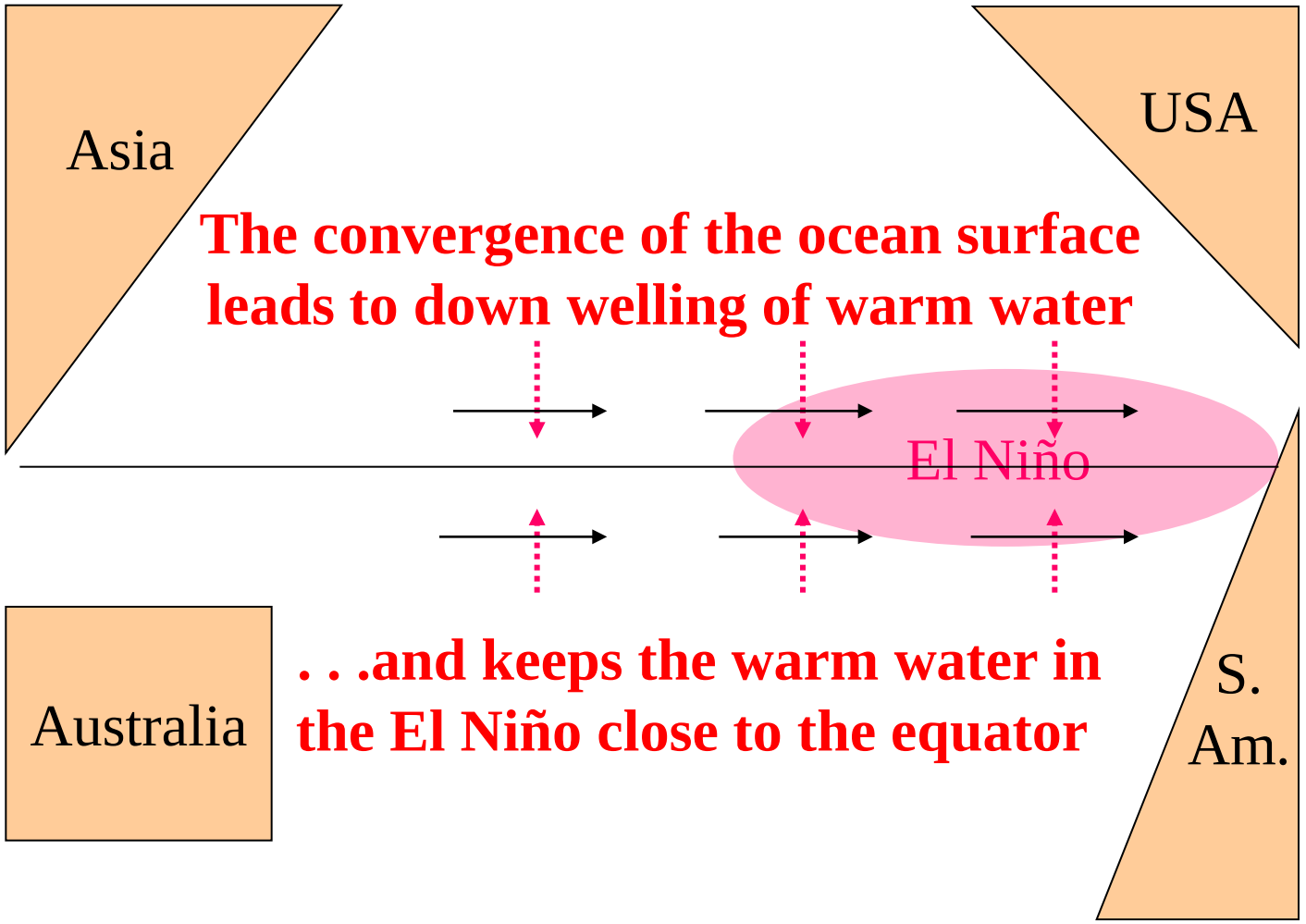


Convergent ocean water at the equator

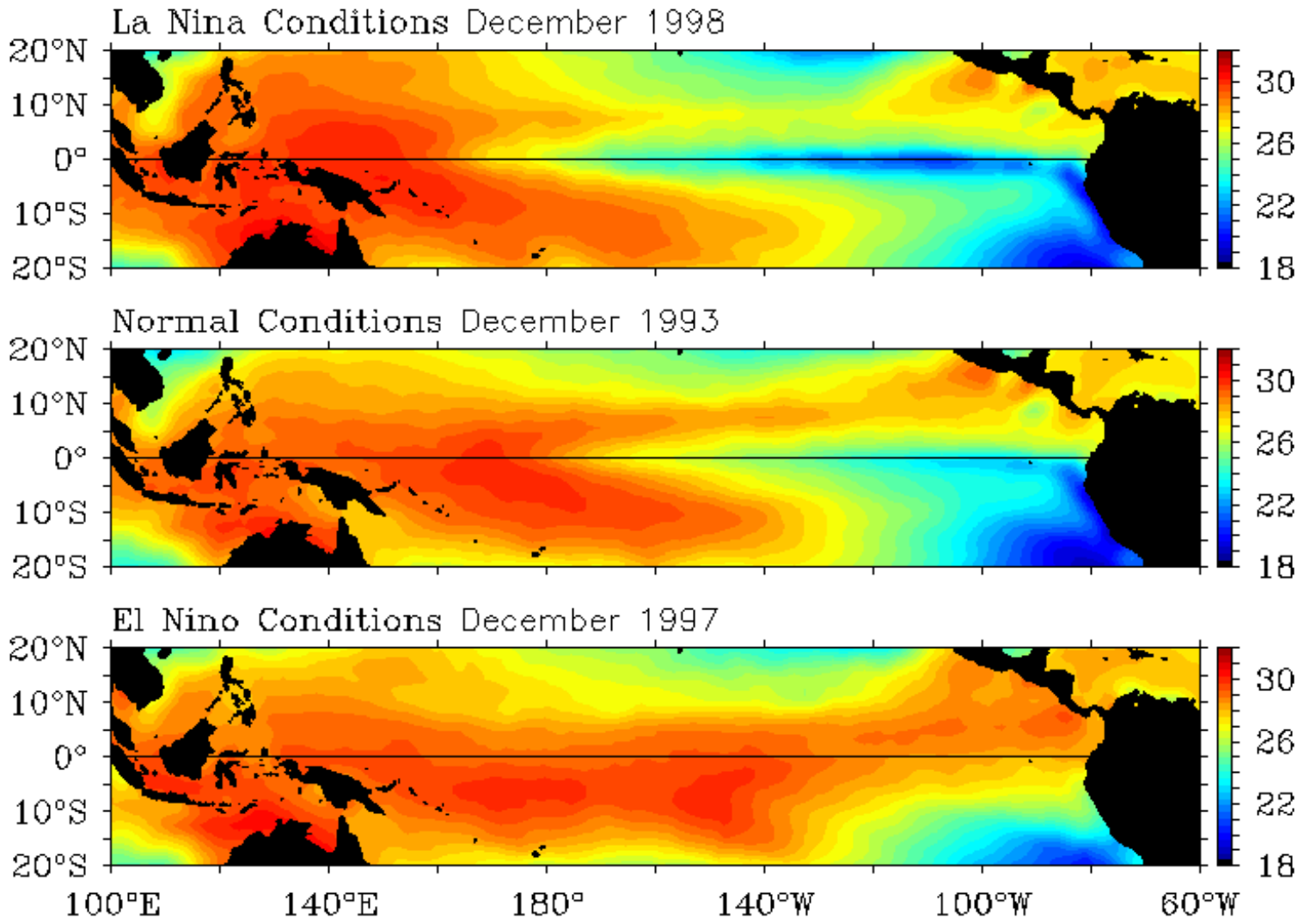


The "anti-trade wind" puts the ocean surface water in motion and is deflected toward the equator by the Coriolis effect

The warm equator during El Niño



Monthly Sea Surface Temperature °C



TAO Project Office/PMEL/NOAA

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