Rossby Waves and remote effect on SE Brazil's Climate

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Outline

- Part 1
  - Intro and motivation
- Part 2
  - Rossby Waves
- Part 3
  - Remote forcing of SE Brazil Climate
- Takeaway notes

Part 1
Intro and motivation

Intro and Motivation

- Horse latitudes
  - Location of most of the deserts
  - Sahara, Arabian, Gobi, Great Basin, Kalahari and Great Victoria deserts are all located in this region of the planet.

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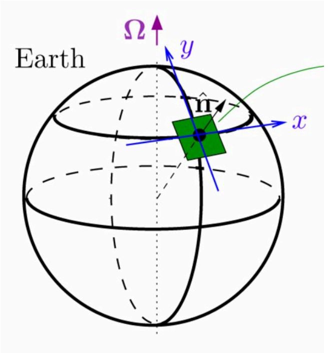
Intro and Motivation

- i) The Andes Mountains block the passage of moist air, and the air recirculates around this area causing precipitation;
- ii) The Amazon rain forest influences the climate around 30 S by releasing great amounts of water vapor, which are transported southward by the so-called aerial rivers
- iii) remote/global forcing modulates the rainfall in this area (e.g. relation between SASA and SE Brazil rainfall)

Part 2
Rossby Waves

Rossby Waves

- Slow waves induced by the spherical geometry of the Earth
- Planetary waves
  - Influenced by rotation
- Use of β-plane approximation



$$f \approx f_o + \beta y$$

$$f_o = 2\Omega \sin(\theta_o) \qquad \beta = \frac{2\Omega \cos(\theta_o)}{R}$$

Rossby Waves

- Basic equations

$$\frac{\partial u}{\partial t} - \beta y v - f_0 v = -g\frac{\partial \eta}{\partial x} \qquad (1)$$

$$\frac{\partial v}{\partial t} + \beta y u + f_0 u = -g\frac{\partial \eta}{\partial y} \qquad (2)$$

$$\frac{\partial \eta}{\partial t} + H\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right) = 0 \qquad (3)$$

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Small scale terms

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Rossby Waves

- Basic equations

$$\boxed{\begin{array}{l} f_0 v \gg \beta y v \\ f_0 v \gg \dfrac{\partial u}{\partial t} \end{array}}$$

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Rossby Waves

- 2-step method
  - Step 1: Assume that the first solution comes from large terms balance
  - Step 2: Substitute back into the full equation as small terms and solve for u and v
- Substitute them into (3) to obtain a single equation for η

Rossby Waves

$$\frac{\partial \eta}{\partial t} - R^2 \frac{\partial}{\partial t}\nabla^2\eta - \beta R^2 \frac{\partial \eta}{\partial x} = 0 \quad (4)$$

Where $R = \frac{\sqrt{gH}}{f_0}$ (Radius of deformation)

Rossby Waves

- Substitute the wave solution into (4):

$$\eta = A\, e^{i(kx+ly-\omega t)}$$

Wave solution

$$\omega = -\beta R^2 \frac{k}{1+R^2(k^2+l^2)} \qquad (5)$$

Dispertion relation for Rossby Waves

Rossby Waves

- Observations on Rossby Wave dispertion relatioship:
  - $\omega = \omega(k, l)$
  - If $\beta = 0$, no Rossby Wave
  - $Cx = \omega/k = -\beta R^2 \frac{1}{1+R^2(k^2+l^2)}$

$$\omega = -\beta R^2 \frac{k}{1 + R^2(k^2 + l^2)}$$

Only propagates to the West (when no background flow)

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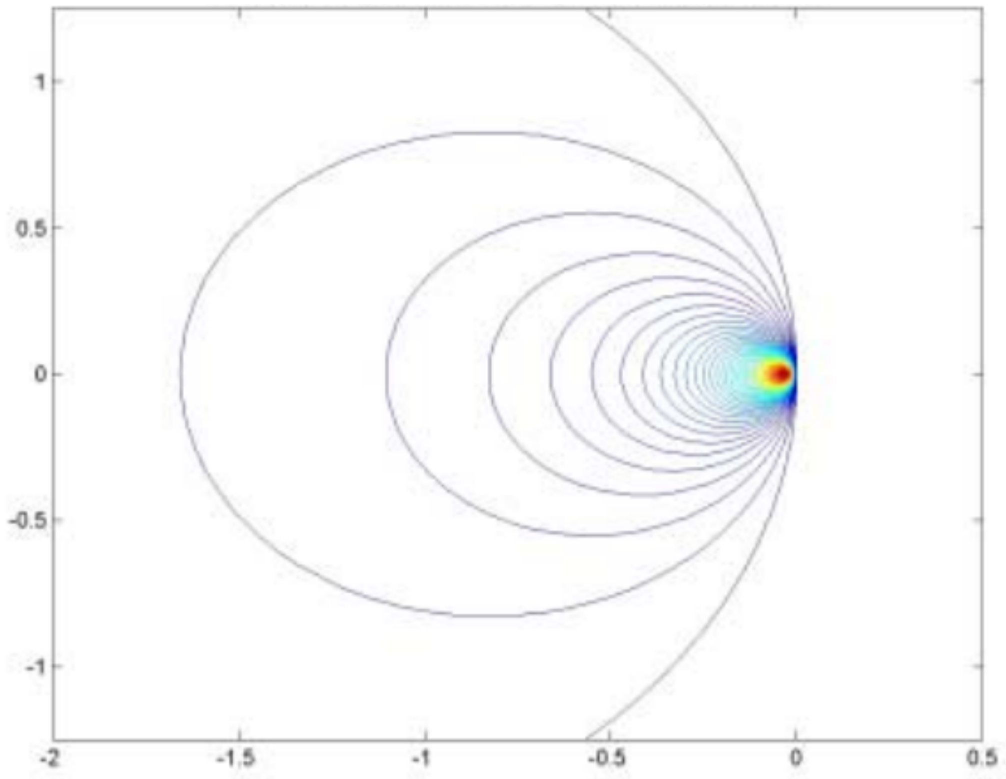
Rossby Waves Dispersion

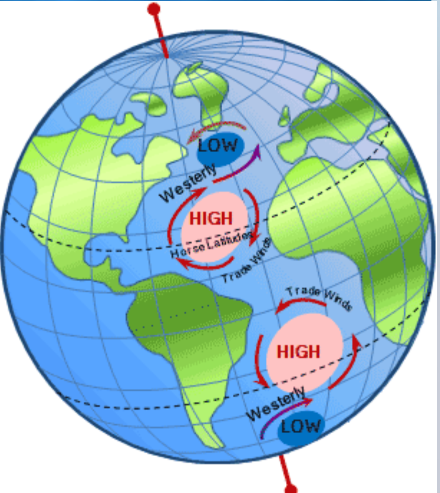


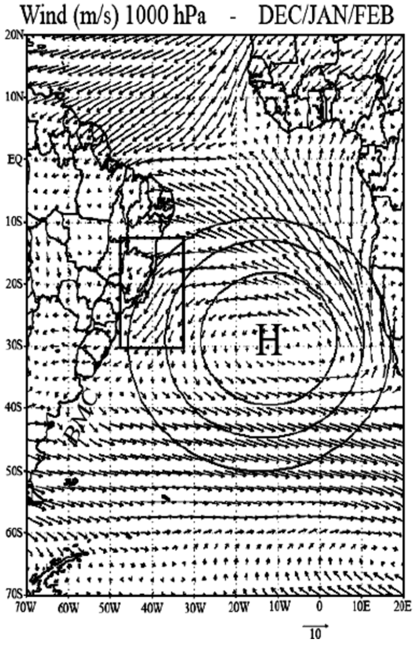
Rhines, 2002

Part 3
Remote forcing of SE Brazil Climate

South Atlantic Subtropical Anticyclone

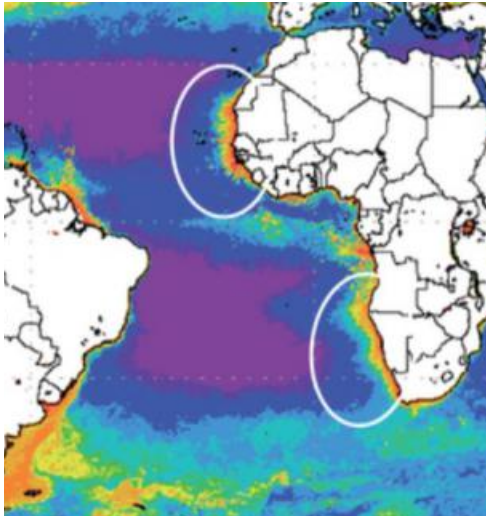
- Hadley Cell
- Sea-air interactions
  - Forced by east-west heating contrasts
- SASA affects the Brazilian weather and climate
  - SE Brazil → drier in winter and moister in summer (Reboita et al, 2019)





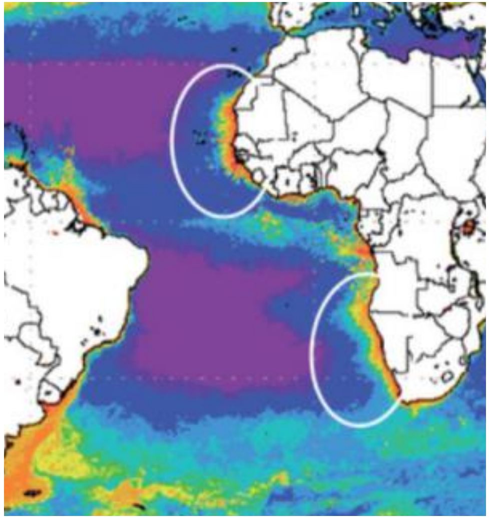
South Atlantic Subtropical Anticyclone

- Latent heat in the western boundary
- SST gradient
  - Western Africa upwelling



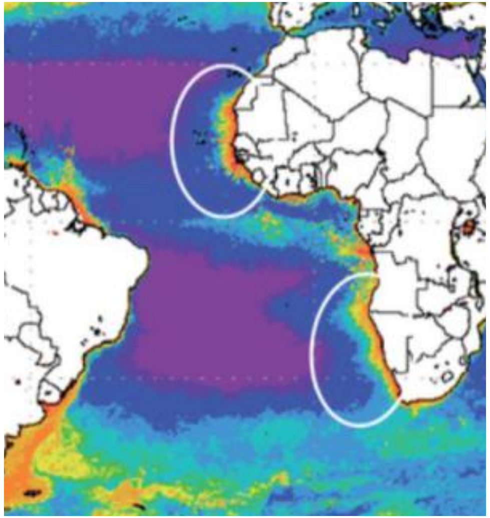
South Atlantic Subtropical Anticyclone

- Western SASA
  - Convection
  - Poleward warm water advection



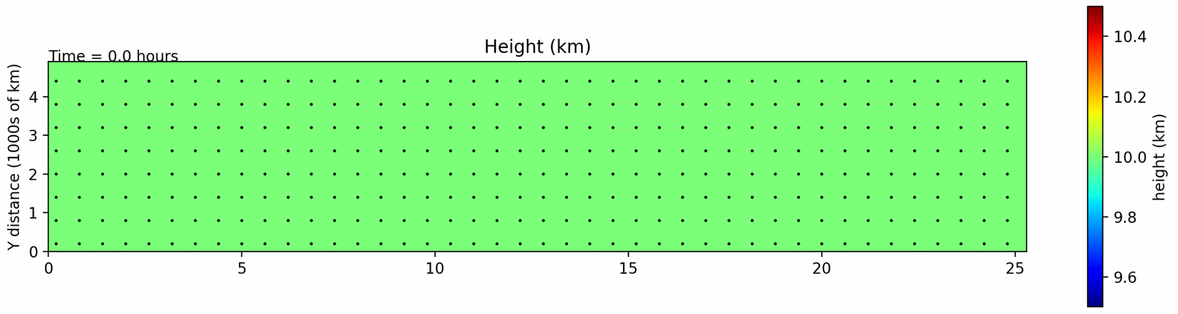
South Atlantic Subtropical Anticyclone

- Eastern SASA
  - Equatorward advection of cold water
  - Atmospheric subsidence
    - ↑ latent heat fluxes
    - Help to maintain colder SST



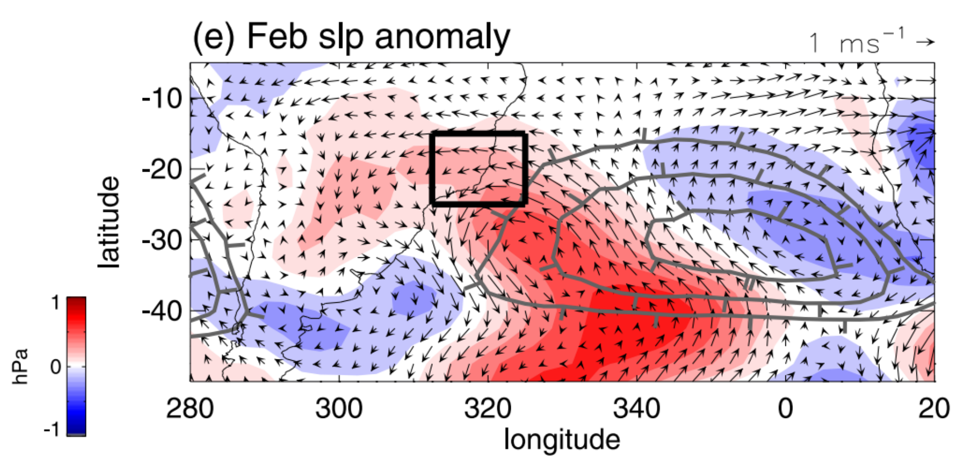
Rossby Waves

- Eastern cooling
  - Drives Rossby Waves
    - Influences the high



South Atlantic High

- Kelly and Mapes, 2016
  - Dry February on SE Brazil
  - westward displacement of the SASA



- Climatology
- interannual variation
- model experiments
- associated with Australian monsoon precipitation

Takeaway notes

Takeaway notes

- I’m glad there is no desert in SE Brazil ☻
- Rossby waves propagate west when there is no background flow
- SE Brazil has drier weather in winter and moister in summer
- Sea-air interactions are important on defining the position of the SASA
- Teleconnections: even Australia’s weather interferes on SE Brazil.

Questions?