Rossby and Kelvin Waves Link the Atlantic SST and Antarctic Sea Ice

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Atlantic SST Variability Impact on Antarctic Atmospheric Circulation through Stationary Rossby Waves

Atmospheric Circulation Changes Further Impact on Antarctic Sea Ice Distribution

Atlantic SST May Interact with SST Changes in the Indian Ocean and Pacific through the Rossby and Kelvin Wave Dynamics.
Recent Work about Atlantic – Antarctic Teleconnection


I. ATMOSPHERIC TELECONNECTION

Recent Work about Atlantic – Antarctic Teleconnection


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Connecting the Tropics to the Polar Regions

Theme Description:

Dramatic climate change is affecting both the Arctic and West Antarctica, yet the relative roles of local versus remote forcings in causing the changes are being debated. As global climate change continues to unfold, the two-way links between the tropics and the poles will play key determining factors in the climatic evolution of these sensitive regions. Thus, the time is ripe for a detailed look at how the tropics and the poles are coupled climatically. This special collection of the Journal of Climate on “Connecting the Tropics to Polar Regions” grew out of a mini-conference on the same topic that was held at Lamont-Doherty Earth Observatory in June 2014: http://www.ldgo.columbia.edu/~xyuan/Mini-Conference/Web.html

Subsequently, contributions were solicited from conference participants as well as colleagues worldwide with prior publications dealing with tropical-polar connections. Primarily, the manuscripts evaluate the remote impacts of various tropical forcings (El Niño-Southern Oscillation, Madden-Julian Oscillation, etc.) on polar and midlatitude atmospheric variability in the contemporary environment, and the Southern Hemisphere is emphasized.

Collection Organizers:
David H. Bromwich
Byrd Polar & Climate Research Center, The Ohio State University, Columbus, Ohio.
Xiaojun Yuan
Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York.

Journal of Climate, Special Collection:
http://journals.ametsoc.org/page/connectingthetropics
Atlantic induced Southern Hemispheric Circulation Changes

- **Relationship**
  - Regression

- **Causality**
  - *Comprehensive Atmospheric Model (CAM)*

- **Mechanism**
  - *Theoretical Rossby Wave Model (Karoly Rossby Wave Model)*
  - *Idealized Model (GFDL dynamical core)*

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I. ATMOSPHERIC TELECONNECTION

Data Analyses VS. Simulations

Statistics

- JJA
- SON
- DJF
- MAM

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I. ATMOSPHERIC TELECONNECTION

Data Analyses VS. Simulations

Statistics + Simulation

- JJA
- DJF
- SON
- MAM

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Mechanism
I. ATMOSPHERIC TELECONNECTION

Generation of Stationary Rossby Waves

Fig. 7. Sixty-day average zonal-mean (over all longitudes) meridional streamfunction anomalies from the ATL\textsubscript{PERT} experiments (shading). Contours denote the climatological streamfunctions from the daily control simulations, and are drawn at intervals of $2 \times 10^{10}$ kg s\(^{-1}\). Solid (dashed) contours denote anticlockwise (clockwise) flow.

- Simpkins et al, 2014
- Hoskins and Karoly, 1981
- Karoly, 1989

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Rossby Wave Dynamics?
Rossby Wave Dynamics?
Rossby Wave Dynamics?

Rossby Wave Dynamics
Theoretical Stationary Rossby Wave Model

- Dispersion relation of Rossby wave
  \[ \omega = U k - \frac{\beta_* k}{K^2} \]

- For stationary wave, \( \omega \) is 0.
  \[ K^2 = l^2 + k^2 = \frac{\beta_*}{U} \]

- Where
  \[ \beta_* = \beta - U_{yy} \]

- We can derive the group velocity at each location
  \[ c_{gx} = \frac{2 \beta_* k^2}{K^4} \quad c_{gy} = \frac{2 \beta_* k l}{K^4} \quad \frac{c_{gy}}{c_{gx}} = \frac{l}{k} \]

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Seasonality of the Stationary Wave Trains
GFDL Dynamical Core
Atlantic Warming Deepens the Amundsen Sea Low
II. Further Impact on SEA ICE

Sea Ice Response to Tropical Atlantic Warming

Observed Trend
Linear Regression
Numerical Simulation

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Interactions between Different Ocean Basins Complicate the Tropical-Polar Teleconnection
Recent Work about Inter-Basin Teleconnections


**Li, Xichen, Shang-Ping Xie, Sarah T. Gille, and Changhyun Yoo.** "Atlantic-induced pan-tropical climate change over the past three decades." Nature Climate Change (2015).


**Graham Simpkins; Yannick Peings, Gudrun Magnusdottir.** Pacific Influences on Atlantic Teleconnections to the Southern Hemisphere High Latitudes, Journal of Climate, (2016)

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Physical Mechanisms of the Inter-basin Teleconnection

III. MULTIPLE-PATHWAYS

**Mechanism**

- **Atlantic Warming**
- **Gill-type Atmospheric Circulation Changes**
- **WES Feedback**
  - Warm Indo-Western Pacific
  - Cool Eastern Pacific
- **Indo-Western Pacific Warming**
  - enhance Walker Circulation
- **Bjerknes feedback further cool the**
  - Eastern Pacific

### a Gill-type Atmospheric Response and WES Feedback

- Atlantic Convection
- WES-Warming
- WES-Cooling

### b Gill-type Atmospheric Response and Bjerknes Feedback

- Atlantic Convection
- Secondary Indo-West Pacific Convection
- Enhanced Upwelling

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III. MULTIPLE-PATHWAYS

Coupled Model Simulations with SST restored in the Tropical Atlantic


Multiple Pathways
III. MULTIPLE-PATHWAYS

Multiple Pathways
Multiple Pathways
Summary

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- Atlantic SST May Interact with SST Changes in the Indian Ocean and Pacific through the Rossby and Kelvin Wave Dynamics.
Thanks 😊