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Austral teleconnection patterns associated to generalized frosts over Southern South America

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Austral teleconnection patterns associated to generalized frosts over Southern South America

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This work is a clear example of how the teleconnection “theory” can be used to explain an important meteorological event being also a good example of how theory, observations and modeling are linked.

OBJECTIVE

To analyze the role played by the propagation of remotely-generated Rossby waves during SH winter, in the development of frost events in southern South America

APPROACH

- A criterion of spatial extension is established in order to identify the frost events
- The frost events take place in Wet Pampa –central-eastern Argentina- the most important agricultural region of the country
SPATIAL EXTENSION CRITERION FOR FROST EVENTS

Why the spatial extension?

- Identifies regional scale frosts and excludes those exclusively local
- Allows the study of associated larger scale conditions

For each day:

\[
\frac{\text{Number of stations with frost}}{\text{Total number of stations with data that day}}
\]

Each day is classified as

- Isolated frost
- Partial frost
- Generalized frost

GENERALIZED FROST: there must be at least 75% of stations with frost

CRITERION OF EXTREME FREQUENCY OF FROST OCCURRENCE

Why extreme frequency of occurrence?

- Generalized frosts display large seasonal and interannual variability in the frequency of occurrence

Therefore:

We identify the winters (JJA) with a number of generalized frosts that is:

- greater than the 1961-90 average +1 $\sigma$, \textit{identified as GF +$\sigma$}
- smaller than the 1961-90 average -1 $\sigma$, \textit{identified as GF -$\sigma$}

GF +$\sigma$ winters: 1970, 1976, 1988


Müller et al. (2005) \textit{Theor. and Applied Climatol.}
It is interesting to notice that these fields are not observed in the composites of other frost groups: (isolated and partial)

**HIPOTHESIS**

The extreme occurrence of frost events are conditioned by large scale patterns of Rossby wave propagation, which are trigged remotely.

**METHODOLOGY**

- Numerical Simulations using a 12 sigma levels Global Baroclinic model (IGCM), T42
- Thermal forcing is placed where tropical convection anomalies are observed

**Basic State:** GF +\(\sigma\) winter *(henceforth GF +\(\sigma\))*

**DATA:** NCEP/NCAR Reanalysis

Additional simulation with other basic state

GF -\(\sigma\) winter *(henceforth GF -\(\sigma\))*
Observed OLR Anomaly (Wm⁻²)

+ σ GENERALIZED FROST COMPOSITES

Statistically significant anomalies

Müller et al. (2008) Annales Geophysicae
BAROCLINIC MODEL SIMULATIONS FOR THE TROPICAL FORCING

250 hPa meridional wind anomalies (ms⁻¹)
Day 10 of simulation

GF +σ

stream function anomalies
(x 10⁻⁶ m²s⁻¹)

GF -σ

Müller et al. (2008) Annales Geophysicae
850 hPa wind vector anomalies

surface temperature anomalies (°C)

GF +σ

GF -σ

DRY and cold air advection  WET and cold air advection

modeling

Müller et al. (2008) Annales Geophysicae
HOW ARE THE OBSERVED WAVE PROPAGATION PATTERNS ASSOCIATED WITH THE GF?

**DATA:** NCEP/NCAR Reanalysis and Argentinean Meteorological stations

**METHODOLOGY:**

- Composite analysis – 14 events during GF +σ

**SELECTION OF THE GF DAYS**

- Two consecutive episodes must be separated by seven days
- The selected episodes cannot be associated with the same synoptic system

Observed 250 hPa meridional wind anomalies (ms\(^{-1}\))

2 days before

1 day before

The event day

In the various numerical experiments of GF +σ associating the observed convection with the propagations pattern it was not obtained this double wave train with the peculiarity of coincidence phases ...

Under which circumstances the atmosphere creates conditions that would generate a propagations pattern as the observed one?

Thus we studied the characteristics of the GF +σ (and GF -σ) basic state from the Rossby wave linear theory point of view

**DISTRIBUTION OF THE ROSSBY STATIONARY WAVENUMBER**

Calculate Ks number: \[ K_s = \left( \frac{\beta_*}{U} \right)^{1/2} \]

\[ \beta_* = \beta - \frac{\partial^2 \bar{U}}{\partial y^2} \]
zonal wind component (ms$^{-1}$) at 250 hPa
The distribution of $K_s$ emphasizes the important of the jets as efficient wave guides and to identify the regions where the Rossby wave propagation is not allowed.

Müller and Ambrizzi (2007) *Climate Dynamics*
Therefore, the previous hypothesis is enlarged:
The Rossby wave which are trigged remotely, propagates along the
subtropical and polar waveguides and their phases coincide before
entering the SA continent in GF +σ

What is the origin of these propagation wave patterns?

METHODOLOGY

- Numerical simulations using a 12 sigma levels IGCM
- Thermal forcing is placed where the conditions are favorable for Rossby wave propagations according to Ks of GF +σ:

in black (K_s=0)
simulated 250 hPa meridional wind anomalies (ms^-1)
Day 14 of integration

Müller and Ambrizzi (2007) Climate Dynamics
surface temperature anomalies (°C) 850 hPa wind vector anomalies

Müller and Ambrizzi (2007) *Climate Dynamics*
As it was mentioned ...

A conceptual scheme on the physical mechanisms that act during the austral winters originating the most “conspicuous” events of generalized frost

“conspicuous” events are the more frequent and/or persistent generalized frost
THE PHYSICAL MECHANISM THAT FAVOUR HIGH FREQUENCY OCCURRENCE OF GF

Origin and evolution of the Rossby waves propagation patterns in the GF +σ austral hemisphere

It emphasizes the phases coincidence

Müller and Ambrizzi (2007) Climate Dynamics
It is similar to the physical mechanism that generates a **MORE PERSISTENT GF EVENTS**

It emphasizes the quasi-stationary **MORE PERSISTENT DOBLE WAVE TRAIN**

The observational evidence and the theoretical-observational analysis of the Southern Hemisphere teleconnection patterns associated to extreme cold events in the Wet Pampa were well simulated by a baroclinic model.

The main wave activity inside the subtropical and polar jets that guide the waves towards South America are dependent of the basic states and they are important in the determination of the final trajectory of the waves.

The two wave trains generated in the South Indian Ocean for GF +\( \sigma \), propagate to the east independently of each other, and before reaching the South American continent they merge in an unique pattern creating the appropriate conditions for generalized frosts. There is no wave phase coincidence when the GF -\( \sigma \) basic state is used.

The phase coincidence found in the wave propagation patterns is the dynamical condition that determines the greater frequency of occurrence of generalized frosts in the Wet Pampa during some specific winters. It maintains a polar air advection over the southern cone of South America, favoring the conditions for a surface temperature drop over a large region.
CLIMATE STUDIES GROUP

THANK YOU FOR YOUR ATTENTION

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