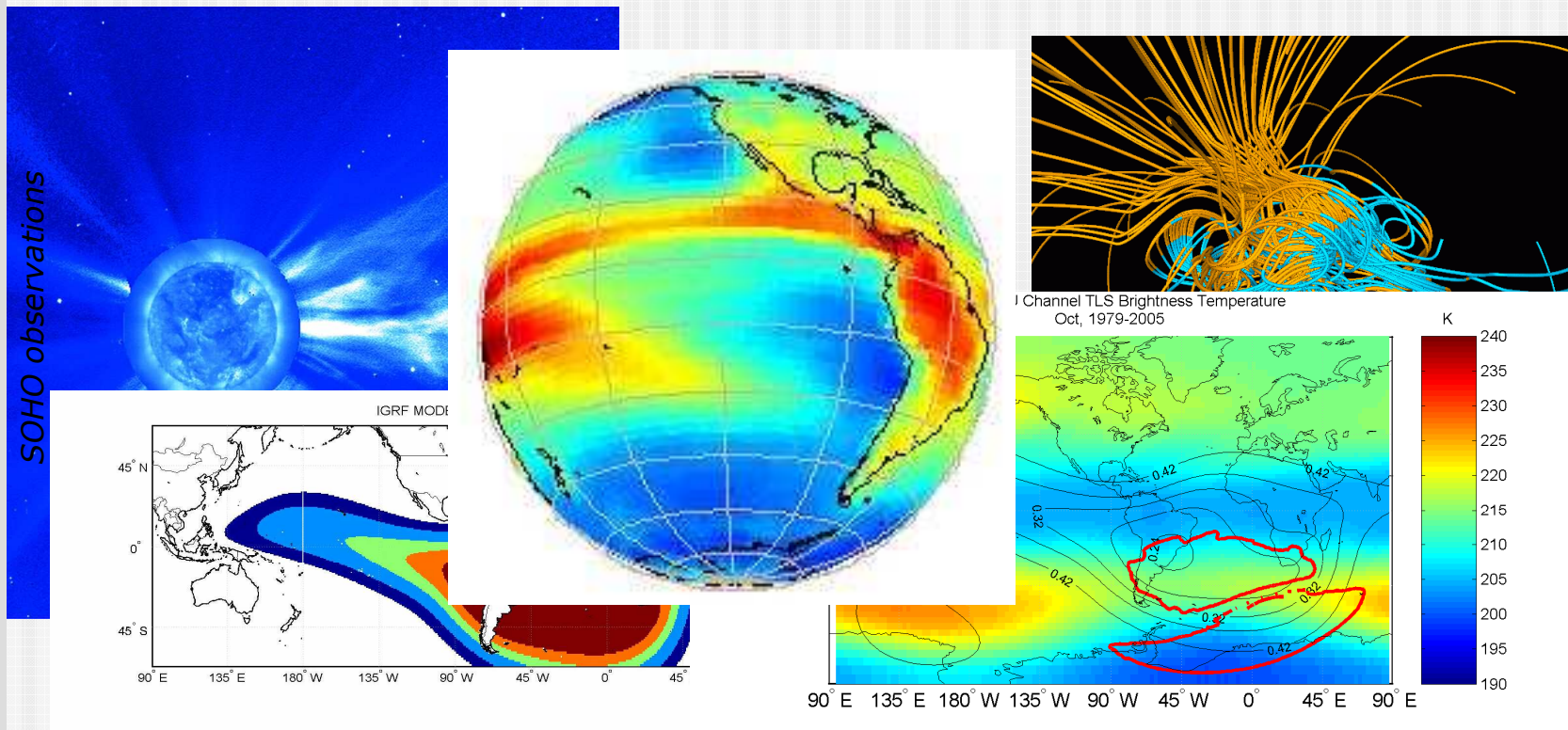


# Solar Influence on climate:

## Particle precipitation effects on the southern hemisphere tropical/subtropical lower stratosphere temperature

*Luis Eduardo Vieira and Ligia Alves da Silva*



July 08

# Outline

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- **Overview**
- **Southern Hemisphere Lower stratosphere temperature distribution**
- **Vertical distribution of O<sub>3</sub> and NO inside and outside the magnetic anomaly**
- **Southern Hemisphere climate sensitivity to zonal ozone asymmetry**
- **Conclusions**

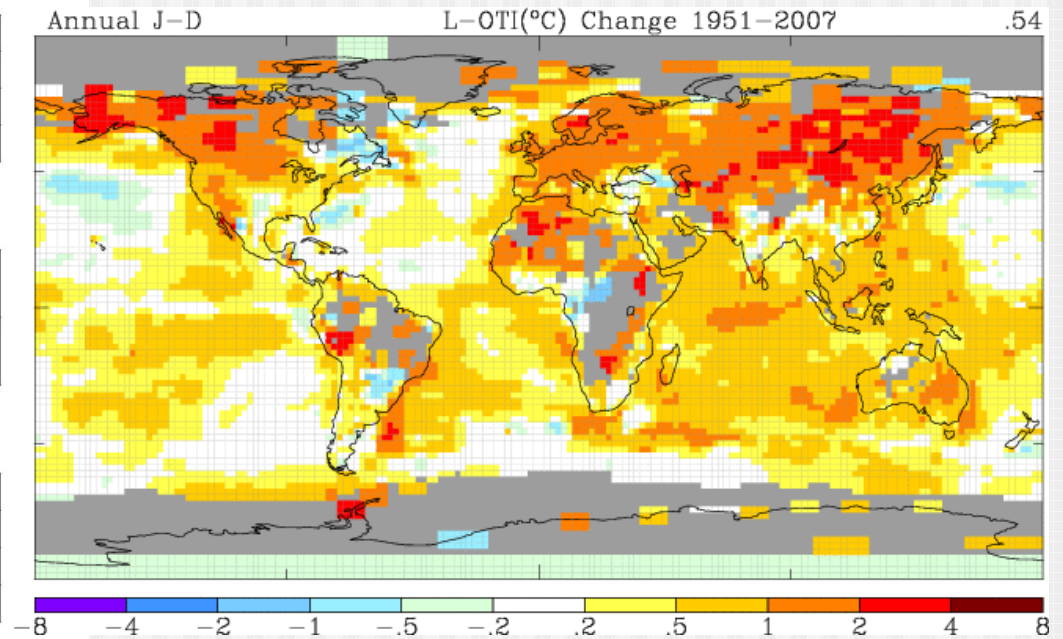
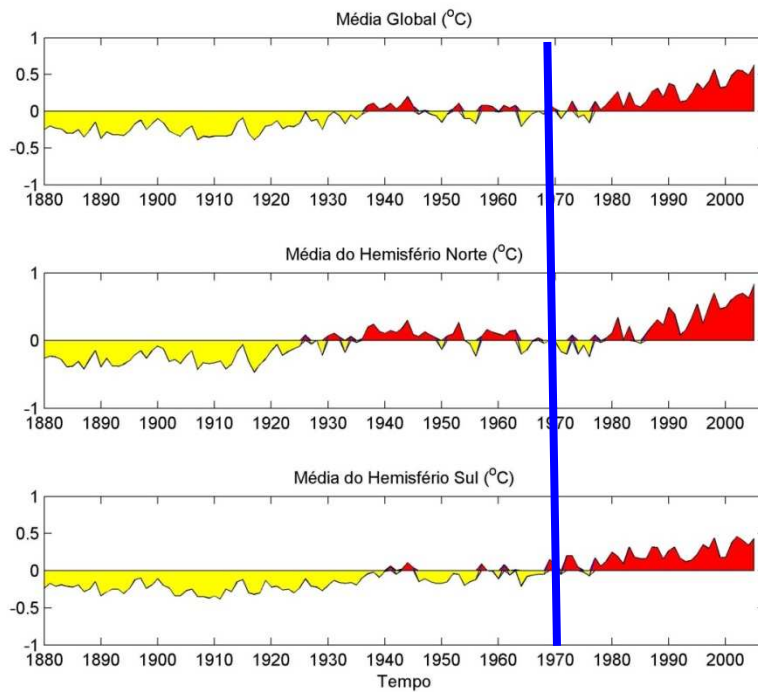
# Sun-Climate Mechanisms

- The variability of the total solar irradiance causing a change in the total energy input to the earth's atmosphere and consequent warming/cooling;
- The variability of the solar ultraviolet emission and its effects on the stratospheric ozone and thermal structure;
- High energy particle precipitation effects on mesospheric and stratospheric ozone in the auroral and/or southern hemisphere magnetic anomaly regions; and,
- The cosmic rays effects on the cloud coverage.

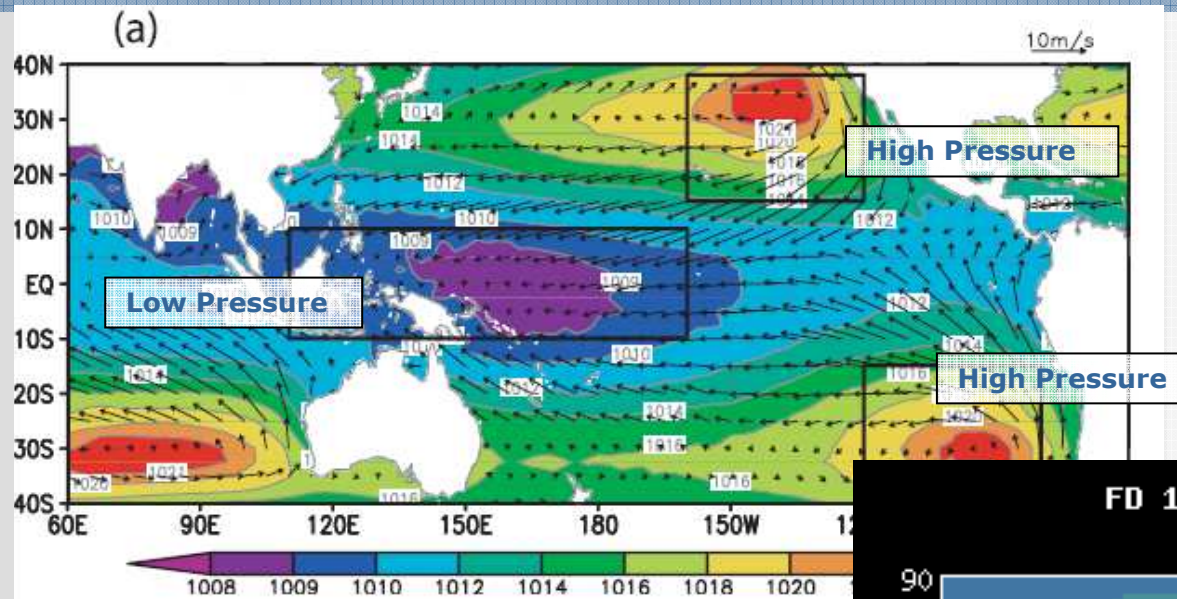
**Geomagnetic Modulation**

# Motivation: Increase of global surface temperature

## GISS Surface Temperature

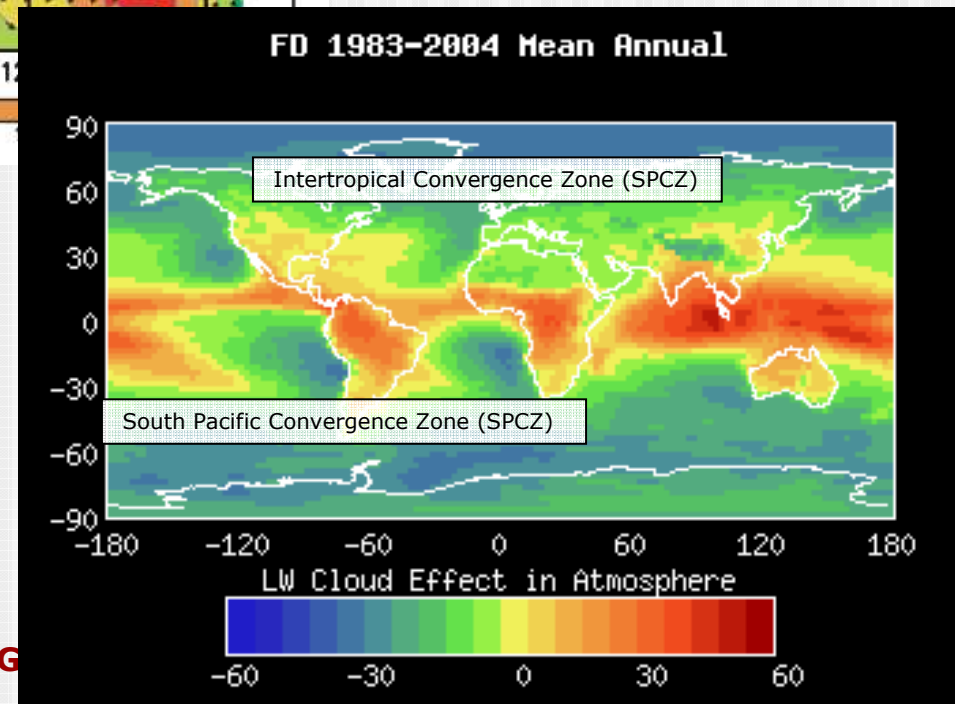


# Sea-level Pressure

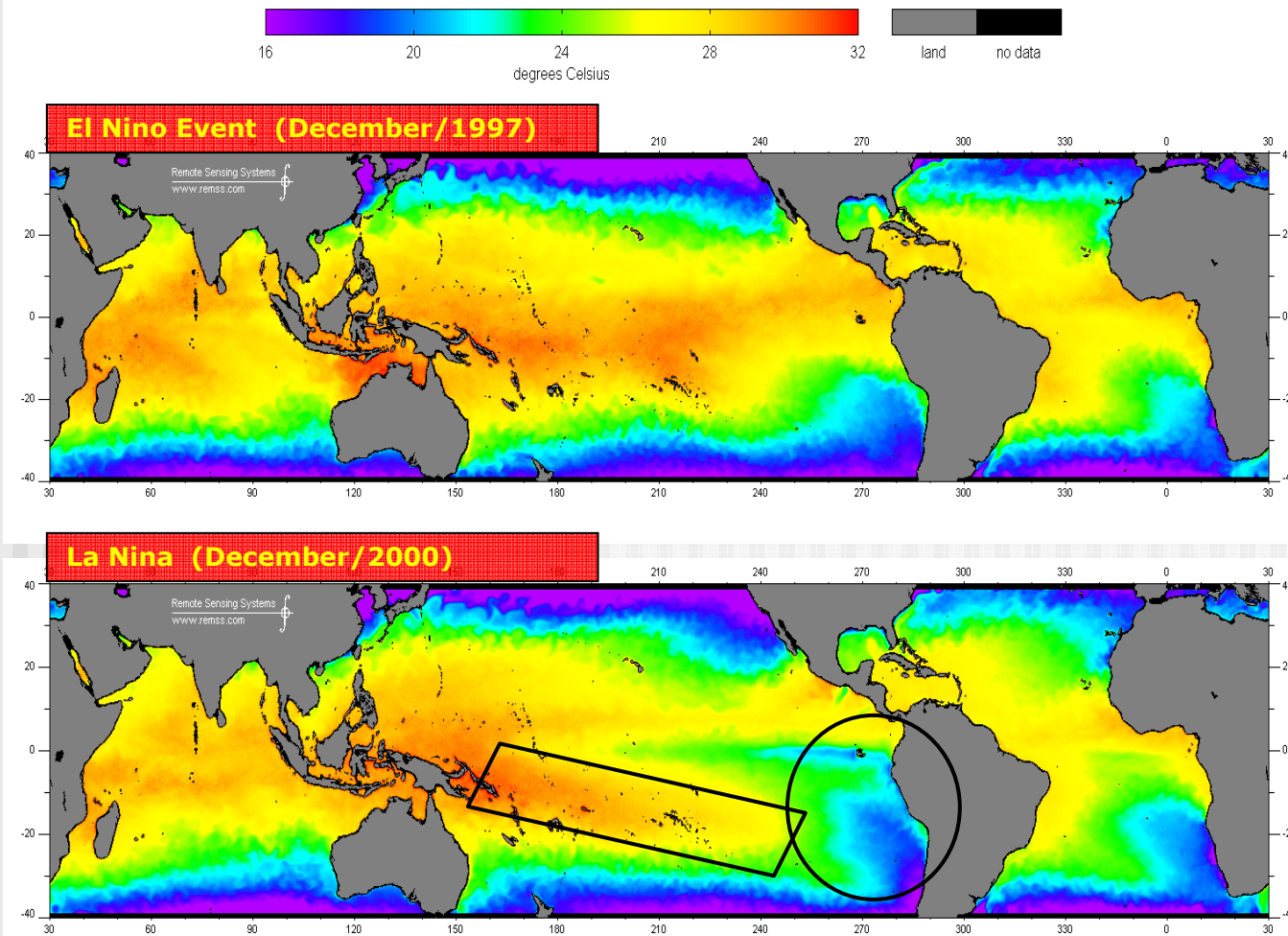


- Source: Zhang, M., and H. Song (2006), Evidence of deceleration of atmospheric vertical overturning circulation over the tropical Pacific, *Geophys. Res. Lett.*, 33, L12701, doi:10.1029/2006GL025942.

- The ISCCP D2 data/images were obtained from the International Satellite Cloud Climatology Project web site <http://isccp.giss.nasa.gov> maintained by the ISCCP research group at the NASA Goddard Institute for Space Studies, New York, NY.



# Long-standing debate in the climate community



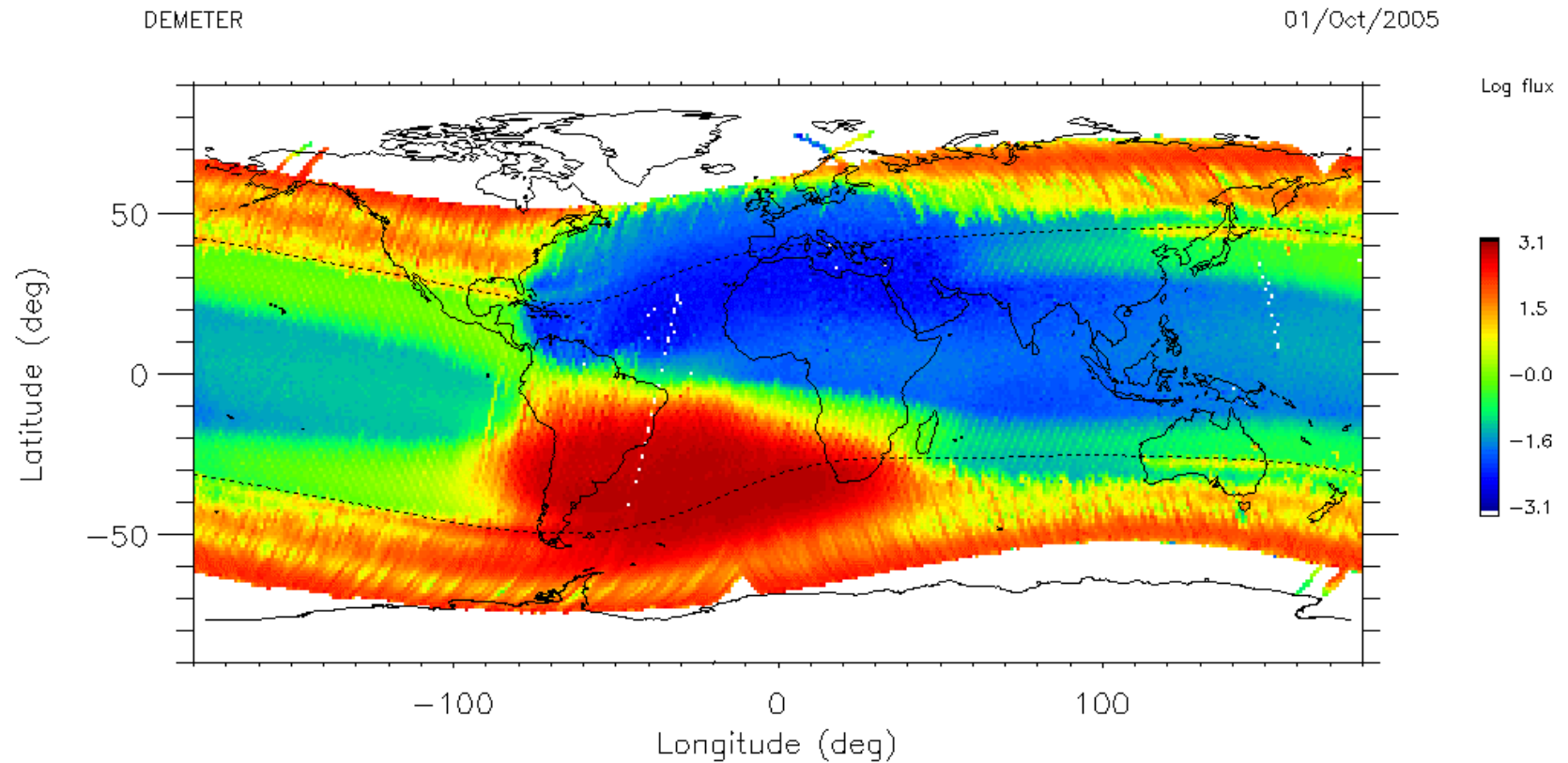
How the **tropical Pacific** will respond to increase greenhouse gases:

Will the structure of changes in the ocean surface more closely **resemble** an **El Niño** or a **La Niña**?

(Vecchi et al., EOS, Transactions, v. 89, February 2008)

Sea-Surface Temperature  
TRMM Microwave Imager (**TMI**) satellite observations

# The geographical distribution of the quasi trapped electron fluxes for an energy of 200 keV, as deduced from measurements by the IDP instrument



September-2005 - September 2006

Note the large flux enhancement inside the Southern hemisphere Magnetic Anomaly and its counterpart with weak fluxes in the northern hemisphere.

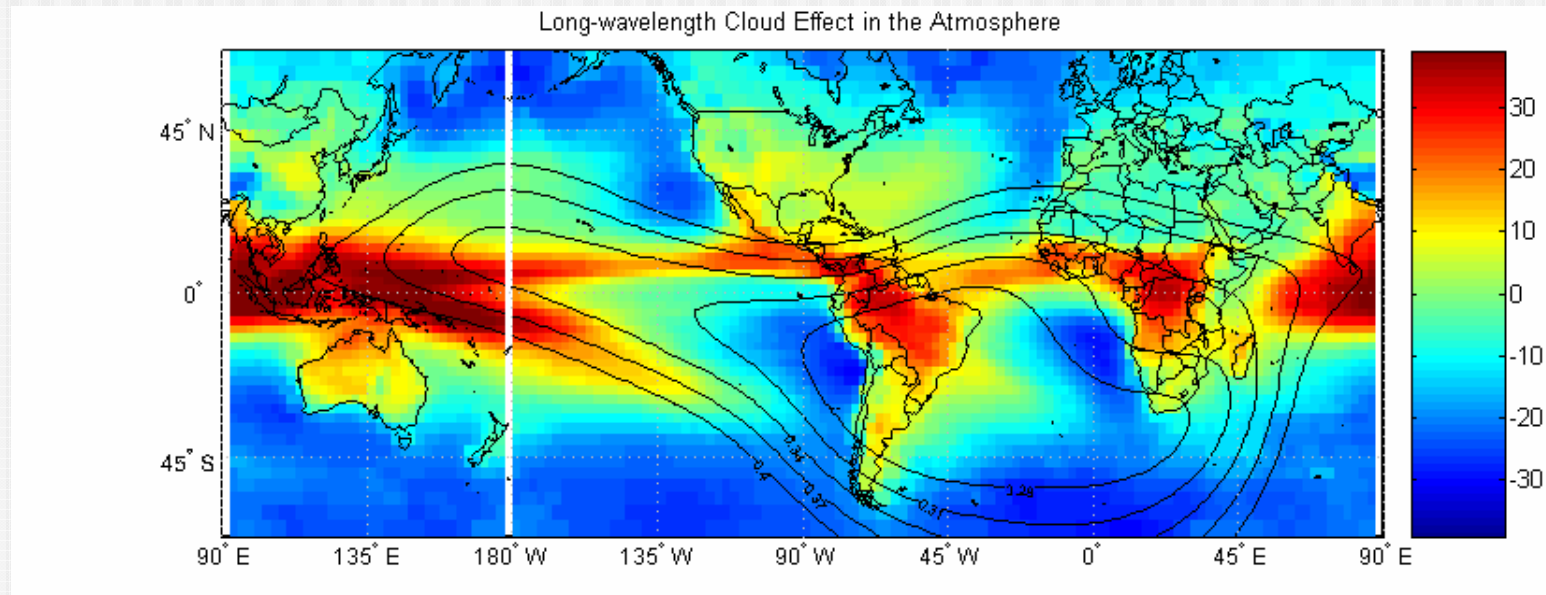
Sauvaud et al. (2008), Radiation belt electron precipitation due to VLF transmitters: satellite observations, GRL.

15/11/2007

**Global Change**

7

# Long-wavelength cloud effects on the radiative flux in the atmosphere



- Annual means of the long-wavelength effects on radiative flux in the atmosphere for the period July 1983 to June 2001. The superposed black lines show the iso-intensity contours of the geomagnetic field at ground for year 1990.

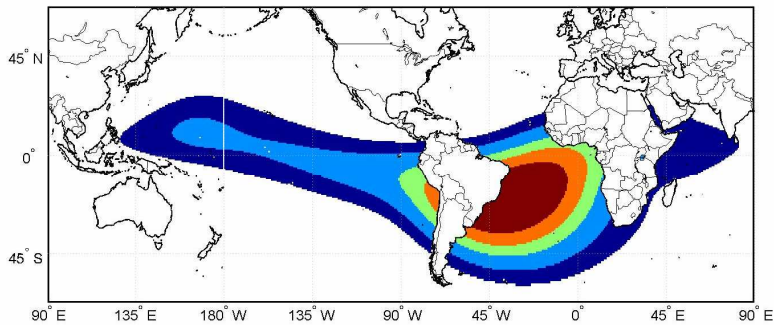
- The ISCCP D2 data/images were obtained from the International Satellite Cloud Climatology Project web site <http://isccp.giss.nasa.gov> maintained by the ISCCP research group at the NASA Goddard Institute for Space Studies, New York, NY.

Vieira and Da Silva (2006), GRL

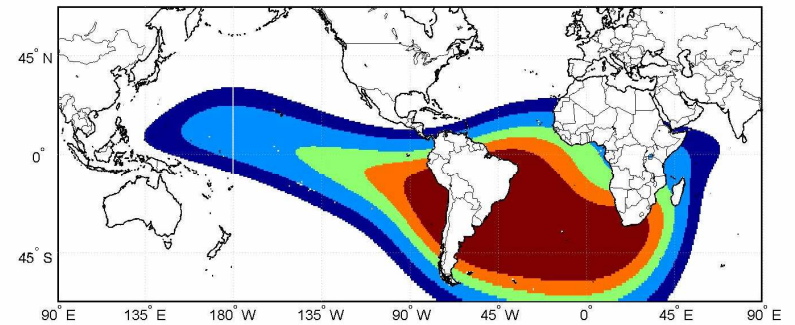


# SHMA Evolution

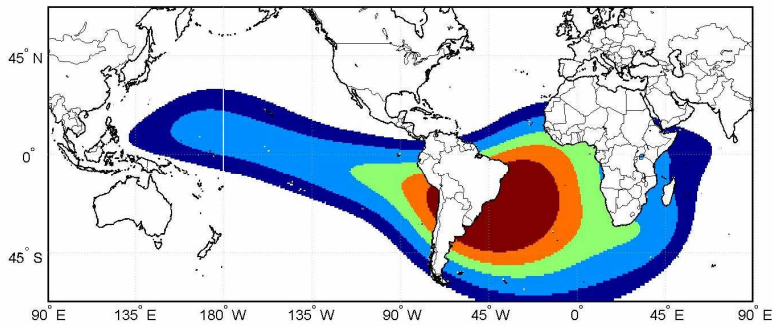
IGRF MODEL Year: 1900



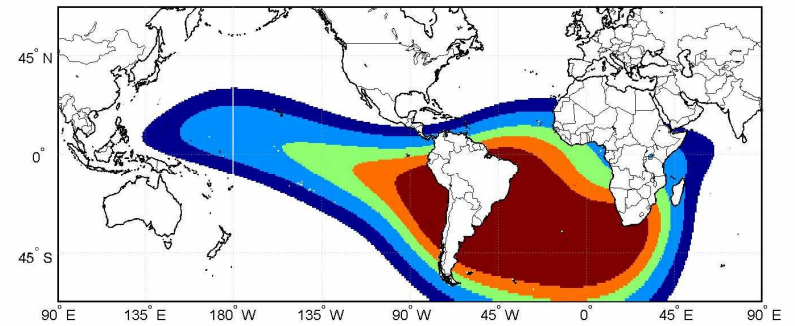
IGRF MODEL Year: 2000



IGRF MODEL Year: 1950

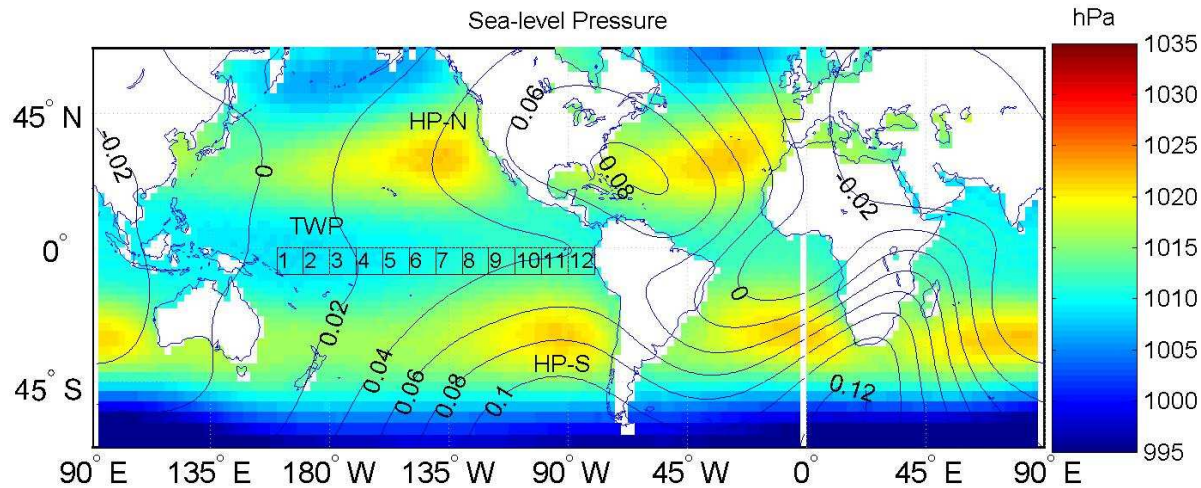


IGRF MODEL Year: 2010

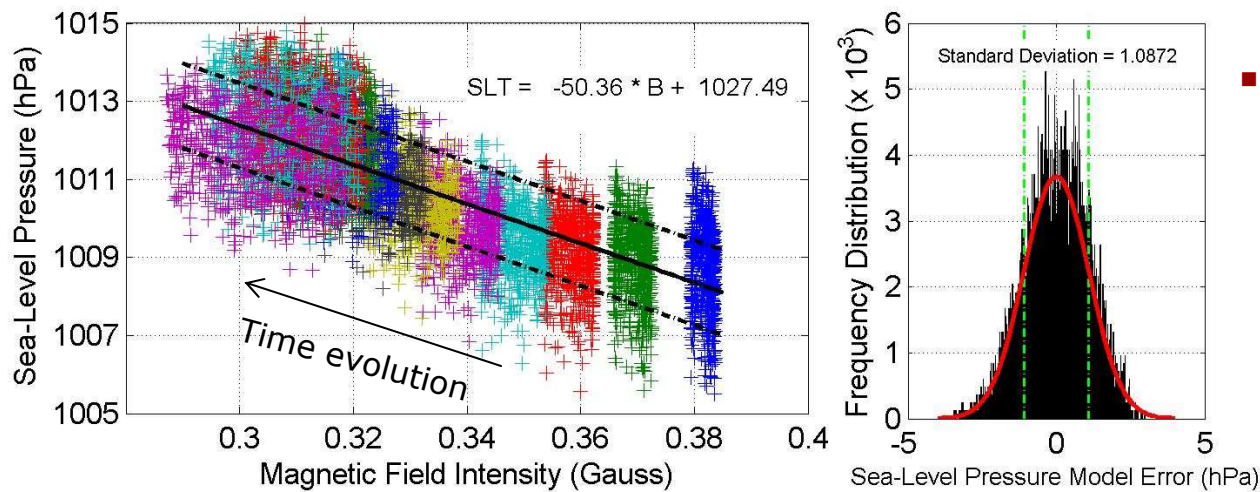


**IGRF Model**

# The evolution of the Sea-Level Pressure in the Pacific SHMA region

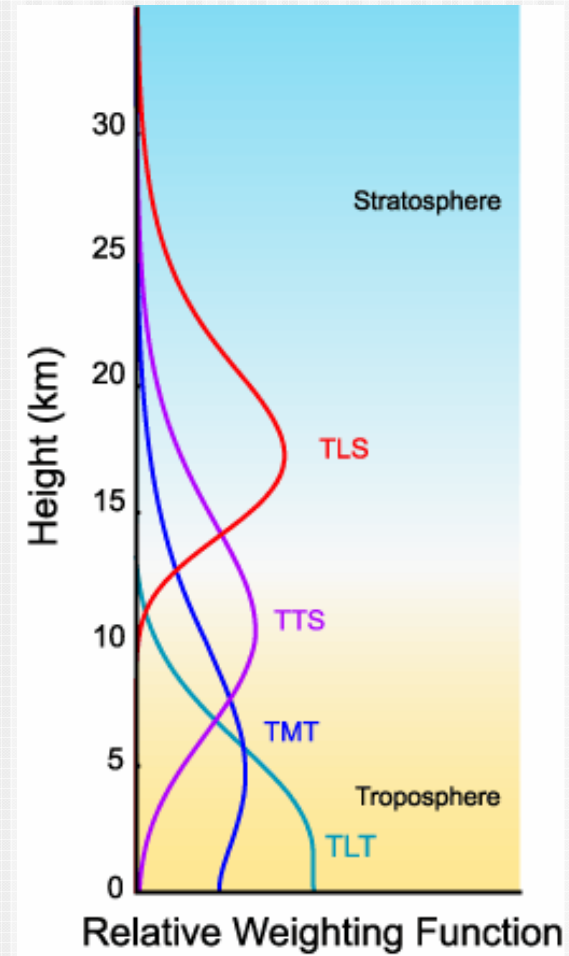
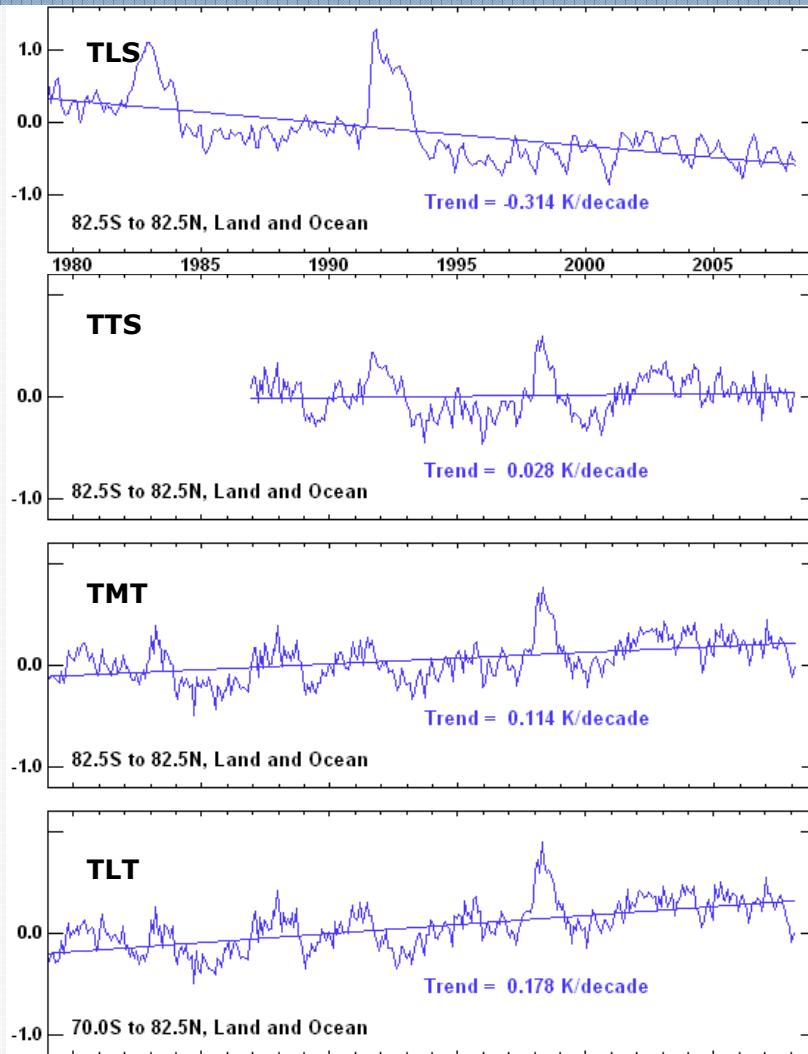


- Figure: It is shown in the upper panel the climatology of the sea-level pressure from 1948-2005. The superposed black lines show the difference of the geomagnetic field intensity at surface between years 2000 and 1940.



- Figure: It is shown in the left upper panel the scatter plot of the Sea-level Pressure versus the Magnetic field intensity. The black line shows the best linear fit for the whole data set. The dotted black lines show the 1-sigma model error. It is shown in the right panel the frequency distribution of the Model Error.

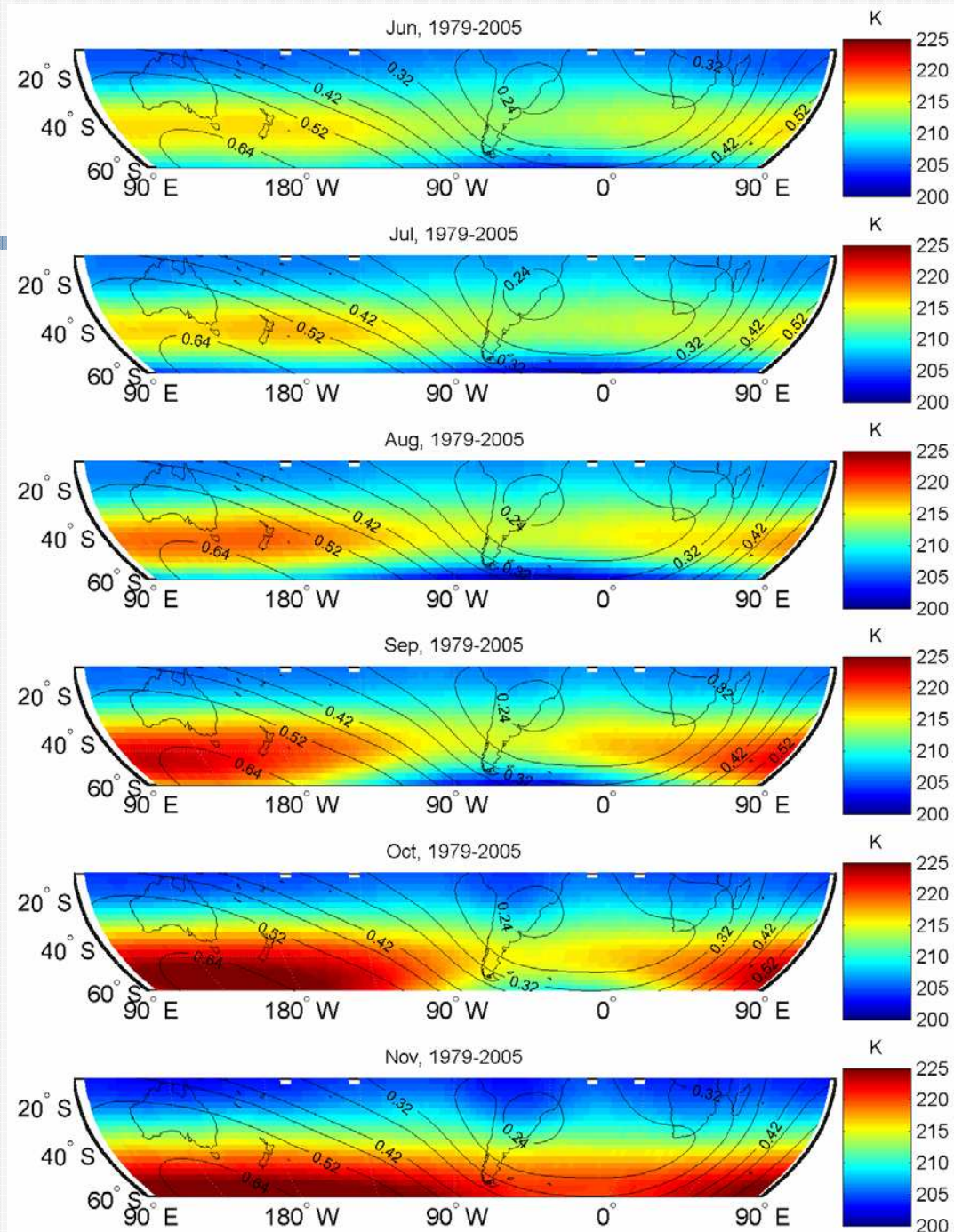
# The Microwave Sounding Units (MSU) Data



# The Microwave Sounding Units (MSU) Data

Southern hemisphere lower stratosphere temperature climatology for June to November. The superimposed black lines show the iso-intensity contours of the geomagnetic field at 10 km for year 1990.

Da Silva et al. (2008), GRL, submitted



# November

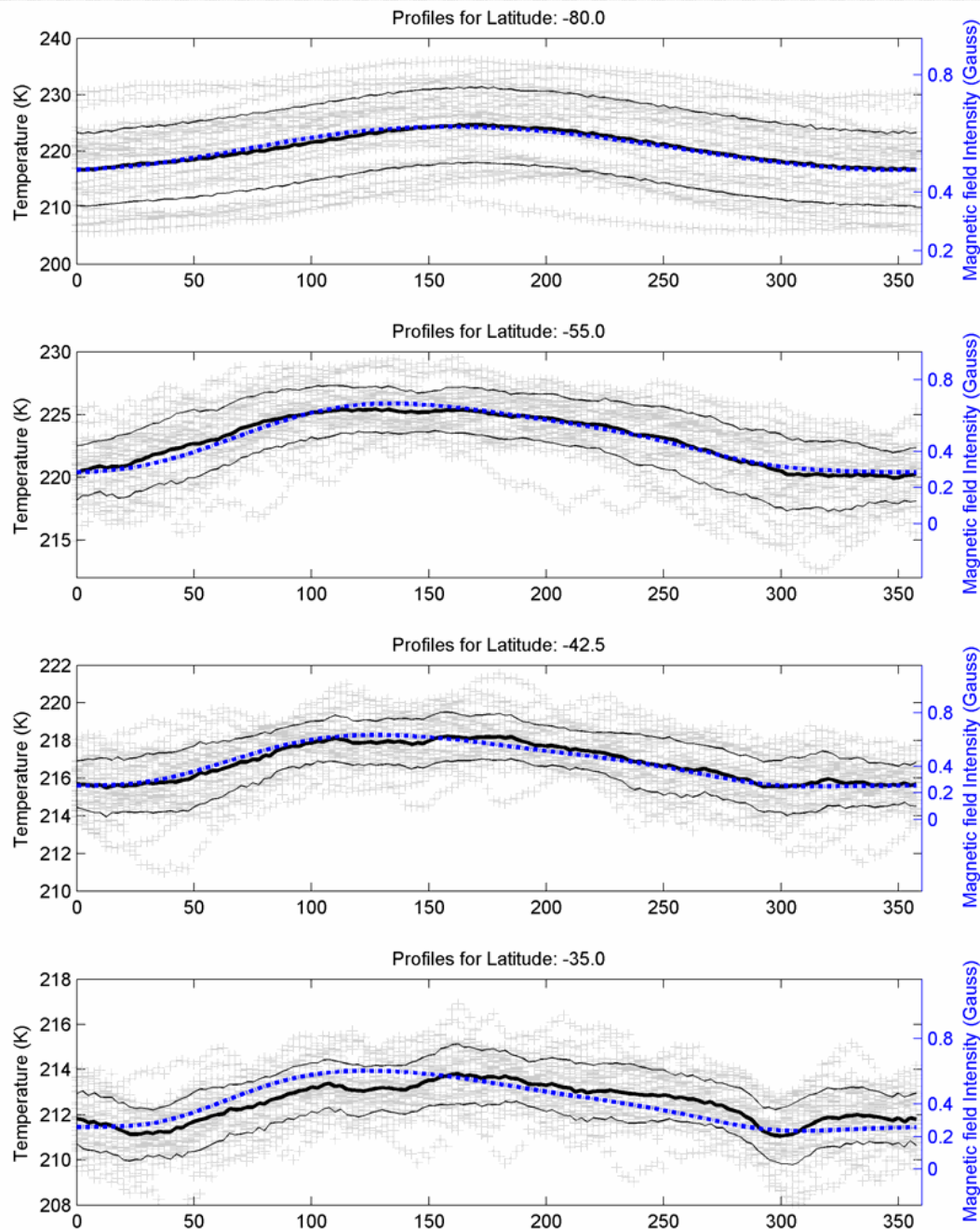


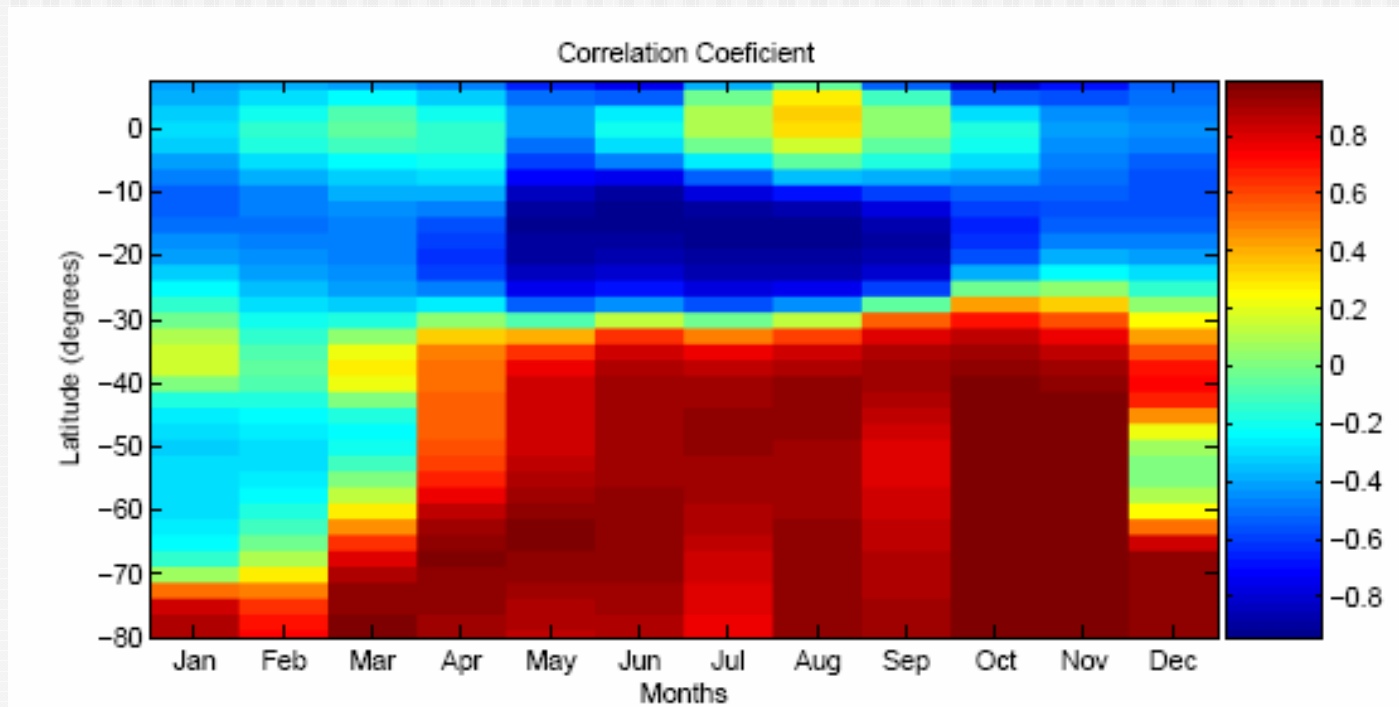
Figure:

Longitudinal profiles of the lower stratosphere brightness temperature and the magnetic field intensity for November for the latitudes 80o S, 55o S, 42o S and 35o S.

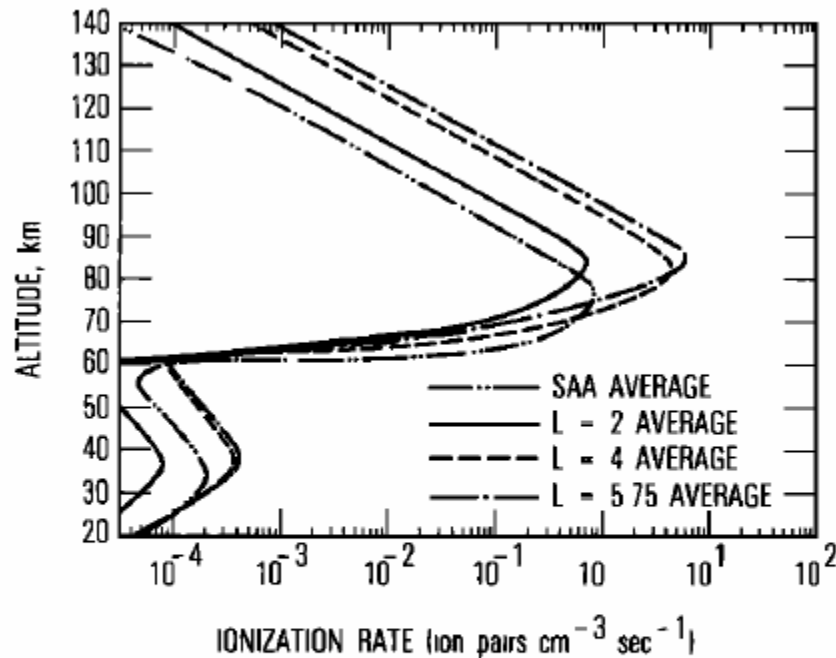
Monthly observations are shown in light gray '+'. The continuous outsized lines show the mean temperature profiles and the tiny lines show the standard deviations.

The dotted lines magnetic field intensity.

Correlation coefficients obtained comparing the longitudinal profiles of monthly lower stratosphere brightness temperature climatology and the magnetic field intensity near surface.



# Ionization rates as a function of altitude



**Fig. 8.** Plots of ionization rates as a function of altitude for the average electron precipitation spectra shown in Figures 1 and 2. The peak around 80 km is due to the primary electrons, whereas the secondary peak around 40 km is due to bremsstrahlung X rays.

Vampola, A., and D. Gorney (1983), Electron Energy Deposition in the Middle Atmosphere, *J. Geophys. Res.*, 88(A8), 6267-6274.

# SABER/TIMED Data

## Vertical O3 and NO Profiles

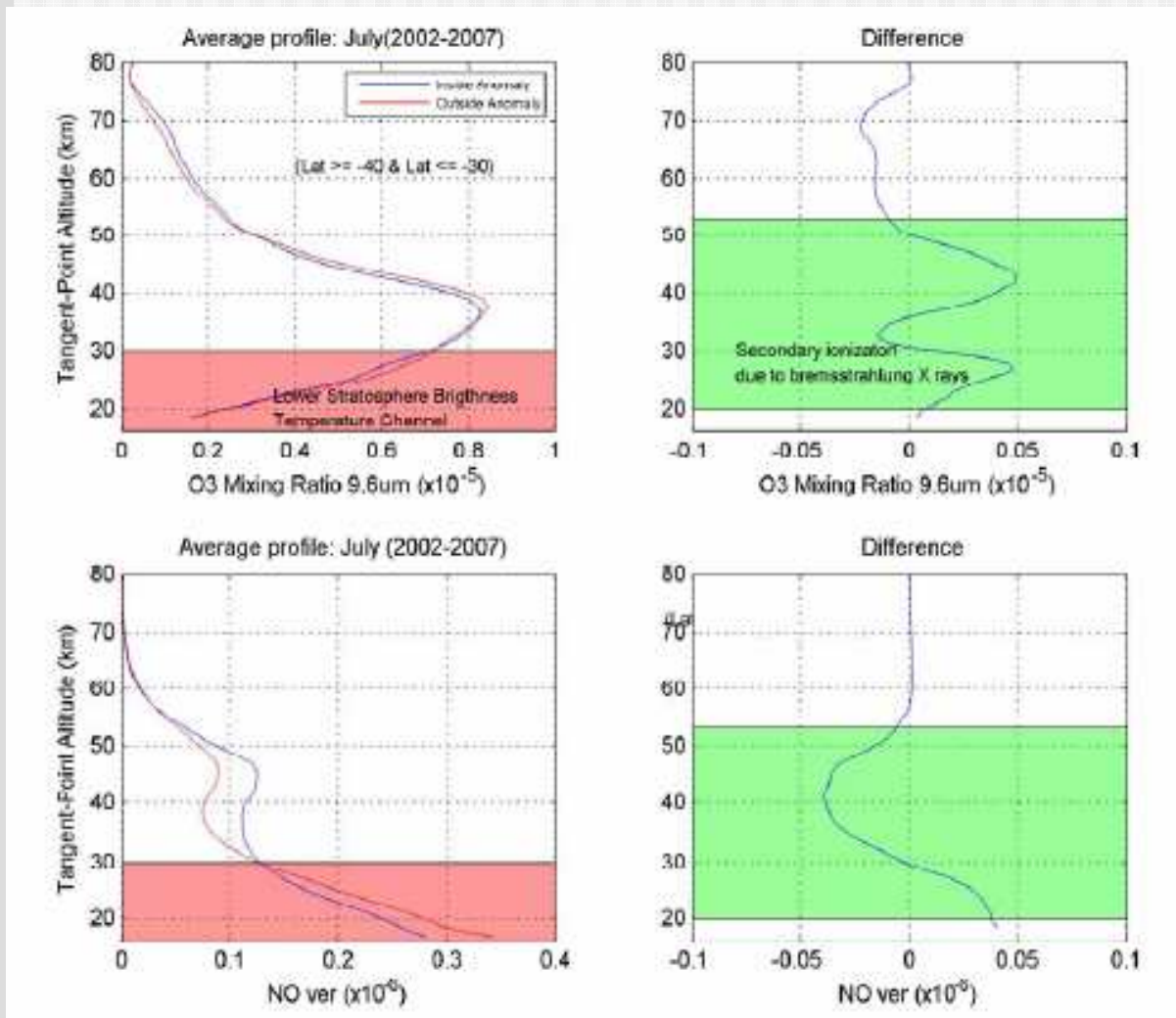


Figure:

The left panels show the vertical profiles inside and outside the magnetic anomaly of the O<sub>3</sub> and NO volumetric emission rate, and, temperature for the latitude 35° S to 30° S.

The right panels show the difference between the profiles inside and outside the magnetic anomaly.



# Numerical Experiment

## Experimental Configuration

- We use the Goddard Institute for Space Studies GCM Model E version
  - run at 4x5 degree horizontal resolution with 20 vertical layers extending up into the stratosphere.
  - GISS Dynamic ocean model (Russell ocean model). Resolution (4x5xL13)
- The basic physics of the model are similar to those used in recent climate studies.
- **Dynamics:**
  - The scheme is leap frog in time with an initial 2/3 time step every 8 leap-frog steps to prevent solution splitting. T
  - The dynamics are based on the dry physics (no water vapour effects in the pressure gradient calculation) and use potential temperature as the advected variable.
- Two experiments:
  - Realistic three-dimensional distribution of ozone
  - Zonal mean ozone (no effects of the zonal asymmetry)
- The atmospheric model is coupled to the GISS Dynamic ocean model (Russell). 13 levels.
- 62 years (the initial 48 years of each experiment, during which the model was reaching equilibrium, were discarded).

[Schmidt, G.A., R. Ruedy, J.E. Hansen, I. Aleinov, N. Bell, M. Bauer, S. Bauer, B. Cairns, V. Canuto, Y. Cheng, A. Del Genio, G. Faluvegi, A.D. Friend, T.M. Hall, Y. Hu, M. Kelley, N.Y. Kiang, D. Koch, A.A. Lacis, J. Lerner, K.K. Lo, R.L. Miller, L. Nazarenko, V. Oinas, Ja. Perlwitz, Ju. Perlwitz, D. Rind, A. Romanou, G.L. Russell, Mki. Sato, D.T. Shindell, P.H. Stone, S. Sun, N. Tausnev, D. Thresher, and M.-S. Yao, 2006: Present day atmospheric simulations using GISS ModelE: Comparison to in-situ, satellite and reanalysis data. \*J. Climate\*, \*\*19\*\*, 153-192, doi:10.1175/JCLI3612.1.](#)

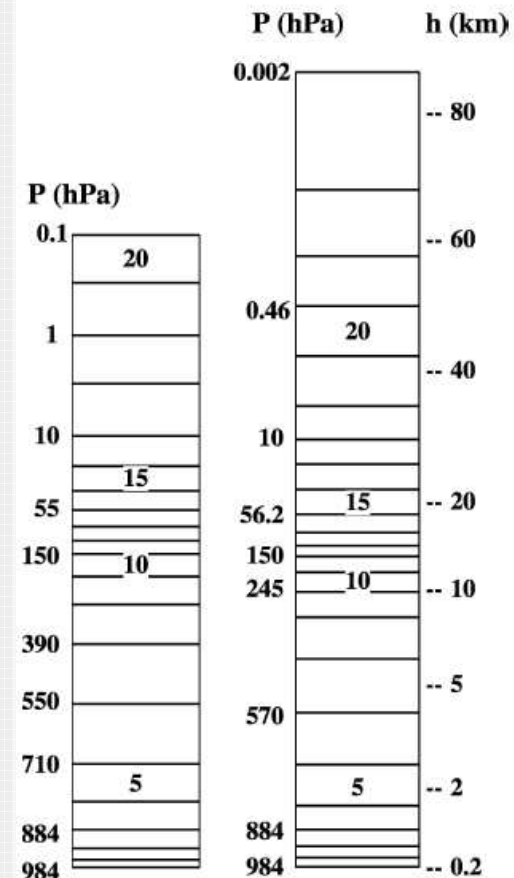
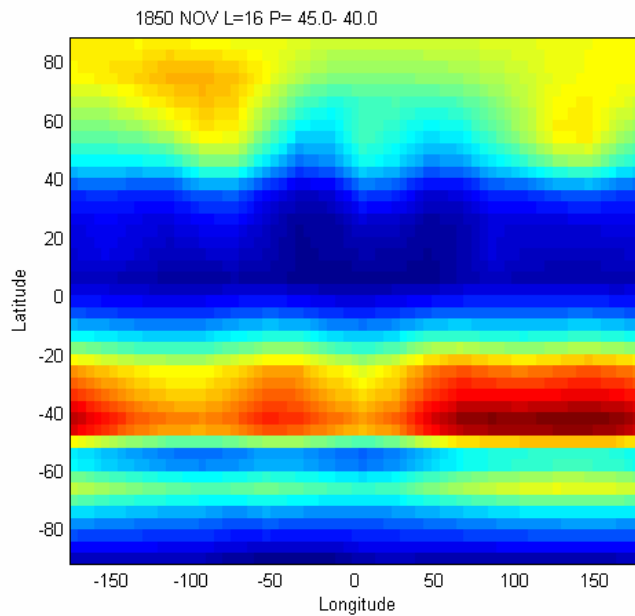


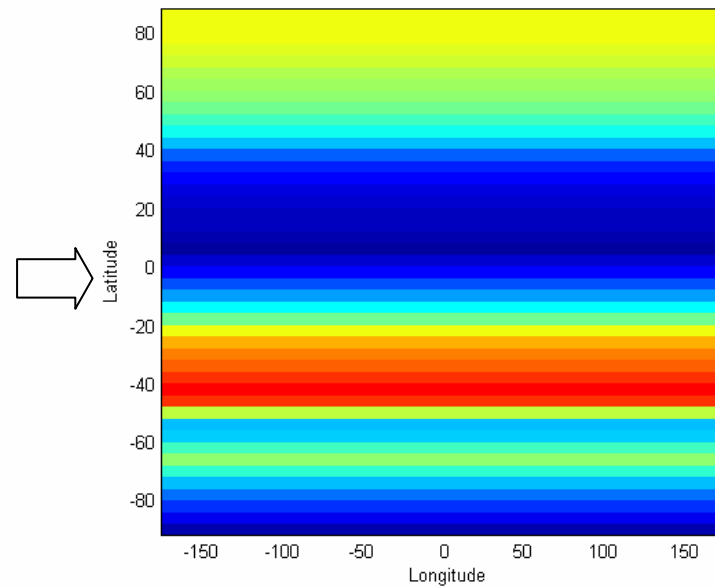
FIG. 1. Vertical layering for the 20- and 23-layer model configurations (for graphical convenience, the vertical coordinate shown here is linear in pressure to 150 hPa, logarithmic above).

# Stratospheric Ozone

**Asymmetric Distribution**



**Symmetric Distribution**

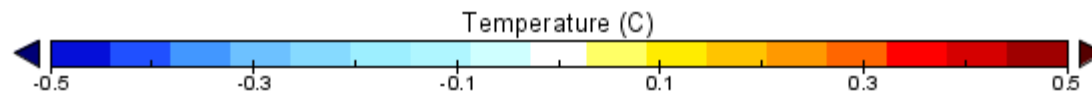
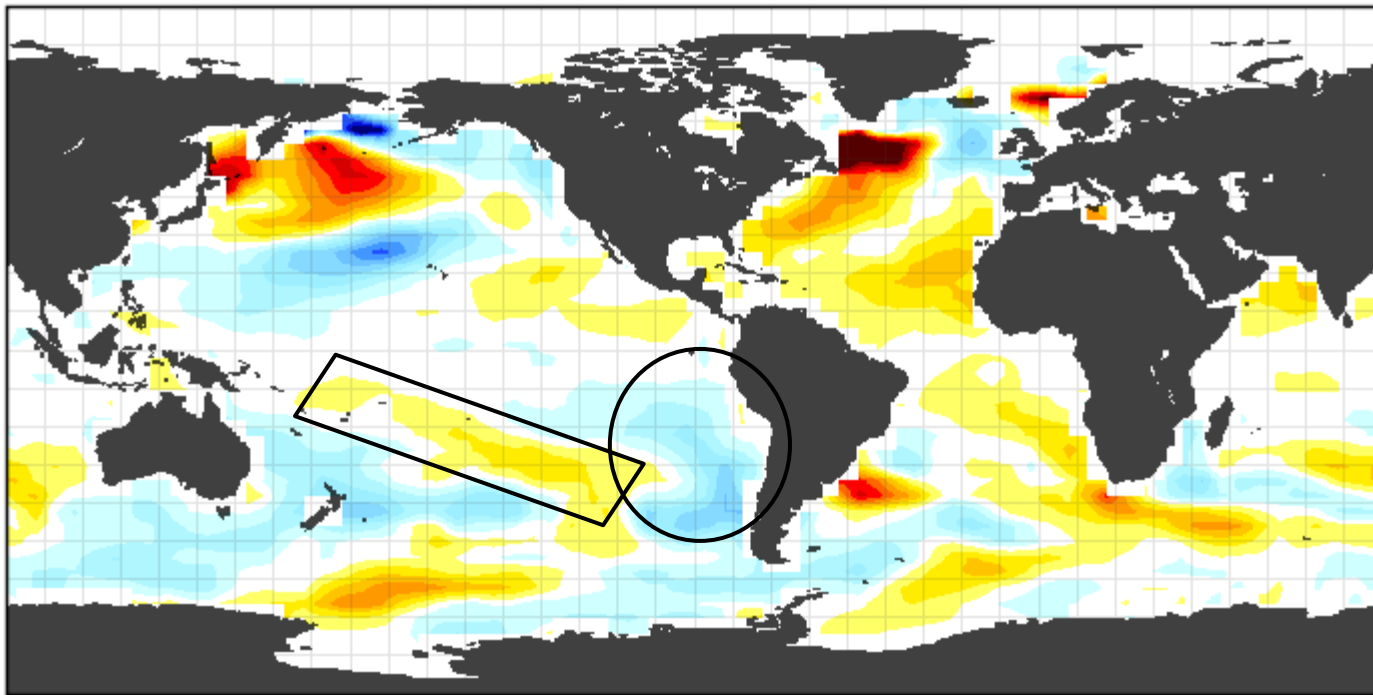


The boundary between stratospheric and tropospheric ozone: 125-hPa level.

# Annual mean Sea Surface Temperature

**Difference between symmetric and asymmetric configurations**

SEA SURFACE TEMPERATURE

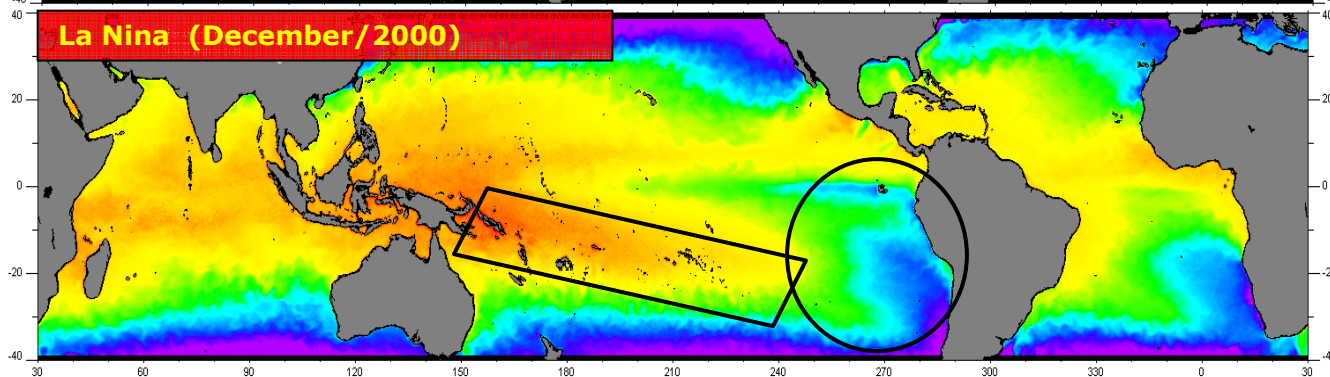
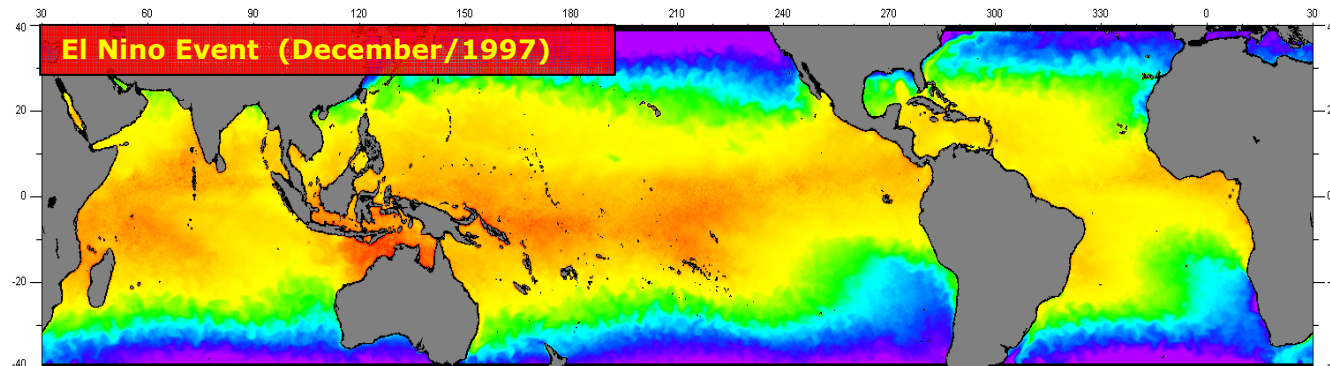
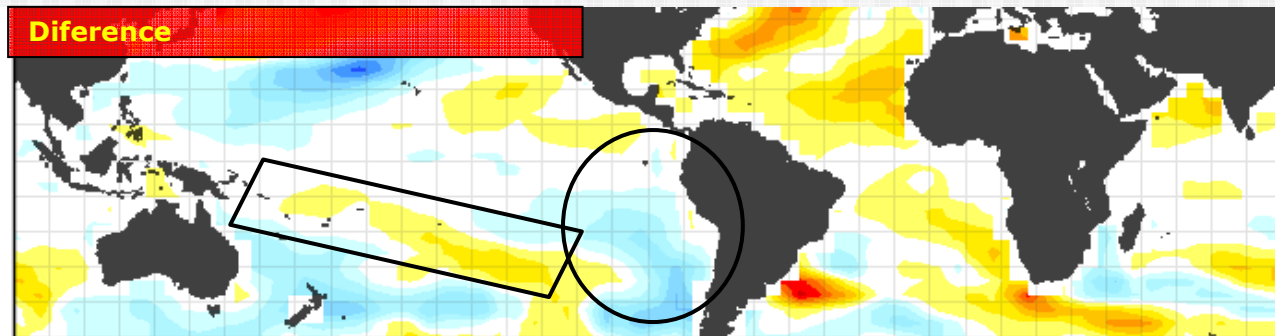


Equirectangular projection centered on -90.0°E

Data Min = -0.6, Max = 1.0

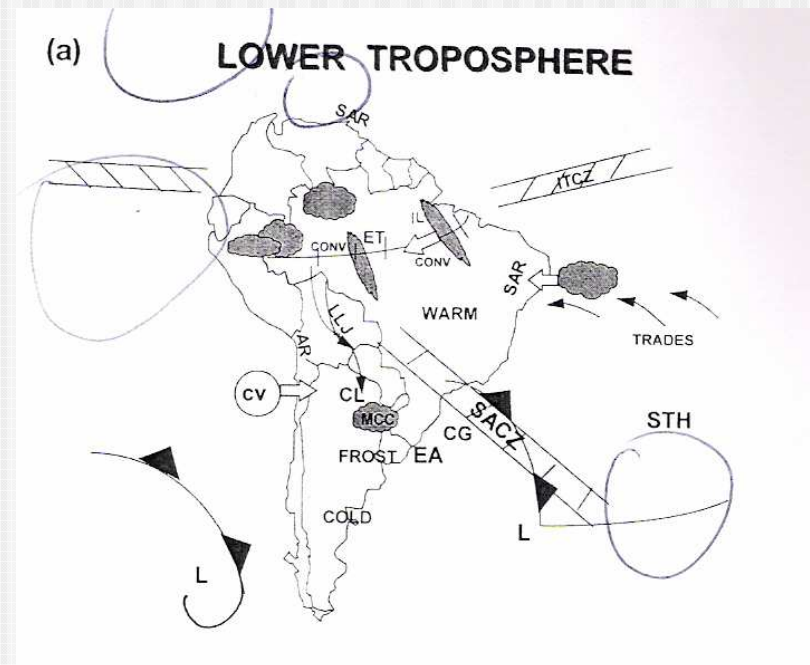
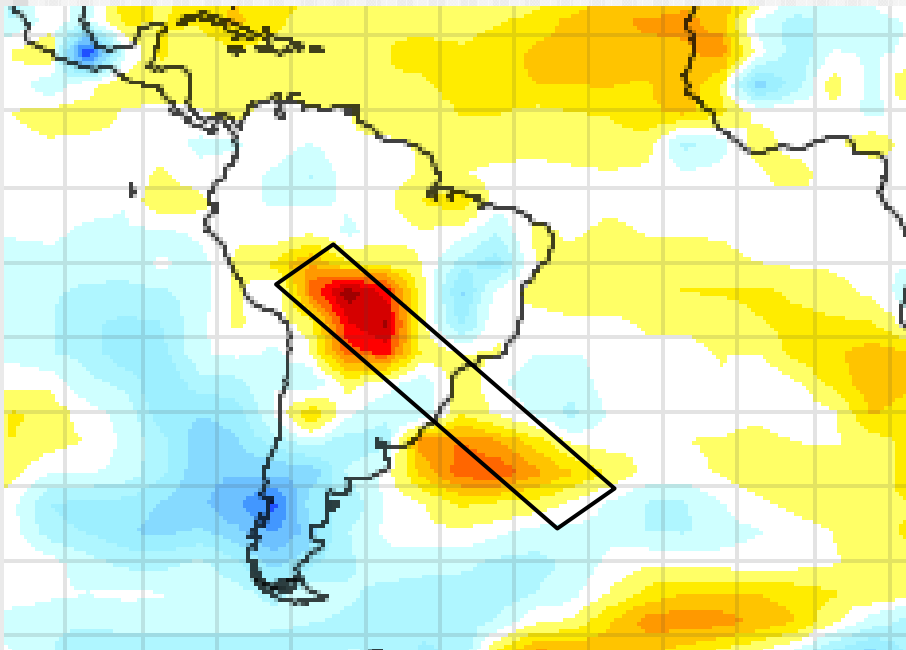
**Global Change**

# La Nina Signature



# South Atlantic Convergence Zone

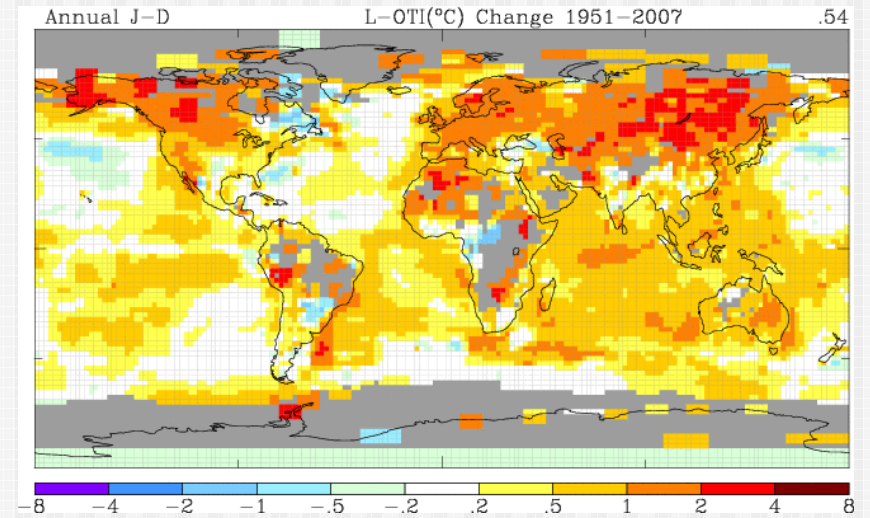
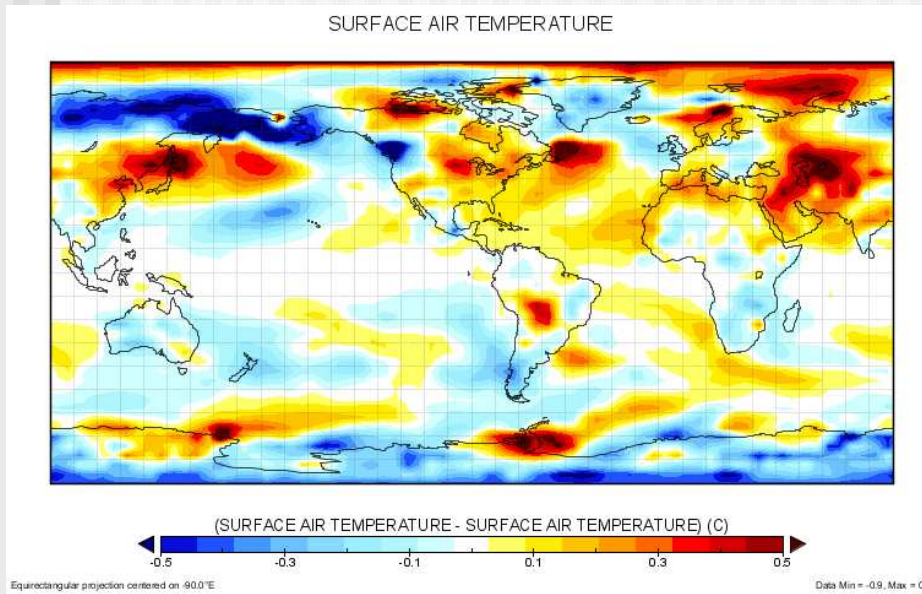
Surface Temperature

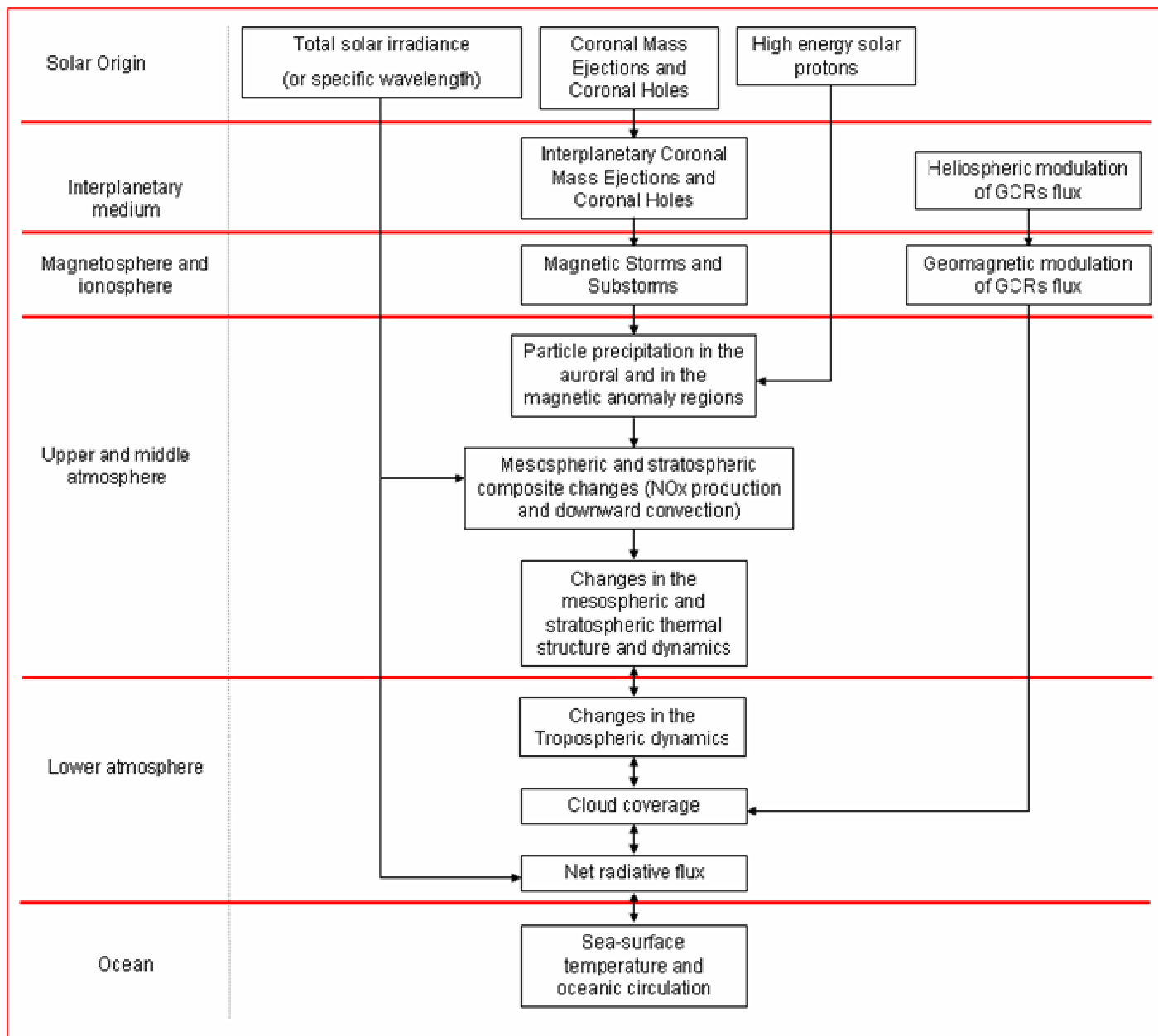


# Surface Temperature

**Difference between symmetric and asymmetric configurations**

GISS Surface Temperature Analysis



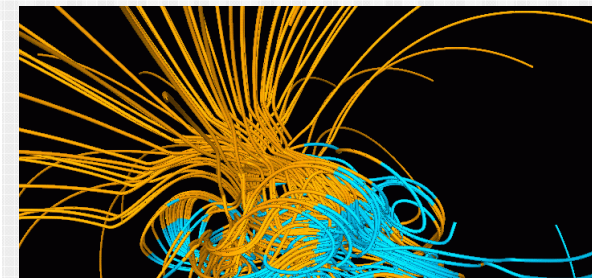
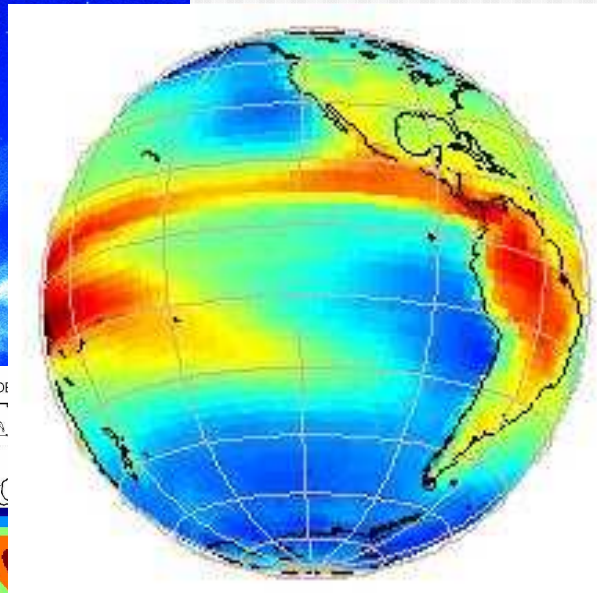
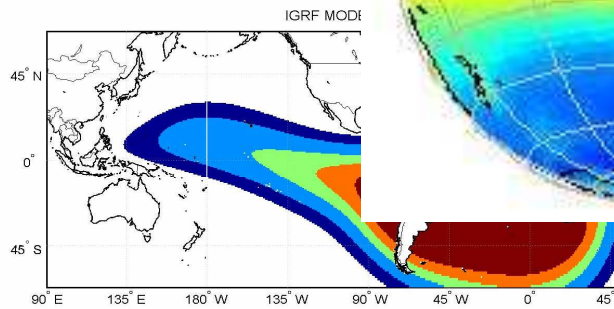
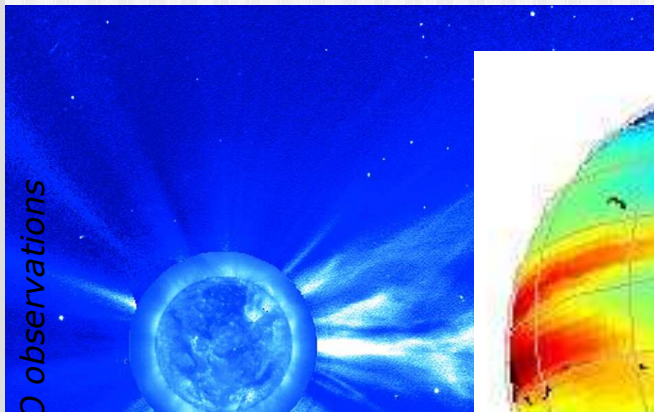


# Solar Influence on climate:

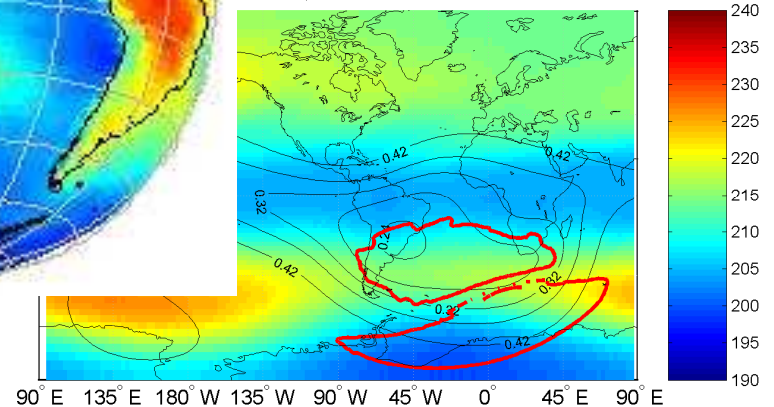
Particle precipitation effects on the southern hemisphere  
tropical/subtropical lower stratosphere temperature

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SOHO observations

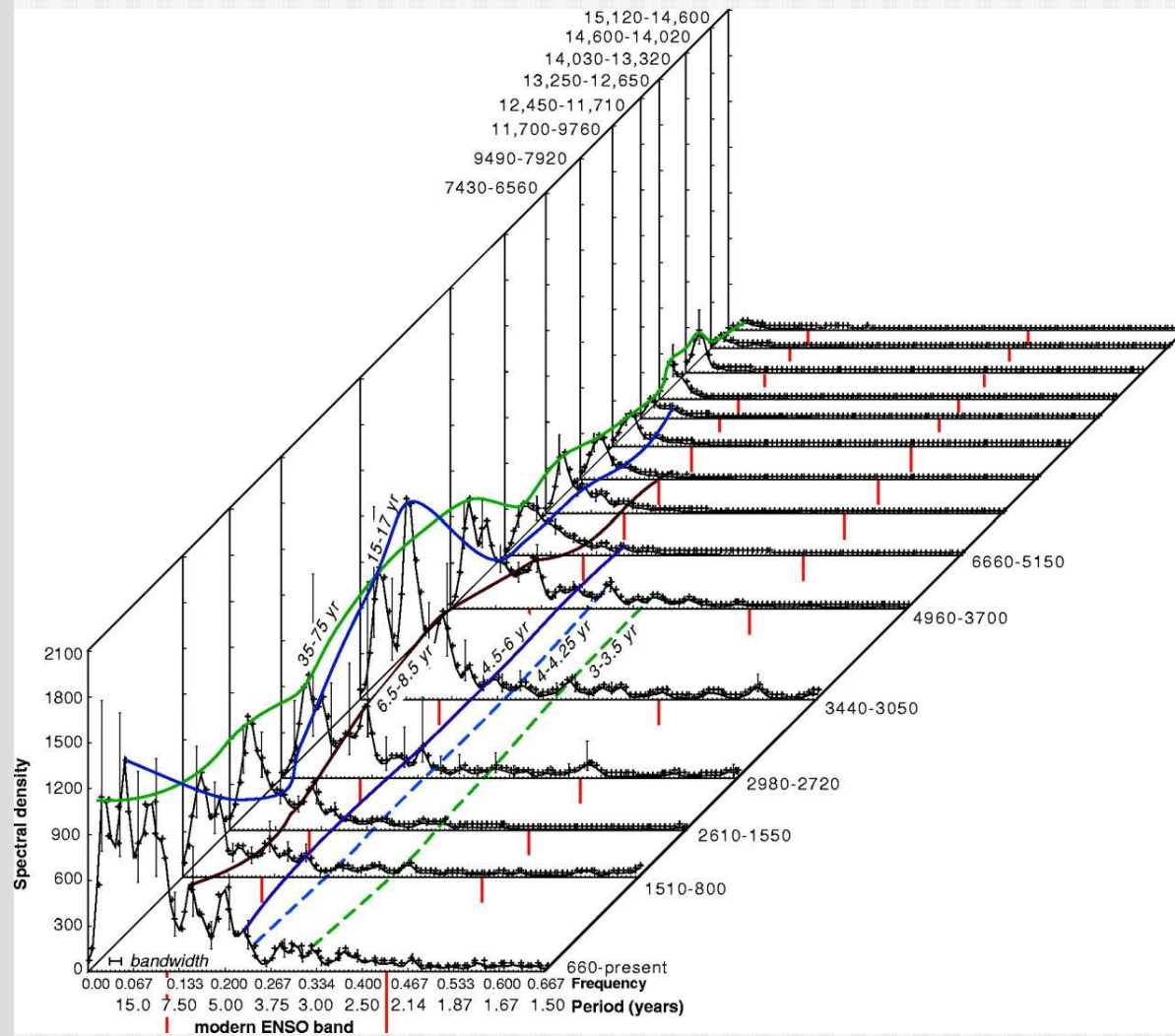


Channel TLS Brightness Temperature  
Oct, 1979-2005





# ENSO evolution from the Late Glacial through the Holocene



**Figure 5.** Results of time series analysis (16) of the gray-scale record (Fig. 3C); age ranges are in calendar years before the present. Because of breaks in the core (Fig. 3A), we performed the time series analysis on individual sections of the core and treated these as discrete time series. There is a clear spectral evolution from the Late Glacial through the Holocene with the ENSO band (19), which progressively achieves its modern strength by ~5000 cal yr B.P.

RODBELL *et al.* (1999), *Science*, Vol. 283, no. 5401, pp. 516 - 520  
DOI: 10.1126/science.283.5401.516