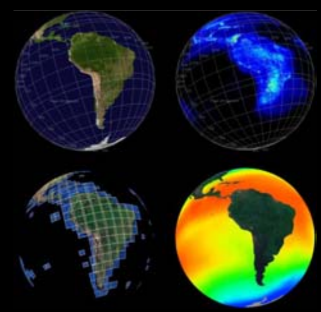
El Clima actual y su variabilidad sobre Sud América



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Universidad de Chile

DATA SOURCES AND PRODUCTS

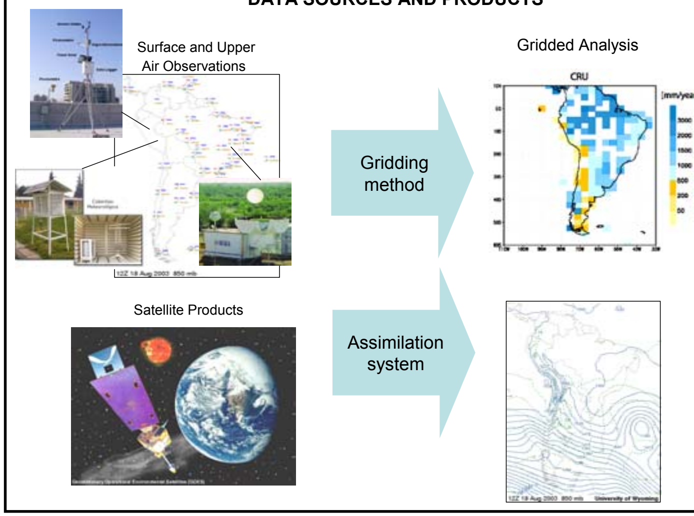
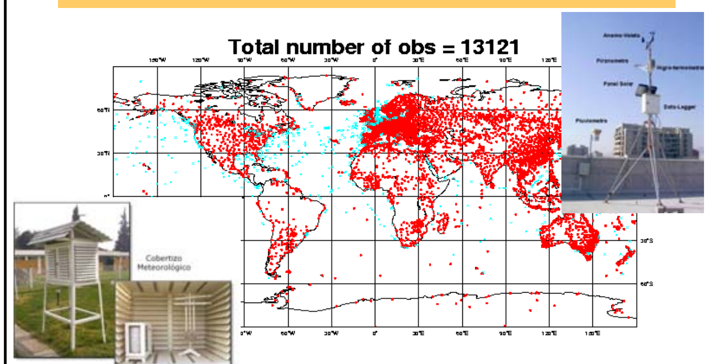


Table 1. Main features of datasets commonly used in climate studies

Dataset	Key references	Input data - Variables	Spatial resolution - Coverage	Time span - Time resolution
Station GHCN	Peterson and Vose (1997)	Sfc. Obs Precip and SAT	N/A Land only	1850(*) – present Daily and Monthly
Gridded GHCN	Peterson and Vose (1997)	Sfc. Obs Precip and SAT	5° × 5° lat-lon Land only	1900 – present Monthly
Gridded UEA-CRU	New *et al.* 2000	Sfc. Obs Precip and SAT	3.75° × 2.5° lat-lon Land only	1900 – present Monthly
Gridded UEA-CRU05	Mitchell and Jones (2005)	Sfc. Obs Precip and SAT	0.5° × 0.5° lat-lon Land only	1901 – present Monthly
Griddded U. Delware	Legates and Willmott (1999a,b)	Sfc. Obs Precip and SAT	0.5° × 0.5° lat-lon Land only	1950 – 1999 Monthly
Gridded SAM-CDC data	Liebmann and Allured (2005)	Sfc. Obs Precip	1° × 1° lat-lon South America	1940 – 2006 Daily and Monthly
Gridded CMAP	Xie and Arkin (1987)	Sfc. Obs.; Sat. data Precip	2.5° × 2.5° lat-lon Global	1979 – present Pentad and Monthly
Gridded GCPC	Adler *et al.* (2003)	Sfc. Obs.; Sat. data Precip	2.5° × 2.5° lat-lon Global	1979 – present Monthly
NCEP-NCAR Reanalysis (NNR)	Kalnay *et al.* 1996 Kistler *et al.* 2001	Sfc. Obs.; UA Obs; Sat. data Pressure, temp., winds, etc.	2.5° × 2.5° lat-lon, 17 vertical levels Global	1948 – present 6 hr, daily, monthly
ECMWF Reanalysis (ERA-40)	Uppala *et al.* (2005)	Sfc. Obs., UA Obs, Sat. data Pressure, temp., winds, etc.	2.5° × 2.5° lat-lon, 17 vertical levels Global	1948 – present 6 hr, daily, monthly

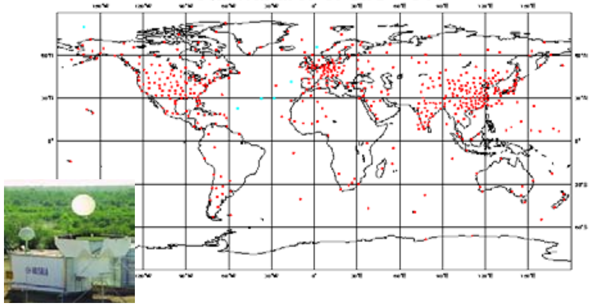
Surface (land/ocean) Synoptic Stations
Met. Observations (T,Td,P,V,…) @ 0, 6, 12, 18 UTC are transmitted in real-time to WMO and Analysis Centers



Red de Radiosondas (OMM, GTS)

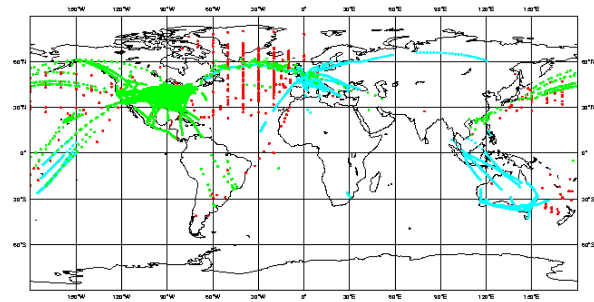
Perfiles verticales (20 km) de T, HR, viento, presión, cada 12 / 24 hr

Total number of obs = 511



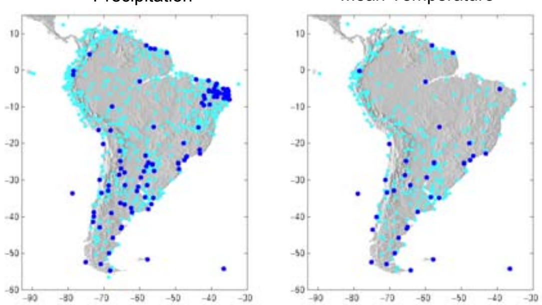
Observaciones en altura IV:
Info. Obtenida por Aviones comerciales

Perfiles verticales (0-10 km) de T, HR, viento, presión, y datos a nivel (10 km) a distintas horas. También se transmiten via GTS



Global Historical Climate Network (GHCN)

Precipitation | Mean Temperature



- All stations (anytime, any length)
- Century-long stations (Ti<1905, Tf>1995, missdata<20%)

Reanalysis?!

Because analysis are produced in real-time, some data is not assimilated, but it was archived. In the 90's the NCEP-NCAR (USA) began a major project in which they re-run their assimilation system with all the available data.

The result is the widely used "Reanalysis" data, including many fields (air temperature, wind, pressure) on a regular 2.5°x2.5° lat-lon grid, from 1948 to present every 6 hours (also available daily, monthly and long-term-mean means). Fields are 2- or 3-Dimensional. Preferred data format: NetCDF. Freely available.

Reanalysis

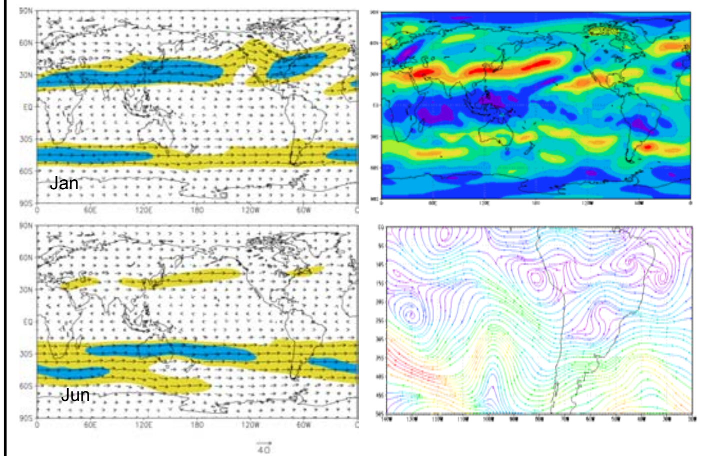
Reanalysis system also includes a meteorological model from which precipitation and other not-observed variables (e.g., vertical motion) are derived.

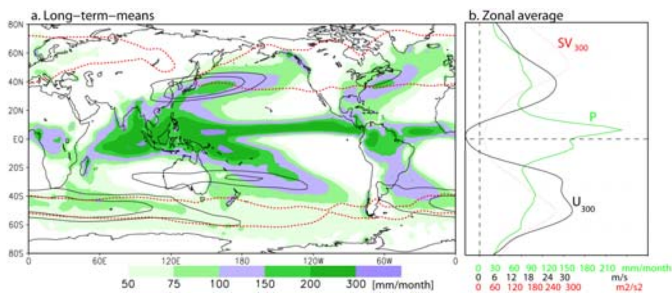
Reanalysis data is great for studying interannual and higher frequency variability. Interdecadal variability and trends are not so well depicted (we don't trust much before the 70's, particularly in the SH).

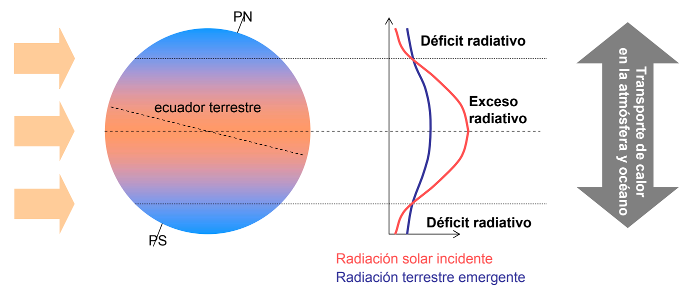
European Center (ECMWF) did a similar effort (ERA-15 and ERA-40). Higher horizontal resolution (1.25°x1.25°), but harder to get.

Climatology of 300 hPa winds (10-12 km) from NNR

Example of some daily fields from NNR



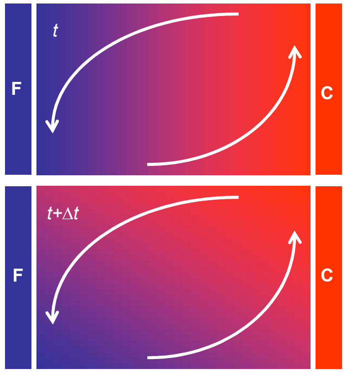




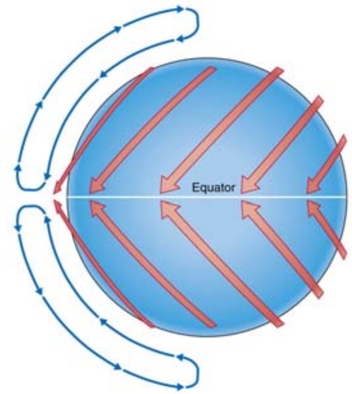
La circulación de la atmósfera y océano distribuye el exceso de energía que reciben las zonas tropicales hacia latitudes altas, manteniendo así el equilibrio térmico del planeta

Celda de circulación térmica directa

Modelo simple de circulación de un fluido sometido a una diferencia de temperatura en sus paredes mantenida en el tiempo.

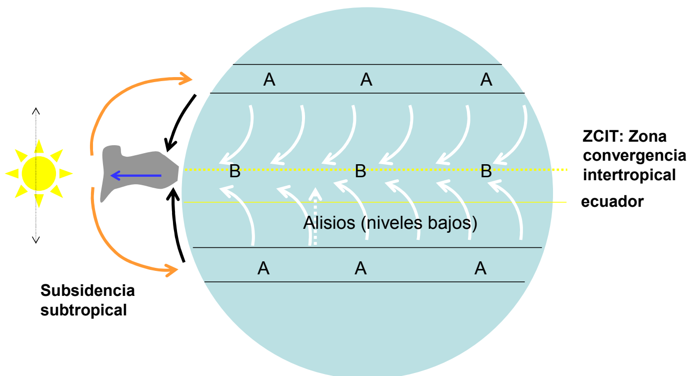


Simple, bonito….

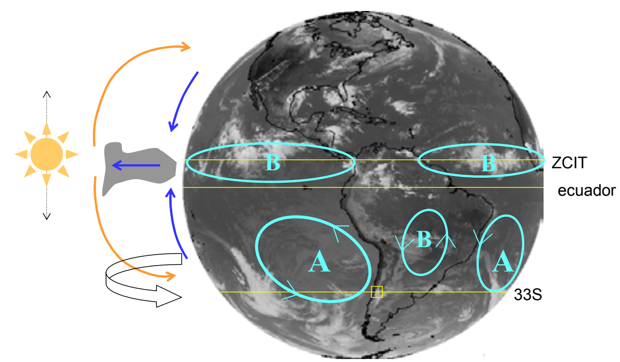


Sin embargo, observaciones muestra una celda de circulación directa (celda de Hadley) restringida a ±30º latitud.

Notar efecto de rotación terrestre en vientos Alisios (niveles bajos): NE / SE

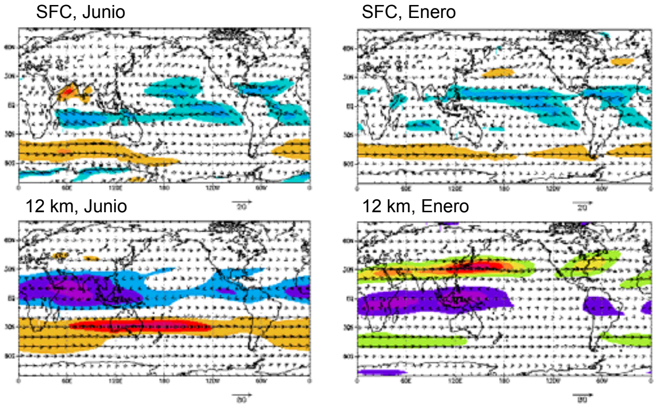


Planeta real bastante más complejo



ZCIT asociado a un cinturon de bajas presiones. Subsidencia subtropical asociada a la formación de anticiclones subtropicales, interrumpidos por bajas continentales.

En latitudes medias y altura, también predominan los W. Corrientes en Chorro (Jet Stream, Máxima velocidad, >80 km/h) entre 30-40º lat.



Régimen de Rossby

Las corrientes en chorro son inestables... perturbaciones tienden a amplificarse formando dorsales y vaguadas de gran amplitud, instigando ciclogenesis y frontogenesis.

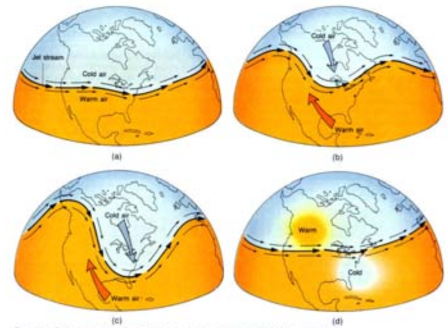
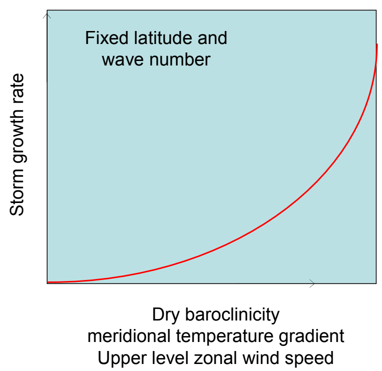
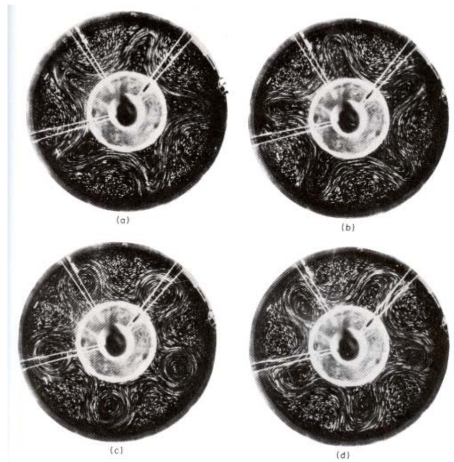


Figure 8-9 Cyclic changes that occur in the upper-level airflow of the westerlies. The flow, which has the jet stream as its axis, starts out nearly straight and then develops meanders that are eventually cut off.

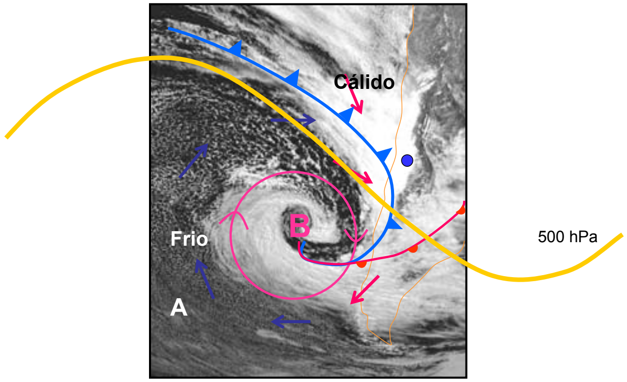
According to the linear quasi-geostrophic theory:



At monthly and longer timescales, stronger westerlies aloft are conducive of a rapid growth and rapid succession of baroclinic disturbances and therefore enhanced precipitation

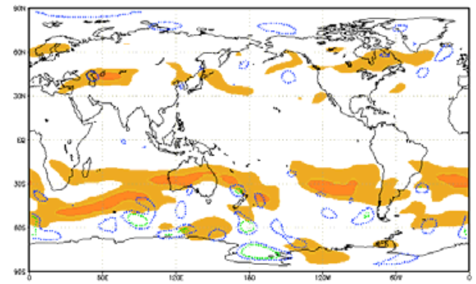


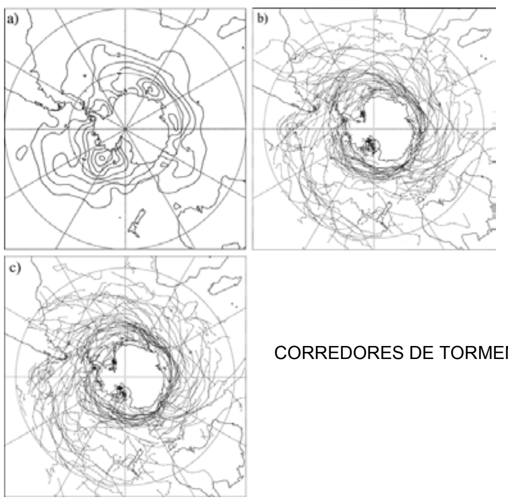
Las perturbaciones de latitudes medias (ver clase anterior) también transportan calor hacia latitudes altas, continuando el proceso de transferencia de calor que realiza la atmósfera.



Upper tropospheric jet stream and surface depresions

30 day animation of 300 hPa zonal wind speed (shaded, 25 and 50 m/s) and 925 hPa relative vorticity (contours, -3 and -6 10^{-5} s^{-1}). Time resolution is 6 hours





CORREDORES DE TORMENTAS

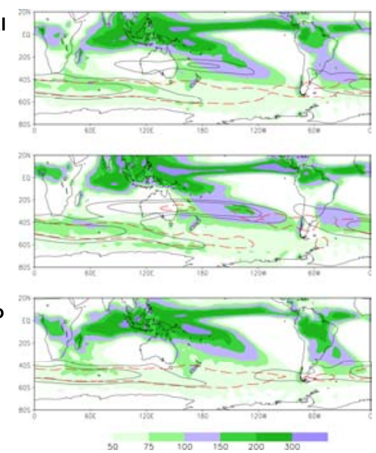
Corredores de tormentas

(Varianza de vorticidad, viento zonal, precipitación)

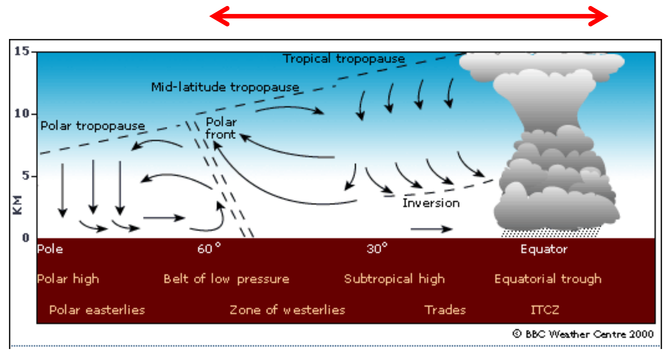
Anual

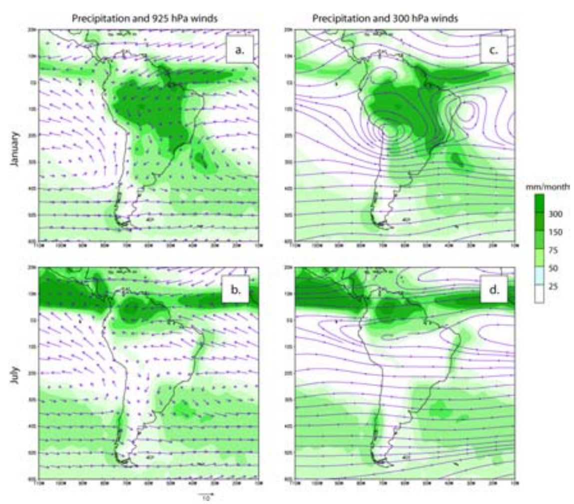
Junio

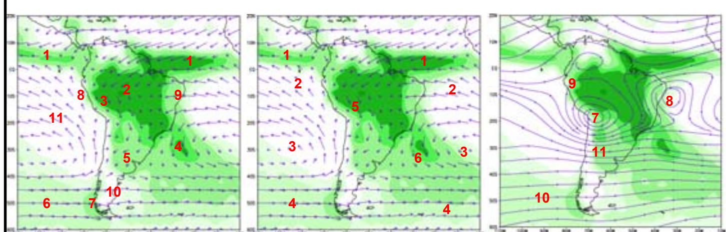
Enero



Because of its long meridional extent, South America exhibits tropical, subtropical and extratropical climatic regimes







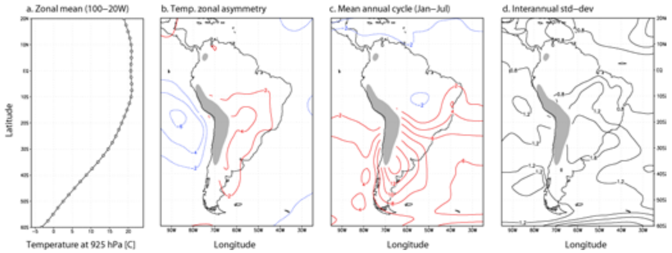
Precipitation features

1. ITCZ
2. Continental convection
3. Altiplano convection
4. SACZ
5. Pampas convection
6. Midlatitude storm track
7. Orographic precipitation
8. Coastal desert
9. NE Brazil semiarid
10. Patagonia dry zone
11. Ocean desert

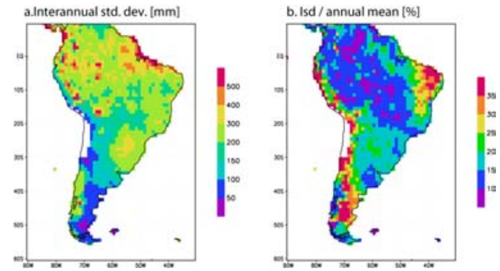
Circulation features

1. ITCZ
2. Trade winds
3. Subtropical high
4. Midlatitude westerlies
5. Low level jet
6. SACZ
7. Bolivian high
8. NE Brazil trough
9. Tropical easterlies
10. Midlatitude westerlies
11. Jet stream

The low-level air temperature field

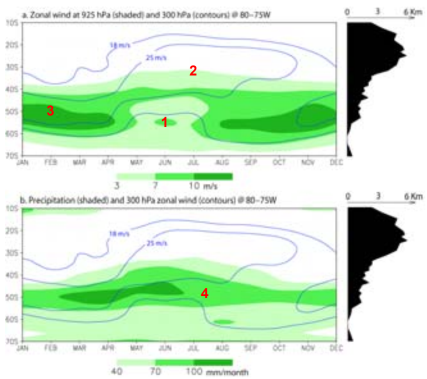


The Precipitation Variability (UdW data)

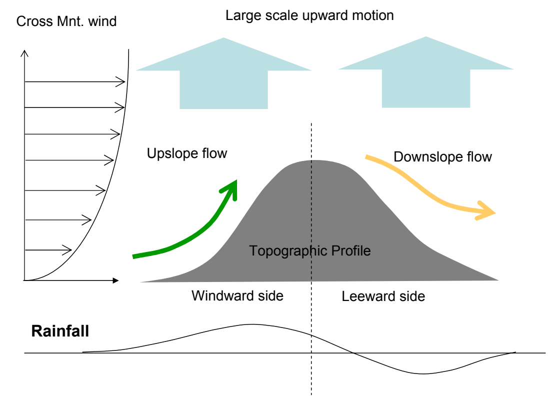


Which regions exhibit large year-to-year variability?

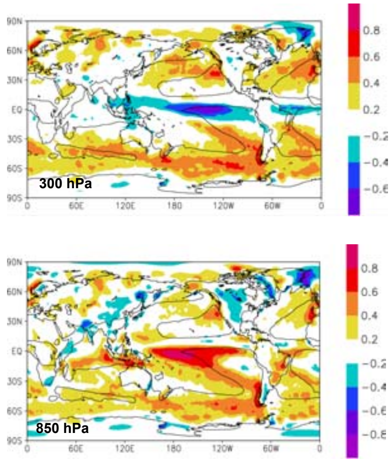
Modest annual cycle in the extratropics



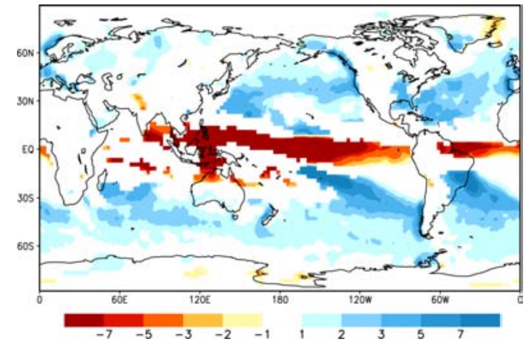
Orographic Effects



Local Correlation Uwind – CMAP Precipitation
using monthly anomalies (1979-2005)



Local Correlation Uwind(300) – CMAP Precipitation
using monthly anomalies (1979-2005). Now we show the slope of the linear fit between U300 and R (only where r<U300,R> is significant)



$\delta R = b^* \delta U300$ [b] = [mm/month]/[m/s]

For instance, in southern Chile a δu=-10 m/s produces a decrease of 70 mm/month = 840 mm/year.

Patterns / modes of large-scale circulation…be aware

1. Introduction

The climate dynamics literature abounds with patterns of variability; some labeled as teleconnection patterns, oscillations, clusters, seesaws, or modes; many others known only by mode number. The documentation of structures in sea level pressure (SLP) and upper-tropospheric geopotential height fields has proceeded largely independently, each yielding its own set of patterns.

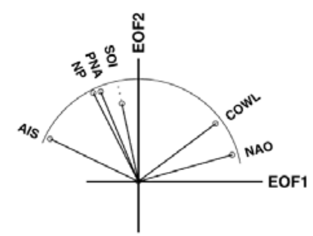
The different analysis techniques used in climate dynamics research also yield different patterns, and even the same technique can yield quite different results, depending upon whether it is applied to a total field or to the zonally symmetric or asymmetric components of that field. The patterns that have emerged in various studies have also been conditioned by the spatial domain of the analysis, the manner in which seasonality is treated, and the time interval over which the data are averaged before the analysis is performed.

Quadreli and Wallace, J. Climate, 2002

How to make a circulation mode?

- Choose a variable/level from reanalysis
- You may want to pre-filter the data and select a sub-domain
- Use your favorite stat-software (Matlab, Maple, etc)
- Select a complicated tool (e.g., complex-rotated-extended-multidimensional EOF)
- Get your spatial pattern and loading factors (time series)

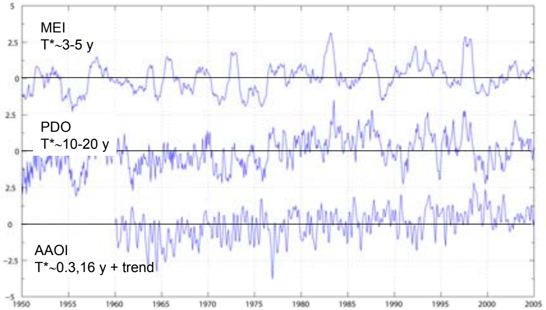
Unfortunately, it is very likely that you get a mode that is very similar to something already known.

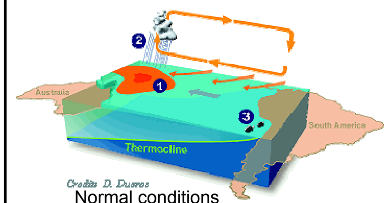


Quadreli and Wallace
J. Climate, 2002

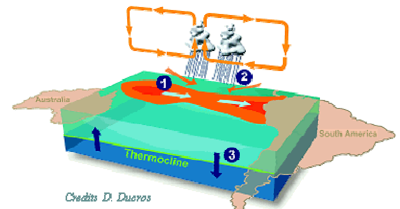
FIG. 4. Projections (area-weighted spatial correlations) of patterns associated with various indices on the phase space defined by the two leading EOFs of monthly DJFM NH SLP anomalies, north of 20°N. For reference, a circle of unit radius is shown in the plots. Positive values of the EOFs denote polarities indicated in Fig. 1.

Leading large-scale circulation modes: time-domain





Normal conditions



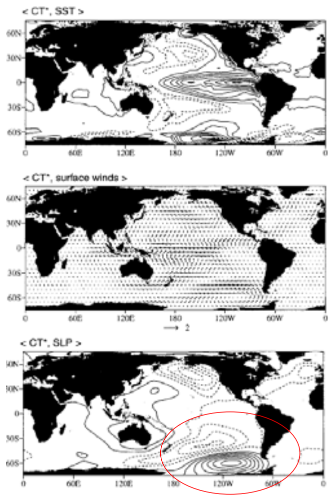
El Niño conditions

El Niño – Southern Oscillation (ENSO) is the leading mode of tropical variability, caused by the instability of the air-sea interaction over the equatorial Pacific.

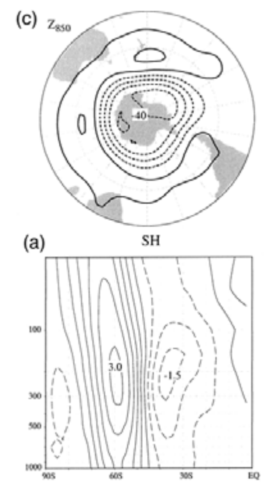
Changes in the SST/wind pattern in the tropical Pacific alters the distribution of deep convective clouds.

In turn, the anomalous outflow from convective clouds have a significant effect on the atmospheric circulation elsewhere, including the excitation of Rossby wave trains in the SH extratropics.

ENSO signatures



Garreaud and Batisti
J. Climate, 1999



Thompson and Wallace 1999

The **Southern Hemisphere Annular mode** (SAM), or **Antarctic Oscillation**, is the leading mode of monthly and longer variability of the tropospheric circulation poleward of 20ºS.

SAM is tropospheric deep, highly symmetric mode, involving mass exchange between high and mid latitudes. What causes SAM is not well known, likely eddy – mean flow interaction

The SAM has shown a trend toward decreases pressure over Antarctica (positive polarity; faster polar vortex), partially attributed to decrease in stratospheric O3.

← AAOI regressed upon SLP (upper panel) and zonal average of zonal wind (lower panel)

The "Pacific Decadal Oscillation" (PDO) is a long-lived El Niño-like pattern of Pacific climate variability. While the two climate oscillations have similar spatial climate fingerprints, they have very different behavior in time. Causes for the PDO are not currently known.

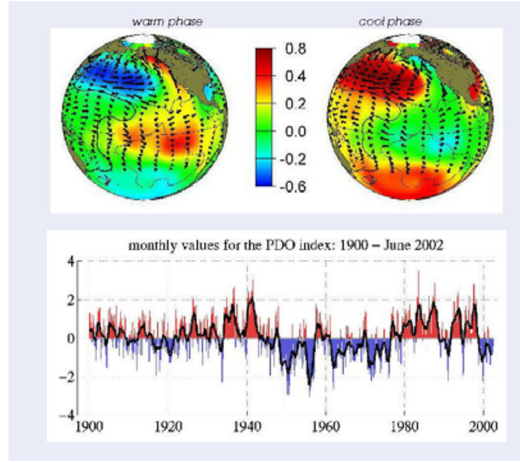
Two main characteristics distinguish PDO from ENSO:

1. 20th century PDO "events" persisted for 20-to-30 years, while typical ENSO events persisted for 6 to 18 months

2. The climatic fingerprints of the PDO are most visible in the North Pacific/North American sector, while secondary signatures exist in the tropics and the SH - the opposite is true for ENSO.

Several independent studies find evidence for just two full PDO cycles in the past century: "cool" PDO regimes prevailed from 1890-1924 and again from 1947-1976, while "warm" PDO regimes dominated from 1925-1946 and from 1977 through (at least) the mid-1990's.

PDO Basics

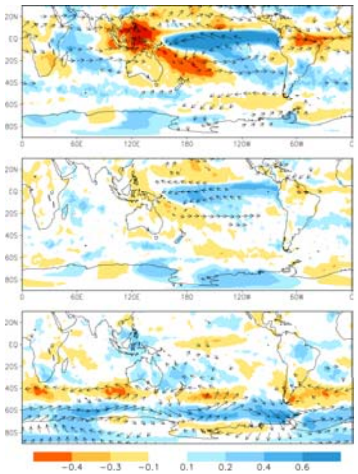


ℜ<Index, Precipitation> and ℜ <Index, V_{300}>
Based on monthly anomalies, 1979-2005

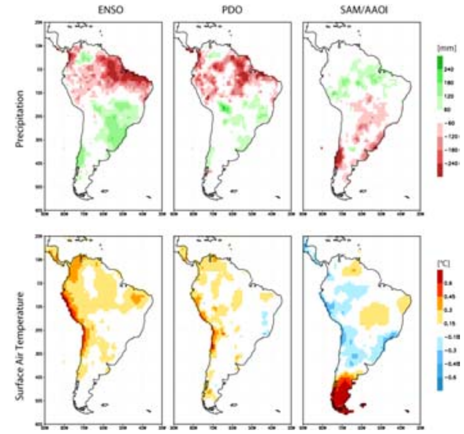
Multivariate ENSO Index

PDO Index

SAM Index (AAOI)



Annual mean Precip/SAT regressed upon
index of large-scale modes (50 years of data)



Seasonal correlation between Precip/SAT and
Multivariate ENSO Index (50 years of data)