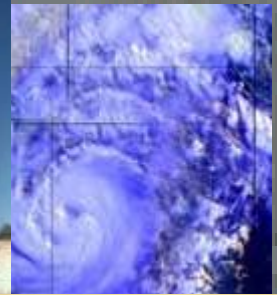


The « El Niño » Southern oscillation (ENSO)

Pascale Delecluse

*Laboratoire des Sciences du Climat et de l'Environnement,
CNRS/CEA,
Gif-sur-Yvette, France*

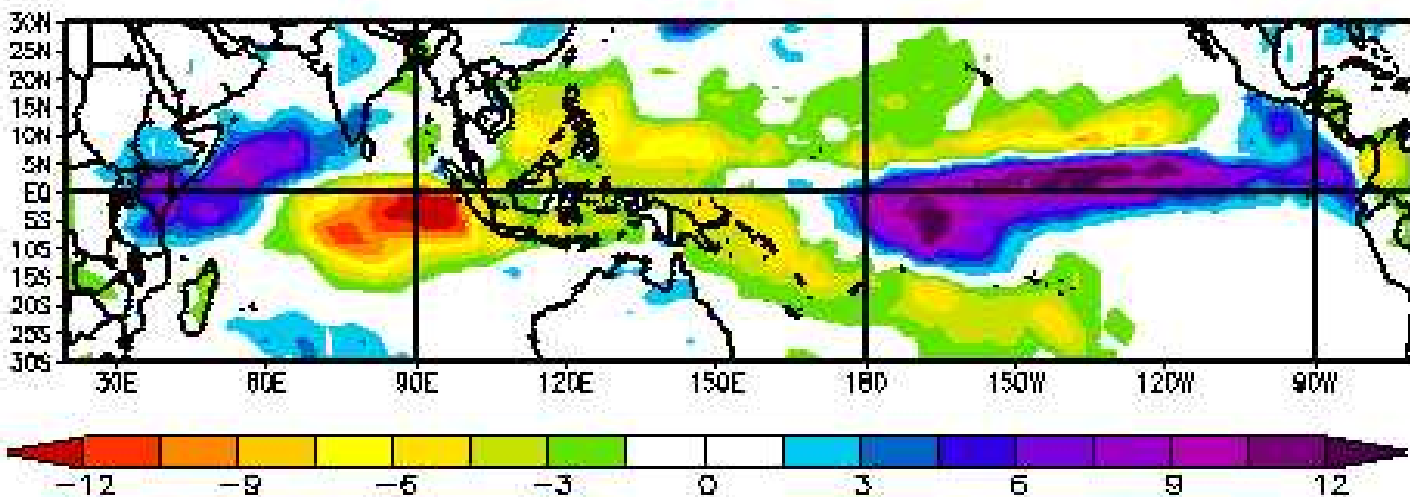
El Niño



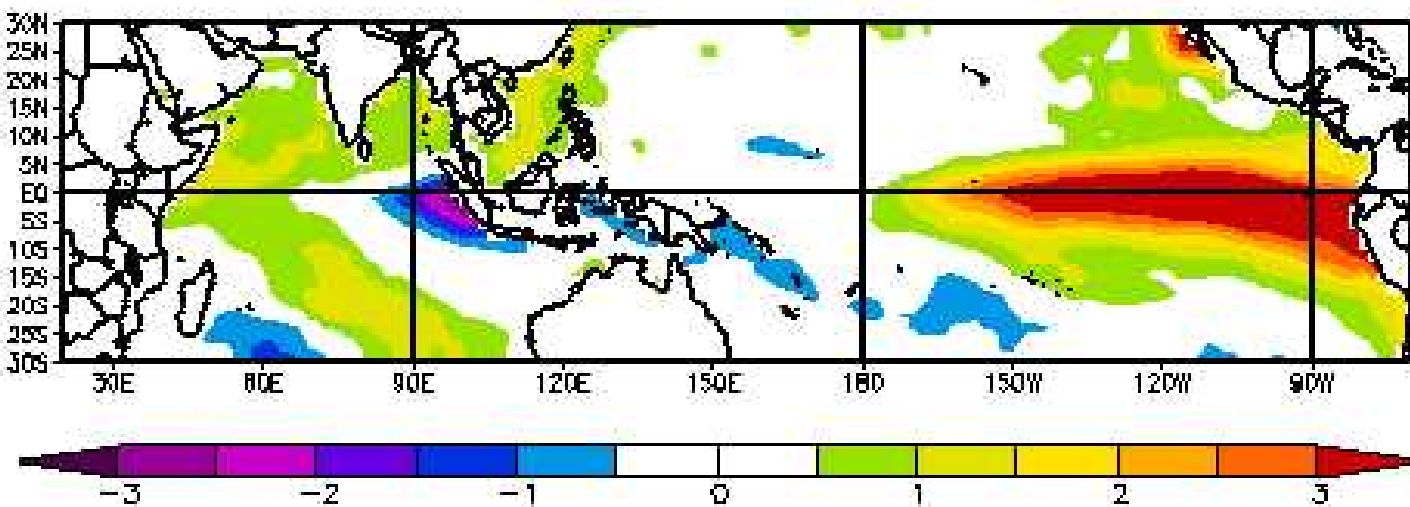
...the phenomenon and its
consequences

October 1997

precipitation anomalies



surface oceanic temperature anomalies



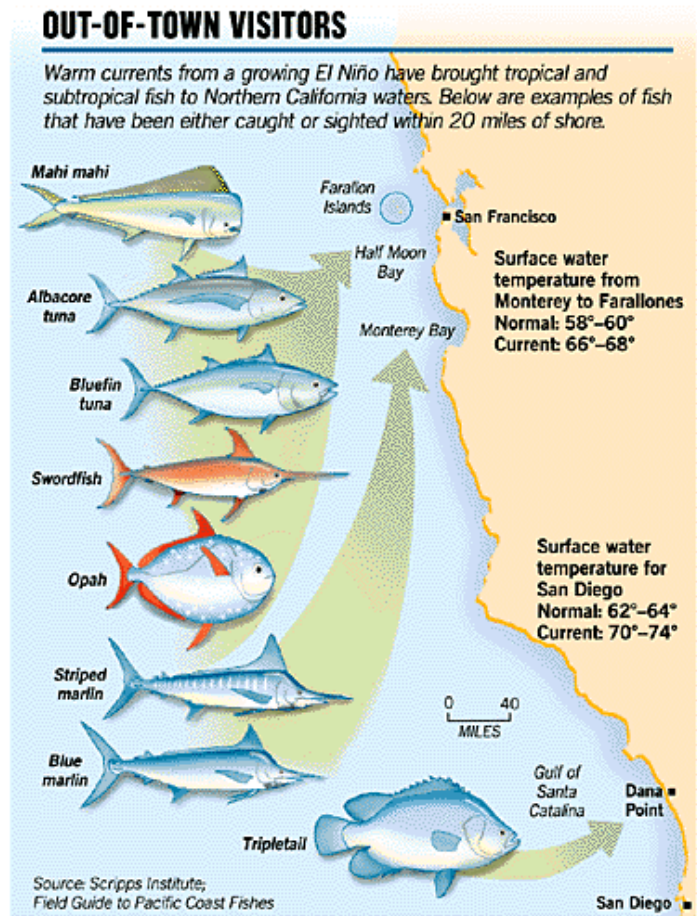
What happened in 1997-98

- Temperature anomalies in the ocean at the scale of the Pacific ocean associated with precipitation and wind anomalies
- Climatic anomalies observed at the scale of the entire planet



A small story of El Niño

Christmas Gifts for Peruvian (and Californian) fishermen ...



JOHN BLANCHARD / The Chronicle

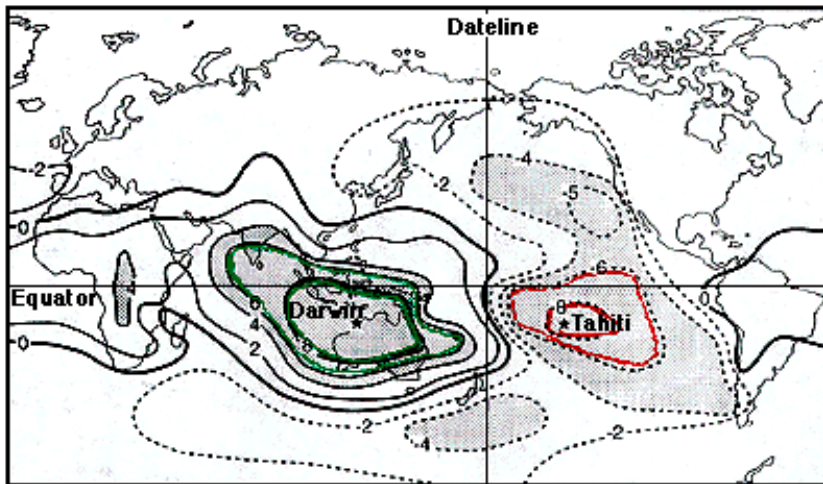
El Niño, warm current appearing during Christmas period... or?

A small story of El Niño

« Austral Oscillation »

Atmospheric phenomenon at the scale of the Pacific ocean

SOI: Tahiti and Darwin as "centers of action",
mslp correlations between two locations



Sir Gilbert Walker

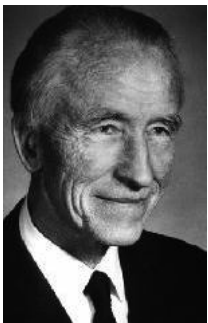
Tahiti and Darwin are at opposite ends of the Southern Oscillation's seesaw, and so the difference in pressure between them is used to measure the Southern Oscillation. The numbers represent a statistical measure called the correlation coefficient. The figure shows that the pressure variation at Tahiti is as closely related to Darwin as are locations near to Darwin, but with the opposite sign (i.e., if the Pressure is high at Darwin, it is low at Tahiti and vice versa). [After Rasmusson, 1984.]

...or ?

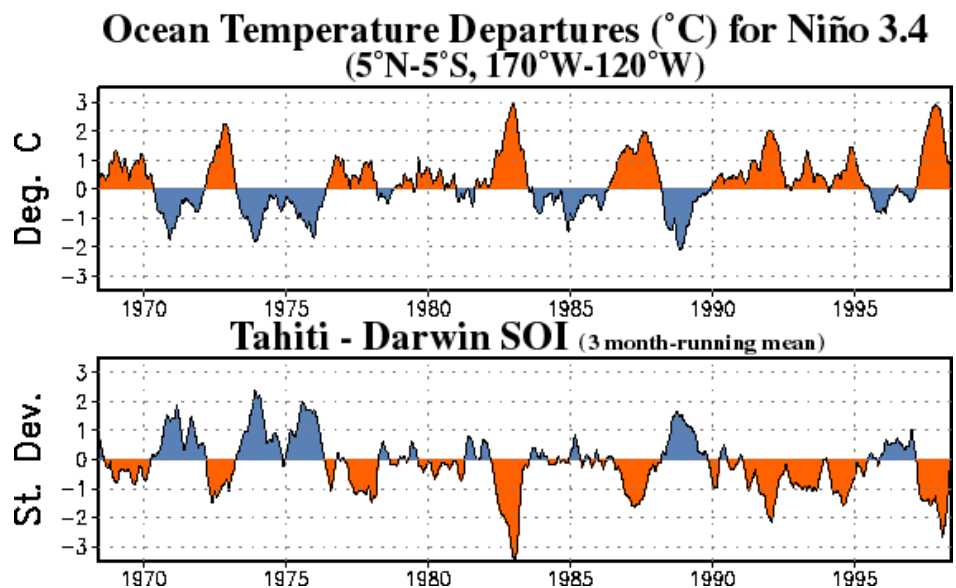
A small story of El Niño

Bjerknes' hypothesis:

El Niño and the austral Oscillation are the same phenomenon : ENSO



J. Bjerknes

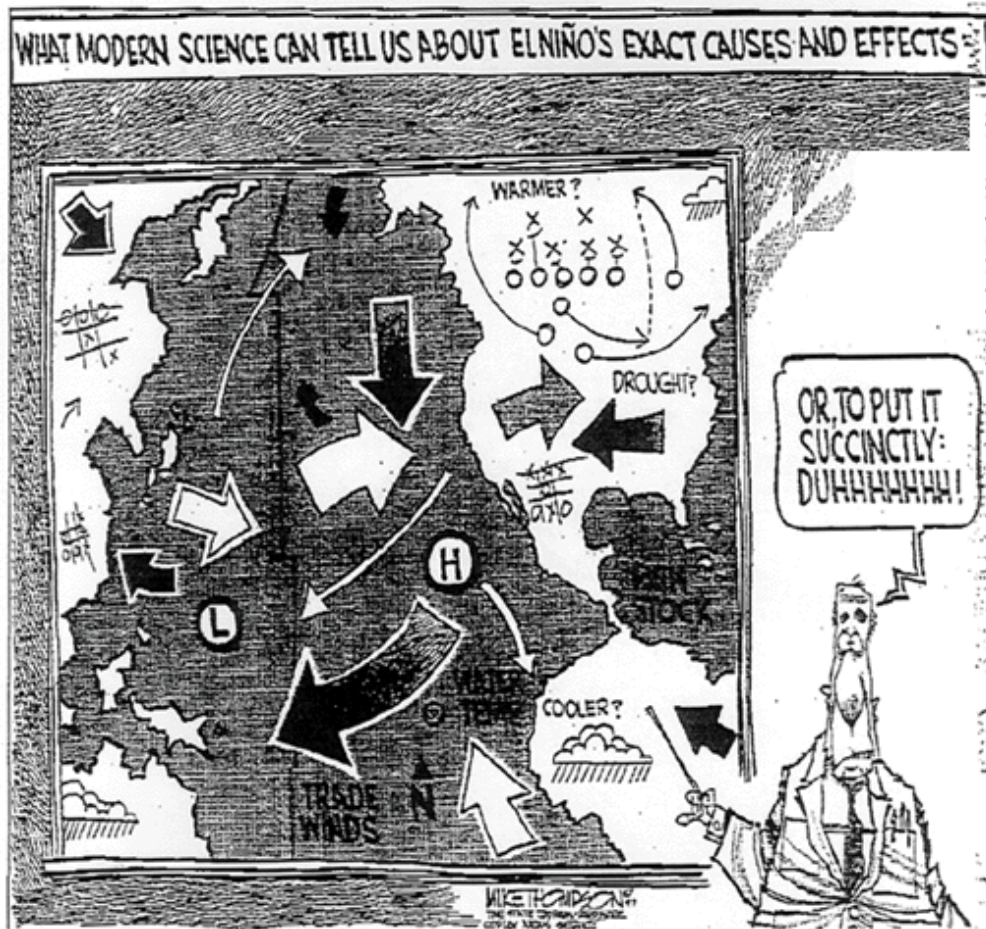


The media and the practice have imposed the name « El Niño »

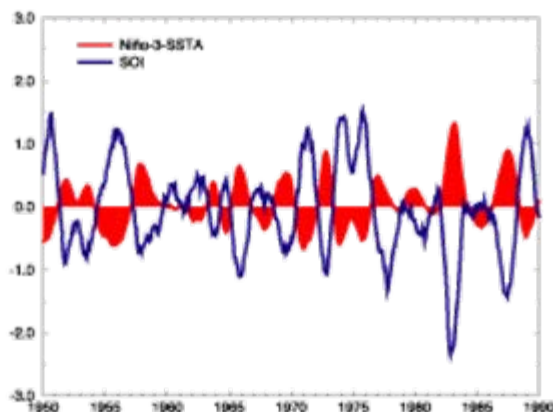
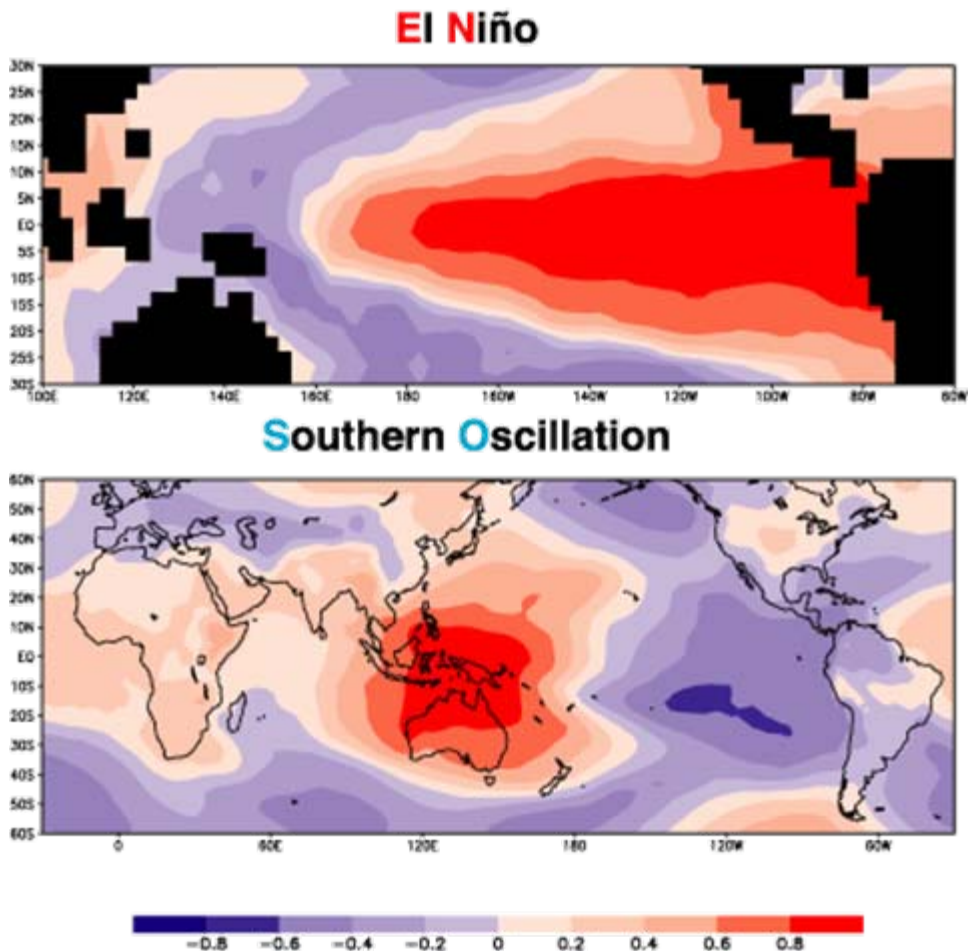
Plan

- 1) Introduction
- 2) State of knowledge about El Niño
- 3) Climatic, environmental and economical impacts of El Niño
- 4) Previsibility and predictability of El Niño
- 5) El Niño and beyond...

State of knowledge about El Niño



Two indices to define
Niño3: oceanic T anomaly
SOI : atmospheric P anomaly



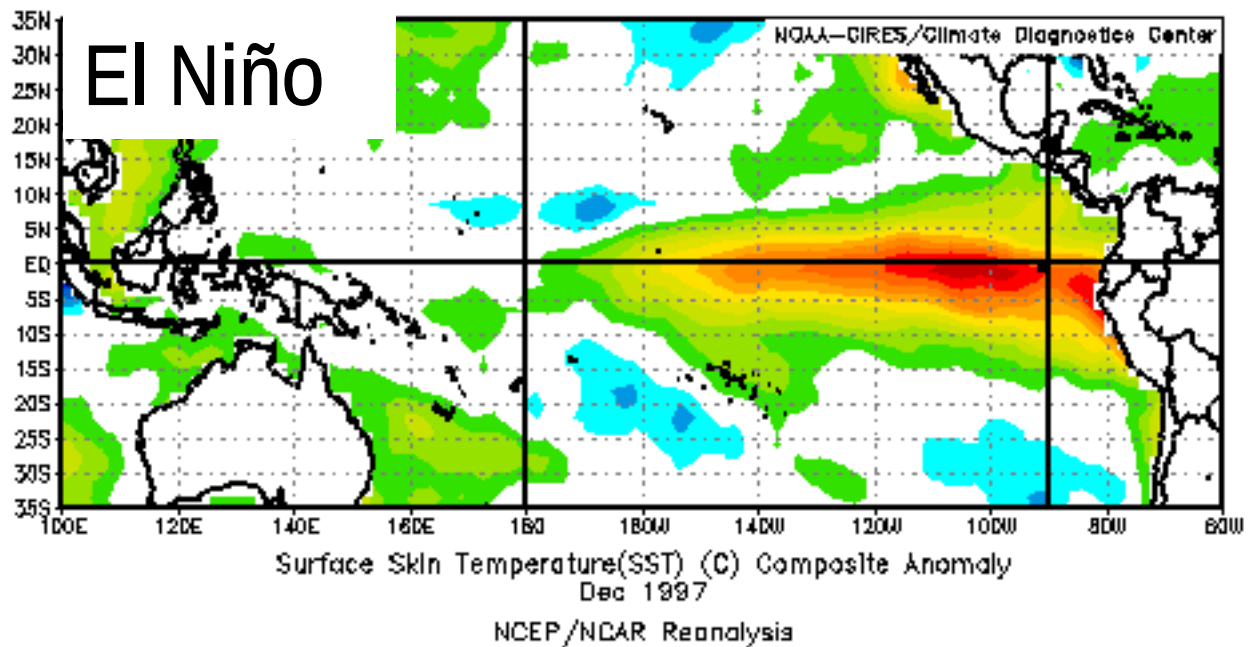
State of knowledge about El Niño

El Niño - questions:

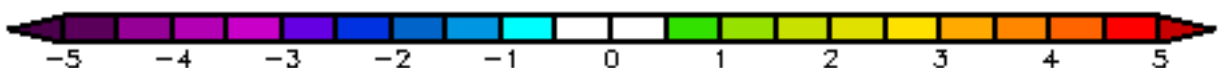
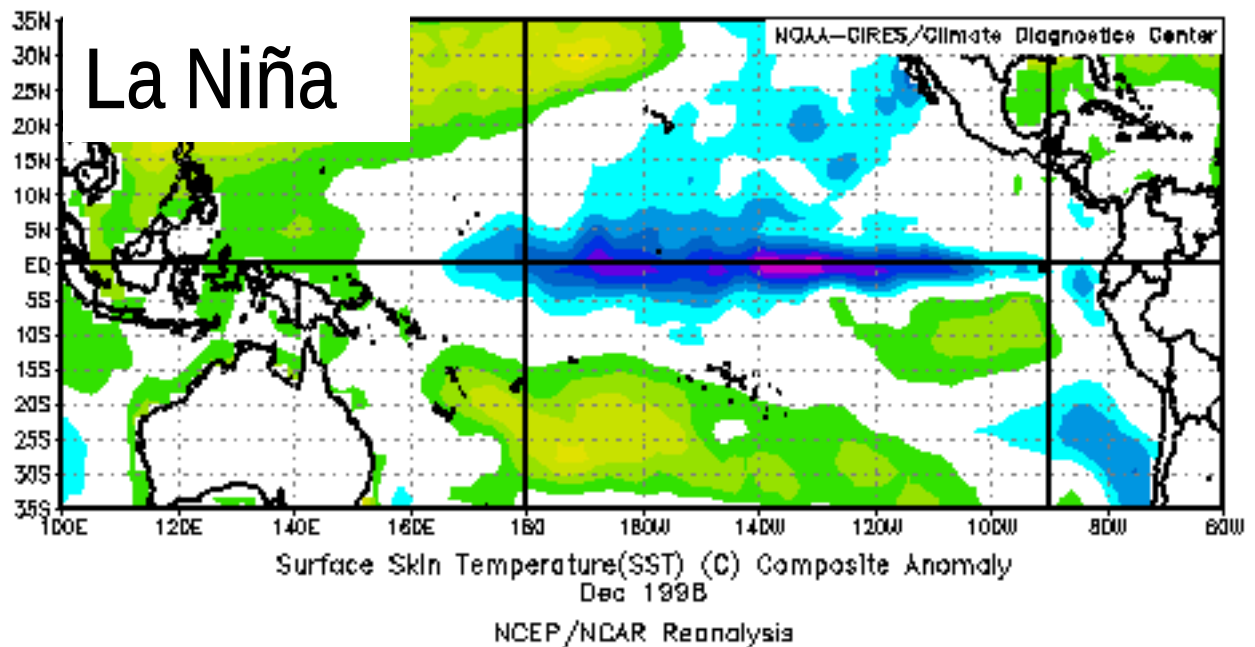
- Who is la Niña ?
- Since when does El Niño exist? Is it regular?
- What are the observation means of El Niño ?
- What are the principal characteristics of an El Niño event?
- What are the mechanisms of El Niño ?
- What are the impacts of El Niño ?
- Is El Niño predictable and how can we anticipate it?

Who is La Niña ?

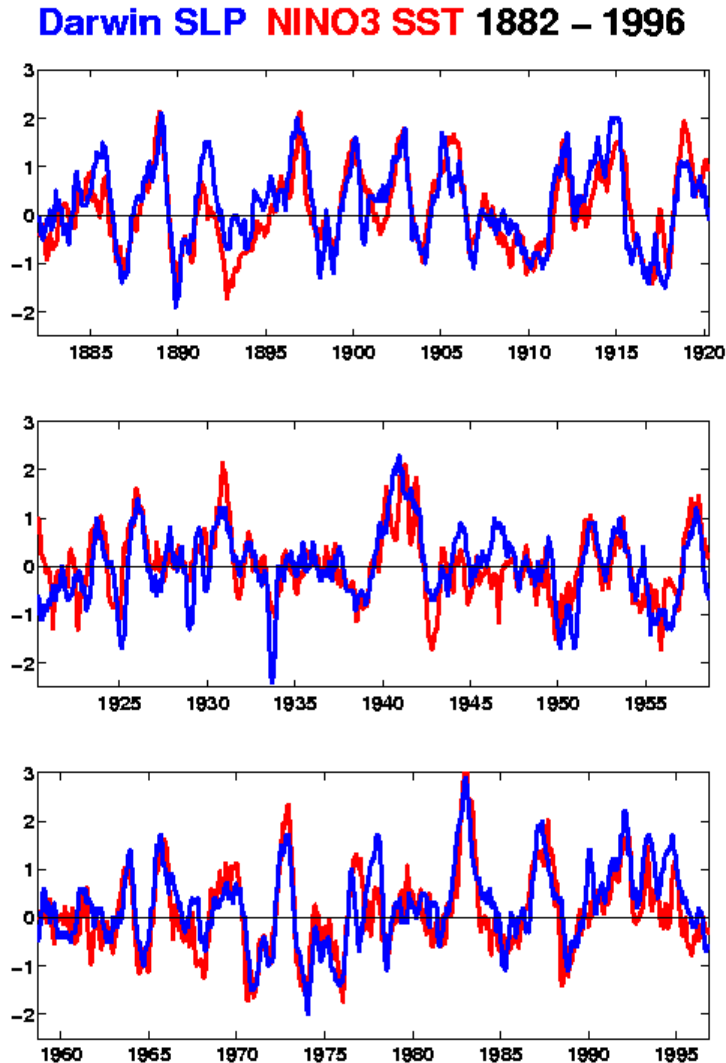
El Niño



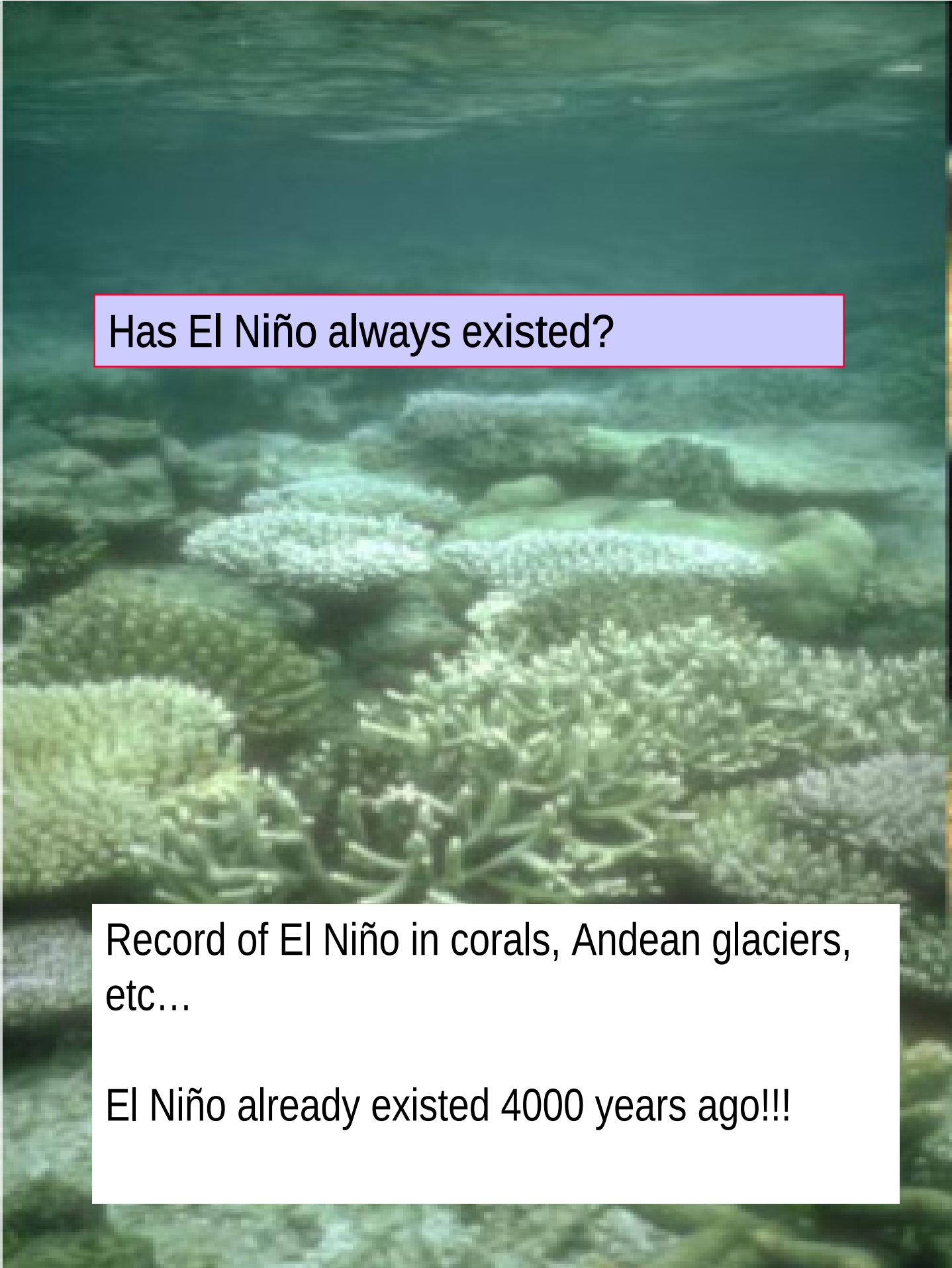
La Niña



- Since when does El Niño exist? Is it regular?



El Niño is not a periodic phenomenon.
An El Niño occurs every 2 to 7 years as an average.

An underwater photograph of a coral reef. The water is a deep, clear blue. In the foreground, there are various types of coral, including some with white, branching structures and others that are more rounded and greenish. The background shows more coral and the surface of the water with some light reflecting off it.

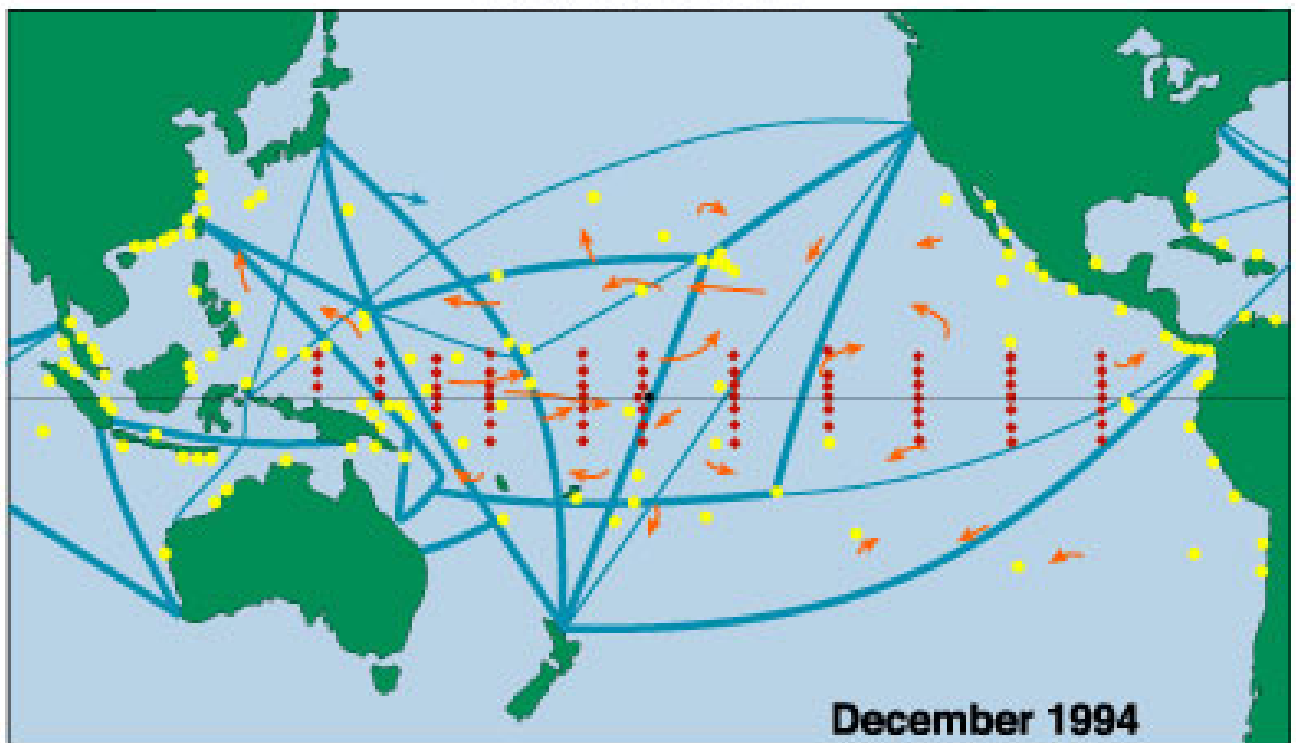
Has El Niño always existed?

Record of El Niño in corals, Andean glaciers,
etc...

El Niño already existed 4000 years ago!!!

What are the observation means for El Niño ?

TOGA in Situ Ocean Observing System Pacific Basin

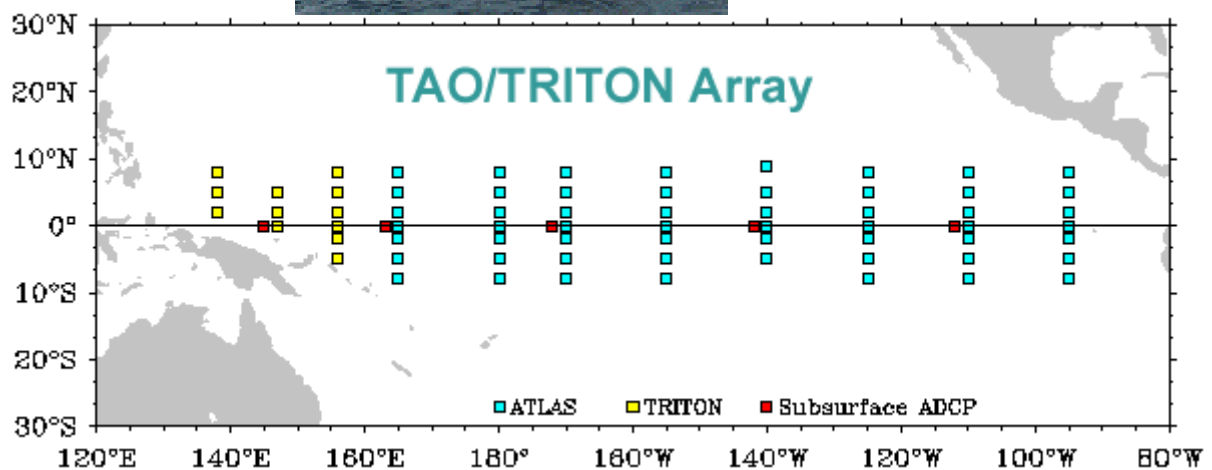
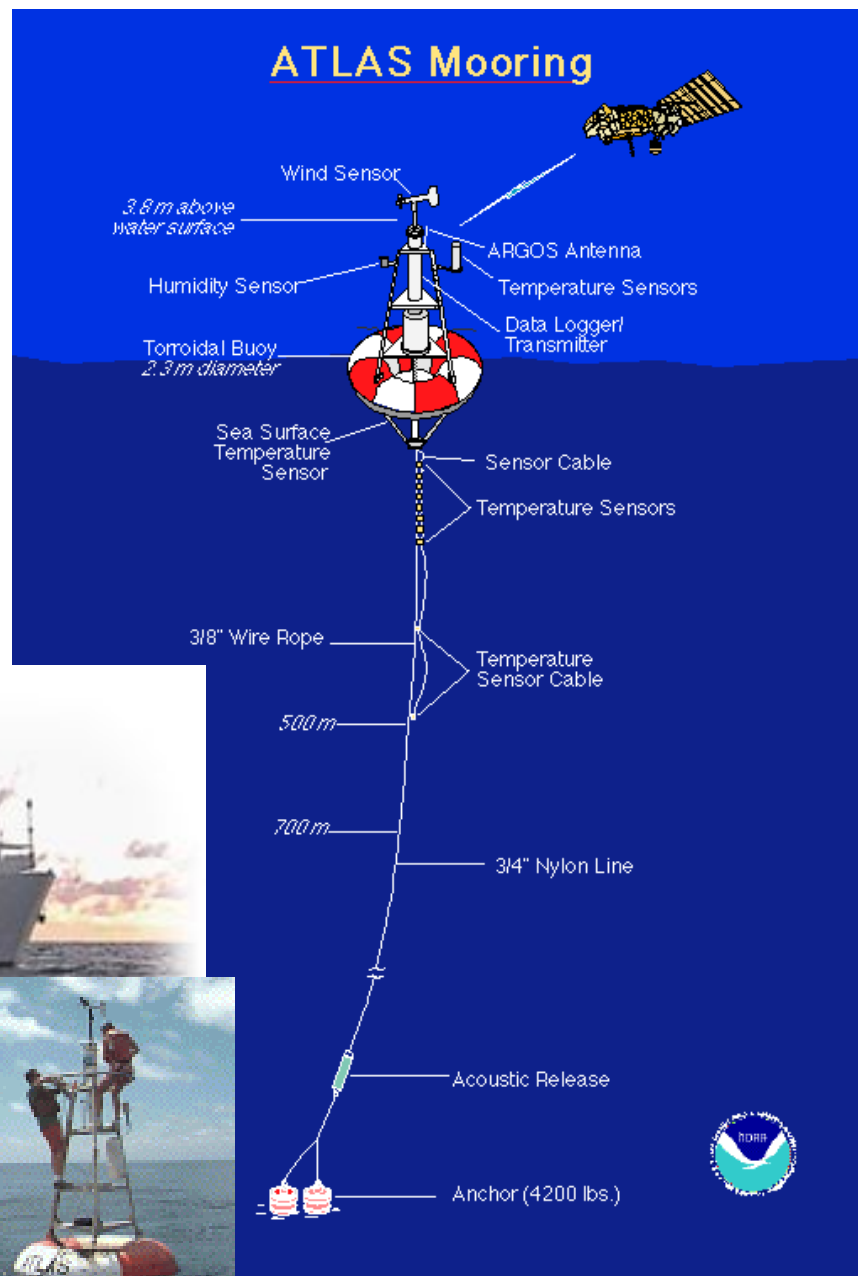


To observe

El Niño:

TAO

Buoys

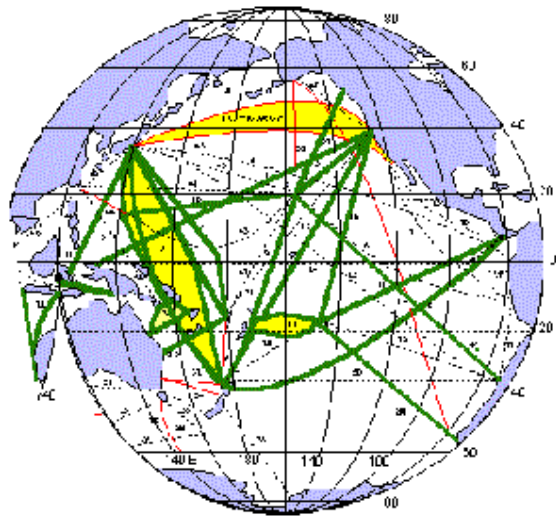


To observe

El Niño:

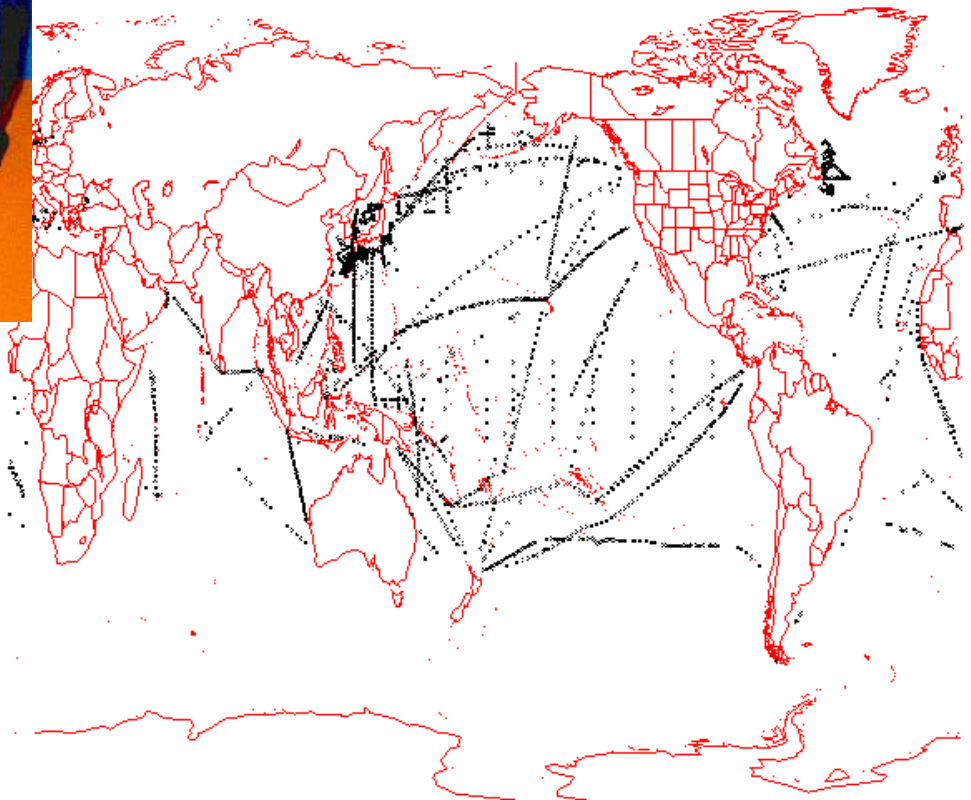
XBT

Network



**Lignes de navigation dans le Pacifique
équipées de système d'observations XBT**

(from <http://ioc.unesco.org/igossweb/xbtlines.htm>)

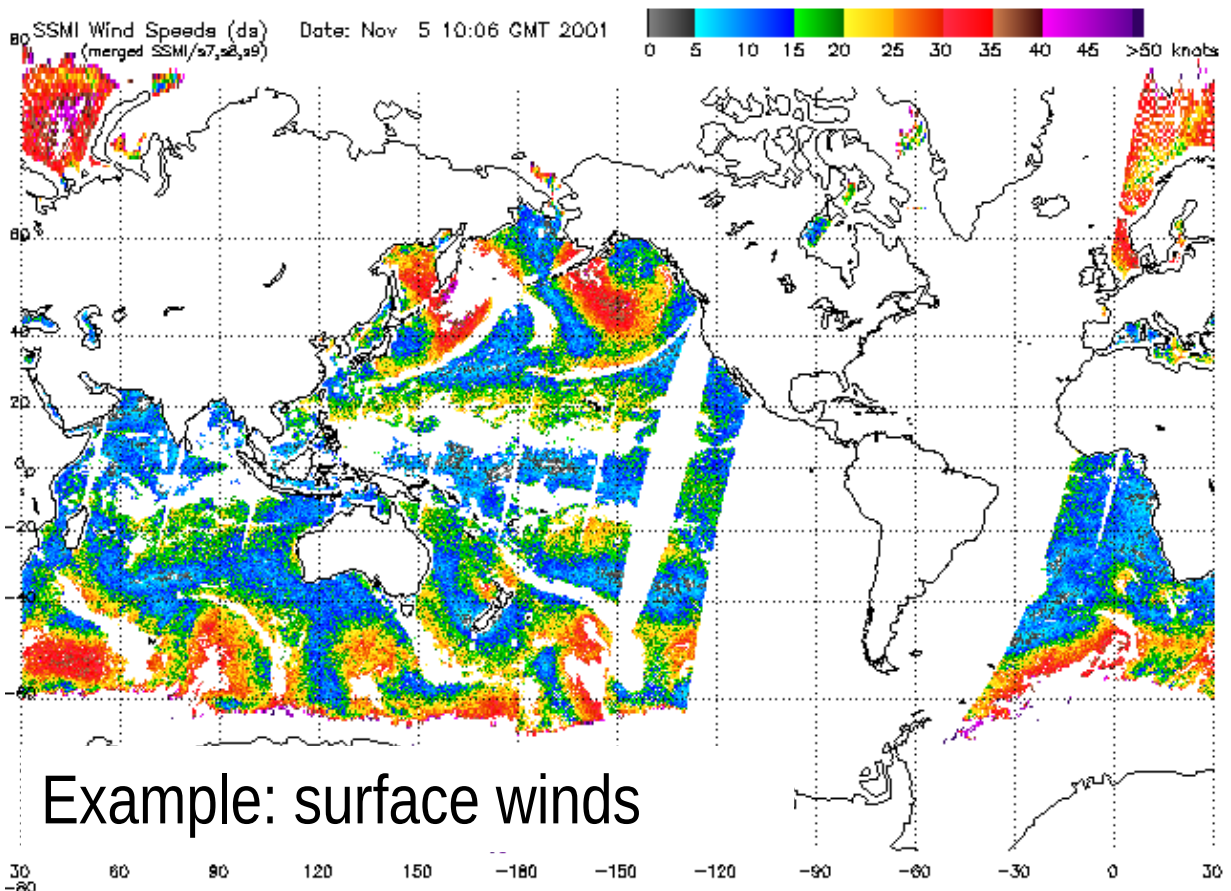


To observe El Niño:

Satellite data (1)

Satellites allow to observe numerous parameters:

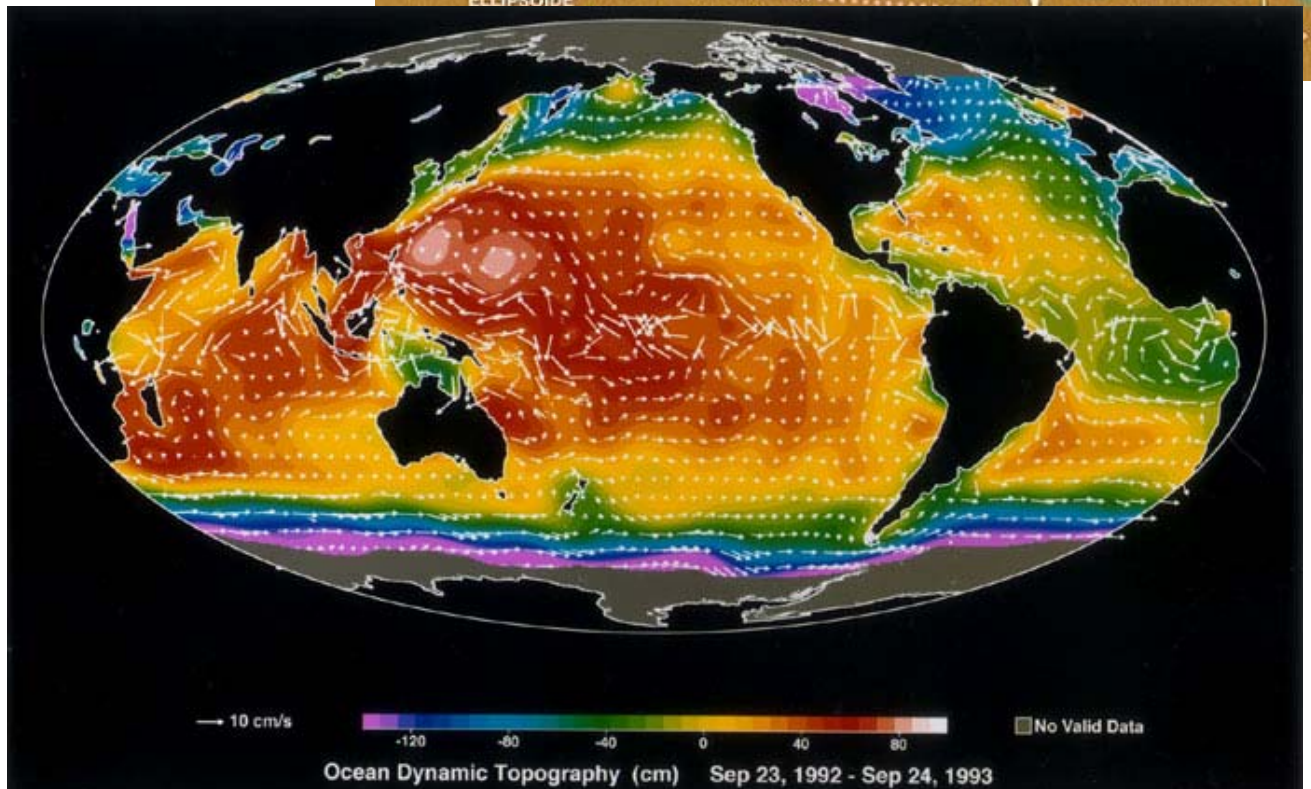
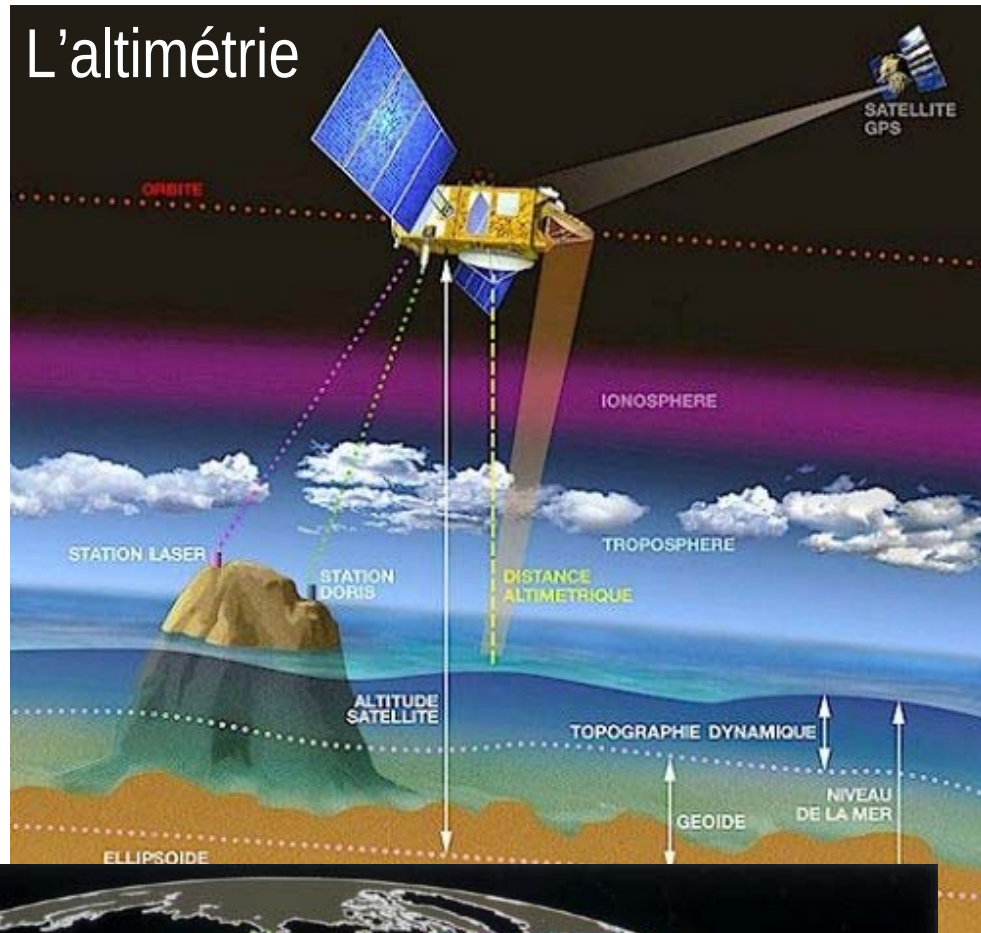
- The surface temperature of the ocean
- The surface wind
- The precipitations and convective clouds
- The sea level...



To observe El Niño:

Satellite data (2)

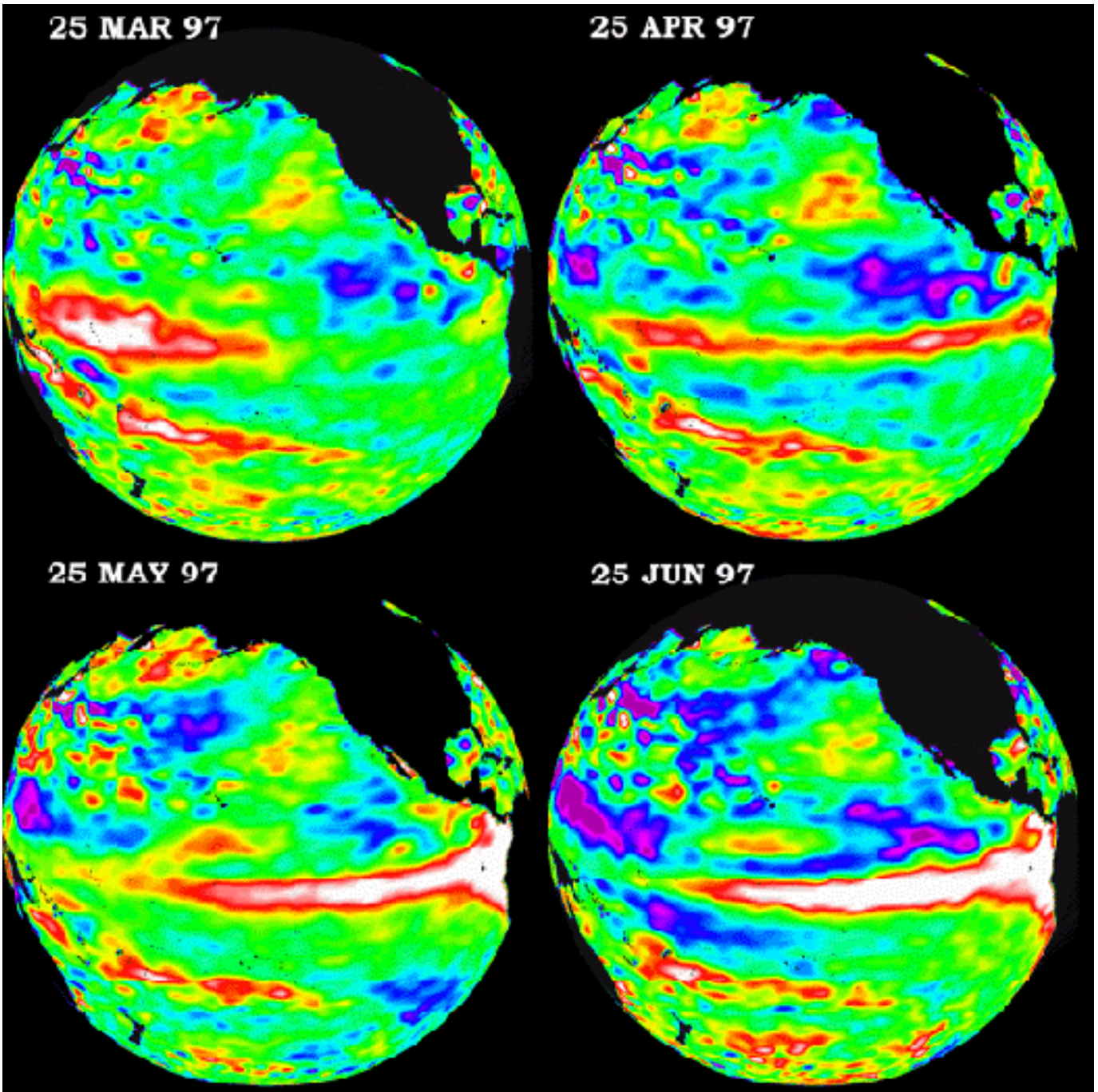
L'altimétrie



To observe El Niño:

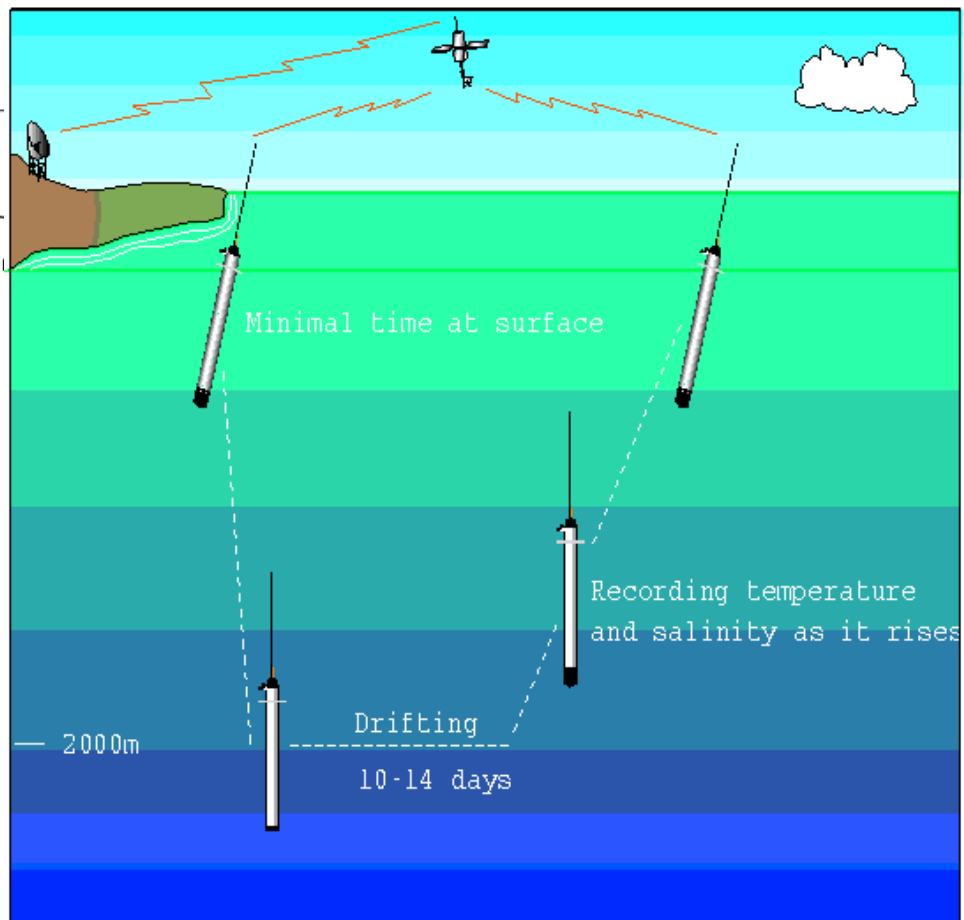
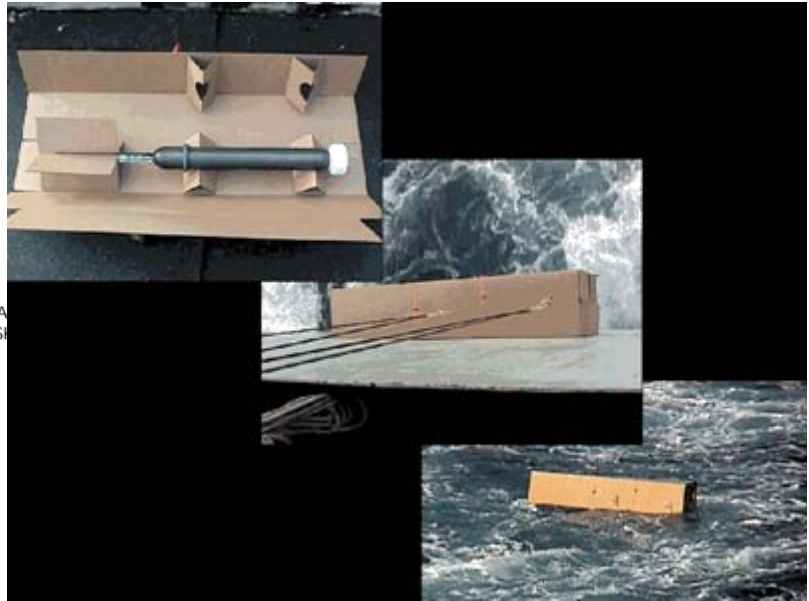
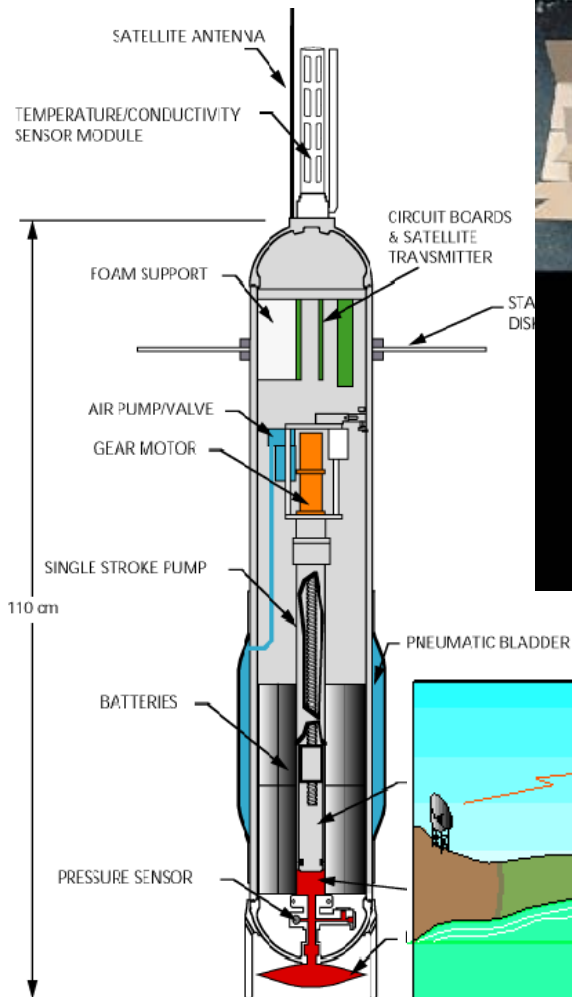
Satellite data (3)

Sea level anomalies of the sea observed during El Niño
1997-98

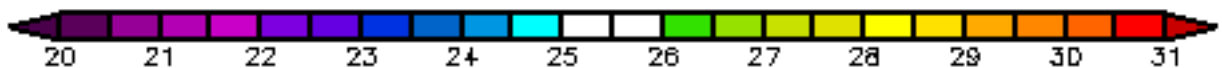
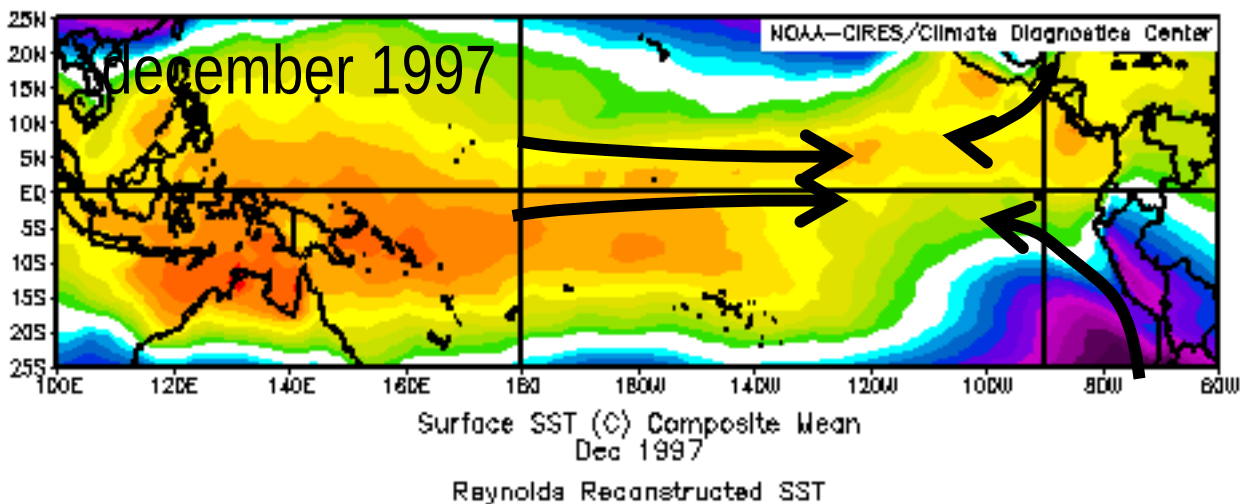
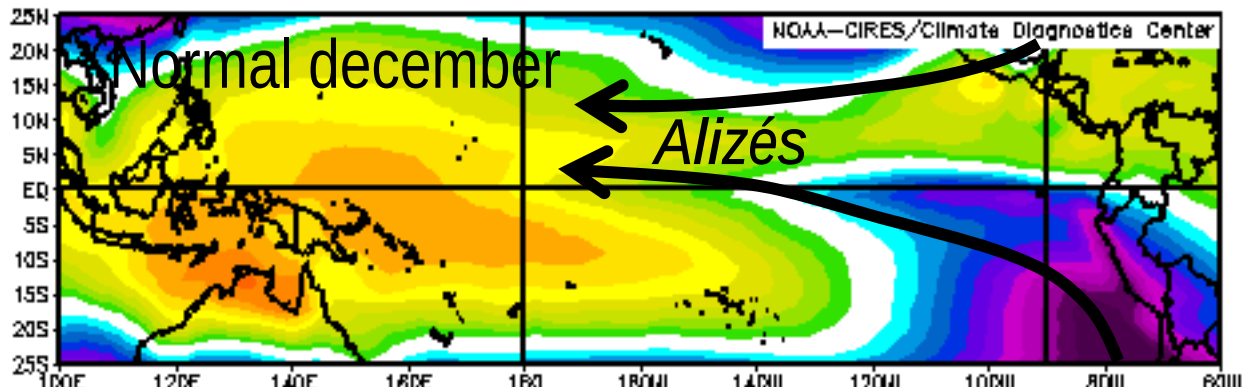


To observe the ocean

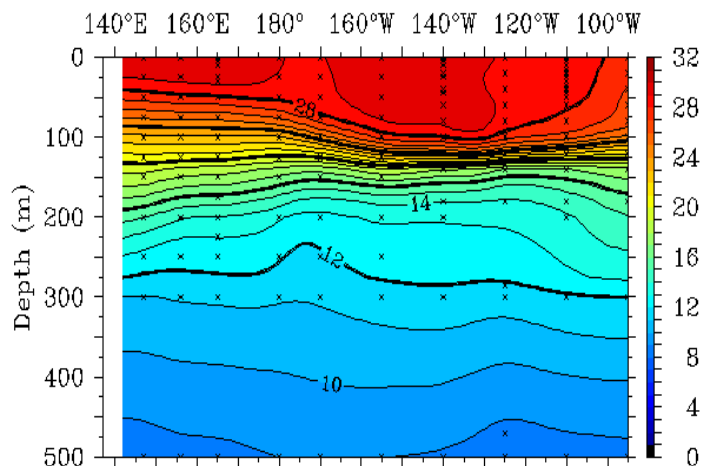
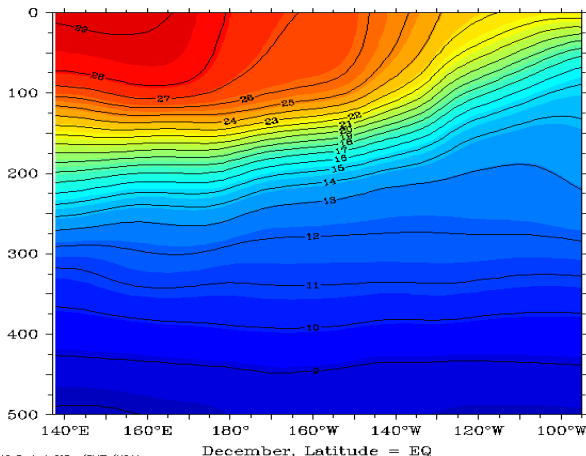
future: the ARGO system

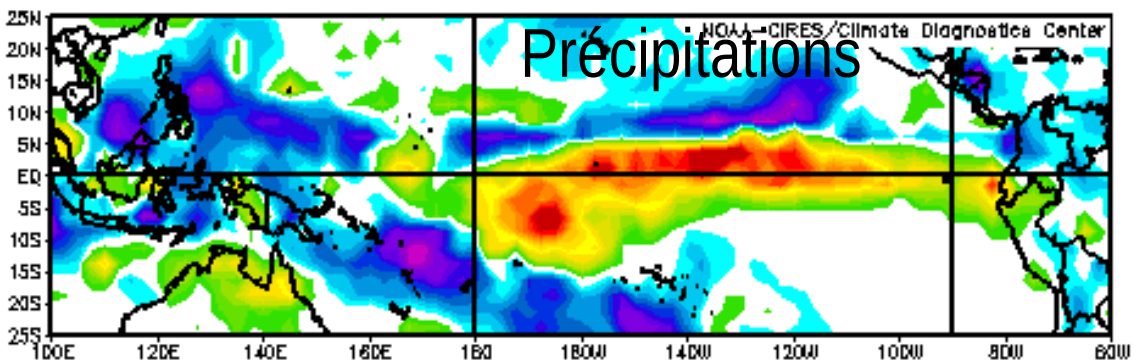
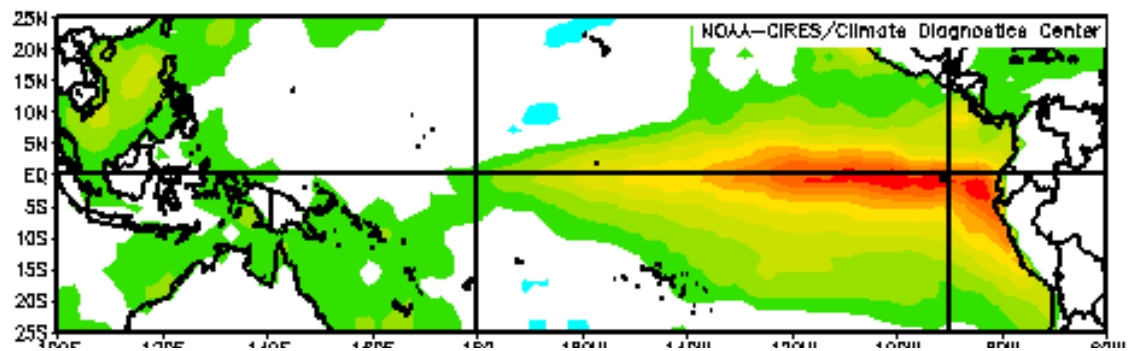
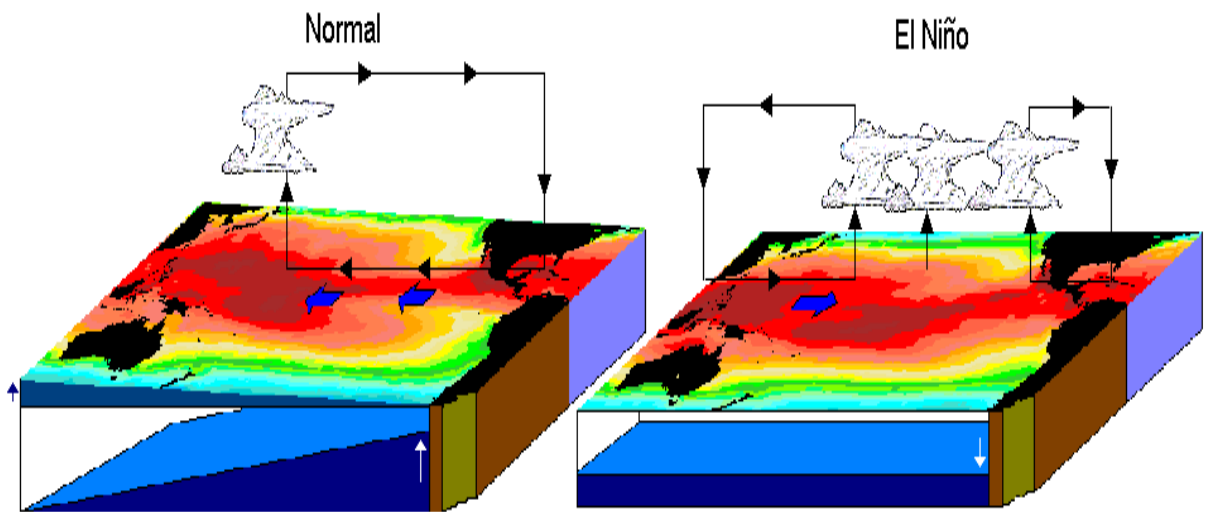


What are the principal characteristics of an El Niño event?

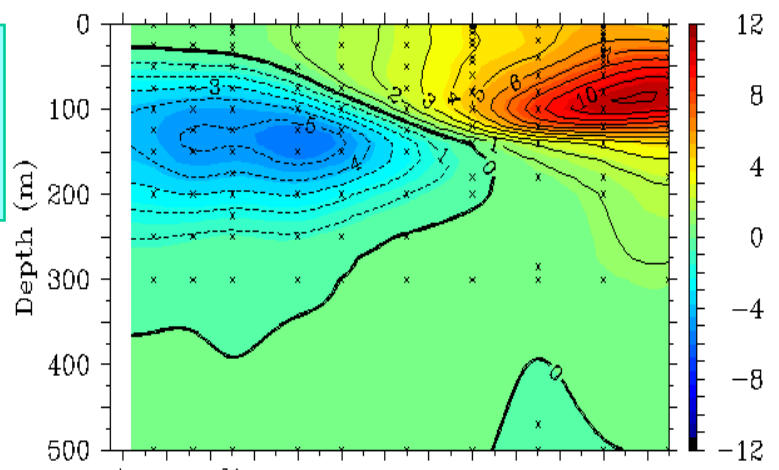


Kessler Objective Analysis of XBT and CTD Temperatures (1994)





subsurface
temperature



State of knowledge about El Niño

What are the mechanisms of El Niño ?

Bjerknes' idea: a coupled instability...

Yes but ?

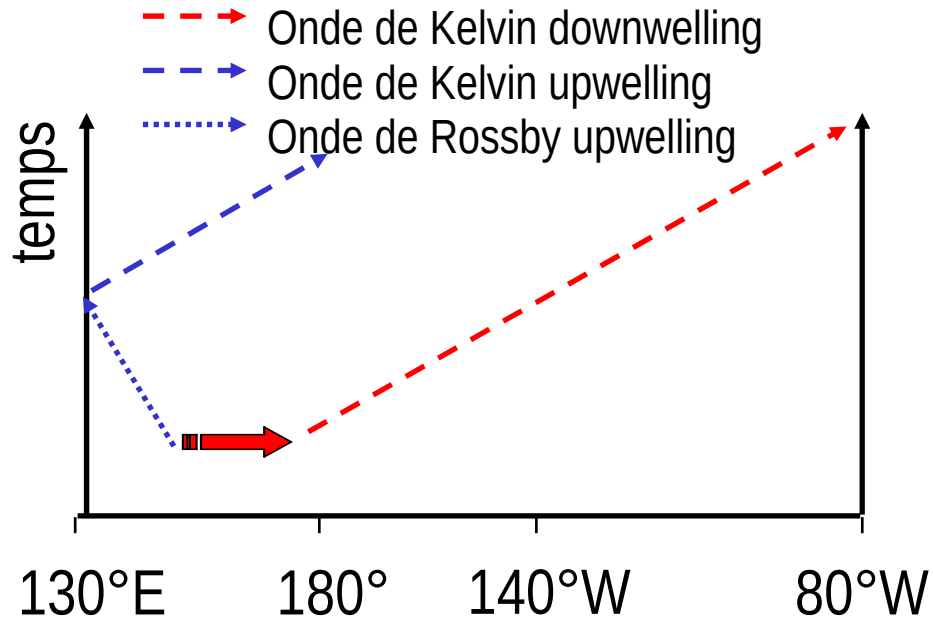
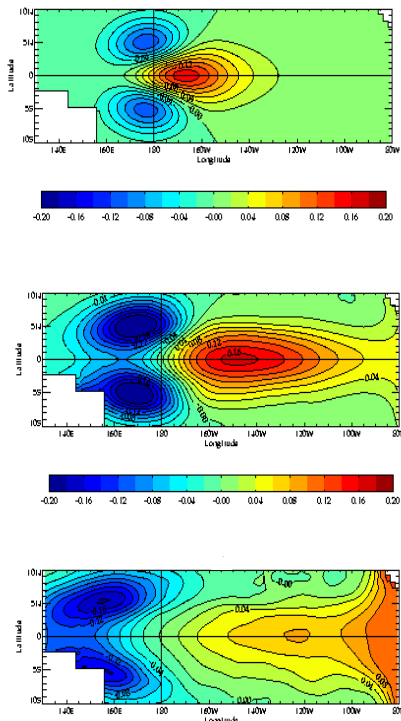
What triggers El Niño ?

What « ends » El Niño ?

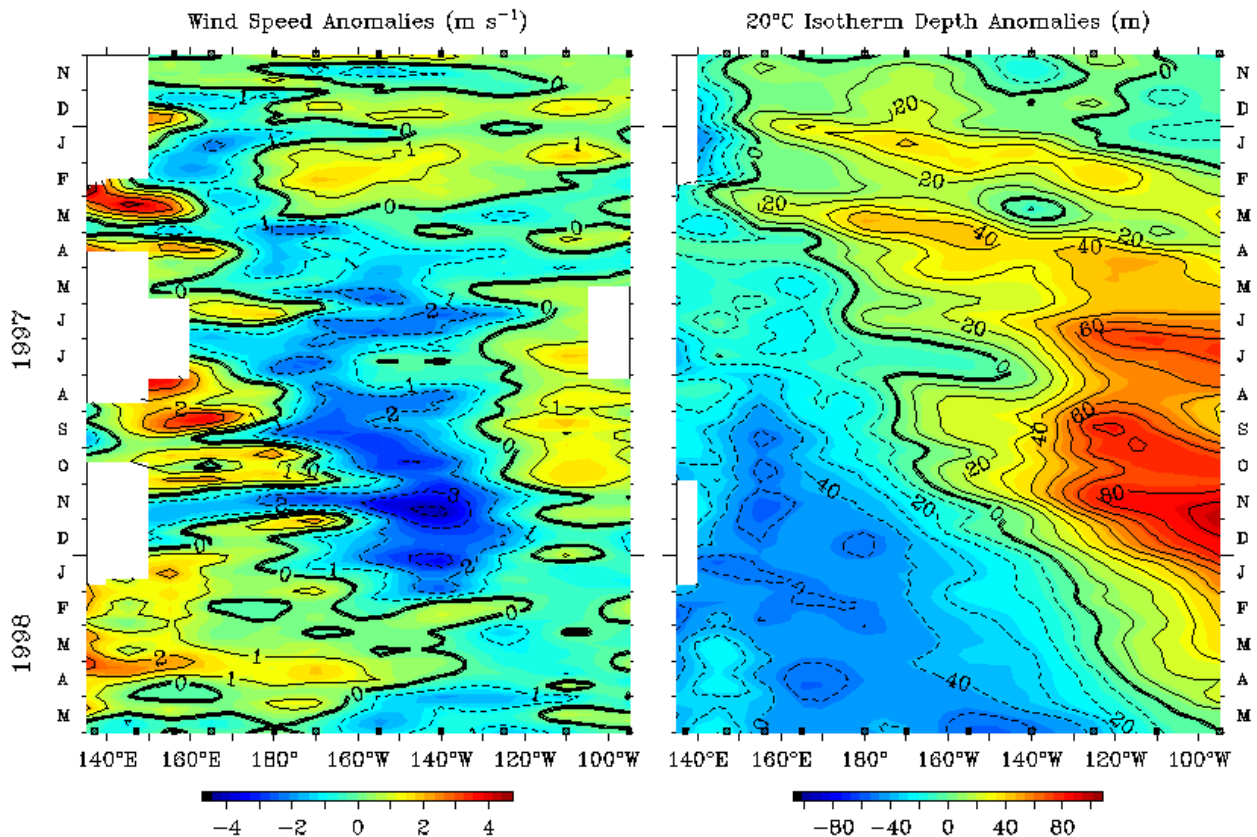
=> the concept of « equatorial waves »
and the theory of the delayed oscillator

The equatorial waves

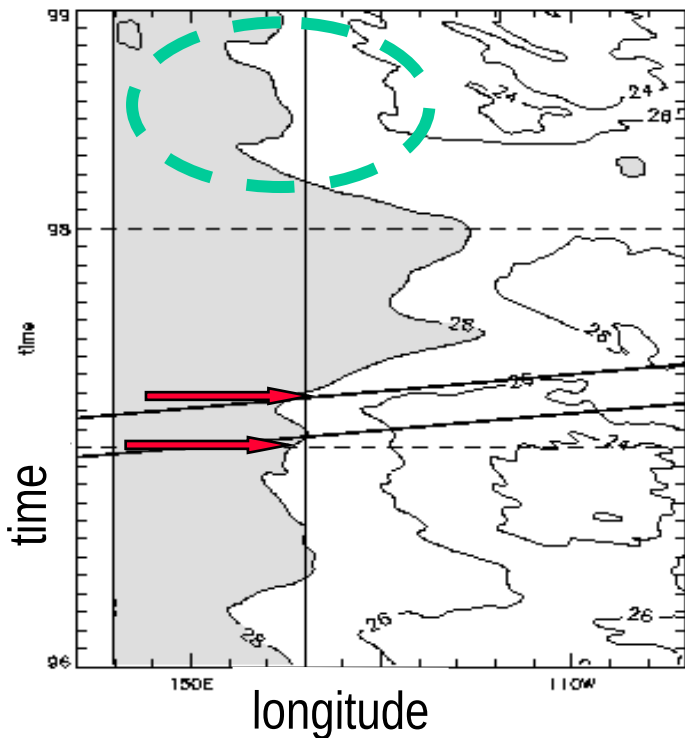
Evolution du niveau de la mer sous l'effet d'un coup de vent d'ouest



Five-Day Wind Speed and 20°C Isotherm Depth 2°S to 2°N Average



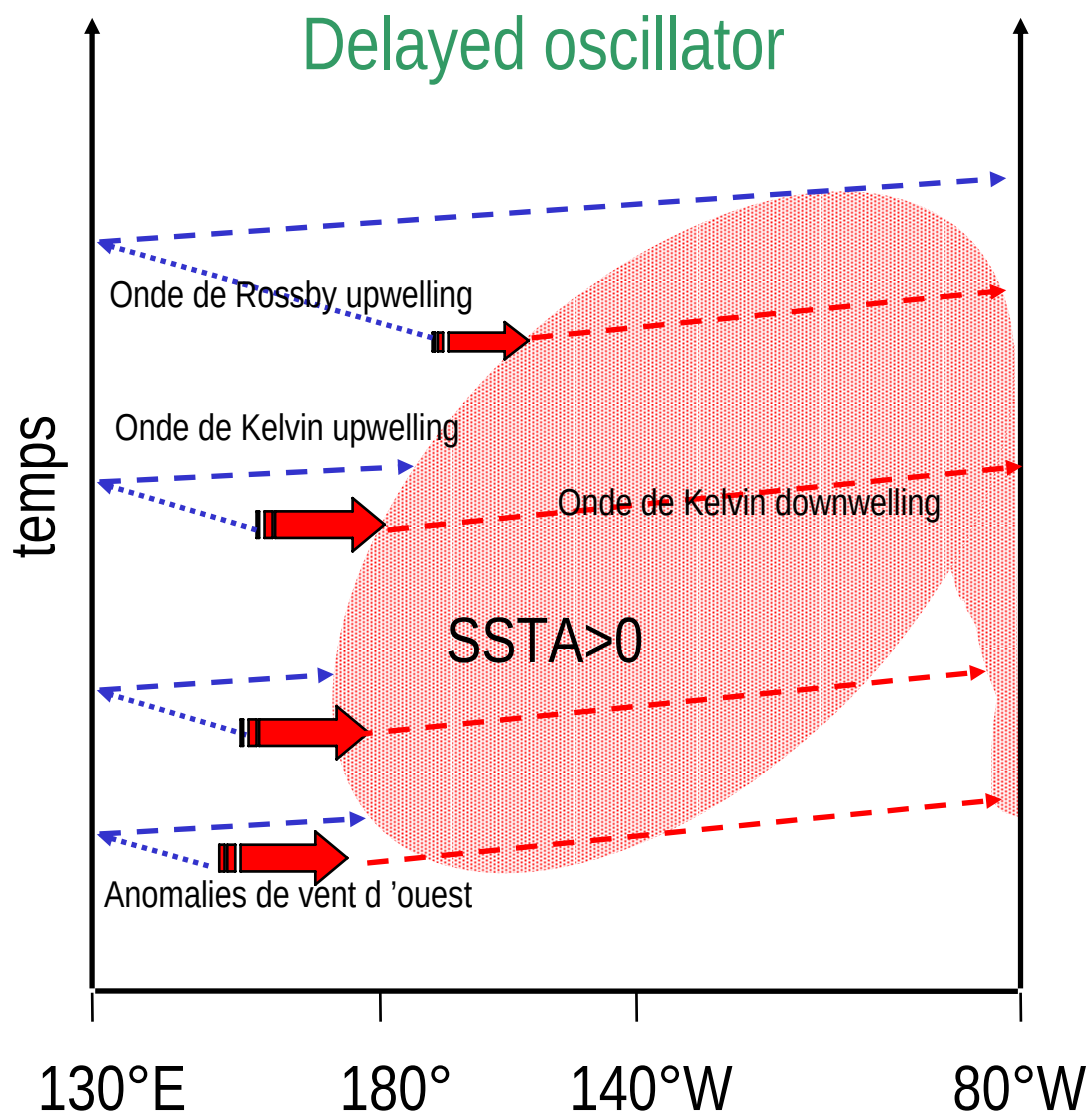
The example of El Niño 1997-98



trigger : gust of wind

Development : coupled instability

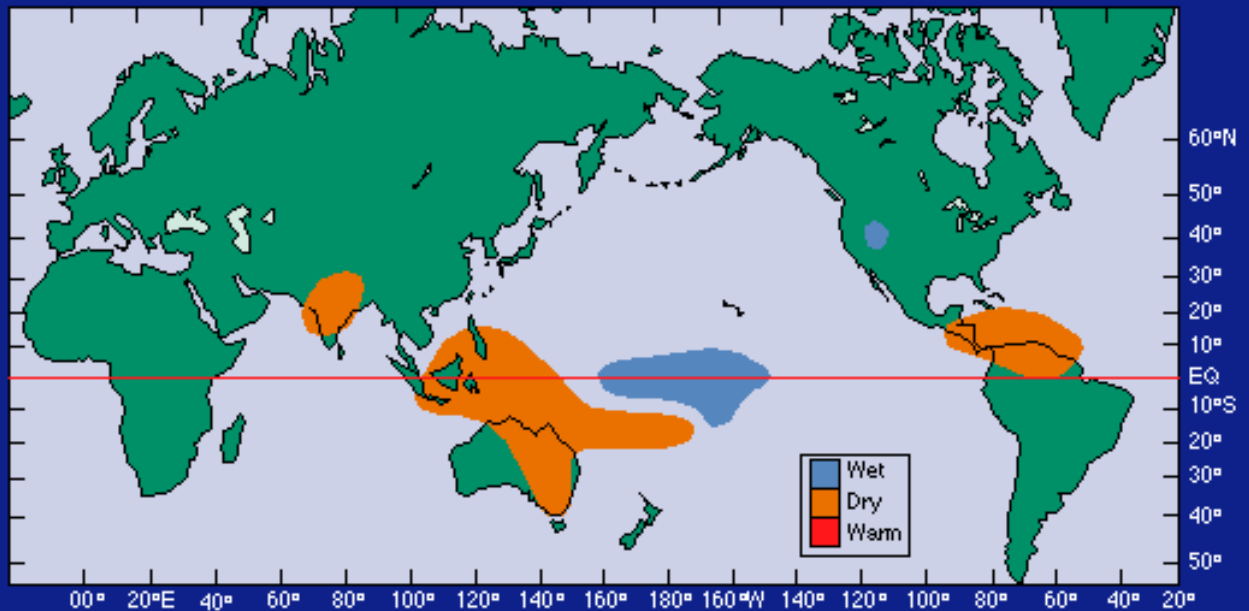
End : delayed oscillator (and local wind)



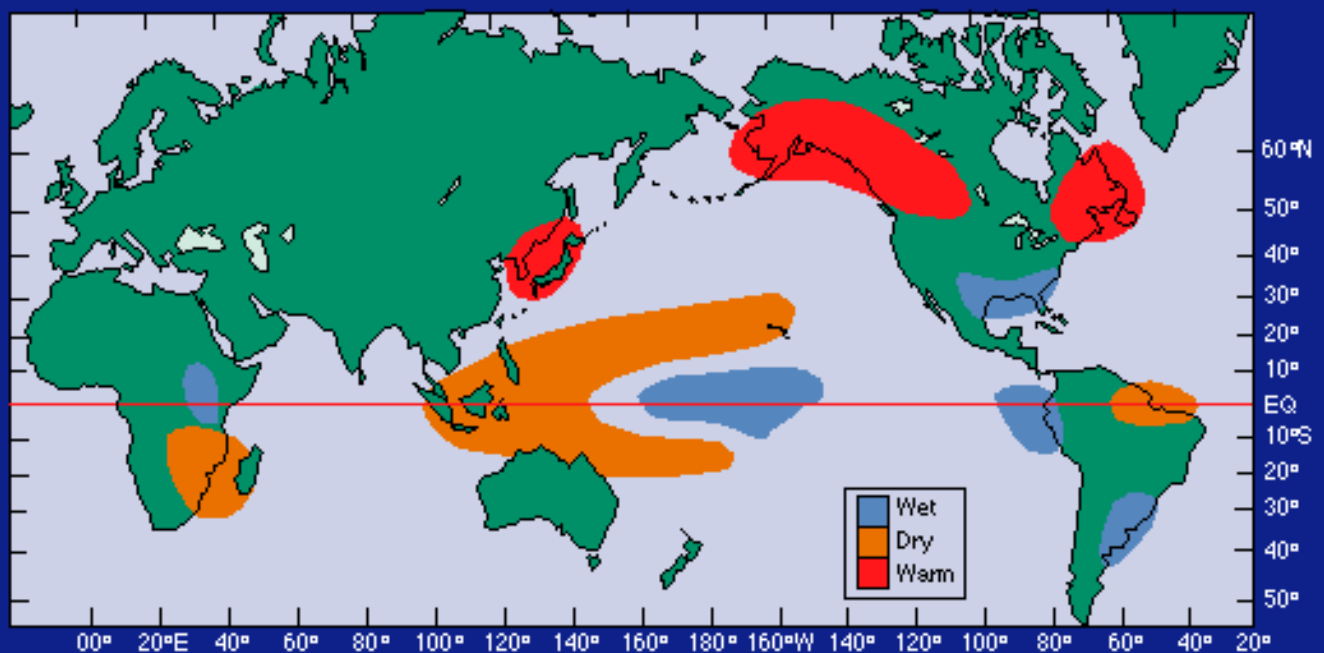
El Niño Impacts

Rain and drought

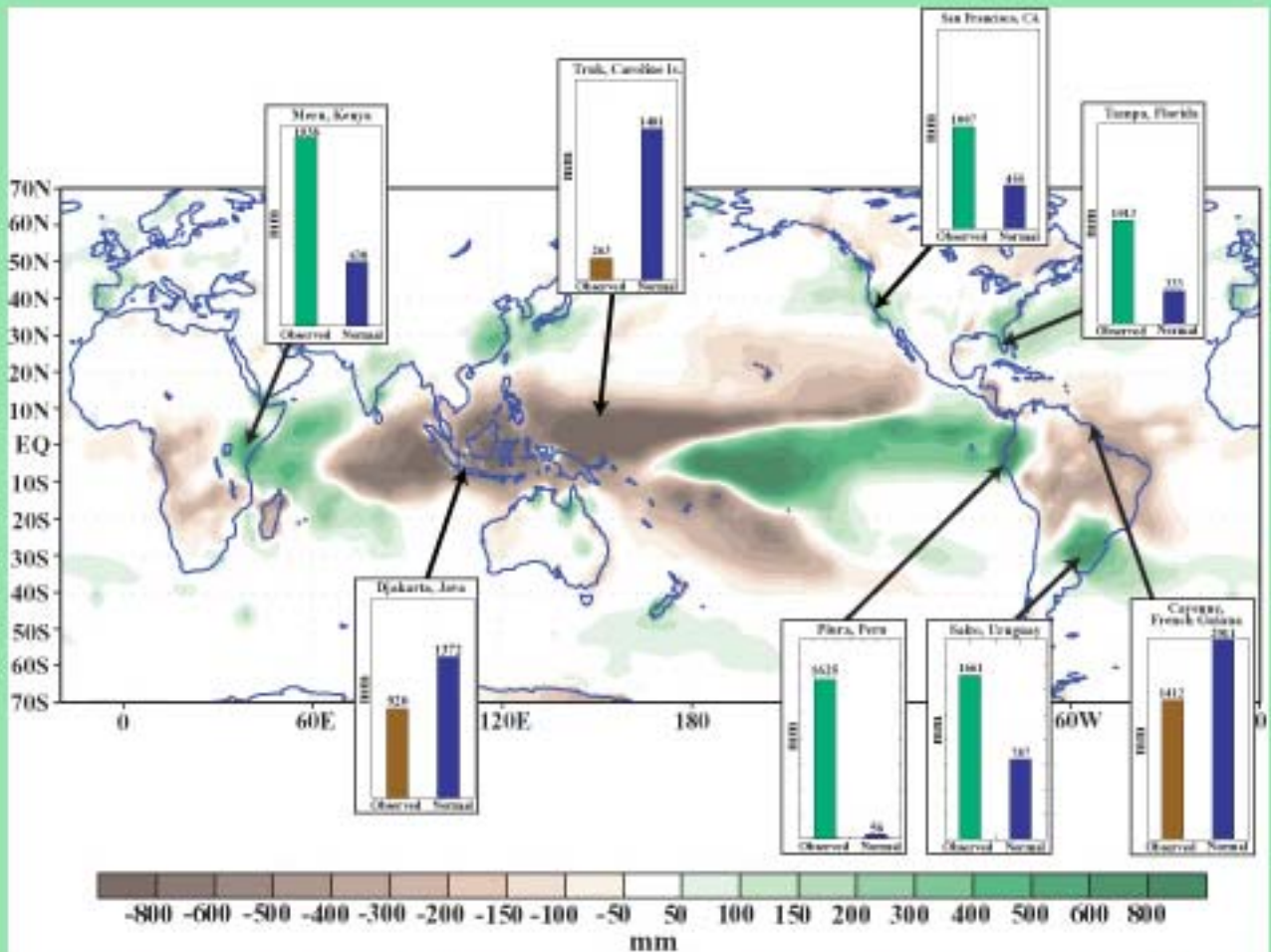
Northern Hemisphere Summer



Northern Hemisphere Winter



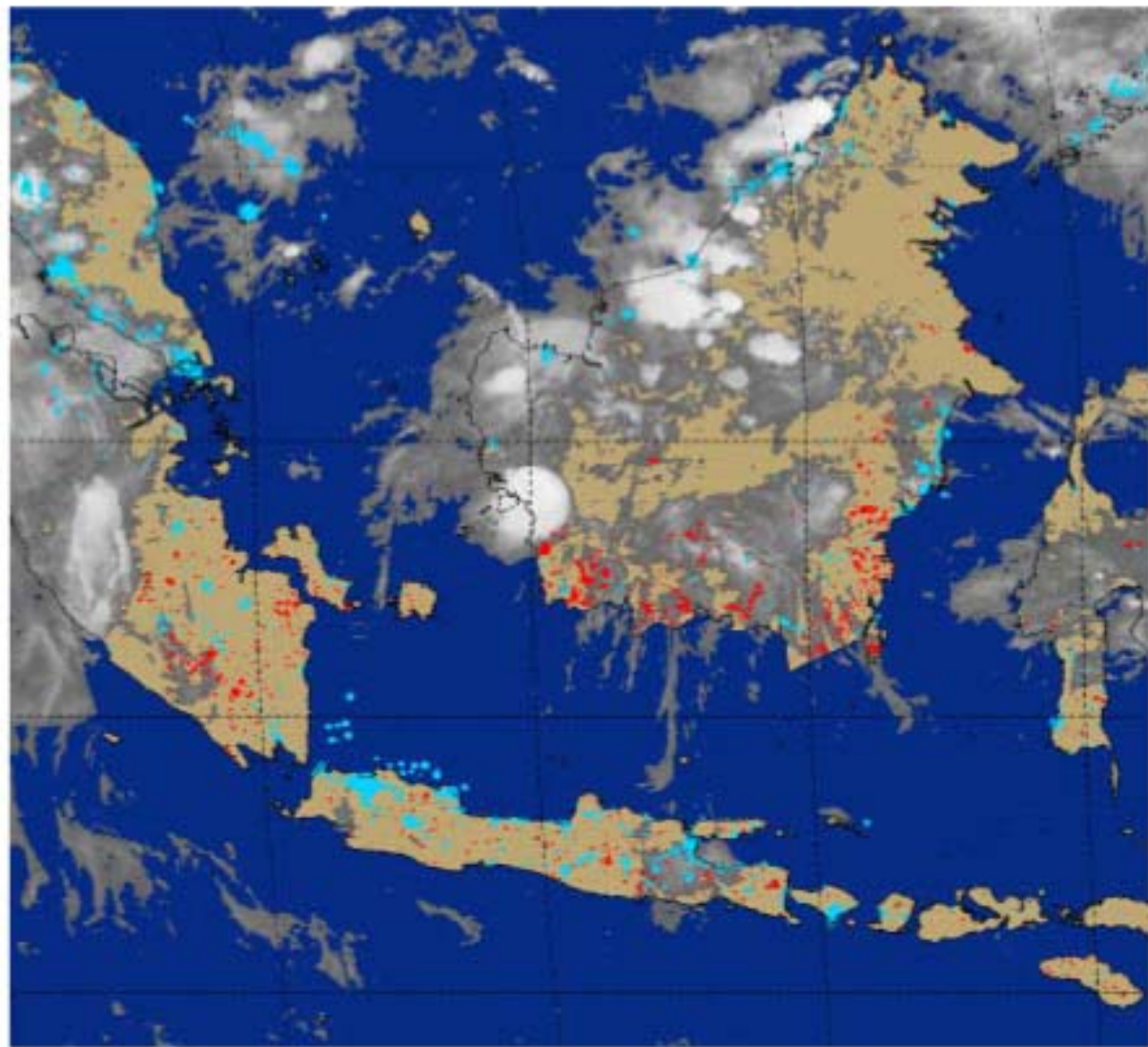
Global Rainfall Anomalies Winter 1997/98



Accumulated rainfall departures during November 1997-April 1998. Precipitation amounts are obtained by merging rain gauge observations and satellite-derived precipitation estimates. The satellite estimates are generated by the outgoing longwave radiation precipitation technique (Xie and Arkin, 1998), and are merged with rain gauge data via a method adapted from Xie and Arkin (1996). Anomalies are departures from the 1979-95 base period means (from BAMS, 1999, 80, S1-48).

ENSO Impacts

ENSO events have tremendous impact in various regions of the world. For example, warm ENSO extremes are accompanied by droughts in parts of Africa, south-east Asia, Australia and Brazil and flooding in western South and North America and Florida.



Fires in the tropical forest of Indonesia (red dots), snapshot on September 30, 1997 (courtesy of NOAA/Significant Event Imagery)

El Niño Impacts: Hurricanes

El Niño modifies the atmospheric circulation (structure of the vertical winds) and influences the occurrence frequency of the hurricanes:

El Niño + hurricanes over the eastern Pacific
 - hurricanes over the Atlantic

(6 hurricanes in French Polynesia in 1982-83 !)

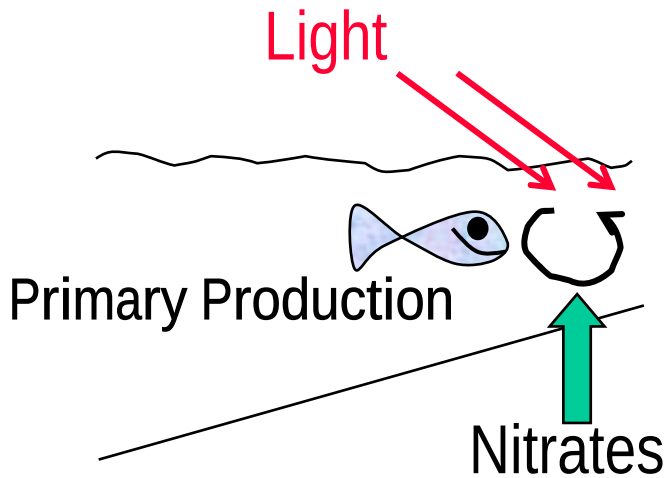
La Niña + hurricanes over the Atlantic



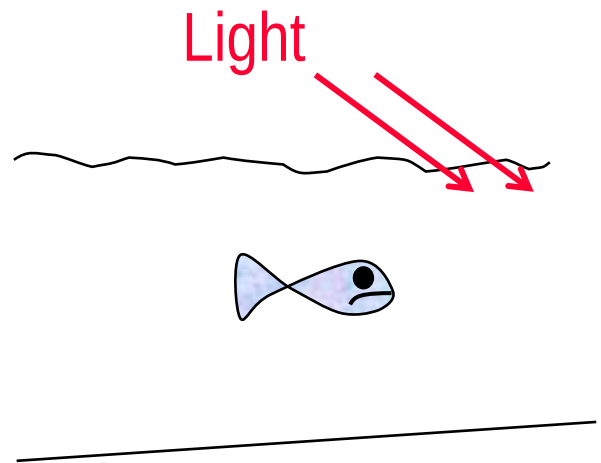
George, september 1998

El Niño Impacts Ecosystems and resources

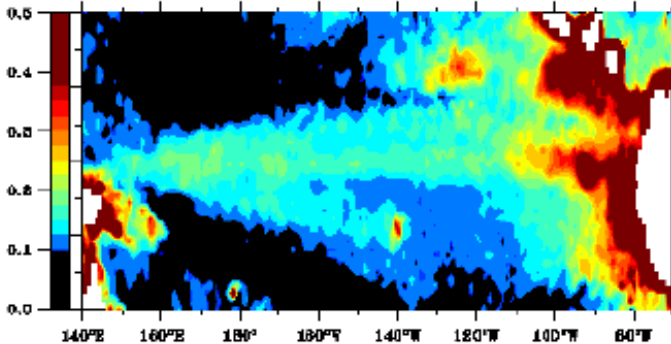
Normal year



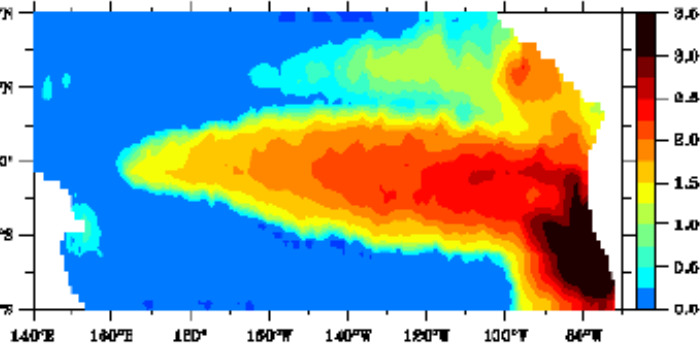
El Niño



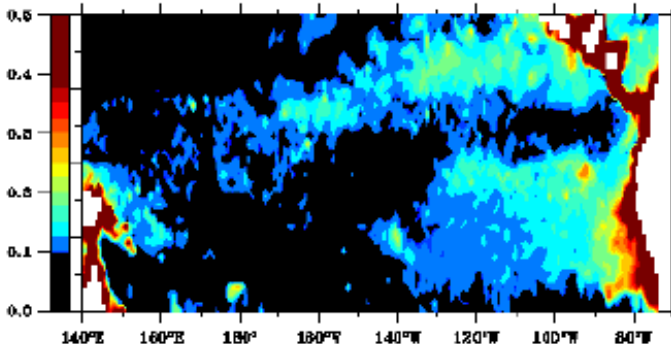
NOVEMBER 96 - POLDER chl ($\mu\text{g l}^{-1}$)



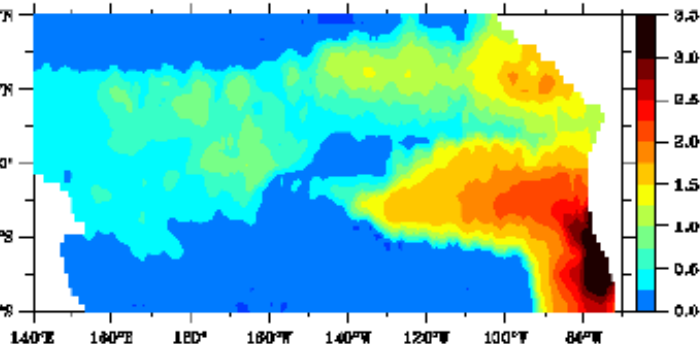
modeled new production ($\text{mole N m}^{-2} \text{d}^{-1}$)



DECEMBER 1997 - SeaWiFS chl ($\mu\text{g l}^{-1}$)



modeled new production ($\text{mole N m}^{-2} \text{d}^{-1}$)

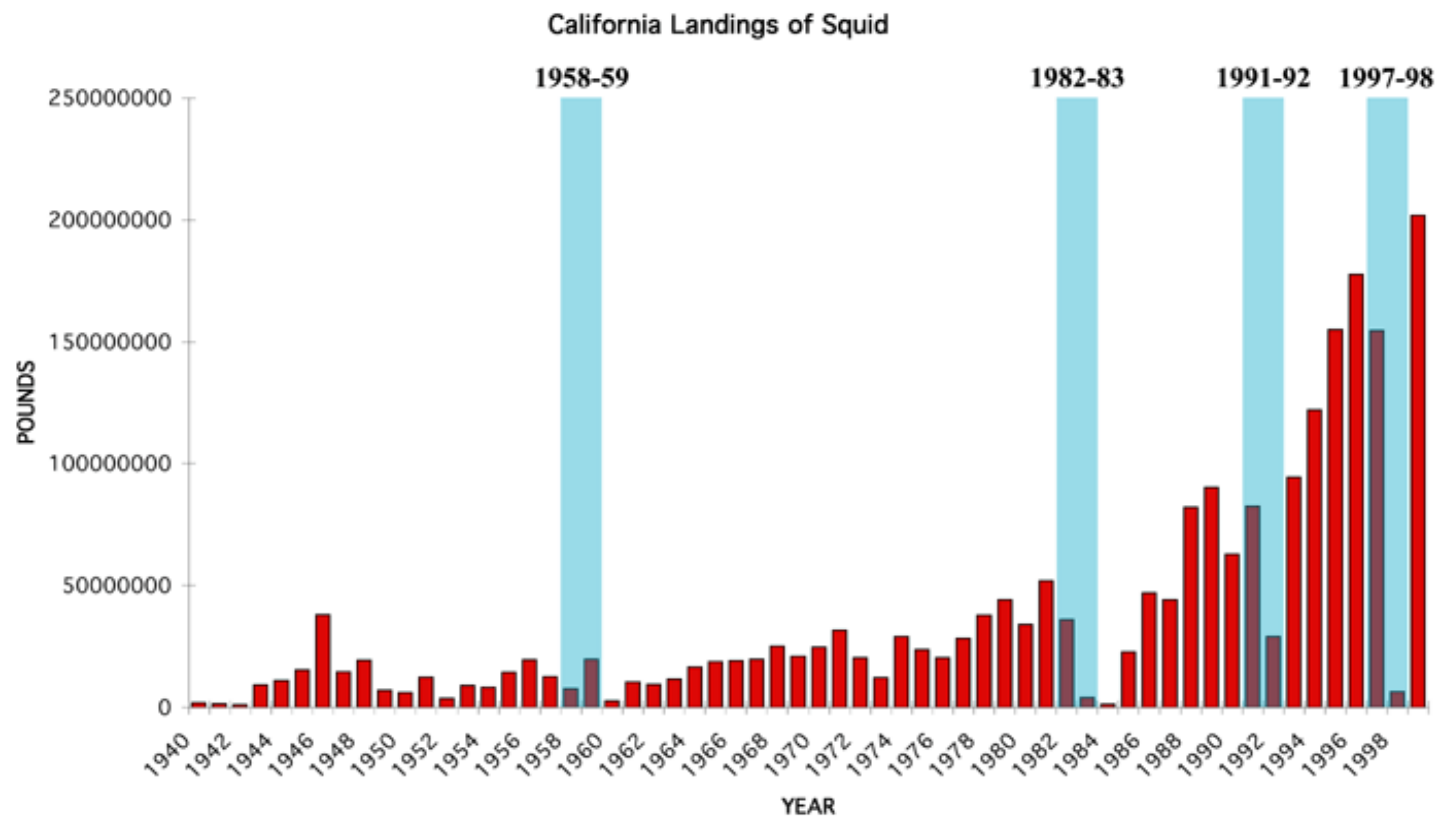


adapted from Radenac et al., 2001

=> Impact for fisheries

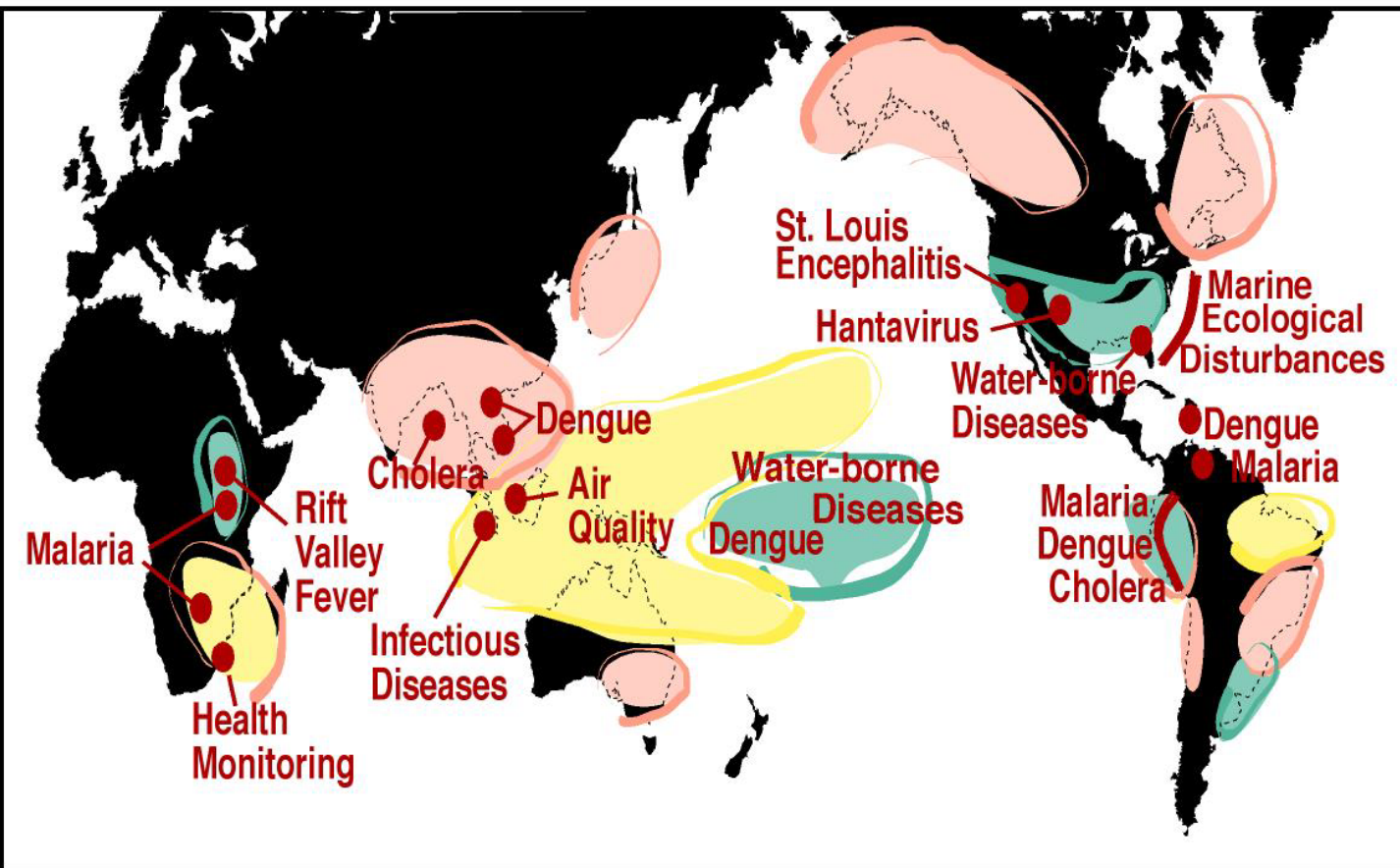
El Niño Impacts Marine populations

Marine populations and therefore...
fisheries, fauna from the Pacific islands...



El Niño Impacts Health

Exploring the Linkages between the
El Niño-Southern Oscillation (ENSO) and Human Health



Generalized El Niño-Southern Oscillation (ENSO) Impacts

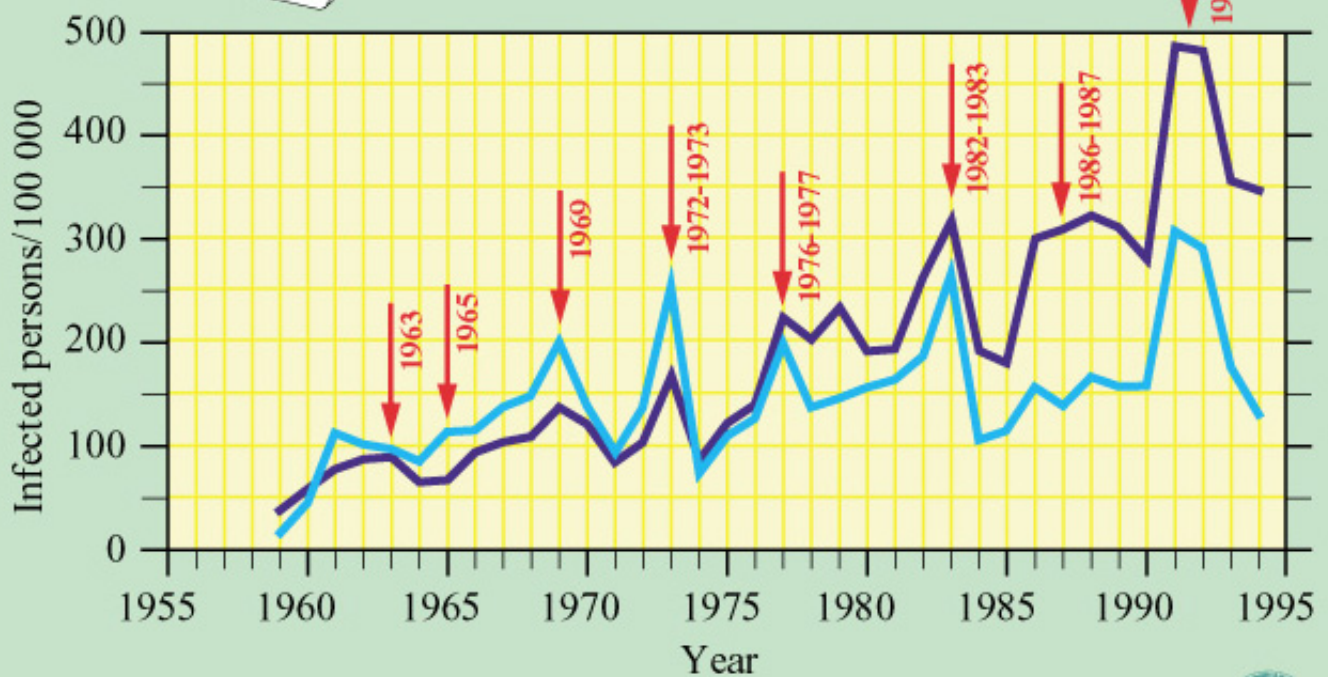
Yellow = DRY
Green = WET
Orange = WARM

Yellow = DRY & WARM
Green = WET & WARM
Light Green = WET & COOL

El Niño Impacts Health



Malaria in Colombia



courtesy M. Latif



AV/G1/0101

El Niño Impacts

- Evaluation of the economic price of El Niño in 1982-83

Affected Zones:

Peru, Indonesia, Australia...
South Africa, Nordeste, India...
African horn, western Africa

Impacts:

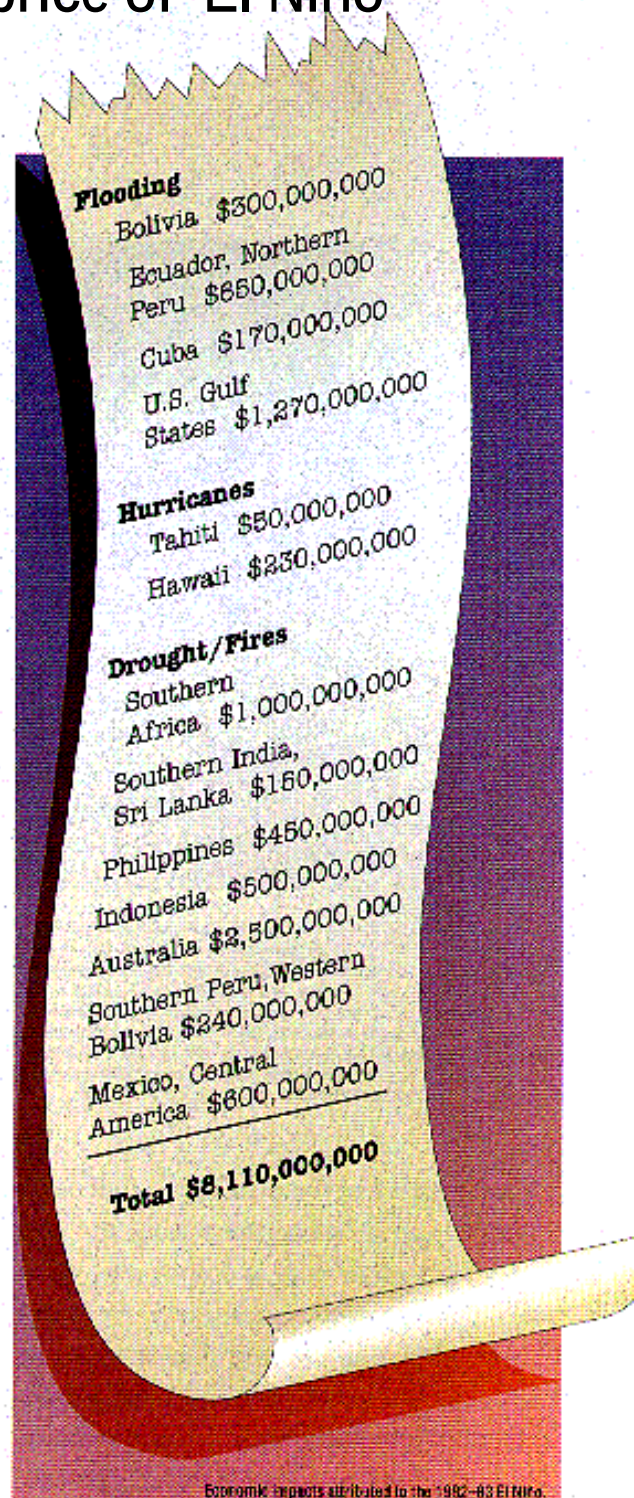
hurricanes

Floods

Drought



Socio-economical
consequences

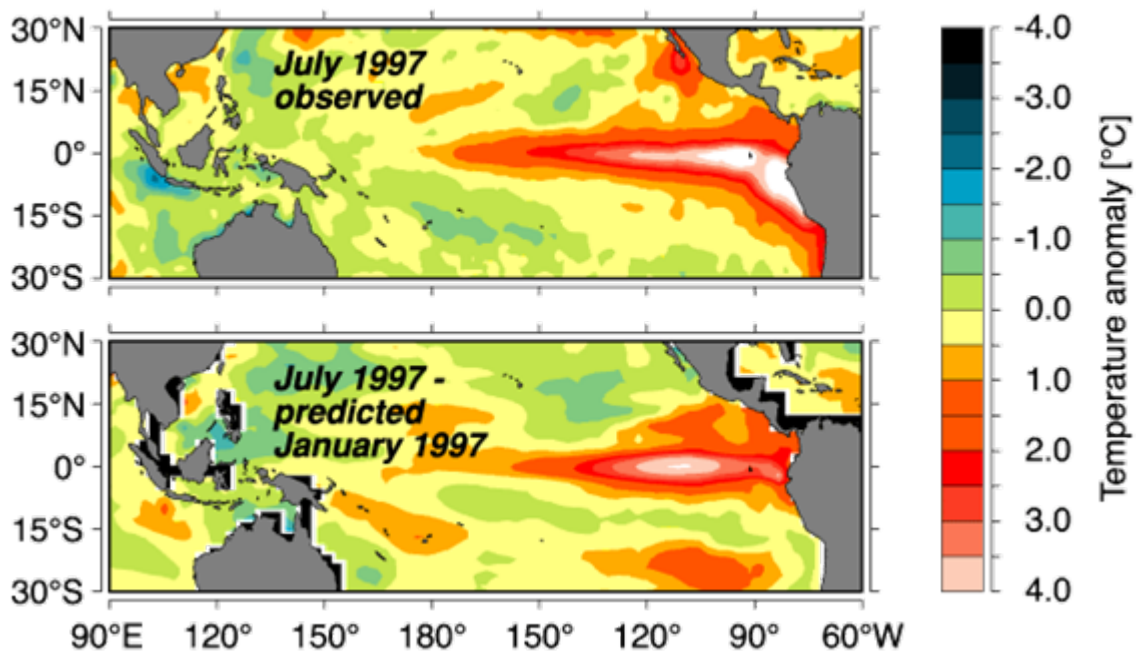


Previsibility and predictability of El Niño

El Niño, a capricious child from nature...



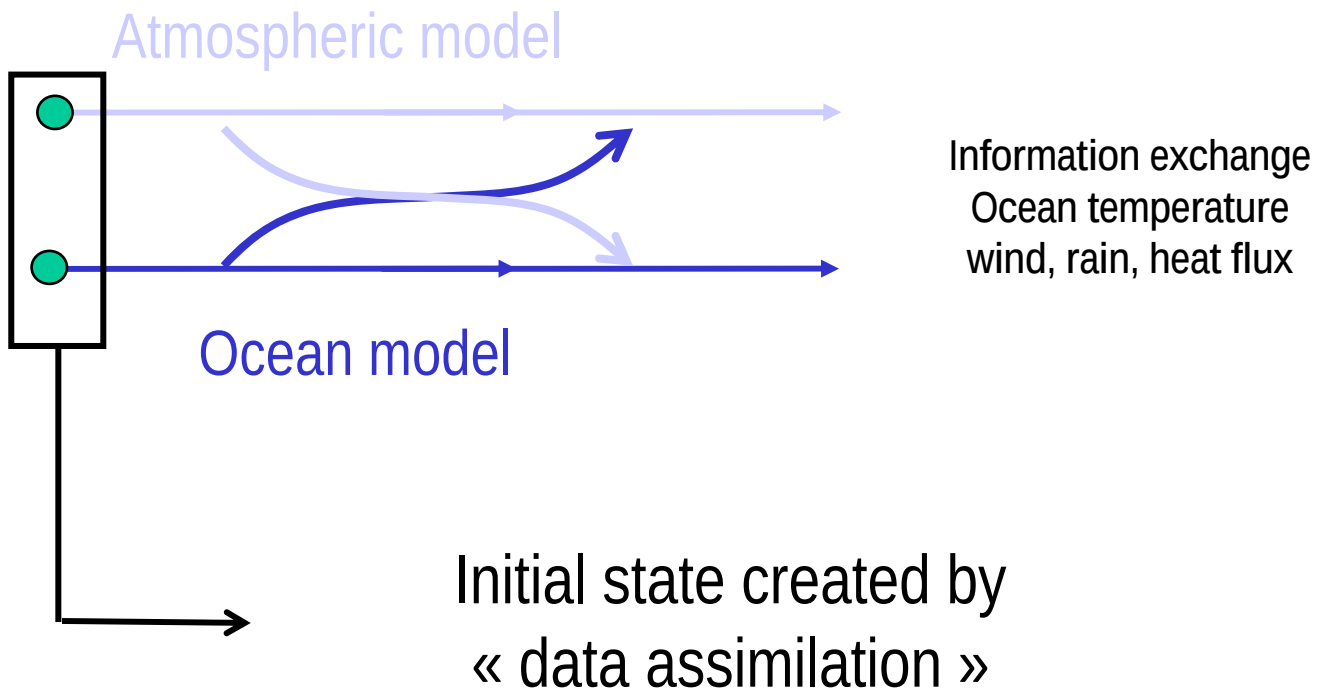
Is El Niño predictable?



Previsibility and predictability of El Niño

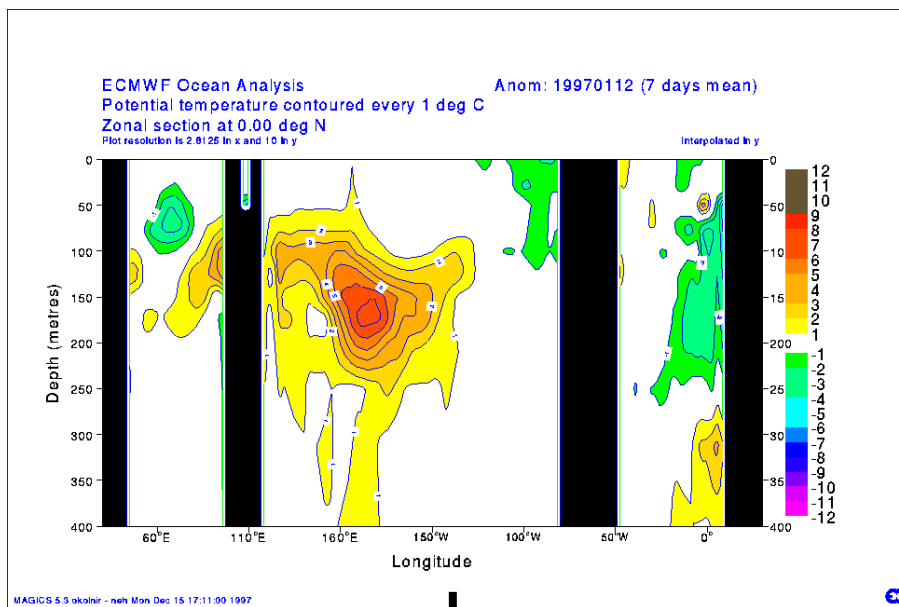
Various techniques for predictability of El Niño
(statistics, based on physical models)

Prediction system of the European Center



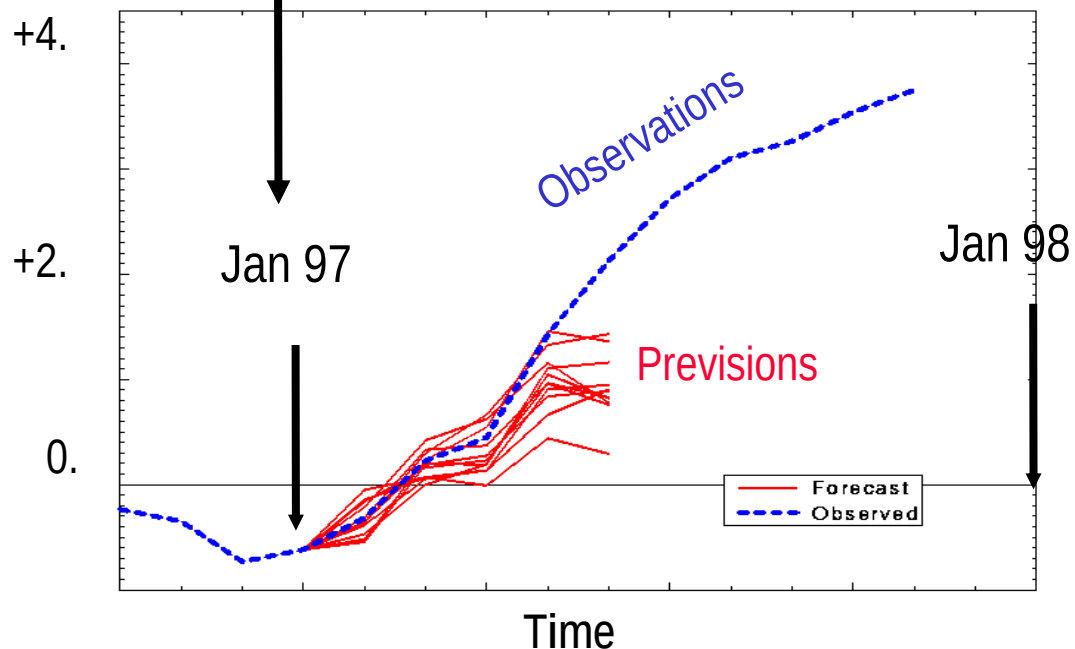
Previsibility and predictability of El Niño

Prevision of El Niño 1997-98 by the system of the European center



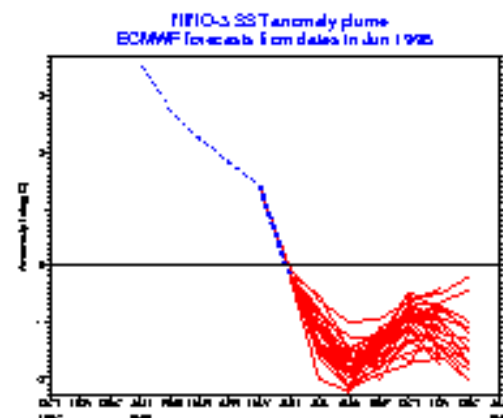
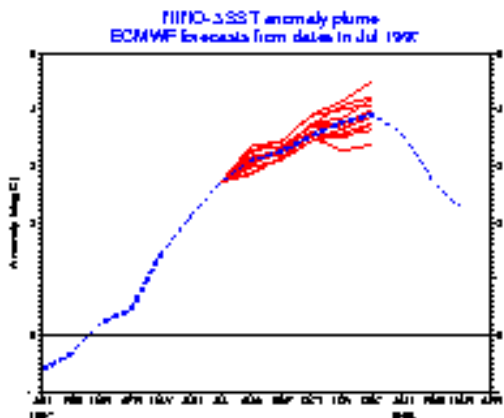
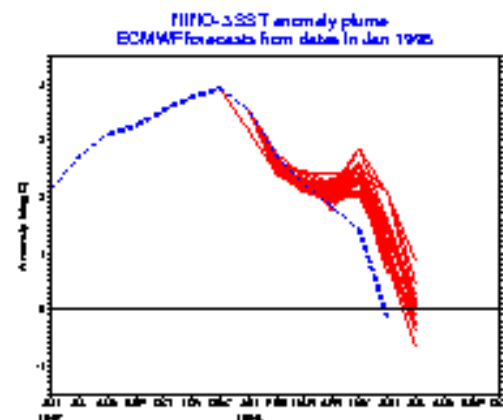
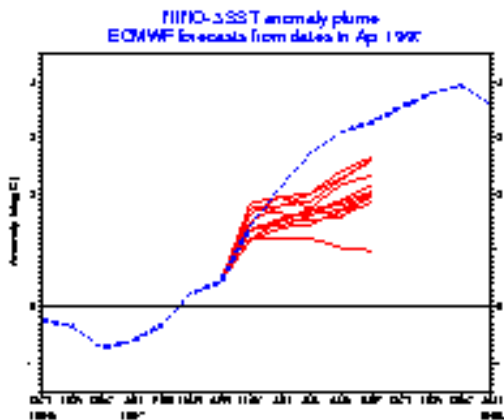
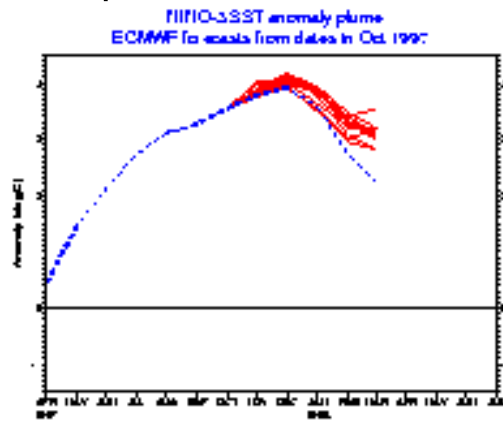
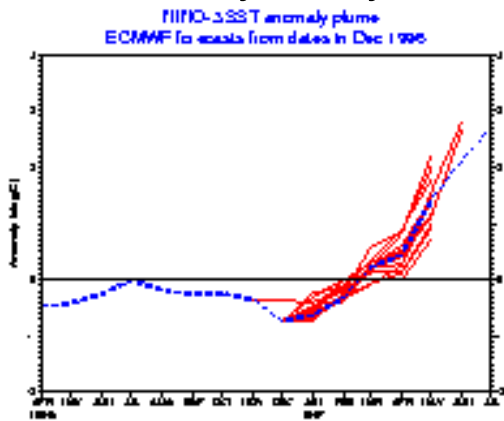
Initial oceanic conditions

Ocean:
Memory of the
ocean-atmosphere
coupled system



Previsibility and predictability of El Niño

Prevision of El Niño 1997-98
by the system of the European center



Previsibility and predictability of El Niño

El Niño can be forecasted with some reliability (6 month)
but ...

the performances of the prevision systems are still
dissimilar (dependence of the amplitude, the sign, the
starting period...) : strategy of the models

-> need of better determining the initial conditions, local and
non local

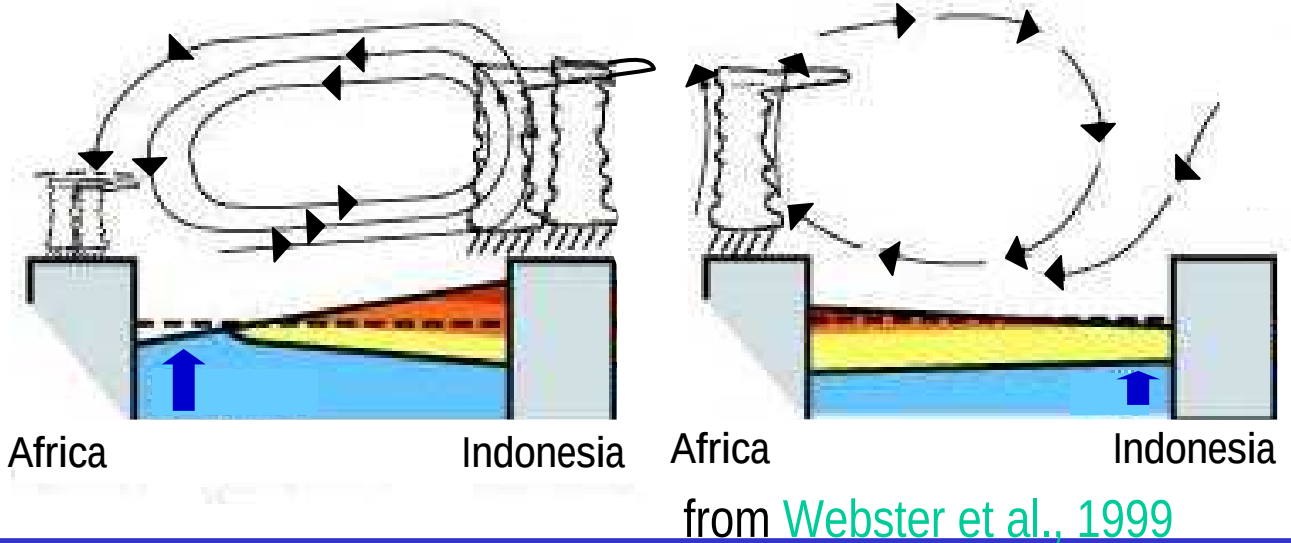
-> need of better representing the atmospheric tropical
synoptic activity

What are the consequences of El Niño ?

In the tropics, the consequences are rather systematic, and
thus predictable

Toward higher latitudes, the predictions are not
« **deterministic** » any more but « **probabilistic** », due to the
« **chaotic** » character of the atmosphere

The Indian Ocean



Climatic Impacts



Consequences

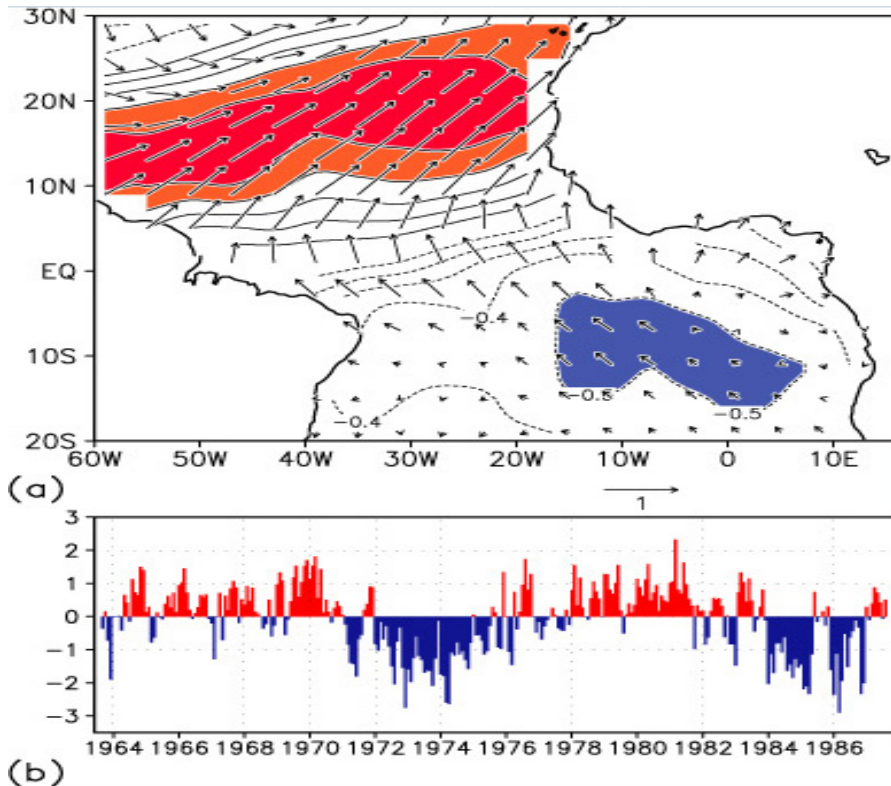
Epidemic (RVF, Cholera, Malaria)

Floods (e.g. White Nil 1961-82)

Fires (Indonesia, 1997)

Tuna fishing (Marsac et Le Blanc, 1999)

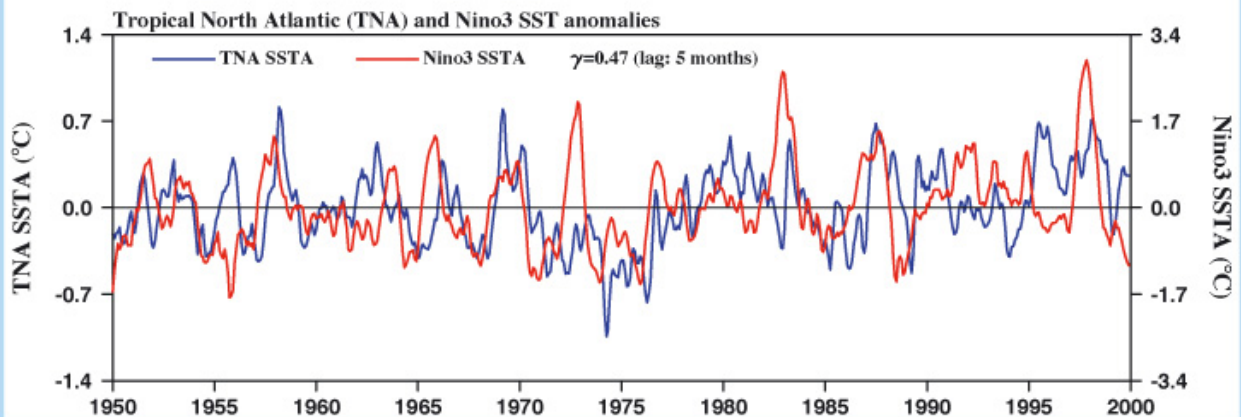
El Niño and beyond tropical Atlantic Ocean



weak
precipitations in
the Bresilian
Nordeste

ENSO and Atmospheric Circulation Cells

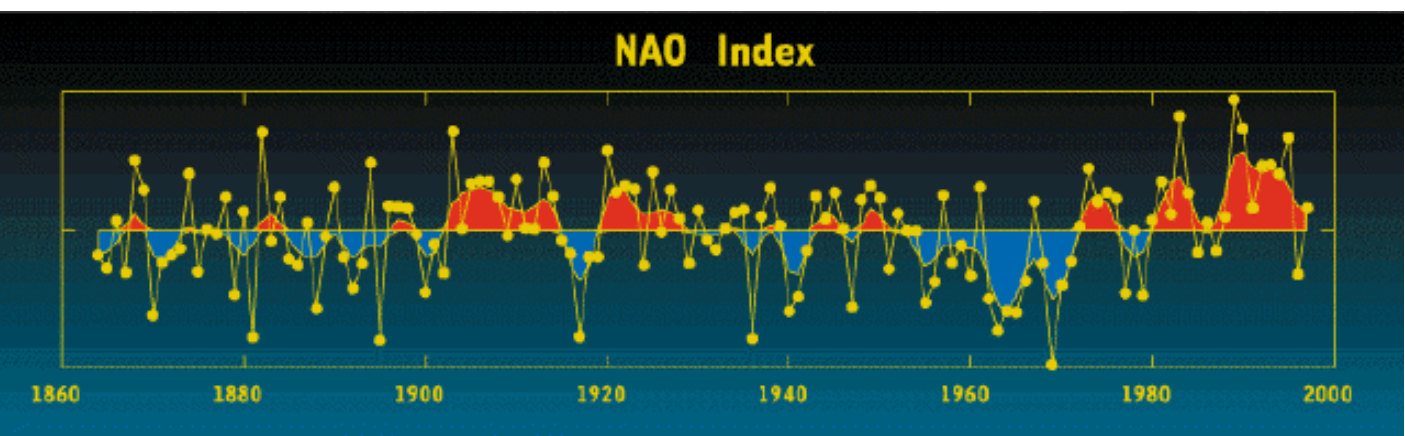
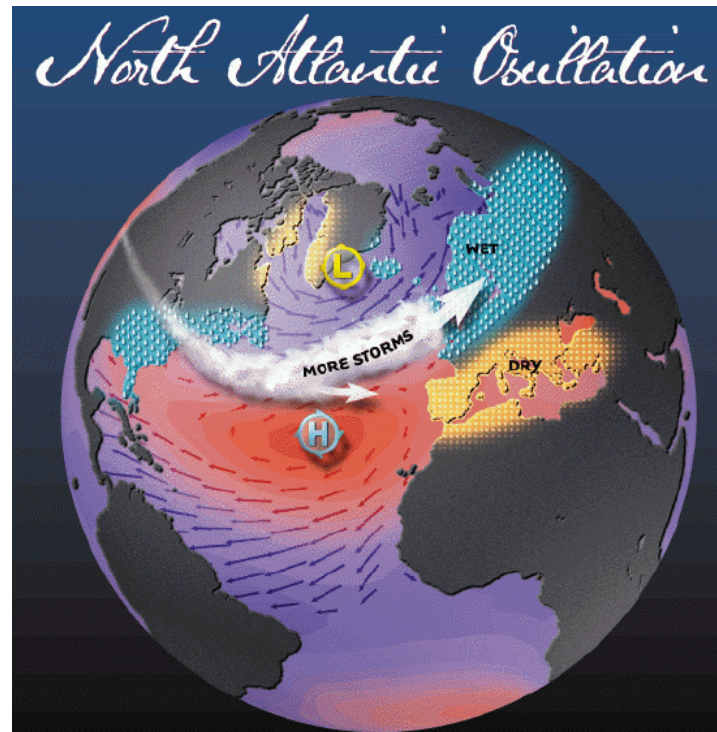
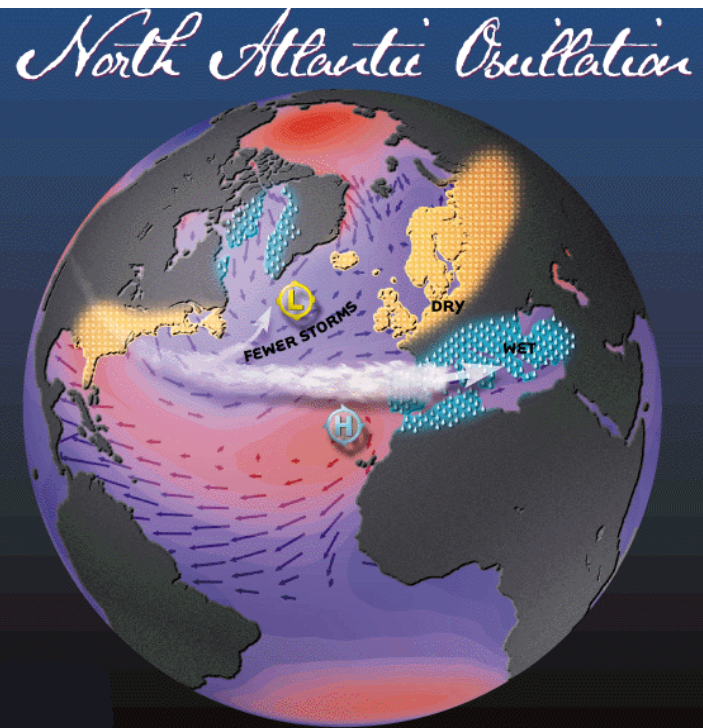
Relationship of ENSO with the tropical North Atlantic



Three-month running means of SST anomalies in the tropical North Atlantic (TNA) region (5°N-25°N, 55°W-15°W) and SST anomalies in the Niño-3 region (5°S-5°N, 150°W-90°W). The γ represents correlation coefficient. The data are from the NCEP SST.
(From Wang, CLIVAR Exchanges, 2/2002)

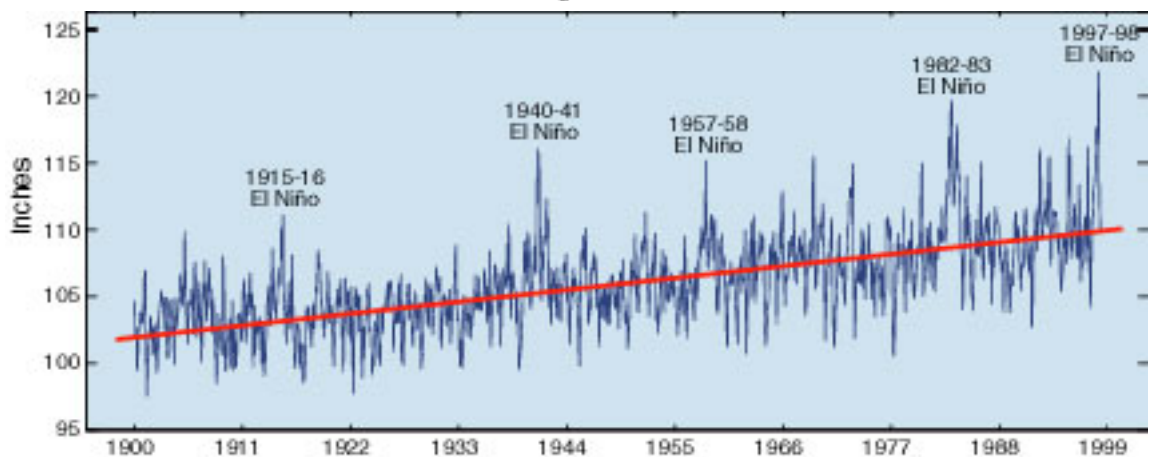
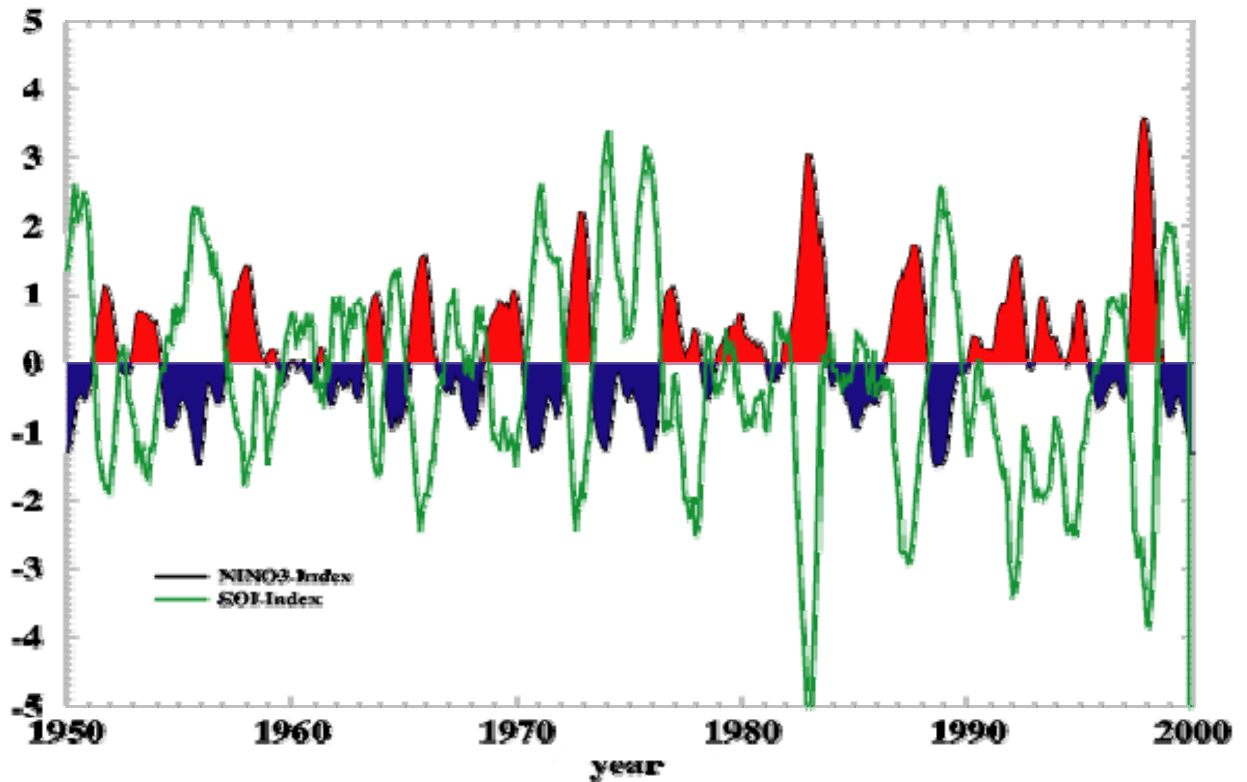
El Niño and beyond

North-Atlantic oscillation

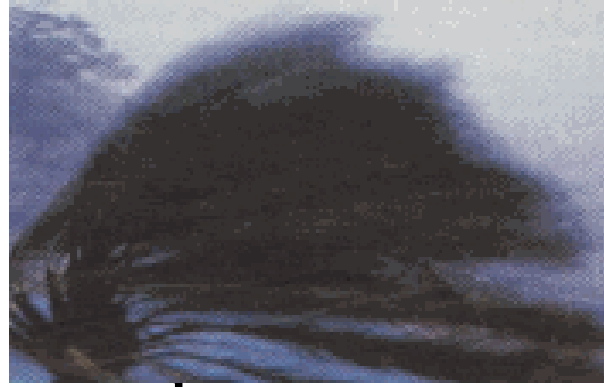


And the Climatic change ?

ENSO 1950 - 1999



In summary...



El Niño, coupled climatic phenomenon between ocean and atmosphere, impacts everywhere in the world.

Twenty years of international collaborative research to explore the scientific grounds and to start to elaborate prediction systems based on the coupled use of observations and models

El Niño is predictable several months in advance (as well as the expected impacts)

There exist other ocean-atmosphere coupled models. We now need to understand the mechanisms and learn how to predict the events.

