


**Recent Progress
in Observing and Understanding
Tropical Ocean Variability
from Satellite Altimetry**



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and...**

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(2) ESR, Seattle, USA

(3) ESSIC, Maryland, USA

(4) University of Maryland, USA

(5) NOAA/NESDIS, Maryland, USA

(6) LEGOS, Toulouse, France

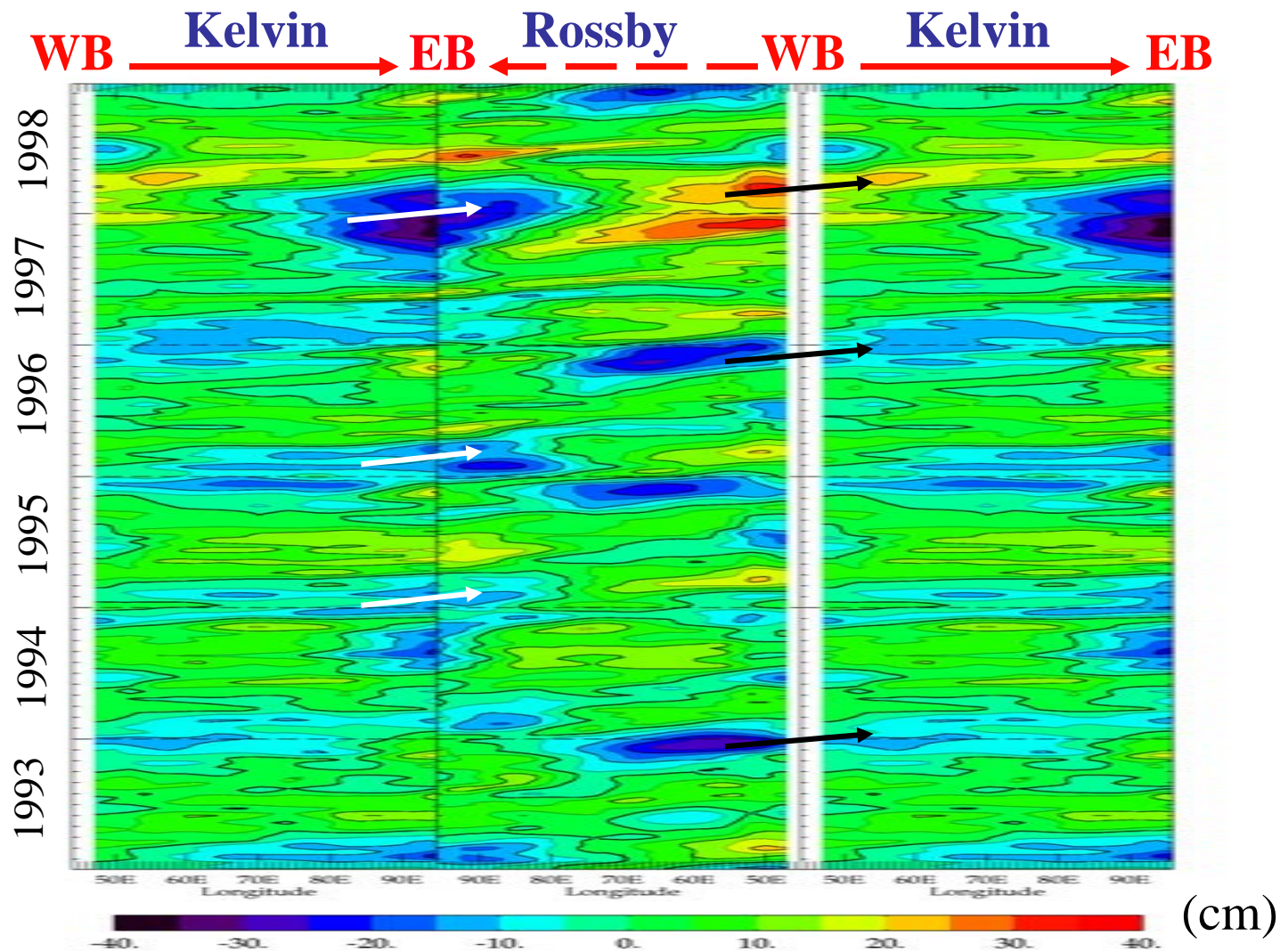
(7) University of South Florida, USA

(8) NOAA/PMEL, Seattle, USA

Outline

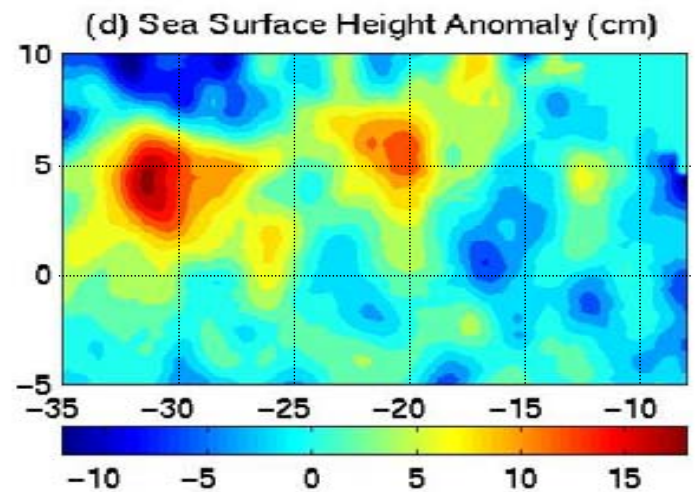
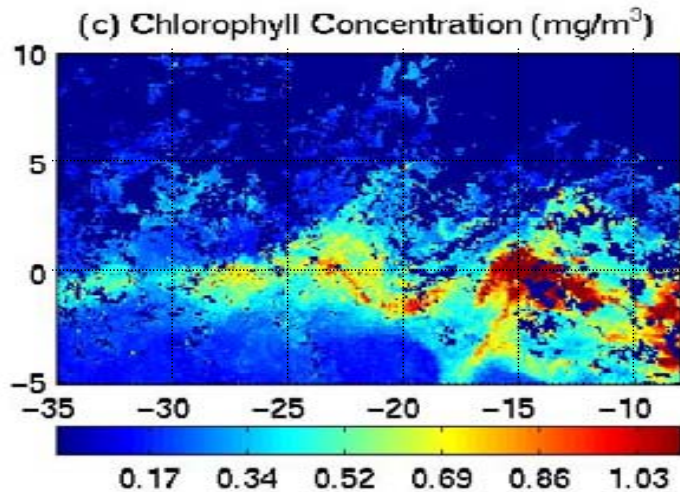
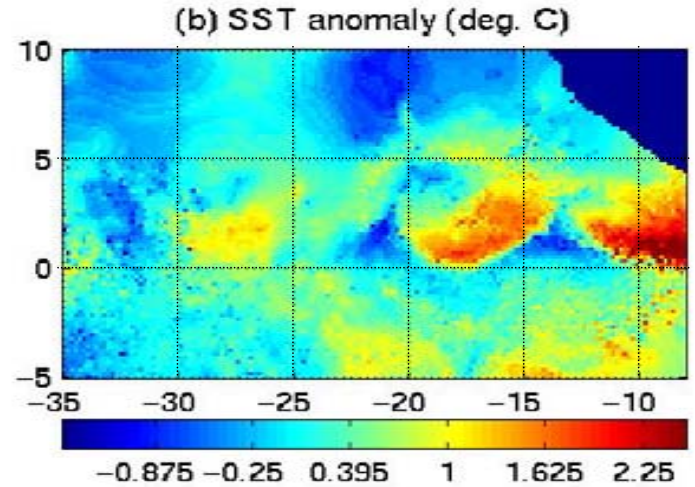
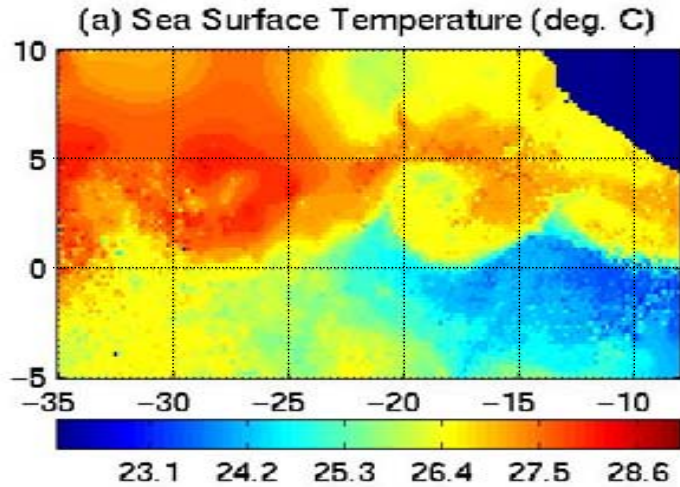
- **Brief results on the Indian Ocean and tropical Atlantic Ocean**
- **Understanding the 1997-98 El Niño-La Niña**
- **Testing ENSO (El Niño-Southern Oscillation) theories**
- **Difficulties in ENSO prediction**
- **Need for multiple and long-lasting altimetry missions**
- **Conclusions**

Equatorial wave reflection in the Indian Ocean



Le Blanc, Boulanger, 2001

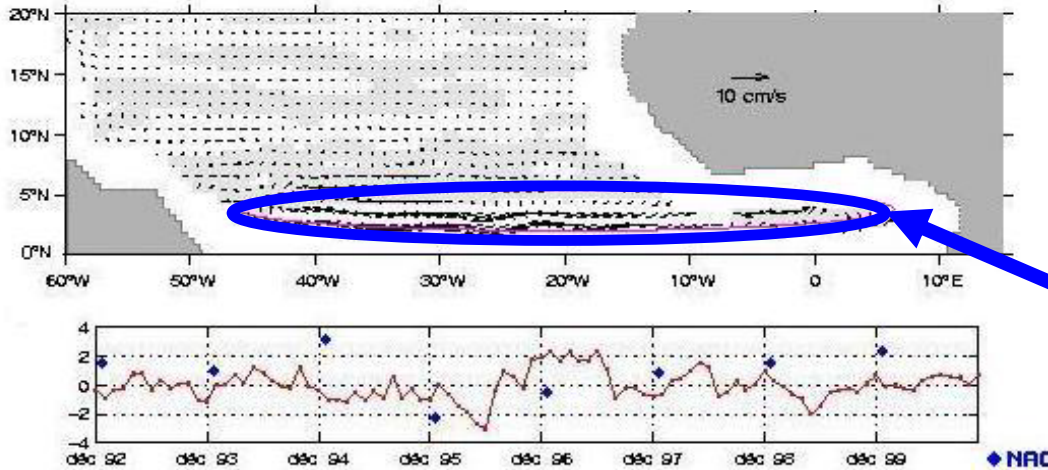
Tropical Instability Waves in the tropical Atlantic



Foltz, Carton, Chassignet, 2003

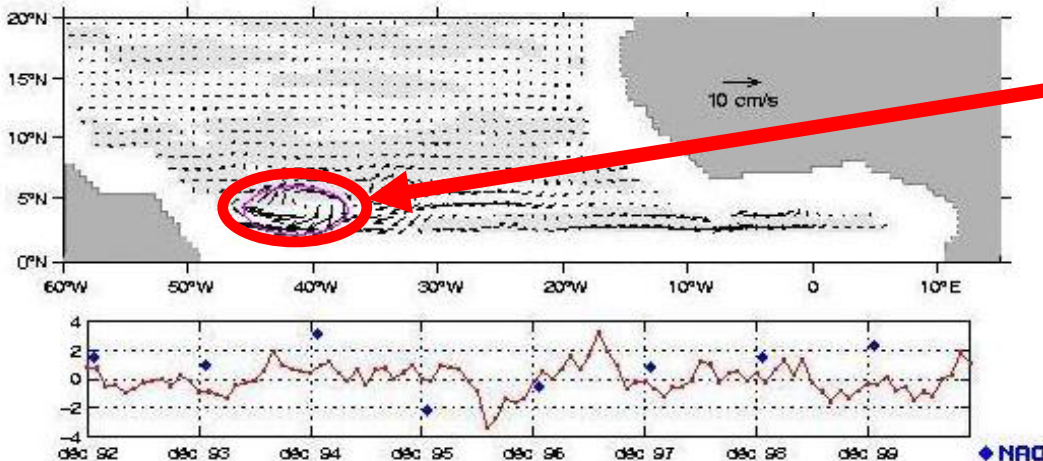
Major current patterns in the tropical Atlantic from 10 years of TOPEX/Poseidon

EOF#1 (10%)



A large pattern involving the NECC and SEC circulation

EOF#2 (8%)



A smaller pattern located near the western boundary in the NECC retroreflection area

S. Arnault, ongoing study

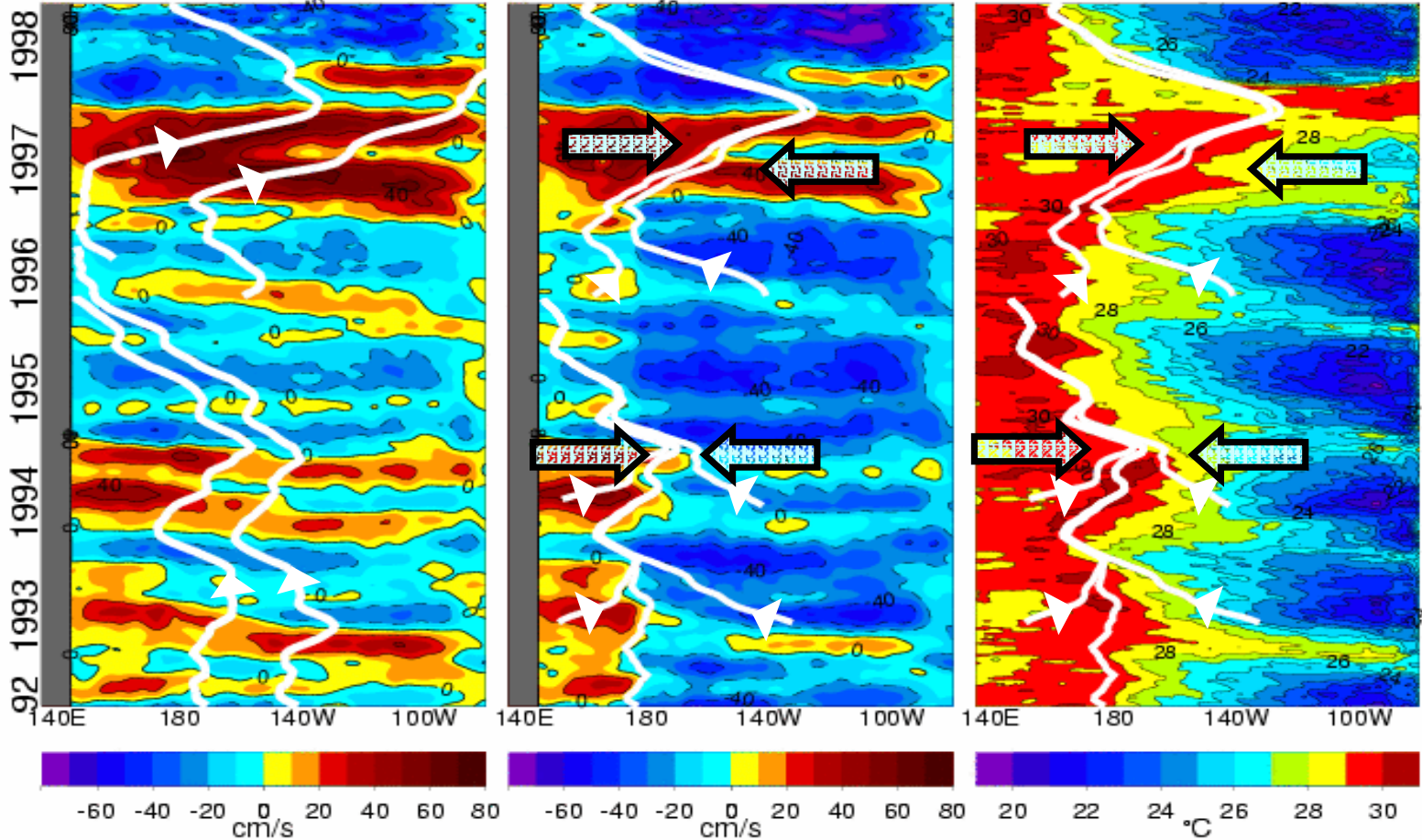
Evidence of an oceanic zone of convergence on the eastern edge of the Pacific warm pool

TOPEX/Poseidon derived zonal currents along the equator

Anomalous currents

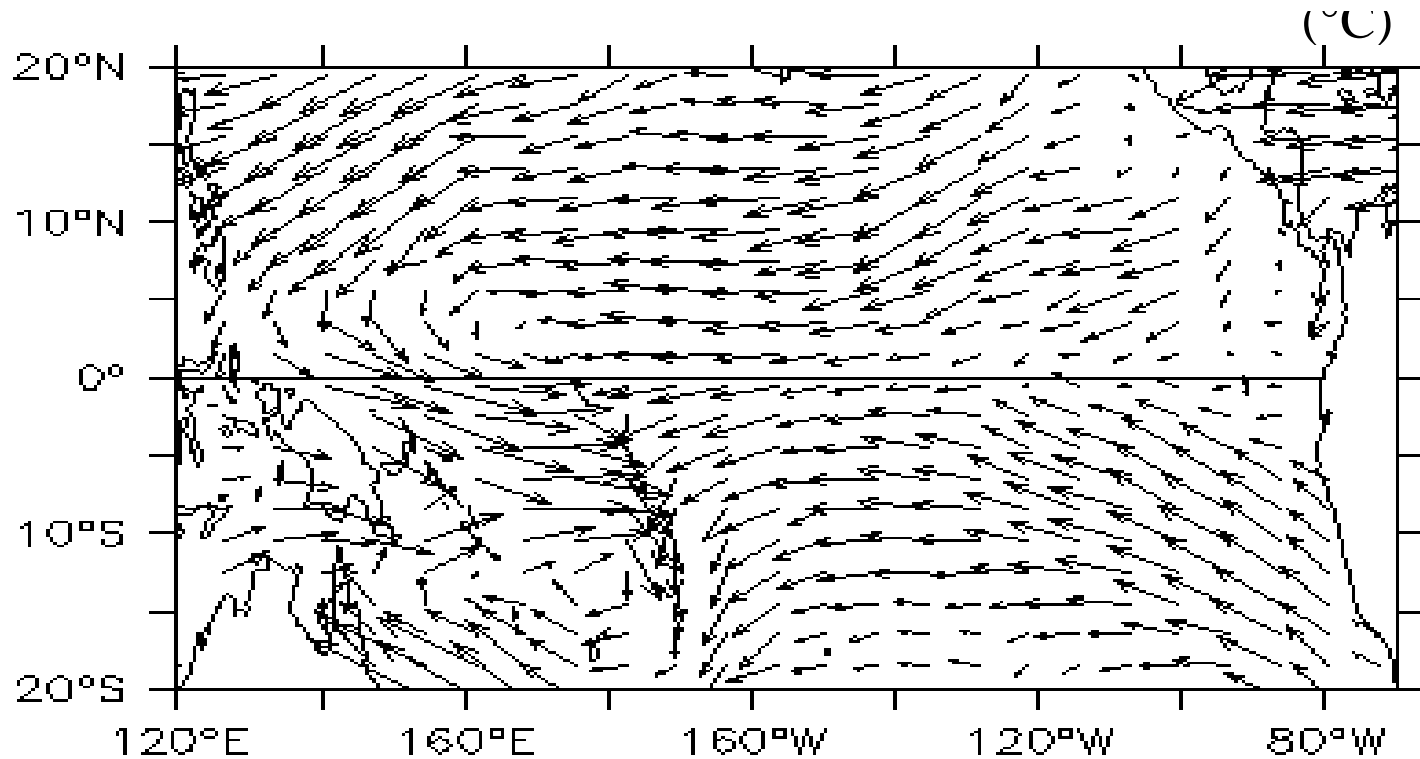
Full currents

Sea surface temperature



Picaut et al., 2001

Onset of the 1997-98 El Niño

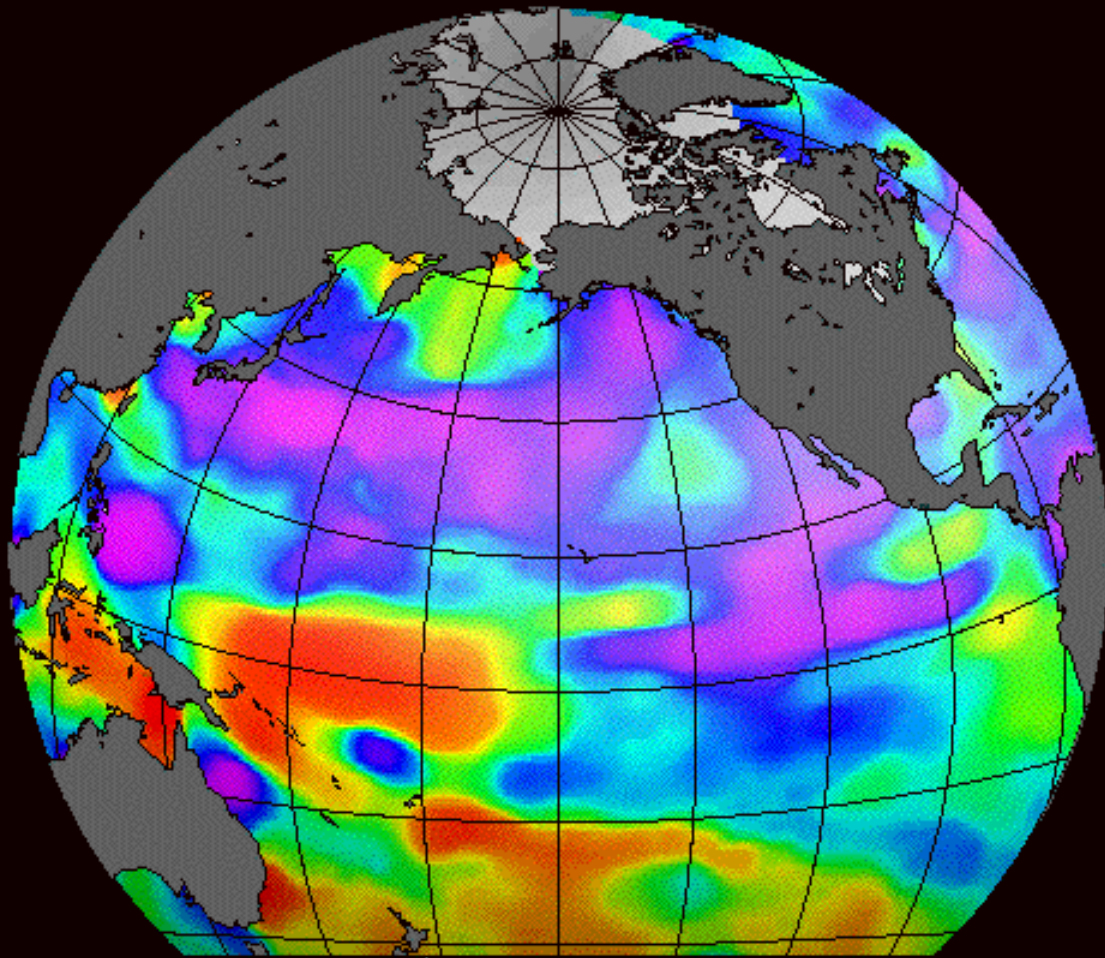


Westerly Wind Burst in March 1997

Topex Poseidon

El Nino 97-98

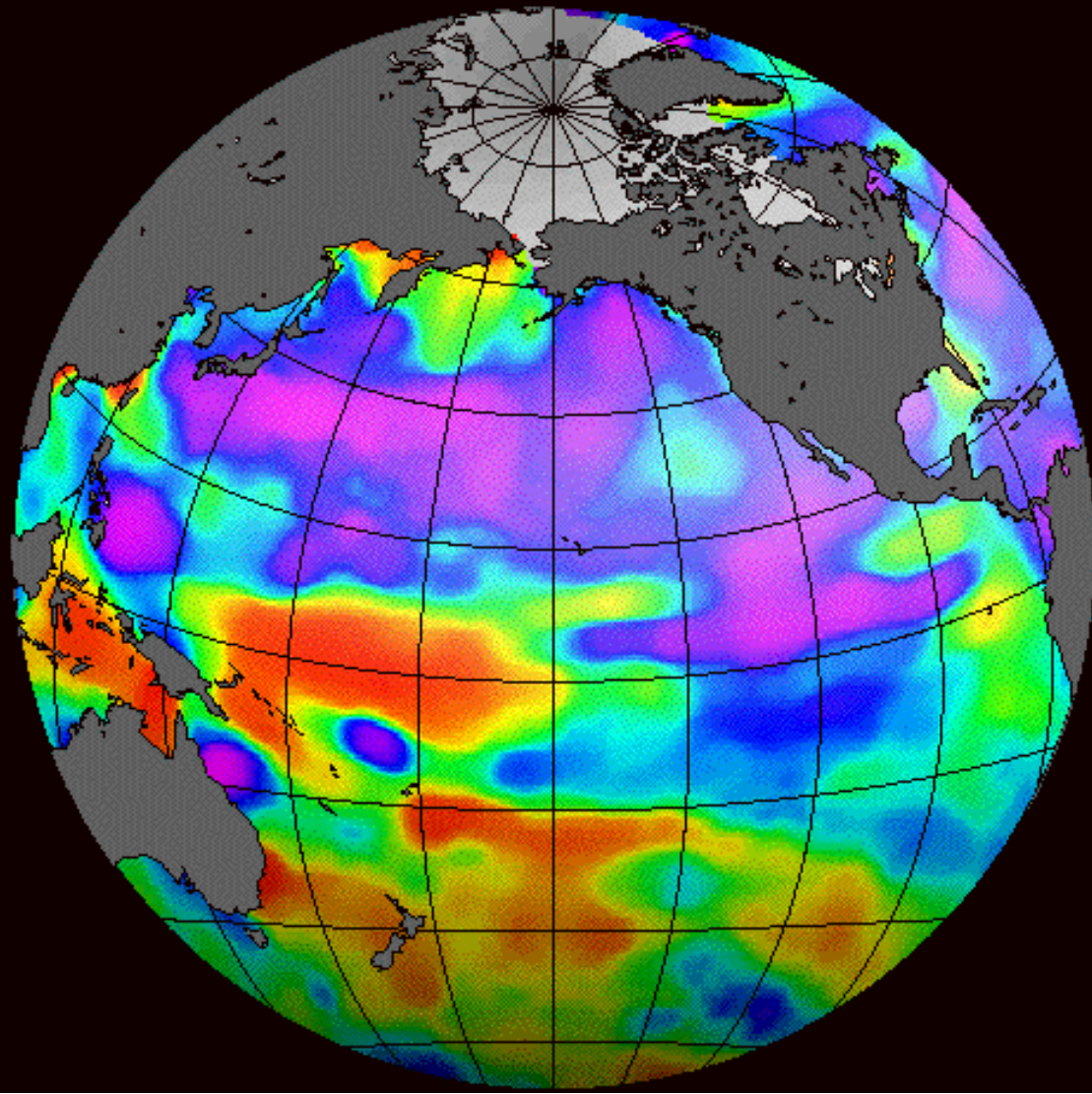
17 mars 97



Topex Poseidon

El Nino 97-98

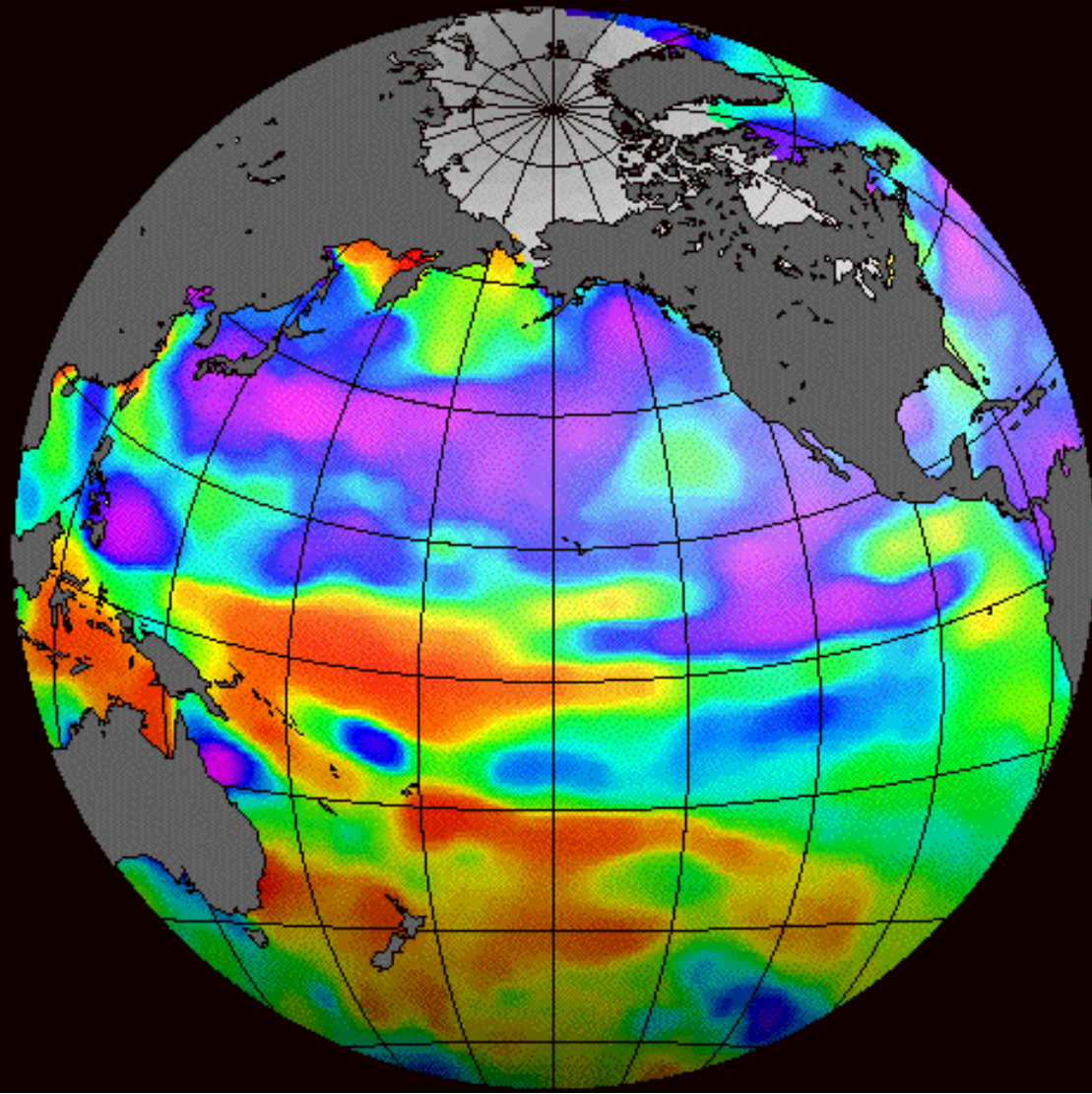
22 mars 97



Topex Poseidon

El Nino 97-98

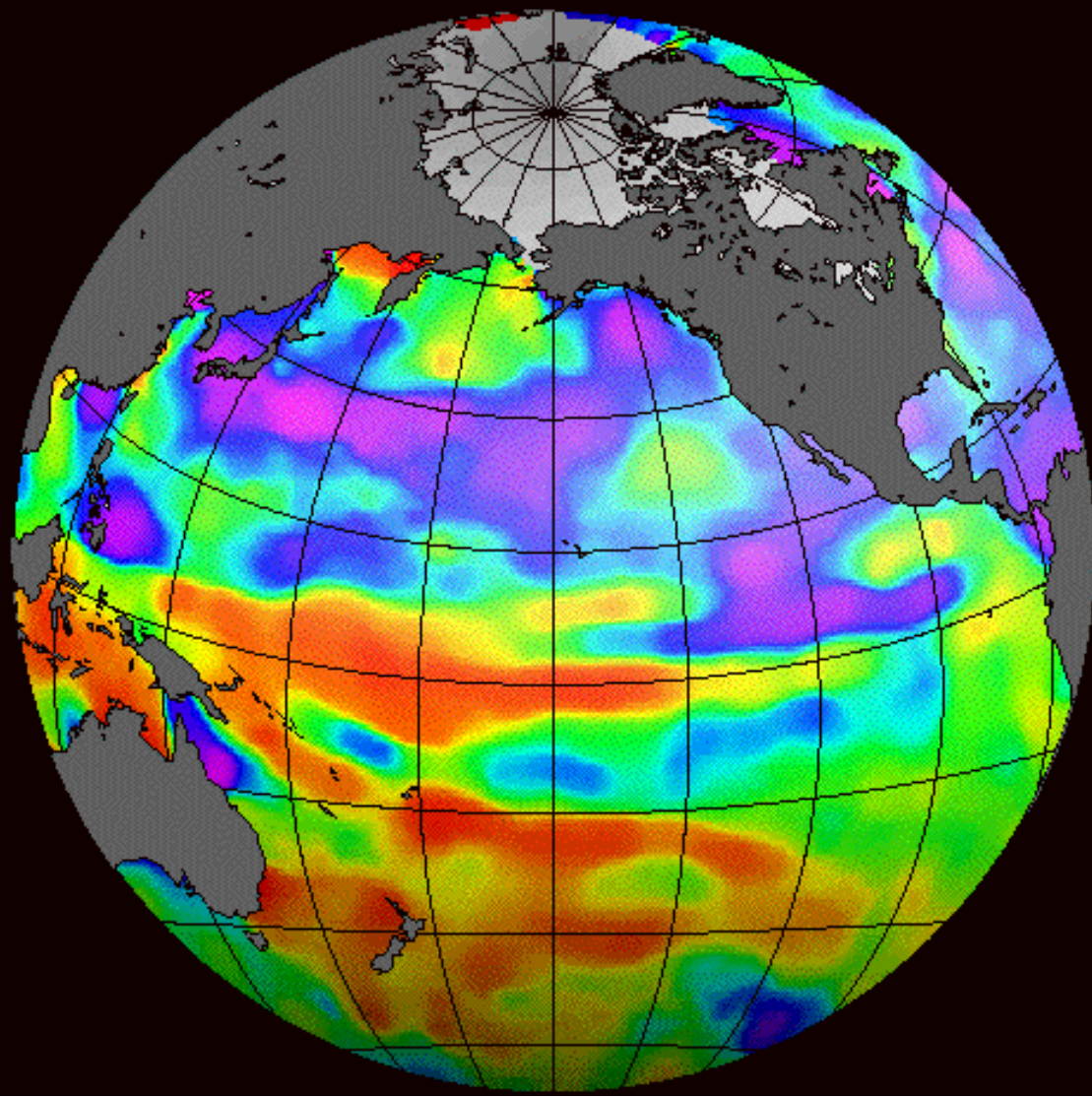
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Topex Poseidon

El Nino 97-98

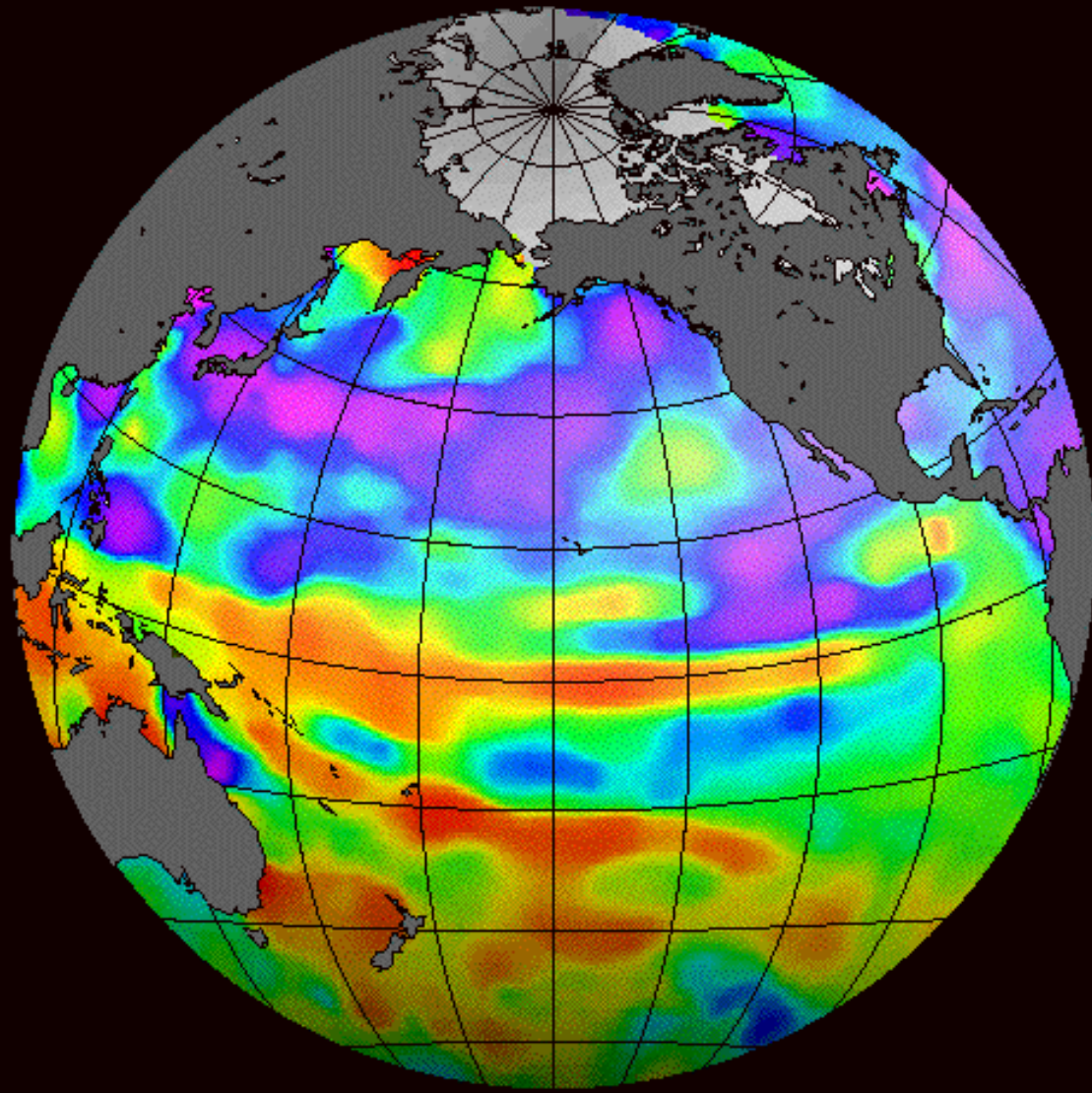
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Topex Poseidon

El Nino 97-98

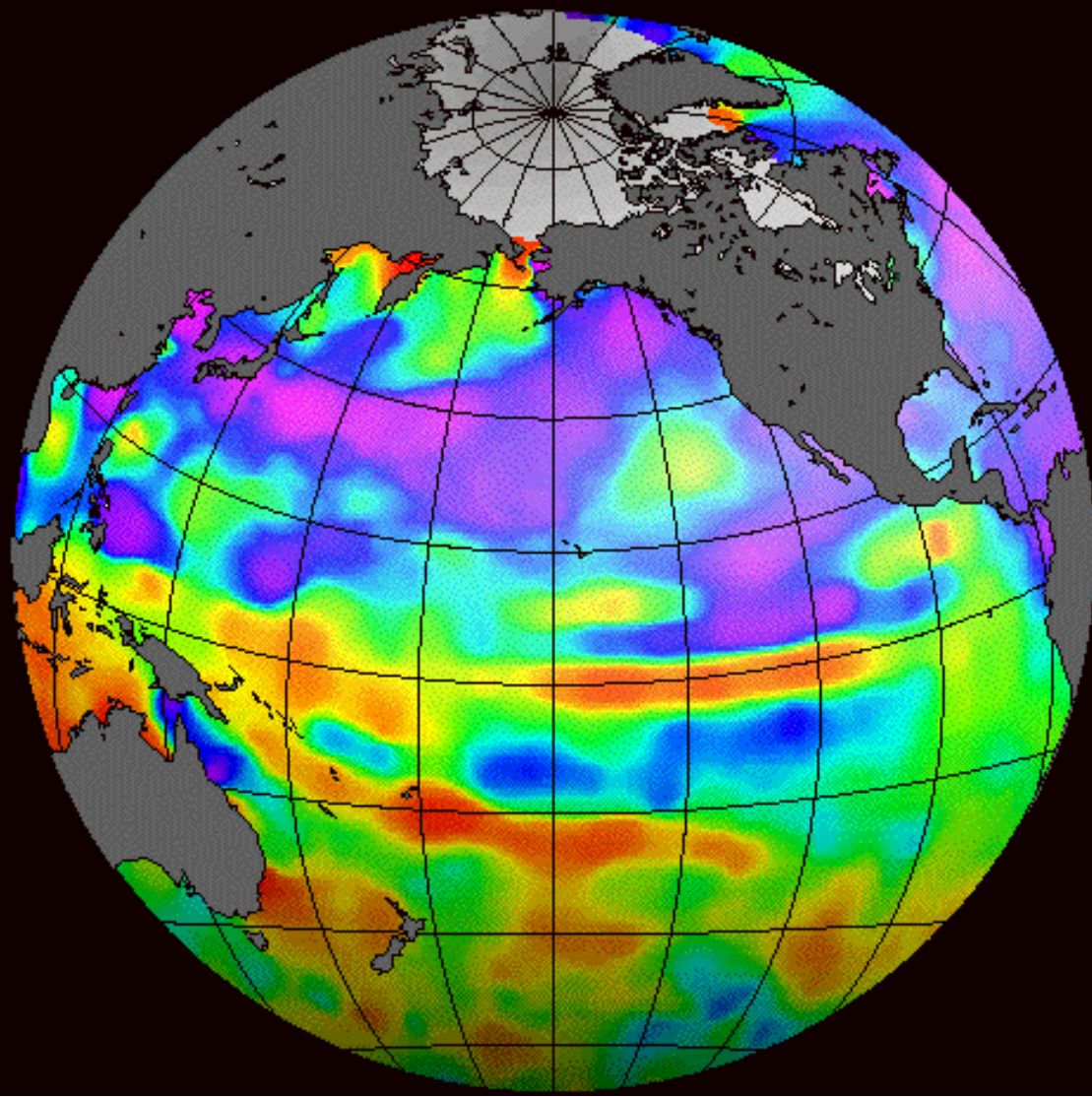
05 avril 97



Topex Poseidon

El Nino 97-98

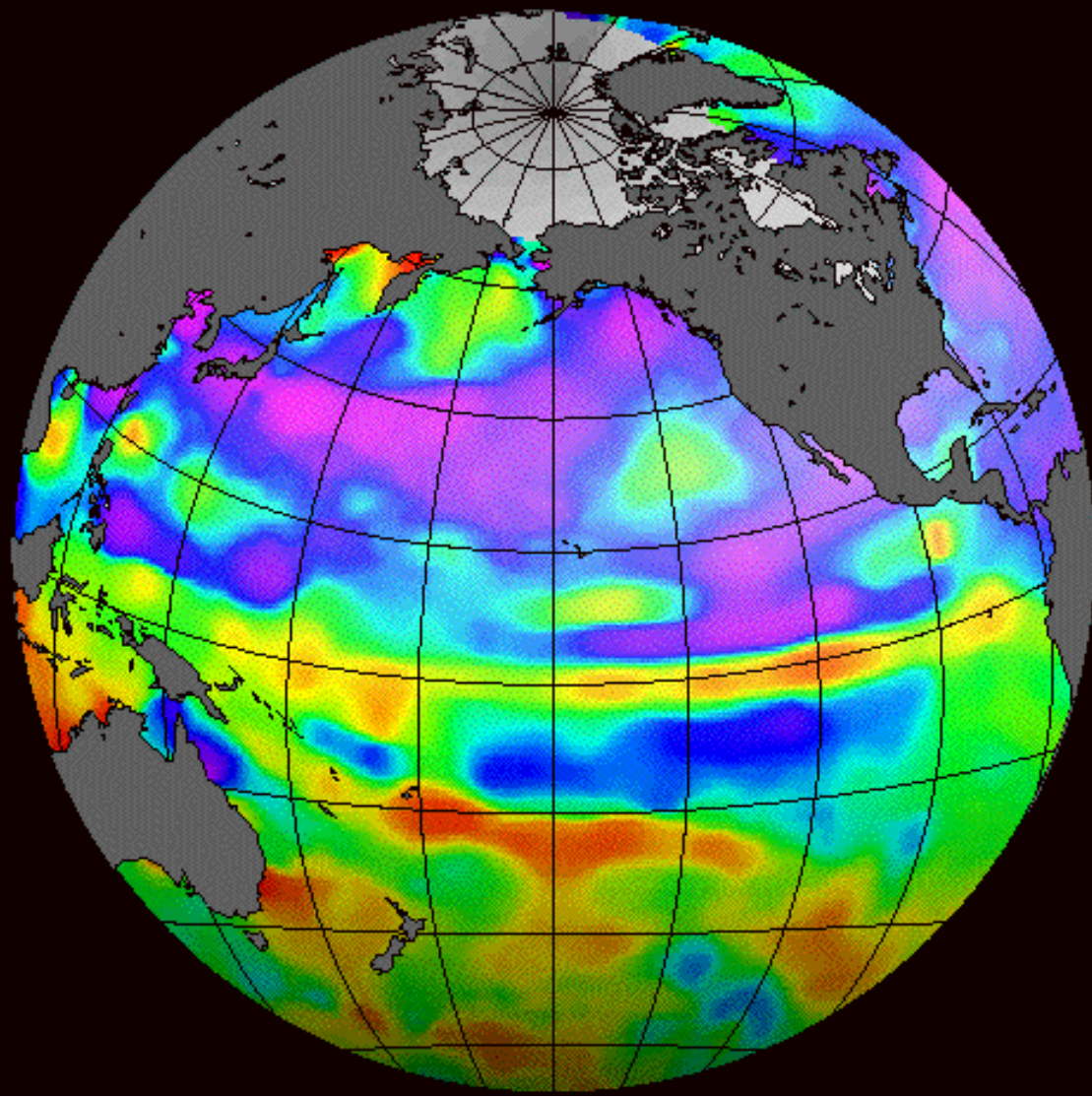
10 avril 97



Topex Poseidon

El Nino 97-98

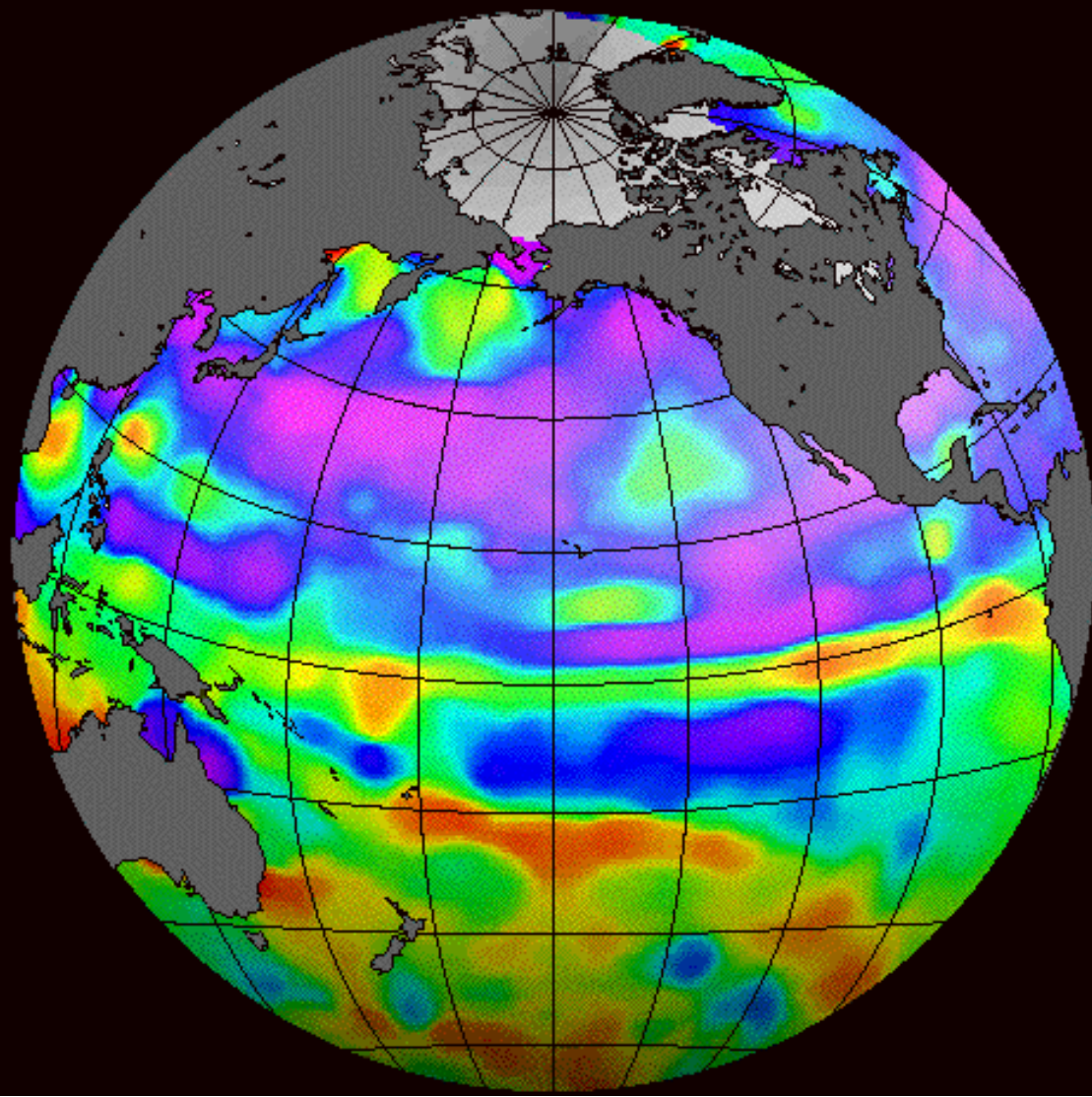
15 avril 97



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El Nino 97-98

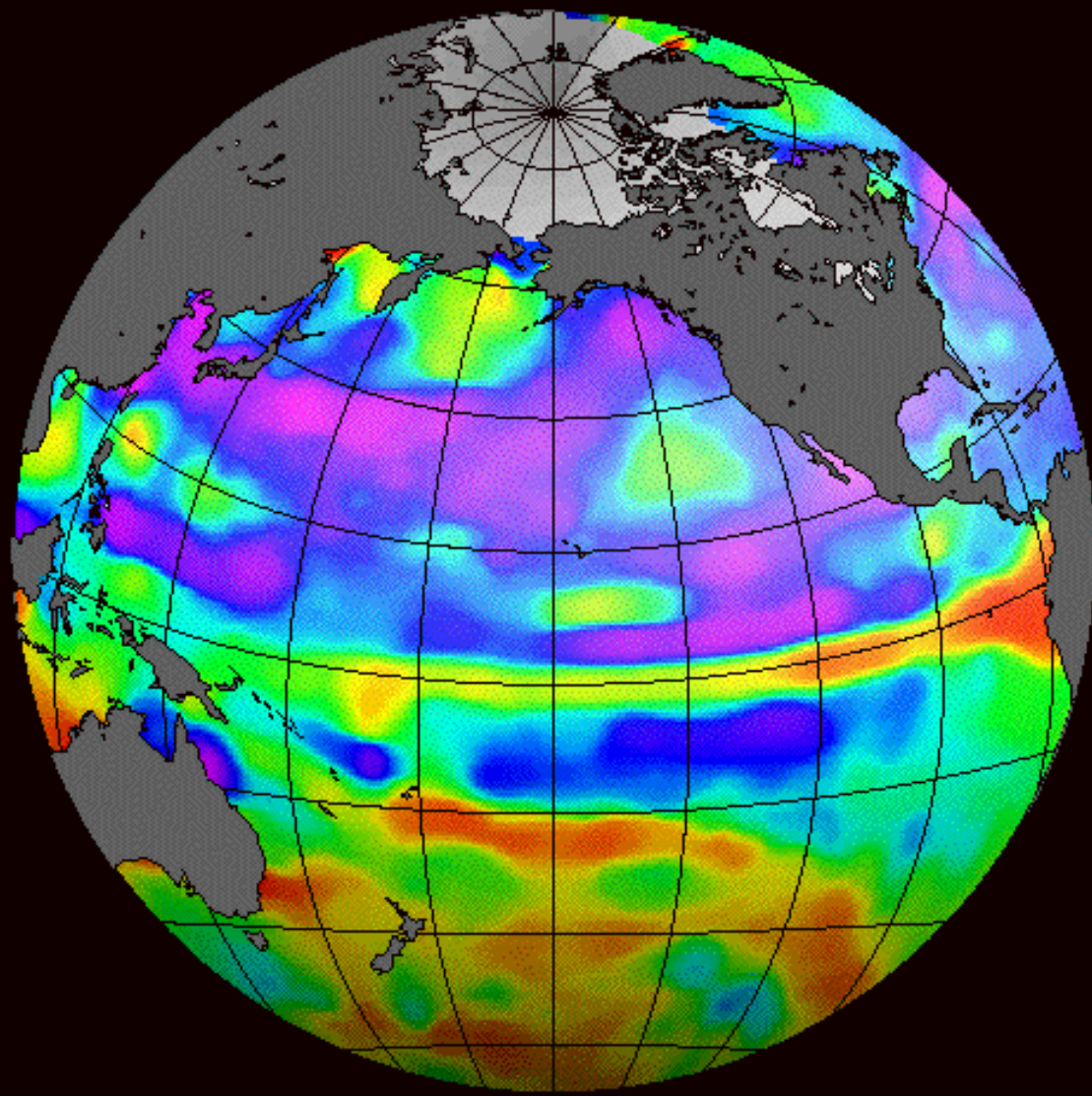
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El Nino 97-98

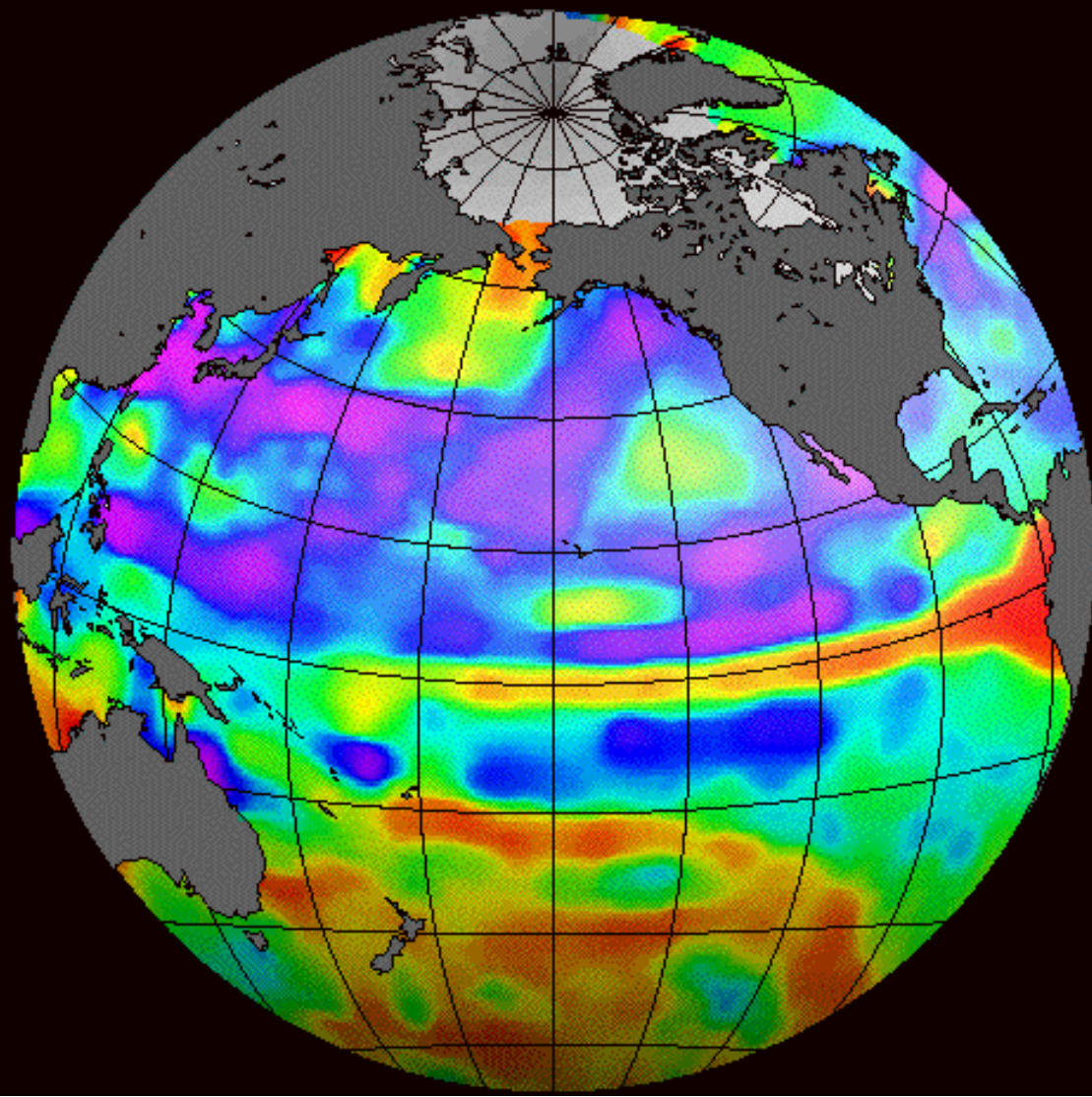
25 avril 97



Topex Poseidon

El Nino 97-98

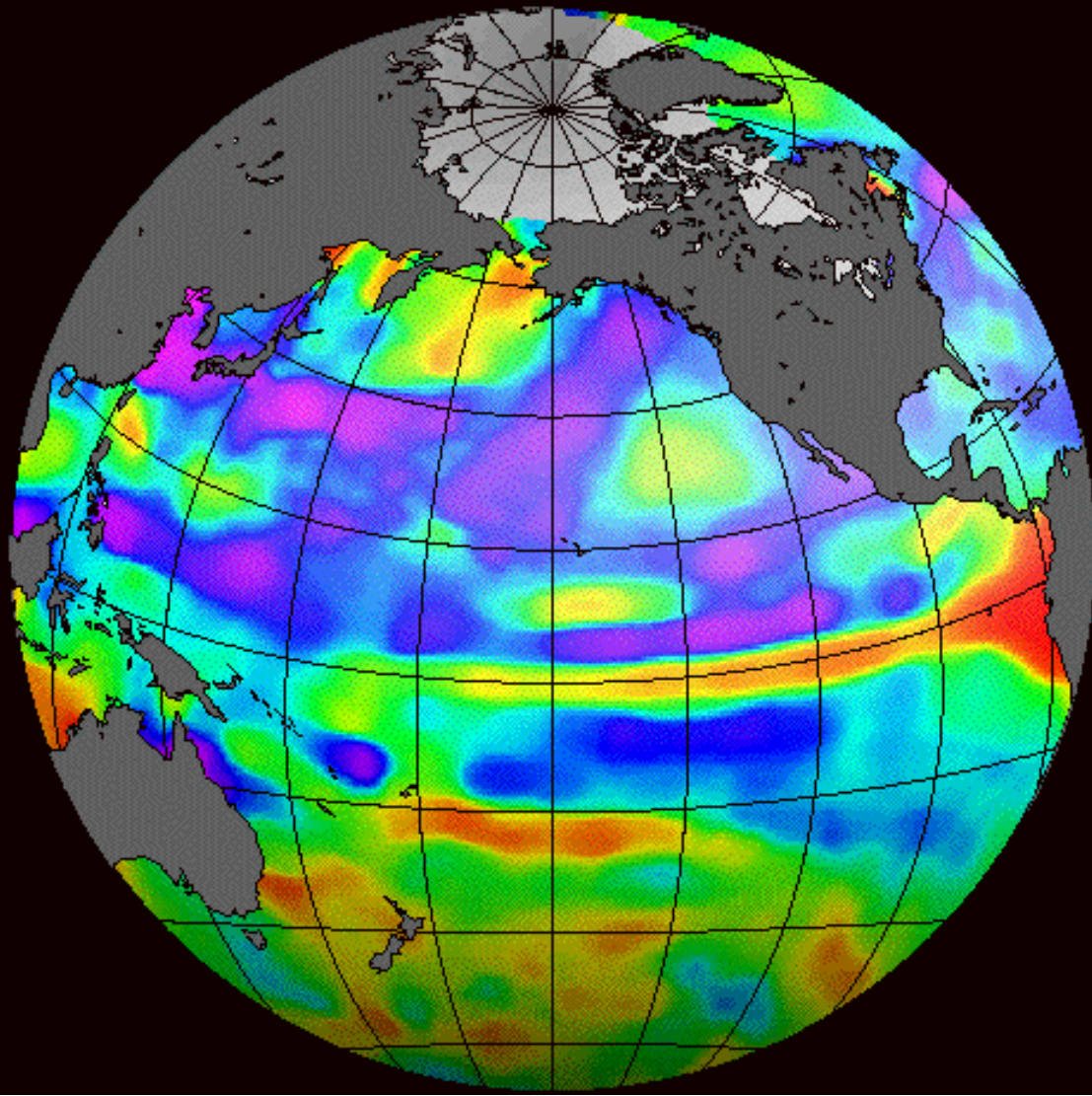
30 avril 97



Topex Poseidon

El Nino 97-98

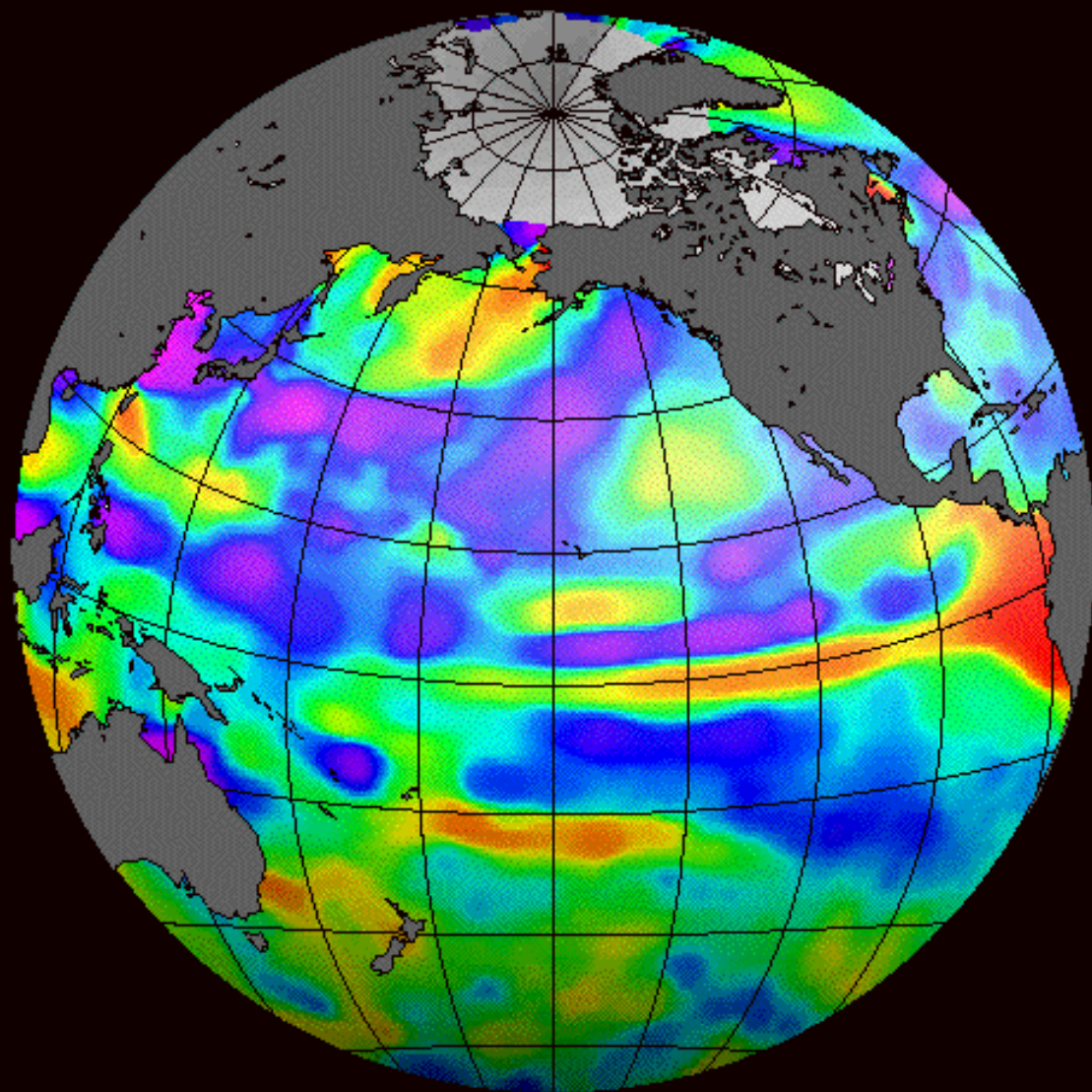
05 mai 97



Topex Poseidon

El Nino 97-98

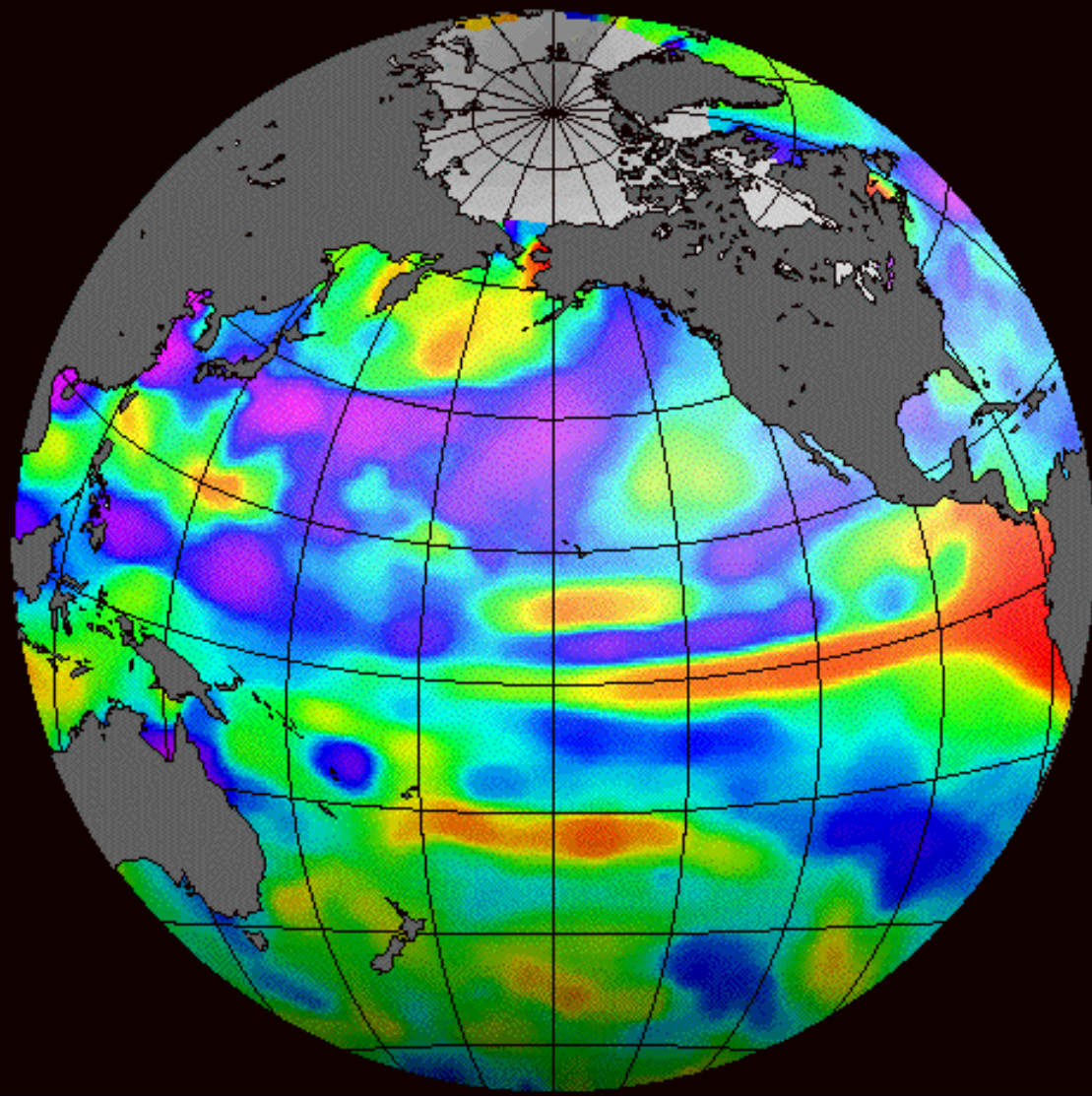
10 mai 97



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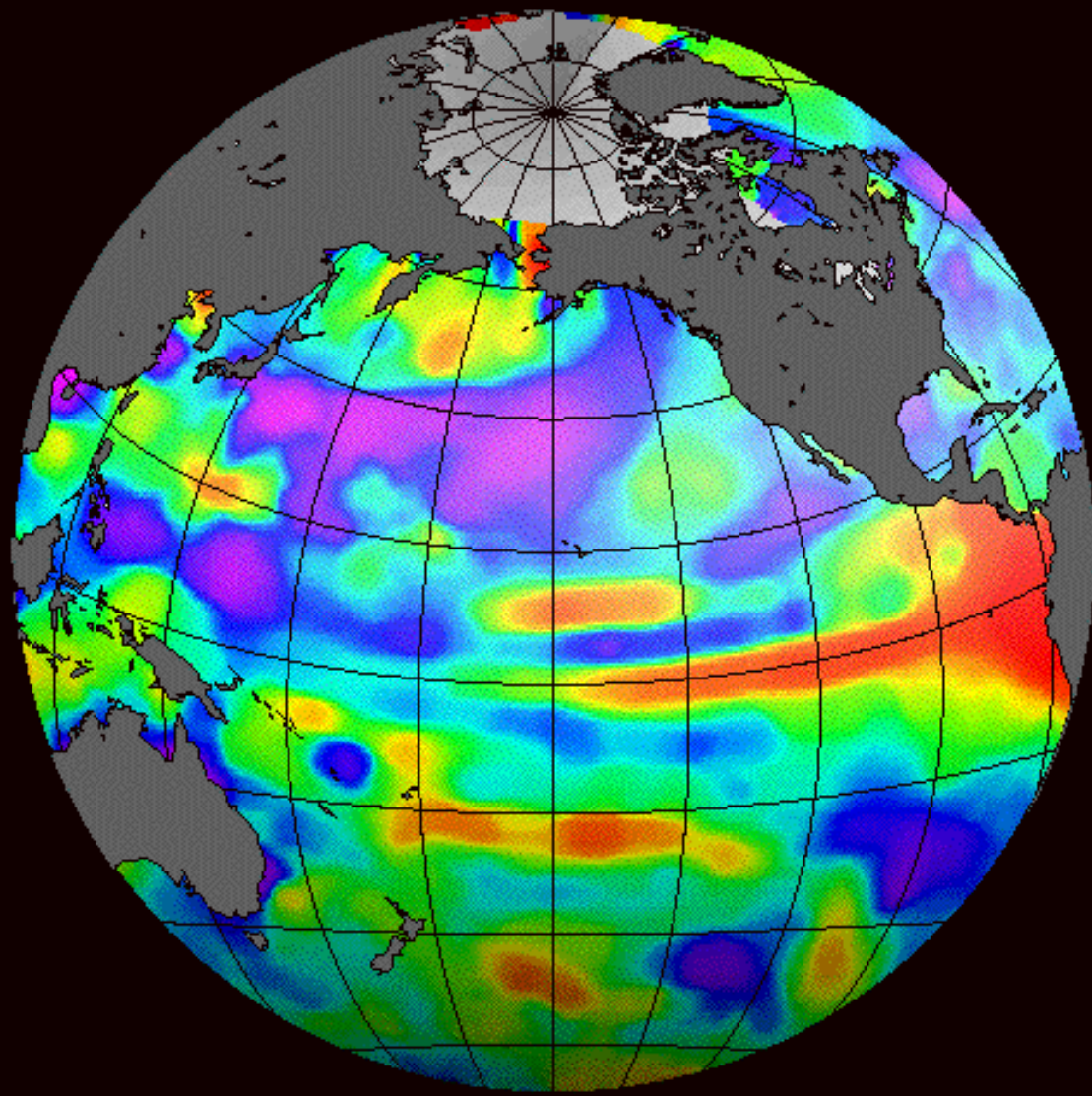
15 mai 97



Topex Poseidon

El Nino 97-98

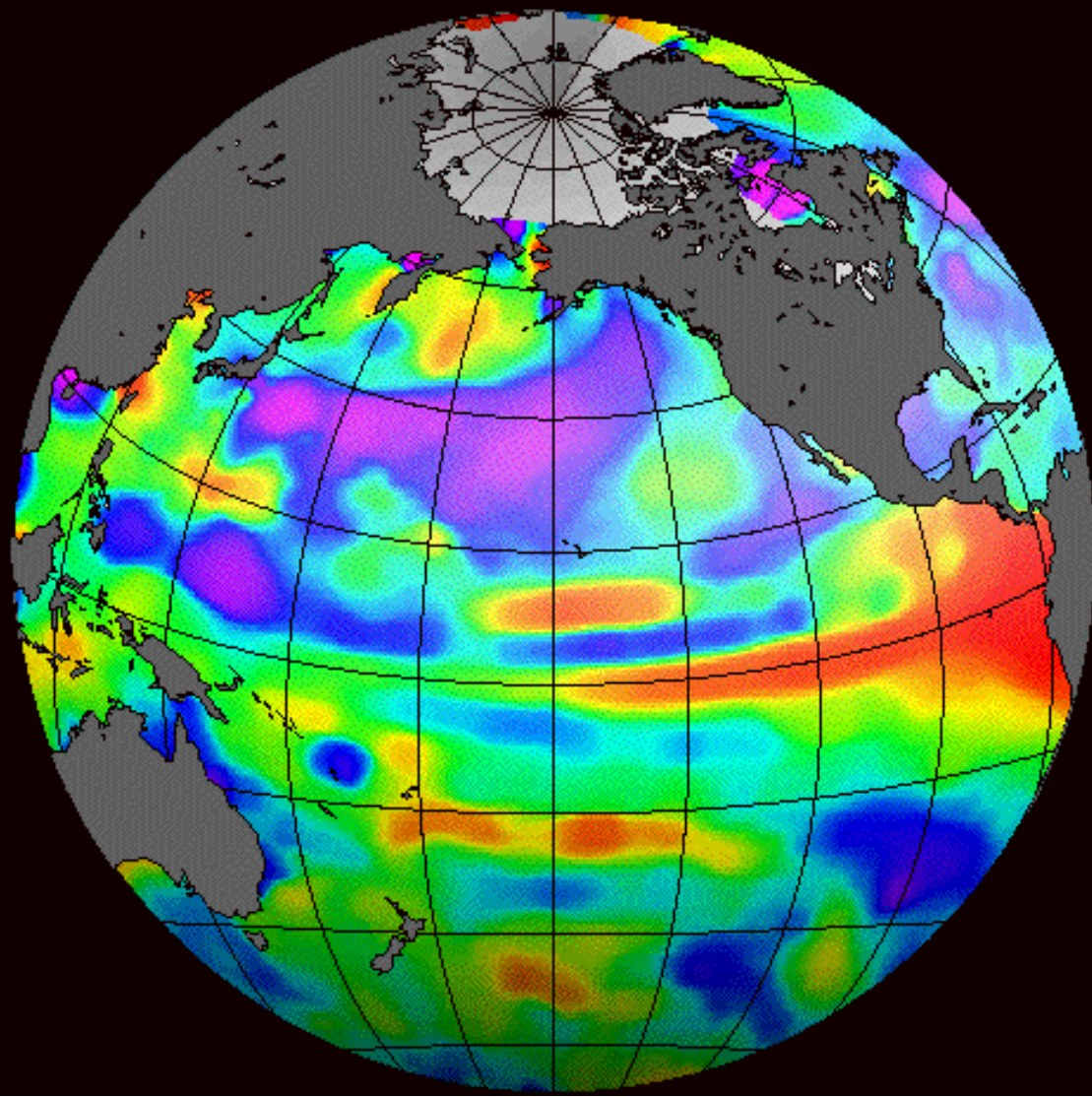
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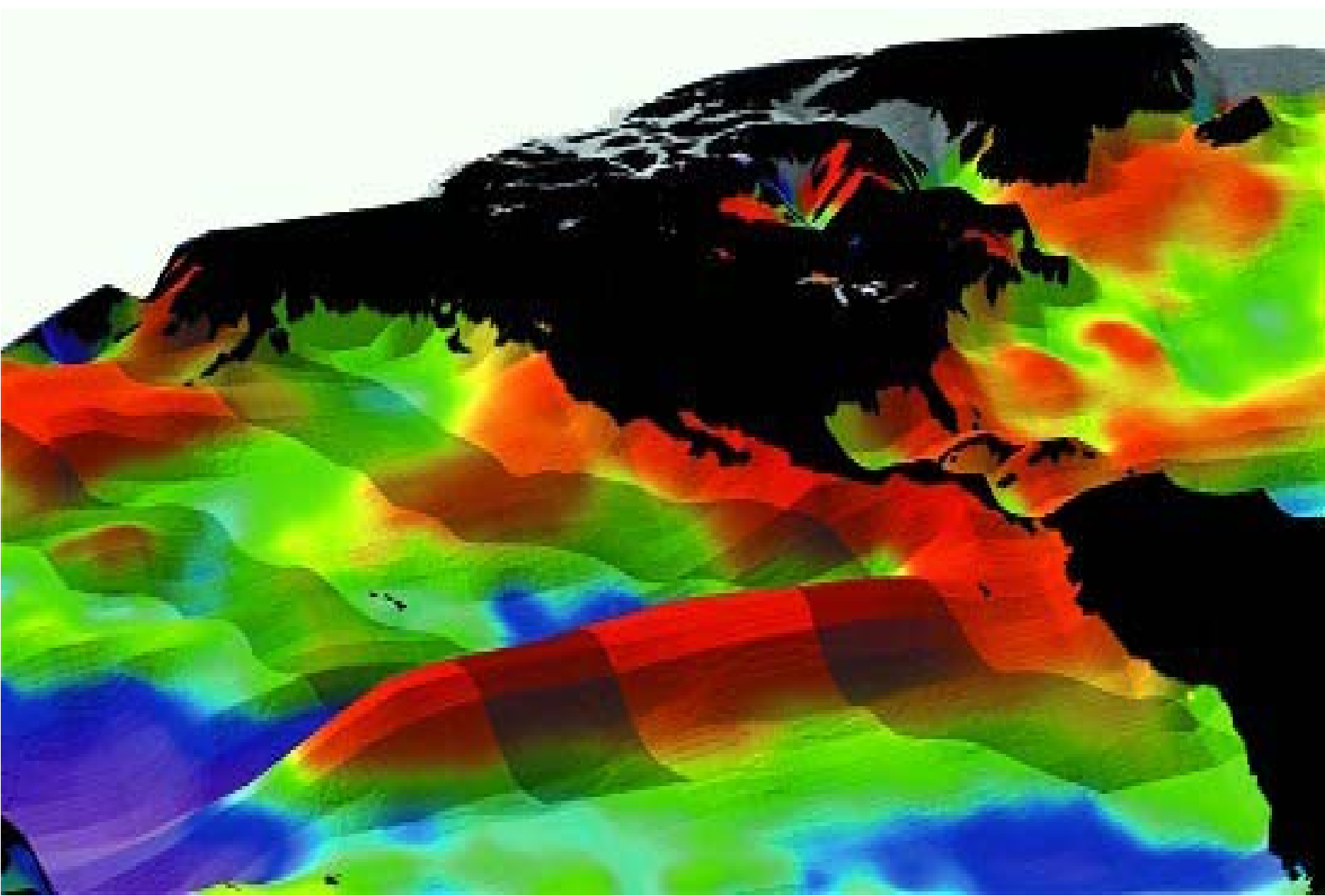


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El Nino 97-98

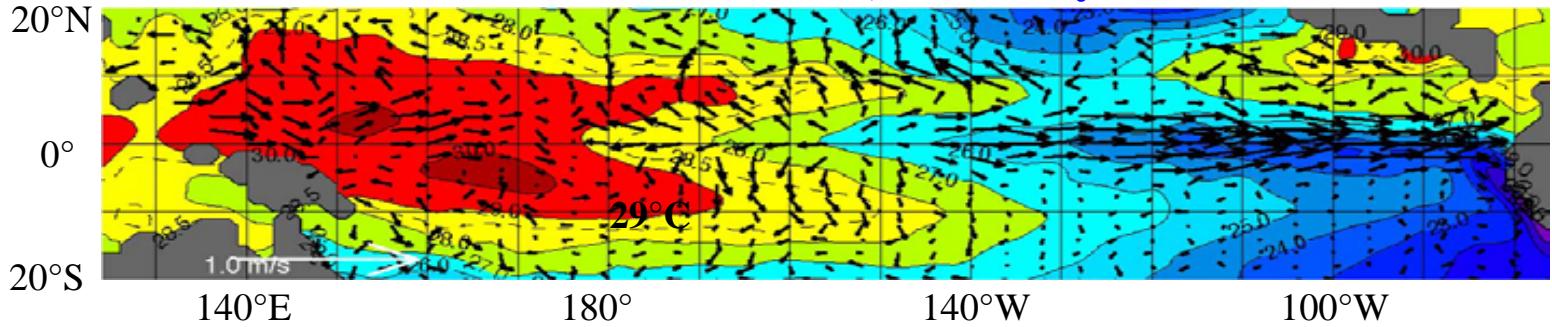
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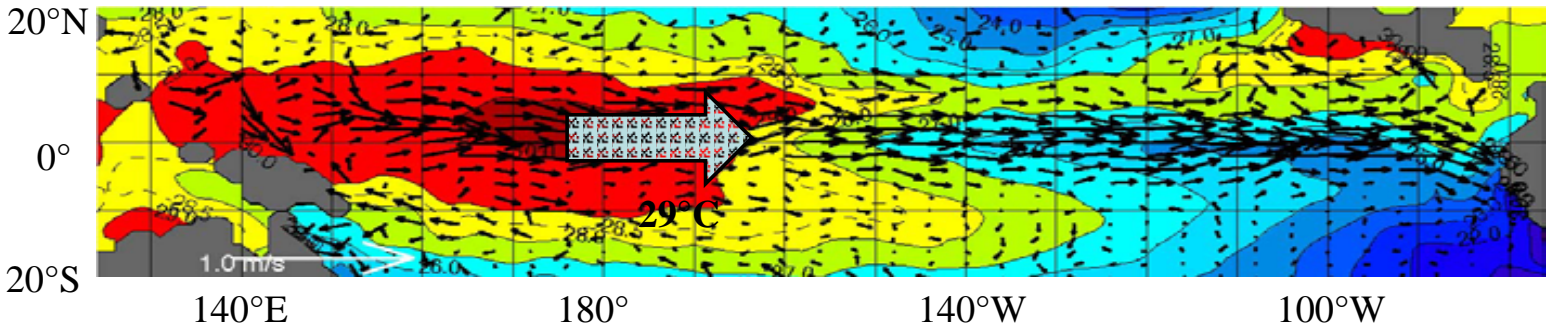


Zonal advection of the warm pool

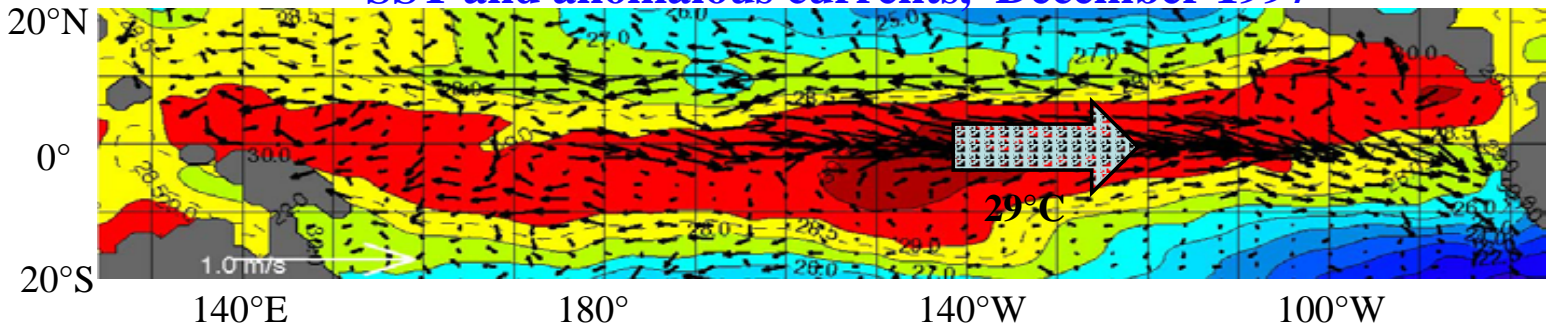
SST and anomalous current, February 1997



SST and anomalous current, April 1997

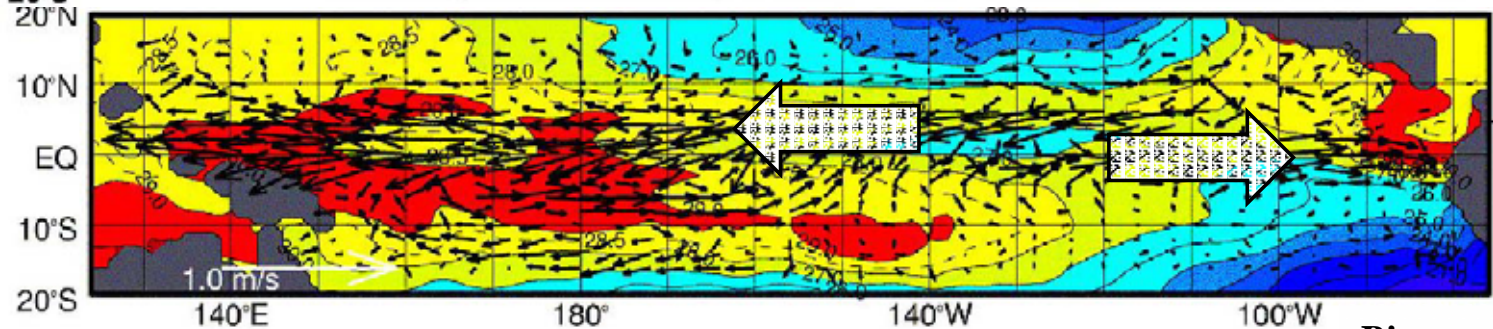
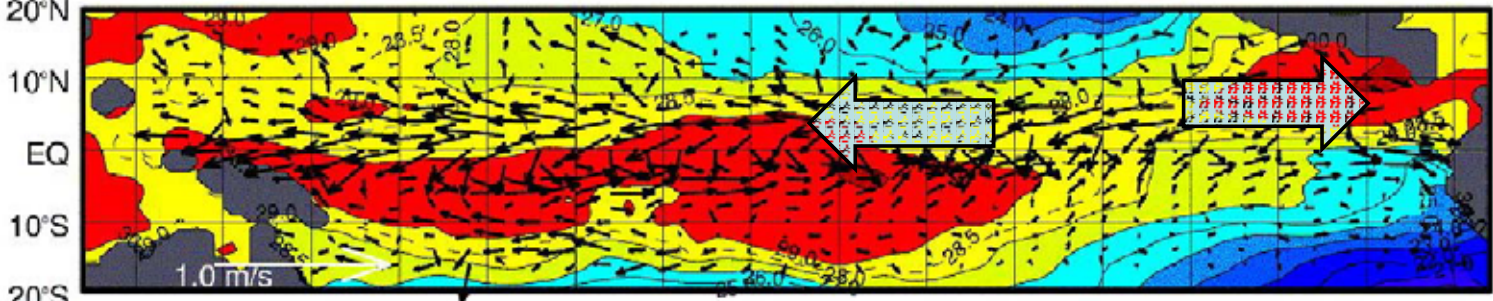
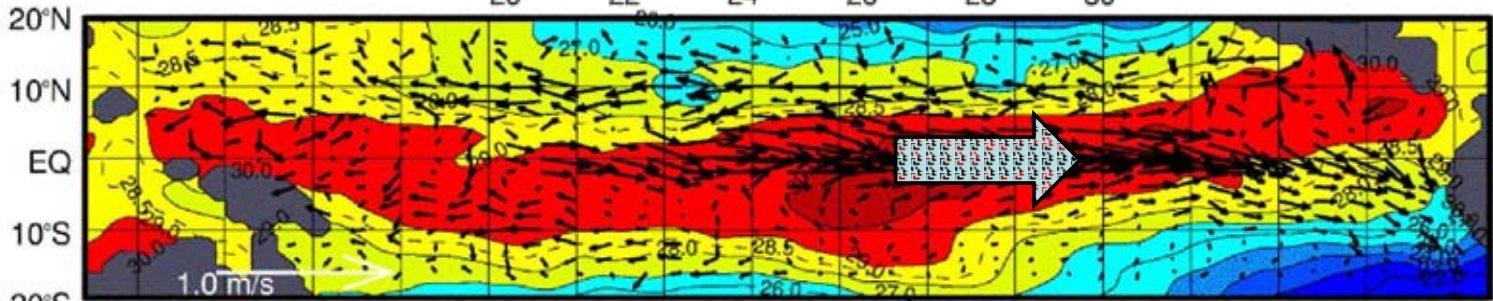


SST and anomalous currents, December 1997

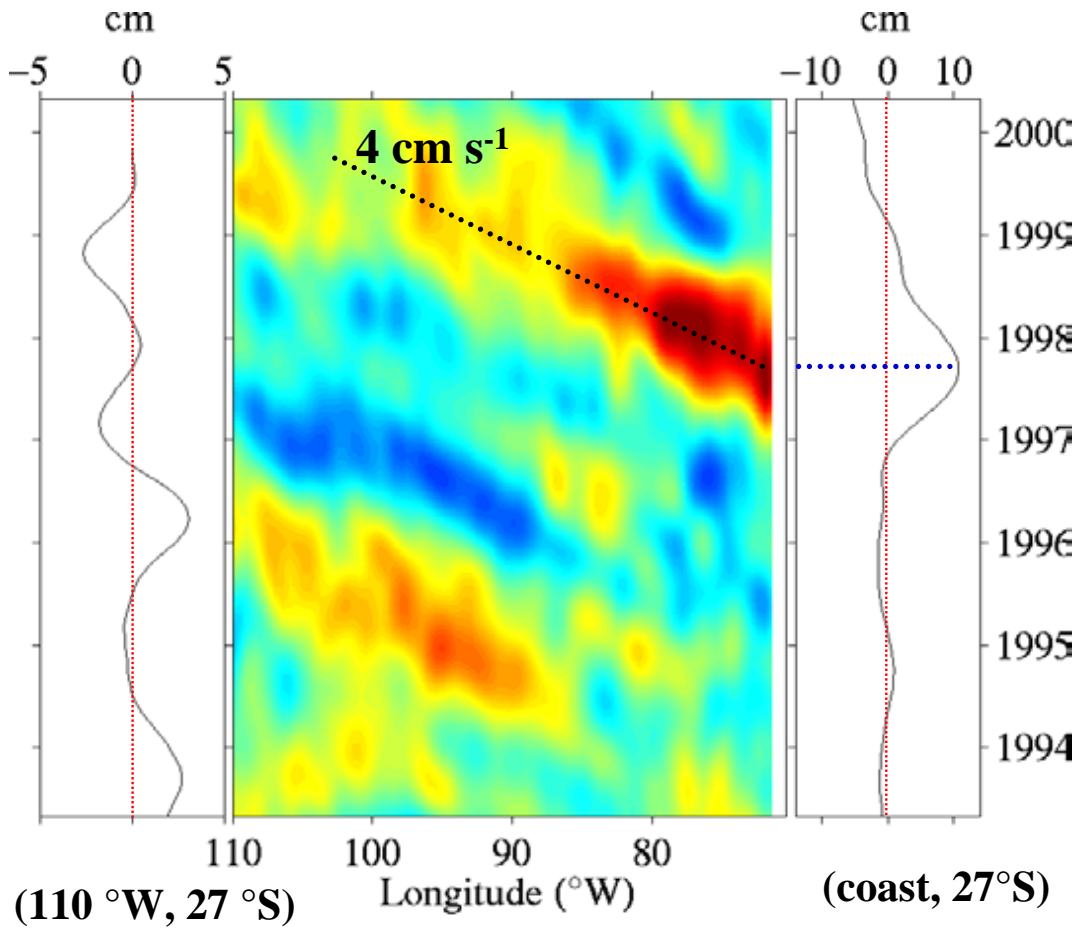


Break-up of the warm pool and turn into La Niña

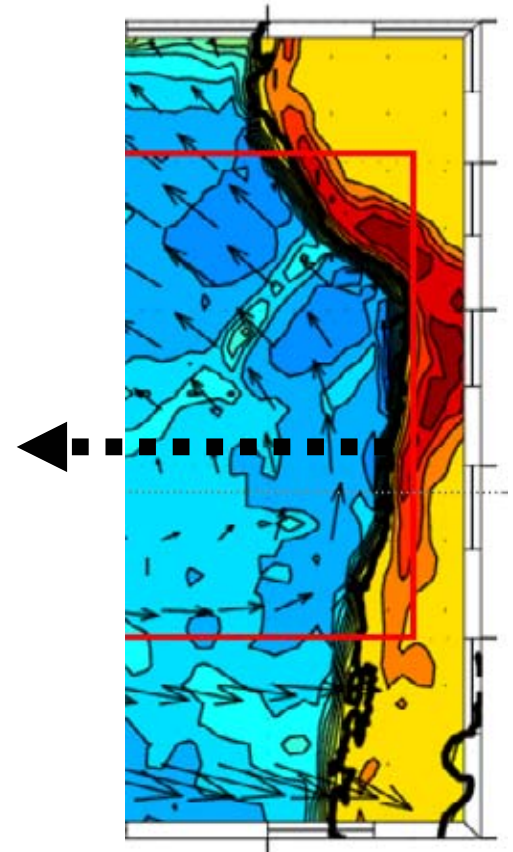
Anomalous surface currents



Rossby waves off South America



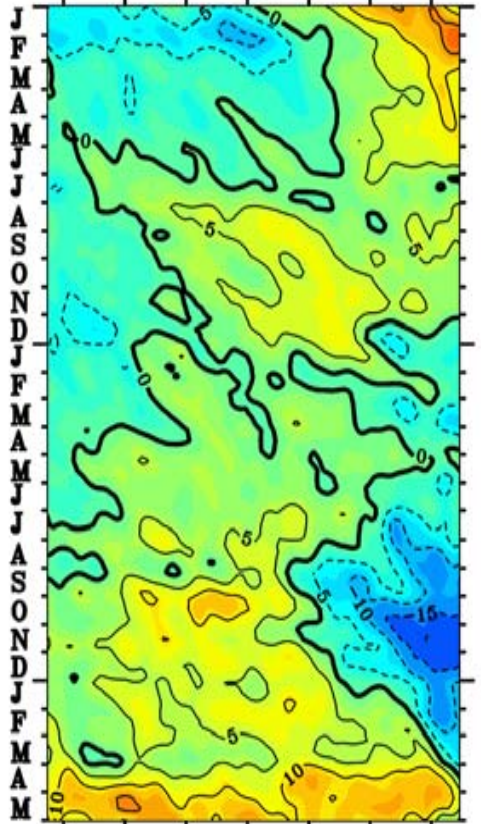
TOPEX/Poseidon + ERS



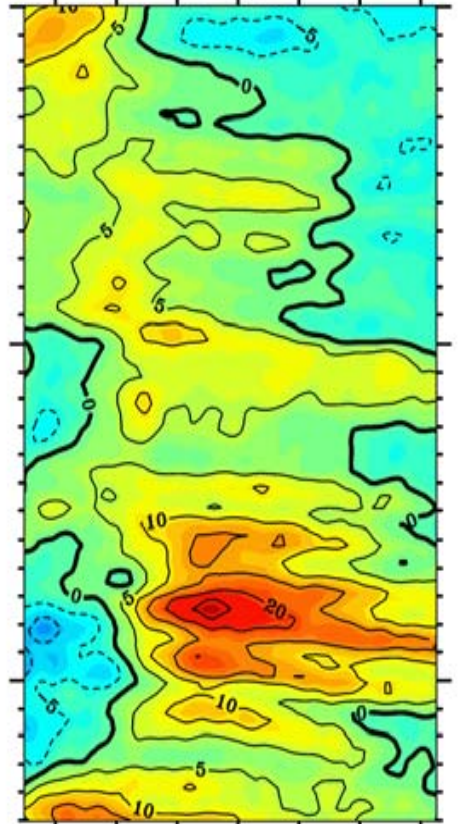
Véga et al., 2003

The 2002-03 El Niño

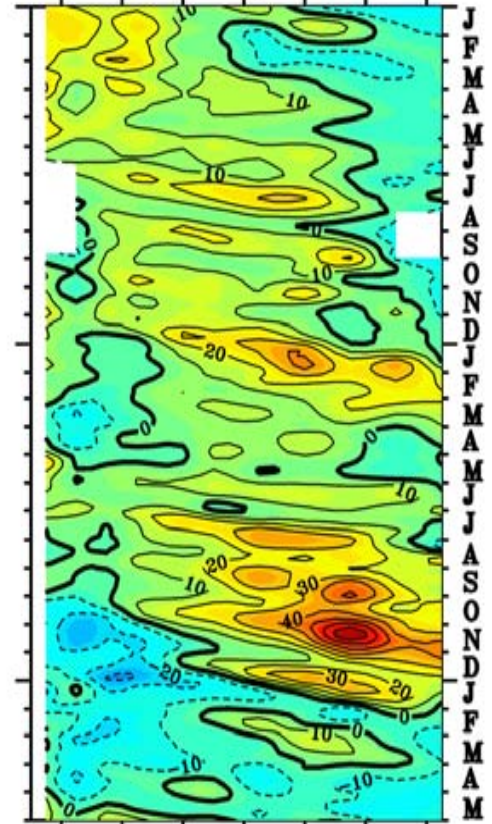
TOPEX-Poseidon/JASON 5°N
Sea Surface Height Variations



TOPEX-Poseidon/JASON EQ
Sea Surface Height Variations



TAO/TRITON EQ
20°C Isotherm Depth Anomalies



time

2001

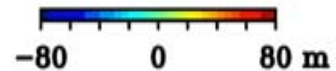
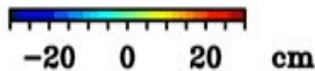
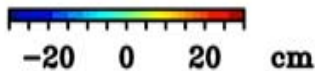
2002

2003

100°W 140°W 180° 140°E

140°E 180° 140°W 100°W

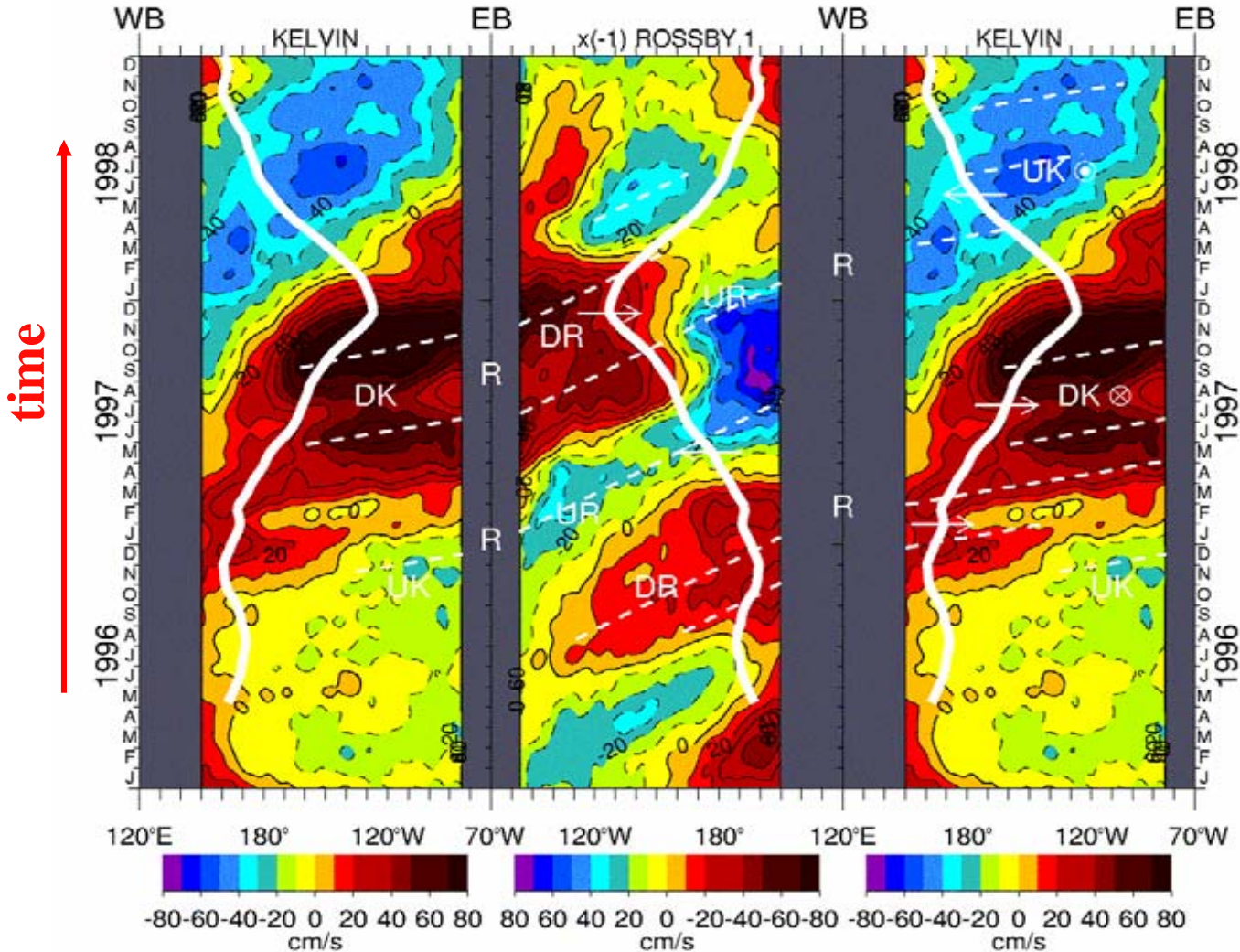
140°E 180° 140°W 100°W



McPhaden, 2003

Testing ENSO theories

Delayed action & convergence zone oscillators



McPhaden and Yu, 1999

Boulangier and Menkes 1999, 2001

Delcroix et al. 2000

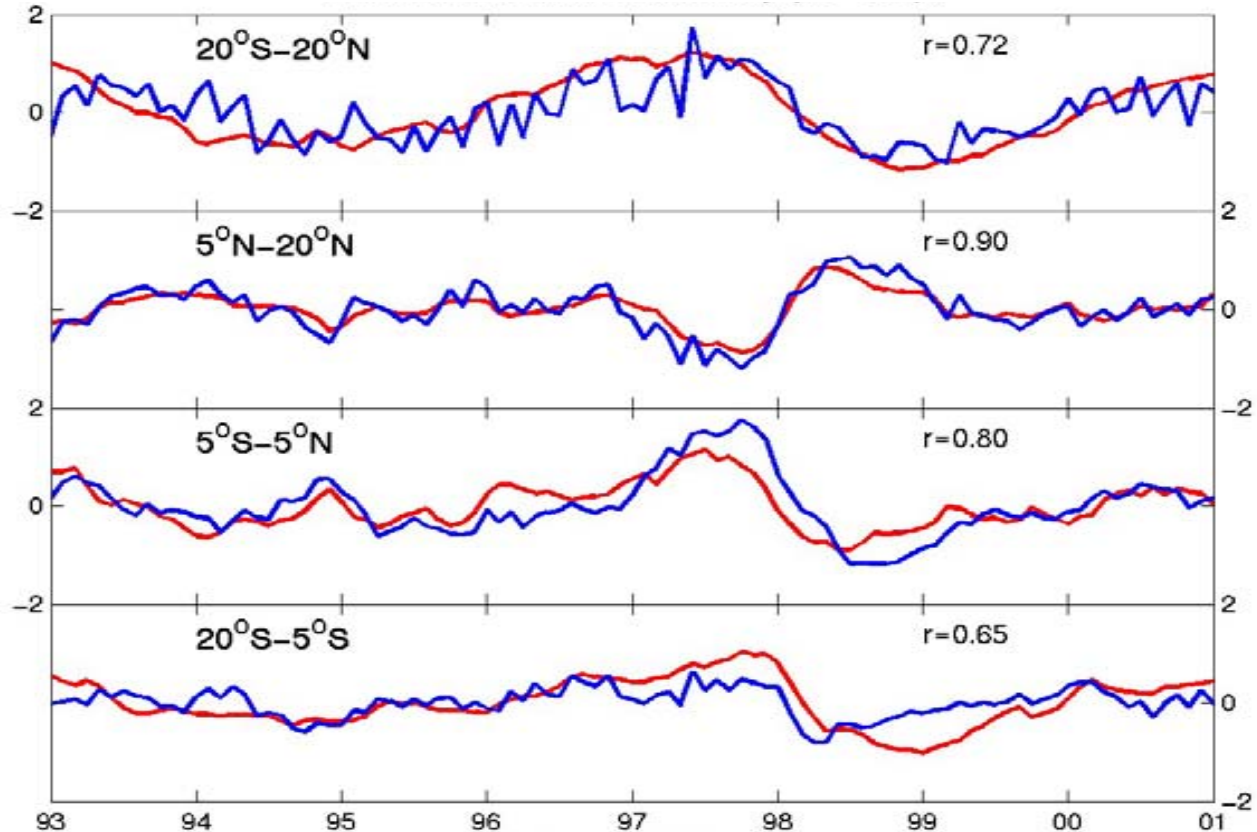
Picaut et al. 2002

Dewitte et al. 2003

Testing ENSO theories

Recharge/discharge oscillator

Interannual volume variability in different band of latitude



TOPEX/Poseidon

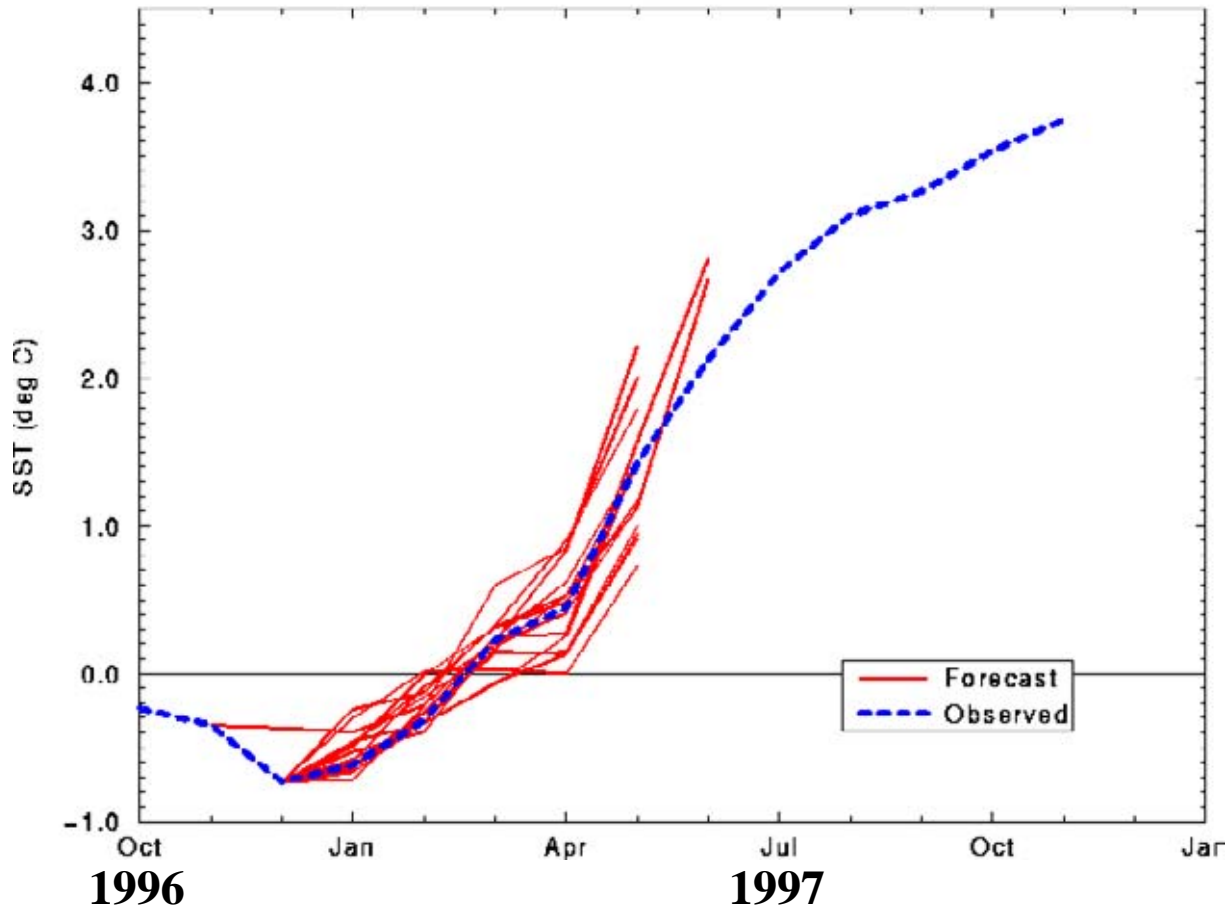
OGCM

Holland, Mitchum, 2003

Prediction of the 1997-98 El Niño

SST in the eastern equatorial Pacific (°C)

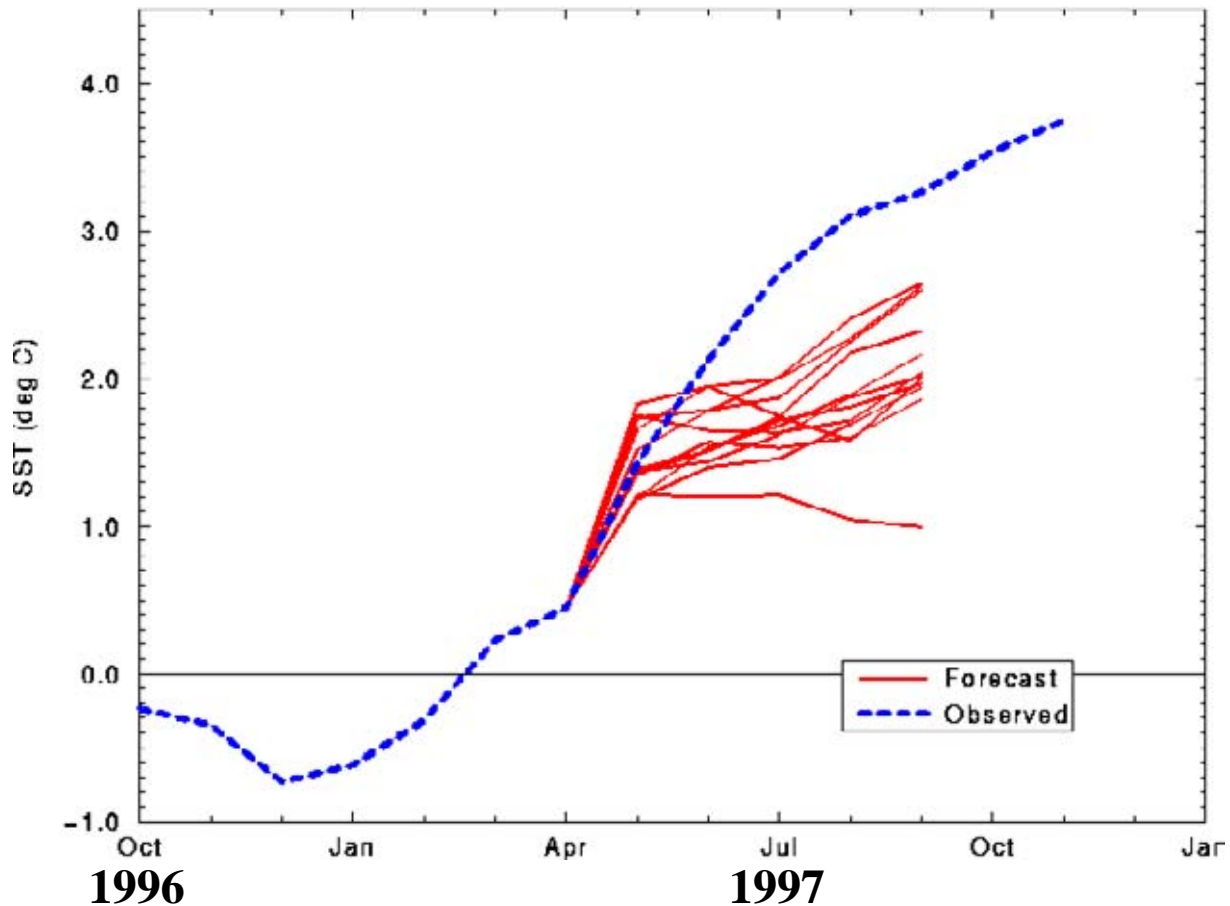
ECMWF forecast done in December 1996



Prediction of the 1997-98 El Niño

SST in the eastern equatorial Pacific (°C)

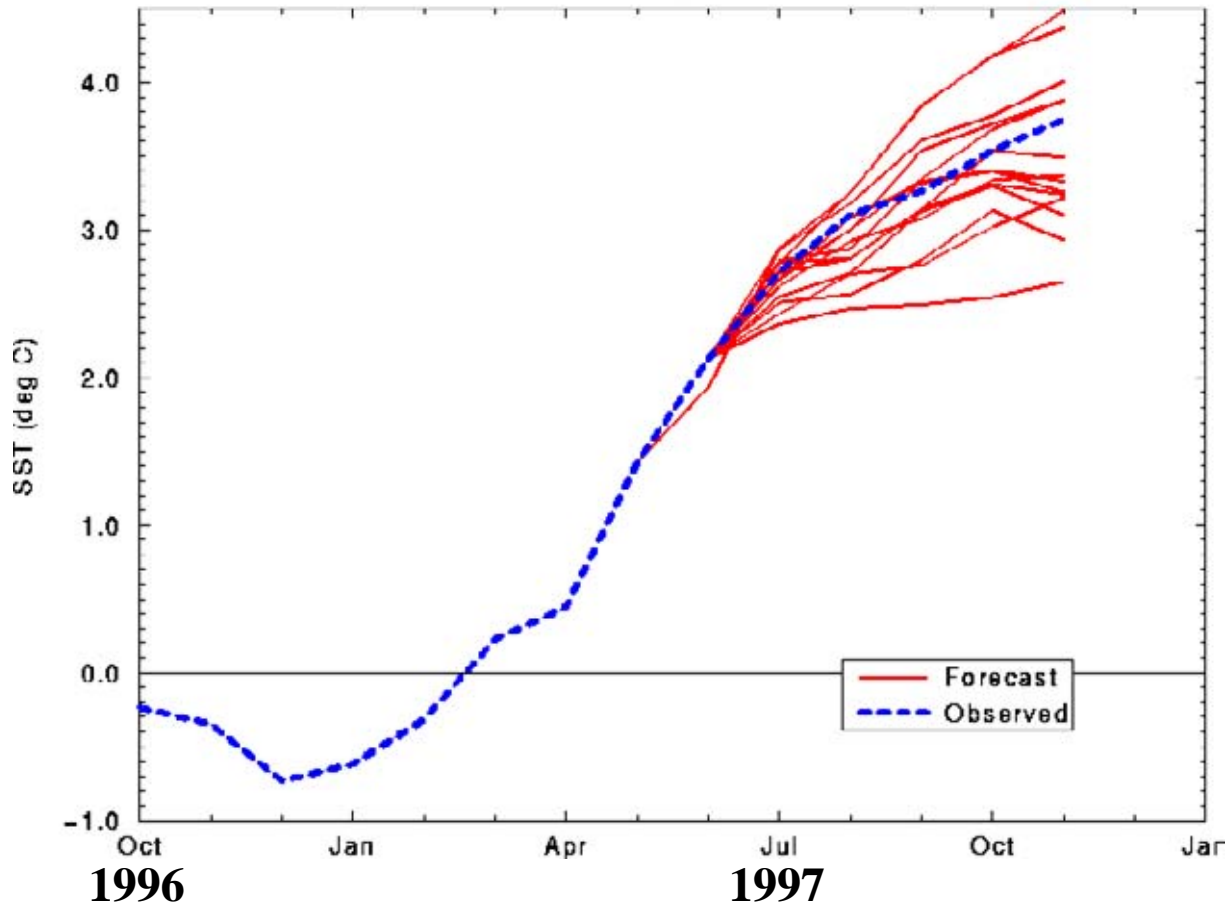
ECMWF forecast done in April 1997



Prediction of the 1997-98 El Niño

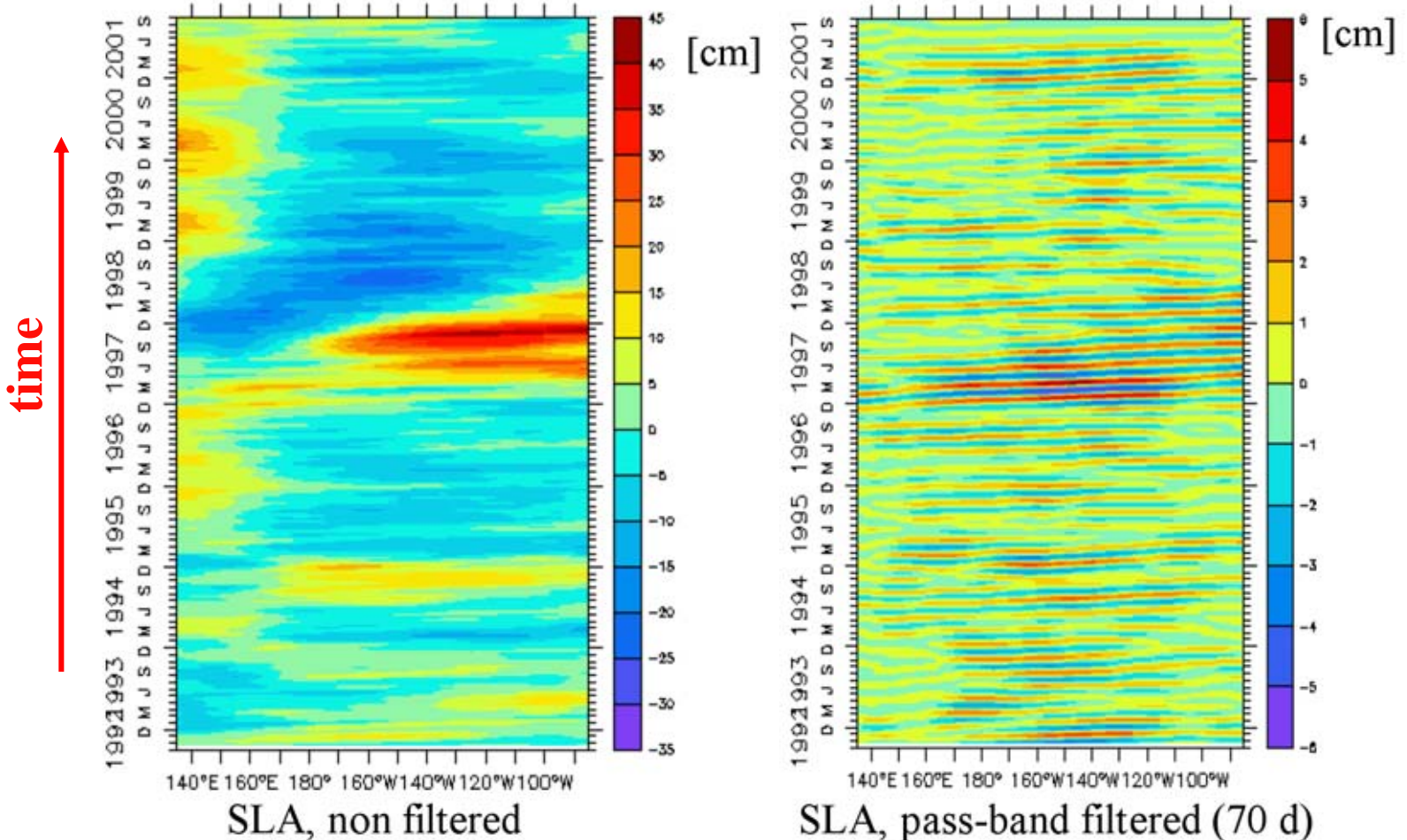
SST in the eastern equatorial Pacific (°C)

ECMWF forecast done in June 1997



Intraseasonal equatorial Kelvin waves and El Niño

TOPEX/Poseidon SLA along the equator

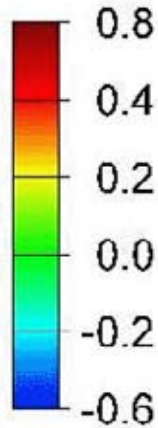
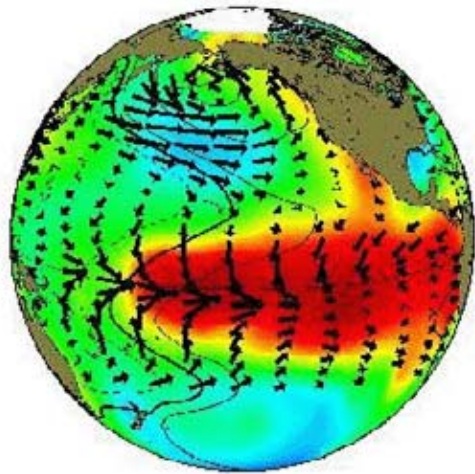


ENSO, decadal variability, global warming

El Nino Southern Oscillation

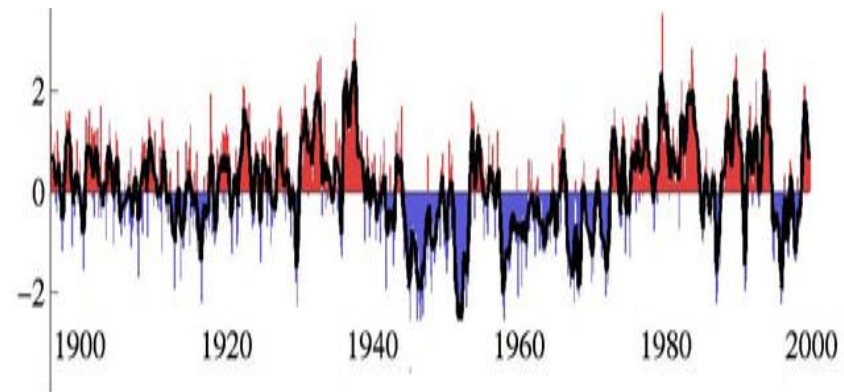
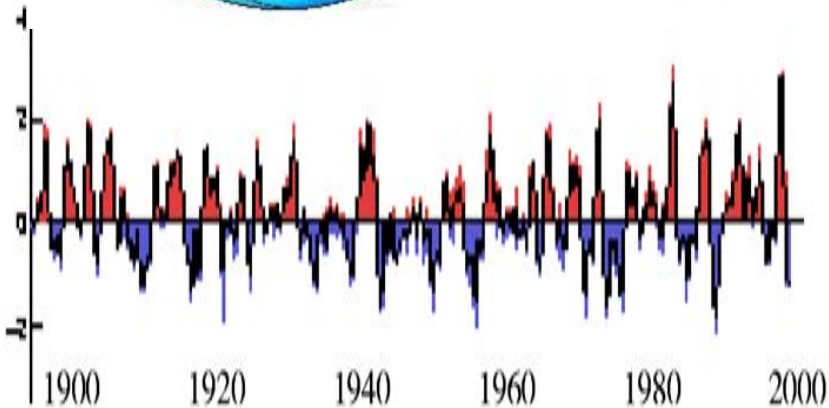
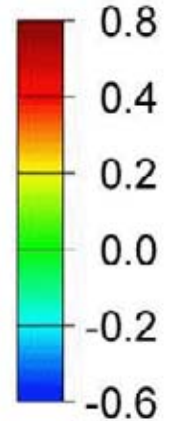
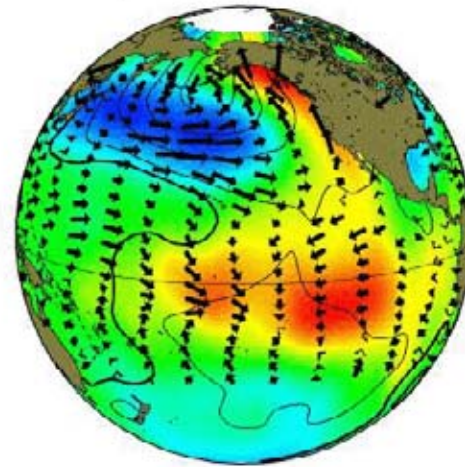
El Nino

Wind-SST



Pacific Decadal Oscillation

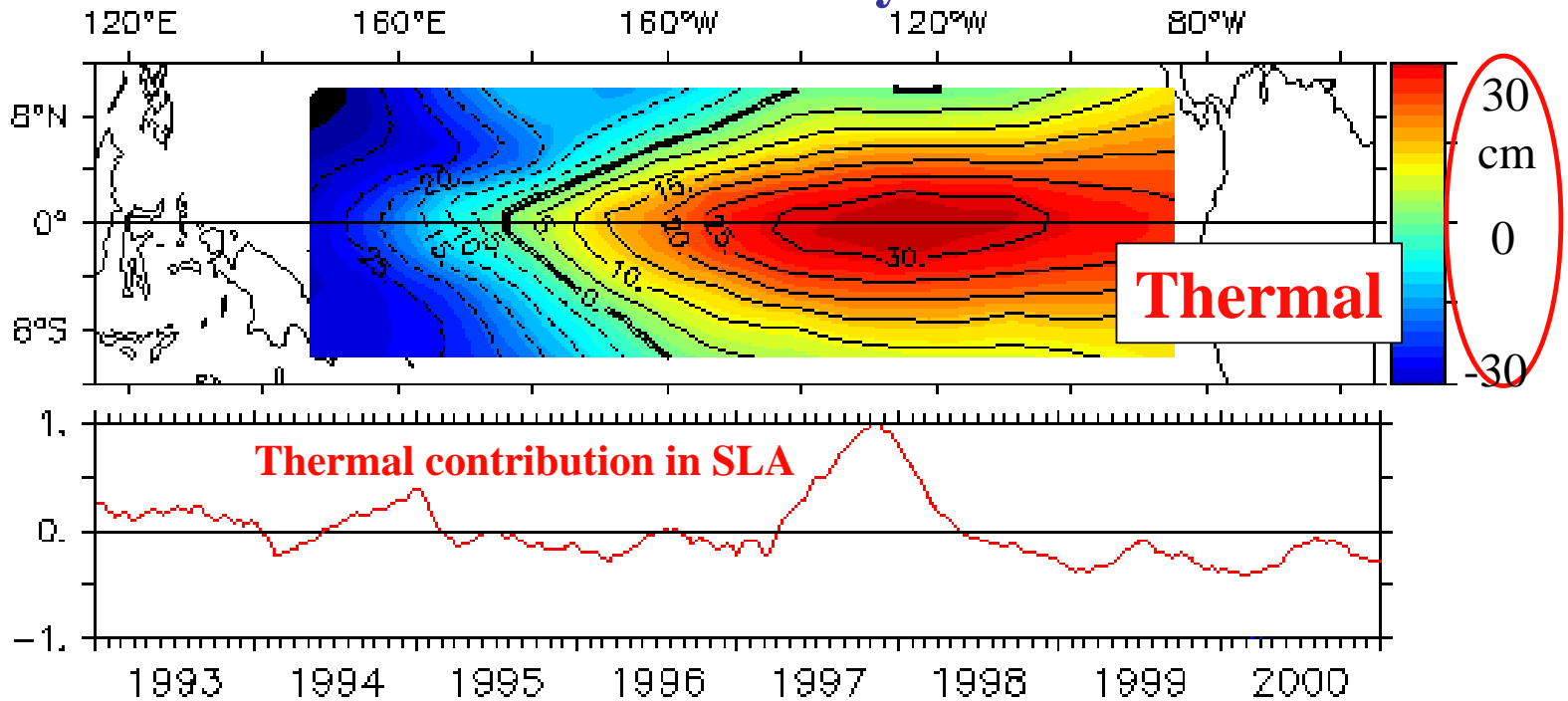
positive phase



Mantua and Battisti, 1994

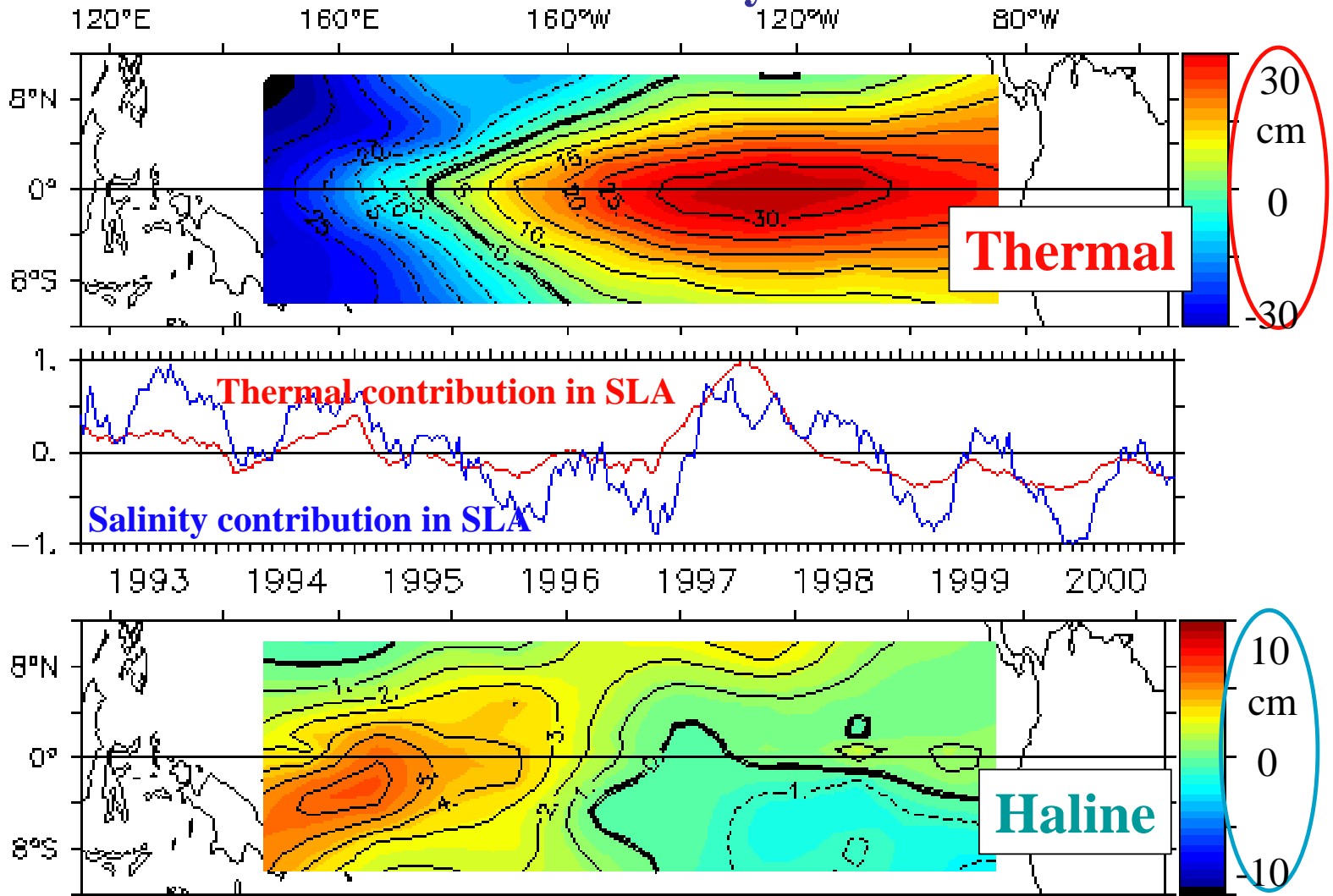
Thermal and haline contributions in sea level

EOF analysis



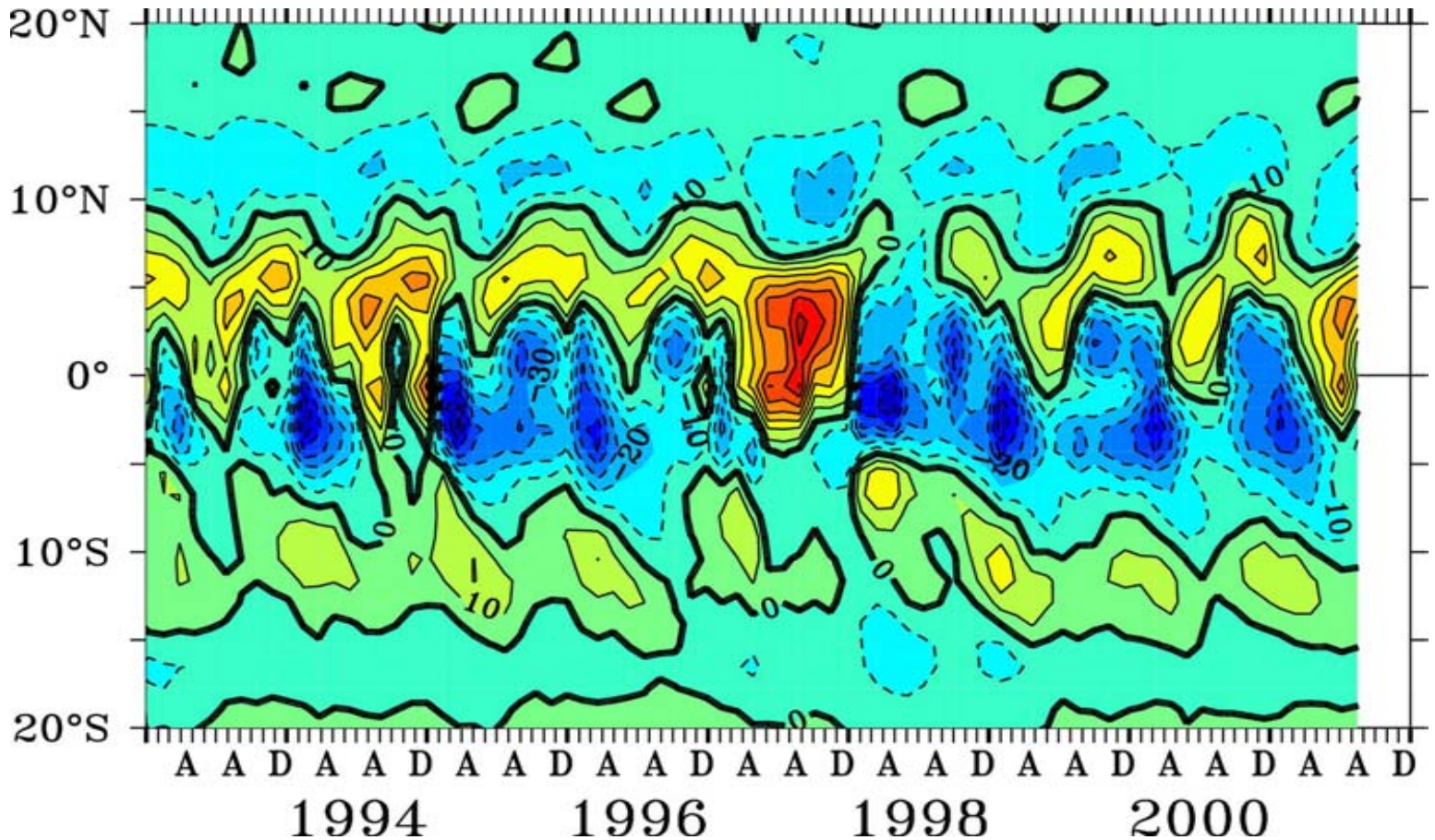
Thermal and haline contributions in sea level

EOF analysis



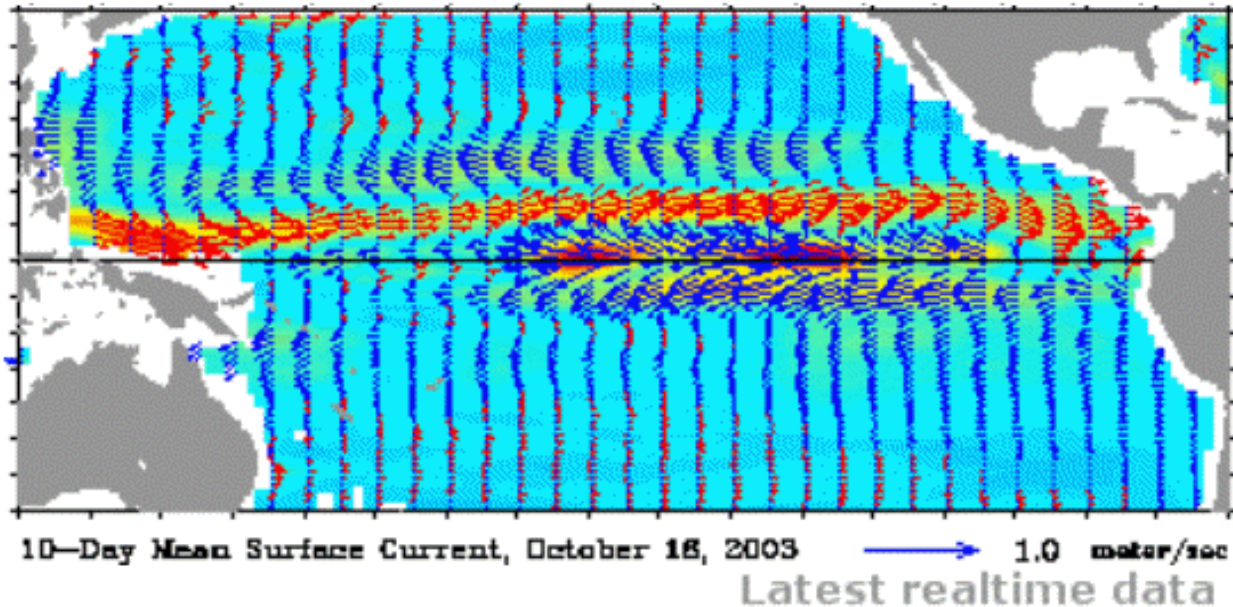
Total geostrophic currents derived from altimetry and gravity missions

Total currents along 175°E



Near-realtime ocean surface currents derived
from satellite altimeter and scatterometer

OSCAR



Pilot project for a NOAA/NESDIS
Operational Surface Current Processing and Data Center
National Ocean Partnership Program (NOPP)

Netscape: OSCAR - Ocean Surface Current Analyses - Real time

Location: <http://www.oscar.noaa.gov/index.html>

National Oceanic and Atmospheric Administration

OSCAR

Ocean Surface Current Analyses - Real time

Home | Project Overview | Data Display & Download | General Interest

Near-real-time ocean surface currents derived from satellite altimeter and scatterometer data




10-Day Mean Surface Current, October 18, 2003 → 1.0 meter/sec
Latest realtime data

Pilot project for a NOAA/NESDIS Operational Surface Current Processing and Data Center National Ocean Partnership Program (NOPP)

Home | [Project Overview](#) | [Data Display & Download](#) | [General Interest](#)

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NESDIS

ESR

USF

FSU

NRL

NCEP

PMEL

Conclusions

- **Altimetry sea level and derived currents are used intensively and successfully over the three tropical oceans**
- **Altimetry is fundamental for understanding the basic mechanisms of ENSO**
- **ENSO prediction is complicated by short and long term climate variability**
- **There is a definitive need for multiple and long-lasting altimetry missions**

