A Future Sustained Tropical Pacific Ocean Observing System for Climate Research and Forecasting

International and Multidisciplinary Scientific Requirements for the Tropical Pacific Observing System for 2020 (TPOS-2020)

Regional applications of observations in the eastern Pacific: Western South America

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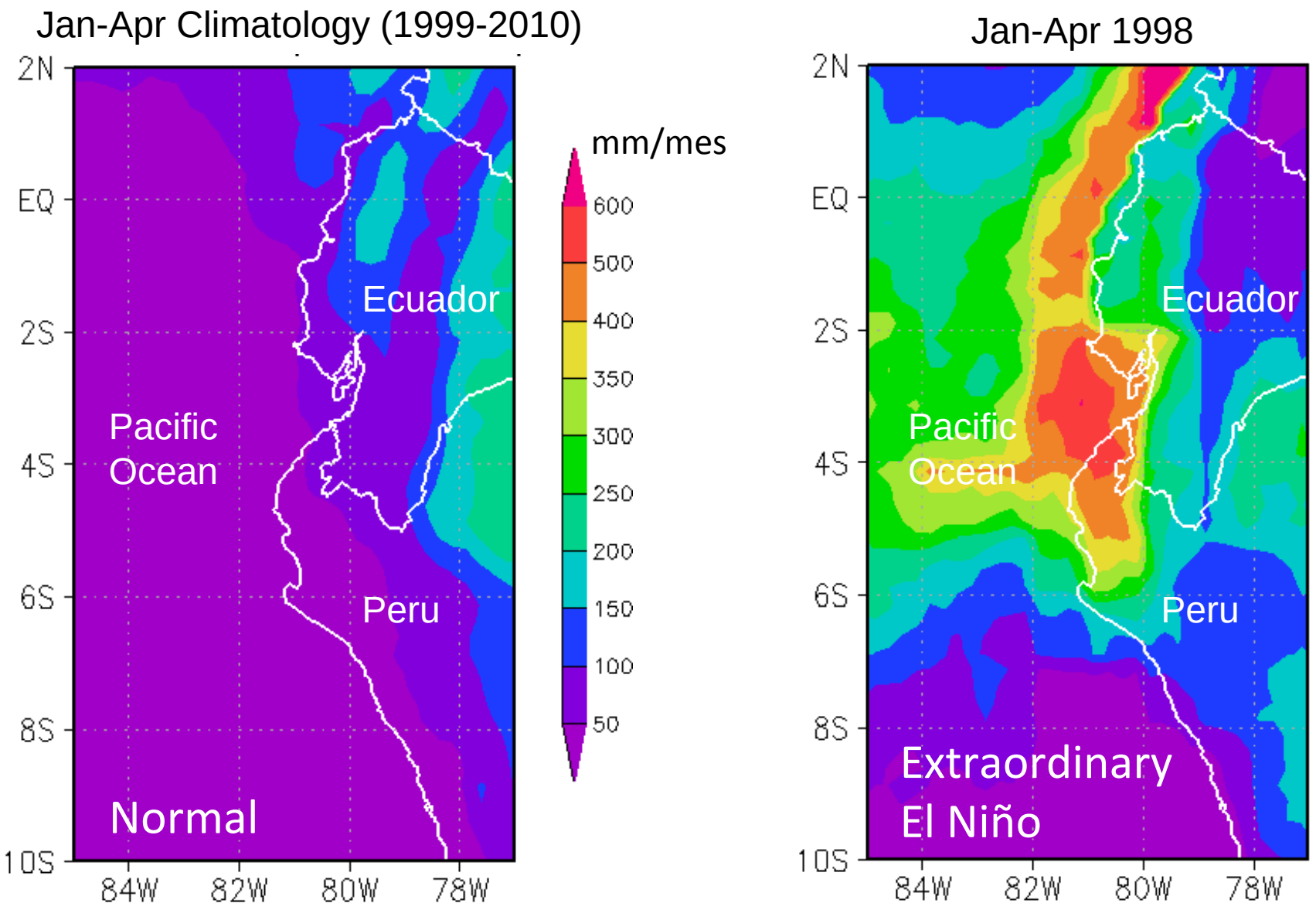
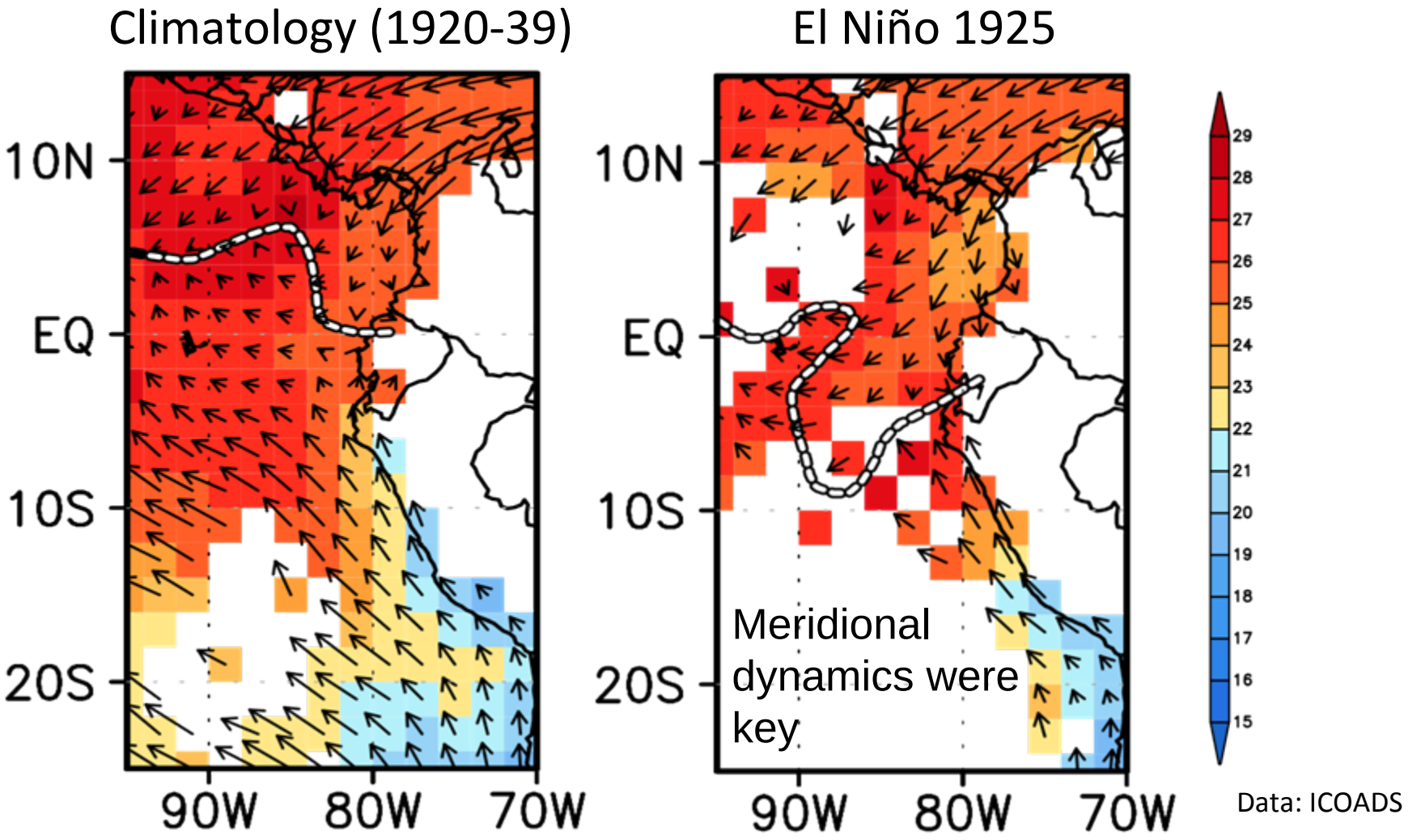
El Niño and rainfall in northwestern South America



Data: TRMM 3B43

Very strong El Niño 1925-26 in the *far-eastern* Pacific

SST and surface wind in March

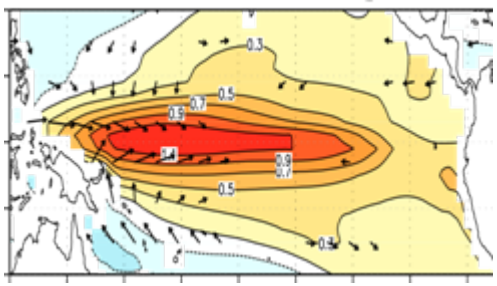


Data: ICOADS

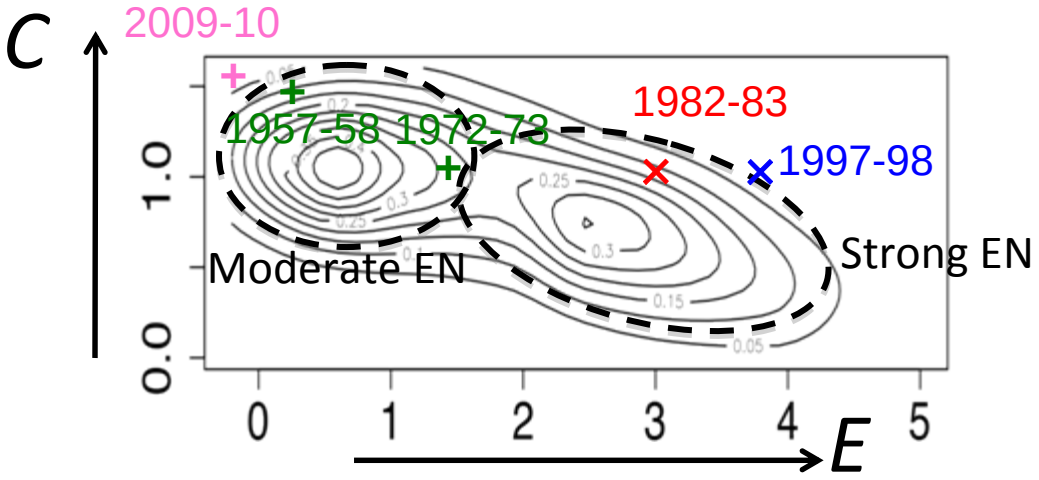
Takahashi et al 2014

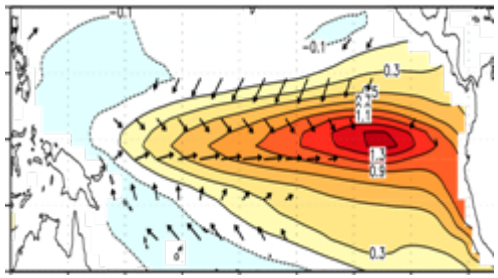
El Niño related impacts on western tropical South America

Strong and moderate El Niño regimes in GFDL CM2.1 and observations

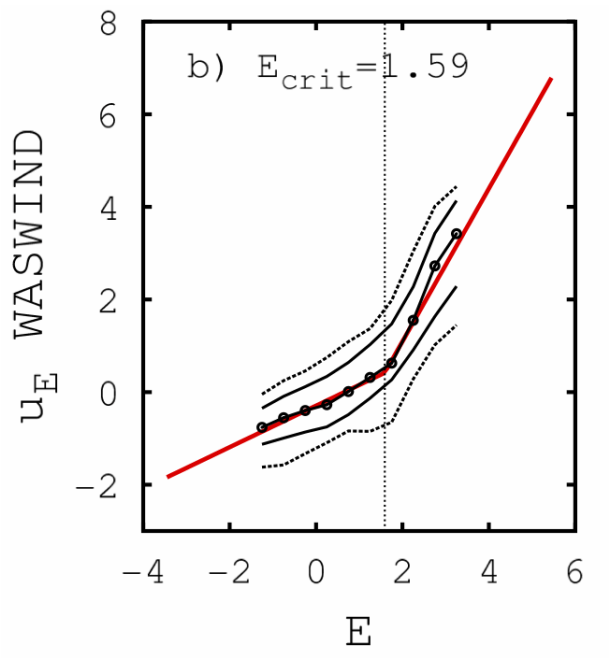


Probability distribution of El Niño peaks in GFDL CM2.1 and observed extraordinary events





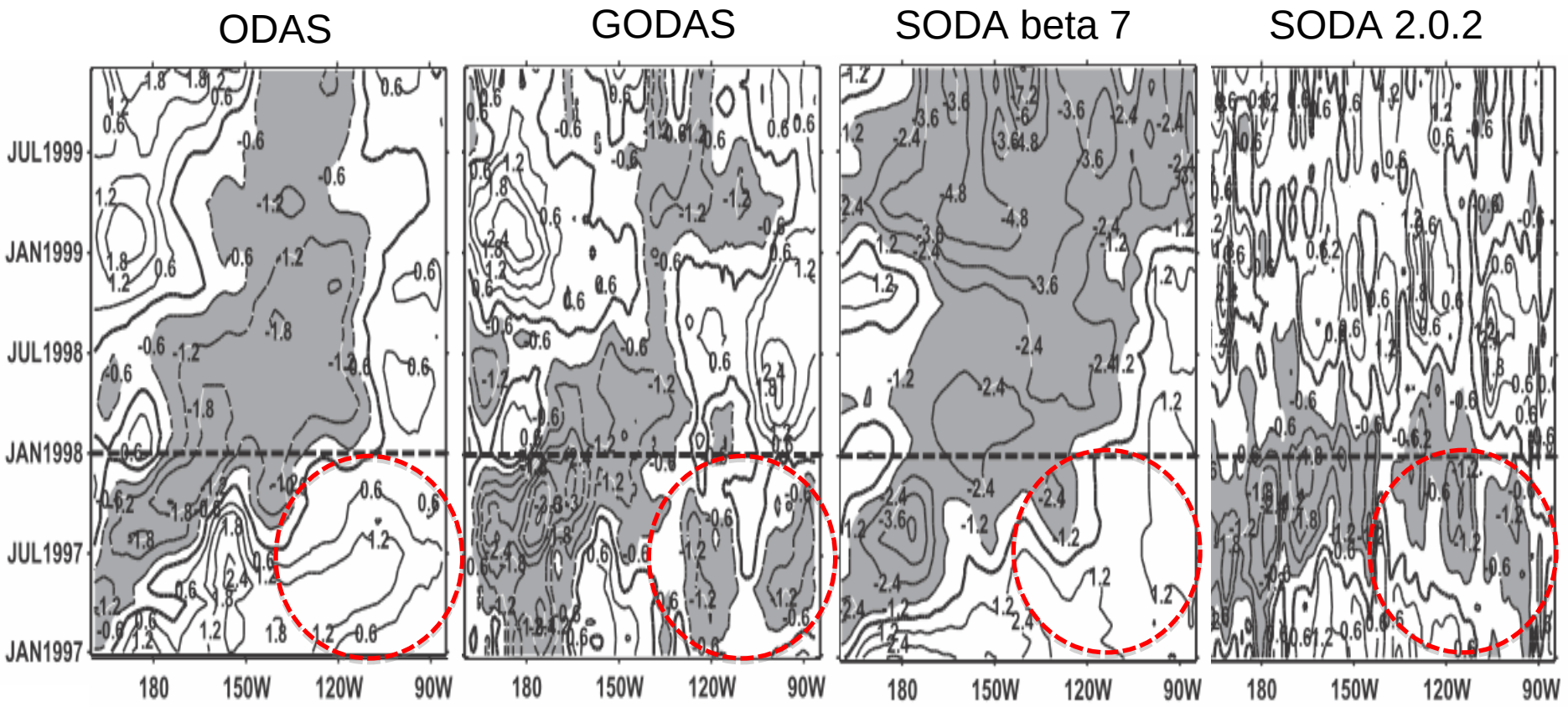
Observed E.Pac. zonal wind stress nonlinearity



Nonlineality in the eastern Pacific atmosphere, helped by nonlinear advection, can result in two El Niño regimes

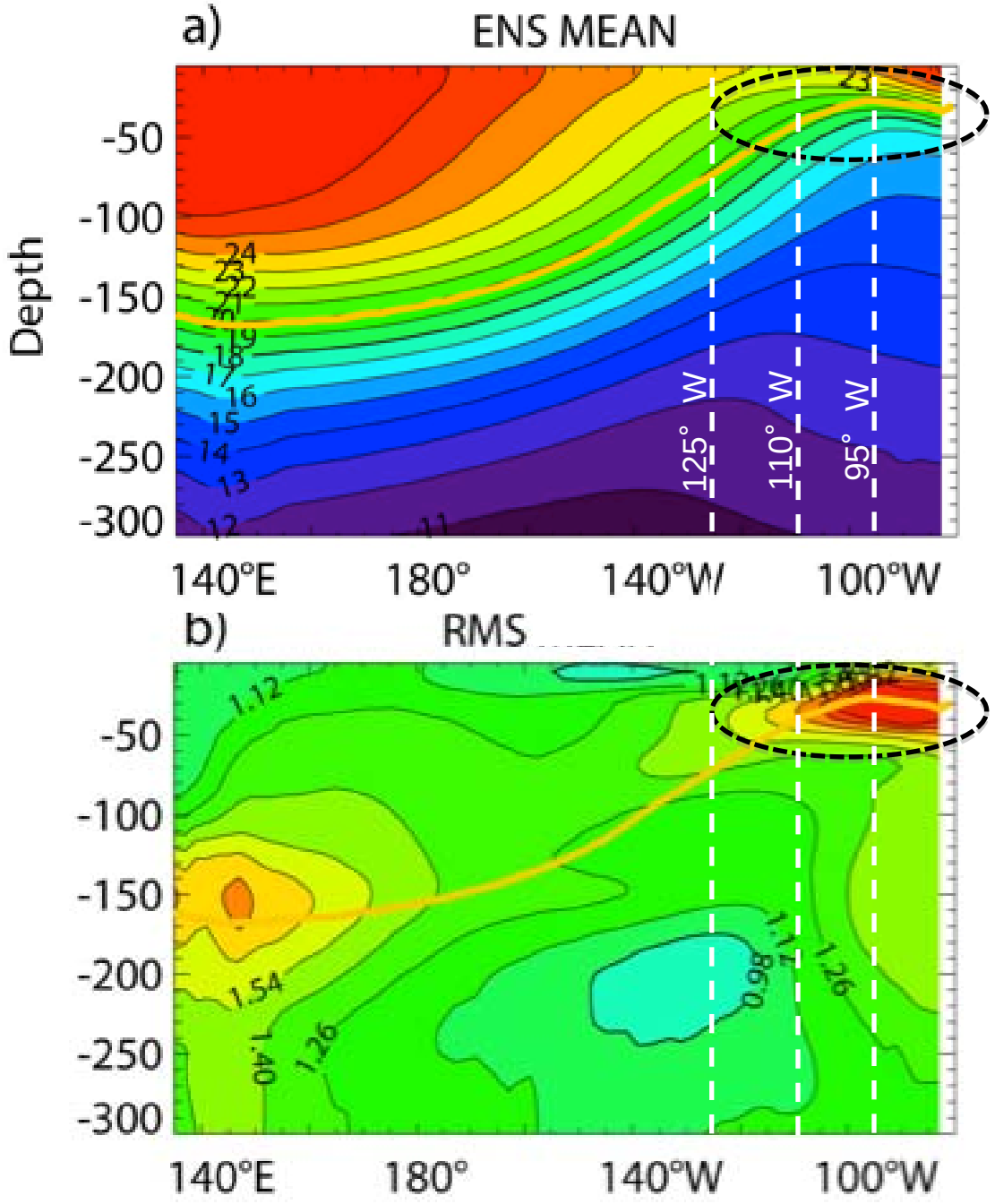
Takahashi and Dewitte, 2014

Equatorial ocean vertical velocity anomaly (10^{-5} m/s)during the 1997-98 El Niño



Vertical velocity in the eastern Pacific is not well constrained in reanalysis products. Need in situ data.

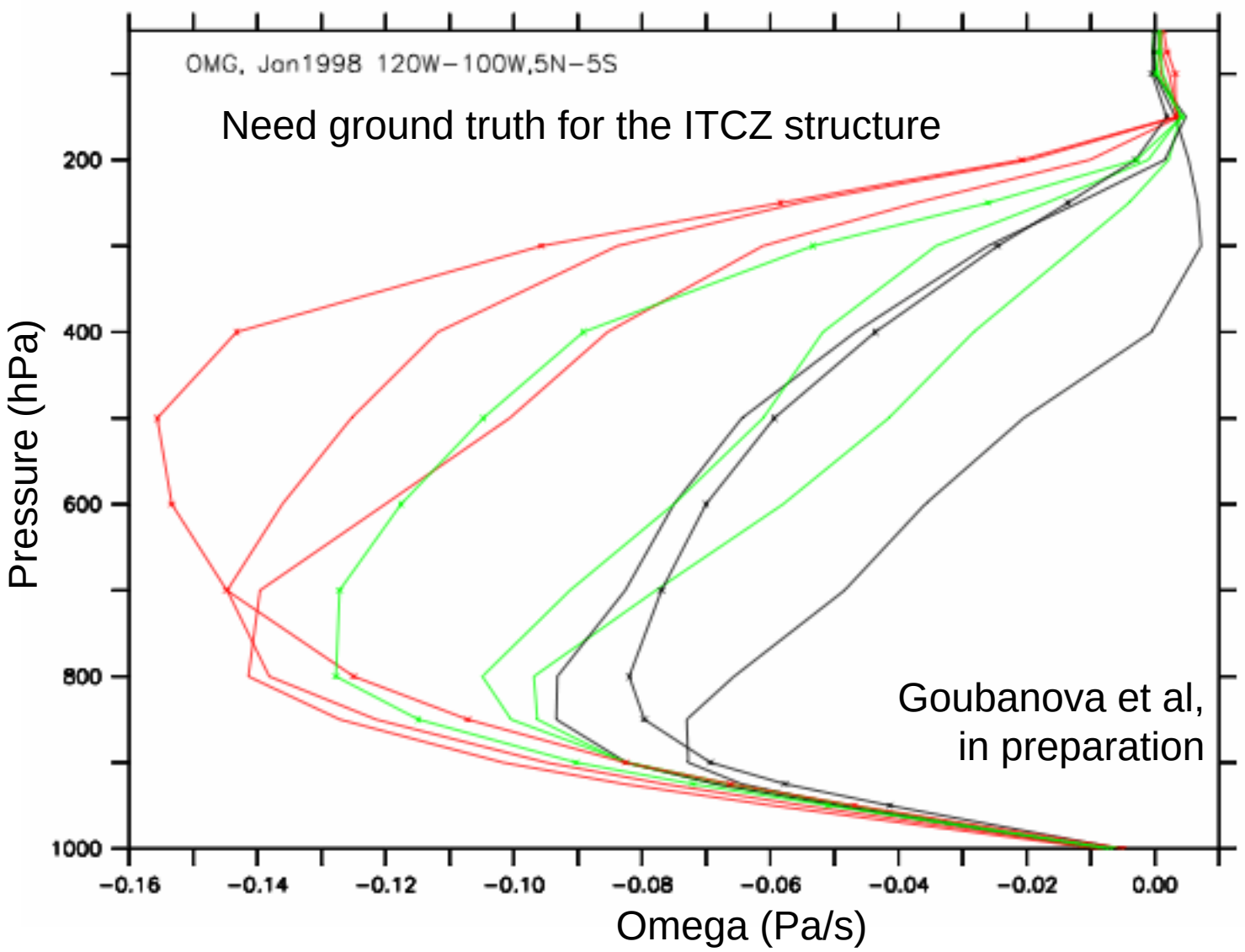
Su et al., 2010



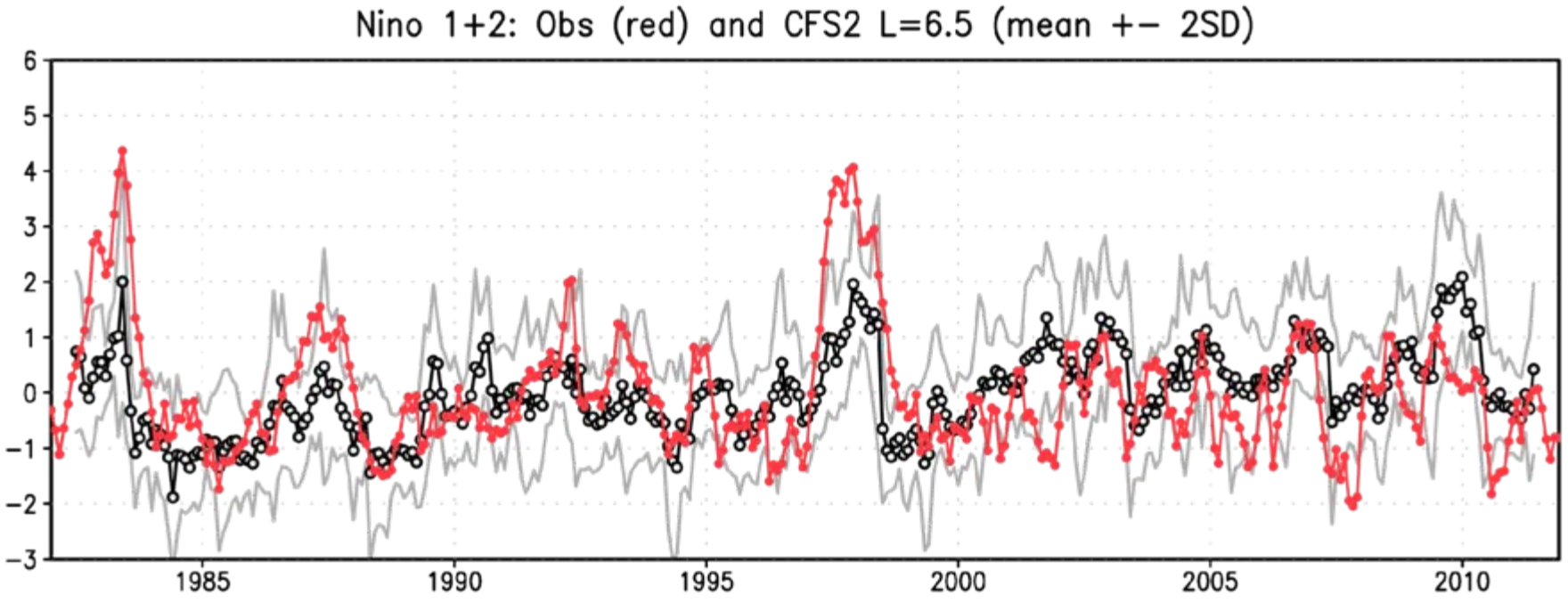
Climatological equatorial temperature in 15 CMIP3 models

B. Dewitte

Vertical velocity in the E.Pac. ITCZ during the 1997-98 El Niño in WRF with different parameterization schemes



6 month forecast of Niño 1+2 (NOAA CFS2 model)



Scientific issues related to the eastern Pacific

i) **Role of the eastern Pacific in ENSO Diversity**: El Niño regimes, nonlinear feedbacks, meridional processes involving the ITCZ or subtropical winds

ii) **Dispersion of the equatorial Kelvin waves**: Associated with the thermocline tilt, affects propagation and impact on SST

iii) **Quantifying wave dissipation in the eastern Pacific**: Vertical propagation below the thermocline, timescale-dependent

iv) **The thermocline feedback in the eastern Pacific**: Key “parameter” for ENSO stability, requires estimation of vertical advection

v) **Coastal dynamical and biogeochemical processes**: Coastal waves impacts on ecosystems and biogeochemistry, upwelling as carbon source, oxygen minimum zone

vi) **Convective processes in the eastern Pacific and ENSO**: Vertical structure of ITCZ in normal and El Niño conditions, equatorial convectively coupled waves and SST anomalies (multiplicative noise?)

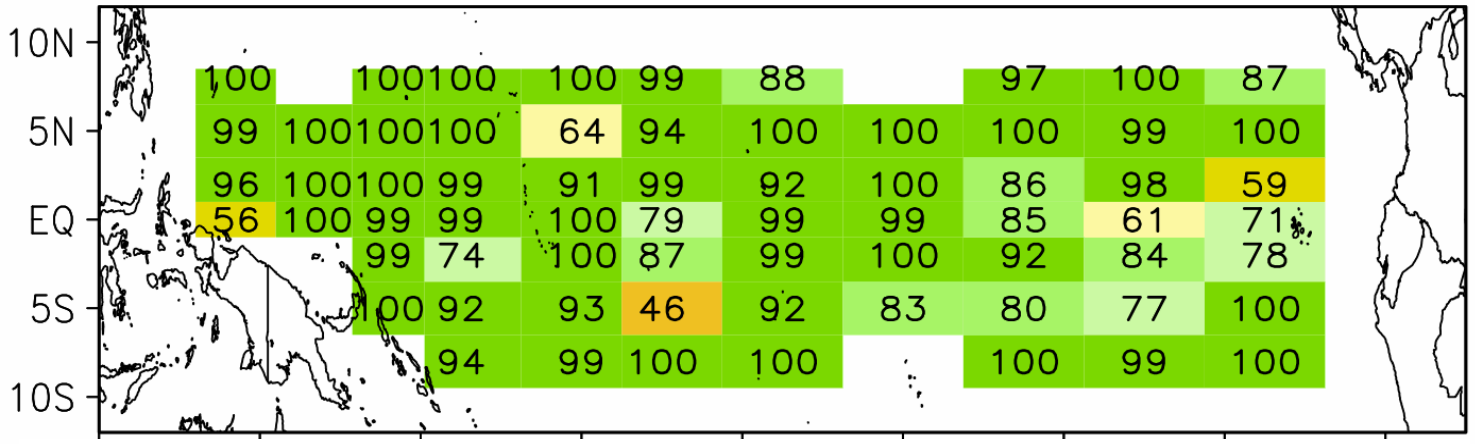
vii) **Decadal variability and climate change in the tropical-south Pacific**: Local vs equatorial winds/cloudiness, effects on ENSO and global warming

viii) **Seasonal and intraseasonal prediction**: Inability to reproduce different ENSO patterns, missing data?, deficient physics?

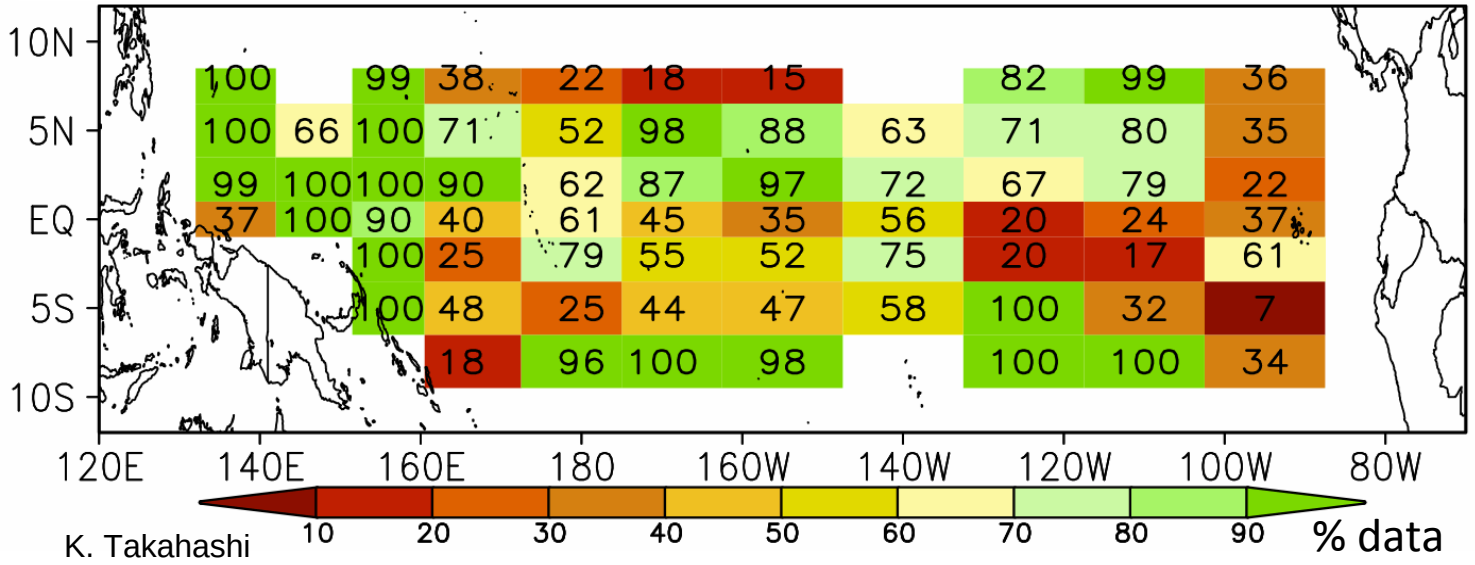
ix) **Regional impacts and applications**: Coastal vs remote warming impacts, statistical models and national systems using TAO/TRITON data

Completeness (%) of daily 100 m-depth temperature TAO/TRITON data

2010-2011



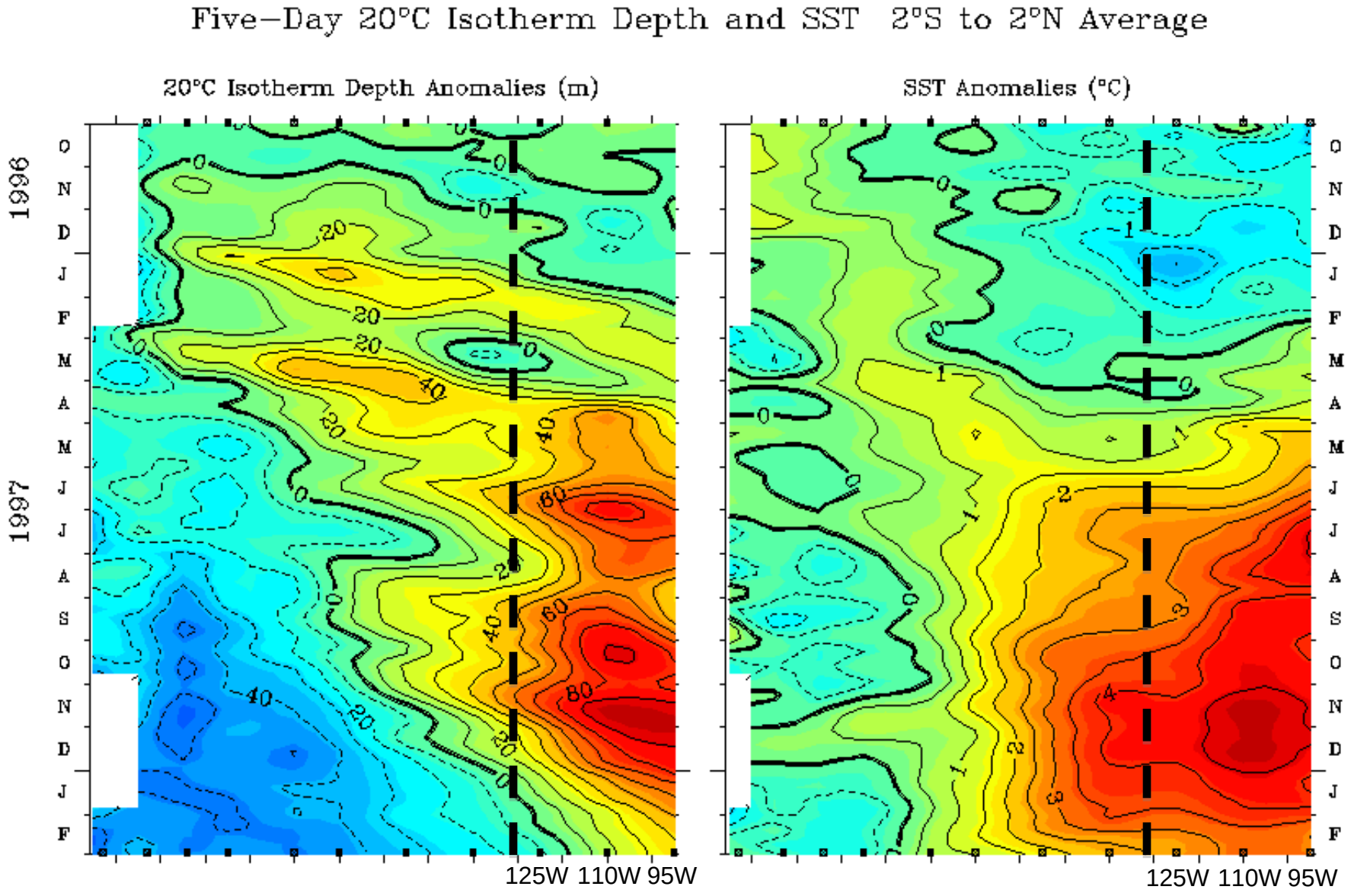
2012-2013



K. Takahashi

The far-eastern equatorial Pacific is particularly prone to failure, specially when maintenance is not done.

The 1997-1998 El Niño according to TAO



Applications of ocean observations

Scientific applications:

•...improve the understanding of critical processes in the equatorial eastern Pacific ...

•... monitor CO_2 and pH in the equatorial and coastal zone ...

Operational applications:

• ... real-time monitoring of equatorial Kelvin wave propagation ...

•... seasonal forecast ...

•... atmospheric intraseasonal waves ... used in operational weather and climate forecast ...

• For marine ecosystems management and associated fisheries, is essential to identify environmental changes through ocean biogeochemical variables monitoring...

Potential synergies and opportunities with countries in western South America

1) In 2003, Colombia, Ecuador, Peru and Chile established the GOOS Regional Alliance for the South Eastern Pacific. It has a Strategic Plan that could be updated and discussed in line with the TPOS new challenges and objectives.

2) Annual coordinated regional cruises by SE Pacific countries. Good opportunity as support of TPOS, especially for buoys maintenance, and as platforms for addressing critical gaps in research .

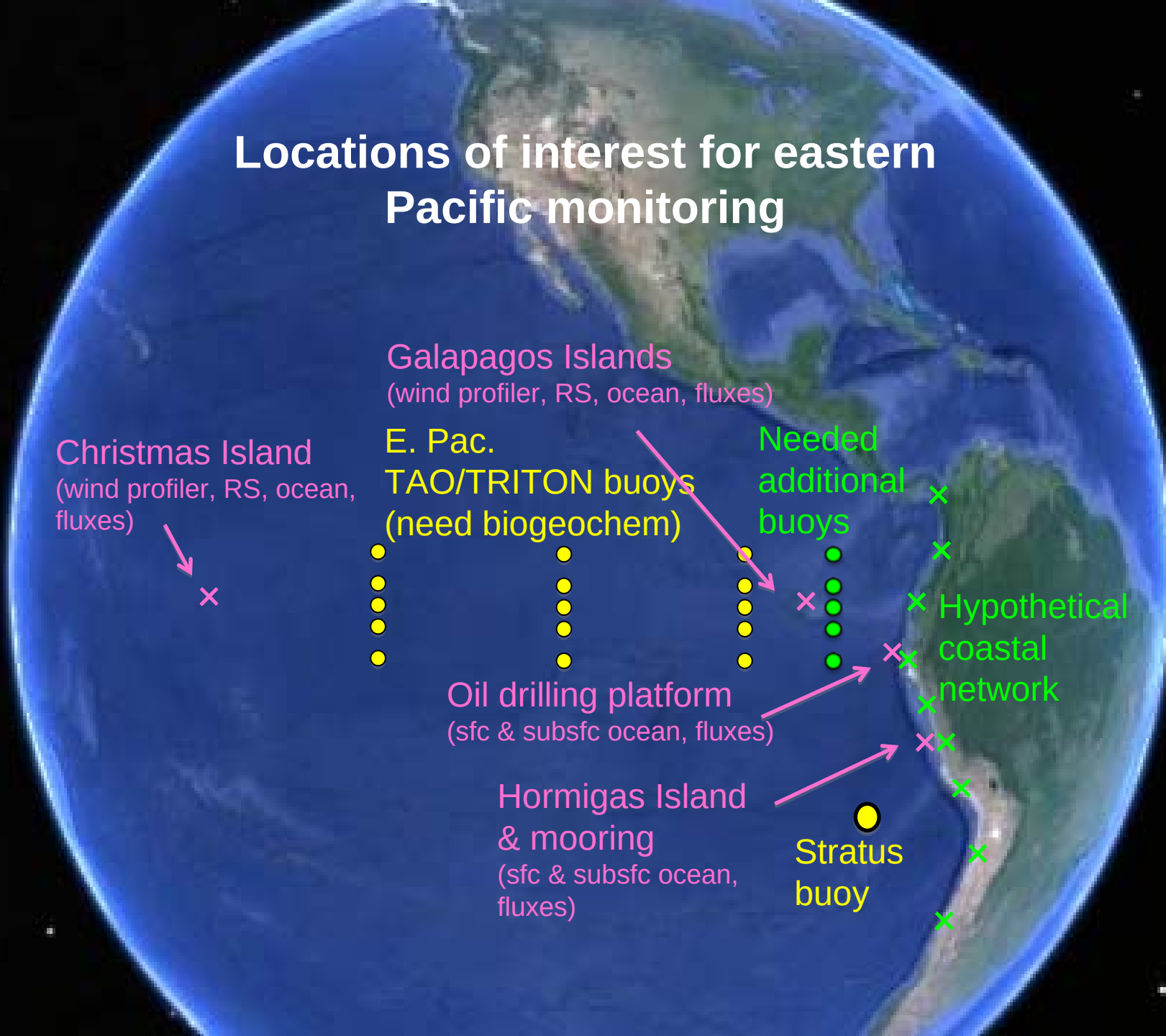
3) Regional organizations such as CPPS/ERFEN and CIIFEN could make a significant contribution to hasten cooperation for the TPOS.

4) Since 2001 to 2009, relevant efforts of IOC-UNESCO were developed in the region to enhance the ocean data exchange and evolve the traditional observing systems to near real time systems.

5) Galapagos islands (Ecuador), Hormigas Island (Peru) and oil drilling platforms, are strategic places to concentrate observations and multipurposes platforms. In addition, there is increasing interest of local and international organizations to enhance observations.

6) SE Pacific countries have increased their near real time gauges and coastal stations.

Locations of interest for eastern Pacific monitoring



Recommendations

1. Explore bilateral or regional cooperation mechanisms for ship employement as contribution to TPOS, particularly for the maintenance of TAO buoys and/or other components of the observational system.
2. Define a road map for a high level cooperation mechanism between TAO/TRITON and GRASP.
3. Extend the TAO array into the far eastern Pacific with a line at 85W to characterize Kelvin wave propagation across the zonal thermocline gradients.
4. Promote and support a sustained real-time coastal network of sea level, SST, and wind measurements based on national systems to be incorporated into TPOS.
5. Promote and support a network of sustained coastal subsurface temperature, currents, DO and pH measurements, and surface heat/momentum/gas fluxes. The data should be made available as part of TPOS at least monthly.
6. Include biogeochemical sensors (DO, pCO2, pH) in the eastern Pacific TAO buoys.
7. Explore synergies between SE Pacific region scientific networks with GEWEX.
8. Organize an international meeting in SE Pacific region with the support of International agencies, IOC, WMO and JCOMM to define the road map to the enhancement of TPOS in the Eastern Pacific region inclusing the presence of financial institutions.

Variable requirements

Variable	Application Area(s)	Resol.	Depth	Spatial	Temporal
Sea level	Coastal monitoring	1 cm	NA	Coastal stations	> 20 years, daily
Sea surface temperature	Coastal monitoring	0.1 K	NA	Coastal stations	> 20 years, daily
Horizontal wind	Coastal monitoring	0.5 m/s	NA	Coastal stations	> 20 years, daily
Ocean subsurface temperature	Coastal monitoring	0.1 K	5 m in upper 100 m	Coastal stations	> 20 years, daily
Ocean currents	Coastal monitoring	1 cm/s	5 m in upper 100 m	Coastal stations	> 20 years, daily
surface winds and heat fluxes and upper ocean vertical thermal structure	Coastal monitoring	1 cm/s	5 m in upper 100 m	Stratus buoy (85W, 20S)	> 20 years, daily
Ocean currents	Coastal monitoring	1 cm/s	5 m in upper 100 m	Coastal stations	> 20 years, daily
pH	Coastal monitoring		5 m in upper 100 m	Coastal stations	> 20 years, daily
Dissolved oxygen	Coastal monitoring		5 m in upper 100 m	Coastal stations	> 20 years, daily
Surface energy, momentum and gas fluxes	Ocean-atmospheric interaction in upwelling region			Isla Hormigas (Peru)	> 20 years, hourly

Variable	Application Area(s)	Resol.	Depth	Spatial	Temporal
Ocean subsurface temperature	Kelvin wave, extreme El Niño, decadal changes	0.1K	0-500 m / dz=10 m in upper 200 m	Eastern equatorial Pacific: 125W-80E, 5S-5N/ dx=15 deg, dy=2 deg	> 20 years, daily
Surface wind (and wind stress)	Equatorial ocean forcing	0.5 m/s	Surface	Equatorial Pacific: 125W-80E, 10S-10N/ dx=15 deg, dy=2 deg	> 20 years, daily
Surface energy fluxes	ENSO energetics, long term climate variability and change	0.5 W/m2	Surface	Equatorial Pacific: 125W-80E, 10S-10N/ dx=15 deg, dy=2 deg	> 20 years, daily
Turbulent microstructure (CT, etc)	Ocean mixing	?	0-500 m / dz=10 m in upper 200 m	Eastern equatorial Pacific: 125E-80E, 5S-5N/ dx=15 deg, dy=1 deg	> 20 years, daily
Precipitation				TAO buoys	hourly
3D wind profiles	Atmospheric convection and large-scale circulation	1 m/s, 0.02 Pa/	1000-200 hPa, dp=50 hPa	Wind profilers in Galapagos island (0.9S, 89.7W), Christmas Island (2.0S, 157.4W)	> 20 years, hourly
Ocean currents	Advective processes, wave dynamics	1 cms^{-1}	0-500 m / dz=10 m in upper 200 m	ADCPs at 95W, 85W, 2.5S, 2.5N for divergence	> 20 years, pentadal
pH, pCO_2 and DO	Biogeochemistry /transports to South America	?	0-500 m / dz=10 m in upper 200 m	Eastern equatorial Pacific: 125W-80E, 5S-5N/ dx=15 deg, dy=2 deg	> 20 years, daily
Ocean vertical velocity	Advective processes	5×10^{-6} ms^{-1}	0-500 m / dz=10 m in upper 200 m	ADCPs at 95W, 85W, 2.5S, 2.5N for divergence	> 20 years, pentadal
Wind stress	Atmospheric forcing/response to ENSO			scatterometer	> 20 years, daily
Radiosoundings	ITCZ, convectively coupled waves			Galapagos island (Ecuador)	> 20 years, daily