Historical Chronologies of El Nino Events and Instrumental ENSO Indices

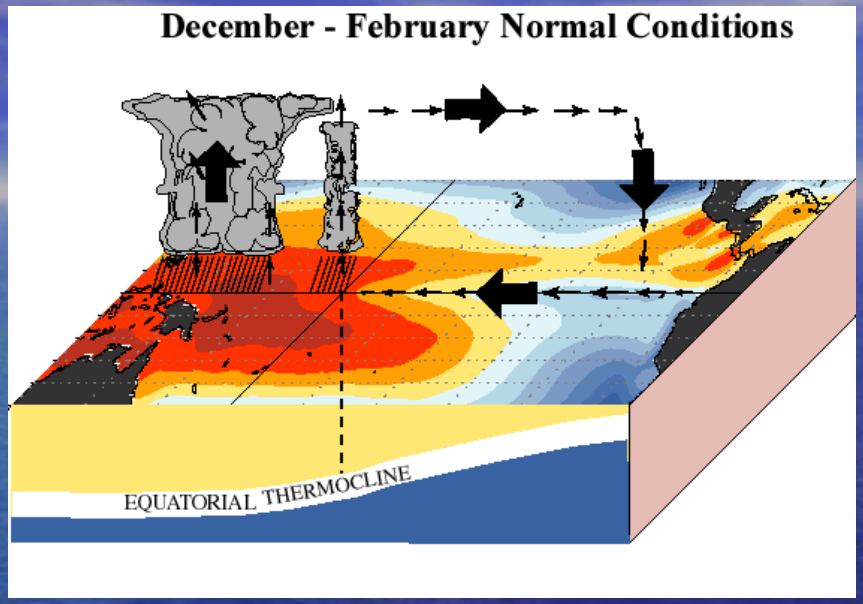
Alexey Kaplan
LDEO of Columbia University

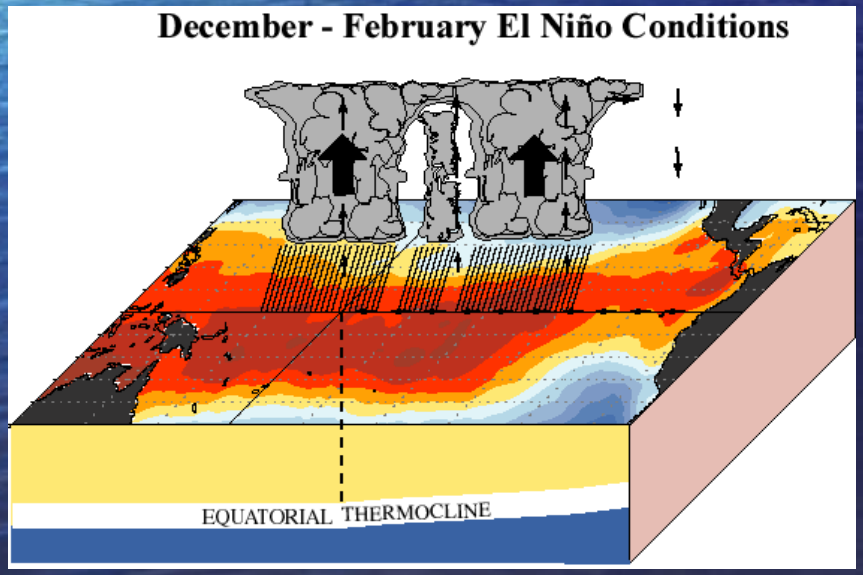
In collaboration with:
Jesse Conan, Mike Evans, Mark Cane, Yochanan Kushnir

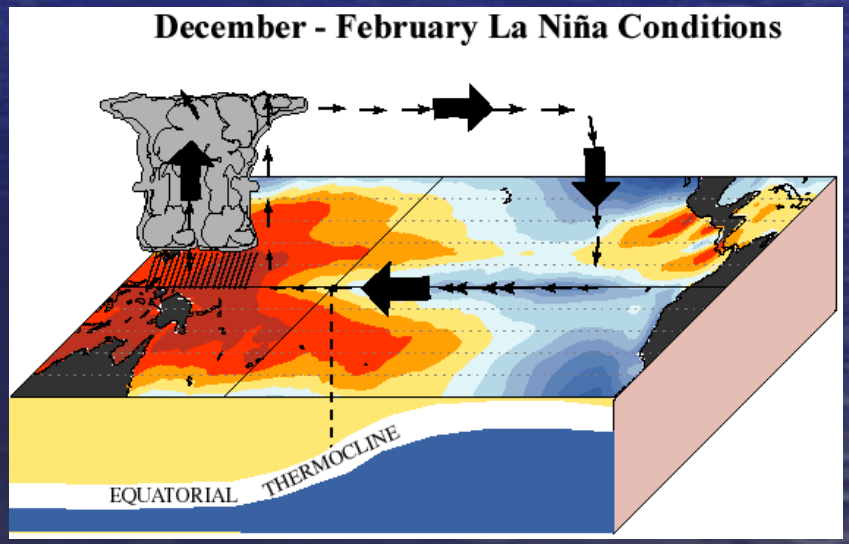
OUTLINE

- Historical chronologies of El Nino event occurrences intensities
- Instrumental reconstructions.
- Reconciling and revising efforts.
- (In)consistency between indices.

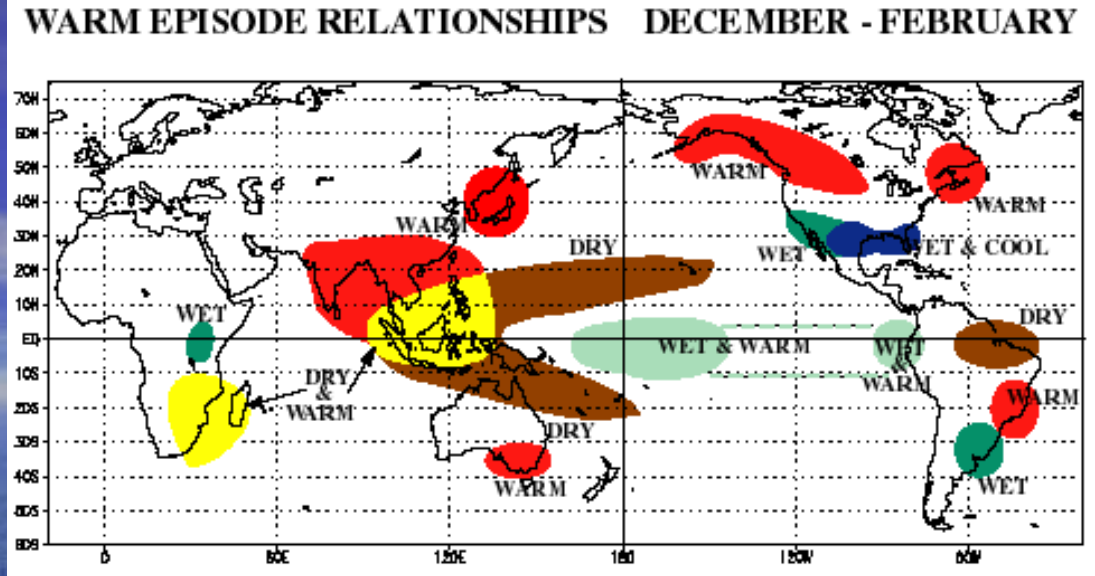
Dynamics of El Niño – Southern Oscillation

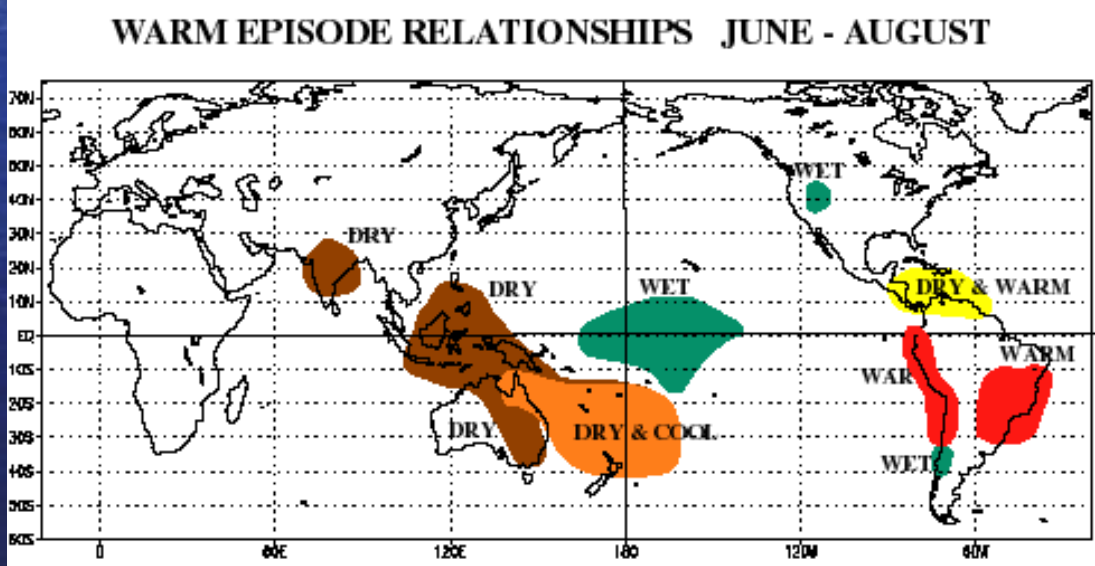






Global Impacts of El Niño make it possible to compile historical chronologies of El Niño events (best known are original chronologies of W.Quinn, their revisions by L.Ortlieb)





Climate Prediction Center
NCEP

William Quinn's *et al.* [1987] criteria for El Niño events

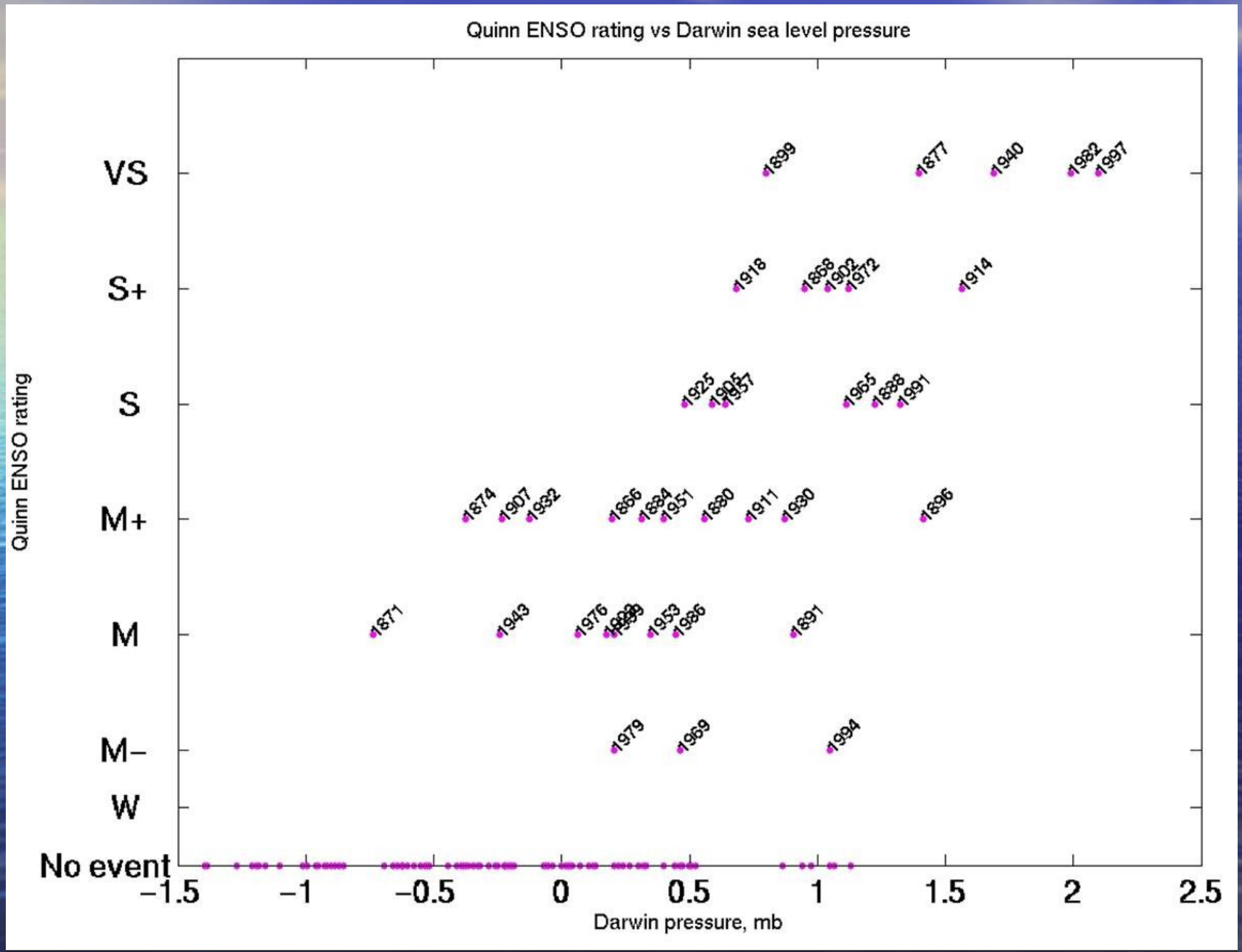
(1) very high sea and air temperatures with SST anomalies reaching 6-12°C above normal in peak months;
(2) presence of aguaje (red tide);
(3) thunderstorms, torrential rainfall, floods and erosion of the normally arid coastal lowlands;
(4) significant rises in sea level along the coast;
(5) invasion of northern and central Peruvian coastal waters by tropical nekton;
(6) destruction of housing areas, large buildings and sometimes whole cities by river inundations and flood waters;
(7) interruption of transportation as a result of destruction of bridges, roadways and railroad facilities by hydrological forces;
(8) departure of guano birds from coastal islands;
(9) mass mortality of various marine organisms, including guano birds, often with subsequent decomposition and a great stench from the release of hydrogen sulfide;
(10) destruction of agricultural crops and livestock;
(11) conditions causing the spread of tropical diseases;
(12) drastic reduction in coastal anchoveta fishery catches and fishmeal production.

William Quinn's *et al.* [1987] references for El Niño events chronologies

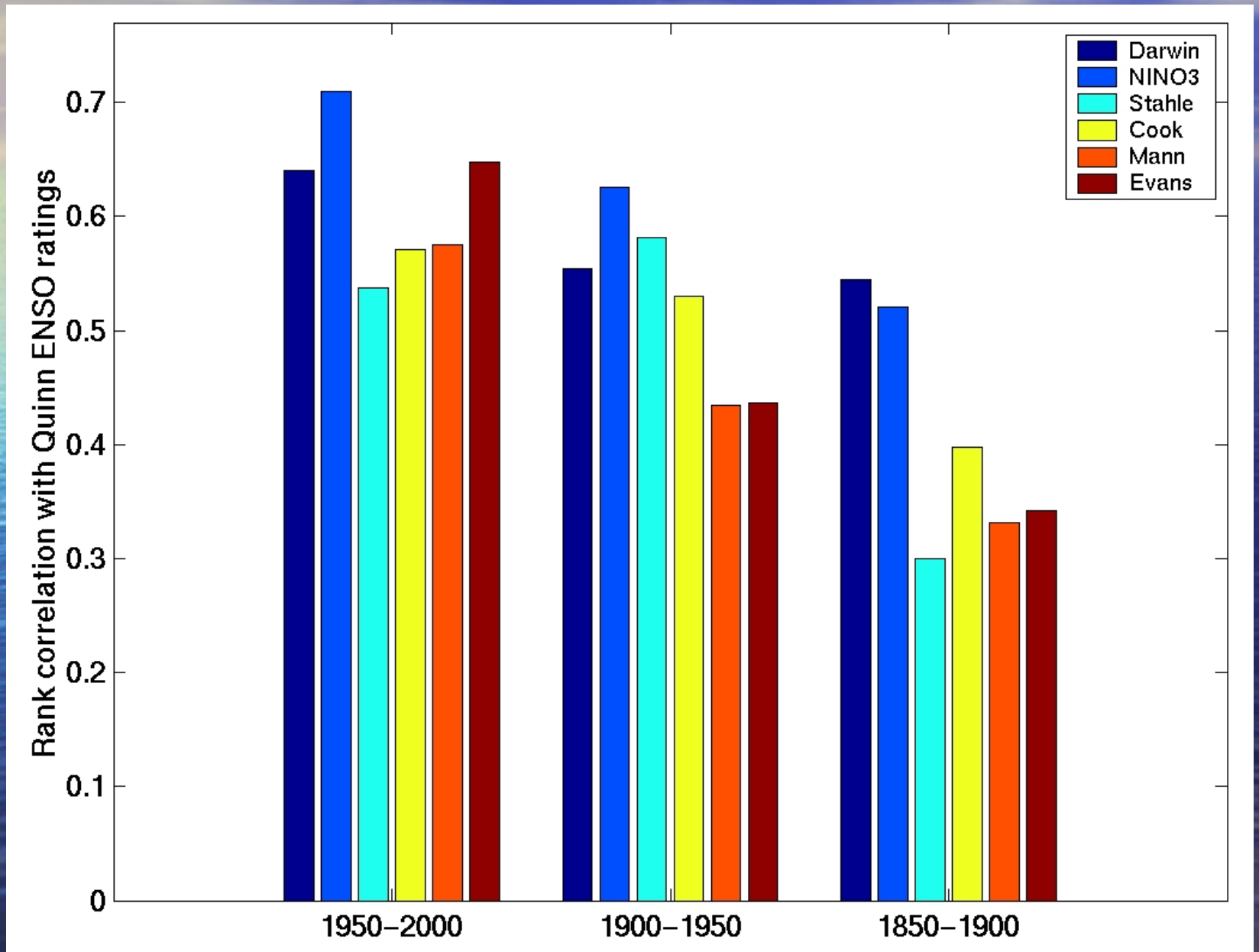
TABLE 2. El Niño Events of Moderate and Near-Moderate Intensities, Their Confidence Ratings, and Information Sources

El Niño Event	Event Strength	Confidence Rating	Information Sources
1806–1807	M	3	*Stevenson* [1829], *Remy* [1931], and *Unanue* [1815]
1812	M	4	*Palma* [1894] and *Gonzalez* [1913]
1817	M+	5	*Eguiguren* [1894], *Labarthe* [1914], *Portocarrero* [1926], and *Taulis* [1934]
1819	M+	4	*Eguiguren* [1894] and *Taulis* [1934]
1821	M	5	*Eguiguren* [1894], *Fuchs* [1925], *Remy* [1931], and *Taulis* [1934]
1824	M	5	*Spruce* [1864], *Basadre* [1884], and *Eguiguren* [1894]
1832	M	5	*Spruce* [1864], and *Eguiguren* [1894]
1837	M	5	*Eguiguren* [1894], *Labarthe* [1914], *Portocarrero* [1926], and *Taulis* [1934]
1850	M	5	*Eguiguren* [1894], *Fuchs* [1925], and *Taulis* [1934]
1854	W/M	4	*Spruce* [1864], *Eguiguren* [1894], and *Taulis* [1934]
1857–1858	M+	5	*Eguiguren* [1894], *Labarthe* [1914], *Portocarrero* [1926], *Gaudron* [1925], *Zegarra* [1926], and *Taulis* [1934]
1860	M	4	*Labarthe* [1914], *Portocarrero* [1926], and *Taulis* [1934]
1866	M	4	*Eguiguren* [1894], *Labarthe* [1914], *Bachmann* [1921], and *Portocarrero* [1926]
1867–1868	M	4	*El Comercio* (January 10, 1872), *Raimondi* [1897], *Taulis* [1934], and *Eguiguren* [1894]
1874	M	4	*Bravo* [1903], *La Patria* (February 9, 1874), and *Bachmann* [1921]
1880	M	4	*Eguiguren* [1894], *Puls* [1895], and *Taulis* [1934]
1887–1889	W/M	5	*Eguiguren* [1894], *Labarthe* [1914], *Portocarrero* [1926], and *Taulis* [1934]
1896–1897	M+	4	*Bravo* [1903], *El Comercio* (February 3, 1897, and February 22, 1897), and *Bachmann* [1921]
1902	M+	4	*El Comercio* (February 17, 1902), *Bachmann* [1921], and *Taulis* [1934]
1905	W/M	4	*Bachmann* [1921], and *Taulis* [1934]
1907	M	3	*Remy* [1931], and *Paz Soldan* [1908]
1914	M+	5	*Labarthe* [1914], *Portocarrero* [1926],

Quinn ENSO ratings vs Darwin atmospheric pressure



Historical chronologies vs instrumental and paleoproxy ENSO indices



Reconstructing SST via Reduced Space Optimal Smoother

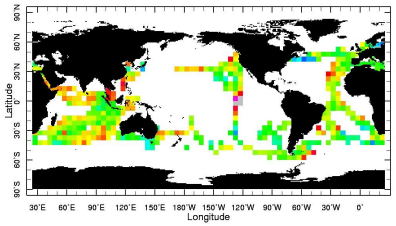
Reconstruction from sparse 1877 data shows a huge El Nino, confirming climatologists' beliefs.

The reconstruction of the moderate strength 1986 El Nino is quite believable.

The reconstruction comes out almost the same if the 1986 data are resampled as if they were measured in 1877!

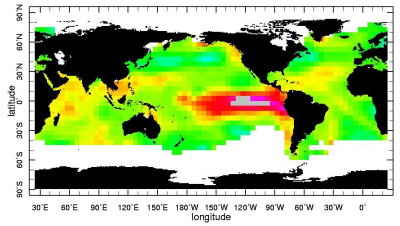
These reconstructions lack many small-scale features which we try to bring in by using their statistical description from satellite data.

Dec 1877: Available observations



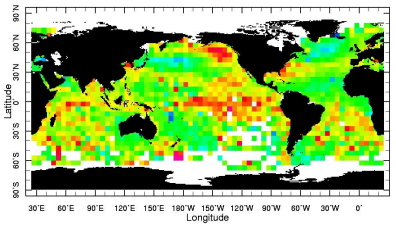
Dec 1877

Dec 1877: Reconstruction



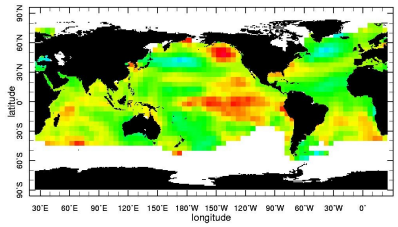
Dec 1877

Dec 1986: Available observations



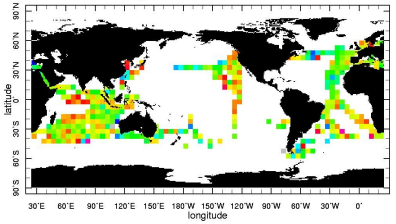
Dec 1986

Dec 1986: Reconstruction



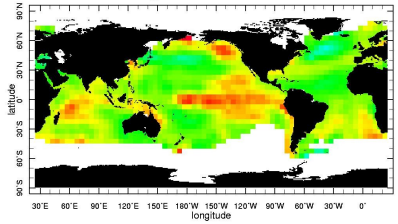
Dec 1986

Dec 1986: observations resampled as in Dec 1877



Dec 1986

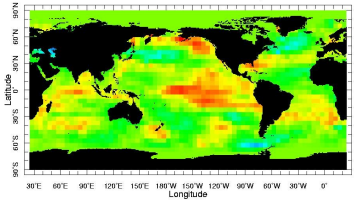
Dec 1986: Reconstruction from the resampled set



Dec 1986

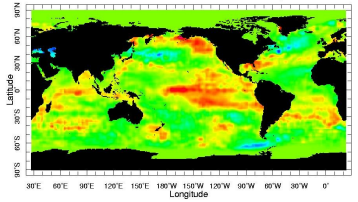
Targets for imrovement: small scales from the satellites

Dec 1986: NCEP OI, $5^o \times 5^o$

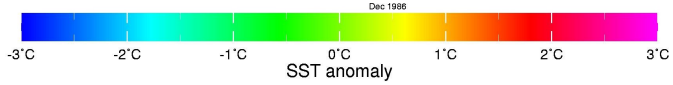


Dec 1986

Dec 1986: NCEP OI, $1^o \times 1^o$



Dec 1986

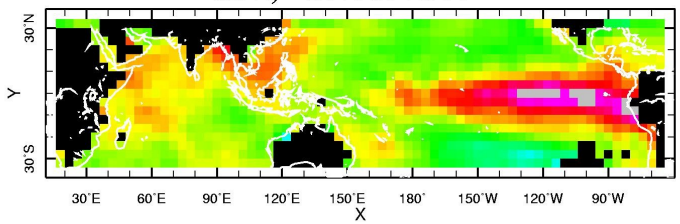


Trial reduced space OI analyses of basic ICOADS variables SST (with FP95 correction), SLP, winds, cloudiness, humidity; GHCN land station data: air temperature and precipitation, all on the same 4x4 degree monthly grid.

Intercomparison of different variables and with paleo and documentary data.

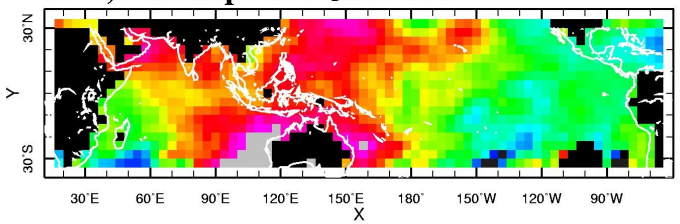
El Niño of 1877-1878 in analyzed anomalies

SST, °C: Dec 1877

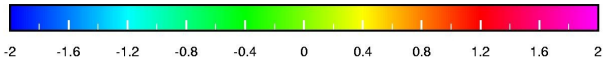


RSA_COADS_sstFP95 OS sstca T=Dec 1877
point mean: 0.45326 ± 0.81865 range [-1.7467 to 3.7493]

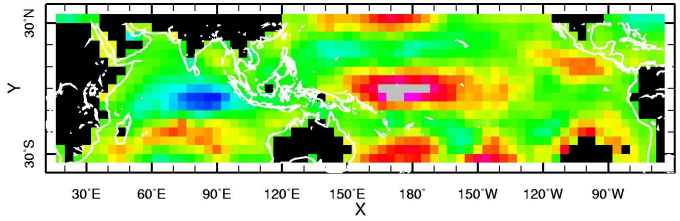
SLP, mb: Sep 1877-Jan 1878



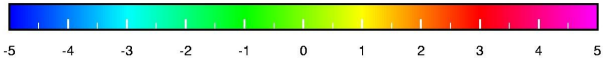
RSA_COADS_slp OI mslpa T=Nov 1877
point mean: 0.26096 ± 0.97148 range [-3.1618 to 5.633]



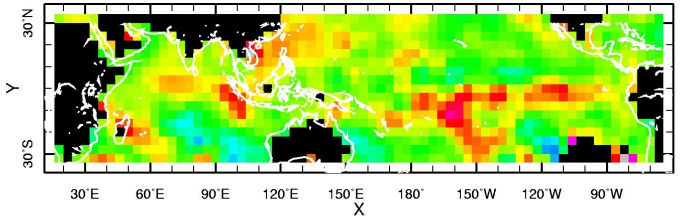
Zonal wind, m/s: Nov 1877



RSA_COADS_uwnd OI uwnda T=Nov 1877
point mean: 0.0229419 ± 1.4972 range [-4.8119 to 5.9475]
Reduced space (80 EOFs) analysis of COADS uwnd data

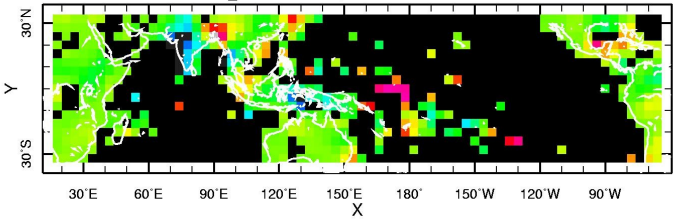


Meridional wind, m/s: Nov 1877

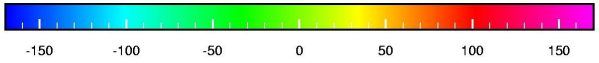


RSA_COADS_vwnd OI vwnda T=Nov 1877
point mean: 0.20265 ± 0.96678 range [-3.1376 to 4.5608]

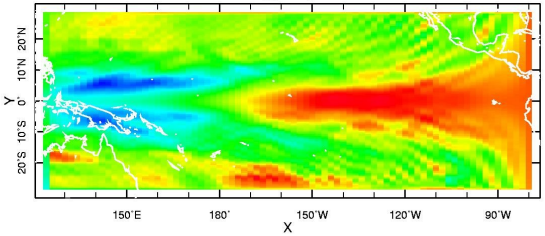
Precipitation, mm: Jul 1877



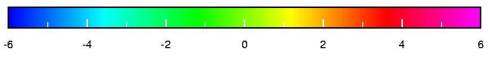
RSA_GHCN_prcp_anoml_cgrid OI prcpa T=Jul 1877
point mean: -9.2232 ± 53.891 range [-320.72 to 200.16]



Sea surface height, cm: Dec 1877



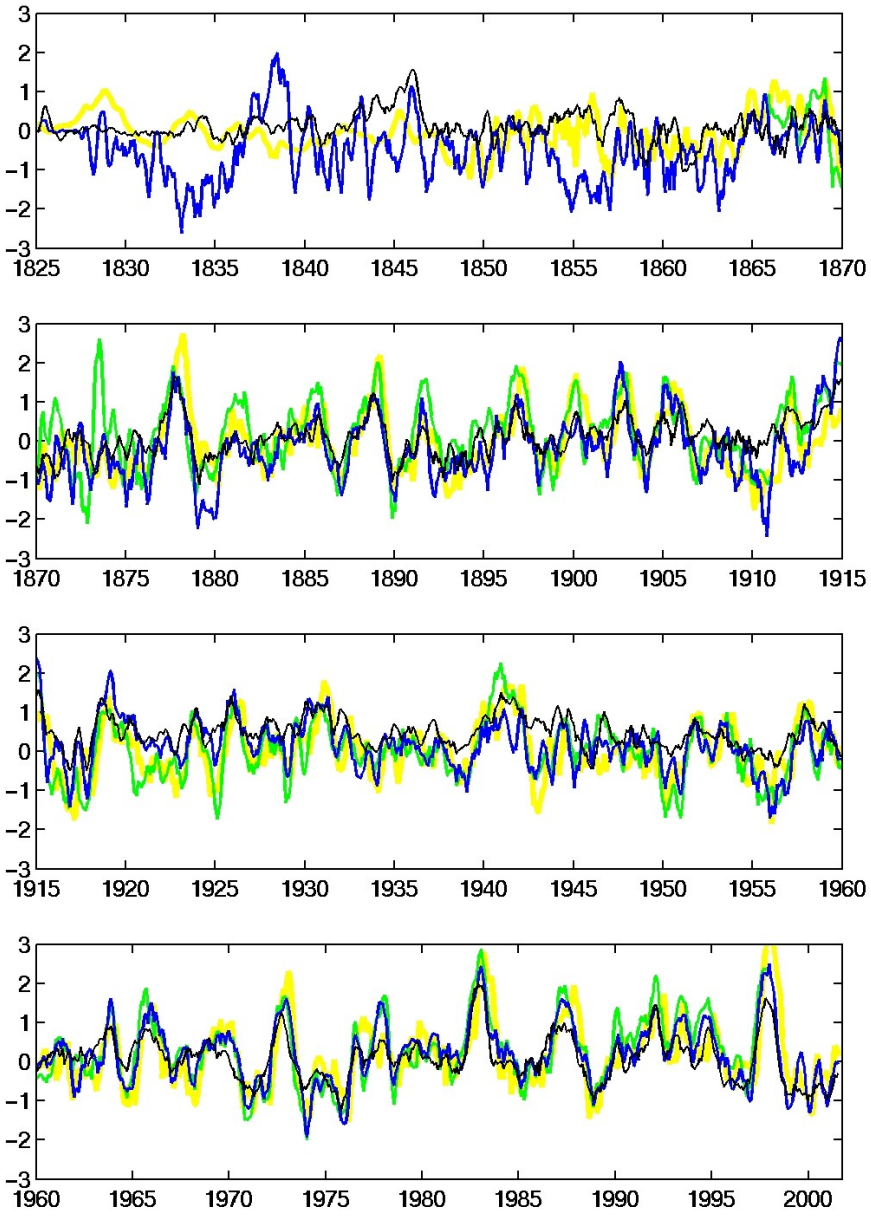
sl_OI Sea_Level Z=0 T=Dec 1877
point mean: 0.00201655 ± 1.9395 range [-5.8358 to 3.8843]



I-COADS analyses

GHCN analysis

Ocean model response to the wind analysis



Legend:

Data vanishes

NINO3
(SST from ships)

Reasonable consistency

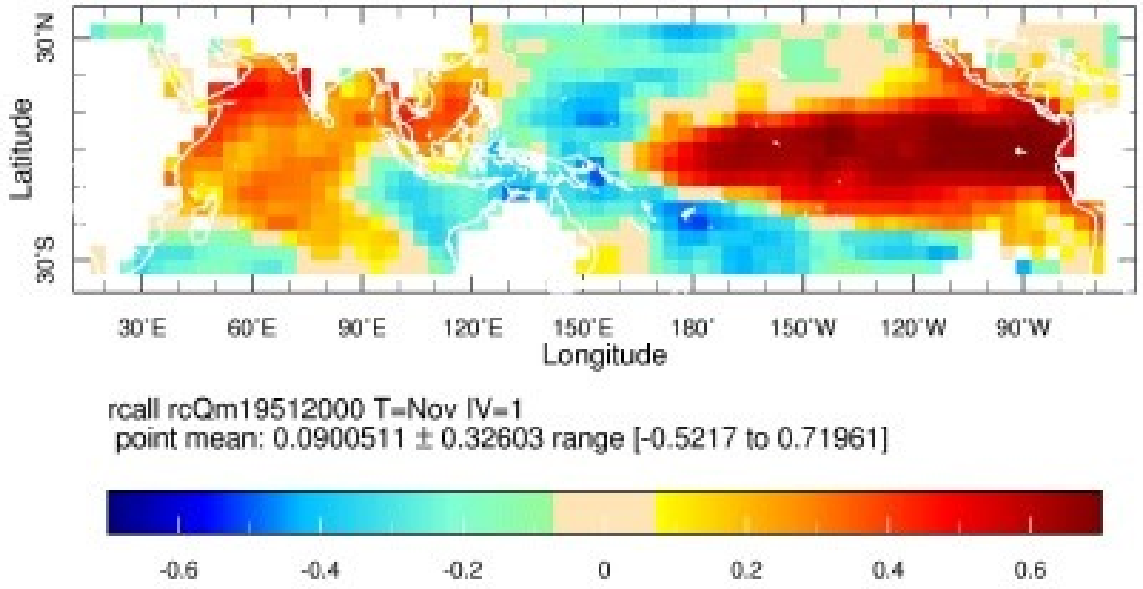
Central Eq Pacific zonal wind (ships)

Reasonable consistency

Darwin vicinity pressure (ships)

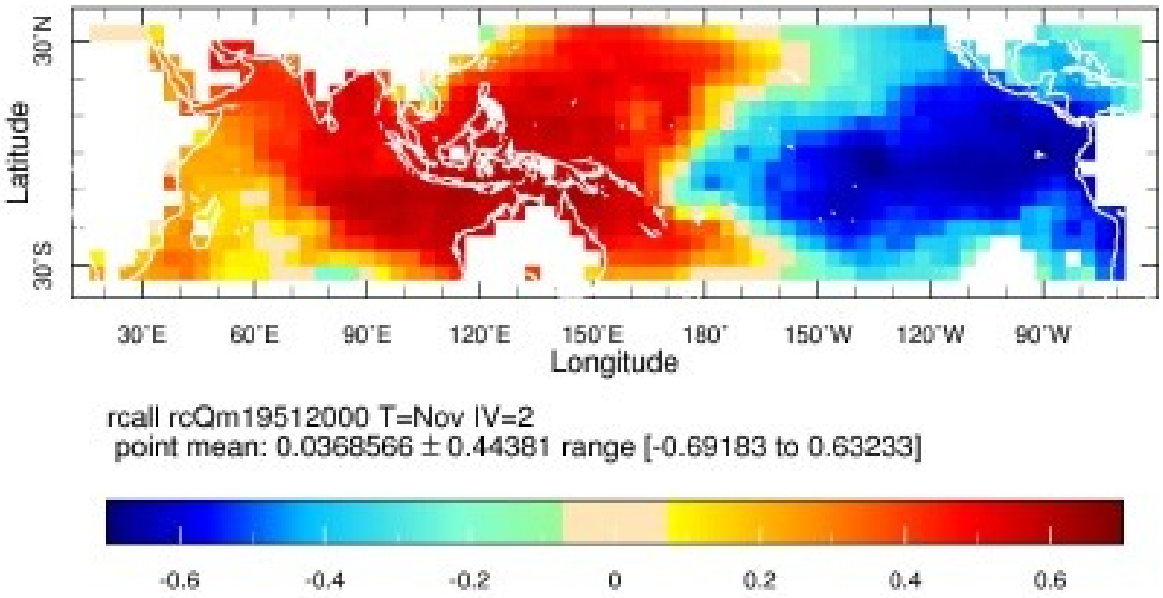
Darwin pressure (land station)

Good consistency

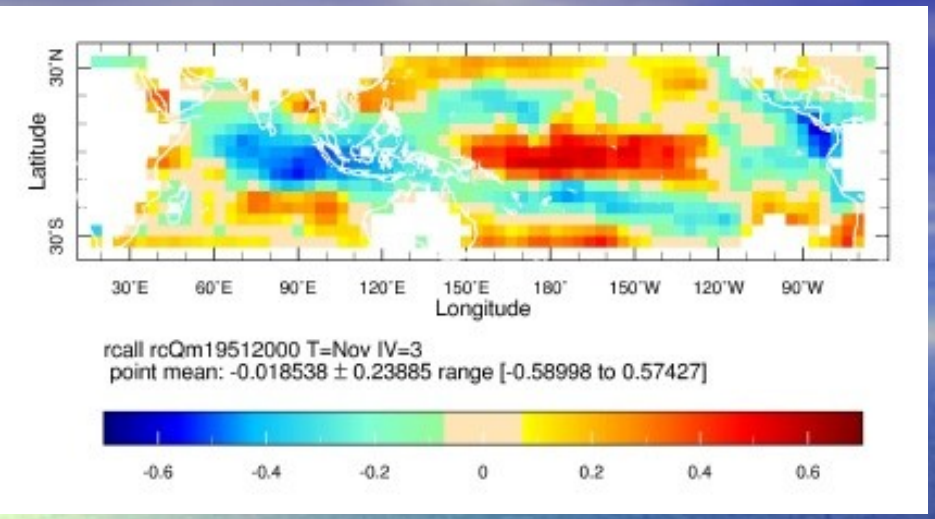


Traditional index-making fields:

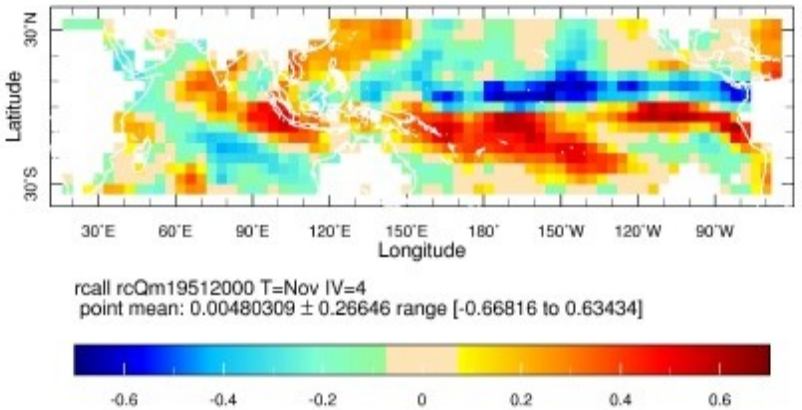
SST



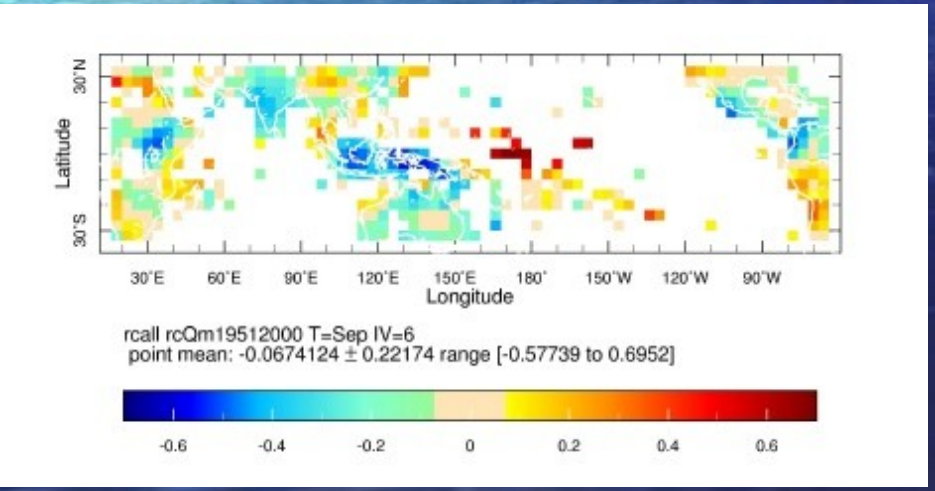
SLP



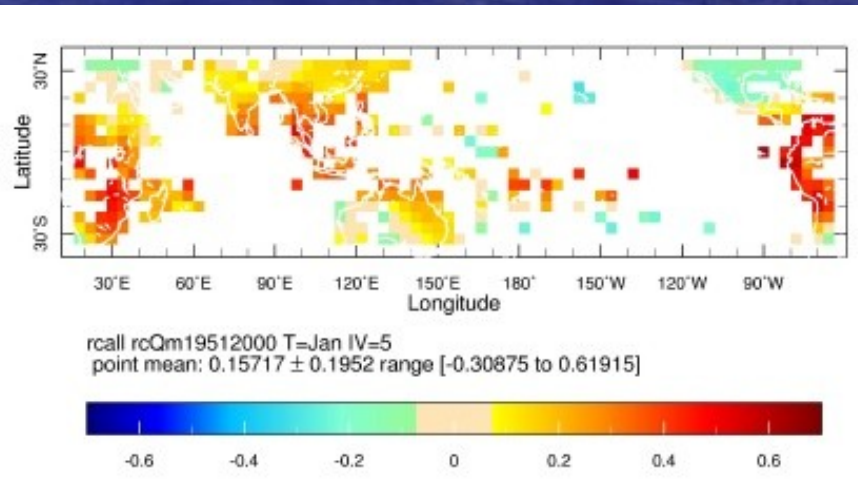
Zonal wind



Meridional wind



Land precipitation

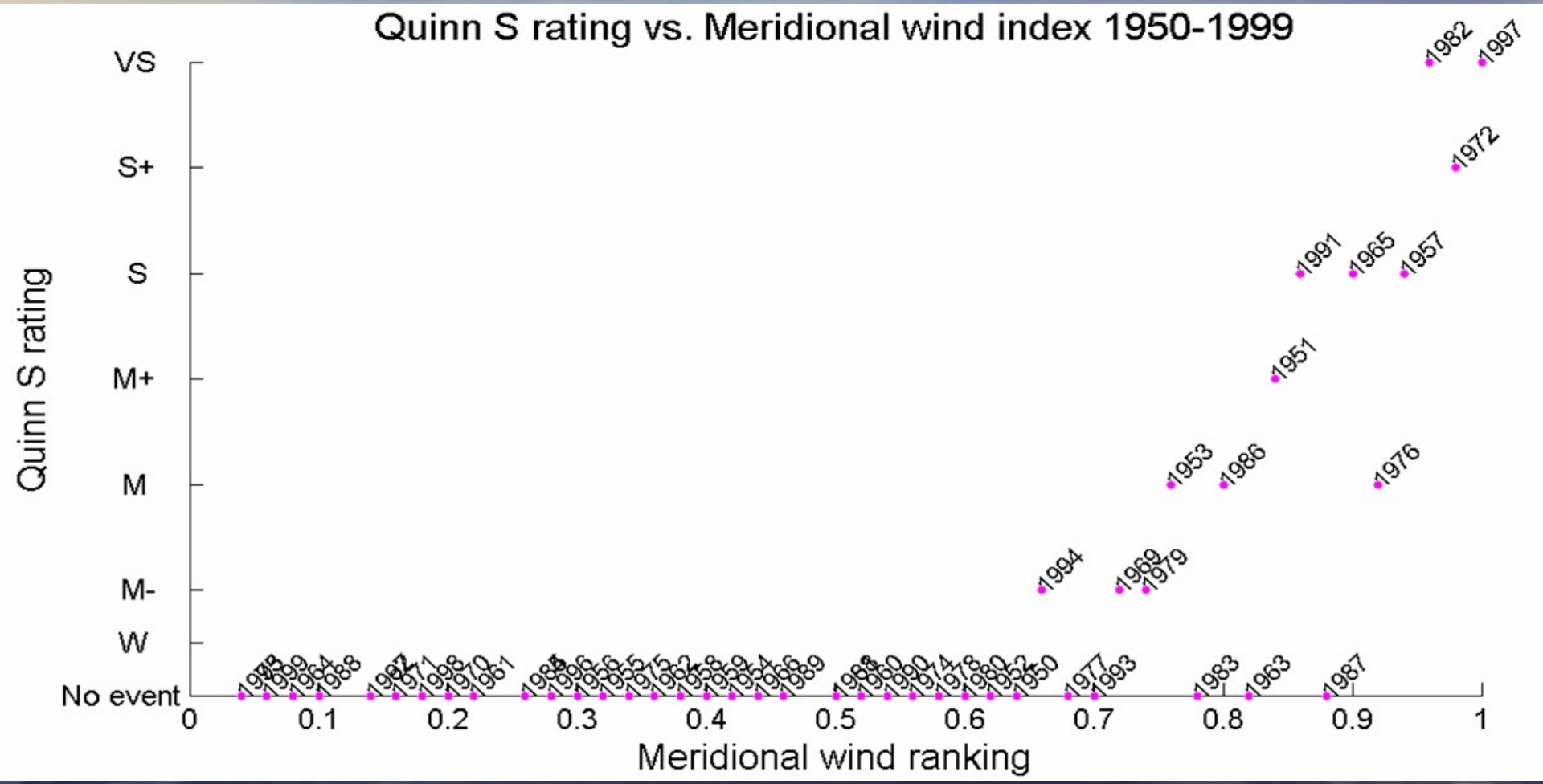


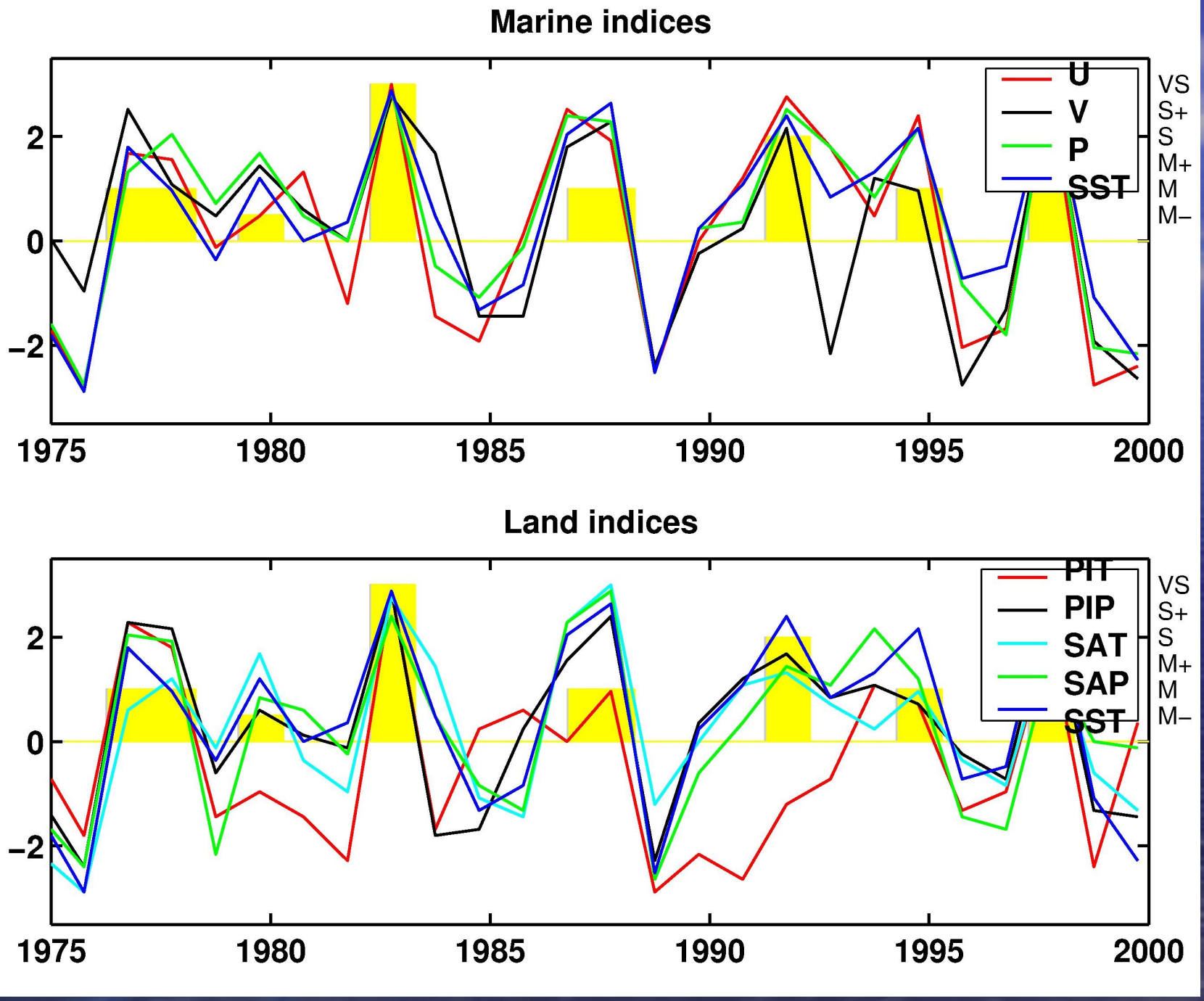
Land air temperature

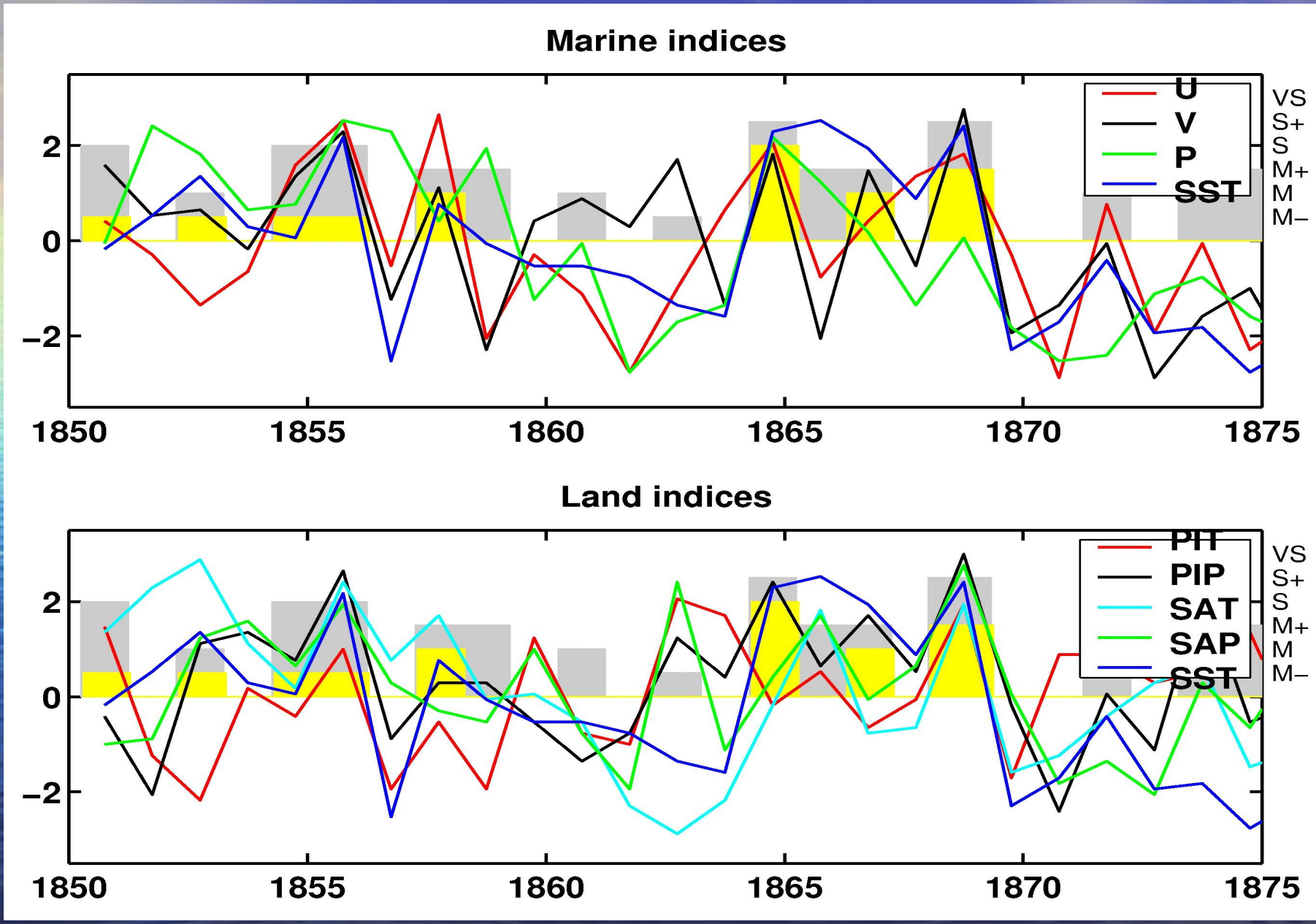
New instrumental indices of El Nino – Southern Oscillation (ENSO)

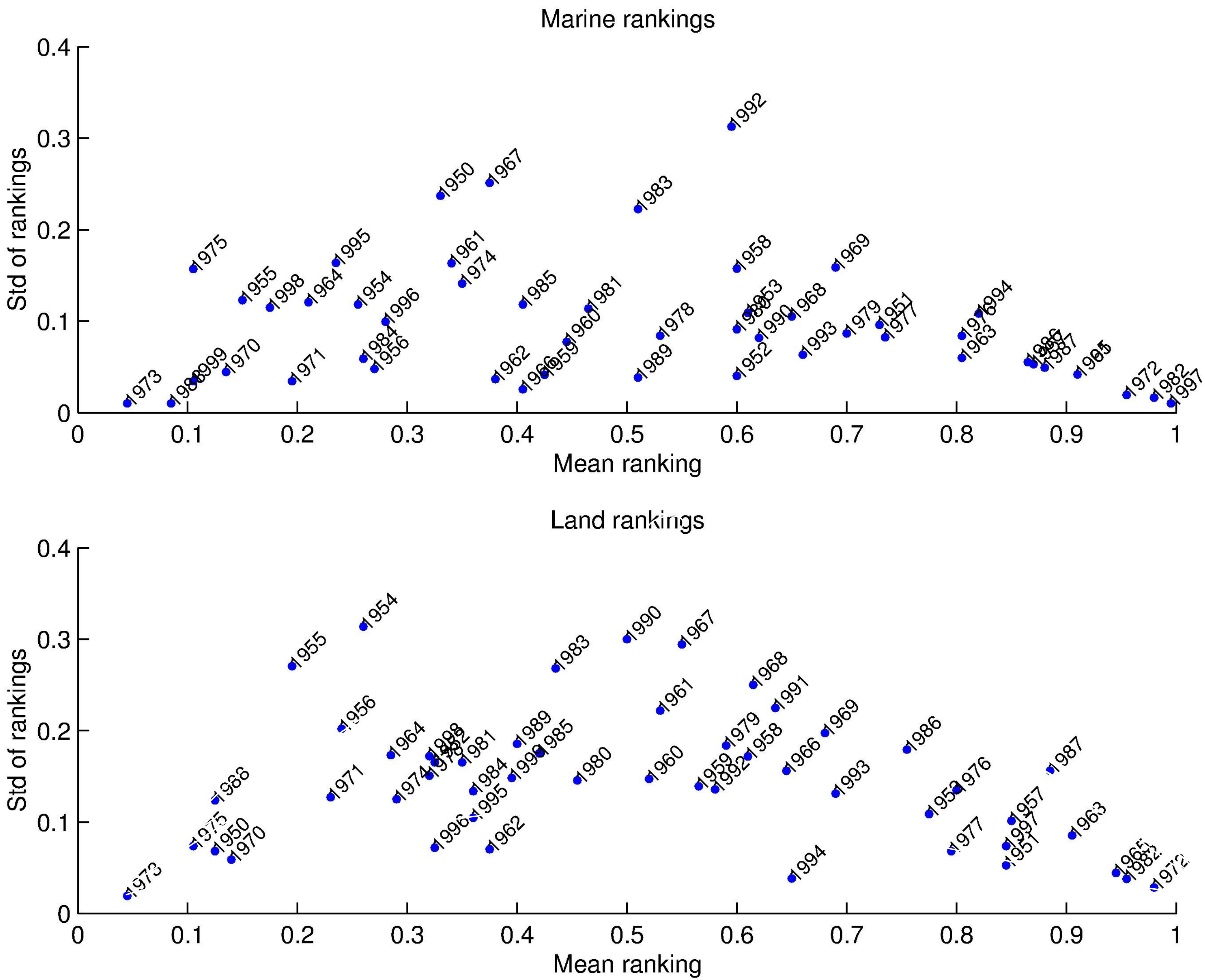
Variable	Abbr	Definition
Pacific Sea Surface Temperature	PST	Aug-Feb (180º-South American Coast, 10ºN -10ºS)
Sea Level Pressure Difference	PD	Jul-Feb [(150ºE-80ºE, 30ºS-10ºN) - (70ºW-160ºW, 30ºS-18ºN)]
Zonal Wind	ZW	May-Sept (130ºE-180º,10ºN-4ºS)+Sept-Mar(160ºE-140ºW,4ºN-8ºS)
Meridional Wind	MW	Jul-Feb (170ºE-90ºW, 0º-15ºS) - Jul-Feb (170ºE-90ºW, 0-15ºN)
Indonesian Precipitation	IP	May-Dec (100ºE-150ºE, 10ºS-10ºN)
Pacific Island Precipitation	PIP	Jun-Dec (160ºE-150ºW, 8ºN-8ºS)
Coastal South American Air Temp	CSALT	Jun-Mar (83ºW-60ºW, 30ºS-20ºN)
Pacific Island Air Temperature	PILT	Apr-Oct (160ºE-140ºW, 0º-30ºS)

Quinn's El Nino event strength chronology vs meridional wind (equatorial convergence) index: 1950-1999




Marine indices
U
V
P
SST
VS
S+
S
M+
M
M–
2
0
–2
1975
1980
1985
1990
1995
2000
Land indices
PIT
PIP
SAT
SAP
SST
VS
S+
S
M+
M
M–
2
0
–2
1975
1980
1985
1990
1995
2000


Marine indices
U
V
P
SST
VS
S+
S
M+
M
M–
2
0
–2
1850
1855
1860
1865
1870
1875
Land indices
PIT
PIP
SAT
SAP
SST
VS
S+
S
M+
M
M–
2
0
–2
1850
1855
1860
1865
1870
1875


Marine rankings
Std of rankings
Mean ranking
0.4
0.3
0.2
0.1
0
0.1
0.2
0.3
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0.6
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1992
1950
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1952
1972
1982
1997
Land rankings
Std of rankings
Mean ranking
0.4
0.3
0.2
0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
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0.8
0.9
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1994
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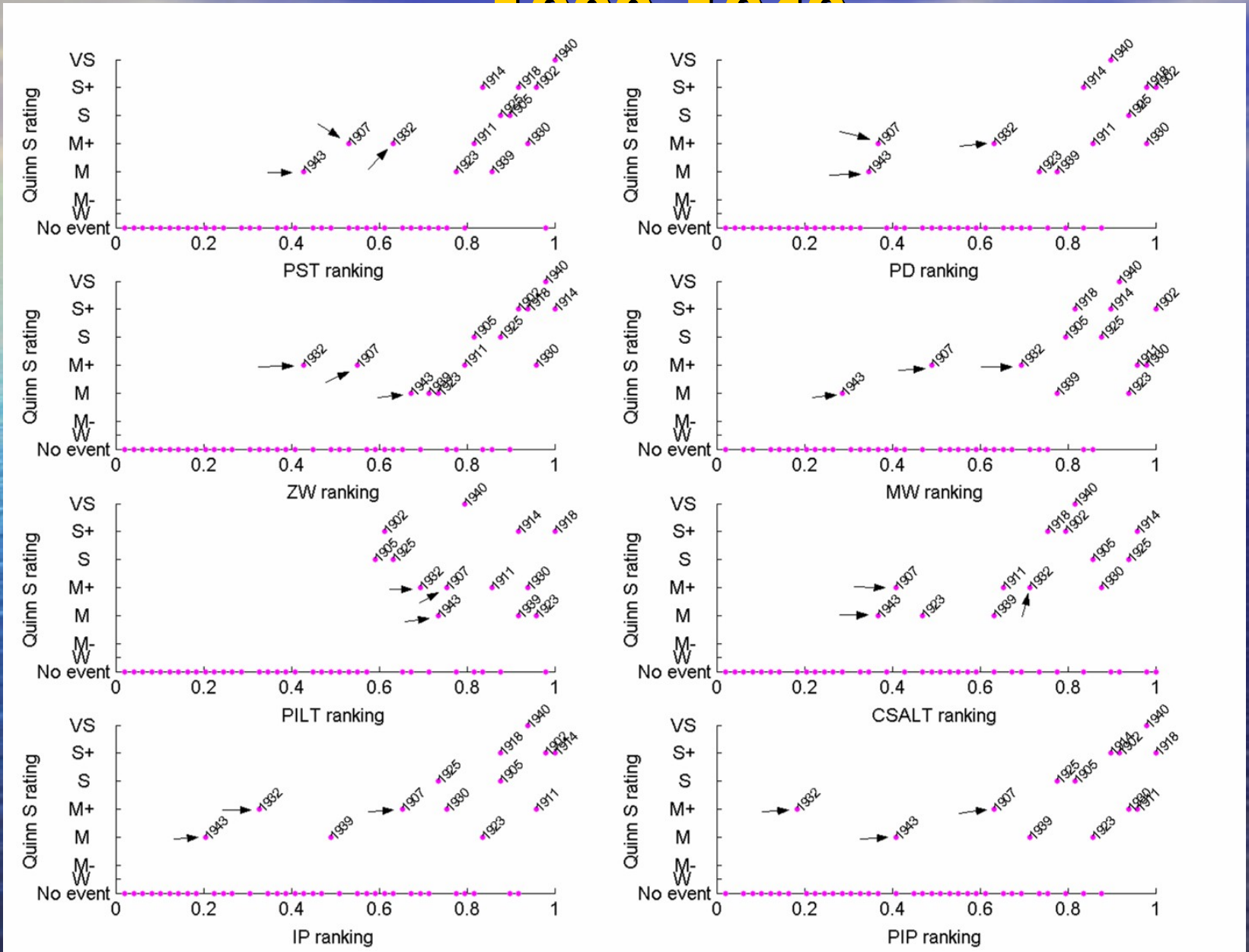
1957
1951
1963

Independent ENSO indices vs Quinn:

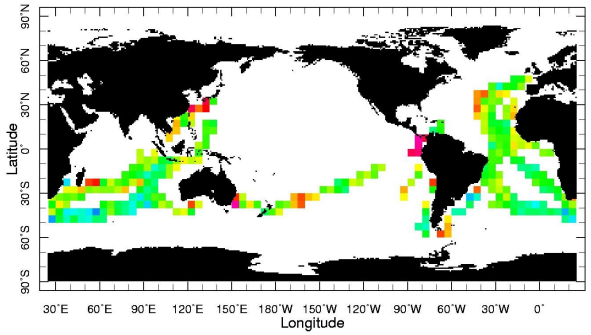


CONCLUSIONS:

- There is a consistency across instrumental indices.
- We need to know more about connections between off-shore conditions, coastal environment and land impacts in order to do reliable reconstructions of historical events.
- The episodes of South American coastal warming without a large-scale El Nino event seem more predominant before 1950 than after that.
- There are a many El Nino-like climate events in the past which merit further investigation and reconciling efforts.

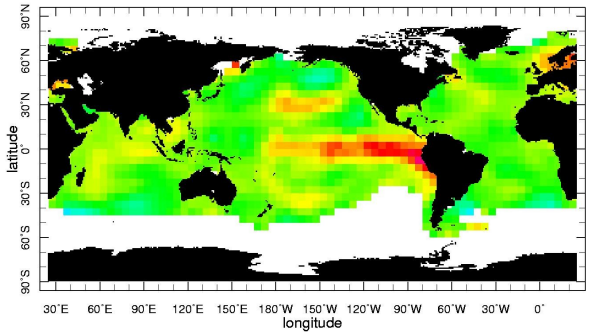
EXTRAS:
1868 El Nino

Dec 1868: Available observations



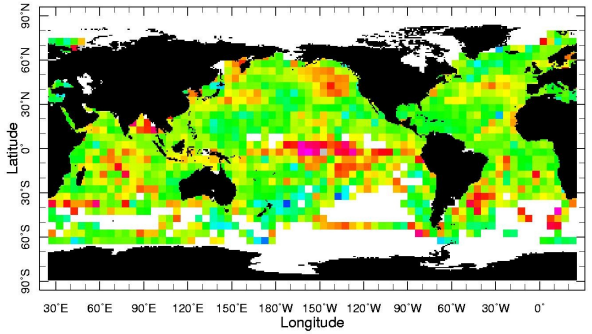
Dec 1868

Dec 1868: Reconstruction



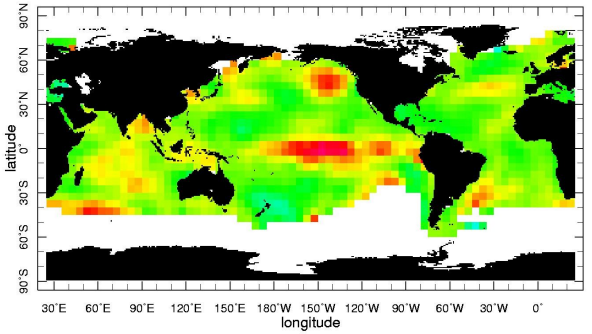
Dec 1868

Dec 1991: Available observations



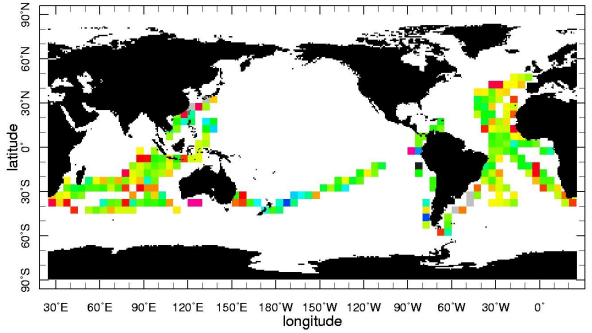
Dec 1991

Dec 1991: Reconstruction



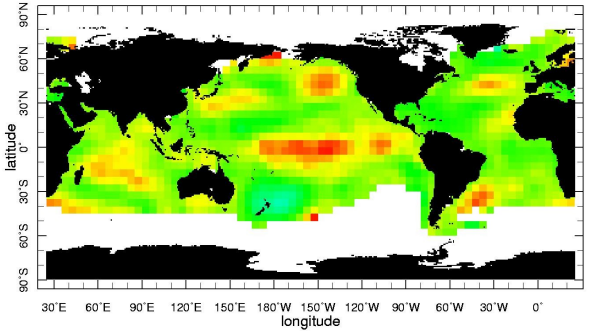
Dec 1991

Dec 1991: observations resampled as in Dec 1868

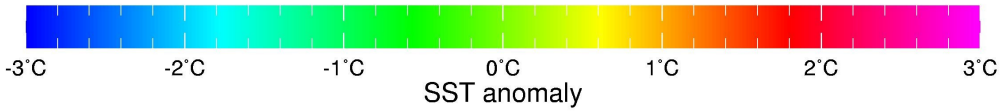


Dec 1991

Dec 1991: Reconstruction from the resampled set



Dec 1991



Ortlieb's revisions

Table 7.1 (*cont.*)

Years	Event intensity in QNA (*Q&N)	Confidence rating in QNA (*Q&N)	Major original sources in QNA and (*) in Q&N	Precise location of relevant quote (§: in H&O)	Location of climatic/ oceanographic anomaly	Phenomenon/effects leading to the reconstruction of EN event	Remarks	Proposed interpretation
1867–1868	M *M+	4	Eguiguren 1894	pp. 250–251 §	Piura	1867: drought in Piura 1868: weak rainfalls	No EN conditions in 1867 and 1868!	No EN
			Raimondi 1897, in Schweigger 1964	p. 151 §	Guañape and Sta Magdalena de Cao, N Peru	November 1867: thunder (?) and rainfall; warm SST, red tide; yellow fever epidemic	Interpreted as submarine volcanic eruption!	
			*Bachmann 1921			Data not found in ref.		
			Raimondi 1874	***p. 363 §***	***Piura***	***Chira River flood***	Sierra rains and no EN conditions?	
			El Amigo del Pueblo 1906, in Mabres et al. 1993	***p. 398***	***Piura***	***Drought in 1867–70***		
1871	S+	5	Hutchinson 1873	(2): 147, 211–212 §	Trujillo and N Peru coast	Large flood (and locust plague) in 1870 (not 1871)	Date confusion 1870/1871	S
			Eguiguren 1894	pp. 250–251 §	Piura	Exceptional rainfalls		
			Tizón y Bueno 1907				Ref. not seen	
			Sievers 1914			Data not found in ref.		
			Labarthe 1914	p. 316	Piura, Lambayeque, and Lima	Floods and destruction in February–March in Lambayeque; 450 m^3/s in Rímac River	Coincidence of Rímac flood and rains in N Peru	

BOLETIN

DE LA

Sociedad Geográfica de Lima

TOMO VII

Lima, Viernes 31 de Diciembre de 1897.-Núms. 7, 8 y 9.

PUBLICAMOS á continuación un importante estudio sobre Geografía física que hallamos entre los manuscritos dejados por el sabio Raimondi. Los datos que suministra sobre sondeos en la costa del Perú, así como sobre Oceanografía General, seismología y climatología de nuestro litoral, hacen este artículo de sumo interés para nuestros lectores, que encontrarán en él informaciones útiles aprovechables para posteriores estudios.

Como en los anteriores trabajos del señor Raimondi que hemos insertado en el BOLETIN, conservamos en éste la redacción y opiniones del autor, corrigiendo tan sólo ciertas incorrecciones del lenguaje, muy disculpables por cierto en persona poco versada en el idioma español. Sinembargo, indicaremos, por medio de notas, aquellos ligerísimos puntos en que notemos divergencias ó en que no nos hallemos del todo acordes con el autor; pues hay que tener presente que el estudio que va á continuación fué escrito por el Sr. Raimondi el año de 1882, y por consiguiente algunas de sus apreciaciones se refieren á aquella época.

GEOGRAFÍA FÍSICA

(DE LOS MANUSCRITOS DEL SEÑOR RAIMONDI)

Antonio Raimondi's evidence

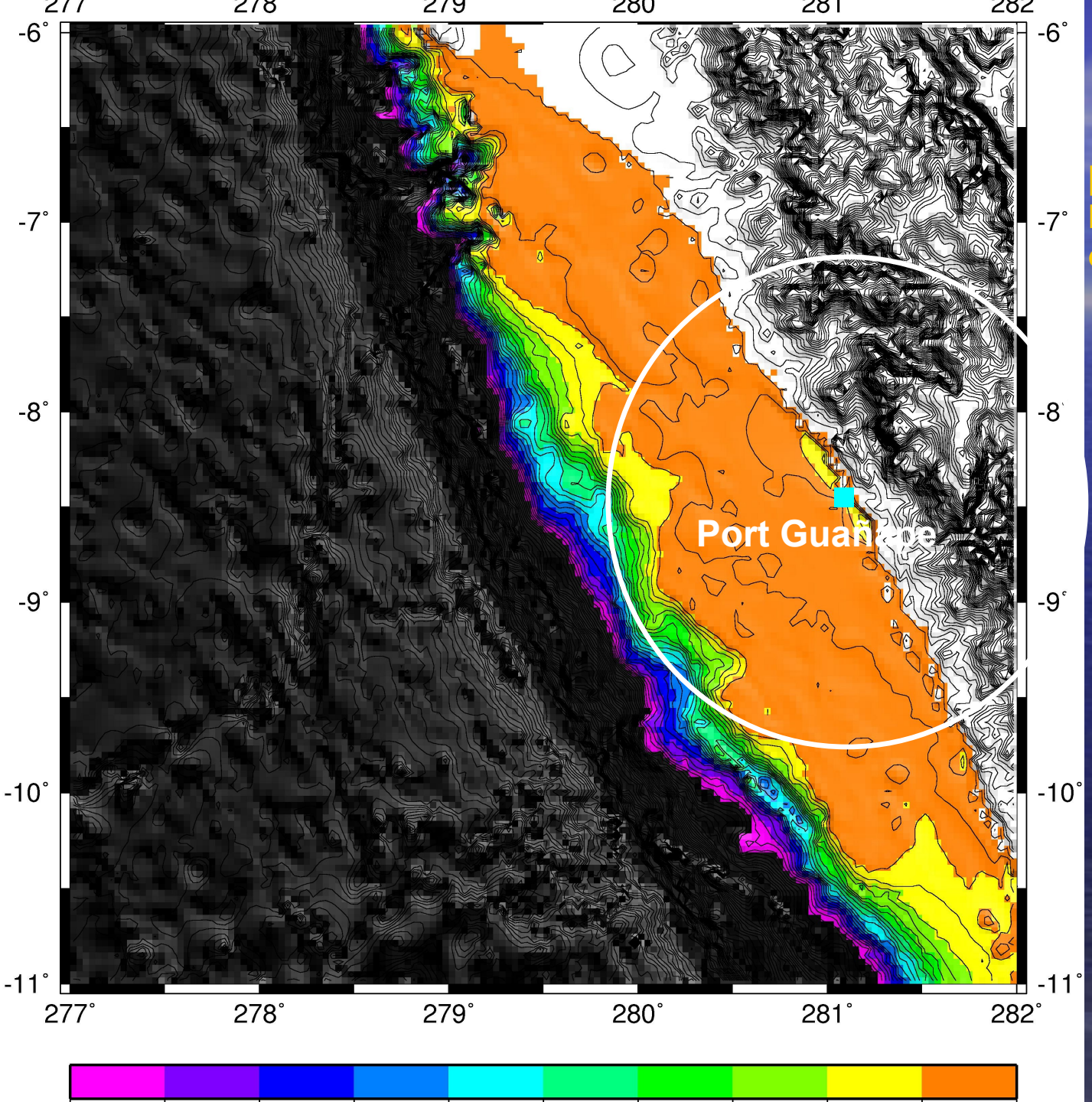
La tercera observación describe Raimondi (1897) en la siguiente forma:

"En una noche del mes de noviembre de 1867 se oyeron en varios pueblos de la costa del Norte algunas detonaciones a manera de cañonazos. En el puerto de Guañape tuvo lugar este fenómeno con cielo claro y sereno; las detonaciones se oyeron hacia el mar viendo como del Norte y eran precedidas de una luz muy viva que iluminaba toda la playa; y según algunos se notaba a larga distancia en el mar al NO una luz fija. Este fenómeno empezó a las 7 de la noche y duró hasta las dos de la mañana.

En Trujillo se experimentó lo mismo, pero con cielo nublado. Mas al Norte, en el pueblo de Magdalena de Cao, se oyeron truenos, seguidos de un fuerte aguacero, que fue tan copioso que dió lugar a que el agua corriese por las calles, fenómeno rarísimo en la costa del Perú.)*

Por la larga duración del fenómeno que se observó en el puerto de Guañape, y que fue de 7 horas, no puede ser debido a una simple tempestad como la que se experimentó en Magdalena de Cao, y todo hace presumir que haya habido en alta mar alguna erupción submarina y que la tempestad que tuvo lugar en Magdalena de Cao no ha sido sino un efecto de este último.

Sea lo que fuere, lo cierto es que este fenómeno fué seguido de un cambio de la dirección de la corriente marina, de una elevación en la temperatura del mar, de una mortandad en los peces cuyos cadáveres eran arrojados en cantidad a la playa, y por último la aparición en Trujillo y sus alrededores de los primeros casos de fiebre amarilla



[Courtesy of Dallas Abbott of LDEO]