U.S. CLIVAR ENSO Diversity Workshop, Boulder, CO, Feb. 2013

El Niño typology and trends

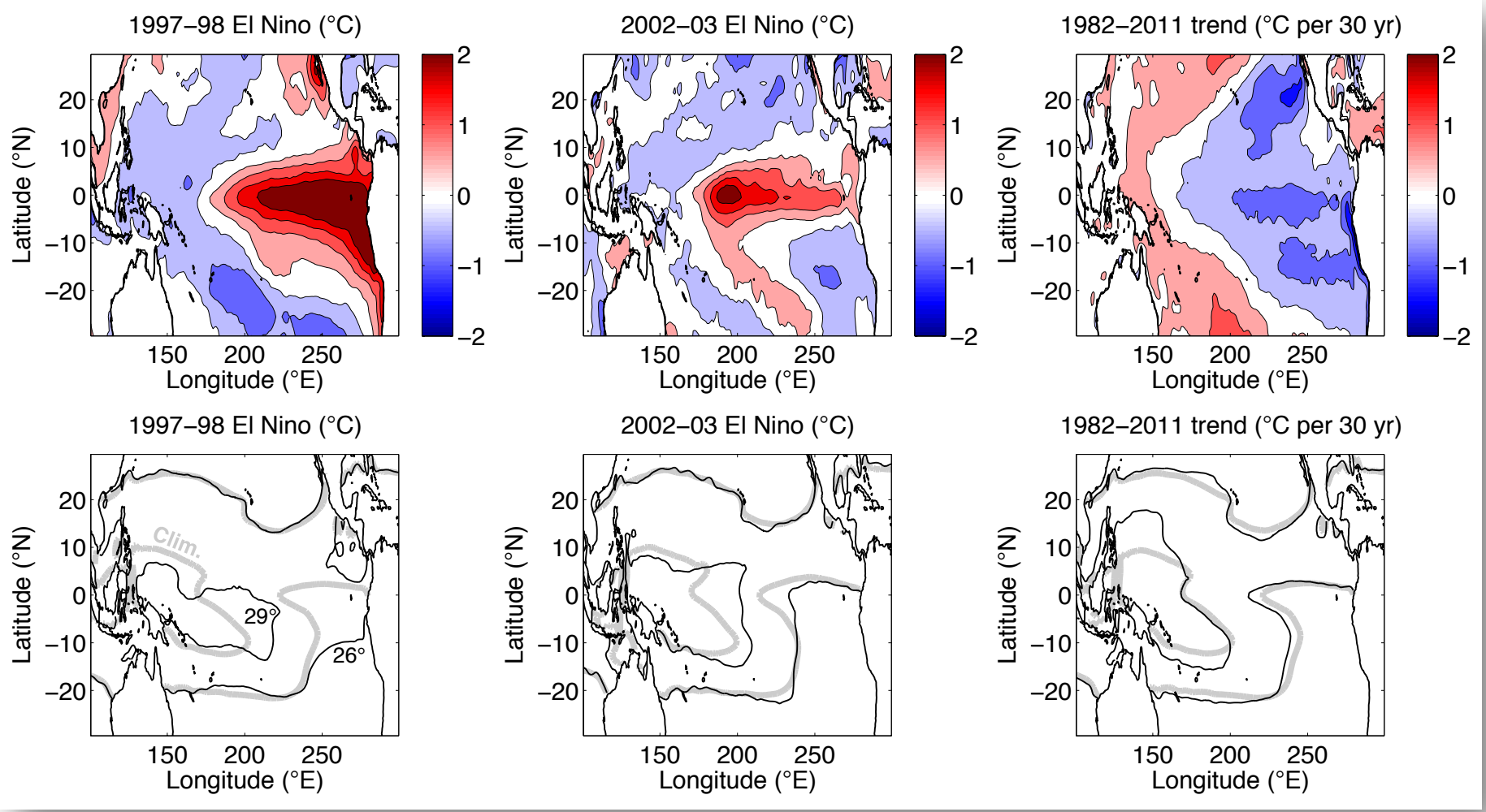
Insight from three decades of weekly SST (and wind stress)

Kristopher B. Karnauskas

Karnauskas, K.B. (2013) Can we differentiate canonical El Niño from Modoki? *Geophys. Res. Lett.*, in revision.

This Ensō symbol is from http://zenbuddhismforthought.blogspot.com/2012/05/enso-and-ending.html (not sure of the original source).

Three views on tropical Pacific SST variability



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Papers about "Modoki"

Questioning		2
Identifying		5
Contrasting		12
Diagnosing		3
Impacts		18
Antarctica	1	
Biology	2	
Coastal	1	
Monsoons	10	
Stratosphere	1	
Trop. Cyclones	3	
Predictability		2
Trends		12
Total		**54**

*All but **3** from 2009–*

1. N. K. Larkin, D. E. Harrison, On the definition of El Nino and associated seasonal average US weather anomalies. *Geophys Res Lett* **32**, (Jul 12, 2005).
2. K. Ashok, S. K. Behera, S. A. Rao, H. Y. Weng, T. Yamagata, El Nino M possible teleconnection. *J Geophys Res-Oceans* **112**, (Nov 8, 2007).
3. J. Y. Yu, S. T. Kim, Identification of Central-Pacific and Eastern-Pacific in CMIP3 models. *Geophys Res Lett* **37**, (Aug 13, 2010).
4. J. Y. Yu, H. Y. Kao, T. Lee, S. T. Kim, Subsurface ocean temperature indic Pacific and Eastern-Pacific types of El Nio and La Nia events. *Theor* **103**, 337 (Mar, 2011).
5. H. L. Ren, F. F. Jin, Nino indices for two types of ENSO. *Geophys Res Let* 2011).
6. K. E. Trenberth, L. Smith, Variations in the Three-Dimensional Str Atmospheric Circulation with Different Flavors of El Nino. *J Climate* 2009).
7. H. Y. Kao, J. Y. Yu, Contrasting Eastern-Pacific and Central-Pacific Ty *Climate* **22**, 615 (Feb, 2009).
8. J. S. Kug, F. F. Jin, S. I. An, Two Types of El Nino Events: Cold Tongu Warm Pool El Nino. *J Climate* **22**, 1499 (Mar, 2009).
9. J. S. Kug, J. Choi, S. I. An, F. F. Jin, A. T. Wittenberg, Warm Pool and C Nino Events as Simulated by the GFDL 2.1 Coupled GCM. *J Climate* **2** 2010).
10. J. Y. Yu, S. T. Kim, Relationships between Extratropical Sea Level Press and the Central Pacific and Eastern Pacific Types of ENSO. *J Climate* **2** 2011).
11. A. Singh, T. Delcroix, S. Cravatte, Contrasting the flavors of El N Oscillation using sea surface salinity observations. *J Geophys Res-Oce* 23, 2011).
12. T. Shinoda, H. E. Hurlburt, E. J. Metzger, Anomalous tropical oce associated with La Nina Modoki. *J Geophys Res-Oceans* **116**, (Dec 2, 201
13. T. J. Zhou, J. Zhang, The Vertical Structures of Atmospheric Temperatu Associated with Two Flavors of El Nino Simulated by AMIP II Models 1053 (Feb 15, 2011).
14. Z. Z. Hu *et al.*, An analysis of warm pool and cold tongue El Nios: ai processes, global influences, and recent trends. *Clim Dynam* **38**, 2017 (
15. M. H. Radenac, F. Leger, A. Singh, T. Delcroix, Sea surface chlorophyll si tropical Pacific during eastern and central Pacific ENSO events. *J Geoph* **117**, (Apr 4, 2012).
16. N. Ramesh, R. Murtugudde, All flavours of El Nino have similar ea origins. *Nature Clim. Change* **advance online publication**, (2012).
17. B. Dewitte, J. Choi, S. I. An, S. Thual, Vertical structure variability a waves during central Pacific and eastern Pacific El Nios in a co circulation model. *Clim Dynam* **38**, 2275 (Jun, 2012).
18. J. Y. Yu, S. T. Kim, Three evolution patterns of Central-Pacific El Nino. *Geophys Res Lett* **37**, (Apr 29, 2010).
19. W. Kim, S. W. Yeh, J. H. Kim, J. S. Kug, M. Kwon, The unique 2009-2010 El Nino event: A fast phase transition of warm pool El Nino to La Nina. *Geophys Res Lett* **38**, (Aug 10, 2011).

37. M. M. Gierach, T. Lee, D. Turk, M. J. McPhaden, Biological response to the 1997-98 and 2009-10 El Nino events in the equatorial Pacific Ocean. *Geophys Res Lett* **39**, (May 16, 2012).

ng, E. J. Steig, D. S. Battisti, M. Kuttel, Winter warming in West Antarctica y central tropical Pacific warming. *Nat Geosci* **4**, 398 (Jun, 2011).

rre, N. Calvo, The El Nino-Southern Oscillation (ENSO) Modoki signal in the here. *J Geophys Res-Atmos* **117**, (Feb 23, 2012).

lls, Recent trends in the seasonal and temporal behaviour of the El Nino- Oscillation. *Geophys Res Lett* **35**, (Oct 2, 2008).

et al., El Nino in a changing climate. *Nature* **461**, 511 (Sep 24, 2009).

M. J. McPhaden, Increasing intensity of El Nino in the central-equatorial *Geophys Res Lett* **37**, (Jul 24, 2010).

, B. P. Kirtman, J. S. Kug, W. Park, M. Latif, Natural variability of the central l Nino event on multi-centennial timescales. *Geophys Res Lett* **38**, (Jan 25,

nati, K. M. Cobb, E. Di Lorenzo, Decadal-Scale SST and Salinity Variations in tral Tropical Pacific: Signatures of Natural and Anthropogenic Climate *J Climate* **24**, 3294 (Jul, 2011).

se, S. Ray, El Nino variability in simple ocean data assimilation (SODA), 08. *J Geophys Res-Oceans* **116**, (Feb 17, 2011).

Phaden, T. Lee, D. McClurg, El Nino and its relationship to changing und conditions in the tropical Pacific Ocean. *Geophys Res Lett* **38**, (Aug 13,

nan, S. I. Shin, M. A. Alexander, Natural variation in ENSO flavors. *Geophys* **38**, (Jul 27, 2011).

Phaden, A 21st century shift in the relationship between ENSO SST and ater volume anomalies. *Geophys Res Lett* **39**, (May 3, 2012).

, T. P. Sabin, P. Swapna, R. G. Murtugudde, Is a global warming signature g in the tropical Pacific? *Geophys Res Lett* **39**, (Jan 18, 2012).

, K.-Y. Kim, S.-W. Yeh, Statistical evidence for the natural variation of the Pacific El NiÒo. *J. Geophys. Res.* **117**, C06014 (2012).

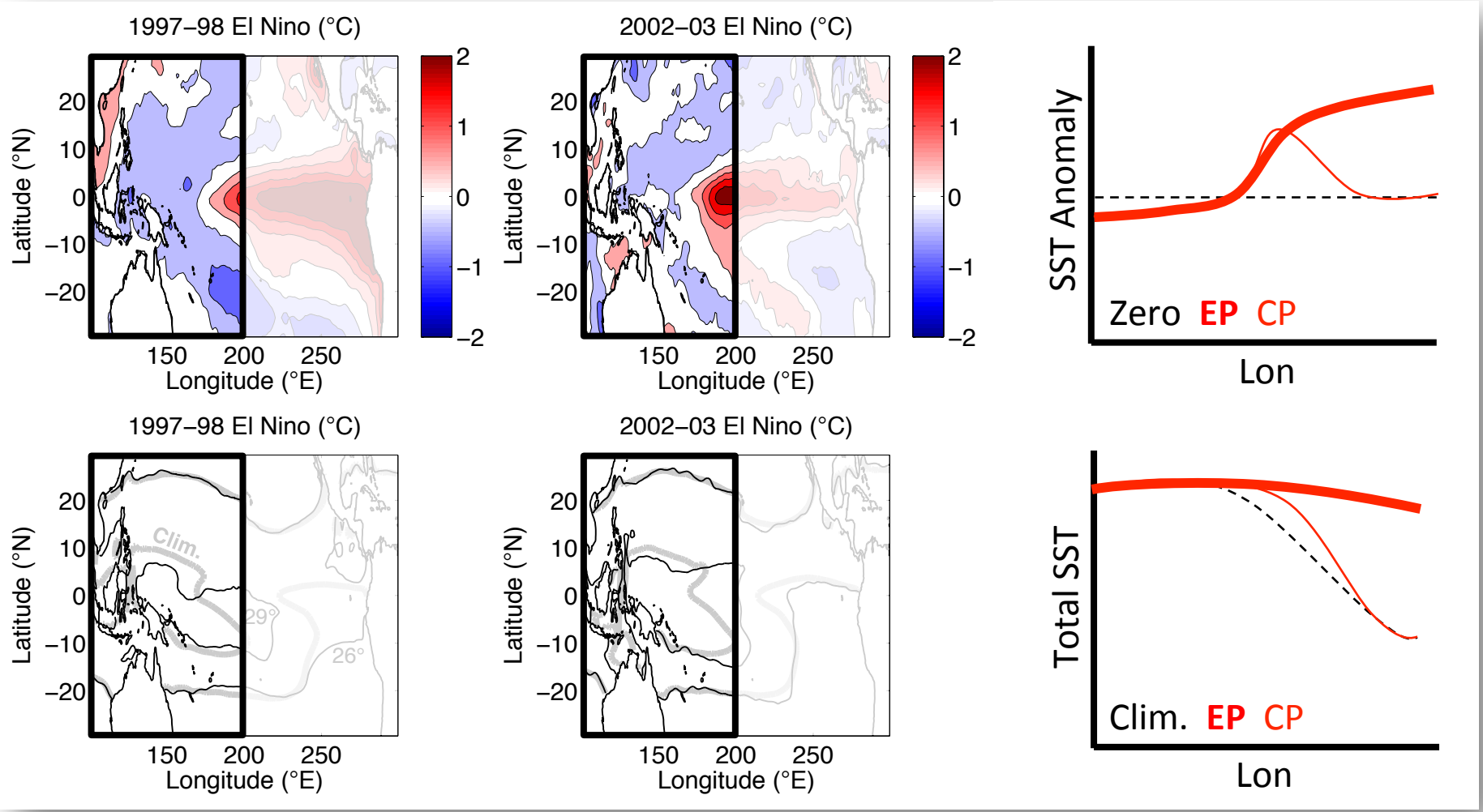
ureux, D. Collins, Z.-Z. Hu, Linear trends in sea surface temperature of the Pacific Ocean and implications for the El Niño-Southern Oscillation. *Clim* (2012/03/01, 2012).

ahashi, A. Montecinos, K. Goubanova, B. Dewitte, ENSO regimes: reting the canonical and Modoki El Nino. *Geophys Res Lett* **38**, (May 27,

Y. G. Ham, Are there two types of La Nina? *Geophys Res Lett* **38**, (Aug 19,

changing El Nino patterns for biological dynamics in the equatorial Pacific Ocean. *Geophys Res Lett* **38**, (Dec 3, 2011).

What is the “simplest” hypothesis?



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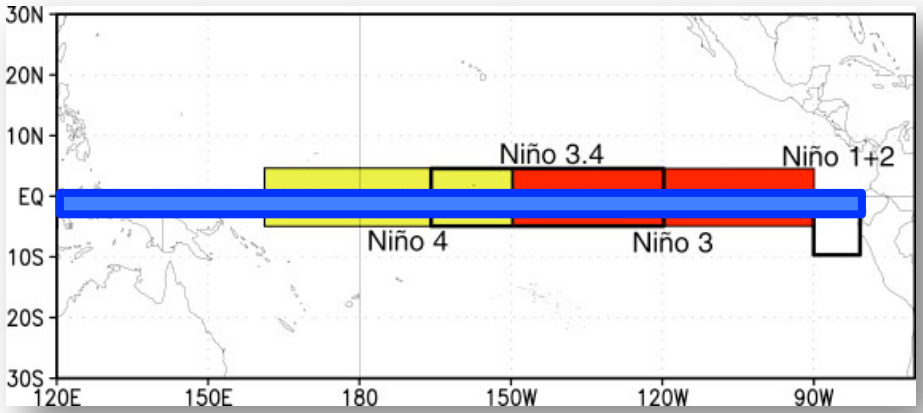
Various types of global, gridded SST data

Type	Example(s)	Time Res.	Time coverage	Spatial Res.	Spatially complete?
Pure instrumental	ICOADS	Monthly	1800–present	2°	No
Instrumental analyses	HadISST, ERSST	Monthly	~1880–present	1–5°	Yes, via OI or EOF
Pure satellite	AVHRR, MODIS	Daily+	1982/2000s–present	~4 km	~Yes for weekly+
Satellite–era blends	NCEP OI v.2	Daily+	1982–present (30 yr)	¼–1°	Yes

Niño$_\infty$

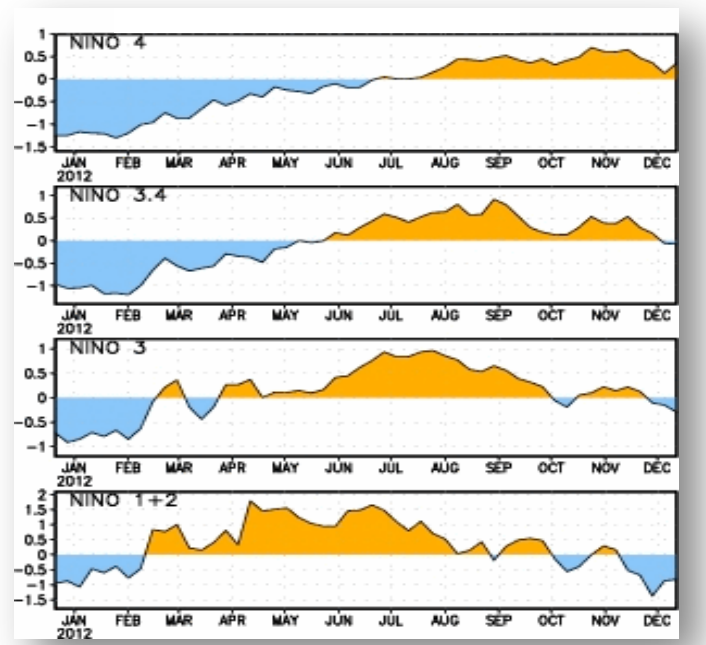
~~Traditional ENSO indices~~



$$\text{Niño}_\infty(t) = \overline{T'_{\varphi=0}(\lambda, t)} \text{ for } T' > 0$$

$$\text{Niña}_\infty(t) = \overline{T'_{\varphi=0}(\lambda, t)} \text{ for } T' < 0$$

2012 ENSO evolution



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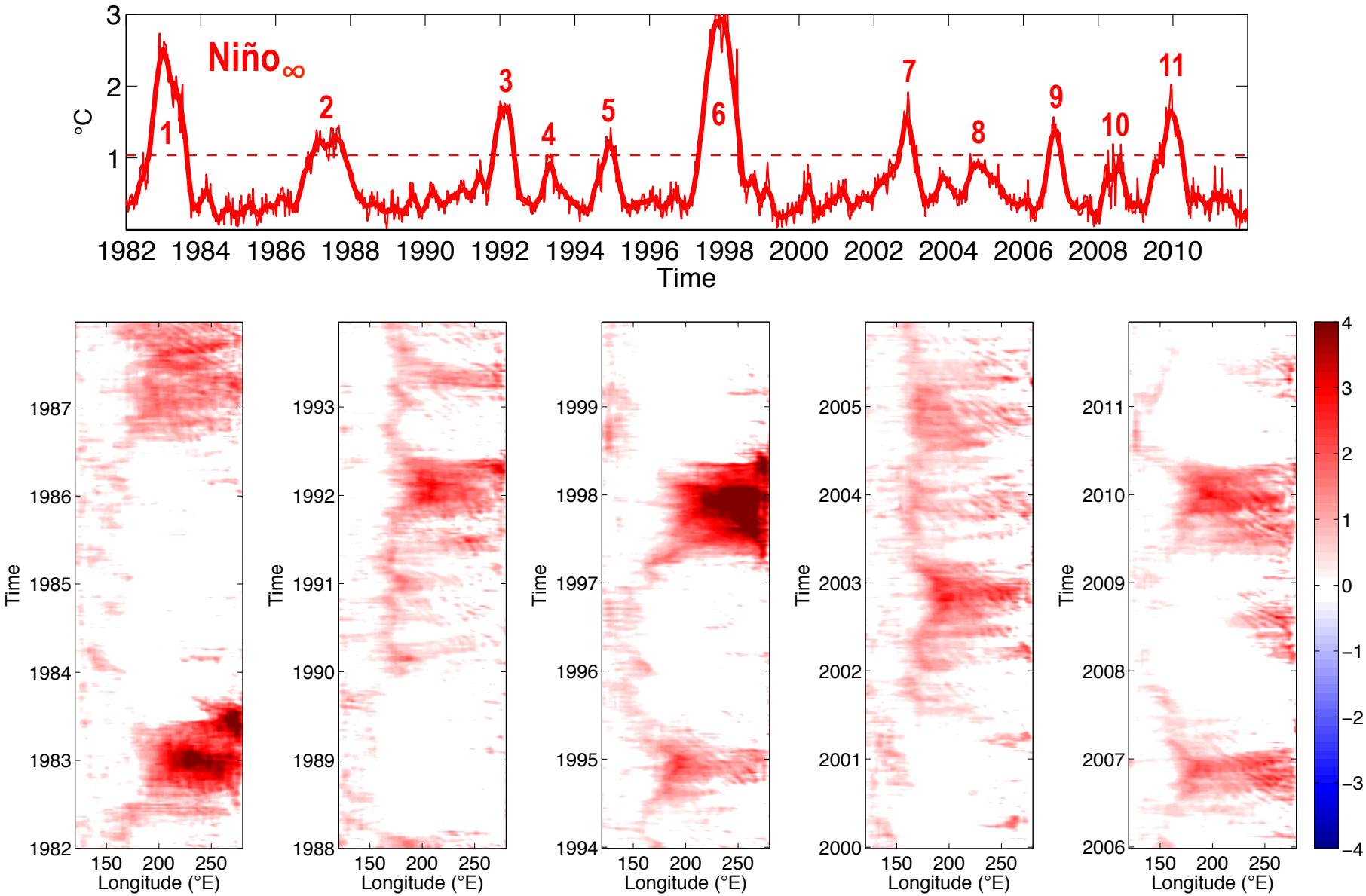
30 years of unclassified **warm** events



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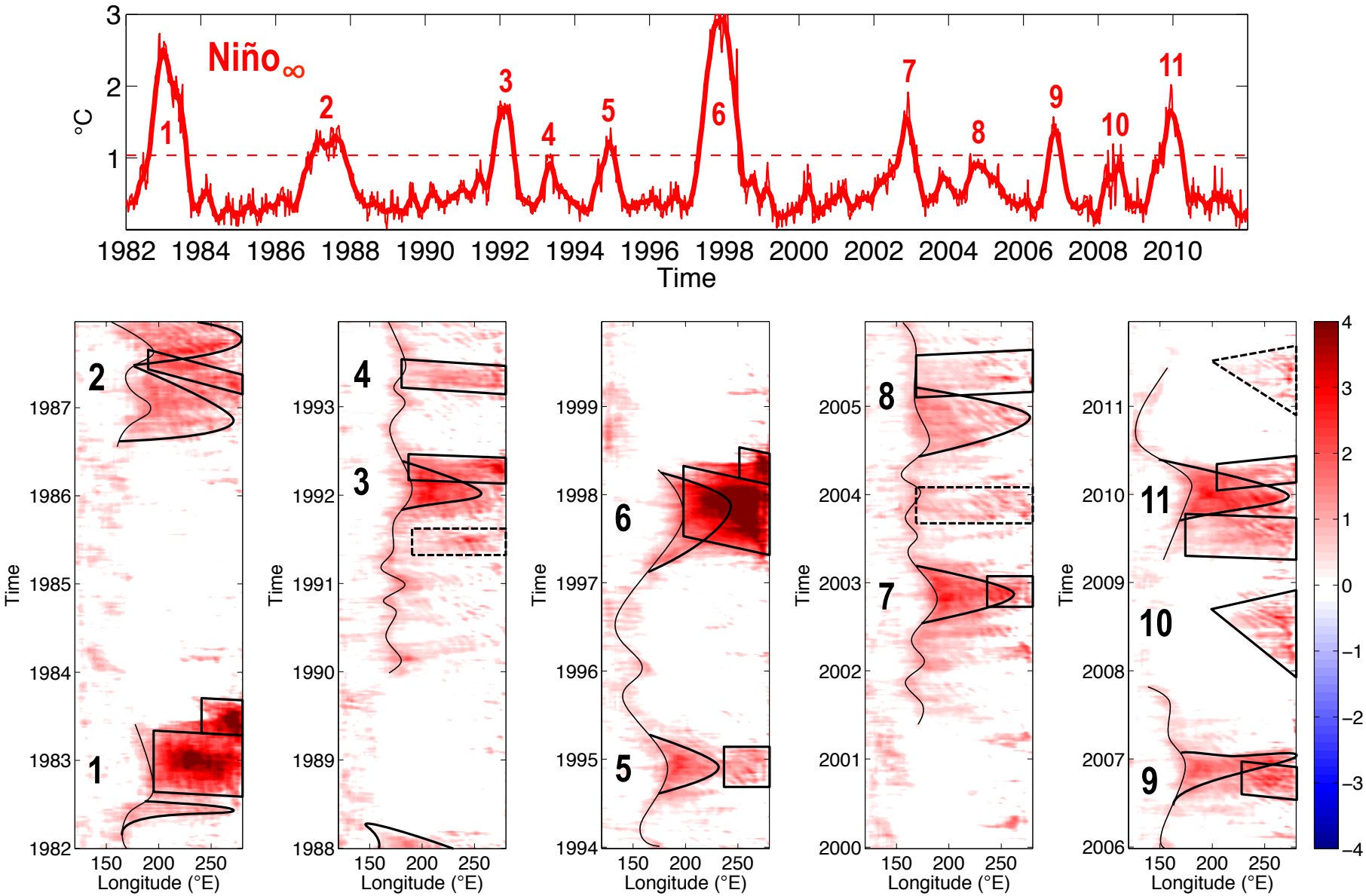

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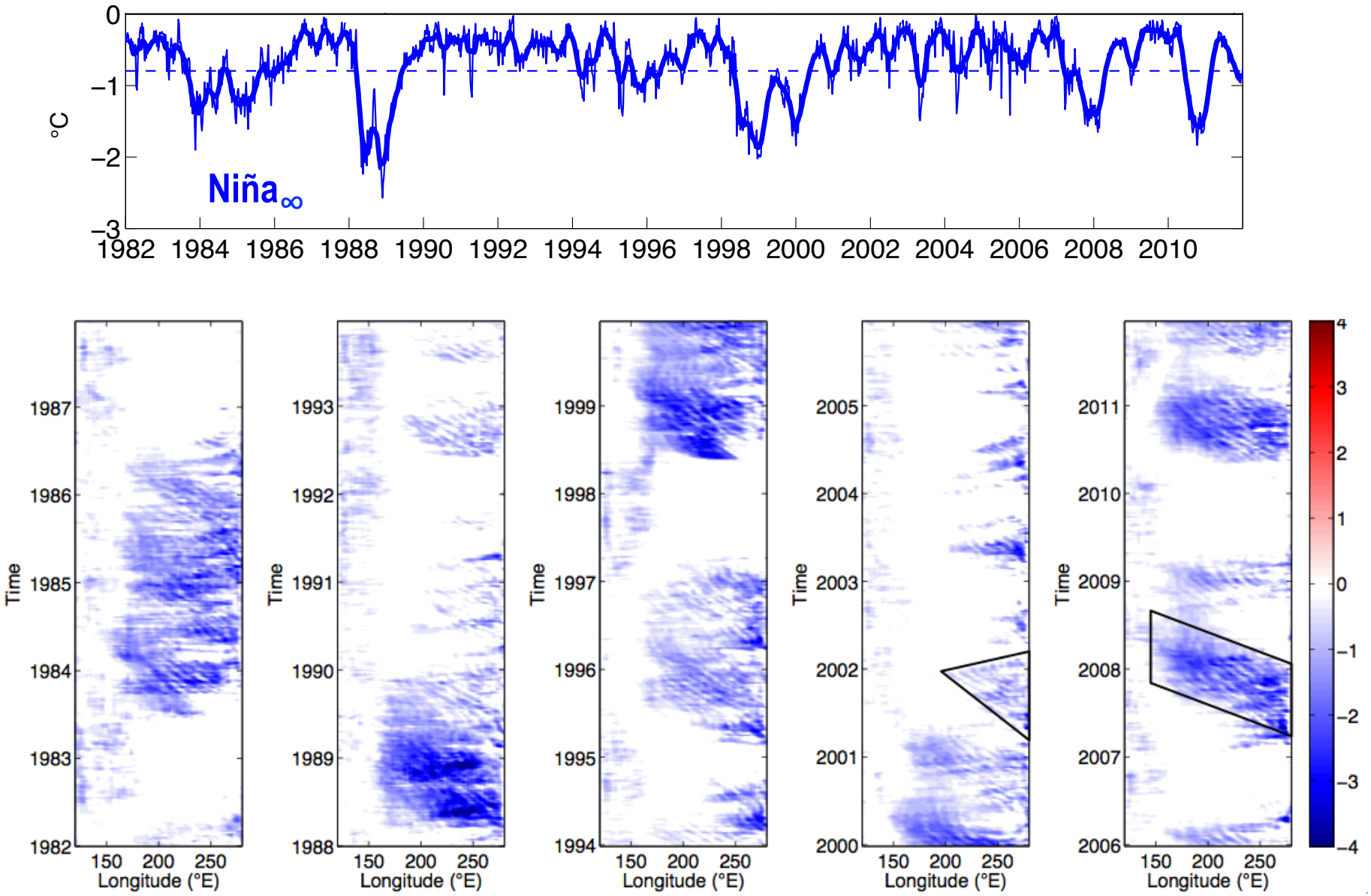
30 years of unclassified **cold** events



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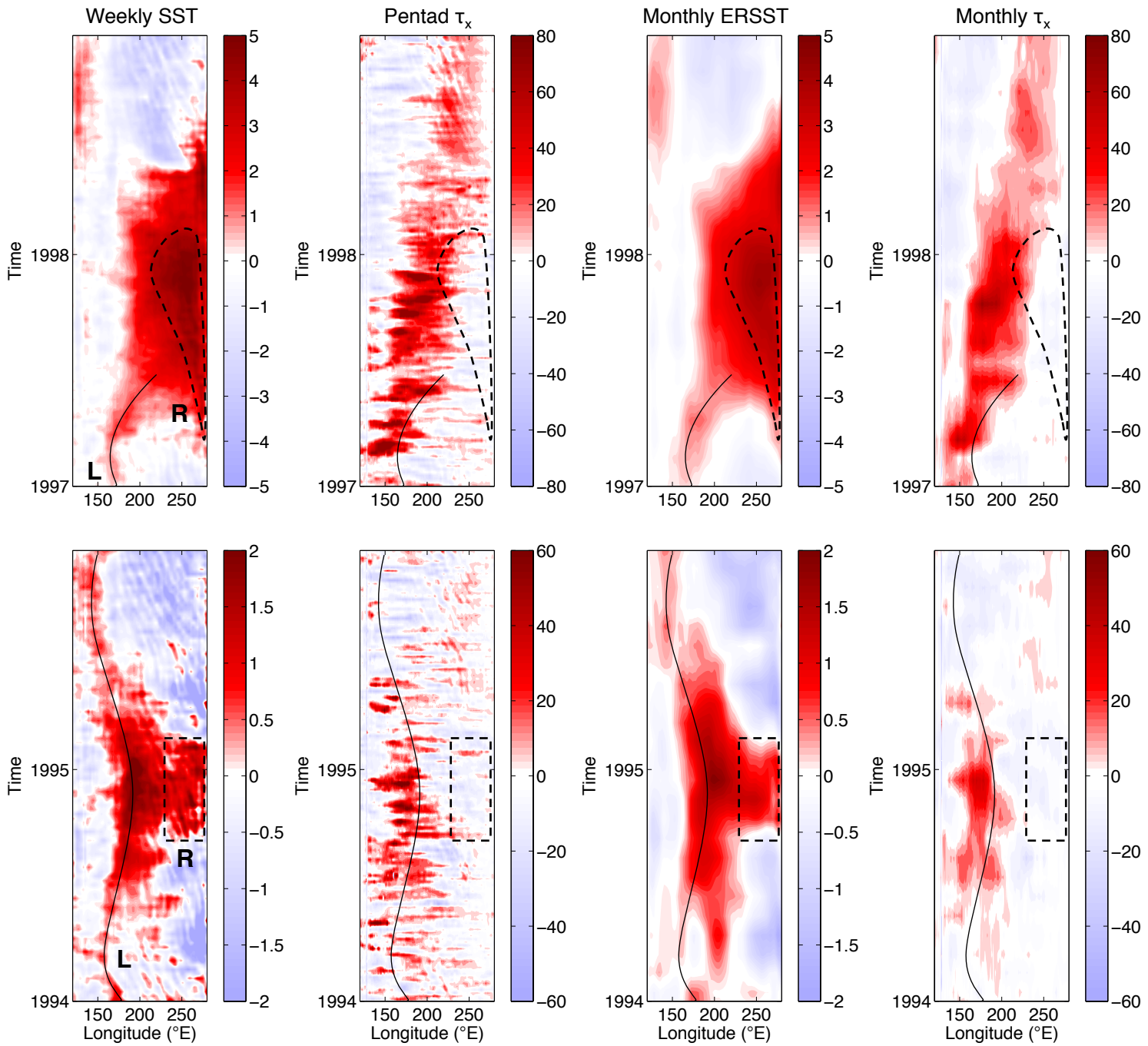

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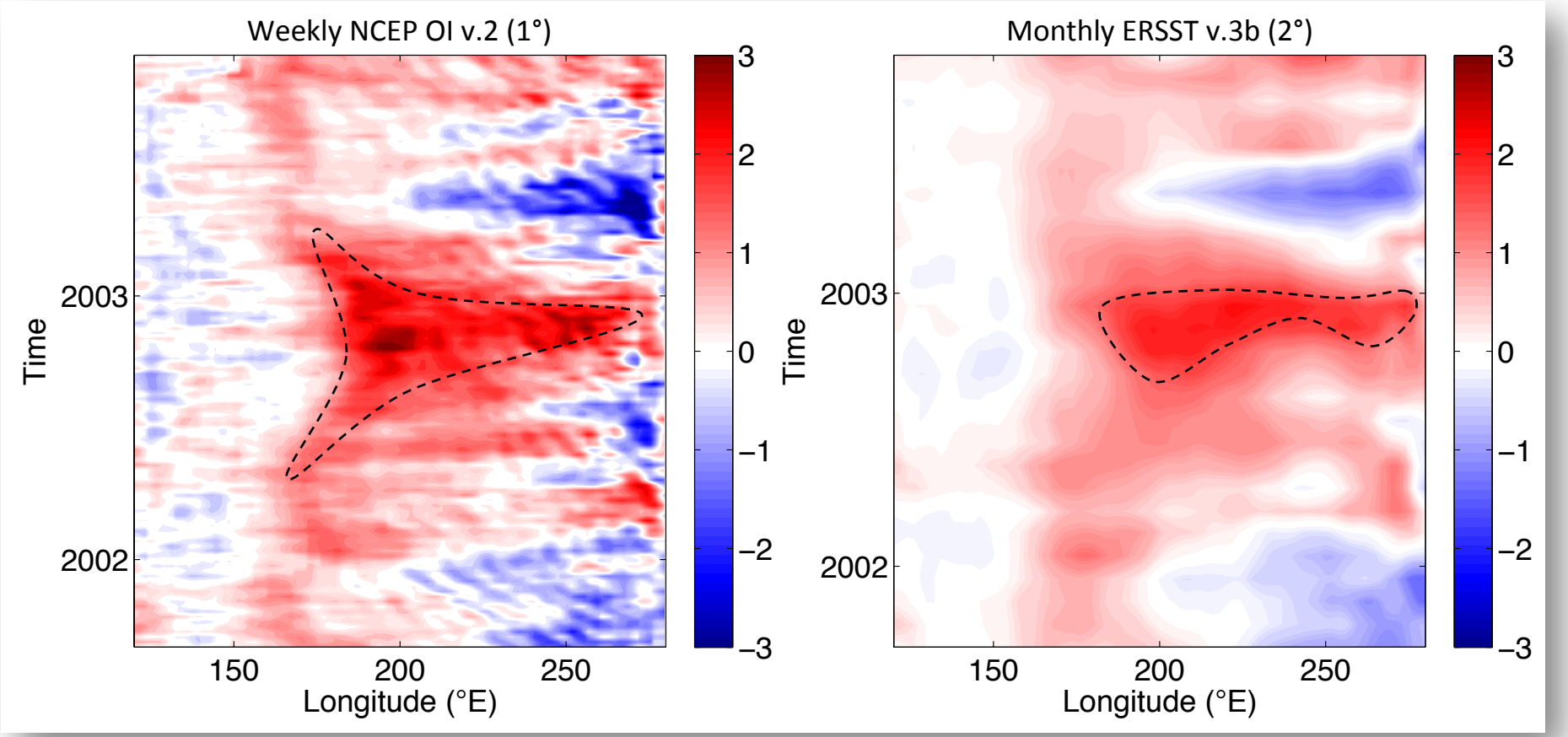
Example of the 2002–03 El Niño



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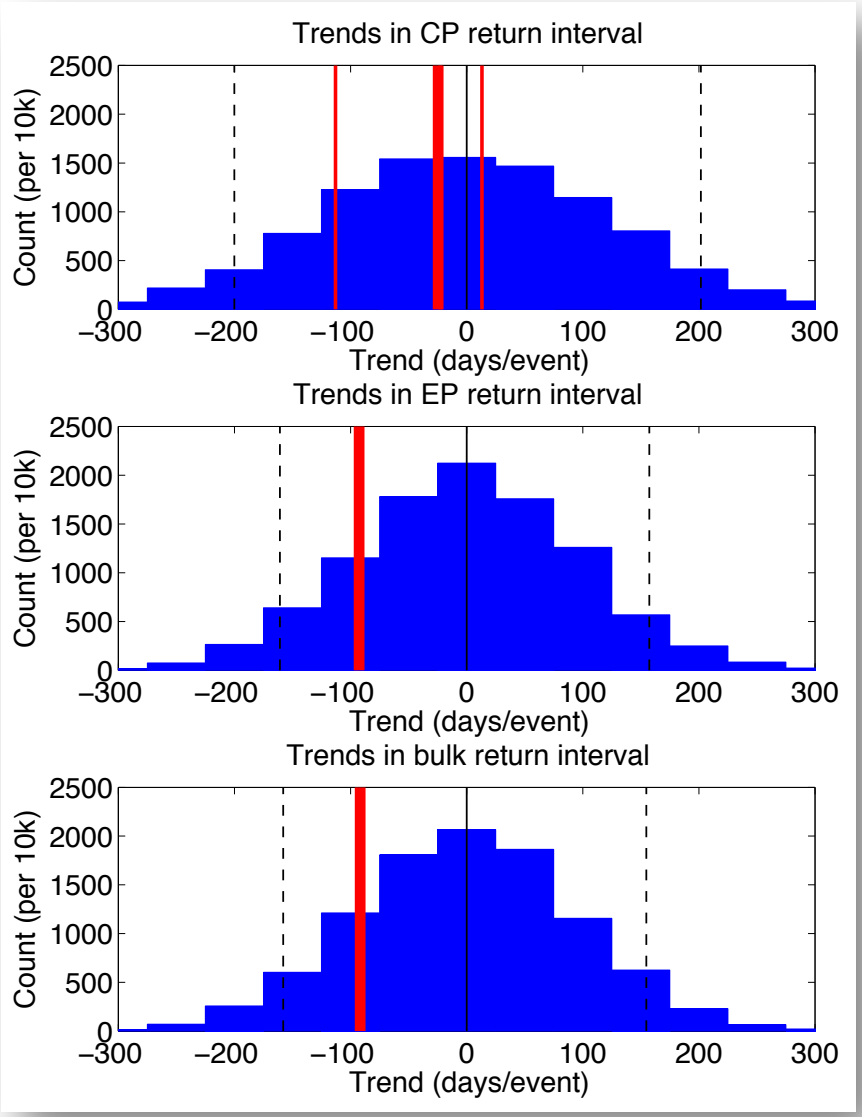
#	Year(s)	Type(s)	Max. SSTA (°C)
1	1982–83	CP, EP+	2.5
2	1986–88	CP, EP, CP	1.3
--	1991	EP	0.7
3	1991–92	CP, EP	1.7
4	1993	EP	0.9
5	1994–95	CP, EP	1.2
6	1997–98	CP, EP+	2.9
7	2002–03	CP, EP	1.5
--	2003–04	EP	0.7
8	2004–05	CP, EP	0.9
9	2006–07	CP, EP	1.4
10	2008	EP2	0.9
11	2009–10	EP, CP, EP	1.7
--	2011	EP2	0.5

Table 1: Three decades of El Nino typology (1982–2011).

Identifying number (#), year(s), type(s) of El Niños involved, and peak 3–month running mean SSTA (°C) of each event indicated on Figs. 2 and 3. Events without a number (--) did not pass the threshold on Fig. 2 but are marked with dashed lines on Fig. 3 and discussed in the main text. CP stands for Central Pacific, EP for East Pacific, and EP+ refers to the sequence of EP El Nino followed by a very strong warm anomaly in the far eastern Pacific between the Galapagos and mainland South America. See main text for discussion of EP2.

Trends in CP and EP El Niño events



(No trend in amplitude)

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Summary, conclusions, and a haiku

- Presented a straightforward interpretation of 30 years of reliable weekly SST and wind stress observations across the equatorial Pacific Ocean in time–longitude space.
- Are there two distinct types of El Niños?

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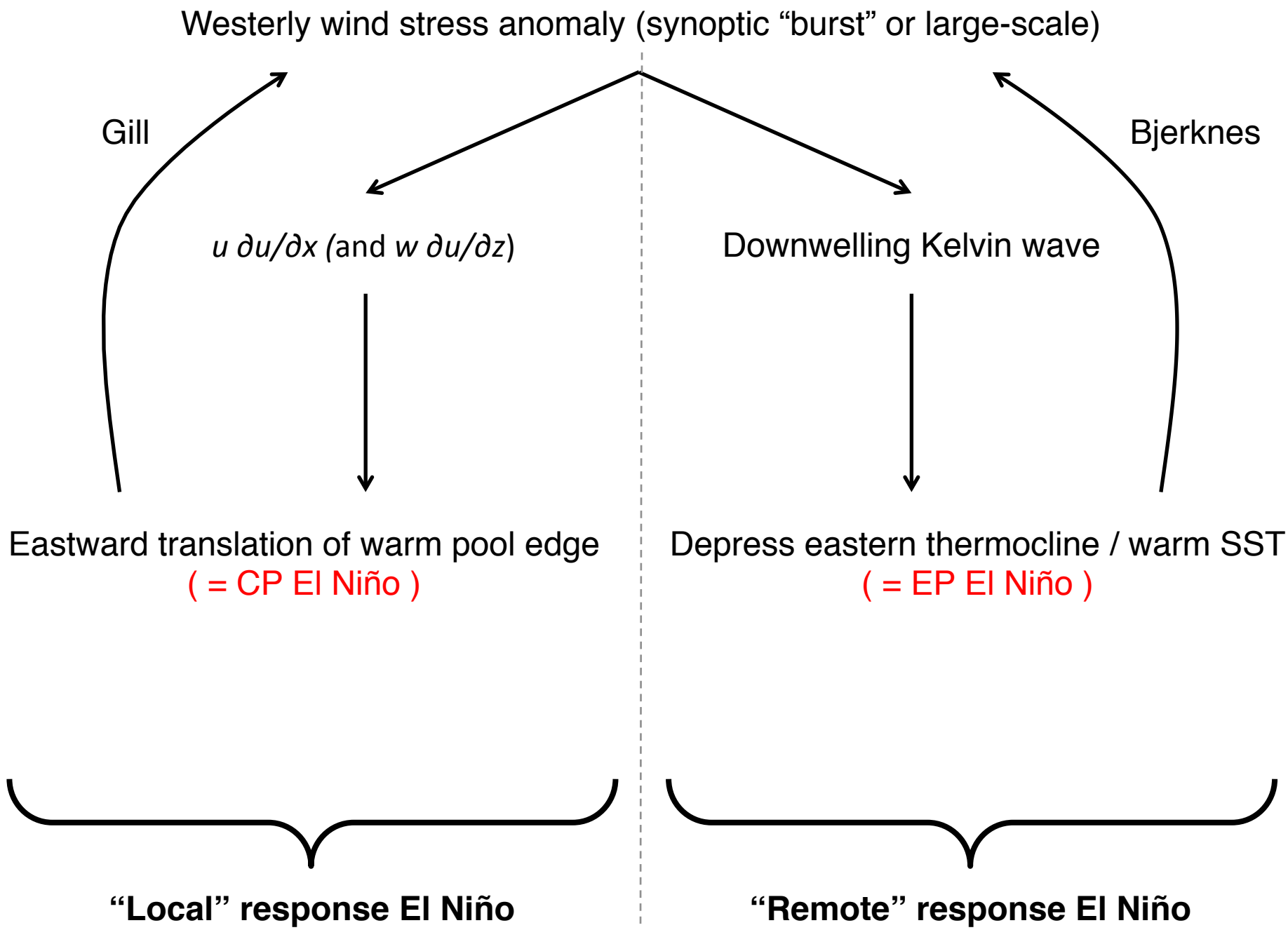

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Summary, conclusions, and a haiku

- Presented a straightforward interpretation of 30 years of reliable weekly SST and wind stress observations across the equatorial Pacific Ocean in time–longitude space.
- Are there two distinct types of El Niños?
- Any appearance of a trend over this period of time, particularly for Modoki, is heavily in favor of random chance.
- Cannot evaluate trends in amplitude for different types separately.

Many want to know,
Modoki, or come and go?
Decades, I can't show.

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