Revisiting ENSO Atmospheric Teleconnections and Challenges

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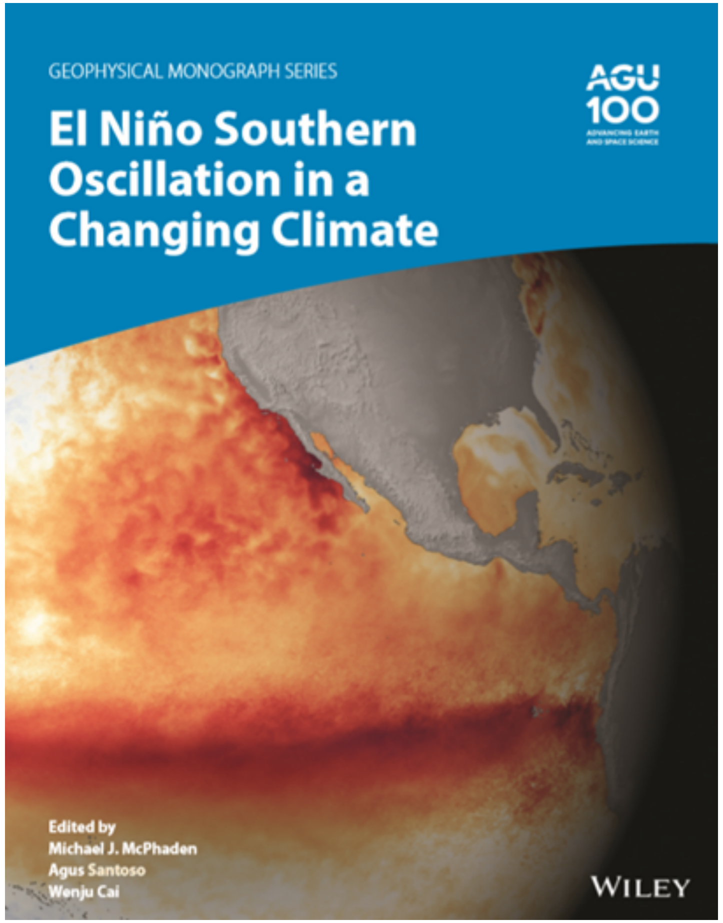

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El Niño – Southern Oscillation in a Changing Climate

Book to be launched in 2020 second semester.

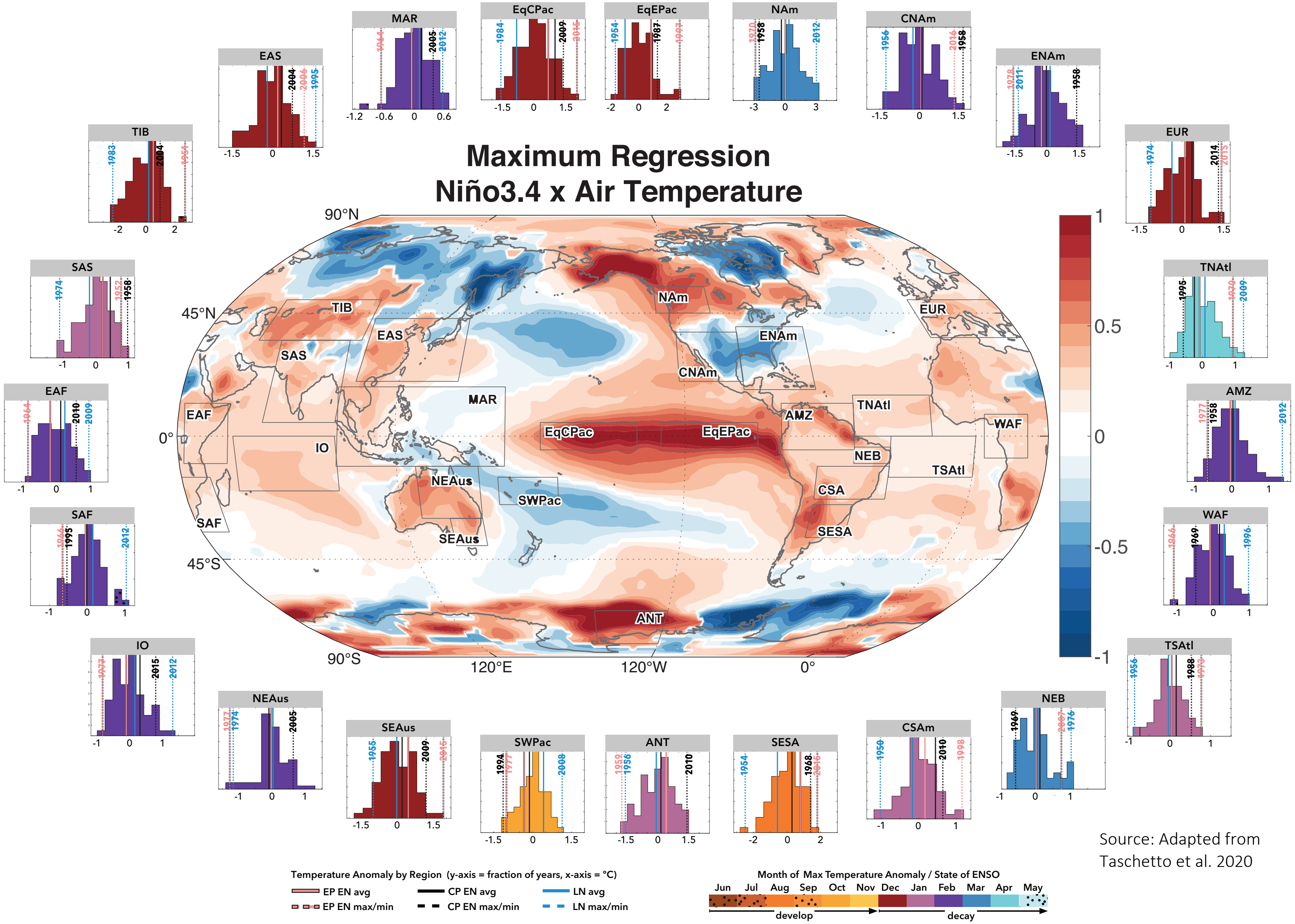
Edited by Michael McPhaden, Agus Santoso and Wenju Cai

Result of a collaborative research on ENSO, involving 98 authors and 21 chapters:

A comprehensive view of ENSO, historical background, characteristics, impacts on climate and extreme weather, theories, conceptual framework for ENSO projections, consequences for society, fisheries and global carbon cycle, advances in modelling, paleo-reconstructions and operational climate forecasting, and factors affecting ENSO events.

Air Temperature response to ENSO

El Niño events usually lead to a short-term rise in averaged temperatures, while global-mean temperatures typically decrease during La Niña.



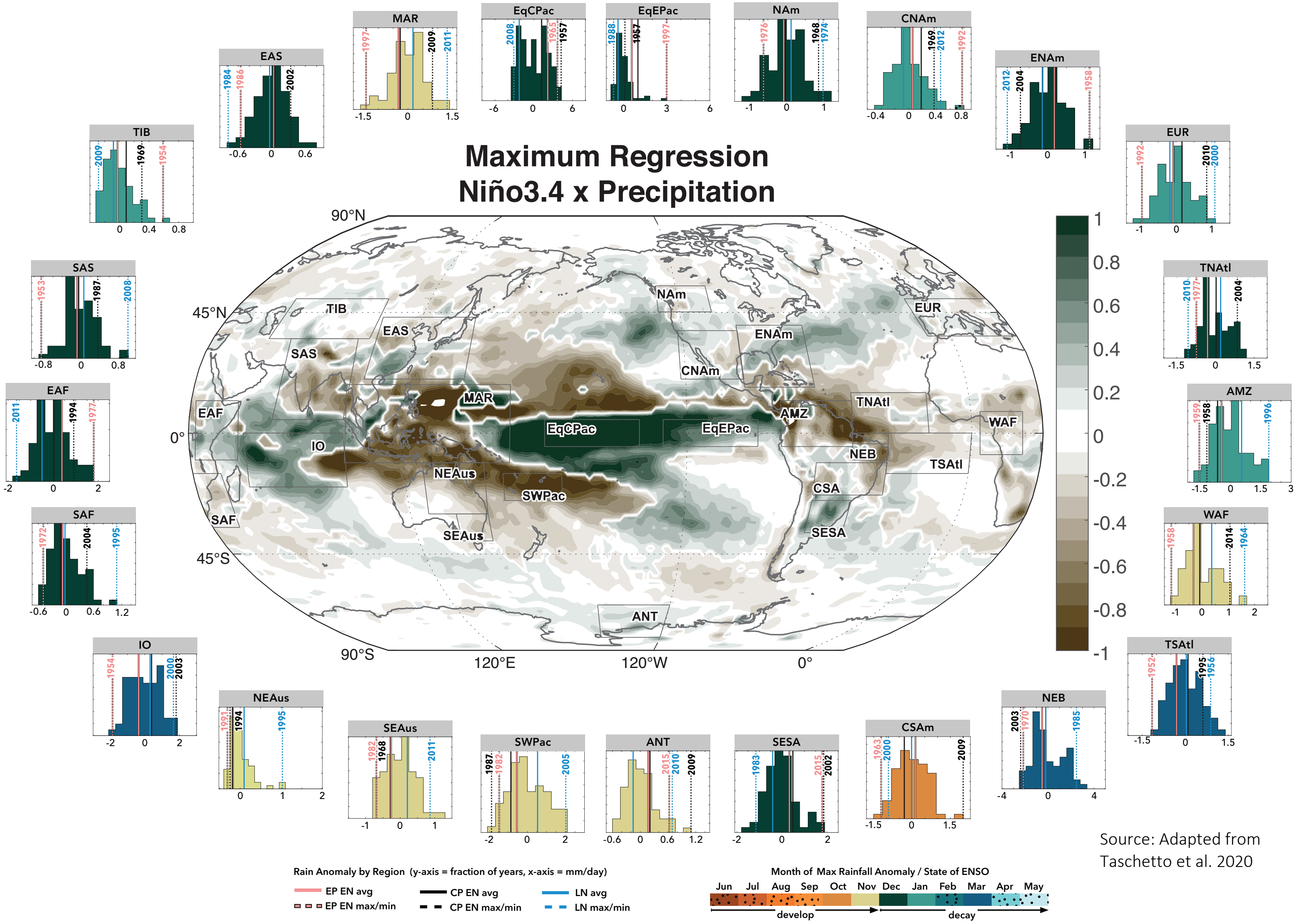
Maximum regression of 3-month mean air temperature anomaly onto Nov-to-Jan Niño3.4 index. Units in Celsius/std. Histograms for regions encompassing the boxes : Distribution of mean air temperature anomalies in the 3-months when maximum correlation with ENSO peak occurs. Vertical lines are anomalies when maximum correlation occurs during Eastern Pacific El Niño (red line), Central Pacific El Niño (black line) and La Niña (blue line). Dashed lines represent the year of largest anomalies.
Data from HadISST and NCEP/NCAR Reanalysis (Dec/1948 to Nov/2017).

Source: Adapted from Taschetto et al. 2020

Precipitation response to ENSO

El Niño events typically induce dry conditions in the Maritime Continent, Australia, northern South America, South Asia and South Africa, and wet conditions in southwestern North America, western Antarctica, and east Africa.

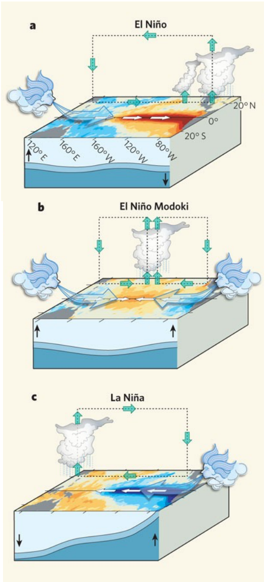
Maximum regression of 3-month mean precipitation anomaly onto Nov-to-Jan Niño3.4 index. Units in mm/day/std. Histograms for regions encompassing the boxes: Distribution of mean precipitation anomalies in the 3-months when maximum correlation with ENSO peak occurs. Vertical lines are anomalies when maximum correlation occurs during Eastern Pacific El Niño (red line), Central Pacific El Niño (black line) and La Niña (blue line). Dashed lines represent the year of largest anomalies.
Data from HadISST and NCEP/NCAR Reanalysis (Dec/1948 to Nov/2017).



Source: Adapted from Taschetto et al. 2020

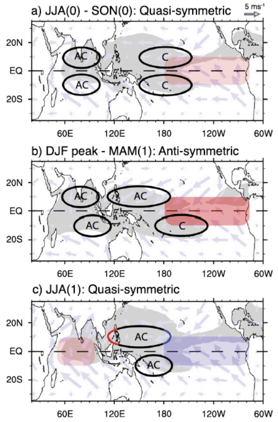
Mechanisms for Teleconnections

Equatorial Pacific and Walker Circulation: Bjerknes 1969; Matsuno 1966; Gill 1980



Source: Ashok and Yamagata 2009

NWP and Combination Mode: Stuecker et al. 2013, 2015



Tropospheric Temperature Mechanism: Chiang and Sobel 2002

Atmospheric Bridge: Lau and Nath 1996; Trenberth et al. 1998; Klein et al. 1999; Alexander et al. 2002

Pacific-Japan/East Asia-Pacific patterns: Nitta 1989; Xie et al. 2016

East Asia: Kumar et al. 1999, 2006; Wang et al. 2000; Weng et al. 2007; Zhang et al. 2016; Yeo et al. 2018; Kim et al. 2018; Son et al. 2014

South Asia: Ashok et al. 2004, 2007; Ummenhofer et al. 2011b

Indian Ocean: Chambers et al. 1999; Saji et al. 1999; Xi et al. 2009; Stuecker et al. 2017

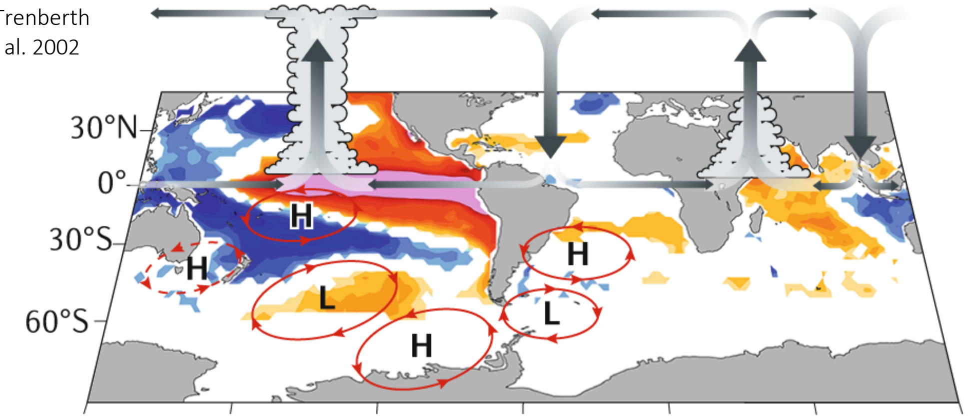
Maritime Continent: Hendon 2003; Tangang and Juneng, 2004; Chung et al. 2014

SPCZ and ITCZ: Folland et al 2002; Brown et al. 2011; Vincent et al. 2011; Cai et al. 2012

Australia: Wang and Hendon 2007; Taschetto et al. 2009, 2010; Ummenhofer et al. 2009, 2011a; Cai et al. 2011; Chung and Power 2017

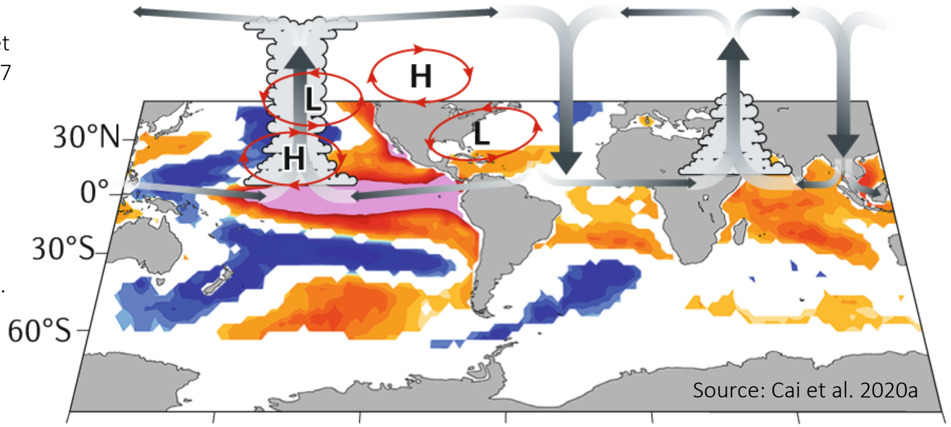
Stratosphere: Ineson and Scaife 2009; Domeisen et al. 2019

Arctic: Thompson and Wallace 1998; Deser 2000; Ding et al. 2014



Pacific-South American (PSA): Karoly 1989; Mo and Higgins 1998

Pacific-North American (PNA): Horel and Wallace 1981; Wallace and Gutzler 1981

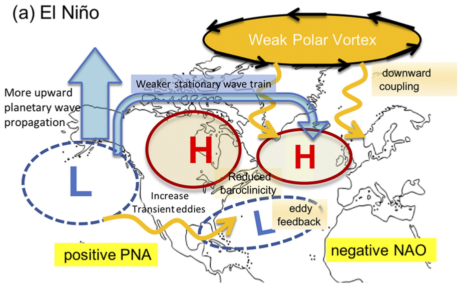


Source: Cai et al. 2020a

Southern Annual Mode: L'Heureux and Thompson 2006; Ciasto et al. 2015

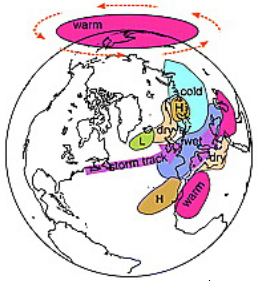
Antarctica: Turner 2004; Kwok and Comiso 2002; Stuecker et al. 2017; Yuan et al. 2018; Schlosser et al. 2018

North Atlantic and NAO: Huang et al. 1998; Pozo-Vázquez et al. 2001; Toniazzo and Scaife 2006; Jiménez-Esteve and Domeisen 2018



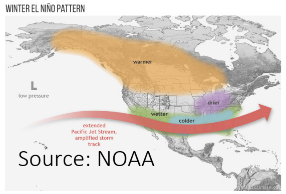
Source: Jiménez-Esteve and Domeisen (2018)

Europe: Fraedrich 1994; Brönnimann 2007; López-Parages et al. 2016



Source: Brönnimann (2007)

North America: Hoerling et al. 1997; Kumar and Hoerling 1998; Seager et al. 2005; Meehl and Teng 2007; Zhou et al. 2014; Guo et al. 2017



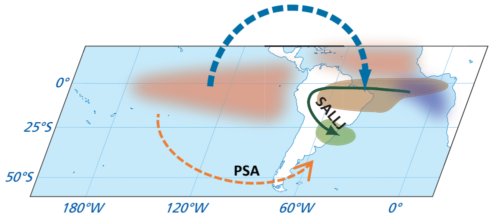
Source: NOAA

Tropical Atlantic: Huang et al. 2002; Giannini et al. 2004; Chang et al. 2006; Amaya and Foltz 2015; Taschetto et al. 2016

South Atlantic: Rodrigues et al. 2015

Africa: Cook 2001; Rowell 2001; Ratnam et al. 2014; Preethi et al. 2015; Pomposi et al., 2016; Nicholson and Kim 2017

South America: Nobre and Shukla 1996; Grimm 2003, 2004; Hill et al. 2009, 2011; Rodrigues et al. 2011; Tedeschi et al. 2013; Cai et al. 2020a



Why is ENSO climatic impact difficult to predict?

Nonlinearity of ENSO: While the global effects of La Niña are assumed to be opposite to El Niño, this is not true for all regions (Hoerling et al. 1997; Dommenget et al. 2013; Frauen et al. 2014; Chung et al. 2014)

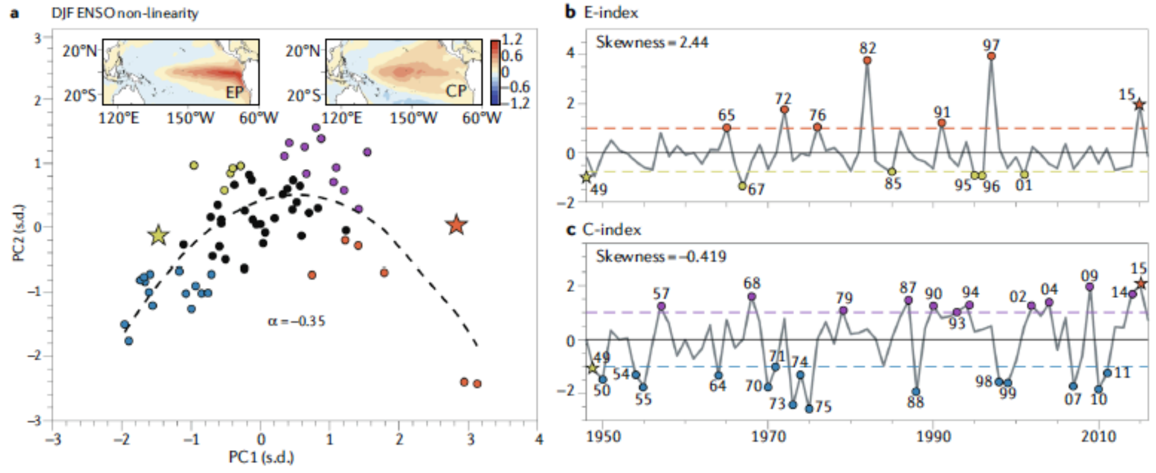
ENSO diversity: location of ENSO-related SST warming affects atmospheric teleconnections, i.e. anomalous equatorial warming superimposed on the Pacific mean state (Capotondi et al. 2015; Timmerman et al. 2018)

ENSO non-stationarity: teleconnections can be modulated by deterministic and/or random low-frequency variations (e.g. IPO; Power et al. 1999; Wittenberg 2009; Yun and Timmermann, 2018).

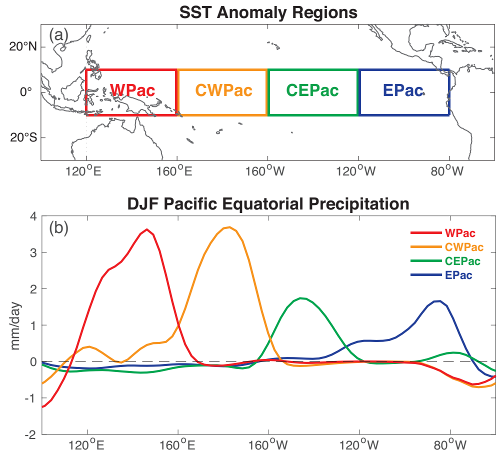
ENSO atmospheric teleconnections depend on **many factors**:

- magnitude of the forcing
- location of tropical convection
- time of the year, i.e. interactions with the annual cycle
- interactions of ENSO with local atmospheric conditions
- interactions with other ocean basins and modes of variability
- Stochastic variability

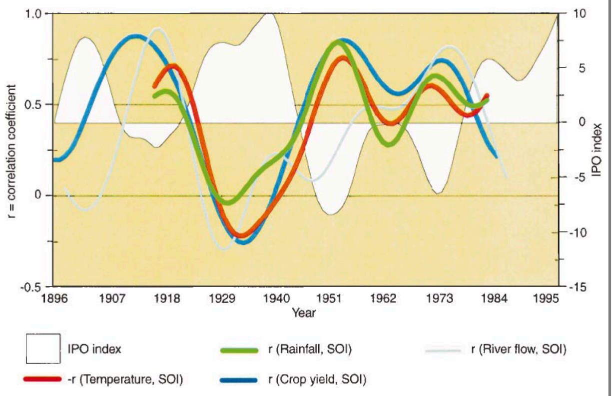
ENSO nonlinearity and diversity: EOF patterns of DJF SST. Relationship between PC1 and PC2, with a quadratic function fitted onto the PC1-PC2 scatter. (b) E- index [(PC1 – PC2)/ 2] (c) C-i ndex [(PC1 + PC2)/ 2] (Takahashi et al. 2011). Source: Cai et al. (2020).



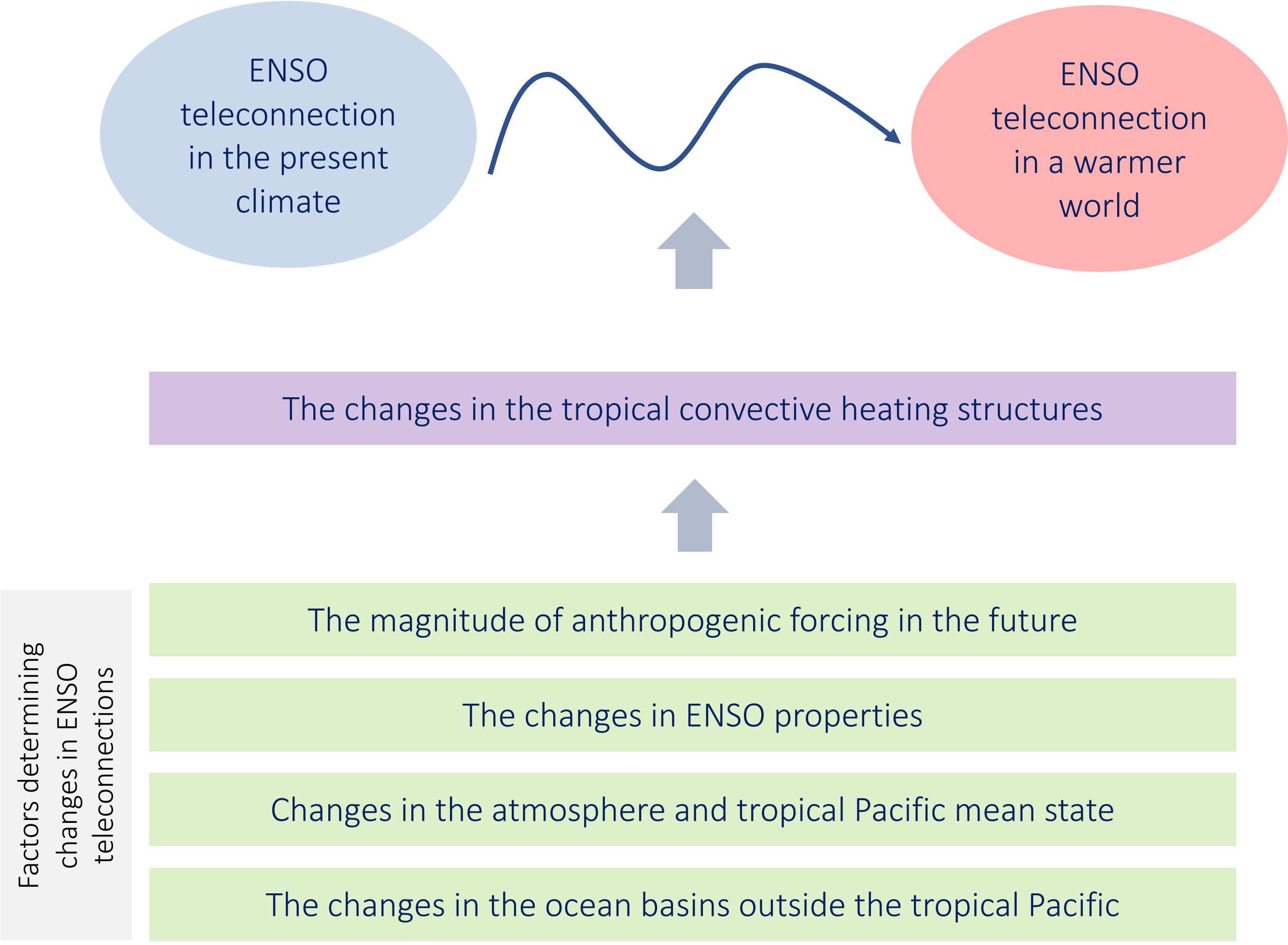
Non-linear precipitation response to a 1C SST warming imposed along the equatorial Pacific.



Relationship between SOI and Australian climate variables during IPO phases. Source: Power et al. (1999)



ENSO Teleconnections in a Warmer Climate



Credit to Sang-Wook Yeh. Yeh et al. (2018)

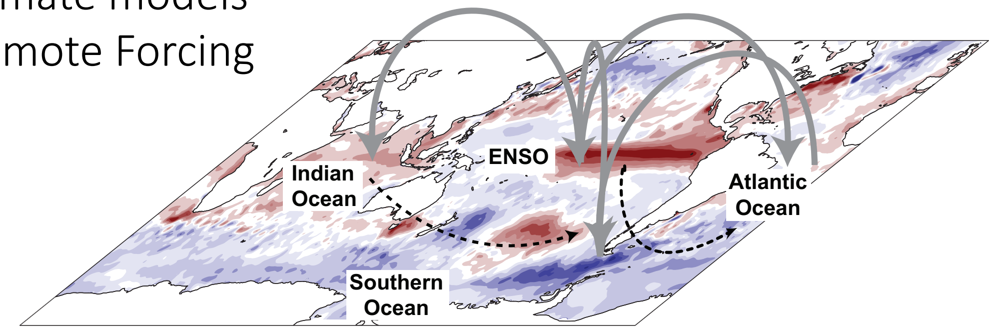
- Large uncertainties across climate models in how ENSO will change in the future (Collins et al. 2010)
- Despite that there are some consistent projections in ENSO-related precipitation due to a better agreement on Pacific mean state projections, i.e. enhanced equatorial warming and weakened Walker Circulation (Vecchi et al. 2006; Cai et al. 2020b)
- Regions with robust ENSO signal in current climate are expected to experience a 15-20% increase in ENSO-driven precipitation variability in the future (Bonfils et al. 2015; Power and Delage 2018)
- The location of the maximum SST moves eastward in a warmer world, leading to an eastward shift both of the mean convection center and in response to El Niño (Power et al. 2013; Bayr et al. 2014)
- The coherence of ENSO with climate modes outside the Pacific may in turn reinforce or offset ENSO's atmospheric teleconnection over a given region within and surrounding the Pacific (Cai et al. 2019)

Future Challenges in ENSO Research

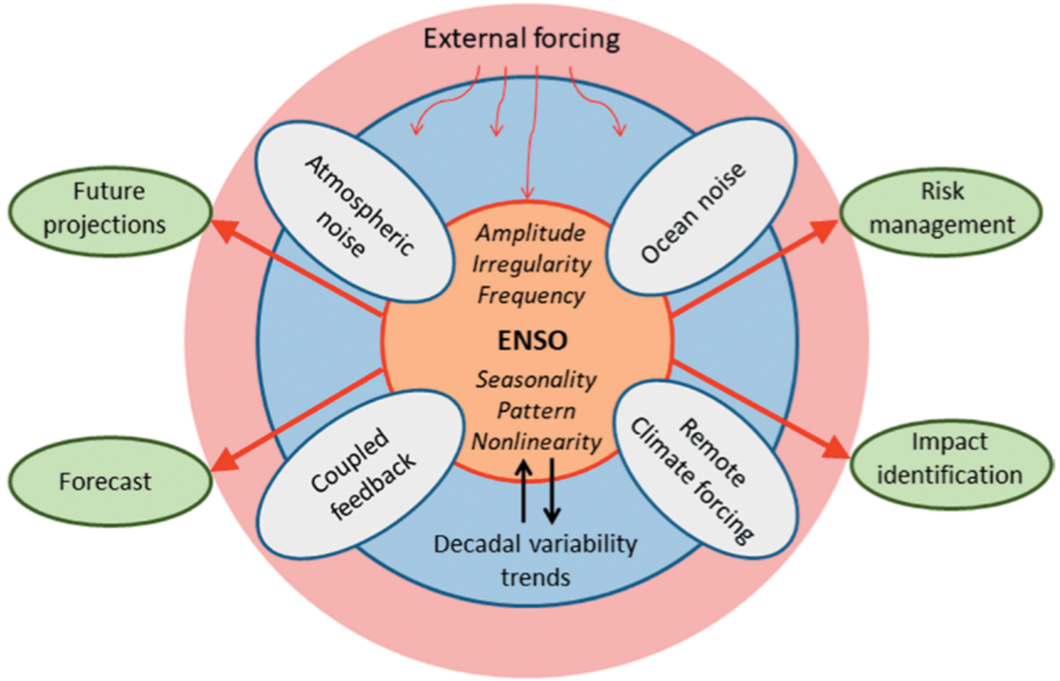
Understanding the different processes/mechanisms will help reduce reduce uncertainties in ENSO predictions and projections.

Challenges in Understanding ENSO:

- Short observational record
- Limited paleo-reconstructions
- Dynamics & Theories
- Biases in climate models
- External/Remote Forcing
- Prediction
- Impacts



A combined view of the climate system with interactions across other climate drivers is necessary to understand the physical mechanisms for ENSO teleconnections and improve climate predictions.



The climate impacts of ENSO are influenced by several factors: coupled feedback processes, atmospheric and oceanic noise, forcing from other oceanic basins, the basic mean state that evolves on long time scales. These components interact with one another and are influenced by external forcing. Source: Santoso et al. (2019, BAMS).

Credit to Agus Santoso

References

Note: There are many excellent papers about ENSO Teleconnections. Below are only a few of them, I am not able to list them all.

Alexander et al. 2002. The Atmospheric Bridge: The Influence of ENSO Teleconnections on Air–Sea Interaction over the Global Oceans. J Clim, 15(16), 2205–2231.

Amaya and Foltz. 2014. Impacts of canonical and Modoki El Niño on tropical Atlantic SST. J Geophys Res-Oceans.

Ashok et al. 2004. Individual and Combined Influences of ENSO and the Indian Ocean Dipole on the Indian Summer Monsoon. J Clim, 17, 3141-3155.

Ashok et al. 2007. El Niño Modoki and its possible teleconnection, J. Geophys. Res., 112, C11007.

Bayr et al. 2014. The eastward shift of the Walker Circulation in response to global warming and its relationship to ENSO variability. Clim Dyn, 43(9-10), 2747–2763.

Bjerknes 1969. Atmospheric teleconnections from the equatorial Pacific. Mon Wea Rev, 97, 163–172.

Bonfils et al. 2015. Relative Contributions of Mean-State Shifts and ENSO-Driven Variability to Precipitation Changes in a Warming Climate. J Clim, 28, 9997–10013.

Brönnimann. 2007. Impact of El Niño-Southern Oscillation on European climate. Rev Geophys, 45, RG3003.

Brown et al. 2011. Evaluation of the South Pacific Convergence Zone in IPCC AR4 Climate Model Simulations of the Twentieth Century. J Clim, 24(6), 1565–1582.

Cai et al. 2011. Teleconnection Pathways of ENSO and the IOD and the Mechanisms for Impacts on Australian Rainfall. J Clim, 24(15), 3910–3923.

Cai et al. 2012. More Extreme Swings of the South Pacific Convergence Zone Due to Greenhouse Warming. Nature 488(7411), 365–69.

Cai et al. 2019. Pantropical climate interactions. Science, 363, eaav4236.

Cai et al. 2020a. Climate Impacts of the El Niño–Southern Oscillation on South America. Nature Reviews Earth & Environment 1(4), 215–31.

Capotondi et al. 2015. Understanding ENSO Diversity. Bull Am Meteor Soc, 96, 921–938.

Cai et al. 2020b. ENSO Response to Greenhouse Forcing. In El Niño Southern Oscillation in a Changing Climate (eds M. McPhaden, A. Santoso, W. Cai). American Geophysical Union. in press.

Chambers et al. 1999. Anomalous warming in the Indian Ocean coincident with El Nino. J Geophys Res-Oceans, 104(C2), 3035–3047.

Chang et al. 2006. The cause of the fragile relationship between the Pacific El Niño and the Atlantic Niño. Nature, 443, 324–328.

Chiang and Sobel, A. H. 2002. Tropical Tropospheric Temperature Variations Caused by ENSO and Their Influence on the Remote Tropical Climate. J Clim, 15(18), 2616–2631.

Chung and Power. 2017. The Non-Linear Impact of El Niño, La Niña and the Southern Oscillation on Seasonal and Regional Australian Precipitation. J Southern Hemisphere Earth Systems Science 67(1): 25–45.

Chung et al. 2014. Nonlinear precipitation response to El Niño and global warming in the Indo-Pacific. Clim Dyn, 42(7-8), 1837–1856.

Ciasto et al. 2015. Teleconnections between Tropical Pacific SST Anomalies and Extratropical Southern Hemisphere Climate. J Clim, 28(1).

Cook 2001. A Southern Hemisphere Wave Response to ENSO with Implications for Southern Africa Precipitation. Journal of the Atmospheric Sciences, 58(15), 2146–2162.

Deser. 2000. On the Teleconnectivity of the 'Arctic Oscillation. Geophys Res Lett 27(6), 779–82.

Ding et al. 2014. Tropical forcing of the recent rapid Arctic warming in northeastern Canada and Greenland. Nat, 509, 209-212.

Domeisen et al. 2018. The Teleconnection of El Niño Southern Oscillation to the Stratosphere. Rev Geophys.

Dommenget et al. 2013. Analysis of the Non-Linearity in the Pattern and Time Evolution of El Niño Southern Oscillation. Clim Dyn 40, 2825–47.

Folland 2002. Relative influences of the Interdecadal Pacific Oscillation and ENSO on the South Pacific Convergence Zone. Geophys Res Lett, 29(13), 1643.

Fraedrich 1994. An ENSO impact on Europe? A review. Tellus, 46A, 541-552

Frauen et al. 2014. Analysis of the nonlinearity of El Niño-Southern Oscillation teleconnections. J. Clim., 27, 6225–6244.

Giannini et al. 2004. The preconditioning role of tropical Atlantic variability in the development of the ENSO teleconnection: implications for the prediction of Nordeste rainfall. Clim Dyn, 22, 839–855.

Gill. 1980. Some simple solutions for heat-induced tropical circulation. Quart J Roy Meteor Soc, 106, 447–462.

Grimm 2003. The El Niño impact on the summer monsoon in Brazil: regional processes versus remote influences. J Clim, 16, 263–280.

Grimm 2004. How do La Niña events disturb the summer monsoon system in Brazil? Clim Dyn, 22, 123–138.

Guo et al. 2017. Distinct patterns of tropical Pacific SST anomaly and their impacts on North American climate. J Clim, 30, 5221-5241

Hendon 2003. Indonesian rainfall variability: Impacts of ENSO and local air-sea interaction. J Clim, 16(11), 1775–1790.

Hill et al. 2009. South American rainfall impacts associated with inter-El Niño variations. Geophys Res Lett, 36, L19702

Hill et al. 2011. Sensitivity of South American summer rainfall to tropical Pacific Ocean SST anomalies. Geophys Res Lett, 38, L01701.

Hoerling et al. 1997. El Niño, La Niña, and the Nonlinearity of Their Teleconnections. J Clim, 10, 1769–1786

Horel, J. D., & Wallace, J. M. (1981). Planetary-Scale Atmospheric Phenomena Associated with the Southern Oscillation. Mon Wea Rev, 109(4), 813–829.

Huang 2004. Remotely forced variability in the tropical Atlantic Ocean. Clim Dyn, 23(2), 133–152.

Huang et al. 1998. The relationship between the North Atlantic Oscillation and El Niño-Southern Oscillation. Geophys Res Lett, 25, 2707-2710

Ineson and Scaife. 2009. The role of the stratosphere in the European climate response to El Niño. Nat Geo, 2, 32-36

Jiménez-Esteve and Domeisen 2018. The Tropospheric Pathway of the ENSO–North Atlantic Teleconnection. J Clim, 31(11), 4563–4584.

Karoly 1989. Southern Hemisphere circulation features associated with El Niño-Southern Oscillation events. J Clim, 2, 1239–1251.

Kim et al. 2018. Relative Roles of Equatorial Central Pacific and Western North Pacific Precipitation Anomalies in ENSO Teleconnection over the North Pacific. Clim Dyn 51(11–12), 4345–55.

Klein et al. 1999. Remote sea surface temperature variations during ENSO: Evidence for a tropical atmospheric bridge. J Clim, 12(4), 917–932.

Kumar and Hoerling. 1998. Annual Cycle of Pacific–North American Seasonal Predictability Associated with Different Phases of ENSO. J Clim 11(12), 3295–3308.

Kumar et al. 1999. On the weakening relationship between the Indian monsoon and ENSO. Science. 284. 2156–2159.

Kumar et al. 2006. Unraveling the Mystery of Indian Monsoon Failure During El Nino. Science, 314(5796), 115–119.

Kwok and Comiso 2002. Southern Ocean Climate and Sea Ice Anomalies Associated with the Southern Oscillation. J Clim, 15(5), 487–501.

L'Heureux and Thompson. 2006. Observed relationships between the El Nino-Southern Oscillation and the extratropical zonal-mean circulation. J Clim, 19(2), 276–287.

Lau and Nath. 1996. The Role of the "Atmospheric Bridge" in Linking Tropical Pacific ENSO Events to Extratropical SST Anomalies. J Clim, 9(9), 2036–2057.

Lopez-Parages et al. 2016. ENSO influence on the North Atlantic European climate: a non-linear and non-stationary approach. Clim Dyn, 47, 2071-2084

Matsuno. 1966. Quasi-Geostrophic Motions in the Equatorial Area. J Meteor Soc Japan 44(1), 25–42.

Meehl and Teng. 2007. Multi-model changes in El Niño teleconnections over North America in a future warmer climate. Clim. Dyn.

Mo and Higgins. 1998. The Pacific–South American Modes and Tropical Convection during the Southern Hemisphere Winter. Mon Wea Rev 126(6), 1581–96.

Nicholson and Kim 1997. The relationship of the El Niño – Southern Oscillation to African rainfall. Int J Climatol, 17(2), 117–135.

Nitta 1989. Global Features of the Pacific-Japan Oscillation. Meteorology and Atmospheric Physics 41(1), 5–12.

Nobre and Shukla. 1996. Variations of sea surface temperature, wind stress, and rainfall over the tropical Atlantic and South America. J Clim, 9, 2464–2479.

Pomposi et al. 2016. Understanding Pacific Ocean influence on interannual precipitation variability in the Sahel. Geophys Res Lett, 43(17), 9234–9242.

Power and Delage. 2018. El Niño–Southern Oscillation and Associated Climatic Conditions around the World during the Latter Half of the Twenty-First Century. J Clim, 31(15), 6189–6207.

Power et al. 1999. Inter-decadal modulation of the impact of ENSO on Australia. Clim Dyn, 15(5), 319–324.

Power et al. 2013. Robust twenty-first-century projections of ElNiño and related precipitation variability. Nat, 502(7472), 541.

Pozo-Vazquez et al. 2001. The association between ENSO and winter atmospheric circulation and temperature in the North Atlantic region. J Clim, 14, 3408-3420

Preethi et al. 2015. Impacts of the ENSO Modoki and other Tropical Indo-Pacific Climate-Drivers on African Rainfall. Sci Rep, 5, 16653.

Ratnam et al. 2014. Remote Effects of El Niño and Modoki Events on the Austral Summer Precipitation of Southern Africa. J Clim, 27(10), 3802–3815.

References

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Rodrigues et al. 2011. The impacts of inter-El Niño variability on the tropical Atlantic and northeast Brazil climate. J Clim, 24, 3402–3422.
Rodrigues et al. 2015. The impact of ENSO on the South Atlantic subtropical dipole mode. J Clim, 28, 2691-2705.
Rowell 2001. Teleconnections between the tropical Pacific and the Sahel. Quarterly Journal of the Royal Meteorological Society, 127(575), 1683–1706.
Saji et al. 1999. A dipole mode in the tropical Indian Ocean. Nature, 401(6751), 360–363.
Santoso et al. 2019. Dynamics and Predictability of El Niño–Southern Oscillation: An Australian Perspective on Progress and Challenges. Bull Am Meteor Soc, 100, 403–420.
Schlosser et al. 2018. Atmospheric influences on the anomalous 2016 Antarctic sea ice decay, The Cryosphere, 12, 1103-1119.
Seager et al. 2005. Mechanisms of ENSO-Forcing of Hemispherically Symmetric Precipitation Variability. Quarterly Journal of the Royal Meteorological Society 131(608), 1501–27.
Son et al. 2014. Winter Precipitation Variability over Korean Peninsula Associated with ENSO. Clim Dyn 42(11–12): 3171–86.
Stuecker et al. 2013. A combination mode of the annual cycle and the El Niño/Southern Oscillation. Nature Geoscience. 6. 540-544.
Stuecker et al. 2015. Combination Mode Dynamics of the Anomalous Northwest Pacific Anticyclone. J Clim. 28.
Stuecker et al. 2017a. Revisiting ENSO/Indian Ocean Dipole phase relationships. Geophys Res Lett. 44.
Stuecker et al. 2017b. Conditions leading to the unprecedented low Antarctic sea ice extent during the 2016 austral spring season. Geophys Res Lett. 44.
Takahashi et al. 2011. ENSO regimes: Reinterpreting the canonical and Modoki El Niño. Geophys. Res. Lett., 38, 1–5.
Tangang and Juneng 2004. Mechanisms of Malaysian Rainfall Anomalies. J Clim, 17(18), 3616–3622.
Taschetto et al. 2009. Effect of anomalous warming in the central Pacific on the Australian monsoon. Geophys Res Lett, 36, L12704.
Taschetto et al. 2010. Australian Monsoon Variability Driven by a Gill–Matsuno-Type Response to Central West Pacific Warming. J Clim, 23(18), 4717–4736.
Taschetto et al. 2016. How sensitive are the Pacific–tropical North Atlantic teleconnections to the position and intensity of El Niño-related warming? Clim Dyn, 46, 1841–1860.
Taschetto et al. 2020. Atmospheric Teleconnections of ENSO. In El Niño Southern Oscillation in a Changing Climate (eds M. McPhaden, A. Santoso, W. Cai). American Geophysical Union. in press.
Tedeschi et al. 2013. Influences of two types of ENSO on South American precipitation. Int J Climatol, 33, 1382–1400.
Thompson and Wallace. 1998. The Arctic oscillation signature in the wintertime geopotential height and temperature fields, Geophys Res Lett, 25, 1297-1300.
Timmermann et al. 2018. El Niño–Southern Oscillation complexity. Nature, 559, 535–545.
Toniazzo and Scaife. 2006. The Influence of ENSO on Winter North Atlantic Climate. Geophys Res Lett 33(24).
Trenberth et al. 1998. Progress during TOGA in understanding and modeling global teleconnections associated with tropical sea surface temperatures. J Geophys Res, 103, 14,291-14,324
Turner 2004. The El Niño–southern oscillation and Antarctica. J Climatology, 24(1), 1–31.
Ummenhofer et al. 2009. What causes southeast Australia's worst droughts? Geophys Res Lett, 36(4), L04706.
Ummenhofer et al. 2011a. Indian and Pacific Ocean influences on southeast Australian drought and soil moisture. J Clim, 24(5), 1313–1336.
Ummenhofer et al. 2011b. Multi-decadal modulation of the El Niño–Indian monsoon relationship by Indian Ocean variability. Env Res Lett, 6(3), 034006.
Vecchi et al. 2006. Weakening of Tropical Pacific Atmospheric Circulation Due to Anthropogenic Forcing. Nat, 441(7089), 73–76.
Vincent et al. 2011. Interannual variability of the South Pacific Convergence Zone and implications for tropical cyclone genesis. Clim Dyn, 36(9-10), 1881–1896.
Wallace and Gutzler. 1981. Teleconnections in the Geopotential Height Field during the Northern Hemisphere Winter. Mon Wea Rev, 109(4), 784–812.
Wang and Hendon. 2007. Sensitivity of Australian Rainfall to Inter–El Niño Variations. J Clim 20, 4211–26.
Wang et al. 2000. Pacific-East Asian Teleconnection: How Does ENSO Affect East Asian Climate? J Clim. 13. 1517-1536.
Weng et al. 2007. Impacts of recent El Niño Modoki on dry/wet conditions in the Pacific rim during boreal summer. Clim Dyn 29:113–129.
Wittenberg. 2009. Are Historical Records Sufficient to Constrain ENSO Simulations? Geophys Res Lett, 36, 12, L12702.
Xie et al. 2009. Indian Ocean Capacitor Effect on Indo-Western Pacific Climate during the Summer following El Niño. J Clim. 22. 730-747.
Xie et al. 2016. Indo-Western Pacific Ocean Capacitor and Coherent Climate Anomalies in Post-ENSO Summer: A Review. Advances in Atmospheric Sciences, 33, 411-432.
Yeh et al. 2018. ENSO Atmospheric Teleconnections and Their Response to Greenhouse Gas Forcing, Rev Geophys, 56, 185-206.
Yeo et al. 2018. Monthly climate variation over Korea in relation to the two types of ENSO evolutions. Int J. Climatology, 38, 811-824.
Yuan et al. 2018. The Interconnected Global Climate System—A Review of Tropical–Polar Teleconnections. J Clim, 31(15), 5765–5792.
Yun and Timmermann. 2018. Decadal Monsoon-ENSO Relationships Reexamined. Geophys Res Lett. 45, 2014-2021.
Zhang et al. 2016. Unraveling El Niño's impact on the East Asian Monsoon and Yangtze River summer flooding. Geophys Res Lett. 43. 11,375-11,382.
Zhou et al. 2014. Global Warming–Induced Changes in El Niño Teleconnections over the North Pacific and North America. J Clim, 27(24), 9050–9064.