Multiyear Statistical Prediction of ENSO Enhanced by the Tropical Pacific Observing System

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ISGlobal

ENSO Prediction Model

The model in dynamic component form is:

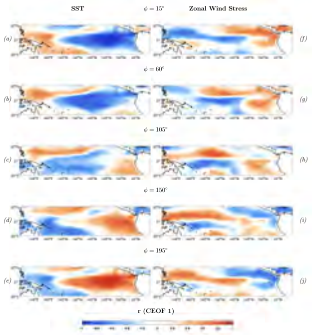
$$y_t = \mu_t + \psi_{1t} + \psi_{2t} + \psi_{3t} + \psi_{4t} + \psi_{5t} + \psi_{6t} + x_t'\delta + \varepsilon_t$$

- ψ_{1t} - semi-annual cycle
- ψ_{2t} - annual cycle
- ψ_{3t} - near-annual cycle
- ψ_{4t} - quasi-biannual cycle
- ψ_{5t} - quasi-quadrennial cycle
- ψ_{6t} - decadal cycle

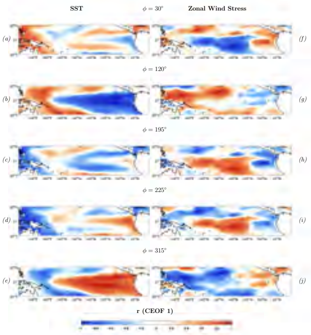
Spatio-Temporal Evolution of the Cycle Components

SST and zonal wind components involved in the ENSO variability

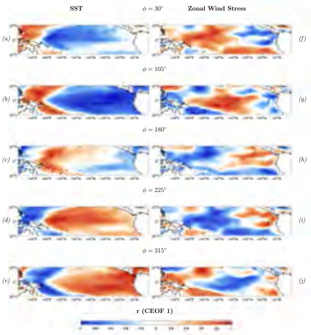
Near-Annual



Quasi-Biannual

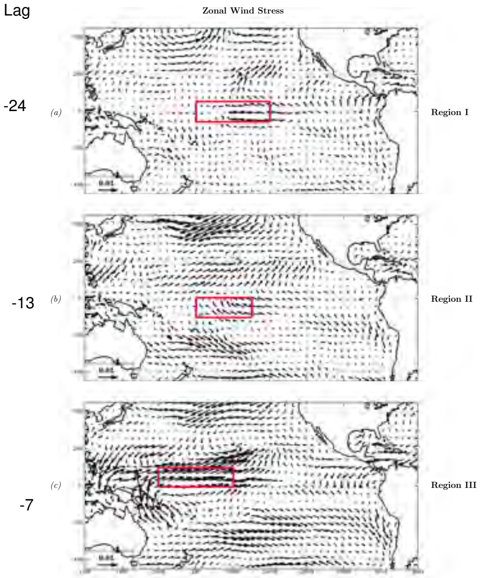


Quasi-Quadrennial



Petrova et al. 2017, Clim. Dyn.

ENSO origin and precursors: Zonal Wind Stress



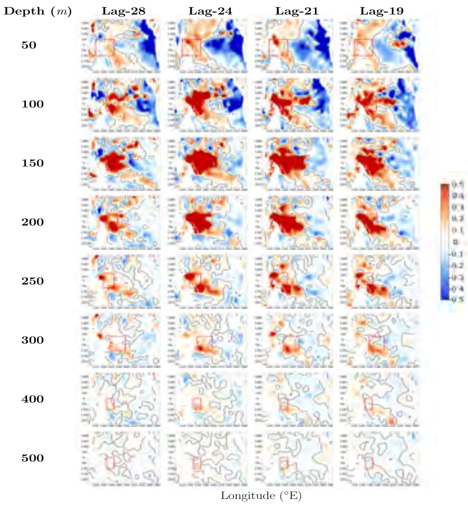
[180e-220e] x [4s-4n]

[180e-210e] x [10s-0]

[160e-200e] x [0-10n]

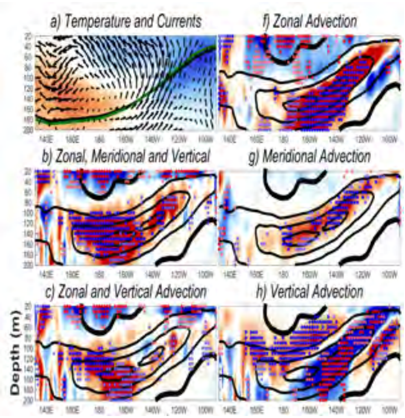
Petrova et al. 2017, Clim. Dyn.

ENSO origin and precursors: Heat Accumulation in the WPAC Subsurface



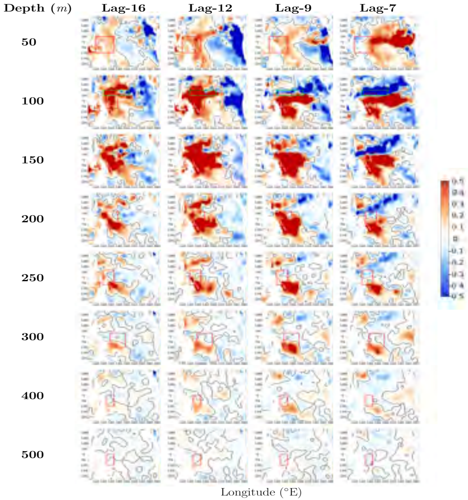
Petrova 2017, PhD Thesis

Temperature tendency and heat advection (lags 27-16)



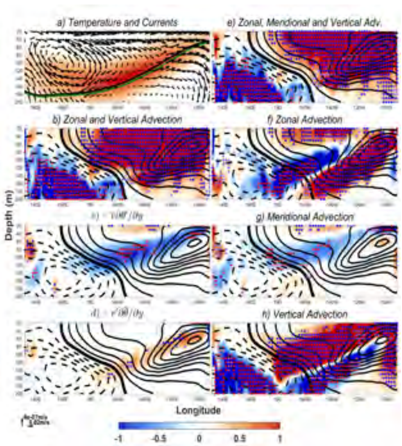
Ballester et al. 2016, J. Geophys. Res.: Oceans.

ENSO origin and precursors: Heat Migration to the CPAC and EPAC Subsurface



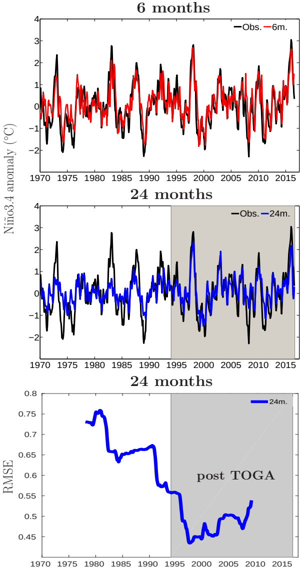
Petrova 2017, PhD Thesis

Temperature tendency and heat advection (lags 15-4)



Ballester et al. 2016, J. Geophys. Res.: Oceans.

Forecast of Pre- and Post-TOGA Niño3.4 Time Series

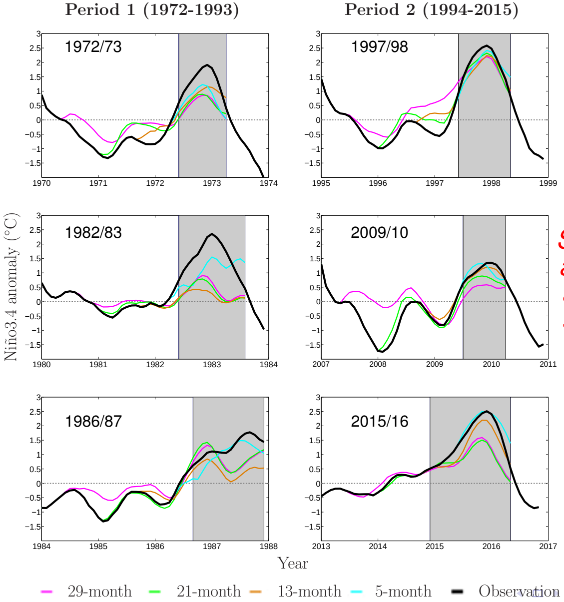


Petrova et al. 2020, J. Clim.

Fig: Retrospective prediction of the Niño3.4 index. Monthly observations (black curve) and model prediction at (a) 6-month lead (red curve) and (b) 24-month lead (blue curve). (c) 16-year moving RMSE of the prediction in (b) (blue curve) before and after (shading) the completion of the observing system in 1994.

The Tropical Pacific Observing System and especially subsurface temperature in situ observations have substantially contributed for the long-lead predictive capacity of our ENSO model.

Forecast of Pre- and Post-TOGA El Niño Events



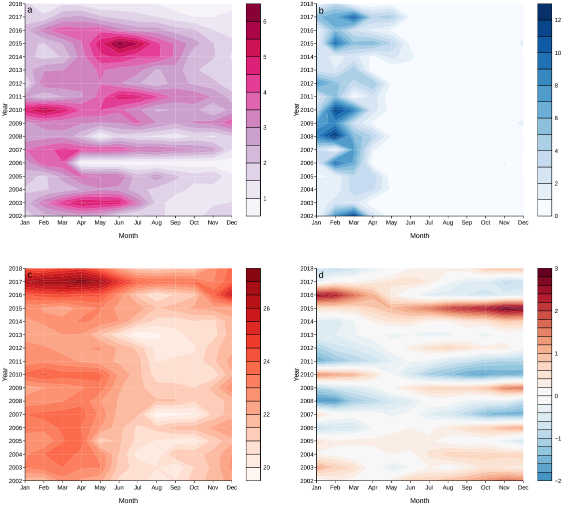
Strong El Niños are better predicted as a result of subsurface observations

Petrova et al. 2020, J. Clim.

Dengue incidence and climate relationship in Machala, Ecuador

Dengue incidence (cases per 100,000 inhabitants)

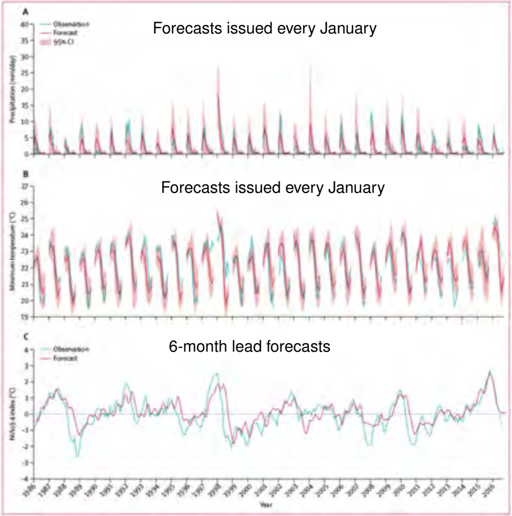
Precipitation (mm/month)



Tmin (°C)

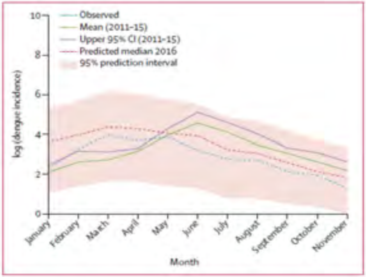
Nino 3.4 index

Predicting climate in Machala in 2016



Lowe et al. 2017, Lancet Planet. Health

Predicting dengue fever in Machala in 2016



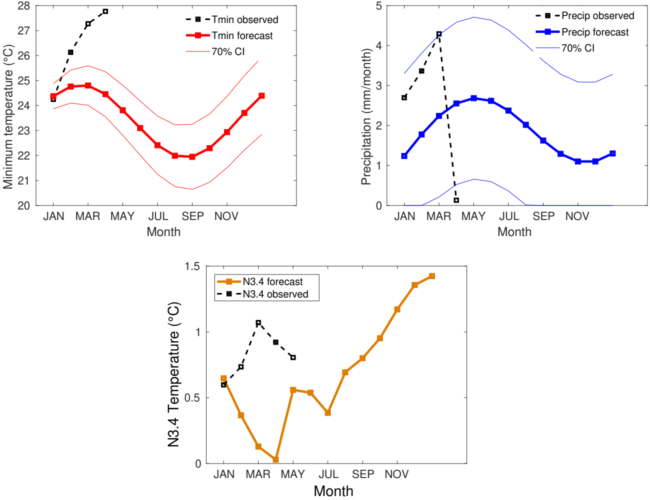
	Mean (2011–15)			Upper 95% CI (2011–15)		
	Cases	Incidence	Probability of exceeding mean	Cases	Incidence	Probability of exceeding upper 95% CI
January	18	8	90%	27	11	84%
February	33	13	87%	58	23	76%
March	37	15	90%	56	22	85%
April	59	23	82%	68	26	79%
May	133	51	54%	186	71	41%
June	248	95	24%	430	162	9%
July	154	59	17%	251	97	5%
August	79	31	33%	140	54	13%
September	52	21	31%	69	27	21%
October	33	13	29%	53	22	13%
November	20	9	34%	32	14	17%

Mean and upper 95% CI of dengue (cases and incidence per 100 000 population) for the last 5 year period 2011–15. Probability of dengue incidence exceeding both the 5 year mean and upper 95% CI are shown.

***Table:* Monthly probabilistic dengue risk forecasts for Machala, Ecuador, January–November, 2016**

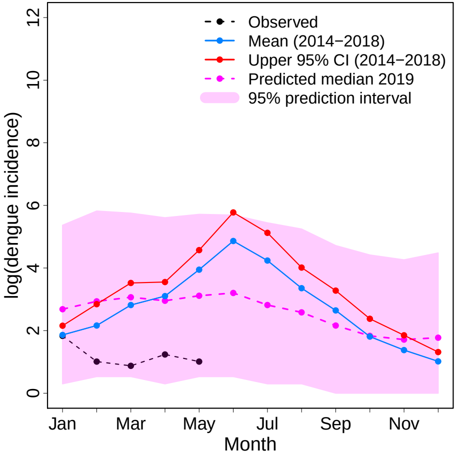
Lowe et al. 2017, Lancet Planet. Health

Predicting climate in Machala in 2019



Petrova et al., 2020, Int. J. Climatol.

Predicting dengue fever in Machala in 2019



Petrova et al., 2020, Int. J. Climatol.

Conclusions

- Statistical ENSO prediction models still need to take full advantage of the availability of ocean subsurface variables, provided regularly for the last several decades as a result of the TOGA Program.
- Temperatures at different depths and regions of the tropical Pacific Ocean are good predictors of ENSO, along with SSTs and zonal wind stress.
- We have issued skillful predictions of the Niño3.4 index in the period 1970-2016 with a flexible statistical dynamic components model that predicts the strong El Niño episodes up to 2.5 years in advance.
- Warm and cold events are much better predicted after the completion of the observational array system in the tropical Pacific in 1994.
- The amplitudes of the major ENSO events are better reproduced by the model due to the improved observations.
- Real-time El Niño forecasts with the model were used in a prototype for an early warning system for dengue in Machala, Ecuador. The prediction system can distinguish dengue risk during strong or weak El Niño years.


Thank You!

- **Petrova, D.**, Ballester, J., Koopman, S.J., Rodó, X. **Multiyear statistical prediction of ENSO enhanced by the tropical Pacific observing system** Journal of Climate 33, no. 1 (2020): 163-174.
- **Petrova, D.**, Koopman, S.J., Ballester, J., Rodó, X. **Improving the long-lead predictability of El Niño using a novel forecasting scheme based on a dynamic components model**, Clim. Dyn., 2017, DOI 10.1007/s00382-016-3139-y
- **Petrova, D. A New Approach to El Niño Southern Oscillation Origin and Forecasting: Implications for Predictability** PhD Thesis, 2017, Physics Department, University of Barcelona.
- Ballester, J., Bordoni, S., **Petrova, D.**, Rodó, X. **Heat advection processes leading to El Niño events as depicted by an ensemble of ocean assimilation products**, Journal of Geophysical Research: Oceans, 2016, 121(6), pp.3710-3729.
- Ballester, J., **Petrova, D.**, Bordoni, S., Cash, B., García-Díez, M., Rodó, X. **Sensitivity of El Niño intensity and timing to preceding subsurface heat magnitude**, Scientific Reports, 2016, 6(1), pp.1-9.