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

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The model in dynamic component form is:

\[ y_t = \mu_t + \psi_1 t + \psi_2 t + \psi_3 t + \psi_4 t + \psi_5 t + \psi_6 t + x'_t \delta + \epsilon_t \]

- \( \psi_1 t \) - semi-annual cycle
- \( \psi_2 t \) - annual cycle
- \( \psi_3 t \) - near-annual cycle
- \( \psi_4 t \) - quasi-biannual cycle
- \( \psi_5 t \) - quasi-quadrennial cycle
- \( \psi_6 t \) - 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

ENSO origin and precursors: Zonal Wind Stress

ENSO origin and precursors: Heat Accumulation in the WPAC Subsurface

Temperature tendency and heat advection (lags 27-16)

Petrova 2017, PhD Thesis

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

Petrova 2017, PhD Thesis
Forecast of Pre- and Post-TOGA Niño3.4 Time Series

**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

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

Forecasts issued every January

6-month lead forecasts

Predicting dengue fever in Machala in 2016

Predicting climate in Machala in 2019

- **Minimum temperature (°C)**
  - Tmin observed
  - Tmin forecast
  - 70% CI

- **Precipitation (mm/month)**
  - Precip observed
  - Precip forecast
  - 70% CI

- **N3.4 Temperature (°C)**
  - N3.4 forecast
  - N3.4 observed

*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!


