Seasonal predictions of equatorial Atlantic SST in a low-resolution CGCM with surface Heat Flux Correction

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GEOMAR

A Niño-like mode of variability in the tropical Atlantic

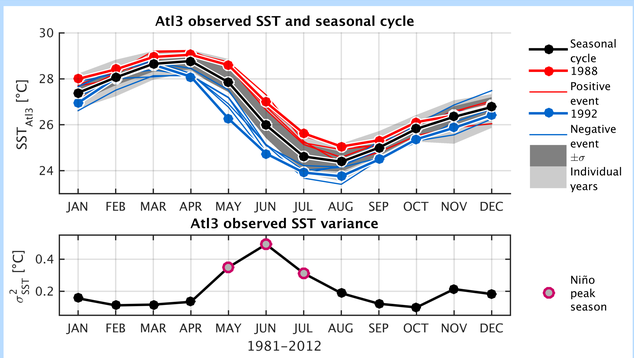

Fig. 1: Observed seasonal cycle (*top*) and variance (*bottom*), 1981-2012. 1988 (1992) was the most positive (negative) Atlantic Niño. The Atlantic Niño index is the Atl3 SST anomaly averaged for May-July. An event occurs if the index exceeds one standard deviation.

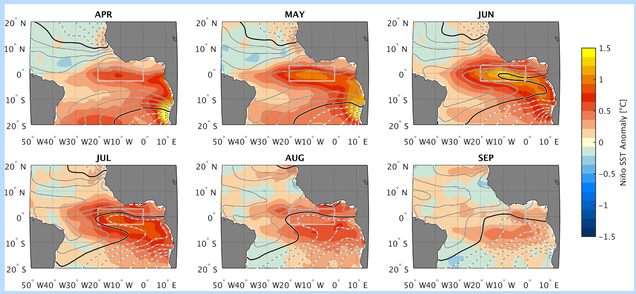

Fig. 2: Evolution of the Atlantic Niño pattern (shading) as positive minus negative composites. Composites are based on the Atlantic Niño index. Contours show climatological SSTs, 1981-2012: solid: >25°C, thick: 25°C, dashed: <25°C; the contour interval is 1°C. Box: Atl3-region.

- **Atlantic Niño**: Mode of **coupled interannual variability**. Manifestation in the onset and magnitude of the equatorial cold tongue[1]
  → Phase-locked to boreal summer[2] (Figs 1, 2)
- **Dynamics**: Similar to the Pacific, but **seasonally active**[3]

Heat Flux Correction improves simulated variability

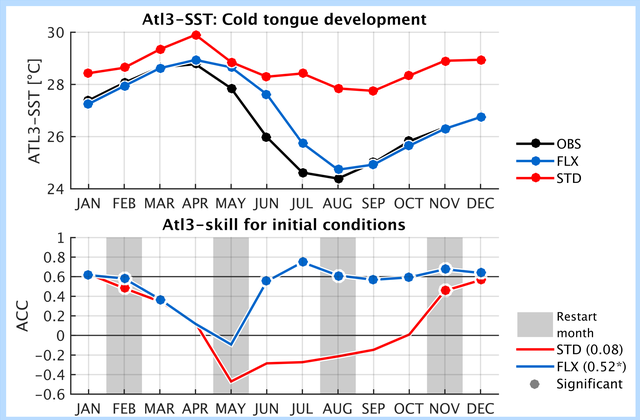

Fig. 3: (*Top*): Evolution of Atl3 SSTs in observations (black line, same as in Fig. 1), the heat-flux corrected experiment (blue, FLX), and the standard experiment (red, STD). (*Bottom*): Anomaly correlation coefficient (ACC) between observed and simulated Atl3 SST. Simulations are for the assimilation runs, i.e. for the initial conditions of the forecast. Blue: FLX, red: STD. Circles indicate correlations that are significantly different from 0 at the 95%-level. Grey background shading denotes the restart months.

- Produce **initial conditions** for forecasts via **partial coupling**[4] with the Kiel Climate Model (KCM). Partial coupling forces the ocean-sea ice component of the KCM with observed wind stress anomalies. Surface heat fluxes, SST, and the wind field remain fully prognostic. Hence, the modeled balance between wind stress and the ocean pressure gradient is not disturbed[5].
- Two experiments:
  - STD: Standard partial coupling.
  - FLX: Apply additional surface heat flux correction, i.e. strong **SST bias alleviation** (Fig. 3, *top*)
- **Results** (Fig. 3, *bottom*):
  - **Strong improvement** of simulated variability in boreal summer and fall → **Atlantic Niño peak season** well captured in initial conditions
  - Pitfall: Still **no skill in May** → problematic for Niño event forecasts
- **Implications** for forecasts started from these initial conditions?

Predicting the Atlantic Niño 2-3 months ahead

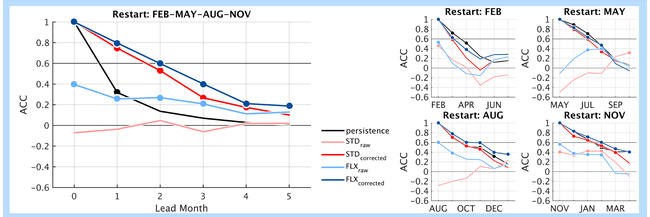

Fig. 5: ACC between forecasts and observations. (*Left*): All forecasts. (*Right*): Individual restart months. See legend for line styles. „Corrected" indicates forecasts that incoporate persistence skill.

- **Forecasts**: Started in Feb, May, Aug, Nov
- Corrected: Add difference between lead month 0 forecast and observations to entire forecast – i.e. incorporate persistence
- Find **useful skill** for about **2-3 months** for corrected forecasts

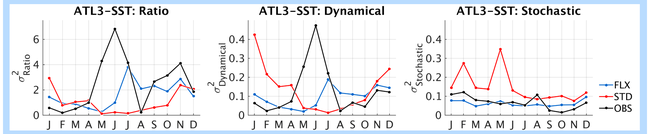

Fig. 5: Dynamically driven SST variance in Atl3 for observations (black), FLX (blue), STD (red). (*Left*): Ratio of dynamically and stochastically driven SST variance. Note two predictability barriers in boreal spring and August. (*Middle*): Dynamical SST variance. (*Right*): Stochastic SST variance.

Summary

- **SST bias alleviation systematically improves both the initial conditions and the forecasts** (Figs 4,5).
- Incorporating persistence skill allows for useful forecasts 2-3 months ahead.
- The presence of **two predictability barriers** (Fig. 6) and the seasonal nature of the Atlantic Niño suggest that potential predictability does probably not persist for more than a few months.

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[1] Xie & Carton, 2004: Tropical Atlantic Variability: Patterns, Mechanisms, and Impacts. *Earth's Climate, AGU*. **[2] Sutton et al., 2000**: The Elements of Climate Variability in the Tropical Atlantic Region. *JClim*. **[3] Burls et al., 2011**: Similarities between the tropical Atlantic seasonal Cycle and ENSO: An Energetics Perspective. *JGR: Oceans*. **[4] Ding et al., 2013a**: Hindcast of the 1976/77 and 1998/99 Climate Shifts in the Pacific. *JClim*. **[5] Bell et al., 2004**: Assimilation of Data into an Ocean Model with systematic Errors near the Equator. *QJRMS*.

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PREFACE