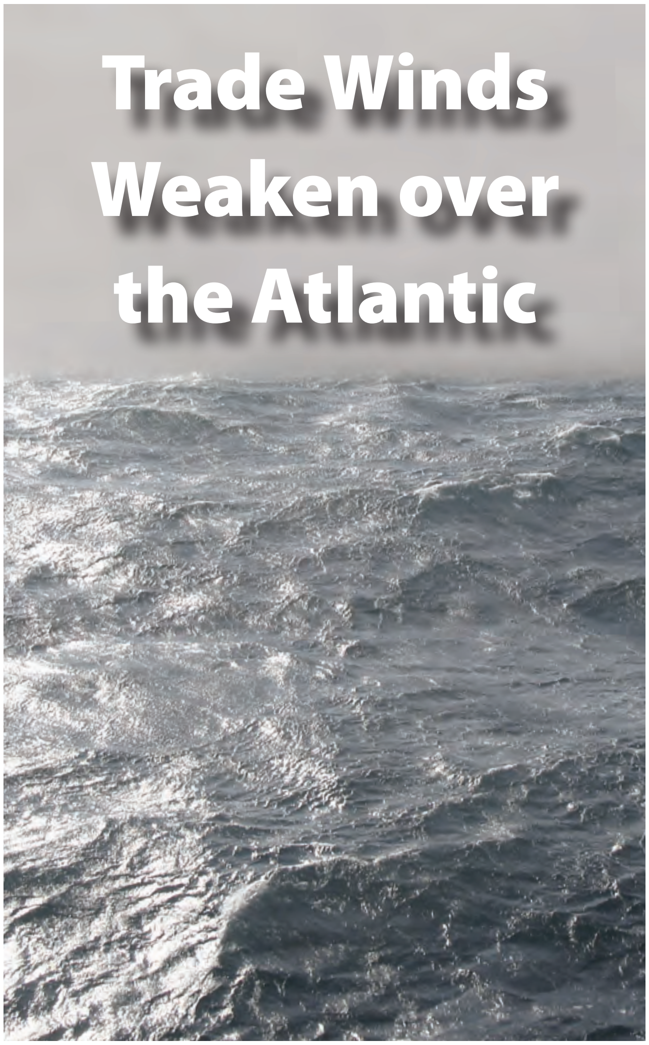
Trade Winds Weaken over the Atlantic



Tracking climate trends is essential, if we wish to understand and project future climate changes. This task is hampered by deficiencies in data sources, one of the most serious having been a lack of accurate historical observations of winds over the World's oceans. Before satellites, meteorologists relied on extensive surface-wind-related observations taken on ships-of-opportunity. These raw observations, though, have biases that may mask real long-term trends. For example, the reported ship-based wind measurements include direct anemometer observations. As reporting ships have on average become taller over the years, anemometers are being placed higher, biasing direct wind observations towards higher wind speeds. **Hiroki Tokinaga** and **Shang-Ping Xie** at the IPRC have developed a method to minimize the biases and have constructed a long-term (1950–2009) product of monthly mean near-surface winds over the global ocean called "Wave- and Anemometer-based Sea surface Wind" (WASWind; see *IPRC Climate*, Vol. 10, no. 2).

Tokinaga and Xie have now used WASWind to track the winds in the tropical Atlantic from 1950 to 2009. According to raw wind measurements from major shipping lanes in the tropical Atlantic, the southeasterly trade winds have intensified during the last six decades. The corrected WASWind, however, suggests a weakening of the trade winds over the eastern tropical Atlantic, as illustrated by the westerly trends in Figure 1a. The long-term relaxation of the trade winds explains other findings: Not only has sea surface temperature (SST) over the whole basin risen, but the cold tongue of water stretching westward from the African Coast has warmed more than the adjacent regions (Figure 1b). The flattened east-west gradient of SST leads to a climate reminiscent of the Atlantic Niño that replaces from time to time the usual cold tongue of the eastern tropical Atlantic.

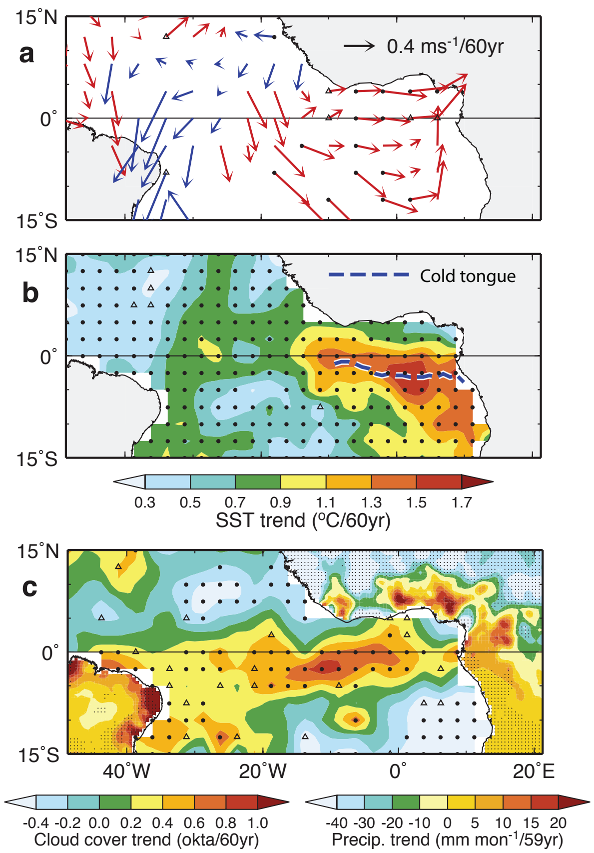


Figure 1. The tropical Atlantic patterns of the 60-year trend: (a) May–July surface wind. Westerly (easterly) trends are shown by red (blue) arrows; (b) June–August SST, the blue dashed line denotes the axis of the climatological equatorial cold tongue; (c) June–August marine cloud cover and land precipitation. Grid points marked with filled circles (triangles) exceed the 95% (90%) confidence level based on the Mann–Kendall test.

The 60-year decline of the cold tongue is accompanied by a significant warming of subsurface ocean temperature. Expendable bathymograph observations with bias corrections show that in the eastern equatorial Atlantic, the warming extends down to 250-m depth, indicating a deepening of the thermocline. This deepened thermocline suppresses equatorial upwelling, affecting marine ecosystems through reduction in ocean nutrient.

The equatorial warming and the slackening trade winds have altered the tropical Atlantic climate in other ways. The intertropical convergence zone with a large amount of rainfall has shifted equatorward, according to cloudiness data from historical ship observations. Associated with this cloud- and rain-band shift, land rainfall has also increased in the adjacent areas—the equatorial coastal regions of the Amazon and the Guinea Coast—according to rain gauge-based observations (Figure 1c). For example, the August rainfall at Ibadan, one of the largest cities in Nigeria, has increased by 79 mm/month from 1950 to 1998, representing a remarkable 93% increase in the long-term August average for 1900–1949. This enhanced coastal rainfall has been accompanied by a trend to even drier conditions in the Sahel. Tokinaga and Xie's results also suggest that the year-to-year variations of the cold tongue and the Guinea Coast rainfall are less during recent decades, implying fewer extreme events.

An experiment with an ocean general circulation model forced with WASWind reproduces many of the changes seen in the observations over the last six decades and confirms the impact of the weakened trade winds. But what has caused these changes in tropical Atlantic climate?

"We could not find any observational evidence that the changes are linked to a weakened Atlantic Meridional Over-

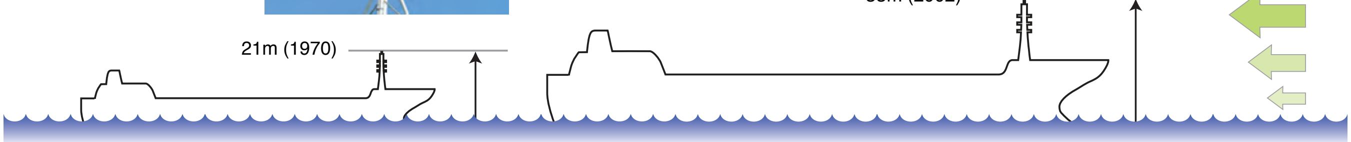
Antique Dutch map of Guinea Coast. Credit antiquemaps-fair.com.

turning Circulation or multidecadal climate variations in the North Atlantic. Rather, we speculate the change is due to a greater concentration of man-produced aerosols in the Northern than in the Southern Hemisphere, reducing solar radiation asymmetrically and weakening the north-south SST gradient. This weakened interhemispheric SST gradient relaxes the cross-equatorial trade winds," explains Tokinaga.

There is evidence for this scenario: The CMIP3 20th century experiments that include sulfate aerosols simulate regional patterns of climate change similar to the observations. If aerosol emissions decrease over the next decades but greenhouse-gas concentrations increase, the tropical Atlantic climate may shift yet again. If such climate shift recovers the year-to-year variability of the Atlantic cold tongue, the resulting increase in climate extremes would add burdens to an ecosystem and to a society already stressed by global warming.

This story is based on
Tokinaga, H., and S.-P. Xie, 2011: Weakening of the equatorial Atlantic cold tongue over the past six decades. *Nature Geoscience*, **4** (4), 222-226, doi:10.1038/ngeo1078.

Anemometer



Change in average ship height and anemometer placement from 1970 to 2002 and increasing wind strength over the ocean with height (green arrows). Image courtesy Hiroki Tokinaga.