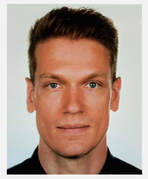
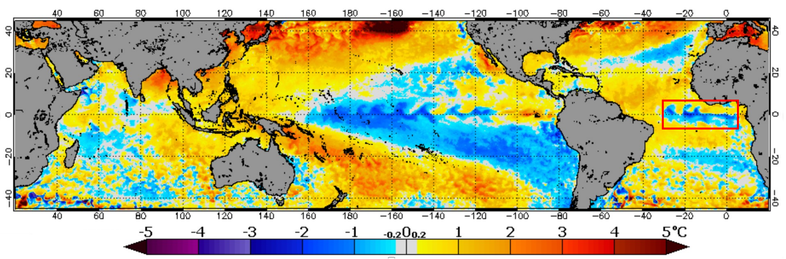
Investigating long-term variability and trends of Atlantic Tropical Instability Waves

Franz Philip Tuchen[1] (franz.philip.tuchen@noaa.gov), Renellys C. Perez[1], Gregory R. Foltz[1], Peter Brandt[2], Rick Lumpkin[1]
[1] NOAA / Atlantic Oceanographic and Meteorological Laboratory, Miami, USA
[2] GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany



What are Tropical Instability Waves (TIWs)?

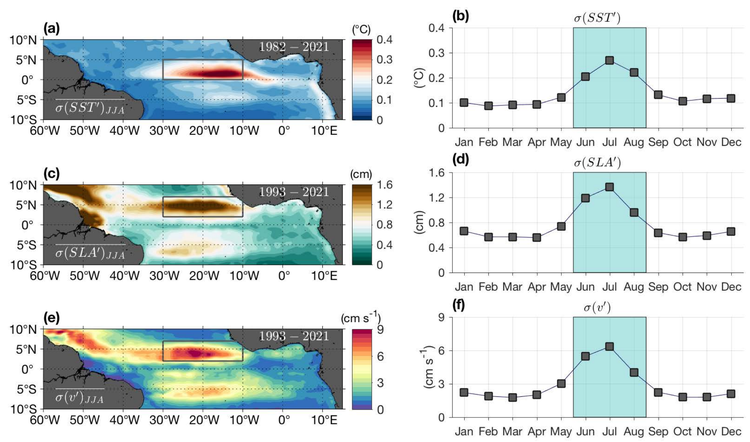


Satellite sea surface temperature (SST) anomaly on August 2, 2022

- Tropical Instability Waves (**TIWs**) can be seen as waves or cusp-like anomalies of, e.g., sea surface temperature in satellite observations
- Many physical and biogeochemical variables show variability at intraseasonal time scales due to TIWs: temperature, salinity, sea surface height, currents, oxygen, chlorophyll, nutrients, ...
- **Atlantic TIWs**: westward propagation with 20-60 cm/s, periodicity of 20-50 days, and zonal wavelengths of 600-1200 km
- The strength and seasonality of TIWs is determined by **barotropic** and **baroclinic instability** processes

How are TIWs affecting the tropical Atlantic?

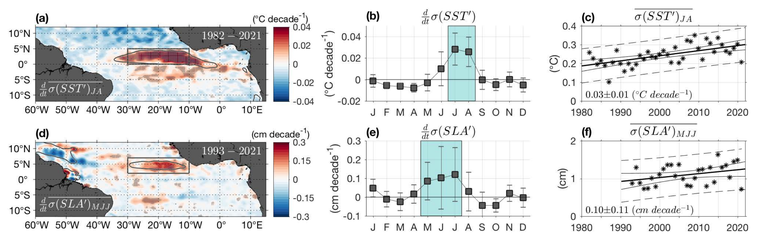
- TIW-induced variability peaks from June to August when the equatorial cold tongue is most pronounced and the zonal currents are strongest
- Westward-propagating TIWs cause **advection** and **mixing** of upper-ocean waters (but their overall net effect on, for instance, heat and freshwater budgets is still under debate)



TIW-induced variability patterns and seasonality for three variables

Multidecadal intensification of Atlantic TIWs

- Satellite observations, and in-situ mooring data show a **multidecadal intensification** of Atlantic TIWs in SST and sea level anomaly (SLA)
- The observed TIW intensification pattern agrees well with the spatio-temporal mean variability pattern (i.e., a temporal or spatial shift of TIW activity can be excluded)

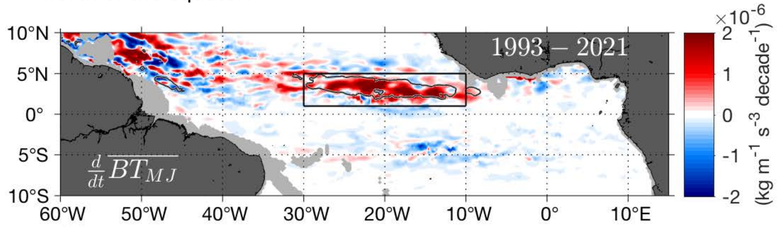


Decadal trends of TIW-induced SST and SLA variability

- TIW activity is subject to pronounced year-to-year variability and likely connected to **interannual tropical Atlantic climate modes** such as a strong Atlantic Niño event in 2021 (causing extremely low TIW activity)

Why have Atlantic TIWs become stronger?

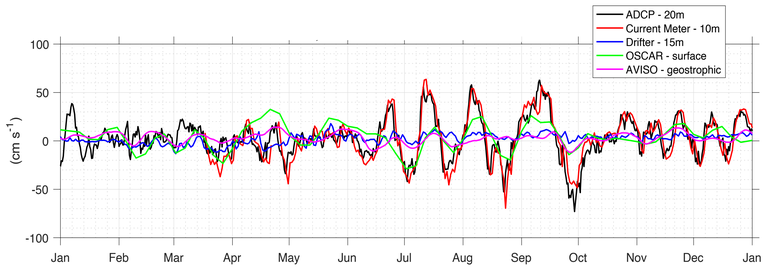
- TIWs form when kinetic and/or potential energy is converted into **eddy kinetic energy** (i.e., barotropic and baroclinic energy conversion)
- **Barotropic energy conversion** near the surface (derived from a drifter-wind-altimetry synthesis product) shows a long-term intensification north of the equator:



Decadal trend of near-surface barotropic energy conversion (BT) during May and June

- When breaking down the barotropic energy conversion term, it shows that not the mean zonal currents intensified, but the high-frequency velocity fluctuations ($\overline{u'v'}$)
- Estimates of **baroclinic energy conversion** are only possible at a few mooring sites (where, however, no significant intensification is observed)

Observational limitations and recommendations



Timeseries of meridional velocity at 0°, 23°W from different products during 2020

- Velocities inferred from altimetry, geostrophic and Ekman balance (OSCAR, AVISO, drifter synthesis) **fail to reproduce in-situ observations** from moorings
- Equatorial moorings are an invaluable source of (subsurface) current velocity data and must be maintained, expanded and/or supported by targeted observational campaigns
- Satellite missions that focus on near-surface ocean currents could be validated against equatorial moored velocities

Where can you find more information?

Tuchen, F. P., Perez, R. C., Foltz, G. R., Brandt, P., & Lumpkin, R. (2022): Multidecadal Intensification of Atlantic Tropical Instability Waves, *Geophysical Research Letters,* 49, e2022GL101073, https://doi.org/10.1029/2022GL101073

The **PIRATA** moored surface buoy array provides upper-ocean data at approx. 20 sites in the tropical Atlantic. At 0°, 23°W current velocity data is combined with velocity data from an additional subsurface mooring:

Servicing the PIRATA surface buoy at 0°, 23°W in 2022