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Climate and Ocean
Variability, Predictability and Change

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Introducing TBIMIP: The Tropical Basin Interaction Model Intercomparison Project

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Summary

- TBIMIP: coordinated experiments for the study of interbasin interaction
- led by CLIVAR Research Focus on Tropical Basin Interaction
- data to be made available through the ESGF under CMIP6Plus
- several model centers participating
- additional participants welcome
- alternative experiments and different approaches important for comprehensive understanding of Tropical Basin Interaction (TBI)
- TBIMIP description paper published in Geoscientific Model Development (Richter et al. 2025; https://doi.org/10.5194/gmd-18-2587-2025)

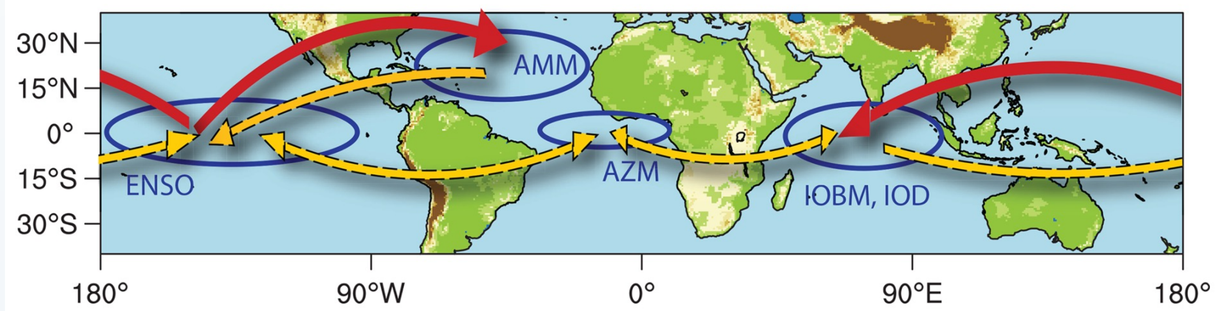

Fig. 1: Schematic of tropical basin interaction
Several pathways of TBI are displayed. The solid red arrows show well-established influences, while the dashed yellow arrows show influences that are under debate or inconsistent. The variability patterns shown are ENSO (El Niño–Southern Oscillation), AMM (Atlantic Meridional Mode), AZM (Atlantic Zonal Mode), IOD (Indian Ocean Dipole), and IOBM (Indian Ocean Basin Mode).

Motivation for TBIMIP

- tropical basin interaction (TBI) influences global climate variability on seasaonal-to-decadal time scales and may also shape global warming patterns
- progress in understanding TBI has been made but puzzles remain:

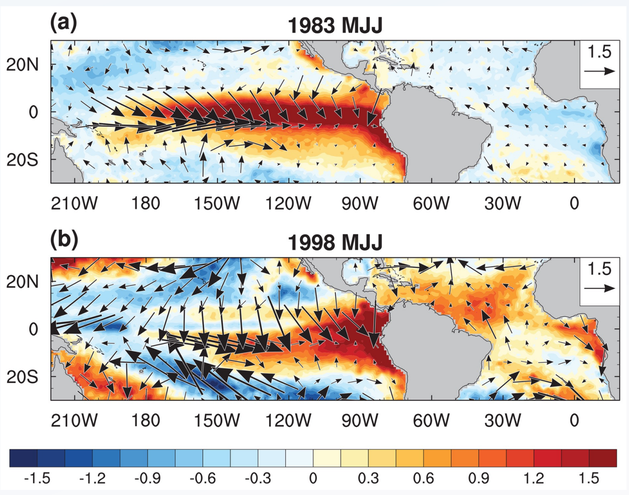

Fig. 2: Two El Niños with opposite outcomes in the equatorial Atlantic
SST (shading) and surface winds (vectors) from the ERA5 reanalysis for May-June-July (MJJ) in (a) 1983 and (b) 1998. Both years are El Niño decaying years but the SST response in the equatorial Atlantic showed opposite signs: cooling in 1983 and warming in 1998. The reasons for this are still not fully understood.

- observational analysis is essential for understanding TBI but
  - observational record is short
  - quantifying TBI influences is difficult
  - disentangling cause and effect is challenging

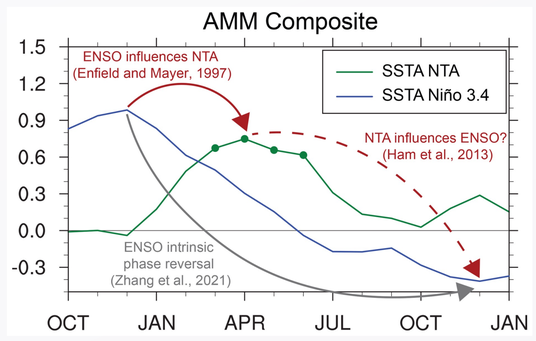

Fig. 3: Disentangling cause and effect
Composite of a positive Atlantic meridional mode (AMM) event based on ERA5. The lines show SST anomalies in the northern tropical Atlantic (NTA; green line) and the Niño 3.4 region (blue line). The fact that El Niño events tend to precede AMM+ events is well established but is the subsequent El Niño phase reversal due to intrinsic ENSO variability or partially influenced by the AMM+?

- GCM pacemaker experiments are an important additional tool
- many experiments have been performed but conflicting results exist
- potential reasons for discrepancies:
  - inconsistent experiment design
  - model biases
- TBIMIP addresses these issues by
  - requiring a consistent experimental protocol
  - using a multi-model approach

TBIMIP design

- pacemaker experiments (SST restoring to observations) in each basin

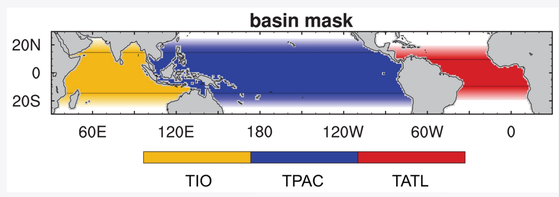

Fig. 4: Basin mask
Mask used for specifying SSTs in the three tropical ocean basins. The core restoring regions are 15S-15N in the Pacific and Indian oceans, and 10S-10N in the Atlantic. The restoring is linearly tapered off over 10° bands north and south of the core regions.

- use relatively weak restoring (15d/50m) to avoid unrealistic air-sea fluxes
- Tier 1 experiments: anomaly SST restoring
- Tier 2 experiments: full-field SST restoring
- Tier 3: reserved for additional experiments
- two branches: (1) historical experiments; (2) seasonal reforecasts

Results from TBIMIP

- analysis of the TBIMIP output is ongoing
- a group paper is in preparation
- some of the results are unexpected…

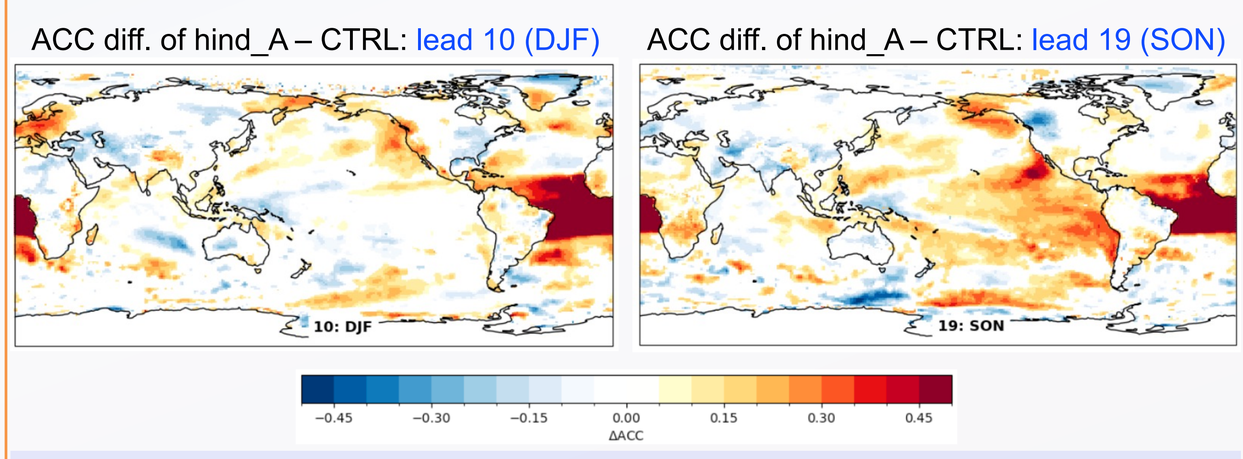

Fig. 5: Lack of ENSO skill improvement in reforecasts with Atlantic SST restoring
Difference of anomaly correlation coefficient (ACC) between a reforecast with SST restoring in the tropical Atlantic and the control reforecast without any intervention. The simulations were performed by Stephen Yeager (NCAR) using CESM2. The forecasts were initialized on February 1 of each year between 1982 and 2021. The effect of the Atlantic SST restoring is apparent in the large positive ACC difference in the Atlantic basin. In the tropical Pacific, however, there is almost no change in skill during the first forecast year (left panel). Interestingly, tropical Pacific ACC does show improvement during the second forecast year (right panel).

Data sharing

- currently six model centers have completed their simulations
- two contributions are in preparation
- additional contributions are highly welcome

Model	Center	Type of expmnt	status
CESM2	NCAR	hindcast+standard	completed
CESM2	SCSIO, China	Tier 2 experiments	completed
NorCPM	U. of Bergen	reforecast+standard	completed
SINTEX-F2	JAMSTEC	pacemaker reforecast	completed
MIROC6	JAMSTEC	reforecast+standard	completed
IPSL-CM6A-LR	IPSL, France	standard pacemaker	completed
ACCESS-CM2	CSIRO, Australia	Tier3 expmnts	completed
ACCESS-ESM1-5	CSIRO, Australia	standard pacemaker	in preparation
FOCI-OpenIFS	ICCP, South Korea	standard pacemaker	in preparation

Table 1: Models participating in the project

- currently the data is only shared among group members
- data will be made available to the community through the Earth System Grid Federation (ESGF) as part of CMIP6Plus

Additional experiments

- some additional experiments have been performed by individual groups:
  - SST restoring to climatolgoy (ACCESS-CM2)
  - strong SST restoring (1d/50m) (NorCPM, SINTEX-F2)
  - different initialization months in reforecast experiments (SINTEX-F2)
  - extended reforecast integration (lead 13-24) (CESM2, MIROC6)
- additional experiments could be tried, e.g., North Atlantic restoring

Alternative approaches

- important to pursue multiple lines of evidence
- examples: interbasin LIM, extended recharge oscillator, analog models