Pacific influences on the meridional temperature transport of the Indian Ocean

Jie Ma, Ming Feng, Sloyan Bernadette, Jian Lan
Data and method

Ocean Forecasting Australia Model version 3 (EI_SPINUP_OFAM3)

OFAM3 is based on Modular Ocean Model. OFAM3 we used here is forced by 3-hourly surface heat, freshwater, and momentum fluxes from ERA-Interim.

- **Horizontal resolution:** 0.1° (75°S-75°N)
- **Vertical:** 51 vertical levels (from 0 to 5000 m)
  - 5 m vertical resolution in upper 40 m
  - 10 m vertical resolution to 200 m
- **Time range:** Jan 1979-Dec 2014
Temperature transport decomposition:

\[ \text{MHT}(t) = \int_{-H}^{0} [v][\theta] dz \, dx + \int_{-H}^{0} v^* \theta^* dz \, dx \]

Dynamical decomposition

From Lee and Marotzke (1998) and Hirschi and Marotzke (2007)

\[ \psi(z') = \int_{-H}^{z'} dz \int_{x_w}^{x_e} dx \, \bar{v} + \int_{-H}^{z'} dz \int_{x_w}^{x_e} dx \, v_{sh} + \int_{-H}^{z'} dz \int_{x_w}^{x_e} dx \, (v_{ek} - \bar{v}_{ek}) \]

\[ v_{sh} = \bar{v}(x,z') - \bar{v} = -\frac{g}{\rho^* f} \int_{-H}^{z'} \frac{1}{L(z)} (\rho_e - \rho_w) \, dz - \frac{1}{H(x)} \int_{-H(x)}^{0} \bar{v}(x,z) \, dx \]
Objective:

1. examine the interannual-decadal variations of the IO meridional temperature transport and their mechanisms

2. explore the link between the IO meridional temperature transport and meridional overturning streamfunction
• Significant fluctuations of temperature transport anomalies in the south of 10°S

• Some of the fluctuations are closely related to ENSO variability
- The wind anomaly pattern is similar to the ENSO teleconnection in the Indian Ocean.
- The wind stress curl regression shows an anomalous anticyclonic ridge along approximately 12°S.
Good correlation between zonal temperature difference and PC1 of low frequency meridional temperature transport in the 12° - 27°S latitude band.
The meridional temperature transport variability is significantly associated with the leading mode of Indian Ocean meridional overturning streamfunction.
Dynamical decomposition of meridional transport streamfunction

- Different processes act together to form this coherent pattern

Regression maps at lag 0 on the normalized PC1 of meridional temperature transport
A dynamical decomposition of the meridional streamfunction supports the different mechanisms of transport variability with latitude.
A schematic diagram of Indian Ocean temperature transport responds during the La Niña period.
The meridional temperature transport is found to be highly influenced by remote ENSO forcing.
The variability is dominated by the different mechanisms at various latitudinal bands:
- tropical NIO: surface Ekman transport
- tropical SIO: the geostrophic transport associated with the steric height anomalies off Java and Sumatra
- southern IO: remote ENSO forcing from Pacific through both oceanic and atmospheric waveguides

The meridional temperature transport variability is significantly associated with the leading mode of Indian Ocean meridional overturning streamfunction.
Comparison of different models

(a) OFAM3-EI-spinup-0.10° 1979-2014
(b) OFAM3-JRA55-spinup-0.10°
(c) JRA55-spinupA-0.25°
(d) JRA55-redi3-0.25°

Vertical layers

year 181-200
year 131-150
The overturning strengths and depths in OFAM3 under the ECMWF forcing have a good agreement with the JRA55 forcing. The latter two models using the repeat forcing also show the similar patterns.

- Both models with repeat year forcing (latter two models) show much smaller deep MOC than the OFAM3 models.
Thank you