Ongoing Observation and Circulation Dynamics in the Tropical Eastern Indian Ocean

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The special location of the Indian Ocean and its impact on climate

The Indian Ocean goes hand in hand with the monsoon and has important social implications on a global scale

- The Indian monsoon affects 1/3 of the tropics (1/6 of the world's surface area)
- The Indian monsoon region is home to 65% of the world's population
The rapid warming of the Indian Ocean has a profound impact on water vapor transport and ecological balance in South and East Asia.

Rapid warming

Long-term SST variation series from 0m to 700m in the Indian Ocean
Solid cooperation
Observation progress
Next plan
To promote the establishment of the China-Sri Lanka Joint Center for Education & Research, Chinese Academy of Sciences.
In 2012, Vice President of CAS Ding Zhongli visited Sri Lanka to sign the first memorandum of cooperation.

Based on the solid foundation of cooperation, University of Ruhuna and CAS actively promoted the signing of the No. 1 cooperation agreement between the SCSIO and University of Ruhuna, and urged the construction of the ‘Marine Environmental Research Center’ in 2012.

In 2013, Vice President of CAS Zhang Yaping visited Sri Lanka to establish ‘Marine Environment Research Center’.
Air-sea observation network construction

Focus on the international frontier, monsoon influence, and ‘Maritime Silk Road’ environmental safety; the TIO-CEC voyage & shore-based observation is the largest scale in the world, with about 30TB of observation data obtained.
2021.03: One monsoon observation station was added, and the data was sent back to China in real-time and displayed on the open website. http://www.csl-cer.com/research/Ocean

2021.02: Successfully salvaging 1 wave tide meter and retrieving tide data of 200 days.
The x-Press PEARL, a cargo ship full of chemicals, caught fire in the east sea of Sri Lanka. CSL-CER provides the scientific basis for predicting the diffusion of chemicals after leakage.
A contract has been signed for glider observation technical services.

An underwater glider scientific expedition will be carried out in the South China Sea to prepare for technical verification and other preparations for the Indian Ocean scientific expedition. Tiantong communication plan will be used in the experiment.
China-Sri Lanka Joint Coastal Cruise

SCSIO observations in the Indian Ocean, 2010–2019

- Shipboard CTD/ADCP/AWS
- CTD
- GPS sounding
- Mooring array
- Air-sea flux tower
- Automatic meteorological observation system
- Real-time hydrological/meteorological buoy

80°E 85°E 90°E 95°E 100°E 105°E

12°N 6°N 0° 6°S 12°S
- Solid cooperation
- Observation progress
- Next plan
Dynamics of tropical circulations

① Tropical Indian Ocean circulation

② ITF variability
The expedition is scheduled to take place from September 16 to December 1, 2020, with a total voyage of 77 days. The operating range is about 8000km (the total voyage is about 12000km);

4 sections were designed with a total of 28 CTD stations.

Automatic weather station (AWS), Marine current profile observation (ADCP), surface sea temperature and salinity observation (CT);

5 mooring stations, 1 buoy station and 1 capture station.

Participants: SCSIO (CAS), IDSSE (CAS), Sun Yat-sen University, Tianjin University, Tianjin University of Science and Technology, Shandong University, Ocean University of China, East China Normal University…
(a) High-resolution GPS balloon soundings released during the TIOCEC missions and (b) vertical air temperature and relative humidity profiles obtained by two kinds of GPS radiosonde devices (GPS-TK: red and magenta lines; CF-06-A: blue and green lines) at 86.0° E along the equator during the daytime on 5 Apr 2012.
Real-time air-sea buoy observations in the Near equatorial Indian Ocean

Position: 79°E, 2.5°N
Water depth: 3980m
Vessel of operation: Shiyan 3
Receive data: every 30min
key technologies: low power data acquisition system, iridium timing data transmission technology and rich remote human-machine data/control interface software.

As one of the important observation nodes of the online observation network of the profound ocean environment in SCSIO, the buoy fills in the gap in the observation of air-sea interaction in the Deep-ocean region of the Indian Ocean and provides high-quality field observation data for relevant scientific research.
Detailed information of the observations in the eastern tropical Indian Ocean accomplished by the TIOON during 2010 and 2019.

The deployment of a TIOON mooring in the eastern Indian Ocean.

Zeng, ... , Wang*,... et al. (2021, BAMS)
TIO-CEC CTD observations. (a) Temperature T and salinity (S) data from the equatorial transect of TIO-CEC 2010 (shown in the subgraph with black solid triangle) and (b) T–S diagrams in 4 boxes (shown in the subgraph with solid boxes) of the eastern tropical Indian Ocean.

Zeng, ..., Wang*,..., et al. (2021, BAMS)
Advances in marine environmental changes in the Tropical Indian Ocean

Mechanism and dynamic relationship of circulation changes in equatorial Eastern Indian Ocean

The equatorial zonal current and the eastern upwelling maintain the thermohaline and water balance in the eastern and western basins

Chen et al., 2020a, *JPO*
The tropical southern Indian Ocean is strongly responsive to both local and remote forcing effects. Chen et al., 2020b, *JPO*; Huang et al., 2020, *JPO*

(a) Daily zonal velocity obtained from the TIOON mooring Q5 at 0°, 80°E from 2015 to 2017 and (b) as is in (a), but for the RAMA mooring at 0°, 80.5°E.

Chen et al., 2020b, *JPO*; Huang et al., 2020, *JPO*
The net ITF transport changes are dominated by remote buoyancy forcing changes over the North Atlantic through inter-basin wave propagation.

During the transient stage of global warming, the Island rule should combine the effects of both wind stress and thermohaline circulation changes.

The remote forcing for ITF weakening under the global warming is revealed.

Peng&Wang* et al., 2022, JC
Southern tropical Indian Ocean dipole mode (STIOD)

- **Bjerknes feedback** is crucial to STIOD;
- Intensity of STIOD experienced interdecadal changes due to the variations of Bjerknes feedback strength:
  - Higher climatological SST $\Rightarrow$ SST & uwnd $P_3 > P_2 > P_1$
  - ITF & zonal wind $\Rightarrow$ thermocline & SST $P_2 >> P_3 > P_1$
- STIOD may be stronger in the future climate.
Solid cooperation

Observation progress

Next plan
Next plan: boundary layer observation tower and AWS construction

1. A boundary layer observation tower is planned to be built in the south of Sri Lanka:
   Parameters: wind, pressure, temperature, humidity, up & down shortwave and longwave radiation, sensible heat, latent heat, momentum, CO2 flux…
   Height: 10m
   Sensors: NR01, Young-05106, IRGASON, etc.
   Sampling frequency: 1s scanning, 1min, 10min, 30min

An AWS will be added in the south of Sri Lanka
Parameters: wind, pressure, temperature, humidity, up & down shortwave radiation, visibility, precipitation
Height: 2m
Sensor: WS550, etc.
Sampling frequency: 5s scan, 1min statistics, real-time transmission

The next step is to build a new boundary layer observation tower and an AWS at the main observation field in southern Sri Lanka
Next plan: long-range underwater glider commissioning and mission planning

It plans to purchase a 1000m class ‘Haiyan-L’ long-range underwater glider, which is the only underwater glider product in China that has been finalized by the military and applied in marine security assurance.
Thanks!