Press Releases

February 22, 2010
Japan Agency for Marine-earth Science and Technology
Graduate School of Science, the University of Tokyo

Sea Surface Temperature in Indian Ocean Acts as Predictor for Following Year's El Niño - Influence of Indian Ocean Dipole on El Niño First Revealed -

Overview

El Niño and La Niña events in the tropical Pacific Ocean induce anomalous weather patterns around the world, with significant socio-economic impacts. The occurrence of El Niño/La Niña now may have become more predictable, thanks to the study conducted by a team of scientists from the Japan Agency for Marine-Earth Science and Technology(JAMSTEC), Graduate School of Science of the University of Tokyo, and the French Research Institute for Exploration of the Sea(IFREMER).The team confirmed that the El Niño/La Niña occurrence is strongly influenced by the negative/positive phase of the Indian Ocean Dipole(*1), the Indian Ocean equivalent of ENSO, and its occurrence is predictable with great precision beyond a year ahead, by use of sea surface temperature (SST) data in the Indian Ocean.

Combined with an IOD forecast model, the finding will serve to increase the predictability of climate fluctuations responsible for abnormal weather patterns, as early as around 20 months prior to their occurrences. This will allow people to better prepare against extreme weather conditions and help reduce impacts of possible disasters.

Their work will be published in the online issue of science journal Nature Geoscience on February 22.

Title:	Influence of the state of the Indian Ocean Dipole on following year's El Niño
Authors:	Takeshi Izumo, Jerome Vialard, Matthieu Lengaigne, Clement de Boyer Montegut, Swadhin K. Behera, Jing-Jia Luo, Sophie Cravatte, Sebastien Masson and Toshio Yamagata

Background

A group of scientists led by Toshio Yamagata, Application Laboratory of JAMSTEC and Professor at Graduate School of Science, the University of

Tokyo, discovered a climate phenomenon responsible for global weather anomalies in 1999 and named it the Indian Ocean Dipole. Their following studies using the Scale Interaction Experiment-FRCGC (SINTEX-F) coupled general circulation model (CGCM) developed by JAMSTEC, and the high-performance supercomputer "Earth Simulator," successfully predicted IOD events five to six months in advance for the first time in the world, serving to push the boundaries of world's climate change studies. Yet, the relationship between the IOD state and El Niño/La Niña conditions in the Pacific Ocean was still waiting for answers.

Summary of method and discussion on results

El Niño is a climate phenomenon characterized by a pool of warm water along the central to eastern tropical Pacific Ocean, which causes warm anomalies of sea surface temperature (SST). La Niña, in contrast, causes the opposite effects, creating cool SST anomalies in these regions and pushing the warm water toward the west Pacific Ocean or the equatorial north and south Pacific.

Knowing this mechanism, it is possible to use the equatorial warm water volume (WWV) to forecast the occurrence of El Niño/La Niña events, almost eight months ahead in time. Nevertheless, WWV alone is not sufficient to predict El Niño/La Niña events beyond the winter-spring "predictability barrier" (*2).

In this study, the team carried out a 500-year long SINTEX-F CGCM simulation. The results are analyzed, along with atmospheric and oceanographic observational data in the equatorial Pacific and the India Ocean. The results indicated that the negative/positive IOD phase precedes the following year's El Niño/La Niña state with a significant correlation with its occurrence (Fig. 1). A modeling using the observational data and IOD indices (*3) also revealed that the observations alone could predict El Niño/La Niña conditions more than a year ahead without being disturbed by the winter-spring predictability barrier(Fig. 2).

A high hindcast correlation skill of the modeling, as much as 80 percent between SST anomalies and the predicted El Niño state beyond one-year lead time (more than a year ago), exceeds any of its predecessors obtained by statistical and dynamic predictions (around 60 percent correlation) in the world. The combination of this new prediction equation with the SINTEX-F CGCM could enable reliable forecasting of El Niño conditions more than twenty months of lead time.

Future perspectives

The study highlighted the importance of a better understanding of atmospheric and oceanic variables in the Indian Ocean for improving El Niño predictions.

In fact, the frequent occurrence of positive IOD in recent years brought about extreme weathers, such as the flooding in Kenya and draughts in Australia. These events are attributed to warmer SSTs induced by global warming, which are modulating the frequency, occurrence and intensity of IOD and El Niño conditions.

As evidenced above, the predictability of climate fluctuations plays a significant role in better coping with global warming. The World Climate Conference-3(WCC3) held in last year also underlined the importance of climate prediction data and a framework to deliver them.

JAMSTEC and the University Tokyo will work in close cooperation with overseas research institutions to improve observing systems in the Indo-Pacific region - the key areas in the climate prediction, develop simulation models capable of better predictions, and deliver reliable climate forecasts, thereby contributing to the world.

***1 Indian Ocean dipole (IOD)**

IOD is a coupled ocean-atmosphere phenomenon in the Indian Ocean. A positive phase of IOD causes an anomalous cooling of SST in the eastern Indian Ocean (off Java Island), bringing draughts in the Indonesian and Australian region. On the other hand, the western Indian Ocean (off the east coast of Africa) will experience an anomalous warming of SST, which activates atmospheric convections and brings increased rainfall. A negative phase of IOD, in contrast, involves anomalously high SSTs in the eastern Indian Ocean and low SSTs in the west, bringing more rain to the Indonesia and Australia region and less to the east African countries.

***2. Winter-spring predictability barrier**

El Niño event prediction for the next spring onward is considered to be difficult as a new oceanic mixed layer is reformed in the springtime.

***3: Dipole Mode Index (DMI)**

DMI is a measure of anomalous SST gradient across the tropical Indian Ocean. It is obtained by deducting the average SST in the western equatorial Indian Ocean (50°E-70°E and 10°S-10°N) from that in the south eastern equatorial Indian Ocean (90°E-110°E and 10°S-0°N). When the DMI value is positive, the phenomenon is referred as positive IOD. When negative, the phenomenon is called negative IOD. DMI is internationally recognized and is based on the Dr. Yamagata and his collaborators' article published in the science journal Nature in 1999.

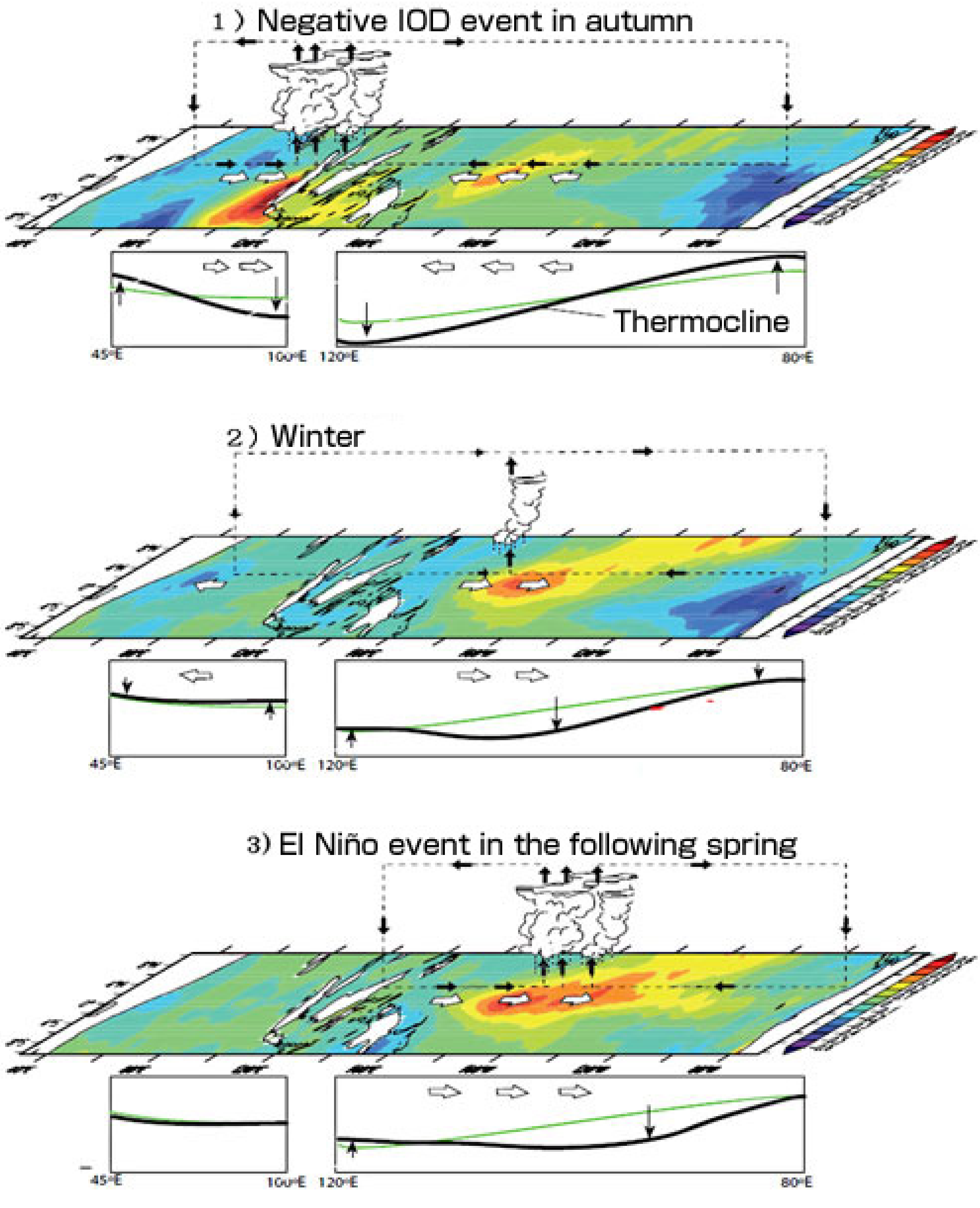

Figure 1. Diagram showing IOD as a precursor of the following year's El Niño state.
1) Increased easterly winds favor the build-up of warm water in the western Pacific, pushing down the thermocline. 2) When easterly winds weaken, the warm water pool shifts to the east. 3) Increased westerly winds trigger El Niño conditions.

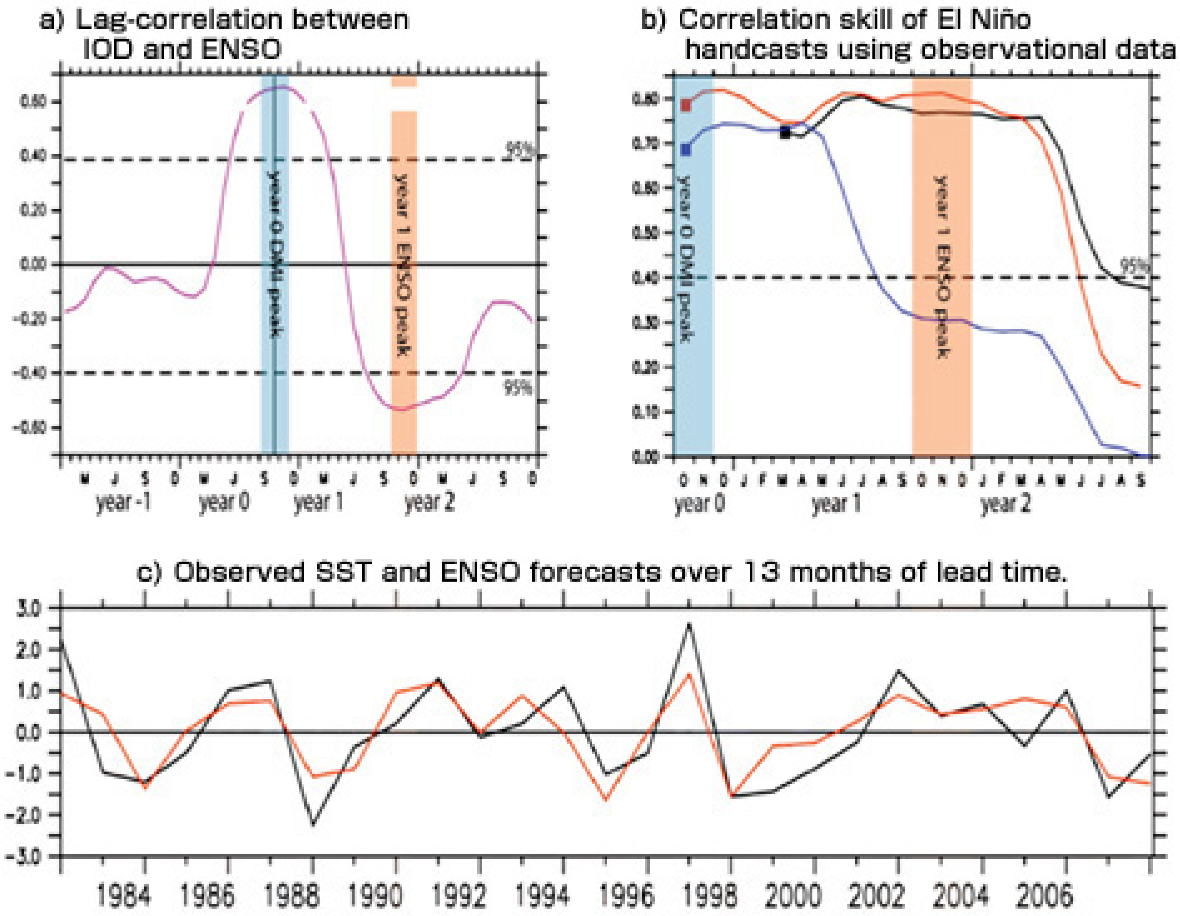

Figure 2.

a) Lag-correlation between IOD index and ENSO(*) indices.

The lag-correlation describes the strength of the relationship between two elements in a time series. In this study, the lag-correlation coefficient was calculated by hindcasting the ENSO index from the IOD index (DMI) in previous years. The vertical axis denotes the lag-correlation coefficient and the horizontal axis denotes time (year 0: IOD index peak, year 1: following year, year -1: previous year). The ENSO peak in year 0 shows high negative correlations, suggesting a strong relationship between negative IOD events and the following year's El Niño conditions. The dashed lines indicate the 95% confidence limit.

***ENSO(El Niño-Southern Oscillation)**

ENSO is a coupled climate mode composed of an oceanic phenomenon (El Niño) and an atmospheric east-west oscillation (Southern Oscillation). The two phenomena, previously dealt with separately, were combined in the 1980s as El Niño-Southern Oscillation. In tropical oceans, high SSTs are accompanied by low surface pressures and low SSTs by high surface pressures.

b) Correlation skill of El Niño hindcasts using observational data

(Blue): using WWV in September-November of year 0. Due to the influence of the winter-spring predictability barrier, the prediction skill drops sharply in May and June.

(Black): using WWV and western Pacific zonal wind in February-April of year 1. No influence of the winter-spring predictability barrier is seen but forecasts beyond one year of lead time are not possible.

(Red): using WWV+IOD index in September-November of year 0. No influence of winter-spring predictability barrier. The correlation scores beyond one year of lead time exceed 0.75.

c) Observed (black) and predicted (red)ENSO index over 13 months of lead time

The vertical axis denotes SST anomalies in the El Niño monitoring area.

Contacts:
(About the study)
Toshio Yamagata
Laboratory Head
Application Laboratory
JAMSTEC

(About the publication)
Toru Nakamura, e-mail: press@jamstec.go.jp
Manager, Planning Department Press Office

Hiromi Yokoyama
Associate Professor, Science Communication
Graduate School of Science
The University of Tokyo