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EMERGING RESEARCH FRONTS - 2009

August 2009

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Saji N. Hameed & Toshio Yamagata talk with *ScienceWatch.com* and answer a few questions about this month's Emerging Research Front Paper in the field of Environment & Ecology.

Article: Possible impacts of Indian Ocean Dipole mode events on global climate
Authors: Saji, NH;Yamagata, T
Journal: CLIMATE RES, 25 (2): 151-169 DEC 5 2003
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SW: Why do you think your paper is highly cited?

The discovery of an ocean-atmosphere coupled mode named the "Indian Ocean Dipole mode" (IOD)—Saji NH, *et al.*, "A dipole mode in the tropical Indian Ocean," (*Nature* 401[6751]: 360-63, Sep 23 1999)—radically changed prevailing paradigms on the role of the Indian Ocean in the world climate variability. Prior to that, most climate scientists had written off the Indian Ocean just as a slave of the "king of climate variations," i.e., El Niño Southern Oscillation (ENSO) phenomenon in the adjoining tropical Pacific.

However, our 1999 work revealed that the Indian Ocean is capable of generating its own climate mode, now known as IOD. For a while, after this finding, the IOD was perceived to be a regional mode of climate variability with impacts restricted to the Indian Ocean rim countries. Our work in 2003 objectively analyzed global climate variations associated with IOD and demonstrated, for the first time, that it influences worldwide climate to a more or less similar extent as ENSO.

Climate science is a very young discipline. In the last two or three decades, major research and exploration had revolved around a few phenomena such as ENSO. There is no doubt that ENSO has had a significant impact on worldwide climate. However, it cannot consistently explain notable climatic anomalies. This is partly because no El Niño is alike and hence the impacts also differ.

El Niño is even changing within a changing climate as discussed in Ashok K, *et al.*, "El Niño Modoki and its possible teleconnection," (*Journal Of Geophysical Research-Oceans*: 112: C11007, 2007) and also in Weng HY, *et al.*, "Impacts of recent El Niño Modoki on dry/wet conditions in the Pacific rim during boreal summer," (*Climate Dynamics*: 29[2-3]: 113-29, AUG 2007).

Another reason is that other climatic phenomena may play major yet unknown roles. Our work revealed the previously unknown role of IOD. Some of the impacts had been falsely attributed to ENSO because of some apparent co-occurrences of IOD and ENSO. Therefore, we clarified, again for the first time, the differential impacts of IOD and ENSO by use of the partial correlation method. These efforts have brought a better understanding of year-to-year climate variations and enhanced the predictability of climate variations at seasonal time scales.

Another reason for the popularity of the work is due to the recent frequent IOD activity in our changing climate system. The last few years have seen three consecutive IODs—in 2006, 2007, and 2008—which is unheard of in the previous 50 years of available historical records. It is also revealed that the IOD is a major cause of the severe drought in Australia. All these aspects are bringing more and more attention to the Indian Ocean Dipole and its impacts.

Coauthor
Toshio Yamagata

SW: Would you summarize the significance of your paper in layman's terms?

The paper discusses and reveals, for the first time, the possible climate anomalies that are expected to happen during the duration of an IOD event. Note that active IOD events can potentially generate worldwide climate impacts lasting for a half-year period from June to November. The paper also explores and addresses some critical issues regarding the relation between IOD and ENSO.

During the first few years following the discovery of IOD, there was a vigorous scientific debate on the relation between IOD and ENSO, with many researchers considering that the IOD was a local climate fluctuation driven by ENSO. This issue was well-explored in our analysis and we were able to demonstrate that not only is IOD an independent phenomenon, but that it has its own unique effect on worldwide climate.

SW: How did you become involved in this research and were any particular problems encountered along the way?

The discovery of the IOD was made while I was a postdoctoral fellow working with Professor Toshio Yamagata at the University of Tokyo, at the then Frontier Research System for Global Change (currently the Research Institute for Global Change). Soon after I joined the group, in early 1998, I became involved in some new work with another postdoctoral fellow, Dr. P.N. Vinayachandran, now an Associate Professor in the Oceanography Centre for Atmospheric and Oceanic Sciences at the Indian Institute of Science in Bangalore, India.

We were puzzled by an unusually strong oceanic event that had taken place in the Indian Ocean in 1994. The year 1994 was a very strange year, with an extremely hot summer in Japan, and Professor Yamagata had already begun an investigation to identify its root cause.

Prof. Vinayachandran, a physical oceanographer by training, had noted an unusual reversal of the direction of the so-called Wyrtki-Yoshida jet in the ocean. This is a fast ocean surface current that moves from west to east along the equatorial Indian Ocean during the boreal spring and fall seasons.

He noted that, in 1994, the jet was absent in spring and that by fall it had reversed direction and was moving from east to west. On further examination we found that the breakdown and subsequent reversal of the jet were related to overlying changes in the atmosphere itself, especially in the surface winds. After we solved this puzzle, we were faced with the harder question of whether the event was a rare one, perhaps related to the rapid global warming in the 90s.

I took our new exciting results with me on a trip to my alma mater in India and discussed it with my thesis advisor, Professor B. N. Goswami, of the Oceanography Centre for Atmospheric and Oceanic Sciences at the Indian Institute of Science in Bangalore, India. At that time he had been exploring several hypotheses to link surface current and temperature variations in the Indian Ocean with the monsoons and was very interested in our work.

Thus an inter-country, inter-institutional collaboration was born, and we joined forces to attack the problem from all possible directions. After a year of rigorous examination of a variety of available historical datasets, we discovered that the phenomenon occurred at various times in the past records and was definitely not a new kind of variability related to possible changes in the climate system brought about by global warming.

We also constructed and examined various competing hypotheses to explain the existence of these climate events. After careful analysis, often accompanied by numerical experimentation, we ruled out all the hypotheses except for one—that the event was driven by inherent air/sea interactions in the Indian

Ocean itself. The concept of IOD was born then and there and I have been involved with this research ever since.

The concept of IOD as an independent phenomenon arising out of inherent air/sea interactions within the Indian Ocean was not well accepted in the beginning. As I mentioned earlier, it painted a picture of an active role of the Indian Ocean in global climate variations that was radically different from the prevailing ideas. It took a few years of scientific debates and further explorations to establish the status of the IOD as an independent forcing agent of global climate variations.

SW: Where do you see your research leading in the future?

I have been interested in extending IOD research in several new directions. One of the exciting works I am currently doing is looking at the interaction between IOD and ENSO events. I am also very interested in interdecadal modulations of the IOD. It has been noted that IOD activity is strong in some decades and weak in others. For example, the 1960s and '70s experienced a string of moderate to strong IOD events, the '80s experienced only a single strong IOD event.

As I noted, the IOD activity has reemerged in the global climate system since the mid '90s. While it is clear that there are decade to decade changes in IOD activity, we need to understand why IOD is active in some decades but not in others. Finally I am also interested in multiscale interactions during IOD, for example how the intraseasonal activities happening on the much shorter time scale of 30 to 70 days are modulated or modulate the phenomenon.

SW: Do you foresee any social or political implications for your research?

Definitely. IOD events have a significant impact on worldwide temperatures and rainfall. Through these variations it affects societies significantly, perhaps mostly in developing or underdeveloped countries. The disastrous consequences of severe floods that displaced nearly two million people in East Africa and the severe drought that caused widespread wildfires in Indonesia and Malaysia, besides triggering unprecedented haze in neighboring countries during an IOD event in 2006, could have been managed better if the event was predicted in advance and affected countries were alerted to its possible impacts.

Also, the rapid rise of global wheat prices can be related to the droughts of 2006, 2007, and 2008 in Australia, all of them coinciding with IOD events during the same years. The ongoing efforts by several countries, including Australia, India, Indonesia, Japan, and the USA to implement a sustained climate observing network over the Indian Ocean is a testimony to the fact that scientists and policymakers worldwide are beginning to realize the practical importance of understanding and predicting IOD variability.

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KEYWORDS: DIPOLE MODE INDEX; TELECONNECTION PATTERN; MULTIPLE REGRESSION ANALYSIS.

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