The Indonesian Throughflow: Project Overview

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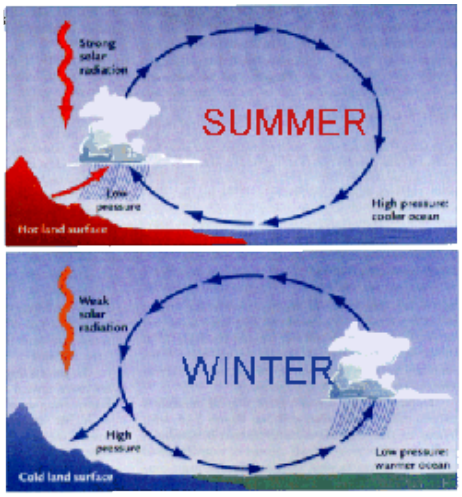

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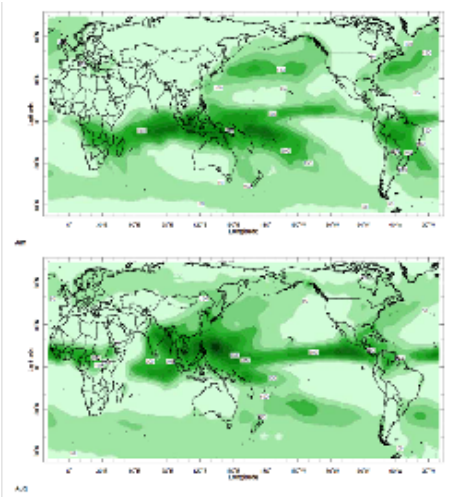
Seasonal changes in the strength of solar radiation affect the surface of the land more than the ocean. In summer, intense solar heating of the land causes the inland circulation of mist air from the ocean. In winter, weak solar radiation allows the land to cool off and creates a seaward circulation of cold dry air. (Modified from W.F. Ruddiman's "Earth's Climate")



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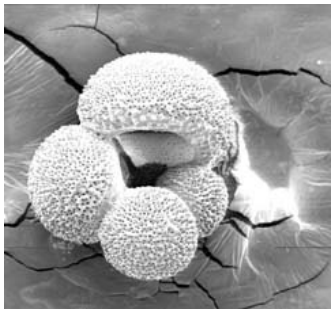
Images of January and August precipitation depicting shifting patterns of rainfall in response to monsoonal changes; south in boreal winter and north in boreal summer. (IRI/LDEO)

Oceanography is the scientific study of the world's seas. More specifically, it is the investigation and interpretation of the ocean's biological, chemical, geological and physical characteristics. Oceanographers come from a diverse array of backgrounds; the natural sciences, mathematics, engineering, political science and more. As a student in the Geology and Environmental Studies departments at Macalester College, my interest in oceanography pertains to the interconnected nature of the oceans and the climate system and how the oceans preserve long-term (paleo) records of climate change. These records are extremely important because the more we know about how climate has behaved in the past, the more accurately we can predict what changes are likely to occur in the future.

Scientists can't directly determine past climates from the oceans (human records don't go back that far) so instead we rely on other kinds of data that can indirectly tell us about climate. This kind of data is called a proxy. You may have heard of investigators gathering climate data from ice cores or tree rings; these are both proxies for climate change. In paleoceanography we use foraminifera, corals and more to provide our proxy data.

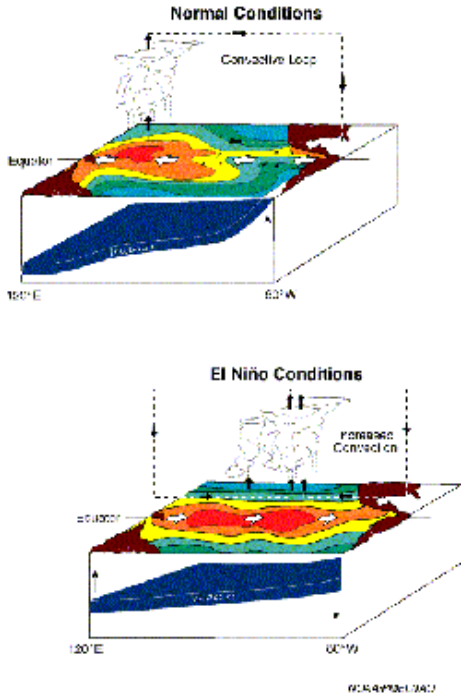
This summer I am looking at a number of ocean-atmosphere phenomenon, one of which is the East Asian Monsoon. A monsoon is a wind which reverses seasonally, blowing onshore in summer and offshore in winter. A diagram of this seasonal pattern and its effects on rainfall can be seen at the left.

My work seeks to develop records of monsoonal variability (and changes in oceanic-atmospheric phenomenon that influence the monsoons) in the Indonesian region to examine past climate variability. I hope to examine paleoclimate as far back as the early Holocene (~10,000 years ago). In this study, my data are derived from the abundance of specific organic constituents in the sediment, which can be used to provide a history of climate in the region.



Plankton G-Bulloides (NOAA)

Coral Montastrea *Cavernosa*
(znanje.org)



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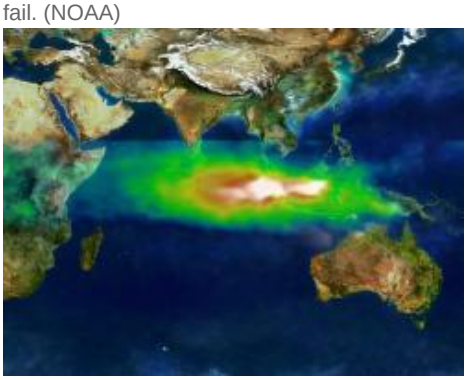
Schematic of 'normal' and 'El Nino-like' conditions in the Pacific Ocean. During El Nino years, the movement of cool air and water from the Pacific is inhibited, causing the thermocline to shallow and the monsoons to fail. (NOAA)



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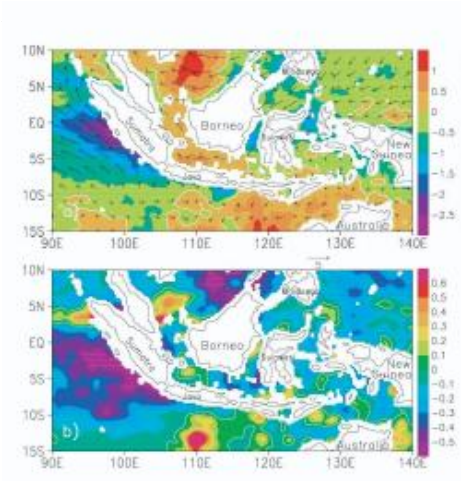
Satellite image of aerosol particles over Indonesia produced by fires during the 1997/98 drought. (NASA GSFC Scientific Visualization Studio)



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(a) SST anomalies during 1997/98 IOD/ENSO year indicating a dramatic trend towards increased salinities in Indonesia. (b) Precipitation anomalies during the same year

Intermediate

The Indonesian throughflow (ITF) is an ocean current that transfers relatively cool, fresh thermocline water, and relatively warm and fresh surface water from the Pacific to the Indian Ocean. The flow and mixing regimes of the ITF are affected by changes in winds, temperature and precipitation caused by seasonal variations and climate phenomenon like El Niño.

During years with a strong El Niño (EN), the trade winds weaken and warm water spreads from the east across the Central Pacific, allowing for upwelling in the Western Pacific. In a non-EN year, cool air and water are drawn up from the Pacific and transported landward causing the East Asian Monsoons. In EN years, this movement is inhibited causing the monsoons to fail. This can have drastic impacts on the Indian Ocean region as seen during 1997/98, when a strong El Niño caused damaging droughts and fires in Indonesia and flooding in west Africa.

Previous research has suggested that patterns in EN have varied over the course of the Holocene but little is known about the peridocity or amplitude of this variability. Because this phenomenon has the ability to dramatically impact the climate of the region, past variability is important to consider when attempting to predict the consequences of future climate change. Research has shown, contrary to what might be expected, that the trade winds are strengthening, "suggesting that the mechanisms of tropical Pacific climate change associated with global warming may be distinct from those of known interannual variability" and making research efforts like mine, to understand the mechanisms that couple the tropical Pacific atmosphere and ocean, even more important (Karnauskas, 2009).

Using sterols as bio-indicators of upwelling and water column stratificaton we hope to demonstrate changes in climate in the ITF region over the past 10,000 years.

To learn about how you can participate in oceanographic research like this, check out the WHOI Summer Student Fellowship Program.

The Indonesian throughflow (ITF) is an ocean current that transfers relatively cool, fresh thermocline water, and relatively warm and fresh surface water from the Pacific to the Indian Ocean. The ITF is intricately linked with El Niño (EN) cycles. This ocean-atmosphere phenomenon is capable of drastically altering ‘normal’ patterns of temperature and precipitation in the Indian Ocean region. Evidence its power was observed during 1997/98, when a strong El Niño caused damaging droughts and fires in Indonesia and flooding in west Africa.

The ITF is located on the west margin of the Western Pacific Warm Pool (WPWP) an area from which the atmosphere derives much of its heat and moisture. Consequently, changes in the climate of the ITF have dramatic potential to perturb atmospheric circulation globally. Previous reconstructions have suggested that during the Holocene El Niño and the East Asian Monsoon underwent distinctive changes in strength, indicating the potential for future variability.

My work seeks to develop direct records of water column stratification and upwelling over the Holocene and to relate observed variations in the East Asian Monsoon/ITCZ system and ENSO. Using sterols as molecular organic geochemical proxies, we hope to demonstrate changes in these two phenomenon over the past

showing drought in much of the area. (Qu et al., 2005)

10,000 years.

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