CMFRI

Winter School on
Impact of Climate Change on Indian Marine Fisheries

Lecture Notes

Part 1

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ROLE OF THE OCEANS IN CLIMATE CHANGE

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Introduction

To maintain the global water balance, the evaporation from oceans worldwide should be balanced by precipitation into the oceans plus runoff from the continents. The earth's atmosphere contains only 0.001% of the earth's water, yet it is an important part of the global hydrological cycle. Atmospheric currents carry water vapor to land which gives precipitation and which in turn sustains life on land.

Increasing atmospheric concentrations of greenhouse gases (GHGs)**,** mainly carbon dioxide, have led to a warming at the surface, by nearly 0.6^{o}C during the twentieth century, and it is widely believed that this trend will continue in the twenty-first century, leading to a higher sea surface temperature, among other factors.

One important consequence of a warmer ocean surface is a larger vapor pressure difference between the sea surface and adjacent atmosphere, which in turn will enhance the evaporation rate and hence increase the other components of the hydrologic cycle.

Evidence of Hydrologic Changes

The following evidences suggest that the hydrological cycle has measurably intensified:

a) Daily minimum temperatures have increased at twice the rate of the day time temperatures since 1950. This in turn will increase cloudiness and humidity at night and increased evaporative cooling during daytime.

b) Radio-sonde and satellite data suggest that the mean (average) atmospheric water vapor has increased. This will help the cyclones to generate more precipitation and also we will have more intense rainfall events.

c) Precipitation amounts have changed in different ways in various regions during the last several decades. They have increased significantly in the middle and high latitudes, often in excess of 10%. The largest increase in precipitation is expected in the polar regions.

d) Decrease in precipitation is also noted in several regions. In the northern hemisphere tropics, especially in Africa, a significant decrease in rainfall has occurred since 1950.

e) Changes in rainfall events such as monsoon rains can have either beneficial or detrimental effects, namely, decreased rainfall can cause water shortage, and increased rainfall can aggravate flooding.

Consequences of Global Warming

An enhanced hydrological cycle, in turn, may enhance global warming through several mechanisms. One such mechanism is the water vapor feedback, because water vapor is a key GHG. Also, increased cloudiness heats the planet, at least if the clouds are high or deep, as in the case for most of the storms or cyclones. This is because high or deep clouds reduce the outgoing longwave radiation (OLR, Gruber and Krueger, 1984) more than the net incoming solar radiation. We should look at the role of global warming on the various air-sea interaction parameters such as sea surface temperature, surface wind speed and other related air sea fluxes over the tropical Indian Ocean in the context of marine activities, such as coral bleaching and migration of fisheries which takes over the Indian Ocean.

Satellite Oceanography

Reliable sea surface temperature (SST) and wind measurements from the space based sensors have been a major goal of the oceanographers. This was achieved way back in 1978 when SEASAT was launched. In the current satellite scenario, the Tropical Rainfall Monitoring Mission provides the SST, with the help of the microwave sensor TMI which can penetrate the clouds. Further, the QuikSCAT can provide wind velocity (both speed and direction) over the ocean. QuikSCAT can provide high resolution wind maps which can be used to study specific process such as coastal upwelling, and synoptic scale process such as El Nino.

The Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data (HOAPS) set is a completely satellite-based climatology of precipitation, turbulent heat fluxes and freshwater budget (evaporation minus precipitation) as well as related atmospheric state variables over the global oceans. The main advantage of this dataset is that both daily, pentad and monthly datasets of various air-sea interaction parameters such as sea surface temperature, specific humidity, wind speed, evaporation, rainfall, fresh water flux, integrated columnar water vapour and cloud liquid water are available for ice free regions over the global oceans from 80^{o} S to 80^{o} N for more than 18 years (*i.e.,* from 7^{th} July 1987 to 31^{st} December, 2005). All variables are derived from SSM/I passive microwave radiometers, except for the SST, which is taken from AVHRR measurements. The dataset includes multi-satellite averages, inter-sensor calibration, and an efficient sea ice detection procedure. Changes in this version are a longer time series, now containing data from 1987 to 2005, a new neural network based precipitation algorithm, and inclusion of the RSMAS/ NODC Pathfinder Version 5 SST fields. Additionally a new 85 GHz synthesis procedure has been implemented, making a continuous time series for all parameters.

All pentad (5-day) mean products are distributed in separate monthly files. The first day of a 5-day average period determines the monthly file wherein it is saved. Each year is subdivided in 73 pentads starting at the same day of the year. During leap years, the twelfth pentad (starting at February 25) is the average of six days. Apart from pentad (5-day) and monthly means on a global $0.5^{o} \times 0.5^{o}$ grid, twice-daily multi-satellite composite data on a global $1^{o} \times 1^{o}$ grid are available. More information of the dataset is available at http://www.hoaps.org/.

Summary

The satellite data has given a totally new dimension to oceanographic studies which in conjunction with the complementary ship, buoy and other oceanographic data can give valuable information about the various marine features and processes taking place over the ocean such as coastal upwelling, oceanic fronts and phytoplankton blooms, which was not possible earlier.