Abstract

The atmosphere over the Arabian Sea perennially contains high levels of mineral dust aerosols transported from the surrounding arid and semi-arid regions of Asia and North Africa. Observations and models have demonstrated that mineral dust over the Arabian Sea can influence the climate of the region by modulating the hydrological cycle, the radiative budgets and especially the large-scale monsoon system. In spite of the importance of mineral dust in this region, a holistic view of the dust cycle and its variability has not emerged. There is no understanding, till date, of how the different climate modes can exert an influence on the interannual variability of dust over the Arabian Sea. Over the last three decades studies have postulated an interesting possibility that there might be some association between dust depositions and the phytoplankton biomass. The Arabian Sea is a highly productive region due to upwelling during the southwest monsoon and winter convection during the northeast monsoon. However, till date no study has tried to explore if the oceanic supply of nutrients are sufficient to support the observed levels of phytoplankton biomass and how much nutrients can be supplied by dust depositions.

The aim of this thesis is to study the temporal variability of dust cycle at seasonal scale, the influence that different climate modes may exert on the levels of dust activity at interannual time scale and to identify mechanistic relations between dust depositions and phytoplankton biomass in the Arabian Sea. In order to achieve this, a regional climate model has been set up and the dust cycle has been simulated for 10 years from 2001 to 2010. The model results have been used to study the seasonal cycle of dust emission, transport and depositions along with the factors that control this seasonal cycle. The interannual variability of dust load over the Arabian Sea and its
surroundings has been studied using time-series of 26 years of Aerosol Index data derived from satellite. This has been used to explore how the climate modes such as El Nino-Southern Oscillation and the Indian Ocean Dipole can remotely control the climatic conditions over the dust source regions. Lastly, the possibility of dust depositions leading to phytoplankton biomass enhancements in the Arabian Sea has been studied with particular stress on the northeast monsoon period. Using satellite-derived chlorophyll concentrations as a proxy to phytoplankton biomass, any episodic increase in chlorophyll levels following dust storms have been marked and the demand for macro and micro nutrients have been calculated. Comparing this demand with the possible supply of water column and the atmospheric depositions of different nutrients has revealed how far dust depositions are important in driving phytoplankton blooms in the Arabian Sea.

The results from the thesis show that at seasonal scale 47% of dust emissions and 79% of dust depositions into the Arabian Sea take place during the southwest monsoon season. To the east and the south of the intertropical convergence zone, the mobilization and transport of is controlled by the strength of the southwest monsoon wind system. To the north and the west of the convergence zone, the same is controlled by the northerly and northwesterly wind system related to the surrounding high pressure regions. At the top of the Troposphere, dust transport is accomplished by the easterly return flow of the monsoon system, thereby, transporting dust to long distances. At interannual scale, La Nina conditions are conducive to increased dust production and dust transport, while El Nino conditions lead to suppression of dust activity in the Arabian Sea and the surroundings. This is affected by El Nino remotely modulating the amount of winter precipitation over the dust source regions and is related to the intensity of convection over the Indo-Pacific warm pool region. El Nino-Southern Oscillation explains about 36% of the
interannual variability of dust activity over the Arabian Sea and its surroundings. The effect of the Indian Ocean Dipole on dust activity in this region is to counteract the effect of El Nino. Finally, the thesis also suggests that dust depositions can lead to episodic enhancements of the phytoplankton biomass in the central Arabian Sea during the northeast monsoon by supplying micronutrient iron. It is likely that any deepening of the mixed layer within the central Arabian Sea can supply enough macro-nutrients, but not enough micro-nutrient dissolved iron. This possibly leads to iron limitation. Following episodic dust depositions, if enough dissolved iron is supplied by dust, phytoplankton blooms can take place. The high dust years account for 47% of the total chlorophyll concentrations in the Arabian Sea during the northeast monsoon. Any such definitive conclusions cannot be arrived at for other seasons.