Interannual Variation of Biological Productivity in the Arabian Sea

An Analysis of Multiple Remote Sensing Products

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Background

Previous research shows seasonal monsoons in the Arabian Sea are strengthening due to global warming and less snow cover in the Himalayas. These stronger monsoons lead to increased upwelling and more phytoplankton *(figures 1 & 2)*. As global warming continues, so will this trend, resulting in a more productive upwelling ecosystem *(figure 3)*.[1]

This study further examines this trend. We analyze longer time series of multiple remote sensing products for the upwelling region in the Arabian Sea.

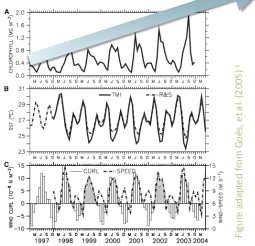

Figure 3. From 1997-2004 the amount of chlorophyll *a* (top panel) during the summer monsoons increased. It is predicted to continue increasing.

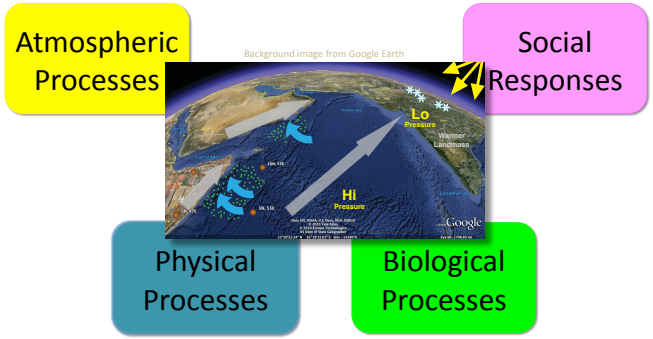

Figure 1. Lower snow cover in the Himalayas (white) causes an increased air pressure gradient (yellow). This gradient leads to stronger summer monsoonal winds (grey arrows). As a result upwelling (blue arrows) is stronger and there is more phytoplankton (green).

Conclusions

- Using two different statistical methods we find chlorophyll increasing from 1997-2003 due to strengthening summer monsoon winds, which agrees with the previous study. After 2004, the increase did not continue but instead decreased because of the summer monsoon winds changing.
- With a simple regression we examined a smaller data set (i.e. only summer months). With HHT we identified multiple temporal signals with the seasonal cycle being the dominate one. We also detected long-term trends that agree with the simple regression analysis.

Methods

Regression

Linear regression was preformed on area-averaged (5-10°N; 47-55°E) chlorophyll *a* and sea surface temperature (SST) satellite derived data from 1997 to 2009.

It focused on the summer monsoon months (June, July, August) which are the upwelling period of the Arabian Sea.

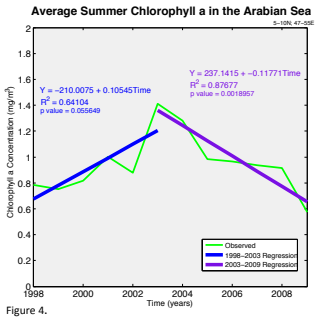

Figure 4.

Results showed chlorophyll *a* increasing until 2003, and then decreasing afterwards *(figure 4)*. This confirms the previous study *(figure 3)*, but also reveals the decreasing trend after 2003.

SST showed a decreasing trend up to 2003 and then an increasing trend after.

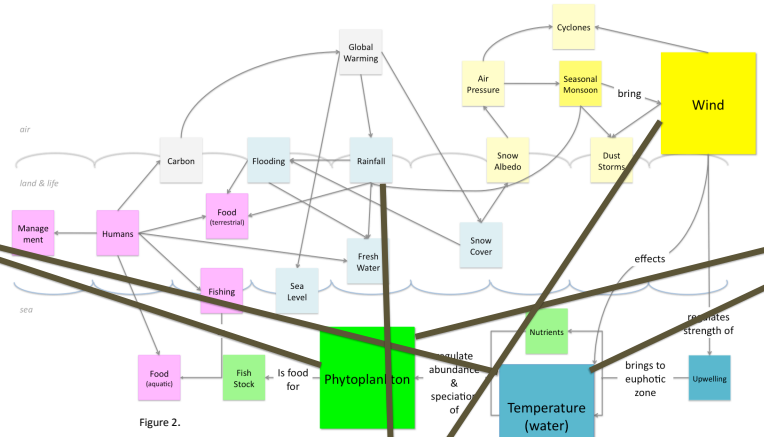

Figure 2.

Next Steps

- Analyze alongshore wind data for the upwelling region using regression and HHT.
- Examine the IPCC SST, wind and precipitation projections for the Arabian Sea region using HHT.

Hilbert Huang Transformation

Hilbert Huang Transformation (HHT) is a method for analyzing nonlinear, nonstationary data which can reveal physical processes (e.g. seasonal cycles) from the original data.[2] HHT was run on weekly, area-averaged (5-10°N; 47-55°E) chlorophyll *a* and SST satellite derived data.

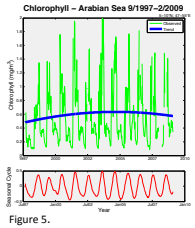

Figure 5.

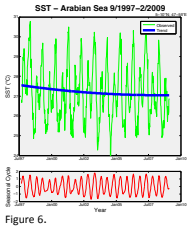

Figure 6.

Chlorophyll *a* increased until 2004 and then decreased *(top of figure 5)*. 1997-2009 SST showed a decreasing trend until 2004 then a plateau *(top of figure 6)*. HHT also depicts the seasonal cycle which is the dominate signal in the Arabian Sea *(bottom of figures 5 & 6)*.

References:
1. Goes, J. I., P. G. Thoppil, et al. (2005). "Warming of the Eurasian Landmass is Making the Arabian Sea More Productive." Science 308(5721): 545-547.
2. Huang, N. E. and Z. Wu (2008). "A review on Hilbert-Huang transform: Method and its applications to geophysical studies." Reviews of Geophysics 46(RG2006): 23.

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