Response to precipitation anomalies in Earth's dustiest regions: Vegetation, sediment, and soil constraints

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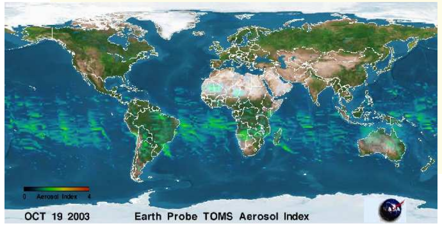
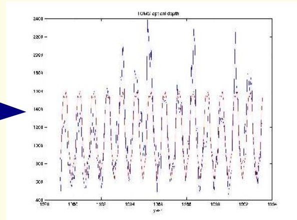
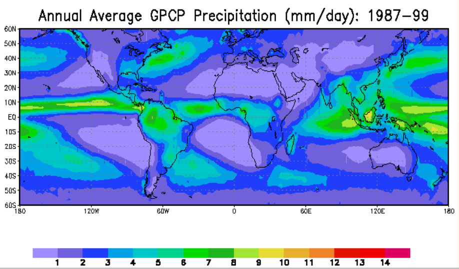
ABSTRACT

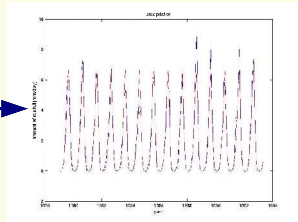
The mechanisms by which drought or excess rainfall affect atmospheric dust loading are investigated by time series analysis. We estimate the cross-correlations of monthly mean precipitation (Global Precipitation Climatology Project data, Huffman et al., 1997) and Dust Optical Depth data (Torres et al., 2002) from 1979 to 1994. The cross-correlograms are plotted over mineral dust source areas (characterized by Prospero et al., 2002). Results are site-specific in both correlation magnitudes and lags of significant correlations (only p<0.01 are shown). From these correlations and lags, we infer the dominant erodibility response to rainfall. First, the extent of seasonal vegetation is sensitive to the amount of rainfall in semi-arid areas and constrains source region size (Nicholson et al., 1998). Second, inundation of ephemeral lakes and surface disturbance from rain splash provide fine materials vulnerable to wind erosion (McTainsh et al., 2002). Third, soil properties including soil water content mediate between rainfall and dust deflation (Prospero and Nees, 1986). We integrate these processes to classify, for the first time, the dominant surface constraints on wind erosion in Earth's major dust source regions.

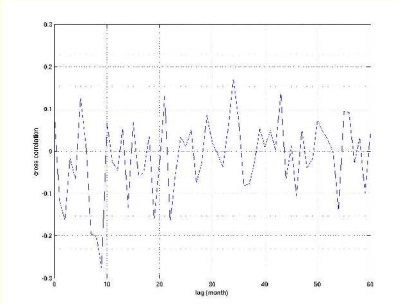
METHOD







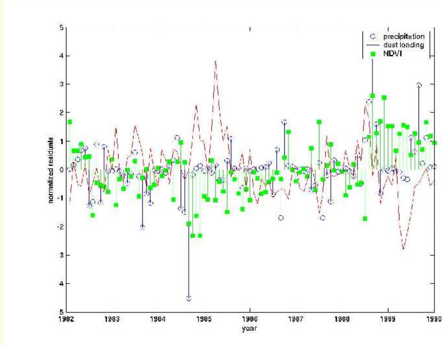


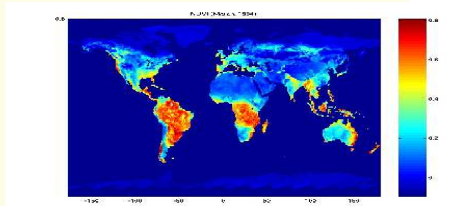


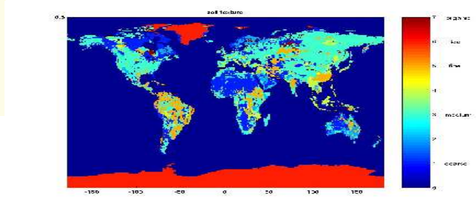
Cross-correlations between precipitation and optical depth anomalies are estimated after removing a seasonal cycle and auto regressive process (over Sahel in North Africa)

NEXT STEP

The plot below shows precipitation, NDVI, and dust loading departures over Sahel in North Africa. Can we tell vegetation activities caused by rainfall anomalies affects atmospheric dust loading in this region? The maps of NDVI and soil properties in addition to references might help to understand the estimated cross correlations.







RESULTS

: Negative correlations with short to seasonal lags indicate vegetation or soil moisture constraints.

: Positive correlations with short to a few years lags indicate source sediment constraints. (* indicates the number of months (lag))

Region	+ Cross-correlations	- Cross correlations	Source type/ dominant controlling mechanism
Sahel (North Africa)		-0.27(9*), -0.21(8)	Seasonal vegetation
Lake Chad (North Africa)		-0.28(9)	Basin, relatively little vegetation compared to Sahel
Tarr desert (India)	0.25(0)	-0.24(1), -0.21(2)	Monsoon driven soil disturbance and replanishment
Eyre basin (Australia)		-0.36(1)	Salt lake
Loess plateau (China)		-0.27(0)	Loess formed by aeolian process, disturbed by intense agricultural activity
Great salt lake (North America)		-0.37(0)	Remnant of prehistoric lake, blocked by Sierra Nevada
Western US (North America)		-0.22(0)	Extensive system of playas and aeolian, lacustrine, and fluvial sediments
South Africa		-0.39(1), -0.23(0)	
Chott (North Africa)	0.21(44)		Ephemeral lakes
Oman (Middle East)	0.40(0)		Monsoon driven soil disturbance and replanishment
Saudi Arabia	0.36(0)		Monsoon driven soil disturbance and replanishment
Tigris Euphrates (Middle East)	0.21(14)		Basin, Monsoon driven soil disturbance and replanishment
Tarim (China)			Basin, thick alluvial deposits
Gobi (China)			Stony desert, front generated