Analysis of the relationship between climate and NDVI variability at global scales

Fan-Wei Zeng (fanwei.zeng@nasa.gov)[1,2], **G. James Collatz**[2], **Jorge Pinzon**[1,2], **Alvaro Ivanoff**[2,3]

1. Science Systems and Applications, Inc. 2. NASA's Goddard Space Flight Center 3. ADNET Systems, Inc.

1. Introduction:
interannual variability in modeled (CASA) C flux is in part caused by interannual variability in NDVI (FPAR) (Fig. 1).

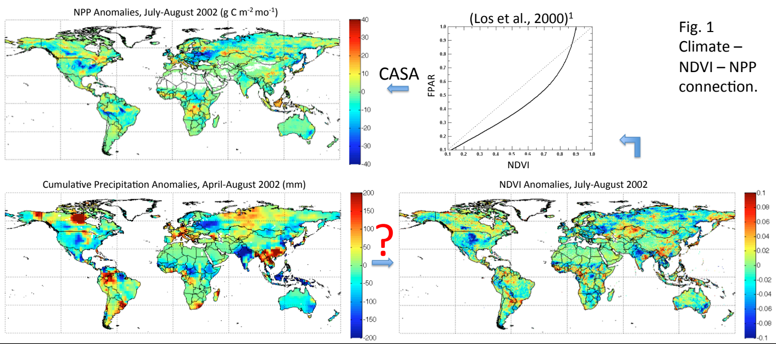


Fig. 1 Climate – NDVI – NPP connection.

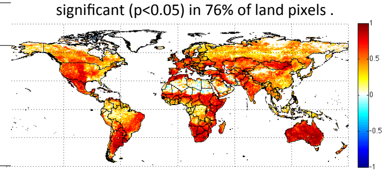
2. Justification: Is interannual variability in NDVI explained by climate?
Here we examine the sensitivity of NDVI to interannual variability in precipitation and temperature.

3. Data:

Table 1. Data sets used.

	Resolution		Period
	Spatial (°)	Temporal	
GIMMS 3g NDVI[2]	0.08	Semimonthly	1981-2010
GPCP precipitation[3]	2.5	Monthly	1979-2009
CRU climatology[4]	0.5	Monthly	1961-1990 (base)
GISS temperature anomaly[5]	2	Monthly	1880-2010

Fig. 2 GIMMS – MODIS Aqua NDVI[6] (0.25°, monthly, 2003-2010) anomaly correlations significant ($p<0.05$) in 76% of land pixels .



- Data sets used: long record; global coverage; consistent with data sets of higher quality (Fig. 2);
- Use of TRMM precipitation (40°N-40°S, 0.25°, semimonthly, 1998-2010)[7] gives the same result.

4. Methods:

4.1. Conducted Pearson's correlation analyses at pixel level with varying lags (of NDVI response to climate) on:
- 1982-2009 NDVI – precipitation anomaly time series (monthly, 1°×1°);
- 1982-2010 NDVI – temperature anomaly time series (monthly, 0.5°×0.5°);

4.2. Accounted for first-order temporal autocorrelation following Dawdy and Matalas (1964)[8]. Only significant correlation coefficients (r values with corrected p values <0.05, two-tailed *t*-test) are shown.

5. Results:

5.1. NDVI – precipitation anomaly correlations:

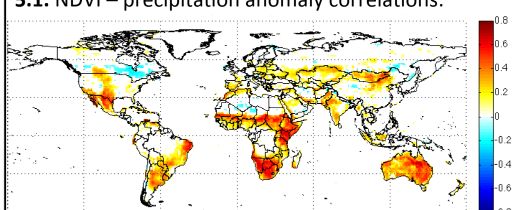
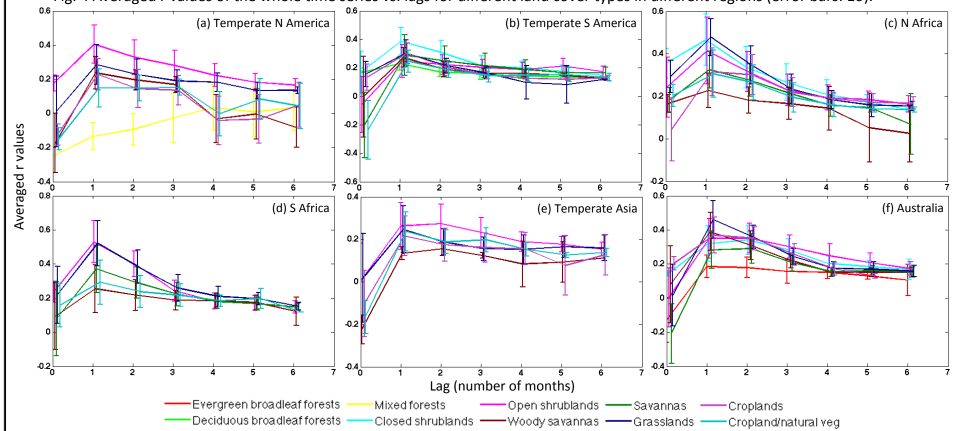


Fig. 3 NDVI – precipitation correlations for the whole time series (1 month lag). (Results using monthly precipitation here were consistent with those using accumulative precipitation (not shown).)

- Strongest for 1-month preceding precipitation;
- Significant in 36% of land pixels;
- Positive in arid and semiarid areas where grasslands and shrublands are the dominant land cover types.

Fig. 4 Averaged r values of the whole time series vs. lags for different land cover types in different regions (error bars: 1σ).



- Higher herbaceous cover (forests -> woody savannas -> savannas -> closed+open shrublands & grasslands): stronger correlations and clearer 1-month peak lag pattern.

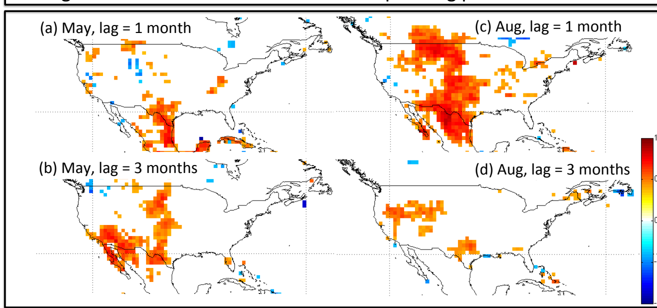


Fig. 5 NDVI – precipitation correlations for May (left) and August (right) in central US.

- Early growing season (May): NDVI most sensitive to precipitation during winter and spring;
- End of growing season (August): NDVI most sensitive to more recent precipitation.

5.2. NDVI - temperature anomaly correlations:

Fig. 6 For the whole time series (no lag).

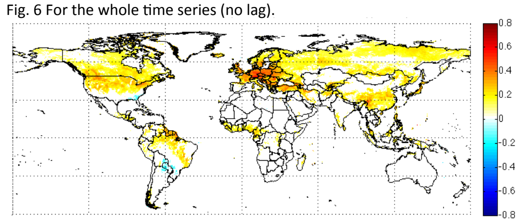
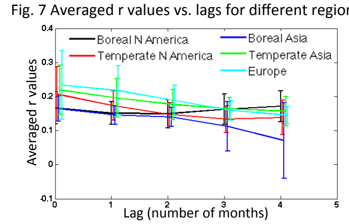
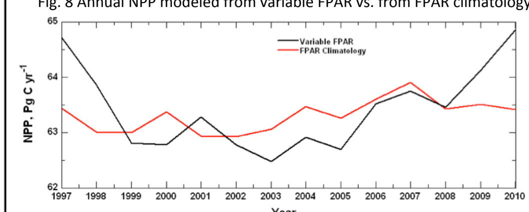


Fig. 7 Averaged r values vs. lags for different regions.



- Strongest for current month temperature (Fig. 6&7);
- Significantly positive in 40% of total land pixels, and 77% of these pixels are north of 35°N (Fig. 6);
- Not associated with land cover types.

Fig. 8 Annual NPP modeled from variable FPAR vs. from FPAR climatology.



6. Conclusion:

- This study confirms a mechanism producing variability in modeled NPP:
  - NDVI (FPAR) interannual variability is strongly driven by climate;
  - The climate driven variability in NDVI (FPAR) can lead to much larger fluctuation in NPP vs. the NPP computed from FPAR climatology (Fig. 8).

References:
1. Los, S.O., et al. (2000) *J. of Hydrometeorology*, **1**, 183-199.
2. Tucker, C.J., et al. (2005) *International J. of Remote Sensing*, **26**(20), 4485-4498.
3. Huffman, G.J., et al. (2009) *Geophys. Res. Lett.*, **36**, L17808, doi: 10.1029/2009GL040000.
4. New, M., et al. (1999) *J. of Climate*, **12**(3), 829-856.
5. Hansen, J., et al. (1999) *J. of Geophys. Res.*, **104**, 30997-31022.
6. MODIS Aqua NDVI (MYD13C2, https://lpdaac.usgs.gov/products/modis_products_table).
7. Huffman, G.J., et al. (2007) *J. of Hydrometeorology*, **8**(1), 38-55.
8. Dawdy, D.R., and N.C. Matalas (1964) *In* V.T. Chow, ed. *Handbook of Applied Hydrology, A Compendium of Water-resources Technology*, 68-90, McGraw-Hill Book Company, New York.

Acknowledgements: This work is supported by NASA's Carbon Monitoring System project and Carbon Cycle Science element of the Terrestrial Ecology Program.