Using Giovanni in Investigating the Links between Environmental Processes and Drought in Northern sub-Saharan Africa

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Dust from Bodele Depression

Mix of dust and smoke obscure coastline

Aqua-MODIS image of January 17, 2007 (NASA EarthObservatory)

Outline

- Sub-Saharan African Environment and Drought
- Hypothesis and Study Design
- Exploratory Data Analysis and Preliminary Findings
- Ongoing Detailed Analysis and Modeling Efforts
- Future Outlook
“Although the droughts have had climate experts scratching their heads, the impacts have been obvious. During the worst years, between 1972 and 1975, and 1984 and 1985, up to a million people starved to death.”
Lake Chad: poster child of African Sahel Droughts

Terra-MODIS image of 7 February 2008 at 12:40 UT

Fires ➔ Bare Soil ➔ Dust ➔ Desertification
In the 1973 image the vegetation inside and outside the protected areas appears green and robust.

In the 2002/2003 dramatic change is apparent; some of the northern reserves have been decimated and the northern edge of the forest zone has moved south.
Lack of interest in global change issues, non-participation in mitigation efforts, more biomass burning to survive.

- **Drought**
  - Lack of water
  - Lack of rain, deeper water exploitation
  - Low evaporation, low cloudiness

- **Biomass Burning**
  - Surface heating, vegetation drying
  - Intense heat and smoke
  - Existing vegetation obliterated

- **Increased Desertification**
  - Drying of vegetation

- **Climate Forcing**
  - Large change in atmospheric composition and circulation
  - Less cloudiness, higher surface albedo

- **Reduced Precipitation**
  - Weak or stunted new vegetation
  - Atmospheric heating, cloud evaporation

- **Human suffering, poverty, frustration, and wars; with regional and global ramifications**

- **Rapid global climate change**

Low food production, rapid depletion of available resources, poor health.
Science Questions:
- To what extent does the seasonal biomass burning affect land-cover and ecosystem changes, smoke and dust emissions, atmospheric heating rates, and the consequent climate forcing in the NSSA region?
- How do these surface and atmospheric changes affect soil moisture content and retention, as well as rainfall variability and surface runoff?
- What are the links between the surface and atmospheric hydrologic processes induced or modified by biomass burning and the drying of Lake Chad, and what is the status and trend of the ground-water reserves in the greater Lake Chad basin and surrounding regions?
- What is the future of the regional climate and ecosystem balance, and how can the current degradation trend be mitigated to enhance societal benefits both in the present and the future?
Data Sources (NASA Giovanni)
NDVI => Terra/Aqua MODIS
Fire Radiative Power (FRP) => Terra/Aqua MODIS
Aerosol => Terra/Aqua-MODIS
Carbon Monoxide => Aqua-AIRS
Precipitation => TRMM
Soil Moisture => Aqua AMSR-E
Surface Evaporation => MERRA

Regional Data Analysis Based on Rough Ecosystem Segmentation
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![Regional data analysis map and graph showing FRP over land area in various regions.](image-url)
Regional Data Analysis Based on Rough Ecosystem Segmentation

[Map showing regional data analysis with regions labeled NW, MC, SW, etc., and graphs showing precipitation data with months from Sep-02 to Sep-10.]
Regional Data Analysis Based on Rough Ecosystem Segmentation

The image illustrates a map divided into various regions labeled as NW, NC, NE, MW, MC, ME, SW, SC, and SE. Each region is associated with a symbol indicating a trend: an arrow for movement, a plus sign for increase, and a delta symbol for a decrease.

Below the map, there is a graph showing precipitation data from Sep-02 to Sep-10. The graph includes lines representing different regions: NE (red), ME (black), and SE (blue). The y-axis represents precipitation in millimeters per hour (mm/hr), and the x-axis shows the months from Sep-02 to Sep-10.
Regional Data Analysis Based on Rough Ecosystem Segmentation

The diagram shows a regional analysis with segments labeled NW, NC, NE, MW, MC, ME, SW, SC, and SE. Each segment is marked with arrows indicating directional influences. A graph below the map illustrates precipitation data over a period from Sep-02 to Sep-10, with lines for NW, MW, MC, and SW segments.
Regional Data Analysis Based on Rough Ecosystem Segmentation

Evaporation from Land [kg/m²/hr]

- NW
- MW
- NC
- MC
- NE
- ME
- SW
- SC
- SE

Graph showing evaporation from land for different regions over time.
Preliminary Findings

- Time Series Analysis of Regionally Aggregated Monthly Mean Satellite Measurements Shows That:
  - Fire activity appears to show a slightly decreasing trend in the Central and Eastern parts of the NSSA region starting in 2006/7.
  - This decrease in fire activity coincides with precipitation: increase in the Western, no change in the Central, and decrease in the Eastern parts of the NSSA.
  - Surface evaporation minima appear to have increased during the same period in the Western and Central parts.
Hypothesis: the impact of biomass burning on albedo will depend on landcover type.
Smoke Particulate Emissions from fires
in Northern Sub-Saharan Africa during Dec 2009

Total emissions: 2.98 Tg
Fire and Plume Observation and Modeling Synergy

MODIS

CALIPSO

WRF/Chem (800m) 2008-02-04_01
Land cover change around Lake Chad

(a) 

(b) 

(c) 

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(b) 

Log Area (Km²)

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Groundwater Field Survey in the summer of 2009
Plans

- Continue detailed data analysis and modeling to understand the different aspects of the issue.

- Closely coordinate the different components of the study to establish linkages in a coherent manner.

- Publish results in peer-reviewed literature.

- Collaborate with and share data and knowledge with various regional and local subject matter experts.

- Provide applicable findings to relevant agencies and organizations for use in decision making.