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

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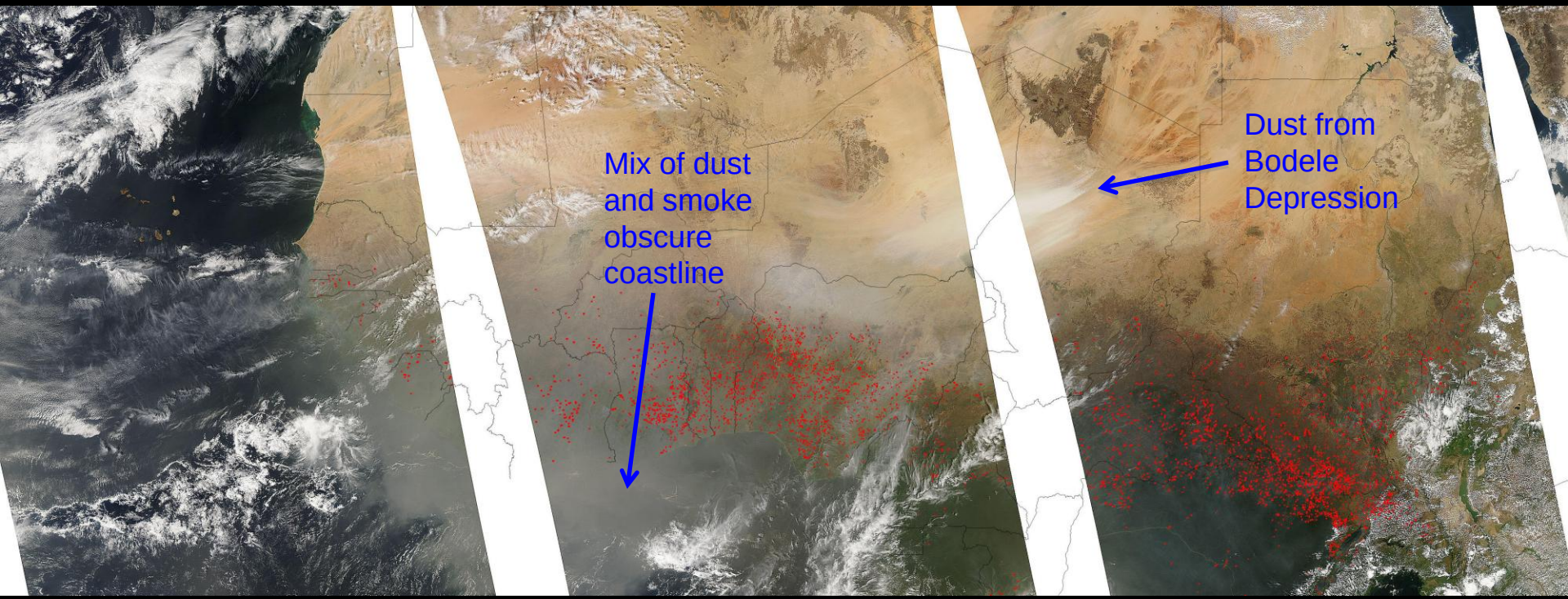


Aqua-MODIS image of January 17, 2007 (NASA EarthObservatory)

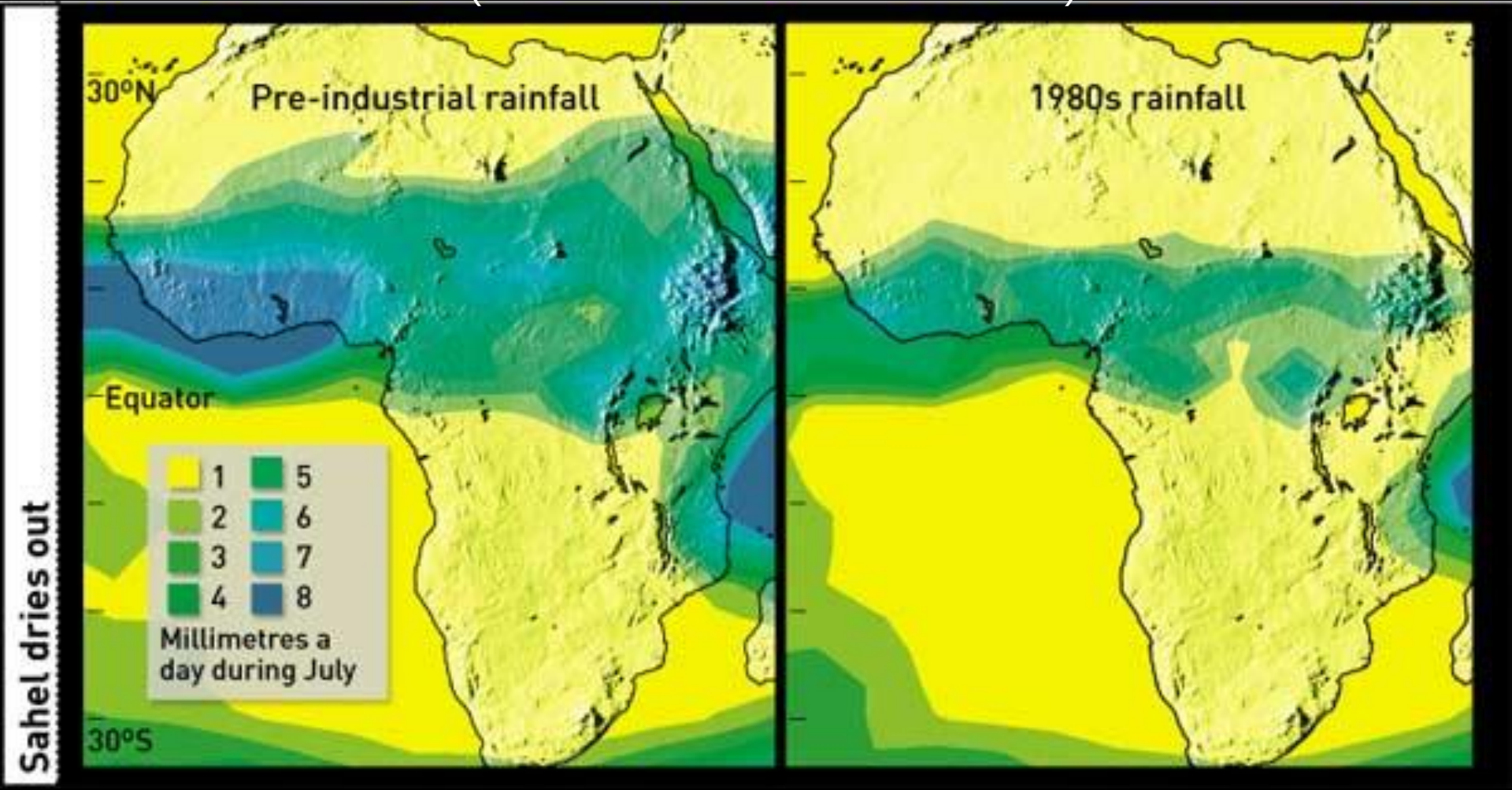
Presented at the Gregory G. Leptoukh Online Giovanni Workshop, NASA/GSFC, Greenbelt, MD, 25 – 27 September, 2012.

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

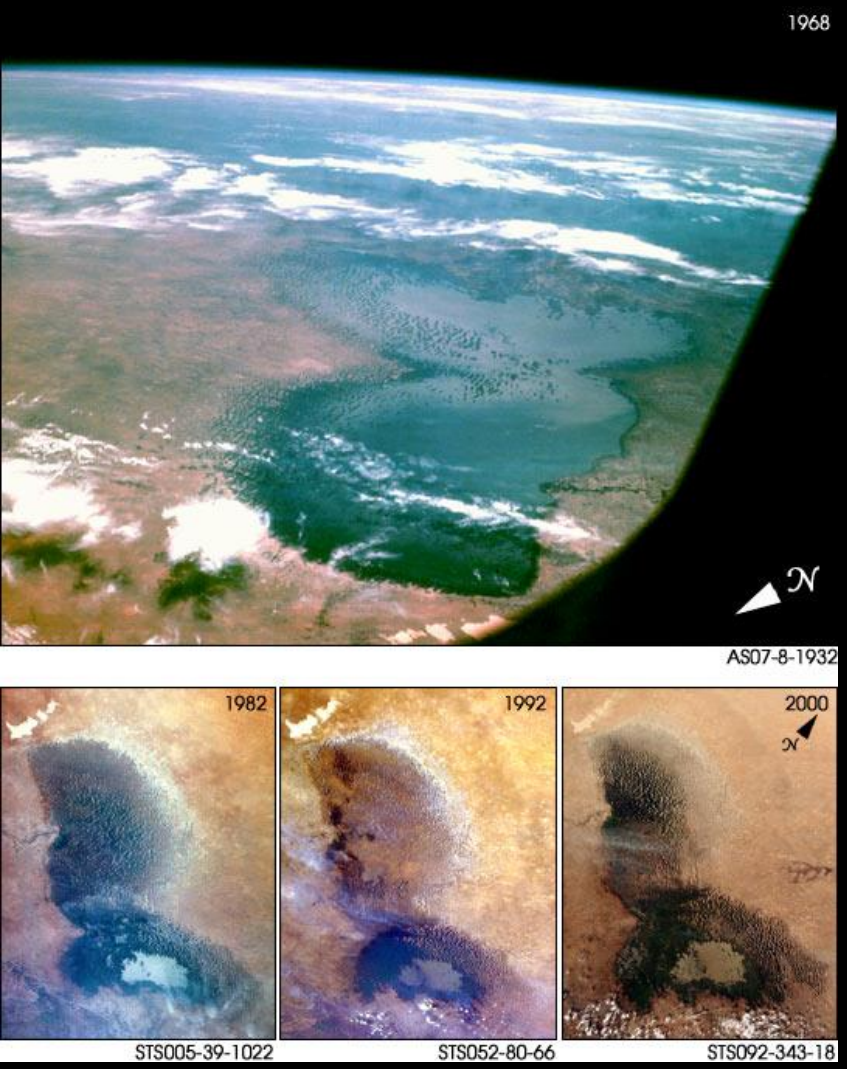
African Droughts

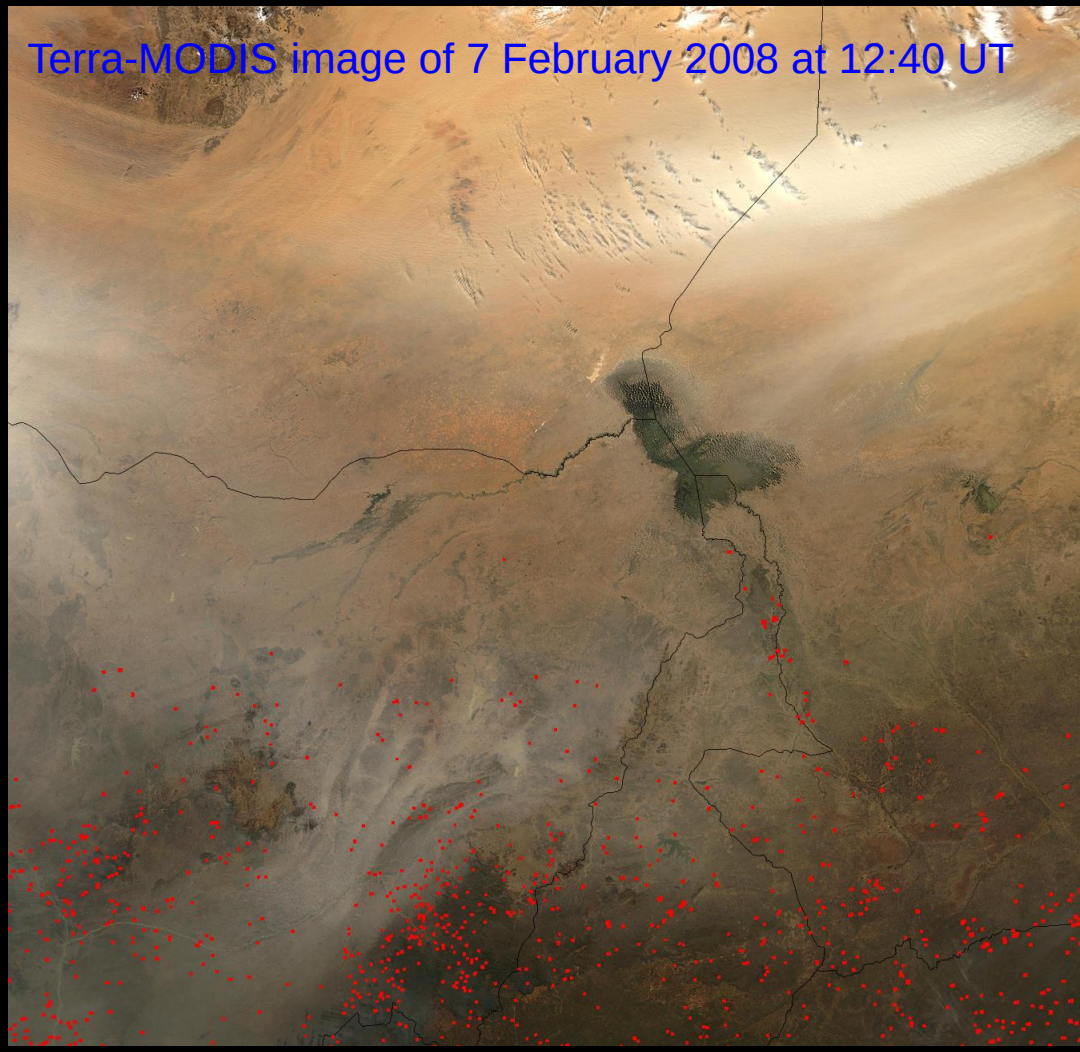
(New Scientist: 19:00 12 June 2002)



“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





Fires ➔ Bare Soil ➔ Dust ➔ Desertification

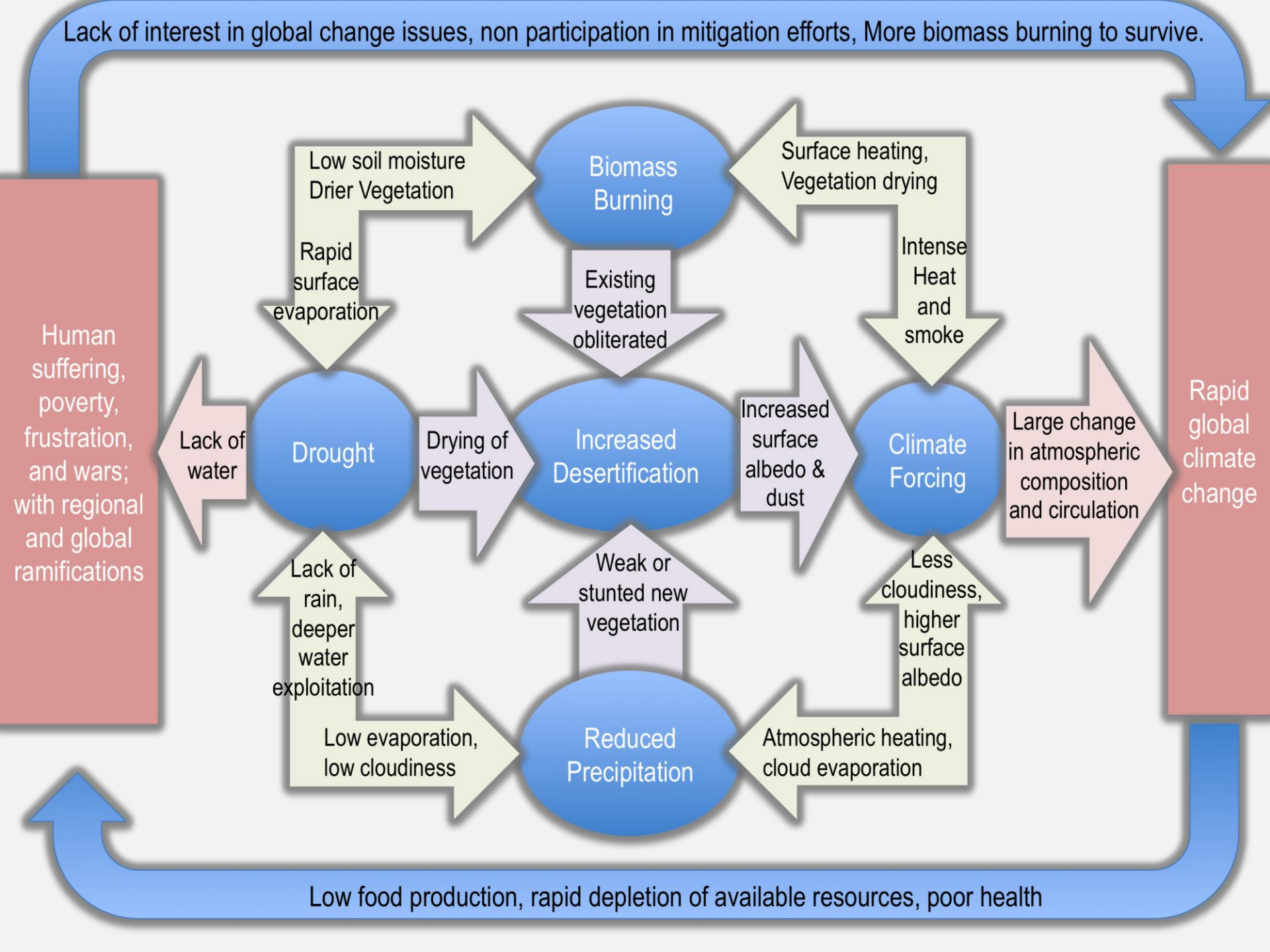
Republic of Ghana

Forest Reserves Under Pressure in Ghana

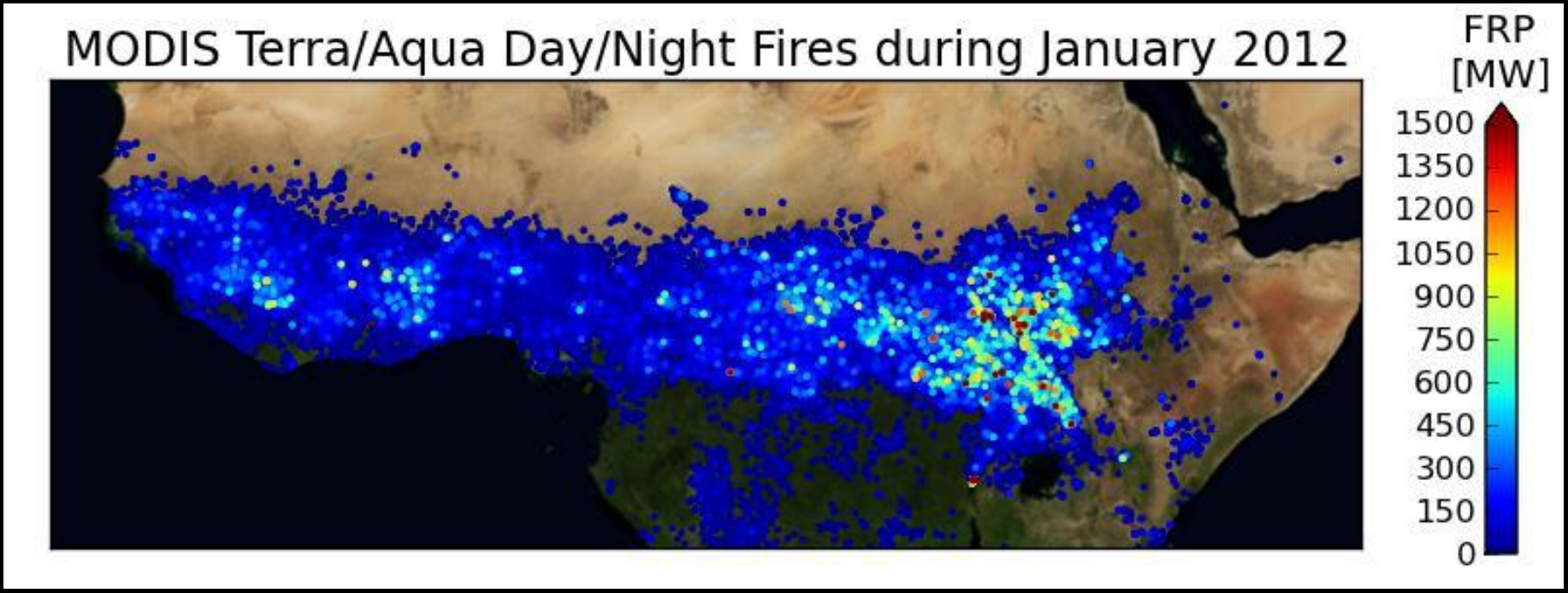
In the 1973 image the vegetation inside and outside the protected areas appears green and robust

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

UNEP


Lack of interest in global change issues, non participation in mitigation efforts, More biomass burning to survive.
Human suffering, poverty, frustration, and wars; with regional and global ramifications
Biomass Burning
Low soil moisture
Drier Vegetation
Surface heating,
Vegetation drying
Rapid surface evaporation
Existing vegetation obliterated
Intense Heat and smoke
Lack of water
Drought
Drying of vegetation
Increased Desertification
Increased surface albedo & dust
Climate Forcing
Large change in atmospheric composition and circulation
Rapid global climate change
Lack of rain, deeper water exploitation
Weak or stunted new vegetation
Less cloudiness, higher surface albedo
Low evaporation, low cloudiness
Reduced Precipitation
Atmospheric heating, cloud evaporation
Low food production, rapid depletion of available resources, poor health

Biomass burning and water-cycle dynamics across Sub-Saharan Africa



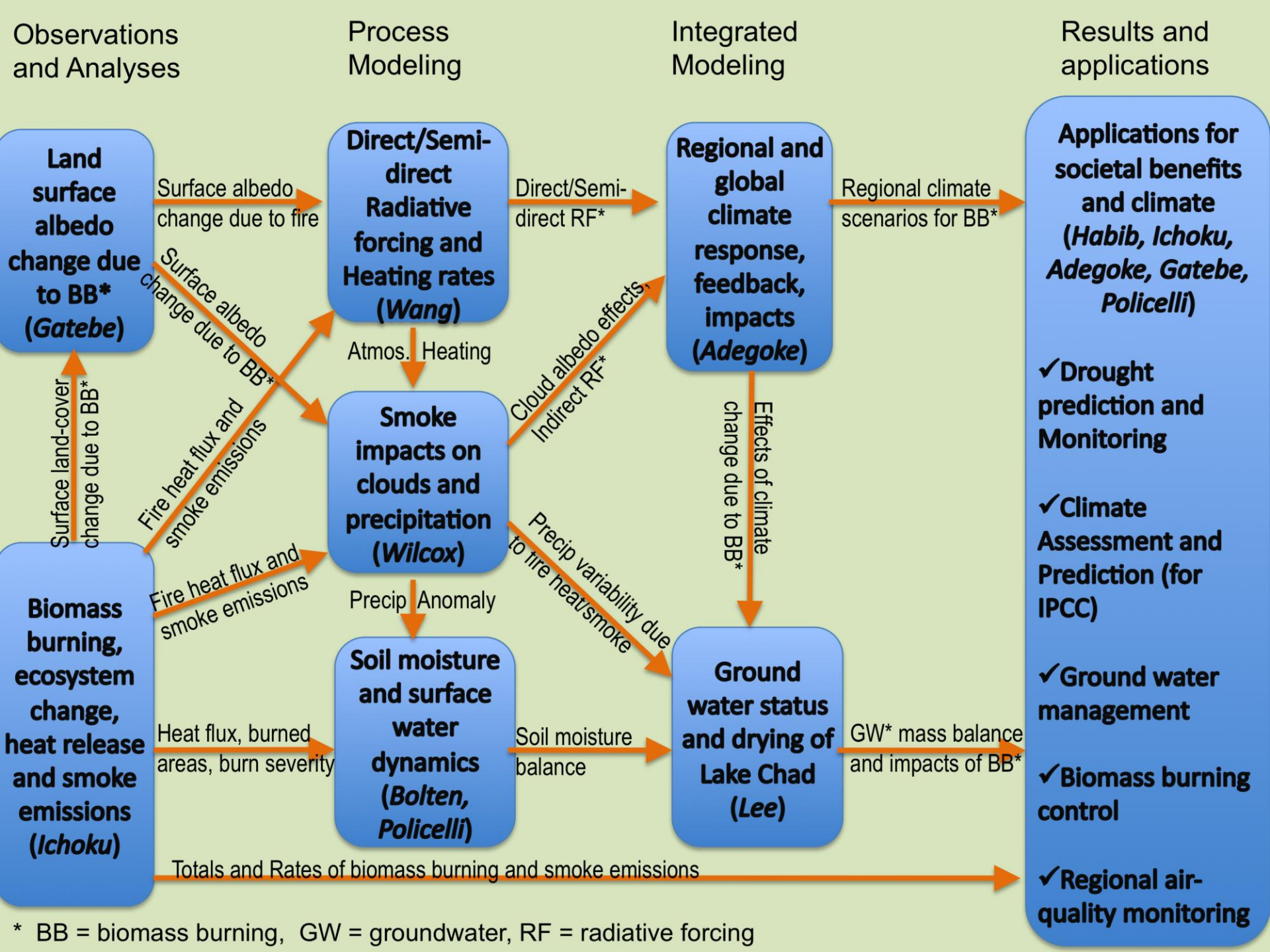
Science Questions:

- 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?

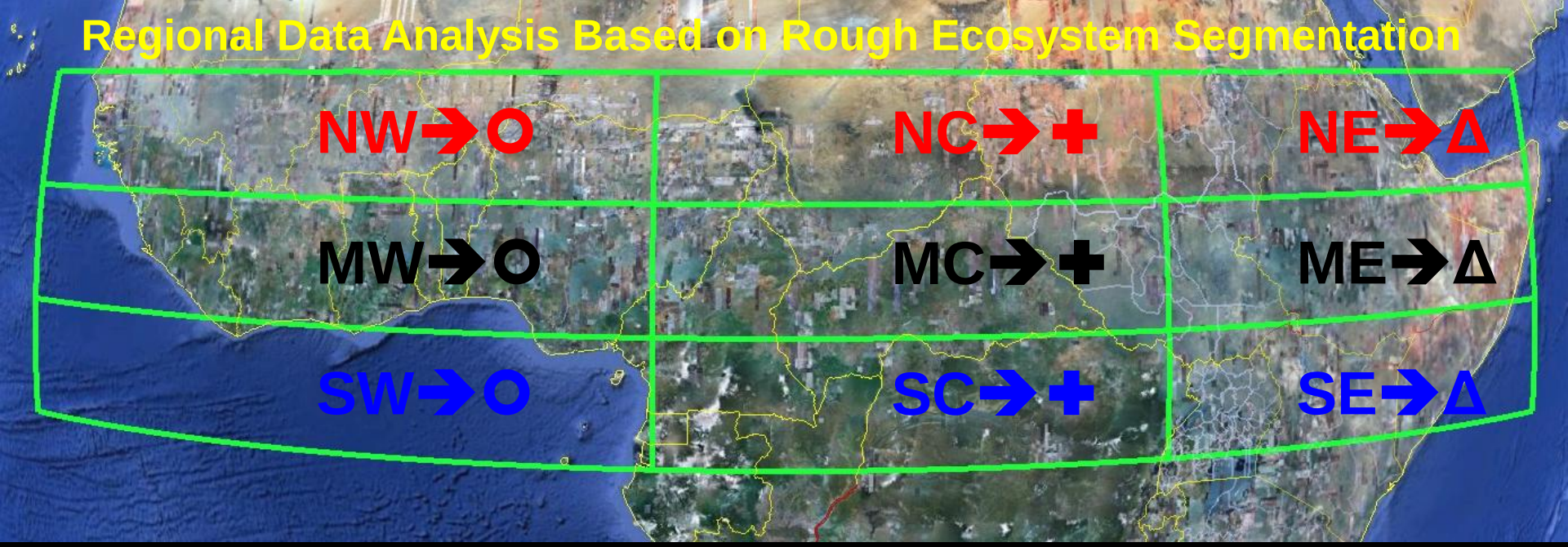
- How do these surface and atmospheric changes affect soil moisture content and retention, as well as rainfall variability and surface runoff?

- 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?


Observations and Analyses
Process Modeling
Integrated Modeling
Results and applications
Land surface albedo change due to BB* (Gatebe)
Surface albedo change due to fire
Direct/Semi-direct Radiative forcing and Heating rates (Wang)
Direct/Semi-direct RF*
Regional and global climate response, feedback, impacts (Adegoke)
Regional climate scenarios for BB*
Applications for societal benefits and climate (Habib, Ichoku, Adegoke, Gatebe, Policelli)
Surface albedo change due to BB*
Surface land-cover change due to BB*
Atmos. Heating
Smoke impacts on clouds and precipitation (Wilcox)
Cloud albedo effects, Indirect RF*
Fire heat flux and smoke emissions
Effects of climate change due to BB*
Precip variability due to fire heat/smoke
Fire heat flux and smoke emissions
Precip Anomaly
Biomass burning, ecosystem change, heat release and smoke emissions (Ichoku)
Heat flux, burned areas, burn severity
Soil moisture and surface water dynamics (Bolten, Policelli)
Soil moisture balance
Ground water status and drying of Lake Chad (Lee)
GW* mass balance and impacts of BB*
Totals and Rates of biomass burning and smoke emissions
✓Drought prediction and Monitoring
✓Climate Assessment and Prediction (for IPCC)
✓Ground water management
✓Biomass burning control
✓Regional air-quality monitoring
* BB = biomass burning, GW = groundwater, RF = radiative forcing

Regional Data Analysis Based on Rough Ecosystem Segmentation



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

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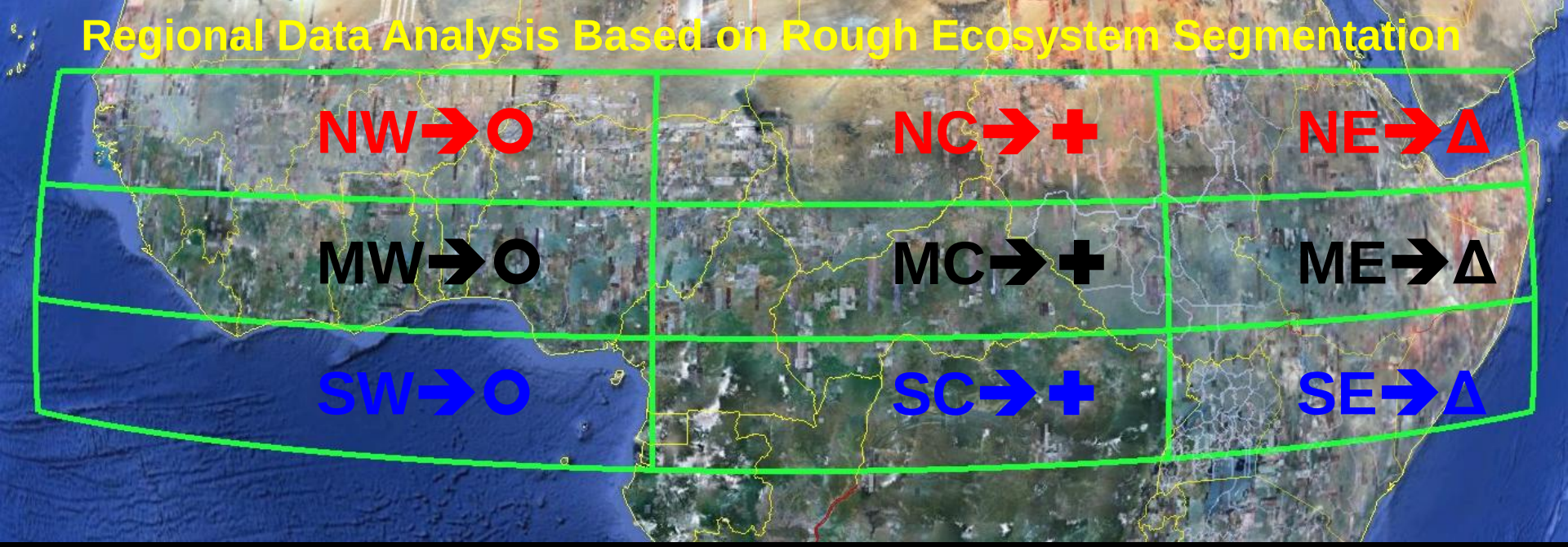

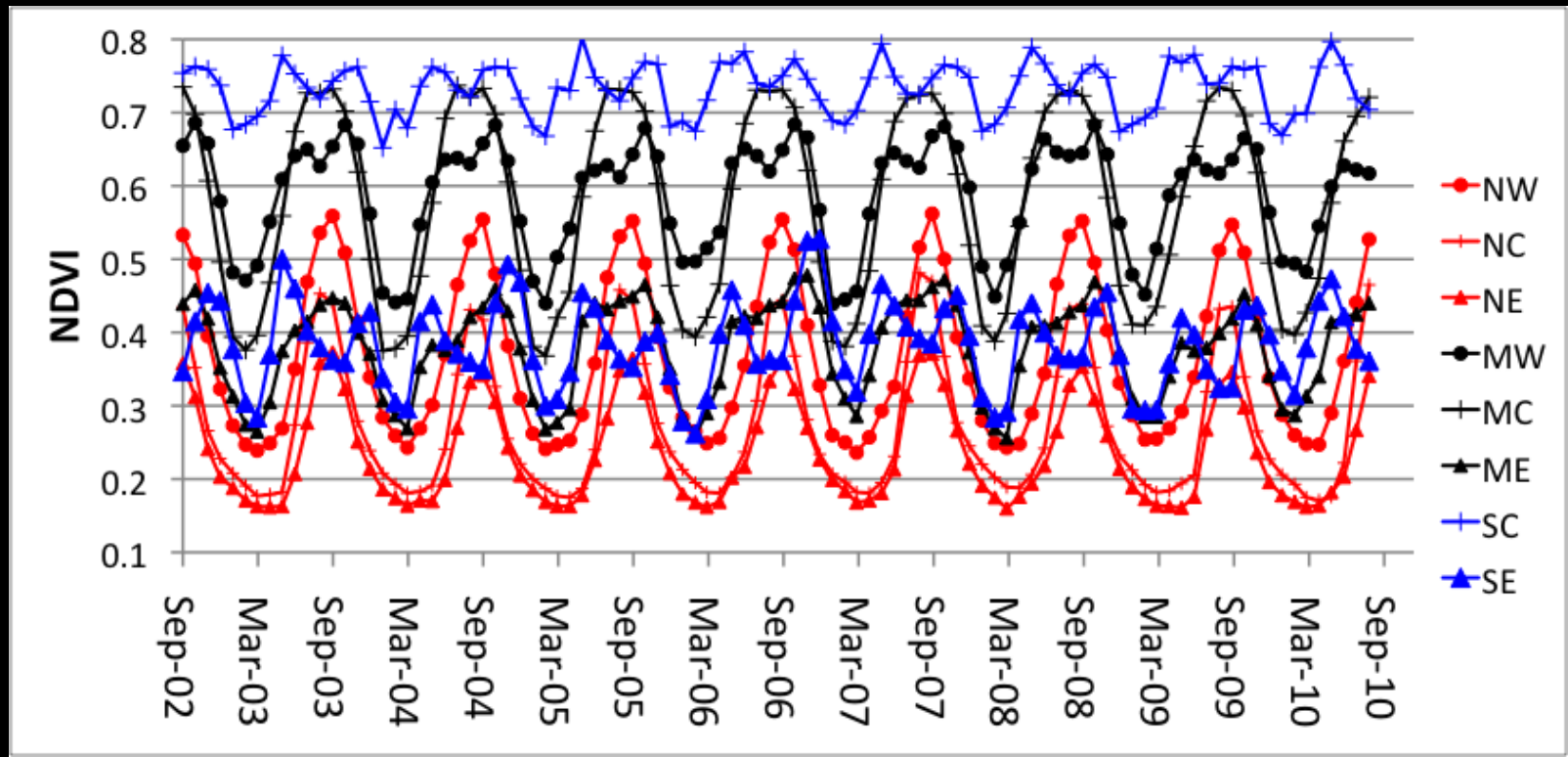

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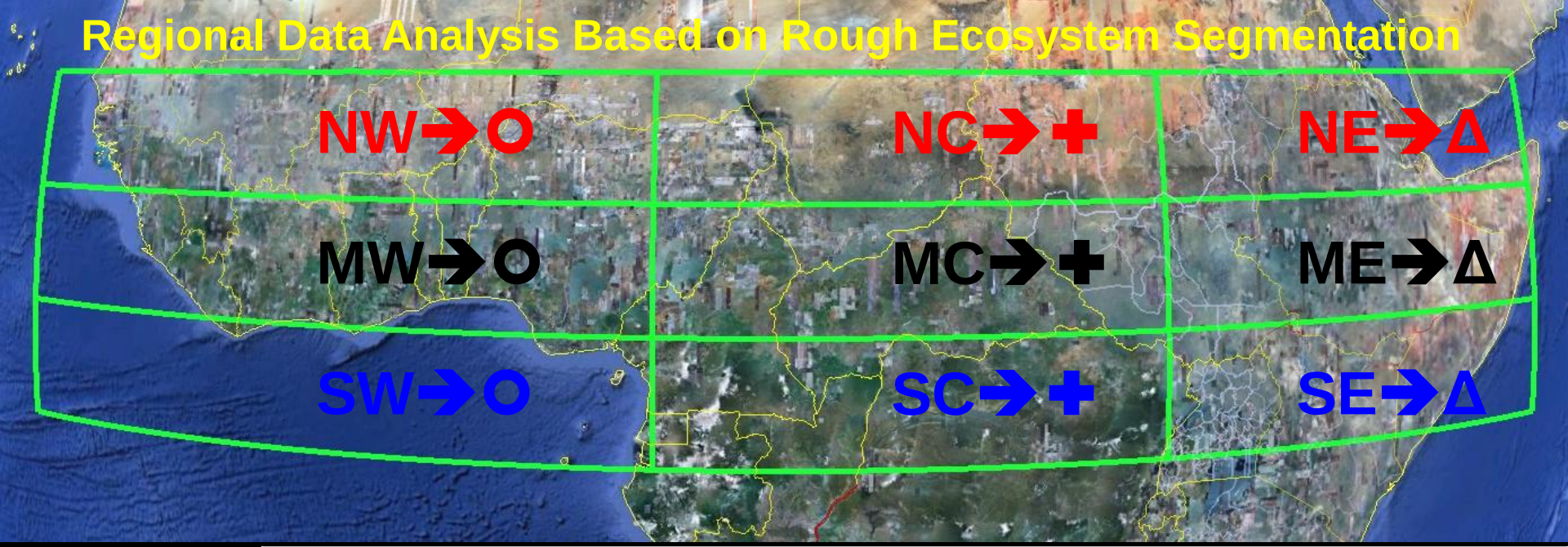

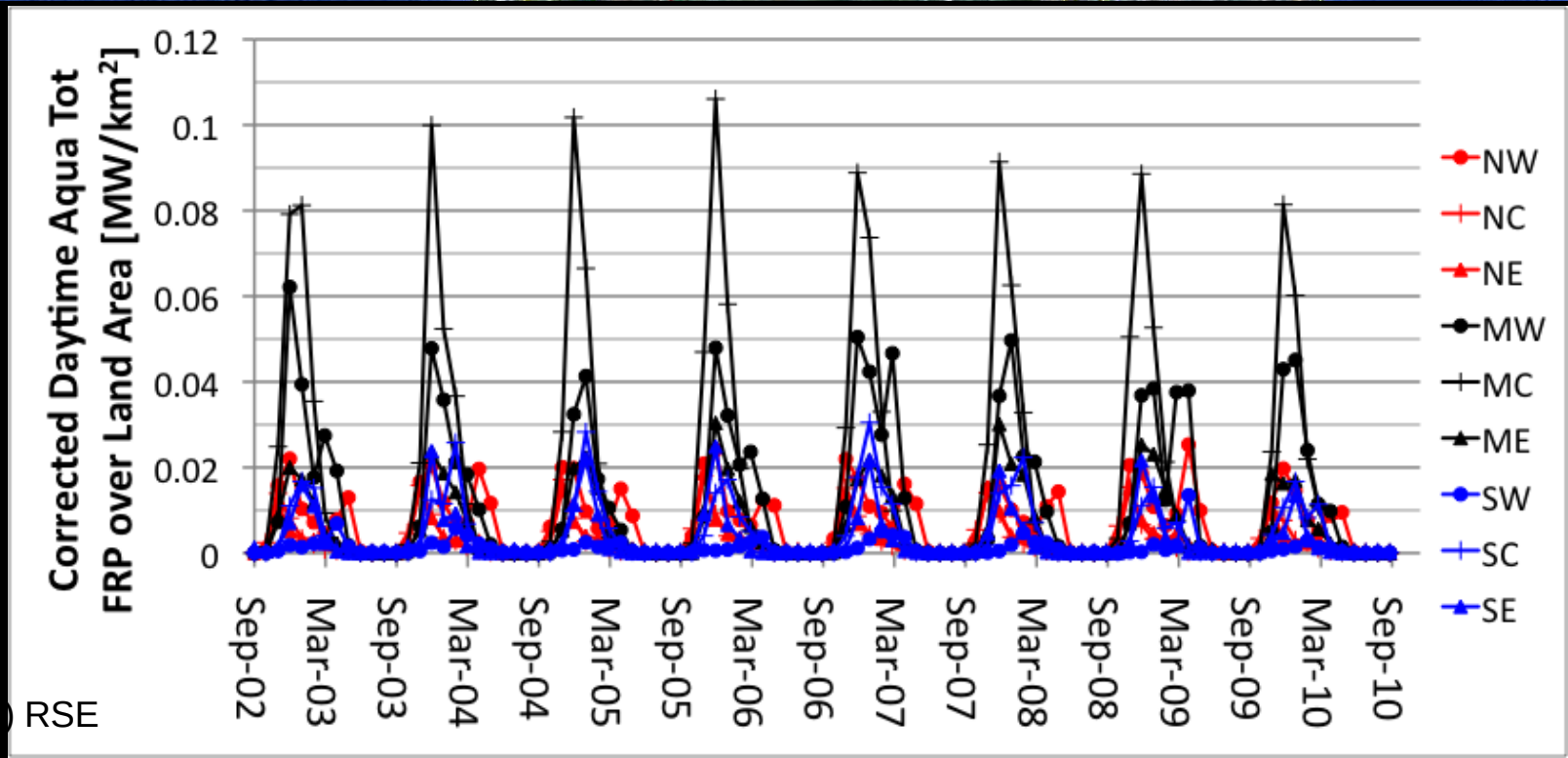

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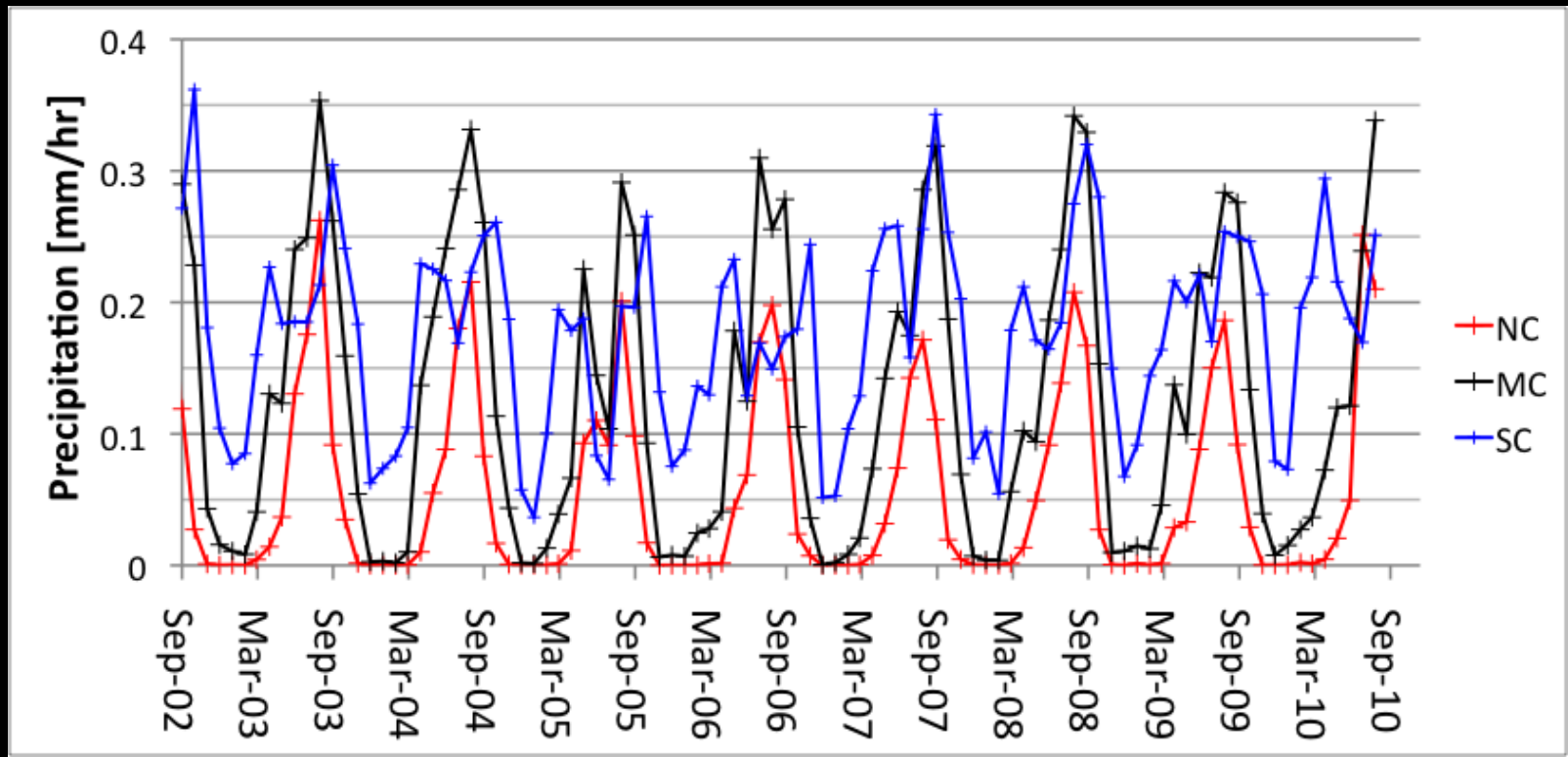
Regional Data Analysis Based on Rough Ecosystem Segmentation



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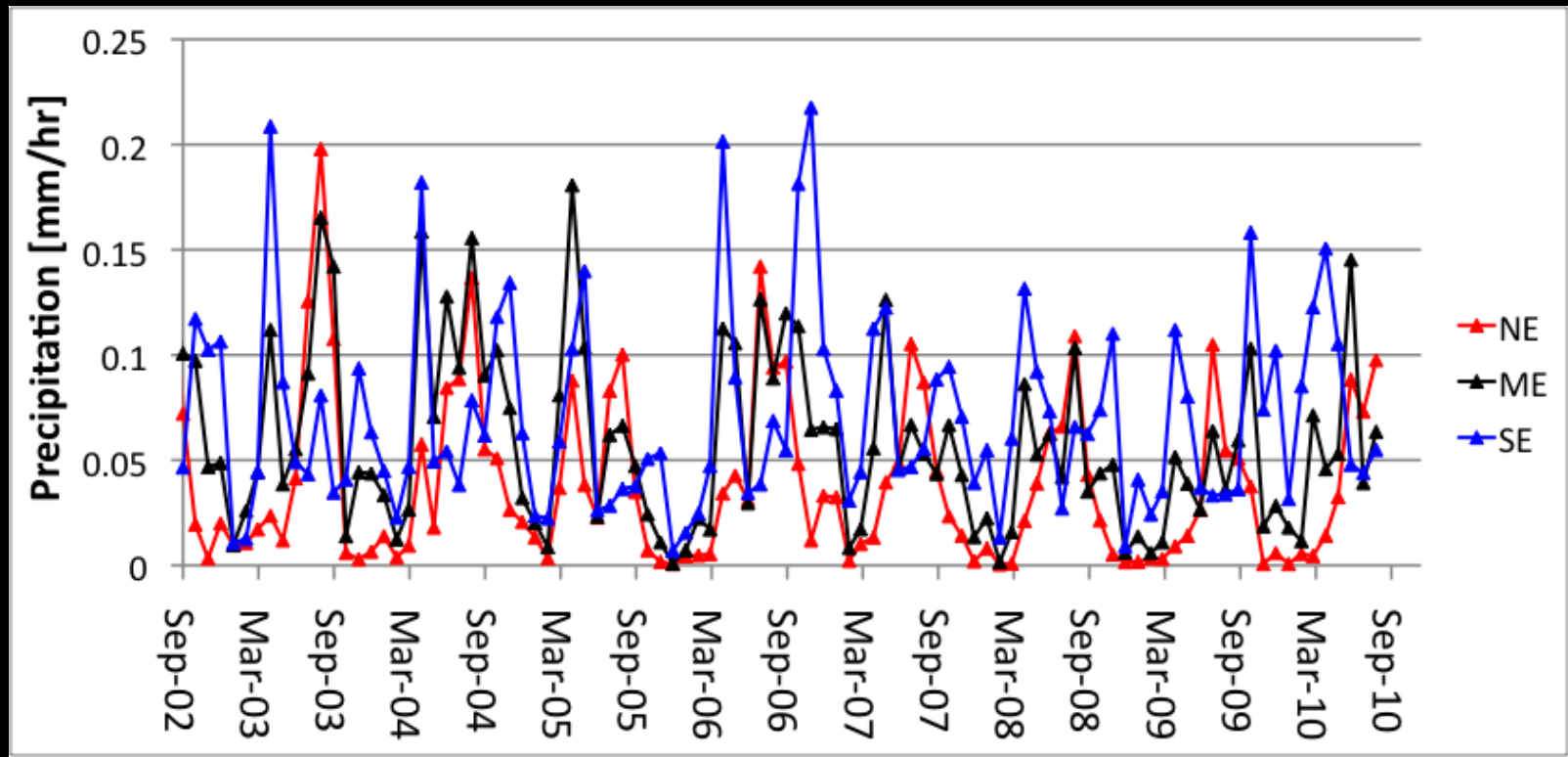

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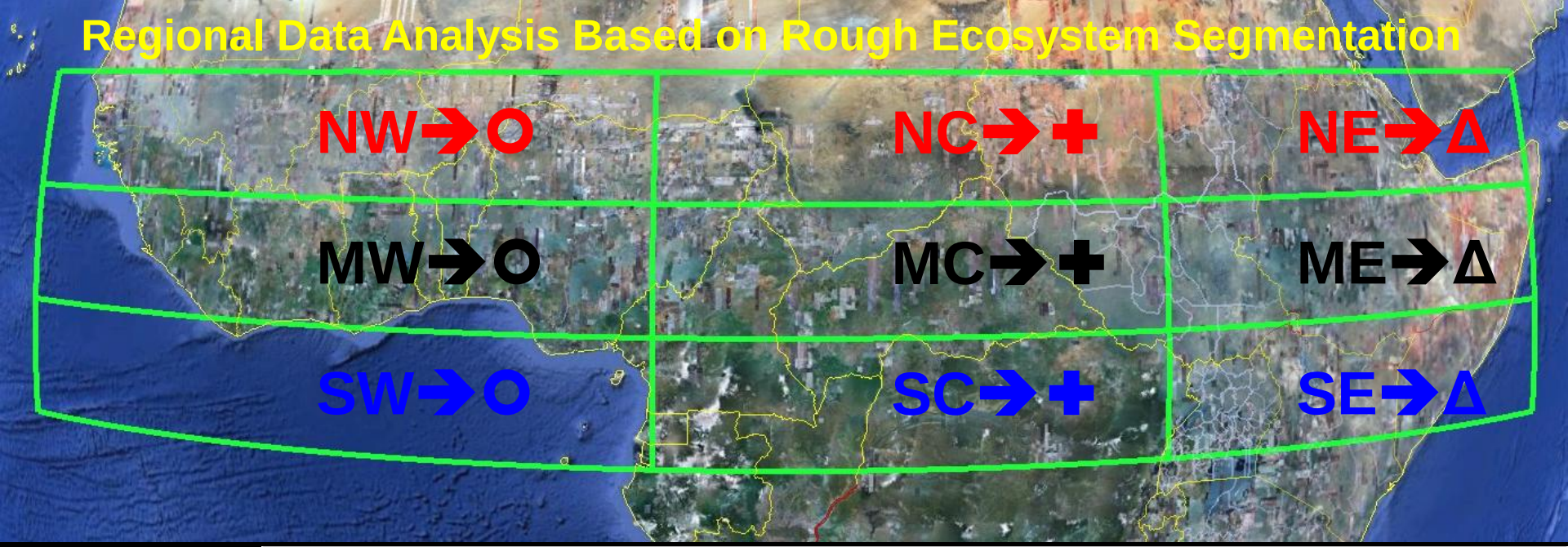

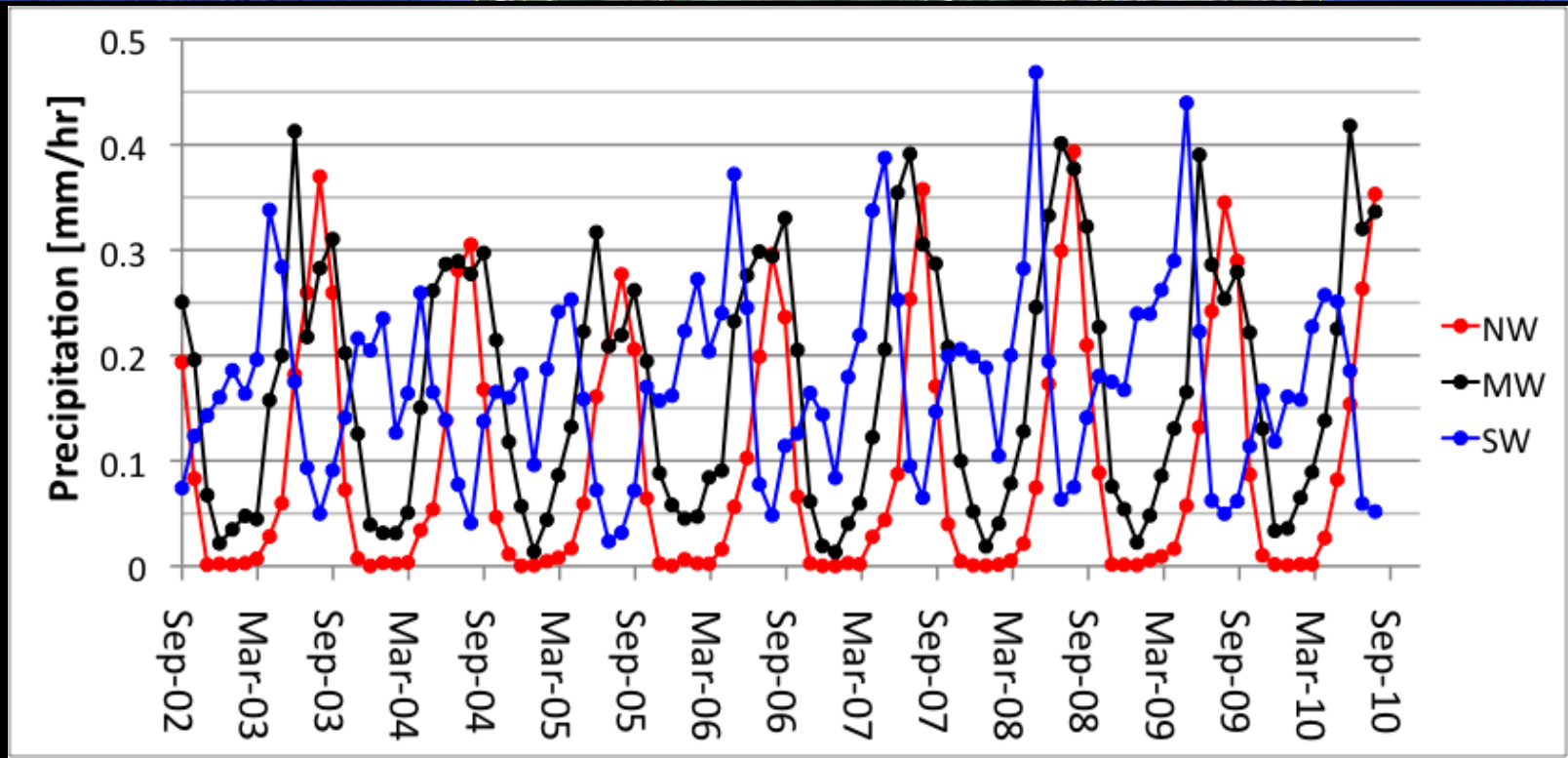

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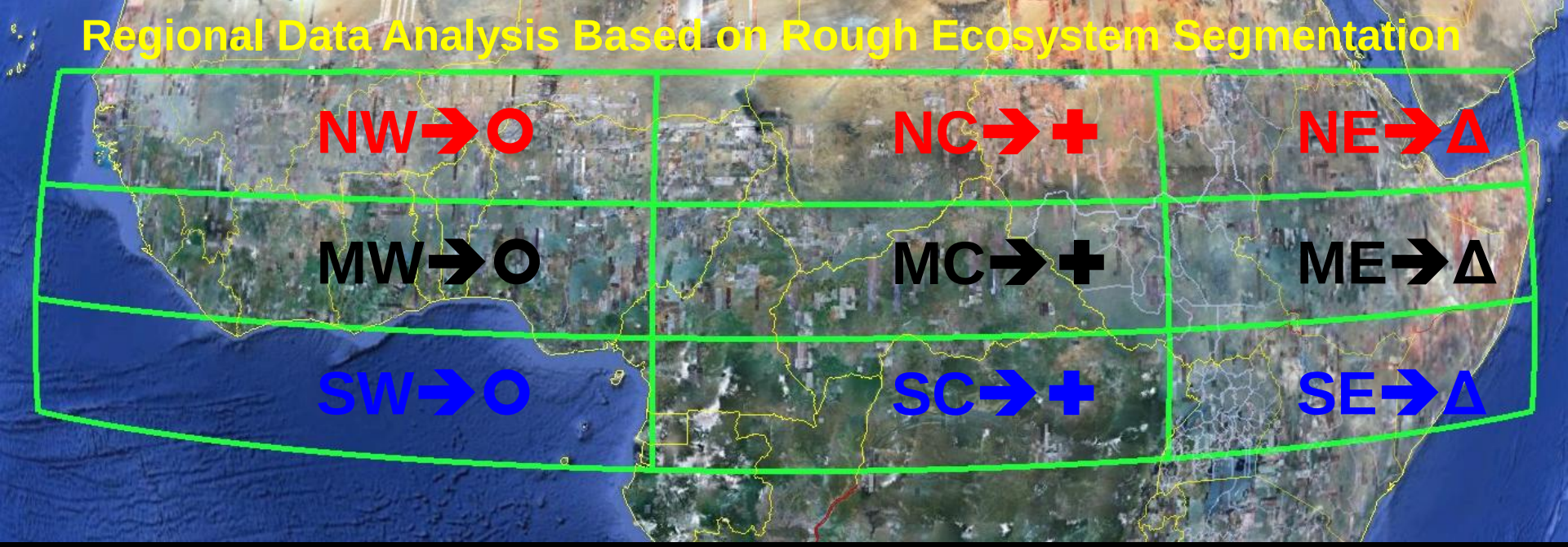
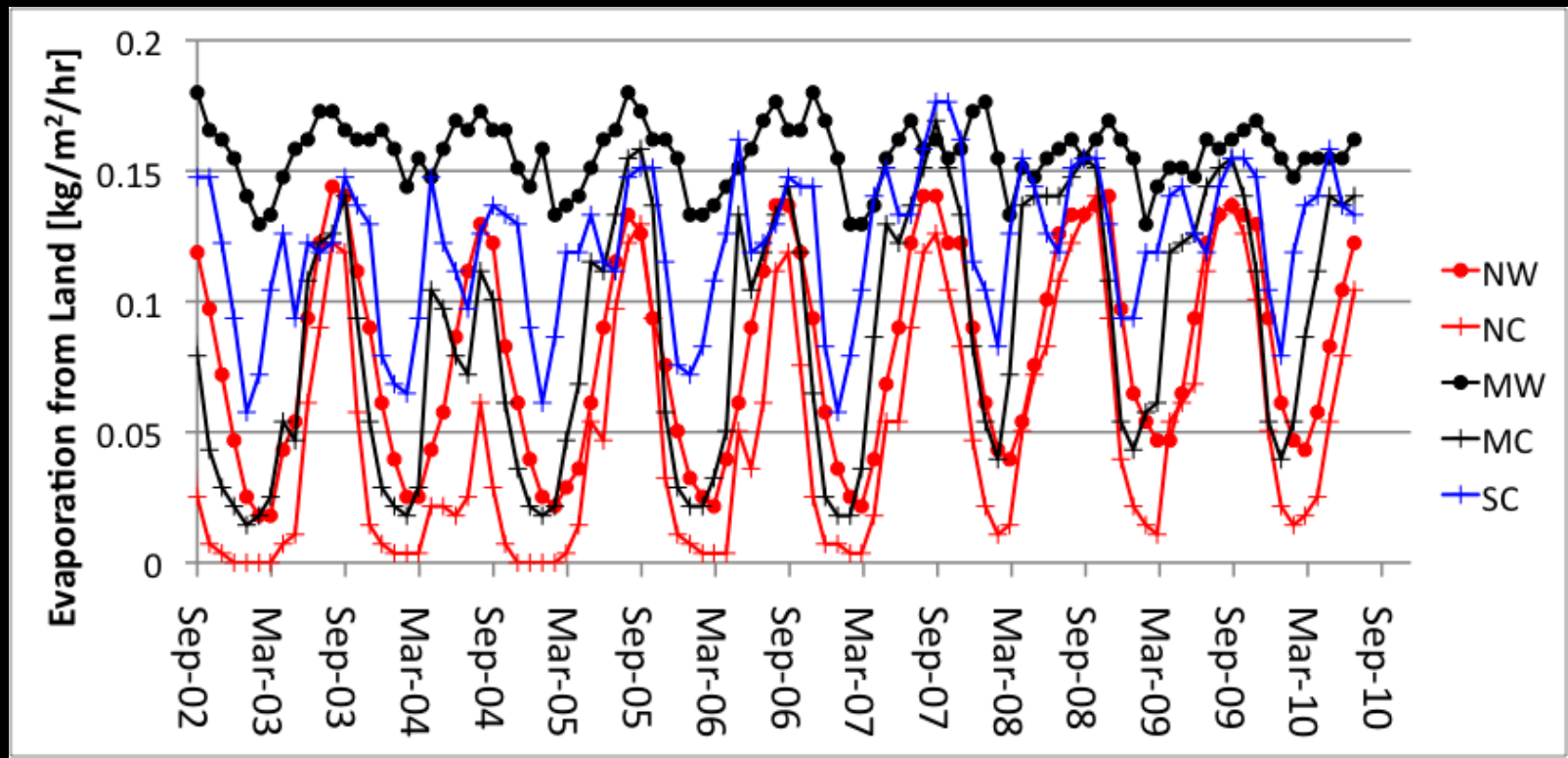




Preliminary Findings

- Time Series Analysis of Regionally Aggregated Monthly Mean Satellite Measurements Shows That:

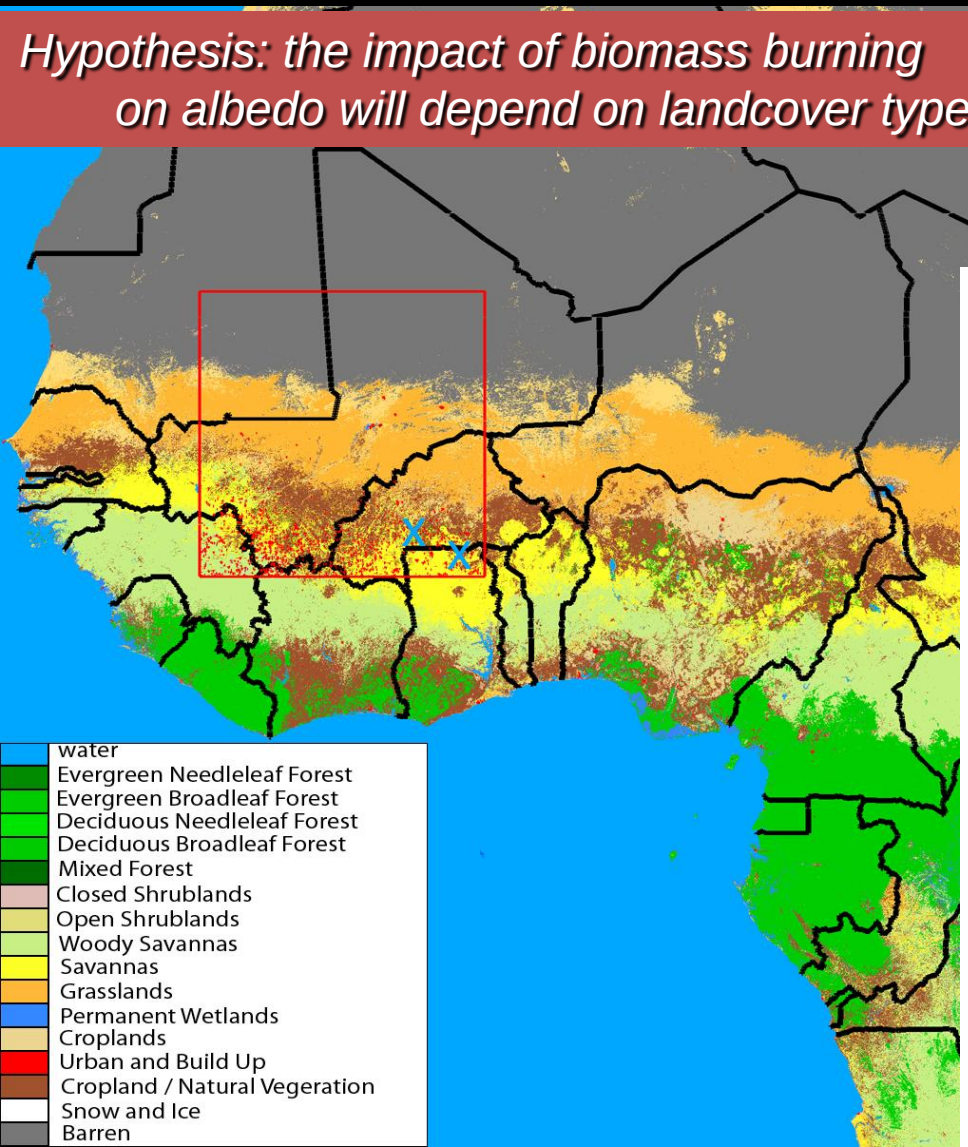
- Fire activity appears to show a slightly decreasing trend in the Central and Eastern parts of the NSSA region starting in 2006/7.

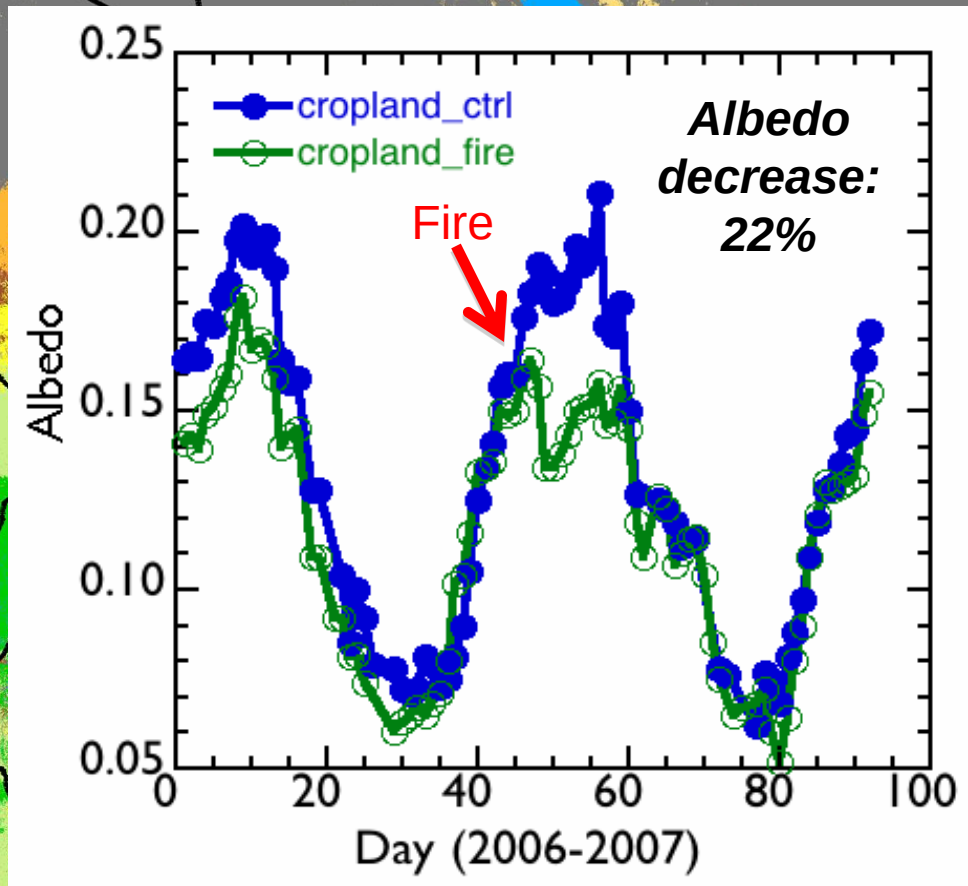
- This decrease in fire activity coincides with precipitation: increase in the Western, no change in the Central, and decrease in the Eastern parts of the NSSA.

- Surface evaporation minima appear to have increased during the same period in the Western and Central parts.

Landcover type and Albedo Change

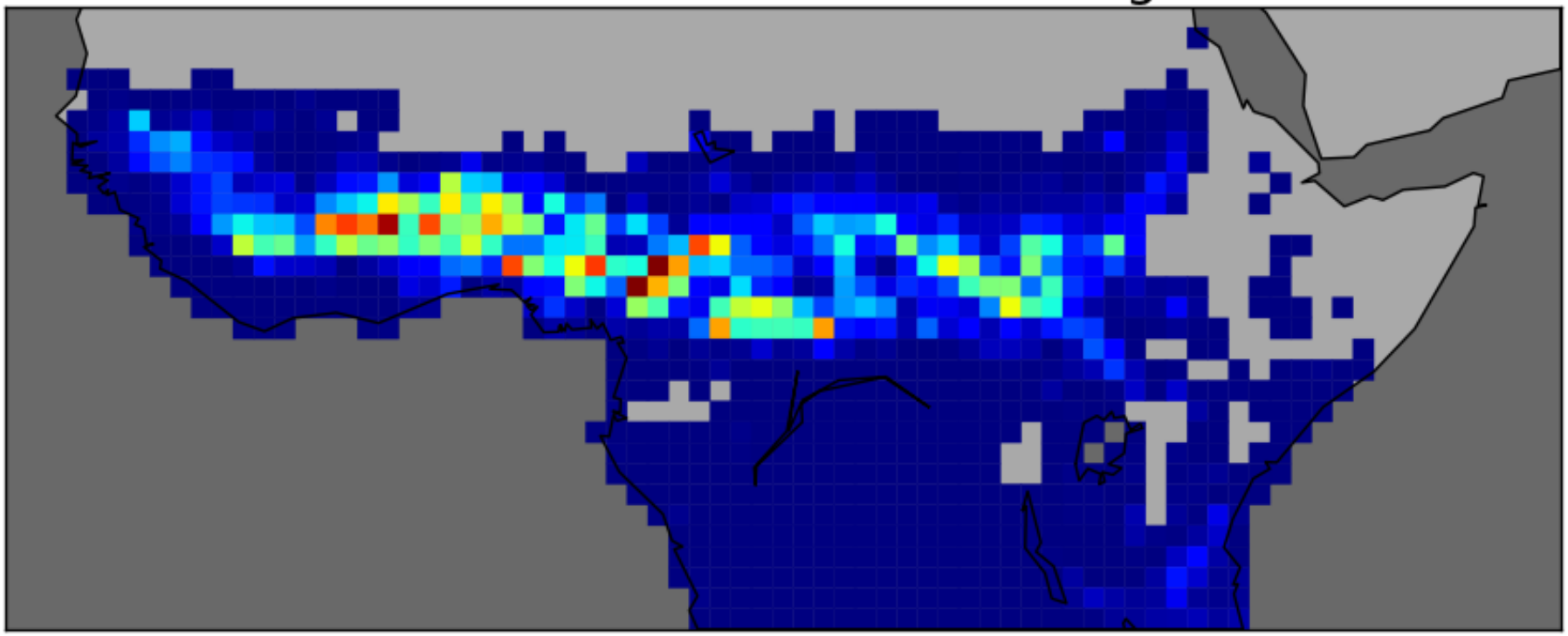
Hypothesis: the impact of biomass burning on albedo will depend on landcover type



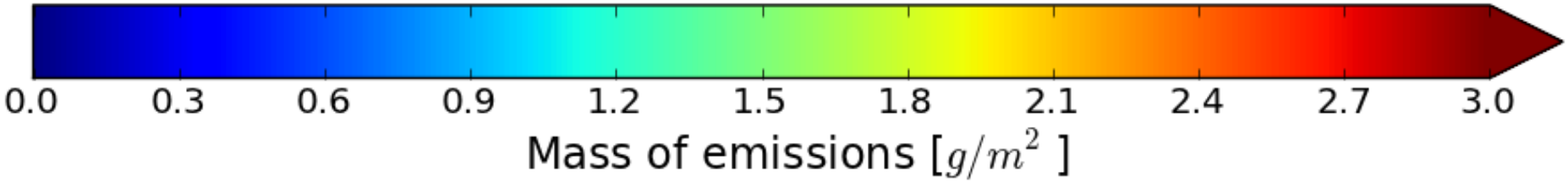


Smoke Particulate Emissions from fires

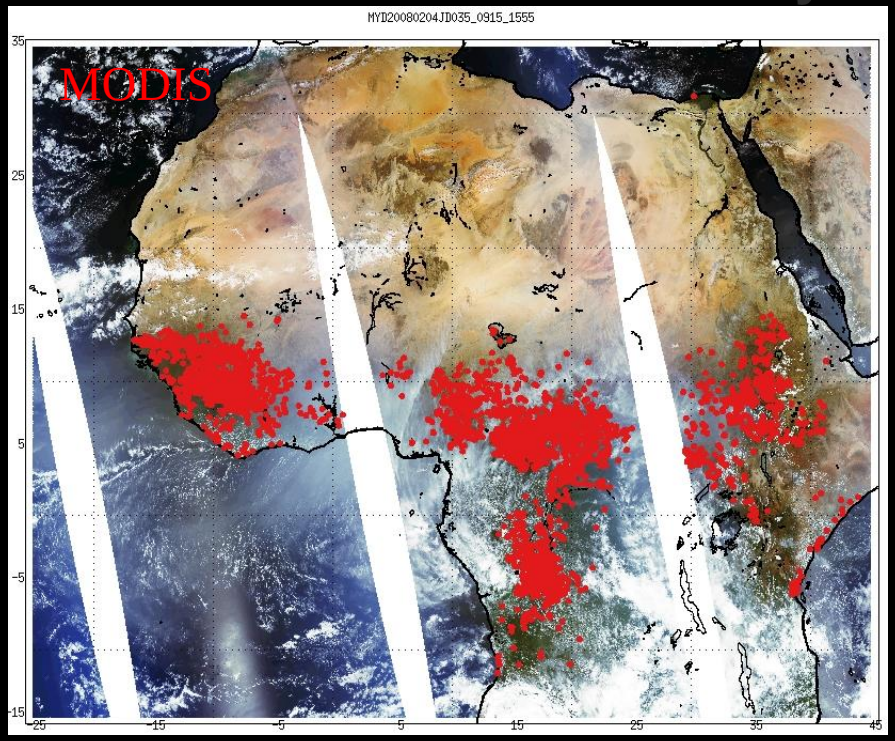
in Northern Sub-Saharan Africa during Dec 2009

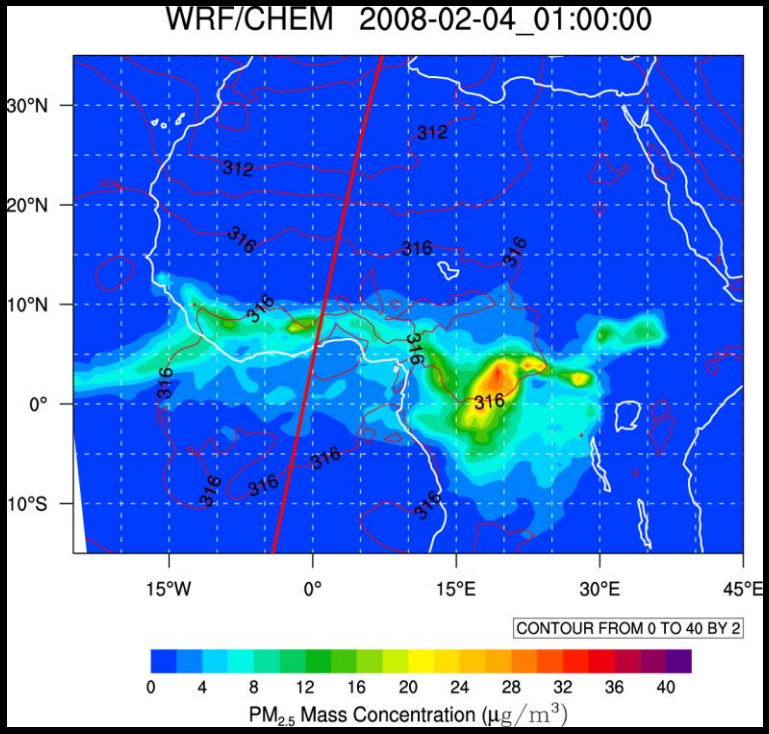


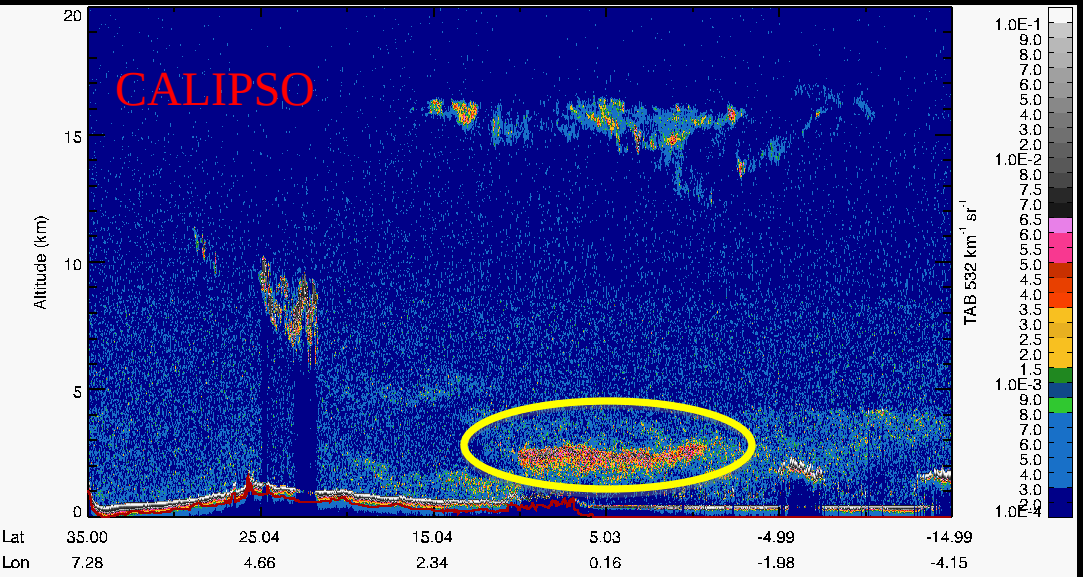
Total emissions: 2.98 Tg

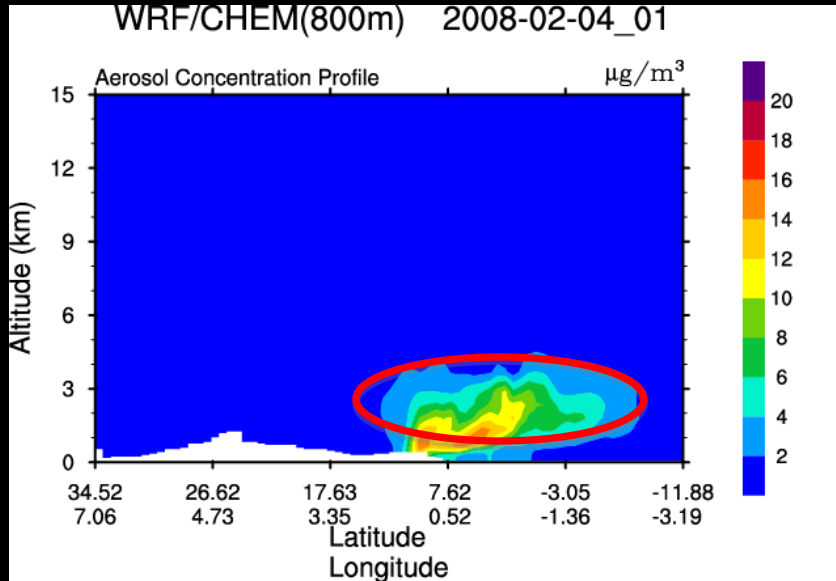


Fire and Plume Observation and Modeling Synergy







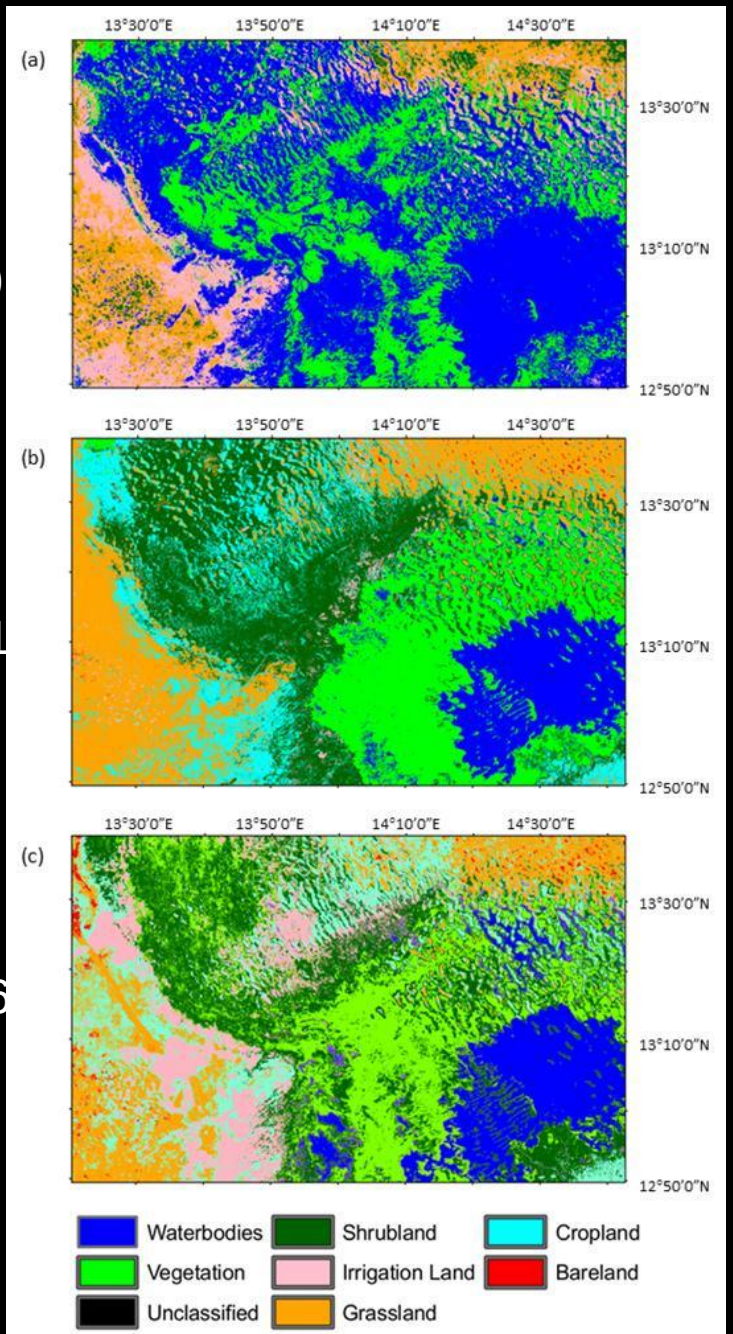


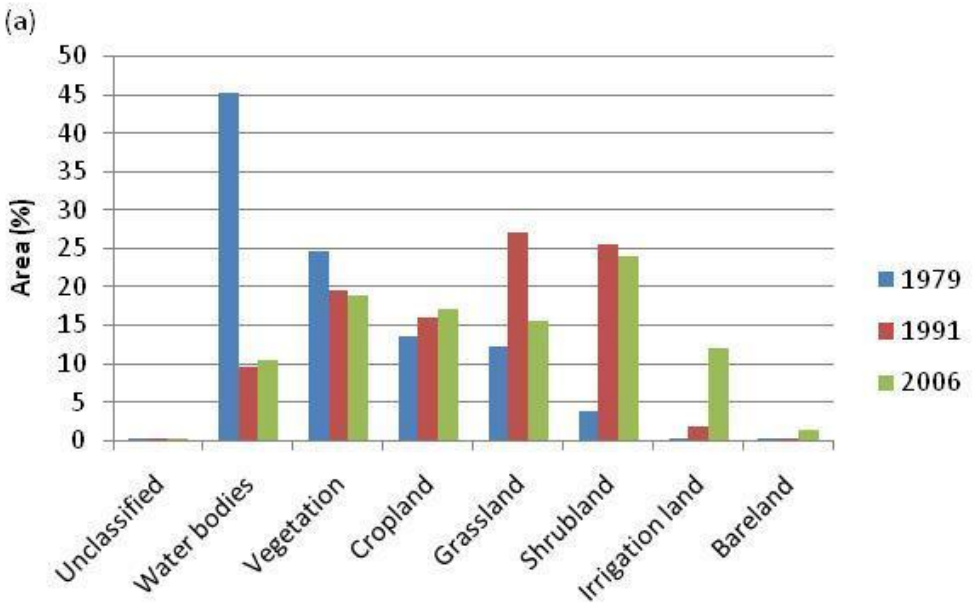
Land cover change around Lake Chad

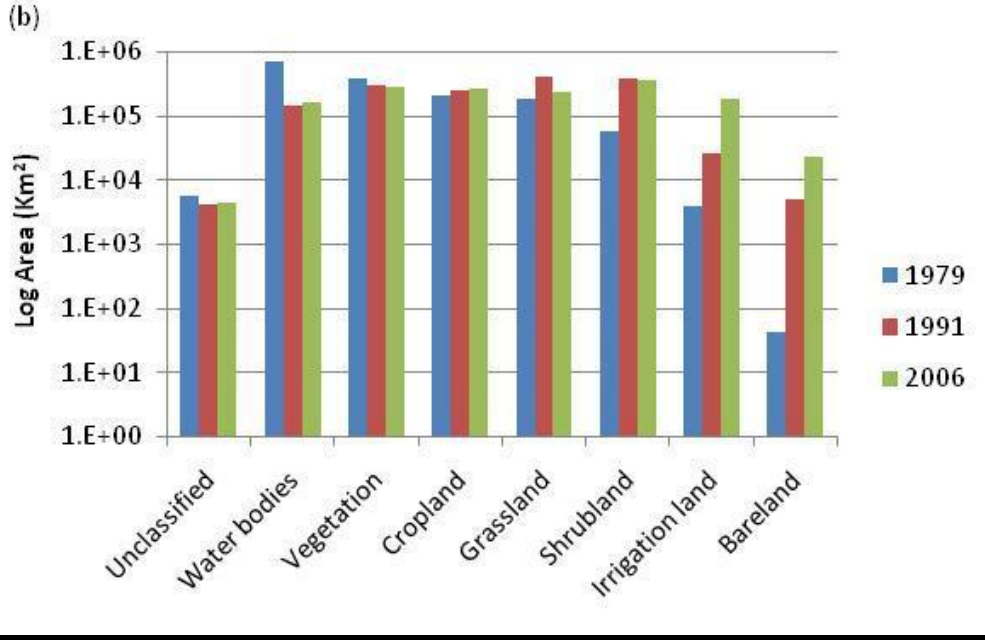
1979

1991

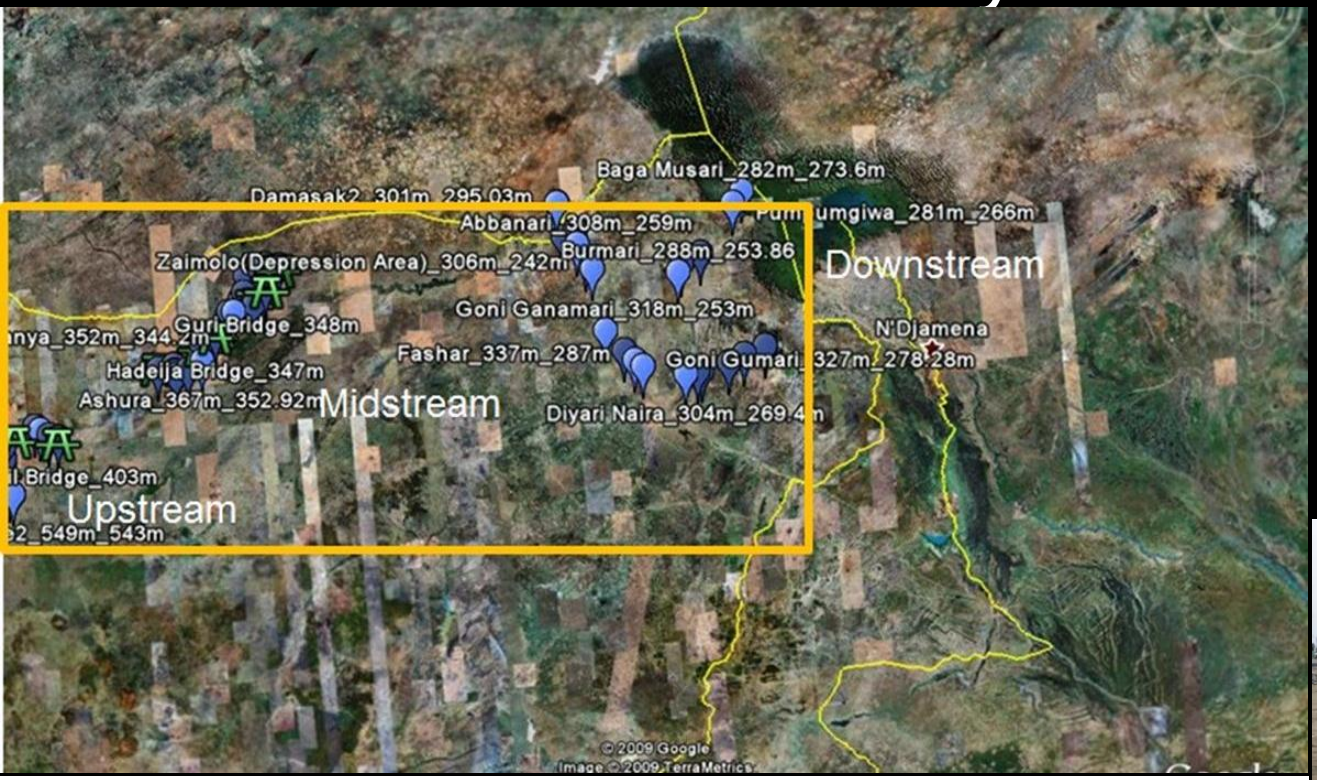
2006

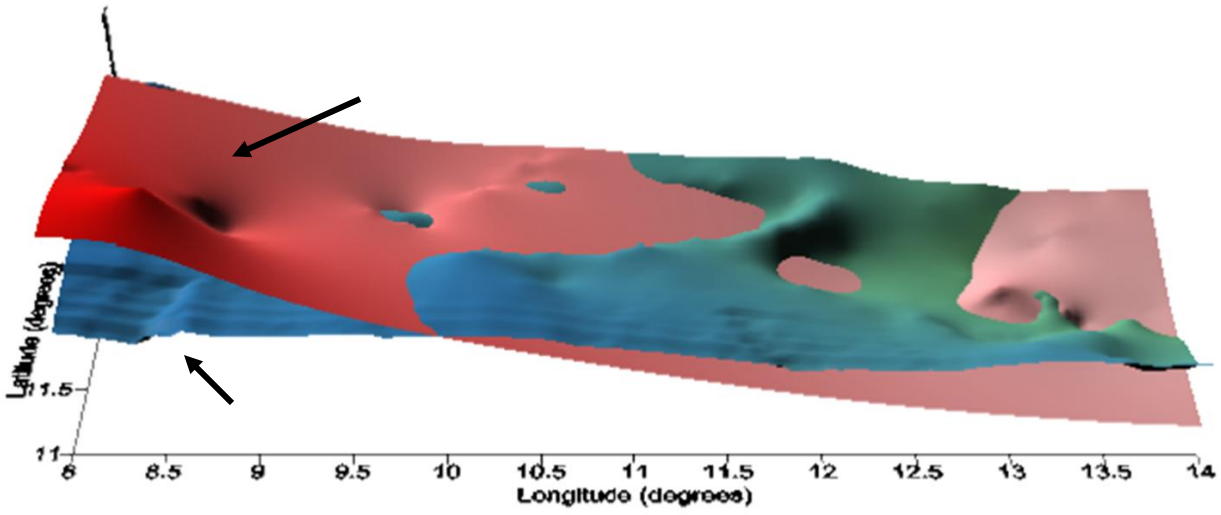






Groundwater Field Survey in the summer of 2009





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.