

Response of Himalayan ecosystems to global change based on 1982-2006 satellite data

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Background

- Human induced shift in the Earth's physical, chemical, and biological environment
- Dieback of the Amazon rainforest, greening in higher latitudes and increase in extreme climatic events; largely attributed to global change drivers such as rising atmospheric CO₂, increasing air temperatures, changes in rainfall regimes, and increasing nutrient deposition.
- The predictions about the scale and velocity are continually being revised upwards; for eg. Horizontal velocity of temperature change – 0.42 km/yr

Background (*contd.*)

- **High elevation environments - significant variation in climatic, cryospheric, hydrological, and thereby ecological properties over relatively short distances**
- **Because temperature decreases with altitude by 5–10⁰ C/km, a first-order approximation regarding the response of vegetation to climate change is that species will migrate upwards to find climatic conditions in tomorrow's climate which are similar to today's**
- **The high elevation areas are also vulnerable to local changes due to population and economic growth.**
- **Very difficult to ascertain whether the observed changes is due local drivers or global drivers!!**

Background (*contd.*)

- **Protected Areas (PAs) - only areas to disentangle the impact of macro scale physical phenomena from the local drivers of change.**
- **Since PAs have limited human presence or activities, the forces which are acting could certainly be an external driving force.**
- **Development of mitigation and adaptive measures against climate change based on PAs have widely been accepted, but its role in monitoring of global change processes have rarely been addressed.**

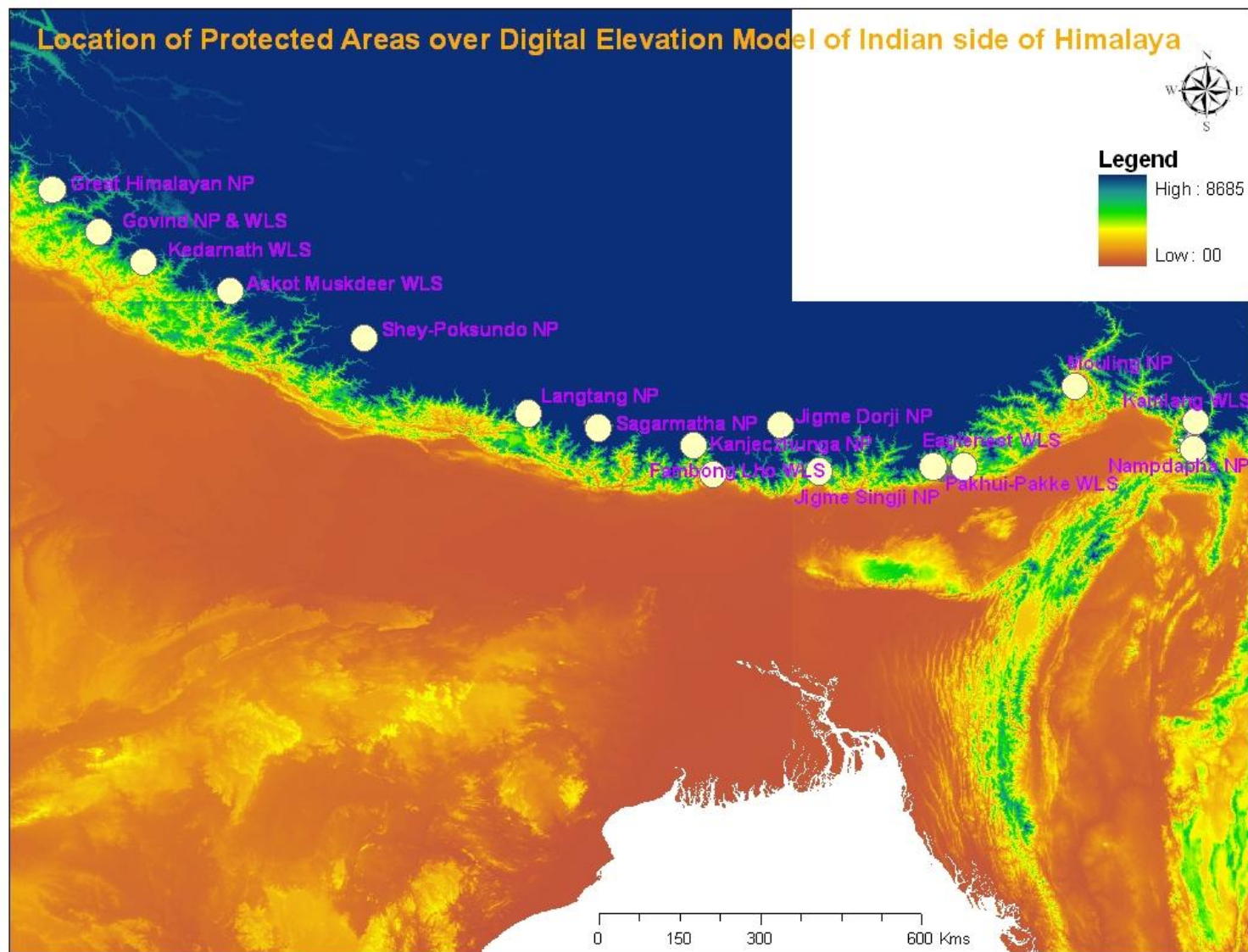
Objective

- To characterize the trends in biophysical response (greening) in protected areas of Himalayas across an elevation gradient.

Hypothesis

- We hypothesize that the ecosystem productivity at higher elevations is constrained by temperature relative to lower elevations, and therefore, the effect of global warming on greening trend should be more pronounced at higher elevations.

Study area



Data sources

- **NDVI Datasets - AVHRR 8-km NDVI data from 1982 to 2006 available from the Global Inventory, Monitoring, and Modeling Studies (GIMMS) database. These data are available as maximum NDVI values for each 8 x 8 km pixel from each 15-day composite period.**
- **Elevation data - obtained from the ASTER Global Digital Elevation Model (GDEM). This data is having a spatial accuracy of 30 m and vertical accuracy of 20 m.**

Methods

- 1. All the NDVI pixels which are falling within the PA were extracted. The maximum NDVI attained in a year was used for the analysis to avoid atmospheric and topographic distortions.**
- 2. The corresponding elevation values were obtained from ASTER data by subsetting the tiles ($1^0 \times 1^0$) to the size of NDVI pixels i.e., 8 x 8 km.**
- 3. Seasonal Trend Decomposition using LOESS (STL) technique - to analyse the changes in NDVI with respect to time.**
- 4. Sen slope estimator - assess the rate of greening across elevation gradient.**

Seasonal Trend Decomposition using LOESS (STL)

$$Y_{year,month} = T_{year,month} + S_{year,month} + R_{year,month}$$

Where,

$Y_{year,month}$ - observed value for a given year and month

$T_{year,month}$ - the trend component

$S_{year,month}$ - the seasonal component

$R_{year,month}$ - the residual component

Sen slope estimator

The technique involves computing slopes of NDVI over time for all pairs of time intervals and then calculating the median of all these slopes as an estimate of magnitude and direction of change in NDVI over the entire time period.

$$Q_i = \frac{x_j - x_k}{j - k} \quad \text{where } x_j \text{ and } x_k \text{ are data values at times } j \text{ and } k \text{ respectively, and where } j > k.$$

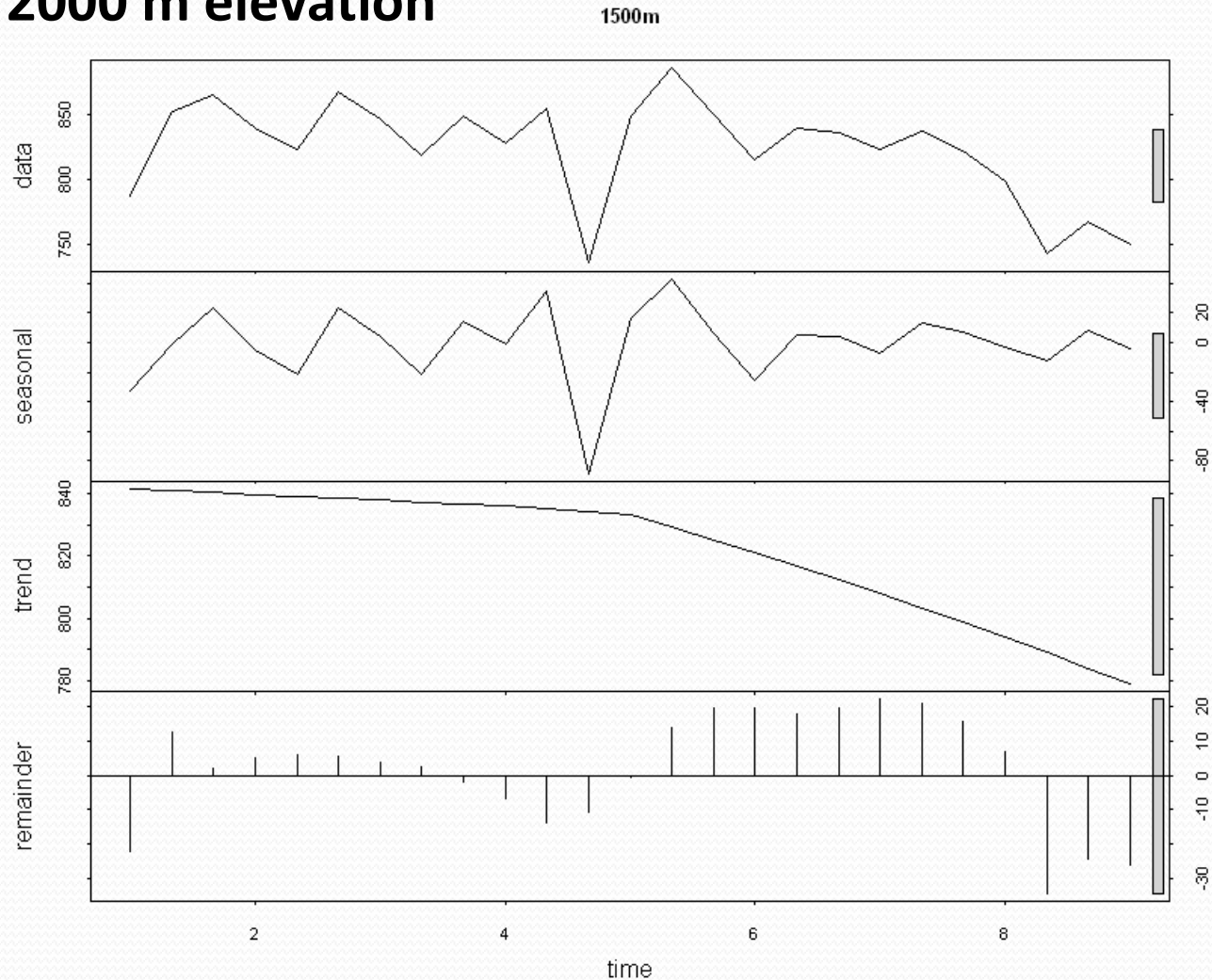
If there are n values of x_j in the time series, we get as many as N slope estimate Q_i where

$$N = \frac{n(n-1)}{2}$$

The median of these N values of Q_i is Sen's estimator of slope. This method is not greatly affected by gross data errors or outliers. It also allows determination of the median slope is statistically different from zero or not.

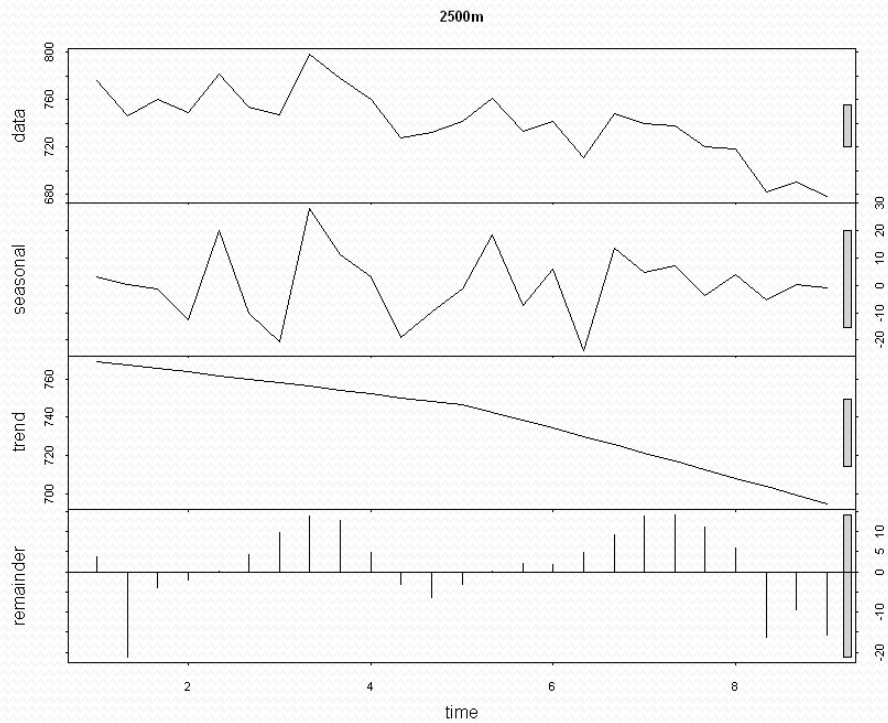
Results - Seasonal Trend Decomposition using LOESS (STL)

i. < 2000 m elevation

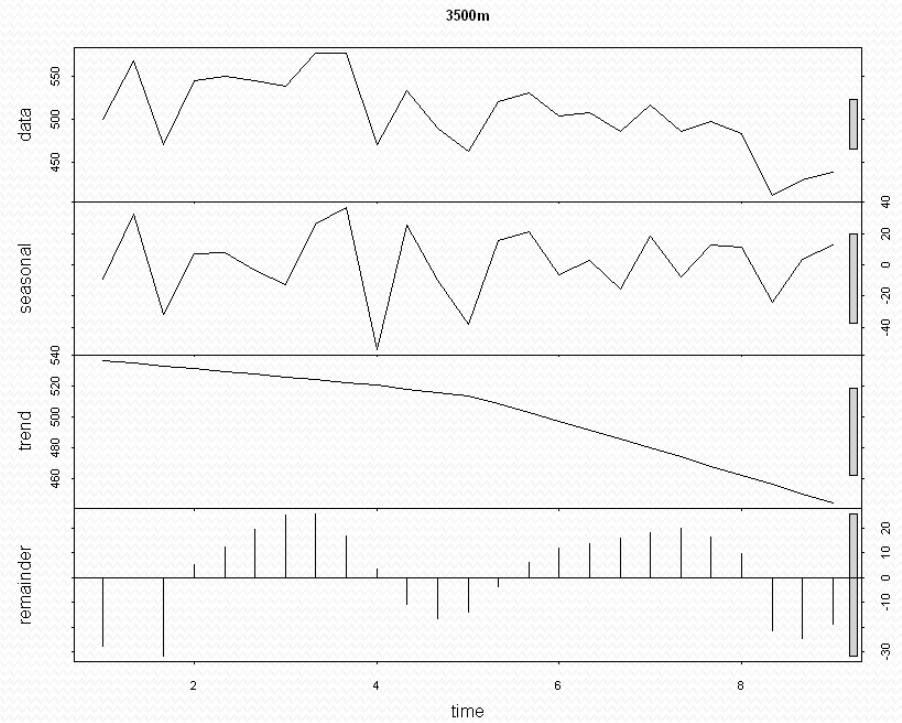


Results - STL

ii. 2000 – 3000 m elevation

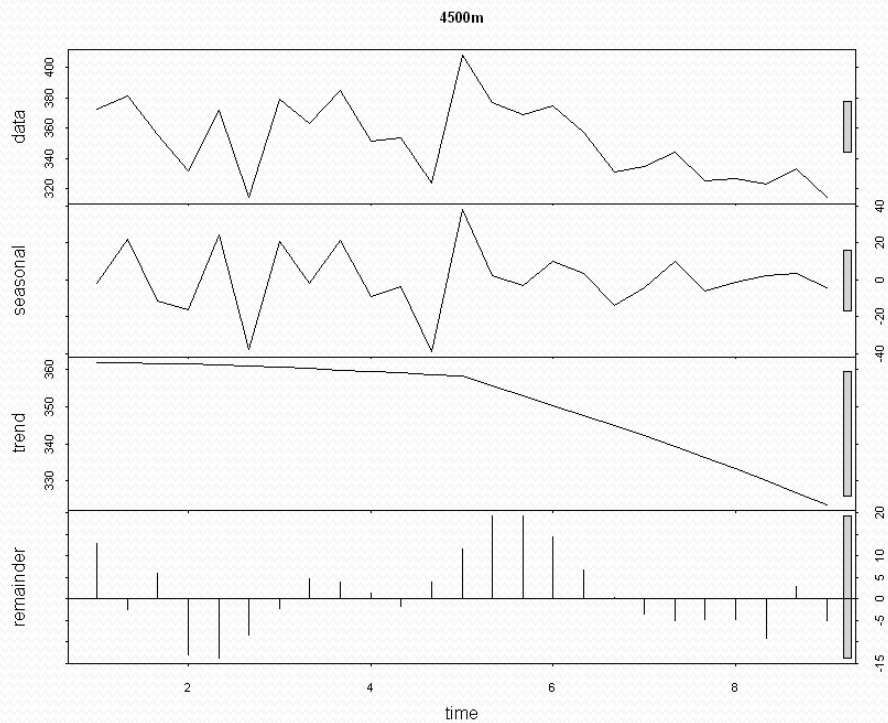


iii. 3000 – 4000 m elevation

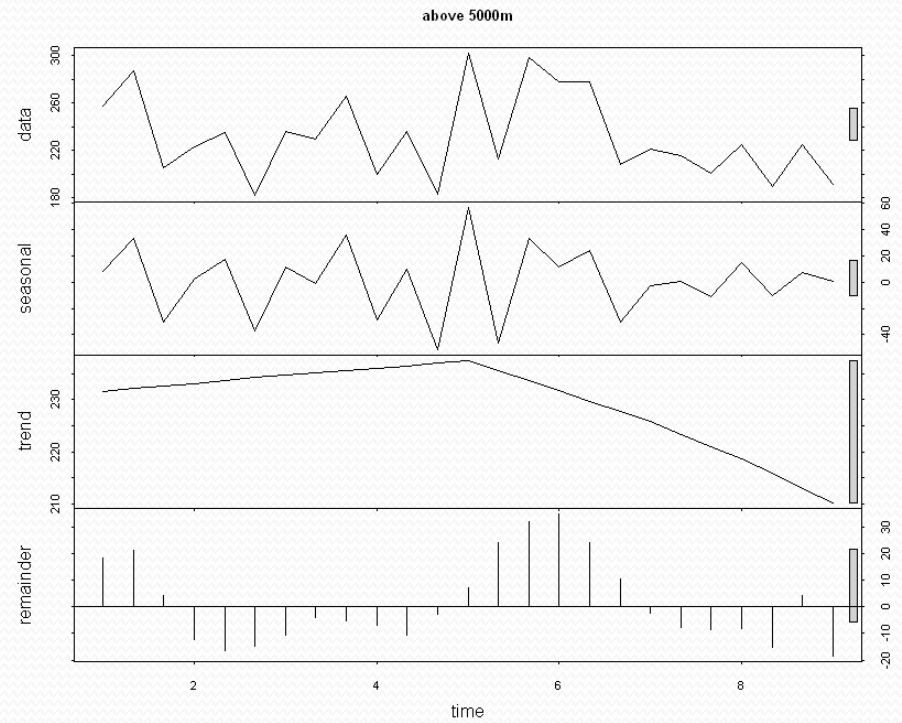


Results - STL

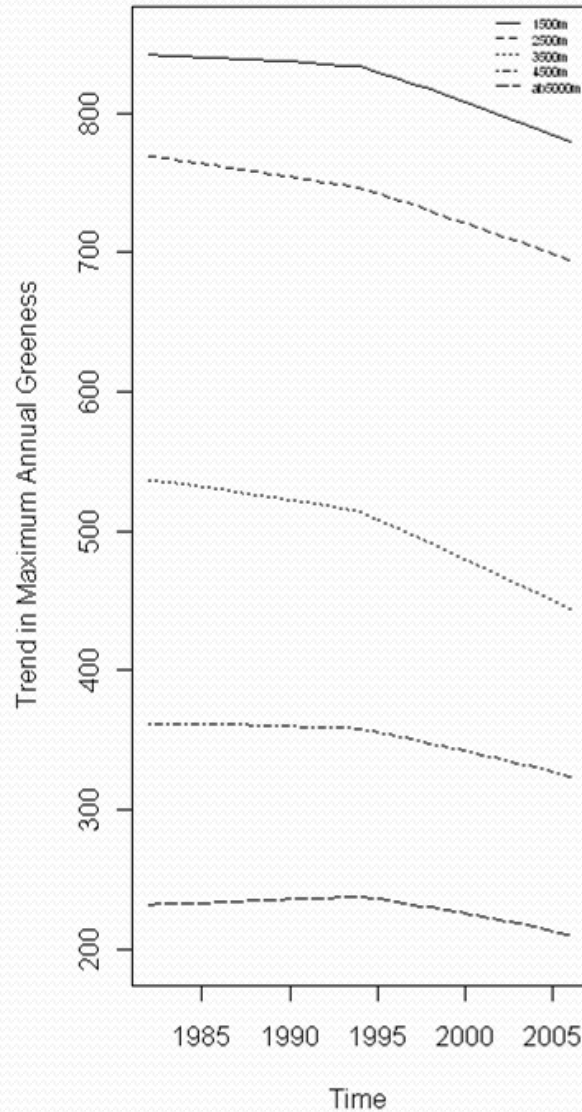
iv. 4000 – 5000 m elevation



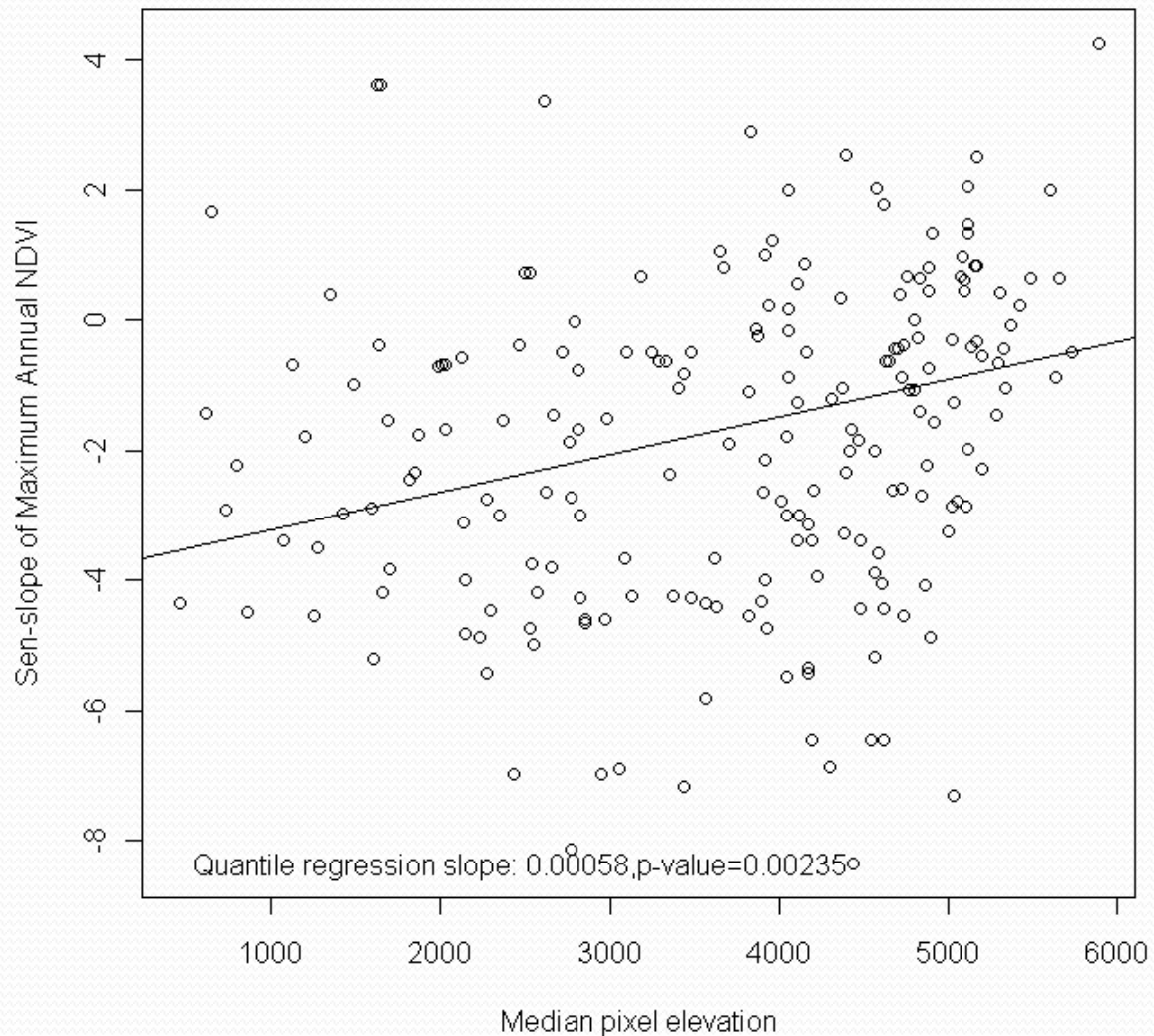
v. > 5000 m elevation



Trend across elevations



Sen slope estimate



Conclusion

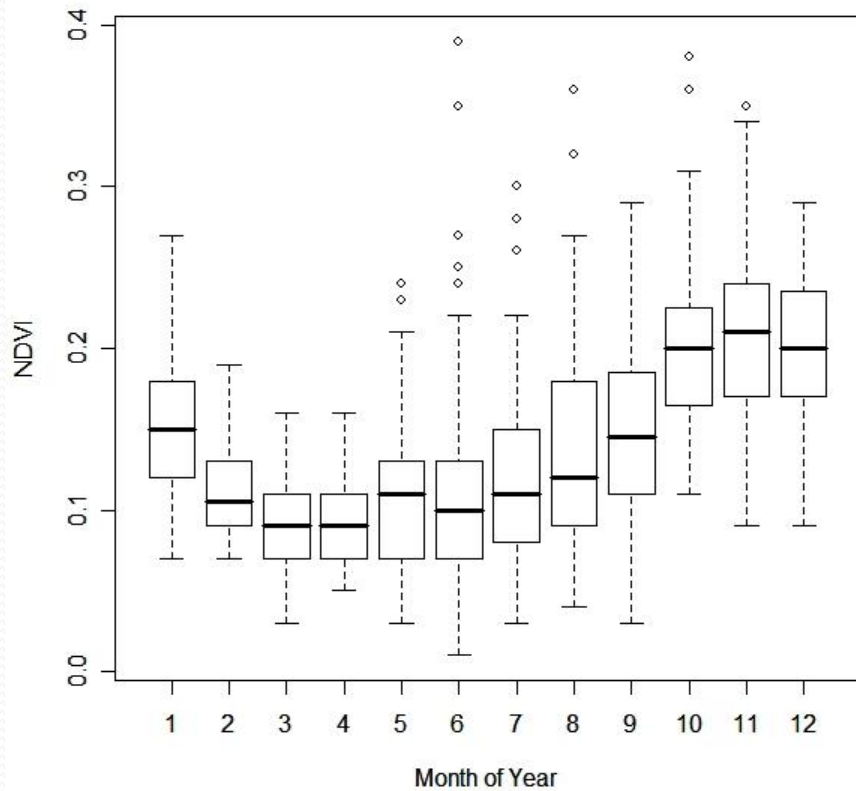
- The pilot study on response of Himalayan ecosystems to global change indicated two major trends. i.e., decrease in NDVI with respect to time (1982-2006) and increase in NDVI across elevation gradient during the same time period
- The negative greenness trend from 1982-2006 might be due to - decrease in precipitation, cloud dynamics and changes in IPAR, and/or biotic pressure and associated land cover change ??
- The positive greenness trend across the elevation gradient could be as result of recent warming in global average temperature.
- Further research is required to identify the exact **reasons of greenness change** over protected areas of Himalaya.



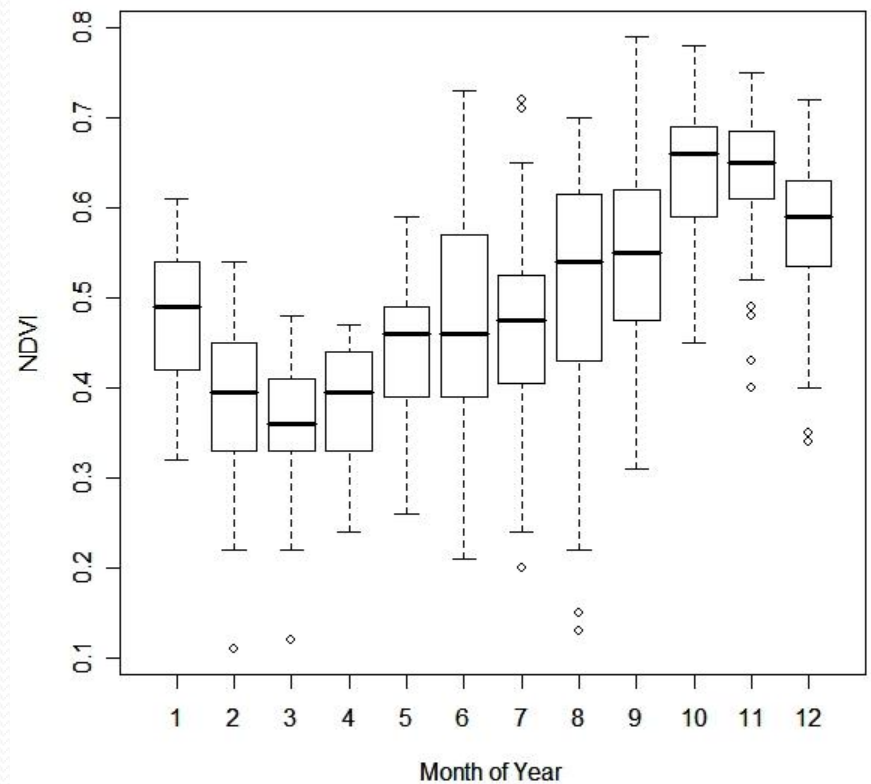
Thank You

Preliminary findings

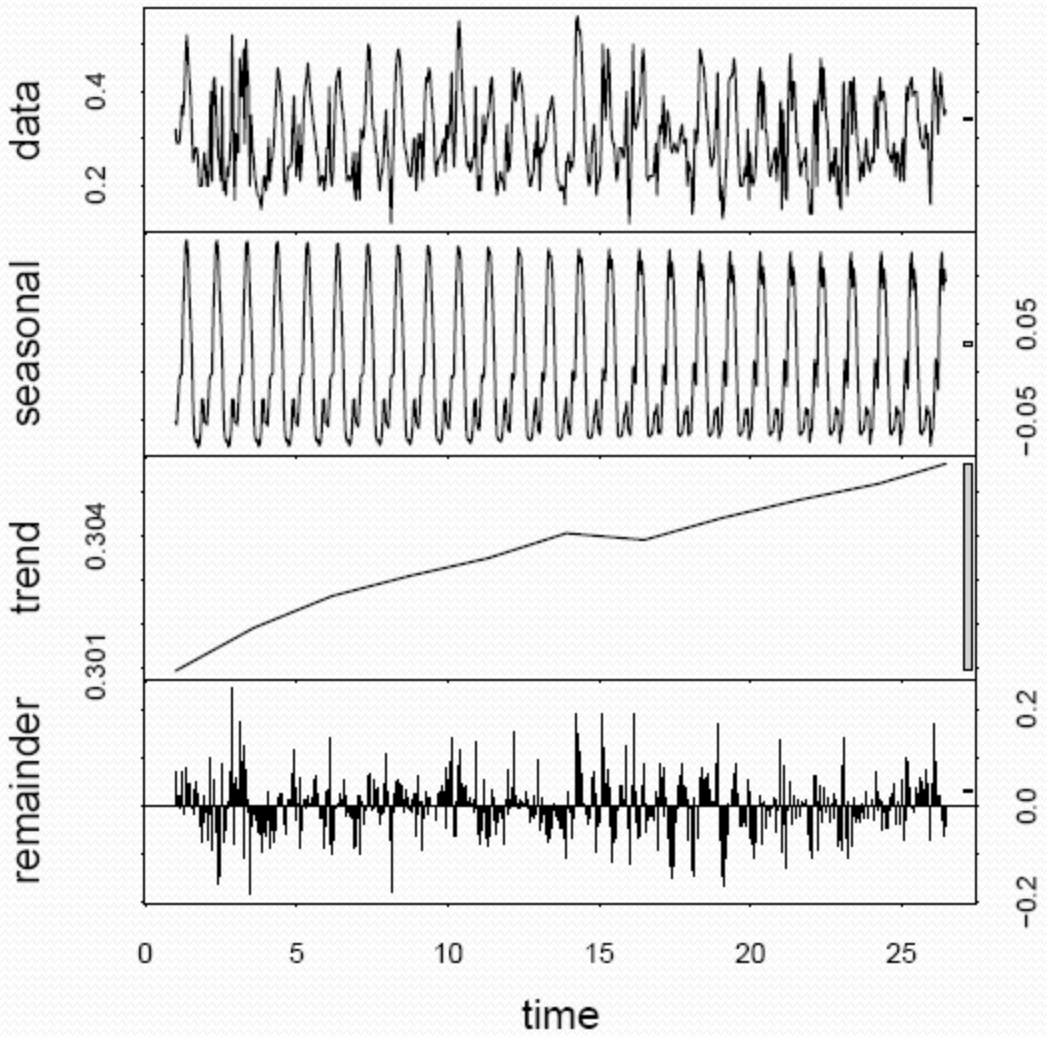
Shingba WLS, Sikkim



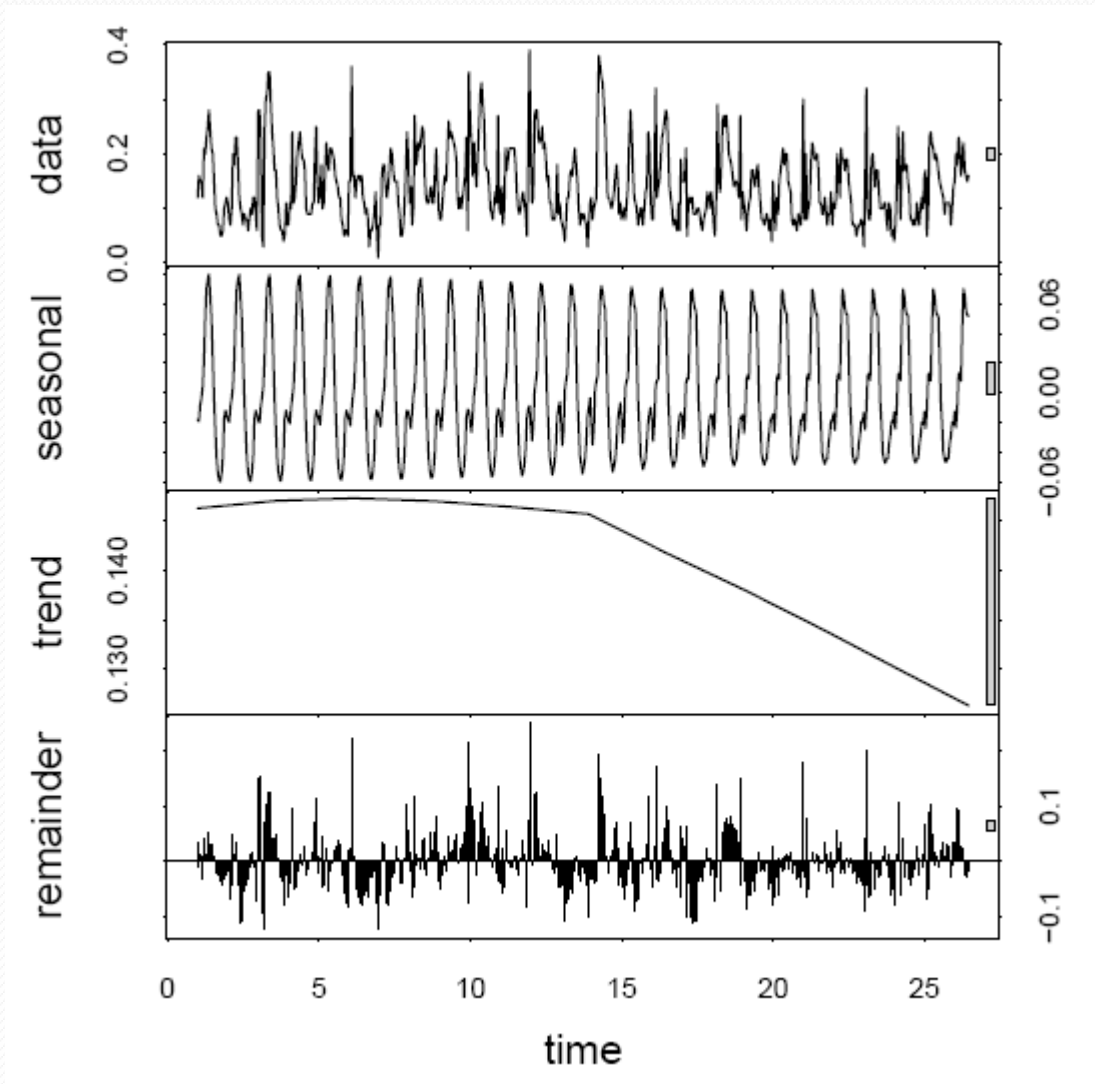
Barsay WLS, Sikkim



Khangchendzonga NP – Median elevation: 4061m

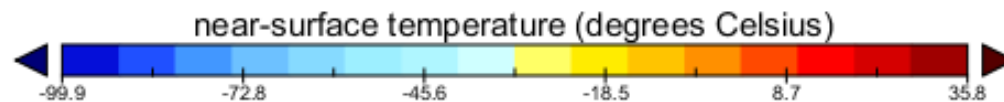
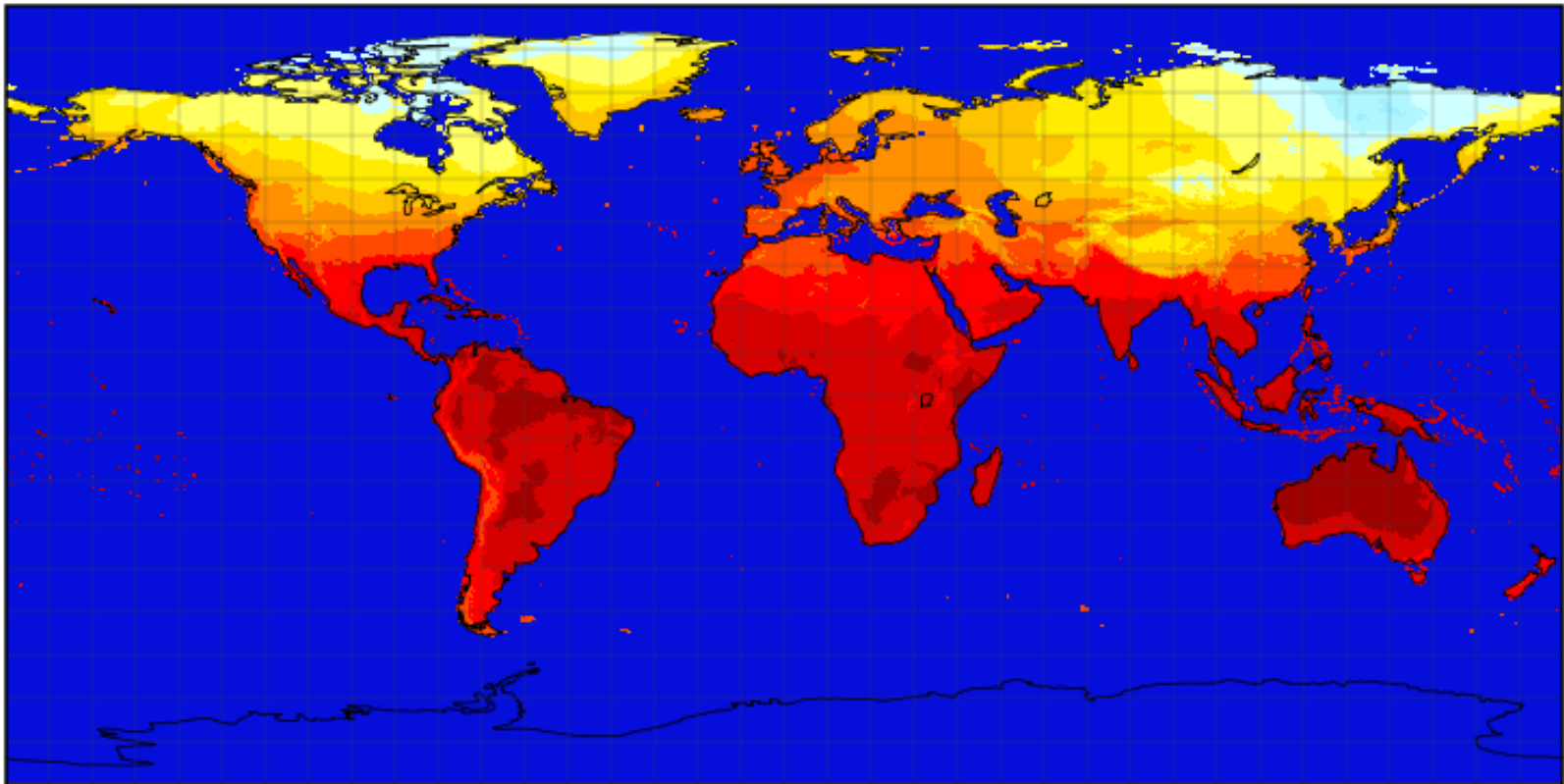


Fambong Lho WLS - Median elevation: 1628 m



Mean surface temperature – January, 2005

near-surface temperature



Data Min = -99.9, Max = 35.8

Preliminary findings

Rate of Greening in the Himalayas

