# REMOTE SENSING OF CARBON STOCK AND CARBON SEQUESTRATION POTENTIAL IN SOUTHERN AFRICAN FORESTS

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# Estimating NPP

- NPP is the amount of Carbon fixed per unit area per unit time and is a useful proxy for measuring carbon sequestration by terrestrial ecosystems
- NPP is the first step to removal of carbon dioxide from the atmosphere and turning it into biomass.
- Estimation of NPP has mainly been based on few experimental plots which are localized without a wider application in larger landscapes.
- Thus, there is need for methods that lead to fast and robust assessments of carbon fixation and storage.

## Estimating NPP

- **NPP = APAR * LUE**
  - APAR is Absorbed Photosynthetically Active Radiation and LUE is light use efficiency
- For APAR there is need to estimate shortwave radiation (SWR) and the fraction of Photosynthetically active radiation absorbed by vegetation (FPAR).
- SWR & LUE estimation has normally been based on weather stations & data are sparse.

## Estimating NPP

- In this study we used GIS and remote sensing (RS) methods based on MODIS to estimate “continuous field” SWR and LUE respectively
- We also used NPP to estimate forest carbon stocks based on the NPP-Standing carbon relationship
- Standing carbon was estimated using the indirect method based on 9 carefully selected areas in spread over southern Africa
- We used MODIS NPP and NOAA AVHRR NDVI relationship to estimate NPP and then carbon stock based on NPP-Carbon relationship

# MATERIALS AND METHODS

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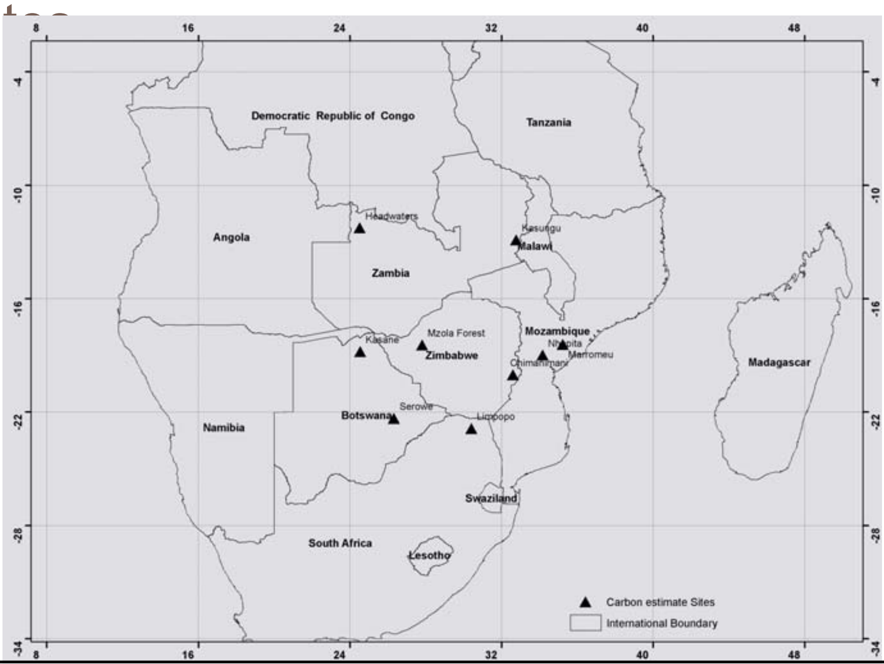
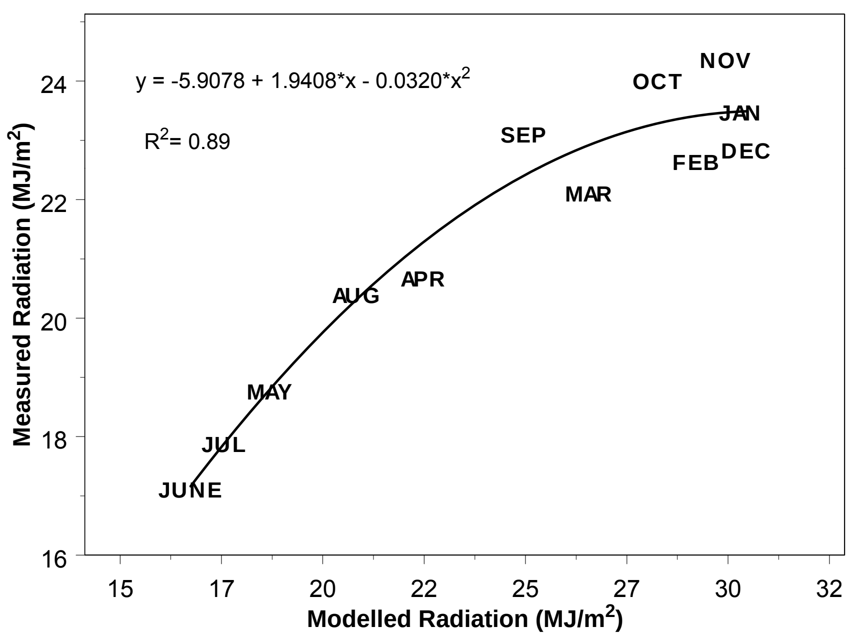
## Study Area and Carbon estimation si



# Shortwave Radiation Modeling

- The GIS DEM based model that uses solar altitude angle (α), solar azimuth angle (θ), angle of latitude (L), and solar declination angle (∂s), as well as hour angle (φh) to calculate the amount of radiation received at a given surface per month given the location's slope and aspect was used (Kumar et al,1998).

# Validation of modelled SWR



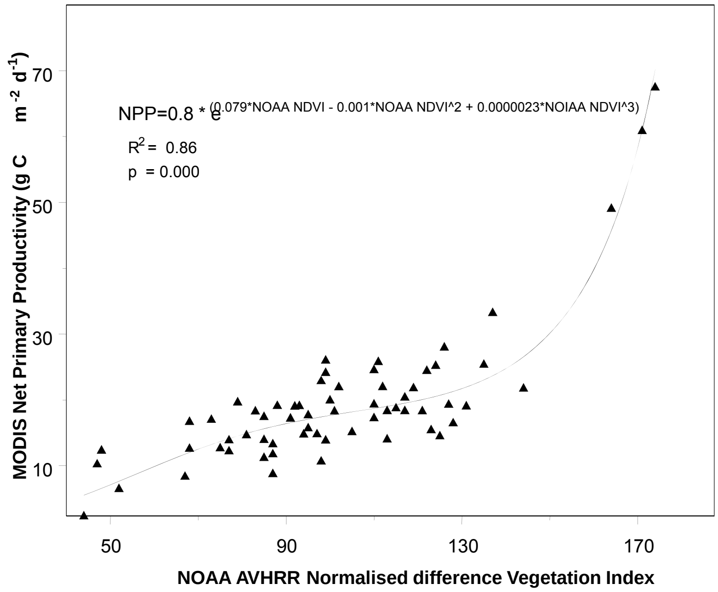
## Modelling LUE

- We use a scaled Photochemical reflectance index (PRI) based on MODIS bands 11 (531nm) and 12 (570nm):
  - **PRI= ((*R531- R570)/ (R531+R570) +1)2***
- Reflectance of green leaves at 531 nm is related with the epoxidation state of the xanthophyll cycle pigments involved in foliar photosynthetic light regulation through the heat dissipation mechanisms of leaves.

## Estimation of NPP

- **NPP(**g C $m^{-2}$ $d^{-1}$ **) =0.5139(PRI*APAR)-1.9818**
- **APAR =FPAR*PAR**
- **FPAR = 1.24*NDVI-0.168**
- **PAR = 0.5*SWR**

# MODIS NPP vs. NOAA AVHRR NDVI




# Carbon estimates for 9 sites in Southern Africa

- AGB=GS x WD x BEF (Source: IPCC)
- BGB=AGB x R (Source: IPCC)
- Where: AGB=Above Ground Biomass (tons), BGB=Above Ground Biomass, GS=Growing stock ($m^3$ over bark), WD=Basic wood density ($t/m^3$), BEF=Biomass expansion factor (1.5), R=Root/Shoot ratio (0.25)
- For carbon a 0.5 default value was used

# IPCC based carbon estimates for 5 sites

The Gross Tree stem Volume (growing stock) has been calculated as:

$Dbh^2/4 * \pi * H_{tot} * \pi * f_{gross}$

Where

| | | |
|---|---|---|
| Dbh | = | Tree diameter at breast height |
| $H_{tot}$ | = | Tree total height |
| $\pi$ | = | 3.1416 |
| $f_{gross}$ | = | 0.74 |

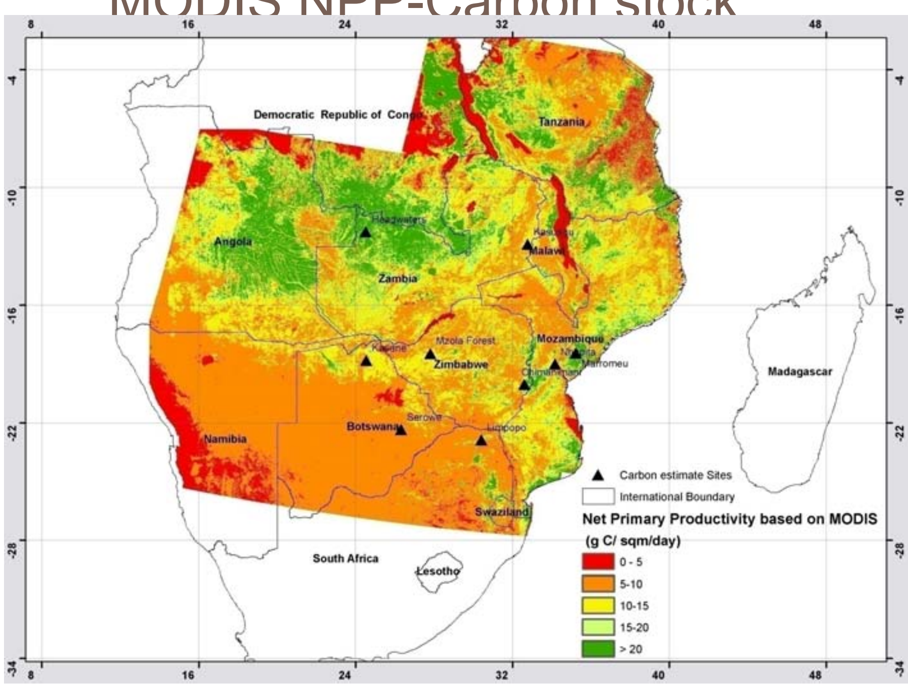
# Predicting Carbon stock from NPP

- Regression analysis was used to predict carbon stock from NPP
- Regression applied in a GIS to spatially predict carbon stock using the NPP map as a predictor

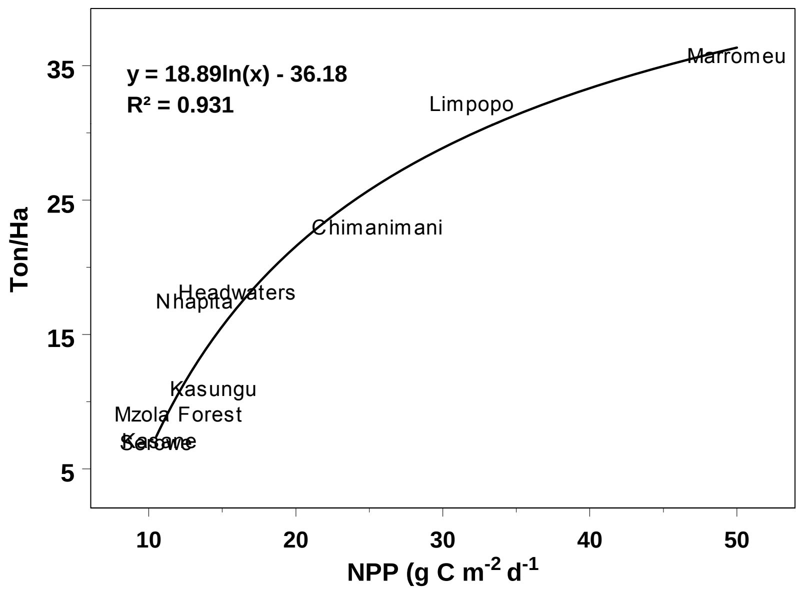
# CARBON STOCK AND CARBON SEQUESTRATION IN SOUTHERN AFRICA

**Amon Murwira & team from WWF SARPO, Zambia (J. Mukosha & Masinja) and Botswana (D. Lesole)**

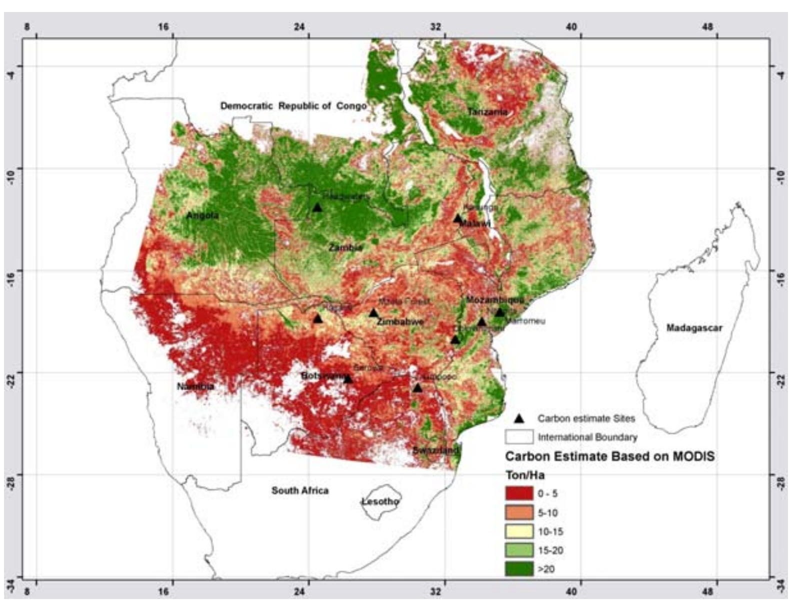
# MODIS NPP-Carbon stock



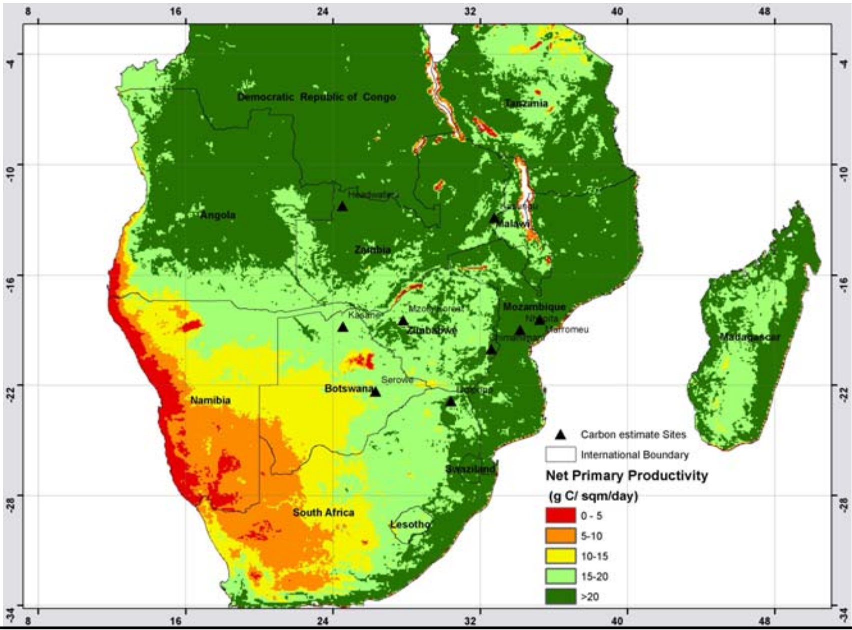
# MODIS NPP-Carbon stock relationship



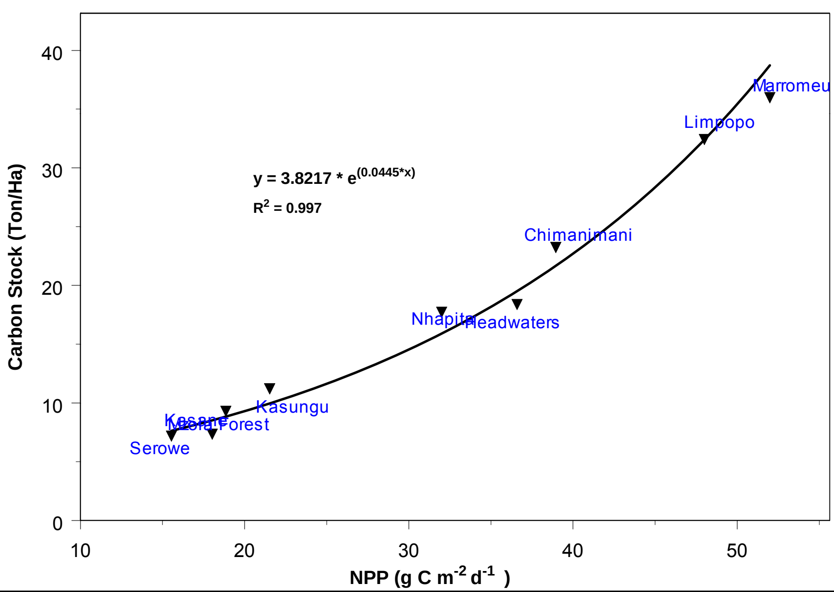

# MODIS NPP-Carbon stock



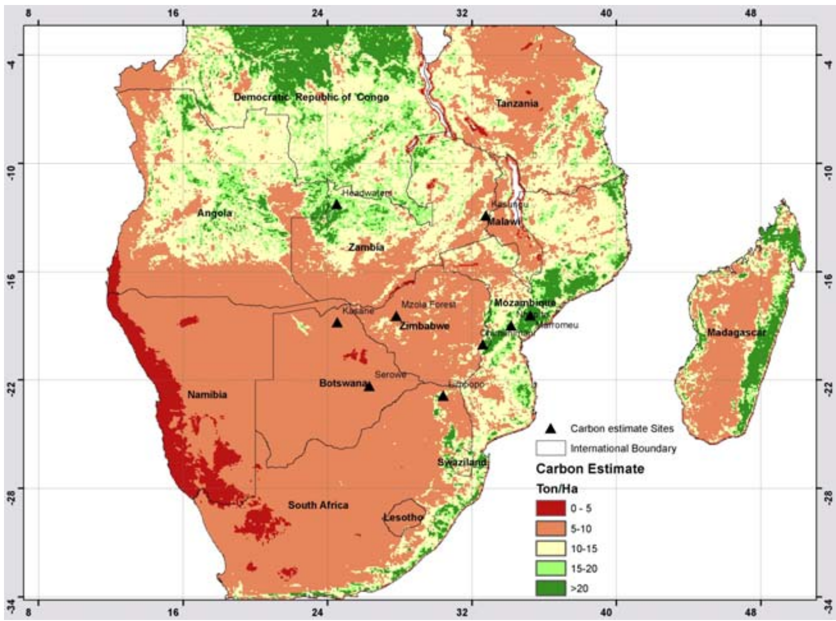
# MODIS-NOAA NDVI: NPP




# MODIS-NOAA NDVI (NPP)-Carbon stock relationship



# MODIS-NOAA NDVI: Carbon stock




# Discussion & Conclusions

- Modelled radiation significantly related with measured radiation giving confidence to our NPP estimates
- We successfully used remotely sensed NPP to estimate carbon stock in Southern Africa based on the NPP-Carbon relationship
- Remote sensing and GIS in combination with ground samples important in the improving mapping of carbon

Thank You for your Attention