Modelling NPP and NPP- proxies

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Outline

$$\mathbf{NPP = GPP - R_a}$$

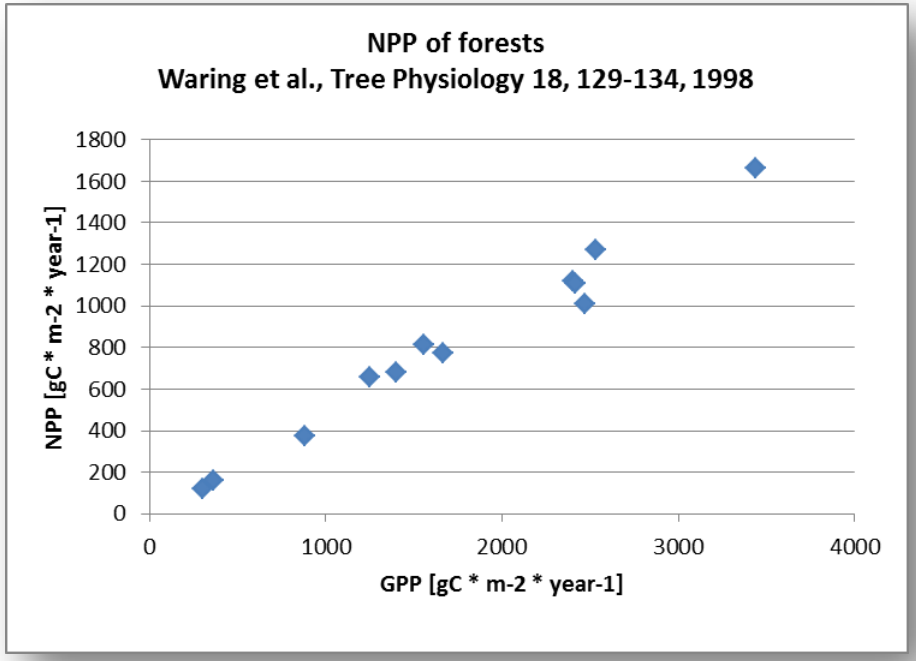
NPP: Net Primary Productivity [gC * m-2 * time.step-1]

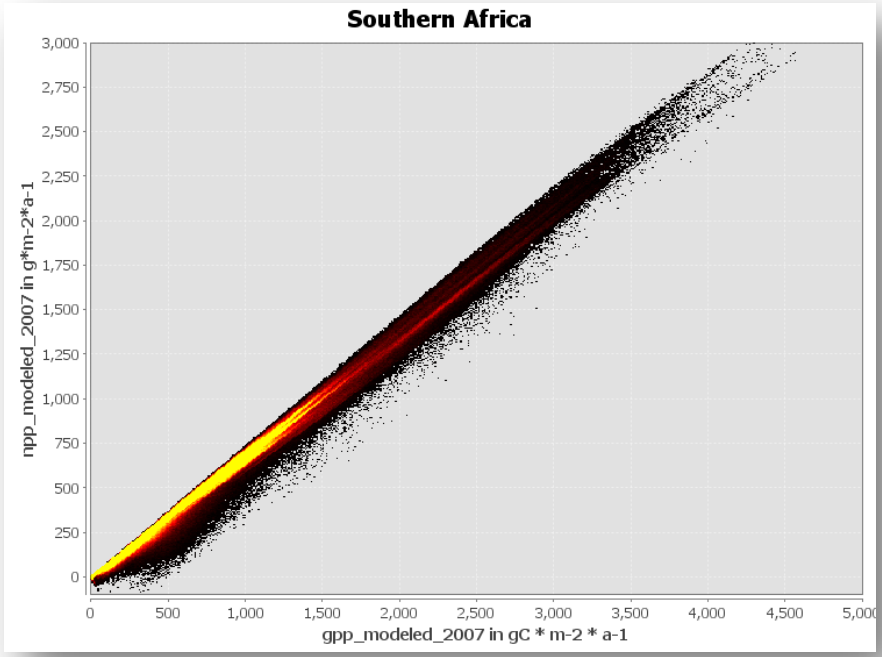
GPP: Gross Primary Productivity

R_a: Autotrophic respiration

- **Some NPP-proxies**
  - Precipitation
  - Temperature
  - Vegetation length
  - LAI (or fAPAR)
  - Leaf chlorophyll
- **Modelling NPP**

NPP ~ GPP



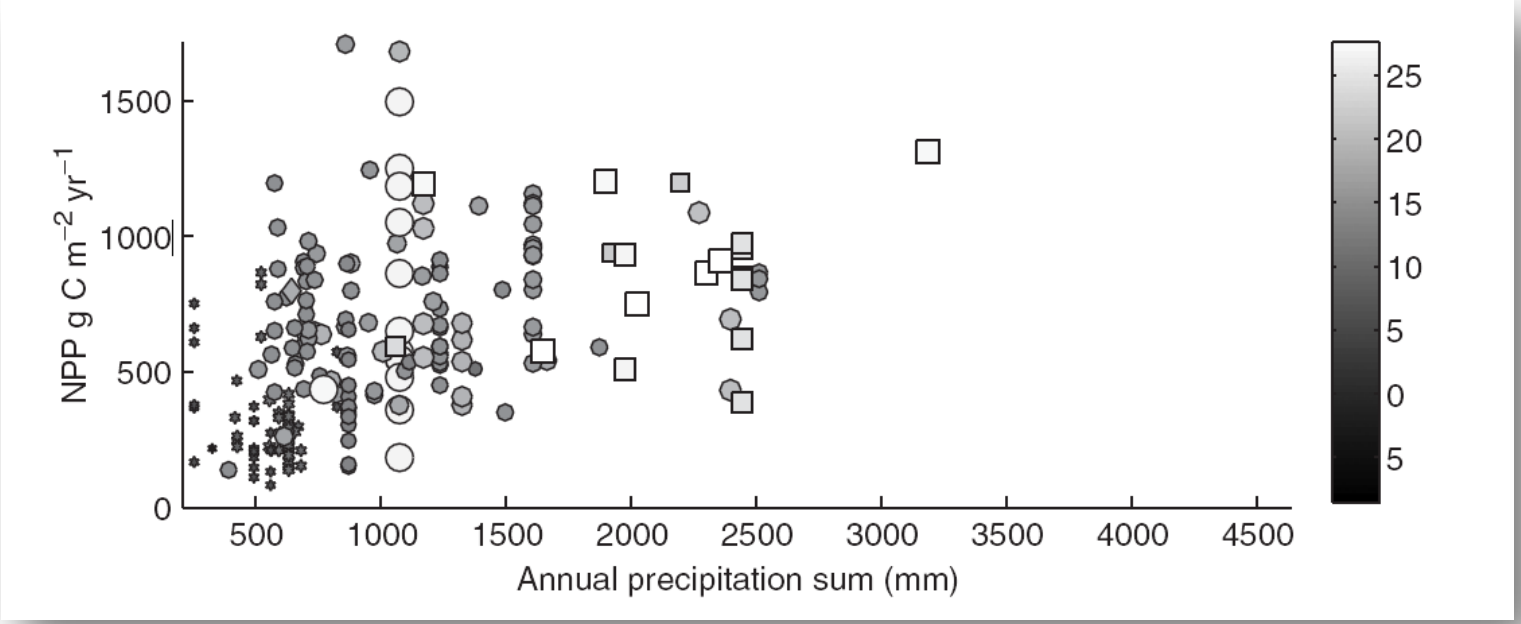


Measured data

BETHY/DLR modeling for 2007

GPP >= 0; NPP can be positive (sink) or negative (source)

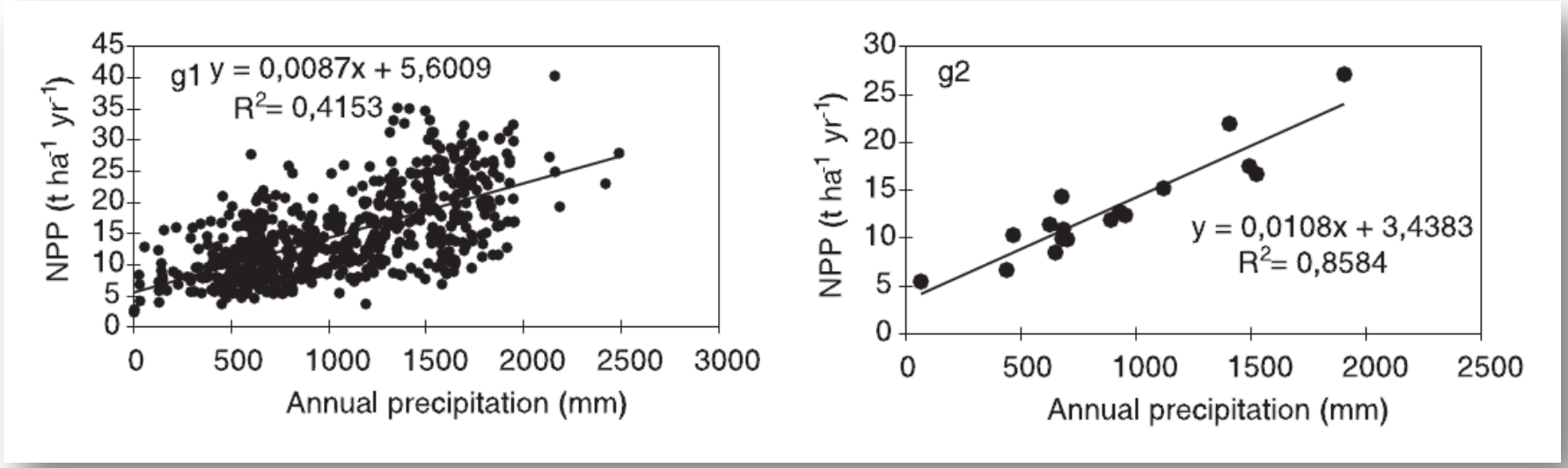
Annual precipitation as proxy?



Stars, boreal;
circles, temperate;
diamonds, Mediterranean;
squares, tropical forests.
The size and color of the marker is a measure for the mean annual temperature (°C).

Source: Luyssaert et al., CO2 balance of boreal, temperate and tropical forests derived from a global database, GCB 13, 2509-2537, 2007

Annual precipitation as proxy?

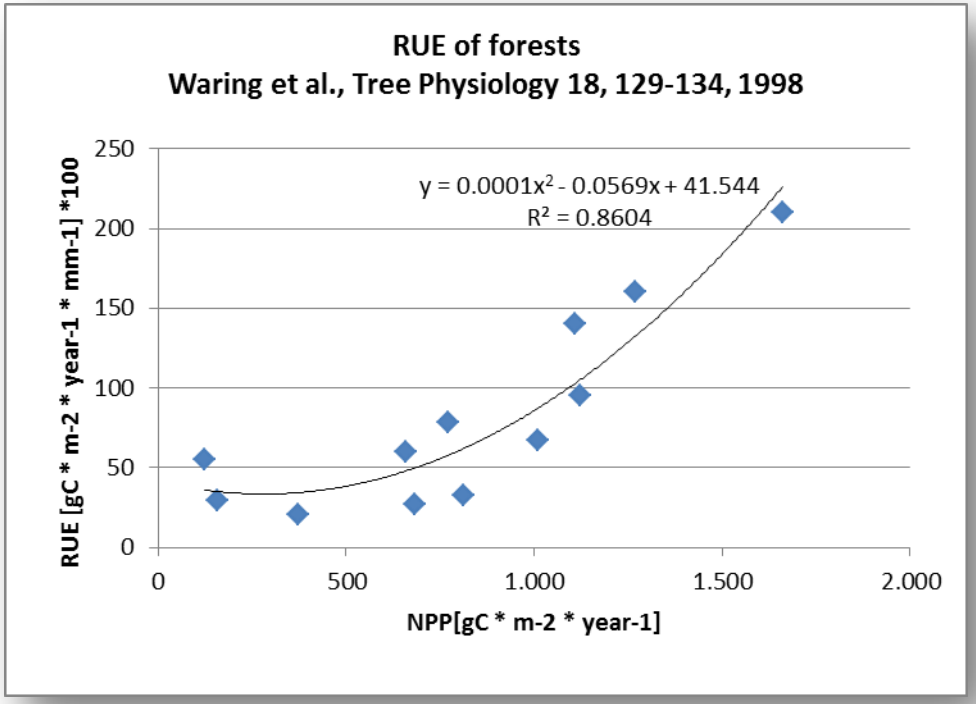


Left column, 690 sites- based comparison (1); right column, 17 forest types-based comparison (2)

10 tC * ha^{-1} *yr^{-1} corresponds to 1000 gC * m^{-2} *yr^{-1}

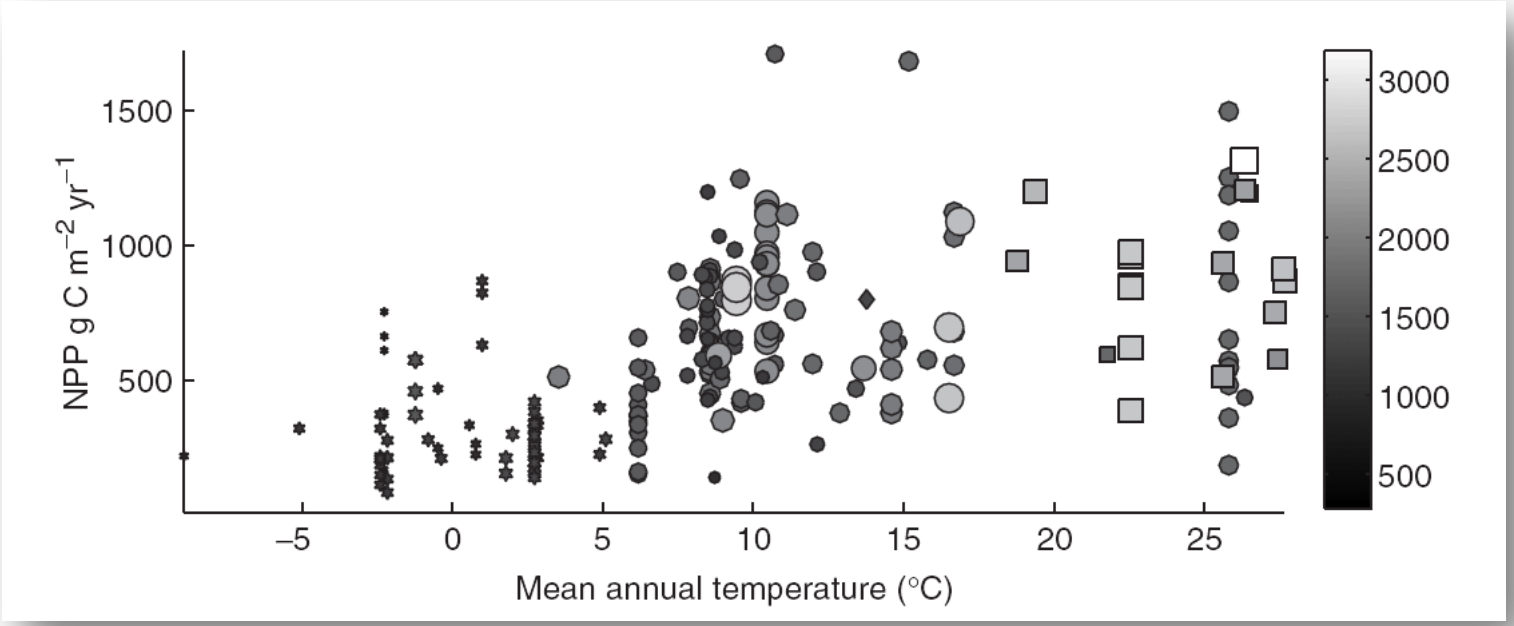
Source: Ni et al., Synthesis and analysis of biomass and net primary productivity in Chinese forests, Ann. For. Sci. 58 (2001) 351–384

Rain Use Efficiency (RUE)



$$RUE = \frac{NPP}{precipitation} = \frac{a + b * precipitation}{precipitation} = b + \frac{a}{precipitation}$$

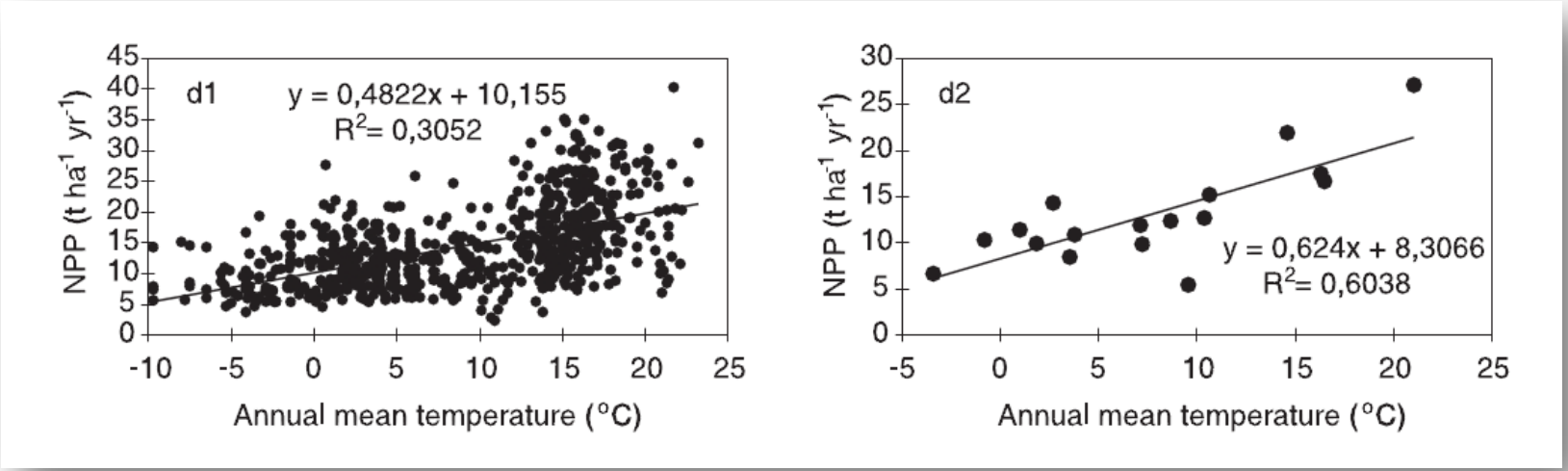
Mean annual temperature as proxy?



Stars, boreal;
circles, temperate;
diamonds, Mediterranean;
squares, tropical forests.
The size and color of the marker is a measure for the annual precipitation sum (mm)

Source: Luyssaert et al., CO2 balance of boreal, temperate and tropical forests derived from a global database, GCB 13, 2509-2537, 2007

Mean annual temperature as proxy?



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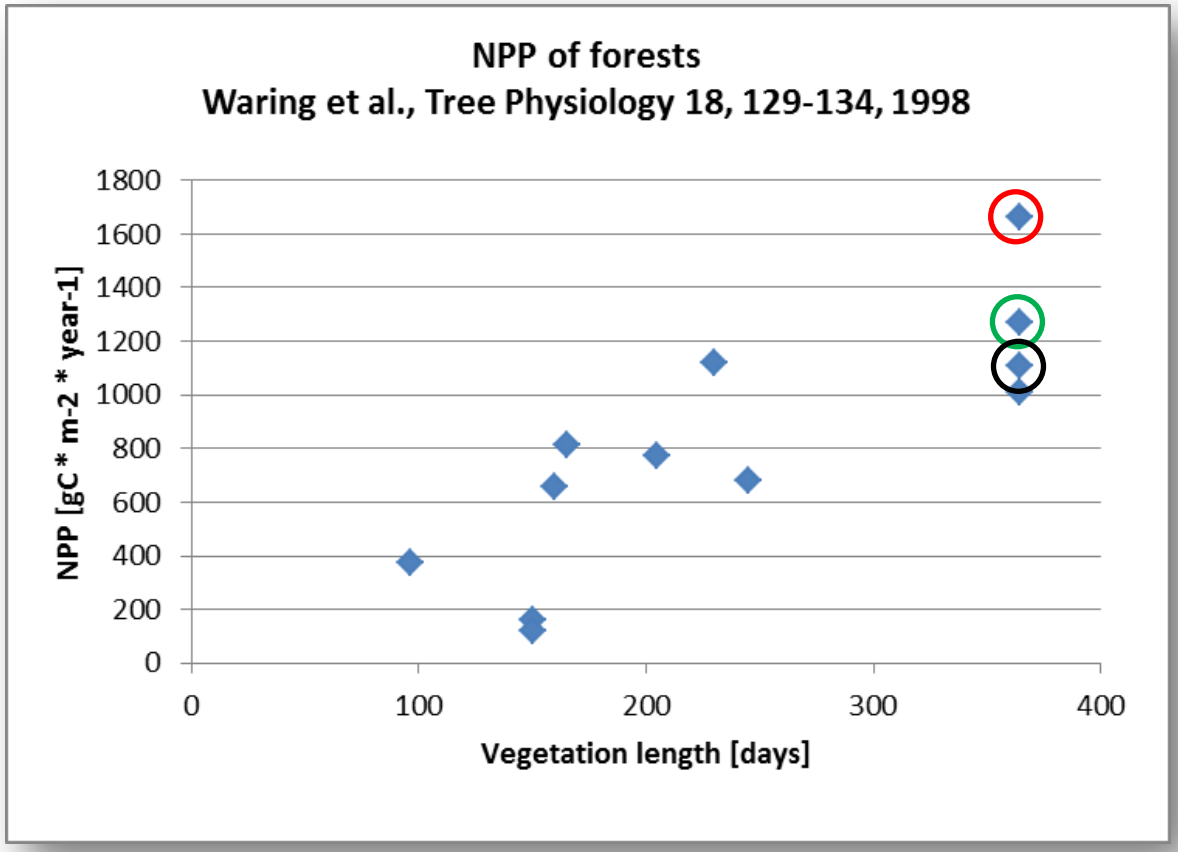
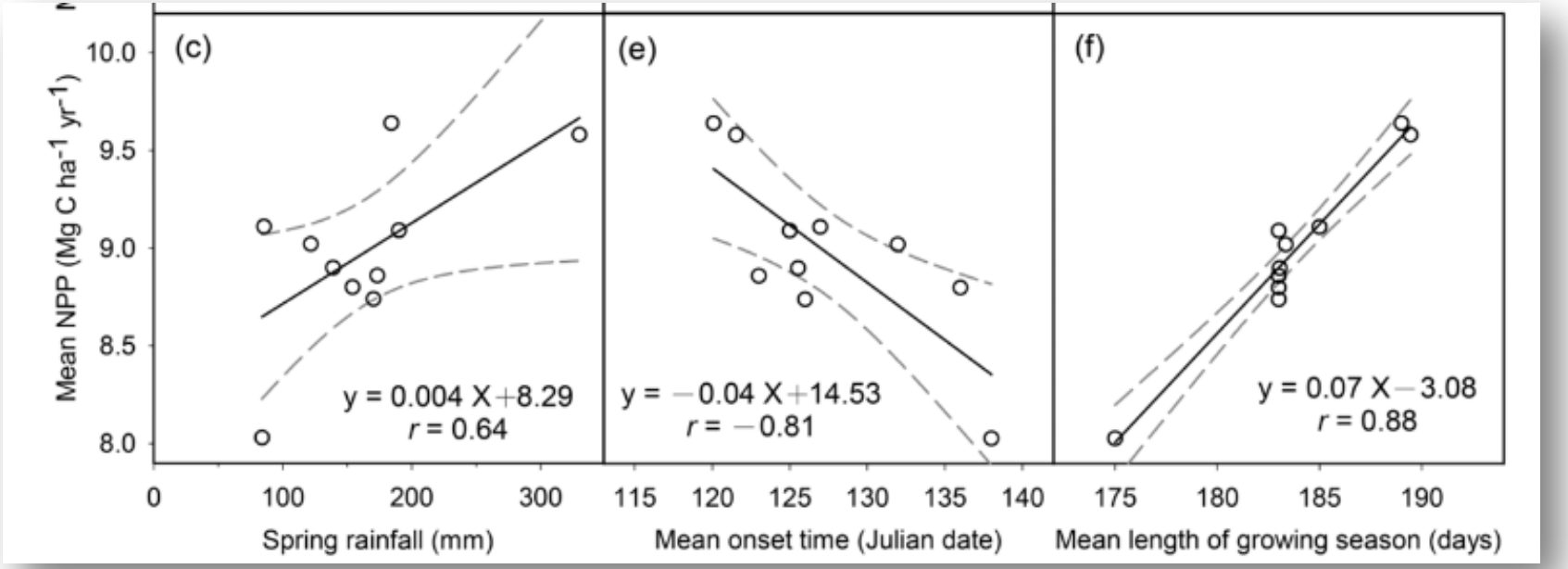
Vegetation length as proxy?



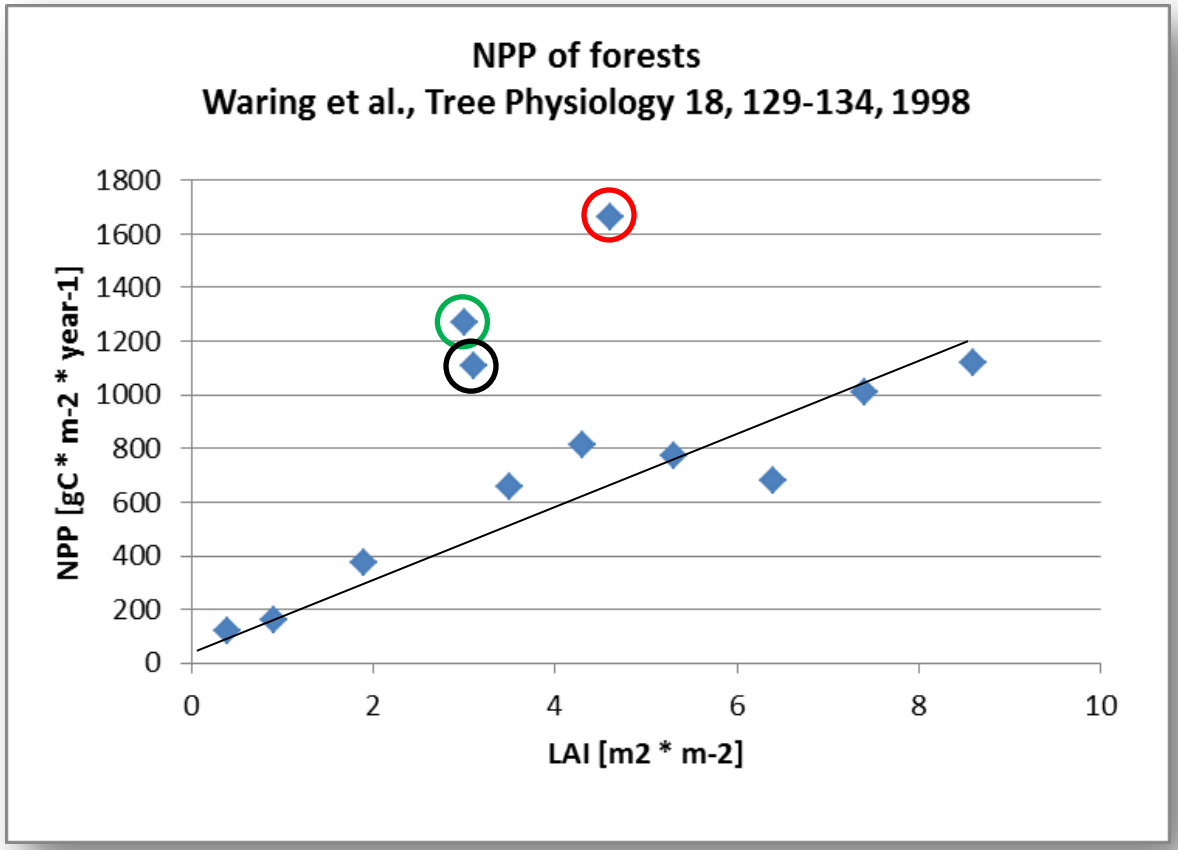
Pinus radiata
- Fertilized and irrigated
- Irrigated
- control

Vegetation length as proxy?



Source: Chang et al., Environ. Res. Lett. 8 (2013) 045030 (11pp)

LAI as proxy?



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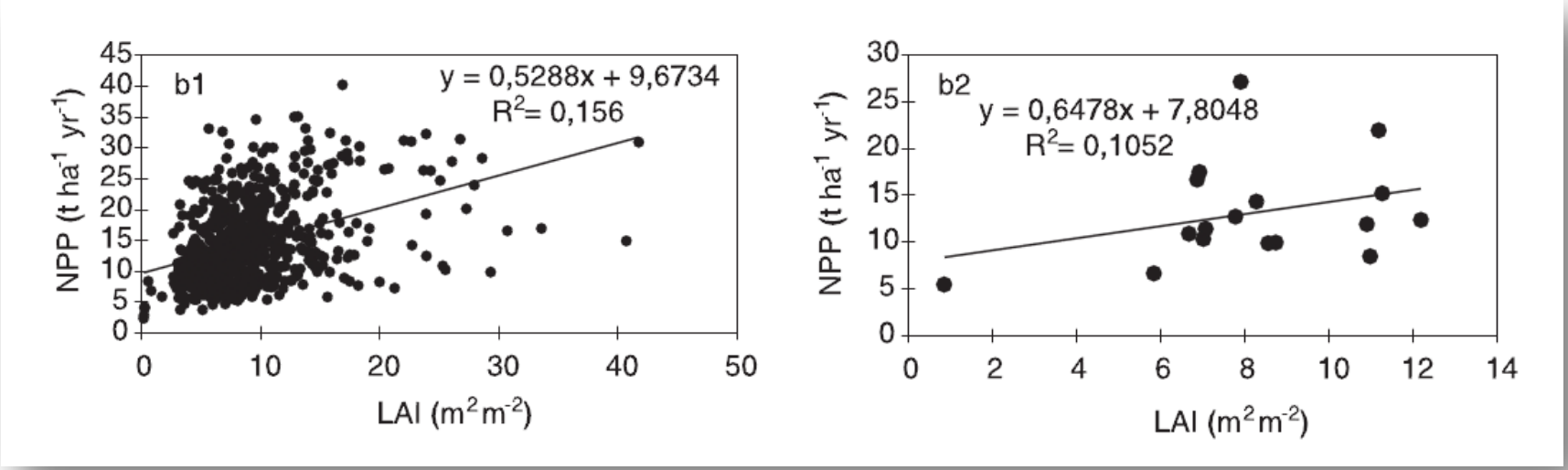

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Source: Ni et al., Synthesis and analysis of biomass and net primary productivity in Chinese forests, Ann. For. Sci. 58 (2001) 351–384

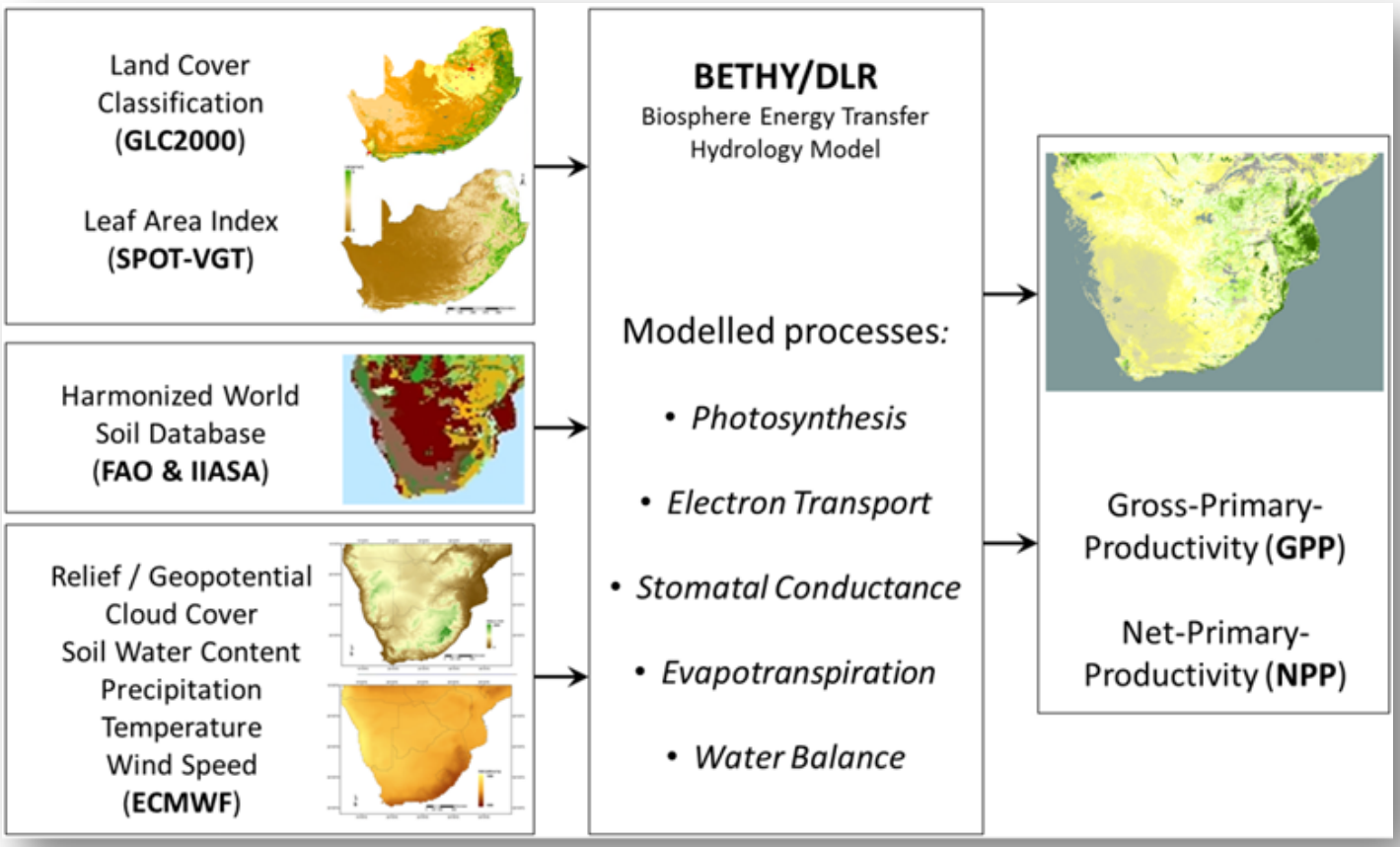
First summary

- From literature, we can find that annual NPP
  - increases with annual precipitation sum (-> plant water availability)
  - increases with annual mean temperature
  - increases with vegetation length (or mean length of growing season)
  - increases with LAI (and thus with fAPAR)

  - These findings correlate with global observations (climate variables) and plant types (not individual species).

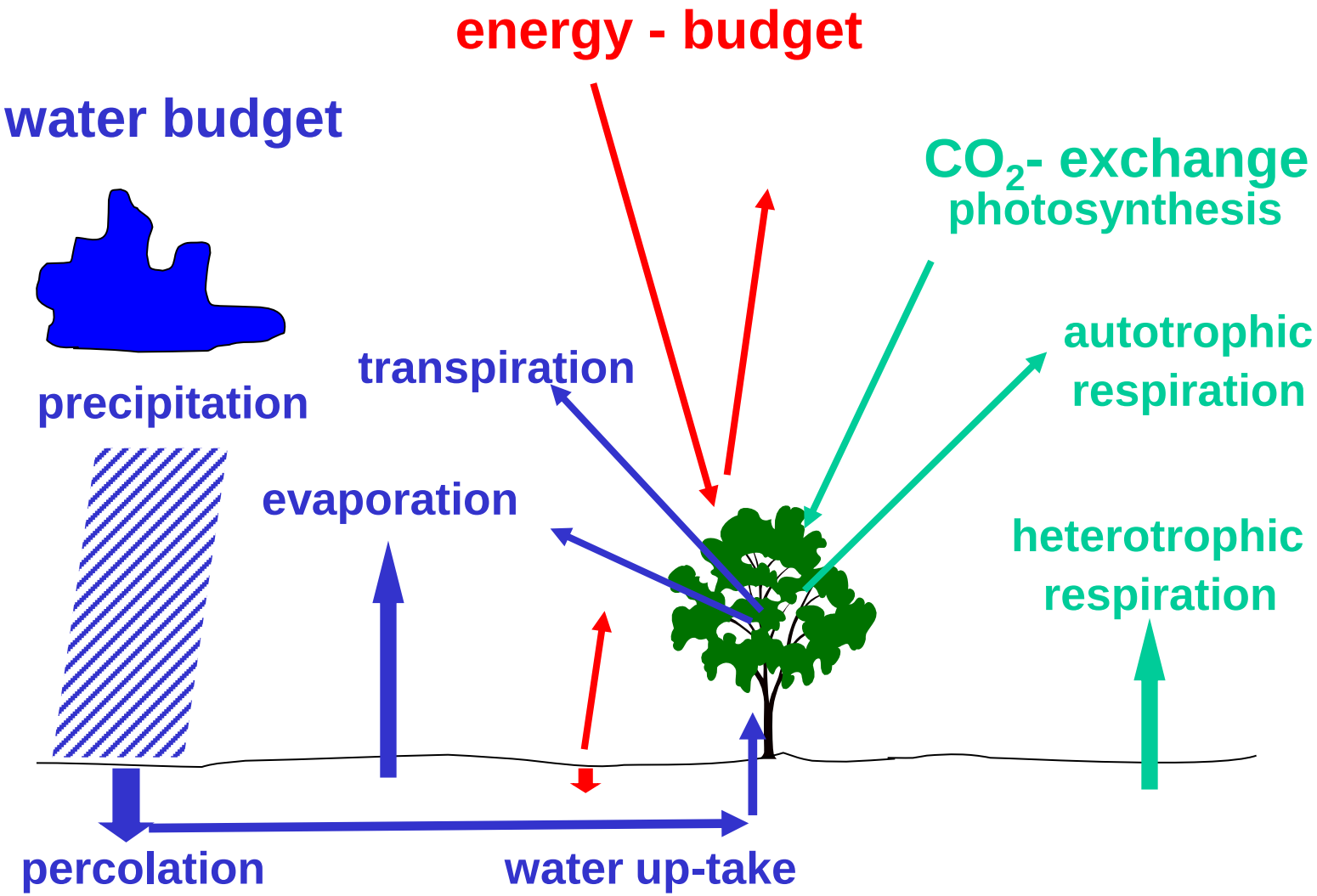
- Looking for smaller scales (time and space) we find, that e.g. daily NPP is mainly determined by solar irradiation (when plant water and nutrient availability is not limited and ambient temperature is between T_{min} (~ 5°C) and T_{max} (~40°C).

Modelling NPP using BETHY / DLR

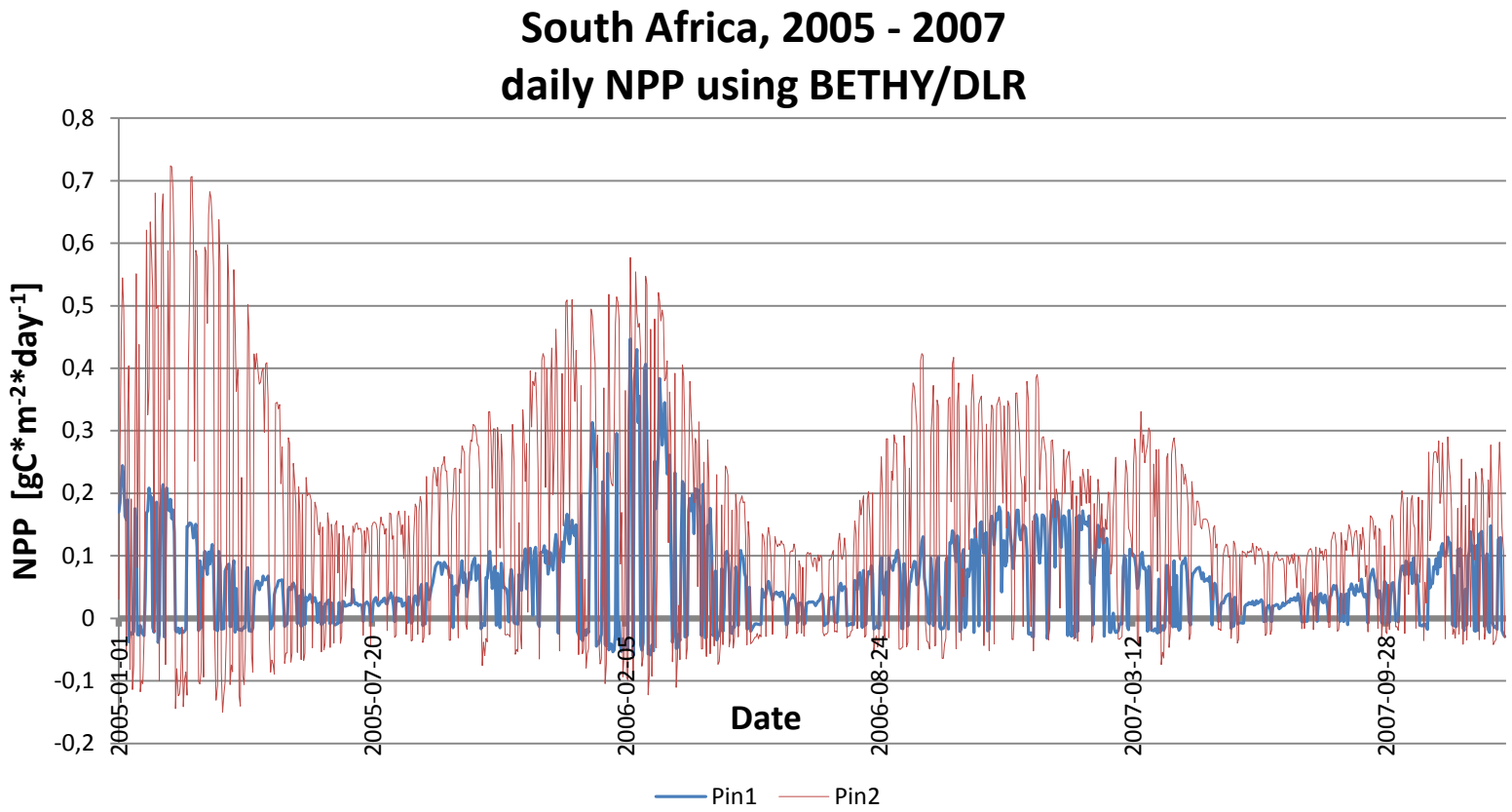


Source: Niklaus et al., Assessing Land Degradation in Arid and Semi-Arid Regions of Southern Africa Using Modeled Time-Series of Net Primary Productivity, Geoinformatics & Geostatistics, accepted for publication, 2014.

Relevant processes in BETHY/DLR

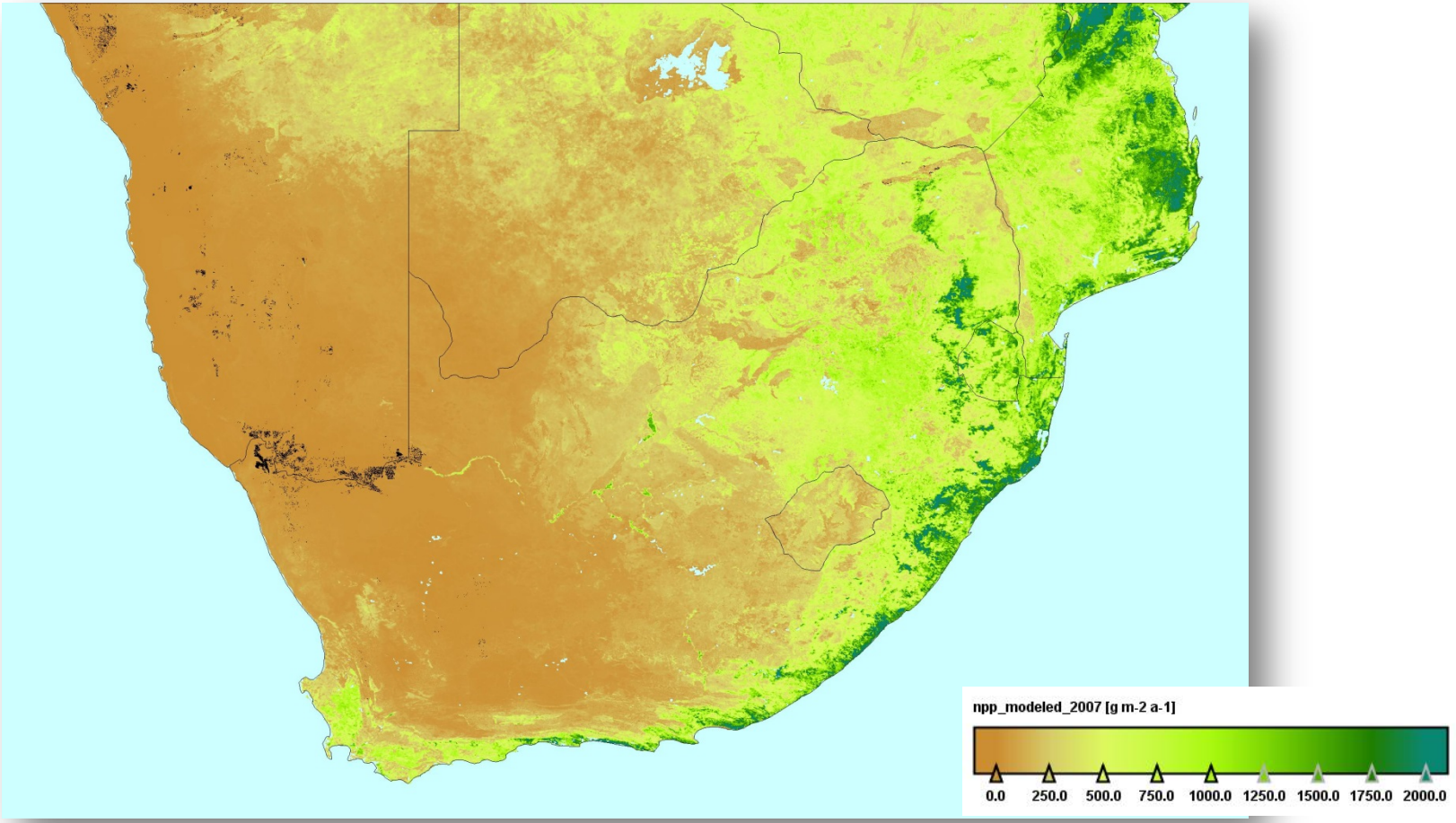


Modelled daily NPP using BETHY/DLR



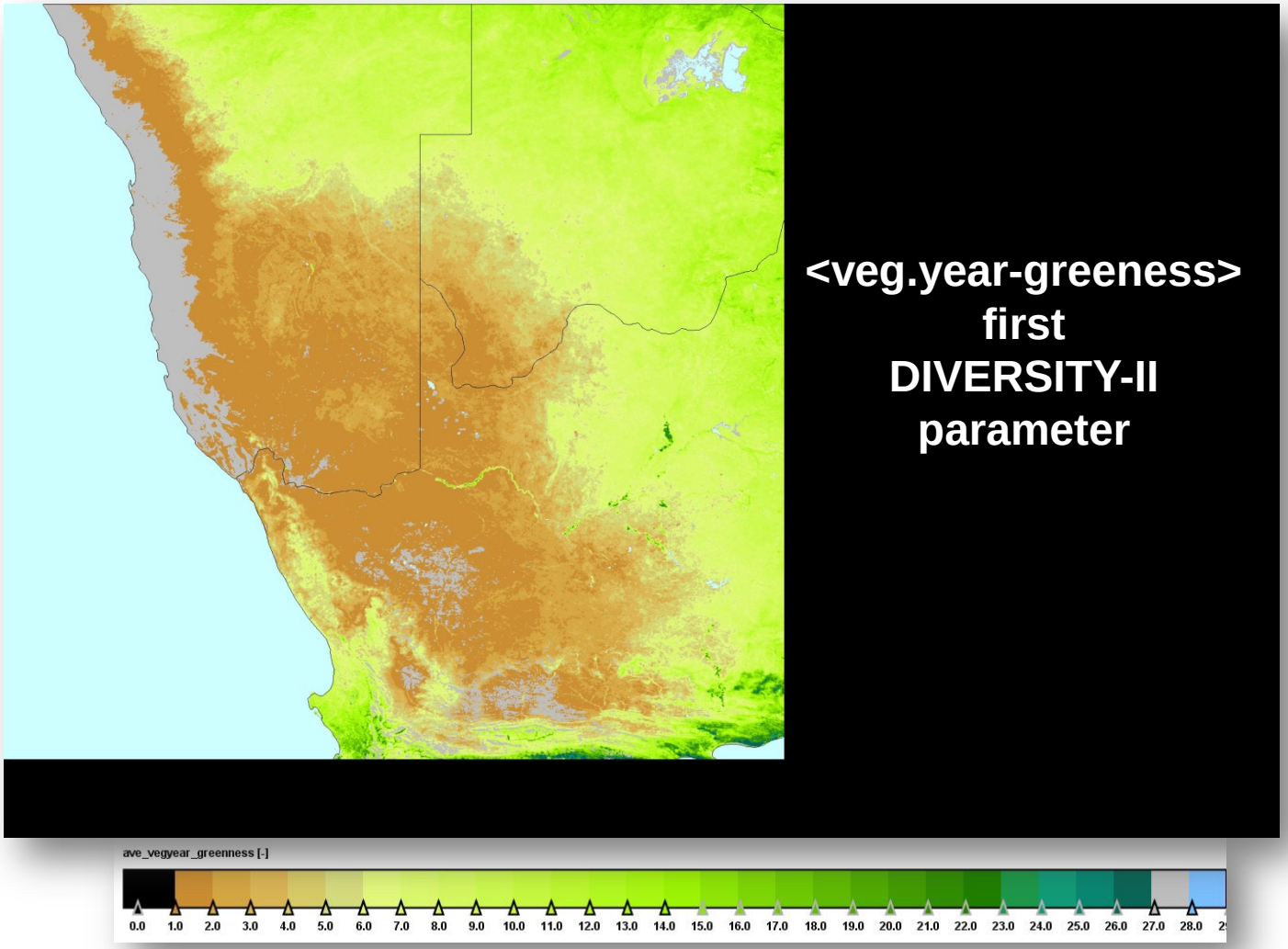
BETHY/DLR modelled NPP time series for the two pins in Southern Africa.

BETHY/DLR NPP sum (Jan 2007 – Dec 2007)



Black pixels show negative NPP

<vegetation year greenness> derived from MERIS-fAPAR



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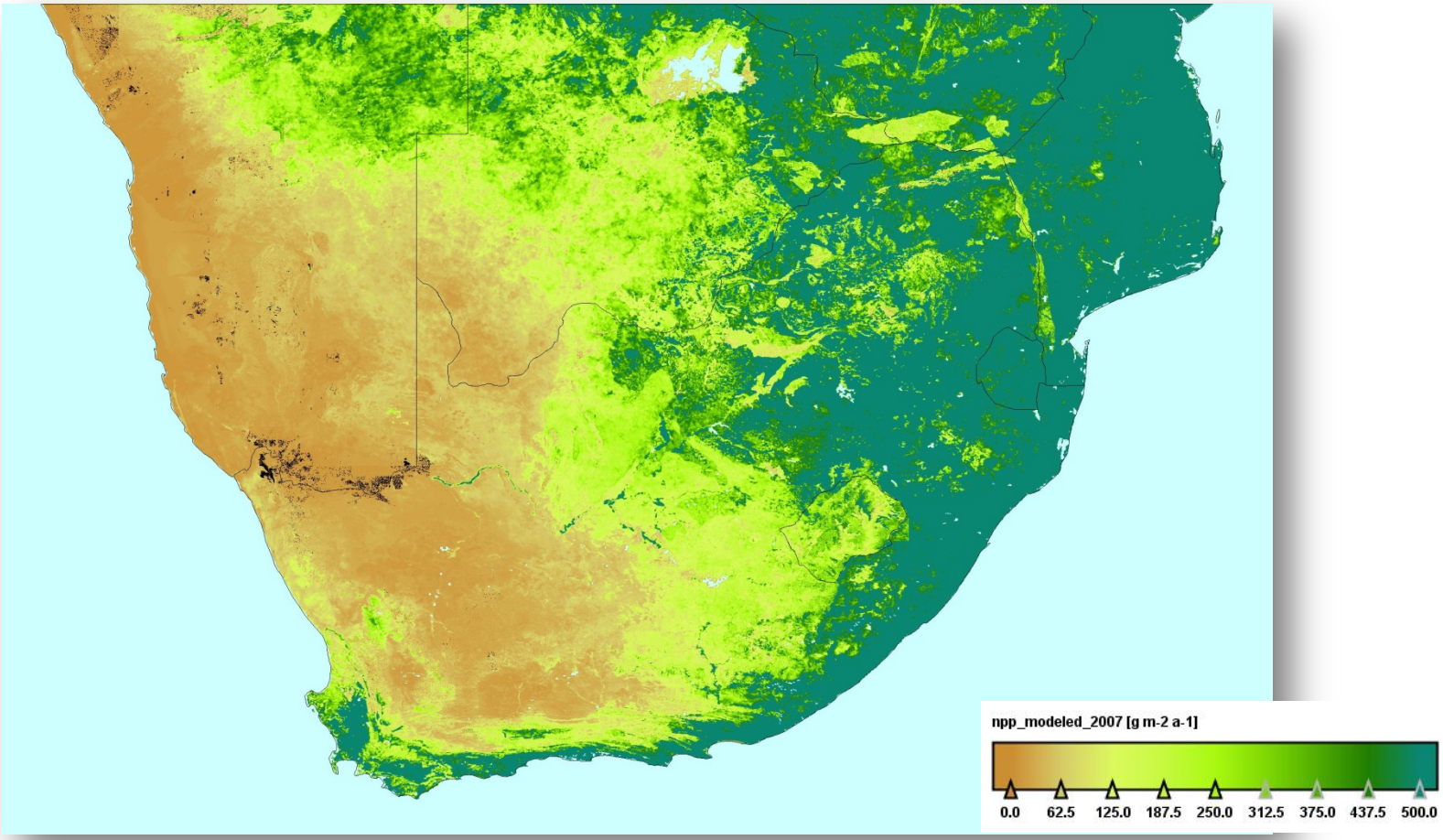
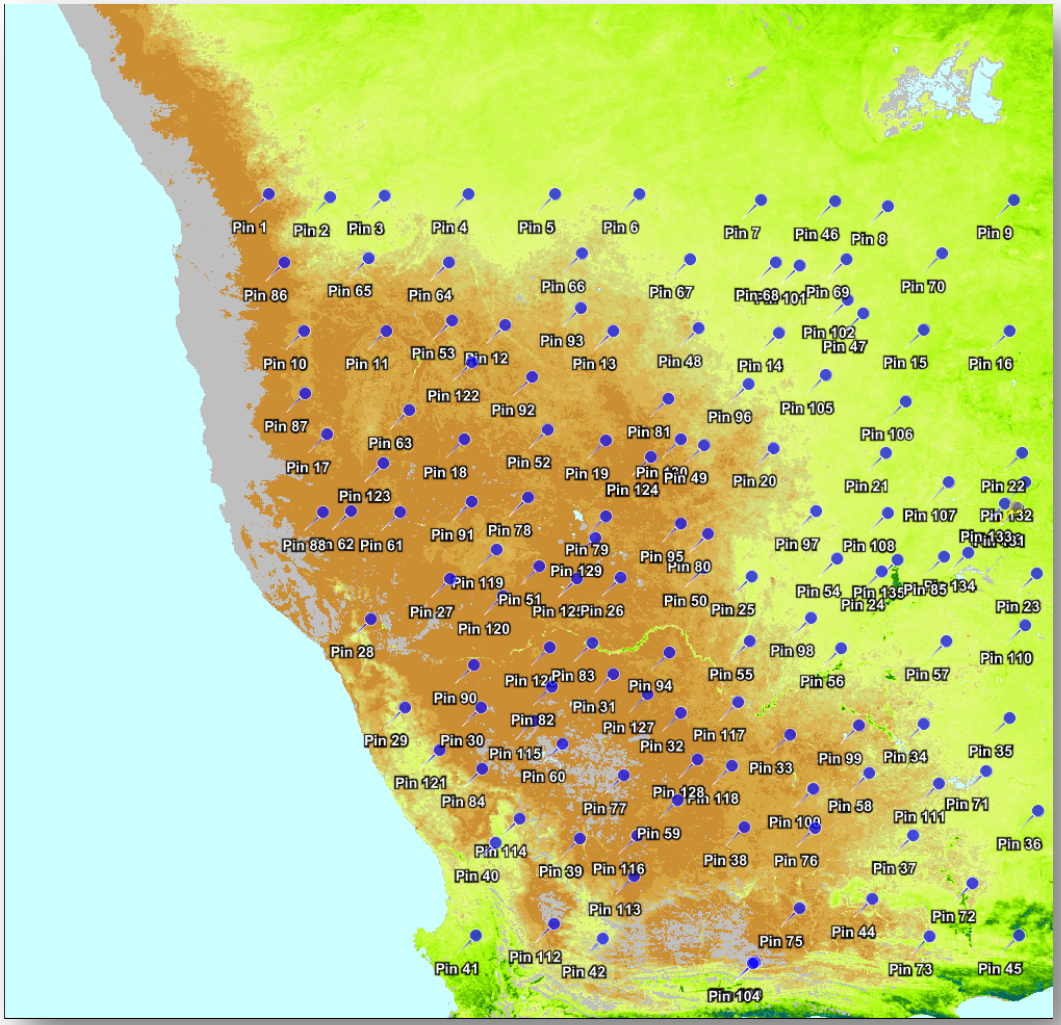
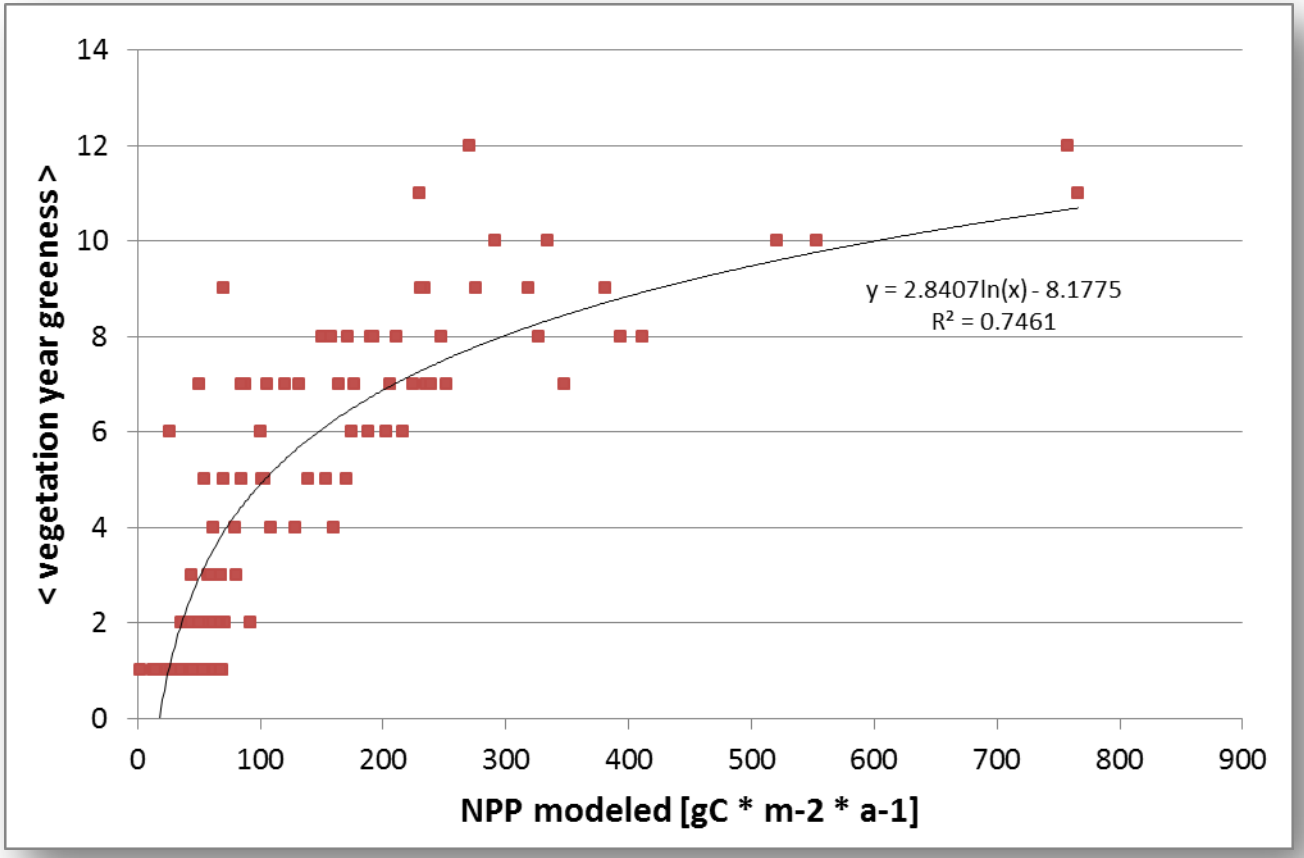


Black pixels show negative NPP

Pins for comparison

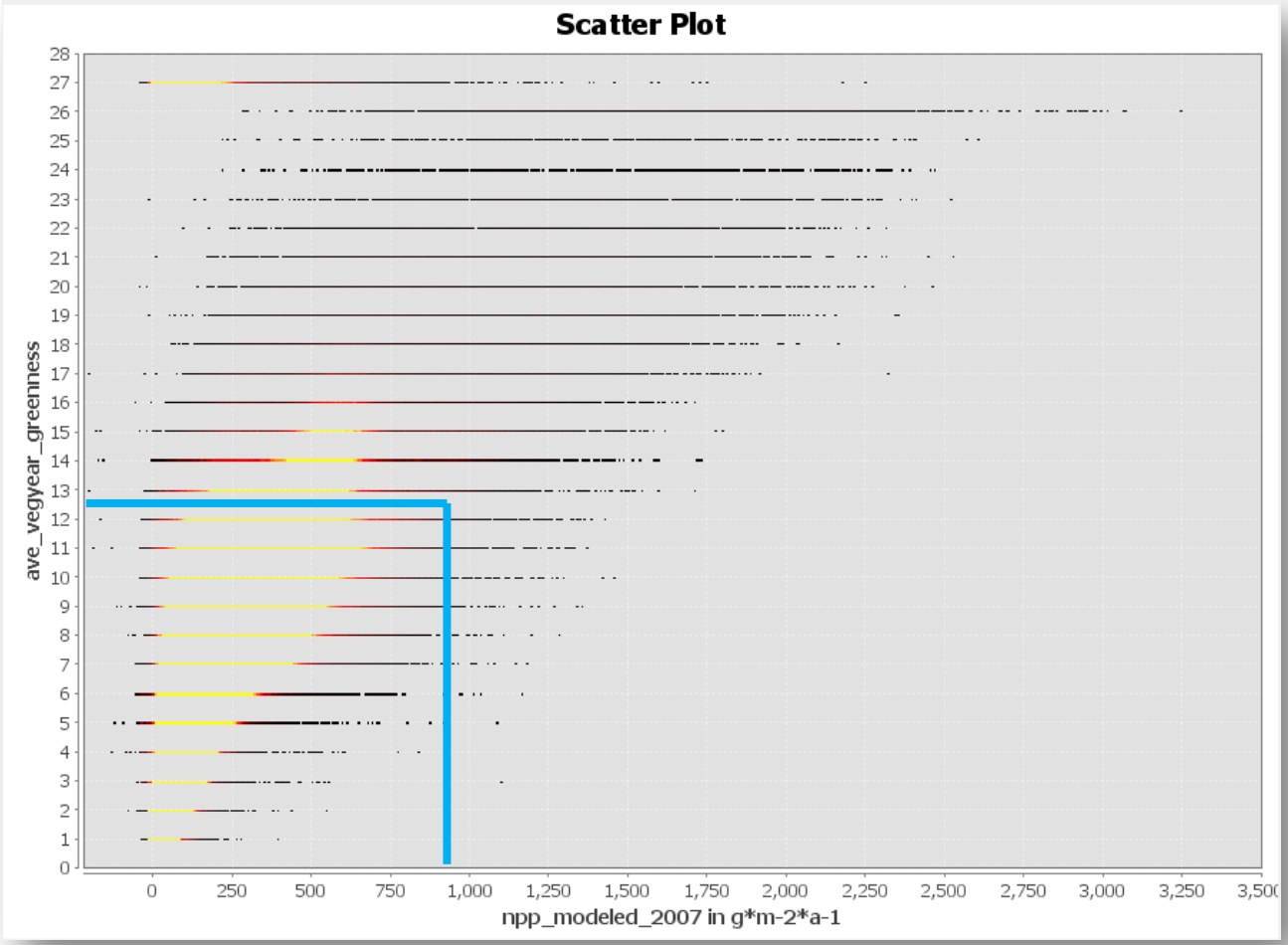


Comparing modelled NPP and DIVERSITY.proxy.1 for dryland

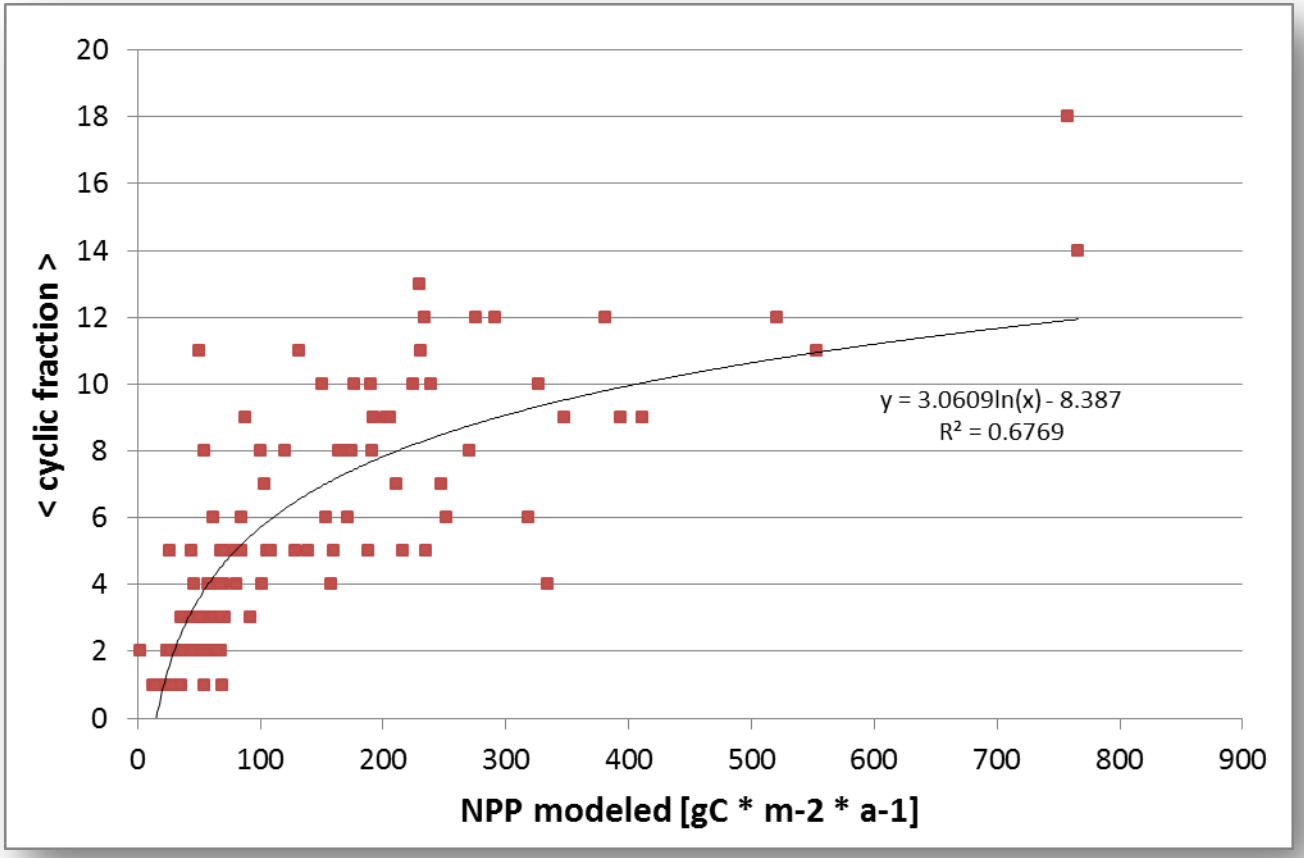


129 pixels for comparison selected

Comparing modelled NPP and DIVERSITY.proxy.1 (all pixels)

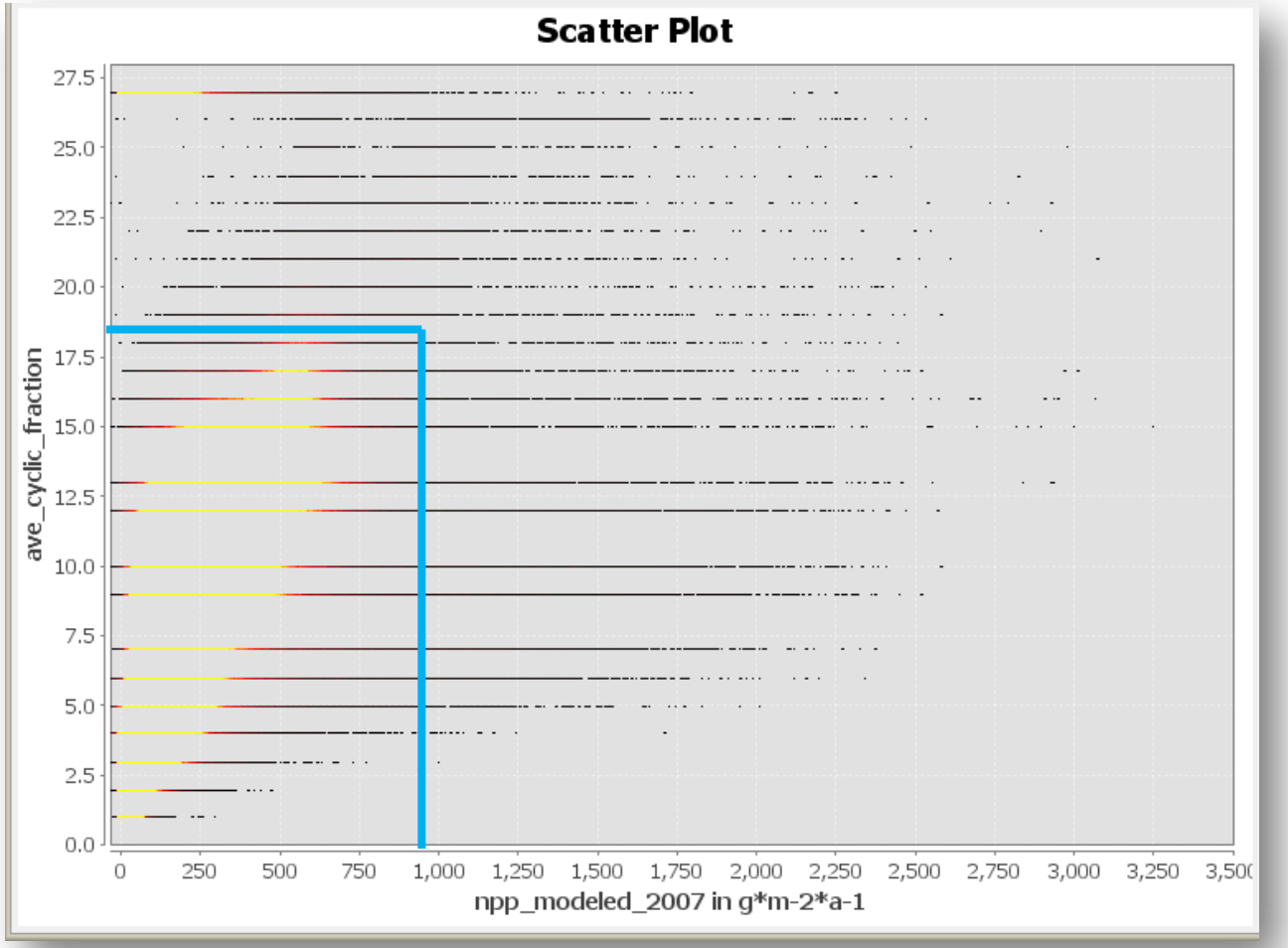


Comparing modelled NPP and DIVERSITY.proxy.2 for dryland

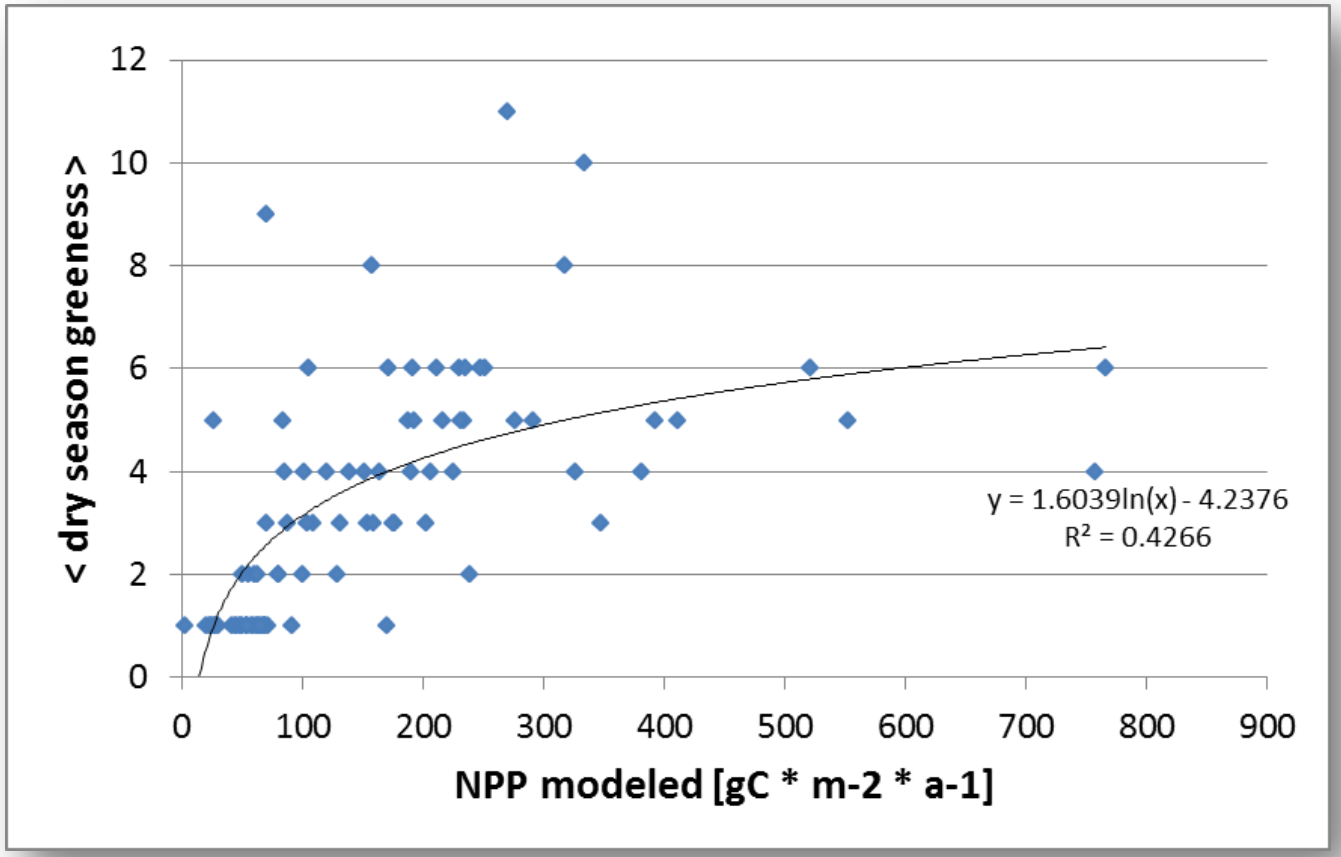


129 pixels for comparison selected

Comparing modelled NPP and DIVERSITY.proxy.2 (all pixels)

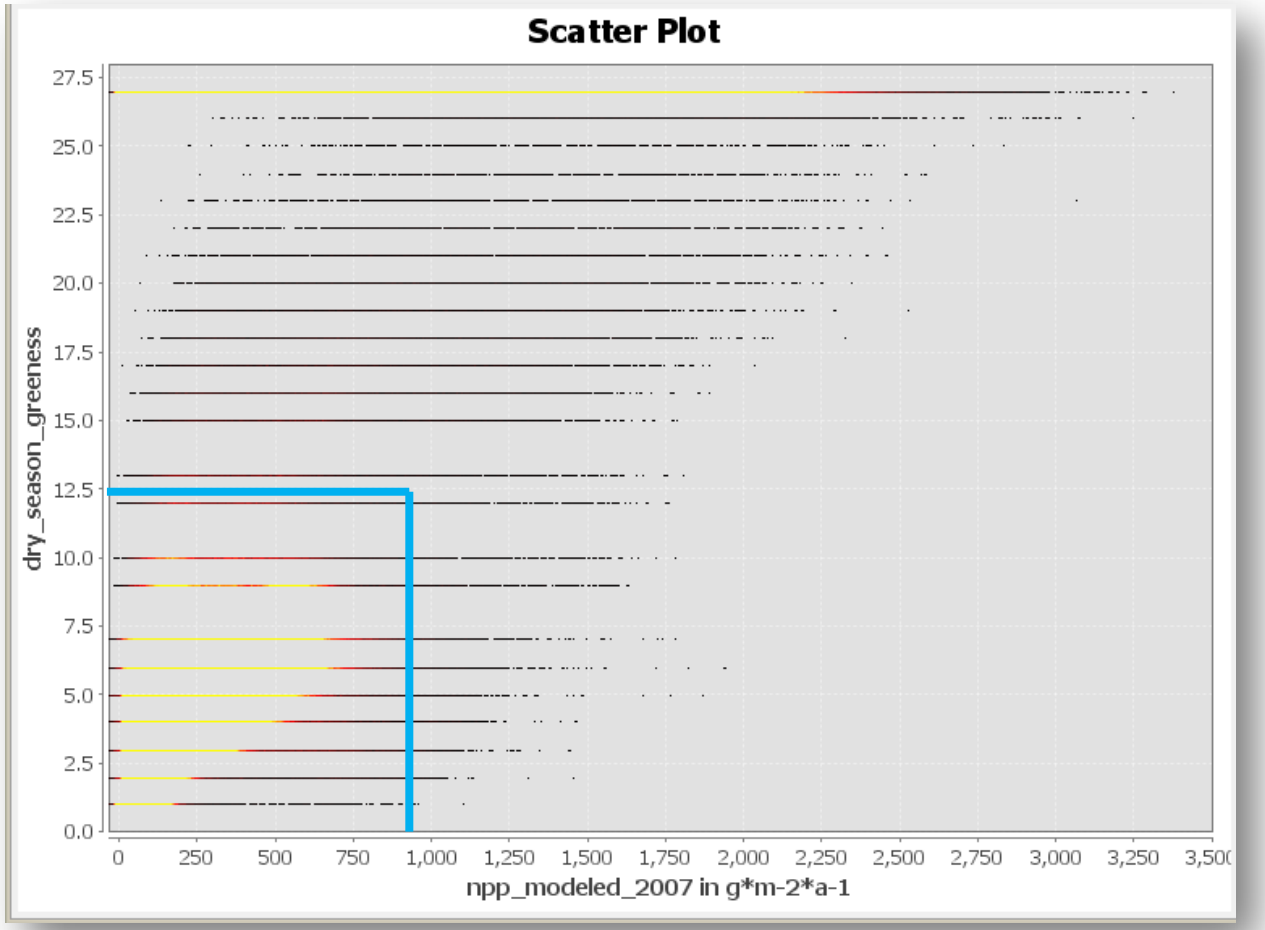


Comparing modelled NPP and DIVERSITY.proxy.3 for dryland



96 pixels for comparison selected

Comparing modelled NPP and DIVERSITY.proxy.3 (all pixels)



Summary

- Using MERIS-fAPAR time series proxies for NPP are derived as:
  - “average vegetation year greenness”
  - “cyclic fraction”
  - “average dry season greenness”.

- The correlation of the proxies with modeled NPP (derived from BETHY/DLR) results in correlation coefficients of:
  - $R^2 \sim 0.75$ for “average vegetation year greenness”
  - $R^2 \sim 0.68$ for “cyclic fraction”
  - $R^2 \sim 0.43$ for “average dry season greenness”.

Time to calculate time series of NPP for Southern Africa

- Time span: 2000 – 2010
- Number of processors: 10
- Memory per processor: ~1.5 GB
- Mass storage: ~ 150 GB
- Computing time: ~ 40 hours (for parallel processing)
  ~ 400 hours (on one processor)