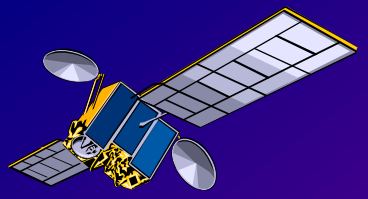

Characterizing Net Primary Productivity of Forests and Non-Forest Areas in the Philippines Using Satellite Imagery

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AUSTRALIA

Outline of Presentation

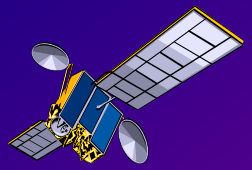
Background

- Net primary productivity (NPP)
- Queensland's NPP-drought study
  - Introduction
  - Objectives
  - Methods
  - Results and Conclusions

Philippines Study

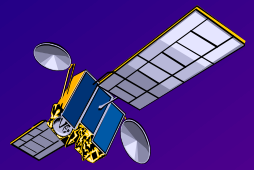
- Datasets Used
- Data Processing and Analysis
- Results
- Conclusion

Introduction



- The rate at which light energy is converted to plant biomass is termed primary productivity (PP).
- Net primary productivity (NPP) is the difference between Gross PP and energy lost during plant respiration.
- NPP represents the net amount of carbon **($gC/m^2/yr$)** added to plant biomass per unit of space and time.
- NPP may be measured and monitored to understand the impacts of environmental / climate change

Introduction



Vegetation Type	Mean NPP ($gC/m^2/yr$)
• Tropical rain forest	2,200
• Tropical seasonal forest	1,600
• Temperate evergreen forest	1,300
• Temperate deciduous forest	1,200
• Boreal forest	800
• Savanna	900
• Temperate grassland	600
• Tundra	140
• Cultivated land	650
• Algal beds and reefs	2,500
• Estuaries	1,500

Source: http://rainforests.mongabay.com/03net_primary_production.htm

Queensland's NPP–Drought Study (Shiba & Apan, 2011): The Precursor of our Philippine Study

Rationale:

- Droughts in Australia put enormous stress upon the survival of flora and fauna with high water needs.
- Wetland ecosystems and temperate rainforests are particularly vulnerable.




Photo source: ABC

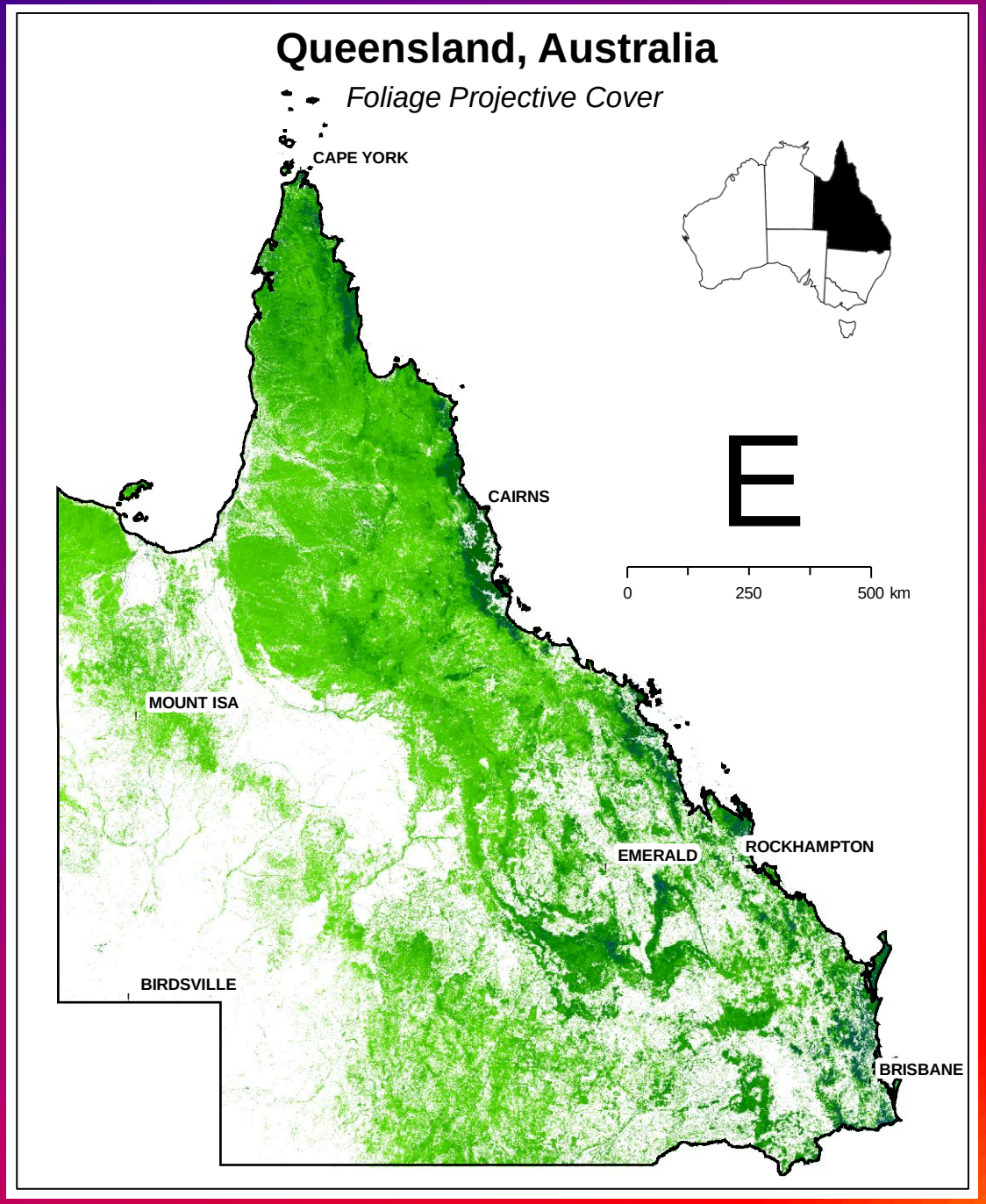
Queensland Study: Objectives

- To compare the interannual variation of NPP between major vegetation groups in relation to variability in annual rainfall.

- To assess the potential effects of drought on the NPP of major vegetation groups.

State of Queensland

- second largest state (1,852,642 km^2).
- Diverse climatic conditions and vegetation types



Major Vegetation Group in Queensland

Rainforests and Vine Thickets

Eucalypt Open Forests

Eucalypt Woodlands

Acacia Forests and Woodlands

Tussock Grasslands

Hummock Grasslands

Spatial Datasets Used

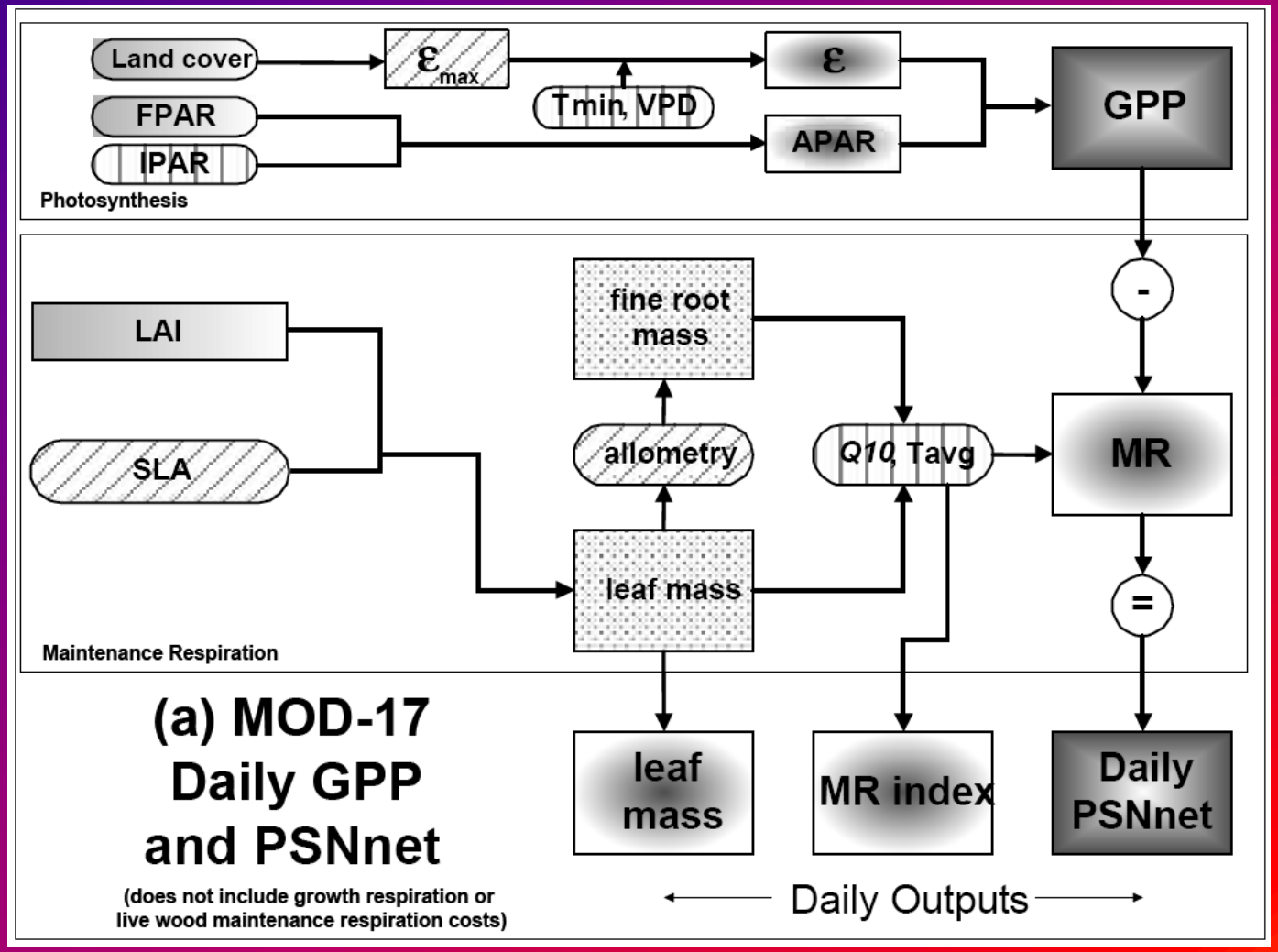
- MODIS Satellite Imagery (“MOD17” product from NASA EOS Project)
- Major Vegetation Groups of Australia
- Rainfall
- Rainfall anomaly
- Temperature
- Temperature anomaly
- Available Soil Water Holding Capacity
- Digital Elevation Model
- Incoming Solar Radiation

MODIS (Moderate Resolution Imaging Spectrometer)

- Carried by “Terra” (1999) & “Aqua” (2002) satellites
- 36 spectral bands (0.405 to 14.835μm)
- spatial resolutions of 250m, 500m, and 1km
- swath width of 2,330 km
- equatorial crossing time: 10:30 and 13:30
- at least once every two days

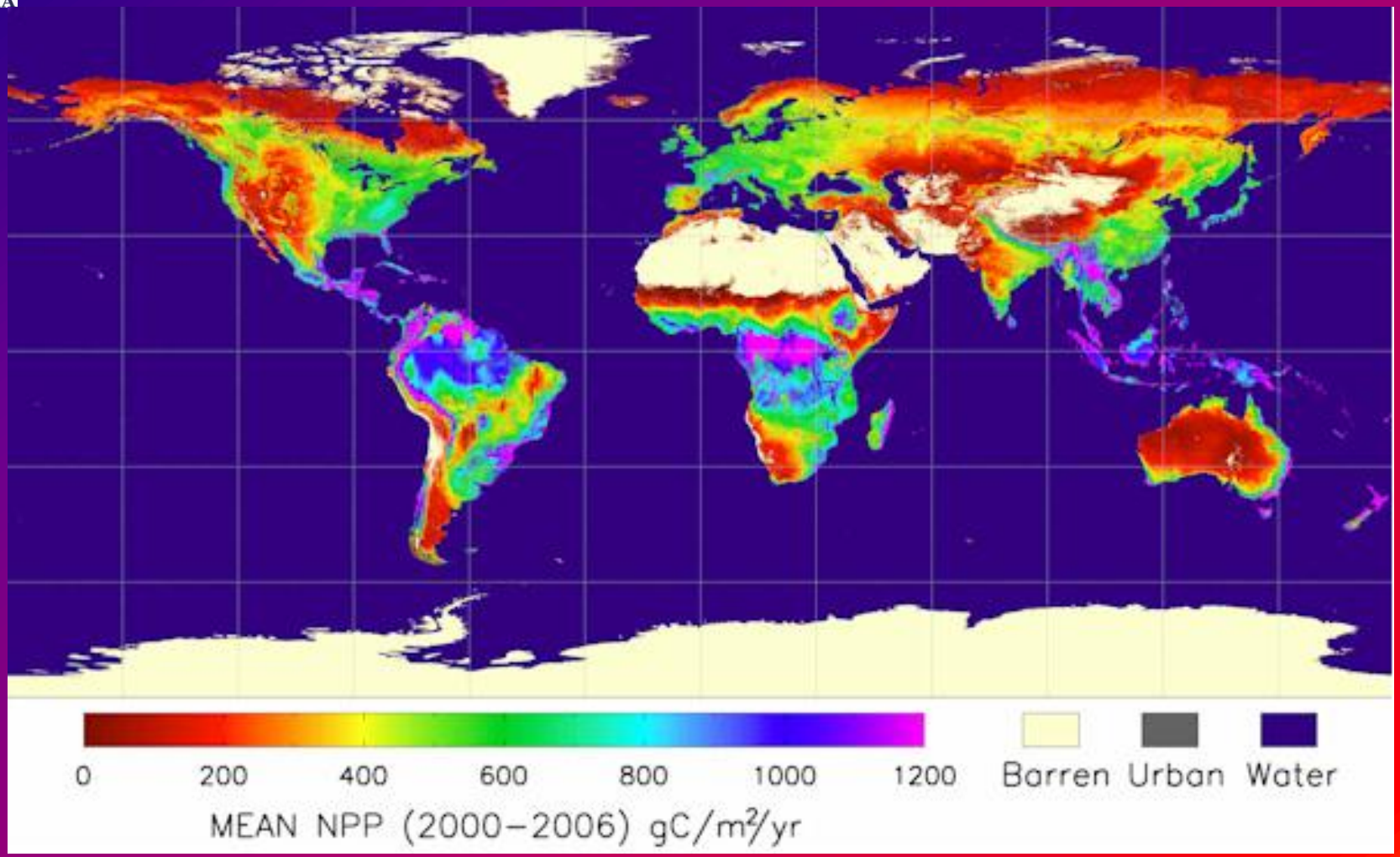
Satellite-based estimates of NPP available

- Relationship exists between absorbed photosynthetically active radiation (APAR) and NPP (Monteith, 1972)



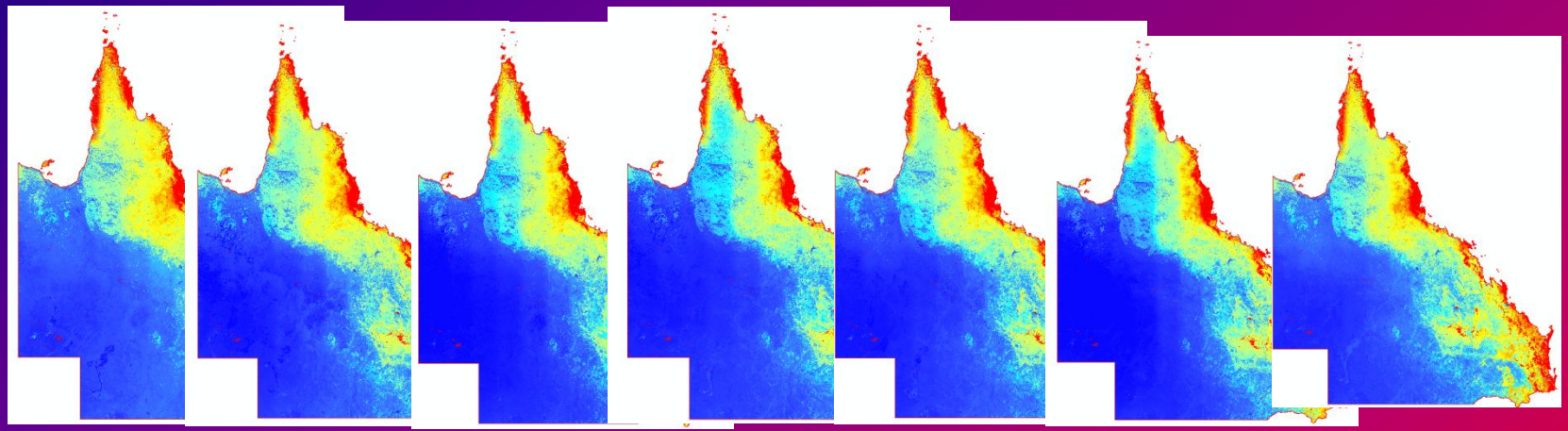
Mean NPP of the World from MODIS

1km x 1km spatial resolution

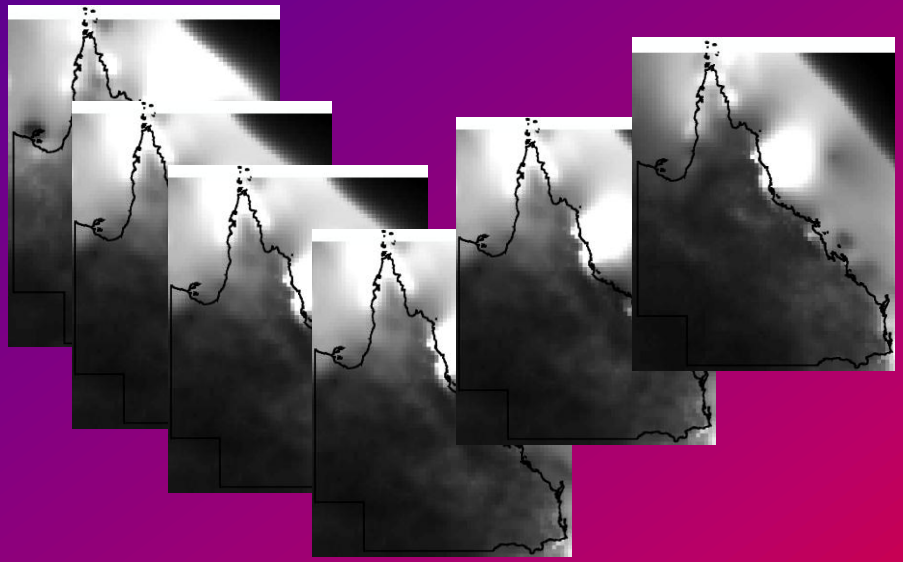


Source: University of Montana

Correlating NPP and bio-physical variables



2000 2001 2002 2003 2004 2005 2006



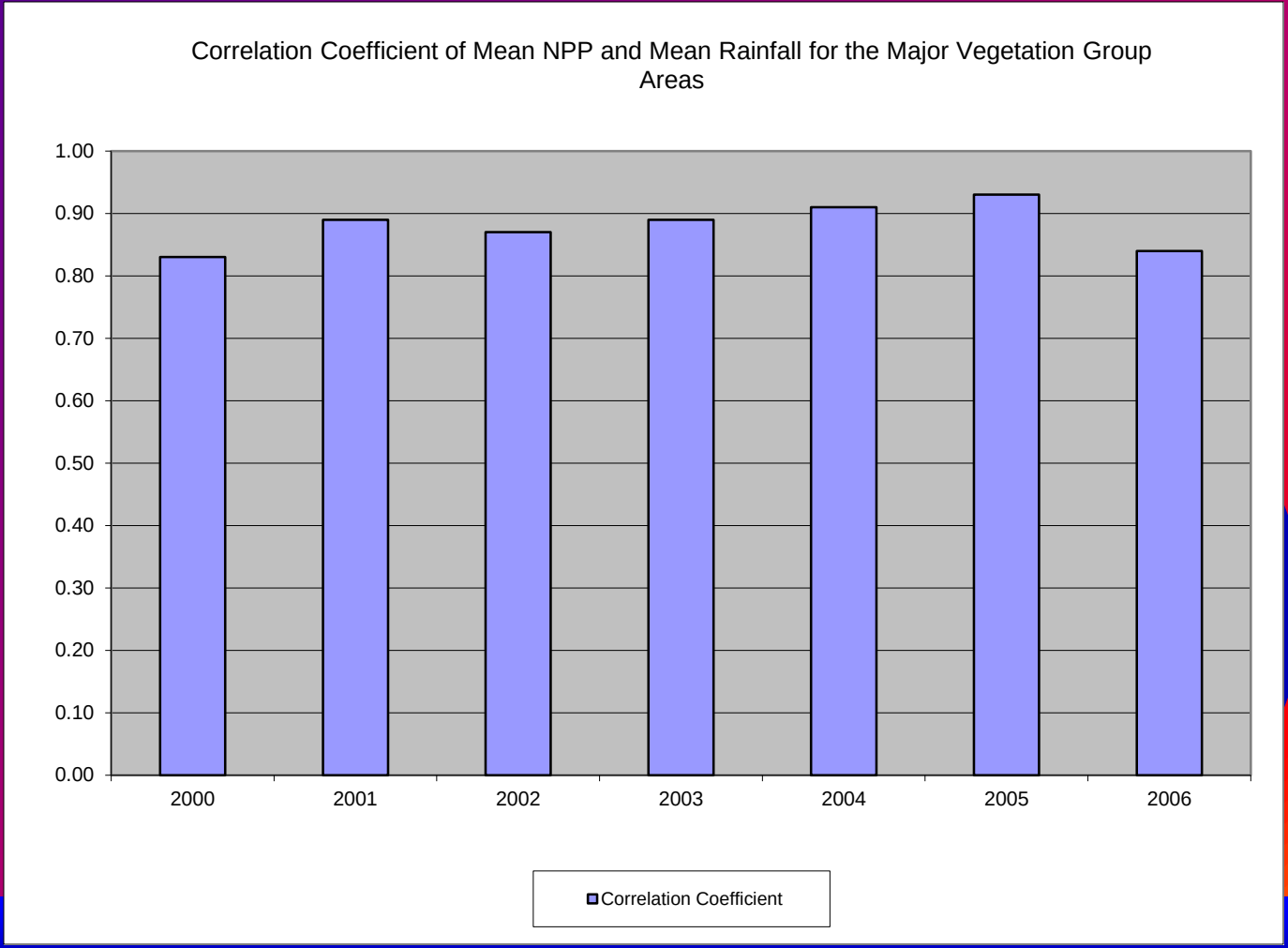
Rainfall intensity (2000-2006)

Year	Condition
2000	La Niña (weak)
2001	
2002	El Niño
2003	El Niño
2004	El Niño
2005	El Niño
2006	El Niño

Results

- High correlations between MODIS-derived NPP and mean rainfall for Major Vegetation Group

Year	Correlation Coefficient
2000	0.83
2001	0.89
2002	0.87
2003	0.89
2004	0.91
2005	0.93
2006	0.84



Results

No correlation between NPP and Selected Variables

- Soil water (r = 0.09 to 0.13)
- Aspect (slope direction) (r = 0 to 0.03)

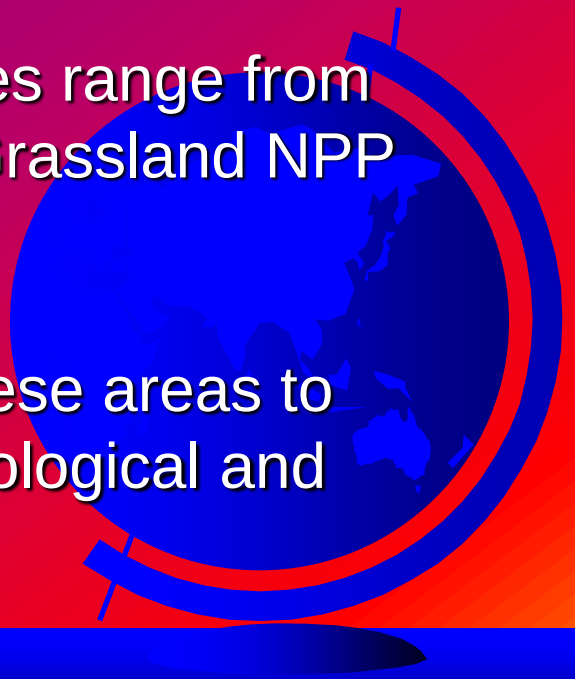
Results

NPP Difference between Drought and Non-drought Year

MAJOR VEGETATION GROUPS	MEAN2000 (NON-DROUGHT YEAR)	MEAN2002 (DROUGHT YEAR)	DIFFERENCE
	NPP (gC/m^2/yr)	*NPP (gC/m^2/yr)*	*%*
• Rainforests and Vine Thickets	1,878	2,071	10.3
• Eucalypt Open Forests	1,032	1,032	0.0
• Eucalypt Woodlands	848	804	-5.2
• Acacia Forests and Woodlands	260	175	-32.5
• Callitris Forests and Woodlands	671	556	-17.1
• Casuarina Forests and Woodlands	1,197	1,119	-6.5
• Melaleuca Forests and Woodlands	459	314	-31.6
• Tussock Grasslands	71	11	-84.1
• Hummock Grasslands	62	2	-95.6
• Chenopod-Samphire Shrublands and Forblands	84	14	-83.4

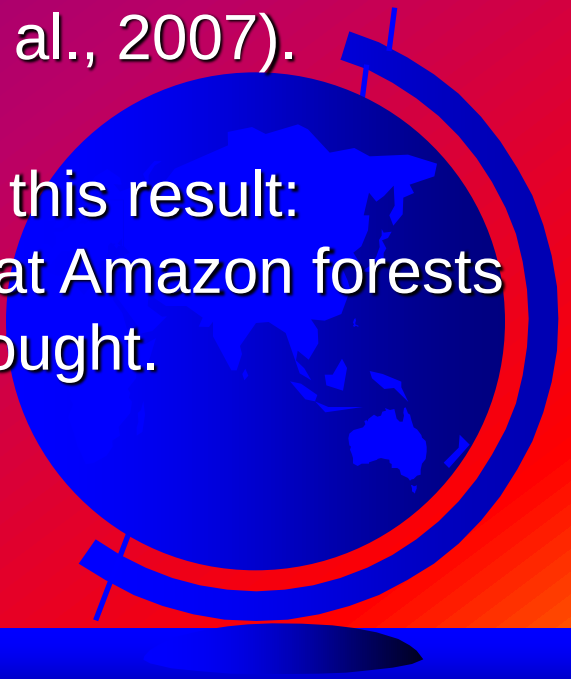
Results

- There is a significant spatio-temporal variability of NPP over major vegetation groups in Queensland
- In wet year, the mean NPP of rainforests and vine thickets was 1,878 gC/m2/yr-1, in contrast to hummock grasslands (62 gC/m2/yr-1).
- During drought, the mean NPP values range from 2,071 gC/m2/yr-1 to 2 gC/m2/yr-1. Grassland NPP has decreased by up to 96%.
- This highlights the vulnerability of these areas to drought events which can impact ecological and agricultural systems.



Results

- Some vegetation groups did not significantly change (e.g. Eucalypt open forests, Casuarina forests, etc.).
- Rainforest's NPP increased by 10% during drought! This agrees with a study of the Amazon rainforests during the 2005 drought (Saleska et al., 2007).
- However, more recent study refuted this result: Samanta, et al. (2010) concluded that Amazon forests did not green-up during the 2005 drought.



Conclusions

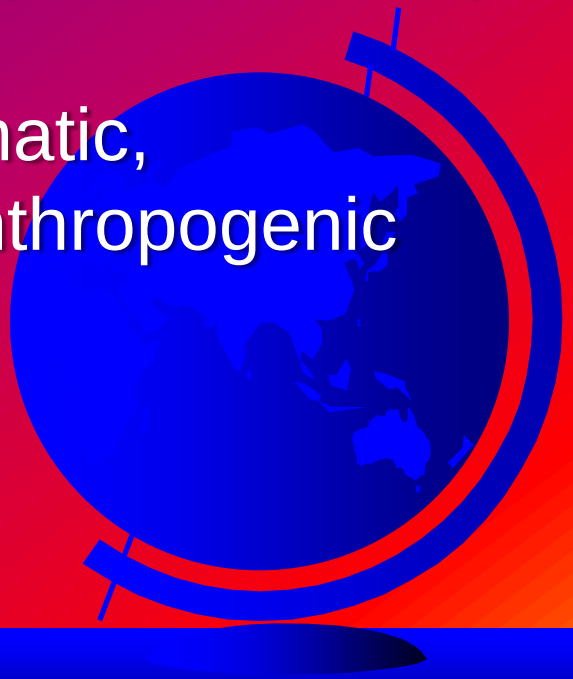
- It seems that vegetation NPP's response to drought is related to vegetation's structural complexity.
- High correlations between NPP and rainfall, TWI, solar radiation, FPC, etc. None for soil water and aspect.

The Philippine Study

Objectives:

- to characterize the net primary productivity (NPP) of forests and non-forest areas and to assess their spatial distribution. (reported here)

- to relate the NPP areas with climatic, topographic, ecosystems and anthropogenic variables. (more work)



Datasets Used

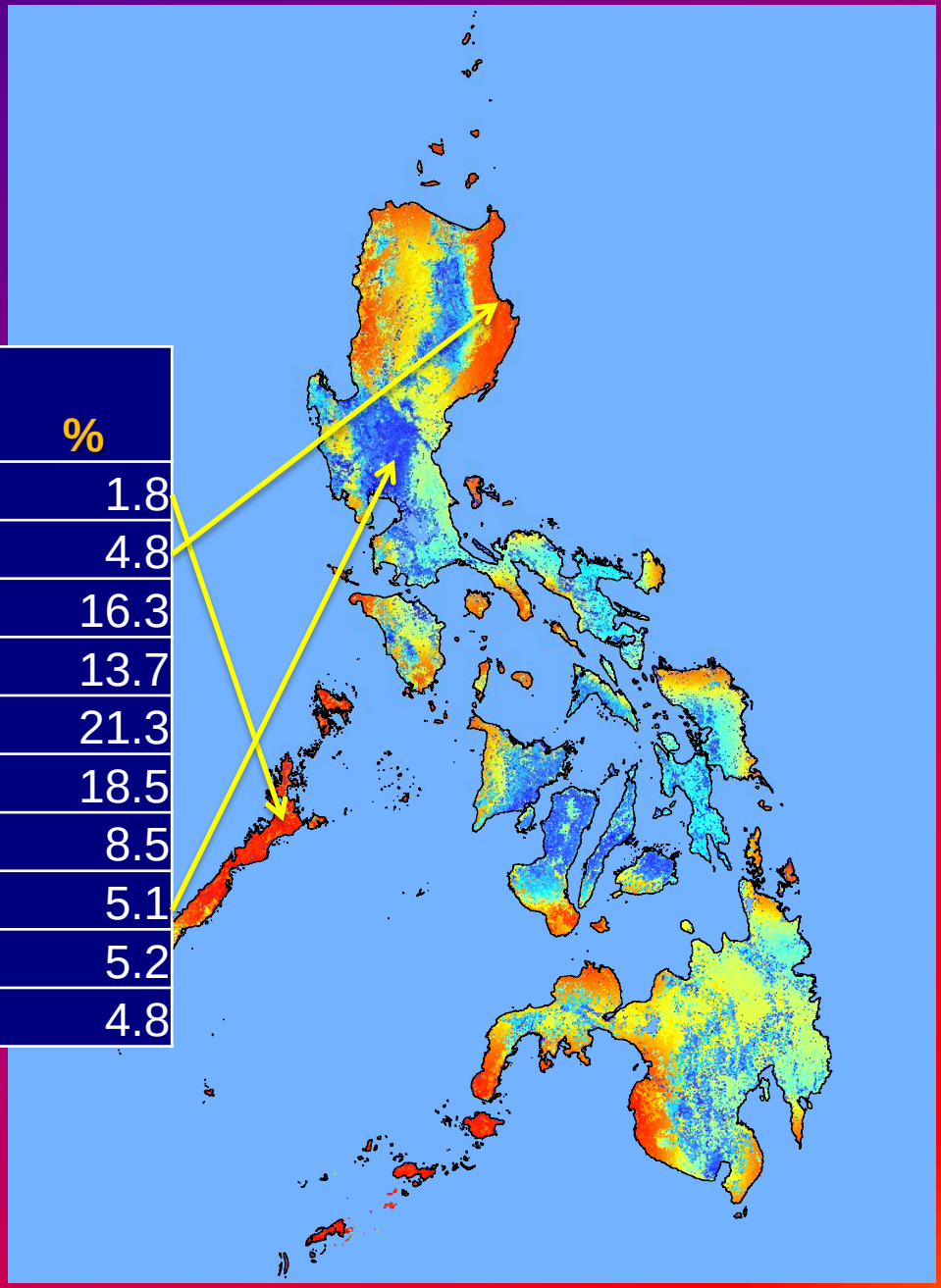
- MODIS NPP Product (MOD17)
- Country Boundary
- Country Provinces

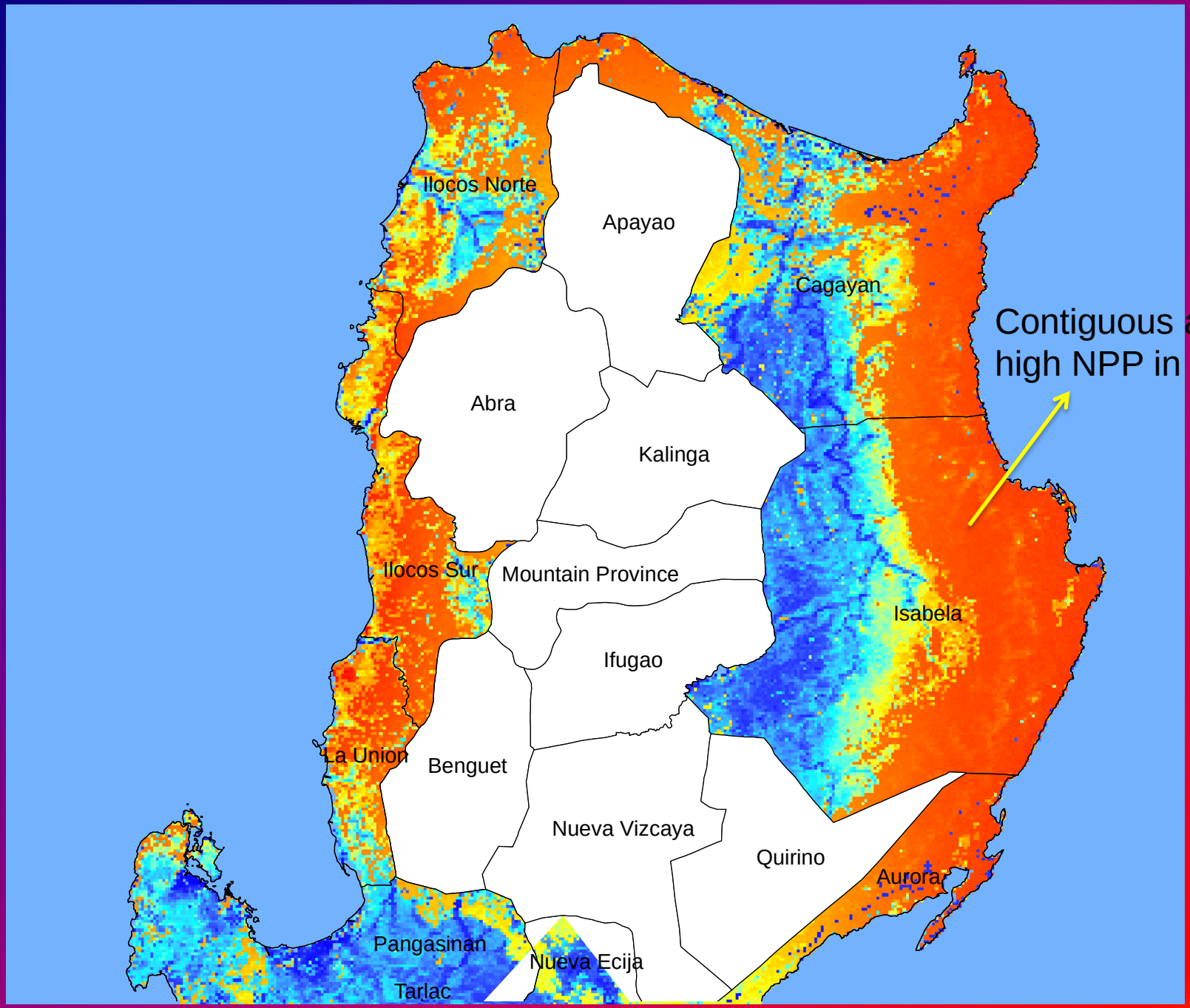
Data Processing and Analysis

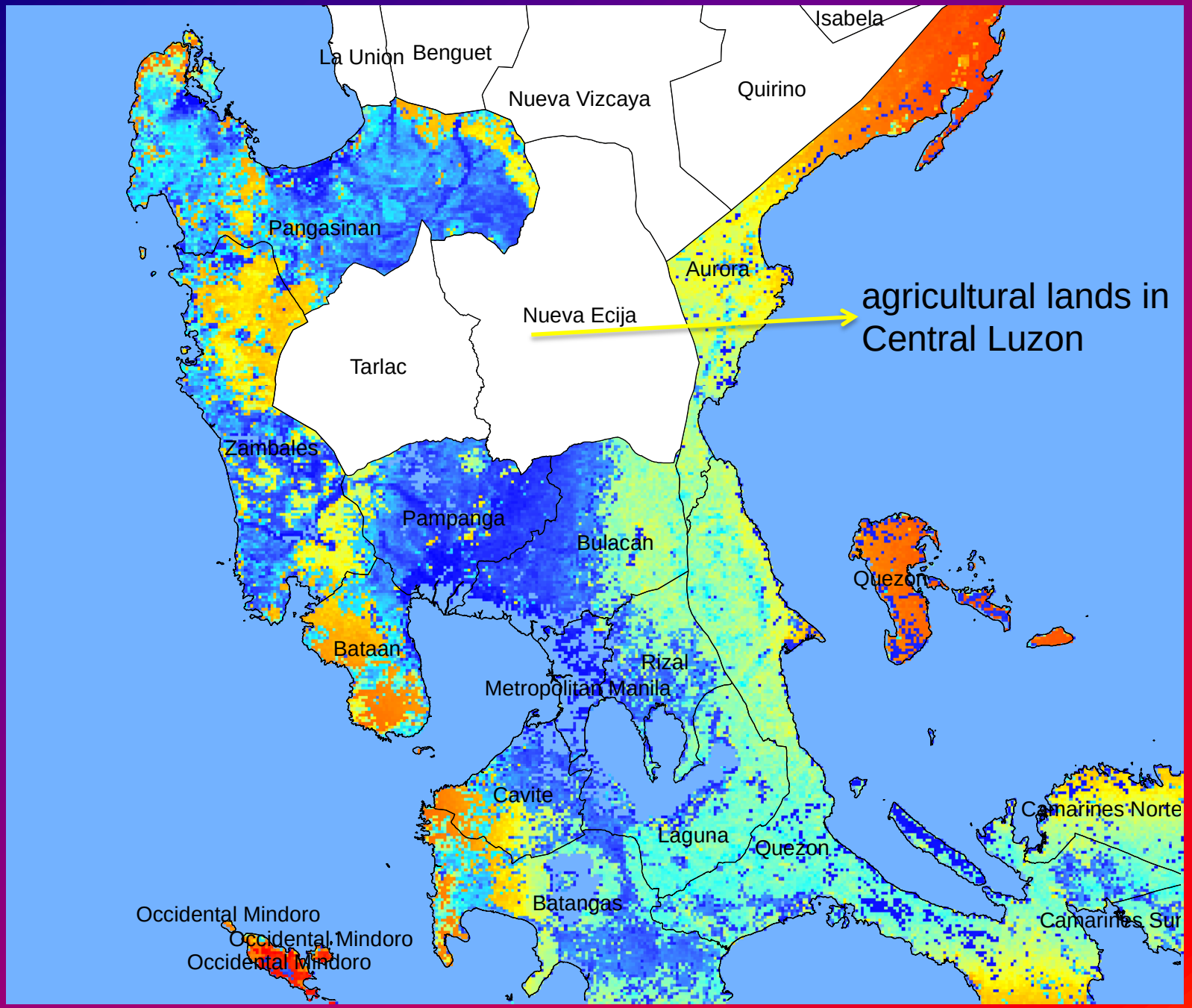
- Re-projection, Clipping
- Reclassification (into 10 NPP classes)
- Grid map overlay of NPP and province layer
- Simple logical query of the output tables
- Basic statistics

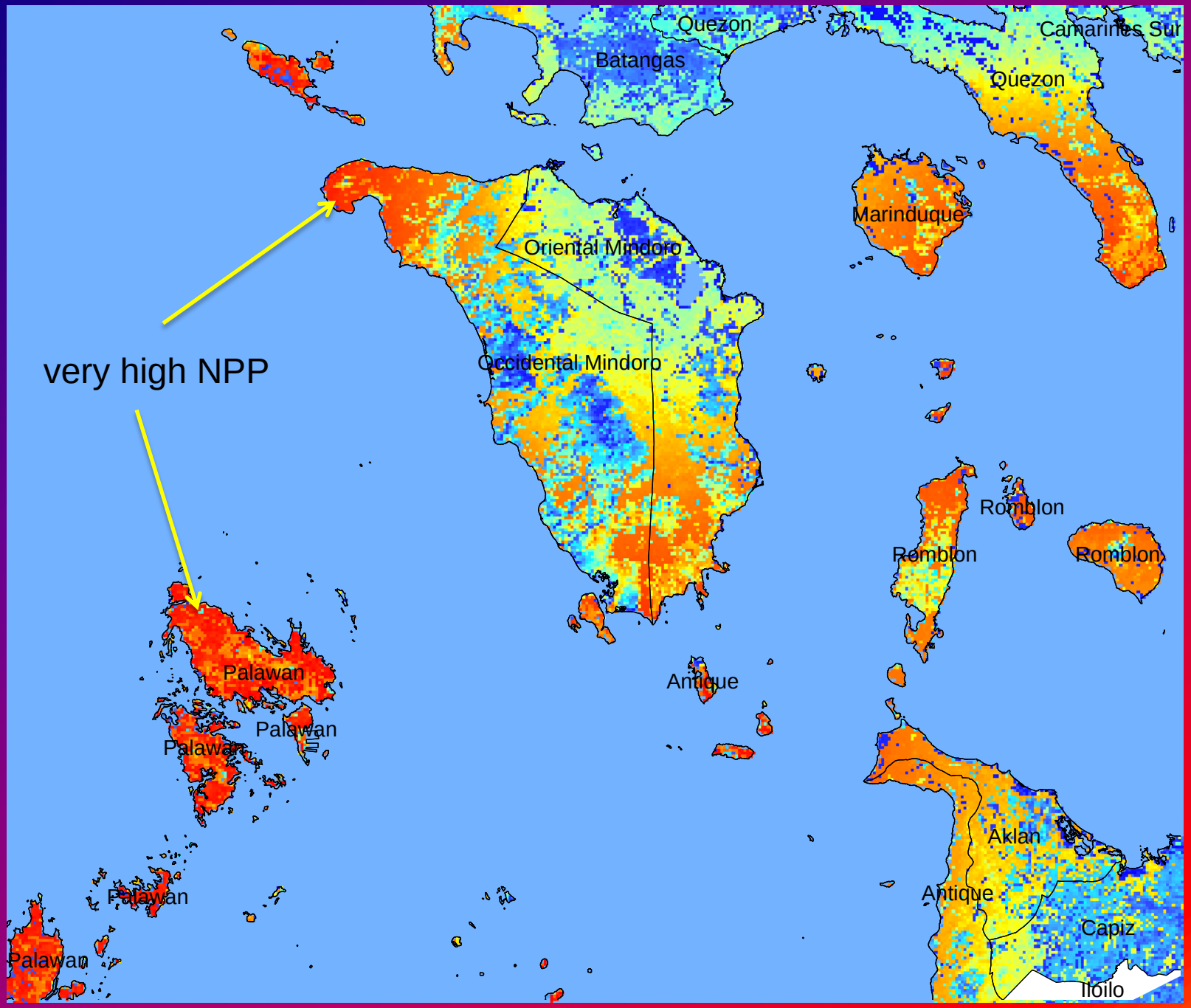
Results

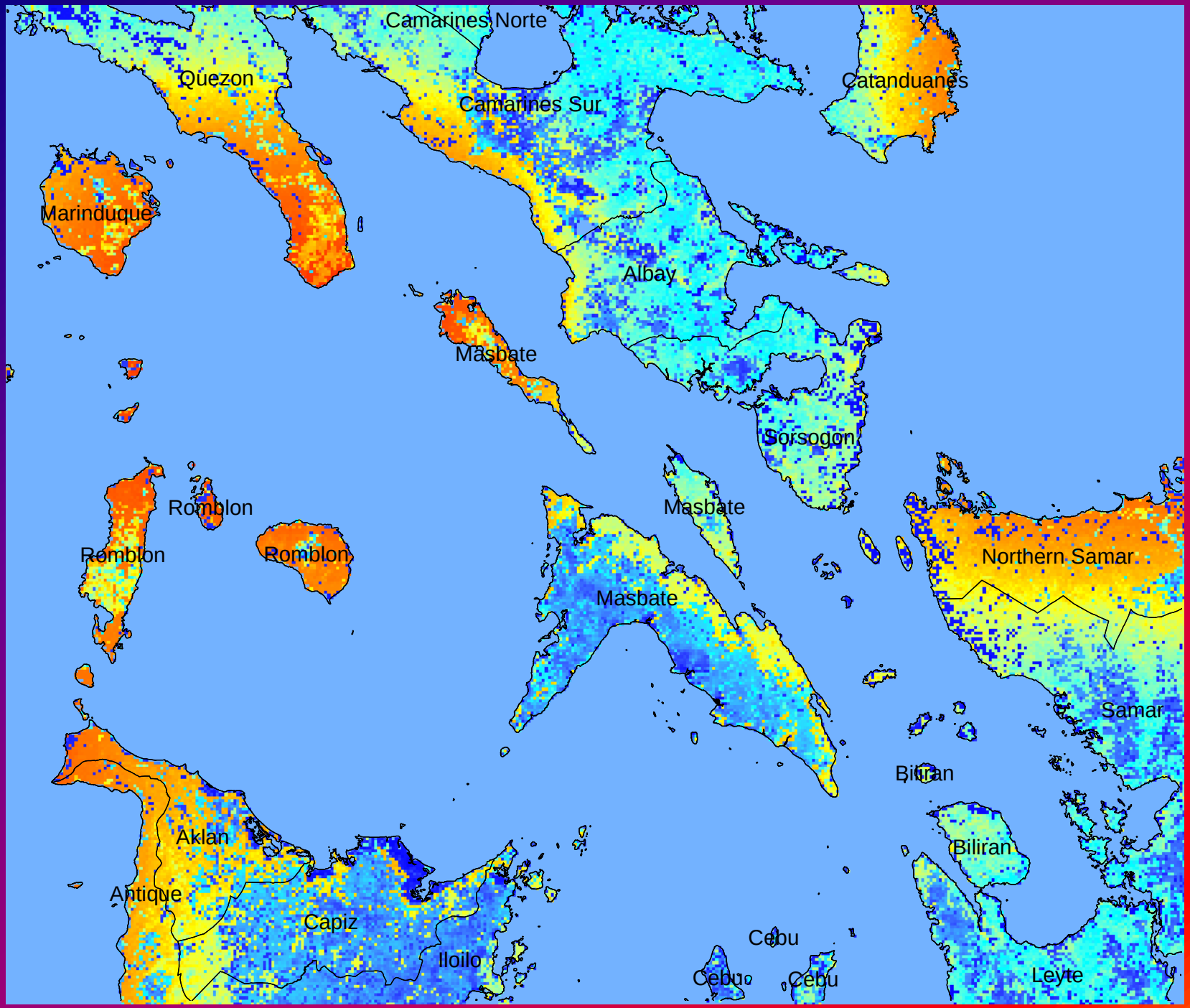
NPP Class	NPP (gC/m2/yr)	Area (km2)	%
1	2,163	6,229	1.8
2	1,749	16,429	4.8
3	1,524	55,997	16.3
4	1,312	47,257	13.7
5	1,140	73,239	21.3
6	1,013	63,711	18.5
7	897	29,330	8.5
8	770	17,461	5.1
9	625	17,859	5.2
10	380	16,438	4.8

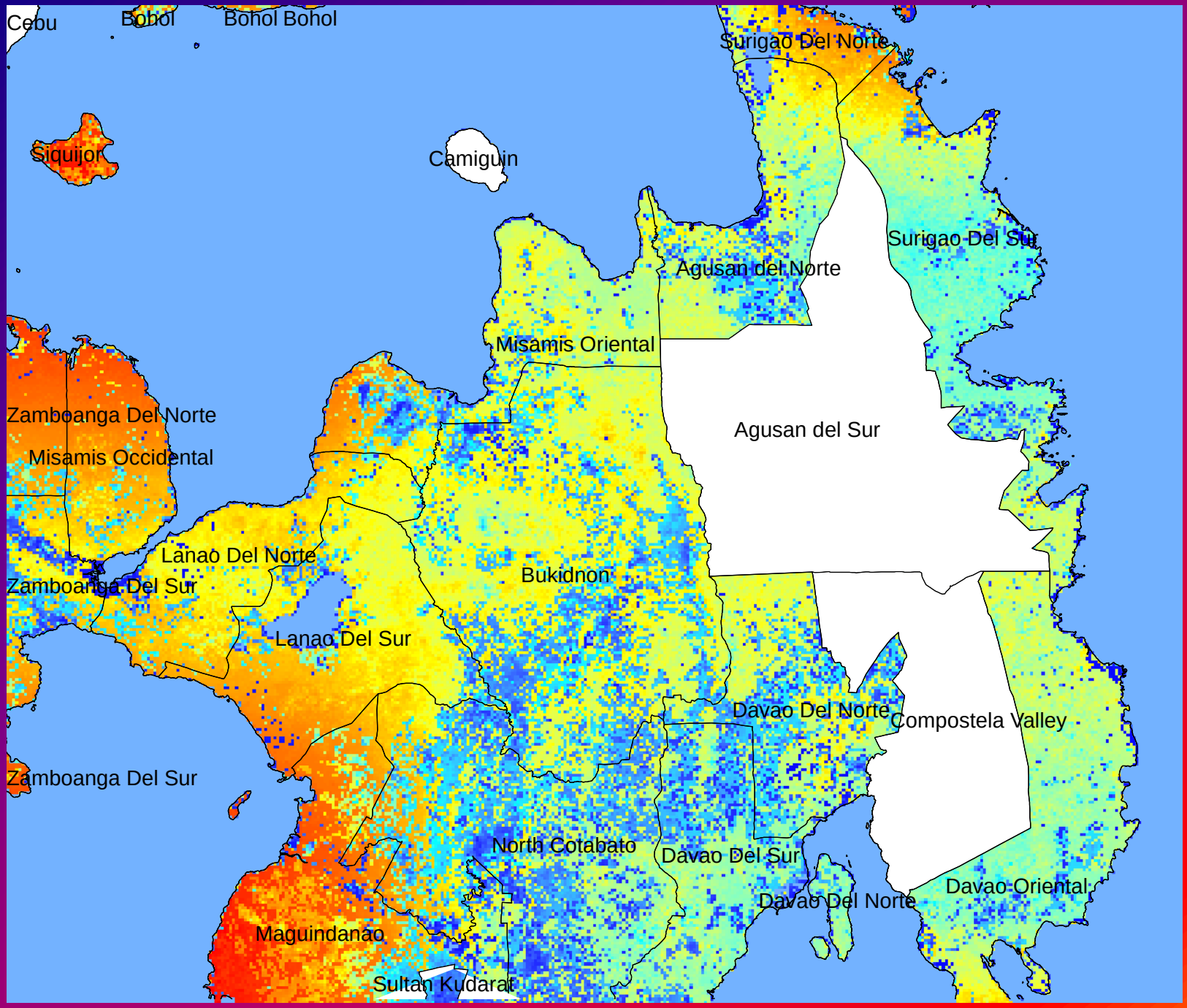


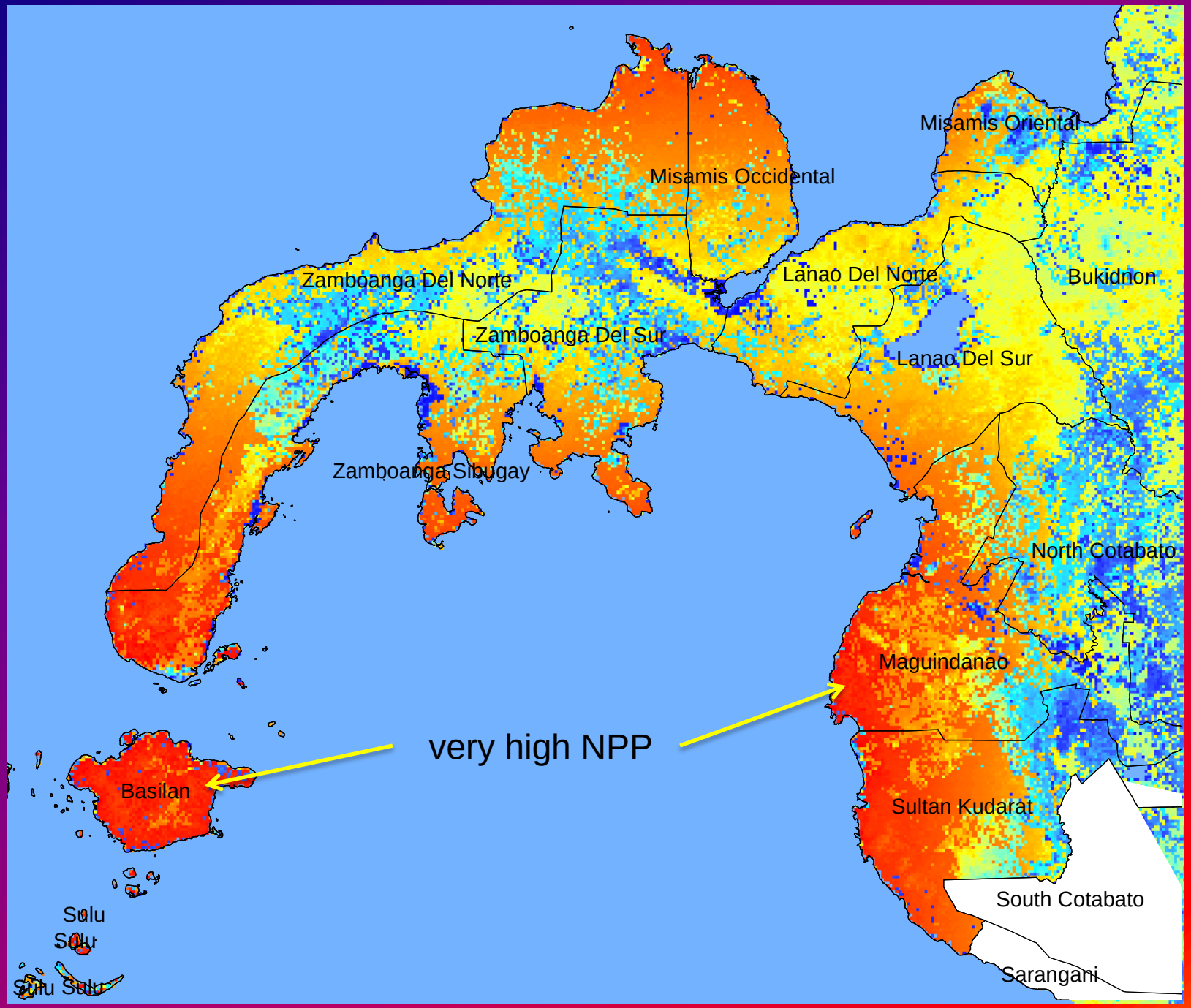

Ilocos Norte
Apayao
Cagayan
Abra
Kalinga
Ilocos Sur
Mountain Province
Isabela
Ifugao
La Union
Benguet
Nueva Vizcaya
Quirino
Aurora
Pangasinan
Nueva Ecija
Tarlac
Contiguous area of high NPP in N. Luzon

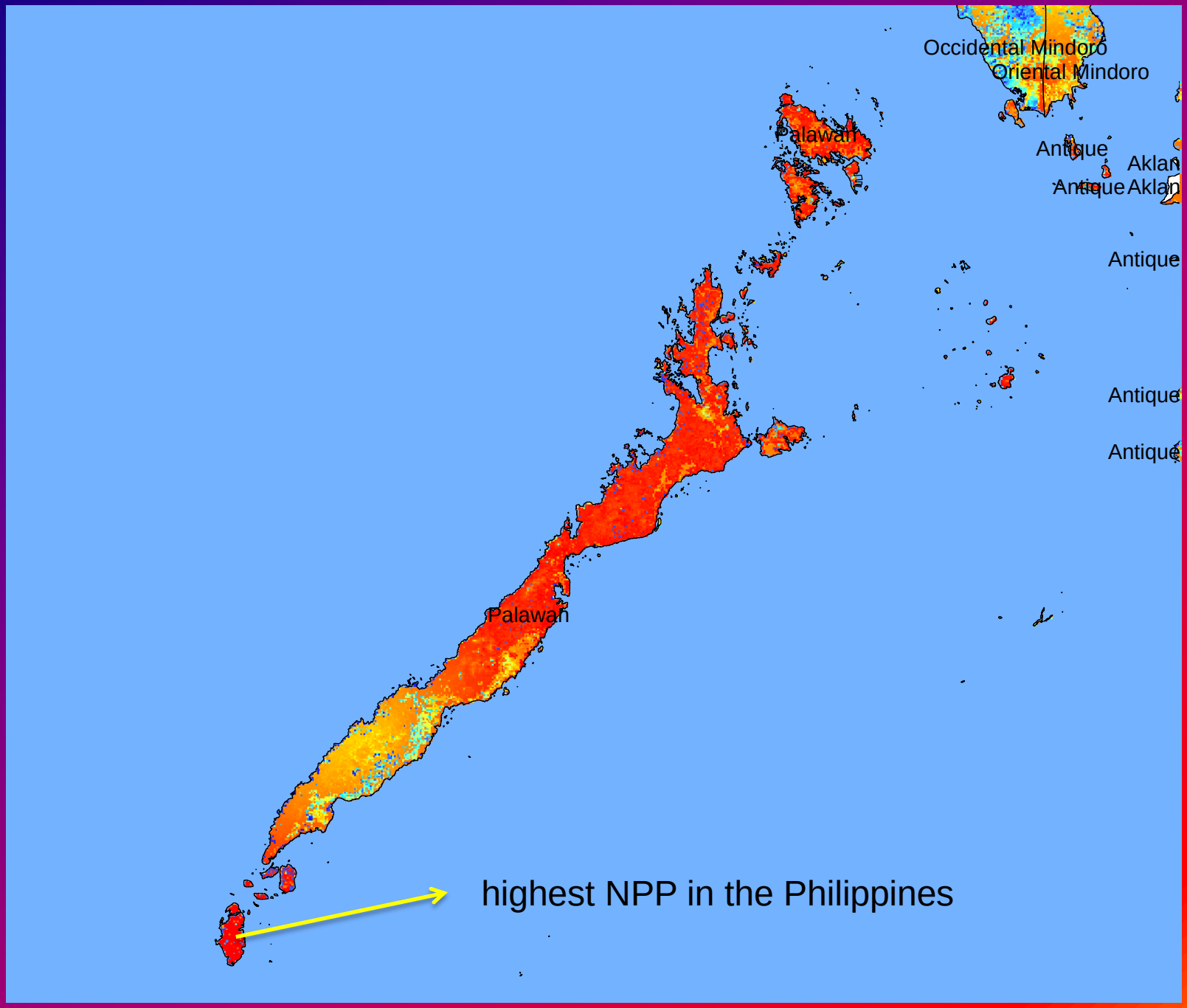

Isabela
La Union
Benguet
Nueva Vizcaya
Quirino
Pangasinan
Aurora
Nueva Ecija
agricultural lands in Central Luzon
Tarlac
Zambales
Pampanga
Bulacan
Quezon
Bataan
Rizal
Metropolitan Manila
Cavite
Laguna
Quezon
Camarines Norte
Batangas
Occidental Mindoro
Occidental Mindoro
Occidental Mindoro
Camarines Sur


very high NPP
Quezon
Batangas
Quezon
Camarines Sur
Marinduque
Oriental Mindoro
Occidental Mindoro
Romblon
Romblon
Romblon
Antique
Palawan
Palawan
Palawan
Palawan
Palawan
Aklan
Antique
Capiz
Iloilo


Camarines Norte
Quezon
Catanduanes
Camarines Sur
Marinduque
Albay
Masbate
Sorsogon
Romblon
Masbate
Romblon
Romblon
Northern Samar
Masbate
Samar
Biliran
Biliran
Aklan
Antique
Capiz
Iloilo
Cebu
Cebu
Cebu
Leyte


Cebu
Bohol
Bohol Bohol
Surigao Del Norte
Siquijor
Camiguin
Surigao Del Sur
Agusan del Norte
Misamis Oriental
Zamboanga Del Norte
Agusan del Sur
Misamis Occidental
Lanao Del Norte
Bukidnon
Zamboanga Del Sur
Lanao Del Sur
Davao Del Norte
Compostela Valley
Zamboanga Del Sur
North Cotabato
Davao Del Sur
Davao Oriental
Davao Del Norte
Maguindanao
Sultan Kudarat


Misamis Oriental
Misamis Occidental
Zamboanga Del Norte
Lanao Del Norte
Bukidnon
Zamboanga Del Sur
Lanao Del Sur
Zamboanga Sibugay
North Cotabato
Maguindanao
very high NPP
Basilan
Sultan Kudarat
South Cotabato
Sarangani

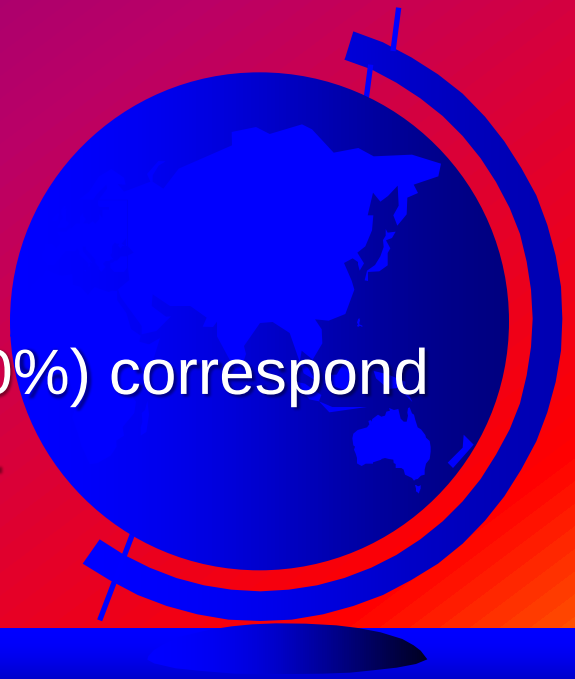

Occidental Mindoro
Oriental Mindoro
Palawan
Antique
Aklan
Antique
Aklan
Antique
Antique
Antique
Palawan
highest NPP in the Philippines

Results

Top 10% NPP areas in the Philippines

(,750 to 2,160 gC/m^2/yr^{-1})

1. Palawan
2. Basilan
3. Sulu
4. Sultan Kudarat
5. Maguindanao



These “most productive forests” (top 10%) correspond to 4.8% of the country’s total land area.

Results

Second Band of Top NPP areas in the Philippines

(1,520 to 1,750 gC/m^2/yr^{-1})

1. Isabela
2. Cagayan
3. Palawan
4. Sultan Kudarat
5. Ilocos Sur
6. Aurora

Results

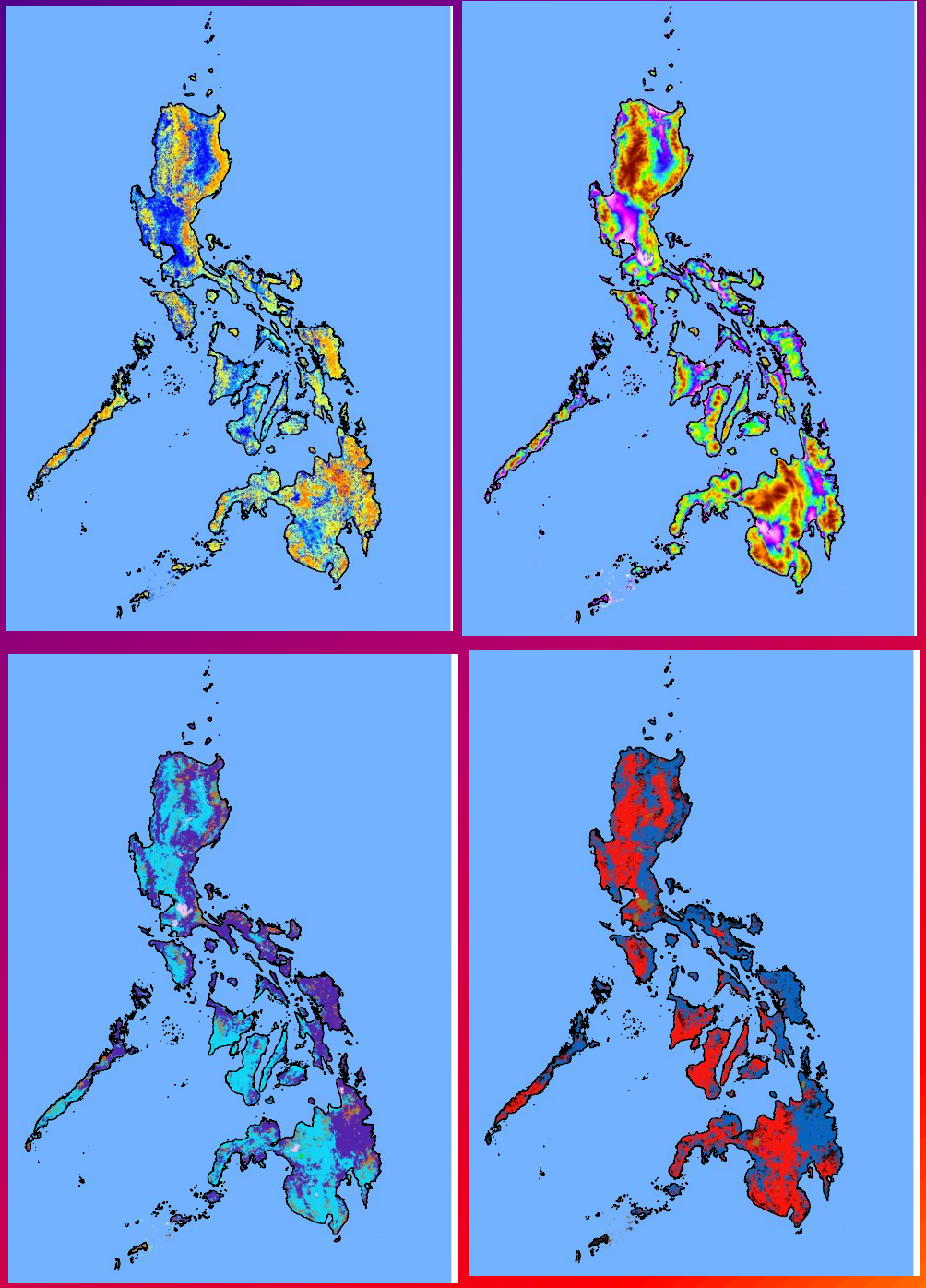
- Low NPP sites (0 to 770 $gC/m^2/yr^{-1}$) -- **22.9%** of the total land area.
- Moderately low NPP regions (770 to 897 $gC/m^2/yr^{-1}$) -- **13.7%** of the total area
  - potential sites that can be prioritized for forest rehabilitation (e.g. FRNI: Apan, 1997) / REDD+ mechanism.
  - can be subjected to detailed land assessment.

More Work

- describe and relate the NPP areas with regards to climatic, topographic, ecosystems and anthropogenic variables.

Already acquired datasets:

- Land use
- Land cover
- Tree height
- DEM



Conclusions

- High, moderate and low NPP areas were identified spatially: demonstrated of utility of satellite-derived NPP data.

- At the country level, the information can be useful for planning rehabilitation efforts, protection of forested areas, etc.


THANK YOU!