UMBC

Vegetation Mapping of Africa using Machine learning

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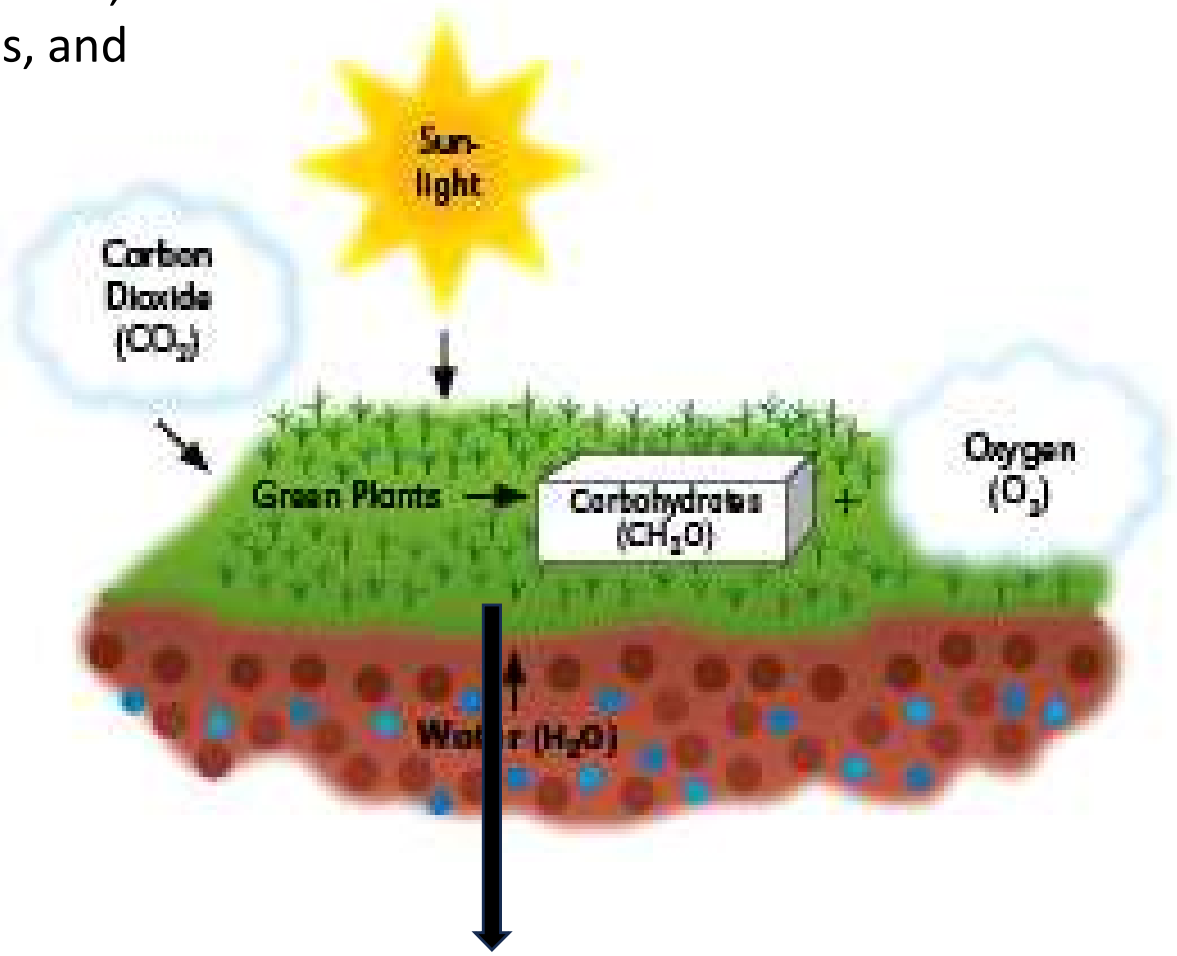
Vegetation-Climate Dynamics

CLIMATE

- Provide solar radiation, atmospheric gases, and precipitation

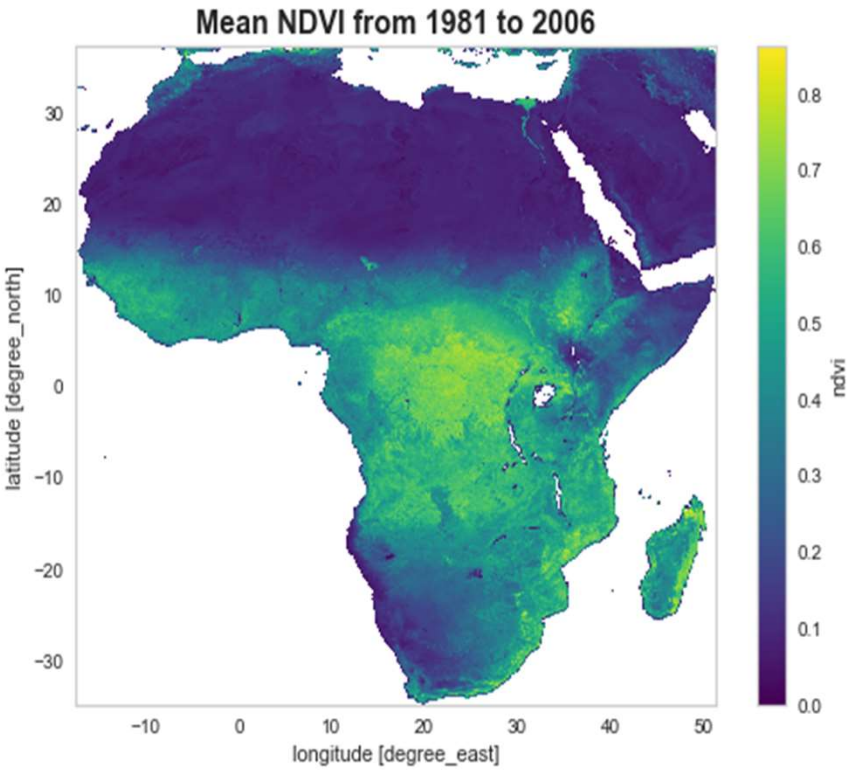
VEGETATION

- Modulate water, energy, and carbon



Vegetation → Understanding climate and vegetation variability

Why Africa?



- It has 17% of the global forest cover
- One of the regions most susceptible to the impacts of climate change
- It remains relatively understudied

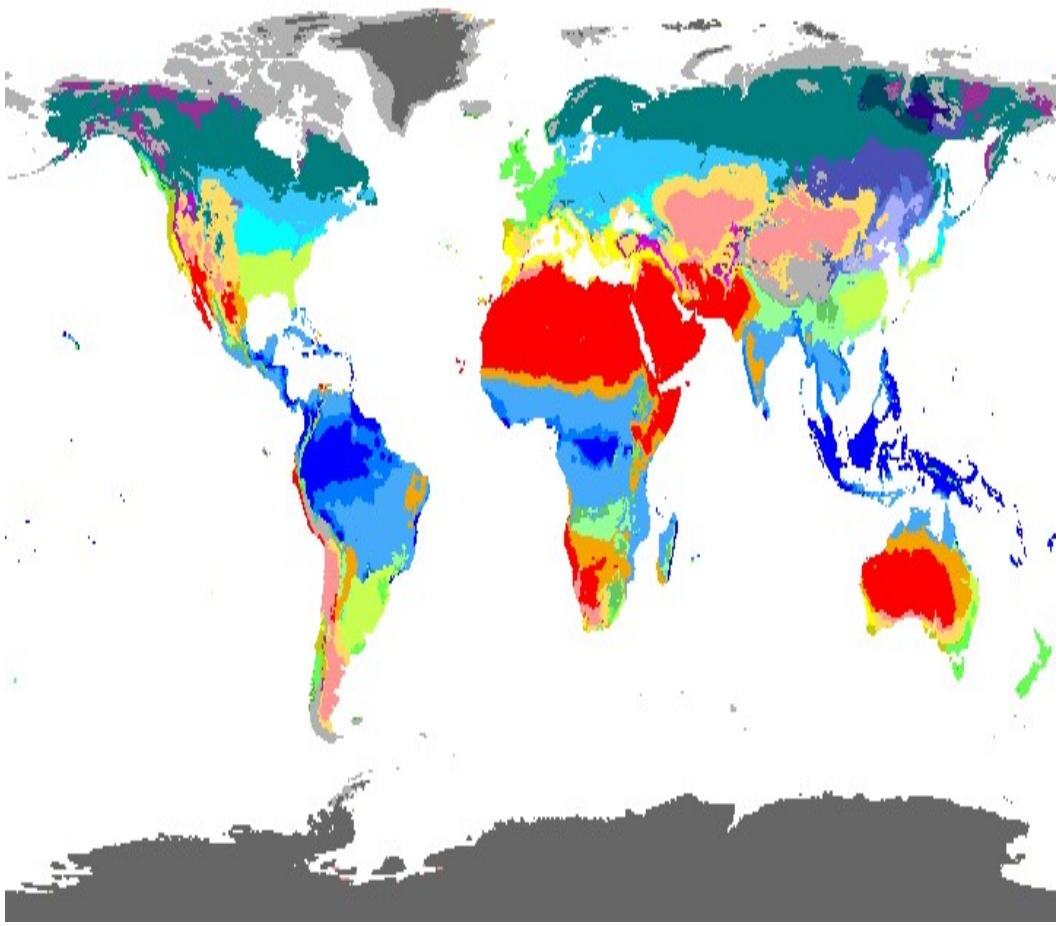
How is Vegetation and Climate distributed?

A systematic review of vegetation phenology in Africa

Tracy Adole [a,*], Jadu Dash [a], Peter M. Atkinson [b]

[a] *Global Environmental Change and Earth Observation Research Group, Geography and Environment, University of Southampton, UK*
[b] *Faculty of Science and Technology, Lancaster University, UK*

Vegetation Distribution → Temperature & Precipitation threshold



Koppen-Geiger classification

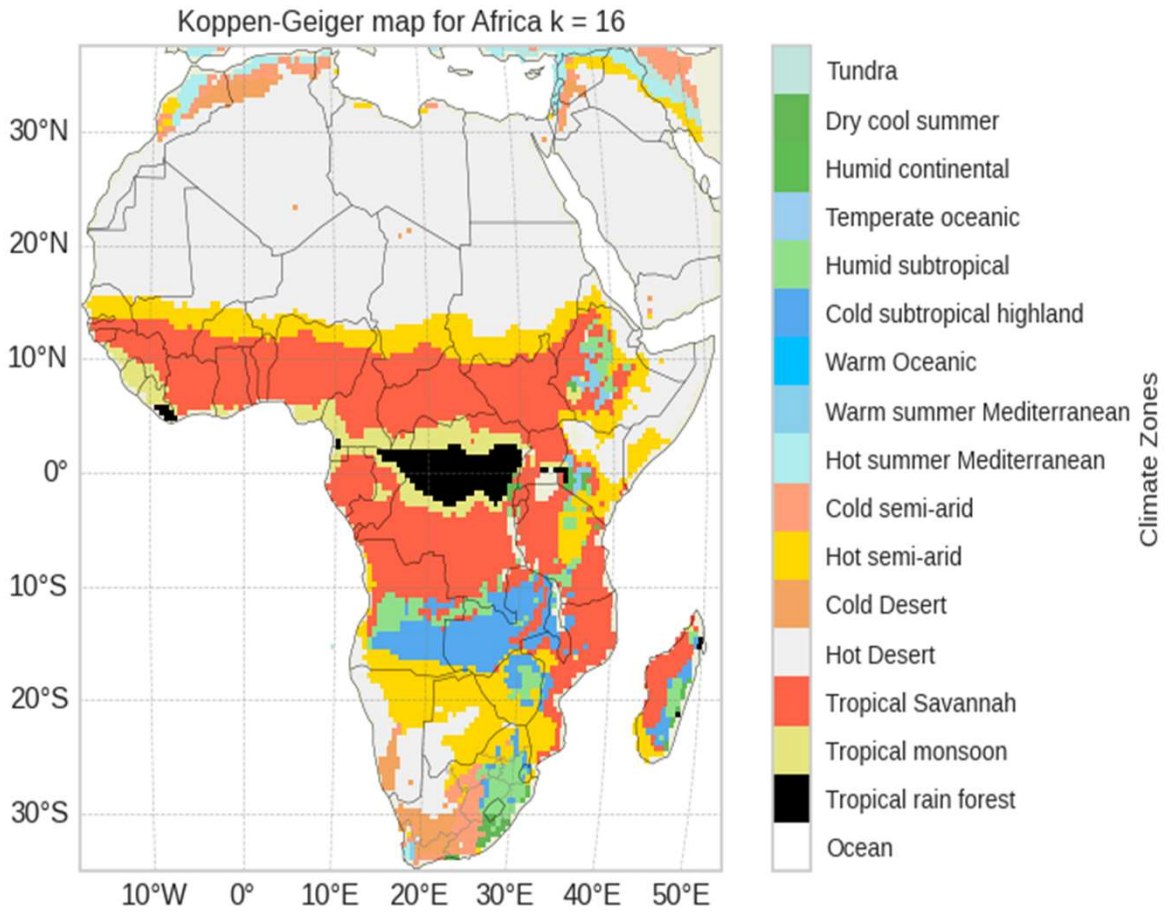
- **It is a manual decision tree based on seasonal temp. and prec. threshold**
- **Vegetation is a function of climate only**
- **It divides vegetation into five main climate groups**

Sci Data. 2018; 5: 180214.
Published online 2018 Oct 30. doi: 10.1038/sdata.2018.214
PMCID: PMC6207062
PMID: 30375988

Present and future Köppen-Geiger climate classification maps at 1-km resolution

Hylke E. Beck,[a,1] Niklaus E. Zimmermann,[2,3] Tim R. McVicar,[4,5] Noemi Vergopolan,[1] Alexis Berg,[1] and Eric F. Wood[1]

Koppen-Geiger: Africa



Climate type	Area Covered (%)
Hot Desert	45.7
Tropical Savannah	22.7
Hot semi-arid	11.7
Warm Oceanic	3.6
Tropical monsoon	3.4
Hot summer Mediterranean	2.6
Cold subtropical highland	2.5
Tropical rain forest	2.3
Cold semi-arid	2.3
Cold Desert	1.7

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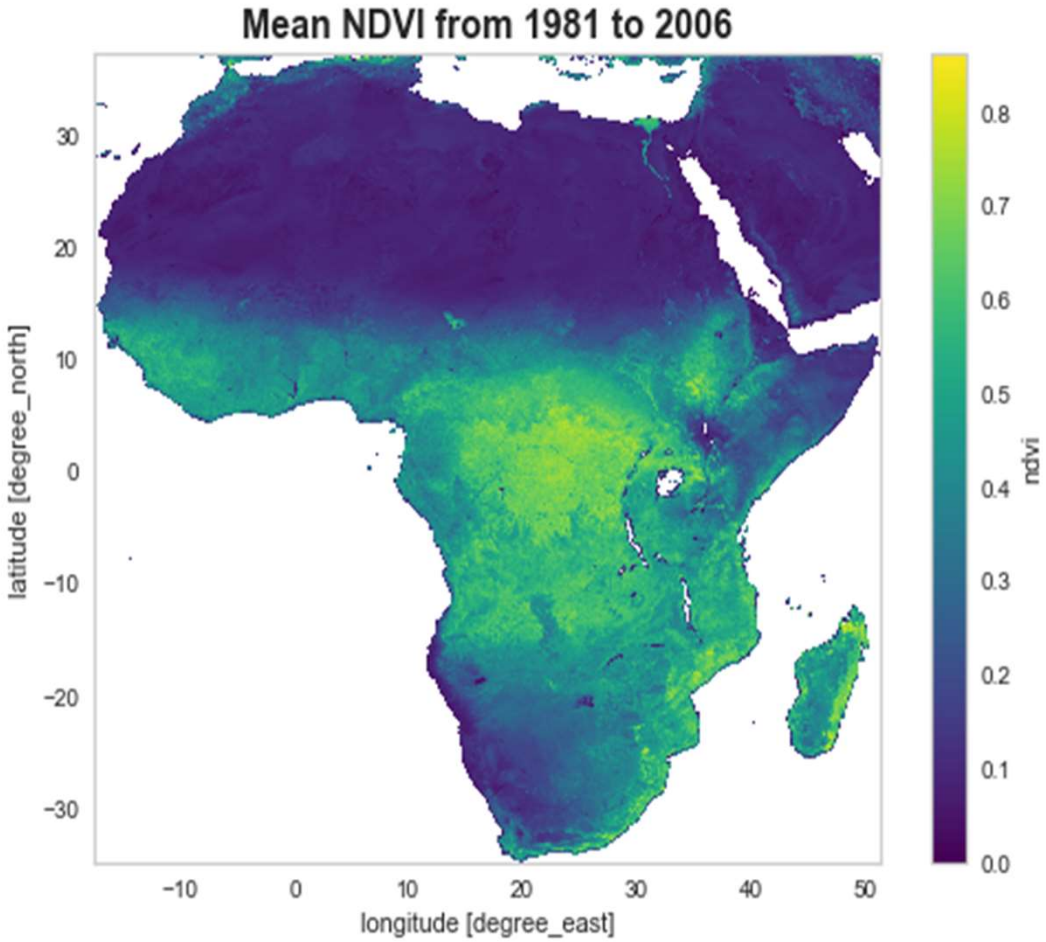
Is it possible to categorize vegetation into distinct classes using satellite-derived vegetation data?

Normalized Difference Vegetation Index (NDVI)



$$NDVI = \frac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + \rho_{RED}}$$

ρ → Spectral reflectance

- 8km resolution AVHRR NDVI 15-day composites of GIMMS (July 1981 – December 2006)

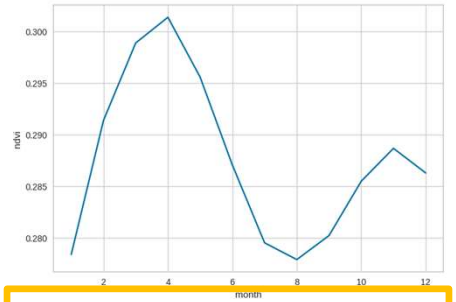
Methodology

1

8km resolution AVHRR NDVI 15-day composites of GIMMS (July 1981 – December 2006)

```
<xarray.Dataset>
Dimensions:  (T: 612, Y: 145, X: 138)
Coordinates:
  * T        (T) datetime64[ns] 1981-07-08T12:00:00 1981-07-24 ... 2006-12-24
  * X        (X) float64 -17.49 -16.98 -16.48 -15.98 ... 49.95 50.45 50.96 51.46
  * Y        (Y) float64 -34.89 -34.39 -33.88 -33.38 ... 35.76 36.26 36.76 37.26
Data variables:
    ndvi     (T, Y, X) float64 nan nan nan nan nan ... 0.2183 nan nan nan nan
```

Climatological representation



(12, 145, 138)

Months → Features

Pixels → Samples	1	2	3	4	5	6	7	8	9	10	11	12
1												
2												
3												
.												
.												
.												
11067												

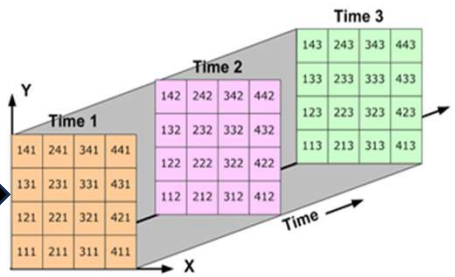
5

(11067,)

1
2
3
4
5
6
7

2

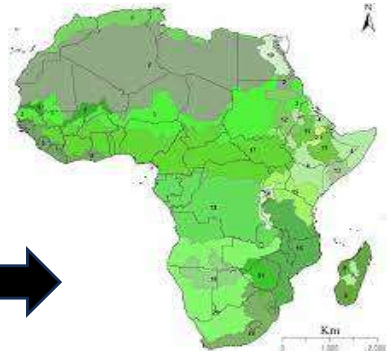
2D representation



(12, 20010)

3

Masking out oceans

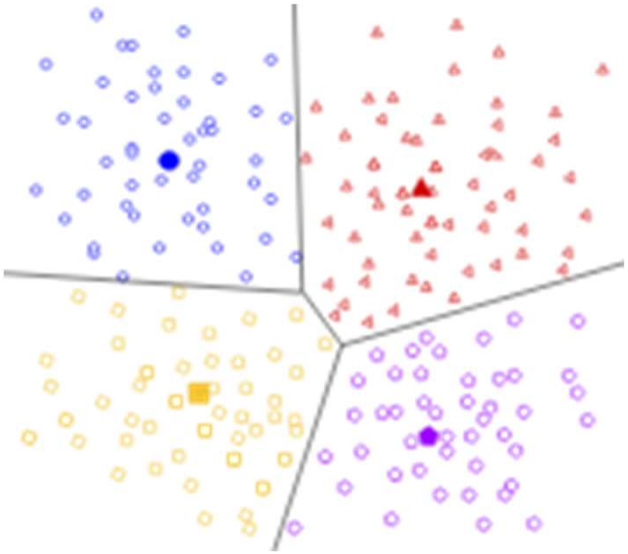


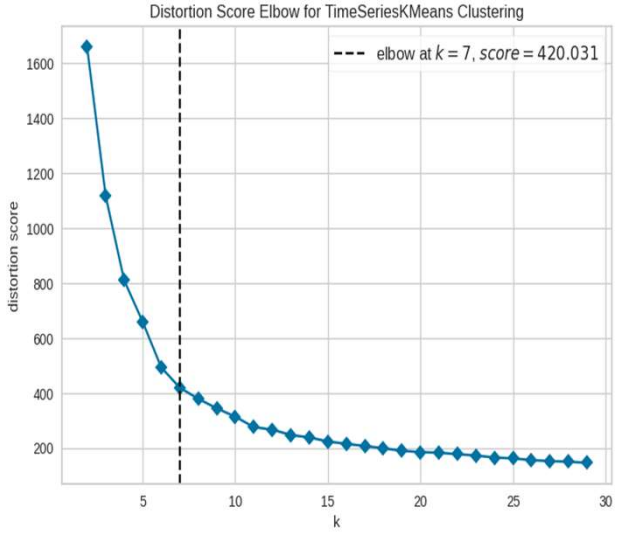
(11067, 12)

4

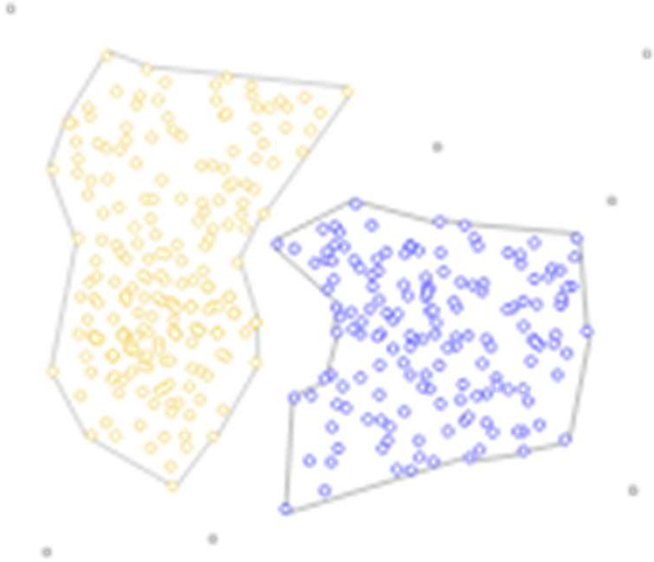
Clustering Algorithms

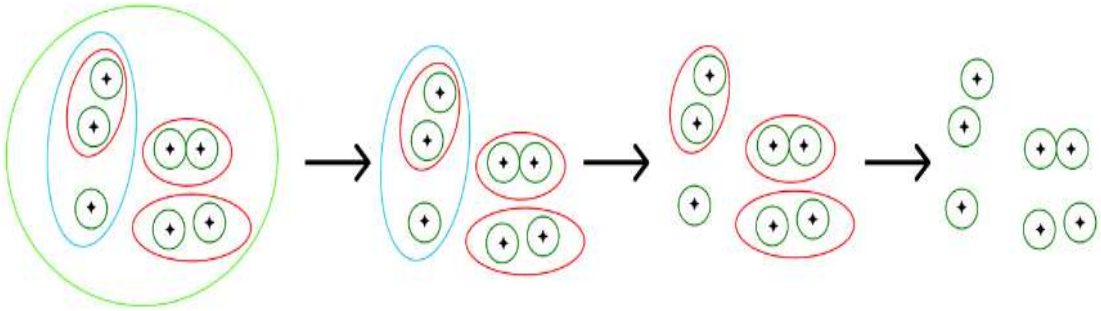
Centroid-based: KMeans





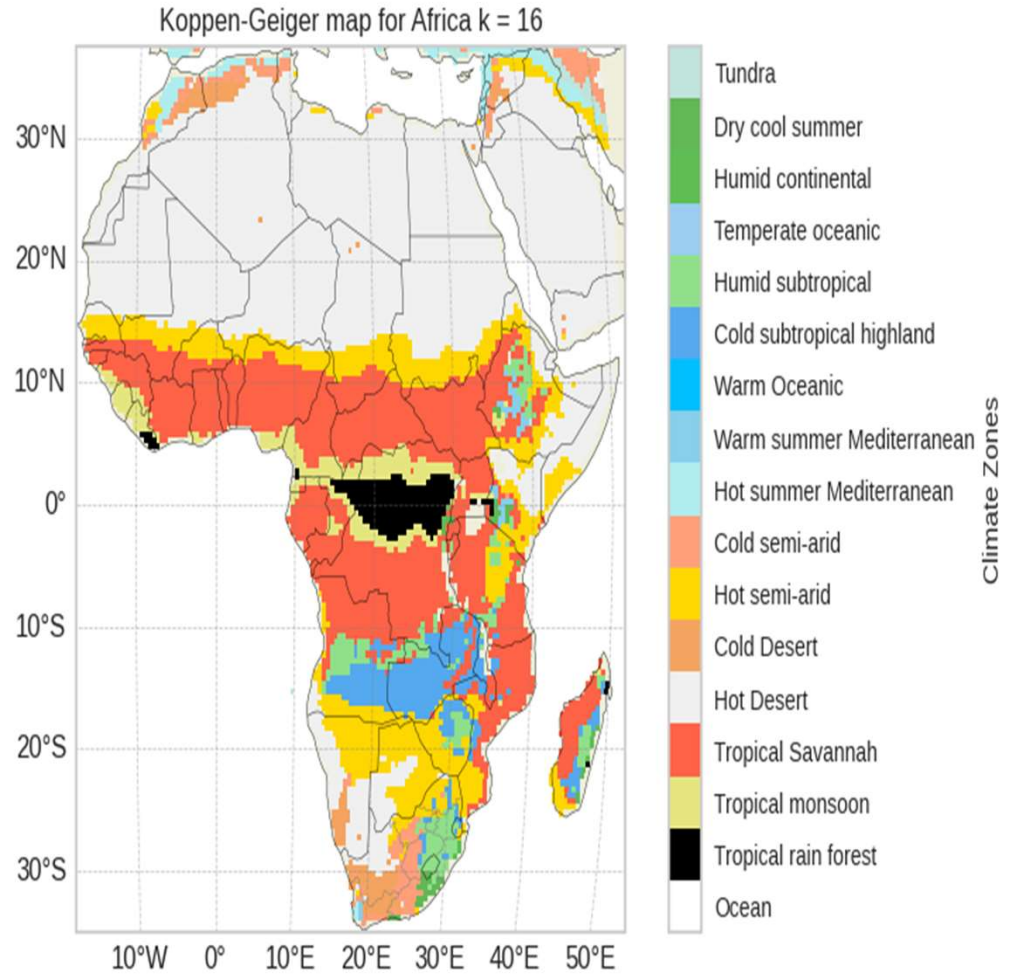
Density-based: HDBSCAN

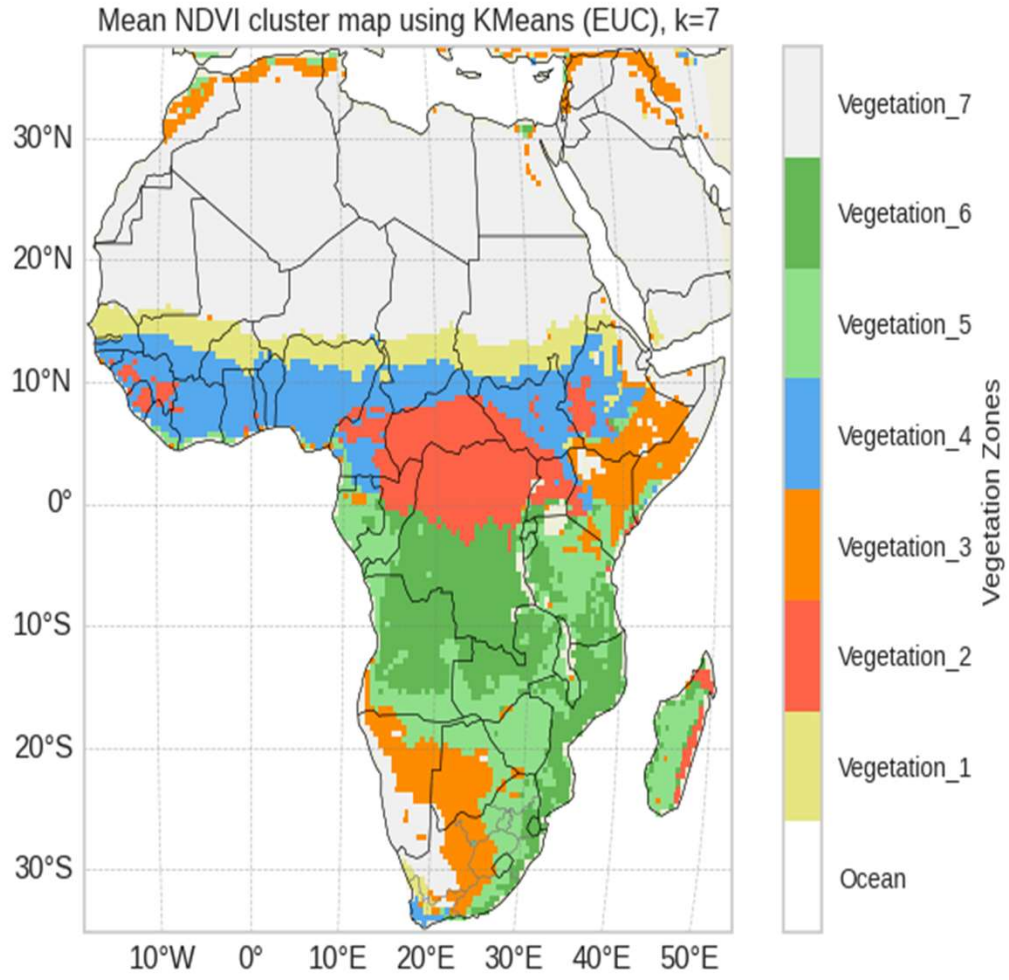




Hierarchical-based: Divisive

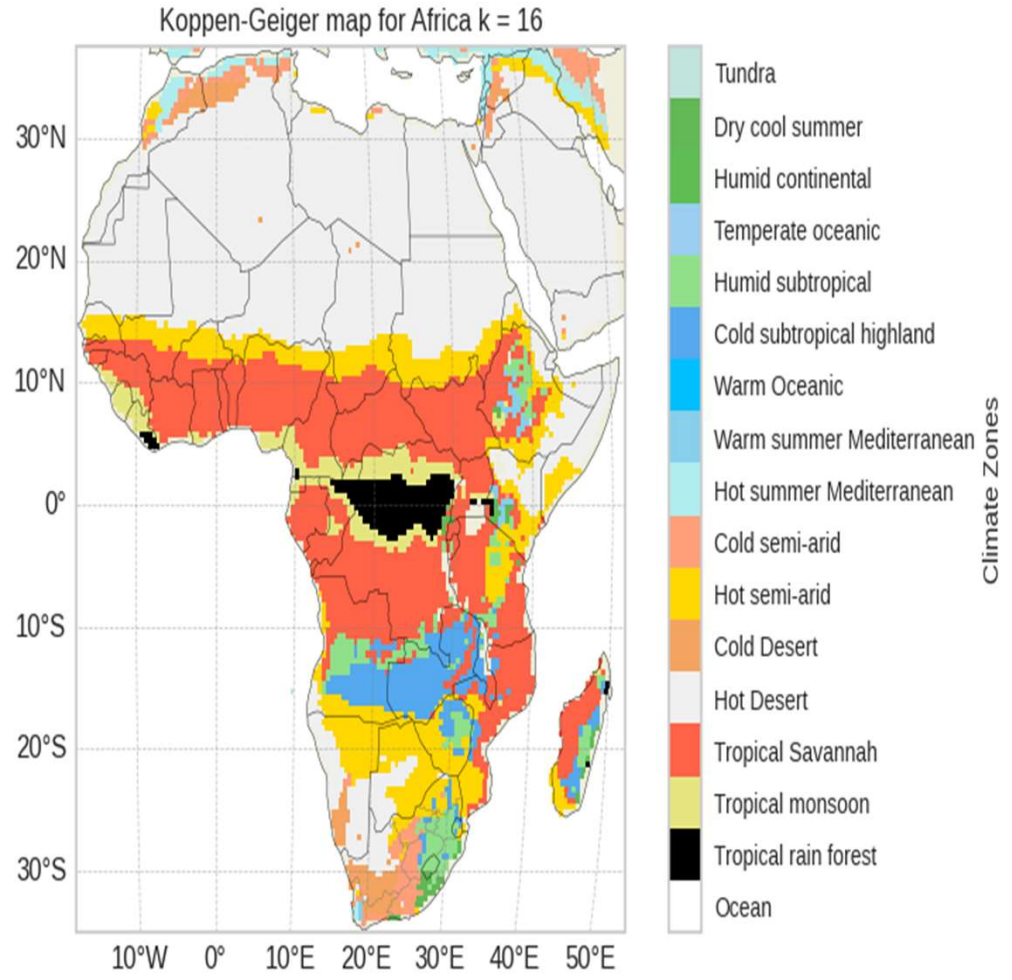
Vegetation vs Climate Map: KMeans

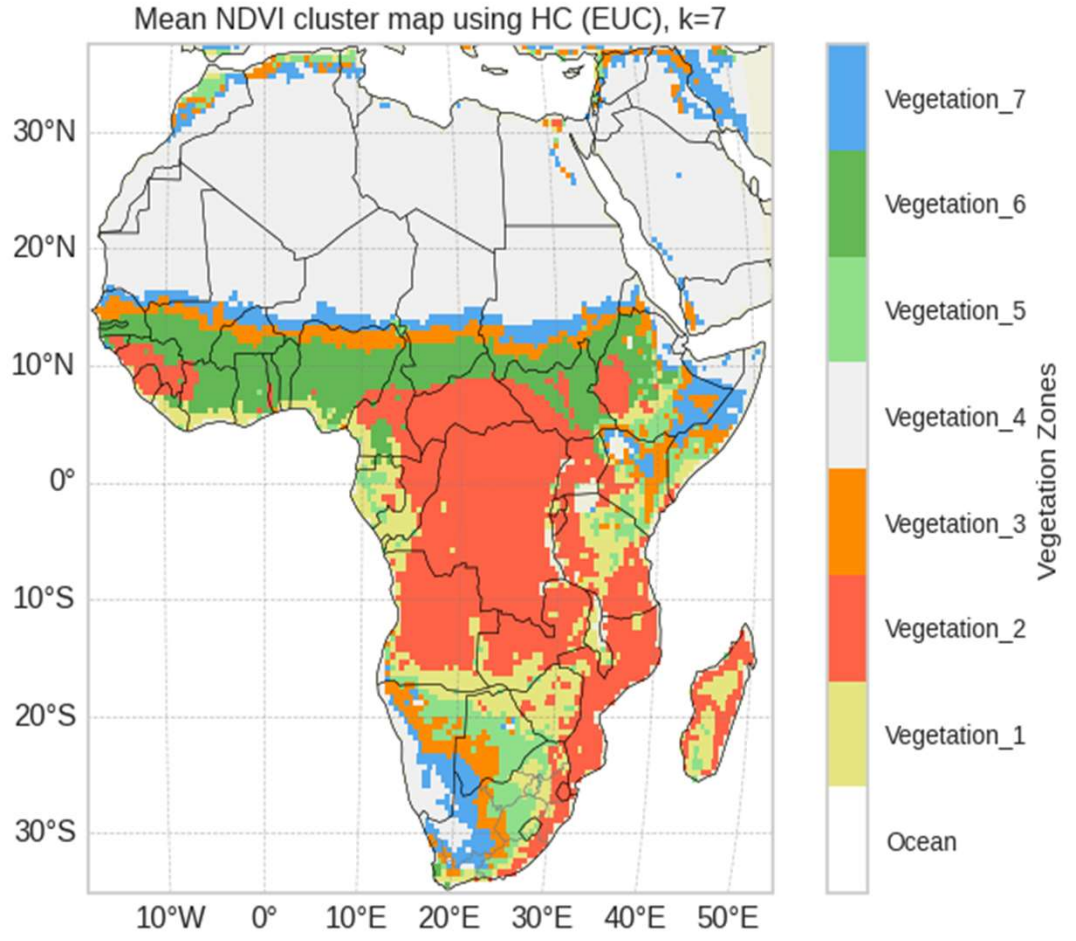




Performed better in the northern and equatorial region than in the southern region

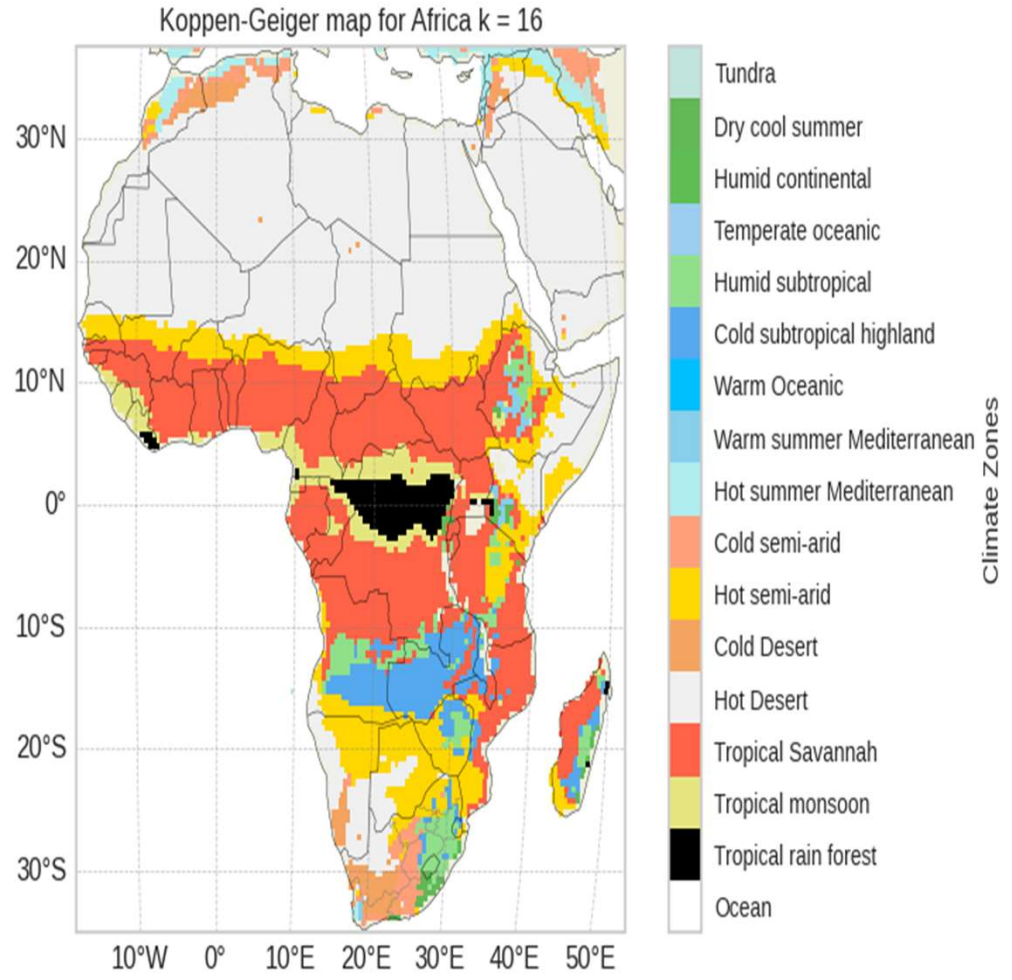
Vegetation vs Climate Map: Hierarchical

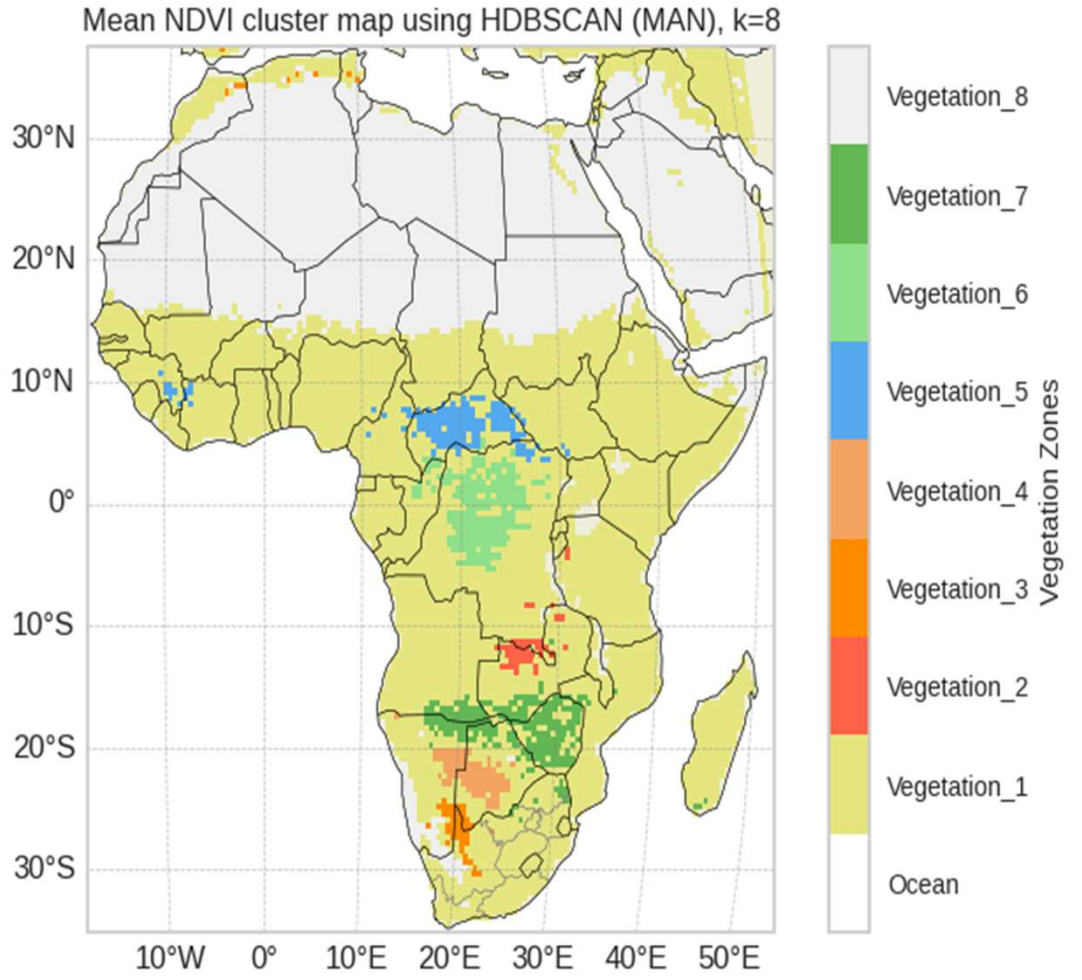




Performed better in the northern, fairly in the equatorial region and poorly in the southern region

Vegetation vs Climate Map: HDBSCAN

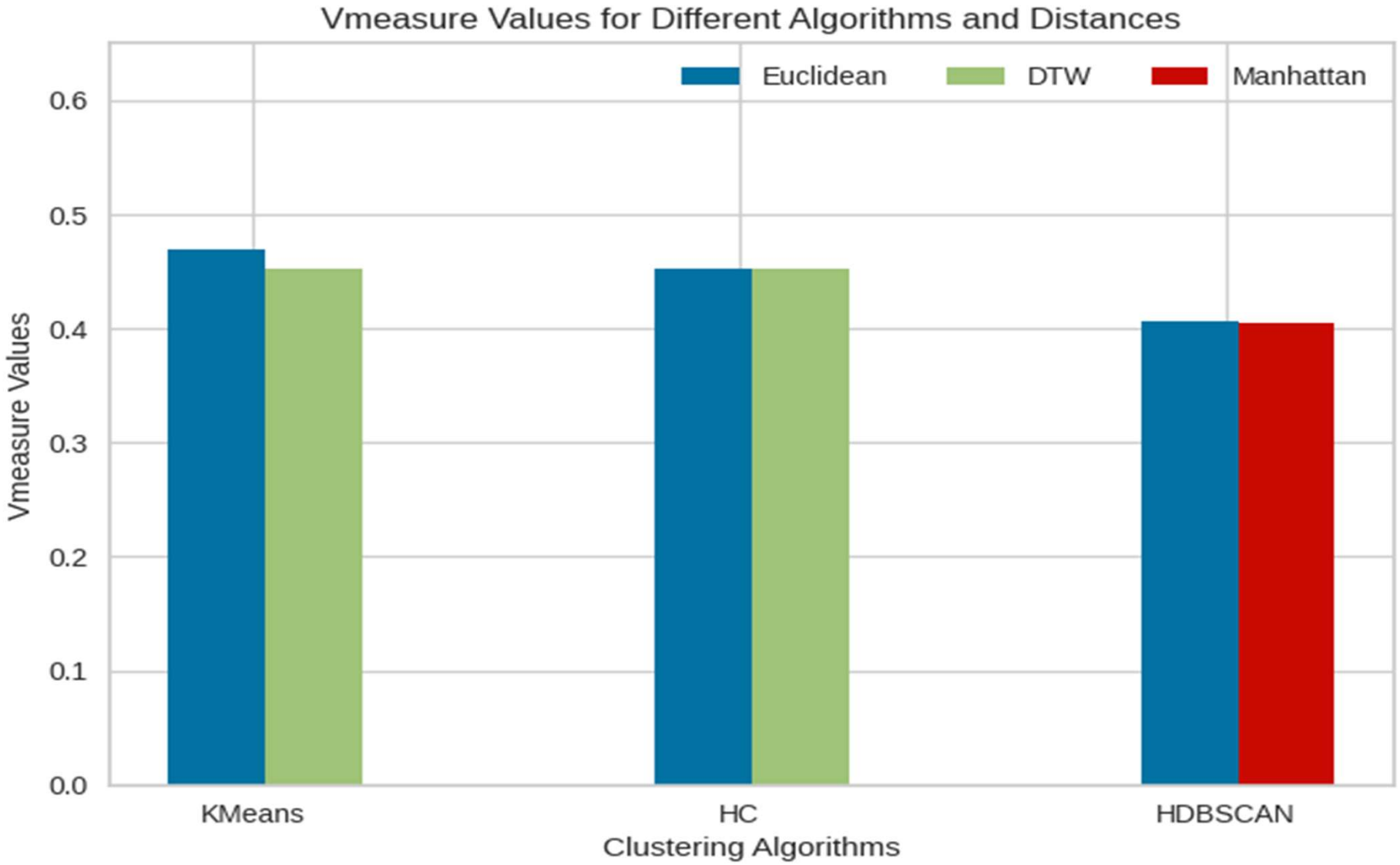




Only captured the hot desert region correctly

Vegetation vs Climate Map: Vmeasure

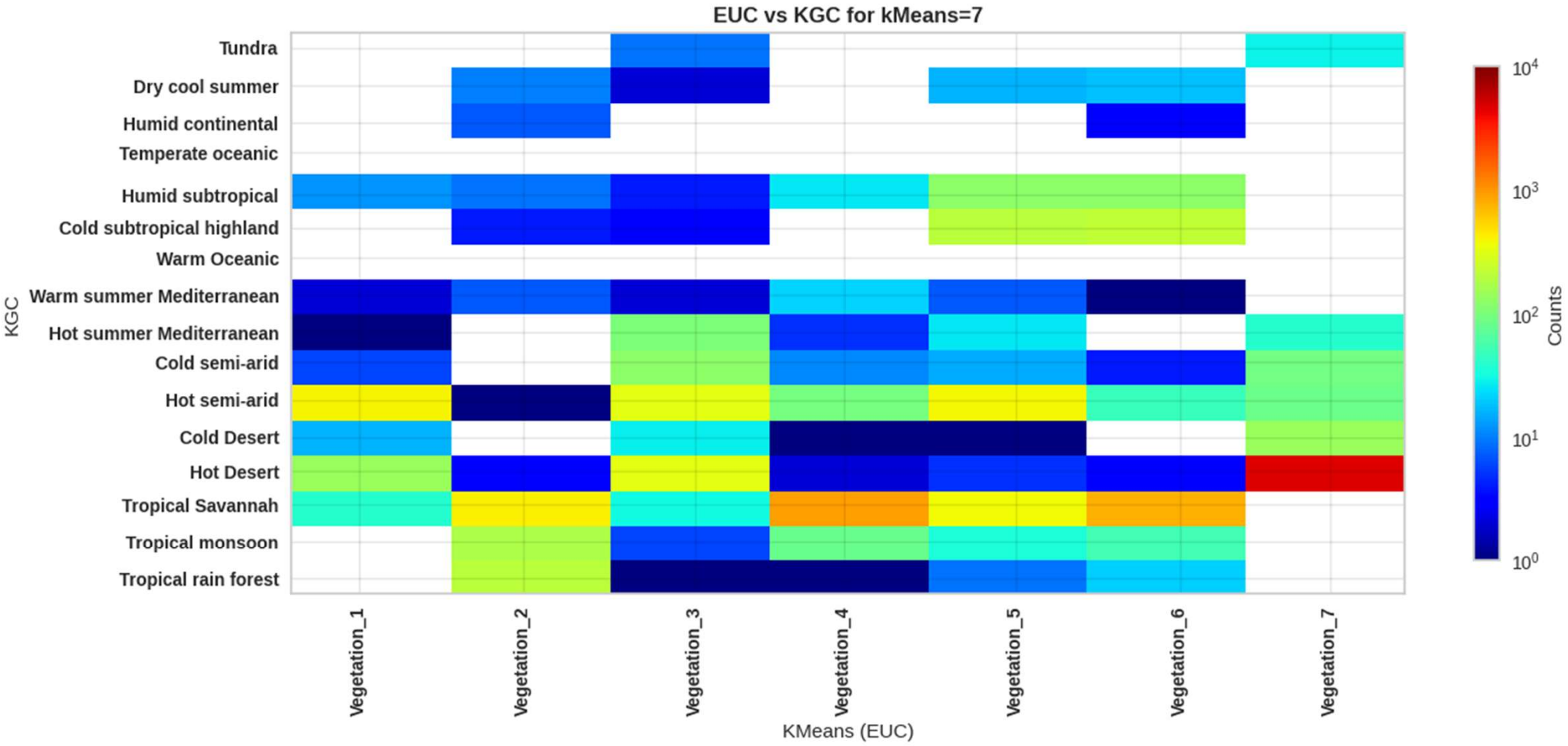
0 < Vmeasure < 1



Kmeans performed better than other algorithms

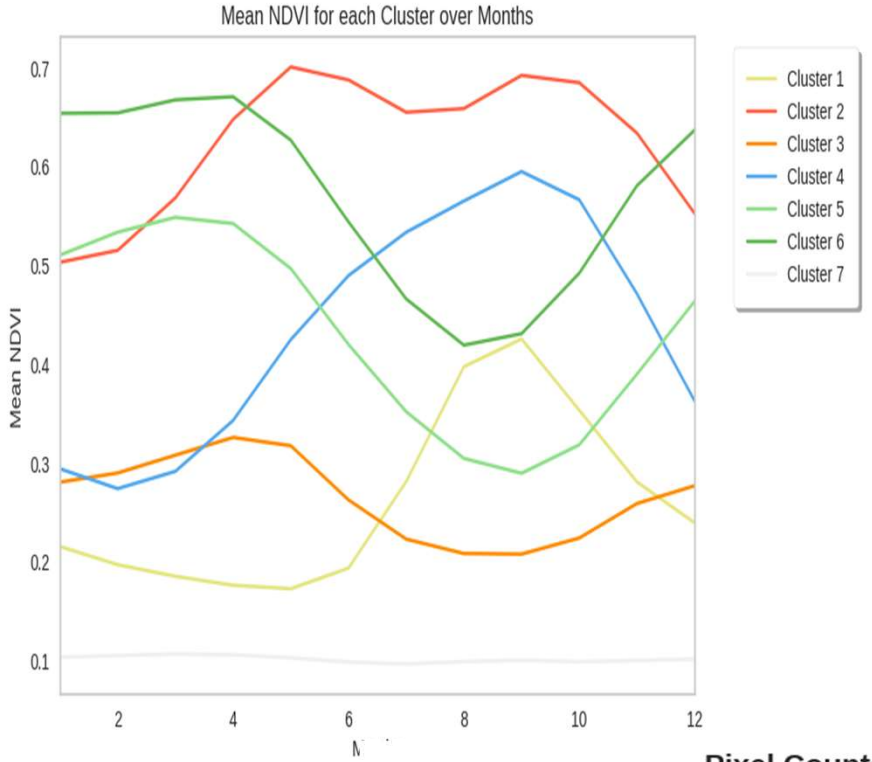
Vegetation-Climate interaction

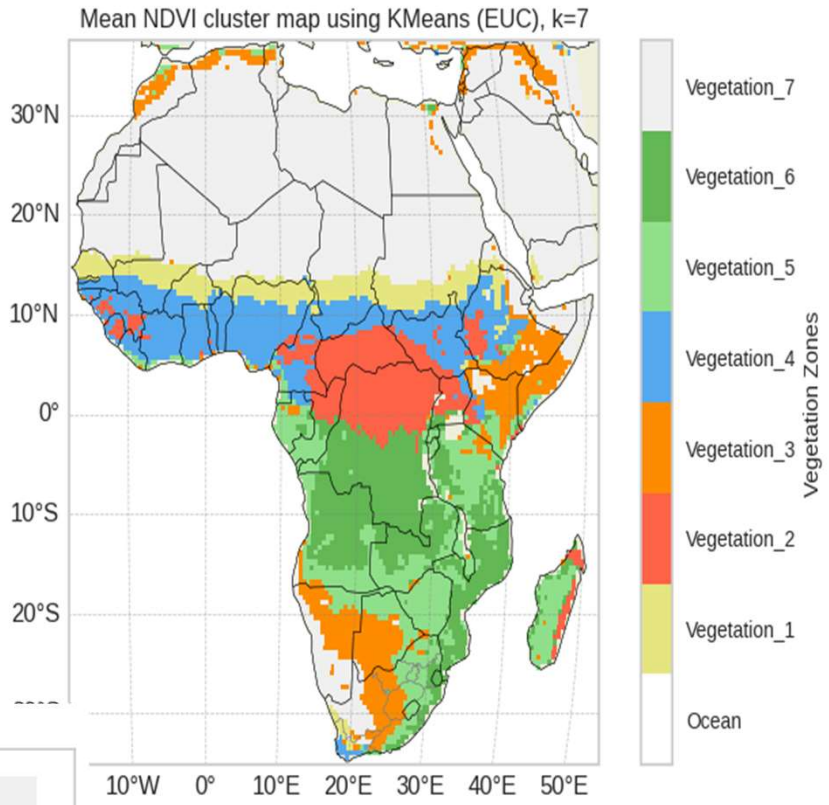
What are the dominant climate types in each vegetation zones of Africa?

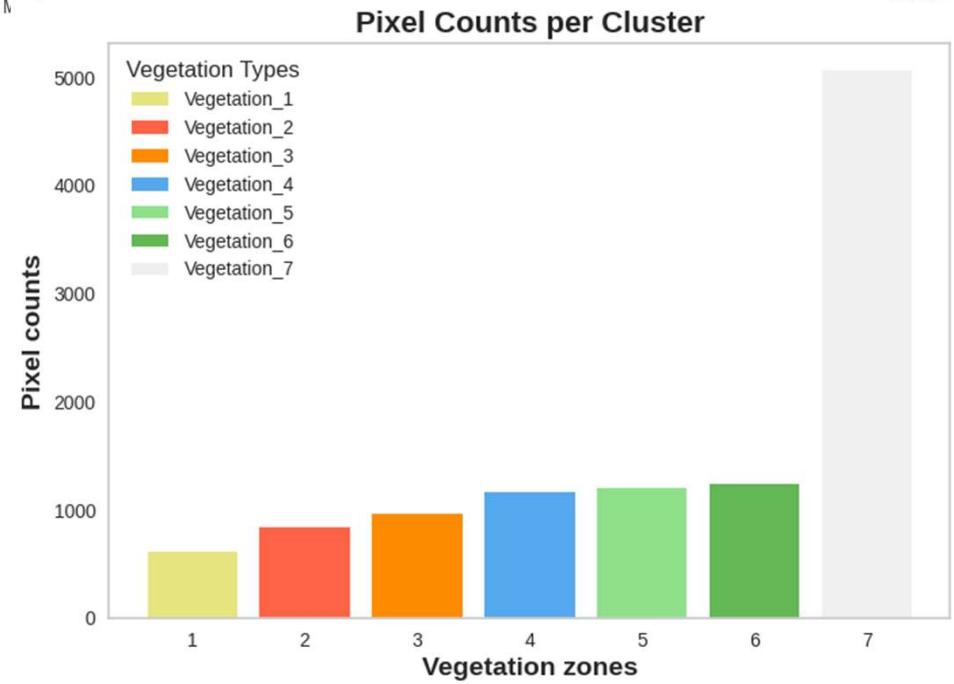


V-measure: 0.4693077586332355

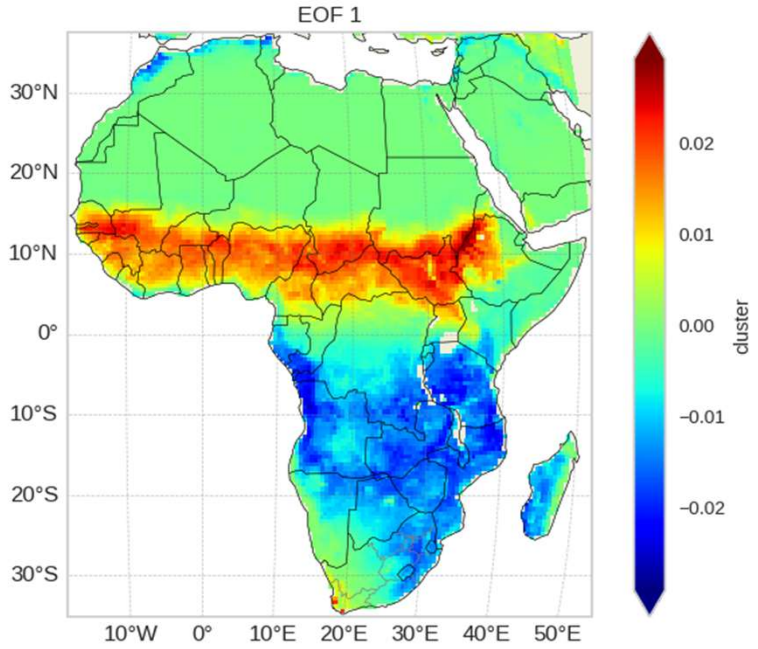
Variation in Vegetation zones

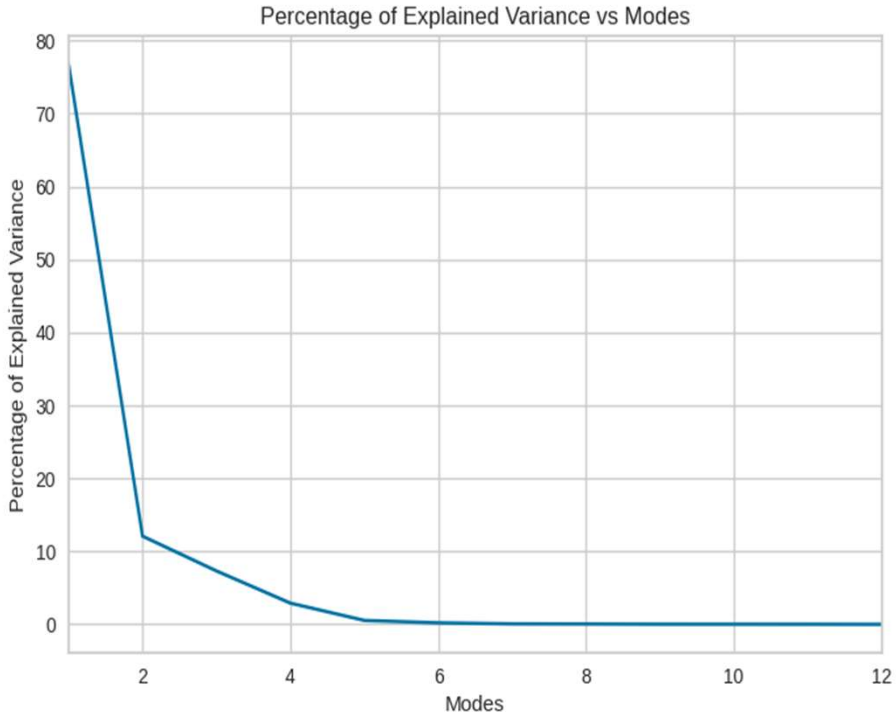


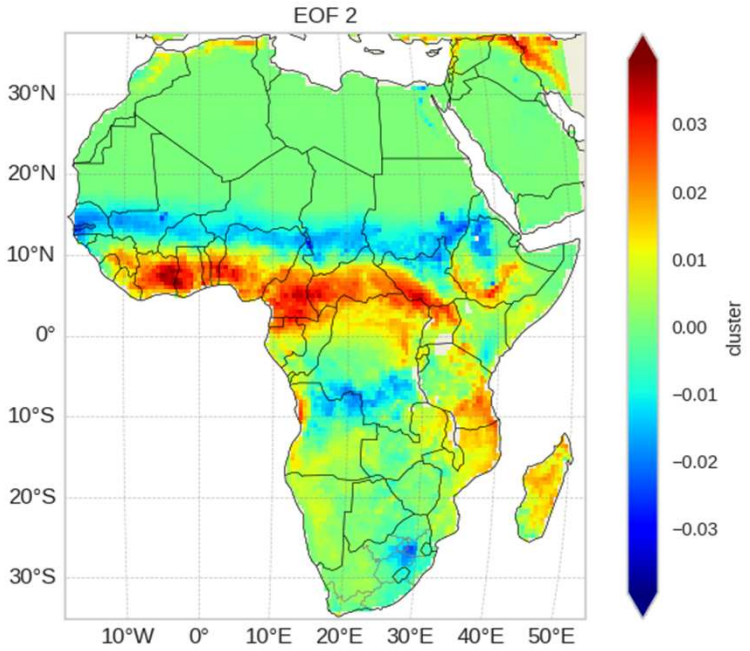


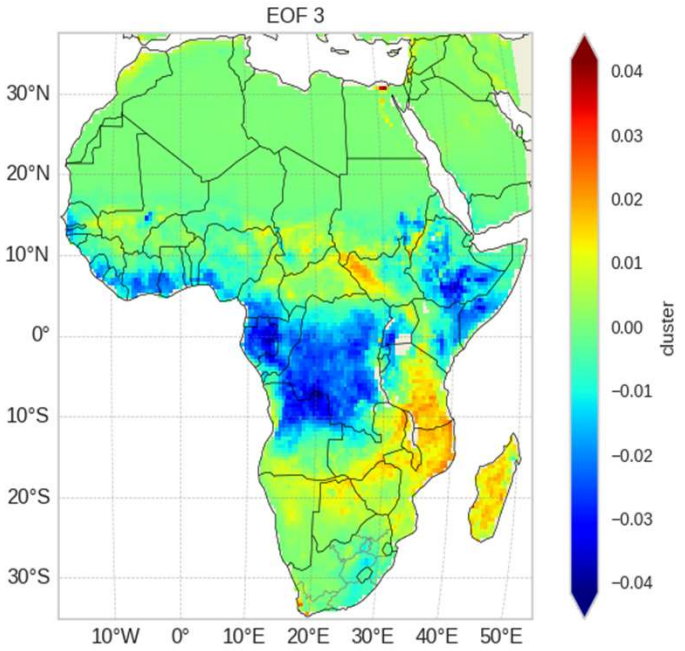


EOF Analysis









What's next?

Can the spatial and temporal variability of vegetation phenology explain the distribution of different vegetation in Africa?

Are there long-term and abrupt changes in vegetation phenology in Africa indicating anthropogenic climate change and land use change impacts?

How sensitive is vegetation phenology in Africa to different climatic drivers?

To what extent do changes in vegetation affect the climate?

Thank you!