AMAP theme Dyafor – October, 5th 2021

Not all species will migrate poleward as the climate warms: the case of the seven baobab species in Madagascar.

Ghislain VIEILLEDENT[1] Mario M. TAGLIARI[1,2] Jonathan LENOIR[3]

[1] **Cirad** UMR AMAP, [2] **University of Santa Catarina** ECOHE
[3] **University of Picardie** EDYSAN

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Outline

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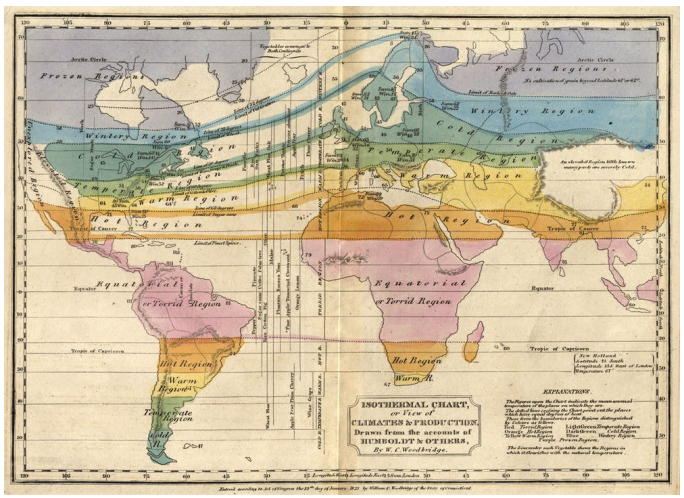
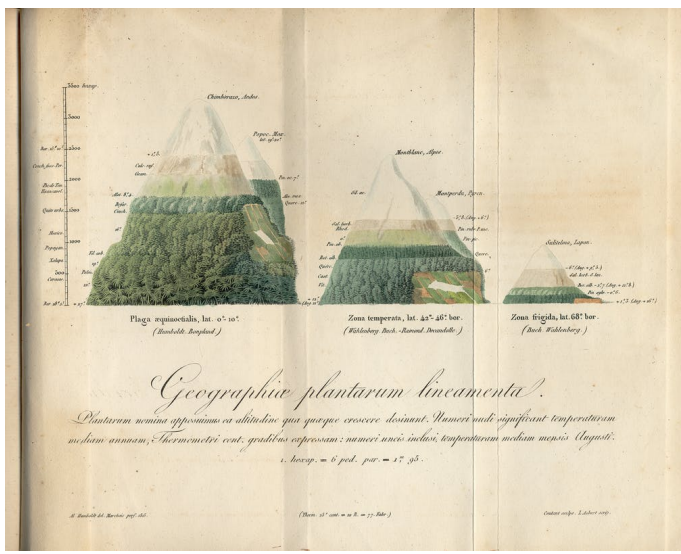
Isotherms

Species should move towards the poles and upslope to track shifting isotherms as climate warms :

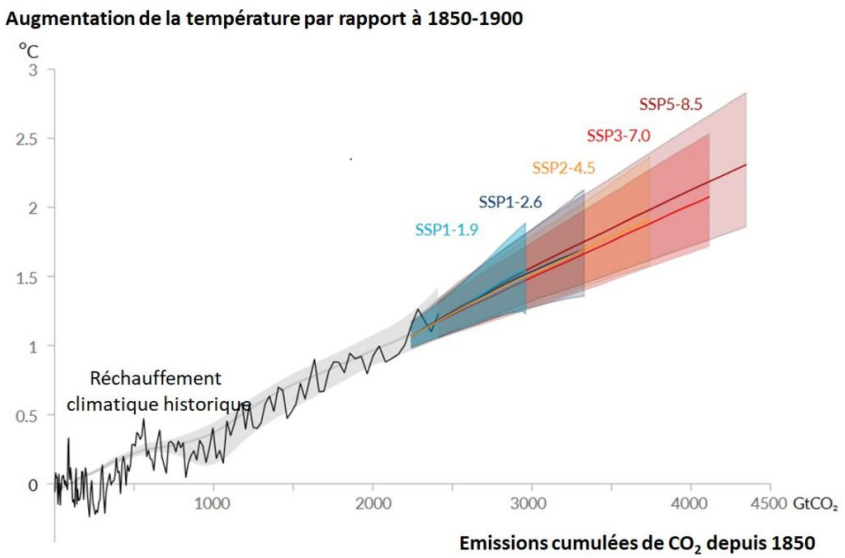
- Temperature is an easy to measure climatic variable (Fahrenheit, 1724).
- Temperature is a strong determinant of species biology and distribution.
- Concept of isotherm (Alexander von Humboldt / 1769–1859).





Temperature and CO_2

- Temperature is strongly correlated with CO_2 concentration in the atmosphere.



Scientific question

- Species should move poleward and upslope : is it always true ?
- Case of the seven baobab species of Madagascar

Baobabs of Madagascar

- Seven species out of the height baobab species existing on Earth.
- Six are **endemic** to Madagascar.
- Emblematic species (Baobabs' Alley), representative of the biodiversity of Madagascar.
- High endemism (>85%) in almost all taxonomic groups.



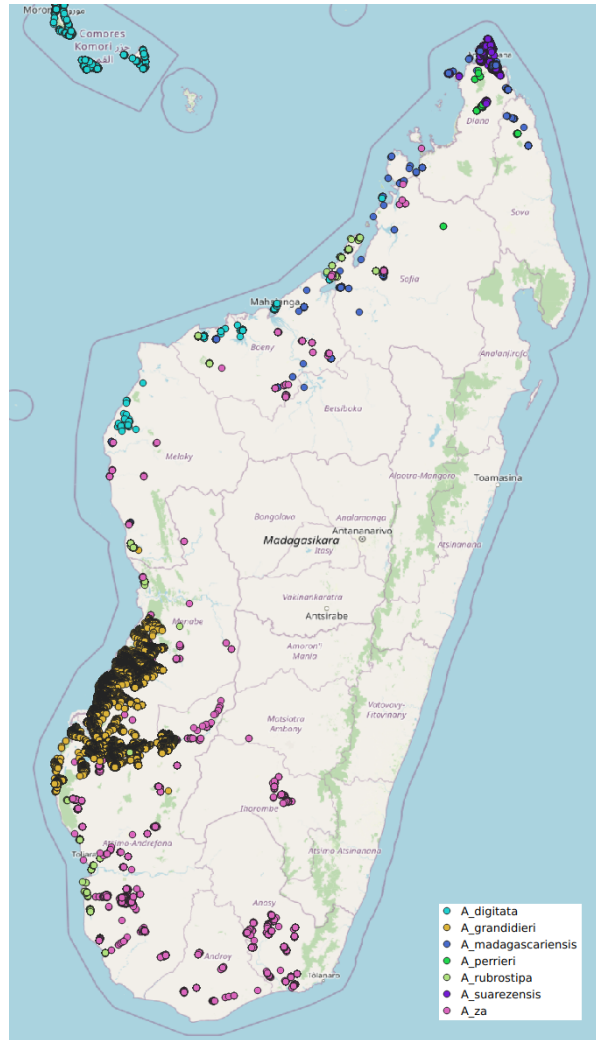
Outline

Species distribution models

- Species distribution models.
- 1. Species climatic niche, 2. Current distribution, 3. Future distribution (2055, 2085).
- **Ensemble modelling** : four statistical algorithms (GLM, GAM, RF, MaxEnt).
- **Ensemble forecasting** : three Global Circulation Models (NorESM1-M, GISS-E2-R, HadGEM2-ES).
- **Two dispersal scenarios** : full dispersal (possible dispersal outside current range), zero dispersal (no dispersal outside current range).
- Presence : the majority of the models predicts a presence.
  Uncertainty : number of models predicting a presence.

Occurrence data

- Large occurrence data-base.
- Since 2000, field inventories and photo-interpretation of satellite images.



Climatic data

- Four climatic variables : mean annual temperature (tmean, °C), annual precipitation (precip, mm/yr), temperature seasonality (tseas, °C sd x 1000), climatic water deficit (cwd, mm/yr).
- Two climatic scenarios : RCP 8.5 and RCP 4.5.
- WorldClim data.

Ecological interpretation of SDMs

General use of SDMs in the studies on climate change :

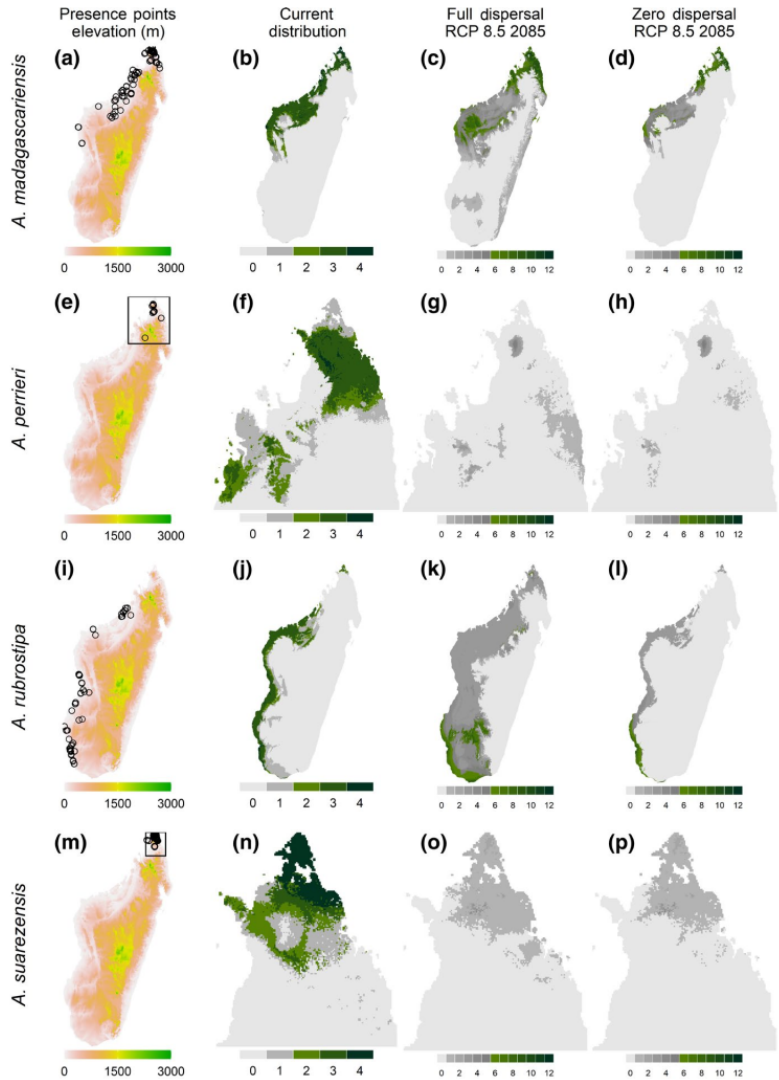
- Correlative models used to derive maps of species range.
- Species vulnerability to climatic change (range contraction or expansion).
- Not much ecological interpretation of the results.

We wanted to push the interpretation further :

- Climatic anomalies in space in the future.
- Variable importance in determining species niche.
- Climate change in current species range.
- Species range shift in latitude and elevation.
- Relationship between temperature and latitude/elevation in Madagascar.

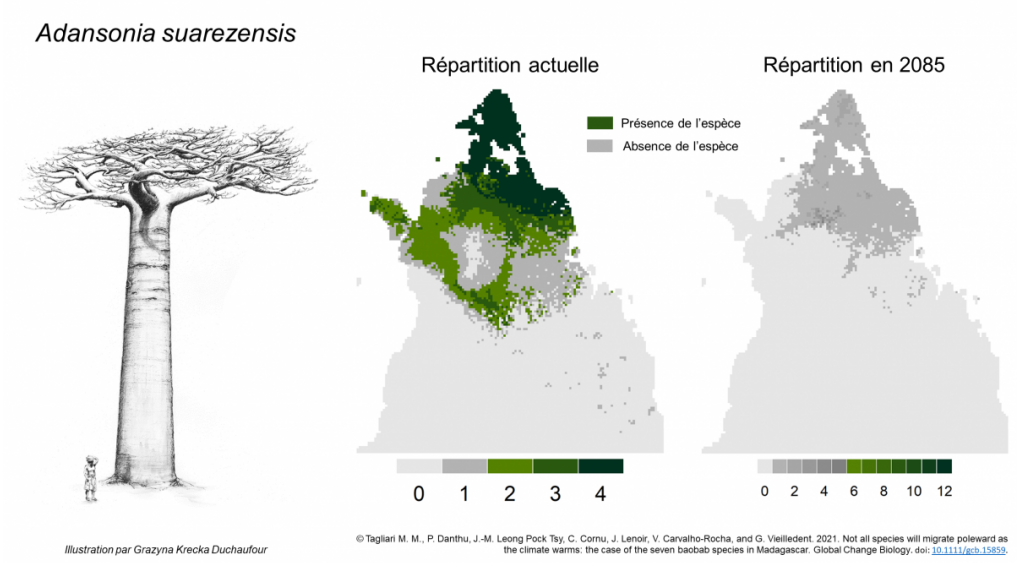
Outline

Range contraction

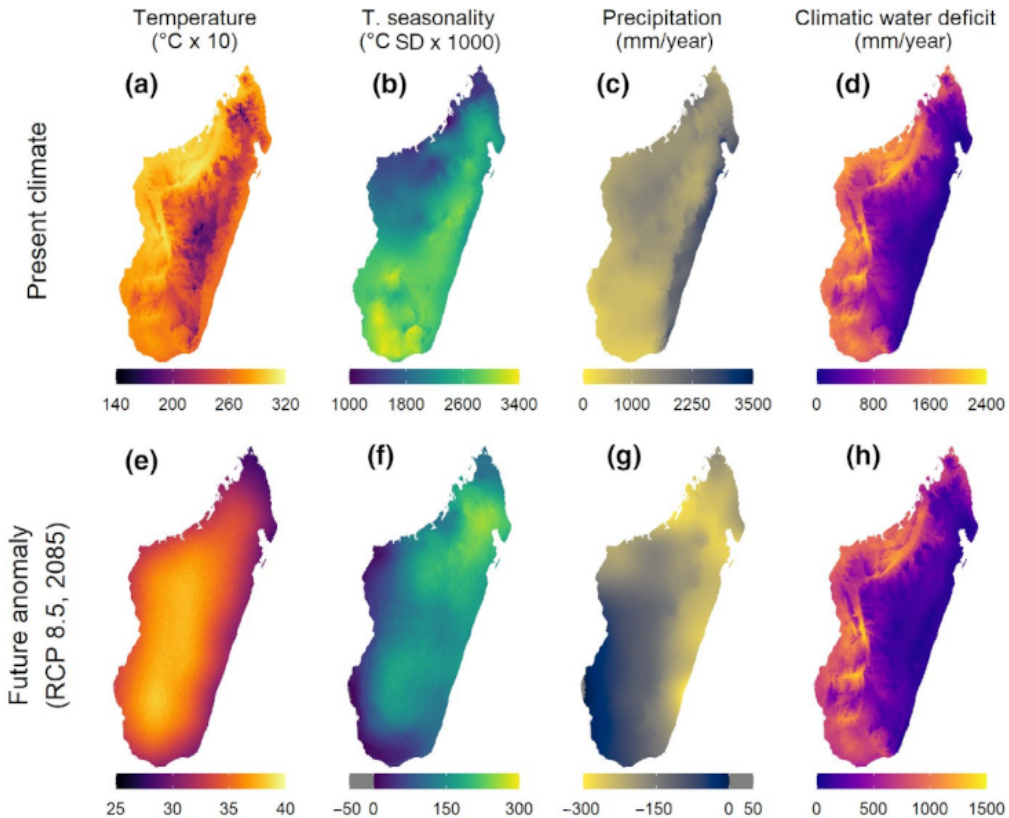


Range contraction

- Four species will experience a strong range contraction (>70%) under RCP 8.5 in 2085.
- Out of these four species, three are threatened by a change in temperature seasonality.



Climatic anomalies

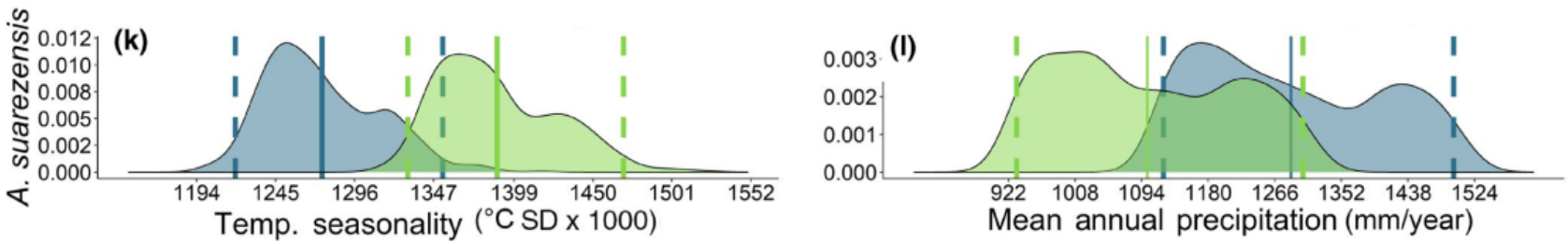


Variable importance

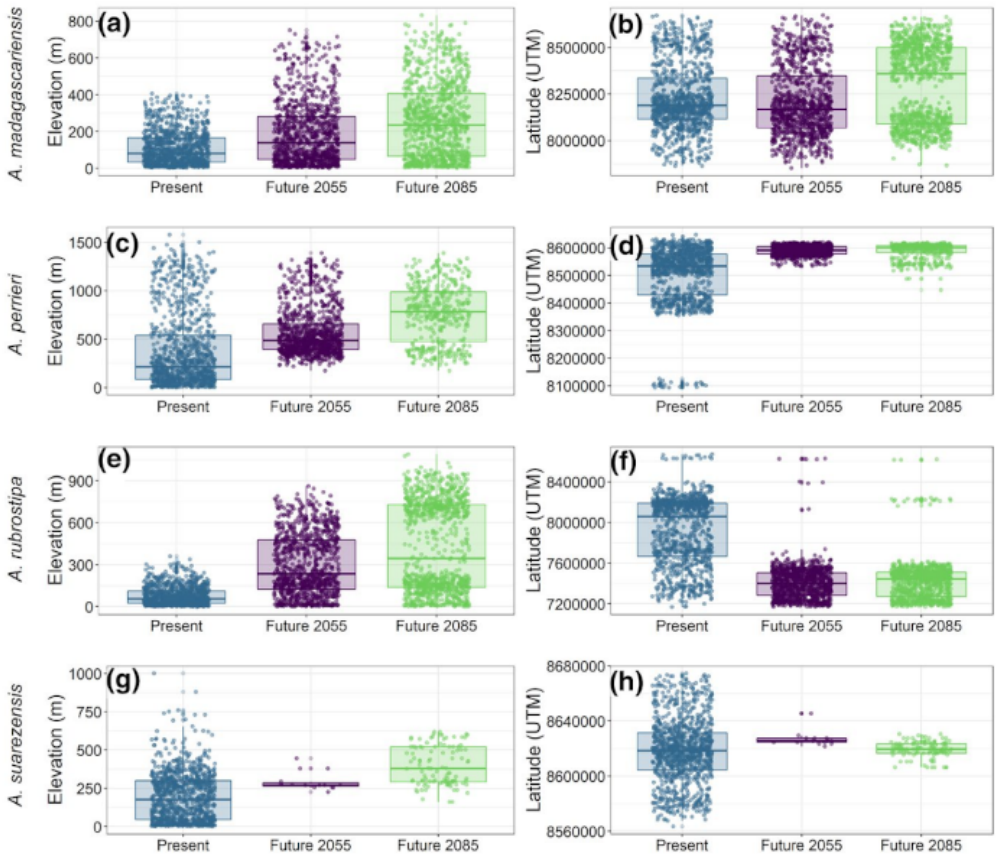
TABLE 2 Relative importance of the four bioclimatic variables in determining species distribution

Species	Mean annual temperature	Temperature seasonality	Precipitation	Climatic water deficit	Most important variables (first and second)
A. digitata	0.364	**0.633**	0.372	**0.552**	Tseas/Cwd
A. grandidieri	**0.526**	0.239	**0.550**	0.110	Prec/Tmean
A. madagascariensis	**0.651**	**0.824**	0.309	0.153	Tseas/Tmean
A. perrieri	0.369	**0.954**	0.336	**0.518**	Tseas/Cwd
A. rubrostipa	0.320	0.330	**0.360**	**0.730**	Cwd/Prec
A. suarezensis	0.211	**0.987**	**0.620**	0.150	Tseas/Prec
A. za	**0.471**	0.309	**0.625**	0.168	Prec/Tmean

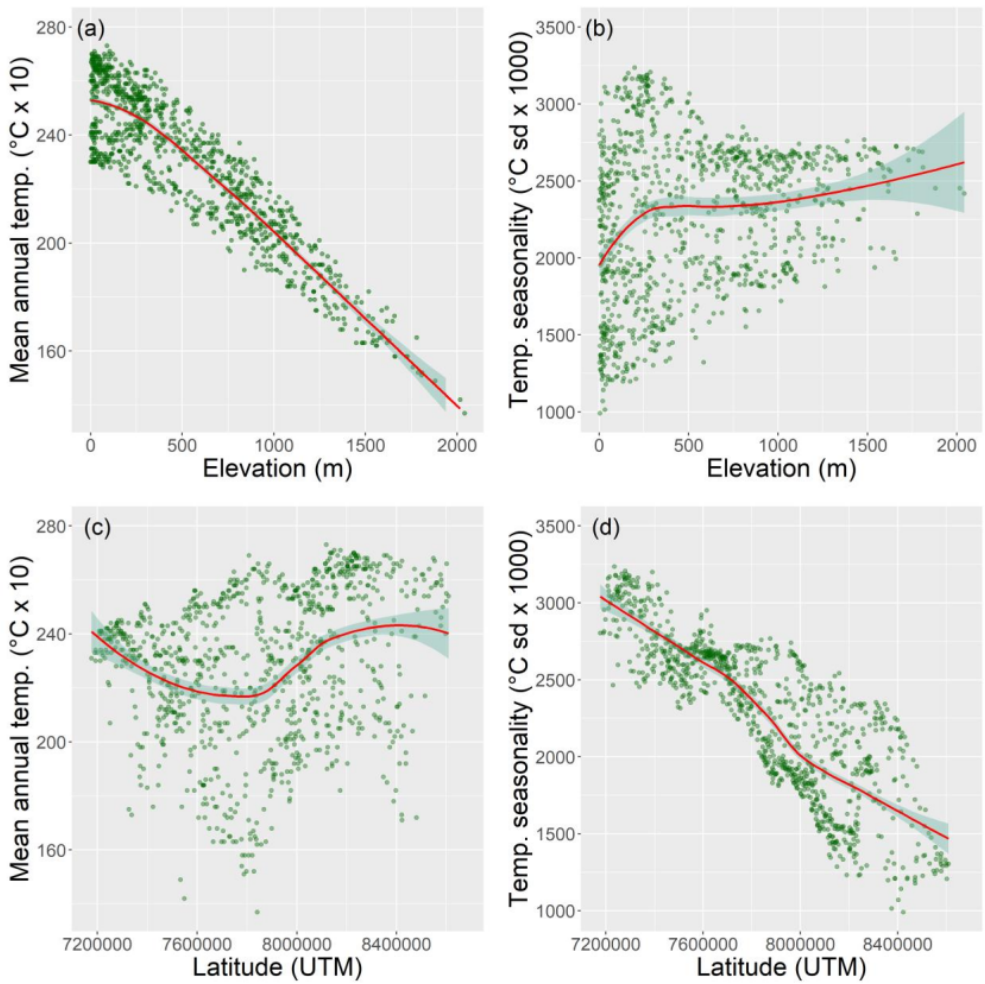
Climate change in current species range



Species range shift in latitude and elevation



Relationship between temperature and latitude/elevation



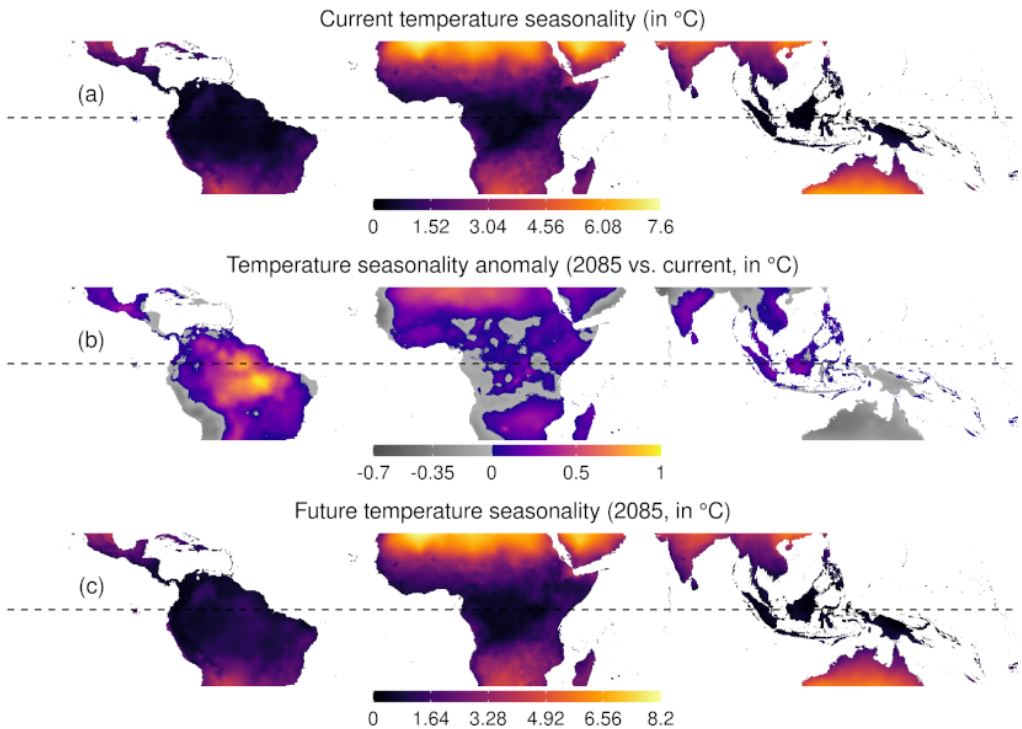
Outline

Species range shift

- Some species might move equatorward to track change in temperature seasonality.
- Range shift direction depends on several things : species climatic niche (variable importance), climatic anomalies in space in the future.
- It is not contradictory to move both equatorward and upslope.

Generalization to the tropics

- General increase of temperature seasonality in the tropics.
- Tropical species usually adapted to low seasonality (cf. tree growth, phenology).



Perspectives

- What does it mean an increase in seasonality under climate change ? (much warmer rainy season or colder dry season ?)

. . . Thank you for attention . . .

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