

International Symposium on Climate Geoengineering
SESSION II - POTENTIAL IMPACTS

Impacts on the Earth Ecosystems

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Summary

- Biological forcing on climate change
- Diverse landscape and resilience
- Effects of changes in nature physical resources
- Models - GVCMS

“climate trends are highly variable in terms of geography, and regions have to be individually evaluated for determination of the site-specific impacts on environment, agriculture, public health and a range of areas that are prone to temperature changes”, Scientific Reports (2018) DOI:10.1038/s41598-018-25212-2

“[...] injecting aerosols into the stratosphere could cool the planet at a cost of disrupting seasonal weather patterns, leading to widespread flooding or drought. We could harm our food supply, either by reducing the amount of sunlight that reaches crops or by reducing the amount of rainfall, or both.” Rachel Kaufman, smithsonian.com, March 11, 2019

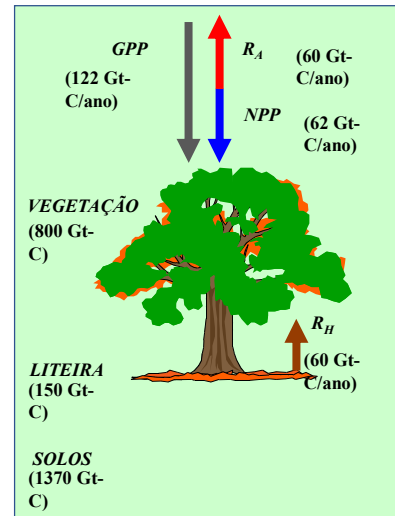
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$$GPP - R = NPP$$

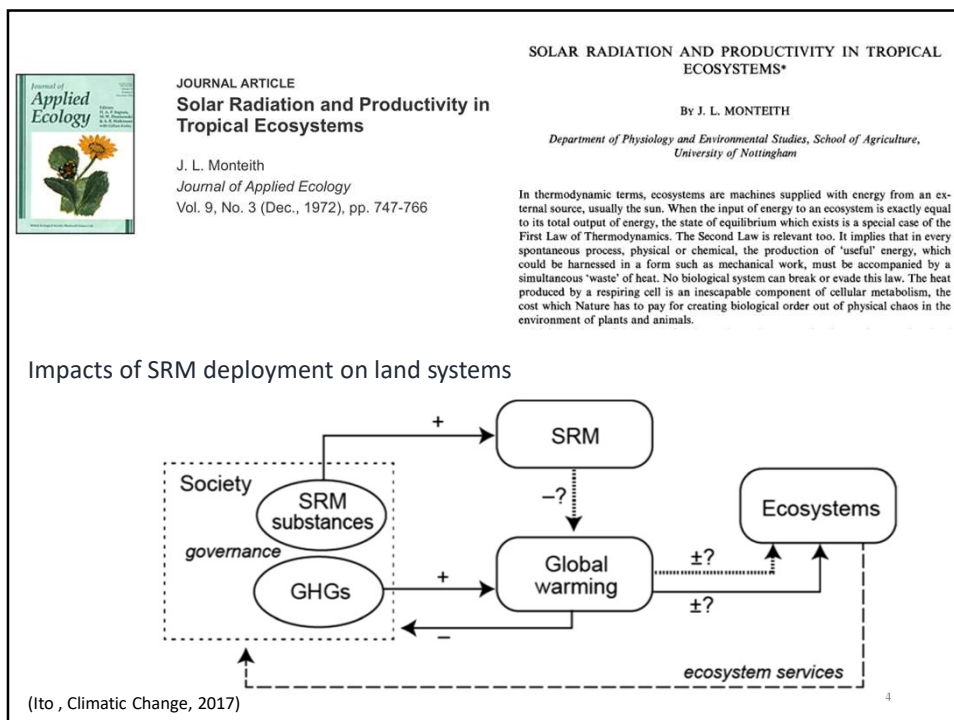
Net Primary Production = Gross Primary Production - Respiration (maintenance and growth)

- NPP is the “sink” rate by vegetation
- NPP → what we eat, fiber, wood, biofuel, oil, ..
- The GPP uses about 0.06% of the total solar energy that reaches the top atmosphere per year
- The NPP represents about 0,05% of the Solar constant (due to costs with the respiratory process), reaching about a $4.95 \times 10^6 \text{ cal m}^{-2} \text{ yr}^{-1}$.



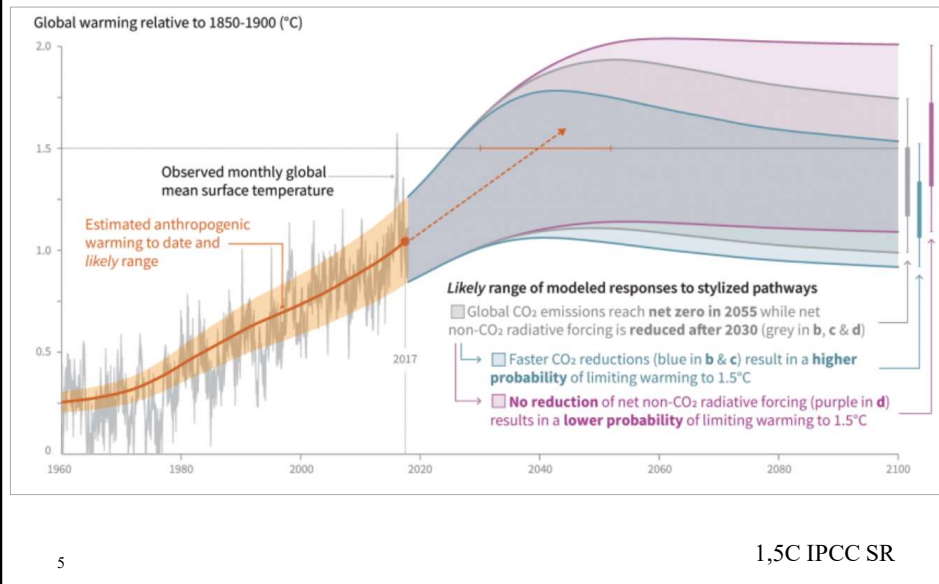
Slides modificado de M. Costa_UFV

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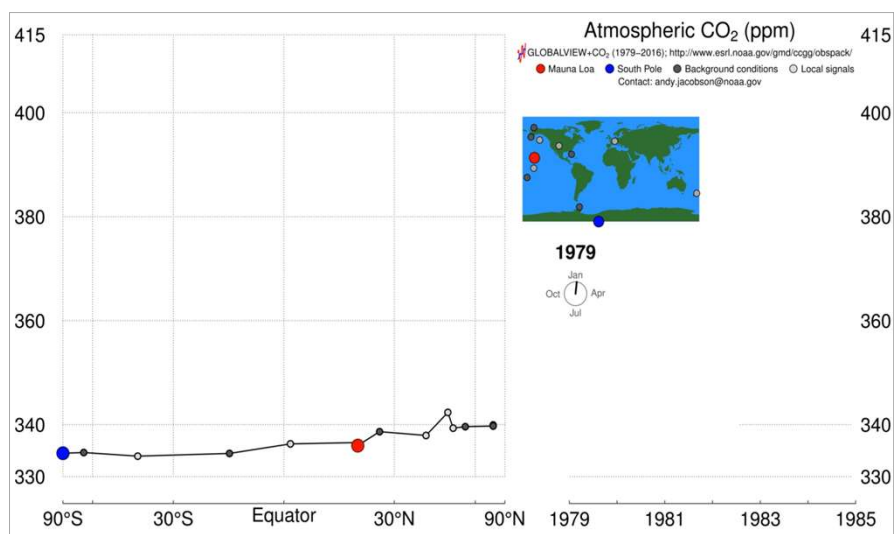
The greatest challenge – keep atmosphere temperature under ‘danger’ range



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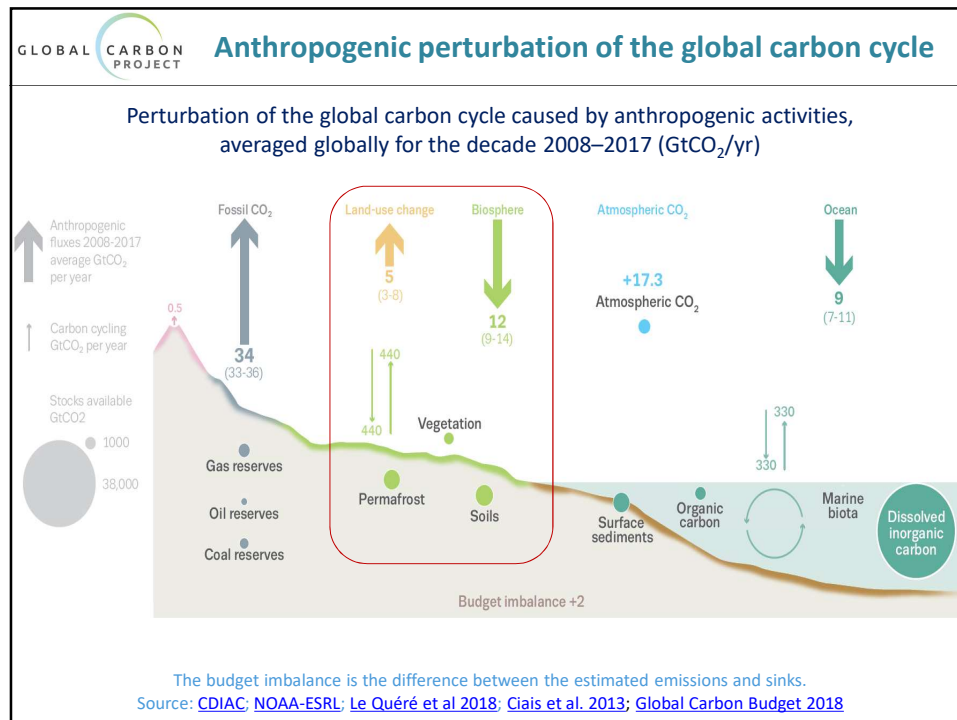
CO₂ concentration evolution, from 800 mil BC to 2016

<https://www.esrl.noaa.gov/gmd/ccgg/trends/history.html>

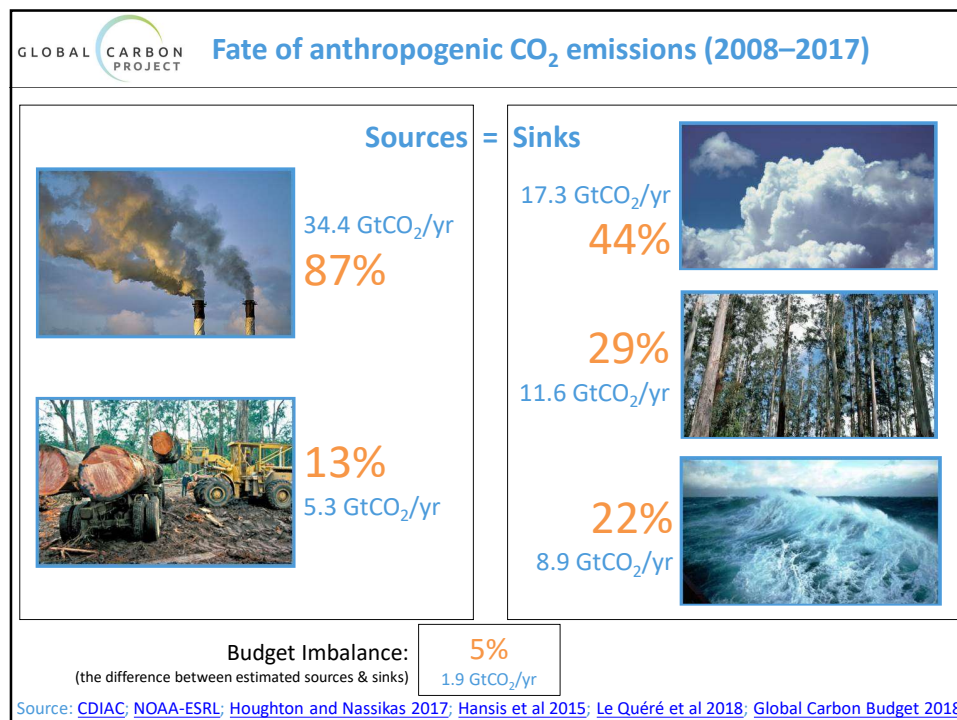


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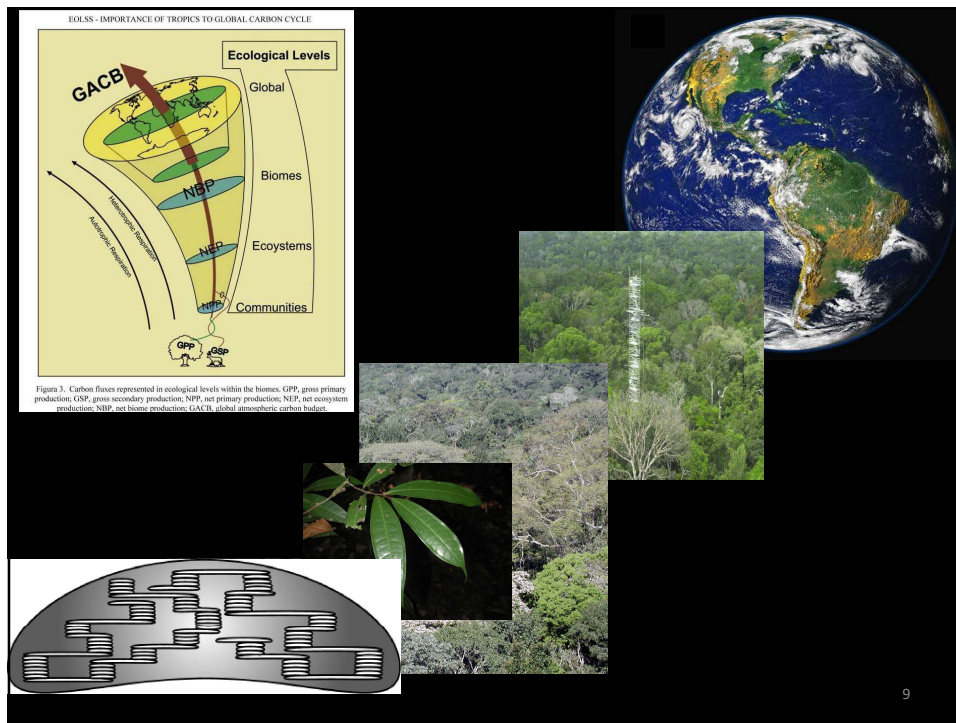
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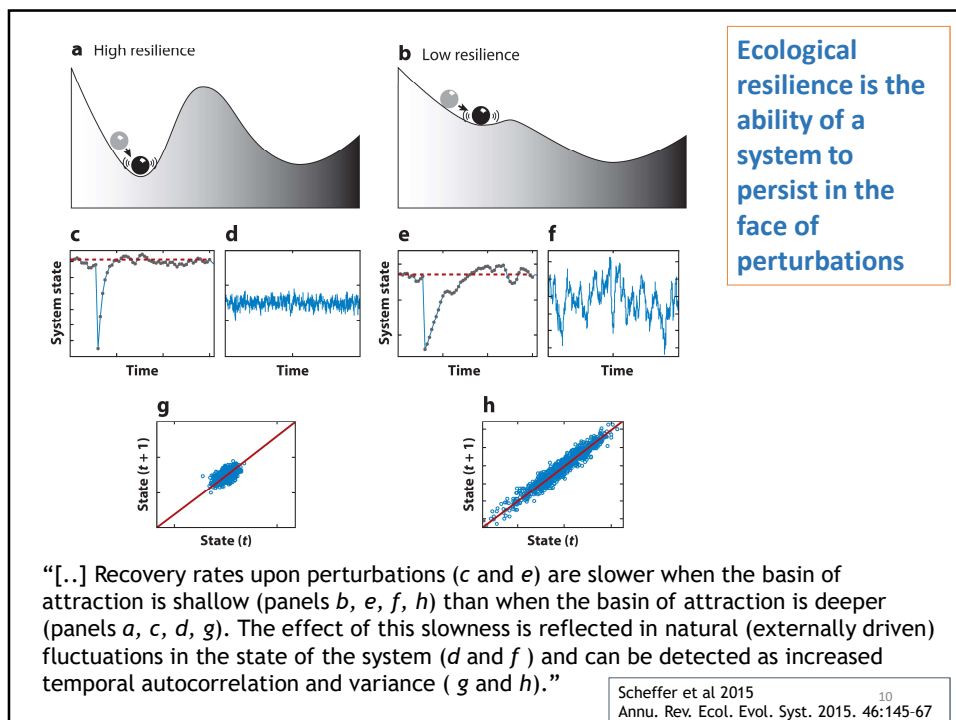
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Savanna Vegetation-Fire-Climate Relationships Differ Among Continents

Caroline E. R. Lehmann,^{1,2,*} T. Michael Anderson,³ Mahesh Sankaran,^{4,5} Steven I. Higgins,^{6,7} Sally Archibald,^{8,9} William A. Hoffmann,¹⁰ Niall P. Hanan,¹¹ Richard J. Williams,¹² Roderick J. Fensholt,¹³ Jeanine Feltri,¹⁴ Lindsay B. Hutley,¹⁵ Jayashree Ratnam,³ Jose San Jose,¹⁶ Ruben Montes,¹⁷ Don Franklin,¹⁸ Jeremy Russell-Smith,¹⁹ Casey M. Ryan,² Giselda Durigan,¹⁸ Pierre Hiernaux,¹⁹ Ricardo Huidobro,²⁰ David M. J. S. Bowman,¹⁰ William J. Bond²¹

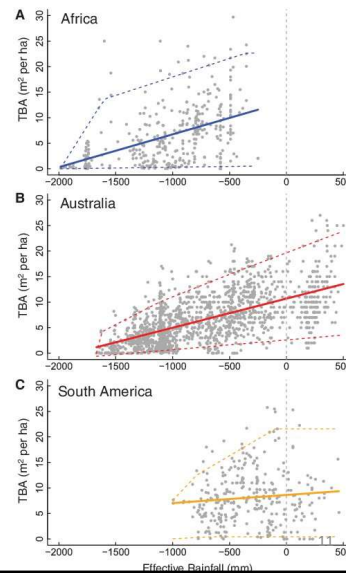
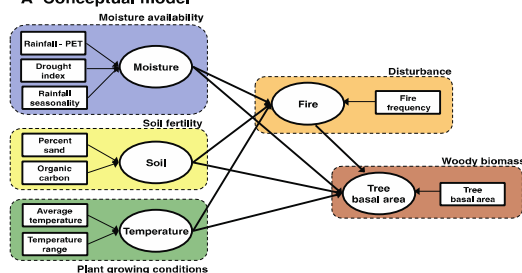
"Savannas cover 20% of the global land surface and account for 30% of terrestrial net primary production (NPP) and the vast majority of annual global burned area "[..]

"Plant growing conditions"

Energy => the amount of light radiation available to terrestrial ecosystems to maintain their structure and functioning.

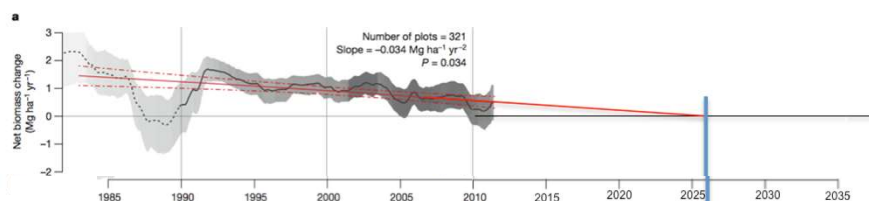
Temperature as 'proxy' of energy => the annual mean temperature (positively correlated) and the annual temperature amplitude (negatively correlated).

A Conceptual model

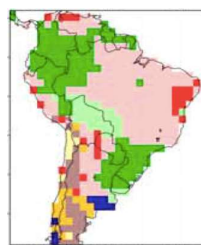


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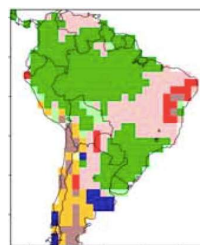
Amazon biomass is increasing (~1 ton/ha/ano in average) But this absorption capacity has decreased 30% since 1990



Climate change & no CO₂ fertilization effect in 2100:
Amazon forest dieback!



Climate change with CO₂ fertilization effect in 2100:
Amazon forest is maintained!



1 Tropical Evergreen Forest
13 Tropical Seasonal Forest

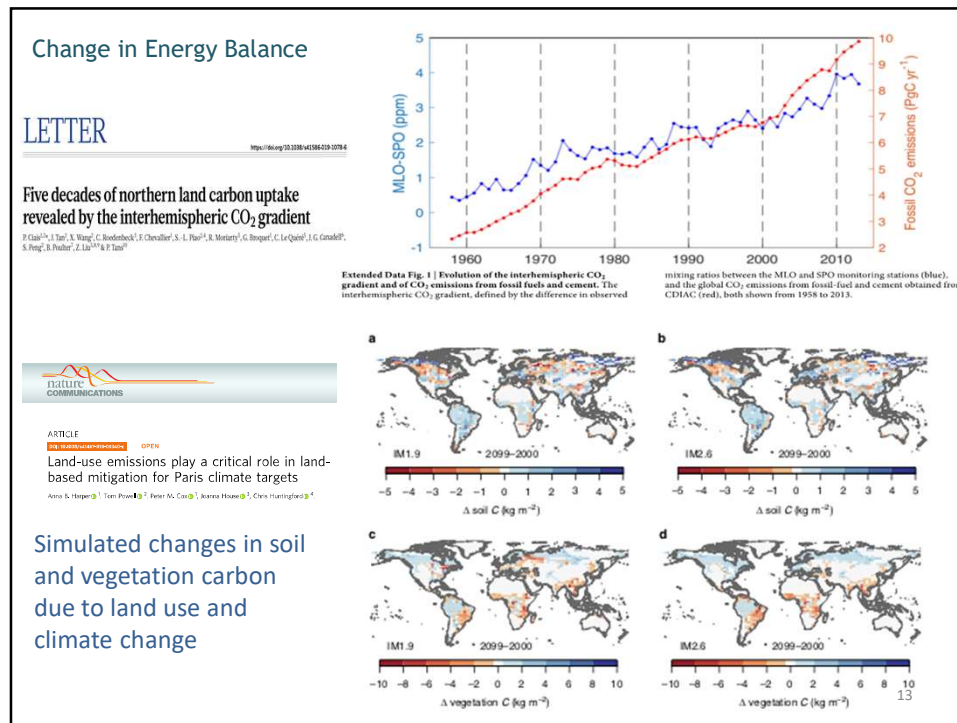
6 Savanna
8 Shrubland

How can atmospheric CO₂ increase, or energy balance, influence the carbon storage and biodiversity of the Amazon forest?

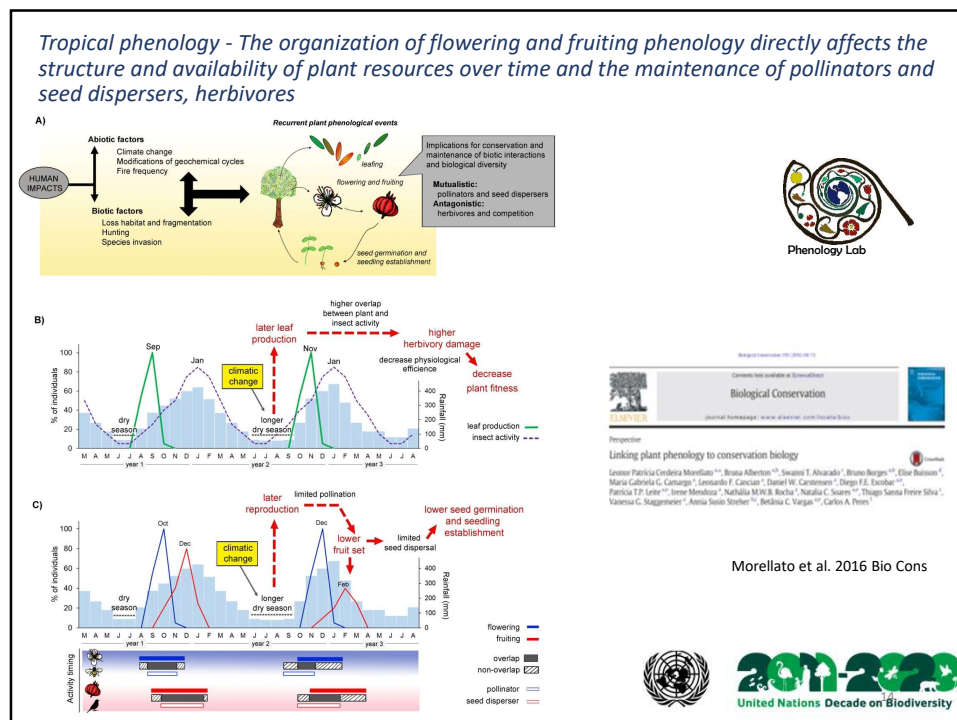
Slide by D. Lapola

Brienen et al. 2015 Nature; Lapola et al. 2009 GBC

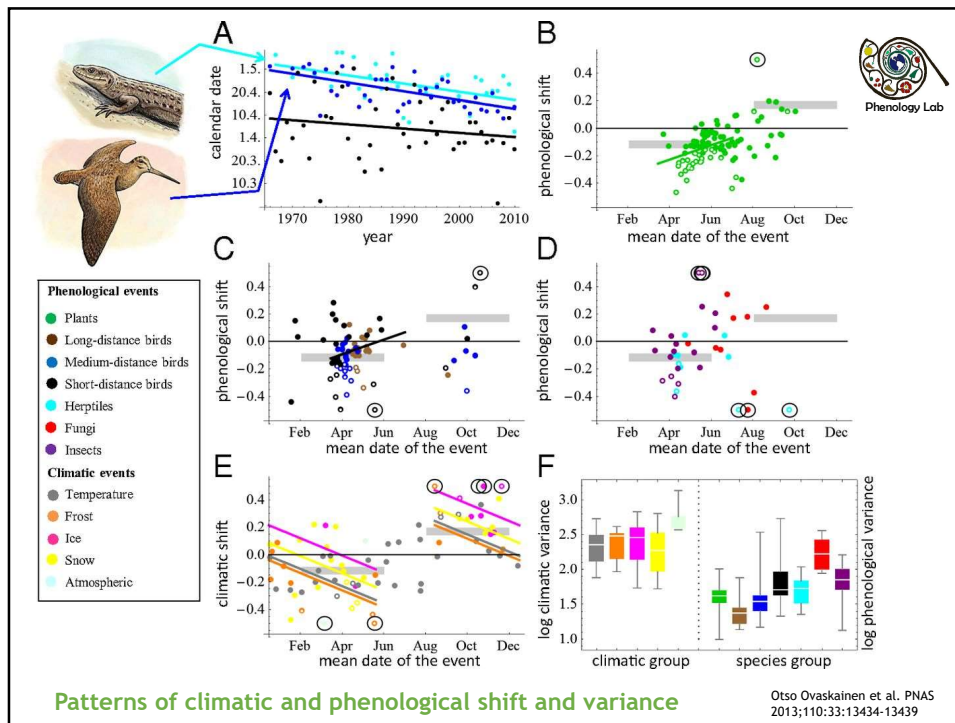
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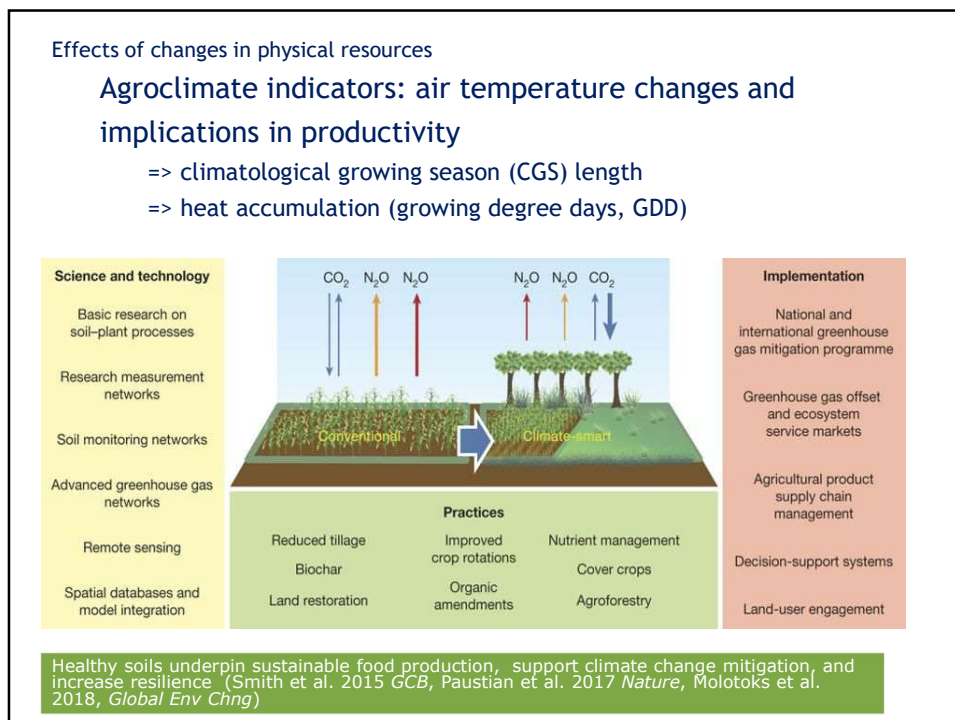
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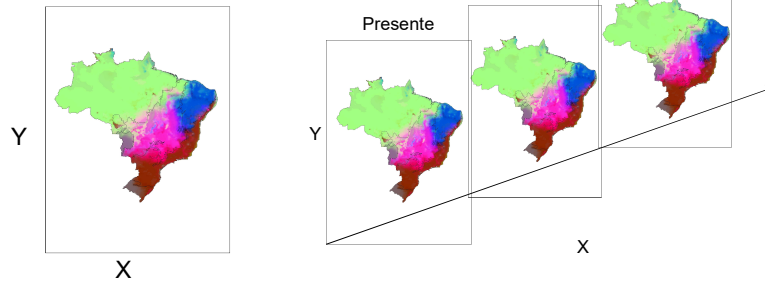


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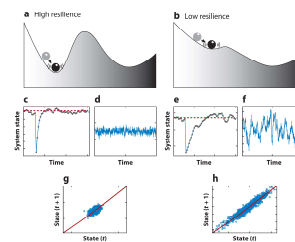


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Resilience Gradient on space and time



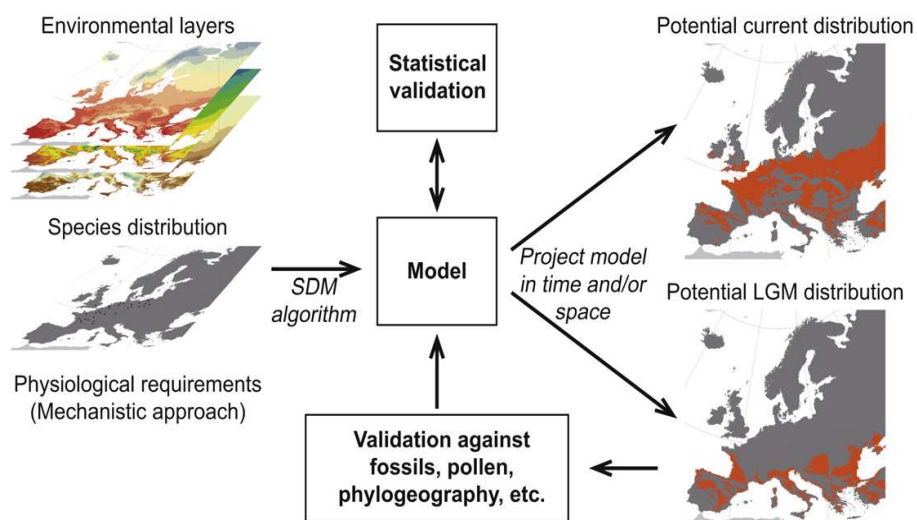
- Each biome represents a stable state among those possible for terrestrial ecosystems;
- The distribution of the biomes is in balance with the climate;
- A biome will only have high resilience in one place if there are favourable weather conditions;



Model: Luciano dos Anjos

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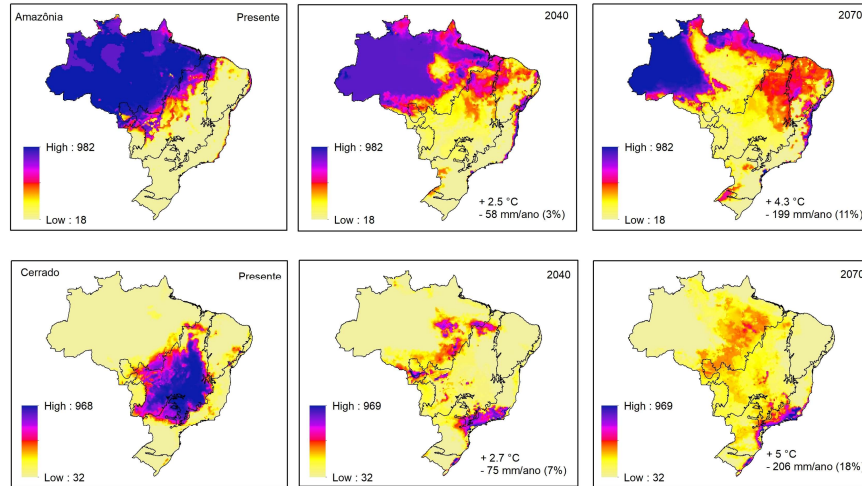
Ecological niche modelling



Svenning et al 2011

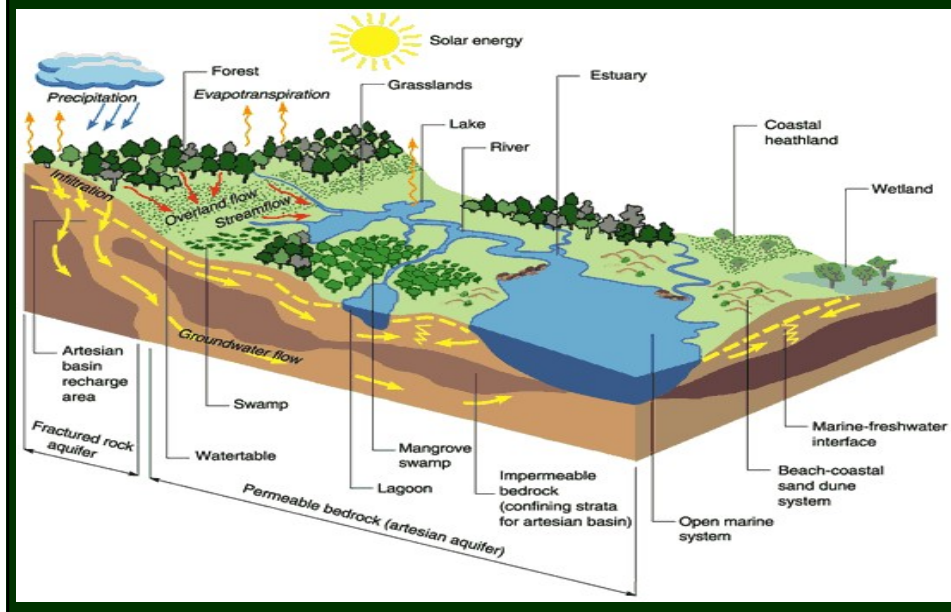
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Resiliency – Future projection

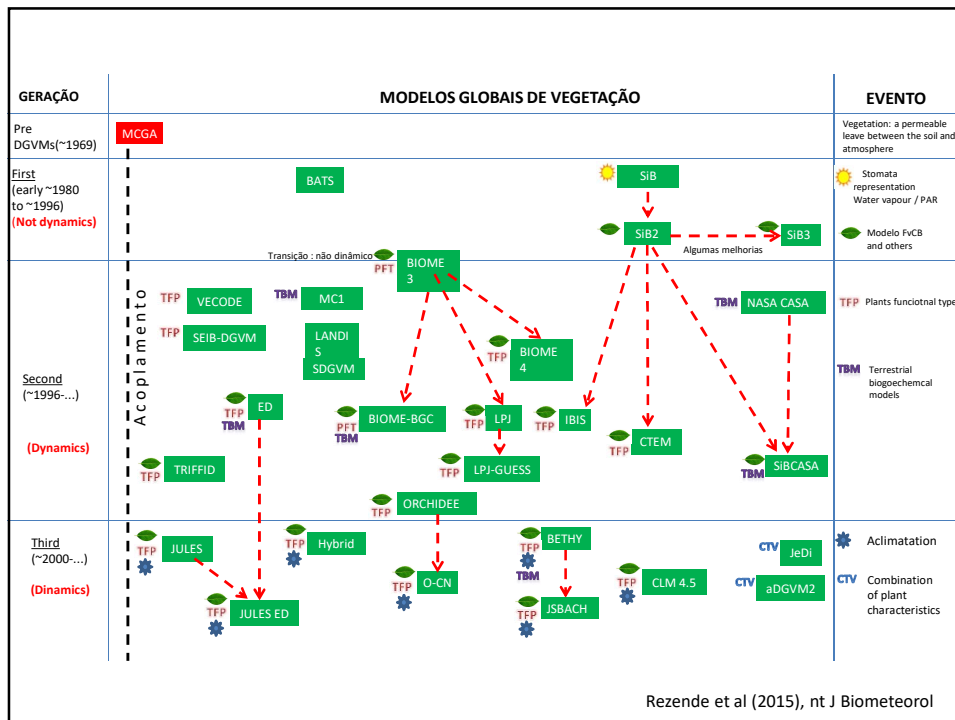


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Complex landscape; Complex effect How to simulate ?



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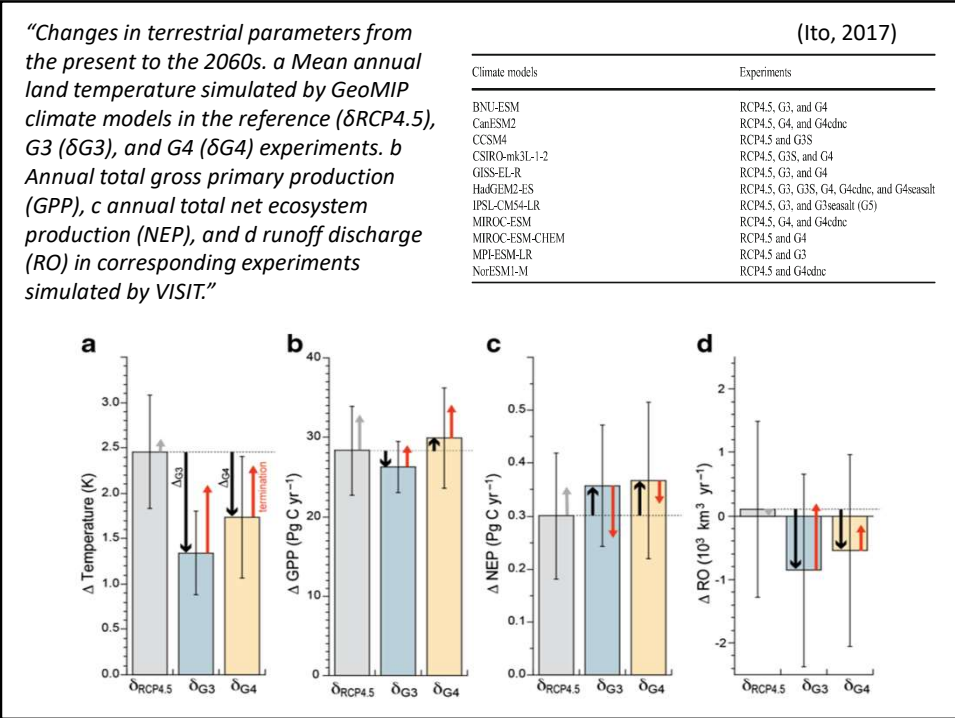


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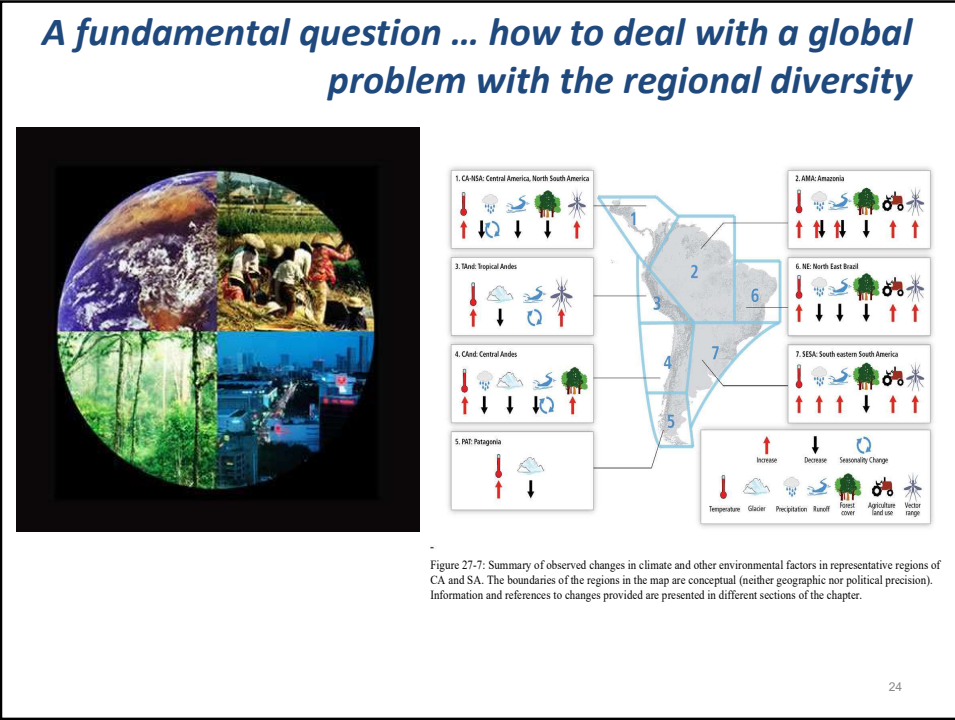
Some challenges for modelling...

- Temporal variability in ecosystem functions not well capture by models;
- Complexity of the landscape at local level;
- Capture change in carbon uptake by a specific 'event' (e.g., volcano explosion).
 - Change in CO2 level by increasing photosynthesis by change in diffused radiation balance and by reducing respiration rates due to decrease in temperature (e.g., soil respiration (Le Quere et al, 2016; Gu et al, 2013))
 - Change in "post-deployment" or "termination" of the event. Normally leading to increasing rates of ecosystem production
- Integrate nutrient availability
- Integrate human responses

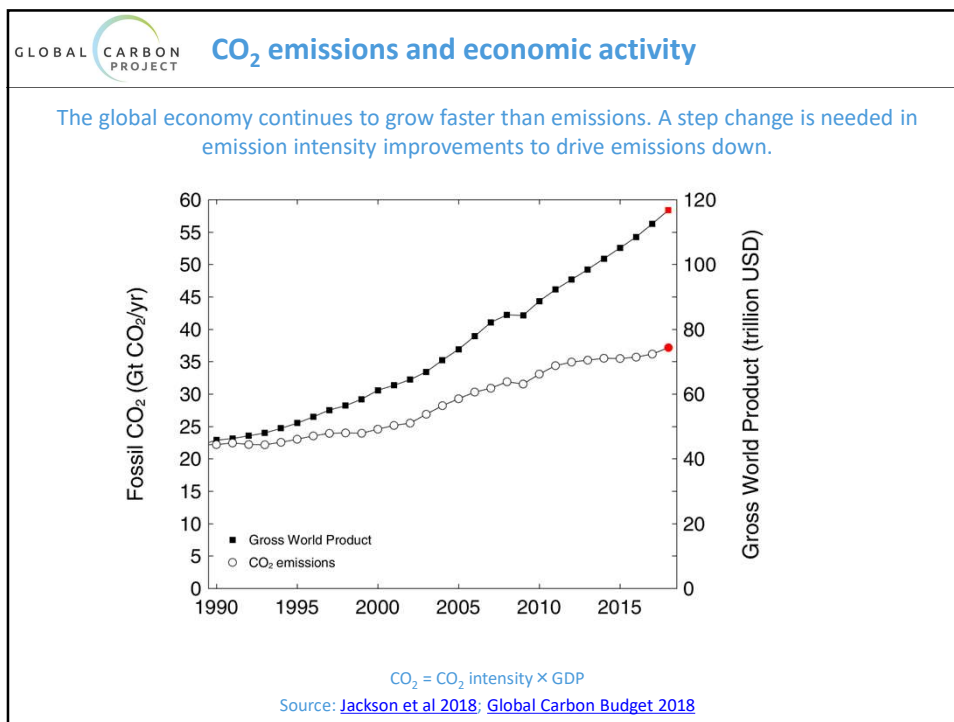
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