PANGEA

PAN tropical investigation of bioGeochemistry and Ecological Adaptation

A scoping study for a NASA Tropical Forest Terrestrial Ecology Campaign

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Biological Diversity and Ecological Conservation Meeting - May 9, 2024

NASA Terrestrial Ecology field campaigns are meant to:

a) Answer **big science questions** targeted on **important regions or biomes**;

b) Enable **more effective interpretation and analysis of space-based measurements**;

c) Foster **collaborative interactions** and building **new relationships** within the scientific community;

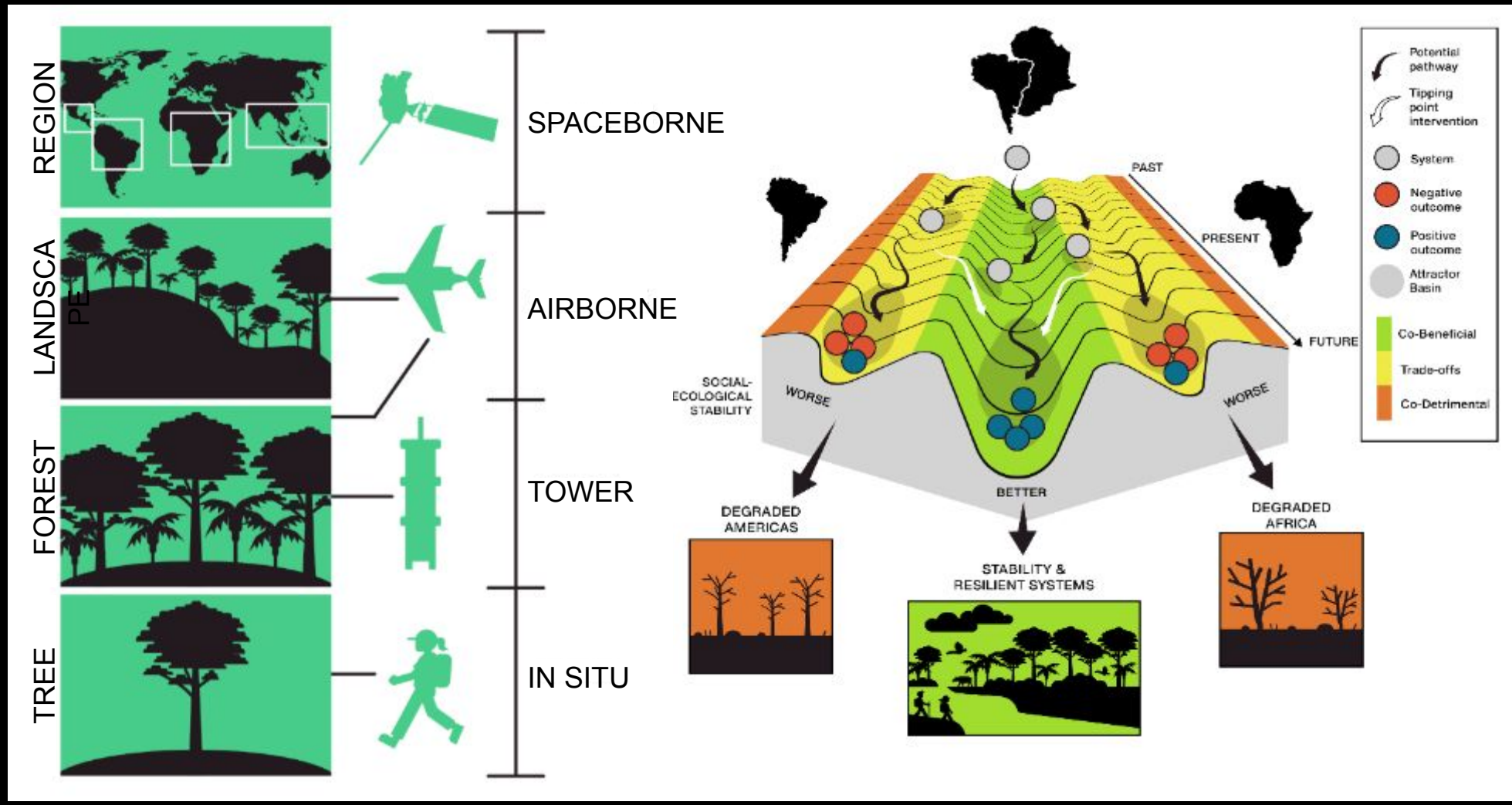
d) Provide valuable opportunities for **training and educating the next generation of scientists**; and

e) Leave a **legacy** data set of great value for future research

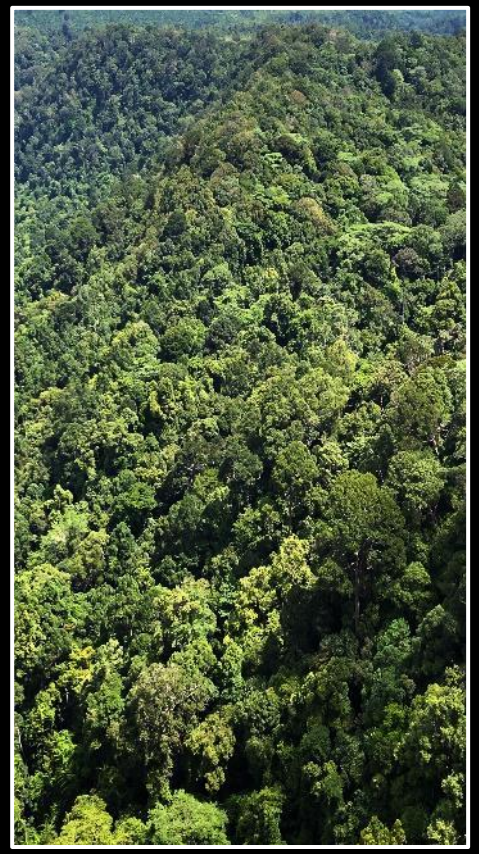
Past NASA TE Field Campaigns

- FIFE: First International Satellite Land Surface Climatology Project (ISLSCP) Field Experiment (1987-1989)
- BOREAS: Boreal Ecosystem-Atmosphere Study (1992-1999)
- LBA: Large-scale Biosphere-Atmosphere Experiment in Amazonia (1998-2011)
- ABoVE: Arctic Boreal Vulnerability Experiment (2015-2024)

What is PANGEA?



Tropical forest regions are **critically important**



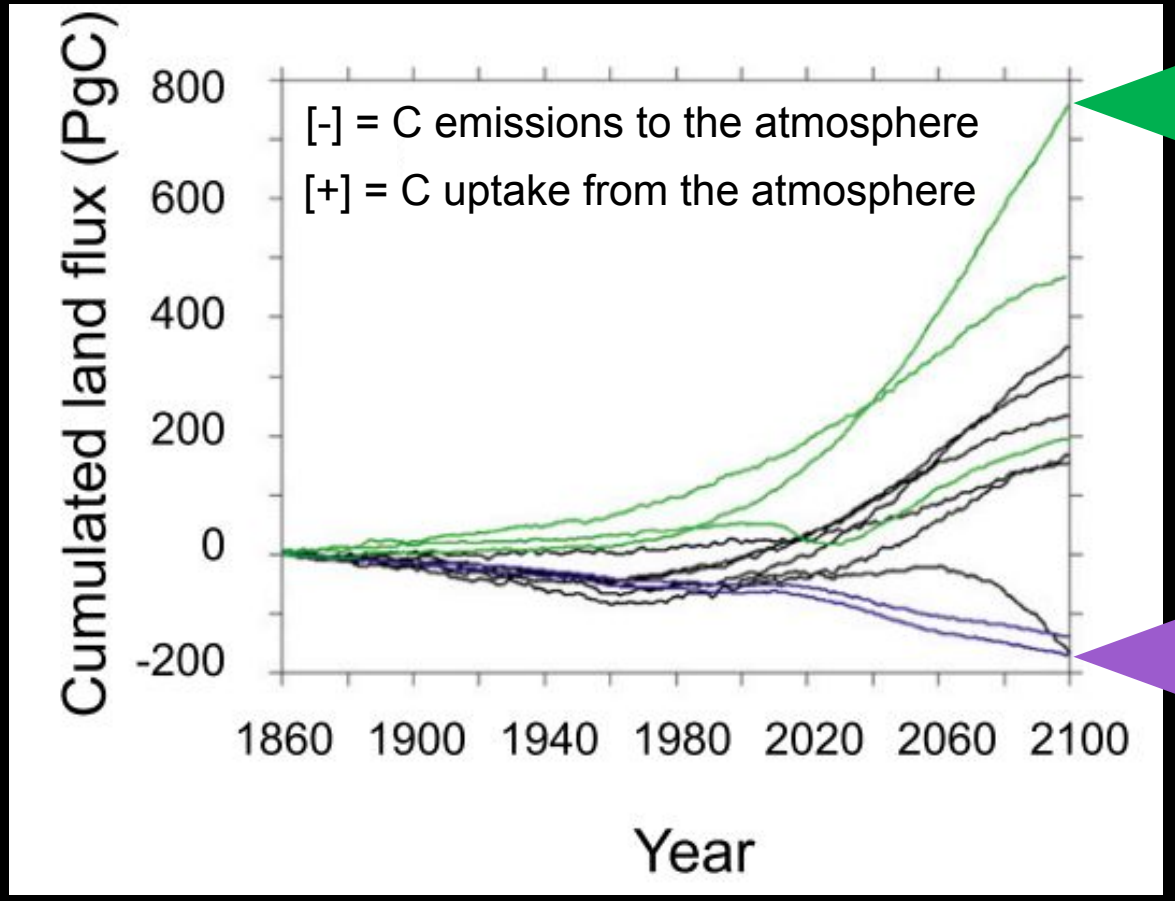
Tropical ecosystems:

- Cover 10% ice-free land surface
- Maintain 66-80% of all species
- Are home to over 3 billion people
- Constitute major water and heat pumps, contributing to regional and global climate
- Account for >30% of terrestrial NPP
- Store 25-40% of total terrestrial biomass

Tropical forest regions are changing rapidly

- Tropical ecosystems are entering a no-analog state – compositionally different than anything found today
- Temperatures will soon be hotter than most tropical ecosystems have experienced in their evolutionary history (range shifts, adaptation, acclimation)
- Tropical forest function could be greatly diminished by the end of the century, resulting in critical climate feedbacks
- Even though tropical forests have a huge impact on the entire Earth System, we still lack basic knowledge about them

High uncertainty in future terrestrial C flux



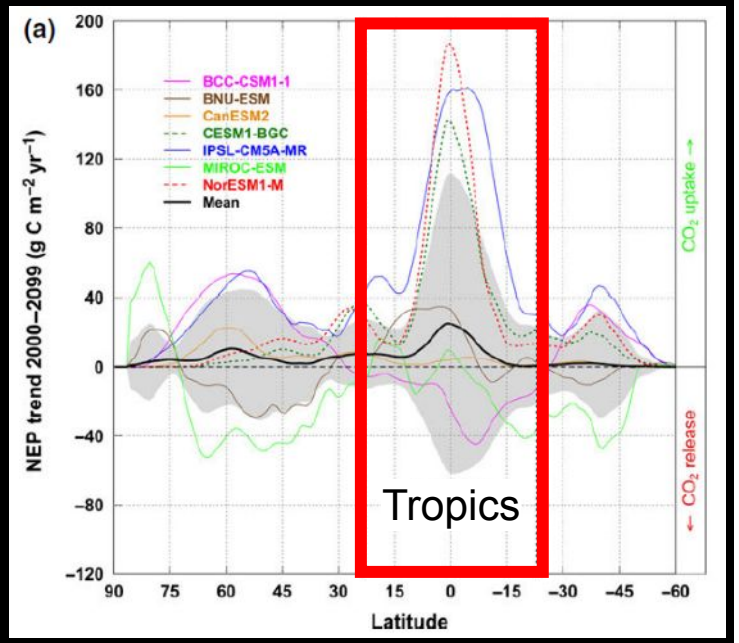
Terrestrial systems **store** ~750 PgC by 2100

Terrestrial systems **emit** ~170 PgC by 2100

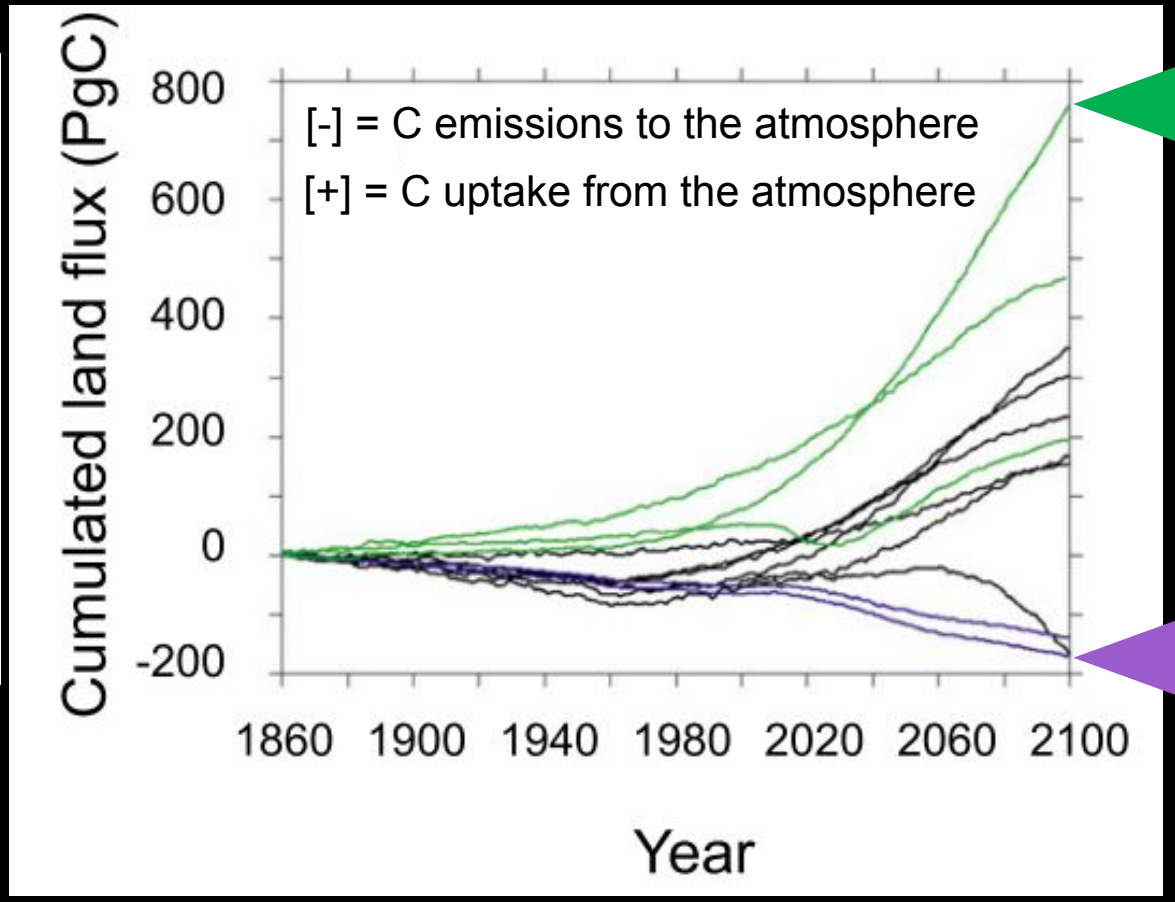
Friedlingstein et al 2014 *AMS*

Earth System Models accounting for terrestrial N cycle
Earth System Models prescribing land use change emissions

High uncertainty in future terrestrial C flux



Cavaleri et al. 2015 *Global Change Biology*



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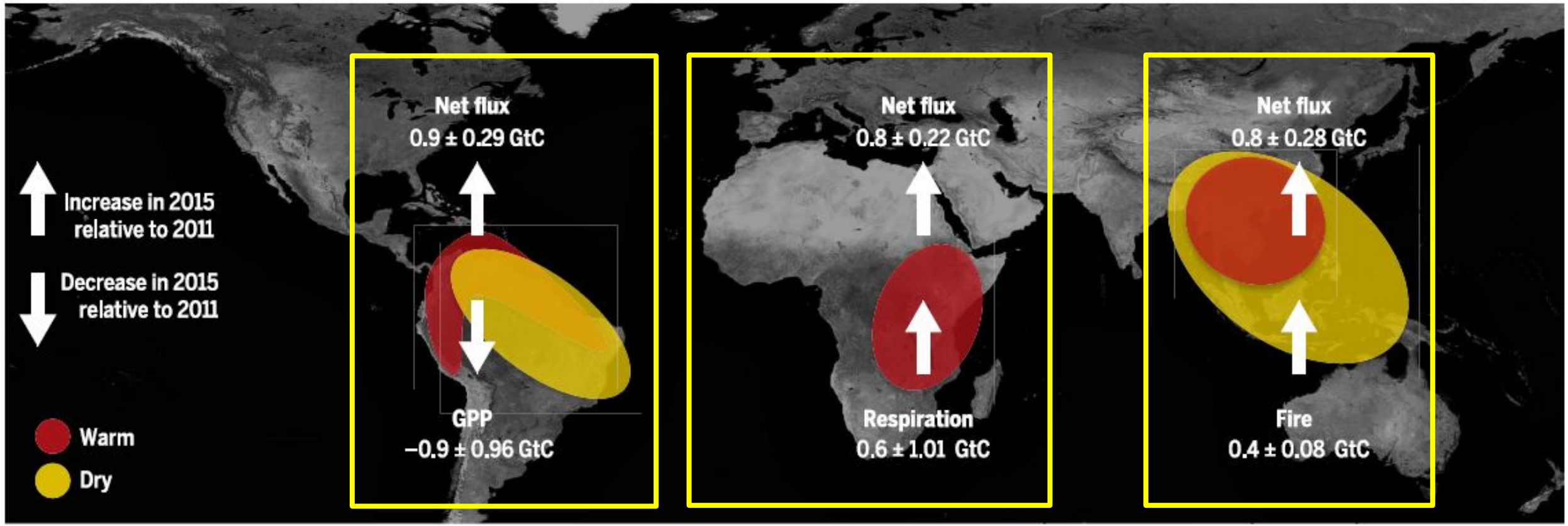
Earth System Models accounting for terrestrial N cycle
Earth System Models prescribing land use change emissions

Improved understanding of the role of biodiversity in heterogeneity across tropical landscapes is critical

Pan-tropical C source following 2015 El Niño

Distinct regional pathways resulted in net C emissions across tropics



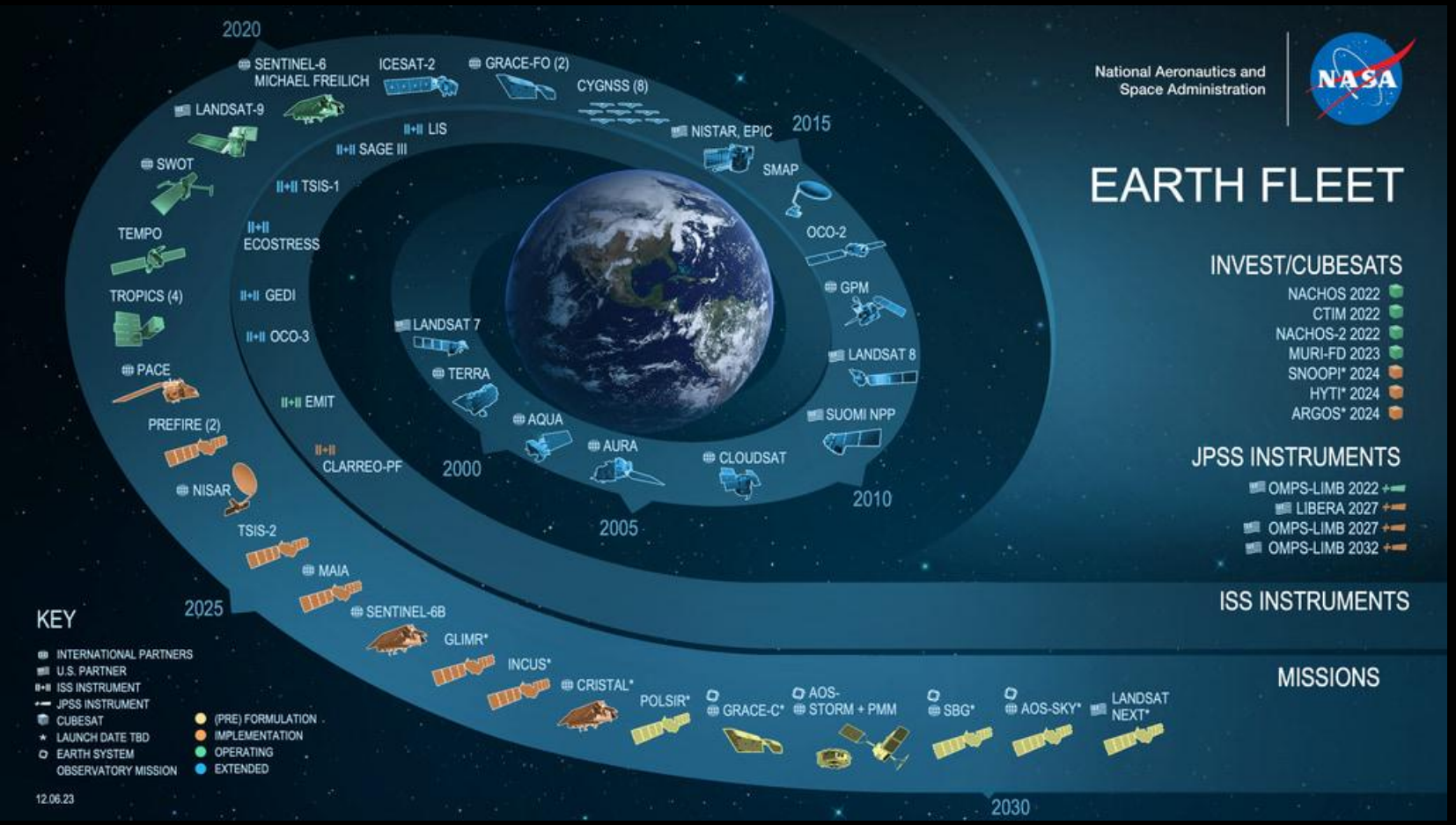
Liu et al. & Eldering et al. 2017 *Science*

Drier land surface □
Less plant growth □
More CO_2

Higher temperatures □
Increased respiration □
More CO_2

Hotter and drier □
More fire □
More CO_2

Data-rich era of satellite Earth observations



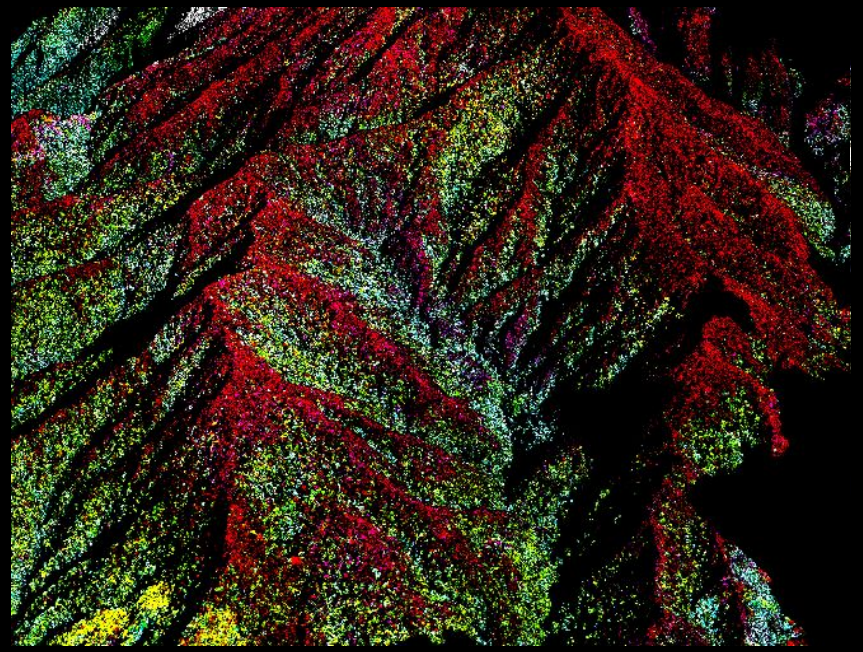
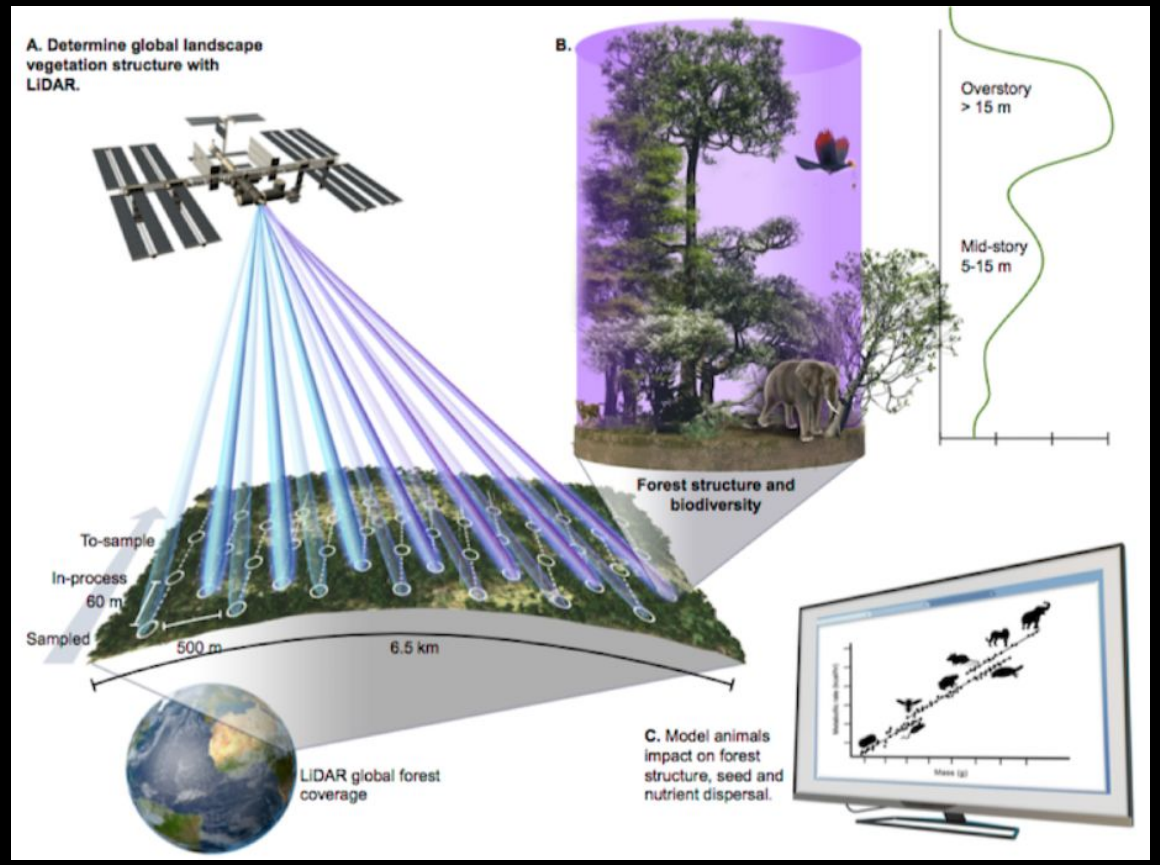
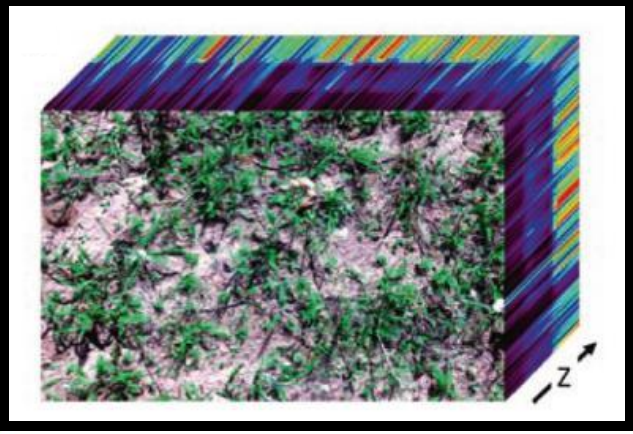
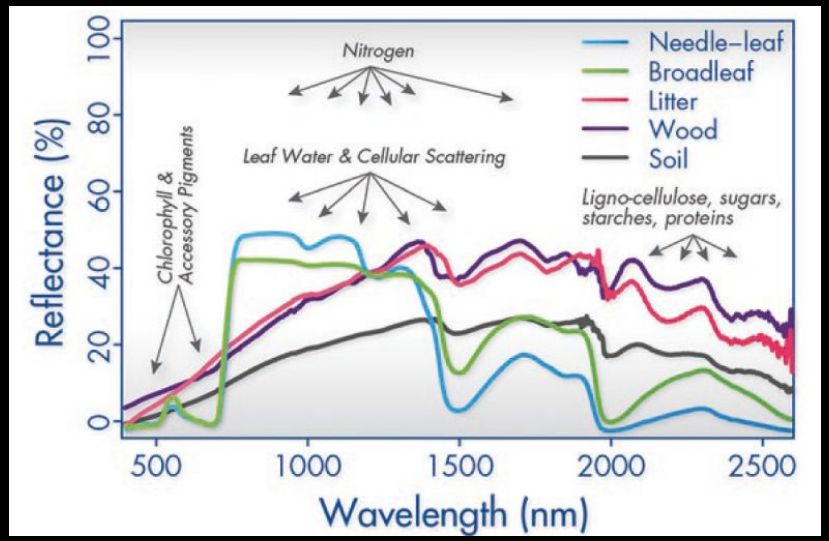


Image credit: K. Dana Chadwick

New airborne and spaceborne sensors



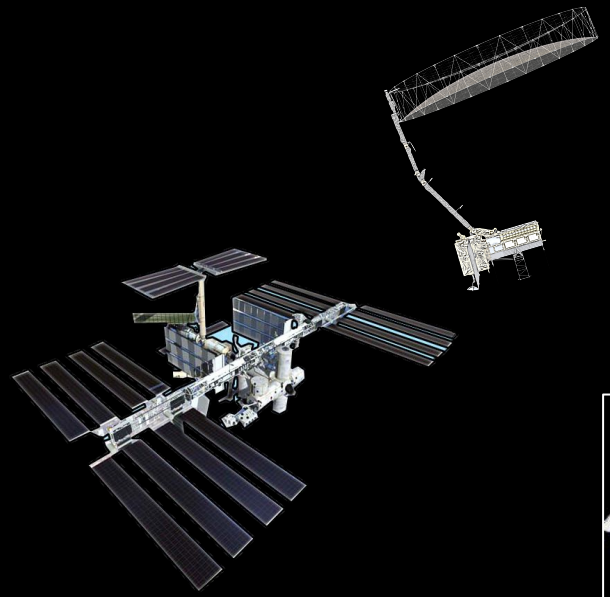




Scientific Focus

1. What are the similarities and differences within and between each tropical region?
2. How are the vulnerability and resilience of tropical forest ecosystems changing with global change?
3. How can this information be used to guide decision-making for climate adaptation & mitigation and biodiversity conservation?

A multi-scalar campaign



Multi-scalar: Surface, airborne and spaceborne observations

Interdisciplinary: Ecology, Biogeochemistry, Hydrology, Atmospheric Sciences, Socio-Ecological systems, and more

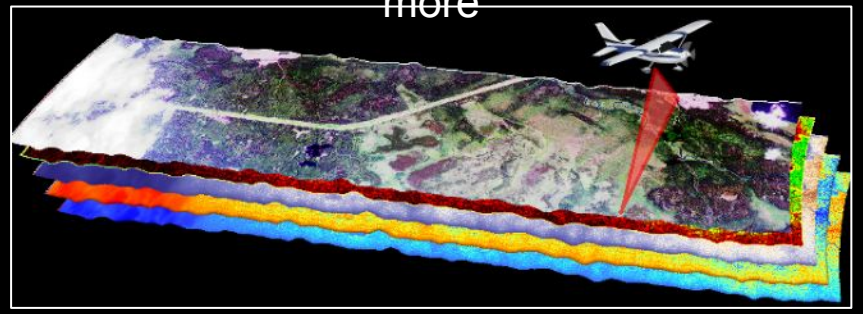
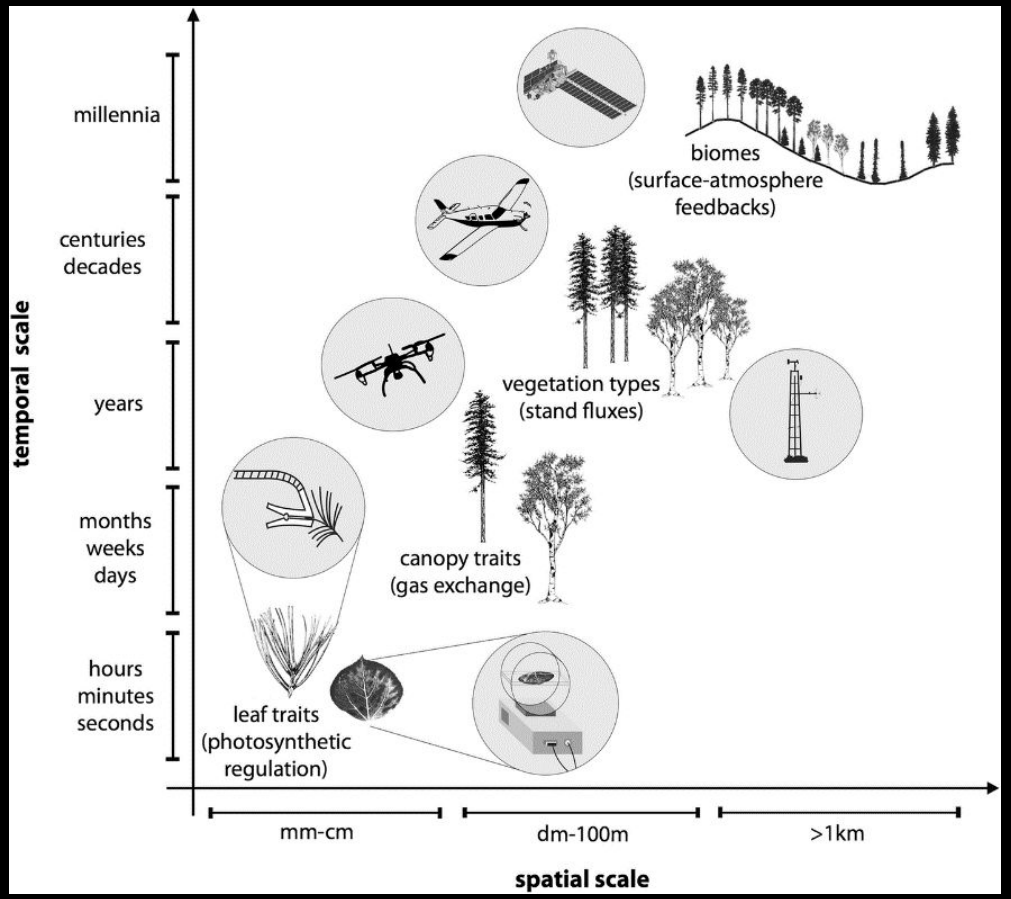


Image credits: CongoFlux, AVIRIS-NG



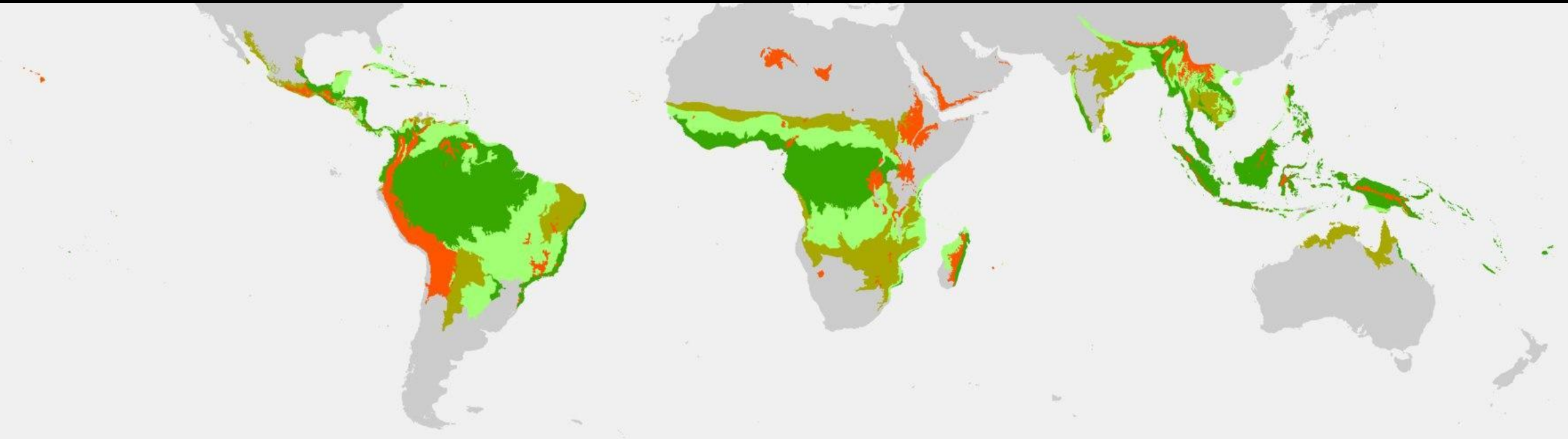
PANGEA's 3 pillars

1. **Science**: Advance scientific understanding of the region.
2. **Capacity Building**: Train the next generation of scientists from the region to be able to lead these scientific efforts.
3. **Pathways to Action**: Improve capabilities for monitoring carbon, biodiversity, and agriculture using satellite remote sensing.

What does it mean to scope a TE field campaign?

- A one-year effort to engage with the research community to:
  - Identify scientific research priorities and opportunities
  - Build relationships and define shared goals
  - Evaluate campaign feasibility
  - Determine the geographic scope
- Only 2 scoping proposals funded – PANGEA and ARID
- **Deliver white paper reporting findings by November / December 2024**
- If campaign funded, a 6- to 9-year campaign

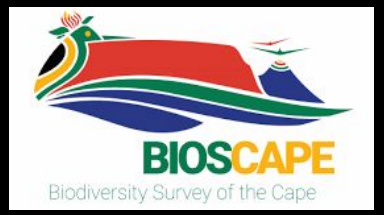
Exact PANGEA domain - TBD

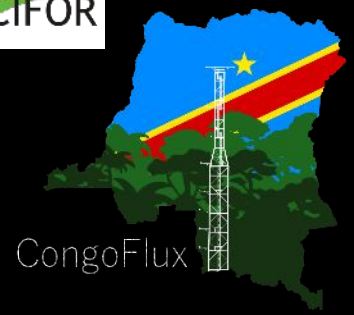


PANGEA – Landscape Approach

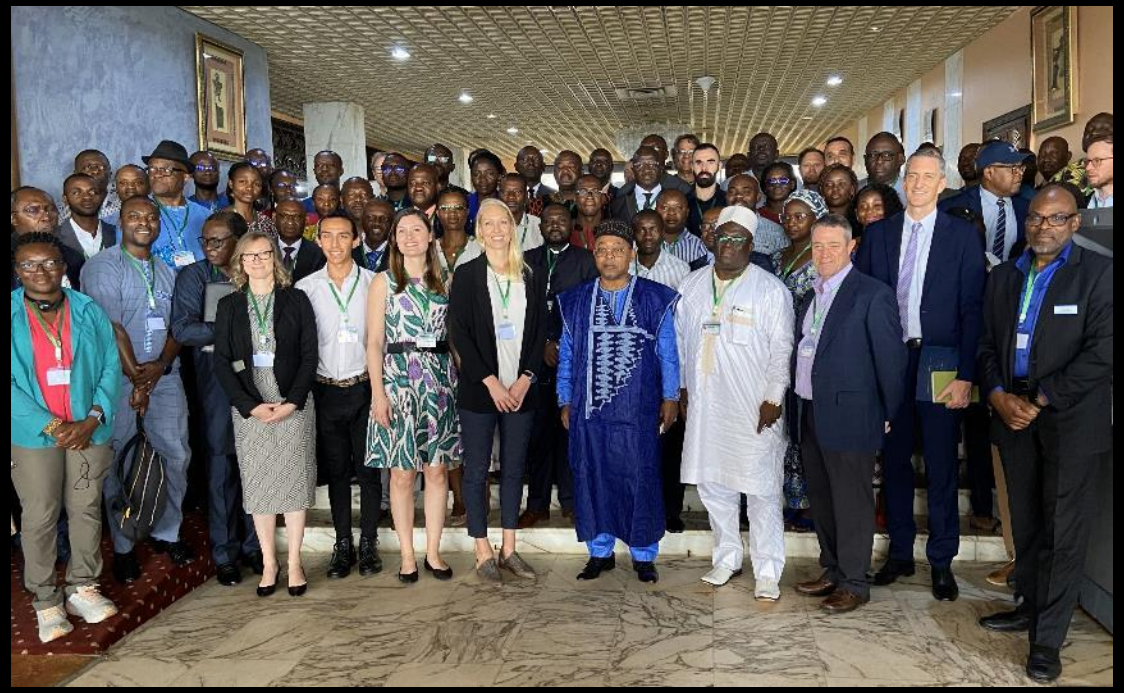
- Identify candidate ‘Landscapes’ across the tropics
- Locations that capture complex landscape mosaics:
  - Intact, logged, degraded, and disturbed forests
  - Wetlands and peatland systems
  - Agroecosystems
  - Mangroves (in coastal landscapes)
- Coordinated ground, drone, and airborne observations

Institutional Partners





An energizing workshop with the African research community



Well-attended Washington DC workshop in

Working Groups

Science Themes

- Ecosystem structure, function, & biodiversity
- Biogeochemical cycles & carbon dynamics
- Climate feedbacks & interactions
- Socio-ecological systems
- Modeling & data synthesis

Cross-C utting

- Feasibility
- Community Engagement
- Research & Applications Output

PANGEA Working Group Leads

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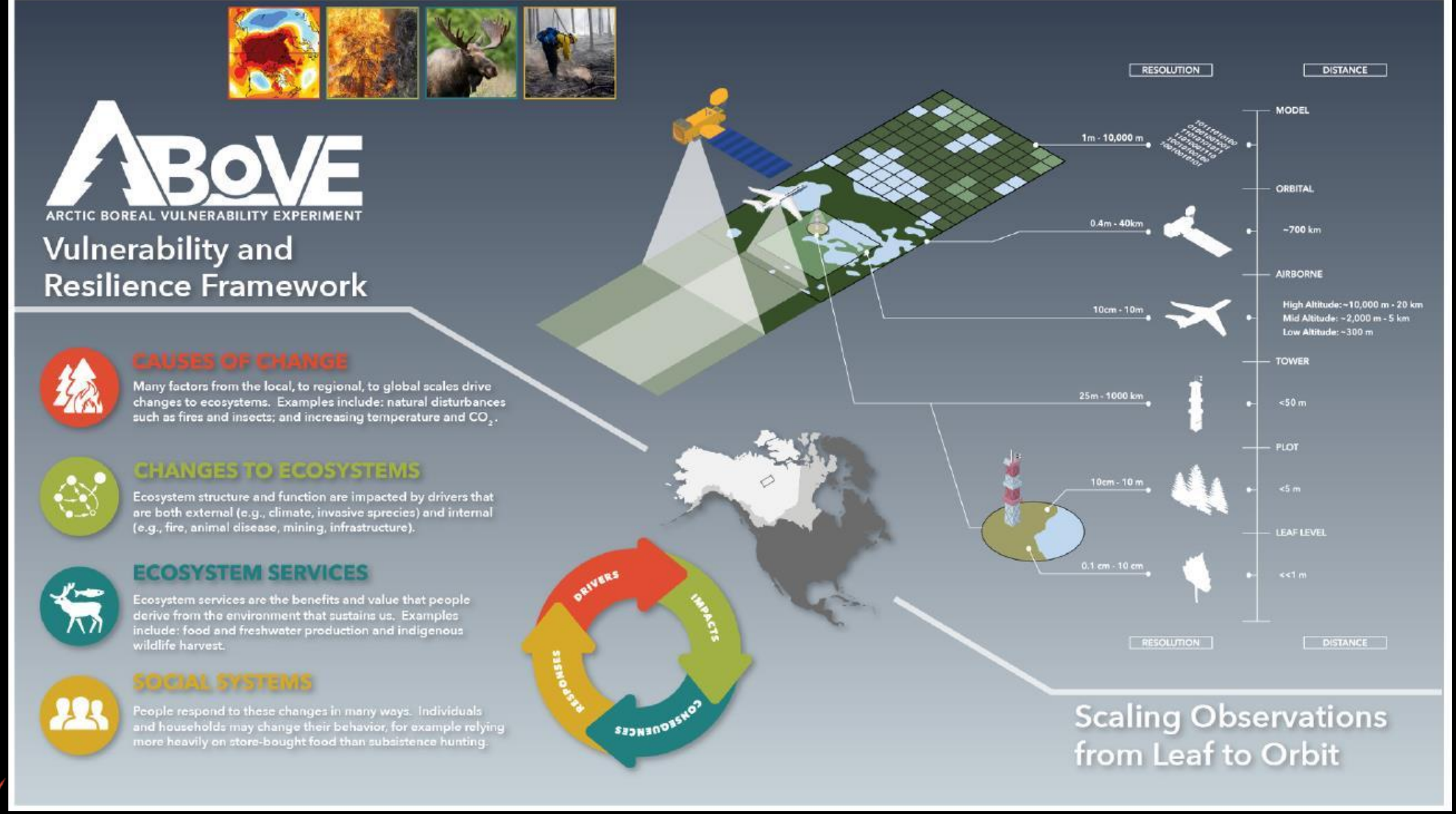
Funding Support

Get Involved!

PANGEA Website

tinyurl.com/tropicalscoping


ABoVE
ARCTIC BOREAL VULNERABILITY EXPERIMENT
Vulnerability and Resilience Framework
CAUSES OF CHANGE
Many factors from the local, to regional, to global scales drive changes to ecosystems. Examples include: natural disturbances such as fires and insects; and increasing temperature and CO_2.
CHANGES TO ECOSYSTEMS
Ecosystem structure and function are impacted by drivers that are both external (e.g., climate, invasive sprecies) and internal (e.g., fire, animal disease, mining, infrastructure).
ECOSYSTEM SERVICES
Ecosystem services are the benefits and value that people derive from the environment that sustains us. Examples include: food and freshwater production and indigenous wildlife harvest.
SOCIAL SYSTEMS
People respond to these changes in many ways. Individuals and households may change their behavior, for example relying more heavily on store-bought food than subsistence hunting.
DRIVERS
IMPACTS
CONSEQUENCES
RESPONSES
RESOLUTION
DISTANCE
MODEL
1m - 10,000 m
ORBITAL
0.4m - 40km
~700 km
AIRBORNE
10cm - 10m
High Altitude: ~10,000 m - 20 km
Mid Altitude: ~2,000 m - 5 km
Low Altitude: ~300 m
TOWER
25m - 1000 km
<50 m
PLOT
10cm - 10 m
<5 m
LEAF LEVEL
0.1 cm - 10 cm
<<1 m
RESOLUTION
DISTANCE
Scaling Observations from Leaf to Orbit

LBA - Large-Scale Biosphere-Atmosphere Experiment in Amazonia