Enhancing Global Forest Observations in a Changing Climate

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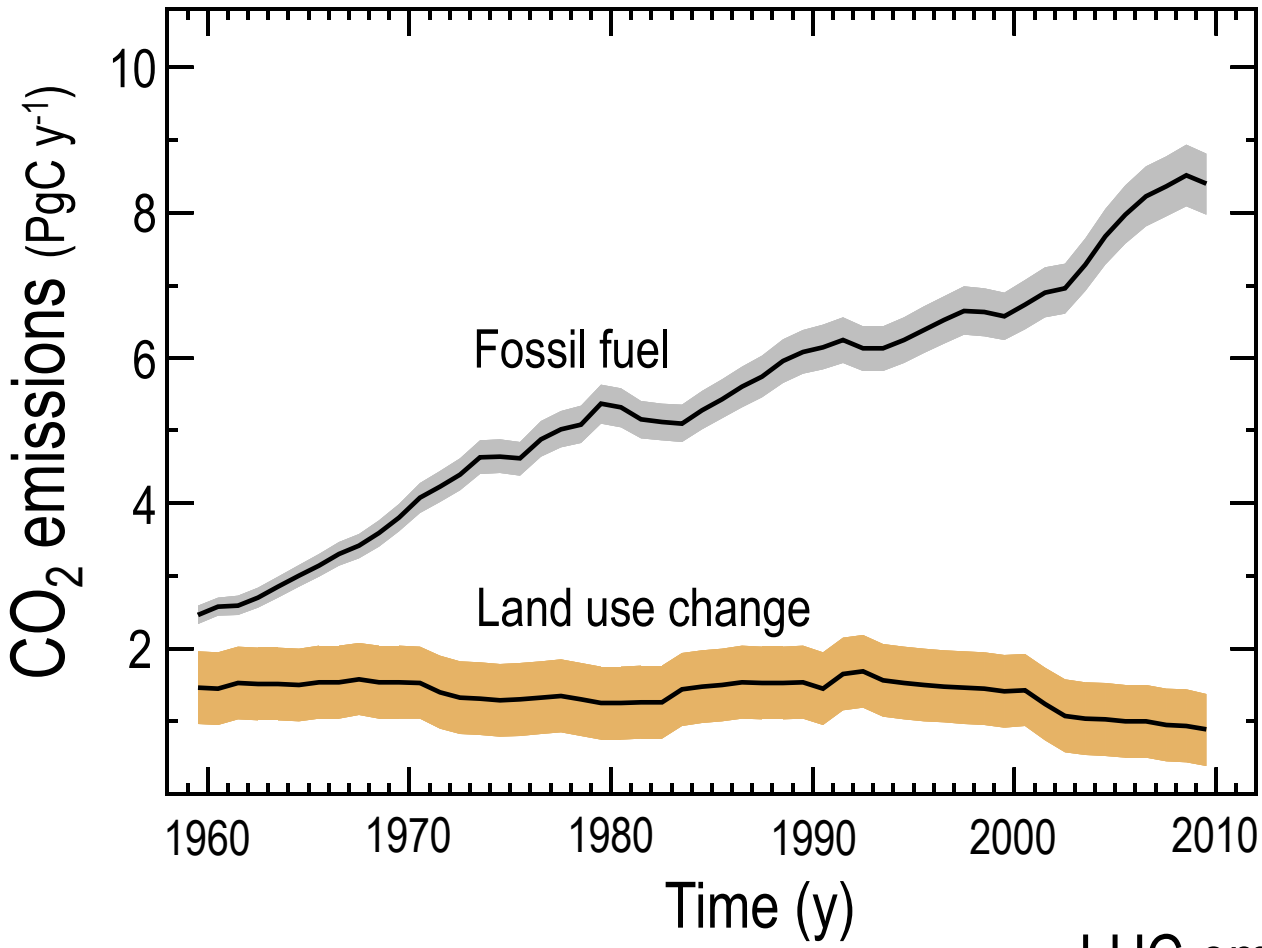
Science Objectives to Address Policy & Management Needs

- Detect and understand changes in forest ecosystems, feedbacks to climate
- Effects of deforestation, afforestation, and degradation on the land-based carbon sink
  - Carbon budgets (soil, above and belowground vegetation)
  - Interaction with changing climate (e.g. water cycle)
- Effects of climate and management on natural adaptation
  - Vulnerability to shifts in distribution of species, biomes
  - Mitigation effects in the face of climate change

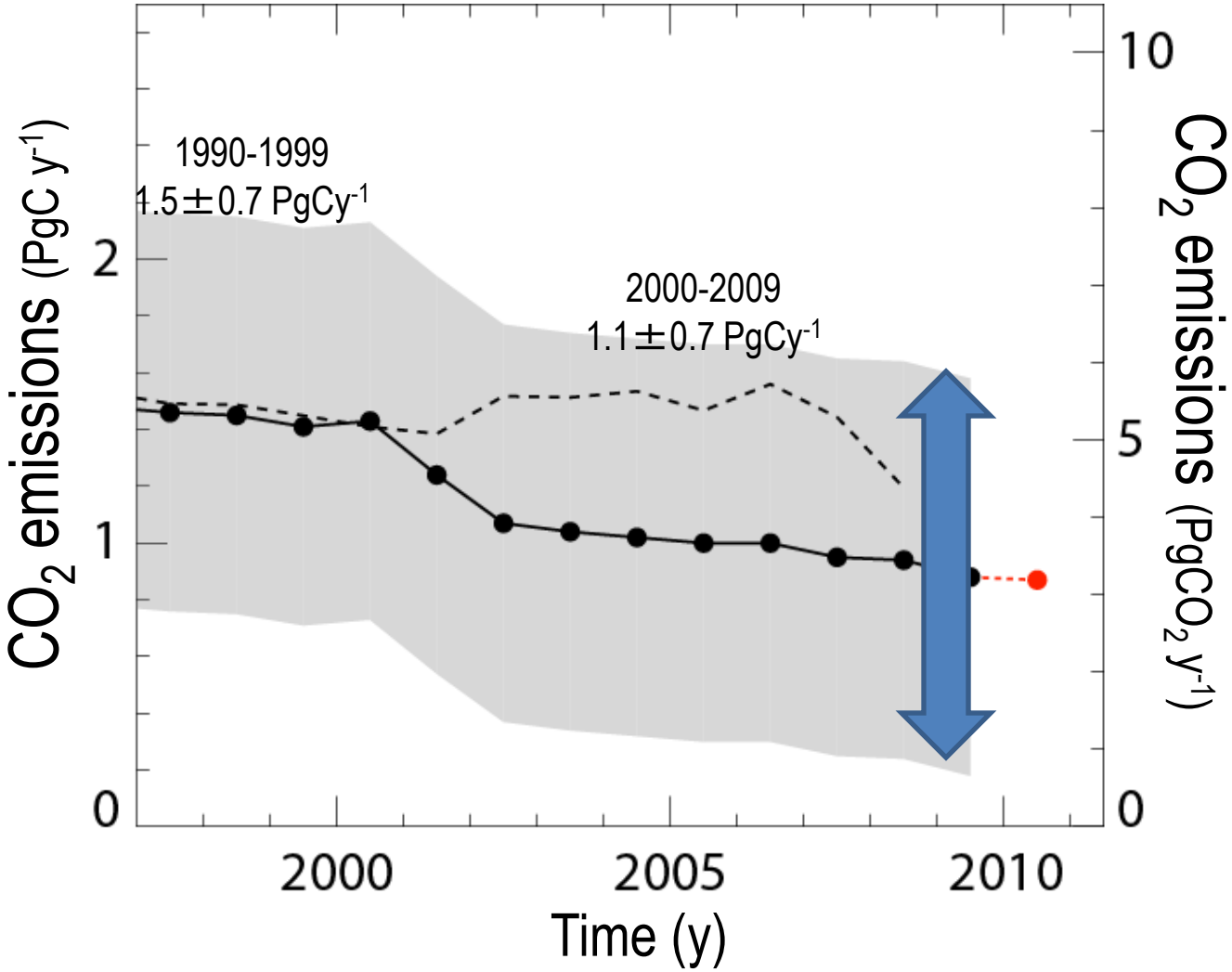
CO_2 Emissions from Land Use Change (1960-2009)



LUC emissions now ~10% of total CO_2 emissions

Updated from Le Quéré et al. 2009, Nature Geoscience

CO_2 Emissions from Land Use Change



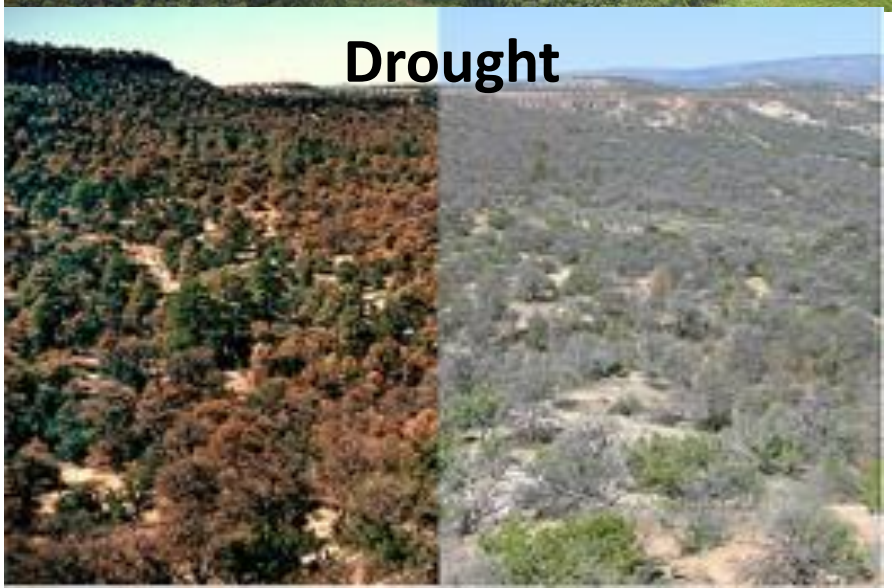
1990s
Emissions: 1.5±0.7 PgC

2000-2005
Emissions: 1.3±0.7 PgC

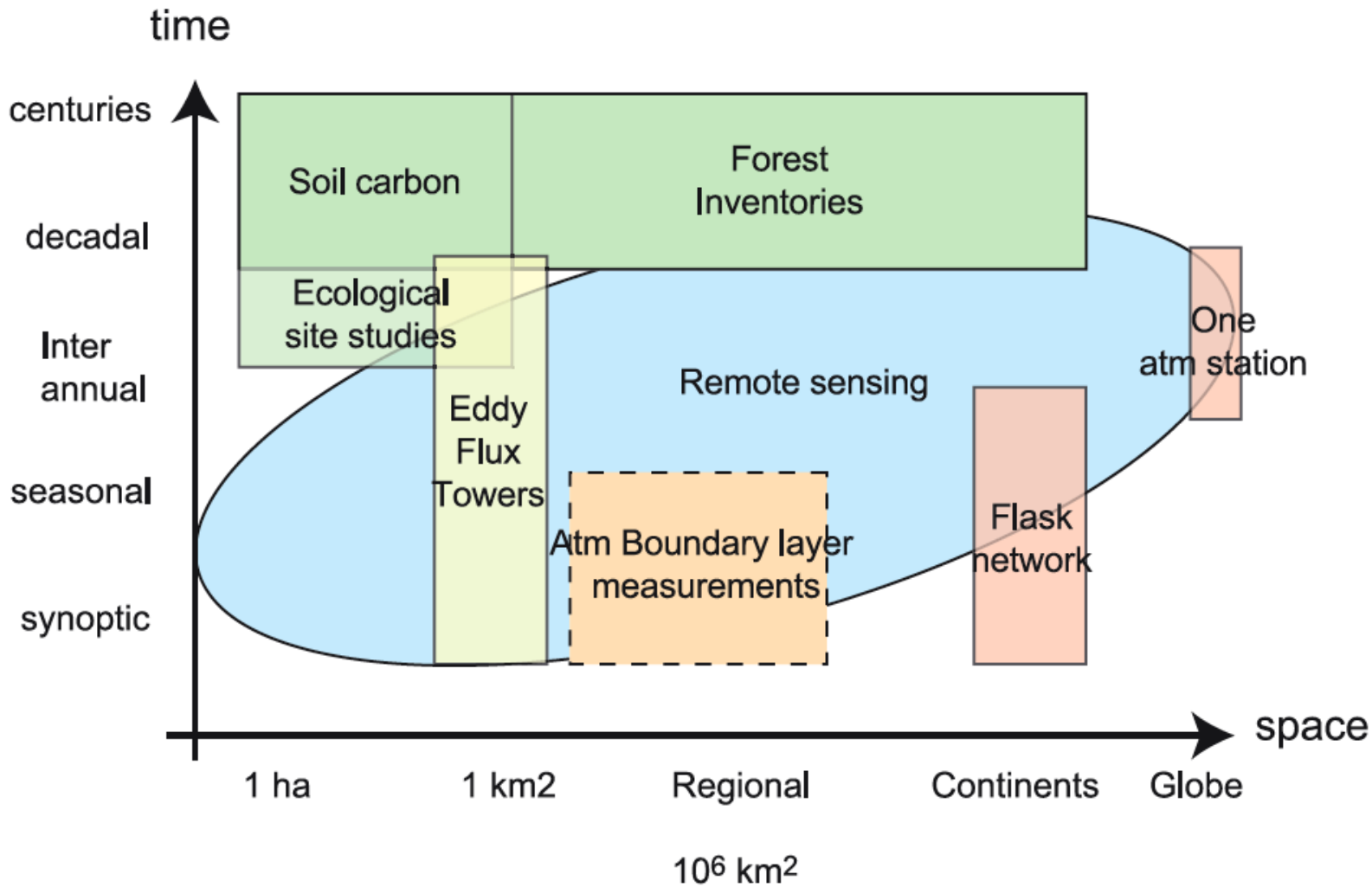
2006-2010:
Emissions: 0.9±0.7 PgC

Friedlingstein et al. 2010, Nature Geoscience; Data: RA Houghton, GFRA 2010

Carbon in Plants and Soil Vulnerable to Land Use, Drought, Fire, Insects/Diseases

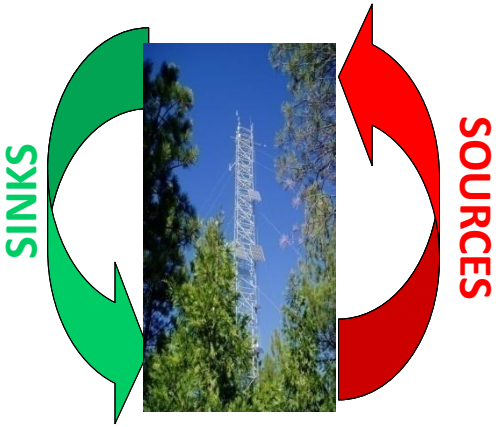


Observations Need to be Integrated Across Time and Space Scales



Integration for Regional Mapping of Terrestrial Carbon

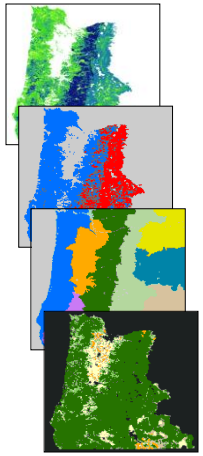
Terrestrial Carbon Modeling



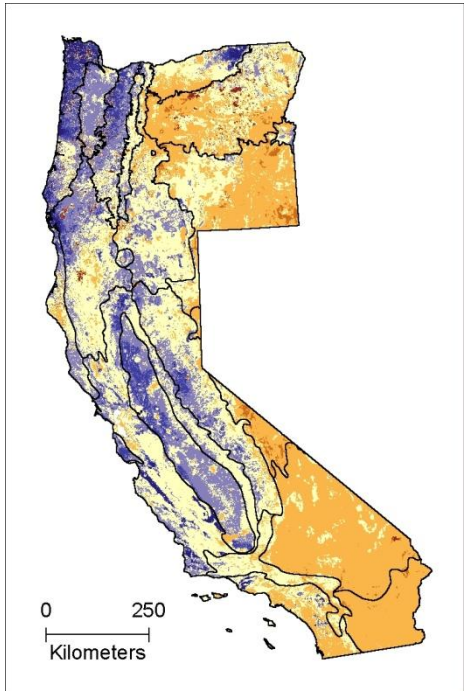
Biosphere CO_2 Flux Observations

Understanding of terrestrial carbon processes

Inventories Carbon Stocks

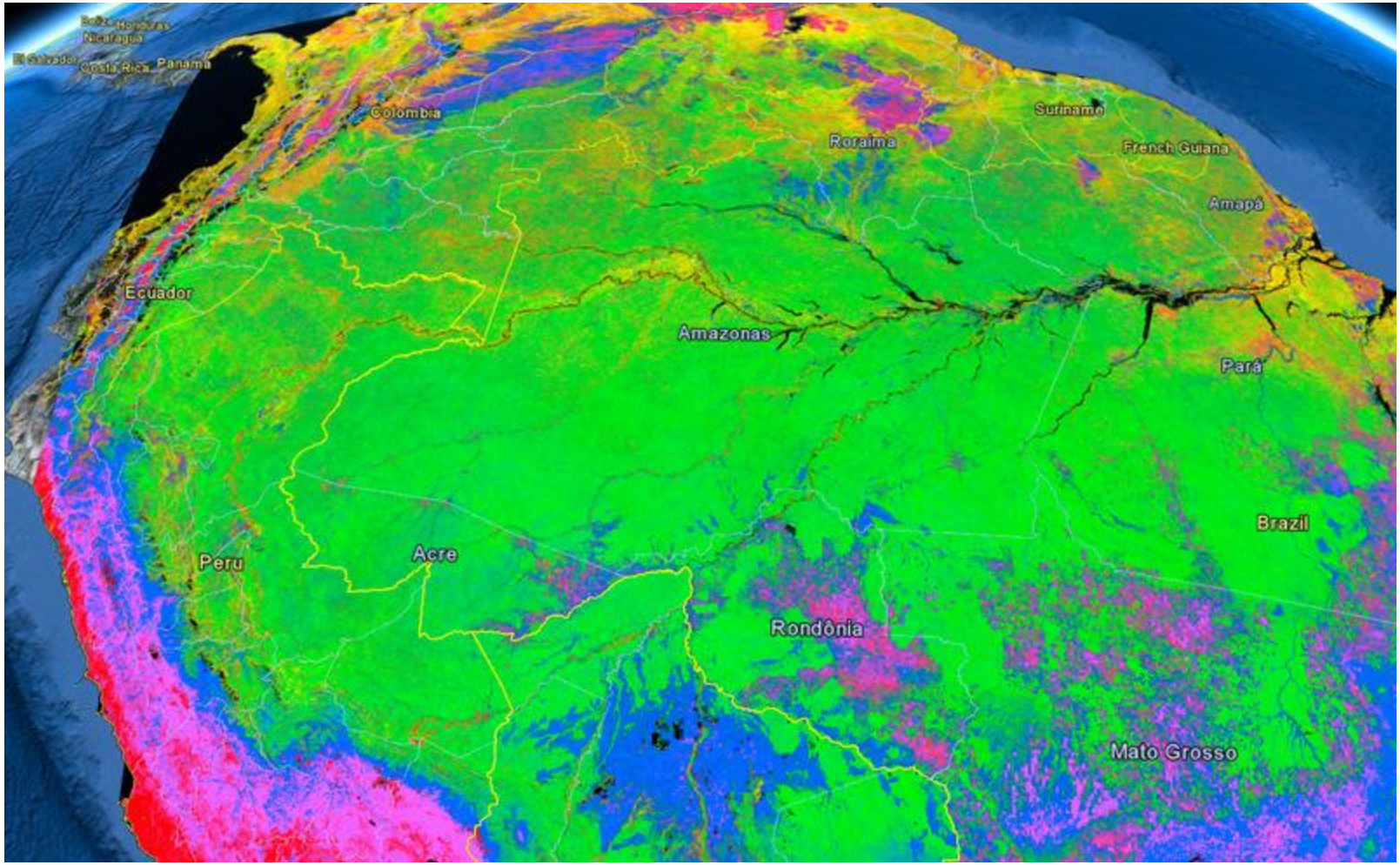


Spatial data: Land-use, land cover, meteorology



Maps of Terrestrial Carbon Stocks and Fluxes

Monitoring Deforestation



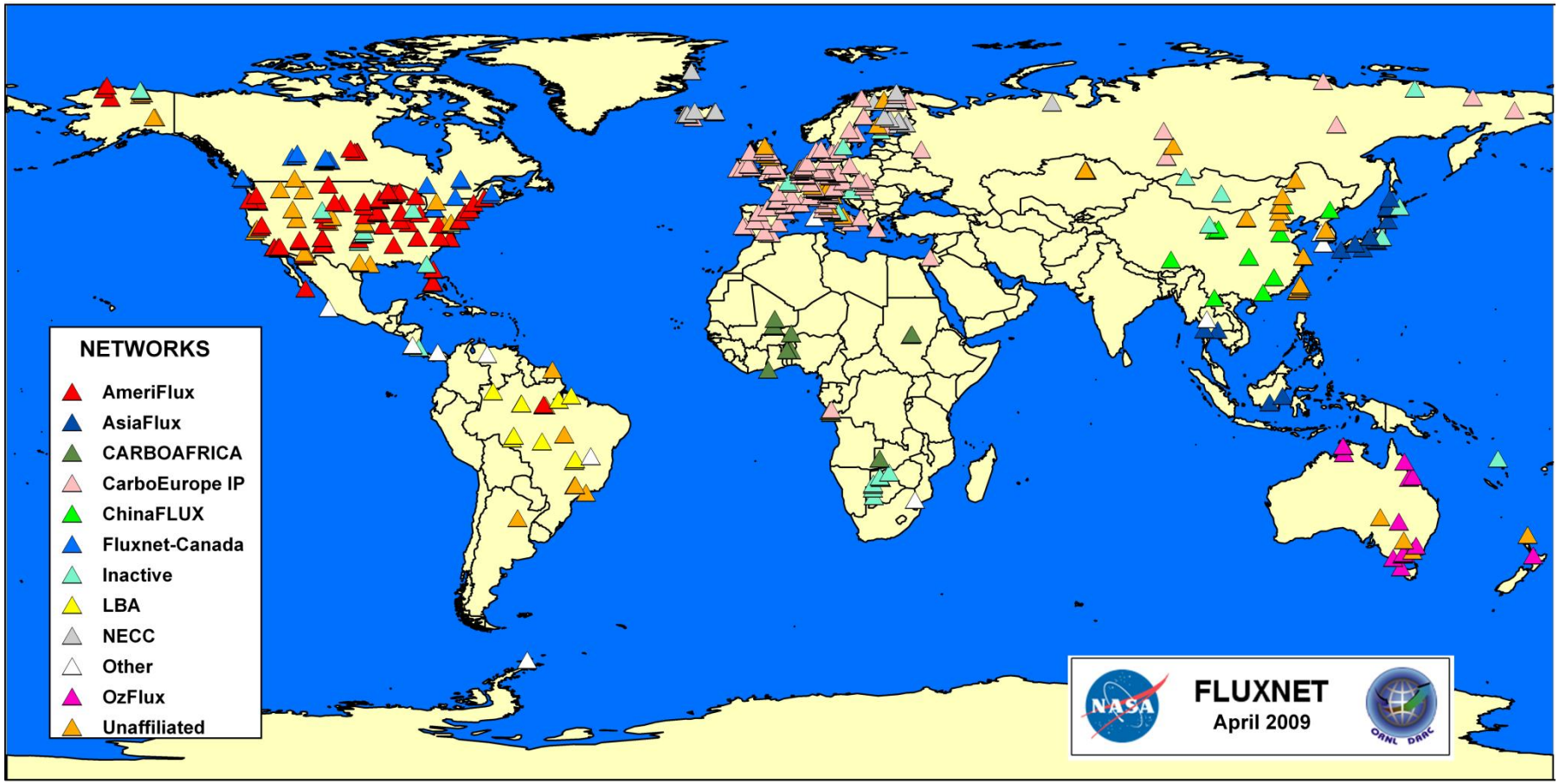
To qualify for payments under REDD, countries must be able to quantify reductions in deforestation against a historical baseline

Deforestation and Degradation Uncertainty

- Total annual change in *forest area* has an uncertainty of 10-25% in northern forests, up to 100% in tropical forests
- Uncertainties in *emissions* are high for annual values and trends (25 -100%) due to uncertainties in parameters used to translate area into CO_2 emissions
- Improved observations and integration with modeling will reduce uncertainty

(UN-REDD, NRC 2010)

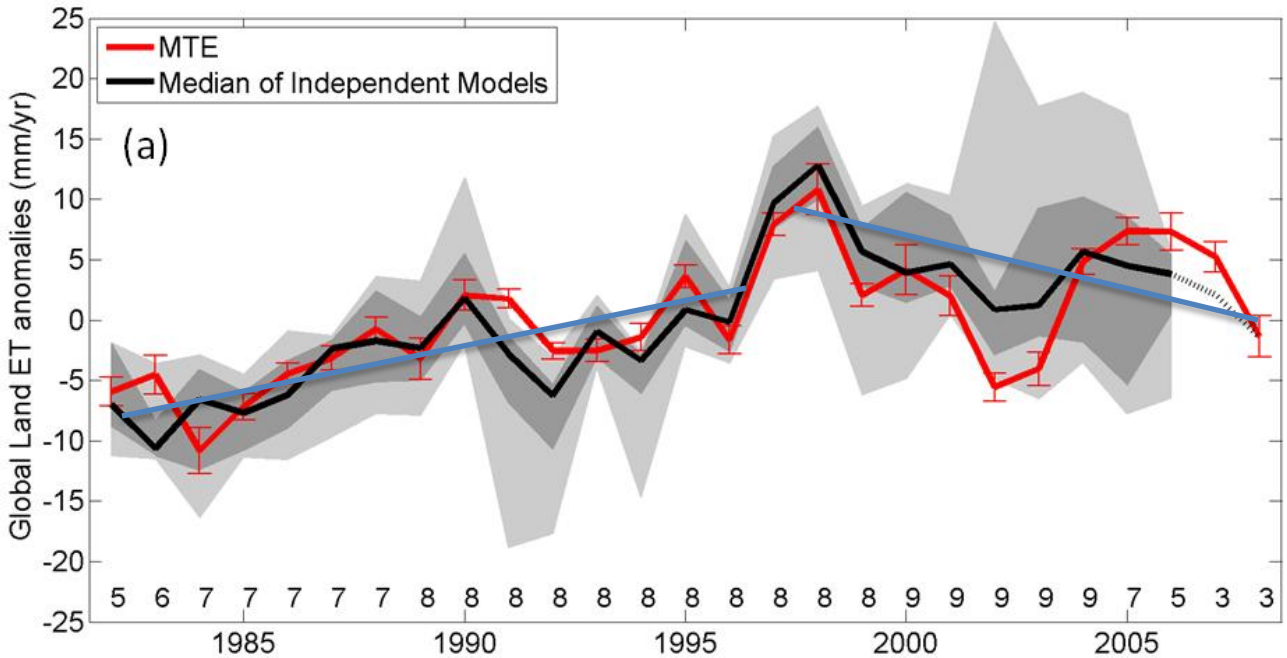
FLUXNET: A Global Network of Observation Sites
500+ Sites, 10 Regional Networks, 45 Countries



Quantify and understand causes of variation in terrestrial exchange of carbon, water and energy with atmosphere

www.fluxdata.org

It's Not Just About CO_2:
Decline in Trend of Global Land Evapotranspiration

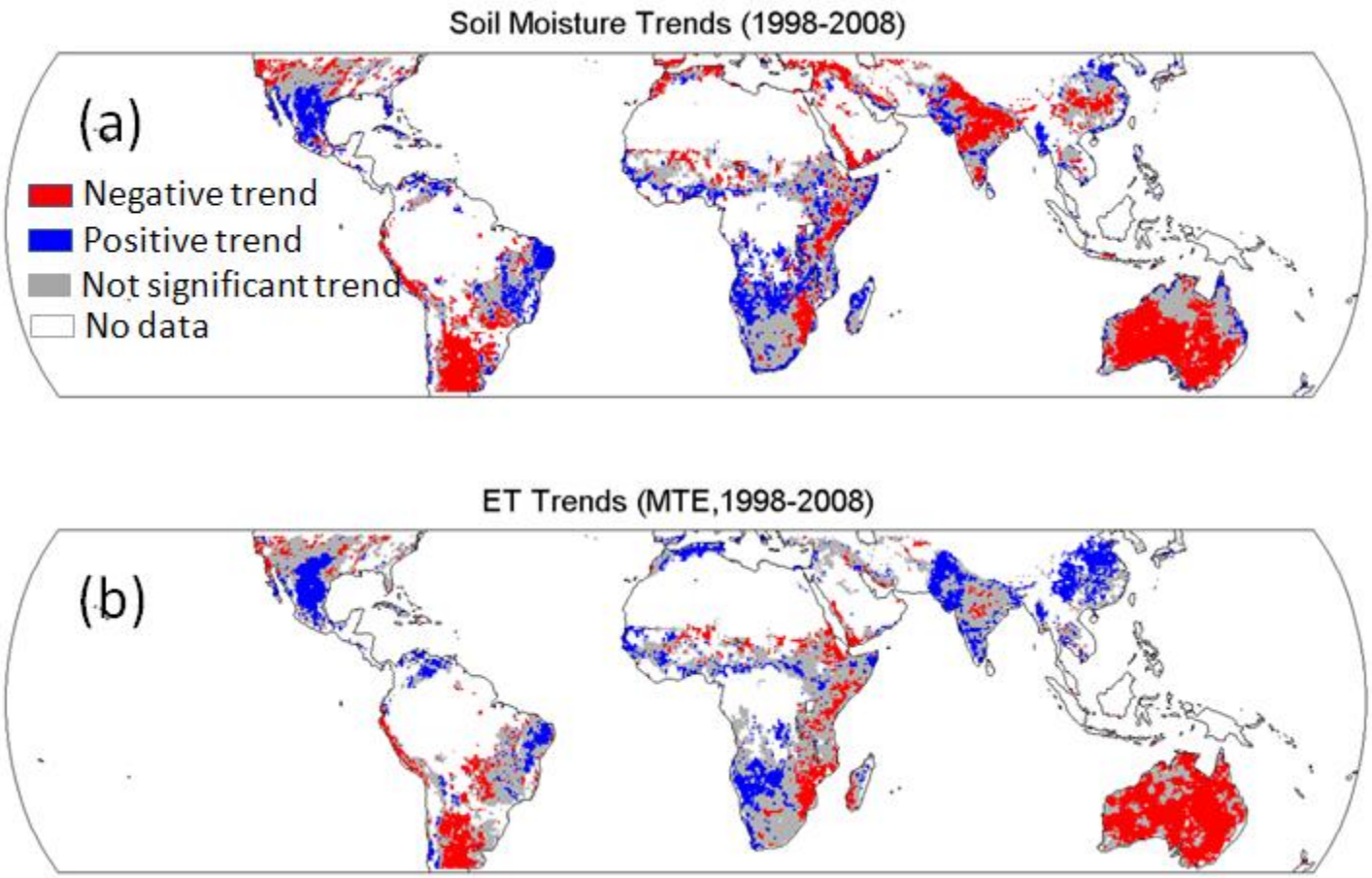


- Data-driven estimate of global land ET using tower flux, meteology, remote sensing data and models
- Implications to feedbacks to climate

Jung et al. (2010), Nature

Soil Moisture Limits Evapotranspiration Trends

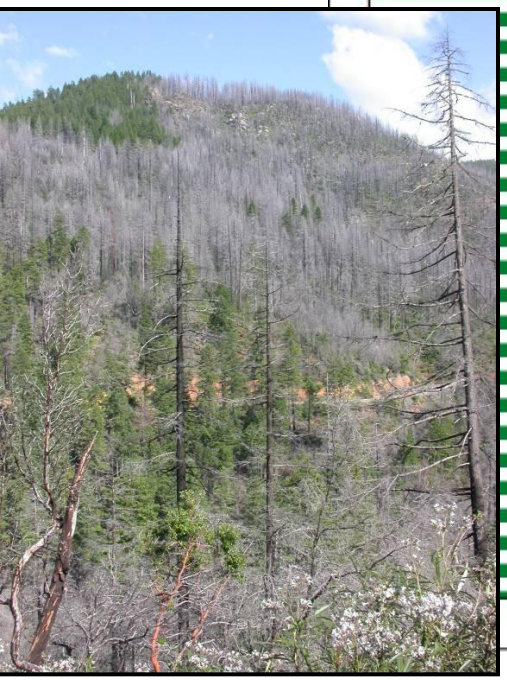
Identified by integration of tower fluxes, remote sensing & models

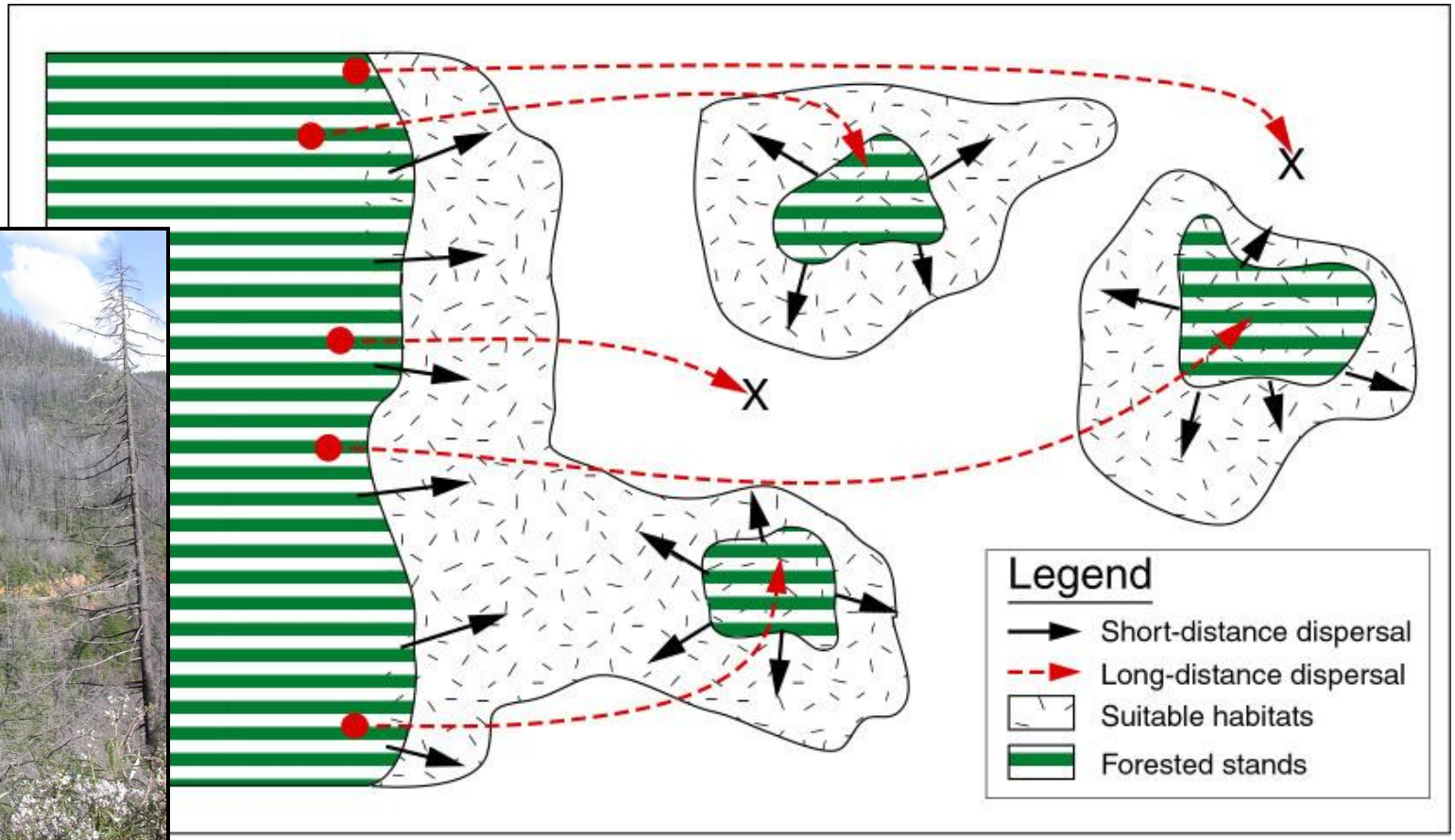


Negative trend (red) = drier soil, decreasing ET

Jung et al. (2010), Nature

Forest Species Migration Under Climate Change:
Integration of Observations and Models to Predict Potential





Long-term in situ observations of dispersal, habitat, and species distribution used to develop and parameterize models

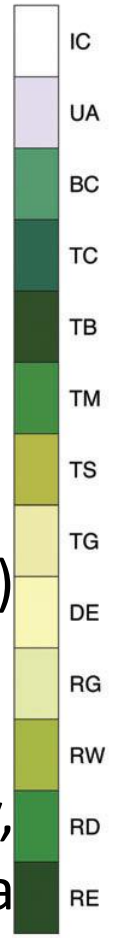
Simulated Vulnerability to Biome Changes (1990-2100)

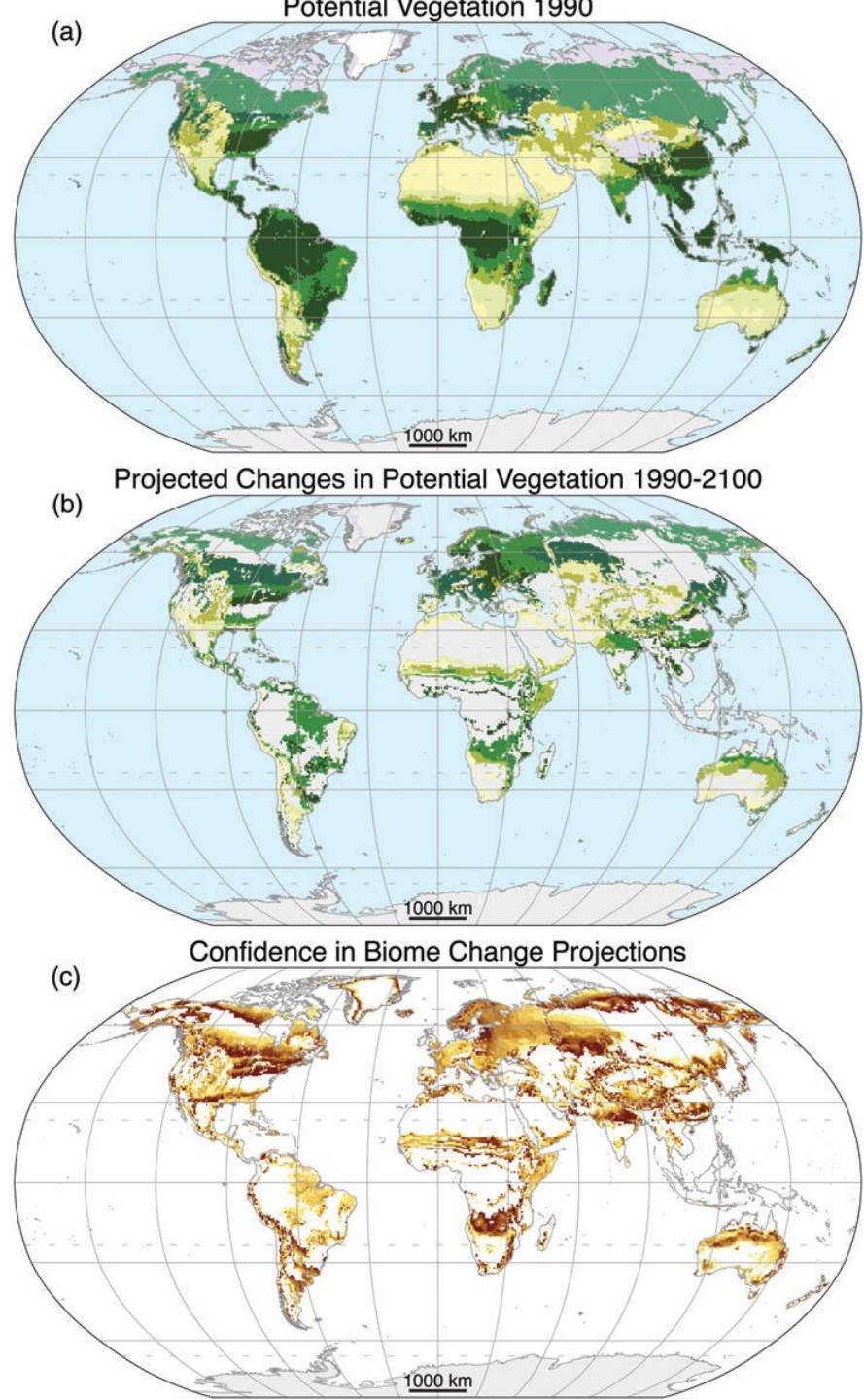
Simulations suggest 10-50% of global land may be highly vulnerable (fair comparison with remote sensing land cover)

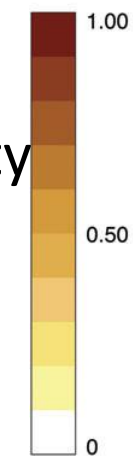
Field observations detected biome changes in 20th -century, yet there is a lack of spatial data on vulnerability

Hinders identification of priority areas for adaptation measures

(Gonzalez et al. 2010)





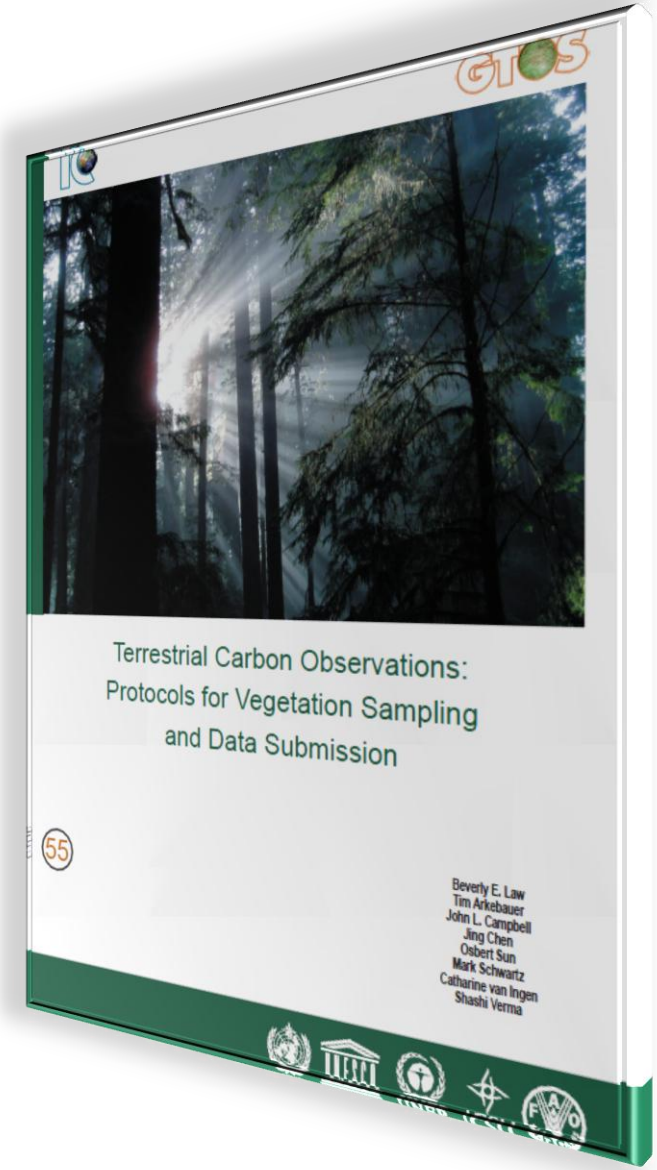


Summary of Need for Systematic Forest Observations and Integration

- Changes in terrestrial carbon sources and sinks
- Changes in water cycle, energy balance
- Natural or ‘ecological’ adaptation, vulnerability

Protocols for Data Collection and Submission

- Need:
  - Uniform methods, standards for high quality observations
  - Uniform database for global assessments
- Important standards/definitions:
  - Carbon stocks in vegetation and soil, productivity, component fluxes
  - Vegetation types, structure
  - Land use
- Reference for other documents (ECV, GEO Carbon Report)

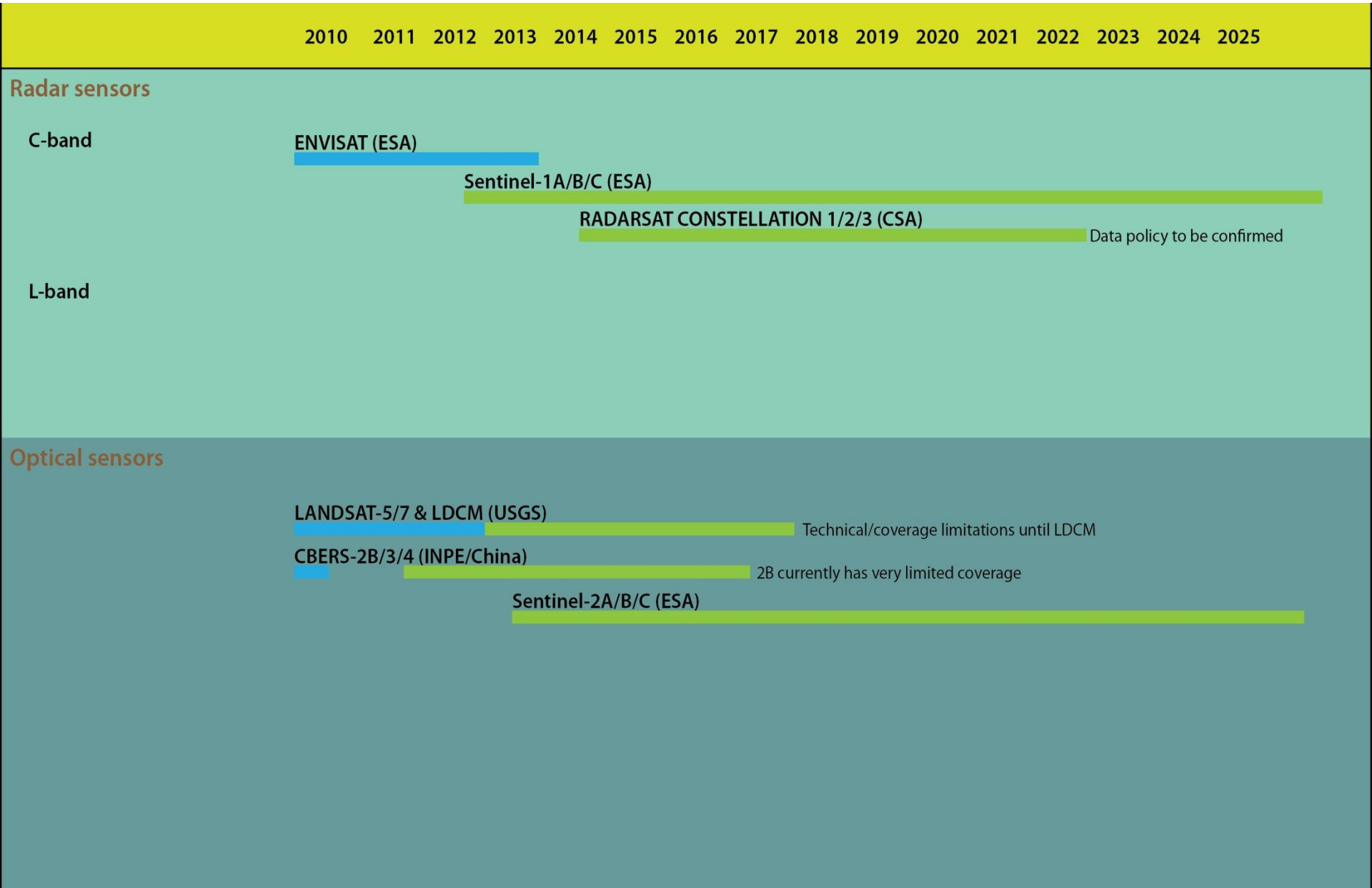


Challenges and Gaps
Land Ecosystems

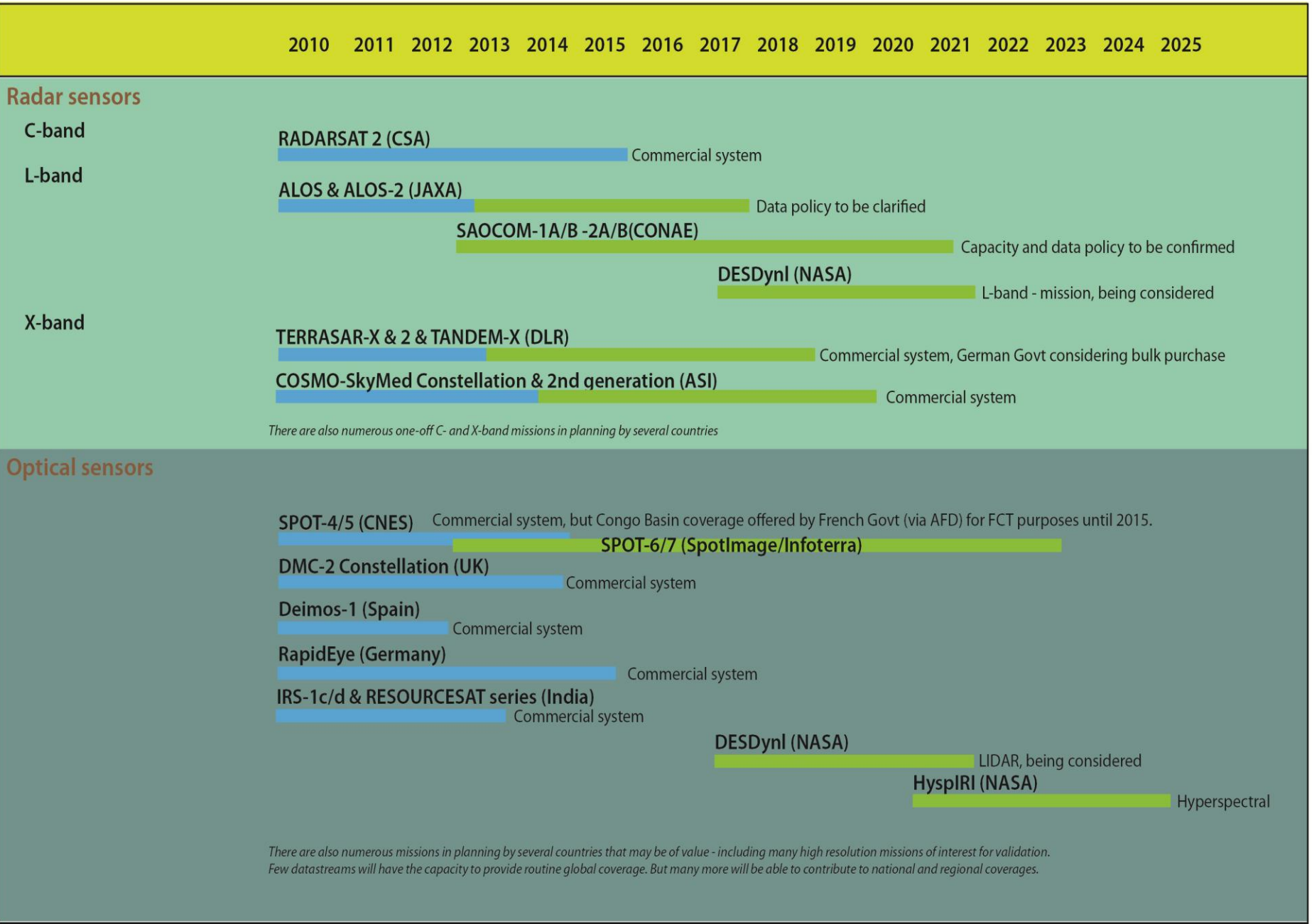
- Some countries without resources for inventories
- Consistent *in situ* methodology
- Sustained, systematic measurements
  - e.g. soil carbon monitoring, NPP, total biomass, species
- Remote sensing – gaps in coverage over time
- Data sharing – transparent, timely, standardized
- Observation/model integration – transition from research to application

Extras

Sub-30m Satellite Data Streams for Continuous Annual Global Coverage



Further Satellite Data Streams of Potential Value

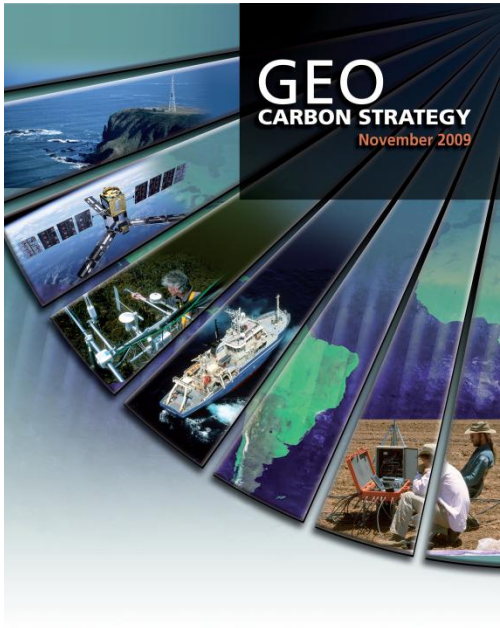


Soil Carbon Monitoring

- Soil carbon is probably the best indicator of soil quality. soil carbon loss ~ land degradation
  - Soil and ecosystem C in plantations and reforested areas tends to be lower than natural forests
- Higher uncertainty than most other pools
- Certain soil C pools (e.g. permafrost soils) are highly vulnerable to decomposition
- Deforestation and tillage cause rapid oxidation of plow-layer soil carbon (location of highest concentrations)
- Soil carbon monitoring is needed to understand and predict net long-term effects of deforestation, reforestation and afforestation

GEO Integrated Global Carbon Observations

- **Provide** long-term observations required to improve the understanding of the current state and future behavior of the global carbon cycle
- **Monitor** and **assess** the effectiveness of carbon sequestration and/or emission reduction activities on global atmospheric CO_2 levels



GEO GROUP ON EARTH OBSERVATIONS