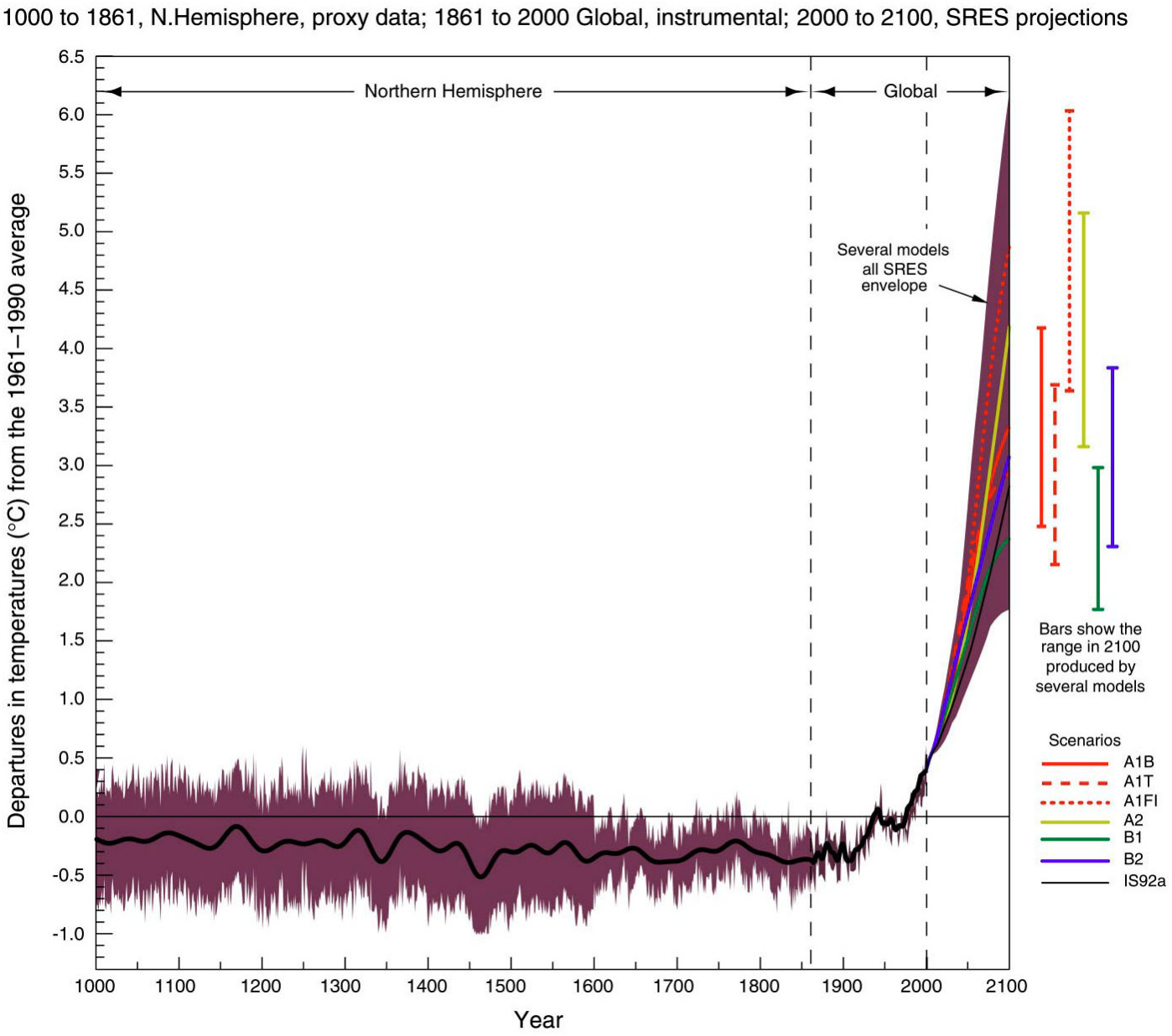
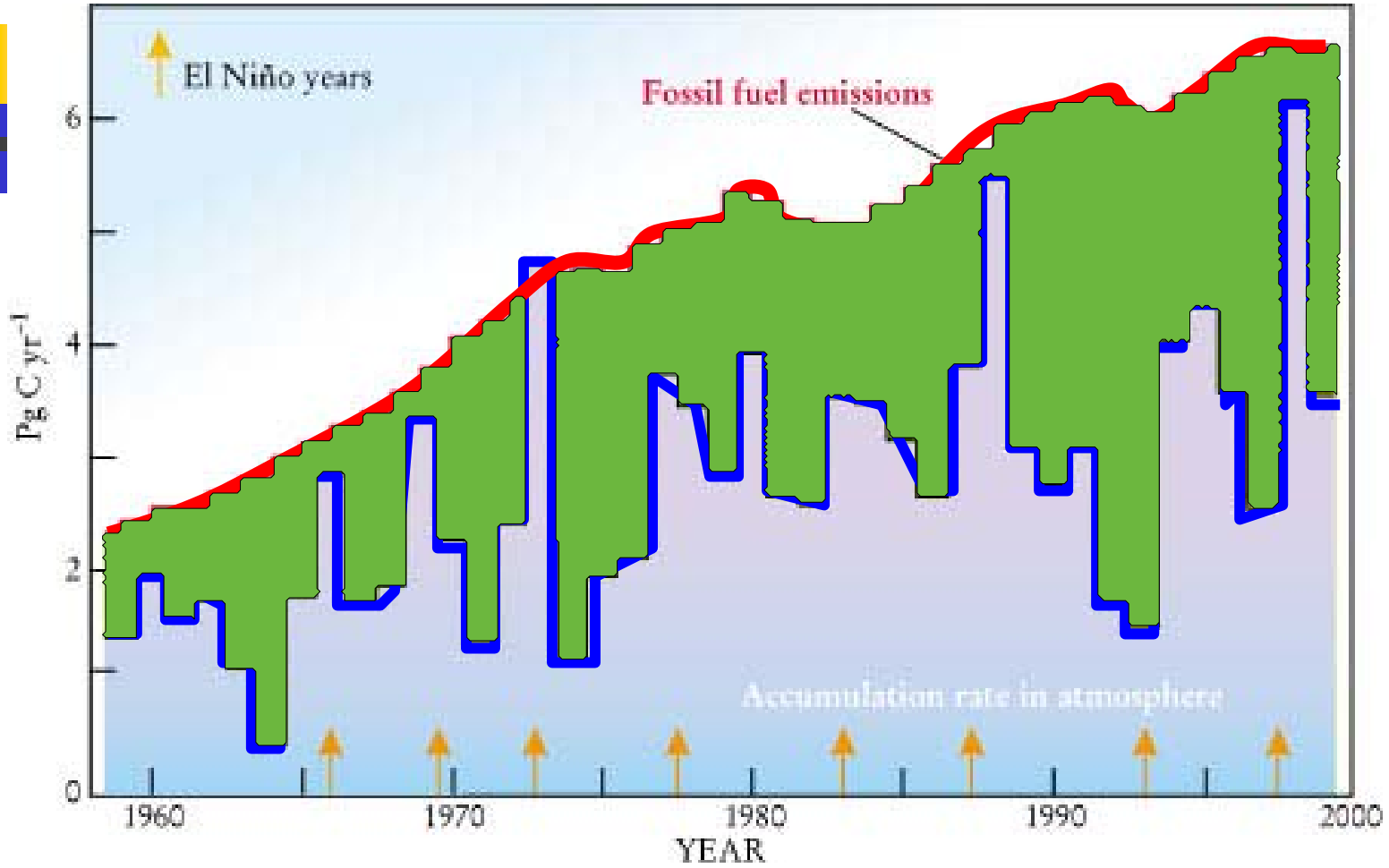
Lecture 1: Introduction

- Atmospheric CO_2 concnetrations
- The global carbon balance
- What is the role of land biosphere?
- Observations at multiple scales
- The role of flux stations
- Linking measurements and models

Variations of the Earth's surface temperature 1000 to 2100

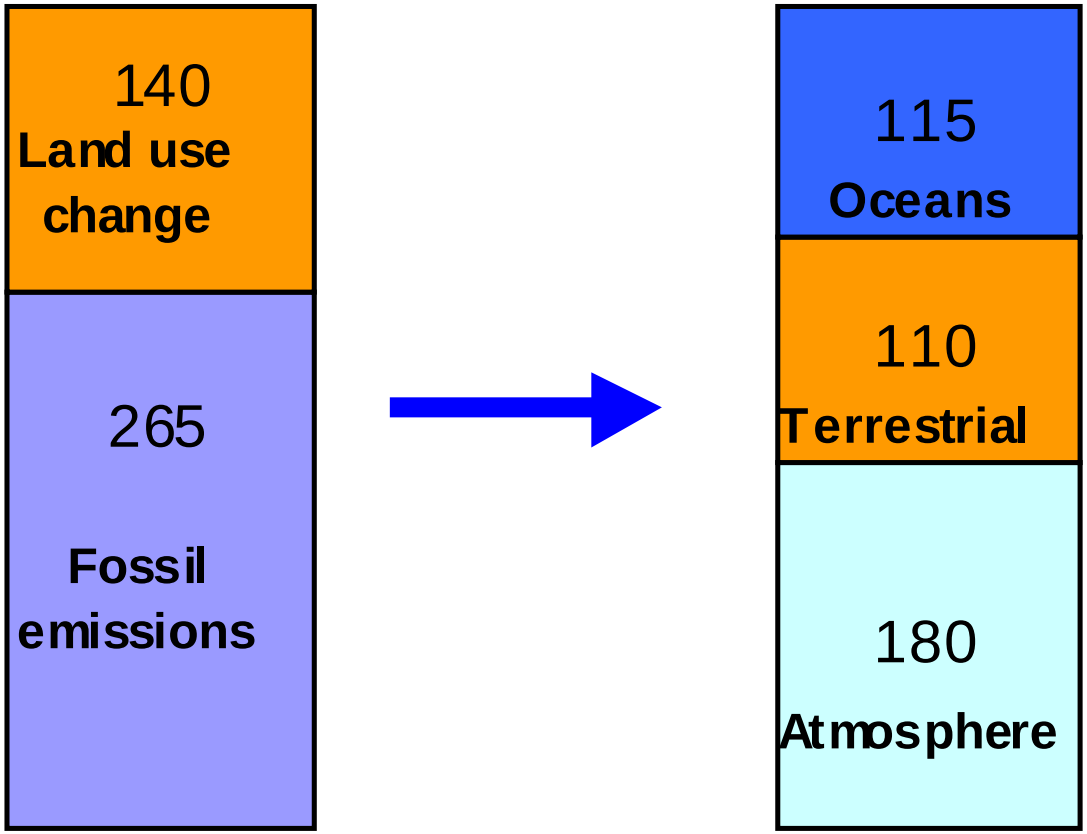


$CO_{2,Atm}$ Accumulation = CO_2 Source - Land & Ocean Sinks



Sarmiento and Gruber, 2002: **Figure 3: Growth rate of carbon reservoirs.** Since 1958, the yearly accumulation rate of atmospheric carbon dioxide has grown, on average, from about 1 Pg C/yr to about 3.0 Pg C/yr (light blue area). Over the same period, fossil-fuel emissions (red line) have grown from about 2.5 Pg C/yr to about 6.5 Pg C/yr. Net uptake by the ocean or terrestrial biosphere (green region) must account for the difference. Note the large interannual variation in the annual atmospheric CO_2 growth rate. Higher growth rates generally appear to be associated with El Niño episodes (orange arrows), the exception being the period following the eruption of Mt. Pinatubo in the early 1990s.

Carbon emissions and uptakes since 1800 (Gt C)

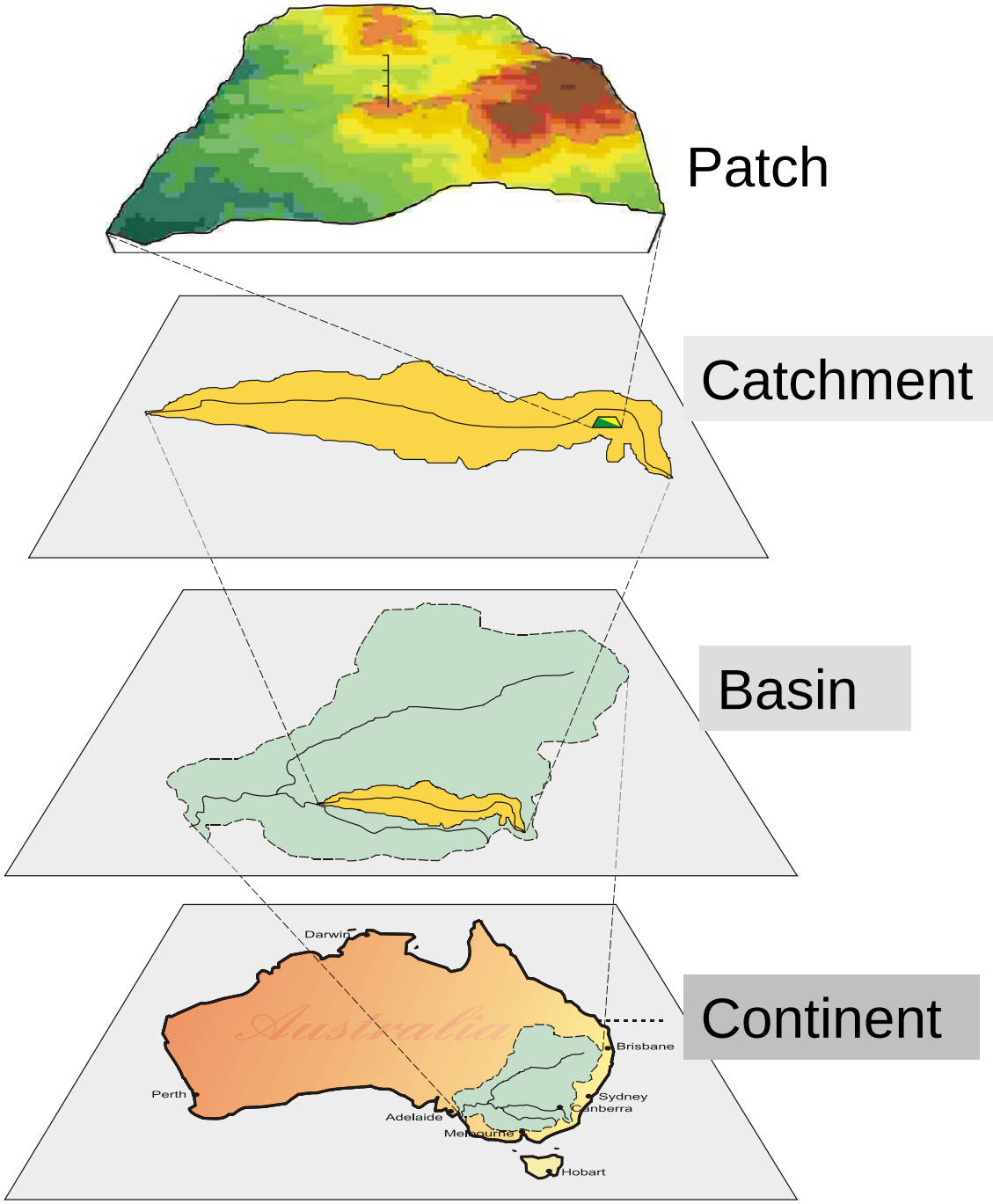


An earth systems science question

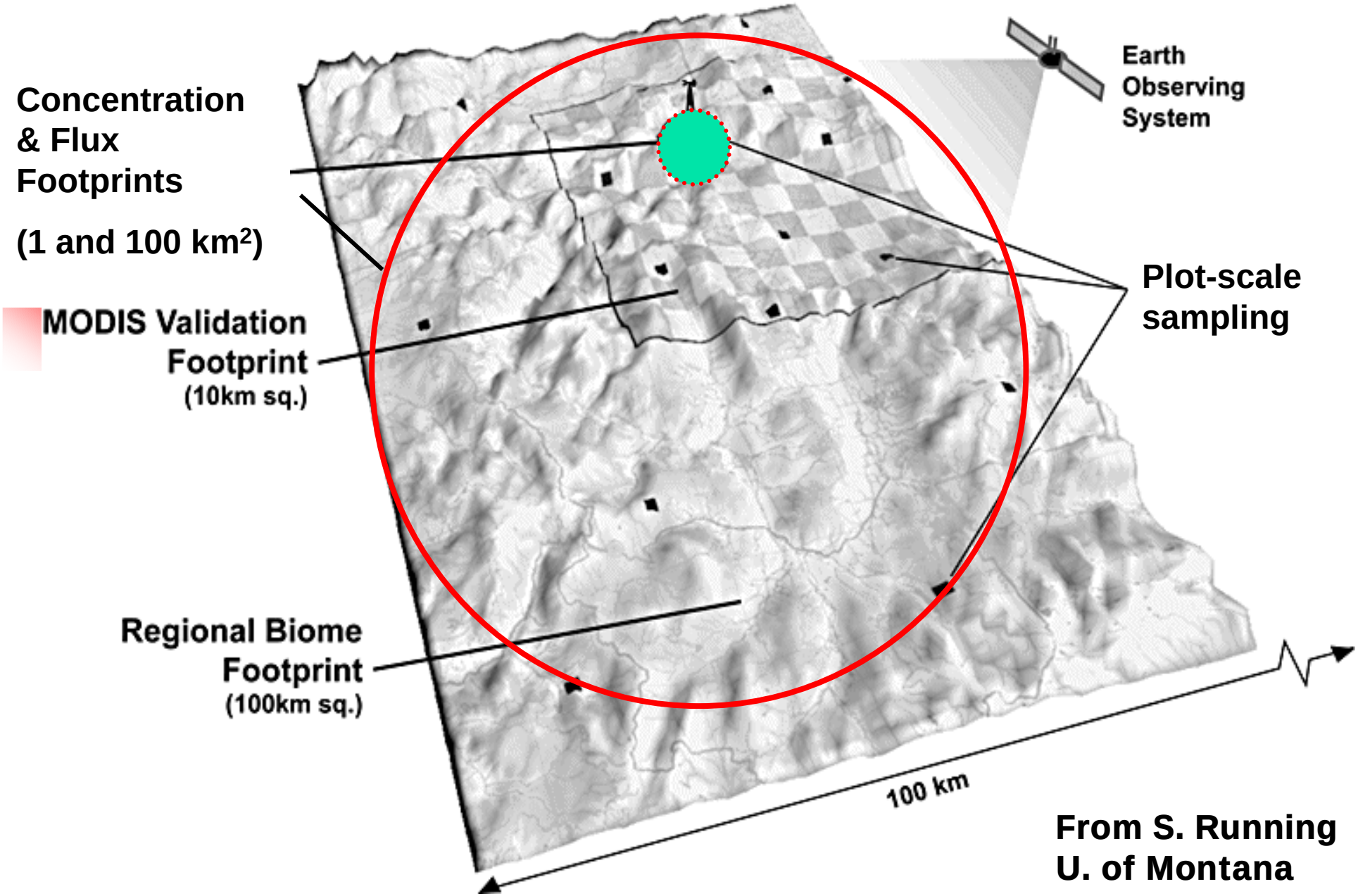
- “What controls the terrestrial CO_2 balance, and how does it influence climate trends?”

The challenge

Estimate energy, water & carbon fluxes at multiple, interlinked scales



Multi-scale Measurement Strategy



From S. Running
U. of Montana

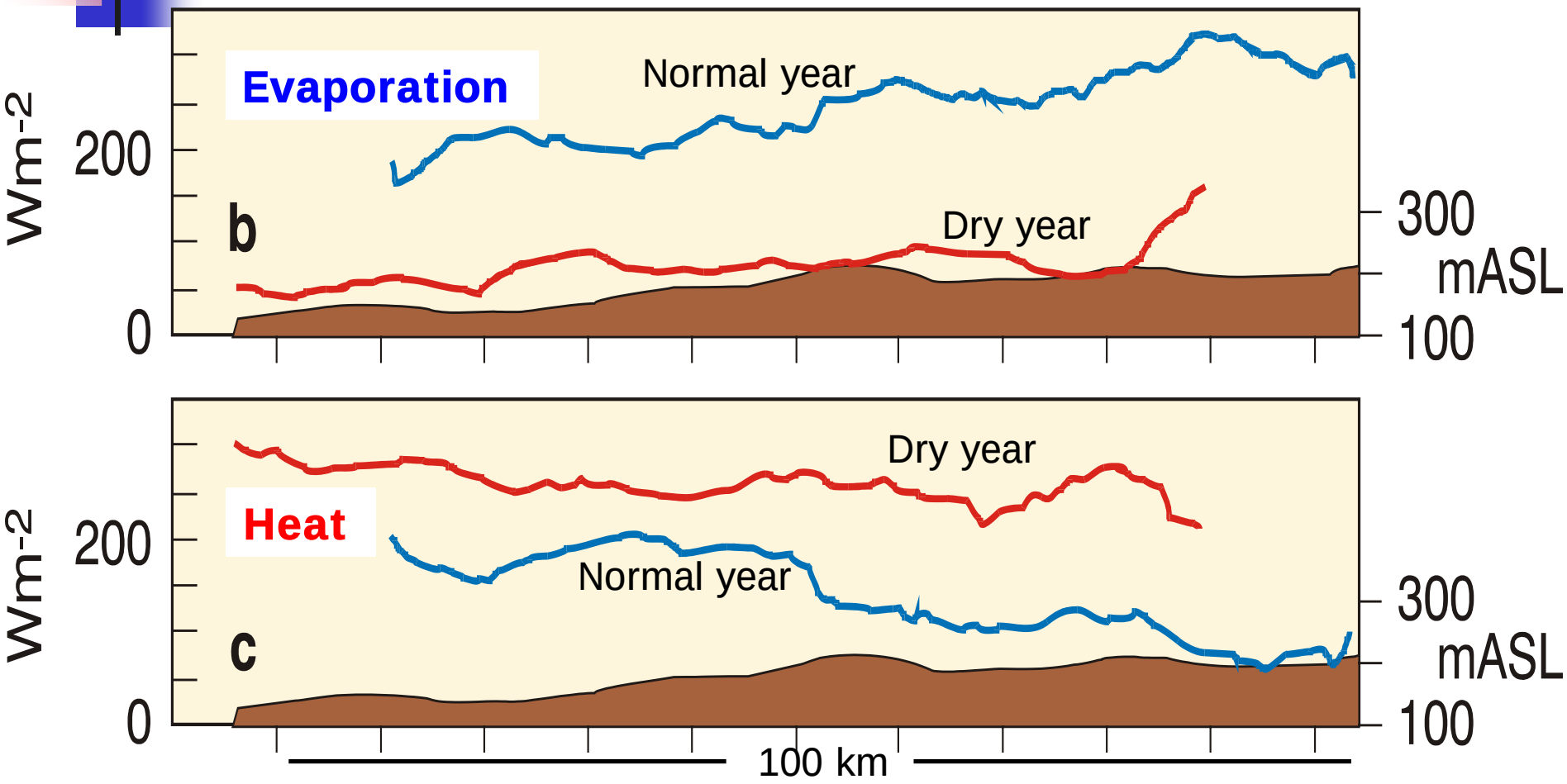
Some observations

Prof. HaPe Schmid, Indiana University

We can't cover everything all of the time …

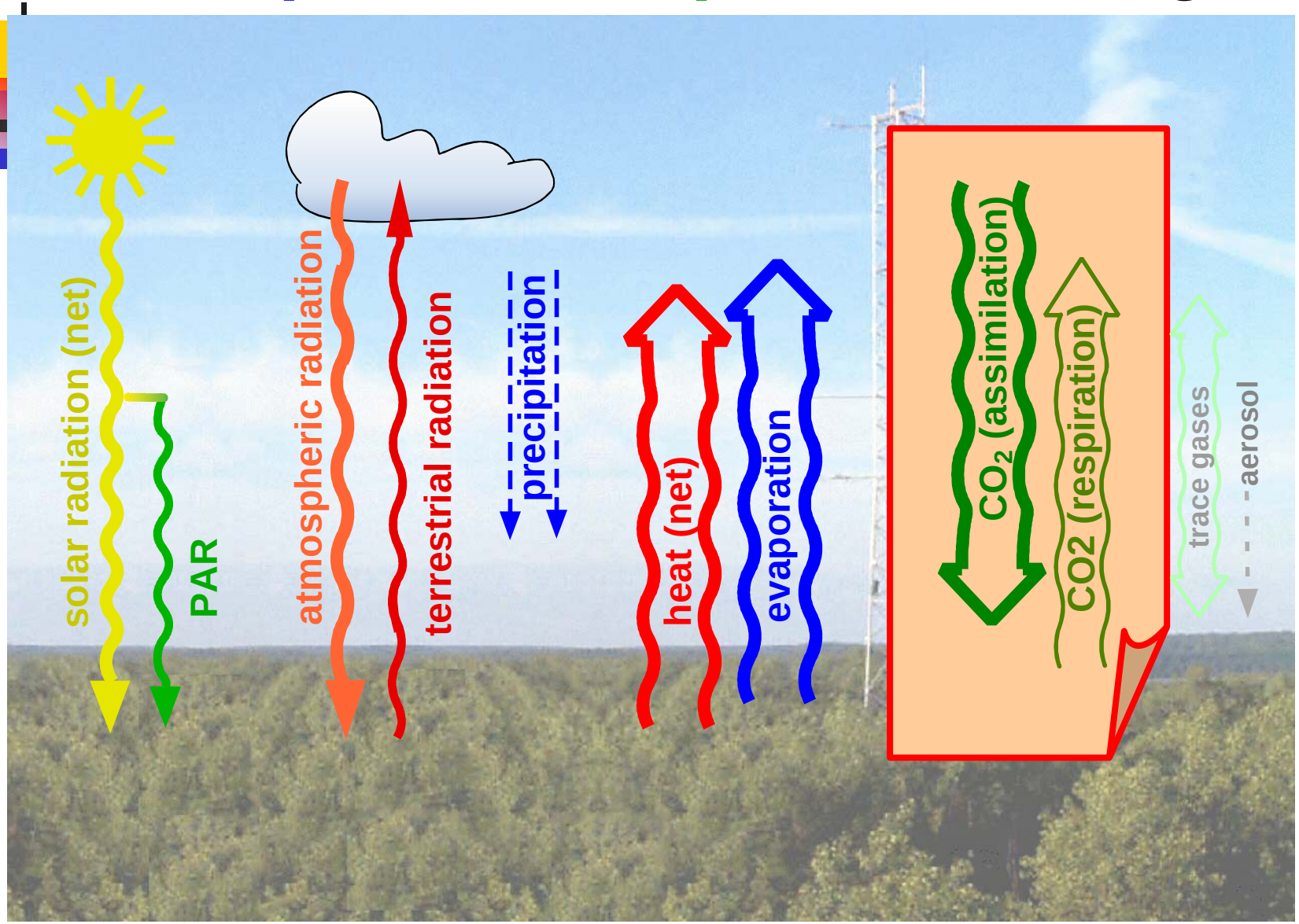
- **in-situ observations:** (chambers, flux towers)
  cover almost nothing but most of the time
- **aircraft observations:** (fluxes, concentrations)
  cover almost everything but hardly ever
- **modeling:** (leaf …. region)
  only pretend to **cover everything all of the time**

Aircraft flux measurements at 10 – 100 km scale at OASIS



From Leuning *et al* (2004). Boundary-Layer Met. **110**:3-38

Atmosphere - Biosphere Exchange



Use of flux stations (1)

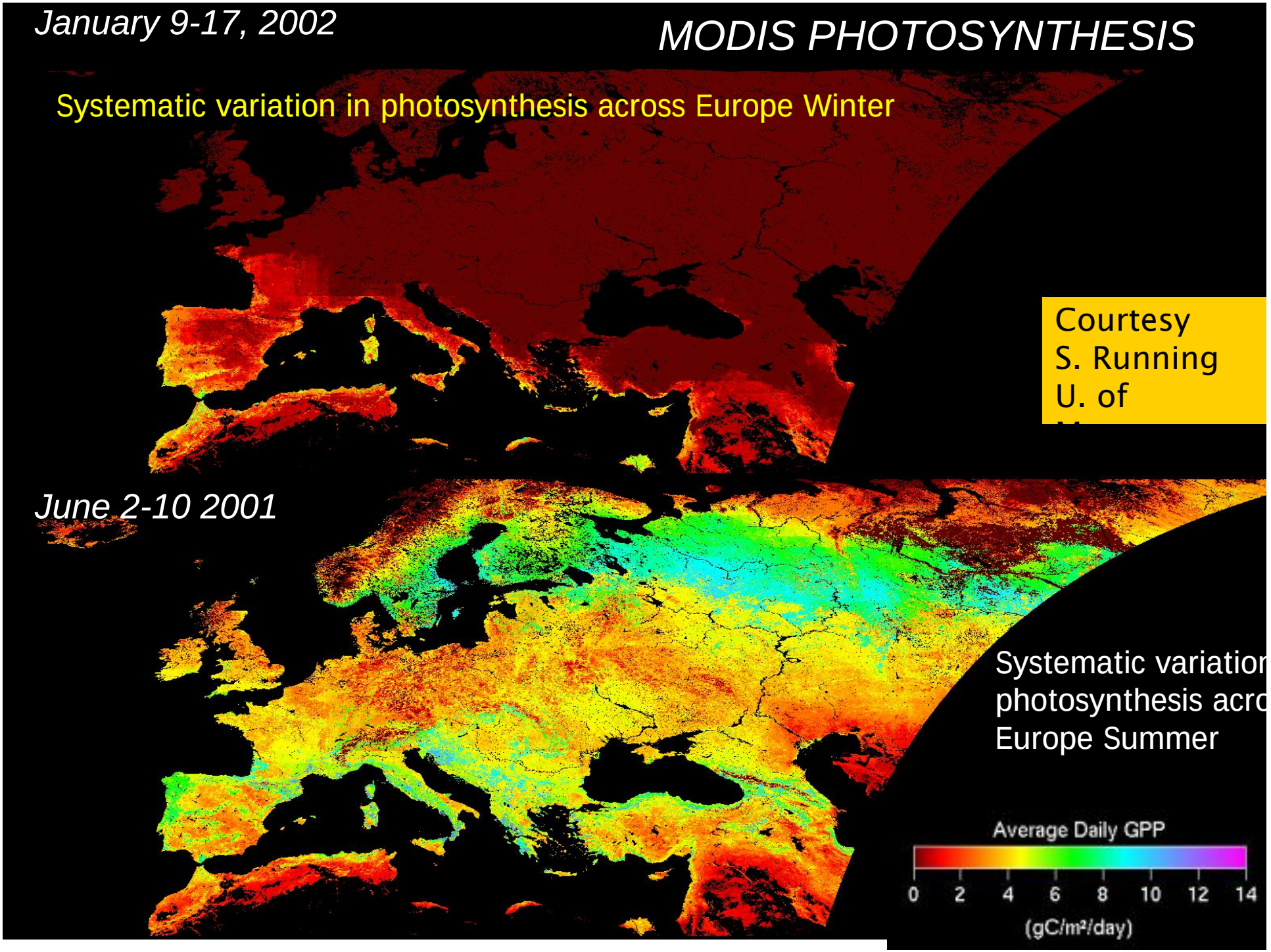
- For local flux station “footprint”
  - Directly **measure** mass & energy **budgets**
  - High temporal resolution → **new insights**
  - Data for land surface **model validation** & development
  - Data for **model parameters** for many land surface types (Fluxnet, ChinaFlux, OzFlux ….)

Use of flux stations (2)

- Improve micrometeorology
  - Air flow in canopies on hills
  - Stable stratification
    - Nocturnal drainage flows and measurement of respiration
  - Flux-gradient relationships
    - Virtual tall tower
    - Better coupling with mesoscale models

Use of flux stations (3)

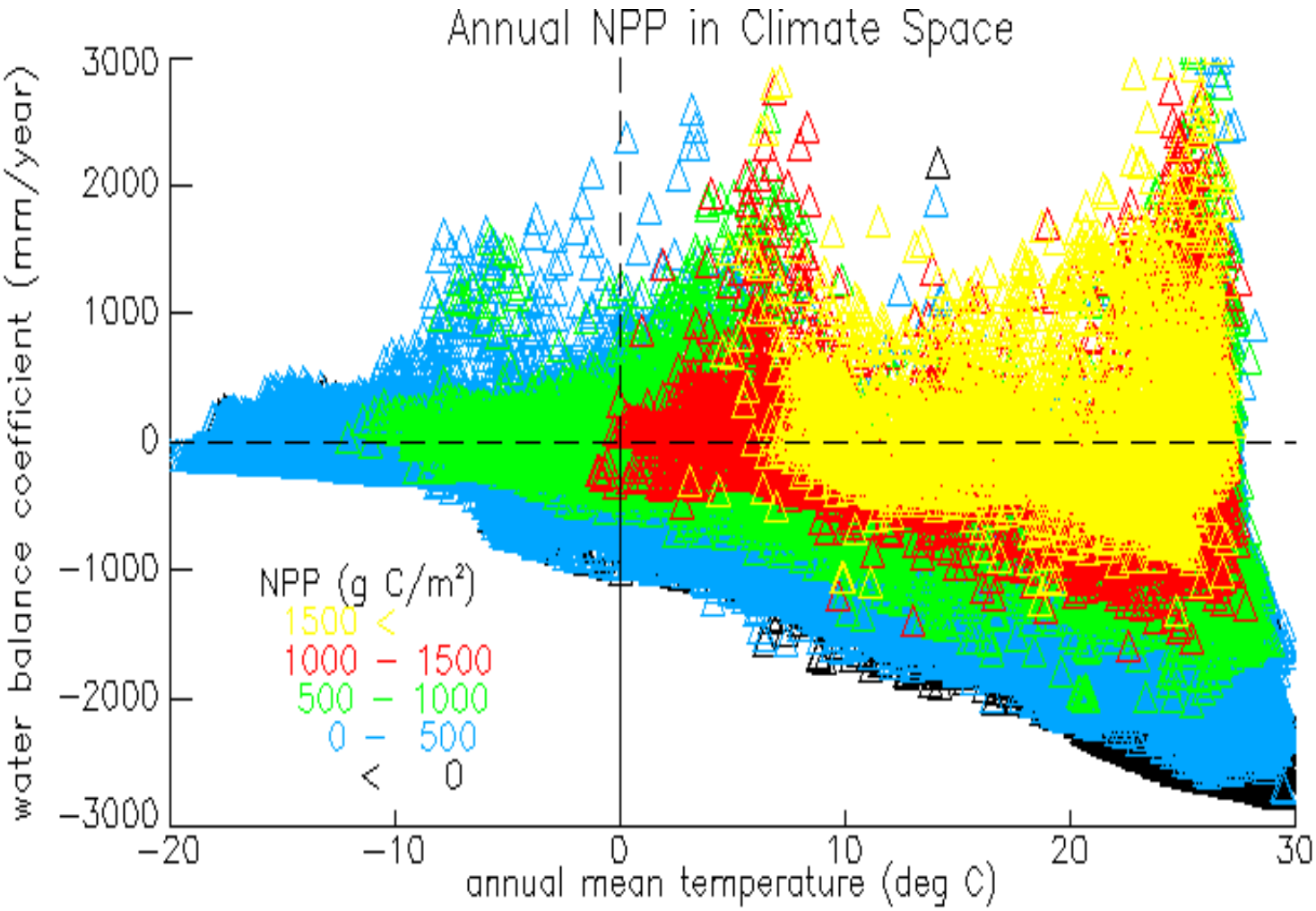
- Validation of remote sensing products
  - LAI
  - GPP
  - Parameter estimation
  - Evaporation


January 9-17, 2002
MODIS PHOTOSYNTHESIS
Systematic variation in photosynthesis across Europe Winter
Courtesy
S. Running
U. of
June 2-10 2001
Systematic variation
photosynthesis acro
Europe Summer
Average Daily GPP
0 2 4 6 8 10 12 14
(gC/m²/day)

Use of flux stations (4)

- Test and improve land surface models
  - Carbon cycling
  - Hydrology
  - Model parameter estimation
  - Model validation

Sampling in climate space



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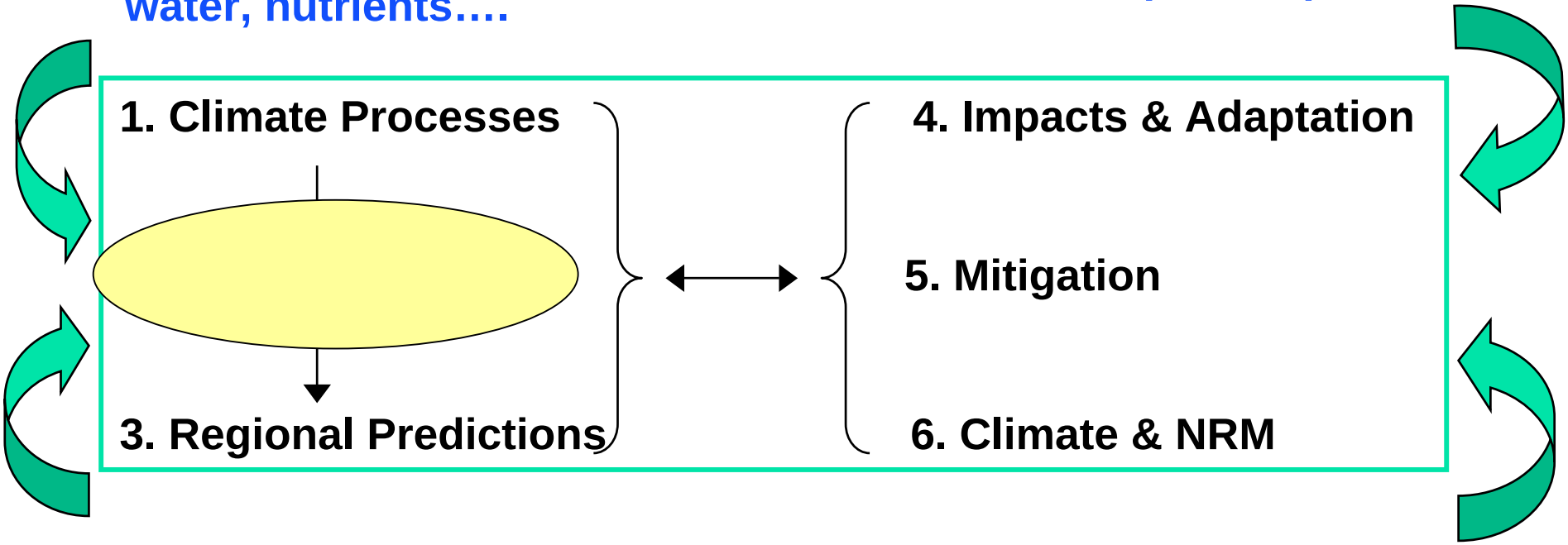
An Integrated Earth Observing System

- remote sensing
- fluxes and atmospheric concentrations
- biosphere-climate model

Near real-time budgets of carbon, water, nutrients….

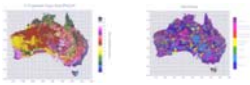
Improved predictions



Improved land surface and climate models

Monitoring and evaluation

An integrated modelling approach



Our knowledge

parameters (initial)

vegetation types

soil types, depth

LAI

Boundary conditions

Land surface model

Atmospheric transport model

Model output

Fluxes

Concentrations

Radiances ….

Observations

Fluxes

Concentrations

Radiances….

Inverse analysis

Parameters (revised)

Formalism applicable at all interlinking scales

CSIRO