

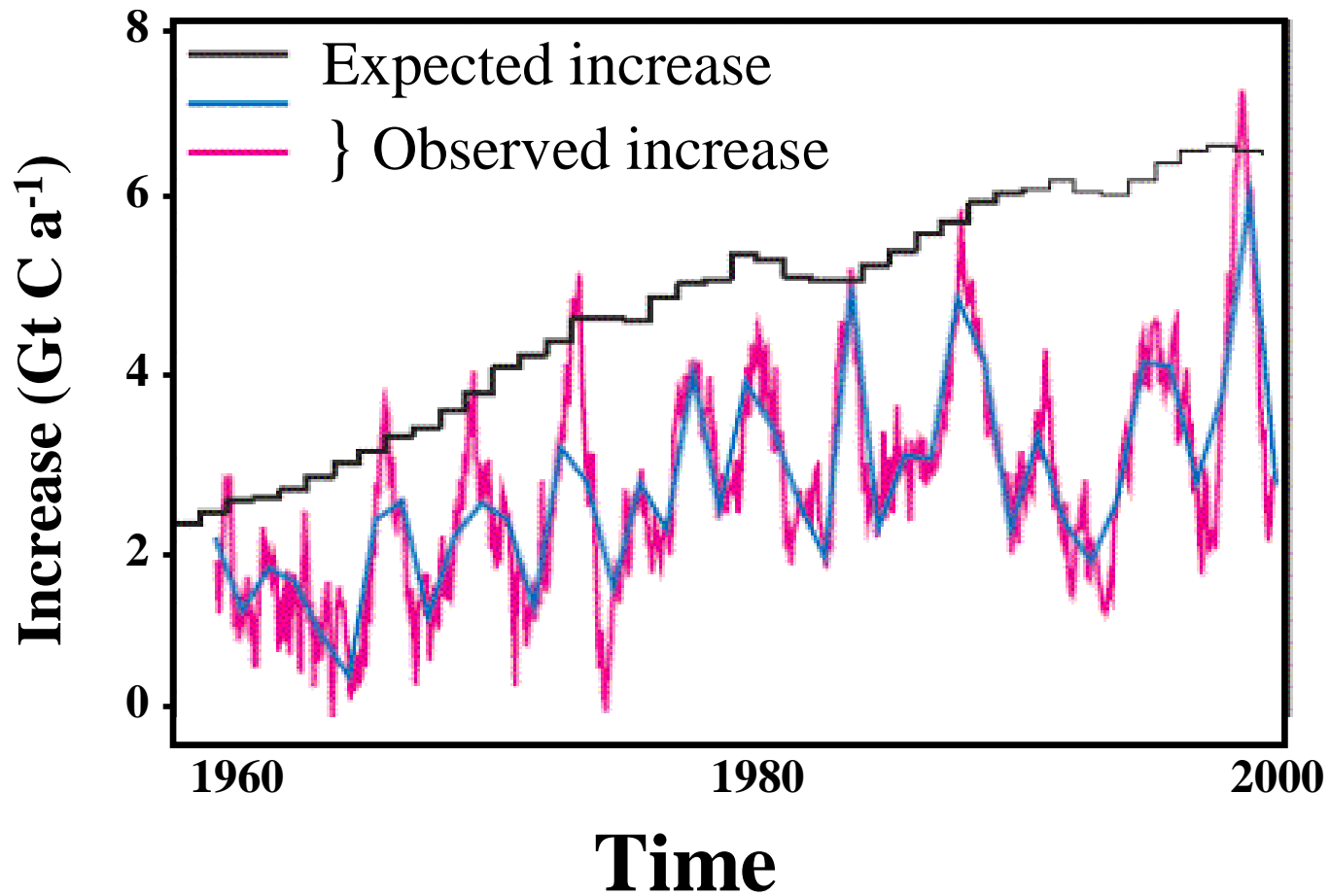
*Bottom-up and top-down
quantitative assessment of the role
of forests, cropland, grazing lands
etc.*

Ivan Janssens

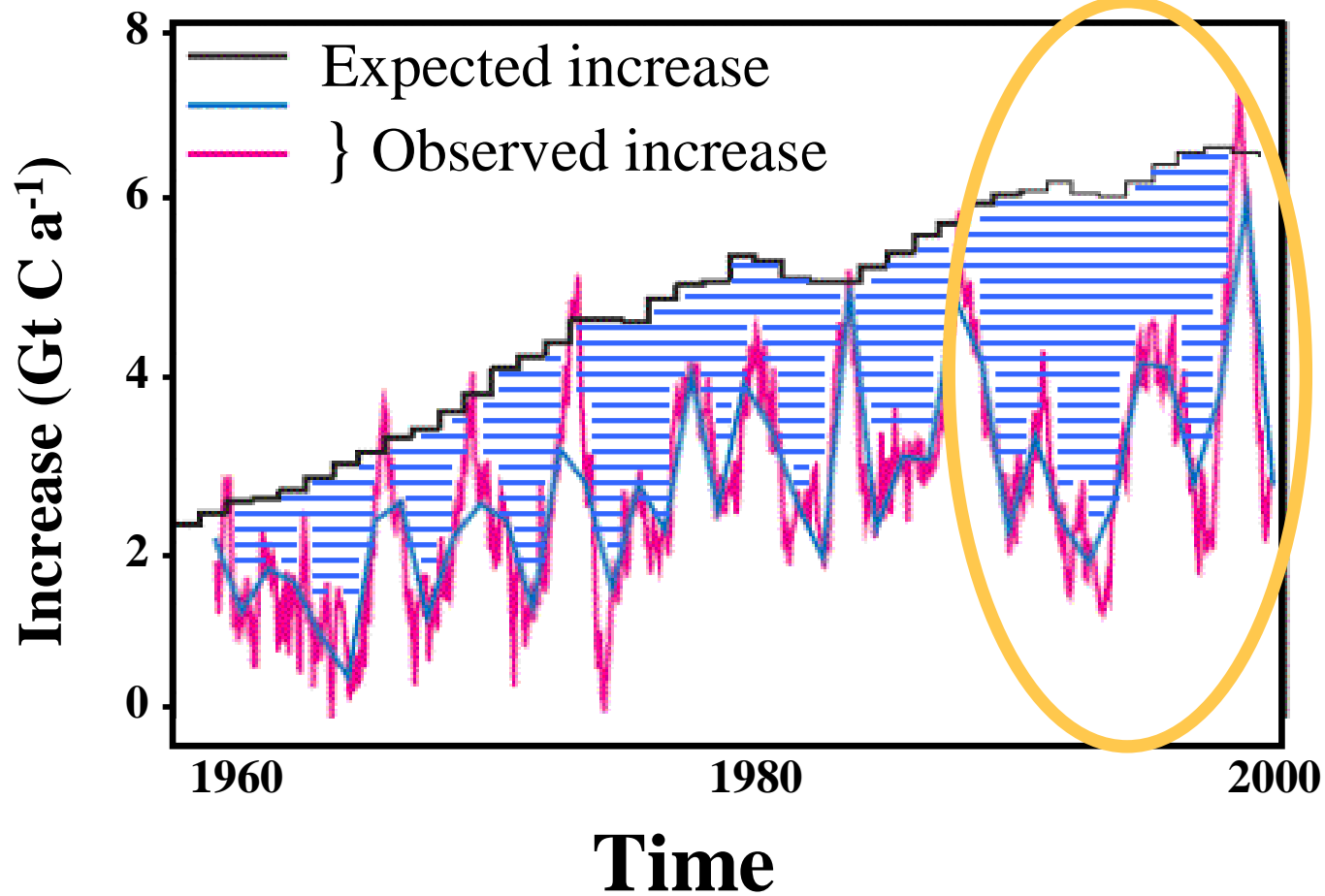
Outline:

1. Top down versus bottom up
2. Some results from bottom-up
3. Dual constraint: independent verification of bottom-up approach

But first, a little intro ...



>30% of emitted CO₂ is taken up

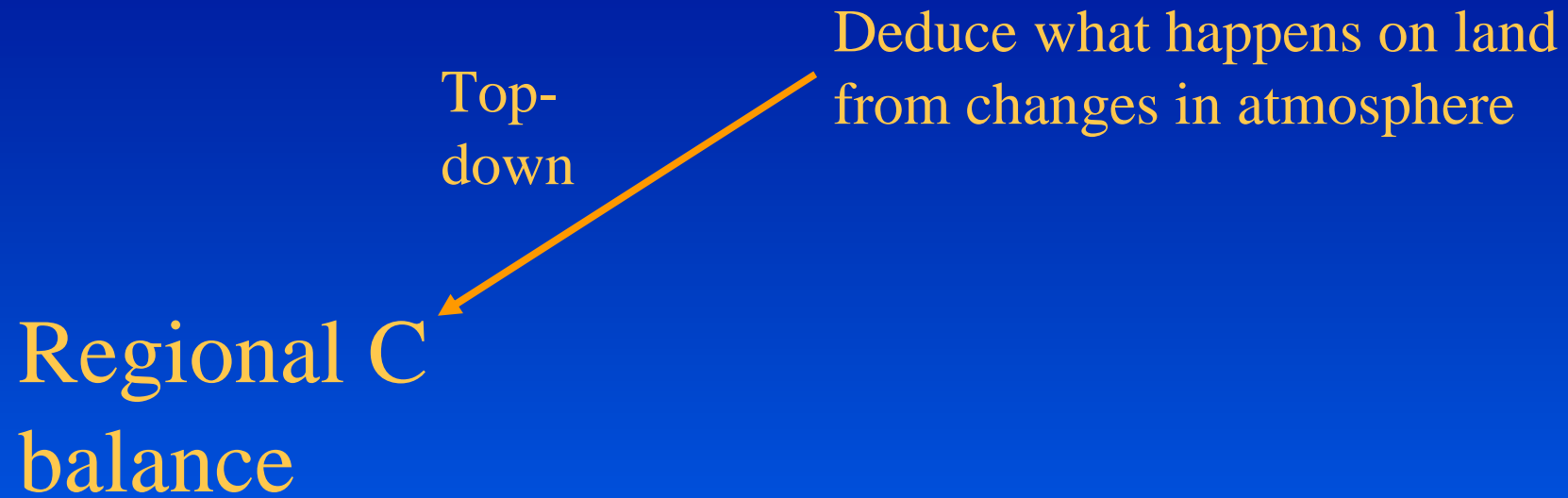


**Terrestrial ecosystems absorb
2 billion ton C more than they
release**

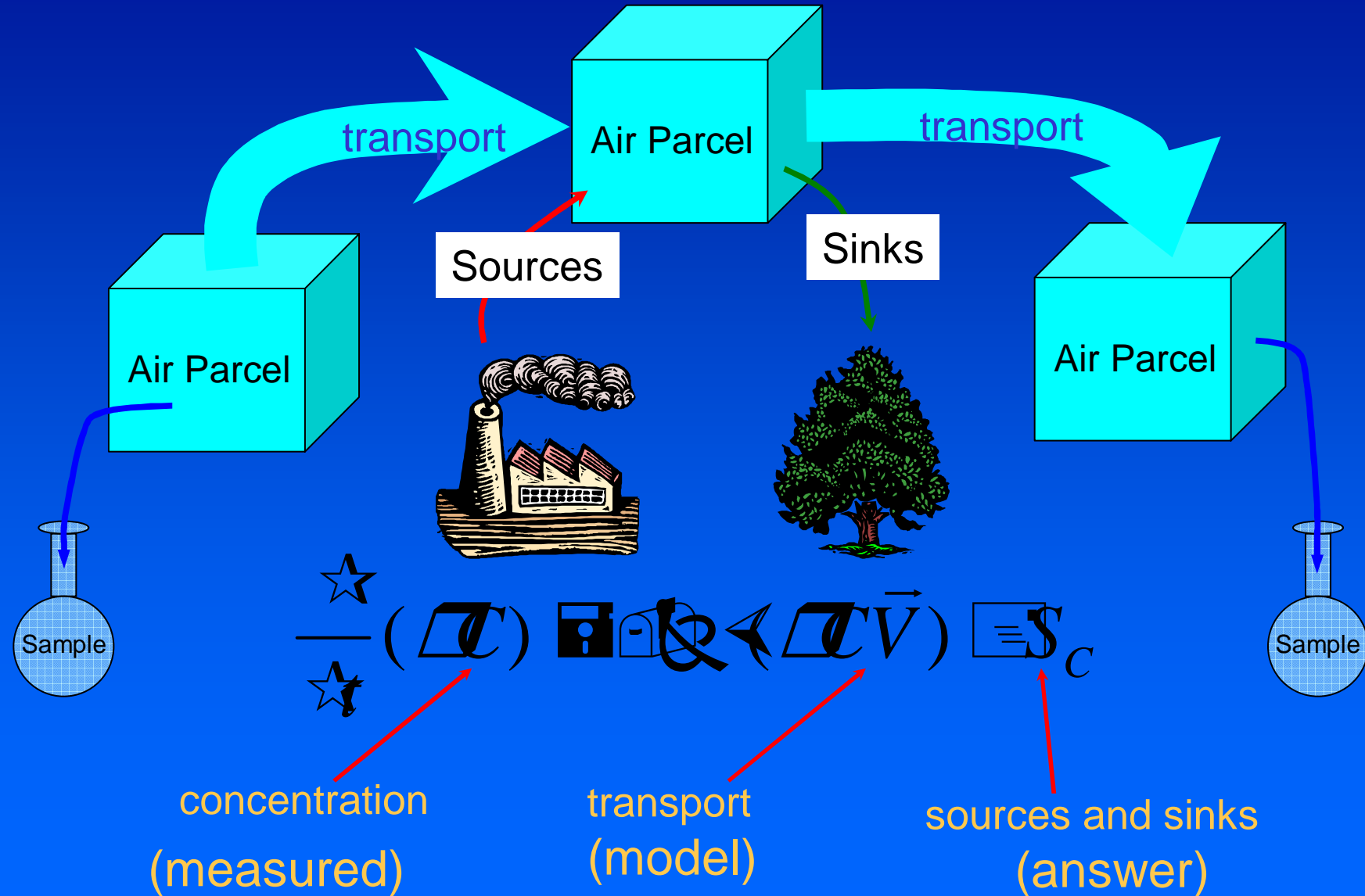
2 billion ton C =

400 000 football fields 1 m under water !

TOP-DOWN APPROACH



Inverse Modelling



TOP-DOWN APPROACH

Measured CO₂ concentrations + global transport model (wind speed and direction)

↓ Inverse model

Regional-scale CO₂ sources and sinks

↓ - fossil emissions

Regional-scale biotic CO₂ sources and sinks

TOP-DOWN APPROACH

Advantage : no spatial upscaling necessary

Disadvantages :

- Small signal relative to fossil emissions
- Impossible to follow national boundaries
- Impossible to distinguish different sectors

Regional C balance

Top-
down



Bottom-
up



Upscale field measurements to
total land area

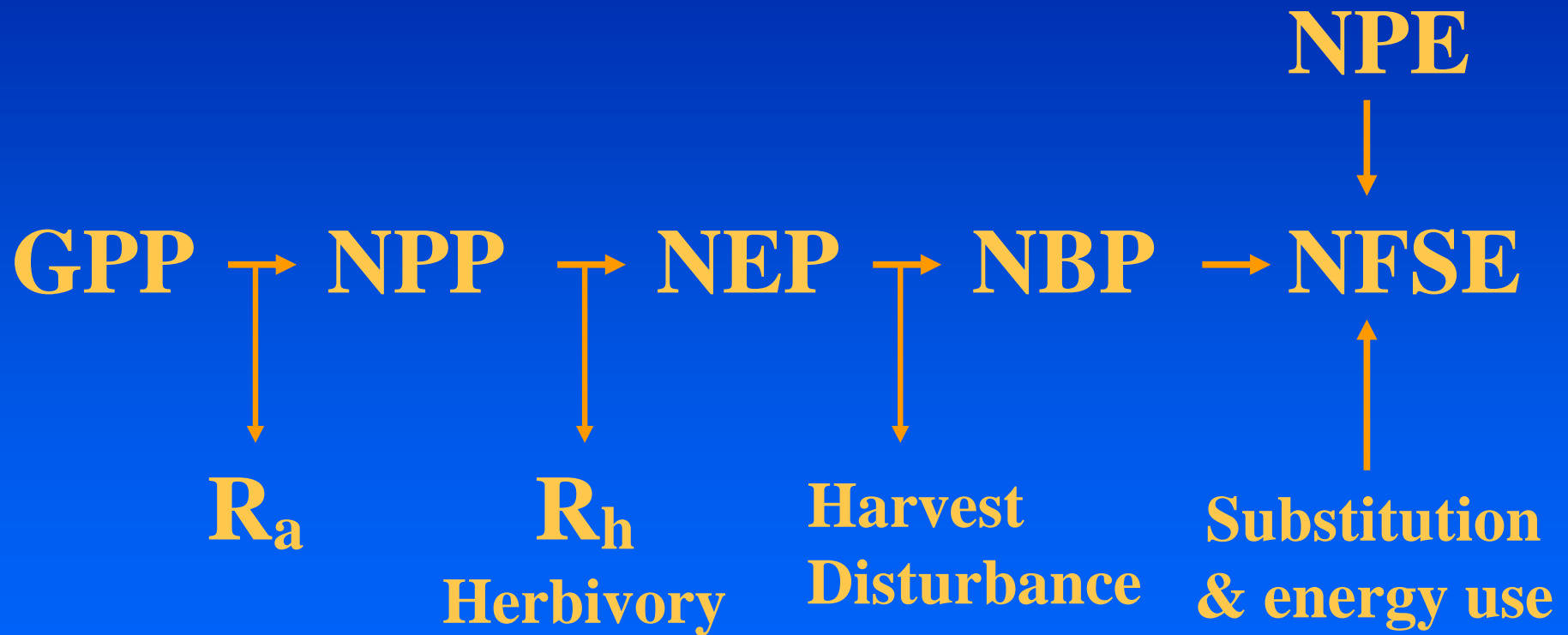
BOTTOM-UP APPROACH

Forest Sector C Budget

Studies are not always directly comparable:

- Studies differ in forest area
 - Different source of area estimates
 - Different definition for forest
- Studies may report different fluxes

Forest Sector C Budget

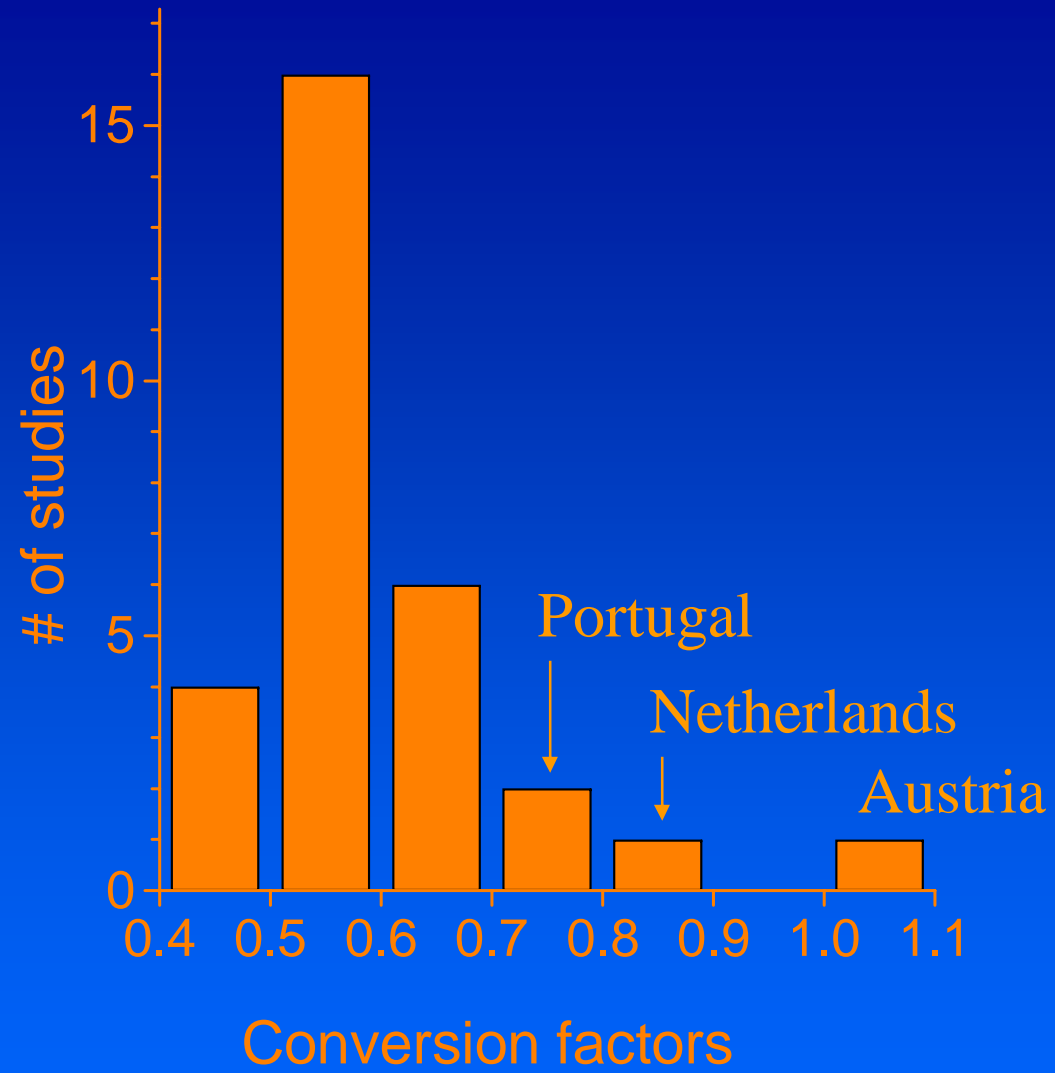


Forest Sector C Budget

1) Methods based on National Inventories:

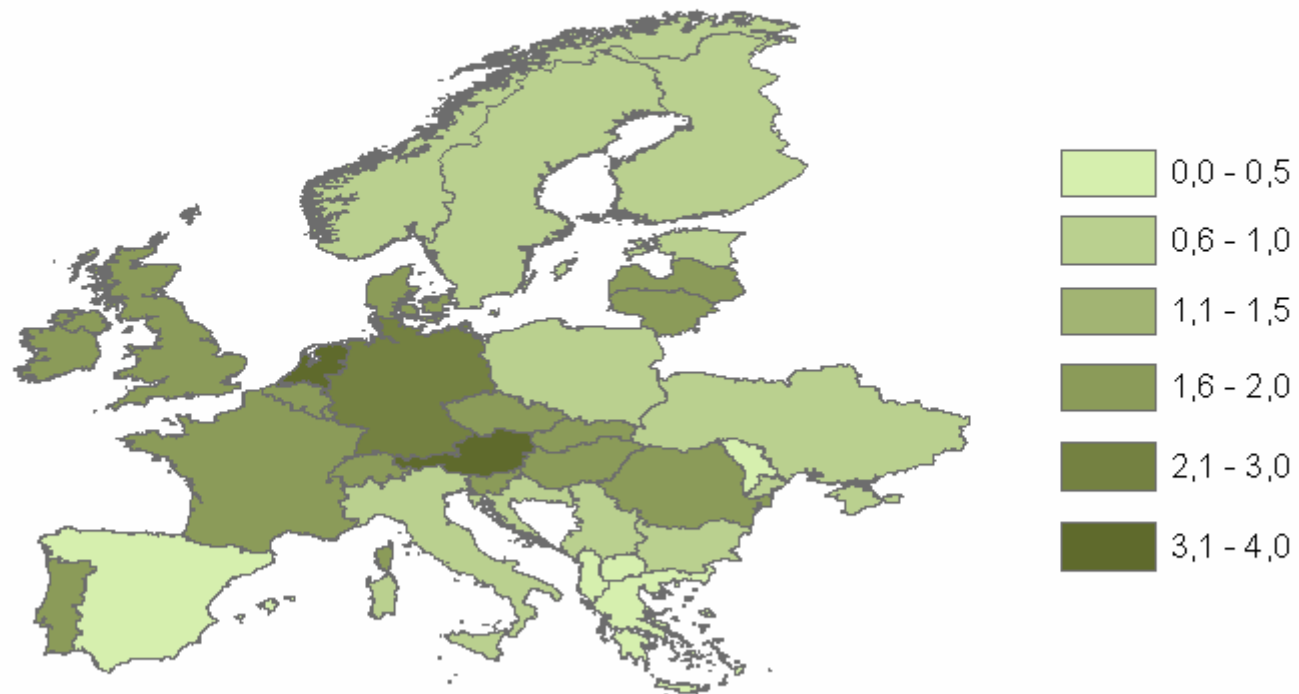
Stem Volume Increment

Add **Harvests** and Model Change in Biomass = **NBP**_{trees}



Stem volume to total tree dry mass (conifers)

Forest productivity (t C ha⁻¹ a⁻¹)



Forest Sector C Budget

1) Methods based on National Inventories:

Stem Volume Increment

Add **Harvests** and Model Change in Biomass = **NBP_{trees}**



Model total C Inputs to Soil

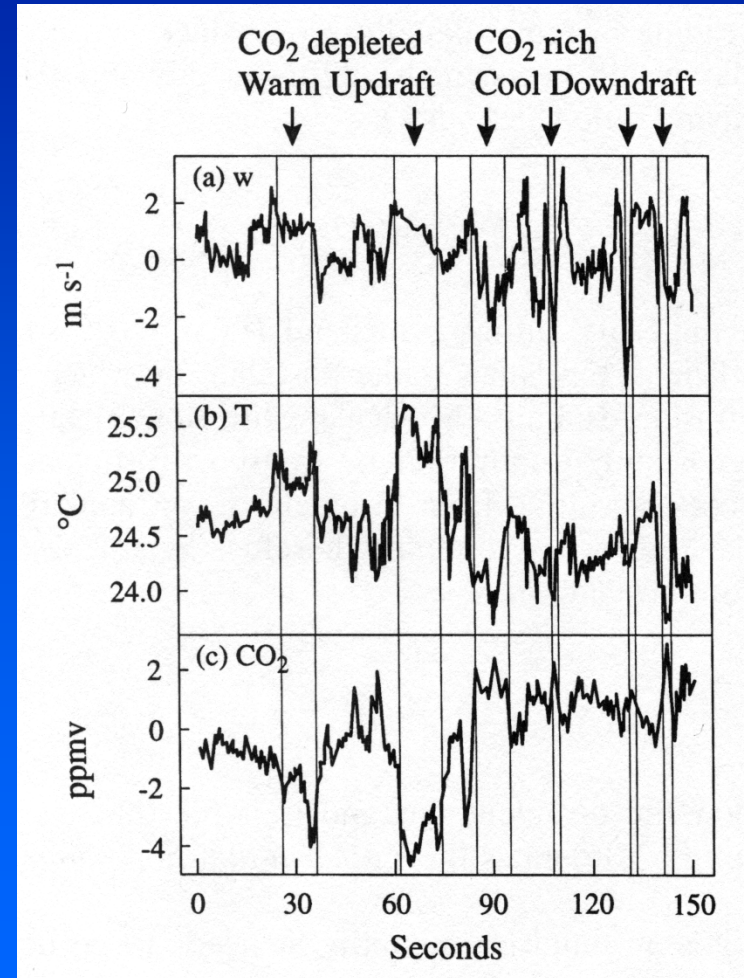
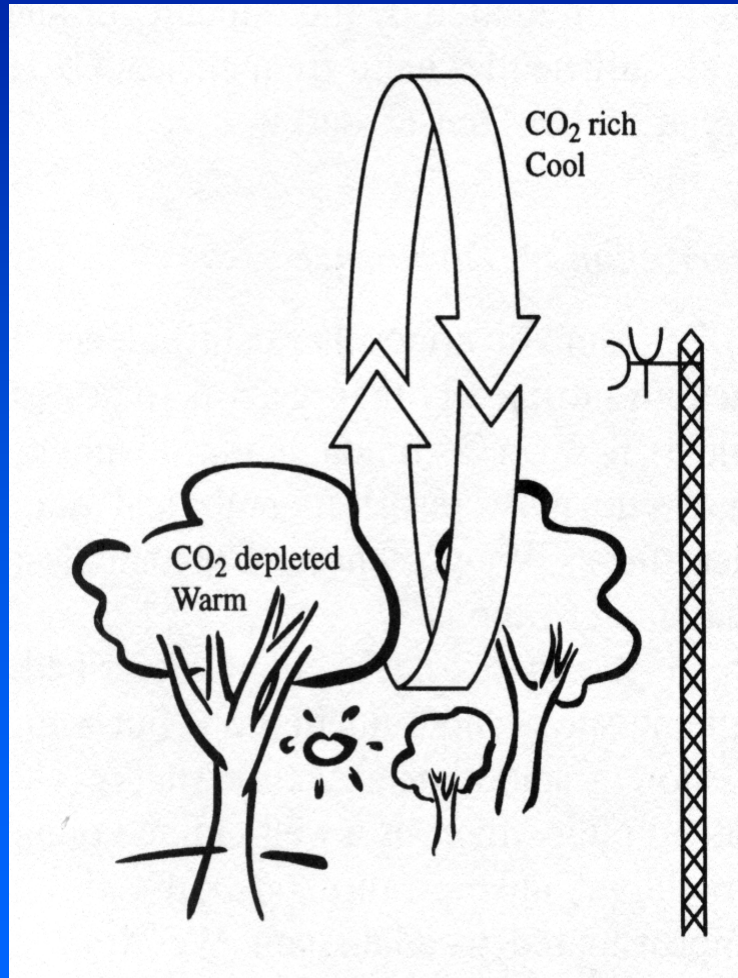
Model Decomposition of Litter and SOM = **NBP_{soil}**

Unvalidated soil models → large uncertainties

Forest Sector C Budget

2) Methods based on Measured NEP:

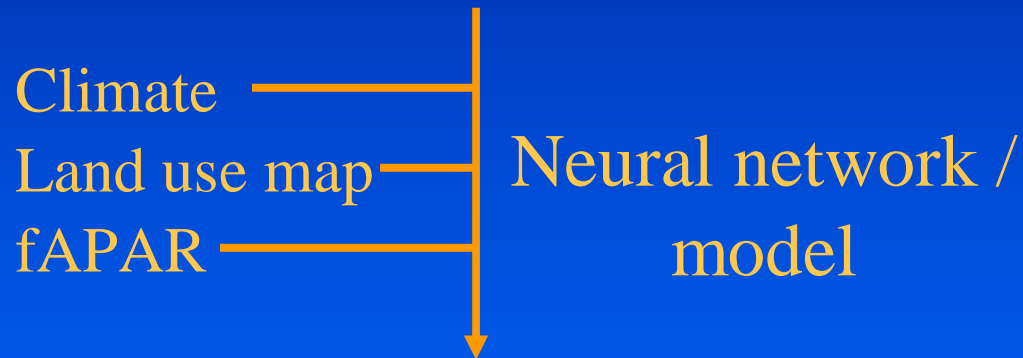
the eddy covariance method



Forest Sector C Budget

2) Methods based on Measured NEP:

Eddy Covariance measurements of NEP (few forests)



Region-wide **NEP** estimate

Multiply with assumed or known **NBP/NEP ratio**

Natural reasons for the current sink in forests

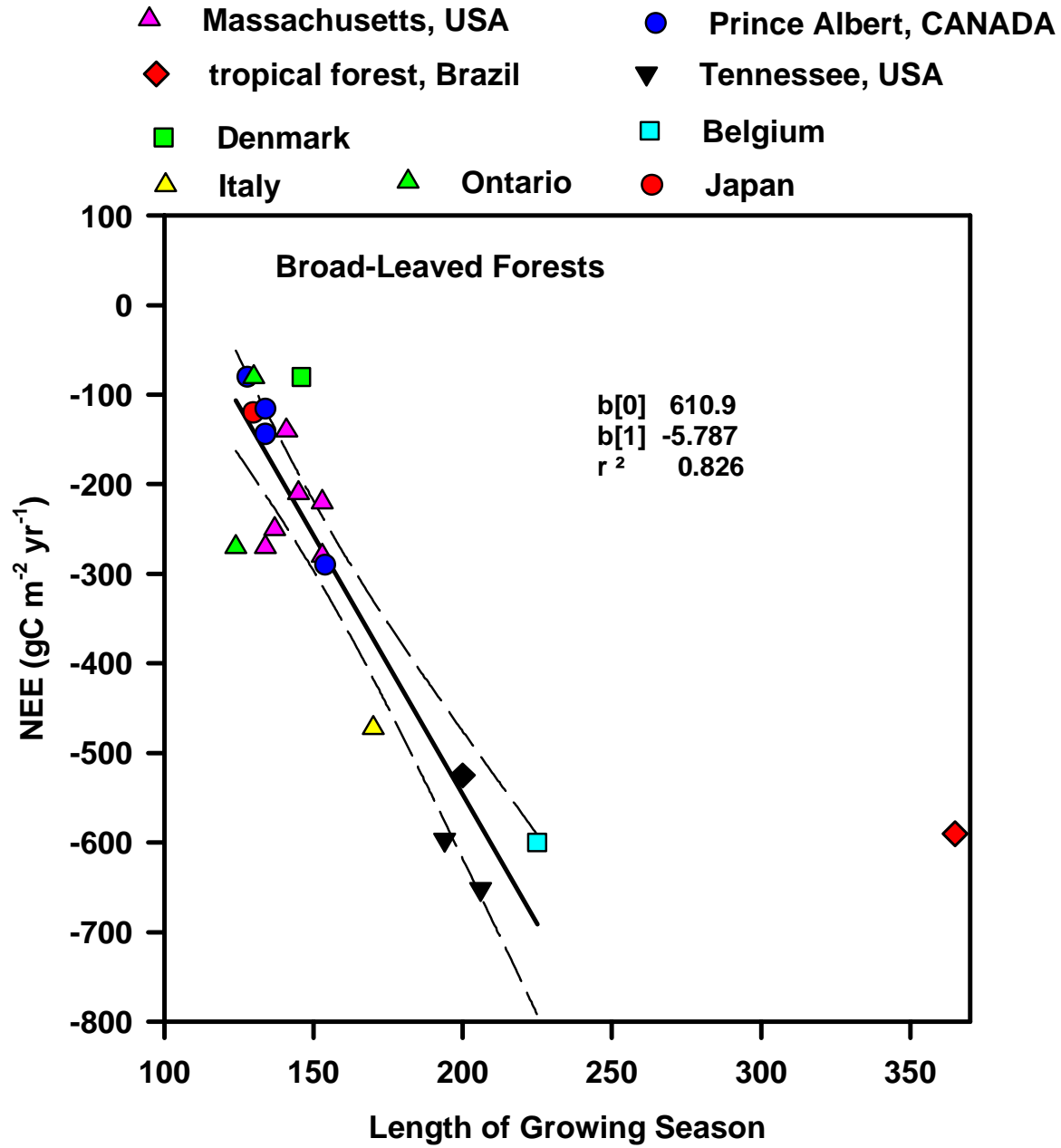
- CO₂ concentrations increase

plants “eat” CO₂

- N deposition

- Temperatures go up

longer growing season



Human-induced reasons for the current sink

- European forests are relatively young

Exponential growth phase

- Annual wood harvest $<$ annual wood increment
- Afforestation on C-poorer soils
- Ecosystem sink will saturate !!
Substitution effects will not

Arable soils : Bottom-up

1. Huge numbers of repeated SOC measurements
2. Country-specific model

Disturbed ecosystems (arable lands)

are not sequestering C

But losing it !

Why ?

Ploughing accelerates decomposition of humus



**Arable soils are typically poor in C and
contain no biomass !**



**Arable soils contain less C than other
ecosystems**

Land use change (rotation with grassland or deforestation)



start with high C-content, end with low C



Net loss of C to the atmosphere

In other countries no land use change and still
large C losses from cropland soils !!

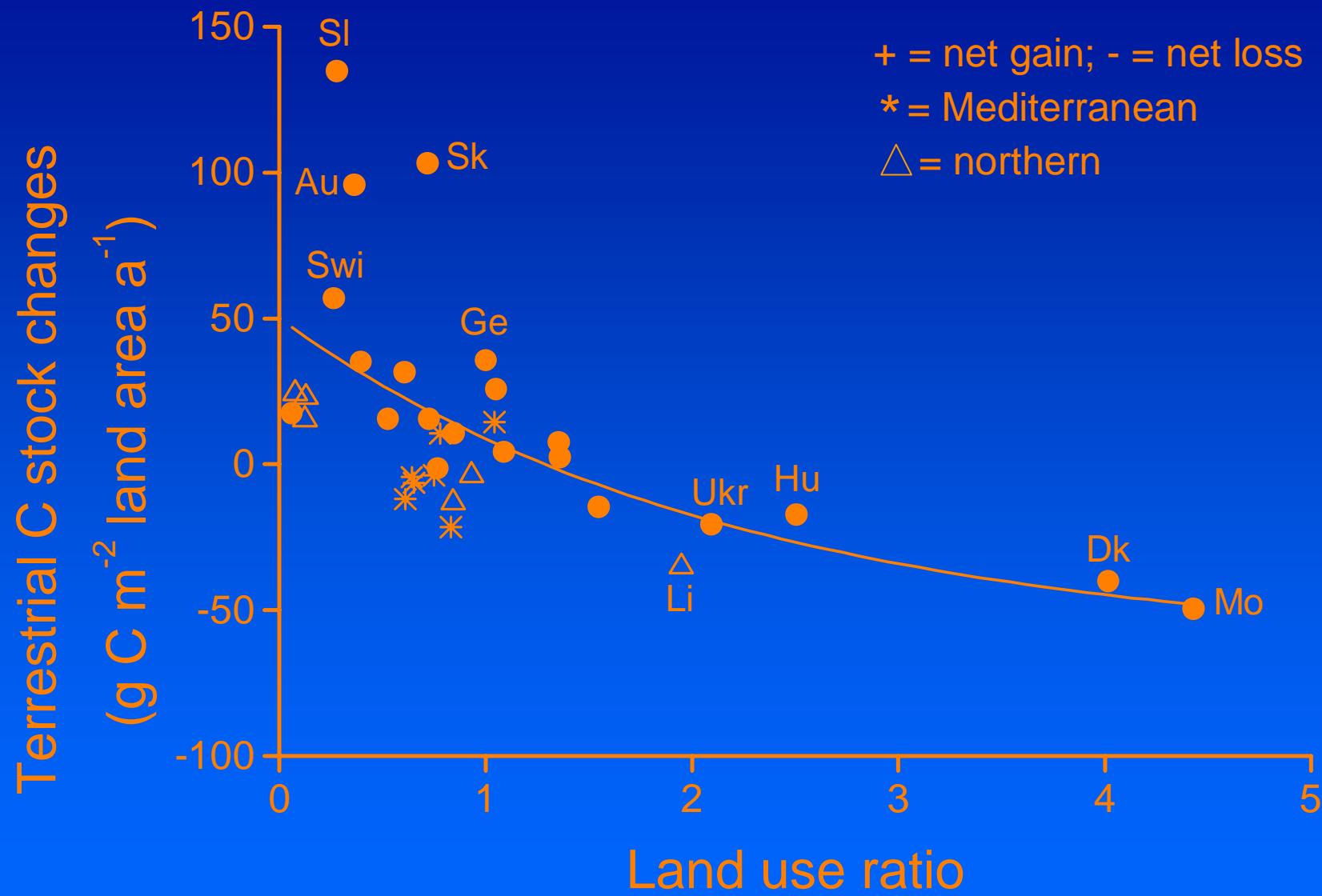
**Replacement of organic manure by artificial
fertilizers (= reduced C inputs)**

Forests and grasslands are C sinks

Arable soils are C sources



Terrestrial C stock changes should
depend on past and current land use



Arable/(forest+grassland)

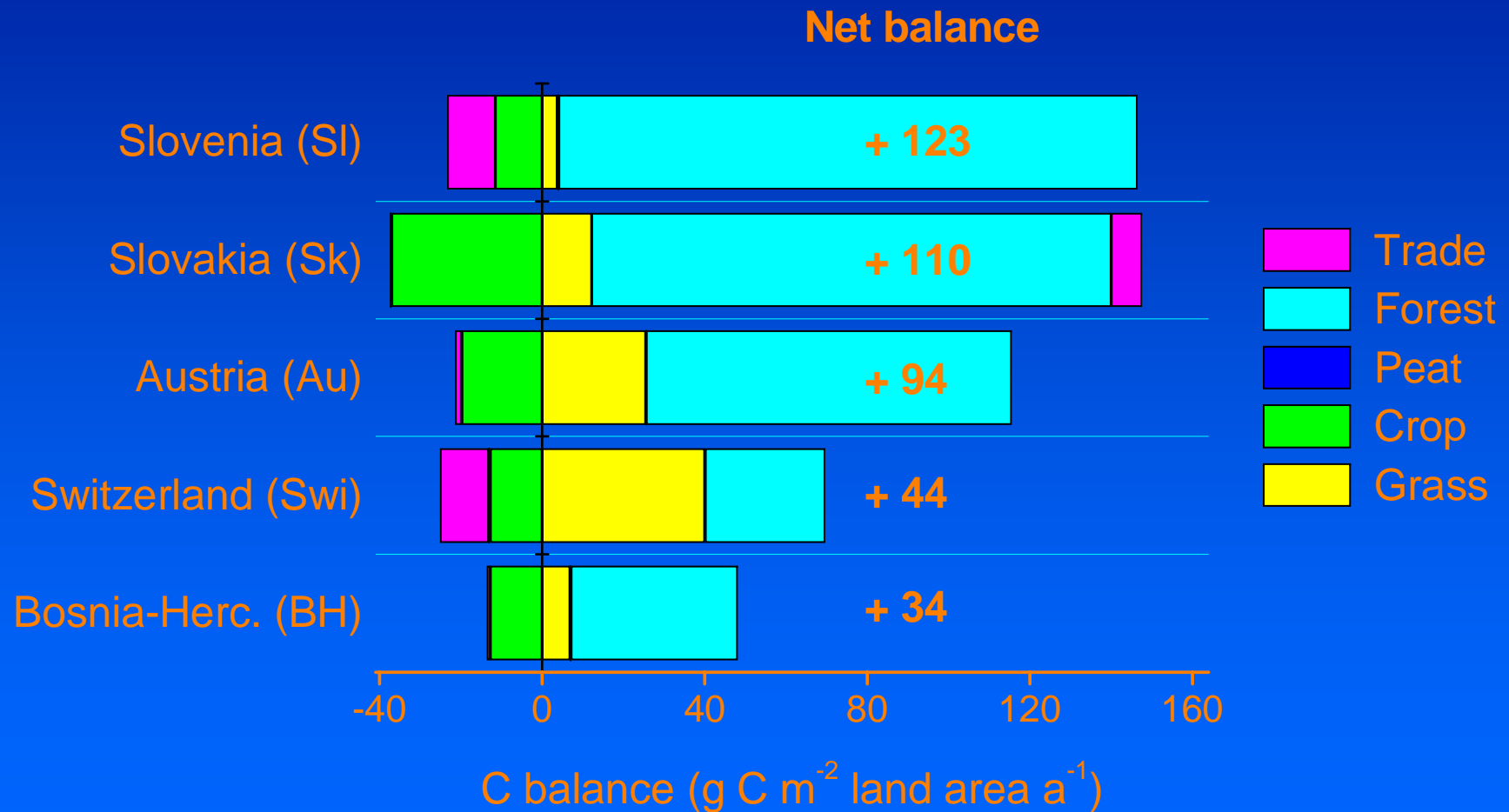


Terrestrial carbon stock changes depend on ...

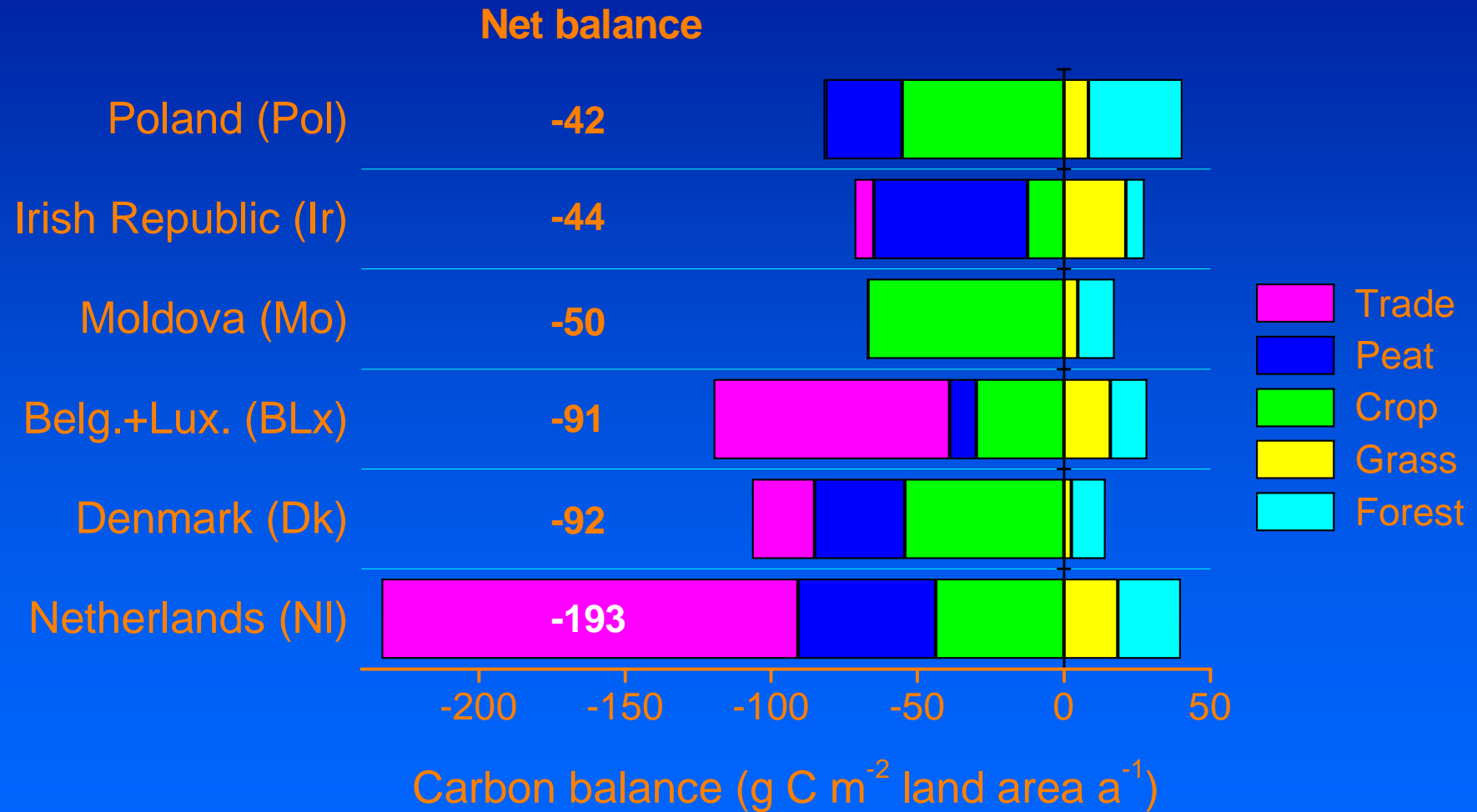
1. Land use
2. Geography (climate, nutrients, management ...)
3. Peat disturbance

... but are very uncertain ...

Strongest absorbers

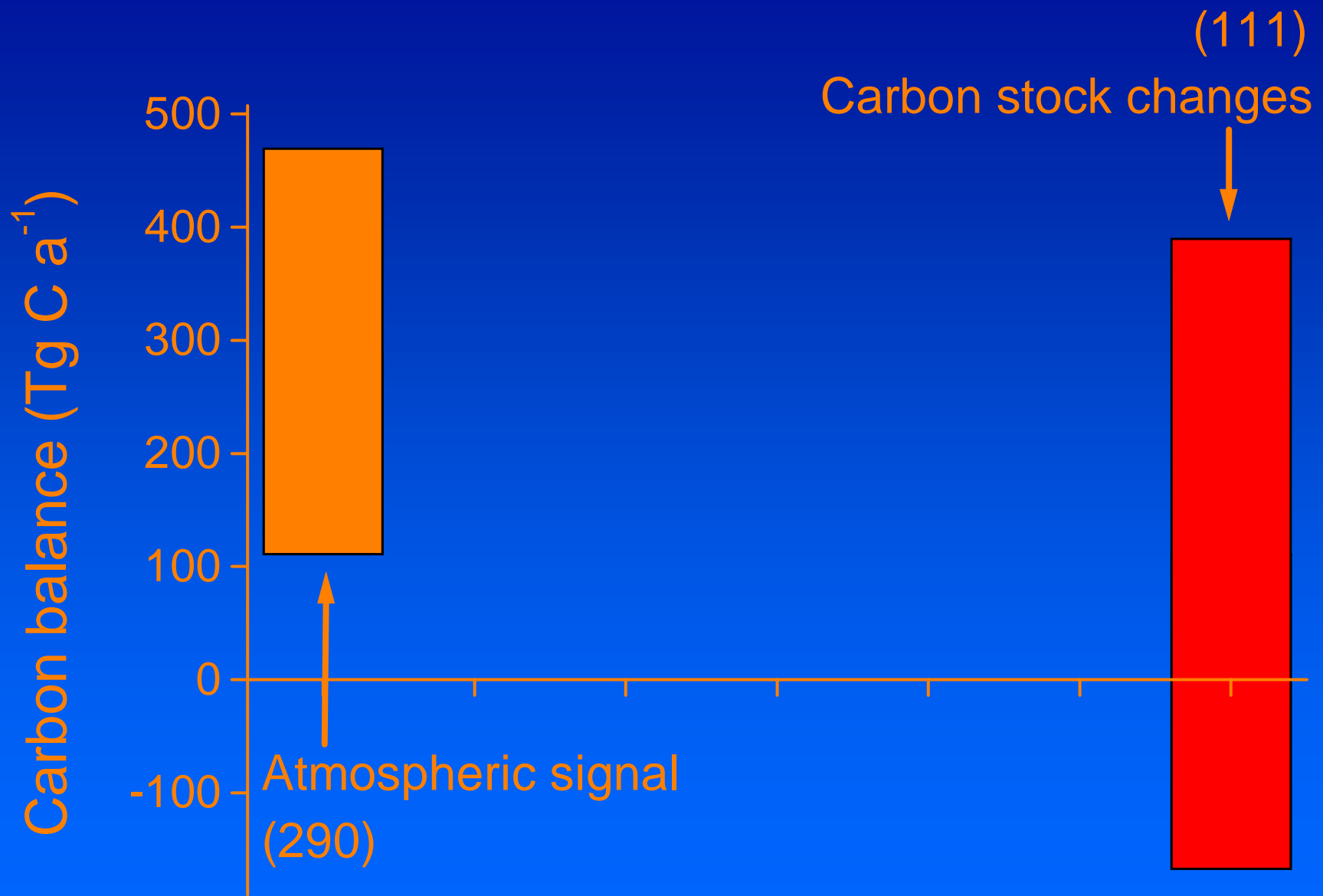


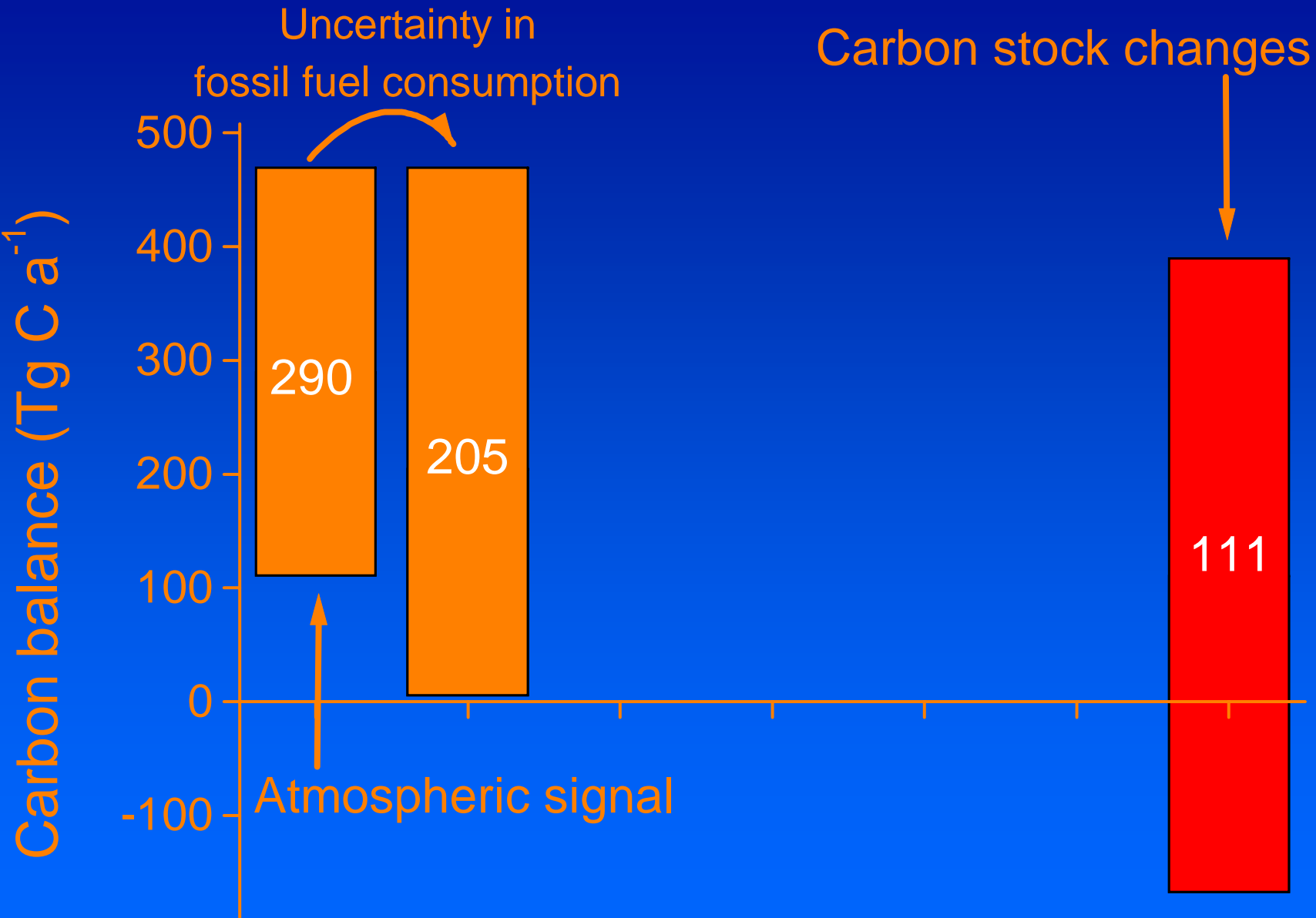
Strongest emitters

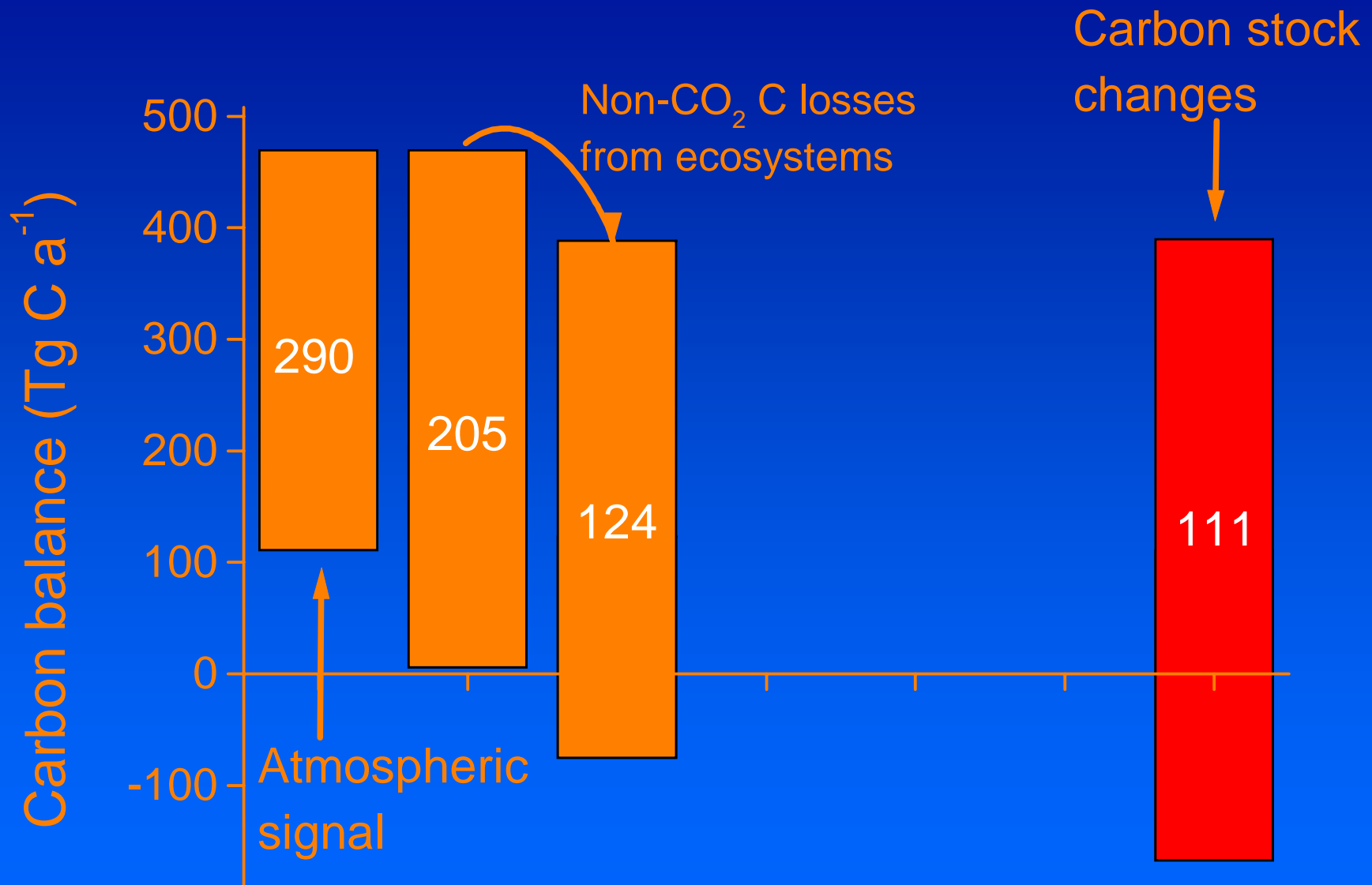


Dual constraint approach

Combine top-down with bottom-up approach
to reduce uncertainties







Horizontal displacement of carbon

Uptake from atmosphere



Continent

A

Trade



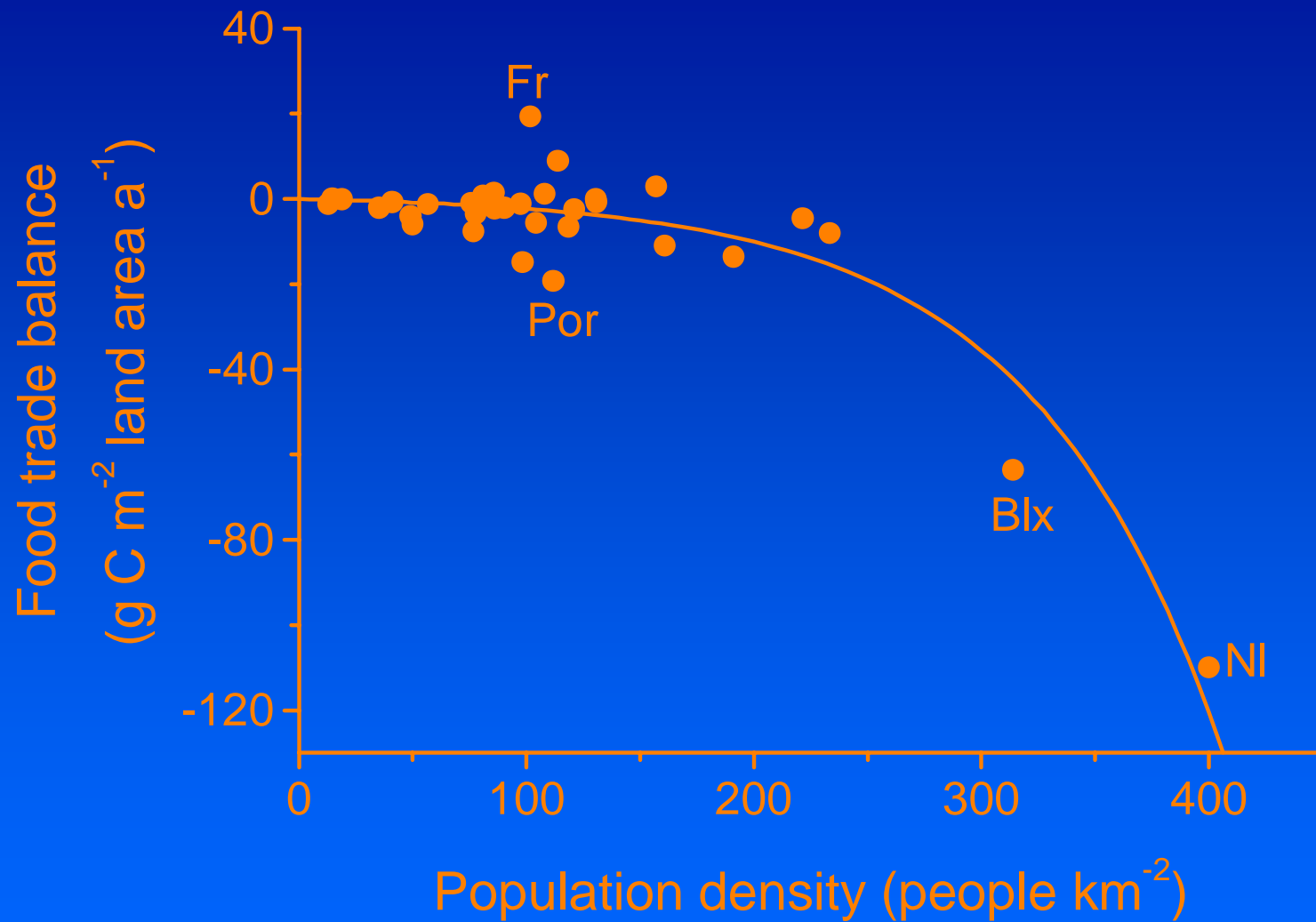
Continent

B

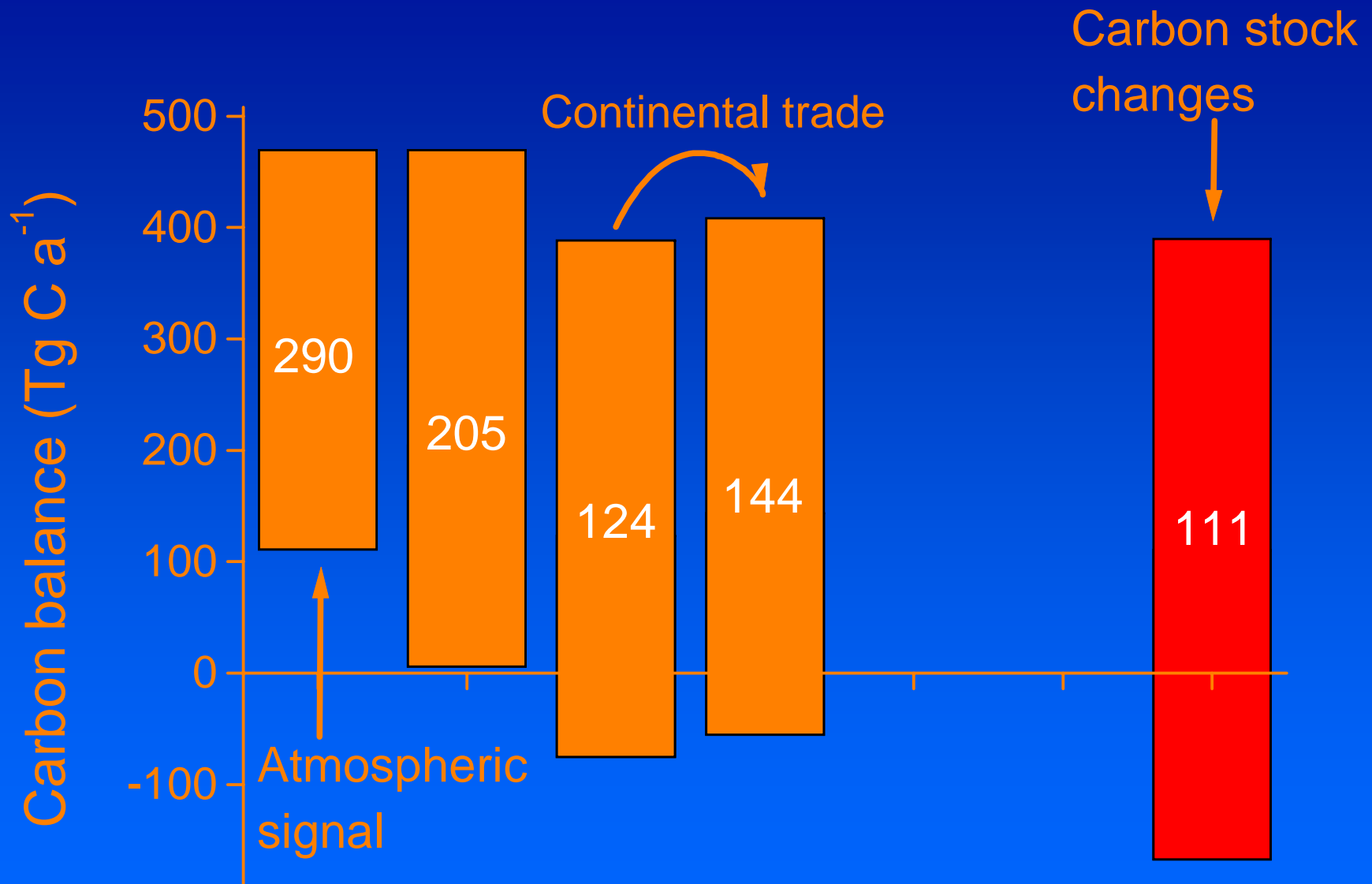
Release to
atmosphere

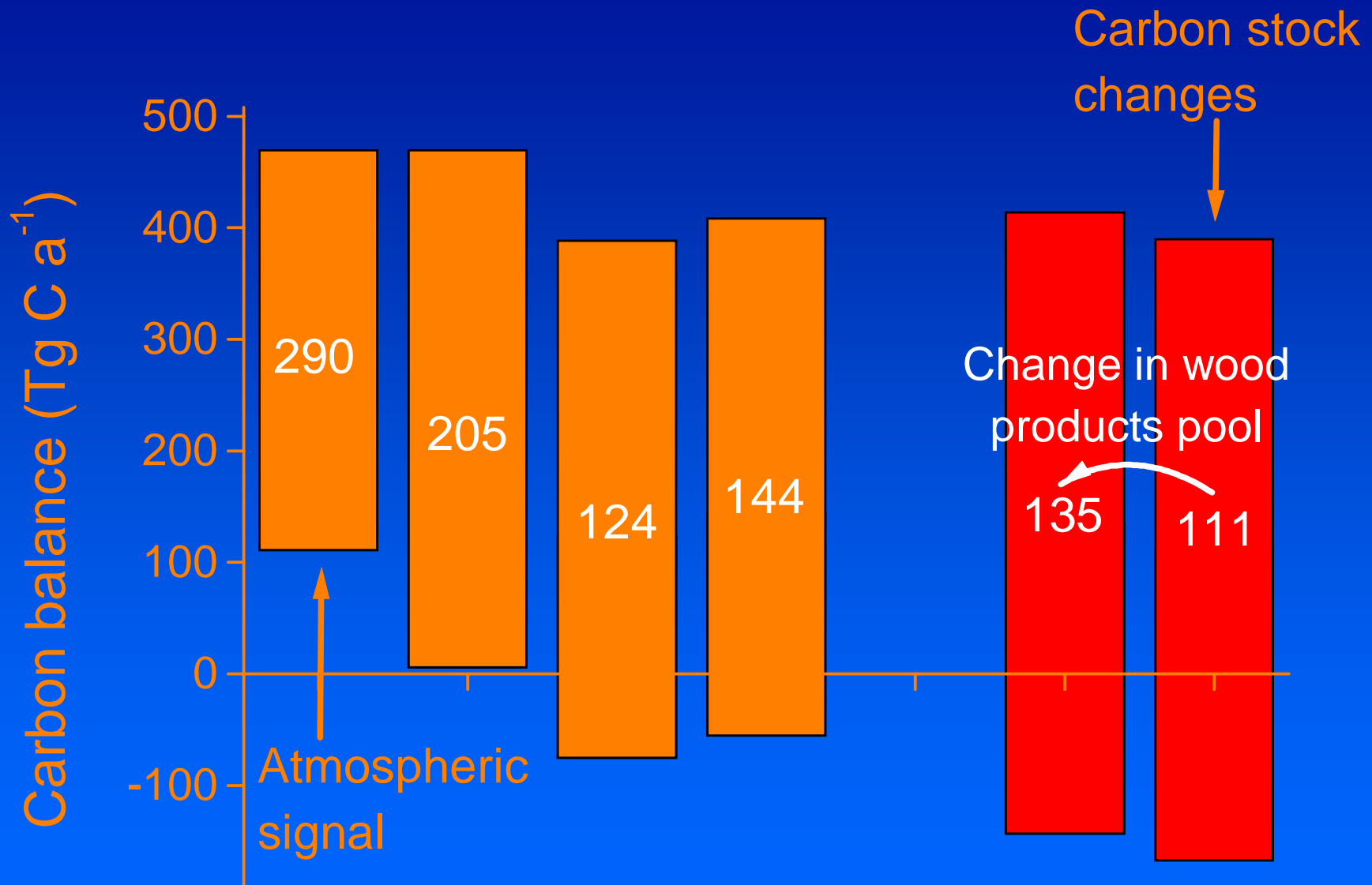


Food/feed trade



+ = net exporter = decreased source = increased sink





Thank you