4. Terrestrial Ecosystems

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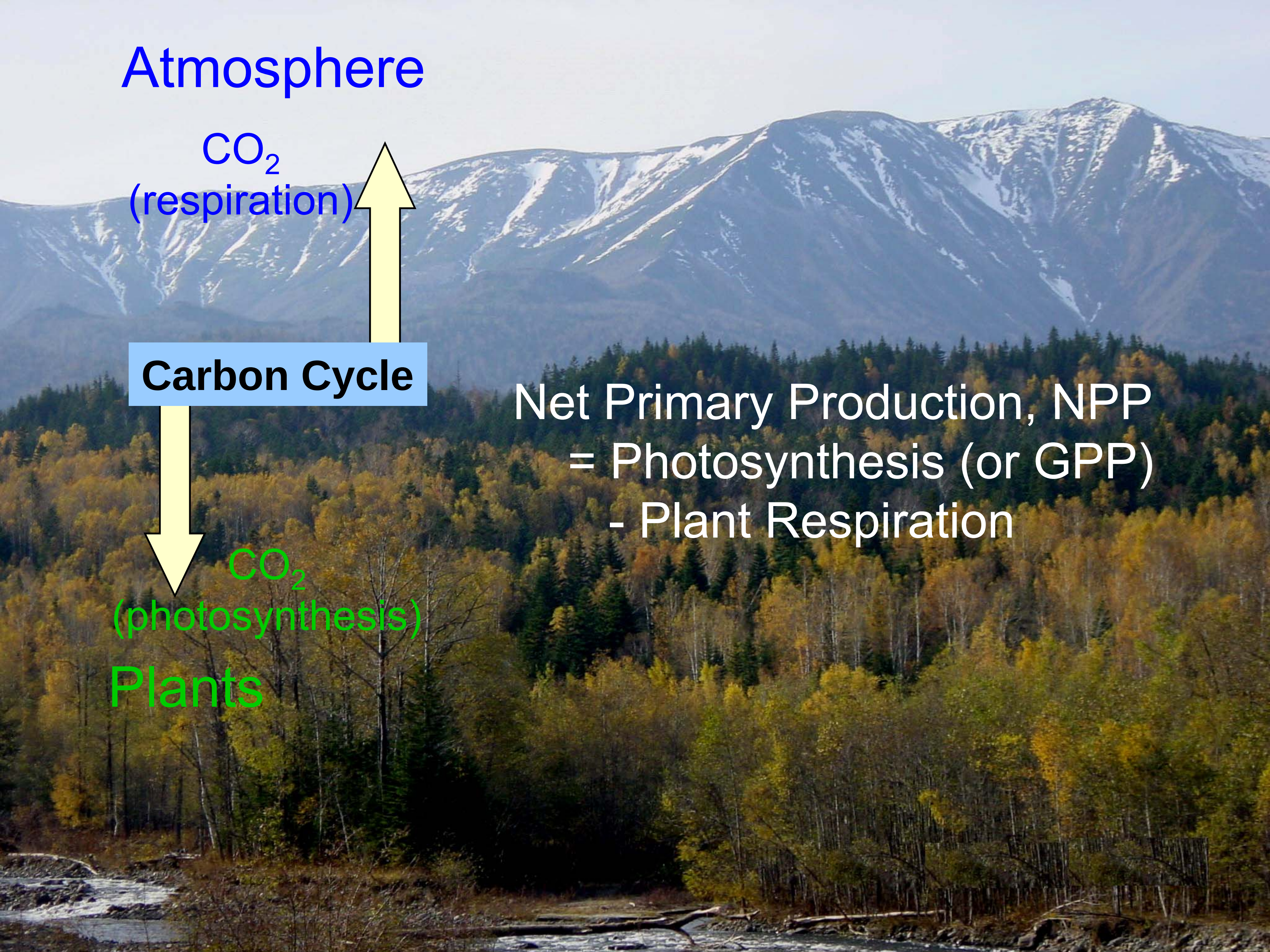
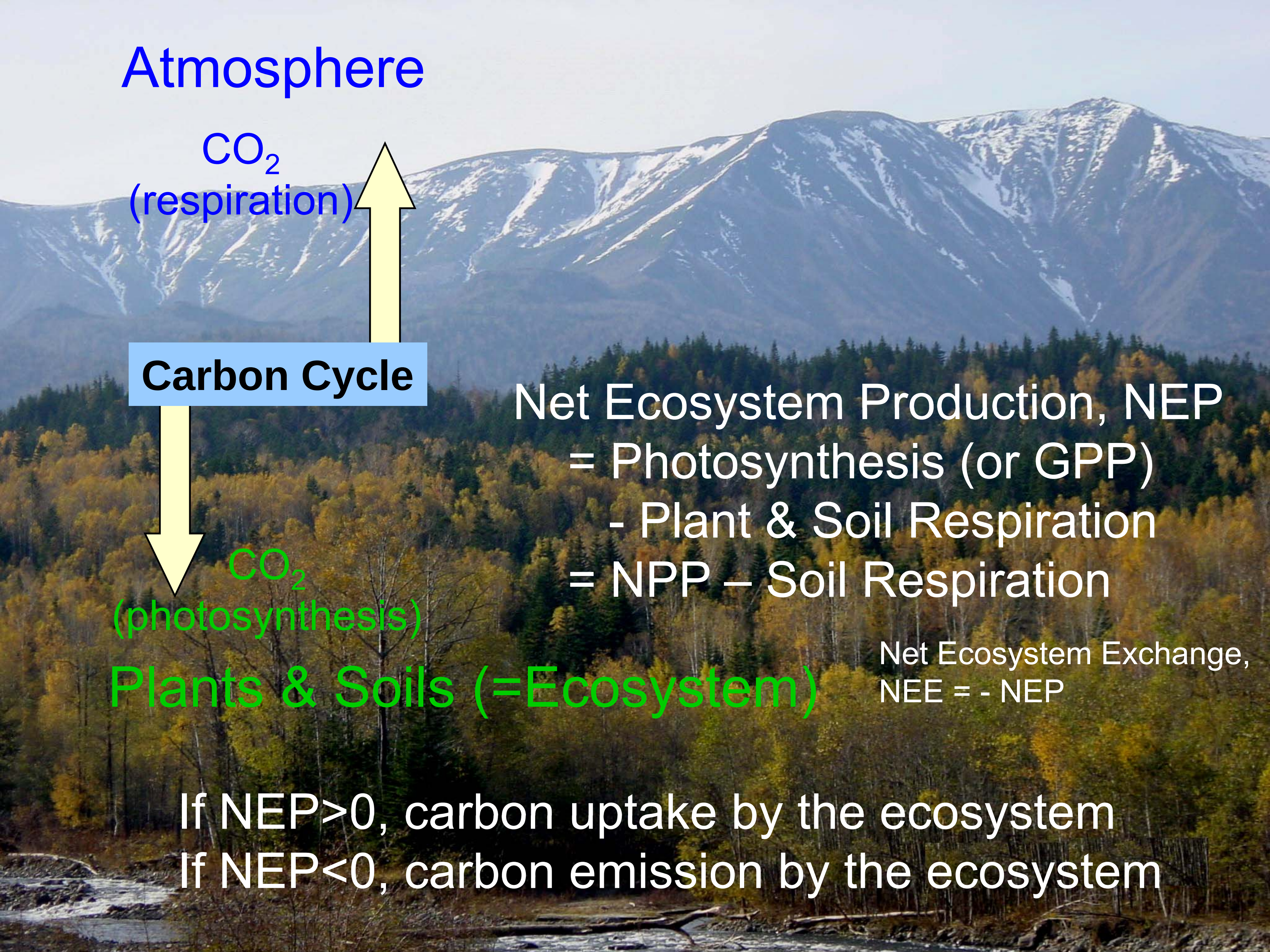

Atmosphere
CO2
(respiration)
Carbon Cycle
CO2
(photosynthesis)
Plants
Net Primary Production, NPP
= Photosynthesis (or GPP)
- Plant Respiration



Atmosphere

CO_2
(respiration)

Carbon Cycle

CO_2
(photosynthesis)

Plants & Soils (=Ecosystem)

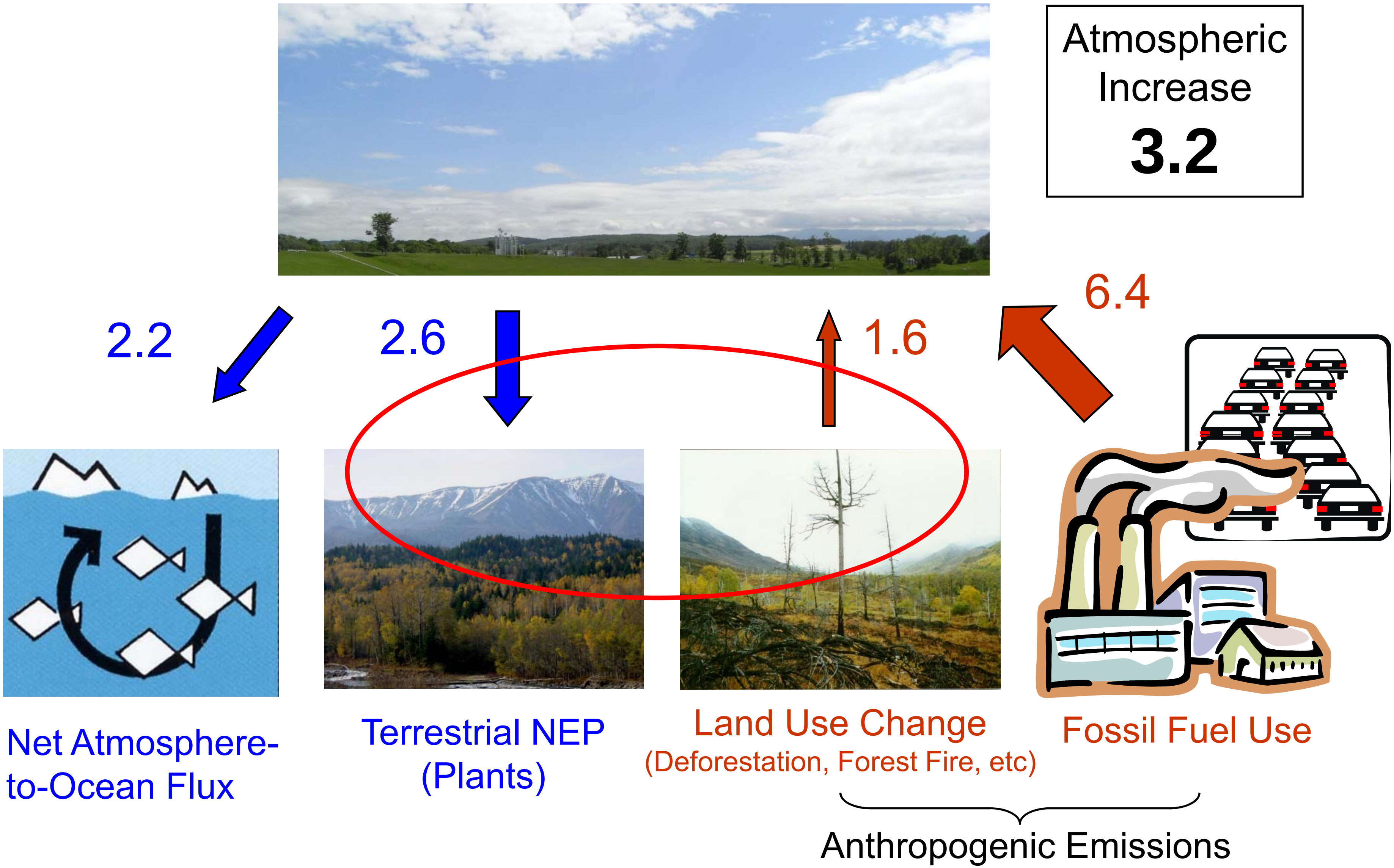
Net Ecosystem Production, NEP
= Photosynthesis (or GPP)
- Plant & Soil Respiration
= NPP – Soil Respiration

Net Ecosystem Exchange,
NEE = - NEP

If NEP>0, carbon uptake by the ecosystem
If NEP<0, carbon emission by the ecosystem

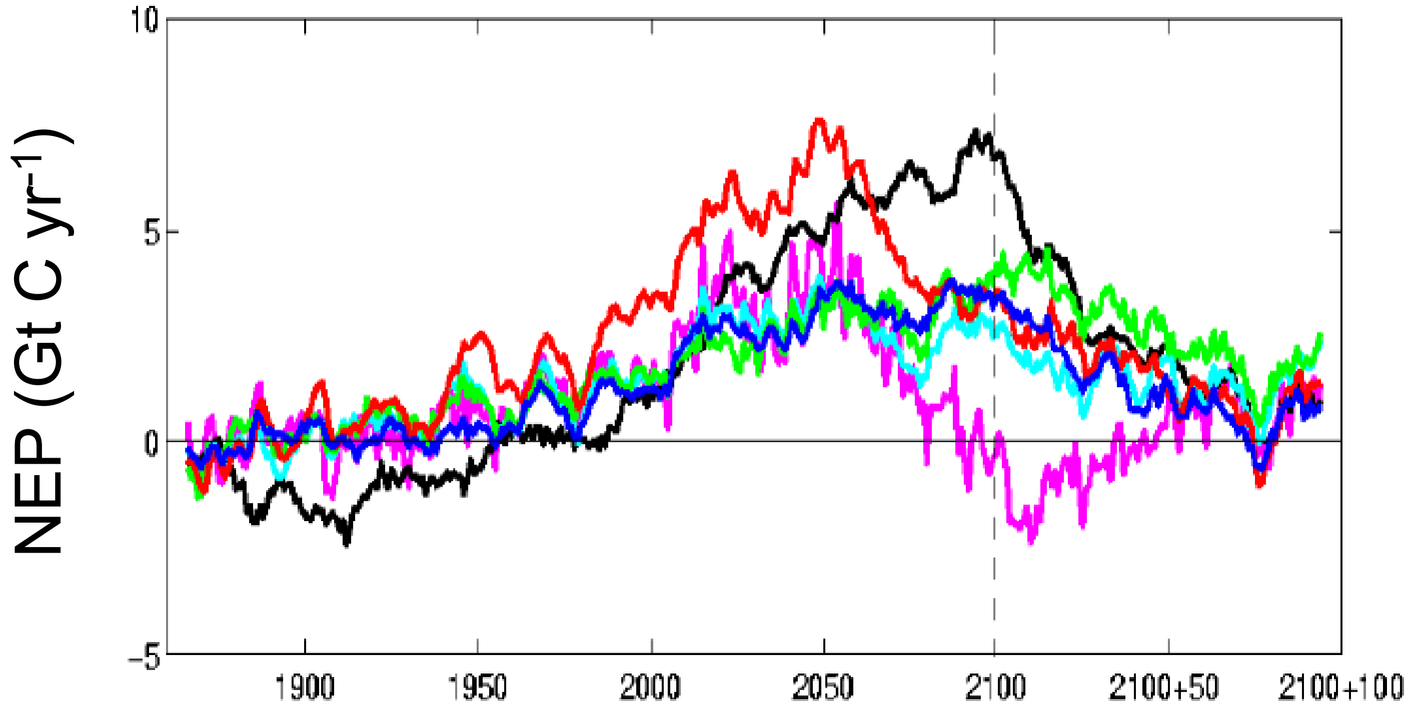
Global Carbon Budget (Gt C yr^{-1}), 1990-1999 (1 Gt=10^9t)

(based on the IPCC Assessment Report 4, 2007)



Net Ecosystem Production under global warming predicted by various models

(from Cramer *et al*. 2001)



- Models predict that terrestrial ecosystems under global warming will absorb more carbon until 2050-2100 and then carbon uptake will reduce.
- However, the quantitative results are different among the models.

Carbon uptake or emission by terrestrial ecosystems

- Models predict that terrestrial ecosystems under global warming will absorb more carbon until 2050-2100 and then carbon uptake will reduce.
- However, the quantitative results are different among the models.
- Many uncertain components are involved in the present models – the subject of this session.
- More careful studies are needed to estimate terrestrial NEP under global warming.

How to overcome the uncertainties? - Discussion

Part of the reason for the uncertainties in NEP prediction models under global warming …

difficulties in developing mechanistic models
for several important ecophysiological processes
(empirical modelling is possible)

- root biomass, soil respiration

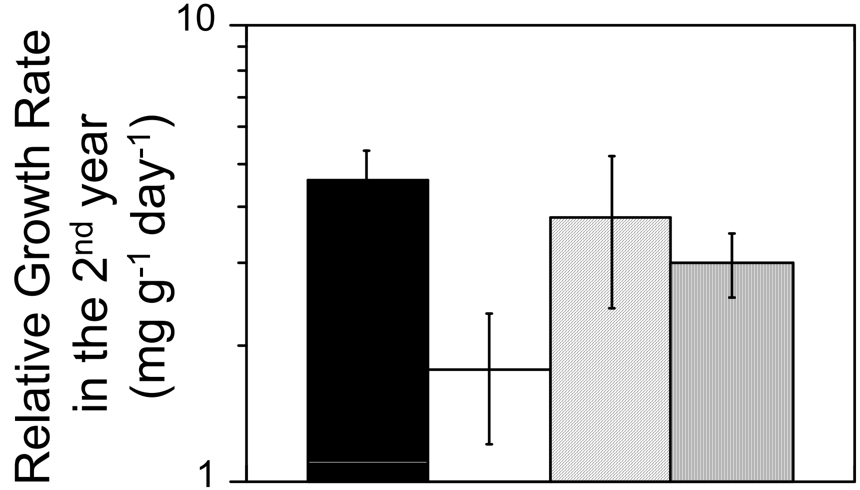
the hidden half of terrestrial ecosystems
not so many data available, we need more data

- plant adaptation, acclimation, plasticity

have hardly been dealt with explicitly in prediction models.
how should we deal with these processes?

An Example of Plant Adaptation to Drought Stress

(from Tabata *et al*. 2008)



Betula ermanii (birch)

1st year: well irrigated
2nd year: well irrigated

1st year: well irrigated
2nd year: drought stressed

1st year: drought stressed
2nd year: drought stressed
(many fine roots produced)

plant adaptation seems to take place quickly; in other species also?

long-term study for various species is needed (several years for trees)

Land Use Change

50-year-old *Larix* (larch) forest
after a forest fire (Kamchatka, Russia)

50-year-old *Picea* (spruce)-*Abies* (fir) forest
after a big typhoon (Hokkaido, Japan)

In boreal regions, it takes a long time for a forest to develop after disturbance

Effects of land use change (deforestation, forest fire, etc)
on terrestrial NEP differ among regions

how and to what extent? – uncertainties; we need more data

The Carbon Cycle of Permafrost-dominated Ecosystems

Boreal Zone
Observations

Prof. Trofim Chr. MAXIMOV
Institute for Biological Problems of Cryolithozone
Russian Academy of Sciences,
Yakutsk, Russia

Model Analysis of Terrestrial Response and Feedback to Global Warming

Temperate and Tropical Zones
Global Modelling

Dr. Akihiko ITOH
National Institute for Environmental Studies,
Tsukuba, Japan
& JAMSTEC, FRCGC, Yokohama, Japan

The Carbon Cycle of Permafrost-Dominated Ecosystems

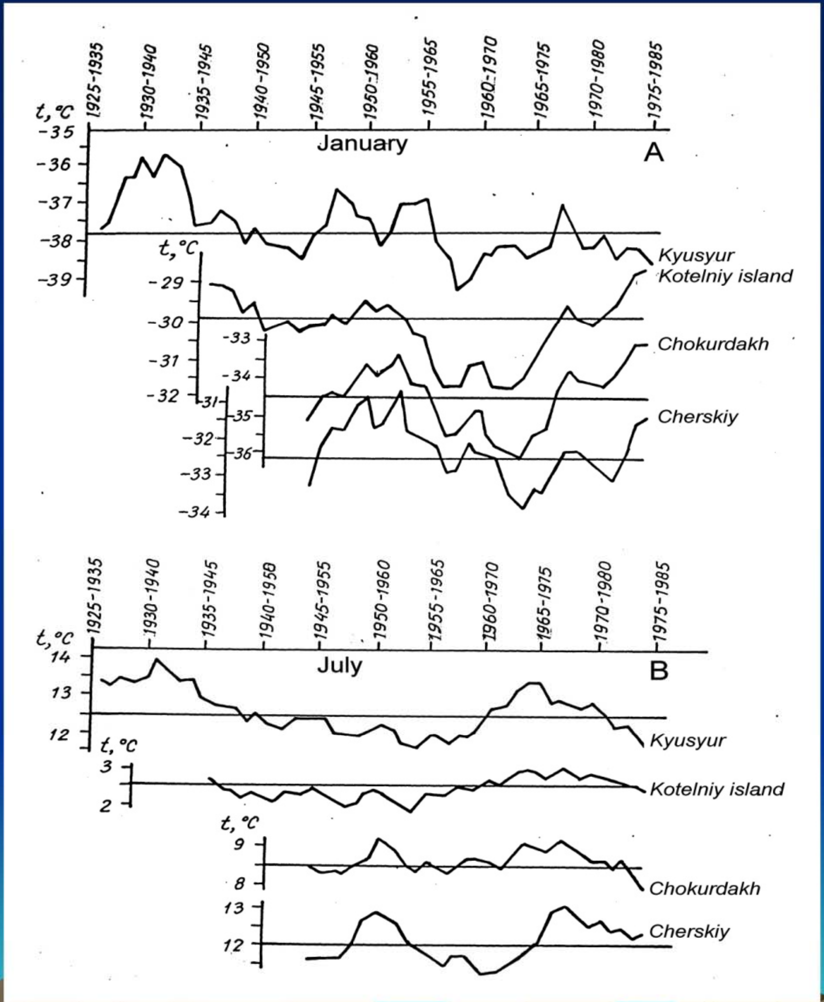
[1]Trofim Chr.MAXIMOV, [2]Han DOLMAN, [2]Michiel van der MOLEN,
[3]Takeshi OHTA and [4]Atsuko SUGIMOTO

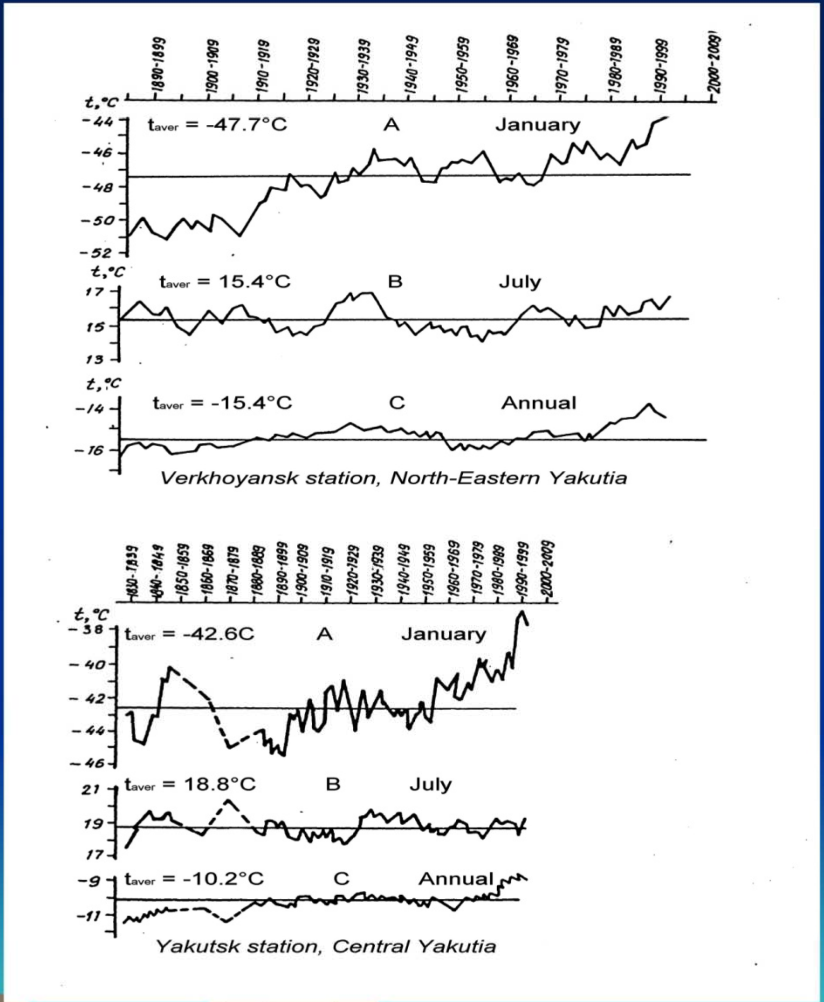
[1] Institute for Biological Problems of Cryolithozone SB RAS, Russia;
[2] Free University of Amsterdam, The Netherlands
[3] Nagoya University, Japan
[4] Hokkaido University, Japan

Meteorological data for the last 100-150 years in the zones of permafrost in Siberian and Central Asia has revealed the following:

- **The 20th century through out the northern part of Asia was warmer than the 19th century. Thus, since the end of the 19th century the winter temperatures in Eastern Siberia have risen by 10°C in Yakutia. The annual temperatures for the last century have risen by 2-3,5° C in all regions studied**
- **A steady warming process started in the second half of the 20th century, particularly in the 1970s and 1980s. For the last 50 years the January temperatures have risen by 7°C in Yakutia. The annual temperatures have risen by 1-2° C**

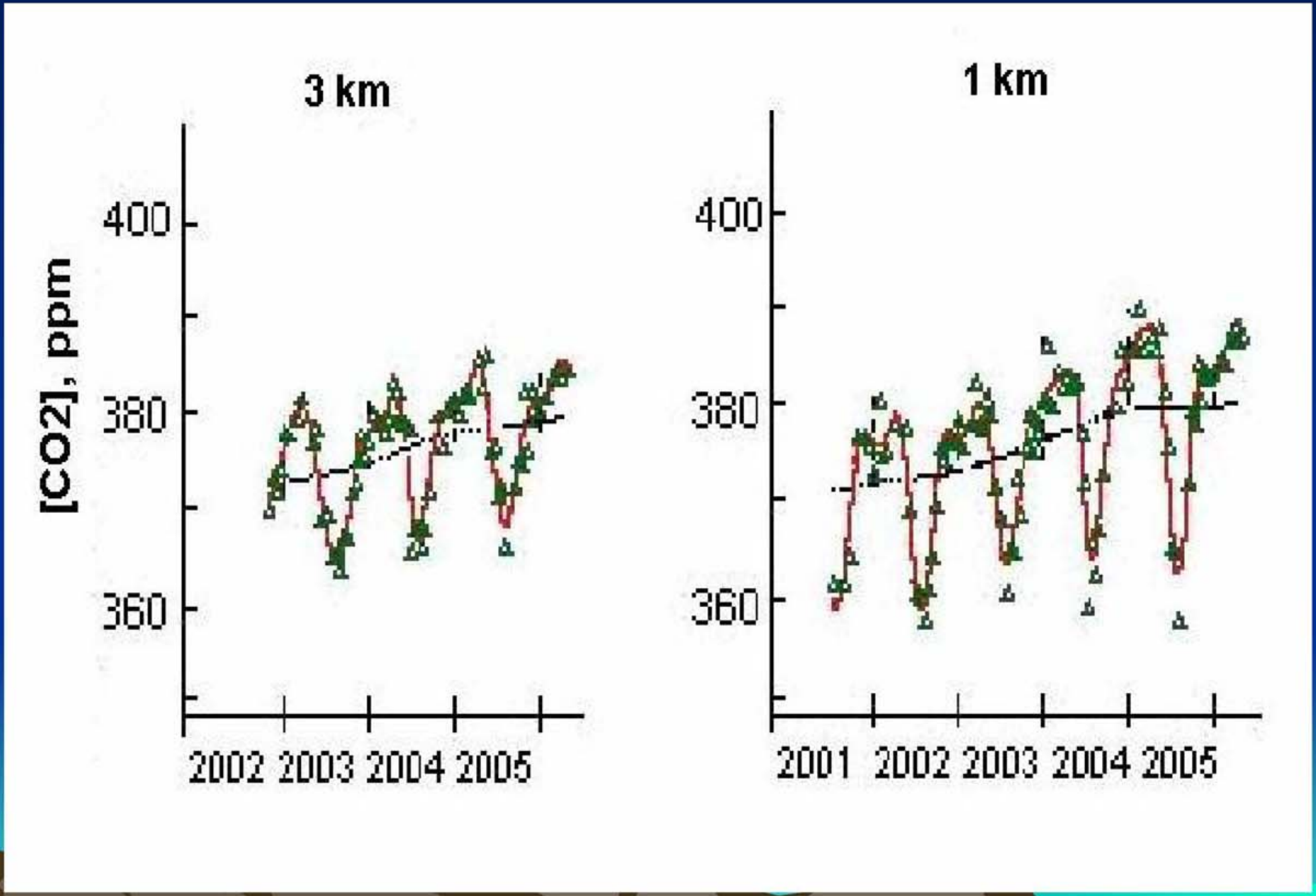
Sliding 10-year average temperatures, °C, Arctic, Northeastern and Central Yakutia





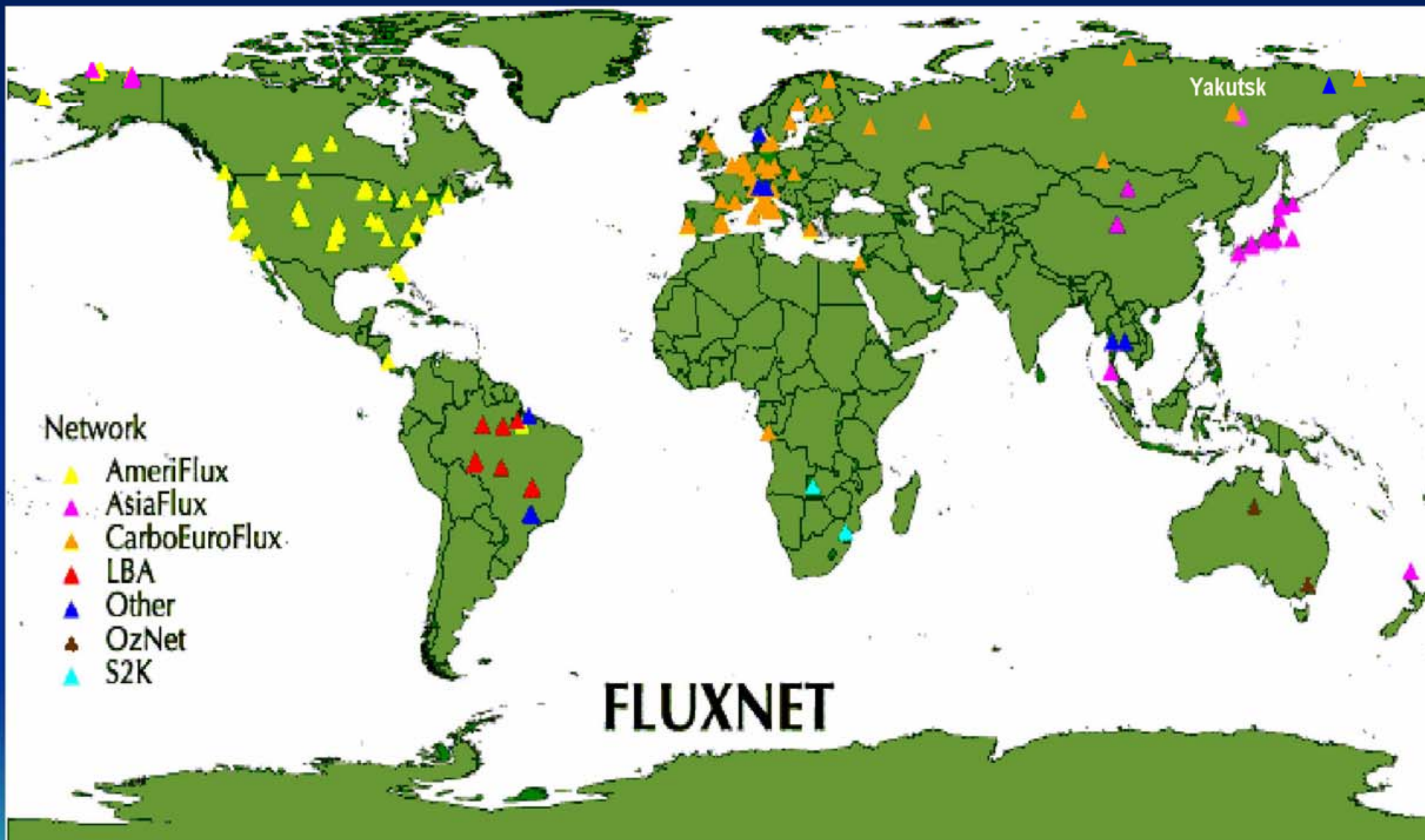
Gavrilova, 2003

Atmospheric $[CO_2]$ over Yakutsk area



Takahashi et al., 2005

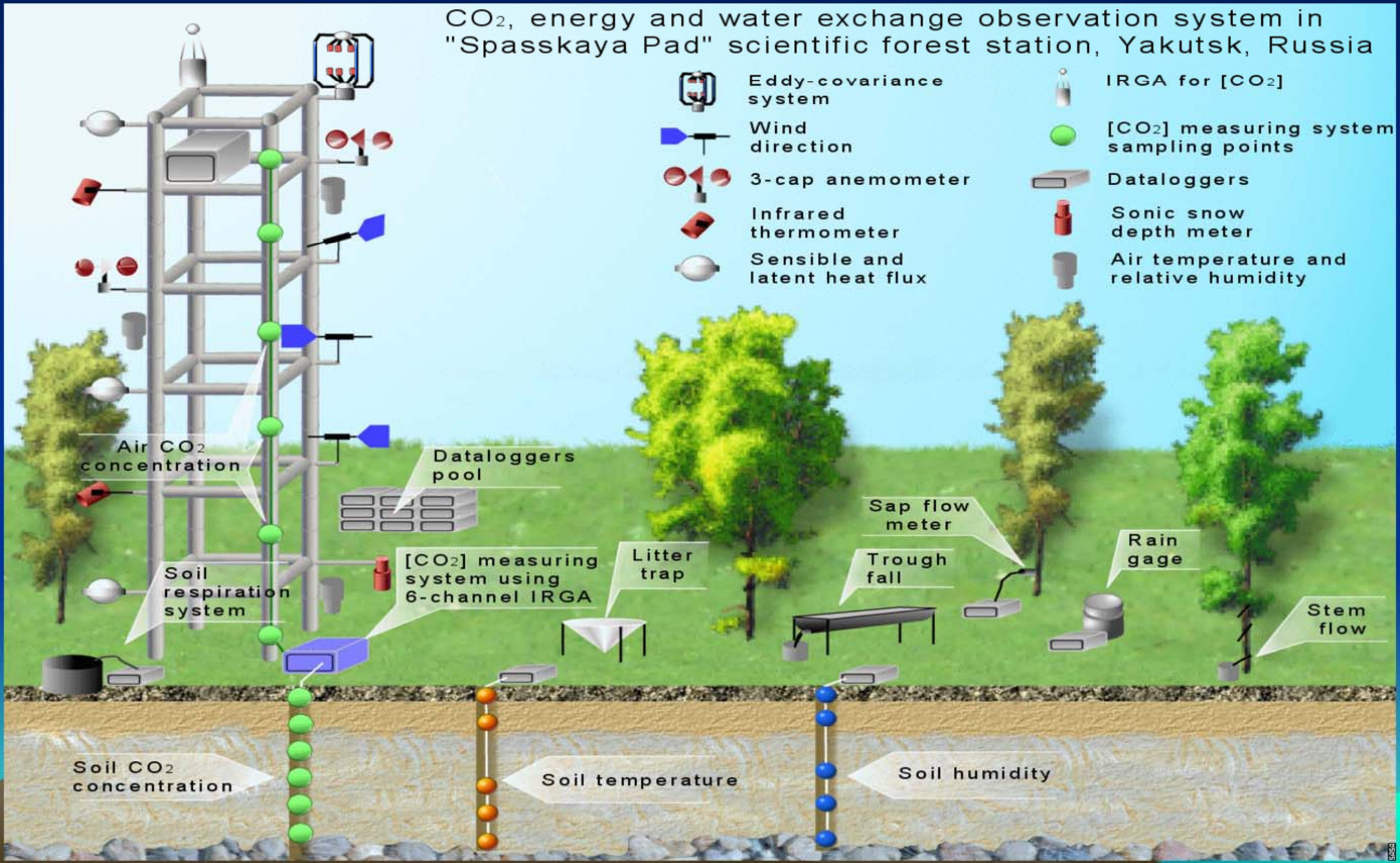
Global, continental and regional observational networks of heat, water and carbon dioxide fluxes



Scientific forest station «Spasskaya Pad» of IBPC SD RAS is the only station in the world that assesses methodologies of scientists of Asia and Europe (*CarboEurope* and *AsiaFlux* projects)

Scientific forest station «Spasskaya Pad» of IBPC SD RAS

Local level of studies on heat, water and carbon dioxide fluxes in forest ecosystem. Central Yakutia. Spasskaya Pad, 62°14′29″ N, 129°39′2″ E.



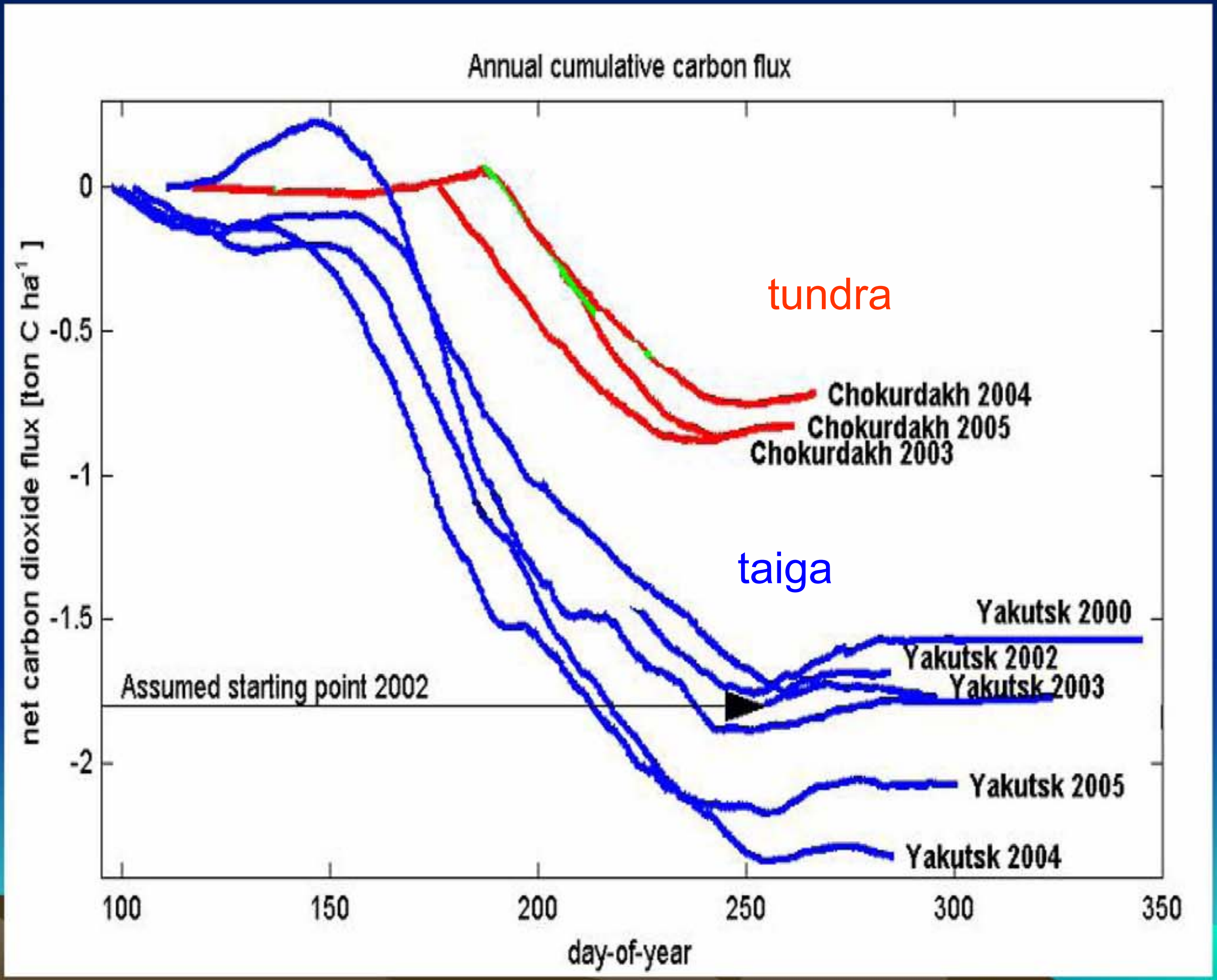

CIRAS-SC


Scientific tundra station
“Chokurdakh” of IBPC SD RAS

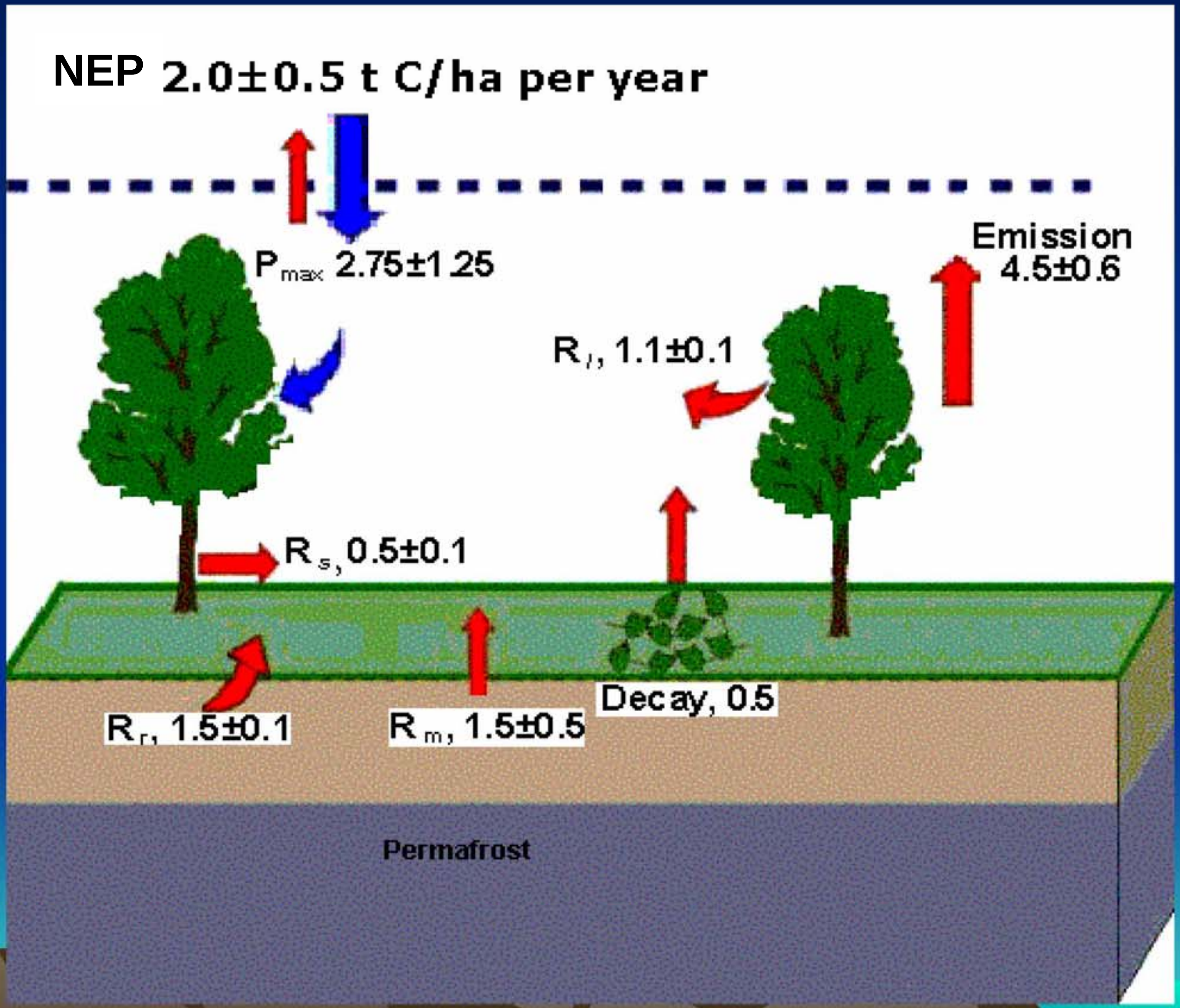
Local level of studies on heat, water and carbon dioxide fluxes in tundra ecosystem. Arctic Yakutia. Chokurdakh, 70°49’30” N, 147°29’21” E.

Comparison of carbon sequestration by forest and tundra ecosystems

NEE
(=-NEP)



Annual carbon budget of permafrost forest ecosystems, *t C/ha per year*



Maximov, 2003

Summary taiga

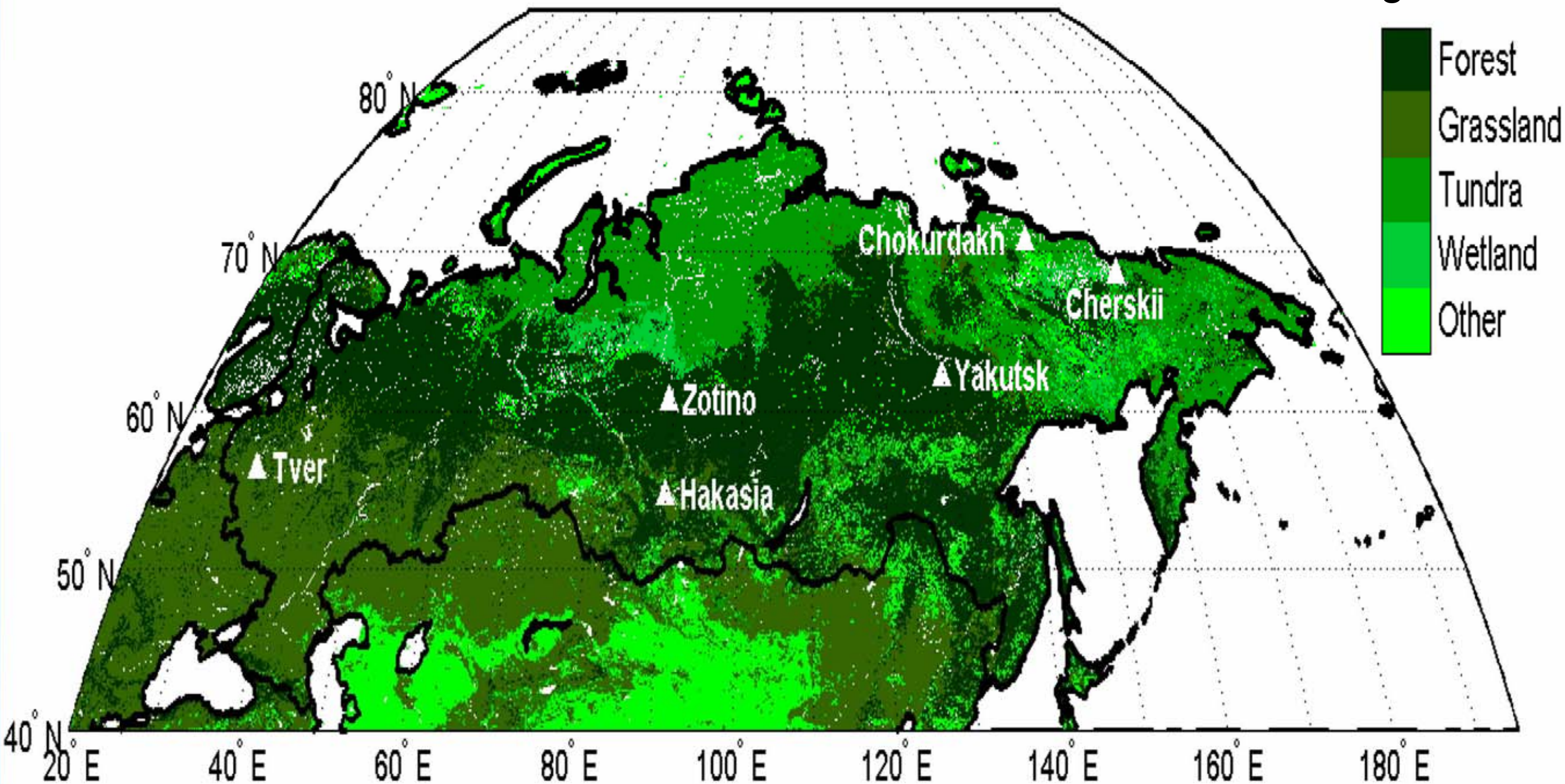
- Taiga is an on-off system
- Strong control of humidity
- Relative high rates of NEP in short growing season
- 3 months activity
- Annual uptake 2.0 ton Cha^{-1} (+/-0.5)
- June highest uptake

Summary tundra

- Only 50% annual uptake of taiga
- Largest uncertainty in beginning and end (respiration bulge)
- 2 months activity
- How is the lateral exchange through the hydrology?
- How spatially variable is the flux

Land cover map of the Russian Federation and measurement sites

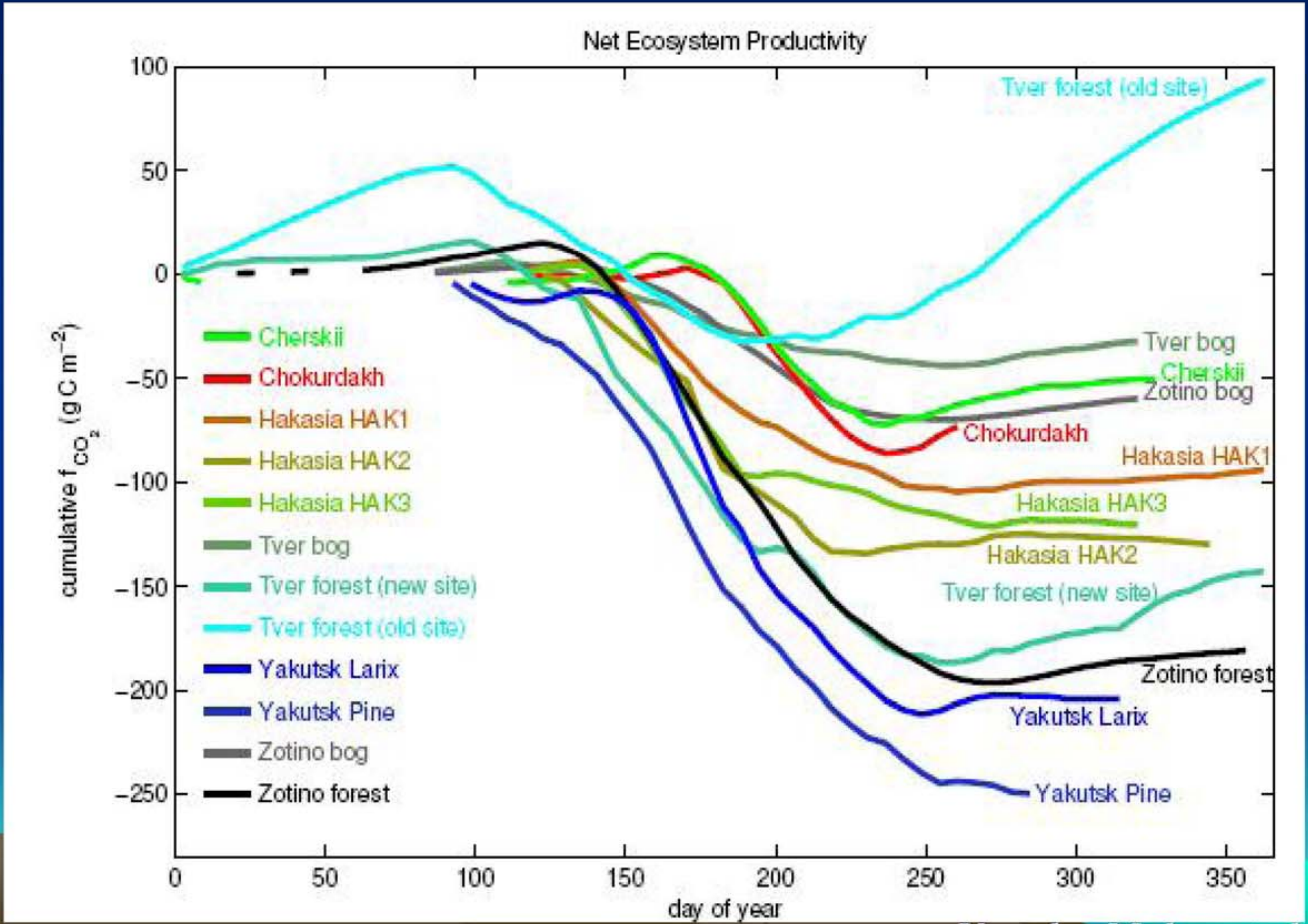
12 sites in 6 regions



Van der Molen et al,, submitted

The multi-annual net NEE derived from EC measurement at the 12 sites in Russia

The data are u-corrected and gap-filled



Van der Molen et al, 2006

Annual carbon fluxes in representative biomes of Russian Federation

47 annual dataset from 12 stations on the frame Project TCOS-Siberia (EU-10) и JST CREST (Japan)

www: michiel.van.der.molen@falw.vu.nl

	annual flux $g\ C\ m^{-2}\ yr^{-1}$	area $10^{12}\ m^2$	%	annual land cover flux $10^{12}\ g\ C\ yr^{-1}$
land cover type				
wetlands	-54 ± 66	4.4	25.9%	-236 ± 338
grasslands	-115 ± 66	2.7	15.7 %	-310 ± 198
Tver forest oldsite	94 ± 66	1.7	49.1%	158 ± 162
forests	-194 ± 66	6.7		-1306 ± 589
other	-104 ± 66	1.6	9.2%	-166 ± 114
total		17.1		-1861 ± 1401

Russian NEE

Our estimate of 1.9 *G t C per year* or 24 % of global emission due to fossil fuel burning (6 *G t C per year*) and deforestation (2 *G t*), forest fire (0.19 *G t*) and river transport (0.020 *G t*)

According to Prof. Maximov,

total Russian NEP = 1.9 Gt C yr^{-1} (!?)

ca. 75% of the global terrestrial NEP, 2.6 Gt C yr^{-1},

estimated by the IPCC 2007

energy-water-carbon flux measurements
at 12 plot-scale sites in Russia

→ estimate of total Russian NEP

spatial variations and uncertainties must be involved!