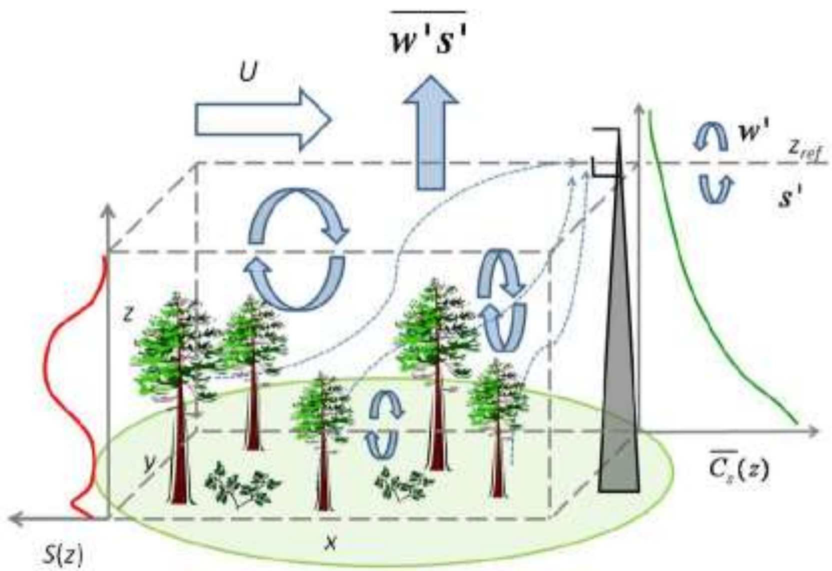
Cool forests at risk?

The critical role of boreal and mountain ecosystems for people, bioeconomy, and climate

17-20 September 2018 @ IIASA, Laxenburg, Austria

Large-scale quantifying of sources and sinks of atmospheric carbon in Siberia



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ЛАБОРАТОРИЯ биогеохимических циклов в лесных экосистемах

ZOTTO

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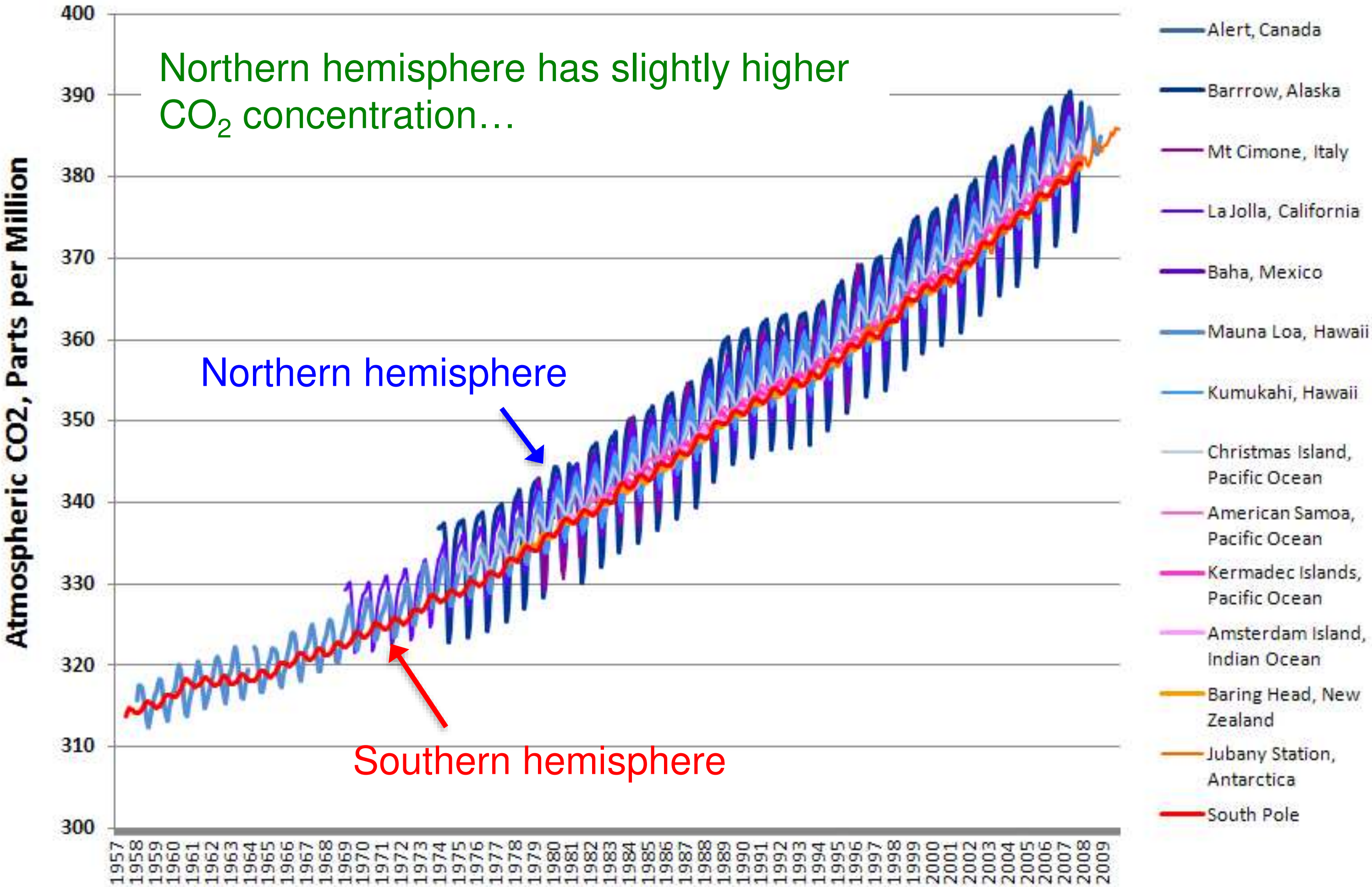
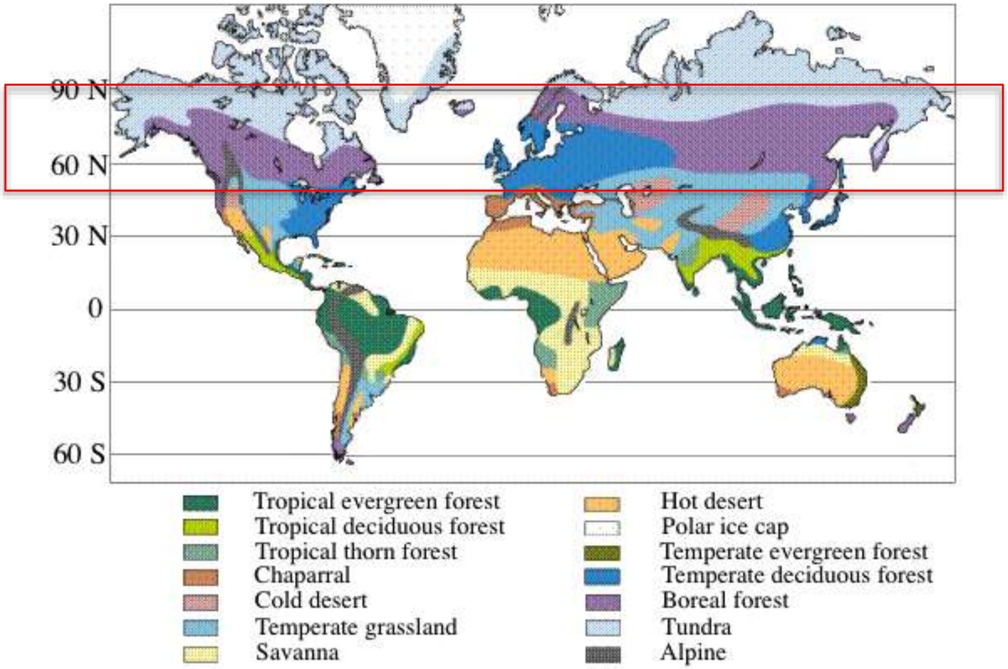
Anthropogenic perturbation of the global carbon cycle

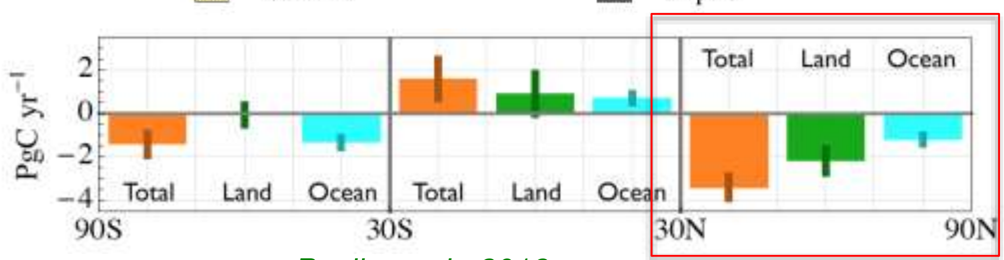


Data: Keeling et all http://cdiac.ornl.gov/trends/co2/

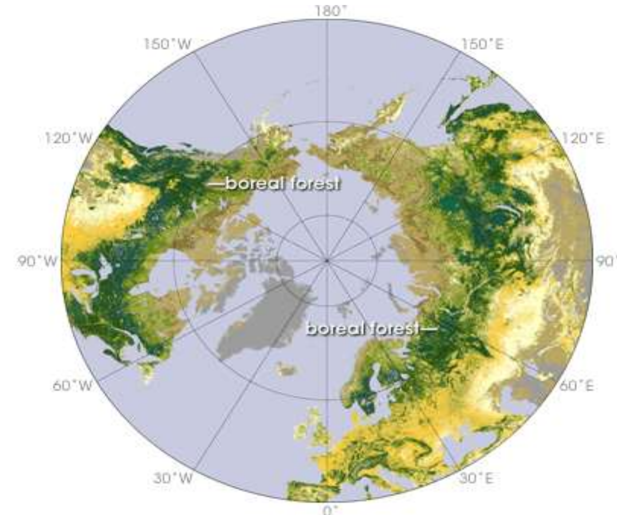
ЛАБОРАТОРИЯ биогеохимических циклов в лесных экосистемах

Boreal forests: biospheric role





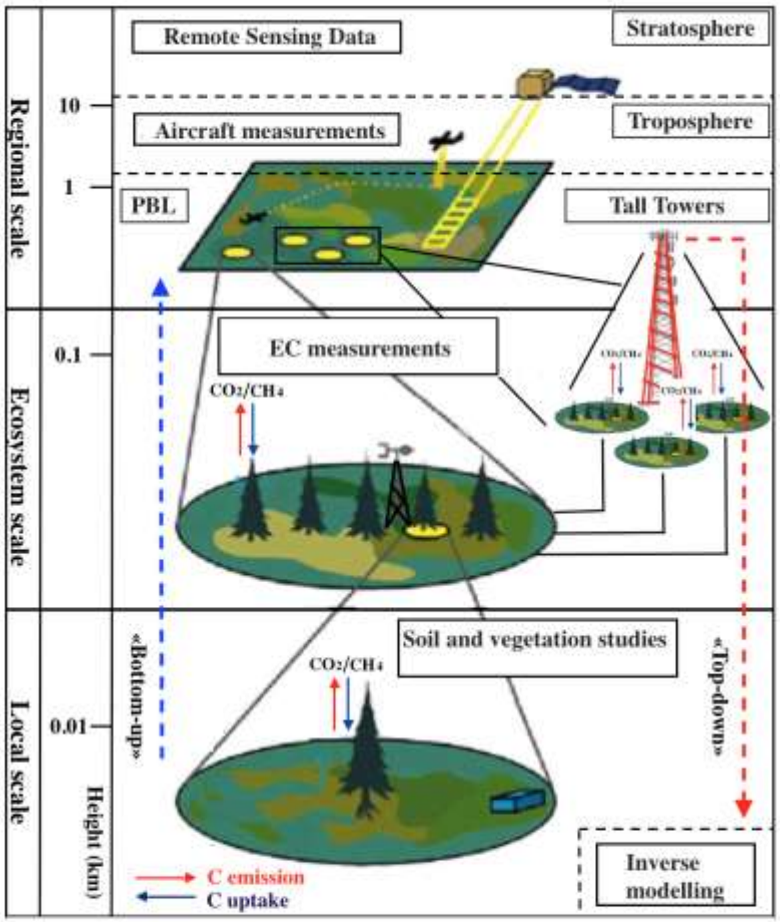
Peylin et al., 2013



The world's largest land biome, and makes up 29% of the world's forest cover with the largest areas located in Russia and Canada

Siberian forests comprise ~ 10% of the global C stored in vegetation and soils, and contribute up to 10% of the global terrestrial NPP

Observational strategies of the global carbon cycle



'top-down'

…uses observations of the atmospheric composition at remote locations and only insignificantly influenced by local processes

Bridging the gap in scale is an important scientific challenge, for which direct observations are indispensable

'bottom-up'

…is based on local in-situ observations of fluxes or changes in ecosystems, to be extrapolated and scaled up in order to make inferences at continental scale

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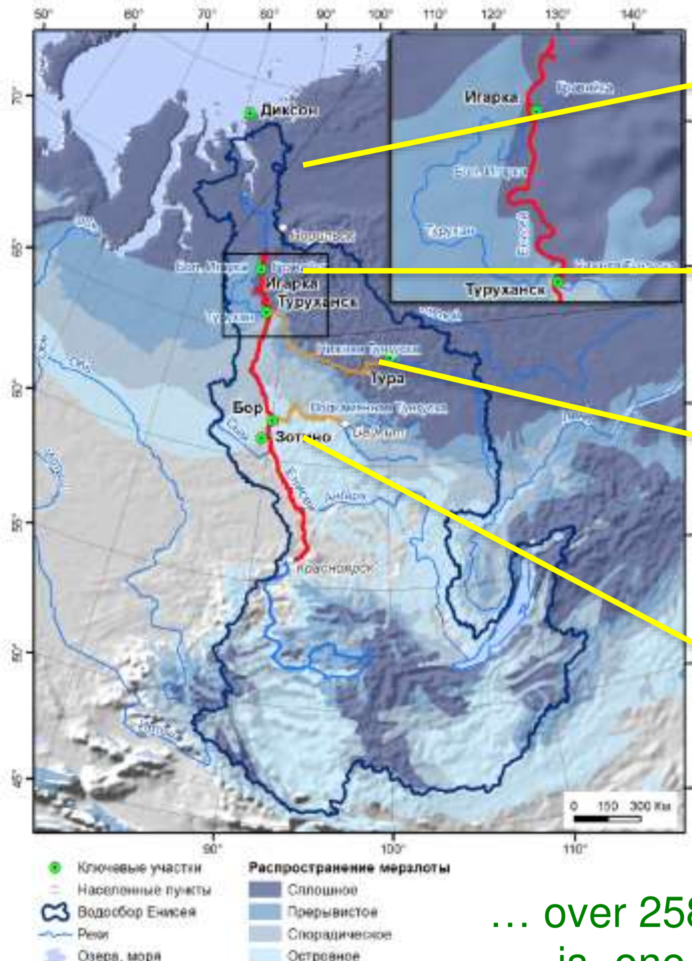
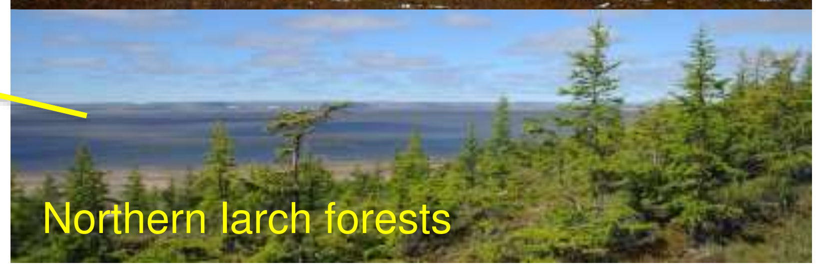
Yenisei River basin





… over 2580 thousand km^2

… is one of the most unique regions of Siberia to analyze biogeochemical processes due to high climatic, geomorphologic and ecological diversity

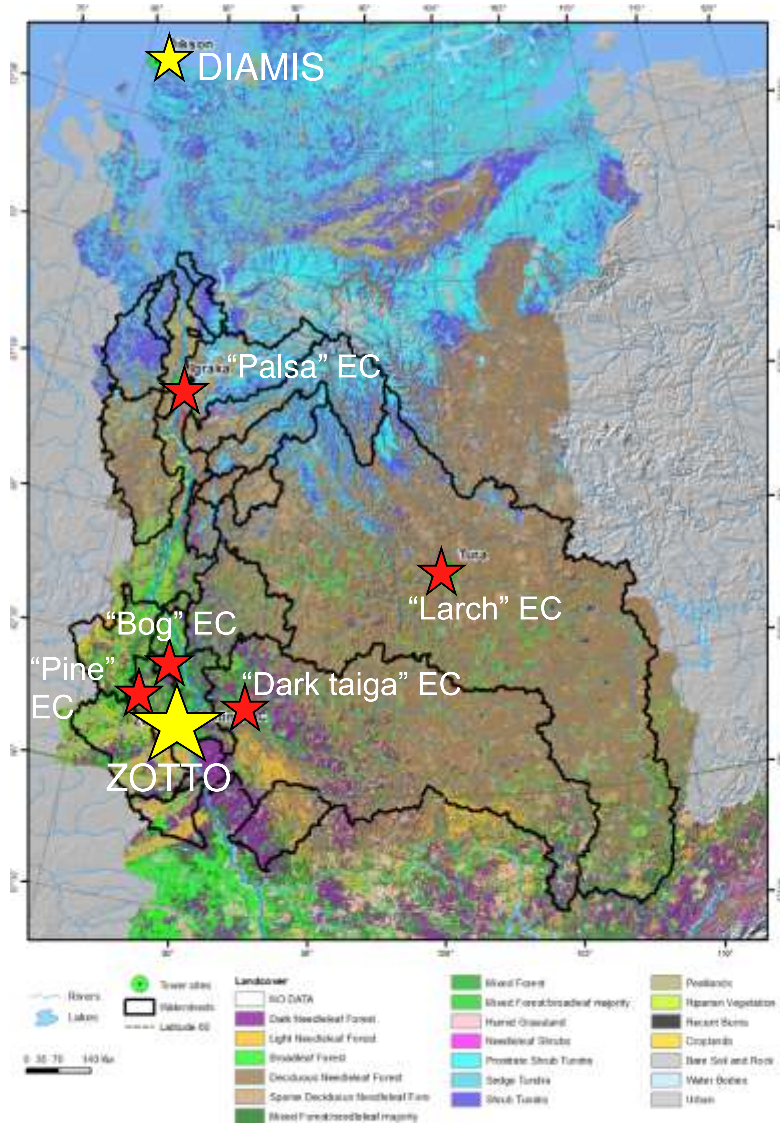
Observational network: major biomes of Yenisei River basin

2 Atmospheric observatories:

ZOTTO – continental observatory (since 2006)

DIAMIS – arctic/oceanic observatory (since 09.2018)

5 Eddy Covariance stations ("KrasFLUX")



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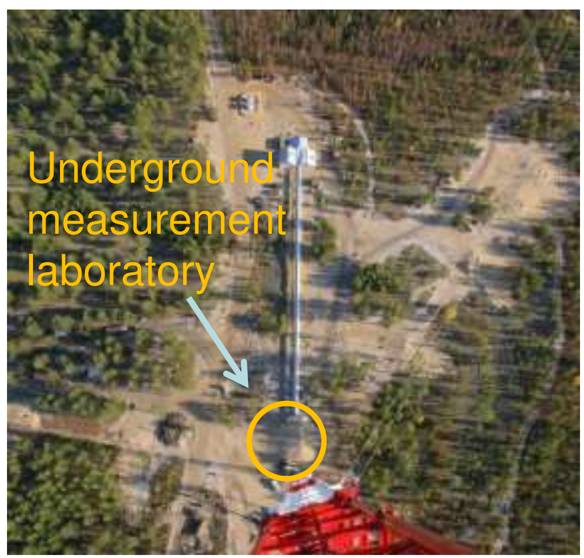
ZOTTO – continental observatory

ZOTTO has been established as a Eurasian mid-continental observatory with a long-term perspective (>30 years). Details of the project, contact points and access to data can be found on the project website (http://www.zottoproject.org).



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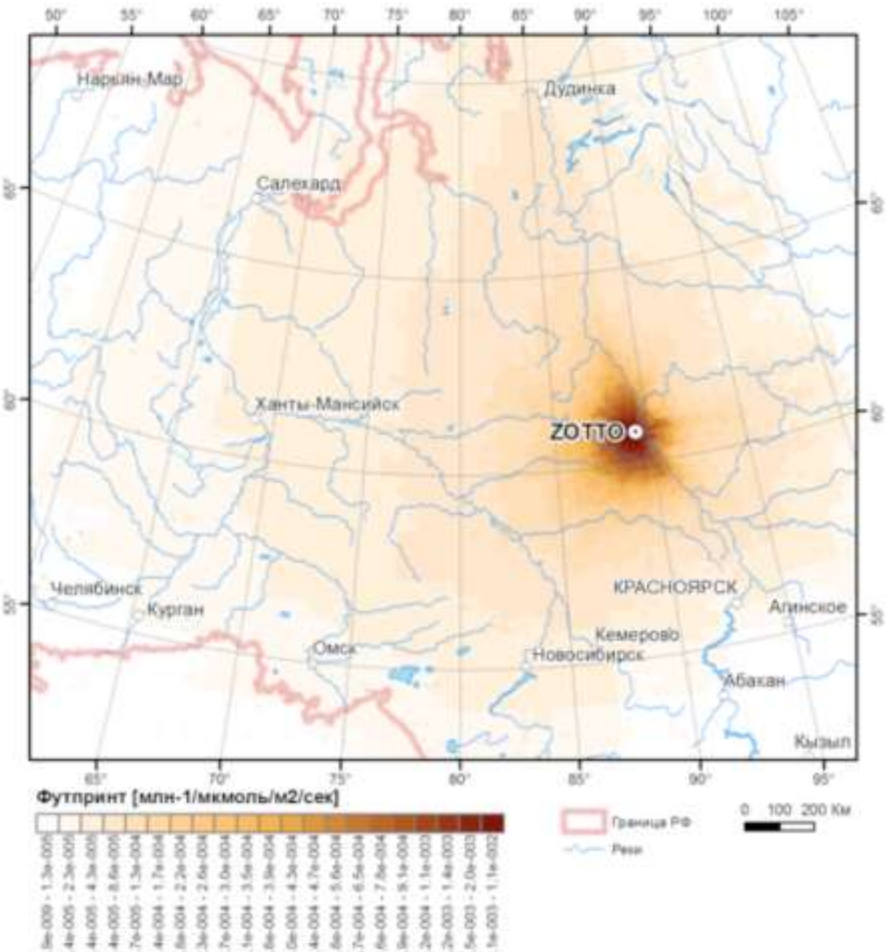
ZOTTO site

… is located in a boreal zone, in the center of Siberian taiga, 20km west of the Yenisei River and ≈600km north of Krasnoyarsk

ZOTTO footprint area: cumulative STILT



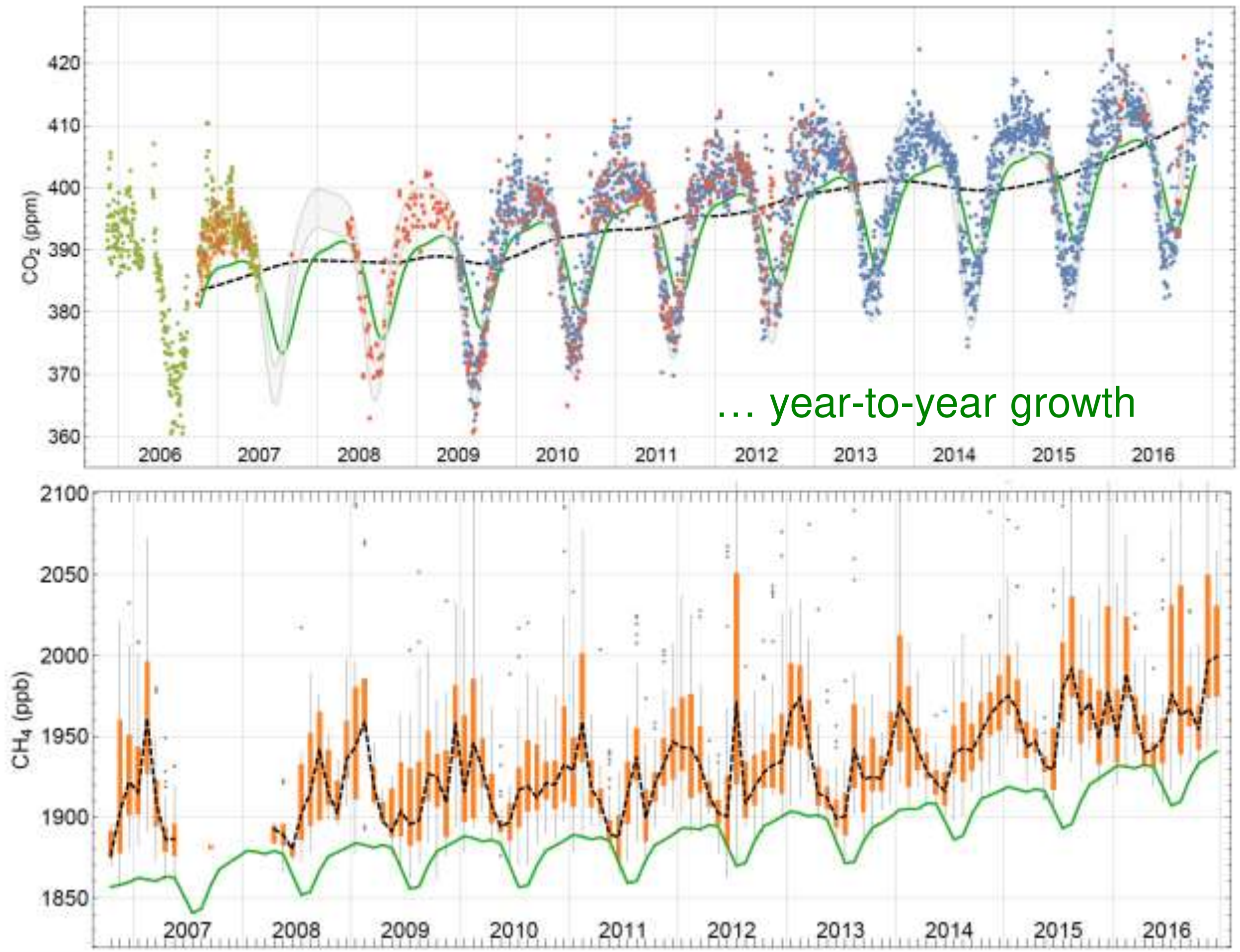
Average monthly footprint:
2.4×10^6 - 4.2×10^6 km^2

Coniferous forests: 39±2%
Tundra: 11±3%
Bogs: 11±1%
Mixed forests: 10±1%
Larch forests: 9±1%
Deciduous: 6±2%

The near-field of the tower produces the main influence on the measured mixing ratios up to 10 ppm/(μmol/(m²s))

The driving meteorological fields are prescribed into STILT by forecast values of the European Centre for Medium-Range Weather Forecasts (ECMWF http://www.ecmwf.int/)

ZOTTO: daily daytime mean CO_2 and CH_4 mixing ratios



Heimann et al., 2017

Over 10 yrs of continuous measurements

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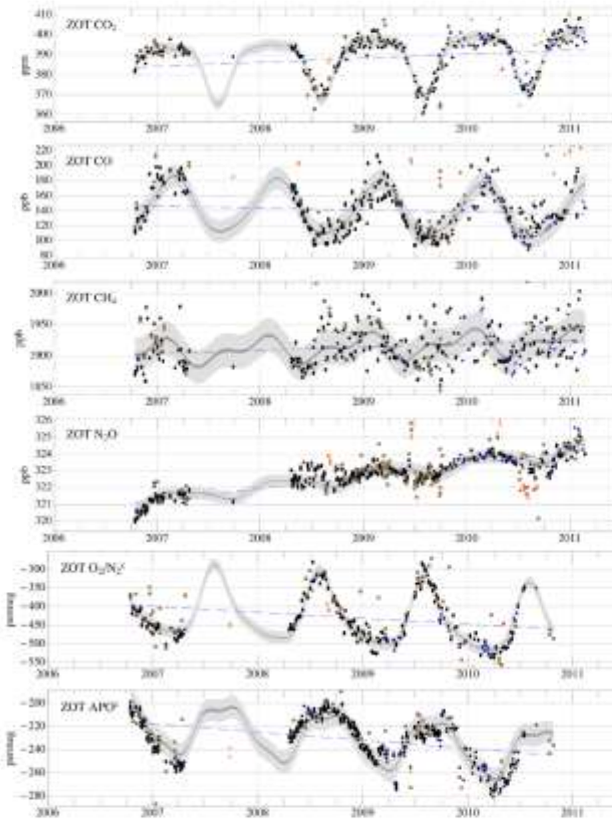
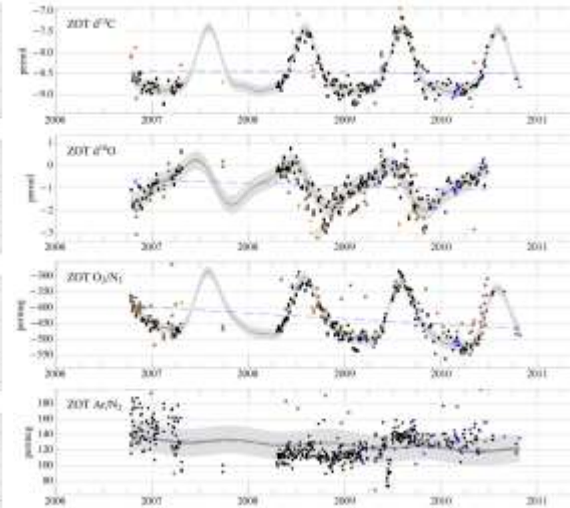
ZOTTO: Isotopic composition of GHG





Lavric et al., 2013

Flasks:
CO_2, O_2/N_2, CH_4, CO, N_2O, H_2, Ar/N_2, $^{13}C/^{12}C$, ^{18}O

iSAAC – Isotope System for Analysis of Air Constituents (Wendeberg et al., 2011)

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"KrasFLUX" EC network – 5 major vegetation types

Lichen Pine
60°48'N; 89°22'E
% in the basin: 4.5%
MAAT: -3.3 C°
MAP: 558 mm
Since 2012

Peat Bog
60°48'N; 89°22'E
% in the basin: 6%
MAAT: -3.3 C°
MAP: 558 mm
Since 2012

Dark coniferous forest
61°01'N; 89°49'E
% in the basin: 6%
MAAT: -3.3 C°
MAP: 558 mm
Since 2015

Northern larch forest
64°12'N; 100°27'E
% in the basin: 48%
MAAT: -8.5 C°
MAP: 347 mm
Since 2004

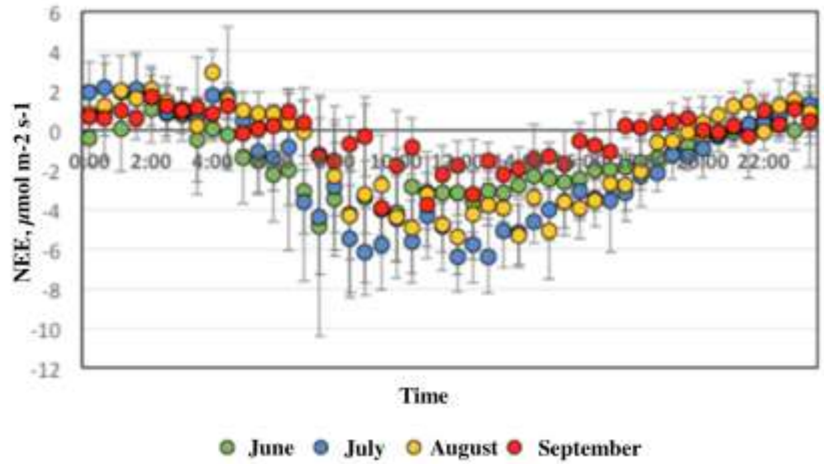
"Palsa" site
67°28'N; 86°29'E
% in the basin: 13%
MAAT: -7.8 C°
MAP: 481 mm
Since 2016

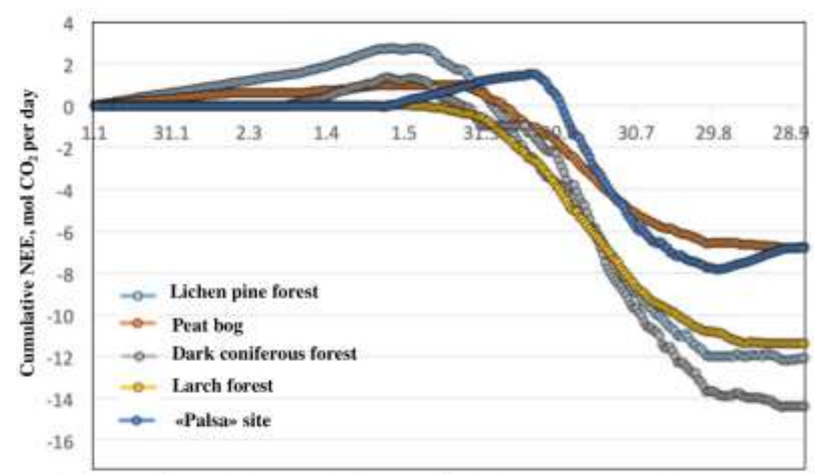
Instrumentation:
- $CO_2/CH_4/H_2O$ - LI-7700, LI-7500a, LI-7200, LI-7210,
- Heated anemometers: METEK, Gill-R3
- Meteorological packages

“KrasFLUX”– measuring CO_2 fluxes

- Seasonal variability of NEE and climatic parameters
- Inter- and intra- annual variability of NEE (sink/source) in major biomes
- Scaling up to the region estimates using vegetation maps, forest biomass inventories and remote sensing information

Site	Loc.	2015	2016	2017
Lichen pine	60°48’N 89°22’E	-11.0	-21.1	-12.1
Dark coniferous	61°01’N 89°49’E	n/a	-12.9	-14.4
Peat bog	60°48’N 89°22’E	-10.4	-9.2	-6.8
Larch forest	64°12’N 100°27’E	-14.0	-9.0	-11.4
“Palsa” site	67°28’N 86°29’E	n/a	-0.2	-6.8





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Winter CO_2 fluxes – a case study

Cold season CO_2 flux is increasingly recognized as an important component of the terrestrial carbon cycle

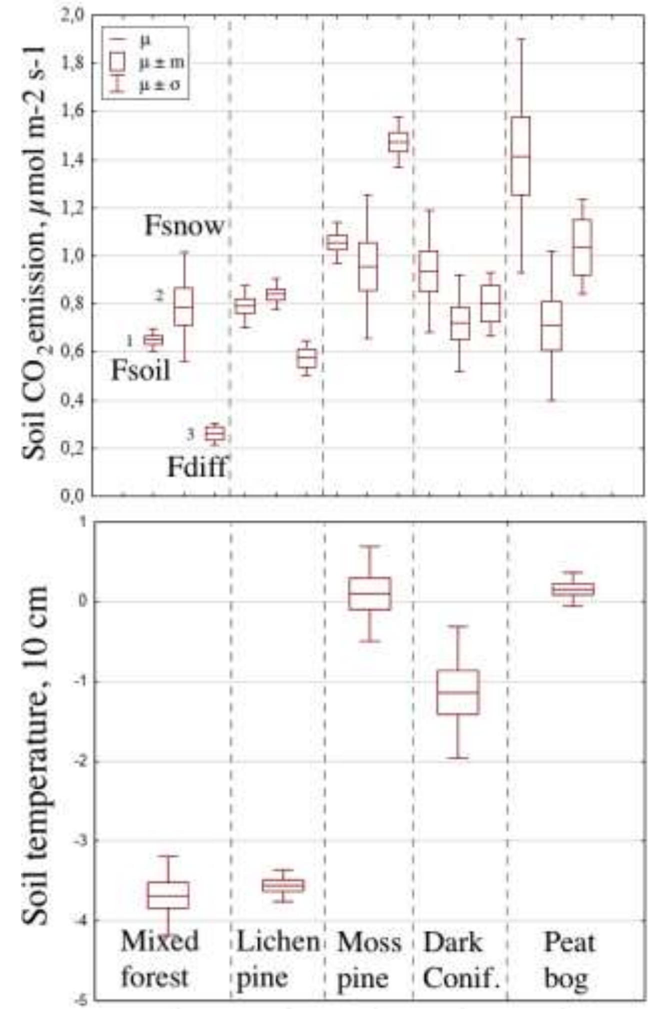
Three methods of measuring sub-snow CO_2 flux were compared:

(1) dynamic chamber measurements at the soil surface via snowpack (F soil),

(2) dynamic chamber measurements at the upper snowpack surface (F snow),

(3) static estimates based on measured concentrations of CO_2 and conductance properties of the snowpack (F diffusional)

Wintertime respiration constitutes on average 0,82 μmol m^{-2} s^{-1} in forest ecosystems and up to 1,05 μmol m^{-2} s^{-1} in peat bog – contributes ca. 15-40% of summer soil respiration rates



Panov et al., 2019 (in prep.)

DIAMIS – arctic/oceanic observatory

A key Arctic location (set.Dikson) given the recent Arctic warming and the expansion of gas/oil production in the Yamal area. In the estuary of Yenisei River basin.

73°33' N; 80°34' E

Tasks:

- Better constrain the budgets of GHG in Siberia
- Trace the ocean-continent transport of GHG
- Extend the circum-Arctic observational network

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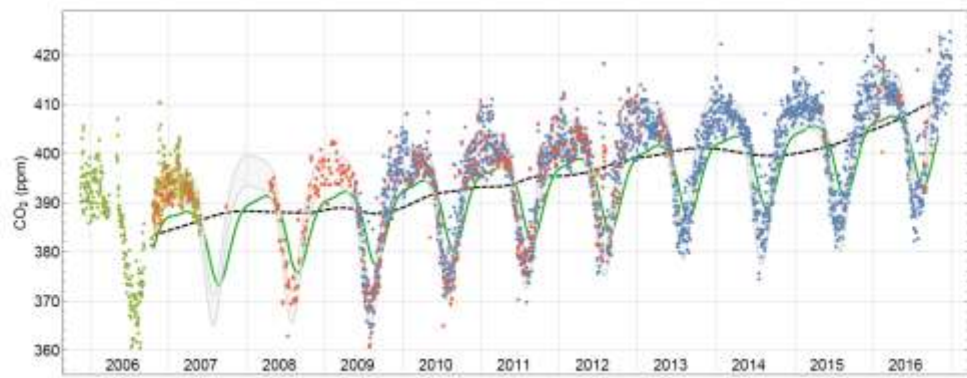
ЗАПОВЕДНИКИ ТАЙМЫРА

Focus:

Fate of carbon pools in a warming climate. Siberian forests contain large amounts of carbon stored in the forests and soils, in wetlands and the underlying permafrost. Knowledge of their response to climate change is vital.

Key challenges:

A year-to-year growth of atmospheric carbon dioxide concentration in the pristine conditions of Siberia.



Suggestions:

Longer periods of measurements should improve statistical significance of the observations and permit to distinguish between short-term variations and multi-decade climate variability.
Multidisciplinarity and coordination of efforts in studying environment are of a great importance in addressing global challenges.

ЛАБОРАТОРИЯ биогеохимических циклов в лесных экосистемах

Thank you for your time!