

## USING OF BIOMARKERS FOR ANALYSIS OF FIRE PLUMES IN COMPLEX RESEARCH OF WILDFIRES IN CENTRAL SIBERIA



Alexey Panov<sup>1</sup>, A. Prokushkin<sup>1</sup>, A. Bryukhanov<sup>1</sup>, M. Korets<sup>1</sup>, E. Ponomarev<sup>1</sup>,  
A. Myers-Pigg<sup>2</sup>, P. Loucharn<sup>2,3</sup>, N. Sidenko<sup>1</sup>, R. Amon<sup>2</sup>, M. Andreae<sup>4</sup>, M.  
Heimann<sup>5</sup>

[alexey.v.panov@gmail.com](mailto:alexey.v.panov@gmail.com)

<sup>1</sup> V.N. Sukachev Institute of Forest SB RAS, Krasnoyarsk, Russia

<sup>2</sup> Department of Oceanography, Texas A&M University, Texas, USA

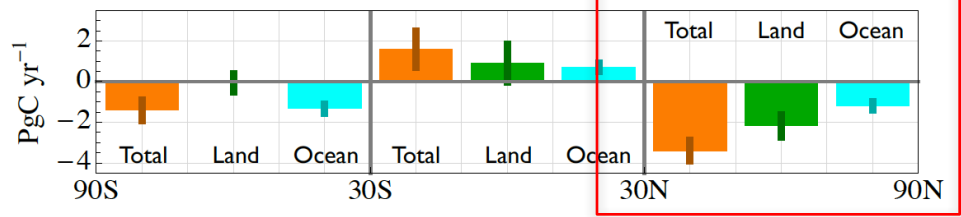
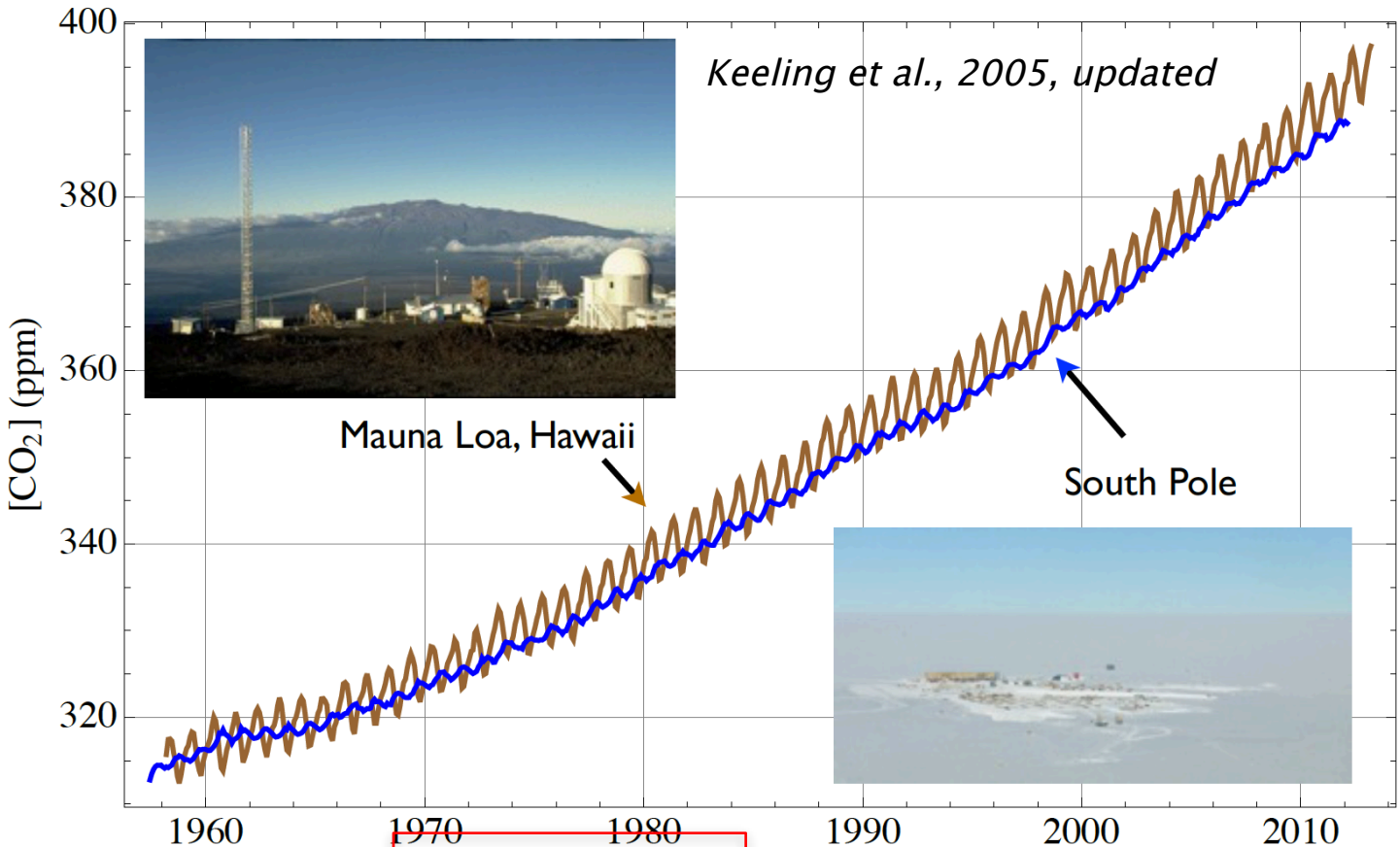
<sup>3</sup> Department of Marine Sciences, Texas A&M University, Texas, USA

<sup>4</sup> Max Planck Institute for Chemistry, Mainz, Germany

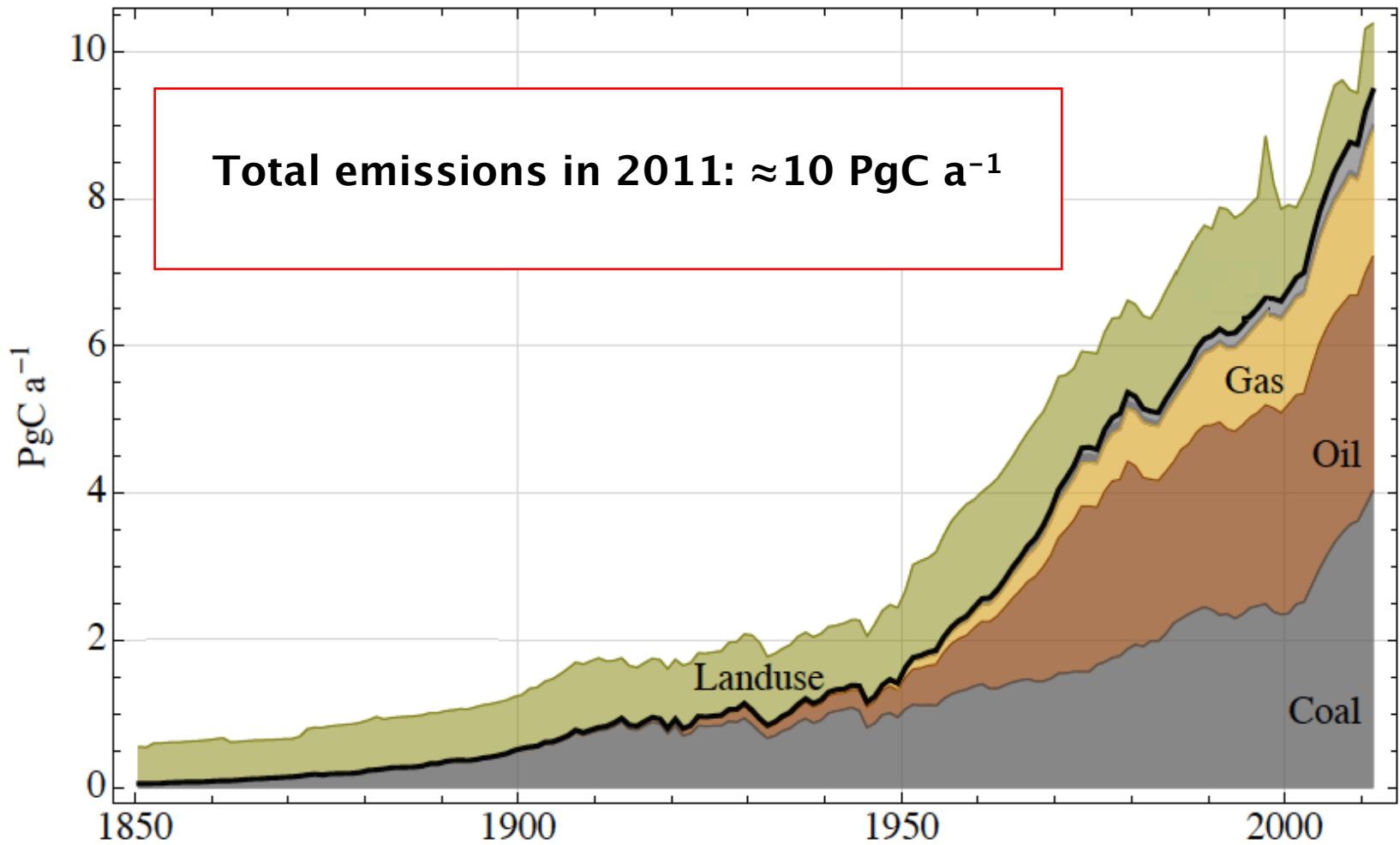
<sup>5</sup> Max Planck Institute for Biogeochemistry, Jena, Germany



# Anthropogenic Perturbation of the Global Carbon Cycle: Northern hemisphere has slightly higher concentrations



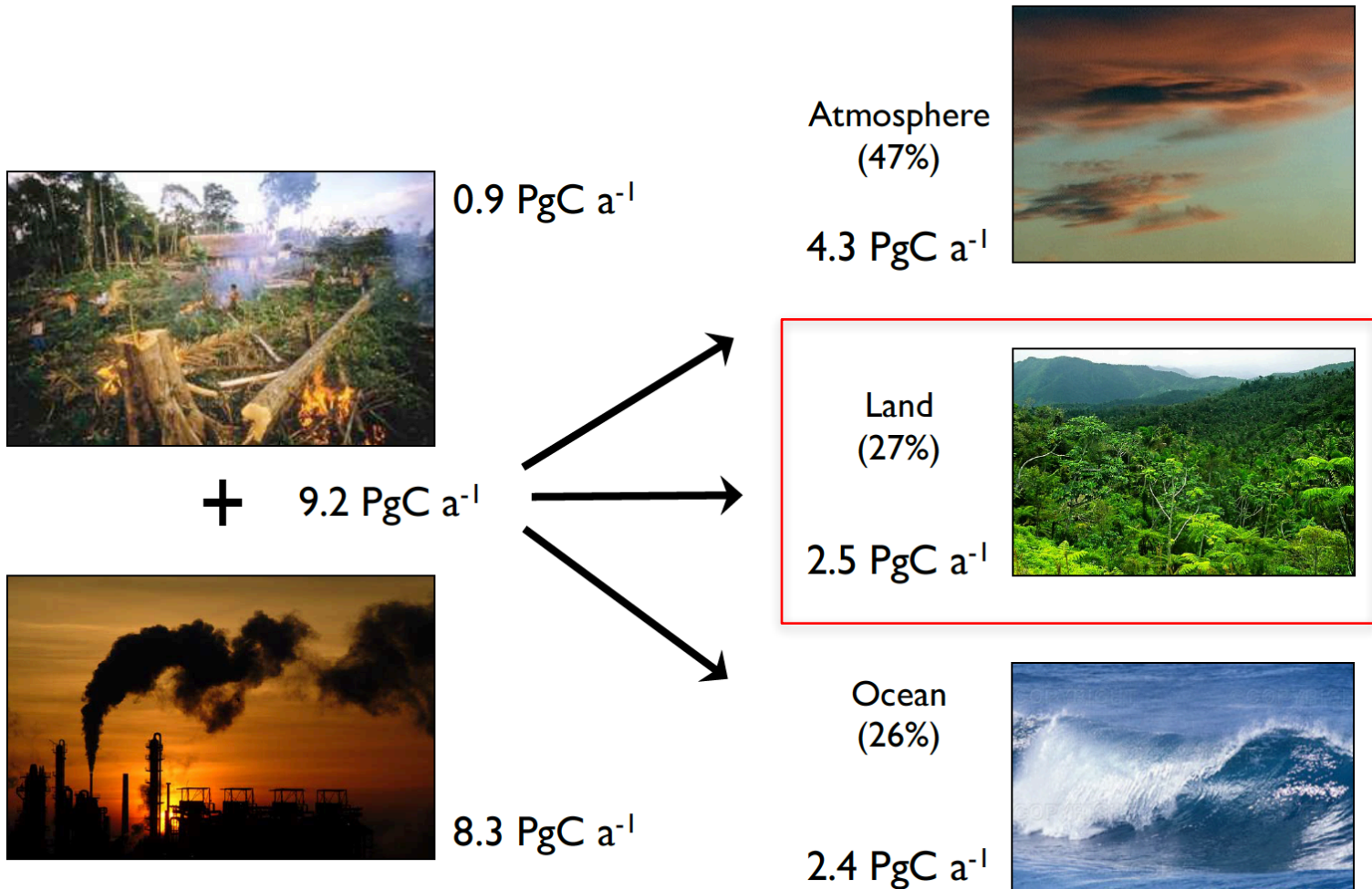
# Anthropogenic Emissions



IPCC, Assessment Report 5, 2013



# The fate of anthropogenic emissions (2002 – 2011)

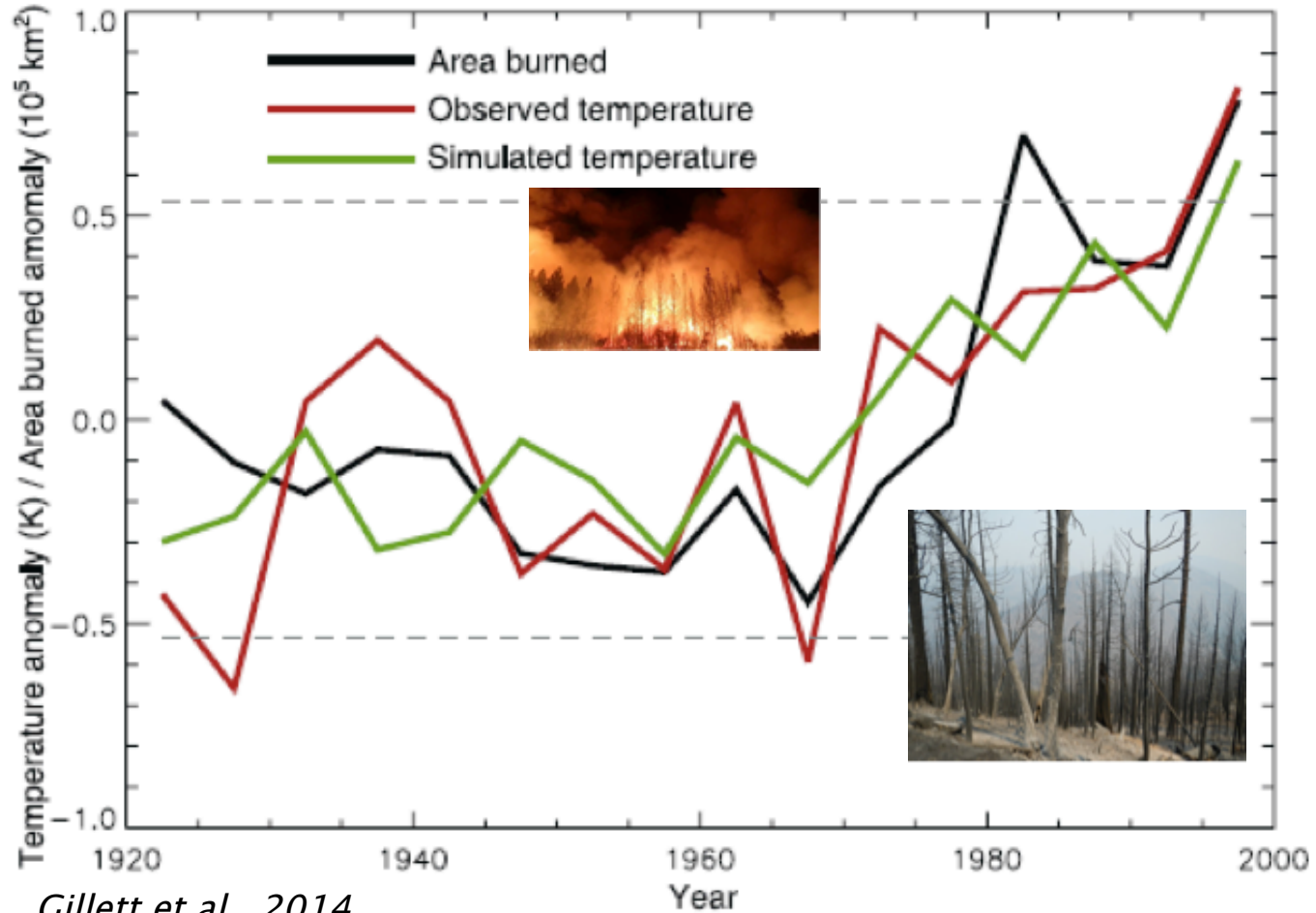


Global Carbon Project, 2015



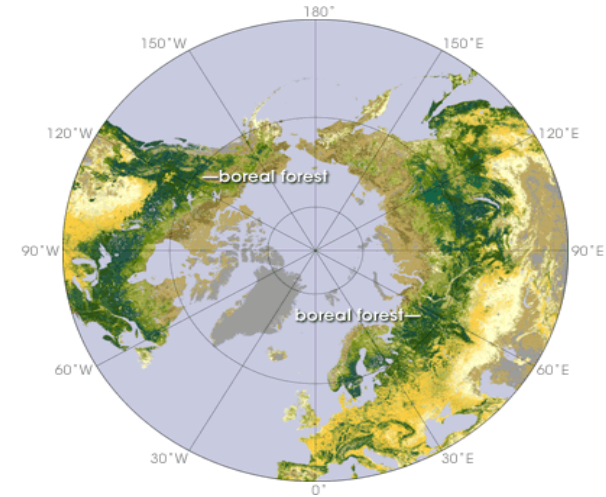
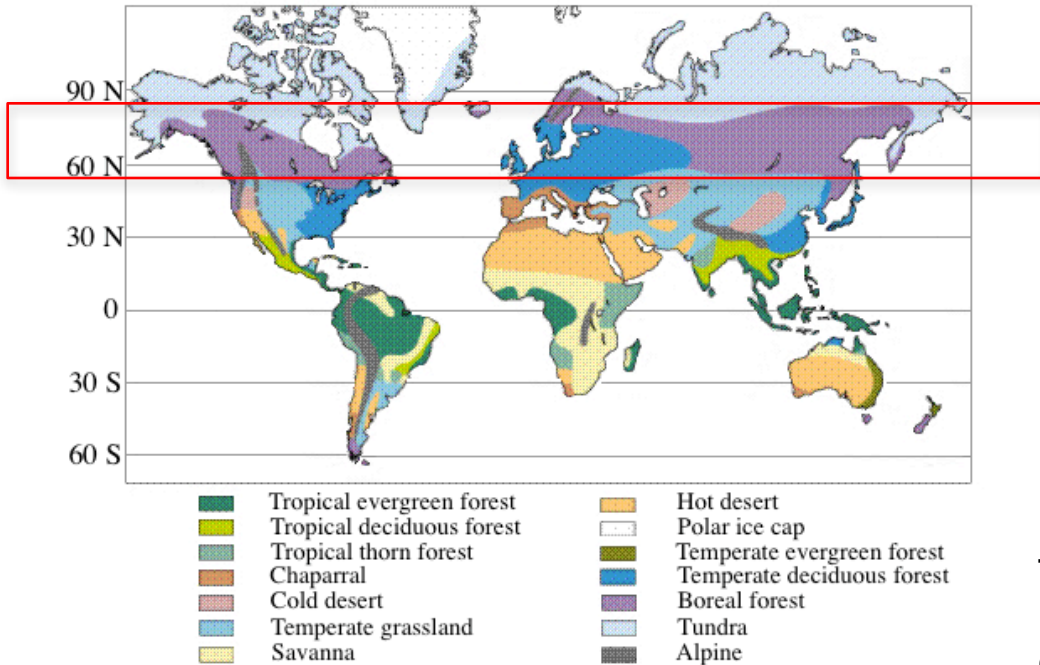


# Growth of amount of wildfires and areas burned: what is more crucial over the long-term?

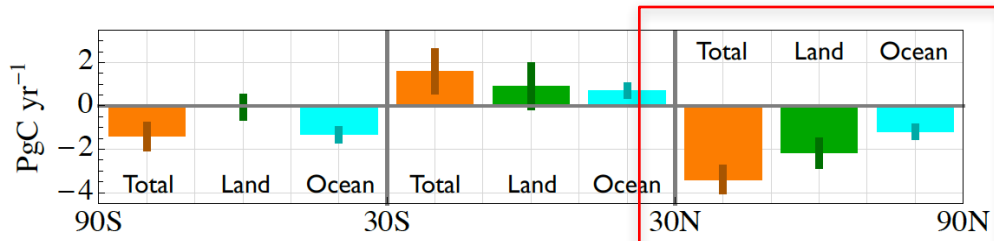


*Gillett et al., 2014*

# Boreal forests



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



*Peylin et al., 2013*

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



# Top-down/bottom-up observation strategies

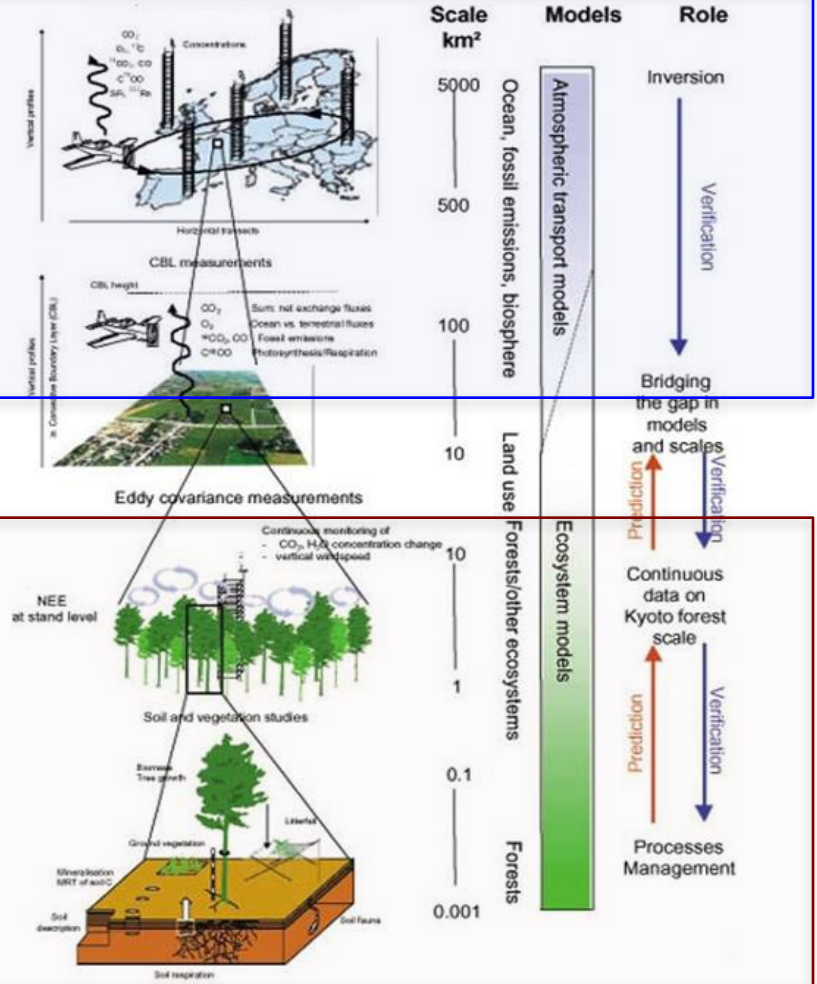
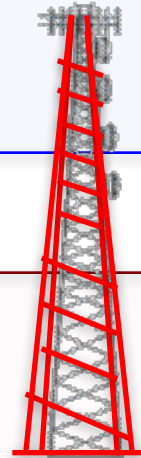
## 'top-down'

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

Tall Towers bridge the gap in scales between global integrative approaches and local process studies

## 'bottom-up'

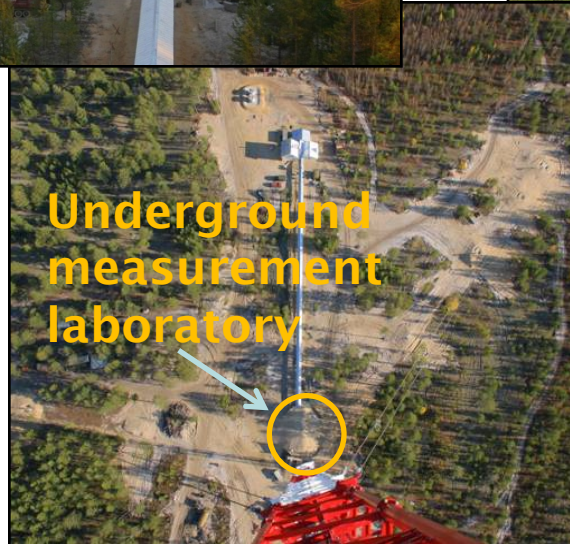
...is based on local in-situ observations of fluxes or changes in ecosystems, to be extrapolated and scaled up in order to make inferences at continental scale





# The Zotino Tall Tower Facility (ZOTTO)

Since 2006, as part of a global cooperative effort the Zotino Tall Tower Facility (ZOTTO; [www.zottoproject.org](http://www.zottoproject.org)) – unique international research platform for large-scale climatic observations is operational in the middle of Siberia



ZOTTO is embedded in the NEESPI, an external project of the International Geosphere-Biosphere Program (IGBP)





## ZOTTO site



Zotino Tall Tower Observatory  
60°N, 90°E

ZOTTO

Krasnoyarsk

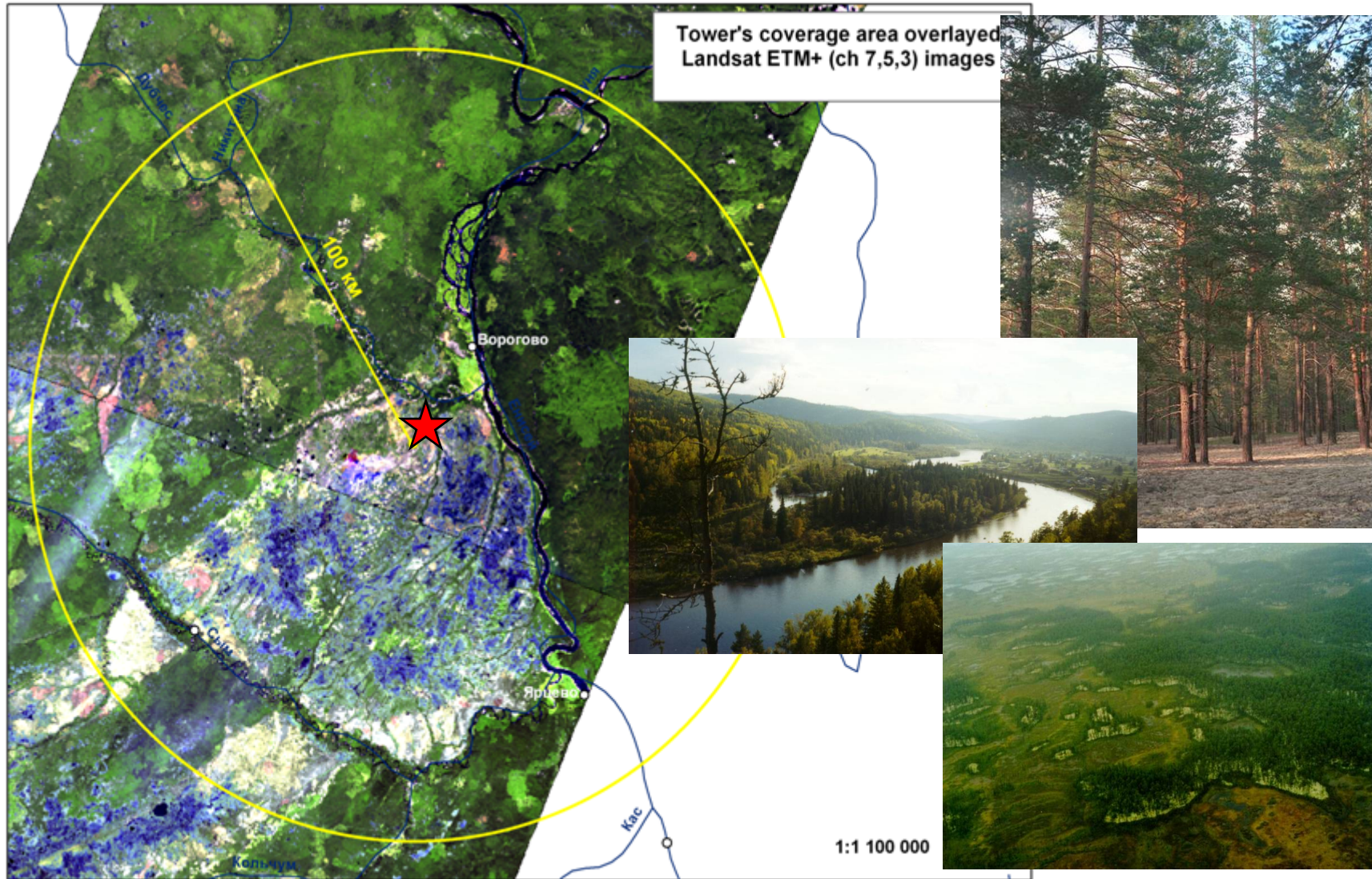


... is located in a boreal zone, in the center of Siberian taiga, 20km west of the Yenisei River and  $\approx 600$ km north of Krasnoyarsk, Siberia





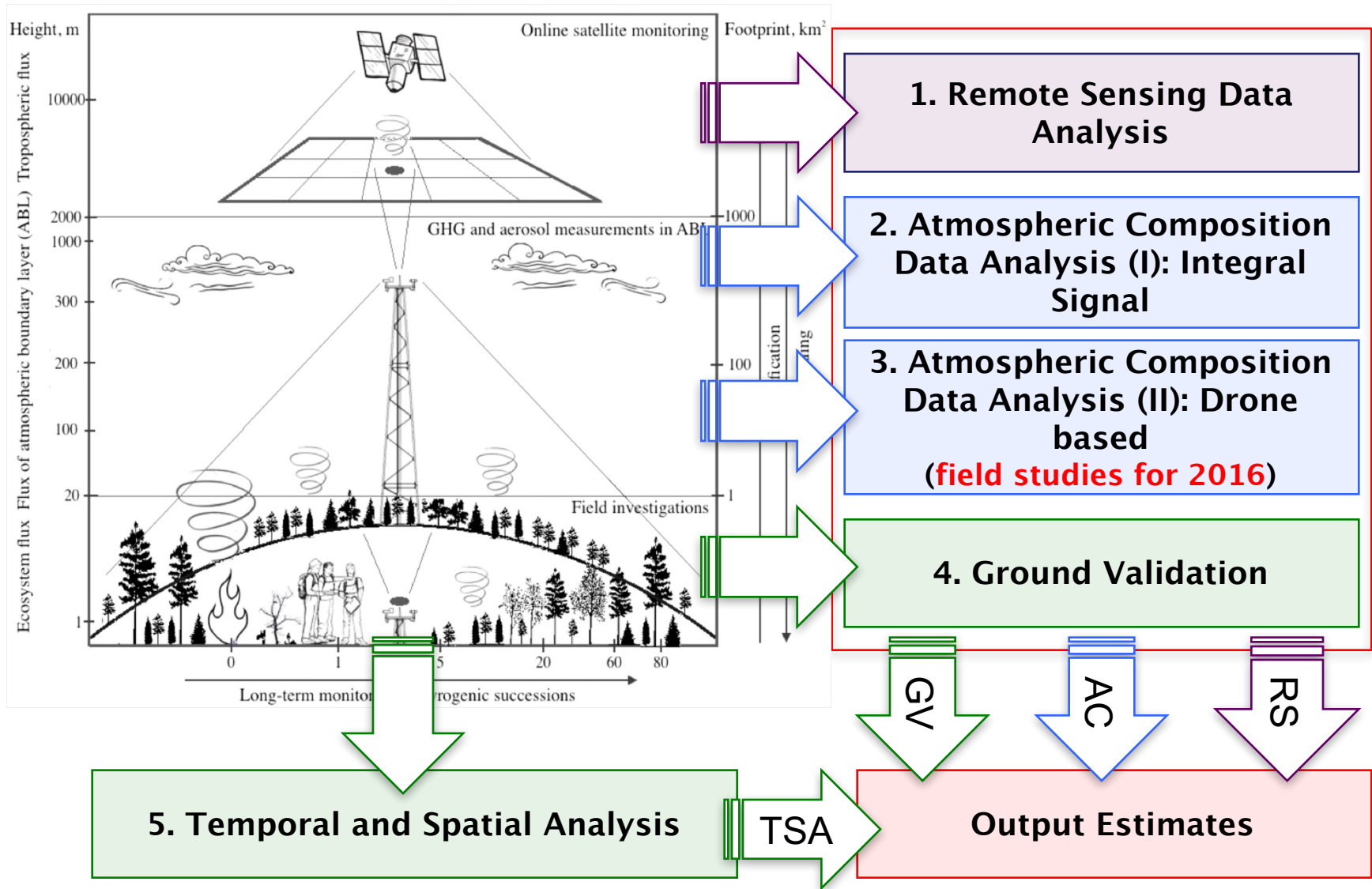
# ZOTTO footprint area



... covers mosaic of light, dark and mixed forests and wetlands – the most representative ecosystem types in Central Siberia

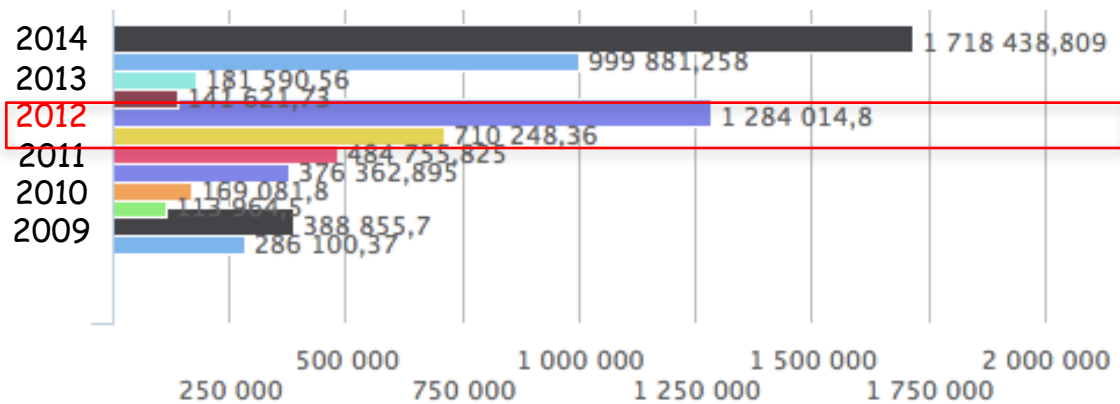
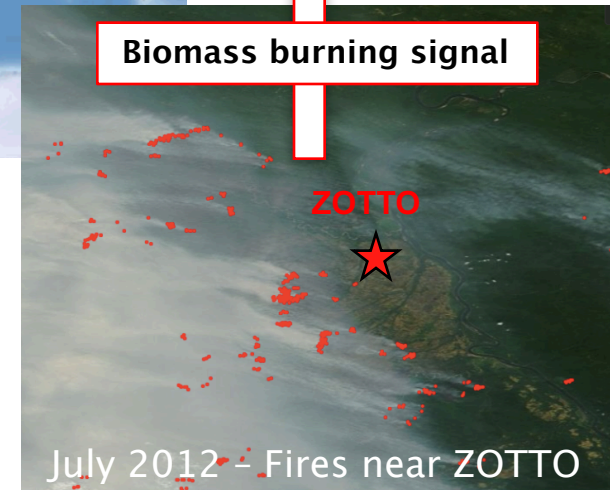
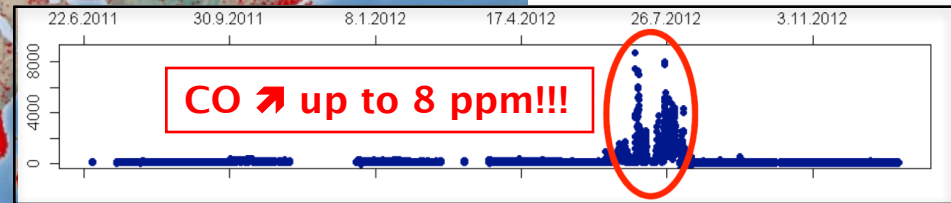
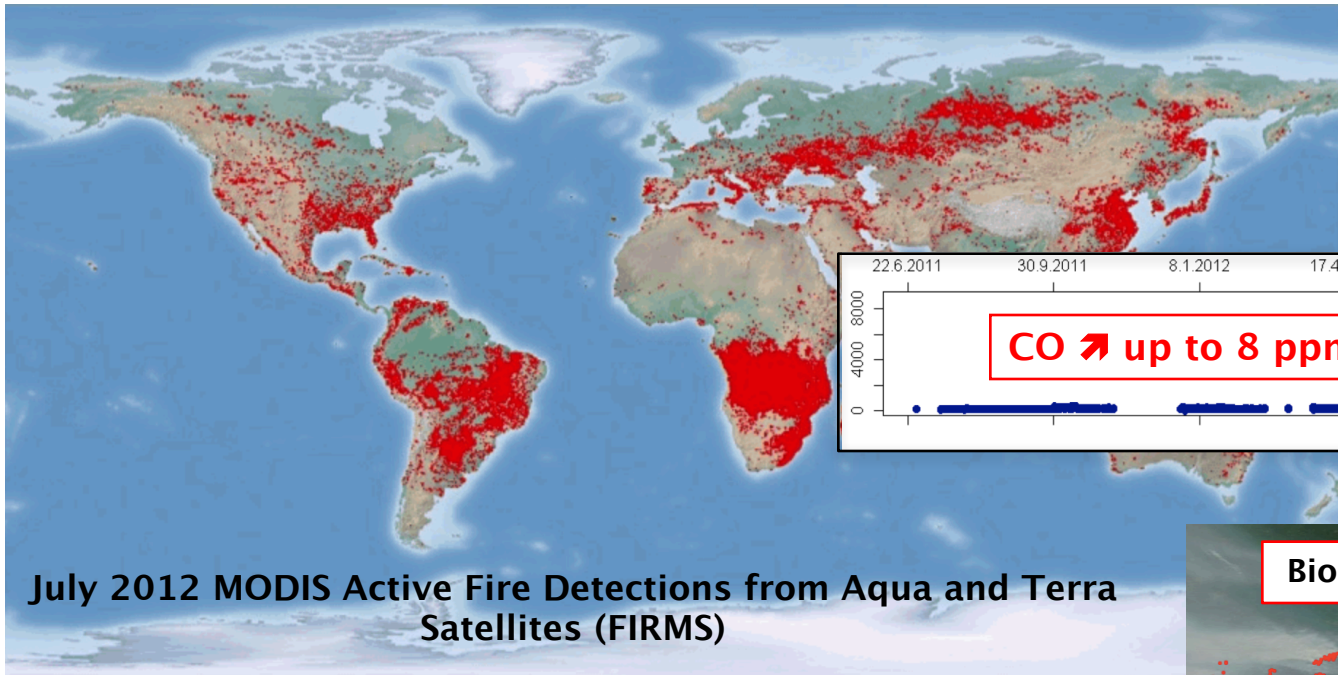


# Study of wildfires: multilevel research platform





# Wildfires in July–August 2012 (Case Study)

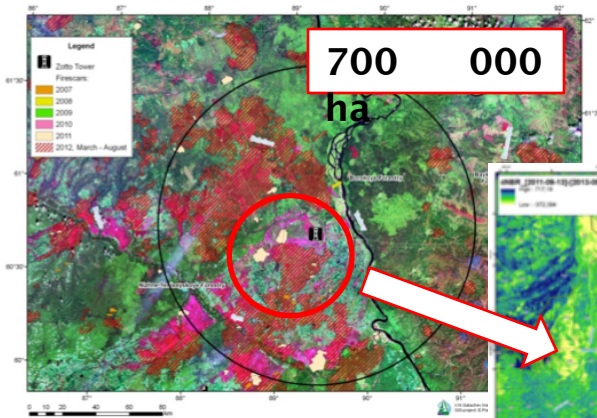


Areas disturbed by wildfires in Siberia (2009–2014), ha

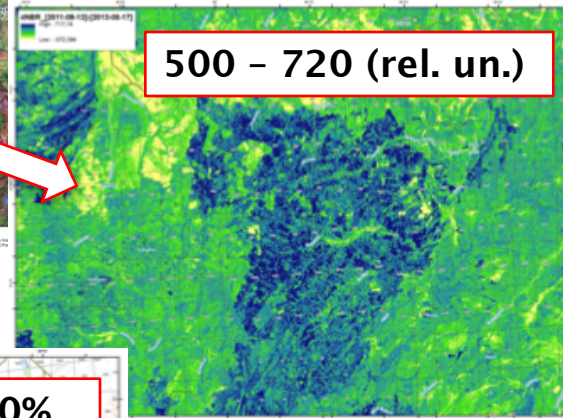




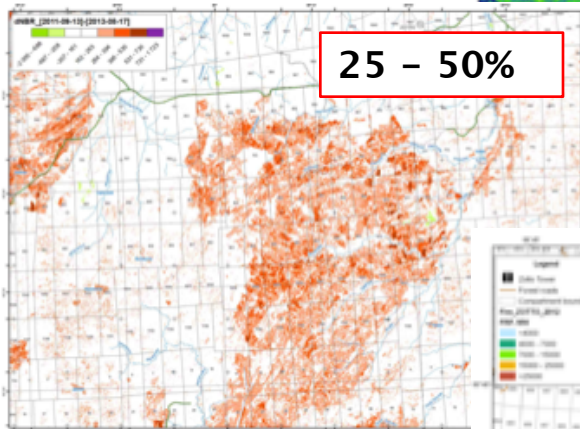
# Remote Sensing Data Analysis



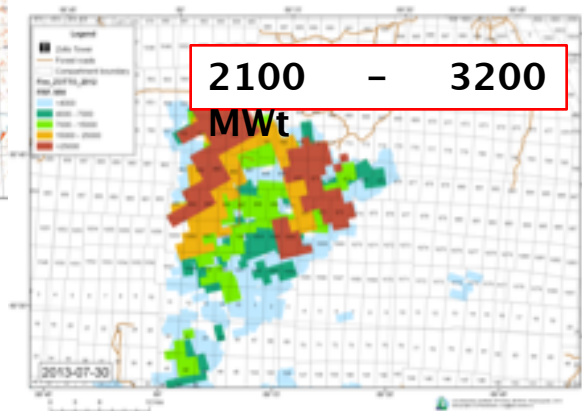
**Active fires and disturbed areas** – Hot Spot Detection Technology from NOAA and Terra MODIS



**“Burn severity”** – Normalized Burn Ratio index (*dNBR*) – preliminary estimation



**Calibration of “Burn severity”** – a field based Composite Burn Index (*CBI*) – verified estimation



**Fire heat release intensity** – fire radiative power (*FRP*) – key for feedback estimations

## Ground Validation of the Remote Sensing and Atmospheric Signal: Network of Study Plots



Lichen pine forest  
12% of area



Moss pine forest  
14% of area



Mixed forest  
35% of area



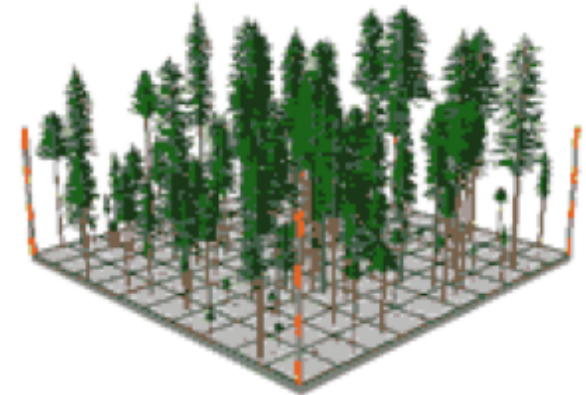
Dark coniferous  
6% of area



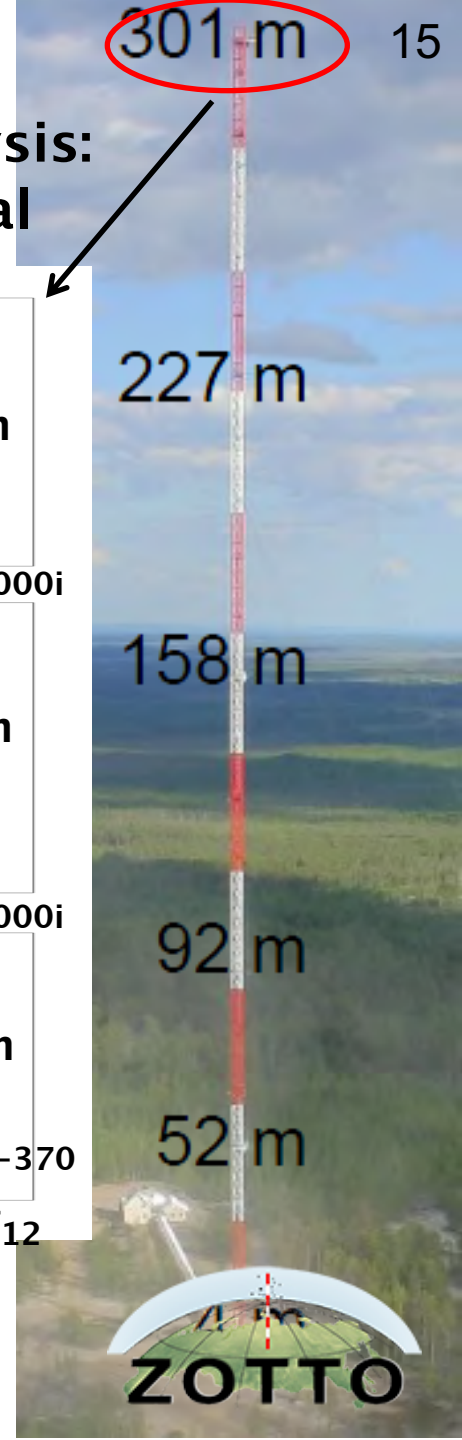
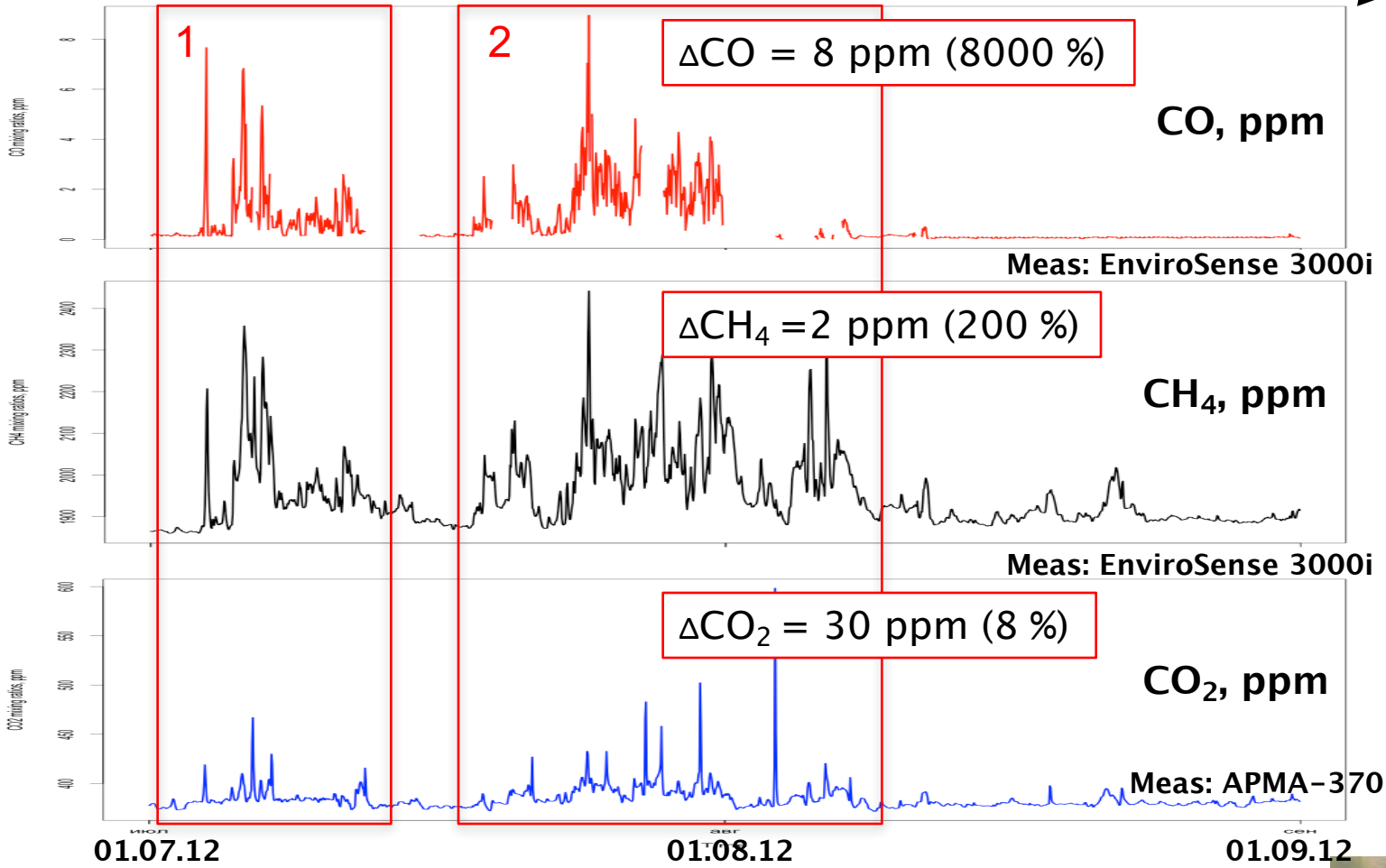
Peat Bog  
13% of area

Permanent study plots within the fire scars areas in dominant ecosystems – will further used for long-term research of biogeochemical processes during ecosystem restoration

Major carbon pools – advance Field Map mapping technology



# Atmospheric Composition Data Analysis: Detection of Biomass Burning Signal

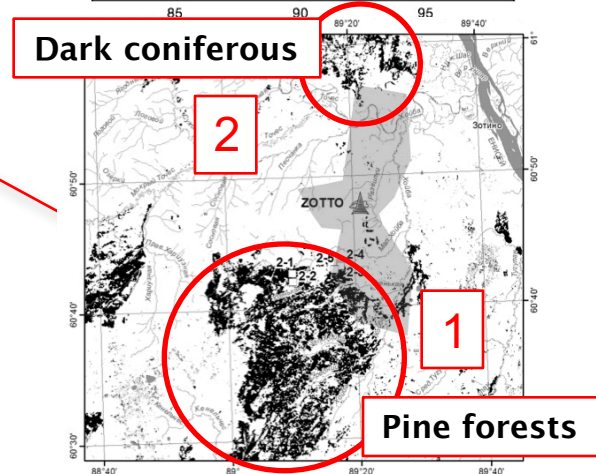
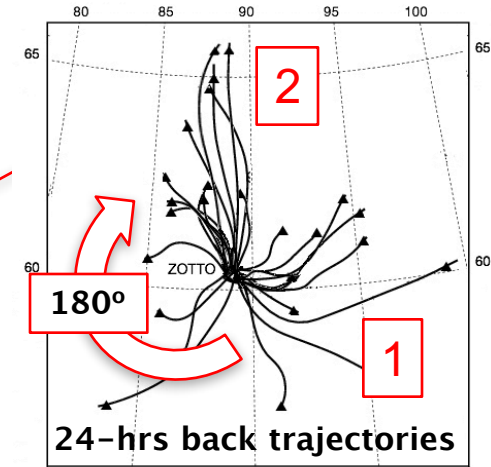
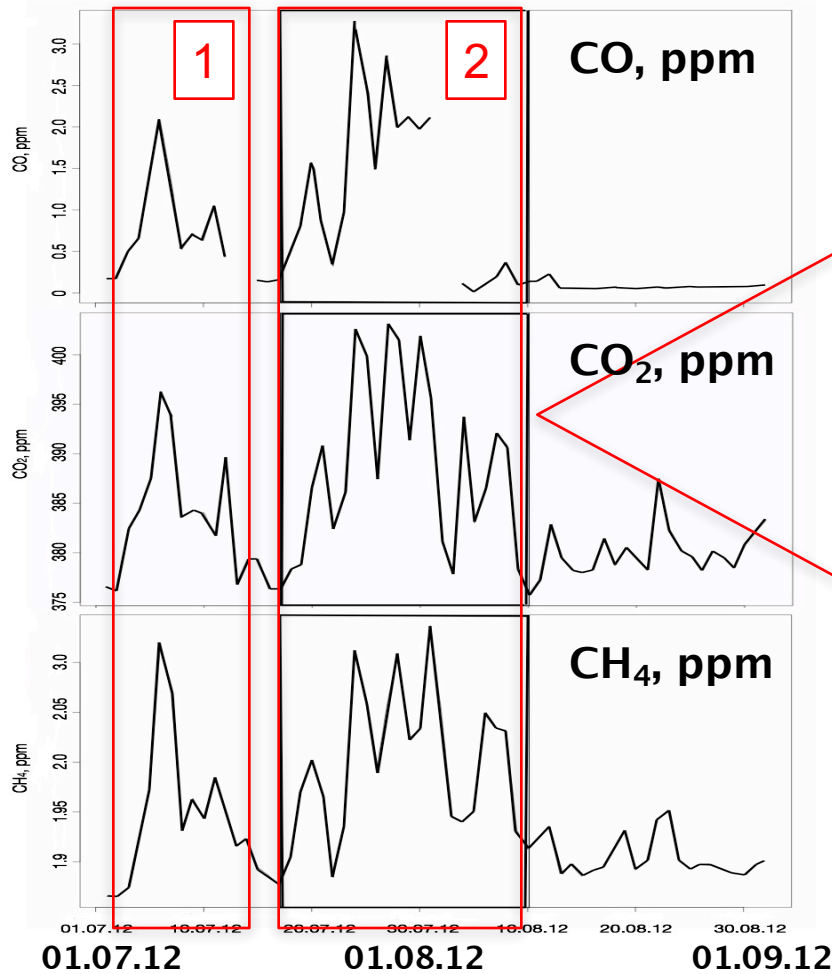


**GHG mixing ratios at 300 m a.g.l.  
(hourly averages)**





# Atmospheric Composition Data Analysis: Integration with Backward Trajectory Modeling (HYSPLIT)

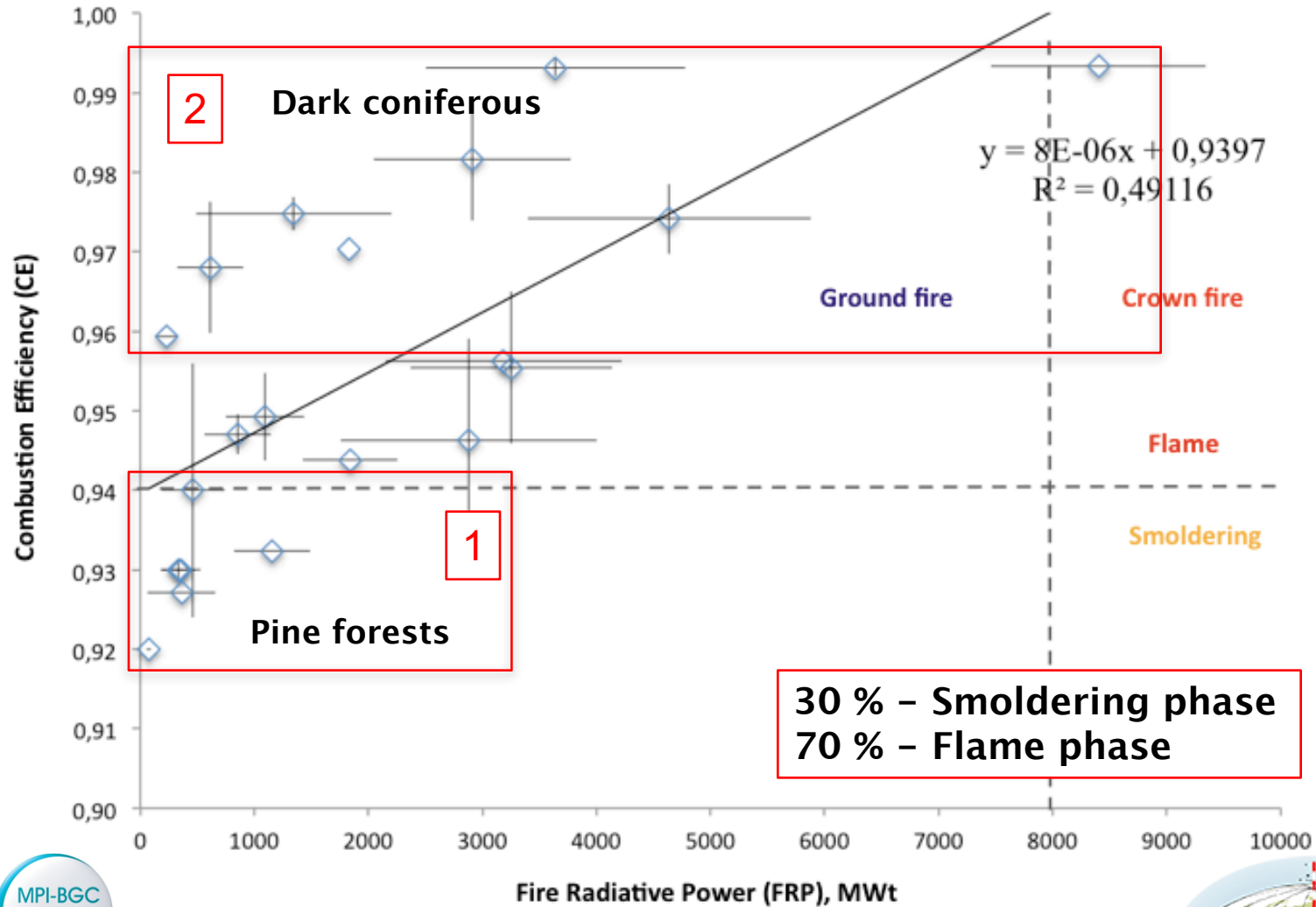


Wind rose/**disturbed areas**

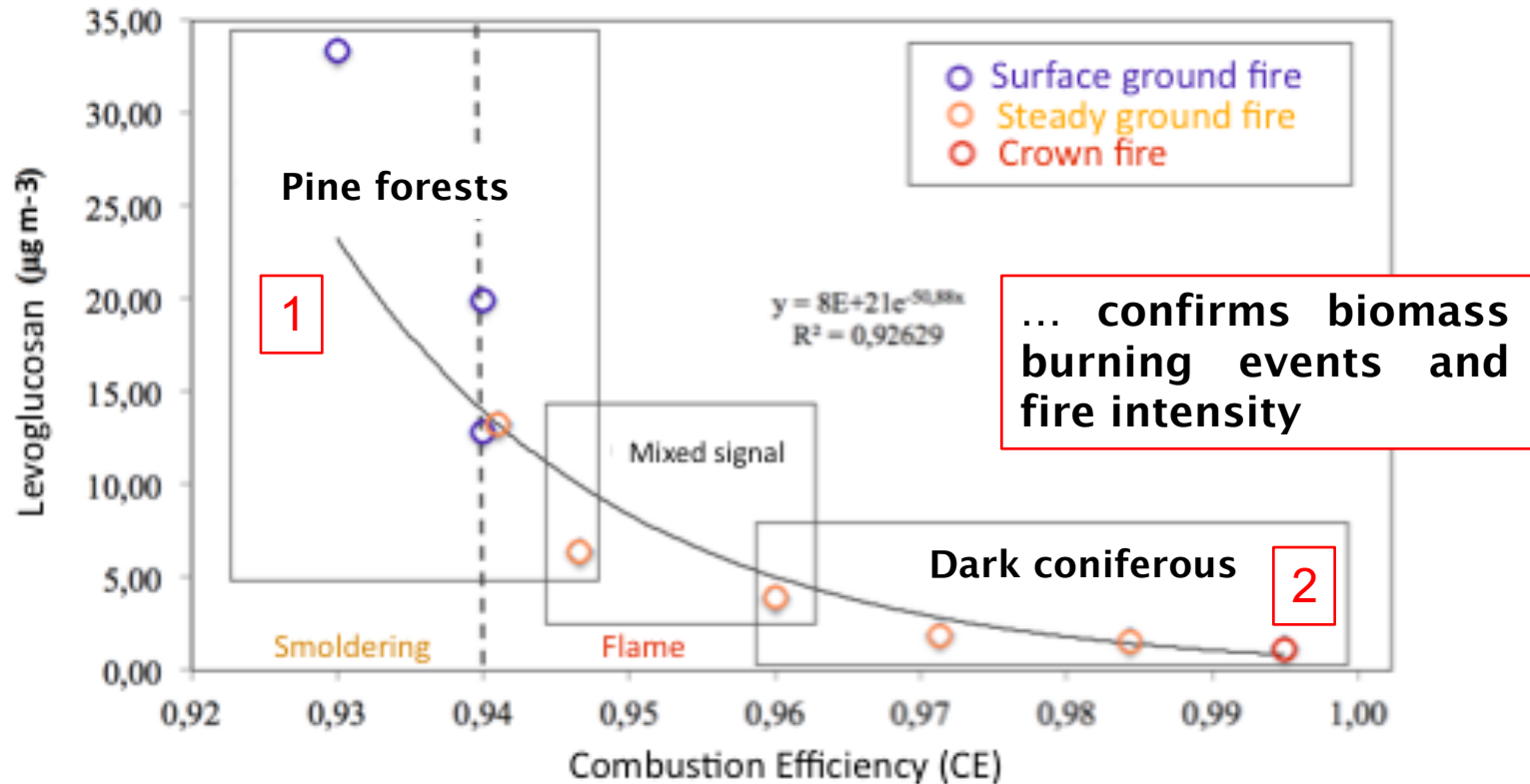




# Atmospheric Composition Data Analysis: Integration with the Remote Sensing

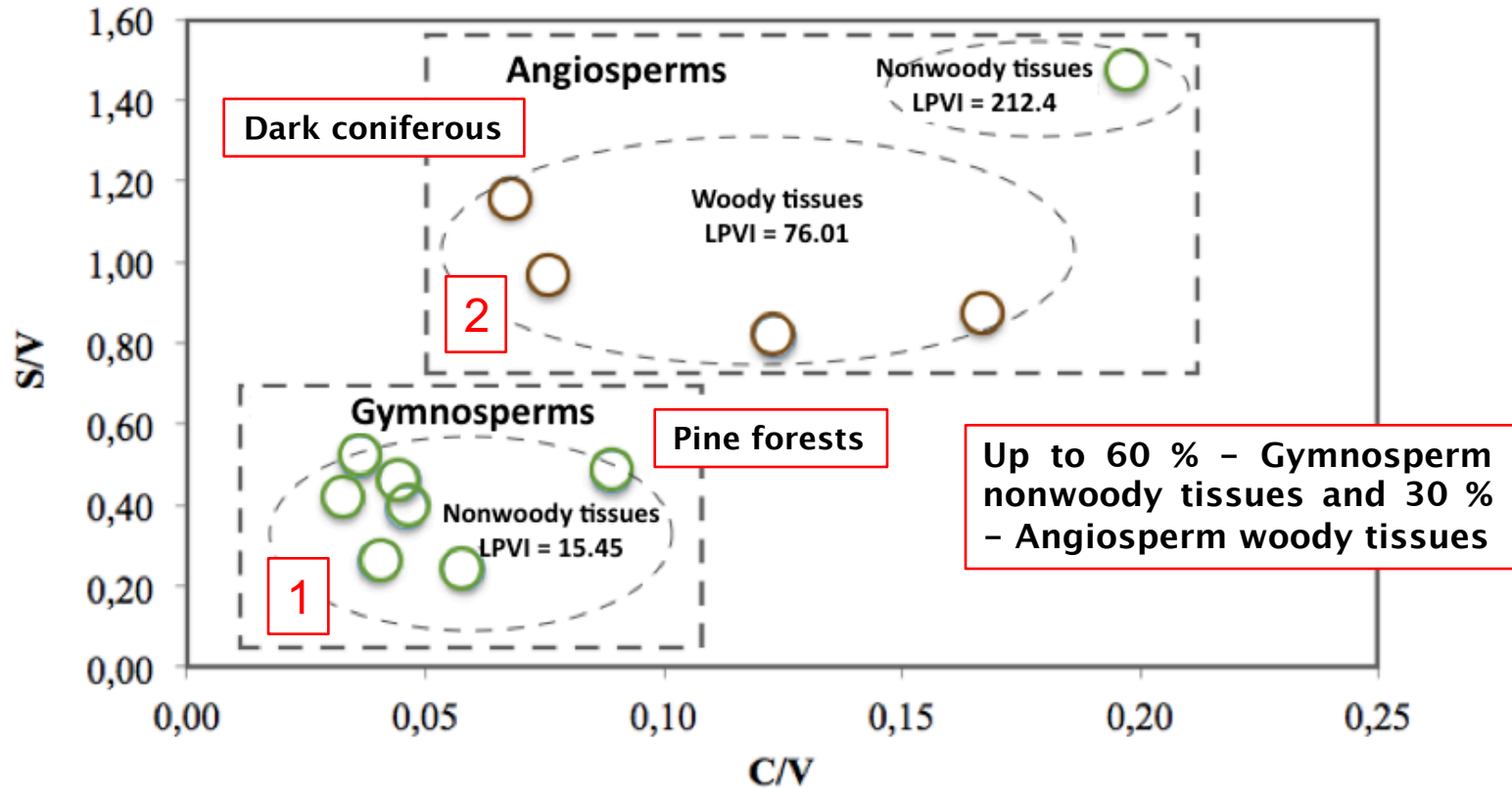


## Atmospheric Composition Data Analysis: Identification of Biological Sources with Biomarkers



Levoglucosan and its isomers (mannosan and galactosan) as dehydro-monosaccharide derivatives are formed exclusively during incomplete fuel combustion containing cellulose/hemicellulose

## Atmospheric Composition Data Analysis: Identification of Biological Sources with Biomarkers



Lignin phenols (vanillyl, syringyl and cinnamyl) – used to differentiate signals among tissue types and vascular plant groups

## Integration of the Remote Sensing, Atmospheric Composition in BL and Ground Validation: Output Estimates

- Remote estimates of atmospheric composition in fire plumes (trace gases, aerosols) over the large area of Central Siberia;
- Emission ratios, factors and other gas/aerosol related parameters (averaged and site-specific) to be used in terms of C emission estimates;
- Biomass burning emissions (total and site-specific);
- Remote and field-based identification of biological sources of OM in wildfire plumes – and conversely – remote detection of fire characteristics based on the biomarkers;
- Feedback modeling of different research outputs in this platform: atmospheric composition, ground estimates and the remote sensing data;
- Temporal and spatial estimates of carbon changes in different Central Siberian ecosystems after wildfires (long-term task);
- **Linking ecosystem signal during restoration after wildfires and the atmospheric response (short-term/long-term).**





**Thank you for your time!**

