18 Years of Collaborative Fire Research in Siberia:
Accomplishments and Perspectives

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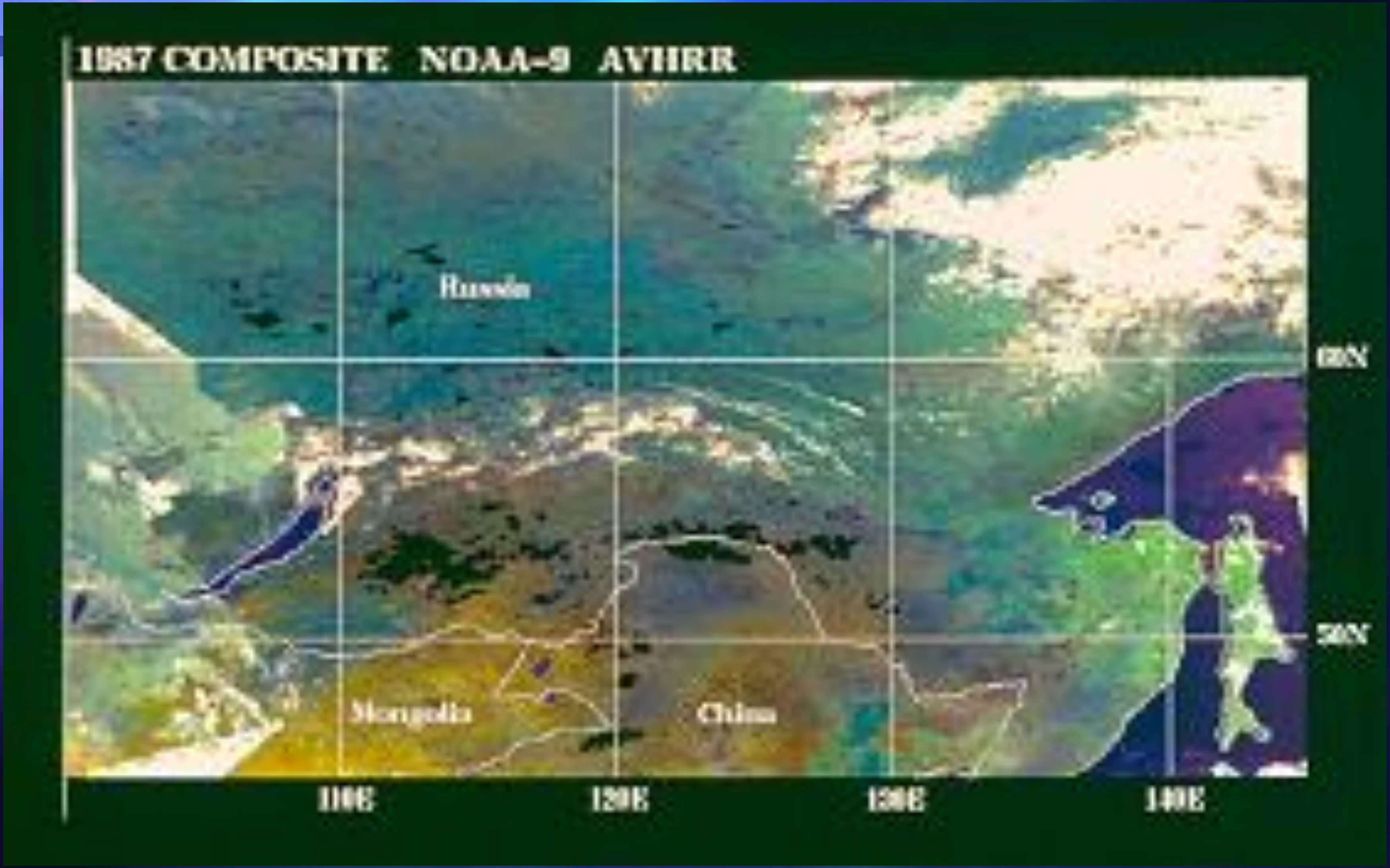
Background

- Globally there are about 1.2 billion ha of boreal forest and woodlands
- Over 30% of the global terrestrial biomass is in boreal forests (2/3 of this in Russia).
- Until recently the international science community had little understanding of the important role of fire in northern Eurasia.
- We now know that wildland fire affects some 10 to 20 million ha of boreal forest annually—mostly in Russia.

Beginnings of awareness (in NA)



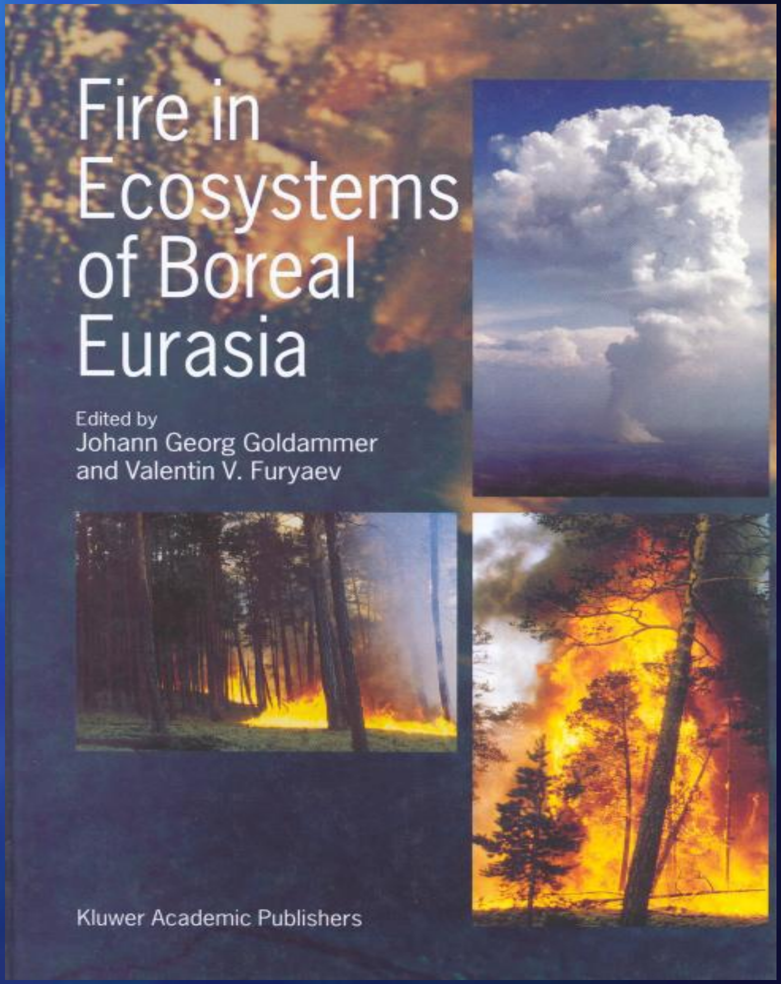
Cahoon et al. 1991

Seminal "intergovernmental" collaborations on forest and fire research in Russia

- 1991 International Boreal Forest Research Association (IBFRA) " promote and co-ordinate research…on…the role of…boreal forests in the global environment and the effects of environmental change..."
- Early 1990's—USFS R&D collaborations on forest research in Russia (Alexeyev and Birdsey; Tchebakova and Monserud; McFadden and Baranchikov).
- 1993-2000--U.S. Russian Joint Commission on Economic and Technological Cooperation Environmental Working Group (Gore-Chernomyrdin)
  - NASA, RNAS, U VA, U Mich., etc. compared remote sensing data for fire and land surface observations. (Gore-Chernomyrdin)
- 199?-2000--NASA Earth Science Working Group (ESWG); US researchers and Russian National Academy of Sciences; later also Canadian researchers.
- 2000-present NEESPI; spin-off from ESWG, initiated by NASA

A Pivotal Event

- 1993--Conference on Fire in Boreal Ecosystems was the first large international research conference on fire in Siberia. (Goldammer and Furyaev)
- Conference led to the first English-language book on fire in Russia



Bor Forest Island—1993

- 1993--Bor Forest Island experiment associated with this meeting brought together fire researchers from nine countries in a joint field project in central Krasnoyarsk Region of Siberia.
- Beginning of a number of ongoing research collaborations.

Growing collaboration in fire research

- Many current collaborations on fire research in Siberia were stimulated or enhanced by the 1993 Fire Congress and the Bor Forest Island fire experiment.
- Fire history research (Tom Swetnam and Sukachev Institute researchers)
- Remote sensing, fire effects and fire behavior research
  - 1994-95—AVHRR satellite downlink station established at Sukachev Institute in Krasnoyarsk in collaboration with NASA.
  - 1996-present—broad coverage from this receiving station.
  - 1994-97 annual visits by Conard and others to Russia—building understanding and collaboration—lots of field trips!
  - Ongoing discussions on experimental approach to assessing fire behavior and effects in Scots pine forests.

The FIREBEAR (Fire Effects in the Boreal EurAsian Region) project—1998 to present

- Collaboration on remote sensing of active fires and burned area
- Experimental burns in Scots pine and mixed conifer/larch forests
- Integrating experimental data with aircraft and satellite remote sensing and with weather data
- Research on interactions between fire and logging
- Better understanding of role and effects of fire and variability in time and space
  - Fire emissions
  - Fire behavior
  - Ecosystem effects
  - Management impacts
  - Carbon and fire/climate interactions

FIREBEAR funding

Early funding (1993-1999)

- USDA Foreign Agriculture Service
- USFS International Programs
- USFS R&D

2000-present

- NASA grants in 2000, 2004, 2009
- CRDF grant in 2002
- USFS
- Canadian FS
- Russian National Academy of Science
- ISTC (International Science and Technology Cooperation) program

Research Collaborators:

Russian Forest Service

- Forestry Committee and Leshozes, Krasnoyarsk Region
- Forest Protection Airbases, Krasnoyarsk Region
- Avialesookhrana headquarters, Pushkino, Moscow region

Russian National Academy of Science, Siberian Branch

- V.N. Sukachev Institute of Forest, Krasnoyarsk
- Institute of Chemical Kinetics and Combustion, Novosibirsk

Universities

- Siberian Technological University
- St. Petersburg Forestry University
- University of Arizona

US Forest Service

- Rocky Mountain Research Station
- Northern Research Station
- International Programs

Forestry Canada, CFS

- Great Lakes Forestry Centre

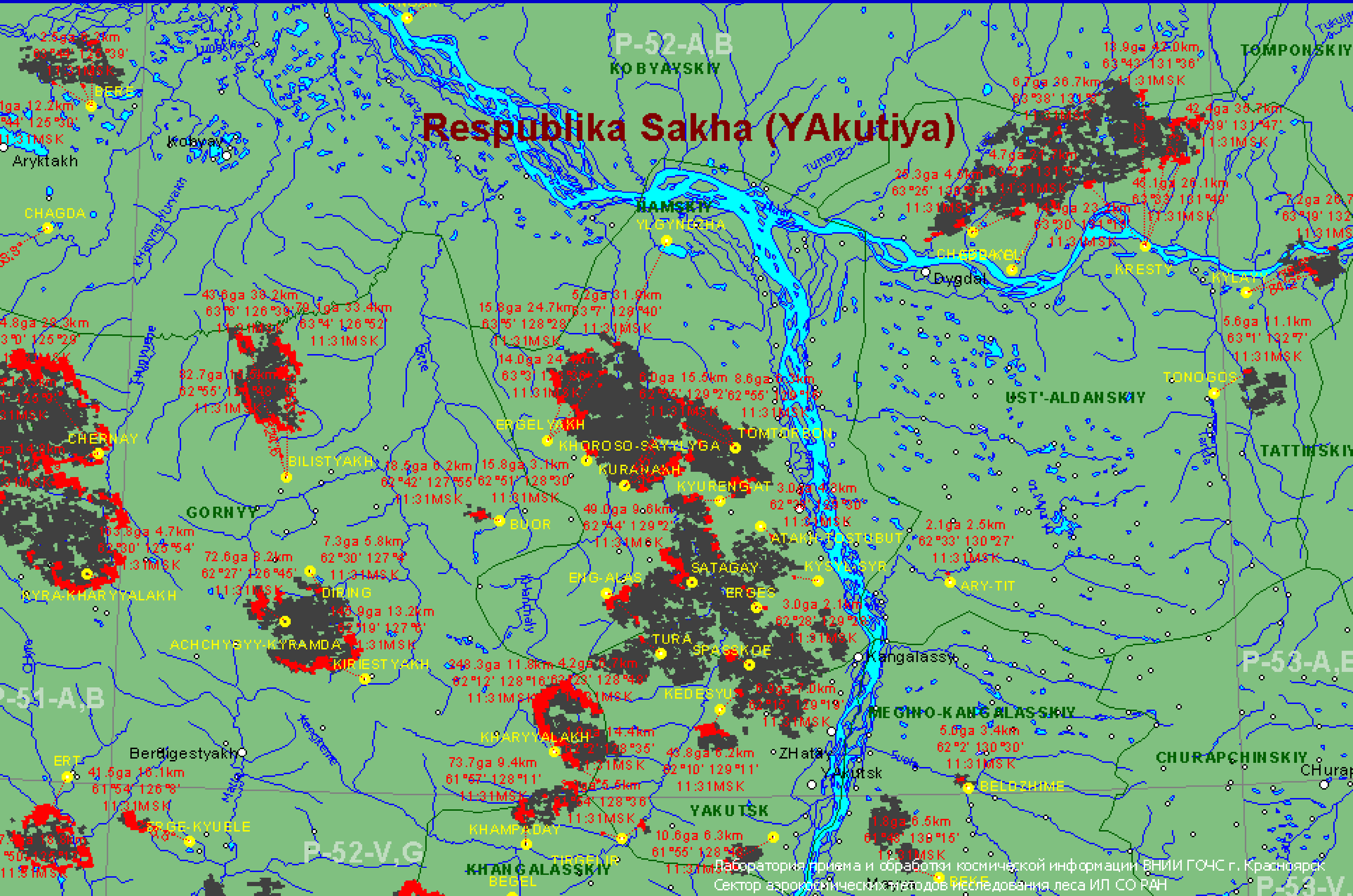
National Institute of Aerospace

Coordination with other NASA, ISTC and CFS-funded research

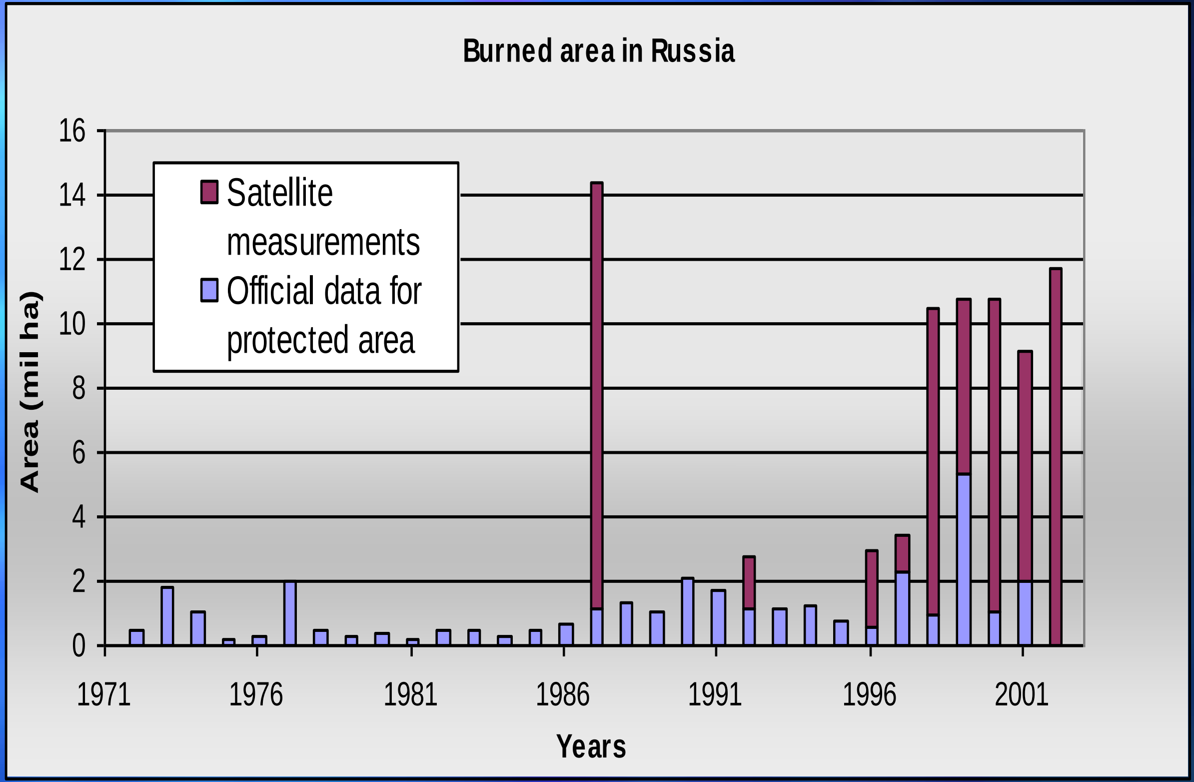
Collaborations, spinoffs, outputs

- Linkages with U MD, ERIM, UVA, etc.
  - *e.g.* Amber Soja initially came to Russia with us in 2001, got her PhD with Hank Shugart, and is now a LCLUC investigator
  - Collaborations between Sukhinin (Sukachev) and French, Soja, Csiszar, Hao and others on remote sensing of fires
- Russian colleagues achieved Phd or "Doctor" level based on work conducted under this project.
  - Three Doctoral dissertations
  - 6 "candidate" dissertations
- 30+ project-related publications since 2002; many in Russian-language journals.
  - IJWF Special Issue in process
- 70+ presentations and proceedings publications.
- Many awards
  - Fulbright Fellowship—Elena Kukavskaya

Fire hot spot polygons in Yakutia
(red for 14.08.02, black – from beginning of season)



What have we learned?



- Remote sensing data have improved accuracy of burned area estimates for Russia.
- Historically, official data on burned areas in Russia were substantial underestimates.
- There are large interannual variations in burned area.
- Variations are not synchronous across the boreal zone, or within Eurasia.

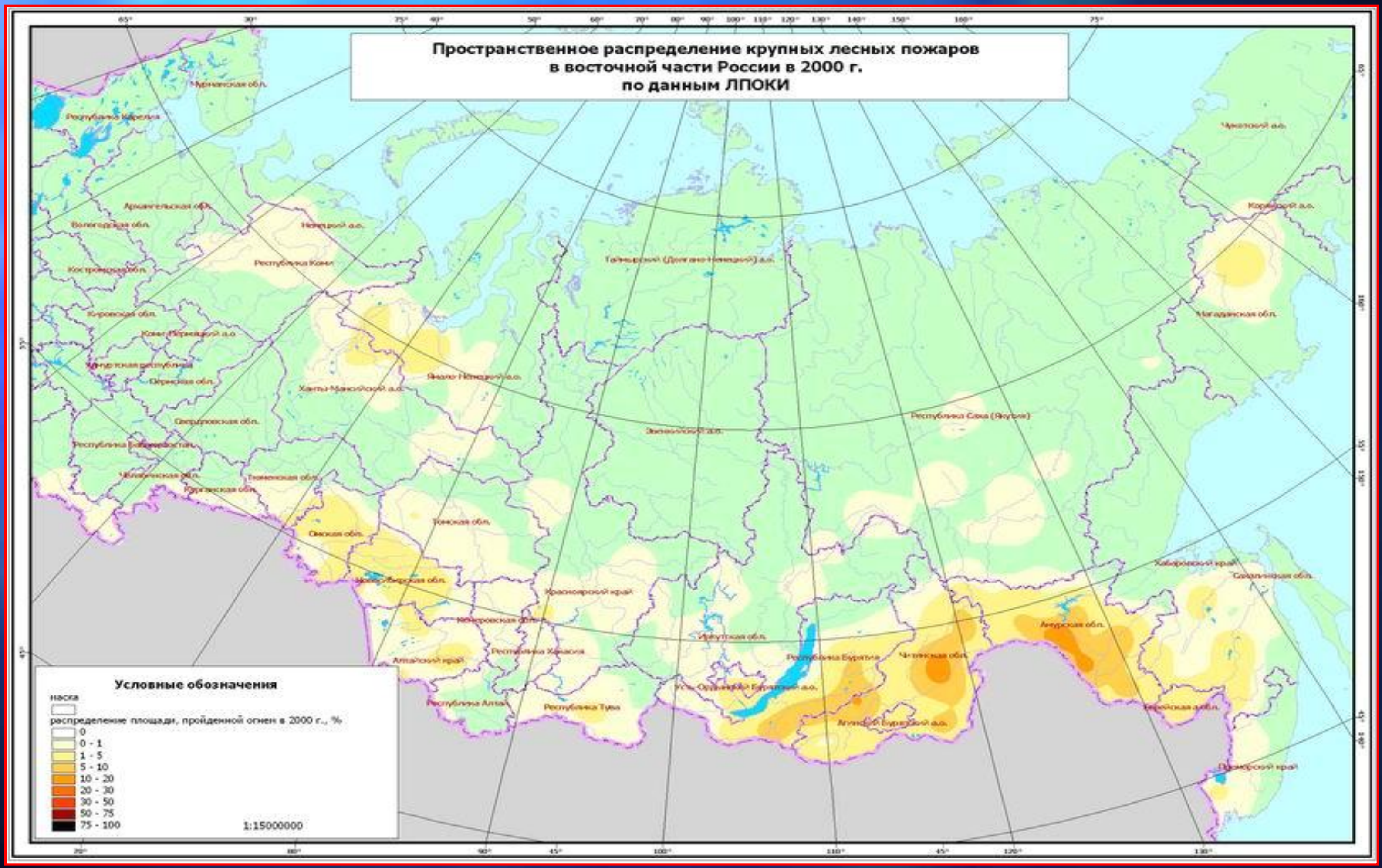
Fire patterns vary from year to year

1998

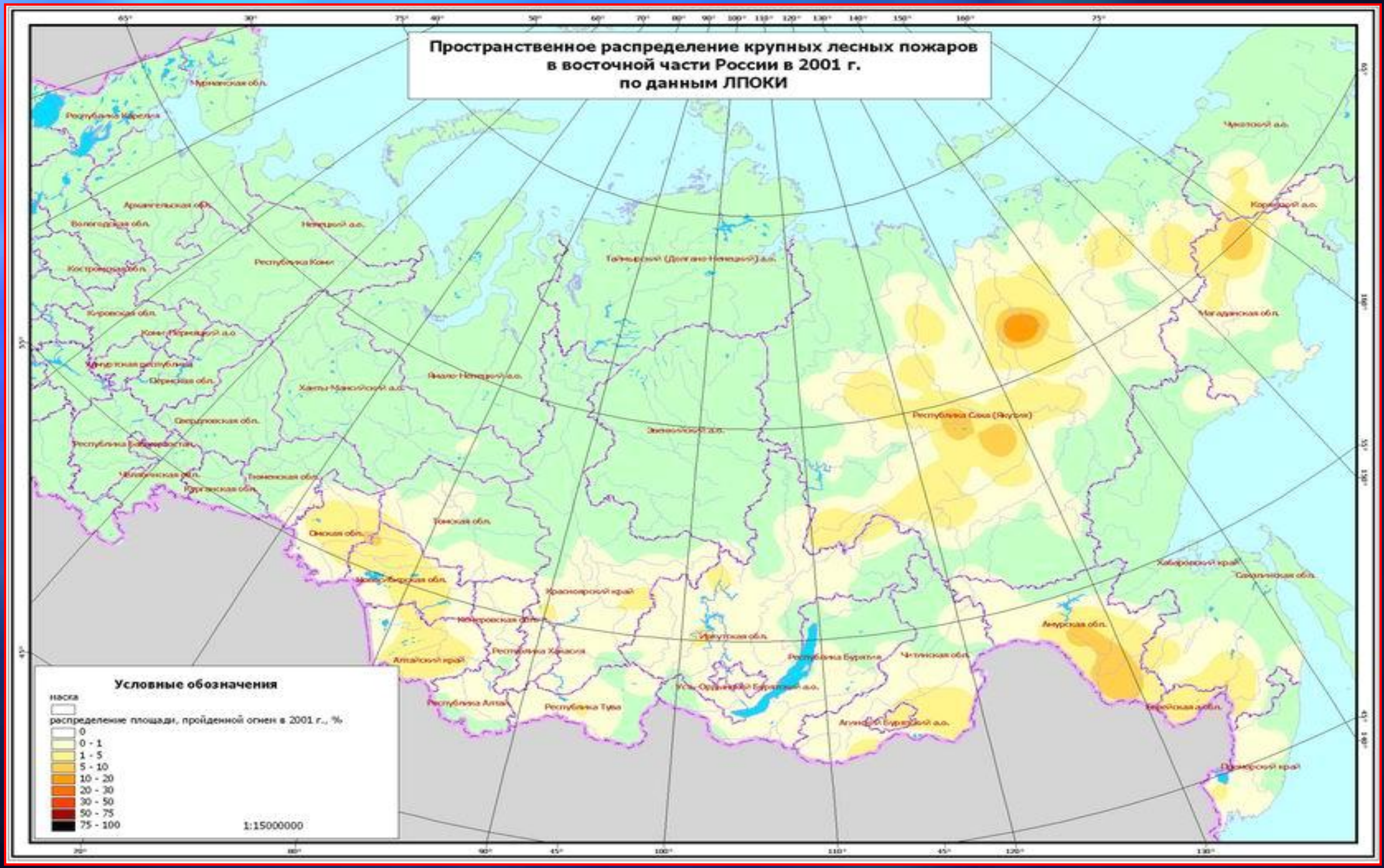
(courtesy Anatoly Sukhinin)

Fire patterns vary from year to year
1999

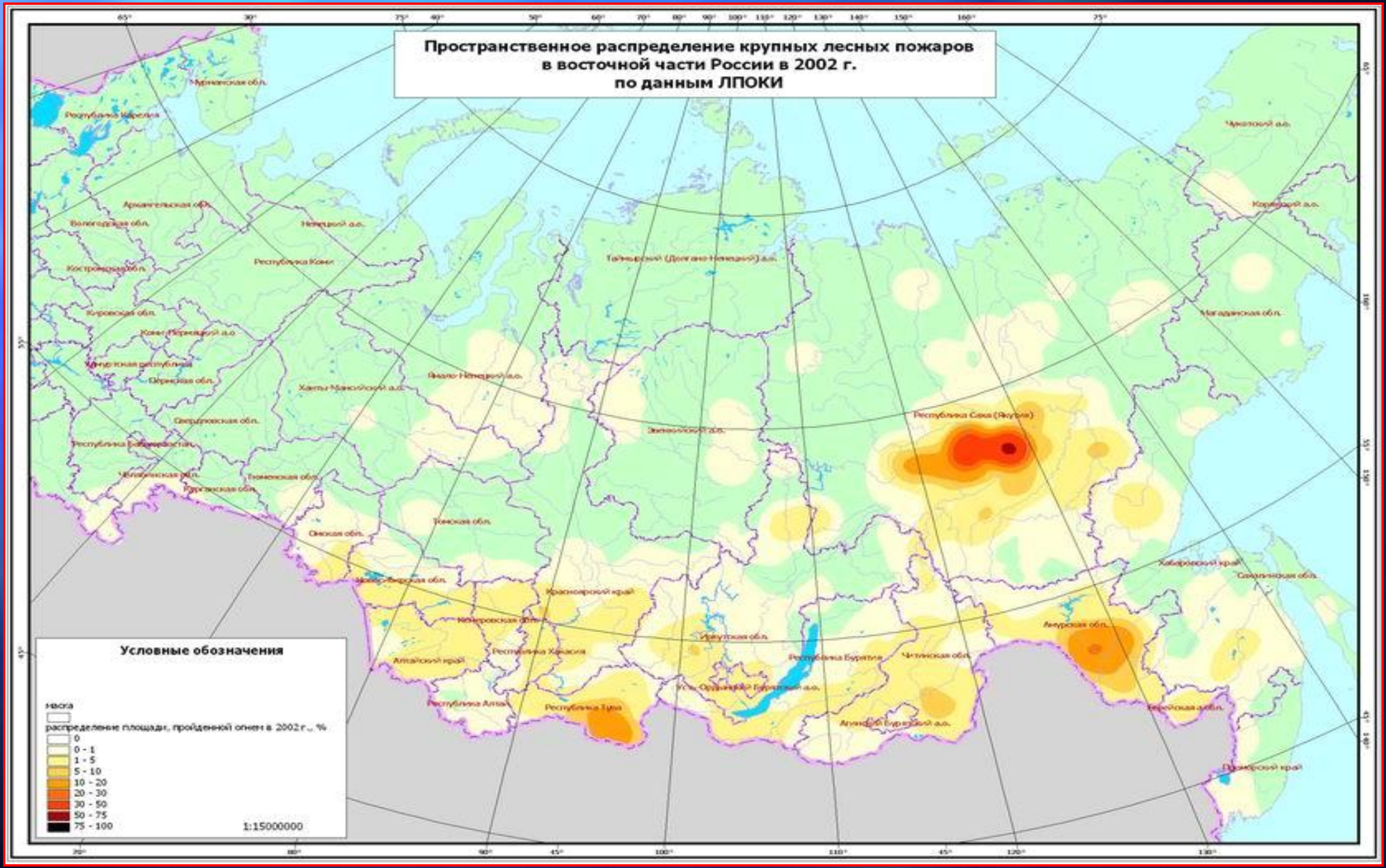
Fire patterns vary from year to year
2000



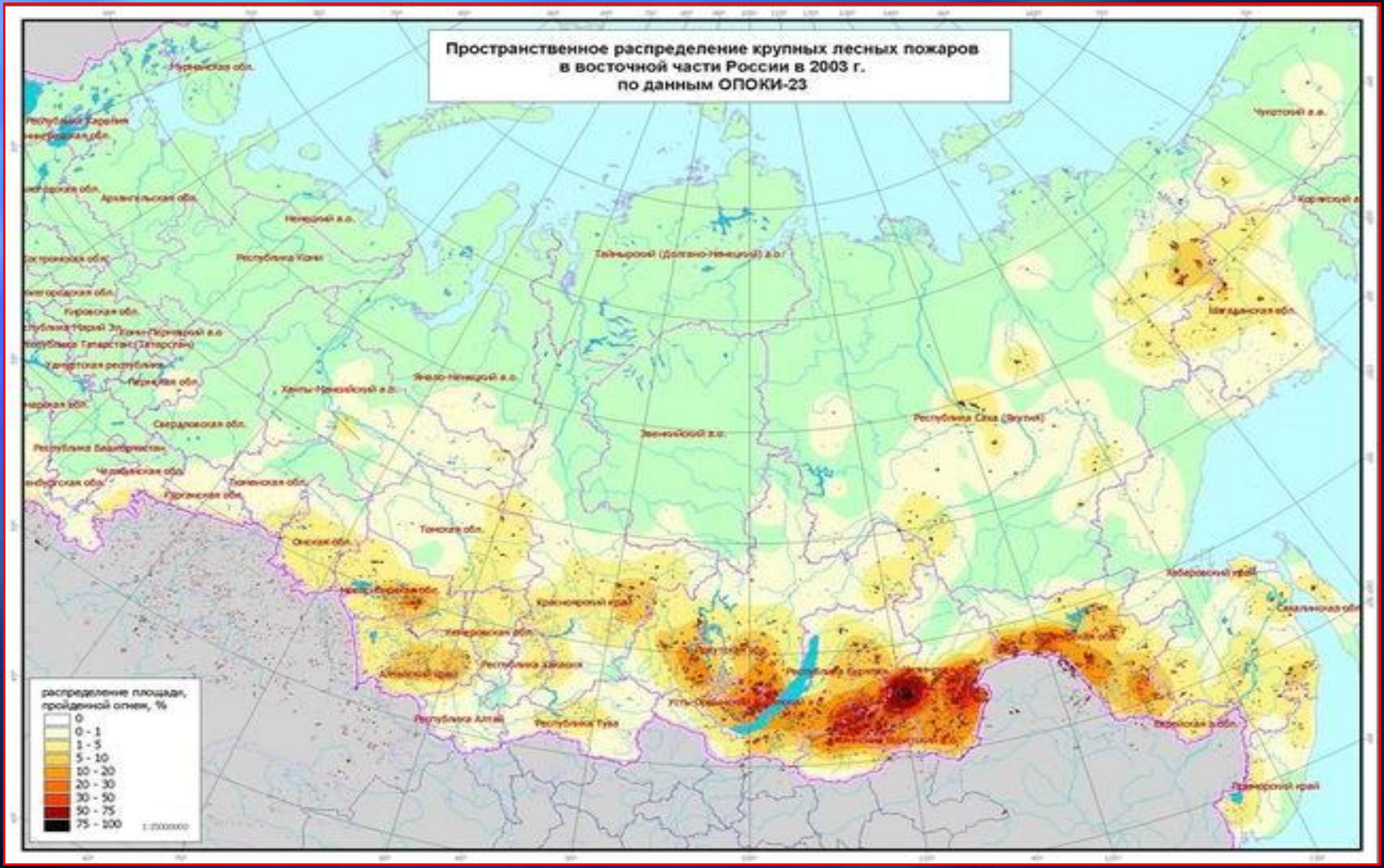
Fire patterns vary from year to year
2001



Fire patterns vary from year to year
2002



Fire patterns vary from year to year
2003



Fire patterns vary from year to year
2004

Fire patterns vary from year to year

2005

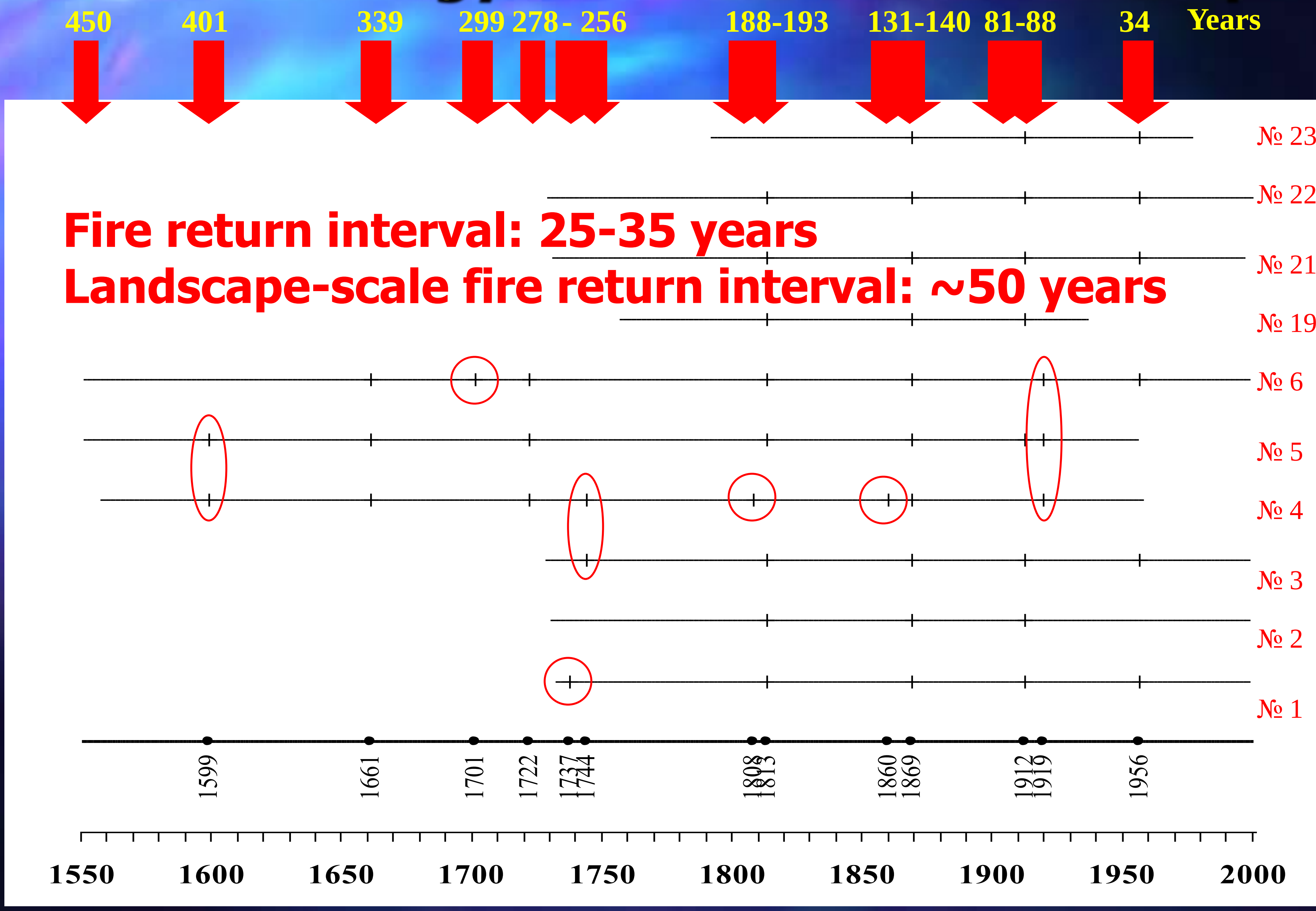
Variations in fire behavior and effects

- Fires in Siberian Scots pine and larch forests vary widely in intensity and severity—both among and within fires
- Surface fire is much more common than crown fire and mortality is usually low over much of the landscape

Fire chronology—central Siberia Scots pine

Fire return interval: 25-35 years

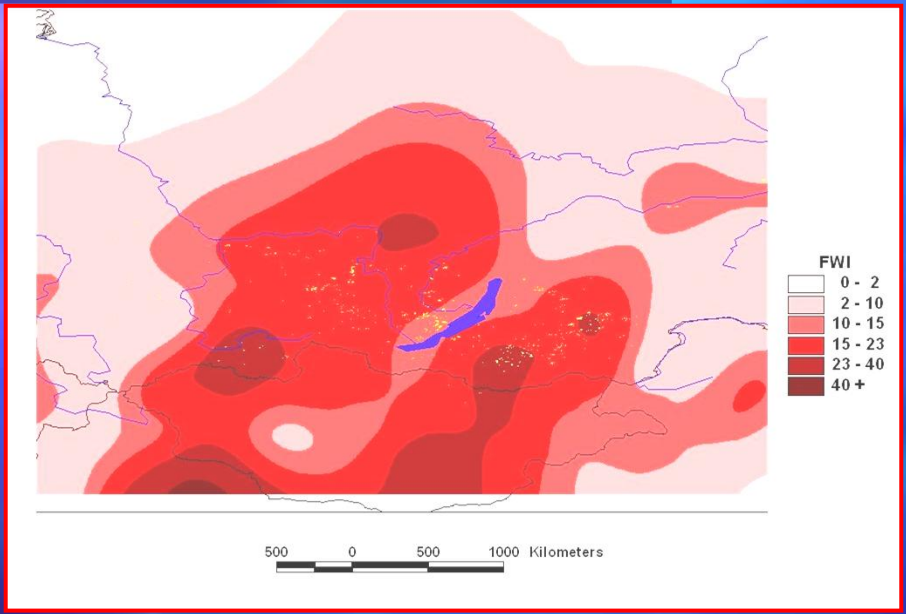
Landscape-scale fire return interval: ~50 years

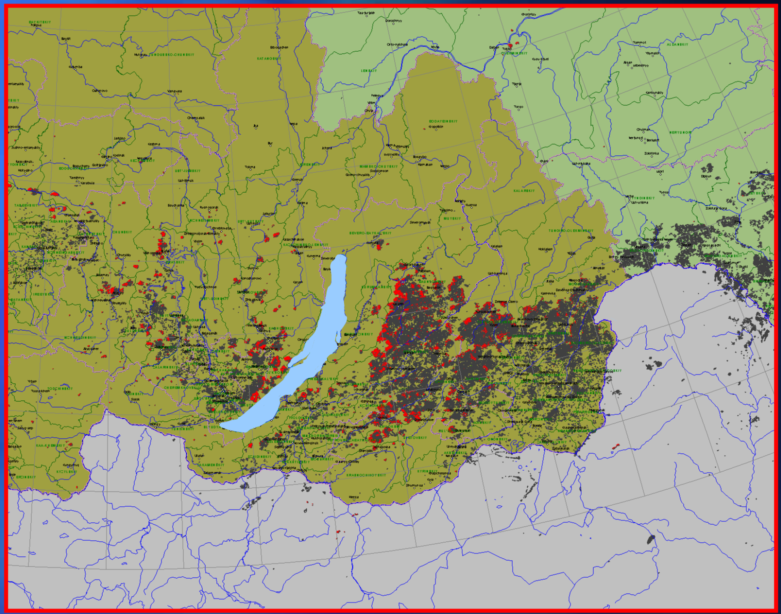


Quantifying and modeling fuel consumption and fire emissions

- The wide range in fire behavior in these forests leads to highly variable emissions and potential impacts on carbon cycle in stands of similar structure, composition and fuel loads.
- Emissions from experimental surface fires varied 4-fold depending largely on burning conditions.
- Because of the variability in burn severity, especially in Scots pine forests, we have been developing models to relate fire weather and fuels to fuel consumption and emissions.
- Such models enable predictions of potential burn severity and emissions over large areas.

Weather-based fire hazard indices can relate well to distribution and severity of fires in Siberia:

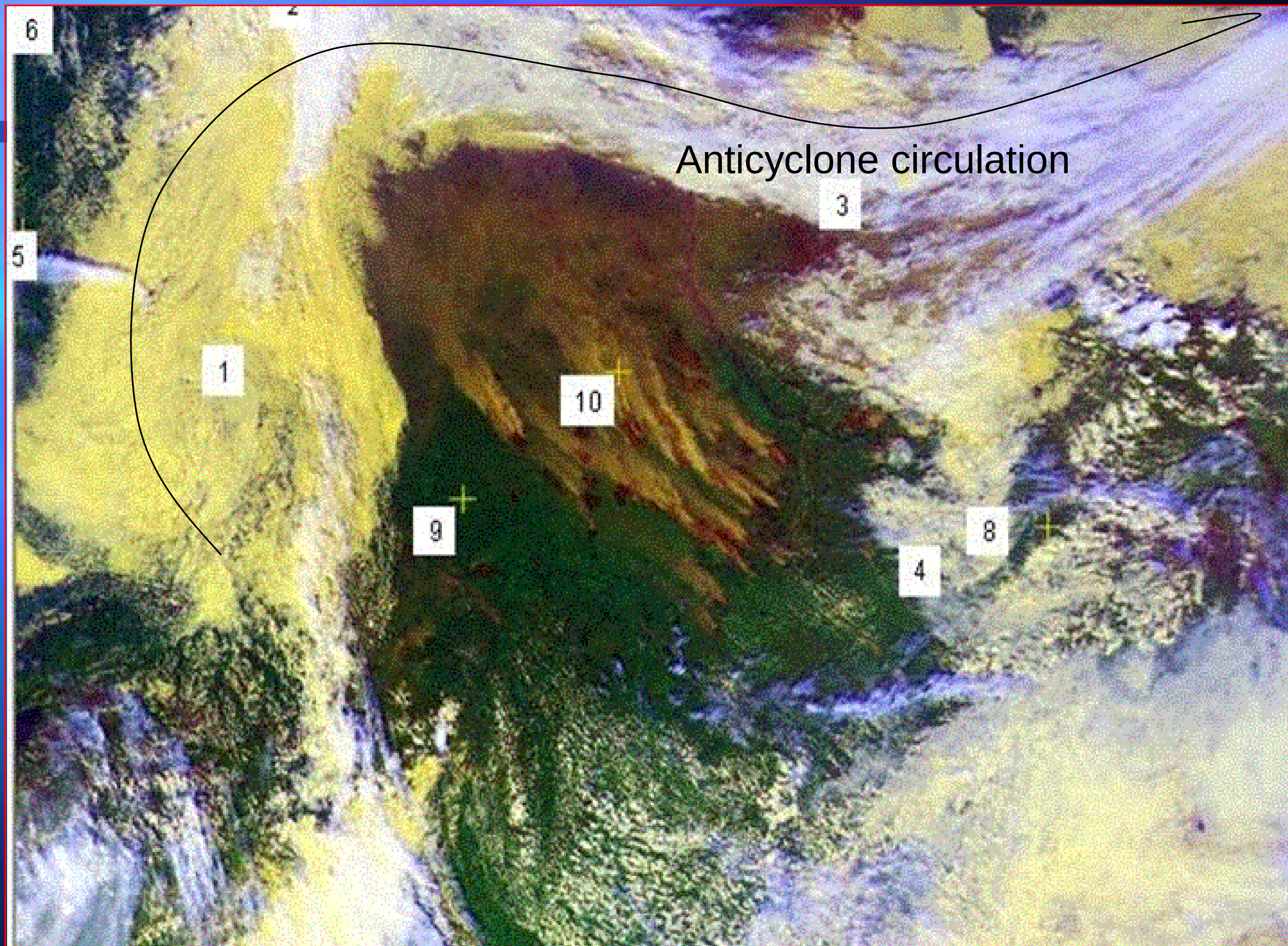




Fire Weather Index	Carbon emissions t/ha
2 to 10	4.1 to 7.7
10 to 15	7.7 to 10.0
15 to 23	10.0 to 13.7
23 to 40	13.7 to 21.4

Canadian Fire Weather Index (FWI) in part of central Siberia for 6-15 June 2003. High FWI values are associated with areas of high fire activity. Estimates of potential fuel consumption are based on data from experimental fires in Scots pine. Active fires from MODIS over the same period are shown in red on the right.

Atmospheric circulation patterns affect regional mass fire events

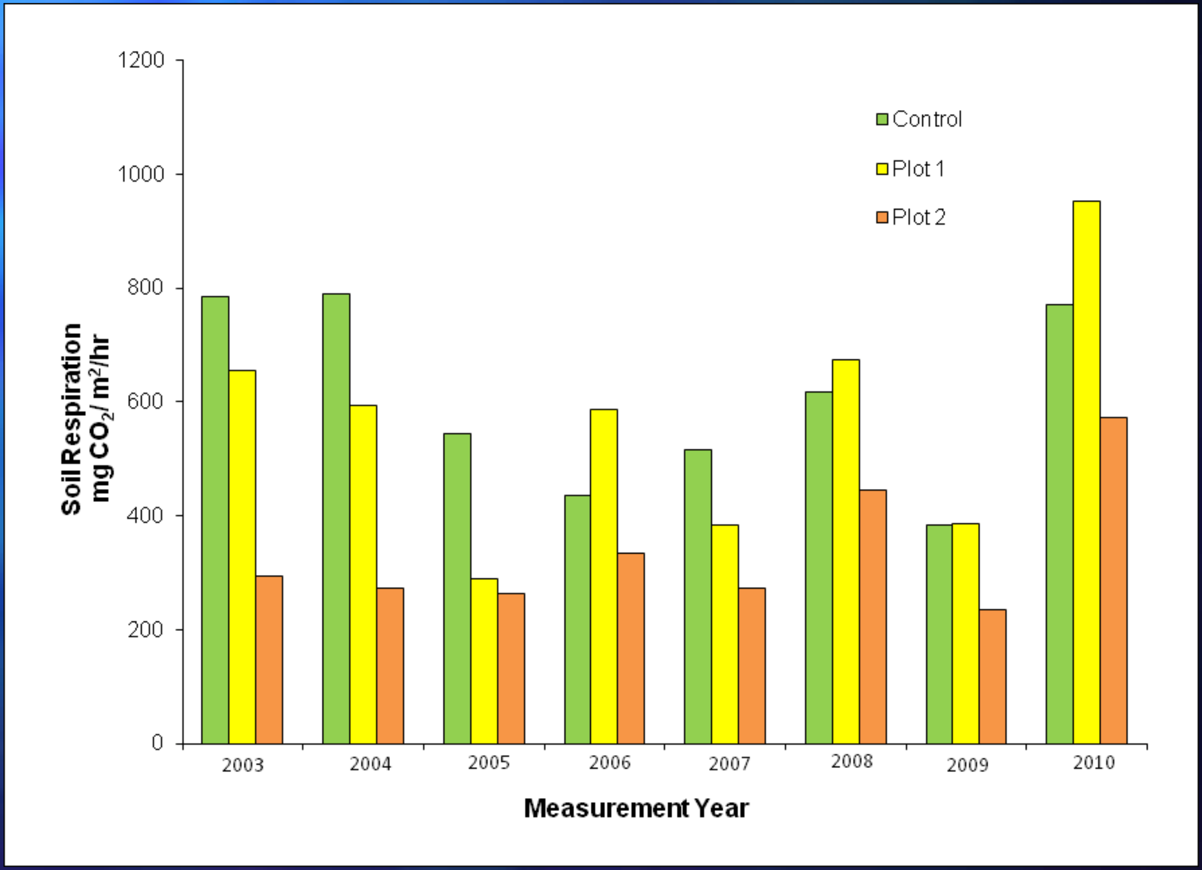


Cloud fronts indicate a blocking ridge that forces circulation around mass fire areas in the Yakutia Region in 2002 (Sukhinin et al. , poster)

Burn severity affects soil respiration

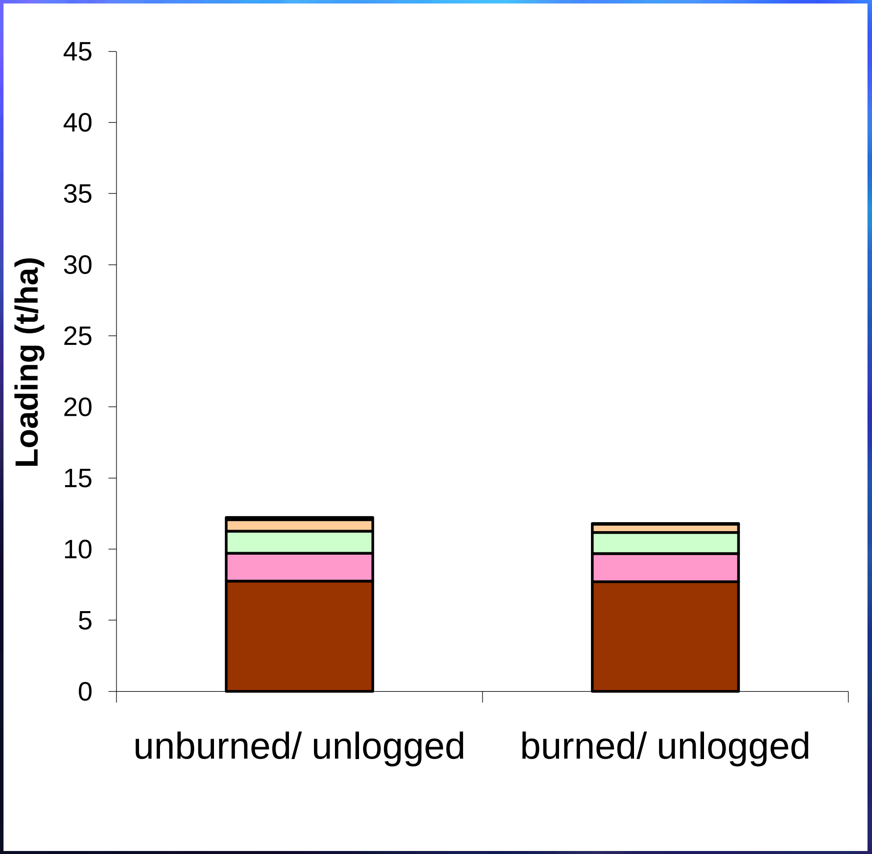
- **After even low-severity surface fires in Scots pine and larch forests, soil respiration decreases significantly. Recovery to prefire levels may take several years (Poster—Baker and Bogorodskaya)**

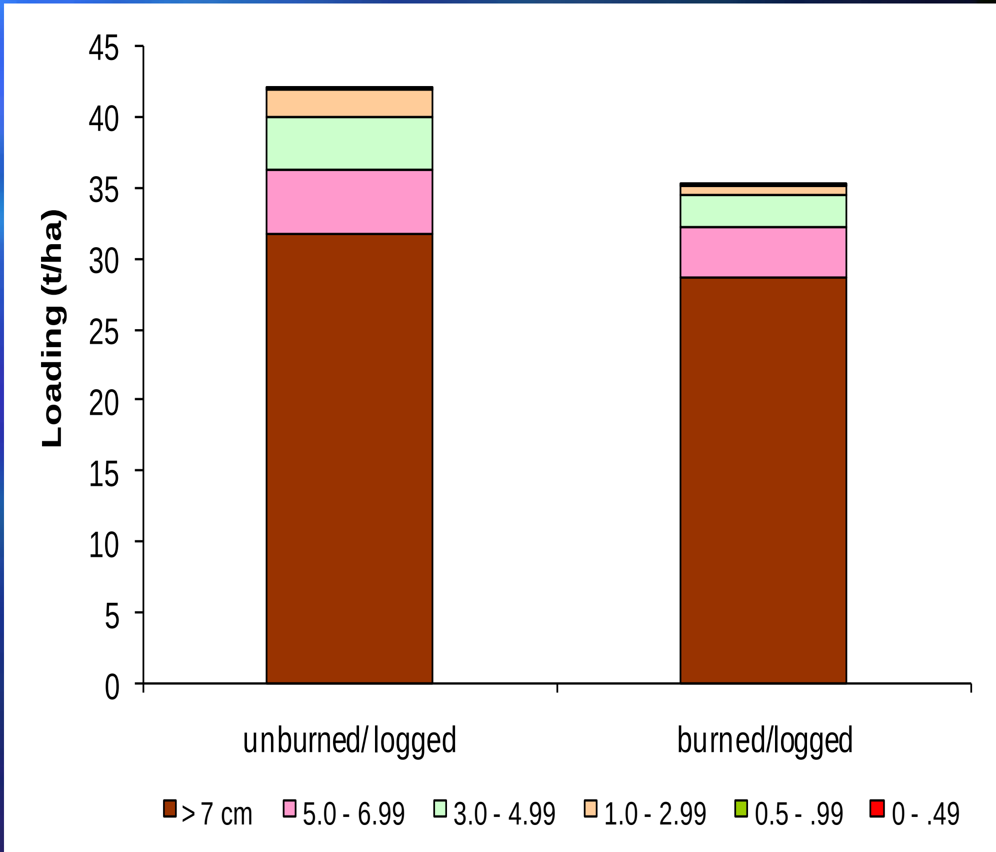
- **The fire intensity and severity were higher on Plot 2 than on Plot 1**



Interactions between fire and logging

- Fuel consumption in fires on logged sites is typically twice that in fires on unlogged sites (Poster—Ivanova et al.)
- We can estimate GHG and aerosol emissions from fuel consumption data. (Baker, Hao, Samsonov, and others).

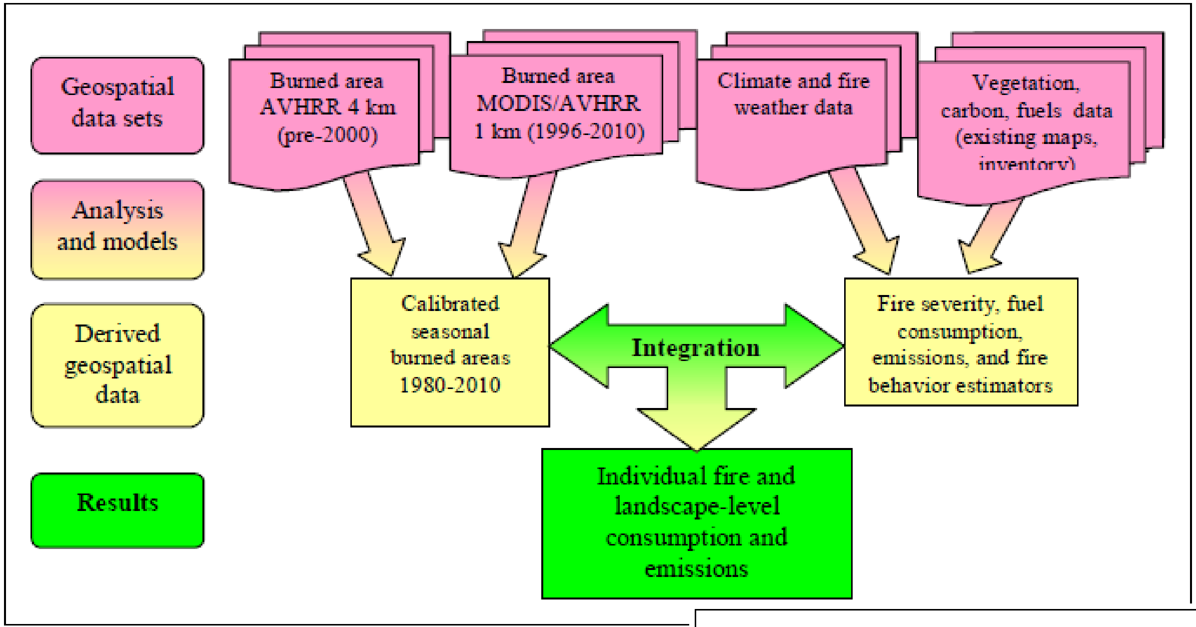




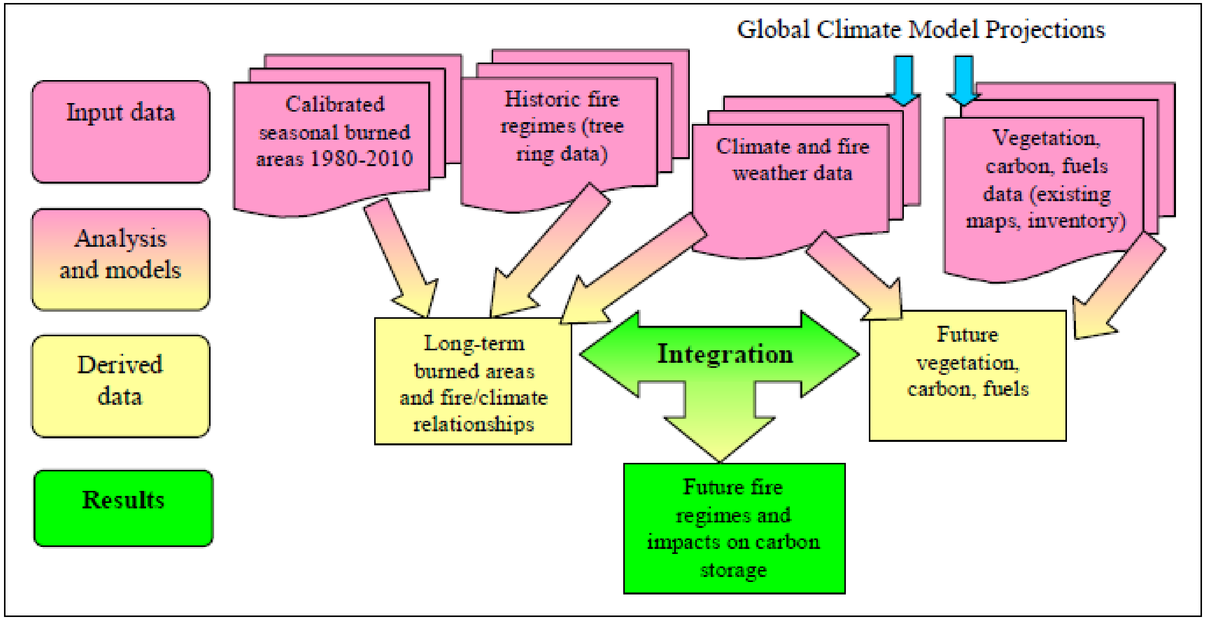
- We are evaluating various remote-sensing based indices for their usefulness in characterizing type and degree of disturbance and forest type (Poster—Buriak et al.)

Site type	Tree mortality	NDVI	Index 57	Index 47	Index 54
Fire scars	20-40%	0,183	0,300	0,175	0,131
	40-60%	0,106	0,275	0,154	0,127
	60-80%	0,105	0,279	0,099	0,185
	80-100%	0,039	0,241	0,013	0,229
Harvested sites	Category of regeneration				
	Very bad	0,048	0,274	0,055	0,221
	Bad	0,118	0,292	0,123	0,172
	Satisfactory	0,233	0,323	0,253	0,076
	Good	0,344	0,370	0,413	-0,054
Undisturbed forests	Forest type				
	Coniferous	0,143	0,295	0,338	-0,049
	Deciduous	0,398	0,385	0,472	-0,107
	Mixedwood	0,299	0,352	0,428	-0,090

Integrating Historic Patterns of Wildfire, Emissions, and Climate for Siberia, Estimating Impacts of Fire on Carbon Cycling, and Quantifying and Projecting Fire/Climate Interactions



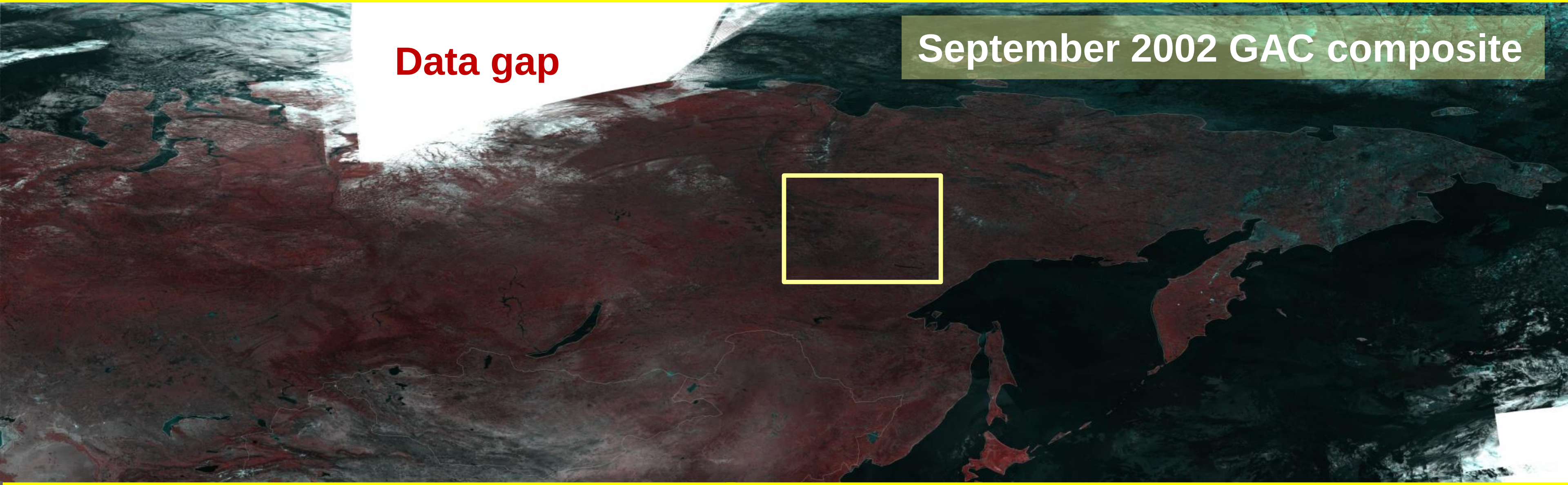
A "new" NASA TE/ NEESPI Carbon Cycle project



Accomplishments related to TE Project

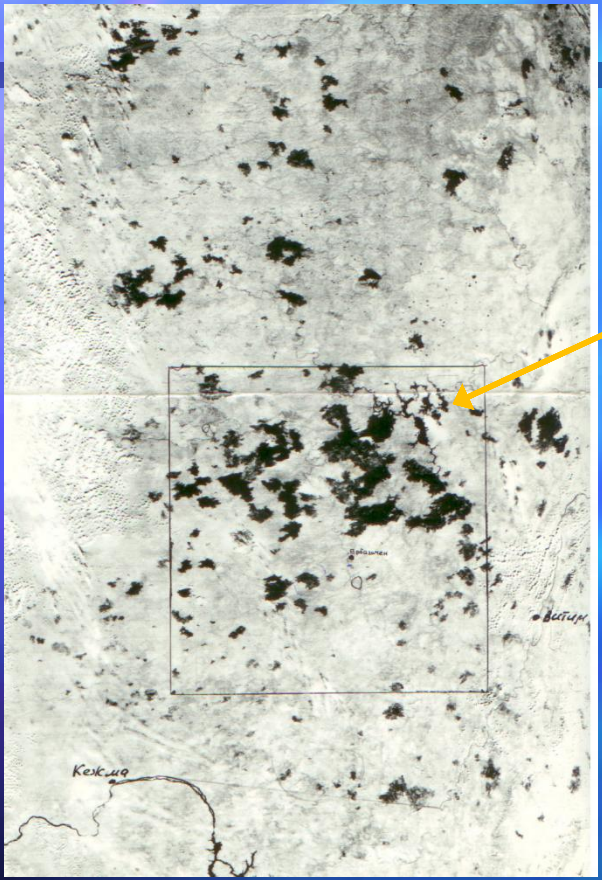
- Large scale fire events in forested areas typically occur during periods when there is a blocking anticyclone (Sukhinin et al., Poster here)
- Daily fire occurrence over the past 10 years in northern Eurasia (from MODIS) was categorized according to type of vegetation burned and regional distribution and timing of active fire detections (Hao et al.—AGU Poster)
- Recent studies by Soja and colleagues in Tyva (Tuva) have shown marked decreases in forest area, likely associated with changing climate (Kukavskaya et al.—AGU Poster)
- Methods developed, and initial analysis conducted, to reconstruct post-1979 fire activity in Russia from large-scale AVHRR data (Cahoon and Stocks, AGU presentation)

Development of long-term (30-yr) remote sensing data sets on fire in Russia



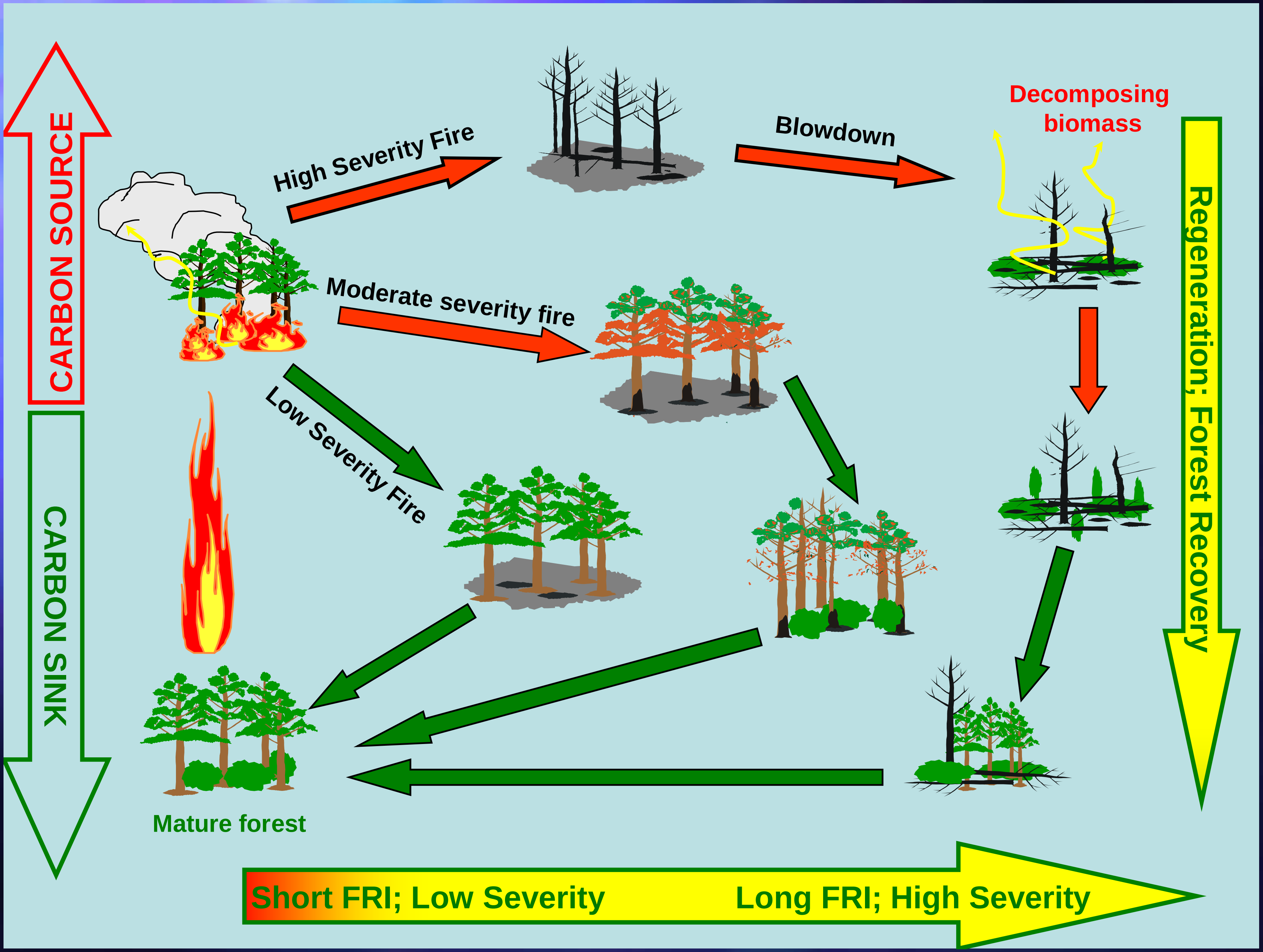
Validation of GAC composites—Evenkia 1984 fires

reservoir



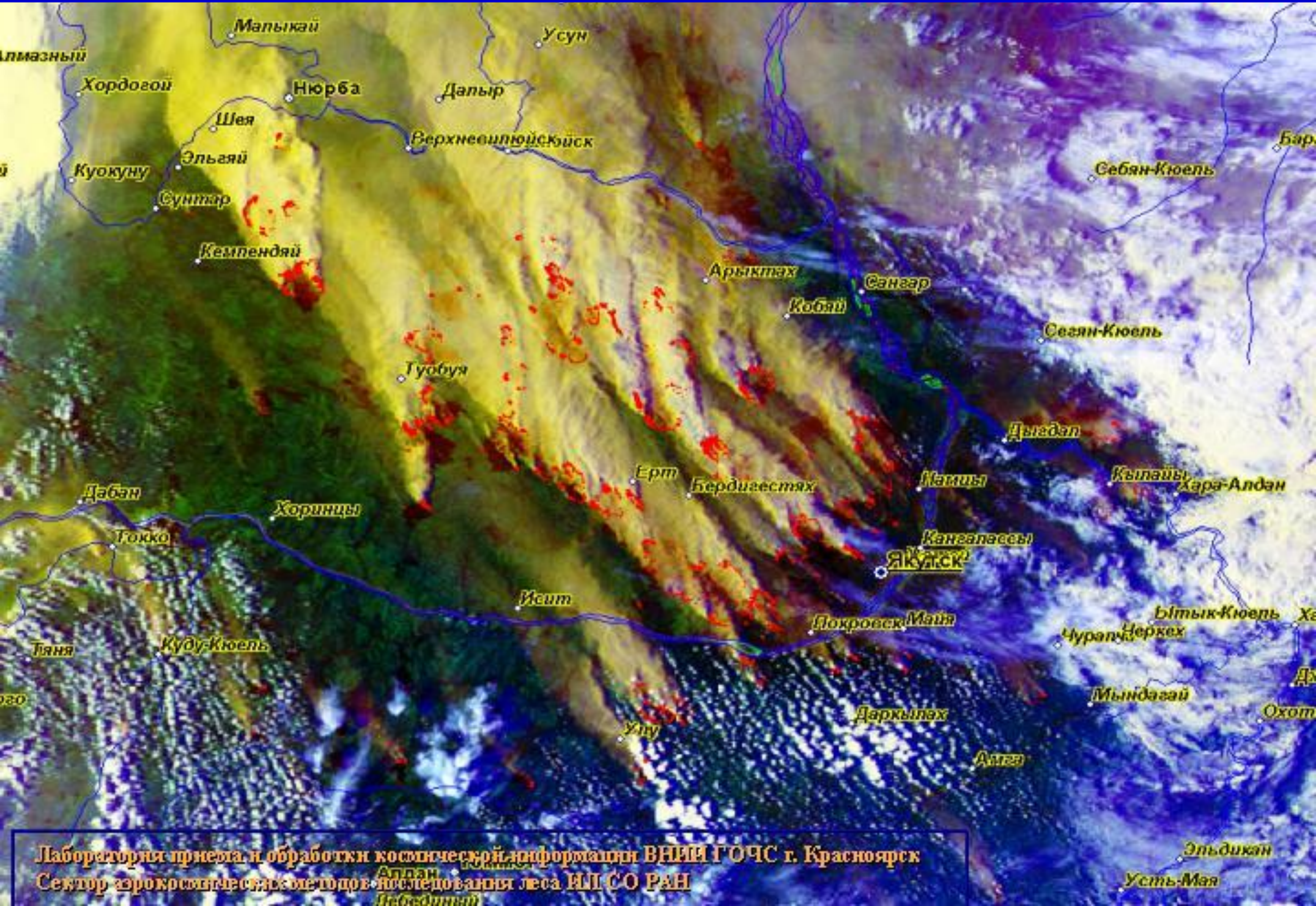
Wildfire Situation 1984, Evenkia, Katanga, Yakutia (Resours-O3 image 22.08.1985)

GAC Composite August 1985



CARBON SOURCE
CARBON SINK
High Severity Fire
Moderate severity fire
Low Severity Fire
Blowdown
Decomposing biomass
Regeneration; Forest Recovery
Mature forest
Short FRI; Low Severity
Long FRI; High Severity

Smoke over Yakutia 16.08.2002

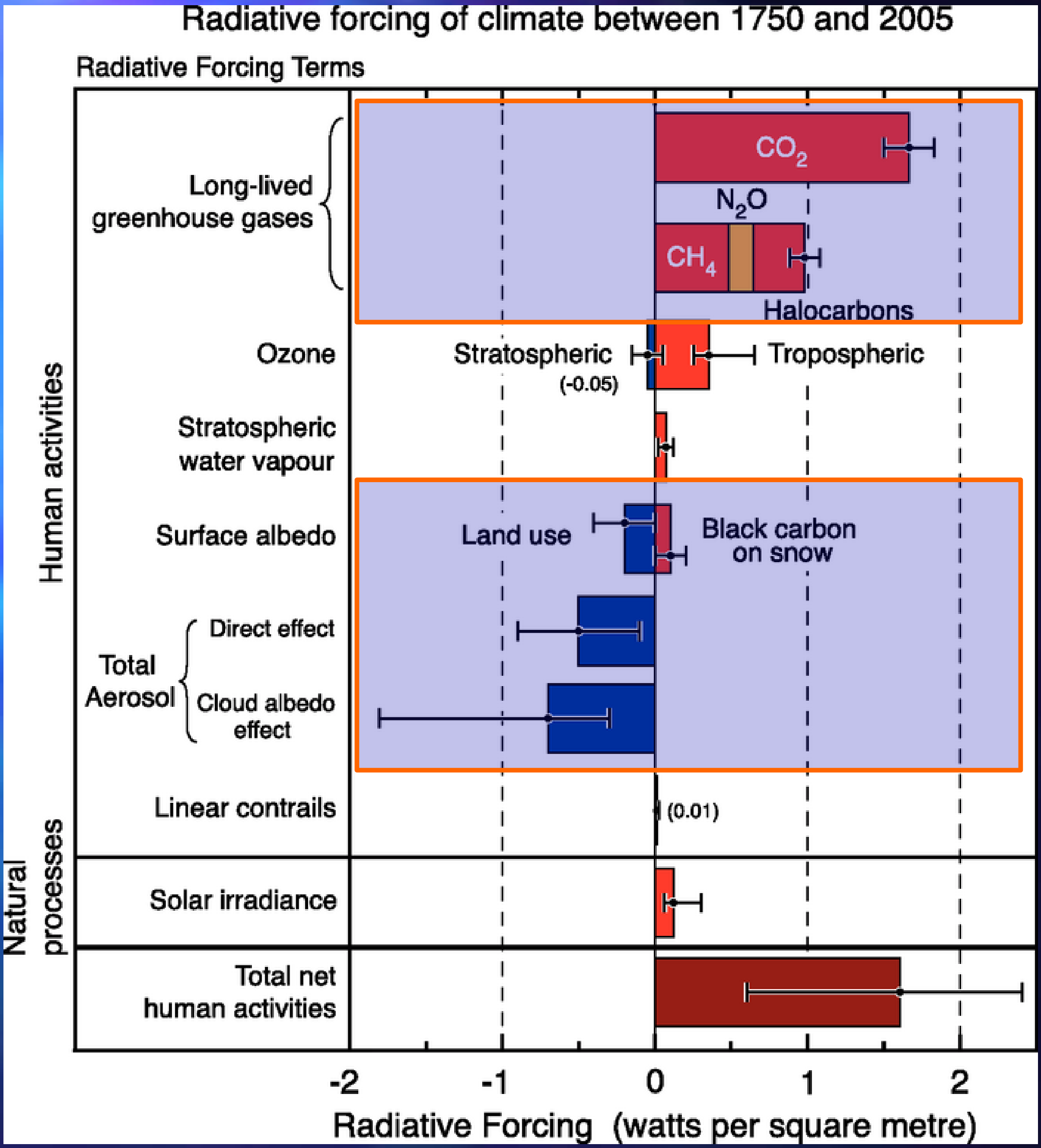


All emissions are not created equal

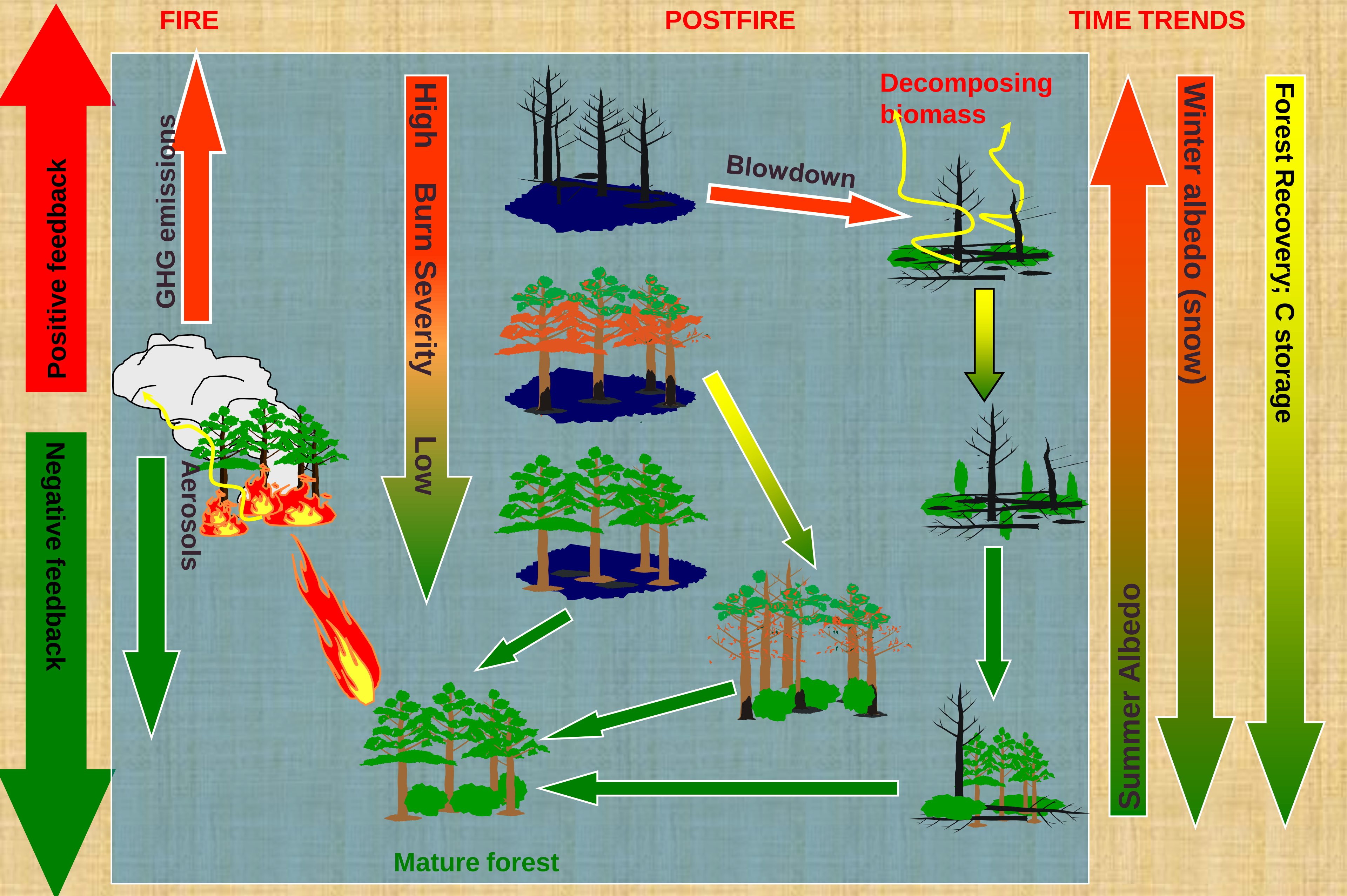
- Wildfire emissions are dominated by CO_2
- Many other components: Methane, SO_x, NO_x, other hydrocarbons, soot
- All have different forcings—some positive and some negative
- Different air quality impacts and climate change feedbacks

Summary of the principal components of the radiative forcing of climate. The values represent the forcings in 2005 relative to the start of the industrial era (about 1750).

The forcings potentially affected by biomass fire are shown in grey boxes. (Figure adapted from Figure 2.20 of IPCC AR-4, WG 1)



Potential Fire Feedbacks to Climate—An Example

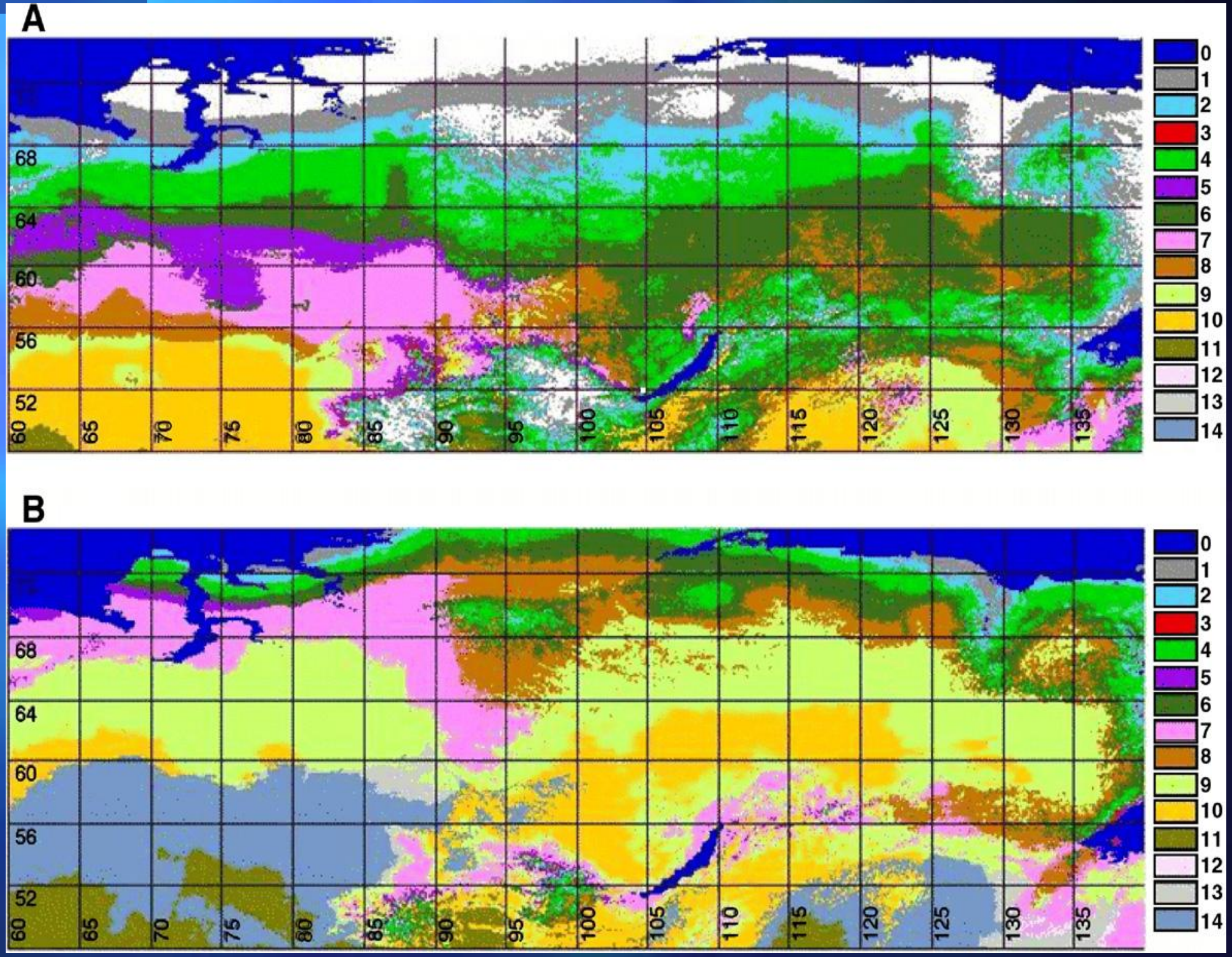


Fire/Climate Interactions

- Primary feedbacks between fire and the atmosphere are emissions and regrowth.
- Regrowth of burned areas recaptures emitted carbon, if there are no changes in burned area, vegetation, C uptake, or emissions per unit area.
- Key questions: how are fire regimes changing; effects on regional and global emissions and terrestrial carbon storage.
- How do we quantify the impacts of burn severity on emissions and albedo?
- How significant are fire emissions of other GHG and of smoke aerosols in terms of climate forcing?
- How do changes in vegetation surface characteristics due to fire or other causes affect surface temperatures and the atmosphere?

Changing climate will impact vegetation and fuels: what will be the interactions with other disturbances?

Vegetation distribution in Siberia: (A) current and (B) future (2100) modeled vegetation based on a Hadley scenario (HadCM3GGal) (IPCC, 1996). Water (0); tundra (1); forest–tundra (2); northern dark taiga (3) and light taiga (4); middle dark taiga (5) and light taiga (6); southern dark taiga (7) and light taiga (8); forest–steppe (9); steppe (10); semi-desert (11); broadleaved (12); temperate forest steppe (13) and temperate steppe (14). From Soja et al. 2007.



Summary

- Forest and steppe fires are widespread disturbances in Siberia that may have important feedbacks with climate.
- Variability in behavior and effects of fire is high—both spatially and temporally.
- To be more than locally significant, the *effects of fire on carbon and other climate forcings* must be large enough to make a difference regionally or globally.
- Fires primarily affect regional or global carbon cycle if they are changing in *frequency*, *extent*, or *severity.*
- To understand and predict global /regional effects of fire we must understand processes, estimate effects at stand and landscape levels, and quantify changes over time.

Research needs

- Improved data and model validation on burned area, fire severity, emissions, postfire recovery, albedo effects (including BC), and interactions between disturbances.
- Improved methods for monitoring and predicting interactions between fire and changing climate.
- Full accounting of forcing factors related to fire and associated ecosystem changes.
- Our most recent NASA-funded NEESPI project, which is integrating data on fires, fire effects, and fire/climate interactions at multiple scales has the potential to go a long way toward meeting these needs for Russia.
- US Department of State has also recently sponsored a new project to look at effects of BC in the boreal and arctic zones of Eurasia.

International Boreal Forest Research Association

15th IBFRA conference August 15-21, 2011 in Krasnoyarsk, Russia

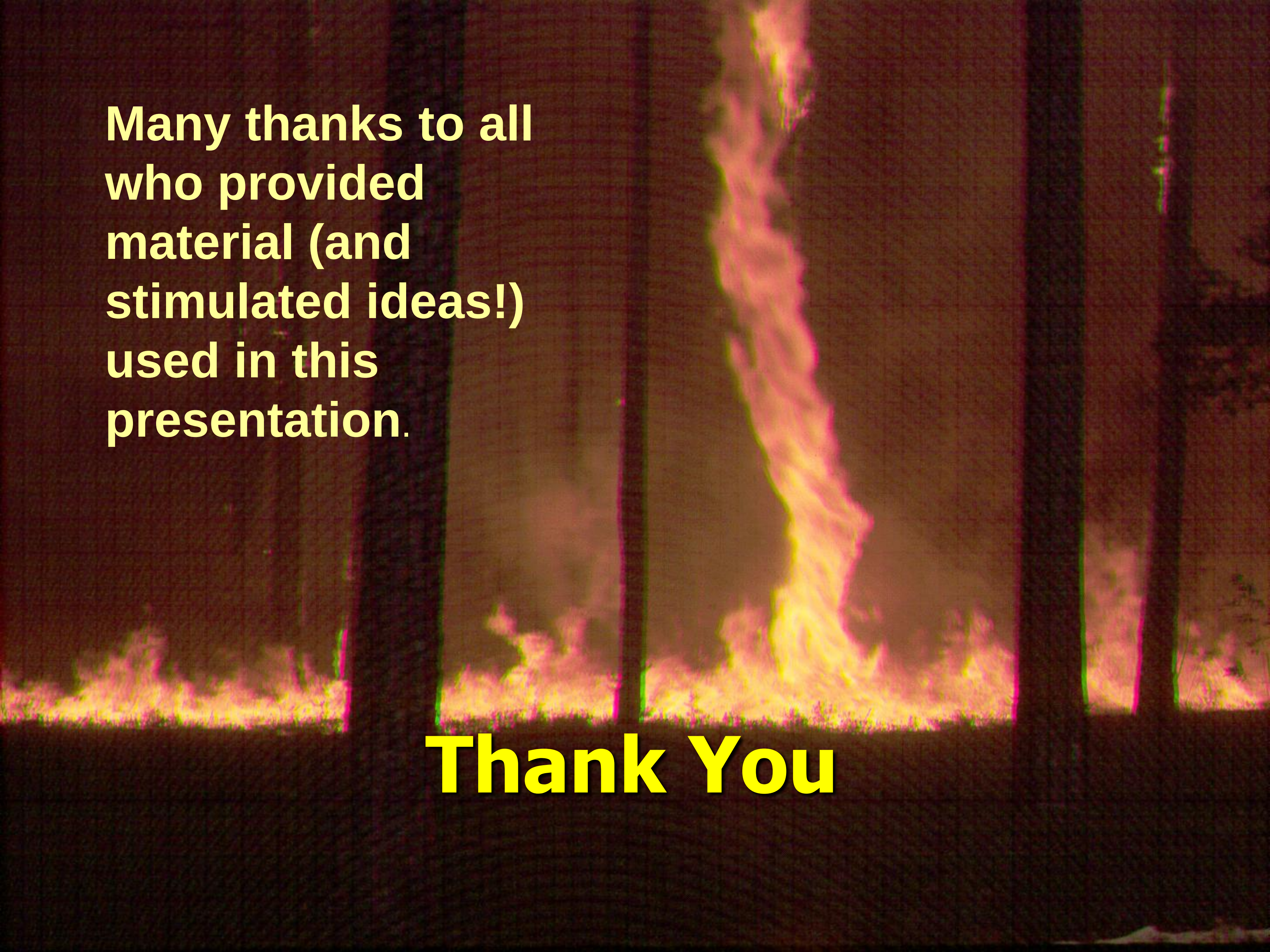
Boreal Forests in a Changing World: Challenges and Needs for Action

20th anniversary of IBFRA

- Boreal forest resources and their multiple uses
- Global environmental significance of boreal forests
- Natural and human-induced disturbances in boreal forests
- Resilience and productivity of boreal forests under climate change
- Boreal carbon and forest management in a changing world
- Socio-economic problems and governance of boreal forests

Abstract deadline: April 1, 2011

http://forest.akadem.ru



Many thanks to all who provided material (and stimulated ideas!) used in this presentation.

Thank You