Impacts of climate change on plant productivity in the Cajander larch woodlands of northeastern Eurasia

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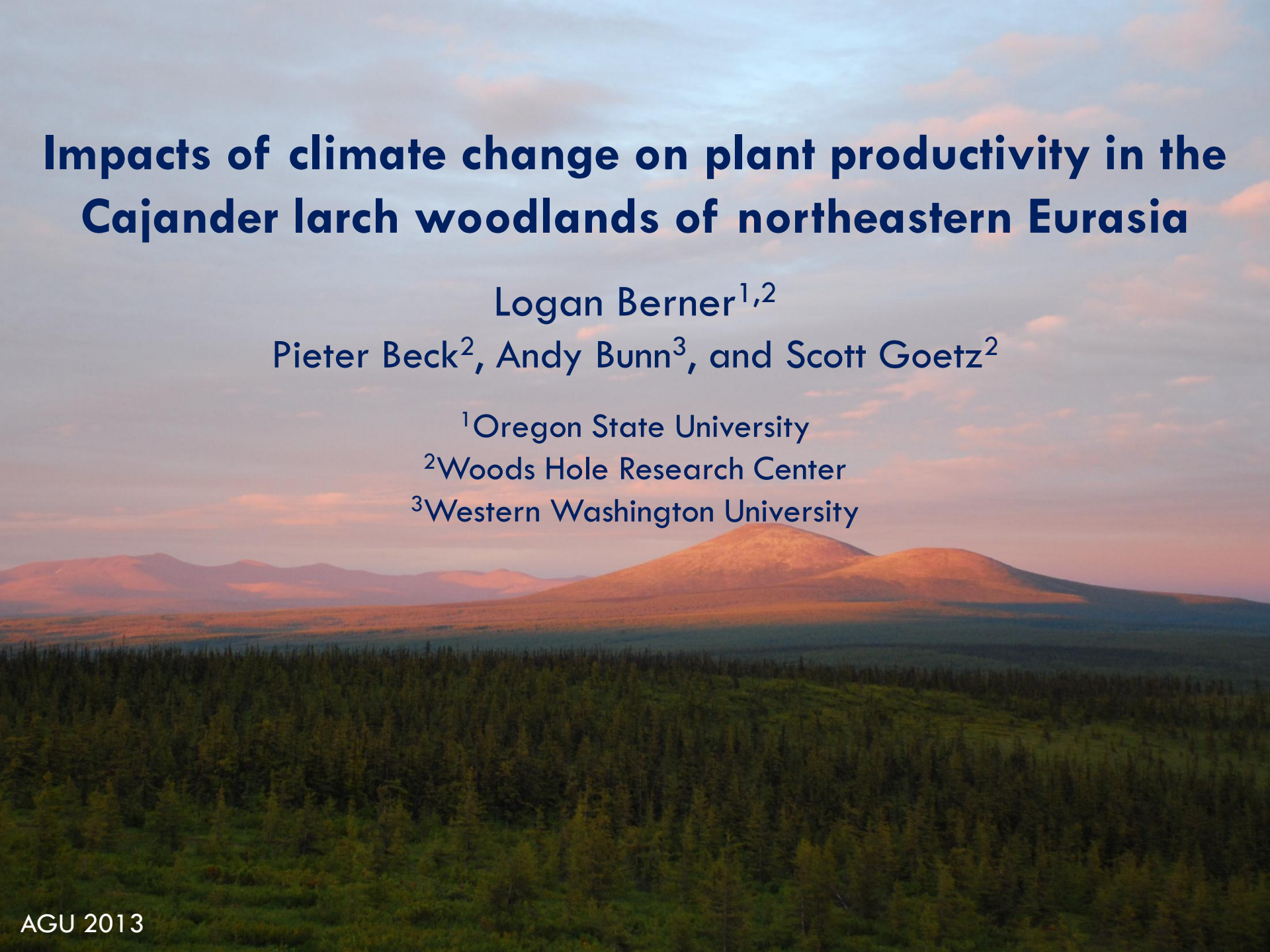


AGU 2013

Overview

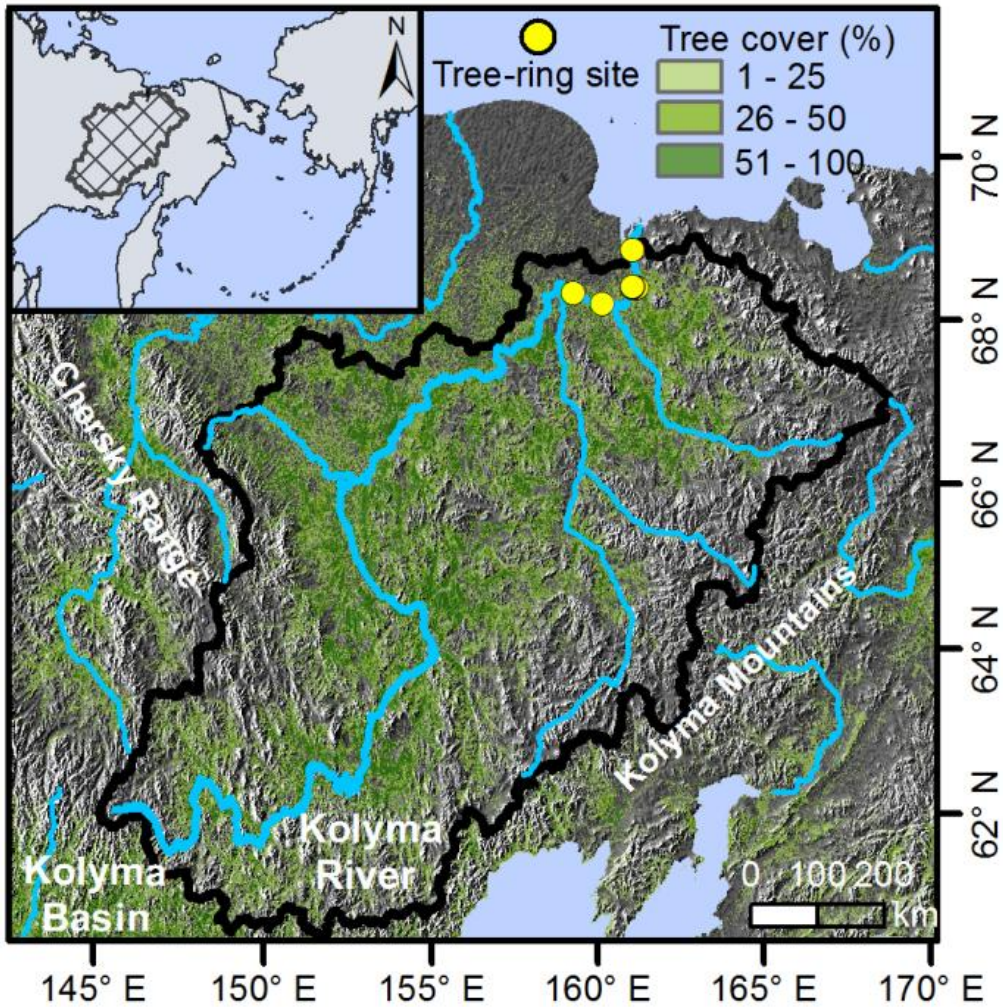
I. Siberia's changing forests
II. Ecotone in Kolyma Basin
III. Plant growth and climate?
IV. Satellite perspective
V. Larch tree ring perspective

Siberian forests and climatic change

- Siberian forests span ~6 x 10^6 km^2 [1]
- Pronounced observed and projected warming [2]
- Climate-driven changes in forest productivity [3], extent [4], and composition [5] in some areas
- Drastic vegetation shifts projected for 21st century [6,7]
  - Large social, ecological and biophysical implications
- Changes expected initially along forest margins

[1]Shvidenko and Nilsson 1994, [2]IPCC AR5 2013, [3]Beck et al. 2011, [4]Devi et al. 2008, [5]Kharuk et al. 2007, [6]Tchebakova et al. 2010, [7]Pearson et al. 2013

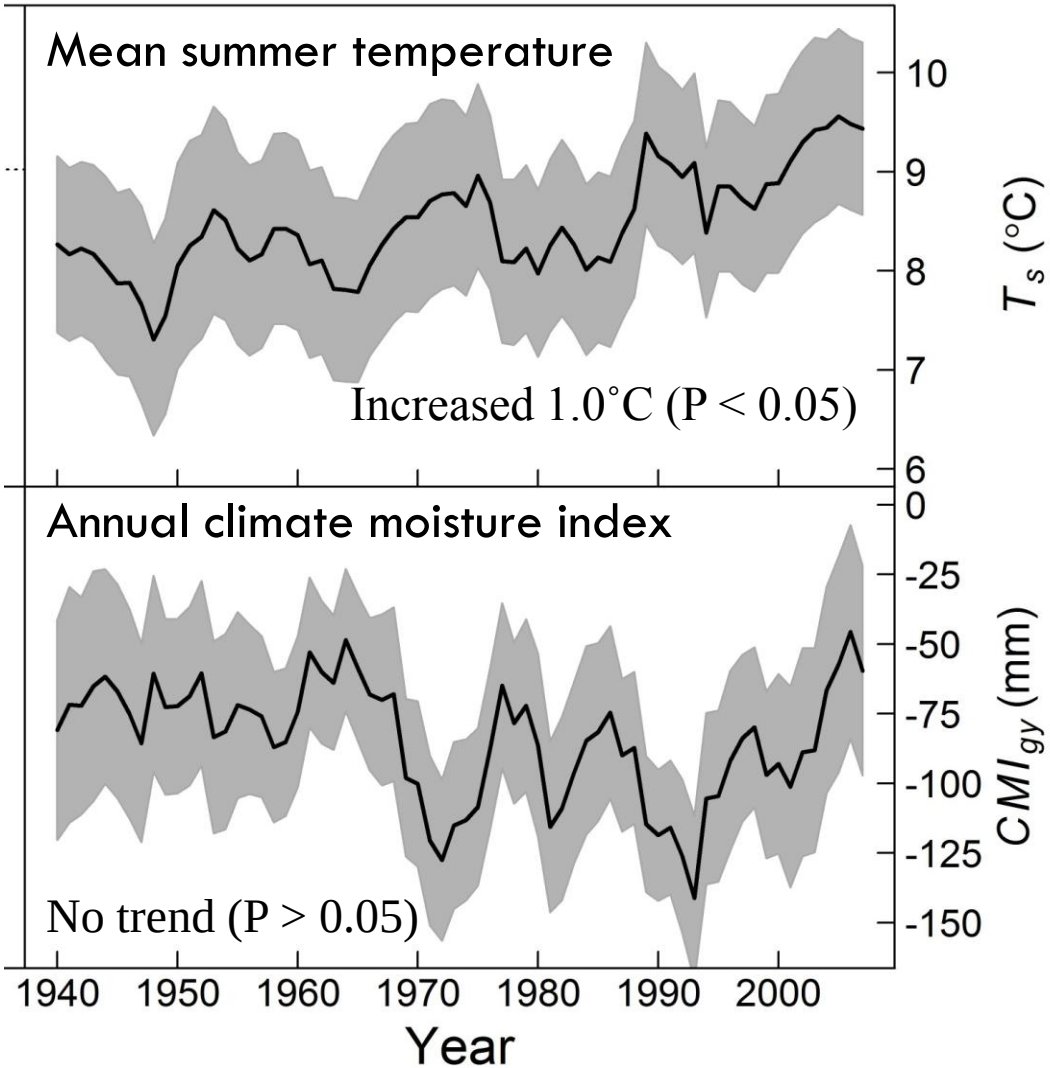
The Kolyma Basin



- Covers 657,000 km^2
- Largest watershed with continuous permafrost[1]
- Large carbon stores in permafrost[2]
- Grassland steppe during Pliestocene[2]
- Currently Cajander larch (*Larix cajanderi*) woodlands and tundra shrublands[3]

[1]Holmes et al. 2012, [2]Zimov et al. 2006, [3]Berner et al. 2012

Climate in the Kolyma Basin



- CRU and GPCC data 1938-2009
- CMI = P – PET
- Very cold and dry
  - MAT = -13.0 ± 0.7°C
  - MAP = 282 ± 37 mm
  - CMI = -84 ± 47 mm
- Expect plants are sensitive to climate…

Research questions

To what extent was interannual variability in plant growth related to climate?

Did recent warming drive systematically changes in plant productivity ?

Remote sensing analysis

Photo credit: ESA

Tree-ring analysis

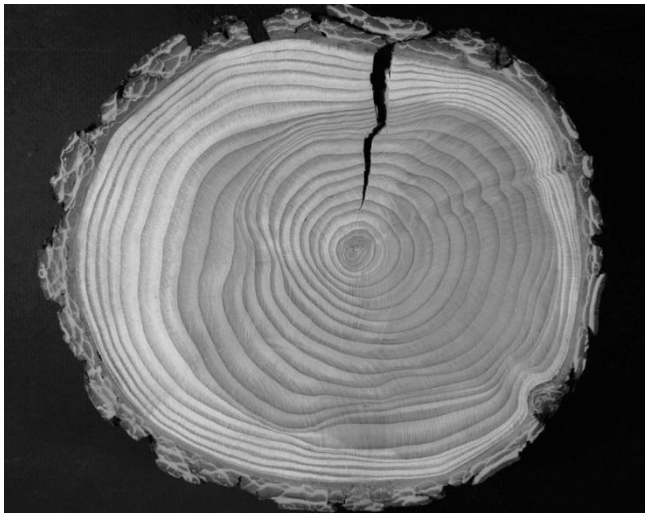
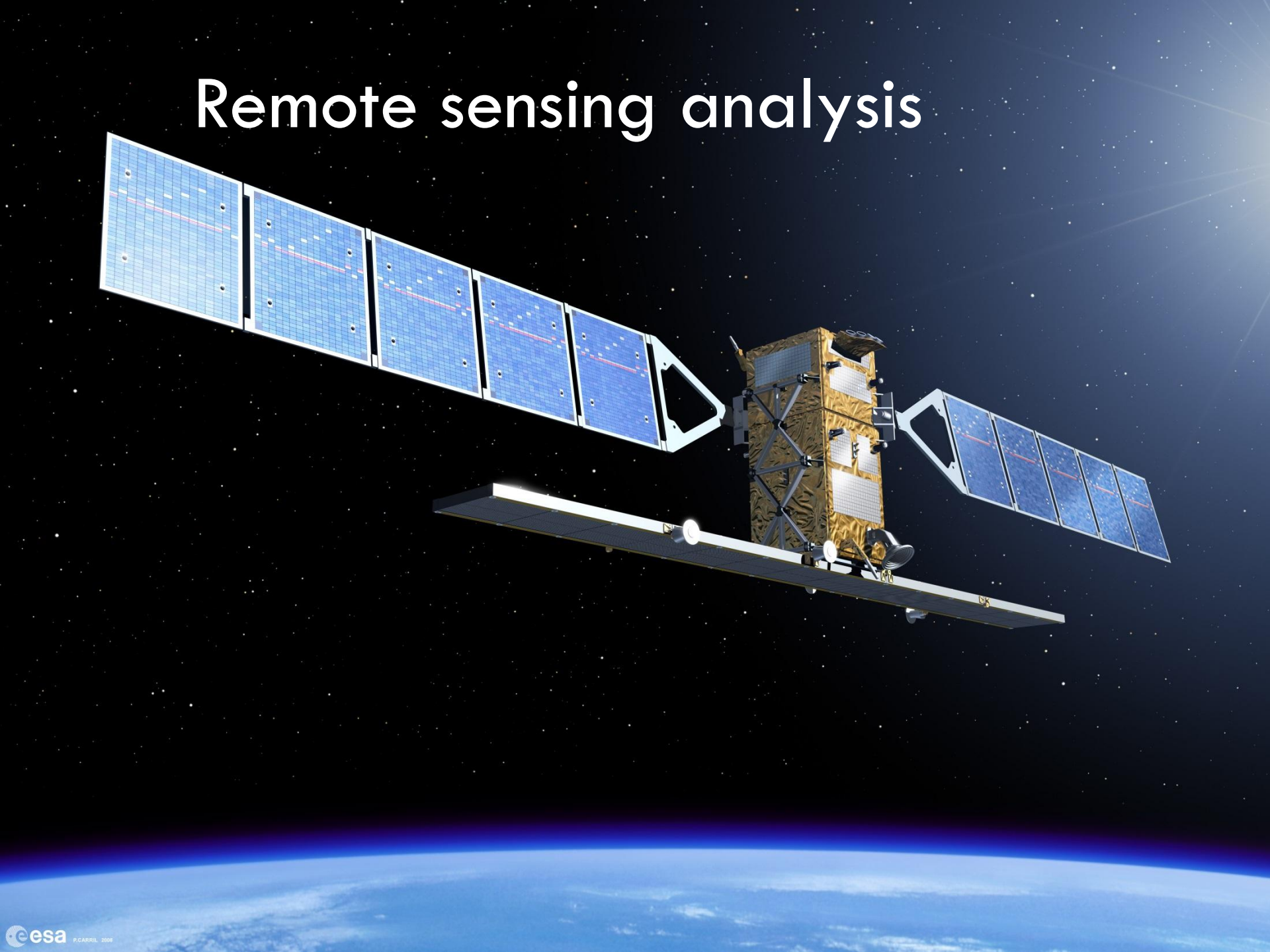


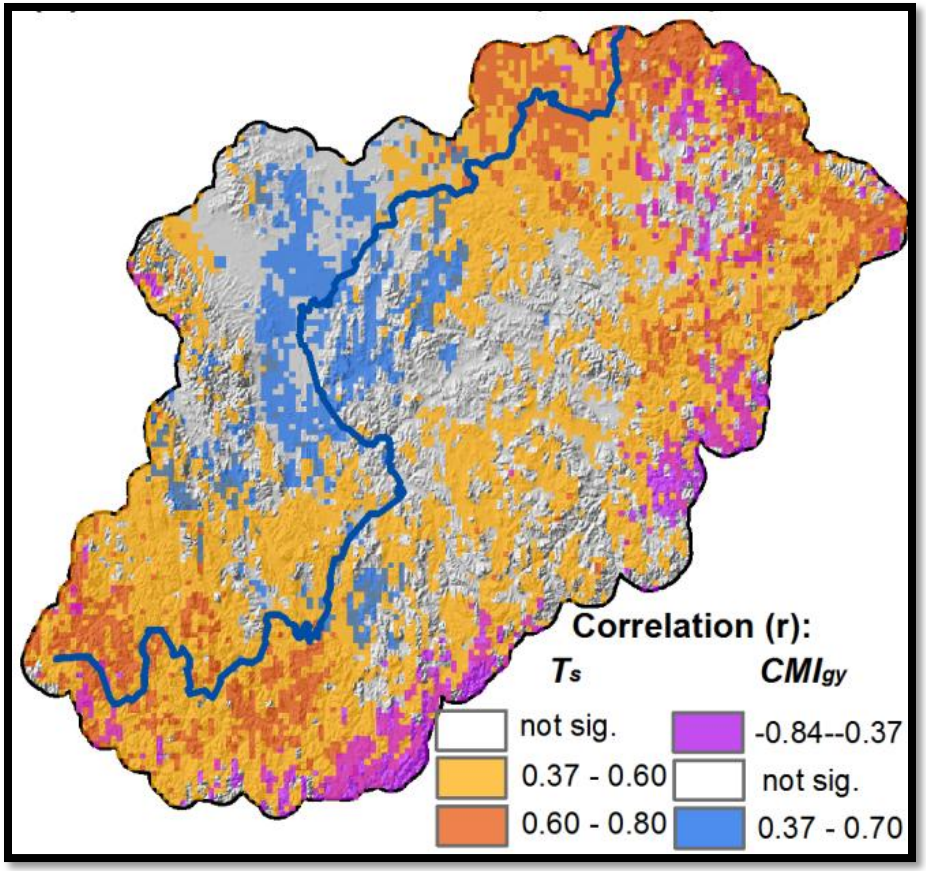
Photo credit: Natural Resources Canada

Remote sensing analysis

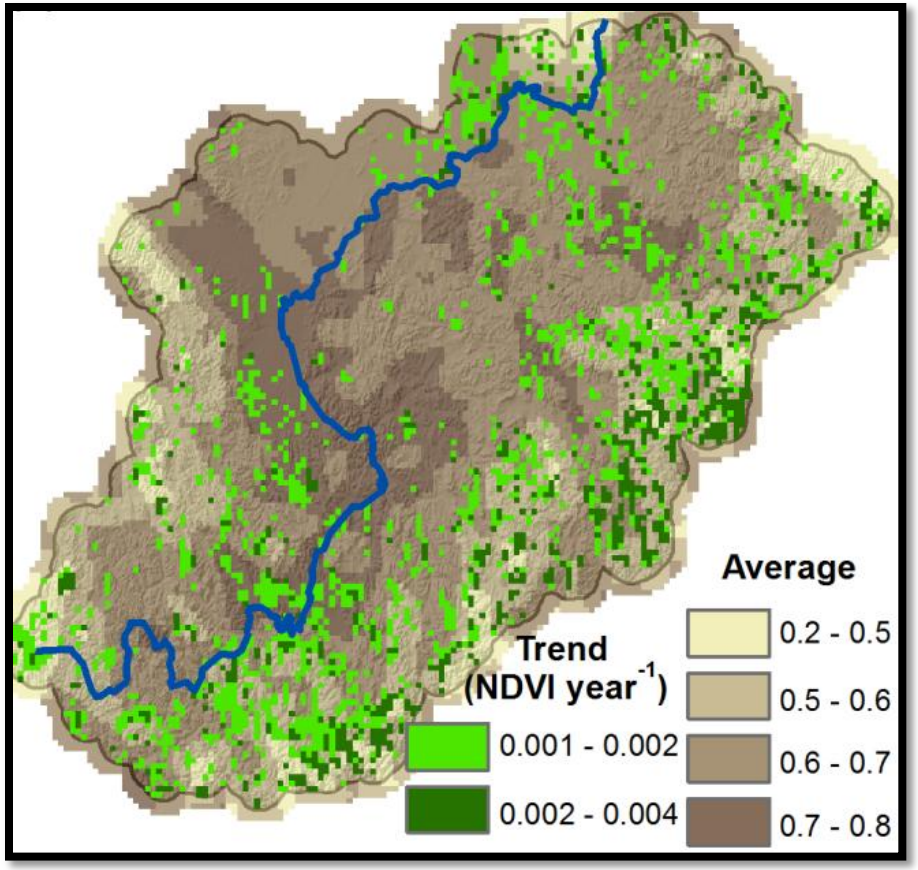


Regional productivity trends and climate correlations (1982-2009)

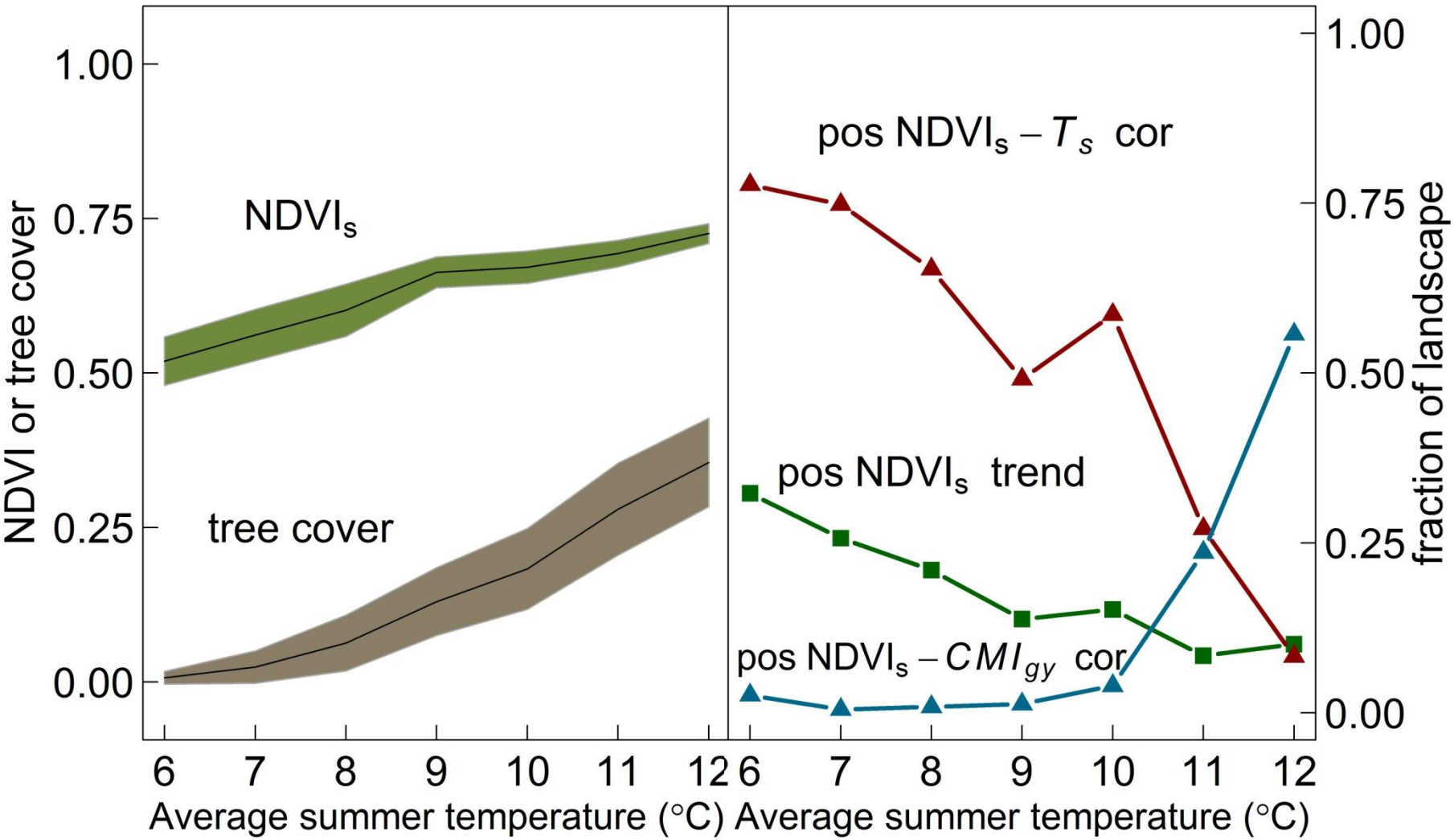
NDVI-climate correlations



Trends in mean summer NDVI



Plant dynamics along gradient in summer temperature



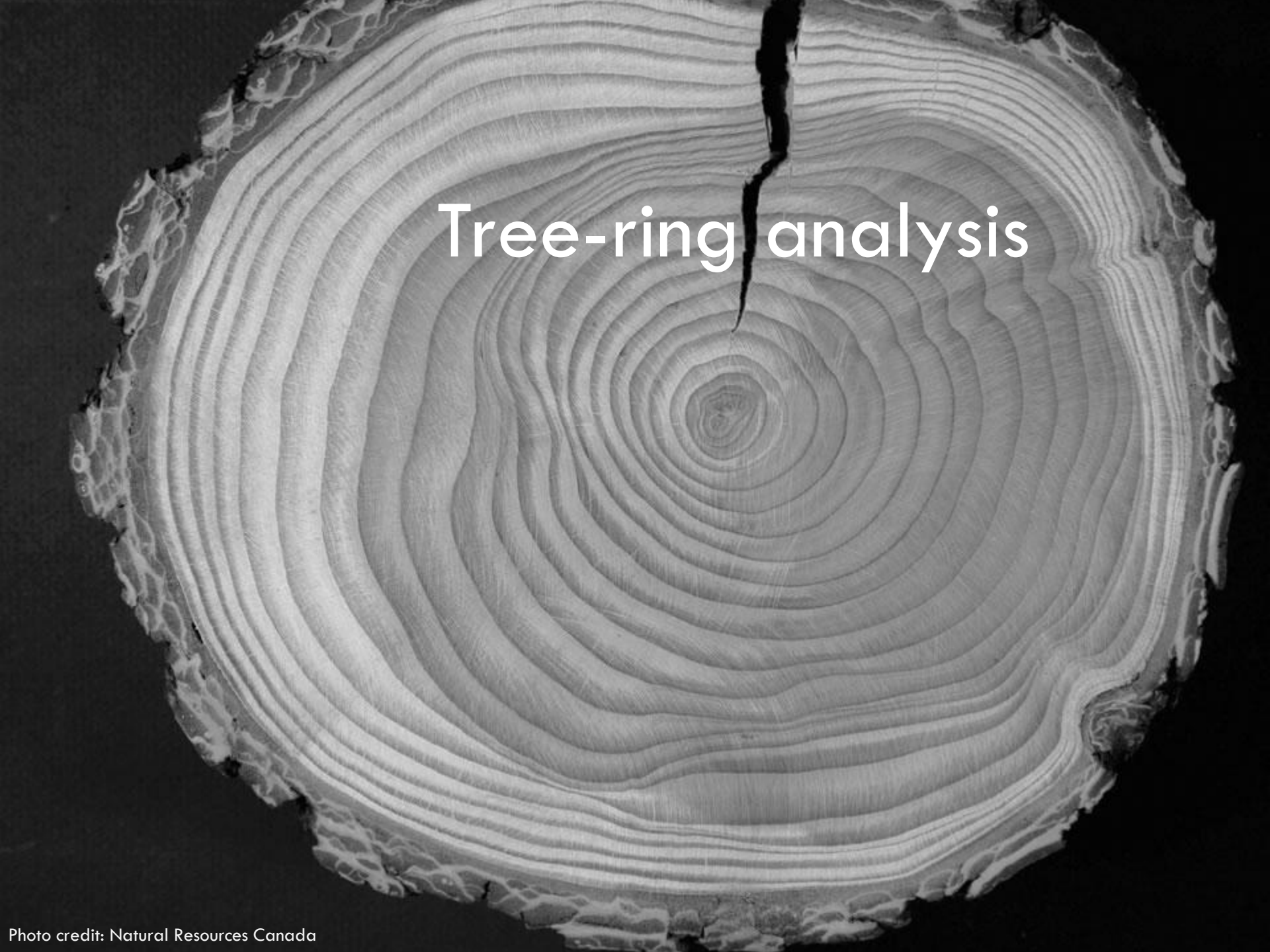
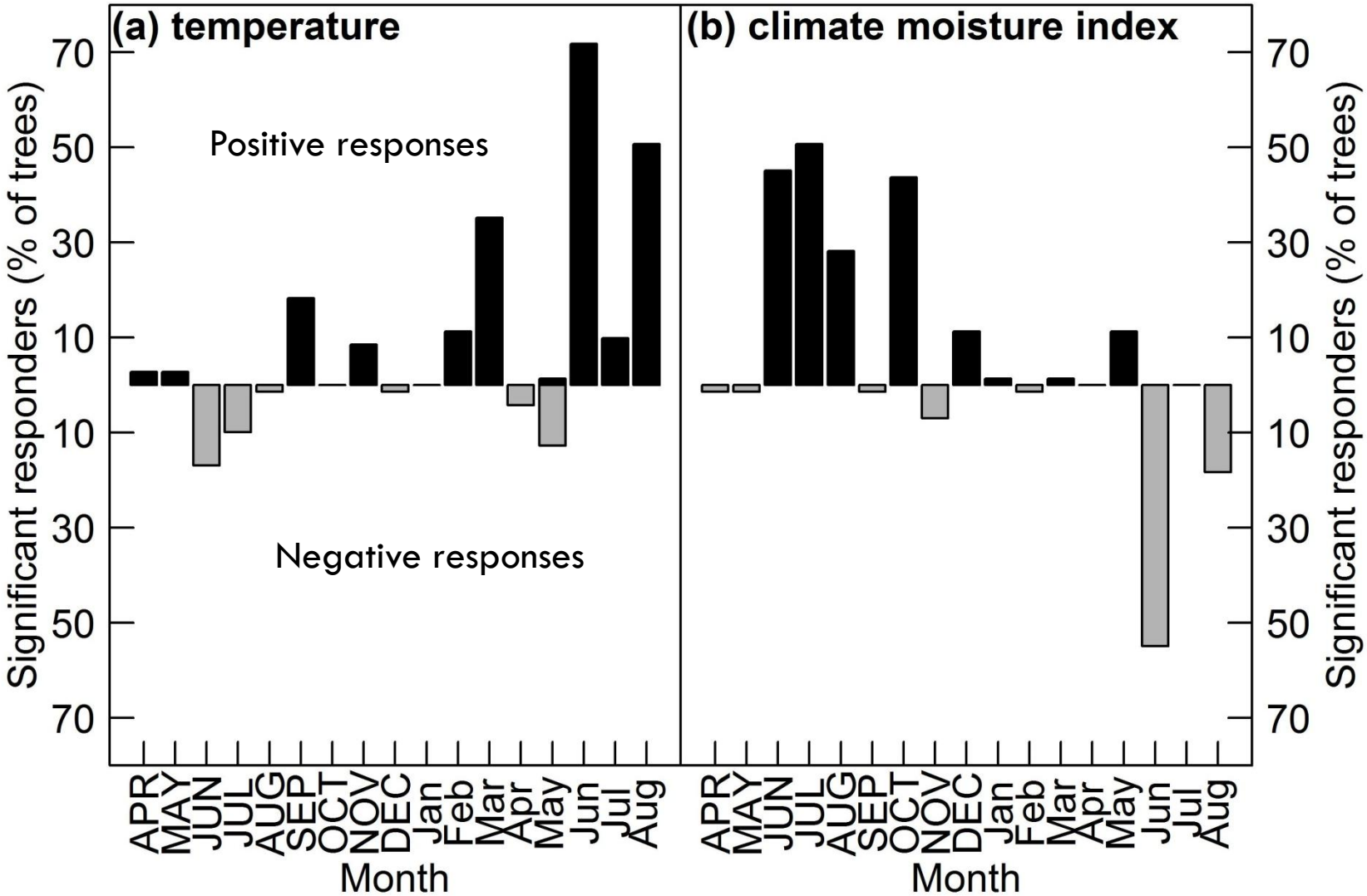


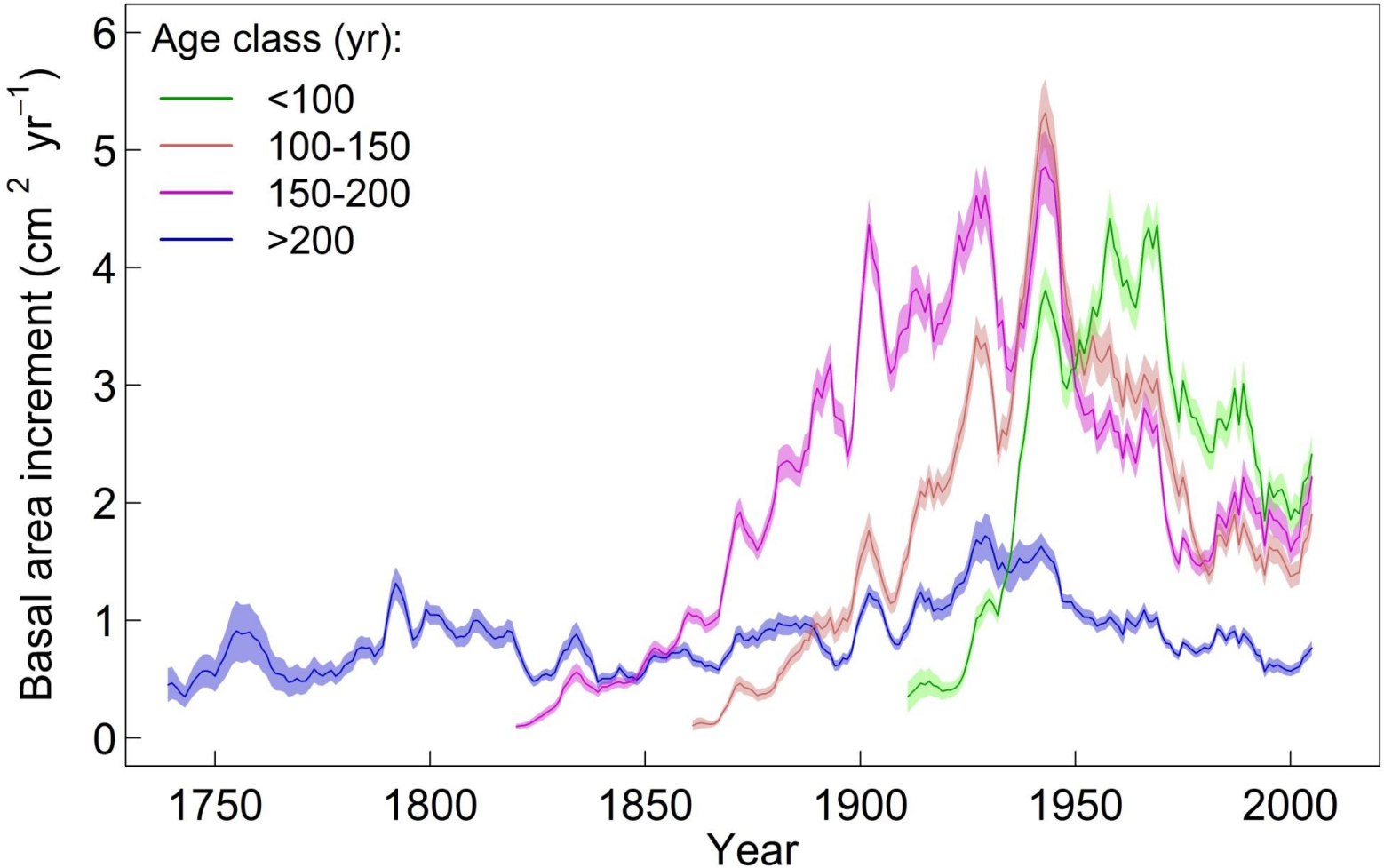
Photo credit: Natural Resources Canada

Larch climate response (1938-2007)



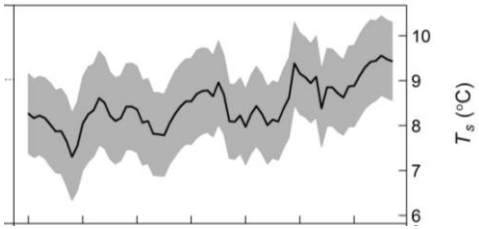
Larch growth trends

NDVI-BAI correlation: r = 0.44, P<0.05

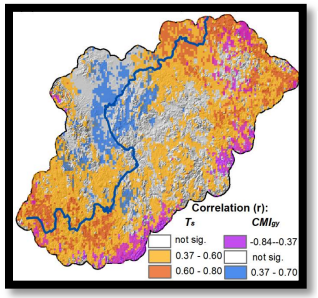


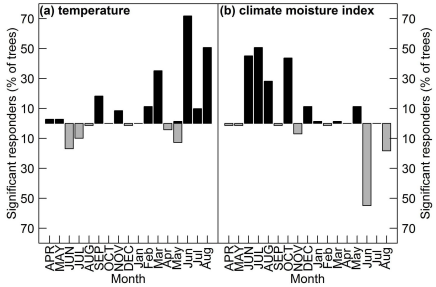
Conclusions

I. Climate warmed in northeastern Siberia since the 1940s

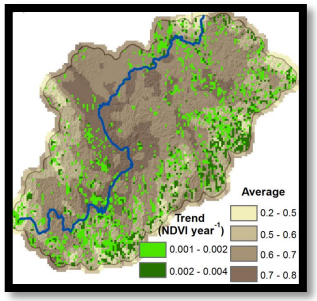


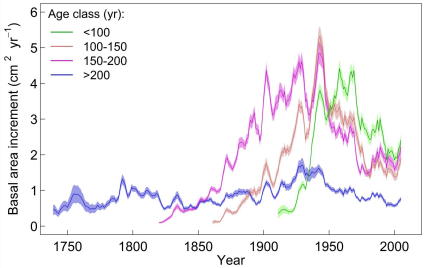
II. Low temperatures and moisture limited annual plant productivity





III. Warming enhanced growth in some areas





Implication

Feedback

Warming → Δ albedo, ET, C storage, permafrost thaw, fire regimes

Thank you

For more information:

Berner, L. T., P. S. A. Beck, A. G. Bunn, and S. J. Goetz. 2013. Plant response to climate change along the forest-tundra ecotone in northeastern Siberia. Global Change Biology **19**:3449-3462

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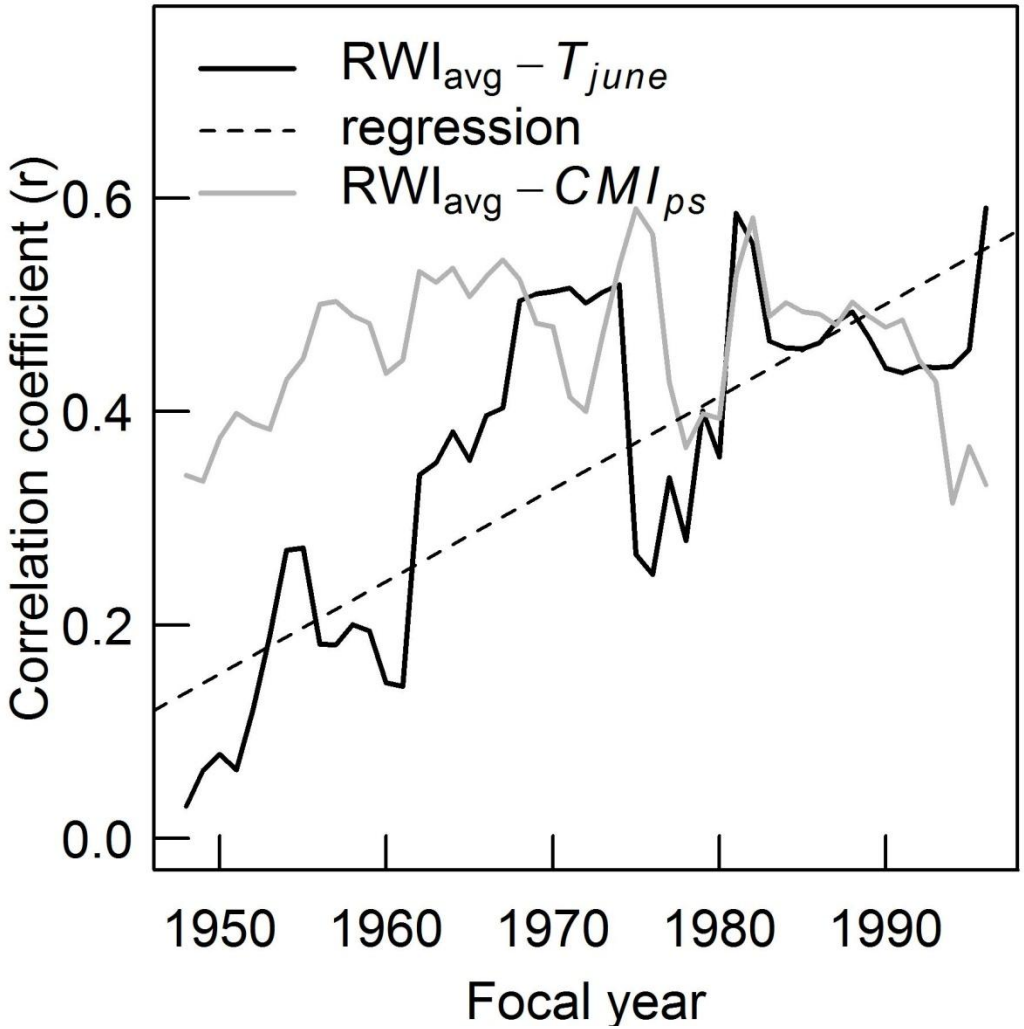
Nikita and Sergey Zimov
GIMMS at NASA for providing NDVI data

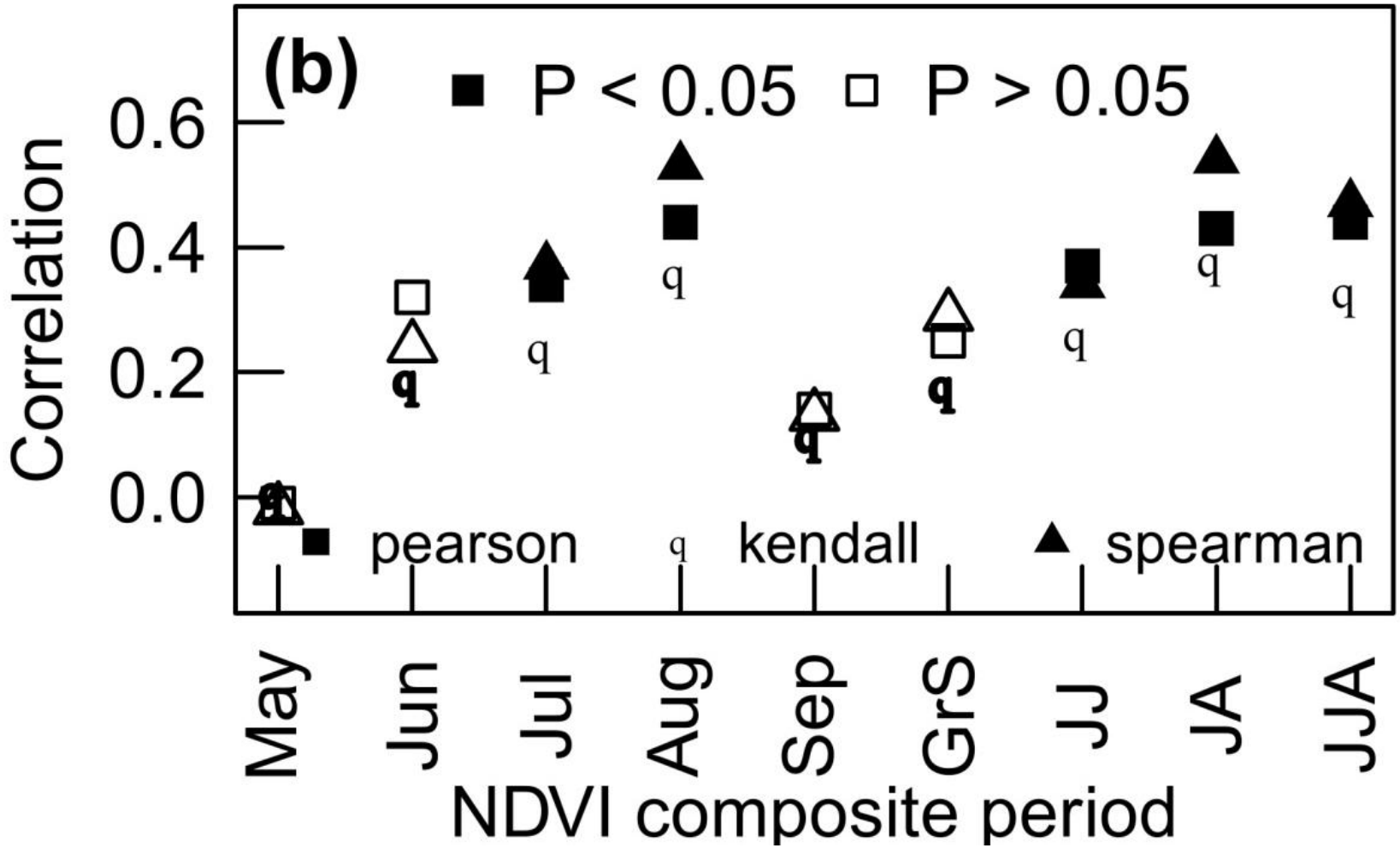
Data sets

Type	Name	Period	Resolution	Source
Satellite	Normalized Difference Vegetation Index (NDVI)	1982-2010	biweekly	AVHRR GIMMS 3G
Tree-ring	Larch ring-width 9 sites, 104 trees	1750-2007	annual	Berner et al. 2011
Climate	Temperature (T)	1938-2009	monthly	CRU 3.10
	Potential Evapotranspiration (PET)	1938-2009	monthly	CRU 3.10
	Precipitation (P)	1938-2010	monthly	GPCC 6

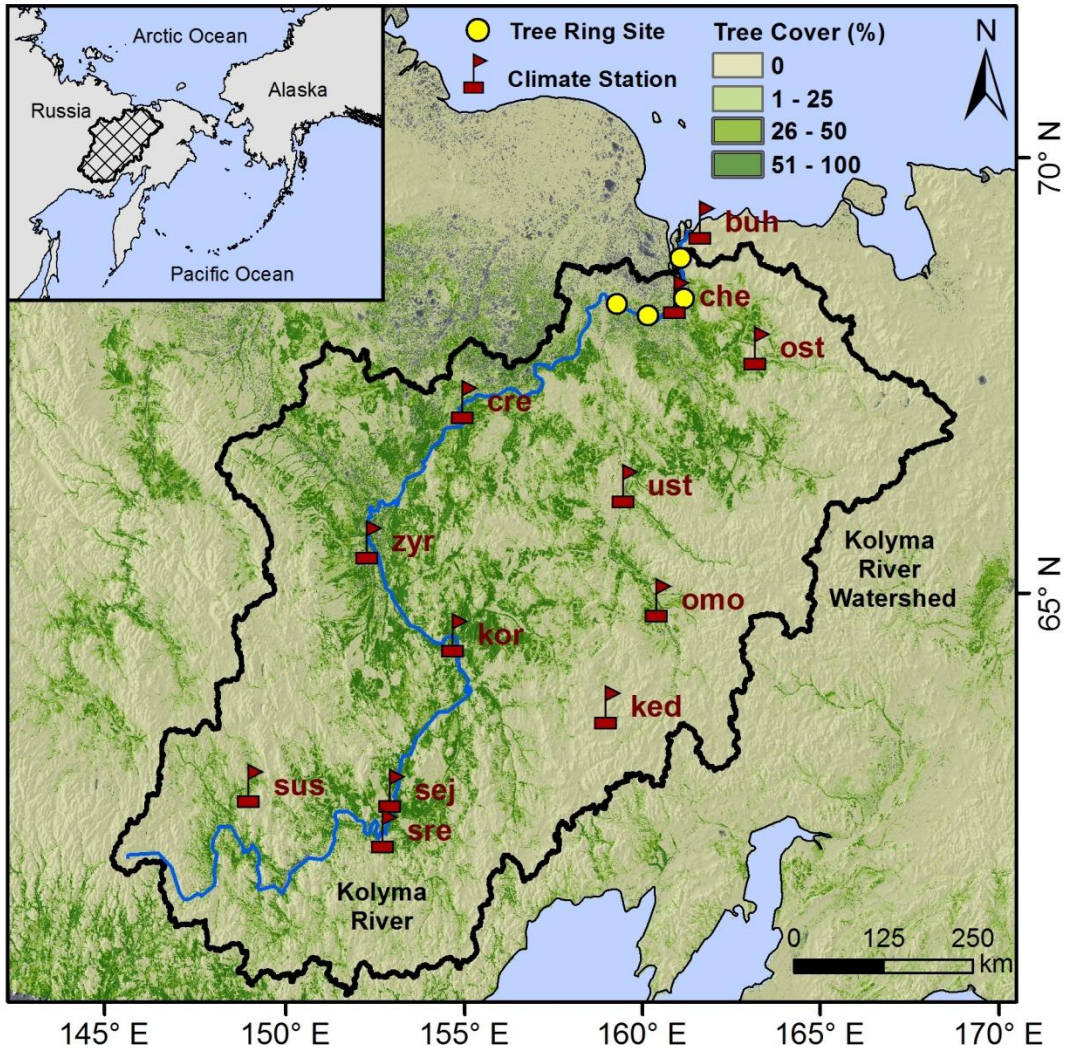
11-yr moving RWI-climate correlations



NDVI-tree ring correlations

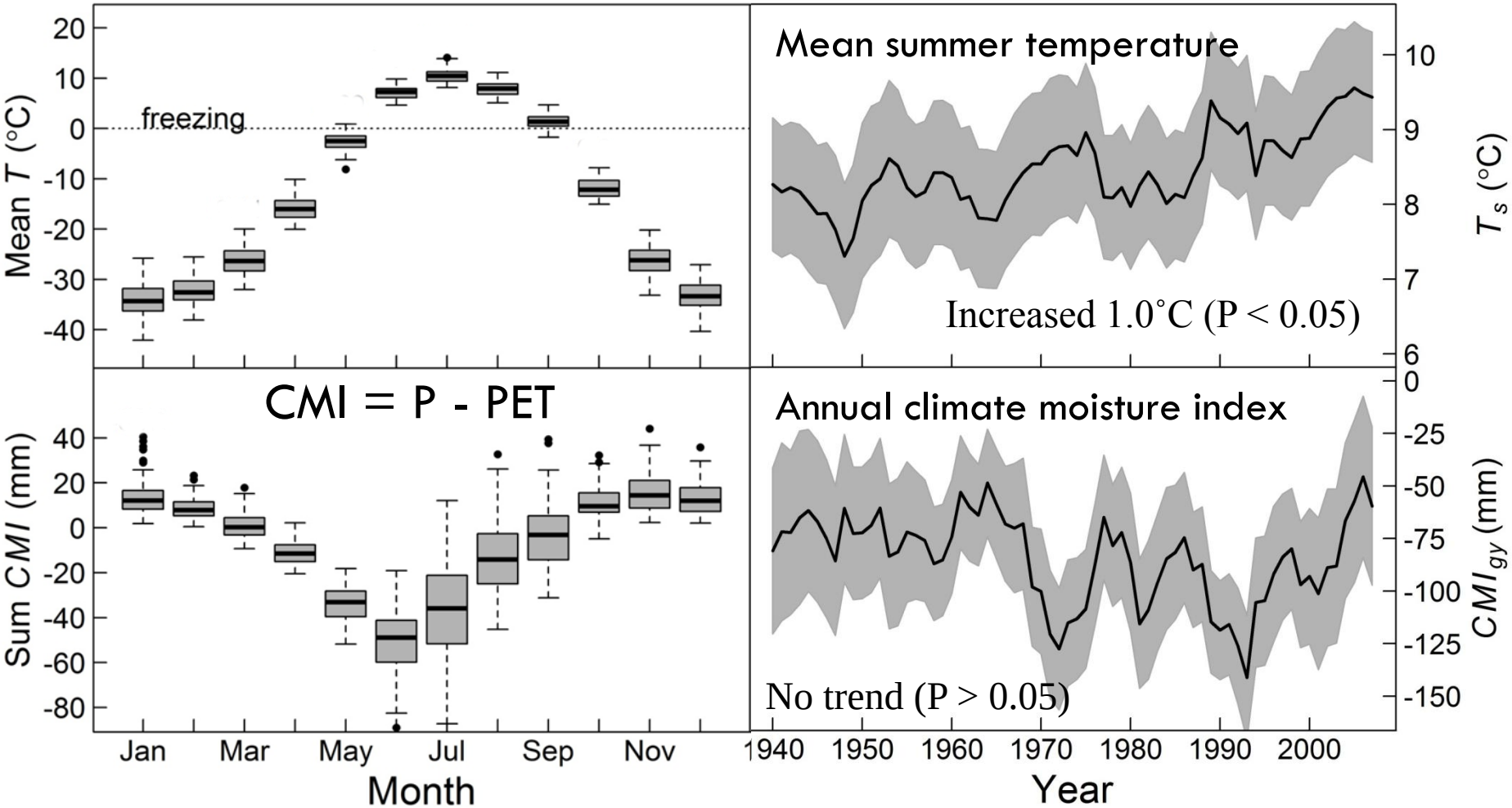


Climate stations



Climate in the Kolyma Basin

Data: CRU and GPCC, 1938-2009



Conclusions

I. Climate warmed in northeastern Siberia since the 1940s

II. Temperature and moisture limit annual plant productivity
   - Spatially, temperature constraints decreased with increased average temperature

III. Warming enhanced growth in some areas
   - Primarily cold, shrub-dominated areas
   - Tree growth declined despite increasing temperatures

IV. Future changes in plant dynamics in the forest-tundra ecotone likely dependent on relative shifts in temperature and water