

The circumpolar *changescape*: a view from above

Daniel J. Hayes

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**The 13th International Circumpolar
Remote Sensing Symposium**

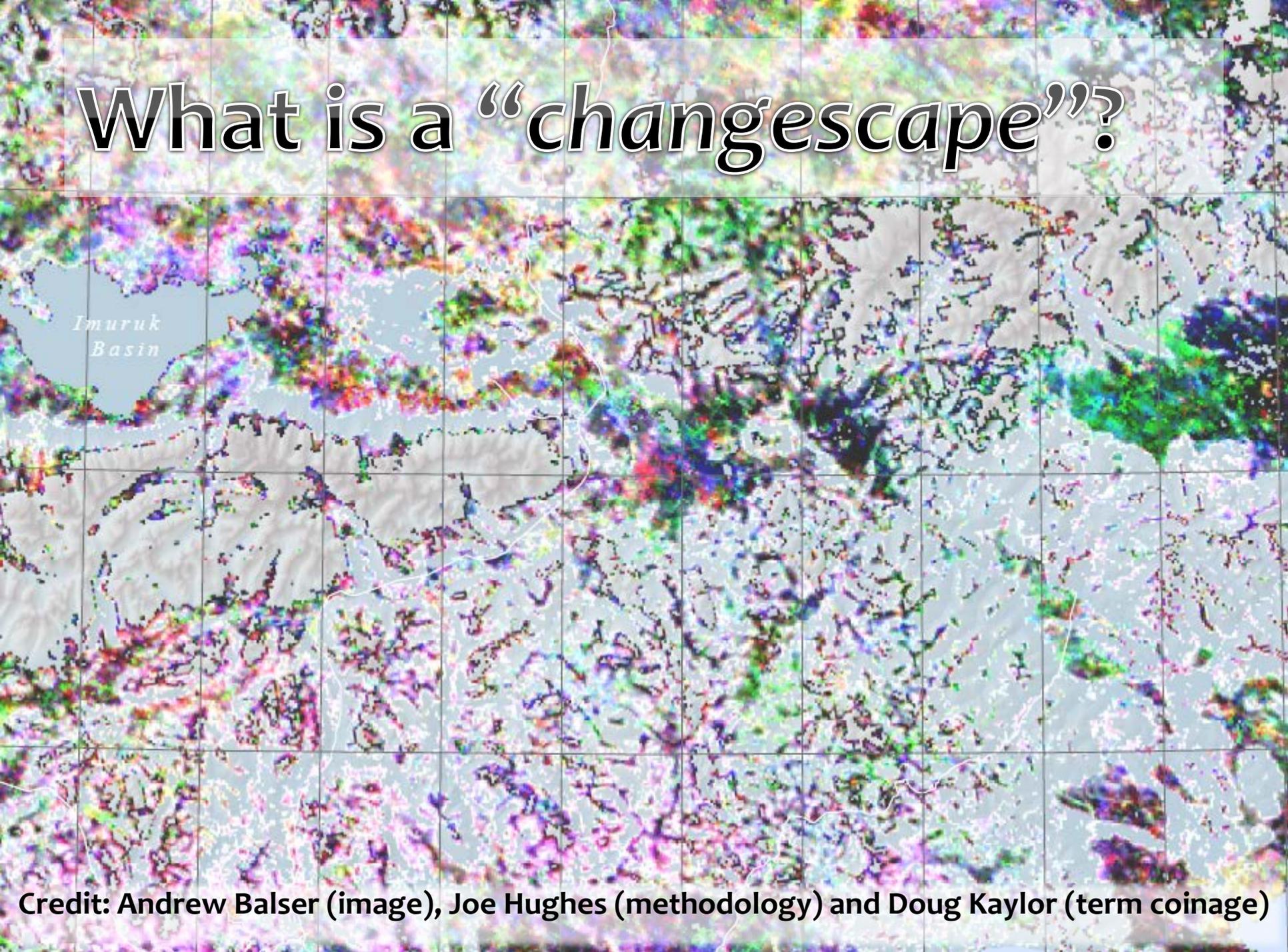
11 September 2014
Reykjavík, Iceland



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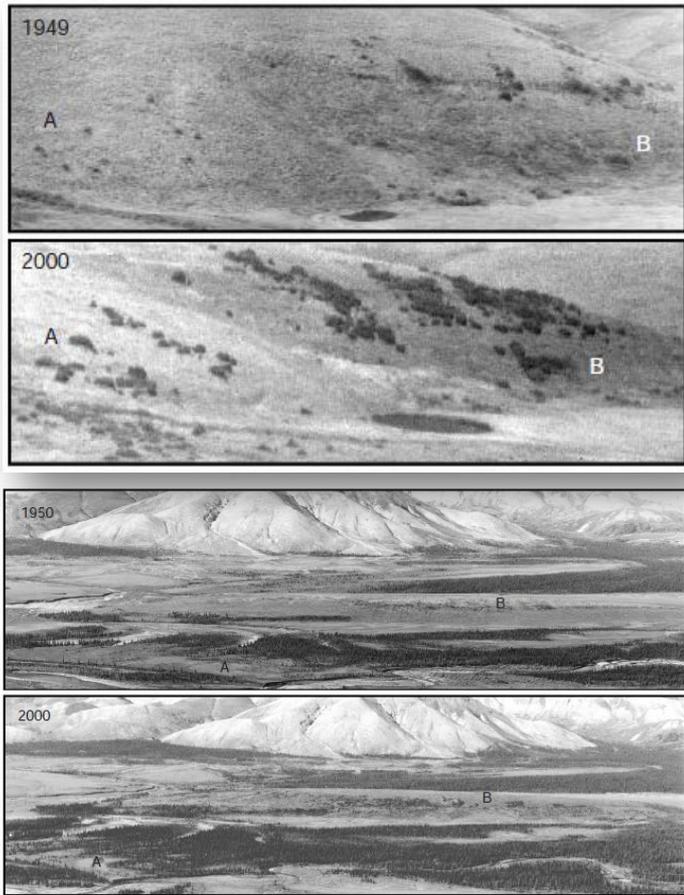
What is a “changescape”?

*Imuruk
Basin*

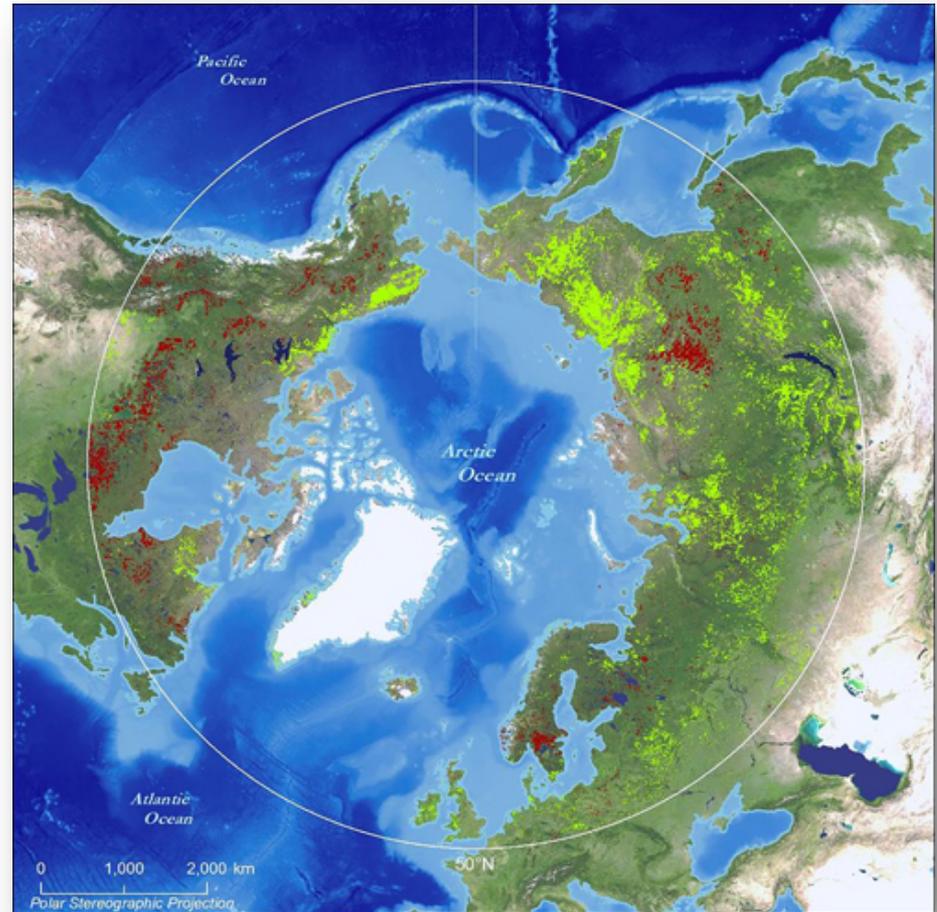


Credit: Andrew Balsler (image), Joe Hughes (methodology) and Doug Kaylor (term coinage)

“The Map is Changing” – M. Sturm, pers. comm.



Sturm et al. (2001)



Goetz et al. (2007)

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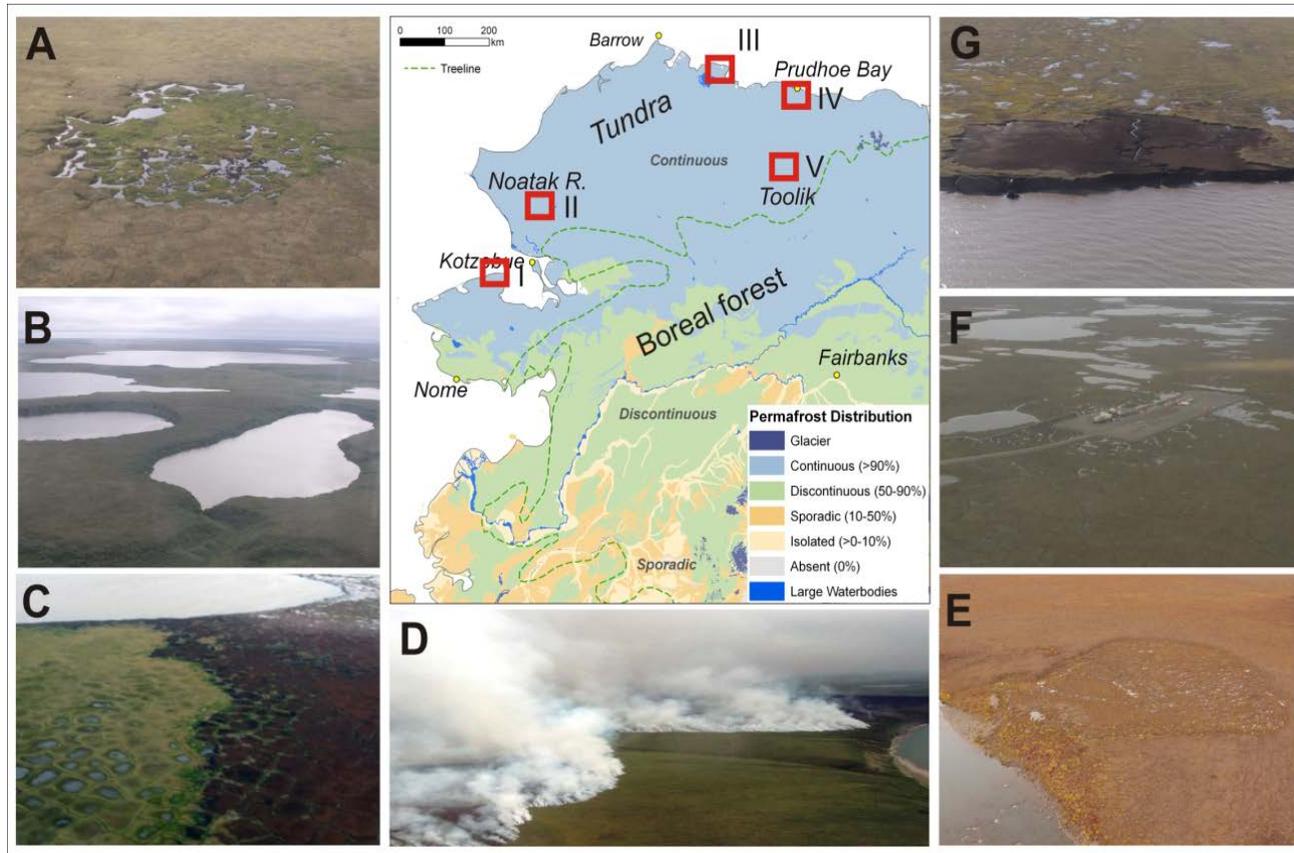


Figure: G. Grosse

A – Thermokarst collapse, B – Thermokarst lakes, C – Salt-burned tundra at coast, D – Tundra fire, E – Active layer detachment slide, F – Gravel pad with oil extraction facility, G – Drained lake (G. Grosse: A, B, E, F, G; C. Arp: C; P. Higuera: D)

Remote sensing in the study of changing northern high latitude terrestrial and aquatic ecosystems

Dan Hayes and Santonu Goswami – *Oak Ridge National Laboratory, USA*



Guido Grosse – *Alfred Wegener Institute, Germany*



Ben Jones – *US Geological Survey, USA*



Remote sensing in the study of changing northern high latitude terrestrial and aquatic ecosystems

Accomplishments, findings, challenges and opportunities...

Remote Sensing of Northern High-latitude Terrestrial and Aquatic Ecosystems

Santonu Goswami¹, Daniel J Hayes¹, Guido Grosse² and Benjamin M Jones³, (1)Oak Ridge National Laboratory, Oak Ridge, TN, United States(2)Alfred Wegener Institute Helmholtz-Center for Polar and Marine Research Potsdam, Potsdam, Germany(3)U.S. Geological Survey, Anchorage, AK, United States

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*remote
sensing*

"Remote Sensing of Changing Northern High Latitude Ecosystems"

A special issue of [Remote Sensing](#) (ISSN 2072-4292).

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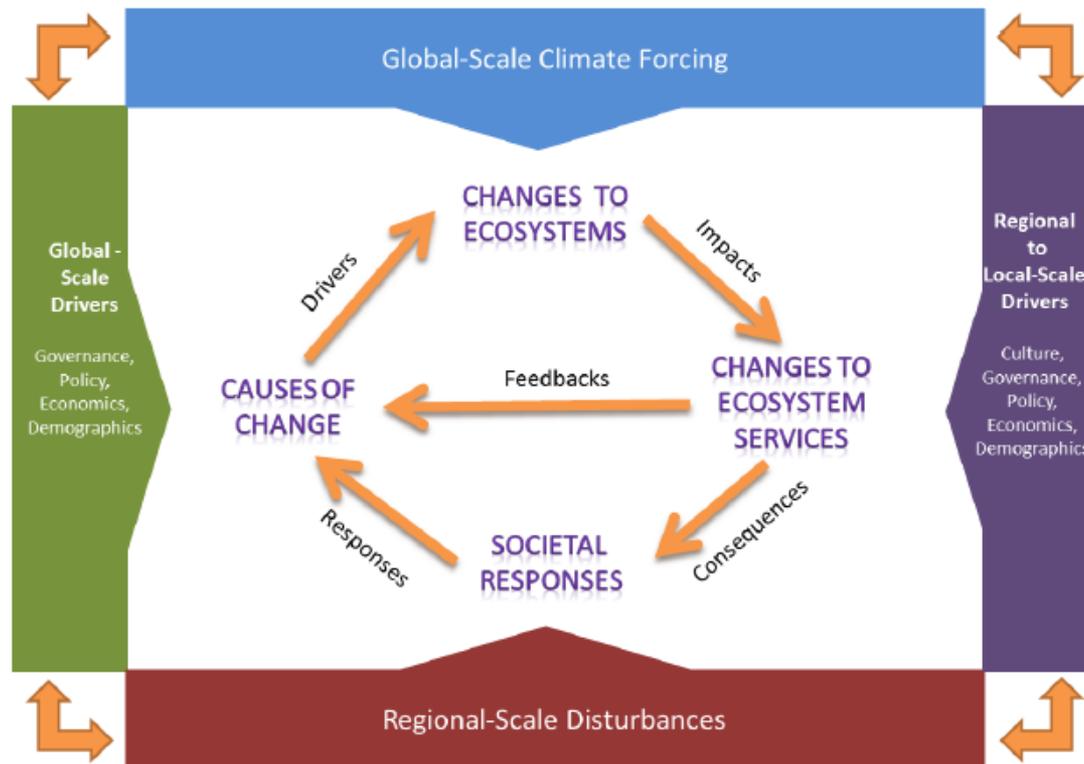
Outline

- Disturbance in Arctic-Boreal Ecosystems
 - Drivers, impacts and consequences of disturbance
 - Disturbance characteristics
- Remote Sensing of Arctic-Boreal Landscape Changes
 - Overview of methods & review of literature
 - Trends in vegetation productivity, composition and structure
 - Changes in the cryosphere: snow and ice
 - Changes in hydrology: lakes, rivers and coastal systems
 - Pulse disturbances: fire, insects, land use
 - Press disturbances: active layer thickening and permafrost thaw
- Challenges and Opportunities
 - New methods
 - New applications

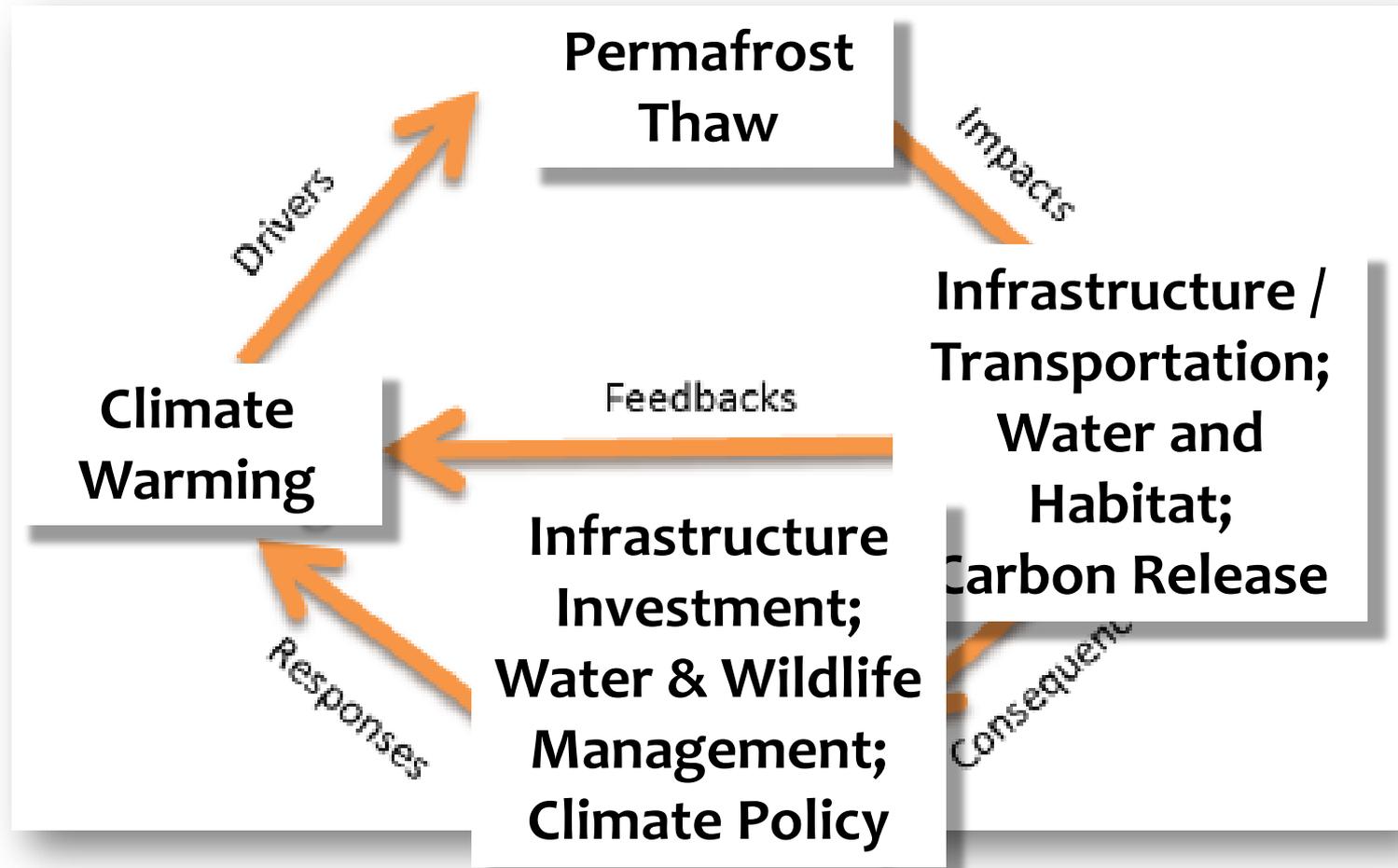
Socio-ecological Vulnerability / Resiliency

ABOVE Concise Experiment Plan – NASA

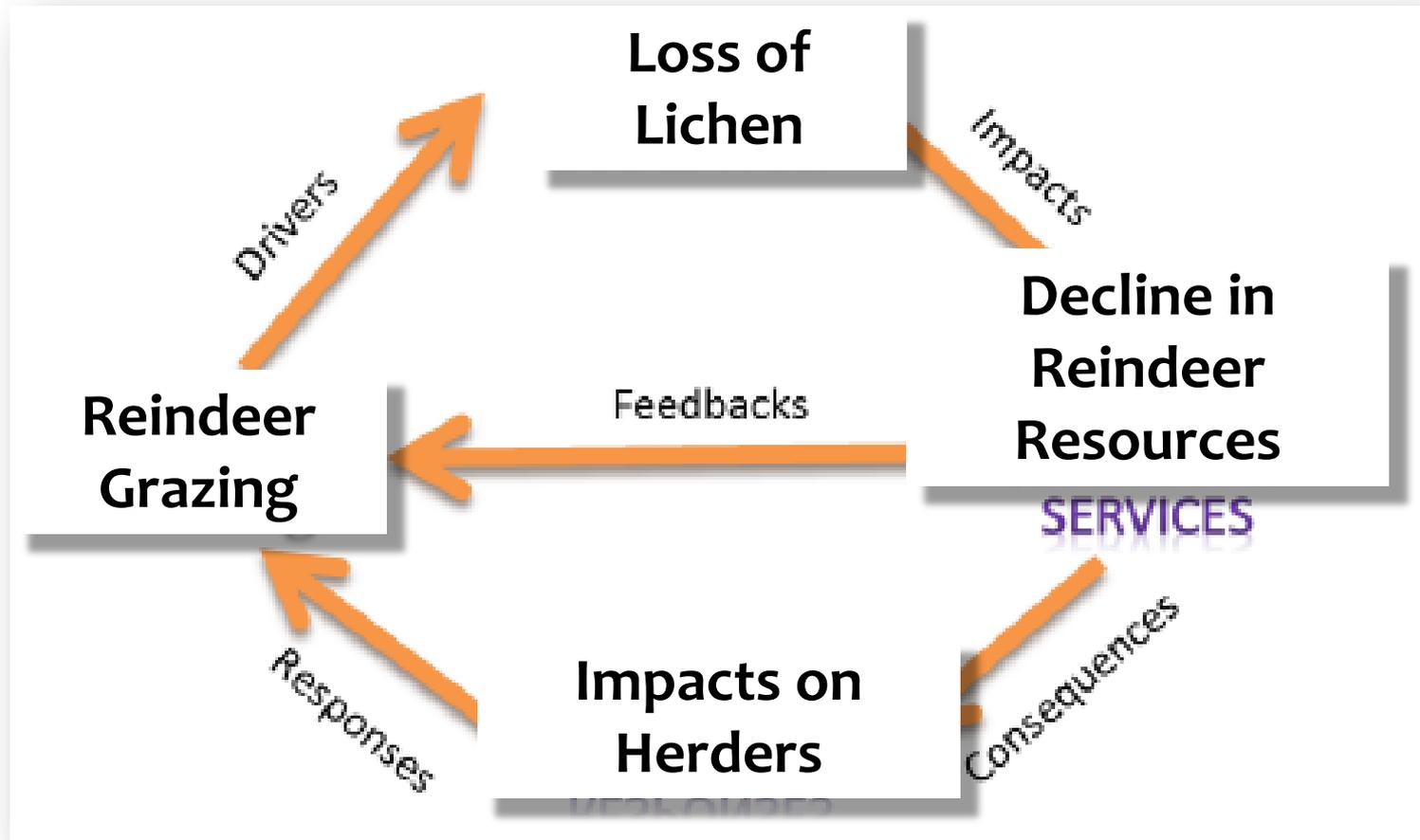
Figure 2.1. Conceptual diagram of the Vulnerability/Resilience Framework used for organizing the science questions and objectives to be addressed during ABoVE. Changes to social-ecological systems (center) within the Study Domain are being driven by a combination of global-scale climate forcing that drive press disturbances, regional-scale pulse disturbances, and local- to global-scale socio-economic processes.



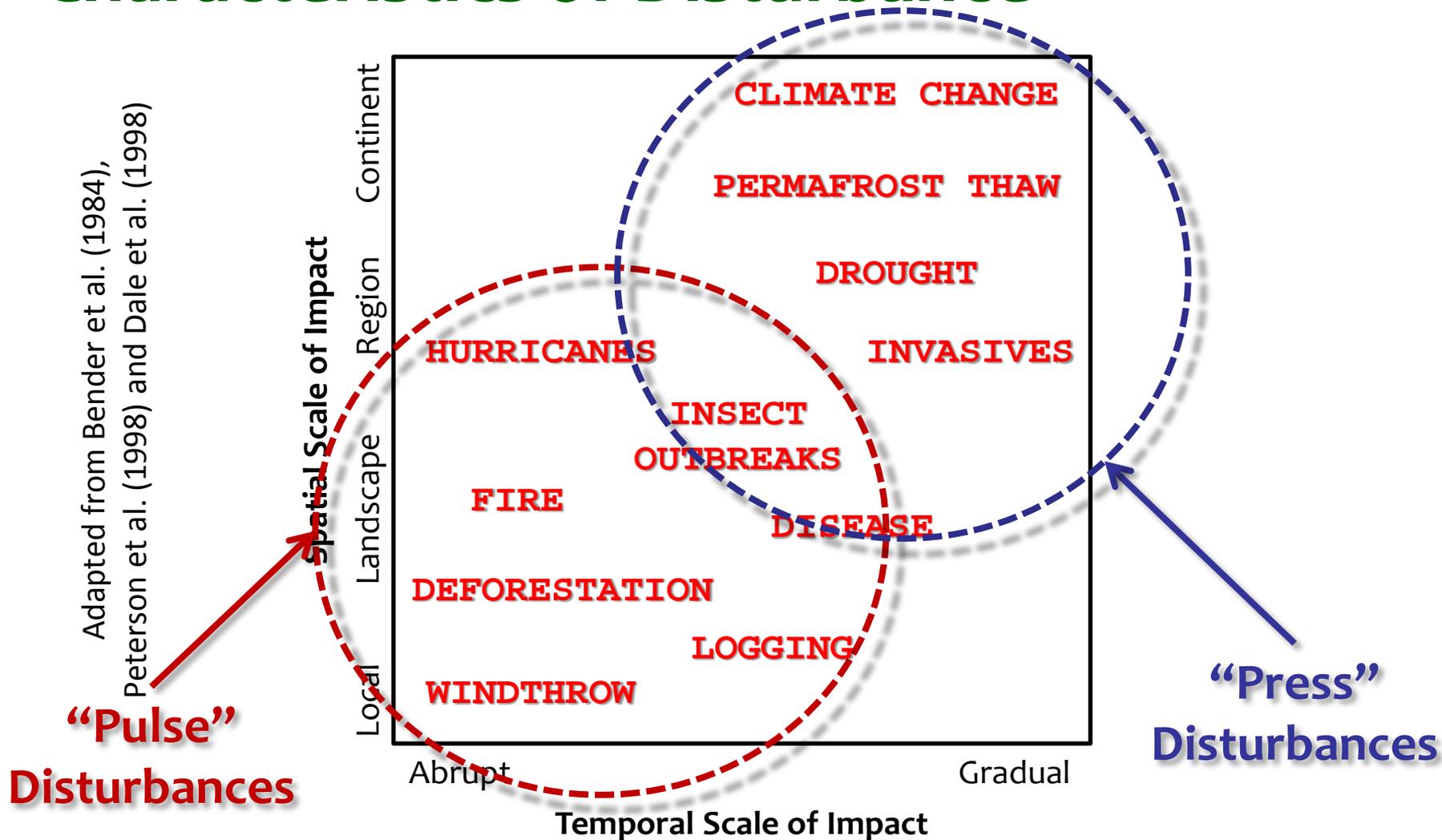
Vulnerability: Permafrost



Vulnerability: Reindeer

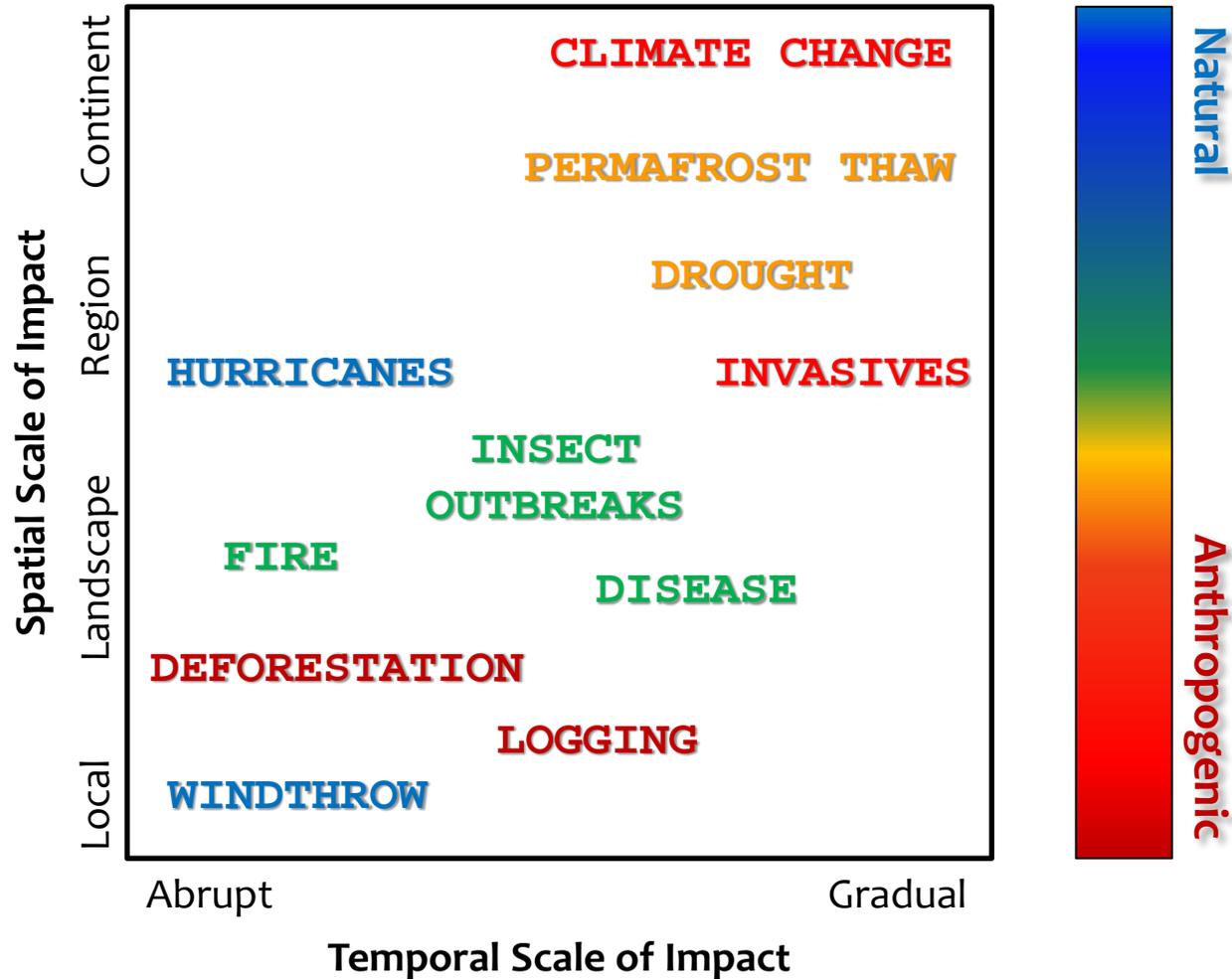


Characteristics of Disturbance



Characteristics of Disturbance

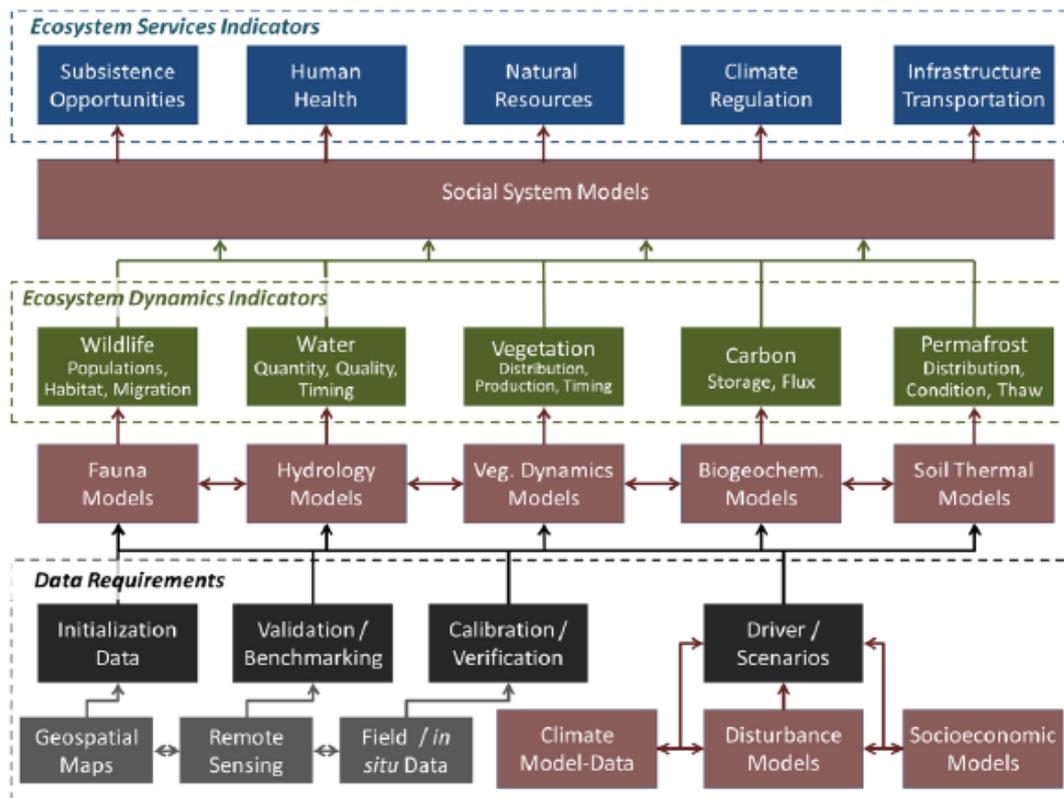
Adapted from Bender et al. (1984),
Peterson et al. (1998) and Dale et al. (1998)



The role of remote sensing

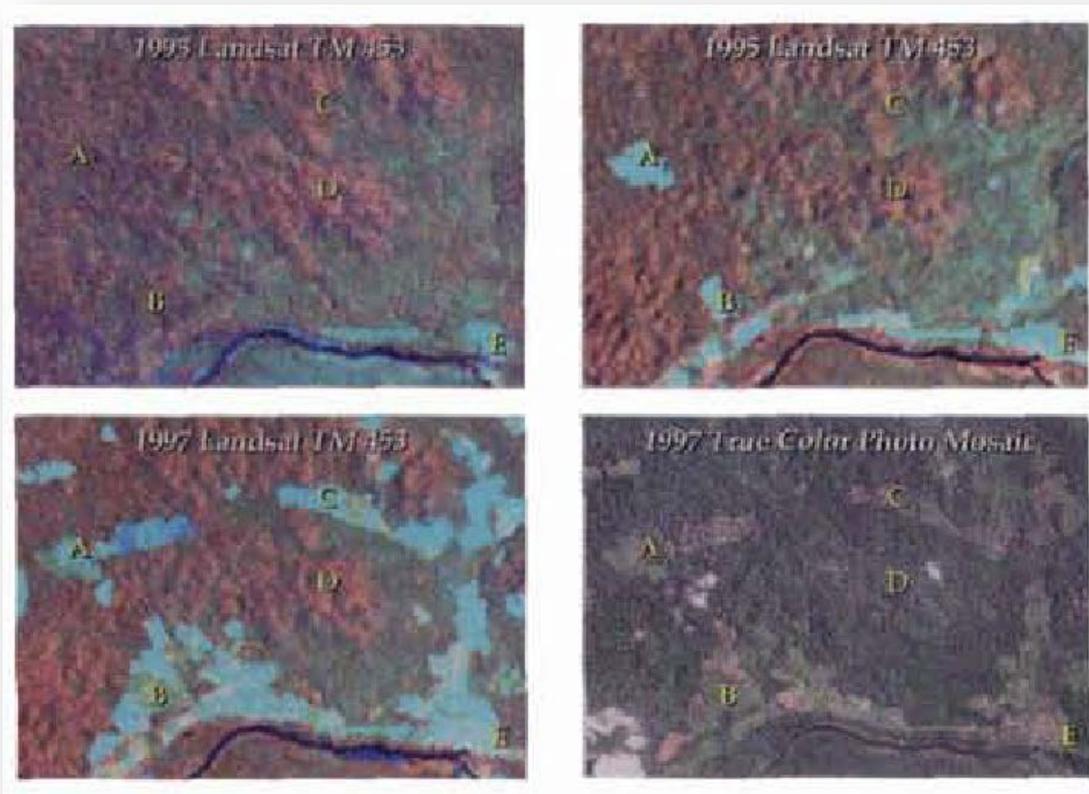
ABOVE Concise Experiment Plan – NASA

Figure 4.3 Modeling research during ABoVE will involve a portfolio of model types (red boxes) needed to simulate the key ecological indicators (green) that impact ecosystem services (blue), across which there are generic needs for data (black) that can be satisfied by research products generated during ABoVE (gray).



Remote Sensing of Disturbances

Large and severe “pulse” disturbance (deforestation) on Landsat imagery



Hayes and Sader (2001) PERS

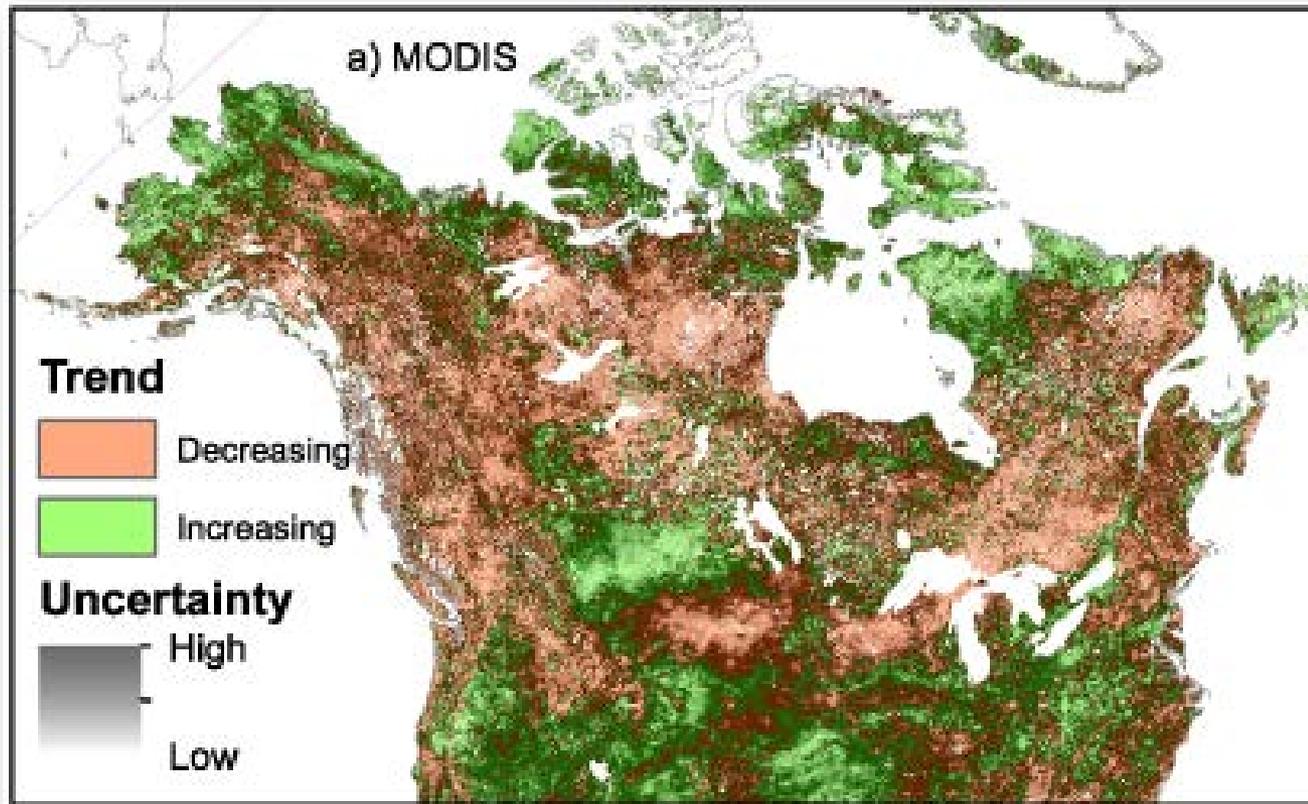
Remote Sensing of Disturbances

Change Detection Techniques

- **Before 2009:**
 - **Discrete comparison** (differencing, thresholding, classification, etc.) between each specific image (airphoto or satellite) acquisition date (two or more years)
- **Since 2009:**
 - **Trend analysis** over a more full and continuous archive of satellite imagery

Remote Sensing of Ecosystem Dynamics

Trends in arctic vegetation productivity



Beck and Goetz (2011) ERL

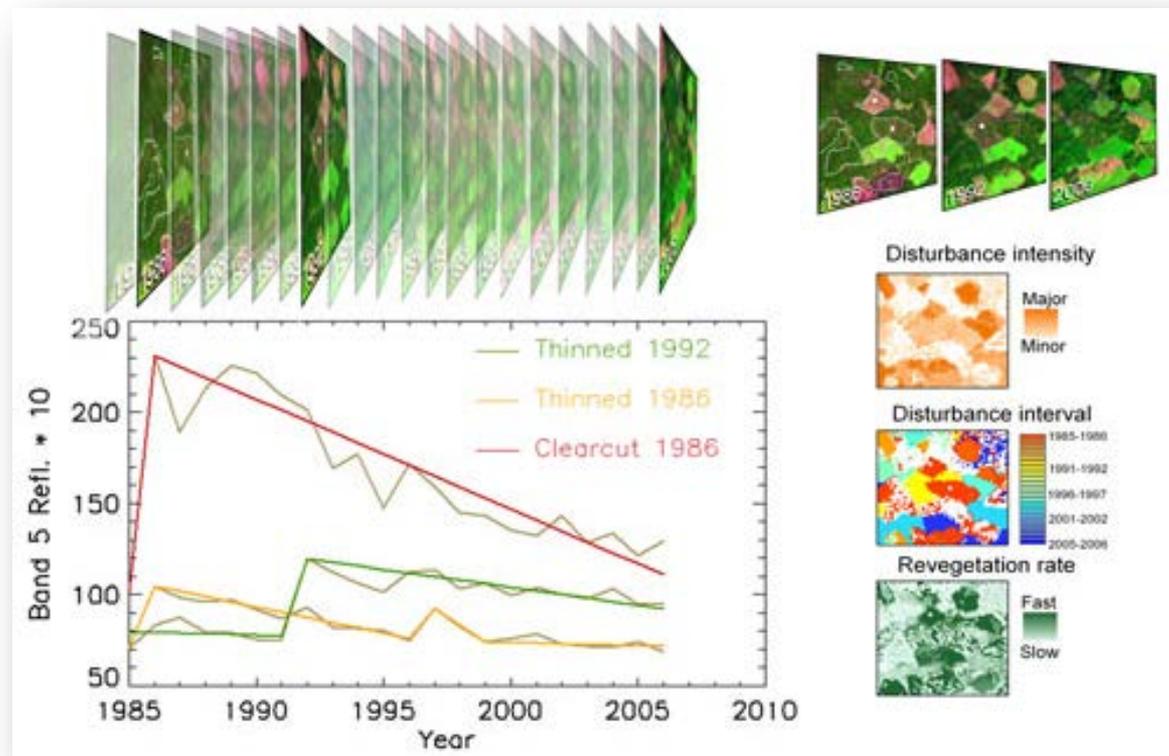
Remote Sensing of Ecosystem Dynamics

Trends in arctic vegetation productivity



Remote Sensing of Disturbances

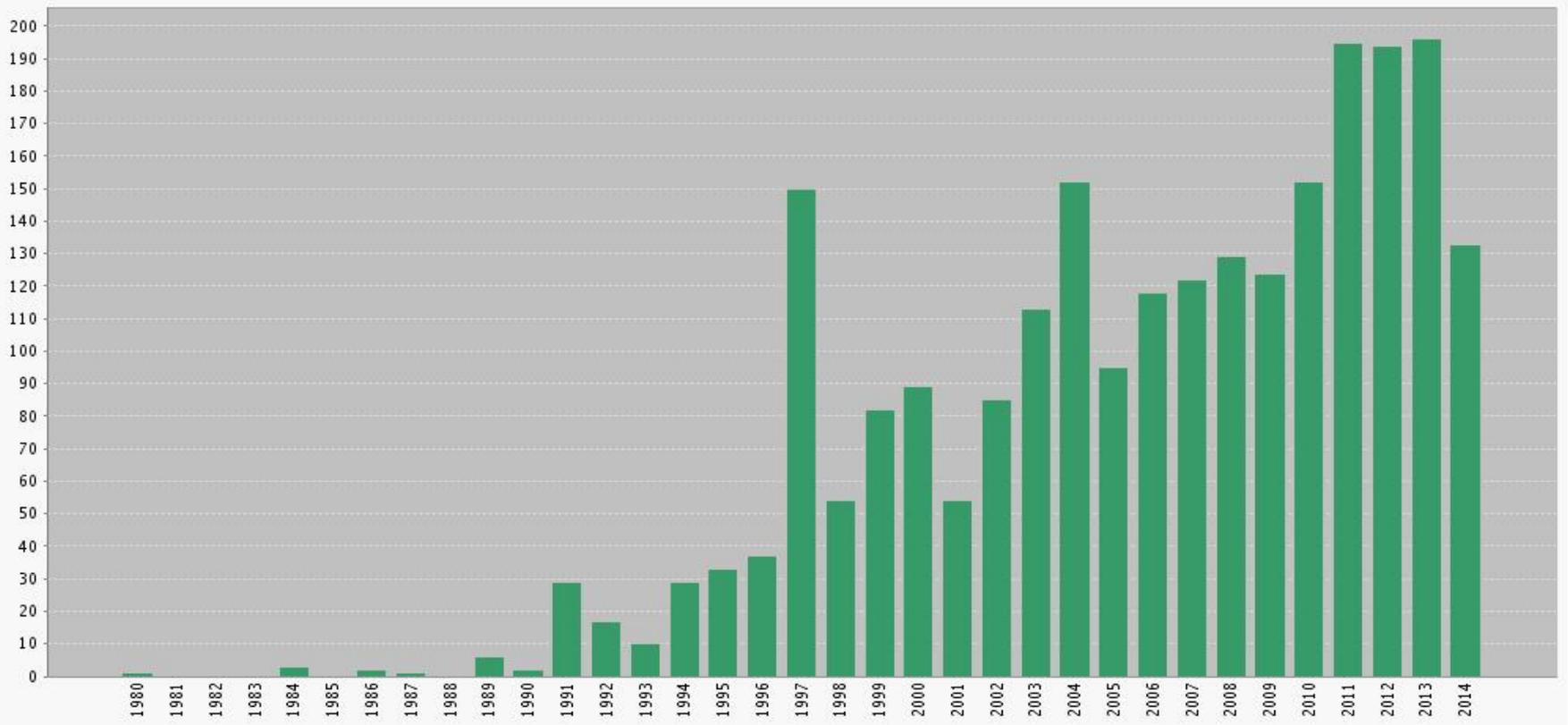
Trends in disturbance and recovery:
exploiting the full historical Landsat archive



Kennedy et al. (2010) RSE

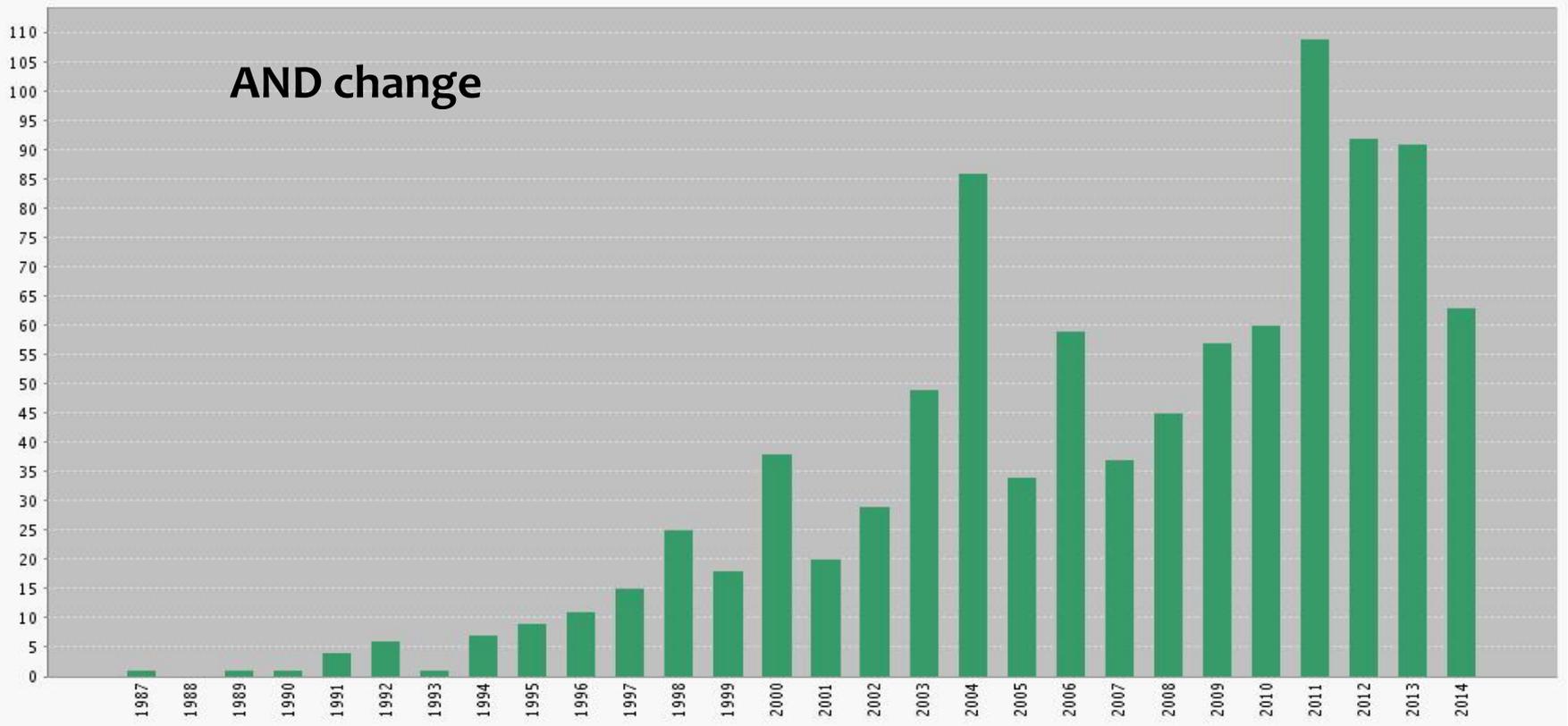
Circumpolar Remote Sensing

remote sensing AND (arctic or tundra or boreal or circumpolar)

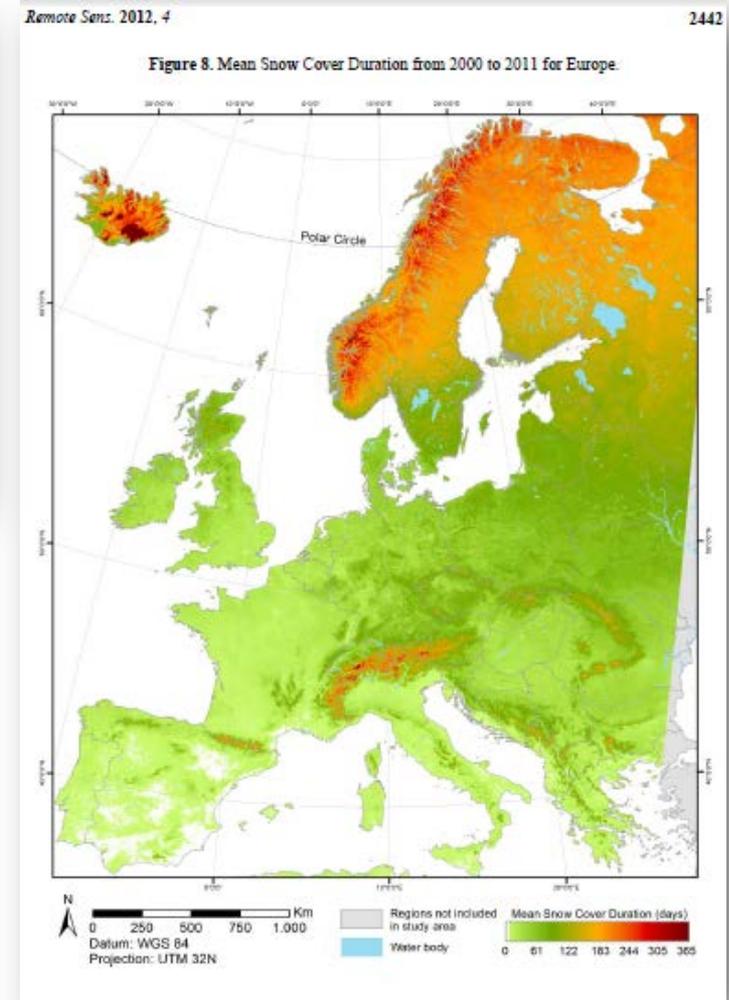
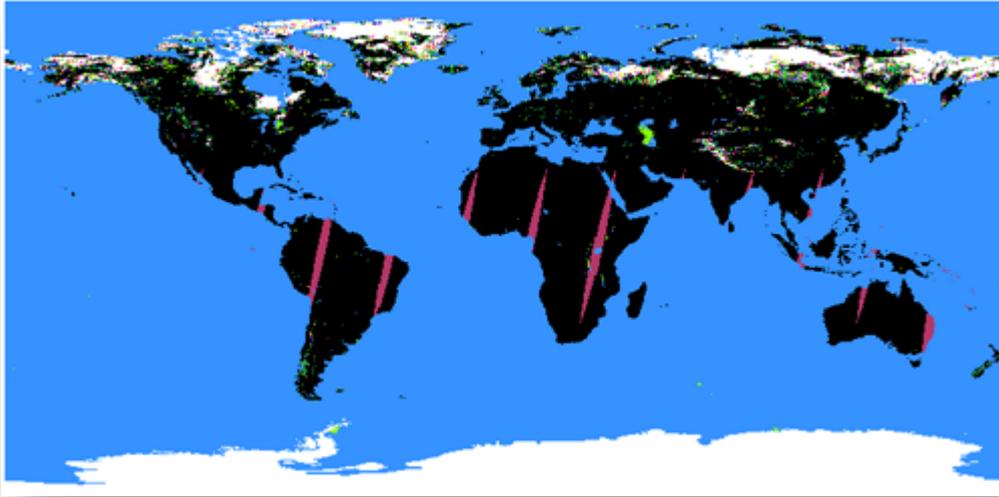


Circumpolar Remote Sensing: Change

remote sensing AND (arctic or tundra or boreal or circumpolar)

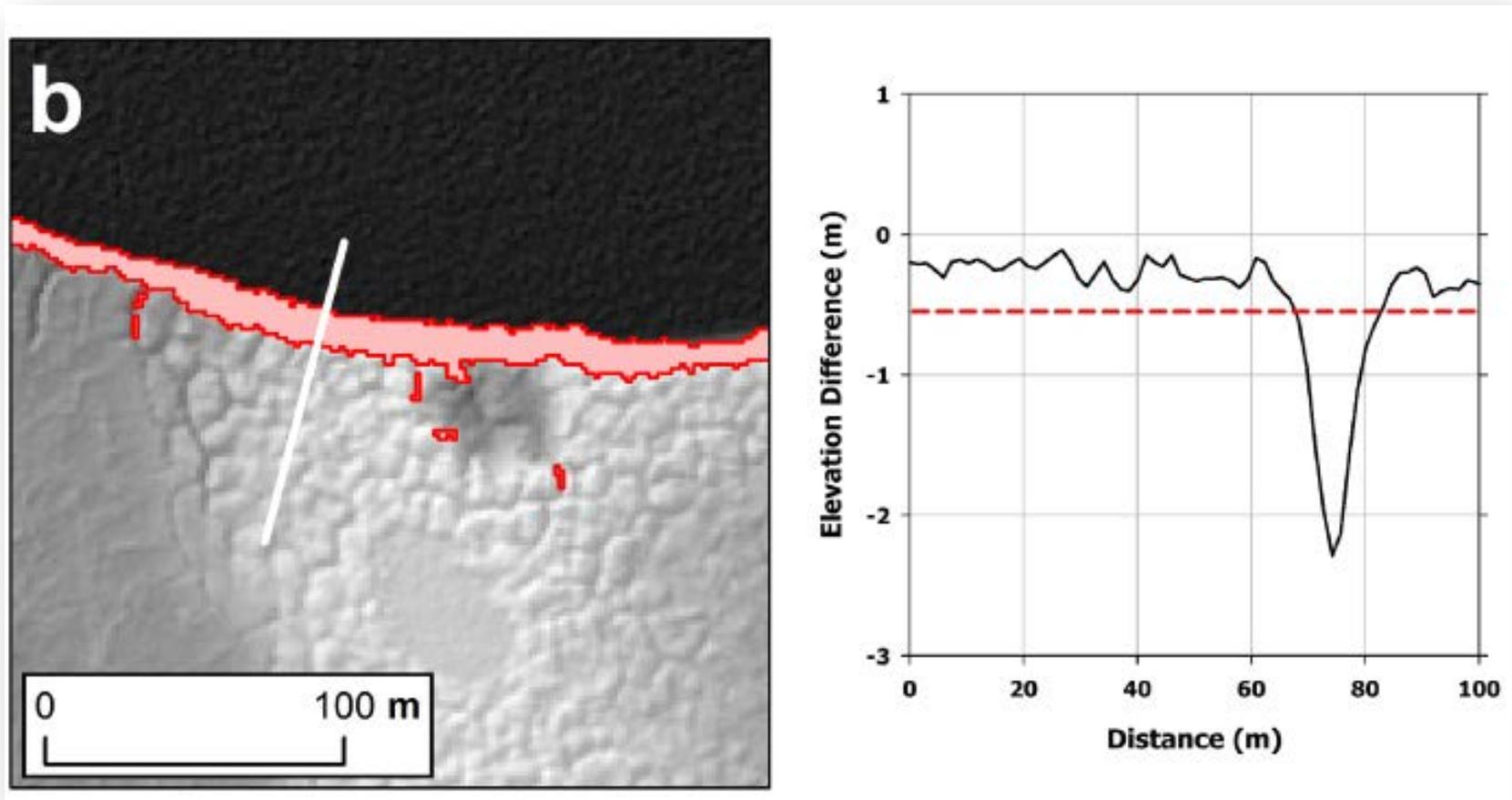


Changes in the cryosphere: snow and ice



Deitz et al. (2012) Rem. Sens.

Changes in hydrology: lakes, rivers and coastal systems



Jones et al. (2013) ERL

Pulse disturbances: fire, insects, land use

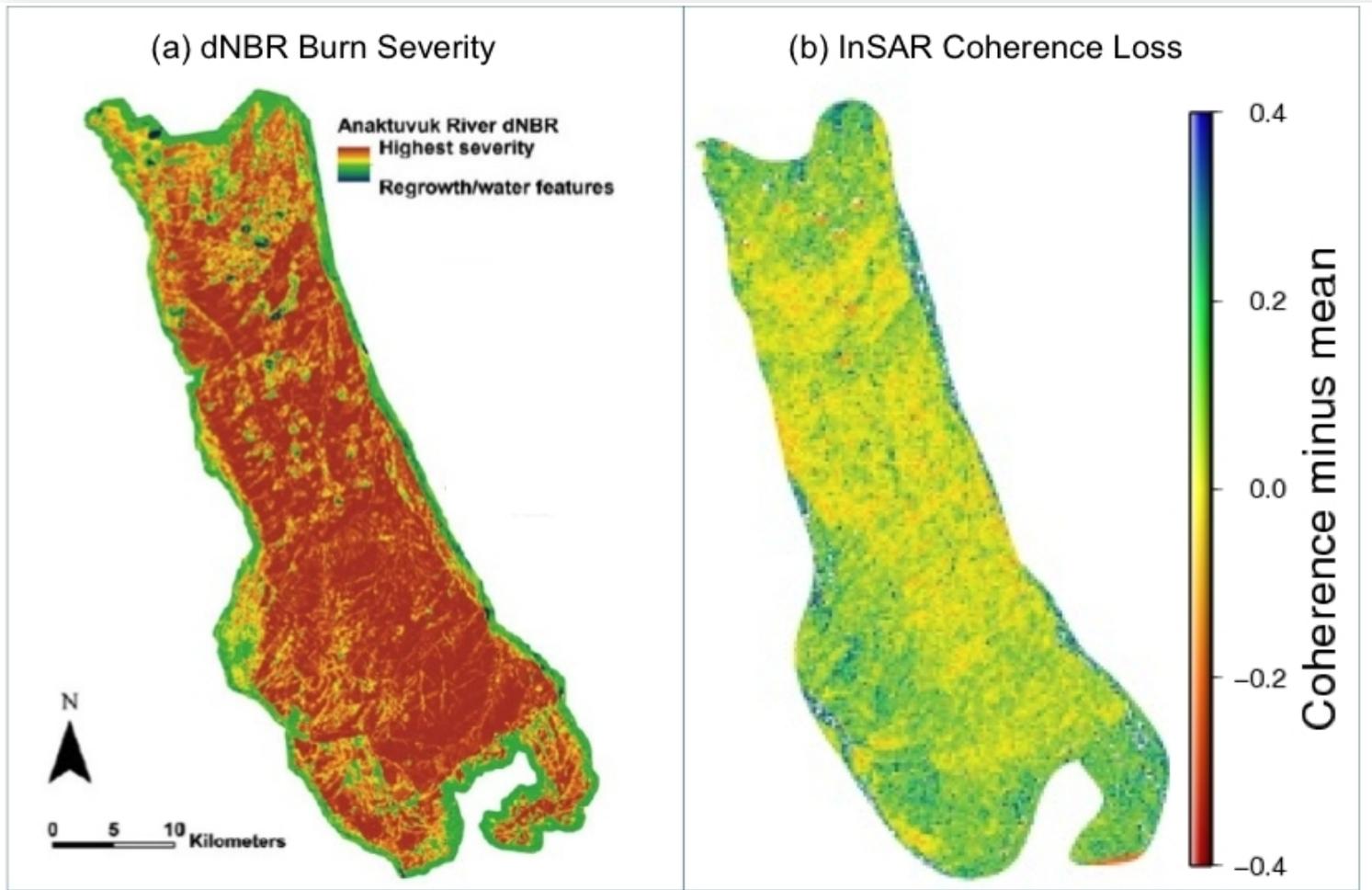


Table 4.2. High importance remote sensing data products (Importance Factor = 1 in Table C3) required for addressing ABoVE Tier 2 science questions and objectives. Maturity levels are based on NASA definitions discussed in Appendix C. (Maturity of satellite data products: A – research grade products where algorithms require further development and validation; B – Products based on existing algorithms that require further refinement and validation for the conditions present in Arctic and boreal regions; and C – Existing algorithms whose accuracies have been well quantified can be used to generate data products for ABoVE. Multiple sources are available for some of the satellite remote sensing data products, and are identified in Table C1).

| Required Information | Satellite Remote Sensing Data Products | | | Airborne Remote Sensing Data Products |
|--|--|-------------|-----------------------|--|
| | Resolution | Domain Wide | Landscape to Regional | Airborne Sensors |
| | | Maturity | Maturity | |
| Seasonal Snow Depth | Coarse | A | | Small footprint LiDAR, SAR, Microwave Radiometer |
| Atmospheric mole fractions of CO ₂ | Coarse | B | | CARVE Payload, AFT |
| Snow extent time series (single product) | Moderate | B | | |
| Soil Moisture | Coarse to Moderate | B | | Microwave Radiometer, SAR |
| Wetland maps | Medium | B | | |
| Winter thaw events | Coarse | B | | |
| Annual maps of surface water extent (lake/pond) | Medium | C | | |
| Forest cover change | Medium | C | | |
| Area extent and severity of biotic disturbances | Medium | | A | |
| Burn Severity (organic layer consumption, mortality, etc.) | Medium | | A | Small footprint LiDAR, InSAR |
| Active layer (depth of thaw) dynamics | Medium | | A | |
| Distribution and extent of thermokarst features | Fine to Medium | | A | |
| Post-disturbance soil moisture | Medium | | A | Microwave Radiometer, SAR |
| Post-disturbance vegetation recovery | Medium | | A | |
| Anthropogenic disturbance | Fine to Medium | | A | |
| Biomass/canopy Structure | Fine | | | Small footprint LiDAR, InSAR |
| Deep substrate properties | Fine | | | Electromagnetic Resonance Imager, SAR |
| Vegetation Composition | Fine | | | Hyperspectral Imager |
| Atmospheric CO ₂ , CH ₄ , CO | Fine | | | CARVE Payload, Airborne Fourier Transform |
| Season Surface Deformation | Fine | | | Small footprint LiDAR, InSAR |

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Thank You!

Dan Hayes

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