http://above.nasa.gov

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NASA Carbon Cycle and Ecosystems Office

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AAAS Science Policy Fellow, NASA

Additional Team Members

Dan Hodkinson and Leanne Kendig (NASA Carbon Cycle and Ecosystems Office)

– Logistics & Safety Coordination for ABoVE Project

Acknowledgements

- ABoVE Science Definition Team. Membership can be found at

  http://above.nasa.gov

- Authors of the ABoVE Scoping Study Report: E. Kasischke, S. Goetz, J. Kimball, M. Mack
- Manager of NASA's Terrestrial Ecology Program: Diane Wickland

Meeting Goals

Goals for the ABoVE trip to the Northwest and Yukon Territories are three-fold:

1. Provide information about ABoVE
2. Learn about ongoing research and monitoring activities
   - Research/monitoring needs
   - Decision-makers' use of information (at all levels)
3. Explore possible interactions between NASA/ABoVE and Canadian researchers and decision-makers

Briefing Overview

- *Overview of ABoVE*
- Why NASA?
- Review of the ABoVE Concise Experiment Plan
  - Motivation and compelling imperative for ABoVE
  - Vulnerability framework and key areas for research
  - Research questions/objectives
  - Activities to be supported through ABoVE
  - Overall strategy for ABoVE

What is ABoVE?

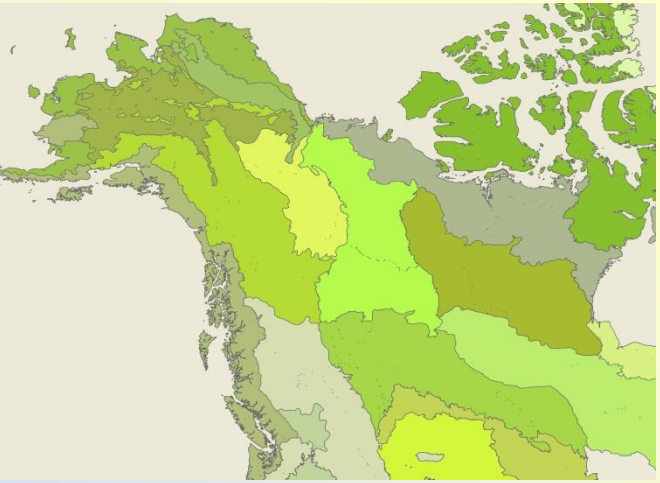
- The Arctic-Boreal Vulnerability Experiment is a major field campaign sponsored by NASA's Terrestrial Ecology Program
- ABoVE will be a 4 to 6 year study beginning in ~2015
- ABoVE will focus on
  - *Developing a fuller understanding of ecosystem vulnerability to climate change in the Arctic and boreal regions of western North America*
  - *Providing the scientific understanding required to develop options for societal responses to the impacts of these changes*

Overarching Science Question for research to be carried out during ABoVE

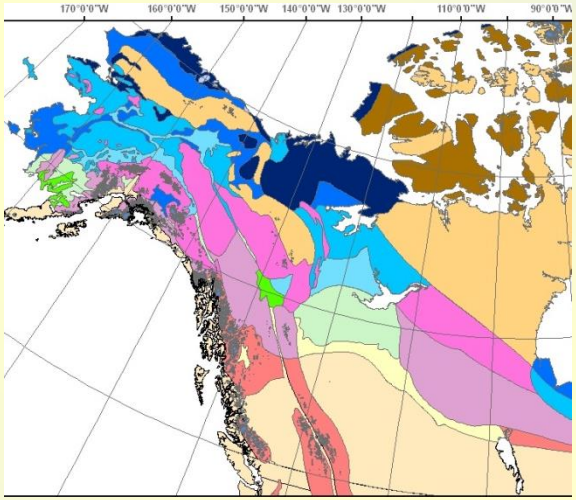
How vulnerable and resilient are ecosystems and society to environmental change in Arctic and boreal regions?

ABoVE Study Region

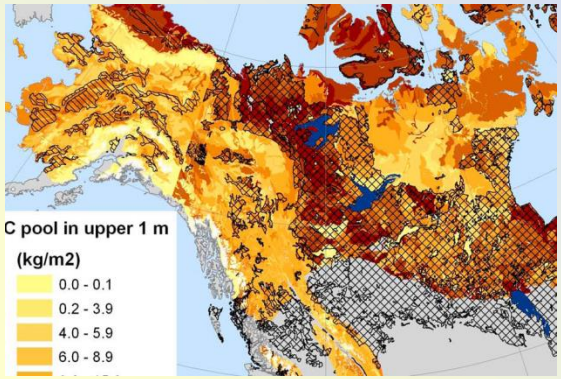
Ecoregions



Permafrost



Soil Carbon



The ABoVE Study Region provides the opportunity to carry out research across gradients of ecosystems and land surface characteristics that are unique to the Arctic/Boreal Region

ABoVE Timeline

- October 2008 – NASA Terrestrial Ecology Program Solicits Proposals for Scoping Studies to define future field campaigns
- February 2009 – NASA Funds VuRSAL Scoping Study
- October 2010 – ABoVE Scoping Study Report submitted to NASA
- October 2011 – ABoVE Scoping Study report review completed and NASA decides to move forward
- July 2012 – Workshop convened to further refine ABoVE science questions
- February 2013 – NASA selects Science Definition Team to produce ABoVE Concise Experiment Plan
- April 2013 – NASA funds five pre-ABoVE projects to develop data products presumed to be of high relevance for ABoVE science
- *January 2014 – ABoVE Concise Experiment Plan completed*
- *Mid 2014 – Initial solicitation of proposals by NASA for ABoVE research. (ABoVE Concise Experiment Plan will serve as a resource to guide the development of this solicitation.)*

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Why NASA?

- NASA develops advanced airborne and spaceborne remote sensing systems and generates new information products from these systems
- NASA conducts end-to-end, integrative, cross-disciplinary earth science research focused on providing answers to major scientific questions of societal importance

Goal: **The goal of NASA's Terrestrial Ecology research is to improve understanding of the structure and function of global terrestrial ecosystems, their interactions with the atmosphere and hydrosphere, and their role in the cycling of the major biogeochemical elements and water.**

Primary Science Questions:

- ***How are global ecosystems changing?***
- ***How do ecosystems, land cover and biogeochemical cycles respond to and affect global environmental change?***
- ***What are the consequences of land cover and land use change for human societies and the sustainability of ecosystems?***
- ***How will carbon cycle dynamics and terrestrial and marine ecosystems change in the future?***

Why NASA?

Data products derived from airborne and satellite remote sensing systems provide:

1. Unique information on many large-scale terrestrial processes occurring in the Arctic-boreal region
2. The basis for extrapolating local scale observations and measurements to landscape and regional scales
3. Data to parameterize and validate models

NASA-Sponsored Remote Sensing Activities

- Develop new remote sensing systems
- Generate global-scale data products from a variety of satellite remote sensors
- Organize research campaigns based on spaceborne and airborne remote sensors (Earth Venture missions, Terrestrial Ecology field campaigns)

Development of New Satellite Remote Sensors - The NASA Soil Moisture Active Passive Mission (SMAP)

Key science objectives:

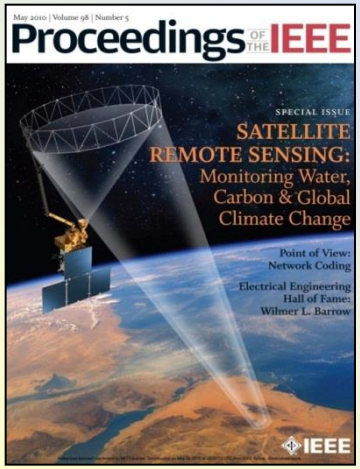
- Improve understanding of processes linking terrestrial water, carbon & energy cycles
- Quantify net carbon flux in boreal landscapes

Design:

- L-band (1.26/1.4 GHz) SAR & radiometer; 3km & 40km resolution
- 2-3 day global revisit, 6AM/PM orbital crossing
- Planned Launch: October 2014
- Mission duration: 3 years

Products relevant to carbon & ecosystems:

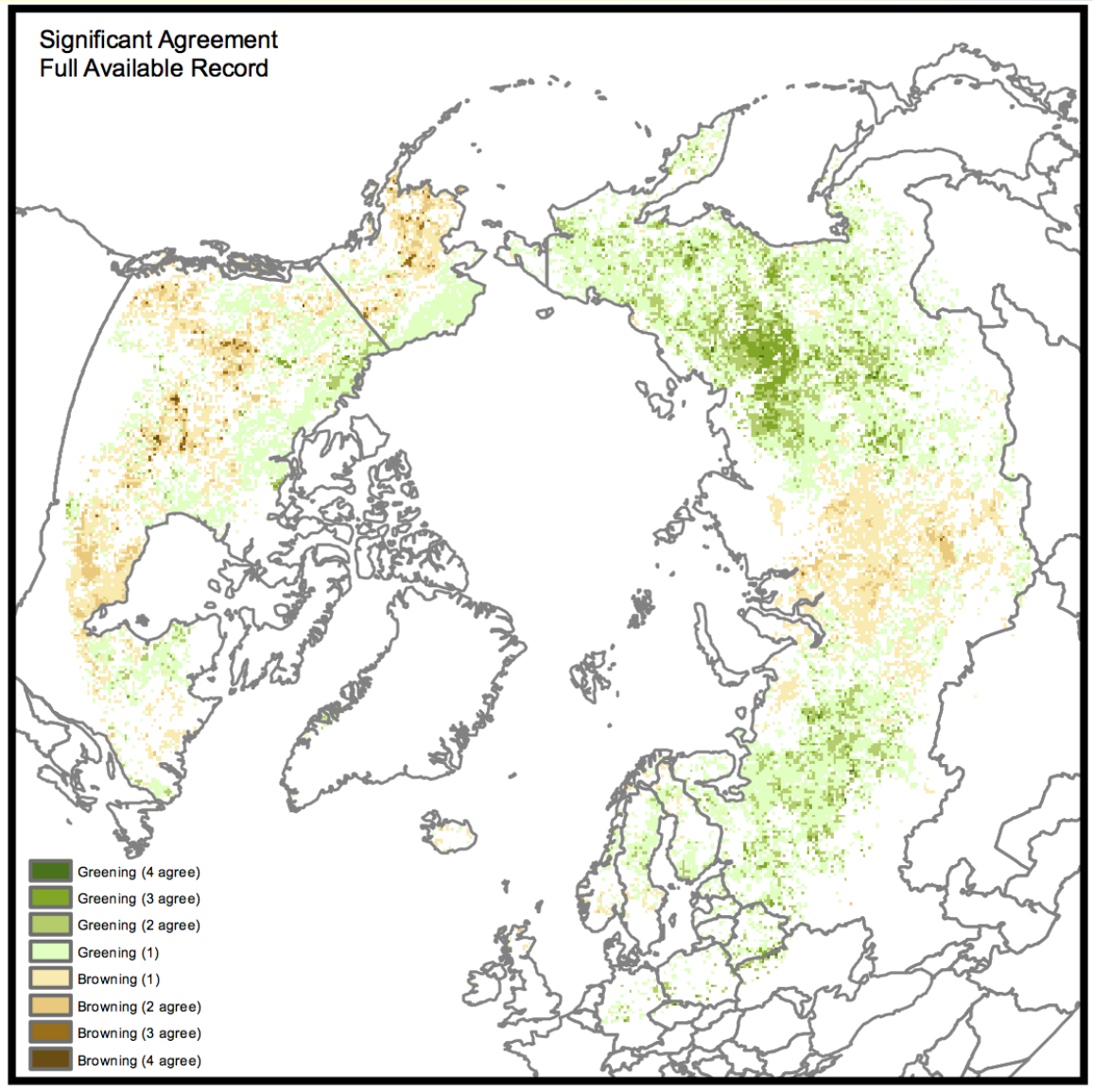
- Land surface freeze-thaw state dynamics
- Surface & root zone soil moisture from Model-data assimilation (L4_SM)
- Net ecosystem CO_2 exchange (NEE) from satellite data-driven carbon (L4_C) model outputs
- SMAP website: http://smap.jpl.nasa.gov



SMAP Product Table

Product	Description	Gridding (Resolution)	Latency	
L1A_TB	Radiometer Data in Time-Order	-	12 hrs	Instrument Data
L1A_S0	Radar Data in Time-Order	-	12 hrs	
L1B_TB	Radiometer T_B in Time-Order	(36x47 km)	12 hrs	
L1B_S0_LoRes	Low Resolution Radar σ_0 in Time-Order	(5x30 km)	12 hrs	
L1C_S0_HiRes	High Resolution Radar σ_0 in Half-Orbits	1 km (1-3 km)	12 hrs	
L1C_TB	Radiometer T_B in Half-Orbits	36 km	12 hrs	
L2_SM_A	Soil Moisture (Radar)	3 km	24 hrs	Science Data (Half-Orbit)
L2_SM_P	Soil Moisture (Radiometer)	36 km	24 hrs	
L2_SM_AP	Soil Moisture (Radar + Radiometer)	9 km	24 hrs	
L3_FT_A	Freeze/Thaw State (Radar)	3 km	50 hrs	Science Data (Daily Composite)
L3_SM_A	Soil Moisture (Radar)	3 km	50 hrs	
L3_SM_P	Soil Moisture (Radiometer)	36 km	50 hrs	
L3_SM_AP	Soil Moisture (Radar + Radiometer)	9 km	50 hrs	
L4_SM	Soil Moisture (Surface and Root Zone)	9 km	7 days	Science Value-Added
L4_C	Carbon Net Ecosystem Exchange (NEE)	9 km	14 days	

Global Products of Important Land Surface Characteristics

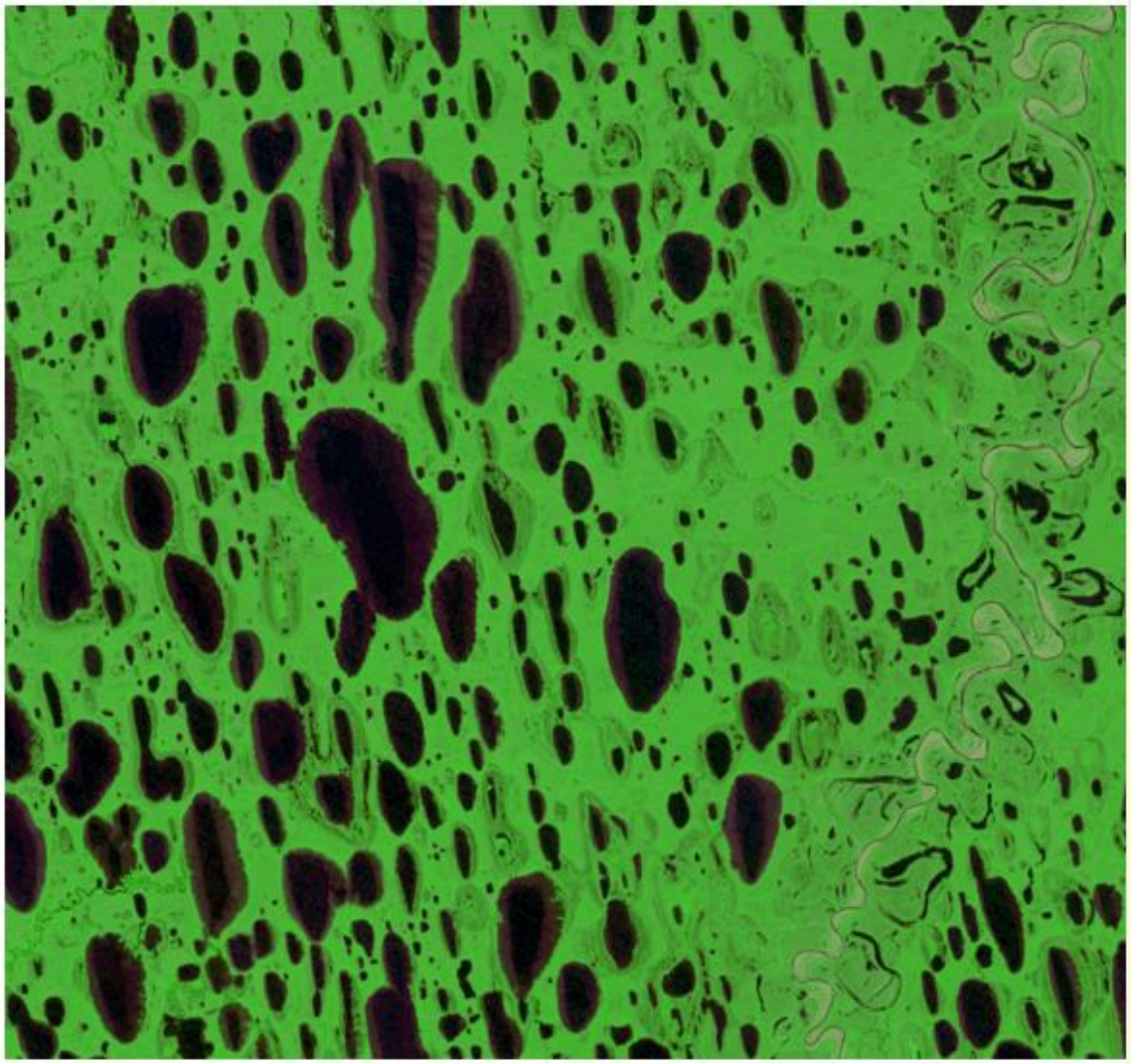


Satellite observed productivity trends vary with warming as well as drying (drought / high VPD).

NDVI Products
GIMMS 3g
SeaWiFS
MODIS (NBAR)
SPOT (VEG NBAR)

Decadal Water Products

(Pre-ABoVE Product, M. Carroll, Sigma Space)



0 km 5

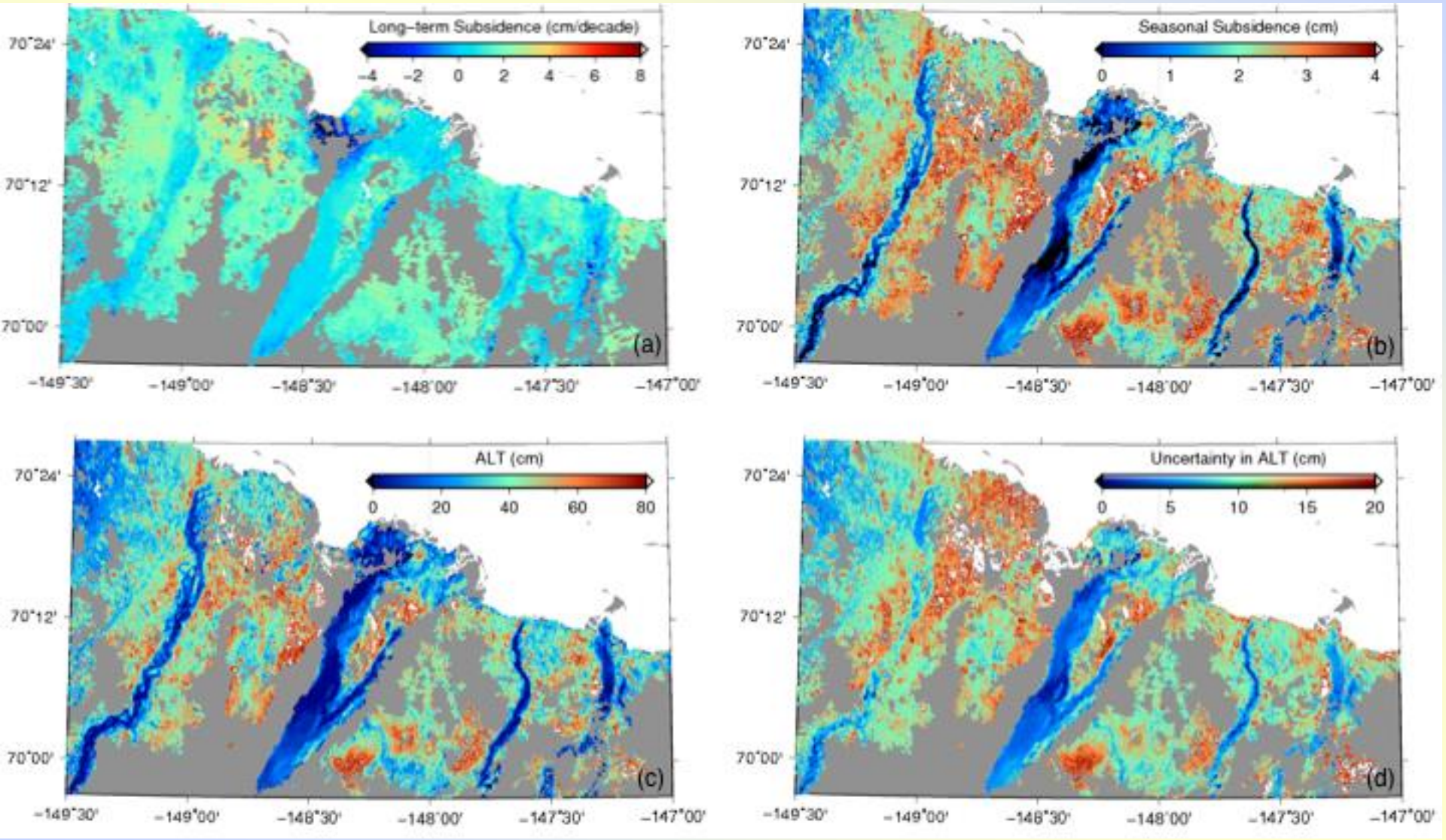
Landsat image, false color composite, from near Barrow, AK

Small lakes and ponds are a prominent feature of the landscape in the High Northern Latitudes.

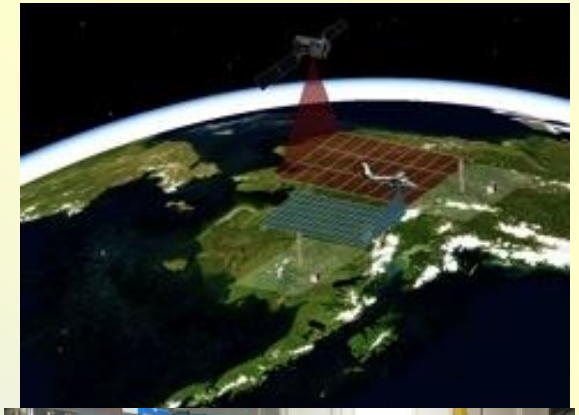
We will map these ponds at 30m spatial resolution at 3 epochs (1991, 2001, 2011) prior to the ABoVE field campaign. This will allow researchers to identify areas to study that are either constant or ones that are changing. We will take advantage of the time series of Landsat data that is available in this region to provide the max, min, and average condition of each lake/pond 1ha or larger for each epoch.

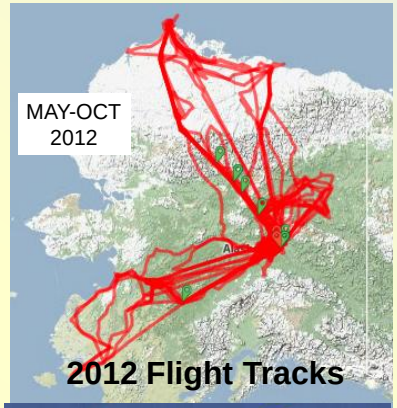
Preliminary Active Layer Thickness results from Prudhoe Bay

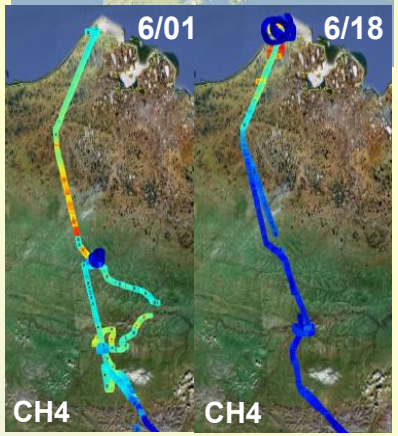
(Pre-ABoVE Product from INSAR data, T. Zhang, Univ. Colorado)



Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE): An EV-1 Investigation







CARVE bridges critical gaps in our knowledge and understanding of Alaskan Arctic ecosystems, linkages between the terrestrial carbon and hydrologic cycles, and the feedbacks from fires and thawing permafrost.

Instrument Payload

- Nadir viewing Fourier transform spectrometer
- Imaging thermal infrared camera
- Continuous in CO_2, CH_4 and CO
- Programmable flask packages (whole air sampling)

Measurements

- Surface parameters controlling carbon emissions: soil moisture, freeze/thaw state, inundation state, surface temperature
- Total atmospheric columns of CO_2, CH_4 and CO
- Atmospheric concentrations of CO_2, CH_4 and CO
- Ground-based measurements of $^{14}CO_2$ and $^{14}CH_4$

Earth Science Relevance

- High priority objectives across NASA's Carbon Cycle & Ecosystems, Atmospheric Composition, and Climate Variability & Change focus areas
- Air Quality and Ecosystems elements of Applied Sciences Program

Mission Implementation

- **Mission:** Oct 2010 – Sep 2015
- **PI:** Charles Miller **PM:** Steve Dinardo
- **Aircraft**: Shorts C-23 Sherpa
- **Science Operations**: Monthly deployments Spring – Fall each year 2012 – 2015 when arctic carbon fluxes are large and change rapidly

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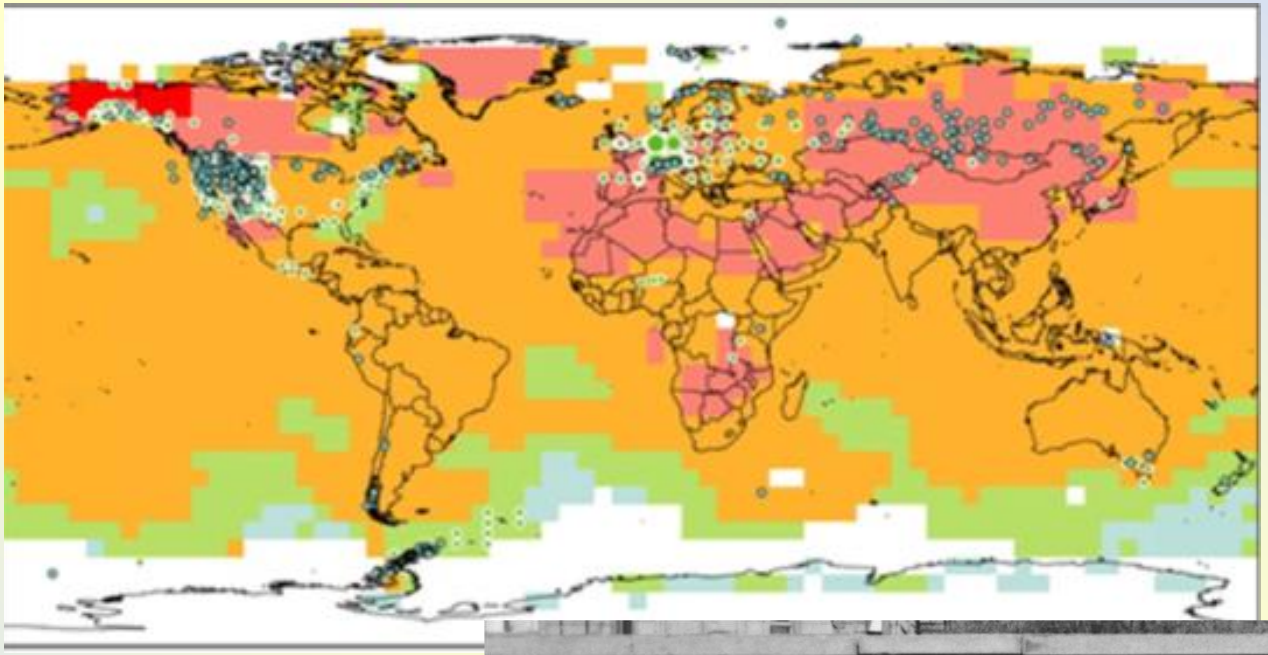
Disclaimer

- Details of the ABoVE Concise Experiment Plan (CEP) are currently being developed by the Science Definition Team
- The material related to the CEP should be considered preliminary in nature and will likely be refined as the ABoVE CEP is further developed

Why ABoVE?

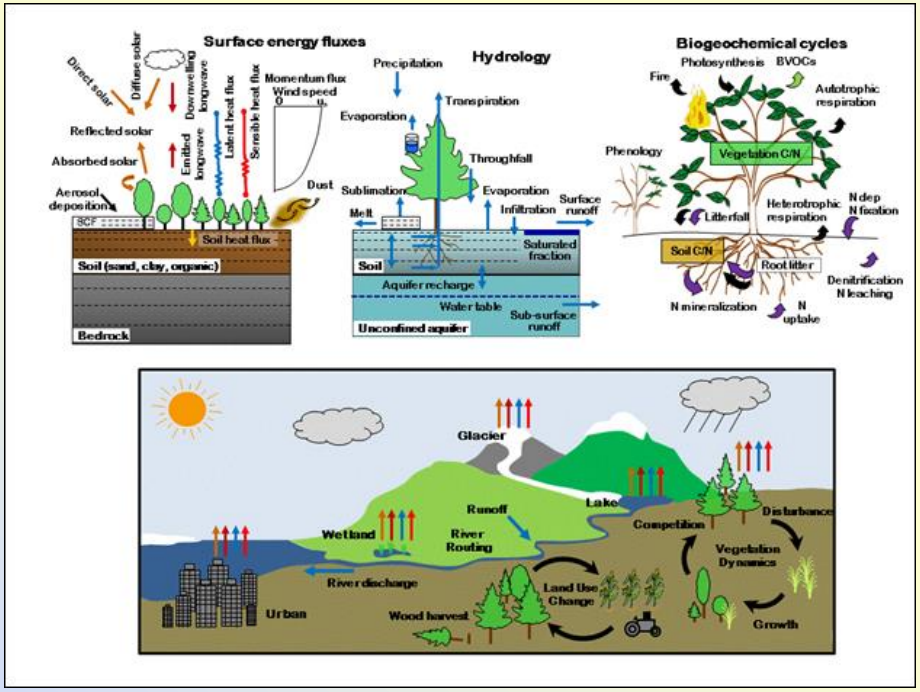
1. *Climate change is occurring most rapidly in the Arctic-Boreal region (ABR) and this change is projected to continue over the next century*
2. *Climate and other human driven environmental changes are having significant impacts on ABR ecosystems*
3. *Our current scientific understanding is insufficient to explain how ABR ecosystems are responding to climate change*
4. *Changes to ABR ecosystems will have impacts on society at local, regional, and global scales*

Source of graphic: 4th IPCC Assessment Report



Why AboVE? - Models of key arctic/boreal processes do not adequately explain current impacts nor can they project future impacts

- Additional research is needed to
  - Address known areas of uncertainty (the “known unknowns”; e.g. interactions between disturbance, permafrost& hydrologic processes)
  - Identify novel and new patterns of landscape change and ecosystem reorganization (the “unknown unknowns”; e.g. tipping points)



source: http://www.cesm.ucar.edu/models/clm/

Why ABoVE? – Climate and environmental change in the ABR will have significant impacts on society

1. Local Scale – Impacts on human health and safety, subsistence, infrastructure, and economic activities
2. Regional scales – Impacts on forest resources, fish and wildlife habitat, transportation infrastructure
3. Global scales – Impacts on climate regulation

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Context for ABoVE

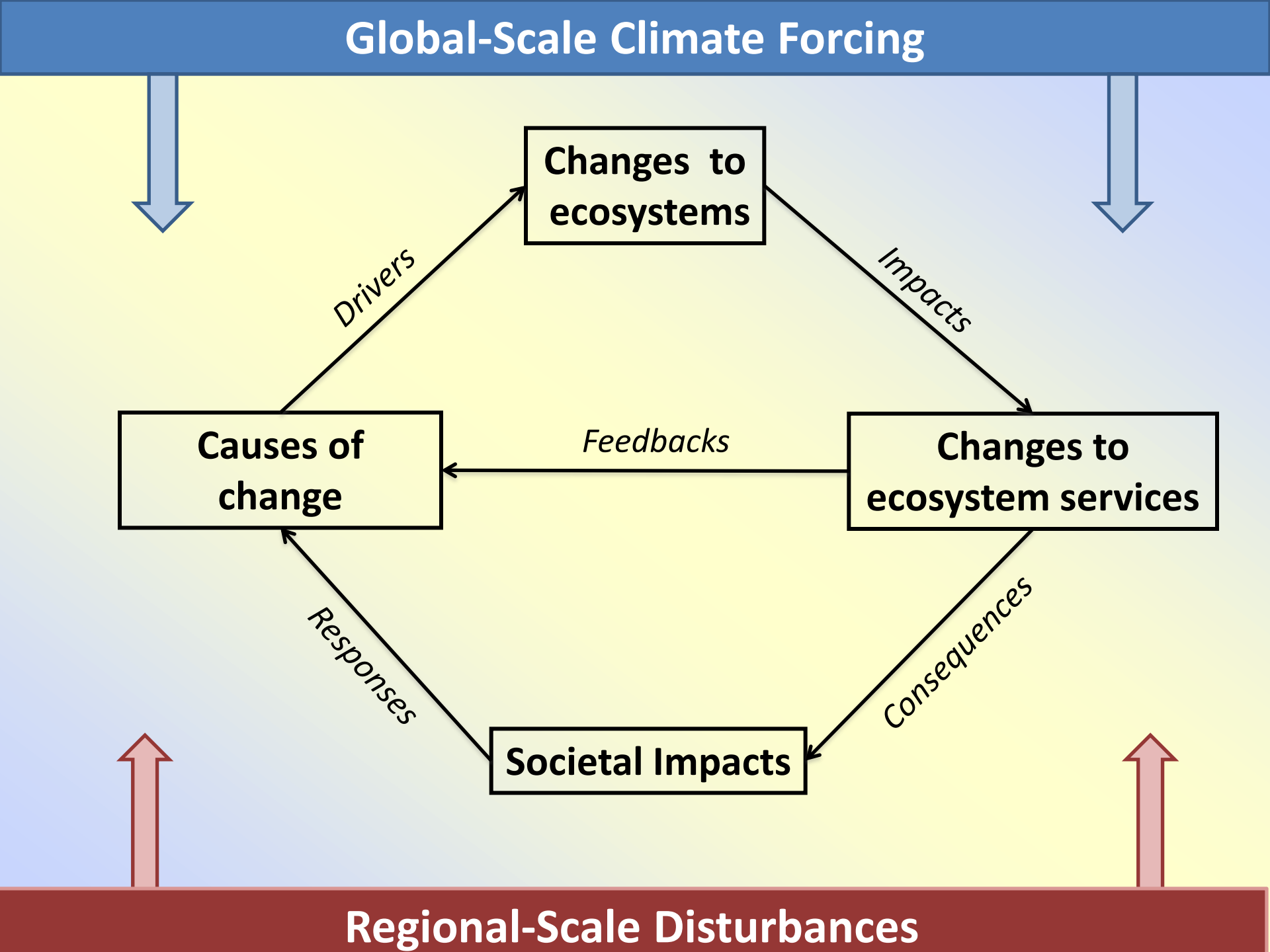
Goal 1. Advance Science: Advance scientific knowledge of the integrated natural and human components of the Earth system.

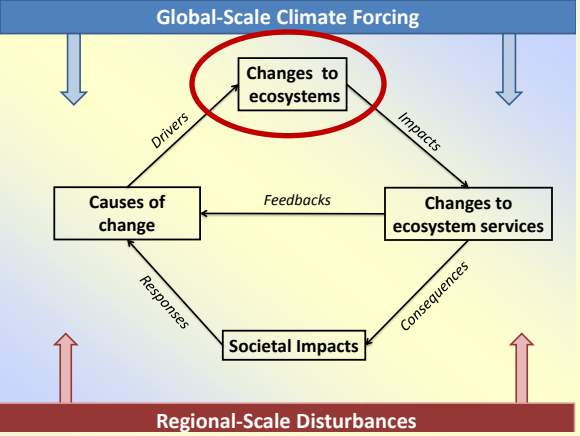
Goal 2. Inform Decisions: Provide the scientific basis to inform and enable timely decisions on adaptation and mitigation.

Goal 3. Conduct Sustained Assessments: Build sustained assessment capacity that improves the Nation's ability to understand, anticipate, and respond to global change impacts and vulnerabilities.

Goal 4. Communicate and Educate: Advance communications and education to broaden public understanding of global change and develop the scientific workforce of the future.

As clearly articulated in the US Global Change Research Plan (as well as similar plans in Canada), research must move well beyond just understanding the causes and impacts of climate change on natural systems, but must also address the human drivers of change as well as the societal responses to change


Global-Scale Climate Forcing
Changes to ecosystems
Drivers
Impacts
Causes of change
Feedbacks
Changes to ecosystem services
Responses
Consequences
Societal Impacts
Regional-Scale Disturbances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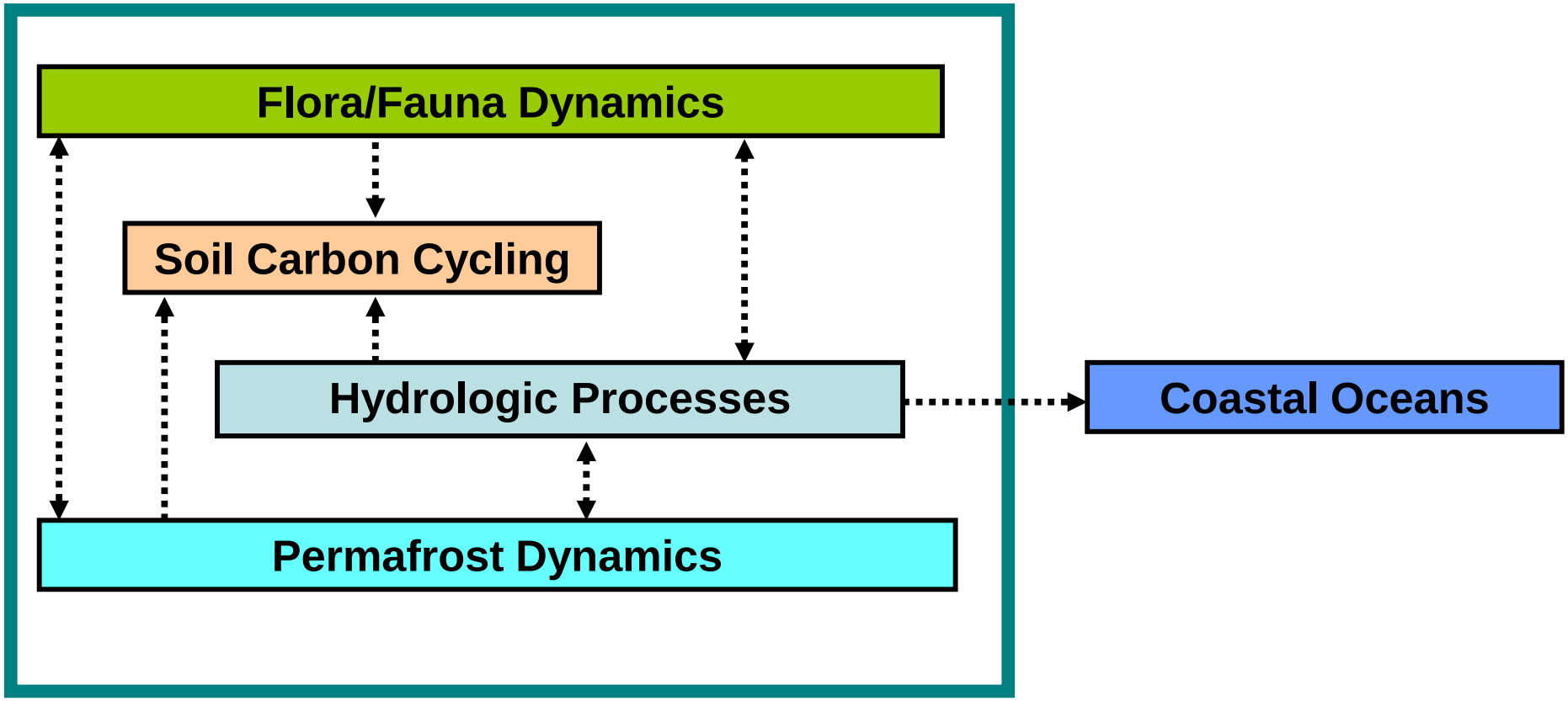
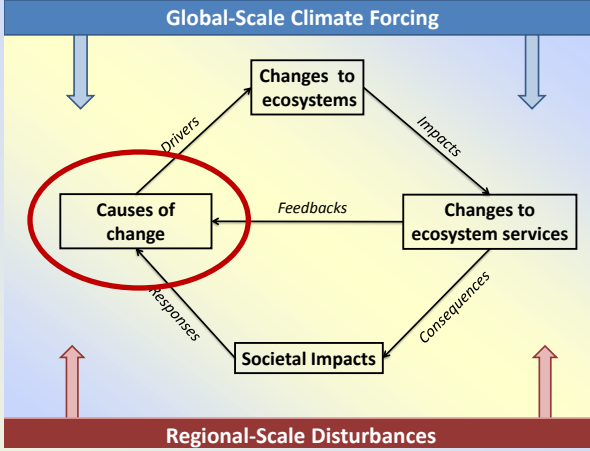

Flora/Fauna Dynamics
Soil Carbon Cycling
Hydrologic Processes
Coastal Oceans
Permafrost Dynamics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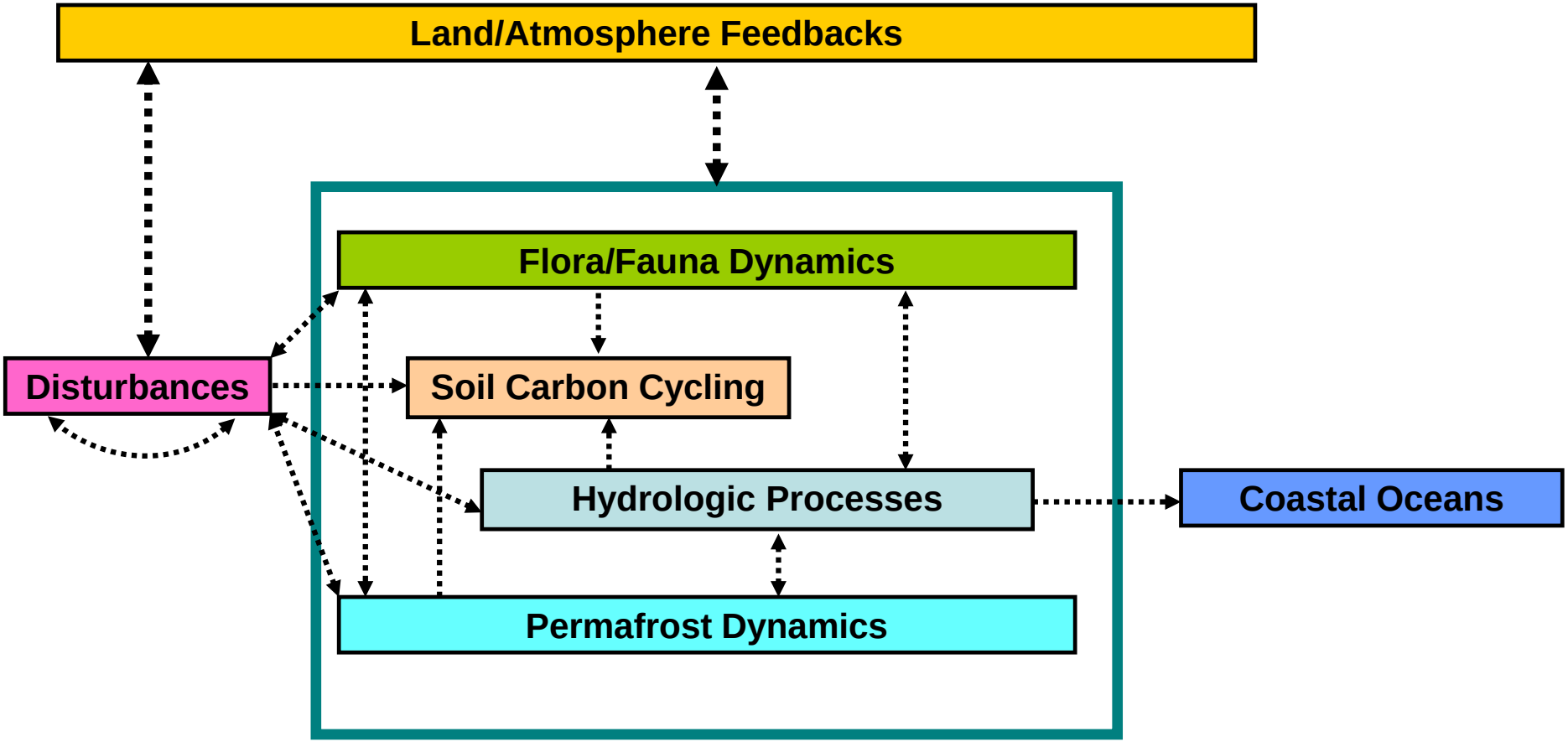
Land/Atmosphere Feedbacks
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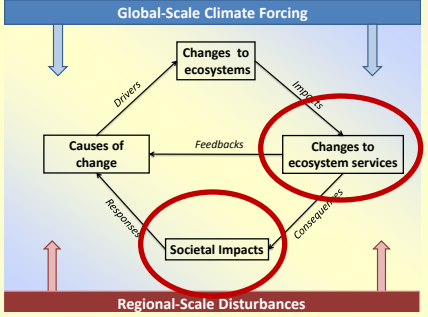

Land/Atmosphere Feedbacks

Flora/Fauna Dynamics

Disturbances

Soil Carbon Cycling

Hydrologic Processes

Permafrost Dynamics

Ecosystem Services

Societal Impacts/Responses

Policy/Management Decisions

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Tier 2 Science Questions

1. How are *disturbance regimes* in ABR changing and what processes are controlling those changes?
2. What are the changes in the distribution and properties of *permafrost* in the ABR and what is controlling those changes?
3. What are the changes in the spatial distribution of *water,* and the amount and timing of *water discharge* in the ABR and what is controlling those changes?
4. How is the magnitude and fate of *soil organic carbon* pools in the ABR changing, and what are the processes controlling the rates of those changes?
5. How are ABR *flora and fauna* responding to changes in biotic and abiotic conditions, and what are the impacts on ecosystem structure and function?
6. How do *complex interactions* affect the trajectory of ecosystem structure and function and ecosystem services in the ABR?
7. How are environmental changes in the ABR affecting *natural and cultural resources* and climate regulation, and how are *human societies* within and beyond the region responding?

Tier 2 Science Questions and Objectives

How are disturbance regimes in ABR changing and what processes are controlling those changes?

Objectives:

(a) Determine the controls on the spatial and temporal patterns of the primary natural disturbances in the ABR (fire, insects/pathogens, rapid permafrost thaw)

(b) Identify the most important factors controlling disturbance regimes

(c) Understand the consequences of variations in disturbance regimes for ecosystems and landscapes

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What research activities will be carried out during ABoVE?

Research activities that will be supported by NASA include:

- Development and validation of information products from remotely-sensed data (spaceborne and airborne)
- Collection of field data (provide information to address critical uncertainties, including ecosystem processes and human-environment interactions, validation of remote sensing products)
- Integration, analysis, and synthesis
- Modeling activities (model development and validation, use of models for diagnosis and prognosis)

What does a NASA field campaign do?

How does NASA do a field campaign?

ABoVE is expected to be supported by an Office within NASA's Carbon Cycle & Ecosystems Office at Goddard Space Flight Center. Shared staff include: a project manager, web developers, field logistics & safety personnel, and geospatial, modeling, and data management scientists, responsible for:

- Science team coordination
- Websites for internal and external communication
- Implementation of the project-wide data management strategy
- Cyberinfrastructure coordination among projects and programs
- Development and/or augmentation of field infrastructure
- Field safety planning, training, and oversight
- Coordination of airborne assets
- Scientific and logistical organization of meetings
- Education and outreach
- Coordination with NASA, interagency and international partnerships (e.g. NASA Oceans/Atmosphere/Cryosphere programs, DOE NGEE, North American Carbon Program, CarboNA)

ABoVE Arctic-Boreal Vulnerability Experiment

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Climate change in the Arctic and Boreal region is unfolding faster than anywhere else on Earth, resulting in reduced Arctic sea ice, thawing of permafrost soils, decomposition of long– frozen organic matter, widespread changes to lakes, rivers, coastlines, and alterations of ecosystem structure and function. NASA's Terrestrial Ecology Program is in the process of planning a major field campaign, the Arctic Boreal Vulnerability Experiment (ABoVE), which will take place in Alaska and western Canada during the next 5 to 8 years. ABoVE will seek a better understanding of the vulnerability and resilience of ecosystems and society to this changing environment.

ABoVE Announcements

- 16th International Boreal Forest Research Association (IBFRA) Conference: October 7 to 10, 2013 Go to website
- Fall 2013 Relevant AGU Sessions
  Due Date for Abstracts: August 6, 2013
- ARCUS Workshop on Needs in Arctic Research Support and Logistics: October 7 to 9, 2013 in the Washington, D.C. area
  Go to website

NASA News

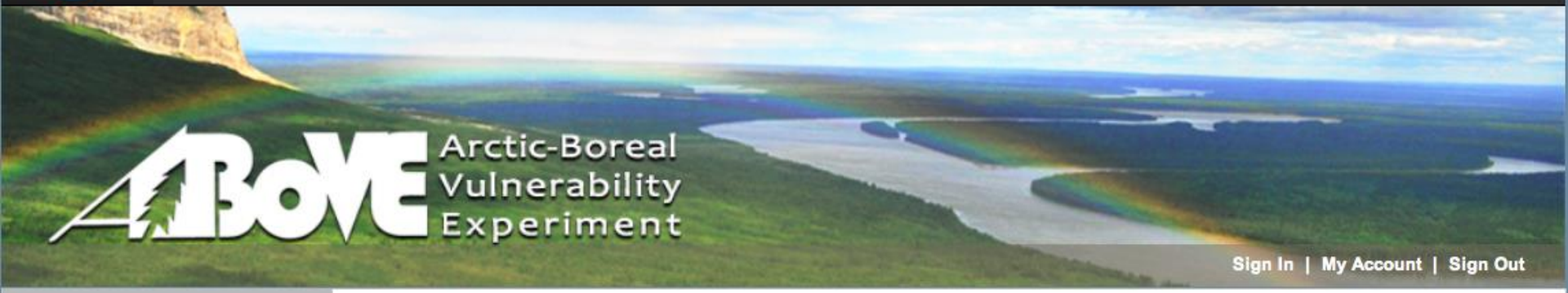
Arctic Sea Ice Update: Unlikely To Break Records, But Continuing Downward Trend.
Go to article
August 23, 2013

Earth Observatory Image of the Day "At the Intersection of Clouds and Smoke"
Go to article

Where Are We Now?

- The ABoVE Science Definition Team is currently preparing a concise experiment plan which will serve to guide NASA's solicitation for the ABoVE science team sometime in 2014. The second face to face meeting will be in Fairbanks, AK mid July 2013.
- Working groups are being developed to manage Data, Logistics,..etc.
- In July 2013 the ABoVE Support Office travelled to Fairbanks, Toolik Lake and Barrow, Alaska evaluating existing site infrastructure and logistics support resources. Overview
- Check out the NGEE Blog featuring our visit to Barrow.

In late August, the next phase of site visits will take place



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NASA pre-ABoVE Funded Research Projects

Project Lead	Project Title (view profile)
Carroll, Mark	**Carroll-01:** Determining the Extent and Dynamics of Surface Water for the ABoVE Field Campaign (view)
Loboda, Tatiana	**Loboda-01:** Long-Term Multi-Sensor Record of Fire Disturbances in High Northern Latitudes (view)
Munger, J. (Bill)	**Munger-03:** Development of a Data-Assimilation Framework for Integrating 25 Years of Surface and Airborne observations to assess patterns of net CO2 Exchange from Arctic Ecosystems (view)
Walker, Donald (Skip)	**Walker-01:** Recovery and Archiving of Key Arctic Alaska Vegetation Map and Plot Data for Long-Term Vegetation Analyses (view)
Zhang, Tingjun	**Zhang-02:** Remotely-Sensed Active Layer Thickness (ReSALT) Product Derived from InSAR Data Over North American Arctic Regions (view)

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Disturbance

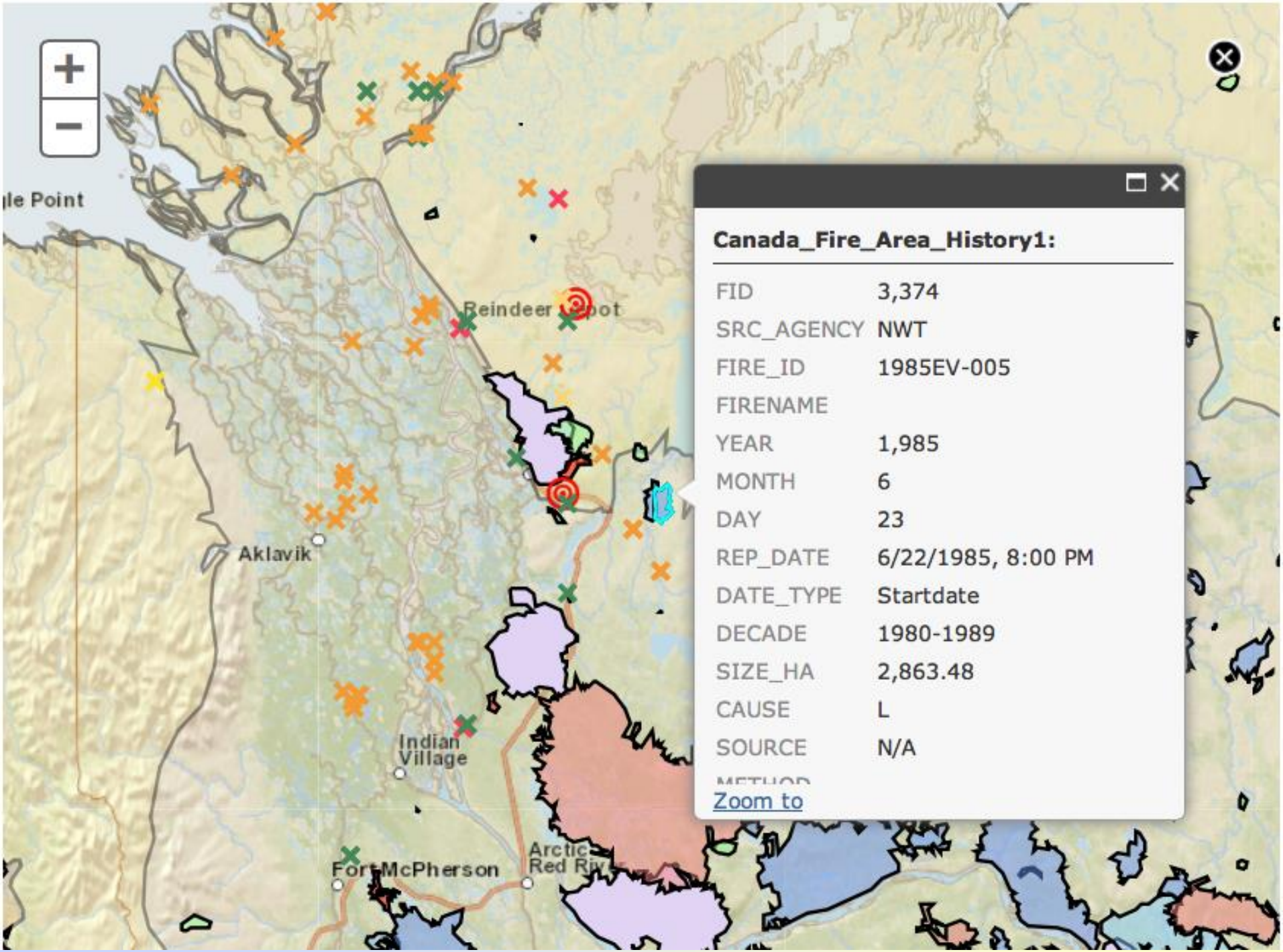
MAP Canada Fire History

REST Alaska Fire Area History

REST Canada Fire Area History

Alaska Insect Forest Damage ...

Alaska Insect Forest Damage ...


Canada_Fire_Area_History1:
FID 3,374
SRC_AGENCY NWT
FIRE_ID 1985EV-005
FIRENAME
YEAR 1,985
MONTH 6
DAY 23
REP_DATE 6/22/1985, 8:00 PM
DATE_TYPE Startdate
DECADE 1980-1989
SIZE_HA 2,863.48
CAUSE L
SOURCE N/A
Zoom to
Aklavik
Indian Village
Fort McPherson
Arctic Red Riv
Reindeer Depot

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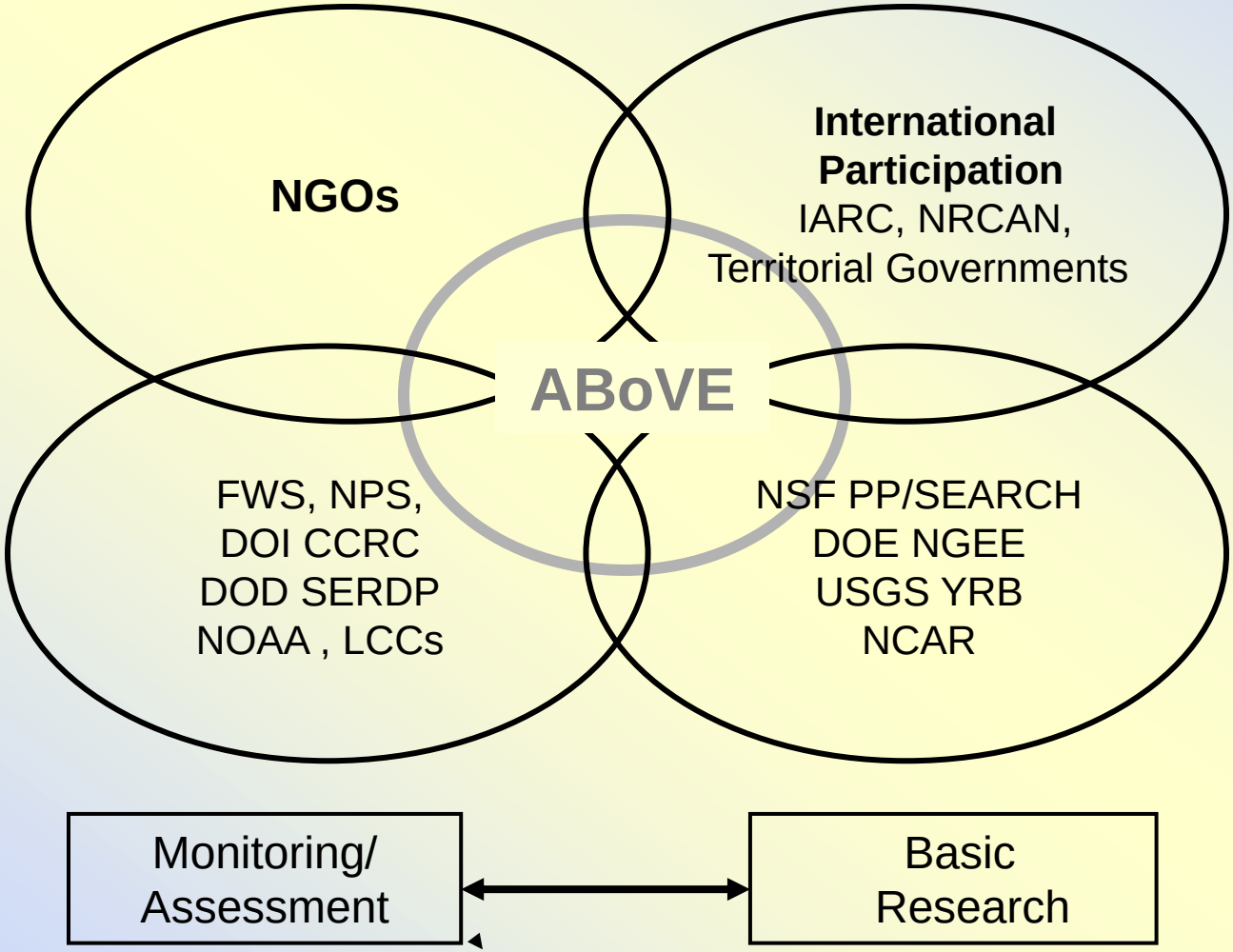
Strategic Vision for Development of ABoVE Field Campaign

Key steps in developing the ABoVE Concise Experiment Plan

- Insure that questions and objectives for ABoVE are consistent with those of other organizations
- Identify ongoing and planned monitoring activities being conducted by other organizations
- Identify partnerships/collaborations with other organizations in the ABoVE study domain
- Determine the research that needs to be carried out that will be funded by NASA

To be successful, ABoVE must coordinate with research and monitoring activities being carried out by a broad coalition of national & international organizations



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Interagency and International Partnerships

CarboNA

An international collaboration between Canada, Mexico, and the United States for carbon cycle science research throughout North America and adjacent ocean regions.

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MISSION STATEMENT CarboNA (formerly the Joint North American Carbon Program, JNACP) is a joint government-level initiative between Canada, the US and Mexico whose goal is to establish greater cohesion across North America in the fields of carbon pool and greenhouse gas flux dynamics and of carbon related mitigation strategies, through the identification of continental-scale priority issues and promotion of collaborative research in areas of common interest and complementary expertise.

GOAL

To determine the temporal and regional distribution and magnitudes of carbon pools and greenhouse gas fluxes throughout North America, and to understand how these affect and are affected by disturbances, human behavior, and climate and related changes, in order to predict future climate change and evaluate carbon related mitigation strategies and new technologies.

Français - Español

ABoVE Partners/Collaborators

Advanced discussions

- Dept of Energy Next Generation Ecosystem Experiment
- Dept of Interior Landscape Conservation Cooperatives
- North Slope Science Initiative
- Bonanza Creek and Arctic LTERs
- Natural Resources Canada/Canadian Forest Service
- US Geological Survey
- Bureau of Land Management
- Alaska Fire Science Consortium
- Alaska Center for Climate Assessment and Policy

Ongoing discussions

- Changing Cold Regions Network (NSERC)
- Ducks Unlimited
- Government of the NWT
- Government of the Yukon Territory
- International Arctic Research Center
- Japanese Research Community