Arctic-COLORS (Arctic-COastal Land Ocean inteRactionS) Field Campaign Scoping Study Update and Plans

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Abstract

The realization that changes within the Arctic have profound impacts on ecosystems and human populations across the globe has motivated greater attention. Yet major gaps remain in our understanding of the feedbacks, response, and resilience of coastal Arctic ecosystems, communities, and natural resources to current and future pressures. Most importantly, the Arctic coastal zone, a vulnerable and complex contiguous landscape of lakes, streams, wetlands, permafrost, rivers, lagoons, estuaries, and coastal seas—all modified by snow and ice—remains poorly understood. To improve our mechanistic understanding and prediction capabilities of land-ice-ocean interactions in the rapidly changing Arctic coastal zone, our team proposed a Field Campaign Scoping Study called Arctic-COLORS (Arctic-COastal Land Ocean inteRactionS) to NASA's Ocean Biology and Biogeochemistry Program. Arctic-COLORS aims to quantify the response of the Arctic coastal environment to global change and anthropogenic disturbances – an imperative for developing mitigation and adaptation strategies for the region. Arctic-COLORS is unprecedented, as it represents the first attempt to study the nearshore coastal Arctic (from riverine deltas and estuaries out to the coastal sea) as an integrated land-ocean atmosphere-biosphere system. The overarching objective of Arctic-COLORS is to quantify the coupled biogeochemical/ecological response of the Arctic nearshore system to rapidly changing terrestrial fluxes and ice conditions, in the context of environmental (short-term) and climate (long-term) change. The science of our field campaign will focus on three key science themes and several overarching science questions per theme: (1) Effect of land on nearshore Arctic biogeochemistry (2) Effect of ice on nearshore Arctic biogeochemistry (3) Effects of future change (warming land and melting ice) on nearshore Arctic biogeochemistry This field campaign will be composed of an integrative measurement approach utilizing a broad range of proven sampling approaches from a multitude of platforms including autonomous vehicles to achieve sufficient seasonal and spatial coverage to resolve the science questions proposed by the Arctic-COLORS team as well as remote sensing and development of coupled physical-biogeochemical models.

Arctic-COLORS *Coastal Land Ocean Interactions in the Arctic*

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http://arctic-colors.gsfc.nasa.gov

NASA Programmatic questions & feedback
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Arctic-COLORS is a proposed NASA Field Campaign that aims to quantify the coupled biogeochemical/ecological response of the Arctic nearshore system to rapidly changing terrestrial fluxes and ice conditions, in the context of environmental (short-term) and climate (long-term) change.

Why the Coastal Arctic?

- Significant increase in summer SST over past 50 years
  - Substantial reduction in sea ice coverage and ice season length.
- Increasing Primary Productivity and changing food web dynamics
- Permafrost is thawing
  - 1672 Petagrams of organic carbon stored in Arctic permafrost globally (feedbacks to climate)
- Changing flows in Arctic rivers
- Substantial Coastal Erosion
  - 17-20 m/yr in most exposed Beaufort sites
  - 0.3 m/yr in Chukchi Sea sites
- Ocean acidification of Arctic seas
- Extreme biophysical changes
- Arctic ecosystems shifting from benthic- to pelagic-dominated
- Consequences for Arctic wildlife and human populations

Why NASA?

- Remote sensing (RS) from satellite and airborne platforms are essential for capturing the spatial and temporal variability of the Arctic coastal study domain (past and present).
  - NASA has the satellites, airplanes, airborne sensors and RS data processing and distribution capability to enable Arctic-COLORS.
- The development/parameterization and robustness of models necessary to address the goals of Arctic-COLORS will be accelerated with NASA remote sensing observations.
- Synergies with ABoVE and other NASA field campaign and modeling programs.

Science Plan Developed with Community Consensus

- Science Team Workshops in 2014 & 2015
- Open community workshop with OCB in July 2016
- Feedback from many town halls and conference presentations
- Peer review panel & NASA programmatic input

Science Team

Name	Institution	Name	Institution
Carlos Del Castillo	NASA GSFC	**David Kirchman**	U. Delaware
Marjorie Friedrichs	VIMS	**Diane Lavoie**	Fisheries & Oceans Canada
Peter Hernes	UC-Davis	**Bonnie Light**	U. Washington
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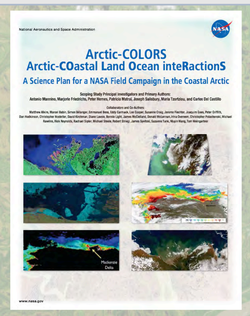
Joaquim Goes	Lamont-Doherty	**Tom Weingartner**	U. Washington
Peter Griffith	SSAI/ GSFC	Paula Bontempi	NASA HQ
David Kirchman	U. Delaware		

Potential Partners (to be explored further):

- NSF, NOAA, BOEM, USGS, etc.
- Canada (Polar Knowledge, Sentinel North, Arctic Research Foundation, etc.)
- Other NASA Programs
- International partners (Pan-Arctic: EU, Japan, Korea, etc.)

REVISED Science Plan submitted Jan. 2018



Science Plan Peer Review recently completed and Approved by NASA Panel

Science Themes

I. **Effect of land on nearshore Arctic biogeochemistry**
(rivers, thawing permafrost, coastal erosion)

II. **Effect of ice on nearshore Arctic biogeochemistry**
(snow, landfast ice, sea ice)

III. **Effects of future change (warming land and melting ice) on nearshore Arctic biogeochemistry**
(seasonal and interannual first, then future scenarios /predictions)

Science Questions

I. Effect of land on nearshore Arctic biogeochemistry

- How do freshwater carbon, nutrient, and sediment fluxes to the coastal zone change as a result of:
  - changing riverine and groundwater inputs?
  - passage through estuaries and gradients?
  - coastal erosion and thawing permafrost?
- How do these changing fluxes affect nearshore Arctic biogeochemical and ecological processes?
- How has the relative magnitude of inputs from rivers and coastal erosion changed across the nearshore Arctic seasonally and interannually?

II. Effect of ice on nearshore Arctic biogeochemistry

- How does flow alteration/channeling by morphological ice conditions impact terrestrial fluxes into, and attenuation within, the nearshore Arctic?
- How does the coastal snow/ice cover impact nearshore Arctic biogeochemical processes by controlling rates of mixing and by modulating light availability?
- How does the timing of sea ice formation/retreat, duration of sea ice cover and ablation, snow accumulation, and the morphology of the coastal ice zone influence nearshore Arctic biogeochemical and ecological processes?

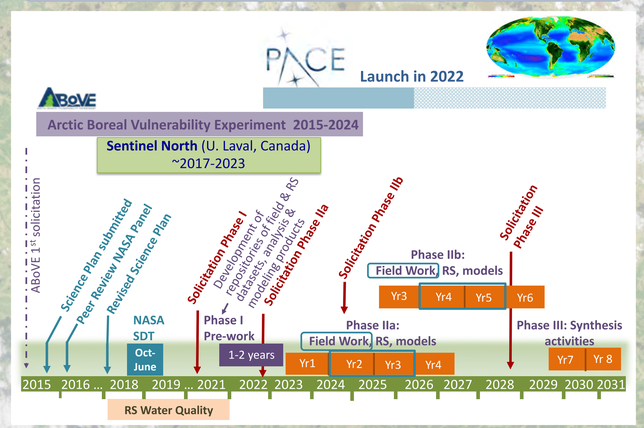
III. Effects of future change (warming land and melting ice) on nearshore Arctic biogeochemistry

- On seasonal and interannual timescales, how will changing land (Question 1) and melting ice (Question 2) impact nearshore Arctic biogeochemical and ecological processes?
- On interdecadal timescales, how will changing land (Question 1) and melting ice (Question 2) impact nearshore Arctic biogeochemical and ecological processes?

WHEN?

The proposed timeline for Arctic-COLORS is 2021-2031,
(i) to overlap with NASA's ocean color mission PACE, and
(ii) to overlap with 3rd phase of NASA's ABoVE program to benefit from ABoVE's results and possible follow-on activities, thus linking processes in the Arctic coastal oceans and terrestrial ecosystems.

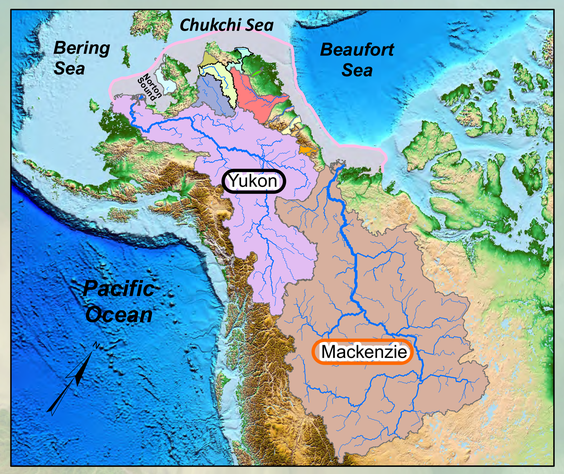
Notional Observational Program Timeline

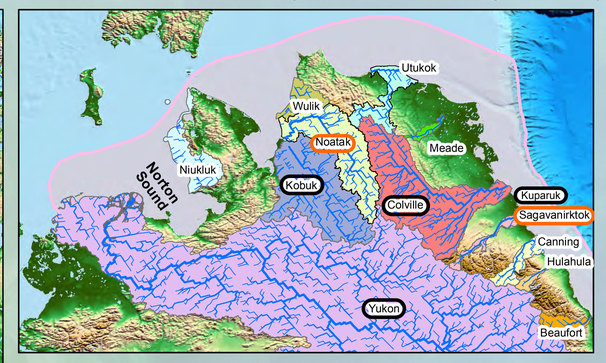


Where? What? How? When?

WHERE?

From the Yukon Delta to the Mackenzie Delta, from the head of tidal influence to the coastal shelf (pink-shaded coastal region on map)





Primary Sites
River-Delta-Sea

Secondary Sites
River-Delta-Sea

WHAT?

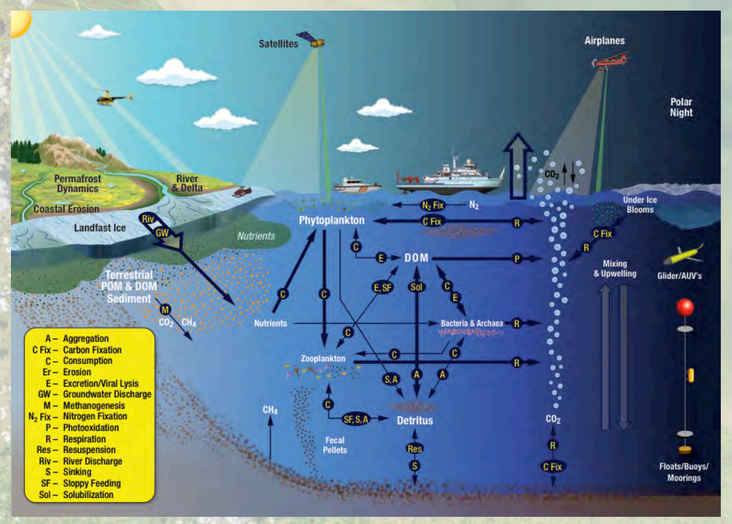
Intensive sampling and process experiments will be conducted **from river mouths to near-shelf** of the Yukon, Mackenzie and a select number of small rivers (Map 1) plus coastal erosion sites.
Core process measurements will include: Primary production, assimilation/grazing, community respiration, aggregation/ flocculation, photochemical and bacterial transformation of organic matter.
Complete seasonality: **continuous year-round measurements** with floats, buoys, moorings, AUVs, satellites, … weather and ice permitting. Intensive process studies during key months (plus airborne remote sensing)

Survey studies undertaken along and across the continental shelf to
(1) Assess spatial heterogeneity across different shelf regions,
(2) Determine interactions and teleconnections between the outer shelf and shallow shelf regions occupied during the process studies,
(3) Evaluate model simulations across temporal and spatial scales,
(4) Permits scaling up using remote sensing observations
Timing: July-August and September-October

How?

Early March	May-June	July	September	October
• End of winter condition	• Peak river discharge • Ice breakup • Under ice blooms	• Under ice blooms • Increasing biological & photochemical activity	• Max open water/min sea ice • Low river discharge • Pre-conditioning of systems prior to winter • Peak respiration late Sept-early Oct	• Freeze-up period

Integrative Observational Approach



- Diverse approaches proven to be effective in the Arctic for **year-round measurements and sampling**
  - Ice camps, ATVs, sleds (lower river, delta, landfast ice)
  - Small boats and small ships (lower river to nearshore)
  - Medium and large icebreakers (nearshore to outer shelf seas)
    - Deployable small vessels for shallow-water & near ice work
  - Helicopter-enabled sampling
  - Moorings, floats, buoys, gliders and other autonomous vehicles
  - Airborne and satellite remote sensing

Feedback to Science Team on Science Plan:
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