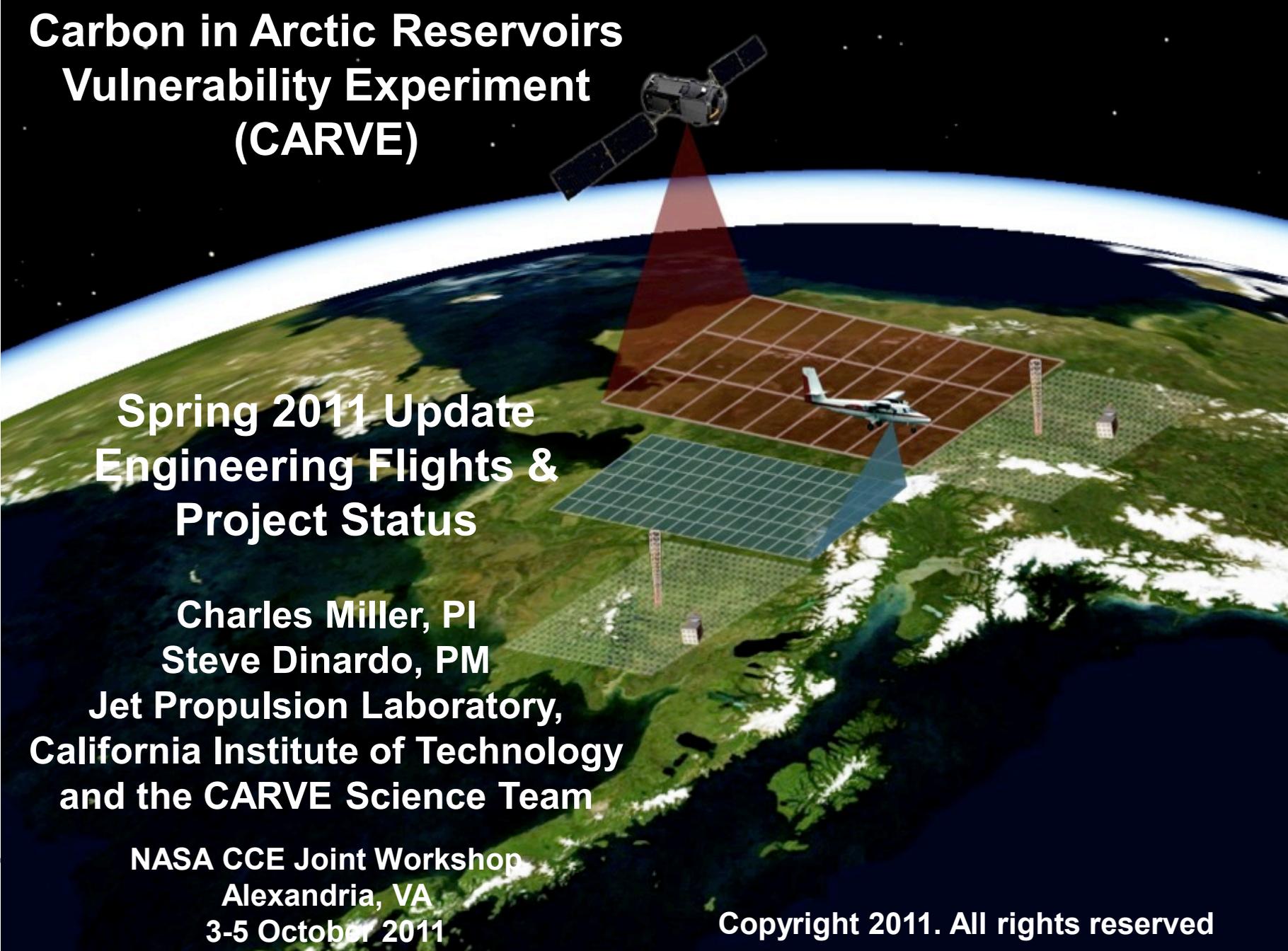


Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE)



**Spring 2011 Update
Engineering Flights &
Project Status**

**Charles Miller, PI
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Jet Propulsion Laboratory,
California Institute of Technology
and the CARVE Science Team**

**NASA CCE Joint Workshop
Alexandria, VA
3-5 October 2011**

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Massive Reservoirs of Arctic Carbon are Vulnerable to Climate Change



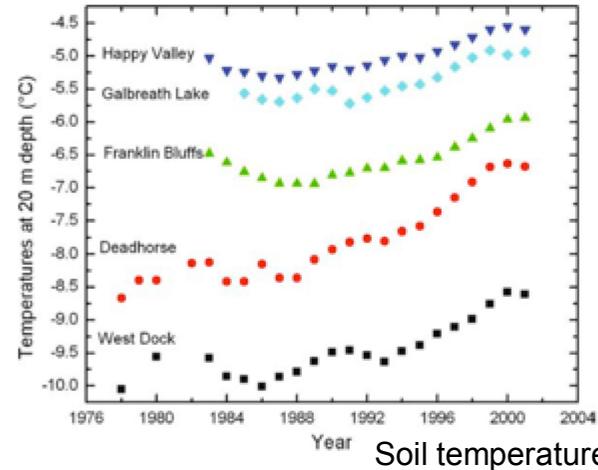
Rapidly increasing temperatures threaten to mobilize permafrost C into dynamic cycling, creating a potentially massive perturbation to the climate system

An estimated 1400–1850 PgC are stored in permafrost and frozen soils [McGuire et al., 2010]

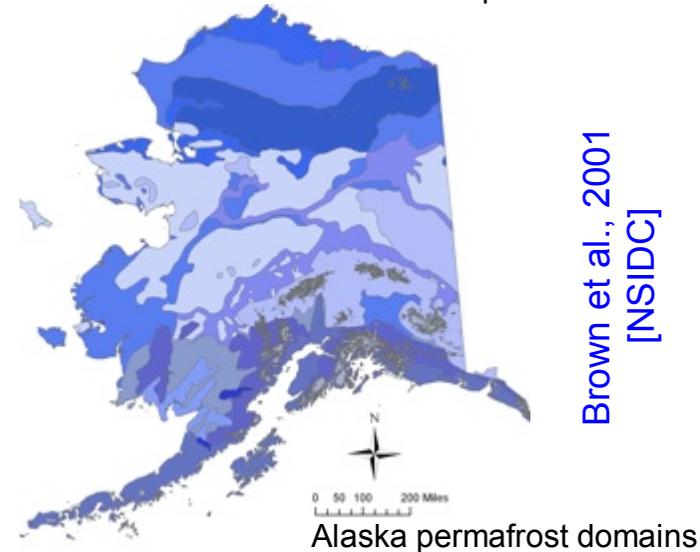
- ~200 PgC at depths 0 – 30 cm
- ~500 PgC at depths 0 – 100 cm
- ~1000 PgC at depths 0 – 300 cm

[Tarnocai et al., 2009]

- How much C is vulnerable to release?
- How fast might it be released?
- What fraction would be released as CO₂? As CH₄?
- Are there signatures that an irreversible climate system “tipping point” is approaching?



Osterkamp, 2003



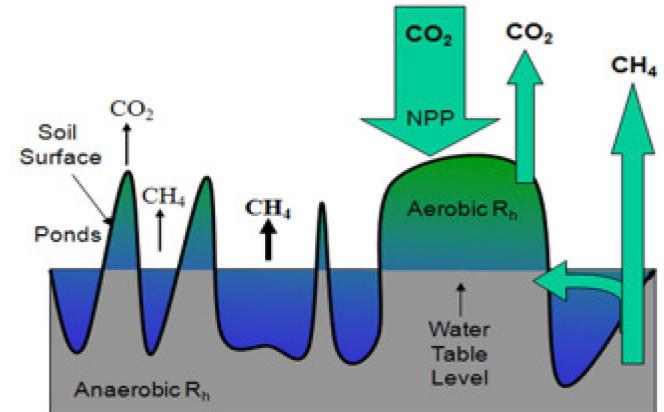
Brown et al., 2001 [NSIDC]



CARVE Addresses Key Unanswered Science Questions



- 1) What are the sensitivities of the Alaskan Arctic carbon cycle and ecosystems to climate change?
- 2) How does interannual variability in surface controls (e.g., soil moisture) affect landscape-scale atmospheric concentrations and surface-atmosphere fluxes of CO_2 and CH_4 in the Alaskan Arctic?
- 3) What are the impacts of fire and thawing permafrost on the Alaskan Arctic carbon cycle and ecosystems?



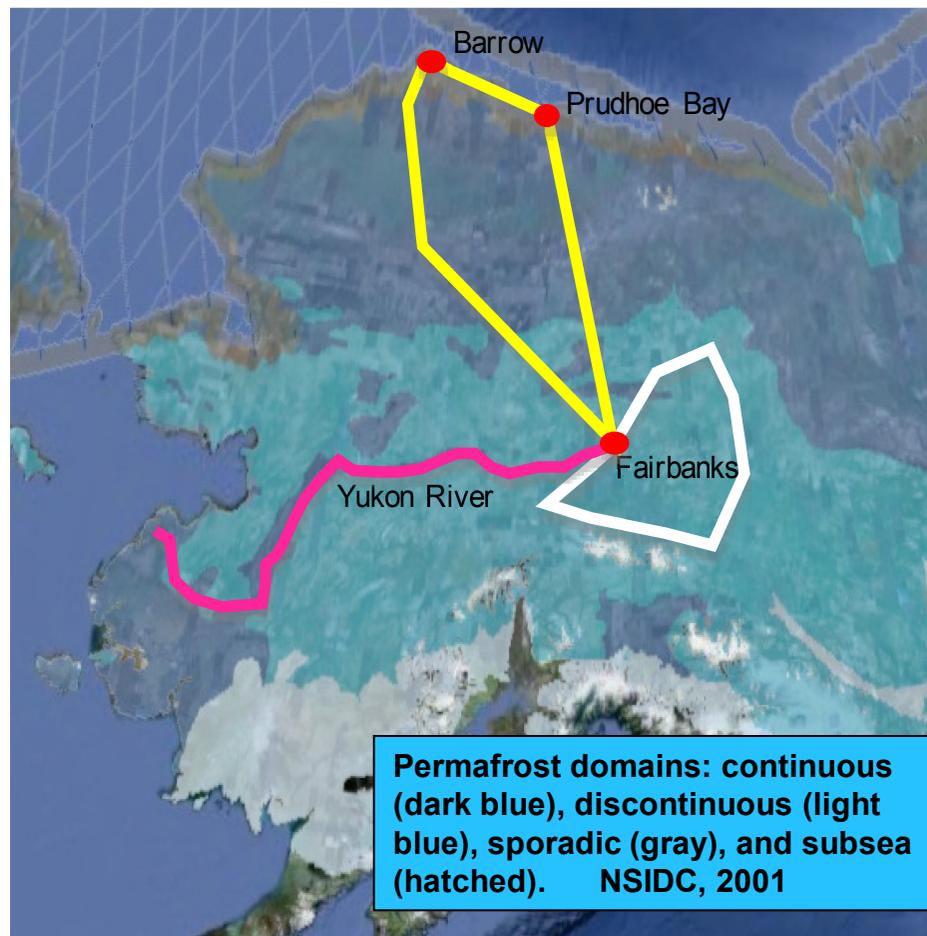
A mosaic of wet and dry areas is common for regions in the Arctic. Microtopography dictates the partitioning of soil respiration into aerobic processes (CO_2 release) and anaerobic processes (CH_4 release). The partitioning of carbon fluxes from Arctic ecosystems is not known accurately.



The CARVE Science Investigation

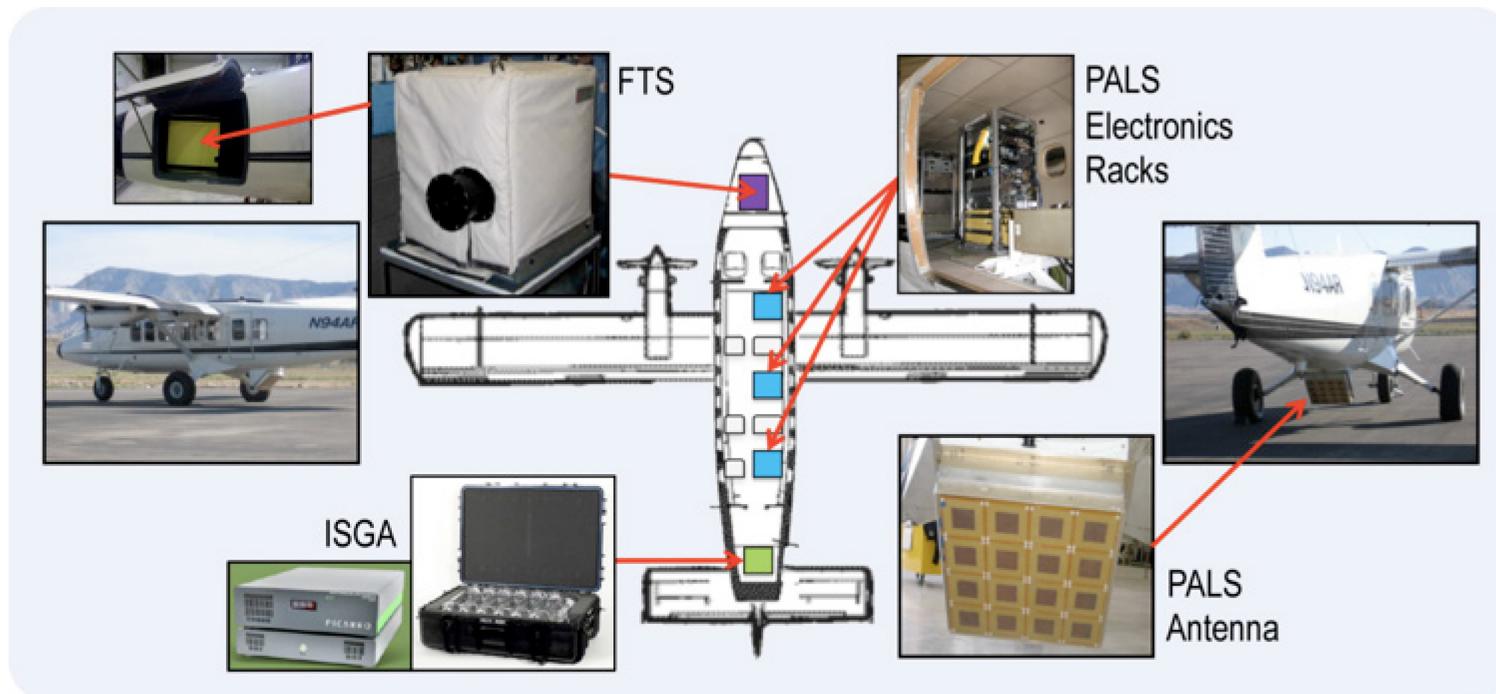
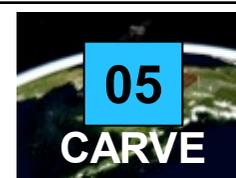


- CARVE operates out of Fairbanks, AK
- Each colored loop represents a single day's flight path. Each flight path would be covered multiple times per intensive.
- CARVE flight plans sample multiple permafrost domains, ecosystems, burn-recovery chronosequences, and well-instrumented ground cal/val sites
- Flight plans sample regions where conditions and variability may be used as a proxy for climate change
- CARVE measurements will provide strong model constraints on key processes





The CARVE Flight System: Twin Otter + Science Instruments

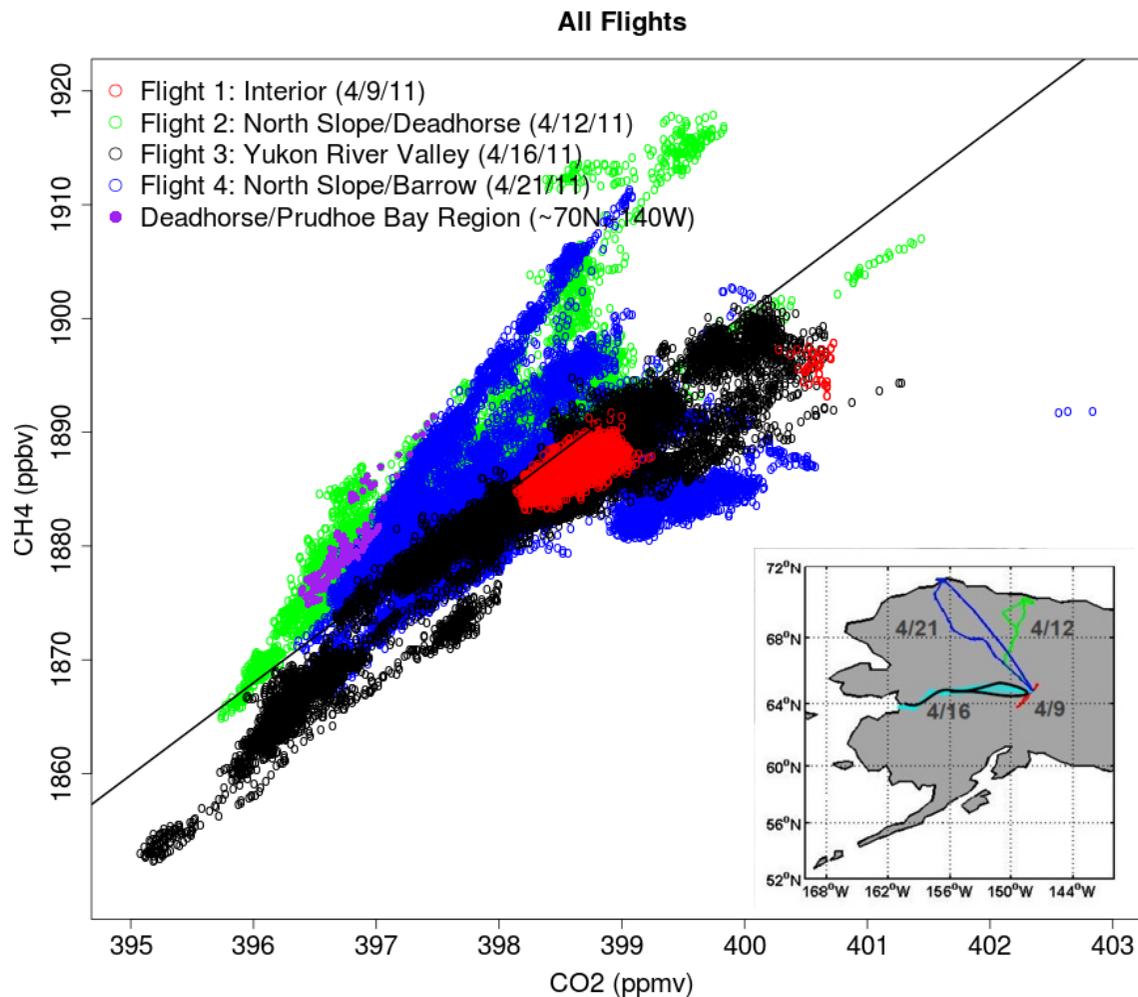


The CARVE Science instruments include

- PALS (Passive-Active L-band System)—surface control variables
- FTS—Column CO₂, CH₄, and CO
- ISGA (In situ Gas Analyzer)—atmospheric trace gas concentrations



Summary of CARVE AK 2011 Test Flights



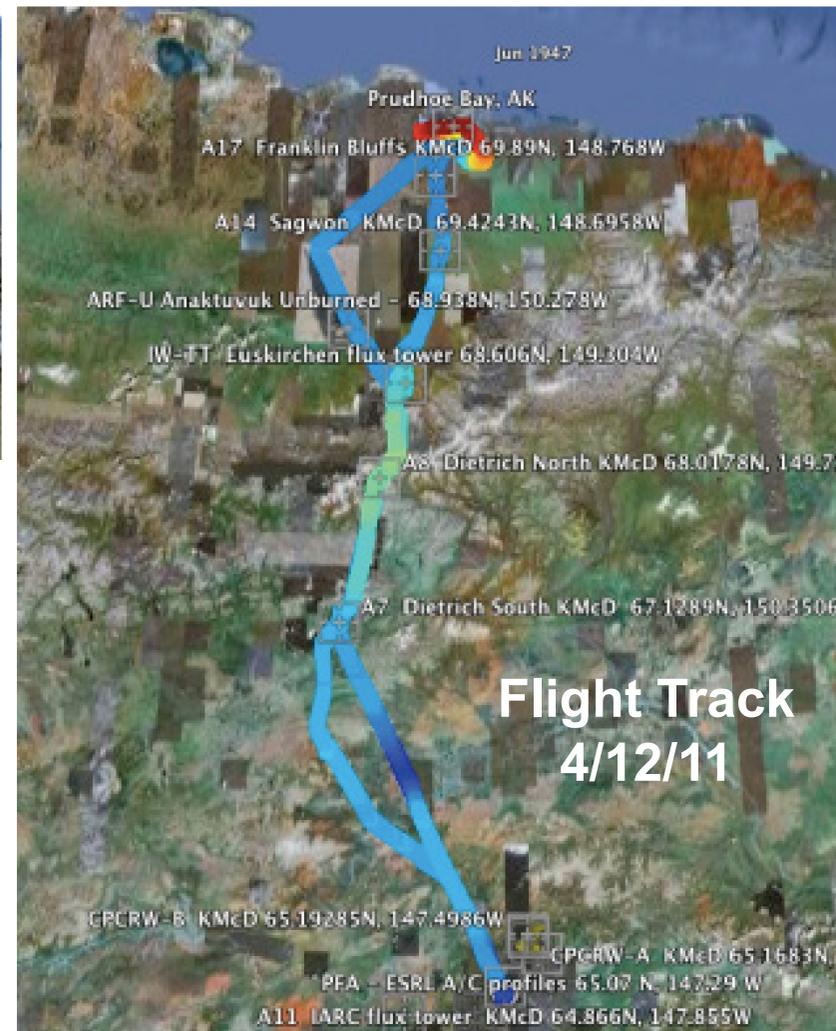
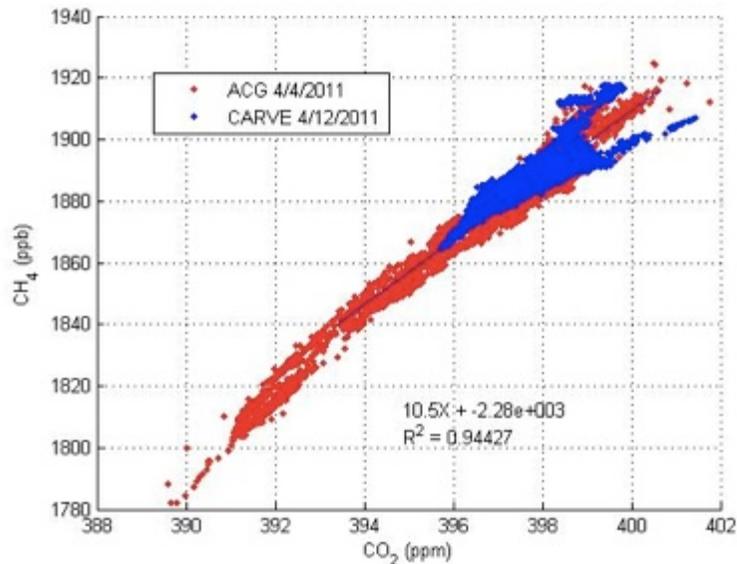


AK Test Flight #2 - 12 April 2011

North Slope/Deadhorse AK Flight Path



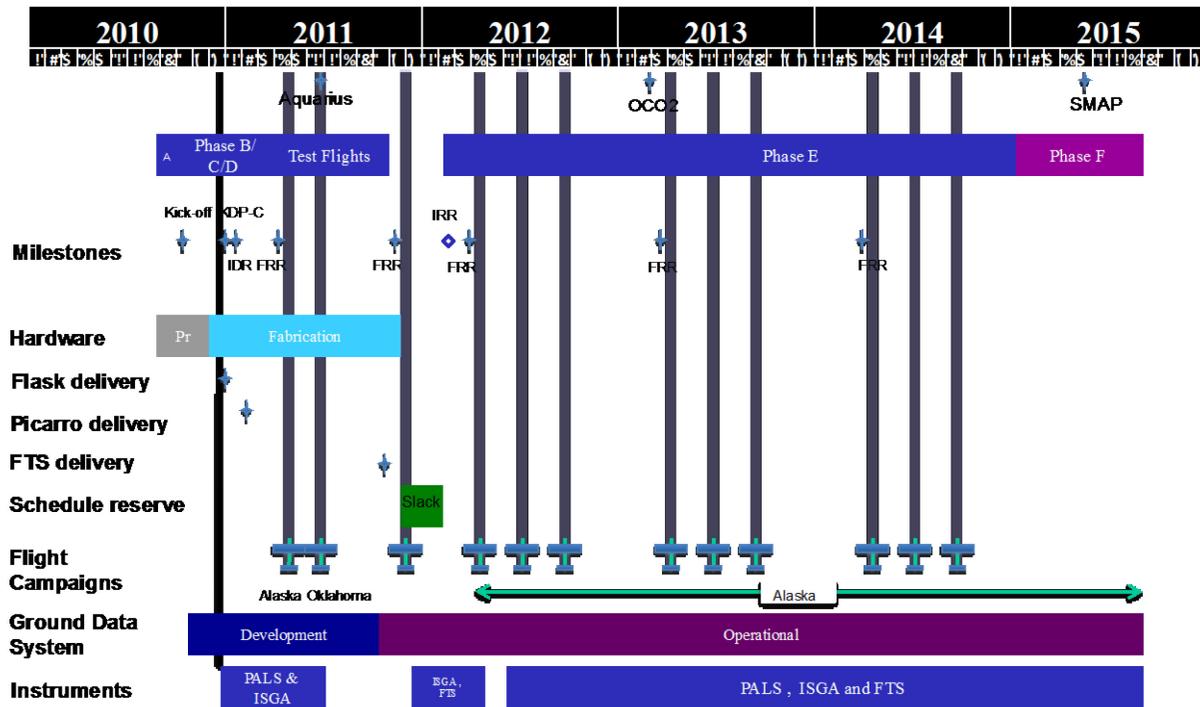
Spiral over Deadhorse



Flight Track 4/12/11



Science Operations are Scheduled 2012–2014



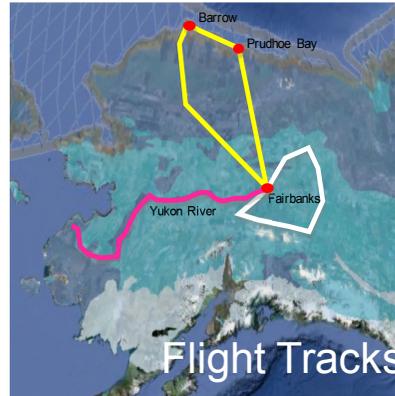
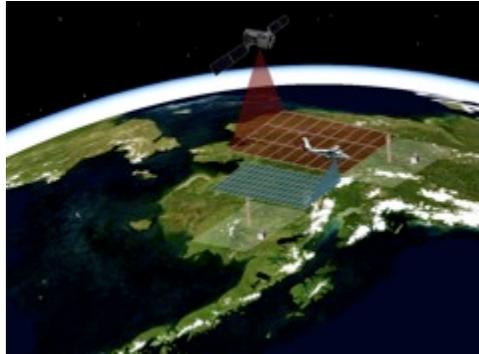
CARVE Master Schedule

The CARVE Science Investigation entails

- Engineering test flights in summer–fall 2011
- Intensive field deployments in Alaska during the spring, summer, and fall of each year from 2012 to 2014
- Each campaign will provide up to 80 hours of flight data



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

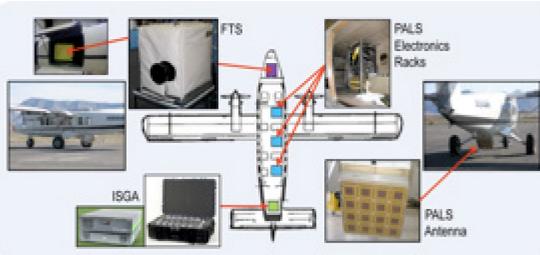
- L-band radar/radiometer
- Nadir viewing Fourier transform spectrometer
- Continuous in CO₂, CH₄ and CO
- Programmable flask packages (whole air sampling)

Measurements

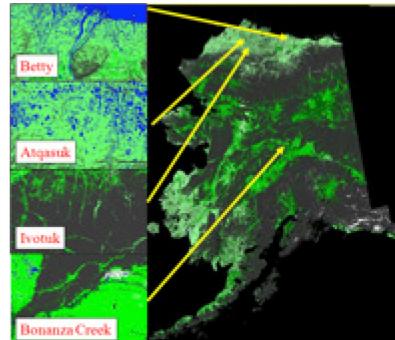
- Surface parameters controlling carbon emissions: soil moisture, freeze/thaw state, inundation state, surface temperature
- Total atmospheric columns of CO₂, CH₄ and CO
- Atmospheric concentrations of CO₂, CH₄ and CO
- Ground-based measurements of ¹⁴CO₂ and ¹⁴CH₄

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



Principal Investigator: Charles Miller
Project Manager: Steve Dinardo
Implementation Center: JPL



Flights

- **Platform:** De Havilland DHC-6 Twin-Otter
- **Engineering test flights** start in April 2011
- **Science Operations:** Regular spring, summer and fall deployments annually 2012 – 2014 when arctic carbon fluxes are large and change rapidly