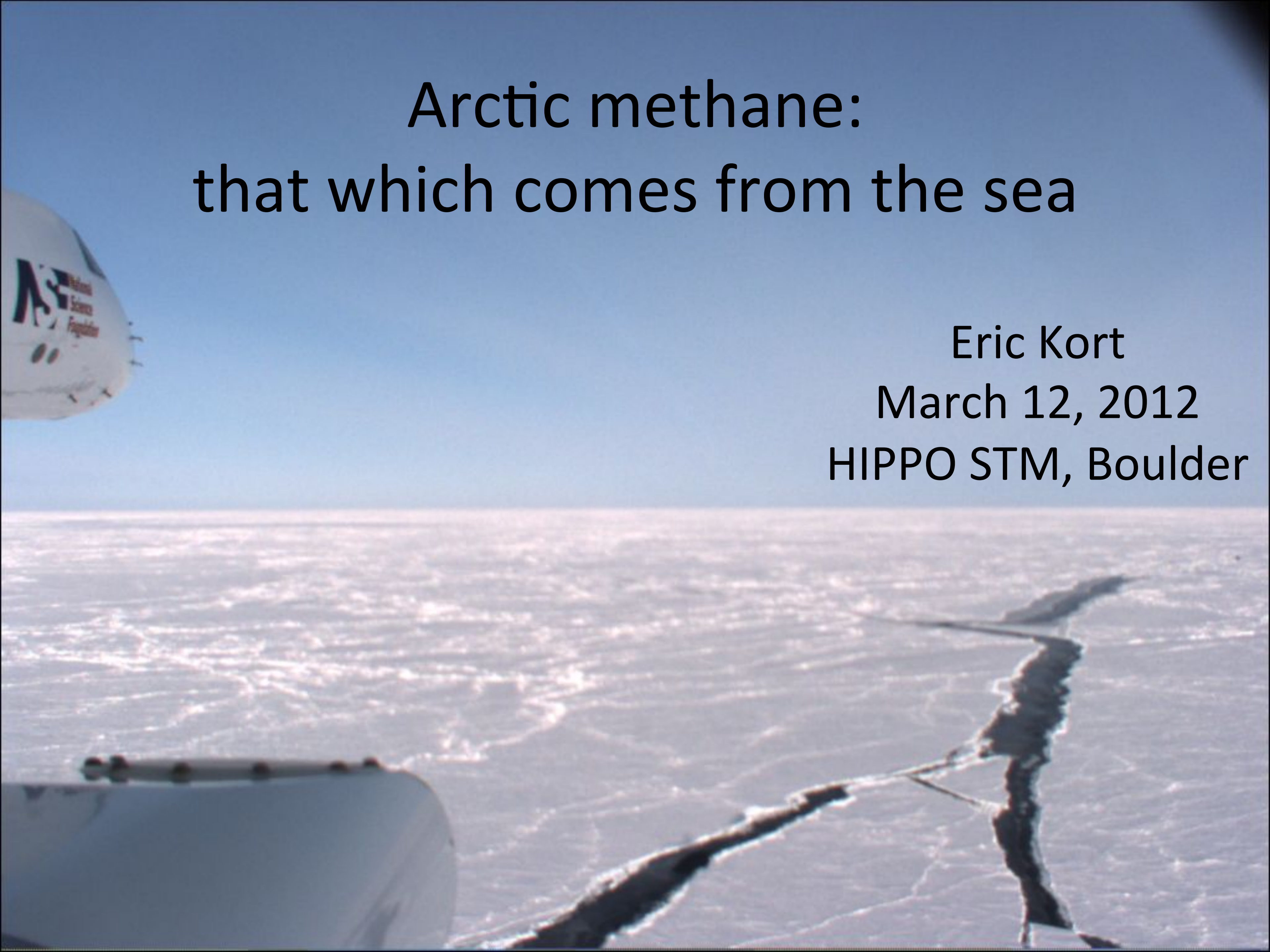
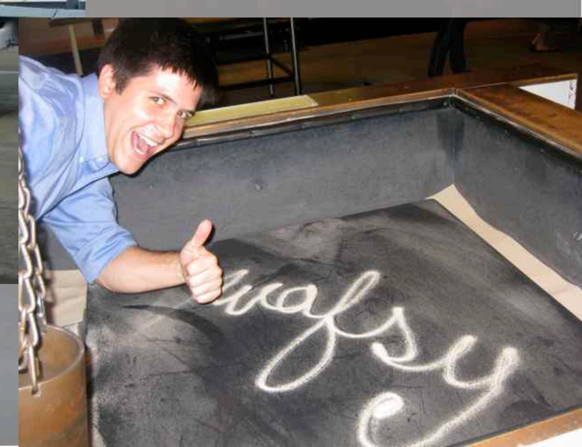
Arctic methane:
that which comes from the sea



Eric Kort
March 12, 2012
HIPPO STM, Boulder

With much thanks to



And many more…

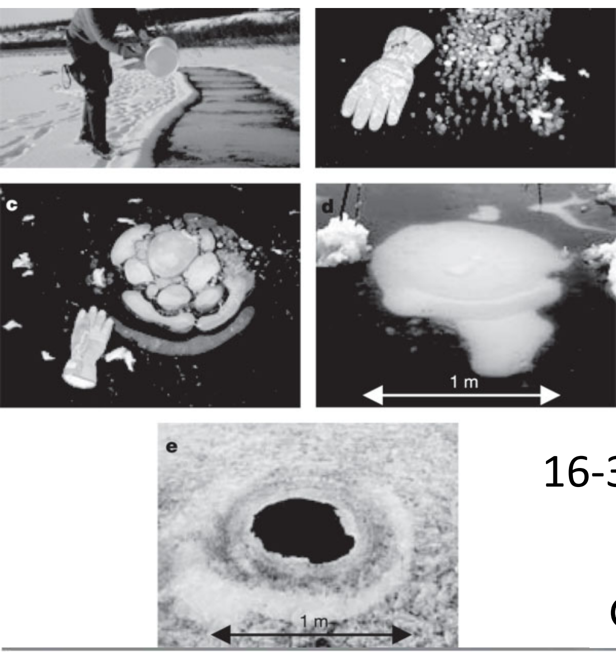
The Arctic:
Large, Vulnerable Carbon Reservoir

- ~ 1000 Pg C in top 3 m of Arctic land surface
- Methane Hydrates on shallow Arctic continental shelves ~30-170 Pg CH_4
- Terrestrial permafrost soils: 2-65 Pg of CH_4 in clathrate

- Boreal Wetlands
- Permafrost
- Arctic Lakes
- Thermokarst
- Sub-sea sediments
- Hydrates

Methane bubbling from Siberian thaw lakes as a positive feedback to climate warming

K. M. Walter[1], S. A. Zimov[2], J. P. Chanton[3], D. Verbyla[4] & F. S. Chapin III[1]

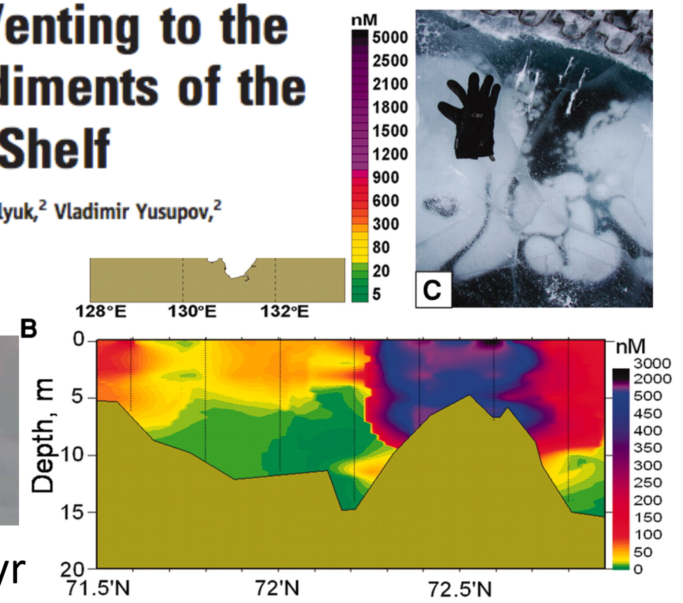


16-35 Tg CH_4/yr

Extensive Methane Venting to the Atmosphere from Sediments of the East Siberian Arctic Shelf

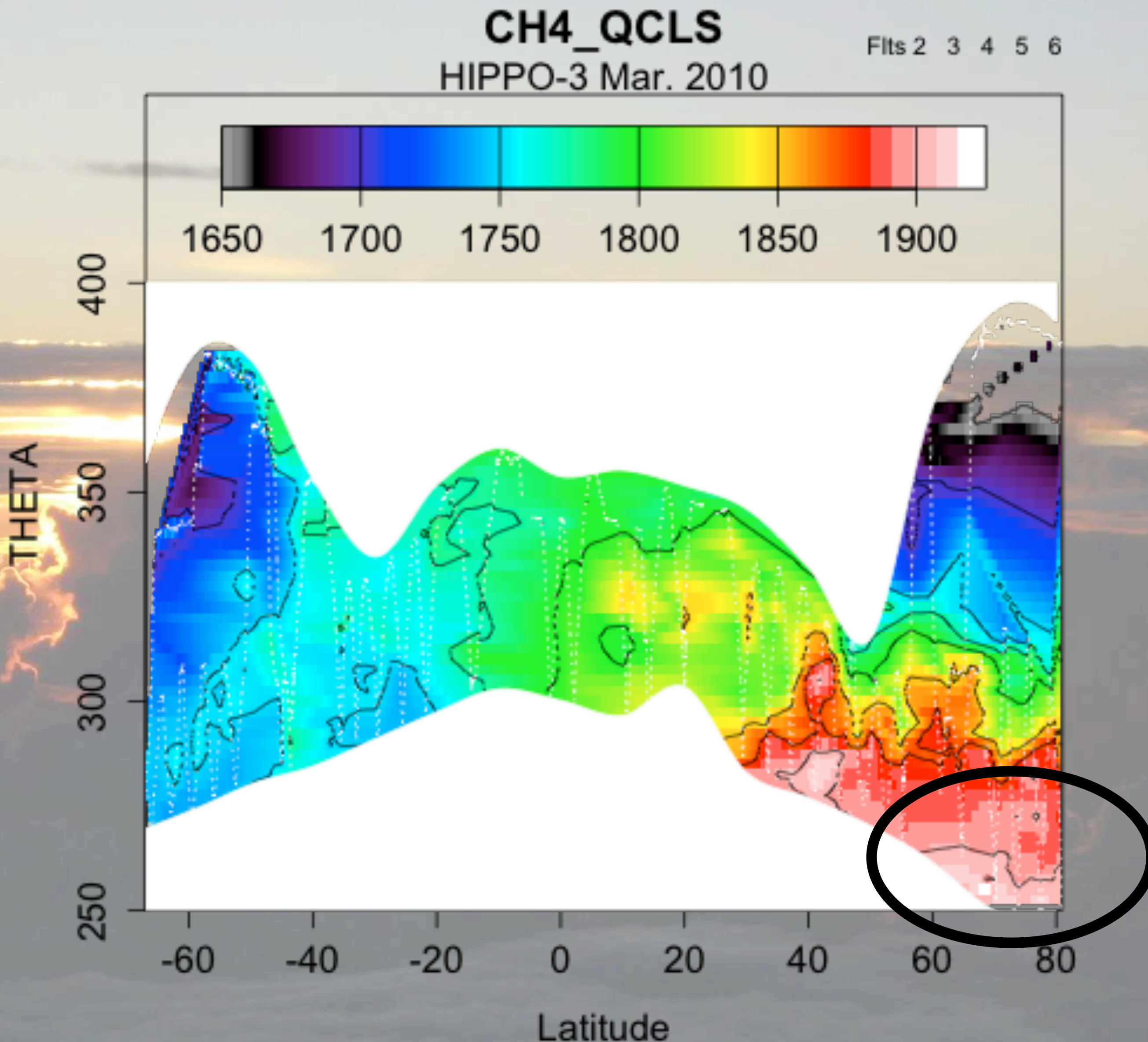
Natalia Shakhova,[1,2]*† Igor Semiletov,[1,2]* Anatoly Salyuk,[2] Vladimir Yusupov,[2] Denis Kosmach,[2] Örjan Gustafsson[3]

~8 Tg CH_4/yr

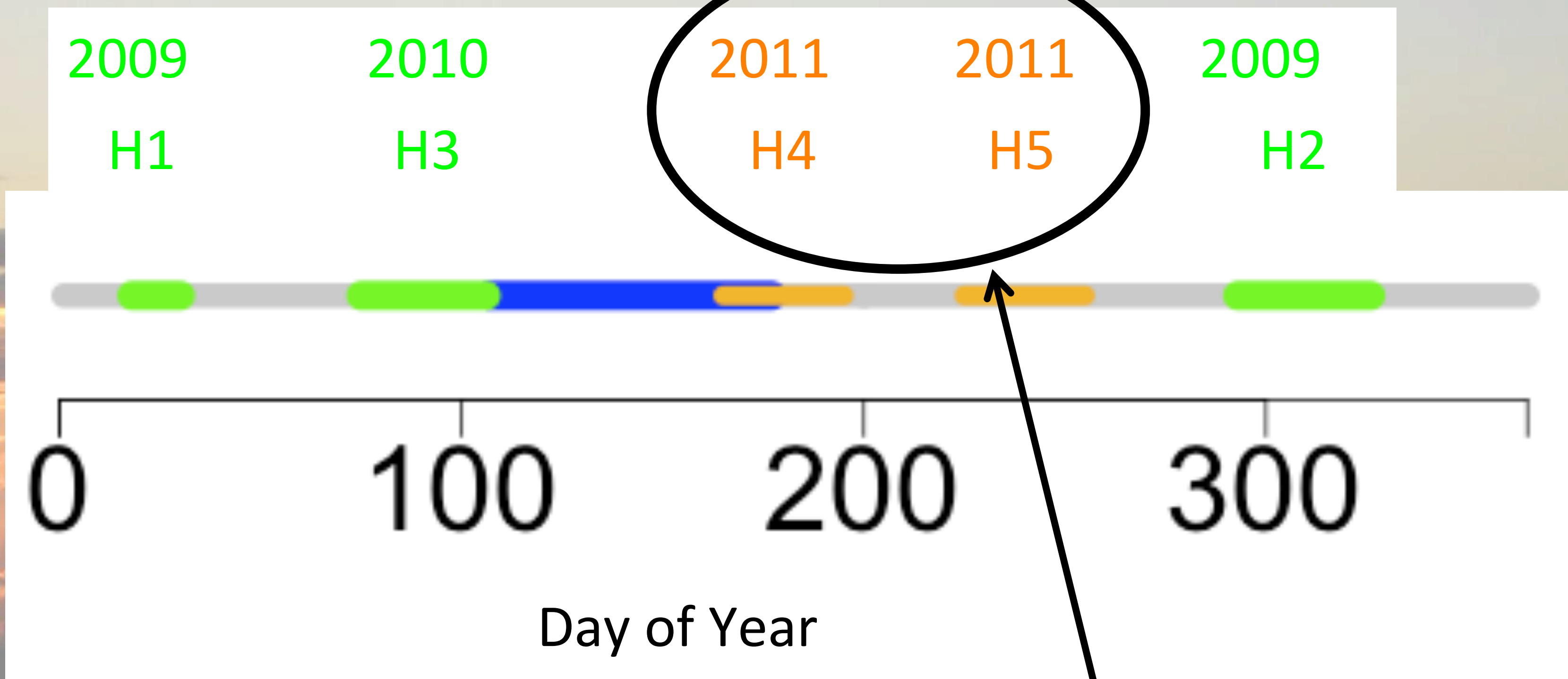


Global annual: 500-600 Tg CH_4/yr

Arctic Methane

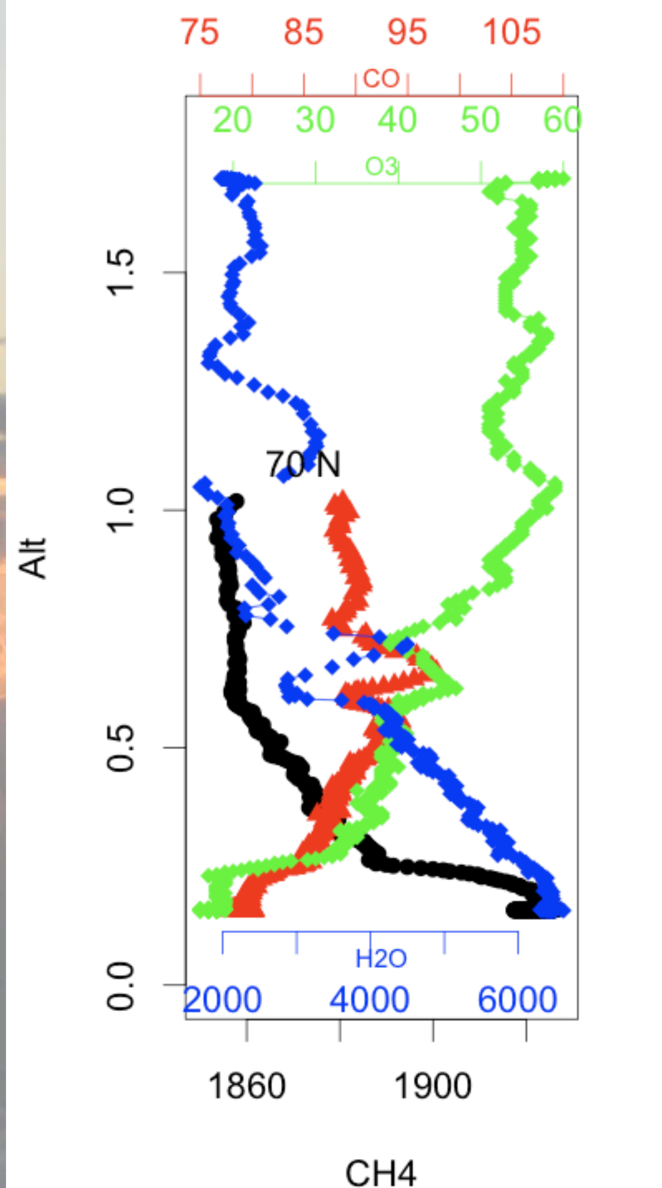


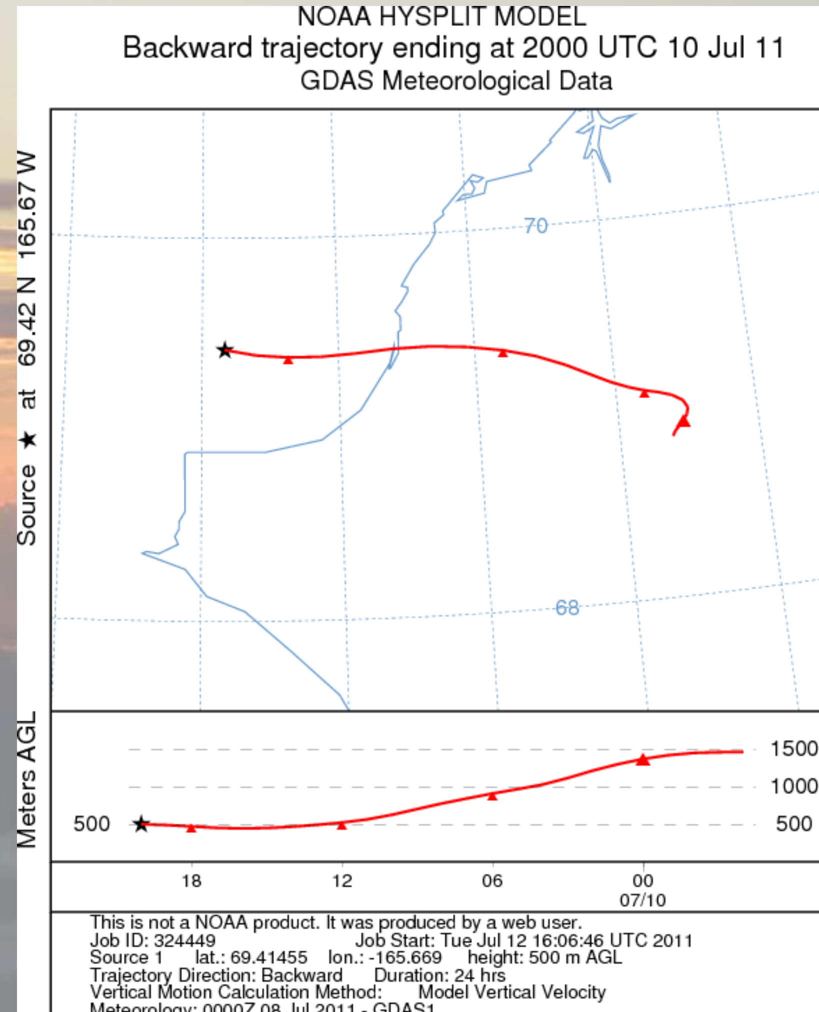
HIPPO timing



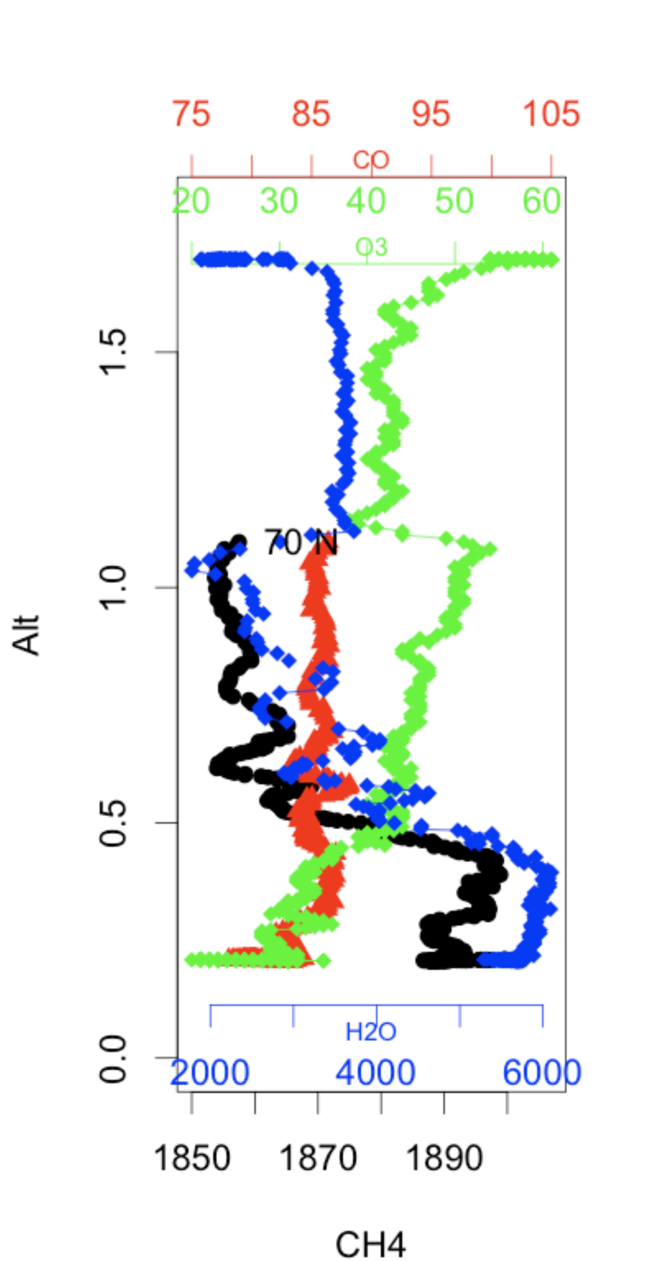
Coastal Porpoise
Low Sea Ice
Very Active Terrestrial Biosphere

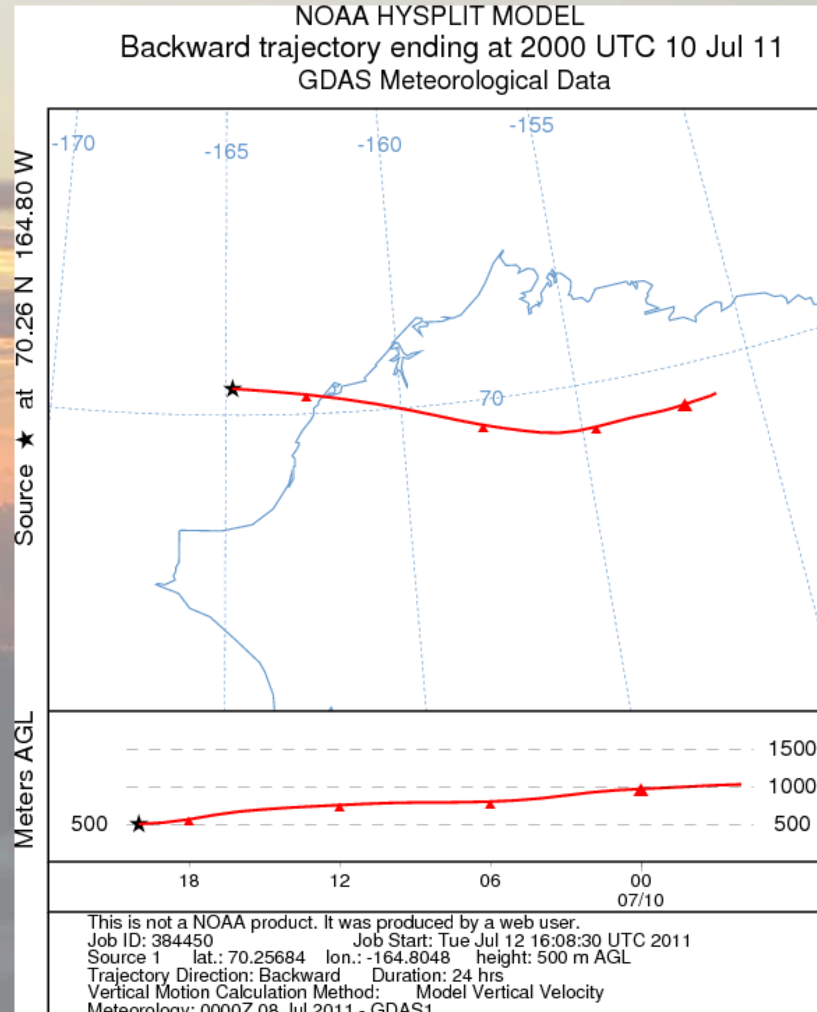
Significant Methane enhancements: From land or sea?



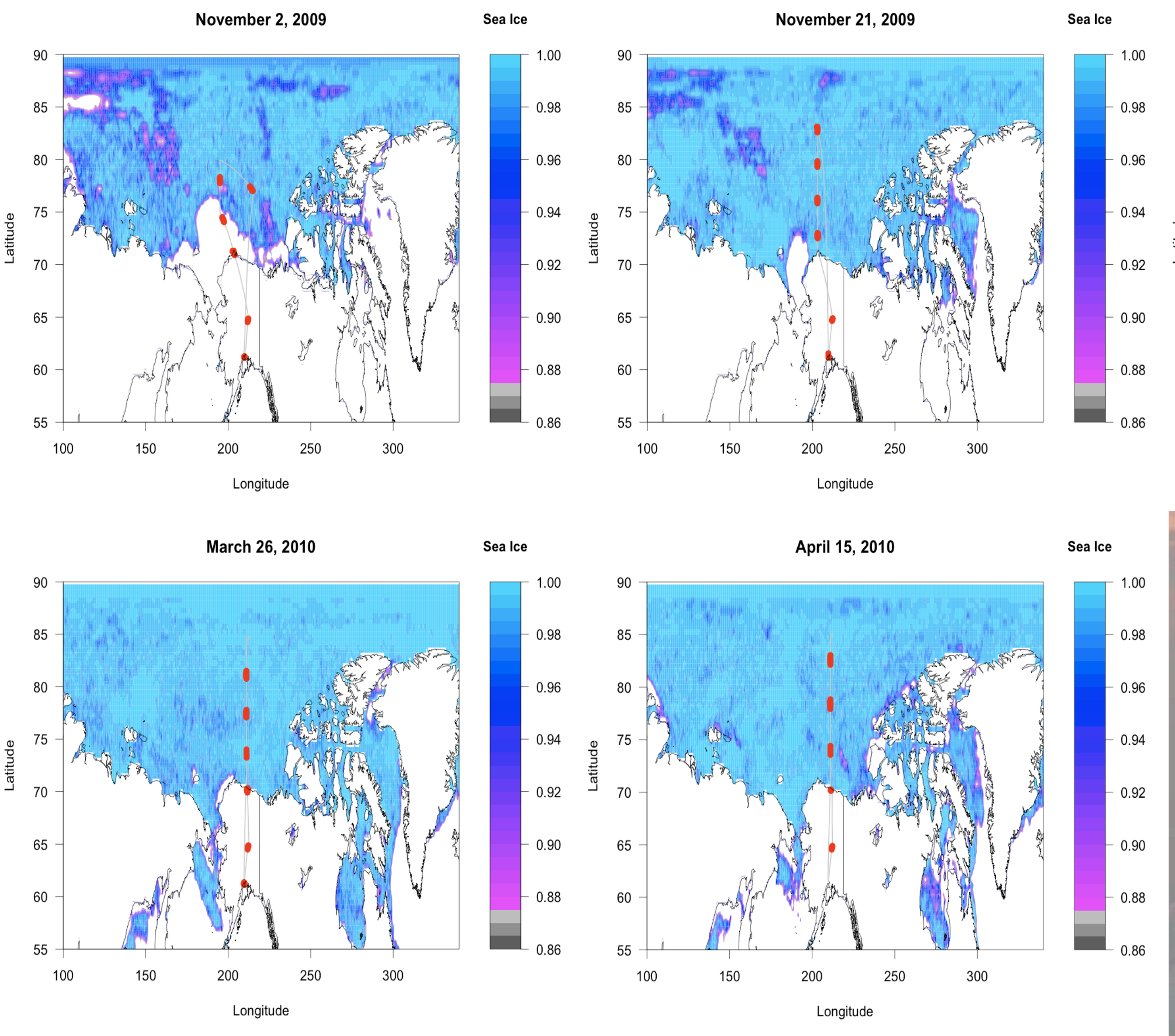


Significant Methane enhancements: From land or sea?



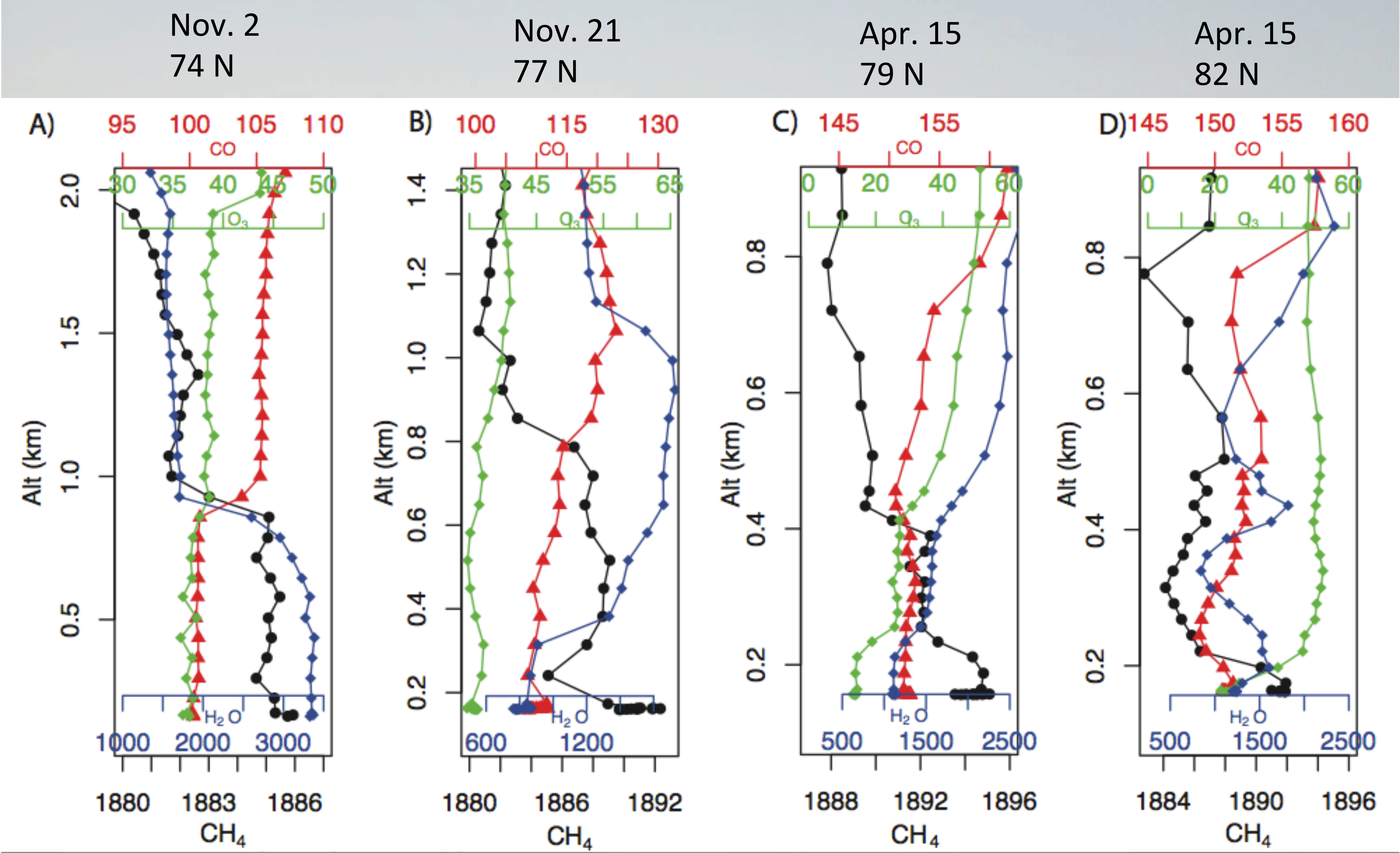


Focus on Nov. – Apr.

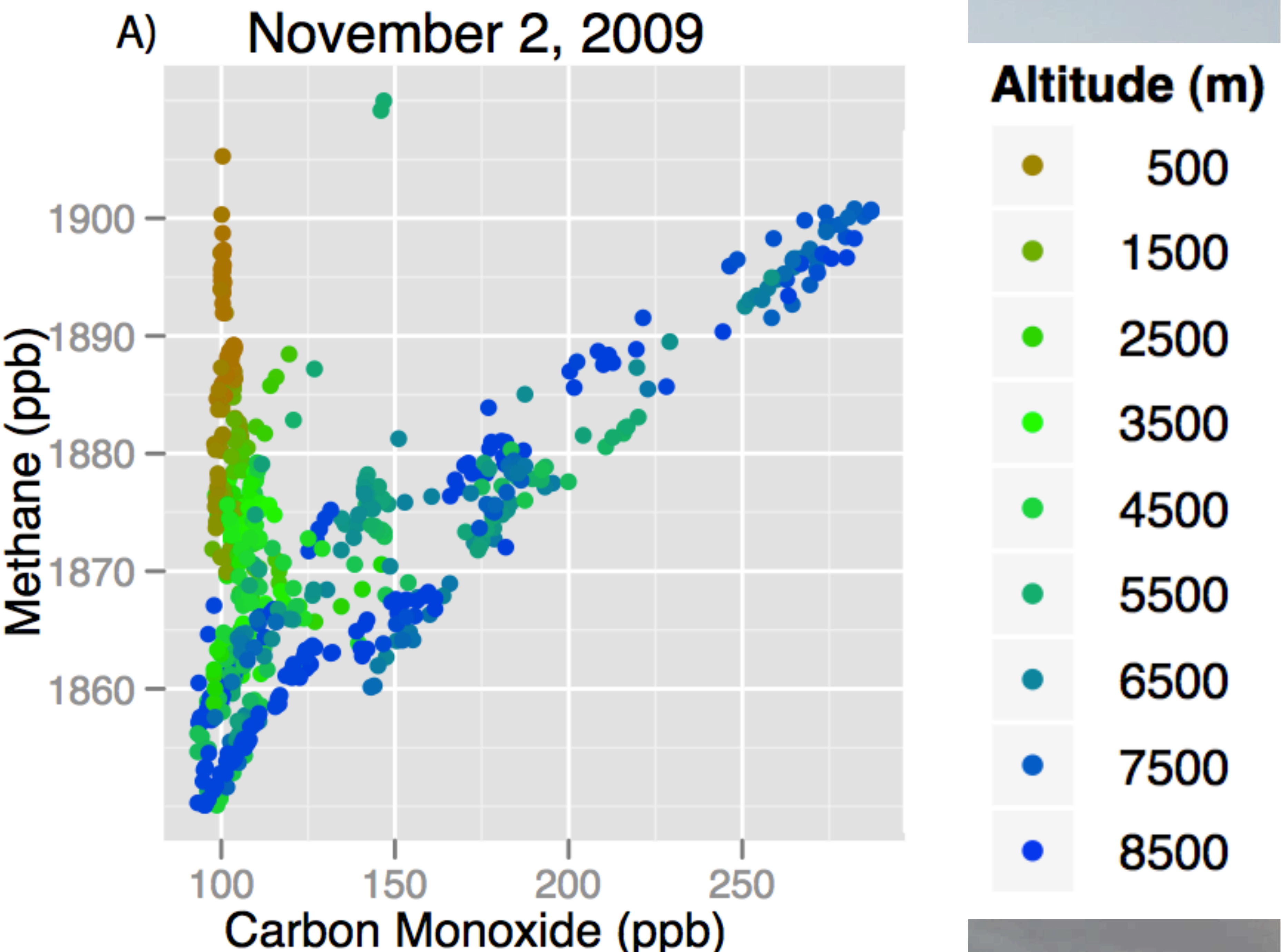


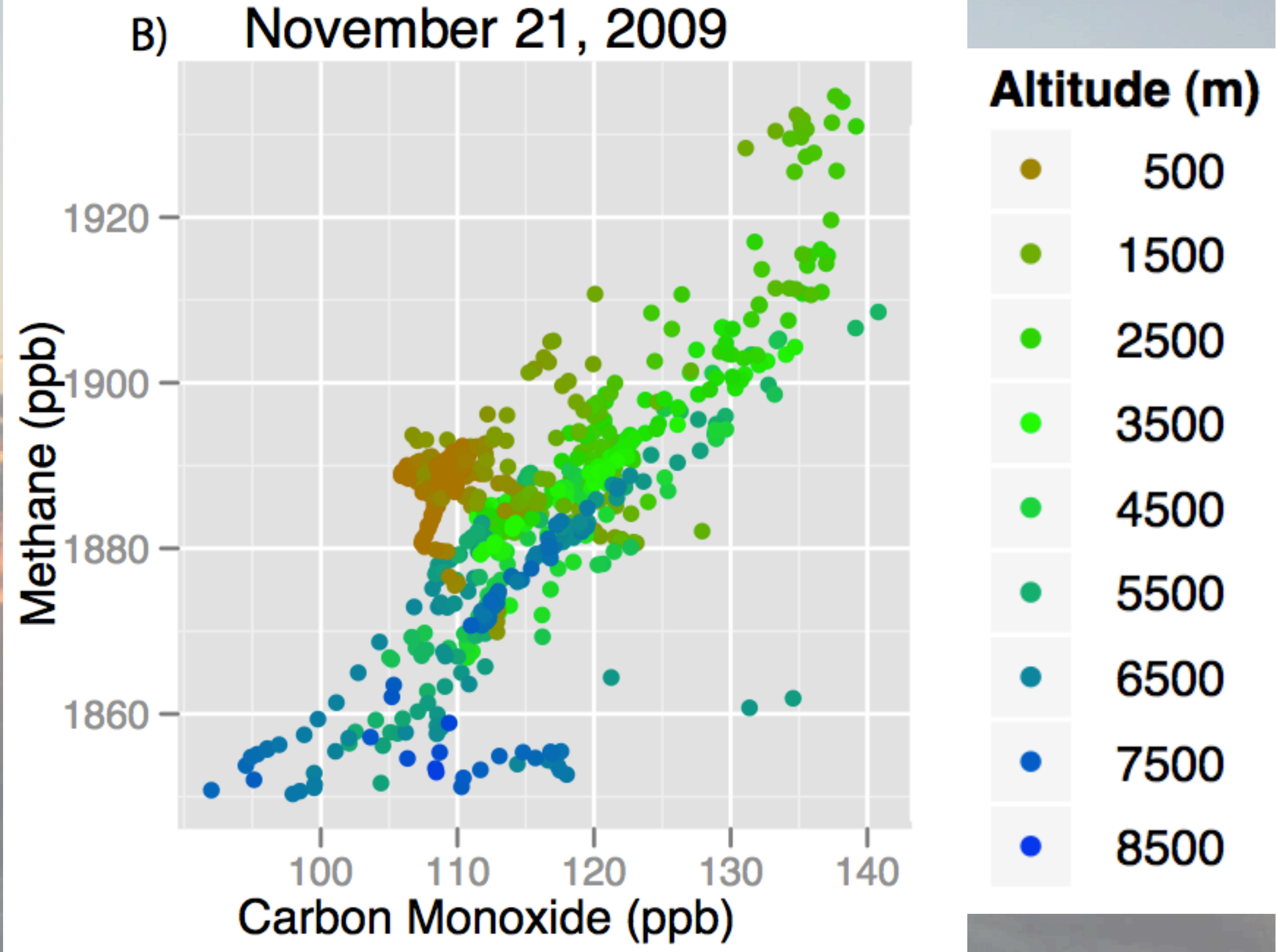
Extensive ice cover: not continuous

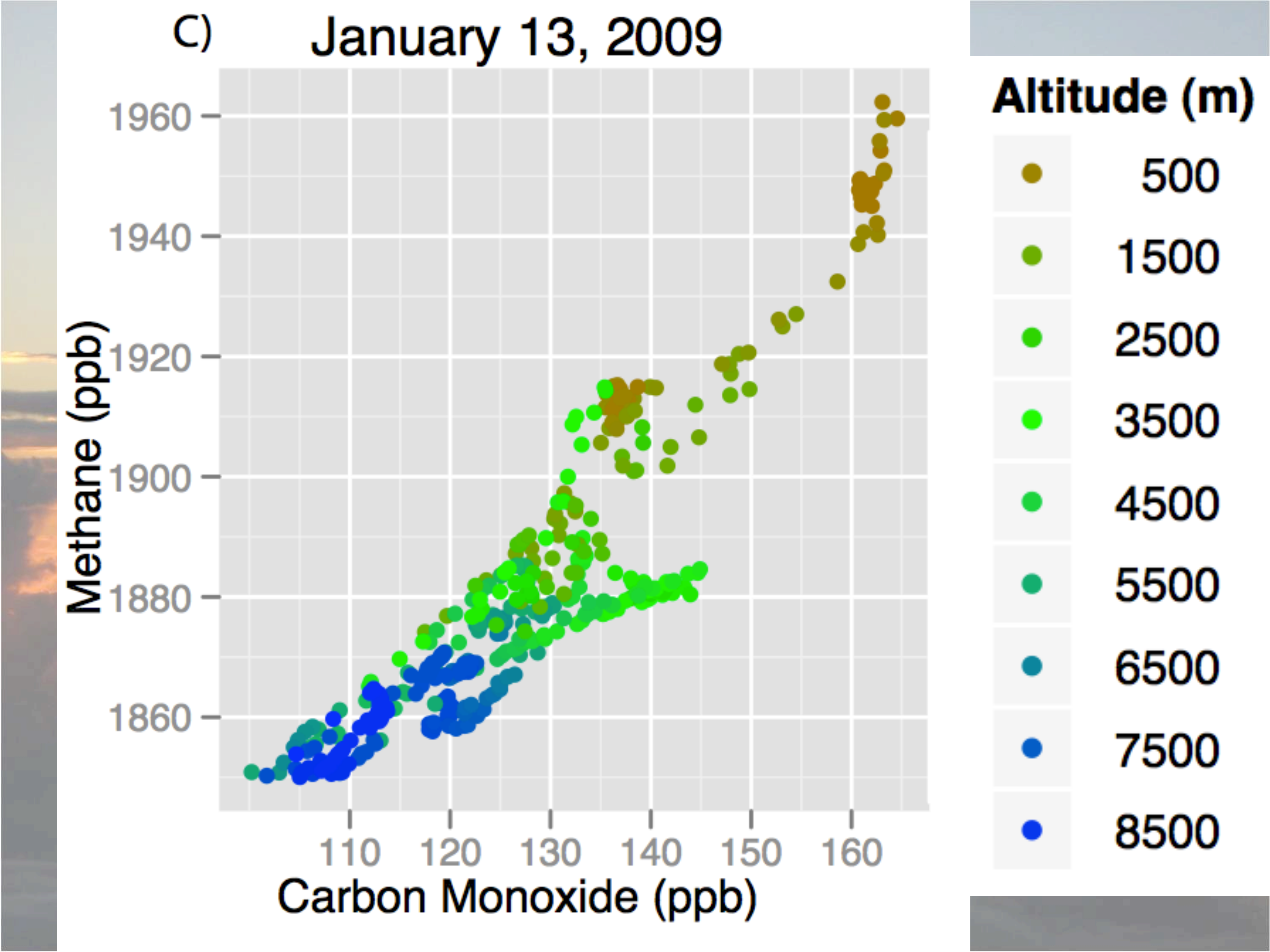
Movie from wing camera

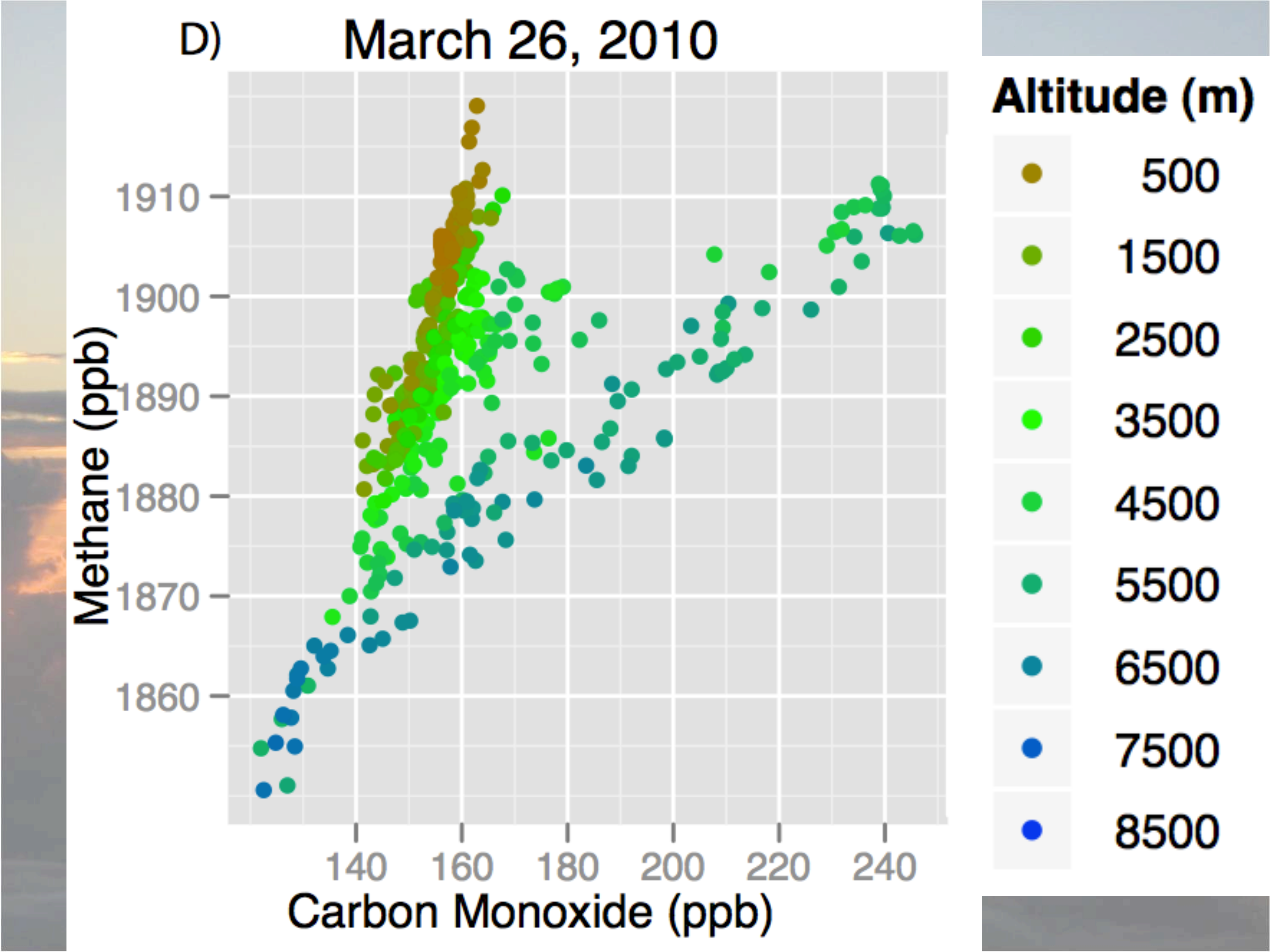


Black: Methane, Blue: H2O, Green: Ozone, Red: CO

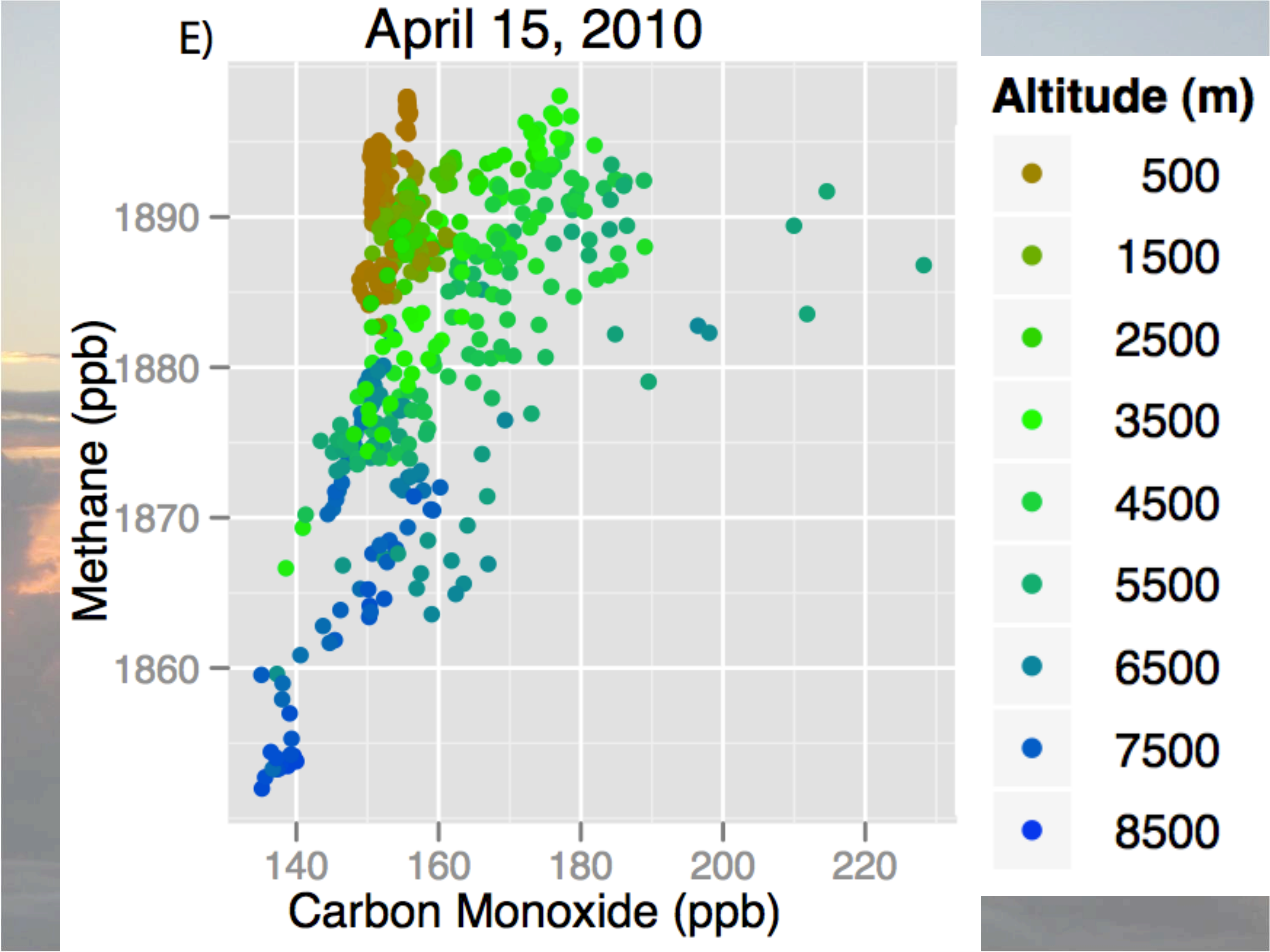

A)
November 2, 2009
Methane (ppb)
1860
1870
1880
1890
1900
100
150
200
250
Carbon Monoxide (ppb)
Altitude (m)
500
1500
2500
3500
4500
5500
6500
7500
8500


B)
November 21, 2009
Methane (ppb)
1920
1900
1880
1860
Carbon Monoxide (ppb)
100
110
120
130
140
Altitude (m)
500
1500
2500
3500
4500
5500
6500
7500
8500

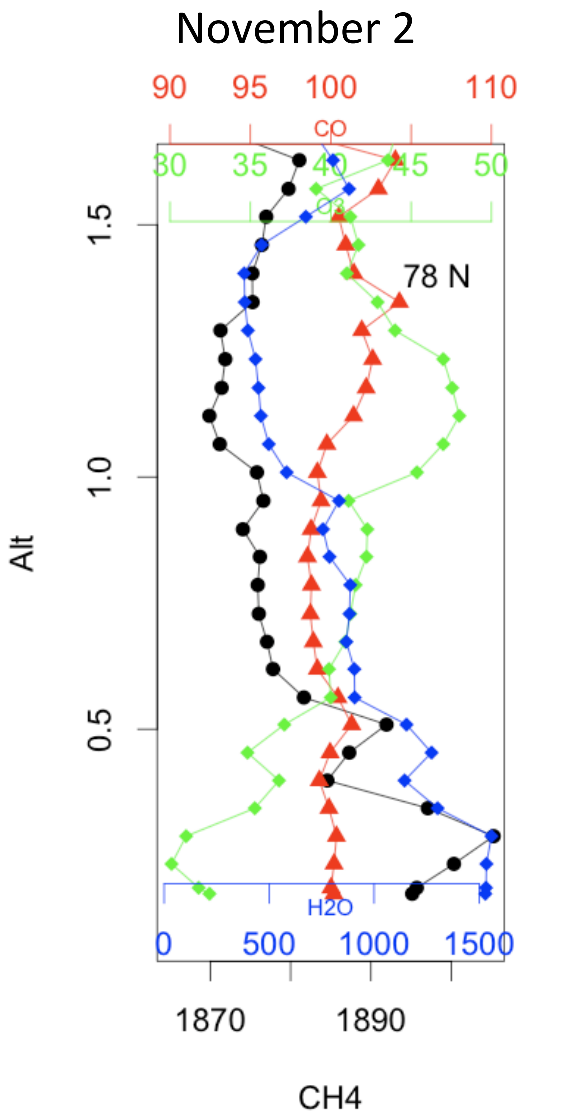

C)
January 13, 2009
Methane (ppb)
1960
1940
1920
1900
1880
1860
110
120
130
140
150
160
Carbon Monoxide (ppb)
Altitude (m)
500
1500
2500
3500
4500
5500
6500
7500
8500

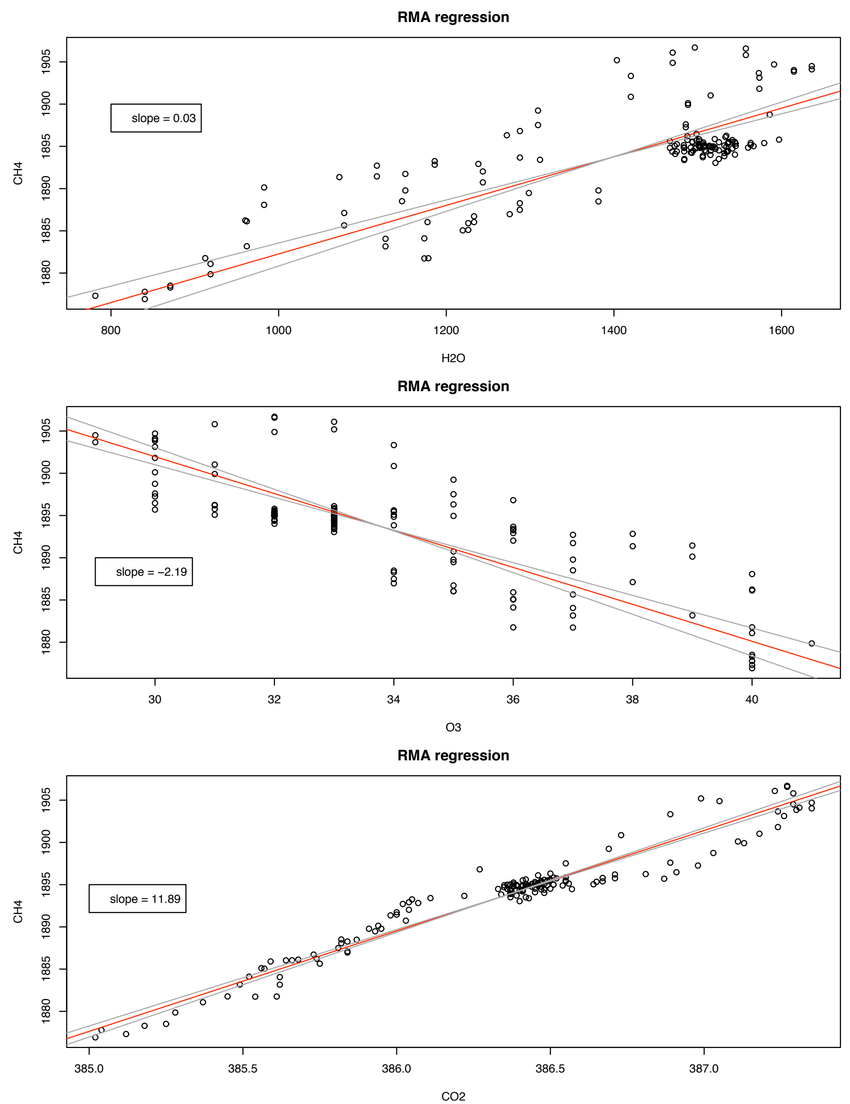


D)
March 26, 2010
Methane (ppb)
1910
1900
1890
1880
1870
1860
140
160
180
200
220
240
Carbon Monoxide (ppb)
Altitude (m)
500
1500
2500
3500
4500
5500
6500
7500
8500

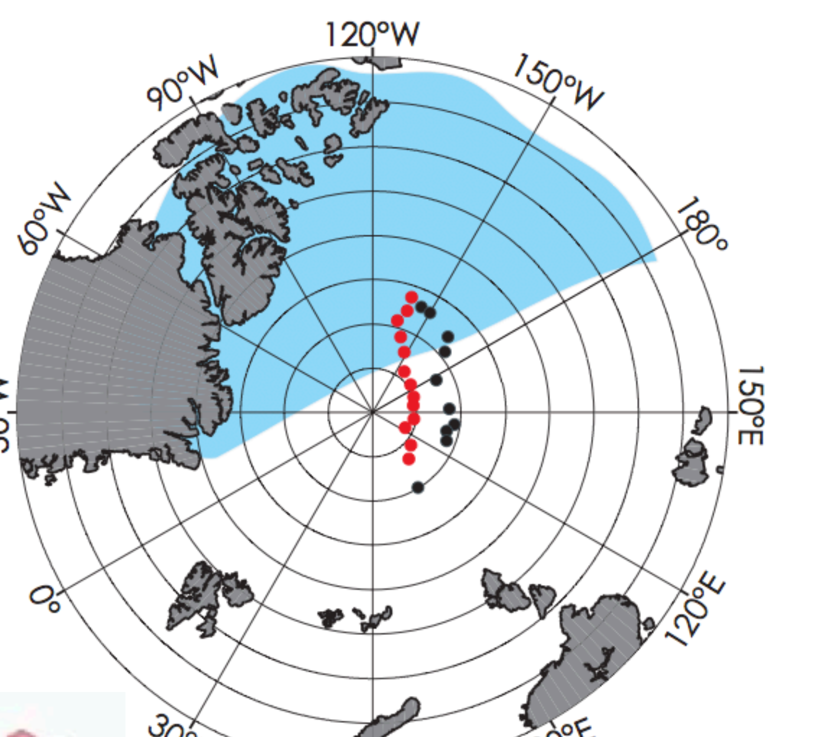

E)
April 15, 2010
Methane (ppb)
1890
1880
1870
1860
140
160
180
200
220
Carbon Monoxide (ppb)
Altitude (m)
500
1500
2500
3500
4500
5500
6500
7500
8500

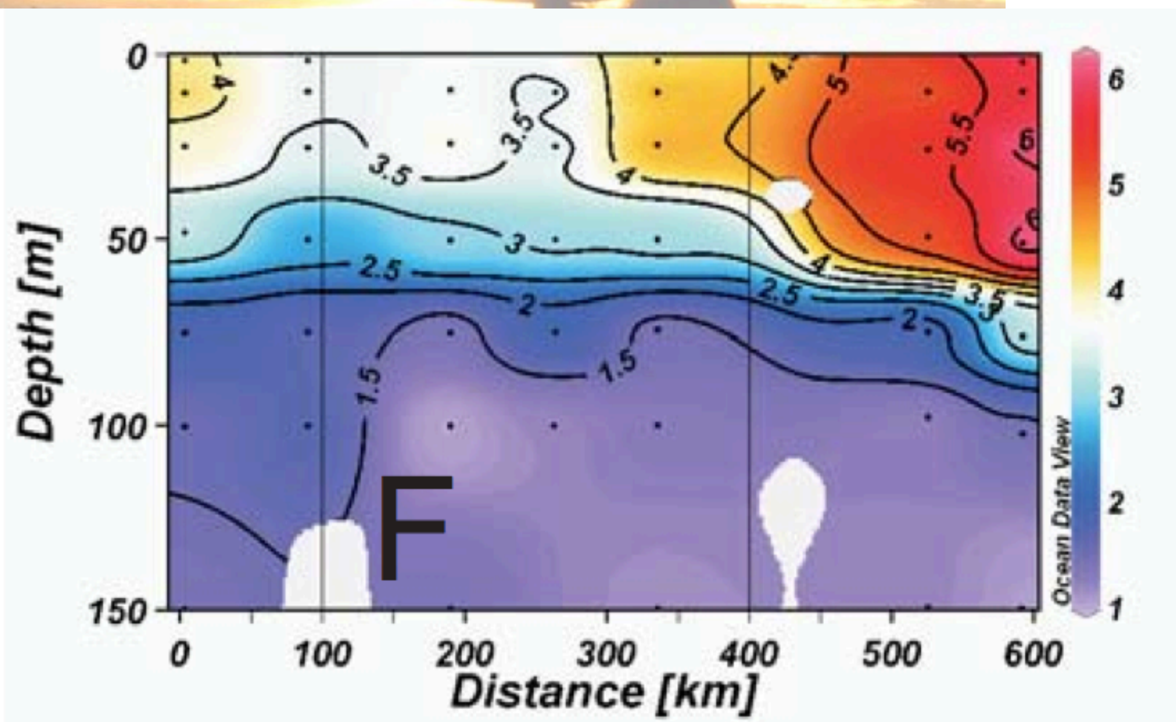
Correlations point to ocean as source





What is the origin of this methane?

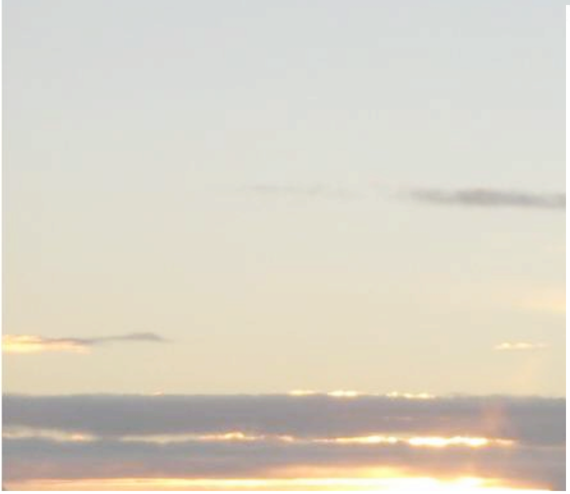


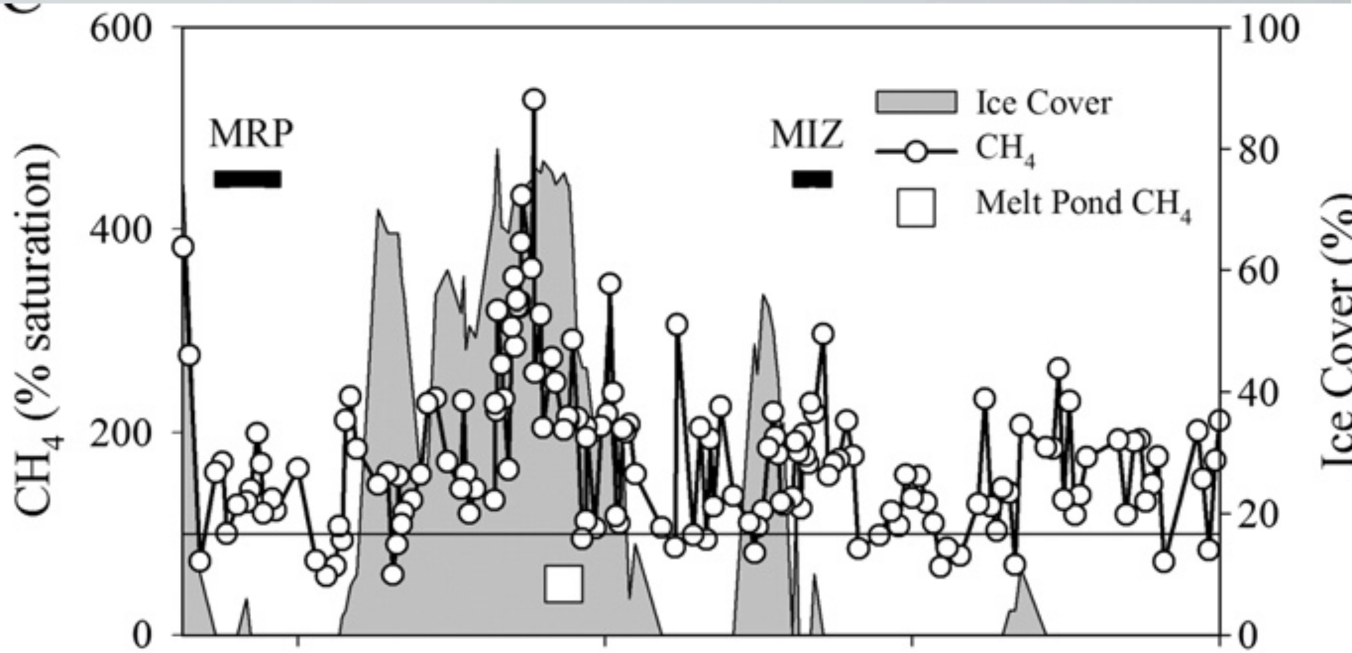


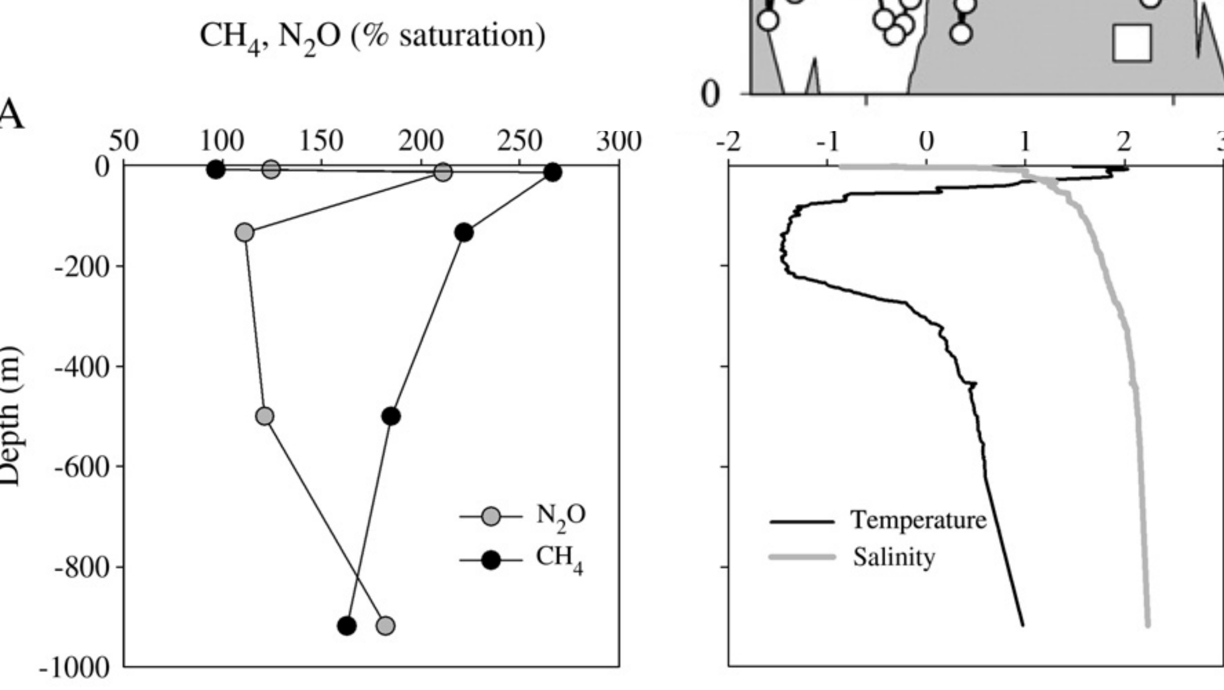
Aerobic biological production in oligotrophic arctic surface waters?

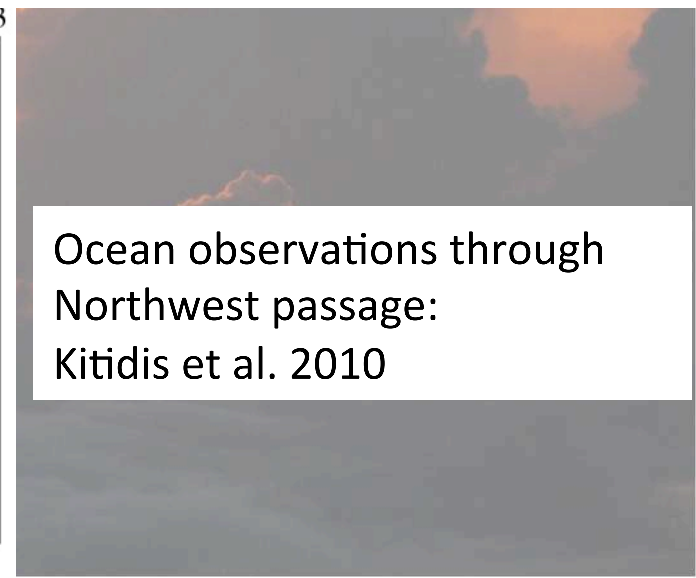
Damm et al., 2010

Correlation with sea-ice cover?









Ocean observations through
Northwest passage:
Kitidis et al. 2010

What is the flux magnitude

- Assume vertical transport was associated with eddy-scale processes, estimate flux from observed methane gradient (dCH_4/dz) and the eddy diffusivity (K_z):

$$\text{Flux} = K_z * dCH_4/dz$$

- 2 Approaches to get K_z
  - Ekman layer approximation
    - 0.3 m^2/s
  - Ensemble of 1-D boundary layer model results (Anderson & Neff 2008)
    - 0.1 - 1 m^2/s

Flux Magnitude

2 mg d^{-1} m^{-2} (0.5 – 8 mg d^{-1} m^{-2})

compare to Shakhova ESAS ~12 mg d^{-1} m^{-2}

To Summarize

- Airborne evidence of emissions from remote Arctic Ocean
- Emissions emerge from leads and areas of partial ice cover
- This source is expected to exhibit sensitivity to changing sea-ice cover and dynamics