



FUGITIVE EMISSION FROM FOSSIL FUEL PRODUCTION WITH IMAGING SPECTROSCOPY MEASUREMENTS

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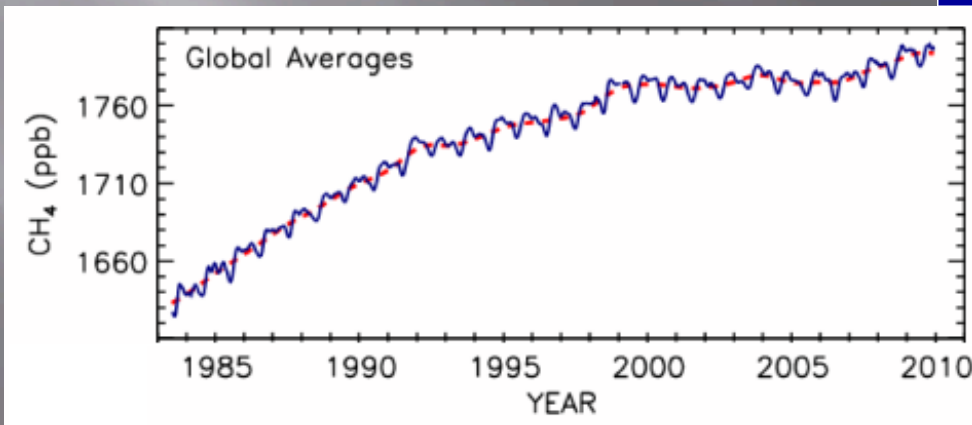
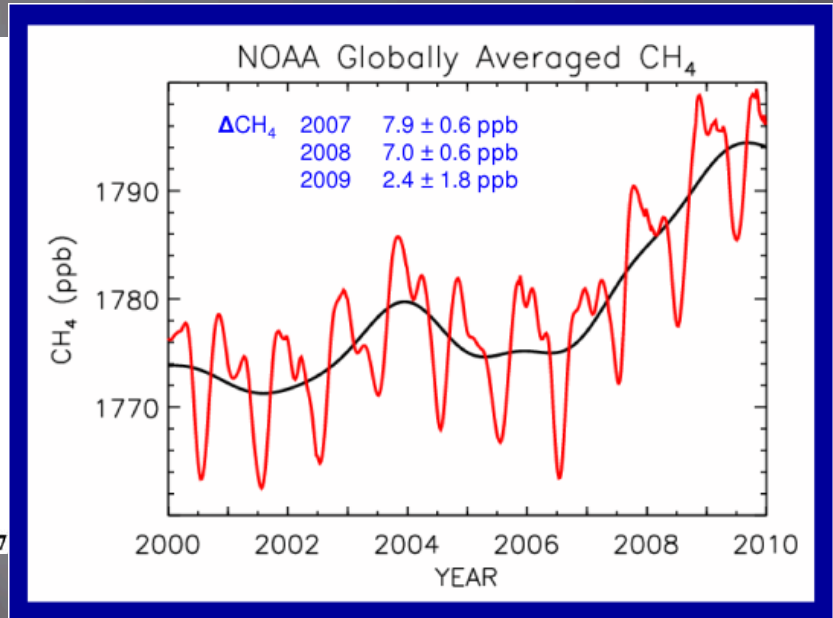
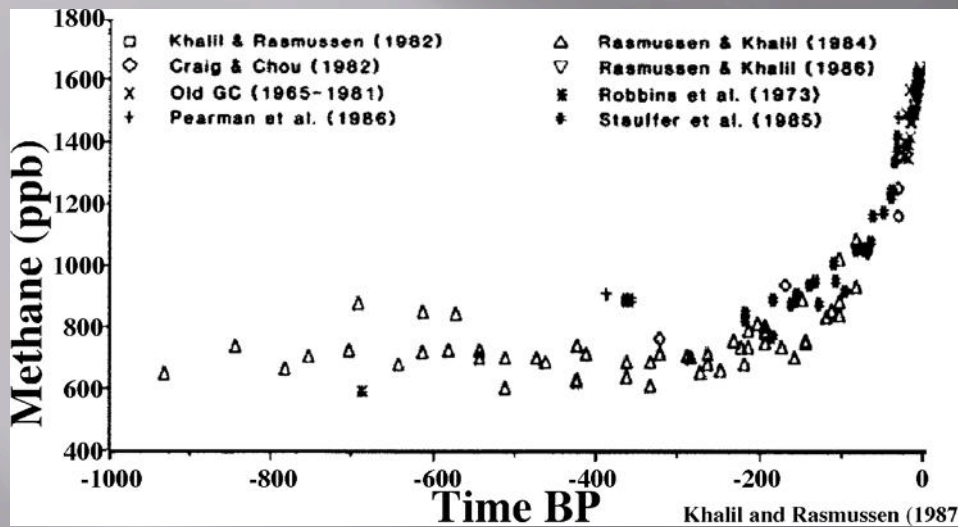
HyspIRI workshop Pasadena, CA, 24-26 Aug 2010

THANKS TO THE ENABLING SUPPORT

- 1 University of California, Santa Barbara
- 2 Jet Propulsion Laboratory
- 3 NASA HQ
- 4 US Geologic Survey
- 5 University of Utah
- 6 NOAA
- 8 University of California, Davis

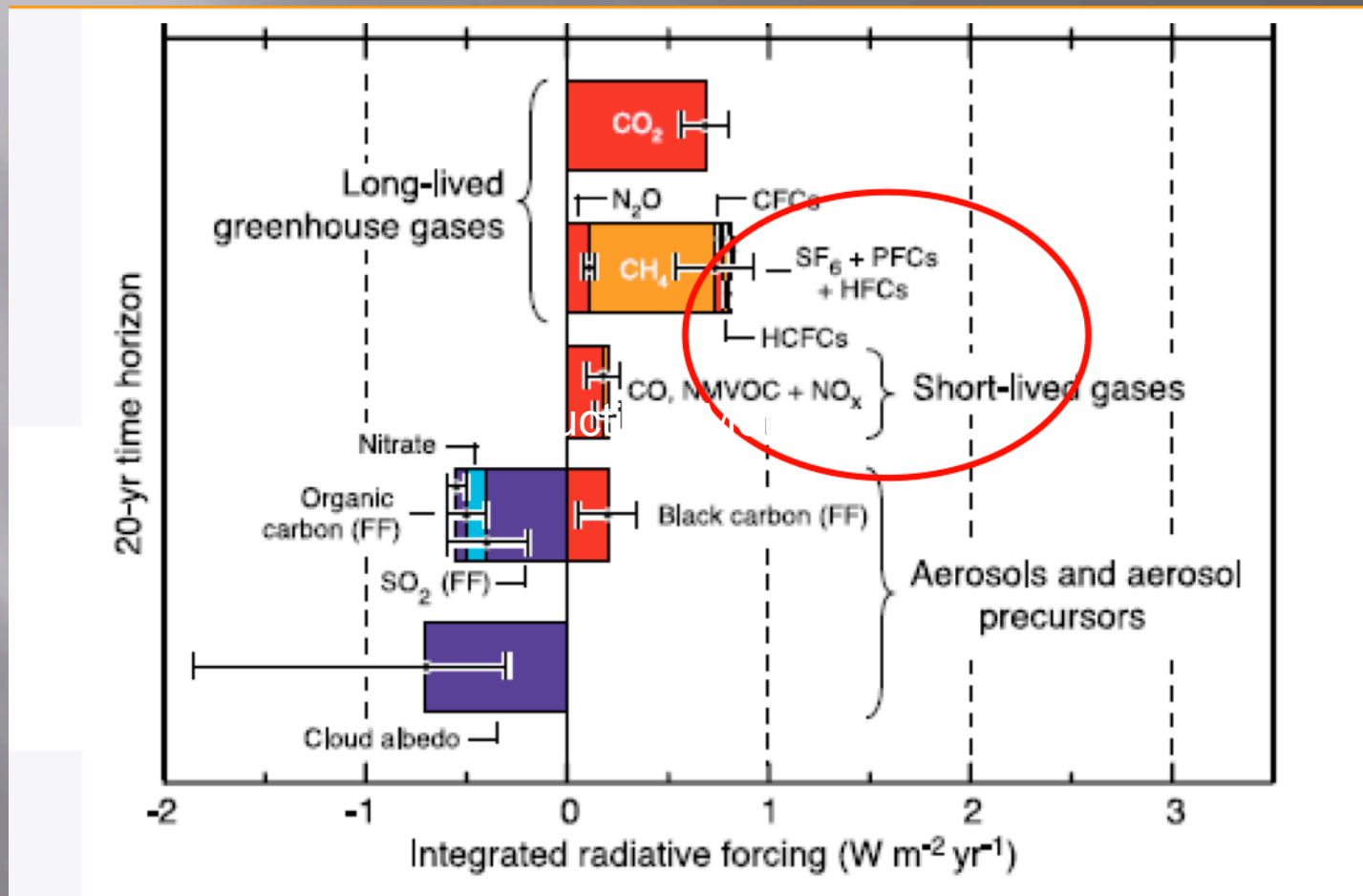
And critical enabling support from

Methane – Stable until 1700s



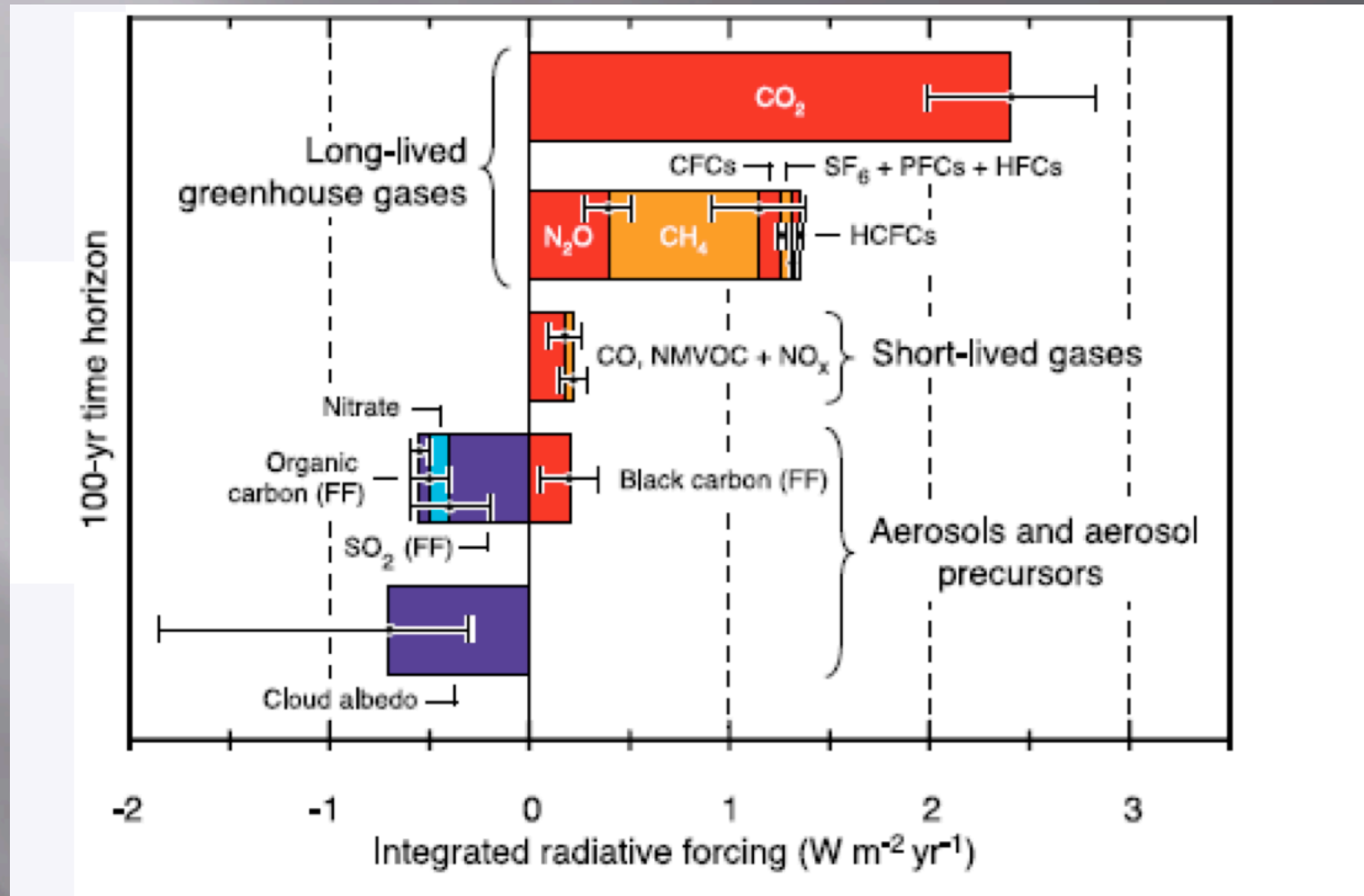
Dlugokencky et al. A Long-term Perspective on Recent Increases in Atmospheric CH₄ Abundance, Global Monitoring annual Conference, 18-19 May 2020, Boulder CO.

Why methane? 20 yr time scale



Methane is a greenhouse gas with 72 times the Global Warming Potential of carbon dioxide on a 20-year time horizon. (IPCC4, Ch2, Fig.2.22, 2007)

Why methane? 100 yr time scale



Methane is a greenhouse gas with **26 times the Global Warming Potential of carbon dioxide** on a 100-year time horizon. (IPCC4, Ch2, Fig.2.21, 2007)

Methane – Human Sources

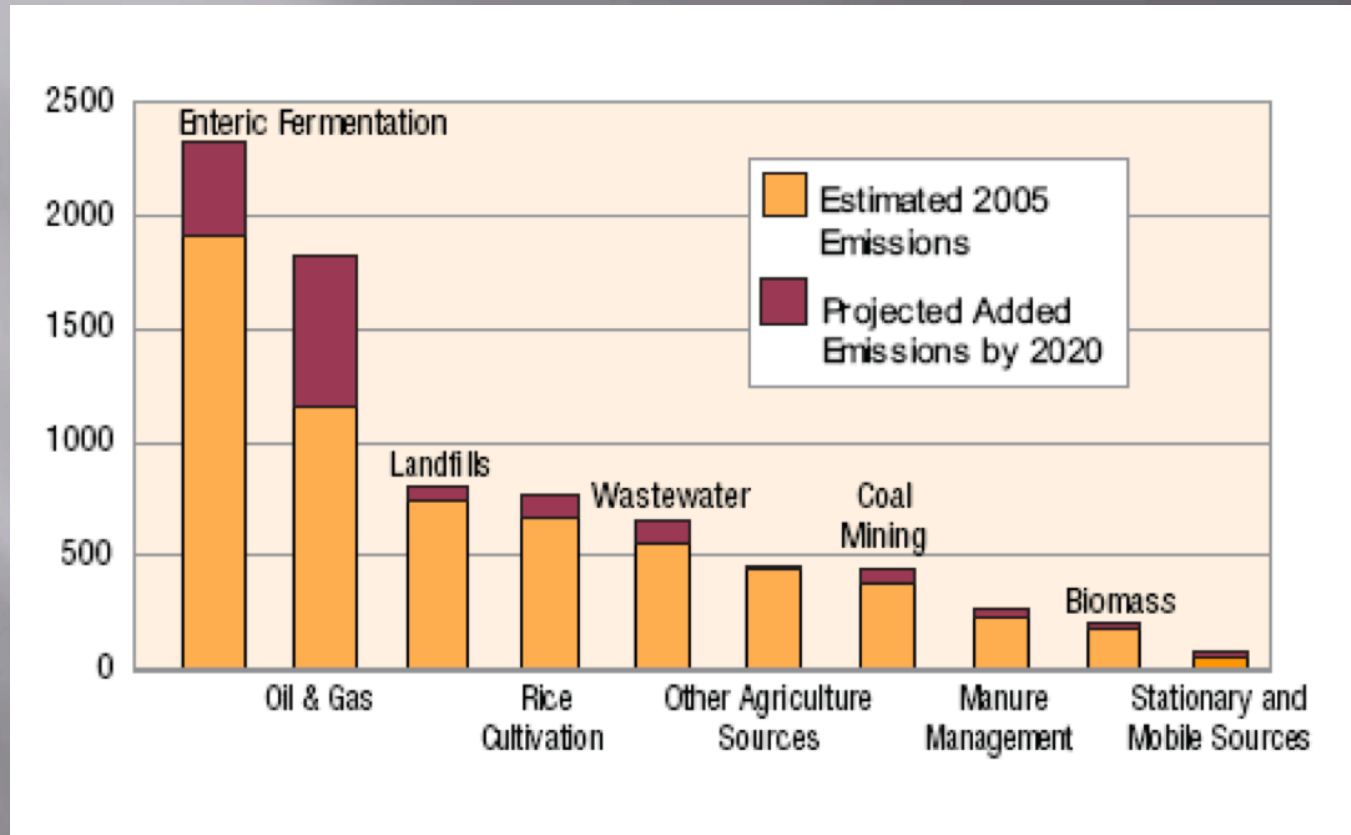
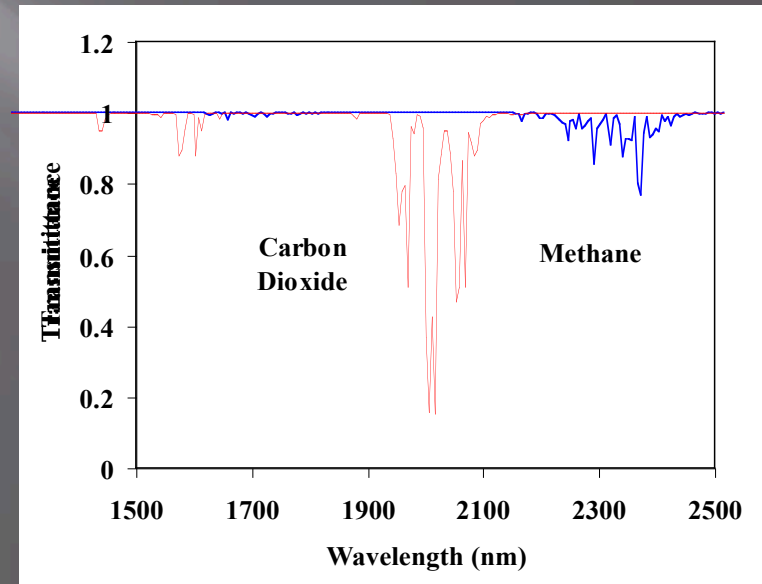
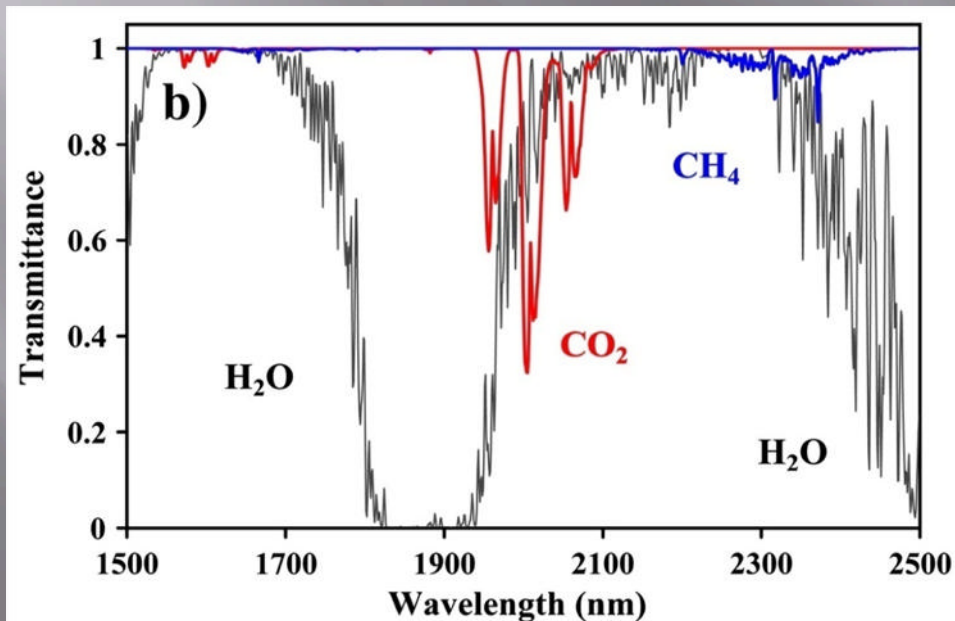
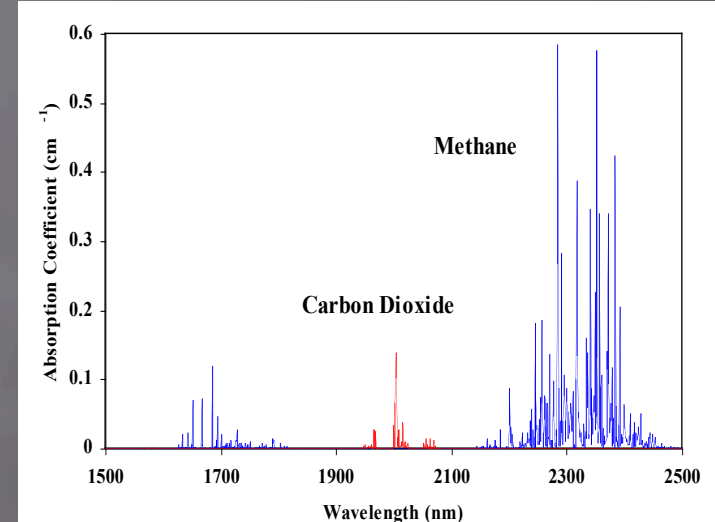


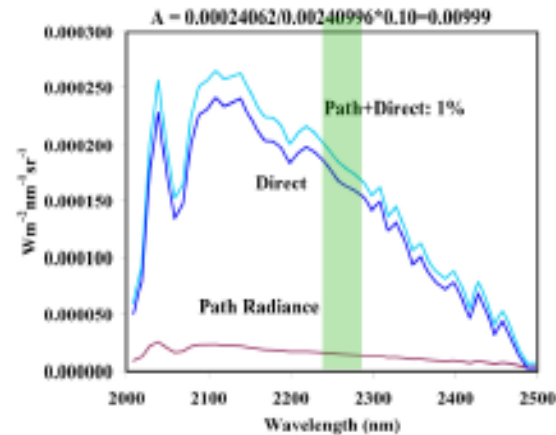
Figure 1 a) Showing absorption coefficients for methane (blue) and carbon dioxide (red) calculated from HITRAN 2004 (Rothman et al., 2005)

Figure 1 b) Transmission spectra of methane and carbon dioxide calculated using MODTRAN 4.3 (Berk et al., 1999) for one airmass and concentrations of 1.8 and 380 ppm for methane and carbon dioxide, respectively

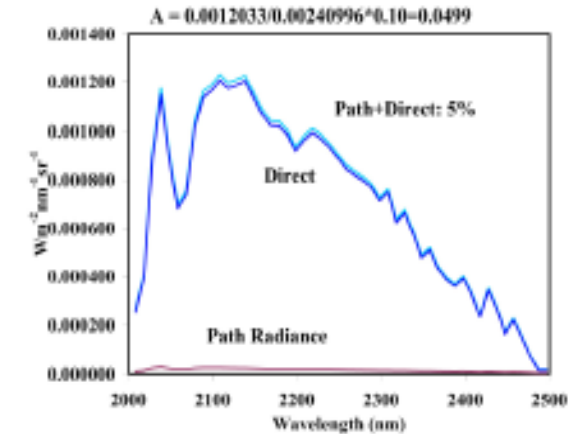


AVIRIS Modtran Simulations

1% Albedo

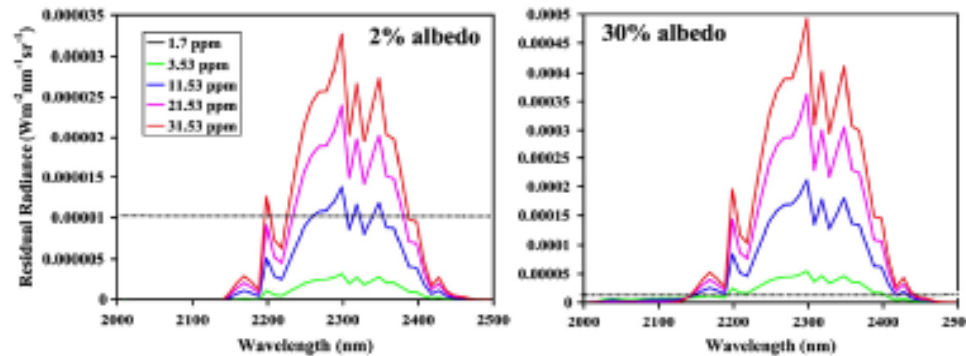


5% Albedo



For darker surfaces, path radiance becomes more important

Residual Analysis



Detection Limit ~11.8 ppm, 1-km layer

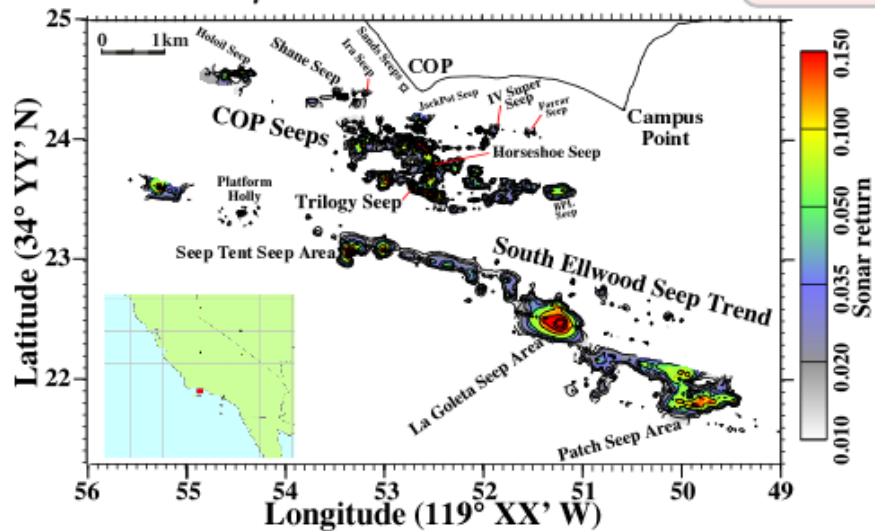
Detection Limit ~very low

Dark surfaces have high detection limits.

The Highly Accessible Coal Oil Point Seep Field

one of the largest and best characterized seep fields in the world!!!

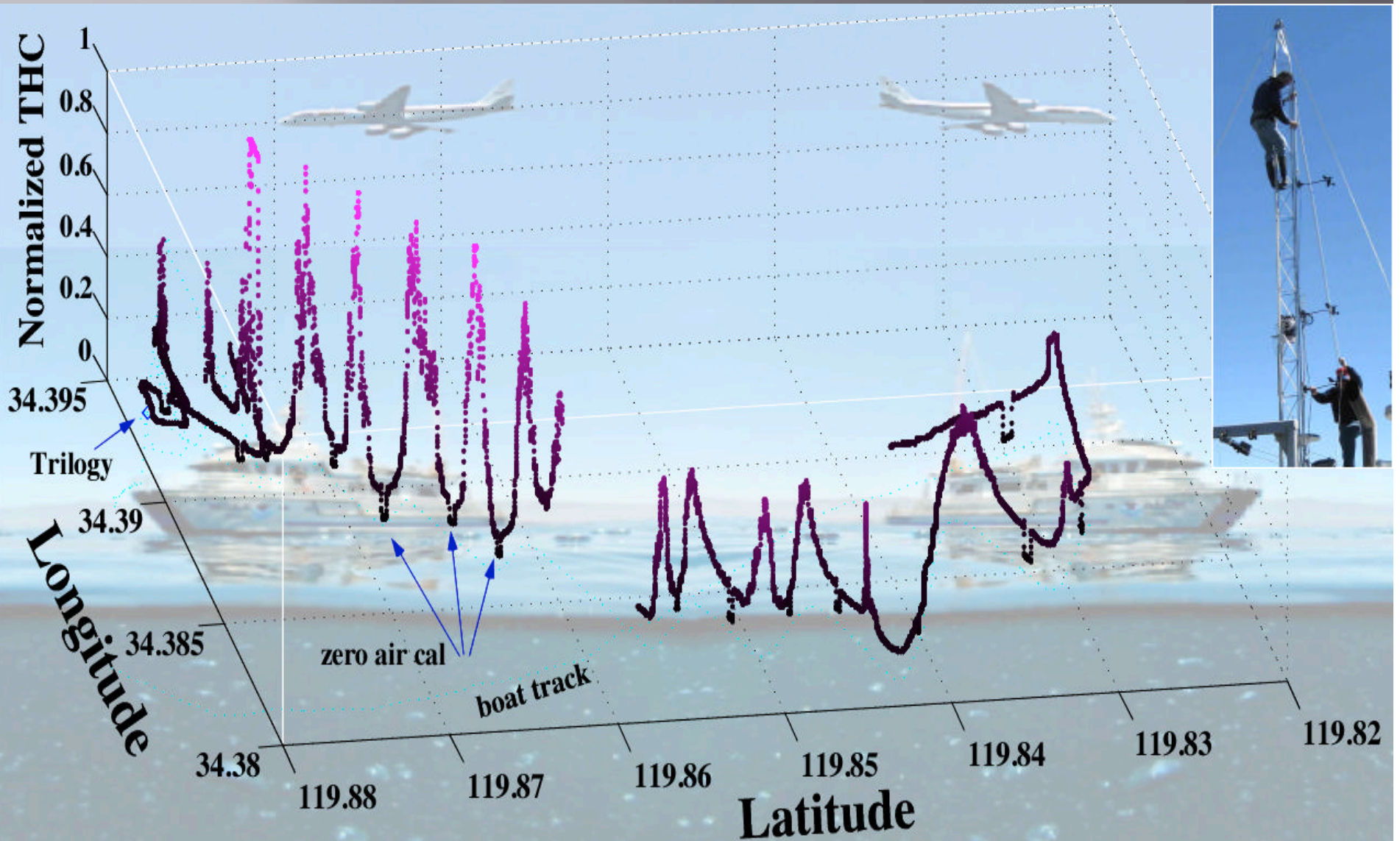
10^5 m³/dy gas
100 bbl oil/dy



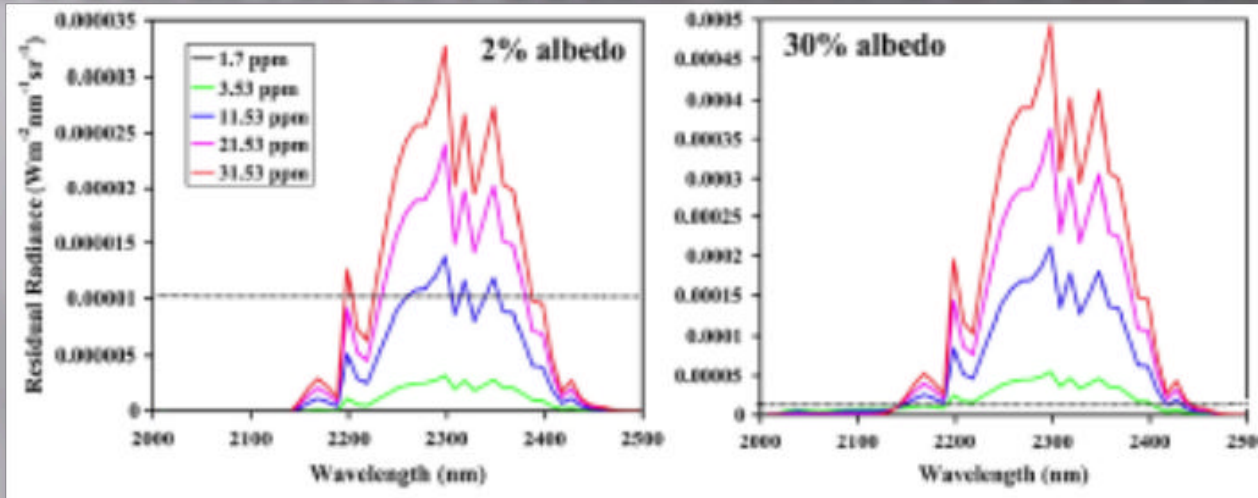
Methane

- Total: 580 ± 50 Tg yr⁻¹
- Ancient: 104 Tg yr⁻¹
- Fossil Fuel Industry: 50 Tg yr⁻¹
- Seepage: 50 – 85 Tg yr⁻¹
- Marine Seepage: 20-30 Tg yr⁻¹

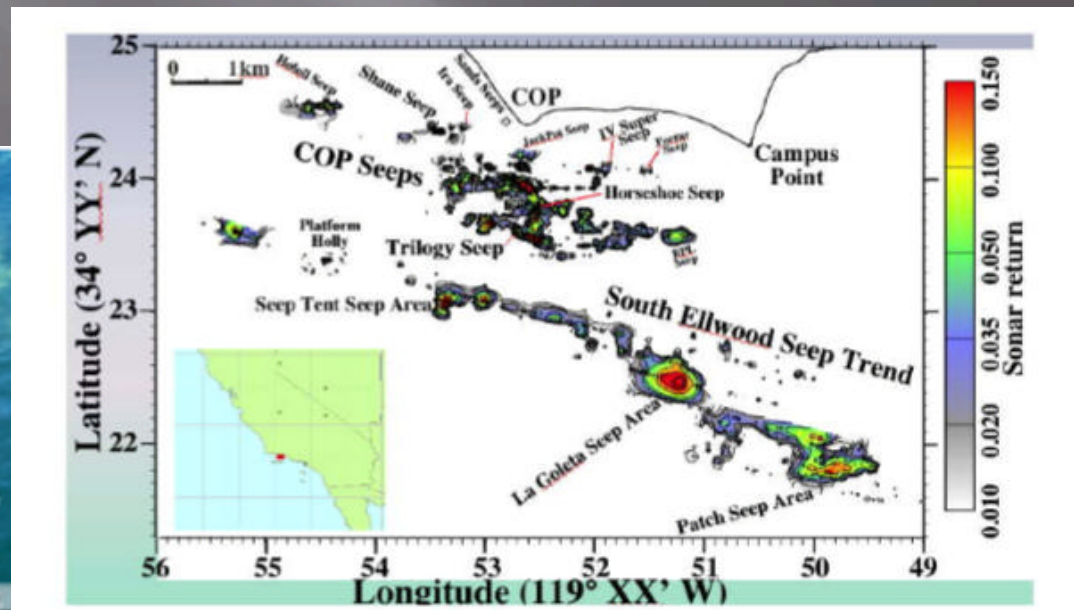
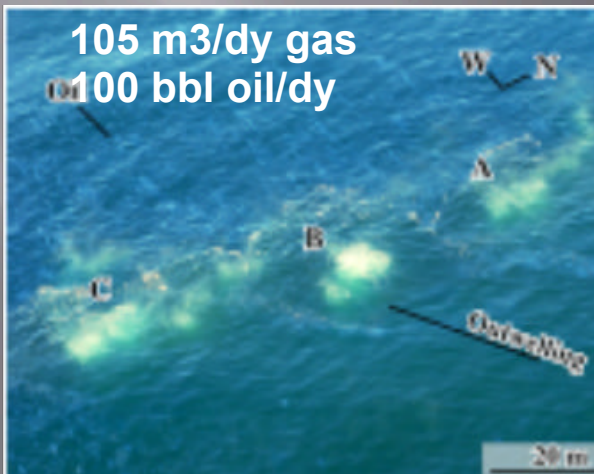
Total Hydrocarbon Plume from Trilogy Seep



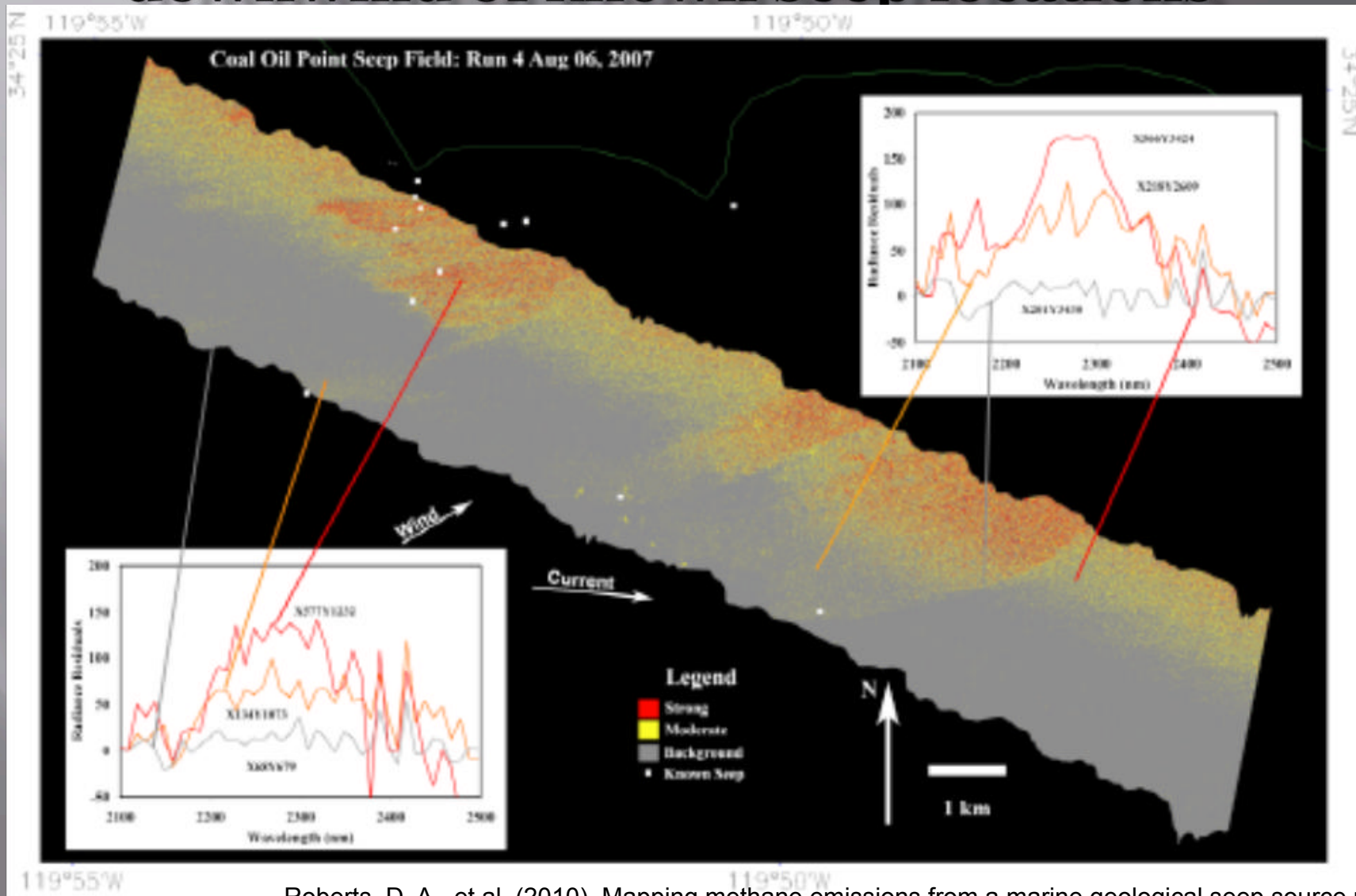
METHANE AVIRIS REMOTE SENSING



MODTRAN calculated residuals show AVIRIS can observe methane for typical Coal Oil Point seep field emissions and sea surface albedos.



All strong methane signatures located downwind of known seep locations

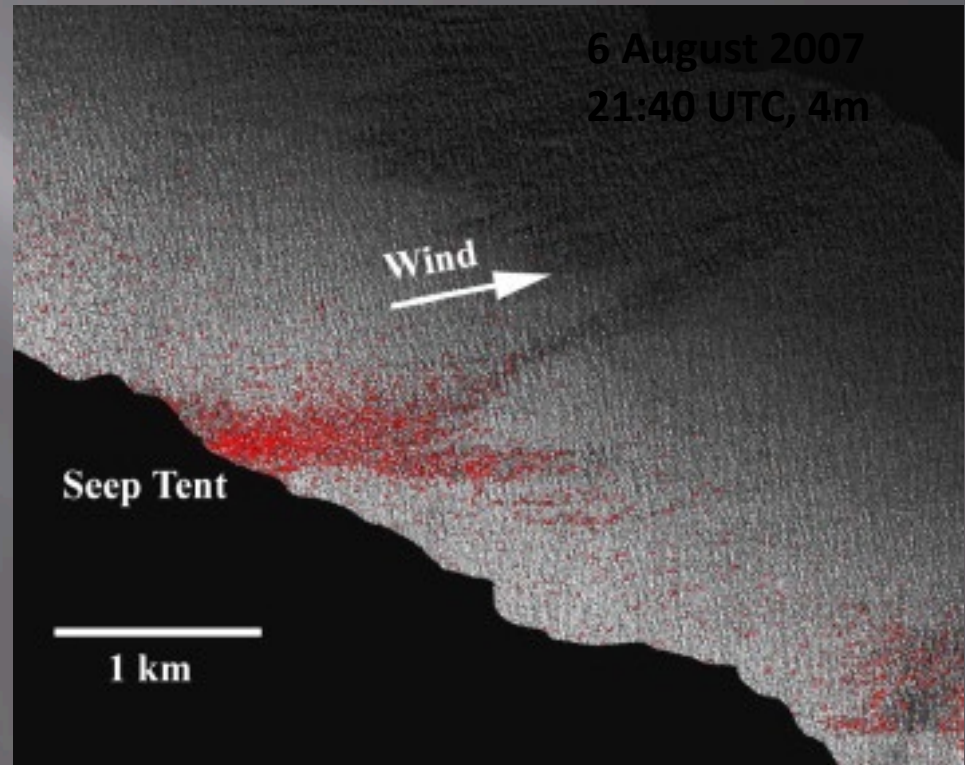
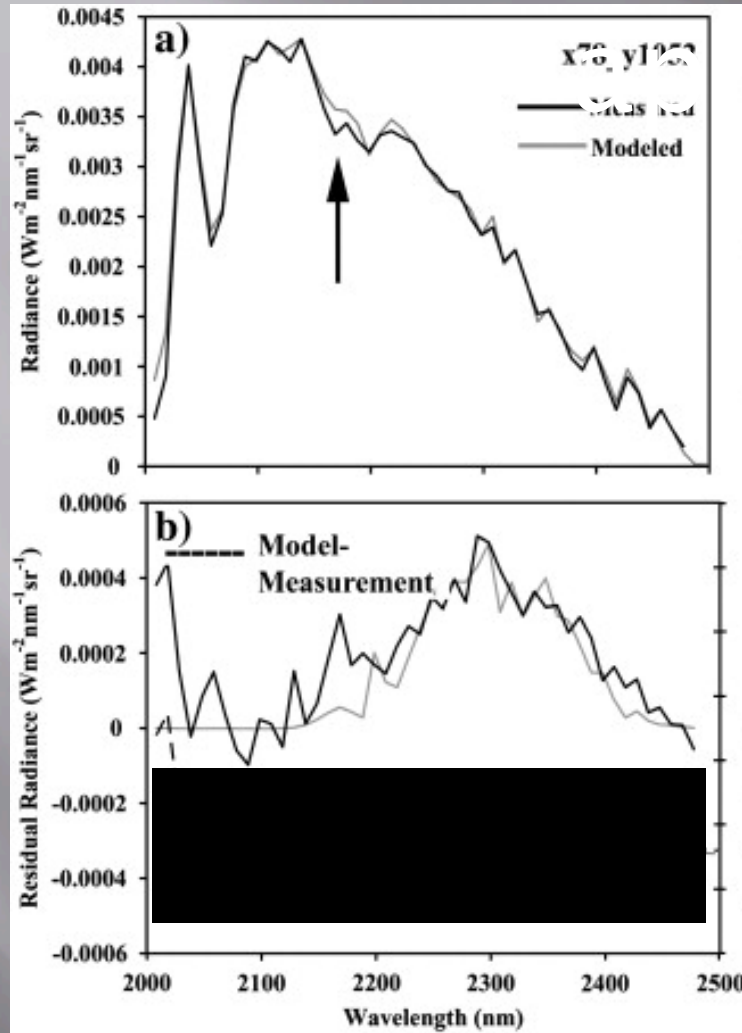


Roberts, D. A., et al. (2010), Mapping methane emissions from a marine geological seep source using imaging spectrometry, *Remote Sensing Environments*, 114(3), 592-606

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AVIRIS methane residual approach

(Roberts et al. 2010)

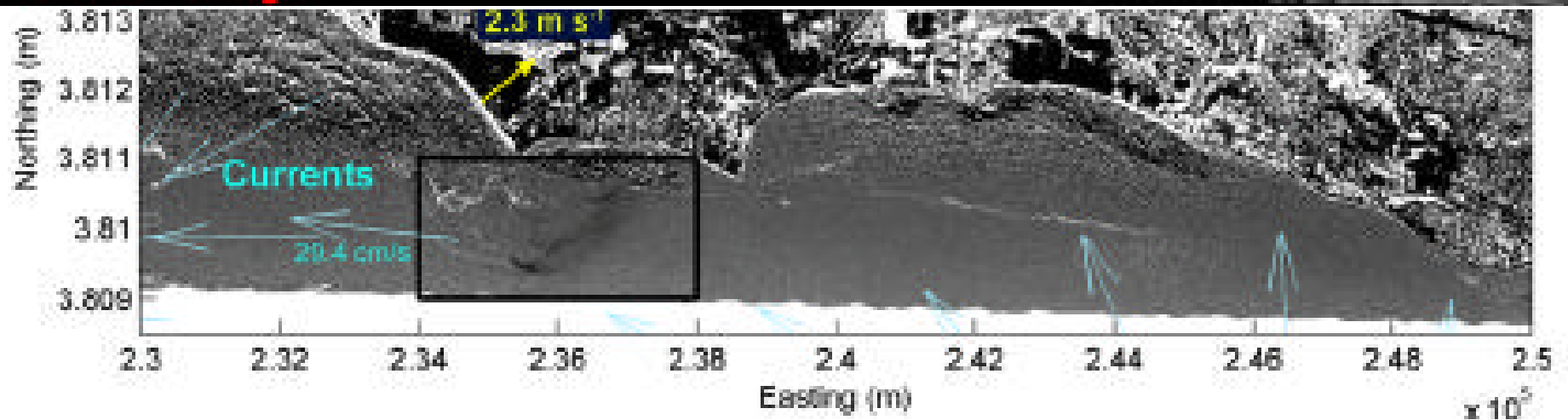


- Imagery complications (clouds, surface patterns, etc.)
- Assumes fixed path length

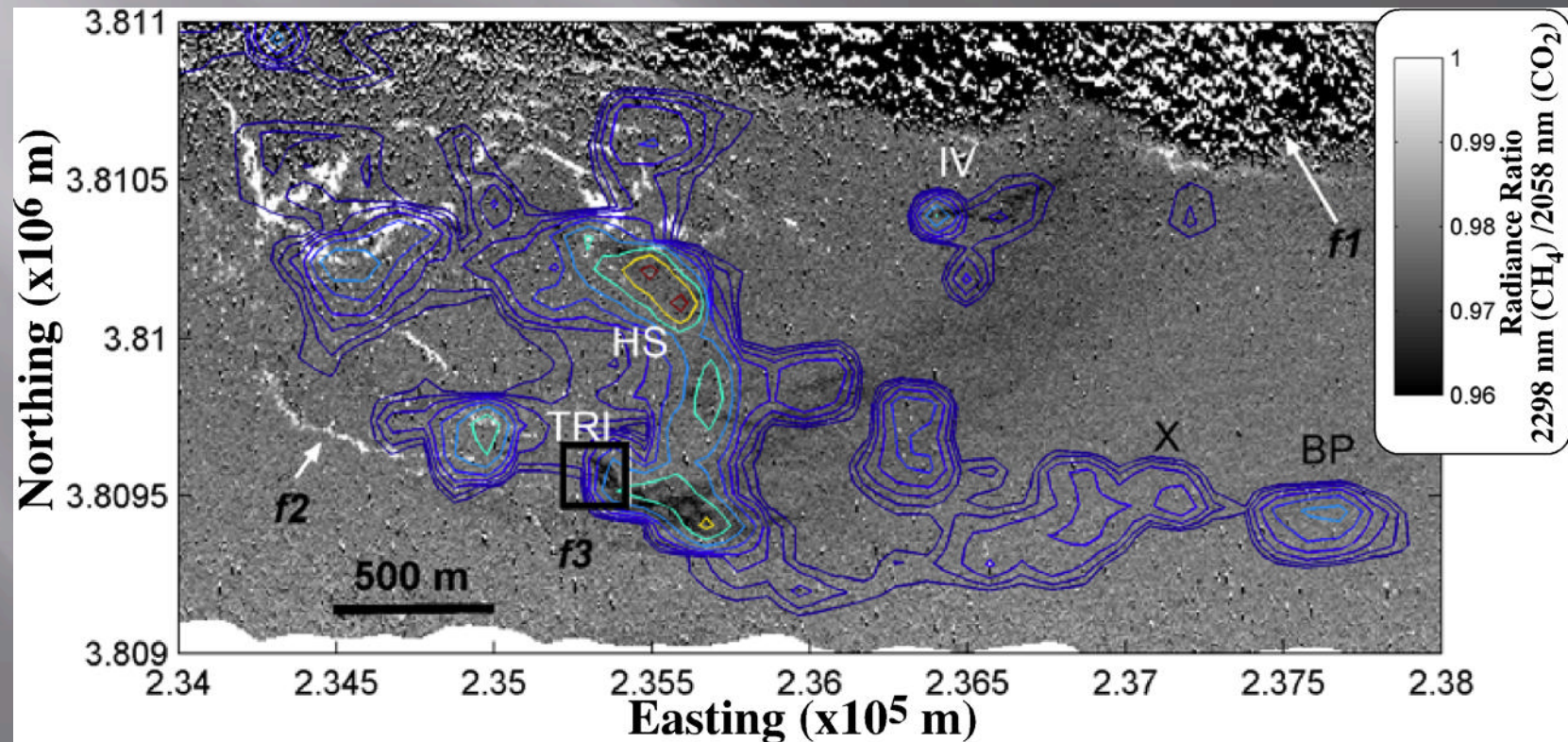
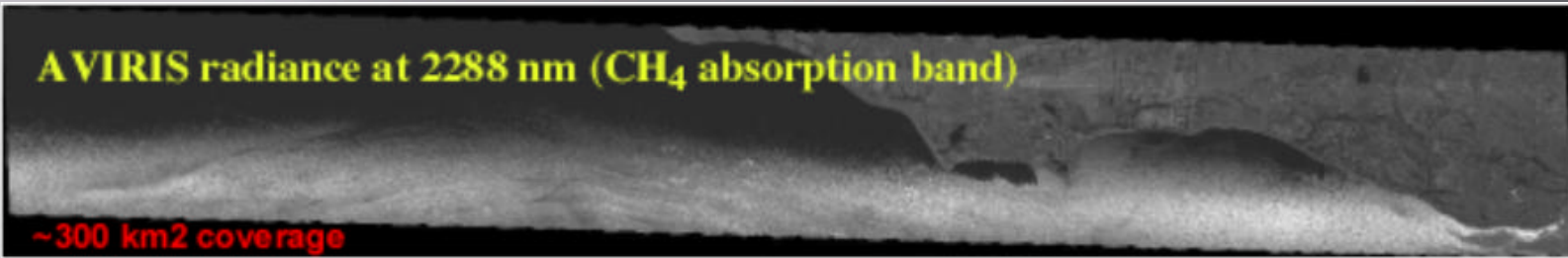
Equinox (June 19), solar noon, ER2

AVIRIS radiance at 2288 nm (CH₄ absorption band)

~300 km² coverage

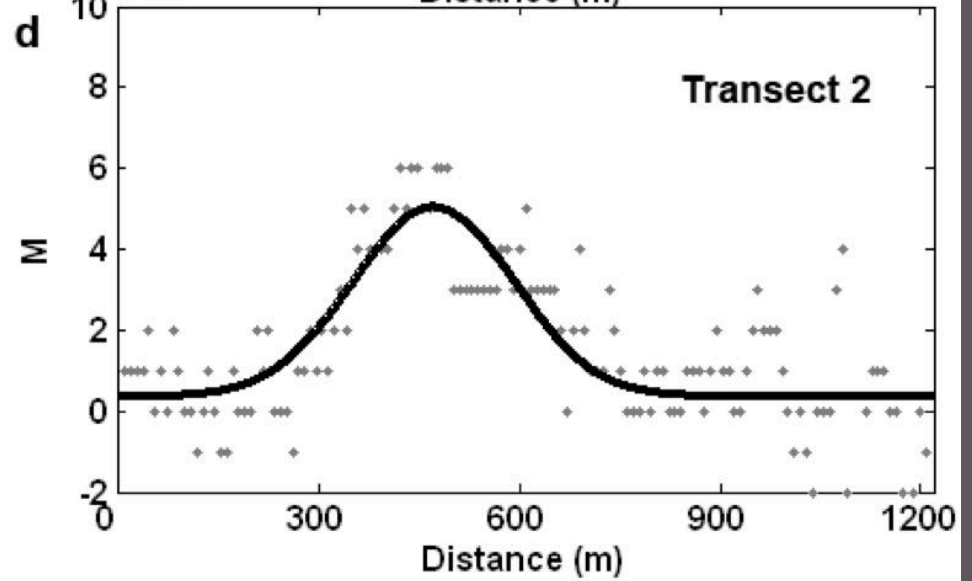
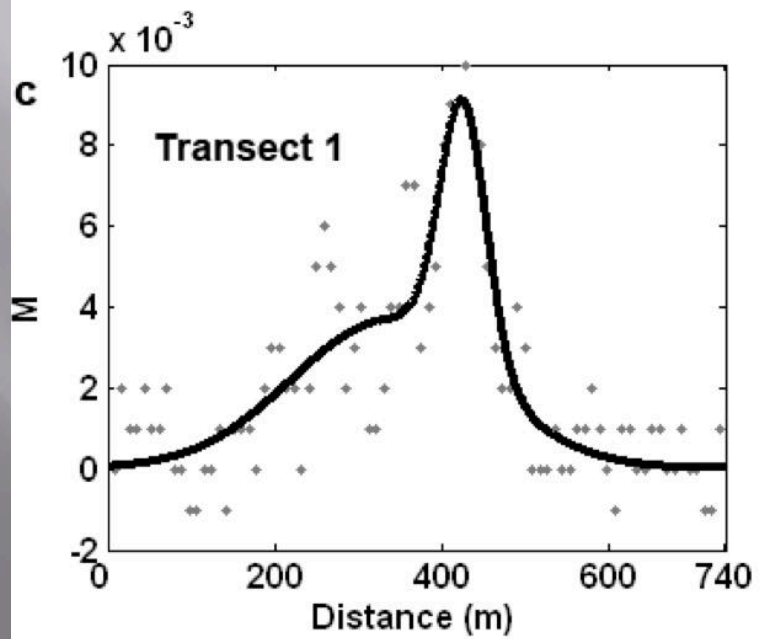
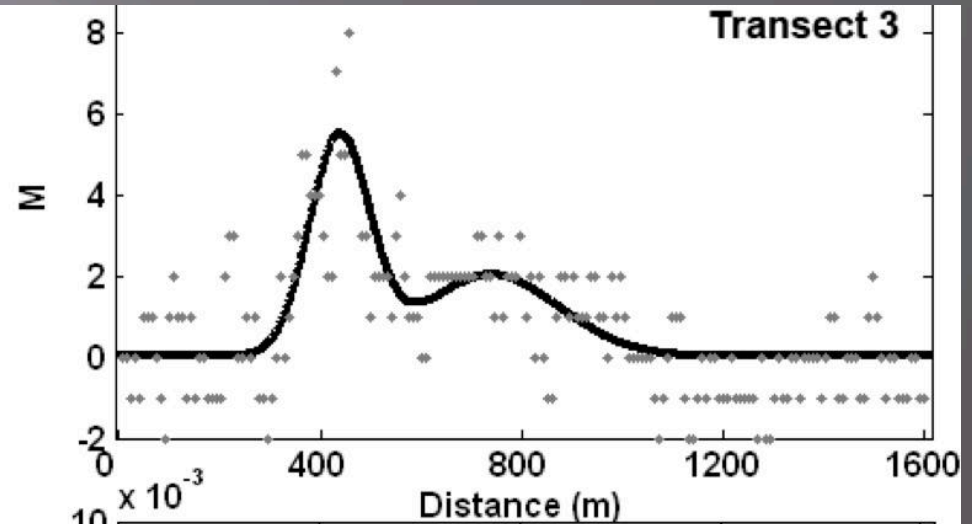
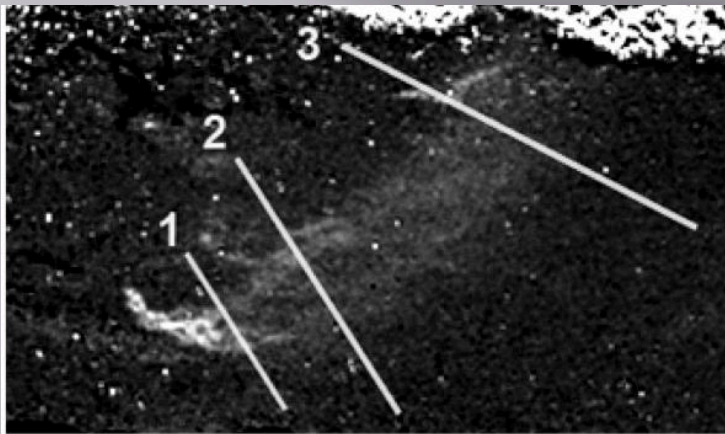


BAND RATIO ANALYSIS OF METHANE PLUMES

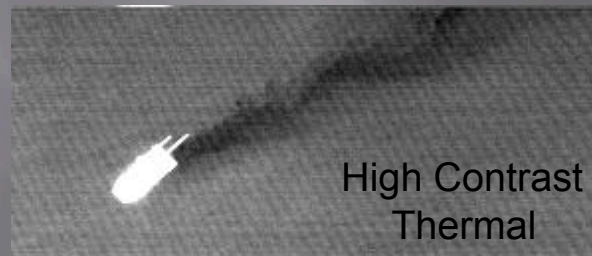
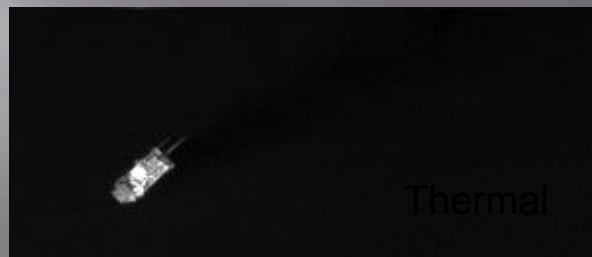


Bradley, E.B., et al. (2010) *in progress*

Band ratio plume

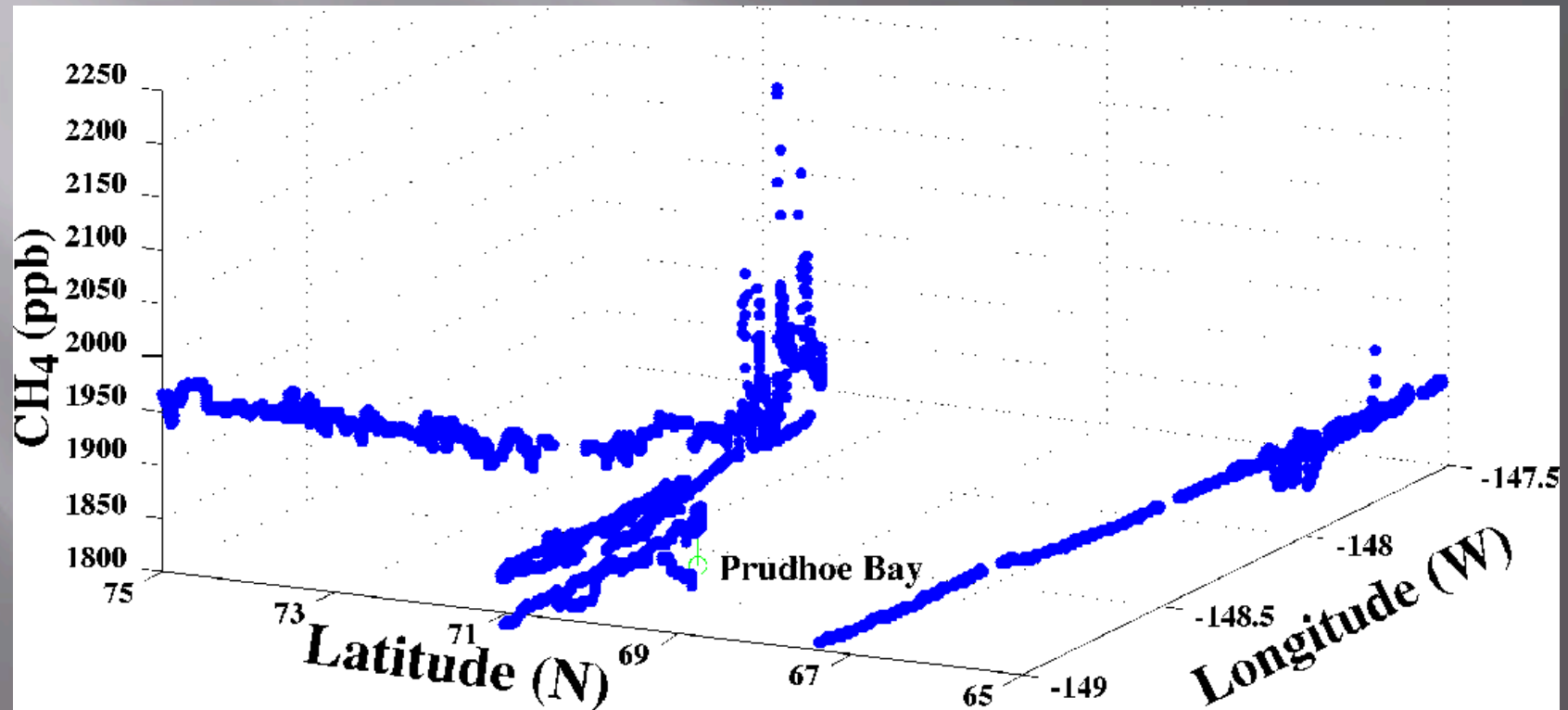


Platform Habitat; 4/7/2010



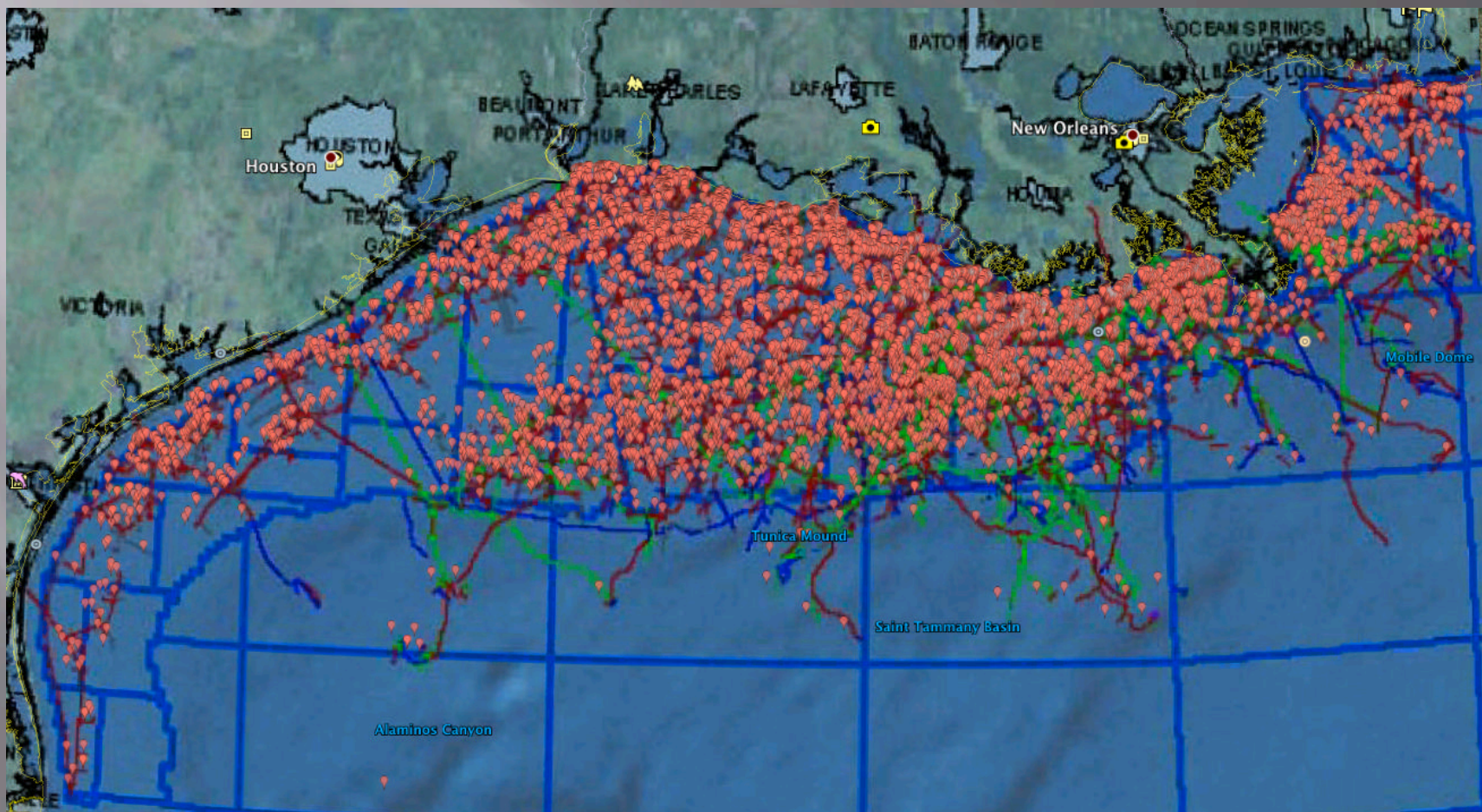
Cold water outflow
from platform

Prudhoe Bay



Courtesy Glenn Diskin, NASA Langley

Gulf offshore oil facilities and pipelines

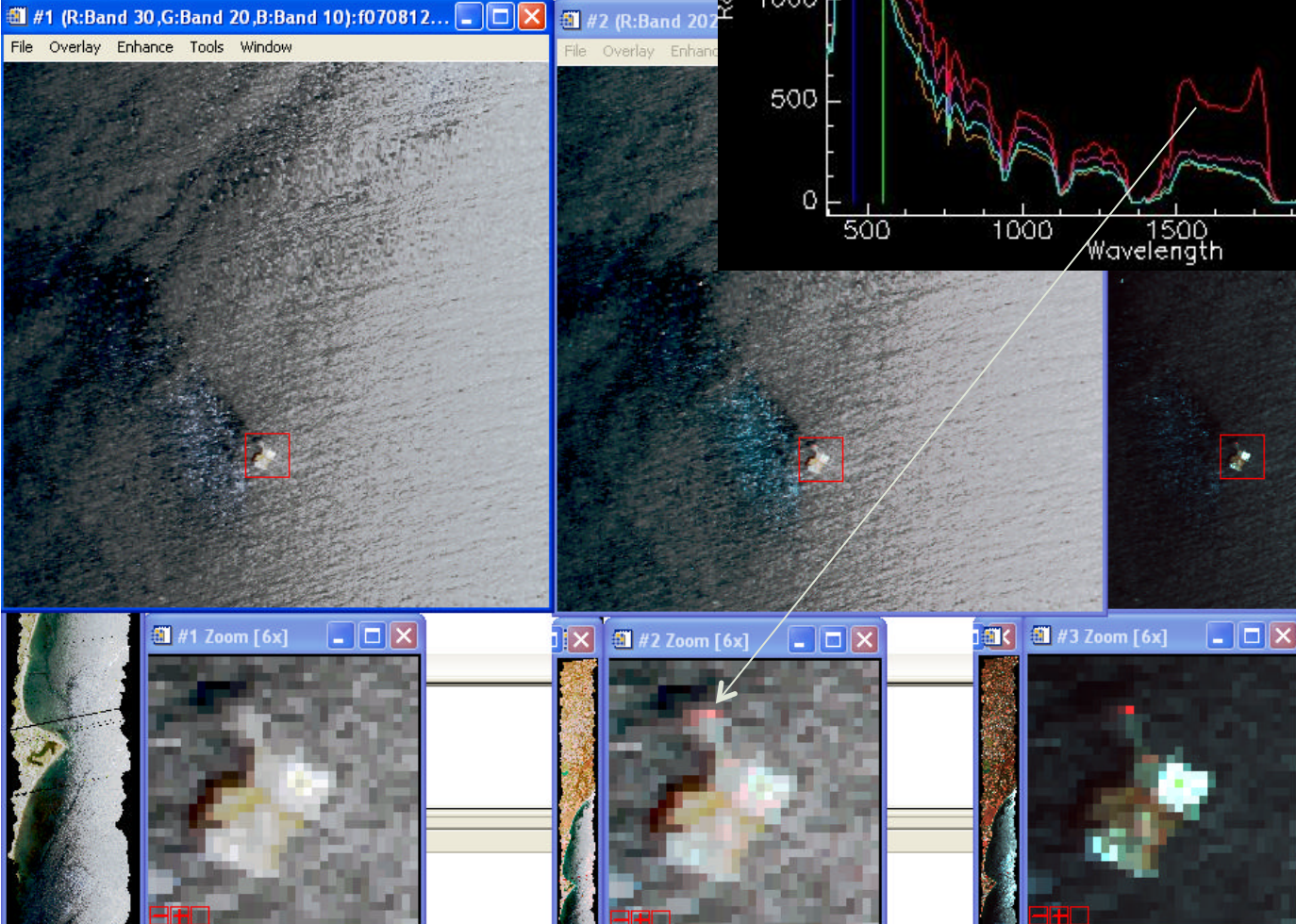
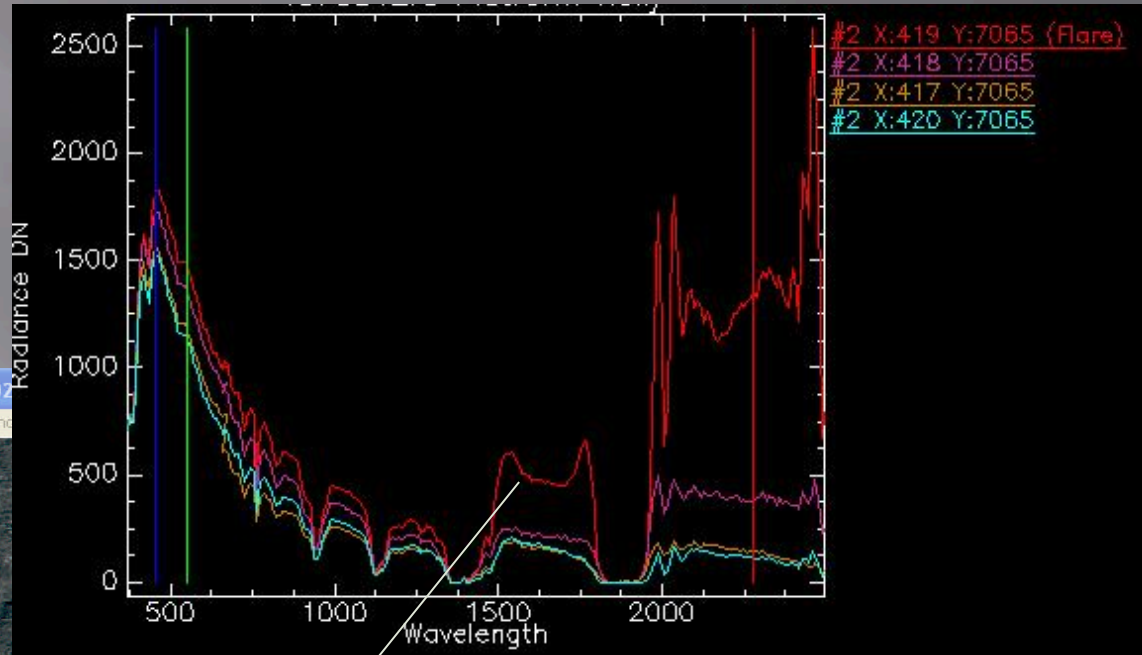


F070812r3 (3.4m pixels): flare at Platform Holly (x419,y7065 unrotated)

Platform Holly

RGB

(SWIR-G-B)

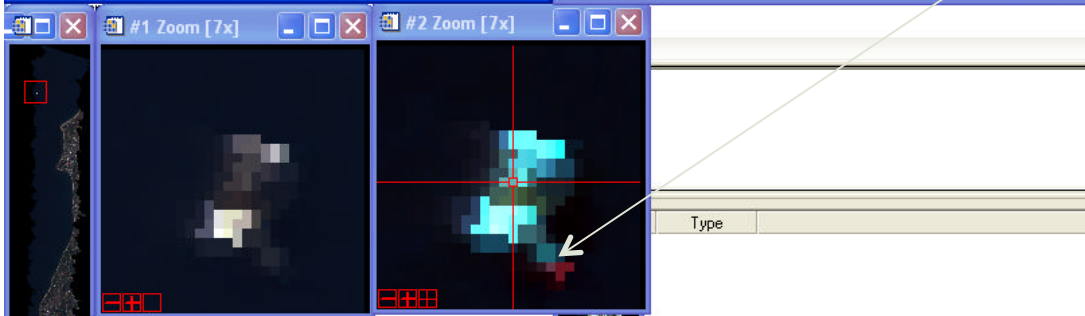
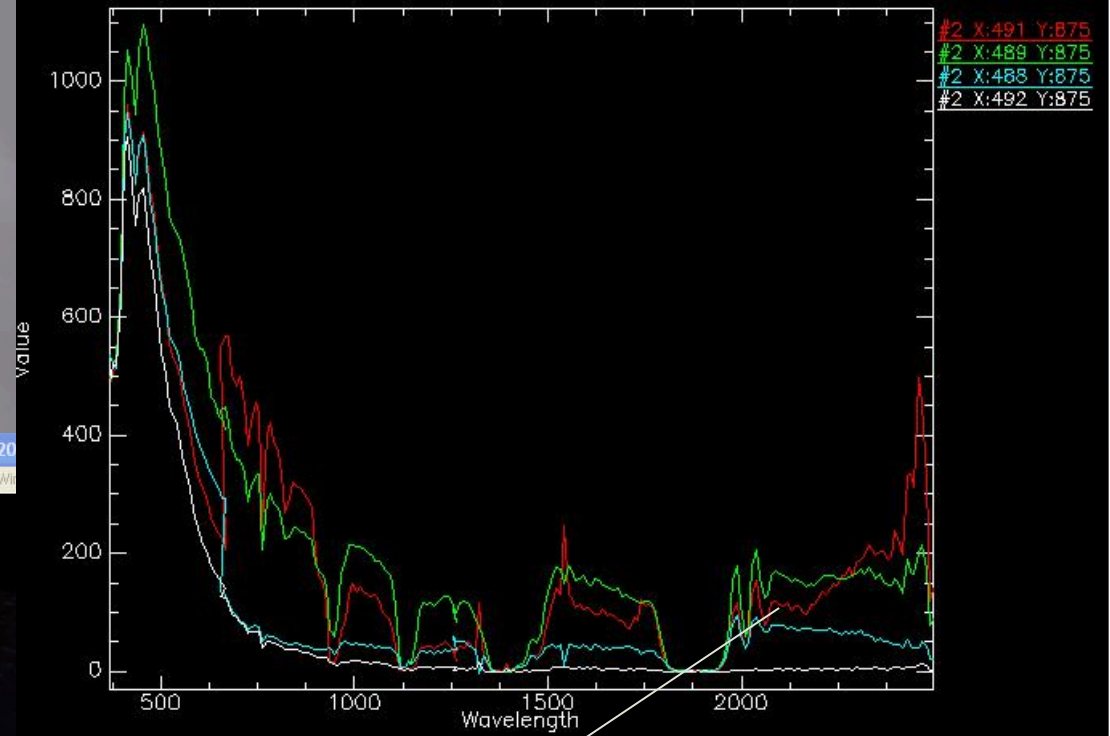


F070812r11_sc01 (4.3m pixels): flare
at Platform Holly (x491,y7875
unrotated)

Platform Holly

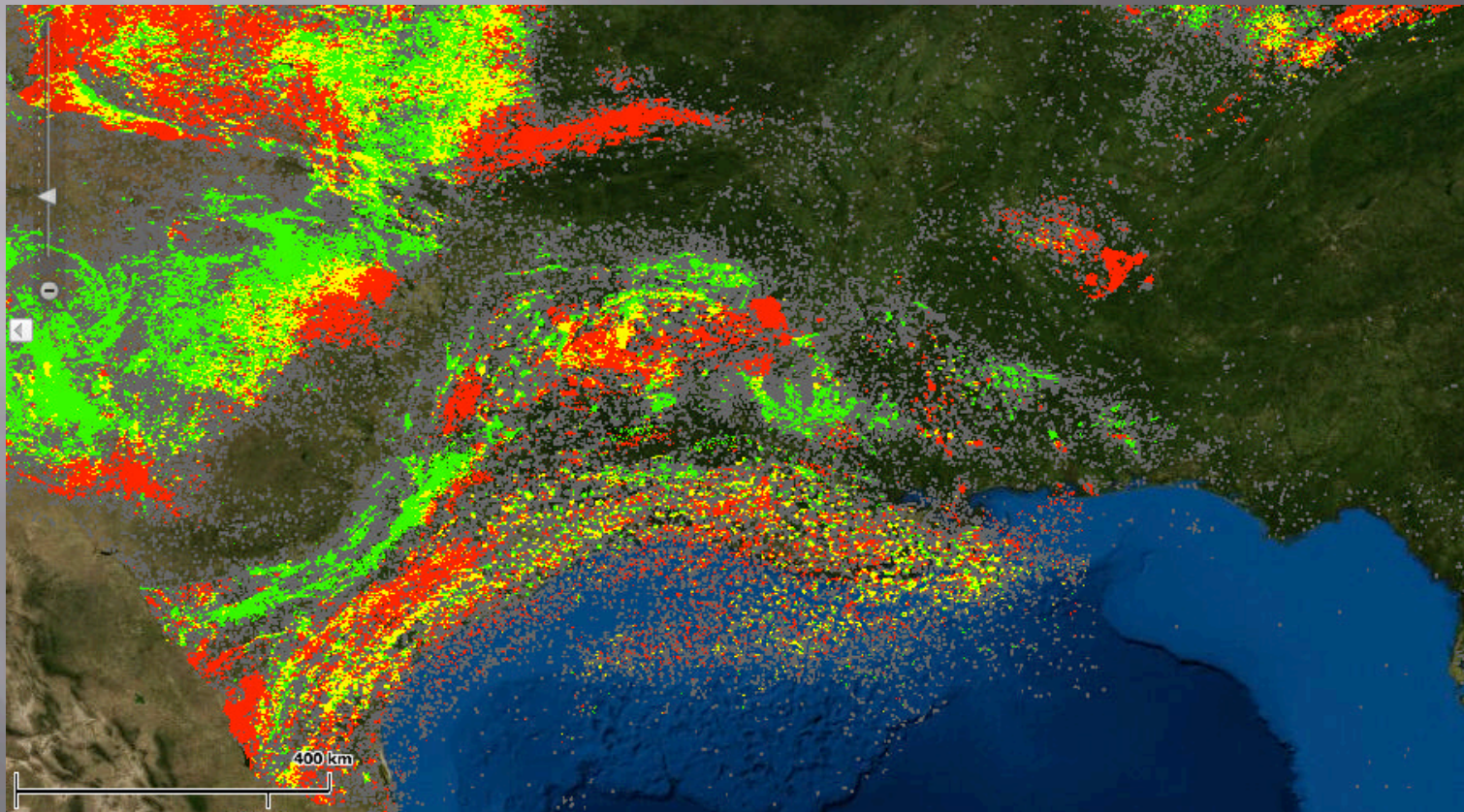
RGB

(SWIR-G-B)

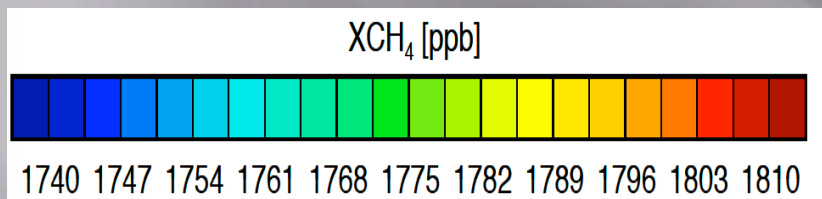


US Fossil Fuel Production

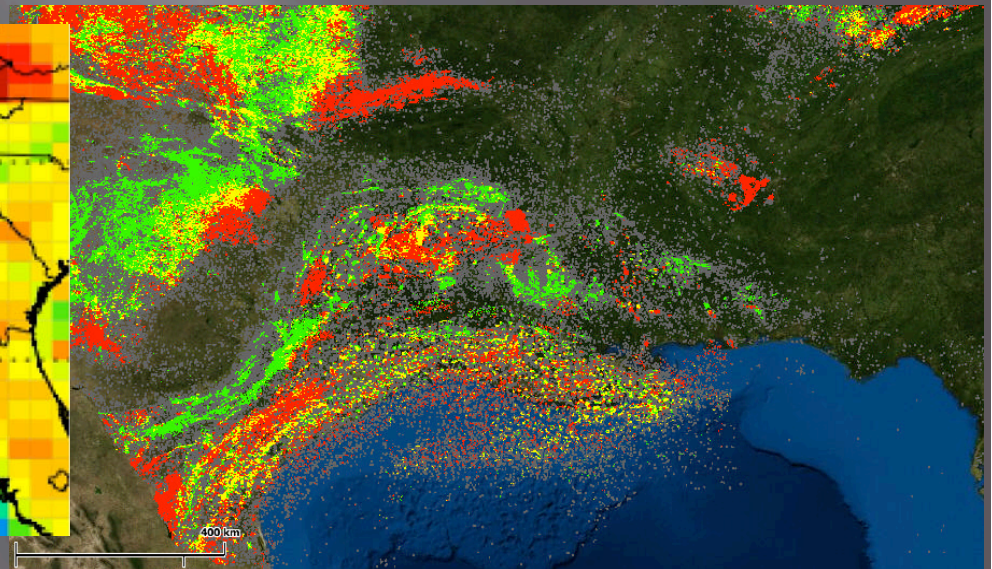
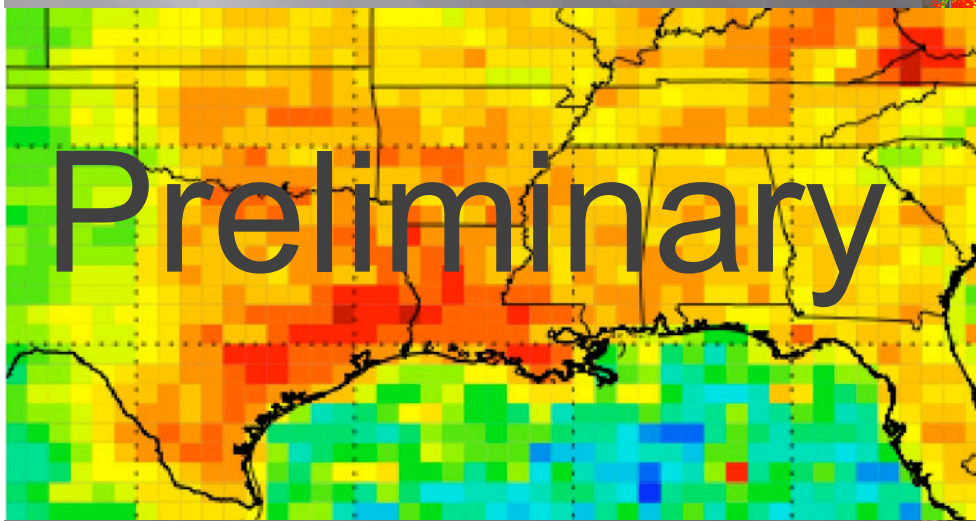
Red- Gas, Green – oil, Yellow- both



Strong Methane Anomalies co-located with production



Prevailing Gulf winds from east



Conclusion

The background of the slide is a faded, light-colored image of a Japanese woodblock print. It depicts a large, powerful wave crashing over a boat, a classic scene from the 'Great Wave off Kanagawa'. The wave is rendered with intricate, layered patterns of blue and white, while the boat below is a small, dark silhouette. The overall tone is historical and artistic.

Marine hydrocarbon seep fields provide an ideal natural laboratory to understand, investigate, and validate petroleum related processes.