MEASURING ATMOSPHERIC EMISSIONS OF CH_4 FROM PERMAFROST WITH REMOTE LOW-POWER AUTOMATED STATIONS

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METHANE IN PERMAFROST

- Important greenhouse gas, with 23-63 times the CO_2 warming potential
- Up to 1.5 Tt of CH_4 is stored in permafrost, and if released, could *double* the present CH_4 concentration
- Understanding at ecosystem level is presently insufficient for quantification, long-term modeling, or predictions
- Mostly measured by chambers: good, but discrete in space and time, difficult to get hourly variations, annual fluxes, and coverage of non-uniform areas (polygonal tundra)
- Eddy Covariance can be a powerful addition to chambers

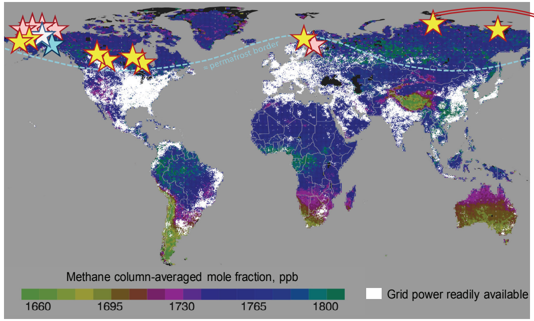
EDDY COVARIANCE METHOD

- Eddy covariance (EC) – a widely used micrometeorological method for measuring ecosystem methane flux [1,2]
- One of the most direct ways to measure emissions, and exchange rates of gas from area, and not a single spot
- Observes time scales from 20 times per second to years; results are hourly fluxes and long-term integrations
- Describes the entire ecosystem exchange, not just soil layer
- Need to measure fast 3-D wind speed and gas of interest

CHALLENGES AT REMOTE SITES

- Eddy covariance has its challenges at remote CH_4 sites [3]
- Past instruments are good, but use closed-path design and vacuum pumps; systems need grid power (300-1500 Watts), and can weigh 100-200 kg [3,4]
- Most permafrost CH_4 production areas are in remote unpopulated areas, with no infrastructure or power grid
- As a result, *power, weight and operational costs* limit the science, and may be a reason why CH_4 is understudied
- New low-power lightweight technology can address this problem, and allow researchers to place flux station at virtually any remote place, where CH_4 is produced [3,4,5]

OVERCOMING CHALLENGES: NEW CH_4 STUDIES

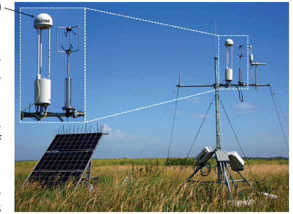


- Permafrost CH_4 flux stations utilizing low-power open-path measurements can now be located in the middle of any producing ecosystem, and not just where the power grid or roads are available [3,4,6,7,8,9,10,11,12]:

★ Solar- and wind-powered
★ Large generator, or grid
☆ Airborne, small airplane
★ Floating or ice-mounted, boat/float

LOW-POWER LIGHTWEIGHT OPEN-PATH STATION

- Open-path CH_4 instrument, LI-7700 takes ≈8 W of nominal power [3,5]
- Whole flux station takes ≤35 W, and measures fluxes of CH_4, CO_2, H_2O, T, humidity, wind speed, *etc.*
- Easy to power by solar and wind, easy to place in the center of ecosystem, easy for mobile setup
- Need to keep the instrument clean, but self-cleaning and heating is built-in to reduce contamination



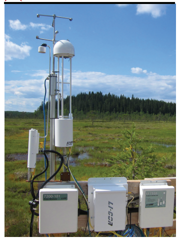
Solar-powered station above measures fluxes of CH_4, CO_2 and H_2O, and transmits data wirelessly to closest wired location

EMERGING RESEARCH ON CH_4 RELEASE USING OPEN-PATH EDDY COVARIANCE

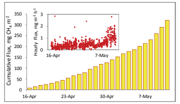
2010-2012: Siberia

- 72° 22' N, 126° 29'E
- Permafrost
- Wet polygonal tundra [12]
- Delta of Lena River
- *Extremely remote*
- *Solar- and wind-powered*
- Wind data: CSAT3 (CSI)
- CH_4 data: LI-7700 (LI-COR)

2010-2012: Finland



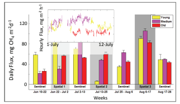
- 61°50'N, 24°12'E
- Seasonally frozen
- Boreal bog [6]
- *No grid power available*
- *Solar-powered in summer*
- Wind data: USA-1 (METEK)
- CH_4 data: LI-7700 (LI-COR)



2008–2012: Alaska

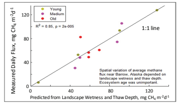
Stationary Towers

- 71°17' N, 156°35'W
- Permafrost
- Coastal wetlands [7,8,9]
- Large complex experiment
- Power: industrial generator
- Wind: WM-Pro (Gill)
- CH_4 data: LI-7700



Mobile Towers

- North slope, AK
- Permafrost
- Coastal wetlands [9]
- *Extremely remote*
- *Solar-powered*
- Wind: CSAT3 (CSI)
- CH_4 data: LI-7700 (LI-COR)



Airborne Fluxes

- North slope, AK
- Permafrost
- Coastal wetlands
- *Extremely remote areas*
- *Powered by small airplane*
- Airplane: Sky Arrow 650TCN
- Wind: BAT Pressure Sphere
- CH_4 data: LI-7700 on a wing

CONCLUSIONS

- Low-power open-path technology allows placing flux station at the center of CH_4 source, and not just where power or roads are available
- At least 15 such new stations have been established in past 2-4 years supporting research in permafrost regions [3,4,6,7,8,9,10,11]
- Parts of Alaska and Canada have been represented more heavily than northern Europe, and especially, more than northern Eurasia
- **The low-power open-path approach is a useful addition to previous methods: it can considerably expand CH_4 flux coverage, and can significantly improve measurements of permafrost CH_4 emissions**

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