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Towards constraining the methane flux from the Arctic Ocean to the atmosphere using atmospheric inverse modeling

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1. Introduction

- East Siberian Arctic Shelf: subsea permafrost, methane hydrates

→ Methane flux to the atmosphere, estimated using data from ship-based summer campaigns: 17 Tg CH_4 / yr [1]

- This project: estimating the methane flux from the Arctic Ocean to the atmosphere based on year-round continuous observations of atmospheric methane mixing ratios
- Method: inverse modeling of atmospheric tracer transport
- Data: newly established Atmospheric Carbon Observation Station Ambarchik, other circumpolar sites depending on data availability

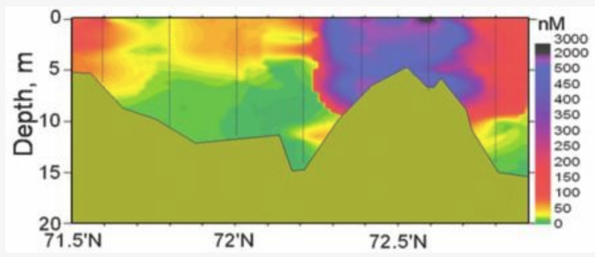

Fig. 1. Vertical distribution of dissolved CH_4 along a transect beneath sea ice (from [2], Fig. 2B).

2. Atmospheric Carbon Observation Station Ambarchik

- Abandoned rural locality at 69.6N, 162.3E (Fig. 2, 4)
- 300 m to the coast
- 27 m tall tower
- Picarro G2301 (CO_2, CH_4, H_2O)
- Precision: CO_2 18 ppb, CH_4 0.2 ppb
- Sampling rate: 0.3 Hz
- Calibration with standards traceable to the WMO-scale every five days
- Established in August 2014

Fig. 2. The Ambarchik station. *Bottom:* Northward view from the top of the tower.

3. First data from Ambarchik in comparison with simulated CH_4 mixing ratio timeseries

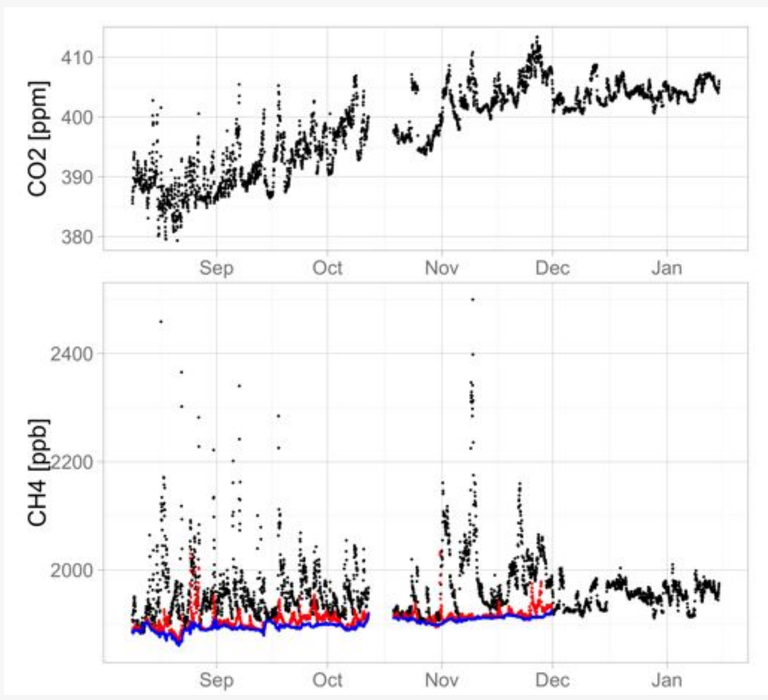

Fig. 3. *Black:* Ambarchik data (preliminary hourly averages). *Red:* simulated methane mixing ratios (box 5). *Blue:* contribution of boundary conditions to simulated methane

- Baseline CH_4 trends of observations and simulation are similar
- Wetland fluxes in the domain cause short-term CH_4 variability at the Ambarchik station
- Temporal variability of modeled CH_4 much lower than observed

→ Possible contributing factors:
- low spatiotemporal resolution of flux fields and driving meteorology
- no ocean shelf emissions included

→ **Need for high spatiotemporal resolution of flux- and meteorology fields**
→ **uncertain effect of shelf emissions**

4. Planned inverse modeling framework

- Jena Inversion System[3]
- (1) Global model TM3, 4° x 5°, 3-hourly ERA Interim
- (2) Greater Arctic: Polar WRF[4]-STILT, 30 km x 30 km
- (3) East Siberian Arctic Shelf: Polar WRF-STILT, 3 km x 3 km
- Preparatory study: Observation System Simulation Experiment using synthetic data

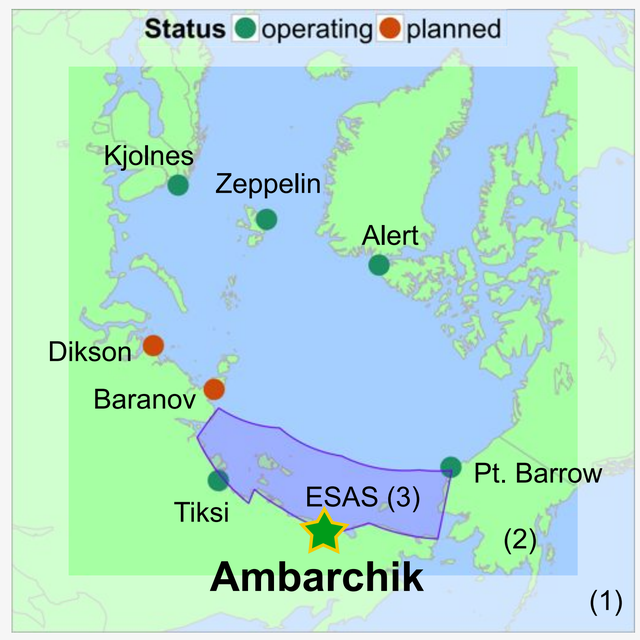

Fig. 4. Circumarctic methane measurement stations and regions of interest

5. Setup for simulated CH_4 mixing ratio timeseries at Ambarchik (box 3)

- STILT forward run driven by ECMWF fields
- Domain boundaries (Fig. 4): 80N, 123E, 53N, 20W
- CH_4 flux fields: LPJ-Bern, 2004, from the WETCHIMP intercomparison[5]
- CH_4 boundary conditions: Jena Inversion System 2011, adjusted for mean annual increase

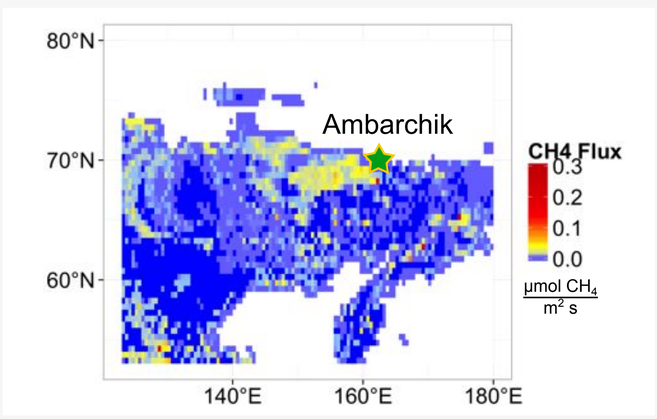

Fig. 5. LPJ-Bern fluxes in the model simulation domain for August

6. Footprint coverage of the East Siberian Arctic Shelf

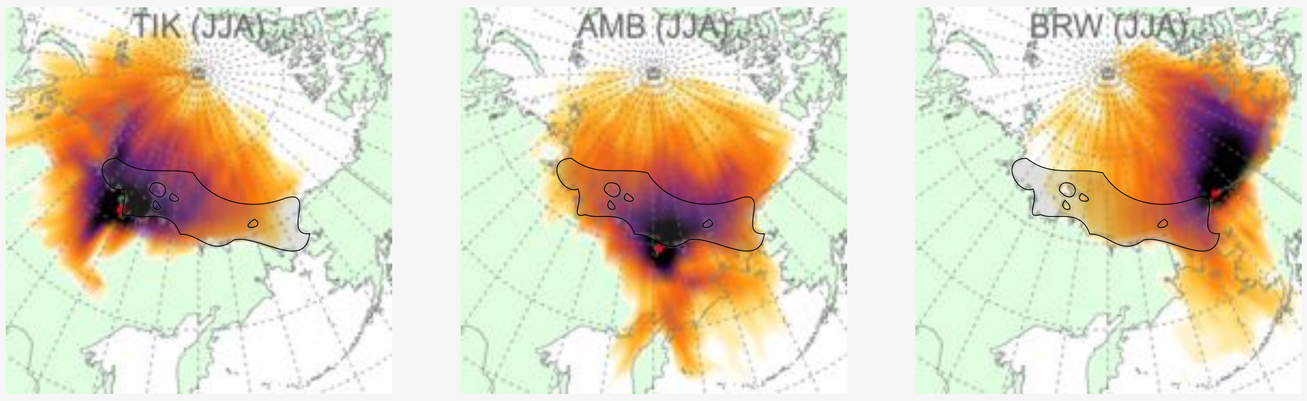

Fig. 6. Four-day back-trajectories of the HYSPLIT model for Tiksi (TIK), Ambarchik (AMB) and Point Barrow (BRW), 2005-2013 average

- Ambarchik air is more strongly influenced by exchange processes with the East Siberian Arctic Shelf than adjacent stations

→ **Ambarchik closes an important gap for inverse modeling studies of the East Siberian Arctic Shelf**

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