CARB-ARC: Recent advances in assessment of methane stocks in Arctic and subarctic areas

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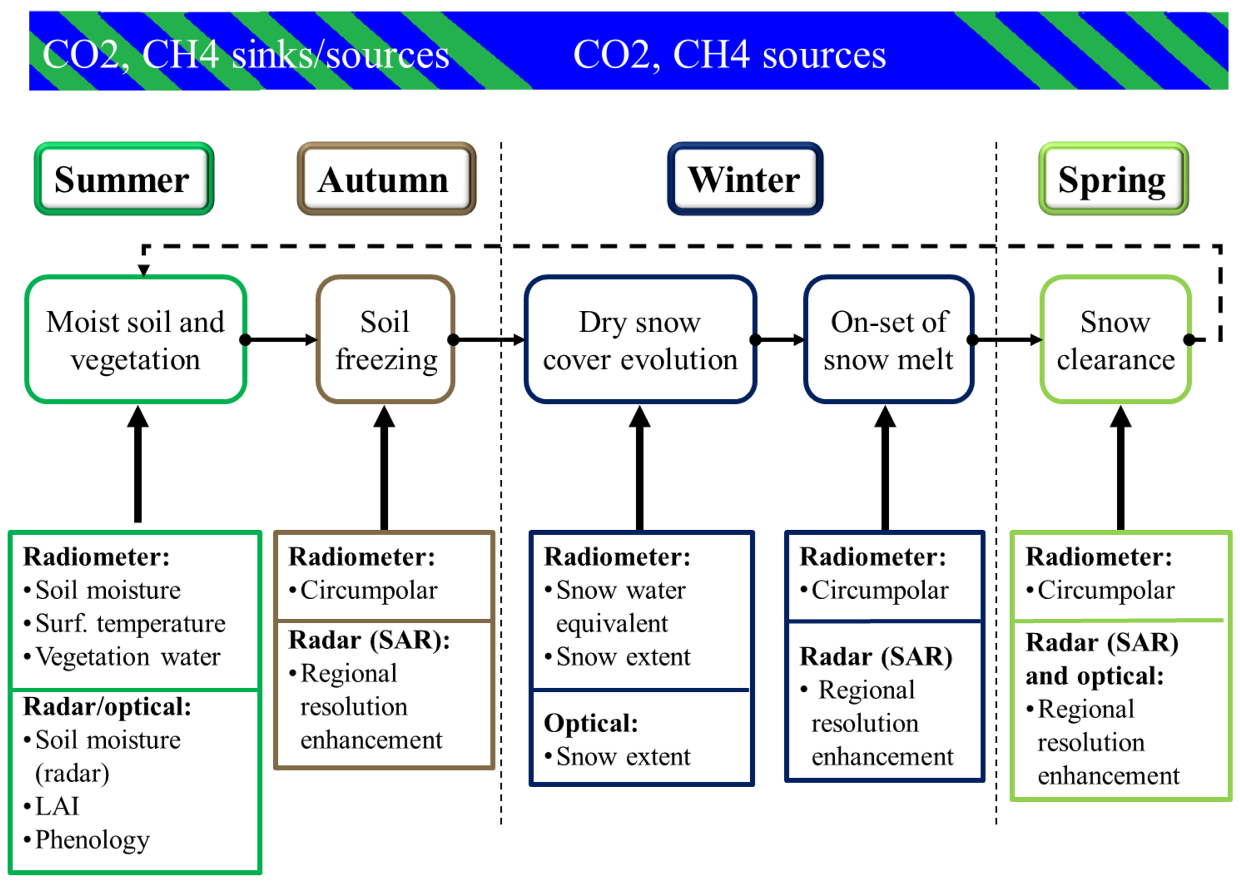


Fig 1: The instruments are sensitive to the amount and phase of water in or on the ground.

The goal of the CARB-ARC (Carbon Balance under Changing Processes of Arctic and Subarctic Cryosphere) project is to develop and demonstrate continental-scale mapping of carbon dioxide and methane sources and sinks in the boreal forest and subarctic zones based on novel Earth Observation products.

Using diverse and novel Earth Observation (EO) data at the Arctic areas allows full seasonal view on soil and vegetation processes that are relevant for carbon exchange and annual carbon balance.

Satellite observations allow us to study the seasonal cycle of methane in the Arctic

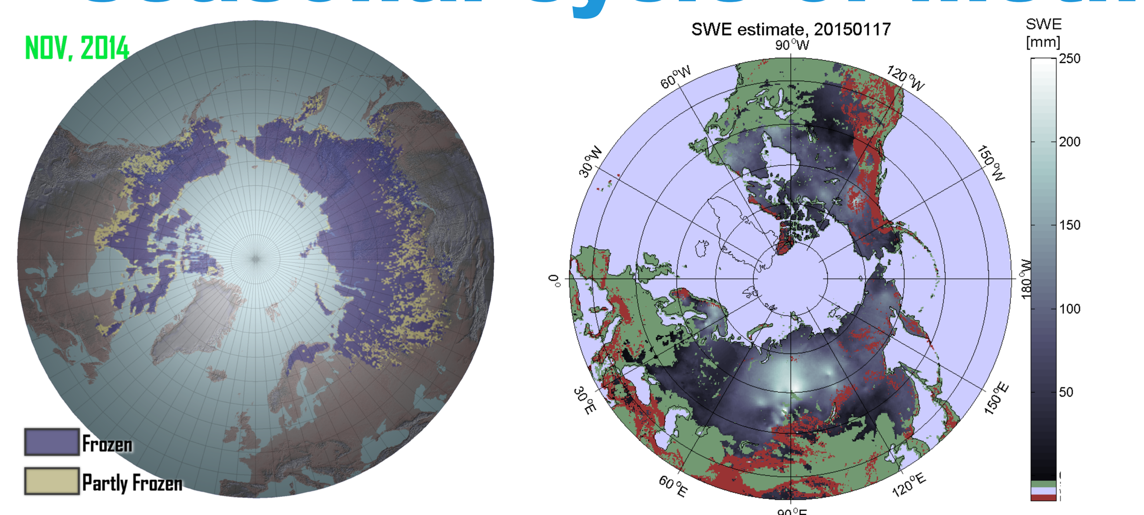


Fig 2: Snow Water Equivalent and SMOS Freeze/Thaw satellite products are developed at FMI, SWE especially for CARB-ARC.

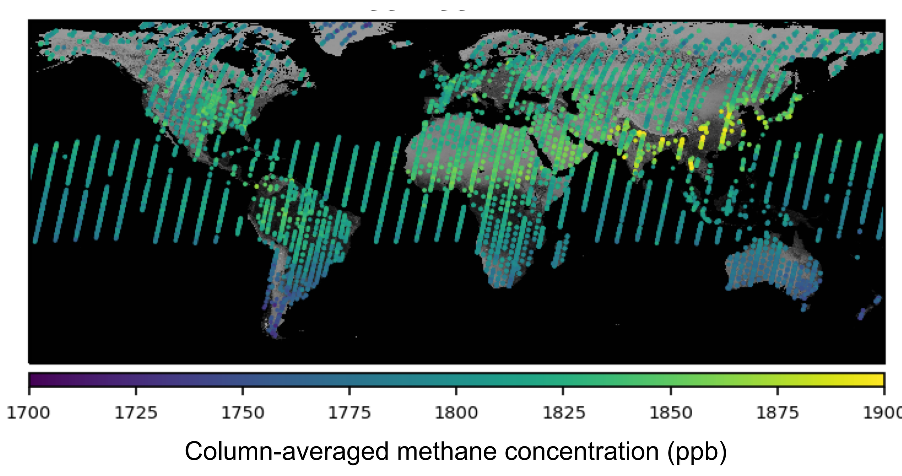


Fig 3: Space-based GOSAT column-averaged methane observations from Sep 2014 .

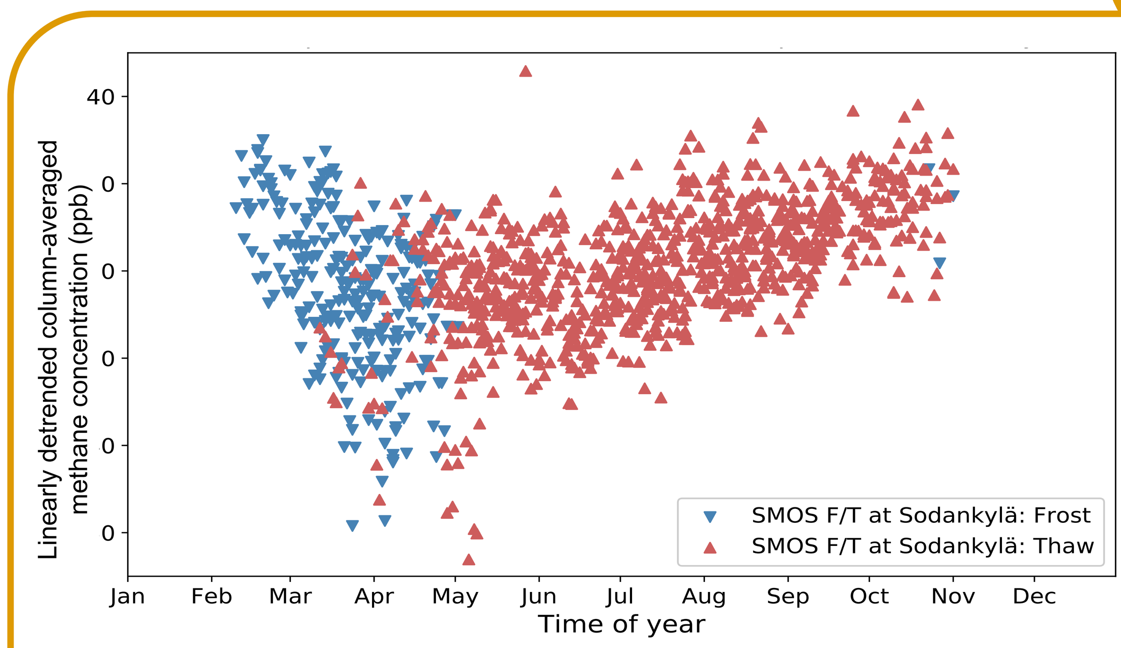


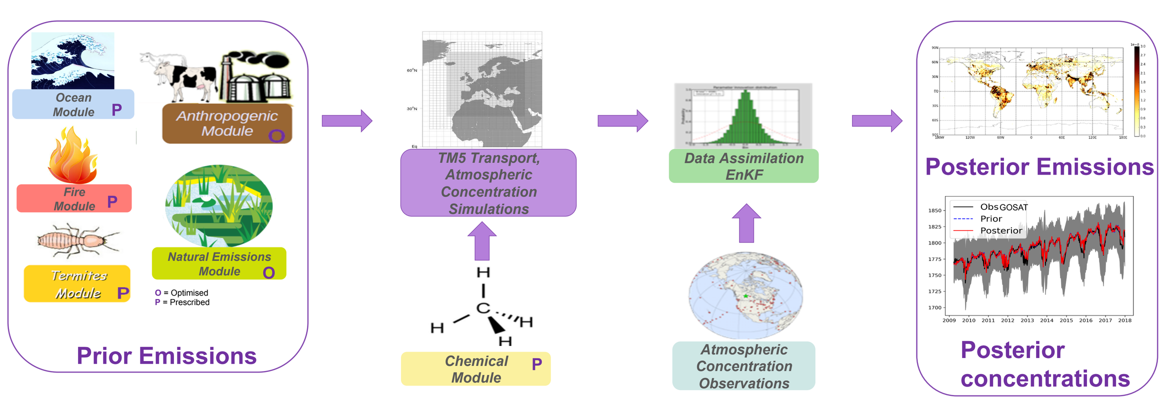
Fig 4: First comparison of ground-based column-averaged methane retrievals and space-based SMOS Freeze/Thaw product at Sodankylä. There are in total eight years of data in Fig. 4.

We investigate the correlations between satellite-based snow, frost and methane observations to define how the seasonality of snow and frost affects the seasonal cycle of methane in the Arctic and boreal regions.

For example, as we can see clearly from Fig. 4, when the frost thaws the atmospheric methane concentration increases. The observations during winter are scarce due to the limited amount of solar light for ground-based methane retrievals.

Solving methane fluxes at Northern latitudes using EO data

Atmospheric inversion model: CarbonTracker Europe – CH4 (CTE–CH4)



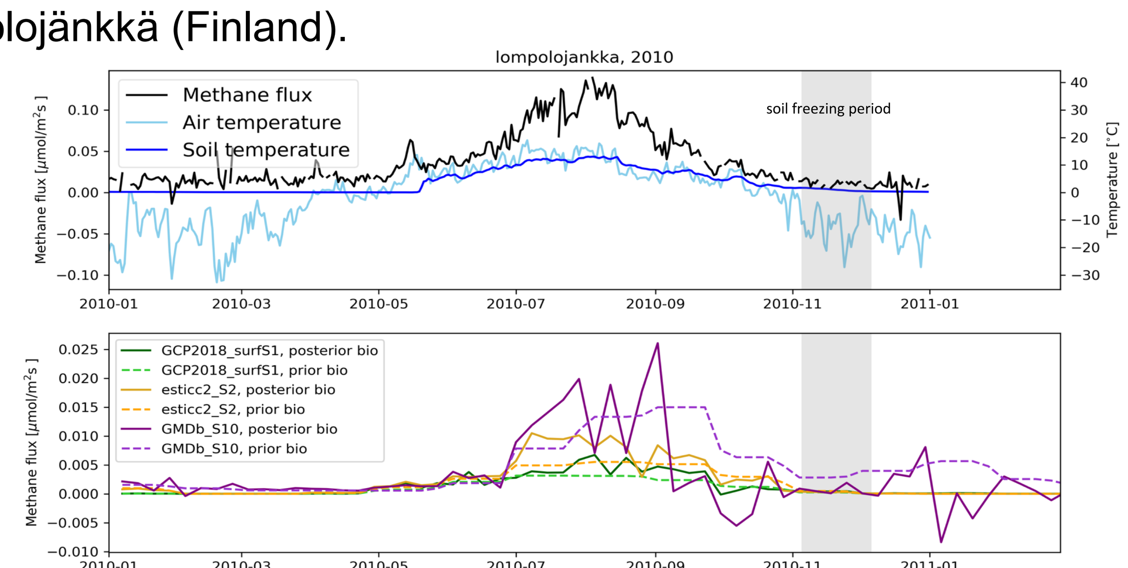
CTE-CH4 is a data assimilation system which uses global atmospheric concentration observations to optimize the prior emissions (Tsuruta et al., 2017)

Methane column observations on the ground and in-situ measurements

These data sets will be used, in addition to the CTE-CH4 data assimilation, to evaluate the satellite methane retrievals.

We improve methane flux modelling in Northern latitudes by combining different EO data sets. In addition, we will identify the magnitude of methane sources and analyse the trend in methane emissions and their correlation with the soil Freeze/Thaw data in the Arctic region by using both modeled and EO data.

Fig 5: Soil freezing period methane emissions are of specific interest in the warming climate. Figures show measured and modeled methane fluxes at Lompolojänkkä (Finland).



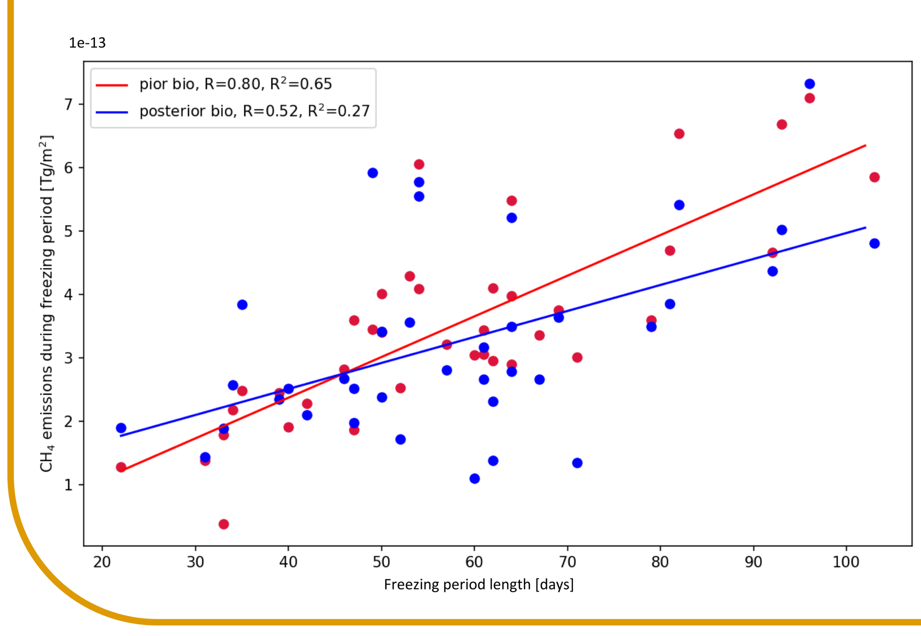
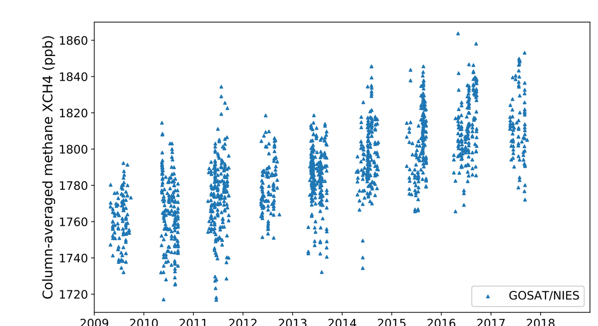


Fig 6: The length of the freezing period is correlated with the methane releases. Each point in the figure refers to one year and one Arctic/Boreal TransCom region. Fluxes are summed over freezing period, and expressed per wetland area.

Space-based methane observations from GOSAT and Sentinel-5P TROPOMI



The main data source is column-averaged methane observations from the Japanese Greenhouse Gases Observing Satellite (GOSAT), launched in 2009. In addition, ESA's TROPOMI, launched in 2017, methane observations will be used in the analysis.

Global soil freezing information from the ESA's Soil Moisture and Ocean Salinity (SMOS) satellite

Fig. 2 shows example of the SMOS Freeze/Thaw product, developed at FMI (Rautiainen et al., 2016).

Rautiainen et al., SMOS prototype algorithm for detecting autumn soil freezing, Remote Sens. Environ. 147, 206–218, 2016,
Tsuruta et al., Global methane emission estimates for 2000-2012 from CarbonTracker Europe-CH4 v1.0, Geosci. Model Dev. 10, 2785-2800, 2017.