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Satellite observations of methane in the North

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21.5.2019

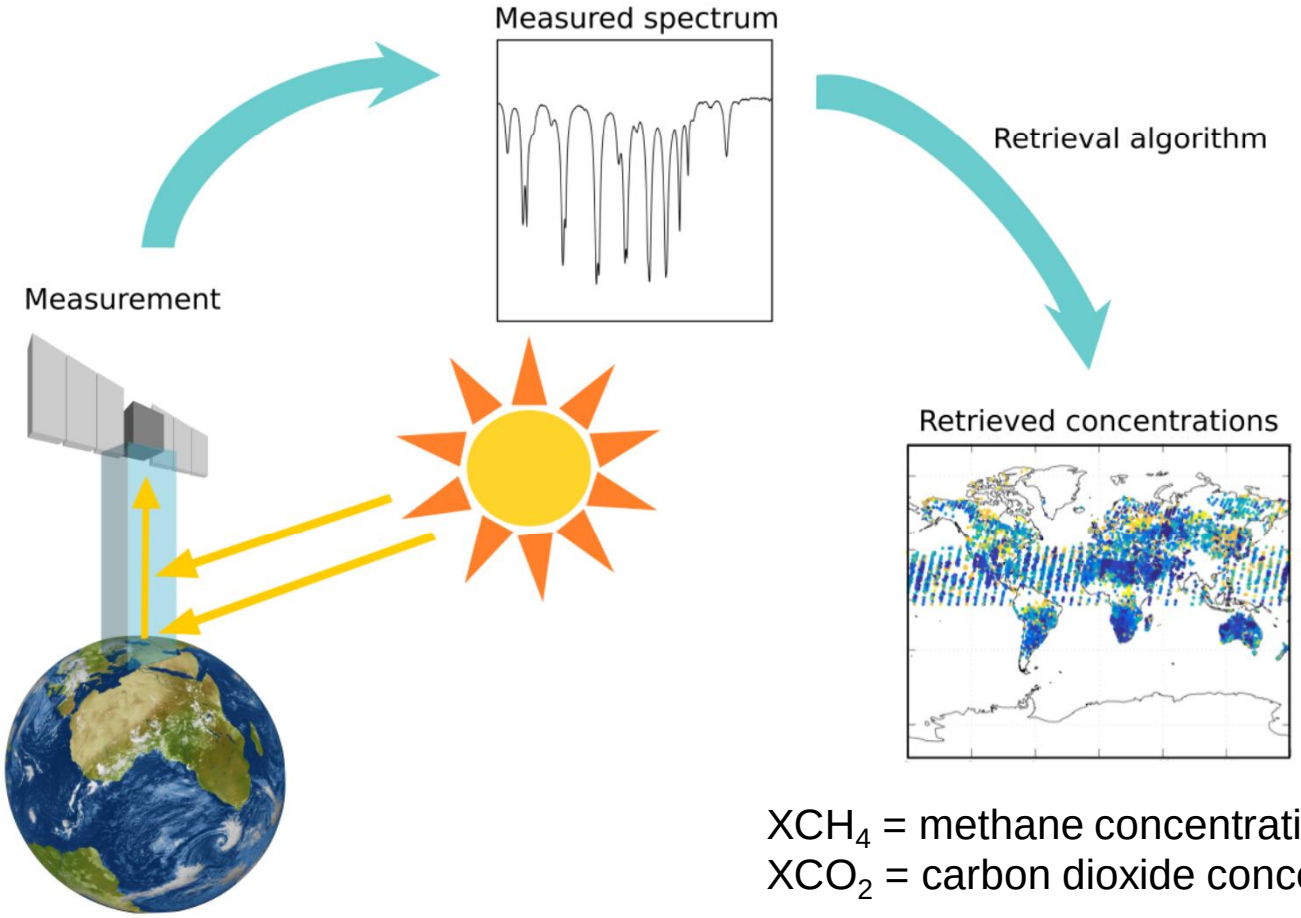
Motivation

Why to measure Greenhouse Gases (GHGs) and especially methane (CH_4) ?
Greenhouse gases are warming the atmosphere. Methane concentrations are relatively small (~ 1800 ppb) but the warming potential is ~ 30 times more than for carbon dioxide.

Why by satellite observations?
To increase the spatial coverage of the observations and to ultimately reduce the uncertainties related to the sources and sinks of GHG.

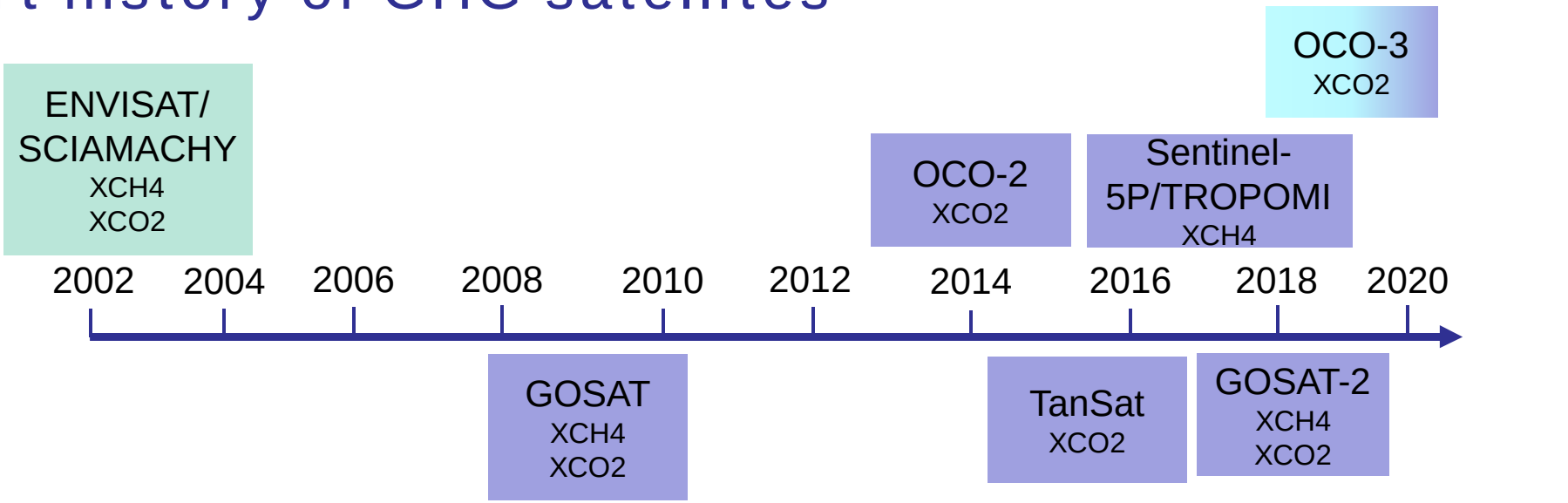
Why in the North?
The role and potential of Northern latitudes in the climate change are unclear. When considering methane, the seasonal frost and snow have both indirect and direct effects on methane fluxes.

GHG satellites measure short-wavelength infrared (SWIR) radiance reflected from the Earth's surface and atmosphere



XCH_4 = methane concentration
XCO_2 = carbon dioxide concentration

Short history of GHG satellites



Exhausted missions

On-going missions

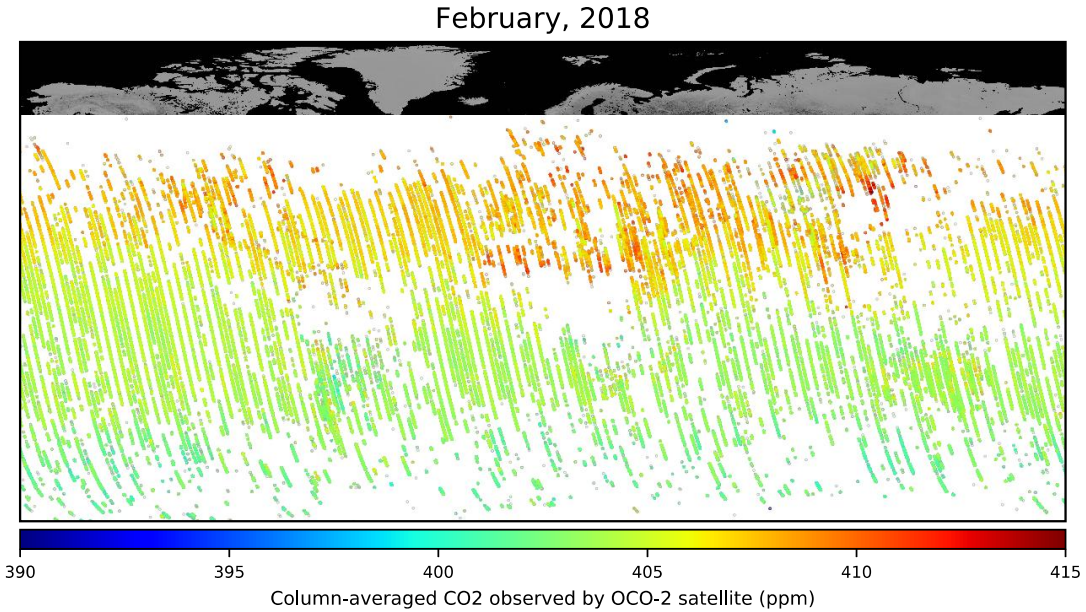
Future missions

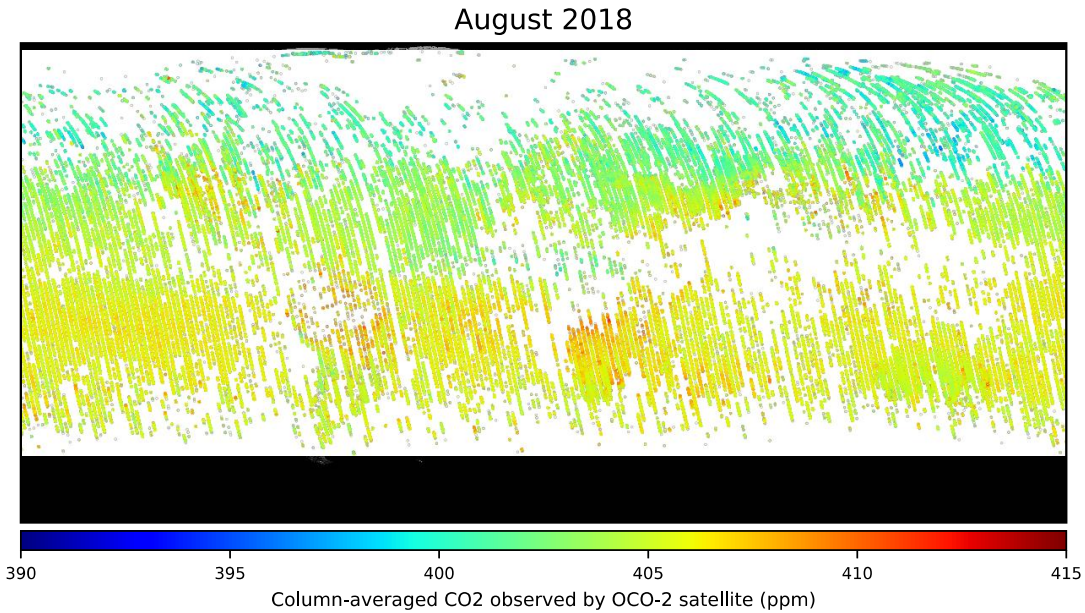
All in on-going missions on polar sun-synchronous orbit!

MicroCarb
Merlin
GeoCarb
GOSAT-3
AIM-North
TanSat-2
Sentinel-7A/B/?

?

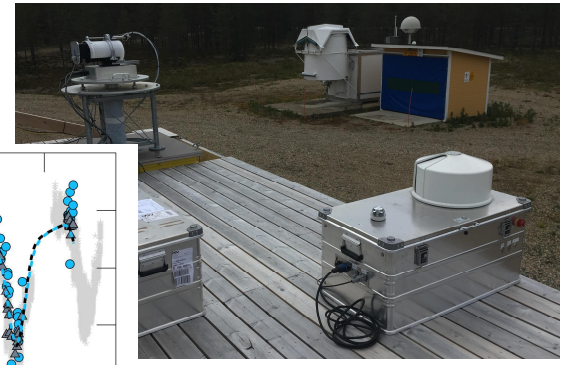
How the observations look on the map?



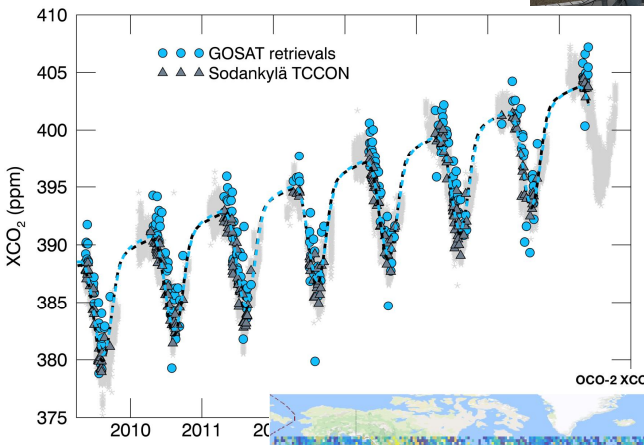


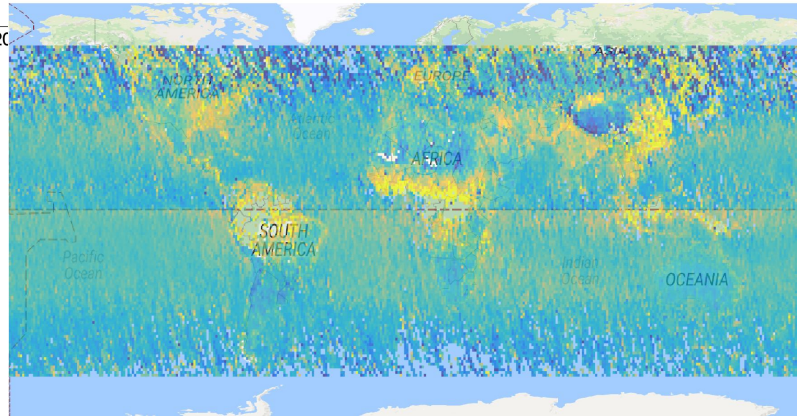
Greenhouse Gases and Satellite Methods group: Research interests

- GHG satellite validation at high latitudes – measurements in Sodankylä
  - **Time series analysis for XCO_2 and XCH_4**
- Develop satellite-data-driven methods to evaluate:
  - Anthropogenic CO_2
  - Biospheric fluxes and land surface models
- Quantify GHG retrieval uncertainties:
  - Sensitivity to aerosols
  - Sensitivity to the retrieval priors
  - Develop profile retrievals for GHG



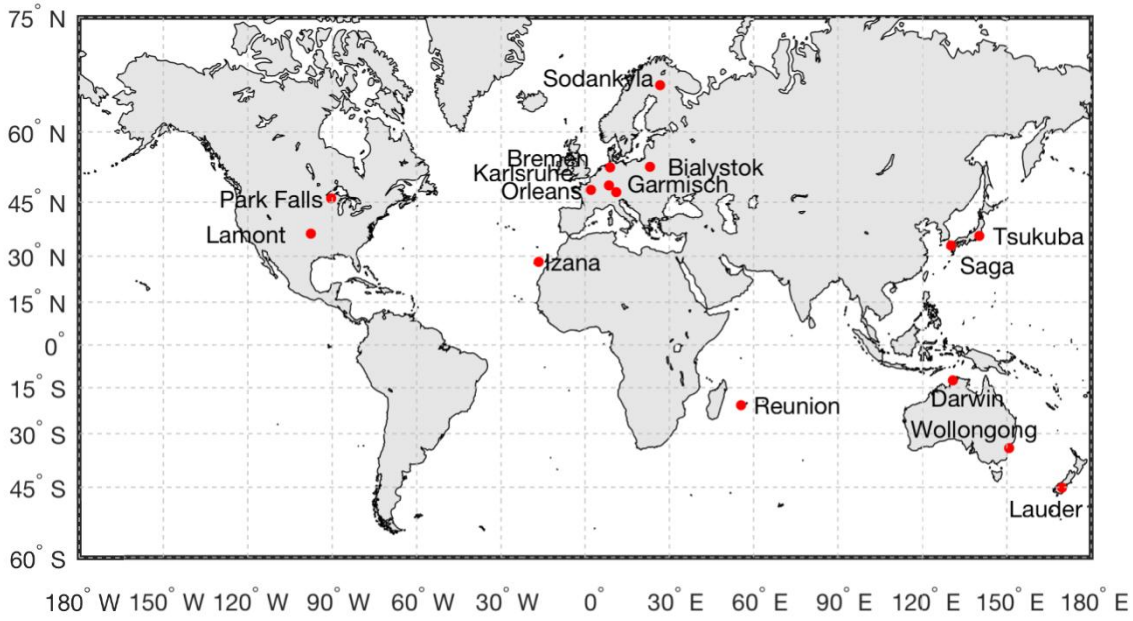
Based on Lindqvist et al. (ACP, 2015)





Based on Hakkarainen et al. (GRL, 2016) and Eldering et al. (Science, 2017)

GOSAT satellite observes the seasonal cycle and trend of methane accurately



We evaluated and analysed the seasonal cycle of three GOSAT XCH_4 retrievals at **15 TCCON** (Total Carbon Column Observing Network) stations nearly globally. In addition, the **latitudinal dependence** of the seasonality and trend were studied.

Kivimaki et al.: Evaluation and Analysis of the Seasonal Cycle and Variability of the Trend from GOSAT Methane Retrievals. Remote Sens. 2019, 11, 882.

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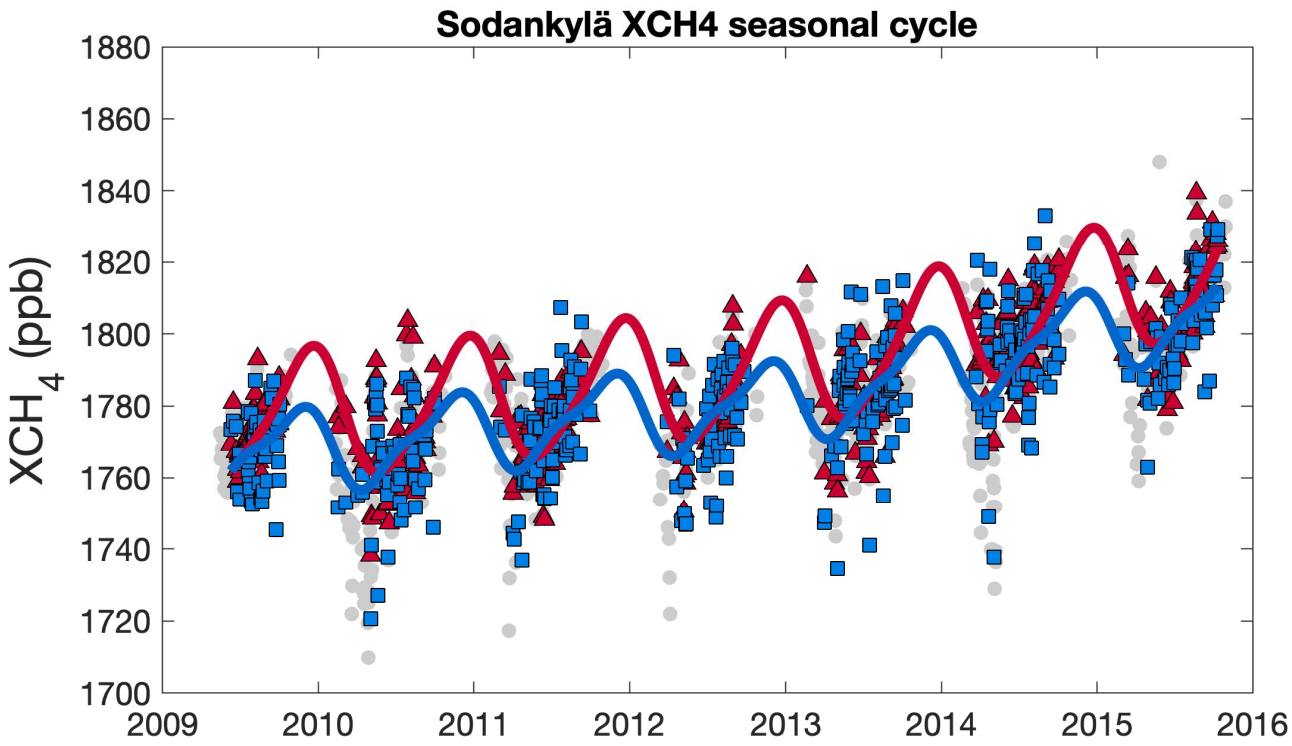
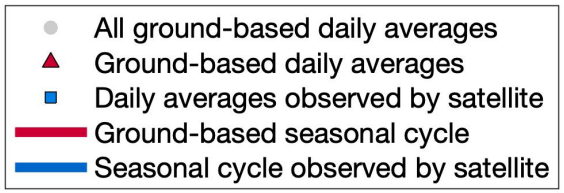


The model used to represent the seasonal cycle allows us to study the non-linear trend and detrended seasonal cycle separately



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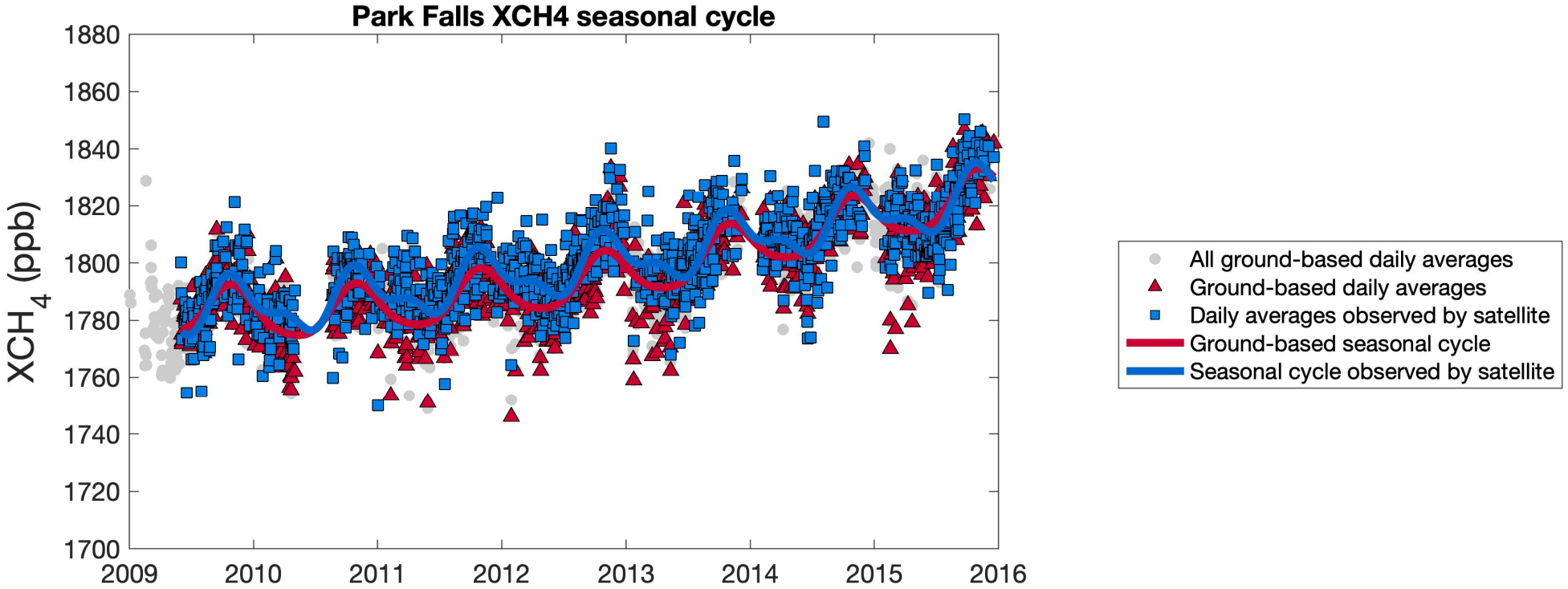

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Ongoing work - Seasonality and trend of XCH_4 and their connection to cryosphere in the Arctic and Subarctic regions

Seasonality and trend of methane can be observed from satellite

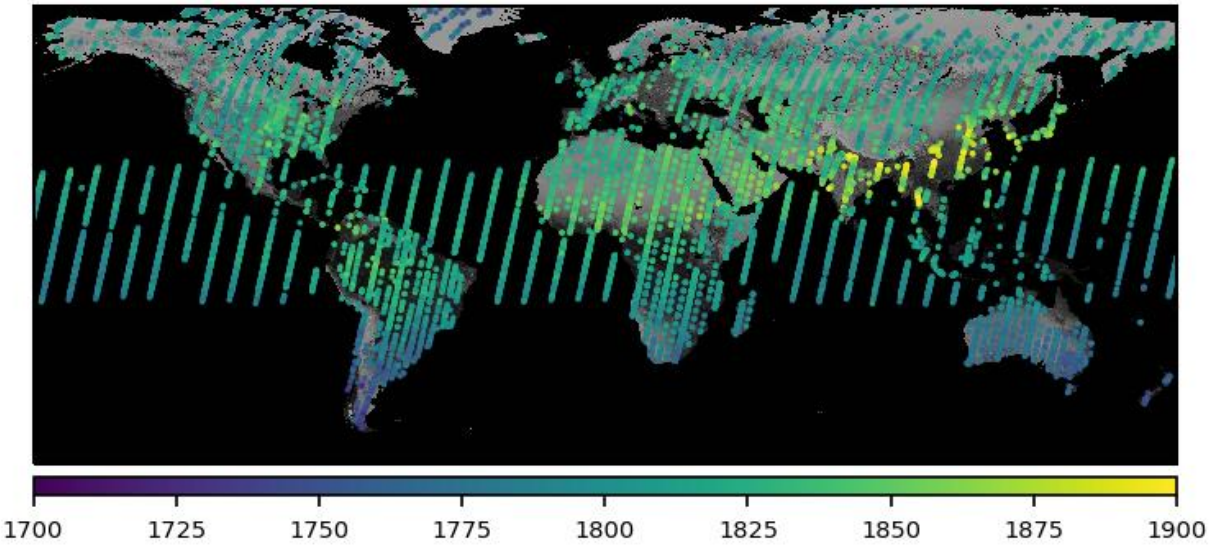
Methane observations from **GOSAT**, S5P/TROPOMI and GOSAT-2

Snow cover and the state of soil freeze can be observed from satellite

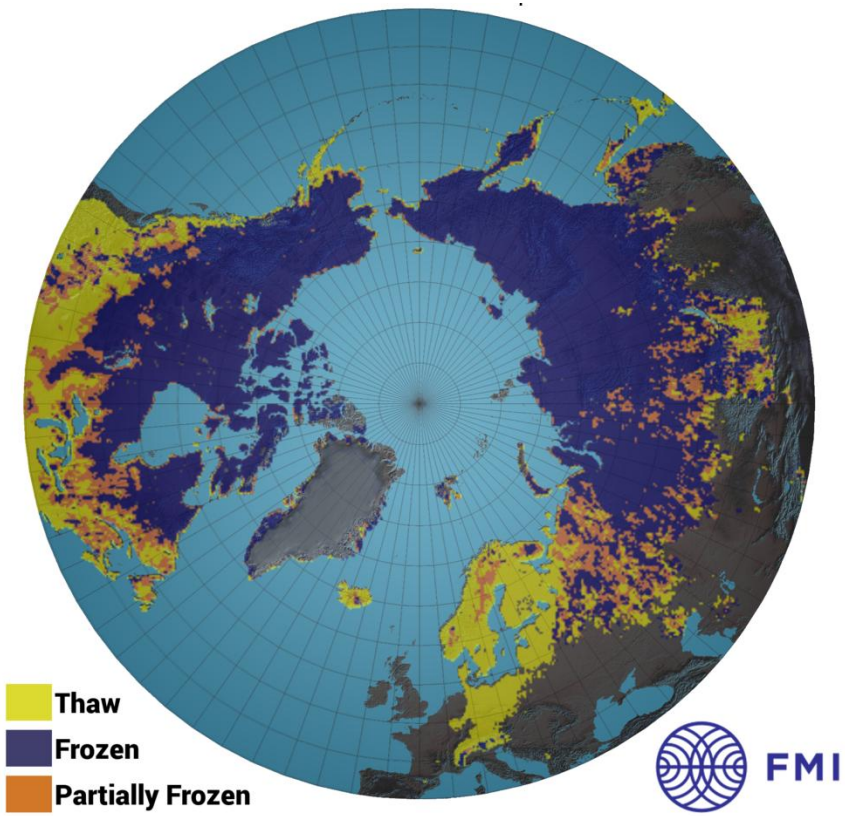
Global soil freezing information from the ESA's Soil Moisture and Ocean Salinity (SMOS) Satellite: **SMOS Soil Freeze/Thaw satellite product**

By combining different satellite products we can reduce the uncertainties related to the role of Arctic and Subarctic regions

Ongoing work - Seasonality and trend of XCH_4 and their connection to cryosphere in the Arctic and Subarctic regions

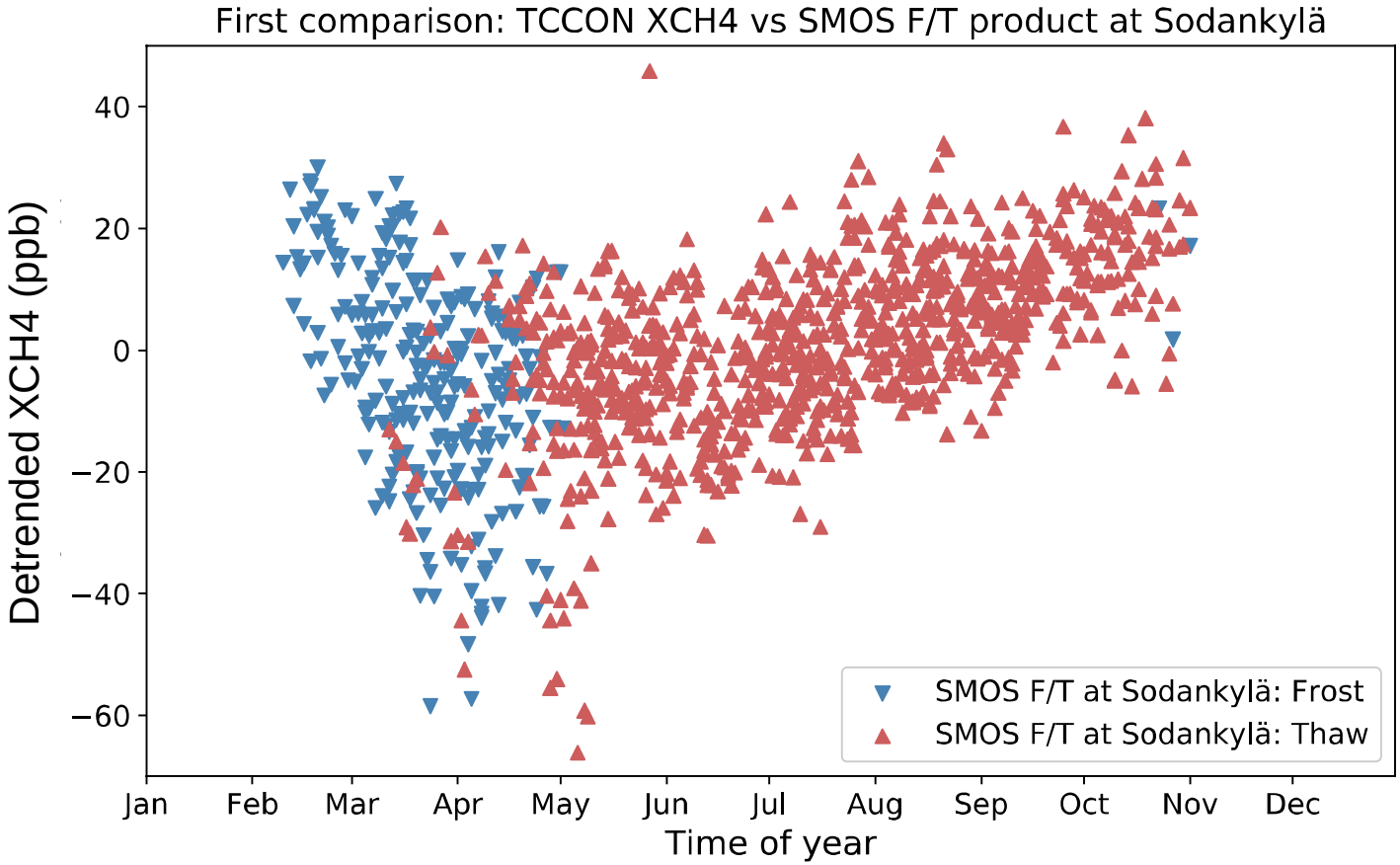


GOSAT XCH_4 observations from Sep 2014



SMOS soil status on 21 Nov 2018

Ongoing work - Seasonality and trend of XCH_4 and their connection to cryosphere in the Arctic and Subarctic regions



The figure has data from 2010 to 2018. Next step is to do similar comparison for GOSAT observations covering the continental areas of the Arctic and Subarctic regions.

Thank you!

Satellite observations of GHGs provide independent data on currently understudied regions.

The satellite observation of GHGs are used to reduce the uncertainties related to the sources and sinks of GHGs.

The seasonal cycle and trend of methane and the processes related to them can be studied by using satellite observations.

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This work is partly funded by Tiina and Antti Herlin Foundation.