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Modelling and measuring atmospheric methane

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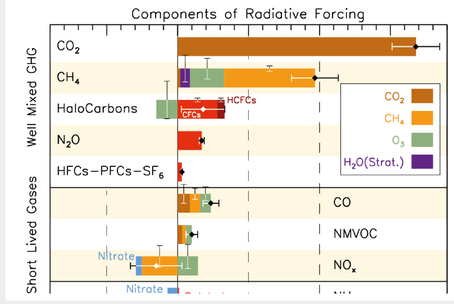
Motivation

Significance of Methane (CH4)

- Important anthropogenic greenhouse gas, second only to CO2
- Important source for O3 in troposphere
- Current increase: ~ 6 ppb/year
- Relatively short (as greenhouse gas) atmospheric lifetime: ~ 8 -10 years

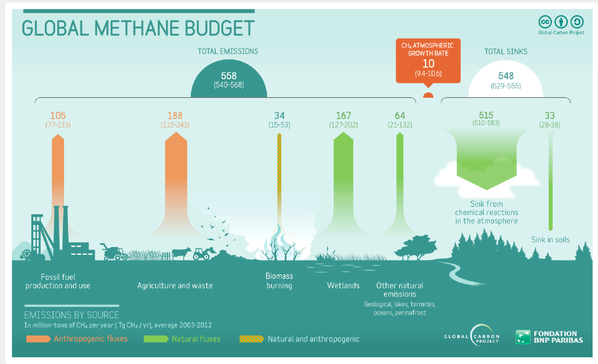


Radiative Forcing bar chart for the period 1750–2011 [1]

Modelling Methane:

- Uncertainty concerning global distribution of sources and sinks [2]
- Discrepancies of bottom-up and top-down approaches [3]

→ Quantification of processes



Methane Budget: Sources and Sinks [4]

Methods

FTIR Measurements

NDACC Station:

Kiruna, Sweden
67.84° N, 20.41° E
419 m asl

FTIR (Bruker 120 HR)

- Since 1996
- Ø 51 days of measurements/year (Ø 99 measurements/year)

Location Kiruna [5]

Climate Models

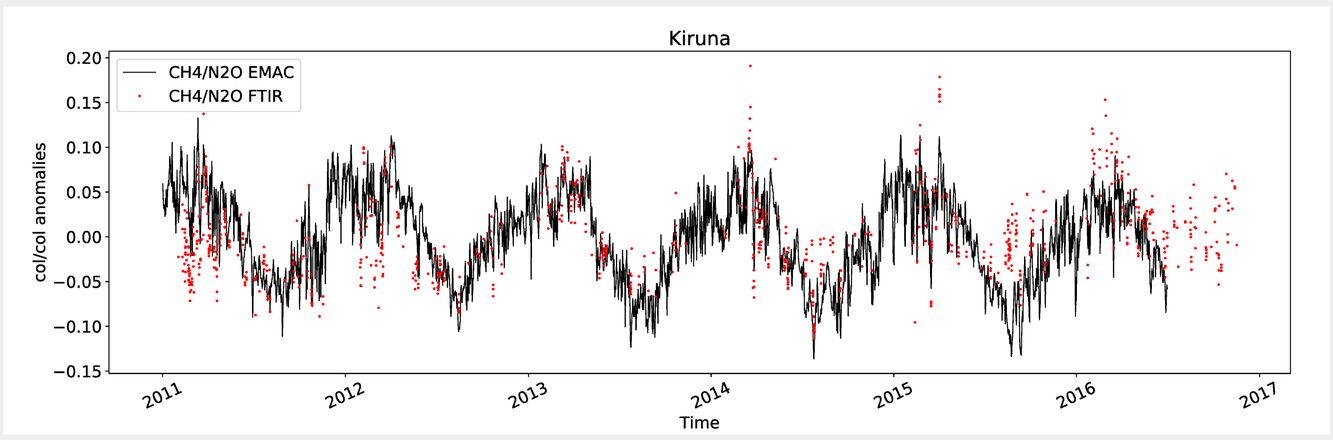
EMAC

- ECHAM5 MESSy Atmospheric Chemistry
- Run: ESCiMo 2.52, Δt=720s, T42LMA90, ~ 2.8°x2.8° [6]
- Emission inventory: MACCity (IPCC AR5, 1960-2012, monthly, 0.5°x0.5°)
- CH4, N2O: pseudo-emissions (TNUDGE)

ICON-ART

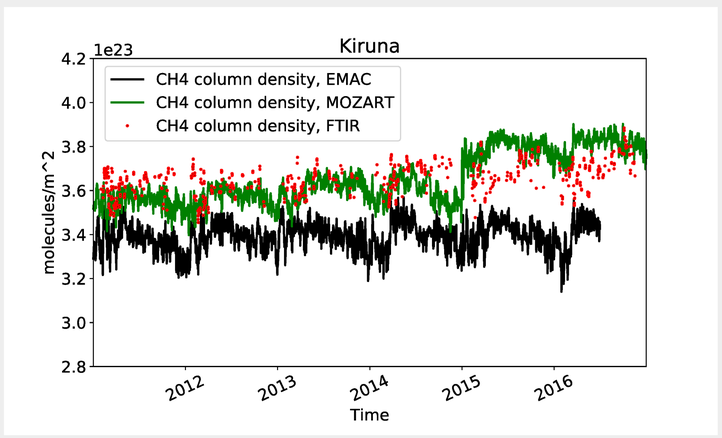
- ICON-ART 2.3 in same configuration as [7]
- Run: R2B04, $\overline{\Delta x}$ ~ 160km, Δt=460s, output: 1°x1°
- "Cold Start" with ERA-I
- Emission inventory: EDGARv4.2 (1970-2008, yearly, 0.5°x0.5°)
- CH4, N2O: lifetime based module

Data Comparison



Comparison of EMAC and FTIR

- Starting from 2011
- Ratio CH4 column density/ N2O column density to reduce dynamic variability
- Different offsets → Anomalies from mean for observed period
- Seasonality for both time series with maxima in spring



CH4 column density comparison since 2011

EMAC:

- Matches seasonality
- Partly underestimates spring

→ Polar methane sources (thawing permafrost)?

ICON-ART in preparation:

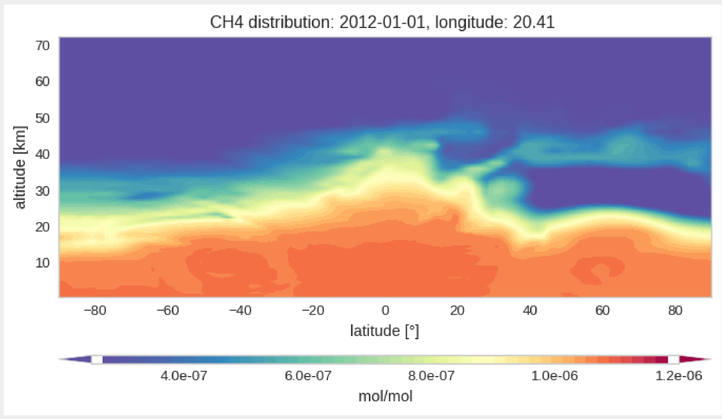
- Little seasonality
- Lower value range, spin-up time

→ No full gas phase and yearly emissions in current model run

Measurements (FTIR) and two models (EMAC, MOZART [8]) agree in value range

→ Objective for ICON-ART: adjust chemical processes for N2O and CH4 by accounting for different chemical scenarios

Outlook



Lat cross-section of CH4 concentration at longitude of Kiruna

Investigation with ICON-ART:

- Comparison of inventories and transport

Further implementation in ICON-ART:

- 3D initialisation for CH4, N2O (MOZART data)
- Full gas phase

Quantification of influence of polar regions:

- Statistical analysis of seasonality
- Backward trajectories

References

[1] climatechange2013.org/images/figures/WGI_AR5_Fig8-17.jpg
[2] Saunois, Marielle, et al. "The global methane budget 2000-2012." Earth System Science Data 8.2 (2016): 697.
[3] Khalil (Ed.), Atmospheric methane: Its role in the global environment, Springer, (2000).
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[8] Emmons, Louisa K., et al. "Description and evaluation of the Model for Ozone and Related chemical Tracers, version 4 (MOZART-4)." (2010): 43-67.

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