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

Modelling Methane:
- Uncertainty concerning global distribution of sources and sinks [2]
- Discrepancies of bottom-up and top-down approaches [3]
  → Quantification of processes

Methods

FTIR Measurements
NDACC Station: Kiruna, Sweden 67.84° N, 20.41° E 419 m asl
FTIR (Bruker 120 HR):
- Since 1996
- 51 days of measurements/year (59 measurements/year)

Climate Models

EMAC:
- ECHAM5-MESy Atmospheric Chemistry
- Run: ESCMo 2.52, Δt=720s, T42LMA90, ~ 2.8° x 2.8° [6]
- Emission inventory: MACCity (IPCC AR5, 1960-2012, monthly, 0.5° x 0.5°)
- CH₄, N₂O: pseudo-emissions (TNUDGE)

ICON-ART:
- ICON-ART 2.3 in same configuration as [7]
  → Run: R28504, Δx ~ 160km, Δt=460s, output: 1° x 1°
  - "Cold Start" with ERA-I
  - Emission inventory: EDGARv4.2 (1970-2008, yearly, 0.5° x 0.5°)
  - 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

EMAC:
- Matches seasonality
- Partly underestimates spring
  → Polar methane sources (thawing permafrost)?

ICON-ART:
- 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

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/figure/ARC_AR5_Fig8-17.jpg
[5] openstreetmap.de

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