MOCA-
Methane Emissions from the Arctic OCean to the Atmosphere: Present and Future Climate Effects

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Summary

Methane hydrates (MH) in ocean seabed sediments are a potential source of methane (CH_4) to the atmosphere, where CH_4 has potential to act as a powerful greenhouse gas. However, current scientific results show diversity in the flux of CH_4 that actually reaches the atmosphere. MH are potentially susceptible to ocean warming, which could trigger a positive feedback resulting in rapid climate warming. MOCA is a new project that will apply advanced measurements and modelling to quantify the amount and present atmospheric impact of CH_4 originating from MH. Furthermore, the project will investigate potential future climate effects from destabilisation of MH deposits in a warming climate, and will focus on scenarios in 2050 and 2100. MOCA is an interdisciplinary project that utilises measurement campaigns and powerful modelling tools in collaboration with international investigators and existing projects. The project is anticipated to generate new knowledge on the entire Earth system and climate change using the region around Svalbard as an experimental test bed to study polar processes.

The overall objective of MOCA is to "Quantify the present atmospheric effects of methane from gas hydrates at the seabed, and future potential climate impacts on decadal to centennial timescales."

Total budget:
~23.3M NOK (Norwegian Research Council, POLPROG)

Project start:
1. October 2013

Project leader:
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Project team

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International collaborators

Dr. Jens Greinert Helmholtz Centre for Ocean Research, (GEOMAR), Germany	Ocean (ship-based) measurements
Prof. Euan Nisbet Royal Holloway, University of London, UK (RHUL)	Atmosphere (ship-based, aircraft-based, surface-based) isotopic composition measurements
Dr. Jean-Daniel Paris Laboratoire des Sciences du Climat et l'Environnement, France (LSCE)	Atmosphere (aircraft-based) measurements (collaboration with YAK-AEROSIB [1] project)
Dr. Boris Belan V.E. Zuev, Institute of Atmospheric Optics, Russian Academy of Sciences, Russia	
Prof. John Pyle Centre for Atmospheric Science, University of Cambridge, UK (UCAM)	Atmosphere (aircraft-based) measurements and climate modelling (collaboration with MAAM [2] project)
Dr. Carolyn Ruppel Gas Hydrates Project, U.S. Geological Survey, USA (USGS)	Ocean-atmosphere (ship-based) flux measurements
Dr.rer.nat. Hans Schlager Deutsches Zentrum für Luft- und Raumfahrt, Germany (DLR)	Atmosphere (aircraft-based) measurements (collaboration with MERLIN [3] project)
Dr. Renato Spahni Physics Institute, and Oeschger Centre for Climate Change Research, University of Bern, Switzerland (BERN)	Terrestrial CH_4 fluxes

Collaborative projects:

[1] YAK-AEROSIB — Airborne Extensive Regional Observations in SIBeria (https://yak-aerosib.lsce.ipsl.fr)

[2] MAAM — Methane and other greenhouse gases in the Arctic – Measurements, process studies and Modelling (http://www.faam.ac.uk/index.php/current-future-campaigns/354-mamm-methane-mapping)

[3] MERLIN — Methane Remote Sensing Lidar Mission (https://directory.eoportal.org/web/eoportal/satellite-missions/m/merlin)

1 Work description

MOCA aims to improve the description of the current environmental state of the Svalbard region with particular focus on changes in CH_4 emissions from the ocean, and the ocean–atmosphere fluxes of CH_4.

Objectives

- Quantify Present Day CH_4 emissions from the seabed west of Prince Carl Forland (Svalbard) and identify main processes that influence emission rates
- Improve the knowledge about the overall activity of the marine seep sites offshore from Svalbard
- Identify the main areas where seabed CH_4 emissions are likely to take place in the Arctic region
- Produce estimates of CH_4 emissions to the atmosphere that are related to MHs and other sources in the Arctic Ocean
- Describe the climate impact and radiative forcing (direct and indirect effects) of CH_4 release from the seabed under present-day and future atmospheric composition scenarios

1.1 Work Package description

MOCA consists of four complementary Work Packages (WP) to organise the work:

WP1 Improved process understanding and description of the present state of the ocean and atmosphere around Svalbard (NILU)

WP2 Understanding of present and future methane release from ocean (UiT)

WP3 Present and future projections of climate effects (CICERO)

WP4 MOCA management and coordination (NILU)

Figure 1 shows the relation between the process-based measurements and modelling activities. MOCA will combine land-, ship- and aircraft-based measurements (WP1) in coordinated measurement campaigns to improve the description of the current environmental state of MH in the Svalbard region. Measurement and modelling activities will quantify the present-day CH_4 emissions from marine seep sites west of Prince Carl Forland to the atmosphere, and will identify the main influences on the atmospheric fraction. The detailed observation and process-based studies in WP1 will be up-scaled spatially over the Arctic region and for future time periods to generate CH_4 emission estimates related to MH in the Arctic Ocean (WP2). Finally, the radiative forcing (direct and indirect effects) and climate impact from MH-based CH_4 emissions will be calculated under present-day atmospheric composition and realistic future temperature scenarios (WP3). The potential of the biogeochemical cycle as a strong feedback mechanism will also be investigated.

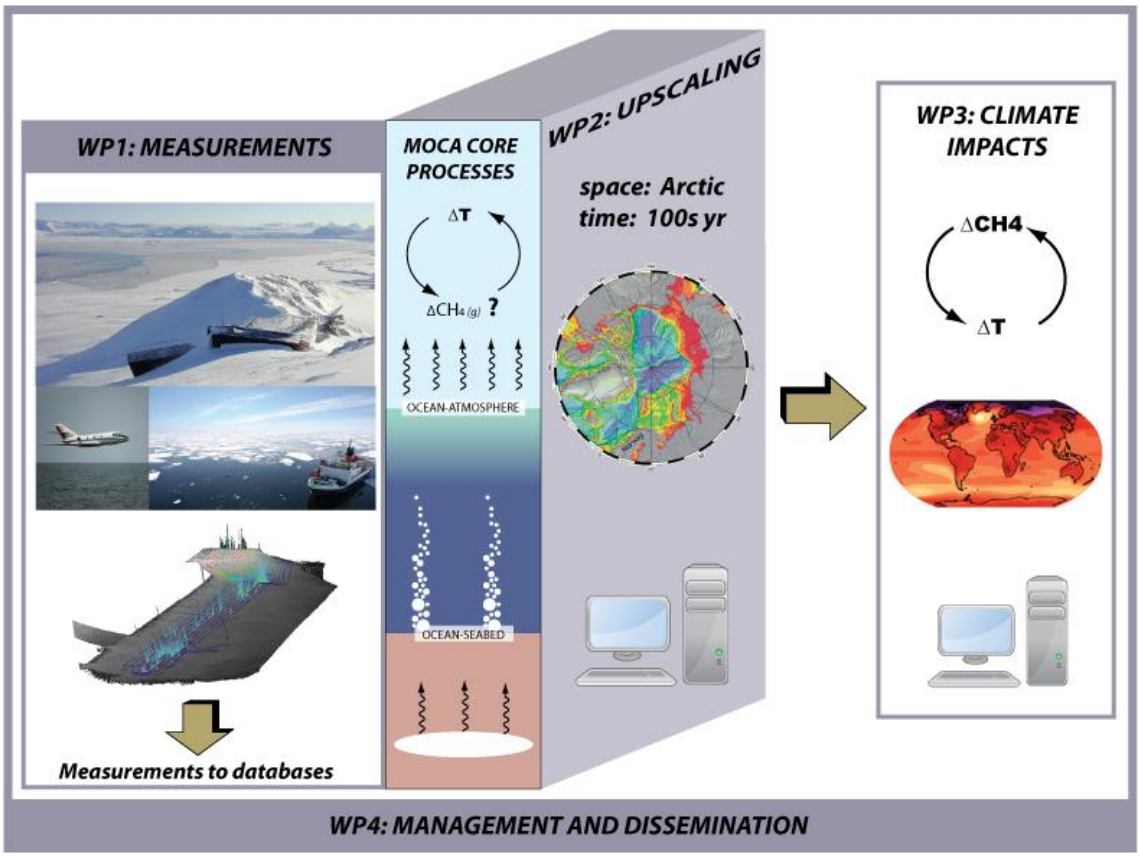

Figure 1. The core processes that will be investigated through the activities planned in MOCA are illustrated in the centre of the figure. WP1 includes measurements of CH_4 in the ocean, ocean interface and atmosphere to improve process-based understanding and to quantify CH_4 emission to the ocean and atmosphere. WP2 is concerned with spatial upscaling and radiative simulations constrained by process-based understanding developed in WP1 over the Arctic region. WP3 estimates the potential climate impacts of these emissions over timescales of 10s to 100s of years.

WP1 Understanding and description of present state of system around Svalbard

NILU (lead), UiT, GEOMAR, USGS, DLR, CEA, UCAM

1.1 Seabed-ocean methane fluxes (UiT)

- In situ seabed measurements (MASOX landers and accompanying buoys with measurement instrumentation) targeting CH_4 bubble release area offshore from Prins Karls Forland

1.2 Determination of MH and oceanic emissions to the atmosphere (UiT)

- Ocean-atmosphere interface CH_4 fluxes and isotope abundances (USGS, GEOMAR)
- Ocean column profile sampling for dissolved and gaseous CH_4 and isotope abundances (GEOMAR)

1.3 Vertical profile and extended time-series measurements of atmospheric CH_4 (NILU)

- In situ CH_4 mixing ratios and isotope abundances at Zeppelin Observatory
- Aircraft-based vertical profiles of CH_4 concentration and isotope abundances over the ocean around Svalbard and Siberia (collaboration with DLR, LSCE and UCAM projects)

WP2 Present and future methane release from the ocean
UiT (lead), NILU, CICERO, GEOMAR, USGS

2.1 Identify MH regions in Arctic (UiT)
- Synthesis of available information on known (and possible) MH areas in the Arctic

2.2 Detailed CH_4 emissions inventory at Present Day for the Arctic (NILU)
- Source attribution and CH_4 emission maps using FLEXPART inverse modelling (observational data from WP1 in addition to published sources)

2.3 Upscaling of CH_4 emissions over time (CICERO)
- Parameterization of MH-derived CH_4 emissions as a function of temperature and other key parameters
- Future temperature changes and uncertainty for scenarios in 2050 and 2100 without CH_4 emissions from MH
- Estimate upper and lower bounds of CH_4 emissions from MH for 2050 and 2100 in two Arctic regions

WP 3 Present and future projections of climate effects
CICERO, UCAM

3.1 Current influence of methane emissions from the seabed on atmospheric composition (CICERO)
- Simulations on changes in atmospheric composition from the current emissions of CH_4 from MH to the ocean (derived from WP1 and WP2) using the OsloCTM3 model

3.2 Future impact of methane emissions from the seabed (CICERO)
- Radiative forcing and associated temperature changes from projected future changes in atmospheric CH_4 composition related to MH dissociation
- Focus on 2050 and 2100 scenarios
- Sensitivity study of climate impacts related to duration of CH_4 emissions

3.3 Investigation of the strength of the biogeophysical cycle of methane emissions from the seabed (CICERO)
- Potential impact of a warming ocean on MH CH_4 emissions
- Potential strength of the biogeophysical cycle