WP3 Natural emissions, their fate in the atmosphere and their relation to warming and cryospheric changes

CHAIRS: Henrik Skov, Jaana Bäck

Participants:

1. Jon Egill Kristjansson University of Oslo
2. Michael Boy University of Helsinki
3. Sven-Erik Gryning Technical University of Denmark
4. Henrik Skov Aarhus University
5. Quynh Nguyen Aarhus University
6. Radovan Krejci Stockholm University
7. Adam Kristensson Lund University
8. Andreas Massling Aarhus University
9. Marianne Glasius Aarhus University
10. Eva Emanuelsson Aarhus University
11. Merete Bilde Aarhus University
12. Anne Maria Hansen Aarhus University
13. Matt Salter Stockholm University
14. Øyvind Seland Meteorological Institute Norway
15. Pekka Rantala University of Helsinki
16. Jaana Bäck University of Helsinki
17. Ingeborg Elbak Nielson, Aarhus University
18. Lise Lotte Sörensen, Aarhus University

AGENDA WP3

Monday 13.01.2014

12.00:13.00: Lunch at the Hotel

13.00: Welcome and aims (Henrik, Douglas & Jaana): Overview of WP3

Session 1. SOURCES: Presentations (30 minutes incl. discussions)

- Adam Kristensson: Influence of Arctic emissions on new particle formation in Greenland
- Jaana Bäck: Boreal ecosystems as sources for aerosol precursor gases
- Henrik Skov: Interaction of Cryosphere with Persistent Organic Pollutants in the atmosphere

15.30-16.00: Coffee break

Session 2. REACTIONS: Describe reaction pathways and effects on aerosol and ozone formation of the emitted gases;

- Eva Emanuelsson: End- and exo cyclic terpenes reactions with O_3 and OH
- Lise-Lotte Sörensen: Introduction to Greenland field sites and moving platform

Session 3. AEROSOLS:

- Marianne Glasius: Insights gained from chemical analysis of Arctic aerosols part 1.
- Merete Bilde: Sea-spray aerosol and our results from the sea-spray tank
- Sven-Erik Gryning: On the structure and adjustment of inversion-capped neutral atmospheric boundary layer flows: large-eddy simulation study

19.00: Dinner

Tuesday 14.01.2014

9.00-10.30: Future plans. How will we meet the objectives and make the deliverables

- Jon Egill Kristjansen: Integration of observations and models, The need from WP3 to Earth System Models

- Planned experiments at Villum Research Station, Station Nord
- Laboratory experiments??……
- Boreal forest?
- Sea spray……
- ….

10.30 –11.00: coffee break

11.00-12.00

Discussion about how to implement the results to ESMs

12.00:13:00: Lunch and end of the meeting

Minutes of the meeting

Monday Jan 13, 2014

13.00 Welcome and aims (Michael, Co-chairs Henrik & Jaana): Overview of WP3; aims of the Workshop

Session 1. **SOURCES:**

- Adam Kristensson: Influence of Arctic emissions on new particle formation in Greenland.
  - NPF events in St Nord from June to early Sept; measurements from 10 nm up
  - no NPF with winds from central Greenland
  - growth rate very low
  - sea salt from 20 nm, can perhaps be seen sometimes
  - planned measurements in St Nord:
    - use of NanoMap method
    - NAIS/AIS/PSM + sulfuric acid? who?
    - the science Board will accept proposals of those who are committed to participate in campaign
    - a planning meeting in spring 2014 (3rd of April 2014), also modelers should be invited to workshop
    - in 2015 St Nord (=Villum station) will be part of the INTERACT project (travels and subsistence can be applied from INTERACT TNA!)
    - Q: what will CRAICC cover, what will other projects cover?
    - not only atmospheric, but also biological studies possible
    - sun rises end of Feb, March-April-May Arctic haze maximum
    - transition period May-June ????
    - Campaign objectives to be defined – then timing and instrumentation
    - important to measure small sizes

- Jaana Bäck: Boreal ecosystems as sources for aerosol precursor gases – how confident estimates can we give?
    - are we missing an important source? are we underestimating/overestimating source strengths? is there mismatch in timing of sources? potential stress effects?
    - temperature responses of VOC emissions/concentrations are varying from exponential to linear, depending on when they are measured
    - cryosphere changes will impact amount and timing of emissions (and their t-responses)

- emission from soil, below-canopy (trunk) and lakes may contribute up to 20%

- Henrik Skov: Interaction of Cryosphere with Persistent Organic Pollutants in the atmosphere
    - POPs in Arctic
    - Villum research station (villumresearchstation.dk)
    - large fluxes of a-HCH (pesticide) when ice cover is smallest; coming likely from cryosphere storages?
    - west coast concentrations in sea water 100 times higher than east coast? From model calculations taken both atmospheric and marine levels this cannot be correct?
    - melting of cryosphere is releasing 'old' pollutants and form a source for them in the Arctic

Session 3. AEROSOLS:

- Marianne Glasius: Insights gained from chemical analysis of Arctic aerosols
    - St Nord: atmospheric PM10 organosulphates highest (50 ng m-3) in midwinter
    - SO2 very low (measured as weekly averages)
    - air masses mainly from North pole in St Nord, but in Svalbard also sometimes from Scandinavia
    - important to define the multi-year ice and first year ice effects (frost flowers)
    - acidic sulphates needed for organosulphates
    - ongoing and future: gas-particle separation, CCN activity, Pallas samples, data analysis and modelling, Villum campaign

- Merete Bilde: Sea-spray aerosol and our results from the sea-spray tank.
    - new postdocs: Quyhn Nguyen, Eva Emanuelsson
    - 2 open PhD positions
    - 2 new seaspray tanks (Aarhus & Stockholm)
    - different sea salts and organics (sugars, surfactants)
    - NaCL and artificial sea salts have different CCN activity
    - enrichment of organics in bubbles in some cases but not all
    - verification of experimental conditions to actual wave processes in real world with energy dissipation rate

- Sven-Erik Gryning: On the structure and adjustment of inversion-capped neutral atmospheric boundary layer flows: large-eddy simulation study
    - stable conditions create very different parameterisations for wind profiles in Arctic (only possible to see when the heat flux is zero for prolonged period)
    - possible to do in St Nord?

Session 2. **REACTIONS:**

- Eva Emanuelsson: End- and exo cyclic terpenes reactions with O_3 and OH
    - precursor chemistry: limonene very reactive, pinenes less
    - α-pinene endocyclic, β-pinene exocyclic, limonene both: effect on reaction rates and products
    - G-FROST (Göteborg Flow Reactor for Oxidation Studies at low Temperatures)
    - stabilized Criegee – reaction with water - 'hydroperoxide channel'
    - effect of OH scavenger on SOA, competition between OH and O3

- Lise-Lotte Sörensen: Introduction to Greenland field sites and moving platform
    - 2013 Nuuk: Defrost/CRAICC
    - 2014 Zackenberg/Daneborg: Defrost
    - 2015 St Nord: ARC campaign on a small island connected to Station Nord; C cycle in water (marine biologists)
    - 2015-16: cooperation with Univ of Manitoba and Aarhus
    - 3 new inspection ships (2 ready now); instrumentation ongoing and can be planned (booms, wind tunnels…); following ice border (can break 80cm ice)

Tuesday

9.00 **Future plans. How will we meet the objectives and make the deliverables**

Jon Egill Kristjansen: Integration of observations and models, The need from WP3 to Earth System Models

- Limitations of the ESM compromise coarse resolution and simplified chemistry (parameterization)
- The model needs to be credible (Validation)
- Examples:
  1 Possible aerosol-related feedback loops in the Earth System (Climate-> terrestrial biosphere -> SOA->clouds->climate)
  2 Climate ->sea ice -> sulfate, POM
  3 Sea salt -> clouds -> climate

- Paramerization in the Climate model means expressing processes that are too small-scale or complex to be physically represented in the model by simplified relations using model resolved variables =>
- Examples of what has been made: Sea salt emissions (Stockholm experiments; Mårtensen et al. 2003) Sea salt emission dependency on temperature and wind speed
- SW Optical properties of clouds Needs: Droplet size distribution -> effective radius reff , liquid water content; extinction (optical depth), Phase function -> asymmetry parameter, absorption -> single scattering albedo => Feed into 2-stream radiative transfer calculation -> cloud albedo
- So, how do we achieve integration obs<-> models in the last 2 years of CRAICC
  - Unique opportunity: Station Nord campaign 2015
  - ARM campaign Hyytiälä

Properties to ESM

- Analysis of particle number from station Nord and other stations: Identification of period with < 1 cm-3
- Effective radius of particles and hygroscopicity
- Consider using models such as WRF-chem or Oslo CTM/EMEP/…. Or NorESM at 0.5^{o} with nudging to ECMWF data
- Identify processes where progress is urgently needed or where progress can be achieved quickly (‘low hanhing fruit’)

- Priority to processes that closely address CRAICC objectiveness (cryosphere-atmosphere interaction)
- Öystein: urgently needed progress: classifying the organics as regards to their volatility, size distributions
- Henrik: possibility to use DEHM ? (AMAP model)

How do we address the feedback arrows? Can we formulate specific 'low-hanging fruits'?

VOC emissions (hygroscopicity properties),

Sea salt content

A list of what is available from WP3 right now to other WP's; discussion whether a list of measurements is needed - or should we start from formulating the research questions and then define what is needed, and if it is already existing!

<u>We should define focused projects that are addressing "burning" questions and 'low-hanging fruits', implementing to models</u>

1. Origin of particles - importance of long range transport compared to local emissions

   PEOPLE: Henrik, Jacob Klenø Nøjgaard, Andreas Massling LiseLotte Sørensen, Jesper Christensen, Rossana Bossi

   - what is the effect of open water/partially ice covered sea/ice? transport processes….
   - where is NPF happening vertically? over which surfaces? is it regional or open phenomenon? is free troposphere needed? (Flex part, Nanmap, eulerian models)
   - what is emitted from the ice covered/open sea surface (CO2, CH4, sea spray, DMS, org. amines, isoprene…)
   - what is the spatial scale? ESM 200 km grid – how to tackle the small scale issues ?
   - detailed trajectories (nanoMet method?)

2. What is the key in aerosol formation in Arctic- aerosol processes or atmospheric dynamics?

   PEOPLE: Radek? others?

   - The importance of processes in the boundary layer and in the free troposphere (boundary layer height)
   - comparison between St Nord and Svalbard (difference in BL height)
   - transport patterns in boundary layer vs above boundary layer?
   - Using the measurements of ozone, NOx and other gasses to interpret
   - Transport from aloft (mixing between boundary layer end free troposphere)
   - can we make fingerprints for different sources ? isotopes?
   - source apportionment (DEHM?) New Ålesund – Barrow comparison

3. Biogenic (both terrestrial and marine/aquatic) emissions (VOCs, Br, DMS, sea spray, other unknown compounds…) - changes due to warming and links to cryosphere; Air/sea/atmosphere interchange

   PEOPLE: Jaana? Matt & Douglas? others?

   - High Arctic is disappearing; where it used to be tundra now trees are growing!
   - boreal forest with vegetation growth and changes as well as seasonal variations in emission functions, new parameterization of SOP with increasing temperature
   - marine and aquatic sources: role of algae in VOC production, changes due to temperature? Br from frost flowers?
   - testing in global models (now only in CTM)? formulation of parameters for summer and winter separately?
   - some data in literature available even though our measurements are scarce for marine sources (for VOCs: ASCOS campaign etc.);
   - sea spray data existing (Douglas and Matt), also the effect of temperature change has been analysed
   - The effect decreasing sea ice and changing sea ice composition:
     - Test the importance of more open water on the production of sea spray (effect from T, wind speed and area) using the latest lab data from Stockholm

4. Chemistry of boundary layer and troposphere (halogens, other)

PEOPLE: Marianne, Merete, Ngyunh

- are precursors or oxidized products transported? O3 variations when NPF observed
- characterizing aerosols from cryosphere sources
- CCN properties of organic sulphates
- release of N-compounds from melting ice and permafrost can be significant!

Deliverables; update on what is finished and what need to be done:

TO BE FINISHED BY THE END OF 2014? 3: Snow sample analyses results (M40) Aki Virkkula, Henrik Skov, Ingeborg,

DONE 4: Identification and quantification of sources of SLCFs in the Arctic (M12)

DONE 5: Report on model analysis on past variation in emissions on SLCFs and their influence on the Arctic climate and cryosphere (M18)

DONE 7: Report on quantified records of variations of SLCFs over short (seasonal) and long (millennial) time-scales (M30)

DONE 10: Data and parameterizations on the cloud droplet and ice nucleating properties of different aerosol types from laboratory studies, and aerosol-cloud interactions based on the process-oriented Arctic field campaigns and process-based modeling. (M30)

DONE 12: Analysis of cryosphere-atmosphere interactions that need to be included in Earth System Model simulations (M12)

WILL BE DONE AS A RESULT OF THESE WORKSHOPS AND LAST TWO YEARS' WORK 13: Analysis and quantification of cryosphere-atmosphere-climate feedback loops in the ESM results (M50)

Further discussion about:

- Planned experiments at Villum Research Station (=Station Nord)
    - a planning meeting will be organized by Henrik Skov in early April (in Park Hotel Copehnagen?) In the Station Nord Cryosphere atmosphere interaction will add info to point: 5, 12

Extra notes from Jon Eigil Kristjamsson: the need from WP3 to Earth System Models

Limitations of the ESM compromise coarse resolution and simplified chemistry (parameterization)

The model needs to be credible (Validation)

Examples:

1. Possible aerosol-related feedback loops in the Earth System (Climate-> terrestrial biosphere -> SOA->clouds->climate

2. Climate ->sea ice -> sulphate, POM

3. Sea salt -> clouds -> climate

Parameterization in the Climate model means expressing processes that are too small-scale or complex to be physically represented in the model by simplified relations using model resolved variables =>

Examples of what has been made: Sea salt emissions (Stockholm experiments; Mårtensen et al. 2003) Sea salt emission dependency on temperature and wind speed

SW Optical properties of clouds Needs: Droplet size distribution -> effective radius r_{eff} , liquid water content; extinction (optical depth), Phase function -> asymmetry parameter, absorption -> single scattering albedo => Feed into 2-stream radiative transfer calculation -> cloud albedo

So, how do we achieve integration obs<-> models in the last 2 years of CRAICC

- Unique opportunity: Station Nord campaign 2015
- ARM campaign Hyytiälä

Properties to ESM

Analysis of particle number from station Nord and other stations: Identification of period with < 1 cm^{-3}

Effective radius of particles and hygroscopicity

Consider using models such as WRF-chem or Oslo CTM/EMEP/…. Or NorESM at 0.5^{o} with nudging to ECMWF data

Identify processes where progress is urgently needed or where progress can be achieved quickly ('low hanhing fruit')

Priority to processes that closely address CRAICC objectiveness (cryosphere-atmosphere interaction)

DISCUSSION

VOC emissions (hygroscopicity properties),

Sea salt content

A list of what is available from WP3 right now to other WP's

We should define focused projects that are addressing "burning" questions

1. Origin of particle importance of long range transport compared to local emissions
2. What is emitted from the ice covered sea surface (DMS, org. amines, isoprene…)
3. The importance of processes in the boundary layer and in the free troposphere (The boundary height): Using the measurements of ozone, NOx and other gasses to interpret
4. Transport from aloft, (mixing between boundary layer end free troposphere
5. Terrestrial emission changes from boreal forest with vegetation growth and changes as well as seasonal variations in emission functions, new parameterization of SOP with increasing temperature

6. Do from lakes
7. Air/sea/atmosphere interchange (Br, VOC and oxidation product) relevant for now only for CTM models
8. The effect decreasing sea ice and sea ice composition
9. Test the importance of more open water on the production of sea spray (effect from T, wind speed and area) using the latest lab data from Stockholm
10. New particle formation where does it happen and what are the sources…. (Flex part, Nanmap, eulerian models)
11. CCN properties of organic sulphates