Arctic Ocean Acidification Assessment 2010–2013

What is the status?
What are the potential consequences?

The (necessary) chemistry part...

Pelejero et al., TrEE, 2010

Adapted from Bellerby, et al, 2005.
and in NORACIA 2010

Surface ocean pH reduction over this century will exhibit large regional variability

Reductions in pH over this century will be greatest in the Arctic

Change in surface ocean pH in the 21st Century

AOA - Arctic Ocean Acidification
- Delivered to the 2013 Ministerial meeting
- Science report
- Layman style summary report
- Film – 3 & 14 min.

AOA Chapters:
1. Introduction
2. Arctic Ocean Acidification
3. Biological responses to OA in the Arctic
4. OA’s Economic impacts on Arctic Fisheries
5. Conclusions and recommendations

http://www.amap.no
The ocean pH changes will persist for thousands of years. Because the fossil fuel CO$_2$ rise is faster than natural CO$_2$ increases in the past, the ocean will be acidified to a much greater extent than has occurred naturally in the past [Caldeira and Wicket, 2003].

**Ocean Acidification is Accelerating**

A recently published analysis projects that changes in the acidification of the deep ocean may exceed anything seen in the past 65 million years. Andy Ridgwell, et al., *Nature Geoscience*, 14 February 2010

**Trends over the Past Decade in Three Locations**

*Projected Global Mean Ocean/Land Temperature for 2100*

Projections based on publically available emission targets of 193 nations: UNFCCC, including the Copenhagen Accord Commitments

**Relative isolation of Arctic air means high-latitude sources primarily determine Arctic BC loads**

1. Poll/Inj - injection into arcticstratosphere
2. Fast transport to high tropopause with multiple aerosol removal events
3. Slow atmospheric transport
4. Lifting at high latitudes
5. Top of Greenland does not reach low-level transport
6. Fast transport from BC deposition on snow
7. Agricultural fires reach aerosols into free troposphere with little removal

**Annually Averaged Temperature Increase due to CO$_2$ vs. Short-Lived Pollutants (relative to pre-industrial)**

- CO$_2$ average
- BC-atmos
- BC-snow
- CH$_4$
Emissions of BC by Sector and Region

<table>
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<tr>
<th>Sector</th>
<th>Arctic Council Nations</th>
<th>US</th>
<th>Canada</th>
<th>Russia</th>
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<tr>
<td>Agricultural Fires</td>
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<tr>
<td>Grass + Forest Fires</td>
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</tr>
</tbody>
</table>

Note different y-axes for Arctic Council Nations and ROW!

Lamarque et al., ACP, 2010

BC - Summary findings

- Reductions in the emissions of CO$_2$ are the backbone of any meaningful effort to mitigate climate change.
- BC deposited to Arctic snow and ice results in a positive radiative forcing.
- Global direct atmospheric forcing due to BC leads to Arctic warming.
- BC emitted near or within the Arctic will have the greatest impact on Arctic climate and especially on surface temperatures

AMAP Deliverables 2011-2017

- ArcRisk - Combined Effects of Contaminants and Climate on humans;
- Arctic Ocean Acidification
- SLCF reports – BC, Ozone & Methane;
- SWIPA Follow up reports.
- OGA, POPs and Mercury follow up.
- Arctic Change Assessment - ACA
- climate, resource extraction, transport, new species, immigration of people, tourism, etc.

Arctic - the barometer of the globe