Multiproxy climate and sea ice reconstruction of the industrial era at the Western Antarctic Peninsula

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IMPORTANT NOTE:
I reduced the content of this presentation to the most important results. The full story can be found in the open discussion of the manuscript.
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Introduction and study area

The Western Antarctic Peninsula (WAP) is a region heavily exposed to recent rapid warming that experienced sea ice retreat recently.

We studied the development of spring sea ice and environmental conditions in the pre-satellite era (about 240 years) using the novel proxy IPSO$_{25}$ (Ice proxy for the Southern Ocean C$_{25}$) in a multiproxy study.

IPSO$_{25}$ is an organic biomarker derived from sea ice diatoms (Belt et al., 2016).

We reconstructed climate and sea ice conditions at the WAP using the three short marine sediment cores PS97/056-1, PS97/068-2 and PS97/072-2 and compared our findings with satellite sea ice observations, numerical modelled data and ice core data. Dating based on $^{210}$Pb.
Methods: Analyses

We analysed compound specific lipid biomarkers and diatom fossils.

<table>
<thead>
<tr>
<th>Biomarkers</th>
<th>Proxy for</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly branched isoprenoids (HBIs)</td>
<td>HBI diene = <strong>IPSO</strong>&lt;sub&gt;25&lt;/sub&gt; (Ice proxy for the Southern Ocean C&lt;sub&gt;25&lt;/sub&gt;) = spring sea ice proxy (Belt et al., 2016)</td>
<td>Lipid extraction, GC-MS</td>
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<tr>
<td></td>
<td>HBI Z- and E-trienes = open marine proxies</td>
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<tr>
<td>Glycerol dialkyl glycerol tetraethers</td>
<td>Subsurface ocean temperature based on TEX&lt;sub&gt;86&lt;/sub&gt; and OH-GDGTS</td>
<td>Lipid extraction, HPLC</td>
</tr>
<tr>
<td>Diatom fossils</td>
<td>Winter sea ice cover (WSI)</td>
<td>Microscope slides, identification, counting, transfer function</td>
</tr>
<tr>
<td></td>
<td>Summer sea surface temperature (SSST)</td>
<td></td>
</tr>
</tbody>
</table>

+ Satellite data + Numerical modelling + Marine Sediments + Ice Cores

**AWI-ESM2**
We applied a sea ice index for spring sea ice cover: a combination of an open marine proxy with the sea ice proxy.

\[ \text{HBI Z-triene} + \text{IPSO}_{25} \rightarrow \text{P}_2\text{IPSO}_{25} \]

\[ \text{PIPSO}_{25} = \frac{[\text{IPSO}_{25}]}{([\text{IPSO}_{25}] + [\text{HBI Z - triene}])} \]

(after Vorrath et al., 2019; based on PIP_{25} from Müller et al, 2011)
Results (only PS97/068-2)

Phytoplankton biomarker rise

Winter sea ice rise

Subsurface ocean temperature no trend

Sea ice biomarker rise

Sea ice index rise

Summer SST no trend

Subsurface Ocean temperature decrease

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Sea ice biomarker vs. satellite sea ice observations vs. modelled sea ice

✓ Spring Sea ice biomarkers (IPSO$_{25}$, PIPSO$_{25}$) correspond to spring satellite sea ice cover (satSSIC)

✗ Modelled spring sea ice cover (mSSIC) does not compare well to any of the biomarkers or satellite data

✓ Winter sea ice (WSI) derived from diatoms corresponds to winter satellite sea ice cover (satWSIC)
A close look on sea ice from the last 240 years (all cores)

IPSO\textsubscript{25}, PIPSO\textsubscript{25} and WSI indicate rising sea ice cover towards present

Modelled sea ice, MSA (methanesulphonic acid, Abram et al., 2010), reconstructed and modelled sea ice edges show a decrease of sea ice cover/extent towards present

= Sea ice biomarker and index are not significant for the quantity of sea ice but more for the quality

= High seasonal sea ice contrasts promote the growth of both sea ice and open ocean diatoms although there might be less sea ice in total
Conclusion

- If the pattern of sea ice and phytoplankton biomarker are similar, sea ice conditions have been favorable for both sea ice diatoms and phytoplankton

Higher biomarker concentrations remain from:
- Melting of sea ice releases nutrients
- Primary production is high at sea ice edges
- Freshwater input stabilizes the water column
- Thinner sea ice allows a higher light penetration and higher sea ice diatom growth

At the Western Antarctic Peninsula, seasonal sea ice contrasts have significantly increased since the 1930s
References


