TIME SERIES AND BOX MODEL SIMULATION OF N₂O AND CH₄

at the Time Series Station Boknis Eck, SW Baltic Sea

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46th International Liège Colloquium
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Motivation & Outline

N$_2$O and CH$_4$: climate-relevant trace gases

- recent & future emissions?
- biogeochemical cycles
- Time Series

How do concentrations vary in time?

Which processes are major sources and sinks?

Are coastal areas similar worldwide?
...a suitable location to study oxygen sensitive trace gases.
Temporal Variations: N\textsubscript{2}O

Mean seasonal profile (8 years)

- Depth (m)
- N\textsubscript{2}O (nmol L\textsuperscript{-1})

Graph showing N\textsubscript{2}O concentration over time from January 2006 to January 2014.
Temporal Variations: CH$_4$

Mean seasonal profile (7 years)

Mean water column

CH$_4$ (nmol L$^{-1}$)

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Nitrous Oxide: Box Model

Air-sea exchange

$n_2O$

Mixed layer

nitrification (in situ)

Upward mixing, Diffusion across pycnocline

![Graph showing nML over time from Jan06 to Jan13]
Nitrous Oxide: Sources and Sinks

**Sources**

- January: ±0.03 (Mixing)
- February: ±0.03 (Emission)
- March: ±0.03 (Vent. Peak)
- April: ±0.03 (Diffusion)
- May: ±0.03 (Diffusion)
- June: ±0.03 (Diffusion)
- July: ±0.03 (Diffusion)
- August: ±0.03 (Diffusion)
- September: ±0.03 (Diffusion)
- October: ±0.03 (Diffusion)
- November: ±0.03 (Diffusion)
- December: ±0.03 (Diffusion)

**Sinks**

- January: ±0.03 (Emission)
- February: ±0.03 (Emission)
- March: ±0.03 (Emission)
- April: ±0.03 (Emission)
- May: ±0.03 (Emission)
- June: ±0.03 (Emission)
- July: ±0.03 (Emission)
- August: ±0.03 (Emission)
- September: ±0.03 (Emission)
- October: ±0.03 (Emission)
- November: ±0.03 (Emission)
- December: ±0.03 (Emission)
Methane: Box Model

Air-sea exchange

Enhanced production 1 month after bloom (in situ)

Mixed layer

CH$_4$

mixing

Sediment flux

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Model results

Measurements

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Methane: Sources and Sinks

Sources

Sinks

Mixing
Emission
Sediment
Chl. a

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Longterm trends

\[ \text{N}_2\text{O} \]

Production vs. oxygen

\[ \text{CH}_4 \]

Concentration vs. depth

Solubility vs. temperature

⇒ Emissions are likely to increase

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Comparison to...

... shelf off Chile

... Arabian Sea

Farias et al. in Naqvi et al., 2010

Naqvi et al., 2010
Conclusions

<table>
<thead>
<tr>
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<th>$\text{N}_2\text{O}$</th>
<th>$\text{CH}_4$</th>
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</thead>
<tbody>
<tr>
<td><strong>Temporal variation</strong></td>
<td>seasonal cycle ($T, O_2$) no trend</td>
<td>seasonal cycle (Chl. a, $O_2$) no trend</td>
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<tr>
<td><strong>ML source</strong></td>
<td>transport across ML boundary</td>
<td>sediment flux</td>
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<tr>
<td><strong>ML sink</strong></td>
<td>emission to atmosphere</td>
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Shallow coastal areas are complex systems, where simple generalisations should be applied with caution.
Thank you for your attention!

More information at www.bokniseck.de

Thanks to:
Captain & crew of RV Littorina,
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Tina Baustian,
Ma Xiao.
Nitrous Oxide: dN2O vs. AOU

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Nutrients
Methane: Time lag

Bange et al., 2010
Nitrous oxide: Time Series
Time Series CH$_4$
Boknis Eck: Seasonality

**Strong summer stratification**

**Regular hypoxia in late summer**
Ongoing decline in bottom water oxygen concentration
Seasonal Variations: N₂O

The role of apparent oxygen utilisation for N₂O production
Seasonal Variations: \( \text{N}_2\text{O} \)

\( \text{N}_2\text{O} \) concentration rises after breakdown of summer stratification.
Temporal Variations: $\text{N}_2\text{O}$

- AOU ($\mu$mol L$^{-1}$)
- $\Delta$ $\text{N}_2\text{O}$ (nmol L$^{-1}$)

bottom layer (25 m)