RETRIEVAL OF SUSPENDED PARTICULATE MATTER FROM TURBIDITY

– MODEL DEVELOPMENT, VALIDATION, AND APPLICATION TO MERIS DATA

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Why to retrieve Suspended Particulate Matter?

- SPM causes most of the scattering in natural waters
  - Strong influence on underwater light field and consequently to the whole ecosystem
- SPM is the parameter of main interest for sediment transport and hence a good indicator of coastal dynamics
- Assessment of the eutrophication status of the Baltic Sea can be improved by monitoring SPM
Aims

• To provide a reliable model to estimate Suspended Particulate Matter (SPM) concentration from turbidity for the Baltic Sea

• To improve the retrieval of SPM concentration from remote sensing reflectance via turbidity
Study area

- Six measurement areas along the Swedish coast of the Baltic Sea
  - Transects from coastal to open sea
  - In total 26 measurement locations
## Dataset

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Number of measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>August</td>
<td>10</td>
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<tr>
<td>2011</td>
<td>July-August</td>
<td>23</td>
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<tr>
<td>2012</td>
<td>April-July</td>
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<tr>
<td>2013</td>
<td>June-September</td>
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<tr>
<td>2014</td>
<td>February-May</td>
<td>22</td>
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<tr>
<td></td>
<td>In total</td>
<td>113</td>
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</table>
## Dataset

### Model development

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**Dataset**

**Model development**

**Validation**
Methods

In situ - measurements

• **SPM** concentration measured gravimetrically according to Strickland and Parsons (1972)
• **Turbidity** measured with a portable turbidity meter – Hach Lange 2100Qis (ISO 7027)

Remote sensing methods

• **MERIS** (Medium Resolution Imaging Spectrometer)
  The standard processor MEGS 8.1
  • SPM product
  • Reflectance at 620 nm
Results
Results

- SPM model

\[
\ln(\text{SPM}) = -0.081 + 0.97\ln(\text{turbidity})
\]

\[r^2 = 0.93\]
Results

• Including these possible explanatory variables did **not** improve the model
  - Area
  - Coastal / Open sea –status
  - Proportion of Inorganic Matter
Results

• Including these possible explanatory variables did not improve the model
  o Area
  o Coastal / Open sea –status
  o Proportion of Inorganic Matter

• Importance of correlation of measurement stations was assessed by
  o grouping the data (same date + area + coastal/open sea -status)
  o fitting a mixed model

• The variance between individual measurement stations was more important than between the groups
Results

- Validation with 2013-2014 data set

\[\text{RMS} = 25.5\%\]
\[\text{MNB} = 2.6\%\]
\[n = 44\]
Conclusion 1:

- SPM concentration can be derived reliably from in situ turbidity along the Swedish coast of the Baltic Sea with our SPM model
Application to MERIS data
## Match-up Dataset

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<td>2010</td>
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<tr>
<td></td>
<td></td>
<td><strong>In total</strong> 32</td>
</tr>
</tbody>
</table>
Application to MERIS data

- Comparison of MERIS SPM product with in situ SPM concentration
  - The standard processor MEGS 8.1

![Graph showing the comparison between SPM MERIS and SPM in situ with RMS = 47.4 %, MNB = 11.3 %, n = 32](image)
Application to MERIS data

- Nechad (2009) algorithm to retrieve turbidity from MERIS reflectance at 620 nm

$$\text{Turbidity}_{\text{Nechad}} = \frac{174.41 \cdot \text{reflectance}_{620}}{1 - (\text{reflectance}_{620}/0.1533)} + 0.39 \ [\text{FNU}] \ (1)$$

- The SPM model to retrieve SPM concentration from turbidity

$$\text{SPM} = -0.081 + 0.97 \cdot \ln \ (\text{Turbidity}_{\text{Nechad}}) \ [\text{gm}^{-3}] \ (2)$$
Application to MERIS data

• Nechad (2009) algorithm to retrieve turbidity from MERIS reflectance at 620 nm

\[
\text{Turbidity}_{\text{Nechad}} = \frac{174.41 \cdot \text{reflectance}_{620}}{1 - (\text{reflectance}_{620}/0.1533)} + 0.39 \ \text{[FNU]} \quad (1)
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• The SPM model to retrieve SPM concentration from turbidity

\[
\text{SPM} = -0.081 + 0.97 \cdot \ln (\text{Turbidity}_{\text{Nechad}}) \ \text{[gm}^{-3}] \quad (2)
\]
Application to MERIS data

- Comparison of modelled SPM with in situ SPM concentrations

MERIS reflectance at 620 nm

Nechad’s Turbidity

SPM model

SPM concentration

RMS = 40.3%
MNB = -4.9%
n = 32
Distribution of SPM in the coastal zone

MERIS SPM product 2008-07-15

Modelled SPM 2008-07-15
Distribution of SPM in the coastal zone

MERIS SPM product 2008-07-28

Modelled SPM 2008-07-28
Conclusion 2:

• The retrieval of SPM concentration from MERIS data can be improved when retrieving turbidity from remote sensing reflectance and applying our SPM model
Conclusions

• With our SPM model, SPM concentrations can be derived reliably both from in situ turbidity and from remote sensing reflectance via turbidity.

• We recommend regular in situ turbidity measurements and the use of remote sensing data in monitoring programs of the Baltic Sea.
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