Ocean color remote sensing for the study of Arctic marine ecosystems: II- Algorithm development and data processing platforms

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TAKUVIK
Outline

• Rational

• Primary production processing chain

• Sediment export from the Mackenzie River

• Conclusion and recommendation
Primary production in the Ocean Arctic is increasing but no consensus has been reached (Ardyna et al., 2011; Arrigo and van Dijken, 2011; Wassmann and Reigstad, 2011; Tremblay et al., 2012; Pe-trenko et al., 2013)

Phytoplankton community structure is shifting in the Arctic Basin from large to small cells (Li et al., 2009) with implication on carbon cycle, transfer of energy to higher trophic level

More frequent incursion of fish and zooplankton from intermediate latitudes waters to Arctic waters (Falardeau M., Robert D., Fortier L., 2014)

River Discharge is increasing causing an increase in sediment and carbon (particulate and dissolved) export towards the arctic shelf and basin and modification of the light regime
\[ PP(z, t) = C \times P_B^{max} \left( 1 - \exp^{-PUR(z)/E_K(PUR)} \right) \]
\[
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\]

- Light Regime
- + RT Model

MODIS and ISCCP dataset

- Level 3 data: Cloud Fraction, cloud optical thickness, Ozone
- Wind field (NCEP, NCARR) 
  (Bélanger et al. 2013)
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- **Light Regime + RT Model**
  - MODIS and ISCCP dataset

- **Marine Bio-optical environment**
  - SeaWiFS, MODIS and MERIS

- **Phytoplankton phenology and vertical distribution**
  - Phenology from OC remote sensing
  - Phytoplankton vertical distribution from a large archive of in situ Chl data
    (Ardyna et al. 2013, 2014)
Light Regime + RT Model

Marine Bio-optical environment

Phytoplankton phenology and vertical distribution

- Pan Arctic Primary Production and associated products (42 products in total)
- From 1998 to 2014, daily and monthly at 4km resolution
- Includes most recent regional algorithms
- Monthly PP data are on the process of being distributed through the Polar Data Catalogue (https://www.polardata.ca/)
\[ PP(z, t) = C \times P_B^{max} \left(1 - \exp^{-PUR(z)/E_K(PUR)}\right) \]

Time series of PP in a sub-region of the Beaufort Sea

Year

Need to address sensor inter-calibration to compile “climate change compatible” dataset
How is our model performing?

Participation in the Net Primary Productivity Algorithm Round Robin (PPARR):
- 32 Ocean color models (6 versions from Takuvik)
- 560 stations, 83 with satellite matchups

✓ In general models performed best when using in situ Chl
✓ Takuvik-UQAR models among the best performing model
✓ Results published in the coming year
How much confidence can we have in Satellite-retrieved Chl?

- HPLC-derived Chl database averaged over top 20m: 279 samples
- 4 algorithms tested

Russian waters are under sampled
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SeaWiFS

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Russian waters are under sampled

Pursue effort to develop best possible bio-optical algorithms (more in situ sampling is needed)
Suspended Particulate Matter (SPM) in the Mackenzie River

- Increase in air temperature and precipitation
- Decrease in sea-ice: thickness and extent
- Increase in the active layer of permafrost

What is the impact on sediment transport and particulate carbon fluxes?

- Time series of Level 1 MODIS-Aqua data (2003-2013)
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Doxaran, Devred and Babin, submitted to Biogeosciences
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- Original atmospheric correction scheme
- State-of-the-art SPM algorithm from in situ data (MALINA 2009)
Monthly composite from May to September and from 2003 to 2013

Sea-ice is used to remove contaminated pixels (SIC > 10%)

Between 2 and 25 images per month out of 180 possible, cloud cover is a major issue

Doxaran, Devred and Babin, submitted to Biogeosciences
Significant increase in SPM concentration and fluxes of particulate organic carbon in the mouth and delta of the Mackenzie River

Significant increase in the export of SPM and fluxes of particulate organic carbon from the Mackenzie River to the continental shelf and Arctic Basin

<table>
<thead>
<tr>
<th>SPM increase (%)</th>
<th>Concentration</th>
<th>Fluxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouth</td>
<td>46</td>
<td>36</td>
</tr>
<tr>
<td>River</td>
<td>51</td>
<td>71</td>
</tr>
<tr>
<td>Delta</td>
<td>33</td>
<td>_</td>
</tr>
</tbody>
</table>

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Remote sensing of ocean colour remains the only mean to obtain a detailed description of carbon cycle at the pan-arctic scale, including, phytoplankton production, export of particulate and dissolved organic matter. Some algorithms still suffer from a lack of regional tuning, even if an important effort is being carried out to develop local algorithms based on data collected in situ (c.f., M. Babin presentation). Regions such as the Beaufort Sea, the Baffin bay and the Russian continental shelf appeared as key areas to sustain or increase efforts to study processes in a rapidly changing Arctic (Russian waters are under sampled). Limitation of OC observations in the Arctic Ocean, as a result of cloud cover, remains a challenging issue.
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