OCEAN COLOUR REMOTE SENSING IN HIGH LATITUDE AREAS

Co-Chairs: Emmanuel Devred (U. Laval), Maria Tzortziou (CCNY), Toru Hirawake (Hokkaido U.), Antonio Mannino (NASA GSFC), & Rick Reynolds (SIO, UCSD)

Part I: ***Past field campaigns in Polar Seas: State-of-the-art, challenges, and gaps in existing datasets and remote sensing algorithm approaches***

09:30-09:35	**Introduction and overview** Antonio Mannino (NASA GSFC)
09:35-09:45	**Environmental challenges for polar remote sensing: surface to top-of-atmosphere** Knut Stamnes (Stevens Institute of Technology)
09:45-09:55	**Bio-optical relationships in high-latitude seas** Rick Reynolds (SIO, UCSD)
09:55-10:05	**Space-based estimates of marine primary production in polar waters** Kevin Arrigo (Stanford U.)
10:05-10:15	**Using remote sensing observations to address the role of calcifiers in high-latitude seas** Barney Balch (Bigelow)
10:15-10:25	**Ocean colour algorithms and datasets developed within the framework of the GRENE (Green Network of Excellence) Program** Toru Hirawake (Hokkaido U.)
10:25-10:45	**Discussion**
10:45-11:00	**Coffee Break**

Part II: ***Future oceanographic field campaigns in high-latitude areas, and needs for new remote sensing approaches and capabilities***

11:00-11:10	**The green edge project, tracking ice-edge bloom in a changing Arctic** Emmanuel Devred (U. Laval)
11:10-11:20	**Remote sensing of ocean colour in the Arctic using airborne hyperspectral sensors** Heidi Dierssen (U. Connecticut)
11:20-11:30	**"Arctic-ColourS: Coastal Land Ocean Interactions in the Arctic" - A field campaign scoping study funded by NASA's OBB (Ocean Biology and Biogeochemistry) Program** Maria Tzortziou (CCNY)
11:30-11:40	**"ICESOCC: Interdisciplinary Coordinated Experiment of the Southern Ocean Carbon Cycle" - A NASA OBB funded field campaign scoping study** Greg Mitchell (SIO, UCSD)
11:40-12:15	**Discussion**

OCEAN COLOUR REMOTE SENSING IN HIGH LATITUDE AREAS

1. Satellite remote sensing and bio-optical models

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OCEAN COLOUR REMOTE SENSING IN HIGH LATITUDE AREAS

1. **Satellite remote sensing and bio-optical model**
2. **Field campaigns and new approaches**

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Context

- Impacts of climate change most pronounced at high latitudes
  - Thawing permafrost
  - Warming seas, melting glaciers, land-fast and sea ice
- Remoteness hampers our traditional oceanographic sampling (infrastructure and cost)
- Remote sensing is clearly essential to resolve time and space scale issues in the Arctic and Southern Ocean, but
  - Ice cover, seasonal darkness, low sun elevation, cloud cover
  - Standard algorithms do not work well (regional tuning needed)
  - High winds … bubbles, breaking waves,

- High latitudes also important in regards to calcification and PIC

- Currently an IOCCG working group on Polar Seas

Satellite remote sensing

1. Issues with atmospheric corrections
   - usual coastal issues (high SPM, turbidity)
   + signal contamination by sea ice (edge and floating ice)
   + low sun zenith angles

<u>Current Response</u>

- Pseudo spherical approximation to deal with low solar zenith to account for Earth curvature (correction for Rayleigh scattering, but not implemented in current software)
- Flagging of ice contaminated pixels (regional)

<u>New approach</u>

- 3-D radiative transfer simulation couple with sea-ice BRDF measurement to quantify and correct for contamination
- Use NIR spectral information (physical state of water, sea-ice)
- High spatial resolution

Satellite remote sensing

2. Cloudiness and fog, no observations by early October (still open water)

=> Challenge in obtaining matchups

<u>Possible actions</u>

Geosynchronous satellite with inclined orbit (or other orbit permitting longer integration times in polar seas such as elliptical), lidar technology and other mean of measurements to complement OCRS (Airborne radiometer, Gliders, drones, unmanned autonomous vehicles), increase sun angle threshold (75^{o})

Satellite remote sensing

3. Bio-optical models and primary production

Acknowledge the peculiar properties of polar phytoplankton (low light adapted large species, strong packaging effect),

Large contrast of absorption budget between Arctic (strongly impacted by CDOM) and Southern Ocean (typically phytoplankton dominated): fundamental difference between the Southern Ocean (ocean surrounding a continent) and the Arctic (ocean surrounded by continent)

Semi-analytical approaches to estimate IOPs can potentially improve predictions compared to empirical models

- constituent-IOP relationships to estimate biogeochemical stocks
- direct utilization of a_ph to estimate NPP

Satellite remote sensing

3. Bio-optical models and primary production (continue)

NPP models need to account for deep chlorophyll maximum, can have significant regional impact but may balance out at the pan-arctic scale

Statistical approach to derive Chl(z) from Chl(surf)

Contribution to PP by under ice algae and water column blooms, how do we deal with it?

Field campaign initiatives

Lack of matchups (Rrs, Chl) in polar regions

Persistence of bias in sampling toward Summer and western part of Arctic Ocean. Southern Ocean regional bias, primarily because of logistical constraints

Under sampling in Arctic Ocean Basin as sea-ice retreats and in the Russian seas

Issue with localisation of autonomous underwater vehicles (gliders), issues related to extreme conditions

No socio-economic issues associated with these campaigns

Field campaign initiatives

Opportunities for new bio-optical measurements & development of RS retrievals in high latitude seas

Field Campaign Studies in Polar Seas currently under consideration for implementation by NASA (OBB Program):

- **Arctic-COLORS: Arctic Coastal Land Ocean interactions (Notional Timeline: Phase I to start in 2017)**
- **ICESOCC: Scoping for Interdisciplinary Coordinated Experiment of the Southern Ocean Carbon Cycle**
- **(Notional Timeline: Field Campaign to start in 2019)**

Green Edge, Canadian lead initiative to study the phytoplankton edge bloom

Also smaller scale field campaigns that allow collection of bio-optic data ex: ArcticNet continuous field campaign (Canadian archipelago and Beaufort Sea)

Take away message

A number of challenges but not insurmountable...

Ocean colour remote sensing remains essential to study remote Polar regions

Better database with better regional representation

Upcoming field campaigns will help address the challenges