→ ATLANTIC FROM SPACE WORKSHOP

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National Oceanography Centre
Southampton, UK

Potential of Sentinel-2 to monitor Arctic sea ice

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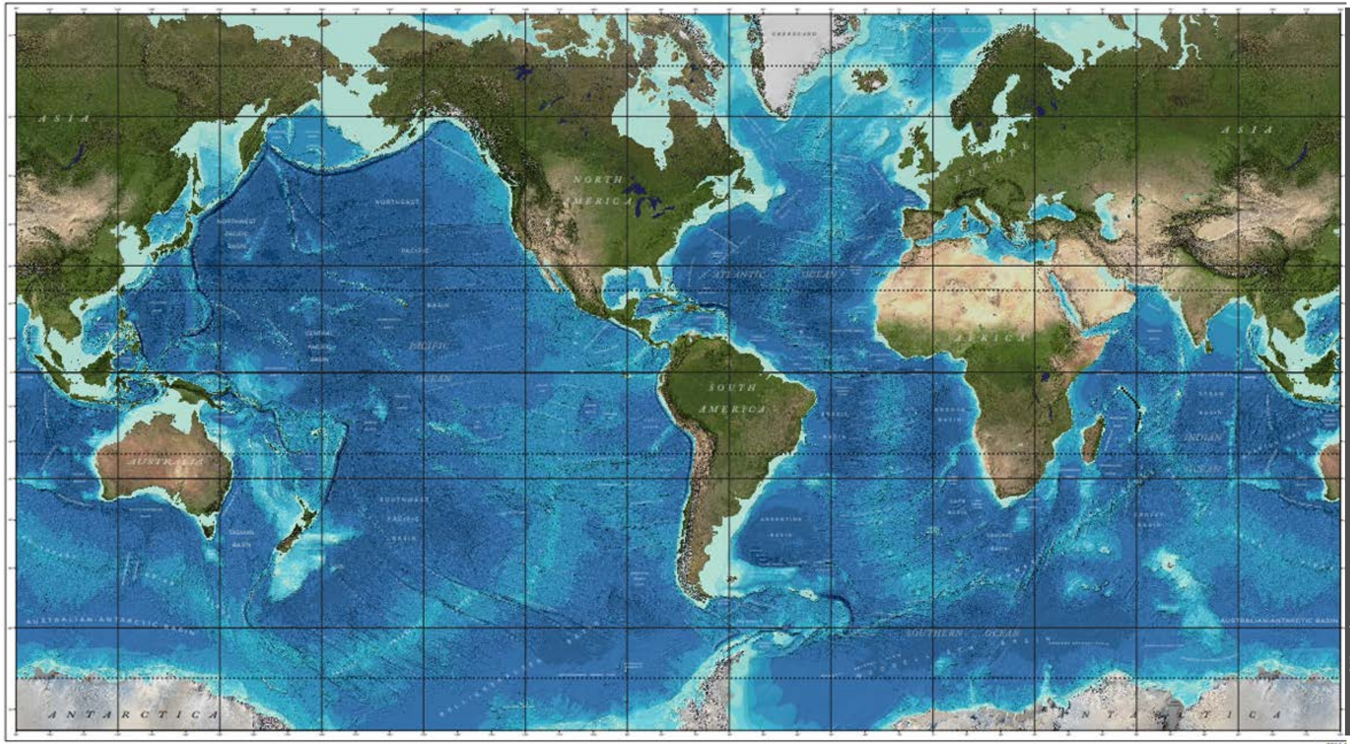
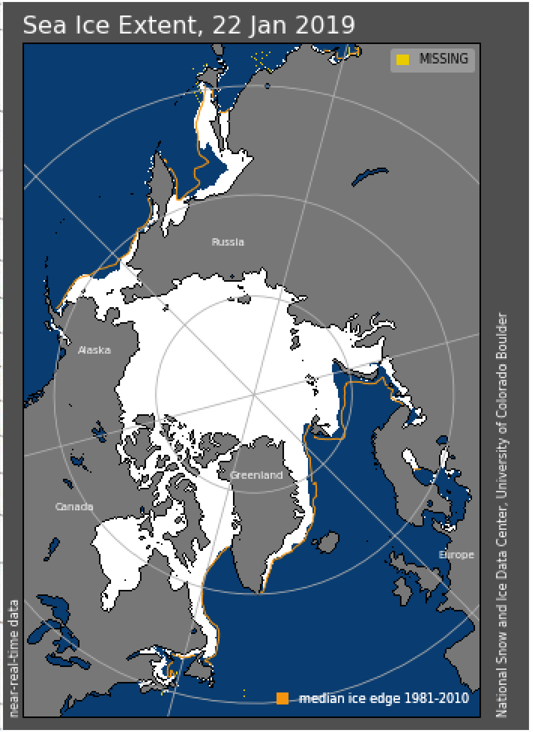
The Arctic



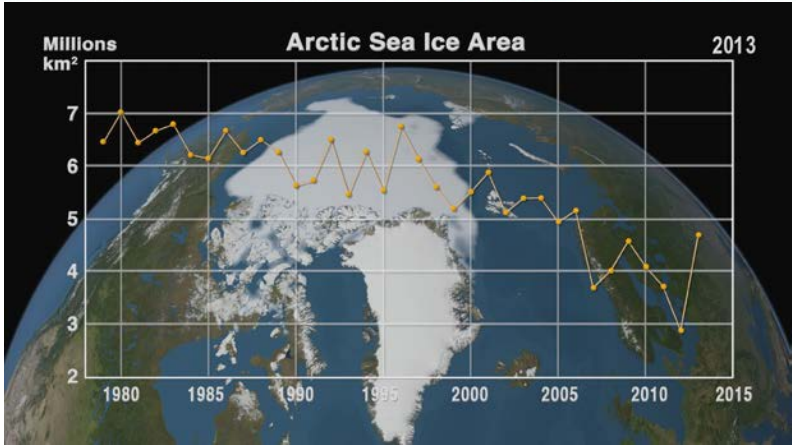
(www.gebco.net)



State of Arctic Sea Ice

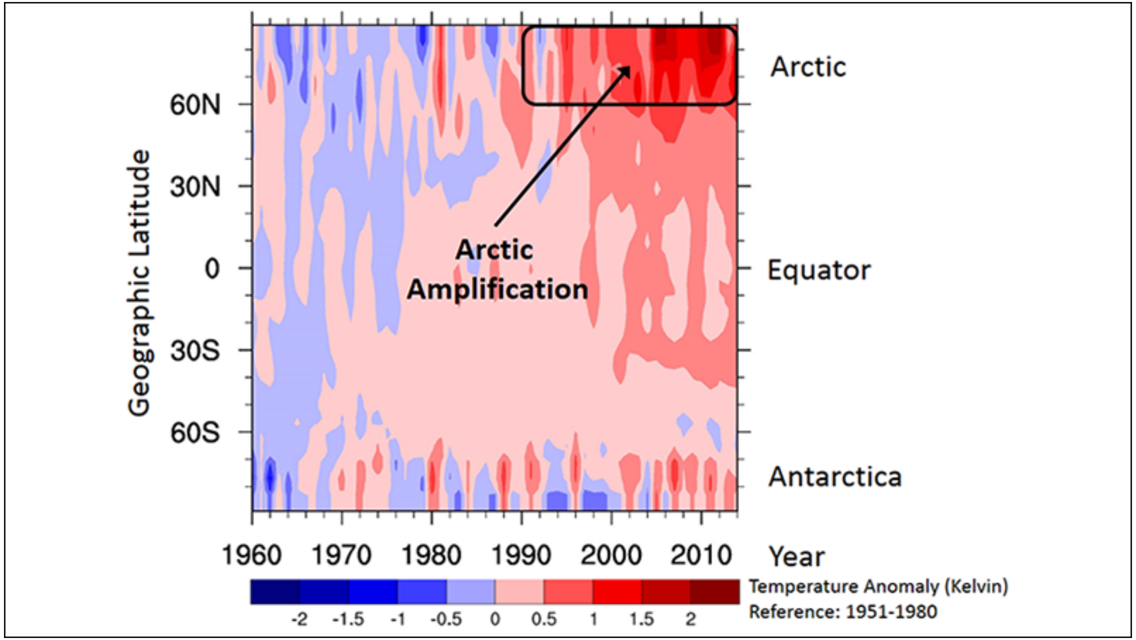
– Arctic sea ice extent is decreasing

– Arctic sea is thinning



(credit to NASA/Goddard Space Flight Center Scientific Visualization Studio)

Arctic Amplification

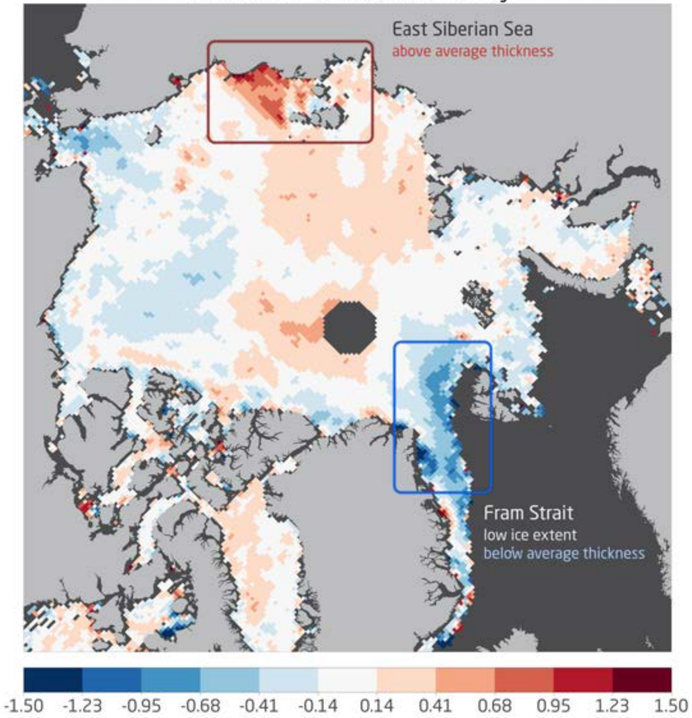


(Wendisch, M., et al. 2017. *Eos 98*, https://doi.org/10.1029/2017EO064803)

State of Arctic Sea Ice

Mainly active sensors,
e.g. CryoSat-2

Winter 2017/18 Thickness Anomaly

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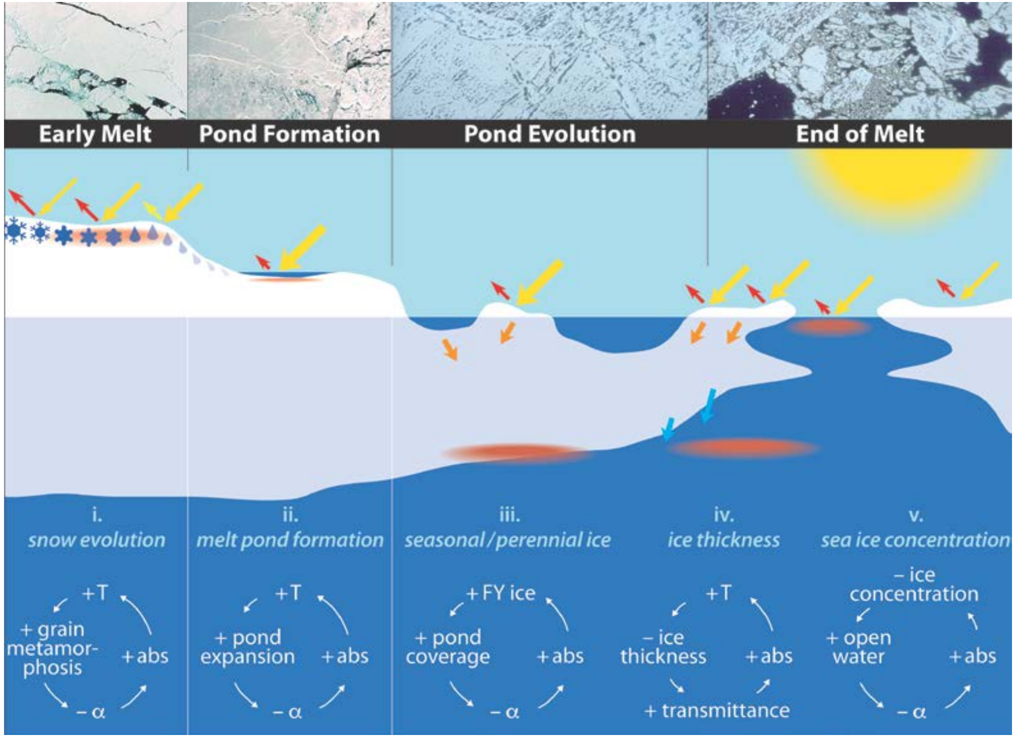
Development of Sea Ice during Arctic Summer



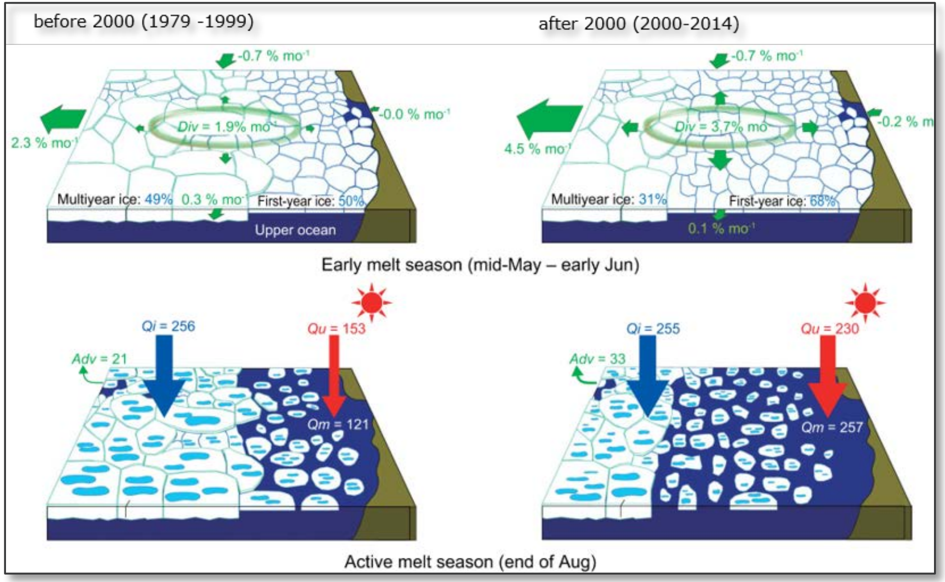
Motivating the measurements:

- Evolving optical properties of snow/sea ice cover drive changes in surface heat balance
- Factors that drive key feedbacks:
  - (i) Melting snow
  - (ii) Pond expansion
  - (iii) Pond coverage on FY/MY ice
  - (iv) Reduced ice thickness
  - (v) Reduced ice concentration
- Optical properties, increased heat, decreased ice, and decreased ice longevity all act to decrease albedo or increase transmittance

State of Arctic Sea Ice

Less multi year ice/more first year ice
⇨ More melt ponds
⇨ Deeper ponds

Impact on:
– Heat/radiation balance
– Ocean circulation
– Ecology
– Economy

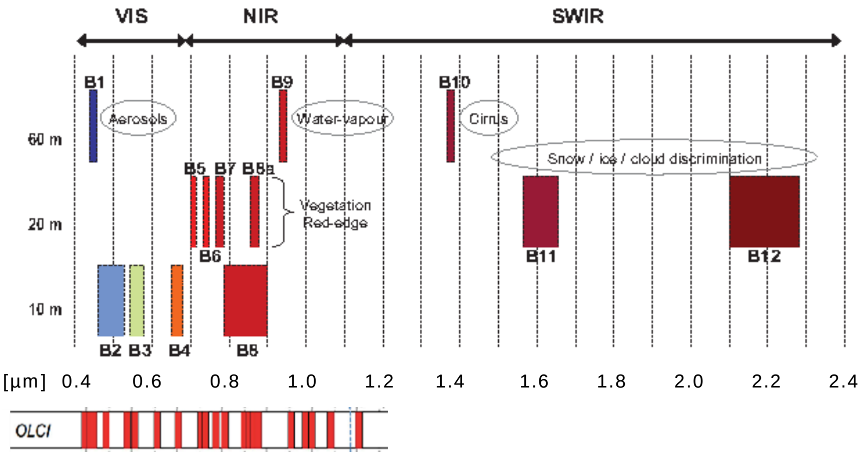


Heat input into upper ocean through open water fraction = Qu
Heat input at the ice surface and melt ponds = Qi

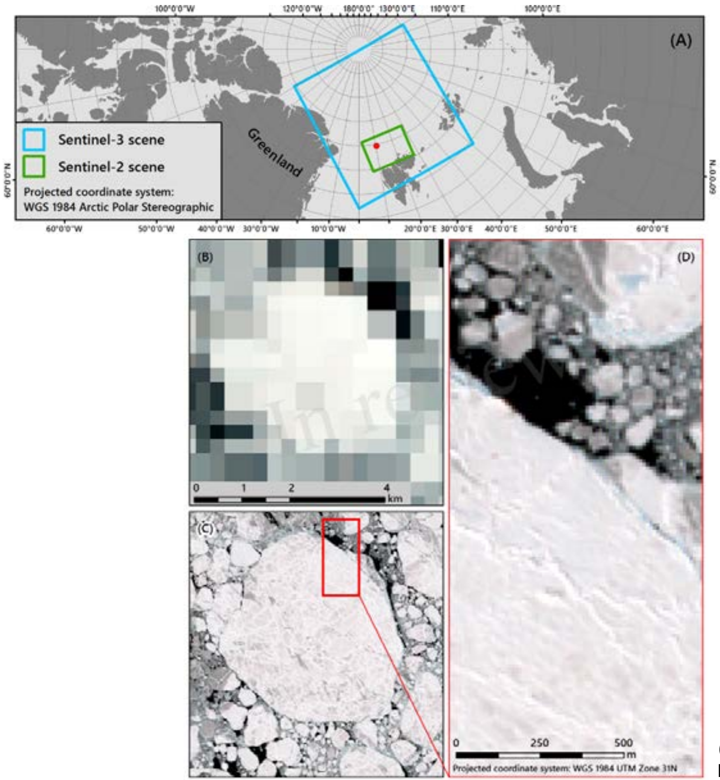
(Kashiwase et al. 2017. DOI:10.1038/s41598-017-08467-z)

Monitoring of the Arctic Sea Ice

- Sentinel-2 (A and B)
- Repetition rate : 5d (combined)
- MSI = 290 km swath, 10-60 m pixel



- Sentinel-3 (A and B)
- Repetition rate < 2 d (combined)
- OLCI: 1270 km swath, 300 m pixel



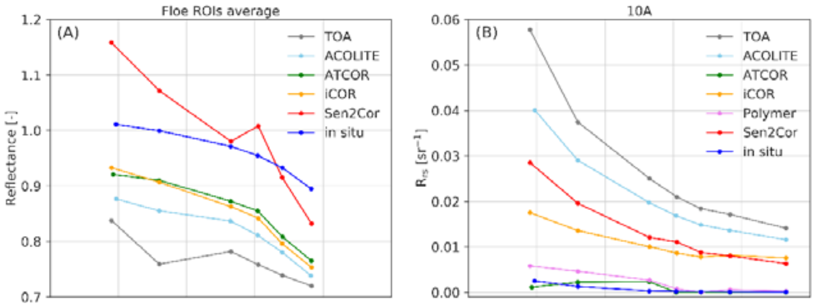
(König & Oppelt, Front. Mar.Sci. 2019)

European Space Agency

Monitoring of the Arctic sea ice with Sentinel-2

Optical measurements during Arctic summer

- ⇨ Albedo (spectral and broadband)
- ⇨ Pond fraction



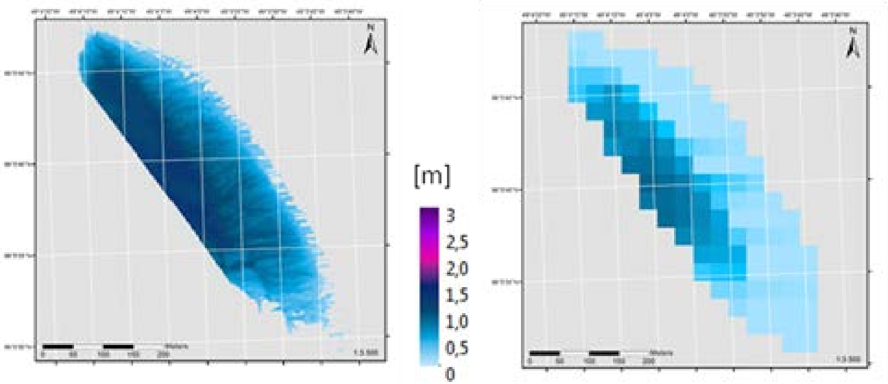
(König & Oppelt, Front. Mar.Sci. 2019)

(S2-A Julne 10, 2017)

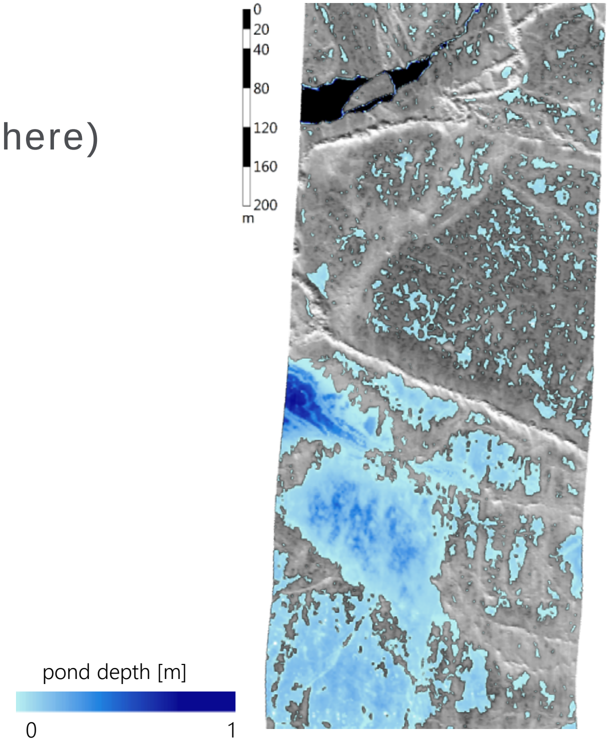
Monitoring of the Arctic sea ice - Optics

Optical measurements during Arctic summer

- ⇨ Cal/val measurements for radiative transfer models (atmosphere)
- ⇨ Cal/val for radiative transfer models (water)
- ⇨ Pond depth



Water depth modelling of AISA and Landsat ETM data (Meltex II, 2016)



Water depth modelling of AISA data (PS106, 2017)

Cal/Val Activities for Sentinel-2

- Arctic expeditions in 2016 and 2017
- Multidisciplinary drifting Observatory for the study of the Arctic Climate

September 2019 – September 2020

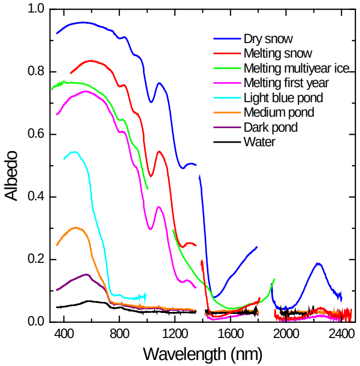
MOSAiC Ground Truth Measurements - Optics

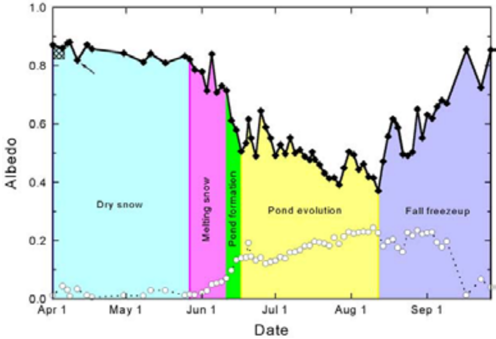
MOSAiC

Repeat transects

Albedo

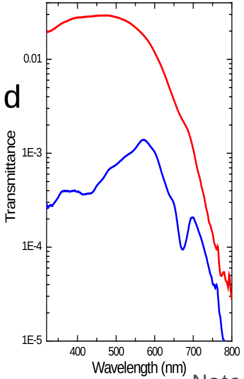
surface measurements (>200 meter, 5 m spacing)
spectral (350 – 2500 nm) and broadband
seasonal cycle (sun up)
non-destructive sampling
weekly / every other day

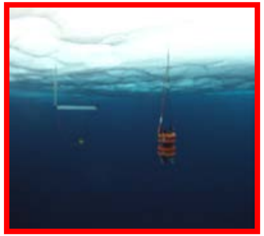


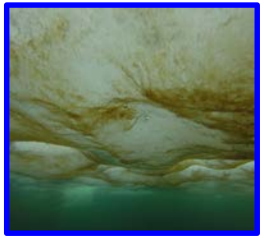


Transmittance

under-ice measurements on 100 m x 100 m grid
1 m spacing
spectral (350 - 1000 nm) and broadband
one-time destructive hole
minimize large scale surface drainage
weekly measurements



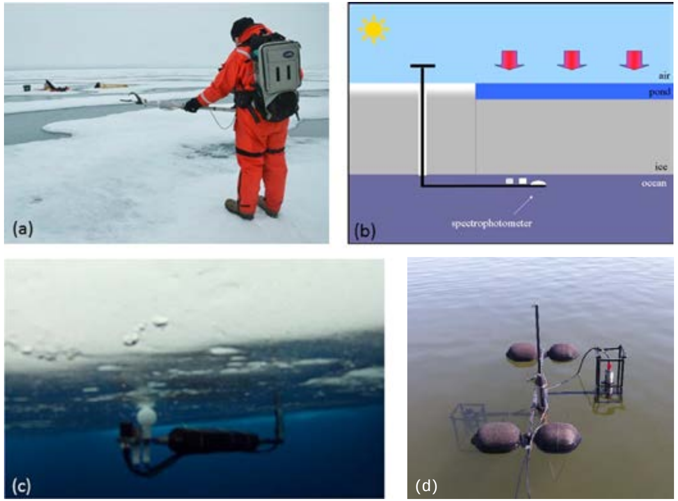




MOSAiC Ground Truth Measurements - Optics

Optical study sites

- some repeat visit sites
- some “one and done”
- albedo
- transmittance
- vertically resolved light attenuation
- variety of evolving surface types



Improved Understanding of Processes at different Scales

GROUND TRUTH MEASUREMENTS

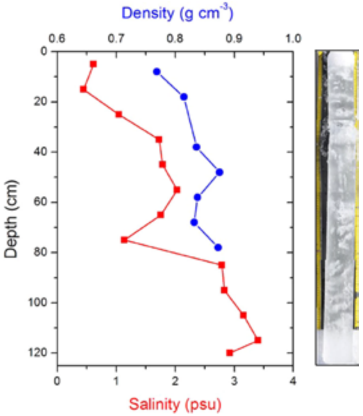
RADIATIVE TRANSFER MODELLING

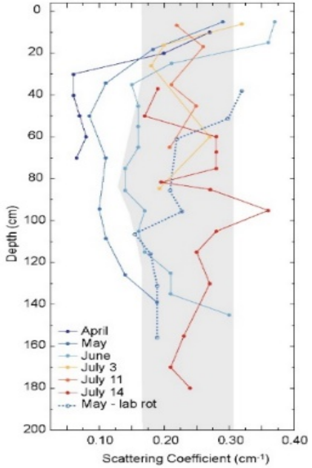
Improved model parameterization + improved feedback sensitivity (e.g. remote sensing, ice physics models)

OCEAN & CLIMATE MODELLING

STRUCTURAL-OPTICAL RELATIONSHIPS

Core samples measured for light transmittance and inferred vertical scattering coefficient profiles





Correlate with physical property data

Recommendations

- Continuous Sentinel-2 based monitoring of sea ice during Arctic summer instead of event driven tracking (aiming at the big picture)
- Increased repetition in high latitudes may balance out high cloud coverage
- Foster fusion of active and passive sensors in high latitudes
- Hyperspectral Sentinel-10 (?) covering high latitudes

Potential:

- Assessment/monitoring of sea ice and melt pond status during Arctic summer
- Analysis of changes and feedbacks (e.g. as an input for models)
- Ecosystem research (models allow assessment of water parameters, e.g. chl-a, organic substances in leaks and ponds)
- Monitoring of new transport routes
- ...