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ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Assessing the Influence of Water Constituents on the Radiative Heating of Laptev Sea Shelf Waters

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Motivation

- Optically active water constituents → attenuation of light penetration → impact ocean heat content → potentially contribute to sea ice melting.
- **Laptev Sea shelf** and **Lena River** (Arctic Siberia, Fig. 1A) → **river system with highest annual flux of dissolved organic carbon and silica to Arctic Ocean** [1,2].
- **Aim**: to **investigate influence of coloured dissolved organic matter (CDOM) and total suspended matter (TSM) on radiative heating of Laptev Sea shelf waters**.

Data and Methods

- **Validation** of **MERIS Chla and a_{CDOM}(443) from C2RCC and C2X algorithms** (Fig. 1B, blue) + **Evaluation of RTM SCIATRAN** (Fig. 1B, green) + **Radiative Transfer simulations of radiative heating** (Fig. 1B, red).

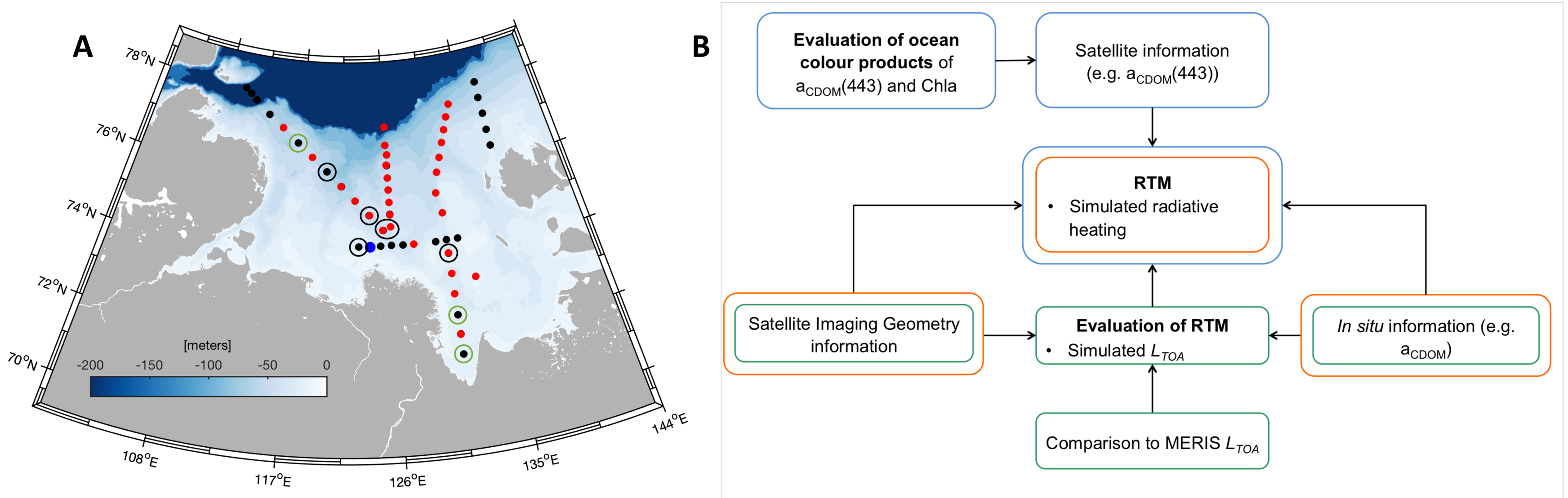
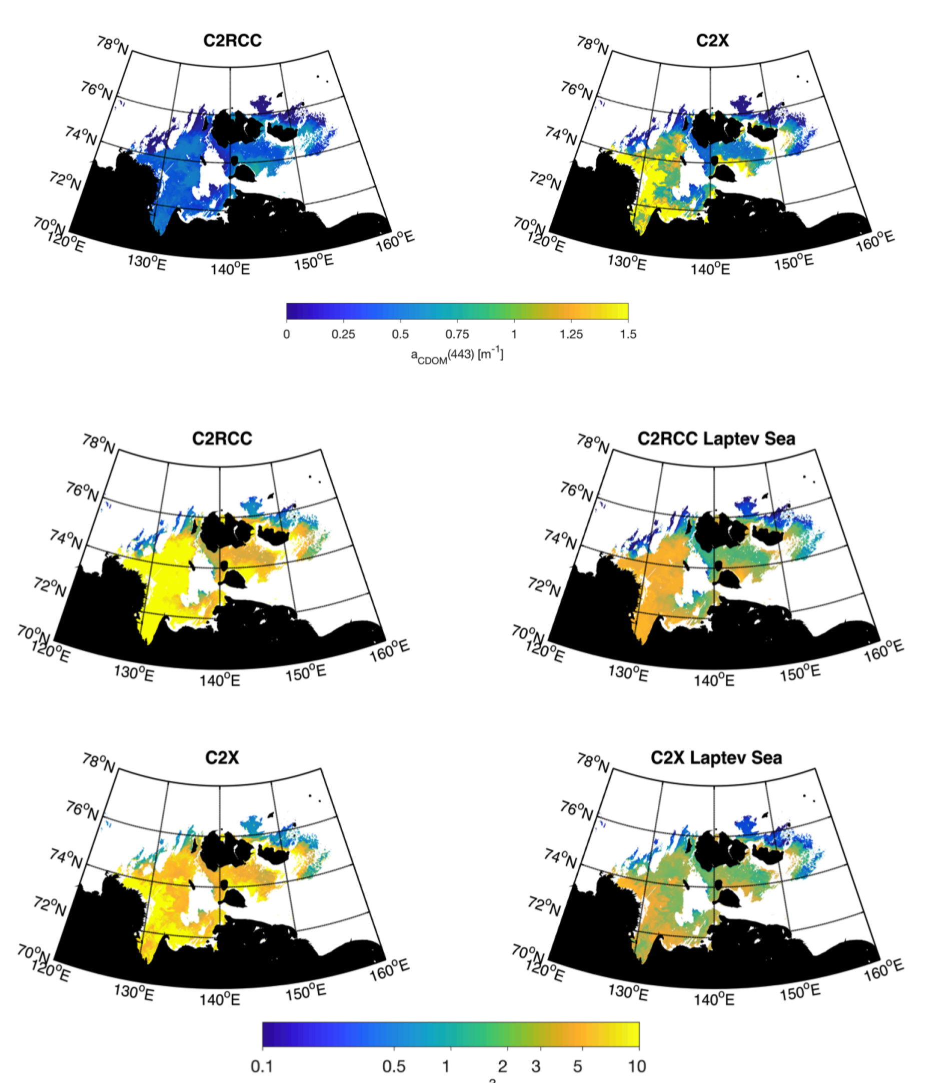


Figure 1. A) The Laptev Sea and location of sampling stations of TRANSDRIFT-XVII (black) and TRANSDRIFT XIX (red) expeditions. Stations matched with satellite data for validation of ocean colour products were circled in black and stations used for RT simulations in green. One station was used in both analysis and is showed in blue. B) Scheme summarizing the methods.

- ***In situ* dataset**: vertically resolved a_{CDOM} spectra, SPM, Chla, temperature and salinity taken during August-September 2010 and 2011 by the TRANSDRIFT-XVII (2010) and TRANSDRIFT-XIX expeditions (Fig. 1A).
- **Simulations with RTM SCIATRAN:**
  - spectral RT calculations for a coupled atmosphere-ocean system [3] ;
  - atmosphere: thermal emission, absorption by several trace gases, Rayleigh scattering and scattering by aerosol and cloud particles.
  - ocean: scattering by water and TSM, absorption by water, CDOM, Chla and TSM.
  - **simulations**: spectrally scalar irradiance (E_0, W/m^2, 300 - 900 nm) for July 1 at 76°N, 126°E, for 24 solar zenith angles and using MERIS imaging geometry information.
  - input data: *in situ* and satellite Chla, CDOM and TSM.

Station	Date	Longitude	Latitude	Bottom Depth	Temperature	Salinity	a_{CDOM}(443)	TSM	Chla
S01	09.09.10	131.00	71.5	14	7.66	7.80	1.77	1.60	2.03
S03	09.09.10	131.00	72.47	18	7.77	7.02	1.67	0.40	1.95
S16	13.09.10	123.99	74.33	17	4.10	19.05	1.08	7.20	0.84
S40	19.09.10	116.69	76.84	42	-0.19	28.04	0.20	0.17	0.40

Validation of MERIS a_{CDOM}(443) and Chla



Algorithm	a_{CDOM}(443) r	RMSE	Bias	Slope	N
C2RCC	0.68	*0.44*	-0.39	*0.43*	*8*
C2RCC Laptev Sea					
C2X	*0.81*	0.57	*0.01*	2.57	7
C2X Laptev Sea					

Algorithm	Chla r	RMSE	Bias	Slope	N
C2RCC	*0.68*	0.80	0.50	3.05	*8*
C2RCC Laptev Sea	*0.68*	0.63	*0.07*	3.05	*8*
C2X	0	0.82	0.61	*-0.01*	7
C2X Laptev Sea	0	*0.58*	0.18	*-0.01*	7

- ✓ a_{CDOM}(443): underestimation by C2RCC and small overestimation by C2X.
- ✓ Chla: overestimation by all four products, but at less extent using the Laptev Sea conversion factor for a_{ph}(443) to Chla [4] of 7.8 (default is 21)

Figure 2. MERIS a_{CDOM}(443) (top) and Chla (bellow) on August 04, 2010. White areas correspond to flagged pixels (Rtosa_OOS, Rtosa_OOR,Rhow_OOR and l1_flags).

Absorbed Energy and Radiant Heat

- E_0abs (Fig. 3): incident solar radiation strongly absorbed in the first meters of the water column → increased rate of sea ice melt (dH/dT, mm/h) compared to clearer waters.
- Greater E_0abs by CDOM and TSM increased the radiant heating rate (RH, °C/day).

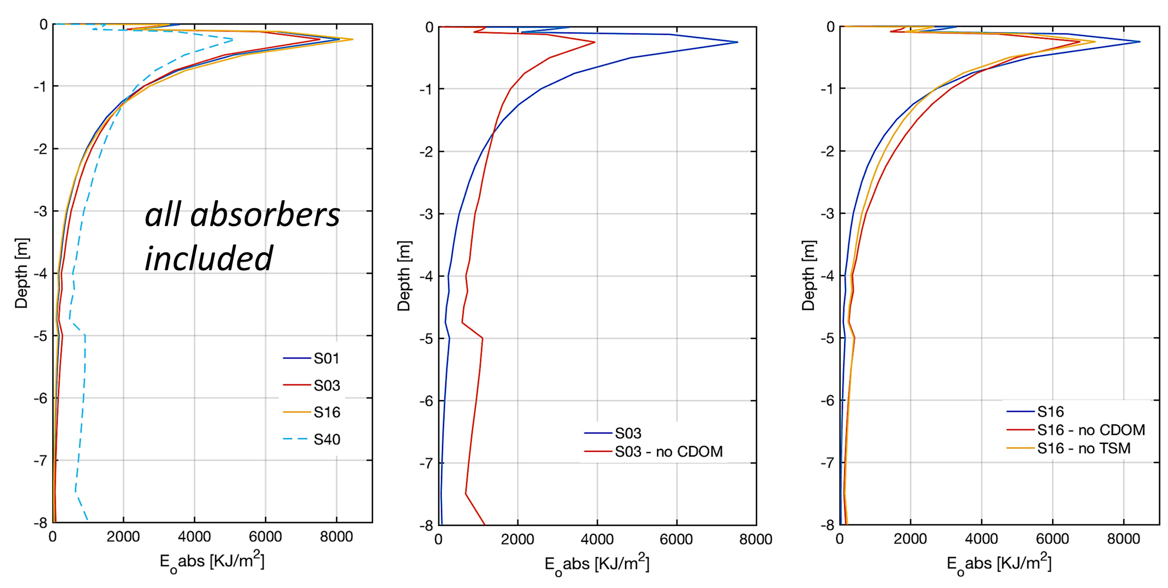
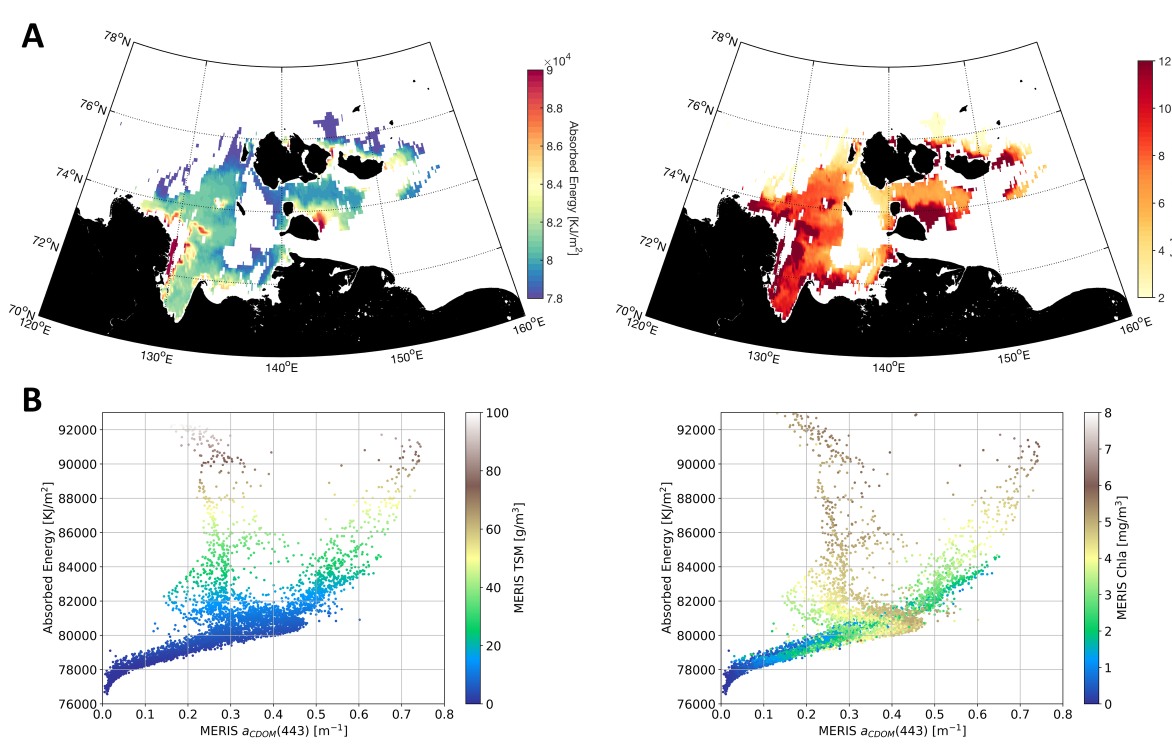


Figure 3. Profiles of absorbed energy (E_0abs).

Scenarios	ΔE_0abs	$\%\Delta E_0$abs	$\Delta E_0 abs_{2\text{-}9\,m}$	ΔRH	ΔdH/dT
S01 - S01 no CDOM	14170	15.8%	-9500	1.76	0.61
S03 - S03 no CDOM	17046	20.0%	-10232	2.12	0.73
S16 - S16 no TSM	4425	4.6%	-4095	0.55	0.19
S16 - S16 pure water	27967	38.0%	-3936	3.44	1.2
S01 - S40	11831	12.87%	-10928	1.47	0.5

Spatial Distribution



⬆ Absorbers
⬆ E_0abs
⬆ *ΔRH*

✓ when TSM > 10 g/m^3 and Chla > 3 mg/m^3 → less direct relationship between E_0abs and a_{CDOM}

Figure 4. A) Spatial distribution of absorbed energy (E_0abs, KJ/m^2 - left) and radiant heat difference (ΔRH, °C - right) on August 04, 2010. B) scatterplot of E_0abs, a_{CDOM}(443) and TSM (left) and scatterplot of E_0abs, a_{CDOM}(443) and Chla (right).

RTM Evaluation

✓ Radiative processes are well implemented in the model.

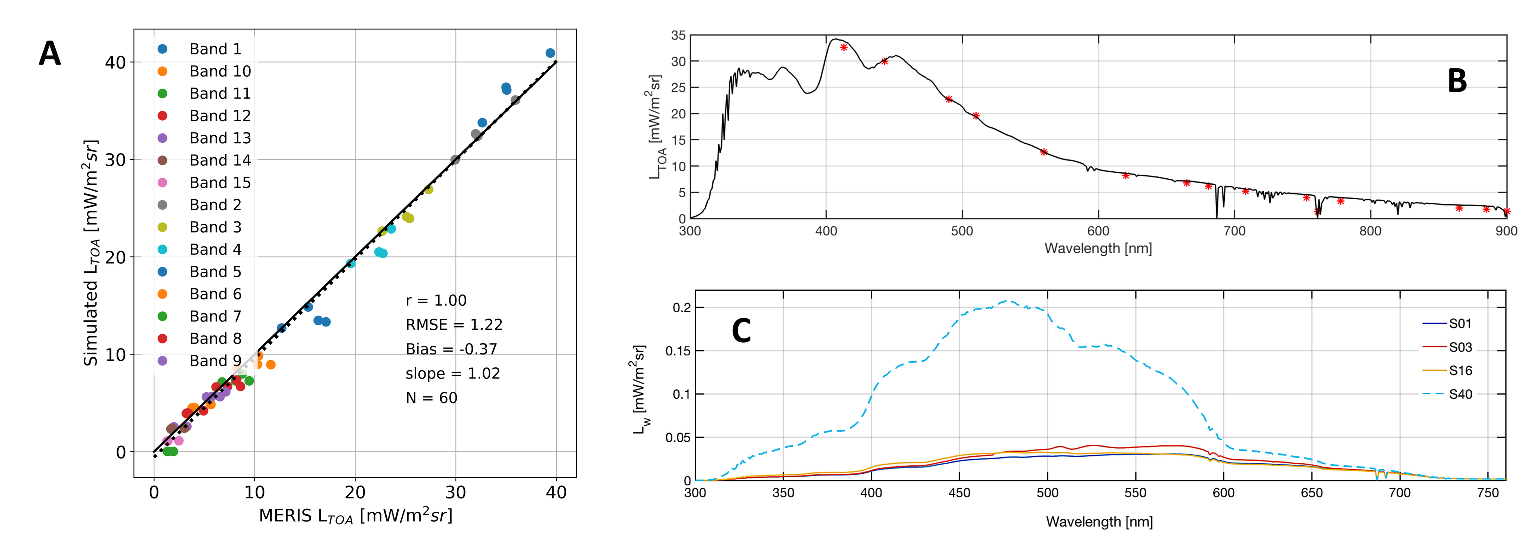


Figure 5. A) Evaluation of simulated top-of-atmopshere radiance (L_{TOA}) against collocated MERIS L_{TOA}. B) Comparison of SCIATRAN simulated (black) and MERIS-L1b (red) LTOA at S35. C) Water leaving radiance (L_W) spectra of stations selected for simulations.

Acknowledgements

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