Modeling Biogenic Aerosol Precursors in the Arctic Ocean: Occurrence patterns and long-term trends

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Concept

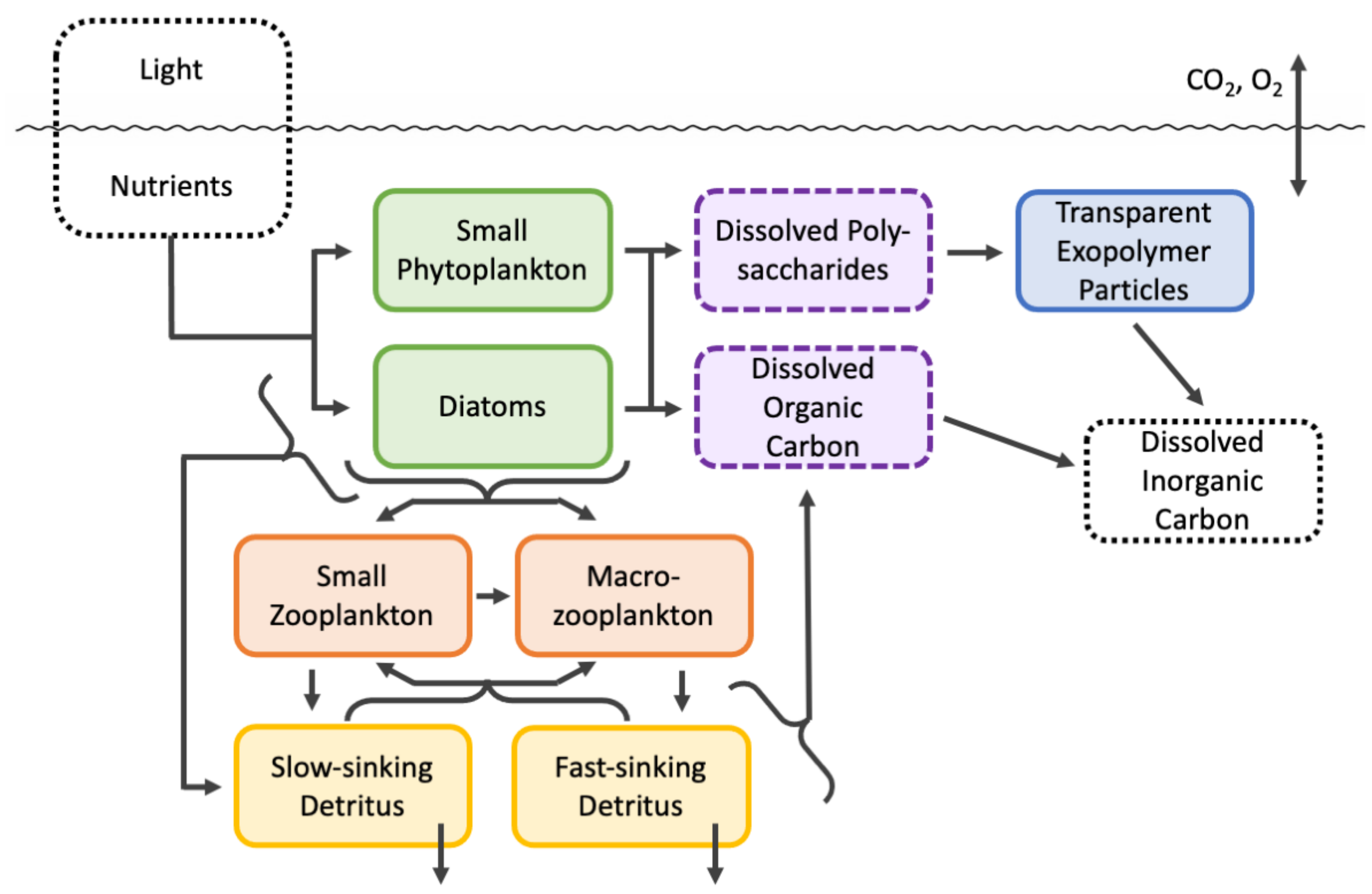
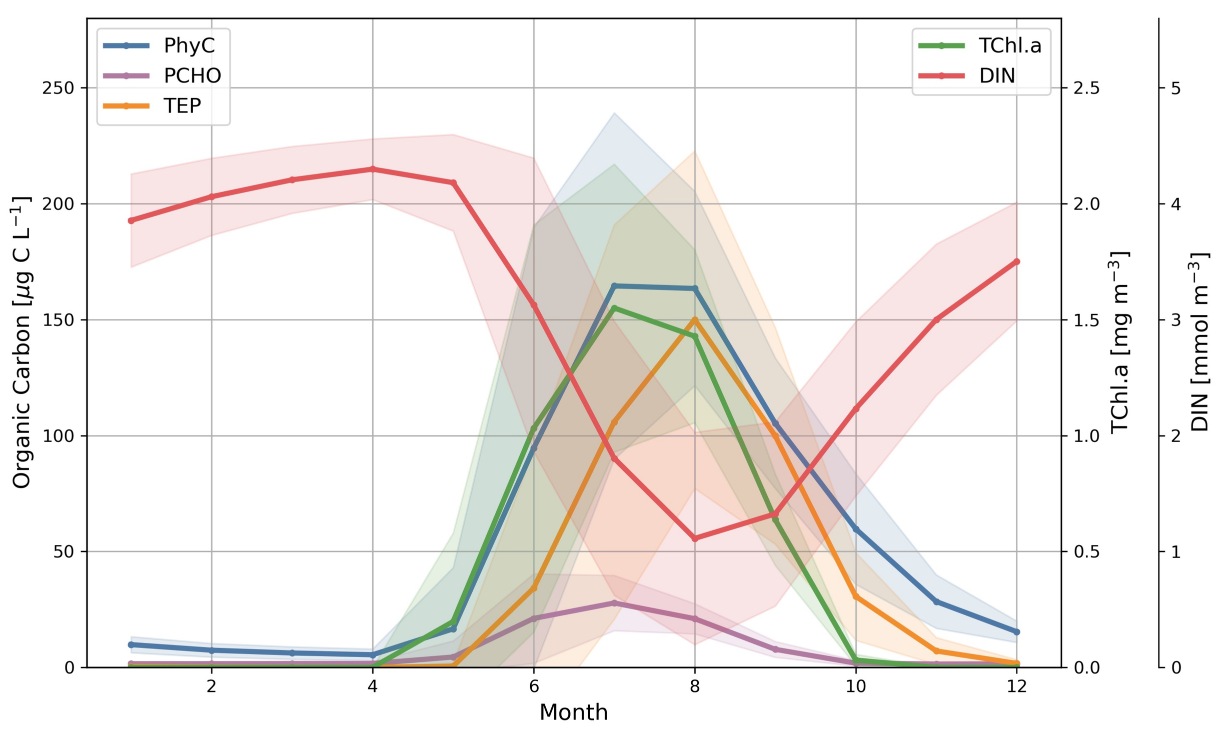


Fig. 1: Concept of organic carbon fluxes in REcoM3.

- Integration of dissolved, carboxylic acid containing polysaccharides
- Integration of Transparent Exopolymer Particles (TEP)
- Exudation of organic carbon, carbon overflow
- Aggregation

Example: East Fram Strait

Fig. 2: Seasonal cycle of simulated organic phytoplankton carbon (PhyC), PCHO, TEP, total Chlorophyll a (TChl.a) and Dissolved Inorganic Nitrogen (DIN) (0-30m) of 2000-2019 averaged over East Fram Strait.



Model Equations in REcoM3

$$S(\mathrm{DOC}) = \underbrace{(1-f_{PCHO})\cdot\varepsilon^{C}_{phy}\cdot f^{lim}_{phy}\cdot C_{phy}}_{\text{excretion by small phytoplankton}} + \underbrace{(1-f_{PCHO})\cdot\varepsilon^{C}_{dia}\cdot f^{lim}_{dia}\cdot C_{dia}}_{\text{excretion by diatoms}}$$
$$+ \underbrace{\varepsilon^{C}_{zoo1}\cdot C_{zoo1}}_{\text{excretion by zooplankton}} + \underbrace{\varepsilon^{C}_{zoo2}\cdot C_{zoo2}}_{\text{excretion by macrozoo.}} + \underbrace{\rho_{DetC}\cdot f_T\cdot C_{det1} + \rho_{DetC}\cdot f_T\cdot C_{det2}}_{\text{detritus remineralization}}$$
$$- \underbrace{\rho_{DOC}\cdot f_T\cdot C_{DOC}}_{\text{remineralization to DIC}}$$

$$S(PCHO) = \underbrace{f_{PCHO}\cdot\varepsilon^{C}_{phy}\cdot f^{lim}_{phy}\cdot C_{phy}}_{\text{excretion by small phytoplankton}} + \underbrace{f_{PCHO}\cdot\varepsilon^{C}_{dia}\cdot f^{lim}_{dia}\cdot C_{dia}}_{\text{excretion by diatoms}}$$
$$-\underbrace{\alpha_{PCHO}\cdot\beta_{PCHO}\cdot C_{PCHO}\cdot C_{PCHO}}_{\text{aggregation of PCHO with PCHO}}$$
$$-\underbrace{\alpha_{TEP}\cdot\beta_{TEP}\cdot C_{PCHO}\cdot C_{TEP}}_{\text{aggregation of PCHO with TEP}}$$

$$S(TEP) = \underbrace{\alpha_{PCHO}\cdot\beta_{PCHO}\cdot C_{PCHO}\cdot C_{PCHO}}_{\text{aggregation of PCHO with PCHO}}$$
$$\underbrace{+\alpha_{TEP}\cdot\beta_{TEP}\cdot C_{PCHO}\cdot C_{TEP}}_{\text{aggregation of PCHO with TEP}}$$
$$- \underbrace{\rho_{TEP}\cdot f_T\cdot C_{TEP}}_{\text{remineralization to DIC}}$$

Seasonal Cycle

- Highest TEP concentration on continental shelves (200-400 µg C L⁻¹)
- Low TEP concentration in the central basins (10-50 µg C L⁻¹)

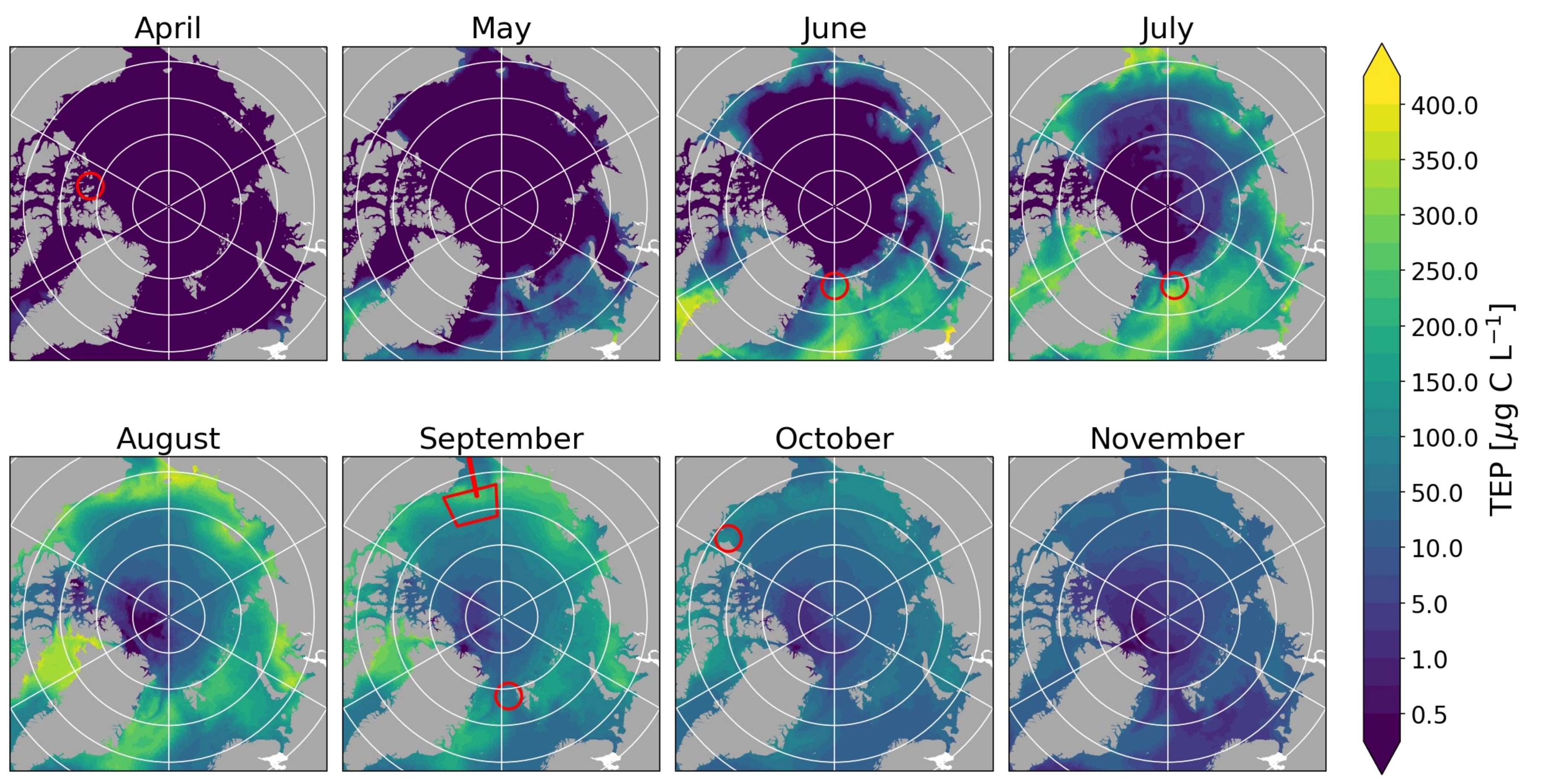


Fig. 3: Climatological maps of TEP concentration (0-30 m) of 2000-2019. Overlayed are the positions of the observation data points in red.

Tab. 1: Comparison of TEP-C of observational campaigns and simulation. Model results are volume-weighted and averaged corresponding to the depth range, area, and month of observations. Mean and standard deviation of the years 2000-2019 is stated in brackets.

Period	Region	Depth [m]	Modeled TEP-C [µg C L⁻¹]	Observed TEP-C [µg C L⁻¹]	Number of Gridpoints	Reference
Mar-Apr 2010	Catlin Ice Base	0-14	**0±0** (0±0)	405.9±344.7	65	Wurl et al. (2011)
Jun 2015	Fram Strait	5-200	**16.0±11.3** (20.9±16.6)	8.2±6.1	935	Engel et al. (2020)
Jul 2018	Fram Strait	0-100	**102.9±23.5** (88.4±35.3)	21.4±14.5	1631	von Jackowski et al. (2020)
Sep-Oct 2018	Fram Strait	0-100	**32.3±7.5** (27.7±11.6)	7.1±5.2	2440	von Jackowski et al. (2020)
Sep-Oct 2012	Chukchi Shelf	0-50	115.3±72.6 (77.5±46.9)	138.9±64.7	1106	Yamada et al. (2015)
Sep-Oct 2012	Canada Basin	0-200	**29.2±6.9** (23.8±11.0)	70.4±15.5	14940	Yamada et al. (2015)
Oct 2009	Northwest Passage	0-29	**137.0±12.1** (108.0±33.0)	126.1±69.7	174	Wurl et al. (2011)

Trends: TEP & NPP

- regionally diverging trends in late summer
- decrease of TEP in Fram Strait, Barents Sea, Eurasasian Basin along NPP decrease
- increase of TEP in Kara, Laptev, Beaufort Seas along NPP increase and low nutrient availability

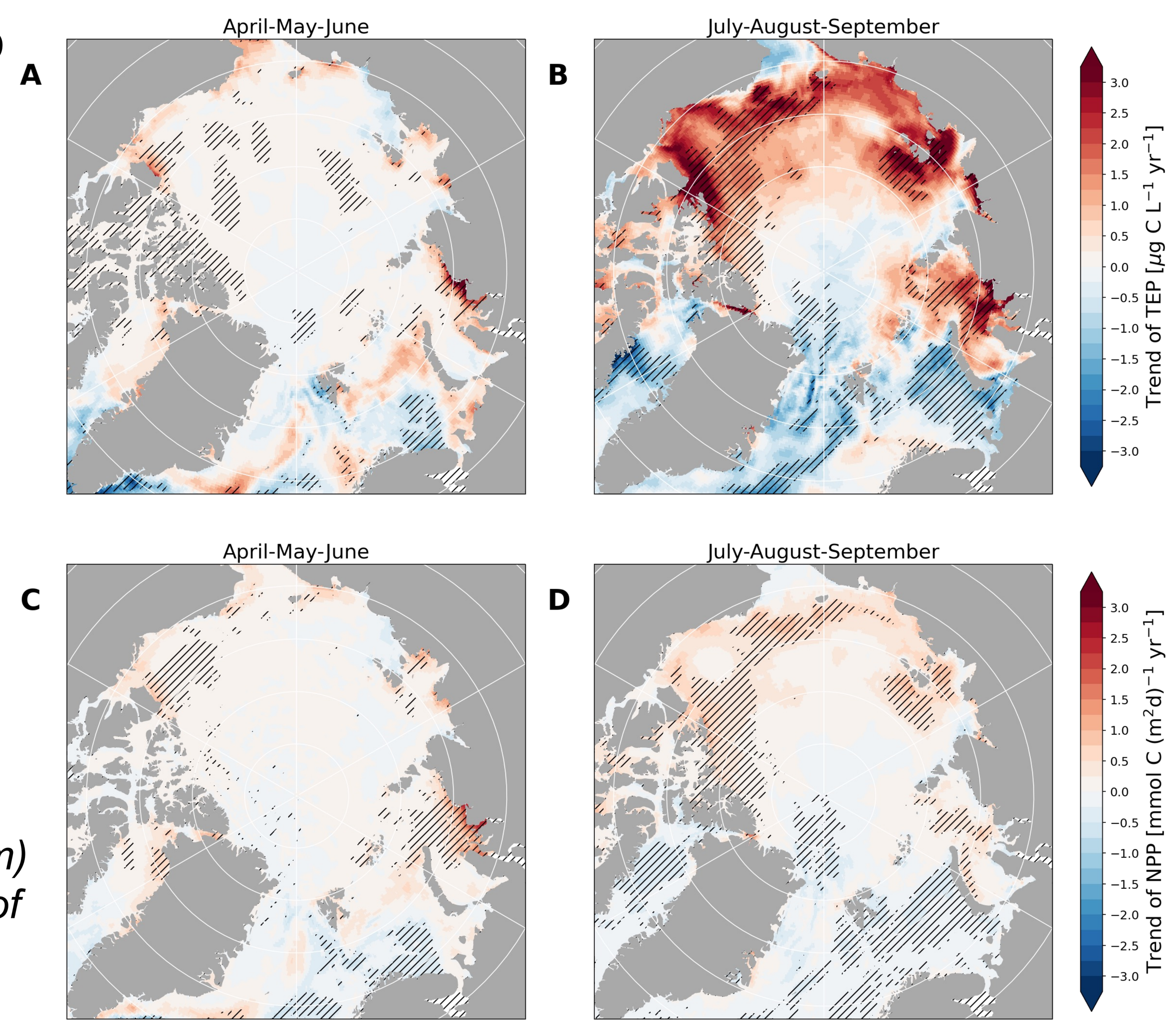


Fig. 4: Maps of trend of TEP (0-30 m) and Net Primary Production (NPP) of 1990-2019. Significant trends displayed as hatched areas.

Summary

- Simulation of PCHO & TEP as biogenic aerosol precursors
- Good agreement of model with observations
- Long-term trends diverging: Atlantic/Pacific influence
- Contribution to aerosol/cloud modeling & impacts to Arctic Amplification

Preprint

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