



*Supplement of*

## **Estimates of carbon sequestration potential in an expanding Arctic fjord (Hornsund, Svalbard) affected by dark plumes of glacial meltwater**

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Table S1 List of satellite images used in this study

Year	Satellite images	Resolution [m]	Bands
1976	LM02_L1GS_230004_19760718_20180423_01_T2	60	3-2-1
1980	LM02_L1GS_229005_19800801_20210624_02_T2	60	4
1985	LM05_L1GS_211005_19850726_20210919_01_T2	60	3-2-1
1990	LM05_L1GS_212005_19900901_20211008_02_T2	30	3-2-1
1995	LT05_L1TP_208005_19950903_20200912_02_T2	30	3-2-1
2000	LE07_L1TP_213005_20000725_20200918_02_T1	15	3-2-1 and 8
	LE07_L1TP_209005_20000729_20200917_02_T1		
2006	LT05_L1TP_210005_20060814_20201008_02_T2	30	3-2-1
2010	LE07_L1TP_210005_20100817_20200910_02_T1	15	3-2-1 and 8
2015	LC08_L1TP_209005_20150731_20200908_02_T1	15	4-3-2 and 8
2019	LC08_L1TP_212005_20190816_20190902_01_T1	15	4-3-2 and 8
2022	LC08_L1TP_028239_20220815_20220823_02_T2	15	4-3-2 and 8

Table S2 Location of the data points

Variable	Data type	Location
Sea surface temperature (SST)	Satellite data	HOR: 77.000°N 15.325°E; 77.000°N 15.375°E; 77.000°N 15.425°E
Sea ice concentration (SIC)		HOR: 76.950°N 16.225°E; 76.950°N 16.275°E; 76.950°N 16.325°E
Suspended particulate matter (SPM), sedimentation flux (SF), salinity	Field data	M5 (H1_11): 77.017°N 15.636°E
		M4 (H1_09): 77.012°N 15.629°E
		M3 (H1_08): 77.009°N 15.624°E
		M2 (H1_06): 77.003°N 15.624°E
		M1 (H1_04): 70.000°N 15.623°E
Air temperature (AT) and precipitation		PPS (Polish Polar Station Hornsund): 77.000°N 15.550°E

Table S3 List of state variables

N	Abbr.	Definition	Initial value	Unit
1	<i>F</i>	Flagellates	0.1	mgC·m <sup>-3</sup>
2	<i>D</i>	Diatoms	0.1	mgC·m <sup>-3</sup>
3	<i>Chl<sub>F</sub></i>	Chlorophyll <i>a</i> for flagellates (prognostic state variable)	0.005	mgC·m <sup>-3</sup>
4	<i>Chl<sub>D</sub></i>	Chlorophyll <i>a</i> for diatoms (prognostic state variable)	0.005	mgC·m <sup>-3</sup>
5	<i>Z<sub>S</sub></i>	Microzooplankton	0.01	mgC·m <sup>-3</sup>
6	<i>Z<sub>L</sub></i>	Mesozooplankton	0.01	mgC·m <sup>-3</sup>
7	<i>MB</i>	Macrobenthos	0.5	mgC·m <sup>-3</sup>
8	<i>iSPM</i>	Inorganic Suspended Particulate Matter	0.0	mg·m <sup>-3</sup>
9	<i>D<sub>1</sub></i>	Fast sinking detritus	0.0	mgC·m <sup>-3</sup>
10	<i>D<sub>2</sub></i>	Slow sinking detritus	0.1	mgC·m <sup>-3</sup>
11	<i>DOM</i>	Dissolved Organic Matter	3.0	mgC·m <sup>-3</sup>
12	<i>NH<sub>4</sub></i>	Ammonium	50.0	mmolN·m <sup>-3</sup>
13	<i>NO<sub>3</sub></i>	Nitrate	1035.0	mmolN·m <sup>-3</sup>
14	<i>PO<sub>4</sub></i>	Phosphate	1100.0	mmolP·m <sup>-3</sup>
15	<i>SiO<sub>2</sub></i>	Silicate	300.0	mmolSi·m <sup>-3</sup>
16	<i>Opal</i>	Biogenic Opal	2.0	mmolSi·m <sup>-3</sup>
17	<i>O<sub>2</sub></i>	Oxygen	85.0	ml·l <sup>-1</sup>
18	<i>S<sub>CN</sub></i>	Sediment Carbon Nitrogen	0.0	mg·m <sup>-3</sup>
19	<i>S<sub>P</sub></i>	Sediment Phosphate	0.0	mgC·m <sup>-3</sup>
21	<i>S<sub>S</sub></i>	Sediment Silicate	0.0	mgC·m <sup>-3</sup>
22	<i>S<sub>iSPM</sub></i>	Sediment iSPM	0.0	mgC·m <sup>-3</sup>

Table S4 The Spearman's correlation between results of simulations (station 2 in 2006 and 2009) and field studies (stations M4 and M5 in 2019) plotted in Sup. Fig. 3.

Station (year)	M4 (2019)	M5 (2019)
2 (2006)	Rho = 0.74, p<0.001	Rho = 0.77, p<0.001
2 (2009)	Rho = 0.75, p<0.001	Rho = 0.79, p<0.001

Table S5 Literature data for model assessment in the West Spitsbergen fjords: KGF – Kongsfjorden, HOR – Hornsund, ISF – Isfjorden, Rij - Rijpfjorden

Variable	KGF	HOR	ISF	RIJ	Reference
<b>Silicate</b> [ $\mu\text{mol}\cdot\text{l}^{-1}$ ]	1.9 -6.0	1.0 -6.0			Hegseth and Tverberg 2013;
<b>Nitrates</b> [ $\mu\text{mol}\cdot\text{l}^{-1}$ ]	<0.67	<1.96			Węśławski et al. 1988;
<b>Phosphates</b> [ $\mu\text{mol}\cdot\text{l}^{-1}$ ]	0.83	0.3			Hodal et al. 2012 Eilertsen et al. 1989; Węśławski et al. 1988; Hodal et al. 2012;
<b>Ice algae</b> [ $\text{mgC}\cdot\text{m}^{-2}$ ]				50 – 450	Leu et al., 2017
<b>Phytoplankton</b> [ $\text{gC}\cdot\text{m}^{-2}$ ]	0.254 – 2.77	0.608 - 2.1		<0.002	Piwosz et al., 2009 Błachowiak-Samołyk et al., 2015
<b>Zooplankton</b> [ $\text{gC}\cdot\text{m}^{-2}$ ]			1-6	6-8	Zajączkowski et al., 2010 Błachowiak-Samołyk et al., 2015
<b>Macrobenthos</b> [ $\text{gC}\cdot\text{m}^{-2}$ ]	4.8 – 7.73	6.44 – 20.48		2.31 – 8.34	Włodarska-Kowalczyk et al., 2019
<b>Summer pelagic primary production</b> [ $\text{mgC}\cdot\text{m}^{-2}\cdot\text{day}^{-1}$ ]	59 -108 80 - 155	173 - 1333			Piwosz et al., 2009 Iversen and Seuthe, 2011
<b>Spring pelagic primary production</b> [ $\text{mgC}\cdot\text{m}^{-2}\cdot\text{day}^{-1}$ ]	405 - 445 30 - 1850	320 - 2770			Iversen and Seuthe, 2011 Hodal et al., 2012 Vonnahme et al., 2021
<b>Zoobenthos production</b> [ $\text{gC}\cdot\text{m}^{-2}\cdot\text{y}^{-1}$ ]	9.4 2.1 – 6.6	19.2 1.2 – 2.6			Włodarska-Kowalczyk et al., 2019 Zaborska et al., 2018 (only macro.)
<b>Burial rate of OC</b> [ $\text{gC}\cdot\text{m}^{-2}\cdot\text{y}^{-1}$ ]	28 ± 6 9 - 13 5.7-10.0 15	28 ± 1 19.3-30.3 38			Włodarska-Kowalczyk et al., 2019 Kuliński et al., 2014 Koziorowska et al., 2018 Zaborska et al., 2018

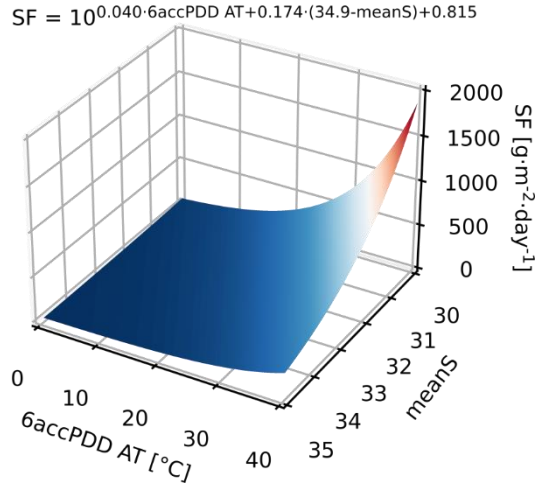


Figure S1 Inorganic sediment flux as a function of 6accPDD AT and mean salinity. 6accPDD is the accumulated daily temperature for positive degree days for 6 days window ( $^{\circ}\text{C}$ ), 34.9 is a reference salinity for Atlantic Water (Moskalik et al., 2018), and meanS is the mean salinity above the sediment trap.

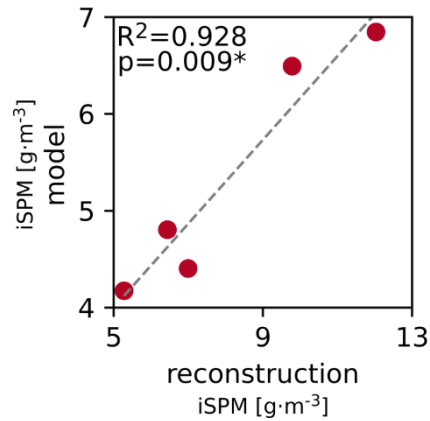


Figure S2 Assessment of inorganic SPM (iSPM) simulations at station HH1 (2): correlation of mean summer-time integrated iSPM concentration from reconstruction and model for 2005-2009 ( $\text{g}\cdot\text{m}^{-3}$ ).

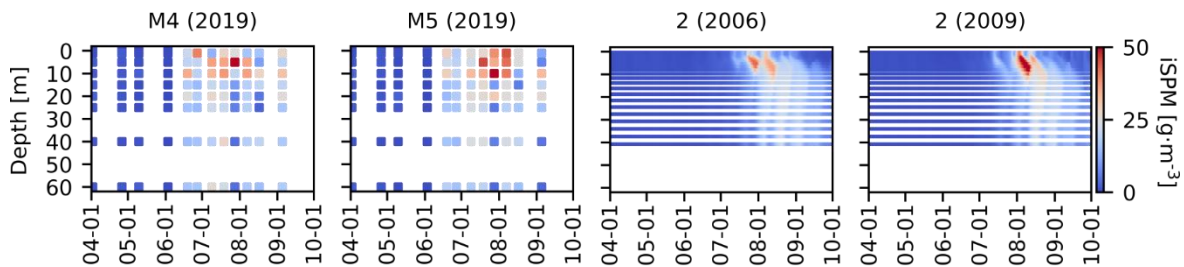


Figure S3 Inorganic SPM concentration (iSPM,  $\text{g}\cdot\text{m}^{-3}$ ) at monitoring stations (M4 and M5) in 2019 and at modelled station (2) in 2006 and 2009.

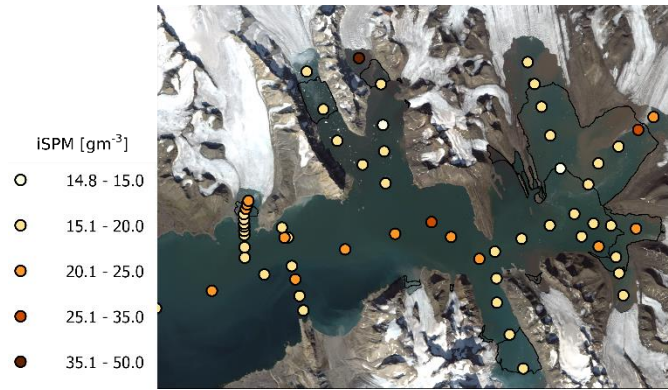


Figure S4 Spatial distribution of inorganic SPM (iSPM) concentrations in Hornsund in summer 2017 (late July-early August, 0 m). The black lines indicate newly ice-free areas extent in 2006. Landsat8 satellite image (04/08/2020) downloaded from <https://glovis.usgs.gov/app>.

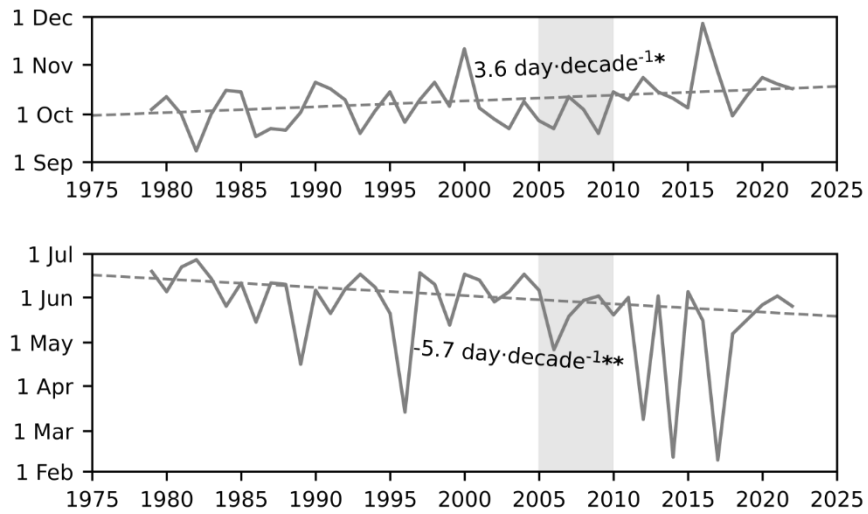


Figure S5 The trends in the start and end of the melt season in Hornsund defined as the start of the first six consecutive days when daily average air temperatures exceed or fall below 0°C, respectively. \*  $p < 0.05$ , \*\*  $p < 0.001$  for Modified Mann Kendall Test.

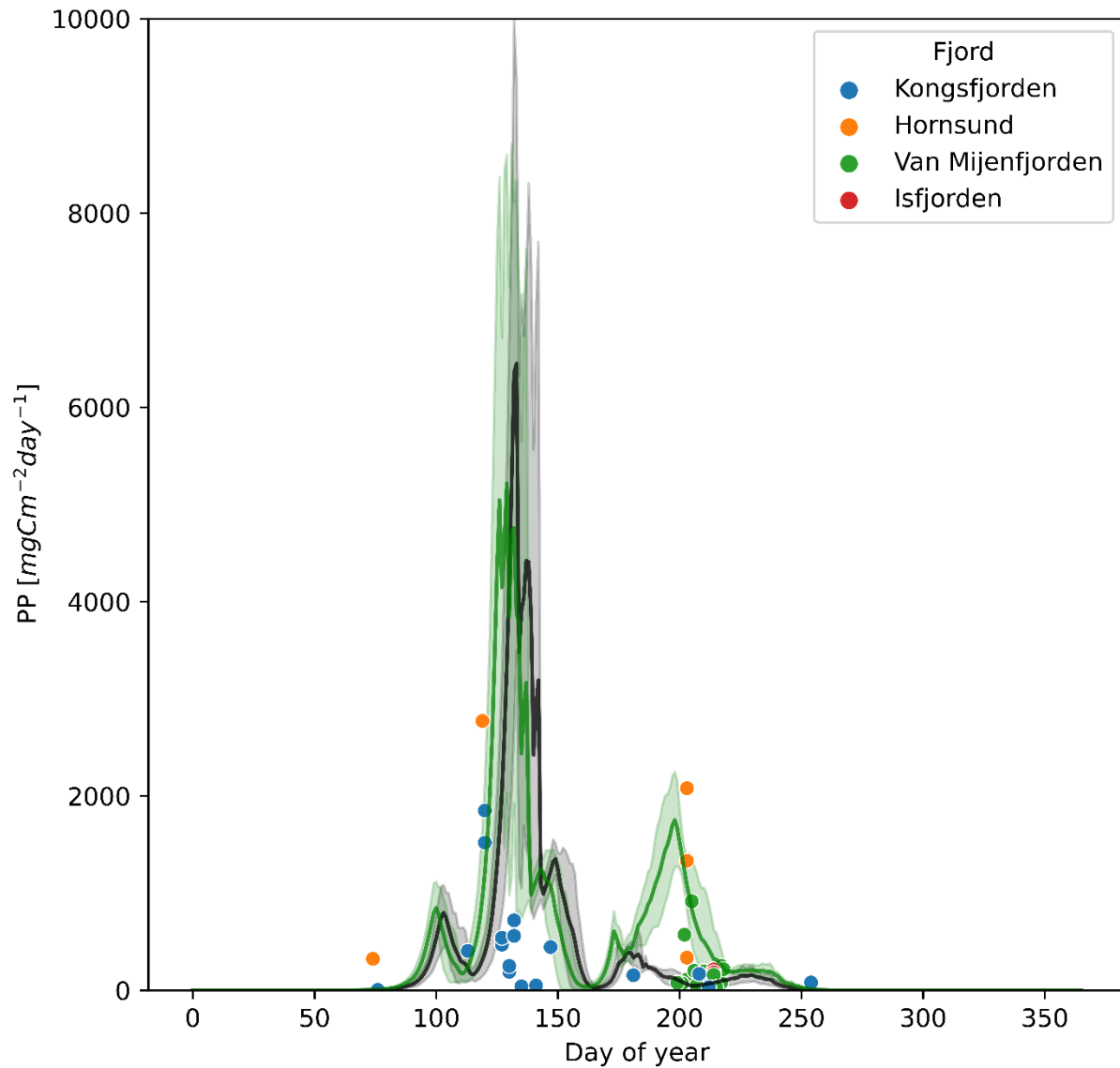


Figure S6 Comparison of pelagic primary production from the modeling (station H3, black - iSPM scenario, green - noSPM scenario; average for 2005-2009 with standard deviation) and field studies as reported by Hodal et al., 2012 (Kongsfjorden), Iversen and Seuthe 2011 (Kongsfjorden), Piwosz et al., 2009 (Kongsfjorden and Hornsund), Eilertsen et al., 1989 (Kongsfjorden, Isfjorden, Van Mijenfjorden and Hornsund).

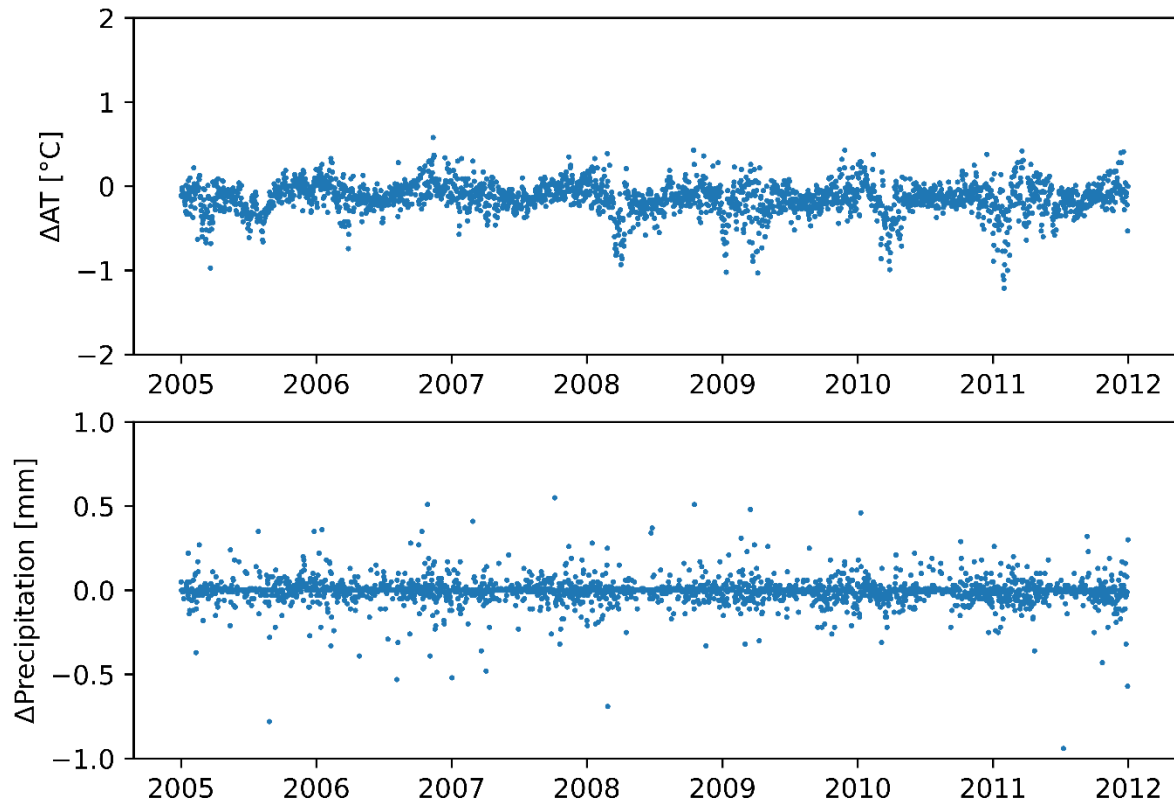


Figure S7 The differences in daily average air temperature (AT), and daily precipitation between the inner and outer fjord based on ERA-interim reanalysis (Dee et al., 2011).