Supplementary Table 1 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 LE07_L1TP_209005_20000729_20200917_02_T1	15	3-2-1 and 8
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

Supplementary Table 2 Location of the data points

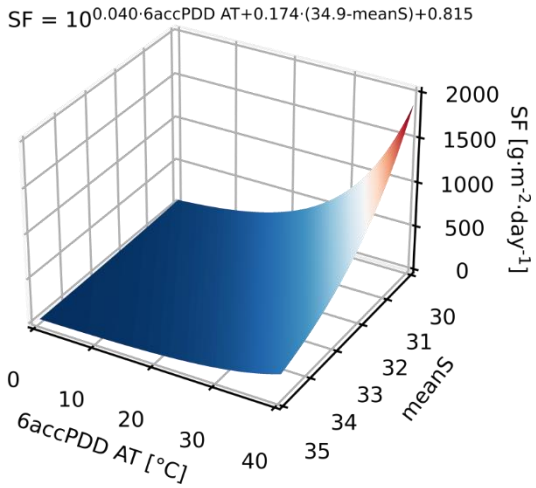
Variable	Data type	Location
Sea surface temperature (SST)	Satellite data	HOR: 77.000°N 15.325°E; 77.000°N 15.375°E; 77.000°N 15.425°E
Sea ice concentration (SIC)		HOR: 76.950°N 16.225°E; 76.950°N 16.275°E; 76.950°N 16.325°E
Suspended particulate matter (SPM), sedimentation flux (SF), salinity	Field data	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

Supplementary Table 3 List of state variables

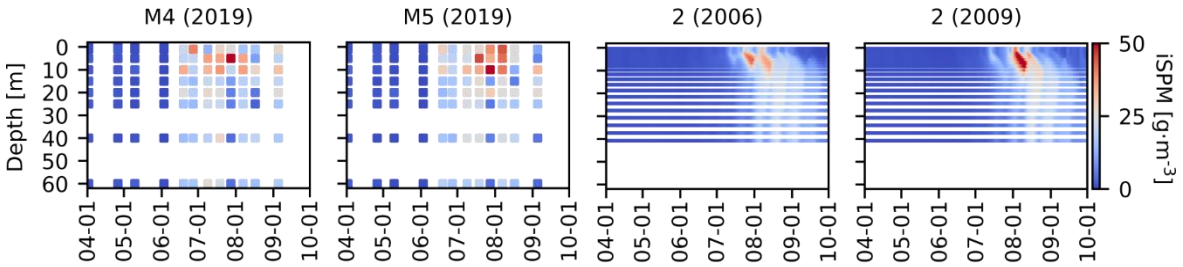
N	Abbr.	Definition	Initial value	Unit
1	F	Flagellates	0.1	$mgC \cdot m^{-3}$
2	D	Diatoms	0.1	$mgC \cdot m^{-3}$
3	Chl_F	Chlorophyll *a* for flagellates (prognostic state variable)	0.005	$mgC \cdot m^{-3}$
4	Chl_D	Chlorophyll *a* for diatoms (prognostic state variable)	0.005	$mgC \cdot m^{-3}$
5	Z_S	Microzooplankton	0.01	$mgC \cdot m^{-3}$
6	Z_L	Mesozooplankton	0.01	$mgC \cdot m^{-3}$
7	MB	Macrobenthos	0.5	$mgC \cdot m^{-3}$
8	$iSPM$	Inorganic Suspended Particulate Matter	0.0	$mg \cdot m^{-3}$
9	D_1	Fast sinking detritus	0.0	$mgC \cdot m^{-3}$
10	D_2	Slow sinking detritus	0.1	$mgC \cdot m^{-3}$
11	DOM	Dissolved Organic Matter	3.0	$mgC \cdot m^{-3}$
12	NH_4	Ammonium	50.0	$mmolN \cdot m^{-3}$
13	NO_3	Nitrate	1035.0	$mmolN \cdot m^{-3}$
14	PO_4	Phosphate	1100.0	$mmolP \cdot m^{-3}$
15	SiO_2	Silicate	300.0	$mmolSi \cdot m^{-3}$
16	$Opal$	Biogenic Opal	2.0	$mmolSi \cdot m^{-3}$
17	O_2	Oxygen	85.0	$ml \cdot l^{-1}$
18	S_{CN}	Sediment Carbon Nitrogen	0.0	$mg \cdot m^{-3}$
19	S_P	Sediment Phosphate	0.0	$mgC \cdot m^{-3}$
21	S_S	Sediment Silicate	0.0	$mgC \cdot m^{-3}$
22	S_{iSPM}	Sediment iSPM	0.0	$mgC \cdot m^{-3}$

Supplementary Table 4 Literature data for model assessment in the West Spitsbergen fjords: KGF – Kongsfjorden, HOR – Hornsund, ISF – Isfjorden, Rij - Rijpfjorden

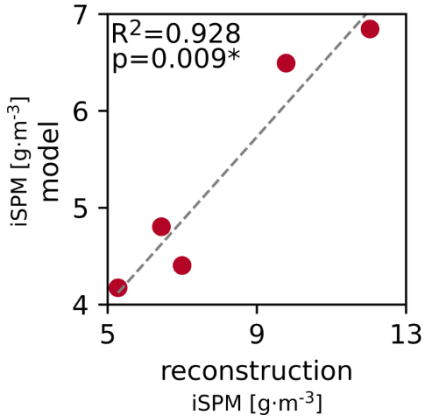
Variable	KGF	HOR	ISF	RIJ	Reference
Silicate [µmol·l^{-1}]	1.9 -6.0	1.0 -6.0			Hegseth and Tverberg 2013;
Nitrates [µmol·l^{-1}]	<0.67	<1.96			Węsławski et al. 1988;
Phosphates [µmol·l^{-1}]	0.83	0.3			Hodal et al. 2012
					Eilertsen et al. 1989;
					Węsławski et al. 1988;
					Hodal et al. 2012;
Ice algae [mgC·m^{-2}]				50 – 450	Leu et al., 2017
Phytoplankton [gC·m^{-2}]	0.254 – 2.77	0.608 - 2.1			Piwosz et al., 2009
				<0.002	Błachowiak-Samołyk et al., 2015
Zooplankton [gC·m^{-2}]			1-6		Zajączkowski et al., 2010
				6-8	Błachowiak-Samołyk et al., 2015
Macrobethos [gC·m^{-2}]	4.8 – 7.73	6.44 – 20.48		2.31 – 8.34	Włodarska-Kowalczuk et al., 2019
Summer pelagic primary production [mgC·m^{-2}·day^{-1}]	59 -108 80 - 155	173 - 1333			Piwosz et al., 2009 Iversen and Seuthe, 2011
Spring pelagic primary production [mgC·m^{-2}·day^{-1}]	405 - 445 30 - 1850	320 - 2770	 42.6		Iversen and Seuthe, 2011 Hodal et al., 2012 Vonnahme et al., 2021
Zoobenthos production [gC·m^{-2}·y^{-1}]	9.4 2.1 – 6.6	19.2 1.2 – 2.6			Włodarska-Kowalczuk et al., 2019 Zaborska et al., 2018 (only macro.)
Burial rate of OC [gC·m^{-2}·y^{-1}]	28 ± 6 9 - 13 5.7-10.0 15	28 ± 1 19.3-30.3 38			Włodarska-Kowalczuk et al., 2019 Kuliński et al., 2014 Koziorowska et al., 2018 Zaborska et al., 2018



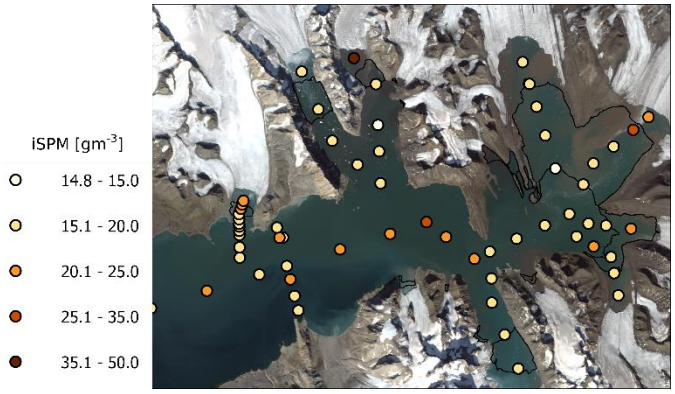
Supplementary Figure 1 Inorganic sediment flux as a function of 6accPDD AT and mean salinity. 6accPDD is the accumulated daily temperature for positive degree days for 6 days window (°C), 34.9 is a reference salinity for Atlantic Water (Moskalik et al., 2018), and meanS is the mean salinity above the sediment trap.



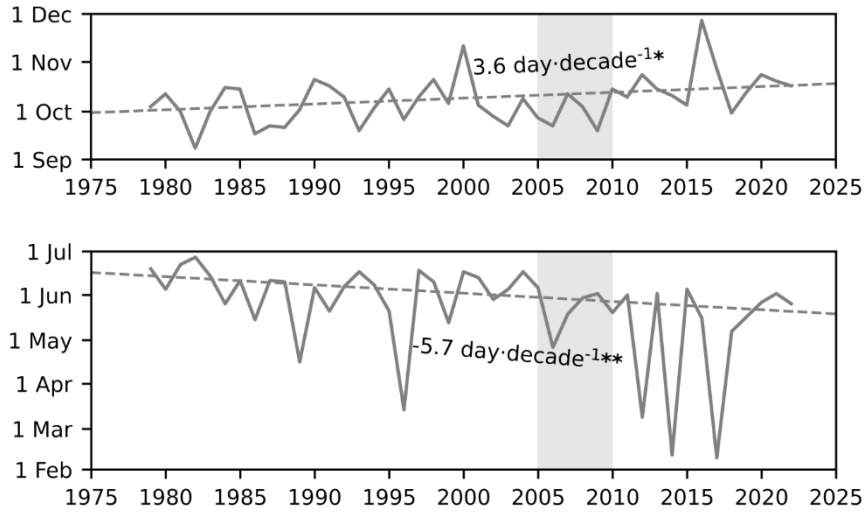
Supplementary Figure 2 Inorganic SPM concentration (iSPM, g·m^{-3}) at monitoring stations (M4 and M5) in 2019 and at modelled station (2) in 2006 and 2009.



Supplementary Figure 3 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 (g·m^{-3}).



Supplementary Figure 4 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.



Supplementary Figure 5 The trends in a 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.