Supplements

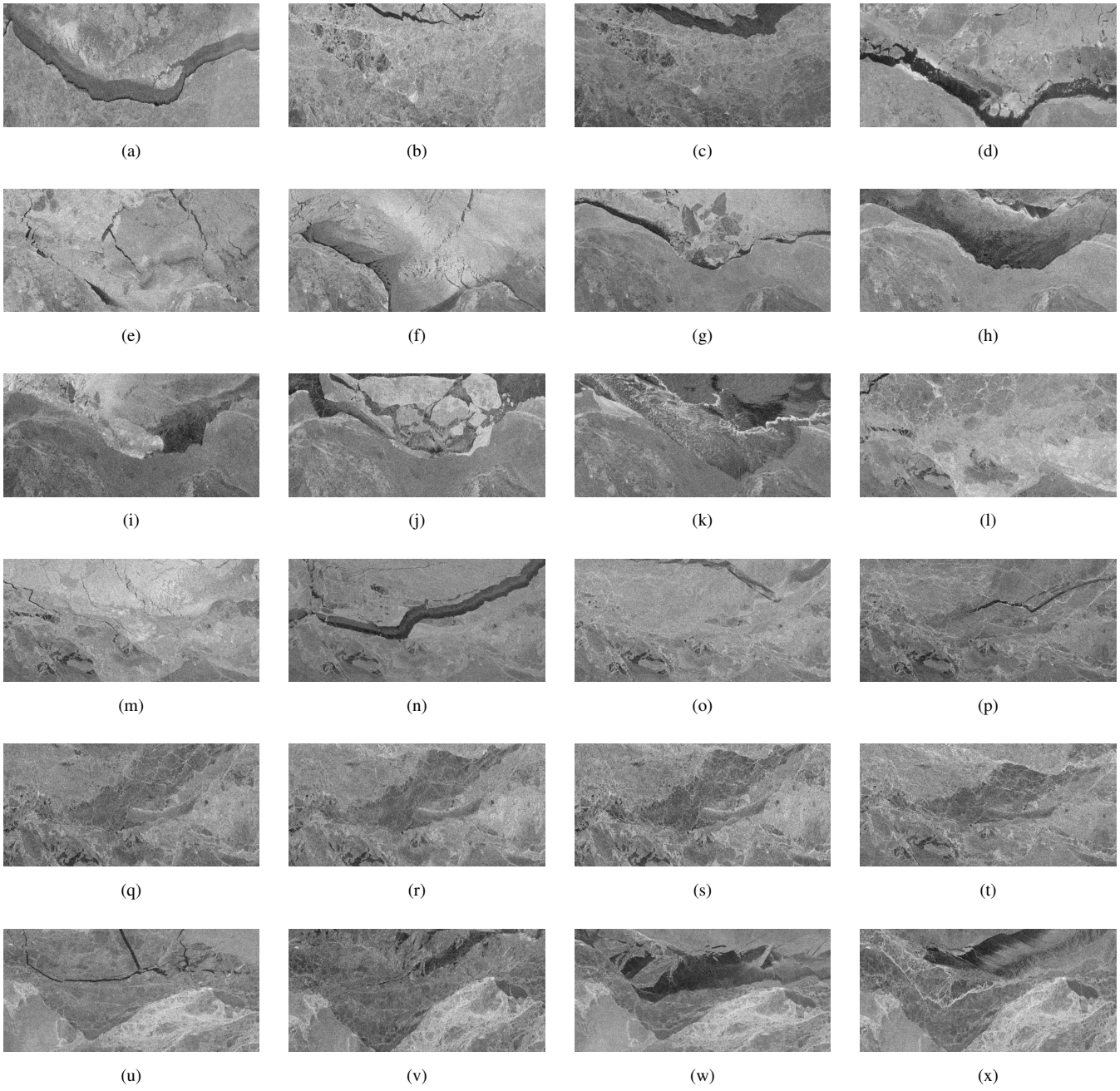

Figure S1. Preprocessing results of SAR imagery alongside thresholded outputs, with corresponding calculations from 500m and 1km moving grid windows. The figure highlights spatial variations in backscatter features and fractures in the sea ice. Subfigures correspond to SAR acquisitions on the following dates: (a) 20161225, (b) 20170211, (c) 20170213, (d) 20181205, (e) 20181217, (f) 20181229, (g) 20190210, (h) 20190306, (i) 20190316, (j) 20190421, (k) 20190505, (l) 20191207, (m) 20191219, (n) 20200117, (o) 20200205, (p) 20200217, (q) 20200308, (r) 20200320, (s) 20200401, (t) 20200417, (u) 20210106, (v) 20210116, (w) 20210211, (x) 20210305

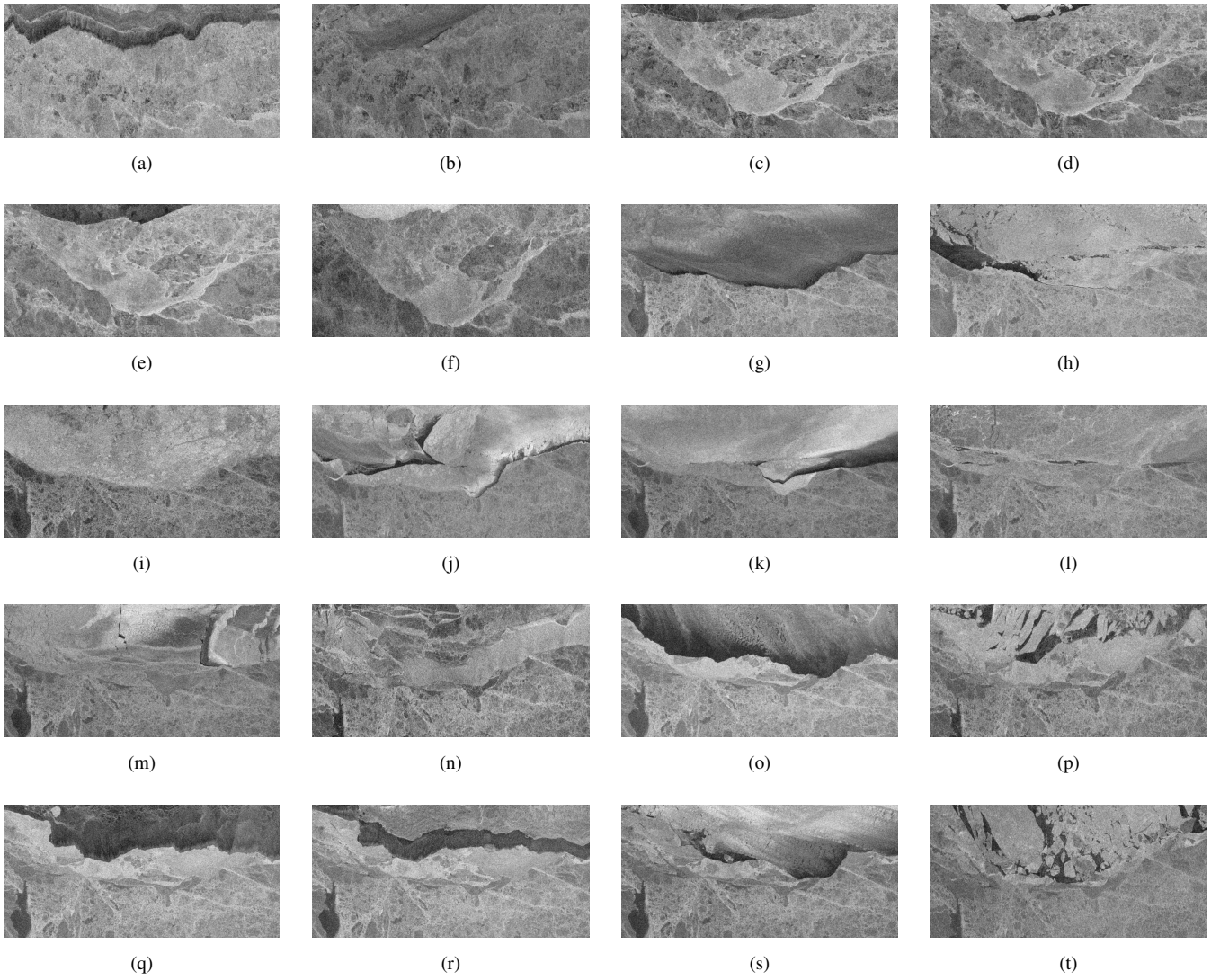

Figure S2. Continued from Figure A1 of SAR imagery preprocessing results and thresholded outputs, with corresponding calculations from 500m and 1km moving grid windows. These subfigures highlight additional temporal coverage of sea ice backscatter and fracture features. Subfigures correspond to SAR acquisitions on the following dates: (a) 20211206, (b) 20211218, (c) 20220223, (d) 20220407, (e) 20220424, (f) 20220509, (g) 20221208, (h) 20221215, (i) 20230101, (j) 20230104, (k) 20230108, (l) 20230113, (m) 20230120, (n) 20230223, (o) 20230309, (p) 20230319, (q) 20230321, (r) 20230326, (s) 20230402, (t) 20230504

Table S1: The table presents the average wind speed (Km/h) and temperature (°C), along with the percentage distribution of wind originating from land (L: E, ESE, SE, SSE, S, SSW, SW, WSW, and W) and ocean (O: WNW, NW, NNW, N, NNE, NE, and ENE). WS: Wind Speed, WD (L, O): Wind Direction (Land, Ocean), T: Temperature

Dates	7 Days			3 Days			2 Days			1 Day			On the Day		
	WS	WD (L, O)	T	WS	WD (L, O)	T	WS	WD (L, O)	T	WS	WD (L, O)	T	WS	WD (L, O)	T
2016-12-25	26.30	(98.21, 1.79)	-18.52	19.91	(95.83, 4.17)	-16.70	20.16	(97.92, 2.08)	-16.88	19.33	(95.83, 4.17)	-15.98	13.14	(100.00, 0.00)	-19.99
2017-02-11	24.58	(15.48, 84.52)	-15.75	30.88	(15.28, 84.72)	-20.73	27.03	(4.17, 95.83)	-22.92	22.42	(0.00, 100.00)	-24.74	16.84	(100.00, 0.00)	-28.27
2017-02-13	23.93	(44.05, 55.95)	-21.43	19.58	(66.67, 33.33)	-28.11	18.16	(100.00, 0.00)	-29.80	19.47	(100.00, 0.00)	-31.33	13.49	(100.00, 0.00)	-29.64
2018-12-05	17.80	(75.00, 25.00)	-11.49	16.93	(66.67, 33.33)	-10.97	18.35	(54.17, 45.83)	-10.48	22.55	(54.17, 45.83)	-9.42	13.95	(70.83, 29.17)	-10.92
2018-12-17	25.45	(57.14, 42.86)	-19.60	24.96	(100.00, 0.00)	-19.49	25.15	(100.00, 0.00)	-20.04	24.86	(100.00, 0.00)	-18.63	13.99	(41.67, 58.33)	-17.63
2018-12-29	21.40	(50.60, 49.40)	-22.94	31.61	(100.00, 0.00)	-23.75	34.17	(100.00, 0.00)	-21.38	29.56	(100.00, 0.00)	-19.03	15.23	(100.00, 0.00)	-21.57
2019-02-10	29.73	(92.26, 7.74)	-17.64	36.19	(81.94, 18.06)	-14.69	38.29	(72.92, 27.08)	-10.75	31.24	(45.83, 54.17)	-6.97	21.62	(66.67, 33.33)	-10.84
2019-03-06	27.00	(85.12, 14.88)	-14.10	27.76	(77.78, 22.22)	-10.34	25.41	(68.75, 31.25)	-9.41	29.06	(100.00, 0.00)	-9.17	11.52	(100.00, 0.00)	-11.45
2019-03-16	21.07	(57.14, 42.86)	-15.91	22.72	(66.67, 33.33)	-20.05	29.08	(100.00, 0.00)	-19.28	29.30	(100.00, 0.00)	-16.02	16.57	(87.50, 12.50)	-14.58
2019-04-21	27.37	(92.86, 7.14)	-9.82	28.25	(83.33, 16.67)	-8.83	29.86	(85.42, 14.58)	-8.83	28.36	(100.00, 0.00)	-7.77	16.51	(100.00, 0.00)	-4.79
2019-05-05	20.60	(63.69, 36.31)	-7.52	27.34	(86.11, 13.89)	-7.76	24.07	(89.58, 10.42)	-6.69	21.99	(79.17, 20.83)	-5.65	16.45	(75.00, 25.00)	-5.00
2019-12-07	26.16	(19.44, 80.56)	-18.12	31.59	(5.56, 94.44)	-19.44	32.97	(0.00, 100.00)	-17.83	28.57	(0.00, 100.00)	-17.03	12.18	(95.83, 4.17)	-18.76
2019-12-19	20.11	(72.62, 27.38)	-21.45	14.70	(45.83, 54.17)	-24.04	15.79	(27.08, 72.92)	-24.71	11.38	(8.33, 91.67)	-25.52	18.99	(91.67, 8.33)	-25.17
2020-01-17	26.03	(52.98, 47.02)	-21.22	28.23	(69.44, 30.56)	-18.82	28.43	(54.17, 45.83)	-17.66	19.97	(41.67, 58.33)	-19.01	23.97	(100.00, 0.00)	-20.91
2020-02-05	16.80	(52.38, 47.62)	-27.80	21.05	(100.00, 0.00)	-28.64	20.28	(100.00, 0.00)	-29.99	24.31	(100.00, 0.00)	-29.15	14.86	(54.17, 45.83)	-23.62
2020-02-17	13.95	(67.26, 32.74)	-29.58	10.22	(65.28, 34.72)	-30.70	8.92	(83.33, 16.67)	-31.20	14.02	(100.00, 0.00)	-31.78	27.73	(100.00, 0.00)	-28.02
2020-03-08	17.48	(61.31, 38.69)	-28.41	21.80	(77.78, 22.22)	-27.75	19.75	(93.75, 6.25)	-27.44	25.20	(100.00, 0.00)	-26.22	19.04	(75.00, 25.00)	-23.07
2020-03-20	32.24	(69.05, 30.95)	-13.14	25.58	(63.89, 36.11)	-11.01	25.98	(95.83, 4.17)	-9.88	24.02	(100.00, 0.00)	-6.61	21.12	(100.00, 0.00)	-4.83
2020-04-01	26.72	(42.86, 57.14)	-19.26	20.88	(70.83, 29.17)	-20.08	22.29	(100.00, 0.00)	-19.29	28.78	(100.00, 0.00)	-17.05	30.20	(100.00, 0.00)	-12.92
2020-04-17	17.69	(65.48, 34.52)	-9.73	20.69	(52.78, 47.22)	-6.57	22.54	(56.25, 43.75)	-6.06	25.82	(29.17, 70.83)	-6.43	12.06	(41.67, 58.33)	-9.33
2019-12-07	26.16	(19.44, 80.56)	-18.12	31.59	(5.56, 94.44)	-19.44	32.97	(0.00, 100.00)	-17.83	28.57	(0.00, 100.00)	-17.03	12.18	(95.83, 4.17)	-18.76
2019-12-19	20.11	(72.62, 27.38)	-21.45	14.70	(45.83, 54.17)	-24.04	15.79	(27.08, 72.92)	-24.71	11.38	(8.33, 91.67)	-25.52	18.99	(91.67, 8.33)	-25.17
2020-01-17	26.03	(52.98, 47.02)	-21.22	28.23	(69.44, 30.56)	-18.82	28.43	(54.17, 45.83)	-17.66	19.97	(41.67, 58.33)	-19.01	23.97	(100.00, 0.00)	-20.91
2020-02-05	16.80	(52.38, 47.62)	-27.80	21.05	(100.00, 0.00)	-28.64	20.28	(100.00, 0.00)	-29.99	24.31	(100.00, 0.00)	-29.15	14.86	(54.17, 45.83)	-23.62
2020-02-17	13.95	(67.26, 32.74)	-29.58	10.22	(65.28, 34.72)	-30.70	8.92	(83.33, 16.67)	-31.20	14.02	(100.00, 0.00)	-31.78	27.73	(100.00, 0.00)	-28.02
2020-03-08	17.48	(61.31, 38.69)	-28.41	21.80	(77.78, 22.22)	-27.75	19.75	(93.75, 6.25)	-27.44	25.20	(100.00, 0.00)	-26.22	19.04	(75.00, 25.00)	-23.07
2020-03-20	32.24	(69.05, 30.95)	-13.14	25.58	(63.89, 36.11)	-11.01	25.98	(95.83, 4.17)	-9.88	24.02	(100.00, 0.00)	-6.61	21.12	(100.00, 0.00)	-4.83
2020-04-01	26.72	(42.86, 57.14)	-19.26	20.88	(70.83, 29.17)	-20.08	22.29	(100.00, 0.00)	-19.29	28.78	(100.00, 0.00)	-17.05	30.20	(100.00, 0.00)	-12.92
2020-04-17	17.69	(65.48, 34.52)	-9.73	20.69	(52.78, 47.22)	-6.57	22.54	(56.25, 43.75)	-6.06	25.82	(29.17, 70.83)	-6.43	12.06	(41.67, 58.33)	-9.33
2021-12-06	17.33	(51.67, 48.33)	-26.16	19.98	(79.17, 20.83)	-26.07	16.70	(100.00, 0.00)	-25.84	19.88	(100.00, 0.00)	-25.33	29.03	(100.00, 0.00)	-19.13
2021-12-18	19.30	(27.98, 72.02)	-24.58	18.41	(61.11, 38.89)	-27.31	20.64	(91.67, 8.33)	-27.87	26.60	(100.00, 0.00)	-27.45	17.89	(100.00, 0.00)	-25.61
2022-01-23	20.05	(77.98, 22.02)	-28.01	24.85	(68.06, 31.94)	-27.10	24.77	(93.75, 6.25)	-26.64	29.13	(100.00, 0.00)	-26.85	34.55	(100.00, 0.00)	-18.22
2022-02-23	22.82	(54.17, 45.83)	-23.50	22.53	(65.28, 34.72)	-23.59	24.98	(97.92, 2.08)	-21.95	34.14	(100.00, 0.00)	-16.57	24.49	(70.83, 29.17)	-13.83
2022-02-28	23.59	(61.90, 38.10)	-21.57	21.39	(52.78, 47.22)	-24.43	21.74	(79.17, 20.83)	-24.79	27.41	(100.00, 0.00)	-24.75	28.09	(100.00, 0.00)	-21.03
2022-04-07	12.68	(27.98, 72.02)	-24.76	12.44	(65.28, 34.72)	-23.58	14.77	(97.92, 2.08)	-22.74	20.91	(100.00, 0.00)	-20.42	18.37	(100.00, 0.00)	-12.99
2022-04-24	14.43	(73.81, 26.19)	-13.15	20.20	(77.78, 22.22)	-11.48	26.19	(100.00, 0.00)	-9.55	29.75	(100.00, 0.00)	-6.45	7.68	(70.83, 29.17)	-6.58
2022-05-01	14.22	(46.43, 53.57)	-7.84	16.21	(80.56, 19.44)	-7.19	18.66	(100.00, 0.00)	-5.52	14.37	(100.00, 0.00)	-3.63	23.44	(100.00, 0.00)	-0.30
2022-05-09	17.61	(57.14, 42.86)	-1.04	18.72	(77.78, 22.22)	-1.10	21.51	(100.00, 0.00)	-0.93	25.30	(100.00, 0.00)	-0.45	26.68	(100.00, 0.00)	1.06
2022-12-08	31.63	(61.31, 38.69)	-18.33	35.15	(100.00, 0.00)	-24.03	31.78	(100.00, 0.00)	-24.06	24.96	(100.00, 0.00)	-23.90	26.12	(100.00, 0.00)	-27.53
2022-12-15	25.34	(87.50, 12.50)	-20.95	28.82	(70.83, 29.17)	-17.13	23.57	(56.25, 43.75)	-15.11	20.42	(50.00, 50.00)	-15.27	24.35	(83.33, 16.67)	-16.17
2023-01-01	19.88	(88.10, 11.90)	-25.30	18.93	(100.00, 0.00)	-20.83	19.45	(100.00, 0.00)	-20.10	20.58	(100.00, 0.00)	-19.20	25.20	(100.00, 0.00)	-18.82
2023-01-04	26.18	(97.62, 2.38)	-19.93	35.66	(100.00, 0.00)	-17.11	40.89	(100.00, 0.00)	-16.25	37.22	(100.00, 0.00)	-14.63	19.41	(100.00, 0.00)	-14.21
2023-01-08	27.35	(91.07, 8.93)	-17.80	21.69	(79.17, 20.83)	-19.68	22.23	(72.92, 27.08)	-21.15	23.17	(91.67, 8.33)	-22.45	18.27	(100.00, 0.00)	-19.79
2023-01-13	20.23	(66.07, 33.93)	-21.68	21.02	(51.39, 48.61)	-23.99	19.38	(77.08, 22.92)	-25.01	21.34	(100.00, 0.00)	-25.59	25.20	(100.00, 0.00)	-24.83
2023-01-20	17.93	(79.76, 20.24)	-20.97	15.27	(86.11, 13.89)	-18.46	15.08	(79.17, 20.83)	-16.57	12.15	(79.17, 20.83)	-15.60	18.04	(83.33, 16.67)	-18.58
2023-02-23	15.80	(83.93, 16.07)	-30.07	14.99	(70.83, 29.17)	-28.17	16.64	(56.25, 43.75)	-27.25	13.94	(54.17, 45.83)	-28.51	40.77	(100.00, 0.00)	-22.86
2023-02-25	22.29	(83.93, 16.07)	-26.04	30.27	(76.39, 23.61)	-20.94	38.43	(87.50, 12.50)	-17.15	36.09	(75.00, 25.00)	-11.45	29.83	(66.67, 33.33)	-12.18
2023-03-09	17.27	(60.71, 39.29)	-26.31	24.91	(100.00, 0.00)	-24.93	32.56	(100.00, 0.00)	-23.66	40.63	(100.00, 0.00)	-20.08	25.55	(79.17, 20.83)	-16.82
2023-03-19	14.89	(69.64, 30.36)	-24.00	12.09	(100.00, 0.00)	-26.74	14.07	(100.00, 0.00)	-26.38	16.20	(100.00, 0.00)	-25.14	23.35	(100.00, 0.00)	-17.98
2023-03-21	16.28	(82.74, 17.26)	-22.60	21.79	(100.00, 0.00)	-17.71	24.58	(100.00, 0.00)	-14.00	25.82	(100.00, 0.00)	-10.02	23.42	(100.00, 0.00)	-8.47
2023-03-26	25.68	(92.26, 7.74)	-10.41	28.86	(81.94, 18.06)	-9.31	29.38	(72.92, 27.08)	-9.21	27.27	(45.83, 54.17)	-9.13	23.64	(75.00, 25.00)	-12.38
2023-04-02	26.78	(73.81, 26.19)	-12.06	29.52	(100.00, 0.00)	-15.44	32.32	(100.00, 0.00)	-15.85	30.21	(100.00, 0.00)	-16.01	23.63	(100.00, 0.00)	-16.12
2023-05-04	17.64	(35.71, 64.29)	-8.02	21.21	(40.28, 59.72)	-4.21	16.44	(60.42, 39.58)	-2.55	16.82	(54.17, 45.83)	-1.66	19.81	(100.00, 0.00)	-4.68

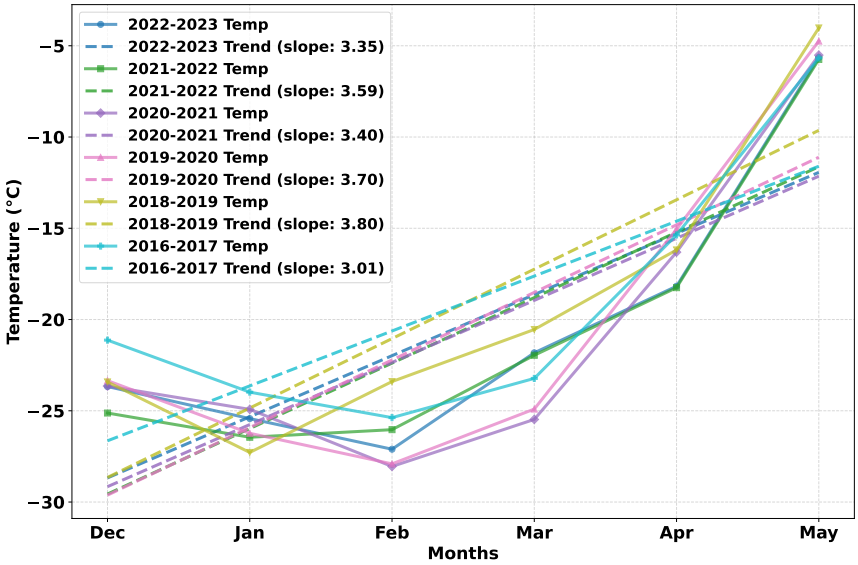

Figure S3. Seasonal Temperature Trends from 2016 to 2023: A comparison of daily temperature variations and trend lines from December to June, highlighting temperature variability across multiple years

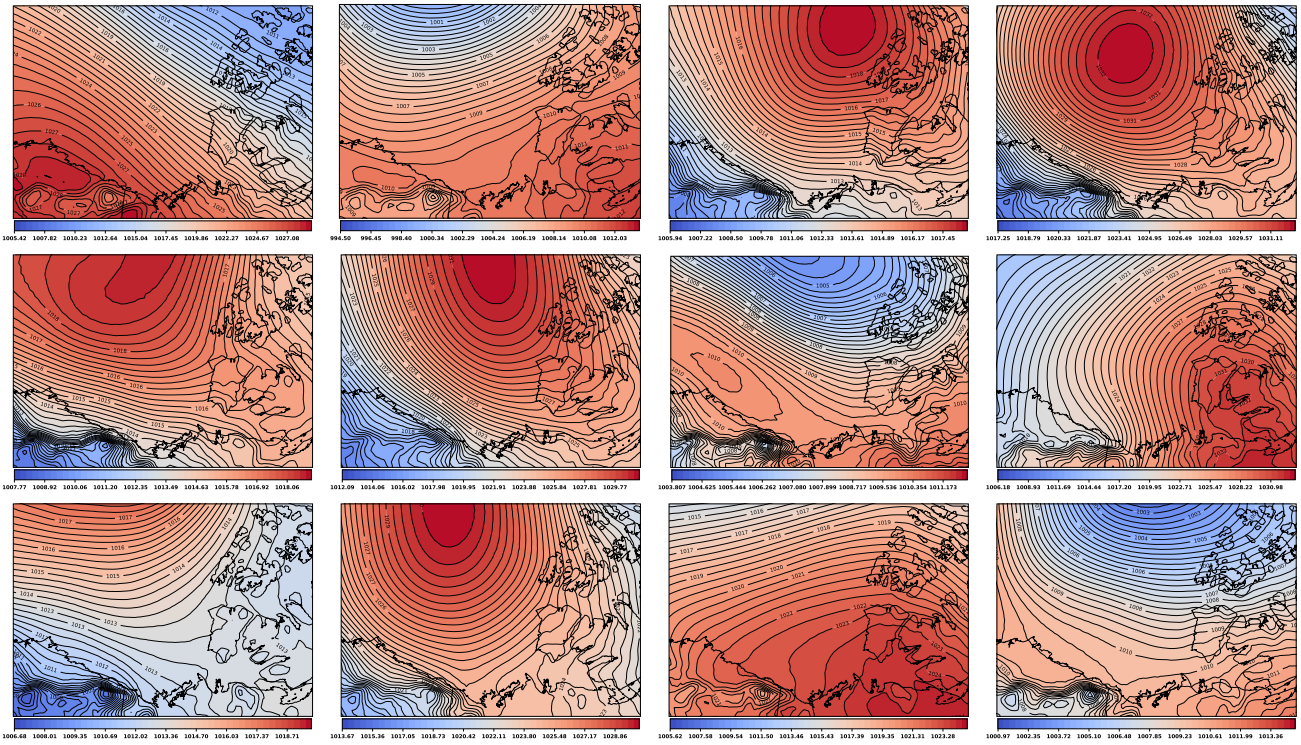

Figure S4. The maps represent the output of the trained SOM, with each plot displaying the mean pattern for clusters 0 through 3, arranged from left to right. The clusters are shown for the years 2016–2017 to 2022–2023, organized from top to bottom.

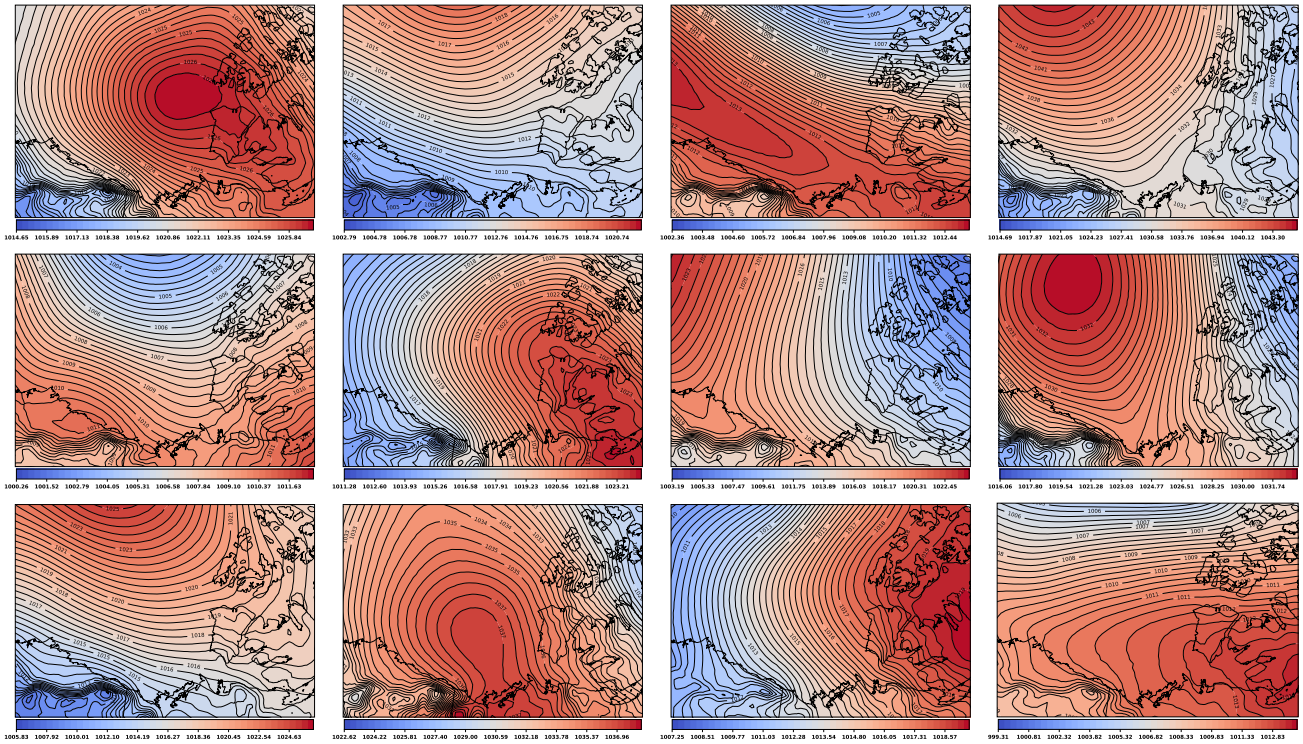

Figure S4. (continued)