



Supplement of

Relationships between Arctic sea-ice concentration, temperature, and specific humidity in the lower troposphere during 1980–2021

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Table S1. Change per 10 years during February–March–April in sea-ice concentration (SIC), temperature at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (Ts, T2m, T950, T850, T750, T600), and specific humidity at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (Qs, Q2m, Q950, Q850, Q750, Q600) over the areas of eight Arctic basins (as shown in Fig. 1). Changes were calculated from area-averaged annual means (of daily means in February–March–April) during 1980–2021 as slopes of ordinary-least-square-regression line using time as an independent variable. Units of temperature and specific humidity changes are K per 10 years and g kg⁻¹ per 10 years, respectively. Statistically significant results at the confidence level $p < 0.05$ are marked in bold. Standard errors of the slopes are marked in italics.

	Central Arctic	Beaufort Sea	Chukchi Sea	East Siberian + Laptev Sea	Kara + Barents Sea	Greenland Sea	Baffin Bay	Hudson Bay
SIC	-0.000 <i>0.0001</i>	0.004 <i>0.0001</i>	0.002 <i>0.0002</i>	-0.002 <i>0.0001</i>	-0.025 <i>0.0007</i>	-0.007 <i>0.0004</i>	-0.007 <i>0.0004</i>	-0.006 <i>0.0003</i>
Ts	1.08 <i>0.020</i>	0.58 <i>0.021</i>	0.77 <i>0.026</i>	1.04 <i>0.020</i>	0.97 <i>0.022</i>	0.21 <i>0.012</i>	0.90 <i>0.026</i>	0.57 <i>0.026</i>
T2m	1.11 <i>0.020</i>	0.68 <i>0.022</i>	0.84 <i>0.026</i>	1.09 <i>0.020</i>	0.88 <i>0.023</i>	0.16 <i>0.014</i>	0.87 <i>0.026</i>	0.53 <i>0.025</i>
T950	0.90 <i>0.017</i>	0.65 <i>0.021</i>	0.77 <i>0.024</i>	0.82 <i>0.017</i>	0.60 <i>0.020</i>	0.23 <i>0.013</i>	0.75 <i>0.025</i>	0.25 <i>0.028</i>
T850	0.81 <i>0.016</i>	0.55 <i>0.020</i>	0.69 <i>0.021</i>	0.69 <i>0.016</i>	0.48 <i>0.017</i>	0.48 <i>0.015</i>	0.73 <i>0.023</i>	0.10 <i>0.029</i>
T750	0.60 <i>0.015</i>	0.36 <i>0.019</i>	0.48 <i>0.018</i>	0.47 <i>0.014</i>	0.13 <i>0.015</i>	0.21 <i>0.014</i>	0.47 <i>0.022</i>	-0.05 <i>0.028</i>
T600	0.49 <i>0.013</i>	0.33 <i>0.016</i>	0.45 <i>0.016</i>	0.39 <i>0.012</i>	0.04 <i>0.013</i>	0.20 <i>0.015</i>	0.35 <i>0.020</i>	-0.11 <i>0.025</i>
Qs	0.05 <i>0.001</i>	0.02 <i>0.001</i>	0.05 <i>0.002</i>	0.07 <i>0.001</i>	0.12 <i>0.003</i>	0.06 <i>0.002</i>	0.08 <i>0.002</i>	0.02 <i>0.003</i>
Q2m	0.05 <i>0.001</i>	0.03 <i>0.001</i>	0.05 <i>0.002</i>	0.07 <i>0.001</i>	0.08 <i>0.003</i>	0.02 <i>0.002</i>	0.05 <i>0.002</i>	0.02 <i>0.002</i>
Q950	0.04 <i>0.001</i>	0.02 <i>0.001</i>	0.04 <i>0.002</i>	0.05 <i>0.001</i>	0.06 <i>0.002</i>	0.03 <i>0.002</i>	0.05 <i>0.002</i>	0.00 <i>0.002</i>
Q850	0.03 <i>0.001</i>	0.00 <i>0.001</i>	0.01 <i>0.001</i>	0.01 <i>0.001</i>	0.03 <i>0.002</i>	0.04 <i>0.002</i>	0.03 <i>0.002</i>	-0.03 <i>0.002</i>
Q750	0.02 <i>0.001</i>	0.00 <i>0.001</i>	0.01 <i>0.001</i>	0.01 <i>0.001</i>	0.02 <i>0.001</i>	0.03 <i>0.001</i>	0.02 <i>0.001</i>	-0.03 <i>0.001</i>
Q600	0.01 <i>0.001</i>	0.01 <i>0.000</i>	0.01 <i>0.001</i>	0.01 <i>0.000</i>	0.00 <i>0.000</i>	0.01 <i>0.001</i>	0.01 <i>0.001</i>	-0.01 <i>0.001</i>

Table S2. Coefficient of determination (R^2) between detrended seasonal means (calculated from daily means) of sea-ice concentration (SIC) and temperature at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (Ts, T2m, T950, T850, T750, T600), and specific humidity at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (Qs, Q2m, Q950, Q850, Q750, Q600) over the areas of eight Arctic basins (as shown in Fig. 1) for February–March–April during 1980–2021. Statistically significant results at the confidence level $p < 0.05$ are marked in bold.

	Central Arctic	Beaufort Sea	Chukchi Sea	East Siberian + Laptev Sea	Kara + Barents Sea	Greenland Sea	Baffin Bay	Hudson Bay
SIC, Ts	0.42	0.16	0.40	0.23	0.81	0.72	0.70	0.36
SIC, T2m	0.37	0.15	0.36	0.22	0.74	0.51	0.62	0.30
SIC, T950	0.14	0.08	0.24	0.11	0.62	0.33	0.52	0.17
SIC, T850	0.06	0.03	0.14	0.06	0.36	0.10	0.38	0.12
SIC, T750	0.04	0.01	0.13	0.05	0.29	0.06	0.33	0.14
SIC, T600	0.04	0.01	0.17	0.03	0.22	0.03	0.26	0.20
SIC, Qs	0.43	0.15	0.49	0.25	0.90	0.83	0.79	0.36
SIC, Q2m	0.40	0.13	0.44	0.24	0.68	0.30	0.58	0.29
SIC, Q950	0.19	0.10	0.35	0.18	0.57	0.22	0.51	0.14
SIC, Q850	0.06	0.04	0.24	0.12	0.41	0.14	0.29	0.08
SIC, Q750	0.06	0.05	0.22	0.08	0.28	0.06	0.21	0.10
SIC, Q600	0.05	0.06	0.27	0.04	0.20	0.03	0.16	0.19

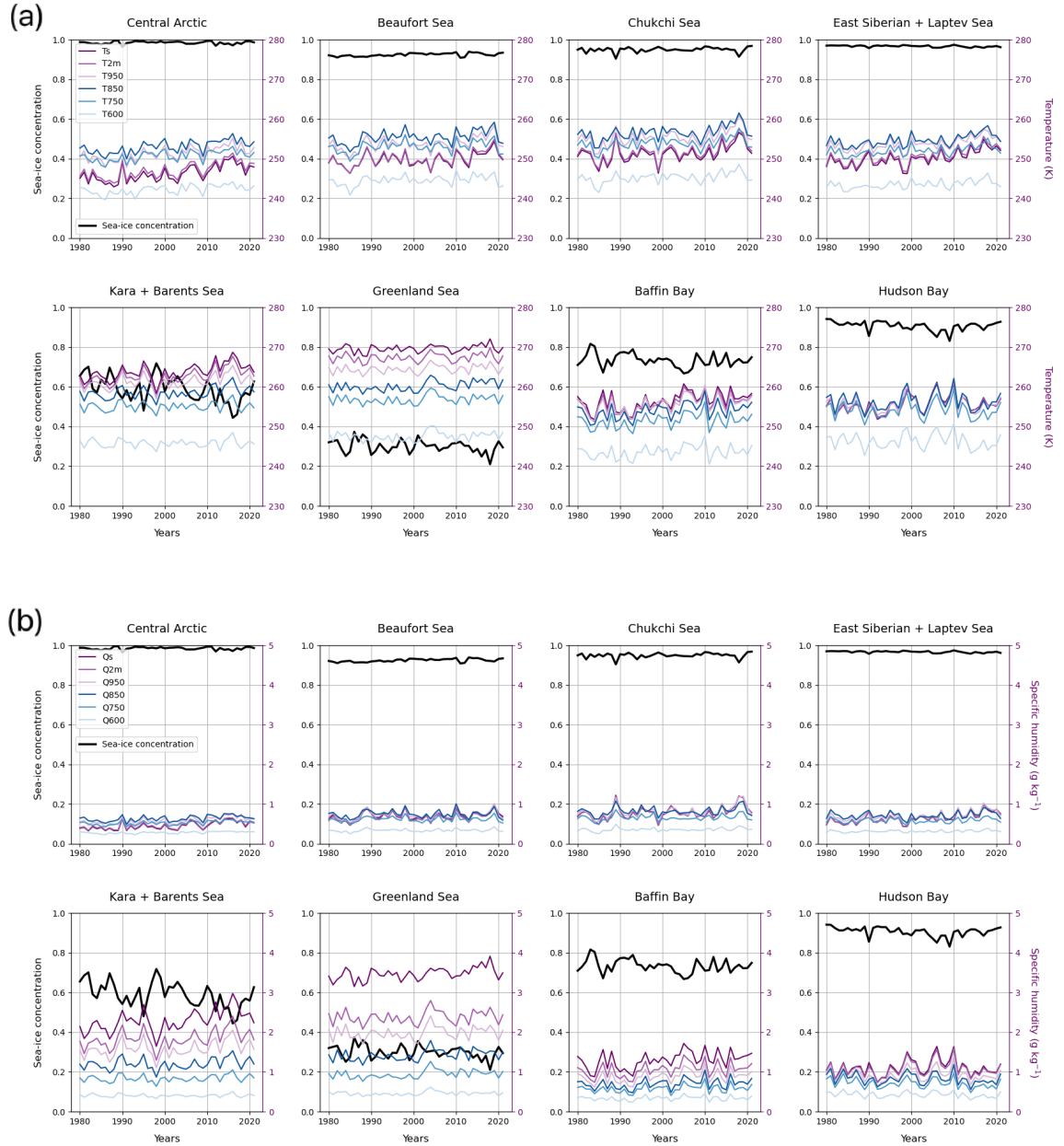


Figure S1. Seasonal means calculated from daily means in February–March–April during years 1980–2021 averaged over the areas of eight Arctic basins (as shown in Fig. 1). **(a):** Sea-ice concentration and temperature at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (T_s , T_{2m} , T_{950} , T_{850} , T_{750} , T_{600}). **(b):** Same as **(a)** but for the surface and air specific humidities. Only grid cells fully covered by the sea were considered in this analysis.

Table S3. Change per 10 years during May–June–July in sea-ice concentration (SIC), temperature at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (Ts, T2m, T950, T850, T750, T600), and specific humidity at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (Qs, Q2m, Q950, Q850, Q750, Q600) over the areas of eight Arctic basins (as shown in Fig. 1). Changes were calculated from area-averaged annual means (of daily means in May–June–July) during 1980–2021 as slopes of ordinary-least-square-regression line using time as an independent variable. Units of temperature and specific humidity changes are K per 10 years and g kg⁻¹ per 10 years, respectively. Statistically significant results at the confidence level $p < 0.05$ are marked in bold. Standard errors of the slopes are marked in italics.

	Central Arctic	Beaufort Sea	Chukchi Sea	East Siberian + Laptev Sea	Kara + Barents Sea	Greenland Sea	Baffin Bay	Hudson Bay
SIC	0.003 <i>0.0002</i>	-0.010 <i>0.0007</i>	-0.019 <i>0.0006</i>	-0.021 <i>0.0007</i>	-0.034 <i>0.0007</i>	0.004 <i>0.0003</i>	-0.017 <i>0.0004</i>	-0.000 <i>0.0008</i>
Ts	0.13 <i>0.009</i>	0.25 <i>0.008</i>	0.36 <i>0.009</i>	0.30 <i>0.008</i>	0.43 <i>0.007</i>	0.17 <i>0.004</i>	0.25 <i>0.008</i>	0.11 <i>0.008</i>
T2m	0.11 <i>0.009</i>	0.23 <i>0.009</i>	0.36 <i>0.010</i>	0.34 <i>0.009</i>	0.44 <i>0.009</i>	0.23 <i>0.005</i>	0.31 <i>0.009</i>	0.17 <i>0.010</i>
T950	-0.07 <i>0.011</i>	-0.02 <i>0.012</i>	0.15 <i>0.012</i>	0.16 <i>0.012</i>	0.31 <i>0.012</i>	0.32 <i>0.007</i>	0.27 <i>0.013</i>	0.11 <i>0.015</i>
T850	0.41 <i>0.017</i>	0.40 <i>0.012</i>	0.46 <i>0.014</i>	0.48 <i>0.015</i>	0.49 <i>0.011</i>	0.46 <i>0.010</i>	0.55 <i>0.014</i>	0.47 <i>0.014</i>
T750	0.35 <i>0.015</i>	0.25 <i>0.010</i>	0.28 <i>0.012</i>	0.31 <i>0.013</i>	0.23 <i>0.009</i>	0.20 <i>0.010</i>	0.34 <i>0.013</i>	0.28 <i>0.012</i>
T600	0.41 <i>0.012</i>	0.34 <i>0.009</i>	0.35 <i>0.009</i>	0.36 <i>0.011</i>	0.26 <i>0.009</i>	0.25 <i>0.009</i>	0.41 <i>0.012</i>	0.36 <i>0.011</i>
Qs	0.02 <i>0.002</i>	0.06 <i>0.002</i>	0.09 <i>0.002</i>	0.06 <i>0.002</i>	0.15 <i>0.002</i>	0.07 <i>0.001</i>	0.07 <i>0.002</i>	0.04 <i>0.002</i>
Q2m	0.00 <i>0.002</i>	0.04 <i>0.002</i>	0.07 <i>0.002</i>	0.05 <i>0.002</i>	0.12 <i>0.002</i>	0.08 <i>0.002</i>	0.07 <i>0.002</i>	0.05 <i>0.002</i>
Q950	-0.02 <i>0.002</i>	0.02 <i>0.002</i>	0.04 <i>0.002</i>	0.02 <i>0.002</i>	0.10 <i>0.002</i>	0.11 <i>0.002</i>	0.09 <i>0.002</i>	0.07 <i>0.003</i>
Q850	-0.07 <i>0.002</i>	0.01 <i>0.002</i>	0.04 <i>0.002</i>	0.03 <i>0.002</i>	0.10 <i>0.002</i>	0.12 <i>0.002</i>	0.09 <i>0.003</i>	0.06 <i>0.003</i>
Q750	-0.02 <i>0.002</i>	0.03 <i>0.002</i>	0.04 <i>0.002</i>	0.03 <i>0.002</i>	0.06 <i>0.002</i>	0.06 <i>0.002</i>	0.05 <i>0.002</i>	0.05 <i>0.002</i>
Q600	0.02 <i>0.001</i>	0.01 <i>0.001</i>	0.01 <i>0.001</i>	0.01 <i>0.001</i>	-0.00 <i>0.001</i>	-0.00 <i>0.001</i>	0.02 <i>0.001</i>	0.01 <i>0.001</i>

Table S4. Coefficient of determination (R^2) between detrended seasonal means (calculated from daily means) of sea-ice concentration (SIC) and temperature at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (Ts, T2m, T950, T850, T750, T600), and specific humidity at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (Qs, Q2m, Q950, Q850, Q750, Q600) over the areas of eight Arctic basins (as shown in Fig. 1) for May–June–July during 1980–2021. Statistically significant results at the confidence level $p < 0.05$ are marked in bold.

	Central Arctic	Beaufort Sea	Chukchi Sea	East Siberian + Laptev Sea	Kara + Barents Sea	Greenland Sea	Baffin Bay	Hudson Bay
SIC, Ts	0.03	0.41	0.35	0.33	0.61	0.41	0.50	0.63
SIC, T2m	0.02	0.45	0.36	0.40	0.49	0.41	0.46	0.66
SIC, T950	0.00	0.52	0.17	0.37	0.22	0.26	0.32	0.52
SIC, T850	0.03	0.36	0.04	0.19	0.14	0.12	0.24	0.44
SIC, T750	0.07	0.35	0.03	0.12	0.04	0.09	0.23	0.47
SIC, T600	0.09	0.28	0.02	0.09	0.02	0.11	0.19	0.40
SIC, Qs	0.04	0.57	0.53	0.44	0.57	0.32	0.50	0.67
SIC, Q2m	0.01	0.40	0.43	0.49	0.40	0.36	0.40	0.60
SIC, Q950	0.05	0.21	0.21	0.55	0.25	0.35	0.28	0.18
SIC, Q850	0.03	0.22	0.12	0.40	0.12	0.23	0.19	0.20
SIC, Q750	0.00	0.13	0.07	0.28	0.02	0.17	0.13	0.27
SIC, Q600	0.00	0.07	0.01	0.05	0.00	0.10	0.06	0.21

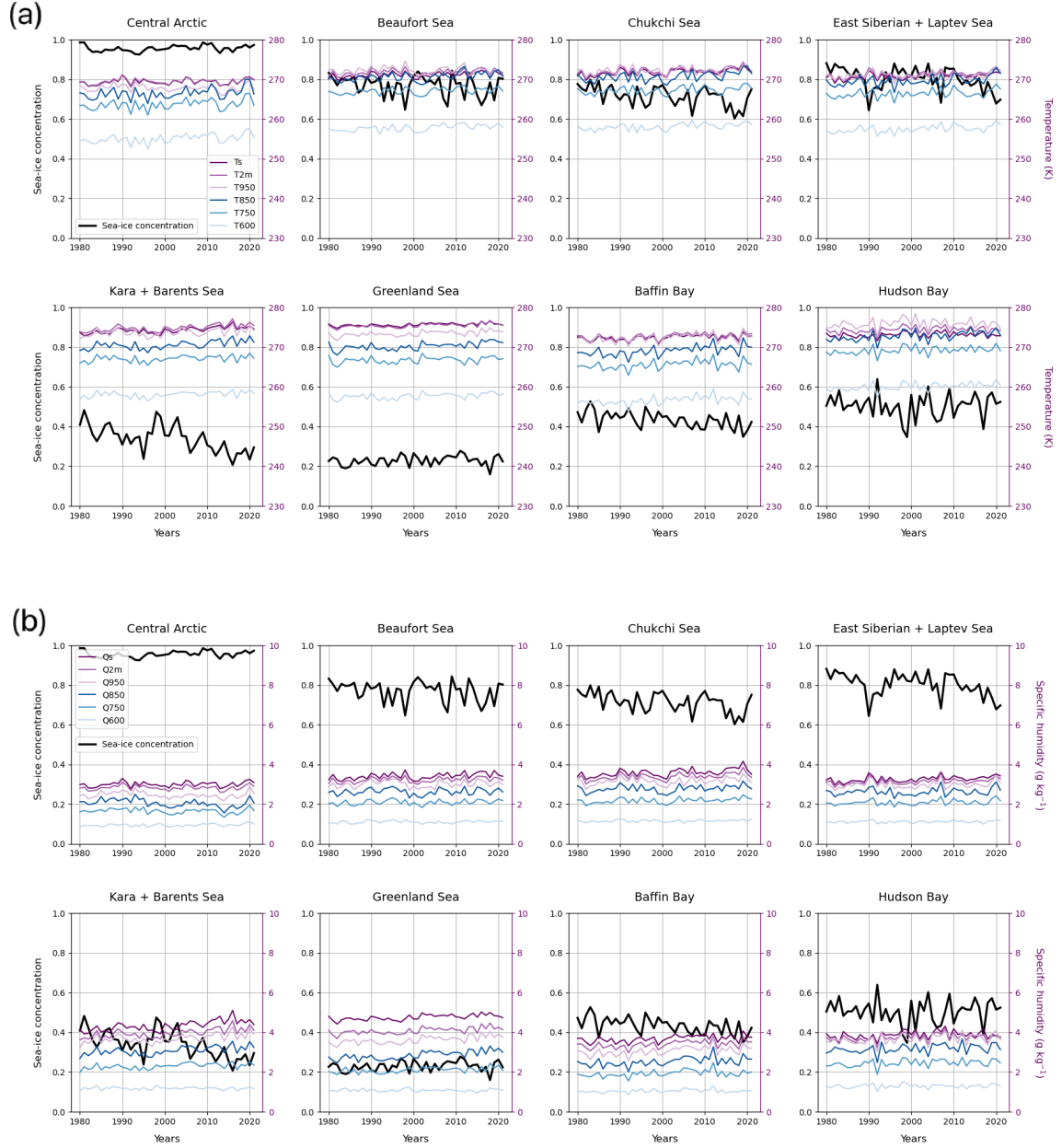


Figure S2. Seasonal means calculated from daily means in May–June–July during years 1980–2021 averaged over the areas of eight Arctic basins (as shown in Fig. 1). **(a):** Sea-ice concentration and temperature at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (Ts, T2m, T950, T850, T750, T600). **(b):** Same as **(a)** but for the surface and air specific humidities. Only grid cells fully covered by the sea were considered in this analysis.

Table S5. Change per 10 years during August–September–October in sea-ice concentration (SIC), temperature at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (Ts, T2m, T950, T850, T750, T600), and specific humidity at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (Qs, Q2m, Q950, Q850, Q750, Q600) over the areas of eight Arctic basins (as shown in Fig. 1). Changes were calculated from area-averaged annual means (of daily means in August–September–October) during 1980–2021 as slopes of ordinary-least-square-regression line using time as an independent variable. Units of temperature and specific humidity changes are K per 10 years and g kg⁻¹ per 10 years, respectively. Statistically significant results at the confidence level $p < 0.05$ are marked in bold. Standard errors of the slopes are marked in italics.

	Central Arctic	Beaufort Sea	Chukchi Sea	East Siberian + Laptev Sea	Kara + Barents Sea	Greenland Sea	Baffin Bay	Hudson Bay
SIC	-0.006 <i>0.0006</i>	-0.056 <i>0.0010</i>	-0.079 <i>0.0010</i>	-0.104 <i>0.0013</i>	-0.034 <i>0.0006</i>	-0.006 <i>0.0004</i>	-0.013 <i>0.0003</i>	0.001 <i>0.0001</i>
Ts	0.45 <i>0.016</i>	0.79 <i>0.013</i>	1.11 <i>0.016</i>	1.32 <i>0.018</i>	0.77 <i>0.011</i>	0.42 <i>0.006</i>	0.53 <i>0.009</i>	0.37 <i>0.011</i>
T2m	0.46 <i>0.015</i>	0.75 <i>0.013</i>	1.14 <i>0.016</i>	1.28 <i>0.017</i>	0.77 <i>0.012</i>	0.55 <i>0.008</i>	0.53 <i>0.010</i>	0.41 <i>0.011</i>
T950	0.52 <i>0.011</i>	0.58 <i>0.011</i>	0.93 <i>0.016</i>	0.98 <i>0.017</i>	0.64 <i>0.013</i>	0.63 <i>0.009</i>	0.49 <i>0.011</i>	0.38 <i>0.012</i>
T850	0.83 <i>0.013</i>	0.76 <i>0.012</i>	0.88 <i>0.016</i>	0.77 <i>0.015</i>	0.71 <i>0.013</i>	0.81 <i>0.010</i>	0.64 <i>0.013</i>	0.71 <i>0.015</i>
T750	0.66 <i>0.012</i>	0.50 <i>0.011</i>	0.54 <i>0.016</i>	0.42 <i>0.014</i>	0.42 <i>0.012</i>	0.50 <i>0.010</i>	0.36 <i>0.014</i>	0.51 <i>0.016</i>
T600	0.66 <i>0.012</i>	0.48 <i>0.011</i>	0.48 <i>0.016</i>	0.36 <i>0.013</i>	0.41 <i>0.012</i>	0.49 <i>0.010</i>	0.39 <i>0.014</i>	0.52 <i>0.016</i>
Qs	0.05 <i>0.002</i>	0.17 <i>0.003</i>	0.25 <i>0.004</i>	0.27 <i>0.004</i>	0.25 <i>0.003</i>	0.14 <i>0.002</i>	0.16 <i>0.003</i>	0.14 <i>0.004</i>
Q2m	0.05 <i>0.002</i>	0.12 <i>0.002</i>	0.20 <i>0.003</i>	0.21 <i>0.003</i>	0.20 <i>0.003</i>	0.17 <i>0.002</i>	0.12 <i>0.002</i>	0.14 <i>0.004</i>
Q950	0.06 <i>0.002</i>	0.11 <i>0.002</i>	0.19 <i>0.003</i>	0.19 <i>0.003</i>	0.18 <i>0.003</i>	0.18 <i>0.002</i>	0.13 <i>0.002</i>	0.15 <i>0.003</i>
Q850	0.06 <i>0.002</i>	0.11 <i>0.002</i>	0.16 <i>0.003</i>	0.15 <i>0.003</i>	0.16 <i>0.003</i>	0.19 <i>0.002</i>	0.12 <i>0.002</i>	0.16 <i>0.003</i>
Q750	0.05 <i>0.001</i>	0.07 <i>0.002</i>	0.09 <i>0.002</i>	0.07 <i>0.002</i>	0.09 <i>0.002</i>	0.12 <i>0.002</i>	0.07 <i>0.002</i>	0.11 <i>0.002</i>
Q600	0.03 <i>0.001</i>	0.02 <i>0.001</i>	0.03 <i>0.001</i>	0.01 <i>0.001</i>	0.01 <i>0.001</i>	0.03 <i>0.001</i>	0.02 <i>0.001</i>	0.04 <i>0.001</i>

Table S6. Coefficient of determination (R^2) between detrended seasonal means (calculated from daily means) of sea-ice concentration (SIC) and temperature at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (Ts, T2m, T950, T850, T750, T600), and specific humidity at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (Qs, Q2m, Q950, Q850, Q750, Q600) over the areas of eight Arctic basins (as shown in Fig. 1) for August–September–October during 1980–2021. Statistically significant results at the confidence level $p < 0.05$ are marked in bold.

	Central Arctic	Beaufort Sea	Chukchi Sea	East Siberian + Laptev Sea	Kara + Barents Sea	Greenland Sea	Baffin Bay	Hudson Bay
SIC, Ts	0.42	0.60	0.68	0.80	0.70	0.63	0.68	0.20
SIC, T2m	0.37	0.50	0.63	0.74	0.64	0.54	0.51	0.22
SIC, T950	0.05	0.24	0.46	0.50	0.41	0.35	0.27	0.16
SIC, T850	0.01	0.05	0.14	0.15	0.18	0.22	0.25	0.06
SIC, T750	0.01	0.01	0.11	0.07	0.12	0.17	0.14	0.03
SIC, T600	0.02	0.00	0.10	0.05	0.11	0.14	0.17	0.02
SIC, Qs	0.46	0.77	0.65	0.83	0.53	0.51	0.60	0.18
SIC, Q2m	0.38	0.55	0.54	0.68	0.45	0.39	0.33	0.18
SIC, Q950	0.13	0.31	0.44	0.57	0.32	0.32	0.26	0.11
SIC, Q850	0.04	0.12	0.25	0.35	0.16	0.20	0.14	0.09
SIC, Q750	0.03	0.07	0.16	0.14	0.07	0.13	0.08	0.06
SIC, Q600	0.02	0.04	0.03	0.03	0.05	0.08	0.13	0.03

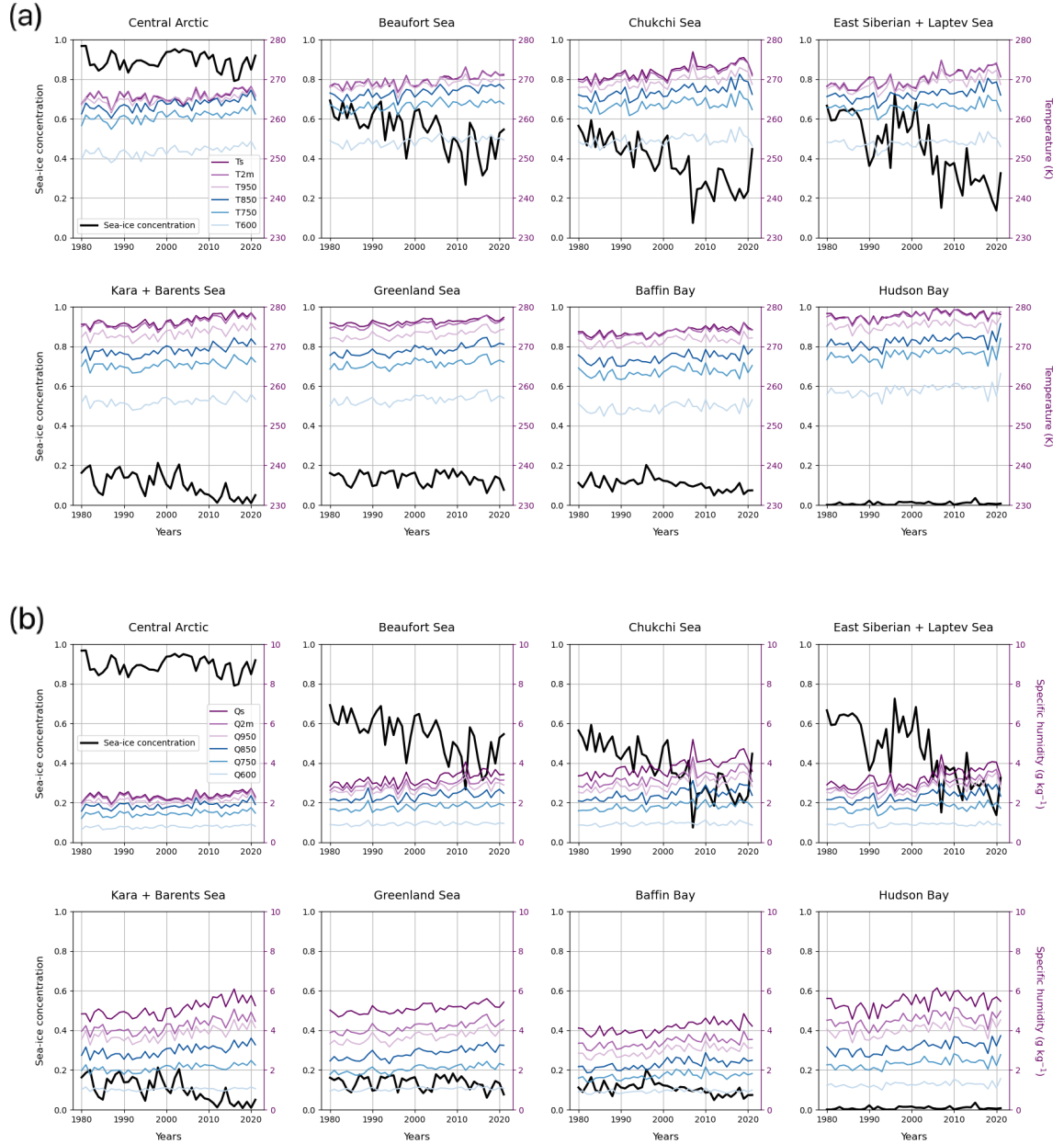


Figure S3. Seasonal means calculated from daily means in August–September–October during years 1980–2021 averaged over the areas of eight Arctic basins (as shown in Fig. 1). **(a):** Sea-ice concentration and temperature at the surface and the levels of 2 m, 950 hPa, 850 hPa, 750 hPa, and 600 hPa (Ts, T2m, T950, T850, T750, T600). **(b):** Same as **(a)** but for the surface and air specific humidities. Only grid cells fully covered by the sea were considered in this analysis.

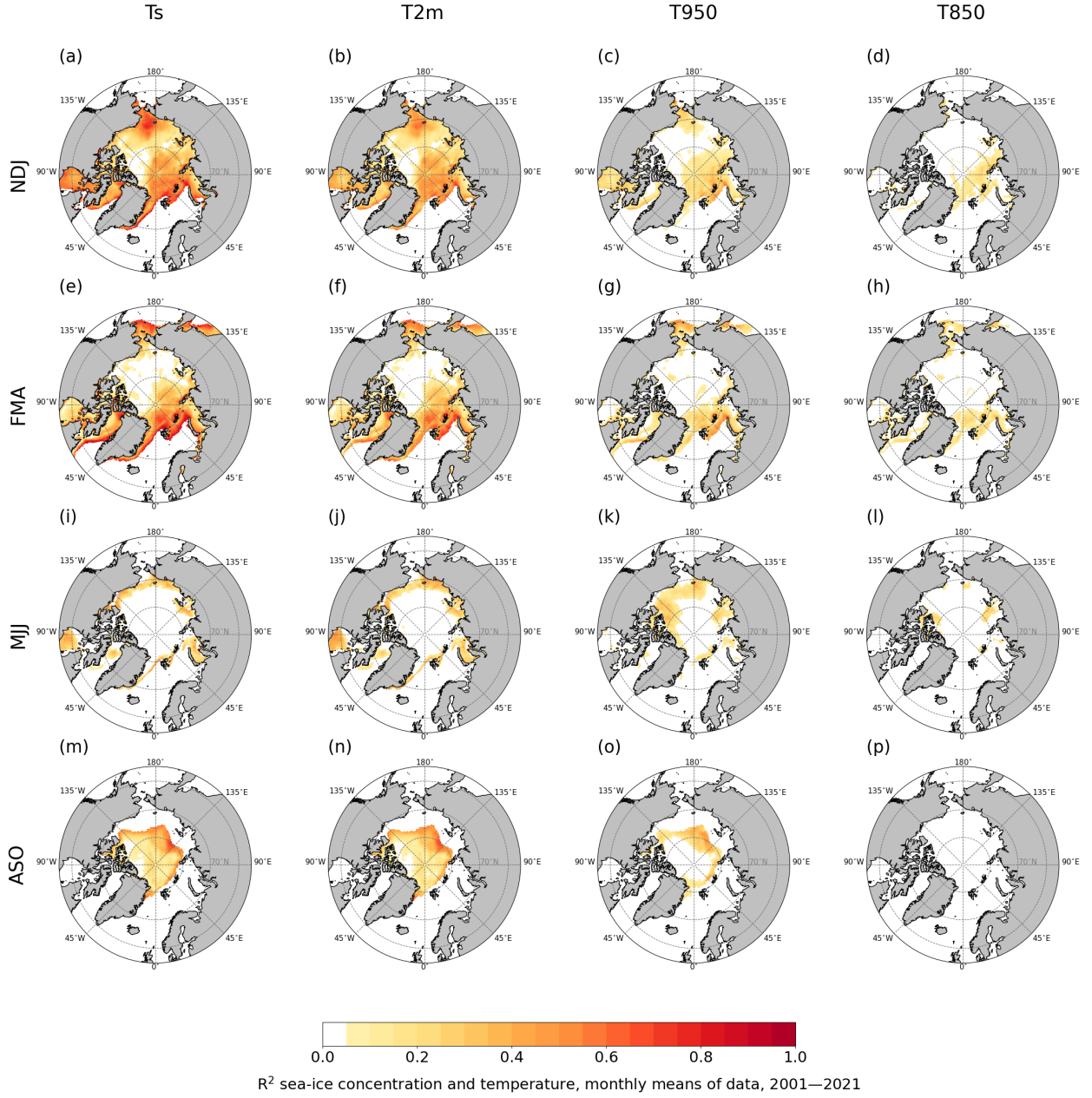


Figure S4. Coefficient of determination (R^2) between detrended anomalies of sea-ice concentration and temperature at the surface and the levels of 2 m, 950 hPa, and 850 hPa (Ts, T2m, T950, T850) in four seasons (November–December–January, February–March–April, May–June–July, August–September–October) in 2001–2021. The results are based on linear ordinary-least-squares-regression model using monthly means of NCEP/CFSR data. Only grid cells with a mean of SIC > 0.5 were considered and only statistically significant results at the confidence level $p < 0.05$ are shown (insignificant ones are masked in white).

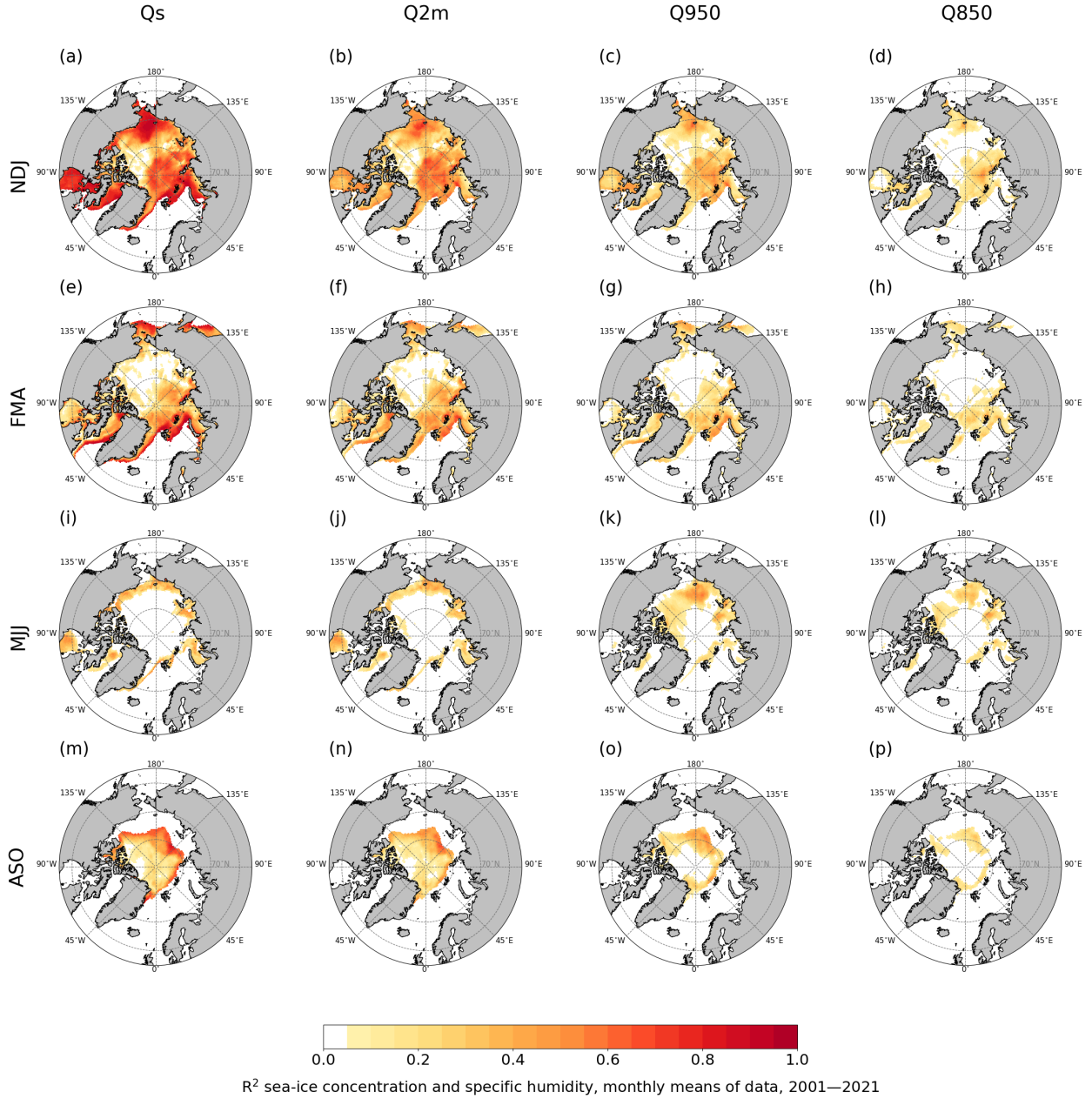


Figure S5. Coefficient of determination (R^2) between detrended anomalies of sea-ice concentration and specific humidity at the surface and the levels of 2 m, 950 hPa, and 850 hPa (Qs, Q2m, Q950, Q850) in four seasons (November–December–January, February–March–April, May–June–July, August–September–October) in 2001–2021. The results are based on linear ordinary-least-squares-regression model using monthly means of NCEP/CFSR data. Only grid cells with a mean of SIC > 0.5 were considered and only statistically significant results at the confidence level $p < 0.05$ are shown (insignificant ones are masked in white).

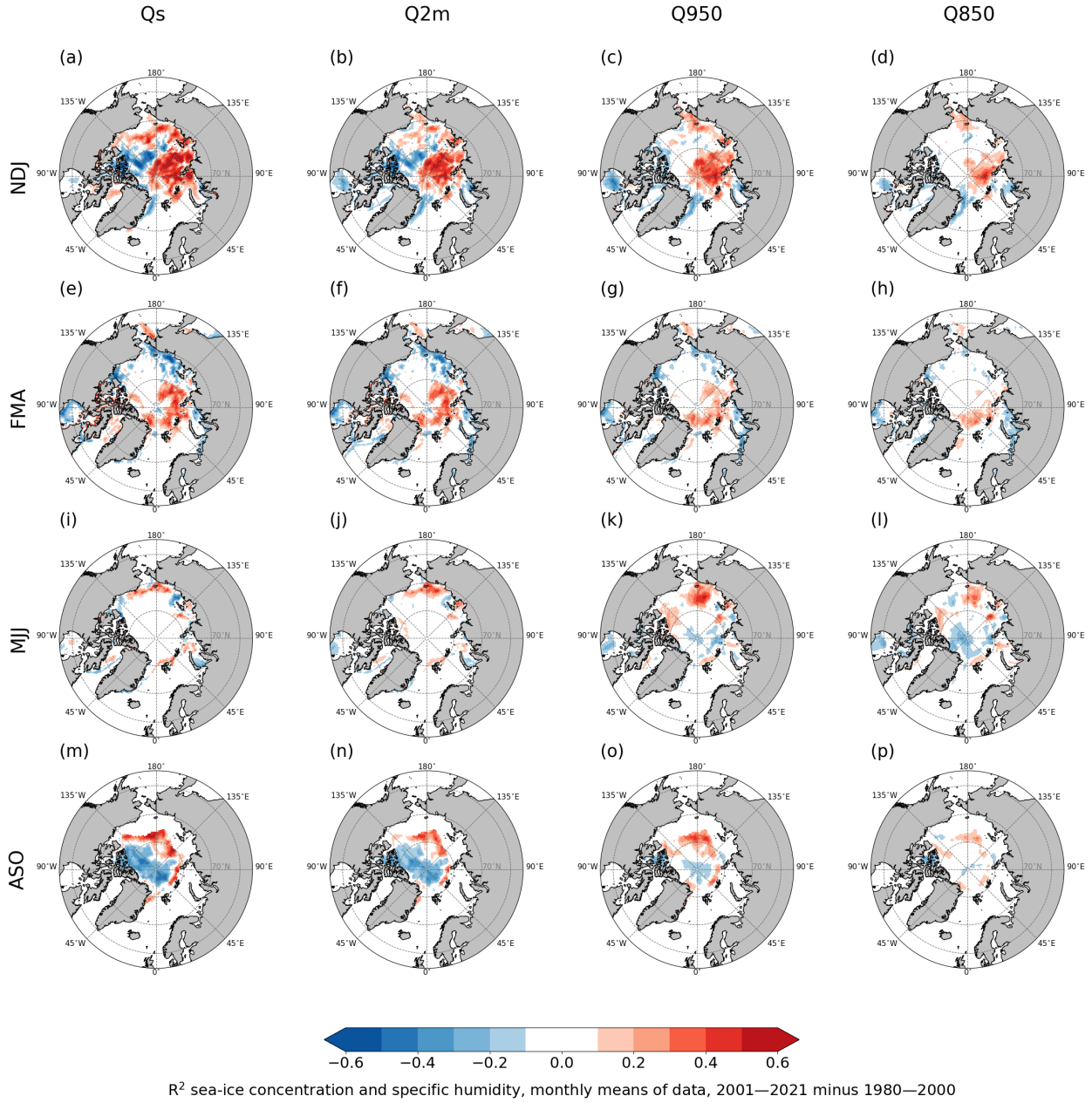


Figure S6. Difference in coefficients of determination (R^2) for detrended anomalies of sea-ice concentration and specific humidity at the surface and the levels of 2 m, 950 hPa, and 850 hPa (Qs, Q2m, Q950, Q850) between 1980–2000 and 2001–2021. The results are based on linear ordinary-least-squares-regression model using monthly means of NCEP/CFSR data. Only grid cells with a mean of SIC > 0.5 were considered.