Supplementary Materials for

Deep Learning on a Novel Ising Model to Study Arctic Sea Ice Dynamics

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1 Ising model / CNN results for 2022

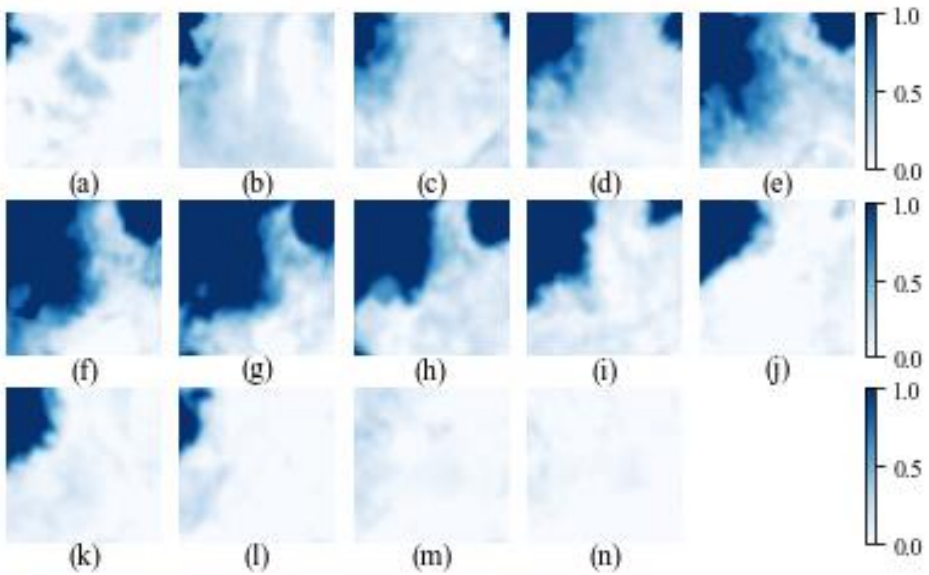

Figure 1: The actual semi-monthly evolution of sea ice in our focus area in 2022: (a) June 16th, (b) July 1st, (c) July 16th, (d) Aug 1st, (e) Aug 16th, (f) Sept 1st, (g) Sept 16th, (h) Oct 1st, (i) Oct 16th, (j) Nov 1st, (k) Nov 16th, (l) Dec 1st, (m) Dec 16th, 2022, and (n) Jan 1st, 2023.

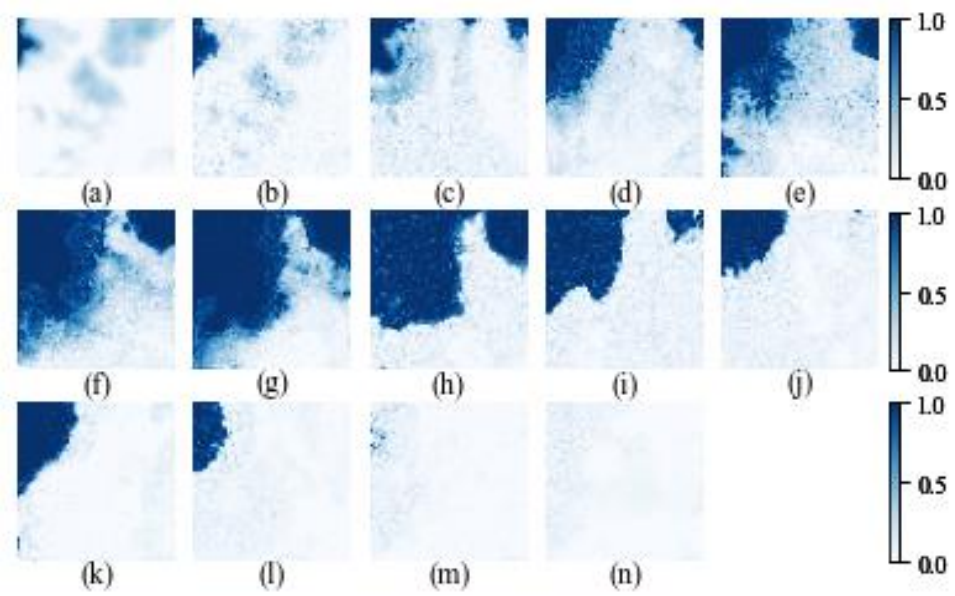

Figure 2: The simulated semi-monthly evolution of sea ice for our focus area in 2022. (a) is the actual image on June 16th, 2022; (b) - (n) are simulated images on (b) July 1st, (c) July 16th, (d) Aug 1st, (e) Aug 16th, (f) Sept 1st, (g) Sept 16th, (h) Oct 1st, (i) Oct 16th, (j) Nov 1st, (k) Nov 16th, (l) Dec 1st, (m) Dec 16th, 2022, and (n) Jan 1st, 2023.

	6/16 to 7/1	**7/1 to 7/16**	**7/16 to 8/1**	**8/1 to 8/16**	**8/16 to 9/1**	**9/1 to 9/16**	**9/16 to 10/1**	**10/1 to 10/16**	**10/16 to 11/1**	**11/1 to 11/16**	**11/16 to 12/1**	**12/1 to 12/16**	**12/16 to 1/1/2023**
J	2.1	2.6	2.9	2.6	2.5	2.5	2.3	2.4	3.5	2.1	2.6	2.3	2.8
Bo	2.9	0.5	5.1	7.7	2.8	4.0	-7.1	-12.1	-30.0	-9.4	-18.6	-11.5	-28.0
Bx	3.5	-16.9	-14.9	2.7	-10.6	-7.6	-0.7	-4.1	-28.7	6.8	-1.9	-4.9	-4.3
By	-9.0	6.5	-4.7	3.4	-3.9	1.7	4.7	-6.2	-12.8	-34.5	-12.0	4.3	11.6
I	7.6	10.4	12.1	10.6	9.8	10.2	9.2	9.7	15.4	8.5	11.2	9.3	11.9

Table 1: CNN predicted Ising parameters for the 2022 sea ice evolution.

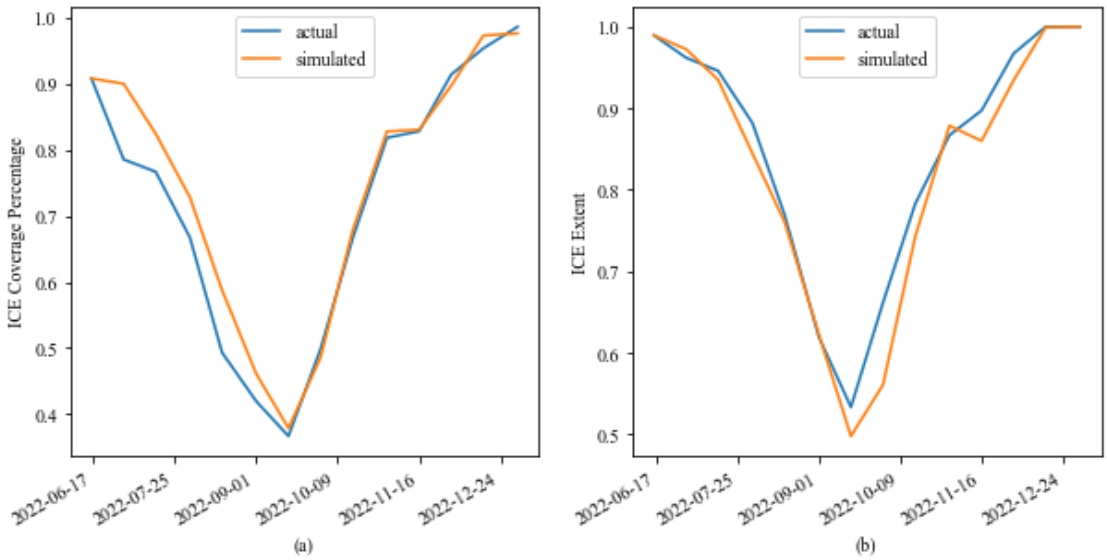

Figure 3: (a) The average ice coverage percentage in our focus area from June 16th, 2022 to Jan 1st, 2023; (b) The sea ice extent (the percentage of areas with at least 15% ice coverage) for the same period. Blue curves are the actual measures from the NRTSI data; orange ones show the IM simulation results.

2 Ising model / CNN results for 2012

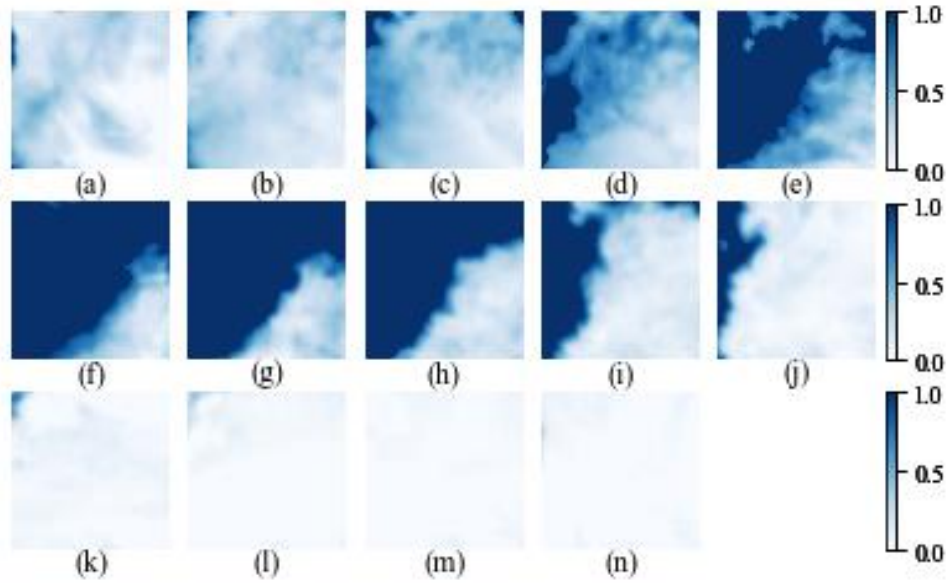

Figure 4: The actual semi-monthly evolution of sea ice in our focus area in 2012: (a) June 16th, (b) July 1st, (c) July 16th, (d) Aug 1st, (e) Aug 16th, (f) Sept 1st, (g) Sept 16th, (h) Oct 1st, (i) Oct 16th, (j) Nov 1st, (k) Nov 16th, (l) Dec 1st, (m) Dec 16th, 2012, and (n) Jan 1st, 2013.

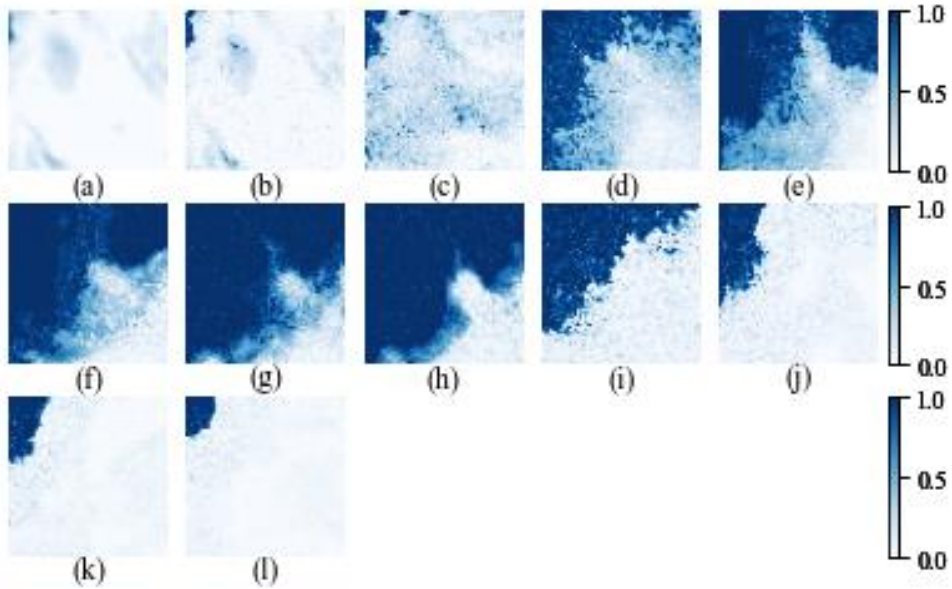

Figure 5: The simulated semi-monthly evolution of sea ice for our focus area in 2012. (a) is the actual image on June 16th, 2022; (b) - (n) are simulated images on (b) July 1st, (c) July 16th, (d) Aug 1st, (e) Aug 16th, (f) Sept 1st, (g) Sept 16th, (h) Oct 1st, (i) Oct 16th, (j) Nov 1st, (k) Nov 16th, (l) Dec 1st, (m) Dec 16th, 2012, and (n) Jan 1st, 2013.

	6/16 to 7/1	7/1 to 7/16	7/16 to 8/1	8/1 to 8/16	8/16 to 9/1	9/1 to 9/16	9/16 to 10/1	10/1 to 10/16	10/16 to 11/1	11/1 to 11/16	11/16 to 12/1	12/1 to 12/16	12/16 to 1/1/2013
J	2.8	3.3	3.4	3.3	2.9	2.5	2.7	2.6	3.1	2.8	3.5	3.1	3.2
Bo	5.5	8.7	8.3	10.5	8.9	-2.3	-6.5	-13.3	-27.7	-27.1	-27.6	-27.3	-20.9
Bx	-2.4	-11.9	-8.4	-0.2	-17.8	-5.6	-6.9	-4.5	-15.4	-5.1	-25.5	15.7	-11.6
By	2.9	-7.2	-9.1	0.8	-14.9	7.3	-11.8	-11.5	-31.2	-9.7	-8.4	3.0	-20.9
I	12.0	14.4	15.2	15.4	11.7	10.1	11.2	10.3	13.1	11.1	14.9	13.6	13.4

Table 2: CNN predicted Ising parameters for the 2012 sea ice evolution.

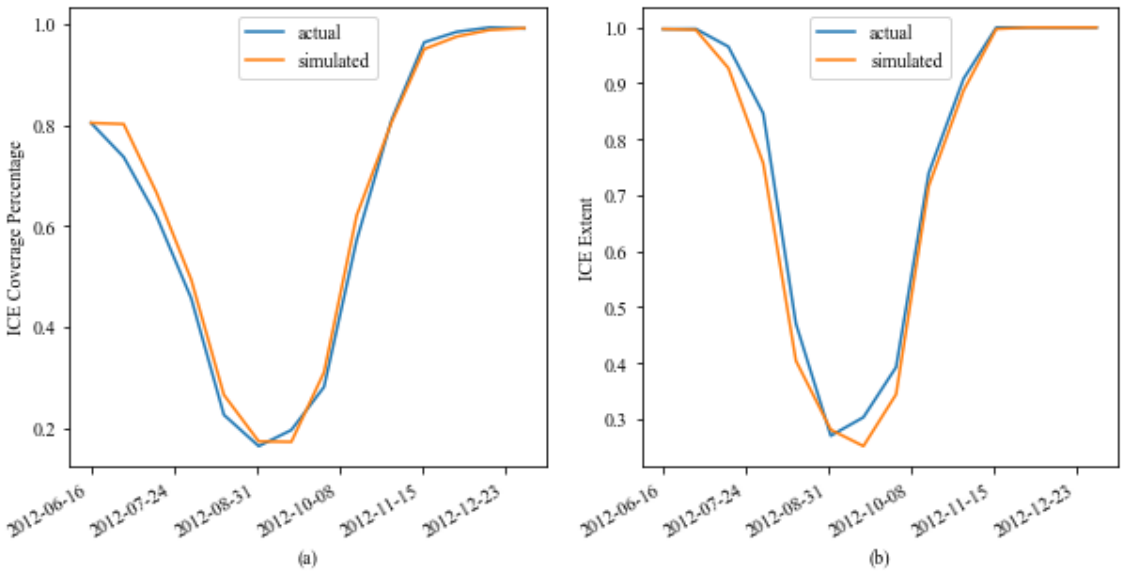

Figure 6: (a) The average ice coverage percentage in our focus area from June 16th, 2012 to Jan 1st, 2013; (b) The sea ice extent (the percentage of areas with at least 15% ice coverage) for the same period. Blue curves are the actual measures from the NRTSI data; orange ones show the IM simulation results.

3 CNN architecture diagram plotted by Keras