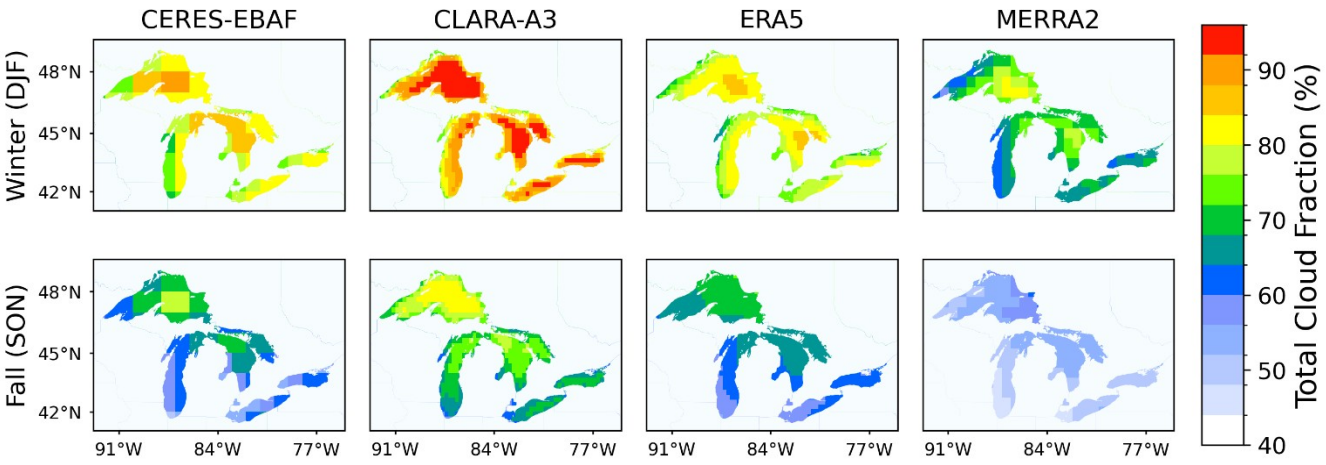
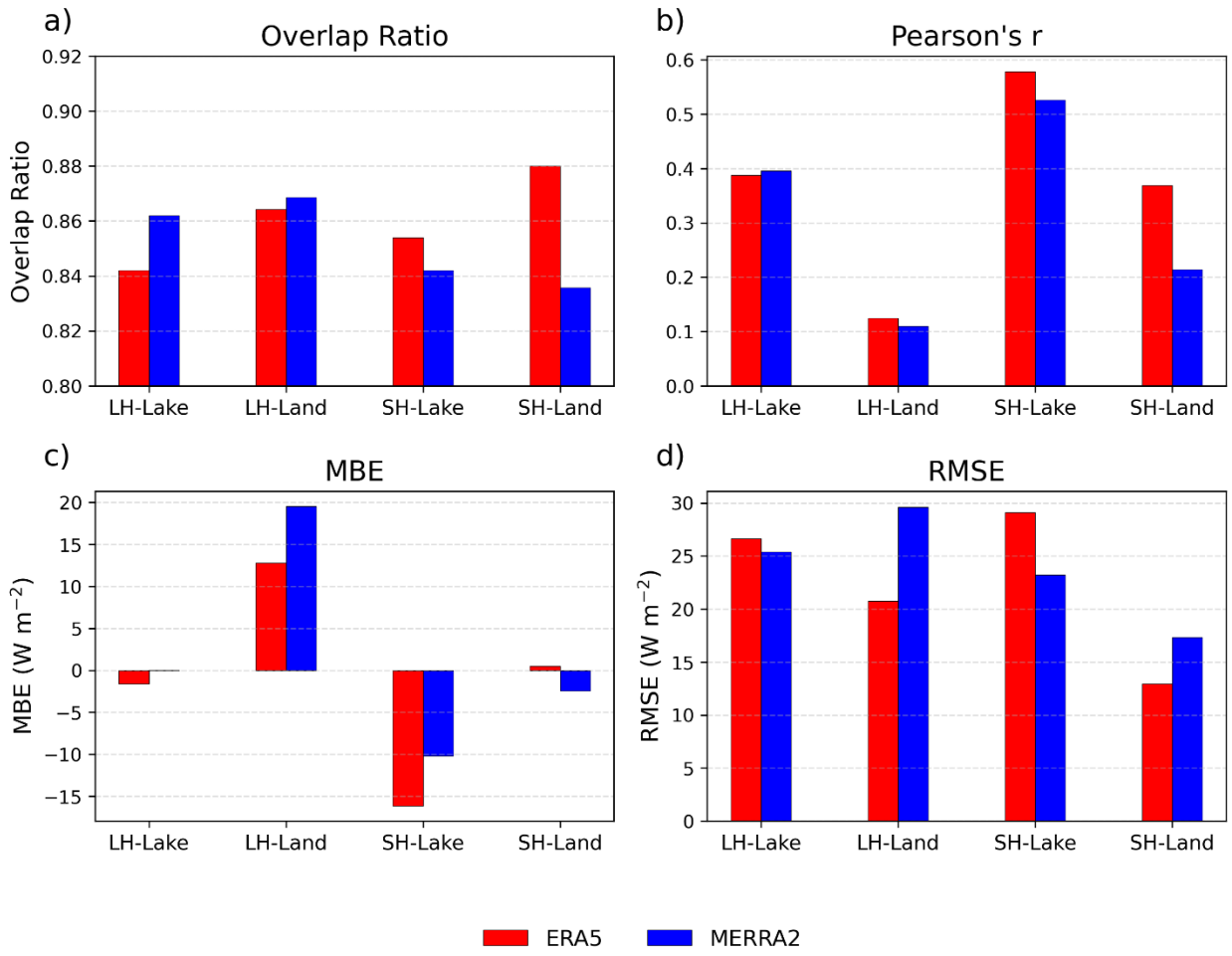


ESM Fig. S1. Average total cloud fraction per season (winter/fall) for CERES-EBAF, CLARA-A3, ERA5, and MERRA2 covering 2001-2020



ESM Fig. S2. Average statistical metrics, OR (a), Pearson's r (b), MBE (c), and RMSE (d) for latent heat and sensible heat fluxes for both lake and land observational locations. For lake locations, only years 2014 onward were included to eliminate influence from ERA5's lake temperature and ice cover bias

ESM Table S1. Statistical metrics for each gridded dataset for downwelling shortwave radiation

Station	CERES-EBAF				CLARA-v3				ERA5				MERRA2			
	OR	*RMSE*	*MBE*	*r*	*OR*	*RMSE*	*MBE*	*r*	*OR*	*RMSE*	*MBE*	*r*	*OR*	*RMSE*	*MBE*	*r*
Long Point	0.98	12.79	-4.26	0.64	0.97	10.36	0.36	0.82	0.97	15.72	11.23	0.75	0.96	18.07	14.5	0.72
Spectacle Reef	0.98	20.79	1.5	0.71	0.96	23.55	8.23	0.73	0.94	29.96	19.64	0.75	0.95	28.38	18.07	0.74
Stannard Rock	0.98	14.55	3.23	0.56	0.97	21.74	13.36	0.58	0.95	25.63	21.45	0.63	0.96	20.77	17.27	0.75
White Shoal	0.98	14.58	-6.67	0.7	0.97	10.44	1.2	0.83	0.97	13.18	10.27	0.86	0.96	16.8	9.38	0.75
Buoy 45013	0.97	14.78	-4.52	0.71	0.95	16.03	2.02	0.67	0.93	17.4	7.12	0.61	0.87	25.93	19.37	0.5
Buoy 45028	0.89	21.37	12.43	0.67	0.86	25.17	17.5	0.63	0.87	24.12	18.31	0.79	0.8	43.71	37.15	0.33
Buoy 45170	0.87	33.27	22.69	0.77	0.87	39.54	28.86	0.84	0.81	48.34	40.51	0.84	0.78	52.25	45.87	0.71
Buoy 45175	0.9	37.09	33.04	0.83	0.89	35.64	31.34	0.83	0.87	50.86	47.3	0.81	0.86	55.39	49.64	0.5
CA-Gro	0.97	8.57	3.81	0.99	0.89	11.45	9.54	0.93	0.97	11.93	8.29	0.91	0.94	20.91	13.58	0.81
CA-TPD	0.98	15.16	-8.84	0.6	0.98	9.63	-7.98	0.93	0.98	12.13	7.75	0.84	0.98	13.43	9.36	0.78
US-CRT	0.99	5.11	1.35	0.98	0.99	7.08	4.37	0.98	0.95	17.66	15.53	0.98	0.95	21.26	18.01	0.94
US-MMS	0.99	5.96	-1.91	0.94	0.99	5.46	2.2	0.96	0.97	10.87	7.69	0.91	0.92	22.42	19.13	0.71
US-Orv	0.94	26.28	23.19	0.85	0.93	30	25.95	0.83	0.92	34.91	32.38	0.85	0.91	48.57	45.21	0.72
US-Syv	0.93	19.34	-11.92	0.72	0.95	15.86	-4.75	0.74	0.95	16.87	-1.73	0.68	0.94	20.02	9.29	0.63
US-UMB	0.98	9.89	-3.92	0.86	0.99	5.92	0.79	0.93	0.95	13.57	11.36	0.88	0.93	20.5	13.7	0.68

ESM Table S2. Statistical metrics for each gridded dataset for downwelling longwave radiation

Station	CERES-EBAF				CLARA-v3				ERA5				MERRA2			
	OR	*RMSE*	*MBE*	*r*	*OR*	*RMSE*	*MBE*	*r*	*OR*	*RMSE*	*MBE*	*r*	*OR*	*RMSE*	*MBE*	*r*
Long Point	0.96	9.02	-1.25	0.94	0.94	12.78	-9.53	0.91	0.93	15.34	-12.04	0.91	0.86	23.68	-21.21	0.9
Spectacle Reef	0.94	11.22	-8.98	0.89	0.89	21.04	-19.91	0.9	0.88	23.17	-21.96	0.86	0.81	31.18	-30.57	0.89
Stannard Rock	0.95	9.51	-0.87	0.72	0.93	14.09	-8.19	0.61	0.93	17.86	-13.35	0.6	0.84	18.9	-17.71	0.79
CA-Gro	0.97	6.1	-0.72	0.92	0.97	8.67	-6.12	0.94	0.97	5.35	-1.84	0.95	0.93	9.29	-3.72	0.88
CA-TPD	0.95	7.29	-1	0.85	0.92	14.76	-11.61	0.77	0.91	16.55	-14.83	0.82	0.85	24.96	-23.99	0.83
US-CRT	0.85	31.56	-31.04	0.83	0.83	34.91	-34.59	0.91	0.85	35.43	-35.1	0.94	0.8	46.63	-46.35	0.89
US-MMS	0.93	10.82	-8.88	0.91	0.92	13.13	-12.05	0.92	0.94	11.55	-10.05	0.91	0.88	25.25	-23.57	0.86
US-UMB	0.94	8.48	4.55	0.85	0.92	11.55	-9.08	0.88	0.92	10.52	-7.79	0.88	0.85	17.41	-15.29	0.78

ESM Table S3. Statistical metrics for each reanalysis dataset for sensible heat flux. Statistics for lake locations are calculated on years 2014 onward, where ERA5 lake temperature and ice cover issues are resolved

Station	**ERA5**				**MERRA2**			
	OR	RMSE	MBE	r	OR	RMSE	MBE	r
Long Point	0.9	20.5	3.5	0.57	0.78	15.3	12.7	0.49
Granite Island	0.95	20.7	-17.9	0.61	0.95	19.5	-11.7	0.61
Spectacle Reef	0.72	35.8	-21.8	0.61	0.77	24.6	-21.7	0.6
Stannard Rock	0.92	25.4	-17.1	0.59	0.93	17.5	-11.9	0.62
White Shoal	0.78	43.2	-27.5	0.51	0.78	39.3	-18.5	0.31
CA-Gro	0.88	9.9	-7.5	0.25	0.76	21.3	-18.5	0.15
CA-TPD	0.91	16.3	-4.4	0.52	0.95	15.8	0.8	0.35
US-CRT	0.83	6.2	4.4	0.4	0.82	9.5	6.2	-0.1
US-MMS	0.91	14.7	0.6	0.55	0.84	17.5	-8	0.53
US-Orv	0.8	22.6	8.8	0.26	0.79	27.3	12.9	0.16
US-Syv	0.92	7.8	3.8	0.12	0.9	11.8	-0.3	0.05
US-UMB	0.91	13	-2	0.48	0.79	18.1	-10.2	0.36

ESM Table S4. Statistical metrics for each reanalysis dataset for latent heat flux. Statistics for lake locations are calculated on years 2014 onward, where ERA5 lake temperature and ice cover issues are resolved

Station	**ERA5**				**MERRA2**			
	OR	RMSE	MBE	r	OR	RMSE	MBE	r
Long Point	0.84	40.5	29.5	0.39	0.82	38.2	30.2	0.34
Granite Island	0.97	11.1	-7.4	0.59	0.97	14.9	-12.8	0.57
Spectacle Reef	0.88	31.5	-9.4	0.25	0.92	31.3	-3.6	0.36
Stannard Rock	0.8	15.5	2.1	0.31	0.81	12.8	2.5	0.27
White Shoal	0.72	34.7	-22.9	0.4	0.79	29.8	-16.2	0.44
CA-Gro	0.92	15.9	11.2	0.07	0.88	37.1	28.8	0.28
CA-TPD	0.87	27.3	26.5	0.27	0.81	24.6	21.2	-0.01
US-CRT	0.83	11.6	7.3	0.01	0.86	18.1	9.1	-0.29
US-MMS	0.84	28.5	24.4	0.16	0.81	41.9	36.3	0.41
US-Orv	0.83	21.1	-6.5	0.21	0.95	21.4	-3.7	-0.07
US-Syv	0.94	18.3	5.8	-0.04	0.93	30.5	16.2	-0.05
US-UMB	0.82	22.6	20.9	0.19	0.84	33.8	28.8	0.5