Figure S1. The mean (left) January and (right) July difference in (a,b) 2-m surface air temperature (SAT, °C) and in (c,d) precipitation rate (mm day^{-1}) between RASM1 simulations using ERA-Interim and CFSR as lateral boundary conditions and for upper atmospheric nudging to reduce circulation biases for 1990-1999. The shading indicates grid cells that are not statistically significant at the 95% level according to the Welch's two-sided t-test.

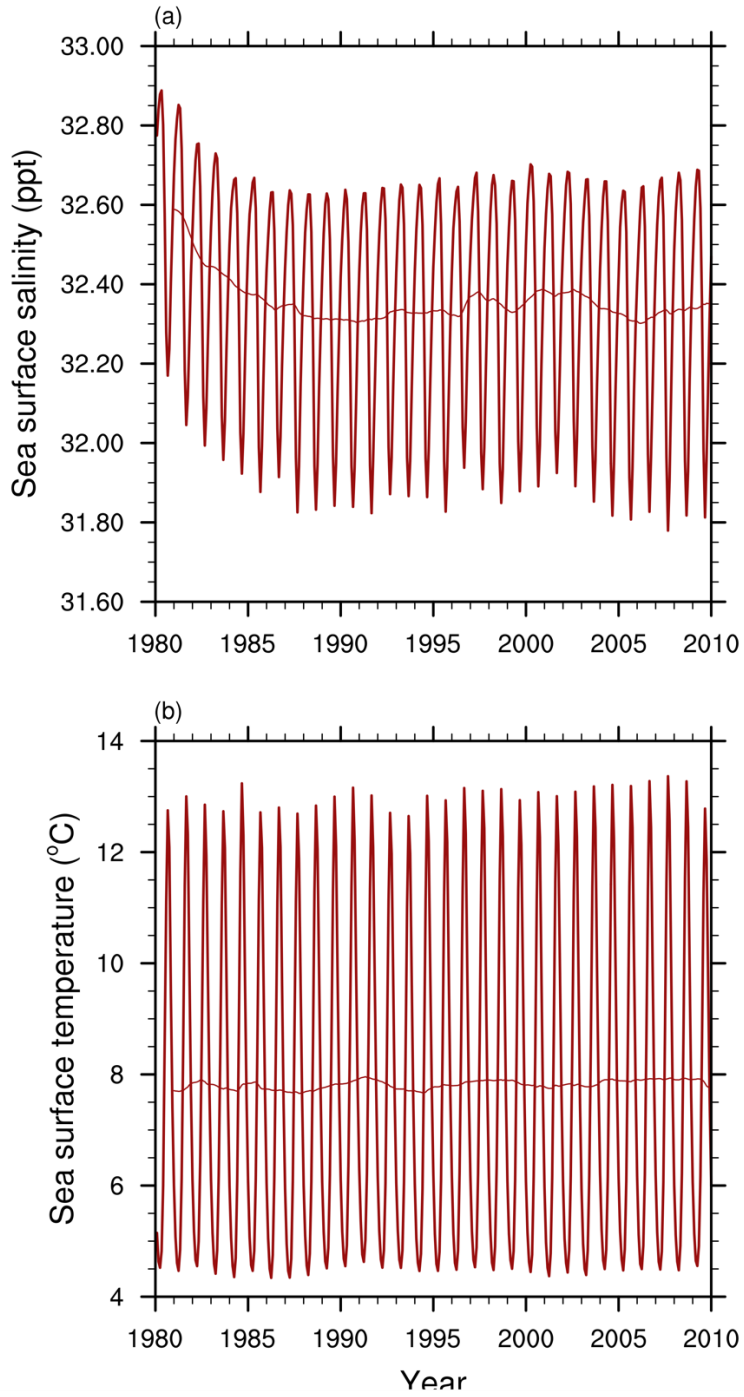
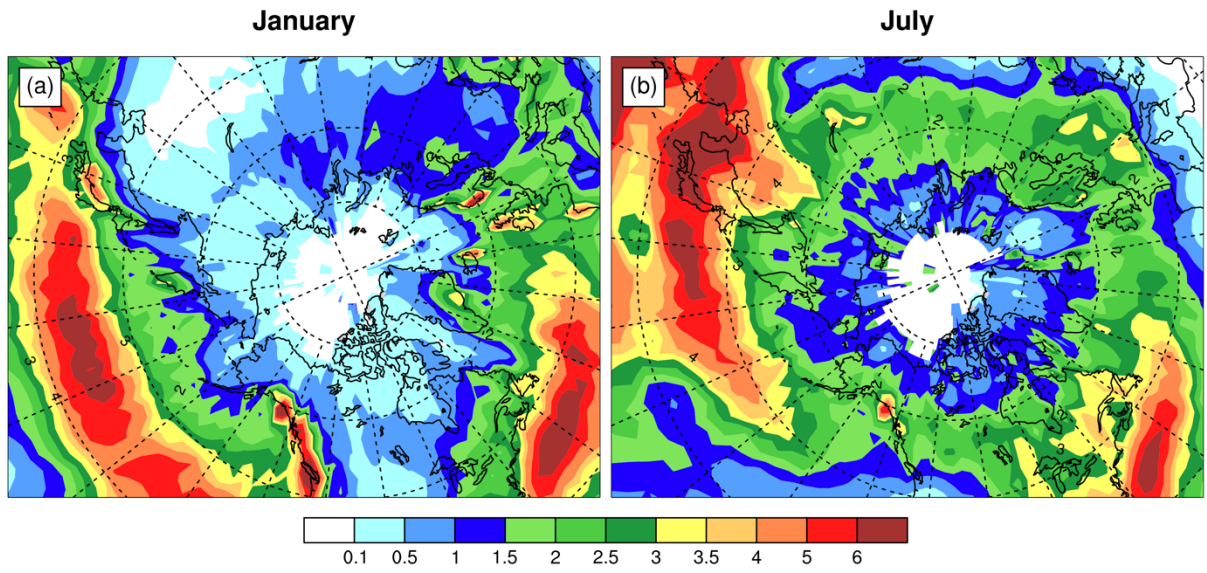



Figure S2. Domain average monthly mean (a) sea surface salinity and (b) sea surface temperature in the RASM1 (red) simulation for 1979-2010. The smoother lines represent the 12-month running mean.

January

July

Figure S3. Monthly mean precipitation (mm day^{-1}) in CMAP in (a) January and (b) July for 1990-2009.

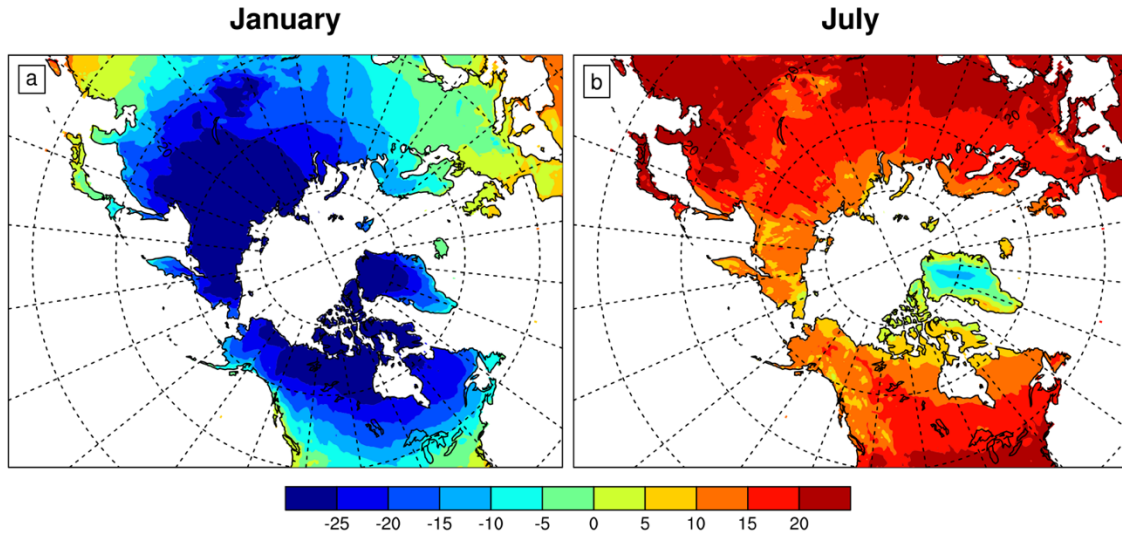



Figure S4. Monthly mean SAT (°C) in the Wang and Zeng (2013) dataset in (a) January and (b) July for 1990-2009.

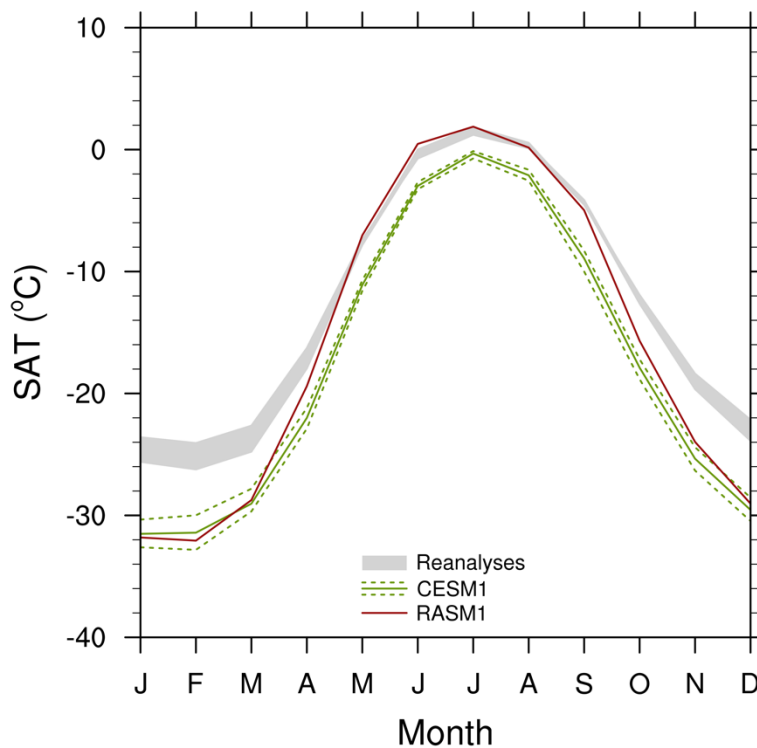



Figure S5. The mean annual cycle in 2-m air temperature (SAT) for the central Arctic defined as 70°N and poleward. Means are given for RASM1 (red) and CESM1 (green) along with the range in the three reanalyses (MERRA, ERA-Interim, and CFSR) indicated by the gray shading. The green dotted lines surrounding CESM1 indicates the ensemble maximum and minimum values.

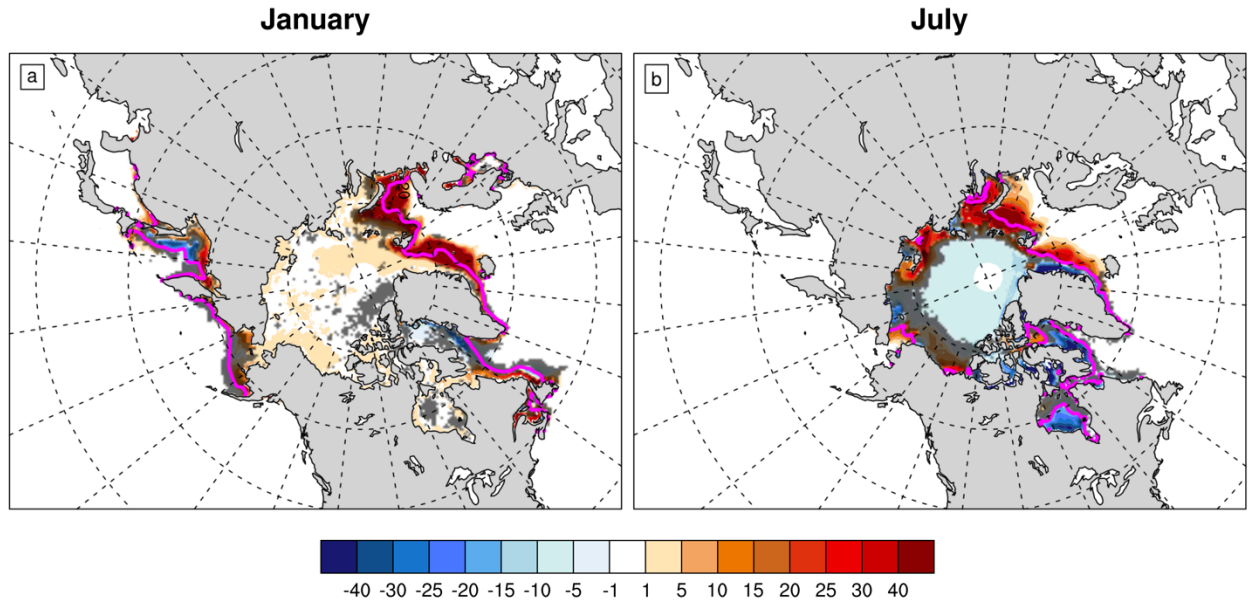



Figure S6. The sea ice concentration bias (%) in RASM1 from the NOAA CDR dataset in January (left) and July (right) for 1990-2009. The shading indicates grid cells that are not statistically significant at the 95% level according to the Welch's two-sided t-test. The magenta line represents the ice edge in the NOAA CDR dataset as defined by the 15% concentration isoline.

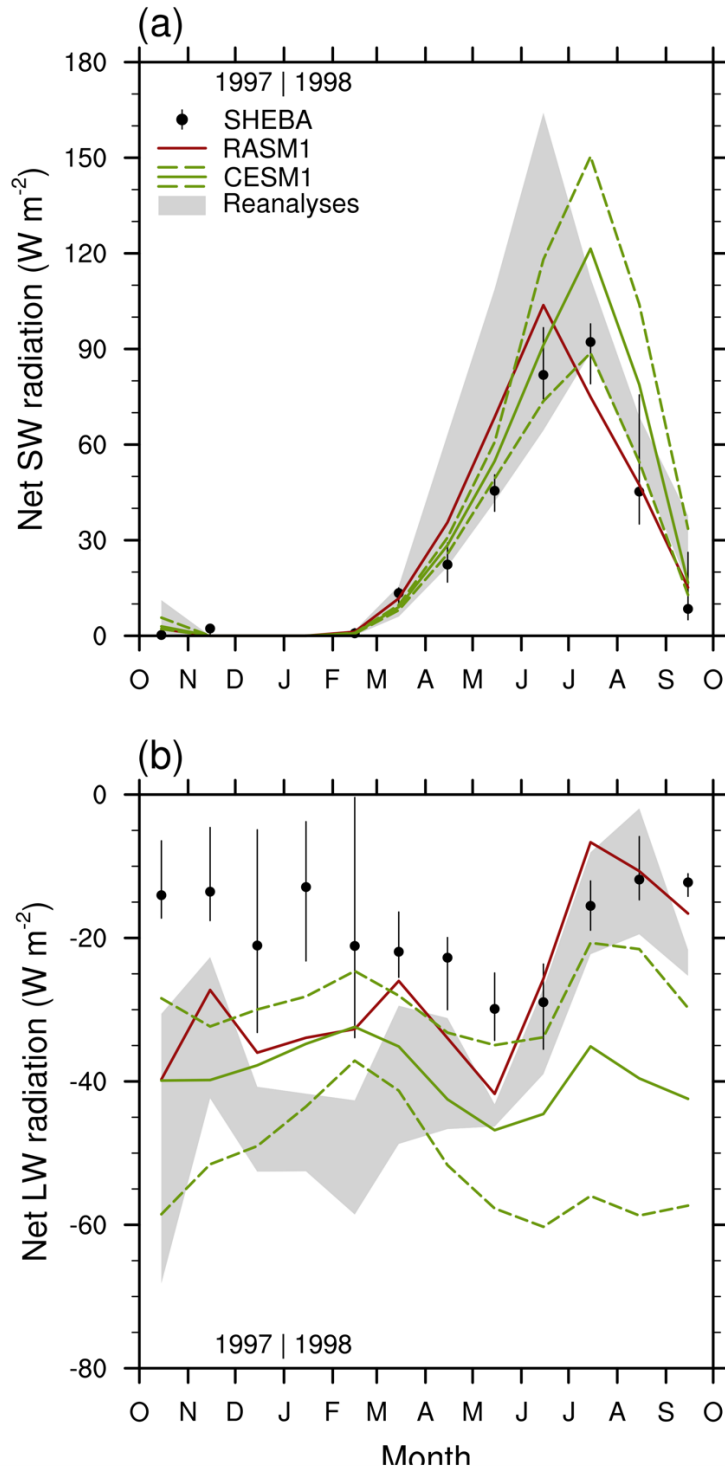



Figure S7. Comparison of monthly mean (a) net shortwave (SW) and (b) net longwave (LW) radiation from SHEBA observations (black) with RASM1 (red), RASM1a (purple), CESM1 (green), and reanalyses. Negative values indicate net upward fluxes. Observational spread is indicated by the vertical black lines extending from the circles, and the spread in reanalyses is shown by the gray shading. The green dashed lines surrounding CESM1 indicates the ensemble spread (minimum to maximum).

Table S1. The Temporal and Horizontal Resolutions of the Reanalyses Used in This Study

	Highest temporal resolution	Highest horizontal resolution
MERRA-2	hourly	$0.5° \times 0.625°$
ERA-Interim	3-hourly	$\sim 0.703° \times 0.702$
CFSR	hourly	$\sim 0.31° \times 0.31°$

Table S2. The Greenland Automated Weather Stations Used in This Study

Site Name	(Latitude, Longitude)	Elevation (m)
NGRIP	(75.10°N, 43.33°W)	2941
NASA-E	(75.00°N, 30.00°W)	2614
Summit	(72.58°N, 38.51°W)	3199
Saddle	(66.00°N, 44.50°W)	2467
South Dome	(63.15°N, 44.82°W)	2901

Table S3. The Flux Tower Sites Used in This Study

Abbrev.[a]	Site name	Veg. cover[b]	(Lat, Lon)[c]	Period	Lead PI
Manitoba cluster					
CA-Man	Northern Old Black Spruce	ENF[d]	(55.88°N, 98.48°W)	1994-2008	Brian Amiro
CA-NS1	UCI 1850	ENF	(55.88°N, 98.48°W)	2002-2005	Mike Goulden
CA-NS2	UCI 1930	ENF	(55.91°N, 98.52°W)	2001-2005	Mike Goulden
CA-NS3	UCI 1964	ENF	(55.91°N, 98.38°W)	2001-2005	Mike Goulden
CA-NS4	UCI 1964 wet	ENF	(55.91°N, 98.38°W)	2002-2004	Mike Goulden
CA-NS5	UCI 1981	ENF	(55.86°N, 98.49°W)	2001-2005	Mike Goulden
CA-NS6	UCI 1989	ENF	(55.92°N, 98.96°W)	2001-2005	Mike Goulden
CA-NS7	UCI 1998	ENF	(56.64°N, 99.95°W)	2002-2005	Mike Goulden
Other boreal sites					
CA-SF3	Saskatchewan 1998 fire	ENF	(54.09°N, 106°W)	2001-2006	Brian Amiro
CA-Gro	Groundhog River mixed wood	Mixed forest	(48.22°N, 82.16°W)	2003-2014	Harry McCaughey
CA-Qcu	Quebec 2000 harvested black spruce/jack pine	ENF	(49.27°N, 74.04°W)	2001-2010	Hank A. Margolis
CA-Qfo	Quebec Eastern Old Black Spruce	ENF	(49.69°N, 74.34°W)	2003-2010	Hank A. Margolis
FI-Hyy	Hyytiala	ENF	(61.85°N, 24.30°E)	1996-2014	Timo Vesala

FI-Sod	Sodankyla	ENF	(67.36°N, 26.64°E)	2000-2008	Tuomas Laurila
RU-Zot	Zotino	Woody savanna	(60.80°N, 89.35°E)	2002-2004	Corinna Rebmann
Tundra sites					
US-HVa	Happy Valley	Open shrubland	(69.14°N, 148.84°W)	1994	Walt Oechel
US-Ivo	Ivotuk	Open shrubland	(68.49°N, 155.75°W)	2003-2007	Donatella Zona
US-Brw	Barrow	Barren	(71.32°N, 156.63°W)	1998-2007	Walter Oechel
RU-Che	Cherskii	Open shrubland	(68.61°N, 161.34°E)	2002-2005	Lutz Merbold,
RU-Cok	Chokurdakh	Open shrubland	(70.83°N, 147.49°E)	2003-2014	Han Dolman
Temperate sites					
US-Los	Lost Creek	Mixed forest	(46.08°N, 89.98°W)	2000-2014	Ankur Desai
US-Ho1	Howland Forest main tower	Mixed forest	(45.20°N, 68.74°W)	1996-2014	David Hollinger
BE-Bra	Brasschaat	Mixed forest	(51.31°N, 4.52°E)	1996-2014	Eleonora Canfora
BE-Vie	Viesalm	Mixed forest	(50.31°N, 6.00°E)	1996-2014	Caroline Vincke
RU-Fyo	Fedorovskoje	Mixed forest	(56.46°N, 32.92°E)	1998-2014	Andrej Varlagin
RU-Ha1	Hakasia grassland	Grass	(54.73°N, 90.00°E)	2002-2004	Dario Papale

[a]Abbreviation. [b]University of Maryland vegetation cover. [c](Latitude, Longitude). [d]Evergreen needleleaf forest.