Geoscientific
Model Development

*Supplement of*

# Evaluation of the atmosphere–land–ocean–sea ice interface processes in the Regional Arctic System Model version 1 (RASM1) using local and globally gridded observations

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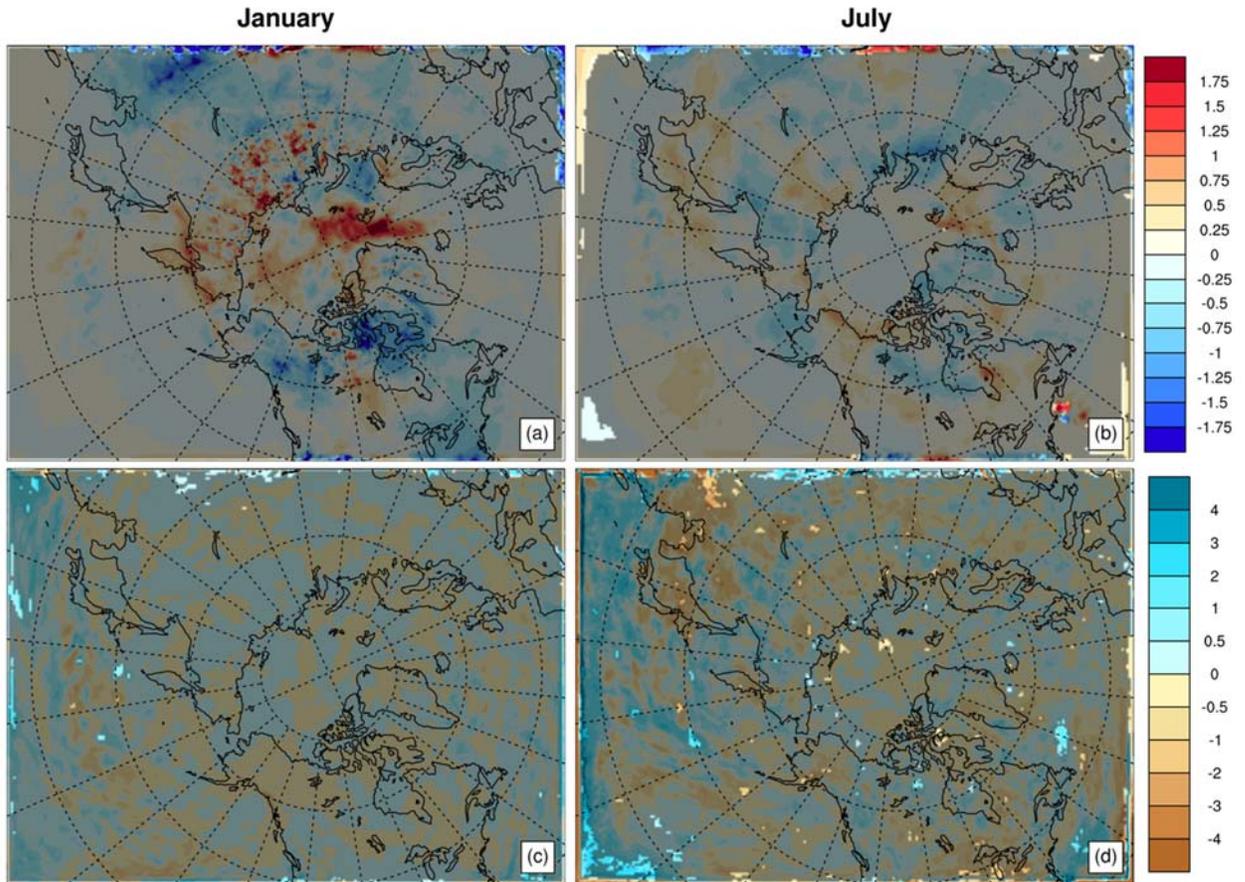
**Figure S1.** The mean (left) January and (right) July difference in (a,b) 2-m surface air temperature (SAT, °C) and in (c,d) precipitation rate (mm day$^{-1}$) between RASM1 simulations using ERA-Interim and CFSR as lateral boundary conditions and for upper atmospheric nudging to reduce circulation 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.
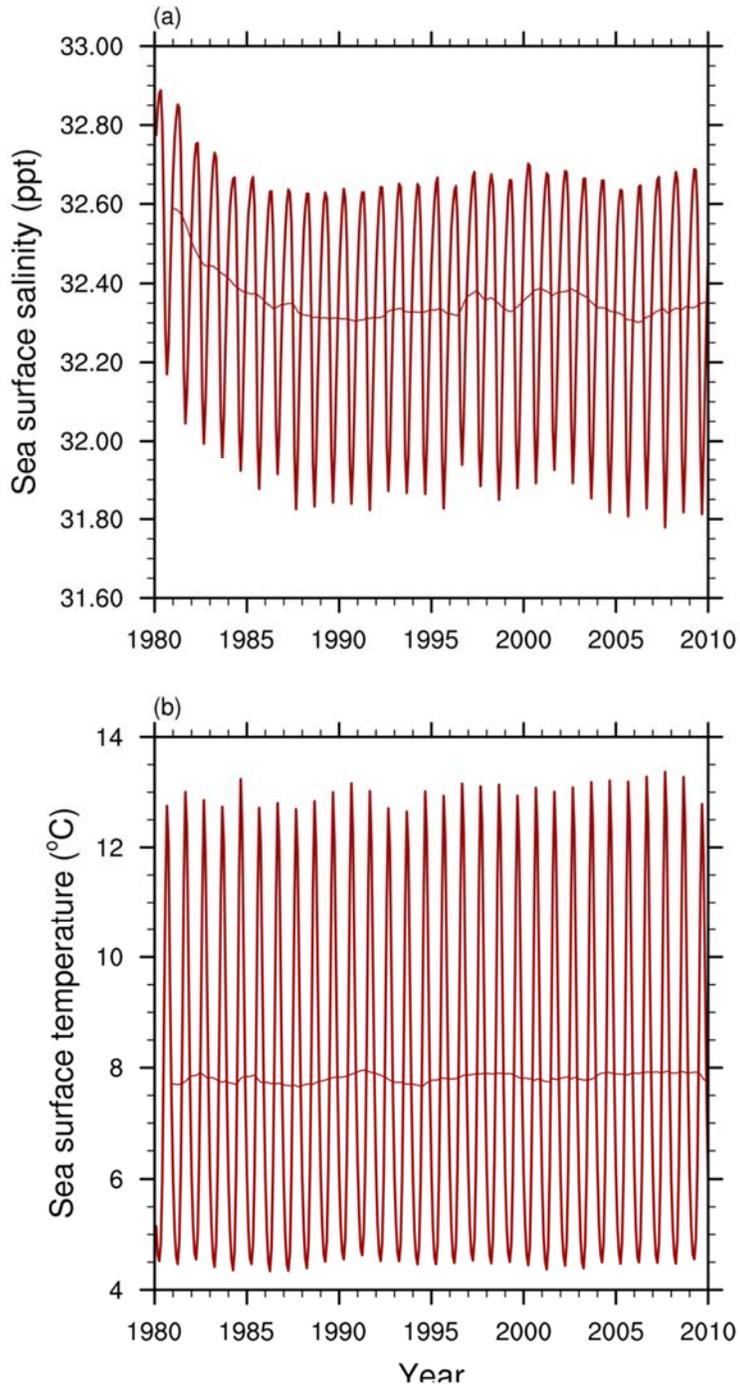
**Figure S2.** Domain average monthly mean (a) sea surface salinity and (b) sea surface temperature in the RASM1 (red) simulation for 1979-2010. The smoother lines represent the 12-month running mean.
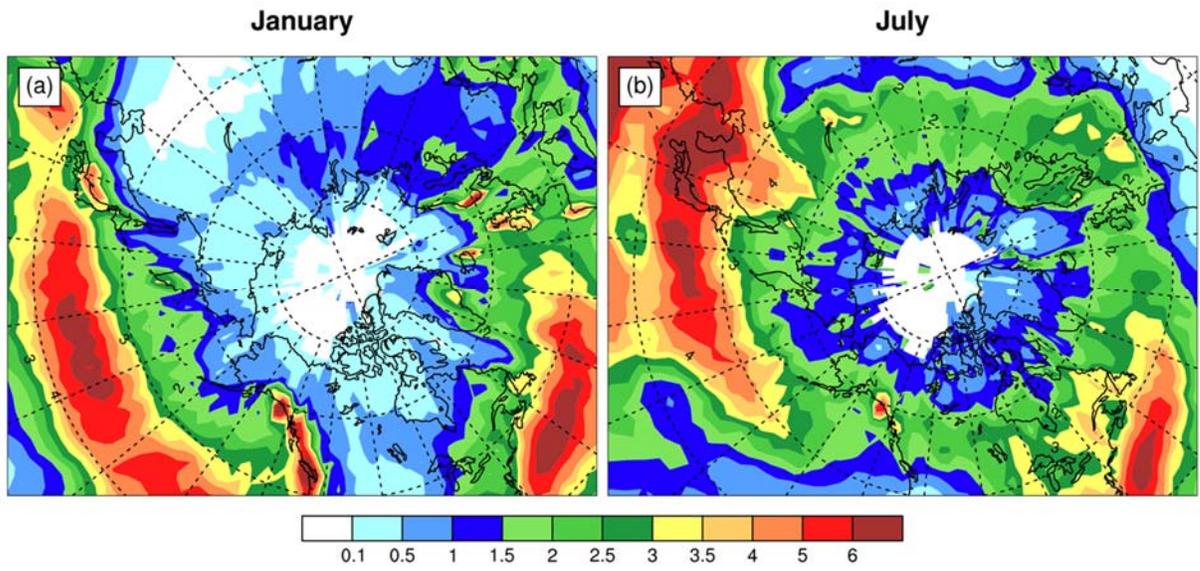
**Figure S3.** Monthly mean precipitation (mm day$^{-1}$) in CMAP in (a) January and (b) July for 1990-2009.
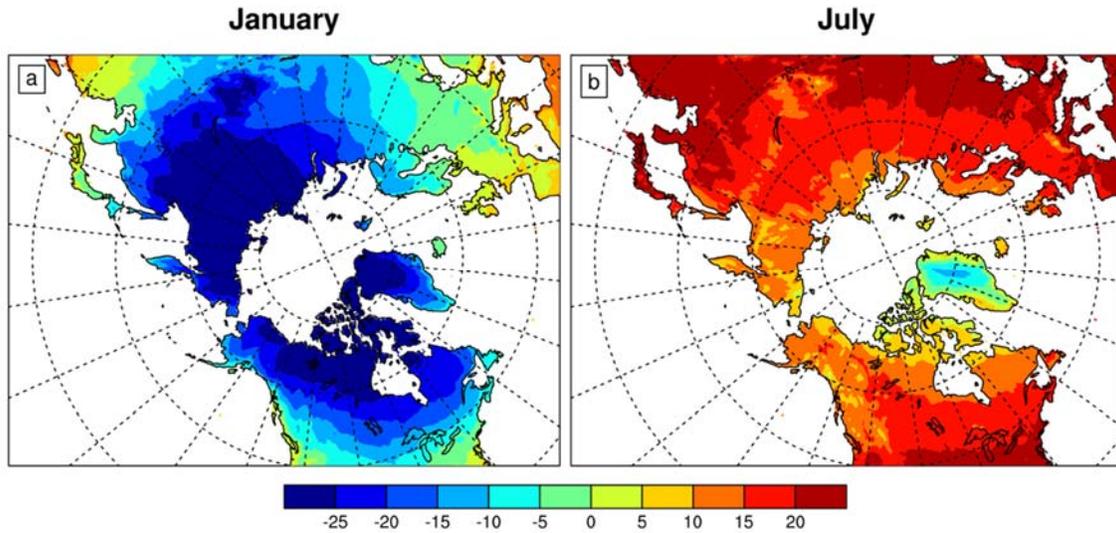
**Figure S4.** Monthly mean SAT (°C) in the Wang and Zeng (2013) dataset in (a) January and (b) July for 1990-2009.
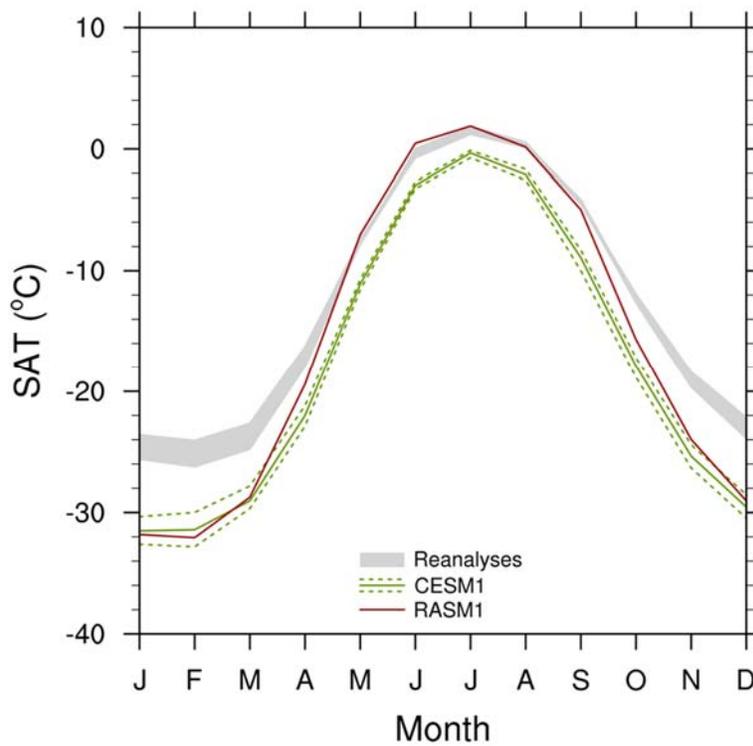


**Figure S5.** The mean annual cycle in 2-m air temperature (SAT) for the central Arctic defined as 70°N and poleward. Means are given for RASM1 (red) and CESM1 (green) along with the range in the three reanalyses (MERRA, ERA-Interim, and CFSR) indicated by the gray shading. The green dotted lines surrounding CESM1 indicates the ensemble maximum and minimum values.
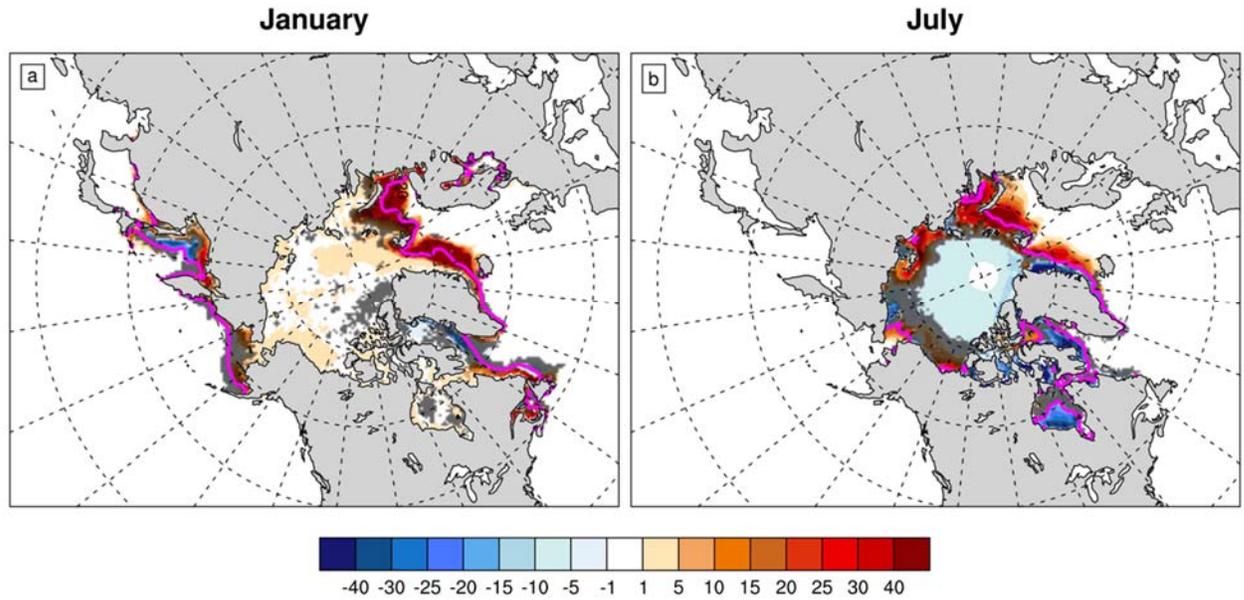
**Figure S6.** The sea ice concentration bias (%) in RASM1 from the NOAA CDR dataset in January (left) and July (right) for 1990-2009. The shading indicates grid cells that are not statistically significant at the 95% level according to the Welch's two-sided t-test. The magenta line represents the ice edge in the NOAA CDR dataset as defined by the 15% concentration isoline.
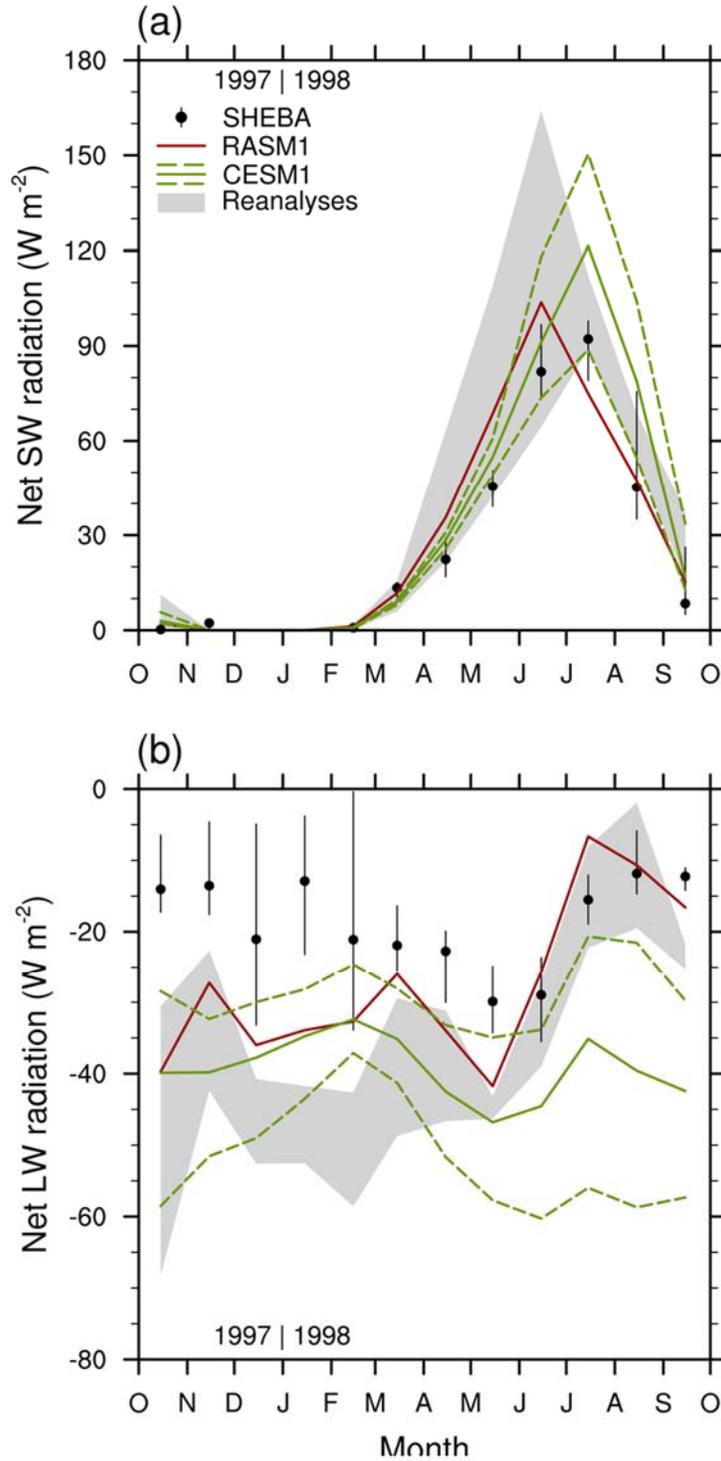
**Figure S7.** Comparison of monthly mean (a) net shortwave (SW) and (b) net longwave (LW) radiation from SHEBA observations (black) with RASM1 (red) CESM1 (green), and reanalyses. Negative values indicate net upward fluxes. Observational spread is indicated by the vertical black lines extending from 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 | $\sim0.703° \times 0.702$ |
| CFSR | hourly | $\sim0.31° \times 0.31°$ |

**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.