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Introduction

Figures S1 to S4 are temporal changes in the meteorological conditions derived from atmospheric reanalysis data sets used in this study. Figure S5 show the growth period ($GP^M$, $GP^{MD}$ and $GP^{MDF}$) calculated from the snow algae model in each study site. Figures S6 and S7 demonstrate the snow algal cell concentration simulated using Bio-MATSIRO with GSWP3-FD and CRUJRA, respectively. General information of the data sets is summarized in Table S1.
Figure S1. Temporal changes in surface air temperature at each site. Each line indicates the meteorological condition derived from different atmospheric reanalysis data set. The data sets were corrected using elevation information at the sites in this study.
Figure S2. Temporal changes in downward shortwave radiation at each site
Figure S3. Temporal changes in snowfall rate at each site
Figure S4. Temporal changes in surface air temperature corrected using elevation information at each site and various temperature lapse rates. Each solid line indicates corrected air temperature with each lapse rate.
Figure S5. Cumulative curves of growth period of snow algae at different locations. Red, green and blue lines indicate $GP^M$, $GP^{MD}$ and $GP^{MDF}$, respectively. Note that red lines at SV-S, GL-Q, SV-W, SB-S, AT-A and TN-U are overlapped with green lines.
Figure S6. Distribution of red snow algal abundance on the surface snow, as simulated using the land surface model with the atmospheric reanalysis data set GSWP3-FD (1980–2014)
Figure S7. Distribution of red snow algal abundance on the surface snow, as simulated using the land surface model with atmospheric reanalysis data set CRUJRA (1980–2014)
| Experiment ID | Period (Temporal resolution) | Region (Spatial resolution) | Components | Reference |
|--------------|-----------------------------|-----------------------------|------------|-----------|
| WFDEI        | 1979-2015 (3hourly)         | Global (0.5° × 0.5°)        | $T_{\text{atm}}$, $Q_{\text{atm}}$, $P_{\text{atm}}$, $WS$, $SW$, $LW$, $P$ (rain and snow components) | Weedon et al., 2014 |
| GSWP3-FD     | 1901-2014 (3hourly)         | Global (0.5° × 0.5°)        | $T_{\text{atm}}$, $Q_{\text{atm}}$, $P_{\text{atm}}$, $WS$, $SW$, $LW$, $P$ (rain and snow components) | Hurk et al., 2016; Kim, 2017 |
| CRUJRA       | 1901-2017 (6hourly)         | Global excluding Antarctica (0.5° × 0.5°) | $WS$ (zonal and meridional components), $SW$, $LW$, $P$ (total precipitation) | Harris, 2019 |

**Table S1.** Overview of atmospheric reanalysis data sets used in this study. The variable names in component list correspond to those in Table 2.