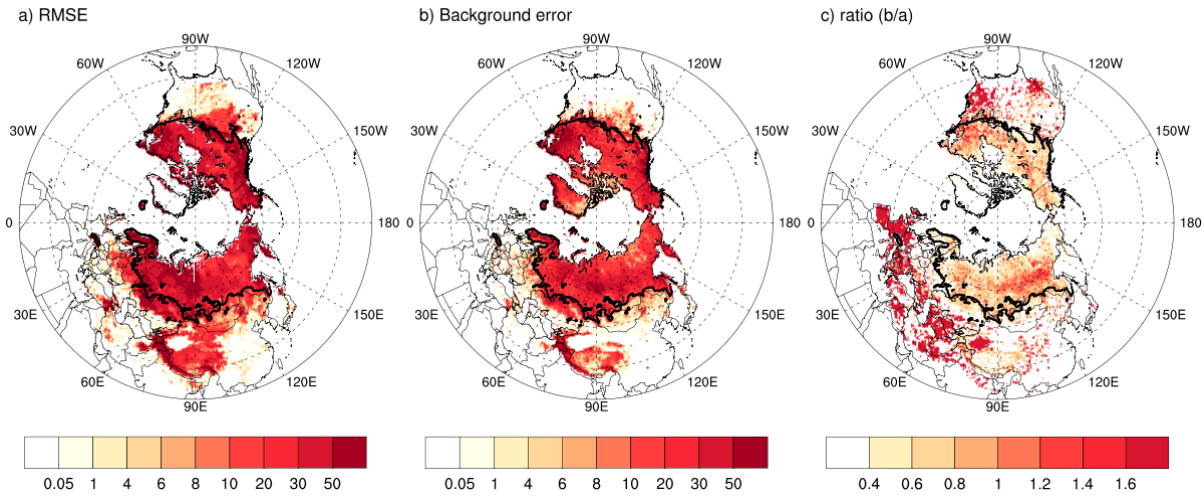
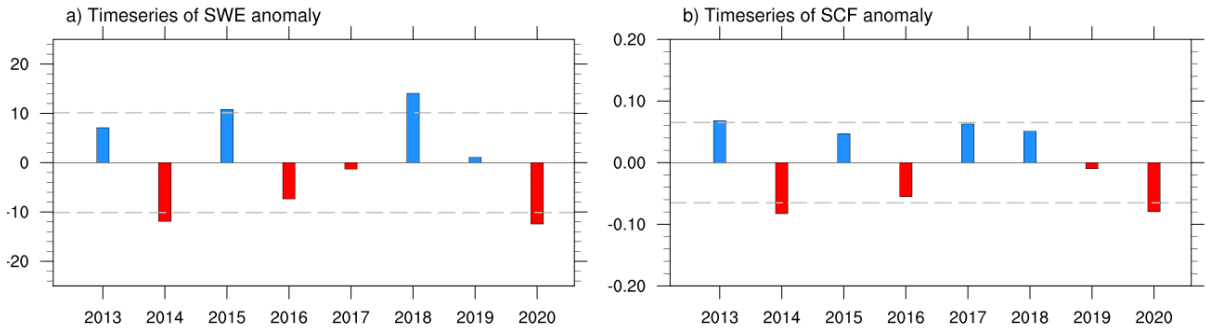
Supplementary Information

Supplementary Table 1 Confusion matrices for the experiment products (e.g., AMSR2, Openloop, JRA55, and the DA) against IMS data. Overall accuracy = (A+D) / (A+B+C+D)

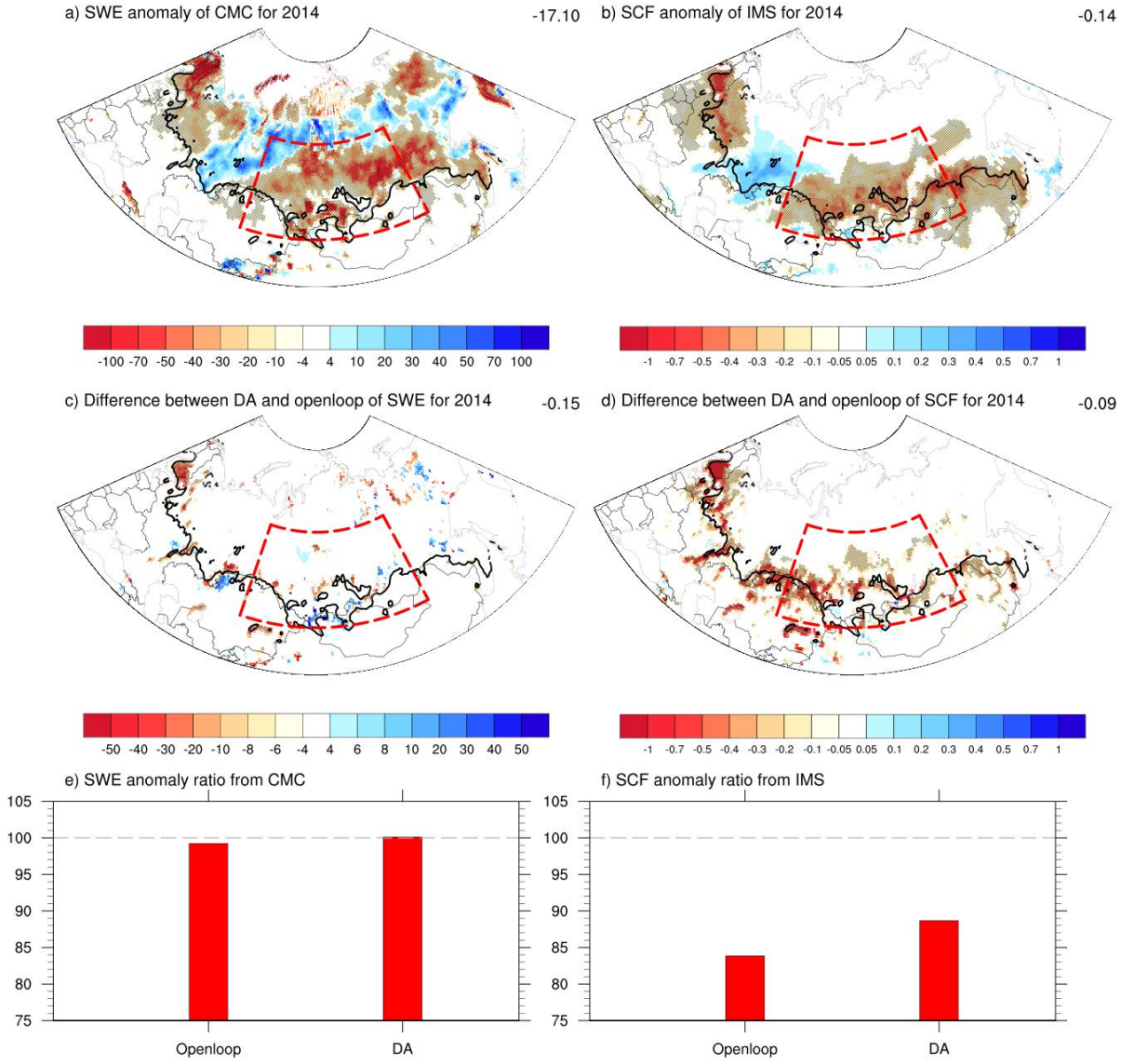
	IMS SNOW	IMS NO SNOW
EXPERIMENT SNOW	A	B
EXPERIMENT NO SNOW	C	D



Supplementary Fig. 1 Spatial distribution of root mean square error (RMSE) with CMC, background error, and ratio. The black line represents the boundary of the transition region, defined as the climatological-mean SWE of less than 16mm.



Supplementary Fig. 2 Time series of the area-averaged SWE and SCF anomaly of CMC and IMS, respectively, in Eurasian bounded by 48–65 ^{o}N and 55–120 ^{o}E, as shown by the red box in Figure 10. The dotted lines represent the one standard deviations of each variable.



Supplementary Fig. 3 Anomalies of a) SWE from CMC and b) SCF from IMS as well as the difference (c, d) of variables between DA and Openloop in April 2014. Bar chart (e, f) indicates the ratio of DA and Openloop to verification data such as CMC and IMS in the red box (48–65°N and 70–120 °E), which is the region associated with extreme high-temperature events, focused on this study. Negative values are indicated with a diagonal line.