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Supporting Information for

Impact of satellite observations on forecasting sudden stratospheric warmings

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Text S1.

The horizontal resolution of the MRI-AGCM used in this study is TL159 (~110 km), and there are 60 vertical layers with the top boundary at 0.1 hPa. The vertical resolution of this setting is consistent with that of the NWP model at the time of JRA-55 production. Although the horizontal resolution is coarser than the JRA-55 (TL319; ~55 km), we selected this resolution to maintain consistency with the submitted ensemble forecast data for a multi-NWP system comparison of SSW forecast skill (Tripathi et al., 2016). As boundary conditions, we used the monthly climatological sea surface temperature (SST) with the addition of a constant SST anomaly from the climatology at the initial time. The concentration of ozone is specified by the zonal mean climatological value. As one on the important parametrizations for the stratosphere, MRI-AGCM adopts a scheme for orographic gravity wave drag (Iwasaki et al., 1989).

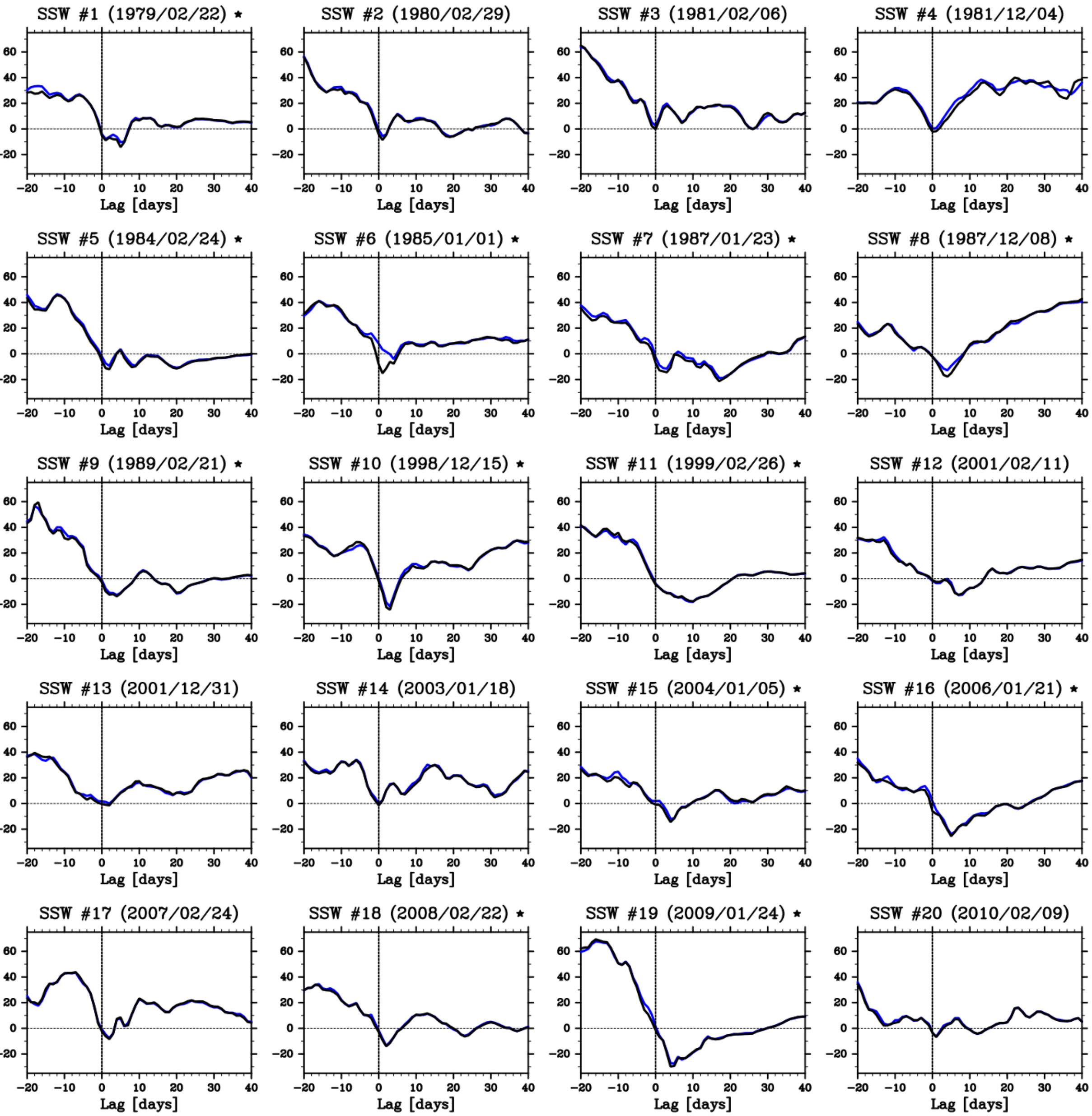

Figure S1. Zonal-mean zonal winds (m s^{-1}) at 60°N and 10 hPa for the 20 SSW events that occurred during 1978/1979–2011/2012 winters. Time series of JRA-55 (black lines) and JRA-55C (blue lines) are shown from D-20 to D+40. The onset date (D0) is shown in the format of YYYY/MM/DD. The event with a star mark is a prominent SSW, which shows under -10 m s^{-1} easterly within 5 days after D0.

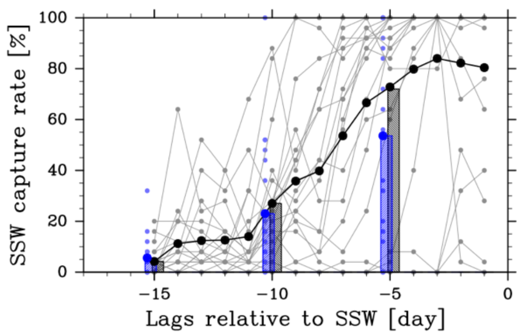

Figure S2. Same as Figure 1, except for all (20) SSW events.

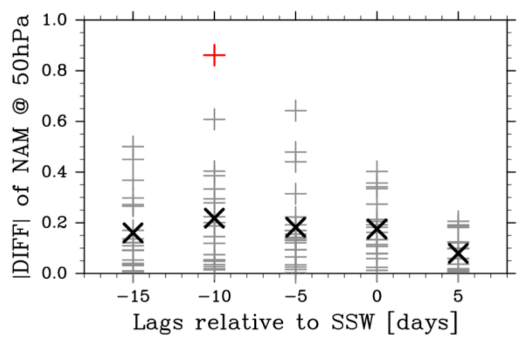

Figure S3. Satellite impact on forecasts of lower stratospheric circulation after SSWs. Absolute differences (gray crosses) between JRA-55 and JRA-55C forecasts and averaged differences (black crosses) of the normalized polar-cap (north of 60°N) height anomalies at 50 hPa for approximately one month after SSWs (from D+5 to D+35). A red cross indicates the forecast example shown in Figures 3, 4, and S4.

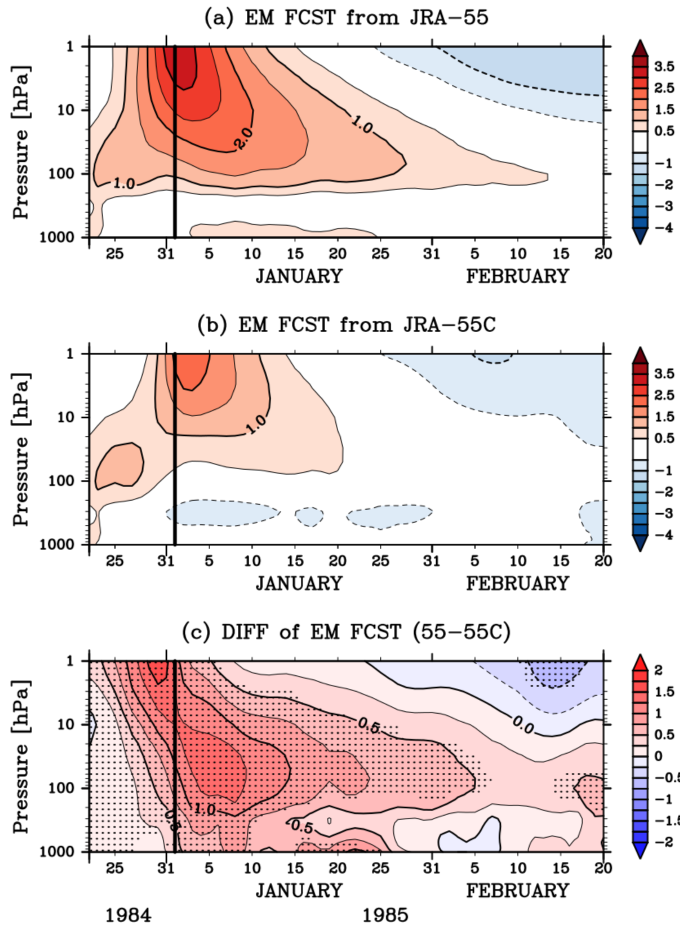

Figure S4. Satellite impact on forecasts of SSW-related anomalies in an extreme case. Time-height cross sections of the normalized polar-cap (north of 60°N) height anomalies in the ensemble mean forecasts from (a) JRA-55 and (b) JRA-55C. The anomalies from the climatological mean values are normalized by climatological standard deviations at each pressure level. Here, the climatological values are calculated for each calendar date from daily data over 30 years (1981–2010) in JRA-55, and then data were smoothed by applying a 31-day running average. (c) Difference between them [(a)-(b)]. The regions where the difference is significant at 95% confidence (estimated by Welch's *t*-test) are hatched.