Impact on Forecasting the Onset of SSWs

- ~20% decrease of SSW capture rate in forecasts from D-5
- JRA-55 forecasts initialized after D-5 can predict SSW onset deterministically
- Skill beyond one week depends strongly on cases
- At lead times beyond one week, the impact from the difference in the initial conditions would be hidden in nonlinear growth of forecast errors

Impact on Forecasting Anomalies After SSWs

- Positive (but significant only 5–10 days after the initialization)
  - Longer predictable period in the stratosphere (~25–27 days if forecasts are initialized after D-5) compared to that in the troposphere (~7–9 days)
  - Large (but not always significant) improvements of the forecasts could be found in the stratosphere after the onset of the SSW in D-5 & D-10 forecasts

Impact of Satellite Observations on Forecasting Sudden Stratospheric Warmings

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Introduction & Experimental Settings

- JRA-55 & JRA-55C (its equivalent assimilating Conventional observations only)
  - These enable us to examine the impact of satellite assimilation on the reproducibility of phenomena in reanalysis by simple comparisons
- Large impact on an SH SSW, but not on NH SSSWs in (re)analysis
  - Since the observational anchoring is stronger in NH, stratosphere-troposphere, coupled variabilities are well reproduced, except for the upper stratosphere
- Ensemble forecast experiment by using JRA-55 & JRA-55C
  - This study investigates the satellite impact on forecasts of NH SSSWs by conducting reforecasts for 20 events in 2001–2012 years as follows

Model: MR-AQCM
- Ensemble Forecast System: MR-EPFS
- Initial Condition: 1 Control run from JRA-55C (25 members), 24 Perturbed runs (%) = (25-15)

Impact on Forecasting Anomalies After SSWs

- This study investigates the satellite impact on forecasts of NH SSSWs by conducting reforecasts for 20 events in 2001–2012 years as follows

Figure 2. Time-height cross sections of the forecast skill measured by Anomaly Correlation (AC) coefficient (validated by JRA-55) for geopotential height fields in the NH (north of 20°N). Forecast results from D-15, D-10, D-5 are distributed from top to bottom. D0 is represented by a vertical broken line. (a)-(e) Composite AC coefficient of ensemble mean JRA-55 forecasts averaged for all (20) SSWs. (d)-(f) Differences of averaged AC coefficient of ensemble mean JRA-55 forecasts from those of JRA-55C forecasts. The hatched regions are where the difference is significant at 95% confidence (estimated by Welch’s t-test).

Figure 3. Satellite impact on forecasts of lower stratospheric circulation after SSWs. Absolute differences (gray squares) between JRA-55 and JRA-55C forecast 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).

Figure 4. Satellite impact on forecasts of SSW onset in an extreme case. JRA-55 (red line) and JRA-55C (blue line) ensemble forecasts starting from D-10 are shown for an SSW occurred on 1 January 1985. Time series of (a) 30-hPa temperature averaged northward of 70°N and (b) vertical component of 50-hPa Eliassen-Palm (E-P) flux averaged over 45.75°N, from D-15 to D-15. Thick lines and shades indicate the ensemble mean values and 0.5 standard deviations among ensemble members. JRA-55 and JRA-55C are also shown by dotted lines. (c) Three-dimensional distributions of the vortex edges (isolines of the vertically weighted potential vorticity) of the stratospheric polar vortex, for a 7-day forecast period (validated at D-3). As a vortex edge, 38 PVU contours of Latitude at isothermal surfaces are plotted for each ensemble forecasts. Thick lines indicate the ensemble means.

Figure 5. Latitude-height cross sections before SSW occurred on 1 January 1985) in an extreme case of satellite impact. Ensemble mean forecasts starting from D-10 fields of (a) JRA-55 and (b) JRA-55C averaged over 1-3 days from D-9 to D-7 are shown as zonal mean zonal wind (contours with an interval of 5 m s⁻¹), E-P flux vector scaled by the inverse of the square of the pressure (arrows: Pa kgs⁻¹), and its divergence (color: in s⁻¹ day⁻¹). The region of isotherm bias is shaded. (d) Difference between them (red). The regions where the difference of E-P flux divergence is significant at 99.9% confidence (estimated by Welch’s t-test) are hatched. The significant (~99.9% in both meridional and vertical differences) of E-P flux are also plotted by four times larger vectors.

Details of the Impact in an Extreme Case

- Initial upper S. diff. triggers completely different time evolution
  - A failure to capture SSW in JRA-55C forecast is clear, although JRA-55C is not so bad
  - The polar vortex in the JRA-55C forecast splits into two pieces with almost barotropic structure, while the JRA-55C forecast holds its shape as a single vortex
  - The growth of EPFZ starts slowing down after D-7 in the JRA-55C forecast

Figure 6. Composite HPa surface analyses. (a) & (c) Pressure profiles of (a) 0C forecast period 1985 by JRA-55 and (c) 0C forecast period 1985 by JRA-55C. (b) & (d) Pressure profiles of (b) D+3 difference of (a) & (c) and (d) D+6 difference of (c) & (d). The contour intervals are 10 hPa.

Summary

- The upper stratospheric initial conditions play an important role in forecasting the onset and development of SSWs
- The 5-day lead capture rate of the onset of major SSW (wind-reversal) degrades ~20% if satellite data are not assimilated
- The absence of satellite observations could affect the extended-range forecast skill related to stratospheric downward influences

References


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