INTRODUCTION. North Hemisphere (NH) gravity wave (GW) activities during the 2008/2009 major SSW are examined through a series of mesoscale simulations. The 2008/2009 SSW event exhibits a clear-cut, polar zonal-mean wind transition from westerly to easterly in January (FIG. 1). Complemented with an analysis product and satellite observations, these simulations illustrate the distributions of GWs and their forcings with respect to planetary waves (PWs) at key dates during SSW as the vortex evolves.

METHOD

GMAO GEOS-5 Data
- Initial Condition
- Varying Boundary Condition

ARPS Version 5.2.8
- Extended vertically to 60 km
- Rayleigh Damping above 55 km
- 995 x 995 x 165 domain
- 5-second time step
- 24-hour runs

Horizontal Wind Divergence (filled contours)
Resulting simulations produce large-scale flows similar to GEOS and MLS. The figure on the left shows a sample comparison between GEOS and ARPS for 10 Jan. GEOS GWs are much smaller in amplitude.

SUMMARY
- Just prior to SSW onset, decelerative GW forcing tends to be stronger than PWs. This forcing is due to westward propagating GWs related mainly to orographic GWs (OGWs) of 400-800 km horizontal scale. PW forcing eventually dominates as SSW occurs.
- The filtering nature of the circulation on westward propagating GWs is evident as the vortex splits and zonal wind reverses. Eastward propagating GWs become more evident as the vortex breaks down.
- During vortex breakdown, the presence of westward and eastward propagating GWs is related possibly to secondary wave breaking and/or adjustments to flow imbalance.

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FIG. 1: (a) The 2008/2009 zonal-mean zonal wind (left) and temperature (right) at 70°N by GEOS and MLS; (b) PW forcing and ω* computed from GEOS. The dashed lines indicate when simulations are performed.

FIG. 2: Wave forcing by PW and GW from ARPS simulation for key dates. Black contour shows zonal-mean zonal wind. Arrows are EP flux and filled contours are flux divergence. Arrow lengths are scaled with respect to the length of 10 Jan.

FIG. 3: Time-averaged ARPS vertical flux of zonal momentum (ω*) of OGWs for key dates, partitioned into various spatial bands. Zonal-mean horizontal scale is multiplied by 2000 for presentation. Zonal-mean zonal wind is overlaid as line contours with the zero wind line thickened.

FIG. 4: Simulated GW vertical flux of zonal momentum (ω*) of OGWs at 1400 UTC. Successive darker gray-shaded regions identify areas of strong horizontal wind speed [40, 60, 80 m s⁻¹]. The geopotential heights are line contours.

FIG. 5: Altitude-longitude cross-sections of horizontal wind divergence (f Sciencedirect.com simulations illustrate the distributions of GWs and their forcings with respect to planetary waves (PWs) at key dates during SSW as the vortex evolves.

FIG. 10: Same as FIG. 4 except for 30 Jan.

FIG. 11: Same as FIG. 4 except for 30 Jan. and at 55°N and 75°N.