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Intercomparison of meteorological analyses and trajectories in the Antarctic lower stratosphere with Concordiasi superpressure balloon observations

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In this study we compared temperatures and horizontal winds of meteorological analyses in the Antarctic lower stratosphere, a region of the atmosphere that is of major interest regarding chemistry and dynamics of the polar vortex. The study covers the European Centre for Medium-Range Weather Forecasts (ECMWF) operational analysis, the ERA-Interim reanalysis, the Modern-Era Retrospective analysis for Research and Applications version 1 and 2 (MERRA and MERRA-2), and the National Centers for Environmental Prediction and National Center for Atmospheric Research (NCEP/NCAR) reanalysis. The comparison was performed with respect to long-duration observations from 19 superpressure balloon flights during the Concordiasi field campaign in September 2010 to January 2011. Most of the balloon measurements were conducted at altitudes of 17-18.5 km and latitudes of 60-85°S. We found that large-scale state temperatures of the analyses have a mean precision of 0.5-1.4 K and a warm bias of 0.4-2.1 K with respect to the balloon data. Zonal and meridional winds have a mean precision of 0.9-2.3 m/s and a bias below +/-0.5 m/s. Standard deviations related to small-scale fluctuations due to gravity waves are reproduced at levels of 15-60% for temperature and 30-60% for the horizontal winds. Considering the fact that the balloon observations have been assimilated into all analyses, except for NCEP/NCAR, notable differences found here indicate that other observations, the forecast models, and the data assimilation procedures have significant impact on the analyses as well. We also used the balloon observations to evaluate trajectory calculations with our new Lagrangian transport model Massive-Parallel Trajectory Calculations (MPTRAC), where vertical motions of simulated trajectories were nudged to pressure measurements of the balloons. We found relative horizontal transport deviations of 4-12% and error growth rates of 60-170 km/day for 15-day trajectories. Dispersion simulations revealed some difficulties with the representation of subgrid-scale wind fluctuations in MPTRAC, as the spread of air parcels simulated with different analyses was not consistent. However, although case studies suggest that the accuracy of trajectory calculations is influenced by meteorological complexity, diffusion generally does not contribute significantly to transport deviations in our analysis. Overall, evaluation results are satisfactory and compare well to earlier studies using superpressure balloon observations.

Reference:

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