Antarctic radiosonde observations reduce uncertainties and errors in reanalyses and forecasts over the Southern Ocean: an extreme cyclone case

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1. Introduction

The large uncertainties are seen over the Polar Regions in the reanalysis data sets. Additional radiosonde observations in high latitudes reduced large uncertainties at upper level, improving forecast skill of surface circulations over the not only high latitude (Yamazaki et al., 2015; Inoue et al., 2015, Sato et al., 2019) but also over the midlatitude (Sato et al., 2017, 2018a,b). Because large uncertainty over the high latitudes reached midlatitudes, causing error of predicted surface circulations over midlatitudes (Sato et al., 2017, 2018a,b, 2019). The uncertainty over the Southern Hemisphere in reanalysis is larger than over the Northern Hemisphere because of lack of the observation over the Southern Ocean. However, no previous study has reported the impact of additional radiosonde observation over the Southern Ocean and Antarctica on reanalysis data and weather forecast. In this study, we investigate the impact of additional radiosonde observations by Japanese Research Vessel (R/V) Shirase and Dome Fuji station on forecast skill of Antarctic cyclone.

2. Data

2.1 Additiona radiosonde observation by Japanese R/V Shirase and Dome Fuji station

Additional radiosonde observations were made over Southern Ocean and Antarctica during December 2017 and January 2018. During the period, twice radiosonde observations were conducted at Japanese R/V Shirase and Dome Fuji station. These data were sent to the Global Telecommunication System, meaning that these data reduced uncertainty at initial time for weather forecast and enhanced forecast skill over the Sothern Hemisphere. However, the National Centers for Environmental Prediction (NCEP) PREPBUFR (available from http://rda.ucar.edu), which is used as the observation for numerical model, did not included these data. Therefore, we need assimilate additional radiosonde observations into numerical model using data assimilation systems.

2.2. Ensemble reanalysis and forecasts

An ensemble data assimilation system, the so-called ALEDAS2, is used in this study. The ALEDAS2 is composed of the Atmospheric general circulation model For the Earth Simulator (AFES) and local ensemble transform Kalman filter (LETKF). The AFES with horizontal resolution T119 and L48 vertical levels provides 63-member ensemble forecasts. National Oceanic and Atmospheric Administration daily 0.25° Optimal Interpolation Sea-Surface Temperature (OISST) version 2 was used for ocean and sea ice boundary conditions. The AFES-LETKF experimental ensemble reanalysis version 2 (ALERA2) dataset is produced with ALEDAS2. In this study, we prepared two reanalysis data to investigate the impact of additional radiosonde by Japanese R/V Shirase and Dome Fuji on weather forecast over the Southern Hemisphere. The first is OSE reanalysis, which assimilated radiosonde data sets from R/V Shirase and Dome Fuji. The other one is CTL, which excluded these sounding data. Ensemble forecasts were conducted using two ensemble reanalysis datasets.

3. Synoptic condition near Japanese Syowa station during January 2018

To investigate the impact of additional Antarctic radiosondes on the prediction of surface systems over the Southern, we examined a cyclone that approached Japanese Syowa station on January 2018. On 1 January, the cyclone developed over the Southern Ocean and moved toward Antarctica. The cyclone with central pressure 945 hPa was located near Japanese Syowa station on 3 December, causing strong wind over the Antarctic coastal region and transport of water vapor toward Antarctica. The upper level trough, which influences the development and track of the cyclone, was located above the west part of the surface cyclone. The track of the cyclone in the OSE is similar to the track in the ERA5. We conducted two ensemble forecasts (hereafter OSEf and CTLf) using two reanalysis data (OSE and CTL) as initial conditions.

4. The impact of radiosonde observations by R/V Shirase and Dome Fuji station on forecasting the midlatitude cyclone

Temporal evolution of the central pressure of the surface cyclone in OSE, OSEf and CTLf (Fig. 1) were analyzed to assess the impact of additional Antarctic radiosonde observations on the skill to forecast cyclone central pressure. In OSE, the cyclone developed rapidly from 12 UTC on 2 January 2018 and the ensemble mean central pressure reached 956 hPa at 00 UTC on 3 January. Most members in OSEf captured the decrease in central pressure from 12 UTC on 2 January, whereas all members in CTLf tended to underestimate the development of the central pressure at 00 UTC 3 January.

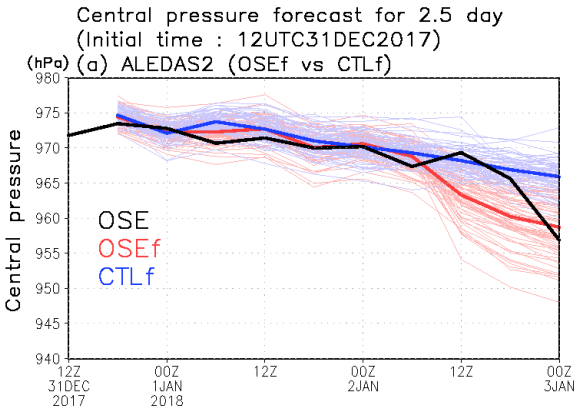

Figure 1 Temporal evolution of cyclone central pressure in (a) OSE (black), OSEf (red), CTLf (blue). Thick lines indicate ensemble mean. Thin lines indicate ensemble members.

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To access the CTL and OSE reanalyses and CTLf and OSE forecast simulation data, contact the corresponding author (satokazu@mail.kitami-it.ac.jp). ALEDAS2 and AFES integrations were performed on the Earth Simulator with the support of JAMSTEC. PREPBUFR compiled by the National Centers for Environmental Prediction (NCEP) and archived at the University Corporation for Atmospheric Research (UCAR) is used as the observations (available from http://rda.ucar.edu).

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