The impact of SST on the weather forecast quality in the Bulgarian Antarctic Base area on Livingstone Island

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Introduction

The weather forecast of good quality is essential for the human living and operating in the Bulgarian Antarctic Base. The numerical weather prediction models in southern high latitude regions still need improvement as the user community is limited, local tests are demonstrated and validation data are scarce. Not last, the challenge of distributing the output results under poor internet connection has been met. Furthermore, the length of each simulation is 72 hours and the results are compared with the temperature at 2 m, sea level pressure and wind at 10 m in the stations and ERA-5 climatic hourly reanalysis data. It is found to represent satisfactorily the temperature at 2 m, sea level pressure and wind at 10 m in the point of BAB during weather shift events.

Model configuration

The modeling system is based on the Weather Research and Forecasting (WRF) model, version 4.0, developed by the National Center for Atmospheric Research (NCAR) and the National Centers for Environmental Prediction (NCEP). The numerical model uses a staggered Arakawa C-grid [1] and the nesting is performed in a 1:1 ratio, with a finest resolution of 1 km. The domain configuration, shown on Figure 1, is centered over the Bulgarian Antarctic Base (BAB) and consists of three nested domains, namely 0.5°, 0.25° and 0.1°. The initial and boundary conditions for each forecast are taken from the GFS 0.25 Degree Re分析arch [2] and the lateral boundary conditions are updated every 3 hours of the simulation. In order to quantify the importance of the sea surface temperature (SST), this variable is taken as a time varying boundary condition and is also updated every 3 hours into the simulation.

The experiment is carried out with four different land use types - snow and ice (as in MODIS), barren tundra and rainfed tundra and grassland. Their land use numbers and respective parameters values are given in Table 1. The results of the simulations for the finest domain are shown in Figure 2.

Land use sensitivity

The influence of the Southern Ocean on the weather over small islands is significant. Thus important to correctly taken into account in the numerical forecast. The ocean mainly affects the weather on high latitudes through its sea surface temperature (SST) and the distribution and movement of sea ice by the currents. The experiments with symmetric modifications are used for a quantitative analysis. Let us introduce the measure of the modification \( \Delta S T \), which takes discrete values of \( \Delta S T \in [-3, -1.5, -1, 1, 1.5, 3] \). We also introduce the variables \( \Delta T_{\text{max}} \) and \( \Delta T_{\text{min}} \) to represent the maximum values of the variable temperature at 2 m, sea level pressure and wind at 10 m in the point of BAB during weather shift events.

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SST sensitivity

A comparison of all our simulations for a snow case in 2016, in the point where BAB is located, are shown in Figure 4. The comparison of the simulations with unmodified GFS and CMEMS SST data show that the second tend to induce higher 2 m temperatures. The calculated values of bias and RMSD for the case study in 2016 and the case study in 2020 are minimal for the run with modified SST with a value of 1 °C, which can also be seen in the graph, as the dash red curve. The comparison of unmodified data for both cases shows slightly better results with the CMEMS SST model - for the case study in 2016 the RMSD has values of 1.69 with GFS SST and 1.62 with CMEMS SST, for the case study 2020, the respective values are 2.23 with GFS SST and 2.08 with CMEMS SST.

Conclusions

A visual representation of the difference in the SST field between the two datasets for one of our simulations is given in Figure 5. Several differences can be noticed in this comparison - the average SST, according to the GFS model, is 2 °C less compared to CMEMS, the distribution of the SST values is different, the temporal evolution shows a significant decrease of about 2.5 °C in the Southern part of the island in the CMEMS field and almost no change in the GFS field. The in-situ measurements of sea temperature at 3 m depth are consistent with the large change in SST, predicted by the CMEMS model. Comparisons of other cases have shown less notable differences between the average SST values in BAB compared to CMEMS. The calculation of the SST sensitivity, experiments with a modified SST are also conducted - the SST is modified with a fixed constant (with values of -1°C, -1°C, 1°C) over the whole field.

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References


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