Scuola di Dottorato in Scienze Polari – Università degli Studi di Siena

Verifica dei modelli meteorologici: Verifiche di punto e di area dei modelli operazionali a scala globale e mesoscala utilizzati per le previsioni meteorologiche in Antartide nella Terra Vittoria

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Abstract

Numerical atmospheric model represents an incredible tool both for atmospheric dynamics research both for more operational tasks especially over the Antarctic continent where the scarcity of observational data necessitates the heavy use of model simulation. In response to the need for improved weather prediction capabilities in support of the field operations of the Italian Program for Research in Antarctica this thesis analyzes the performance of the two numerical weather prediction models that aided meteorologists in forecasting weather throughout the campaigns: the European Centre for Medium-Range Weather Forecasts (ECMWF) global forecast model, and the Antarctic Mesoscale Prediction System (AMPS) Polar MM5 (fifth generation Pennsylvania State University–National Center for Atmospheric Research Mesoscale Model). The ECMWF operational and Polar MM5 model forecasted surface Pressure, Temperature, Dew Point Temperature, Wind Speed and Direction are compared with observations sampled by automatic weather stations of the Meteo-Climatological Antarctic Observatory of the PNRA over the Italian operations field in Antarctica.

To identify specific strengths and weaknesses, the predicted variables for each model are analyzed with statistical tools for all forecasts initialized at 00 UTC between 1993-1997 and 2001-2007 for the ECMWF model with increasing horizontal resolution until 0.25°, and between 2006-2007 for AMPS model on 6.6 km domain.

The results show that increase in spatial resolution for the ECMWF global model exerts important improvements on forecast accuracy, such to overrun those given by MM5 mesoscale model, especially in the complex topography of the Antarctic coastal regions.

The simulated 0–24-h surface pressure and near-surface temperature at most sites present correlations of 0.98 and 0.90 respectively for ECMWF model, with the highest pressure correlations on the Antarctic plateau, while the correlations reach 0.85 both for pressure and temperature for Polar MM5 model, with small biases. Surface wind speeds forecast reflects the difficulties in parameterization of complex topography and generally have correlations between 0.3 and 0.8, the bias is generally lower than 1 for ECMWF and higher than 1 for AMPS, with the best performances at Cape Phillips and Mean Priestley, and the worst ones on High Priestley and Terranova Bay for both the models. Moreover the simulated wind direction has acceptable accuracy only on the plateau. Over the annual cycle, there is little intra-seasonal skill variation more apparent for summer temperature and dew point temperature predicted by AMPS over the coastal regions. The plateau temperature is overestimated by ECMWF over the whole year.

A gradual skill decrease is observed for ECMWF model with the increasing of the forecasted time (from hours 0-168); it becomes considerable after 72 h for pressure, temperature and dew point temperature and even earlier for wind speed and direction (48 h). Substantial efforts are still needed to improve the surface prediction of wind. Both models show a low Treat Score in the prediction of strong wind (greater than 12 m/s).

The thesis shows that the two models perform with quite equivalent skill with ECMWF showing the highest performances, generally having the lowest bias and rmse and highest correlations for the compared fields. Prediction skill of both models is high for surface pressure, good for surface temperature and dew point temperature but modest for wind speed and especially for wind direction. The initial and boundary conditions for the AMPS Polar MM5 play a significant influence on the forecasts and the slightly lower performances with respect to ECMWF are ascribable to worse initial analyses.