Development of a Dynamical/Statistical Operational System to Forecast and Analyze Atmospheric Winds at Surface Level Valid for up to 168-hour Periods

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Summary

This manuscript presents a dynamical/statistical operational system developed as an effort to forecast winds surface for up to 7 days. The wind surface field corresponds to the standard level of 10m height and constitutes the first step to construct a full operational Earth System. The operational forecasting system has two main coupled models: an operational weather forecasting numerical model and a downscaling statistical model that transfer the information from a regular lat-lon grid to any point or region of interest. The system has been tested around the Beaufort Sea region and has been validated with three WMO meteorological stations. The system has proved to be a very promising tool that can be used as a generator of input data for oceanic, sea ice, land surface or hydrologic models.

Introduction

Traditionally the operations in open environment are realized with maps of weather forecast but with poor or no long term forecasting information of surface winds direction and speed at standard level of 10m height. Some reasons for the lack of information available are absence, incompleteness or bad quality of data; also economic and political limitations make it impossible to have gauged stations in regions of interest. When atmospheric data are assimilated using the reanalysis technique and are integrated with dynamic models in real time (to integrate in a regular grid latitude-longitude, and to incorporate information from all available sources like radars, satellites instrumentation, liydar, ships, buoys, etc.), it is possible to generate a lat-lon regular grid that contains winds speed and direction for any region in Canada, North America or in the world.

Methods

The dynamic/statistical operational system is the result of coupling a numerical weather prediction model with a statistical downscaling model that provides the modelling system for forecasting wind surface for up to 7 days ahead and runs four times a day. The native resolution of the operational weather forecasting numerical model is 450 seconds and 30 min arc-degree with unequally-spaced sigma levels in the vertical. The dynamic core model is 3-dimensional, primitive equation with vorticity, divergence, log-pressure, specific humidity, virtual temperature, σ-coordinate and cloud condensate. Horizontal diffusion is the Leith (1971) scheme. Planetary boundary layer uses the Troen and Mahrt (1986) scheme. Roughness lengths over oceans are determined from the Charnock (1955) method. Roughness lengths over land are prescribed. Land surface processes are calculated with the Pan and Mahrt (1987) scheme. Radiation uses the Rapid Radiative Transfer Model (Mlawer et al. 1997). Convection is based on the Grell (1993) scheme.

The statistical downscaling model transfers the regular grid wind surface filed to the region of interest (Herrera et al., 2006). The region can be a point or a regular/irregular grid of points of interest. The interpolation model uses a cubic interpolation scheme for a single point and the continuous curvature splines in tension (Smith and Wessel, 1990) scheme for non-regular grids.

The wind surface data is recorded in geographic representation Lat-Lon or in the following conformal map projections: Mercator (cylindrical), Lambert (conic) or Stereographic Polar (circular).

Case of study

The validation of the operational forecasting system is done by comparing the recorded values of the WMO meteorological stations located in Northwest Territories, Canada. The stations chosen are located on the Canadian cost of the Beaufort Sea region. Table 1 shows the stations used in this study to validate the forecasted wind surface time series values. The values were obtained from Environment Canada historical database.

Table 1. Meteorological stations used to validate the wind surface values forecasted.

Station	Longitude (W)	Latitude (N)	Elevation (m)	WMO ID
Tuktoyactuk	133°01'35"	69°26'00"	4.30	2203912
Paulatuk	124°04'31"	69°21'40"	4.60	2203057
Sachs Harbour	125°16'00"	72°00'00"	86.00	2503650

Conclusions

The system developed has proved to be a very promising tool that can be used as a generator of input data for oceanic, sea ice, land surface or hydrologic models. The operational forecasting model is less computationally exigent on resources than theoretical numerical models. The whole system can be run on a high performance personal computer, where the data can be received, displayed and analyzed.

The operational system has an impact and potential benefit for the scientific, private and public sectors. Knowledge and better understanding of the wind surface improve our capacity to better coordinate all levels of our society. The description per sector is presented below:

Scientific: Wind surface field for sea ice applications is critical to understanding the response of the Arctic climate system. Especially under climate change conditions that can produce alterations on physical/statistical links between phenomena, processes or variables. Given the Arctic sea ice extent and variation, this operational system can make possible the production of scenarios with constant or trends parameters of key sea ice variables.

Private: The sea ice can be considered as static or in movement depending on the relative movement of the industrial structure. If the structure is a moving vessel, the wind surface and the sea ice can be considered quasi-static with respect to the speed at which the vessel is moving. However, if the structure is an off shore oil structure, the sea ice can be considered moving. Therefore, maritime transport industry such as cargo vessels is very sensitive to any change on the distribution and concentration of sea ice trough the navigation channels. Oil companies are sensitive to the current and projected concentration and thickness of the sea ice and the surface wind changes.

Public: The governmental agencies responsible for planning, management, safety, distribution of goods and services and survival of Canadians living in the Arctic region and workers depending of sea activities are very sensitive to wind surface and sea ice conditions. The strategic importance and national security of certain locations such as airports and sea ports depend on the good knowledge of these fields. This is the case of all the entrances of the Canadian Arctic, known as Arctic gate ways like Mackenzie River or the Northwest Passage.

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