11.5 COMPARISON OF NCEP/NCAR REANALYSIS DATA WITH STATION DATA FOR THE CIRCUM-POLAR COASTAL REGIME

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1. INTRODUCTION

The NCEP/NCAR Reanalysis project (NCEP: National Centre for Environmental Prediction; NCAR: Prediction/National Centre for Atmospheric Research) was undertaken to give to the science community accurate, high-resolution data sets for climatological work (Kistler et al. 2001, Kalnay et al. 1996). The Reanalysis project combines an NCAR operational model and observational data from various sources.

In the data sets generated by this project, hereafter "NNR" data, the amount of influence the model exerts on the final result varies according to location, because distribution of climate observing sites over the earth is non-uniform, and the parameter under consideration. Given this, it is of interest to compare NNR data back to in situ data and to assess its ability to reproduce the observed record for a given time and place. This is especially important if the NNR data are to be used to conduct analyses in remote, data sparse regions, or if they are to be used as input to other models to derive secondary parameters, such as wave heights. Studies that have assessed NNR data for use in sea-state derivation, including Proshutinsky (2000), who examined reanalysis data in the context of driving a storm surge model, and Swail and Cox (2000), who utilized NNR data to drive their north Atlantic wave model, have found that the NNR wind speeds are insufficient during times of observed high-magnitude events.

This paper presents limited results from a detailed comparison of NNR 6-hourly 10 mhag (meters height above ground) winds with observational hourly wind data from weather stations located throughout the circum-Arctic coastal region as well as inland stations from Canada, over the period 1950 - 2000. Wind speed and direction will be treated separately. In situ data from inland stations were included to determine if discrepancies between observed and NNR data were due to some artefact of coastal proximity. Use of inland stations also offered the opportunity to assess correlation in mountainous terrain, in which stations are presumably heavily influenced by local topographic factors. Given what has been reported in the literature concerning other efforts to correlate NNR data with in situ data, it was anticipated that observed wind speeds would be under-estimated by NNR wind speeds. Thus, another objective of this work was the identification of consistent patterns to the underestimation and development of objective (i.e., computer-based) correction algorithms so the NNR data could be used to satisfactorily drive models generating other environmental data, while minimizing operator intervention. For example, Swail and Cox (2000) offer corrected winds, but the correction process they employ is labour intensive.

2. DATA

Specific NNR data elements used for this work consisted of the 6-hourly 10 mhag u and v components of wind. In situ data were obtained from the National Climate Data Center "Integrated Surface Hourly" data set for government run surface weather stations located in Alaska, Russia, Norway and Greenland. Coastal and inland Canadian station data came from the Meteorological Service of Canada. Station selection was guided by the specific requirements of the International Arctic Research Center (IARC) supported "Arctic Coastal Dynamics" (ACD) project (Brown and Solomon 2000), and were based on the following criteria: proximity to designated "ACD monitoring sites", proximity to coast, length of record, uniform spatial distribution, and proximity to major rivers. Data preparation consisted of extraction of required data elements for the required time period (1950 – 2000) and interval (6 hourly), separated into files by station. Station locations were then compared to NNR grid point locations. The nearest grid point location was identified, and data for the identified NNR grid point were extracted and merged with the station data file. These files were used for the correlation work in this paper.

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3. METHOD

Correlation calculations for wind direction were performed using vector correlation methods (e.g., Essenwanger 1985) and for wind speed, Pearson's product moment (r) correlation was used. Analyses included all months and were conducted for two speed categories: all wind speeds (hereafter "all speed category") and >10 m/s (hereafter "high speed category"). The 10 m/s cutoff value was selected based upon its use as a general "storm threshold" described in arctic coastal research (e.g. Solomon et al. 1994). Analyses were performed for several time period breakdowns, including annual, the calendar seasons, and an arbitrarily defined "open-water" (July – November) and "freeze-up" (December – June) period. All available data in the period 1950 – 2000 were retained and for each station a single correlation was performed where a minimum of 30 data pair were present. Any station for which a correlation could be calculated was utilized irrespective when its data were available, that is, there will be correlations based on data from 1950 – 1970 plotted alongside those based on 1965 – 1990. The question of temporal drift over the time frame of the study in the relationship between NNR and in situ data is not considered in this paper.

Correction of systematic underestimation in NNR data of observed high-magnitude wind events was undertaken using an algorithm that searches the NNR data series for "events", which are defined by various combinations of magnitude, curve profile, and length of time above a set threshold. These were compared to similar occurrences in the in situ data to determine how corrections should be applied.

4. RESULTS

4.1 Correlations

Overall results in which correlations were performed on data for the entire 1950 – 2000 period indicate that the NNR wind directions have good to very good correlation with in situ data, while wind speeds have moderate to poor correlations. Results are presented for the "all speed" and "high speed" categories (Fig. 1). Direction correlation was good for the all speed category (Fig. 1a), breaking down only in mountainous (e.g., the Yukon) or fiords areas (e.g., Greenland, Baffin Island), or areas in which a strong local forcing agent is at work (e.g., the north coast of Novaya Zemlya). Direction correlation improved noticeably for the high speed category (Fig. 1b). Speed correlation was moderate to good for the all speed category (Fig. 1c), with the best results inland and over areas of low topography, such as central interior Canada. Speed correlation decreased noticeably for the high speed category (Fig. 1d).

Table 1: Correlation summary broken down by type, speed category and temporal period.

	Direction		**Speed**	
	Speed category		Speed category	
Winter	High	All	High	All
Mean	0.84	0.55	0.35	0.52
Median	0.87	0.61	0.35	0.54
Stdev	0.13	0.25	0.15	0.16
n	150	170	150	170
Spring				
Mean	0.85	0.56	0.29	0.51
Median	0.87	0.62	0.31	0.54
Stdev	0.10	0.21	0.15	0.15
n	148	170	148	170
Summer				
Mean	0.85	0.54	0.23	0.48
Median	0.88	0.60	0.26	0.49
Stdev	0.09	0.19	0.18	0.14
n	147	171	147	171
Autumn				
Mean	0.86	0.59	0.34	0.54
Median	0.88	0.68	0.35	0.57
Stdev	0.08	0.21	0.17	0.15
n	153	171	153	171
Open Water				
Mean	0.86	0.57	0.31	0.52
Median	0.88	0.64	0.33	0.56
Stdev	0.07	0.20	0.16	0.14
n	154	171	154	171
Freeze Up				
Mean	0.84	0.56	0.32	0.51
Median	0.87	0.59	0.33	0.53
Stdev	0.13	0.21	0.14	0.16
n	156	170	156	170
All months				
Mean	0.84	0.56	0.32	0.51
Median	0.87	0.61	0.33	0.55
Stdev	0.13	0.21	0.14	0.15
n	163	171	163	171

A complete summary of correlation results is presented in Table 1. The patterns just described for speed and direction correlations are generally evident for all time period breakdowns. Direction correlation especially exhibits little variation between the different periods, with mean values ranging between 0.84 and 0.87 in the "high speed" category and 0.54 and 0.59 in the "all speed" category. Speed correlation exhibited greater range amongst the periods, with mean values ranging between 0.23 and 0.34 in the “high speed” category and 0.48 and 0.54 in the “all speed” category. No one period stands out for direction correlations, however for speed correlations summer stands out in both categories with mean correlations noticeably lower than the other periods. Winter speed had the largest correlation value for the “high speed” category.

Standard deviations for the direction correlations decreased for all time period breakdowns from the “all speed” to the “high speed” categories. This was not the case for speed correlations, for which standard deviations varied little amongst time periods or speed categories. Summer and Autumn exhibited low standard deviations for direction correlations, whereas that for winter was noticeably larger.

An interesting observation is that there is a more consistent discrepancy between the mean and median values for direction correlation than for speed correlations. This suggests that there are more frequent occurrences of stations with low correlations for direction correlation than for speed correlation.

4.2 Correction

Attempts to correct NNR data proved moderately successful. Many events that had been underestimated were trapped and adjusted (e.g., Fig. 3). In some cases the corrections overestimate the observed, while in other cases the algorithm did not correct the NNR data. Most of the time, however, estimates improved the existing situation, i.e., that the NNR data sometimes underestimated wind magnitudes.

5. DISCUSSION

The observed patterns in wind direction correlation are consistent with a model-derived wind field being unable to resolve small-scale fluctuations in lower-speed wind regimes (the latitudinal distance between grid points is ~200 km). The dominance of local-scale influences on the wind regime increases as wind speed decreases. The reverse is also true: as wind speed increases the factors influencing the wind regime also grow in scale until they are of a size that the NNR grid and modelled processes can resolve. This is why direction correlation improves at higher wind speeds in all but the most mountainous or fiord terrain (Fig. 1c). In the case of speed correlation, the large grid spacing and 6-hourly time step precludes the complete depiction of the small, strong low-pressure systems that occur in this region. It is because storms, in particular, are not modelled at their full magnitude that the greatest discrepancies occur during times of the largest magnitude winds (Fig. 1d). The correlation results also indicated that the land/sea interface is problematic for the NNR model to capture, as suggested by the fact that the best speed and direction correlations in the all speeds category (Figs. 1 a-b) tended to be clumped in the continental interior, in areas of low relief. This follows from the spacing between the grid points in the model which, at 200 km, precludes detailed portrayal of many features of the planetary surface.

It is suggested that the difference amongst the seasons of direction correlation standard deviation is caused by the frequency of high-magnitude wind events, which are usually linked to low pressure systems. These are more common in late summer and autumn, and least common in winter. Thus while storms do not seem to be captured at full speed magnitude, prevailing direction of flow seems to be well represented in NNR data.

The effort to undertake correction of NNR wind speed underestimation, while reasonably successful, does currently have two limitations. The first is that the occurrence of a large-magnitude wind event is not always reflected in the NNR record. Usually there was some response from the NNR data; however, sometimes there was not. If an event has no representation in the NNR record, it is impossible to make any sort of objective correction, and the event will be missed. The second limitation concerns the magnitude of correction that is applied. It has proven difficult to consistently estimate how much correction to apply because a given pattern in the NNR record can correspond to a variety of observed events. For this reason the correction parameter is fixed, which results in some underestimation and some overestimation. However, the correction effort is still under development. It is likely that more region-specific corrections will yield more accurate results. Despite some shortcomings, overall the corrected NNR data provide a more realistic representation of the observed record.

6. REFERENCES

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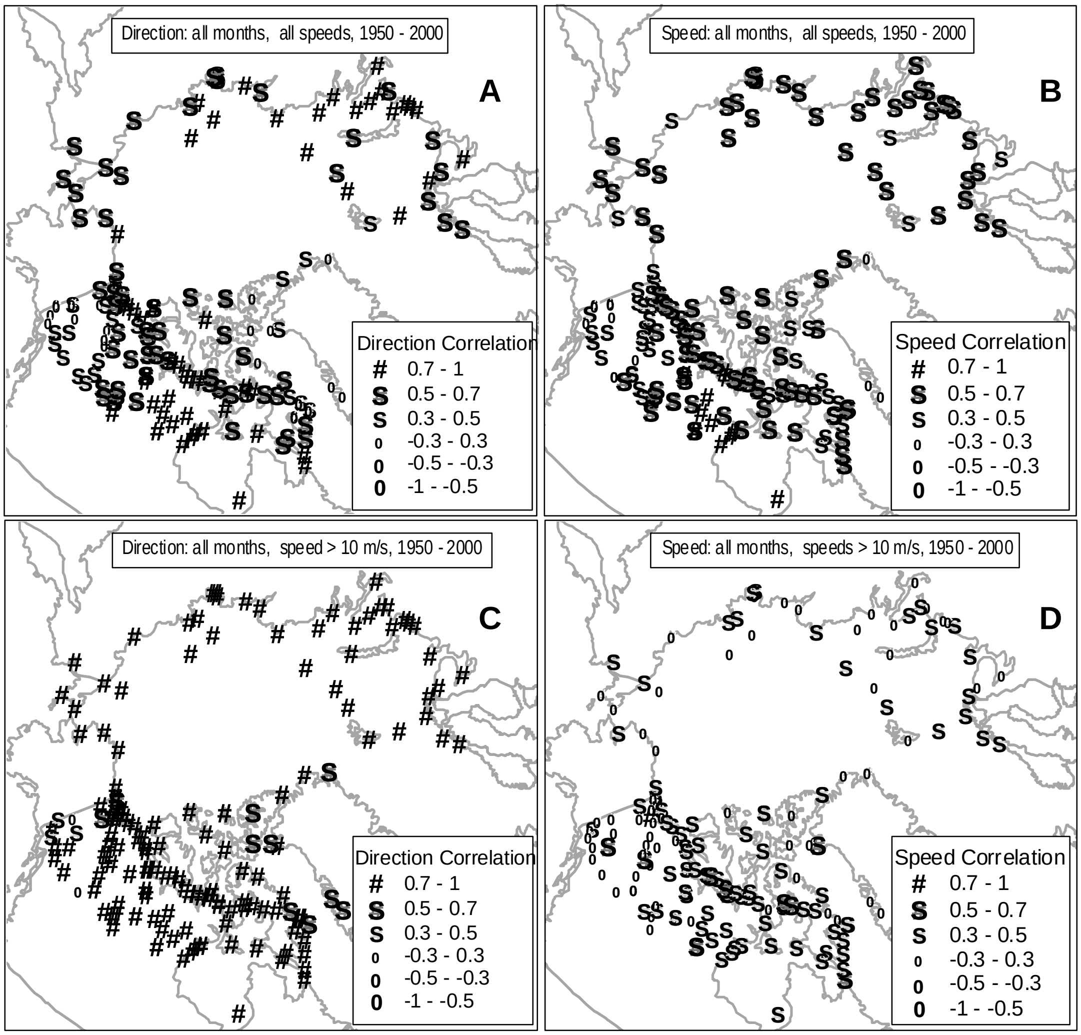

Figure 1: Time aggregate correlation results between wind directions and speeds from NCEP/NCAR 6hly reanalysis data and observed in situ data from weather stations: a) direction correlation results, 1950 – 2000, for all speeds over all months of the year, b) speed correlation results, 1950 – 2000, for all speeds over all months of the year, c) direction correlation results, 1950 – 2000, for high speeds (> 10 m/s) over all months of the year, d) speed correlation results, 1950 – 2000, for high speeds (> 10 m/s) over all months of the year.

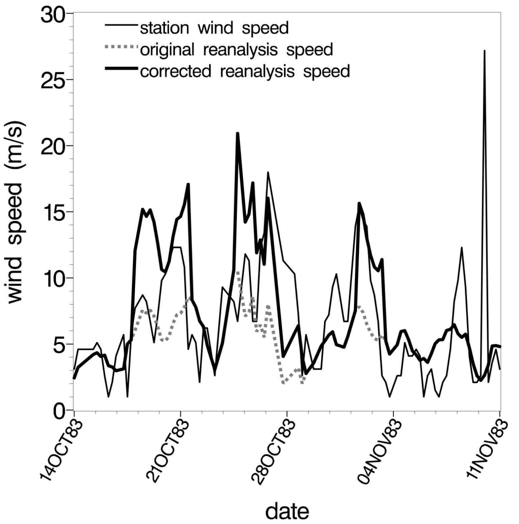

Figure 2: Example of results from the application of a correction algorithm to the NNR wind speed data.