Science and Technology Infusion Climate Bulletin
NOAA's National Weather Service
39th NOAA Annual Climate Diagnostics and Prediction Workshop
St. Louis, MO, 20-23 October 2014

Using the Bering Sea and Typhoon Rules to Generate Long-Range Forecasts

Joseph S. Renken[1], Joshua Herman[2], Daniel Parker[3], Travis Bradshaw[4], and Anthony R. Lupo[5]

[1]*KOPN Radio, Columbia, MO*

[2]*University of Wisconsin, Fox Valley, WI*

[3]*Western Illinois University, Macomb, IL*

[4] *Moberly Area Community College, Columbia, MO*

[5]*Department of Soil, Environmental, and Atmospheric Science, University of Missouri, Columbia, MO, and Belgorod State University, Belgorod, Russia 308015*

1. Introduction

Weather forecasting in the short range and long range has improved dramatically over the years (Anderson *et al.* 1999; Barnston *et al.* 2005; Lupo and Market, 2002, 2003). Weather forecasts in the short range are routinely issued for as long as seven to ten days. Long range forecasts are routinely issued at least one month to more than a year in advance. Short range forecasting is an initial value problem, which is performed within the framework of the primitive equations, whether these are made observationally, or with the aid of numerical models. Long range forecasting relies on a variety of methods, but are generally constructed using statistical methods, and is considered a boundary value problem. The methods used can be persistence, model of the day, contingency, analogues, or using more sophisticated statistical methodologies. There are medium range products available through the cooperation between the National Weather Service (NWS) regional and local offices and the Climate Prediction Center (CPC) in the range of 8 – 14 days (http://www.cpc.ncep.noaa.gov/products/predictions/814day/interactive/index.php). However, there are few products available that provide forecasts in the 6 – 30 day range, especially beyond 14 days, which is considered the dynamical limit for weather forecasting based on the size and rotation rate of the planet as well as the gasses that make up our atmosphere.

The Bering Sea (BSR) and Typhoon (TR) rules are two observations used by weather forecasters. The former was introduced in 2011, while the latter has been used since at least the 1940s and are based on the idea of teleconnectivity within the Pacific Ocean region which was defined statistically by Wallace and Gutzler (1981). For example, the Pacific North American (PNA) pattern will be associated with alternating trough-ridge patterns from the Central Pacific to the East Coast of the US. A ridge-trough pattern from west to east over the US is a positive PNA configuration, while the opposite pattern is negative. Teleconnection is thought to be the result of downstream propagation of Rossby Wave activity in the North and South Pacific basins (*e.g.*, Renwick and Revell, 1999; Wang *et al.* 2011, and references therein). The Bering Sea region is close to one teleconnective centers in the PNA pattern, which should make these rules useful indicators of weather downstream.

Atmospheric blocking, which generally persists for 7-10 day has also been associated with downstream influence on North America's weather (*e.g.* Quiroz, 1984; Wiedenmann *et al.* 2002). Blocking can have a substantial impact on the conditions over a region for an entire month or even a season as many researchers have demonstrated (*e.g.*, Lupo *et al.* 2014). Birk *et al.* (2010) demonstrated the influence of sea surface temperatures associated with El Niño and Southern Oscillation (ENSO) will be influential on the predominant temperature and precipitation regimes of the central USA, and that these are modified by longer term variability such as the Pacific Decadal Oscillation. Blocking is generally associated with troughing over the middle part of the USA, and a dramatic recent example occurred during November, 2014. Thus, the goal of

Correspondence to: Joseph S. Renken, KOPN Radio, Columbia MO; Email: jdrenken7@gmail.com

this research is to develop statistical tools based on the BSR and/or the TR that demonstrate their value and are better than climatology for prediction in the period of 6 to 30 days.

2. Data and methodology

a. data

The data used for this project come from a variety of sources, however the general source of this information is through the National Oceanic and Atmospheric Administration (NOAA), including the National Centers for Environmental Prediction / National Centers for Atmospheric Research (NCEP/NCAR) re-analyses (500 hPa heights) and the National Climactic and Data Center (NCDC) climatic information (climatological normals), and the Weather Underground (www.wunderground.com) for surface information.

b. Methods and definitions

The forecast verification method was based on the methods used by Lupo and Market (2003), and can be described generally as a skill score. In that paper, skill was measured using the formula:

Skill = (Forecast – Base) / (Verification – Base). (1)

For example, in their work, which was originated by Thornes and Proctor (1999), they converted actual temperature information into a point system for use in Eqn. (1), where a forecast within +/- 2^o F of the observed was considered perfect (2 points), and a forecast within +/-2 to +/-4^o F was given 1 point, and 0 was given to forecasts outside the 4^o F range. Here we modified this score system by awarding two, one, and zero point(s), respectively, for a forecast that was within one, two, or more than two seasonal standard deviation(s) (2σ), respectively away from observations.

A quick analysis demonstrated that the scores for the BSR, TR, and climatology were similar for the entire study period as well as within each season. Each method produced a similar number of perfect forecasts (two points) and busted forecasts (zero points). It is apparent that climatology would be difficult to improve upon, since the climatology in theory would result in a normal distribution, or a theoretical score of 1.63. However, anecdotal evidence indicated that the BSR and TR performed well when the temperatures were greater than 2σ from the normal. Scoring long range forecasts based on skill may not be the right way to show value, since climatology would be difficult to improve upon using statistical methods. This, however, does not preclude improvement via dynamical forecasting. Additionally, forecasts that involved 1 point scored can be considered partial successes and there were more contingencies that would fit into this type of analysis.

In this study, a methodology usually used by the National Weather Service and others in short range forecasting and severe weather was borrowed, which is based on a contingency table for events forecast and observed (*e.g.*, http://www.nws.noaa.gov/mdl/scan/test2/awipssvr.htm) (Table 1). Using this methodology will allow the scoring of the BSR and TR independent of climatology, and demonstrate value in abnormal (2σ) weather conditions. Here we will calculate success / probability of detection (POD – X / (X+Y)), false alarm rate (FAR – Z / (X +Z)), success ratio (SRO – X / (X+Z)), critical success (CSI – X / (X + Y + Z)), correct negatives (CRN – W / (W+ Y)), failures (FFR – Y / (W + Y)), and bias (BIAS – (X+Z) / (X + Y)).

Observed (below) / Forecast (right)	Yes	No
Yes	X	Y
No	Z	W

Table 1 The contingency table for BSR and TR forecasts of 2σ events and observations.

The definitions for blocking follow those used in Wiedenmann *et al.* (2002), and the definitions for the teleconnections examined are consistent with the work of Wallace and Gutzler (1981) or definitions found on the NWS and CPC websites. Here we examined the East (West) Pacific Oscillations (EPO(WPO)), the North Pacific Oscillation (NPO), the PNA, the North Atlatnic Oscillation (NAO), and the Arctic Oscillation (AO). The blocking occurrences were obtained from http://weather.missouri.edu/gcc. All statistics were tested using standard methods, which can be found in any elementary statistics text book.

3. Analysis and results

a. The Bering Sea and typhoon rules

In order to examine the BSR and TR, forecasts were made in the 17-21 day time period. These results demonstrate that the BSR and TR performed similarly to climatology during 2013 and 2014 (not shown). Thus, to examine the value of the BSR and TR during extreme events independent of climatology, the method in Table 1 was used, where X is the number of events were forecast correctly and occurred (two points), and Y is the number of events not forecast, but did occur (zero points). The value Z is the number of forecasted events that did not occur (0 points), and W the number of events that did not occur, but not forecast (two points). These results are shown in Tables 2 and 3.

Observed (below) / Forecast (right)	Yes	No
Yes	5 (10)	3 (3)
No	7 (4)	5 (9)

Table 2 As in Table 1, except for the outcome of BSR (TR) forecasts.

Index	BSR	TR
POD	62.5	76.9
FAR	58.3	28.6
SRO	41.7	71.4
CSI	33.3	58.8
CRN	62.5	75.0
FFR	38.5	25.0
BIAS	150.0	107.7

Table 3 The calculated indexes from section 2 for the BSR and TR expresses as a percentage (times 100).

The results demonstrated that the TR in general was more successful than the BSR, but both showed some success in forecasting 2σ events. Both the TR and BSR showed good scores for POD, CRN, but the BSR showed significantly less success in SRO and CSI. The TR showed low scores in FRA and FFR, and showed little bias in the forecasts, whereas BSR was higher in all these negative indicators. In the future this group will continue to track the progress of these forecasts in order to acquire a larger data set. Also, it would be desirable to identify an objective method for discerning those conditions that presage the effective use of the BSR and TR.

b. Blocking

All blocking events in the Pacific Region (140° E – 100° W) and Atlantic Region (80°W – 40° E) were compared over a three year from Sept 2011 – Aug. 2014 period with various teleconnection indexes and the monthly temperature and precipitation anomalies. The results of this preliminary study are shown in Table 4. Pacific (Atlantic) region blocking correlated strongly with the Pacific (Atlantic) Basin teleconnection patterns as expected. Pacific region blocking also correlated strongly with central US temperature and precipitation anomalies, although the temperature correlation was stronger. This might be expected as precipitation anomalies can be influenced by more localized factors as well as large-scale flow regimes. In general, Pacific Region blocking correlated with cooler and drier conditions. Atlantic Region blocking correlated with only the temperature. The correlation with colder temperatures is especially marked in the cold season.

Teleconnectivity	Correlation
At 99% confidence level	
East Pacific Oscillation	-0.60
West Pacific Oscillation	-0.60
Midwest monthly temperature anomaly	-0.45
At 95% confidence level	
Pacific North American	-0.42
North Pacific	0.42
North Atlantic Oscillation*	-0.39
At 90% confidence level	
Arctic Oscillation*	-0.33
Midwest monthly temperature anomaly*	-0.35
Midwest monthly precipitation anomaly	-0.30

Table 4 The correlation between Pacific (*Atlantic) blocking occurrences and days to teleconnectivity influencing Midwest region temperatures and/ or precipitation.

The strong Pacific Blocking event of early to mid-November 2014 was encouraging forecasts of a cooler than normal November within the first ten days of the month. Even one month before, the 30 day outlook projected a warmer than normal November for the far Northern Tier of states (http://www.cpc.ncep.noaa.gov/products/archives/long_lead/llarc.php). This blocking event was not foreseen, but was the result of the development of Super Typhoon Nuri in the west Pacific. Nuri became extratropical, and deepened to about 924 hPa, which is the strongest North Pacific extratropical cyclone on record. This cyclone strengthened a weak blocking event, that forced strong troughing over North America during the week of November 10th.

4. Conclusions

This study examined the utility of the BSR and TR for extended outlooks in the 6 – 30 day time frame. Data from NOAA and CPC were used primarily. The results of this study are preliminary and further study will be done in order to develop usable forecasting tools and a larger data base for performance statistics.

Examining the skill for the BSR and TR over the period the results demonstrate initially that both were consistent with climatology and did not show skill in the classic sense. However, a cursory examination demonstrated that both were able to forecast time periods when the temperatures were greater than two standard deviations from the mean. Thus, a contingency analysis typically used in synoptic and mesoscale meteorology was used in order to test the efficacy of each method for the detection of extreme events. Both methods demonstrated utility in identifying these periods, however the TR was consistently high (low) in those measures associated with positive (negative) performance, and showed small biases. The BSR scored high in false alarm rate as well as displaying more bias.

As expected, blocking in the North Pacific and Atlantic blocking correlated strongly with teleconnections in their respective ocean basins over a three year period of study. While Atlantic region blocking is correlated to central USA monthly temperature anomalies, Pacific region blocking correlated more strongly, and even correlated to monthly precipitation anomalies. As blocking is very difficult to forecast more than a day or two in advance (*e.g.*, Wiedenmann *et al.*, 2002), these events can result in monthly forecasts that are busted by their occurrence as evidenced by November 2014, which showed a forecast of normal to warm conditions. Strong blocking in the early part of the month led to a strong cold wave in the central USA for the last two-thirds of the month.

References

Anderson, J., and Coauthors, 1999: Present-day capabilities of numerical and statistical models for atmospheric extratropical seasonal simulation and prediction. *Bull. Amer. Meteor. Soc.*, **80,** 1349-1362.

Barnston, A.G., A. Kumar, L. Goddard, and M.P. Hoerling, 2005: Improving seasonal prediction practices through attribution of climate. *Bull. Amer. Meteor. Soc.*, **86,** 59-72.

Birk, K., A.R. Lupo, P.E. Guinan, and C.E. Barbieri, 2010: The interannual variability of Midwestern temperatures and precipitation as related to the ENSO and PDO. *Atmofera*, **23**, 95 - 128.

Lupo, A.R., and P.S. Market, 2003: First Conference on Weather Analysis and Forecasting Issues in the Central United States. *Bull. Amer. Meteor. Soc.*, **84**, 1245-1247.

——, and P.S. Market, 2002: The verification of weather forecasts in central Missouri and seasonal variations in forecast accuracy. *Wea. Forecasting*, **8,** 891 - 897.

——, I.I. Mokhov, Y.G. Chendev, M.G. Lebedeva, M. Akperov, and J.A. Hubbart, 2014: Studying summer season drought in western Russia. *Advances in Meteorology, Special Issue: Large Scale Atmospheric Science*, Article ID 942027. 9 pp.

Quiroz, R.S., 1984: The climate of the 1983-1984 winter - a season of strong blocking and severe cold over North America. *Mon. Wea. Rev.*, **112,** 1894-1912.

Renwick, J.A., and M.J. Revell, 1999: Blocking over the south Pacific and Rossby wave propagation. *Mon. Wea. Rev.*, **127,** 2233-2247.

Thornes, J. E., and E. A. J. Proctor, 1999: Persisting with persistence: The verification of Radio 4 weather forecasts. *Weather*, **54,** 311-320.

Wallace, J.M., and D.S. Gutzler, 1981: Teleconnections in the geopotential height field during the northern hemisphere winter. *Mon. Wea. Rev.*, **109,** 784-812.

Wang, Y., X. Xu, A.R. Lupo, P. Li, and Z. Lin, 2011: The remote effect of the Tibetan Plateau on downstream flow in early summer. *J. Geophys. Res.: Atmospheres*, **116,** *D19108, doi:10.1029/2011JD015979.*

Wiedenmann, J.M., A.R. Lupo, I.I. Mokhov, and E. A. Tikhonova, 2002: The climatology of blocking anticyclones for the northern and southern hemisphere: Block intensity as a diagnostic. *J. Climate*, **15,** 3459-3474.