Assessment of 2015 West Nile Virus Risk in South Dakota Based on Temperature Anomalies during the Preceding Winter

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Introduction
Recent research has documented statistical associations between winter temperatures and levels of human West Nile virus (WNV) disease during the subsequent transmission season. Chung et al. (2013) found that December-February minimum temperatures had a positive relationship with West Nile neuroinvasive disease cases in Dallas County, TX. Wimberly et al. (2014) found similar positive associations between winter temperatures and total human WNV disease cases in three regions of the central and eastern United States. The mechanisms underlying these relationships have not been determined, but are hypothesized to reflect winter temperature effects on mosquito survival and WNV overwintering. Other relevant mechanisms may include low temperature effects on survival of overwintering resident host species and subsequent timing of reproduction during the following spring. Based on the reported empirical relationships, a simple index of winter temperature has been developed to assess the annual risk of WNV in South Dakota.

Methods
Accumulated freezing degree days (FDDs) were computed as the sum of daily negative temperature deviations below zero degrees Celsius using climatological data from the North American Land Data Assimilation system (NLDAS). FDDs were computed from October of the preceding year through February of each year to focus on extreme conditions during the coldest months of the year (typically January and February). Yearly FDD values for every NLDAS grid cell were subtracted from the long-term (1984-2013) means and divided by the long-term standard deviations to generate standardized anomalies that were mapped for South Dakota and the surrounding states (Figure 1). The maps indicated that across much of South Dakota, FDD anomalies were generally positive (colder than normal) in years with low levels of human WNV disease (2004 and 2008-2011, and 2014). In contrast, FDD anomalies were generally negative (warmer than normal) in years with higher levels of human WNV disease (2005-2007 and 2012-2013).

Relationship between historical FDD anomalies and human WNV cases were evaluated from 2004-2014 for eastern and western South Dakota, using the Missouri River to divide the state. This stratification was based on the finding that eastern South Dakota has exhibited consistently
higher WNV incidence than western South Dakota since 2014 (Wimberly et al., 2013). There was a statistically significant correlation between accumulated FDDs and West Nile neuroinvasive disease cases in eastern South Dakota ($r=-0.89$, $p=0.0002$) but not in western South Dakota ($r=0.40$, $p=0.23$) (Figure 2). In the western region, significant drought years (2006 and 2012) had relatively low numbers of WNV cases even though they had fewer than expected FDDs. Although sufficiently warm winter conditions appear to be critical for outbreaks of disease to occur during the subsequent summer in eastern South Dakota, other environmental drivers and ecological feedbacks also influence WNV amplification and transmission.

**Conclusions**

During the winter of 2014-2015, South Dakota experienced slightly lower than average statewide accumulations of FDDs during the coldest winter months (Figure 1). These values fall in between the cluster of high WNV years associated with low FDD anomalies and the cluster of low WNV years associated with high FDD anomalies (Figure 2). Based on these results we believe that 2015 has the potential to develop into an outbreak year comparable to 2007 or 2013, but this projection has a high degree of uncertainty. Entomological and epidemiological surveillance data should be monitored carefully to detect amplification of WNV in the mosquito vectors and occurrence disease in the human population. In particular, an early increase in minimum infection rate by the end of June, combined with the lower than average FDD anomaly, could be interpreted as a strong indicator of a high risk of WNV transmission during the 2015 season.

**References**


Figure 1: Maps of October-February freezing degree day (FDD) anomalies for South Dakota and the surrounding states. Units are standard deviations. Positive values indicate colder than average and negative values indicate warmer than average winter conditions at a given location.
Figure 2: Plots of average October-February freezing degree day (FDD) anomalies versus total West Nile neuroinvasive disease cases for (a) Eastern South Dakota (east of the Missouri River) and (b) western South Dakota (west of the Missouri River). Blue dashed lines represent observed FDD anomalies in 2015.