Remote Sensing to Correlate Drought Indices and Prairie Pothole Surface Water Area

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INTRODUCTION

The Prairie Pothole Region (PPR) occupies an area of approximately 900,000 km^2 within the north central United States and southern Central Canada. The geomorphology of the PPR is a result of glaciation during the Pleistocene Epoch. As glaciers retreated approximately 12,000 years ago, buried blocks of stagnant ice melted which caused overlying till deposits to slump, forming kettles, commonly referred to prairie potholes throughout the region (Bluemle, 1991).

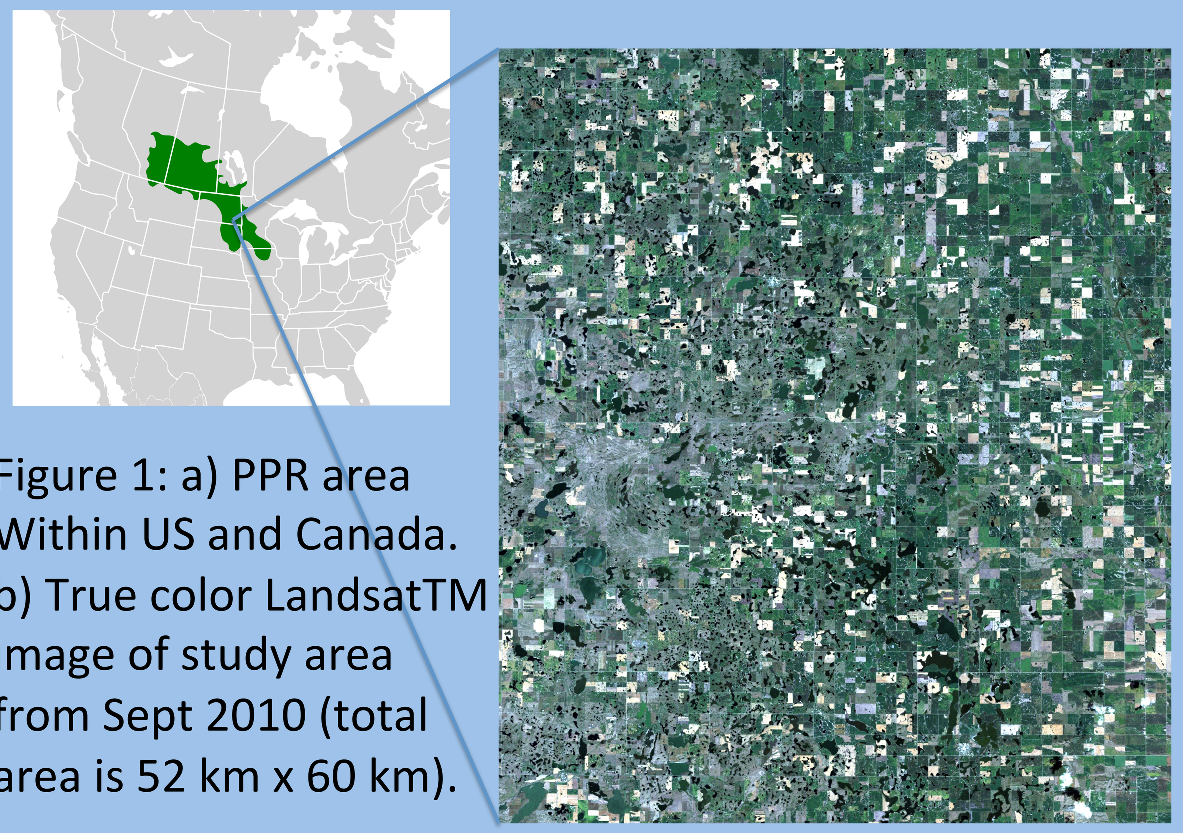


Figure 1: a) PPR area Within US and Canada. b) True color LandsatTM image of study area from Sept 2010 (total area is 52 km x 60 km).

PROJECT GOALS

Due to the number of prairie potholes throughout the PPR despite the recognized importance of the PPR to wildlife populations, it is infeasible to monitor changes in hydrologic conditions by on-the-ground methods. Huang et al. (2011) proposed a remote sensing approach to characterize water dynamics in the PPR related to the Palmer Drought Severity Index, an aridity index based on a soil moisture water balance. <u>The goal of this study is to compare various water aridity indices and water classifying ratios to determine if alternative approaches perform better than those used initially by Huang et al. (2011) to characterize prairie pothole surface water area over time using remote sensing techniques</u>.

METHODS

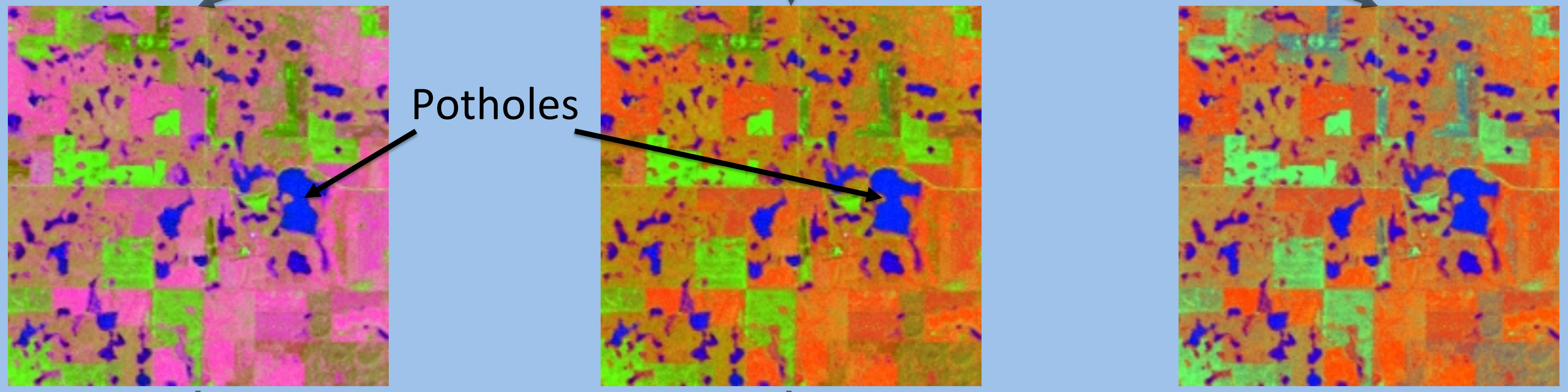
Original downloaded images were atmospherically corrected to remove scattering recorded by the sensor. Secondly, digital numbers (DN) were converted to top-of-the atmosphere reflectance. After DN conversion, band ratios were calculated as illustrated in Figure 2. Classification schemes were used to classify "water" versus "non-water" areas of the images. Details of the method is included in Figure 2.

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

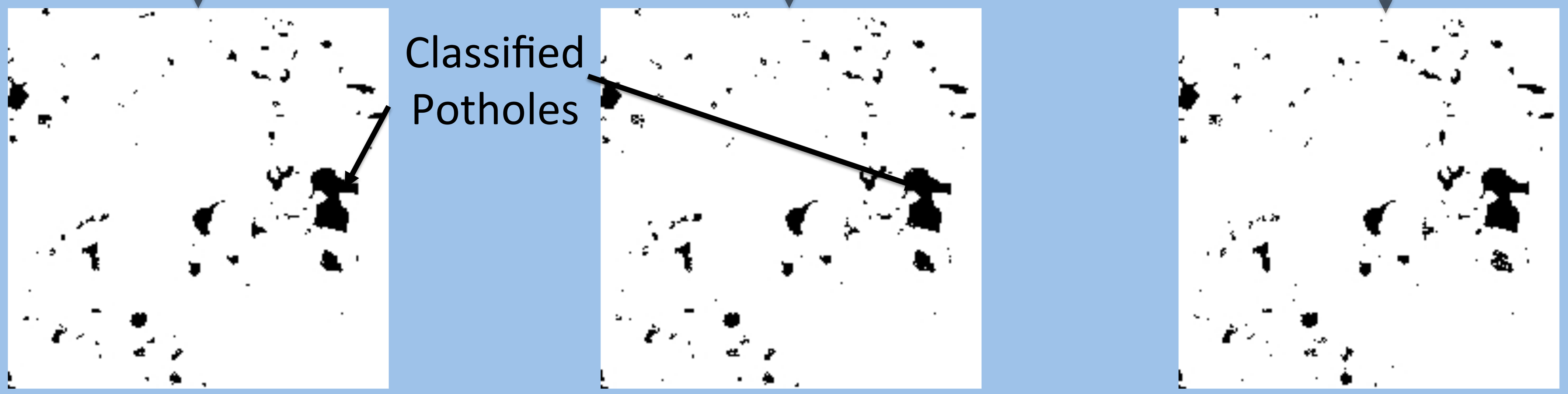
To enhance vegetation within the image, the Normalized Difference Vegetation Index (NDVI) band ratio was used.

Three water ratio methods were tested to optimally classify wetland surface water areas within the images.

$$NDWI_{Gao} = \frac{NIR - SWIR}{NIR + SWIR} \qquad MNDWI = \frac{Green - SWIR}{Green + SWIR} \qquad NDWI = \frac{Green - NIR}{Green + NIR}$$



Supervised classification procedures using the maximum likelihood method was used to classify "water" versus "not water" pixels. Results are summarized in Tables 1 & 2.



Date	Water Areas (km^2) NDWI	MNDWI	$NDWI_{Gao}$
8-Jun-07	141.77	131.90	135.16
12-Sep-07	115.62	115.49	114.92
17-Sep-09	110.06	105.64	125.30
16-Jun-10	169.91	165.51	168.27
4-Sep-10	136.92	137.59	138.07

Table 1: Classified Surface Water Areas

Date	Classification Accuracy (%) NDWI	MNDWI	$NDWI_{Gao}$
8-Jun-07	91.67	94.50	93.33
12-Sep-07	99.22	96.04	94.17
29-Jun-09	98.10	94.05	91.85
17-Sep-09	93.06	91.75	95.60
16-Jun-10	97.21	94.10	94.92
4-Sep-10	96.30	94.14	94.63

Table 2: Classification accuracy as determined from Ground Truth ROIs.

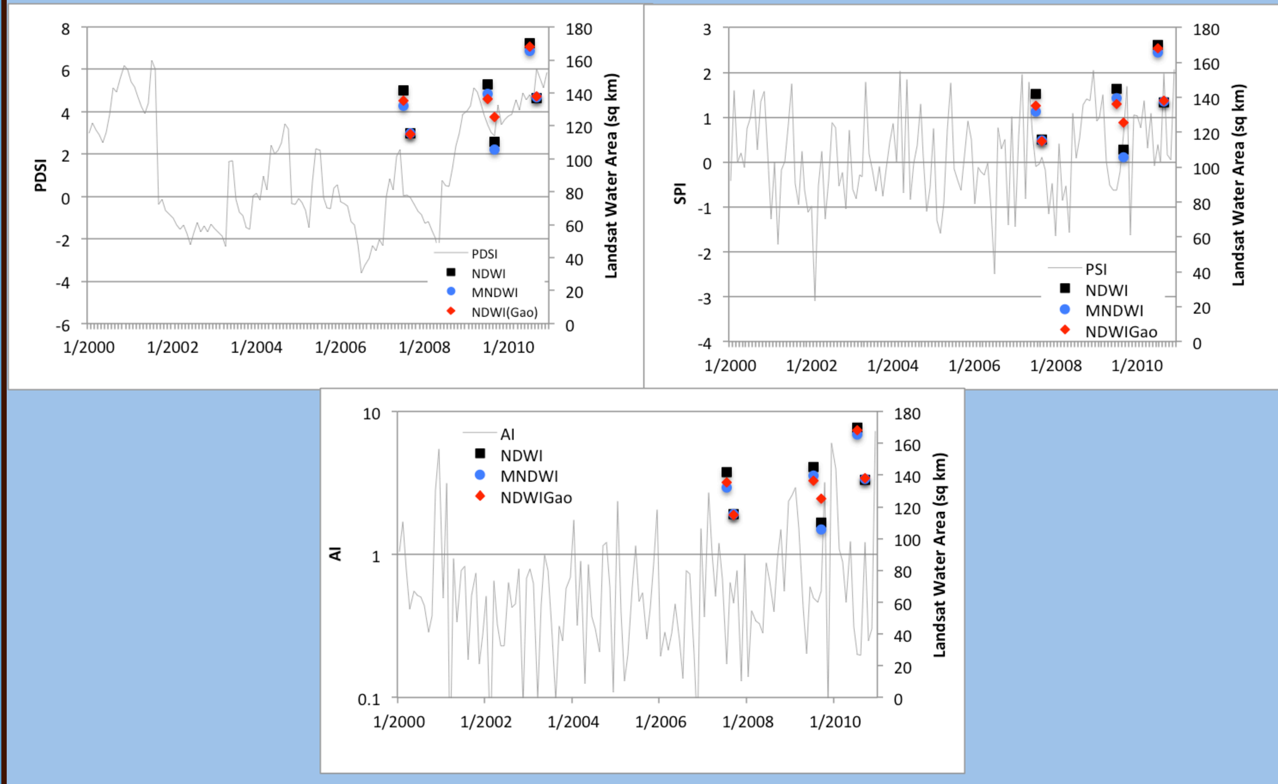
DROUGHT INDICES

Huang et al. (2011) related classified wetland surface water area to PDSI. For this study, the following indices are compared:

<u>Palmer Drought Stress Index</u> (PDSI): Introduced by Palmer (1965) to evaluate soil moisture deficiencies by accounting for the interaction of precipitation (P) and evapotranspiration (ET).
<u>Standardized Precipitation Index</u> (SPI): Probabilistic approach which characterizes precipitation deficits across future time scales.
<u>Aridity Index (AI)</u>: Commonly applied index of P over potential evapotranspiration (PET). PET estimated from Hargreaves Method.

RESULTS

Despite good performance in classifying water areas using various band ratio methods, resulting correlations between climate indices and wetland surface water areas were statistically insignificant suggesting that more complex methods used by Huang et al. (2011) are necessary.



REFERENCES

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Huang, S., D. Dahal, C. Young, G. Chander, and S. Liu, (2011) Integration of Palmer Drought Severity Index and remote sensing data to simulate wetland water surface from 1910 to 2009 in Cottonwood Lake area, North Dakota. *Remote Sensing of Environment*, 115, 3377-3389.

Palmer, W.C. (1965) Meteorological Drought, Research Paper 45. Washington DC, U.S. Department of Commerce Weather Bureau.

Data Sources: LandsatTM: US Geological Survey GLOVIS. Climate data obtained from PRISM (Oregon State University). PDSI and SPI obtained from the National Climatic Data Center.

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