Application of Remotely Sensed Data in the Analysis of the Hydrologic Variables: Case Study on the State of North Dakota

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Objectives and Overview

❑ Climate change would cause a decline on the Snow Cover (SC) and Soil Moisture (SM) content in different regions of the earth, which would result in the alteration of the seasonal variability of hydrologic variables. Analysis of the potential climate change impact requires the availability of the observed data along with the General Circulation Models' future scenario outputs.

❑Satellite products are one of the most spatially comprehensive data resources available for earth observation. Although these data are not as time extensive as gauge station data, they can be used in conjunction with other data to provide a better analysis of hydrologic trends.

❑In this study, the Snow Cover (SC) data from the MODIS (Moderate Resolution Imaging Spectroradiometer) and Snow Water Equivalent (SWE) and Soil Moisture (SM) data from the AMSR-E (Advanced Microwave Scanning Radiometer- Earth Observing System) satellite instruments are used. The trend in the SWE and SM over the state of North Dakota is investigated. SC data from the MODIS is compared with the SWE data from AMSRE to examine the correlation between the two snow datasets. The data is available from 2002 and is downloaded and subset from "The Warehouse Inventory Search Tool (WIST)" provided by NASA.

Study Area

The State of North Dakota, (Fig.1) is located in the Midwestern United States along the Canadian border. North Dakota experiences extreme temperature variations causing cold winters and hot summers. The historical data show the lowest temperature of −51.1 C and the highest of 49 C in this region.
The average annual precipitation is 35.6 cm to 55.9 cm, hence it is considered as a semi arid region. Much of the water demand in this state is provided by seasonal snowpack, which makes SWE and SC important quantities for this state. A rectangular area was subset over this region from latitude of 45 to 49 north and from longitude of 96 to 104 west.

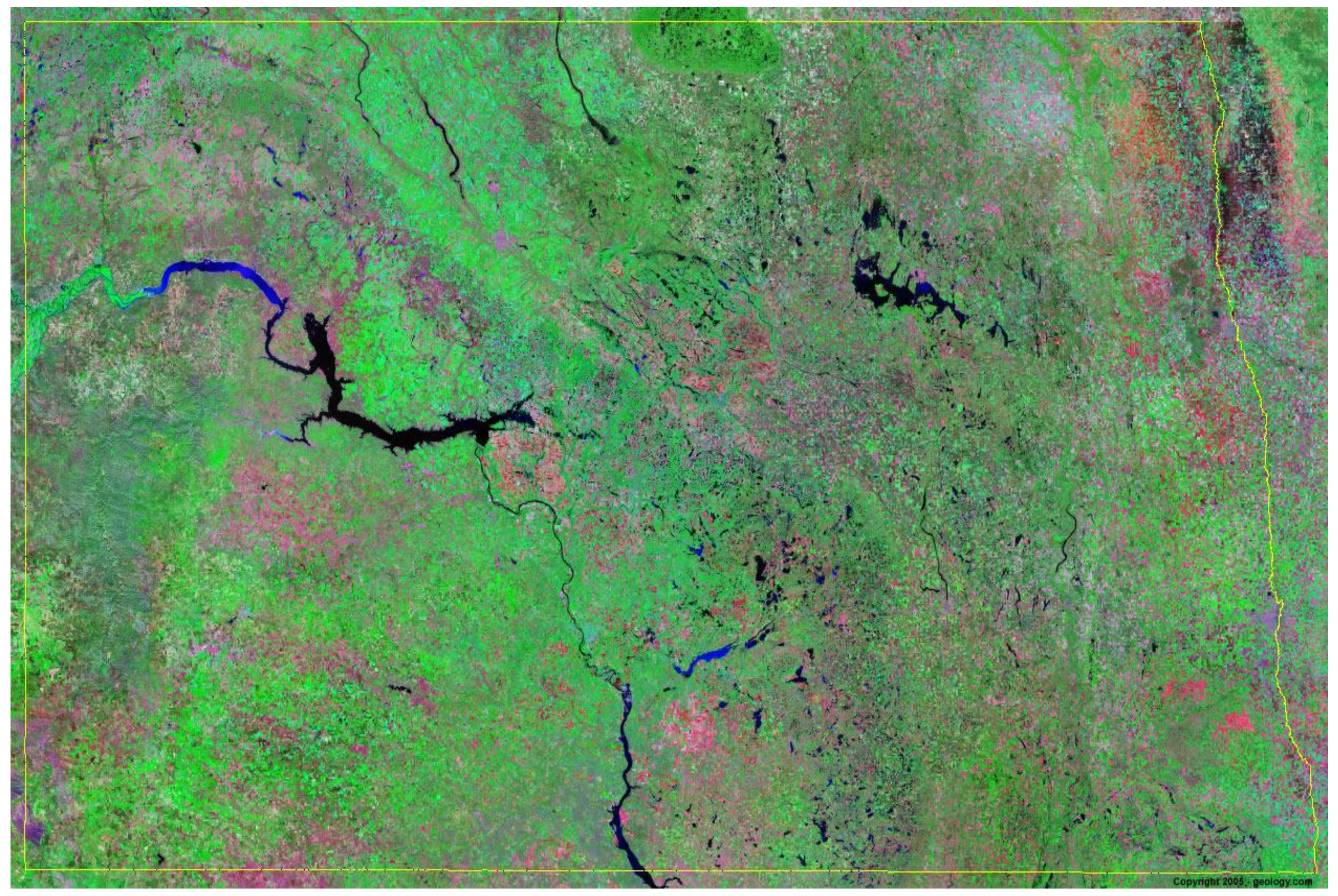

Fig.1- Satellite Image of North Dakota (http://geology.com/satellite/north-dakota-satellite-image.shtml)

Approach

❑Daily measurements of surface SM and SWE were obtained via AMSR-E. The spatial data are projected in global cylindrical 25 km Equal-Area Scalable Earth Grid (EASE-Grid).

❑SM values (g cm-3) show a vertical depth of 1 cm in the top of the soil. In the places with high dense vegetation, measurements of SM are less accurate.

❑All data was downloaded in HDF-EOS format and converted to ASCII files, using MATLAB.

❑The real SWE values (mm) are scaled down by a factor of 2 in order to store them in a HDF-EOS file with a stored data range of 0-240. Hence they were multiplied by a factor of 2 after converting to ASCII files. Values outside this range represent incorrect data, ice sheet or water. These values removed for the analysis.

❑In comparison between SWE (from AMSR-E) with SC (from MODIS), the monthly data are used. The MODIS spatial data resolution is 0.05   by 0.05 .

❑In order to analyze the trend in SWE and SM content of the area, the whole region is divided into four equal size sub-regions (Fig.2 and 3). The graphs represent the 95% confidence bound of the daily values during the 2001-2010 (2009 for December) time period.

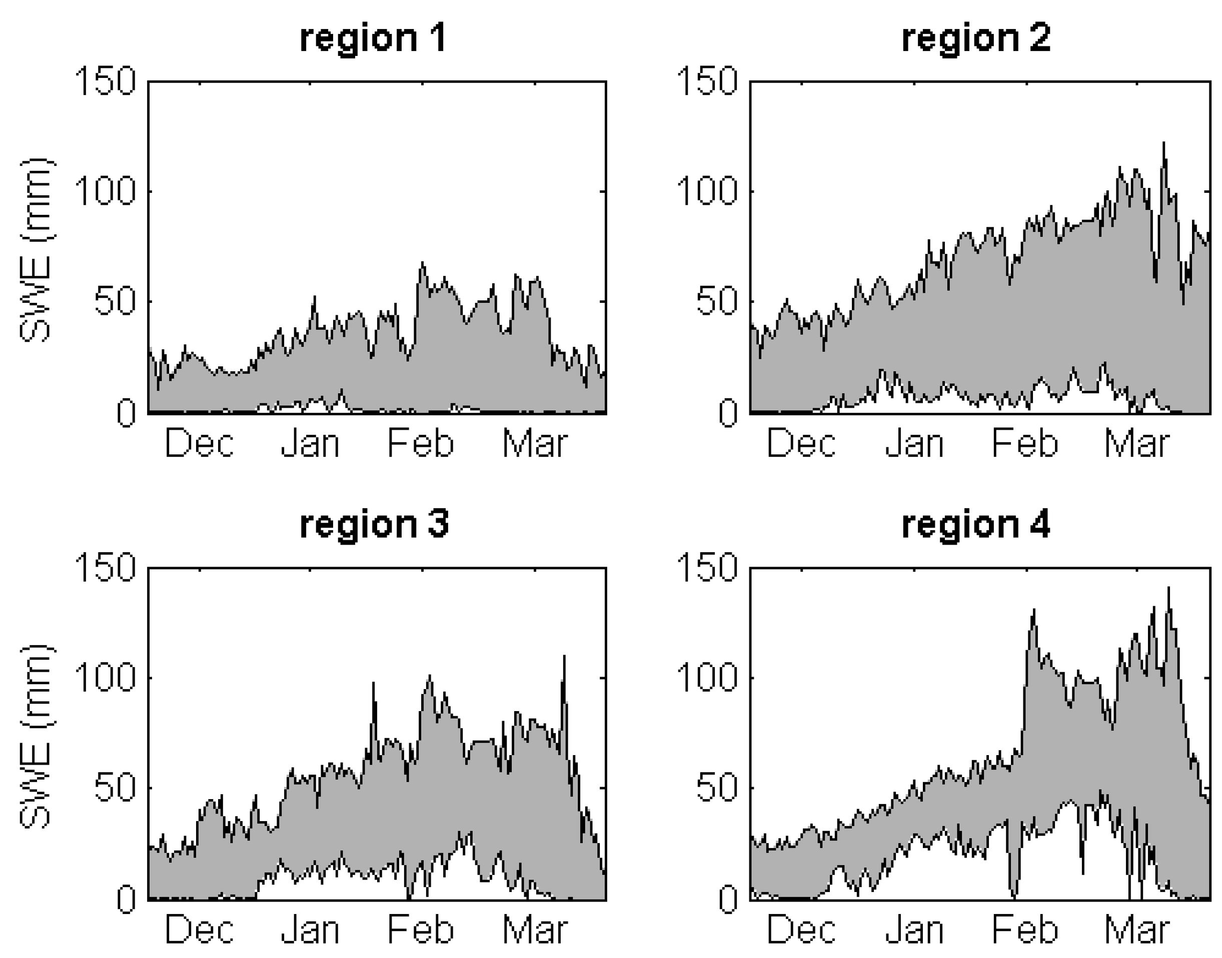

Fig.2- Trend of Snow Water Equivalent in the 4 regions

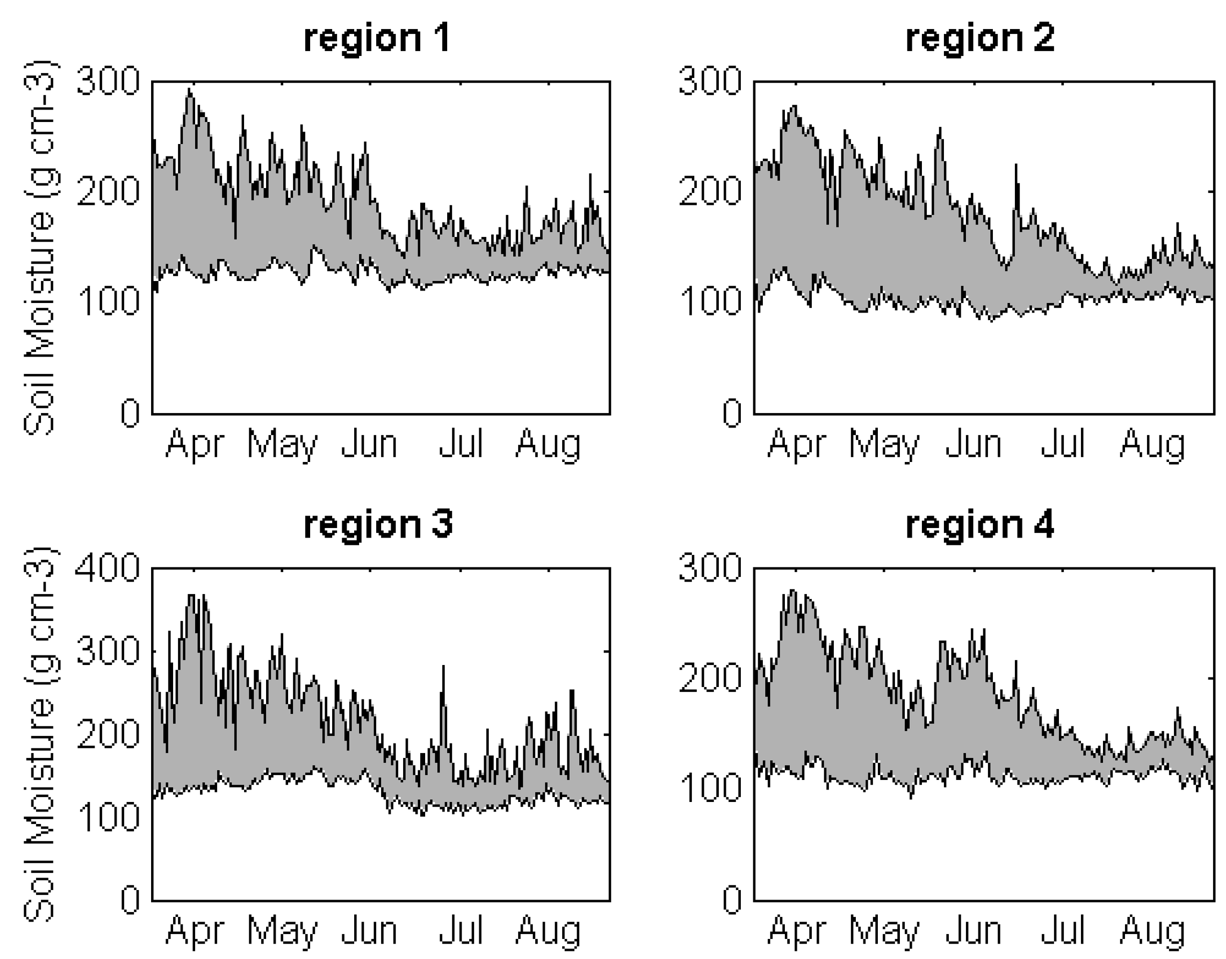

Fig.3- Trend of Soil Moisture in the 4 regions

❑The comparison of the SC and SWE data considers the average values over the whole region (Fig.4). Each point in the figure represents one month (Dec, Jan, Feb, Mar) of each year.

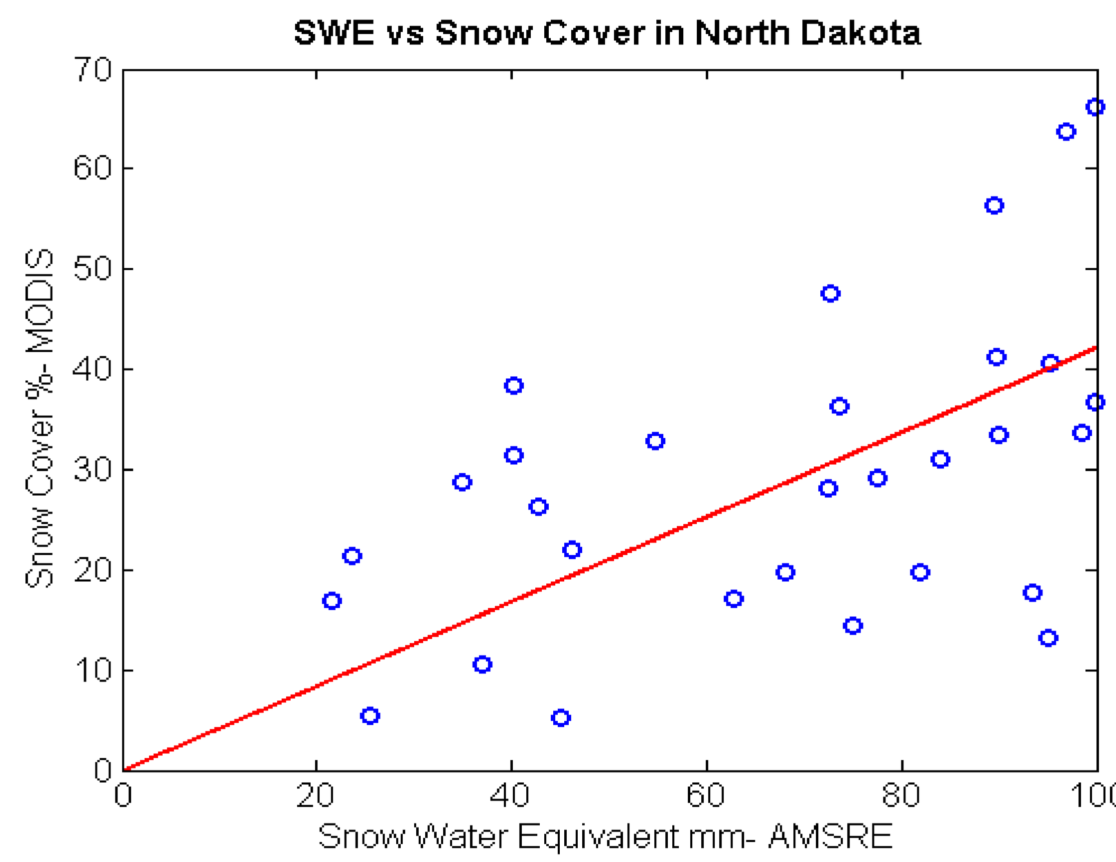

Fig.4- Comparison of the Snow Water Equivalent (AMSRE) with Snow cover (MODIS) over the whole region

Discussion

❑ The Snow Water Equivalent variation in winter months for the years of 2001-2010 over the four regions show that the maximum SWE occurs in the early days of March.

❑In the SWE plots higher annual variations are seen during February-March compared to the other months.

❑The Soil Moisture data variation is lowered in the late months of the summer.

❑There is a significant relationship between SWE and the Snow cover with a correlation of 0.5 using the spearman non-parametric regression method.

References

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