

ASSESSING LAND SURFACE DYNAMICS ACROSS THE NEBRASKA SAND HILLS USING ADVANCED MICROWAVE SCANNING RADIOMETER (AMSR-E) DATA PRODUCTS



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ABSTRACT

The Nebraska Sand Hills is the largest sand dune area in the Western hemisphere and one of the largest grass-stabilized dune regions in the world. It had been suggested that the Sand Hills dunes were active as recently as 900 years ago. To understand the persistence of dune stability, it is important to investigate land surface linkages with the hydrometeorological and biogeophysical processes. Synoptic views of surficial soil moisture and vegetation water content at 25 km spatial resolution have recently become available as standard data products from the multifrequency Advanced Microwave Scanning Radiometer (AMSR-E) on Aqua. In this poster we illustrate the diel, seasonal, and interannual patterns in AMSR-E vegetation water content product using data from 2003 and 2004. Using 14-day maximum AVHRR NDVI composites to capture land surface phenology, we found a strong spatio-temporal correspondence between the vegetation water content product and NDVI.

INTRODUCTION

Within the framework of the NSF-sponsored Sand Hills Biocomplexity Project (<http://sandhills-biocomplexity.unl.edu>), we are investigating the persistence of dune stability from the perspective of land surface linkages between hydrometeorological and biogeophysical processes.

Recently, retrievals for surficial (<5 cm) soil moisture and vegetation water content at 25 km spatial resolution became available as standard data products from the Advanced Microwave Scanning Radiometer (AMSR-E) on the Aqua orbital platform (Njoku et al., 2003; Njoku, 2004). AMSR-E, like other passive microwave radiometers, offers synoptic views of "cool" earthlight, the terrestrial radiation emitted at longer wavelengths (0.34 - 4.3 cm). The sensitivity of the microwaves bands on AMSR-E to the moisture content of vegetation and soil has been amply demonstrated (Wang, 1992; Wang and Choudhury, 1995; Njoku and Li, 1999; Du et al., 2000; Galantowicz et al., 2000).

We focus on the spatio-temporal characteristics of one AMSR-E standard data product - vegetation water content, also sometimes called "vegetation wetness" (Figure 1). This is defined as the water content in the vertical column averaged over the retrieval footprint (Njoku, 1999). Using the data from the 2003 and 2004 growing season, we seek to improve our understanding of the spatio-temporal trends of this retrieved biogeophysical variable within the Sand Hills of Nebraska.

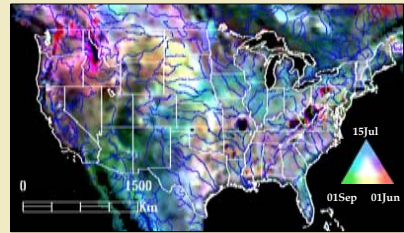


Figure 1. Multitdate composite of vegetation wetness product (ascending mode) in 2004. Red = 01JUN, Green = 15JUL, Blue = 01SEP.

OBJECTIVE

To identify correspondence between the AMSR-E vegetation wetness data product and other hydrometeorological and biogeophysical variables. Of particular interest is the correspondence with land surface phenology as indicated by AVHRR Normalized Difference Vegetation Index (NDVI) data.

STUDY AREA

The Nebraska Sand Hills with the extent of more than 50 000 km², served as study area (Figure 2). The whole ecoregion is represented by approximately 80 AMSR-E pixels (each pixel nominally covers 625 km²). Meteorological data were obtained from 28 stations in the National Weather Service cooperative observer network; specifically, we used the minimum and maximum daily temperature and the daily precipitation. These 28 stations were distributed across 27 separate AMSR-E pixels, which served as the focal sites for study.

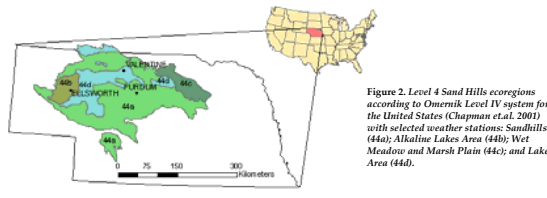


Figure 2. Level 4 Sand Hills ecoregions according to Omernik Level IV system for the United States (Chapman et al., 2003) with selected weather stations: Sandhills (44a); Alkaline Lakes Area (44b); Wet Meadow and Marsh Plain (44c); and Lakes Area (44d).

METHODS

DATA SOURCE

The AMSR-E L3 land products are distributed through the National Snow and Ice Data Center (NSIDC; http://www.nsidc.org/data/ae_land3.html). We restrict our attention to the vegetation water content product. This provides seasonal patterns that can be linked to high spatial resolution imagery, e.g., MODIS and AVHRR.

Smoothed 14-day maximum AVHRR NDVI composites for 2003 and 2004 provided the seasonal phenological trend (B. Reed, USGS).

Meteorological data were gathered through the National Weather Service Cooperative Observer Network and provided by the High Plains Regional Climate Center (<http://www.hprcc.unl.edu/coop/home.html>).

DATA PROCESSING

AVHRR and AMSR-E data products were coregistered to a Lambert azimuthal equal area (LAZEA) projection. Meteorological data from 28 weather stations were downloaded and accumulated growing-degree-days (AGDD) were computed using the minimum and maximum daily temperature values and a base of 0 °C.

Vegetation water content data from both pre-dawn and afternoon acquisitions from years 2003 and 2004 were plotted against the previously computed AGDD. This method has been successfully used in modeling land surface phenology in other grassland biomes (de Beurs and Henebry, 2004, 2005).

The 625 km² polygons of each of the studied AMSR-E pixels were overlaid over the AVHRR data and averaged NDVI values within this extent were retrieved. These were displayed together with the vegetation wetness product. Temporal trends in vegetation wetness product and similarities in AMSR-E and AVHRR were investigated.

RESULTS AND DISCUSSION I

Differences in the seasonal pattern of precipitation between 2003 and 2004 translated into differences in land surface phenology as seen by AVHRR and AMSR-E (Figure 4). In 2003 drought occurred across the Sand Hills with precipitation ceasing around 1400 °C, despite ample early season precipitation (Figure 3). In contrast, the onset of the growing season dry spell in 2004 occurred later and lasted for fewer GDD than in 2003 (Figure 3). The difference in phenological pattern is striking (Figure 4): in 2003, a rapid increase until AGDD equals 1400 and an immediate decrease; whereas, in 2004 smooth parabolic behavior.

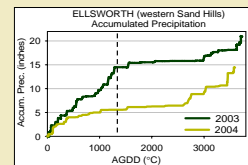


Figure 3. Precipitation-temperature accumulation curves at Ellsworth in 2003 and 2004 plotted against Accumulated Growing Degree Days (AGDD).

The pre-dawn and afternoon acquisitions of AMSR-E data products enable a study of the diel changes in the canopy water content. At the beginning of the growing season when soil moisture does not limit evapotranspiration, the afternoon acquisitions exhibit higher vegetation water content than pre-dawn. Once soil moisture becomes limiting to a mature canopy later in the season, pre-dawn is higher than afternoon.

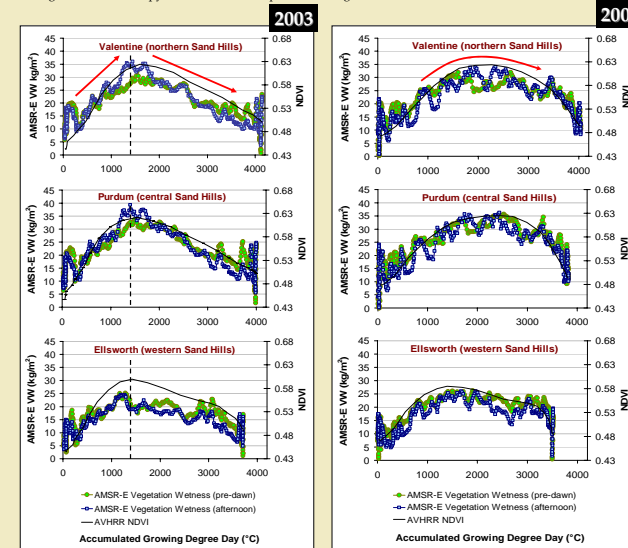


Figure 4. AMSR-E vegetation wetness for descending (pre-dawn) and ascending (afternoon) modes (seven-day moving window sum) and the smoothed AVHRR NDVI time series in 2003 (left) and 2004 (right).

RESULTS AND DISCUSSION II

The spatial trends in both datasets - AVHRR NDVI and AMSR-E vegetation water content (ascending mode) - provided high correlation in both 2003 and 2004. The highest values of NDVI and water content were retrieved over the central and south-central Sand Hills (NDVI of 0.63, AMSR-E 500 g/m²). The southwest and west Sand Hills presented lower values with NDVI < 0.6 and vegetation water content < than 350 g/m². Very low values were found in the north (Lakes Area ecoregion, see Figure 2) on the border with South Dakota.



Figure 5. Multitdate composite of vegetation water content (ascending mode) in 2003. Red = 24Jun, Green = 24Jun, Blue = 06Jul. Overlays: Omernik level IV ecoregion of Sand Hills.

The differences in land surface phenologies are displayed as a multitdate composite in Figure 5 using three dates at the peak of the growing season. Bright cyan hues in central and eastern Sand Hills represent areas with a higher response on all three dates. Darker colors in the west, southwest and north represent areas with lower vegetation water content.

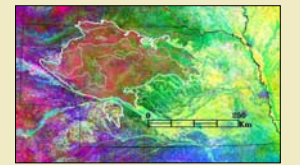


Figure 6. Principal Components Analysis of AVHRR NDVI in 2003 (May-September). Red = PC2, Green = PC1, Blue = PC3. Overlays: Omernik level IV ecoregion of Sand Hills.

The typical land surface phenologies of Sand Hills enable this region to be distinguished from adjacent ecoregions using both data products: AMSR-E vegetation wetness product (Figure 5) and AVHRR NDVI (Figure 6).

CONCLUSION

- We analyzed the AMSR-E vegetation water content product across the Nebraska Sand Hills ecoregion for 2003 and 2004.
- By description of diel, seasonal, and interannual patterns of this product, we were able to characterize the phenology of land surface vegetation.
- We found a strong correspondence between the temporal evolution of daily vegetation water content retrievals and the land surface phenology captured by biweekly composites of AVHRR NDVI.

While these findings are preliminary, they suggest that the AMSR-E vegetation water content product can provide a valuable window into the canopy dynamics of grasslands.

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