Temporal analysis of Great Basin using spaceborne microwave backscatter and radiometric temperature observations

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Abstract

The Great basin is a semiarid endorheic watershed covering most of Nevada and parts of neighboring states. Most of precipitation occurs in the form of snow and this limited resource is fully or over allocated. Due to over exploitation of water resources and periodic droughts, this basin is an endangered ecosystem with decreased biodiversity and various species at risk of extinction (Lahontan cutthroat trout). Great Basin has undergone a region-wide increase in temperature and reduction in snowpack over last 50 years. Due to the ecological and social significance of this basin, it is important to understand its large-scale artificially and naturally induced landcover changes.

In this research, we use multiple spaceborne microwave instruments to analyze the regional scale temporal change in the Great Basin. Backscatter measurements from Ku-band Seasat A Satellite scatterometer (1978), NASA scatterometer (1996-1997), and Seawinds scatterometer (1999-2009); and C-band European Remote Sensing scatterometer (1992–2001) are used for change detection. Ku-band is used to identify key changes over last three decades. C- and Ku-band backscatter temporal variations are linked to landcover (vegetation) and water content (canopy and soil moisture) change. Temporal changes in the thermal characteristics over the last decade are observed using multi-frequency Advanced Microwave Scanning Radiometer (2002–2009) brightness temperature measurements. The expansion of population has resulted in changes linked to the large scale vegetation type conversion and degradation of ecosystems. This research provides preliminary analysis of multisensor microwave observations of the Great Basin.

Introduction

Great Basin is a semiarid watershed covering most of Nevada and Utah. It is the largest contiguous watershed of North America which does not drain into ocean, thus water in Great Basin evaporates or infiltrates. Significant area of the Great Basin is covered with bare ground and shrublands (see Fig 1). Most of these areas correspond to the low elevation areas of the basin (less than 2000 meter). The higher elevation areas are covered by relatively denser vegetation e.g., woodland and forest.

We use multiple spaceborne microwave instruments to analyze the regional scale temporal change in the Great Basin. Backscatter measurements from Seasat A Satellite scatterometer (SASS) (*Kennett and Li, 1989*), NASA scatterometer (NSCAT) (*Naderi et al., 1992*), and Seawinds scatterometer (QSCAT) (*Spencer et al., 1997*); and C-band European Remote Sensing scatterometer (ESCAT) (*Attema, 1991*); and brightness temperature from Advanced Microwave Scanning Radiometer (AMSRE) are used for change detection.

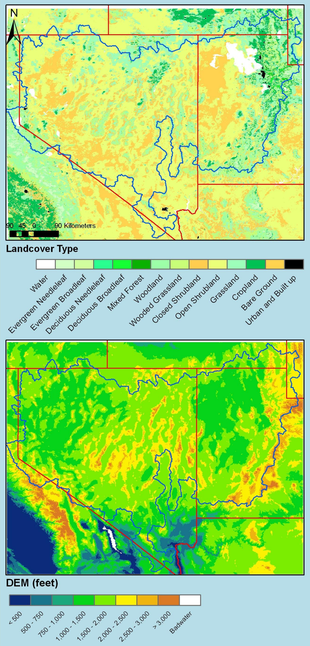

Fig 1. Landcover (top) and Digital elevation (bottom) maps showing boundaries of states and Great Basin.

C-band Time Series

In order to understand the temporal variation of the surface backscatter, ESCAT data is plotted for three landcover types in Fig 2. Backscatter is normalized to 40° incidence angle (*Long and Hardin 1994*). In general, the backscatter is higher at greater vegetation densities. The variations in time series of the backscatter depend upon the surface dielectric and roughness characteristics. The dielectric characteristics are governed by the moisture content and show greater response in backscatter over areas of low vegetation density; whereas, the surface roughness is governed by soil relief and landcover characteristics (*Woodhouse and Hoekman, 2000*). Variations in the vegetation density (autumn vs. spring) and changes in the moisture content during rain events are the primary source of changes in backscatter.

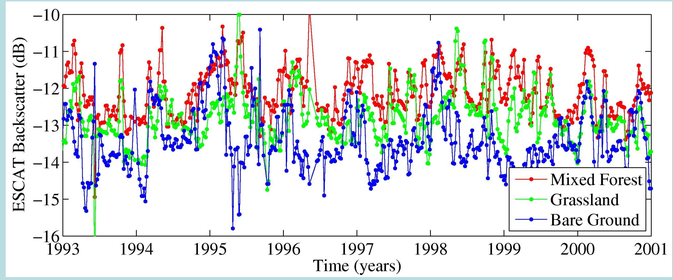

Fig 2. ERS Scatterometer backscatter time series from 1993 to 2001.

Temporal Analysis of Ku-band Images

Ku-band backscatter time series is created using SASS, NSCAT, QSCAT data (see Fig 3). Since SASS and NSCAT observations are made at multiple incidence angles, backscatter for these instruments is normalized to 40° incidence angle (*Long and Hardin, 1994*). QSCAT is a pencil beam scatterometer and provides backscatter measurements at 54° incidence angle. This is the reason the overall tone of QSCAT image is darker than SASS and NSCAT images. Nevertheless, the images represent same time of the year during 1978 (SASS), 1996 (NSCAT), and 2008 (QSCAT). In all the images, a general effect of topography is noted, i.e., backscatter spatial variation is coherent to the surface profile observed in the digital elevation model data (Fig 1). The dark area in the Northeast with low backscatter values corresponds to Great Salt Lake, whereas, relatively higher backscatter in the South is from higher large scale surface roughness.

Although the three images show similar features, distributed changes in the form of these features are observed. Such changes are primarily caused due to shifts in the vegetation communities .

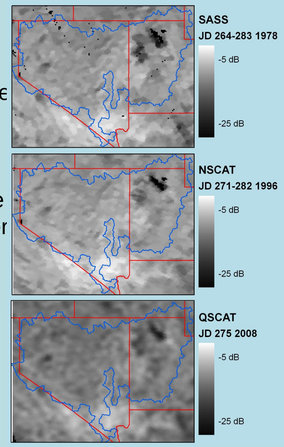

Fig 3. Ku-band backscatter image time series from SASS, NSCAT, and QSCAT.

Radiometric Temperature Time Series

Radiometric temperature (T_b) of the surface depends upon the physical temperature and emissivity. Emissivity depends upon the surface material and its moisture content. Fig 4 shows a plot of T_b for the three landcover types. The changes in the annual cycle can be observed that are linked to the interannual changes in surface moisture content.

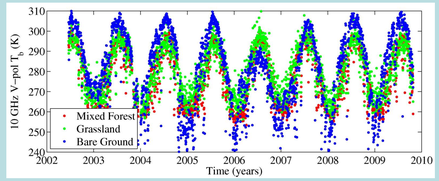

Fig 4. Radiometric temperature (T_b) time series.

Conclusions

Great basin represents an area that is susceptible to be impacted by the climate change. This impact would most likely manifest as shifts in the vegetation communities and changes in the their densities. The temporal variations of backscatter and radiometric temperature are linked to the surface changes that can be used to understand the climate change impact in the Great basin.

References

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