University of Utah
UNDERGRADUATE RESEARCH JOURNAL

ASSESSING SNOW DEPTH FROM PASSIVE MICROWAVE

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Introduction

Water is one of the most precious natural resources on Earth. Global climate changes to the Earth system are altering the distribution of water resources in part through the rapid melting of snow and glaciers, which act as fresh water reserves. “One-sixth of Earth’s population depends on snow- or glacier- melt for water resources, and people in these areas generate one-fourth of the global domestic product” (Barnett et al., 2005). For example, downstream of the Himalayas there are 1.3 billion people, many who depend on the water reserves held in the Himalayan snowpack and glacial ice. Although there is a general understanding of how much water come from snow in these regions, there is limited knowledge regarding snow cover dynamics and snowmelt timing. This region of the world has limited infrastructure, which can buffer the water supply, and therefore is more susceptible to climate change. To prepare for the foreseeable changes an adequate assessment of downstream water resources is needed to support the managerial decision-making process from local to regional scales.

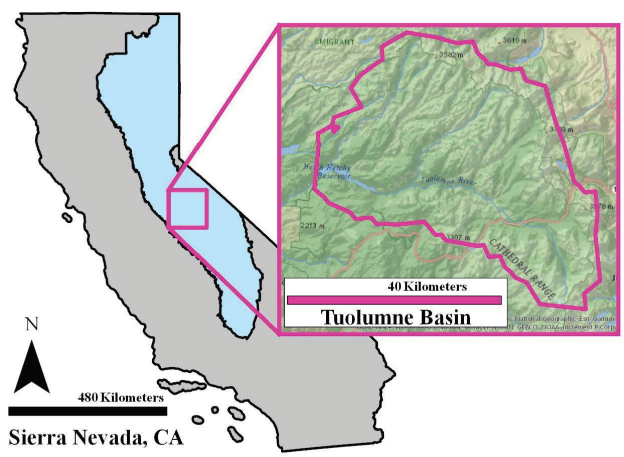

Figure 1: Insert Map

Being able to use satellite imagery is the most plausible method for quantifying the water resources in the Himalayas, especially for snow water resources, because snowfall tends to be concentrated the greatest in regions where direct observations are logistically unrealistic (ICIMOD et al, 2016). Remote sensing technology and tools are advancing, and the information acquired could better prepare resource managers for variability and long terms changes associated with climate change in a highly susceptible region of the world. This project contributes to a NASA SERVIR project (https://www.nasa.gov/mission_pages/servir/himalaya.html), a capacity building effort between NASA and USAID, that transfers remote sensing knowledge to regional stakeholders. The project is developing remote sensing tools to improve water management south of the Himalayas, and one of the final aims of the project is to provide more accurate estimates of the contribution of snow water melt to total runoff over time, and the likely impacts of climate change on this value.

This research contributes to the broader project goals by carrying out a validation of spaceborne snow remote sensing products, over a study region within the Sierra Nevada mountains, to determine their validity for potential future usage in the Himalayas. This region has more observations than the Himalaya, and my project will focus on a comparison between known snow depth values derived from the high-resolution Airborne Snow Observatory (ASO) to the newly developed spaceborne Advanced Microwave Scanning Radiometer (AMSR2) over the study region of Tuolumne basin, California (Figure 1).

Methods

Spaceborne Advanced Microwave Scanning Radiometer, a passive method based on emission of microwaves from the earth, and the Airborne Snow Observatory, which uses lidar to take the difference in snow free and snow on surface elevations, are two ways to map snow depth values. Passive microwave is very coarse spatial resolution, 25 km, whereas lidar is very high resolution, 3m. To address the limitations of the coarse resolution in mountainous terrain we downscaled the AMRS2 data to 500 m using snow covered area from the Moderate Resolution Imaging Spectrometer (MODIS). To facilitate comparison, we upscaled the ASO data to the same 500m resolution. By comparing the more accurate values of ASO to the unknown validity of AMSR2, a metric of accuracy is derived. This determines whether downscaled AMSR2 values are viable for future usage in water resource management. Much of the work conducted resided in the acquisition and processing of the AMSR2 data. Given that the data are only available through an FTP server and the information being accessed needed to overlap with the days that ASO had flown over the study region, it required to download, query, convert and visually analyze the ASMR2 raster data (± 50GB) in order to prep the data for a difference calculation (Figure 2). Once the raster data corelated to the same day, resampled to the same spatial resolution, and encompassed the same areal coverage a difference calculation was conducted to determine the difference in accuracy between ASO and AMSR2 values.

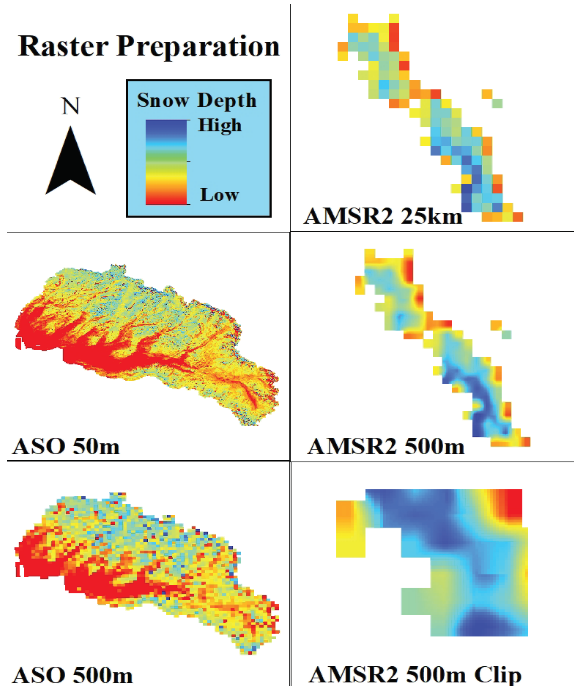

Figure 2: Raster Preparation

Results

The flight days for ASO exist across a series of days ranging from 2016-2018, and difference maps were created based on the availability of data with corresponding days of ASO and AMSR2 data (Figure 3). This resulted in the opportunity to analyze snow depth for only seven days, due to the time of year ASO gathered data and inability of AMSR2 to image low snow-covered area. The reported AMSR2 mean snow depth is off by a magnitude of two or even three times the ASO mean recorded snow depths (Figure 4). Thus, it has been determined that AMSR2 snow depth values are unfeasible for future use in quantifying snow depth over mountainous terrain, given its lack of available data, coarse resolution, and inconsistent magnitudes of error. Additional advancements to spaceborne remote sensing of snow, that do not rely on passive microwave, are recommended in order to be used in snow water estimations.

Difference Between AMSR2 and ASO

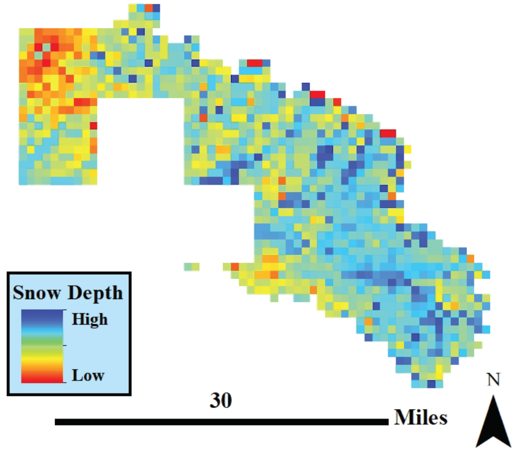

Figure 3: Difference Map

Snow Depth Statistics Comparitive								
AMSR2_2016_[cm]				ASO_2016_[cm]				Difference of Means_[cm]
Date	Mean	Median	StdDev.	Date	Mean	Median	StDev.	AMSR2-ASO
26-Mar	289.23	312.26	78.63	26-Mar	153.36	157.31	108.22	135.87
1-Apr	421.61	440	125.68	1-Apr	144.07	145.27	105.82	277.54
7-Apr	334.38	329	59.46	7-Apr	116.24	112.75	100	218.14
16-Apr	659.1	693	202.91	16-Apr	107.32	100.93	97.53	551.78
26-Apr	429.67	437	72.08	26-Apr	99.96	83.84	97.29	329.71
9-May	296.01	326	95.69	9-May	90.67	65.6	96.41	205.34
27-May	569.5	569.5	8.52	27-May	63.62	26.95	85.45	505.88

Figure 4: Statistical Comparative

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