Application of Satellite Remote Sensing for Mapping and Monitoring of Saline Dust Emission Sources in the Urmia Lake Watershed in Iran

Mohaddese Effati[1,2], Hossien-Ali Bahrami[1], Ebrahim Babaeian[2], and Markus Tuller[2]

[1] Tarbiat Modares University, Department of Soil Science, Tehran, IR

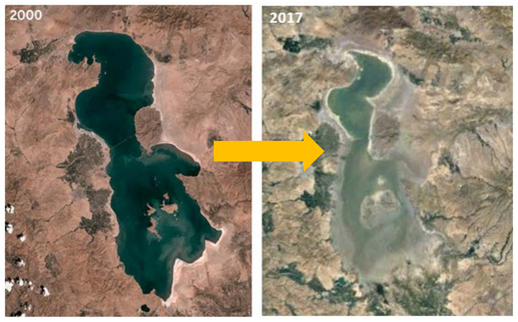
[2] University of Arizona, Department of Soil, Water and Environmental Science, Tucson, AZ, USA

Introduction

- Saline playas in arid and semiarid regions of the world are significant sources of unconsolidated sediments susceptible to aeolian transport. Urmia Lake in Iran, one of the largest saltwater lakes on Earth, has waned to approximately 50% of its original size due to groundwater pumping and surface water diversions. This has led to ecosystem degradation, accelerated desertification and frequent dust storms, causing respiratory diseases and other health problems.
- The presented study aims to identify and map potential dust source locations in the Urmia Lake region by means of satellite remote sensing and laboratory spectroradiometer measurements. The relationships between remotely sensed land surface properties such as soil moisture, soil texture, and dust events pre- and post-dating playa development are explored to inform possible remediation measures and to potentially develop an early dust storm warning system to assist people with respiratory illnesses.

Study Area and Soil Surface Property Measurements

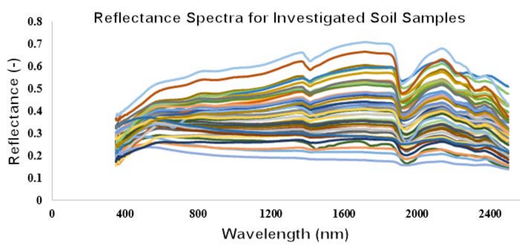
- Lake Urmia, a UNESCO Biosphere Reserve, is located in Northwestern Iran (N: 36˚.45′ to 38˚.20′ E: 44˚.50′ to 46˚.10′) at an altitude of about 1250 m. Its salt concentration ranges from 185 to 220 g L^{-1}, and the average precipitation of the region is about 25 cm yr^{-1}. Due to groundwater pumping and surface water diversions the water level significantly decreased over the last decades, creating large salt flats.

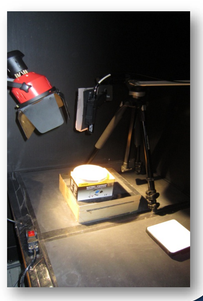


- A total of 45 surface soil samples (0-10 cm depth) were collected from the salt flats, and standard laboratory methods were applied to determine basic soil properties such as texture, organic matter content (SOM), electrical conductivity, calcium carbonate content, and pH.

Sample Set (n=45)				
	Min	Max	Mean	St.dev
$CaCO_3$ (%)	16	56.25	50.18	9.92
SOM (%)	0.18	3.90	0.592	0.670
EC(dS m^{-1})	0.205	2.10	1.05	0.453
pH	7.60	9.26	8.51	0.350
Sand (%)	11	85	75.28	19.63
Silt (%)	3	58	11.95	11.72
Clay (%)	4	30	12.08	7.05

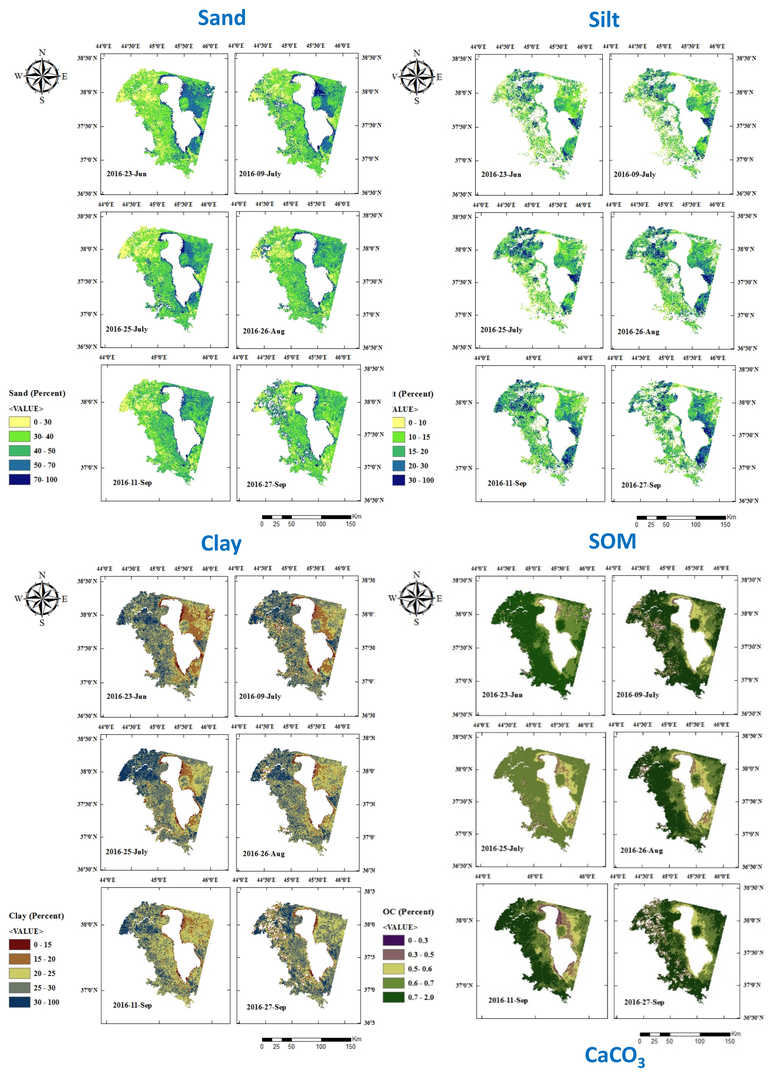
- Spectral reflectance for the SWIR electromagnetic range (i.e., 350-2500 nm) was measured for each air-dry sample with a FieldSpec®3 spectroradiometer (ASD Inc., Longmont, CO, USA). Regression analysis was performed to relate spectral reflectance corresponding to selected Landsat-8 bands to basic soil properties. Because the correlation between reflectance and EC and pH were weak, they were excluded from further analysis.



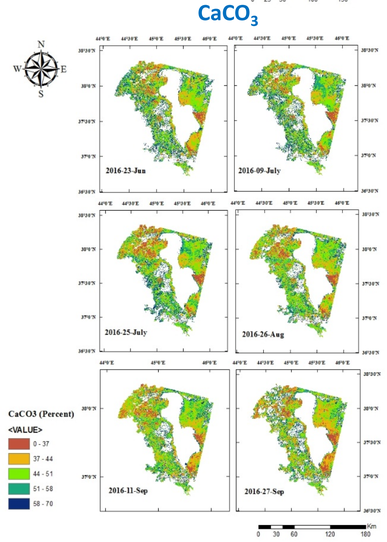


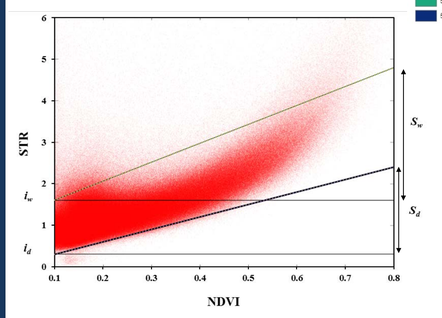
Preliminary Results

- Selected Landsat-8 bands were applied in conjunction with the regression equations developed based on laboratory measurements to generate surface property maps for clay and sand (bands 4 and 7), silt and $CaCO_3$ (bands 5 and 7), and SOM content (bands 1 and 2) for the Urmia Lake region.



- Surface soil moisture maps were generated with a new physical optical trapezoid model (OPTRAM) proposed in Sadeghi et al. (2017). OPTRAM relies on shortwave infrared reflectance data and is based on the pixel distribution within the Normalized Difference Vegetation Index (NDVI)-SWIR transformed reflectance (STR) space. MODIS satellite time series data from 2015 to 2017 were used to determine the NDVI-STR space depicted in the figure below.





Pixel distributions within the NDVI-STR (OPTRAM) space for all considered MODIS images. The top and bottom lines mark the wet and dry edges, respectively.

$$W = \frac{i_d + s_d NDVI - STR}{i_d - i_w + (s_d - s_w) NDVI}$$

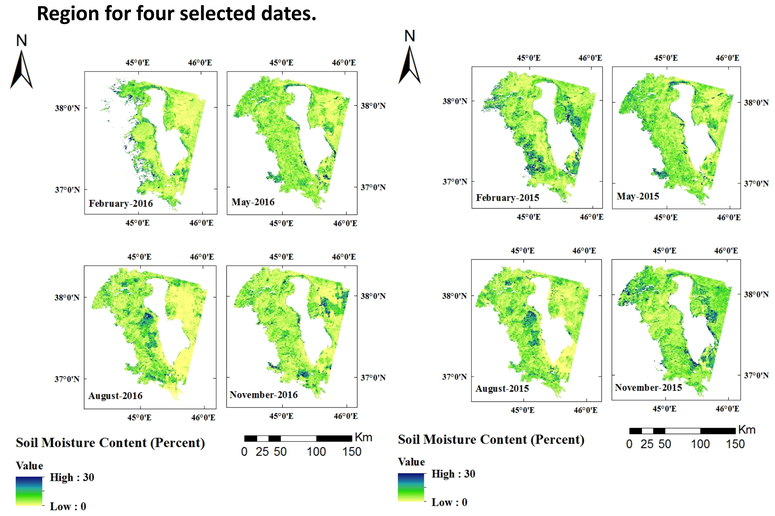
$$STR = \frac{(1 - R_{SWIR})^2}{2R_{SWIR}}$$

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

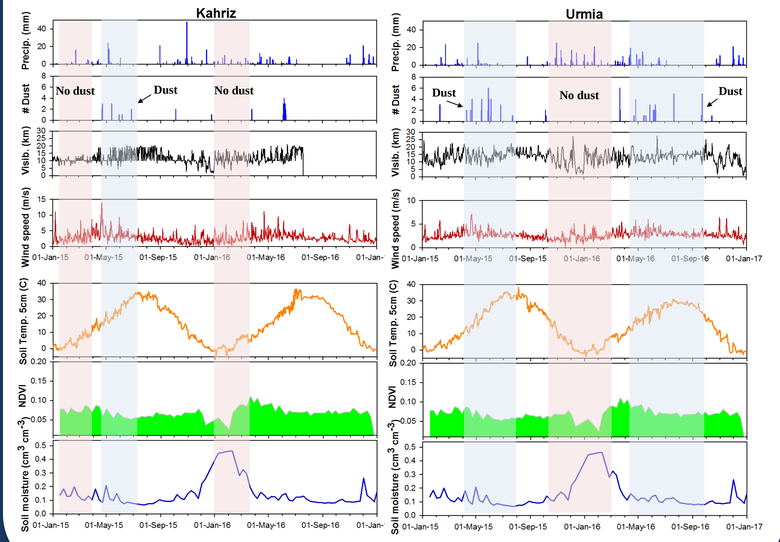
R_{SWIR} and R_{NIR}, R_{Red} are the spectral reflectance in shortwave infrared, near-infrared and red spectral regions

Preliminary Results - Continued

- Surface soil moisture maps generated with OPTRAM for the Urmia Lake Region for four selected dates.



- Meteorological data (2015-2016) including precipitation, wind speed, dust frequency, visibility and soil temperature from two weather stations located in close vicinity of the study area.



Preliminary Findings and Ongoing Research

- Most of the dust emissions occur when both the volumetric surface moisture content and NDVI are below 0.1.
- Atmospheric conditions exhibiting high wind velocities during times of dry land surfaces obviously promote dust generation. However, these complex interrelations need to be interpreted in conjunction with plant cover and surface topology, which is part of ongoing research.
- Further investigations are also needed to localize areas that are highly susceptible to wind erosion in the Urmia Lake region based on land surface topology, potential for salt crust formation, and basic soil properties.

References

Sadeghi, M., E. Babaeian, M. Tuller, and S.B. Jones, 2017. The optical trapezoid model: A novel approach to remote sensing of soil moisture applied to Sentinel-2 and Landsat-8 observations. Remote Sensing of Environment, 198:52-68.

Acknowledgements

E. Babaeian and M. Tuller gratefully acknowledge support from the National Science Foundation (NSF) under grant # 1521469.