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Variability of Surface Albedo and Vegetation Cover in Hyrcanian Forests of Iran

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Abstract
Among all land surface processes potentially affected by climate warming, vegetation greenness which influences the surface energy balance, is one of the most critical issues. The present study examines the relationship between changes in vegetation cover and changes in surface albedo. Using MODIS imagery, mean annual albedo variations (during the growth season) and their relation with the changes in NDVI values in 6 climate zones (located at the North of Iran) were analyzed in a 13-year period (2004–2016). Hot spots for temperature were obtained using the information of 17 weather stations and compared with the changes in albedo. According to the results, surface albedo increased during the study period in all climates, except for the sub-humid sites (SH-C-VW). Generally, increase in surface albedo observed in majority of the study area, while decrease in albedo was detected and no significant change in the remaining areas.
Key words: Surface albedo, NDVI, MODIS.

1. Introduction
Change in vegetation cover could significantly alter the surface albedo which in turn affects the global energy balance and the albedo feedback that influence climate change. Land surface albedo, the fraction of solar energy (shortwave radiation) that reflected from the Earth back into space, describes the Earth's radiation energy budget and the exchange of radiation energy between the atmosphere and the land surface. Land surface albedo plays a crucial role in land surface climate and biosphere models as a key climate deriving variable [1]. The range of typical surface albedo is from as high as 0.8 over a pure snow-covered areas to as low as 0.1 over vegetation during the snow-free period [2]. Vegetation builds an important feature of environmental analysis due to its responses to environmental conditions. The NDVI (Normalized Difference Vegetation Index) is known as the most used vegetation index worldwide. The range of NDVI values are between -1 to 1, and generally higher NDVI values mean more green vegetation. The purpose of the present study is to investigate the effect of vegetation change on albedo variations over a 13-year period during plant season with regard to different agricultural climates in the North of Iran by using NDVI index. Additionally, the spatial relationships between NDVI-rainfall and temperature were investigated. The achievements of this study could be useful in land management and land use for farmers, gardeners and foresters.

2. Material and Methods

2.1. Study Area
Study area, north of Iran, is located in southern shorelines of Caspian Sea between 36° 36' to 38° 36'N to 48° 25' to 50° 20'E with an area of 60711 km^2. The area has various environmental conditions. Proximity with lowlands and plans having the elevation less than zero about sea level along with Alborz mountains resulted to formation of many diversities in climates and vegetation cover include both coniferous plants and Mediterranean plants. The area consisted of a green belt of broad-leaved forests located in north side of Alborz Mountains and southern shorelines of Caspian Sea named as Hyrcanian forests. The forests consisted of 80 tree species, 50 shrub species and hundreds of annual and perennial grass species. The west part of the area has semi-tropical and humid climate which has the most of heavy precipitations in the country by 1900 mm annual precipitation in north-west coasts and by 1400mm in west highlands. Toward central parts, the precipitation rate decreases and the climate being drier so that the central part has annual precipitation by 690 mm and 515mm in the Eastern parts. The highest precipitation occurs in autumn and winter and the lowest is in spring. Temperature distribution is so that mean annual temperature increase from west to east. Mean annual temperature in western, central and eastern parts equal to 15.8, 16.7 and 17.8°C.

2.2 Data
In order to characterize the regional patterns of albedo changes, we used the MODIS MCD43A3 albedo product (Collection 5), which derives from the daily surface reflectance product (MOD09 series), corrected for atmospheric

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molecular scattering, ozone absorption, and aerosols [3]. The MCD43A3 product a data for each 16 days obtains from combining reflectance data from Terra and Aqua satellites [4]. In this study we used black-sky shortwave albedo with 500m spatial resolution.
NDVI images derived from the MYD13A1 MODIS products, which consist of temporal integration of 16 days remotely sensed data at 500m spatial resolution. All MODIS data used in the study were downloaded from NASA's Earth Observing System (https://ladsweb.modaps.eosdis.nasa.gov/)
Also, the temperature data were obtained from 17 synoptic stations in the study area.

2.3 Method

The images of the MODIS were received for the years 2004 to 2016 in April, May, June, July, August, September, according to the growing season in the study area. Data from all images were extracted by using MATLAB software.
Using this information, we estimated the mean annual albedo for each growing season (i.e. from April 1 to August 31 of the following year) considering only the pixels with high quality data. In order to quantify temporal changes in albedo, we performed linear regression analysis of the temporal trend of the albedo values for the 13-year period for each individual pixel. Based on the analysis, we generated regional maps for albedo change slope as well as the significance (p-value) of the change. Only those pixels where this change was statistically significant ($p < 0.05$) were considered. For pixels with significant changes in albedo, the NDVI slope change map were also created. Considering to the decreasing rainfall from the west toward the east, and the difference in soil fertility and other factors affecting the agriculture, the area could be classified into 6 notable zones using UNESCO approach (1979), which is one of the methods used in ACZ mapping (The main parameters that used in this method are moisture regime, winter type and summer type) to 6 significant zones which were shown in the Fig. 1-b. Table 1 shows the characteristics of the 6 zones in the study area (UNESCO, 1979).

Table 1: Characteristics of temperature and humidity in different climates based on the UNESCO method (1979) in 6 significant zones in the North of Iran.

Symbol	Moisture regime	Aridity Index	Temperature regime (Winter)	Range-Winter	Temperature regime (Summer)	Range-Summer
A-C-W	Arid	0.03-0.2	Cool	0-10 ° C	Warm	20-30 °C
SA-C-W	Semi-Arid	0.2-0.5	Cool	0-10	Warm	20-30
SH-C-W	Sub-Humid	0.5-0.75	Cool	0-10	Warm	20-30
SH-C-VW	Sub-Humid	0.5-.075	Cool	0-10	Very Warm	>30
H-C-W	Humid	0.75-1	Cool	0-10	Warm	20-30
PH-C-W	Per-Humid	>1	Cool	0-10	Warm	20-30

Considering to the zoning of the area based on the UNESCO method, the pixels that albedo change was significant, were selected in each zone. To characterize the albedo trends in each class, we randomly selected the pixels. The initial number of randomly selected pixels was restricted by a spatial position in which only those pixels that were away at least 1500 m from pixels of a different class were considered.
After the filtering, we had 100 pixels per classification. In order to estimate the proportion of albedo trend, we estimated the amount of random samples for each climate with significant positive, negative and null (not significant) slope of the change albedo vs. time. In the final selected pixels, the albedo charts were plotted based on NDVI, and the correlation coefficients of these parameters (Pearson correlation) were calculated. The 13-year average of each month was calculated for albedo and NDVI. In order to investigate the relationship between the change of the albedo with the temperature variables in the region, information was obtained from the 17 synoptic stations in the area which had the information during the period (Fig. 2).
After data quality control using statistical analysis, gradient of temperature and precipitation were calculated for 17 stations. In the present study, temperature point data were analyzed using Kriging Interpolation (considering the conditions in the present study, the method had the lowest mean squares of error compared to other interpolation methods).

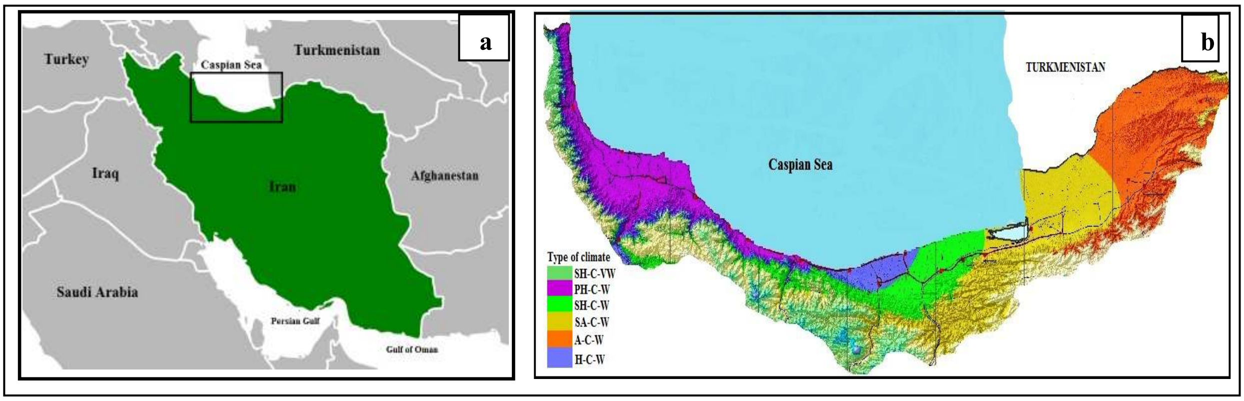


Fig. 1: (a): The study area located in the north of Iran between the Caspian Sea and the Alborz Mountains includes three provinces of Golestan, Gilan and Mazandaran. (b): Climate classification of the studied area based on the UNESCO method (see UNESCO, 1979 for a full list of climates)

Fig. 2: Geographical location of weather stations used for this study in North of Iran.

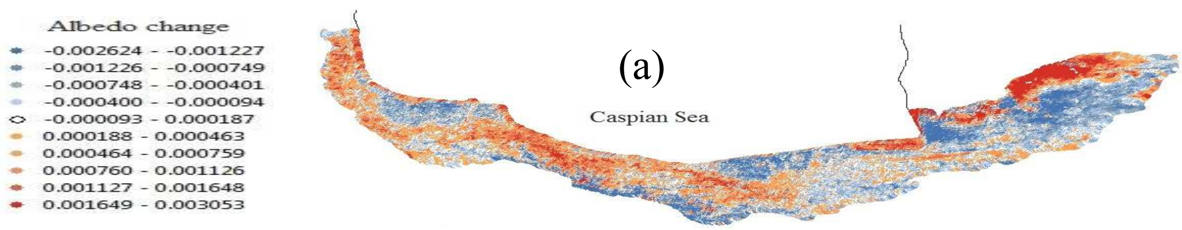
3. Results and Discussion

Significant albedo changes were observed during the 13-year study period in the North of Iran. Increase in Albedo was observed in 61% of the study area, while decreasing in albedo was registered in 30% and Albedo had no change in remaining 9% of the study area. According to the result of this study, it can be said that wet climates have had less albedo changes than dry climates. The lowest variations of albedo are observed in the region with SH-C-VW climate (with an average -0.00019) and the highest in the SA-C-W (with an average -0.01563) climate. However, the slope of albedo change for the whole period is given in Table 2.

Table 2: The slope of albedo's change for the whole period, from April 2004 to August 2016 in random selected pixel.

Type of Climate	A-C-W	SA-C-W	SH-C-W	H-C-W	PH-C-W	SH-C-VW
Slope in albedo	0.005488	0.004456	0.008237	0.015058	0.008887	-0.00005

As shown in Fig.3-a, the areas with decreasing albedo (the areas with SH-C-VW climate) are more in line with the Hyrcanian forests. Figures 3-b show the slope of the NDVI changes. It is clear that albedo decline in Hyrcanian forests has been accompanied by an increase in vegetation indices. According to available documents from the organization of forest and grassland pastures, in the past decade, an average of 13,738 hectares per year have been added to the forest area.



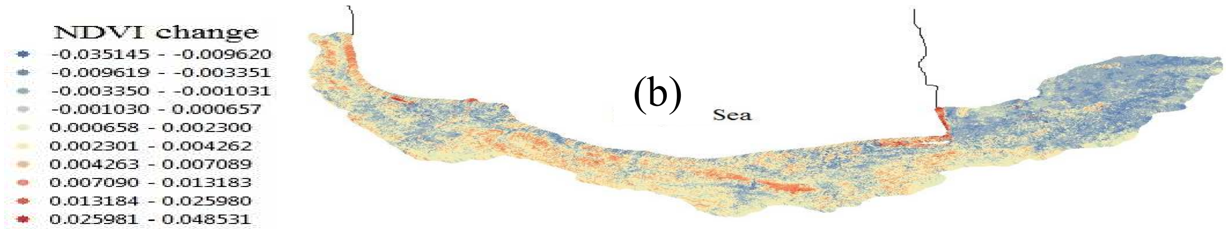


Fig. 3: The areas with an incremental slope, decreasing and close to zero for Albedo (a) and NDVI (b) are shown for all pixels of high quality in North of Iran.

Our analysis revealed that the slope of temperature variation in the northeast of Golestan province correlates with the slope of albedo changes.

4. Conclusions

In the present study, the effect of vegetation change on albedo variations over a 13-year period during plant season by employing NDVI index in the North of Iran was investigated. Results showed that surface albedo has increased with a statistical significant slope in all sites, except SH-C-VW (sub-humid sites). Also, after evaluating the relationship between albedo and NDVI, it was found that in arid and semi-arid climates (A-C-W and SA-C-W) the correlation between the surface albedo and NDVI is stronger than that other climates. Finally, the effect of albedo changes on screen temperature (at 2 meters height) was investigated. According to this study, rising albedo in areas where vegetation cover has been decreased, causes the lowest increase in temperature. This study showed that in the protected Hyrcanian forests, due to policies taken by the government, the surface albedo is decreasing and vegetation indices are increasing.

References

[1] Ollinger S.V, Richardson A.D, Martin M.E, Hollinger D.Y, Frolking S.E, Reich P.B, Plourde L.C, Katul G.G, Munger J.W, Oren R and Smith, M.L. Canopy nitrogen, carbon assimilation, and albedo in temperate and boreal forests: Functional relations and potential climate feedbacks. Proceedings of the National Academy of Sciences 2008; 105(49):19336-19341.

[2] Jin Y, Schaaf C.B, Gao F, Li X, Strahler A.H, Zeng X and Dickinson R.E. How does snow impact the albedo of vegetated land surfaces as analyzed with MODIS data? Geophysical Research Letters 2002; 29(10).

[3] Vermote E.F, El Saleous N.Z and Justice C.O. Atmospheric correction of MODIS data in the visible to middle infrared: first results. Remote Sensing of Environment 2002; 83(1-2):97-111.

[4] Liang S, Stroeve J and Box J.E. Mapping daily snow/ice shortwave broadband albedo from Moderate Resolution Imaging Spectroradiometer (MODIS): The improved direct retrieval algorithm and validation with Greenland in situ measurement. Journal of Geophysical Research: Atmospheres 2005; 110(D10).

[5] UNESCO, Map of the world distribution of arid regions. Map at scale 1:25,000,000 with explanatory note. United Nations Educational, Scientific and Cultural Organization, Paris, 1979, pp. 54.