Quality Improvement of Drought Indices, Using Integration of High and Low Resolution Satellite Imageries

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Abstract

Satellite data are widely used for producing indices that are necessary for drought monitoring models. The images have so far been used for this purpose have usually low spatial resolutions. This means that each individual pixel may contain different features with different characteristics. This may in turn decrease the quality of indices and consequently renders useful application of drought models impossible. This problem can be overcome if we find a way to increase knowledge of the surface cover features in a low spatial resolution image by using high spatial resolution images of the same region produced by sensors on board of the same platform.
To implement this task, we used ASTER images as a magnifier for the MODIS images in order to improve the indices such as NDVI, NDWI, etc. calculated through MODIS images. The results show higher reliabilities in the calculated indices.

Keyword: Remote Sensing, MODIS, ASTER, Drought, Index

Introduction

The development of drought prediction models depends on an unambiguous, replicable definition of the existing terrestrial vegetation. Vegetation characteristics such as amount of coverage and phenology, affect processes such as water cycling, absorption and reemission of solar radiation, momentum transfer, carbon cycling, and latent and sensible heat fluxes. Consequently, variations in the composition and distribution of vegetation represent one of the main sources of systematic land cover change on local, regional, or global scale, and the ability to detect these variations using multi-temporal remotely sensed image data is of utmost importance for both environmental research projects and management activities (Hall et al. 1995; Running et al. 1995).This problem is even more dramatic when dealing with areas where desertification processes may occur (Bolle 1996).
Satellite remote sensing techniques that can be considered for the study of vegetation processes, offer a robust approach in obtaining the required data globally, due to the large

extent, strong spatial and temporal dynamics, and logistical inaccessibility of the vegetation (Laine and Swed, 2004). The Normalized Difference Vegetation Index (NDVI), which can be derived through satellite images, have been considered as the most appropriate index for monitoring agricultural drought condition (Vogt.J.V and F, 2000). However, the high costs, temporal and special limitations are the main limiting factors in application of these indicators.

The images have so far been used for this purpose, had usually low spatial resolutions. This means that each individual pixel may contain different features with different characteristics. This may in turn decrease the quality of the calculated indices and consequently renders useful application of drought models impossible. In the other hand sensors onboard of meteorological satellites such as the MODIS and NOAA Advanced Very High Resolution Radiometer (AVHRR) are able to collect information very frequently but with poor spatial resolution. This problem can be overcome, if we find a way to increase the knowledge of the surface cover features in each individual pixel of the images having low spatial resolution.

The efficient integration of the useful spatial and temporal features of the two data types has therefore become a major challenge for remote sensing experts interested in environmental applications (Fabio Masellia, et al.1999). The paramount importance of the subject is testified by the numerous investigations performed in recent years, which have achieved varying degrees of success (Fabio Masellia, et al.1999). A common and straightforward strategy is to assume a linear combination of the spectral signals to compare high and low resolution data by regression analysis techniques (Puyou-Lascassies et al. 1994; Kerdiles and Grondona 1995; Oleson et al. 1995). To implement this task, we used ASTER images as a magnifier for the MODIS images in order to improve the indices such as NDVI, NDWI, etc. calculated through MODIS images.

Data and field specification

The study area is located in the sugarcane fields in Khuzestan province in the south-west of Iran, The Sugarcane Developing and Lateral Industry Company possessing 7 plants and industries units in 84000 acres of the Khuzestan province and is one of the greatest compounds in its kind in the world. The center of the study area located in 31 44 38.3 N, 48 46 11.98 E. Our study area which is flat and largely covered by sugarcanes, have area of approximately 921 hectares.

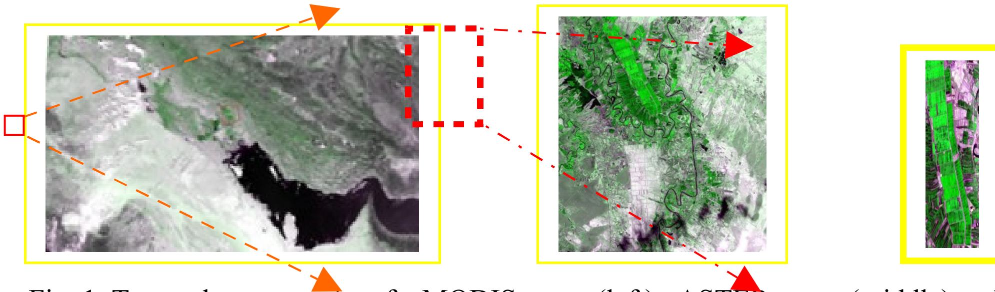


Fig .1. True color composite of a MODIS scene (left), ASTER scene (middle) and a subimage of the ASTER containing an agricultural area selected for validation test (right)

According to the climate classification made by Köppen Climate Classification System, the climate of the area can be defined as Moist Subtropical Mid-Latitude Climates, characterized by a long arid season in summer. This climate generally has warm and humid summers with mild winters. Its extent is from 30 to 50° of latitude mainly on the eastern and western borders of most continents. This climate is often called a Mediterranean climate. This Mediterranean climate is obviously more pronounced in the valleys, since the mean annual temperature and rainfall range from about 34°C and 51 mm to 19°C and 228 mm.

Fig .2. Iran, Ahvaz 31° N , Elevation: 22.5 m

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Temp. ° C	14	16	19	27	33	37	38	39	34	29	20	15	27
Precip. mm	42	82	49	0.1	0	0	0	0	0	0.4	13	40	226

Materials and methods

Satellite Data preparation

Two high spatial resolution L1B ASTER images taken on 8th of November, and 12th of August 2004 were used in this research. A sub-scene of 180×264 pixels was extracted from each of these two scenes. The images were georeferenced by applying the rotation angles provided in header file. ASTER Bands 3n (NIR) and 2 (R) were then converted into apparent reflectance values. Since we intended to compare ASTER and MODIS images of the same scene, neither atmospheric nor topographic corrections were performed at this stage. Using apparent reflectance images in red and NIR bands, the NDVI index was computed by the standard formula:

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

The level 2 (applied radiometric and atmospheric correction, and panoramic bow Tie effect) MODIS data were supplied from Iranian Space Agency's archive on the same day that ASTER images were acquisitioned. A sub-scene of 80×73 pixels was extracted from each of the two ASTER images and the image to image registration procedure were done. Also a nearest-neighbor resampling algorithm trained on about 4 ground control points selected in ASTER image, with a final RMSE lower than 1 pixel on both axes. Projection UTM WGS 84 north zone 39 was applied for both MODIS and ASTER images. MODIS Bands 2 (NIR) and 1 (R) were then converted into apparent reflectance values. Using these two apparent reflectance images, the NDVI index was computed by the same equation as above.

Degradation and regression analysis

To compare MODIS image with ASTER, the following steps were taken:

1)- Selecting one arbitrary MODIS pixel in the NDVI image with spatial resolution of 250m.
2) -Overlaying ASTER image of the same date on the MODIS image. Each MODIS pixel will contain 17 by 17 ASTER pixels approximately.
3) - Each 17 by 17 ASTER NDVI pixels were averaged.
4) -Degradation -The degradation was done in two ways: i) by simple average (mean filtering), as suggested by Kerdiles and Grondona 1995, and ii) by applying a two-dimensional Gaussian filter to simulate the Modis point spread function.
5) -These degraded NDVI values were compared with the underlying MODIS NDVI values and a regression analysis of these values were carried out.
The results were an improvement of MODIS NDVI values.

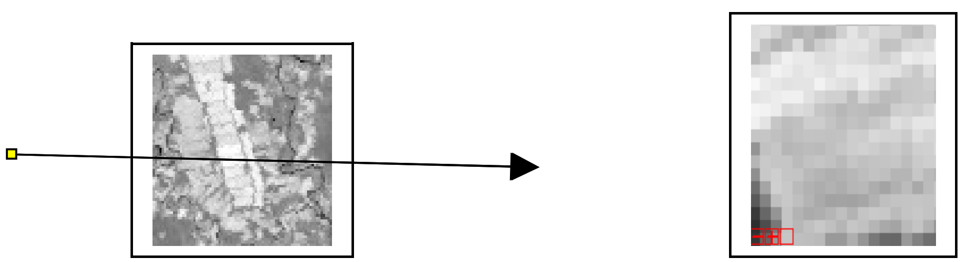
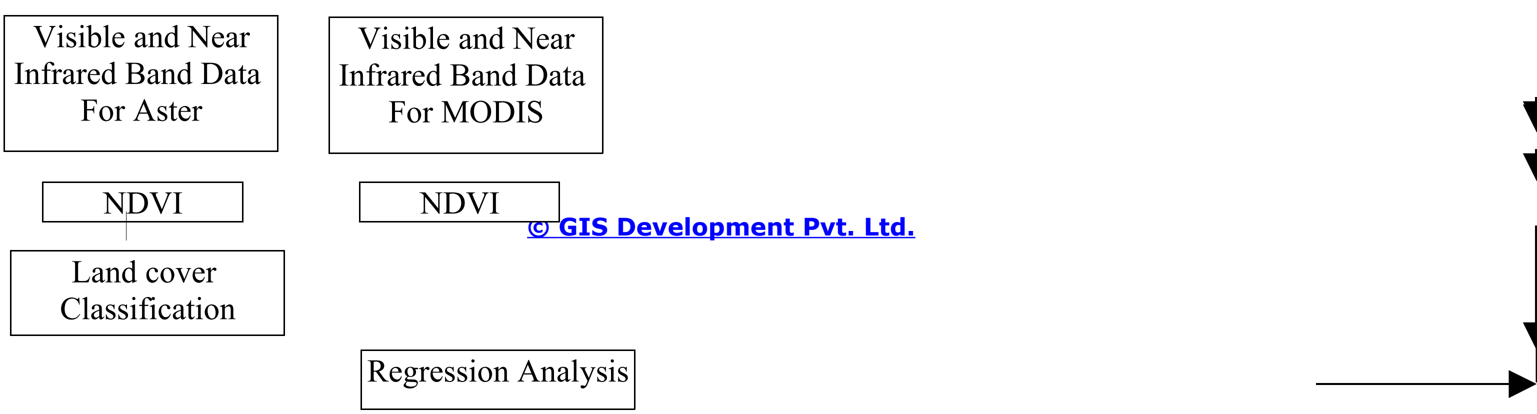


Fig.3. A MODIS NDVI image (left) and an ASTER NDVI image overlaying on a MODIS pixel (right).

The above 4 steps can be summarized in the following conceptual flowchart.



RESULTS

For the integrated analysis with the low spatial resolution data, the outputs of the NDVI-classifications with the ASTER data set had to be compared to the Modis NDVI images. To this purpose firstly ASTER data degraded to produce abundance images with the Modis pixel size The degradation was done in two ways: i) by simple average (mean filtering), and ii) by applying a two-dimensional Gaussian filter to simulate the Modis point spread function .then linear regression analyses were performed between the abundance images and the Modis NDVI images to retrieve the pure class profiles.

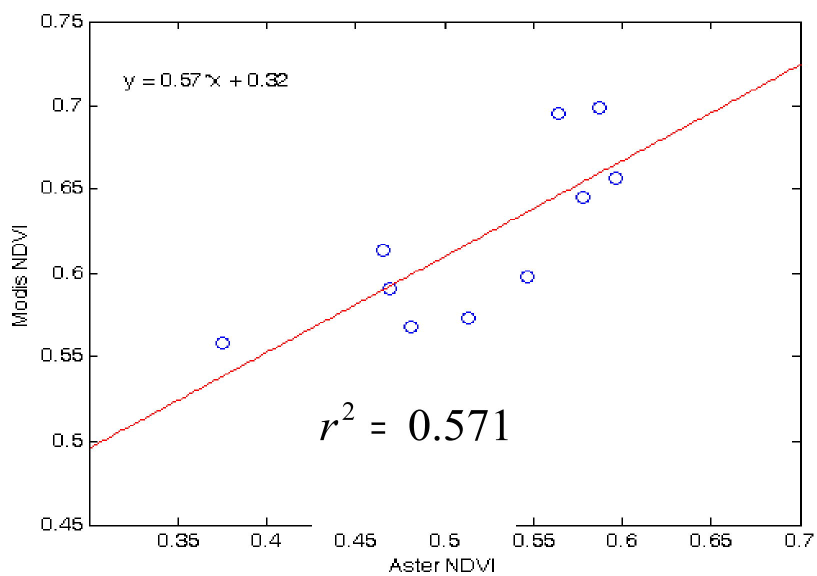


Fig.4.Corroloation between the mean ASTER NDVI values and the MODIS NDVI values as obtained by applying the mean filtering.

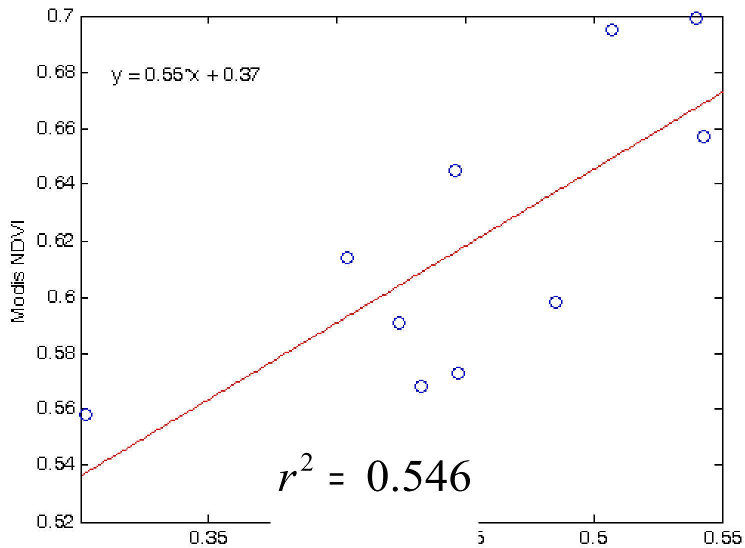


Fig.5.Corroloation between the mean ASTER NDVI values and the MODIS NDVI values as obtained by applying the two-dimensional Gaussian filter.

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