Investigation of the Relationship between Satellite Retrieval CO_2 Concentration and NDVI over IRAN

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ABSTRACT

The global annual mean atmospheric carbon dioxide (CO_2) concentration has increased since the industrial revolution from 280 ppm to current value of about 390 ppm, which caused widespread concern in the international community. Among the greenhouse gases, CO_2 has been introduced as most important anthropogenic greenhouse gas. Human activities such as deforestation, land use and land cover change, forest degradation, industrialization and consumption of fossil fuels have increased the concentration of CO_2 in the atmosphere, which have disrupted the global natural C cycle. Greenhouse Gases Observation Satellite (GOSAT) measures the concentrations of CO_2 and CH_4 in the atmospheres column from the earth's surface to the upper atmosphere. In this research, GOSAT TANSO-FTS level 2 data and MOD13Q1 of MODIS product were used to investigate the relationship between XCO_2 and NDVI for 2013 year in Iran. The NDVI is used to construct seasonal and temporal profiles of vegetation activity enabling inter-annual comparisons of these profiles. Therefore, NDVI was utilized for the investigation of CO_2 concentration in different land covers. According to the results, the strongest correlation was found between monthly XCO_2 values and NDVI value for spring season. A weak correlation was found between XCO_2 and NDVI value for autumn

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season. In other words, the highest correlation coefficient to lowest value observed in spring, winter, summer and autumn was 0.756, 0.472, 0.428, and 0.341 respectively. The southern Iran is located in lower latitude and has warmer weather than northern Iran in autumn and winter, so, the NDVI values are quite low in higher latitude than lower latitude in winter. The most number of XCO_2 column is located in southern Iran in winter, they include higher NDVI values and demonstrate higher correlation coefficient than summer and autumn.

Key Words: Climate change, GOSAT, XCO_2

Introduction

The global annual mean atmospheric carbon dioxide concentration has increased since the industrial revolution from 280 ppm to current value of about 390 ppm, which caused widespread concern in the international community (Zhao et al., 2012). Among the greenhouse gases, CO_2 has been introduced as most important anthropogenic greenhouse gas (Hyman et al., 2003). Human activities such as deforestation, land use and land cover change, forest degradation, industrialization and consumption of fossil fuels have increased the concentration of CO_2 in the atmosphere, which have disrupted the global natural C cycle (Djebou and Singh,2015; Wu et al.,2015). In the terrestrial ecosystems, CO_2 has seasonal amplitude (Keppel-Alex et al.,2013). Photosynthesis by releasing oxygen and absorbing carbon dioxide causes depletion in the level of CO_2, while respiration by releasing carbon dioxide and absorbing oxygen causes increase in the level of CO_2. Respiration and photosynthesis are influenced by temperature, availability of moisture (Schneider, 2009). Recently, observations of greenhouse gases with satellite have been carried out by two types of observation: The thermal infrared (TIR) and short-wavelength infrared (SWIR) observations (Wang et al., 2015). Due to the sensitivity of SWIR observations in the lower troposphere which is also the major source and sinks of CO_2 and CH_4 in the near surface, SWIR observations are more reliable than TIR observation (Yoshida et al., 2011; Wang et al., 2015). Because of the widespread concern about climate change and global warming from the emissions of greenhouse gases and the situation of Iran among top 10 countries producing greenhouse gases and due to the absence of ground station in the whole of Iran for monitoring the emissions of greenhouse gases, GOSAT data was utilized for investigating the trend of CO_2change on a national scale. It is necessary to find out the concentration of CO_2 gas and the trend at which they change in recent years in Iran for better decision making in climate policy and environmental management. .Therefore, the main objective of this research are assessment of relationship between XCO_2 and Normalized Difference Vegetation Index (NDVI) for the year 2013 over Iran.

2. Materials and methods

2.1. Study area

The study area is located in Iran, Middle Eastern part of Asia; it extends between 25°-40° N latitudes and 44°- 64° E longitudes. The location of the study area is shown in Fig1. Iran is located in arid and semi-arid region that cover more than 60% of the country (Modarres and da Silva, 2007). In general, Iran is divided into four climatic regions: Hot – Arid Climate, Hot – Mild Climate, Mild – Humid Climate and Cold Climate (Sanaye et al., 2010). Iran is covered by 90-million-hectare range land (54.6%), 34-million-hectare desert (20.6%),12.4-million-hectare forest (7.5%), 18.5-million-hectare cropland (11.2%), 10.1-million-hectare residential areas and infrastructure (6.4%) (Badripour, 2004).

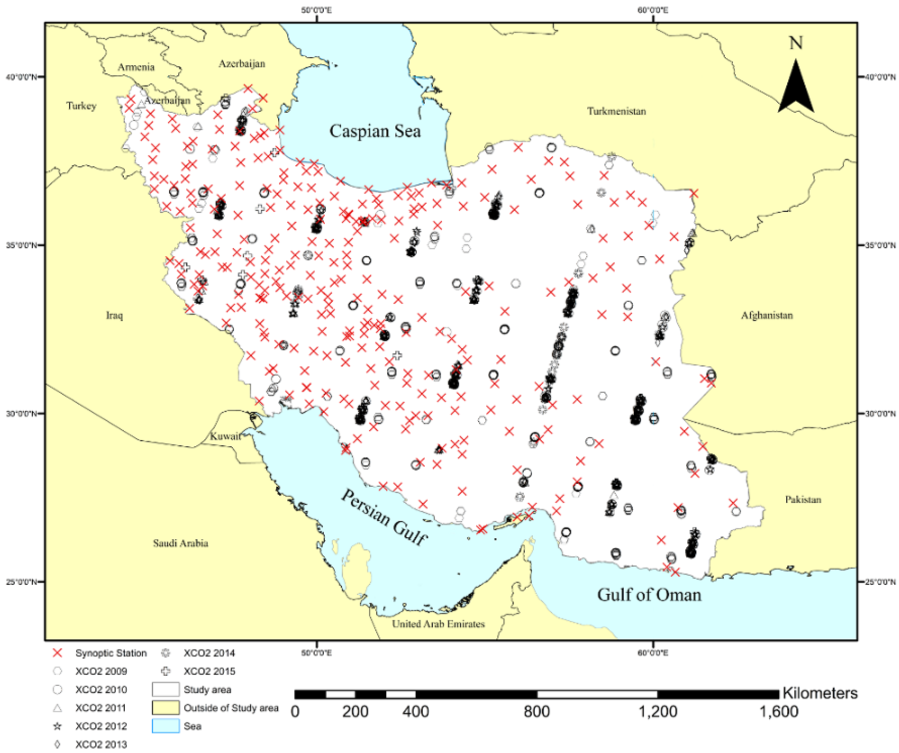

Figure 1 Location of study area and position of GOSAT Column

2.2. Satellite data

2.2.1. GOSAT TANSO-FTS Level 2 data

The Greenhouse Gases Observing SATellite (GOSAT) also known as IBUKI (in Japanese) was launched from Tanegashima Island/Japan, on January 23, 2009. It is a joint project of the Ministry of the Environment (MOE), the National Institute for Environmental Studies (NIES), and the Japan Aerospace Exploration Agency (JAXA) for monitoring of greenhouse gases (Kuze et al., 2009). The GOSAT is the world's first spacecraft designed for monitoring CO_2 and CH_4 column abundance with 1% relative accuracy from SWIR bands (Zeng et al., 2013). The evaluated precisions for the single observations of GOSAT are less than 1% (Yoshida et al., 2011). Since TANSO-FTS cover the entire globe every 3 days, it takes 56000 measurements, but due to the limited observation of area under non-cloud sky conditions only less than 10% of data collected by TANSO-FTS can be utilized to calculate column abundances of CO_2 and CH_4(Morino et al., 2011).

2.2.3. MODIS product

Normalized difference vegetation (NDVI) is the most important vegetation index for studying of land degradation. In this research, MODerate resolution Imaging Spectroradiometer(MODIS) product of MOD13Q1 was used which is available to the public free of charge (https://lpdaac. usgs.gov/data access).This product was a 16-day composite with a horizontal resolution of 250 m ×250 m (Shao et al.2016).The maximum value composite of the NDVI is used in each month.

3. Results and Discussion

The NDVI can provide a potential means to understand changes in the CO_2 flux (Stow et al., 1998). Therefore, NDVI is an ideal vegetation index for activity biomass and parameters such as temperature, precipitation and other metrological parameters that are necessary to explain the variance showed by the NDVI.

The NDVI is used to construct seasonal and temporal profiles of vegetation activity enabling inter-annual comparisons of these profiles (Huete et al., 1999).Therefore, NDVI was utilized for the investigation of CO_2 concentration in different land Covers. Figs 2 to 5 illustrate the relationship between XCO_2 and NDVI in different seasons in whole of Iran.

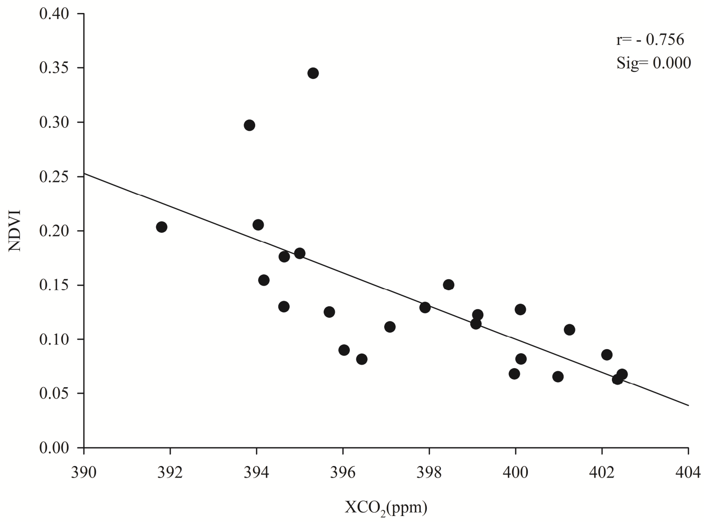

Figure 2 Relationship between monthly TANSO-FTS registration of XCO_2 and NDVI in spring

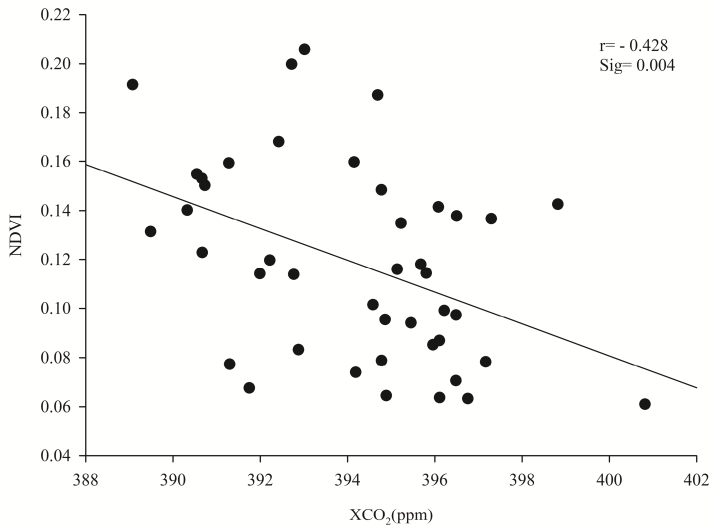

Figure 10 Relationship between monthly TANSO-FTS registration of XCO_2 and NDVI in summer

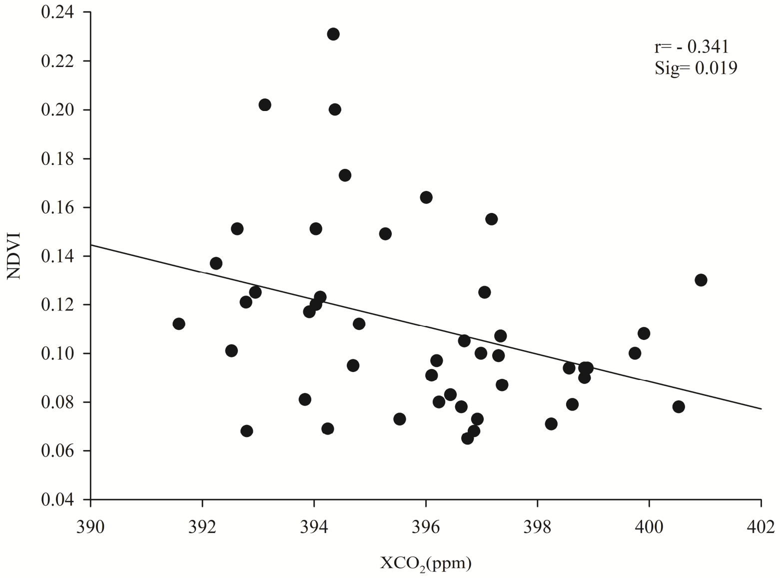

Figure 4 Relationship between monthly TANSO-FTS registration of XCO_2 and NDVI in autumn

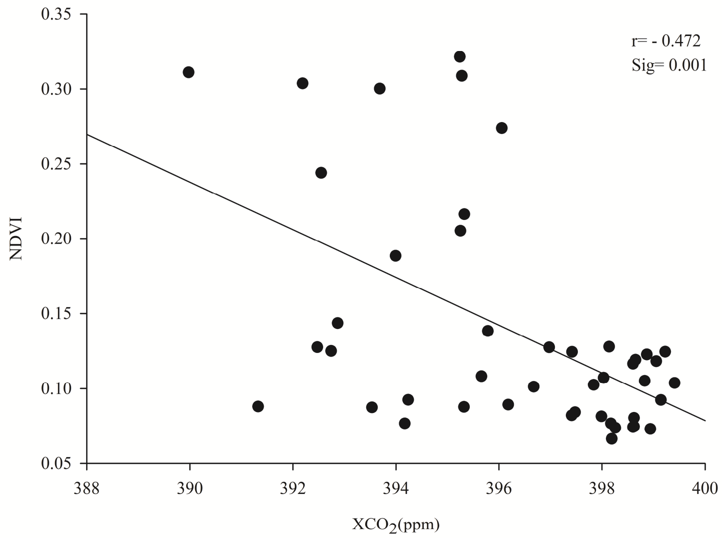

Figure 5 Relationship between monthly TANSO-FTS registration of XCO_2 and NDVI in winter

In all seasons, XCO_2 decreases with increase in NDVI. It shows that the higher values of NDVI correspond to dense vegetation; the XCO_2 value is often quite low in sparse vegetation. NDVI is similar to other vegetation indices measure of contrast (Red and Near infrared reflectance) and are thus integrative functions of canopy structural (cover percentage, leaf area index) and physiological parameters such as photosynthesis (Miura et al., 2006). According to the results, the strongest correlation was found between monthly XCO_2 values and NDVI value for spring season. A weak correlation was found between XCO_2 and NDVI value for autumn season. In other words, the highest correlation coefficient to lowest value observed in spring, winter, summer and autumn was 0.756, 0.472, 0.428, and 0.341, respectively. The southern Iran is located in lower latitude and has warmer weather than northern Iran at autumn and winter, so, the NDVI values are quite low in higher latitude than lower latitude at winter. The of XCO_2column is located in southern part of Iran at winter, they include higher NDVI values and demonstrate higher correlation coefficient for summer and autumn. Whereas, photosynthesis, soil respiration and burning of fossil fuel are the main factors in CO_2 amplitude in national spatial scale in different seasons in Iran, it is suggested to produce spatial distribution of CO_2 map based on meteorological parameters and land cover components for better land use planning and management in climate policy.

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