ESTIMATION OF CHANGES IN LAND SURFCAE ALBEDO DUE TO CROPLAND COVER CHANGE OVER INDIAN REGION

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ABSTRACT

Land surface albedo is one of the essential climate variables for surface energy balance and a critical parameter to assess the climate change over a period of time. This work discusses the changes in land surface albedo due to cropland changes from 2001 to 2012 over Indian region. In the current work, change in the cropland area has been assessed using MODIS data for 2001 over 2012 by applying linear regression analysis. It has been found out that cropland area has been increased by 7% over Indian region. Seasonal and annual black sky and white sky albedo values of shortwave and visible broadband have been estimated over Indian cropland region for 2001 and 2012 using MODIS data. Using linear regression analysis, it has been found that in 2012, black sky visible broadband albedo decreased 26% and white sky broadband albedo has been decreased 37% in compare to 2001. Similarly shortwave black and white sky broadband albedo has been decreased 12.8% and 13.8 % respectively. These results indicate the impacts on average temperature.

INTRODUCTION

Land surface albedo is critical parameter in climate change studies. As the albedo of the system increases/decreases the cooling/warming effects take place. It is defined as the ratio of the solar radiation reflected from Earth's surface to the solar radiation incident upon it, is critical to the regulation of earth surface energy budget [Liang et al 2010, 2013a]. It strongly depends on the solar zenith angle and the three dimensional structure of vegetation canopy [Yang et al 2001, Schaafat al.2002]. Anthropogenic land cover change is one of the leading factors contributing towards widespread global environment changes. [Turnel et al. 2007].The climate response to changes in surface albedo has also been a topic of considerable study (Charmeyet al 1977, Dickson and Henderson sellers 1988; Xue and Shukla 1993) Land surface albedo is highly variable, both spatially and temporally. Satellite data provide a unique opportunity for monitoring surface albedo on a global basis [Liang et al. 2012].Algorithms for albedo estimation have been developed for various different types of remote sensing satellite observations. Surface albedo may change with land cover dynamics caused by deforestation, urbanisation, snowfall, snowmelt etc. The northern Hemisphere contains most of earth's land surface and about 90% of total population. Many studies have been reported warming trends due to climate change in north hemisphere in recent studies [Flanner et al 2011] [He et al 2013] [Jeong et al2011]. The variability study of different climate data set along with long term trend analysis have been done for the assessing the consistency of the climate variable [R K Nayak, N Misra 2015] . It is therefore useful to offer a brief trend analysis of land surface albedo. In the present analysis long term albedo changes has been studied due to cropland cover change over Indian region.

SATELLITE DATA

MODIS data from NASA's on board sun synchronous Terra and Aqua spacecraft has been used in this study. The composite BRDF/ Albedo products available every 16 day is used in this study. Terra has a morning equator crossing time at 10.30 AM, while Aqua has afternoon equator crossing time at 1:30 PM. MODIS sensor on Terra and Aqua provide measurements on a global basis every 1 or 2 days with seven spectral narrow bands and three broadband in range for land applications.

Land cover plays a major role in global scale pattern of the climate and biogeochemistry of the earth system. The primary objective of the MODIS land cover is to facilitate the inference of biophysical information for use in regional and global climate studies. MODIS International Geosphere-Biosphere Programme (IGBP) classification list include 11 classes of natural vegetation, 3 classes of developed and mosaic lands and 3 classes of non- vegetated lands [Friedl et al 2010] These land cover details over Indian region are used in this study.

MODIS BRDF data have been considered for the duration 2001-2012 for the computation of black and white sky albedo values. MODIS yearly lands cover (http://glcf.umd.edu/data/lc/) data have been used in the analysis. Black and white sky albedo values have been mapped on the different land cover specified over the Indian region.

Spatial and Temporal resolution of Data Sets:

MODIS land cover data and MODIS albedo data have been used in the present analysis. The spatial boundary of the both datasets is 65 E 99 W and 5 S 35 N i.e. over Indian region.

MODIS provides global land cover map at 1 Km spatial resolution based on Geosphere-Biosphere Programme (IGBP) classification systems at annual time scale. Spatial resolution of MODIS land cover map is 5'X5' i.e. 8x8 Km. In the present analysis considered MODIS albedo products MCD43C3 are based on a 16- day cycle's observed data. These observation strategies assume that the cropland surface signature does not change during the observation period. 8 day product has been obtained from the algorithm based on 16 day observed data cycle. Spatial resolution of albedo data sets is 5 x5 Km. The aim of the current study is to assess the albedo change due to cropland cover change over Indian region .In the current study data comparison has been done on common platform of spatial and temporal resolution. As the both the data consist of different spatial resolutions; albedo data have been regrided to 8x8 Km over the study region. The MODIS data have been regridded using bilinear interpolation over the study region. As temporal resolution of land cover data is annual so the annual mean albedo values have been computed for the analysis.

METHODOLOGY

In the current work, change in the cropland area has been assessed for 2001 to 2012. By applying linear regression analysis, it has been found out that cropland area has been increased 7.74 % i.e. 0.14 million km^2 over Indian region over 12 year of time period. Change in cropland area has been indicated in the figure 1:

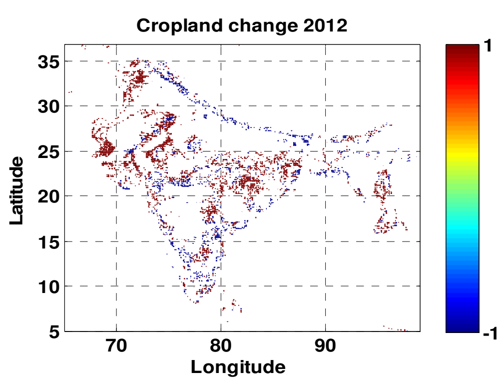


Figure 1: +1 indicates positive increase in cropland area during 2012 and -1 indicate decrease in cropland area during 2012 when compare to 2001 data.

To examine the change in surface albedo due to cropland cover change, MODIS annual land cover data have been used. Land surface albedos have been mapped over the cropland cover over Indian region.

The seasonal and annual mean of the broadband albedo values have been estimated over the Indian region. Mathematical mean have calculated based on reference [George Gutman 1988]. First the relationship between surface albedo and cropland cover has been studied over the Indian region for two different years, i.e., for 2001 and 2012. The black sky MODIS value estimation at solar zenith angle at noon is based on time average method as describe in [George Gutman 1988]. White sky albedo is independent of solar zenith angle.

DATA ANALYSIS AND RESULTS

MODIS BRDF /albedo product MCD43C3, black and white sky (visible and short wave band) broadband albedo values have been mapped on the cropland area over India. Analysis has been carried out for the clear sky days for the visible and shortwave broadband albedo. As the data over cropland area over the missing due to the cloud cover conditions, mean of the clear sky days have been taken for the calculation of mean albedo values in the current analysis. The seasonal black and white sky visible broadband albedo values are shown in the Figure 2 and Figure 3.In the Figure 2 and Figure 3 summer season, corresponds to March, April and May months, winter season corresponds to January and February month, monsoon season corresponds to June, July August and September month and post monsoon season corresponds to October, November and December month of the year. Spatial temporal variability of land surface albedo satellite data shows the decreasing trend in land surface albedo. [Tao He et al 2015]

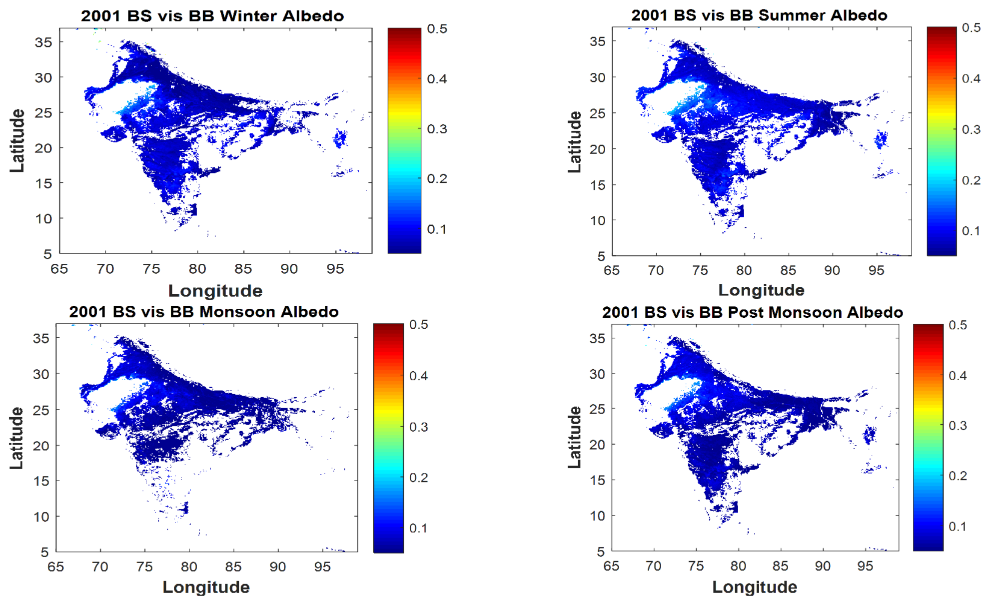


Figure 2: Black sky (BS) visible broadband (BB) seasonal albedo 2001 for cropland area

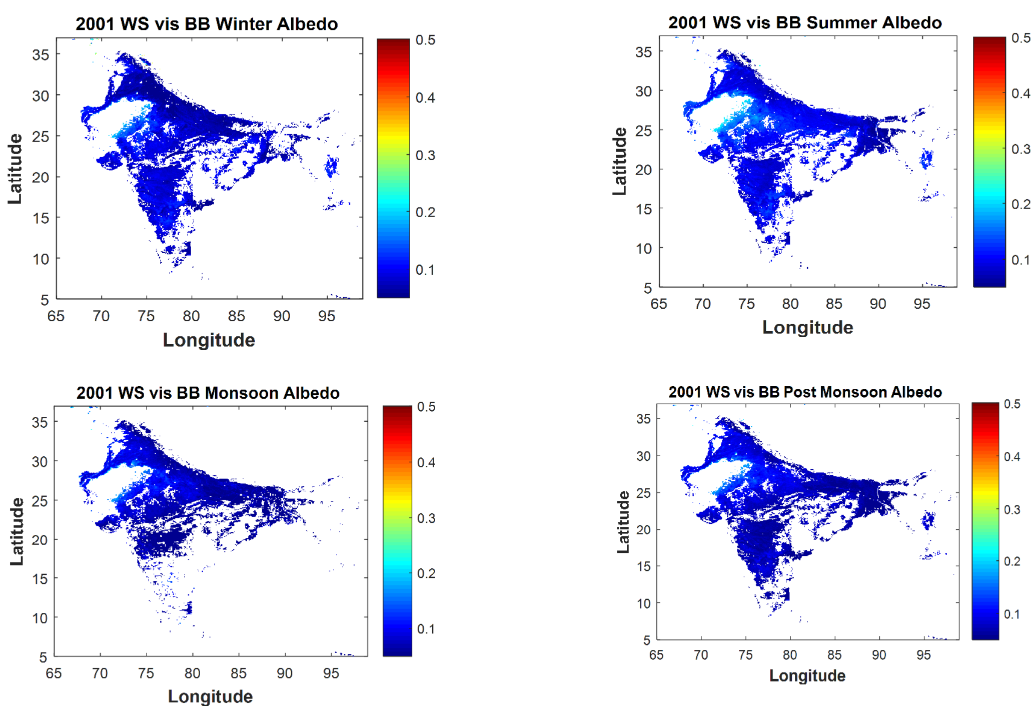


Figure 3: White sky (WS) visible broadband (BB) seasonal albedo 2001 for cropland area

The present work examines the analyses of black and white sky albedos separately for corresponding changes in cropland area.

Comparison has been carried out for the mean value between 2012 and 2001albedo over Indian cropland region. It has been found that in 2012, black sky visible broadband albedo decreased 26% and white sky broadband albedo has been decreased 37% in compare to 2001 over the crop land area (using linear regression analysis). Similarly shortwave black and white sky broadband albedo has been decreased 12.8% and 13.8 % respectively (using linear regression analysis).

In the current study, two major cropland cover change regions have been identified over India, where one region showed increasing trend and the other showed decreasing trend, as shown in Figure 4. Land cover change over these 2 regions has been examined for 2001 to 2012. These regions are approximate 5000 Km^2 area and located South-eastern and North-western regions respectively. 5'x5' MODIS land cover data have obtained for present analysis.

As shown in Figure 4 Region 1 and Region 2 of cropland area indicate land cover changes from 2001 to 2012. Red denotes the increase in cropland area while blue denotes the reduction in cropland area.

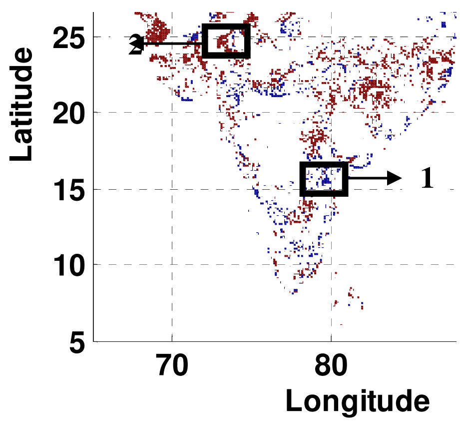


Figure 4: Albedo study Regions over India

Number of cropland grid cells has been identified over Region 1 and Region 2 for the time period of2001 to 2012. Area of one grid cell is 64 Km^2. The results have been shown in the Figure 5.

Mean Black and White sky broadband albedo values for broadband visible and shortwave wavelength albedo have been estimated for the Region 1 and Region 2 of the cropland area. Figure 6 and Figure 7 shows long term data distribution of broadband albedo over the study Regions. Figure 8 shows annual mean of broad band albedo values for 2001 to 2012. From the data analysis it has been estimated that the over the 12 year of time period mean albedo values has found to be the decreasing in trend in both the regions. As clearly seen in long term trend results , the slope of regression line is more in Region 2 as in Region 1. From the result it has been observed that white sky visible broadband albedo has 46% moredecreased over Region 1 as compared to Region 2. Smilarly in black sky visible broadband albedo has 38% more decreased over Region 1 as compared to Region 2. These Results have been shown in Figure 9 to Figure 13.It has been found out climate variability remains 5% from the mean value of the visible white sky broadband albedo as shown in Figure 10. As the mean albedo value is found to be decreasing in trend so the warming effect over both the region has been observed.

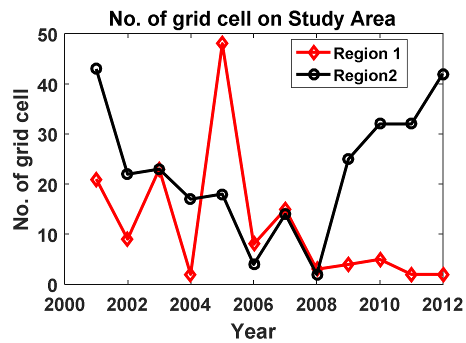


Figure 5: Number of cropland grid cell over Region1 and Region2

As the most of energy transfer takes place at the earth surface in visible broadband region, the result presented in this paper is for the visible broadband albedo. The climate variability has been studied on the long term mean values of black and white sky albedo. It has been found out climate variability remains 5% from the mean value of the visible broadband albedo for black and white sky broadband albedo [MODIS ATBD].

In addition to the above analysis two land cover points (Latitude and Longitude) have been identified over region where forest area has been changed to cropland from 2001 to 2002.Point A is Yeuru in Andhra Pradesh (Latitude, Longitude 14.25, 79.5) and point B is in Patpahari Jharkhand (Latitude, Longitude 24.42, 87.59). 8 day albedo data have been analysed for 2001 and 2002 for point A and B. It has been found that there is a decreasing trend in the albedo values of a particular point. Results have been shown in the Figure 14. It has been clearly indicated that in case of natural vegetative cover depletion the visible broadband albedo value have been decreased on the corresponding point locations.

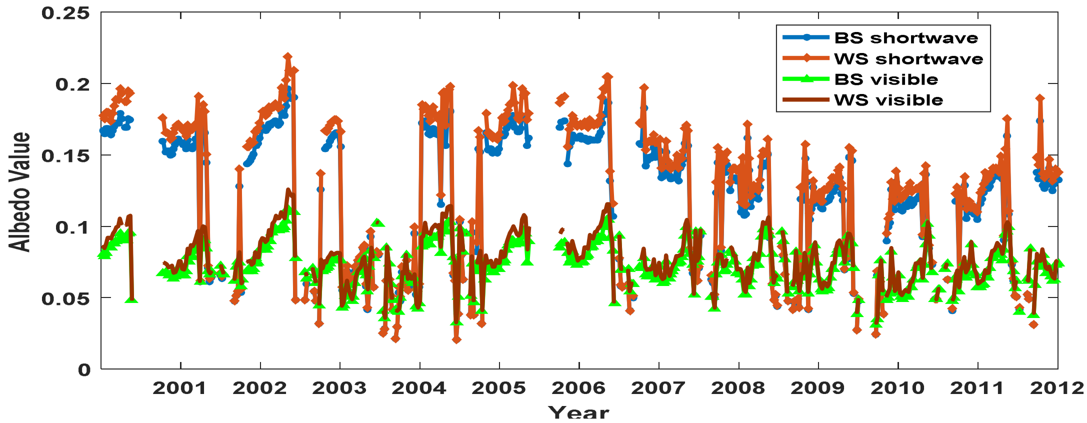


Figure 6: 8 day albedo data distribution over Region 1 for 2001 to 2012

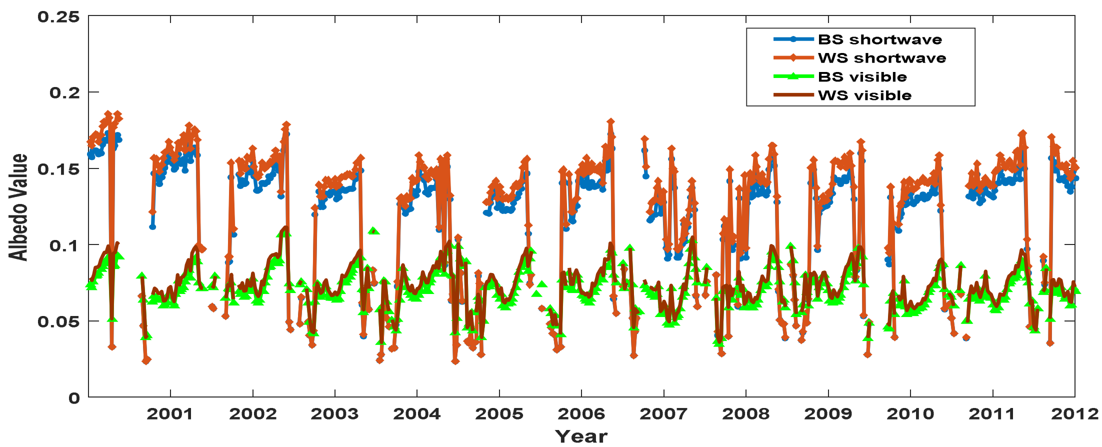


Figure 7: 8 day albedo data distribution over Region 2 for 2001 to 2012

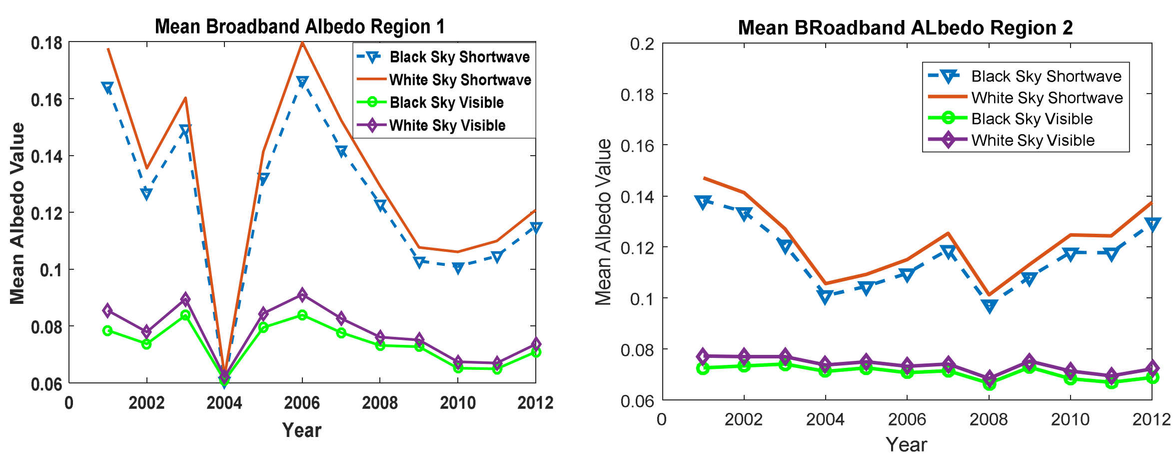


Figure 8: Annual albedo values over Region 1 and Region 2 for 2001 to 2012

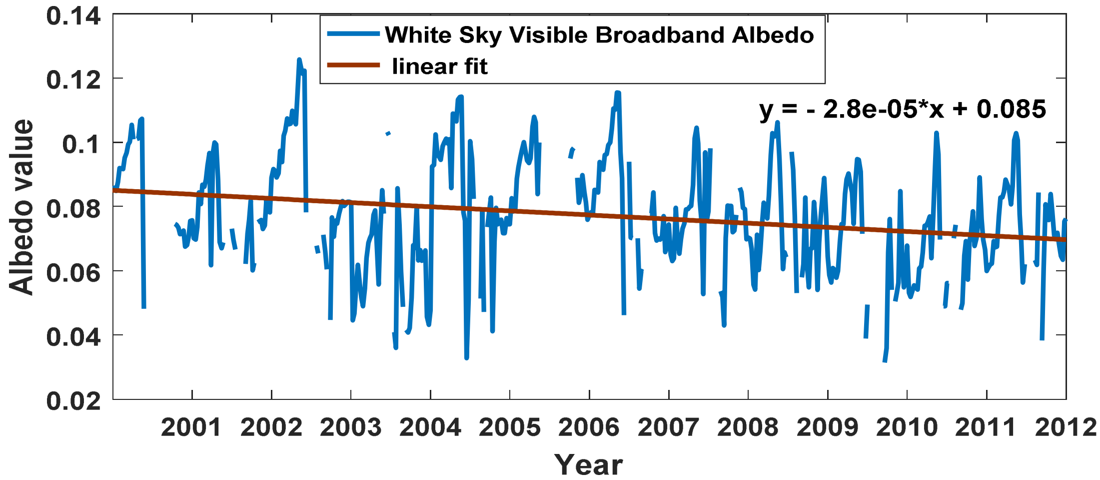


Figure 9: Trend analysis of white sky visible broadband albedo over Region 1

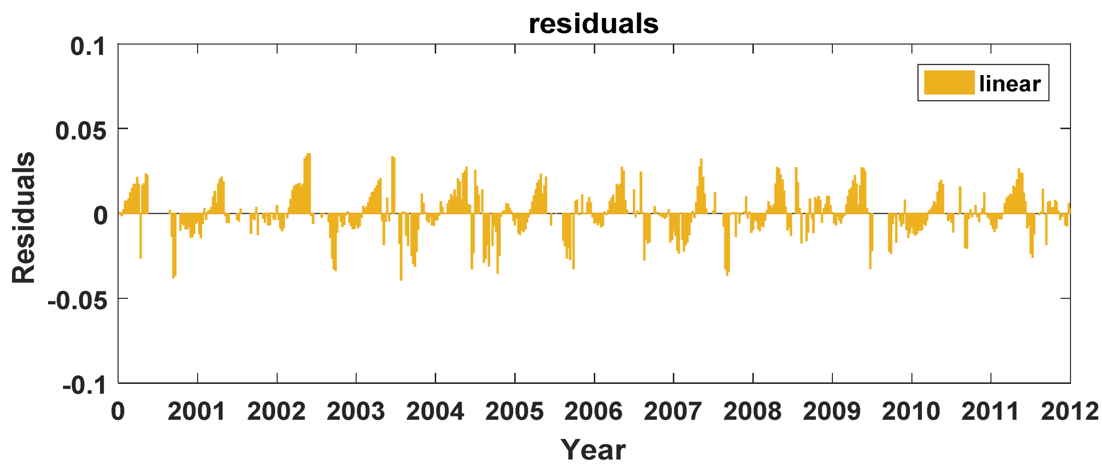


Figure 10: Residue estimation for white sky visible broadband albedo

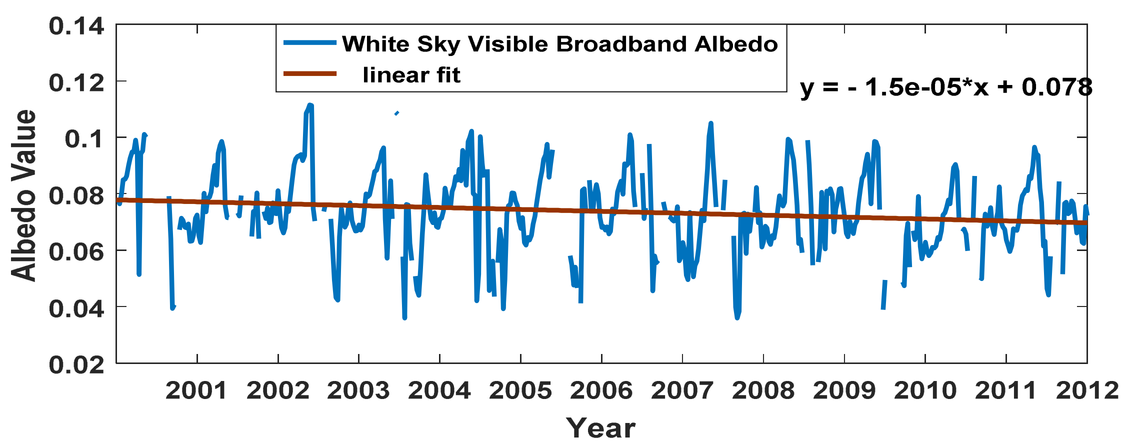


Figure 11 : Trend analysis of white sky visible broadband albedo over Region 2

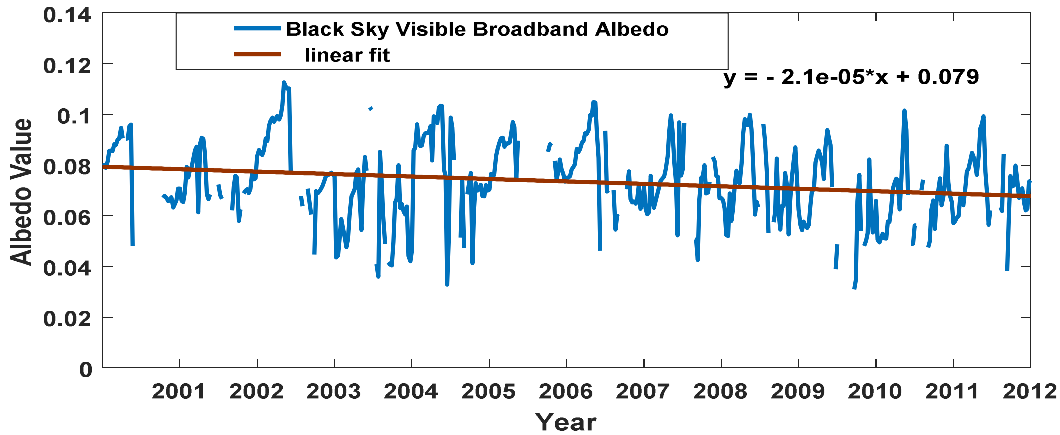


Figure 12: Trend analysis of black sky visible broadband albedo over Region 1

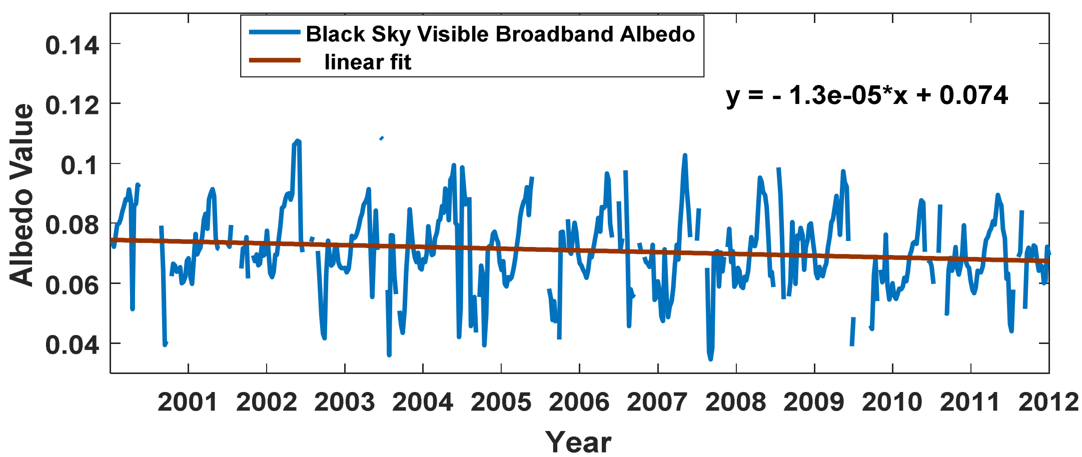
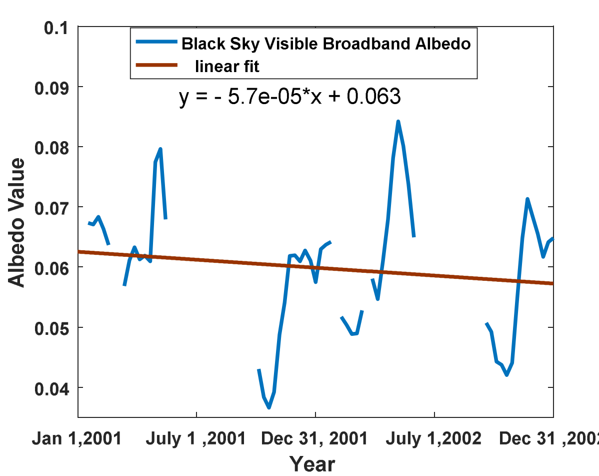
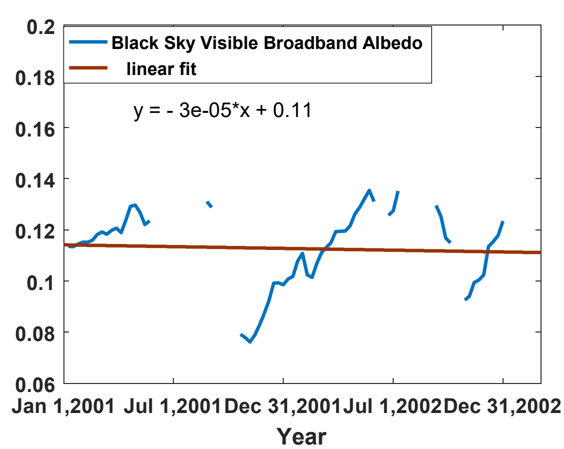


Figure 13: Trend analysis of black sky visible broadband albedo over Region 2

Point A



Point B



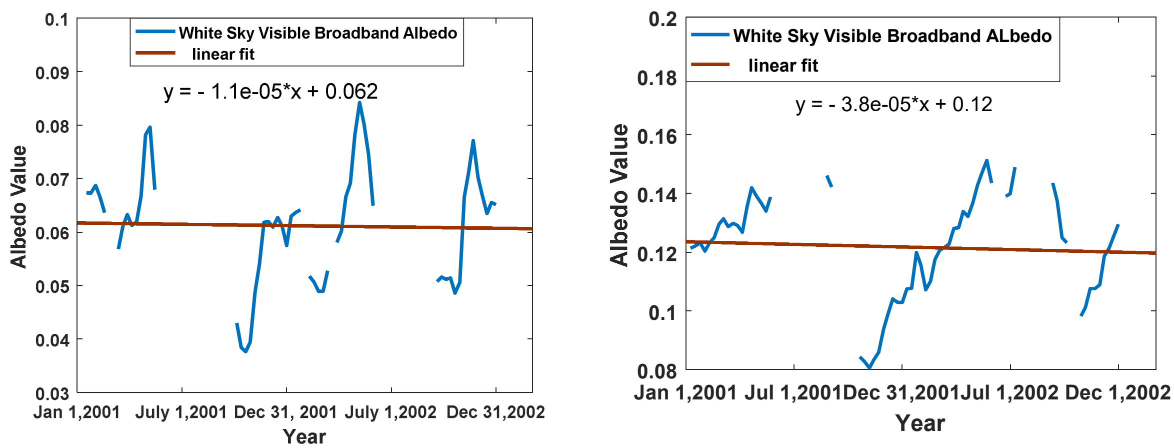


Figure 14: Trend analysis of visible broadband albedo values at points A and B

SUMMARY AND CONCLUSION

The following conclusions have been obtained from the current analysis.

1. Long term cropland surface albedos have been studied over the Indian region for the period of 2001-2012.
2. Seasonal and annual black sky and white sky albedo values of shortwave and visible broadband have been estimated over the Indian cropland region for 2001 and 2012.
3. It has been found that in 2012, black sky visible broadband albedo decreased 26% and white sky broadband albedo has been decreased 37% in compare to 2001. Similarly shortwave black and white sky broadband albedo has been decreased 12.8% and 13.8 % respectively. This analysis is based on linear regression analysis.
4. These results indicate the warming effect.

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