Summary of the Final Report of Research Results

1) Title of the proposed research

Interaction Between Atmospheric Greenhouse Gases & Terrestrial Biospheric Processes Over Indian Subcontinent

2) Principal Investigator (PI) and Co-Investigators (Co-Is)

PI: Dr. R.P. Singh

Co-I:

3) PI's affiliation

Land Hydrology Division

Geosciences, Hydrology, Cryosphere Sciences and Applications Group (EPSA)

Space Applications Centre, ISRO

Ahmedabad-380015

4) Summary of the Final Report of Research Results

(1 or 2 pages or at least 400 words in single spacing, including Figures and Tables if any)

Increasing human population and industrialization are a major cause of concern related to climate change. Inter annual increase in concentration of carbon dioxide (CO_2) in atmosphere is an important indicator of human induced climate change. Interaction of vegetation with atmosphere in terms of photosynthetic uptake of atmospheric CO_2 plays important role in defining seasonal distribution of CO_2 over different regions. GOSAT data provided valuable scientific observations on variability of greenhouse gases (CO_2, CH_4) and biospheric carbon fluxes over Indian subcontinent. Study was focused on (1) analysis of seasonal and inter annual variability of atmospheric CO_2 and CH_4 concentration (2) correlation between changes in carbon dioxide and Methane concentration with respect to changes in biophysical parameters (NDVI as indicator of Vegetation growth characteristics) and (3) spatio-temporal variability of terrestrial biospheric fluxes over the different agro-climatic zones of India and its dependence on various regional climatic factors like insolation, precipitation and mean monthly temperature. SCIAMACHY derived CO_2 and CH_4 data as well as NDVI data from EOS-MODIS and SPOT VEGETATION satellites were used in analysis along with GOSAT data products. Temporal data analysis of average atmospheric CO_2 concentration over India showed characteristic seasonal cycle with high in summer (April and May) and low during monsoon season (Sept and Oct.). NDVI showed an inverse behavior with CO_2 concentration showing highest value in monsoon period (Sept. and Oct.) and lowest in summer (April & May). Empirical model was fitted to relate the inverse relationship.

$$CO_2\ (in\ ppm) = 377.88\ NDVI^{-0.006}$$

Negative Correlation (r = -0.49) was observed between NDVI and CO_2 values. Overall 4.2 ppm difference in CO2 was observed during the seasonal cycle

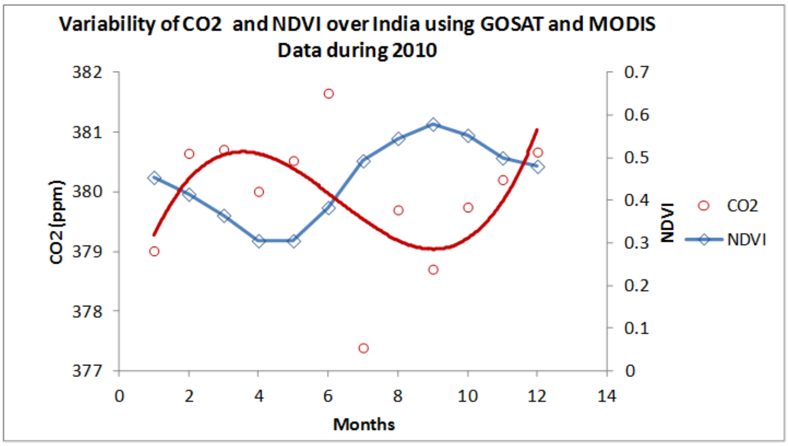

Figure 1. Inverse relationship between average monthly CO_2 and NDVI season cycle over India observed from GOSAT and MODIS data.

It was observed that consistently higher CO_2 was detected by GOSAT over tropical dry deciduous forest (Ranthambhor site) in comparison to moist deciduous forest (Kanha region). Overall an increasing trend was observed in atmospheric CO_2 in both SCIAMACHY as well as GOSAT observations. The CH_4 concentration was found relatively uniform over India during March period. A characteristic increase in CH_4 concentration over India was observed during September data in comparison to June data. The high CH_4 concentration during September is associated with the rice crop sown in Kharif season. The major sources for CH_4 in the Indian region are rice paddies, wetlands and ruminants. High concentrations of CH_4 were observed over eastern coastal regions which have predominantly rice crop. The concentration is generally lower in the western regions.

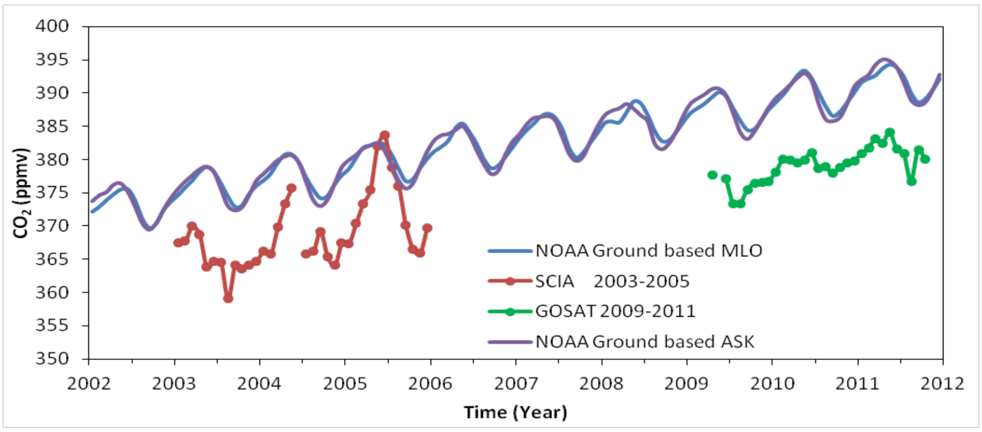

Figure 2. The SCIAMACHY (SCIA) and GOSAT data of CO_2 over India compared with ground NOAA flask data at Mauna Loa (MLO) and Assekrem (ASK).

Study on understanding the spatio-temporal variability of terrestrial biospheric fluxes over the agro-climatic zones of India was carried out and its dependence on various regional climatic factors like precipitation, temperature and incident solar radiation was analysed. The optimised mean biospheric flux varied between -0.47 (October) to 0.37 (April) gC m^{-2} day^{-1}, where negative sign indicates a net uptake of carbon from the atmosphere and positive sign denotes release of CO_2 to the atmosphere by the terrestrial biosphere. This is in accordance with the high vegetation cover during the monsoon season leading to more uptake of carbon whereas the hot and dry conditions during summer months result in release of carbon to the atmosphere. Maximum variability in fluxes was obtained for north-eastern region (-2.18 to +1.38 gC m^{-2} day^{-1}) of India followed by the Western Ghats (-1.55 to 1.24 gC m^{-2} day^{-1}). The dry region of Rajasthan showed extremely low variability with values ranging from -0.1 to +0.1 gC m^{-2} day^{-1}.

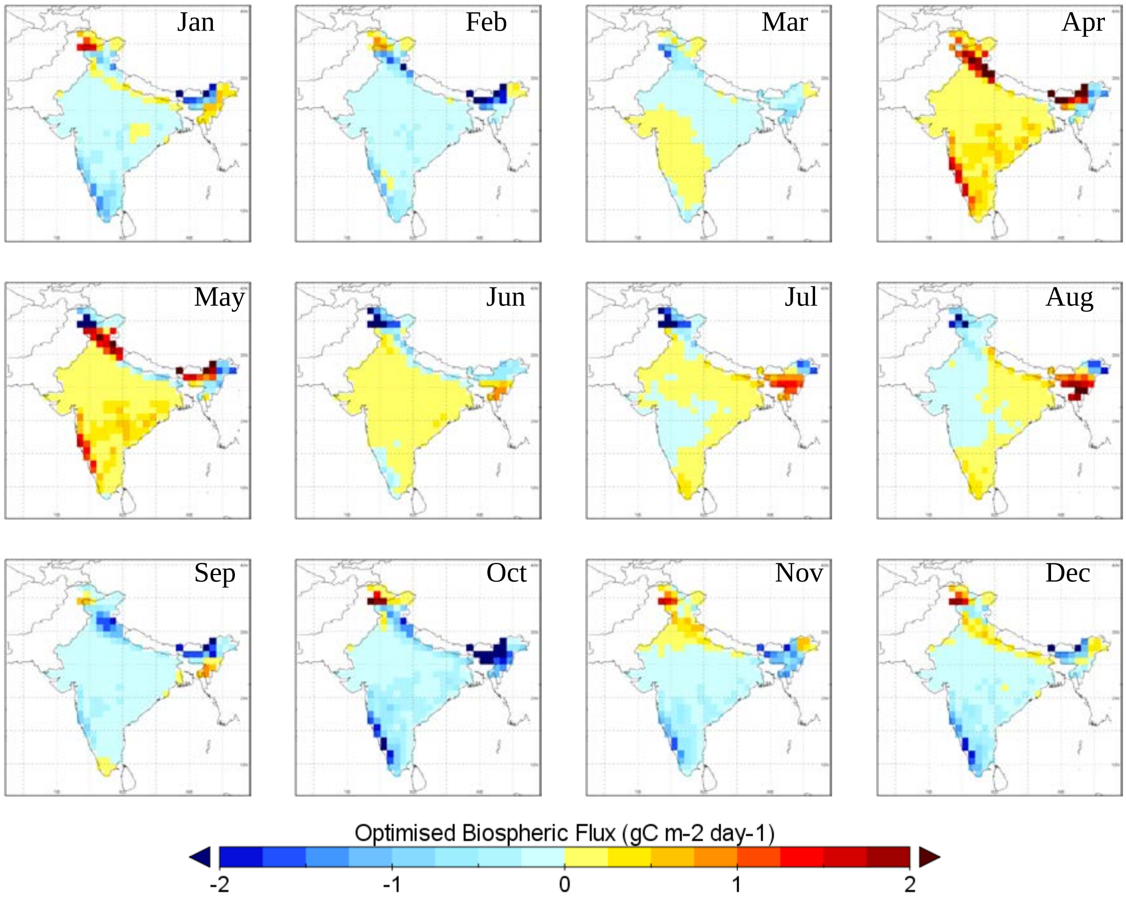

Figure 3. Optimised mean monthly terrestrial biospheric flux for the study region. Monthly mean calculated by taking pixel wise average of images corresponding to same month of different years.

Precipitation showed negative correlation (r<0) with biospheric flux in the arid and semi-arid regions of Rajasthan, Gujarat and parts of Maharashtra and Karnataka, upper and trans-Gangetic plains. Precipitation in these regions results in conducive environment for vegetation growth and leads to carbon sequestration (-ve flux). Similar to insolation, temperature showed positive correlation with biospheric carbon flux in most parts of the country except for regions of North Himalayas, Arunachal Pradesh, and parts of Gangetic plains. High temperatures in arid and semi-arid regions are not favorable for vegetation growth and thus, result in net release of carbon to the atmosphere from the terrestrial biosphere (+ve flux).

5) List of publications relating to the proposed research

(In addition, if there are any publication plans, please also describe them as well.)

1. Prasad P., Rastogi S., and Singh R.P., (2014), Study of satellite retrieved CO_2 and CH_4 concentration over India. Advances in Space Research, 54, 1933-1940.
2. Pradhan, R., Goroshi, S. K., and Singh, R. P., (2014), Spatial and seasonal characterization of terrestrial biospheric carbon flux over India using GOSAT data, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XL-8, 617-621, doi: 10.5194/isprsarchives-XL-8-617-2014, 2014.
3. Goroshi S. K., Singh R.P, Panigrahy S., And Parihar J.S. (2011), Seasonal variability of Methane and Vegetation over India: An analysis using ENVISAT-SCIAMACHY and SPOT-VEGETATION NDVI data. J. Ind. Soc. Remote Sensing DOI 10.1007/s12524-011-097-z.
4. Navalgund R.R. and Singh R.P. (2011), Climate Change Studies using Space based Observation. J. Ind. Soc. Remote Sensing, DOI 10.1007/s12524-011-092-4.
5. Panigrahy S., Manjunath K.R., Singh R.P., Chhabra A., and Parihar J.S. (2010), Spatio-temporal pattern of green house gases over India and up-scaling of methane emission from agriculture using space technology. NNRMS Bulletin, NNRMS (B)-35, December 2010.
6. Singh R.P., Goroshi, S.K, Panigrahy, S., and Parihar, J.S. (2010), Variability of Atmospheric Greenhouse Gases Concentration over India. Kyoto International Conference Centre, Japan, January 28 – 29, 2010.