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SEASONAL CYCLE AND ANNUAL VARIABILITY OF TROPOSPHERIC CH_4 USING GOSAT OBSERVATIONS

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Abstract: Understanding the distribution of methane source and sink regions is important to quantitatively assess the observed changes in atmospheric concentrations and climate change. The Greenhouse Gases Observing Satellite-1 (GOSAT-1), is the world's first Earth observation satellite dedicated to greenhouse gas monitoring which measures the densities of carbon dioxide and methane from 56,000 locations on the Earth's atmosphere. In this regard, GOSAT-1 data from 2010 to 2018 has been analyzed to understand the methane spatiotemporal variability, seasonality and source and sink regions of methane concentration. During the 2010 to 2015 period, growth in atmospheric methane is attributed mostly to an increase in emissions from India, China and areas with large tropical wetlands. Maximum surface flux emits from India (4.756 Tg/y) and China (6.898 Tg/ y). Compared to other regions, China and India have a high source of methane. The hydroxyl radical is the main contributor to the methane's sink (troposphere OH). In India, CH4 concentration is maximum in September, and the minimum is in February/March. The tropical wetland or agricultural or combination of both of the rising global methane 2008 in words. The study helped in understanding the methane spatiotemporal characteristics, source and sink regions of methane, and budgeting the methane concentrations.

Keywords—component GOSAT, in-situ flux data, Harmonic analysis, methane

Introduction

Atmospheric methane is the second most important Green House Gas after carbon dioxide (CO2) in the atmosphere. The methane concentrations have increased by more than doubled since preindustrial times, predominantly due to agriculture and fossil fuel use (IPCC, 2013). Changes in methane concentrations can have significant implications for global warming. Methane in the global radiative forcing of the atmosphere is 0.97 WM^-2 (IPCC, 2013). Methane is emitted from natural and anthropogenic sources. Major anthropogenic emission includes petroleum and natural gas, coal mining, waste (landfill and wastewater), livestock and rice cultivation. The lifetime of atmospheric methane is 9.1± 0.9years (Prather et al., 2012). The main source of methane is human activities with the agricultural, anthropogenic through entire fermentation of livestock (17%), rice (7%) from the formers, coal mining (7%), gas and oil (12%), waste management (11%), natural source of methane includes termites (4%), wetlands (34%), ocean and hydrates (3%), and biomass burning (4%) (Chen and prinn (2006), Fung et al (1991), Kirschki et al (2013)). The major natural source is wetlands. Methane major role in the troposphere as a sink for chlorine atoms and a source of water vapour in the stratosphere (Solomon et al., 2010).

Soil bacterial sink of surface methane and in troposphere methane Oxidation with OH, surface methane sinks in atmospheric so it impacts on atmospheric composition (Lelieveld, 2012). Source of methane in hydrogen and troposphere ozone precursors such as CO and formaldehyde (Montzaka et all.2011). On the sink, the side identified OH radicals with the largest uncertainty -4±14% from 2006 to 2007 (Montake et al 2011) small drop of ~1 % $_{/year}$ in atmospheric methane. Nearly 90% of global CH4 sink because of oxidation by hydroxyl radical OH, Methanotrophic bacteria in soils (~4%), in the stratosphere with chlorine and atom oxygen radical (~3%) and sea salt-chlorine radicals (~3%) near marine boundary layer(Stafanie et al,2013). The tropical wetland or agricultural or a combination of both are causes of the rising global methane from 2008 onwards (bousquest et al 2006). Quantification of methane emissions is required for climate change mitigation plans, but the currently available inventories are highly uncertain (Saunois et al., 2020).

The present work is carried out to identify the local source and sink regions for atmospheric CH4 from GOSAT, GEOS-Chem model and, in-situ observations. Harmonic analysis of these datasets has been carried out to understand the seasonal, annual and, semi-annual variability in comparison with in-situ observations.

2. DATA AND METHODS

2.1 GOSAT

GOSAT was launched on 23rd January2009 by the Japanese Aerospace Exploration Agency (JAXA). It operates in the SWIR (shortwave infrared) at 0.76, 1.6, 2.0 micrometre sensitivity to the near surface(Buchwitz et al., 2015,Kuze et al., 2016). GOSAT has two types of instruments, TANSO-FTS and TANSO-CIA. TANSO-FTS(thermal and near infrared sensor for carbon observation- Fourier transform spectrometer) ha four bands, one is thermal IR channel from 5.5 to 14.3 micrometre remain three are spectral channels with 0.27/cm ,resolution at 0.76,1.6,2.0 micrometre (Kuze et al., 2009).In this study CH4 concentration near surface layer monthly using for period of 2010 and 2018 with 2.5^0 x 2.5^0 Spatial resolution form JAXA . The GOSAT L3 product available monthly average of 2009 to 2018 for Methane over a 2 x2.5 grid in HDF5.

Harmonic analysis of Gosat methane is show variability of different regions.The respective time series are fitted with annual and semi-annual harmonics through the LSP as in the following:

$$dCH4(t)=A_0+\sum_{i=1}^{2} A_i + cos\ cos\ (w_i t + \emptyset_i) + \epsilon$$

where A0 is the stationary component of the time series that represents mean climatology of dCH4; (A1, A2) and ($\emptyset_1$, $\emptyset_2$) terms respectively denote the amplitude and phase angle of annual and semi-annual harmonics; and ϵ is the perturbation/residual term. These annual and semi-annual harmonics together constitute the seasonal cycle and the residual is considered as the non-seasonal variability of the time-series composed of the intra-seasonal and the inter-annual variability.

3. RESULTS AND DISCUSSION

The global distribution of methane observed from GOSAT satellite based CH4 simulation for the period of January 2010 to December 2018 for monthly scale .The GOSAT and model CH4 show similar seasonal over the year and annual variation not apparent ,CH4 max observed in Sep and low concentration around June .Strong Seasonal variability of GOSAT based CH4 is observed during the study period as shown in Figure xx. In all seasons max concentration is observed in SEP-NOV (post monsoon) and low concentration observed in (pre-monsoon) MAR-MAY. The observed seasonal cycles are well in agreements to the earlier reports by various studies carried out. Large latitudinal variations are seen across the seasons with high concentrations along the equatorial regions and high variations are also observed in the regional scale. The observed pattern could be associated with large scale melting of ice and the release of sequestered CH4.

3.1 HARMONIC ANALYSIS

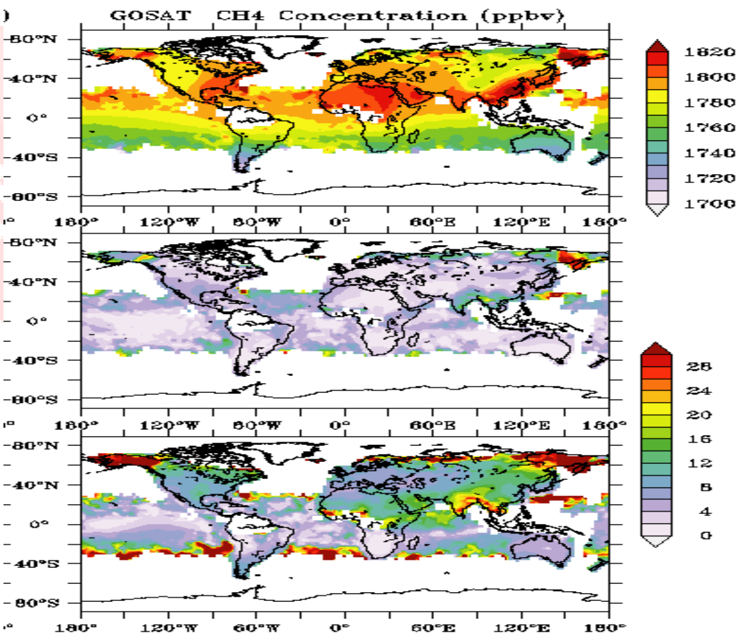

Figure 1 shows us upper panel is mean Climatology, lower is Annual and middle is Semi-annual amplitudes of Harmonic analysis of methane for GOSAT observation methane for the period of 2010-2018.

Harmonic analysis of GOSAT Atmospheric CH4 Concentration based CH4 Concentration is shown in Figure 1. High concentration of methane is observed along the equatorial region, East China,India. Moderate values are observed in Australia, South America, South Tropical Africa ,South Tropical Oceanic regions. Large values of Annual amplitudes are observed over Indian landmass and Arabian sea, China and oceans along the equatorial region .Whereas Europe, North America, North Tropical Africa, Australia show moderate annual amplitude values. High values of Semi annual amplitude of CH4 are exhibited over the Indian region, China and oceans along the equatorial region.

The major source of the oil and gas is Europe countries and North America .Major source of atmospheric methane in India is wetland rice fields(IRRI:2009).In India and south china region has high rice cultivation .In the World the large number of cattle's are available in India ,the total agricultural CH4 emissions nearly ~30% source from Livestock (sirohi and michaelowa,2007).the more livestock emission observe in India ,Europe , south china and South America and moderate values are observed in Africa and North America. Coal mining the major emission source countries are China ,India and North America. Waste soil and Rice cultivation has more in India and South China.

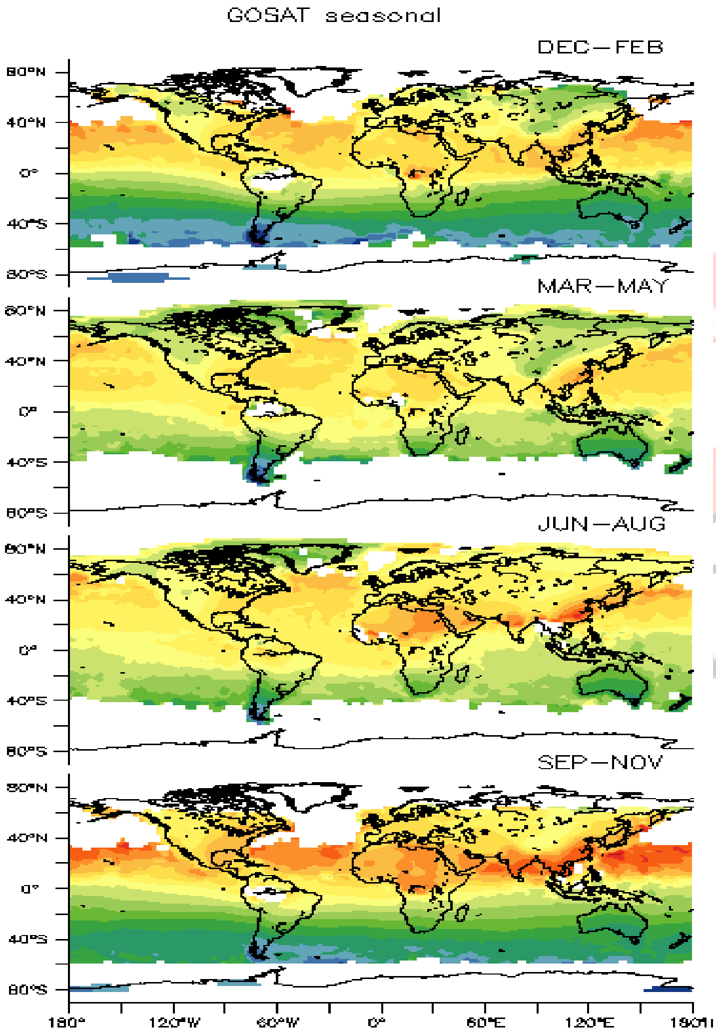

Figure 2 show us Seasonal variation of GOSAT observation of methane

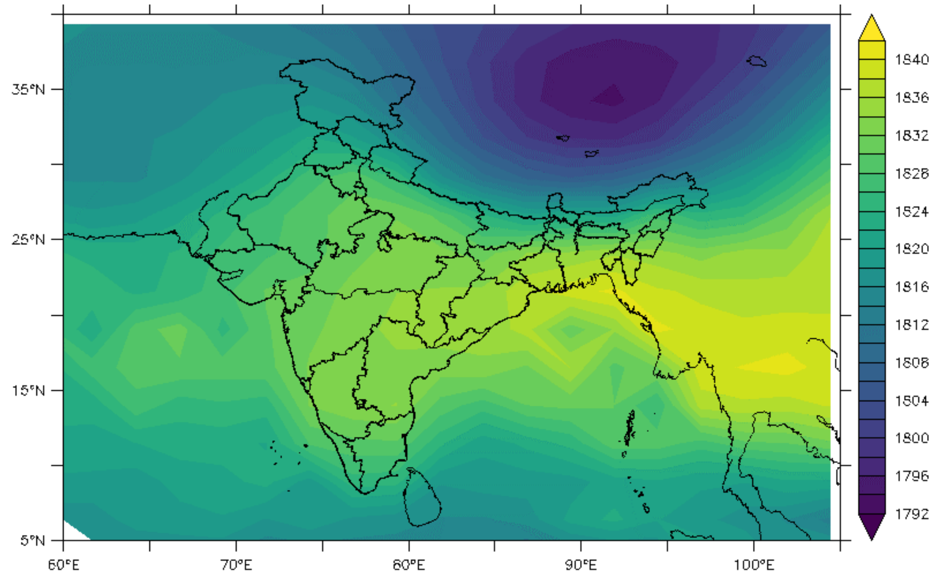

Figure 3 shows the annual climatology mean of atmospheric CH_4 of GOSAT observation

Figure 3 shows us the annual mean climatology of atmospheric surface CH4 over the Indian region . The higher concentration observed in eastern costal regions.GOSAT based Surface fluxes of methane high emission fluxes over India ,China , South tropical Africa and moderate fluxes over Europe , North America and South America (Figure 2).The table describes the surface fluxes of CH4 across different regions, with values along India (4.756 Tg y-1) and China (6.898 Tg y-1). Annual & Semi annual amplitudes of the surface fluxes show similar patterns of variability with small differences in the amplitude values across India, China and Central Africa.

Table1: show us flux emission from different regions(Tg/y)

Region	Total integral of FLUX in Tg/y	Mean value Tg/y
Indian	4.756	0.6280
China	6.898	0.5980
Europe	2.527	0.3983
Africa	4.106	0.2454
North America	4.341	0.2933
South Africa	3.592	0.3119

In the Fig 4 shows us comparison of the GOSAT CH4 with the in situ CH4.The Correlation Coefficient of determination between GOSAT- in situ and in situ is 0.8375 respectively. The satellite based CH4 showed reasonable agreement with the in situ data. Due to the limitation of openly available in situ based CH4 data, we had to restrict the comparison with only one location. We would further improve the model inputs and the simulated CH4 would be compared with more no of insitu data sets in our future studies

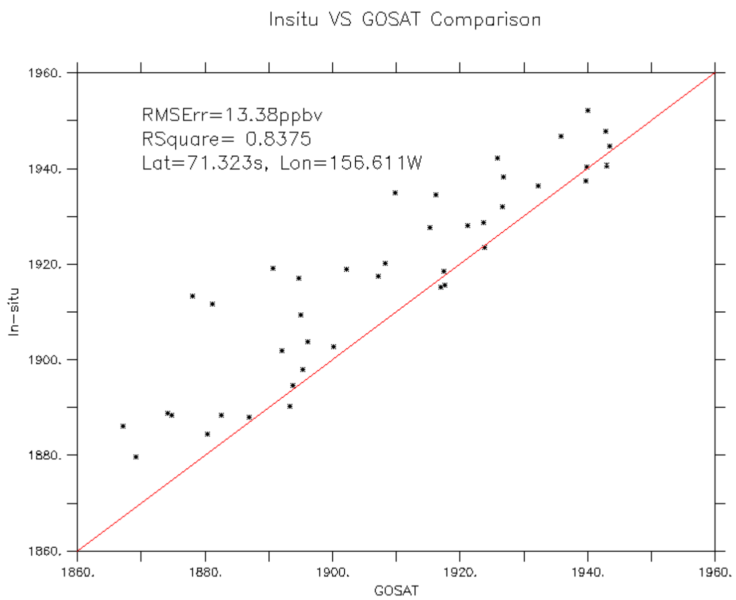

Figure 4 shows us a comparison between in situ and GOSAT

4 Discussion:

In this study , we have attempted to atmospheric CH4 over the Global . This is a preliminary study to understand the seasonal variability of CH4 based on satellite (GOSAT) observation .Harmonic analysis of the data shows that there is a significant semi-annual and annual variability of CH4. The seasonal variability is maximum in Sep-Nov period. Such behavior is exhibited due to the maximum contributions from the wetland emissions and rice cultivations. We have observed large emissions in the Asian regions of India and China because of the rice cultivation and high number of wetland regions present in these areas. This study is carried out based on the limited availability of input emission data and the analysis of the simulated output. We would like to extend this study to analyses the source/sink patterns in regional context with improved emission inventory.

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