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15.	**Abstract:** Planetary Boundary Layer Height (PBLH) over the Indian land mass is estimated using vertical profiles of temperature and relative humidity from Cross track Infrared Sounder (CrIS) onboard Suomi-NPP, through integration of five different methods. The integrated approach is performed by comparing PBLH values estimated from vertical gradients of potential temperature (PT), virtual potential temperature (VPT), relative humidity (RH), refractivity (N) and specific humidity (q). If at least three of them are consistent with the same value, it is considered as the PBLH. PBLH values estimated through the integrated approach show reasonable comparison with the estimates using radiosonde profiles and COSMIC GPS Radio Occultation measurements. Following the integrated approach, day time PBLH over Indian land mass is retrieved on daily basis and are further averaged for seven days and monthly mean values. **Key Words:** Planetary boundary layer height, Atmospheric boundary layer, Suomi-NPP, Cross track Infrared Sounder		

Abstract

Planetary Boundary Layer Height (PBLH) over the Indian land mass is estimated using vertical profiles of temperature and relative humidity from Cross track Infrared Sounder (CrIS) onboard Suomi-NPP, through integration of five different methods. The integrated approach is performed by comparing PBLH values estimated from vertical gradients of potential temperature (PT), virtual potential temperature (VPT), relative humidity (RH), refractivity (N) and specific humidity (q). If at least three of them are consistent with the same value, it is considered as the PBLH. PBLH values estimated through the integrated approach show reasonable comparison with the estimates using radiosonde profiles and COSMIC GPS Radio Occultation measurements. Following the integrated approach, day time PBLH over Indian land mass is retrieved on daily basis and are further averaged for seven days and monthly mean values.

Introduction

Planetary Boundary Layer (PBL) is the lowest part of troposphere, where significant transfer of energy, momentum, and mass between earth surface and atmosphere occurs (Stull, 1988; Hennemuth and Lammert, 2006). As expansion and contraction of PBL govern the surface level concentration of atmospheric constituents, planetary boundary layer height (PBLH) is an important parameter for PBL characterisation and also for evaluation of climate, weather and air quality models. Different methods are being employed for the determination of PBLH using different types of measurements (Davis et al., 2000; Seibert et al., 2000; Seidel et al., 2010). During daytime, strong convection leads to mixing up of atmospheric constituents in lower regions of atmosphere and creates large gradients in different atmospheric parameters and concentration of atmospheric constituents across boundary layer and free troposphere, which are being used for the determination of PBLH in several of the methods (Seibert et al., 2000; Wang and Wang, 2014). Since PBLH show strong spatial and temporal variability, depending on the surface and meteorological conditions, its determination over large regions with sufficient spatial and temporal resolution is essential for weather prediction and climate monitoring. In the present study, day time PBLH is estimated over the Indian land mass through an approach which integrates five different methods, which will be discussed in detail in the following section.

Data and Methodology

Estimation of PBLH is done using vertical profiles of temperature and relative humidity from Cross track Infrared Sounder (CrIS) onboard Suomi National Polar-Orbiting Operational Environmental Satellite System Preparatory Project (SNPP). SNPP orbits earth in a sun-synchronous near polar orbit at an altitude 824km and crosses the equator at 13:30LT in its ascending node (Powell and Weng, 2013; Han et al., 2013). SNPP-CrIS do measurements at 1305 spectral channels in shortwave IR(3.92-4.64μm), mid-wave IR (5.71-8.26μm) and long-wave IR (9.14-15.38μm) bands over a region covered with its wide swath of 2200km (Han et al., 2013; Wang et al., 2013). Large number of channels, high spectral resolution and high signal to noise ratio enable CrIS to provide atmospheric profiles at good vertical resolution at different pressure levels, which includes 18 levels in the lowest 5km region of the atmosphere.

Using temperature and relative humidity profiles from CrIS, PBLH is estimated through an integrated approach, which combines five different methods. PBLH is estimated as the

altitude of maximum vertical gradients in potential temperature (PT), virtual potential temperature (VPT) and of minimum vertical gradients in relative humidity (RH), refractivity (N) and specific humidity (q) (Ao et al., 2008; Basha and Ratnam, 2009; Seidel et al., 2010; Wang and Wang, 2014). Among these five estimates, if three or more are consistent with same value, it is considered as the PBLH. Only those profiles which are continuous, with measurements at all the levels from surface to two altitude levels above the PBLH, are considered for the estimates. All such profiles are smoothed, to reduce the effect of extreme values, by using a 1-2-1 smoother which gives 50% weightage to the value at a given level and 25% to the values at above and below levels (Wang and Wang, 2014). Following the integrated approach PBLH is estimated over the Indian land mass at a spatial resolution of 0.25°×0.25°.

In order to validate the estimates from CrIS soundings, temperature and humidity profiles from radiosonde ascends at ~17:30LT, over different locations of Indian land mass, which are available through the website of University of Wyoming (weather.uwyo.edu) are considered. In addition, comparison is done with the estimates using atmospheric profiles from Constellation Observing System for Meteorology Ionosphere and Climate (COSMIC) GPS Radio Occultation (RO) (Kursinski et al., 1997) measurements.

Results and Discussion

Following the integrated approach described in the methodology section, day time PBLH values are estimated over the Indian land mass on daily basis and are further averaged for seven day mean and monthly mean values. Figure1 depicts estimated PBLH values for a day (04 Jan 2015), (b) averaged for seven days (01-07 Jan 2015) and (c) monthly mean (Jan 2015). As it is shown in figure 1(c), shallow boundary layer is observed over central India during winter season, when the convection activity is weak. Compared to central India, PBLH is observed higher over southern peninsula and north-west India, where the values are found exceeding 1500m. Further analysis reveals significant temporal and spatial variability of PBLH over Indian land mass. PBLH is observed highest during pre-monsoon over most of the regions and shallow during winter, especially over central India (Prijith et al., 2016). Study also reveals decrease in PBLH during summer monsoon in response to heavy rainfall and associated changes in surface and atmospheric characteristics.

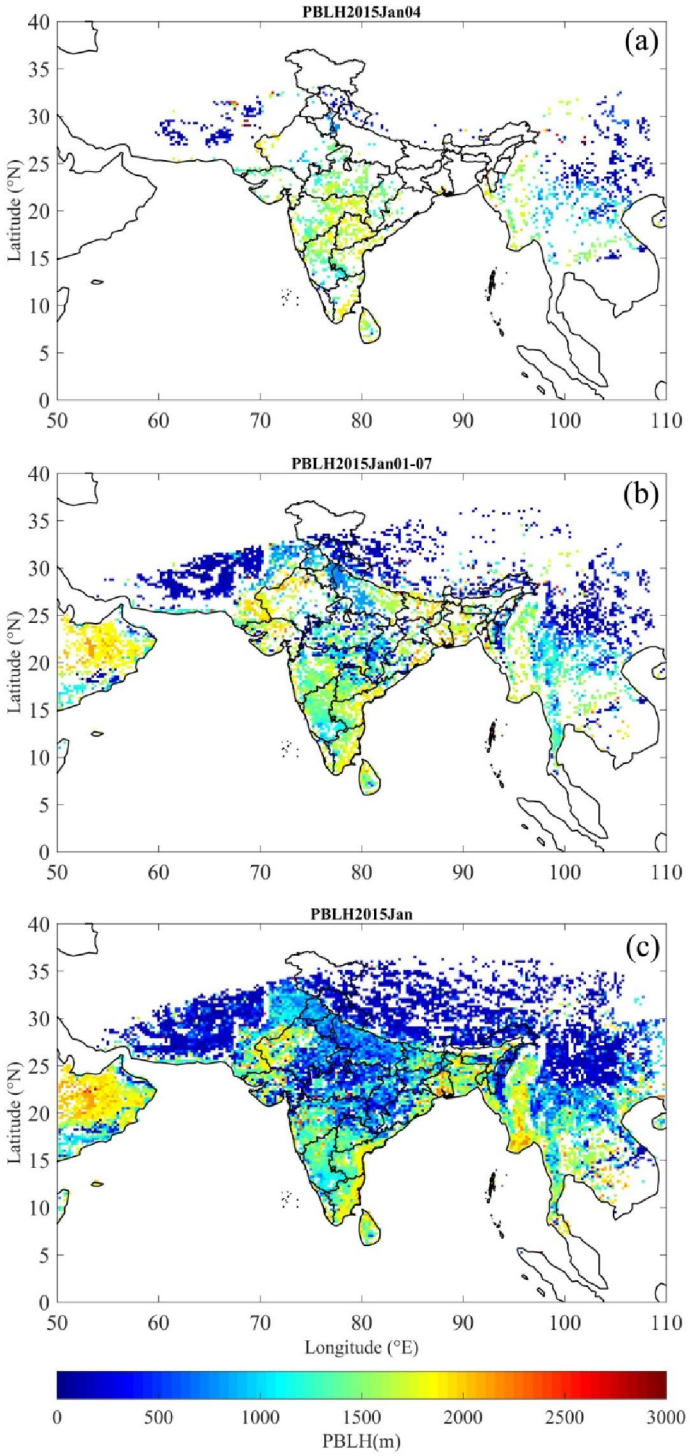

Figure1: (a) Daily (04 Jan 2015), (b) seven day averaged (01-07 Jan 2015) and (c) monthly mean (Jan 2015) PBLH, estimated through the integrated approach.

In order to perform the validation, PBLH values from SNPP-CrIS soundings are compared with the estimates using radiosonde profiles and COSMIC RO retrievals, by considering the profiles which are not separated by more than 25km from the locations of CrIS profiles. The

analysis is carried out using radiosonde ascends in the evening time at ~17:30LT and RO profiles between 13:30 and 16:30LT.

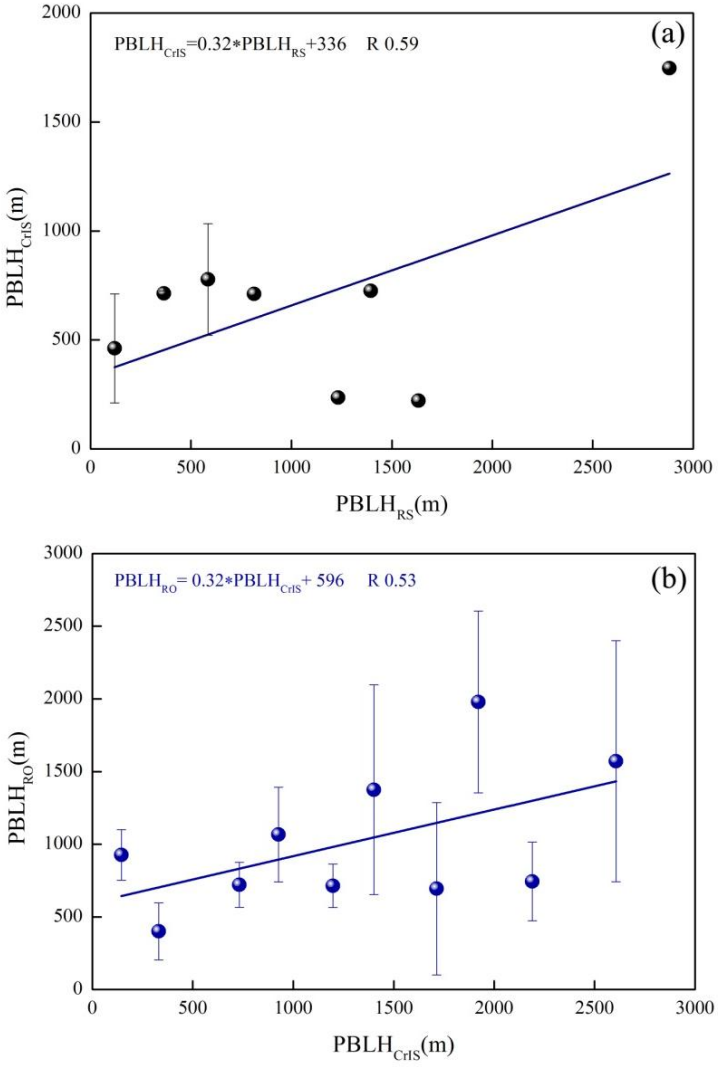

Figure2: Correlation and regression relation between PBLH estimated from (a) radiosonde profiles and CrIS soundings and (b) CrIS and radio occultation retrievals.

Figure 2(a) and 2(b) show correlation and regression relations of estimated PBLH from CrIS soundings with those from radiosonde and RO measurements respectively. PBLH estimates from CrIS show considerably good agreement with the values obtained using radiosonde profiles and RO retrievals. Correlation coefficient between the estimates using CrIS and radiosonde profiles is 0.59, whereas it is 0.53 between the estimates using CrIS and RO measurements. From the regression analysis with the estimates using radiosonde profiles, PBLH values from CrIS are observed to be overestimated at lower values and under estimated at higher values. In general, PBLH from CrIS is overestimated by ~336m, in comparison with the radiosonde based estimates. This could be partly due to the difference in

time of observation. CrIS measurements over the Indian region are in the afternoon hours, when the convection activity and hence the boundary layer height peaks, whereas the radiosonde ascends are in evening at ~17:30LT as mentioned. In addition, coarse spatial resolution of satellite measurements in comparison with radiosonde measurements at specific locations also might have contributed in the observed differences in PBLH. Compared to the values from CrIS, PBLH from RO shows an over estimation, less than 600m. This could be mainly due to the lack of retrievals by several of the RO signals at altitudes below ~500m (Ao et al., 2008; Xie et al., 2012).

Conclusion

Day time planetary boundary layer height over the Indian land mass is estimated using vertical profiles of temperature and relative humidity from CrIS onboard Suomi NPP. The methodology followed an integrated approach, which combines the estimates through five different methods. PBLH from CrIS show good agreement with the estimates using radiosonde and COSMIC RO profiles. PBLH values are estimated on daily basis and further averaged for seven day and monthly mean values over the Indian land mass. PBLH shows strong seasonal variability with highest values during pre-monsoon over most of the regions. During winter, boundary layer is observed shallow, especially over central India. In response to heavy rainfall and associated changes in atmospheric and surface characteristics, decrease in PBLH is observed during summer monsoon.

Description of Data

FileName (Daily) :NNNNYYYYMMDD (N- Parameter, Y-Year, M-Month, D-Date)
FileName (Monthly) :NNNNYYYYMM
FileName (7dayMean):NNNNYYYYMMDD-DD
Geographic Coverage : 05°N -40°N; 50°E-110°E
Unit :Meter
Spatial Resolution :0.25°×0.25°
Temporal Resolution :Daily, 7day and Monthly
File Format (Data) :NetCDF
File Format (Image) :JPEG

Citation

Please do cite the usage of this data as ‘The data were obtained from the National Information System for Climate & Environment Studies (NICES) portal of National Remote Sensing Centre, ISRO’.

Link: http://nrsc.gov.in/nices2/

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