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Satellite derived profile validation

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Abstract:

Satellite data provides the information of data sparse regions which is inaccessible by any other methods. Conventiona measurement of vertical temperature and moisture profiles is done by radiosonde measurements. This is an expensive point observation and sensitivity affected in bad weather conditions and limited twice a day (0000 & 1200 UTC) Remote sensing measurements through satellite also provides an estimate of vertical temperature and moisture profiles ir a cost effective and continuous coverage in all weather conditions in larger domain at hourly basis. Profile estimatior through satellite provides layer average as per the resolution of sounder on board on the satellite. In this paper authors validated the accuracy of National Oceanic and Atmospheric Administration (NOAA) satellite derived profiles by conventional (in-situ) measurements. The results are with close proximity with the in –situ observations. The validatec profiles are further utilized by regional and global weather prediction models.

Key Words: UTC (universal time coordinates), NOAA (National Oceanic Atmospheric Administration), satellite radiosonde and validation.

Introduction

Atmosphere is composed of different layers like troposphere, stratosphere, mesosphere and exosphere based on the thermal structure. The troposphere is heated from below by latent heat, longwave radiation, and sensible heat. Kaplar (1959) proposed that the vertical distribution of temperature in the atmosphere could be determined globally by measuring from satellite as a function of wavelength .The thermal emission of various bands of atmosphere like 15um oi carbon-di-oxide (Co2 band) along with Ozone (O3) & Water vapor (H2O) is the key of profiles of temperature anc moisture by remote measurements. Earlier works for the retrieval of profiles through atmospheric remote sounding via satellite were developed by Wark (1961) and Yamamoto (1961). Temperature retrieval from satellite is sensitive for the transmittance of each layers in the atmosphere and a function of mixing ratio of the absorbing gases. Carbon dioxide oxygen are well mixed gases and there mixing ratio is indendent of height. The Water vapor is variable with time anc space. The weighting contribution of each layer is determined y the weighting function of the layers in a particulai spectral band. The retrieval of temperature can be solved by solving the radiative transfer equation (RTE) or by statistical retrieval (based on the large radiosonde data base) or by hybrid retrievals. This is all accompanied by the software program made by university of Wisconsin in International TOVS Processing Package (ITPP). Polar-orbiting satellites derived profiles have another distinct advantage over geostationary satellites as they are able to observe the earth-atmosphere system with microwave sensors. Microwaves penetrate clouds that would otherwise block the satellite's view of the atmosphere as occurs with visible and infrared observations. Microwave remote sensing allows us to probe the interior of clouds and see both the atmosphere and surface below. Microwave sensors operate day and night as do infrared sensors, and in nearly all weather conditions. Satellite derived sounding products are validated by various authors ion the past (J. wang et al, 2013, Singh et al, 2002, 2003)

Data and Methodology

The data is processed with International ATOVS Processing Package (IAPP) developed by University of Wisconsin USA for the retrieval of atmospheric temperature and moisture profiles, total ozone and other parameters in both clear and cloudy atmospheres from ATOVS radiance measurements. The IAPP algorithm, which operates on NOAA-15 and later data, retrieves the parameters in 4 steps: 1) cloud detection; 2) bias adjustment; 3) regression retrieval; and 4) nonlinear iterative physical retrieval. There are various ways of retrieving the vertical profiles of temperature from satellite measurements. In general, the idea is to know the radiation transfer at different layers in the atmosphere. This involves the contribution from the surface as upwelling radiation and direct emission of various layers of the atmosphere which depend the transmittance of different layers in the atmosphere depending on the concentration of the absorbing gases in the atmosphere. In microwave region, the reflected downward atmospheric emission also plays an important role and that is why emissivity of the surface plays a significant role. All the elements related to vertical satellite sounding said above is shown below as radiative transfer equation.

$$I_\nu(p=0)=\varepsilon_\nu.B_\nu(T_s).\tau_\nu(p_s\rightarrow 0)+\int_{p_s}^{0} B_\nu[T(p)].\frac{\partial\tau_\nu(p\rightarrow 0)}{\partial p}.dp+(1-\varepsilon_\nu).\tau_\nu(p_s\rightarrow 0).\int_{0}^{p_s} B_\nu[T(p)].\frac{\partial\tau_\nu(p\rightarrow p_i)}{\partial p}.dp$$

First term in the above equation shows upwelling radiance from surface depends on emissivity (ε_ν). Second term is the direct atmospheric emission, which depends Plancks function ($B_\nu[T(p)].$) and weighting function ($\frac{\partial\tau_\nu(p\rightarrow 0)}{\partial p}$) and the last term represents the reflected downward atmospheric emission. The transmittance (τ_ν) of each layer affected by the concentration of the absorbing gases, at different layers in the atmosphere and behave differently with season and time. The data is taken from India meteorological Department Lodi road New Delhi as HDF (Hierarchical Data Format) and extracted layer wise through software program which coded in JAVA language. For comparison conventional data (radiosonde) file is made collocated with the satellite derived profiles of temperature at various pressure levels. For validity the temporal, spatial & vertical difference is taken ± 2 hours, ±50 km and ±50 hPa respectively.

Results and dissections

The vertical in-situ profiles of radiosonde data have high vertical resolution along with limited spatial sampling and calibration problems with changing instruments and methods. While satellite borne instruments measures the radiance of earth at microwave frequencies to deduce the temperature of thick atmospheric layers. Satellite derived profiles provides high sampling and coarse vertical resolution. The figure 1 below shows the global radiosonde work which provides the direct profiles of temperature as an in-situ observation. But this network is limited and provides twice a day the profiles of temperature. Keeping in mind the accuracy of satellite derived profiles is necessary to evaluate. Time varying biases that need to removed to the extent to assess climate trends in radiosone and satellite data (Mears et al 2012).

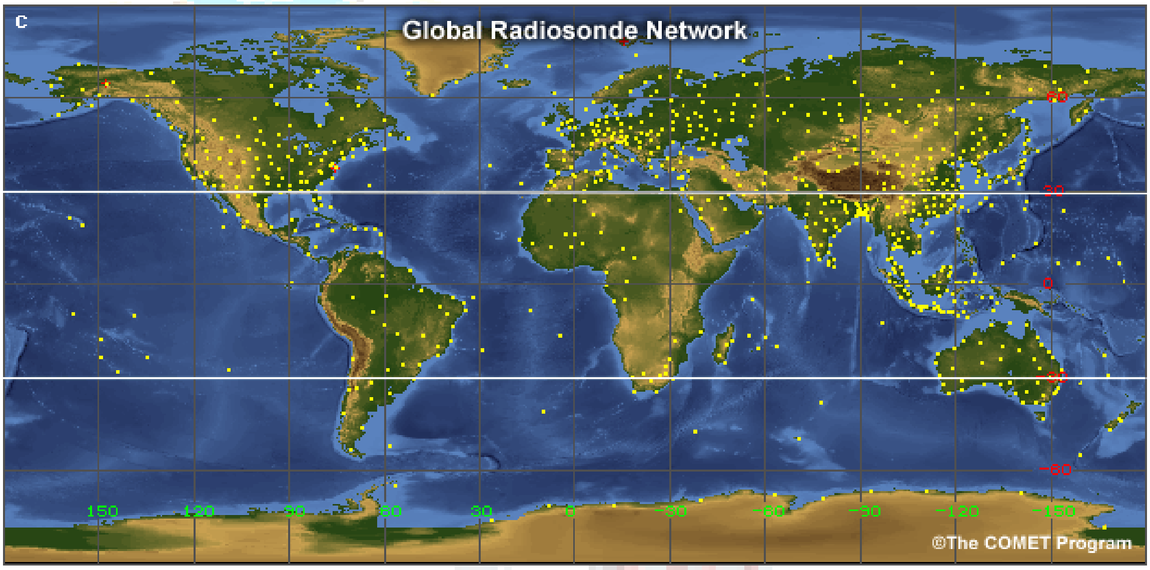
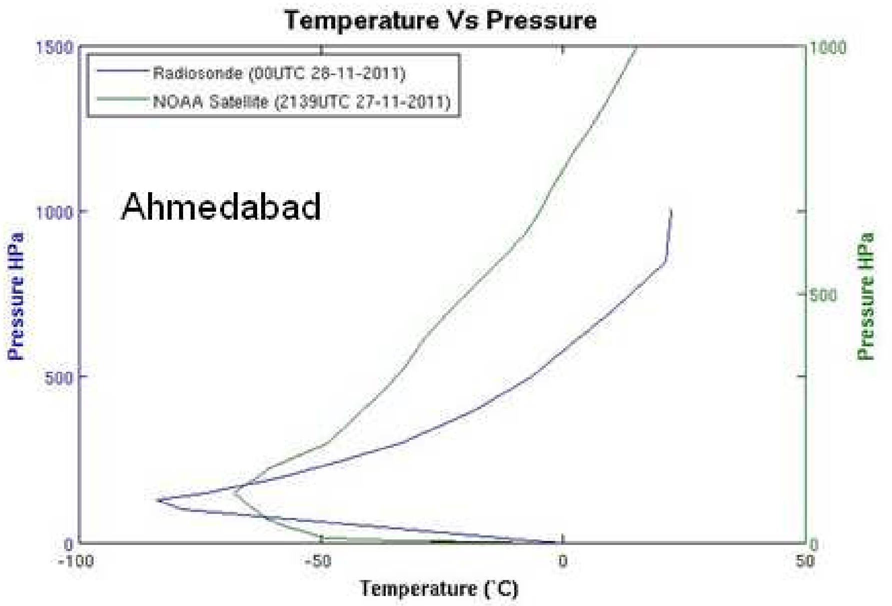
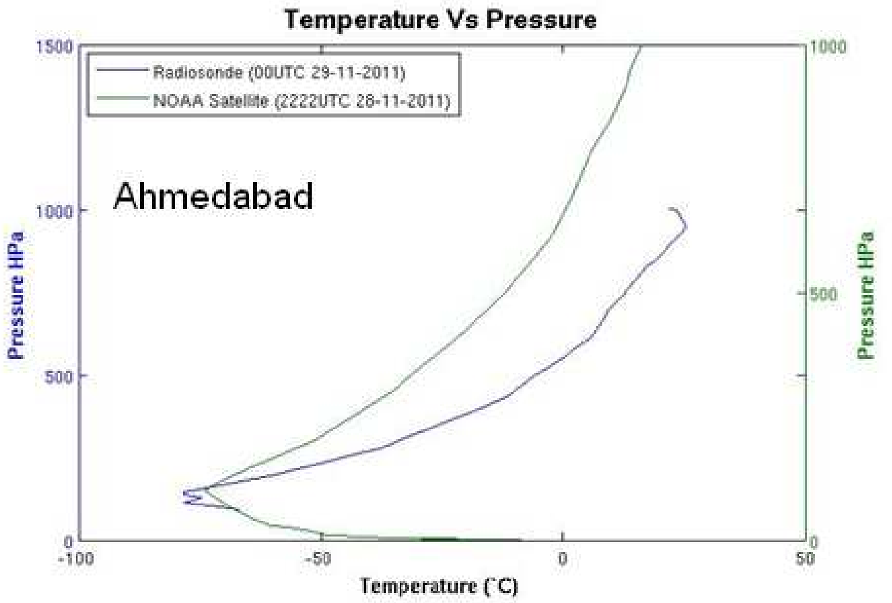


Figure 1: Global Radiosonde Network

The collocated radiosonde and satellite derived profiles are shown in Figs 2 to 6 (a to j) for 27 and 28 November, 2011 passes. The nearest radiosonde profile is selected as per the criteria said above and validated. The stations selection is based on the coverage of the NOAA (National Oceanic Atmospheric Administration) satellite passes. The retrieval accuracy is affected in cloudy areas. This is shown in the case of Ahmedabad temperature profiles. The retrieval in cloud frees areas matches significantly well. The root mean square error (RMSE) and BIAS for 5 stations is shown in table (1) Satellite retrieval has advantage that it is available every time (for Geo satellites), twice a day for Polar satellites and in bad weather condition also. It is cost effective and maintenance free and the information can be utilized better in Numerical Weather Prediction Models to enhance the forecasting accuracy.



(a)



(b)

Figure 2: Temperature profiles of Ahmedabad retrieved from NOAA satellite and Radiosonde (a) 27-11-2011 (b) same but 28-11-2011 NOAA satellite passes

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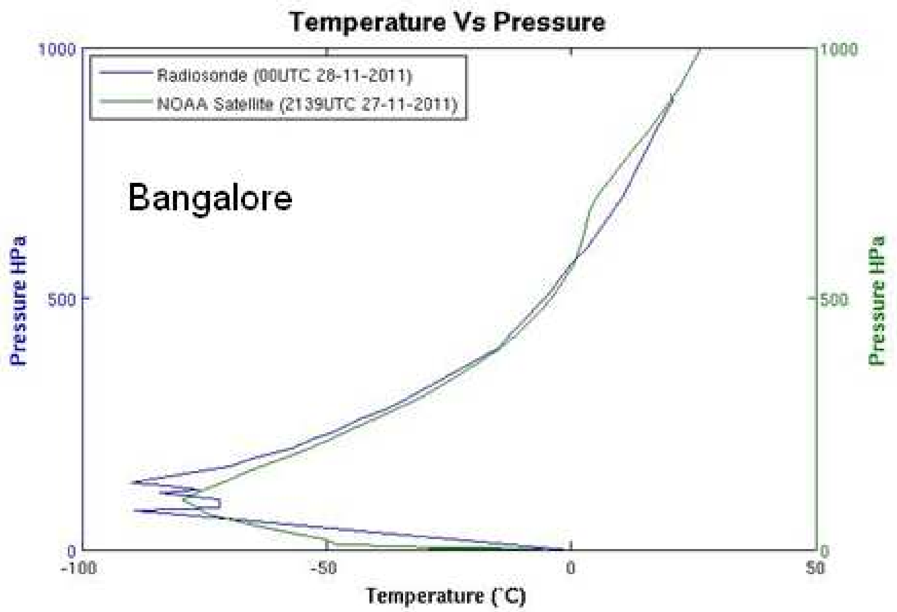

(c)

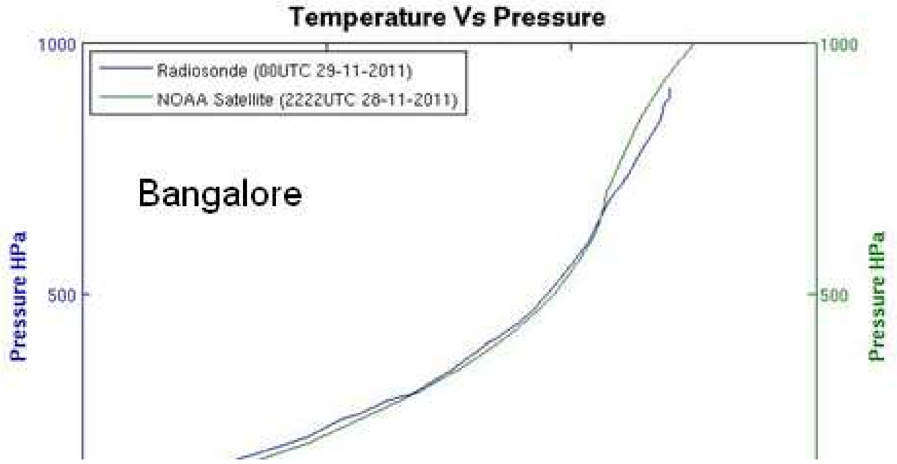

Figure 3: Temperature profiles of Bangalore retrieved from NOAA satellite and Radiosonde (c) 27-11-2011 (d) same but 28-11-2011 NOAA satellite passes

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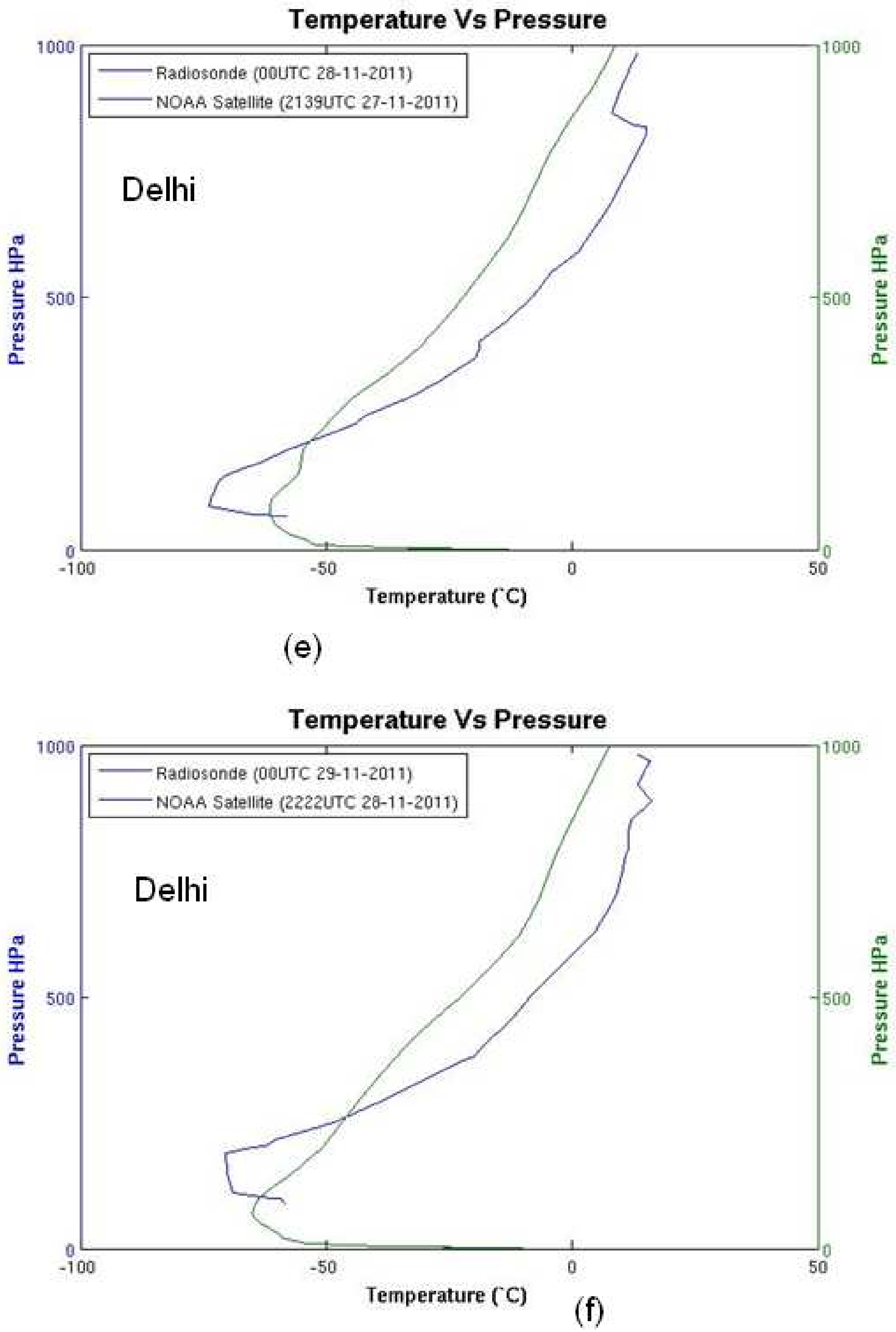


Figure 4: Temperature profiles of Delhi retrieved from NOAA satellite and Radiosonde

(e) 27-11-2011 (f) same but 28-11-2011 NOAA satellite passes

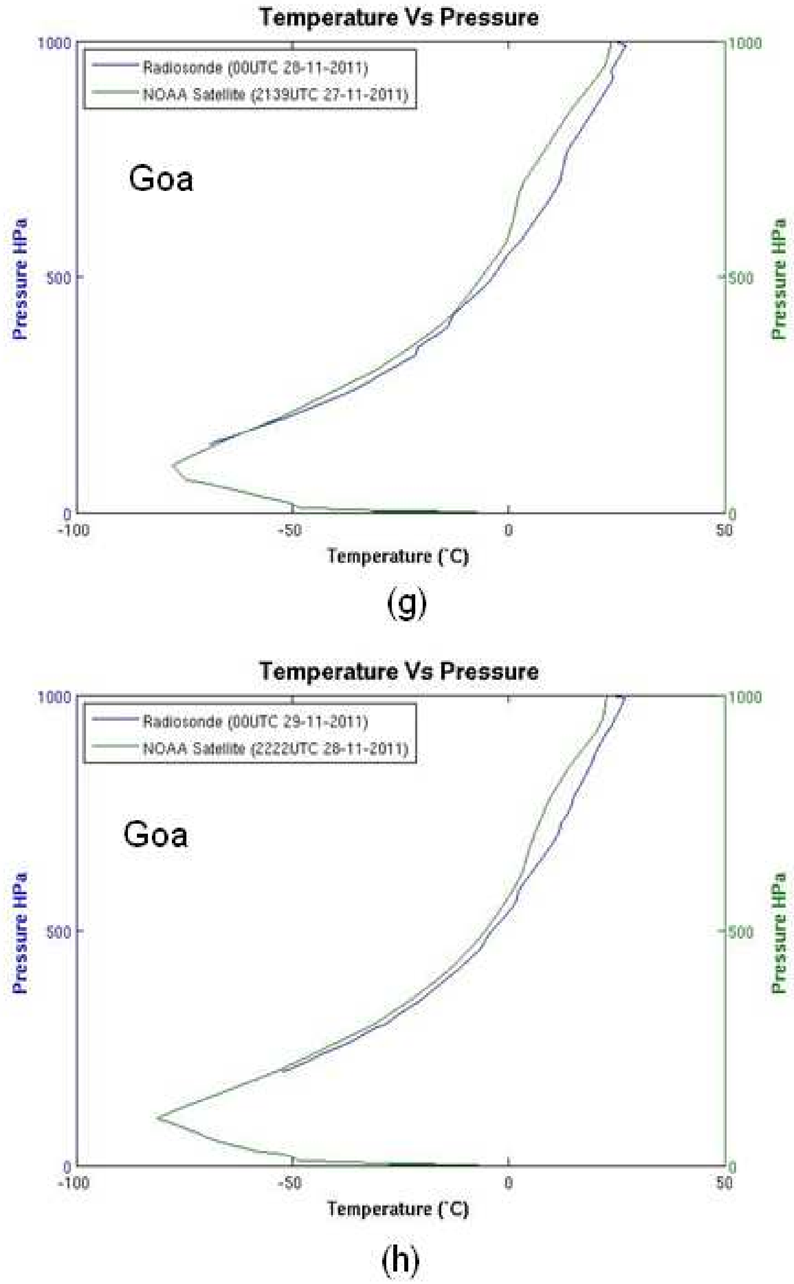
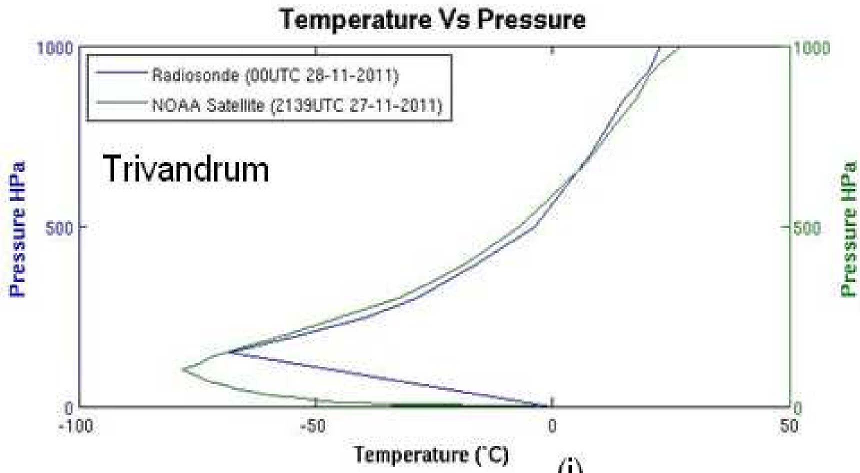
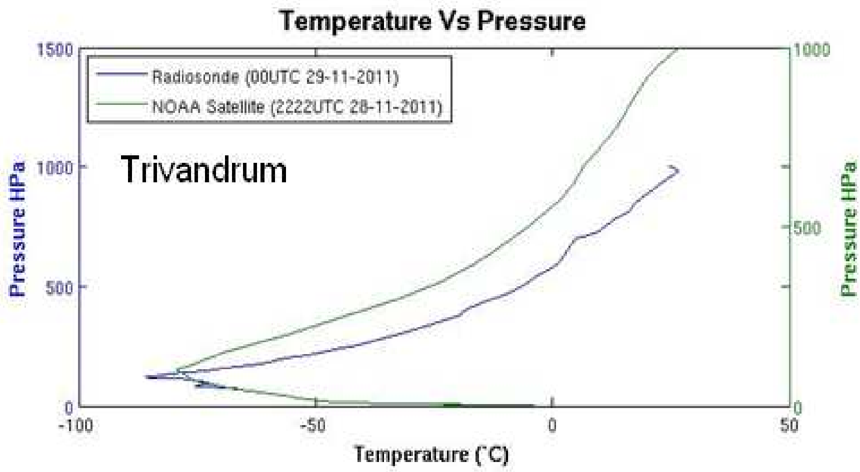


Figure 5: Temperature profiles of Delhi retrieved from NOAA satellite and Radiosonde

(g) 27-11-2011 (h) same but 28-11-2011 NOAA satellite passes



(i)



(j)

Figure 6: Temperature profiles of Trivandrum retrieved from NOAA satellite and Radiosonde

(i) 27-11-2011 (j) same but 28-11-2011 NOAA satellite passes

Table 1: Error analysis (Root Mean Square Error & Bias)

Station name	RMSE Degree C	Bias (Radiosone –Noaa satellite) Degree C
Ahmedabad	8.65	9.23
Bangalore	3.28	-2.18
Delhi	6.78	7.16
Goa	2.34	2.65
Trivandrum	3.20	-2.46

Conclusion:

Temperature profiles retrieved by the satellite are matches well with the conventional measurements. The retrieval results are evaluated by computing the bias and root mean square (RMS) difference between retrievals and collocated Radiosonde sounding profiles. Retrieved Temperature profiles from satellite show both warm and cold bias against the radiosonde data. Information of temperature and moisture distribution in the vertical atmosphere is useful in Aviation meteorology, synoptic forecasting and numerical modeling; Radiosonde instruments provide sounding information over limited land areas, while vast oceanic areas are void of this data. Validation is a crucial exercise due to the radiosonde has geo-location errors (Schmidlin and Evanov 1998) Satellite based retrieval have some limitation like in cloudy regions its accuracy is less. Satellite retrieval provides 10-km average measurements in the horizontal while radiosonde observations are single-point measurements that are far apart. Similarly, Geo –satellite (like INSAT -3D) provides a relatively high, hourly temporal resolution compared to the conventional 12-hour radiosonde observations. The timely information from the INSAT sounder can improve mesoscale analysis and nowcasting of severe weather if used to diagnose the pre-convective environment (for example, moisture gradients and boundary layer cold pools) before significant cloud formation.

References

1. Junhong Wang, Terry Hock, Stephen A. Cohn, Charlie Martin, Nick Potts Tony Reale, Bomin Sun, and Frank Tilley , 2013, " Unprecedented upper-air dropsonde observations over Antarctica from the 2010 Concordiasi Experiment Validation of satellite-retrieved temperature profiles" GEOPHYSICAL RESEARCH LETTERS, VOL. 40, 1–6, doi:10.1002/grl.50246.

2. Kaplan, L.D. (1959). "Inference of atmospheric structure from remote radiation measurements", J. Opt. Soc. Am, 49, 1004

3. Mears, C. A., F. J. Wentz and P. W. Thorne, (2012). "Assessing the Value of Microwave Sounding Unit-Radiosonde Comparisons in Ascertaining Errors in Climate Data Records of Tropospheric Temperatures", J. Geophys. Res. 117(D19), D19103, doi:10.1029/2012JD017710.

4. Schmidlin, F.J and Evanov, A, 1998, "Radiosonde relative humidity performance: The WMO intercomparison, American Met Soc, USA, 59, 257.

5. Singh, Devendra, Bhatia, R.C,Srivastav, S.K, SantPrasad and Mukherjee, S.K., 2002, “Validation of Atmospheric temperature profiles using neural network from AMSU –A measurement onboard NOAA-15 & NOAA -16 satellite and their applications for tropical cyclone analysis” 12th International TOVA/ATOVS workshop Lone Australia.

6. Singh, Devendra, Rao, Y.V, Bhatia, R.C,Srivastav, S.K, SantPrasad and Mukherjee, S.K., 2003, “Recent improvements in temperature and moisture profiles usinf NOAA satellite AMU data and their impact on NWP model over India region” 13th International TOVA/ATOVS workshop Queback Canada.

7. Wark, D.Q. (1970). “On indirect temperature soundings of the stratosphere from satellite”, J. Geophysics, Res. 66, 77.

8. Yamamoto, G. (1961), “Numerical methods for estimating the stratospheric temperature distribution from satellite measurements in the CO_2 band”, J. Met; 18, 581.

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