# LAND SURFACE EMISSIVITY ESTIMATION AT 89 AND 150 GHz FROM AMSU-B MEASUREMENTS

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## Abstract.

Most of the works on estimation of land surface emissivity from satellite radiometric measurements are performed at the frequencies ≤ 100 GHz in the past two decades [1-3]. In the frequency range of AMSU-B (89-183 GHz) the land surface emissivity problems draw attention from scientific community recently mainly because of difficulty associated with precipitation retrievals over land. For liquid precipitation, unlike the ocean areas, the lack of radiometric contrast between land surface and lower atmosphere in the frequency range of 10-37 GHz presents a serious problem for reliable rain rate retrievals [4]. As a consequence, rain rate retrievals over land have to rely on surrogate scattering signals at high frequencies, which originate mainly from storm-associated frozen hydrometeors aloft above the freezing level. For solid precipitation (snowfalls), scattering signals from AMSU-B measurements have been used to retrieve snowfall rate in recent years [5-6]. In both cases, a priori knowledge of surface emissive properties is essential to accurate and reliable precipitation retrievals over land.

In this paper, we focus on estimation of land surface emissivity at 89 and 150 GHz from AMSU-B measurements on January 21, 2007, around 1130 UTC, over an 400 km by 400 km area centered around the C3VP (Canadian CloudSat Calipso Validation Project, 44.23°N, 79.87°W) site under a clear-sky condition. The Goddard WRF (Weather Research and Forecast) modeled atmospheric temperature, humidity and cloud profiles, as well as surface temperatures [7] are used to aid this estimation; these data sets are modeled in hourly intervals and at a spatial resolution of 1 km. Two methods are explored: (1) estimation based on AMSU-B 89 and 150 GHz measurements and WRF-modeled parameters alone, and (2) estimation based on AMSU-B measurements, WRF-modeled parameters, and additional matching with AMSU-B 183 GHz measurements for a more realistic atmospheric condition at the time of the AMSU-B pass. In both methods,

a simplified single-layer atmospheric radiative transfer model characterized by effective atmospheric temperature $T_a(\nu,\theta)$ and optical depth $\tau(\nu,\theta)$ is employed:

$$\begin{aligned} T_b(\nu,\theta) &= T_a(\nu,\theta)\cdot(1-\Gamma(\nu,\theta)) + T_{CB}\cdot(1-e(\nu,\theta))\cdot(\Gamma(\nu,\theta))^2 \\ &\quad + [e(\nu,\theta)\cdot T_s + (1-e(\nu,\theta,))\cdot T_a(\nu,\theta)\cdot(1-\Gamma(\nu,\theta))]\cdot\Gamma(\nu,\theta) \qquad (1) \end{aligned}$$

where $T_b(\nu, \theta)$ is AMSU-B measured brightness temperature at frequency $\nu$ and observational angle $\theta$, Ts is surface temperature, $e(\nu,\theta)$ is surface emissivity, $T_{CB} = 2.7$ K is the cosmic background radiation, and the absorption factor $\Gamma(\nu,\theta) = e^{-\tau(,\nu\theta)}$. Both $T_a$ and $\tau$ can be readily calculated from the WRF-generated temperature, humidity, and cloud liquid profiles. Because we are dealing with AMSUB measurements with mixed vertical and horizontal polarization, the polarization state of both $T_b(\nu,\theta)$ and $e(\nu,\theta)$ is omitted. The application of the above equation implicitly assumes a specular reflection from a flat, smooth surface. When a surface is not completely smooth and Lambert scattering needs to be considered, the up-welling and down-welling atmospheric radiations have to be treated separately, as described by Matzler [8].

The results of estimation from both methods are compared and discussed. In general, the $e(\nu,\theta)$ values estimated by the second method are slightly higher than those estimated by the first method, with an average difference of 0.003 at both frequencies, when cloud liquid profiles are not included in calculations of $T_a(\nu,\theta)$ and $\tau(\nu,\theta)$. When cloud liquid profiles are included, the average difference between the two methods becomes 0.013. There is little difference in the estimated $e(\nu,\theta)$ values using the second method whether the cloud liquid profiles are included or not. In the first method of estimation, inclusion of cloud liquid profiles lowers the $e(\nu,\theta)$ values by an average of about 0.010. For validation, the estimated $e(\nu,\theta)$ values for the surrounding lake waters are compared with the results of emissivity calculations based on fresh water complex dielectric models [9-11], which suggest an estimating accuracy on the order of 0.01. This assessment does not take into account the uncertainty associated with the use of the modeled $T_s$ values, which could well be the major source of error in the $e(\nu,\theta)$ estimation. The effect of rough-surface Lambert scattering has also been explored at these frequencies, and the results will be briefly discussed.

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