A GENERALIZED NEURAL NETWORK FOR SIMULTANEOUS RETRIEVAL OF ATMOSPHERIC PROFILES AND SURFACE TEMPERATURE FROM HYPERSPECTRAL THERMAL INFRARED DATA

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Atmospheric profiles, Land Surface Temperature (LST) and Land Surface Emissivity (LSE) are all key variables controlling biospheric processes and heat exchange between the Earth's surface and its atmosphere, and they are important parameters to be known for many applications, such as agrometeorology, climate, environmental studies, and numerical weather prediction. These land surface and atmospheric parameters can be observed from the ground observation or the radiosonde network. However, the coarse spatial resolution of these observations, which is impossible to capture the fine spatial distribution of surface temperature and atmospheric profiles, do not meet the demands of many disciplines, such as the weather analysis, data assimilation and so on. Fortunately, the satellite can monitor the surface and atmospheric conditions with high spatial and temporal resolutions covering the whole world. In this case, the LST, LSE and atmospheric profiles retrieved from satellite are important for those applications and can be a strong support and promotion on the development of the related disciplines [1]. However, the number of unknowns is always more than that of the observations, making the retrieval unstable and underdetermined. To solve this problem, on the basis of various assumptions, LST, LSE and atmospheric profiles are generally retrieved separately. The shortcoming of this approach is evident. Firstly, from the atmospheric radiative transfer equation, the LSE, LST and atmospheric transmittance, which is affected by atmospheric temperature and the amount and vertical distribution of moisture and other absorption gases, are coupled together. To retrieve these parameters separately, some assumptions on the variables that we do not concern about are needed. Secondly, *a-prior* assumptions are not entirely consistent with the actual facts. For example, when we retrieve atmospheric profiles from the observations, the surface is commonly assumed as a blackbody. Obviously, this can not be true, and the effect of the LSE will have impacts on the results. Therefore, to overcome this problem, it could be an appreciative way to retrieve these parameters simultaneously [2-5].

However, to carry out this work, it demands the sensor with numerous bands and high spectral resolution. The spectral resolution affects the broadness of the contribution functions. The higher the spectral resolution is, the narrower the contribution function is. The satellite receives energy emitted from a thin layer of the atmosphere if the contribution functions are narrow, and vice versa. Besides, the satellite observed data can be regarded as a function of the LST, LSE, atmospheric temperature profile, O_3, H_2O, and other minor constituents. Thus, an accurate retrieval needs enough observation bands. Otherwise, less observed bands may leads to larger RMS errors [6].

Nowadays, the hyperspectral thermal infrared data can be acquired by many sensors, and these data provide us the opportunity to accurately retrieve land surface and atmospheric variables. In our previous paper, a neural network is established [7]. That network can be thought as a 'local' net because the training data set was made by a specified type of atmospheric conditions (tropical atmospheric profiles). In this paper, Further work has been done. We simulated the at-sensor thermal infrared hyperspectral data using the atmospheric profiles selected from the TIGR database as the free-cloud situations including the tropical, mid-latitude and polar atmospheric conditions with the supports of JHU surface material emissivity library and the 4A/OP radiative transfer model. We considered different combination of atmospheric profiles, surface temperature and emissivity encountered in the real world. Because the number of bands for the hyperspectral data is too large, the principal component analysis was employed to compress and de-noise the raw data. As the magnitude of different parameters is different, first, all those data were normalized and weighted, then, the simulated radiances at-sensor together with the corresponding atmospheric and land surface parameters were put into the neural net established elaborately, where the structure and topology of the net was tested a priori.

After the net was trained by these simulated data, it could be employed to retrieve atmospheric profiles and LST. Fig. 1 and Fig. 2 are the results of LST and atmospheric profiles. The net that we established performed better on temperatures, e.g. the surface temperature and atmospheric temperature, than other parameters. For LST (Fig. 1), the retrieval errors were mostly within 1K with only few exceptions. For the temperature profiles of atmosphere (Fig. 2 (a)), the RMSE was around 2K near the surface. It was near 1K in 600 hPa, but the error increased as the altitude increased. The accurate of other parameters was inferior to that of temperature. As shown in Fig. 2(b), the RMSE of profile of moisture was at the same magnitude of their value. There may be several reasons. Firstly, it should be noted that this net was trained using atmospheric profiles varied at a large range. Secondly, the at-sensor radiance may be affected by the temperatures, both surface temperature and atmospheric temperature, more than other parameters.

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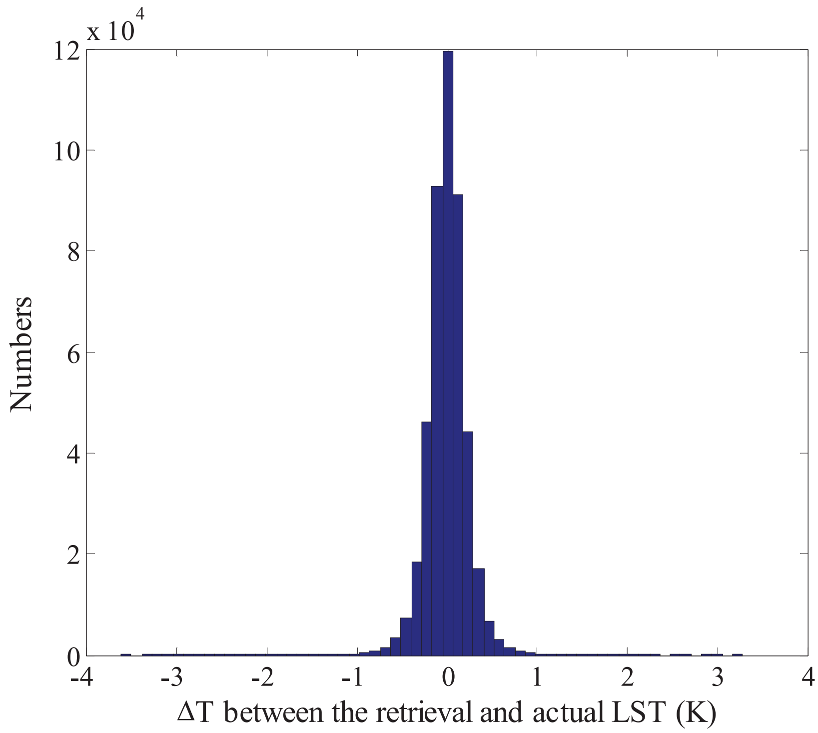

Fig. 1. Retrieval results of LST

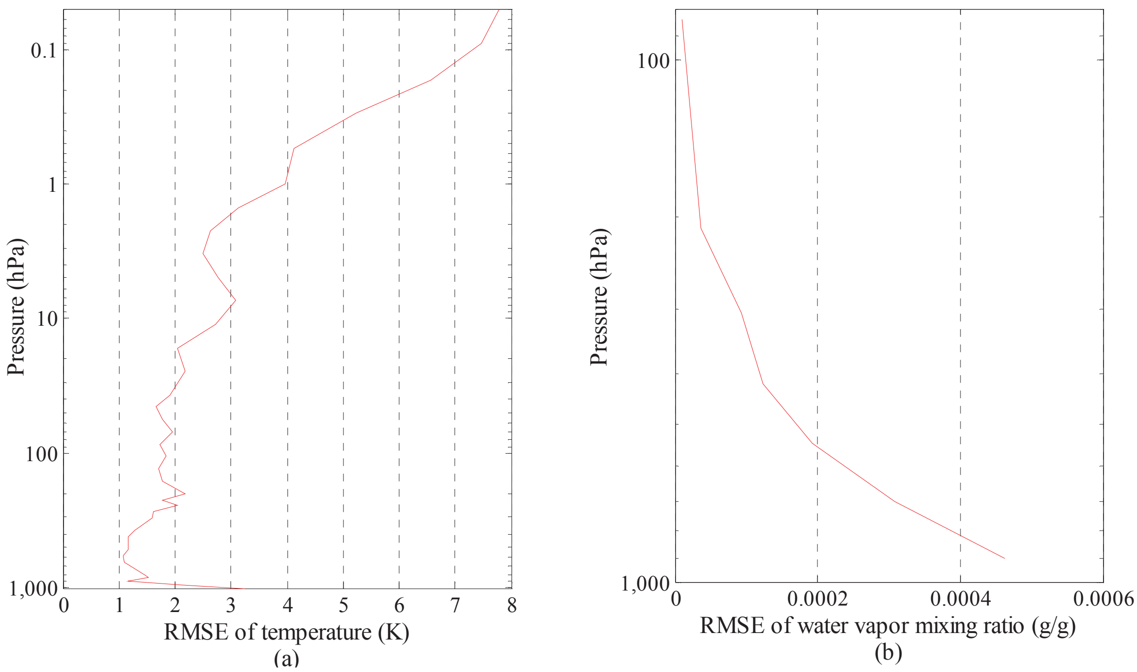

Fig. 2. Retrieval results of atmospheric profiles of temperature and moisture. (a) RMSE of temperature profiles. (b) RMSE of water vapor mixing ratio profiles.