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Surface emissivity retrieved from satellite IR hyperspectral data and its impact on other retrieval products

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INTRODUCTION

The surface emissivity affects thermodynamic parameters (e.g., surface skin temperature, atmospheric moisture, and temperature) retrieved from satellite infrared (IR) spectral radiance will be addressed. Simulation analyses and retrieval validations demonstrate that surface emissivity plays an important role in retrieval of surface skin temperature and terrestrial boundary layer (TBL) moisture. A retrieval algorithm has been developed to retrieve surface and atmospheric parameters. This algorithm has been applied to NAST-I and AIRS hyperspectral data. Results show appropriate surface skin temperature and emissivity retrieval to be critical for atmospheric profile retrievals of temperature, moisture, and chemical species, since satellite observations such as those from AIRS aboard the AQUA satellite, cover a large variety of surface types. AIRS data are used to demonstrate that a large diversity of surface types is captured with this inversion scheme, indicating surface skin temperature and emissivity information is detected by hyperspectral remote sensors such as AIRS, IASI, CrIS, and HES. Accurate surface and atmospheric properties retrieved from satellite measurements can greatly enhance benefits realized from usage of such data for NWP and other applications.

RETRIEVAL APPROACH

The surface emissivity spectrum assigned for each radiosonde profile is randomly selected from a set of laboratory measured emissivity spectra for a wide variety of surface types. Using amplitudes of radiance eigenvectors as the predictors filters the radiance noise and effectively stabilizes the retrieval. Laboratory measured emissivity spectra for a wide variety of surface types are used to compute the emissivity eigenvectors and the eigenvector amplitudes which are actually used in the statistical training; currently the first 5 amplitudes are used to represent a surface emissivity spectrum. The surface emissivity eigenvector amplitudes, the surface temperature, and the atmospheric parameters are then predicted using the radiance eigenvector amplitudes derived from NAST-I measured radiances.

The same retrieval algorithm is applied to AIRS data to show that a large diversity of surface types is captured with this inversion scheme.

SENSITIVITY ANALYSIS

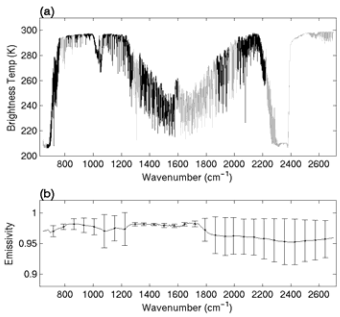


Figure 1. (a) Simulated NAST-I spectral radiance from a radiosonde with the channels used for retrieval highlighted in black. (b) The mean surface emissivity spectrum for a set of laboratory measured emissivity spectra for a wide variety of surface types suitable for the CLAMS geographical location. The vertical bars show the STD of the emissivity for this dataset.

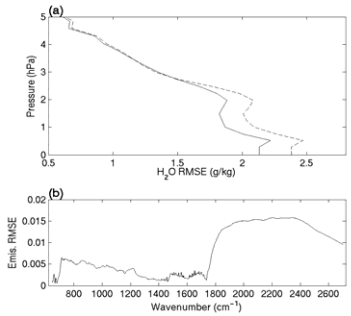


Figure 2. (a) Water vapor retrieval RMSE profile produced by the retrieval for dependent samples with and without variable surface emissivity as shown by the solid and dashed curves, respectively. (b) RMSE of surface emissivity produced from the simultaneous retrieval.

NAST-I RETRIEVAL DEMOSTRATION

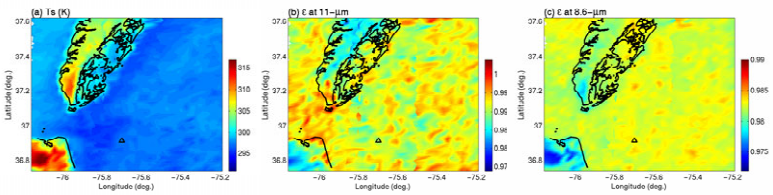


Figure 3. Retrievals of (a) surface skin temperature, (b) surface emissivity at 11 μm, and (c) surface emissivity at 8.6 μm from NAST-I observations on 14 July 2001. The Chesapeake Lighthouse site is shown by the open triangle.

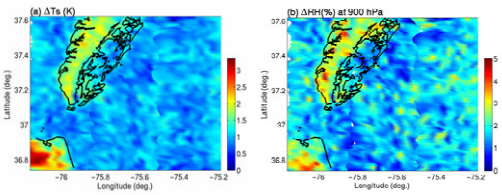
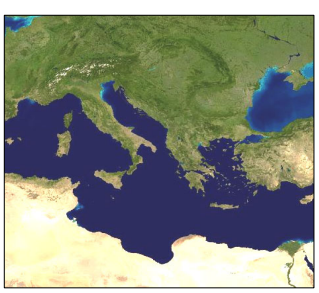
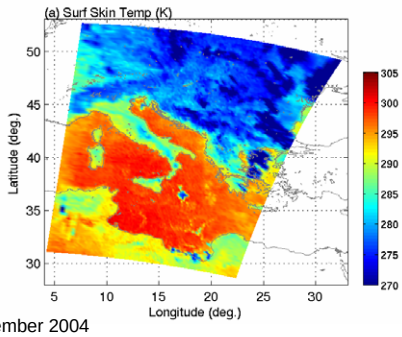
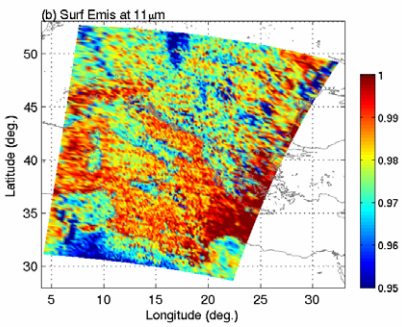


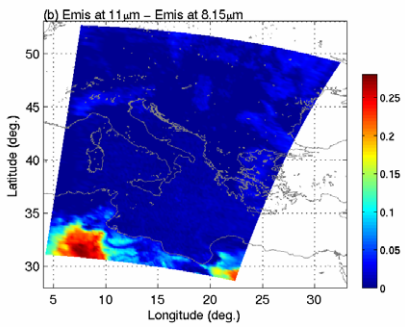
Figure 4. Retrieval discrepancies of (a) skin temperature and (b) relative humidity at 900 hPa (about 1 km above the sea level) produced by the surface emissivity from a constant of 1 to a retrieved value.

AIRS RETRIEVAL DEMOSTRATION

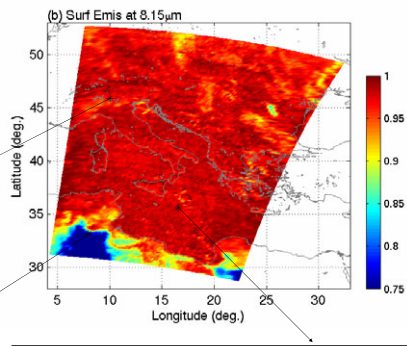


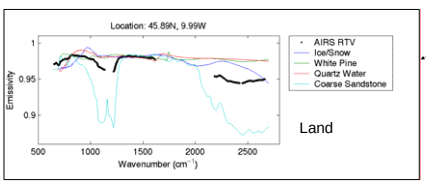




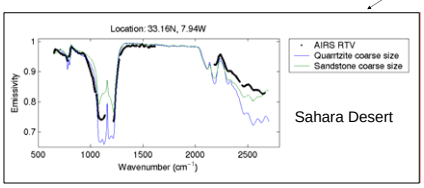


One granule of AIRS data from 10 September 2004 (~01:00 UTC; local nighttime) covers water and land including the vicinity of the Sahara Desert. This is to demonstrate that surface emissivity can be retrieved from hyperspectral data.

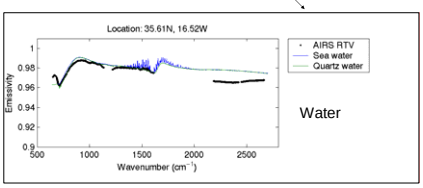




Land



Sahara Desert



Water

CONCLUSION

The sensitivity analyses of surface emissivity to skin temperature and TBL water vapor have been performed using infrared ultraspectral radiances. Retrievals from both simulations and measurements have demonstrated the importance of simultaneous emissivity retrieval. The validation results from the CLAMS field campaign have indicated that the retrievals of surface skin temperature and TBL water vapor are improved when emissivity is taken into account in the inversion scheme. This work also validates the retrieval scheme having surface emissivity retrieved simultaneously. The same retrieval algorithm is also applied to AIRS satellite data indicating a large variety of surface types may be captured. This greatly improves the accuracy of surface skin temperature and atmospheric parameter retrieval when the surface emissivity is not well known. This retrieval algorithm can be improved by using the emissivity when the surface is well known such as open ocean and by retrieving emissivity when the surface type is not well known. Nevertheless, the surface emissivity is one of the key elements for accurately retrieving other thermodynamics parameters which are important to numerical weather prediction application. Retrieval algorithms for future operational satellite sounders such as CrIS and HES/GIFTS must know (land) surface emissivity to accurate retrieve other thermodynamic parameters.

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