Development of a Dynamic Infrared Land Surface Emissivity Atlas based on IASI Retrievals

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Radiative emission from the earth's surface is characterised by its skin temperature and spectral surface emissivity. Uncertainties in these properties limit the use of infrared sounders and imagers over land, for which a more accurate estimate of them is required. This is particularly important in limited area models, where the proportion of land surface is usually higher than in global models. A EUMETSAT Fellowship is being undertaken to produce a high spectral resolution, near real-time global atlas of land surface emissivity using spectral emissivity retrievals from IASI.

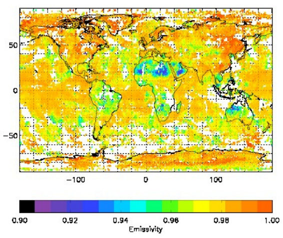
The objective is to produce an effective and valuable product which best suits the needs of all potential users, and comments and suggestions are duly invited from all interested parties.

Introduction

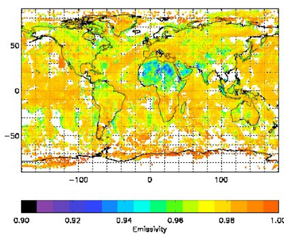
Hyperspectral IR sounders such as IASI allow exploitation of the spectral structure of surface emissivity. This is retrieved simultaneously with skin temperature by solving for principal component coefficients along with cloud parameters and temperature and humidity profiles in a 1dvar pre-processor, using the method of Pavelin and Candy [1].

The product will be updated on an observation-by-observation basis and will be supplied as a gridded dataset in a format to be confirmed.

Daily average retrieved emissivity at ν=787.5cm^{-1} on 23/1/2012



Daily average retrieved emissivity at ν=787.5cm^{-1} on 23/7/2012



Land surface emissivity exhibits considerable variation geographically and seasonally, as the above diagrams of daily averaged 1dvar retrieved emissivity at the frequency of IASI window channel 571 at ν=787.5 cm^{-1} in January (left) and July (right) 2012 demonstrate.

Method

A data driven Kalman Filter (KF) will be run over a specified period, designed to capture the geographical and temporal changes of emissivity, including its diurnal variation.

In general, a prediction equation for the state, x_t, at time t,

$$x_t = M_t x_{t-1} + \xi_t$$

with M_t a known linear evolution operator and ξ_t the process noise, can be used to find an a priori estimate of the state, x_a, and its covariance, S_a .

An updated state estimate

$$\hat{x}_t = x_a + G_t\left(y_t - K_t x_a\right)$$

with error covariance

$$\hat{S}_t = S_a - G_t K_t S_a$$

results, where G_t is the Kalman Gain matrix and y_t is the measurement with random noise ε_t, such that

$$y_t = K_t x_t + \varepsilon_t$$

where K_t is known.

These are the basic linear KF equations as described in [2].

For a persistence model of evolution, M_t is the identity matrix, I, and if both x and y represent emissivity, then K_t is also I. ε_t can be taken as the analysis error from the previous 1dvar assimilation step.

A forgetting factor may be embedded in the Kalman Filter to provide more weight to the most recent data.

• Verification and validation will be performed against other instruments and data sources.

• The resultant dataset will be applicable to any suitable current or future IR instruments, on polar or geostationary missions, benefitting SEVIRI, HIRS, MTG-FCI, MTG-IRS and IASI-NG.

User Requirements

Potential users of the atlas are encouraged to provide suggestions, including:

• their specific requirements for such an emissivity product

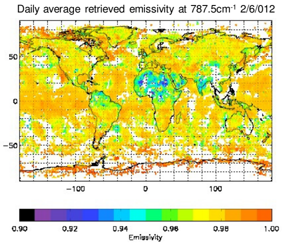
• further issues to consider

• format of the supplied dataset

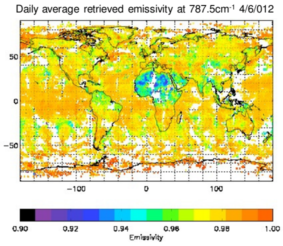
Temporal Variability

The analysed surface spectral emissivity and skin temperature vary at each assimilation cycle, permitting the capture of more temporal variability than possible with a climatologically derived emissivity atlas.

Daily average retrieved emissivity at 787.5cm^{-1} 2/6/012



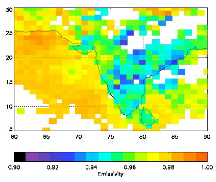
Daily average retrieved emissivity at 787.5cm^{-1} 4/6/012



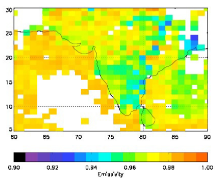
The land surface emissivity can vary significantly over short periods of a few days.

These are plots of the daily averaged emissivity at 787.5cm^{-1} for 2nd (left) and 4th (right) June 2012, at the time of the onset of the Indian monsoon.

Daily average retrieved emissivity, India, at 787.5cm^{-1} 2/6/2012



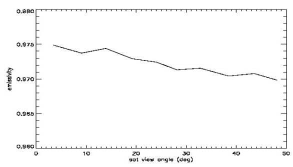
Daily average retrieved emissivity, India, at 787.5cm^{-1} 4/6/2012

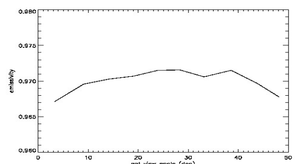


Large emissivity variations have occurred in the Indian region in only two days.

Viewing Angle Dependence

The variation of emissivity with viewing angle is being investigated. The variation could be captured by including a parameterisation to account for the dependency. Below left is a plot showing the reduction of globally retrieved emissivity with viewing angle over the one month period of January 2014 at the wavenumber of IASI window channel 756 (833.75 cm^{-1}).

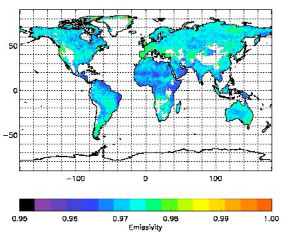


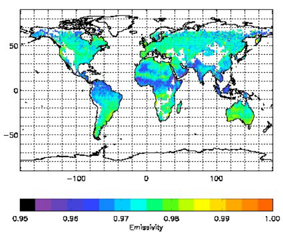


In other circumstances during these initial studies, retrieved emissivity varies with viewing angle in a different manner. The plot above right is at the same wavelength for the month of July 2013, retrieved from global data at night only.

Diurnal Variation

A diurnal cycle followed by the emissivity has been discussed by several authors. The retrievals below show the emissivity at wavenumber 833.75 cm^{-1} retrieved from day only data (left) and night only data (right), for the month of July 2013.





The emissivity generally is found to be significantly higher at night than during the day.

References

[1] E.G.Pavelin and B.Candy, 2013: Assimilation of surface-sensitive infrared radiances over land: Estimation of land surface temperature and emissivity, Q.J.R.Meteorol.Soc.(2013) DOI:10.1002/qj.2218

[2] Clive D. Rodgers, Inverse Methods for Atmospheric Sounding Theory and Practice, World Scientific Publishing Co. Pte. Ltd., 2000

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