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

Rory Gray, Ed Pavelin

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, from all interested parties.

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.

### 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, \( x \), at time \( t \),

\[
\dot{x}_t = A_t x_{t-1} + B_t u + \xi_t
\]

with \( A_t \), a known linear evolution operator and \( \xi_t \), the process noise, can be used to find an a priori estimate of the state, \( x_t \), and its covariance, \( P_t \).

An updated state estimate

\[
\hat{x}_t = x_t + G_t (y_t - K_t x_t)
\]

with error covariance

\[
\hat{P}_t = K_t P_t K_t + P_t
\]

results, where \( G_t \) is the Kalman Gain matrix and \( y_t \) is the measurement with random noise \( \xi_t \), such that

\[
y_t = K_t x_t + \xi_t
\]

where \( K_t \) is known.

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

For a persistence model of evolution, \( K_t \) is the identity matrix, \( I_t \), and if both \( x \) and \( y \) represent emissivity, then \( K_t \) is also \( I_t \). \( \xi_t \) 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.

### 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 761 (833.75 cm\(^{-1}\)).

### Diurnal Variation

A diurnal cycle followed by the emissivity has been discussed by several authors. The retrievals below show the emissivity at wavenumber 633.75 cm\(^{-1}\) retrieved from day only data (left) and night only data (right), for the month of July 2013.

### References
