Several strategies for establishing a land surface emissivity scheme for AMSU have been tested at the Met Office in recent years. The initial approach used an atlas to give a first guess estimate of emissivity\(^{[1]}\). These estimates proved to have little effect on the distributions of observed minus background (O-B) brightness temperatures. A second scheme converted the atlas into a set of parameters to be used in FASTEM\(^{[2]}\), the microwave emissivity parameterization in the RTTOV\(^{[3]}\) forward model. The parameters were used to calculate channel-dependent emissivities as part of a 1-D-Var retrieval. This approach was hampered by poor convergence rates and a lack of significant improvement in the observed minus analysis (O-A) brightness temperatures. A new approach is under development to use Weng and Yan’s (2003)\(^{[4]}\) microwave snow emissivity model to provide a first guess emissivity where appropriate and to retrieve emissivities directly in the 1-D-Var. The reduced O-B values from this scheme are a promising step.

1. The Met Office operational land surface microwave emissivity scheme

The land surface emissivity scheme has been the same throughout the history of direct radiance assimilation at the Met Office. A value of 0.95 is used across the spectrum over all land points regardless of surface type.

This value is unreasonable for many surfaces such as desert, snow and observations which contain significant water fraction, such as lakes or rivers (Figure 1).

The uncertainty in the appropriateness of the emissivity values used means that we reject the lower sounding channels AMSU 4 and 5 over land and also channel 6 over high land.

A more accurate emissivity will allow inclusion of more channels, hopefully improving forecasts.

2. Initial studies with an emissivity atlas

Poulsen (2001)\(^{[1]}\) used FASTEM2 to estimate emissivity for AMSU observations. The FASTEM parameters were derived from Prigent’s emissivity atlas at SSM/I frequencies\(^{[5]}\). AMSU observations were compared with forward modeled calculations (RTTOV67 with Met Office NWP analyses). The approach did not greatly reduce the observed minus forward-modeled background (O-B) values.

Figure 2 shows that areas around lake edges and deserts were poorly modeled. The FASTEM parameter atlas has large areas of missing data (mostly over snow) where parameters could not be derived from the Prigent dataset. This limits its use over data-sparse regions such as Siberia and Antarctica (Figure 3).

Figure 4 shows that in the case of vegetated classes there was very little change in the O-B distribution.

3. A 1D-Var approach using the emissivity atlas as first guess

Poulsen’s study concluded we should retrieve FASTEM parameters (using Prigent’s emissivity atlas as background) in 1-D-Var. This approach was attempted by the author using operational data assimilation code. The intention was to use the lower sounding and window channels in the 1-D-Var to analyse emissivity, and then use channels 4 and 5 in the 3-D-Var assimilation for cloud-free observations.

This approach proved disappointing in several respects. Figure 5 shows little difference in O-B distributions between the control run and the new scheme. The O-R distributions (Figure 6) are slightly improved, but this has come at a cost.

With existing quality control checks, the new scheme causes a 2-3 times more cloud-free observations to be rejected. This was mostly a result of convergence failure. Even those observations which were accepted took more iterations to converge increasing computational cost. The convergence problem was partly due to attempts to retrieve emissivity where the window channels had been rejected by quality control. However, the background error covariance matrix which was difficult to define was an influence.

Again, gaps in the FASTEM parameter atlas (Figure 3) were problematic. In these areas, the first guess remained 0.95 for all frequencies and this contributed to the rejection rate.

4. Weng and Yan’s snow emissivity model\(^{[4]}\)

A flat 0.95 emissivity is a particularly bad approximation for snow covered surfaces but is a reasonable first guess for other surface types (Figure 1). Since snow often covers large areas with few conventional observations (e.g. Siberia), Weng and Yan’s empirical snow emissivity model is being tested as a first guess emissivity in snowy areas. We will then use a 1-D-Var to retrieve an emissivity for all data points, as in Section 3. The Weng and Yan model fits AMSU window channel brightness temperatures to one of a series of reference emissivity profiles for different snow types.

At this stage, only the O-B values have been studied, as more work is required to make the retrieval code function properly. Figure 7 shows that these are much improved for Weng and Yan’s scheme. However, the snow classification results suggest that perhaps this model is more complicated than we need; more than 80% of observations fail to be classified with a snow type and end up with the default emissivity profile of ‘Thick Crust Snow’ (Figure 8).

References

\(^{[1]}\) Poulsen, C. (2001): A quick evaluation of whether knowledge of the land surface will lead to better retrievals over land using AMSU. Unpublished Internal Met Office Short Working Paper


\(^{[3]}\) RTTOV website: http://www.metoffice.gov.uk/research/rttos/rttoo67/rttoo67.html


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Establishing a microwave land surface emissivity scheme in the Met Office 1D-Var

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