Are microwave surface emissivity models good enough to fully exploit AMSU temperature sounding channels?

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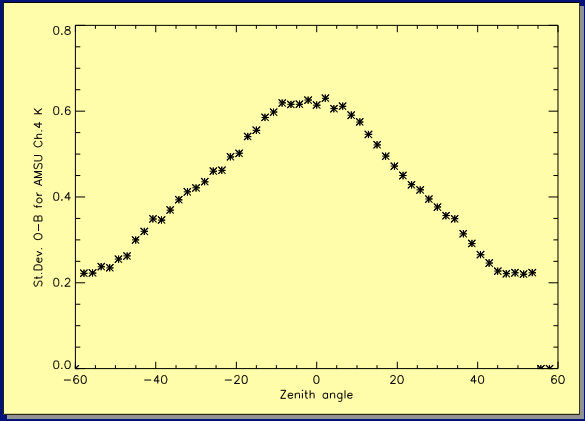
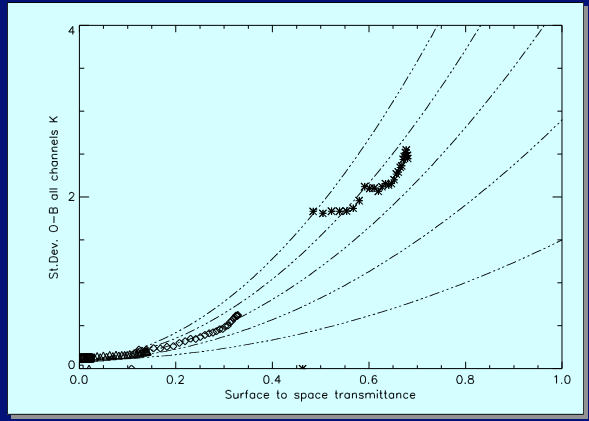
Do we need a model of emissivity to use ATOVS over land? If yes, how accurate does it need to be? English (JAM, 1999) calculated that to extract useful information from ATOVS below 3 km an accuracy of at least 2% is required, and information content increases rapidly as emissivity errors fall to 0.5%.

Are current models achieving this?



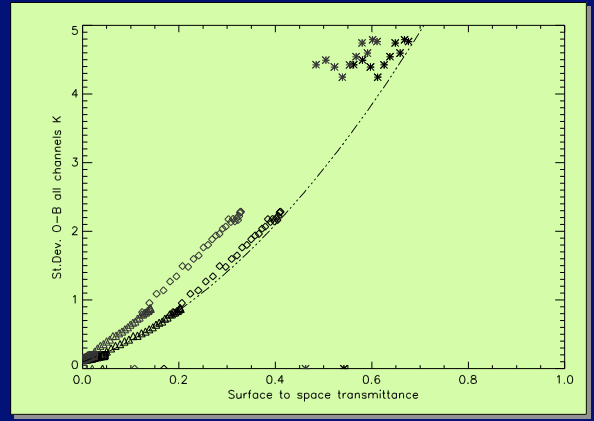
This figure shows the standard deviation of the dfiference between the NWP background and AMSU channel 4 as a funtion of zenith angle.

The fit is better near the edge of the scan. This is because the surface contribution to the measured radiance is largest at nadir, and errors in calculating surface brightness temperature are greater than errors in calculating emission from the atmosphere.



This figure shows the fit of AMSU channels 3-5 as a function of surface to space transmittance and dashed curves corresponding to surface emissivity errors of 0.5 (lowest curve), 1.0, 1.5, 2.0, 2.5 % for ocean points only.

The mis-fit of the channel radiances follow the 1.5% curve for channels 4 and 5, and the 2.0% curve for channel 3. For channel 3 there is more variation with scan position.



The plot for land points (above) has points following closely the 2.5% emissivity curve (dashed line) for all channels when the correct surface to space transmittance for the surface elevation is used (the set of points to the left of the line assume sea level to space transmittance).

For land points the points for channel 5 follow a curve corresponding to a similar emissivity error to channels 3 and 4.

These simulations use RTTOV-7 (Saunders *et al*. 2002), with Fastem-2 (Deblonde and English 2000) surface emissivity (ocean) and 0.95 (land).

References: English, S.J., 1999: J. Appl. Meteorol. 38, 1526-1541.; Saunders R.W. *et al*., 2002: NWP Tech Memo 387; Deblonde and English, 2000: ITSC-XI Proceedings, Budapest, 67-78.

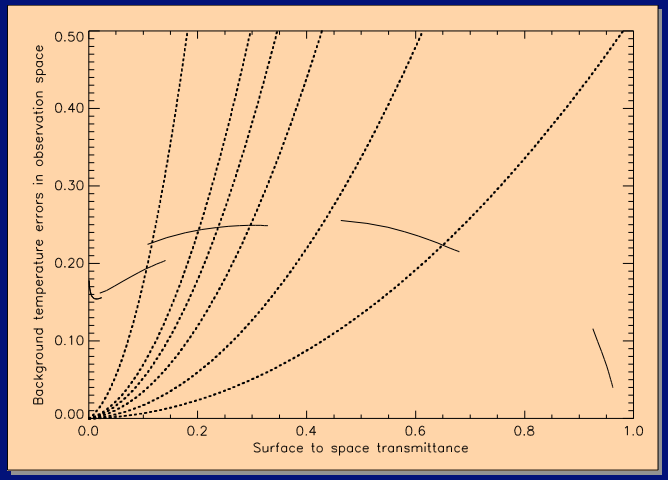
The analysis of the fit of radiances to background suggests emissivity errors of 1.5% for the ocean emissivity model.

Land surface emissivity errors using a fixed emissivity of 0.95 are around 2.5%.

This falls well short of the 0.5% emissivity errors required to fully exploit ATOVS, and explains why fit to background is worst near nadir for surface sensing channels.

However for oceans it is better than the 2% minimum requirement. For land it is not good enough.

Given these errors in surface emissivity model which channels can be used?



The error arising from errors in surface emissivity can be compared with errors arising from errors in the background tmperature, expressed as the Hessian of the cost function, $\mathbf{HBH}^T$. The plot above shows emissivity errors of 0.2% (lowest), 0.5%, 1.0%, 1.5%, 2.0%, 5.0% as dotted lines and background temperature errors as continuous lines (for AMSU channels 6, 5, 4, 3 from left to right), as a function of surface to space transmittance.

For AMSU channel 6 emissivity errors in excess of 5% are tolerable for most of the scan. Therefore AMSU channel 6 can be used over most land surfaces most of the time, without the need for an emissivity model.

For AMSU channel 5 emissivity errors of 5% are tolerable at the edge of the scan, but only 1% near nadir. Therefore part of the scan could be used for AMSU channel 5 without a more accurate model, but near nadir the use of AMSU channel 5 is sub-optimal, even over the oceans. For AMSU channel 4 an emissivity error of 0.2-0.5% is required, depending on scan position, which is beyond the capability of current models, even over the ocean. AMSU channel 3 has negligible information content for atmospheric temperature.

Conclusions

- Emissivity models are not good enough to be able to exploit the atmospheric temperature sensitivity of AMSU channel 4.
- Surface emissivity errors are around 1.5% for the ocean and 2.5% for land.
- The outer edges of the AMSU channel 5 scan could be used over all surfaces (if cloud detection is adequate), whereas near nadir this channel is unlikely to be useful even over oceans.
- Account should be taken of the variation of RT error with scan position when processing AMSU.

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