Prospects for assimilating microwave sounder radiances over snow covered surfaces

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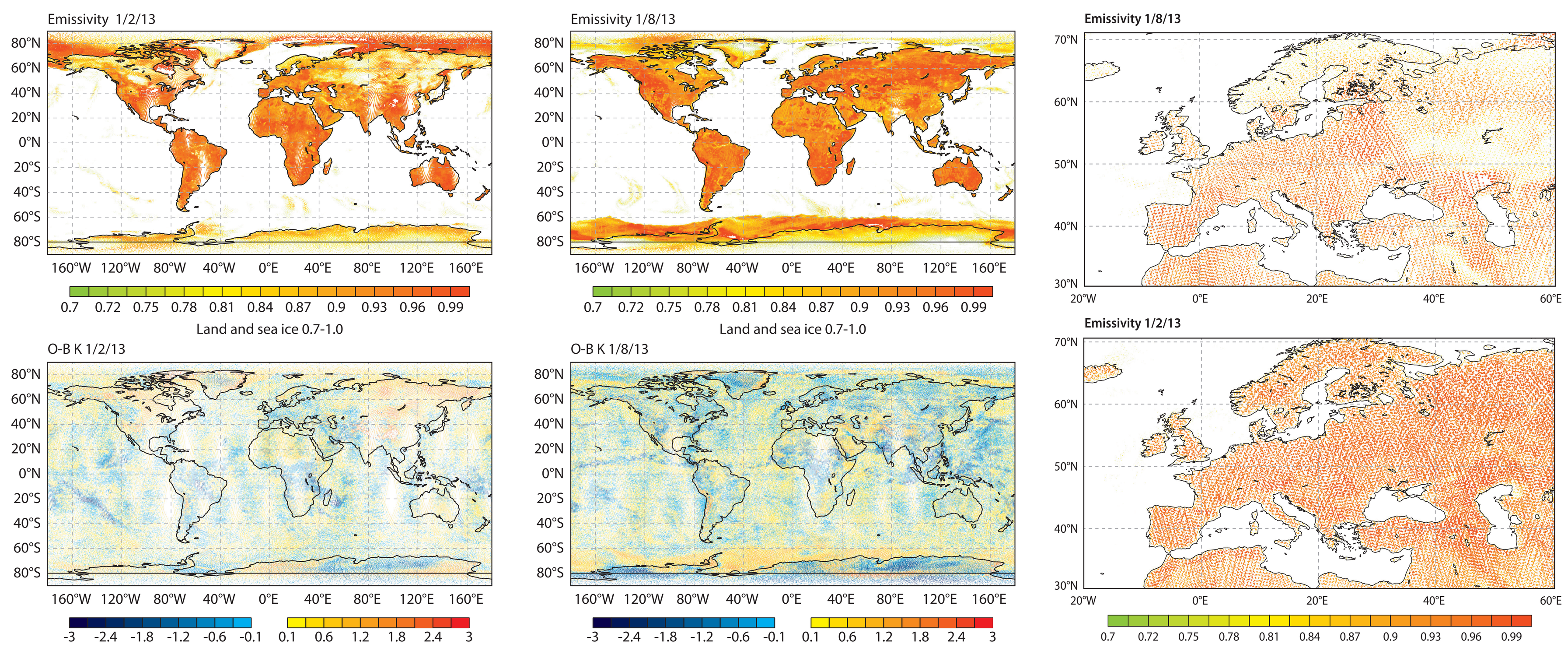
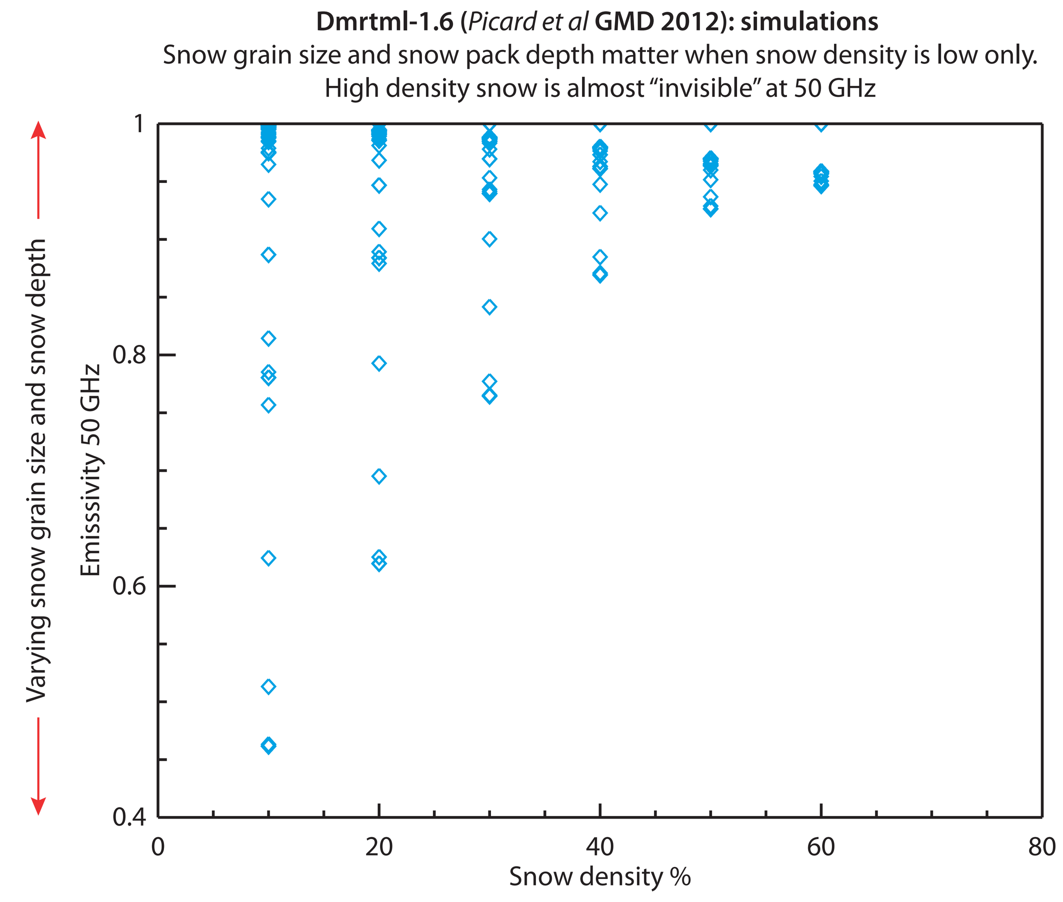
AMSU Ch. 5 O–B and 50 GHz emissivity atlas at ECMWF

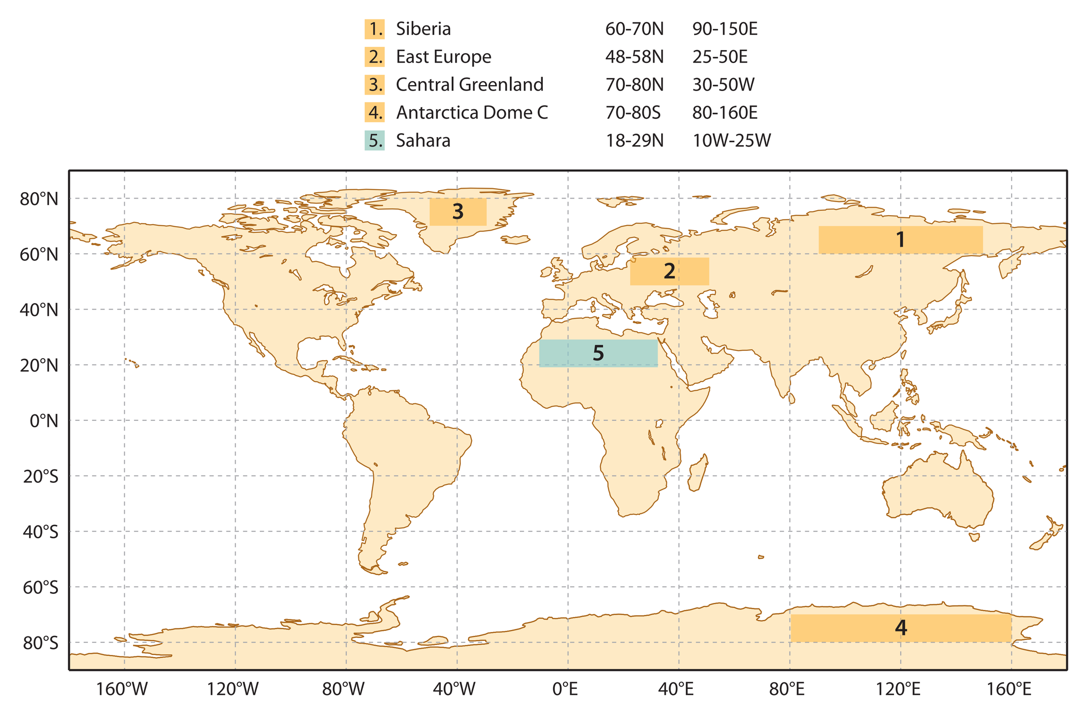
The ECMWF dynamic emissivity scheme produces instantaneous estimates and a Kalman filter analysis of emissivity as described by Karbou (2005) and Krzeminski (2008). This poster is thinking about two questions: (a) can we constrain better the emissivity analysis over snow surfaces using information from snow pack models and snow analysis, combined with radiative transfer models?; (b) can we use the information in the emissivities to improve snow analysis?



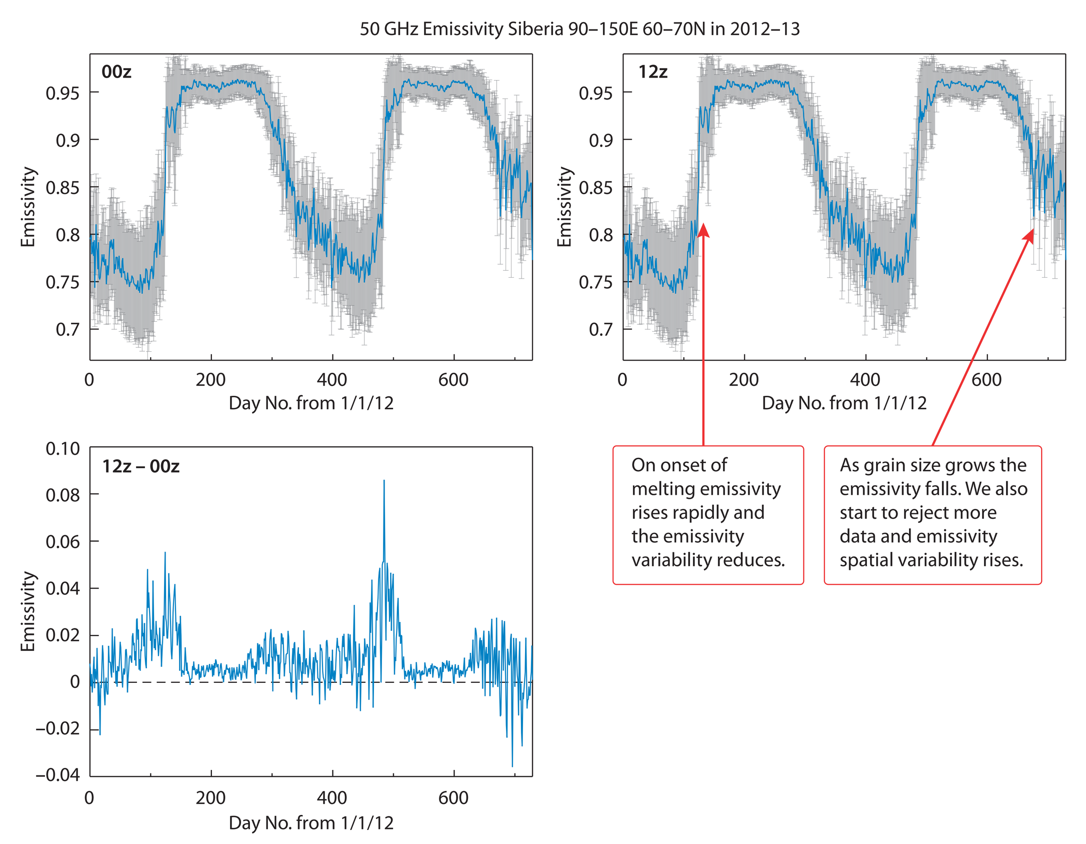
Both higher and lower emissivity values (compared to snow free conditions) are found in the area where the ECMWF snow analysis has more than 0.01m snow. Therefore snow cover can both increase or decrease emissivity, depending on the snow pack characteristics.

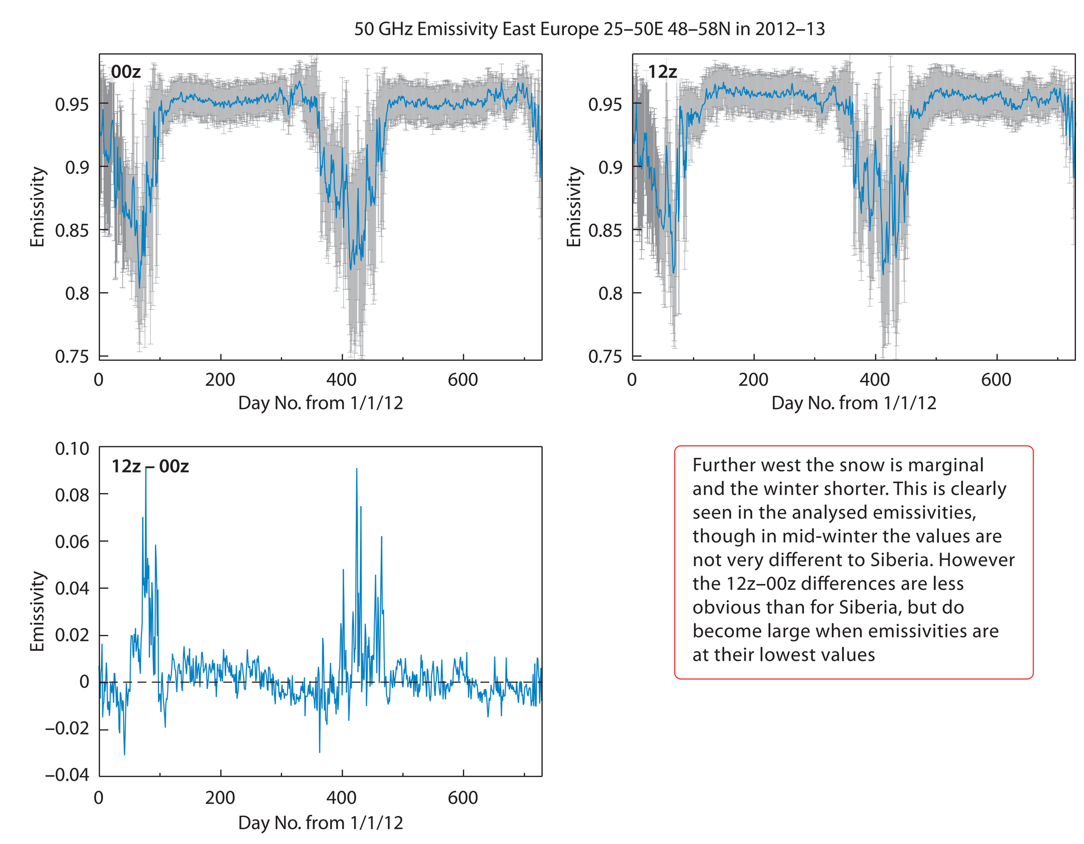


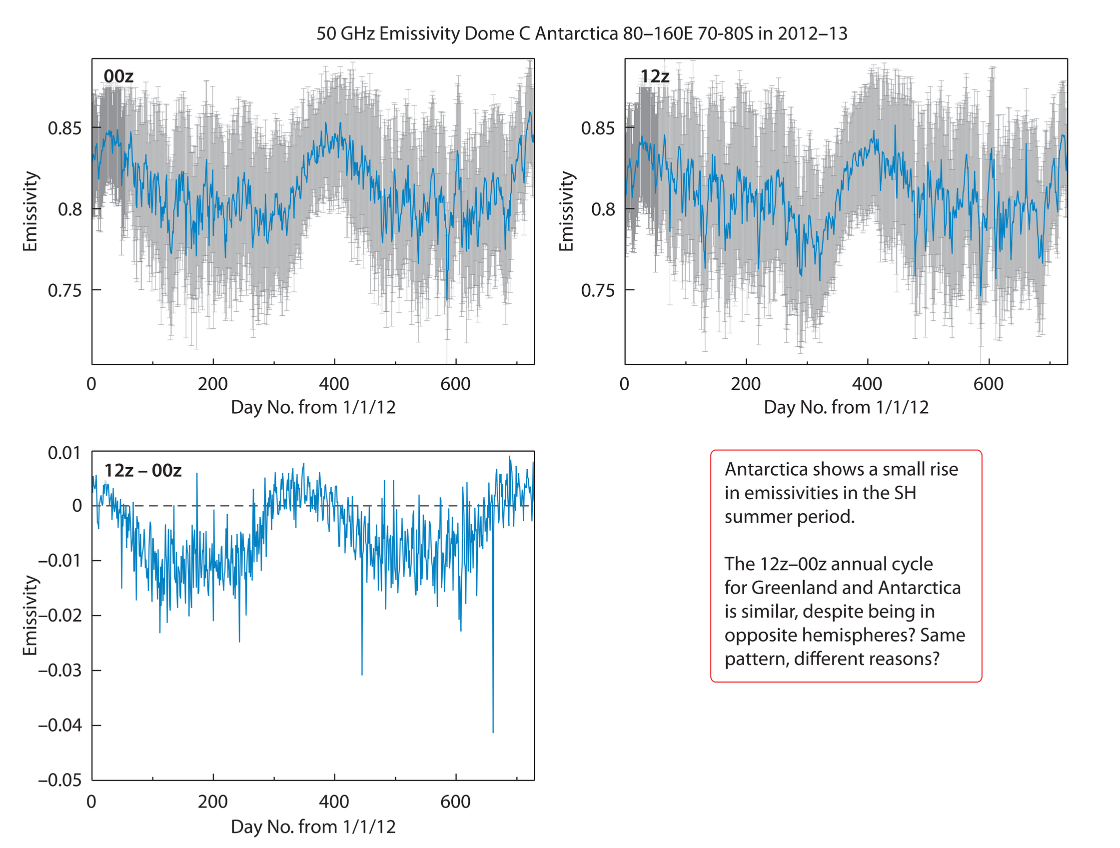
In winter large background departures are seen at ECMWF for AMSU-A channel 5. In the summer these large departures are not seen. They are caused by problems with the quality of the emissivity and skin temperature analysis over snow. This may be use of specular assumption [see discussion in Harlow 2009], poor surface skin temperature, or another factor. In any case its clear we have a problem in the snow covered regions to use satellite sounder radiances. Model runs such as DMRTML (above right) show that low density (dry) snow has highly variable emissivity, depending on snow grain size and snow depth. By contrast high density snow (wet snow) has generally high emissivity. Snow pack models combined with physical emissivity models may help constrain emissivity and skin temperature analysis in some snow regions. The DMRTML results also show that snow can increase or decrease emissivity, a result consistent with the emissivity retrievals.

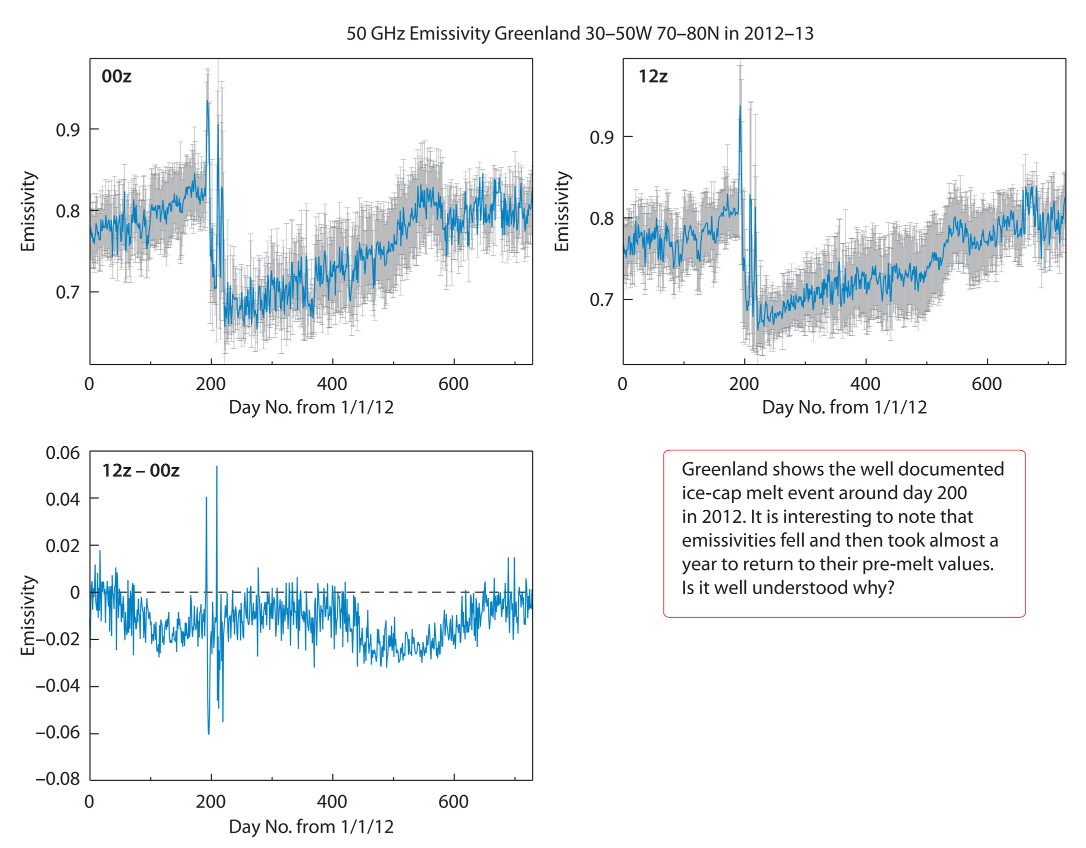


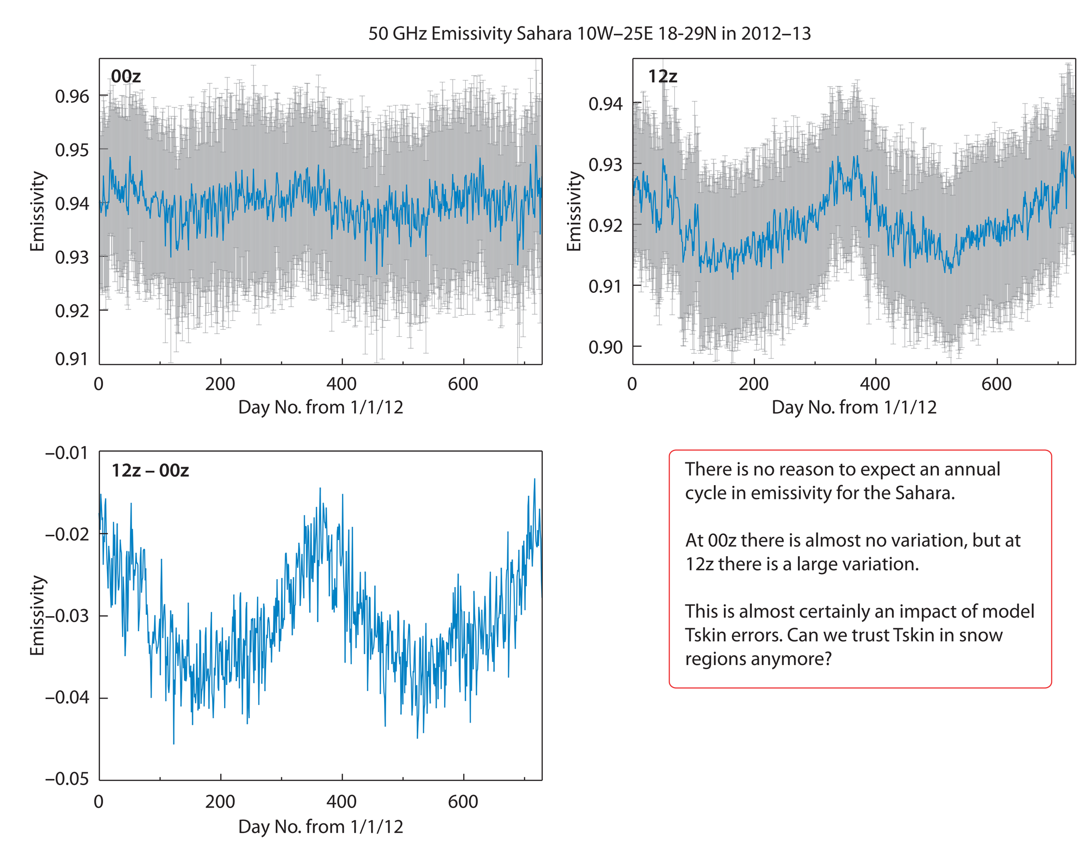
12z = 12z ECMWF data assimilation window, that covers the period 09z-21z and 00z = 00z ECMWF data assimilation window, that covers the period 21z-09z.



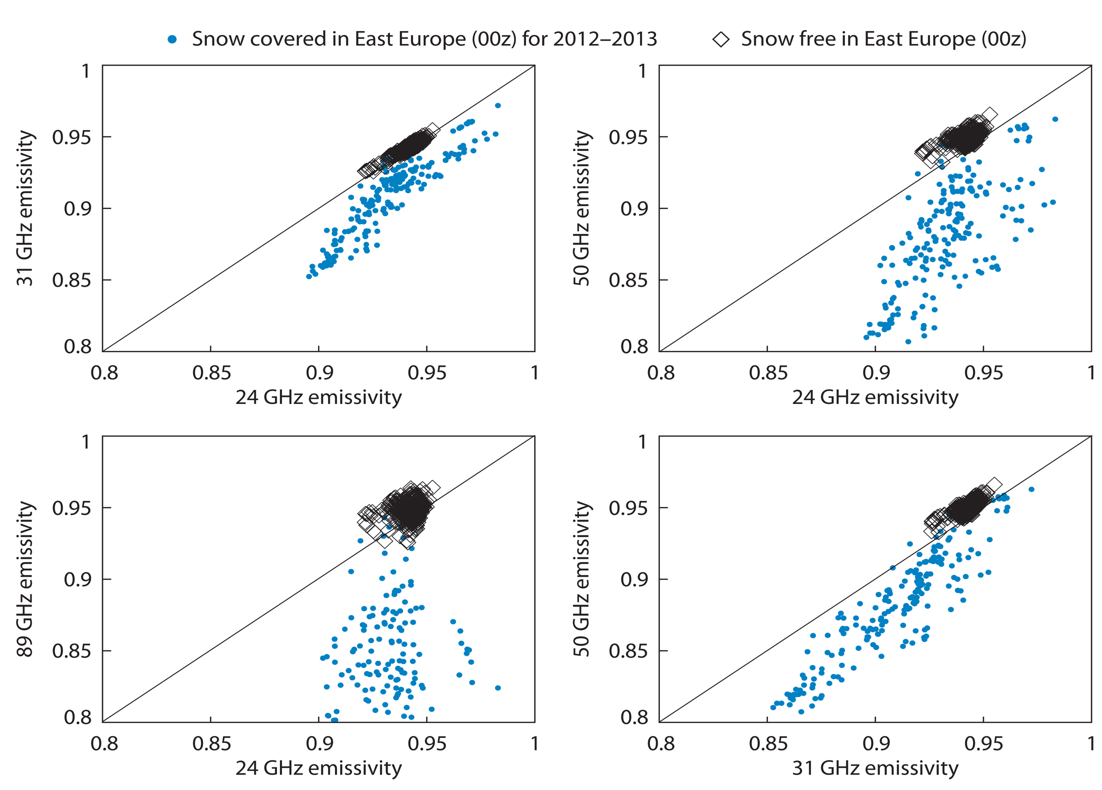








Four case studies of 50 GHz emissivity variation 2012-13 in different snowy regions are shown above, and one for the Sahara for comparison with a snow-free region. The changes in analysed emissivity with season are clear. In addition there are day:night differences in analysed emissivity. The Greenland ice melt event in 2012 is also very prominent, around day 200. The Siberia and East European cases show the timing of the onset of snow cover. The emissivity falls steadily over several months, consistent with an increase in grain size for a dry low density snow pack. These is also an increase in spatial variability, denoted by the error bars which represent standard deviation of emissivity in the target area. This is almost certainly due to a combination of vegetation cover and orography. At snow melt the emissivities initially rise just above the snow-free value, prior to a quick return to a snow-free and almost invariant value. For Antarctica there is also an annual cycle with a brief mid-summer rise in emissivity. During the polar night the 00z emissivities are higher, for reasons which are not understood. At present its not straightforward to understand which changes are real, and which are driven by biases in the system, such as poor skin temperature, cloud screening and errors in background atmospheric fields.



Spectral emissivity variations between 24 and 89 GHz are plotted to the left for East Europe. These show that snow cover introduces large spectral gradients, which contain additional information about the snow. In the absence of snow the correlation in emissivity across the 24–89 GHz range is very high meaning that there is only one degree of freedom in the emissivity, and therefore little information about the surface. It is encouraging to think that if we can fully understand the emissivities we may be able to improve assimilation in these areas using physical constraints, and also improve snow analyses.

Conclusions

1. Snowy regions show very large background departures for microwave sounders. Poor estimation of surface emissivity and skin temperature are a likely explanation for the high departures in these regions, despite the dynamic emissivity estimation technique used at ECMWF.
2. There are day minus night differences in emissivity that are difficult to explain and may be the result of several factors. This is also seen in snow-free areas e.g. the Sahara. This gives reason to believe biases in background skin temperatures may bias the emissivity estimation.
3. Snow surfaces show strong spectral de-correlation in the estimated emissivities. This means different channels give independent information.
4. Collaboration between the land surface model and data assimilation community and the ATOVS assimilation community is strongly encouraged.

References

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