This is paper details an interesting technique for determining thin ice concentrations using passive microwave brightness temperatures only. This paper presents impressive results regardless of the technical issues that I raise below. I believe that it is a step forward in the microwave remote sensing of sea ice.

I have some issues with the underlying theory which I will present first. These are followed by some corrections to the grammar and typos.

Theoretical Issue #1:

On page 191 the statement is made that "The retrieval of surface emissivities from passive microwave imagery requires to model radiation transfer in the atmosphere." This is true, but equation (2) does not contain either of the atmospheric terms nor is the surface term attenuated on its way up to the satellite. These terms are relatively small at 19 GHz but can be more substantial at 89 GHz. (2) should read

$$T_{B,\upsilon} = (1-e^{-\tau_\upsilon})T_{m,\upsilon} + \varepsilon_\upsilon e^{-\tau_\upsilon} T_s + (1-\varepsilon_\upsilon)e^{-\tau_\upsilon} T_{B,\upsilon\Downarrow}$$

where $T_{m,\upsilon}$ is the frequency (and look) dependent mean radiative temperature of the atmosphere, τ_υ is the slant opacity of the atmospheric column, and $T_{B,\upsilon\Downarrow}$ is the downwelling brightness temperature at the surface. As the surface scattering is likely to be diffuse in nature (see Harlow (2009)), the $T_{B,\upsilon\Downarrow}$ should be calculated as an integration over the sky. Whether the ice and snow surfaces are Lambertian or some mixture of Lambertian and specular at these lower frequencies is a matter of current research (Rosenkranz and Matzler, 2008; Guedj et al., 2009). Typical values for $T_{B,\upsilon\Downarrow}$ applicable to Lambertian scattering at the surface are about 15 K and 35 K at 19 and 89 GHz, respectively (some specific values are given in Harlow (2009) at 89 GHz ; these values are based on ARTS calculation with an arctic atmospheric profile observed near Barrow, AK on 16 Feb 2008; I've attached two figures from these calculations: one shows $T_{B,\upsilon\Downarrow}$ for pencil beams of radiation at 0, 48 and 60° zenith angles and the corresponding Lambertian downwelling, while the other shows τ_υ). $e^{-\tau_\upsilon}$ takes into account the frequency dependent transmissivity of the total atmospheric column and is about 0.98 and 0.93 in this ARTS calculation. The first term on the RHS of the above equation due to the radiation of the atmospheric column between the ground and the satellite; the second term is your surface emission term attenuated by the overlying atmosphere; and the third term is the reflected downwelling atmospheric radiation and cosmic background attenuated in its path from the ground up to the satellite. All three of these terms will impact your calculated emissivity ratios. The second term is likely to dominate over the first and last terms, but I think it should be shown (or at least provide a reference that shows) that the other terms are negligible. You should still have a factor of $e^{-\tau_\upsilon}$ in (2) and (3).

Theoretical Issue #2:

In the derivation of (3) you use the assumption that the effective radiating temperature of the surface is the same at 19 GHz as it is at 89 GHz. This is unlikely as 19 GHz radiation originates from a deeper column than the 89 GHz radiation. The 19 GHz radiation might partially penetrate through the entire section of thin ice and be sampling both sea ice and unfrozen water. In any case it will be sampling deeper and warmer portions of the ice than 89 GHz radiation. The differences in these two effective radiating temperatures might be on the order of 10K. This has an impact on your calculated emissivity ratios.

General comment:

Many leads will have widths much less than 500 m, so the “truth” you have taken from MODIS probably vastly underestimates the total area covered by open and refrozen leads. Some discussion of this should be presented. The distribution of lead openings is probably also a function of season.

Proposed Technical Corrections:

p.184 ln. 26: Define/expand SAT.

p.188 ln. 7-8: Replace “requires to model” with “requires the modelling”.

ln. 9: Replace “atmosphere” with “atmospheric”.

p. 189 ln. 8: Provide reference for LSI and median filter techniques.

P 190 ln. 1: Replace “pixel” with “pixels”.

p. 191 ln. 1: Replace “Thin is” with “Thin ice”.

p. 195 ln. 3: Replace “would not be” with “were not”.

p. 196 ln. 7: Replace “, it” with “which”.

p. 196 ln. 13 and p. 197 ln. 14: Replace “stream upwards” with “upstream”.

p. 196 ln 21: Replace “strenght" with “strength”.

p. 196 ln 22-25: This sentence is a run on. Consider changing to “Thin ice and thick multiyear ice are not distinguished in passive microwave ice concentrations; therefore, leads covered by thin ice should show 100% ice concentration (Andersen et al., 2007).” Or make the two phrases into two separate sentences.

p. 197 ln 19: Replace “strong” with “strongly”.

References:

R.C. Harlow, "Millimeter microwave emissivities and effective temperatures of snow covered surfaces: Evidence for Lambertian surface scattering," *IEEE Trans. Geosci. Remote Sens*., Vol. 37, No. 7, 1957-1970, July 2009.

Rosenkranz, P.W., and C. Matzler, "Dependence of AMSU-A Brightness Temperatures on Scattering From Antarctic Firn and Correlation With Polarization of SSM/I Data," *IEEE Geosci. Remote Sens. Lett*., vol. 5, no. 4, pp. 769-773, Oct. 2008.

S. Guedj et al, "Toward a better modeling of surface emissivity to improve AMSU data assimilation over Antarctica," *presented at 2nd Workshop on Remote Sensing and Modeling of Surface Properties, Meteo France, Toulouse, France, 9-11 June 2009.*