REPLY TO REVIEWER 2

Reviewer: This manuscript provides a theoretical error analysis of the effect of the beam and band width on ground-based microwave brightness temperature measurements. While there is a potential scientific significance in this topic, especially in view of up-coming combined radar and radiometric measurements, the manuscript as it is substantially lacks scientific quality. The error analyis is very coarse and does not consider a sufficiently large data set of atmospheric conditions. There is an unsufficient description of the used radiative transfer model. The RT model itself, as it is described in the text, is not adequate from my point of view. And although the authors claim that their study will be useful for combined radar and radiometric retrievals, they use clear-sky atmospheres most of the time (or all the time?)

Reply: It is common to assume the beam width and the bandwidth to be zero in order to simplify the calculations. This paper is to provide a rough estimate of the bias error caused by using such assumptions. The goal of this study is to motivate the scientific community to include these effects in their forward models which are in particular important when non zenith measurements are taken. Scanning radar-radiometer techniques are an emerging area and the paper aims to prepare for that. This paper does not seek to quantify the biases in detail as most of these can be reduced either by including the beam width and bandwidth in their calculation or correcting for them. Rather the paper illustrates the sensitivity in respect to temperature, humidity and liquid water path.

With an extended description of the radiative transfer we hope to convince the reviewer about its quality which has also been accessed by intercomparison with the RT models used in Löhnert et al.. (2003) and Mech et al. (2007). Below you find a point to point response with the **reviewers points in bold**, *italic texts* are excerpts from the new version of the manuscript.

1. Major correction to the Radiative transfer (RT) model:

<u>On the absorption model and the refractive index:</u>

You use the model of Rosenkrantz to model the absorption coefficients that are later on used in your RT model. You should justify your choice of Rosenkrantz and also discuss the errors that are inherent in this model (Hewison et al., MetZ 2006).[…]

We have changed the absorption model to that of Liebe (1989) as the version of the Rosenkranz absorption model did not have the refractive index calculation in it and Hewison et al. 2006 said that this model was closest to the observations. This being said, the difference in the absorption coefficients between Liebe and Rosenkranz is small (Liebe is 3% less than Rosenkranz) and given the analysis is done on difference of TB, this is not so important as long as the absorption models are consistent.

"*The attenuation calculation performed in the forward model can use either the Rosenkranz (1998) or the Liebe (1989) absorption models. The Rosenkranz version includes the correction found by Turner et al. (2009), but this correction was not included in the Liebe version. This being said including or not this correction would not change* *the results shown here. Both of these absorption models show some temperature bias in the absorption coefficients in both K-band and V-band, but in V-band Liebe's code is a better fit to the measurements (Hewsion et al, 2006). In this case, the Liebe MPM-89 code is used for the calculation of the absorption of the atmospheric gases. Hewison et al. (2006) found that Liebe's absorption model was the closest to the measurements although it still over-estimates the absorption. The cloud absorption model used in this study is that of Stogryn (1995). The forward model has several other cloud absorption codes that can be used. This code was chosen because it was found that it yields TB that are more consistent with radiometer measurements (Cadeddu and Turner, 2011). It is to be noted that this cloud absorption scheme was found to yield low TB for cold clouds and this difference increases with the water content of the cloud at the frequencies of 90, 150, and 170 GHz (Cadeddu and Turner, 2011).*" (P. 5, L. 13 -24)

What in particular remains a mystery to me is your choice for a model for the vertical gradient of the refractive index. You use a very coarse model from 1966, while at the same time you have the state-of-the-art model of Rosenkrantz for the calculation of the absorption coefficients. Why not using this model also for the calculation of the refractive index?

Out of consistency we now use the Liebe (1989) model for the refractivity calculations. As can be seen from the table below the difference between the more sophisticated Liebe refractive index and using the old Bean and Dutton (1966) refractive index calculation is negligible and did not cause any changes in our results.

Height (m)	**Refractive index (ppm) (to get refractive index (N units) multiply by 10^{-6})**			**dN/dH (here in N units/km)**		
	Bean and Dutton	**Liebe**	**difference**	**Bean and Dutton**	**Liebe**	**difference**
0	350.592	350.254	0.339	-5.30E-05	-5.29E-05	-1.34E-07
1000	297.588	297.383	0.205	-4.36E-05	-4.35E-05	-9.43E-08
2000	254.024	253.913	0.111	-3.61E-05	-3.60E-05	-7.05E-08
3000	217.933	217.893	0.040	-2.75E-05	-2.75E-05	-3.51E-08
4000	190.446	190.440	0.005	-2.32E-05	-2.31E-05	-2.07E-08
5000	167.288	167.303	-0.016	-1.86E-05	-1.86E-05	-6.15E-09

On the discretization of the model:

There is also no explanation given how your RT model works, i.e., how you numerically solve the RT equation and how you discretize your model atmosphere (how many layers, thickness of these layers).

An explanation of the discretization was added to the paper. The RT model uses directly the height levels of the sounding. Each sounding has 70 levels at a constant height resolution of 1km. The RT has been discretized for numerical calculation:

"The input to the radiometer is proportional to the atmospheric radiance I ($W\ m^{-2}\ sr^{-1} GHz^{-1}$) of the incoming radiation in the non-scattering case given by

$$I(f,\theta) = \int_{\theta'} G\left(\theta' - \theta\right)\left[I_{cos}(f)\tau(f,0,\infty) + \int_0^{\infty} \alpha(f,s)\, \tau(f,0,s)\, B\big(f,T(s)\big)\, ds\right] d\theta' \ ,$$

(1)

where θ is elevation angle, θ' is the elevation angle of specific ray of the beam, G(θ' - θ) is antenna gain, f is frequency, I_{cos} is the emitted radiation of the cosmic radiating background, τ (f,0,∞) is the total transmission from top of the atmosphere to the surface, s is the slant path length, α (f, s) is the absorption coefficient at s in km^{-1} , τ (f,0,s) is the opacity between the surface to s at frequency f, and B(f, T(s)) is the Planck function with temperature at s, T(s) (i.e. Petty, 2006; Huang et al., 2008). This equation must be discretized for numerical calculation. This is done as

$$I(f,\theta) = \frac{1}{\beta} \sum_{\upsilon} k_{bw} \sum_{\omega} w_{\omega}\{ \tau(f_{\upsilon},0,s)\, I_{cos} + \sum_i [1 - exp(-\alpha(f,s_i)\, s_i)]\ \tau(f_{\upsilon},0,s_i)\, B\big(f_{\upsilon},T(s_i)\big)\}, \qquad (2)$$

where β is the channel bandwidth, k_{bw} is a constant to normalize the beam width, ω is the index for each of the angles used to create the beam width, w_{ω} is the Gaussian weight for each of the angles in the beam width, υ is the index for each of the frequencies used to create the bandwidth, f_{υ} represents each of the frequencies in the bandwidth, i is the index of the number of atmospheric layers, and B(f, T(s_i)) is the radiance for each layer. The radiance of each level of the atmosphere is determined using the Planck function

$$B\big(f,T(s_i)\big) = \frac{2\,h\,f_{\upsilon}^3}{c^2}\left\{exp\left[\frac{h\,f_{\upsilon}}{k\,\left(\frac{T_{j+1} + T_j}{2}\right)}\right] - 1\right\}^{-1}, \qquad (3)$$

where h is Planck's constant, c is the speed of light, k is Boltzmann's constant, and T_{j+1} and T_j are respectively the top and bottom levels of the layer (HW00). The radiance, I(f, θ), is converted to brightness temperature (TB) by solving the Planck function for temperature at the end of the radiative transfer calculation." (P.4, L. 13 to P.5, L.11)

On the use of the Planck function:

Why don't you use the Rayleigh-Jeans approximation?

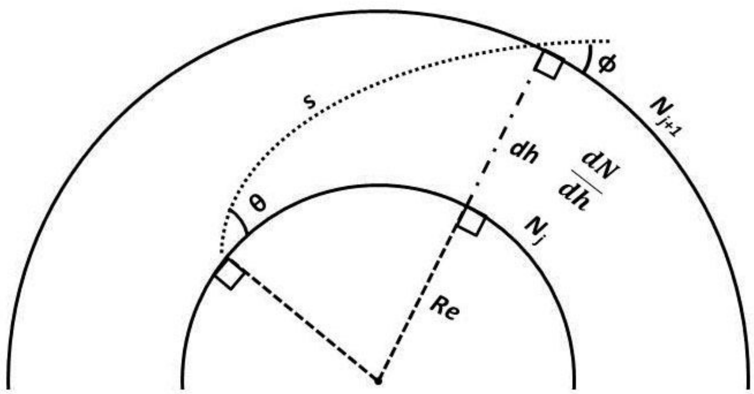
We use the full Planck function, as it is the exact equation of the intensity of radiation emitted by a blackbody, and does not add any significant computing time in this set up. In fact not using the full Planck function can lead to deviations of several 10ths of a degree.

On the atmospheric propagation:

There should be at least a sketch of your model geometry, where it could be seen how the atmospheric layers and the earth curvature are discretized. What in particular remains a mystery to me is your choice for a model for the vertical gradient of the refractive index. […] Then, once you have the refractive indices, how do you calculate

the propagation path? I assume you somehow apply the Snell-Descartes law at the discretization boundaries of your atmospheric profile, but nothing is explained.

You are right. This propagation method is a common approach used by radio-engineers at low elevation angles that simulates the constantly curving propagation of the ray in the atmosphere when the refractivity varies steadily with height. In order to help with comprehension, a figure was added:



"Fig. 1 A sketch showing the propagation at the lowest levels in the atmosphere. The full curved lines represent the 2 first levels of the soundings. On each of these levels is a value of the refractivity of the level N_j and N_{j+1} that are the refractivity for the first and the second level respectively. The small dashed lines represent the Earth's radius (Re). The dash dot line represents the height difference between the level (dh) also this is the thickness of the layer between the two model levels. In this layer, there is a value of vertical gradient of refractive index (dN/dh). The small dotted line is the path followed by the beam in the propagation with path length (s) between the two levels. Θ is the elevation angles of the radiometer, and ϕ is the entrance angle of the next layer." (P. 35, L. 1-9)

<u>On the effect of the beam hitting the ground:</u>

In addition it is also a very strong assumption to choose a ground emmissivity of 1. In the frequency range you consider, the emmissivity is somewhere at 0.9. Imagine you look at a cold sky with a BT of 10 K and the temperature of the ground is 300 K. This means that the ground emmits 0.9*300+0.1*10 = 271 K, which is considerably different to the 300 K that one would have if the emmissivity were 1. Hence this choice needs to be rethought or better justified.

We have revised the scheme to incorporate the emissivity

"*In the case where the beam partially hits the ground, the radiances of that part of the beam are changed to*

$$TB_{hit\ ground} = \varepsilon\, TB_{ground} + (1 - \varepsilon)\, TB_{sky}\,, \qquad (12)$$

where ε is the emissivity of the ground, TB_{ground} is the blackbody radiances emitted by the ground represented by the lowest level in the soundings, and TB_{sky} is the emission from the atmosphere from all directions. TB_{sky} is calculated as

$$TB_{sky} = \int_{0}^{90} cos(\xi)\, TB(\xi)\, d\xi\ , \qquad (13)$$

where ξ includes 89 angles form 1° to 90°. In reality this contribution will depend on the actual position of the radiometer and the emissivity of the ground. This emissivity changes with ground cover type and wetness as well as the frequency and polarization of the radiometer. Here we assume the emissivity to be 0.9." (P.7, L.8 - 18)

On the LWP:

You also mention that you only model the absorption coefficients of the dry atmosphere (page 8088, line 25) but later on in the text you somehow retrieve the liquid water path?

On the comment about the liquid water path (LWP), the original soundings are indeed clear air soundings. However, the bias errors caused by omitting the beam width and bandwidth could lead to apparent liquid water signatures in the water vapor sensitive K-band and W-band channels. Therefore, a retrieval of LWP was done to illustrate this problem. We also included a synthetic cloud in the revised version to investigate the sensitivity in cloudy situations. The texts has been clarified accordingly:

"*LWP retrievals are performed on clear air cases as well as cloudy cases. This is done because the bias error caused by not taking the beam width or bandwidth into account could lead to an apparent liquid water signature in the water vapor sensitive K-band and W-band frequencies.*" (P. 9, L. 21 - 23)

2. Major correction to the error statistics:

On the number of soundings used:

You use only two different atmospheric profiles (midlatitude winter, midlatitude summer) which I consider as insufficient for an in-depth analysis. A proper statistical analysis should also contain some information about the expected fluctuation of the overall bias. Such an analysis should be based on an ensemble of radiosonde profiles. If you use only one climatological profile, your analysis lacks the effects that small scale atmospheric fluctuations have on the incoming brightness temperature (such as temperature inversion layers etc).

The goal of this manuscript as stated before is not to provide a statistical analysis of the biases, but rather encourage the community to take the effects of bandwidth and beam width into their models. Therefore, the use of an ensemble of radiosondes is beyond the scope of this paper. That being said, we have increased the scope of the climatological soundings used in this paper, and now include a tropical summer and subarctic summer climatological sounding in addition to the mid-latitude summer and winter soundings.

On the inclusion of clouds:

One of my main points is the fact that you do not consider a contribution from clouds and rain for your analysis. One one hand, this makes me wonder how you can simulate the effect of LWP retrievals (where did I miss something here?), and on the other hand this dramatically hampers the applicability of your study. Since you state

that this study is useful for potential radar / radiometer retrievals, I don't see how this should be useful if you only consider dry atmospheres since cloud and weather radars measure only meaningful things if hydrometeors are present.

We have added a section on the effects of the beam width and bandwidth biases in the case of cloudy conditions. The simulation was done by adding a cloud that is 1km thick with a LWP of 300g/m^2 starting at a height of 1km. However, the addition of a cloud layer does not affect much the results found in clear air.

"*Since radars are used for hydrometeors detection, we have added a 1km think horizontally homogeneous cloud at a height of 2 km and with a liquid water path of 300 g/m^2 to the previously described soundings. In this cloud, the water vapor was changed from the original values in the climatology soundings to the saturated values. We have not added precipitation as scattering effects must also be accounted for and are, for the moment, not included in the forward model.*" (P.10, L. 8 - 13)

"*As mentioned before, we added a slab cloud to the different soundings and did the same analysis as was done with the previous clear air cases. The biases caused by omitting the bandwidth are not affected by the presence of this cloud. For the bandwidths experiment the results remain very similar to those found in the clear air case. This is due to the fact that the addition of the cloud did not change the curvature of the TB as a function of frequency. On the other hand, most of the beam width biases are reduced except for the K-band that shows little change compared to the clear air. This is because the cloud raised all TB preferentially at low opacity bands and at high frequencies. This reduces all curvatures and hence reduces the biases associated with them. The effect of both the refractive index and the earth curvature were also reduced.*" (P.23, L. 22 to P. 24, L.4)

On the use of off-zenith brightness temperatures:

I have also difficulties to understand why you did not map the off-zenith simulated brightness temperatures to the zenith direction. The lower the zenith angle, the higher is the BT simply due to the increased atmospheric path. It is therefore difficult to compare the errors that stem from simulations at low elevation an- gles with those simulated in zenith direction.

The opacity was added next to the TB values in the text for the K-band and W-band, but not the V-band. In V-band, it is changes in the temperature profile of the atmosphere that drives changes in TB measurements not so much changes opacity.

On the retrieval algorithm:

I have also not understood how you can model the impact of beamwidth and bandwidth effects on the retrieved temperature profile. You use a rather primitive temperature retrieval (Eq 11), but from this equation I don't see how you can get a temperature profile. If you want to calculate the effect of your forward model errors on the radiometer's temperature retrieval capability, you should use some more sophisticated retrieval algorithms (neuronal networks, optimal estimation ...).

The temperature at each height is a linear combination of brightness temperatures at different frequencies and elevation angles. The regression coefficients are determined empirically. Unfortunately, Equation (15) was not very clear to read and has been revised. Crewell and Löhnert (TGARS, 2007) show that such a simple approach provides boundary layer profiles with good accuracy (approx. 1 K) in the atmospheric boundary layer.

$$T_j = d_o + \sum_f \sum_\theta d_{1f\theta} TB(f,\theta) \quad (15)$$

Why didn't you include the W-band frequency?

The reason why the W-band was not included in this simple retrieval, because is that most microwave radiometers do not include the W-band channels. Also, the "classic" approach is to use the K-band channels in the retrieval. ARM is expanding their systems to include the W-band, but this is fairly recent.

Why this separation? Due to the opaqueness of some of the channels?

The separation in V-band is done because it was showed in Crewell and Löhnert (2007) that it is not necessary to include the elevation scans for the lower opacity V-band channels. This is because the temperature information can only be gained through elevation scanning if the atmosphere is optically thick.

I do not see a temperature profile here. What's this temperature T and at which height can it be found? It's a rather primitive retrieval which I doubt is going to work.

Unfortunately the equation was mistyped. See above. The following corrections to the equations in the papers were done:

"A simple retrieval algorithm is used to calculate the response of certain retrieved atmospherics parameters to the errors for both K-band and V-band. The parameters that were derived are integrated water vapor (IWV), liquid water path (LWP), and temperature (T). Both the IWV and LWP are derived using only the 23.8 GHz and 31.4 GHz K-band frequencies for elevation angles 90, 42, 30, 19.2, 10.2, and 5.4°. The W-band was not included in the algorithm, although an improvement of 50% can be made using the 90 GHz frequency in LWP retrievals because of its sensitivity to clouds (Crewell and Löhnert, 2003). Both the LWP and the IWV are derived from quadratic regressions. The LWP was derived from TB measurements as

$$LWP = c_0 + \sum_f \left(c_{1f}\, TB_f + c_{2f}\, TB_f^2\right) \quad (14)$$

where TB_f is the brightness temperature defined previously in Kelvin for each frequency, f, and c_0, c_{1f}, and c_{2f} are the regression coefficients (Löhnert and Crewell, 2003). The same equation is used for the IWV regression, but the regression coefficients are different. All statistical errors refer to the path integrated amounts and are not mapped to zenith values. The temperature profiles retrieval is based on 7 V-band frequencies (51.26, 52.28, 53.86, 54.94, 56.66, 57.3, and 58 GHz) where the first 3 frequencies are used only in zenith pointing and the last 4 consider all the elevations angles used for the IWV and LWP retrievals. The temperature was derived using a linear regression from TB measurements as

$$T_j = d_o + \sum_f \sum_\theta d_{1f\theta} TB(f,\theta) \quad (15)$$

where d_0 and d_1 are the regression coefficients and j is for each level of the sounding (Crewell and Löhnert, 2007). LWP retrievals are performed on clear air cases as well as cloudy cases. This is done because the bias error caused by not taking the beam width or bandwidth into account could lead to an apparent liquid water signature in the water vapor sensitive K-band and W-band frequencies." (P. 9, L. 2 - 23)

If these values are not mapped to zenith, then the statistics are not going to be satisfying (see general comments above).

The lower the zenith angle, the higher is the BT simply due to the increased atmospheric path. It is therefore difficult to compare the errors that stem from simulations at low elevation angles with those simulated in zenith direction.

We don't want to compare different elevation angles. We want to know the error for path integrated water vapor and cloud liquid as a function of elevation angle.

On the specific comments:

Corrected statements or comments are listed here for the specific comments. The references to line and pages are from the original document, not the corrected one.

P 8086 line 11
"The impact of the antenna beam width is higher than the receiver band width". That's a strange sentence since antenna beam width and receiver band width are two completely different things.
Sentenced changed to:
"*The biases caused by omitting the antenna beam width in measurement simulations are larger than those caused by omitting the receiver bandwidth, except for V-band where the bandwidth may be more important in the absorption peaks*" (P.1, L. 20 - 22)

P 8086 line 17
Ground-based radiometers have been used for a lot of other things and not necessarily in zenith-looking mode.
Sentence changed to:
"*Ground-based microwave radiometers have often been used in a stand-alone zenith-pointing mode measuring integrated amount of water vapor and liquid water as well as temperature and water vapor profiles*" (P.2, L. 2 - 4)

P 8087 line 11
An explanation should be given why the beam width for a radiometer is wider for the same frequency than for a radar.
An explanation on why the radar beam width is narrower than radiometers is now given:
"*Radars have often narrower beam width than radiometers, because they traditionally use elevation angles that are very close to the horizon in order to get more information in the atmosphere, i.e. precipitation. Radiometers generally don't scan quasi-horizontally, and thus, may have wider beam widths..*" (P.2, L. 21 - 25)

P 8087 line 20
Explain "TB".

“*However, the use of a wide receiver bandwidth could lead to errors caused by non-negligible changes of the absorption coefficient (equivalently changes in brightness temperature TB) within the bandwidth range.*” (P.3, L. 3 - 5)

P 8087 line 24

90◦ elevation.

“*In their study, they investigated the impact of earth curvature and antenna beam width for elevation angles ranging between zenith (90° elevation) and 14.5°.*” (P.3, L. 8 - 10)

P 8087 line 27

"width" -> "beam width"?

Define "air mass"

Write either "air mass" or "airmass".

Air mass was removed in all instances and replaced by elevation angles. The values of air mass stated were changed to values in elevation angles. The “width” was indeed beam width and was changed:

“*The beam width error increases with increasing beam width, elevation angle, and water vapor amount, but corrections can be applied if the antenna side lobes can be neglected.*” (P. 3, L. 12 - 15)

P 8088 line 1

Use either "beam width" or "beamwidth"

All instances of beam width are now written as beam width and not beamwidth.

P 8088 Eq 1

tau is usually used for the opacity.

A(f,0,s) is the opacity i.e., the integral over the absorption coefficients

Equation was changed to have tau:

“*The input to the radiometer is proportional to the atmospheric radiance I (W m^{-2} $sr^{-1}$$GHz^{-1}$) of the incoming radiation in the non-scattering case given by*

$$I(f,\theta) = \int_{\theta'} G\left(\theta' - \theta\right)\left[I_{cos}(f)\tau\left(f,0,\infty\right) + \int_0^{\infty} \alpha(f,s)\,\tau(f,0,s)\,B\left(f,T(s)\right)ds\right]d\theta' \;, \quad (1)$$

where θ is elevation angle, θ' is the elevation angle of specific ray of the beam, G(θ' - θ) is antenna gain, f is frequency, I_{cos} is the emitted radiation of the cosmic radiating background, τ (f,0,∞) is the total transmission from top of the atmosphere to the surface, s is the slant path length, α (f, s) is the absorption coefficient at s in km^{-1} , τ (f,0,s) is the opacity between the surface to s at frequency f, and B(f, T(s)) is the Planck function with temperature at s, T(s) (i.e. Petty, 2006; Huang et al., 2008). “ (P. 4, L.13 - 20)

P 8088 line 14

The unit of radiance is usually W mˆ(-2) srˆ(-1) fˆ(-1)

Units of radiance was corrected (see italics P8088 Eq1)

P 8088 line 23

Why you define the absorption coefficients in Np kmˆ-1? Does not make sense in your formulation of the RT equation. Explain Np.

Nepers ahave now been ommitted. The units should be: km^{-1}. This was changed.

Why do you choose Rosenkrantz 1998?
The explanation of the Rosenkranz or Liebe was discussed in the general comments (absorption section). In addition to this, a reason for the choice of absorption models is added:
"*In this case, the Liebe MPM-89 code is used for the calculation of the absorption of the atmospheric gases. Hewison et al. (2006) found that Liebe's absorption model was the closest to the measurements although it still over-estimates the absorption.*" (P.5, L. 18 - 21)

P 8088 line 25
Why only the dry atmosphere? What about LWP if you only consider the dry atmosphere?
For comments on LWP and treatment of clouds please see general comments above (LWP section).

P 8089 line 6
Why don't you use the Rayleigh-Jeans approximation?
Define c as the speed of light. Give somewhere a sketch or a drawing that explains your geometry.
Both Rayleigh-Jeans approximation and the sketch for the geometry are answered in the general comments above (Plank and Propagation sections respectively). C was defined at the speed of light:
"*The radiance of each level of the atmosphere is determined using the Planck function*

$$B\big(f,T(s_i)\big) = \frac{2\,h\,f_v^3}{c^2}\left\{exp\left[\frac{h\,f_v}{k\left(\frac{T_{j+1}+\,T_j}{2}\right)}\right]-1\right\}^{-1}, \qquad (3)$$

where h is Planck's constant, c is the speed of light, k is Boltzmann's constant, and T_{j+1} and T_j are respectively the top and bottom levels of the layer (HW00)." (P. 5, L. 5 - 9)

P 8090 line 6
I don't understand the choice of this model (see general comments above).
For choice of model see general comments (absorption section) and specific comment P 8088 line 23

P 8089 line 20
Give some references for this statement.
Reference was added:
"*Typical antenna patterns of radiometer systems show a Gaussian shape and a side lobe suppression of better than -30 dB (Rose et al., 2005).* "(P. 8, L. 2 - 3)

P 8091 line 4
This is a very strong assumption (see general comments above).
See general comments (beam hitting ground section)

P8091 line 7
Emmissivity depends also on polarization.
Indeed, and the effect of polarization was added to the list:
"*This emissivity changes with ground cover type and wetness as well as the frequency and polarization of the radiometer.*" (P. 8, L. 16 - 17)

P 8091 line 19

The water vapor absorption line gives no information on the amount of liquid water.
This phrase was badly written and is now:
"*The K-band, covering the 22.235 GHz water vapor absorption line, provides information on the amounts of liquid water and water vapor (Fig. 3).*" (P. 10, L. 19 - 20)

P 8091 line 22

These channels provide only information about the temperature in the lower tropospere.
The atmosphere was changed to lower-troposphere:
"*The V-band dominated by the 60 GHz oxygen absorption band that provides information on the temperature distribution in the lower troposphere.*" (P. 10, L. 20 - 22)

P 8092 line 3

Define your beamwidth: Is your beamwidth value the point where your fitted Gaussian dropped to 1/e?
Beam widths are defined as half power full width in degrees everywhere in the paper. Phrase changed to:
"*The beam widths chosen range from 0.5° to 10° at half power full width, while the channel bandwidths range between 100 MHz and 1000 MHz.*" (P.11, L. 4 - 6)
Why didn't you include the W-band frequency?
W-band is not included explanation in general comments (retrieval algorithm section).

P 8092 line 24

Please reconsider the notation of this equation. The index 'i' is not the frequency
Index I has been changed to index f see above

P 8092 line 27

If these values are not mapped to zenith, then the statistics are not going to be satisfying (see general comments above).
The mapping to zenith is discussed in the general comments (off-zenith brightness temperature section).

P 8093 line 1

Why this separation? Due to the opaqueness of some of the channels?
Separation between V-band channels elevation use is discussed in general comments (retrieval algorithm section).

P 8093 eq 11

I do not see a temperature profile here. What's this temperature T and at which height can it be found? It's a rather primitive retrieval which I doubt is going to work.
Error in the equation this has been fixed, see general comments (retrieval algorithm section).

P 8093 line 13

Why don't you include cloud liquid water?
Clouds have now been included see general comments (cloud section). Proper statistics are discussed in general comments (number of soundings section).

P 8096 line 12

"minimums" -> minima

All instances of minimums are now written as minima and not minimums.

P 8097 eq 13

Why not "="

The proportional sign was used because a constant that depends on the radiometer hardware type was not included. This equation was changed to reflect the Dicke switch type radiometer (this constant = 2 in this case) and was put as an = sign:

"*The theoretical precision of a Dicke switch radiometer is given by*

$$\Delta T = \frac{2\,(T_N + T_A)}{\sqrt{\beta\ t}}, \qquad (18)$$

where T_N is the instrument's noise temperature (here 700K), T_A is the measured TB (here 300K), β is the channel bandwidth, and t is the measurement integration time (Ulaby et al., 1981)." (P.15, L. 24 to P. 16, L. 4)

P8097 line 22

B" was used for the Planck radiation before and is here now used for the bandwidth.

The B was indeed used for Planck and was changed to β instead for the bandwidth (see italics in P 8096 eq 13).

P 8098 line 7

I do not understand this sentence at all.

Sentence was modified to:

"*The radiometer and atmospheric noises causes a random error around the true measurement value unlike the other errors mentioned in this paper, which are biases.*" (P. 16, L. 5 -7)