QUANTITATIVE EVALUATION OF 6.2µm, 7.3µm, 8.7µm METEOSAT CHANNELS RESPONSE TO TROPOSPHERIC MOISTURE DISTRIBUTION

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Abstract

With the aim to quantitatively evaluate the response of the absorption/air mass channels of SEVIRI radiometer 6.2 µm, 7.3 µm and 8.7 µm to stratification of humidity in the troposphere, calculations by using RTTOV_8 radiation model are performed. A standard temperature profile with troposphere profiles of moisture stratified in individual layers are handled by the model to learn about the response of these three channels to various cases of vertical distribution of humidity.

Two radiation effects of critical importance for interpreting data in the studied absorption channels are considered:

- The effect of portioning between the contributions of the radiation passing through the moist layer from bellow and the radiation emitted by the moist layer itself. The “portioning effect” influences the radiation of 6.2 µm, 7.3 µm and 8.7 µm absorption channels in different ways and allows these channels to be sensitive to tropospheric moisture at different altitudes.

- The “sensitivity range”, which provides an indication of the channels’ ability to detect differences in humidity of atmospheric layers at various altitudes. The sensitivity of 6.2 µm, 7.3 µm and 8.7µm channels to distinguish moisture features of 30% and 97% relative humidity at a range of levels over all troposphere is depicted. It is shown that the 8.7µm channel exhibits maximum sensitivity at about 700 hPa, and its radiance is slightly sensitive to water vapour in a deep layer from 500 to 900 hPa.

INTRODUCTION

Some results of a qualitative study on the information content of the water vapour (WV) channels of Meteosat Second Generation (MSG) are published by EUMETSAT in the MSG Interpretation Guide (Georgiev and Santurette, 2006) to serve as a training material on interpretation of WV radiances for various moisture profiles. They are illustrated by satellite images, corresponding observations from operational upper-air soundings and vertical cross-sections of NWP model-derived humidity associated with specific patterns of image grey shades. Factors, which cause moist layers at different vertical locations to produce large differences in brightness temperature derived by the two MSG WV channels are discussed.

Due to their specific sensitivity to the moisture and temperature profiles in the path of radiation to the satellite, the channels in water vapour absorption band can provide information for a wide range of atmospheric processes. In order to be able to infer such meteorological information it calls for quantitative knowledge on the channel’s radiances depending on moisture and temperature profiles in the troposphere.

Usually, the satellite channels’ response is quantitatively illustrated by the weighting function, which indicate the relative vertical contribution to radiation by atmospheric layers at various altitude for
standard averaged atmospheric profiles of humidity and temperature (e.g. Holmlund and König). Several authors have reported studies, aiming to associate the phenomena visible in the WV images with corresponding tropospheric level for 6.3 µm channel of Meteosat First Generation by using accurate transmittance models (Poc et al., 1980; Fischer et al., 1981). Due to the strong temperature dependence of the Plank function within the considered spectral region, these authors also considered the contribution function, which is a product of the weighting function and the Plank function. In order to describe the region of the atmosphere from which the radiation originates, they investigated the dependence of the contribution function on the vertical distribution of temperature and humidity (see also Santurette & Georgiev, 2005). In these studies, however, the contribution of different atmospheric layers to the radiances is assessed at a homogeneous distribution of moisture in the troposphere. Poc et al. (1980) defined model atmospheres with a constant value of relative humidity (5 %, 50 %, 70 %) between 1000 and 200 hPa or/and varied it in the layer between 600 and 300 hPa to 10 %, 15 %, 20 %, 70 %. Fischer et al., 1981 considered standard atmosphere temperature profiles and relative humidity 10 % or 30 % over the whole troposphere). These concepts are not able to depict the radiance in real cases where the moisture could often be stratified in single layers at different altitudes. Regarding the operational use of the WV channels, it is more efficient to perform the interpretation in the view of specific radiation effects, produced by the water vapour absorption as those considered by Weldon and Holmes (1991) for the WV channels of GOES satellites.

This paper is aiming to fill in the gap between published results and such studies on WV channels’ response to layered moisture distribution in the troposphere for MSG. Among the others, two radiation effects can serve as basic concepts for the interpretation of the radiances measured by the satellite in water vapour absorption band as well as of the corresponding brightness temperatures and image grey shades. These are:

- The portioning effect, which is used for explaining the different dominance to the total WV channel radiance between the contribution of the radiation arriving from below a moist layer at a specific altitude and the radiation emitted by this layer itself.
- The sensitivity range, which represents the ability of the channel to distinguish differences in humidity at various altitudes.

### RTTOV SIMULATION OF RADIANCES FROM TROPOSPHERIC MOIST LAYERS

In general, the radiation from water vapour that reaches the satellite does not arrive from a single surface or level, but from some layer of finite depth. Water vapour—in typical concentrations—is semitransparent for the radiation in 6.2 and 7.3 µm channels, except for the low-level. Therefore, the brightness temperature measured by the satellite is a “net” temperature of some layer of moisture, not the temperature of any single surface or level. As the humidity of a layer is reduced, the contribution from the layer decreases.

The intensity of radiation, reaching the satellite is referred to as ‘radiance’. For the measurements in the infrared (IR) channels, the radiance is related to the brightness temperature through the Plank function. The following analytic relation between the radiances (R) and the equivalent brightness temperatures \( T_b \) for the Meteosat (SEVIRI) channels is adopted:

\[
R(\nu_c) = C_1 \nu_c^3 \exp[C_2 \nu_c / (4T_b + B)] - 1
\]

with: \( C_1 = 1.19104 \times 10^{-5}\ \text{mW m}^{-2}\ \text{sr}^{-1}\text{cm}^{-4}; \ C_2 = 1.43877\ \text{Kcm}^{-1}\); \( \nu_c \) the central wave number of the channel, presented in Table 1; \( A, B \) coefficients, see Table 1.

<table>
<thead>
<tr>
<th>MSG Channel</th>
<th>WV6.2 µm</th>
<th>WV 7.3 µm</th>
<th>IR 8.7µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \nu_c )</td>
<td>1558.790140</td>
<td>1359.929538</td>
<td>1148.276868</td>
</tr>
<tr>
<td>A</td>
<td>0.9942812723</td>
<td>0.9986580685</td>
<td>0.9995245584</td>
</tr>
<tr>
<td>B</td>
<td>1.706687325</td>
<td>0.3196454452</td>
<td>0.09399094187</td>
</tr>
</tbody>
</table>

*Table 1: Central wave numbers and coefficients used in RTTOV for Plank function calculations.*
Transmittance at a given level is the ratio of all the radiation, arriving from bellow that level, which penetrates to the satellite. Considerations on the radiation transfer theory for channels in the water vapour absorption band are available in Eyre (1981) as well as in Santurette and Georgiev (2005).

In this study, radiation characteristics of the absorption channels 6.2, 7.3 and 8.7\(\mu\)m of MSG are obtained by using RTTOV_8 radiation code (Saunders et al., 1999; Saunders and Brunel, 2005). A mean temperature profile, derived by ECMWF 40-years re-analysis is used at a set of 19 isobaric level defined in the RTTOV code. The calculations are performed for 18 moist layers at different altitude locations, at 45 N latitude, which corresponds to zenith angle 51.78° respectively. Descriptions of the RTTOV levels, which are used as well as definitions of the moist layers are presented in Table 2. Standard atmospheric pressure of 1000 hPa is accepted for the surface.

<table>
<thead>
<tr>
<th>RTTOV level</th>
<th>Level Temperature (°C)</th>
<th>Moist Layer No</th>
<th>Bottom–Top Pressure of Layer (hPa)</th>
<th>RTTOV level</th>
<th>Level Temperature (°C)</th>
<th>Moist Layer No</th>
<th>Bottom–Top Pressure of Layer (hPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>222.94 hPa</td>
<td>-55.0</td>
<td>253.7–222.9</td>
<td>32</td>
<td>610.60 hPa</td>
<td>-8.5</td>
<td>610.6–565.5</td>
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<td>23</td>
<td>253.71 hPa</td>
<td>-52.0</td>
<td>253.7–222.9</td>
<td>33</td>
<td>656.43 hPa</td>
<td>-5.2</td>
<td>656.4–610.6</td>
</tr>
<tr>
<td>24</td>
<td>286.60 hPa</td>
<td>-47.2</td>
<td>286.6–253.7</td>
<td>34</td>
<td>702.73 hPa</td>
<td>-2.1</td>
<td>702.7–656.4</td>
</tr>
<tr>
<td>25</td>
<td>321.50 hPa</td>
<td>-41.9</td>
<td>321.5–286.6</td>
<td>35</td>
<td>749.12 hPa</td>
<td>0.6</td>
<td>749.1–702.7</td>
</tr>
<tr>
<td>26</td>
<td>358.28 hPa</td>
<td>-36.0</td>
<td>358.3–321.5</td>
<td>36</td>
<td>795.09 hPa</td>
<td>3.0</td>
<td>795.1–749.1</td>
</tr>
<tr>
<td>27</td>
<td>396.81 hPa</td>
<td>-31.0</td>
<td>396.8–358.3</td>
<td>37</td>
<td>839.95 hPa</td>
<td>5.5</td>
<td>839.9–795.1</td>
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<tr>
<td>28</td>
<td>436.95 hPa</td>
<td>-25.8</td>
<td>436.9–396.8</td>
<td>38</td>
<td>882.82 hPa</td>
<td>7.6</td>
<td>882.8–839.90</td>
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<tr>
<td>29</td>
<td>478.54 hPa</td>
<td>-20.7</td>
<td>478.5–436.9</td>
<td>40</td>
<td>957.44 hPa</td>
<td>11.1</td>
<td>957.4–882.8</td>
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<tr>
<td>30</td>
<td>521.46 hPa</td>
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<td>521.5–478.5</td>
<td>43</td>
<td>Surface (2m)</td>
<td>13.7</td>
<td>1000.0–957.4</td>
</tr>
<tr>
<td>31</td>
<td>565.54 hPa</td>
<td>-12.2</td>
<td>565.5–521.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Description of RTTOV levels used, for monthly mean standard temperature profile (ECMWF reanalysis mid-latitude 45° N) and definition of the moist layers.

For each profile, one of the 18 layers is assigned as a moist layer by setting relative humidity to a constant value of 97%, and 30%. All other 17 layers of the profile are considered as dry layers of “background moisture”: the minimum values of humidity defined by the RTTOV model with the fixed temperature sounding. The background moisture in the dry layers varies from 0.12 \(10^{-2}\) g/kg to 0.67 \(10^{-1}\) g/kg mixing ratio, and from 0.17 % to 2.15 % relative humidity.

In order to assess as clearly as possible the altitude association of MSG channels response to the water vapour content, a set of single moisture layers are defined by setting higher moisture (30 % or 97 % relative humidity) at the two border RTTOV levels with an alternative decreasing of humidity to the background moisture along the entire adjacent dry layers. This approach is referred hereafter to as “sharp moisture changing” and illustrated by the red, solid line in Fig. 1a for a case of a mid-level moist layer of 30 % relative humidity. Applying such a simulation of the moist layers in RTTOV leads to sharp changing in the simulated radiances from layer to layer that will be shown with the consideration of partitioning effect.

![Figure 1](image-url): RTTOV simulation of a mid-level moist layer with (a) sharp (red, solid) and (b) smooth (blue, dashed) changing of humidity from the moist layer to the background moisture at the upper/lower layer.
In order to implement a more realistic moisture distribution, moist layers are defined by setting higher moisture at the two border RTTOV levels with a gradually decrease in humidity from 30/97 % to the background moisture along the entire adjacent dry layers. This approach is referred hereafter to as “smooth moisture changing” and illustrated by the blue, dashed line in Fig. 1b.

For each of the 18 model profiles defined in accordance with sharp/smooth moisture changing approaches, the radiance, brightness temperature and transmittance from the bottom of the layer to space are calculated for the three Meteosat channels considered.

**EFFECT OF PORTIONING AND CROSS-OVER EFFECT**

With the air temperature sounding fixed, water vapour channel radiance, measured by the satellite, is produced by radiation intensities arriving from different origins. Below a specific level in the lower troposphere, the atmosphere becomes relatively opaque to the radiation. This threshold level changes with the WV channel and varies primarily with the temperature. If some moisture is present in layers of finite depth above the threshold level, significant amounts of radiation pass through the layers from some warmer origin located below. The other portion is absorbed and reemitted at low energy by a colder air. Therefore, depending on the mixing ratio and the density of the water vapour in the layer, the radiation at the satellite is partly originated from the moist layer and partly from below. This effect is referred to as ‘portioning effect’, which influences the radiation measured by different WV channels in different ways and allows these channels to be sensitive to the moisture distribution at different altitudes. Fig. 2 illustrates the portioning effect for the two METEOSAT WV channels. The radiances, derived by RTTOV simulations, are presented in Plank function units: mW m\(^{-2}\) sr\(^{-1}\)(cm\(^{-1}\))\(^{-1}\). In order to interpret the portioning effect, three radiation curves are considered.

- Total radiance’ is the net radiation intensity from which the brightness temperature is derived.
- ‘Contribution from the moist layer’ is that portion contributed by the water vapour of the considered moist layer (as well as by the background moisture above).
- ‘Contribution from below’ is that portion of the total radiance contributed by the radiation that passes through the considered moist layer (coming from the earth surface as well as from the background moisture below the layer). In an idealized case of absolutely dry air below the moist layer, this portion represents the contribution of the earth’s surface to the total radiance.

The total radiance is the clear-air radiance \( L_{\text{clr}}(n_l) \) derived directly by RTTOV at the bottom of the moist layer for each one of the 18 profiles, representative for the 18 moist layers at different altitude locations.

The Contribution from the moist layer \( (R_{\text{layer}}) \) to the radiance is derived from the RTTOV output for cloudy radiances referred to as ‘overcast’ radiance \( L_{\text{overcast}} \), which represents cloud-affected radiances assuming black, opaque clouds. In order to eliminate the cloud effect in the overcast radiance and to obtain only the atmospheric contribution, the overcast radiance obtained for the bottom level \( n_l \) of the moist layer is diminished by the cloud-top radiance. The cloud-top radiance is derived from the radiation \( R(n_l) \) of the bottom level multiplied by the transmittance \( \sigma(n_l) \) of that level to space. Thus the portion contributed by the water vapour of the considered moist layer (and the background moisture above) is assigned to the contribution of the moist layer, obtained by expression (2).

\[
R_{\text{layer}} = L_{\text{overcast}}(n_l) - R(n_l)\sigma(n_l)
\]  

The radiation \( R(n_l) \) at the bottom of the layer is calculated using the expression (1), assuming that the temperature of the bottom of the layer is \( T_b \).

Finally the contribution from below the moist layer \( L_{\text{below}} \) is obtained as a difference between the clear-air radiance \( L_{\text{clr}}(n_l) \) derived by RTTOV at the bottom of the layer and the contribution from the moist layer obtained according to the expression (2) as follows:
\[ R_{\text{below}} = L_{\text{cb}}(n_1) - R_{\text{layer}} \]  \hspace{1cm} (3)

The concept of radiance portioning reveals the following important characteristics of the radiances in 6.2 \( \mu \)m and 7.3 \( \mu \)m channels, seen in Fig. 2:

- Layers at low levels often absorb all or most of the radiation, coming from below and produce warm brightness temperatures because the moist layer itself is warm. The contribution from below is small mostly absorbed by the low level moisture. The moist layer contribution to the total radiance is high and dominates the contribution from below.

- Layers of moisture at high altitudes produce relatively warm brightness temperatures. The water content of such a layer is very small and much of the radiation from lower warmer sources penetrates through the layer. For that reason, the moist layer contribution is very small and the most part of the measured radiation is emitted by the lower levels moisture and the earth's surface then passes through the moist layer.

- For 6.2 \( \mu \)m and 7.3 \( \mu \)m WV channels the curves of the two portions of the radiances cross each other at the middle troposphere and for that reason the effect of portioning was referred to as 'cross-over' effect by Weldon and Holmes (1991).

- Moist layers at middle altitudes produce the coldest brightness temperatures measured by the WV channels due to the crossover effect between radiation penetrating from below and radiation from the moist layer.

*Figure 2: Portioning and Cross-over effects for WV channels: 6.2 \( \mu \)m, moist-layer relative humidity (a) 97 % and (b) 30 %; 7.3 \( \mu \)m, moist-layer relative humidity (c) 97 % and (d) 30 %.

Fig. 2 shows that the 6.2 \( \mu \)m and 7.3 \( \mu \)m channels exhibit similar overall cross-over characteristics but there are significant differences in their crossover altitudes. This allows the radiances measured in the
two channels to be used for assessing total moisture content and diagnosing dynamic processes at two different tropospheric layers (Santurette and Georgiev, 2007).

Since the 6.2 µm channel radiation is more easily absorbed by water vapour their radiances are lower and accordingly their brightness temperatures are colder than those for 7.3 µm channel. The crossover level for the 6.2 µm radiance is located at a higher altitude than this for 7.3 µm channel.

The crossover altitude for the two WV channels appears at lower levels with decreasing relative humidity of the moist layer from 97% to 30%. For the 7.3 µm radiation, the crossover altitude falls much more with decreasing of humidity than this for the 6.2 µm channel. For 7.3 µm channel, the contribution of the low-level moist layers is not approximately equal to the total radiance as it is for the 6.2 µm channel. These results are due to much less absorption in 7.3 µm channel that makes air of low water vapour content at low level to be semitransparent for the radiation coming from the surface, while the low-level moisture is always opaque for 6.2 µm channel radiation from below.

The portioning effect for the IR 8.7 µm channel is presented in Fig. 3. There is no cross-over effect for the IR 8.7 µm radiance, since the contribution from the moist layer is very small due to very low absorption by water vapour with this channel. In order to make the considerations valid for all absorption channels, the cross-over concept introduced by Weldon and Holmes (1991) is generalised with this study as the “effect of portioning” between the contribution of the radiation arriving from below and the radiation emitted by the moist layer itself.

![Figure 3: Portioning effect of the IR 8.7 µm channel for moist-layer relative humidity (a) 97 % and (b) 30 %, (c) Brightness temperature.](image)

At each level, the radiation of a specific channel is produced two opposite mechanisms: absorption of the radiation by the moist layer and re-radiation at a lower energetic level; transparency of the layer for radiation coming from below of the layer that moderates the cooling of the radiance due to absorption in the moist layer. Due to the specific portioning effect of these opposite mechanisms, the “cooling effect” on the radiance exhibits its maximum at different levels for the different absorption channels. These are the levels, around which a moist layer produces the coldest brightness temperature.

The moisture stratification with the portioning effect is simulated by applying the approach of “sharp moisture changing” (Fig. 1a). Fig. 3 shows that such a definition of the moist layers in RTTOV enables to indicate levels of sharp changing of the simulated radiances from layer to layer. This effect seems to appear around the layers of strongly non-linear increasing of the absorption from layer to layer. Fig. 2 reveals such non-linearity of the absorption profiles between 400 and 500 hPa for 6.2/7.3 µm channels as well as between 850 and 900 hPa for the 7.3 µm channel. From the profile of 8.7 µm brightness temperature shown in Fig. 3c, it seems there are three layers of non-linear increasing absorption as follows: 400 – 500 hPa, 650 – 750 hPa and 850 – 950 hPa, approximately. Due to this feature of RTTOV_8 model to simulate noisy radiances from moisture, sharply stratified in single layers, we are not able to make clear assessments of the crossover altitudes from the results presented in Figs. 2 and 3. Some rough evaluation of the cross-over effect are given below.
- The coldest 6.2 μm brightness temperature is most likely to be produced by moisture located between 400 – 500 hPa for 97% relative humidity and about 500 hPa for 30% relative humidity.
- For 7.3 μm channel, the coldest brightness temperature appears at 97% relative humidity, and between 700 and 650 hPa for 30% relative humidity.
- For the 8.7 μm channel, the largest variation of the brightness temperature is within 0.7 K in the most humid simulation of 97% relative humidity that is much less in comparison with the 6.2 μm and 7.3 μm WV channels. Due to the absorption of 8.7 μm radiation by water vapour at low level, the coldest brightness temperature is located between 600 and 850 hPa, where two local minima of brightness temperature are located.

The minimum of radiance and the coldest brightness temperature appear around the levels of maximum contribution to the radiance for each channel.

**SENSITIVITY RANGE OF 6.2 μ, 7.3 μ AND 8.7 μ CHANNELS**

The concept ‘Sensitivity range’ introduced by Weldon and Holmes (1991) serves as an indication of the channel’s abilities to detect differences of humidity in atmospheric layers at different altitudes (but it is not a measure of those differences). To illustrate the sensitivity range of the three channels, the profile of the derived differences between the brightness temperatures produced by 30% and 97% relative humidity at each layer are drawn in Fig. 4a. The moist layers are defined applying the approach of “sharp moisture changing” (Fig. 1a).

![Figure 4: Sensitivity range of WV 62 μm, WV 7.3 μm and IR 8.7 μm channels. RTTOV simulations with (a) sharp changing of humidity and (b) smooth changing of humidity from the moist layer to the dry upper/lower layers.](image)

Comparing the cross-over effect (Fig. 3) and the sensitivity range (Fig. 4), it appears that the sensitivity of 6.2 μm, 7.3 μm and 8.7 μm channels increases in the levels of local minima in radiance and brightness temperature. Each of the three channels exhibits a local pair of maximum/minimum of their sensitivity range between 400 and 500 hPa. This feature is associated with the strong non-linear increasing of the absorption between 400 and 500 hPa, as discussed with the portioning effect in the previous section, and the effect is seen in RTTOV output after sharp simulating of moisture in single layers (Fig. 1a). In order to assess the sensitivity range of the absorption channels in a more realistic moisture profile, the brightness temperature differences are considered in moist layers, defined through “smooth moisture changing” (Fig. 1b). Such simulation of the moist layers leads to smooth profiles of RTTOV radiances and, as seen in Fig. 4b, this improves our ability to evaluate the profile of sensitivity of the WV channels.

A summary of the sensitivity range for the three channels is presented in Table 3. A threshold of 4 °C for the difference between brightness temperatures produced by dry (30% relative humidity) and nearly saturated air (97% relative humidity) is applied for definition of sufficiently large sensitivity range. The 6.2 μm and 7.3 μm channels of Meteosat show different overall sensitivity as well as different sensitivity range, depending on the altitude of the moisture features. The 6.2 μm channel exhibits large sensitivity at upper troposphere up to above 200 hPa isobaric level (5.7 °C brightness...
temperature difference at 194.36 hPa, not presented in Fig. 3b). The 7.3 µm channel is sensitive to moisture content in a deep middle troposphere layer centered at about 600 hPa. Two local maxima of sensitivity for the 8.7 µm channel are observed at about 750 and 950 hPa. Although this channel exhibit maximum sensitivity at about 700 hPa, its radiance is slightly sensitive to water vapour in a deep layer from 500 to 900 hPa. Therefore, the IR 8.7 channel is not an efficient tool for inspection of low-level moisture. The radiation in 8.7 µm channel very easy penetrates through the troposphere and its sensitivity range is very low, producing less than 1 °C difference in brightness temperature between 30 % and 60 % relative humidity at all levels. Therefore, the overall sensitivity of the 8.7 µm channel is not significant and it could be only used for quantitative assessment of moisture content and it is not efficient to distinguish moisture features in imagery grey shades.

<table>
<thead>
<tr>
<th>Meteosat channel</th>
<th>WV 6.2 µm</th>
<th>WV 7.3 µm</th>
<th>IR 8.7 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall sensitivity</td>
<td>VERY LARGE</td>
<td>LARGE</td>
<td>POOR</td>
</tr>
<tr>
<td>Layer of large sensitivity range (&gt; 4 °C)</td>
<td>200–550 hPa</td>
<td>400–750 hPa</td>
<td>NONE</td>
</tr>
<tr>
<td>Level of the largest sensitivity range</td>
<td>−400 hPa</td>
<td>−600 hPa</td>
<td>−750 hPa</td>
</tr>
<tr>
<td>Lower threshold of sensitivity (&gt; 1 °C)</td>
<td>−650 hPa</td>
<td>−950 hPa</td>
<td>NOT IMPORTANT</td>
</tr>
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</table>

Table 3: The sensitivity range for METEOSAT water vapour absorption channels.

CONCLUSION

The authors intend to perform further studies on the response of the absorption/air mass channels of SEVIRI radiometer 6.2 µm, 7.3 µm and 8.7 µm with other specific profiles of temperature and humidity in the moist layers. The radiation effects will be assessed for different zenith angles, which correspond to 0, 30, 45 and 60 N latitudes.

REFERENCES

http://oiswww.eumetsat.org/WEBOPS/msg_interpretation/index.html