

General comments

This study evaluates the feasibility of remotely sensing the geomagnetic field at stratospheric and mesospheric altitudes by exploiting the magnetic field's influence on the spectral lines of thermal emission from molecular oxygen, which, via the Zeeman effect, splits these spectral lines and alters the radiation's polarization characteristics. These spectra depend strongly on the geomagnetic field, since oxygen's magnetic dipole couples to it producing measurable spectral shifts. Using the relation between the magnetic field and spectral characteristics, a method is proposed for remote monitoring of geomagnetic variations. The method was validated through observations using the TEMPERA-C radiometer, targeting two oxygen fine-structure transitions at frequencies around 53 GHz. Implementing this technique to monitor magnetic field disturbances requires a full-polarization microwave radiometer capable of detecting oxygen emissions at altitudes of 30–75 km. The authors performed atmospheric radiative transfer modeling to retrieve the characteristics of magnetic field disturbances. Observations conducted during a geomagnetic storm show a disturbance of -130 ± 62 nT in the vertical component of the magnetic field. This result demonstrates the robustness of the proposed method, which is practically the only technique for direct, continuous measurement of geomagnetic field variations at mesospheric altitudes. When scaled up, such data will significantly improve geomagnetic field models for altitudes inaccessible to satellite measurements, particularly under disturbed conditions, making this work both interesting and important.

1. The Abstract does not clearly present the main research question and significant findings of the study. I suggest reorganizing the Abstract to follow the usual structure, as it clearly explains the problem first, then the methods, main results, and the significance of the work. The study is truly innovative. It employs a unique technique to retrieve magnetic field parameters at altitudes inaccessible to other methods. So, the author needs to focus on the principal findings related to the study objectives, which are not clear shown in abstract at the moment.
2. The text in the Introduction (Lines 38-45) is better suited to the Conclusion section, where the results are described. In this place, it is better to formulate the scientific question that is the core aim of the manuscript.
3. It would be useful to add a subsection to discuss the limitations of the proposed method and possible errors in determining the magnetic field parameter during the calculation process. It would also discuss ways to mitigate these errors other than using cryogenic cooling of the receiver. One of the weaknesses of the measurements is the relatively low temporal resolution of the obtained magnetic field parameters (about 20 minutes of integration time). It's worth discussing ways to reduce this time.
4. Figure 9a. The results shown in Figure 9a are very interesting. What causes the jump from positive dH_w to negative dH_w during the transition from the stratosphere to the mesosphere (approximately 50 km)? Why does the positive dH_w disappear between January 18 and January 19? Can such a sharp transition from positive dH_w to negative dH_w exist with altitude, or is it the result of different calculation procedures at stratospheric and mesospheric altitudes, a technical

artifact? However, it should be mentioned that some of these issues are beyond the scope of the manuscript.

Specific comments and technical corrections:

1. In my opinion, the title "On the Feasibility of Remotely Sensing the Earth's Magnetic Field Using a Ground-Based Fully Polarimetric Microwave Radiometer" doesn't quite clearly convey the main advantage of the work—measuring the magnetic field at stratospheric-mesospheric altitudes, which are difficult to access by other methods. However, I find it difficult to suggest the necessary changes while keeping the title concise.

2. The sentence in line 108: "The term $\Phi_{M, M'}$ represents the Mueller matrix describing the polarization of the radiation for the corresponding transition and propagation" is not quite correct. Since the Mueller matrix describes not the radiation but its transformation s So, the following would be more correct: "The term $\Phi_{M, M'}$ represents the Mueller matrix that describes how the polarization of the radiation is transformed for the corresponding transition and propagation."

3. The Mueller matrix generally has 16 nonzero elements, which can also be negative. Therefore, it's unclear which of the normalized elements of the Mueller matrix are depicted in Figure 2. Shouldn't the circle centers for circular polarizations coincide with the center of the polar coordinate system in Figure 2?

4. Maybe, unlike Figure 3, it would be better to clearly indicate the specific Stokes parameters T_Q , T_U or T_V on the vertical axes of the plots in Figure 7; the given general designation T_b here is misleading.

5. In Section 3.3 need to mention what parameters are used in the manuscript from GOES-19.

6. The sketch showing the locations of the microwave radiometer, magnetic field line, LOS, and geographical coordinates to visualize the geometry of the experiment will be useful, at least in the attachment, for better explaining the text at L321-325. Where is an area (bulk) of the atmosphere (geographically/geomagnetically) from which the radiometer receives radiation to retrieve magnetic field parameters under different azimuths?

Other technical comments

Lines 53-54. In equations (3) and (4) probably it is better to use standard designations for the real and imaginary parts of complex numbers ($\text{Re}(X)$, $\text{Im}(X)$), for example, as it is done in the paper referred to by the authors – Randa et al. (2008).

L154. Explain abbreviation AVK

L184. What is accuracy of temperature stabilization and how it influences on magnetic field measurements error?

L264. In the text it would be useful to describe the components of the magnetic field here the magnetic field vector $\mathbf{H} = (\mathbf{H}_u, \mathbf{H}_v, \mathbf{H}_w)$ which if it corrects is in Cartesian components \mathbf{H}_u - zonal or east–west direction, \mathbf{H}_v the meridional or north–south direction and \mathbf{H}_w — vertical direction, pointing upward or downward (?)

Figure 9e. It's useful to draw a zero-horizontal line on this figure to show where and when the transition $d\mathbf{H}_w$ from negative to positive values occurs. This is useful for comparison with the data in figure 9a.

Final conclusions

This paper proposes a method for measuring geomagnetic field variations in a region of the Earth's atmosphere that is least accessible to other methods, such as satellite-based measurements, which is indirect method. The value of this method for measuring geomagnetic field variations will increase as the temporal and spatial resolution and the sensitivity of microwave receivers improve. The manuscript is helpful because it introduces a new technique and method for data acquisition that helps improve geomagnetic field models, especially during magnetic storms.

Comments to Editor

This paper proposes a method for measuring geomagnetic field variations in a region of the Earth's atmosphere that is least accessible to other methods, such as satellite-based measurements, which is indirect methods. The value of this method for measuring geomagnetic field variations will increase as the temporal and spatial resolution and the sensitivity of microwave receivers improve.

It would be useful if, as is now common practice in scientific publications, the authors made the Python code (on GitHub?) for the magnetic field calculations they perform in the manuscript for the proposed method available. Especially since the calculation procedure itself is very complex and cumbersome, and providing the code would allow the community not only to verify the accuracy of the calculations but also to improve them.

The manuscript can be accepted with minor revision after the mentioned corrections.