

## **Manuscript Scheinert et al. (2026)**

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### **Authors' comments to referee comments and community comments**

We structure our response into three main sections. In Section 1 we discuss the issue of defining a proper title to better reflect the scope of our review paper. In Section 2 we summarize our response to the comments to include further observation techniques and/or discuss them in more detail. Section 3 contains our response to all further comments.

Remark on the notation: Referee comments (RC) and community comments (CC) are written in italic type, while our responses are given in normal type.

(RC1: Douglas Wiens; RC2: Wouter van der Wal and Caroline van Calcar)

#### **1. Title of the manuscript**

Both referees as well as one community contribution commented on the title and scope of the manuscript.

**RC1:** *I agree with several earlier comments that the title may convey an overly broad impression of what is covered in this paper. Perhaps add "solid Earth" before geophysics in the title? Then in the introduction, perhaps at the end of the first paragraph, state something like "In this paper, we review the results of geophysical observations made by ground-based networks in Antarctica, with a particular emphasis on applications to solid Earth -ice sheet interactions, and do not attempt to cover the entire range of Antarctic geophysical investigations".*

**RC2:** *The current title suggests a comprehensive review of geophysics in Antarctica, whereas the manuscript primarily focuses on the role of GNSS and seismic observations in advancing geophysical understanding. (...) A title could be: "Geophysics in Antarctica: Insights from Ground-Based Observations" Or "Ground-based Geophysical and Geodetic Observations in Antarctica: Achievements, Current Capabilities, and Future Directions."*

**CC2:** *The title is somewhat misleading, because it infers that the paper includes all geophysical aspects of Antarctica. (...) The lack of (further studies) is not a problem, because their inclusion would exceed the scope of this paper. I therefore suggest to change the title to 'The present geophysical state of Antarctica: Achievements, current capabilities, and future directions' to better indicate that the paper primarily deals with current solid earth conditions and their impact on the cryosphere.*

We fully agree to these comments. Even if we do include some connections to satellite-based and airborne studies, it will be beyond the scope of this review paper to deal in detail with all aspects of geodetic-geophysical investigations in Antarctica. Clearly, a focus is given to ground-based instrumentation and their usage to study the solid Earth

in Antarctica (as treated in detail for GNSS and seismology), but as said above the paper is not limited to ground-based observations. Thus, the paper is clearly framed around present-day ground-based and in-situ observations of the coupled Antarctic solid Earth-cryosphere system, rather than attempting a comprehensive review of all Antarctic geophysics. As suggested, we will much more clarify in the introduction where the emphasis of this paper is put on. For the title, still it should be short (as much as possible) and concise. Therefore, our suggestion for a revised title is:

“Solid-Earth Geophysics and Geodesy in Antarctica: Achievements, Current Capabilities, and Future Directions”

## 2. Treatment of further observation techniques

A second principal issue refers to the arguments by the reviewers as well as by one community comment to consider more detailed discussion of further observation techniques. Although almost most of the mentioned techniques have at least been mentioned we agree that it is needed to give them more attention and clarification to reach a better balance. This said, we would like to emphasize that focus is given to the solid Earth (its interior structure and its present-day response to surface loads), and to ground-based geophysical and geodetic observation techniques applied in Antarctica. This does not exclude to give interlinkages to airborne and satellite-based observations where feasible.

Additionally, we intend to add a table which will give an overview on the considered techniques and their primary targets, together with a reference to the respective section where they will be treated. With that, we hope to provide a tool to give a better guidance throughout our manuscript. This table will be included at the end of Section 1 “Introduction”.

To go in detail through the comments on treating further observation techniques:

**RC2:** *Magnetotellurics* (e.g. Wannamaker et al. 2023)

We agree to this suggestion and will elaborate accordingly.

**RC2, CC1:** *Heat flow measurements* (Talalay et al. (2023))

We agree to these comments to discuss heat flow measurements in more detail. Emphasis should be given to geothermal heat flow to underline the importance of processes at the boundary between the ice sheet and solid Earth (i.e., enthalpy instead of temperature, but not to characterize processes within the ice body). We will aim to update material in the extensive reviews given e.g. by Burton-Johnson et al. (2020), Reading et al. (2022), while complementing the material to be provided by Emma MacKie et al. (in preparation), the preprint of Lösing et al. (2025), Talalay et al. (2026) (<https://doi.org/10.1016/j.earscirev.2025.105357>) and Kerr et al. (2026) (<https://doi.org/10.1029/2025GL120928>).

**RC2: *Tide gauges***

This is indeed a valuable recommendation. Tide gauges provide a link between the (deforming) solid Earth and (local) relative sea-level change. As such, this observation technique is included in the scientific program of the SCAR Expert Group GIANT (Geodetic Infrastructure in Antarctica). One further application is to use TG data to test / constrain / improve ocean tide models. A concise discussion on that topic will be added, including appropriate references (e.g. Rezvani et al. (2024), Galassi and Spada (2017), Sun et al. (2022), Padman et al. (2018), King and Padman (2005)).

**RC2: *...it would make much more sense to also review other geophysical and geodetic ground-measurements collected in field campaigns in Antarctica. (...), and geodetic observations are (...) terrestrial gravity.***

Observation of gravity-field related quantities (mainly scalar gravity) opens up another extensive field of geodetic-geophysical application in Antarctica. Gravity observations are used (a) in geodesy to determine the (exterior) static gravity field (leading to combined gravity field models where satellite observations are combined with terrestrial gravity); (b) in geophysics in inversion methods to infer the location of boundary surfaces such as (b1) subglacial topography, or (b2) local/regional studies of the crustal structure, and the paleogenesis of the Antarctic continent.

Although a few ground-based gravity surveys were accomplished, the vast majority of the gravity observations were (and are being) acquired by airborne surveys, which are not in the very focus of this manuscript. However, we will follow the reviewers' recommendation to clarify the connections of the gravity field observables with solid Earth-related parameters, to elaborate more than already done in Section 2.4.1. We think, this can be done in a concise way while referring to recent papers, which include (and will be included in the list of references, if not cited already):

- For the geodetic application (a) to determine the regional gravity field in Antarctica: Scheinert et al. (2016, GRL) (and PANGAEA) for the Antarctic gravity anomaly solution AntGG v1; Charrassin et al. (2025, Sci. Rep.) and Scheinert et al. (2024, PANGAEA) for the Antarctic AntGG v2
- For inferring subglacial topography (b1):  
for BedMap3: Pritchard et al. (2025);  
for BedMachine v4 – Morlighem, M. (2026). *MEaSURES BedMachine Antarctica*. (NSIDC-0756, Version 4). [Data Set]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center.  
<https://doi.org/10.5067/POJQI54A45HX>;  
for the RINGS project: Matsuoka et al. (2026, in publication, Rev. Geophys.), preprint at: <https://doi.org/10.22541/essoar.175241971.19851046/v1>
- For local/regional studies of crustal structure and tectonics (b2):  
Pappa and Ebbing (2021) <https://doi.org/10.1144/M56-2020-5>  
Haeger and Kaban (2019) <https://doi.org/10.1007/s00024-019-02212-5>

Pointwise measurements using an absolute gravity meter open additional applications, although absolute gravimetry in Antarctica has to be regarded still a special case. On the one hand, absolute gravity points serve as a reference for relative gravimetry campaigns (both land-based and airborne). On the other hand, repeated absolute gravity measurements at identical bedrock locations offer the possibility to infer gravity changes, which can be combined with height changes inferred from co-located GNSS, providing additional information on ice-mass change and associated crustal deformation and GIA. We will add a short, concise paragraph on this issue including respective references such as Näränen et al. (2026); Amalvict et al. (2009), Mäkinen et al. (2007).

### Magnetics

Similar to airborne gravimetry, the vast majority of magnetic recordings have been acquired by airborne geophysics. Similar explanation holds true as in the case of (airborne) gravimetry. Again, the connection of magnetic field observables with solid Earth-related parameters will be much more clarified as already done (e.g. in Section 2.4.1). Respective references are already included (as Golynsky et al. (2018) for ADMAP) or will be added (e.g. Ebbing et al. (2021) <https://doi.org/10.1038/s41598-021-84834-1> and Matsuoka et al. (2026, see above).

To conclude our response to the referee's comment on gravimetry and magnetics, we will add a new short subsection before the subsection on "Multidisciplinary Studies" where we will concisely explain and contextualise gravimetric and magnetic data acquisition w.r.t. scope of this manuscript. Respective recent data compilations and (review) papers will be addressed, as explained above. This new section will be numbered 2.4, and for all subsequent subsections the numbering will be adjusted accordingly. Thus, we think to better and more clearly distinguish between the data acquisition and interpretation (which is the focus of the following subsections).

**RC2:** *It would also make sense to include radar observations which provide key constraints on the geometry of the solid Earth beneath the ice sheet and which is part of the two critical needs.*

Again, radar measurements are (mainly) accomplished using aircraft. Several major review papers on inferring subglacial topography and internal layering (which can provide an indirect proxy for subglacial conditions) were published (SCAR Action Group papers for Bedmap, AntArchitecture and RINGS). Since RES provides the major observation technique to infer subglacial topography, we consider it necessary as well as sufficient to refer to those publications rather than to duplicate information. Additionally, however, we will reference further most recent studies using different input data like Ockenden et al. (2026) <https://doi.org/10.1126/science.ady2532> and the volume of Phil Trans RS A, which dedicated a full volume to ice thickness measurements (<https://royalsocietypublishing.org/rsta/issue/384/2319>)

AntArchitecture: Bingham et al. (2025) (<https://tc.copernicus.org/articles/19/4611/2025/>) provide insights into subglacial layers and bedrock based on internal stratigraphy.

RINGS: upcoming review focussing on the transition between the ice sheet and shelves (preprint: 10.22541/essoar.175241971.19851046/v1)

Overall, we don't think there is any further need to worry separately about bed and radar data in the ice—this is now well-organized, as the communities involved largely overlap.

**RC1:** *Distributed acoustic sensing (DAS) and dense nodal seismograph deployments have a lot of potential for new, detailed studies of cryospheric processes. This should be discussed in more detail in section 3.1.5*

We completely agree that DAS deserves a more detailed discussion. This is a very rapidly evolving area of seismology. It is increasingly important for grounding-line imaging, basal tremor/seismicity, hydrologic processes, ocean-wave coupling, crevasse evolution, distributed strain sensing, and dense passive seismic observations in regions where conventional arrays remain sparse. Thus, we will bring this up in Section 3.1.5.

### **3. Response to further comments**

**RC1:** *Figures 3 and 4 are an important part of this paper, and will be highly useful to readers and future researchers. However, they should be improved. The northern Antarctic Peninsula and Ross Island regions have many stations that are difficult to see, as they plot on top of each other. Magnified insets for these regions would allow these areas to be shown properly. Also, some seismic stations are shown on Figure 4 and but not on Figure 3 (such as the stations near Dome C), which is confusing.*

We fully agree to this comment. Appropriate detailed maps will be added showing magnified insets for the Antarctica Peninsula, Ross Island end probably North Victoria Land, too. We will also dissolve inconsistencies showing seismic stations in Figs. 3 and 4.

**RC1:** *Sections 3.1.6 (seismic wavefields) and 3.1.7 (general circulation models) are not well connected to other discussions and lend this section of the paper a "laundry list" feeling. They should be improved (focused?) or discarded.*

According to your suggestions, we will try to focus the argumentation on these science questions. In doing so, we will also revise the order of the science questions (Appendix A). In detail, Section 3.1.6 will be merged with Section 3.1.5 since there is a natural connection between the topics in these two parts of the manuscript. Investigations of the ice-bed interface zone (IBIZ), where many cryospheric processes occur, depend on the seismic wavefield. In turn, the ambient wavefield strongly depends on sea-ice abundance.

We will also merge Section 3.1.7 (Improved general circulation models) into Section 3.1.1, joining the discussion of climate and atmospheric parameters with those of sea-level change and ice-mass balance. These topics readily go hand-in-hand. We will also

edit the title of this new subsection to “Ice-mass balance and global change” to better reflect the updated content.

**RC1:** *For the history of portable seismology in Antarctica, it would be worth referencing the SEPA project (1997-1999), which deployed temporary broadband seismic stations on the Antarctic Peninsula and nearby islands for several years ([https://www.fdsn.org/networks/detail/XB\\_1997/](https://www.fdsn.org/networks/detail/XB_1997/)).*

We agree with this valuable recommendation and will include the SEPA (Seismological Experiments at the Antarctic Peninsula) project in the introductory paragraph of Section 2.3. The SEPA project (1997-1999) represented an important early deployment of temporary broadband seismic stations on the Antarctic Peninsula and nearby islands (FDSN network code XB, [https://www.fdsn.org/networks/detail/XB\\_1997/](https://www.fdsn.org/networks/detail/XB_1997/)), providing foundational data for understanding the tectonic evolution and seismic structure of this tectonically active region.

**RC2:** *With all geophysical and geodetic observations introduced as suggested above – see our response in Section 2 above – the multi-disciplinary studies section (2.4) can focus on aspects that are more inter-disciplinary and are missing from a review. Surface geology can inform the tectonic structure but also give insight in parameters used in mantle rheology, such as the presence of water which has a strong effect. See Martin (2023) for a review. A discussion on this could be added for example after line 680. Second, modelling approaches such as LitMod3D (Fullea et al. 2009) has been used to combine satellite gravity observations with material properties (Pappa et al. 2019) and in the global mantle model WINTERC-G, which is a good example of combining multi-disciplinary multi-scale data which could be added to section 3.3.3*

Yes, all the mentioned observations can be used in integrated models. We will add links to the mentioned papers as suggested, but have given emphasis to multivariate, statistical methods as this is an emerging field related to machine learning methods. We will complete the section with additional examples.

**RC2:** *Section 2.4.3 seems to focus more on future work than the earlier sections. It would help to move the future efforts to a later section (for example 3.3.3), or at least clarify which studies have already been done.*

We acknowledge this helpful observation. Upon review of Section 2.4.3, we find that it does indeed emphasize future research directions more prominently than completed studies. To improve clarity and maintain consistency with the structure of earlier sections, we propose the following approach:

1. We will reorganize Section 2.4.3 to clearly distinguish between (a) completed multi-disciplinary studies that have already demonstrated the value of integrated approaches, and (b) future research opportunities that would benefit from enhanced multi-disciplinary collaboration.

2. The more speculative discussion of future coupled modeling approaches and emerging multi-disciplinary methodologies will be moved to Section 3.3.3 ("Future directions"), where such forward-looking content is more appropriate.
3. In the revised Section 2.4.3, we will emphasize examples of successful multi-disciplinary integration that have already been published, such as combined seismic-geodetic constraints on GIA (e.g., recent studies combining GNSS vertical motion with seismic velocity structure), and integrated geophysical approaches to understanding ice-sheet–solid-Earth coupling.

This reorganization will provide better balance between documenting achievements and outlining future opportunities, while maintaining the review paper's focus on current state-of-the-art capabilities.

**RC2:** *Section 2.6. It is not clear why the space weather is discussed in a separate section. Also in line 73 this comes somewhat out-of-the-blue. It seems like it could be integrated in section 2.2.6 on "other physical and geophysical effects"?*

We appreciate this suggestion, though we prefer to keep 2.6 as a separate section rather than move it under 2.2. This is because section 2.2 focuses on GNSS instrumentation, whereas 2.6 discusses a range of geophysical instrumentation relevant to space weather and atmospheric studies, including magnetometers, electrometers, and atmospheric sensors that fit under 2.3 as well as 2.2. In some cases, these sensors are not co-located with the GNSS systems discussed in 2.2.

We agree the topic was not introduced well on line 73, and we will adjust that text in the revised manuscript to better describe why section 2.6 is included as a separate section.

**RC2:** *Section 3.1 presents subsections organized by categories of scientific questions but they do not always align with the topics introduced earlier in the manuscript. For example, the topic of section 3.1.4 ("Structure of the deeper mantle and the Earth's core") is introduced only briefly in section 2.3.2. We suggest to merge section 3.1.4 with section 3.1.3. There should also be more discussion on the lower mantle, given the difficulty in imaging it with seismic measurements and its importance for GIA and mantle convection (science question 17 and 18)*

We will add details to Section 2.3.2 regarding the importance of the lower mantle for GIA estimates. Both mantle convection and GIA depend on mantle viscosity, and most viscosity estimates are derived from seismic products. For example, there is a recent paper by Bellas-Manley et al. (2026) [doi: 10.1029/2025GL120160] that illustrates how incorporating seismically derived mantle convection constraints reduces the misfit of GIA models. This topic will be briefly reiterated in Section 3.1.4. That said, we prefer to leave Sections 3.1.3 and 3.1.4 separate from one another as they each address a different set of science questions.

**RC2:** *Section 3.1.7 (“Improved general circulation models”) introduces general circulation models (GCMs) for the first time. Since the discussion extends beyond GCMs alone, it would be better to introduce the role of geodetic observations in constraining atmospheric and climate models earlier in the manuscript and to rename this subsection to “Improved atmosphere and climate models.”*

We are unaware of any current applications of geophysical or geodetic observations in GCMs or even Regional Climate Models, so we prefer to keep any mention in the future section. We will review the wording of this section.

*In addition, line 756 and further makes an important point but it is not clear why it is in this section.*

Thank you for your careful reading and pointing out to this issue. Line 756 to 761 are misplaced here. These will be merged into Section 3.3.4 (respectively, we will carefully check if these statements are already made appropriately).

**RC2:** *On the review aspect of the paper we considered that a paper that touches on so many topics cannot provide a complete review of all of them. Suggestions below are on topics central to the paper or its science questions, such as the comparison with GPS data and models, and the coupled models*

- *Section 2.2.3 could refer in the introduction to a somewhat more extensive review on the topic in van der Wal et al (2023, see page 323).*  
We will follow this suggestion and include more details and a reference to van der Wal et al. (2023).
- *170: suggest to add Whitehouse et al. (2012) and Ivins et al. (2013) who created the recent GIA models*  
We will add these references.
- *181: suggest to add a reference to the table 6 in Ivins et al. (2023b) where more studies are listed.*  
We will add a reference to this table.
- *197: suggest to add Thomas et al. (2011) whose elastic correction is often used*  
We will add this reference, while noting this correction provided by Thomas et al. (2011) is barely used anymore.
- *434: suggest to add a reference to the review on this topic by Pappa and Ebbing (2024)*  
We will do so and add a reference to Pappa and Ebbing (2021) (<https://doi.org/10.1144/M56-2020-5>).

- 492: suggest to add reference for “related approach” and line 497 add reference for physics informed neural network, or alternatively move it to the future directions  
We will add references as suggested.
- 527: suggest to add van Calcar et al. (2025) to the references  
Thank you for this suggestion; we will do so.
- 531: Coupled models are the means to investigate how the solid Earth influences the ice sheet. They are referred to in the abstract and form critical need 2 (line 1025) It seems appropriate to discuss them in more detail and we suggest this location in the text. Ice sheet coupled to 3D solid earth models include Gomez et al. (2018), van Calcar et al. (2023), Albrecht et al. (2024). They have the draw-back of long computation time. Swierczek-Jereczek et al. (2024) and van Calcar et al. (2026) introduce methods to approximate solid earth deformation from 3D viscosity which could be very suitable for ensemble modelling that is necessary to get projections of Antarctica ice sheet melt with uncertainties.

We agree that coupled model frameworks are a key point that deserves more discussion, and thank the reviewer for raising that topic. In response, our revision will expand this paragraph to include a broad overview of recent developments, such as ISMIP7, including but not limited to the suggested publications. The revised text will address process representation, mantle structure and rheology models, and emulation and other scalable approximations to address increasing computation costs.

- 539: It doesn't seem necessary to use the sea-level variations as step in between; they can be considered part of GRD discussed before. There are several parameters related to solid earth that play a role on Antarctic ice sheet projections: bedrock shape (from radar and gravity), heat flow (from ground-based or other measurements), bedrock roughness which controls friction, but also pinning points that could amplify the feedback from bedrock uplift. And beyond solid-earth related there are parameters in the ice sheet models such as basal melt. The conclusion in line 543 could be extended to include this.

We agree with the reviewer that the original wording drifted too broadly toward general uncertainty sources and away from our original intent, which aligns with this comment. In response, we will revise this paragraph to refocus the discussion more tightly on the resolution of datasets constraining the geometry and boundary conditions of the system. The text clearly highlights the role of small-scales features in the bathymetry, ice shelf cavity and grounding zone environment. We also mention analogous limitations affecting mantle viscosity maps derived from seismic tomography and geothermal heat flow datasets.

- *561: could be added here that with stress-dependent rheology older ice thickness changes influence the viscosity in the Amundsen Sea Embayment (Blank et al. 2021)*

Agreed, we will add this statement to the paragraph. We will also double-check if the term 'stress-dependent rheology' will need a short definition to clarify its importance in this context.

- *ITRF is not discussed before even though it is deemed important; we suggest to introduce it in one of the GNSS sections.*

We will follow this suggestion and add the respective statements in Section 2.2

- *646 It should be stressed here that the largest uncertainty in GIA models, at least for several regions, is the unknown ice history. van der Wal et al. (2023) review this issue and shows an aspect of this uncertainty and provide some pathways to address that, varying from exposure dating, to glaciovolcanism, ice dynamic modelling in addition to geological indicators such as uplifted shorelines and sediment records.*

Thank you for emphasising this problem. We agree that inclusion of a sentence or two is important here and suggest a statement, which will be finalised in the revision, for example: "Forward modelling of GIA is underpinned by knowledge of Earth structure and ice loading histories. The ice history is the largest uncertainty in many areas (van der Wal et al. 2023) and so there is a particular need for developing improved ice loading histories. This is particularly acute in areas of Antarctica with weaker mantle where it is important to determine ice sheet changes in the last few centuries, and where the loading effects of the better-constrained Last Glacial Maximum ice sheet extent and thickness are less relevant (van der Wal et al. 2023)."

## **RC2:** Other remarks

- *Topics of science questions 13 and 22 are not really found in the paper. Could this be addressed with a short text on marine geophysics? Reflection seismic could and sonar can reveal past grounding lines and sedimentation and the shape of the ocean basin where it interacts with the ice sheet.*

Since the focus of our paper is on the onshore part of Antarctica and on ground-based observation systems in geophysics and geodesy, adding a description of marine geophysics would go beyond the scope of our manuscript. However, according to your suggestion we will check the formulation of these science questions (especially of question 13). Regarding science question 22, a number of observations provide information about the geology underneath the ice and thus serve as input data sets to constrain the role of sub-ice controls. We will emphasize that in the revision, however without going into details.

- *On the international collaboration (3.4) we could also imagine a contribution not from countries but from individual researchers who could apply for extra money in grants to pay towards the campaigns of the Antarctica data that they use. Could this be a useful addition?*

This is an interesting suggestion, and having a data analysis proposal include funds for data acquisition could help augment support. The mechanism for this is perhaps challenging, but we will address this valuable suggestion in the text of 3.4.

- *Currently not all figures are referred to in the text (for example figure 2 and figure 8). Line 167: figure 6 does not show a comparison between data and models. Maybe showing the uplift rate pattern of a model in the background is more helpful than showing the viscosity. Of course we will follow these suggestions, improve the figures and make appropriate references. For Fig. 6 (bedrock displacement rates shown for GNSS sites, viscosity structure in the background) it was by purpose not to show any GIA pattern in the background since we would not make preference to one model, rather to illustrate the structure of the Earth's interior and its correlation with the magnitude of bedrock displacement.*

- *Figure 11 could benefit from explanation how laboratory experiments are used.*

We will add a more specific wording in the caption of Fig. 11, including appropriate references, such that the first sentence will now read:

„Comparison of upper mantle viscosity estimates based on GPS observations and on shear-wave velocity structure converted to viscosity using calibrated experimental parameterisations of frequency-dependent viscoelasticity (Yamauchi & Takei, 2016; Lloyd et al., 2020; Hazzard et al., 2023).“

Additionally, we will add text at lines 558-561:

„Both forward GIA modelling, constrained against RSL and GNSS measurements, and Bayesian inferences of mantle rheology, obtained by calibrating experimental parameterisations of frequency-dependent viscoelasticity to fit multiple independent geophysical datasets, reveal that effective regional mantle viscosities associated with the last deglaciation and with the loading history over the last century differ by a factor of 3 to 100 (Fig. 11).“

This will hopefully clarify where the laboratory experiments come in (i.e., they are used to convert between seismic velocity and viscosity, and are calibrated against multiple independent geophysical constraints).

- *In Figure 13 the legend could be explained better in the caption.*

Thank you for this comment. We will add respective explanation to the legend and/or to the text in order to clarify the different type of instrumentation used in the studies. Specifically, GNSS receivers are described as GNSS stations and scintillation receivers;

different type of radars for neutral and ionized atmosphere observation are described as ionosondes, SuperDARN, EISCAT radars, HPLA radars; HF receivers for lower ionosphere observation are indicated as riometers; all-sky camera identifies the instruments for optical observation of the middle-upper atmosphere; finally the magnetometer locations are shown in the map. The geomagnetic pole and the geomagnetic parallels from 60° to 80° N/S are drawn to identify the regions of interest to study the Sun-Earth interaction over Antarctica.

**RC2:** (...) *while the attached PDF contains detailed textual suggestions.*

We will follow the additional remarks the reviewers made directly in the manuscript, in conjunction with the above discussed updates and improvements.

**CC1:** *(Community comment by Pavel Talalay)*

See response to second point in Section 2 (page 2).