

## General remarks on the 2<sup>nd</sup> reviews of the manuscript egosphere-2023-1423

The authors are grateful to both referees for their very positive and helpful comments on the revised manuscript. In response to the main criticism of the first version of the manuscript about its length and structure, we have moved the description of research infrastructures to the appendix and sharpened the main text about new research opportunities. This re-structuring is supported by Referee #1, whereas Referee #2 still suggests removing the appendix without significant loss but focus on a to-the-point narrative. Since no reference document exists which summarises the structure and benefits of atmospheric research infrastructures, we prefer to keep the appendix but in an even shorter version.

The following editorial changes were made to the manuscript:

1. The text was again checked for redundancy and concise language.
2. Figure 5 was reproduced with better quality and the colour scheme was adapted to the used one.
3. Table 2 was simplified.
4. One reference was removed, and four references were added on request by co-authors and one reviewer, see the annotated reference list.

In addition to this general change to the manuscript, we are responding to the referees' comments point by point.

### Referee #1

The paper has substantially improved after review and key messages are very clear. Moving the description of infrastructures and examples in the Appendix and shortening of the text was also very helpful and improved the paper.

Nevertheless, I still have a problem with the section 5.2 that contains factual mistakes. I would strongly advise the authors consulting documentation on the Rolling Review of Requirements at <https://space.oscar.wmo.int/applicationareas>. One of the applications the authors refer to does not exist, hence this point needs revision.

Another issue with the section 5.2 is misrepresentation of the “global climate indicators”. These indicators do not exist. GCOS initially set up a framework of Essential Climate Variables. Then to simplify communication the WMO Commission on Climatology established a set of seven headline climate indicators. The process and reasoning behind the selection is described in Trewin et al., 2021, available at <https://journals.ametsoc.org/view/journals/bams/102/1/BAMS-D-19-0196.1.xml>

Hence, before publication, section 5.2 needs to be re-written.

**Reply:** All references to global climate indicators and essential variables have been removed from the manuscript, including Figure 7. The revised text concentrates exclusively on essential climate variables. Please check the whole revised section 5.2 in the annotated manuscript.

### Editorial corrections

There is a number of the small editorial corrections that are needed:

I.23: trends of what?

**Reply:** The full sentence is “In particular, the detection of trends and seasonality in the presence of greenhouse gases and short-lived climate-active atmospheric constituents is an important aspect of climate science.” We have replaced “presence” with “abundance”.

I.26: please use “discuss the potential role” instead of “develop the role”

**Reply:** Done.

I.49: please correct “The Global Climate Observing System (GCOS) is co-sponsored by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC-UNESCO), the United Nations Environment Programme (UN Environment), and the International Science Council (ISC).”

**Reply:** Done.

I.75: please use “discuss the potential role” instead of “develop the role”

**Reply:** Done.

I.89: “in the early 2000s”, remove “years”

**Reply:** Done.

I.95: please use “that impact” instead of “which are acting”

**Reply:** Done.

I.100: the listed are not essential climate variables, but the main contributors to the observed warming

**Reply:** We have rephrased the sentence and the figure caption to “the ATMO-RIs cover the main contributors to the observed warming (IPCC, 2021)”.

I.114: it is better to say “the most recent IPCC report” rather than “current”

**Reply:** Done.

I.135: remove dot after “forcings.”

**Reply:** Done.

I.261 and 163: “At the level”

**Reply:** Done.

I.354-356: the sentence that starts from “In the remaining parts...” can be removed from the text

**Reply:** Done.

I.373: GHGs were defined earlier

**Reply:** Since the acronym GHG was used only two times in the manuscript, we skipped the use of this acronym and used the full term “greenhouse gases”.

I.420: in this context you may want to refer to the World Data Center for Greenhouse Gases run by the Japan Meteorological Agency as an extremely important contribution to the global GHG community in the context of data archiving and dissemination

**Reply:** The reference was implemented. The full sentence is now “Data which were collected before ICOS measurement protocols were put in place, have been secured physically and with respect to data quality. They contribute now to the ICOS record of long-term data sets and to the World Data Center for Greenhouse Gases run by the Japan Meteorological Agency as an extremely important

contribution to the global greenhouse gas community in the context of data archiving and dissemination.”

I.435: “covering observations”

**Reply:** Done.

I.475: WMO GHG Infrastructure is now called Global Greenhouse Gas Watch

**Reply:** Corrected.

I.486: remove extra dot

**Reply:** Done.

I.493: ECVs do not vary depending on application because the ONLY application of ECVs is global climate monitoring (by design)

**Reply:** We have removed all references to application areas and focus on climate monitoring.

I.569: either “is illustrated” or “as illustrated”, not both

**Reply:** We use “as illustrated”.

I.571: “by other scientists”

**Reply:** Corrected.

I.616: “emissions from”

**Reply:** Corrected.

## Referee #2

The manuscript reads much better with few words used to describe and promote the main points. The manuscript is acceptable for publication after the authors consider the following comments.

- The appendix could be eliminated without significant loss. After all this is an Opinion piece which alerts the reader to expect a focused to-the-point narrative. An appendix is antithetical to that expectation. More references/links can mitigate its removal.

- It still feels somewhat repetitive.

**Reply:** As stated in the General Remarks, we prefer to keep the appendix but in an even shorter version. No reference document exists which summarises the structure and benefits of atmospheric research infrastructures. From our understanding, the appendix is needed for readers not that familiar with research infrastructures.

- In 27 The very long sentence 'In particular...' is particularly hard to read/understand. Suggest dividing in two.

**Reply:** The sentence is divided into two shorter sentences: "In particular, we focus on the role of the atmosphere-centred research infrastructures ACTRIS, IAGOS and ICOS, also referred to as ATMO-RIs, with their capabilities for standardised collection and provision of long-term and high-quality observational data, complemented by rich metadata. The ATMO-RIs provide data through open access and offer data interoperability across different research fields including all fields of environmental sciences and beyond".

- In 35 The use of data, environment, observation, and combinations thereof are confusing. For example, the distinction between observations, observational data, and environmental data. Note on In 44, 'data' has no adjective, but 'observations' is used in the prior sentence. So 'data' should perhaps be 'observational data'. And then in In46, 'environmental data' is used without obvious distinction. Suggest making it more clear throughout what is being talked about when these words are used.

**Reply:** We clarified the term 'data' as 'observational data'.

- In 55 'satellite' which is used 8 times is a poor substitute for 'remote sensing' platforms, instruments, observations, data, etc. or 'space-borne', because satellites provide no data, only their instruments do.

**Reply:** Agreed, the inaccurate term 'satellite' was replaced by satellite-borne instrument or space-borne observations, depending on the context.

- In 74 Another long complex hard-to-understand sentence that would benefit from better syntax or separation into 2 sentences.

**Reply:** The sentence has been split into two shorter sentences and repetitive statements have been removed. The revised section reads now: "In our opinion article, we discuss the potential role that atmosphere-centred ENVRI RIs in Europe can play with their capabilities for standardised collection of observational data, complemented by rich metadata, and their provision through open access. As a result of these capacities for data collection and provision of data and services, we elaborate on the novel research opportunities and methods that arise from the combination of open access and interoperable environmental data with the tools and technologies offered by data-intensive science."

- In 88 repeat acronym definition.

**Reply:** The sentence has been rephrased and reads now: “In the early 2000s, ESFRI started a roadmap process to establish a comprehensive landscape of pan-European environmental research infrastructures (ESFRI, 2021b).”

- In 93 acronyms are best defined at first use

**Reply:** The term ATMO-RIs is now introduced in the abstract.

- In 135. ‘forcings,..’

**Reply:** Corrected.

- In 141 ‘post-COVID-19’

**Reply:** Corrected.

- In 142. ‘need’ for what? ‘but’ is negating so suggest replacing with ‘and’

**Reply:** Replaced as suggested. The sentence reads now: “A number of recent post-COVID-19 studies on the effects of reduced anthropogenic emissions on atmospheric chemical composition (Gkatzelis et al., 2021; Sokhi et al., 2021) impressively illustrate the growing need for, and great potential of, scientific approaches that cross the traditional boundaries of scientific disciplines and methods.”

- In 150 Suggest fixing this sentence as: The discovery of scientific knowledge has developed from experimental sciences and by conducting field observations and experiments; and through theoretical approaches using models and mathematical generalizations to simulate phenomena which are too complex for analytical solutions (Gray, 2009).

**Reply:** Corrected as suggested.

- In 155. What ‘challenge’ is being referred to here?

**Reply:** The term “challenges has been replaced by “the challenges of data-driven science”.

- In 158 ‘always’ is hard to defend and unnecessary here so suggest ‘often’

**Reply:** We replaced ‘always’ by ‘in the majority of cases’.

- In 157 ‘infrastructure’

**Reply:** Corrected.

- In 191 Better: ‘In today’s atmospheric sciences and other research areas, scientists are challenged to...’

**Reply:** Corrected as suggested.

- In 192 ‘data that are’

**Reply:** Corrected.

- In 200 Better: ‘intensive workflows are capable of exploiting rich and diverse data sources

**Reply:** Corrected as suggested.

- In 201 What does ‘own’ mean here?

**Reply:** ‘own’ has been replaced by ‘new’.

- In 221 ‘developing’

**Reply:** Corrected.

- In 228 Don't agree with 'for machines, knowledge recorded in scientific articles is not accessible'. AI (large language models) can extract and synthesize significant information from published scientific narratives and ideally should be recognized here.

- In 235 Another very long and complicated sentence. Suggest: 'knowledge in data science. This initiative can fundamentally transform digital scholarship and the way digital infrastructures support scientific knowledge production.'

**Reply to both issues:** The section has been rephrased as suggested and reads now "Initiatives and services such as the Open Research Knowledge Graph (Stocker et al., 2023), are demonstrating advanced technologies like Knowledge Graphs, Natural Language Processing, Terminology Services and Semantic Resources. They also include approaches that integrate the production of FAIR scientific knowledge into data analysis and thus enable the reuse of FAIR scientific knowledge in data science. Recent developments in artificial intelligence are also enabling large language models to extract and synthesise significant information from published scientific narratives. Such initiatives can fundamentally transform digital scholarship and the way digital infrastructures support scientific knowledge production. "

- In 256 'scientists that will'

**Reply:** Corrected.

- In 270 Another very long and complicated sentence

**Reply:** The sentence has been restructured to "On the conceptual side, the database accessible to scientists is significantly broadened by the implementation of the science-based framework of ECVs for the provision of ATMO-RI data, combined with the transparent reporting of provenance information in accordance with the FAIR principles, and the discoverability of data via enhanced search capabilities through standardised keywords and vocabularies."