# Communicating Uncertainty in a Planetarium

Jan SERMEUS (1, 2, 3), Jakub STEPANOVIC (1,4), Sandy CLAES (4,5)

*(1) KU Leuven, Department of Physics and Astronomy, Celestijnenlaan 200C, 3001 Leuven, Belgium*
*(2) KU Leuven, Faculty of Psychology and Educational Sciences, Dekenstraat 2, 3000 Leuven, Belgium*
*(3) Royal Observatory of Belgium, Planetarium, Bouchoutlaan 10, 1020 Brussels, Belgium*
*(4) LUCA School of Arts, Paleizenstraat 70, 1030 Schaarbeek, Belgium*
*(5) KU Leuven, Faculty of Social Sciences, Parkstraat 45, 3001 Leuven, Belgium*

**Abstract.** Missing and sparse data and the associated uncertainty are inevitable in science, and their accurate portrayal is essential for upholding scientific transparency and credibility. Yet revealing uncertainty can be seen as unfavourable in science outreach. Our study, theoretically initiated in Nature of Science, focused on conveying incomplete data on Venus's upper atmosphere to an adolescent audience in a planetarium. Through design-based research, we found that translating data into a Voronoi diagram can make the concept of sparse data understandable and aesthetically pleasing to a broader audience. However, it may come at the cost of lower perceived accuracy.

Uncertainty is a core aspect of science [1]. Factors like experimental design limitations, background noise, measurement precision, and incomplete data are just a few aspects that introduce uncertainty within a single scientific study. Furthermore, because scientific theories are revised or refined, the interpretations of data may change over time. Scientists are aware of this uncertainty; they recognize it and embrace it as a fundamental element of the scientific process. The latter, uncertainty due to changes over time, is captured in Science Education literature as "Tentativeness" in the Nature of Science (NoS) [2].

Improving students' understanding of NoS is important to address both scientism and scepticism (against science) [3]. This is true in the formal context of school-based education, but also for out-of-school science education [4]. Yet, despite the awareness amongst scientists, there are several reasons why communicating uncertainty to the public, either by scientists or by a mediator, remains a challenge [5]. One reason might be that expression formats (e.g., visualizations) are missing.

## Methodology and Context

This work is part of a larger project, VAMOS[1], that studies the upper atmosphere of Venus. In this work, we particularly focus on the missing data and the sparsity of the available data used in the project as sources of uncertainty. Such sources are traditionally not discussed in the context of NoS. The aim of this work is to represent these uncertainties in a visual way, and bring this to adolescents.

We designed two visualizations highlighting the data distribution through Design-based Research (DBR) [6], and we evaluated them in a comparative study. The DBR consisted of four iterative design cycles (DC1-4) with a total of 126 participating high-school students, 13 participating teachers and 8 participating scientists. Data on students' preference and understanding of missing data in science were collected through a questionnaire. Since we suspect that the latter may be confounded by a general interest in science, we also included Science Capital [7] statements in our questionnaire. The data were analysed quantitatively (comparing descriptive statistics) and qualitatively (finding emerging themes in open answers).

[1] **V**enus **A**tmosphere exploration through **M**achine learning and **O**pen **S**cience in preparation to EnVision

## Results

The visualizations design utilized a Voronoi (Fig. 1a) and scatterplot (Fig. 1b). The Voronoi was appreciated more by the participants, but initially introduced a misunderstanding about the quantity of data. The final design removed this misunderstanding. We found no correlations between the participants' Science Capital and their preference for either visualization.

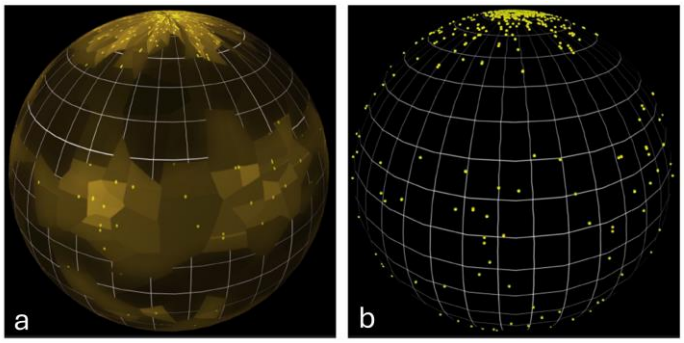


Fig. 1. Scientific visualization in DC3-DC4 (a) Voronoi diagram, (b) Scatterplot showing the locations where data was collected on Venus's atmosphere using the SOIR instrument (aboard the Venus Express mission)

## Conclusion and Outlook

Increasing the general public's understanding of NoS is important. However, we think that the current way in which uncertainty is included in NoS is limited and should be expanded beyond the tentativeness of science. We make suggestions for communicating about uncertainty in science because of sparse and missing data through scientific visualizations.

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