**Research Proposal**

**Title**

Study of the vertical structure of climate-influencing atmospheric gases by ground-based remote IR method

**Project Summary**

The aim of the project is obtaining new information about the vertical structure of the climatically important gases content (CO2, methane, ozone, HCl, HF, CO, etc.) in Peterhof (59.88°N, 29.83°E) for the period 2009-2022 years. For this purpose, the ground-based measurements of solar infrared spectra with a high spectral resolution will be used.

**Introduction**

The gas composition of the Earth's atmosphere plays a significant, decisive role in the formation of the weather and climate of the Earth, in the stability of the Earth ozone layer, in the ecological state of various regions of our planet. In recent decades, it has become apparent that anthropogenic sources of various gases significantly affect these characteristics and processes in the atmosphere. Monitoring the gas composition of the atmosphere requires high-quality measurements of the total content and vertical profiles of greenhouse gases, ozone and ozone-depleting gases, as well as constant monitoring of sources and effluents of a number of toxic gases.

In Russia, there is limited monitoring – there are networks of ground-based measurements of total ozone, radiosonde measurements of water vapor profiles, ground-level concentrations or total contents of a number of greenhouse and polluting gases (e.g. Elansky et al. 2016; Zvjagincev et al. 2015). Measurements of vertical profiles of the climatically important gases content in Russia are very few in number and extremely rare. In this regard, the use of a huge array of ground-based high spectral resolution measurements of direct solar IR radiation, collected in Peterhof (SPbU) in the period 2009-2019, to obtain information about the vertical structure of atmospheric gas content is very important and relevant. Examples of successful definitions of ozone content in 3-4 atmospheric layers are given, for example, in Timofeev et al., 2016.

The importance of studying vertical profiles of the content of climatically important atmospheric gases is determined by the following main reasons:

1. These profiles determine to a large extent the radiation properties of the atmosphere.

2. Vertical profiles of the content of ozone-depleting gases determine the formation of the ozone layer and its long-term dynamics.

3. Vertical profiles of gases content are determined by numerous physical and chemical processes, and, consequently, their measurements provide valuable information about these processes.

**Methodology**

This goal will be achieved by theoretical and numerical studies of information content, errors and vertical resolution of ground measurements of vertical profiles, analysis of modern spectroscopic information about the parameters of the fine structure of molecular absorption of atmospheric gases and selection of optimal spectral regions and intervals for solving the inverse problem. Advanced software will be used to interpret a large volume of already conducted and new measurements of solar spectra (more than 1000 days of measurements). On the basis of the information obtained, the temporal variations of the vertical structure of atmospheric gases (including long-term trends), the quality of modern numerical models of the atmospheric gas composition will be investigated and various satellite measurements of the gas composition will be validated.

**Research timeline**

First year:

1. Theoretical and numerical analysis of informativeness, errors and vertical resolution of ground-based spectral measurements in Voigt and more complex spectral line contours.

2. Analysis of modern spectroscopic information about the parameters of the fine structure of molecular absorption of atmospheric gases. The choice of the optimal spectral regions, intervals and spectral resolution to determine the vertical profiles of the various gases content.

Second year:

3. Clarification of the spectral regions and intervals used to obtain new information about the vertical structure of the contents of various gases in the period 2009-2022 in Peterhof.

4. Mass interpretation of measurements in Peterhof for the period 2009-2022.

5. Validation of obtained information based on comparisons with independent measurements of known quality.

Third year:

6. Analysis of time variations in atmospheric gas content (including long-term trends) in various atmospheric layers.

7. Comparison of the obtained data with the results of three-dimensional numerical simulation of the atmospheric gas composition for the analysis of their quality and further improvement.

8. Validation of satellite measurements of atmospheric composition using Russian and international instruments (ИКФС-2 and ИКФС-3, IASI, TROPOMI, etc.) based on comparisons with ground-based measurements in Peterhof.

**Bibliography**

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