



Improving atmospheric data

Greenhouse gases are accumulating in the Earth's atmosphere and have created a heat-trapping layer which is driving climate change. Satellite instruments are used high in the atmosphere to generate gas concentration data but require on-going performance validation post launch. A more direct link of satellite measurements to the SI throughout their lifetime is necessary to give greater robustness to the data used in climate trend prediction.

Europe's National Measurement Institutes working together

The European Metrology Research Programme (EMRP) brings together National Measurement Institutes in 23 countries to address key measurement challenges at a European level. It supports collaborative research to ensure that measurement science meets the future needs of industry and wider society.

Challenge

Spectro-analytical techniques are used to identify and quantify concentrations of greenhouse and other gases in the atmosphere. These techniques are based on the unique spectral 'finger prints' generated by molecular interactions with specific radiation selected in the near and mid infrared wavelengths of the electromagnetic spectrum.

Satellite borne spectral instruments calibrated pre-launch require on-going performance validation, which is provided by a network of ground based instruments situated in remote locations – one of the largest of many ground based monitoring networks is the Total Carbon Column Observing Network, TCCON. Checking the performance of these remote Earth-based instruments is currently achieved using the World Meteorology Organisation (WMO) in-situ scale, as traceability directly to the SI is both difficult and expensive to achieve.

Spectral measurements from different altitude satellite, air craft and ground based spectrometer measurements made at different temperatures and pressures. These require different pressure and temperature correction procedures for spectrum evaluation before comparison using research databases to produce gas 'fingerprints'. This enables identification of the different gases present and their concentrations. However, only a very small subset of the spectral data in research databases is underpinned by measurements traceable to the SI units, leading to unnecessarily high levels of uncertainty in atmospheric models.

Accurate spectral data and improved ground station instrument traceability directly to the SI is required to reduce measurement uncertainties and generate more robust data for climate predictions.

Solution

The ESA ENVINET satellite launch is leading a significant European investment in atmospheric monitoring for greenhouse gases and in support of this the EMRP project *Spectral reference data for atmospheric monitoring* has enabled development and commissioning of a new validated spectral line data measurement facility capable of greenhouse gas line data generation with improved traceability to the SI.

Impact

The spectral data generated within the project is due to be included in an upcoming revision of the HITRAN database, one of the most widely used spectral databases in the world. Originally compiled in the 1960s, the current HITRAN database is maintained by the Harvard-Smithsonian Center for Astrophysics and contains over 7 million spectral lines for 47 different molecules. However, some of the data accumulated over the years lacks the quality required for robust long-term climate trend analysis.

The project's contribution will mark a significant increase in the amount of traceable spectral data available to researchers using HITRAN. One of the key users of the database is TCCON, made up of 23 ground-based atmospheric monitoring stations distributed across the globe.

The accuracy of TCCON's measurements of carbon dioxide, methane and other gases is dependent on the absolute values of the line strengths and widths in the spectral data bases used in fitting spectra. The inclusion of traceable line data into the data base will reduce remote station reliance on side-by-side validation and calibration, which is both difficult to achieve and expensive to perform.

The improved data provided by TCCON-validated ESA satellites will make a valuable contribution to reducing the uncertainties involved in climate models and support robust predictions of long-term climate change.

Metrology for atmospheric monitoring

The EMRP project *Spectral reference data for atmospheric monitoring* established a European spectroscopy infrastructure enabling traceable measurements of spectral line data under well-controlled conditions. This will support improved accuracy in the measurements used to remotely monitor specific substances in the atmosphere, including gases that are important for assessing climate change and pollution levels.



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EMRP

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