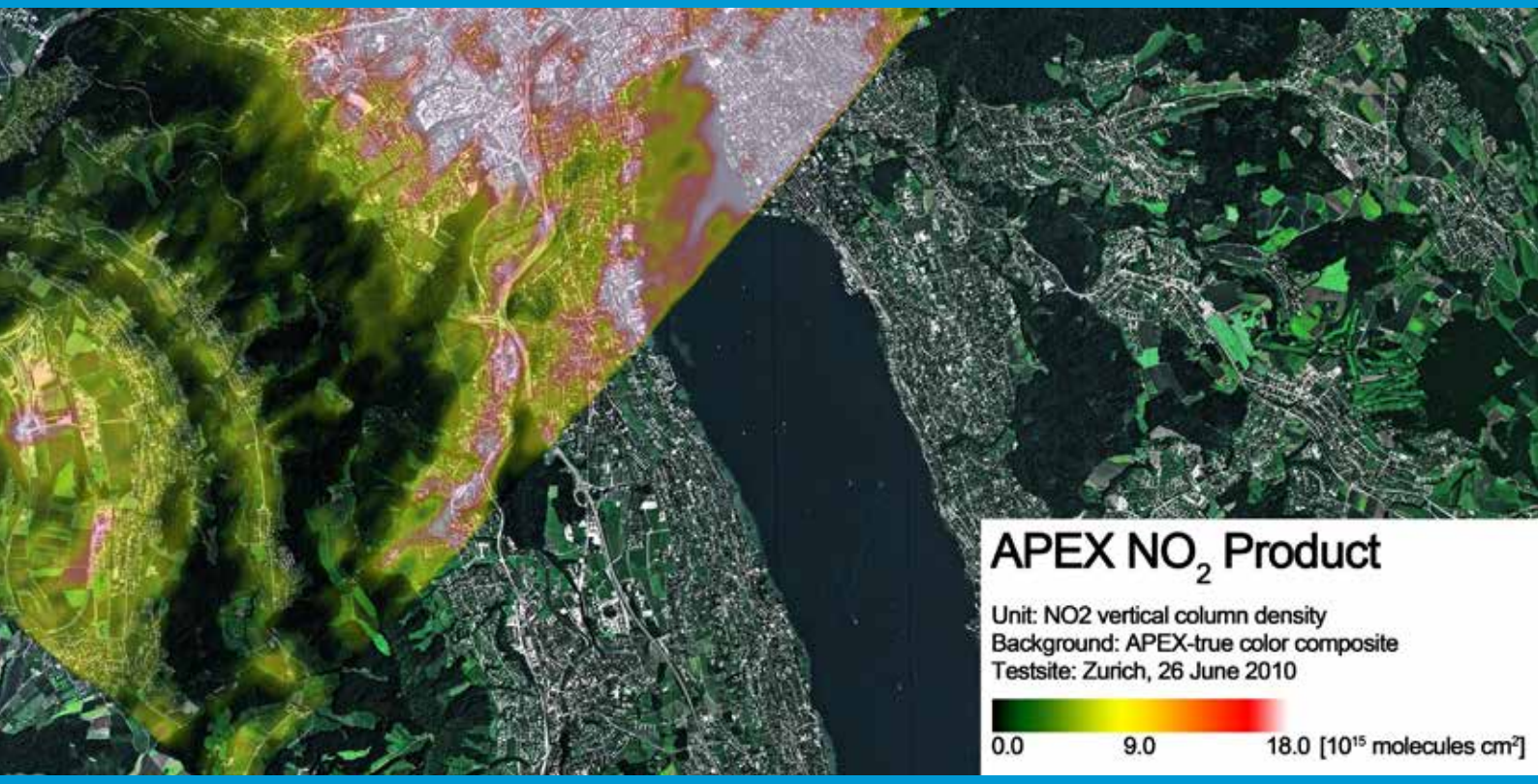
European Metrology Programme for Innovation and Research

Delivering Impact



Improving climate modelling accuracy

Identifying climate trends frequently relies on comparing data for sensitive indicators used in predictive models that can contain variability generated by affects such as measurement altitude. Ground-based, air-borne and satellite made observations need independent scrutiny to increase confidence in data consolidation. The introduction of more rigorous measurement uncertainty derivations for all inputs to predictive models is needed to improve trend analysis and aid data comparability.

Europe's National Measurement Institutes working together

The European Metrology Programme for Innovation and Research (EMPIR) has been developed as part of Horizon 2020, the EU Framework Programme for Research and Innovation. EMPIR funding is drawn from 28 participating EURAMET member states to support collaborative research between Measurement Institutes, academia and industry both within and outside Europe to address key metrology challenges and ensure that measurement science meets the future.

Challenge

Observations of the Earth's atmosphere, oceans and land from space are vital for climate studies. These are built into models used by climatologists to understand and predict how weather patterns are changing. International initiatives such as the Quality Assurance Framework for Earth Observation (QA4EO) are increasing this community's understanding of the importance of quality assurance, rigorous uncertainty analysis and measurement traceability for underpinning climate trend identification.

Measurement data generated by orbiting satellites requires robust links to ground based instrument responses to validate data quality and support its use in climate modelling. However, changes in the ambient temperature and pressure between ground based and satellite borne instrumentation can introduce significant result variability.

The European Space Agency, ESA, believes that there is an increasing need for climatologists to have a good understanding of all the sources of experimental data spread and the effects these introduce in climate trend analysis. Training courses that increase this community's ability to consider parameters that contribute to result variability are needed to increase their skill set and improve the quality of data that underpins reliable climate change trend identification.

Solution

The EMRP projects *European metrology for earth observation and climate* and *Metrology for Earth Observation and Climate* generated training material suitable for analysts working with satellite-borne, air-borne and ground-based observations to evaluate the measurement uncertainties that contribute to data variability. This material was converted into an easy to assimilate course in the EMPIR project *Uncertainty Analysis for Earth Observation e-Learning Training Course* and is accessible via NPL's Learning Management System. All the components of the course are compatible across multiple devices, operating systems and browsers, thereby allowing users easy access remotely.

Modular in concept, the first stage provides the required skills for assimilating the concepts used in the more practically orientated subsequent stages. Module 3 highlights the APEX spectral instrument used during research flights studying natural phenomena such as vegetation cover on hills or air quality using solar reflectance measurements. By linking satellite-generated reflectance measurement data to ground-based instrument responses and understanding the variation in data this creates is achieved using worked examples for post-launch instrument calibration techniques.

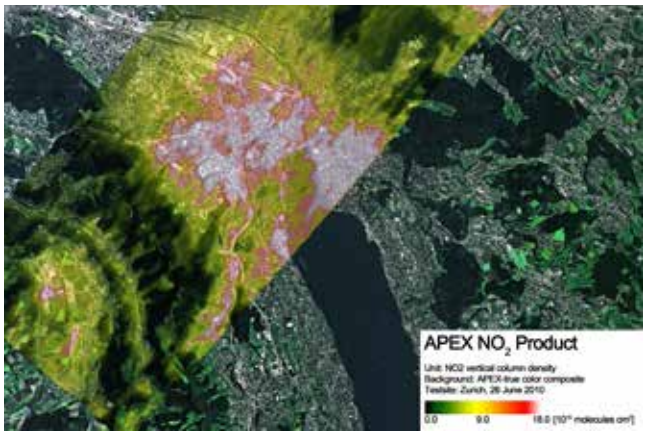
Impact

Paolo Castracane, ESA/ESRIN, evaluated the course and found it 'very well-structured and its technical content well presented with the adequate degree of repetitions and overlaps to fix concepts.' Another course student, Daniel Kükenbrink, applied its methods in his research on the radiance effects of single trees on their surroundings. These effects generate small changes and having a robust method for assessing measurement uncertainties has given the data he generated greater acceptability by the scientific community.

The course concepts support the introduction of Fiducial Reference Measurements – a suite of independent, fully characterized, and traceable ground measurements that follow the guidelines outlined by the GEO/CEOS Quality Assurance framework for Earth Observation (QA4EO). Greater awareness by climatologists of the importance of uncertainty assessments for earth observation measurements is increasing the ability for independent result scrutiny, essential for improving confidence in the predictive modelling that underpins climate change trend analysis.

APEX imaging spectrometer

The APEX imaging spectrometer makes solar reflected radiance measurements during Earth Observation research flights and has contributed to studies of natural phenomena such as vegetation state or air quality. Further developed by the University of Zurich in the EMRP project *European metrology for earth observation and climate*, it provides a link between ground-based and satellite-borne measurements of spectral reflectance. The effects of altitude on measurements introduce result variability which are incorporated into the final data analyses as measurement uncertainties to improve accuracy. The EMRP project *Metrology for Earth Observation and Climate* enabled the validation of APEX's performance during aircraft flights and the generation of robust in-flight measurement uncertainties. These have enabled ESA to use this instrument to confirm the post-launch performance of Sentinel 2 and 3 sensors as they orbit the Earth by comparing results to those from APEX flights over well characterised terrestrial sites.



NO_2 map produced by EMPA using APEX data

EMPIR EURAMET

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