Deliverable D6.7: *Final Report on Training and Education Activities*

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1. Specific objectives of the deliverable

Work Package 6 in the EUROCHAMP-2020 project (outreach, communication and education) aims, via sub-task 6.3, at the implementation of specific training and education activities.

Many of the project partners are educators (professors/lecturers), at universities across Europe, involved in teaching atmospheric science and training young researchers. Therefore, based on the practical experience and theoretical knowledge shared within the EUROCHAMP infrastructure, the WP planned to produce a range of novel educational materials to aid the teaching of atmospheric science, air quality and climate. Such educational material should include:

- the production of online teaching resources to explain major scientific issues
- information flyers and other supporting materials, e.g. demonstration kits
- easy-to-understand short movie clips that explain the EUROCHAMP-2020 research infrastructure and its role in supporting the European research.

The development of educational material is all too often very time consuming and distribution among consortium partners requires clarification of copyright. Despite challenges, some material has been developed and is presented in this deliverable.

Several members of the EUROCHAMP-2020 consortium organised several "teaching events" for different interest groups such as:

- Practical training of master students at the AIDA chamber (in German). In this training the master students in meteorology developed a research objective, planned and performed corresponding AIDA chamber experiments (typically one week), analysed and presented their results.
- Training in atmospheric chemistry for students during the *8th Georgian-German School and Workshop in Basic Science* (*GGSWBS*) held in Georgia, August 20 – 25 2018 (http://collaborations.fz-juelich.de/ikp/cgswhp/cgswhp18/index.shtml and http://collaborations.fz-juelich.de/ikp/cgswhp/cgswhp18/program/program.shtml).
- The module *Usage of atmospheric simulation chamber for atmospheric research* within the Summer School (compact course) held annually in September at FZ Jülich, with the following content:
    - Introduction to modelling of chamber experiments
    - Introduction to chemical box modelling
    - Available online tools for box modelling
    - Lumping of species
    - How to choose the appropriate model for different types of experiments
    - *Exercise: modelling a real chamber experiment*
    - Familiarize with the modelling tools

- Implementation of chamber effects
- Modelling of a real experiment
- Sensitivity studies on the impact of different rate coefficients

2. Production of online teaching resources to explain major scientific issues

Simulation chamber platforms are high-technology labs where access for the wide public is - for safety reasons - not always easy. Even if there are opportunities of visits during so-called "Science Day Events", it seemed necessary to raise the public awareness by giving more people the possibility to discover the labs and facilities and the most trouble-free way goes through *virtual* visits. Accordingly, several partners have provided the wider public with *full immersion 3D movies*, allowing interested people to virtually walk around the EUROCHAMP-2020 facilities.

Eight movies have been produced up to now by using a 3D 360° camera. They are freely available online through our YouTube channel or through our website. These channels will remain accessible after the completion of the EUROCHAMP-2020 project. They can be watched even after the end of the project by anyone equipped with a virtual reality helmet or even only with a recent smartphone.

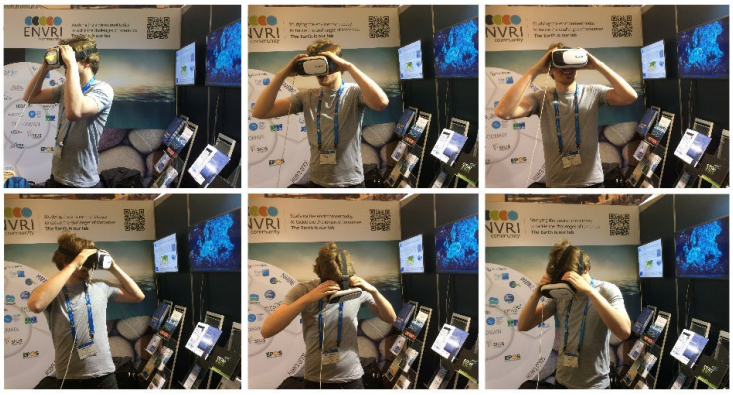

Fig. 1: Example of a virtual visit through the use of a virtual reality helmet

All videos can be accessed through the EUROCHAMP-2020 YouTube channel: https://www.youtube.com/channel/UCZdihDGpKT9OLm2A7x7UBZw.

For students and young scientists it is key, in order to understand atmospheric chemistry, to translate experimental results, e.g. from a relatively simple experiment in a lab course or from a more complex one in a simulation chamber, into chemical processes occurring in the atmosphere. This is commonly performed by chemistry models, which are often complex and difficult to handle.

At Leeds University (UK) – the home of the Master Chemical Mechanism (MCM), a widely used model to describe complex chemical processes in the atmosphere by using experimental data as input – an "Atchem labclass online tutorial" has been developed. With the help of this tutorial, which is available at http://mcm.leeds.ac.uk/MCM/atchem/tutorial_intro.htt, students and

young scientists can learn to handle simple atmospheric chemical processes in a model. The output of the model can be handled in commonly used spreadsheet programs, such as Microsoft Excel.

Although not a novel teaching material as such, the concentrated effort of the EUROCHAMP community to produce a handbook for atmospheric chamber studies is a premiere. The handbook addresses all levels of experience, from undergraduate students to senior researchers. The handbook will be published under the title of "A Practical Guide to Atmospheric Simulation Chambers", and will be available online; its content includes the sum of knowledge accumulated over time concerning best practices for the operation of simulation chambers and the related instrumental techniques.

3. Information flyers and other supporting materials, e.g. demonstration kits

Within a master thesis at the Institute of Atmospheric and Environmental Research at the University of Wuppertal, a simple experiment has been developed and tested to give students the opportunity to study scattering processes such as *Mie* and *Rayleigh scattering* of sunlight in the atmosphere and the corresponding colour change of the sun during the day in a documented school experiment.[1]

As a "real world" experiment, the formation of secondary organics aerosols can be studied, which are generated through the reaction of limonene with ozone. The equipment for the experiments is now available in a suitcase, which can be borrowed from schoolteachers together with a manual for educational purposes in schools.

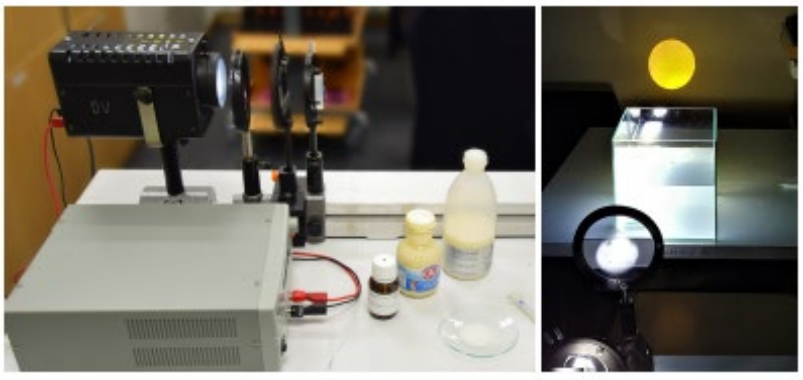

Fig. 2: The set-up of the experiment with a xenon lamp, a diaphragm and an achromatic lens. In between a filter holder is placed. The aquarium is illuminated and the transmitted light is shown on a wall.

[1] Carina Salven: Entwicklung eines Experiments zur Demonstration von Himmelsfarben. Master, Thesis, University of Wuppertal, July 2018 (in German)

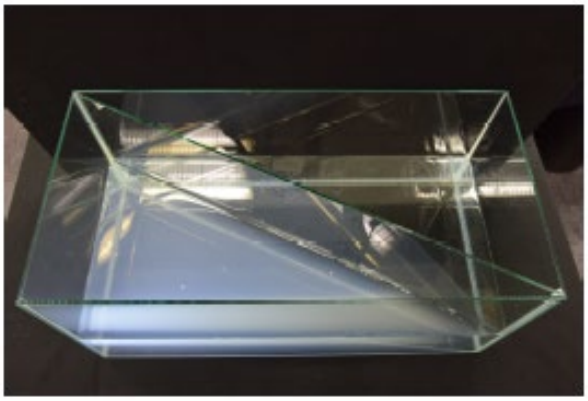

Fig. 3: Aquarium with diagonal partition (picture taken from above).

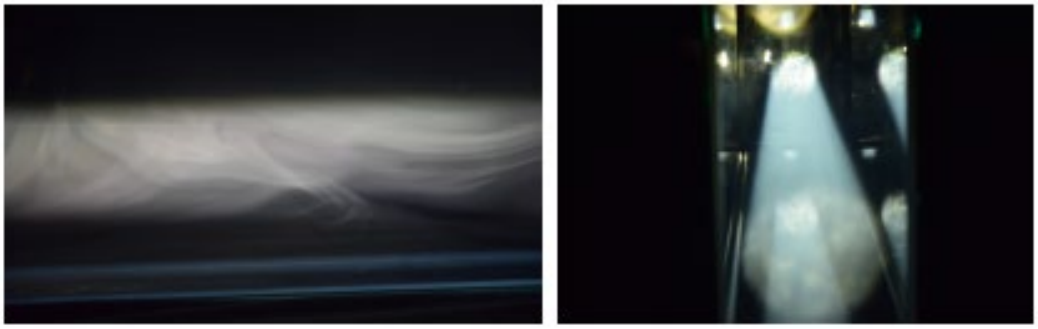

Fig. 4: Stray light in limonene: when we observe the experimental set-up from a point a view 90° to the direction of light propagation the fog appear rather white, while looking at the fog against the propagation direction, a blue colour is visible.

4. Easy-to-understand short movie clips

During the project, two educational movies were produced and distributed. Both of them targeted more specifically undergraduate students, but can be also used by educators with a less expert audience.

The first one – entitled “smog in a box” – is focused on the experimental simulation approach and its benefit for the understanding of air pollution chemistry. It illustrates how smog events are linked to non-linear processes that mix the effect of primary emissions with solar radiation to generate secondary pollution. Thanks to a real experiment carried out in a simulation chamber, it demonstrates how researchers from the EUROCHAMP-2020 consortium are able to reproduce *smog* in a chamber to study these complex phenomena.

The second one – entitled “Clouds soot and Light” – aims at explaining the concept of hygroscopicity of aerosols, its link with cloud formation and how it can change during the atmospheric transit of particles due to atmospheric chemistry. Using a small table top experiment (that can be reproduced by the educator, if needed) it demonstrates how the formation of free radicals under the effect of UV light can change the affinity of water to soot.

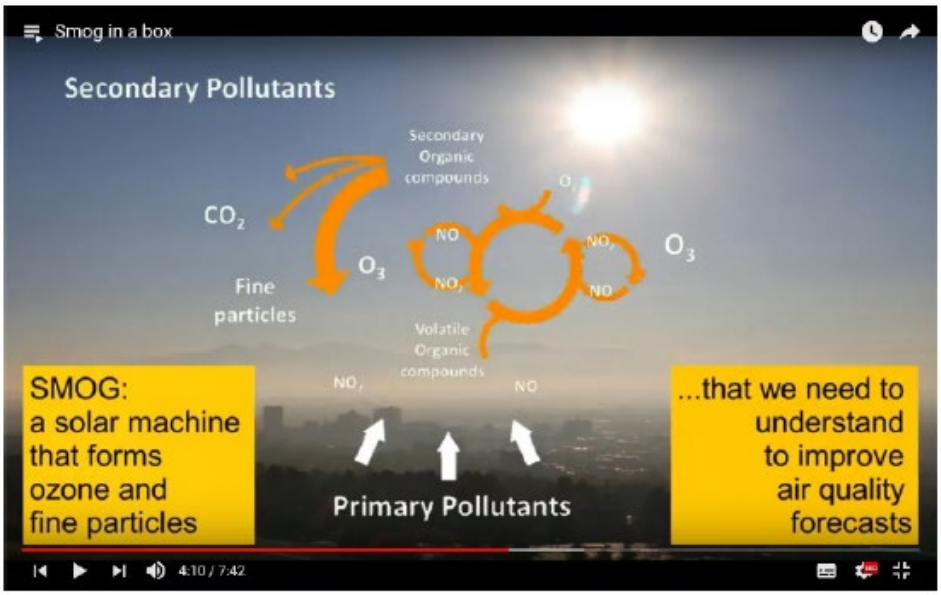

Fig. 5: Frame from the "Smog in a box" movie.

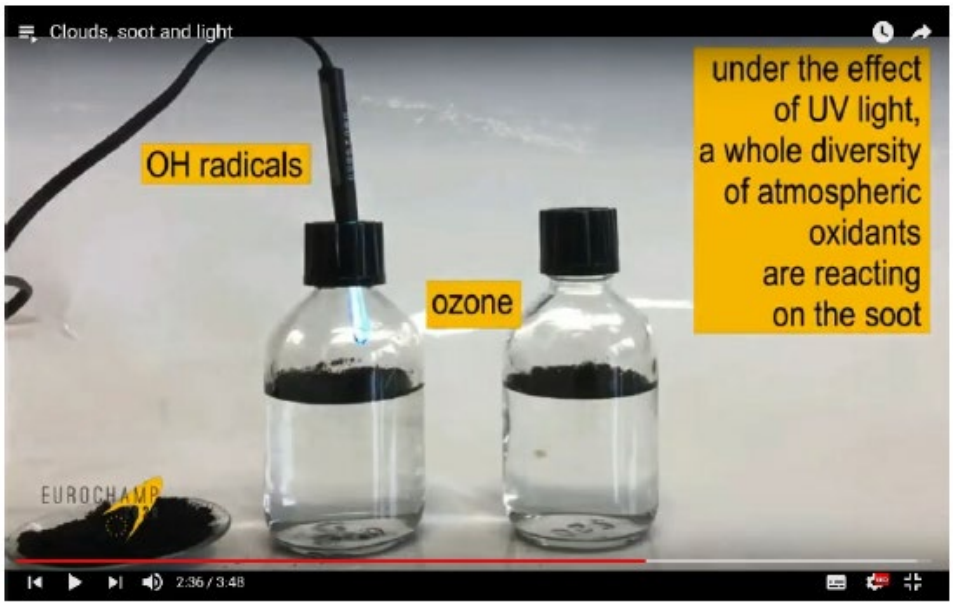

Fig. 6: Frame from the "Clouds soot and Light" movie.

Both videos are freely accessible through the EUROCHAMP-2020 YouTube channel (see above) or directly at:

https://www.youtube.com/watch?v=FGXHkJADFxM and
https://www.youtube.com/watch?v=xxjJWnykHkE.

5. Development of teaching and training during the COVID-19 pandemic

Only few months after the second annual EUROCHAMP meeting, held at the University of

Eastern Finland (Kuopio) in early October 2019, all partners of the EUROCHAMP consortium involved in education, had to change their teaching and training activities due to the COVID-19 pandemic. This unusual situation drove a massive shut down of universities across Europe and imposed travel restrictions, which entered into force during the first quarter of the year 2020.

During this time, most of the teaching – not only related to atmospheric research - was done using web-tools such as *Zoom*, *Webex*, *MS Teams*, *Big blue button* etc. remotely. Many courses have been recorded and the recordings were made available for the students over a longer period of time.

Because of governmental restrictions, even examinations, including PhD examinations, had to be conducted on-line? as well as lab courses. For the lab courses, videos were recorded showing an assistant performing the experiment followed by a tutorial with the students during which the data evaluation and the interpretation of results have been developed.

All these activities have been done in order to avoid any delay and a dramatical fall in the quality of the instruction for the students, even under these very special conditions of the pandemic.

Obviously, the COVID-19 crisis had also a direct impact on the training of young researchers as part of the TNA activities in the EUROCHAMP-2020 project. In order to avoid disruption in the TNA services because of the travel restrictions, the consortium took, with the permission of the European Commission, the decision to conduct these activities, where suitable, remotely. The raw experimental data (produced by the host team) and the results (emerging from assisted processing by the guests) were exchanged via virtual platforms. Several partners who were performing remote TNAs with associated training activities, offered, on a daily basis or as a compact module, tutorials for the guest students during which the experiments and data evaluation were discussed. For example, students and young researchers were introduced to analytical technique theoretically or by providing them with practical hints such as teaching how to handle correctly FTIR spectra, and how to interpret the results.

The general feedback from the involved partners but also from the guest scientists was in general very positive, although it should be pointed out, that remote training is not able to reproduce all aspects of a real TNA and training activity.