NEWSLETTER N°6
JUNE 2023

Welcome to the LEMON project newsletter n°6

The overall objective of LEMON is to provide a new Differential Absorption Lidar (DIAL) sensor concept for greenhouse gases and water vapour measurements from space, based on a versatile transmitter.

Editorial by the Coordinator

We are now in the last weeks of the project. After promising DIAL results obtained with the laboratory breadboard WAVIL, the LEMON project entered a few months ago a new challenging phase with the instrument assembly and testing phase at its core.

This newsletter will be the opportunity to present a status overview of the LEMON DIAL instrument. As the clock is ticking, in this last project phase all means are implemented to achieve the building of the LEMON instrument, in line with our ambitions. Of course, the consortium partners are aware that some technical points should be further investigated after the project end.

In this final issue of the LEMON newsletter, we present the Lidar ground-based tests, the instrument aircraft integration, as well as the airborne campaign planned in June 2023; we also present an interview with Lennart Domdei, Development Engineer for laser systems at InnoLas Laser GmbH, who was in charge of the development of the LEMON pump laser - a key component for the emitter.

Finally, we invite all followers to the **Final Public Workshop of the LEMON project, which is scheduled on Tuesday, 11th July 2023, from 17:00 to 18:00 (CEST) as an online event**. The aim will be to showcase and discuss the main results of the LEMON project in front of a wide audience, including Space Agencies, the Scientific Community, DG DEFIS representatives, but also students from several European countries. More information is provided below.

As this is our last newsletter, I also want to take a moment to thank our partners for their hard work and dedication throughout the project. Without their support, we would not have been able to achieve our ambitious goals. I also want to thank all our followers for their interest in our project and for joining us on this journey.

Enjoy reading us!

Dr. Myriam Raybaut,

Research scientist, ONERA, France

NEWS & EVENTS

LEMON Final Public Workshop leaflet >> download

The LEMON project latest news: >> Read more

The LEMON project leaflet: >> Download

The LEMON project poster: >> Download

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This project has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement N° 821868.

Lidar functional ground-based tests

After the Lidar integration, which took place in the first quarter of 2023, the LEMON instrument was subject to Lidar functional ground-based tests.

Figure 1: DIAL instrument set-up.

As a reminder, the LEMON project ambitions to provide a new tool to be able to target CO_2, water vapor and isotope HDO for range-resolved DIAL from ground, and integrated path DIAL from Safire ATR-42 aircraft.

We are in the final weeks of the project life. Although we are aware that some technical issues deserve further investigation, we are proud of the solid instrument baseline developed by the consortium, which we were able to test successfully for first DIAL functional tests.

Figure 1 show the current LEMON DIAL instrument set-up, at ONERA premises.

Figure 2 shows two examples of DIAL signals and water vapour absorption probing that were recorded during the Lidar functional ground-based tests performed in April 2023.

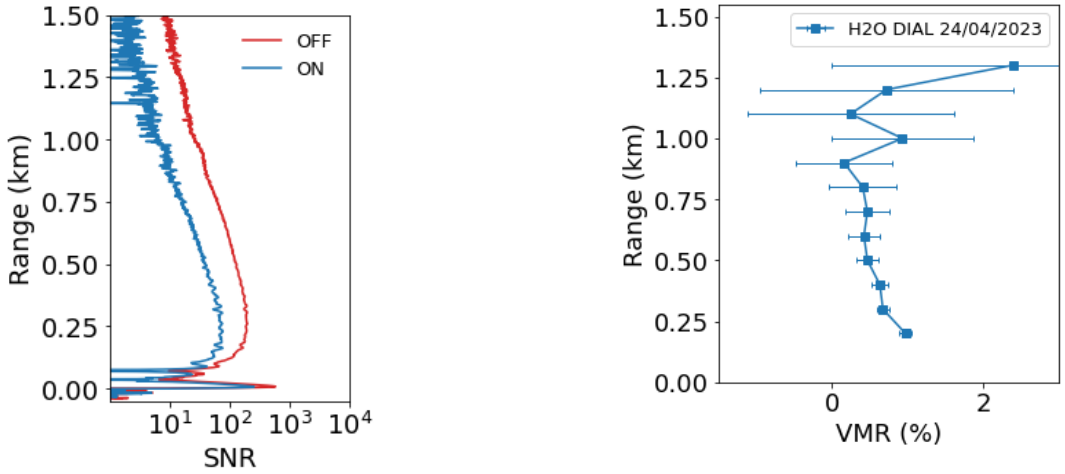

Figure 2: Examples of DIAL signals and water vapour absorption probing: Signal to Noise Ratio (SNR) on the averaged signals for On and Off wavelengths on the left and corresponding water vapor mixing ratio with respect to measurement range on the right.

These tests will need to be consolidated in the future, especially by comparing them with other instruments to analyse the sources of errors and possible bias, and the ways to improve the instrument performances.

As this first step of functional tests was overall successful, the LEMON consortium was convinced to move to the final instrument aircraft integration in the Safire ATR-42

By Myriam Raybaut (ONERA)

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Lidar integration in the Safire ATR-42 aircraft

The LEMON Lidar instrument integration in the Safire ATR-42 aircraft raised some challenges, especially because it was the first time the Onera/DPHY team integrated a Lidar in an aircraft. Also, the instrument is quite heavy and is thus a source of increased energy consumption; this is because of the instrument's intrinsec ambition is to be able to perform integrated-path DIAL from the aircraft as well as ground-based DIAL.

Thanks to the joint efforts of CNRS/Safire and Onera teams, the aircraft integration took place mid-May 2023 in Toulouse, and the remaining mechanical or instrumental issues were successfully tackled before the launch of the airborne tests planned in the first weeks of June 2023.

By Myriam Raybaut (ONERA)

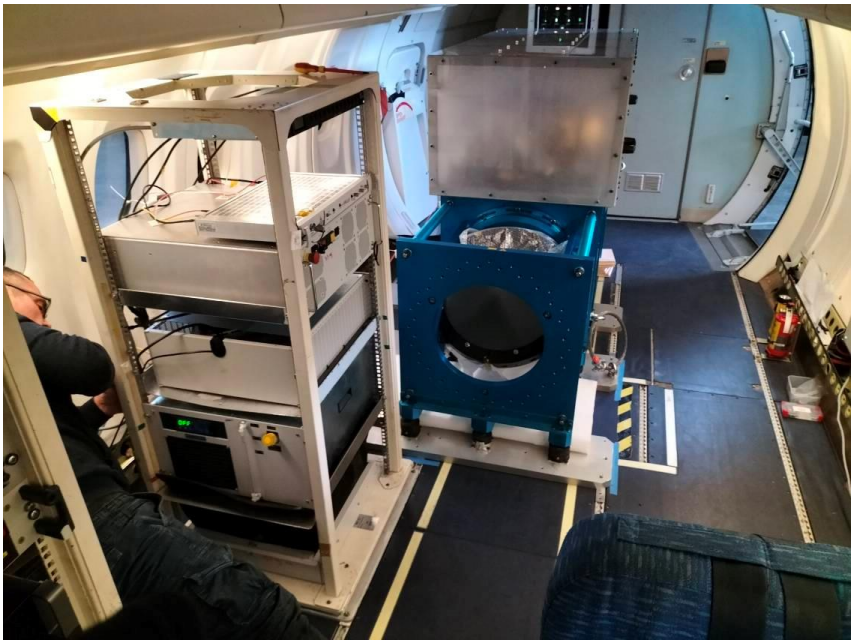

Figure 3: First image of the LEMON instrument within the ATR-42 aircraft, during the integration process.

Figure 4: Philippe Nicolas and Jean-Baptiste Dherbecourt (ONERA) in front of the ATR-42 aircraft during integration.

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LEMON demonstration flights in June 2023

The LEMON demonstration flights onboard the Safire ATR-42 take place from Francazal near Toulouse (France) between 30 May and 10 June 2023. Safire is the operator of the French research aircraft and stands for *Service des Avions Français Instrumentés pour la Recherche en Environnement*. The overarching objective is to demonstrate the potential of LEMON to acquire range-resolved profiles of $H_2{}^{16}O$ and $HD^{16}O$ concentrations in the lower troposphere (below 4 km) from an airborne platform, with LEMON pointing to the nadir. We intend to conduct flights both over land and over ocean/sea in order to get insights into the spatio-temporal variability water vapor stable isotopes in the atmospheric boundary layer in relationship with the type of surface overflown. Over land, the flights are conducted over the plateau de Lannemezan near the Centre de Recherches Atmosphérique where a variety of instruments are operated (incl. an ICOS ecosystem station, a ceilometer and radiosoundings). Regarding the flights over sea, we aim to operate in a dedicated area of the Mediterranean, as well as in the Bay of Biscay (Atlantic Ocean), depending on the meteorological situation and the low-level cloud cover. A total of 5-6 flights of 3,5 hours are scheduled. Staff from ONERA, CNRS, the University of Bergen, SpaceTech and Safire are involved in the LEMON operations. A dedicated flight-preparation cell is hosted by Safire during the campaign, with the objective to monitor the meteorological situation in southwestern France, especially the low-level cloud cover, for the aircraft to operate predominantly in cloud-free conditions.

For the occasion, the ATR-42 is not only equipped with the LEMON Lidar system, but also with a suite of instruments that enable scientists to compare LEMON observations with in situ measurements of the same variables made from the same aircraft. Among the key instruments embarked for comparison/validation of LEMON observations is the Picarro cavity-ring-down spectrometer from the University of Bergen, Norway, for $H_2{}^{16}O/HD^{16}O/H_2{}^{18}O$ measurements. Other instruments that are flown on the Safire ATR-42 are a Picarro G2401 for various greenhouse gas measurements (incl. $H_2{}^{16}O$, CH_4, CO_2 and CO), and a LICOR 7500 for $H_2{}^{16}O$ measurements. The University of Bergen also installed a Picarro system on the ground to document the variability of $H_2{}^{16}O/HD^{16}O/H_2{}^{18}O$ concentrations around Toulouse during the ATR-42 flights.

The LEMON validation strategy is the following: after the transit from Francazal to the area of operation, the ATR-42 overflies its own track back-and-forth 6 to 8 times at different altitudes. Over the plateau de Lannemezan, the flight pattern consists of a triangle with 60 km sides, performed at 6 levels, namely 4 km, 3 km, 2 km, 1,5 km, 1 km and 0,75 km above sea level (i.e. 150 m above ground level, the mean altitude of the plateau being 600 m above sea level). Above sea, the pattern consists of roughly 100 km-long straight legs spanning from the coastline outward over the open sea/ocean at the same levels as above land. Two extra levels are performed at 0,5 km above sea level and at the lowest possible safe flight altitude (i.e., below the height of the Lannemezan plateau).

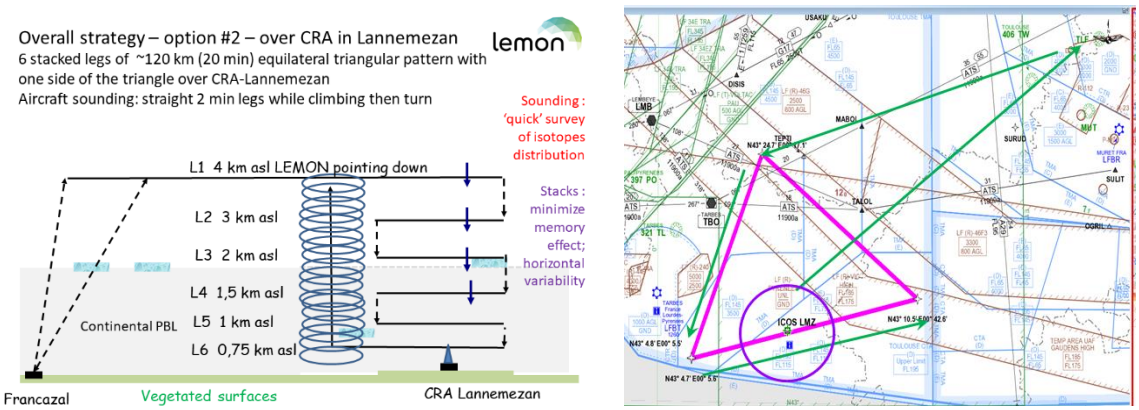

Figure 5: Left: schematic of the Safire ATR-42 flights over the plateau de Lannemezan near le Centre de Recherches Atmosphériques (CRA) showing the aircraft in situ strategy that are implemented to validate the LEMON Lidar measurements. Right: ATR-42 flight plan around the CRA (marked as 'ICOS') designed by Safire.

Cyrille Flamant (CNRS)

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GET TOGETHER

In this chapter you will find a selection conferences, workshops, exhibitions and other events which are of interest for the LEMON community.

LEMON FINAL PUBLIC WORKSHOP, ONLINE, 11 JULY 2023

The LEMON project is happy to announce the organisation of **Final Project Public Workshop which will take place as an online event on Tuesday, 11th July 2023, from 17:00 to 18:00 (CEST).**

The Final Public Workshop of the LEMON project aims to showcase and discuss the main results of the LEMON project, which ends in June 2023. The workshop targets a wide audience, including Space Agencies, the Scientific Community, Project Officers from the DG DEFIS, but also Students communities from different European countries.

Four presentations will be given by LEMON partners on the project key achievements, followed by a final discussion session. The detailed workshop programme is provided in the workshop leaflet (Figure 6).

The Final Public Workshop is an open event that anyone can attend. There are no registration fees. However, **attendees are asked to register by 30th June 2023 by senting an e-mail to myriam.raybaut[at]onera.fr and sofia.santi[at]l-up.com**.

For more information we invite you to:

- visit LEMON website at: https://lemon-dial-project.eu/lemon-final-public-workshop/
- visit LEMON LinkedIn page at: https://www.linkedin.com/company/lemon-dial/
- download the workshop leaflet (PDF),
- contact the LEMON Coordination team (Myriam Raybaut, Sofia Santi).

We look forward to virtually meeting you at the workshop!

Figure 6: LEMON Final Project Public Workshop leaflet.

LIDAR 2023: 3RD INTERNATIONAL WORKSHOP ON SPACE-BASED LIDAR REMOTE SENSING TECHNIQUES AND EMERGING TECHNOLOGIES, MILOS ISLAND, GREECE, 18-23 JUNE 2023

The LEMON project will be represented by several partners at this workshop. **ONERA** will showcase a poster about the LEMON key exploitable results that could be used for future spaceborne differential absorption Lidar applications. **SpaceTech** will give a talk on frequency reference in Lidar. Website: https://lidar-workshop-2023.com/

LASER WORLD OF PHOTONICS 2023, MÜNCHEN, GERMANY, 27-30 JUNE 2023

At the 26th World's Leading Trade Fair with Congress for Photonics Components, Systems and Applications, the highlight topic will be lasers for lidar application. LEMON partner Fraunhofer ILT will attend the event with a booth. It will be an outstanding opportunity to present the LEMON project and more specifically, the developed emitter. Website: https://world-of-photonics.com/en/

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Interview

In this LEMON Newsletter issue, you will read an interview with Lennart Domdei from InnoLas Laser GmbH Laser GmbH.

LENNART DOMDEI, DEVELOPMENT ENGINEER FOR LASER SYSTEMS AT INNOLAS LASER GMBH LASER GMBH

Question (Q) 1: Lennart, could you briefly introduce yourself and explain the path that led you to InnoLas Laser GmbH?

Answer (A) 1: I studied medical physics in Düsseldorf, Germany, and specialized in optics. I did my master thesis in the AO Visionlab Bonn and designed a binocular scanning laser ophthalmoscope to measure eye movements. Then I switched from a laser that is guided into the eye to lasers that are not allowed to hit the eye under any circumstances.

Figure 7: Lennart Domdei.

Q2: Please also introduce your company InnoLas Laser GmbH. How got InnoLas Laser GmbH involved in the LEMON consortium?

A2: InnoLas Laser GmbH is a German innovative medium-sized enterprise based in Krailling, nearby Munich, specialised in the development and manufacture of customized high-quality and high-power pulsed laser sources. As a convinced customer of InnoLas Laser, the LEMON project coordinator, Onera, invited us to join the LEMON consortium.

Q3: Within the LEMON project, InnoLas Laser GmbH was involved in the pump laser requirements and design, whereas after the achievement of that, InnoLas Laser GmbH was responsible for the pump laser realization. What was innovative about these activities?

A3: Innovative in this project was not the pump laser realization but the housing of the laser. The housing was optimized to withstand the expected environmental conditions during the flights checked by detailed thermomechanical, vibrational and shock simulations performed by Fraunhofer ILT.

Q4: How will InnoLas Laser GmbH benefit from the innovations developed within LEMON? Does InnoLas Laser GmbH plan to exploit the results towards other application fields? If so, which ones?

A4: The housing allows our lasers to be used in various carrier systems (ship, car, submarine, aircraft) or other locations where shock and vibration are a factor.

Q5: InnoLas Laser GmbH and Fraunhofer ILT closely collaborated on the pump laser design and fabrication, especially in the testing and improvement of optomechanics and mechanical interfaces. Had InnoLas Laser GmbH and Fraunhofer ILT already collaborated in past projects?

A5: In fact, InnoLas Laser GmbH and Fraunhofer ILT have a history of collaborative projects together. The first project was ATLAS in 2004, followed by other projects such as Lasmet in 2008 (funded by the German Bundesministerium für Bildung und Forschung under funding code: 0330861C), and KOMET in 2009 (funded by the German Bundesministerium für Wirtschaft und Energie). Currently, the Horizon Europe project ReSoURCE (GA n°101058310) deals with the recycling of refractory materials from industrial furnaces.

Q6: Lennart, how would you assess your involvement in a European research and development project such as LEMON, in the perspective of your growing professional career?

A6: Since I am generally interested in optics, I find the intensive insight into the application of the laser very exciting. Equally educational was my recent service visit to the Fraunhofer ILT, where Michael Strotkamp introduced me to some of the ongoing projects at Fraunhofer ILT.

DISCLAIMER: The information, statements and opinions in the above interview are personal views of the individuals involved in the LEMON project and do not necessarily reflect the views of the LEMON consortium as a whole, nor of the European Commission. None of them shall be liable for any use that may be made of the information contained herein.

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