Abstracts of the HEMERA summer school
Heidelberg, Sept. 9 – 13, 2019

Session 1: Background 1 (Convener: Nathalie Huret)

1.1 C. Camy-Peyret, The history of ballooning, early science, past advances and discoveries, scientific interest, Institute Pierre Simon Laplace, France

The first flight of a balloon manufactured by the Montgolfier brothers (giving their name to a class of hot air balloons) changed human dreams into real accomplishments and paved the way for lighter than air vehicles, long before heavier than air platforms. Progress in balloon envelopes, procedures for producing, using and filling them with gases lighter than air, improved instrumentation, development of communication means between balloon gondolas and the ground as well as precise geo-location, all led to significant breakthroughs in the use of balloons for scientific endeavours. Research and operational satellites are now competing with balloons by offering viewing platforms unhampered by the atmospheric blanket for observing extra-terrestrial objects in windows closed from the ground. But balloons are still the only platform from which in situ as well as remote sensing observations of the atmosphere between the ground and the mid-stratosphere can be performed. Progress made, discoveries achieved by balloon experiments as well as the current status and interest of balloons for atmospheric studies will be covered in this introductory presentation.

1.2 P. Ubertini, Early and modern balloon science in astronomy, Istituto Nazionale di Astrofisica (INAF), Italy

The lecture is an overview from the first Human attempt to fly to the era of the modern stratospheric ballooning that have provided a unique flight opportunity for aerospace experiments. The scientific community has used stratospheric balloons since the ’50s and the beginning of the '70s a new ideal launch location was established in Trapani-Milo (Sicily, Italy), were a discontinued airport was refurbished and used to launch the first transatlantic experiment on August 1975 in collaboration between SAS-CNR (Italy) and NSBF-NASA (USA). Then for almost three decades were launched large size payloads under a MoU between ASI (Italy), CNES (France) and INTA Spain). Several campaigns were performed with flight duration lasting 24 hours and payloads recovered over Spain. The reason why the Long Duration Balloon has been then re-oriented in a different direction/technology is analysed and future perspectives discussed in the framework of the Hemera infrastructural EU program.

1.3 T. Deshler, Early and modern stratospheric science using small and medium sized, un-pressurized balloons, Uni. Wyoming, USA

Shortly after discovery of the stratospheric aerosol layer, by balloon-borne measurements from South Dakota by Christian Junge and others, regular balloon-borne stratospheric aerosol measurements began from Laramie, Wyoming, through the work of Jim Rosen and Dave Hoffman. As these early instruments matured, the capability was expanded for campaign style measurements from Panama to the Arctic ice island T-3. These measurements were punctuated by volcanic eruptions: Fuego, El Chichón, Pinatubo, and the discovery of polar ozone loss, all of which challenged the instruments, gondolas, load lines, and ballooning techniques to evolve, expand, and involve new personnel. This talk will review this history with emphasis on the 50 year history of ballooning from the University of Wyoming.

1.4 V. Catoire, Early and modern balloon science using large unpressurized balloons, Le Laboratoire de Physique et de Chimie de l'Environnement et de l'Espace (LPC2E), Centre national de la recherche scientifique (CNRS), France

The lecture will provide an historical overview of the main projects involving large unpressurized balloons. This type of balloons offers unique possibilities, among them reaching the upper stratosphere (>30 km altitude) with vertical profiling down to ground. Simultaneous, accurate and sensitive measurements of many ultra-trace compounds playing major roles in stratospheric chemistry can be performed using both remote-sensing passive and in-situ active optical spectrometers, and in-situ sampling for in-lab post-analysis. Several important scientific achievements obtained during those campaigns will be presented, especially focused on European projects, starting from the 70's with the first supposed threat posed by nitrogen oxides to the ozone layer, and ending to the recent and coming campaigns with new instruments letting hope for new findings.

1.5 A. Hertzog, Science using long duration balloons, Laboratoire de Météorologie Dynamique (LMD), France

Long-duration stratospheric and tropospheric balloons have been used since the late 60's to enable an original, horizontal sampling of the atmosphere. These balloons indeed drift on quasi-horizontal surfaces in the atmosphere, and are passively advected by winds. Flights can last from a few days (for lower tropospheric balloons) to several months (for larger stratospheric balloons). The lecture will provide an historical overview of the main long-duration balloon projects. A selection of major scientific achievements obtained during those campaigns will be presented as well, along with the evolution of technical solutions that have been carried in those flights. A description of the current state-of-the-art will end the lecture.

Session 2: Atmosphere (Convener: Pietro Ubertini)

2.1 T. Birner, The atmospheric structure, Ludwig-Maximilians-Universität München (LMU), Munich, Germany

This talk will review characteristics of atmospheric structure important for ballooning. We will focus on the structures of temperature and winds in the global stratosphere. We will distinguish structures in three separate latitude bands: 1) the polar regions, 2) mid-latitudes and subtropics, 3) tropics. The polar stratosphere is governed by a strong seasonal cycle due to large variations in incoming radiation. This causes strong eastward winds around a cold polar cap during winter (the polar vortex) that give rise to planetary scale dynamics, and weaker westward winds around a relatively warm polar cap with suppressed dynamics during summer. In mid- and subtropical latitudes large variability is observed due to strong planetary scale horizontal mixing. Latitudes near the equator, on the other hand, tend to show fairly isolated properties (the so-called tropical pipe) due to horizontal mixing barriers in the subtropics and an isolated circulation regime of repeating westward and eastward winds at a period of about 28 months (the quasi-biennial oscillation, QBO). Opportunities for new scientific insights using ballooning methods will be discussed.

2.2 N. Huret, Atmospheric dynamics I, Centre national de la recherche scientifique (CNRS) France

The objective of the lesson is to give basics on Atmospheric dynamics related to Thermodynamics (atmospheric stability, cloud formation), atmospheric fluid dynamics (momentum equation, continuity equation, hydrostatic and geostrophic approximation, potential vorticity, for global circulation in the troposphere and in the stratosphere.

2.3 A. Hertzog, Lagrangian observations, waves, microphysics, Laboratoire de Météorologie Dynamique (LMD), France

While observations following a fluid parcel (aka Lagrangian observations) are very common in the ocean, they are less frequent in the atmosphere. Long-duration balloon flights enable us to perform such observations, and recent projects using these balloons have brought unique observations on wave activity in the atmosphere. In particular, unprecedented information on mesoscale gravity waves involved in the forcing of the general Brewer-Dobson circulation have been gained with the help of long-duration balloon flights. The lecture will illustrate some of the major findings obtained during the Vorcore and Concordiasi projects, like (i) the characterization of wave momentum-fluxes over Antarctica and the role of gavity waves in the breakdown of the Southern hemisphere stratospheric vortex, and (ii) the interaction between high-frequency waves and the cirrus life cycle in the Tropical Tropopause Layer.

2.4 A. Butz, Atmospheric radiation and radiative transfer, University of Heidelberg, Germany

Electromagnetic radiation interacts in manifold ways with the Earth's atmosphere controlling many of the climatic, meteorological and chemical mechanisms that make up our environment. Atmospheric radiation originates either from the Sun or from the thermal emission of the Earth's surface and, on top of shaping our environment, we can exploit atmosphere-radiation interactions for remote sensing of atmospheric composition. Here, I will review the general concepts of radiative transfer in the Earth's atmosphere with a particular focus on the stratosphere and on remote sensing experiments typically deployed on stratospheric balloons.

Session 3: Balloon system (Convener: Philippe Raizonville)

3.1 K. Andersson&K. Garg, Flight physics & thermodynamics, Swedish Space Corporation (SSC), Sweden

Balloons work on the principle of buoyancy, and once deployed in the atmosphere, they are subjected to various dynamical and thermal forces. These forces make the balloon flight complex, as they are dependent upon various atmospheric parameters, such as pressure, temperature, solar radiation, planetary surface infrared radiation, atmospheric convection, lifting gas temperature change, etc., which are not easy to estimate. After a few hours of deployment, a high-altitude balloon reaches equilibrium buoyancy and floats in the direction of the winds, making the balloon flight uncertain. As a result, balloon trajectory forecast poses several challenging problems since the subject is both complex and multidisciplinary. Consequently, balloon mission preparation requires an accurate and reliable prediction methodology for both weather and trajectory, in order to accomplish the mission. The first part of the presentation will be focussed on theoretical aspects of thermal and dynamic forces acting on the balloon and the second part will focus on the thermal conditions for the equipment, design criteria’s regarding insulation, heat transfer and launch conditions.

3.2 S. Venel, The different balloon families and associated performances, Centre national d’études spatiales (CNES), France

CNES implements three types of stratospheric balloons: the Zero Pressure Balloon (ZPB), the Super Pressure Balloon (SPB) and the Sounding Balloon (SB). Each type of balloon will be materially described, and its principle of aerostatic behavior will be explained. The performances, mainly in carrying capacity, flight profile and flight duration will then be presented.

3.3 H. Eriksson, Balloon components: equipped envelope; flight-train, on board/ground system and scientific payloads, Swedish Space Corporation (SSC), Sweden

This presentation describes how to build up a balloon system with flight train regarding equipment to enable release, balloon control, and government requirements.

3.4 I. Zenone, On-board services: platform structure, telemetry & tracking & remote control (TT & C), power supply, thermal control and pointing system, Centre national d’études spatiales (CNES), France.

The scientific experiments are accommodated within the gondola / platform provided by CNES. In addition to the structural integration, on-board services are provided to the experiments. Basic services include power supply and telecommunication subsystem, which is operated, in real time, to receive telemetry and configure the experiment during the flight. The most sophisticated service is pointing, which allows a maximum accuracy of 1 arc-second for azimuth and elevation positioning of the experiment (telescope).

3.5 K. Walker, Design of a laser spectrometer for in-situ balloon measurements, University of Toronto, Canada

Putting an experiment into near-space on a high-altitude balloon platform presents a number of technical and scientific challenges that are not present when the experiment is done in the laboratory. This lecture will discuss how to approach these challenges, using the example of making in situ trace gas measurements. Chemical composition measurements are essential for monitoring and understanding changes occurring in the Earth's atmosphere. Altitude-resolved data, such as those from balloon platforms, are a necessary part of this composition data set because many processes occur at specific altitudes or over limited vertical length scales. This presentation will also highlight how balloon-borne results can be used to validate measurements from Earth observing satellites.

3.6 Design of scientific instruments remotely by VC

3.6.1 B. Netterfield, Design of a balloon-borne imaging telescope for stratospheric balloon missions, University of Toronto, Canada

Missing as of Sept. 3, 2019

3.6.2 P. Loewen, Design and Build of Electronic Systems for High Altitude Balloons, University of Saskatchewan, Canada – University of Saskatchewan, CSA/ASC Canada

In 2013 the atmospheric research group at the University of Saskatchewan, under the leadership of Dr. Adam Bourassa, began its journey towards launching instruments on high altitude platforms. The research group in its past had experience with instrumentation development for rocket and satellite experiments. However, the practical knowledge and experience within the group had diminished over the previous decade. Ballooning offered a great re-introduction for the research group into the world of space and near space instrument design and build. There are many ways to build an instrument. This talk goes over some of the practical lessons we have learned from our initial instrument builds up to present day. Specifically, this talk will highlight our group experience with power supplies, grounding, flight computers, custom electronics and COTS components for flight.

3.7 H. Eriksson, Safety requirements: mechanical & electrical design of gondola and flight train, redundancy of house-keeping system, constraints on balloon facility location and on balloon trajectories, Swedish Space Corporation (SSC), Sweden

The presentation will address safety requirements for balloon systems and balloon trajectories. The requirements on balloon system covers both mechanical and electronic design of the gondola and flight train. Briefly systems and procedures to ensure coordination with the air traffic will be covered.

Session 4: Balloon operations (Convener: Andre Vargas)

4.1 A. Vargas, Site selection, launching methods; flight control; trajectory management and recovery, Centre national d'études spatiales (CNES), France

This presentation will generally focus on balloon operations. As a first step, the process of selection of a balloon launching site will be described with the consideration of the experimenter's specifications, which will have to be validated by meteorological analyzes for both the ground-level weather conditions and the trajectories in the stratosphere. The methods of balloon launch, using a mobile/fixed crane or an auxiliary balloon, will then be described. A typical flight timeline will be presented with its preparatory phase from the meteorological confirmation briefing to the balloon take off. Then, will be presented the monitoring of the flight with the piloting operations, and the end of flight with the fallout of the destroyed balloon envelope and the flight chain under its parachute recovery.

4.2 H. Eriksson & A. Vargas, Specificity of CNES and SSC operation, Swedish Space Corporation (SSC), Sweden and Centre national d'études spatiales (CNES), France

In this presentation, the SSC and CNES will present in more detail the balloon operations carried out by the two operators. The main difference is the method of balloon launch: the mobile crane for SSC and the auxiliary balloon for CNES.

4.3 A. Vargas & P. Raizonville, Other balloon operators and associated campaigns: CSBF, NSC, JAXA, etc. Swedish Space Corporation (SSC), Sweden and Centre national d'études spatiales (CNES), France

Beyond SSC (Sweden) and CNES (France), balloon operators from other countries will be presented with their organizations, launch sites, release methods, regular campaigns etc.

Session 5: Applications: Aeronomy (Convener: Flora Kluge)

5.1 A. Kleinert et al., Hyperspectral Limb Sounding, Karlsruher Institut für Technologie, Germany

Hyperspectral limb sounding is a remote sensing technique to determine temperature, trace gas and aerosol distribution of the atmosphere with high spatial resolution. The talk will present two examples of such instruments: The MIPAS (Michelson Interferometers for Passive Atmospheric Sounding) series of limb-scanning instruments that have been operated on balloon, aircraft and satellite between 1989 and 2014 and the GLORIA (Gimballed Limb Observer for Radiance Imaging of the Atmosphere) instrument which is operated on high-altitude aircraft since 2011. A balloon-borne version of GLORIA is currently under construction. Its maiden flight is planned for 2020.

Both instruments are Fourier Transform emission spectrometers and cover the thermal infrared spectral region. An overview of the scientific applications that have been addressed with the balloon-borne MIPAS is provided, and the peculiarities of a limb-imaging system compared to classical limb-scanning instruments are highlighted.

5.2 S. Payan, Balloon-borne mid-IR measurements, Université Pierre and Marie Curie (UPMC), France

Infrared spectroscopy in the infrared is a very powerful technique for remote sensing measurements of atmospheric constituents. As an example, the use of the sun as a radiation source for absorption measurements allows the combination of high spectral resolution together with high signal-to-noise ratio, hence leading to high sensitivity. But the radiation of the atmosphere itself is another source of useful information to infer atmospheric composition using hyperspectral spectrometer. On the other hand, In situ sounding using infrared laser sources allow to performed high precision concentration measurements for given species. The possibility of using such techniques under stratospheric balloons adds the capability of good vertical resolution for the measurement of trace species concentration profiles. A description of such an instrumentation and samples of representative results will be given.

5.3 A. Engel, Balloon-borne whole air and AirCore sampling, University of Frankfurt, Germany

In this lecture the use of sampling methods for stratospheric air will be presented and discussed. This will be based mainly on observations by the whole air samplers operated at University Frankfurt using large stratospheric balloons and by the novel AirCore technique using small balloons. While the whole air sampler provides discrete samples at specific altitudes, AirCores provide a continuous profile but are effected by mixing and diffusion limiting the vertical resolution. An additional difficulty the AirCore technique is the correct altitude attribution of the samples. The method for altitude attribution of AirCore will be presented and discussed, as well as experiments to test this altitude attribution. Finally, some selected results from sampling methods, especially with respect to mean age of air will be presented and discussed.

Session 5: Applications: Light-weight balloon instruments and small balloons

5.4 J. E. Leedham-Elvidge, AirCores in the UK: launching balloons on a small and crowded island, University of East Anglia, UK

AirCores are technically simple and inexpensive to build and deploy. They consist of long coils (up to 200 m) of lightweight stainless steel tubing carried below a large meteorological balloon. The tubing evacuates during ascent as the ambient pressure falls, and fills during the subsequent descent. Due to the payload restrictions sampled air volumes are small, around 200-300 ml of stratospheric air. Because of this, measurements of less abundant (ppt range) trace gases difficult. Analysis on UEA's highly sensitive GCMS system has provided the first measurements of non-CO2/CH4 greenhouse gases and ozone-depleting substances (ODSs) from AirCores flown up to 36 km.

The ERC-funded EXC3ITE project has been analysing AirCore samples for a range of trace gases since early 2016. As well as presenting their collection of stratospheric vertical profiles they will discuss the difficulties of launching balloons on a small island and their solutions to timely sample analysis when the detector cannot leave the university.

5.5 T. Deshler& L. Kalnajs, New aerosol instruments to maintain current in situ measurement capability with small rubber balloons, University of Colorado, USA

In situ aerosol measurements from balloons have been inherently expensive, in frequent, labor intensive, and difficult to maintain, driven by the size of the instruments involved, leading to gondolas on the order of 25 – 50 kg, requiring medium size plastic balloons, trained launch teams, recovery, and air traffic control. Now with new, miniature, optical heads, detectors, microprocessors, telemetry systems, and load line components, the weights have been reduced by a factor of ten by personnel at LASP producing a new optical particle counter (OPC). A similar OPC has been added to a University of Wyoming condensation nuclei growth chamber to measure the total aerosol concentration. Coupling these instruments provides a measurement of aerosol concentration for particles > 0.01 µm and size distribution from 0.15 – 10.0 µm, at a weight and cost low enough to limit restrictions by air traffic control and recovery. These OPCs have seen limited mid latitude use, but are headed to Antarctica for austral polar stratospheric measurements from April to June 2019.

5.6 N. Harris, Sensors for sondes - how many things can be measured? University of Cranfield, UK

A new generation of small sensors are being developed for use on balloons. One effect is to provide a greater variety of measurement options for use on small balloons. I review the types of small sensor being developed in the HEMERA project and beyond.

5.7 S. Salam, Collection of organic particles in the stratosphere over Esrange/Sweden, Fachhochschule Aachen, Germany

The biosphere and ecology of the stratosphere is a generally unexplored and a little understood topic in Biology. There is currently minimal information regarding the diversity of the microbial fauna that resides in the stratosphere. The limited number of previous studies have sampled the stratospheric biosphere using normally one method of collection. This experiment combines the depositional pump suction method and the filter method. The environment of the stratosphere at the far northern latitudes is unique relative to rest of the stratosphere. The temperatures are warmer, ionising radiation is higher, and UV radiation is higher. In this experiment we will build a safe, sturdy, and clean microbial collection device to sample the microbial life forms at several altitudes in the arctic stratosphere. The samples collected were examined with a SEM. The composition was also examined. Organic samples were collected. Some of the samples found appeared at least visually to correspond with previous studies. However, the risk of contamination during labor work or in the manufacturing process of the filter must be acknowledged.

Session 5: Applications: Astronomy

5.8 A. Lagg, Sunrise - a stratospheric solar observatory: Scientific highlights of two successful flights & outlook for the re-flight in 2021, Max-Planck-Institut für Sonnensystemforschung (MPS), Germany

SUNRISE is a balloon-borne, stratospheric solar observatory dedicated to the investigation of the structure and dynamics of the Sun's magnetic field and its interaction with convective plasma flows and waves. Two science flights in 2009 and 2013 have led to many new scientific results, so far described in around 100 refereed publications. This success has shown the huge potential of the SUNRISE concept and the recovery of the largely intact payload offers the opportunity for a third flight. The new scientific instrumentation of SUNRISE 3 will measure magnetic fields, plasma velocities and temperatures with increased sensitivity and over a larger height range in the solar atmosphere, from the convectively dominated photosphere up to the still poorly understood chromosphere. The latter is the key interaction region between magnetic field, waves and radiation and plays a central role in transporting energy to the outer layers of the solar atmosphere including the corona.

5.9 F. Onori, A multi-wavelength view of the transient sky in astronomy, Istituto Nazionale di Astrofisica (INAF), Italy

This lecture is an overview of the main astrophysical sources which populate the transient sky and on the influence of their transient emission, which strongly depends on the wavelength band in which the sky is observed. I will start with brief historical introduction on how our knowledge of the transient sky evolved with time, thanks to the development of new observational facilities in different wavelength band. In particular, the observations of new kind of emission in the high energy, optical and radio brought to the discovery of several exotic compact objects and new discoveries are still ongoing.

The main characteristics of the systems involving compact objects and the transient emissions observed in different wavelength range, from the optical to the high energy, will be discussed.

In the very recent years, with the observation of the gravitational wave signal coupled with the electromagnetic emission of a merging neutron star binary, the new multi-messenger era is started. The implications on the development of new techniques and facilities to study the transient sky in this new era will be also discussed.

5.10 M. Pearce, Hard X-ray polarimetry from a stabilised balloon-borne platform, Royal Institute of Technology, Royal Institute of Technology (KTH), Sweden

Advances in the field of X-ray astrophysics are currently driven by spectroscopy, imaging and timing studies. Many astrophysical X-ray sources are dominated by non-thermal emission with radiation transferred in highly asymmetric systems. A measurement of the linear polarisation of the emitted radiation therefore constitutes a key, but currently under-used, observable and diagnostic for sources which cannot be spatially resolved. PoGO+ is a balloon-borne hard X-ray polarimeter operating in the 20 - ~200 keV energy band. PoGO+ was launched from the Esrange Space Center in July 2016 and made new observations of the Crab pulsar and black-hole binary Cygnus X-1 during a week-long flight to Canada. PoGO+ technology, the mission design, and results from the 2016 flight will be presented.

Session 6: Outlook, future trends in the balloon systems, instruments and related science (Convener Emma Elvidge)

6.1 N. Harris, Future developments for balloon observations of the atmosphere - a personal perspective, University of Cranfield, UK

Measurements of the troposphere and stratosphere can be made from satellites, aircraft, and ground stations. Each have their own strengths and weaknesses. Satellite instruments can provide near-global coverage of many species, but are very expensive, have limited duration and require ground-truthing. Research aircraft can carry heavy payloads which can make simultaneous measurements of many species at fine detail in places selected by the science teams. However, they are expensive to run require large, skilled support teams, and so are best suited to detailed process studies. Ground-based instruments can make long-term measurements whose calibration can be continuously checked. These provide some excellent tools with which to study the atmosphere.

Given these competing options, what will be the role for balloons? What is their role as platforms from measuring the future atmosphere? I will argue that it is critical to define the areas where balloons can make a unique contribution. These include frequently launched small balloons for payloads for suites of small sensors (including sondes with single sensors), long duration balloons in the upper troposphere and lower stratosphere, above where commercial aircraft fly, and large payloads measuring multiple species. Important scientific areas will be understanding trends and variability by making regular measurements (especially climate-related ones) and complementing or filling in for satellite measurements.

6.2 T. Deshler, Profiling of the tropical tropopause layer with in situ instruments deployed from Strateole2 long duration balloons, University of Colorado, USA

The tropical tropopause layer (TTL) is the primary pathway for tropospheric water vapor and other trace gases to enter the stratosphere. Water vapor cools the stratosphere and impacts ozone, which motivates efforts to measure and to model TTL water vapor, but many details are foggy. The measurements planned for a November 2019 engineering, and 2021 science, campaign, are to make multiple nightly in situ profiles of water vapor, cloud occurrence, and temperature across the TTL for up to three months. The planned measurements are part of the French Stratéole 2 campaign to study stratospheric dynamics and ozone chemistry in the TTL with a set of long range, quasi-Lagrangian, balloons drifting at ~18 km, near the top of the TTL, between ±10º of the equator for up to three months, October – February. Our particular *in situ* instruments are: an instrument assembly to measure 2 km profiles of water vapor, cloud occurrence, and temperature across the TTL up to ten times each night, and an optical particle counter on the drifting balloon, near the top of the TTL, for hourly day and night aerosol size distribution measurements. The new equipment designed for these deployments will be described along with the need for the measurements.

6.3 L. Natalucci, Results from gamma-ray instrument probes on balloon flights and perspectives beyond 2020, Istituto Nazionale di Astrofisica (INAF), Italy

Gamma-ray astronomy has been always using scientific ballooning from the early times of the pioneering discoveries to the present days. High energy photons from cosmic sources are absorbed at their impact at the upper atmosphere, so telescopes can be operated only at altitudes >30km from sea level. Balloon flights offer a good opportunity to validate an experimental technique and/or test a gamma-ray detector under harsh conditions, similar to the ones found when operating on a satellite. Sometimes, these flights lead to new discoveries. I will present a short, non-comprehensive history of balloon experiments reporting some relevant examples, from the first observations to the most recent applications opening the path to innovative techniques, like gamma-ray imaging, Compton telescope, gamma-ray polarisation. Finally, I will discuss some perspectives for the next decade.

6.4 P. Raizonville, The HEMERA balloon research infrastructure, Centre national d'études spatiales (CNES), France

In 2017, the HEMERA Research Infrastructure was selected by the European Commission within its H2020 Program. Its objectives are to:

- Provide better and coordinated balloon access to the troposphere and stratosphere for scientific and technological research
- Attract new users
- Enlarge the fields of science and technology research with balloons
- Improve the balloon service to users
- Favour standardization, synergy, complementarities

The project is coordinated by CNES and involves 13 partners from various European entities and Canada. The project started in January 2018 for the years 2018-2021. Six Zero Pressure Balloon flights with a target payload mass of 150 kg are foreseen within HEMERA, offering free of charge access to users and scientists for various measurements and technology tests. In addition, several Sounding Balloon flights are foreseen. Two calls for flight opportunity proposals are planned in the HEMERA project, in 2018 and in September 2019; 39 answers from 12 countries have been received to the first one and 21 selected. Virtual Access to balloon scientific data is also planned.

6.5 M. Becker, The REXUS/BEXUS program, DLR, Germany

The German-Swedish REXUS/BEXUS programme is realised under a bilateral Agency Agreement between the German Aerospace Center (DLR) and the Swedish National Space Agency (SNSA). The Swedish share of the payload has been made available to students from other European countries through a collaboration with the European Space Agency (ESA). EuroLaunch, a cooperation between the Esrange Space Center of SSC and the Mobile Rocket Base (MORABA) of DLR, is responsible for the campaign management and operations. Experts from DLR, SSC, ZARM and ESA provide technical and organizational support to the student teams throughout the project. The programme allows students from universities to carry out scientific and technological experiments on research rockets and stratospheric balloons. Each year, two rockets and two balloons are launched. Surveys show a broad appreciation for the programme, an increasing use for it as part of their university education and strong positive results with regards to employment within science and the (space) industry.

6.6 N. Callens, ESA Academy Programme opportunities, European Space Agency (ESA), Belgium via VC (start 11:40)

The ESA Academy is ESA's overarching educational programme for university students from ESA Member States, Canada and Slovenia. Through a tailored transfer of space know-how and interaction with space professionals, the ESA Academy takes the students through a learning path that enriches their academic education. As a result, the students can enhance their skills, boost their motivation and ambitions, become acquainted with the standard professional practices applied nowadays in the space sector, and be better prepared for the labour market.

ESA Academy Programme is composed of two pillars:

- Hands-on Space Projects, a continuing programme that enables students to gain first-hand, end-to-end experience of space-related projects.
- Training and Learning Programme, a new initiative offering an entirely new set of training sessions and learning opportunities.

In this lecture the objectives of the ESA Education Office will be introduced and the different opportunities offered to University students will be presented.

6.7 Round table discussion (N. Harris, P. Raizonville, M. Becker, T. Deshler, R. Roth, …)

During the round table discussion, various aspects of scientific ballooning and perspectives for future activities will be discussed. These will include

- The various scientific applications, including those in astronomy, aeronomy and Earth observations
- Possible balloon applications in geoengineering
- New balloon types and inferred technologies (c.f. gliders, unmanned air-borne vehicles)
- Existing and new launch sites
- ……