The COBRAT project – scientific payload and mission strategy

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By 2005 the TARANIS (Tool for the Analysis of RAdiations from lightNIngs and Sprites) mission from CNES and the ASIM (Atmosphere-Space Interactions Monitor) from ESA will be operating in space. They are both dedicated to the study of Transient Luminous Events (TLEs) and Terrestrial Gamma-ray Flashes (TGFs). The aim of the COBRAT project (Coupled Observations from Balloon Related to ASIM and TARANIS) is to maximize the scientific return of TARANIS and ASIM by performing coordinated measurements from balloons in the vicinity of the generation regions. Such measurements are needed to identify unambiguously the generation mechanisms of TGFs and TLEs and to quantify their atmospheric effects. The strategy adopted to maximize the scientific return of the COBRAT mission is presented.

1. Introduction

The discovery at the beginning of the 1990s of both Transient Luminous Events (TLEs) and Terrestrial Gamma-ray Flashes (TGFs) has revolutionized our understanding of the terrestrial environment by unveiling the frequent occurrence of impulsive transfers of energy between the troposphere and the space environment.

By the end of 2015, several space experiments designed to study TLEs and TGFs and their generation mechanisms will be operational. Two of them, the ESA Atmosphere-Space Interactions Monitor (ASIM) and the Japanese Global Lightning and Sprite Measurements on JEM-EF (JEM-GLISM), will be embarked on-board the International Space Station. The third one is the CNES satellite mission TARANIS (Tool for the Analysis of RAdiations from lightNIng and Sprites).

According to the altitude range of the generation mechanisms and to the importance of the atmospheric effects, coordinated measurements are needed from the ground (below the generation regions) and from balloons (in the vicinity of the generation regions), in complement with satellite observations (from above the phenomena). The goal of the COBRAT project is to propose the development of dedicated balloons and payloads, providing important complementary measurements to the space borne missions.

2. Mission strategy

2.1. Long duration balloon flight

The strategy of measurements adopted for COBRAT is first to have long duration flights (10 days) in the stratosphere (~30 km) above large convective systems and storms. This would provide observations of several stormy structures per day and would strongly increase the probability to record TGFs and to detect potential NOx and aerosols enhancements. Conventional Zero Pressure Balloon (ZPB) could be used for such purpose. Recent theoretical studies performed by CNES have shown that ZPB could stay several days in the middle stratosphere (altitudes in the 20-40 km range) and can carry heavy gondolas, typically up to 100 kg. During a second phase, short duration flights using conventional stratospheric balloons can be also used in the frame of COBRAT for complementary and/or specific local studies

2.2. Scientific payload of COBRAT (phase 1)

High Energy photon detector (Bergen University, Norway). Priority will be given to TGF observations. Gamma-rays measurements together with both electric and magnetic field measurements are required to identify the generation mechanism of TGFs. Based on the intensity of an average TGF measured by RHESSI and considering a 250 cm^2 gamma-ray detector onboard a COBRAT flight over Central America during the summer months or over Southern South America during winter months, we can expect to detect up to about 20 TGFs.

Detector for Energy and Angular Distribution of Charged Particles (ACATMOS, Brazil). At 30 km altitude, one may expect to cross regions where energetic electrons are accelerated and gamma rays emitted. Accordingly, the angular and energy distribution of charged particles in the atmosphere will be measured onboard COBRAT. This will allow to identify the direction of the incoming charged particles, their energy, and to know whether or not protons are also accelerated..

Field Mill electric field (ACATMOS, Brazil). DC and ULF electric field measurements onboard balloons will provide information one cannot get from ground-based and satellite-based instruments. Such measurements will be performed to the identify electrostatic structures generated just above stormy cells

Short Dipole Antenna (LATMOS, France) and Magnetic Field Instrument (LPC2E, France). ELF and VLF measurements of electromagnetic wave field components are of great interest. Short ELF emissions observed on ground are interpreted in terms of electromagnetic signatures of currents produced within sprites. Such a signature, observed in ~ 20% of the cases, has not been confirmed on satellite so far. Measurements close to the sprite sources may help to better characterize these currents.

High Frequency Electric Field (LPC2E, France; IAP, Czech Republic) - Magnetic Field Instrument (LPC2E, France). High resolution electric and magnetic field measurements are important to determine the kind of lightning related to TGFs. Broadband measurements of both electric and magnetic fields for the LF, MF, and HF ranges can help to determine at what stage of the lightning process the TGFs are produced.

Cameras for TLEs (ACATMOS, Brazil) and (LATMOS, France). Thousands of TLE observations are expected during the COBRAT long duration flights. The priority will be given to Blue Jets and Blue Starters which are difficult to observe from the ground. Optical measurements combined with electric and magnetic field measurements will be performed.

Absorption Spectrometry Instrument for Cobrat (LPC2E, France). It is known that high-energy phenomena like TLEs and TGFs can have a significant impact on the stratospheric chemistry. Both Ozone and NO_2 measurements will be performed by remote sensing techniques, using the Sun and the blue sky as light source during daytime, and the Moon during night-time.

Light Optical Aerosol Counter (LPC2E, France). The production of aerosols associated with high energy phenomena will be investigated. Such aerosols could participate to the initial processes that lead the TLE formation.

2.3. Ground based support and measurements

Ground based observations close to the area of measurements will be necessary to better document the TLEs detected by the balloon instruments.

During the balloon campaign, the semi-autonomous camera systems developed by DTU Space and University of Toulouse, and the Latin-American Network of Transient Luminous Event Observation (LATINELT) will be used to performed ground-based observations of TLEs.

The lightning activity will be analyzed from long range lightning detection networks like WWLLN and STARNET.

The local electric field will be recorded by the Atmospheric Electric Field Metropolitan Monitoring Network (REMCEA) run by the Paraná Meteorological System – SIMEPAR Institute in Brazil. The local atmospheric electric field data can provide information about initial and final moments of thundercloud electrification.

2.4. Modelling

Different modelling teams will participate to the COBRAT project. The impact of TLEs on the stratosphere and mesosphere chemical system will be investigated by LPC2E using a new version of the MIPLASMO model (Microphysical and Photochemical Lagangian Model of Stratospheric Ozone) well adapted for balloon borne measurements.

The TLE kinetic model developed by IAA will be used to predict the (local) chemical impact of TLE/sprite on their surrounding atmosphere. It can be used for both Sprites and Halos and it can be coupled to the electrodynamics of TLEs and, in particular, to the electrodynamics of Sprite streamers. The IAA group will also perform analysis of emission spectra recorded from the Balloon of the first and second positive systems of N_2 excited by TLEs.

Finally, existing codes dedicated to the streamer dynamics in TLE/Sprites will be very useful to interpret electric field measurements performed during COBRAT flights. Similarly, modelling efforts at NSI/DTU, and at the University of Bergen will also be important to understand the relation between TGF production and lightning physics.

3. Partnership

The COBRAT project will include teams from French and International laboratories (England, Spain, Norway, Brazil, Argentina, Peru, Czech Republic).