New physical phenomena in the atmospheric lightning discharges: observations from micro-satellites and ground

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9.3.2 **Cross-cutting activities /** International Cooperation

The project seeks a support for the coordination of 3 micro-satellite missions:

- **Chibis-M** (Russia)
- **TARANIS** (France)
- **ASIM** (Denmark)

and ensuring their ground-based observational support.

These missions are dedicated to studies of fascinating physical effects of lightning discharges in the upper atmosphere:

- Transient Luminous Events (TLEs) above thunderstorms;
- Terrestrial Gamma-ray Flashes (TGFs).

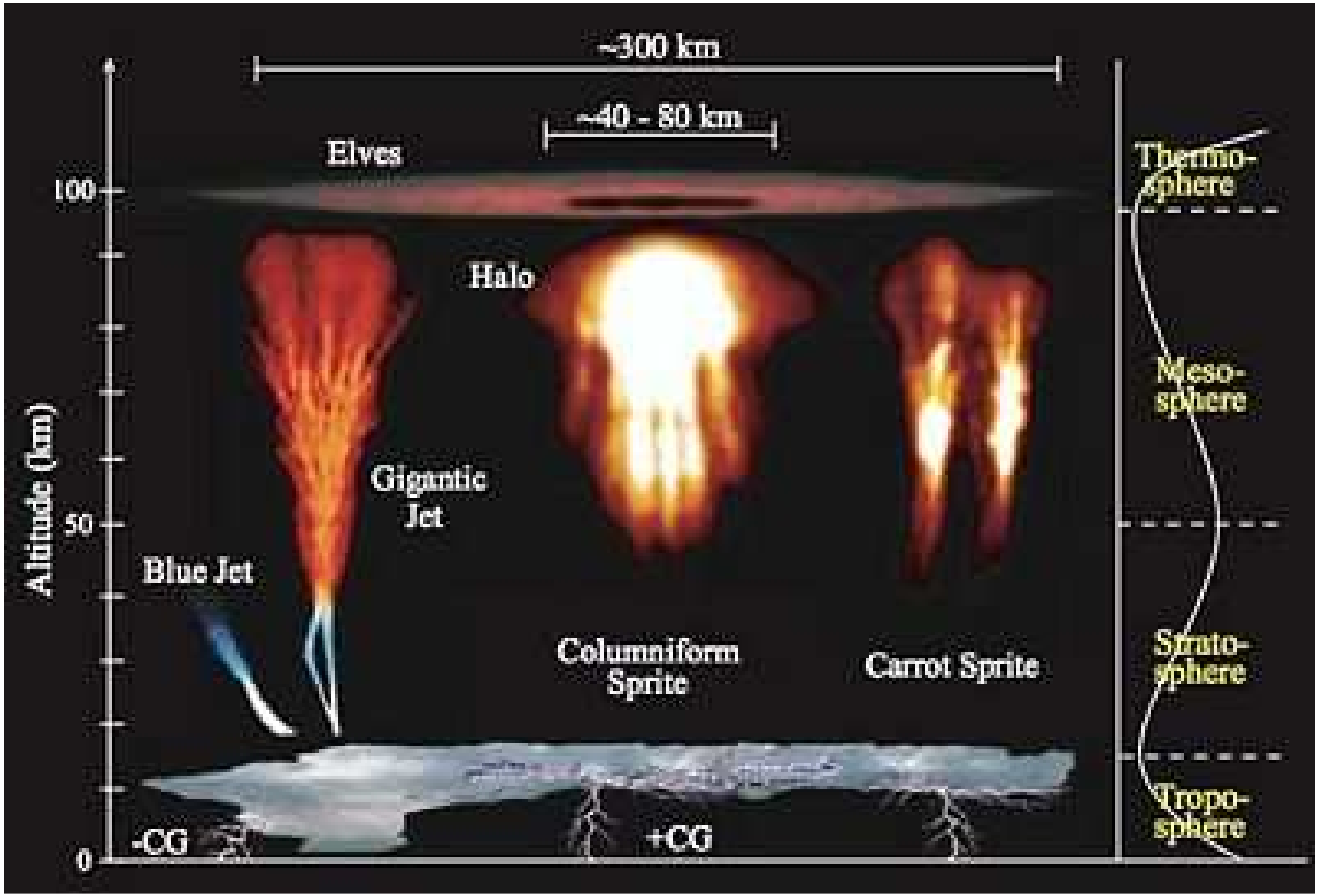
The phenomena associated with atmospheric electric storms

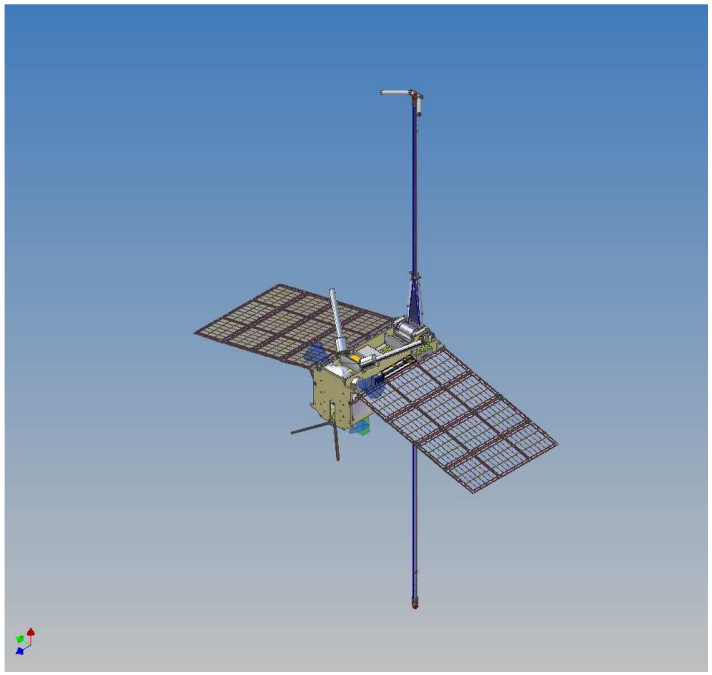
About 2000 storms are permanently active throughout the world, producing 50-100 lightning bolts per second. Surprizingly, a whole new world of various TLEs, such as red sprites, blue jets, elves, halos, gigantic jets, associated with lightning flashes has been discovered unexpectedly. These events are screened by clouds from a ground observer, and can be detected either from high-altitude observatories or from space.

Since the discovery of these phenomena is very recent, current knowledge is mostly limited to visible light. Further studies demonstrate that TLEs are just a small part of a much more complex phenomenon that also involves

- bursts of X and γ-rays (TGFs),
- intense e/m emissions over a large range (0.1 Hz to several tens of MHz)
- electron acceleration up to relativistic energies (up to 30 MeV).

New world of various Transient Luminous Events: red sprites, blue jets, elves, halos, gigantic jets, …





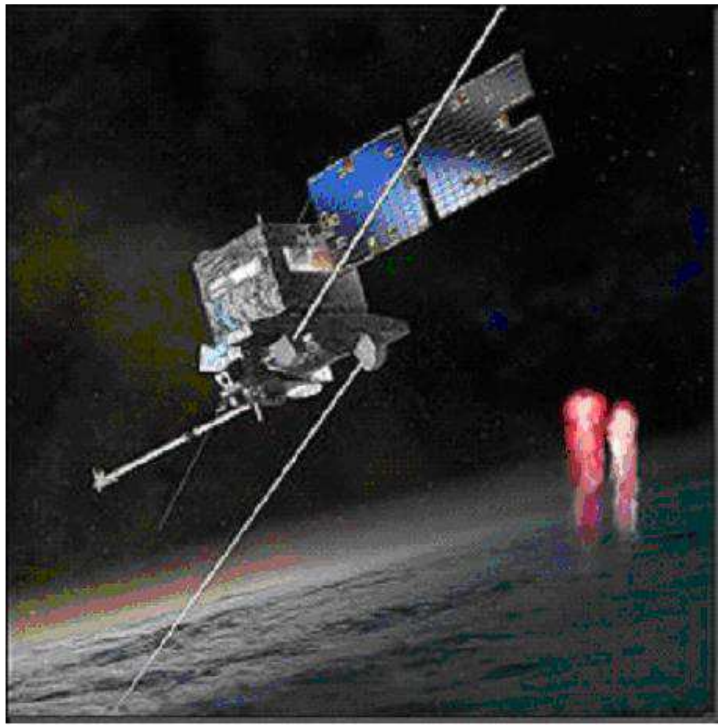
Chibis-M

micro-satellite designed by the Space Research Institute (Moscow) in cooperation with the Lviv Centre of Institute for Space Research (Ukraine), Moscow University, and other research centers

In this mission (*chibis.cosmos.ru*) for the first time the multi-instrument technique is designed for the monitoring of lightning discharges in radio, optical and gamma bands with unprecedented time resolution (~sub-μsec). An experiment with such demands for sampling rate and information flow has never been conducted in any space mission.

Total mass ~40 kg, circular orbit at ~ 500 km, duration > 2 years
Micro-satellite is to be delivered to ISS by the transport vehicle «Progress».

The expected launch – 2010.



TARANIS (Tool for the Analysis of RAdiations from lightNIngs and Sprites)

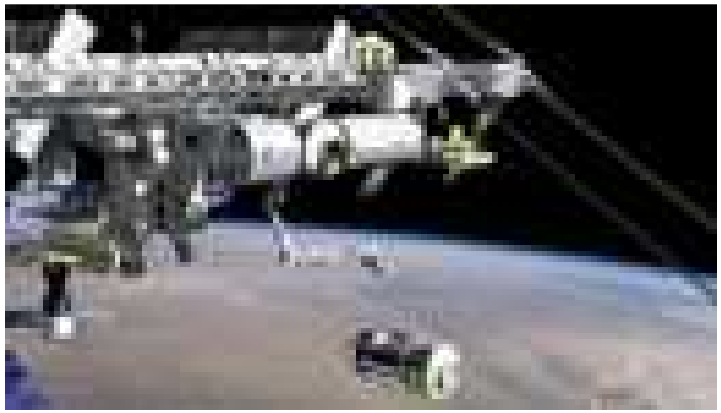
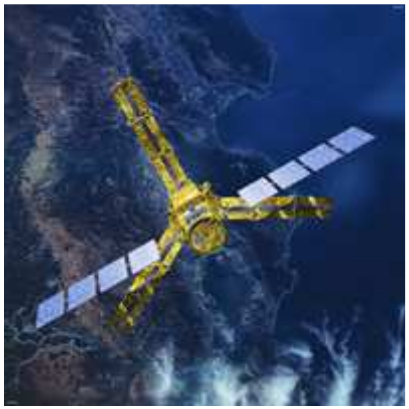
French micro-satellite project managed by the Laboratoire de Physique et Chimie de l'Environnement of Centre National d'Etudes Spatiales (Orleans)

Mission is dedicated to studies of impulsive transfer of energy powered by lightning between the atmosphere, ionosphere and magnetosphere (*smsc.cnes.fr/TARANIS*).

The polar orbit at 650 km altitude,

Payload includes 2 cameras and 3 photometers (from IR to UV), X- and γ-ray detectors (20 kev - 10 Mev), energetic electron detectors (70 kev - 4 Mev), and electric- and magnetic sensors in a wide range (1 Hz - 30 MHz).

Launch is scheduled for 2011.

ASIM (Atmosphere-Space Interactions Monitor)

The scientific management is provided by the National Space Institute - Danish Technical University, with partnership from the Danish company Terma, University of Valencia (Spain), and University of Bergen (Norway).

Mounted on the ISS external module Columbus, ASIM will study giant electrical discharges in the high-altitude atmosphere above thunderstorms.

The package of instruments includes 6 specially designed cameras, 6 photometers, and X- and γ-ray detectors.

Launch is scheduled for 2011, duration ~2 years.

Ground-based support

Ground-based observations coordinated with these space missions are to be performed by

- **Russia** (*Caucasus observatory, Siberian Lightning Monitoring System)*
- **Europe** ("*Eurosprite" network* - France, Spain, Hungary, Greece, Finland)
- **Israel** *(Tel Aviv University*)
- **US** (*Stanford University*, *Duke University)*
- **Brazil** (*Instituto Nacional de Pesquisas Espacias*)
- **New Zealand** (*WWLLN Network*)
- **India** (*Institute of Geomagnetism*)
- **Japan** (*Hokkaido University*)
- ……

Theoretical and Modeling efforts

in support of the data analysis are to be provided by

- **European centers** (*Eindhoven University,*)
- **Russian centers** *(Lebedev Institute of Physics, Institute of the Physics of the Earth, N. Novgorod University)*

Research actuality

The probability of TLE/TGF detection by an individual satellite is rather low. Because of this the most efficient way to enhance the scientific output from these missions is the cooperation of their observational programs and data exchange. A comprehensive understanding of TLE phenomena is impossible without coordinated world-wide ground-based optical and electromagnetic observations.

Successive launches of three dedicated satellites will allow adaptation and correction of operational cyclograms and instrumentation parameters of European missions next CHIBIS-M launch.

Project will synergistically unite efforts of experimentalists, data analysts and modelers in understanding the atmospheric electricity processes influencing every human.

The project will provide a valuable practical information about a possible risk for the airplane passengers from powerful γ-ray emission.

General objectives of this project

- ✓ **Advance physical understanding and identification of the generation mechanisms for TLEs and TGFs and, in particular, the particle and wave field events which are involved in the generation processes.**
- ✓ **Evaluation of the effects of TLEs, TGFs, bursts of lightning-induced precipitated electrons and runaway electron beams on the Earth atmosphere and radiation belts.**
- ✓ **Study of the magnetosphere - ionosphere - atmosphere coupling via transient processes during thunderstorms.**