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FEASIBILITY OF HIGH ALTITUDES LUMINOUS EVENTS STUDY BY INFRARED SPECTRO-IMAGERY EMBEDDED IN A STRATOSPHERICAL BALLOON.

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Abstract

HALESIS (High Altitude Luminous Events Studied by Infrared Spectro-imagery) is an innovative project based on hyperspectral imagery. The purpose of this experience is to measure the atmospheric perturbation in the minutes following the occurrence of Transient Luminous Events (TLEs) from a stratospheric balloon in the altitude range of 20 to 40 km. We present the preliminary study that has established the feasibility of the project.

I – Motivation and scientific context

- 1989: 1st record of transient luminous events (TLEs) in the high atmosphere.
- Demonstration of the existence of another interaction processes between the different atmospheric layers (troposphere, stratosphere, mesosphere and ionosphere).

Consequences:
- Interaction processes between the different atmospheric layers, which was not considered before.
- Impact not yet quantified.
- Chemical processes involved having potential broader consequences.

II – HALESIS PURPOSE

- The presence of oxygen atoms in electronic excited states has an impact on ozone chemistry.
- Atomic or molecular species excited in electronic or vibrational states can induce various chains of chemical reactions and local enhancements of the concentrations of O3, NOx (NO+NO2), NO+, OH, ...

HALESIS PURPOSE:
What happened in the minutes following the events:
To measure the effect of these events on stratospheric chemistry by retrieving the concentration of species potentially produced or perturbed (NOx, O3, NO2, NO+).
To monitor the vibrationally excited chemical reactions associated with TLEs.

III. Physical Processes at the origin of TLE

- An electrical perturbation caused by a thunderstorm can trigger a discharge above the clouds in the upper layers of the atmosphere.
- The associated energized electrons excite, ionize or dissociate the major constituents N2 and O2 of the atmosphere leading to atomic, molecular, or ionic species.
- When relaxing to lower energy states, visible photons are emitted.

III. Physical Processes at the origin of TLE

- N2, O2, H2O, CO2 signatures easily detectable in the MIR;
- NO and CO signature detectable with a multipixel concept.

IV – Instrumental setup

Spectro-imagery is a combination of imaging and spectroscopy. It allows for acquiring images that are spectrally resolved.

- Horizontal spatial dimension: comparison between central and edge pixels.
- Vertical spatial dimension: vertical distribution of species.
- Spectral dimension: depends on the target species produced or perturbed (NO, O2, NO2, NO+).

V – Feasibility study : fundamental bands

- Signature of the O3 effect on “easily” detectable in the TIR.
- NO2 and O3 effect signatures requires multipixel medium resolution concept.

VI – Feasibility study : hot bands

- Preliminary simulations showed that the order of magnitude expected to detect a disturbance are consistent with detection limits of
  - A commercial spectro-imager to (950-1075 cm⁻¹) for NO
  - A multipixel spectrometer (1675-1750 cm⁻¹) for O3.
- Need to explore the hot bands to probe more species and more information;
- Need to explore innovative FTS instrument concepts for an acquisition frequency and sufficient sensitivity (GLORIA/IMK, SIELETERS/ONERA, ...)

VII – Conclusion and Outlook

- Very poor information on the impact of TLEs on the chemical composition of the stratosphere.
- We are currently establishing the feasibility of an innovative project to measure the impact of TLEs on atmospheric compositions.
- Need to simultaneously acquire spectral measurements in disturbed and undisturbed atmosphere, at different time, and at different altitudes ➔ hyperspectral imaging !

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