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# The ESA EE12 Candidate Mission: Keystone

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Keystone is a proposed upper atmospheric limb sounding mission with the aim of providing a comprehensive measurement of the Mesosphere and Lower Thermosphere (MLT) composition, temperature and winds, and its variability (from a diurnal to a seasonal scale). It's currently in Phase-0 study as ESA's 12th Earth Explorer.

The MLT is the upper atmosphere region which goes from 70km to 120km, subject to high energy inputs from space as solar electromagnetic radiation and energetic particles. The resulting photodissociation, photo-ionisation and high-energy collisions generate radicals and ions, often with internal excitation.

The key science objective (SO) of the Keystone mission is to gain knowledge of geophysical parameters in the MLT that will allow a better understanding of its behaviour. Keystone SO has the aim of improving the understanding of space weather and climate change processes, in particular their impact on the MLT region. This translates in understanding the composition, gradients and variability of the atmospheric neutral density, temperature, winds and trace gases.

To deliver its science, Keystone will pursue the following five mission objectives (MOs):

1. "Thermal balance"(MO1): to quantify reaction rates in chemical and photochemical models of the upper atmosphere by providing global vertical distribution profiles of the key MLT species atomic oxygen (O), in combination with co-located measurements of infrared heat fluxes and visible ultraviolet (UV-Vis) airglow. MO1 will be fulfilled from measurements of: O, temperature, infrared (IR) heat loss, and airglow.
2. "Diurnal variations of the whole atmosphere"(MO2): to investigate the 4-D spacetime structure of the diurnal variations (atmospheric tides) in view of dynamics, chemistry, and electromagnetic processes. MO2 will be achieved from measurements of winds, temperature, O, ozone (O3), and ozone related species (e.g., HOx, H2O).
3. "Upward coupling"(MO3): to unveil the vertical propagation of synoptic-to-planetary scale disturbances from the middle atmosphere (non-migrating tides and Sudden Stratospheric Warming (SSW) events) to the upper atmosphere. MO3 will be achieved from measurements of temperature, winds, ion density and gravity waves.
4. "Downward coupling"(MO4): to understand atmospheric variations due to energy inputs from the magnetosphere (particle precipitation and magnetic storms). MO4 will be achieved from measurements of NOx, HOx.
5. "Models & applications"(MO5): to provide benchmarks for the whole atmosphere models and climate models with detailed description of the background thermal structure and distribution of minor species. MO5 will be achieved from measurements of H2O, O3, CO (tracer).

The Keystone concept includes a comprehensive remote sensing payload, covering spectral windows in the Terahertz (THz), IR and UV-Vis regions of the electromagnetic spectrum in order to fulfil its science objectives.

The primary instrument foreseen for this mission is a supra-THz radiometer with high spectral resolution for the retrieval of vertical distribution profiles of trace gases, temperature, and mesospheric winds (passive limb-emission spectroscopy). It would be flown in combination with heritage IR and UV-Vis instruments (passive limb-emission sounding).

Keystone would operate from a Low-Earth Orbit (LEO) satellite platform and scan the limb of the atmosphere at tangent height from 50 km to 150 km with high vertical resolution. The exact orbit parameters and viewing geometry are under investigation in the ongoing Phase-0 science requirements study.

## Solicited or Contributed

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## Author list and affiliations

The Keystone MAG

## Presenting author

Daniel Gerber

**Primary author:** GERBER, Daniel (RAL Space)

**Presenter:** GERBER, Daniel (RAL Space)

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