Space Activities of the Liège Space Center
University of LIEGE BELGIUM

Pierre ROCHUS

Former Chairman of the IAF Space University Administrative Committee (SUAC)
Honorary Professor at the Faculty of Applied Sciences;
Aerospace Department
LTAS, ULg
Head of IES (Space Instrumentation and Testing Lab.)

Invited Professor at KUL (Leuven)

Adjunct Professor of Harbin Institute of Technology Shenzhen

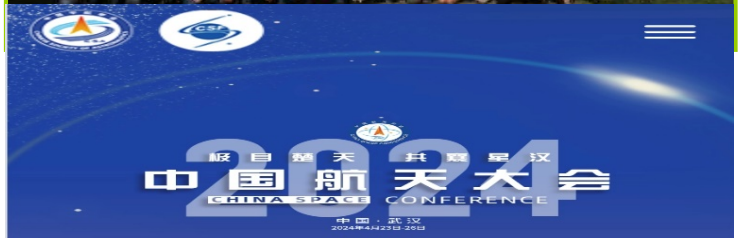
Guest Professor of Shandong University at Weihai

Past Scientific Director of Centre Spatial de Liege

Chairman of Liege Espace

prochus@uliege.be

https://orcid.org/0000-0003-4290-9442



2024 "Flying to Deep Space" International Science and Innovation Cooperation and Development Forum
International Convention Center, Wuhan, Hubei
April 23-26, 2024

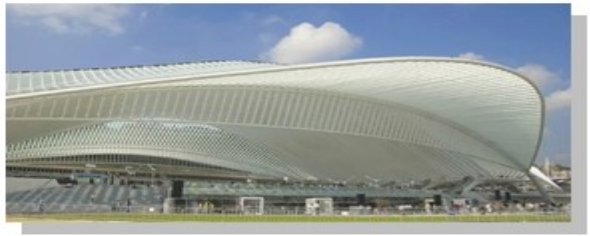
Location

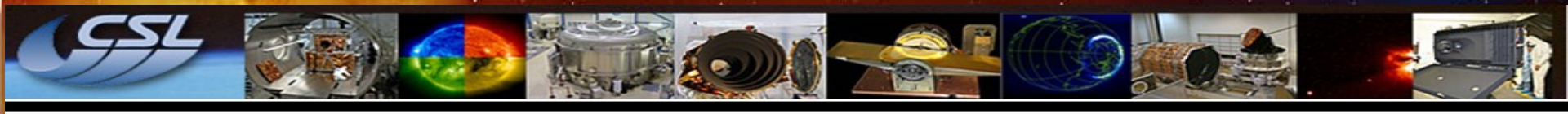
Centre Spatial de Liège
Liege Science Park
Avenue du Pré-Aily, B-4031 Liège
Belgium
+32 4 382 46 00

GPS:
N 50.5980
E 5.5660

WUHAN 8600

We're located 6 km south of the city centre of Liege, next to the University Campus





Training, research, expertise:

the University of Liège is at the forefront of the space field.

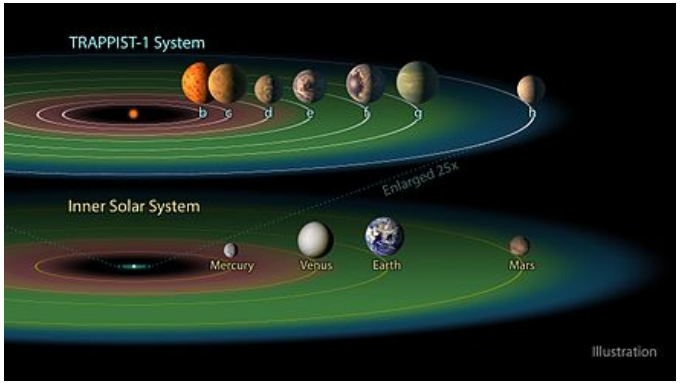
To understand the origin and evolution of the Earth and the Universe...

To participate in the development of advanced space missions.

The most comprehensive course programme in Belgium in Space Science and Technology in the Faculties of Science and Applied Sciences

Research units

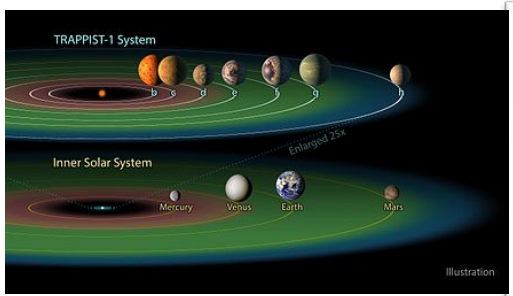
- STAR - Space sciences, Technologies and Astrophysics Research
- ASTROBIOLOGY
- A&M - Aerospace and Mechanics
- Montefiore
- CSL - Centre Spatial de Liège (Liège Space Centre)
  - TRAPPIST telescopes
  - SPECULOOS telescopes
  - TIGRE telescopes
  - Sphinx Observatory at the Jungfraujoch



STAR - Space sciences, Technologies and Astrophysics Research

The STAR research unit conducts research in areas such as

- planetology (detection, characterization and direct imaging of exoplanets, study of planets and small bodies of the solar system, composition and dynamics of the Earth's atmosphere),
- Stellar astrophysics (observational characterisation and modelling of stars and their evolution, interaction of stars with their environment, high energy emission),
- cosmology, dark energy, extragalactic astrophysics and astro-particles (quasars, gravitational lenses, large-scale structures, dark matter, cosmic rays),
- Space instrumentation (Earth observation and other scientific satellites, ground instruments. STAR participates in the development of space missions and ground instruments
- Gravitational waves
- Solar Physics
- Space Weather



LEARN MORE ;
HTTPS://WWW.STAR.ULIEGE.BE/CMS/C_4265211/EN/STAR?ID=C_4265211

ASTROBIOLOGY

Astrobiology combines multidisciplinary approaches to study the origin, evolution, distribution and **future** of life in the universe, including the Earth, the only biological planet known so far. The ASTROBIOLOGY Research Unit studies the habitability of rocky planets and the detection and characterization of biosignatures, from early life traces and evolution on the early Earth, to the detection of possible extraterrestrial biosignatures in the solar system and in potentially habitable exoplanets.

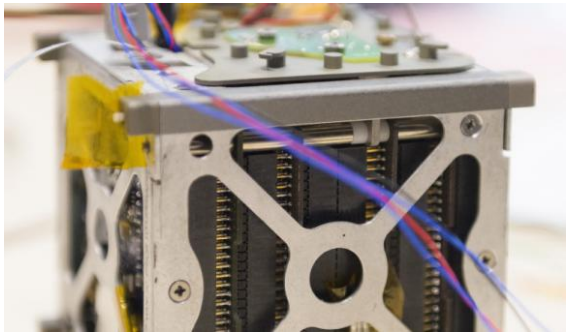
LEARN MORE HTTPS://WWW.SCIENCES.ULIEGE.BE/CMS/C_5037156/EN/FACSC-ASTROBIOLOGY

A&M - Aerospace and Mechanics

(more than 120 people, including 24 academics (20 full-time), 4 permanent researchers, more than 80 researchers (including PhD candidates), and 15 people in the administrative and technical staff. The research unit is composed of 20 core research groups).

The disciplinary foundations of the research activities carried out within the A&M Research Unit are

- the physics of materials,
- the mechanics of continuum (solid and fluid),
- the dynamics of mechanical systems and thermodynamics.
- Astrodynamics (PR)
- Design of Space Instruments (PR)



The main fields of application are

- aeronautics and space,
- land vehicle mechanics,
- mechanical engineering,
- energetics and biomedical engineering.

The methodological approach is based on the successful confrontation of mathematical and numerical modelling with the experimental study of phenomena and mechanical systems.

LEARN MORE HTTPS://WWW.AM.ULIEGE.BE/CMS/C_3711351/EN/AMNEW-RESEARCH-GROUPS
http://www.s3l.be/en/research

A&M (Former LTAS)

History

inherits a long tradition of high standard research from talented professors and researchers who have been active in the Institute of Mechanics of University of Liege.

The research in **computational mechanics and numerical simulation** in Aerospace can be traced back to the **LTAS**, *Laboratoire de Techniques Aéronautiques et Spatiales*, founded in **1961** by late **Professor Fraeijs de Veubeke** as a distinct entity in the Institute of Mechanics.

Prof. Fraeijs de Veubeke was a pioneer of the finite element method and variational principle (US Airforce contract). The research on the **finite element** method at LTAS started in 1965. The laboratory devoted most of its research efforts to the development of numerical methods and application software in aerospace engineering and, more generally, in applied mechanics.

Guy Sander, Michel Géradin, Michel Hogge, Pierre Beckers are the pioneer professors in the numerical methods aspects.

This led in 1970 to the development of an integrated finite element package **SAMCEF** which has evolved in a very continuous manner since that period. Later LTAS developed a second generation FE code, **OOFELIE**, leveraging research in multiphysics simulation.

The research in computational mechanics and numerical simulation is still a very active topic in A&M and it is organized around several research groups sharing the common objective of developing numerical simulation methods and software tools in the field of aerospace and mechanical engineering.

- Besides computational mechanics, experimental research in mechanics, energy and propulsion systems stems from several laboratories that have developed cutting edge facilities in different engineering fields.
- **An aerospace wind tunnel** (since the 1930's a new in 2000).
- **CRM** *Centre de Recherche Metalurgique*
- **Thermodynamics Lab** (

A&M is committed to the development of **multilateral scientific collaborations with other academic partners, research institutes (CHILI (Universidad de Concepcion), CHINA (Northwestern Polytechnical University Xi'an)) and private companies/industries**, to contribute to the advancement of
knowledge and to support high level education/training programs.
A&M has thus a large number of key industrial partners.

Exemple: Weihong ZHANG Professsor and Director at, Northwestern Polytechnical University Structural Optimization

Montefiore

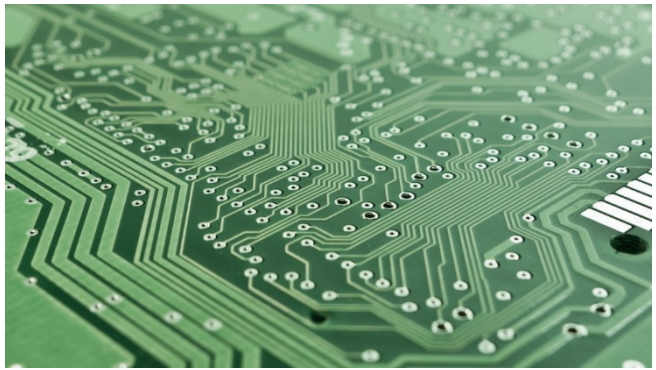
The Montefiore Institute is
- the electricity,
- electronics and
- Information Tehnology
- AI

AI on board for EO

AI in the data treatment of EUCLID

It is active in a range of basic and applied research topics in various fields:
- information and communication technologies,
- computer science,
- electronics,
- power systems and
- mathematical applications.

Applied and Computational Electromagnetics (ACE)



EMC EMI tests of our payloads
Cryogenic low power dissipation electrical motor
Numerical Simulation of LiteBird experiment Tests

LEARN MORE HTTPS://WWW.MONTEFIORE.ULIEGE.BE/CMS/C_4570368/EN/RESEARCH-TOPICS

TRAPPIST telescopes

TRAPPIST (TRAnsiting Planets and PlanetesImals Small Telescope) is dedicated to the detection and characterisation of planets orbiting other stars than our Sun (**exoplanets**) and the study of **comets** and other small bodies of our solar system.
It consists of two 60 cm robotic telescopes, one in the southern hemisphere, installed at ESO's La Silla Observatory in **Chile** in June 2010 and the other in the northern hemisphere, installed in May 2016 at the observatory of Oukaimeden in **Morocco**.

SPECULOOS telescopes

The SPECULOOS Project (Search for habitable Planets EClipsing ULtra-cOOl Stars) aims to **detect telluric planets eclipsing some of the smallest and coldest stars** in the solar neighbourhood.
This strategy is motivated by the possibility of studying such planets in detail with future ambitious observatories such as the European Giant Telescope (E-ELT) or the James Webb Space Telescope (JWST). The exoplanets detected by SPECULOOS should thus offer us the opportunity to analyse the atmosphere of extrasolar worlds similar to our Earth, in particular to look for traces of a biological activity.

TIGRE telescopes

El Tigre (el Telescopio Internacional de Guanajuato, Robótico-Espectroscópico - initially known as "HRT" - Hamburg Robotic Telescope) is a private and flexible telescope partly funded by the University of Liège. The fruit of a German-Mexican-Liege partnership, it will enable the Liège astrophysicists to undertake many completely new studies on the **stars**, and is also an opportunity for amateurs and the general public to discover an unknown science.
LEARN MORE HTTPS://WWW.TRAPPIST.ULIEGE.BE/CMS/C_5006023/FR/TRAPPIST?ID=C_5006023
HTTP://WWW.GAPHE.ULG.AC.BE/HRT/INDEX_F.HTML

For decades now, the Group of the Institute of Astrophysics and Geophysics, and more particularly today the Infrared Group of Atmospheric and Solar Physics (GIRPAS) has been monitoring the visible and infrared solar spectrum at very high resolution. At the beginning, these researches aimed especially at defining the chemical composition of the external layers of the Sun. **Progressively, they have been reoriented towards the composition of the Earth's atmosphere**, using the Sun as a source of radiation.
The **high altitude** of the **Sphinx Observatory at the Jungfraujoch**, combined with **instrumentation providing high resolution** and a high signal-to-noise ratio, allow to overcome most of the absorption produced by high concentration gases in the troposphere and thus make the **quantification and monitoring of trace gases of interest, mainly concentrated in the stratosphere**, possible.

Centre Spatial de Liège
Université de Liège

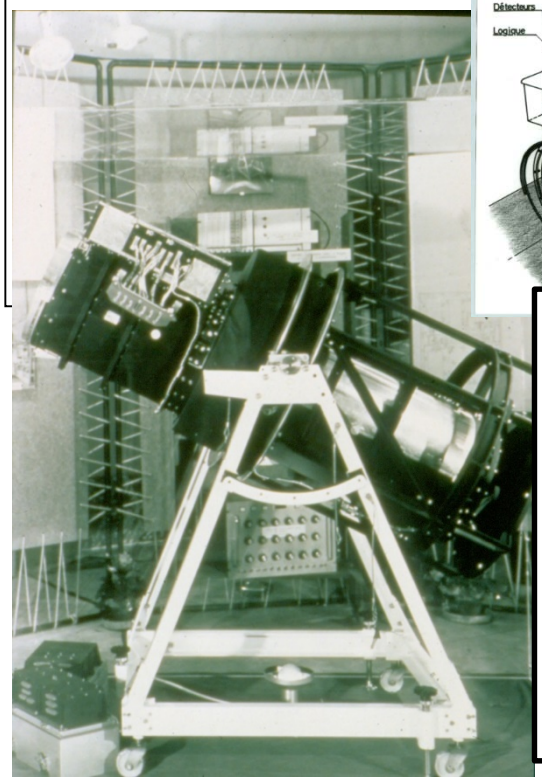
IAL Space (now CSL) one of the European pioneers in Space research

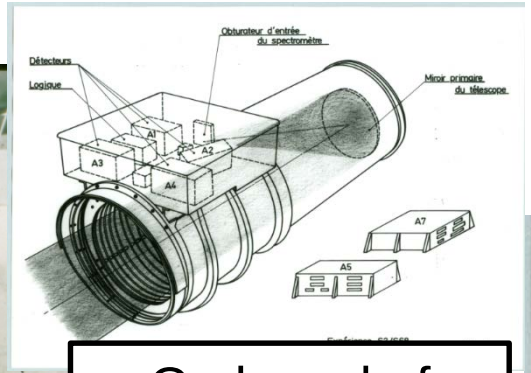
LAUNCH OF 22 SOUNDING ROCKETS FROM ESRANGE (ESRO). KIRUNA IS LOCATED NORTH OF SWEDEN BEYOND THE ARCTIC CIRCLE

The Belgian-Scottish instrument consists of a parabolic mirror off-axis 275 mm in diameter. Made Cervit, it is open at f/13.5. Two slits located in the focal plane give access to a filter photometer and a plane grating spectrometer of 1200 lines/mm.

The S2/68 spectrophotometric sky survey telescope operated in the range 1350 and 2550 Å on the first 3axis stabilized spacecraft of ESA (ESRO-ELDO).

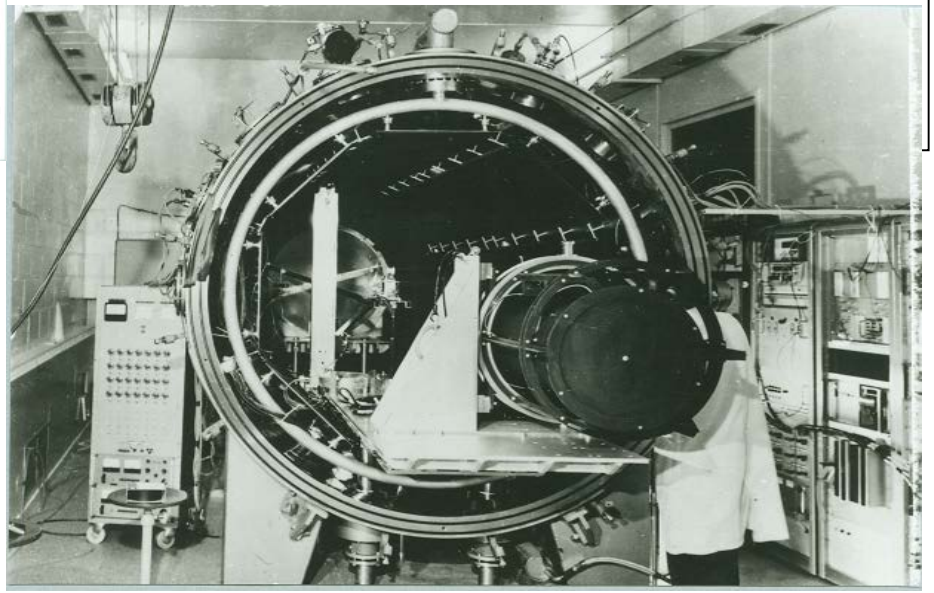
Separate calibrations are performed by the observatory Royal Edinburgh and the Institute of Astrophysics of Liege. The detector used in Edinburgh is calibrated in an absolute reference to the Rutherford Laboratory.





On board of TD1, the first 3 axis stabilized satellite of ESRO.

Launched in March 1972



CSL in a nutshell

CSL OVERVIEW

CENTRE SPATIAL DE LIÈGE

SPACE IS OUR INSPIRATION

- Created in 1959
- First ESA coordinated facility in 1976
- Centre of Excellence in Optics, specialized in space environment and technology

- Staff: ~100

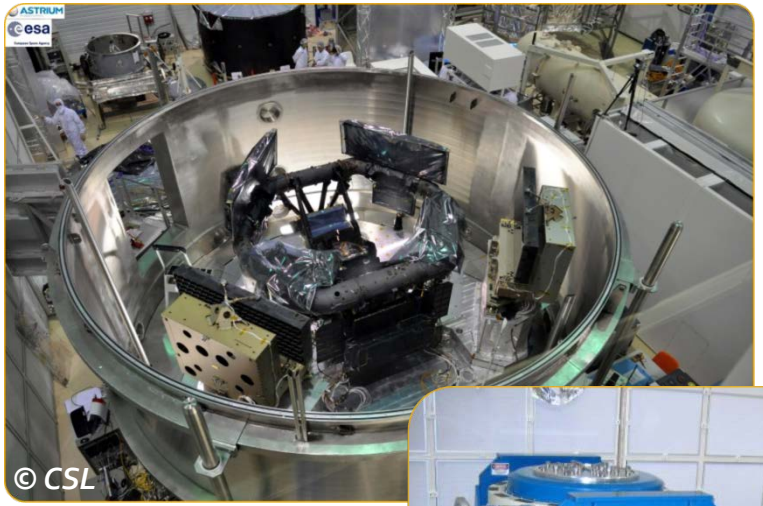
- **Cleanroom**
  - **1,000 m2**
  - **ISO 7** (class 10.000)
  - **ISO 5** (class 100)

    for integration

CSL PROGRAMS

PROGRAMS - *Environmental testing*

- **Thermal Vacuum**
  - *5 facilities*
    - *From **1.5** to **6.5 m** dia.*
    - ***Isolated** from vibration*
    - *With **optical bench***
    - *Cryo cooling **<5K** with LHe*



- **Vibrations**
  - *2 shakers*

- **Design and development of space instruments**

Scientific requirements definition and specification → ***Feasibility study*** → ***System engineering*** → ***AIV***

- *Projects within an **industrial consortium** driven by an industrial prime (ADS, Thales Alenia Space, OHB,…).*
- *Projects within a **scientific consortium**, under the final authority of Space Agencies (ESA, NASA, JAXA, CNES, CSA …)*

PROGRAMS – *Space Systems*

SPACE IS OUR INSPIRATION

SOHO – EIT
(1995)

IMAGE – FUV/SI
(2000)

COROT
(2006)

PROBA2
LYRA & SWAP (2009)

JWST - MIRI
(2011)

JUNO – UVS (2011)

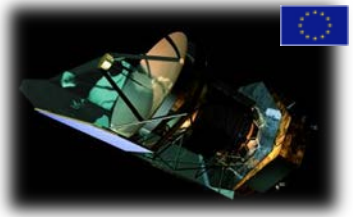
1990 2000 IN FLIGHT OR DELIVERED 2010

XMM – OM (1999)

INTEGRAL
OMC (2002)

STEREO – HI
(2006)

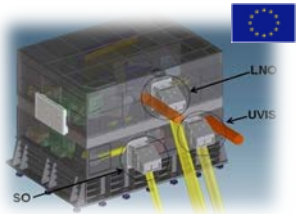
Herschel –
PACS (2009)



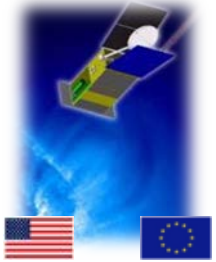
PROGRAMS – *Space Systems*

SPACE IS OUR INSPIRATION

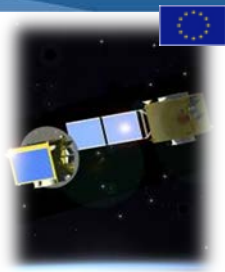
SENTINEL 3 - OLCI (2015)



EXOMARS – NOMAD (2016)



SOLAR ORBITER EUI & HI (2020)



PROBA 3 – ASPIICS (tbl.)

2015 — IN FLIGHT OR DELIVERED — 2030

SENTINEL 2 - MSI (2015 & 2016)

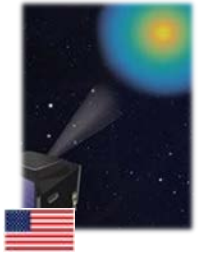
WISPR (2018)

CHEOPS (2019)

MTG – BTA (OGSE)

PROGRAMS – *Space Systems*

SPACE IS OUR INSPIRATION

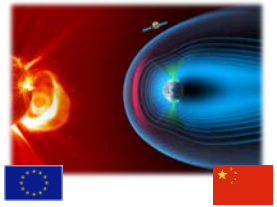


GLIDE GCI (CARRUTHERS) (2025)

ARIEL (ESA M4) (2029)

ARRAKIHS (ESA F2) (2031)

2020 — **UNDER DEVELOPMENT** — **2040**



SMILE (2024-2025)

PLATO (ESA M3) (2026)

Comet Interceptor (ESA F1) (2029)

(New-)Athena (ESA L2) (2037?)

Sun	Solar System	Astrophysics	Fundamental Physics

IMPLEMENTATION

[2018] Solar Orbiter

[2017] BepiColombo

[2022] JUICE

[2017] CHEOPS

[2018] JWST

[2020] Euclid

[2015] LISA Pathfinder

LISA

OPERATIONS / POST-OPERATIONS

[2009] PROBA2

[1995] SOHO

2024 PROBA 3

[1990] Ulysses

[2005] Venus Express

[2004] Rosetta

[2003] Mars Express

[2003] Double Star

[2000] Cluster

[1997] Cassini-Huygens

[2013] Gaia

[2009] Planck

[2009] Herschel

[2002] INTEGRAL

[1999] XMM-Newton

[1990] Hubble

CSL

Historically, students did their Master Thesis on Instruments developed at CSL.
Since 2005, we also involve students on Student µSat (ESEO, ESMO, FLT) and nSat (Oufti, QB50, ExoPlanet Det.)

NASA Scientific Missions

2025 CARRUTHERS
2018 JWST
2018 SPP →PSP
2017 ICON
2011 JUNO
2006 STEREO
1995 IMAGE
1990 HST

COMPLETED

[2003] SMART-1

[1986] Giotto

[1995] ISO

[1989] Hipparcos

[1983] EXOSAT

[1978] IUE [1975] Cos-B

[1972] TD-1

Astrophysics
(continued)

ATHENA (2028)
PLATO (2024

ESA Missions in the Cosmic Vision 2015-2025 Programme

COSMIC VISION	
S-class missions	
	S1 – **CHEOPS**, launched December 2019, operational – space telescope mission focused on studying known exoplanets.
	S2 – **SMILE**, launching 2025, future – Joint ESA-CAS Earth observation mission, studying the interaction between the planet's magnetosphere and solar wind.[15]
M-class missions	
	M1 – ***Solar Orbiter*** , launched February 2020, operational – Solar observatory mission, designed to perform in-situ studies of the Sun at a perihelion of 0.28 astronomical units.
	M2 – ***Euclid*** , launched July 2023, operational – Visible and near-infrared space observatory mission focused on dark matter and dark energy.
	M3 – **PLATO**, launching 2026, future – *Kepler* -like space observatory mission, aimed at discovering and observing exoplanets.
	M4 – **ARIEL**, launching 2029, future – *Planck* -based space observatory mission studying the atmosphere of known exoplanets.[16]
	M5 – ***EnVision*** , launching 2031, future – Venus mapping orbiter mission.[17]
L-class missions	
	L1 – **JUICE**, launched April 2023 with an orbital insertion in July 2031, in transit – Jupiter orbiter mission, focused on studying the Galilean moons Europa, Ganymede and Callisto.
	L2 – **Athena**, launching 2035, future – X-ray space observatory mission, designed as a successor to the *XMM-Newton* telescope.
	L3 – **LISA**, launching 2035, future – the first dedicated gravitational wave space observatory mission.[18][19]
F-class missions	
	F1 - **Comet Interceptor**, launching 2029, future – Comet flyby mission.[16][20]
	F2 – **ARRAKIHS**, launching in the early 2030s, future – Survey of one hundred nearby galaxies and their surroundings to investigate dwarf galaxies and stellar streams.

SCIENCE MISSIONS

FUTURE MISSIONS


Athena [2034]

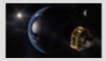

EnVision [2031]


LISA [2037]


ARRAKIHS (ESA F2, (2031)

IN DEVELOPMENT


ACES [2025]


ARIEL [2029]


Comet Interceptor [2029]


Einstein Probe [2023]


Euclid [2023]


ExoMars [2022]


JUICE [2023]

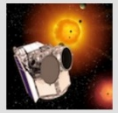

PLATO [2026]

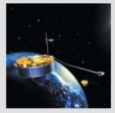

Proba-3 [2024]


SMILE [2024]

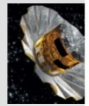
OPERATIONAL AND POST-OPERATIONAL


Bepicolombo [2018]

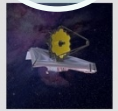

CHEOPS [2019]


Cluster [2000]


ExoMars [2016]


Gaia [2013


INTEGRAL [2002]


JWST [2021]


Mars Express [2003]


Proba-2 [2009]


SOHO [1995

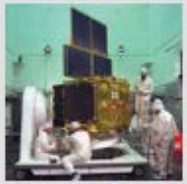

Solar Orbiter [2020]


XMM-Newton [1999]

Our Missions - Cosmos (esa.int)

COMPLETED

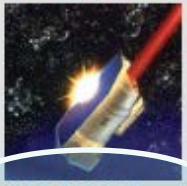

COS-B [1975]


EXOSAT [1983]

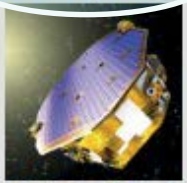

Giotto [1985]


Herschel [2009]

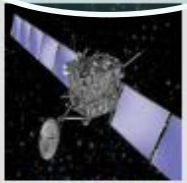

Hipparcos [1989]

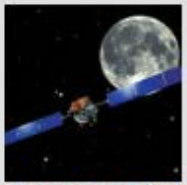

ISO [1995]

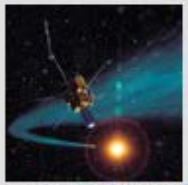

IUE [1978]


LISA Pathfinder [2015]


Planck [2009]

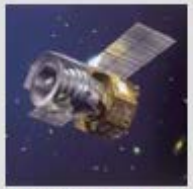

Rosetta [2004]


SMART-1 [2003]

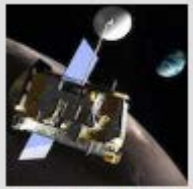

Ulysses [1990]


Venus Express [2005]

COLLABORATIVE MISSIONS


AKARI [2006]

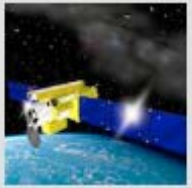

Cassini Huygens [1997]

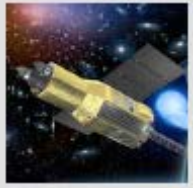

Chandrayaan-1 [2008]


Chang'E [2007]


CoRoT [2006]

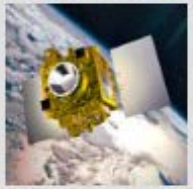

Double Star [2003]

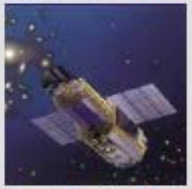

Hinode [2006]


Hitomi [2016]


Hubble [1990]


IRIS [2013]


Microscope [2016]


Suzaku [2005]

COLLABORATIONS WITH CHINA
2004 - 2024

Scientific Missions

Mrs. ZHANG Qiyue
Ambassador of China
to the Kingdom of Belgium during a visit at CSL / University of Liège with Cl. Jamar General Manager of CSL, **Professor Ronglan Xu** and Dr Lei Li, Center for Space Science and Applied Research (CSSAR), Chinese Academy of Sciences

2006

Optical design and calibration of Plasmaspheric EUV camera

Ronglan Xu's research works | Chinese Academy of Sciences, Beijing (CAS) and other places (researchgate.net)

Scientific Missions

COLLABORATIONS WITH CHINA
2004 - 2010

SPACE IS OUR INSPIRATION

A PROTOCOL OF JOINT OPTICAL DESIGN AND THE CALIBRATION OF EUV CAMERA FOR THE SECOND PHASE OF CHINESE LUNAR EXPLORATION PROGRAM

Optical design and calibration of Plasmaspheric EUV camera

In March 23-24, 2006, Professor Ronglan Xu and Dr Lei Li, Center for Space Science and Applied Research (CSSAR), Chinese Academy of Sciences (CAS) paid a visit to Centre Spatial de Liege (CSL) discussing for the cooperation of the joint Optical Design and the Calibration of the Plasmaspheric EUV Camera for the Second Phase of Chinese Lunar Exploration Program. The two parties also discussed the joint data analysis of the EUV camera using Institut d'Aeronomie Spatiale de Belgique (IASB) plasmaspheric models. The preliminary protocol between CSSAR, IASB and CSL during the preparation time (2006-2007) is attached as Appendix I.

In July 10, 2006, CSL proposed the CSL's testing activities for the joint Optical Design and the Calibration of the prototype Plasmaspheric EUV Camera including philosophy and required H/W. The document is attached as Appendix II.

We confirm that both CSSAR and CSL will strongly support the cooperation in the joint Optical Design and Calibration of the prototype Plasmaspheric EUV Camera between CSSAR and CSL. This protocol is of course subject to the agreement of our funding agencies (BELSPO for Belgian activities, CAS and China National Space Agency for Chinese activities).

Professor Ji Wu
Director
Center for Space Sciences and Applied Research
Chinese Academy of Science
China
July 22 2006

Professor Pierre Rochus
Deputy Director
Centre Spatial de Liege

Belgium
July 22 2006

2006

Dr. Ji WU (Former Director National Space Science Center, China) CSSAR

Dr. Ji WU, Professor Pierre ROCHUS Professor Ronglan Xu and Dr Lei Li, (CSSAR), CAS

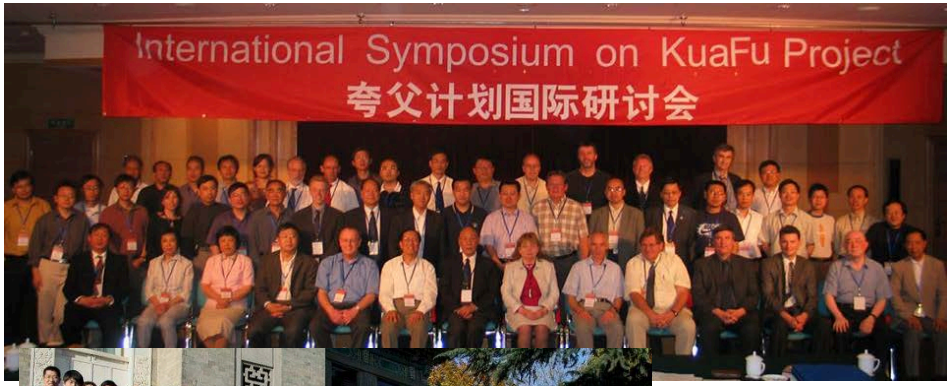
Publication in NATURE : Moon-based Extreme Ultraviolet Camera (EUVC) of the Chang'e 3 mission : https://www.nature.com/articles/srep32362

With CSSAR CAS

COLLABORATIONS 2004 - 2010

KUAFU

KuaFu is an “L1 + Polar” triple Star Project, and an essential element of the ILWS mission lineup. KuaFu is composed of three spacecraft :



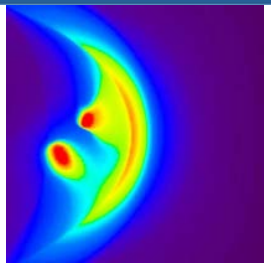
COLLABORATIONS WITH CHINA

Scientific Missions

2016-2024

SMILE

SPACE IS OUR INSPIRATION



- **Joint ESA – CAS mission (S2)** to investigate the dynamic response of the Earth's magnetosphere to the solar wind impact in a global manner
- Combine Solar Wind Charge exchange (SWCX) X-ray imaging of the dayside magnetosheath and the cusps with simultaneous UV imaging of the northern aurora, while monitoring the solar wind conditions in situ
- **Small satellite (300 kg)** in highly elliptical polar orbit (out to 20 Re)
- Instrumentation
  - **SXI** – Soft X-ray Imager of SWCX emission with spectral capability
  - **UVI – UV Imager of the whole northern auroral oval at high temporal and spatial resolution (under fully sunlit conditions)**
  - **LIA** – Light Ion Analyser (p+ and a) for monitoring of solar wind / magnetosheath conditions (density, velocity, temperature)
  - **MAG** – Magnetometer for monitoring of the magnetic field
- The Principal Investigators are Graziella Branduardi-Raymont from Mullard Space Science Laboratory, University College London, UK, and **Chi Wang** from the **State Key Laboratory of Space Weather, NSSC, CAS**.

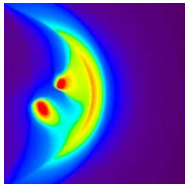
NSSC CAS: China

COLLABORATIONS WITH CHINA

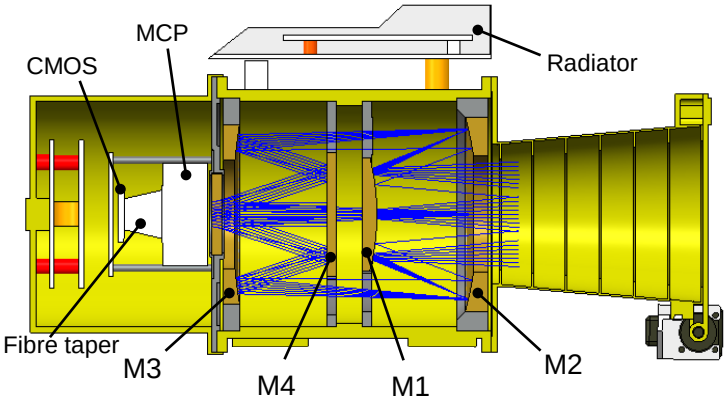
2016-2024

SMILE | UV Imager (UVI)

SPACE IS OUR INSPIRATION



- **Science: Imaging Earth's northern aurora under fully sunlit conditions**
- Wavelengths: 155 – 175 nm fraction of Lyman-Birge-Hopfield N2 band
- Instrument concept
  - Four mirror on-axis telescope, band defining filter coating applied directly onto mirrors (additional filtering through LiF window and detector system)
  - Detector system based on MCP image intensifier and CMOS detector array (1k x 1k pixels)
  - Images binned to 256 x 256 elements
  - FoV: 10° x 10° , offset to SXI: 26°
- Resource requirements:
  - Instrument: 361 x Ø140 mm
  - E-Box: 191 x 101 x 89 mm
  - Mass: 10.5 kg / Power: 32 W
- Pointing: APE, AKE = 0.5°
  Stability 0.05° in 1 min



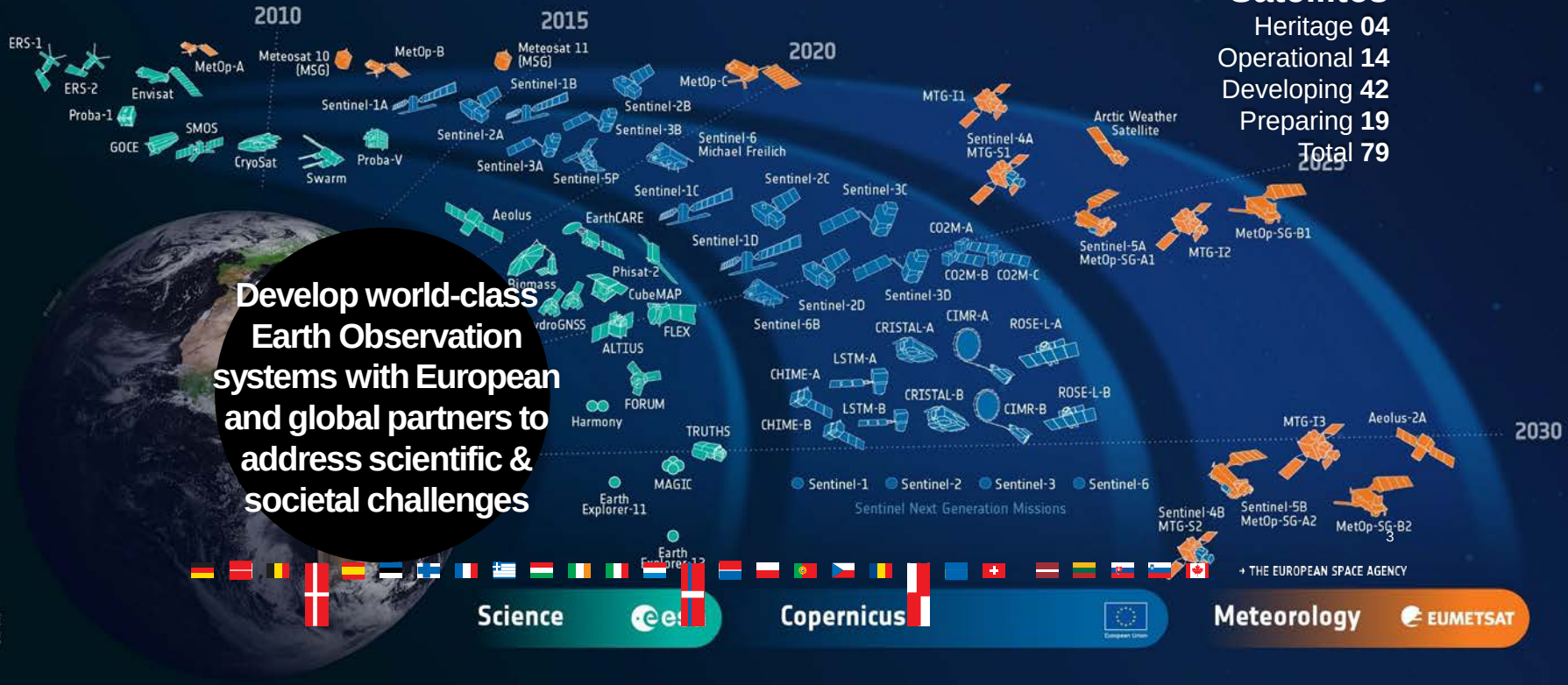
CSL contributions:

- **Full calibration of the Instrument in the UV**
- **Very specific (155 – 175 nm multilayer coating with very high rejection in the visible) development design and manufacturing**

With NSSC

ESA's Earth Observation Mission

Flying to space is a dream
Protecting our habitability on Earth is a need



Develop world-class Earth Observation systems with European and global partners to address scientific & societal challenges

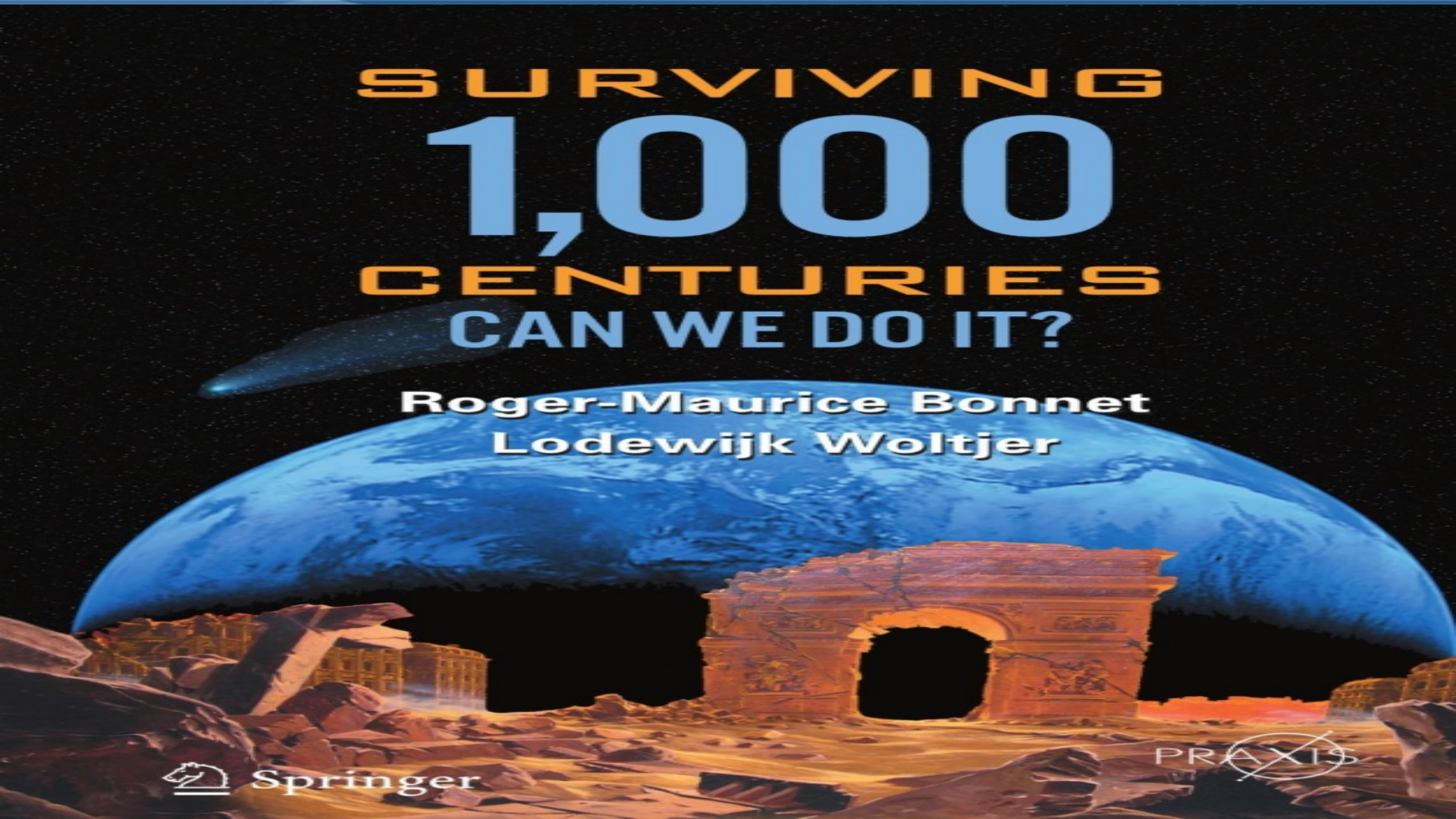
Satellites

Heritage **04**
Operational **14**
Developing **42**
Preparing **19**
Total **79**

SURVIVING 1,000 CENTURIES

CAN WE DO IT?

Roger-Maurice Bonnet
Lodewijk Woltjer



Springer
PRAXIS

Space Activities are changing our perception of the Universe

More than half a century of space activities allows us to consider the next fifty years on much stronger bases than our space pioneers. They had a dream ... we, we live the dream everyday.

Space is always a dream, but today it is a new territory that we are just beginning to explore. Like all explorations, the space adds to our knowledge while providing **new opportunities and new resources but also new responsibilities**.

The research effort nourishes the ***cultural, scientific, technological and economical richness*** .

In addition, access to the spatial dimension has changed our perception of the Universe and our place in it : **we don't consider anymore the man as the master of Earth with infinite resources, but as an individual on board on 'spaceship Earth' fragile and relatively small and UNIQUE habitat sailing into the depths of space**.

EO seems to indicate that Human Activities Contribute to Fast and Dangerous Climate Change more than the Natural Influences?

Space Situation Awareness

Global *environmental* **Change**

Earth Observation

Space Weather (SWE), Near-Earth Objects (NEO): Space Surveillance and Tracking (SST)

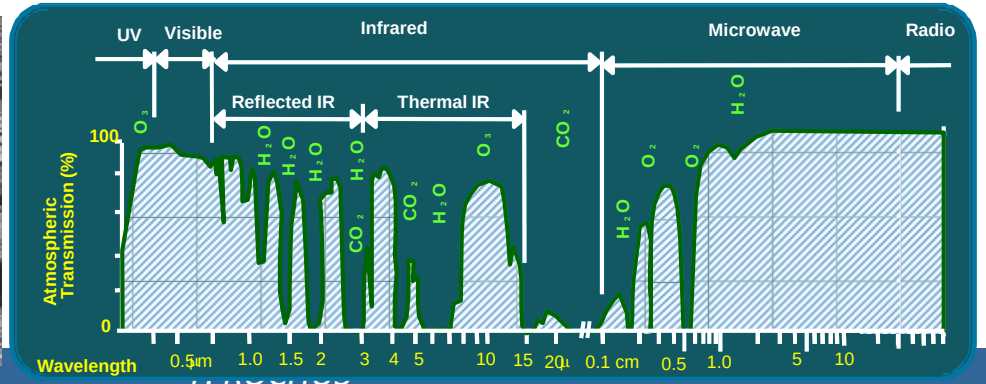
(systemic and cumulative consequences of human activities on the Earth system;
modification of global properties of the Earth systems).

Global Change Understanding needs SPACE

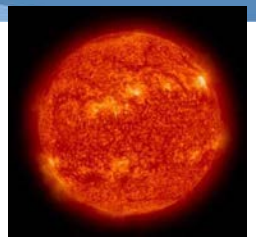
Space is one of the most precious tools we have, to secure our future possibly for 1,000 centuries more, and the fathers of space conquest must be acknowledged as we do now master that tool. *(Tsiolkovsky Goddard Oberth von Braun Korolev)*

What EO Satellites do?

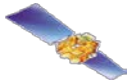
- Characterising Target Signatures with Synoptic coverage across full EM Spectrum
- Spatial domain; Spectral (multi/ hyper); Repeated observations with calibrated instruments; Quantitative measurements, Polarisation
- Global to local applications



Role of Earth Observation (EO) Satellites in Preserving the Planet

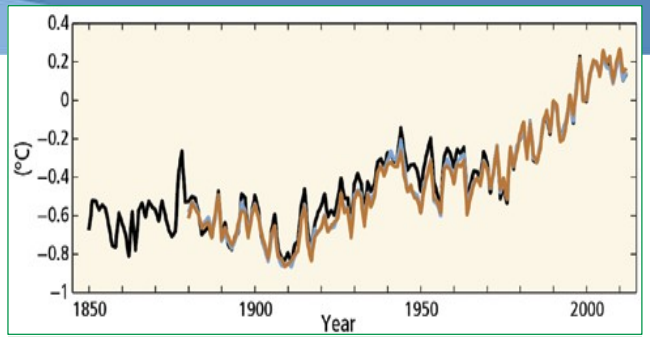


Earth

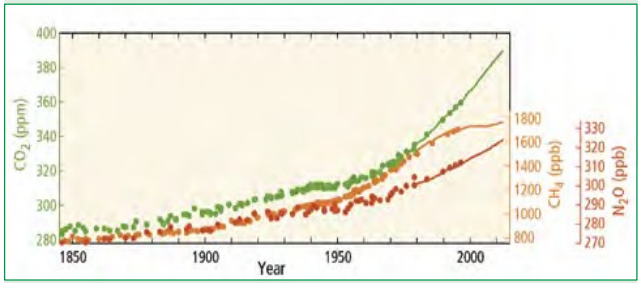


*EO Satellites contribute to more than half of the **50 Essential Climate Variables (ECVs)** identified for the UNFCCC by the Global Climate Observing System (GCOS) and provide unique measurements that would not otherwise be possible.*

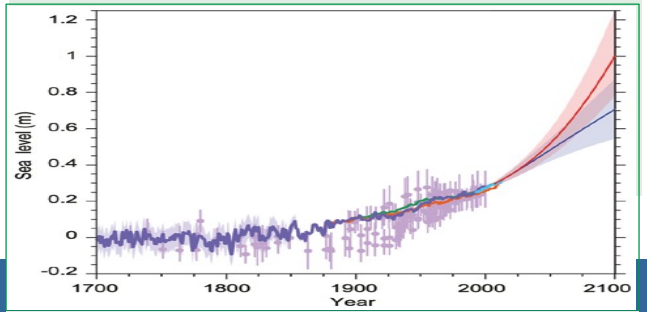
Essential Climate Variables (ECVs)



Annually and globally averaged combined land and ocean **surface temperature anomalies** relative to the average over the period 1986–2005. Colours indicate different data sets



Atmospheric concentrations of the greenhouse gases carbon dioxide (CO2, green), methane (CH4, orange) and nitrous oxide (N2O, red) determined from ice core data (dots) and from direct atmospheric measurements (lines)



Past and **future sea-level rise**. For the past, proxy data are shown in light purple and tide gauge data in blue. For the future, the IPCC projections for very high emissions (red, RCP8.5 scenario) and very low emissions (blue, RCP2.6 scenario) are shown.

THANK YOU FOR YOUR ATTENTION

remote sensing

IMPACT FACTOR 5.0

CITESCORE 7.9

an Open Access Journal by MDPI

Optical Remote Sensing Payloads, from Design to Flight Test

Guest Editors

Dr. Xing Zhong, Prof. Pierre Rochus, Prof. Dr. Fei Xing, Prof. Dr. Xiuqing Hu

Deadline

15 September 2024

Special Issue