Sustainability on Earth and in near-Space

Claude Nicollier
Space Innovation/EPFL

Uraniae200 – AIUB100
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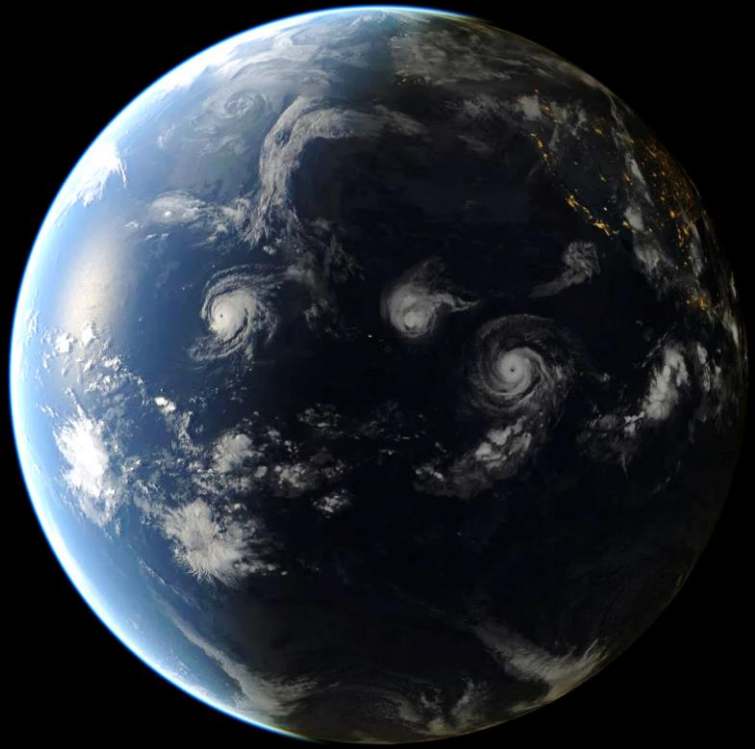
This contribution will be an astronaut’s view on the subject

I will present personal views and opinions, partly driven on work done and data collected by others



Our responsibility, now and forever!

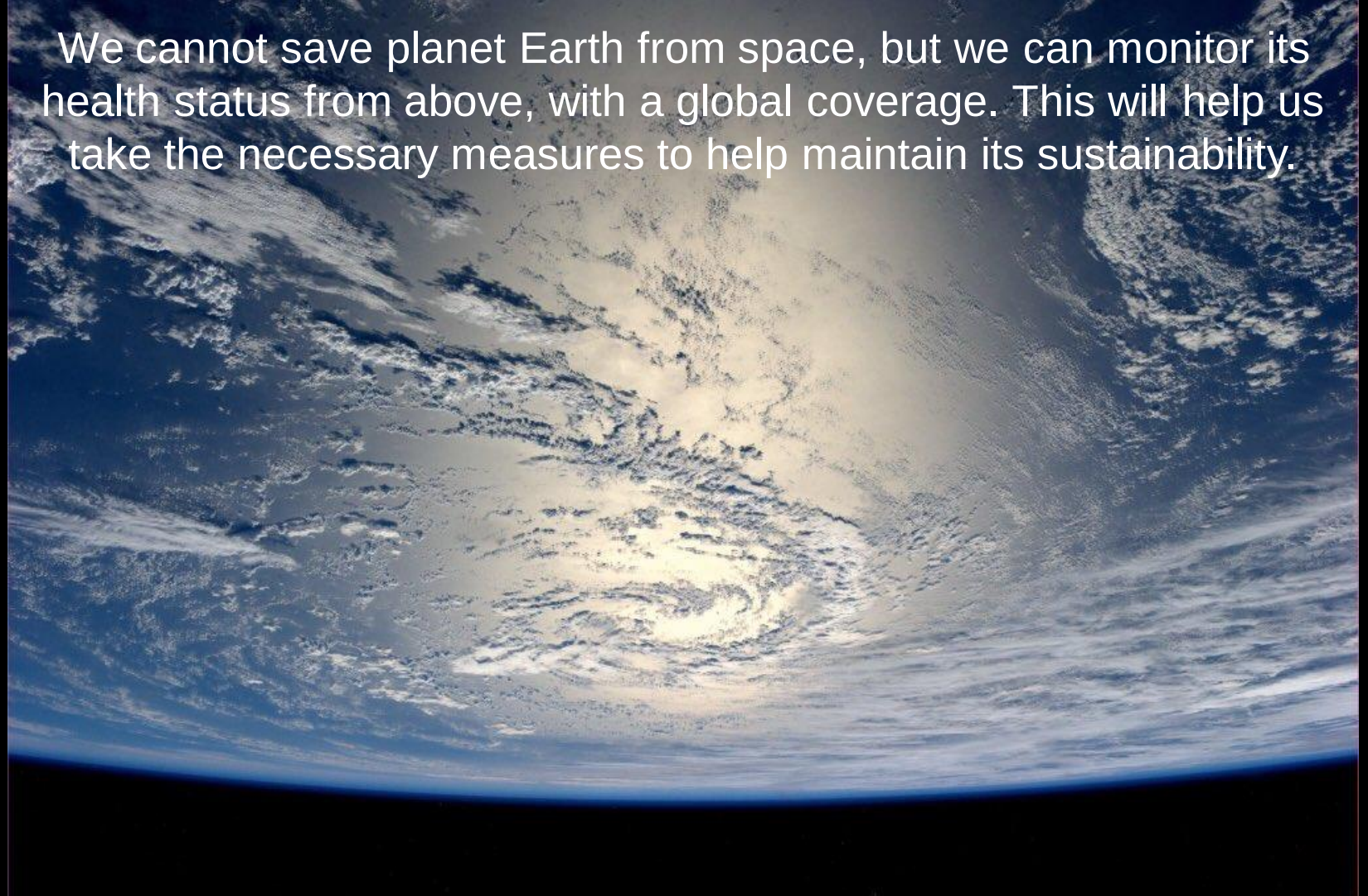
Sustainability = establishment of steady state conditions for Earth and Space environments

Sustainability on Earth (observable from space)

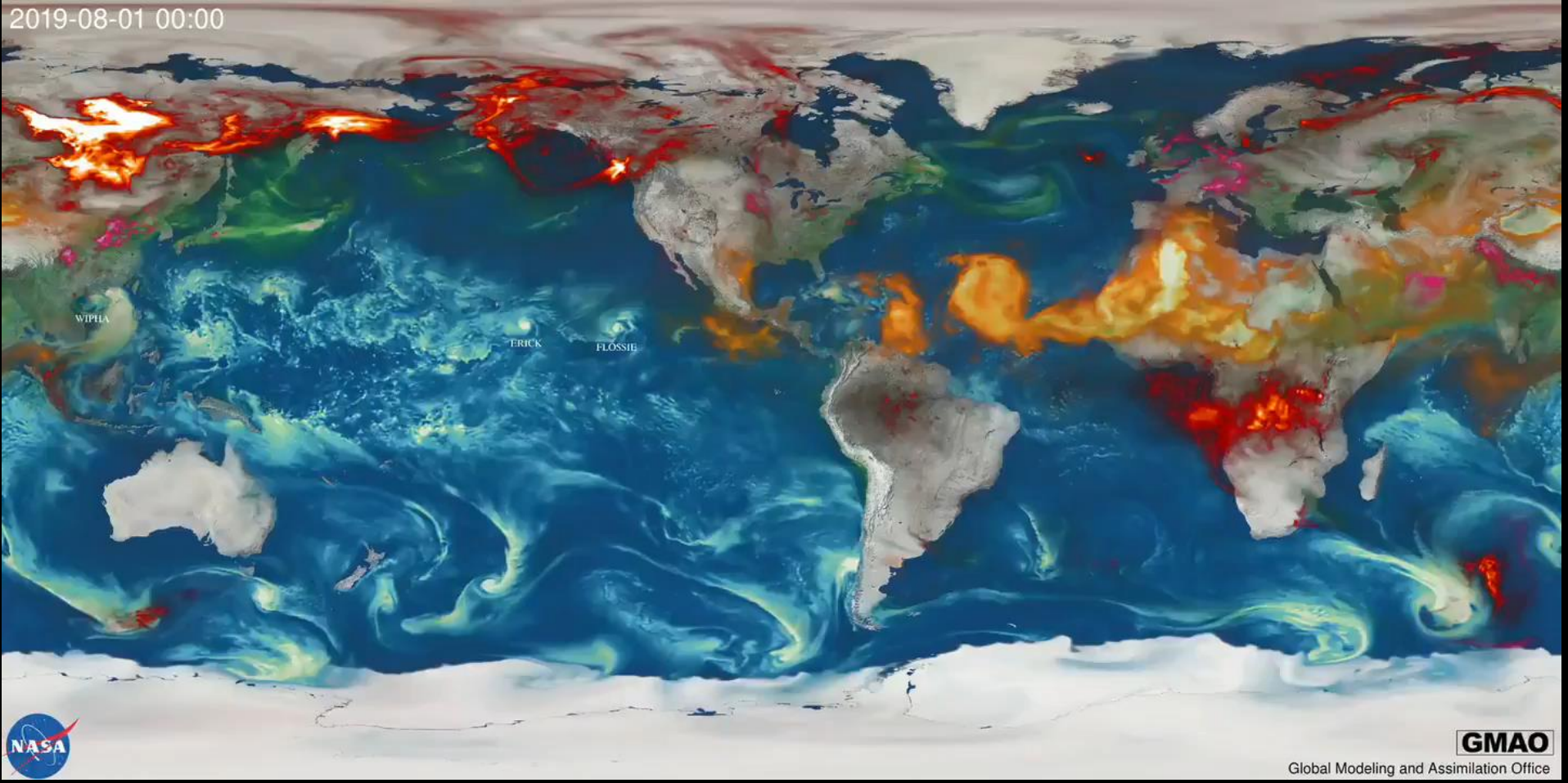
- Protect lives and infrastructures, monitor water levels
- Preserve Earth physical condition and resources. Recycle
- Monitor atmosphere composition and temperature distribution, and aim at a neutral CO_2 balance

Sustainability in space

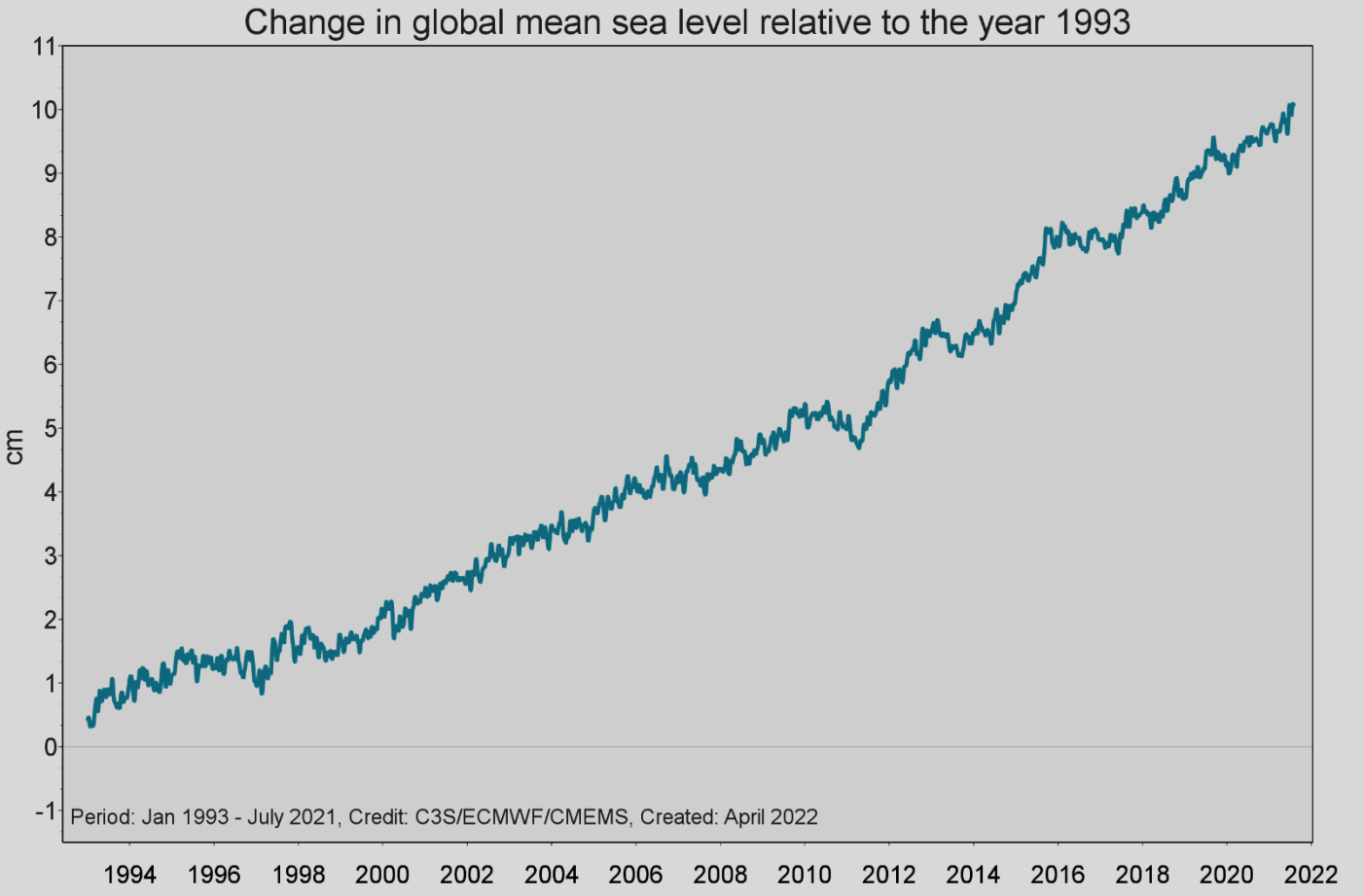
- Keep space clean by removing large debris and avoid collisions
- Manage space traffic
- Monitor the Sun and take appropriate measures to minimize damage to life and equipment when solar storms occur, whenever possible
- Detect and keep track of dangerous asteroids. Develop orbit deflection techniques


We cannot save planet Earth from space, but we can monitor its health status from above, with a global coverage. This will help us take the necessary measures to help maintain its sustainability.


Monitor water pollution



… and air pollution and the dynamics of the atmosphere



Copernicus Climate Change Service
Climate Indicators

PROGRAMME OF
THE EUROPEAN UNION

opernicus
Europe's eyes on Earth

IMPLEMENTED BY
ECMWF

Environmental impact of a rocket launch

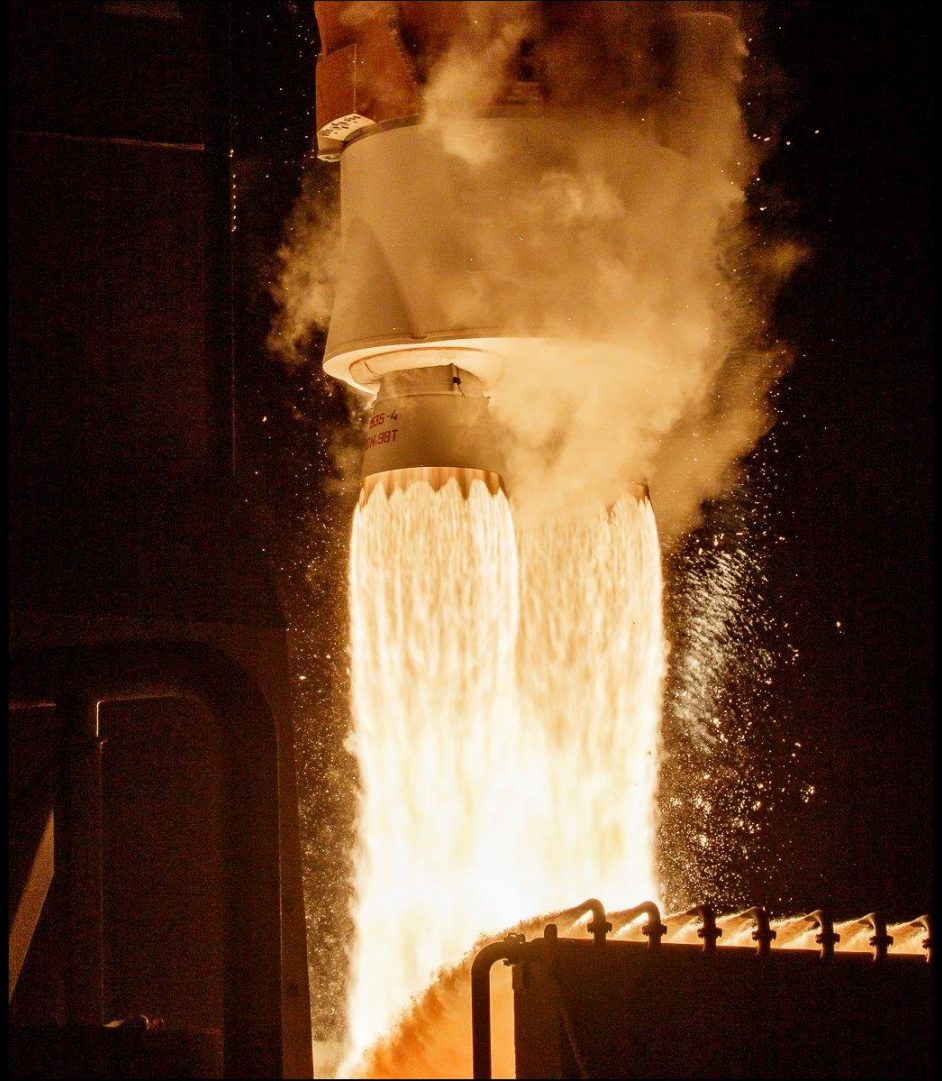
Lift-off is usually the most environmentally harmful stage of any space mission, with vast quantities of fuel burnt up in a matter of minutes. For instance, SpaceX’s Falcon 9 gets through 112 tonnes of refined kerosene, emitting about 336 tonnes of CO2

One greener option is liquid hydrogen and oxygen. Hydrogen can be obtained sustainably by using solar power for water electrolysis


Soyuz

Long March/Shenzhou

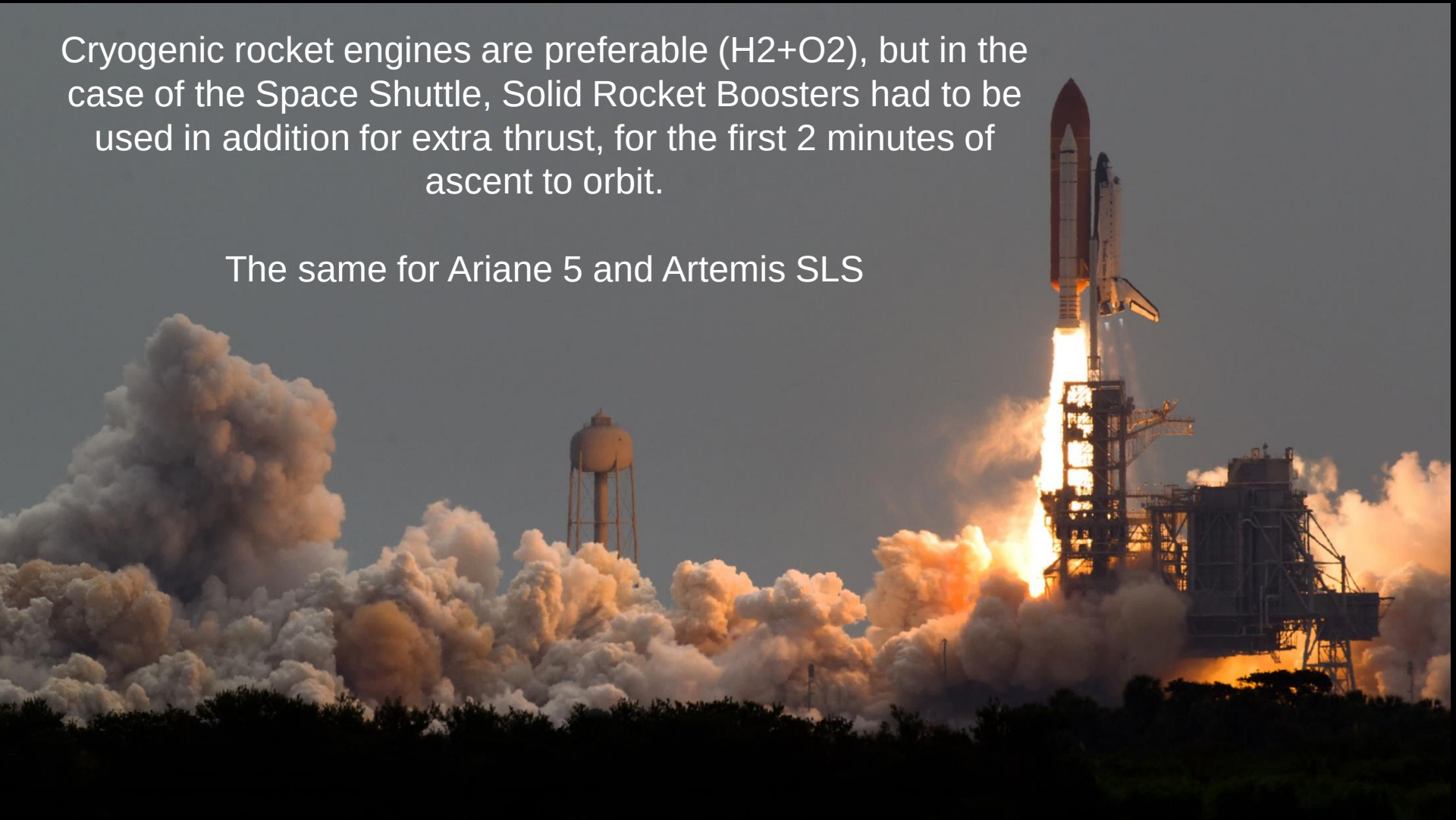
Atlas V

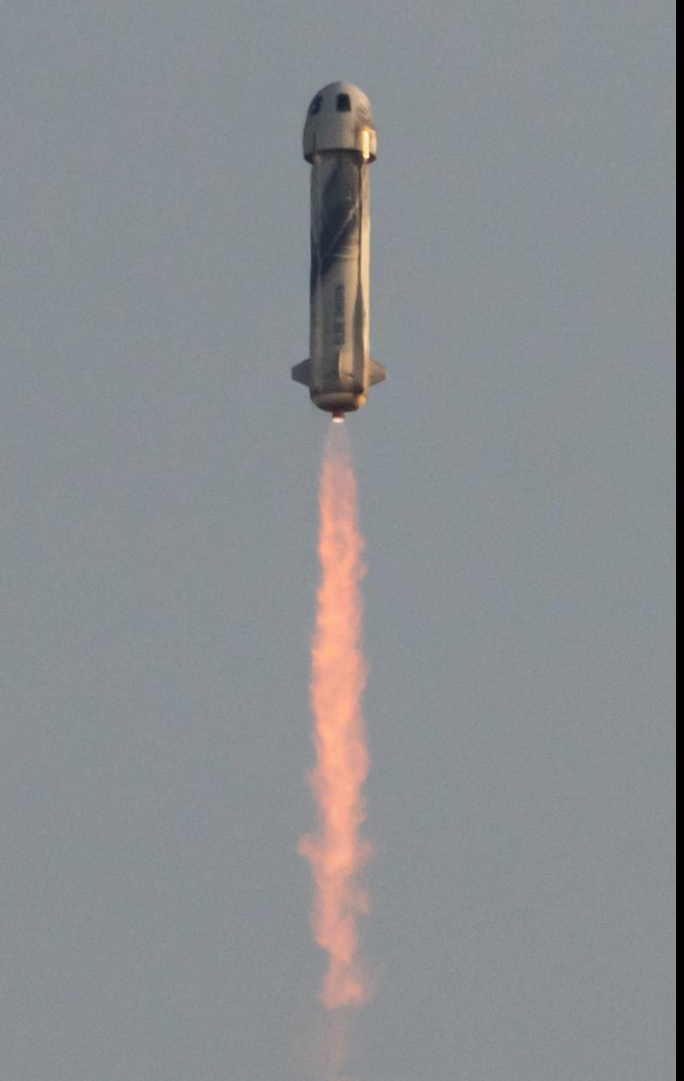



SpaceX Starship
@IzanRamos2002

Cryogenic rocket engines are preferable (H_2+O_2), but in the case of the Space Shuttle, Solid Rocket Boosters had to be used in addition for extra thrust, for the first 2 minutes of ascent to orbit.

The same for Ariane 5 and Artemis SLS





Blue Origin’s New Shepard (suborbital) with one BE-3 cryogenic rocket engine,

No CO_2 emission!

But also, to keep space activities sustainable, we need to operate re-usable rockets, or at least partly reusable (SpaceX does this with Falcon 9)

Falcon 9 first stage recovery on a barge in the Atlantic Ocean

The full SpaceX Starship rocket will be entirely reusable

Test of Starship second stage recovery, Boca Chica, Texas, 2021

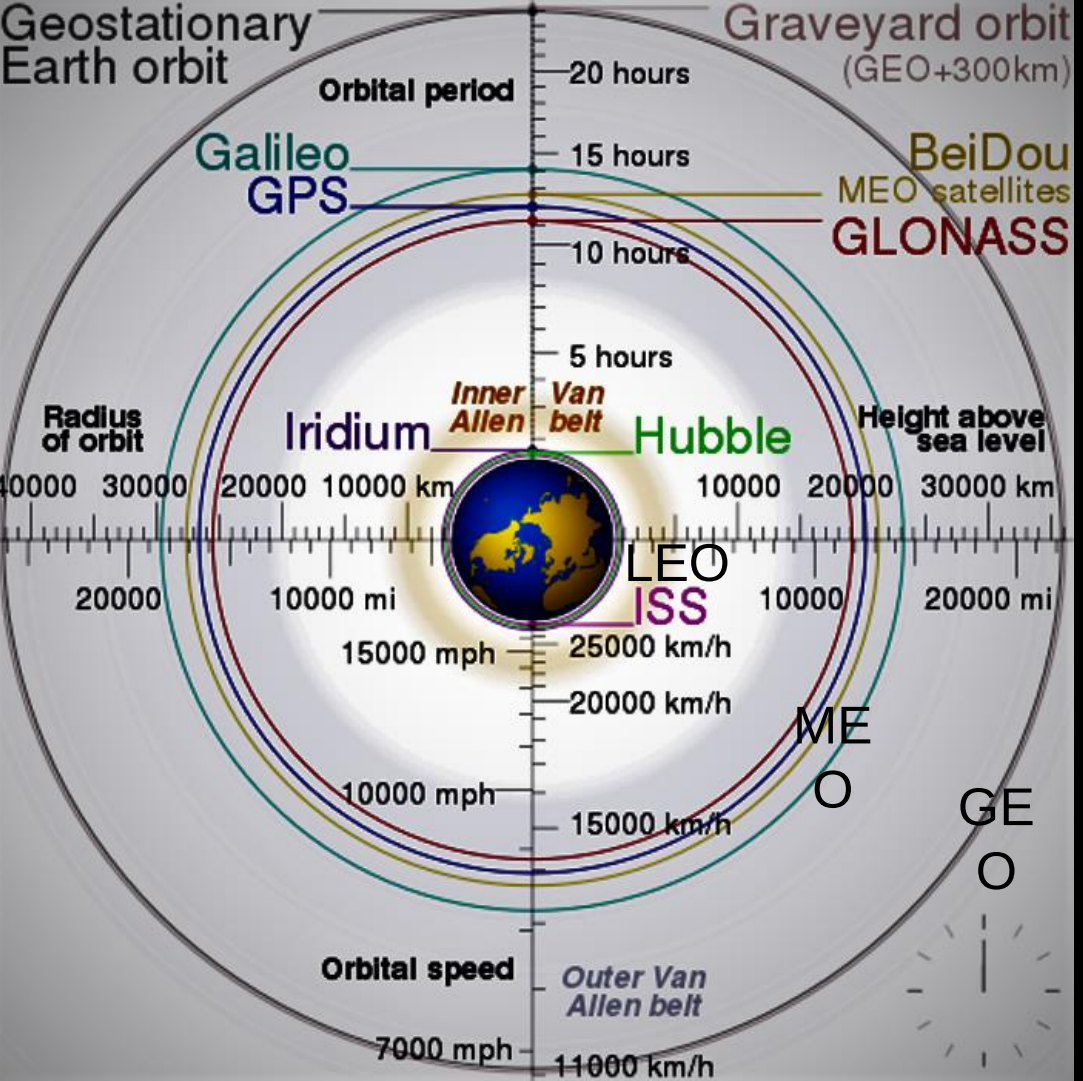
When you are in Low Earth Orbit (LEO), space looks really clean and empty

… but we know that space is not so clean and empty!

Working satellites and debris

A not working satellite is considered a debris (either failed, or end of life)

In LEO, there are many more debris than satellites! (about 7,500 satellites and >20,000 debris more than 10 cm in size)



The mostly used orbits

LEO (<2000 km)

Space Stations
Earth Observation
Communication (Hi speed internet)

MEO

Navigation

GEO

Earth Observation
Communication (TV, Relay)
Weather

Satellites constellations

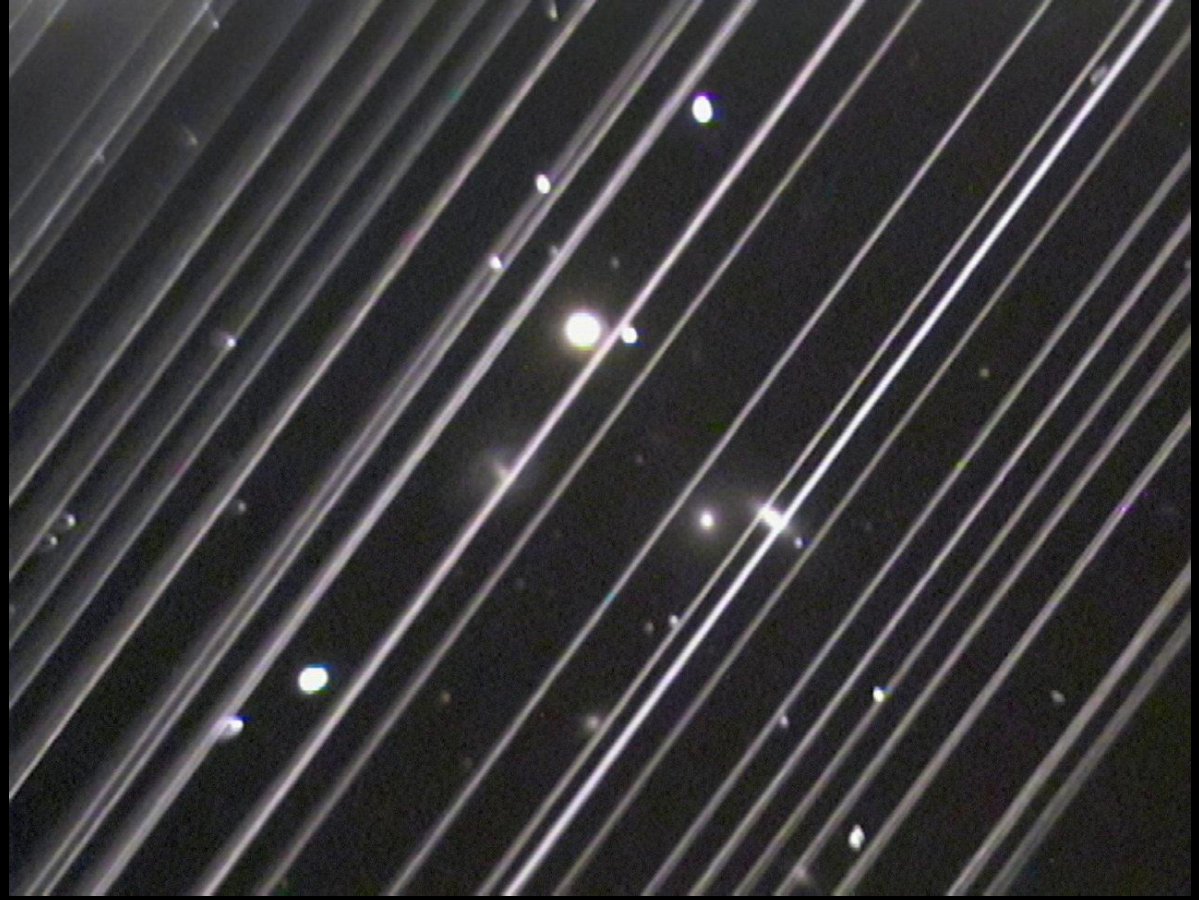
In addition, there is a rapidly increasing number of satellites in LEO constellations

Starlink at 550 km altitude currently 2500, expected 30’000 in the future

OneWeb at 1200 km
Currently 500 and rising

Many more constellations planned in many nations

Deployment of Starlink communication satellites from Falcon 9 upper stage



A lot of very unhappy astronomers, and the public too!

The situation in LEO is not good with high a risk of collisions of debris to debris, or debris to working satellites, with every collision creating more debris!

What to do?

Do nothing

Debris in LEO will eventually fall down, but it may take decades for 600 km, and will take centuries for 1000 km altitude. In the meanwhile, active satellites and debris densities will increase and lead to more collisions with a clear risk of a cascading effect - This is not acceptable.

strictly enforce lifetime limitation of satellites

There are such guidelines published by the IADC (Inter-Agency Space Debris Coordination Committee), but we need strict rules instead of just guidelines, and the current guideline of 25 years lifetime limitation after a satellite becomes inoperative is too long - Reduction of this time to just a few years will be a good measure but probably not sufficient in the long term.

Deorbit rocket upper stages at every launch, and Active Debris Removal or ADR

A targeted removal of large debris (mainly rocket upper stages) is a good way to reduce the risk of a cascading effect. It is estimated that the rate of such debris removal in LEO should be between 5 and 10 large debris per year to be effective - This is a good short term strategy to reduce the collision risk.

A proper handling of the debris risk will also protect the lives of crewmembers onboard ISS

…and onboard any private Space Station in the future

…including during spacewalks

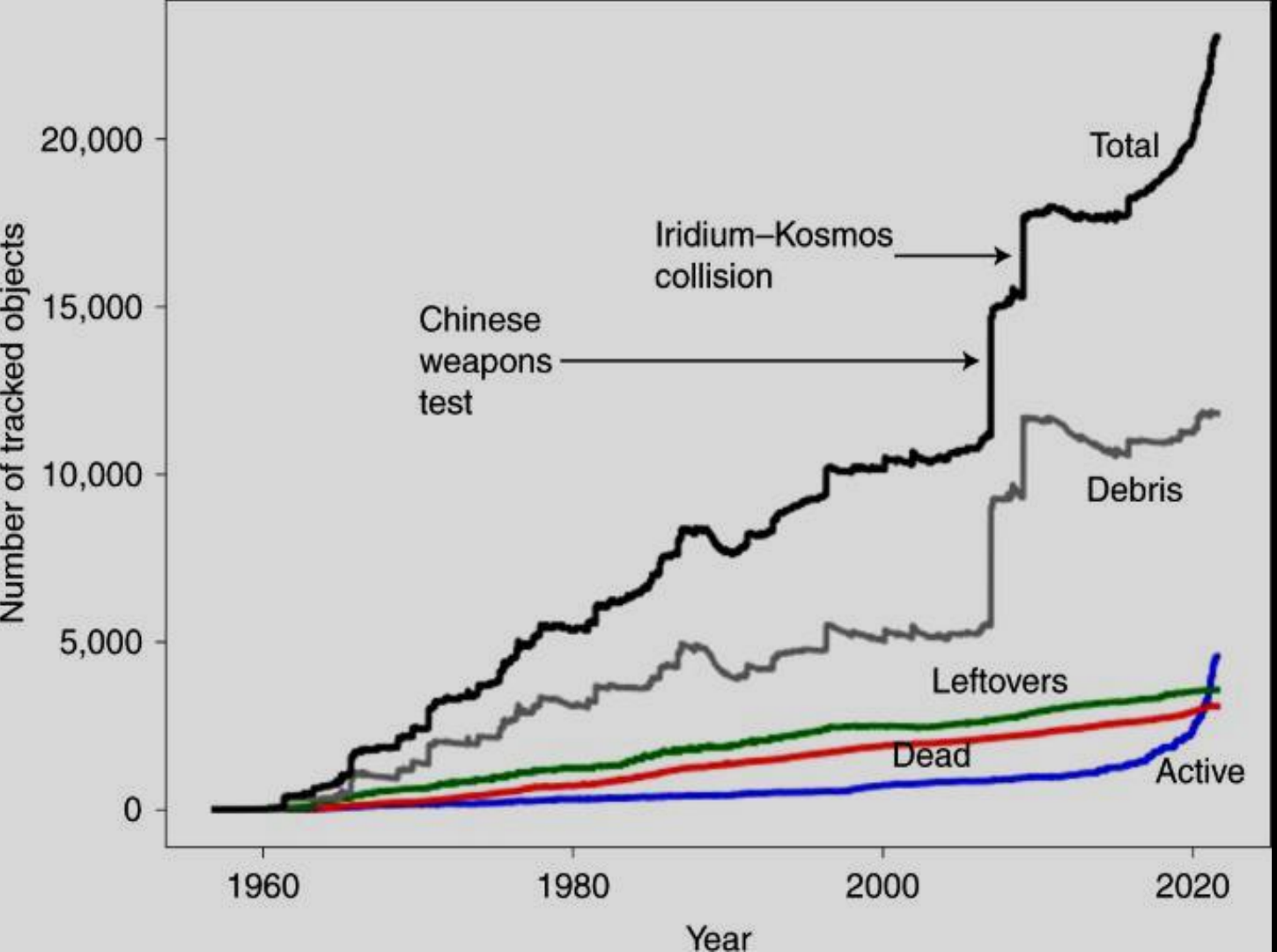
… and during crew transfers to space, or back to Earth

An interesting recent article on the subject of space sustainability:

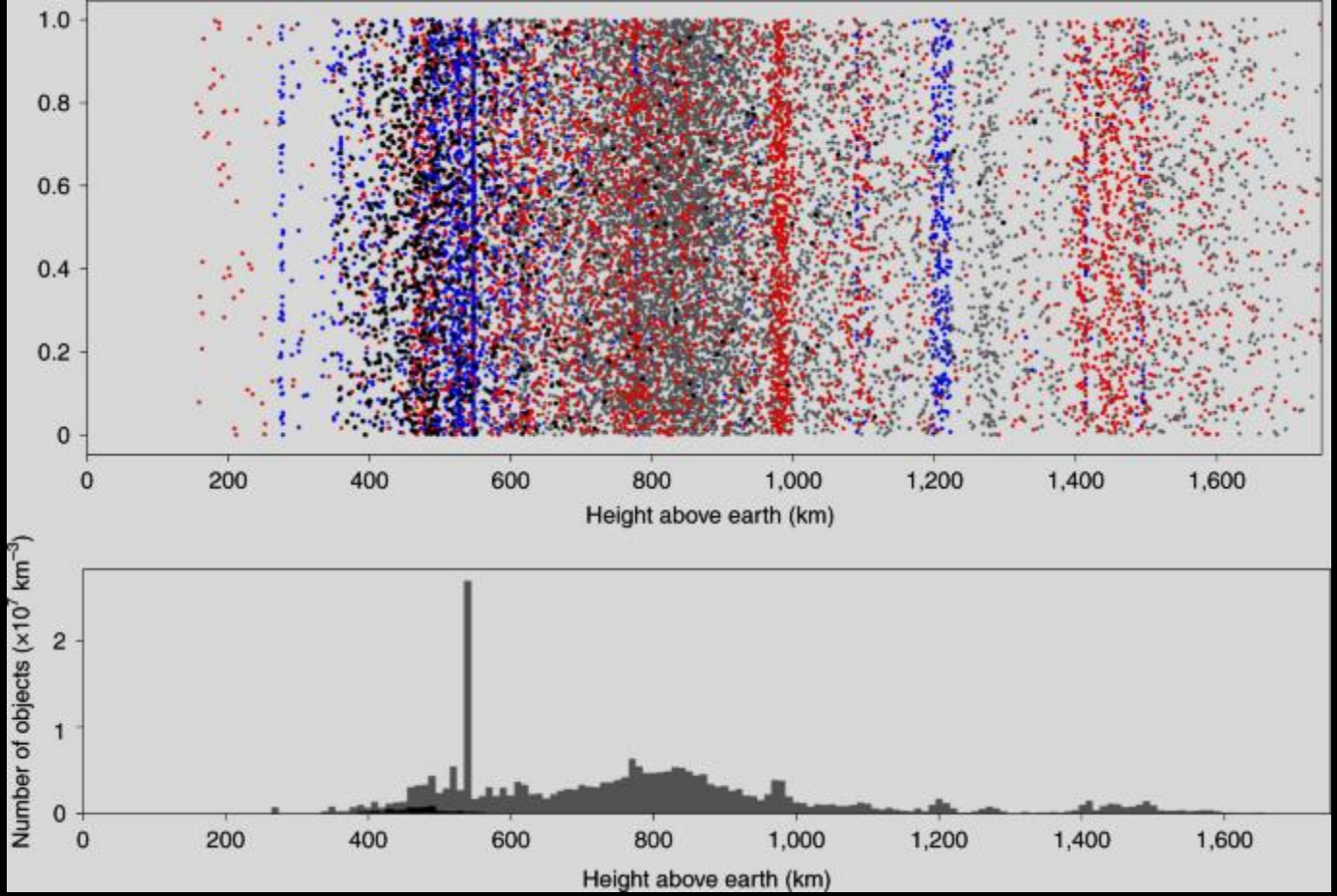
The case for space environmentalism,

by various authors including Moriba Jah, university of Texas at Austin

Nature Astronomy **volume 6**, pages 428–435 (2022)



From this publication, a recent update on the raising number of tracked "Anthropogenic Space Objects" (ASOs) vs. time

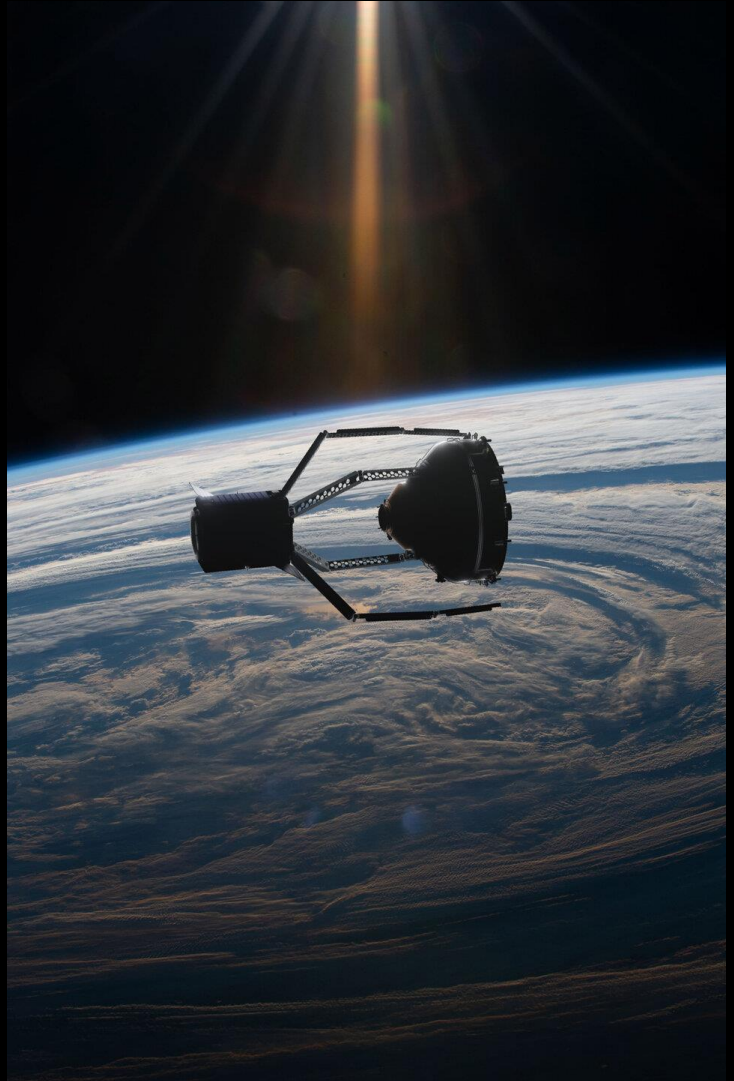


… with data about the height distribution of ASOs

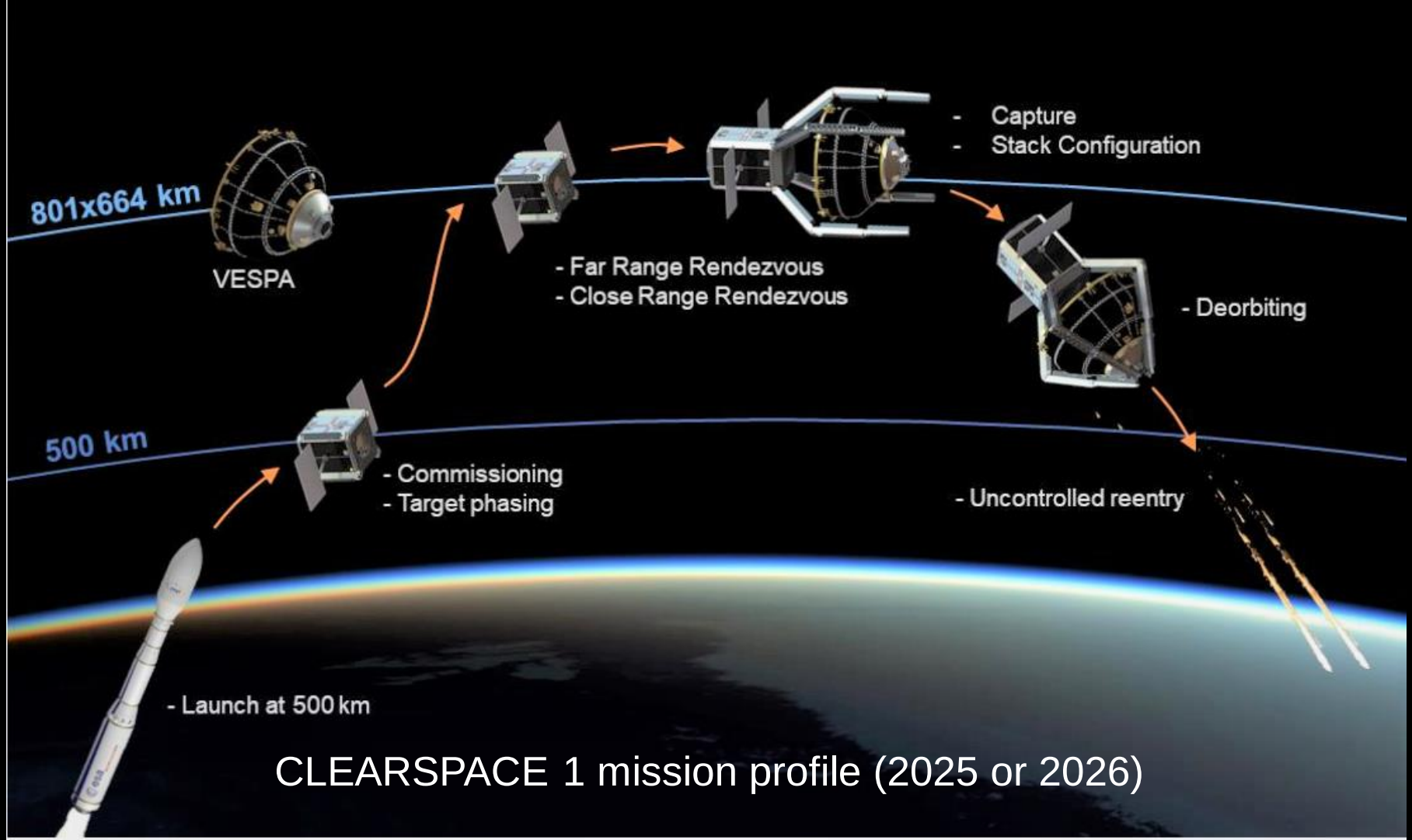
Recent news!

WAILEA, Hawaii - The U.S. Federal Communications Commission adopted a new rule Sept. 29 that will shorten the time for satellite operators to deorbit low Earth orbit satellites from 25 to 5 years. The purpose is to address growing debris in LEO.

Under the new rule, spacecraft that end their lives in orbits at altitudes of 2,000 kilometers or below will have to deorbit as soon as practicable and no more than five years after the end of their mission



CLEARSPACE 1 or ADRIOS mission – Removal of a large high flying space debris (Vega upper stage above 600 km) in 2025



CLEARSPACE 1 mission profile (2025 or 2026)

Safe and regular access to space is not one of the 17 sustainable development goals of the UN, and it should be!

A potential hazard for life on Earth is the impact of an asteroid (typically a NEO or Near Earth Object) on our planet, and this is a sustainability issue!

1 km large asteroid = Planet Killer

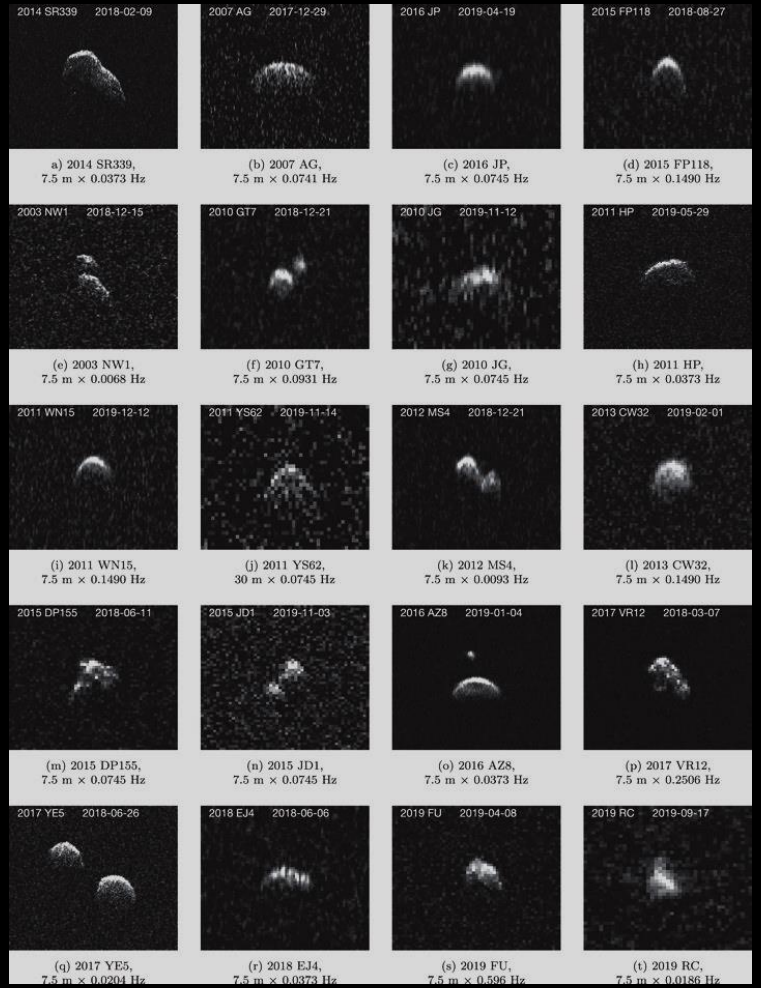
Many Space Agencies are setting up detection capabilities to get an advance warning of a potential impact, with the possibility of a controlled deflection for collision avoidance, if time is available!

News in Space.com Octobe31,2022: Asteroids in the inner system (inside Earth orbit) are notoriously hard to detect because of the glare of the Sun. Astronomers have detected a giant asteroid hiding in the glare of the sun that might one day cross paths with Earth

The 0.9-mile-wide (1.5 kilometers) asteroid is the largest potentially hazardous asteroid spotted in the past eight years and astronomers have dubbed it a «Planet Killer" because the effects of its impact would be felt across multiple continents.


Chasing debris and
NEOs from
AIUB Zimmerwald
observatory

FlyEye telescopes (ESA)
with wide FOV
(44 square degrees)
Now in Chile and Spain,
for NEO detection

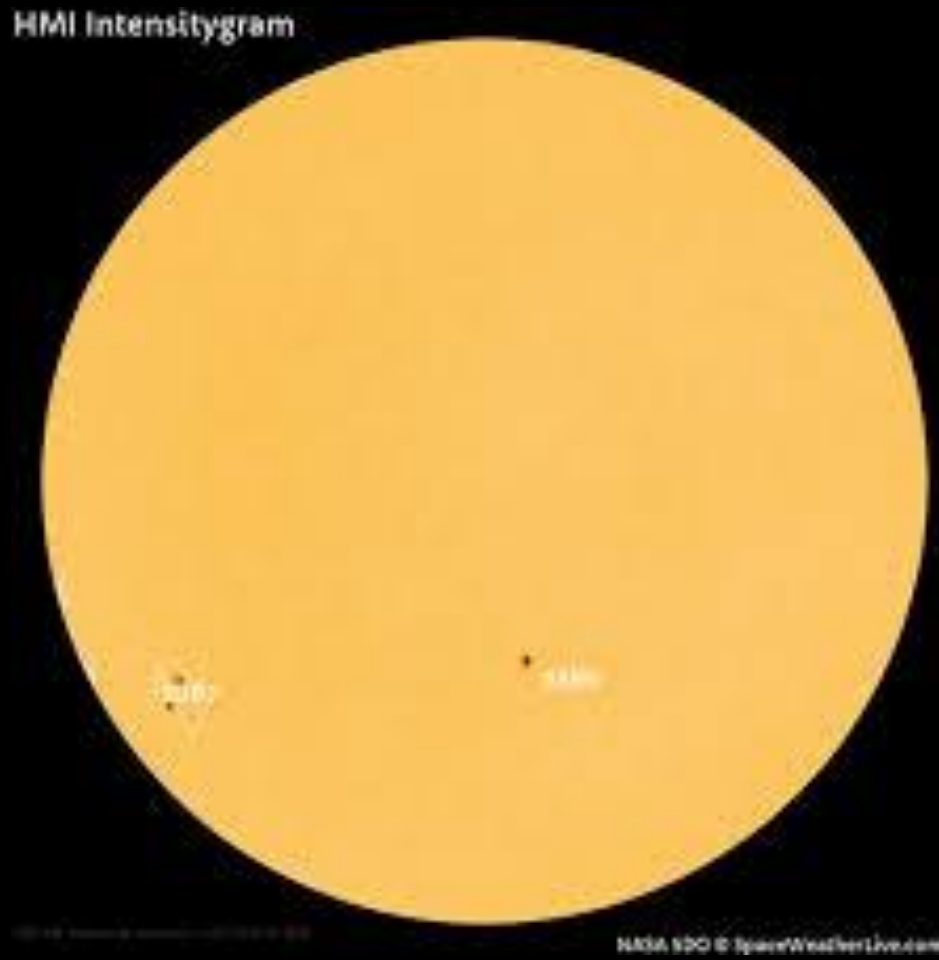


a) 2014 SR339, 7.5 m × 0.0373 Hz
(b) 2007 AG, 7.5 m × 0.0741 Hz
(c) 2016 JP, 7.5 m × 0.0745 Hz
(d) 2015 FP118, 7.5 m × 0.1490 Hz
(e) 2003 NW1, 7.5 m × 0.0068 Hz
(f) 2010 GT7, 7.5 m × 0.0931 Hz
(g) 2010 JG, 7.5 m × 0.0745 Hz
(h) 2011 HP, 7.5 m × 0.0373 Hz
(i) 2011 WN15, 7.5 m × 0.1490 Hz
(j) 2011 YS62, 30 m × 0.0745 Hz
(k) 2012 MS4, 7.5 m × 0.0093 Hz
(l) 2013 CW32, 7.5 m × 0.1490 Hz
(m) 2015 DP155, 7.5 m × 0.0745 Hz
(n) 2015 JD1, 7.5 m × 0.0745 Hz
(o) 2016 AZ8, 7.5 m × 0.0373 Hz
(p) 2017 VR12, 7.5 m × 0.2506 Hz
(q) 2017 YE5, 7.5 m × 0.0204 Hz
(r) 2018 EJ4, 7.5 m × 0.0373 Hz
(s) 2019 FU, 7.5 m × 0.596 Hz
(t) 2019 RC, 7.5 m × 0.0186 Hz

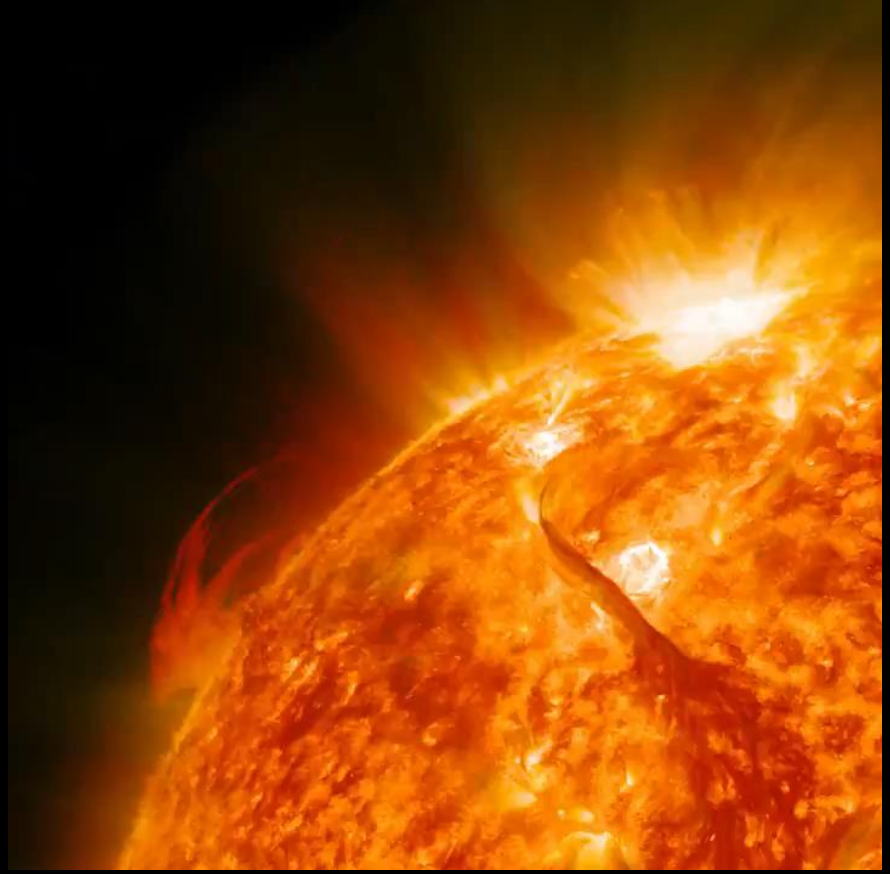
NEOs observed by the defunct Arecibo telescope

Double Asteroid Redirection Test (DART) mission – A test of our ability to deviate a potentially threatening asteroid

Dimorphos' orbit around Didimos previously lasted 11 hours and 55 minutes; in the wake of the impact, that period has decreased by 32 minutes. And because rubble flying off Dimorphos would have contributed to the orbital change, the large decrease indicates how much debris DART created.

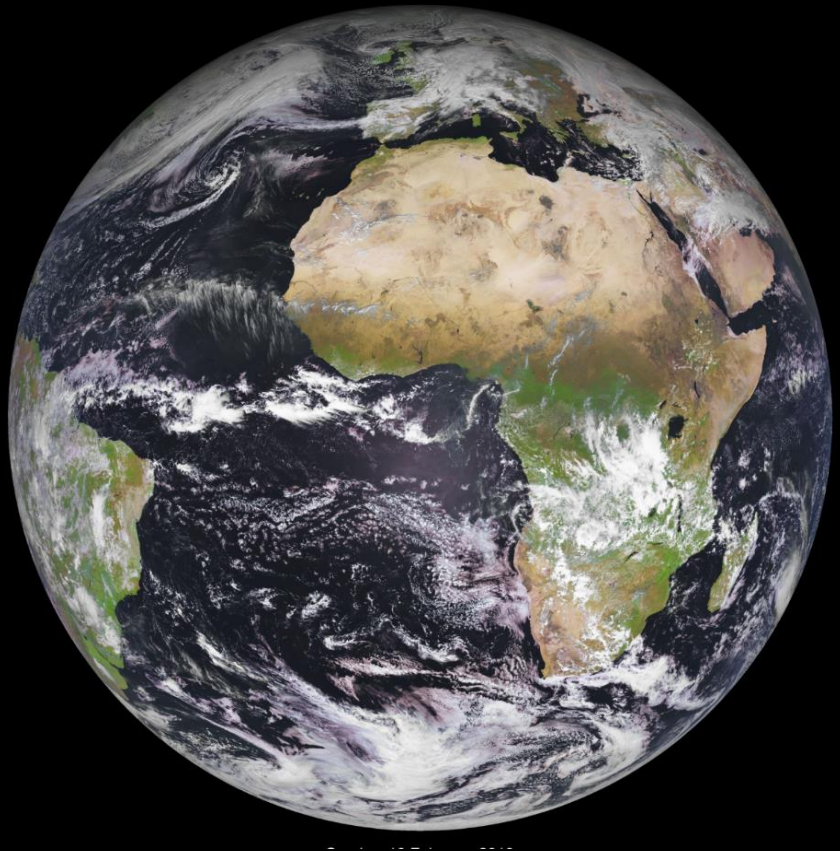


The Sun is most of the time a rather quiet star with a few sunspots, and a mild activity cycle of about 11 years duration



But sometimes, through Coronal Mass Ejections or CMEs, the active Sun becomes a definite hazard to space systems, pover grids, and life on Earth!

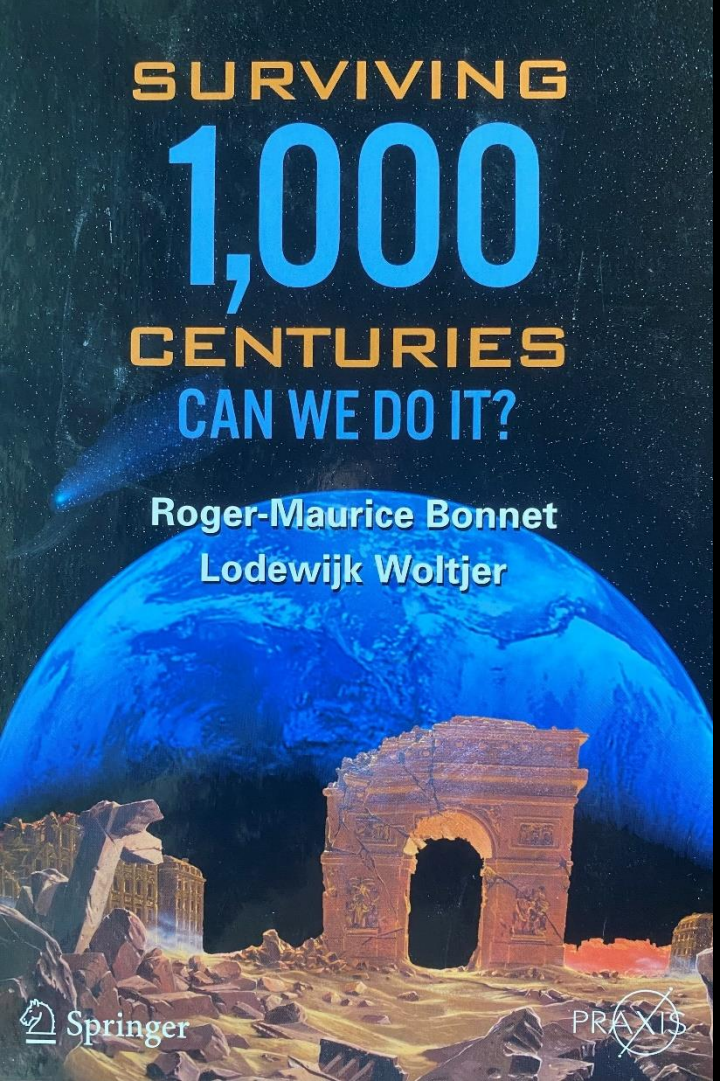
Not much we can do about this, except hardening, as much as possible, potentially affected systems on Earth and in space, as a preventive measure



Taking care of planet Earth, and of nearby space, is a responsibility we take very seriously

On the occasion of this celebration of Uraniae200 and AIUB100, we express our gratitude to the University of Bern for its contribution to this effort!


Thank you for your attention!



← This book was published in 2008

Must read!