



Earth ILLumination Foundations for Citizen Science

Amara Graps, Baltics in Space



What is ELLF?

Funding Call Horizon 2020 Pillar:
Science with and for Society. Frugal
Innovation and Citizen Science

Submitted: 23 April 2020.

Contribution: 2.2 M€

Climate Citizen Science

featuring :

Noctilucent Clouds and **EarthShine**

Budget: 2.2 M€ Funding split between:

57% Tools, Engineering Education, Operations:

Multispectral Imager on 3U CubeSat Platform @ 550 km polar orbit

26% Climate Science Education, Community Engagement

17% Project Management

Project Duration: 3 years. Start date would be June 2021.



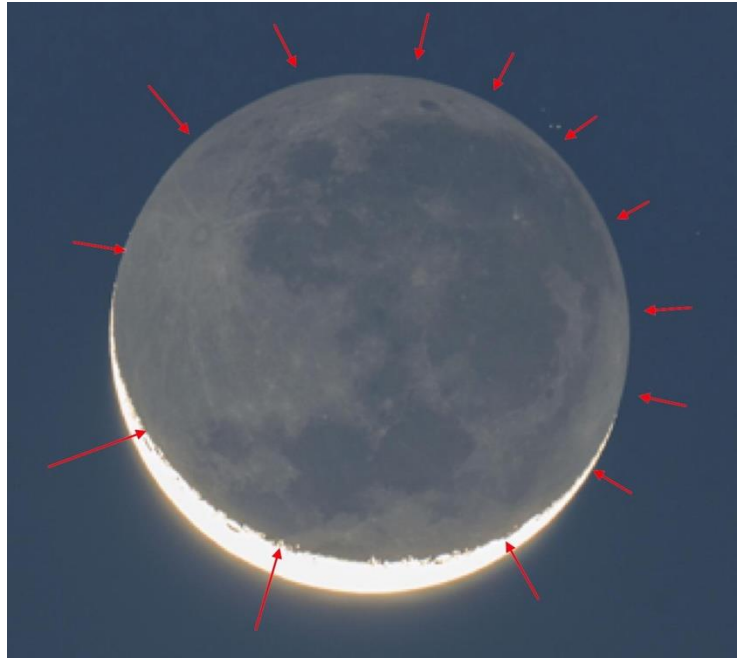
Eleven Partners, Six countries

Finnish Meteorological Institute (FI)
Baltics in Space (LV)
Kaunas University of Technology (LT)
VTT Technical Research Centre of Finland (FI)
Ventspils International Radio Astronomical Center (LV) w/LU sub.
AHHAA Science Center (EE)
Zinoo Centrs (LV)
Lithuanian Museum of Ethnocosmology (LT)
Ursa Astronomical Association (FI)
Unfunded International Formal and Informal Partners:
National Space Innovation Hub (Australia)
Space Science Institute (USA) with NASA/GLOBE (USA)

Earthshine photo by Siti Sarah Nordin. Telok Kemang Observatory, Port Dickson, Malaysia.
7 February 2019, 8:04 pm. MYT.



Earthshine + Smartphone App



Online, Citizen Climate Science Campaigns: **EarthShine**

Gather Earth's Albedo by the thousands
Citizen Science Albedo Education



<https://www.instructables.com/id/The-10min-iPhone-or-smart-phone-tripod-mount-for/>

18 Monthly New Moons. 2 Total Solar Eclipses: Apr 20, 2023 (AU) Apr 8, 2024 (USA)



High Latitude Cloud Observations from Space and from the Ground



Noctilucent clouds (NLC) – the morning of July 14, 2016 – by [Jüri Voit Photography](#) in Estonia (58 degrees north latitude).

Online, Citizen Climate Science Campaign: [Noctilucent Clouds](#) : sensitive climate change indicators.

From Space and from the Ground:

Space: With Earth Observing temperature and moisture data from ELLF's own multispectral imaging camera.

Ground: With citizen scientists plus local data from regional meteorological organizations



Building regional knowledge about measuring Earth's brightness from Space.

Photo by Amara Graps



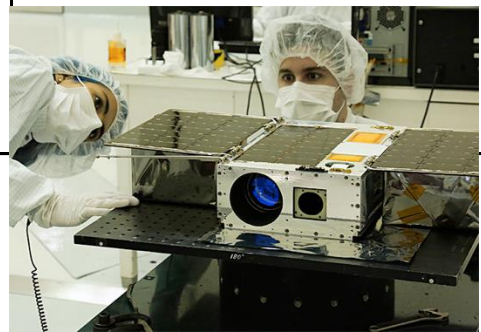
- ELLF as Early Customer of VIRAC 16-m CubeSat Ground Station.

For other CubeSats:

- ELLF prism to test ILRS tracking.
- ELLF Mission Control software.

Blog Post Topic	Video Topic
<ul style="list-style-type: none"> • Prototype, design modifications, parts procurement • VTT Camera: Description, what it will provide for NLC observations, instrument description • CubeSat Review process • Reflectors: Description, what it will provide for satellite tracking • Proflight, design modifications • VTT Cameras: Protoflight for instrument description • what is functional testing • what is vibration testing • what is pressure and thermal vac testing • ELLF readiness • Launch description, satellite integration • satellite tests • Mission operations • Data Downlink • Image Data processing 	<ul style="list-style-type: none"> • interview with KTU (engineer, etc.) of Prototype, design modifications, parts procurement • KTU and/or VTT about the camera • RIGL international laser ranging tracking about the prisms • interview with KTU of ELLF status (engineer, etc.) : Protoflight • CubeSat Review process • interview with KTU engineers (and LV interns): functional, vibration, pressure and thermal vac testing • ELLF readiness • launch site, engineers, satellite and launch!

ELLF as Space engineering education for the region's young. Available Internships.



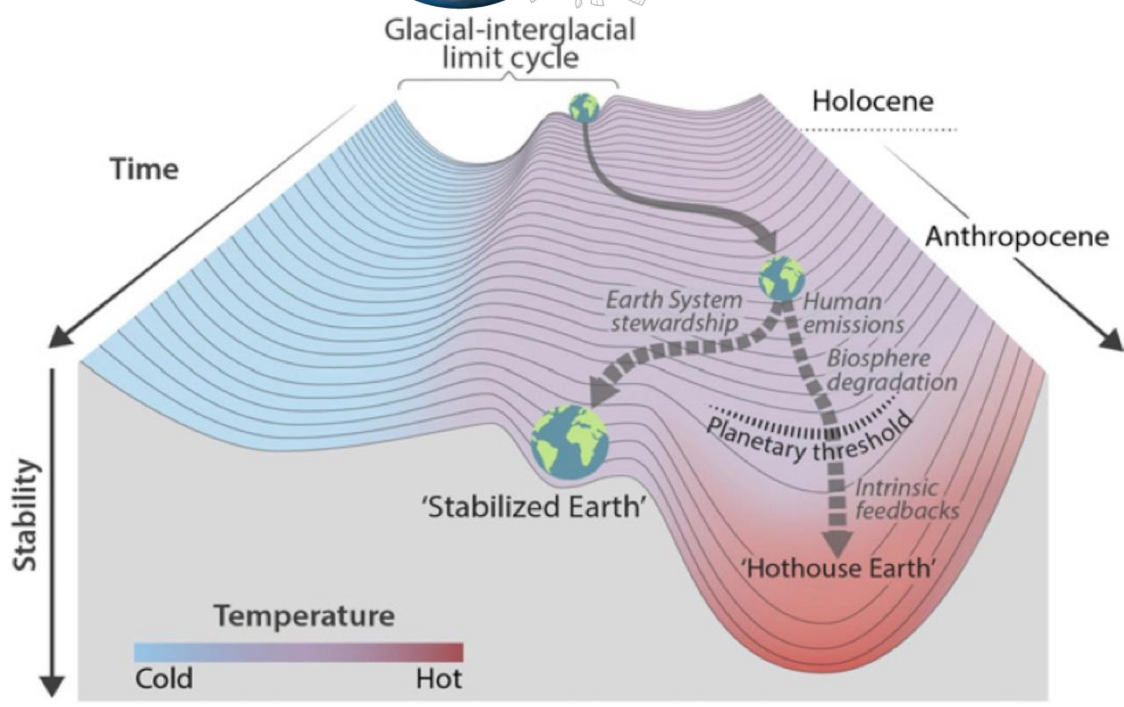
<https://space.stackexchange.com/questions/26541/what-are-the-absolute-maximum-dimensions-of-a-proper-6u-cubesat-does-asteria-co>



Citizen Science meets Climate Science --1

How close is the Earth's climate system to a Tipping Point?

In a *Science-a-Thon* we input our ELLF smartphone albedo and CubeSat Imager vertical temperatures together to experts and explore the Tipping Point.



Stability landscape showing the pathway of the Earth System out of the Holocene and thus, out of the glacial-interglacial limit cycle to its present position in the hotter Anthropocene. The fork in the road is shown here as the two divergent pathways of the Earth System in the future (broken arrows). Currently, the Earth System is on a Hothouse Earth pathway driven by human emissions of greenhouse gases and biosphere degradation toward a planetary threshold at ~2 ° C (horizontal broken line at 2 ° C in Fig. 1), beyond which the system follows an essentially irreversible pathway driven by intrinsic biogeophysical feedbacks. The other pathway leads to Stabilized Earth, a pathway of Earth System stewardship guided by human-created feedbacks to a quasistable, human-maintained basin of attraction. “Stability” (vertical axis) is defined here as the inverse of the potential energy of the system. Systems in a highly stable state (deep valley) have low potential energy, and considerable energy is required to move them out of this stable state. Systems in an unstable state (top of a hill) have high potential energy, From Steffen et al., (2018).



Citizen Science meets Climate Science --2

Can wildfires in the near mid-latitudes affect Noctilucent Clouds (NLCs) in the mesosphere?

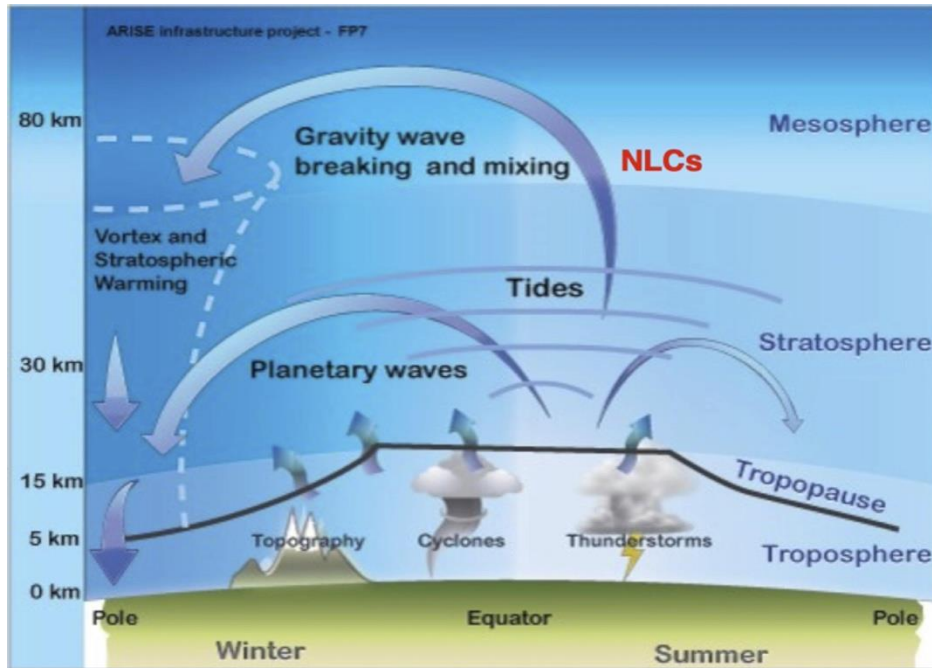


Photo of smoke from bushfires by Merrin Macleod on a flight from Canberra to Melbourne, posted January 4, 2020.

In a *Science-a-Thon*, we will input data from ground NLC citizen science campaigns and vertical temperature and water vapour measurements from ELLF’s imaging system to learn about the region where NLC’s form and potential wave transport mechanisms.



Climate Change Rescue Education Modules

Module 1: What is a Chaos Theory and what are Stability Attractor points in the Tipping Point Concept?

Module 2: How does the Earth's albedo change when different surfaces: vegetation, ice, are illuminated and clouds cover the Earth? And when the full wavelengths in EarthShine are included?

Module 3: How do you determine the wavelengths of a Gravity wave? Of a Planetary Wave?

Module 4: How are satellite, remote, Earth-observing spectra analyzed to determine colours of our planet's landscape?

Module 5: How do greenhouse gas clouds form?

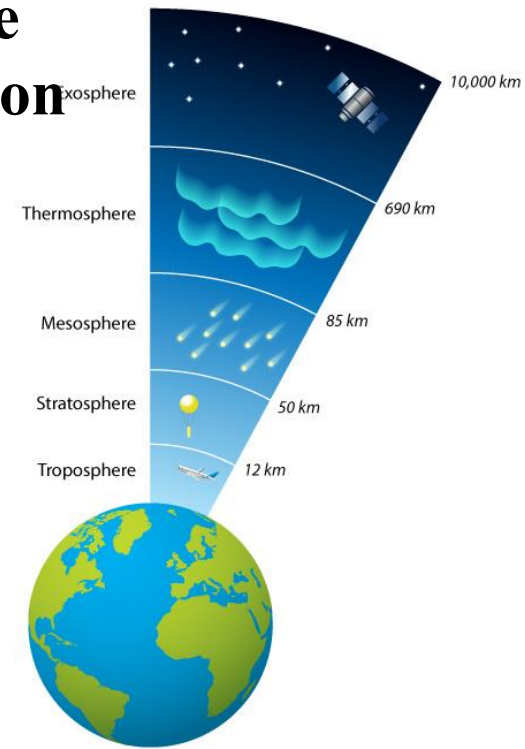
Module 6: How do you find the solar influences, and lunar and solar tides in a data time series?

Module 7: How do you make noctilucent clouds? What is the physical 'recipe' and the 'ingredients'?

Module 8: How do you determine EarthShine? Show the physics and math.

Module 9: What is the troposphere, stratosphere, and mesosphere and the primary physical characteristics of each?

Helping Citizen Scientists become Climate Scientists



Module 10: What are the vertical mechanical and thermal drivers in the troposphere, stratosphere and the mesosphere?

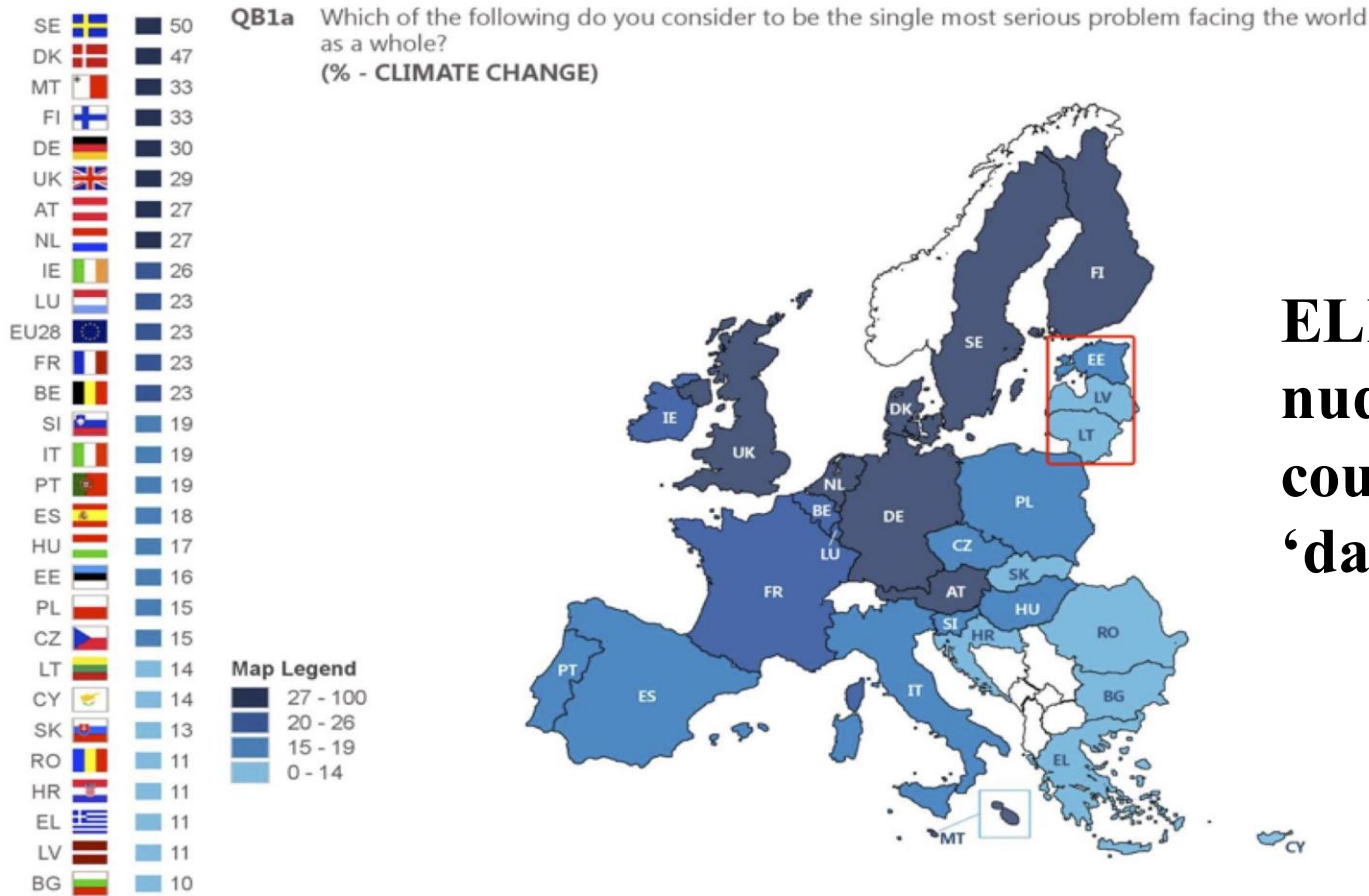
Module 11: How is our middle atmosphere like a refrigerator?

Module 12: What are the most common misunderstandings of Climate Science? Or how to talk to your neighbor to gain a climate change ally.

Module 13: A Simple Energy Balance Model of the Earth



Climate Change Opinions in EU Societies



ELLF aims to nudge Baltic countries ‘darker blue’

2019 Survey by Eurobarometer of Europe’s Climate Change Opinions.

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ELLF Public Engagement Plans -1

Each are multi-steps using mini-opportunities.

- Collect the Climate Policies and Address the Fears.
- Link Concept of Fragile Earth to Sustainable Living



Democracy Festivals encourage frank conversations



Communities that are ripe for Recycling Education.



ELLF Public Engagement Plans -2

- Engage the Young Climate Change Strike Activists
- Baltic Sea Region + European + International Community ELLF Communication
- STEM Education in Space: CubeSat engineering communication and education

The Youth are better communicators than the climate scientists. The ELLF Project will invite them to participate in our climate citizen science campaigns to learn more science.



Fridays for Future, Youth Climate Change Strike. May 24, 2019.
Riga, Latvia. Photo: Amara Graps



Thank you for your Attention !!