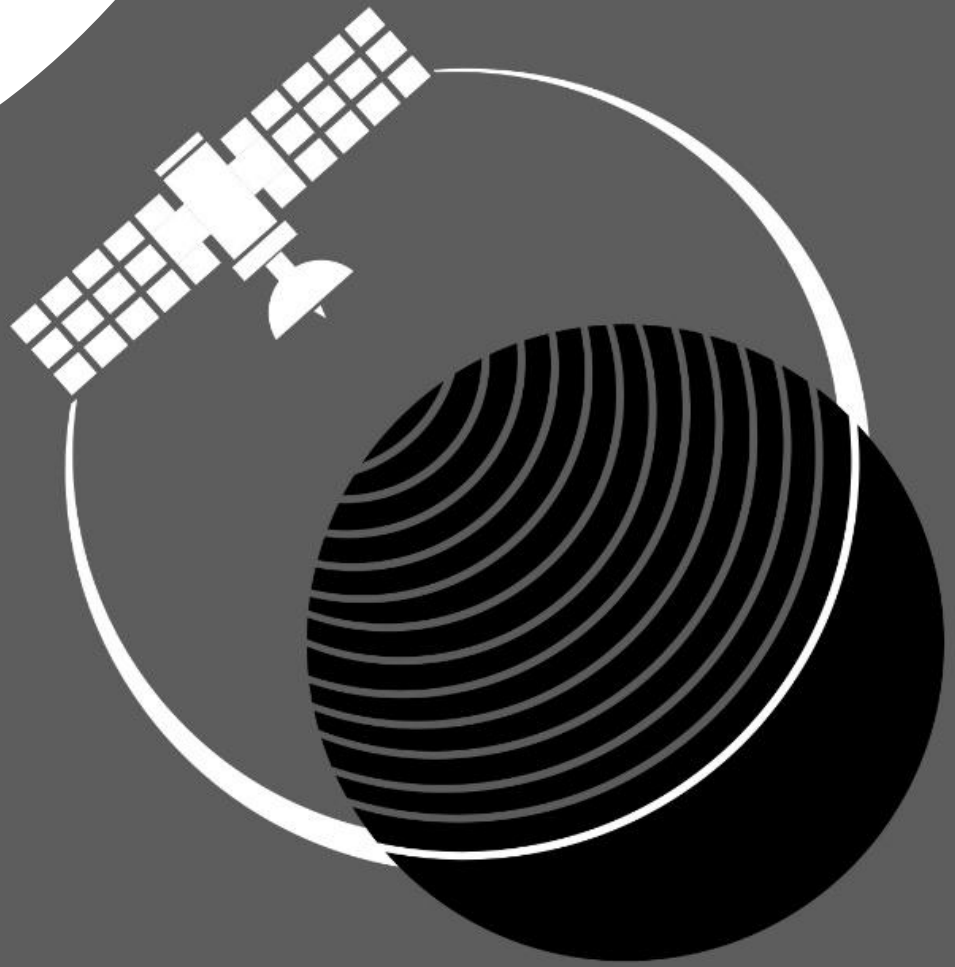
EUROPEAN UNION
Interreg
Botnia-Atlantica
European Regional Development Fund

Antti Kinnunen



Kvarken Space Center

...and the KvarkenSat Mission!

Project KvarkenSpaceEco

Both the Kvarken Kvarken Space Center and the Mission KvarkenSat are part of the project

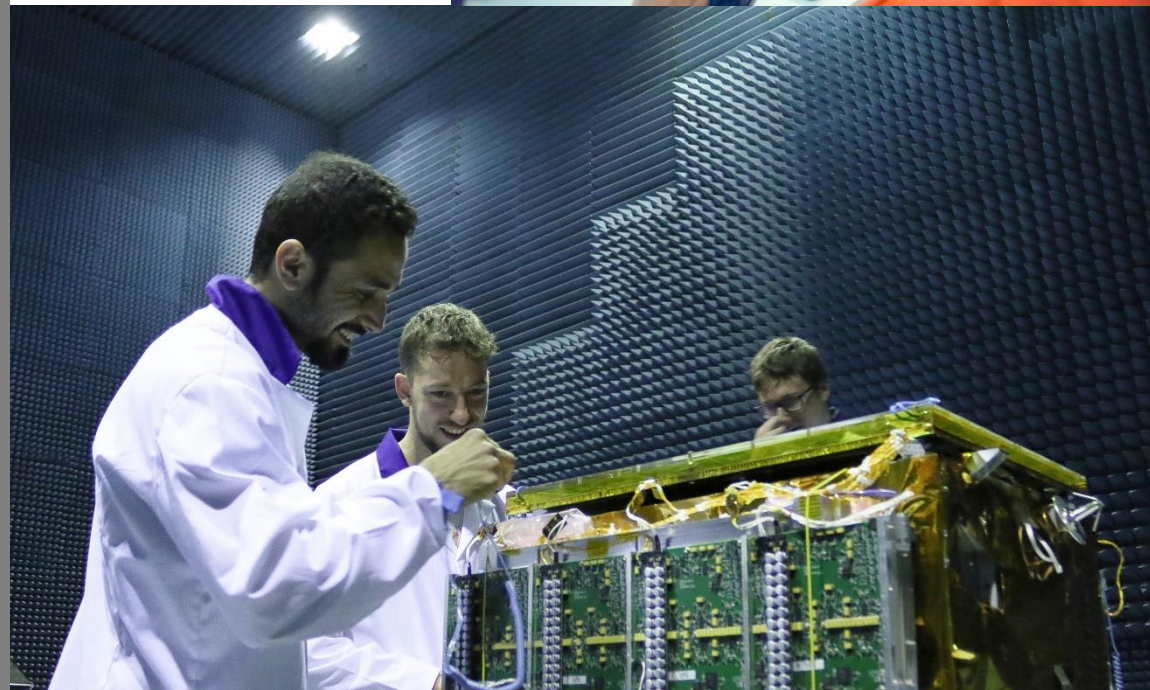
10 partners, coordinated by University of Vaasa

Running from 09/2019 to 06/2022
budget 1.86 Million euros

http://www.kvarkenspacecenter.org

Old Space vs New Space

ICEYE



Kvarken

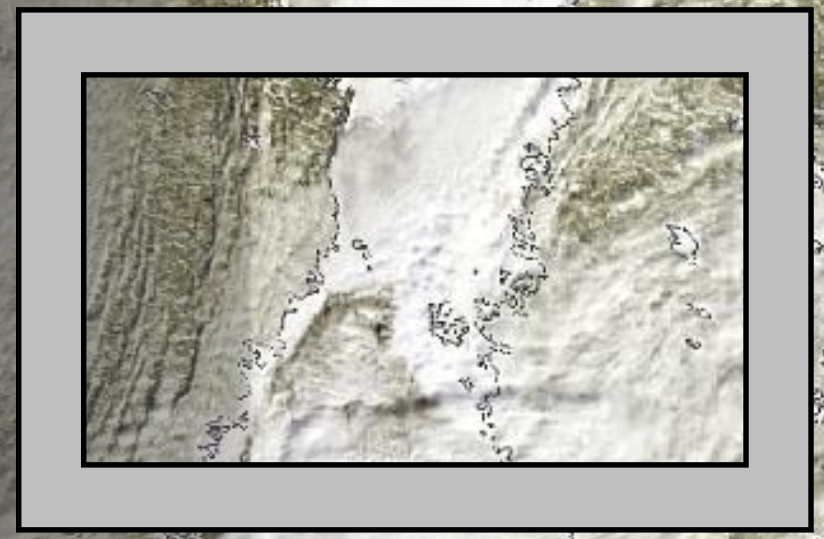
Roughly 526 000 residents

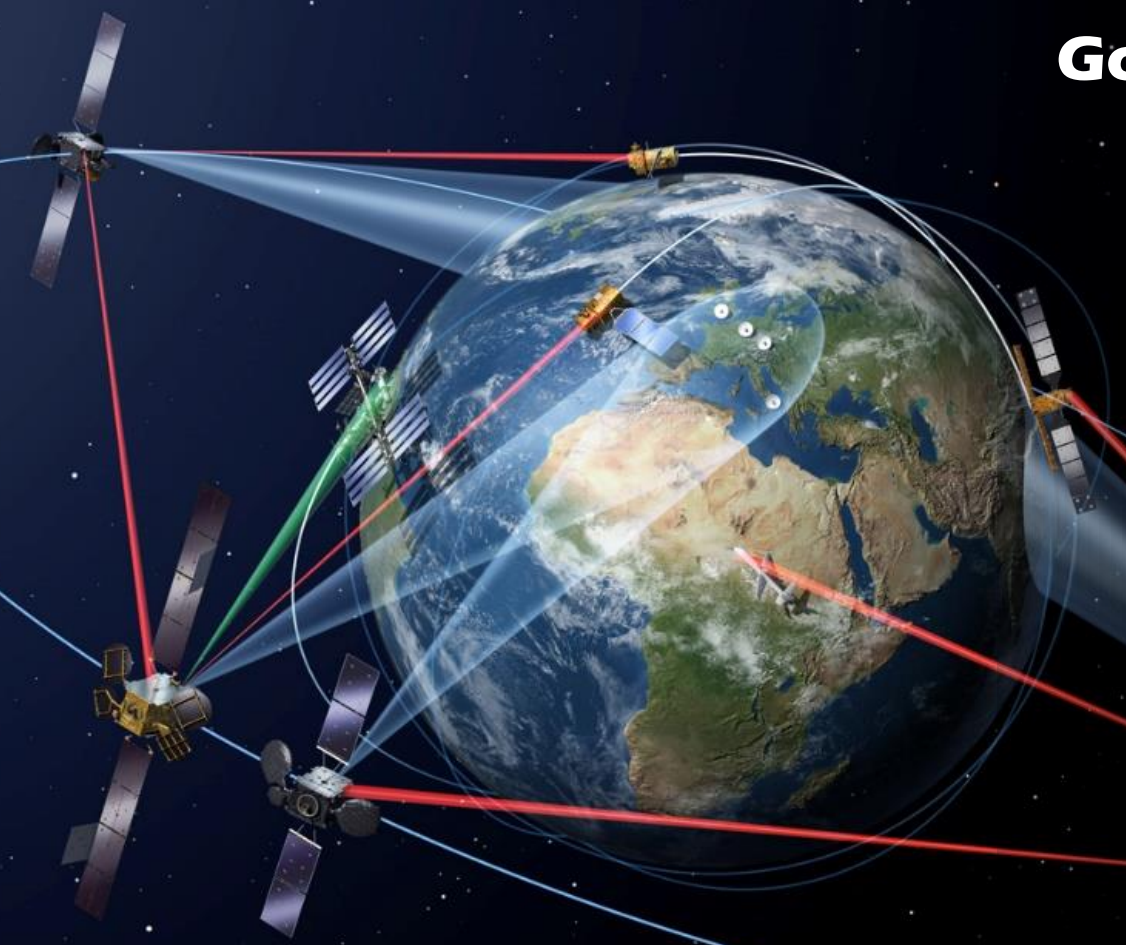
Intersection of commercial routes

Sweden: **Västerbotten**
Örnskldsvik

Finland: **Pohjanmaa (Österbotten)**
Keski-Pohjanmaa (Mellersta Österbotten)
Etelä-Pohjanmaa (Södra ÖsterBotten)

Under utilization of New Space opportunities





Kvarken Space Center

Goals:

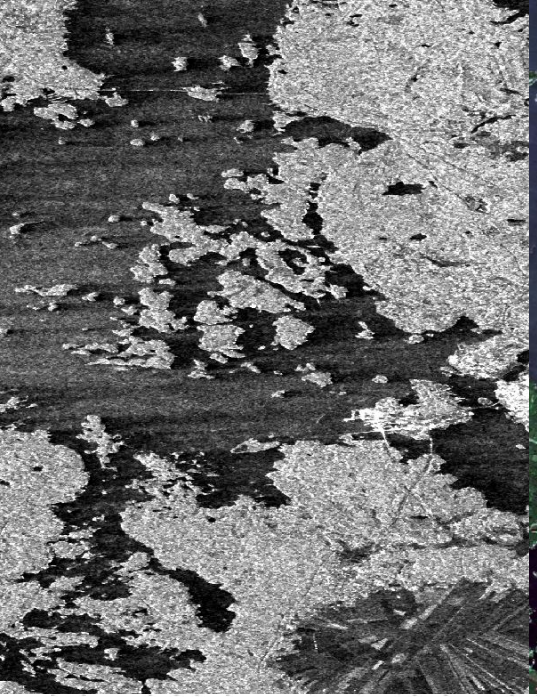
Foster long term space based data utilization in the area

Develop local expertise and local and international co-operation networks

Provide initial and long term industry support

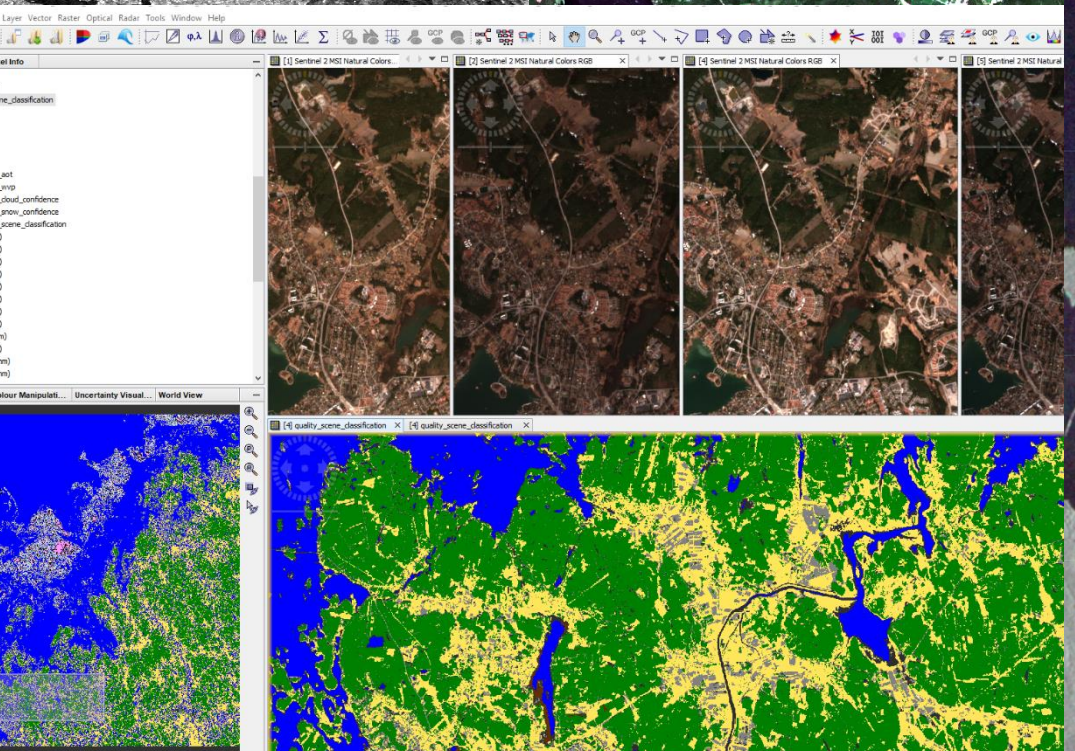
Demonstrate capability

- **Data portal and the ground station**
- **The KvarkenSat Mission**



Demonstration I

Development of *data access and algorithms that create value for local companies and organizations*



Create online portal to facialiate *the usage of the data and the local applications*

Problems of Space Based Data

Multitude of data sources – satellite, other space missions, other relevant geospatial data

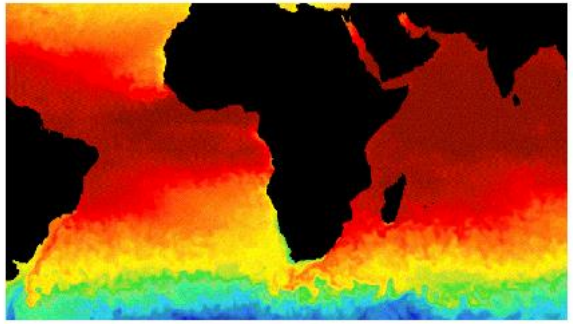
Absolute amount of data transferred from space staggering – at the start of this year, 4987 satellites in orbit of which 1957 are operational (UNOOSA & UCS)

Different data pipelines and transformations for different uses

Problems of transfer, storage and computing power

Google Earth Engine

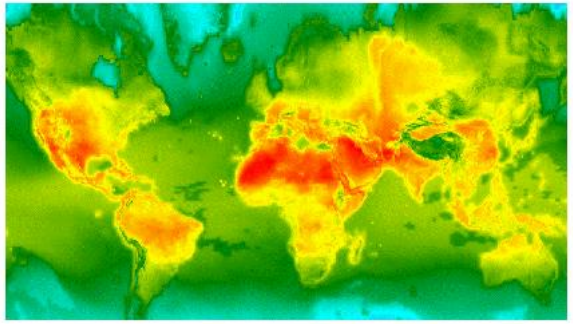
Availability of data, Storage of Data, Computing power



Surface Temperature

Thermal satellite sensors can provide surface temperature and emissivity information. The Earth Engine data catalog includes both land and sea surface temperature products derived from several spacecraft sensors, including MODIS, ASTER, and AVHRR, in addition to raw Landsat thermal data.

Explore temperature data



Climate

Climate models generate both long-term climate predictions and historical interpolations of surface variables. The Earth Engine catalog includes historical reanalysis data from NCEP/NCAR, gridded meteorological datasets like NLDAS-2, and GridMET, and climate model outputs like the University of Idaho MACAv2-METDATA and the NASA Earth Exchange's Downscaled Climate Projections.

Explore climate data

Landsat

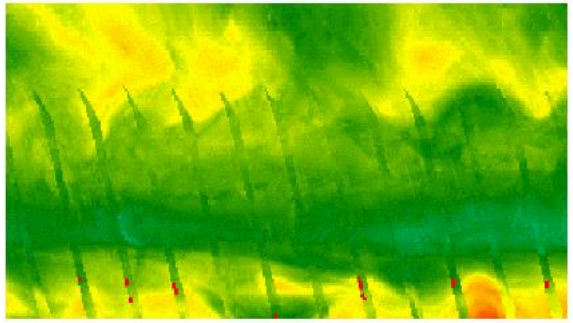
Landsat, a joint program of the USGS and NASA, has been observing the Earth continuously from 1972 through the present day. Today the Landsat satellites image the entire Earth's surface at a 30-meter resolution about once every two weeks, including multispectral and thermal data.

Explore Landsat

Sentinel

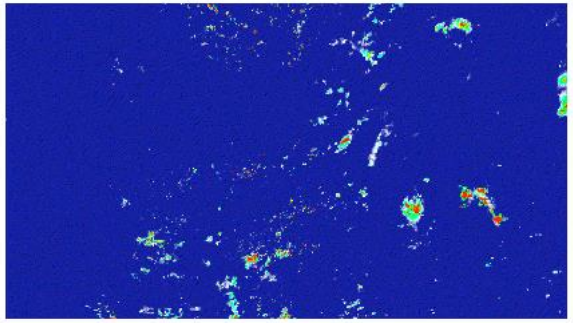
The Copernicus Program is an ambitious initiative headed by the European Commission in partnership with the European Space Agency (ESA). The Sentinels include all-weather radar images from Sentinel-1A and -1B, high-resolution optical images from Sentinel 2A and 2B, as well as ocean and land data suitable for environmental and climate monitoring from Sentinel 3.

Explore Sentinel



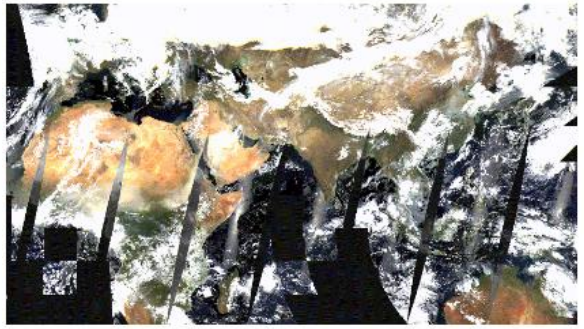
Atmospheric

You can use atmospheric data to help correct image data from other sensors, or you can study it in its own right. The Earth Engine catalog includes atmospheric datasets such as ozone data from NASA's TOMS and OMI instruments and the MODIS Monthly Gridded Atmospheric Product.



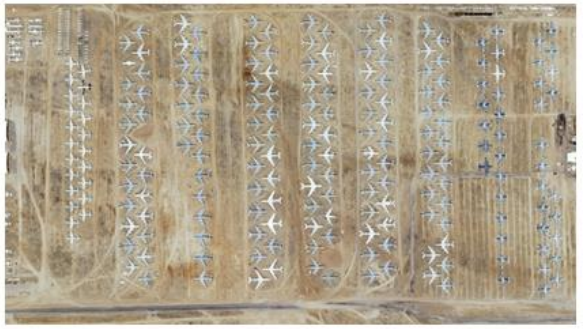
Weather

Weather datasets describe forecasted and measured conditions over short periods of time, including precipitation, temperature, humidity, and wind, and other variables. Earth Engine includes forecast data from NOAA's Global Forecast System (GFS) and the NCEP Climate Forecast System (CFSv2), as well as sensor data from sources like the Tropical Rainfall Measuring Mission (TRMM).



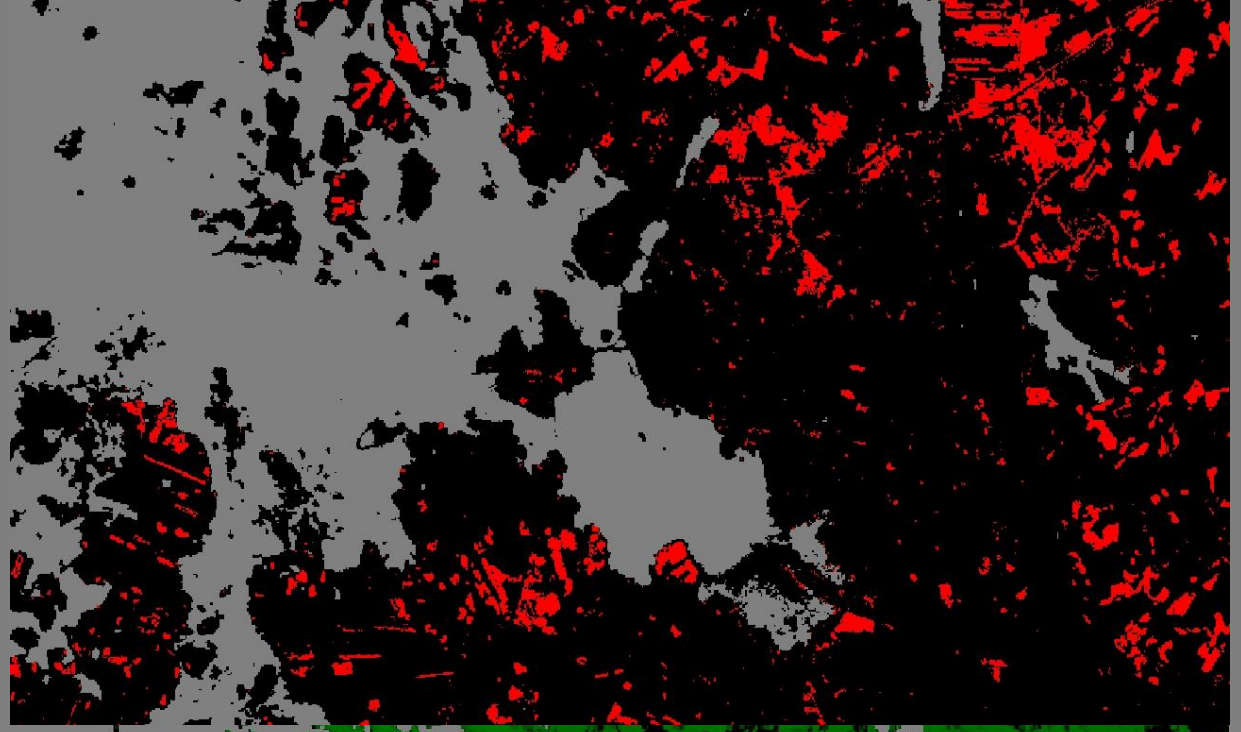
MODIS

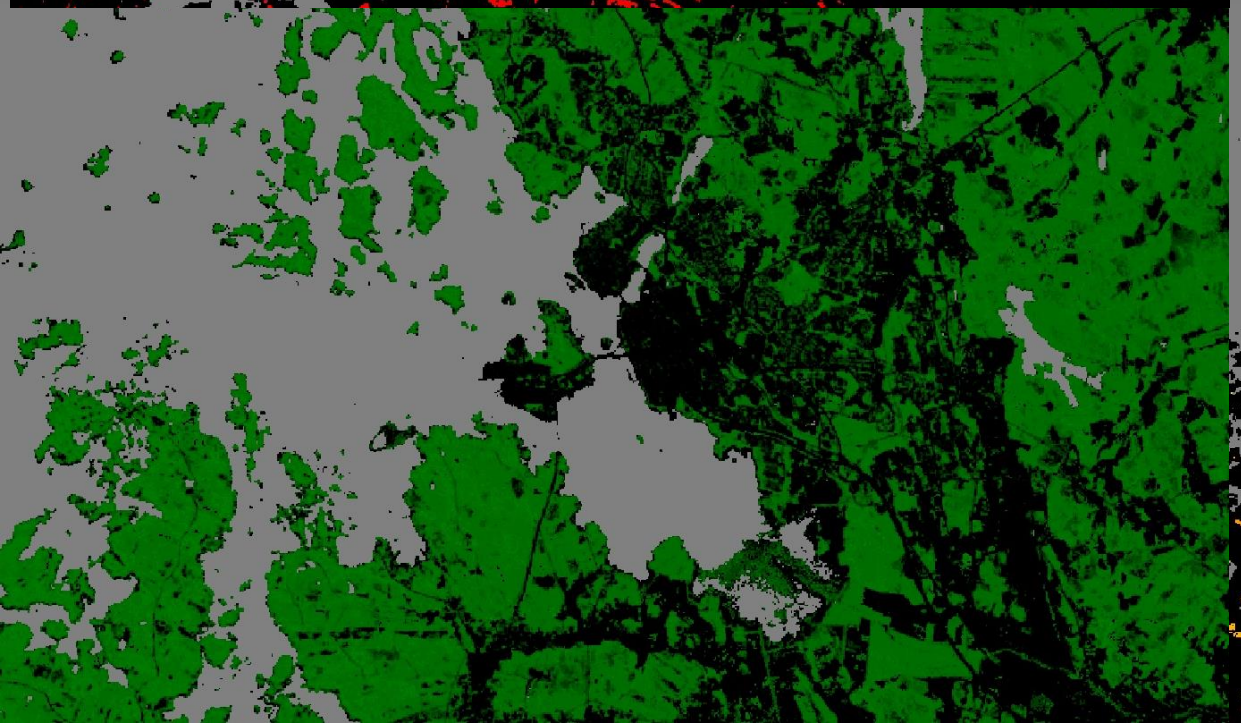
The Moderate Resolution Imaging Spectroradiometer (MODIS) sensors on NASA's Terra and Aqua satellites have been acquiring images of the Earth daily since 1999, including daily imagery, 16-day BRDF-adjusted surface reflectance, and derived products such as vegetation indices and snow cover.



High-Resolution Imagery

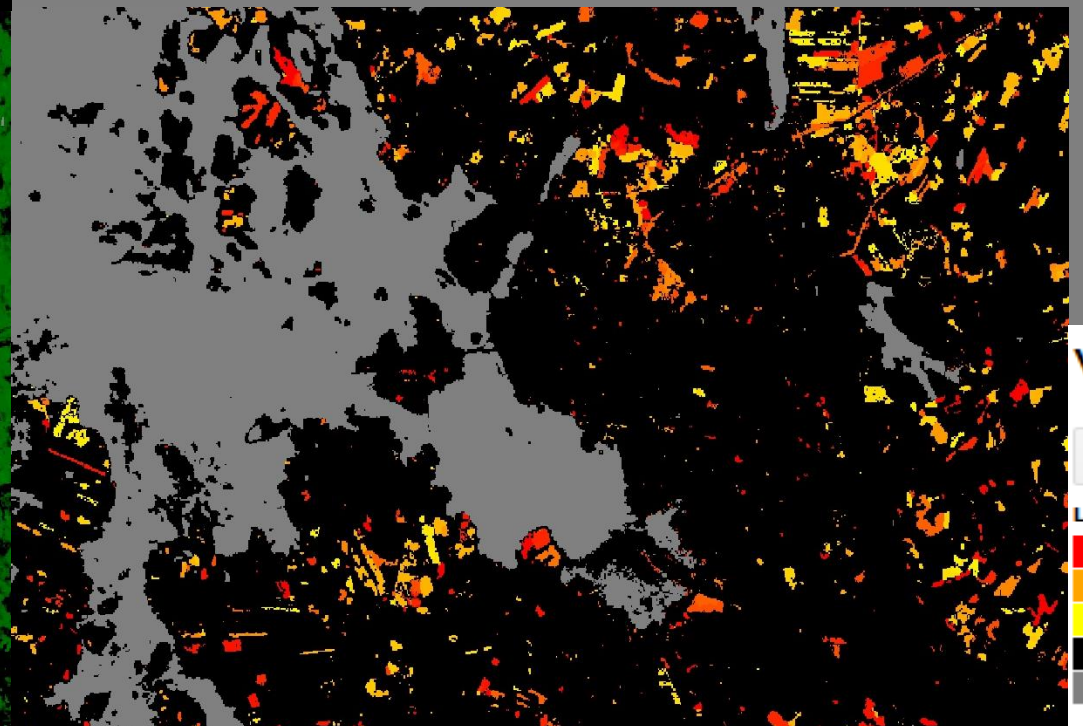
High-resolution imagery captures the finer details of landscapes and urban environments. The US National Agriculture Imagery Program (NAIP) offers aerial image data of the US at one-meter resolution, including nearly complete coverage every several years since 2003.

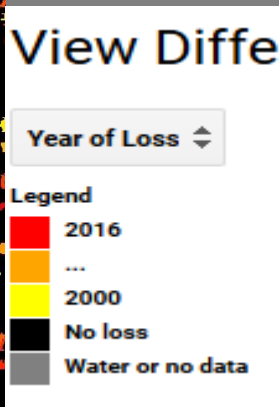




Google Earth Engine App example: Global Forest Change

Based on Landsat data and "High-Resolution Global Maps of 21st Century Forest Cover Change" (2013) Hansen, Potapov, Moore, Hancher, Turubanova and others.





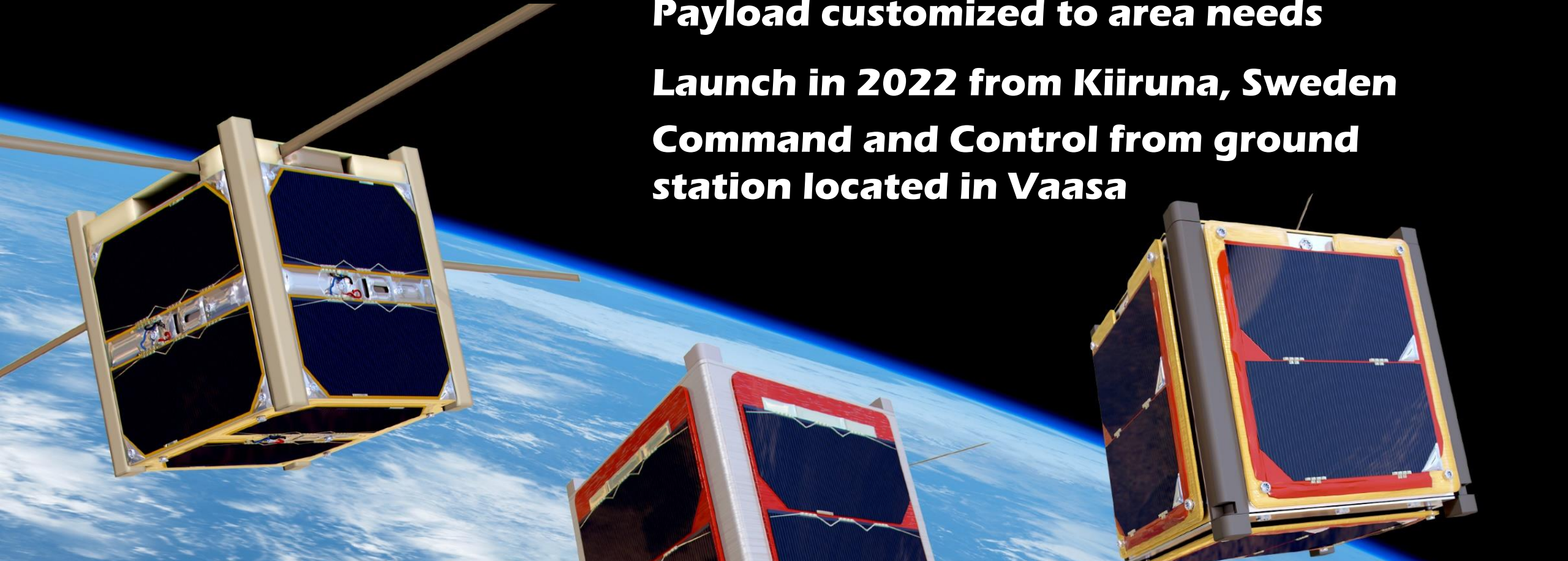
Demonstration II

Satellite Mission "KvarkenSat"

Payload customized to area needs

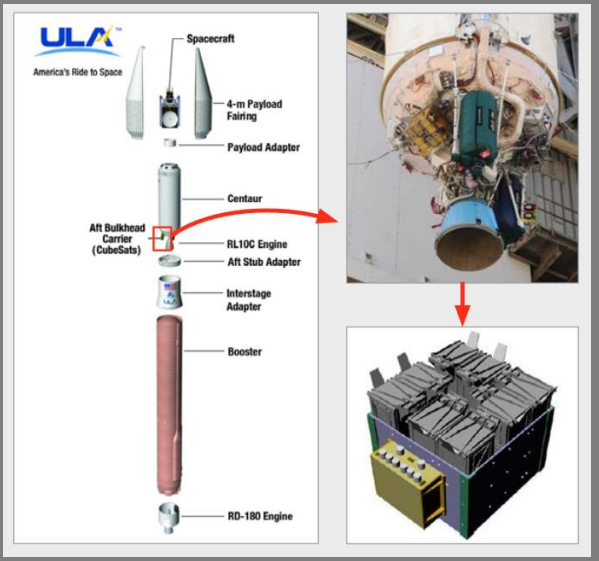
Launch in 2022 from Kiiruna, Sweden

Command and Control from ground station located in Vaasa

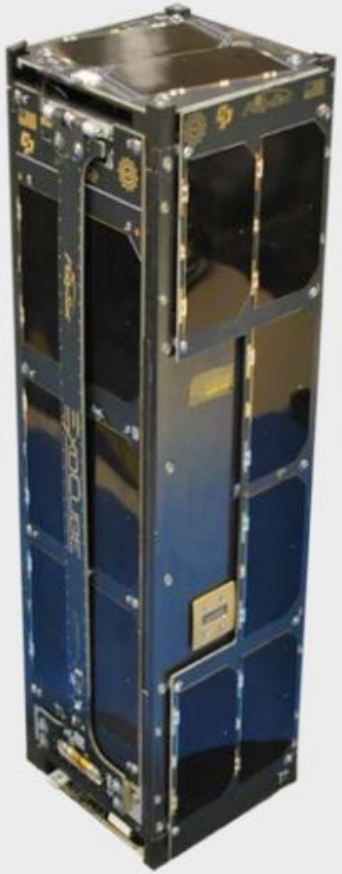


Cubesats

Picture credit: IcEye (left) and NASA Cubesat 101



1U Standard Dimensions:
10 cm × 10 cm × 11 cm



3U Standard Dimensions:
10 cm × 10 cm × 34 cm

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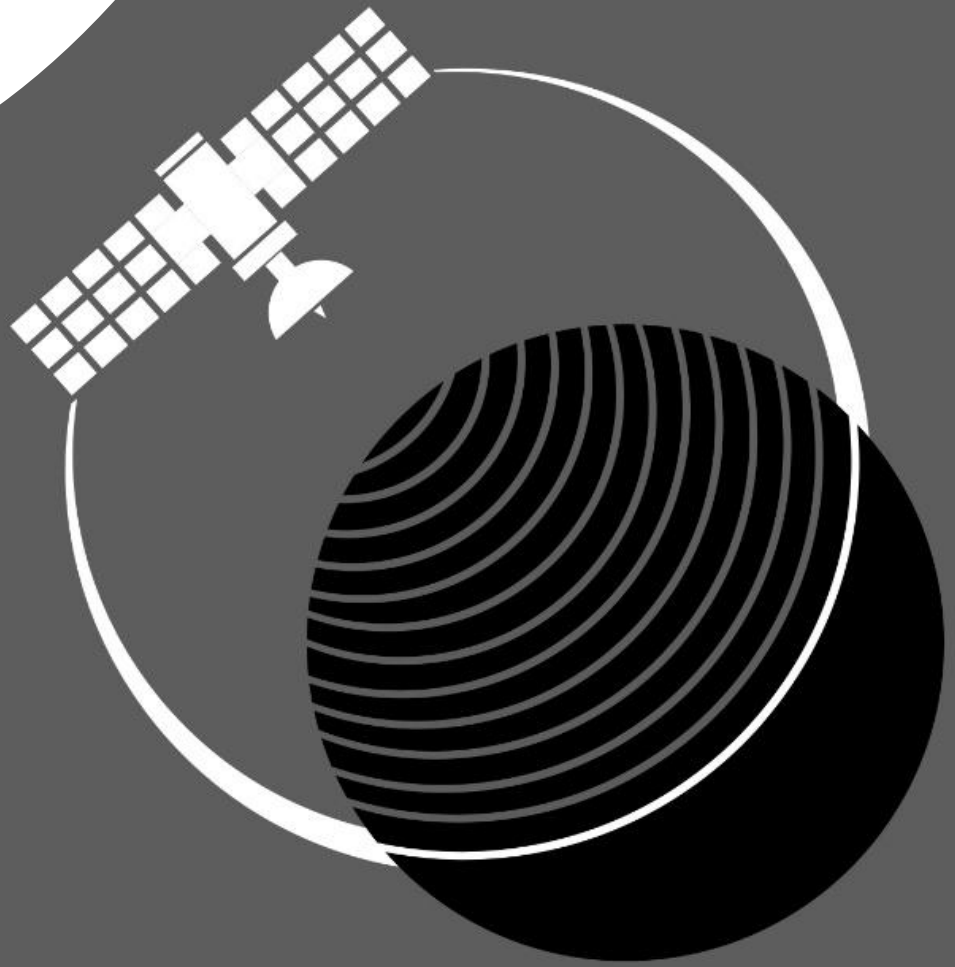
Kannan Selvan

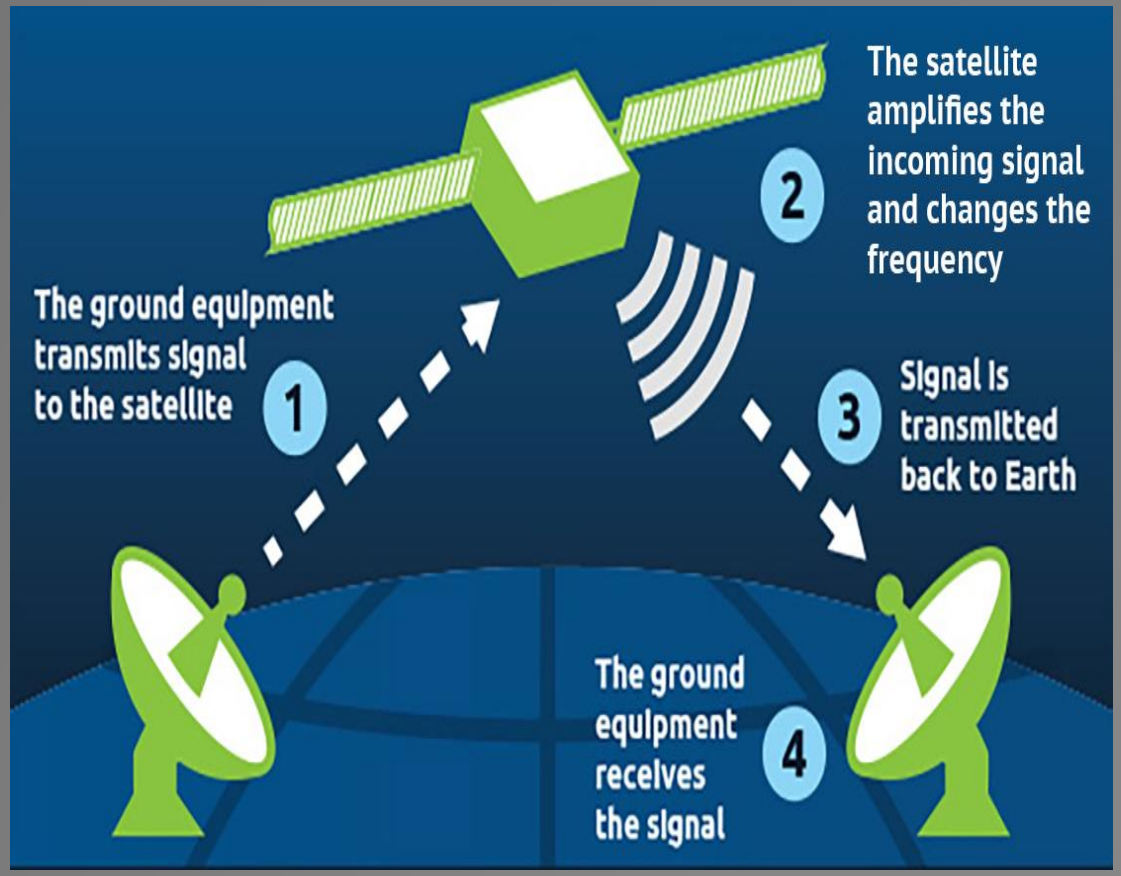


Kvarken Space Center

KvarkenSat Ground Station

Satellite Communication

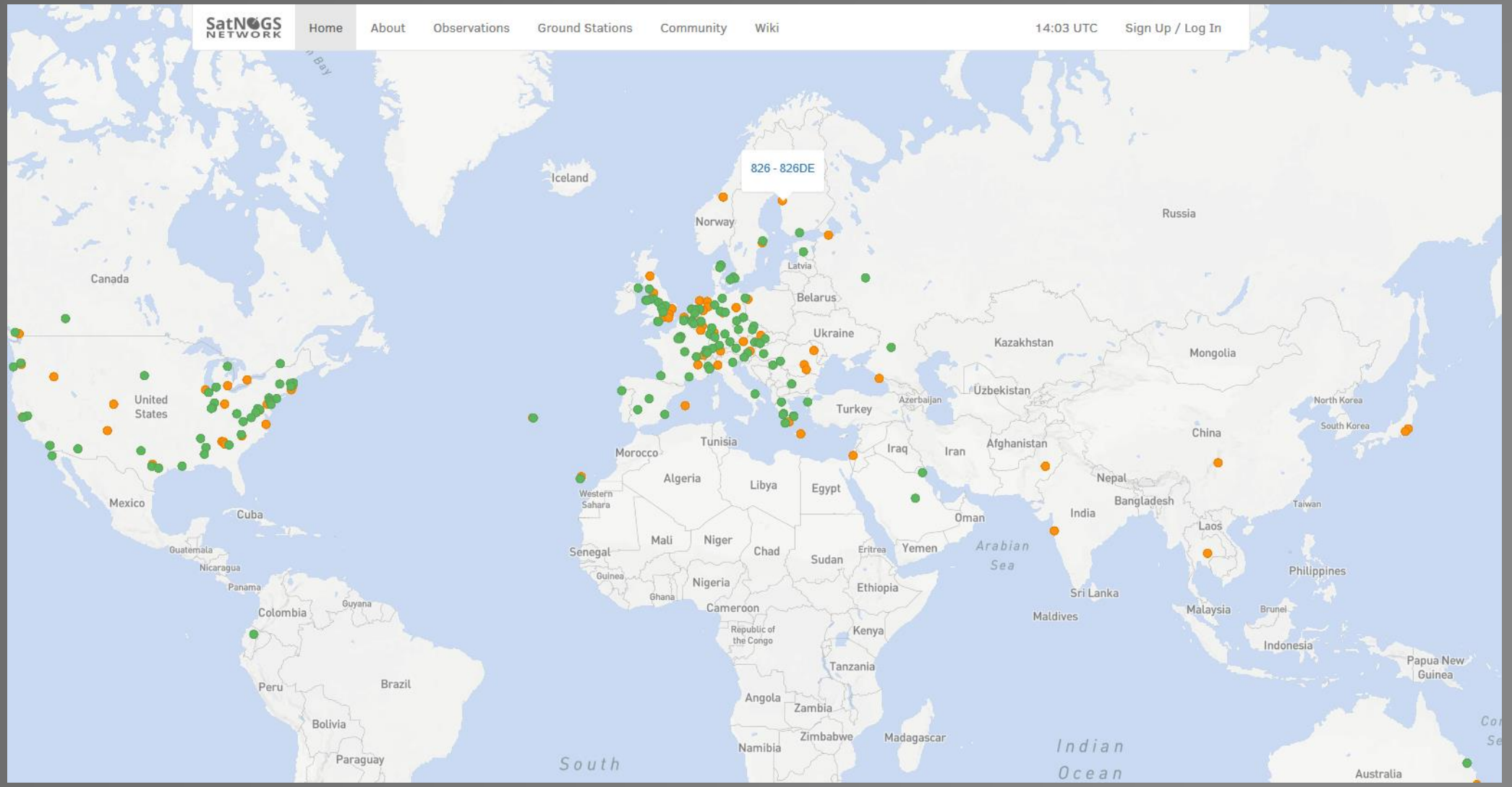
- **Satellite communication is composed primarily of three segments**
  - **Transmitting ground station and uplink media**
  - **The satellite**
  - **Downlink media and receiving ground station**



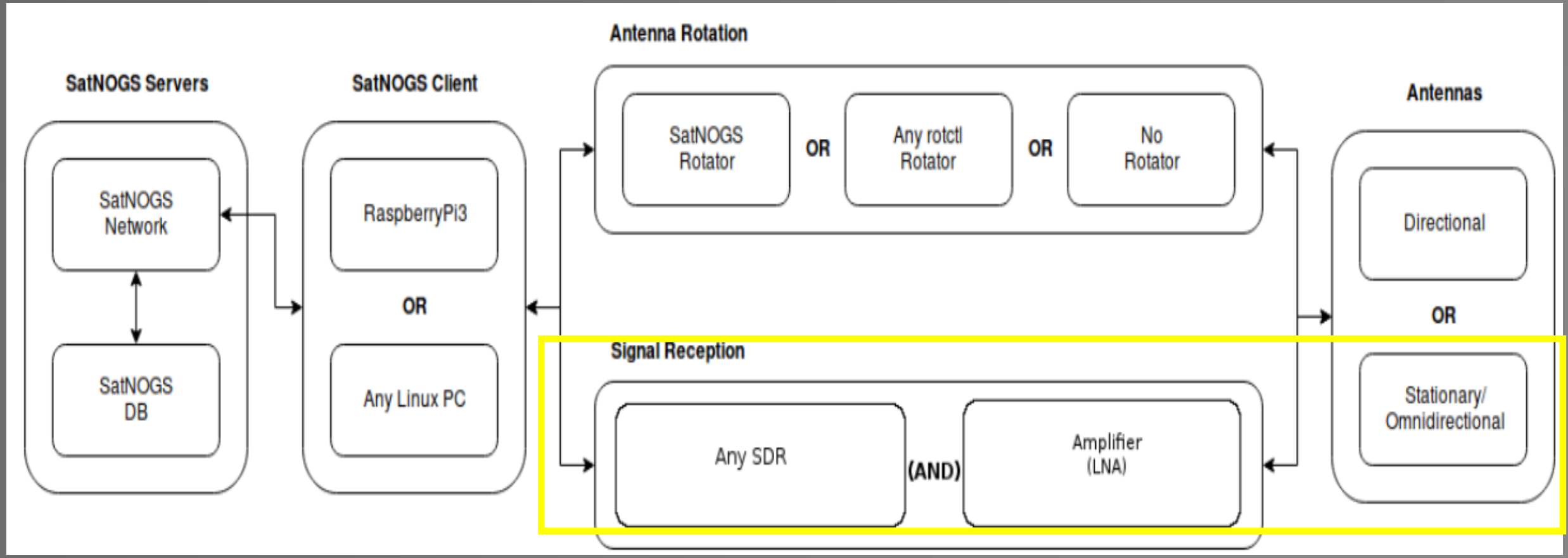
Ground Station

- The primary goal of the ground station is to communicate with the spacecrafts and satellites.
- They are the main source of interaction with the satellite to transmit control commands to the satellites and receive back satellite data.
- Ground station play an important role in any satellite related operations.

SatNOGS Network



SatNOGS Ground Station Block Diagram



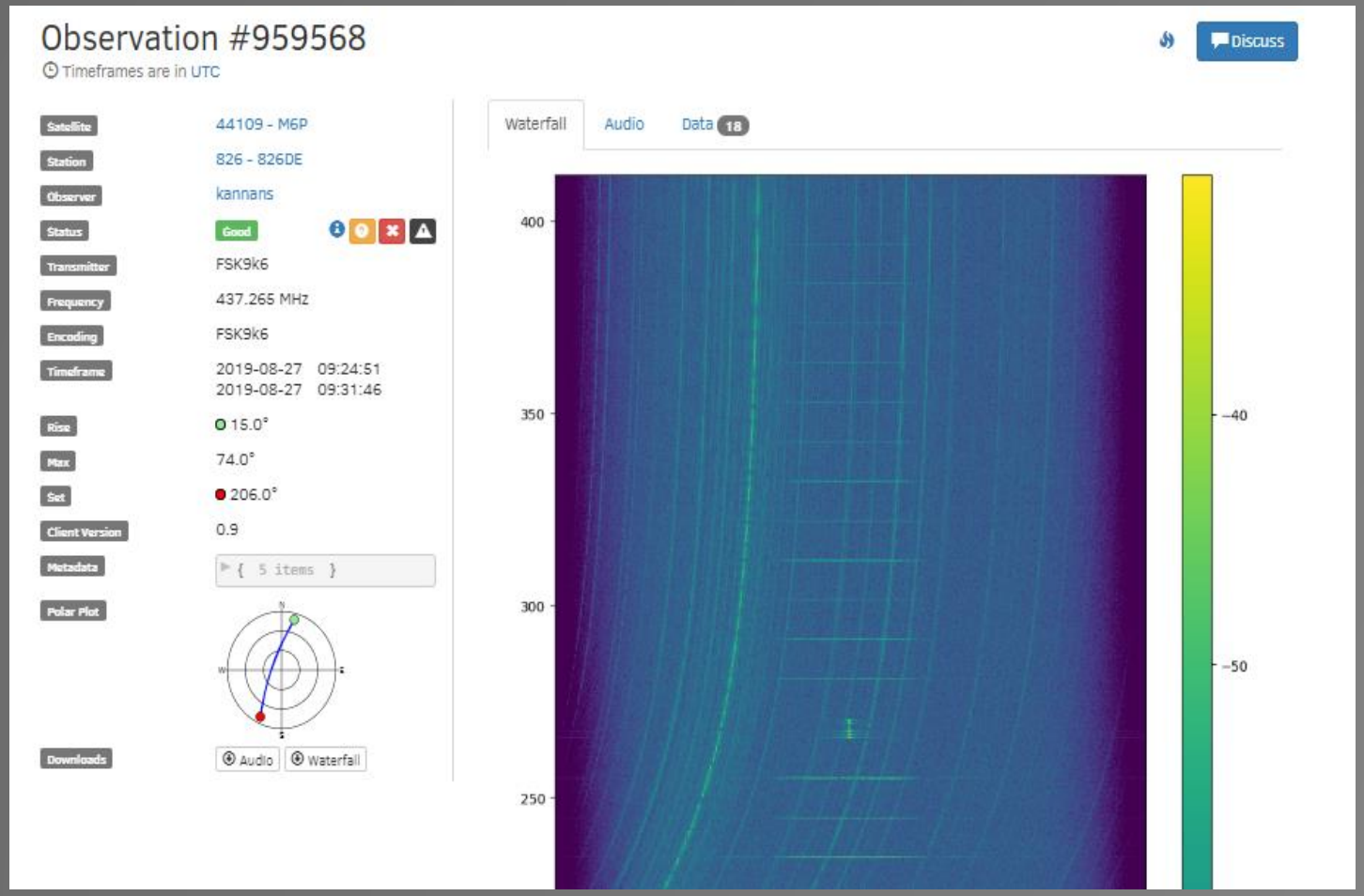
Ground Station Prototype I

- **TA-1 turnstile and Winkler turnstile antenna**
- **Omni-directional antennas with low gain**
- **Used only for reception capabilities**
- **Operating frequencies**
  - **137-152 MHz (VHF)**
  - **435-445 MHz (UHF)**

Ground Station Prototype I

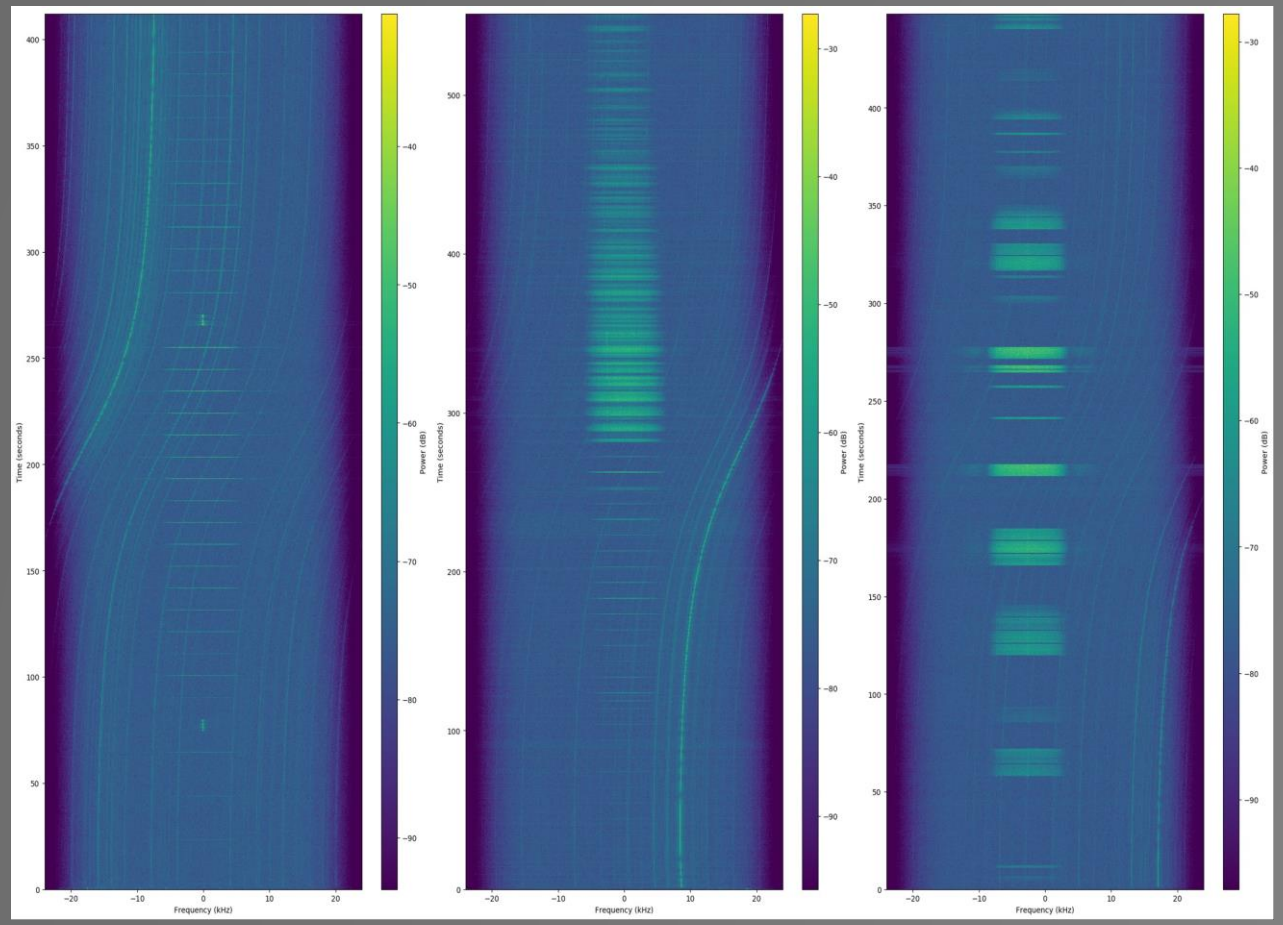
- Ground station running SatNOGS client using raspberry pi 3 and RTL-SDR
- SatNOGS predicts satellite passes, and accordingly activates SDR to save the signals of the right frequency at the right time as an audio file
- Saved audio is then demodulated and possible telmetry values decoded

Prototype I Results



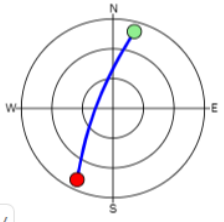
- **Waterfall of beacon signal, audio and demodulated data can be visualized**
- **Beacon – satellite signal signifying its presence tracked by any ground station consisting of telemetry data**

Prototype I Results



- **Waterfall from M6P, UNISAT 6 and AALTO-1 satellites operating at UHF frequencies**
- **Each satellites use different beacon modulation like BPSK, FSK and CW**

Prototype I Results

Satellite	44109 - M6P
Station	826 - 826DE
Observer	kannans
Status	Good
Transmitter	FSK9k6
Frequency	437.265 MHz
Encoding	FSK9k6
Timeframe	2019-08-27 09:24:51 2019-08-27 09:31:46
Rise	15.0°
Max	74.0°
Set	206.0°
Client Version	0.9
Metadata	{ 5 items }
Polar Plot	

/network.satnogs.org/stations/826/

Waterfall | Audio | Data 18

ASCII HEX

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86 A2 40 40 40 40 00 98 B2 60 98 A6 40 01 00 00 58 F0 02 00 00 00 00 0C A7 70 01 00 18 73
01 00 00 56 F0 02 00 00 00 00 0C 4D 7F 01 00 11 89 01 00 01 41 F0 02 00 49 30 00 00 00 00
FA 00 6B 00 03 7B E3 44 3E 00 00 00 00 56 80 D9 BA 8E FE 99 3D 7D F5 49 3D 66 06 CE 44 66
06 E8 44 66 A6 FF 44 33 73 51 C5 14 00 00 00 00 00 80 0C 5B 20 99 01 46 00 00 00 7C 00 00
00 00 00 9B 00 64 00 00 00 01 00 19 00 41 00 00 00 CE 32 8B 32 D1 27 DE 27 0D 00 00 00 0D
00 00 00 00 00 29 01 0F 00 D5 00 5C 40 02 00 0E 00 00 00 00 00 FA 00 00 23 8C 07 2A 7B 00
94 01 01 A9 90 00 00 00 00
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data_obs/959568/data_959568_2019-08-27T09-26-55

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FA 00 6C 00 03 EF 36 E3 3D 00 00 00 00 A6 87 93 BC 1B A0 89 3D 4D 36 1E 3D 66 56 D2 44 33
C3 E0 44 CD 84 00 45 00 80 51 C5 14 00 00 00 00 00 80 0C 53 20 99 01 46 00 00 00 94 00 00
00 00 00 96 00 65 00 01 00 01 00 16 00 4E 00 00 00 28 33 D7 32 E4 26 52 28 04 00 00 00 01
00 00 00 00 00 25 02 04 00 07 00 70 40 02 00 0E 00 00 00 00 00 FA 00 00 23 8C 07 2A 7B 00
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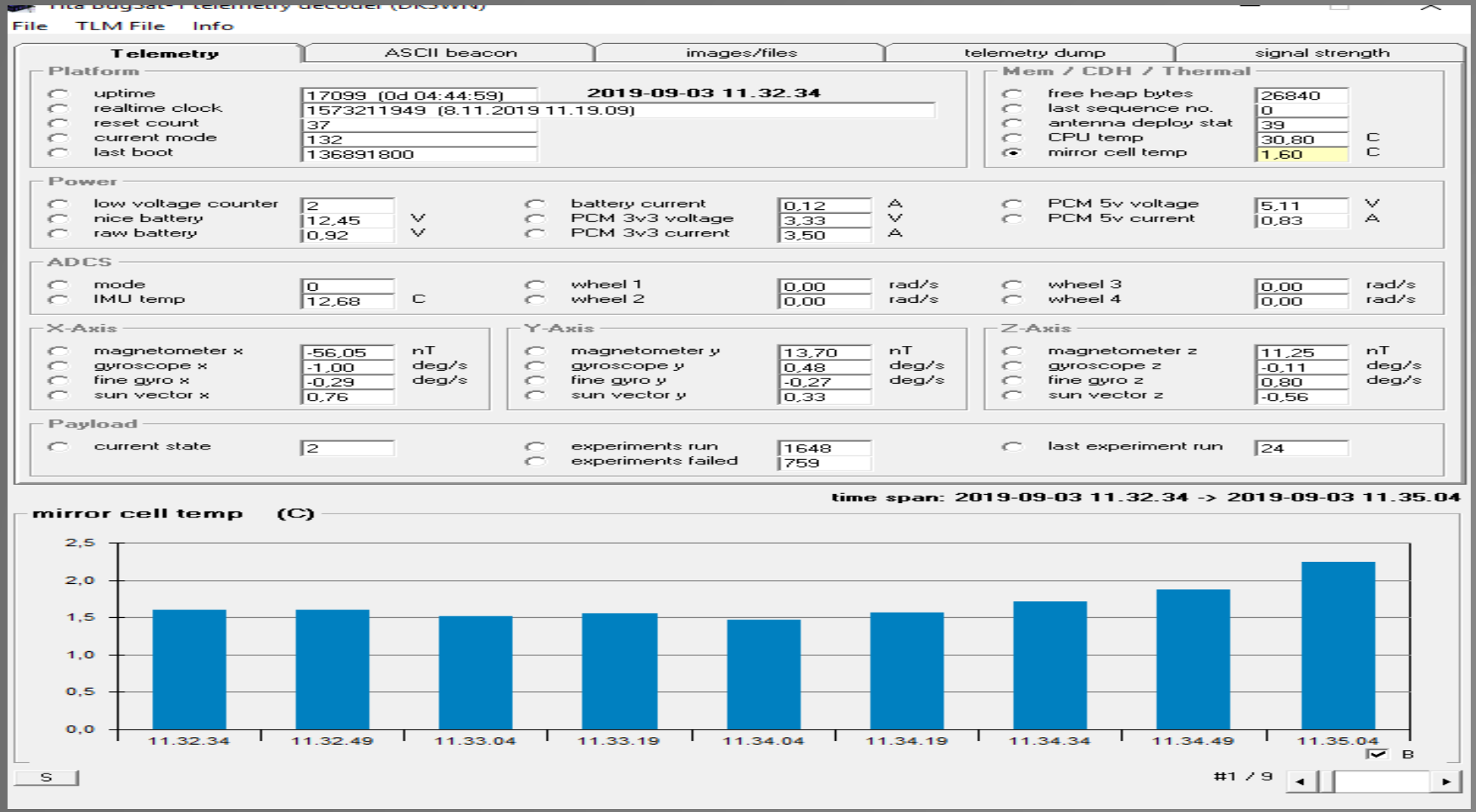
01 00 00 74 F0 02 00 00 00 00 0C A0 86 01 00 F3 8D 01 00 01 5F F0 02 00 49 30 00 00 00 00
FA 00 6D 00 03 AA 0E 02 3E 00 00 00 00 A5 DD 1E BD 4A 00 83 3D 4A 4F F5 3C CD 2C D5 44 9A
89 DA 44 66 1E 00 45 9A 41 52 C5 14 00 00 00 00 00 80 0C 59 20 19 01 49 00 00 00 89 00 00
```

Prototype I Results

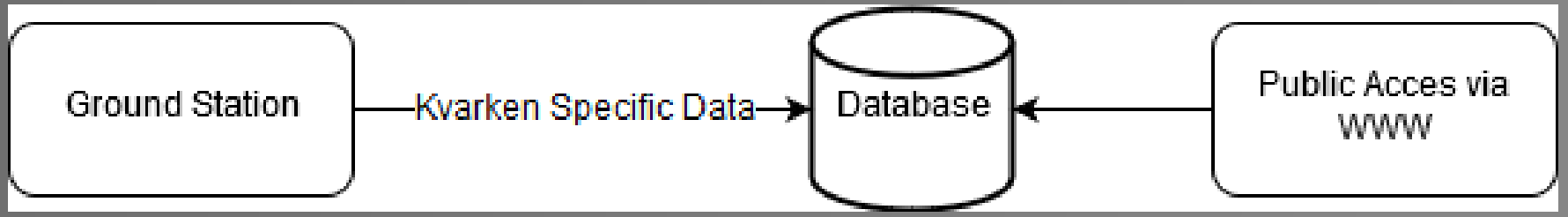


Ground Station Initial Plans (1/2)

- Ground station similar to **stationary** ground station by Aalto or a **mobile** ground station by N66 Connect Sweden
- KvarkenSat ground station will be implemented based on comparison of different ground stations, their documentation and experiences
- Using rotator controllers with both uplink and downlink capabilities

Ground Station Initial Plans (2/2)

- **Will use VHF and UHF yagi antennas for transmitting and receiving operations**
- **Satellite dish reception operating in a certain frequency band – S band, C band or L band, exact band to be chosen.**
- **Upgrade to SDR transrecievers like USRP B210, power amplifiers, LNA, cables and other components to be decided based on comparisons**
- **Goal: to receive and to distribute Kvarken specific data from satellites to different entities to use.**



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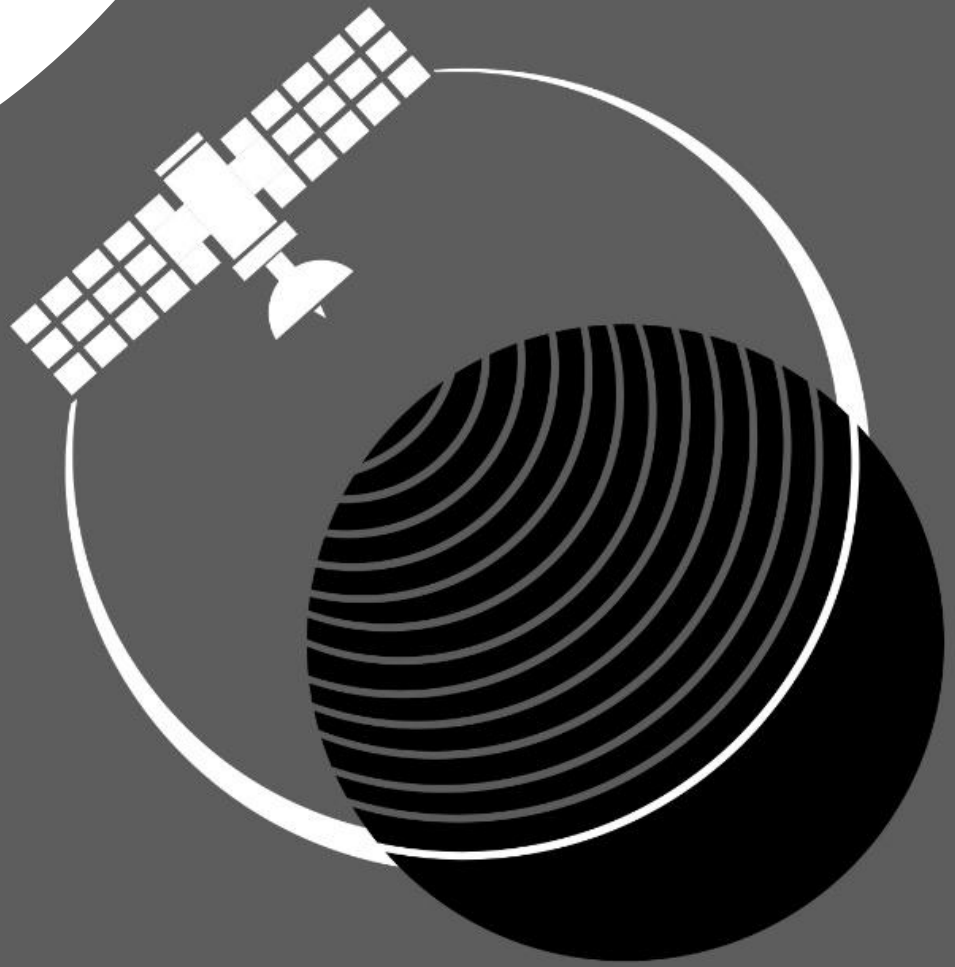
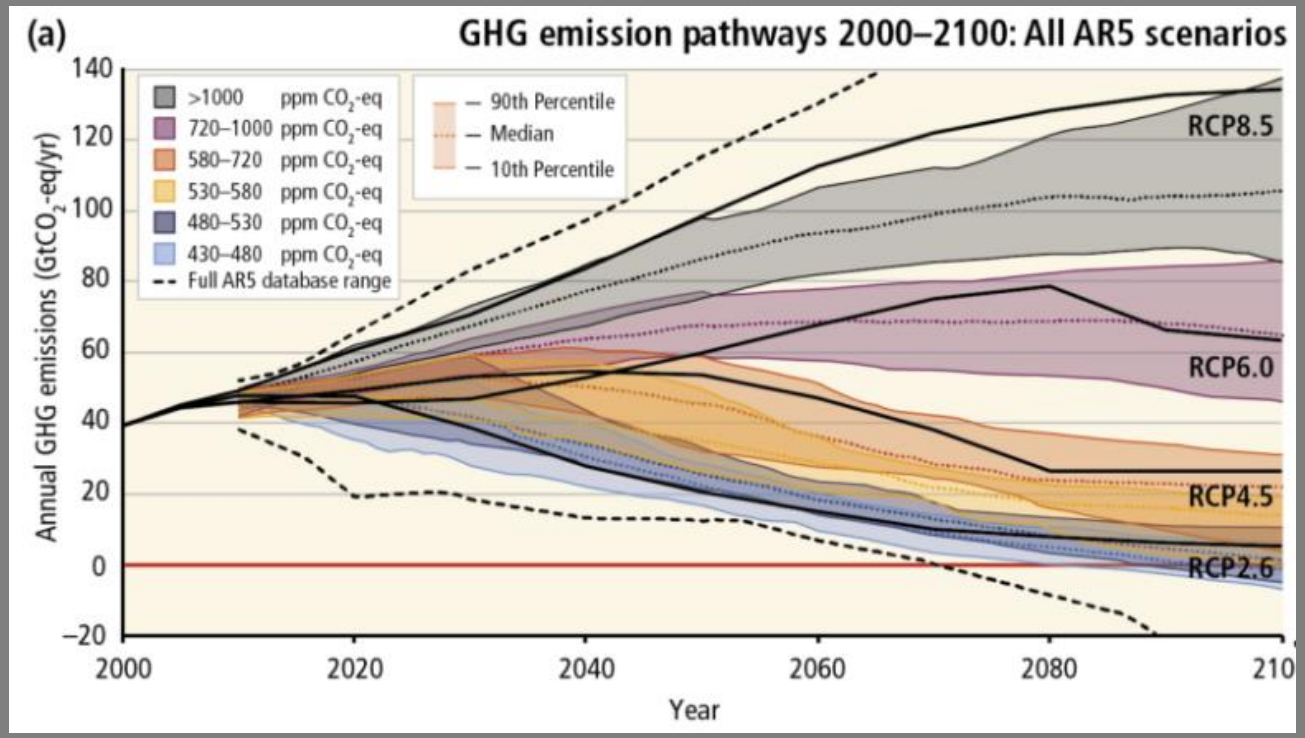
Kendall Rutledge



Kvarken Space Center

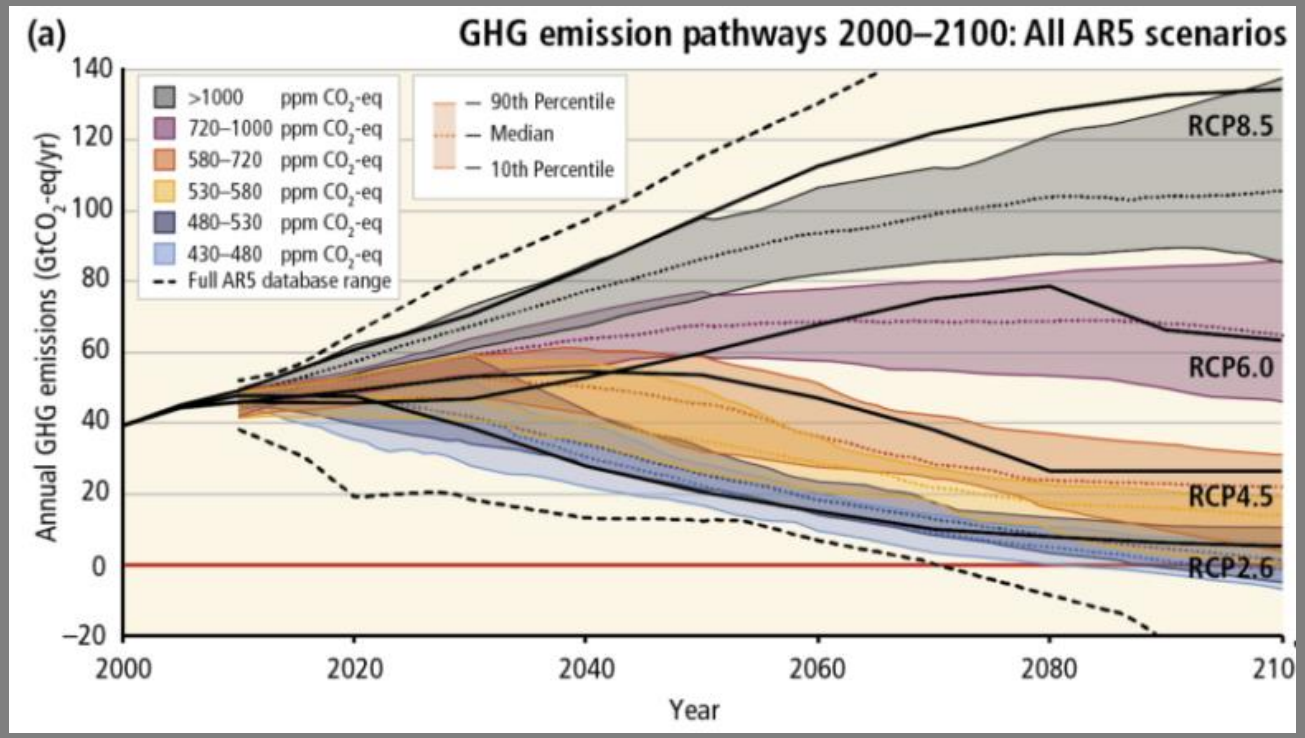
Climate Change

Representative Concentration Pathways



IPCC AR5 Synthesis Report: Climate Change 2014

Representative Concentration Pathways



IPCC AR5 Synthesis Report: Climate Change 2014

Shared Socioeconomic Pathways

SSP1 Sustainability – Taking the Green Road (Low challenges to mitigation and adaptation)

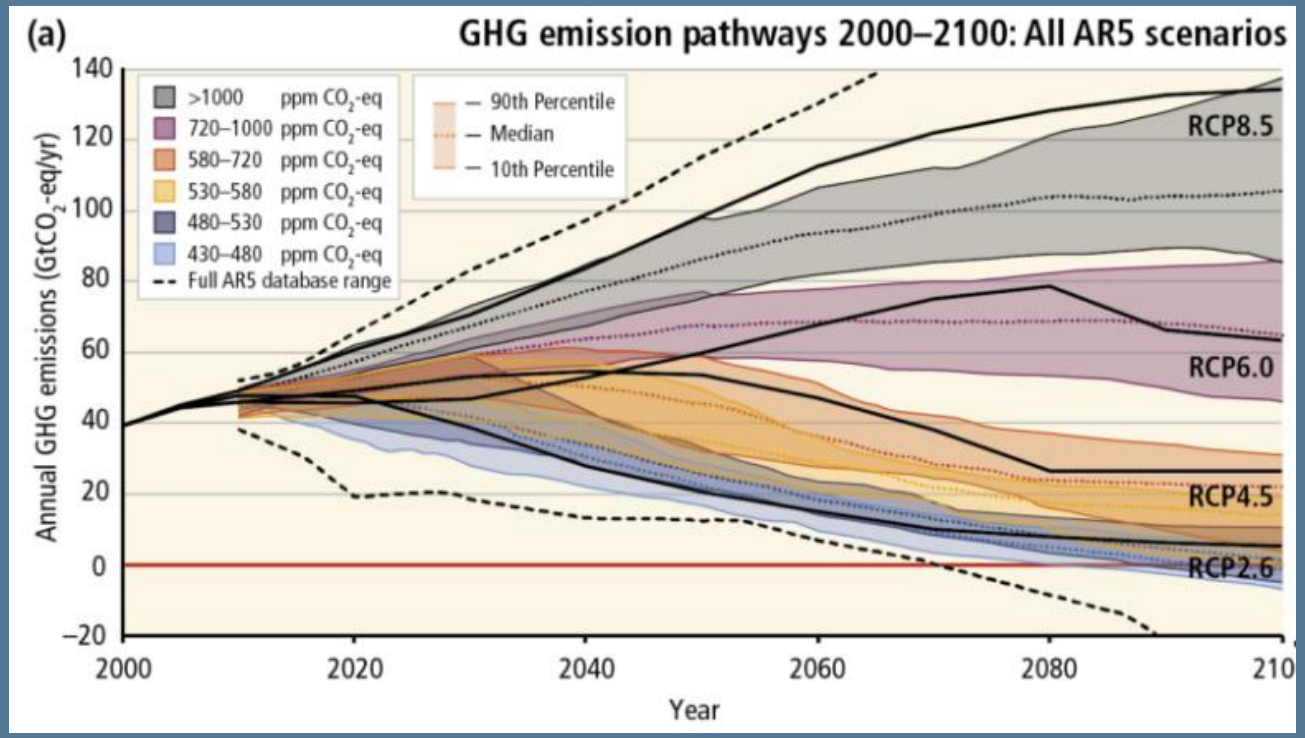
SSP2 Middle of the Road (Medium challenges to mitigation and adaptation)

SSP3 Regional Rivalry – A Rocky Road (High challenges to mitigation and adaptation)

SSP4 Inequality – A Road Divided (Low challenges to mitigation, high challenges to adaptation)

Integrated Assessment Models

Representative Concentration Pathways



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