UVSQ université PARIS-SACLAY | Observatoire de Versailles Saint-Quentin-en-Yvelines | CAMPUS DE SAINT-QUENTIN-EN-YVELINES | cnrs

SORBONNE UNIVERSITÉ CRÉATEURS DE FUTURS DEPUIS 1257

Inspire-Sat, un nouveau satellite du LATMOS en orbite depuis avril 2023

RADIO-CLUB F6KRK.org SAINT-QUENTIN EN YVELINES | AMSAT Francophone

LATMOS

Mustapha MEFTAH [F4IXO]

16 March 2024

cnrs


INSPIRESAT

INSPIRE-Sat & COSPAR-Sat …

INSPIRE

From Teaching Tools to Sun and Earth Observation Satellites

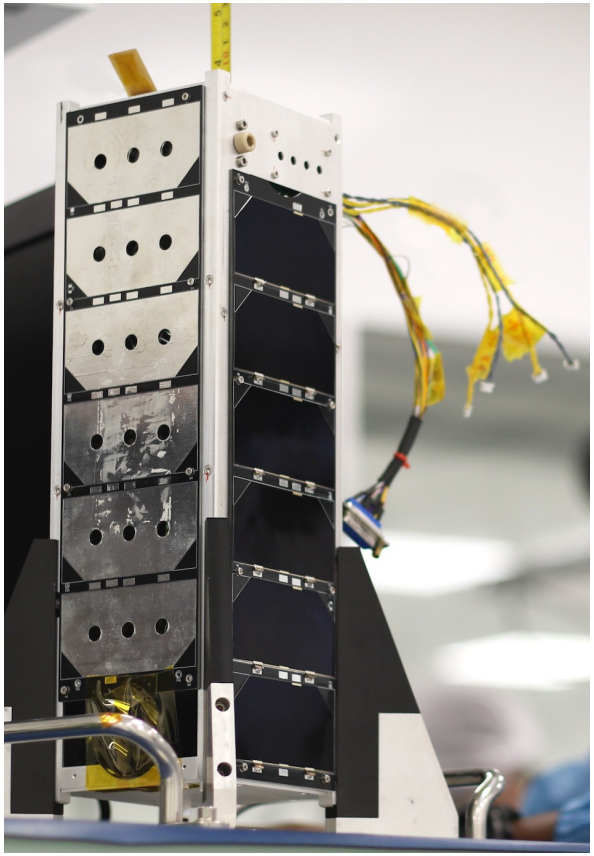
[**Mustapha Meftah** *(CNRS-LATMOS, France)*, **Amal Chandran** *(Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder, USA)*, **Loren Chang** *(National Central University, China: Academy of Sciences Located in Taipei)*, **Leigh Fergus** *(COSPAR, France)*, **Jean-Claude Worms** *(COSPAR, France)* and **Dan Baker** *(Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder, USA)]*

The INSPIRE programme aims to provide a constellation of Earth and space weather observing satellites

The International Satellite Program in Research and Education (INSPIRE) is a global consortium of space universities formed to advance space science and engineering, spearheaded by the Laboratory for Atmospheric and Space Physics of the University of Colorado at Boulder (CU Boulder-LASP) and its international academic partners. Each **INSPIRE** small satellite (Figure 1) typically proceeds from concept to flight in three years, providing the opportunity for undergraduate and graduate student involvement in small satellite design, implementation, testing, and operations. **INSPIRE** brings science, engineering, and management to campuses across the globe. The **INSPIRE** program aims to provide a constellation of Earth and space weather observing satellites. To date, eight satellites are part of this program.

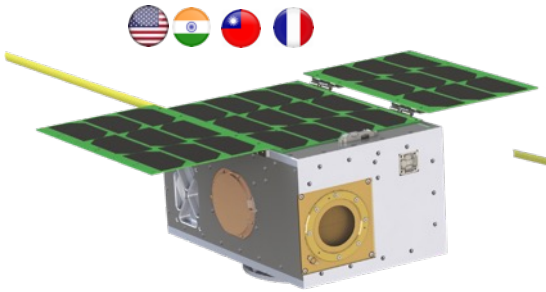
INSPIRE universities involved in this program are:

- **The University of Colorado at Boulder (CU Boulder)**, USA
- **The University of Versailles (UVSQ)**, France
- **The National Central University (NCU)**, China: Academy of Sciences Located in Taipei
- **Nanyang Technological University (NTU)**, Singapore
- **The Indian Institute of Space Science and Technology (IIST)**, India
- **The University of Iowa**, USA
- **The University of Alberta (UoA)**, Canada
- **Sultan Qaboos University at Muscat (SQU)**, Oman
- **Kyushu Institute of Technology (Kyutech)**, Japan
- **Research Centre Jülich, Wuppertal University**, Germany



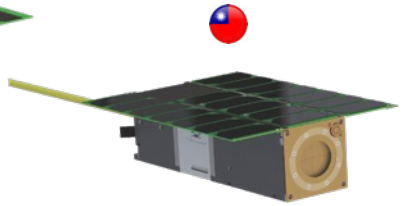
Cospar-Sat 1

INSPIRE-Sat …



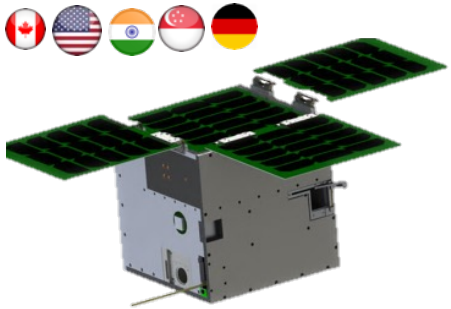
Inspire-Sat 1

Launched on Feb. 2022



Inspire-Sat 2

Launched on Jan. 2021



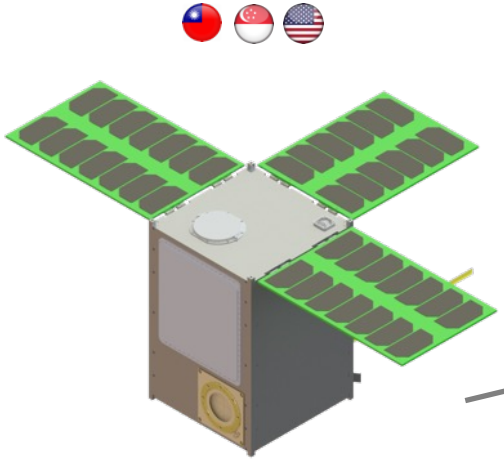
Inspire-Sat 3

Inspire-Sat 4

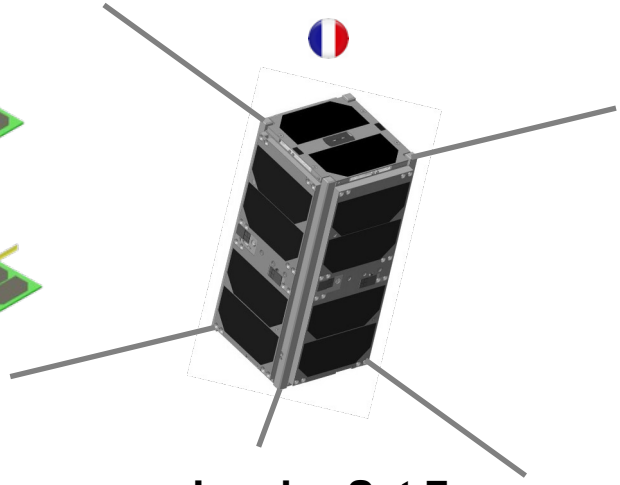
Launched on Jul. 2023

Inspire-Sat 5

Launched on Jan. 2021

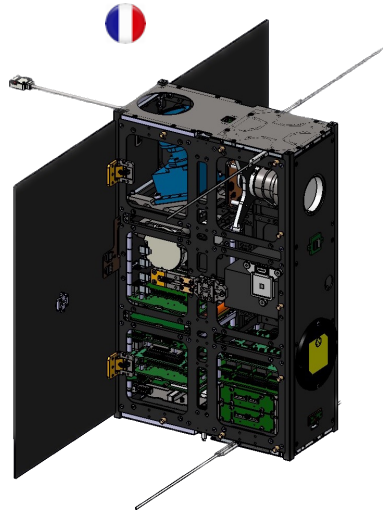


Inspire-Sat 6



Inspire-Sat 7

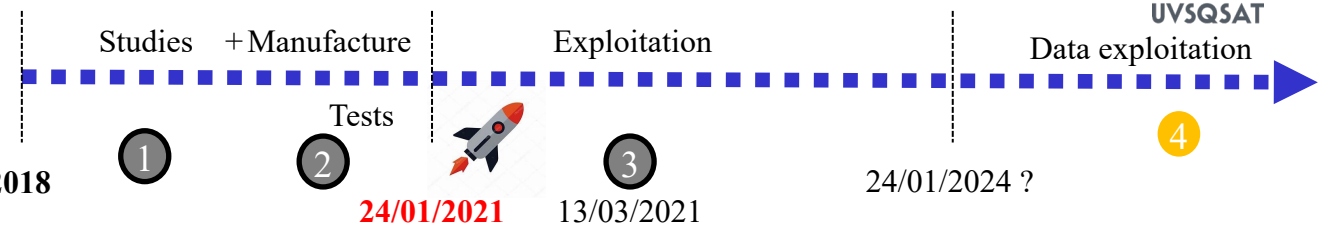
Launched on Apr. 2023

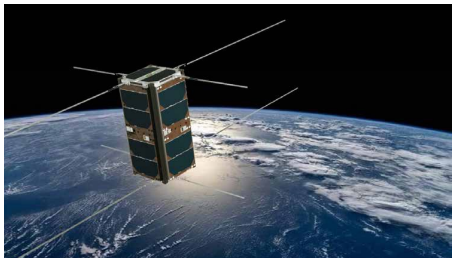


Inspire-Sat X

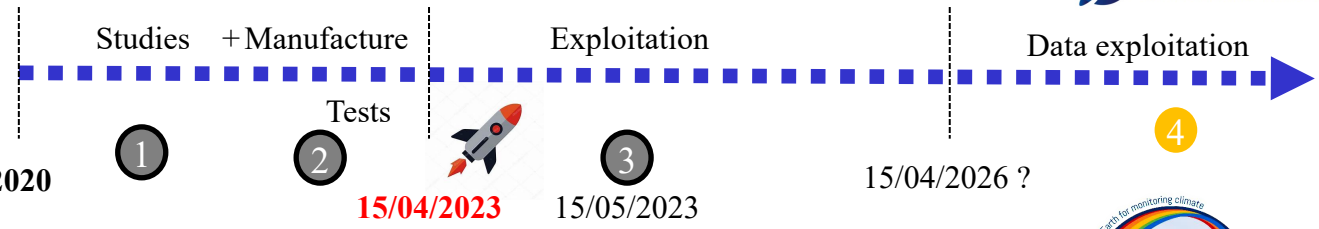
Timeline

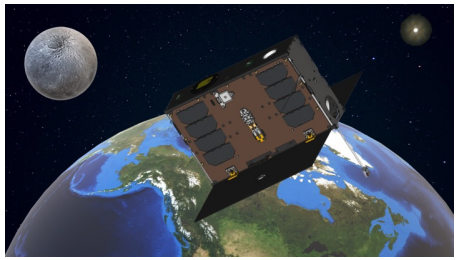
UVSQ-SAT (Inspire-Sat 5)



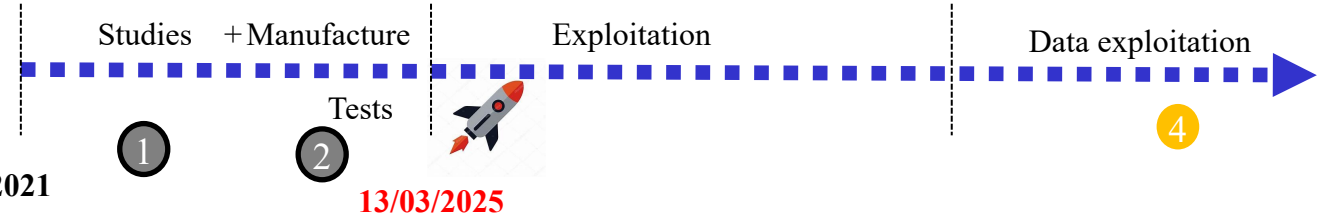


Inspire-Sat 7





UVSQ-SAT NG (Inspire-Sat X)



Phases 0/A, B, C, D **Phase E** **Phase F**

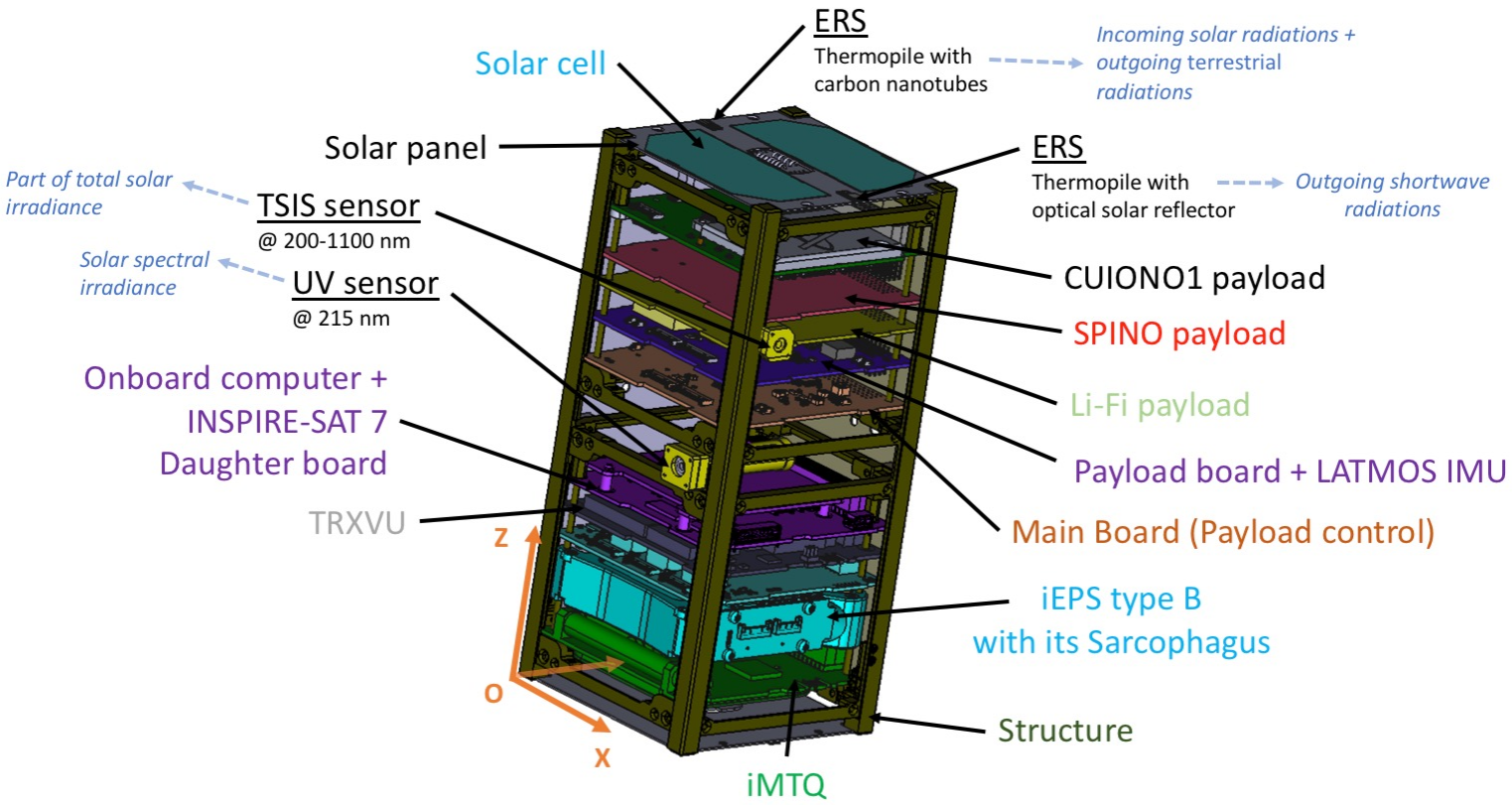
General objectives of Inspire-Sat 7

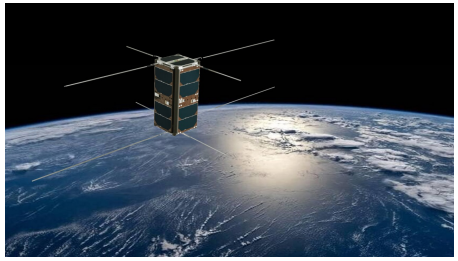
- **(1) Science** : **Earth observation, Climate physics, ERB, Solar physics, …**

- **(2) Education & outreach** : Satellite, Payload development, Software development, Training material.
  - Enable students to move towards Nanosat via start-ups in creation
  - Foster the emergence and development of start-ups in the Nanosat field
  - Make the space field more accessible to technicians
  - Create new vocations
  - Thinking about tomorrow's jobs
  - Promote the 'Space Academy of Île-de-France'

- **(3) Technology demonstration** : Satellite, Payload, Spectrometer, Telescope
  - Instruments miniaturization for Earth observations and solar physics
  - Instruments validation & satellites constellation validation for Earth observations
  - Validation of new low mass, low power and compact design instruments that incorporate artificial intelligence on future space flights
  - Facilitate collaboration with industrial partners
  - Amateur radio payload (SPINO)

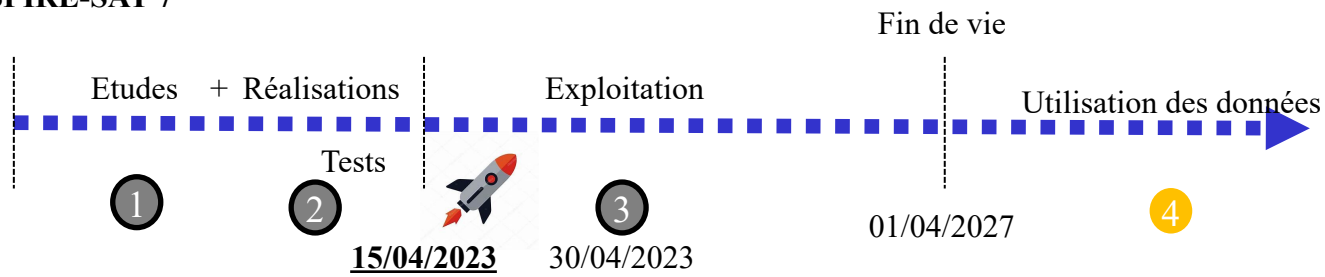
Inspire-Sat 7



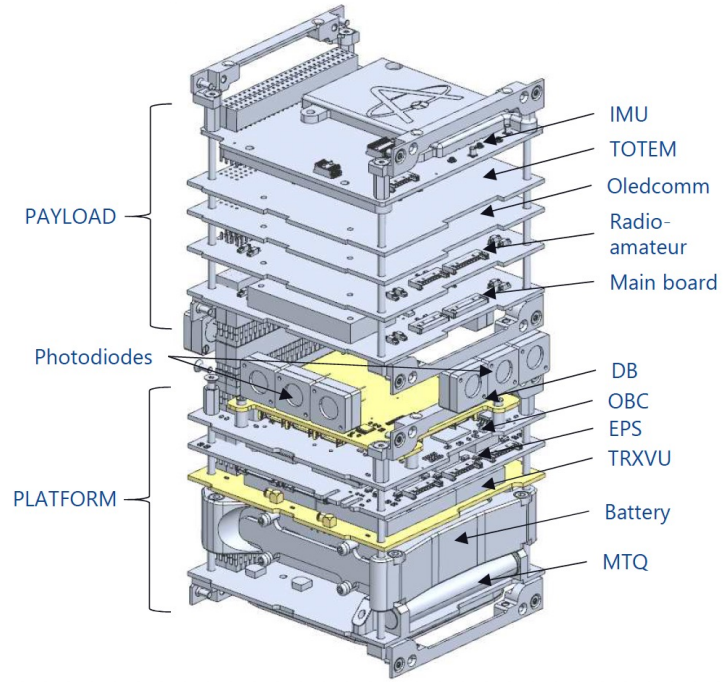


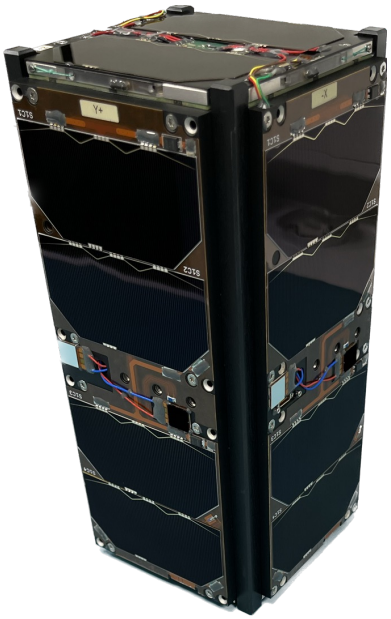
INSPIRE-SAT 7

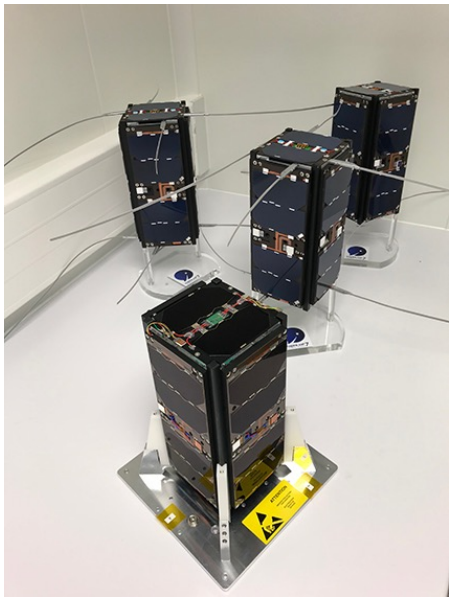
INSPIRE-SAT 7

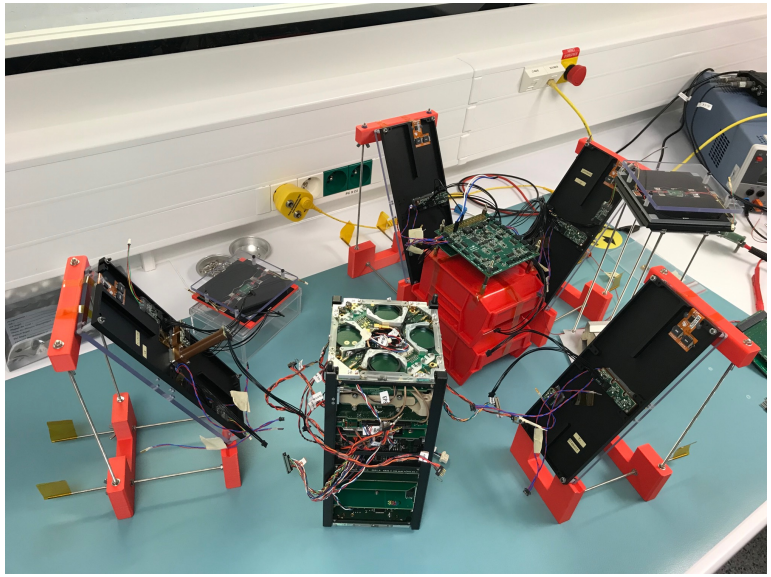


Inspire-Sat









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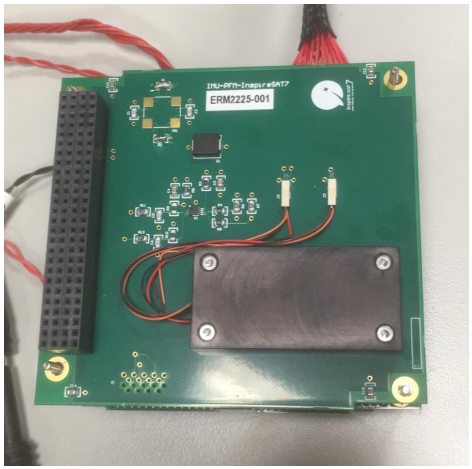
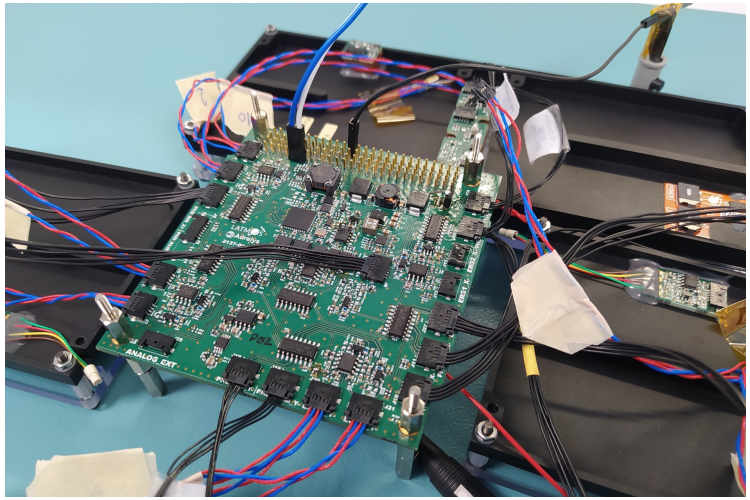
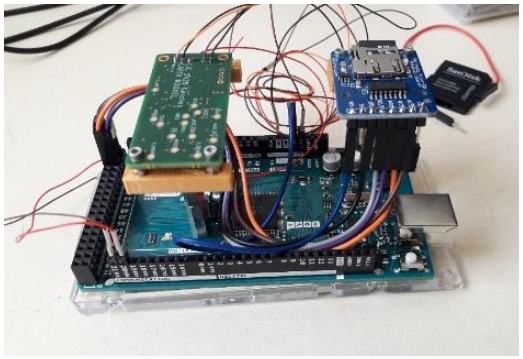
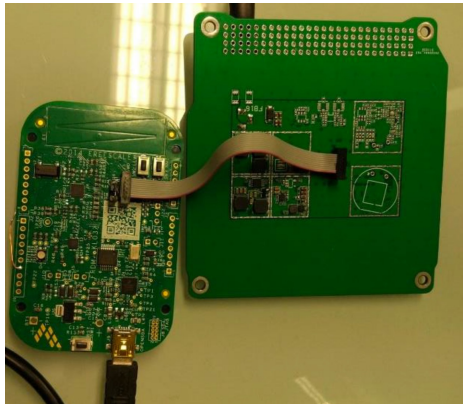
Inspire-Sat

- **(1) Space segment**







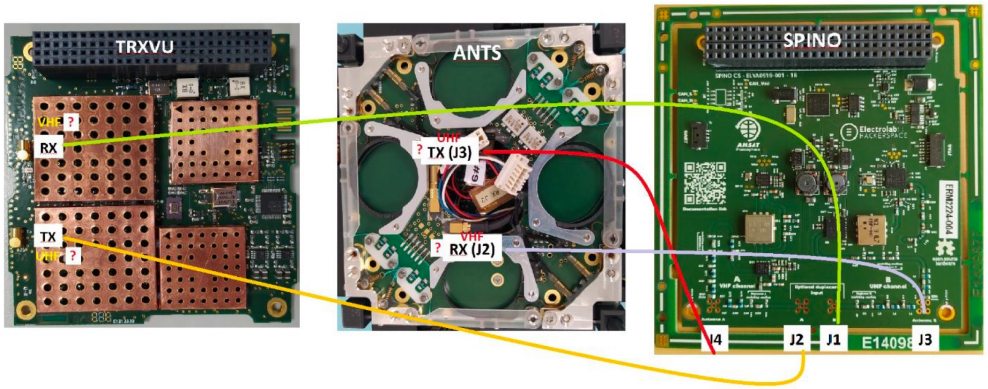


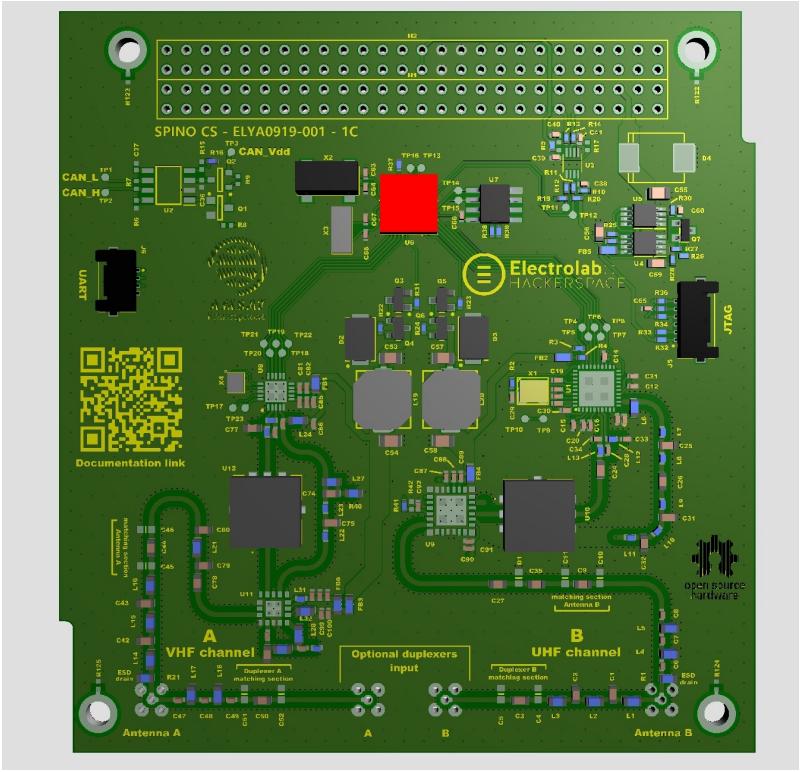
Inspire-Sat

SPINO

- Uplink : 145,830MHz
- Downlink : 435,200MHz

	Mode 1	Mode 2	Mode 3	Mode 4
	TX / RX	TX Only	TX Only	TX Only
Modulation	2FSK (no deviation filter)	2GFSK (gaussian deviation filter, BT=0.5)	4GFSK (gaussian deviation filter, BT=0.5)	4GFSK (gaussian deviation filter, BT=0.5)
Datarate	2400bits/s	9600bits/s	10800bits/s	12800bits/s
Deviation	1200Hz	4800Hz (+/-4800Hz, meaning modulation index is 1)	4212Hz (+/-4212Hz, meaning modulation index is 0.78)	2880Hz (+/-2880Hz, meaning modulation index is 0.45)
Preamble	16x "0xAA"			
Sync Word (32bits)	0x2EFC9827			
Payload length	240 Byte			





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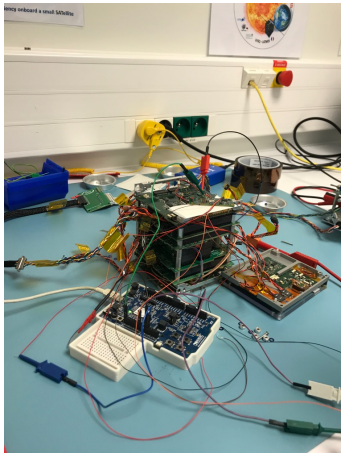

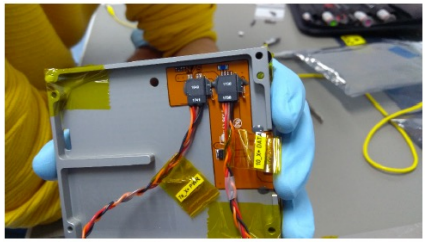


Bouygues 4G
14:41
32 %
Inspire-Sat


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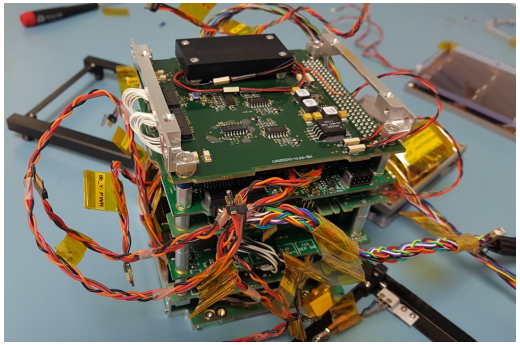
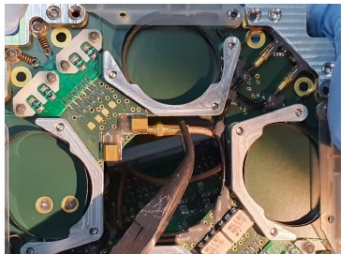
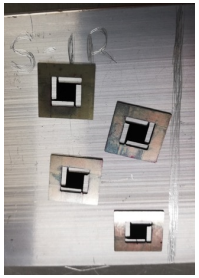
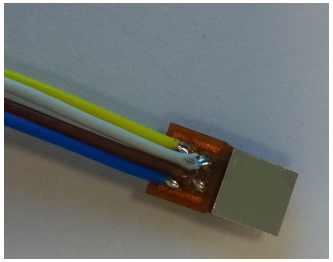
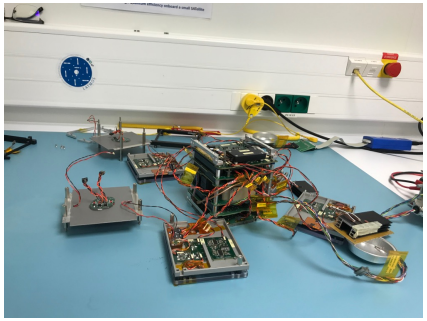
www.latmos.ipsl.fr
France
étages











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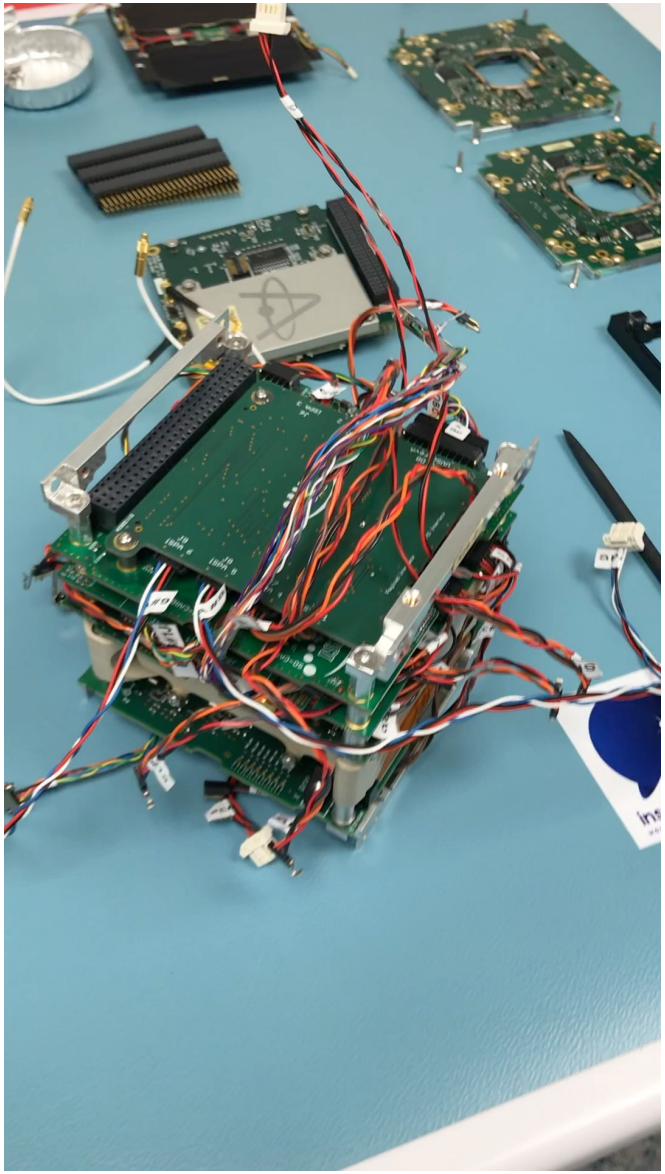

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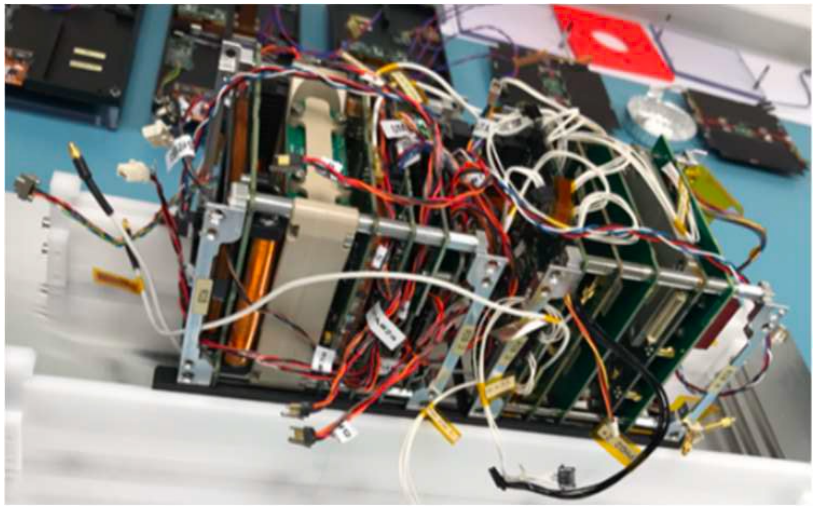

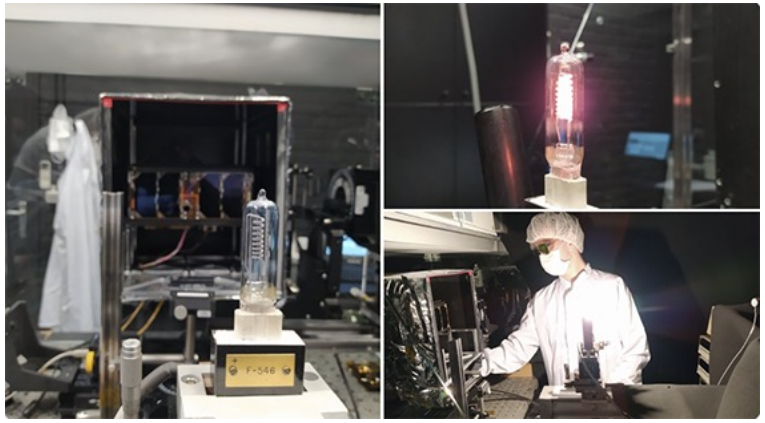

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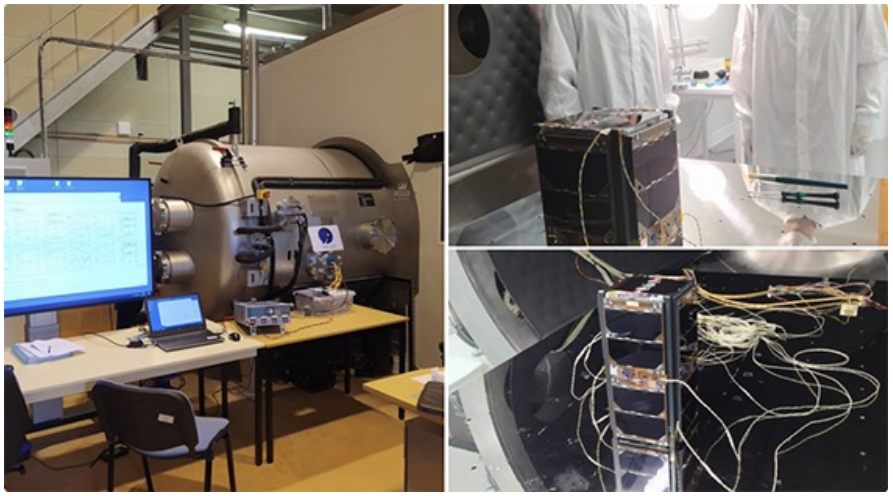

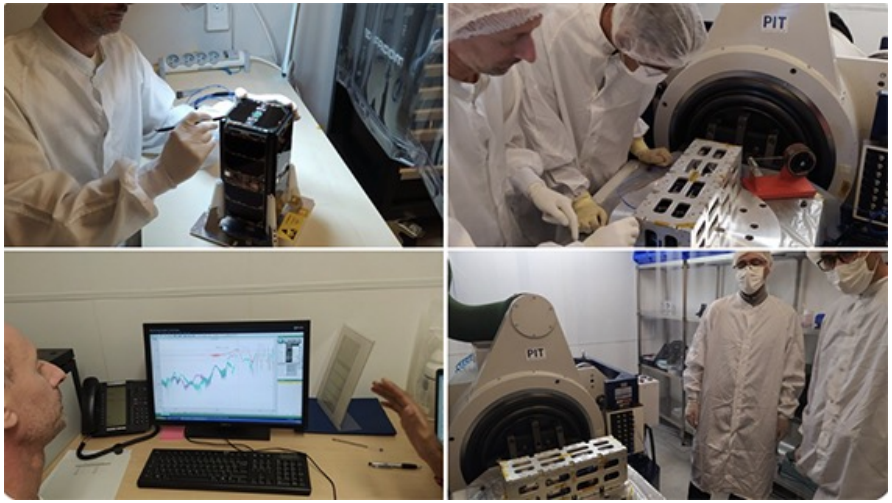

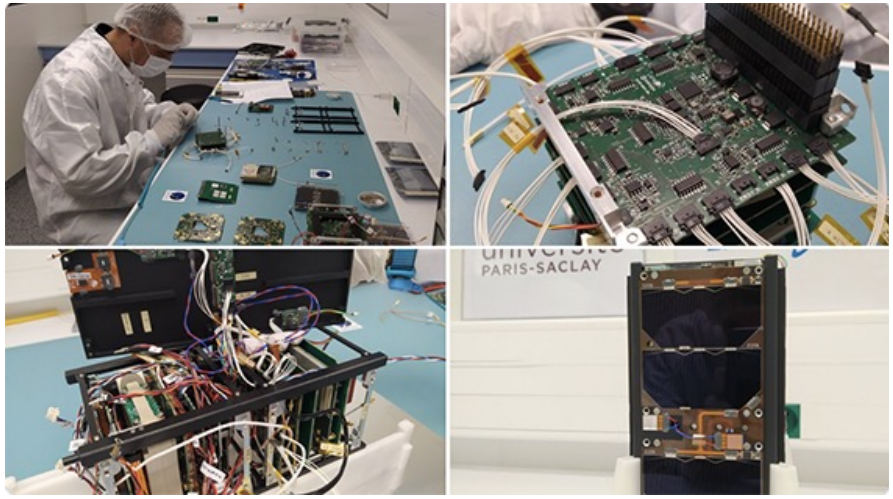

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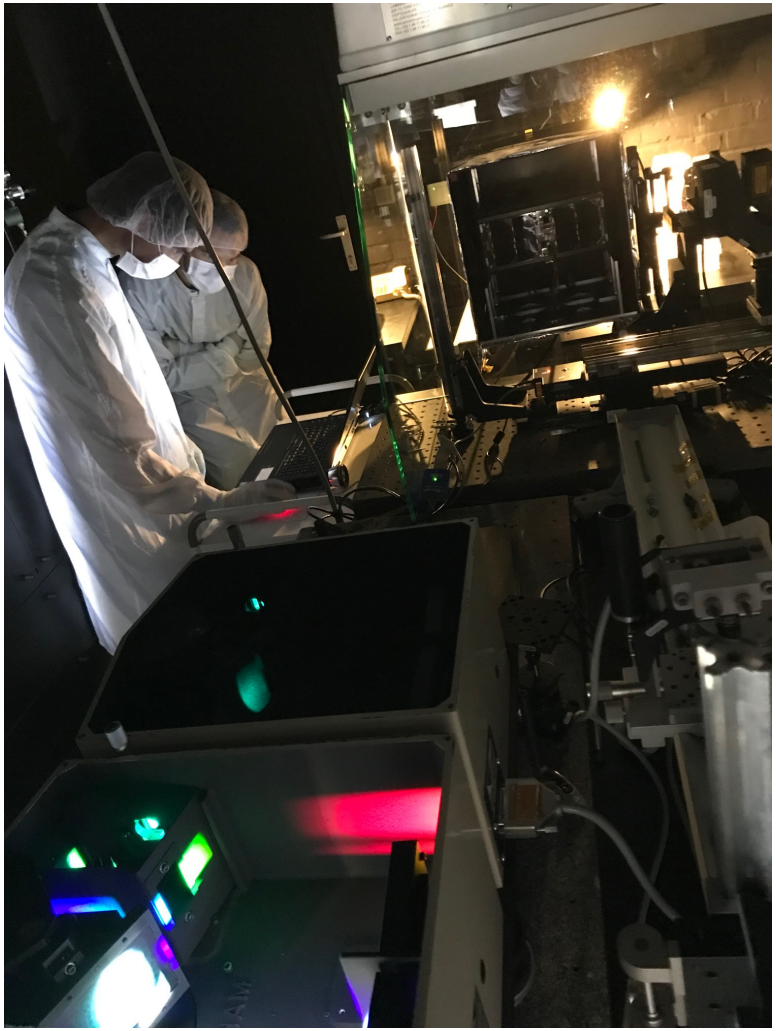

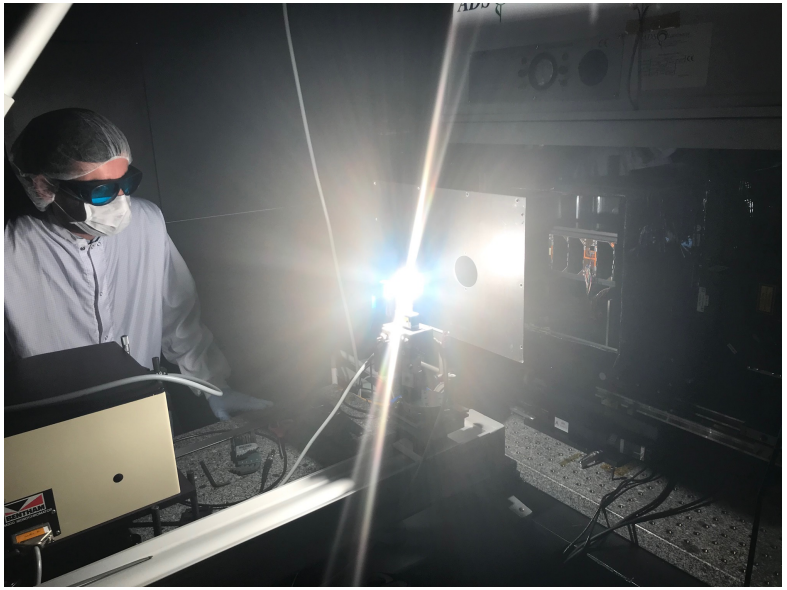

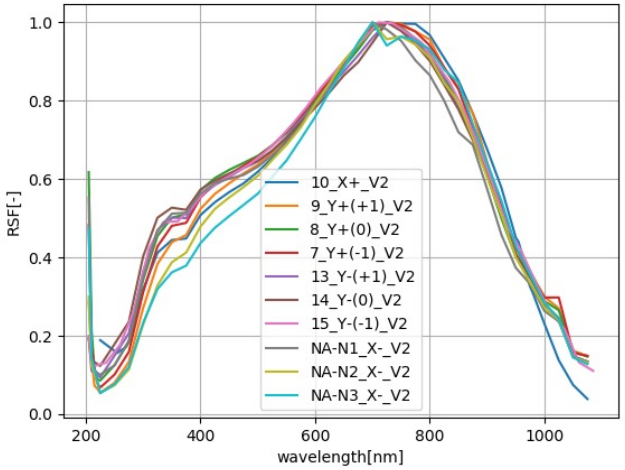
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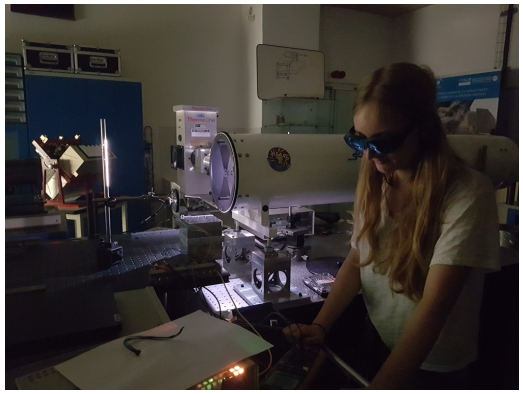
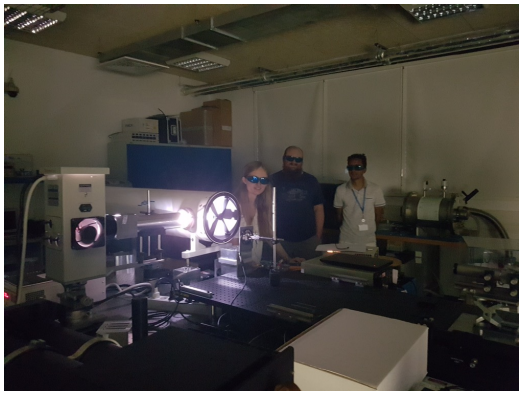
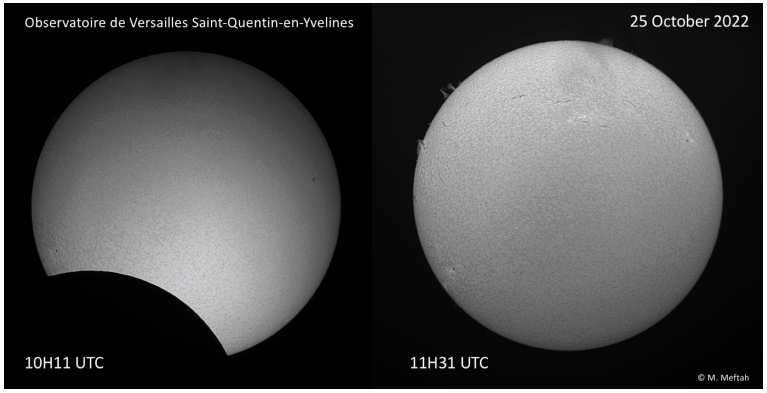
wavelength[nm]
1.0
0.8
0.6
0.4
0.2
0.0
200
400
600
800
1000
10_X+_V2
9_Y+(+1)_V2
8_Y+(0)_V2
7_Y+(-1)_V2
13_Y-(+1)_V2
14_Y-(0)_V2
15_Y-(-1)_V2
NA-N1_X-_V2
NA-N2_X-_V2
NA-N3_X-_V2

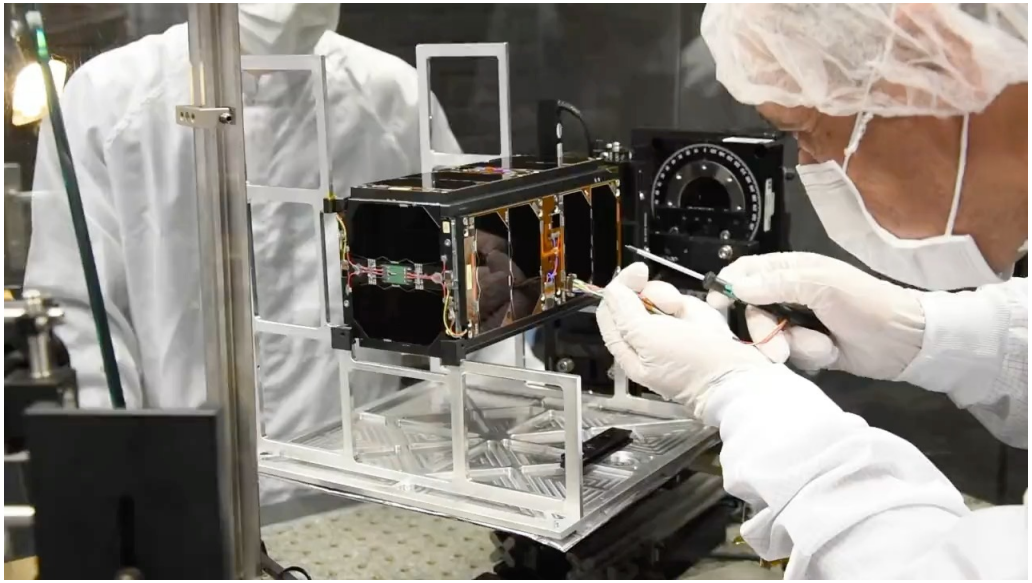
Inspire-Sat

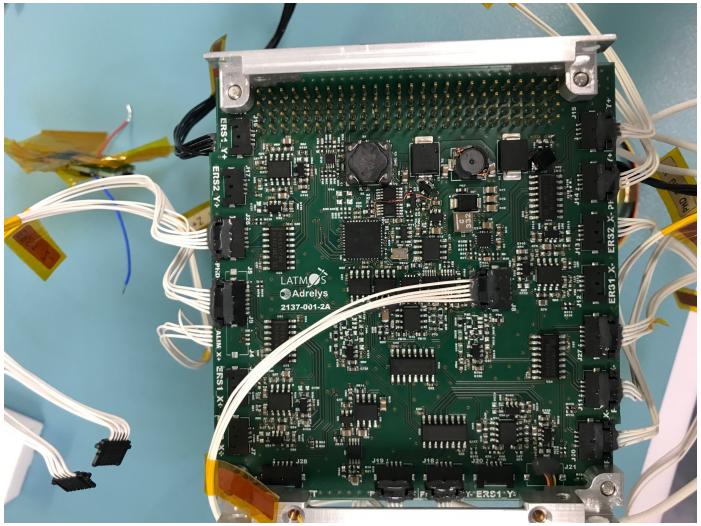





Observatoire de Versailles Saint-Quentin-en-Yvelines
25 October 2022
10H11 UTC
11H31 UTC
© M. Meftah

Inspire-Sat

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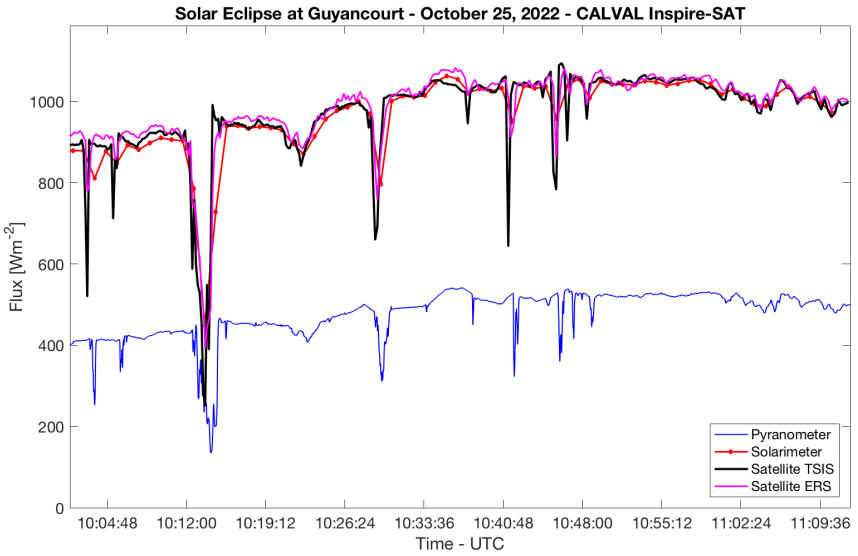

Solar Eclipse at Guyancourt - October 25, 2022 - CALVAL Inspire-SAT
Flux [Wm-2]
0
200
400
600
800
1000
10:04:48
10:12:00
10:19:12
10:26:24
10:33:36
10:40:48
10:48:00
10:55:12
11:02:24
11:09:36
Time - UTC
Pyranometer
Solarimeter
Satellite TSIS
Satellite ERS

Inspire-Sat

- **(2) Ground segment – MOC**

Inspire-Sat

Inspire-Sat

Operator

User

TM

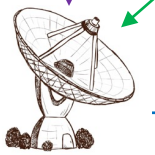
Rotors Az./El.
G5500

Controller
G5500

Driver
GS-232B

Orbito software
SatPC32.exe
(or Gpredict.exe)

Sharing disk
(LATMOS server)



UHF

Low Noise Amplifier
SP-70

UHF Band Pass Filter

Splitter
ZFSC-8-43-S+

RTL-SDR
Nooelec

Multi-Software chain
BPSK G3RUH 9600 bps
VB-Cable, SDR#, SoundModem, AMSAT-F KissTool

Multi-Software chain
BPSB G3RUH 1200 bps
VB-Cable, SDR#, SoundModem, AMSAT-F KissTool

Load 1W (or other decoding chain)

Configuration:

- **Frequency = 437.410 MHz**
- Demodulation = BPSK
- De-scrambling = G3RUH
- Baud rate = ~~1200~~, 9600

Inspire-Sat

Web-Relay

220V

GUI for TC configuration
-
RemoteUVSQSAT.exe
Version 0.98

ON/OFF

TLE, Frequency, TC, …

TC

Operator
Inside/Outside LATMOS

Web

Audio

Tx rack « SDR Node GS »
(SDR-Technologies)
(Nano-computer, radio, VHF filter)

VHF

Pré-amplifier
ZHL-3010+

Power Amplifier (50W)
ZHL-50W-52-S+

TS2000
(Transponder test)

VHF

UHF

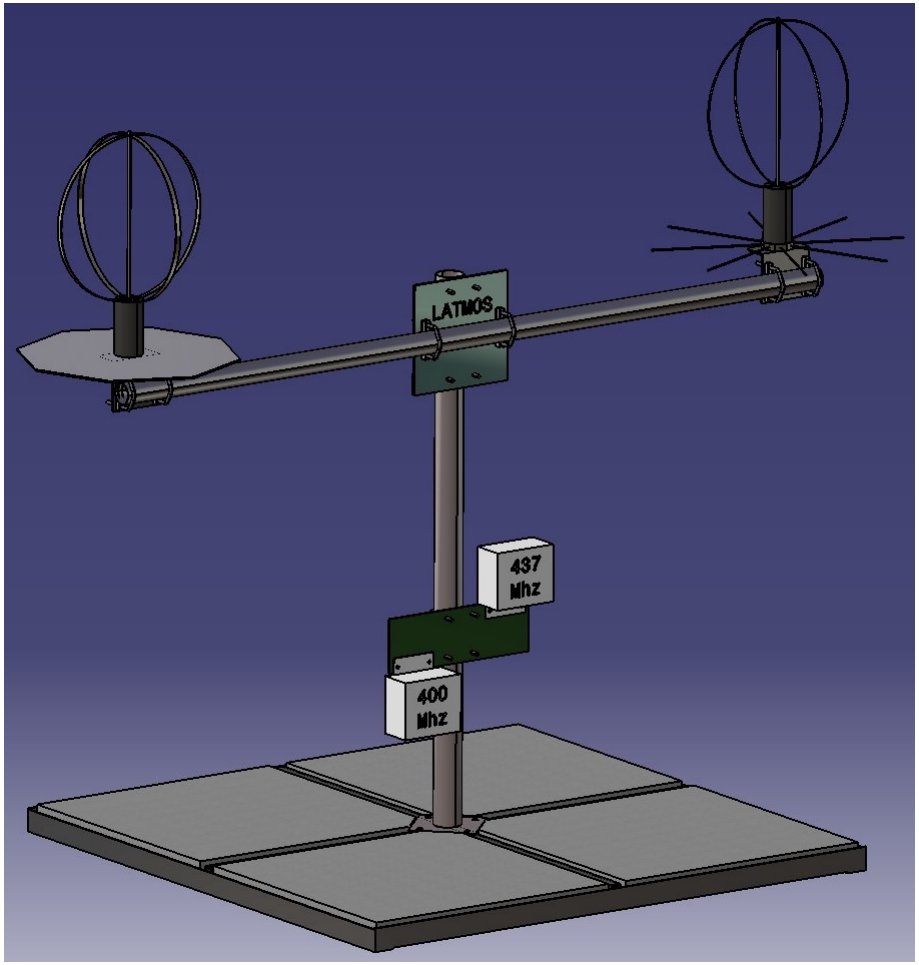
Coaxial Load (TWL-50)

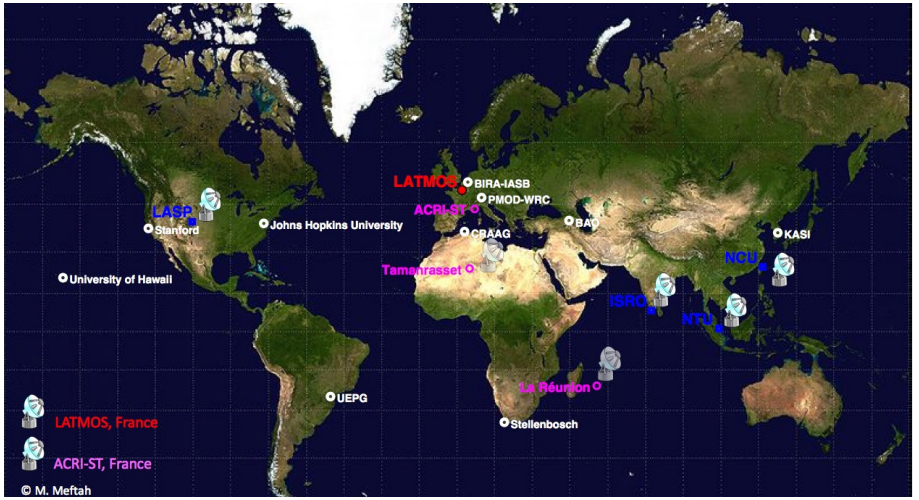
Switch
(Delta2)

Configuration of the coding :

- Frequency = 145.970 MHz
- Modulation = FSK
- Scrambling = G3RUH
- Baud rate = 9600

Inspire-Sat


LATMOS
437
Mhz
400
Mhz


LATMOS
BIRA-IASB
PMOD-WRC
ACRI-ST
LASP
Stanford
Johns Hopkins University
BAO
CRAAG
KASI
NCU
Tamanrasset
University of Hawaii
ISRO
NTU
La Réunion
UEPG
Stellenbosch
LATMOS, France
ACRI-ST, France
© M. Meftah


SDRNode
GS400

Inspire-Sat

❑ (3) Ground segment – SOC

1) SOC

- Database InfluxDB
- Treatments (L0, L1, L2…)
- Grafana
- Automation

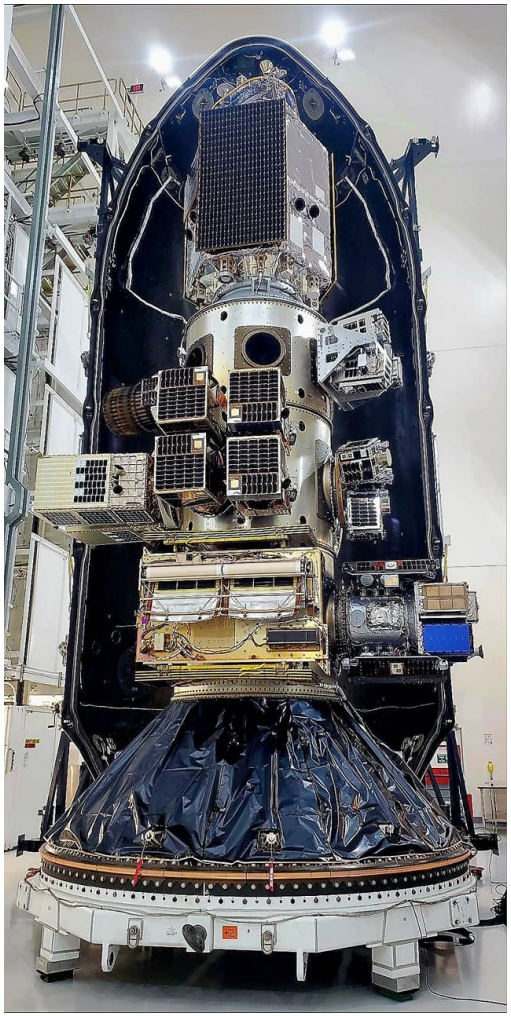
2) External access (≠ official website) :

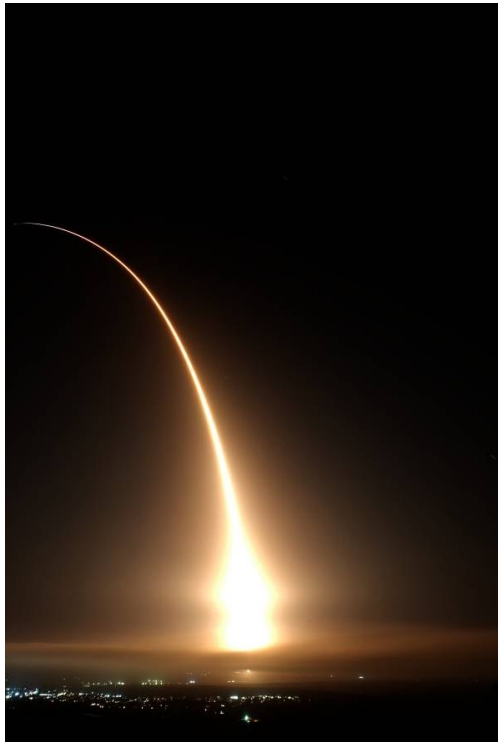
- sFTP (json files)
- Web (SIDS+ Quickview + NEW: Pictures)
- Database MySQL

3) Developpements and tests

Inspire-Sat

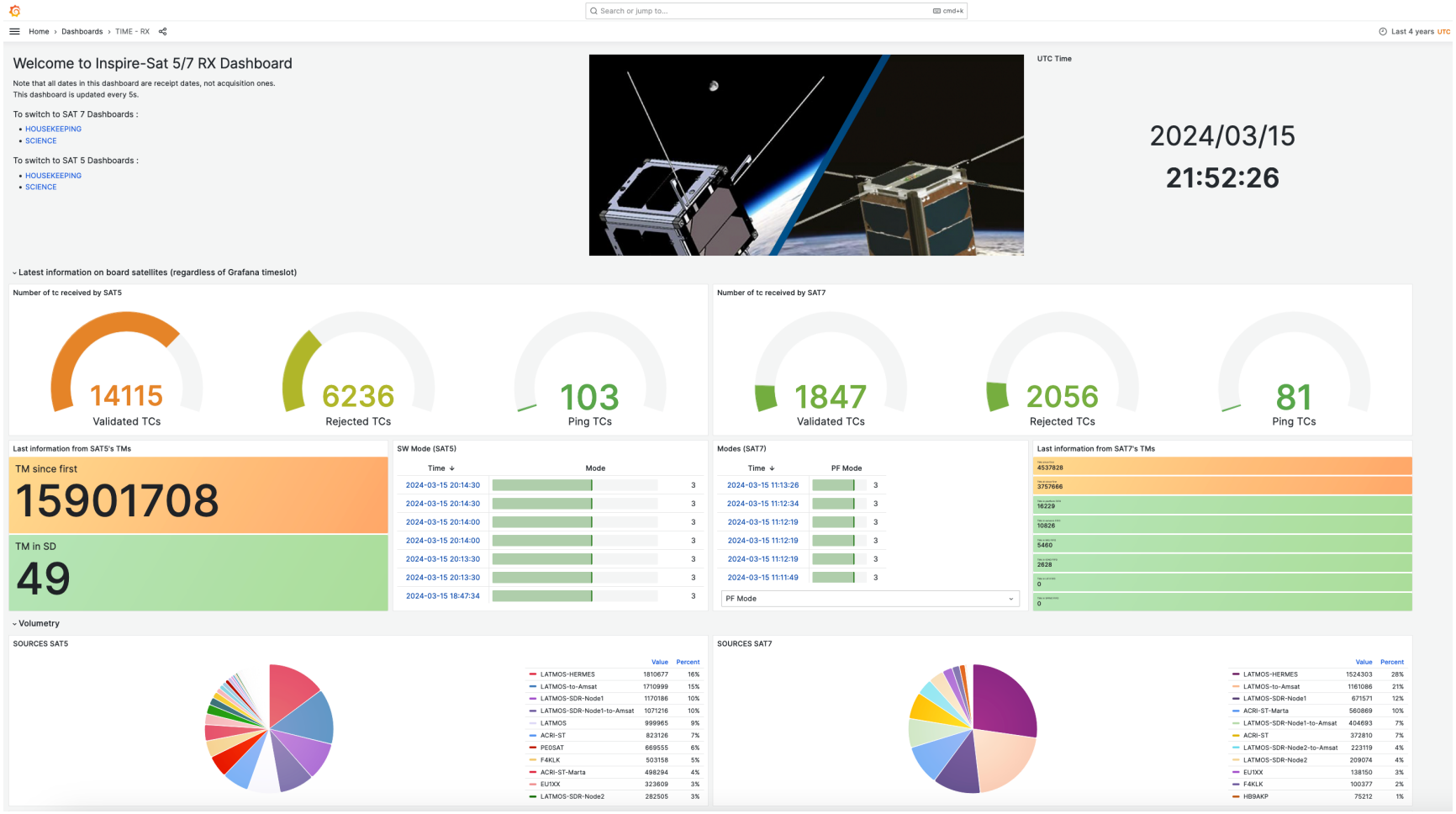
- **Launch with Transporter 7 – 15 April 2023**



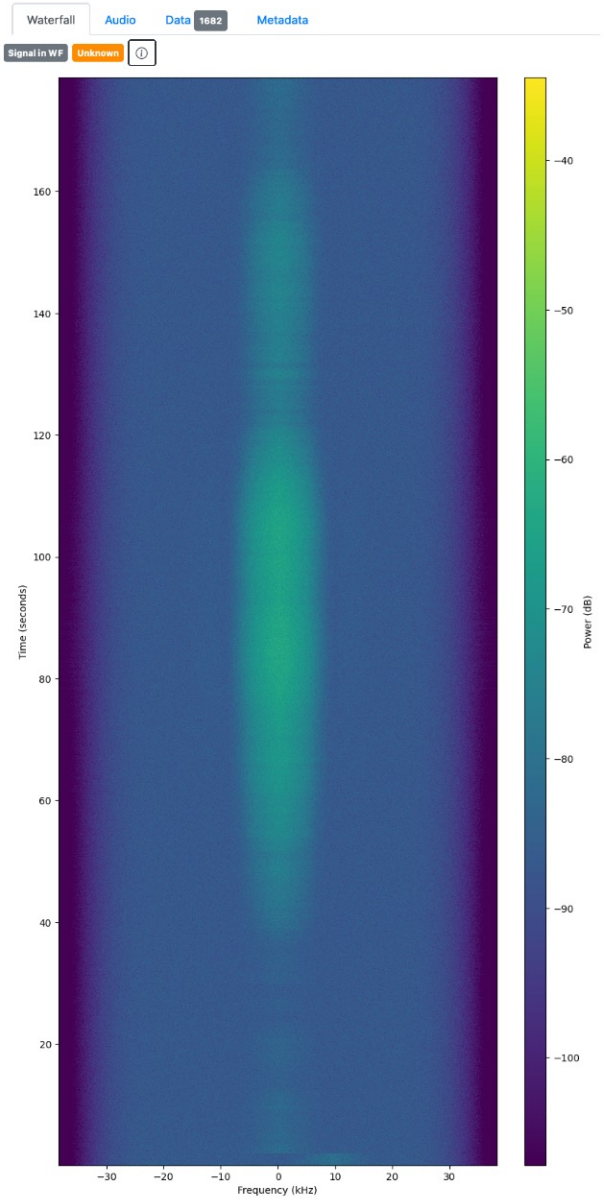


Inspire-Sat

Inspire-Sat

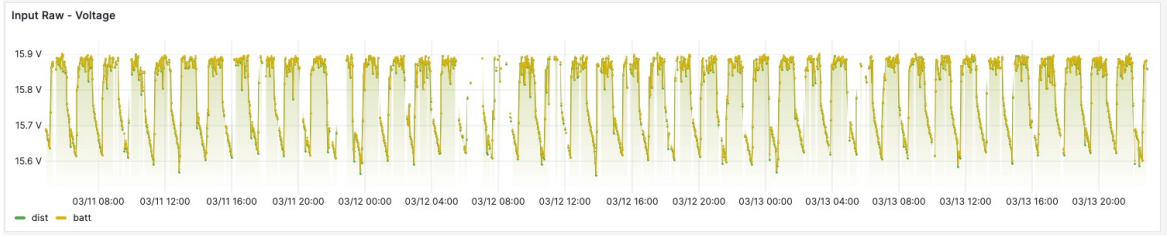

Search or jump to... cmd+k
Home › Dashboards › TIME - RX
Last 4 years UTC
Welcome to Inspire-Sat 5/7 RX Dashboard
Note that all dates in this dashboard are receipt dates, not acquisition ones.
This dashboard is updated every 5s.
To switch to SAT 7 Dashboards :
• HOUSEKEEPING
• SCIENCE
To switch to SAT 5 Dashboards :
• HOUSEKEEPING
• SCIENCE
UTC Time
2024/03/15
21:52:26
Latest information on board satellites (regardless of Grafana timeslot)
Number of tc received by SAT5
14115
Validated TCs
6236
Rejected TCs
103
Ping TCs
Number of tc received by SAT7
1847
Validated TCs
2056
Rejected TCs
81
Ping TCs
Last information from SAT5's TMs
TM since first
15901708
TM in SD
49
SW Mode (SAT5)
Time
Mode
2024-03-15 20:14:30 3
2024-03-15 20:14:30 3
2024-03-15 20:14:00 3
2024-03-15 20:14:00 3
2024-03-15 20:13:30 3
2024-03-15 20:13:30 3
2024-03-15 18:47:34 3
Modes (SAT7)
Time
PF Mode
2024-03-15 11:13:26 3
2024-03-15 11:12:34 3
2024-03-15 11:12:19 3
2024-03-15 11:12:19 3
2024-03-15 11:12:19 3
2024-03-15 11:11:49 3
PF Mode
Last information from SAT7's TMs
4537828
3757666
16229
10826
5460
2628
0
0
Volumetry
SOURCES SAT5
Value Percent
LATMOS-HERMES 1810677 16%
LATMOS-to-Amsat 1710999 15%
LATMOS-SDR-Node1 1170186 10%
LATMOS-SDR-Node1-to-Amsat 1071216 10%
LATMOS 999965 9%
ACRI-ST 823126 7%
PEOSAT 669555 6%
F4KLK 503158 5%
ACRI-ST-Marta 498294 4%
EU1XX 323609 3%
LATMOS-SDR-Node2 282505 3%
SOURCES SAT7
Value Percent
LATMOS-HERMES 1524303 28%
LATMOS-to-Amsat 1161086 21%
LATMOS-SDR-Node1 671571 12%
ACRI-ST-Marta 560869 10%
LATMOS-SDR-Node1-to-Amsat 404693 7%
ACRI-ST 372810 7%
LATMOS-SDR-Node2-to-Amsat 223119 4%
LATMOS-SDR-Node2 209074 4%
EU1XX 138150 3%
F4KLK 100377 2%
HB9AKP 75212 1%

Inspire-Sat

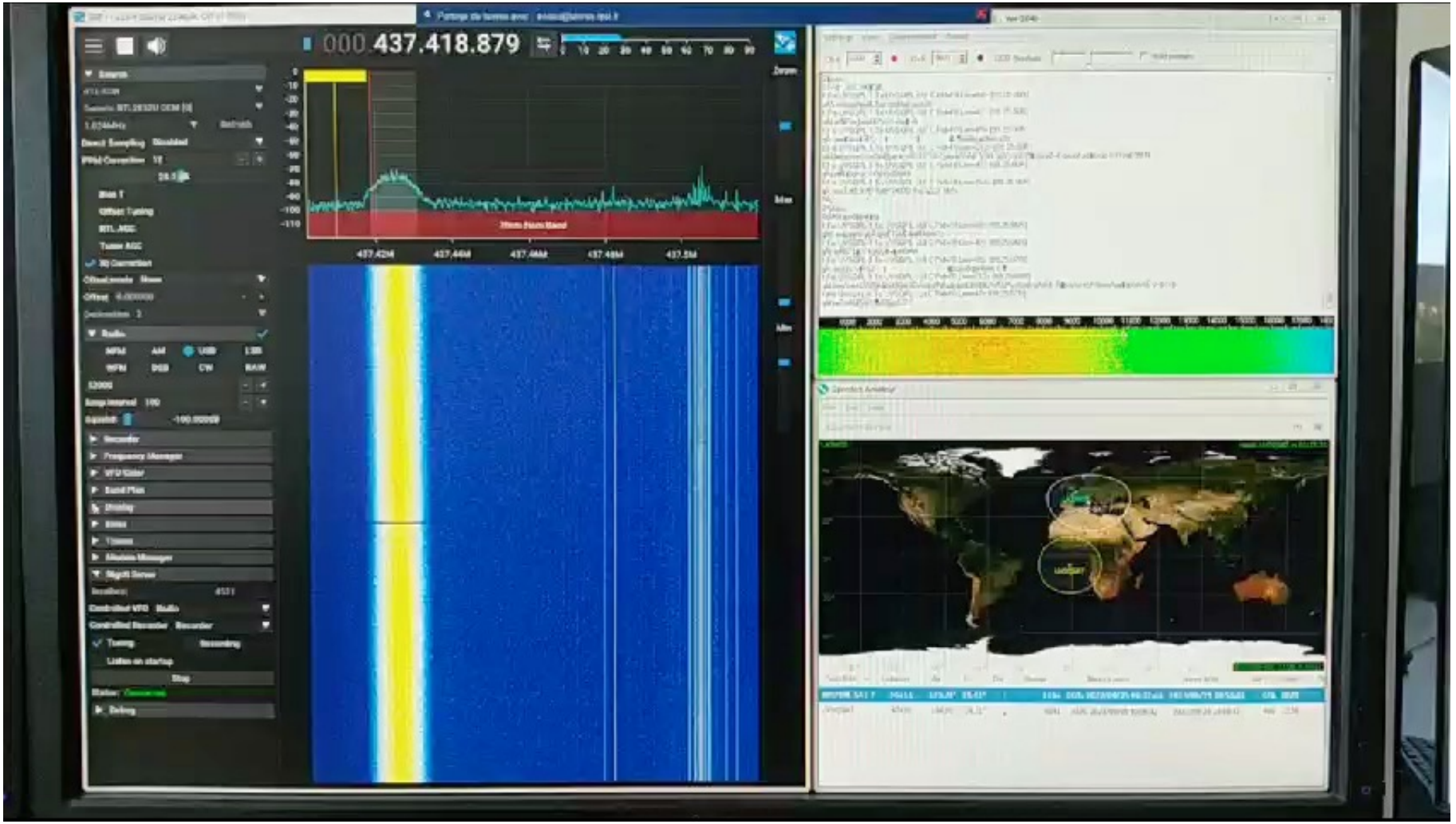

Waterfall
Audio
Data 1682
Metadata
Signal in WF
Unknown
Time (seconds)
Frequency (kHz)
Power (dB)


IOBC Temperature
20 °C
15 °C
10 °C
5 °C
0 °C
-5 °C
-10 °C
03/11 08:00
03/11 12:00
03/11 16:00
03/11 20:00
03/12 00:00
03/12 04:00
03/12 08:00
03/12 12:00
03/12 16:00
03/12 20:00
03/13 00:00
03/13 04:00
03/13 08:00
03/13 12:00
03/13 16:00
03/13 20:00

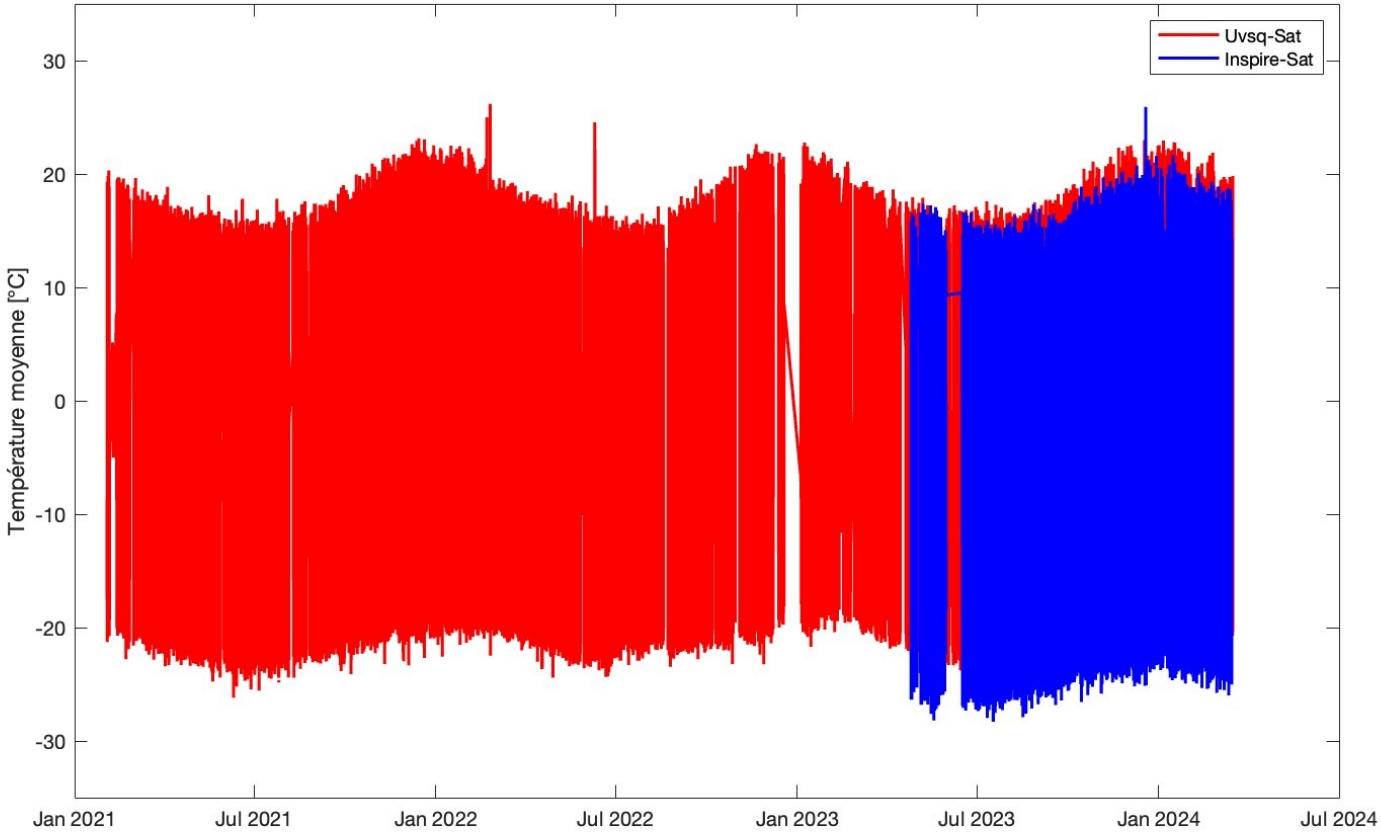

Input Raw - Power
4 W
2 W
0 W
-2 W
-4 W
dist
batt


Input Raw - Voltage
15.9 V
15.8 V
15.7 V
15.6 V
dist
batt

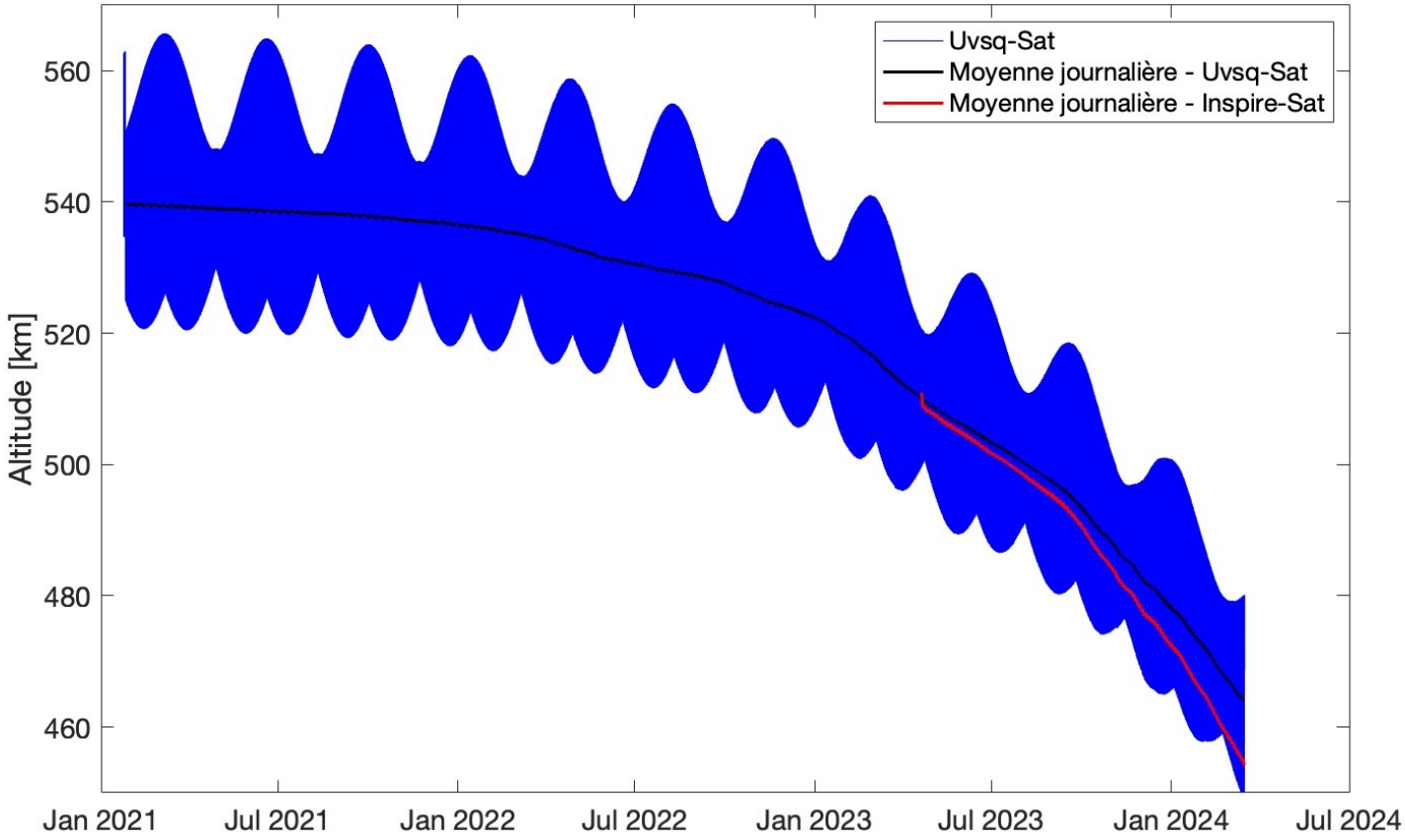
Inspire-Sat



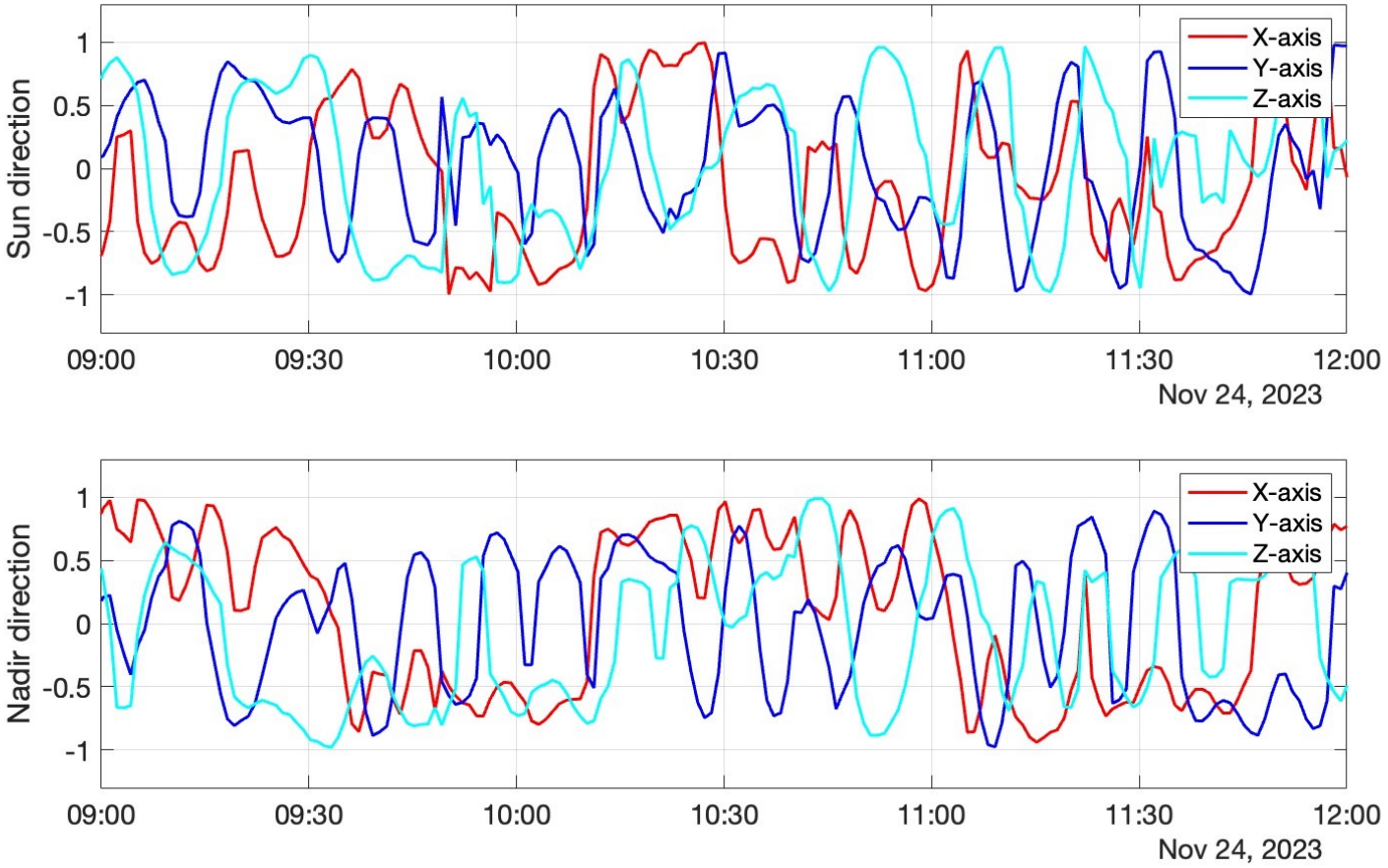
Inspire-Sat


Uvsq-Sat
Inspire-Sat
Température moyenne [°C]
30
20
10
0
-10
-20
-30
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Jan 2024
Jul 2024

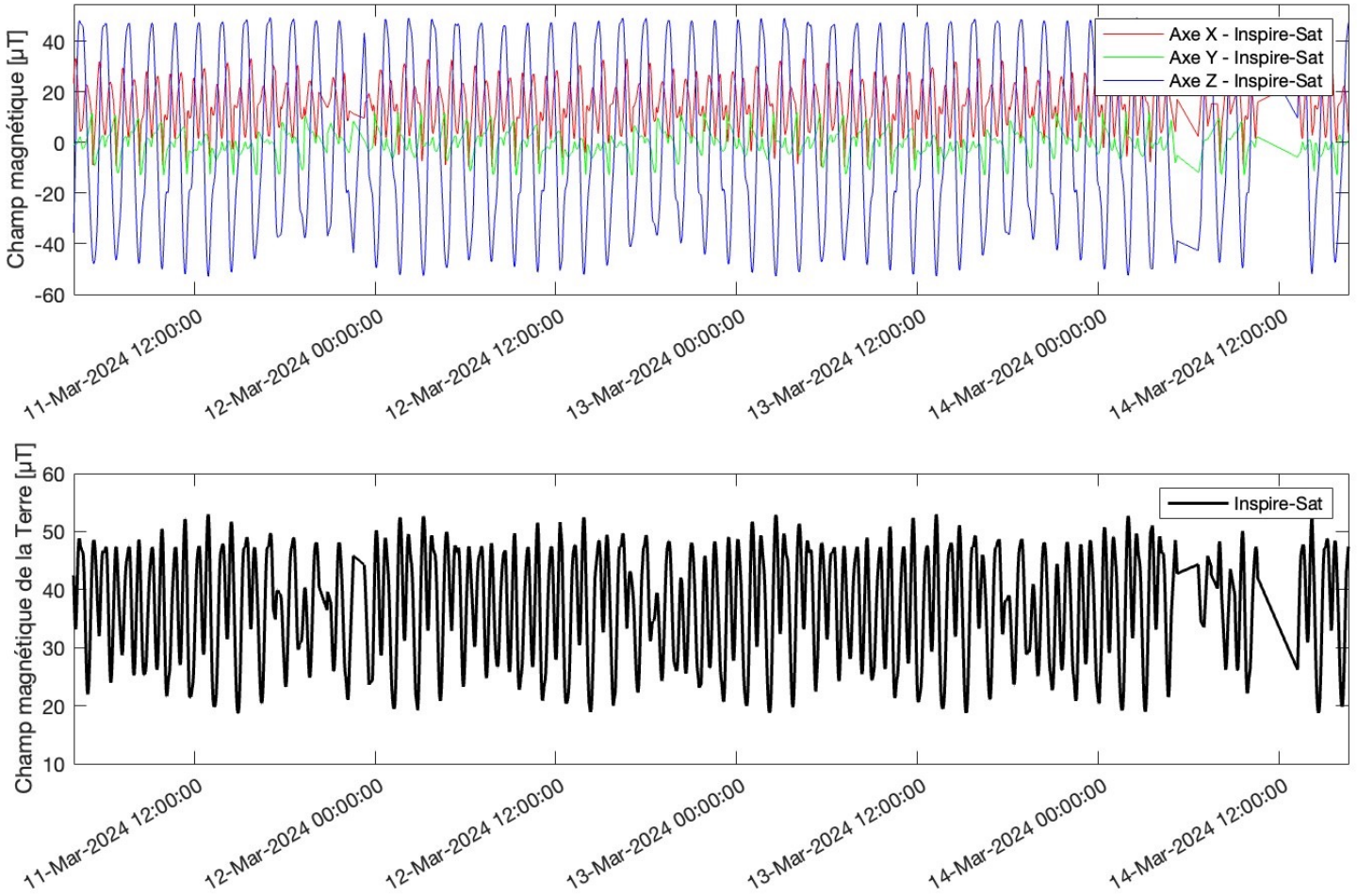
Inspire-Sat


Uvsq-Sat
Moyenne journalière - Uvsq-Sat
Moyenne journalière - Inspire-Sat
Altitude [km]
560
540
520
500
480
460
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Jan 2024
Jul 2024

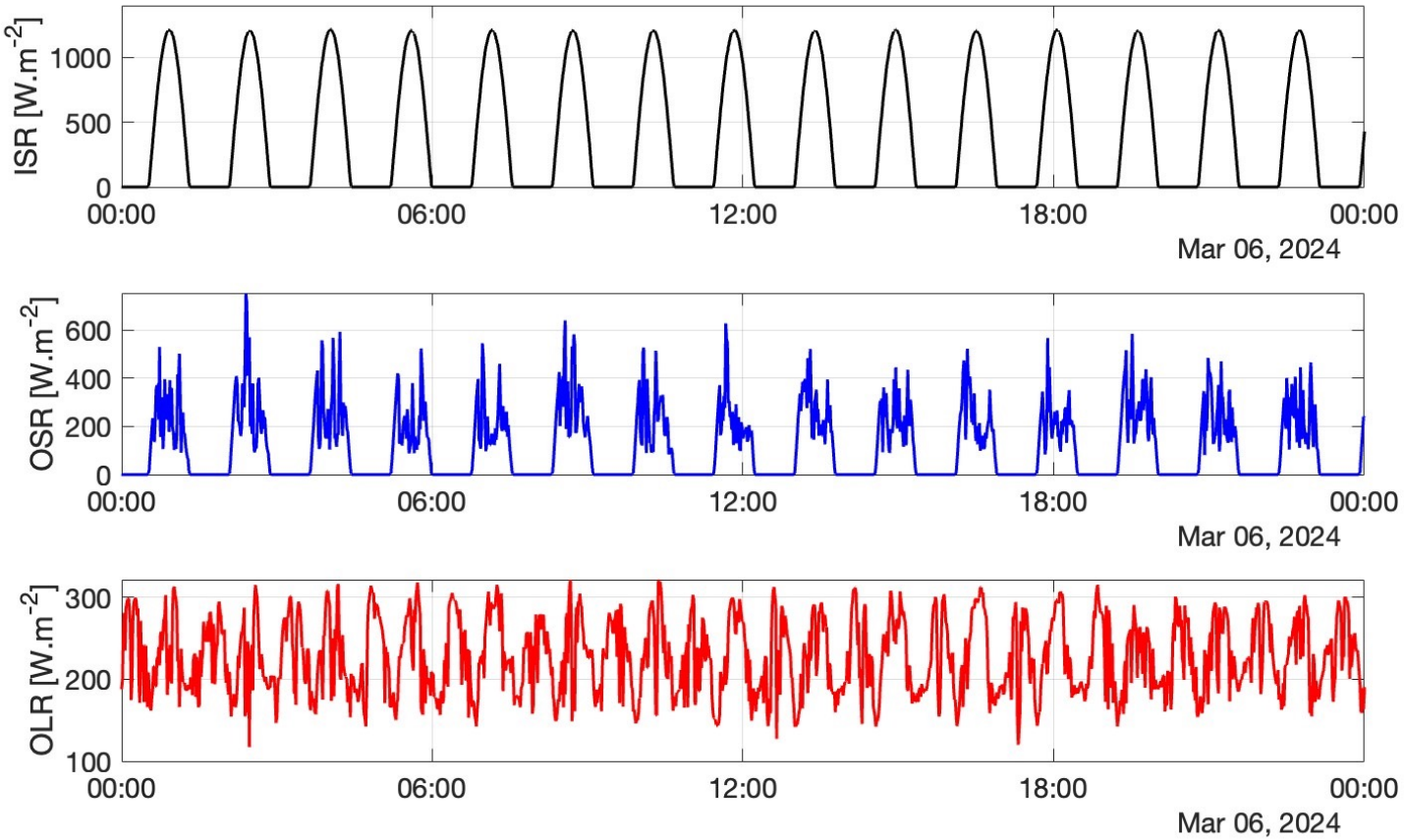
Inspire-Sat


Sun direction
1
0.5
0
-0.5
-1
09:00
09:30
10:00
10:30
11:00
11:30
12:00
Nov 24, 2023
X-axis
Y-axis
Z-axis
Nadir direction
1
0.5
0
-0.5
-1
09:00
09:30
10:00
10:30
11:00
11:30
12:00
Nov 24, 2023
X-axis
Y-axis
Z-axis

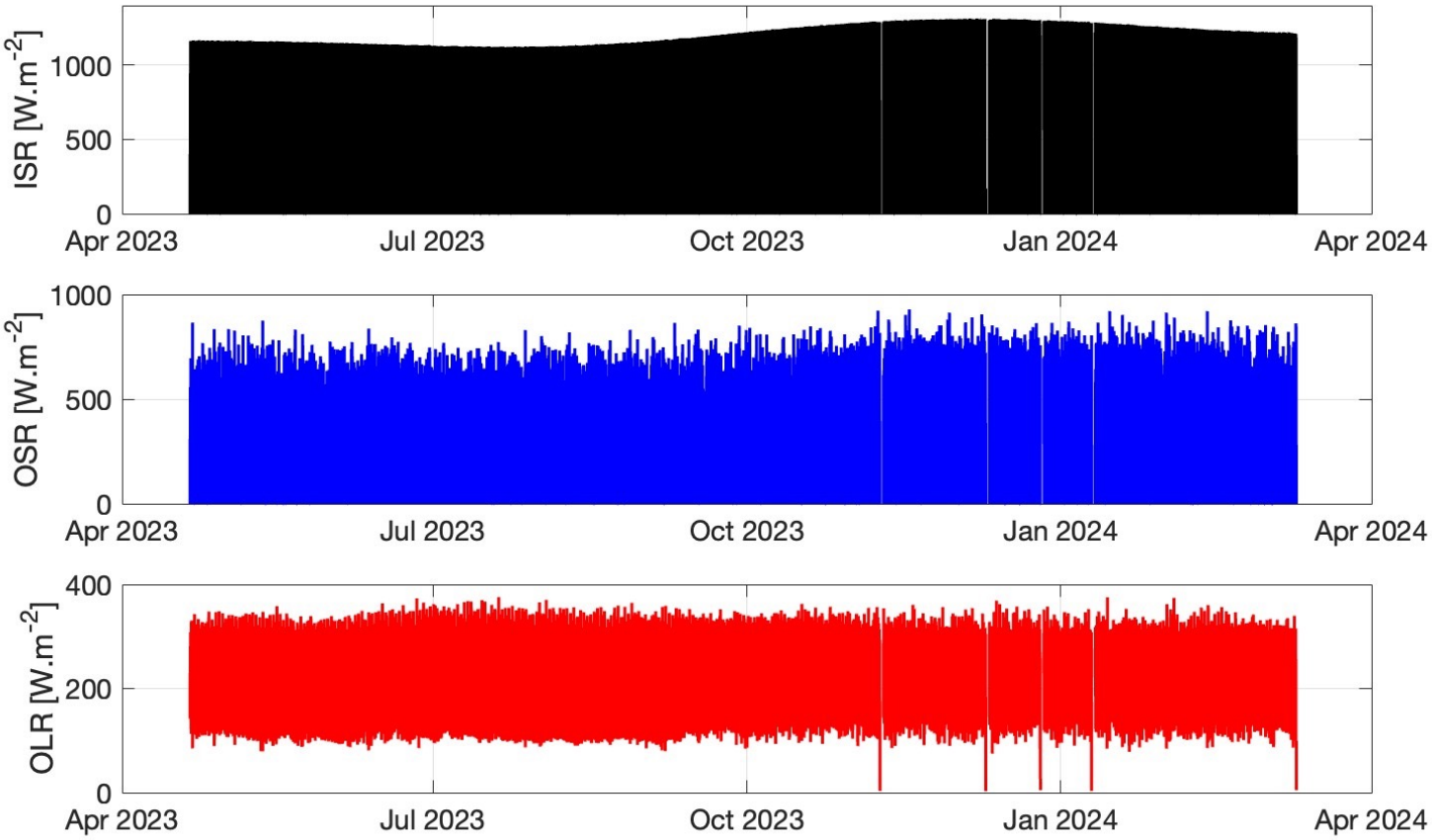
Inspire-Sat


Champ magnétique [µT]
40
20
0
-20
-40
-60
Axe X - Inspire-Sat
Axe Y - Inspire-Sat
Axe Z - Inspire-Sat
11-Mar-2024 12:00:00
12-Mar-2024 00:00:00
12-Mar-2024 12:00:00
13-Mar-2024 00:00:00
13-Mar-2024 12:00:00
14-Mar-2024 00:00:00
14-Mar-2024 12:00:00
Champ magnétique de la Terre [µT]
60
50
40
30
20
10
Inspire-Sat
11-Mar-2024 12:00:00
12-Mar-2024 00:00:00
12-Mar-2024 12:00:00
13-Mar-2024 00:00:00
13-Mar-2024 12:00:00
14-Mar-2024 00:00:00
14-Mar-2024 12:00:00

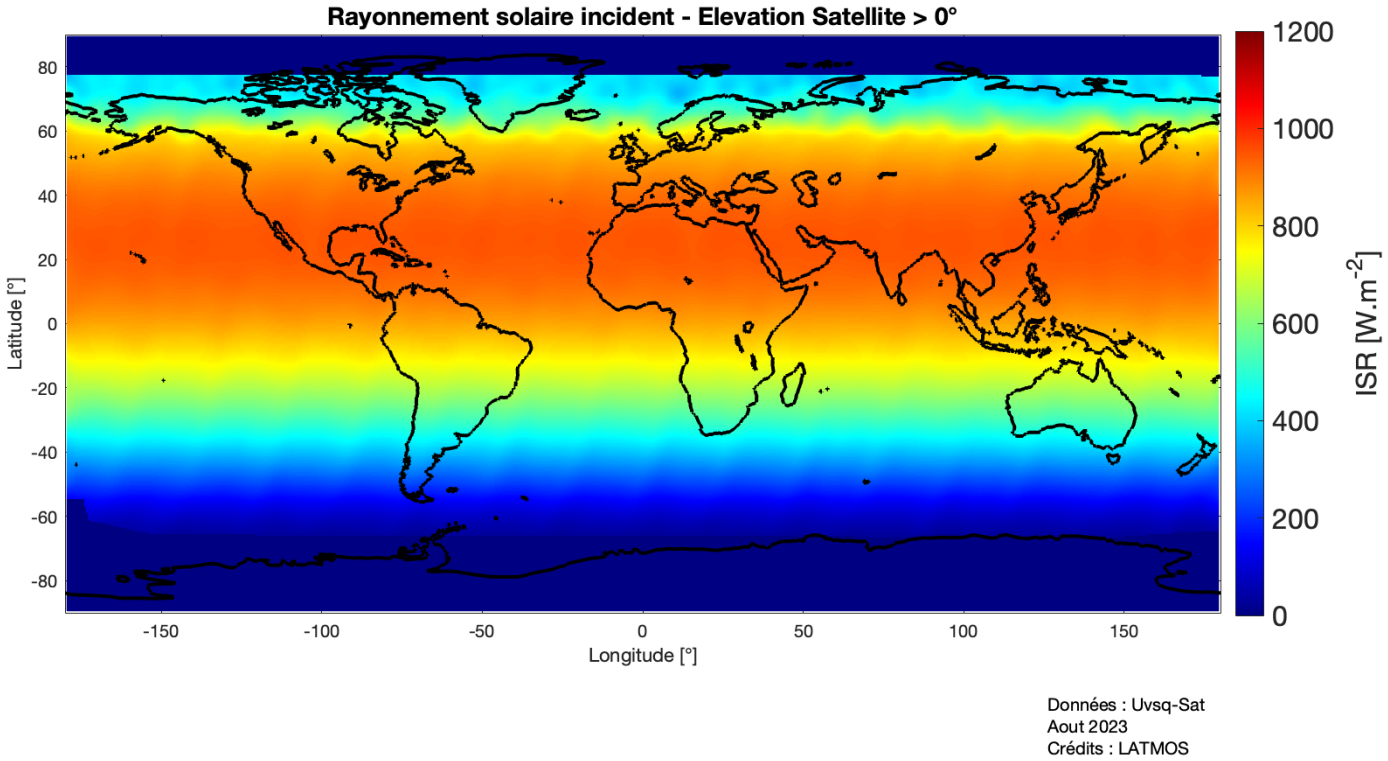
Inspire-Sat


ISR [W.m-2]
1000
500
0
00:00
06:00
12:00
18:00
00:00
Mar 06, 2024
OSR [W.m-2]
600
400
200
0
00:00
06:00
12:00
18:00
00:00
Mar 06, 2024
OLR [W.m-2]
300
200
100
00:00
06:00
12:00
18:00
00:00
Mar 06, 2024

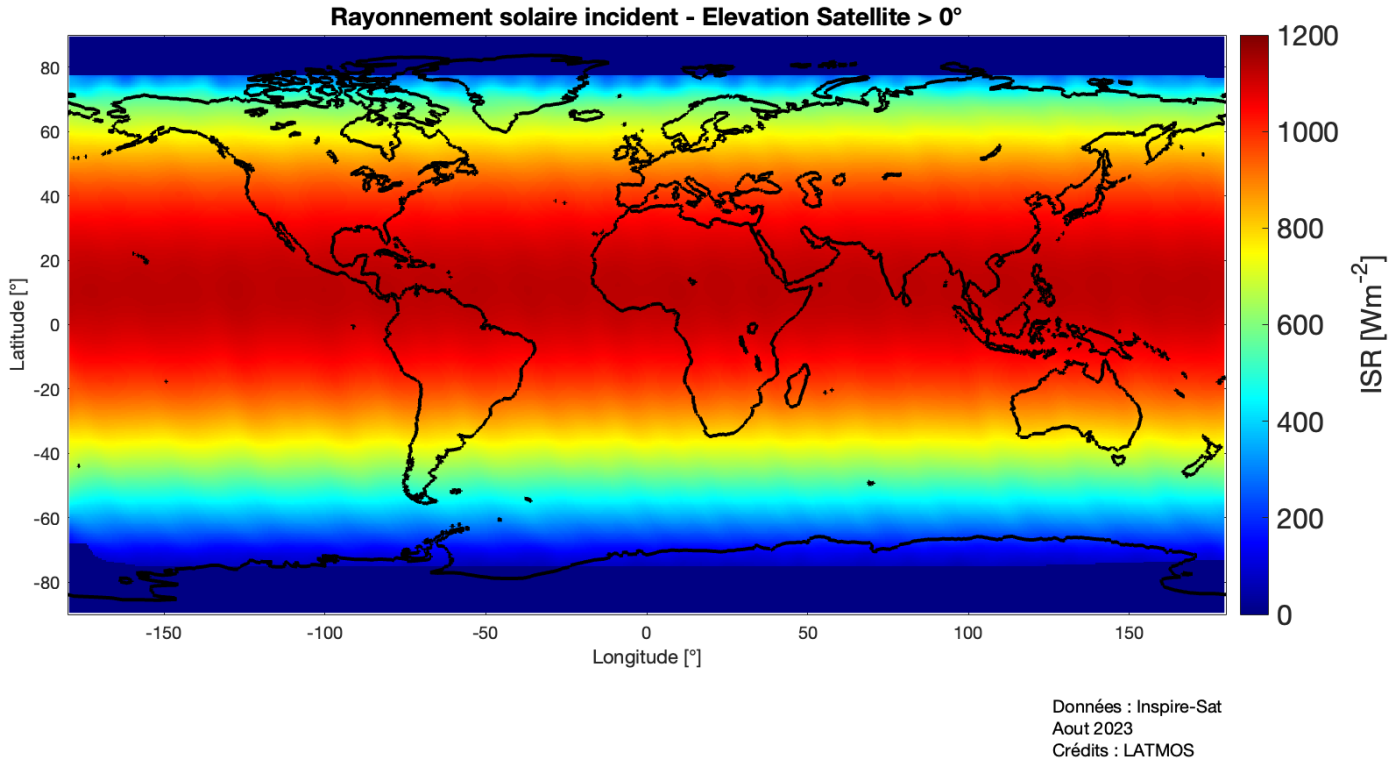
Inspire-Sat


ISR [W.m-2]
1000
500
0
Apr 2023
Jul 2023
Oct 2023
Jan 2024
Apr 2024
OSR [W.m-2]
1000
500
0
Apr 2023
Jul 2023
Oct 2023
Jan 2024
Apr 2024
OLR [W.m-2]
400
200
0
Apr 2023
Jul 2023
Oct 2023
Jan 2024
Apr 2024

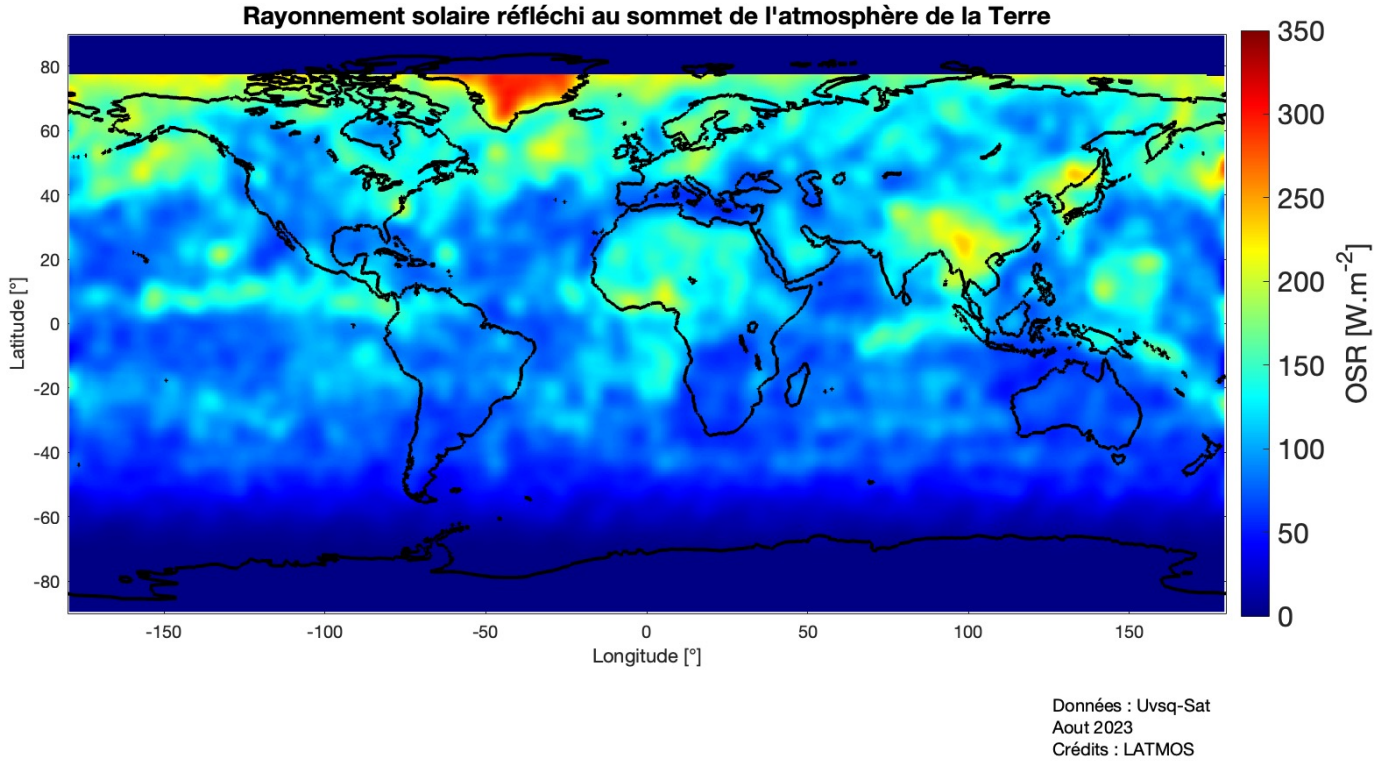
Inspire-Sat


Rayonnement solaire incident - Elevation Satellite > 0°
Latitude [°]
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
Longitude [°]
1200
1000
800
600
400
200
0
ISR [W.m-2]
Données : Uvsq-Sat
Aout 2023
Crédits : LATMOS

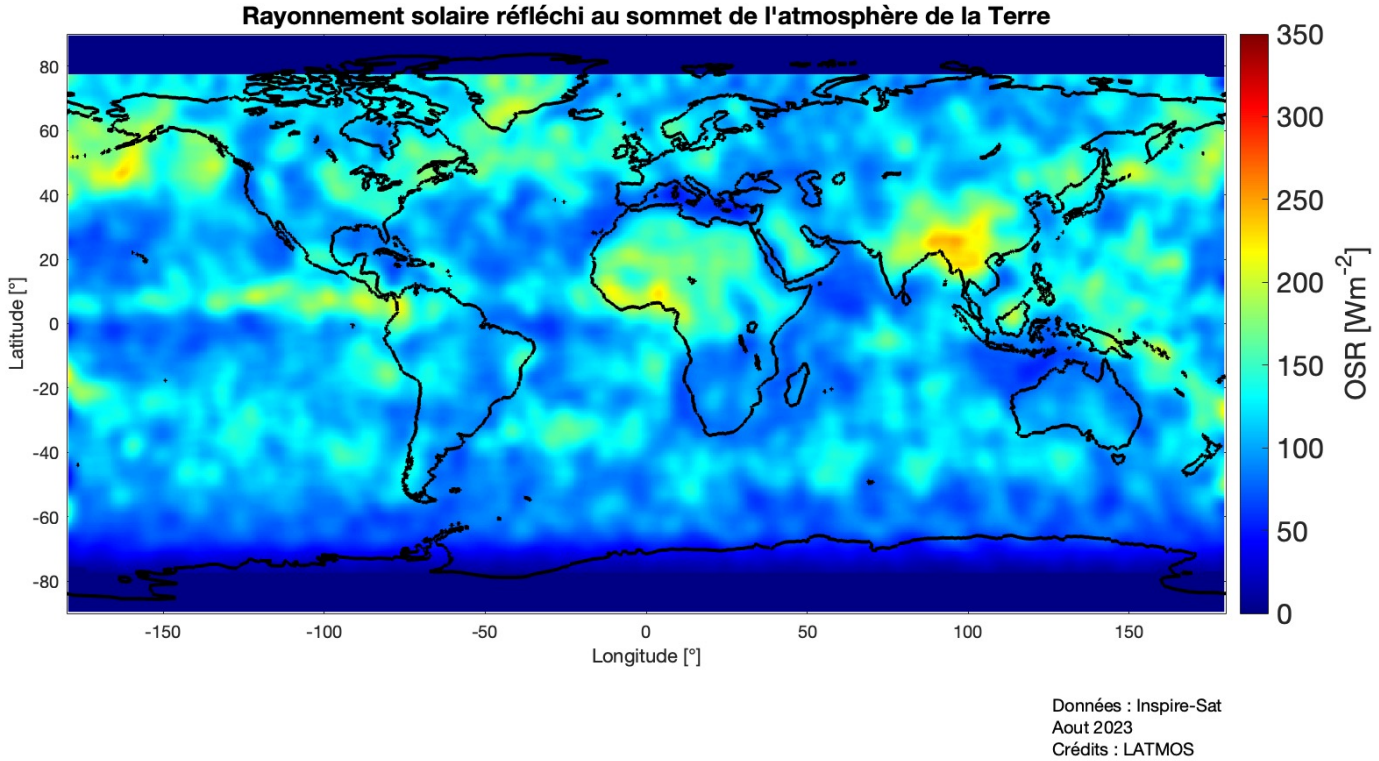
Inspire-Sat


Rayonnement solaire incident - Elevation Satellite > 0°
Latitude [°]
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
Longitude [°]
1200
1000
800
600
400
200
0
ISR [Wm-2]
Données : Inspire-Sat
Aout 2023
Crédits : LATMOS

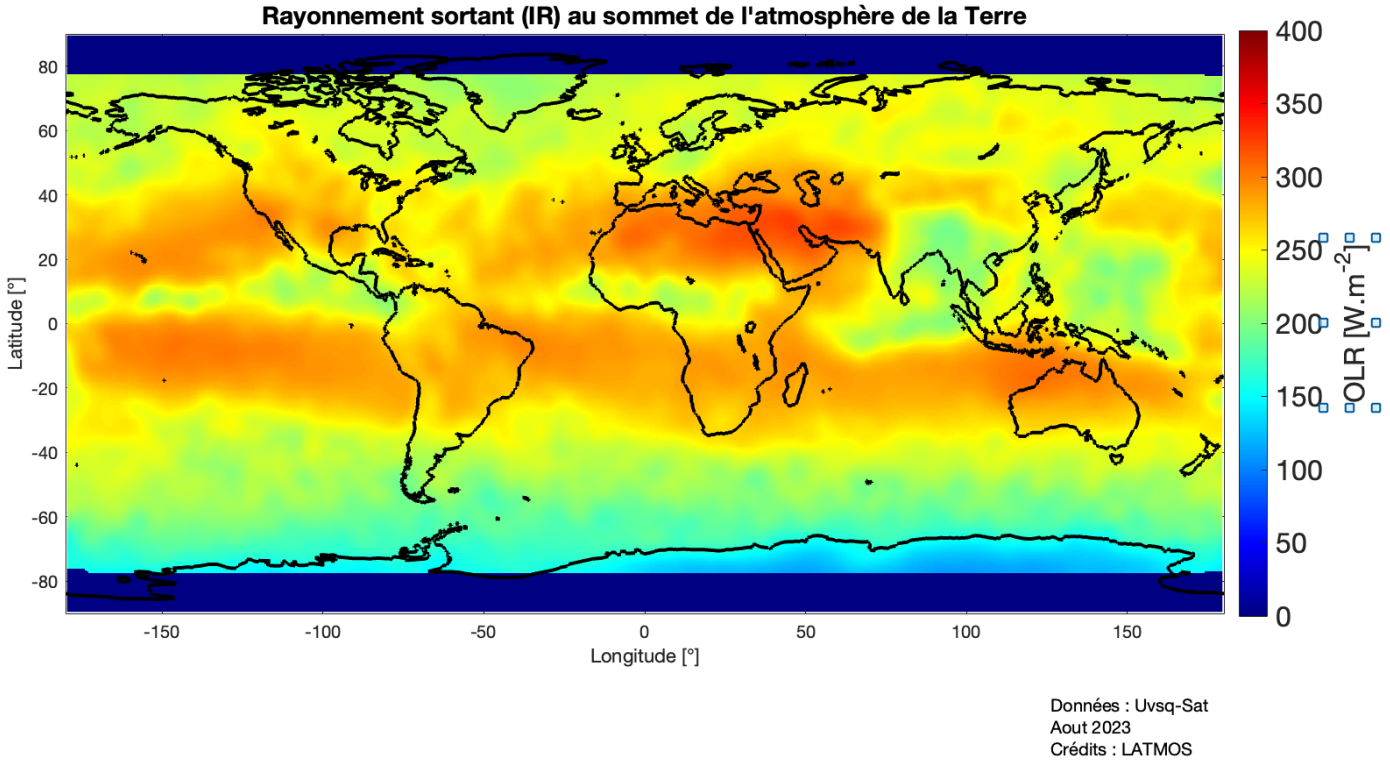
Inspire-Sat


Rayonnement solaire réfléchi au sommet de l'atmosphère de la Terre
Latitude [°]
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
Longitude [°]
350
300
250
200
150
100
50
0
OSR [W.m-2]
Données : Uvsq-Sat
Aout 2023
Crédits : LATMOS

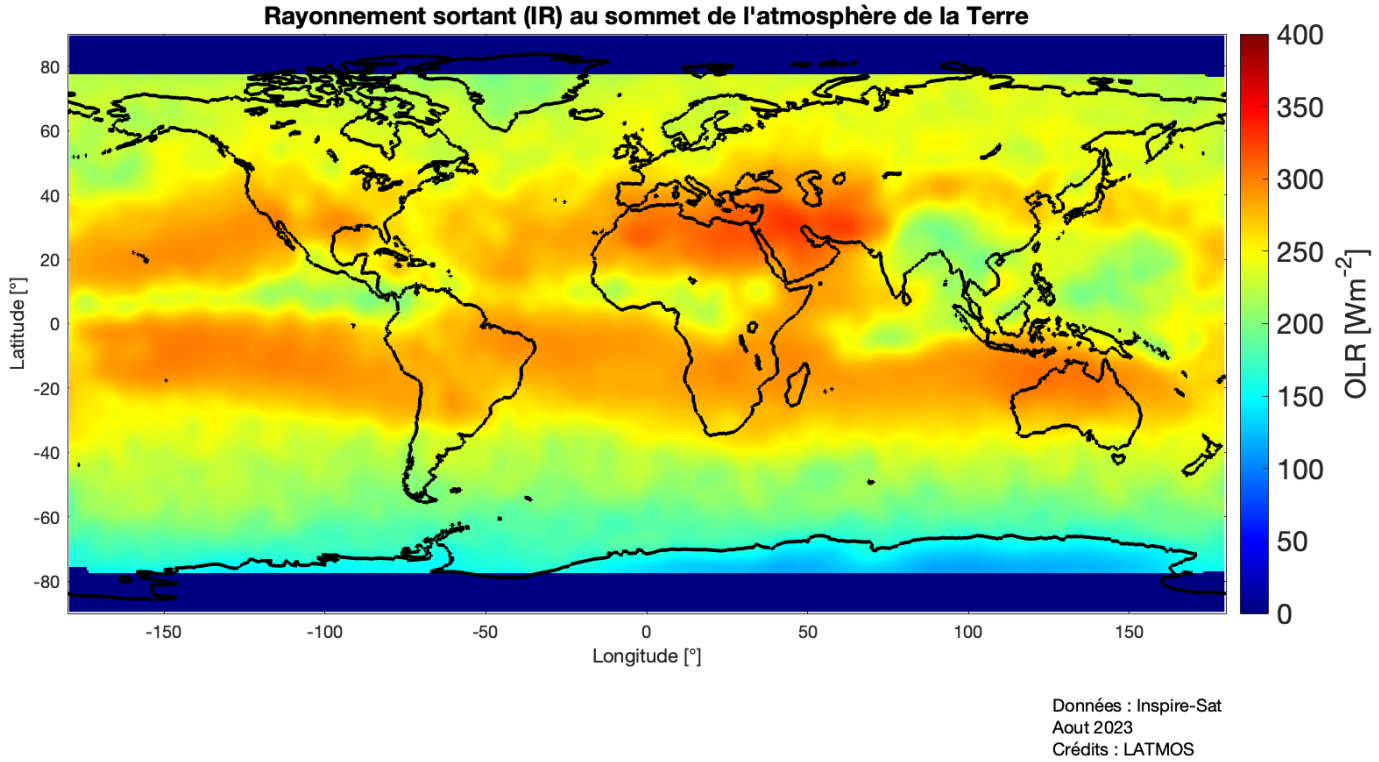
Inspire-Sat


Rayonnement solaire réfléchi au sommet de l'atmosphère de la Terre
Latitude [°]
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
Longitude [°]
350
300
250
200
150
100
50
0
OSR [Wm-2]
Données : Inspire-Sat
Aout 2023
Crédits : LATMOS

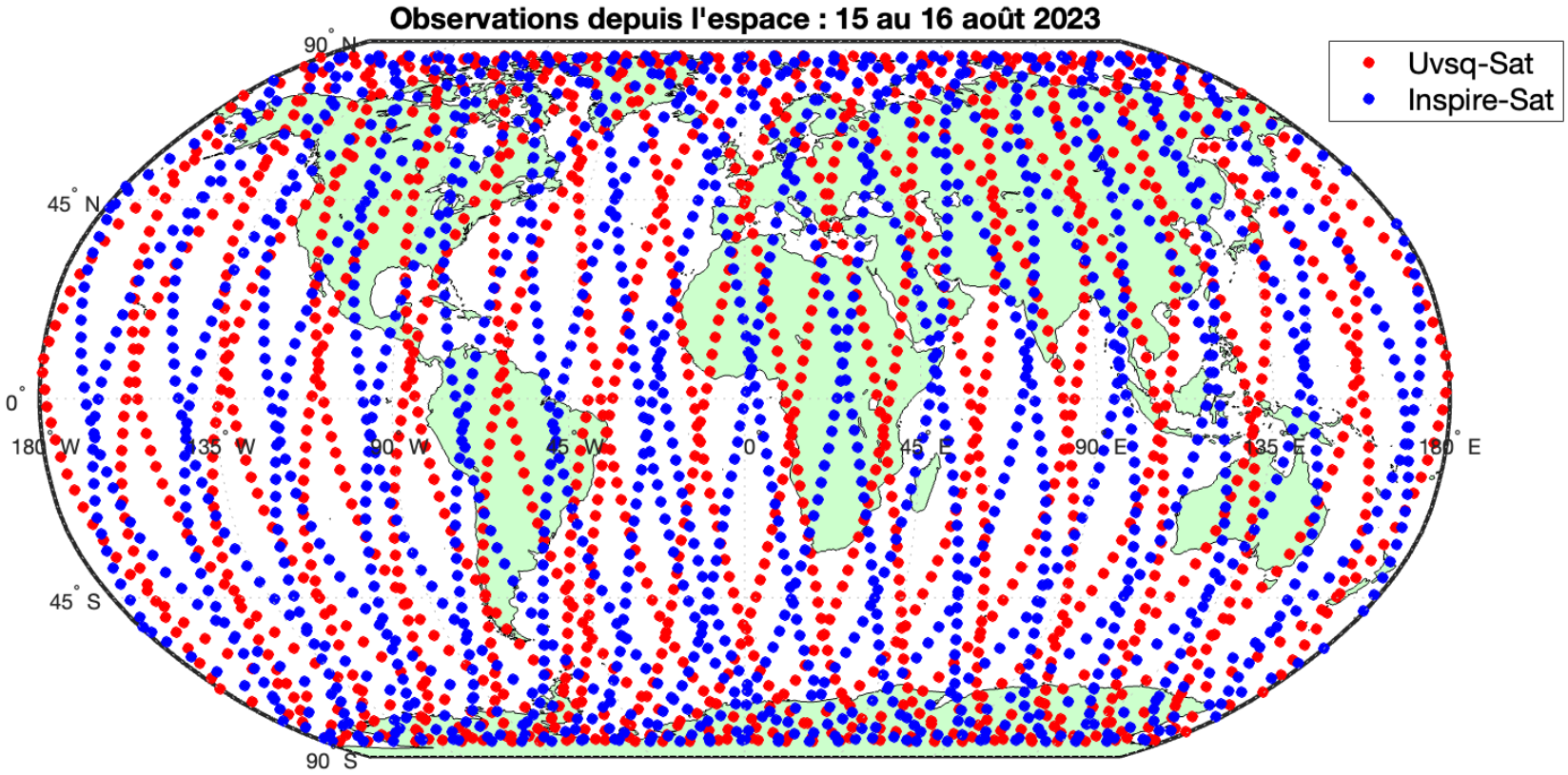
Inspire-Sat


Rayonnement sortant (IR) au sommet de l'atmosphère de la Terre
Latitude [°]
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
Longitude [°]
400
350
300
250
200
150
100
50
0
OLR [W.m-2]
Données : Uvsq-Sat
Aout 2023
Crédits : LATMOS

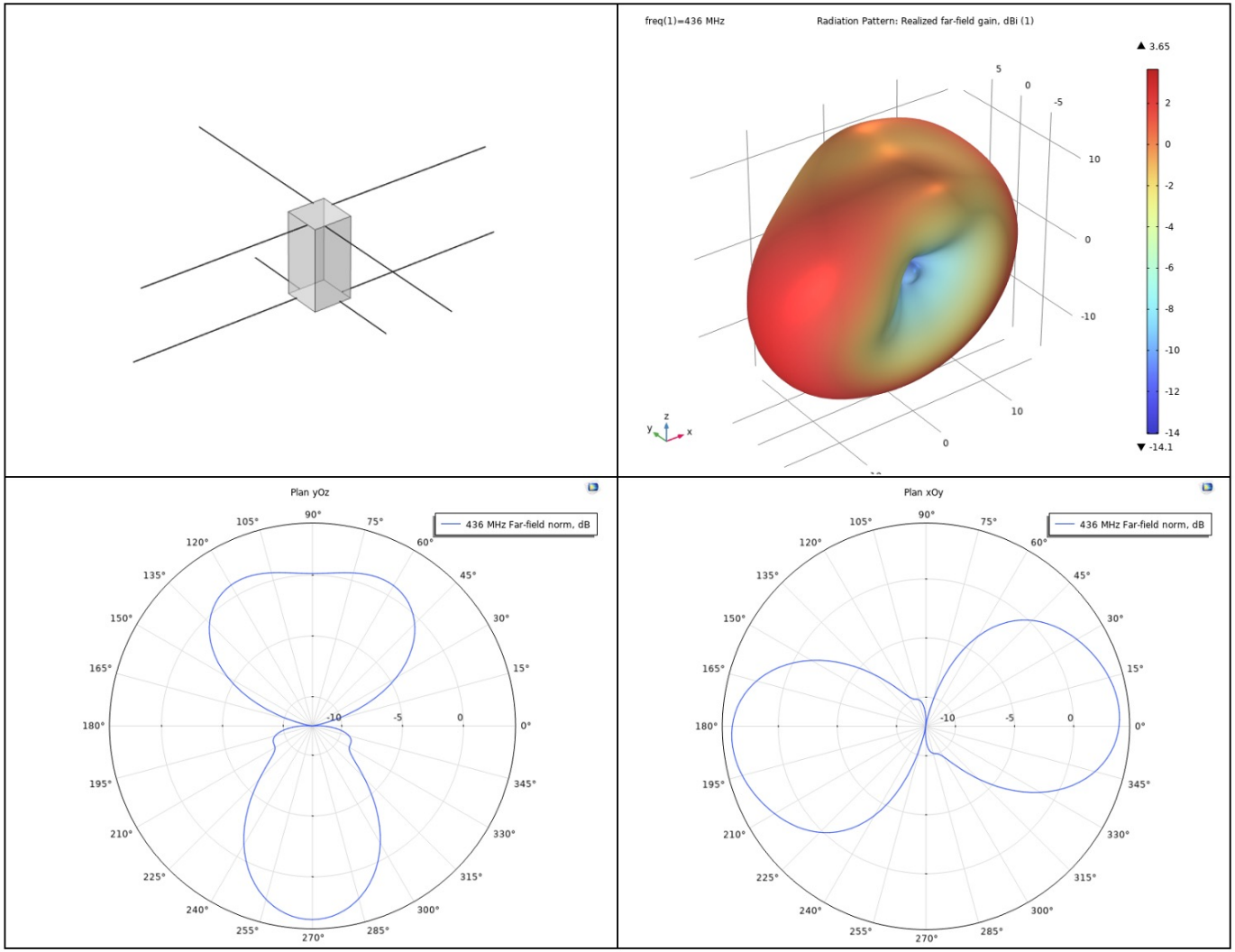
Inspire-Sat


Rayonnement sortant (IR) au sommet de l'atmosphère de la Terre
Latitude [°]
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
Longitude [°]
400
350
300
250
200
150
100
50
0
OLR [Wm-2]
Données : Inspire-Sat
Aout 2023
Crédits : LATMOS

Inspire-Sat

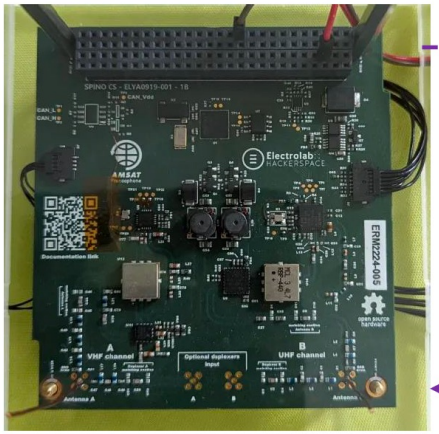

Observations depuis l'espace : 15 au 16 août 2023
Uvsq-Sat
Inspire-Sat
90° N
45° N
0°
45° S
90° S
180° W
135° W
90° W
45° W
0
45° E
90° E
135° E
180° E

Inspire-Sat

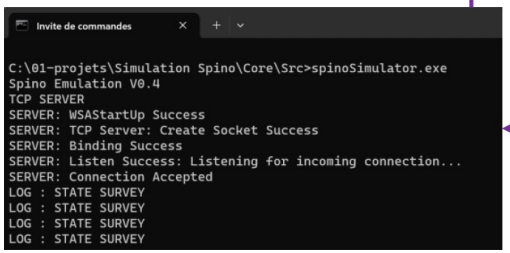

freq(1)=436 MHz
Radiation Pattern: Realized far-field gain, dBi (1)
▲ 3.65
▼ -14.1
Plan yOz
436 MHz Far-field norm, dB
Plan xOy
436 MHz Far-field norm, dB

Inspire-Sat

SPINO Ecosystem

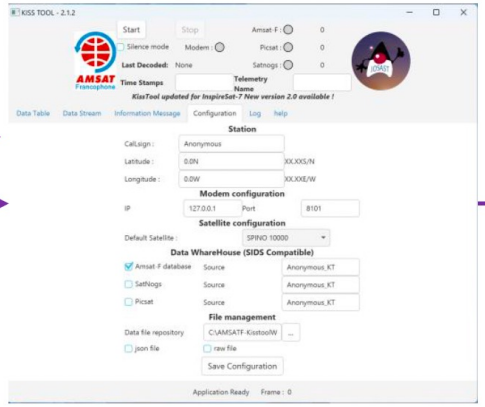


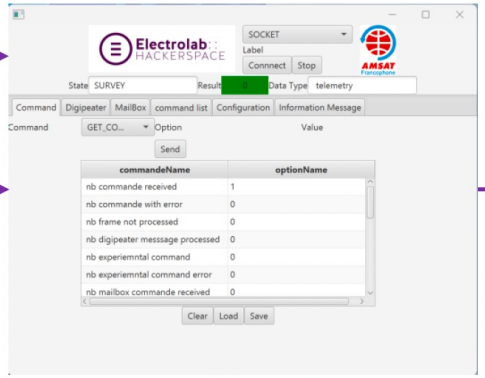
Spino Board



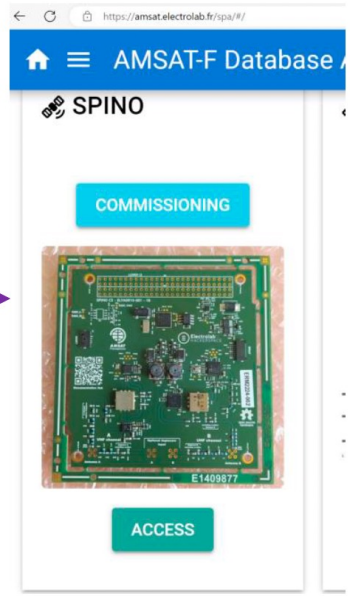
Spino Simulator

Kisstool





ApplicationSpinoController



Amsat-f DataBase

https://amsat.electrolab.fr

Conclusions

Our main scientific goal is:

- To observe essential climate variables with a constellation of small satellites.

The INSPIRE goals are:

- To initiate a Space Program, and to teach courses related to Space.
- To have Laboratory facilities for hardware development and specialized personnel for teaching.
- To have facilities for building and testing CubeSat/small Instruments.
- To have ground stations for satellite operations.

Our positions are:

- To Design for simplicity and robustness:
  - Assume designs will fail and then prove they will work.
  - Design the satellite for easy assembly and disassembly.
  - Have respectable margins, robust safe modes, few deployables, graceful performance. degradation, and frequent preventative satellite resets.
- To Build an experienced team—it matters:
  - A successful team has veteran member(s) and frequent informal peer reviews (discussions) with proven subject matter experts.
- To have an excellent cooperation with radio amateurs.