PACKMAN-Net: A Distributed, Open-Access and Scalable, Network of User-Friendly Space Weather Stations.

M.-P. Zorzano[1,2],

J. Martín-Torres [1,3], T. Mathanlal[1], A. Vakkada Ramachandran[1] and J.-A. Ramirez-Luque[1].

[1]Atmospheric Science Group, Department of Computer Sciences, Electrical and Space Engineering, Luleå University of Technology, 971 87 Luleå, Sweden,

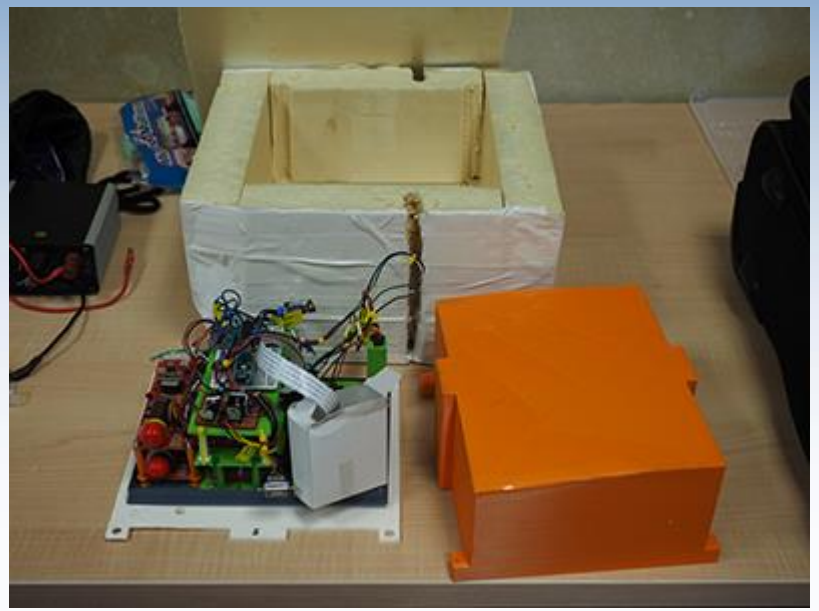
[2] Centro de Astrobiología (INTA-CSIC), Torrejón de Ardoz, Madrid, Spain.

[3] Instituto Andaluz de Ciencias de la Tierra (CSIC-UGR), Armilla, Granada, Spain.

PSIDA Planetary Science Informatics and Data Analytics. 24th -26th April 2018 St. Louis, USA

THE PACKMAN (Particle Counter K-index Magnetic Anomaly) Instrument

Space Weather on Earth



The observations acquired by PACKMAN will be used to provide **open access, real time information**, for:

1) education and public awareness of space weather phenomena;
2) to compare with Earth climate observations;
3) to provide real-time information of space weather variability for potential damage to infrastructures (telecommunications, power generation facilities, aviation, transport, etcetc.);
4) to monitor natural radiation sources at multiple environments;
5) to monitor the variability of the Pfotzer maximum height during different stages of solar activity and seasons and
6) This project may **serve as a reference for future scalable networks where multiple instruments are deployed at different sites or conditions and with different initiation times, and where the informational value increases by adhering to a common PDS4 format and analysing the data in a concurrent way**.

PACKMAN monitoring approach

1. Solar Activity modulating:
Galactic Cosmic Rays
Solar Energetic Particles

LEO (space weather: Near Earth Environment)

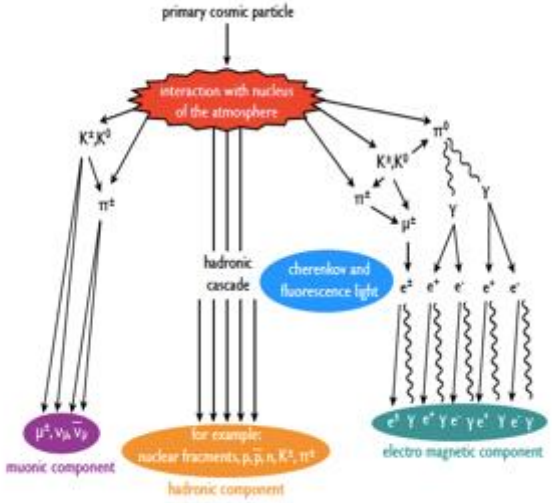
2. Geomagnetic interaction:
Incoming primary rays modulation and deflection

PACKMAN-B (Balloon observations)

3. Atmospheric interaction:
Secondaries generation, Cloud nucleation

PACKMAN-E (Surface Earth observations)

4. Surface measurement:
variation with total column of air, height, latitude and local magnetic field



Arctic balloon campaigns to monitor the variability of space radiation between 10 km and 40 km height.
Complemented with surface measurements
at multiple latitudes.

Atmospheric and surface observations

Atmosphere

- Orbiter based observations are available on-line, in almost real time (graphical).
- Ionosphere monitoring is available on-line (graphical)
- There is a lack of measurements of systematic radiation profiles in the lower layers of the atmosphere in the Arctic.

Surface

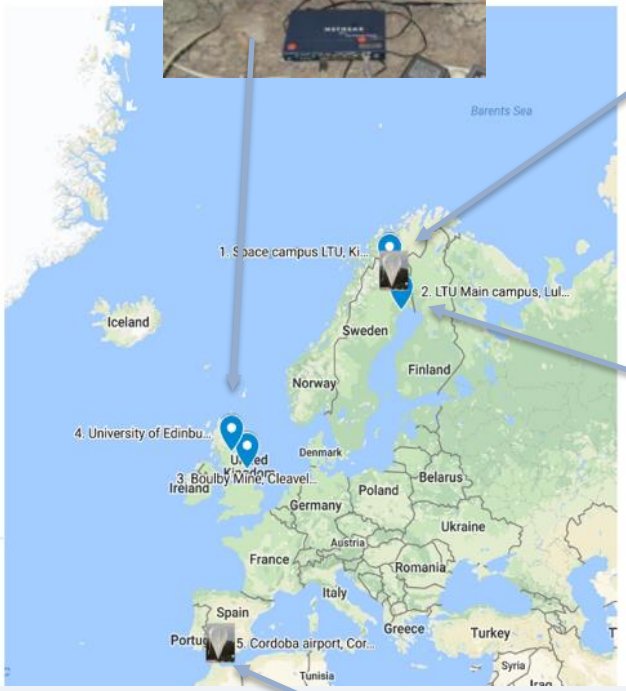
- Only neutron counters (from galactic cosmic rays) are available on-line (graphical).
- K-index (geomagnetic variability) is monitored as a proxy for solar activity at multiple latitudes.
- **It is more complex to have access to crude data in real time. These instruments are operated by scientific institutions.**

Purpose: deploy network of PACKMAN with real time on-line data access, deploy equivalent instrument on balloon campaign with access on-line to the data. Compare time-variability sequence from satellite to surface, and weather/climate records.

PACKMAN Locations

Untitled layer

1. Space campus LTU, Kiruna, Sweden
2. LTU Main campus, Luleå, Sweden
3. Boulby Mine, Cleaveland, United Kingdom
4. University of Edinburgh, United Kingdom
5. Cordoba airport, Cordoba, Spain
6. Esrange Space Center, Kiruna, Sweden



Initial deployment:

Through the initial deployment and testing phase, PACKMAN has demonstrated its operability at multiple latitudes and atmospheric heights:

1. Space campus LTU, Kiruna, Sweden (67.84°N, 20.41°E, 390 m)
2. LTU Main campus, Luleå, Sweden (65.62°N, 22.14°E, 15 m)
3. Boulby Mine, Cleaveland, United Kingdom (54.56°N, 0.82°W, 93 m and -1.1 km)
4. University of Edinburgh, United Kingdom (55.94°N, 3.19°W, 98 m)
5. Cordoba airport, Córdoba, Spain (37.84°N, 4.84°W, 90 m to 27 km)
6. Esrange Space Center, Kiruna, Sweden (67.88°N, 21.12°E, 328 m to 27 km)

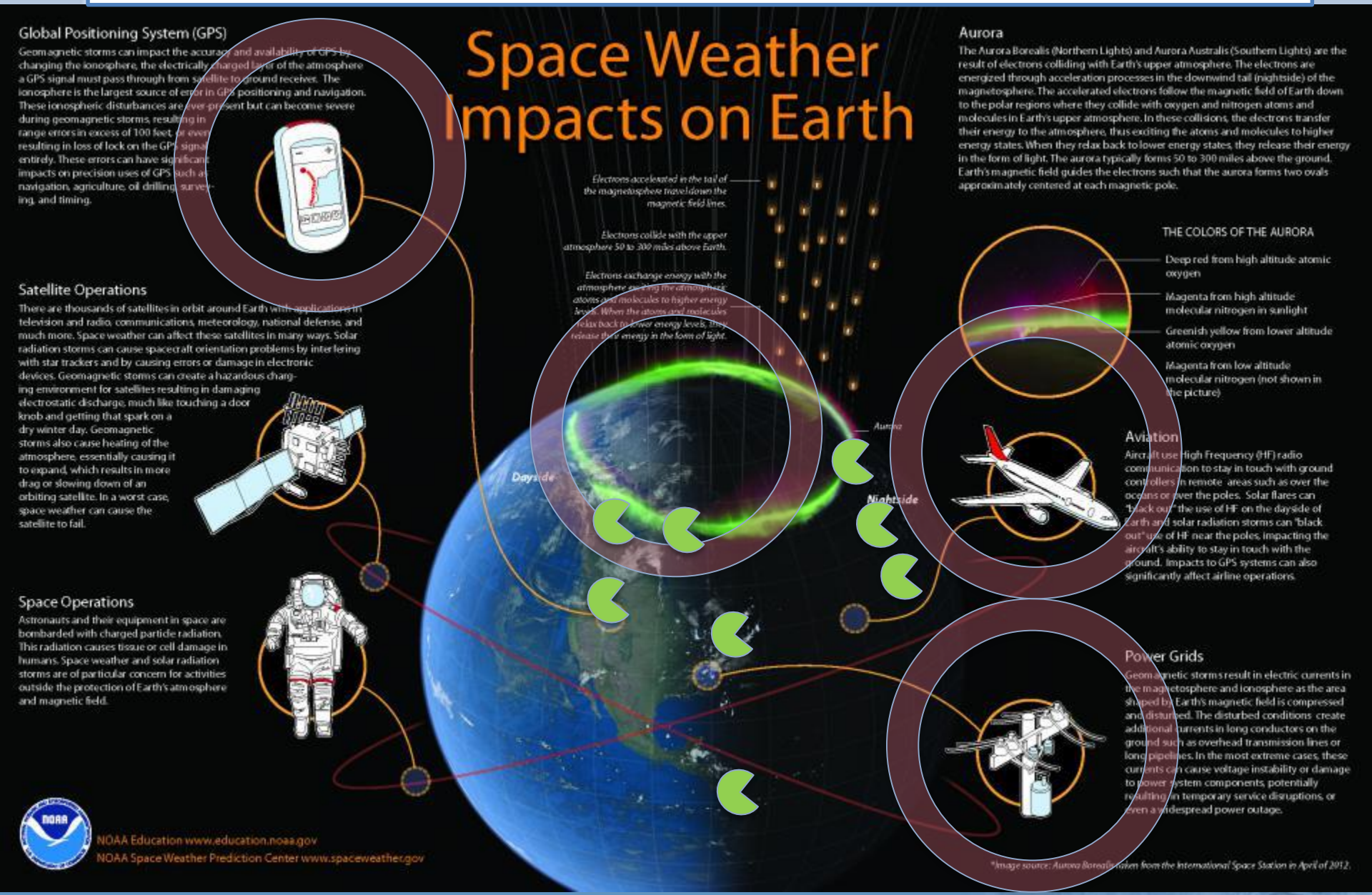
LULEÅ UNIVERSITY OF TECHNOLOGY

Circumpolar long duration stratospheric balloon campaigns

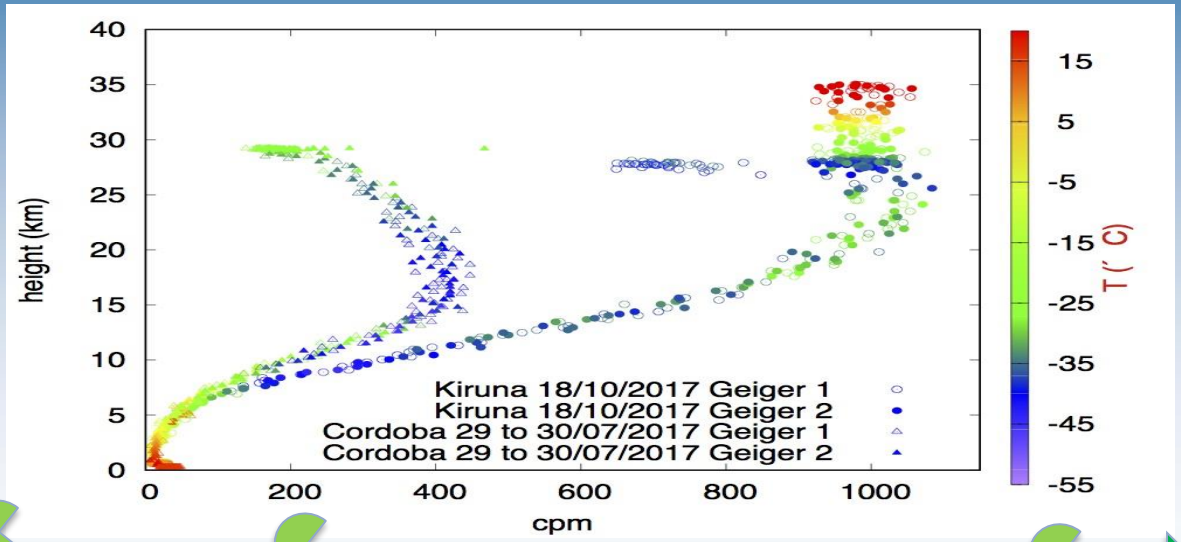
1 week duration space weather stratospheric measurements.

Started from ESRANGE (Sweden) operated by SSC. HEMERA European call for instruments.

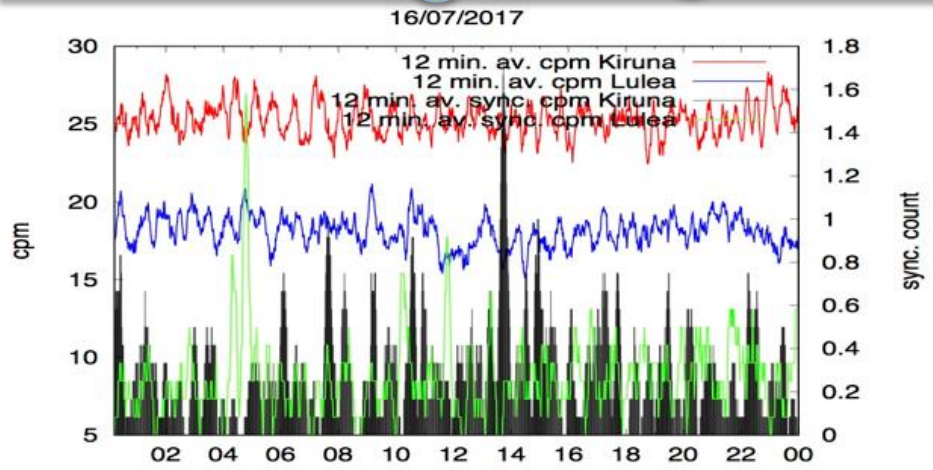
User community

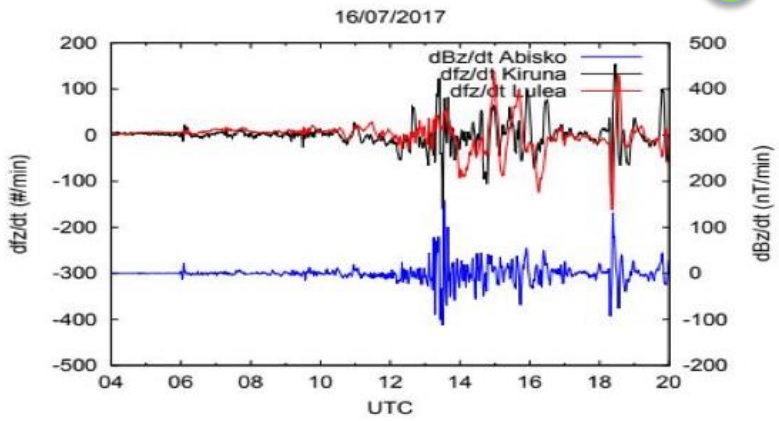


Planet atmosphere and orbit

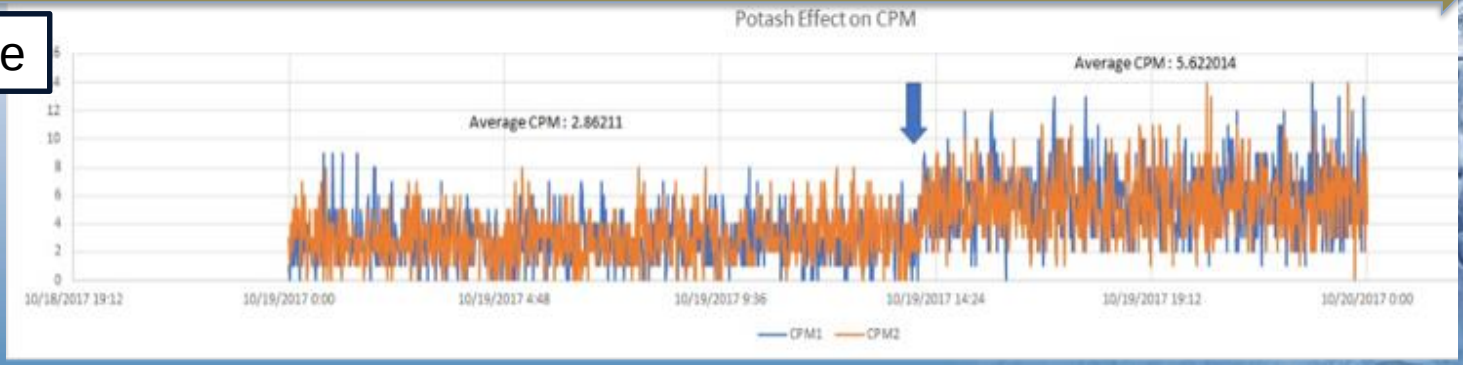


Planet Surface

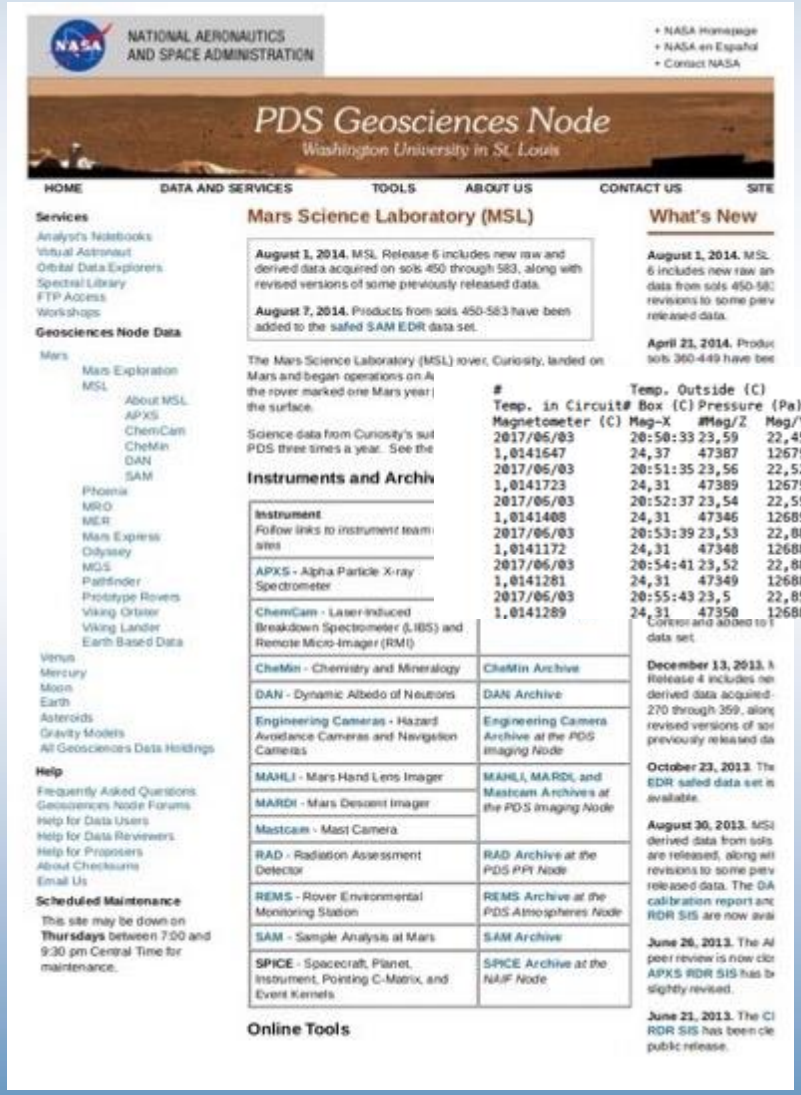




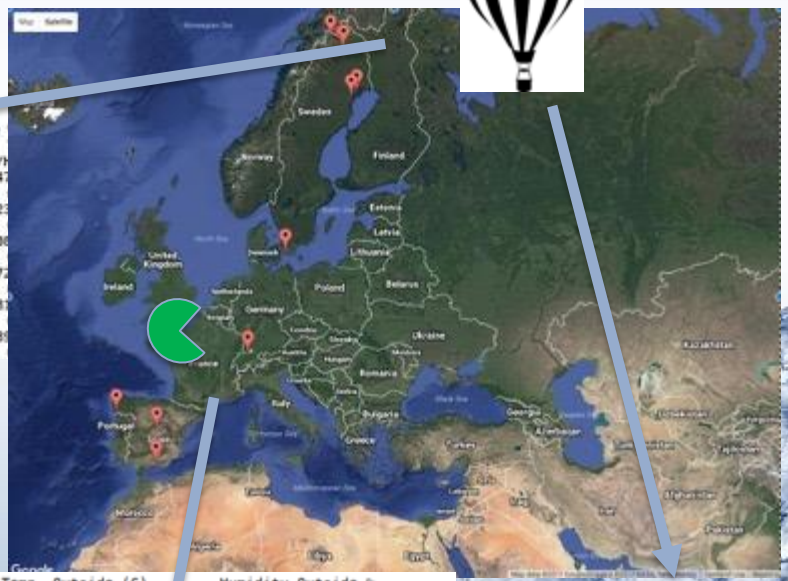
Planet sub-surface



Open access to planetary data



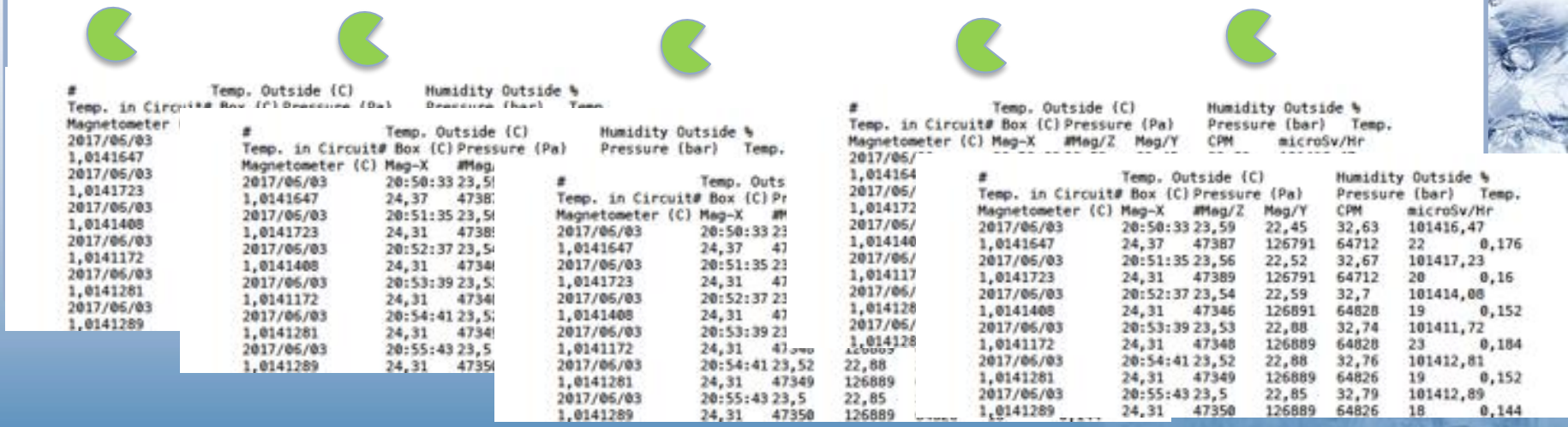
- Because of our heritage from the and the **REMS Mars Science Laboratory (NASA) and the HABIT ExoMars mission (ESA)**: the PACKMAN data will have a similar structure as the PDS4 protocol that is used by NASA/ESA for planeta ation.



#	Temp. Outside (C)			Humidity Outside %	
Temp. in Circuit	# Box (C)	Pressure (Pa)		Pressure (bar)	Temp.
Magnetometer (C)	Mag-Z	#Mag/X	Mag/Y	CPM	microSv/Hr
2017/06/03	20:50:33	23,3	21,7	26,81	101421,11
1,0142111	23,62	125510	62760	77229	21 0,168
2017/06/03	20:51:35	23,28	21,81	26,82	101422,63
1,0142263	23,62	125510	62763	77229	21 0,168
2017/06/03	20:52:37	23,26	21,92	26,88	101427,24
1,0142724	23,62	125610	62666	77521	19 0,152
2017/06/03	20:53:39	23,24	22,21	26,86	101420,78
1,0142078	23,56	125596	62669	77522	18 0,144
2017/06/03	20:54:41	23,22	22,06	26,85	101422,16
1,0142216	23,56	125591	62670	77518	18 0,144

PACKMAN data volume

- Data storage: 132 Kilobytes/Day
- PACKMAN data have 11 columns of measurement that start with a time stamp and latitude/coordinate/elevation information.
- Every new line corresponds to a new time stamp, with measuring interval of 1 minute in UTC.
- All PACKMAN nodes provide observations with the same time stamp, and same observation cadency.
- 365 days of continuous measurements/year.
- Scalable network:
  - Internal nodes uploading daily.
  - External nodes uploading at blocks of 3 months (pre-acceptance required).



PACKMAN data requirements

Data uploading (Instrument)

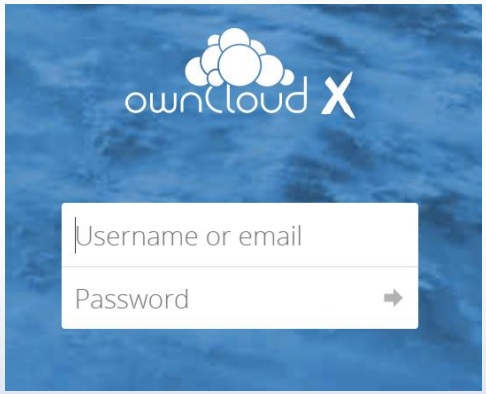
- **Open access –"pre-authorized**" users- data storage.
- Scalable (over time more nodes).
- **Automatic PDS4 labelling**

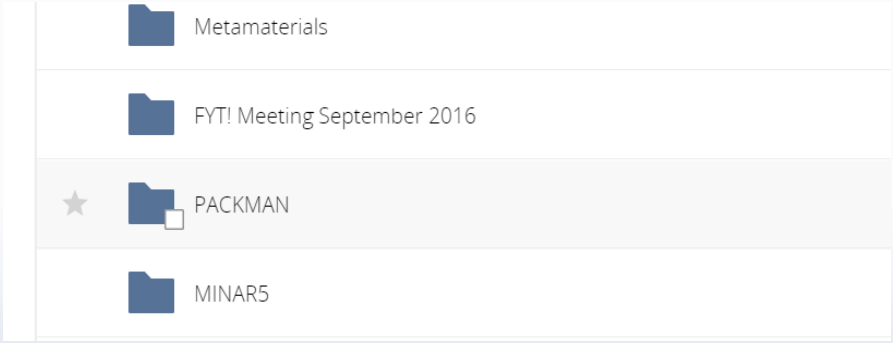
Data downloading (Science/ Infrastructures/ Education/ Outreach)

- Global: open access
- **Online tools for quick** preliminary analysis (online representation, online fast processing) and comparison of multiple nodes-data.
- Accessibility to multiple simultaneous instrument observations.

Open-access pre-authorized data uploading

- Owncloud: Private Owncloud server for third party users to upload their PACKMAN Data automatically using the official Owncloud client.

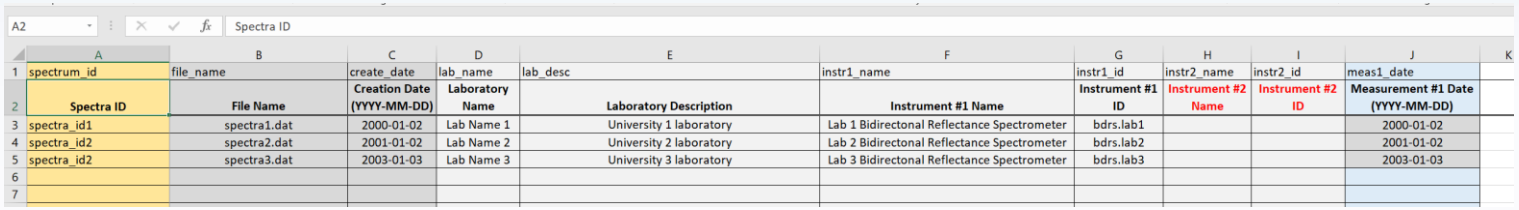




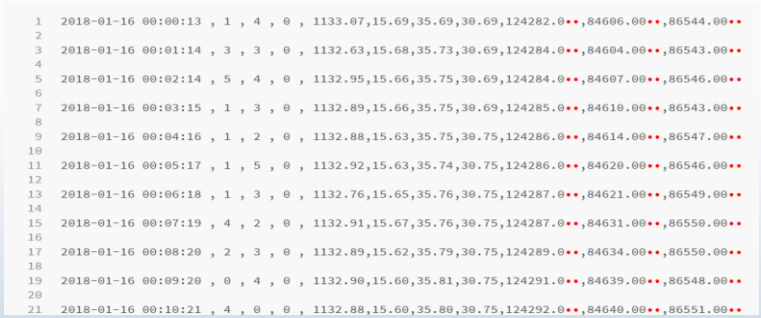
- Automation tools: Using Python scripts to create the repositories and put the data uploaded to owncloud and check new files everyday.

Labelling PDS4

- Label creation: Use of MakeLabelsPDS4 tool created by **Dan Scholes (PDS GeoSciences Node)** using Excel to populate the PDS4 XML fields over XML Templates



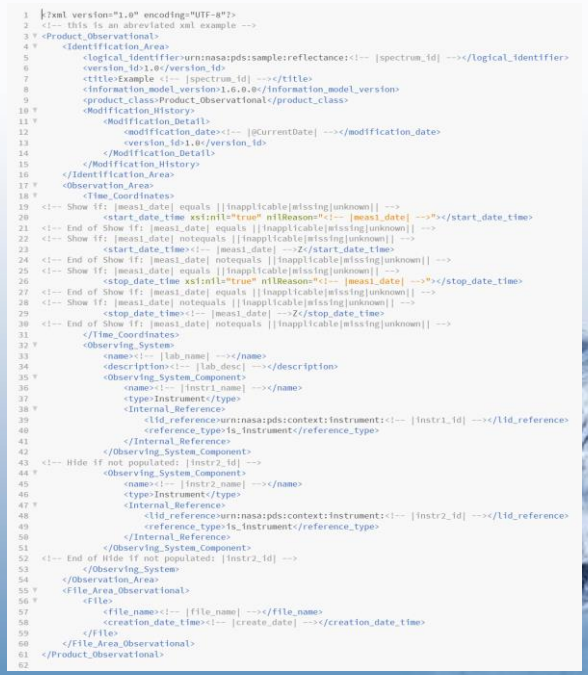
spectrum_id	file_name	create_date	lab_name	lab_desc	instr1_name	instr1_id	instr2_name	instr2_id	meas1_date
Spectra ID	File Name	Creation Date (YYYY-MM-DD)	Laboratory Name	Laboratory Description	Instrument #1 Name	Instrument #1 ID	Instrument #2 Name	Instrument #2 ID	Measurement #1 Date (YYYY-MM-DD)
spectra_id1	spectra1.dat	2000-01-02	Lab Name 1	University 1 laboratory	Lab 1 Bidirectonal Reflectance Spectrometer	bdrs.lab1			2000-01-02
spectra_id2	spectra2.dat	2001-01-02	Lab Name 2	University 2 laboratory	Lab 2 Bidirectonal Reflectance Spectrometer	bdrs.lab2			2001-01-02
spectra_id2	spectra3.dat	2003-01-03	Lab Name 3	University 3 laboratory	Lab 3 Bidirectonal Reflectance Spectrometer	bdrs.lab3			2003-01-03



```
2018-01-16 00:00:13 , 1 , 4 , 0 , 1133.07,15.69,35.69,30.69,124282.0••,84606.00••,86544.00••

2018-01-16 00:01:14 , 3 , 3 , 0 , 1132.63,15.68,35.73,30.69,124284.0••,84604.00••,86543.00••

2018-01-16 00:02:14 , 5 , 4 , 0 , 1132.95,15.66,35.75,30.69,124284.0••,84607.00••,86546.00••

2018-01-16 00:03:15 , 1 , 3 , 0 , 1132.89,15.66,35.75,30.69,124285.0••,84610.00••,86543.00••

2018-01-16 00:04:16 , 1 , 2 , 0 , 1132.88,15.63,35.75,30.75,124286.0••,84614.00••,86547.00••

2018-01-16 00:05:17 , 1 , 5 , 0 , 1132.92,15.63,35.74,30.75,124286.0••,84620.00••,86546.00••

2018-01-16 00:06:18 , 1 , 3 , 0 , 1132.76,15.65,35.76,30.75,124287.0••,84621.00••,86549.00••

2018-01-16 00:07:19 , 4 , 2 , 0 , 1132.91,15.67,35.76,30.75,124287.0••,84631.00••,86550.00••

2018-01-16 00:08:20 , 2 , 3 , 0 , 1132.89,15.62,35.79,30.75,124289.0••,84634.00••,86550.00••

2018-01-16 00:09:20 , 0 , 4 , 0 , 1132.90,15.60,35.81,30.75,124291.0••,84639.00••,86548.00••

2018-01-16 00:10:21 , 4 , 0 , 0 , 1132.88,15.60,35.80,30.75,124292.0••,84640.00••,86551.00••
```

PACKMAN Data File

XML Template Example →



```
<?xml version="1.0" encoding="UTF-8"?>
<!-- this is an abreviated xml example -->
<Product_Observational>
    <Identification_Area>
        <logical_identifier>urn:nasa:pds:sample:reflectance:<!-- |spectrum_id| --></logical_identifier>
        <version_id>1.0</version_id>
        <title>Example <!-- |spectrum_id| --></title>
        <information_model_version>1.6.0.0</information_model_version>
        <product_class>Product_Observational</product_class>
        <Modification_History>
            <Modification_Detail>
                <modification_date><!-- |@CurrentDate| --></modification_date>
                <version_id>1.0</version_id>
            </Modification_Detail>
        </Modification_History>
    </Identification_Area>
    <Observation_Area>
        <Time_Coordinates>
<!-- Show if: |meas1_date| equals ||inapplicable|missing|unknown|| -->
            <start_date_time xsi:nil="true" nilReason="<!-- |meas1_date| -->"></start_date_time>
<!-- End of Show if: |meas1_date| equals ||inapplicable|missing|unknown|| -->
<!-- Show if: |meas1_date| notequals ||inapplicable|missing|unknown|| -->
            <start_date_time><!-- |meas1_date| -->Z</start_date_time>
<!-- End of Show if: |meas1_date| notequals ||inapplicable|missing|unknown|| -->
<!-- Show if: |meas1_date| equals ||inapplicable|missing|unknown|| -->
            <stop_date_time xsi:nil="true" nilReason="<!-- |meas1_date| -->"></stop_date_time>
<!-- End of Show if: |meas1_date| equals ||inapplicable|missing|unknown|| -->
<!-- Show if: |meas1_date| notequals ||inapplicable|missing|unknown|| -->
            <stop_date_time><!-- |meas1_date| -->Z</stop_date_time>
<!-- End of Show if: |meas1_date| notequals ||inapplicable|missing|unknown|| -->
        </Time_Coordinates>
        <Observing_System>
            <name><!-- |lab_name| --></name>
            <description><!-- |lab_desc| --></description>
            <Observing_System_Component>
                <name><!-- |instr1_name| --></name>
                <type>Instrument</type>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:context:instrument:<!-- |instr1_id| --></lid_reference>
                    <reference_type>is_Instrument</reference_type>
                </Internal_Reference>
            </Observing_System_Component>
<!-- Hide if not populated: |instr2_id| -->
            <Observing_System_Component>
                <name><!-- |instr2_name| --></name>
                <type>Instrument</type>
                <Internal_Reference>
                    <lid_reference>urn:nasa:pds:context:instrument:<!-- |instr2_id| --></lid_reference>
                    <reference_type>is_Instrument</reference_type>
                </Internal_Reference>
            </Observing_System_Component>
<!-- End of Hide if not populated: |instr2_id| -->
        </Observing_System>
    </Observation_Area>
    <File_Area_Observational>
        <File>
            <file_name><!-- |file_name| --></file_name>
            <creation_date_time><!-- |create_date| --></creation_date_time>
        </File>
    </File_Area_Observational>
</Product_Observational>
```

Online quick analysis: cross-instrument comparison (multi latitud)

- Online data visualization
- (https://atmospheres.research.ltu.se/pes1)

Online plotting of different variables using → **DYGRAPHS** API (www.dygraphs.org)

Summary: PACKMAN-Net

- This is an example of **planetary instrumentation** relevant data (Space Weather) in our planet which needs a **dedicated scalable data archiving and processing architecture** that adheres to the PDS4 standard.
- Furthermore, this project may be used to **benchmark** the design of archiving, scalable, networks of future planetary instrumentation observations of the Moon or mars or Earth orbiters.
- This project will bridge the gap between society and research, adding **new stake holders** such as teaching institutions (high schools, universities), or industry and infrastructures representatives.