AMICal Sat and ATISE data interpretation with transsolo inversion

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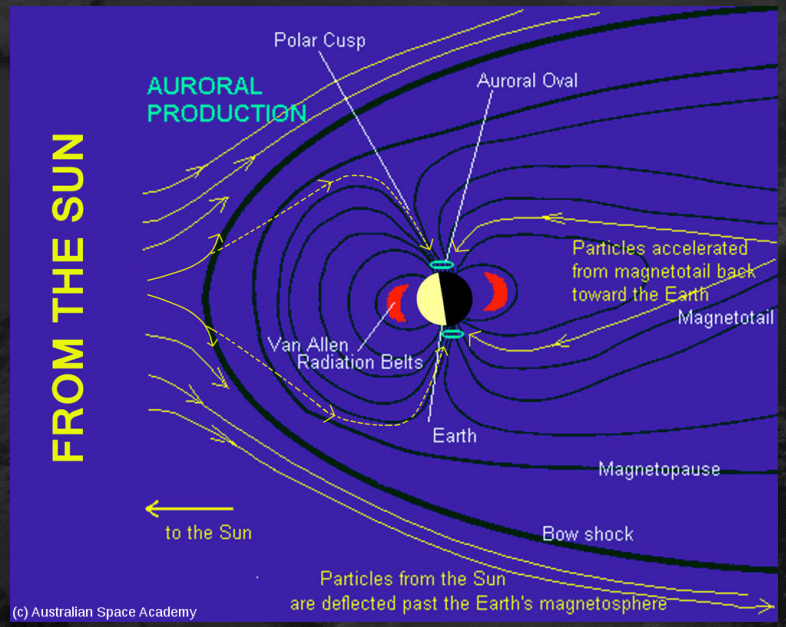
CIFRE Thesis

- Convention between company (SpaceAble) and Laboratory (IPAG).
- Principle : To favorise the development of public-private partnership research and to place doctoral students in employment conditions.
- SpaceAble : is a company engaged in the Space Situational Awarness, that allows its users to access all critical space data, to monitor the risk associated with satellites in Low Earth Orbit.

Context of the thesis

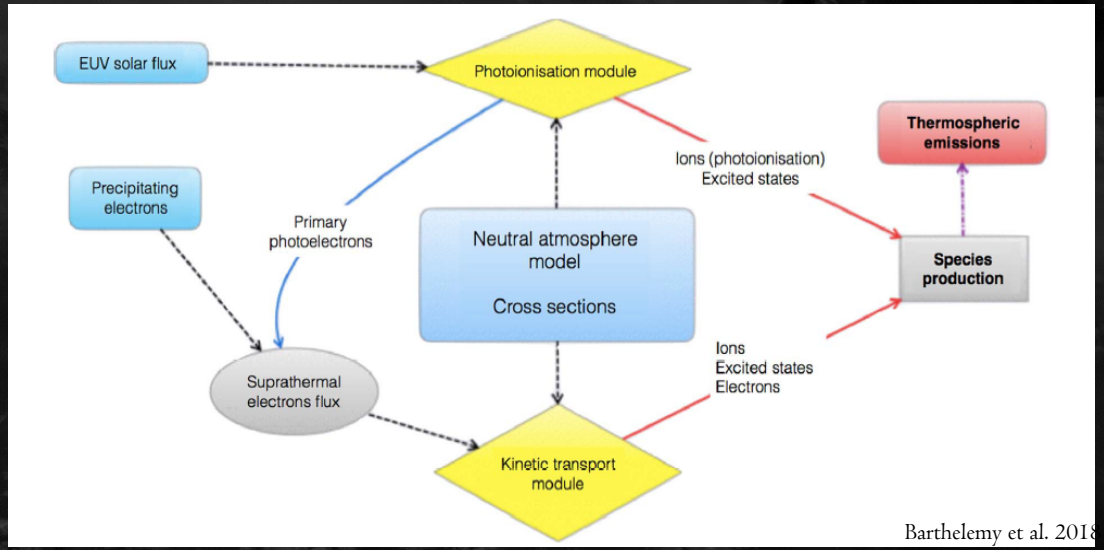
Polar auroras :

- Monitoring of the low energies particles in auroral region.



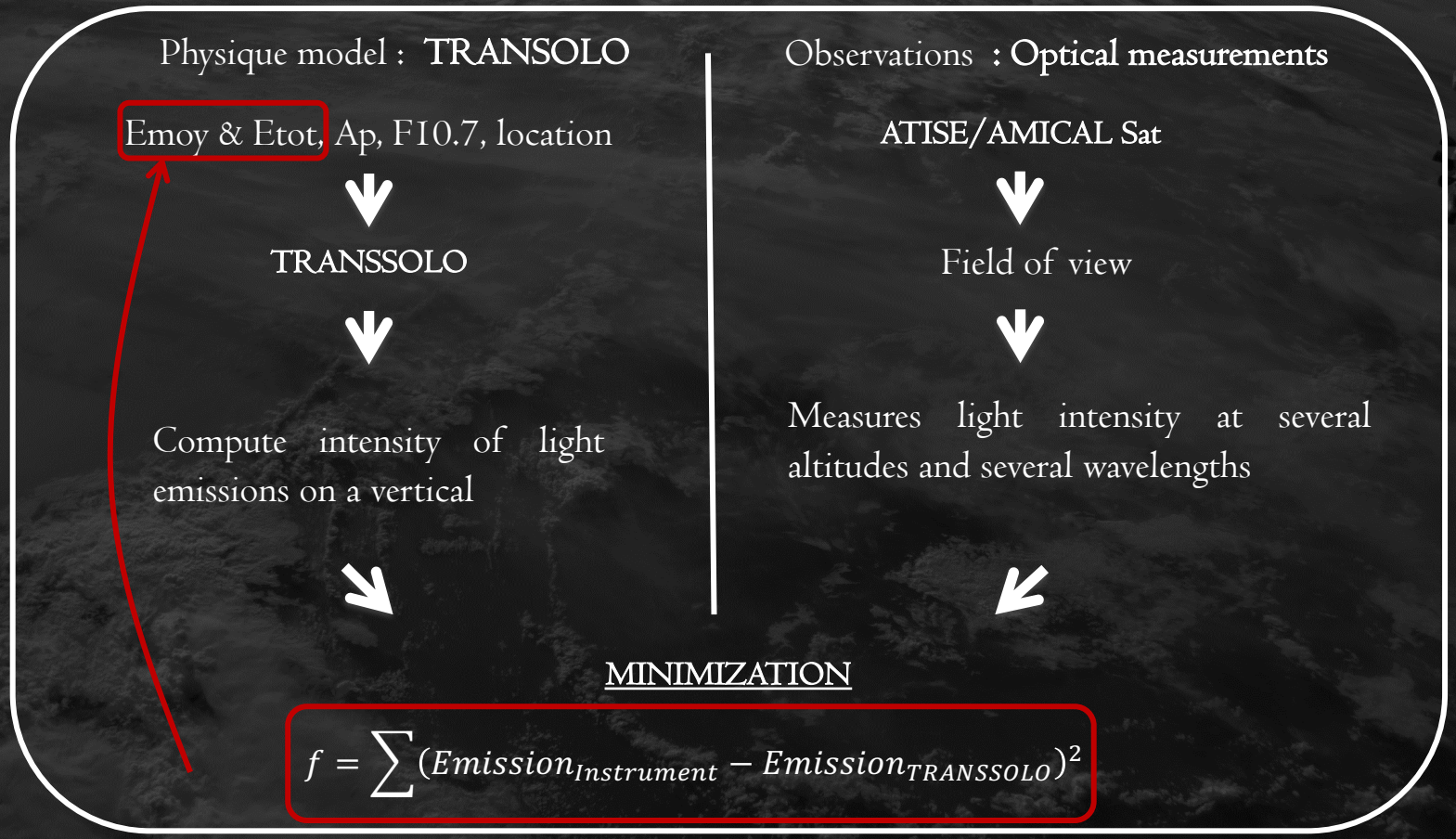
TRANSOLO code :

- A kinetic code solving the Boltzmann equation, to calculate the transport of the particles in the upper atmosphere and the resulting light emissions. This code registres as inputs the electrons precipitating parameters.
- Aim : Implement a reserve method to go up to the electrons energies that allowed the creation of measured polar auroras acquired by instruments in space.



Barthelemy et al. 2018

Optimisation of TRANSOLO



- Minimize emission lines simulations with AMICAL Sat and ATISE measurements to go up the inputs parameters.

Take height

- Advantages of the satellites : field of view larger, no dependent of the terretrial weather conditions.
- Lines of sight on the verticale or following the magnetic field lines and configuration to the limb possible.

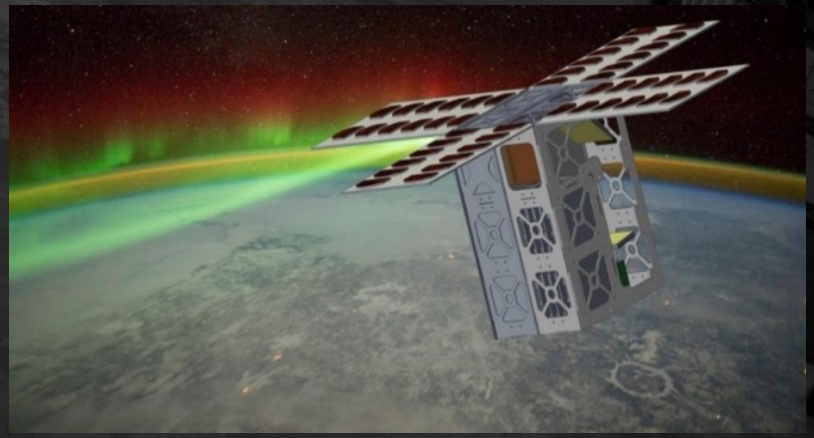
AMICAL Sat & ATISE : Satellites to study electronical precipations

AMICAL Sat (Auroral Moon Intensity Calibration satellite)

(crédit CSUG)

- Launched on September 3, 2020
- Nanosatellite 2 U
- Imager visible to near IR
- Pictures of polar auroras (time of acquisition = 1s)
- Near-polar,orbit, 540 km, 97°
- Configuration of observation : unexpected
- Calibration of the imager with the Moon

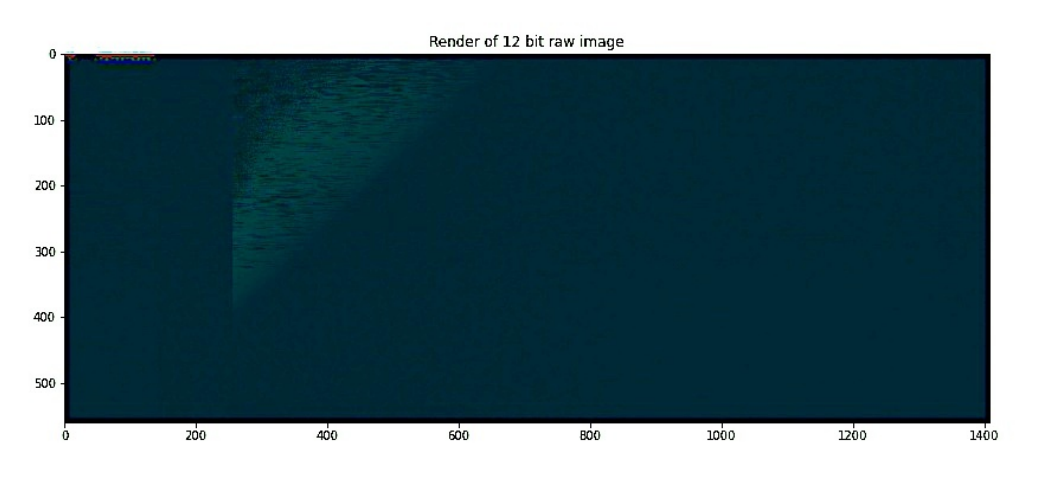
ATISE (Auroral Thermospheric and Ionospheric Spectrometer Experiment)

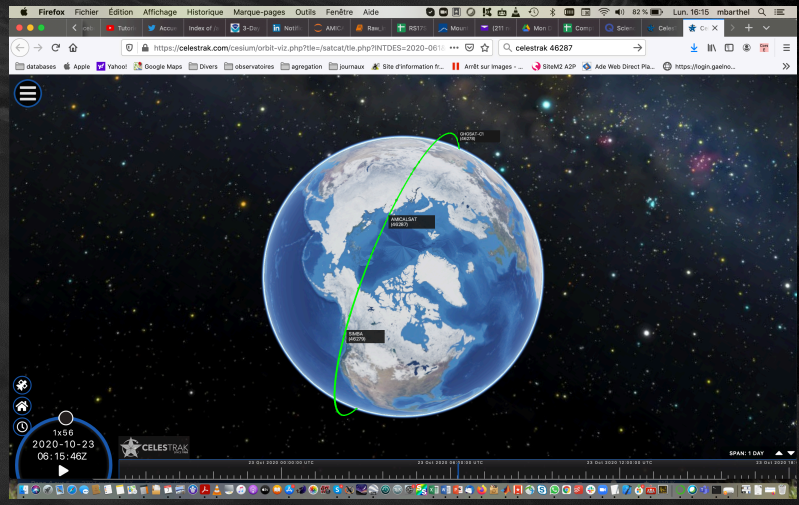


(crédit CSUG)

- Expected for end 2022/ beginning 2023
- Nanosatellite 12 U
- Imager visible to near IR (400 nm à 900 nm)
- Spectrometer based on the µSPOC technology
- Very high sensivity (5 Rayleigh)
- Near-polar orbit, 650 km, 80°
- Configuratin of observation to the limb
- 6 lines of sight (6°x1.5°) of 100 km to 336 km of altitude
- 6 spectras/acquisition (time of acquisition = 1s)

First image of AMICAL Sat from space





- Take it 23/10/20 at 6h15'46 "
- Sparse RGB
- Aurora with domination of green

- Sighting direction unknown
- North oval

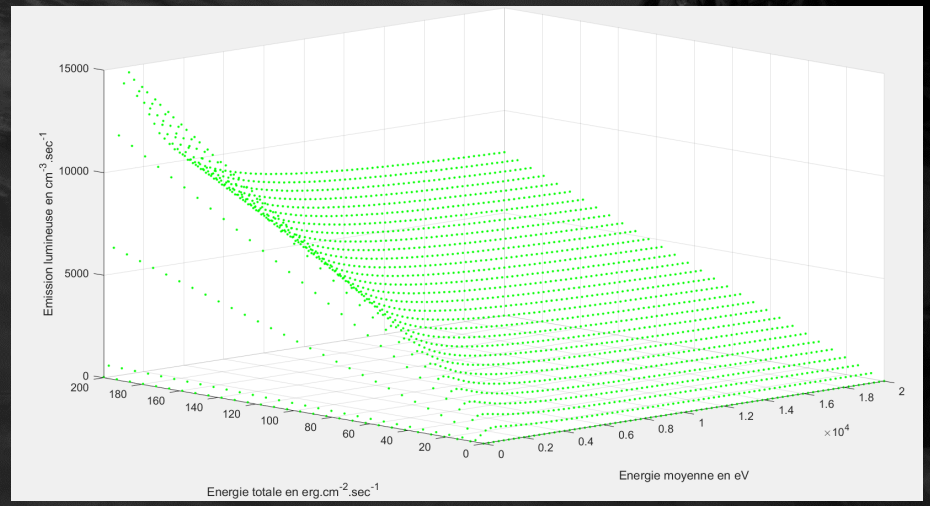
Massive runs

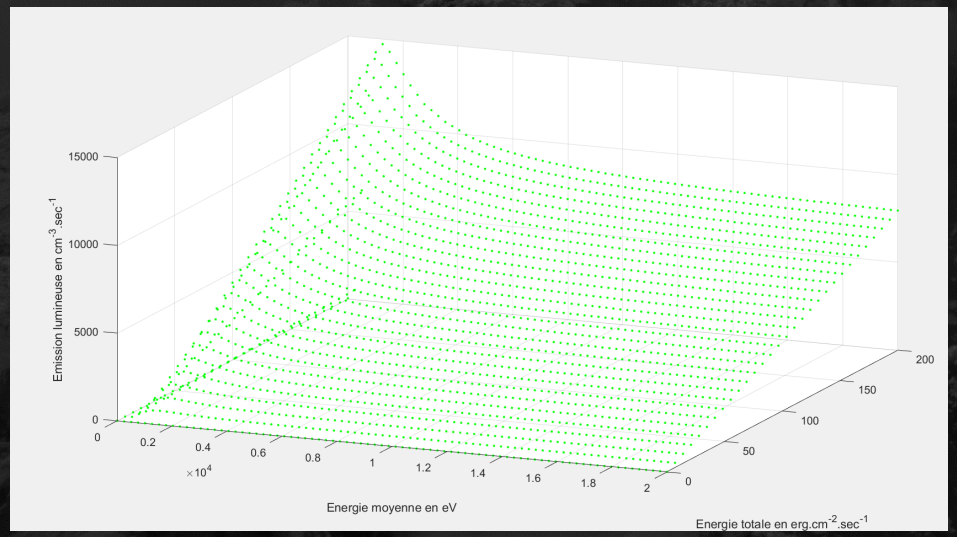
- Massive runs with different initial parameters
- Browse the parameters space
- To trace the transfer function of Transolo in three dimensions
- Based on images do multidimensional interpolation in the grid

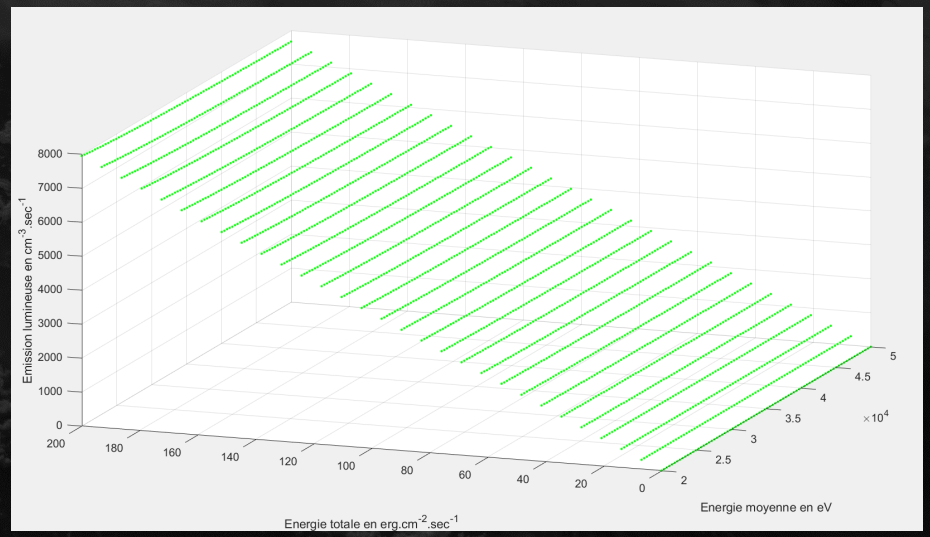
To get a matrix !

Massive runs

- TRANSOLO transfer function for the green line at 121 km.
  - Etot : 0,1 à 200 erg.cm-2.s-1
  - Emoy : 5 eV à 50 keV
  - Year : 2014, Day : 1, Hour : 24
  - Ap : 35
  - f : 250
  - Latitude : 70, longitude : 20

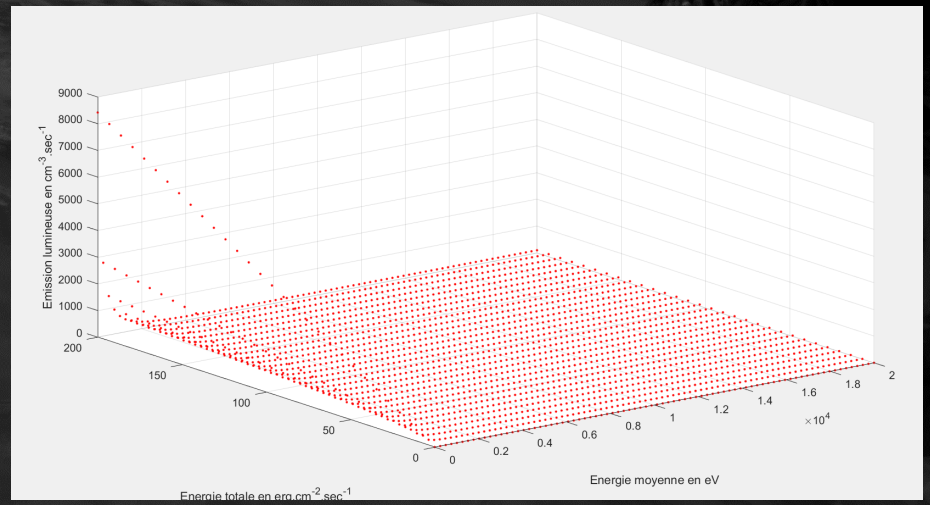


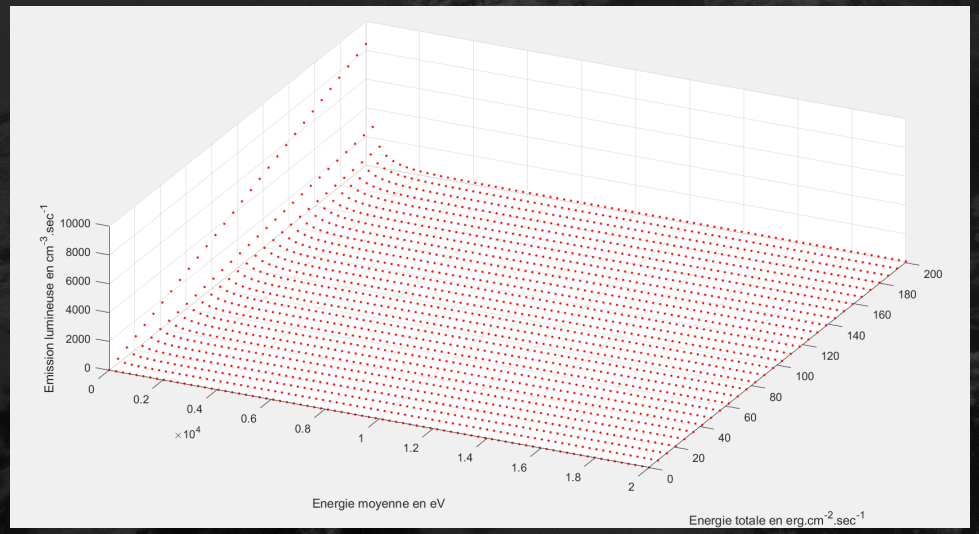


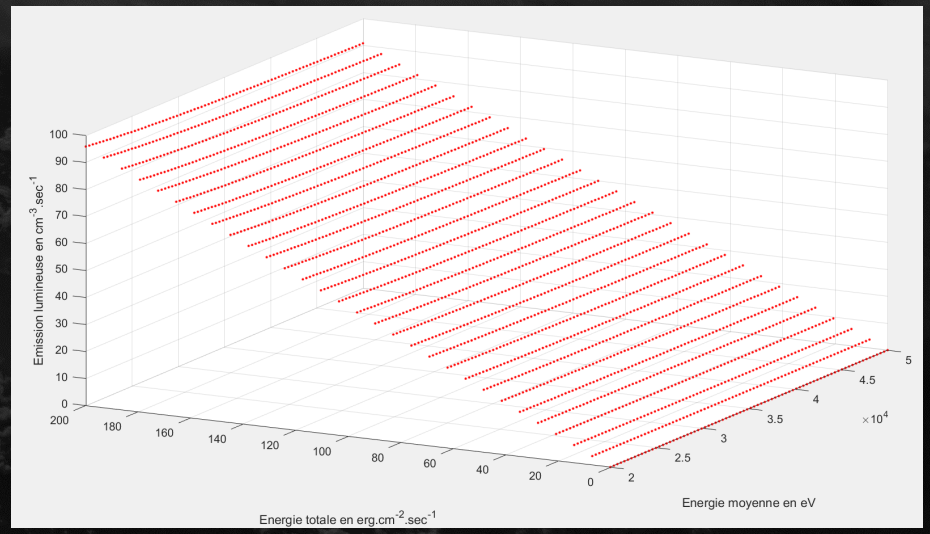


Massive runs

- TRANSOLO transfer function for the red line at 224 km.
  - Etot : 0,1 à 200 erg.cm-2.s-1
  - Emoy : 5 eV à 50 keV
  - Year : 2014, Day : 1, Hour : 24
  - Ap : 35
  - f : 250
  - Latitude : 70, longitude : 20

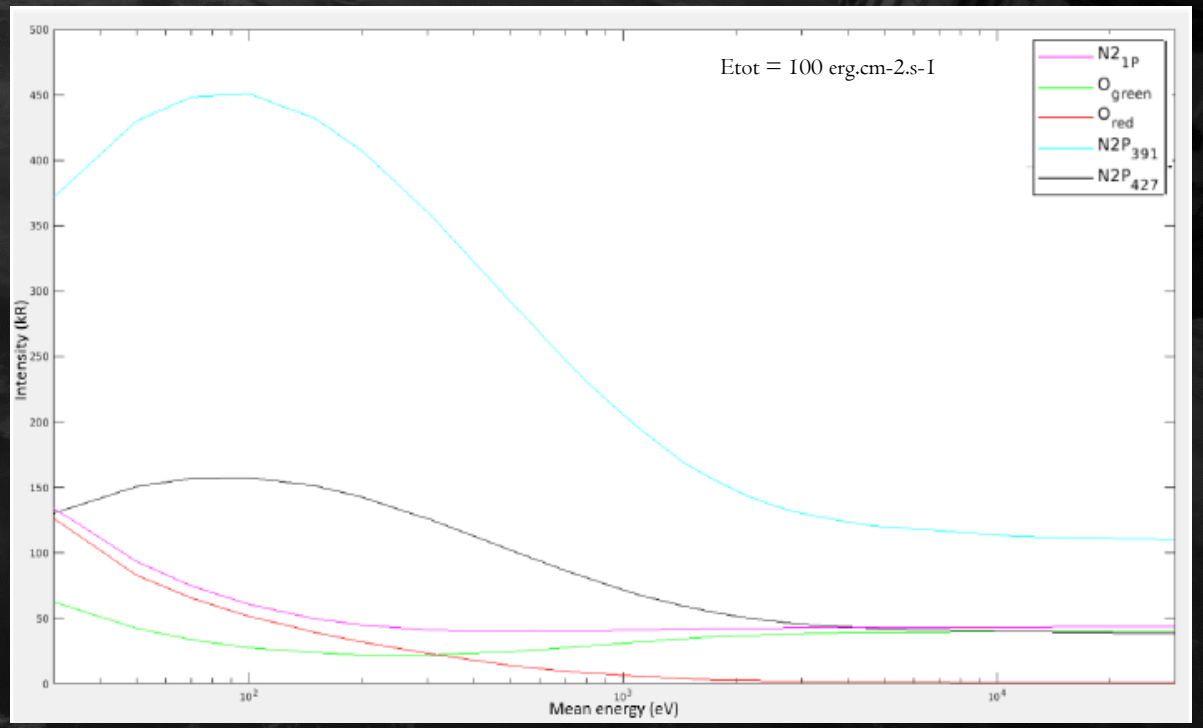






Other representation

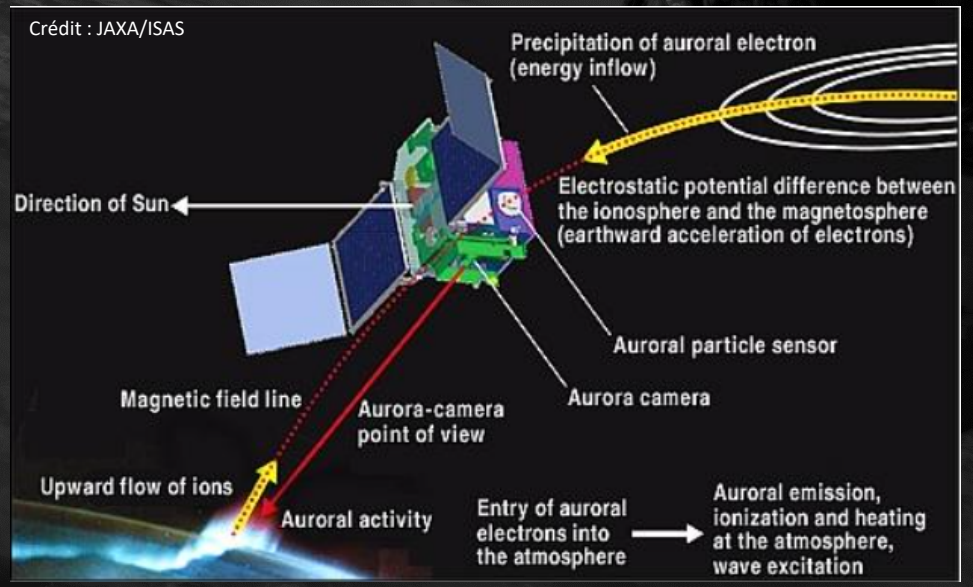
- 2D Representation
- Lines intensity in function of mean energy
- Total energy is fixed
- Integrated on a vertical
- Degenerescence are remarked
- Beyond 3 keV energies are quite difficult to discriminate energies lines intensity



Reimei data used to validate simulations results

Reimei :

- Small satellite of 72 kg
- 70 cm x 62 cm x 62 (H) cm
- Launched on August 23, 2005 at Baikonour
- Polar sunsynchronous orbit, 608 x 655 km d'altitude, 98.17°.
- ISAS/JAXA
- Auroras images and particles measurements simultaneous (Mode-S).



Instruments :

- ❖ Multi-spectral monochromatic auroral imaging camera (MAC) : spatial resolution - 1024 x 1024 pixels, 70 x 70 km à 110 km for three wavelengths 428, 558 et 670 nm every 20ms.
- ❖ Electrons and ion energy spectrum analyzers (ESA/ISA) : energy range - 12ev – 12keV for the electrons, 10 eV/q – 12 keV/q for the ions.

Means that the ESA/ISA could measure auroral particle properties on the same geomagnetic field line on which the auroral emissions could be observed by MAC.

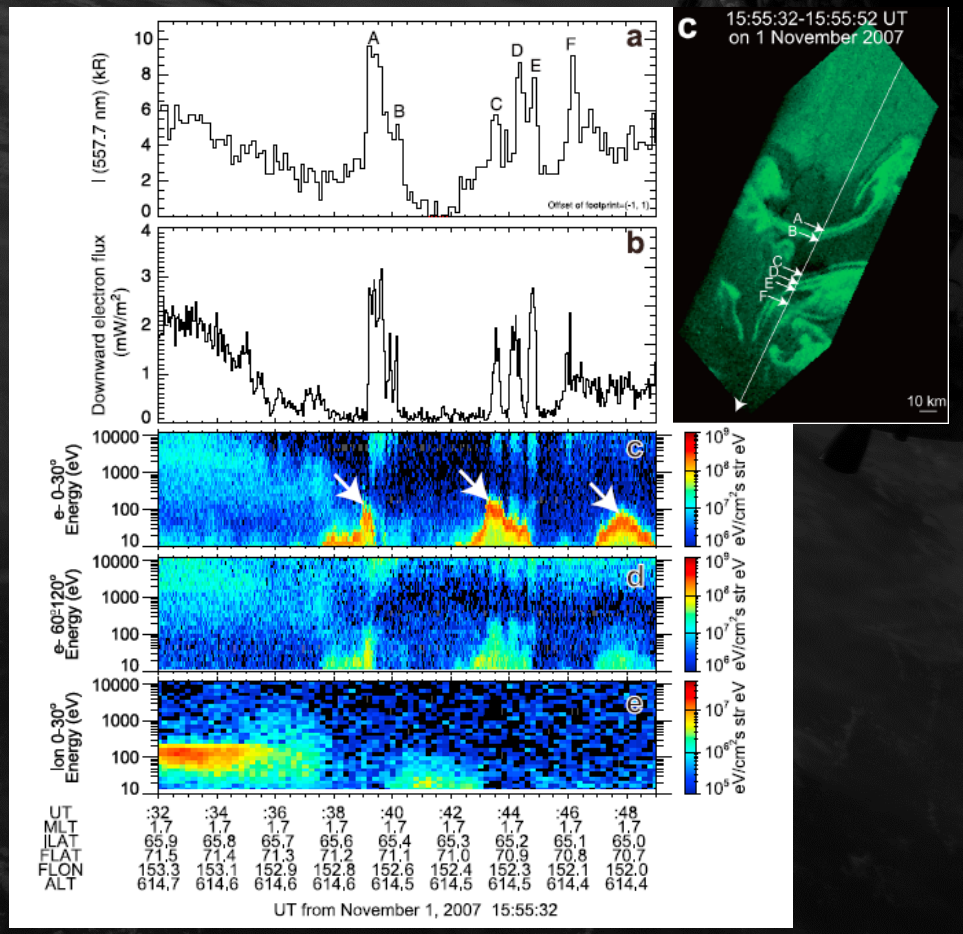
Reimei data used to validate simulations results

Direct method:

- ESA data in inputs of TRANSSOLO and to compare simulations and MAC data.

Reverse method :

- Take optical measurements of AMICAL and check if energies calculated by optimization are similar to the ESA measurements.



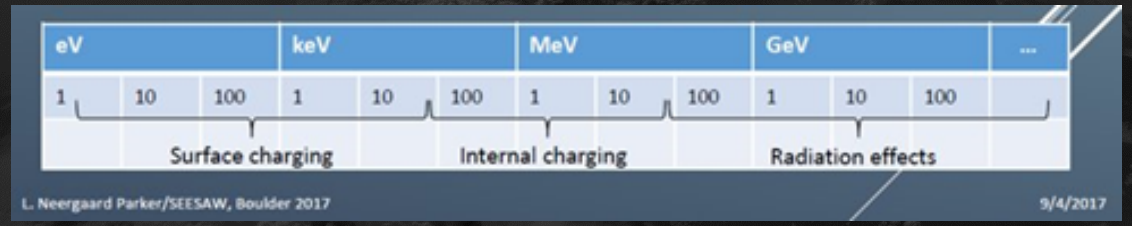
Ebihara, Y., Sakanoi, T., Asamura, K., Hirahara, M., & Thomsen, M. F. (2010). Reimei observation of highly structured auroras caused by nonaccelerated electrons. Journal of Geophysical Research: Space Physics, 115(A8).

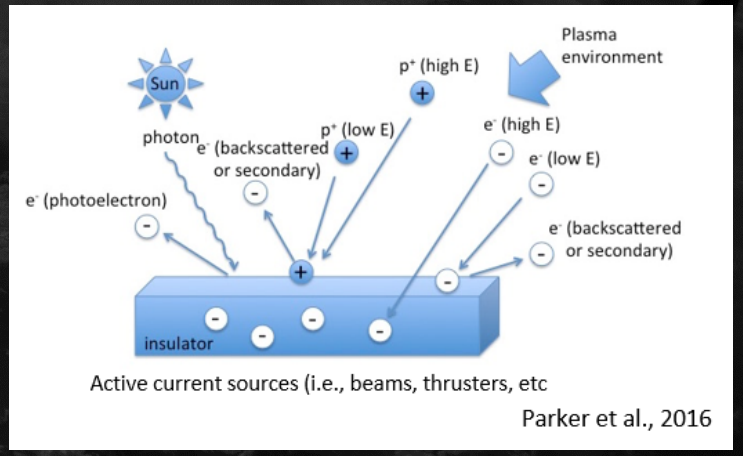
Surface charging & Auroral region

- The surface charging results from charges accumulation (electrons and ions) around the surface of the satellite that moove throught the plasma. The most important effect of the surface charging is the **Electrostatic Discharge** or ESD.

→ Auroral electrons have energies in the range of **eV-keV** and are responsible of the surface charging. Study this electron population allow us to better understand impact of them on satellites.

- Surface charging triggering on satellite when a threshold of particles flux (with a specific energy) is exceed. To follow temporal evolution we need to monitor particles flux.





Conclusion and take home message

- Optimization method implemented from Transolo to monitor low energies particles in auroral region.
  - Minimization between simulations and AMICAL Sat data then ATISE data later
  - Validation of Transolo with Reimei data
  - ALIS data and AMICAL Sat and ATISE measurements taken on the ground can be considered to be used if AMICAL Sat data from space are unsuable.

- Understanding auroral particles can allow us to better understand the surface charging which affected satellites.

Thank you for your attention

References

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