Swarm-Aurora: A web-based tool for quickly identifying multi-instrument auroral events

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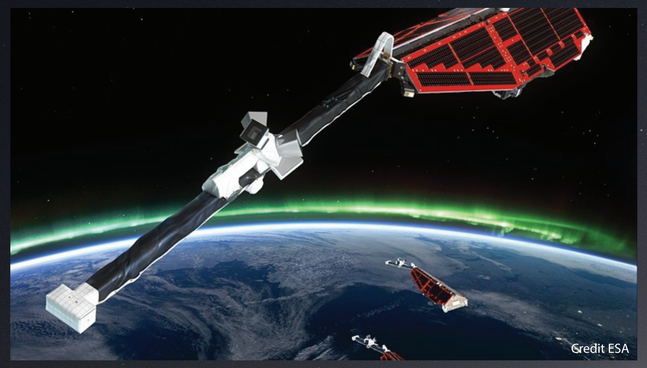
1. Introduction

In recent years there has been a dramatic increase in ground-based auroral imaging systems. These include the continent-wide THEMIS-ASI network, and imagers operated by other programs including GO-Canada, MIRACLE, AGO, OMTI, and more. In the near future, a new Canadian program called TREx will see the deployment of new narrow-band ASIs (All Sky Imagers) that will provide multi-wavelength imaging across Western Canada.

At the same time, there is an unprecedented fleet of international spacecraft probing geospace at low and high altitudes. We are now in the position to simultaneously observe the magnetospheric drivers of aurora, observe in situ the waves, currents, and particles associated with MI coupling, and the conjugate aurora. Whereas a decade ago, a single magnetic conjunction between one ASI and a low altitude satellite was a relatively rare event, we now have a plethora of triple conjunctions between imagers, low-altitude spacecraft, and near-equatorial magnetospheric probes. But with these riches comes a new level of complexity. It is often difficult to identify the many useful conjunctions for a specific line of inquiry from the multitude of conjunctions where the geospace conditions are often not relevant and/or the imaging is compromised by clouds, moon, or other factors.


Credit ESA

Swarm-Aurora was designed to facilitate and drive the use of Swarm in situ measurements in auroral science. The project seeks to build a bridge between the Swarm science community, Swarm data, and the complimentary auroral data and community. Swarm-Aurora (http://swarm-aurora.phys.ucalgary.ca) incorporates a web-based tool which provides access to quick-look summary data for a large array of instruments, with Swarm in situ and ground-based ASI data as the primary focus.

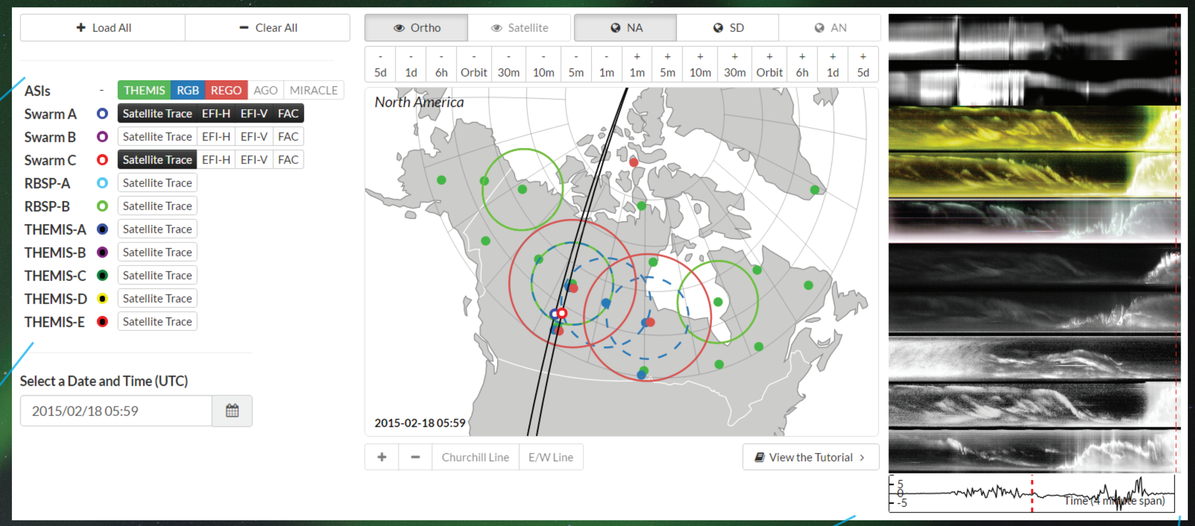
This web interface allows researchers to quickly and efficiently browse Swarm and ASI data to identify auroral events of interest to them. This allows researchers to be able to easily and quickly identify Swarm overflights of ASIs that were capturing images of aurora of interest. Providing interaction with this data in this manner drastically reduces the time needed to do a preliminary survey of Swarm and ground-based instruments for investigating auroral phenomena.

With Swarm-Aurora, we aim to:

- bring a large fraction of the world's auroral imaging capacity to Swarm as efficiently as possible
- enable researchers to identify scientifically valuable Swarm overflights of ASIs
- enable users to utilize ASI data together with Swarm data
- demonstrate the efficacy of the developed tools for addressing cutting edge science
- engage auroral researchers in developing a roadmap for ongoing Swarm-Aurora activity

2. Conjunction Browser

The Swarm-Aurora project has several web-based tools which have been developed to provide an efficient method of browsing auroral and Swarm summary data to determine conjunctions. The primary web tool is the *Conjunction Browser* (shown to the right). The below subsections will explain each major part of the interface.



i) The Instrument / Satellite Selector

- Located on the left-most side of the browser
- Allows you to toggle the visibility of satellite traces
- Allows you to toggle the visibility of ASI projects which had cameras collecting data for the given hour that is being viewed
- As we expand the number of ASI projects and satellites, this section will likely be revamped to accomodate a better use of space

ii) The Interactive Map Area

- Focal point of the Conjunction Browser
- Top row of buttons used for loading different map projections and overall map views. For example, you can switch from the North America map to the Scandanavia map in order to view the MIRACLE instrumentation.
- Second row of buttons allows for easy and quick time movements
- As a result of the design of the Conjunction Browser, changing the time (within a given day) results in near-instantaneous updating of the content displayed on the map
- Displays the satellite footprints and their traces. For Swarm, the trace includes 30 minutes before and after the currently selected time. For RBSP and THEMIS, the trace includes 3 hours before and after.
- Displays the locations of any ASIs (for whichever projects were toggled on in the Instrument / Satellite Selector) for which there is data available for the hour currently being looked at. The site dot indicator will not appear if there is no data.
- To view the keogram (or any other ASI summary data we add in the future) for a given ASI, simply click on the map and the closest site will be toggled on. The FoV (field-of-view) will be displayed and the keogram will be shown in the Summary Data Pane.

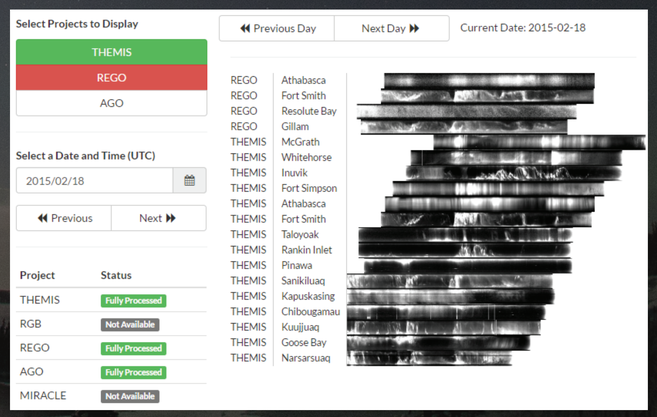
iii) The Summary Data Pane

- Located on the far right
- Where all ASI and Swarm CEFI summary data is displayed if toggled on
- Red dotted lines are overlayed to show you where in the images represent the currently selected time

3. Keogram Browser

The Keogram Browser is a tool that we have begun developing in the last several months. Our goal with this tool is to provide an additional way to quickly scan through summary data from ground-based instruments looking for potential Swarm conjunctions, but, with an opposite focus than the Conjunction Browser.

- Provides an alternate way of searching through summary data. Instead of focussing primarily on a map and satellite traces (ie. satellite-driven discovery), this tool focusses on the ASI data and will overlay the times of Swarm overpasses.
- Still very much a work in progress, partial data available and working out the aethestics



4. Future Work

Looking forward, we hope to include satellite traces from GOES, LANL, Cluster, and MMS, and some cursory summary data from some or all of those. As well, we hope to include auroral/airglow networks beyond the "first five". These should include imagers operated by SRI and Boston University, the Alaska Geophysics Institute, the Polar Research Institute of China, UNIS and the University of Oslo, IRFU, and the University of Nagoya. Furthermore, we hope to include photometer summary data and possibly riometer summary data.

A key objective is to have an effective research enabling tool. This means we are committed to a web application that is, for lack of a better term, "lightning fast". This means we will be keeping the summary data very light. Keep in mind, though, that we are in the age of Big Data, and we expect in the end that a day of summary data will be hundreds of MBytes.

A final (end) goal is to create "Swarm-Aurora On-the-Go", meaning to open up the database so you can download it, completely, on your own computer. This would mean you could run Swarm-Aurora from your computer while not on the web.

The Swarm-Aurora project is supported by the Swarm Discovery Innovation and Science Cluster (Swarm DISC) with administrative support from the European Space Agency (ESA). Additionally, current summary data is provided by the University of Calgary, UC Berkeley, Finnish Meteorological Institute, and The University Centre in Svalbard. Background image courtesy of Astronomy North.