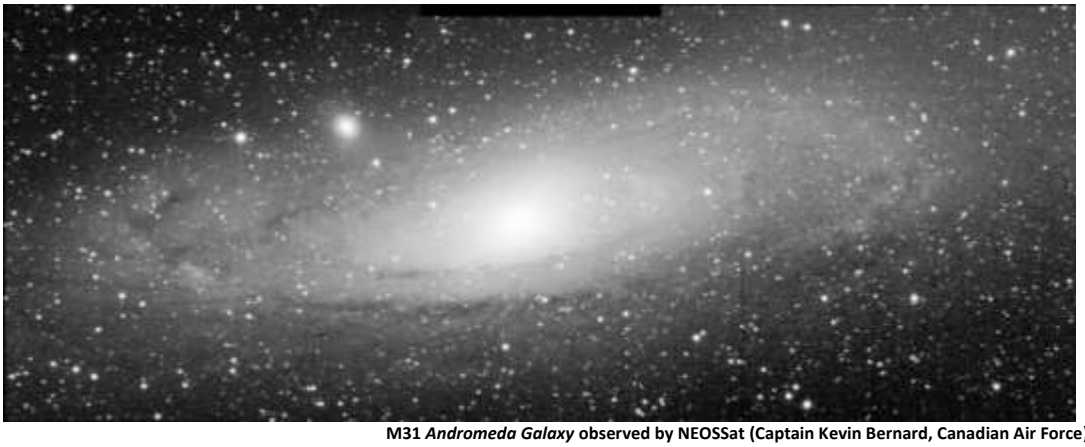
Canadian Space Agency | Agence spatiale canadienne

NEOSSat – Canada's Space Surveillance Telescope



M31 *Andromeda Galaxy* observed by NEOSSat (Captain Kevin Bernard, Canadian Air Force)

THE CHALLENGE:

Explore asteroid data and find solutions to optimize their use and even create your own animation.

Access the full open data archive for NEOSSat:
ftp://ftp.asc-csa.gc.ca/users/OpenData_DonneesOuvertes/pub/NEOSSAT/

THE ISSUE

Currently, there are thousands of NEOSSat astronomy images available online via the Government of Canada's Open Data Platform. These images range from objects relatively close to Earth such as asteroids and comets, to objects outside our solar system such as stars and nebula. However, the consultation, use and application of this very large supply of data could be improved with the development and implementation of search and analysis tools and maybe even playfull app.

THE NEEDS (you can choose to tackle one or more)

1. Searching the data archive and identify images

CSA needs a solution to efficiently search the NEOSSat database and identify images according to specific criteria/information.

Potential output

A database with a search tool that will allow users to quickly and easily find images by searching the metadata. For example, to answer the needs of a user who wants images of a specific section of the night sky : A database and according tool could allow them to input a specific right ascension and declination range that would return all the images that meet that criteria.

How to get started

Each image is in the standard astronomy FITS format, which contains a wealth of metadata.

It could be useful to locally download any random small subset of data (e.g., some surveys, some comet/asteroid images, some exoplanet) in order to access the metadata stored within the FITS files.

- Extracting the metadata into a local database.
- Reading the FITS Image User Guide to understand meanings of different header (the metadata contained in a FITS image) parameters and develop a user interface to fetch images corresponding to the user-specified parameters.

A local copy of the images is only needed to build the metadata database, after which local images can be deleted and be re-fetched from the open data platform using your new database and search tool.

Participants can try and accommodate as many potential use cases as they can think of while maintaining a user-friendly interface. No need to implementing a search for every single parameter. The focus should be more on quality than quantity.

New data gets added all the time, thus making useful an architecture allowing to keep the metadata database up to date over time.

2. Identifying potential asteroids or other objects within the image archive

CSA needs a solution to pin-point asteroids or other type of objects on the images captured by NEOSSat.

Potential output

An algorithm characterizing and categorizing outliers (asteroids, comets, satellites, space weather effects) captured in images taken during NEOSSat's near-Sun space surveillance surveys.

How to get started

NEOSSat has completed several asteroid surveys, including some during its eclipse seasons, (where the sun's light being blocked by the Earth allows it to gather images even closer to the Sun). The following years / days contain survey campaign images:

- 2018 \ DOY 318, 319, 324, 325, 333, 334, 339, 340, 341, 346, 347, 348, 351, 352, 353, 354, 355 , 356, 357, 358, 364, 365;
- 2019 \ DOY 001, 002, 003, 004, 005, 006, 007, 008, 009, 016, 017, 019, 020, 021, 022, 023, 024, 026, 027, 028, 029, 030, 031

Each survey field contains at least 4 different survey images in the telescope's Fine Point state, which is the best state to use (look for MODE=FINE_POINT in the header meta-data). Start with a subset of image sets to refine your technique and then apply your methods to additional groups to see what you can find.

Note 1: the survey data before 2018-355 is easier to use, in that the images of a given survey field are grouped into their own folder. After that, one needs to look at the OBJECT tag in the meta-data to identify the survey field.

Note 2: only the basic, not the advanced image cleaning, has been performed on these images. It would be useful to apply dark subtraction as detailed in the Jason Rowe's Python routines for NEOSSat.

3. "Timelapse" a Near-Earth Asteroid (NEA) or Comet

CSA would like to increase the interest of the public for asteroids. In order to catch people's attention, it would be interesting to have a tool that would use the NEOSSat images and come up with a fun and playful solution that would popularize the images and make them more accessible to people with limited scientific knowledge.

Potential output

Improve the visualization of NEOSSat asteroid/comet data through multimedia means such as an engaging animation from time-series of a Near-Earth Asteroid (NEA) or Comet object as it makes its close approach to the Earth.

How to get started

The proposed dataset contains a selection of astronomical images (asteroid or comet) with embedded metdata - see table below.

The image processing and analysis tools are available to process the images and metadata.

- The participants could use these images with the metadata to work together - potentially alongside new technologies not yet employed by astronomers - to provide a wholly new perspective on these little-known objects that routinely fly through our solar system.
- Subsequent images will not necessarily have the stars in the same place from image to image, as the telescope adjusts its pointing as the asteroid leaves the field of view. To make the animations accessible and easy to understand, you will need to "freeze" the stars in place such that only the asteroid appears to be moving.

Type	Object Name	Days imaged
NEA	2018-RC	2018 / 250,
Comet	46P	2018 / 281, 284, 285, 290, 293, 300, 319, 321, 335, 345, 348, 349
NEA	J12192806	2018 / 314
NEA	C2018-V1	2018 / 321
NEA	2018-KV	2018 / 335
Comet	64P	2018 / 345
NEA	P10KLoS	2019 / 004
NEA	2019-AQ3	2019 / 040
NEA	2019-EA2	2019 / 075, 081,
NEA	1999-KW4	2019 / 118-126 (every day), 128-152 (every day)
NEA	2019-A10dn4M	2019 / 124
NEA	CK19D010	2019 / 128
NEA	A10dQbl	2019 / 150
NEA	A10dRr5	2019 / 150
Comets	2019-K1, 2019-A9, 2019-W1, 2018-F4, 2017-T2,2019-K5	2019 / 243, 244
Interstellar Comet	CK19Q040 (aka 2I/2019 Q4 or Borisov)	2019 / 256 and onwards

BACKGROUND

Launched in 2013, Canada's Near-Earth Object Surveillance Satellite (NEOSSat) is a successful partnership between the Canadian Space Agency (CSA) and Defense Research & Development Canada (DRDC). A nimble suitcase-sized micro-satellite orbiting at 800km altitude, NEOSSat is equipped with a 15-cm telescope capturing a 0.8 degree field of view on a 1024x1024 pixel CCD. The satellite is now producing thousands of images per week, in a variety of applications, including:

- **Space Situational Awareness**: tracking other satellites and space debris to improve orbit predictions and minimize collision risks.
- **Near-Earth asteroids and comets**: Asteroids and comets have garnered more attention in recent years as they could be treasure troves of resources for future space mining expeditions. Every now and then, an asteroid makes a close approach with the Earth, highlighting the potential for Earth impacts and the need to characterize the population of near-Earth asteroids in particular. In addition, asteroids and comets can also help us understand the early origins of the solar system.
- **Exoplanet photometry**: observing stars and searching for small brightness changes can detect exoplanets. NEOSSat is currently being used on known or candidate exoplanets to characterize transits and learn more about the exoplanet systems
- a variety of **other interesting astronomical targets**, including supernova and other variable stars

Astronomy images taken by NEOSSat are published routinely on Open Data Platform, in the standard astronomy Flexible Image Transfer System (FITS*) format, enabling a variety of advanced studies, including astrometry (measuring the positions of space objects) and photometry (measuring the brightness of space objects).

* The NASA FITS Support Office provides a list of FITS software libraries for various programming languages, including an overview of each package to help in the selection of an appropriate library: https://fits.gsfc.nasa.gov/fits_libraries.html

Supporting Data and Software Packages

Understanding Astronomical Data

NEOSSat is routinely publishing raw images in the astronomical standard FITS format. The format allows storing of relevant data such as payload temperatures or the spacecraft's pointing and position. The FITS Image User Guide explains all of the meta-data.

NEOSSat's astronomy data archive is organized by Year, then Day of Year (DOY).

Image Processing Software

Raw, unprocessed astronomy images are always available on the portal, uploaded shortly after downlink from the satellite. In general, users perform their own image processing to remove image artifacts and perform analysis. In some cases, the resulting processed images are returned back to CSA and made available on Open Data Portal. (you can consult these files in *_cord.fits* format)

The NASA FITS Support Office provides a list of FITS software libraries for various programming languages, including an overview of each package to help in the selection of an appropriate library: https://fits.gsfc.nasa.gov/fits_libraries.html

The following software packages are particularly popular and mature:

- Python - AstroPy: http://docs.astropy.org/en/stable/index.html
- C / Fortran – CFITSIO/FITSIO http://legacy.gsfc.nasa.gov/docs/software/fitsio/fitsio.html

FITS viewers/converters are also available (https://fits.gsfc.nasa.gov/fits_viewer.html), such as:

- SAOImage DS9 Astronomical Visualization: http://ds9.si.edu/site/Home.html
- ImageJ: https://imagej.nih.gov/ij/

In addition, custom-built software for NEOSSat image cleaning and photometry is available at:

- https://github.com/jasonfrowe/neossat

This program, which demonstrates how to apply image cleaning on NEOSSat raw images, could help serve as a template to get started with NEOSSat data processing and manipulation.

Further relevant information and data sets

Workshop Presentation by CSA experts

Near-Earth Asteroid Search Programs

Supporting documents