



NASA Crew Earth Observations: A Long-Term Dataset for Earth System Research, Applications, and Education

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Polar orbit

- Sun-synchronous – designed for long term repeatability of data
- Typically nadir viewing, crosses every point on Earth ~ 12-14 days near local solar noon/local midnight
- Landsat series collecting data since 1972
- Pointing capability, satellite constellations

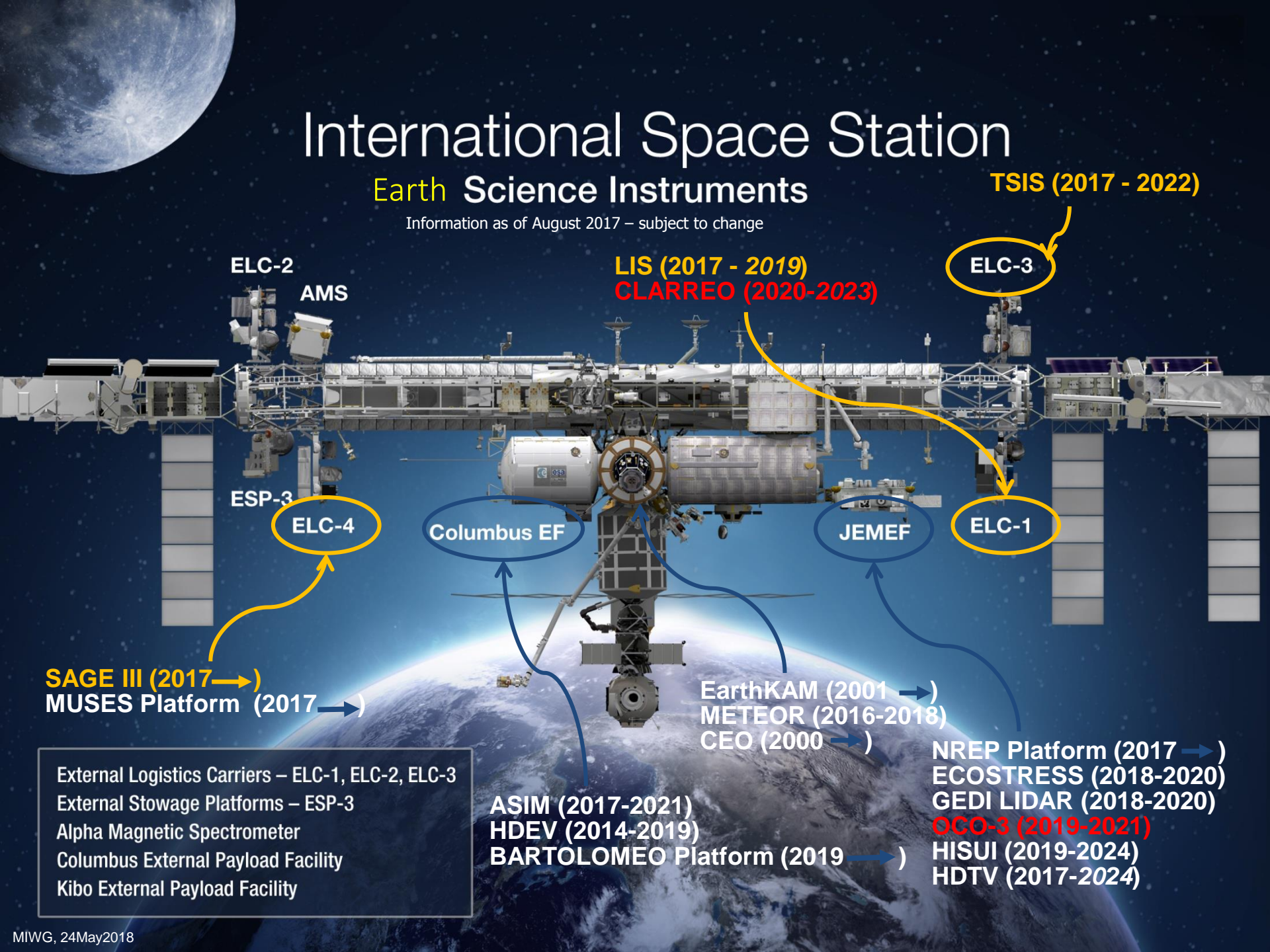
Inclined Equatorial Orbit: ISS

- Sun-asynchronous – similar illumination 3-4 days every 90 days
- Nadir to highly oblique imagery possible from hand-held cameras, WORF, external sensors
- Provides opportunity to collect unique datasets for scientific study, disaster response
- Data is complementary to polar-orbiting satellite data

International Space Station

Earth Science Instruments

Information as of August 2017 – subject to change



TSIS (2017 - 2022)

ELC-3

LIS (2017 - 2019)

CLARREO (2020-2023)

ELC-2

AMS

ESP-3

ELC-4

Columbus EF

JEMEF

ELC-1

SAGE III (2017 →)

MUSES Platform (2017 →)

EarthKAM (2001 →)

METEOR (2016-2018)

CEO (2000 →)

NREP Platform (2017 →)

ECOSTRESS (2018-2020)

GEDI LIDAR (2018-2020)

OCO-3 (2019-2021)

HISUI (2019-2024)

HDTV (2017-2024)

ASIM (2017-2021)

HDEV (2014-2019)

BARTOLOMEO Platform (2019 →)

External Logistics Carriers – ELC-1, ELC-2, ELC-3

External Stowage Platforms – ESP-3

Alpha Magnetic Spectrometer

Columbus External Payload Facility

Kibo External Payload Facility



Sensor: Crew Earth Observations (CEO)

Location: internal, Station windows

Sponsor/Funding: ISSP; “task-listed” activity

Prime Mission: collection of Earth imagery in support of disaster response, and dynamic events with other ISS sensor systems. Also supports education/outreach and focused short-term science objectives.

ISS Timeframe: 2000-2024

Principal Investigator: William L. Stefanov, JSC

Pointing capability: variable, dependent on window and lens

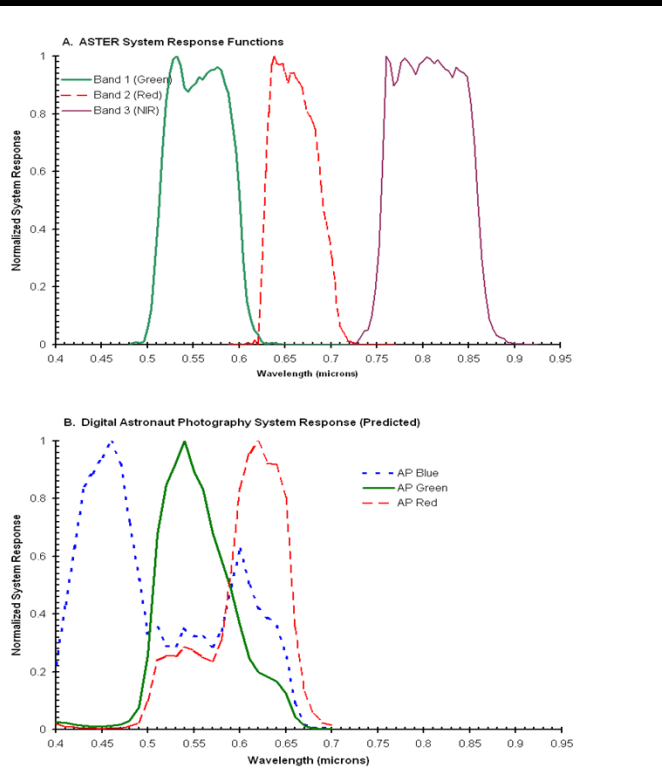
Geometric resolution: variable, depends on lens
 < 3 m/pixel with 1000 mm lens to > 30 m/pixel with 110 mm and shorter lenses

Spectral sensitivity: visible RGB, poorly constrained Bandpasses (potential for NIR imagery using modified camera)

Scene Size: variable, depends on lens, ISS altitude

Data take to availability time: ~ 24 hours for full resolution data, may be possible to expedite; full georeferencing adds 24+ hrs depending on # of frames and difficulty

Data availability: Public; <http://eol.jsc.nasa.gov>

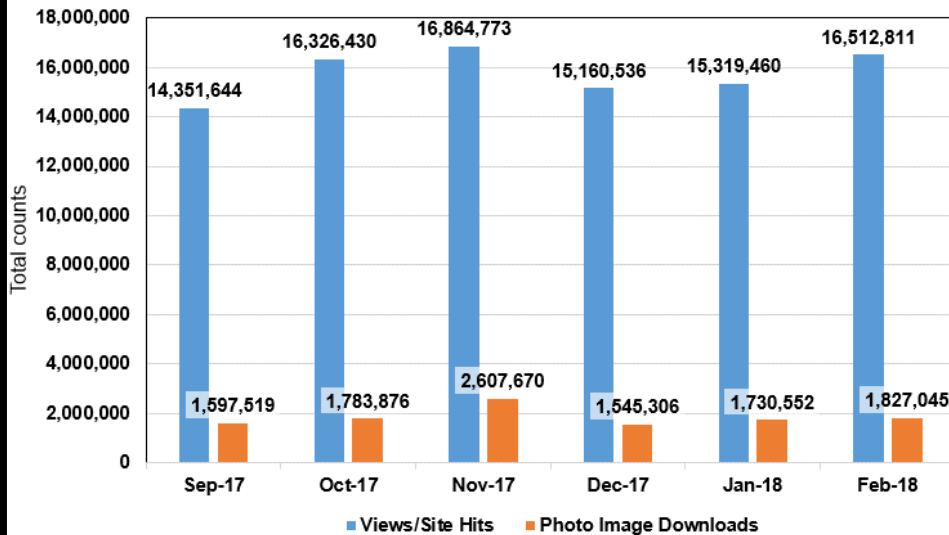




	ISS049	ISS050	ISS051	ISS052	ISS053	ISS054
Images received	29,007	28,411	27,090	48,558	431,526	47,721
Priority 1 images cataloged	3.90%	4.49%	4.35%	5.94%	7.92%	7.70%
No. of requested target list sites	38	60	40	48	78	38
No. of photos taken during requested times	16,159	17,006	17,528	18,982	23,772	24,440
Average frames per day for days where photos were taken	580	189	630	587	4,495	852

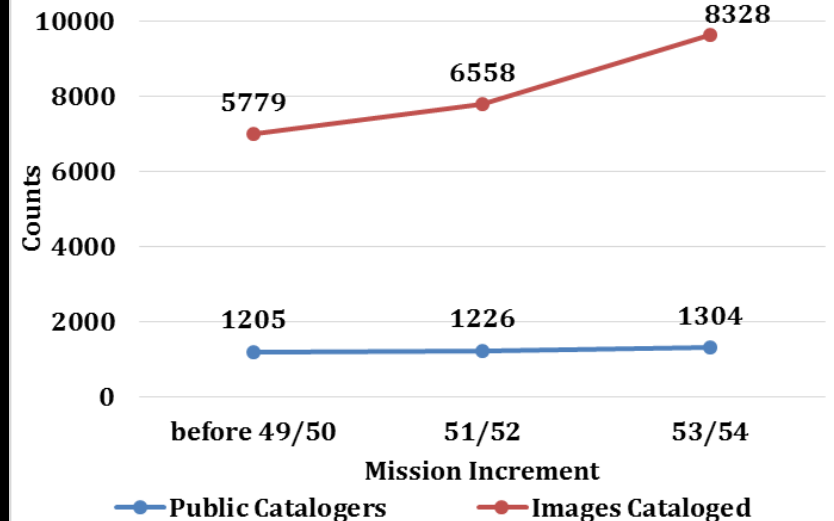
Targeting and crew response statistics up to I54

Gateway to Astronaut Photography (GAPE) Hits : Months 09/2017 - 02/2018



Website and image download statistics up to I54

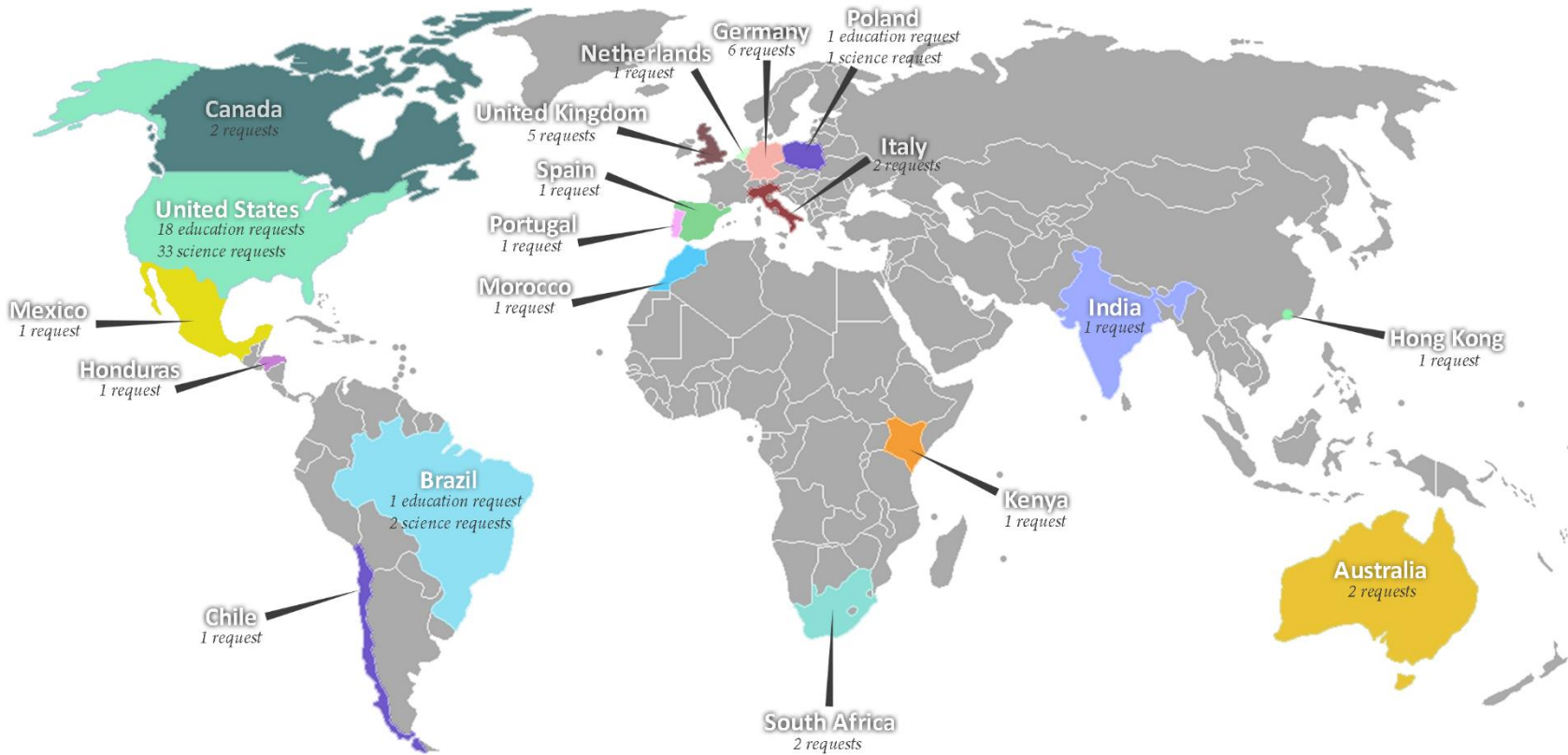
Cumulative Public Catalogers and Images Cataloged



Public cataloging statistics up to I54



External Research and Education



Garcia-Saenz, A., Sánchez de Miguel, A., Espinosa, A., et al. (2018). Evaluating the association between artificial light-at-night exposure and breast and prostate cancer risk in Spain (MCC-Spain study). *Environmental Health Perspectives* 126 (4), DOI:10.1289/EHP1837

Kyba, C.C.M, Garz, S., Kuechly, H., Sánchez de Miguel, A., Zamorano, J., Fischer, J., & Hölker, F. (2015). High-resolution imagery of the Earth at night: New sources, opportunities and challenges. *Remote Sensing* 7: 7-23.

Stefanov, W.L., and Evans, C.A. (2015) Data collection for disaster response from the International Space Station. *The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences* 40, 7/W3: 851-855.

Jehl, A., Farges, T., & Blanc, E. (2013). Color pictures of sprites from non-dedicated observations on board the International Space Station. *Journal of Geophysical Research, Space Physics* 118: 1-8.

Request New Imagery

The International Space Station, while known for scientific and engineering experiments, is also an invaluable remote sensing platform. Astronaut photography offers a unique and dynamic aspect to features all over the Earth. Astronauts on board the ISS use handheld cameras to take images of the Earth with a variety of focal lengths available to capture anything from broad to extremely detailed views. The Crew Earth Observations team has made this asset available to the public, catering from classroom research to scientific research in need of views of a particular Earth feature from space.

Submitted requests will be reviewed by the CEO science team, with approval notice provided within two weeks of submission. Once acquired, electronic copies of images will be sent to the requester. Image acquisition and turn-around time varies.

Educational Request

Astronaut imagery can be a powerful classroom tool helping to inspire and motivate students to conduct research in the classroom. The Expedition Earth and Beyond Program, facilitated by the JSC Astromaterials Research and Exploration Science Directorate, is designed to help promote student research in the classroom through the use of astronaut photography of Earth. In addition to using the images available on our Gateway to Astronaut Photography of Earth website, to help students model the process professional researchers use to request new data, they can submit a data request to have new astronaut photography acquired in support of their investigation.

For additional information about the Expedition Earth and Beyond Program and access to useful classroom resources, visit the EEAB website.

[Submit an Educational Request](#)

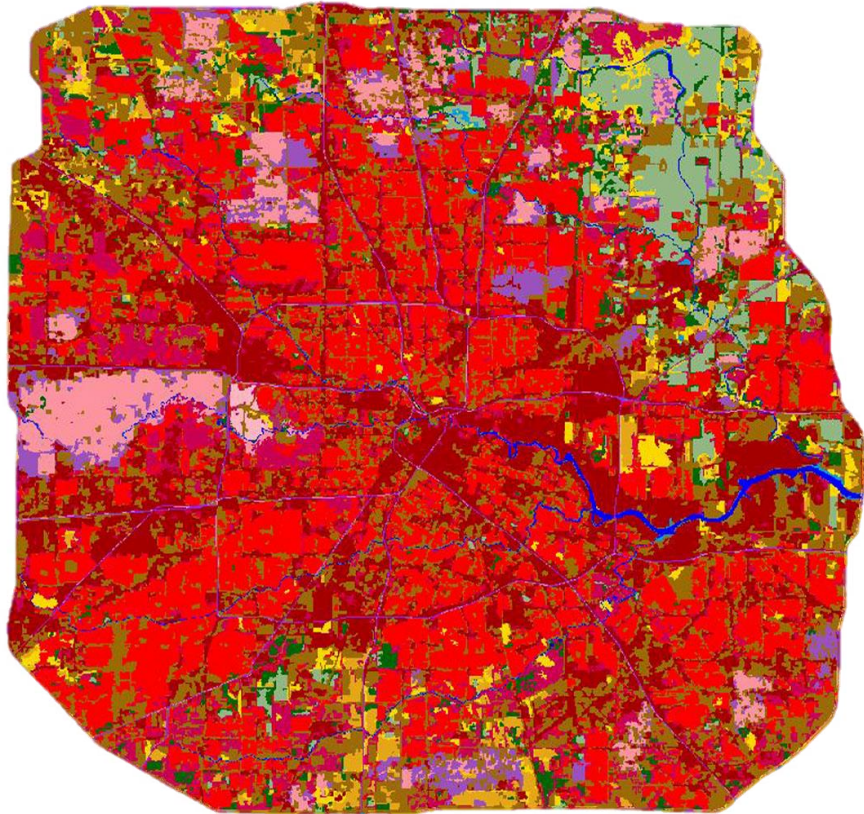
Principal Investigator Request

For submission of detailed proposals to collect new astronaut photography in support of basic or applied research, to be led by a Principal Investigator with optional co-Investigators. Submitted proposals will be reviewed by the CEO science team, with approval notice provided within two weeks of submission.

[Submit a Principal Investigator Request](#)

For requests that do not fall within the scopes of Education or Principal Investigator requests, please contact our Public Affairs Office at 281-483-5111.

Quantifying Change with Astronaut Photography using Geographic-Object-Based Image Analysis



- Mixed Forest: —→ Grassland (35.17%) / Developed – Medium (31.87%)
- Grassland: —→ Developed Low (12.27%) / Developed - Medium (29.57%) / Developed – High (19.54%)
- Developed – Medium: —→ Developed – High (37.50%)
- Developed – Low: —→ Developed Medium (50.32%) / Developed - High (12.18%)

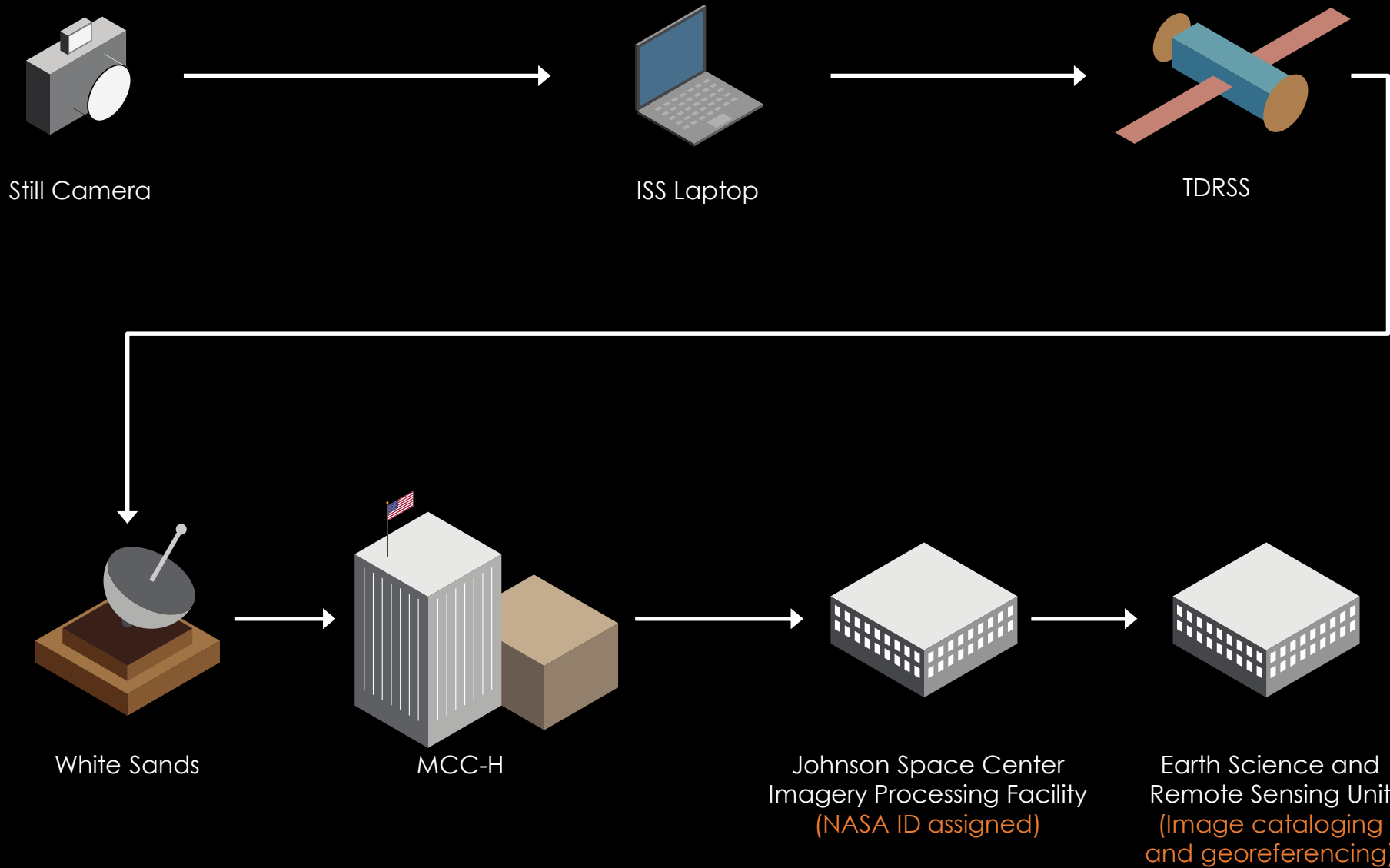


Sacramento-San Joaquin River Delta, California
 1986-2014 (July 1986 to 7/2017)





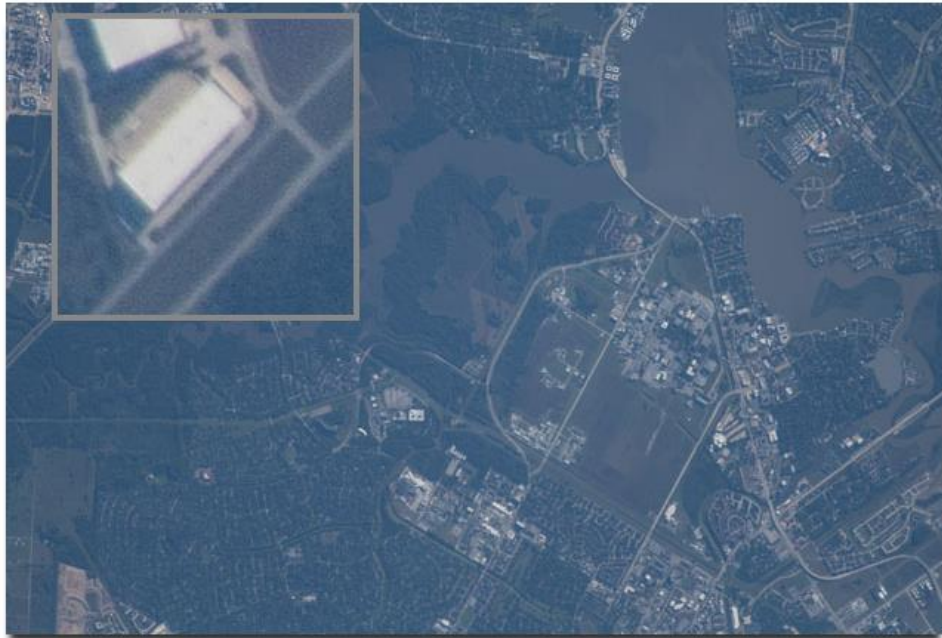
Still Imagery Downlink





ISS053-E-127778

Hor



NASA Photo ID ISS053-E-127778

Focal Length 1600mm

Date taken 2017.10.23

Time taken 13:56:46 GMT

Resolutions offered for this image:

5568 x 3712 pixels

640 x 427 pixels

Zoom image at cursor

MAP LOCATION

latitude/longitude of image

IMAGE DETAILS

features and other details

CAMERA INFORMATION

information about camera used

ALL DOWNLOAD OPTIONS

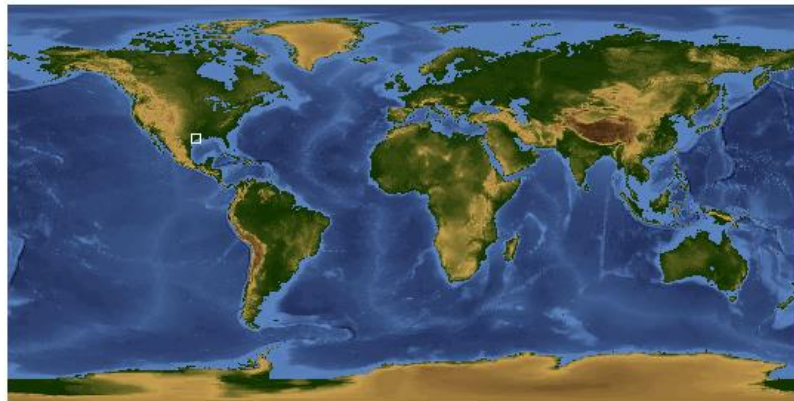
additional formats

Spacecraft nadir point: 30.6° N, 95.4° W

Photo center point: 29.6° N, 95.1° W

Nadir to Photo Center: South

Spacecraft Altitude: 214 nautical miles (396km)



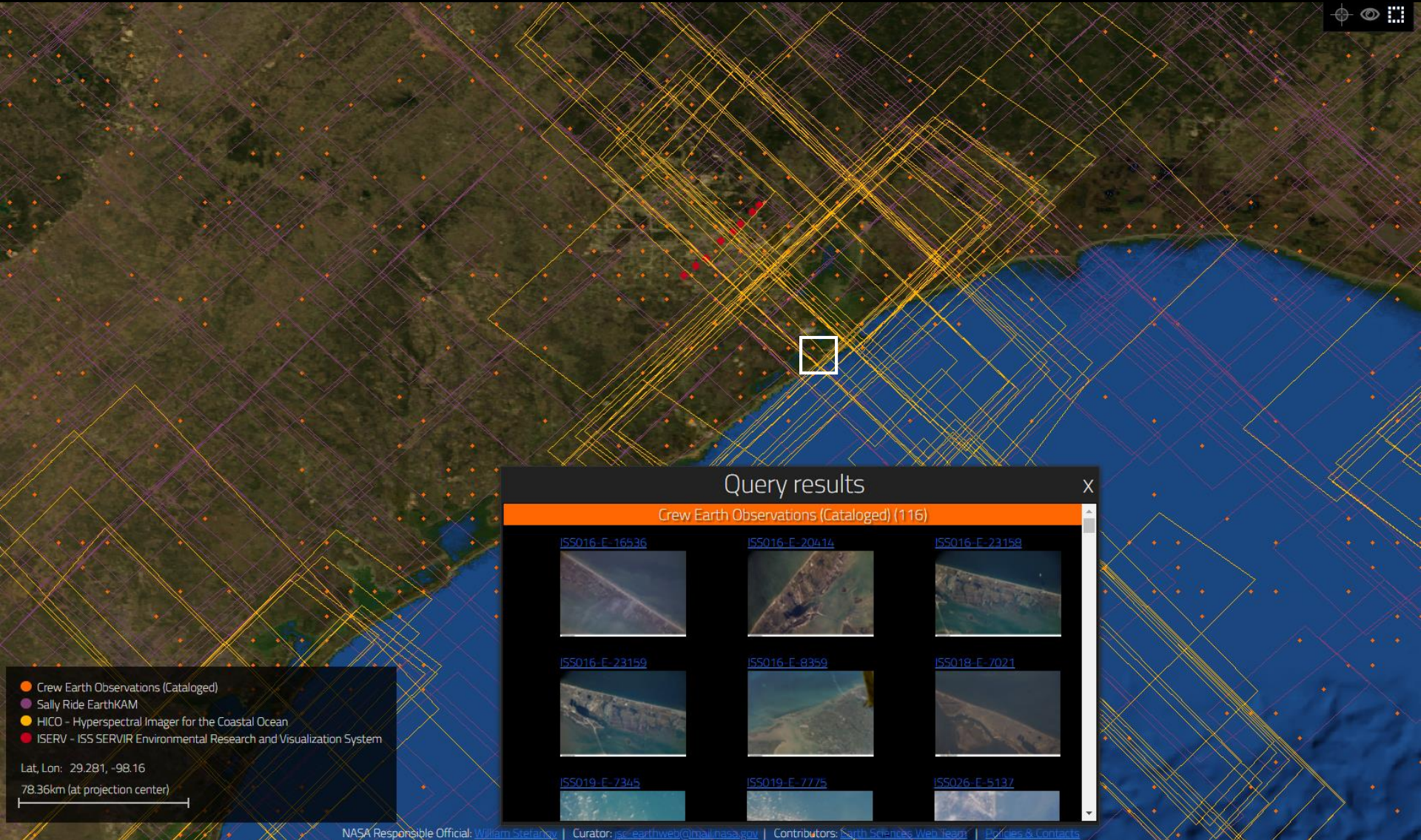
D
S
Q
M



Aurora and Moonglow over W. Europe

Videos produced by the Crew Earth Observations Facility at
NASA Johnson Space Center

For replication and crediting information, please see our guidelines
on our main video page.

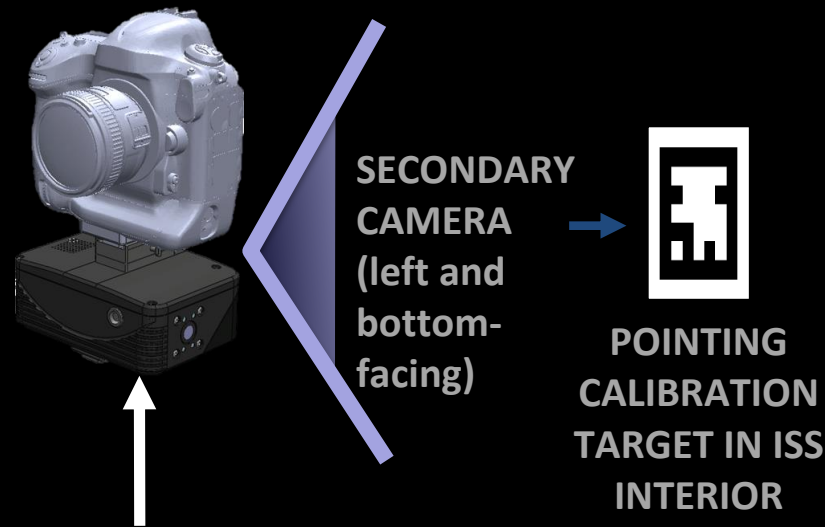


<http://isearthserv.jsc.nasa.gov>

GeoCam Space System – late 2018



GeoSens Hardware

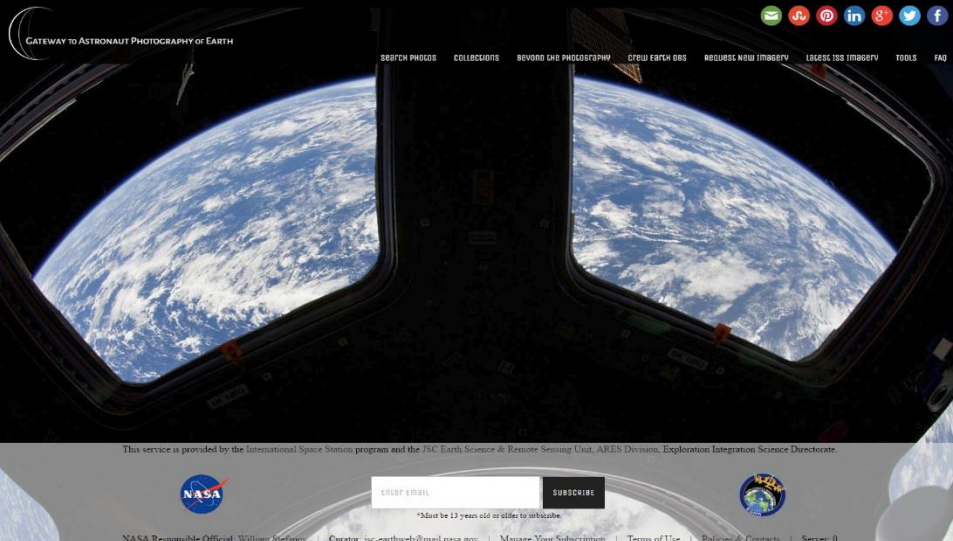


- Pointing Calibration Targets mounted in cupola
 - Ideally, semi-permanent mounting to avoid recurring setup time
- During photography, ensure some calibration target is occasionally in view of secondary camera
 - (Example: In view for at least 1 second every 5 minutes)
 - Given proper target placement, this may happen without explicit astronaut attention
 - Sensor package can use an audible tone to indicate rare cases when astronaut attention is needed
 - Trade-off: More targets vs. higher chance calibration activity is needed

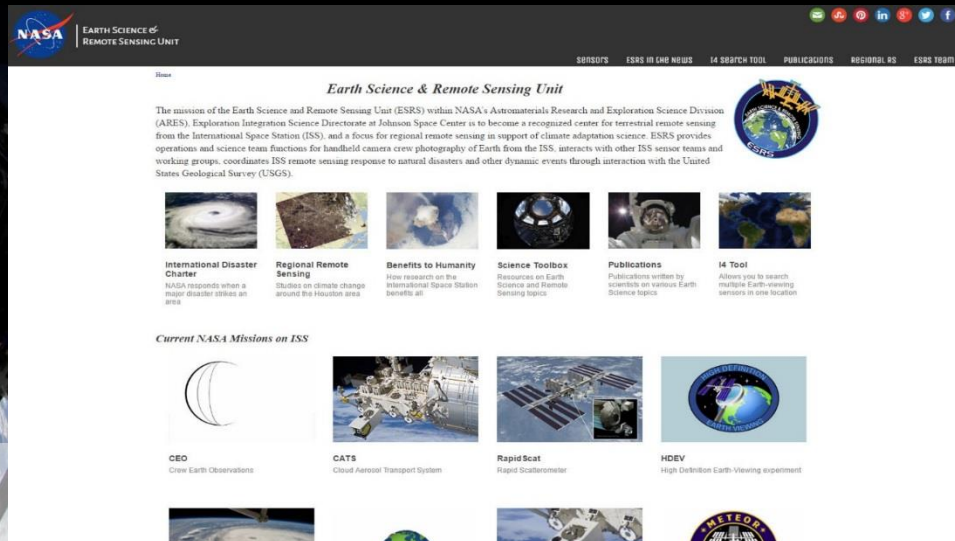


LG Nexus 5

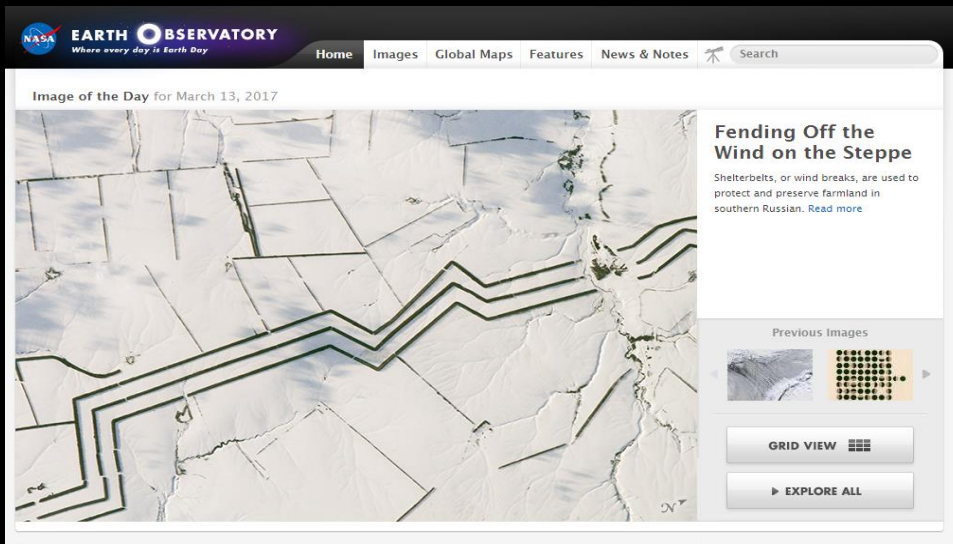




Gateway to Astronaut Photography of Earth - <https://eol.jsc.nasa.gov>



Earth Science and Remote Sensing Unit – <https://esrs.jsc.nasa.gov>



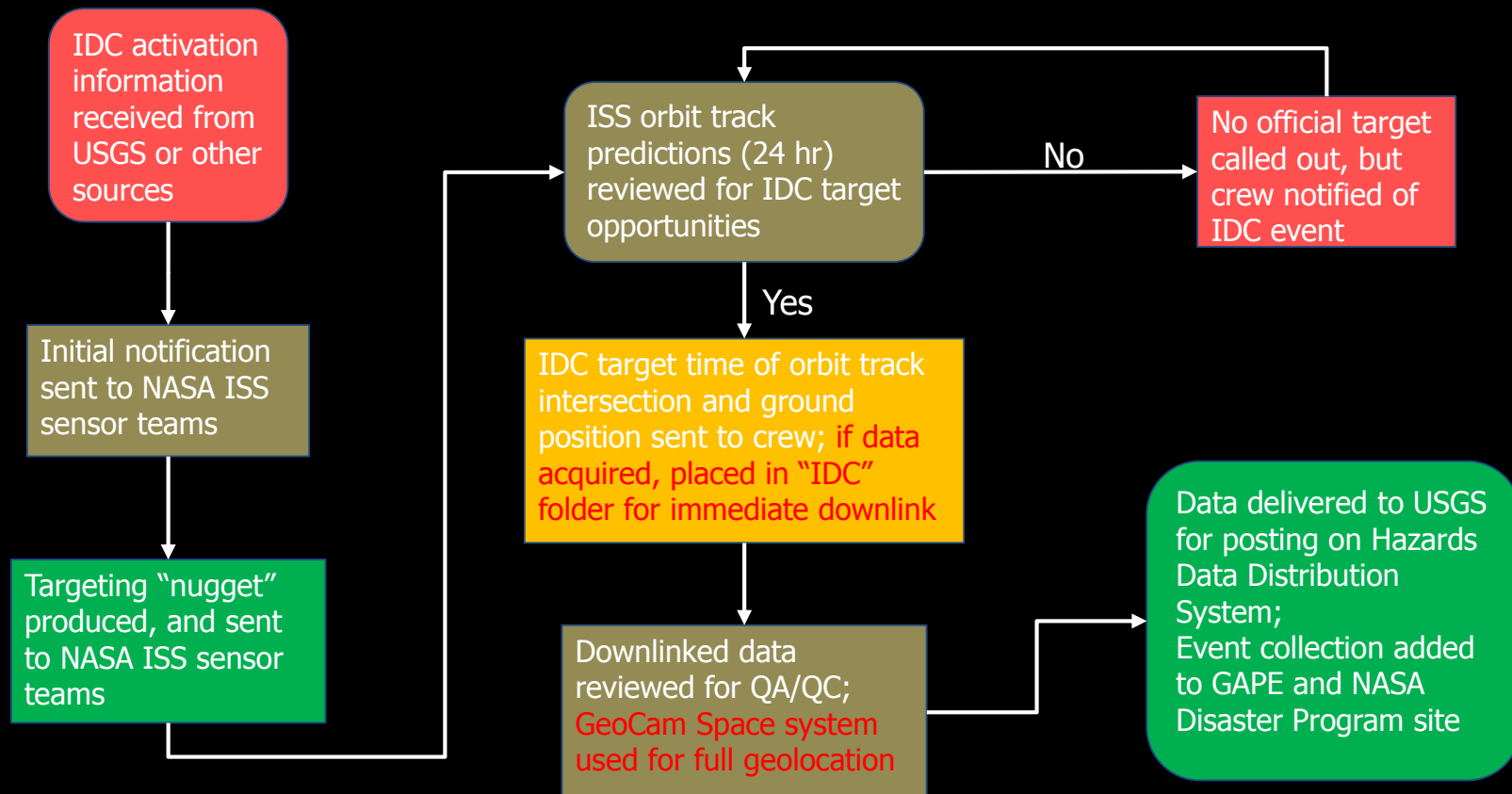
NASA Earth Observatory – <https://earthobservatory.nasa.gov>



NASA Google Earth Layer



NASA ISS Disaster Charter Response (CEO)



Since late April/early May 2012, ISS has received 236 IDC activations; data collected for 63 events and delivered to USGS (ISSAC, CEO, HICO, ISERV)



ISS052-E-78913:
August 31, 2017
95mm lens



Tropical Storm Harvey - August 26-28
2017; 30-61 inches of rain in Houston
metro area

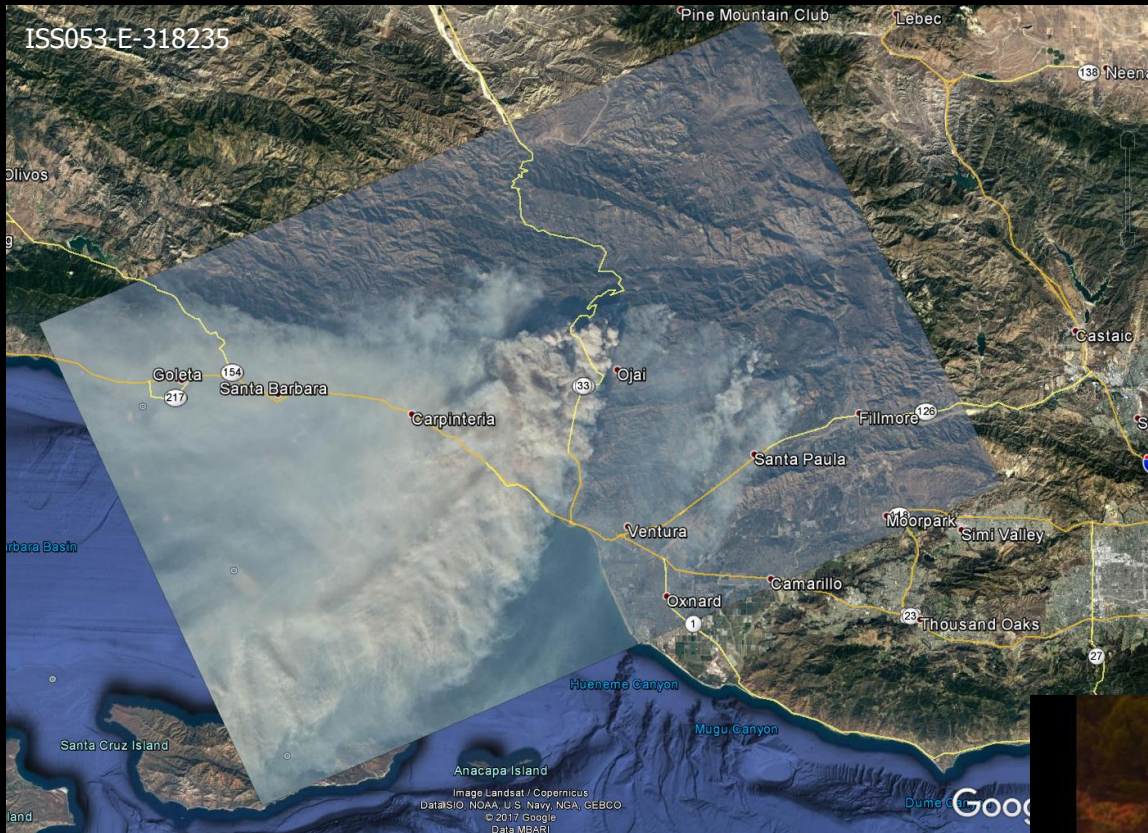
Over \$180 billion USD in damage; 89
reported fatalities, tens of thousands
effected and/or displaced

Astronaut photographs collected following
IDC activation; fully georeferenced and
delivered to USGS

Warming climate allows for
more water to be held in the
atmosphere – leading to greater
occurrence of high precip events



Source: <http://ww4.hdnux.com/photos/65/36/26/14017927/3/920x920.jpg>



- Expansion of urban and suburban development increases brush fire hazard (southwest USA)
- Drier and warmer climate predictions for southwest USA might result in more brush fires – at least initially

California wildfires December 7, 2017



Source: <http://www.cnn.com/2017/12/18/us/california-fires/index.html>



Summary

- Astronaut photography online database includes images from 1961 to present (variable spatial and temporal density): <https://eol.jsc.nasa.gov>
- Entire database searchable using a variety of keyword and graphical search interfaces; images free for download and use with crediting back to NASA
- Both science and education Principal Investigator requests accepted (with acknowledgement of caveats on crew imaging)
- Images are primarily visible RGB of low spectral quality but high spatial quality, amenable to advanced analysis techniques such as Object Based Image Analysis and Neural Networks/Machine Learning
- Currently prime USOS responder to International Disaster Charter and NASA Disaster Program events
- New automated to semi-automated georeferencing system on schedule for delivery to ISS in late 2018
- Strong social media presence and coordination with NASA HQ, GSFC, and ISSP PAO teams



Questions or Comments?



Acknowledgement to the NASA JSC ESRS team - P. Graff, J. Heydorn, M. Higgins, A. Hollier, A. Jagge, M. Lambert, A. Meado, *S. Runco*, *M. Trenchard*, L. Vanderbloemen, and M.J. Wilkinson; mission and imagery operations teams; and special thanks to the astronauts whose Earth observation efforts created and sustain this valuable dataset.