Hyperspectral on the Space Station: Lessons Learned and Goals Achieved

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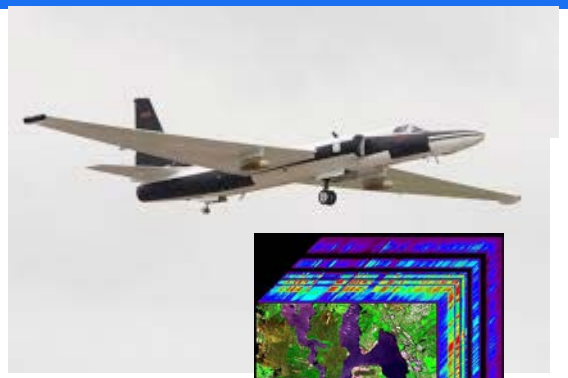
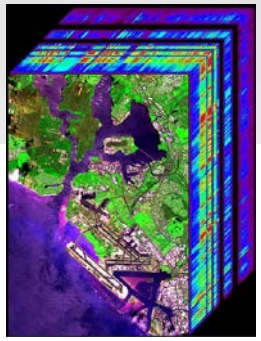
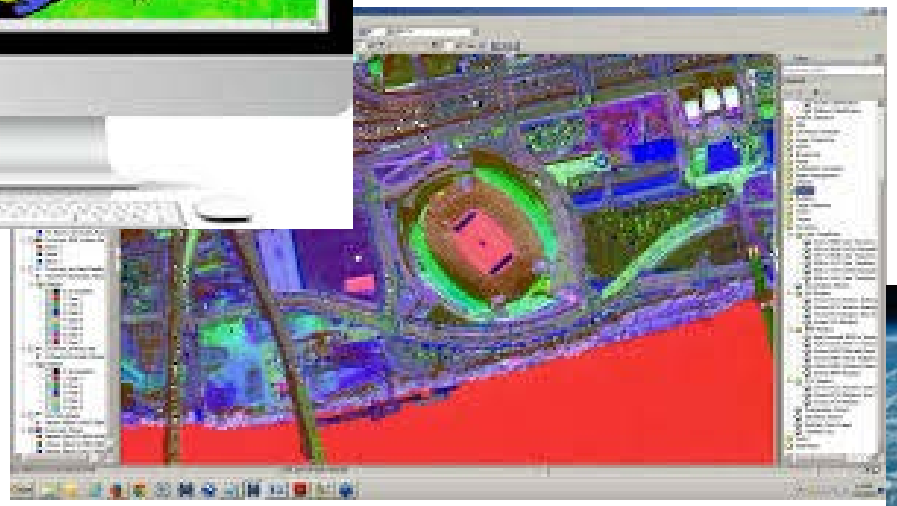
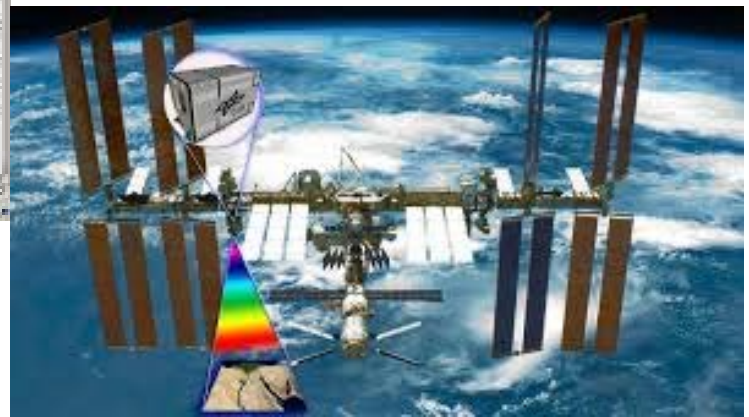
A long time ago in a galaxy far far away…..



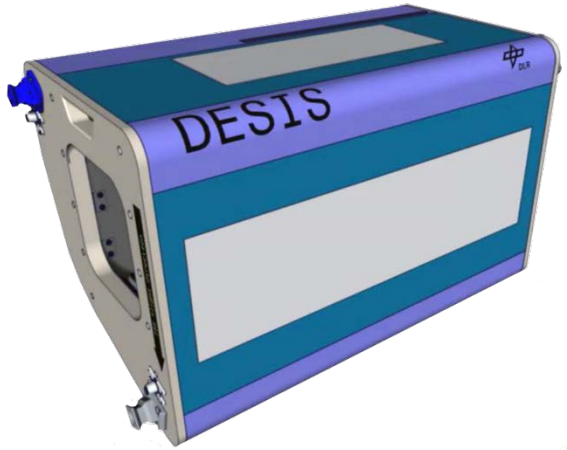


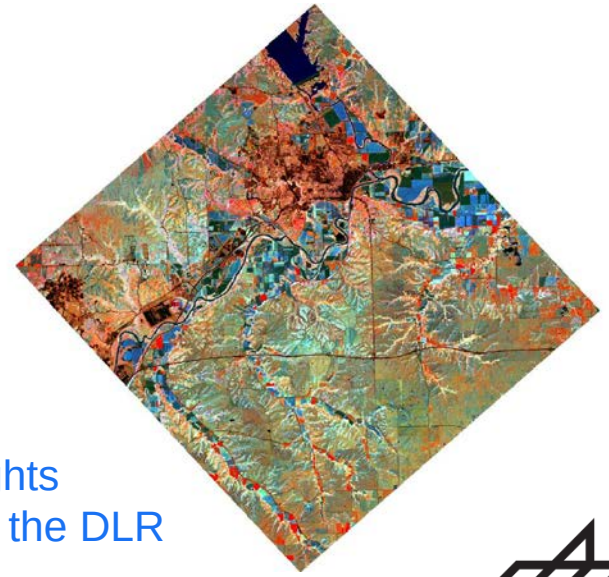




DLR Earth Sensing Imaging Spectrometer

Characteristic	DESIS-30 Features
Ground Sampling Distance	30 m @ 400 km altitude
Ground Swath	30 km @ 400 km altitude
Spectral Range	400 nm – 1000 nm
Spectral Bins	Measured: 235 @ 2.55 nm Programmable binning on-orbit
Quantization	12 bits + 1 gain bit
Signal to Noise Ratio @ 550 nm	205:1 sampled at 2.55 nm 406:1 binned to 10.2 nm
On-board calibration	Dark Field for DSNU LED Array for PRNU
Independent Pointing	Pointing Unit ±15° Along Track
Independent Time and Location	On-board GPS



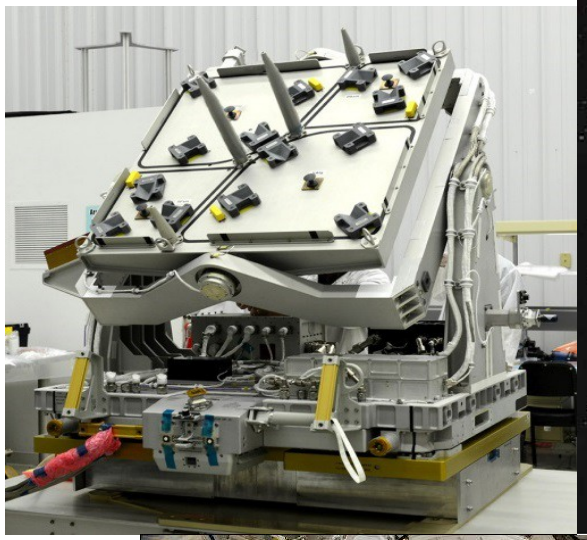


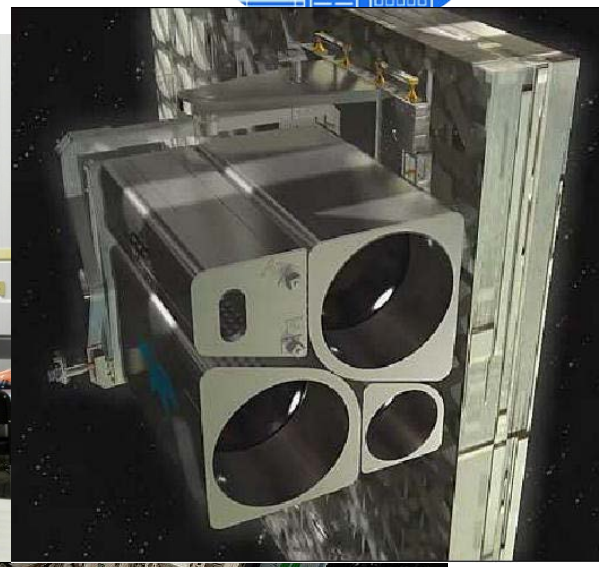
- Teledyne has in the international commercial and government data rights
- Academic and Non-profits can access data freely via a provision from the DLR
- Extensive cross calibration with existing space and aerial assets

DLR

Multi-User System for Earth Sensing (MUSES)

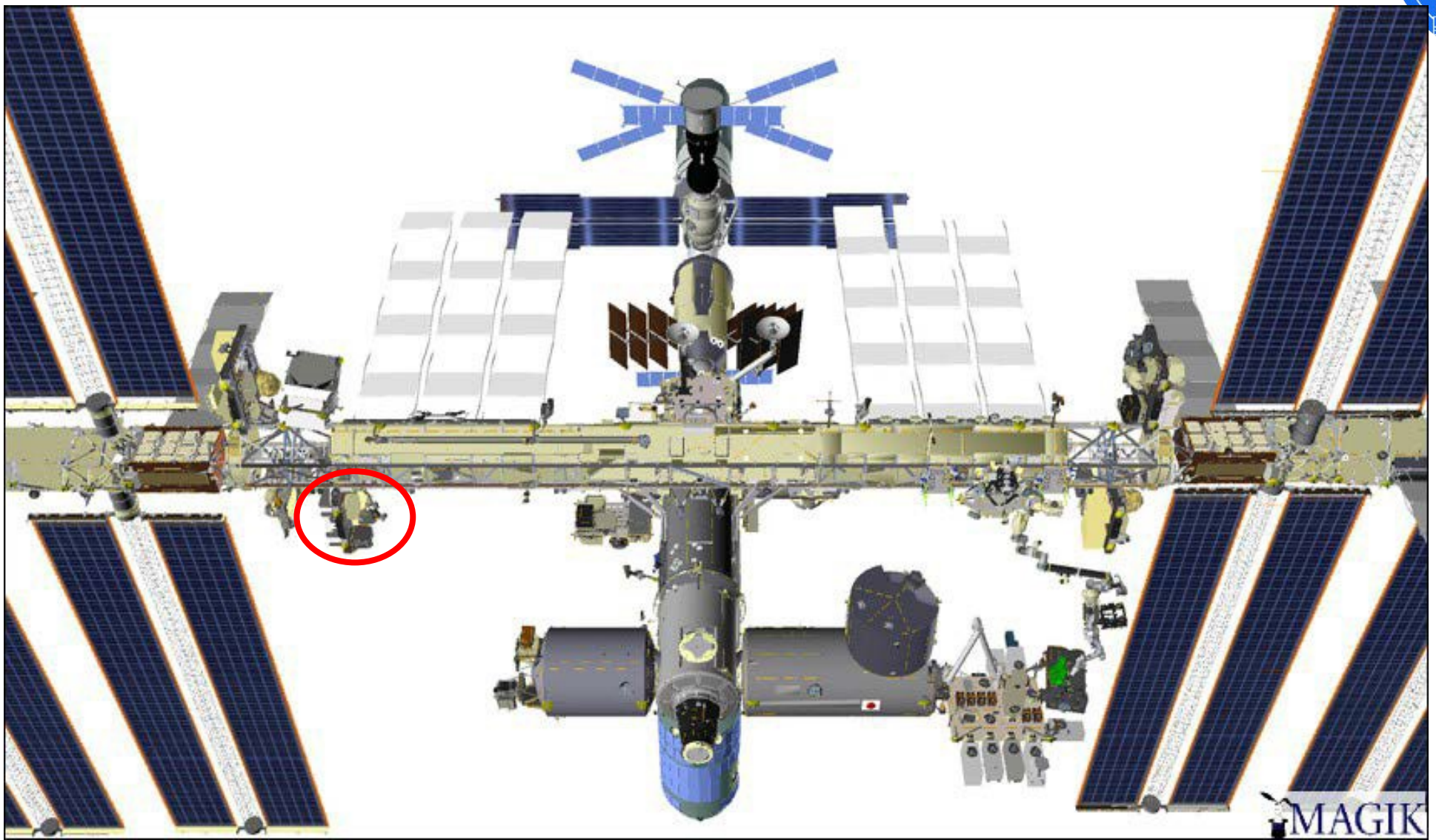
- DESIS is installed on MUSES (Where Teledyne Comes in)
- Inertially stabilized
- Precise pointing and Earth surface target tracking
- Up to 4 robotically installed instruments
- Total data downlink ~225 GB/day
- Onboard processing option
- Instruments launched in “soft stowage”, ISS National Lab covers transport cost, Teledyne manages integration, testing etc.
- 15-20 months from agreement to installation
- Currently exploring SWIR, High res MSI and others to complement DESIS data





Preparations for the installation of DESIS by ESA astronaut Alexander Gerst (image credit: DLR, NASA)

MUSES/DESIS Location on the ISS Express Logistics Carrier 4 (ELC-4)



Earth Observation From the ISS – Why It Works/Challenges

Benefits

- Coverage of ~90% of populated Earth
- Coverage of 100% of tropics and equatorial regions more frequently than other sensors
- Upgrade, repair and exchange of instruments as technology and/or markets evolve
- Traditional barriers to entry minimized

Challenges

- Maneuvers, resupplies, spacecraft location can cause missed collects (field coordination)
- >50 degrees N/S not covered in orbit

How DESIS and Spectral Processing Can Make a Difference in Ocean Studies

- The Great Pacific Garbage Patch (GPGP) orbits on average around 32°N and 145°W, though ocean currents are dynamic and subject to seasonal shifts
- The GPGP is estimated to be over 80,000 tons of plastic and other debris
- Not only here, but all throughout the world’s oceans and coastlines
- Significant wildlife and human health impact

Imaging Remote Areas

- DESIS high frequency coverage of the tropics allowed the collection of relatively clear data in a notorious cloudy area
- This region is so remote aerial hyperspectral assets, drones aren’t possible except from marine vessels
- Spectral signatures can determine types and concentrations of garbage/debris and provide logistical support for clean up efforts
- And determine the areas that can best benefit from clean up and provide marine vessel avoidance guidance

DESIS Mosaic from 7/9/19

How ENVI Enabled Rapid Discovery

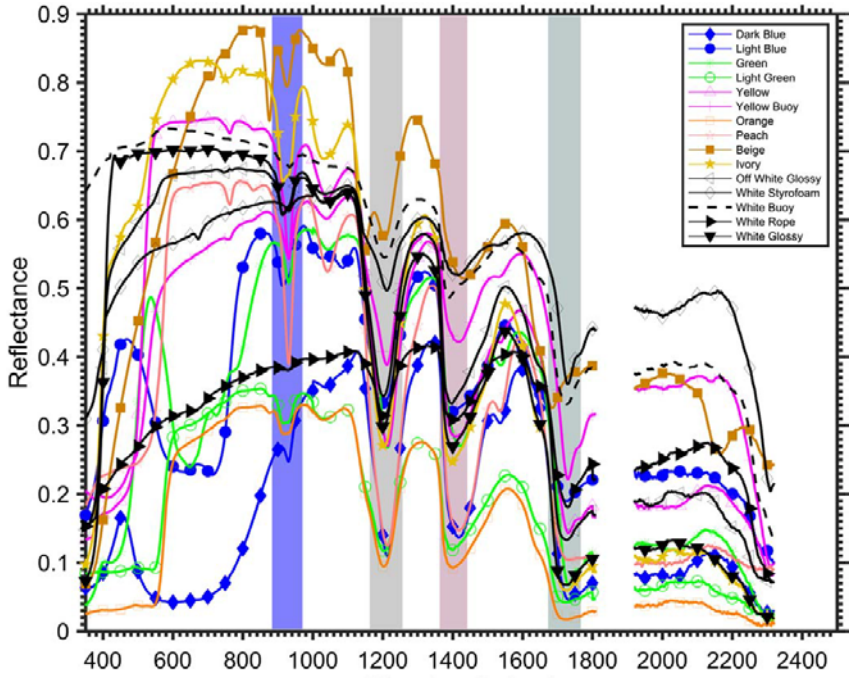
- Prepared DESIS imagery
- Seamless Mosaic
- RXD Anomaly to search a large area
- Spectral Profiles
- Create new spectral signature library and ROIs
- SAM to separate anomalies from real plastics

In the Future

- Automate process for other searches
- On-Board processing to downlink locations

Plastic Spectra in a Lab Setting

- Not exposed to
  - Saltwater
  - Sun
  - Agitation
  - Decomposition



Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

An airborne remote sensing case study of synthetic hydrocarbon detection using short wave infrared absorption features identified from marine-harvested macro- and microplastics

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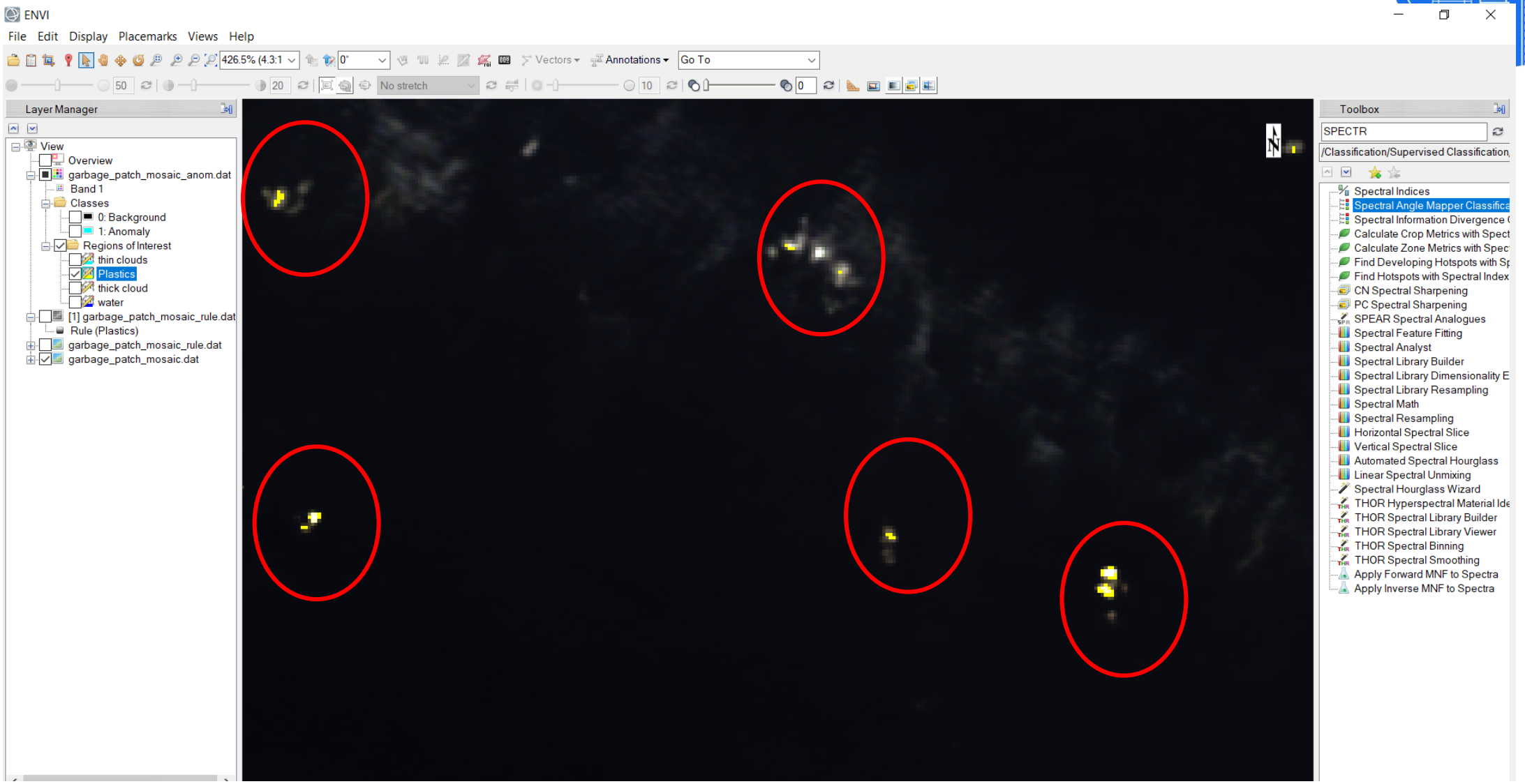
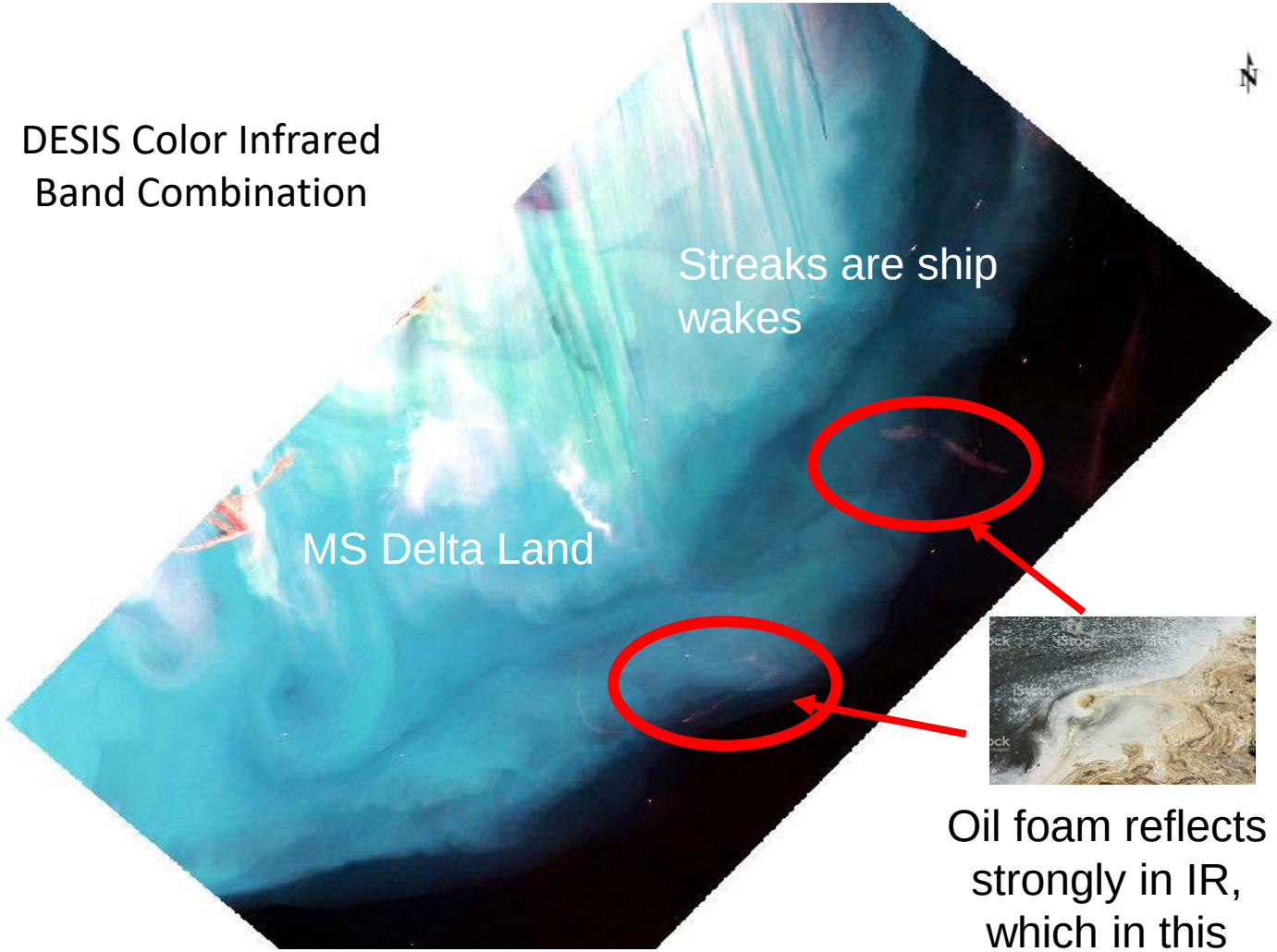
Mapping of Plastics vs Clouds



Oil Slicks and Seeps

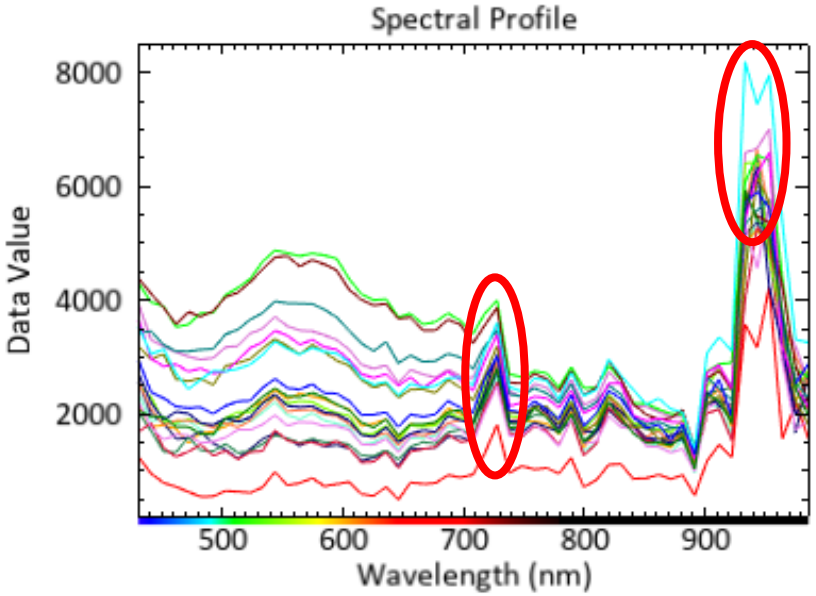
DESIS CIR Band Information

DESIS Color Infrared Band Combination



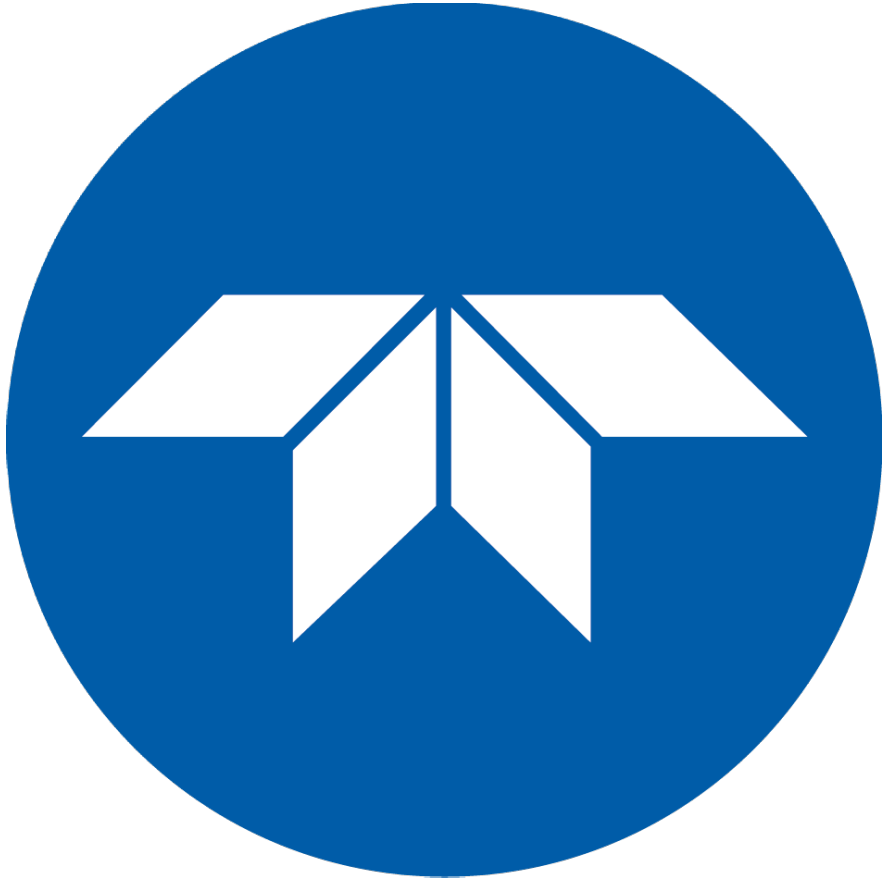
Oil foam reflects strongly in IR, which in this image shows up as red

Spectral Properties to Map Oil Extents



Summary

- New Hyperspectral data and modalities are becoming available with high frequency
- The ISS and Teledyne MUSES platform provide fast access to space
- DESIS is an operational, well calibrated hyperspectral instrument enabling us to ask questions we couldn’t previously with HSI data
- Together with applications like ENVI for discovery and enterprise deployment, rapid progress against environmental catastrophes is possible



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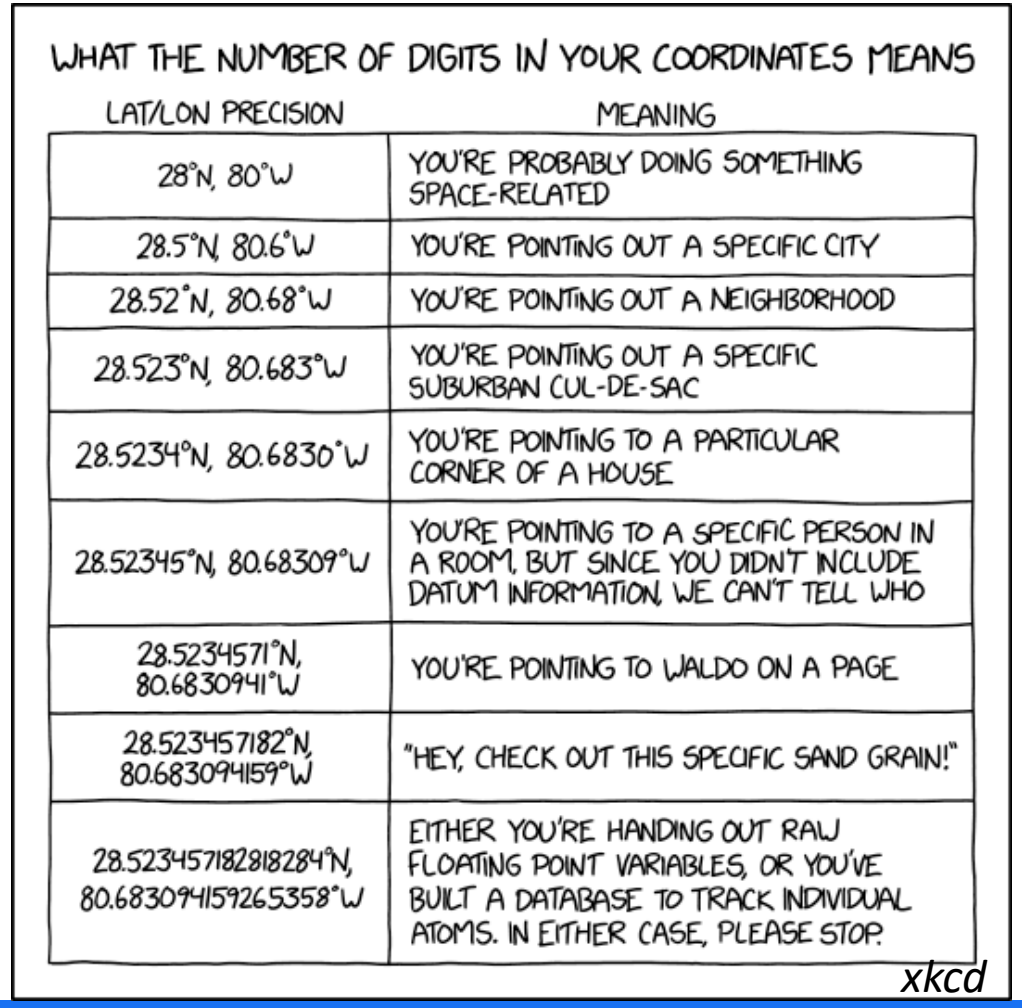
Questions?



WHAT THE NUMBER OF DIGITS IN YOUR COORDINATES MEANS

LAT/LON PRECISION	MEANING
28°N, 80°W	YOU'RE PROBABLY DOING SOMETHING SPACE-RELATED
28.5°N, 80.6°W	YOU'RE POINTING OUT A SPECIFIC CITY
28.52°N, 80.68°W	YOU'RE POINTING OUT A NEIGHBORHOOD
28.523°N, 80.683°W	YOU'RE POINTING OUT A SPECIFIC SUBURBAN CUL-DE-SAC
28.5234°N, 80.6830°W	YOU'RE POINTING TO A PARTICULAR CORNER OF A HOUSE
28.52345°N, 80.68309°W	YOU'RE POINTING TO A SPECIFIC PERSON IN A ROOM, BUT SINCE YOU DIDN'T INCLUDE DATUM INFORMATION, WE CAN'T TELL WHO
28.5234571°N, 80.6830941°W	YOU'RE POINTING TO WALDO ON A PAGE
28.523457182°N, 80.683094159°W	"HEY, CHECK OUT THIS SPECIFIC SAND GRAIN!"
28.5234571828182 84°N, 80.6830941592653 58°W	EITHER YOU'RE HANDING OUT RAW FLOATING POINT VARIABLES, OR YOU'VE BUILT A DATABASE TO TRACK INDIVIDUAL ATOMS. IN EITHER CASE, PLEASE STOP.

xkcd