Flight Validation of Instrument Processing Onboard Earth Observing One: A Status Report, October 2016

Steve Chien, Martina Troesch, Daniel Tran, Steve Schaffer, David R. Thompson, Robert Green, Kiri Wagstaff, Alphan Altinok, Umaa Rebbapragada
Jet Propulsion Laboratory, California Institute of Technology

Daniel Mandl, Elizabeth Middleton, Stephen Ungar, Lawrence Ong, Petya Campbell
NASA GSFC

Bruce Trout, Jerry Hengemihle, Microtel LLC

© 2016 California Institute of Technology
Portions of this work were performed by the Jet Propulsion Laboratory, California Institute of Technology under contract with the National Aeronautics and Space Administration
JPL Clearance CL#16-XXXX

Goals

- Baseline: Demonstrate that hyperspectral data can be used to synthesize multispectral data onboard.
  - Specific: Demonstrate that Hyperion Hyperspectral data can be used to synthesize OLI multispectral data onboard.
- Stretch: Demonstrate other technology push onboard processing techniques
  - Specific: Bayesian Thresholding, Support Vector Machine Learning, Random Decision Forest

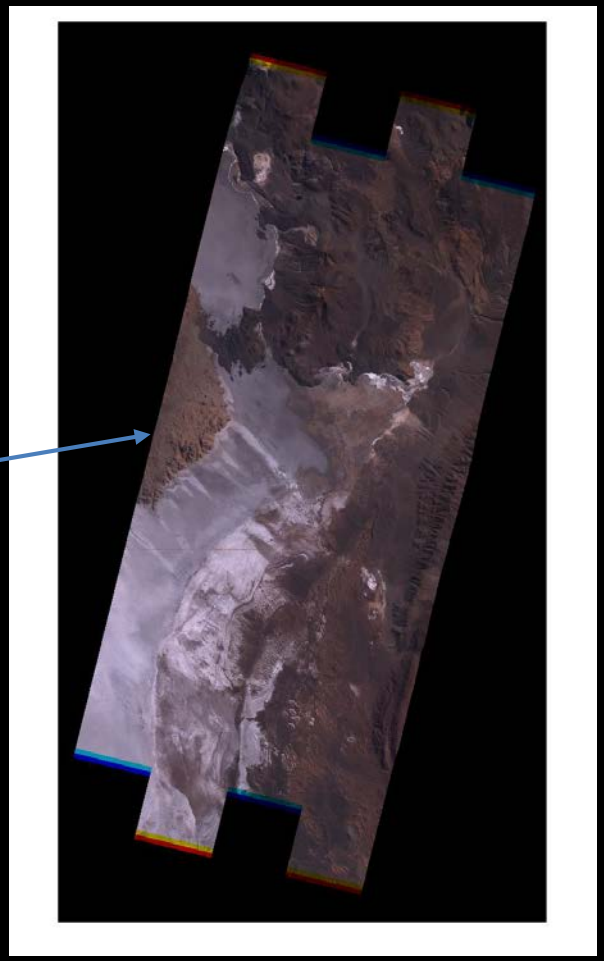
Approach

- Utilize existing capabilities
  - Autonomous Sciencecraft (ASE) Flight Software [Chien et al. 2005] in use to operate EO-1 2004 – present.
  - ASE includes
    - Onboard Hyperion Data Analysis
      - Uses Microtel Band stripping
    - Onboard mission re-planning
    - Onboard execution

ASE Instrument Data Processing

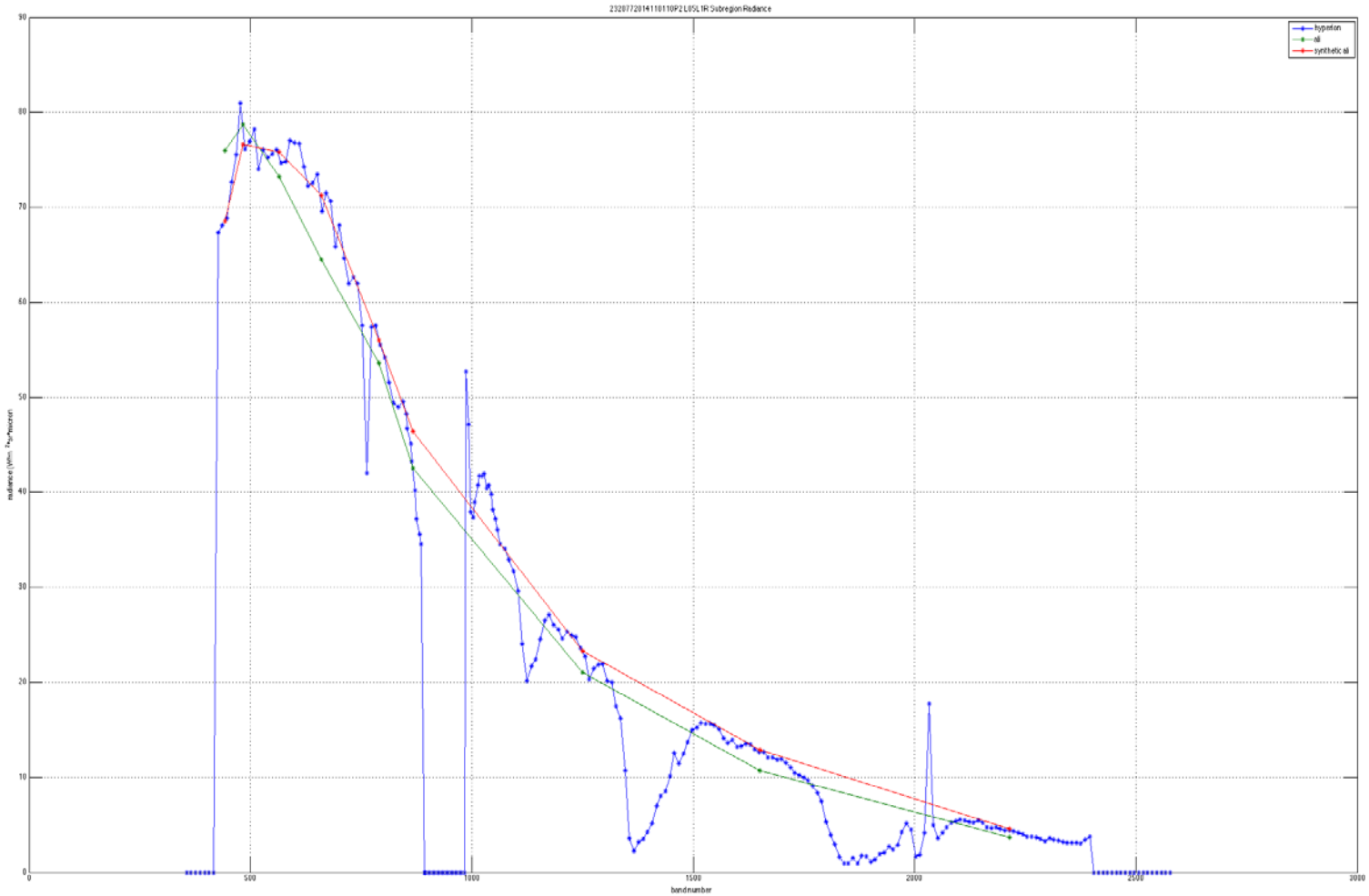
- Band stripping capability
  - Implemented by Microtel
  - Enables band stripping of 12 Hyperion Bands
    - Must include at least 1 SWIR and 1 VNIR band
    - Strips out 1024 x 256 pixel image
    - Requires ~ 20 minutes to strip
  - ASE provides
    - Standard interface for accessing the stripped data
    - Standard interface to output data product
    - Data is then downlinked via S-band
      - Automatic Eng. DL is option as is file download

Sample Hyperion → ALI



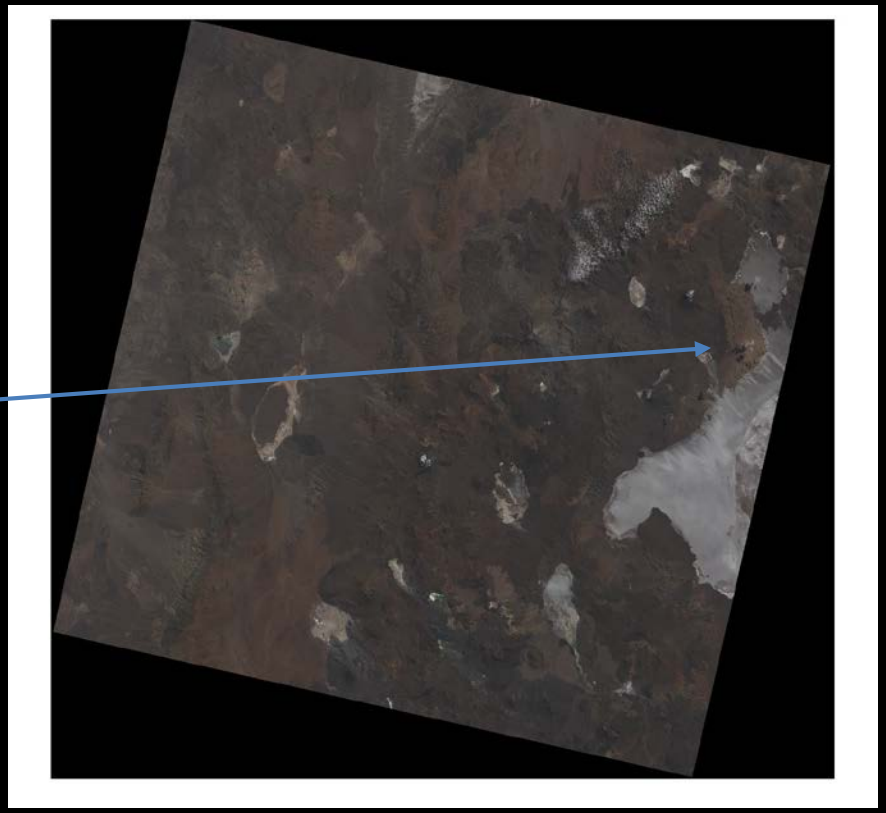
(L) Hyperion Synthesized to ALI (R) ALI
Arizaro Desert, Argentina

Radiance Subregion comparison



Sample Hyperion → OLI

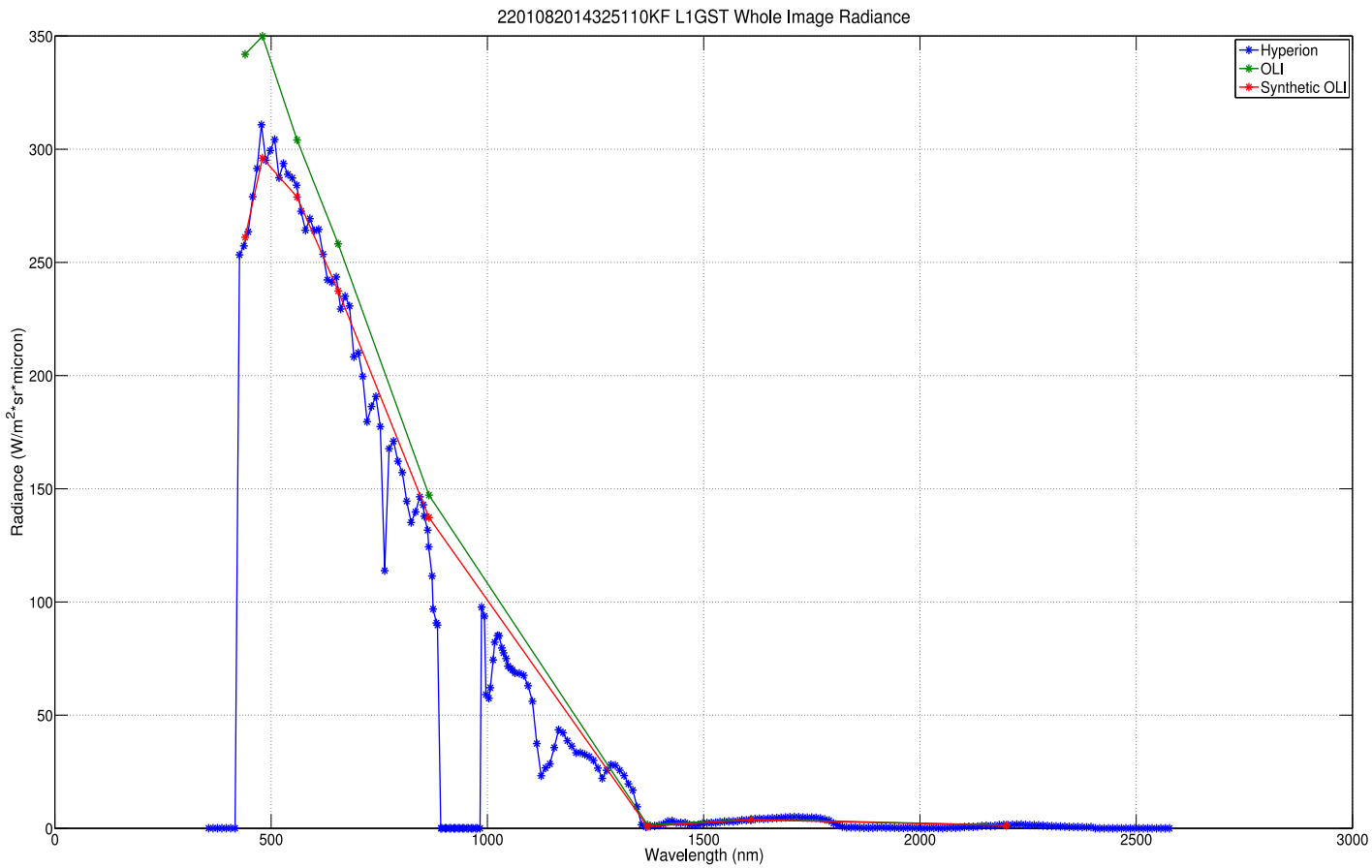
Hyperion→OLI



OLI

Arizaro Desert, Argentina

OLI Radiance Subregion Comparison

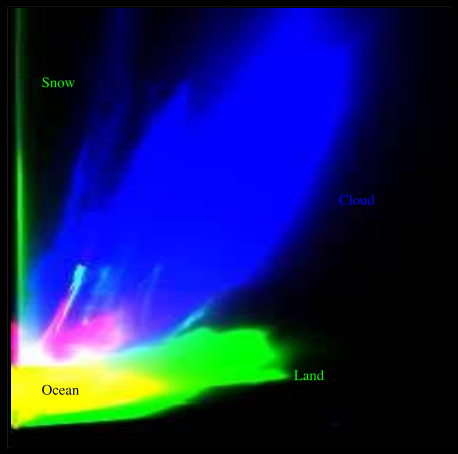


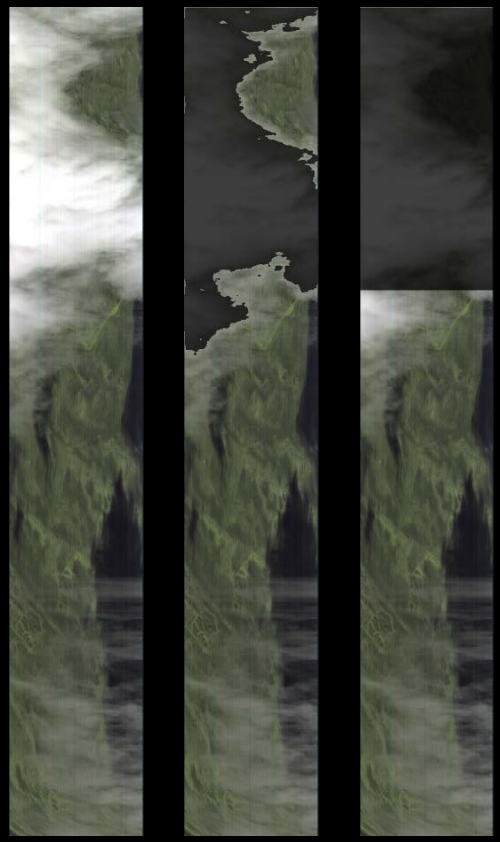
Not nearly as clean as ALI due to geo-correction.

OTHER INSTRUMENT PROCESSING TECHNIQUES

Thresholding Cloud Screening

- Computes optimal thresholds in multi-dimensional spectral space given:
  false negative,
  false positive costs by modeling spectral distribution of pixels
- Previously used on Aviris NG (Thompson et al. 2014 TGARS)



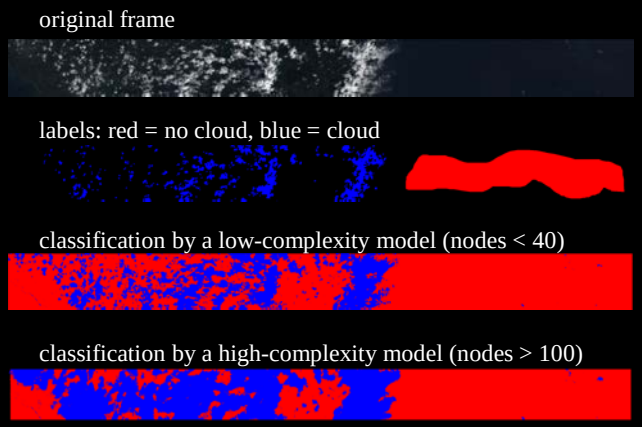


Aviris-NG screened data using 0.45 μm and 1.65 μm bands

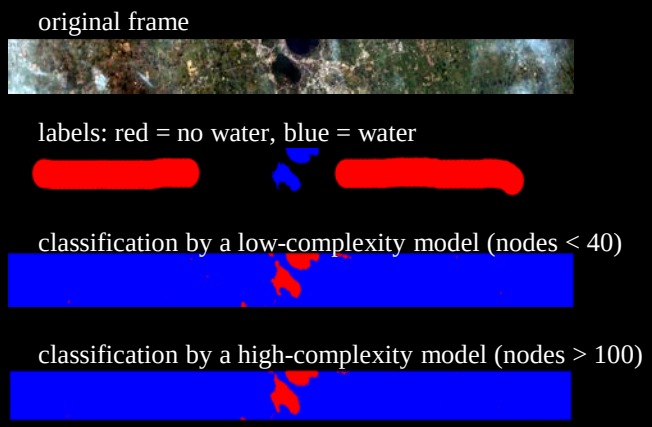
POC: David Thompson/JPL

TextureCam: Random Decision Forests

- **Motivation:** Onboard cloud screening can assist with image triage and prioritization for downlink. Other classification problems can be addressed by RDFs.
- **Problem:** Previous methods have generated larger RDFs, we would like to see if compact RDFs can classify well.
- **Solution:** A forest classification engine designed to classify surfaces in images based on visual appearance.
- TextureCam provides automated cloud cover assessment in EO-1 Hyperion data.



Cloud Classification

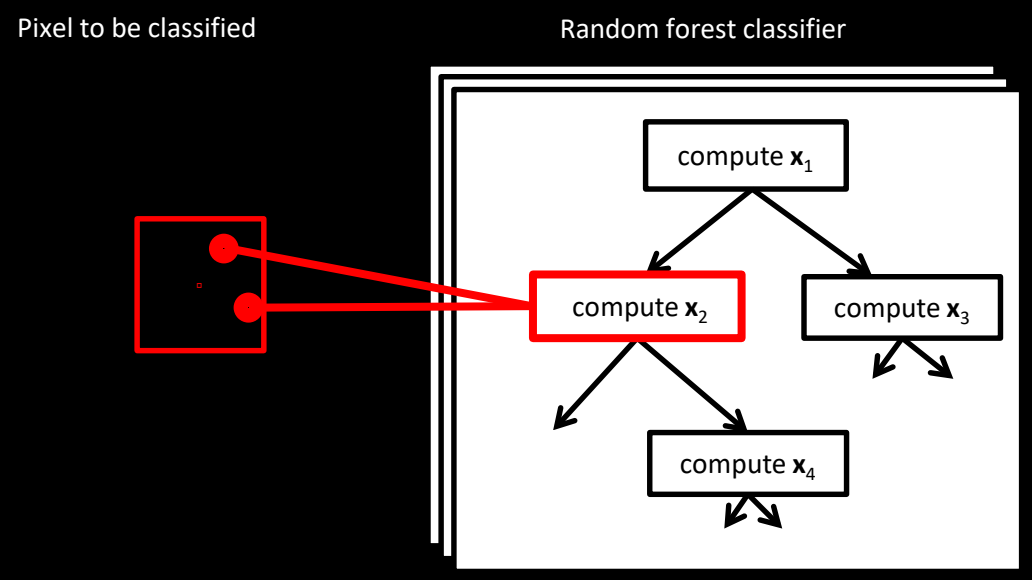


Surface Water Extent Classification

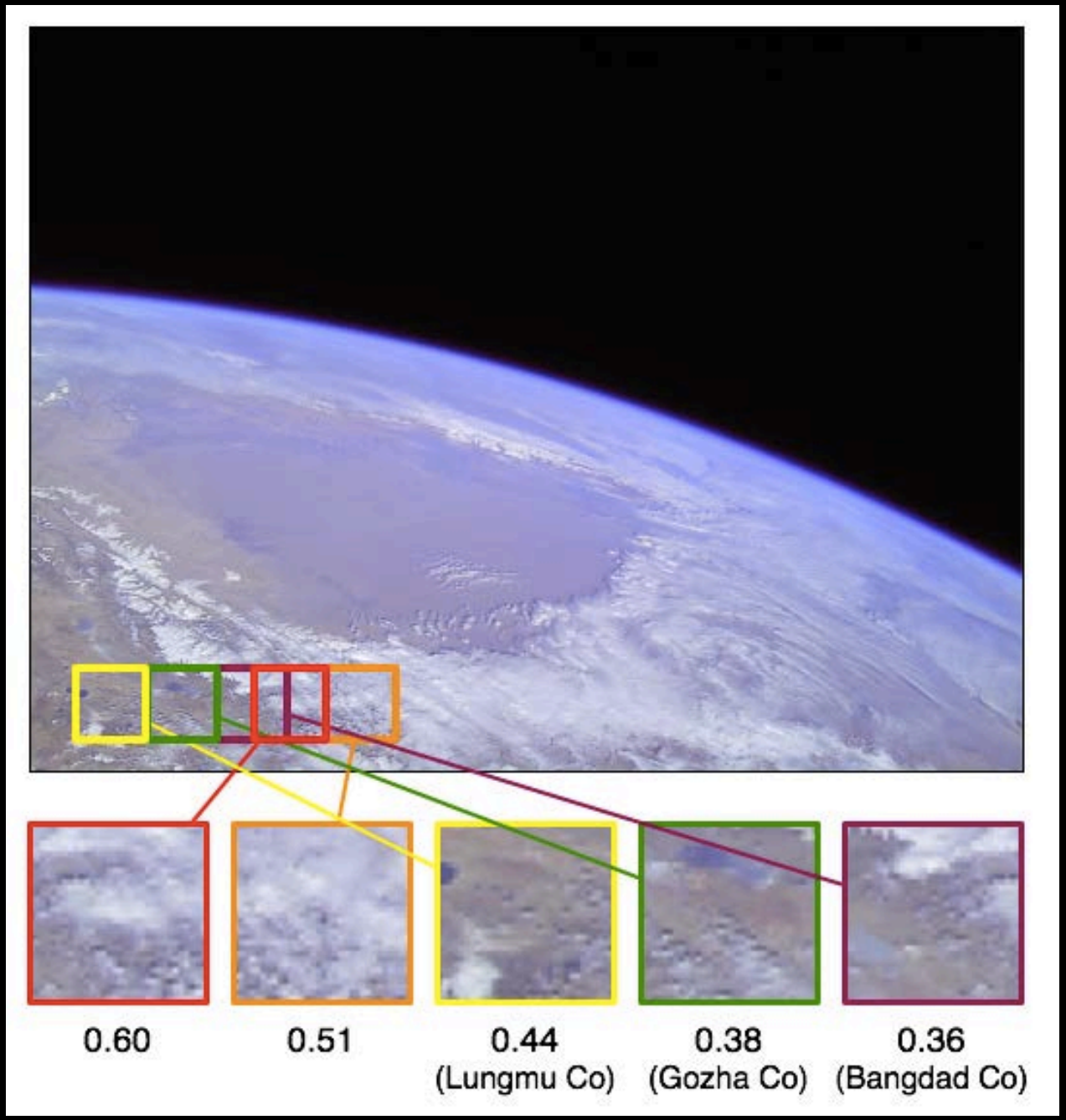
POC: U. Rebapreggada, A. Altinok, D. Thompson /JPL

How it works

- We trained the system on manually-labeled images from ground data set.
- At runtime, the classifier calculates visual attributes by analyzing a local neighborhood around the classified pixel.
- A decision forest aggregates class probability estimates from multiple independent decision trees.



References: Thompson et al., i-SAIRAS 2012; Wagstaff et al., Geosci. Res. Lett. 2013; Bekker et al., *Astrobiology* 2014; Altinok et al. 2015 JFR.



Another Example: Landmark Salience

Image collected onboard IPEX and the salience algorithm's corresponding output. The broad cloud-free region is the Taklamakan Desert in China. The first two sub-regions selected by the algorithm exhibit interesting cloud structure. Regions 3, 4, and 5 pick out interesting ground features, including three lakes in Tibet (Lungmu Co, Gozha Co, and Bangdad Co).

POC: Kiri Wagstaff/JPL

Status

- EO-1 FSW Upload 29 Sep – 4 Oct 2016.
- Jump to new code Monday 10 October 2016.
- Nominal operations follow.
- 1st test scene Arizaro, Argentina scheduled for 14 October 2016.

Conclusions

- EO-1/ASE has excellent supporting infrastructure to flight validate OLI product generation onboard
  - Flight tests for OLI and ALI generation onboard are under way!
- Additional technology push onboard processing technologies will simultaneously be demonstrated
  - Threshold-based cloud screening
  - TextureCam / Random Decision Forest
  - Visual Salience