

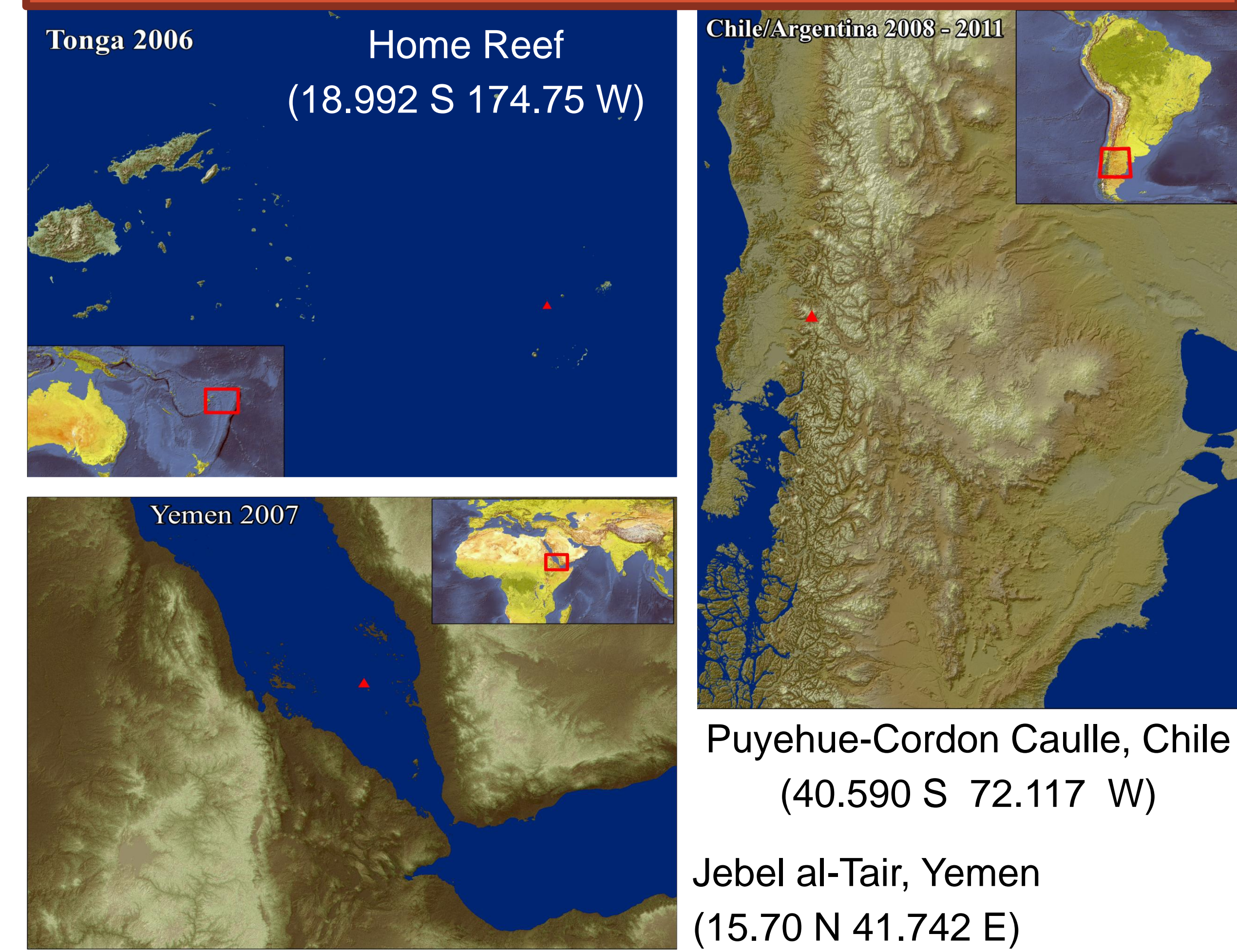
Enhanced Detection and Monitoring of Pumice Rafts Using NASA EOS

Paula Chojnacki, Conor Coady, Quinten Geddes, Lindsey Honaker, William Lyddane, Jason McGilloway, Josh Scott
 NASA DEVELOP Program, NASA Langley Research Center

OBJECTIVES

- Determine effective remote sensing techniques to identify and classify pumice rafts
- Highlight unique capabilities of NASA EOS to detect and monitor pumice rafts
- Create database compiling pumice raft information

STUDY AREA



IMPACTS

Economic

Damages ship engines
Obstructs shipping lanes
Clogs harbors, preventing boats from docking

Ecological

Introduction of invasive species
Blocks sunlight and oxygen, killing fish

Social

Congests rivers that villagers rely on
Forces villagers to clean pumice out of harbors

ABSTRACT

Pumice *rafts* are an occasional byproduct of explosive volcanic eruptions that occur near bodies of water. Rafts can be tens of kilometers across and are a hazard to shipping, as the pumice can block the seawater intake valves for ships' engine cooling systems. In particular, this research focuses on pumice rafts that emanated from the eruptions near Tonga in 2006, Yemen in 2007, and the Chile-Argentina border in 2011 using data from Landsat 5 & 7, MODIS onboard the Aqua and Terra satellites, and ALI aboard the EO-1 satellite. False color composites were created to facilitate visual identification of pumice rafts in high resolution images. Additionally, a material of interest subpixel classification was implemented to automatically demarcate the extent of the pumice rafts. MODIS was found to be the most useful sensor for tracking larger rafts in the open ocean, while Landsat 5 & 7 and ALI were more effective in tracking smaller rafts in lakes and rivers. The pumice rafts generally took on a temperature between that of the ambient air and water temperature. The data collected for this study has been compiled to provide an effective tool for further investigation of pumice rafts.

METHODOLOGY

- LandSat 5, LandSat 7, ALI and MODIS Data obtained for Chile/Argentina, Tonga, and Yemen at level 1
- Data imported and processed using ERDAS IMAGINE 2010

Techniques Used:

- **Material of Interest (MOI) subpixel classification**
 - Background spectra of the image identified
 - Cloud pixels designated to perform environmental correction
 - Manual Signature Derivation (MSD) performed using 4-6 Areas of Interest (AOI's) containing a visually identified pumice raft
 - MOI classification iterated

Temperature Derivation

- Landsat 5 & 7 band 6H digital number values converted to calibrated image radiance values using image metadata:

$$L_{\lambda} = DN \left(\frac{L_{max} - L_{min}}{QCAL_{max} - QCAL_{min}} \right) + L_{min}$$

Where:
 L_{λ} = Radiance Value
 DN = Pixel Digital Number
 $QCAL_{max}$ = Maximum quantized calibrated pixel value
 $QCAL_{min}$ = Minimum quantized calibrated pixel value
 L_{min} = Minimum Spectral Radiance
 L_{max} = Maximum Spectral Reflectance

- Radiance values converted to temperature:

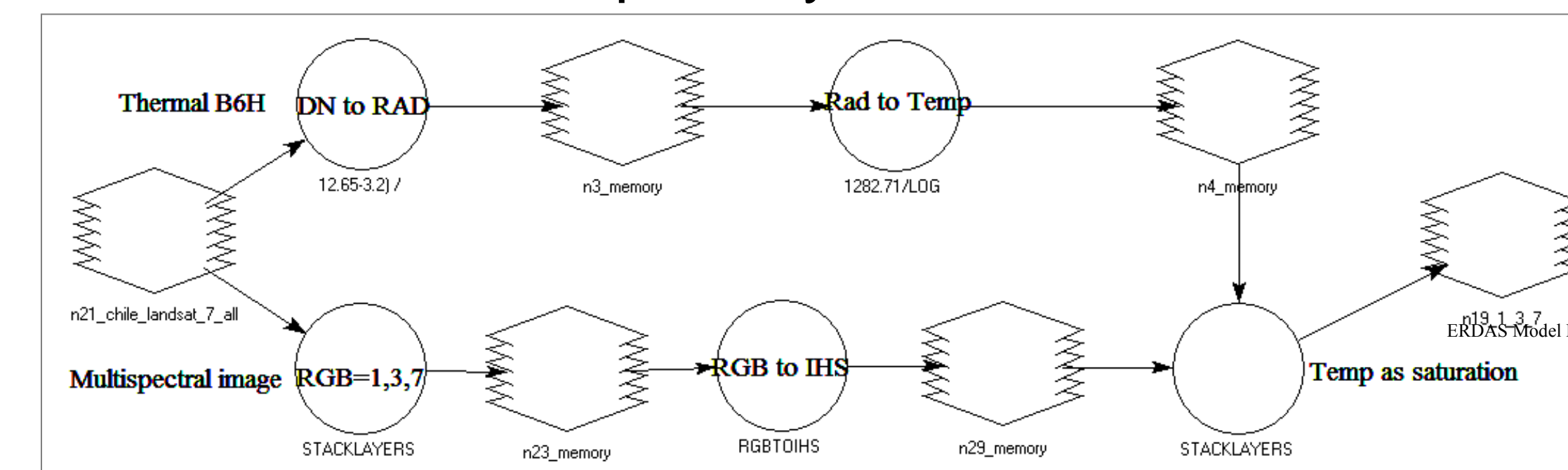
$$T_c = \frac{K_2}{\ln\left(\frac{K_1}{L_{\lambda}} + 1\right)} - 272.15$$

T_c = Surface Temperature (C)
 K_1 = Sensor constant
 K_2 = Sensor constant
 L_{λ} = Radiance Value

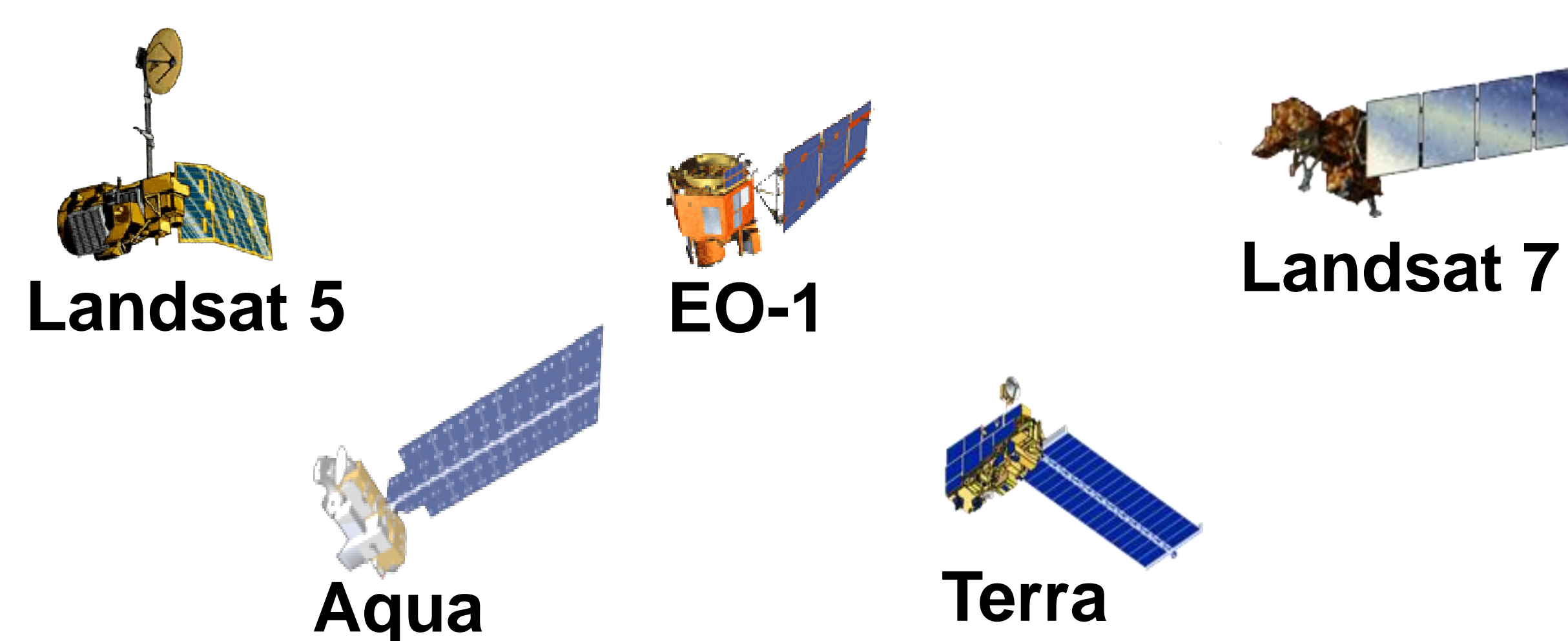
- Temperature images also interpreted using spatial profiles

Composite bands R,G,B = 1,3,7 (land) or 2,3,7 (water)

- Convert RGB false color composite to IHS (Intensity, Hue, Saturation)
- Add band 6H temperature values to composite as Saturation
- Model Builder used to partially automate identification

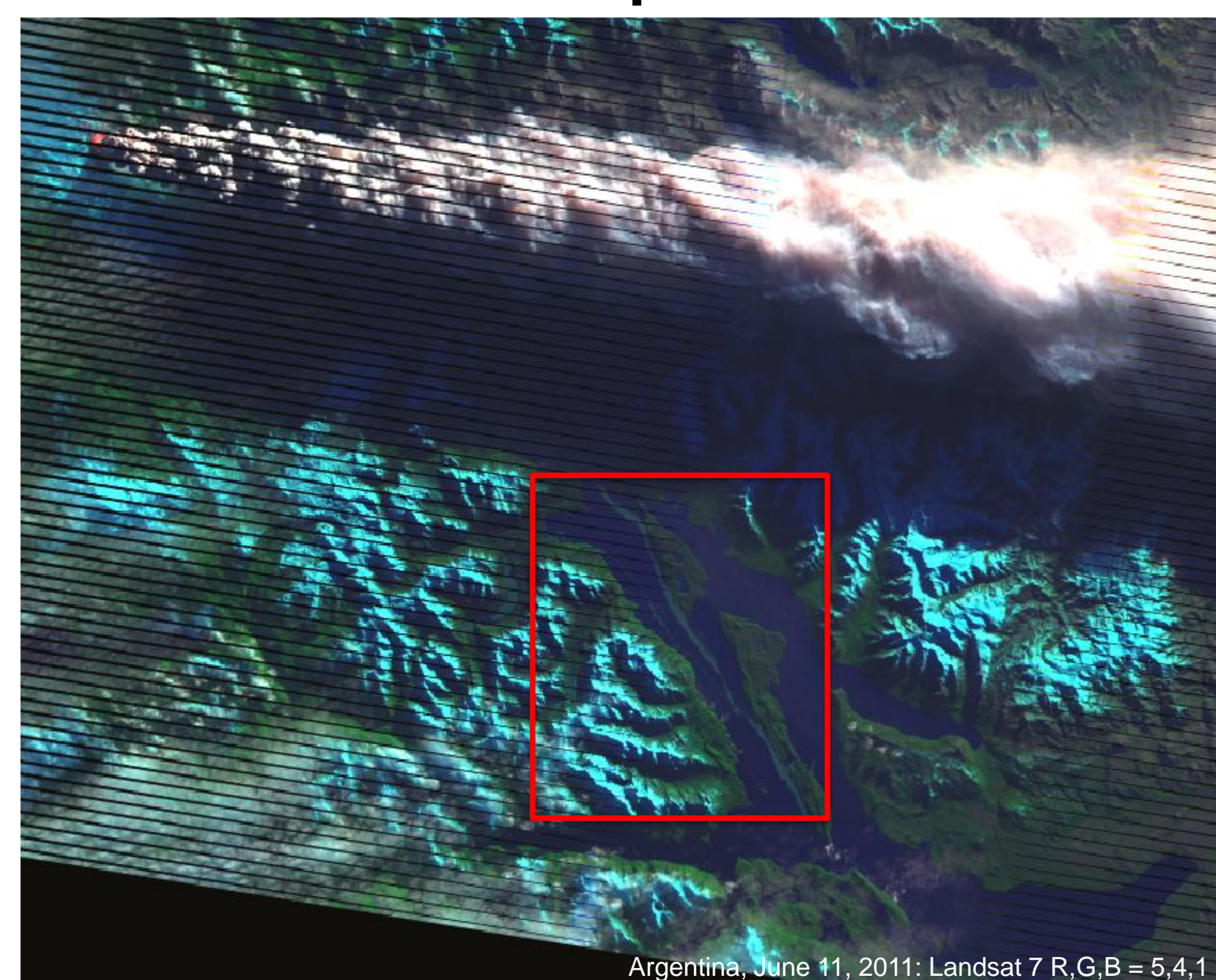


EARTH OBSERVATION SOURCES

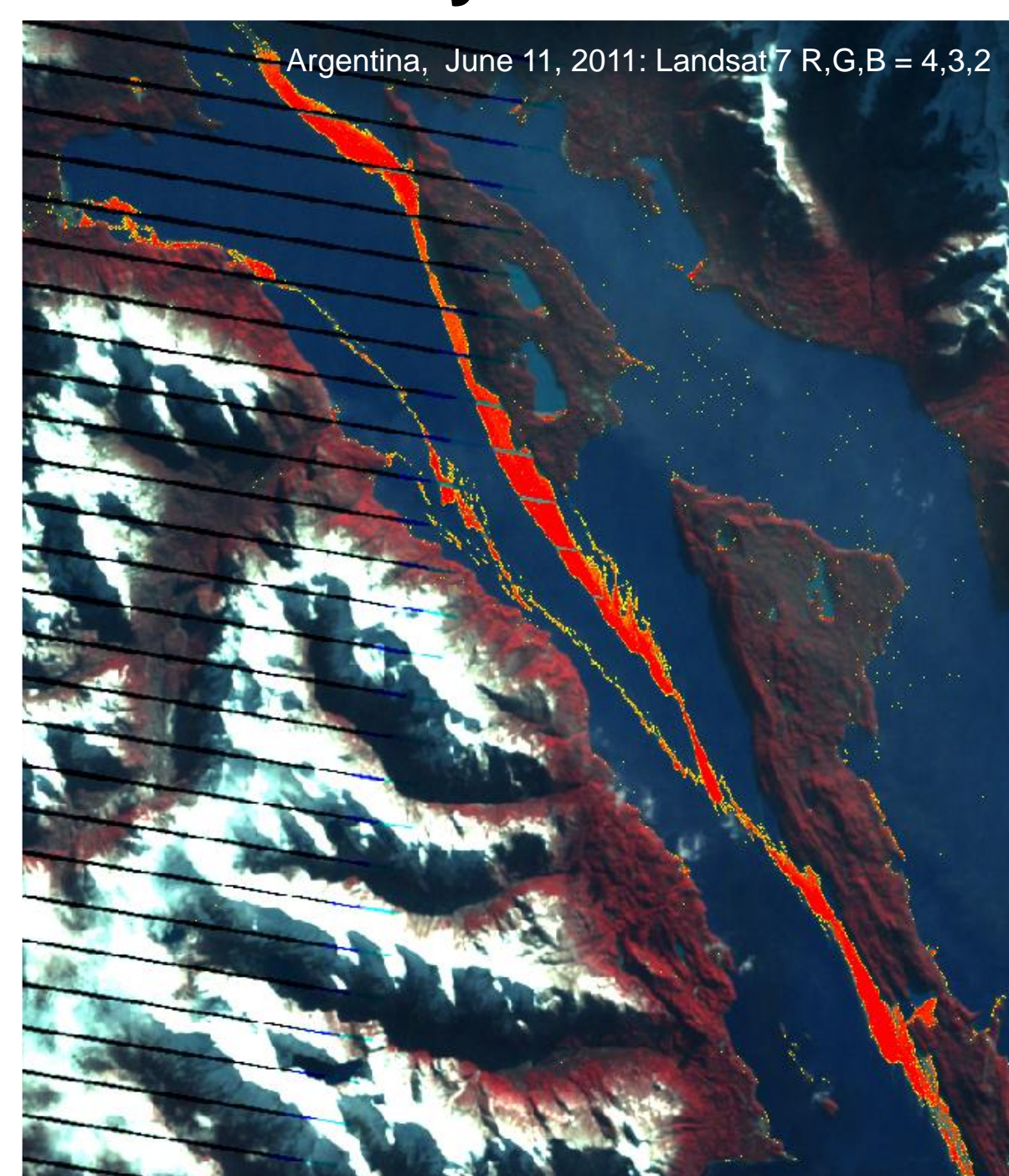


RESULTS

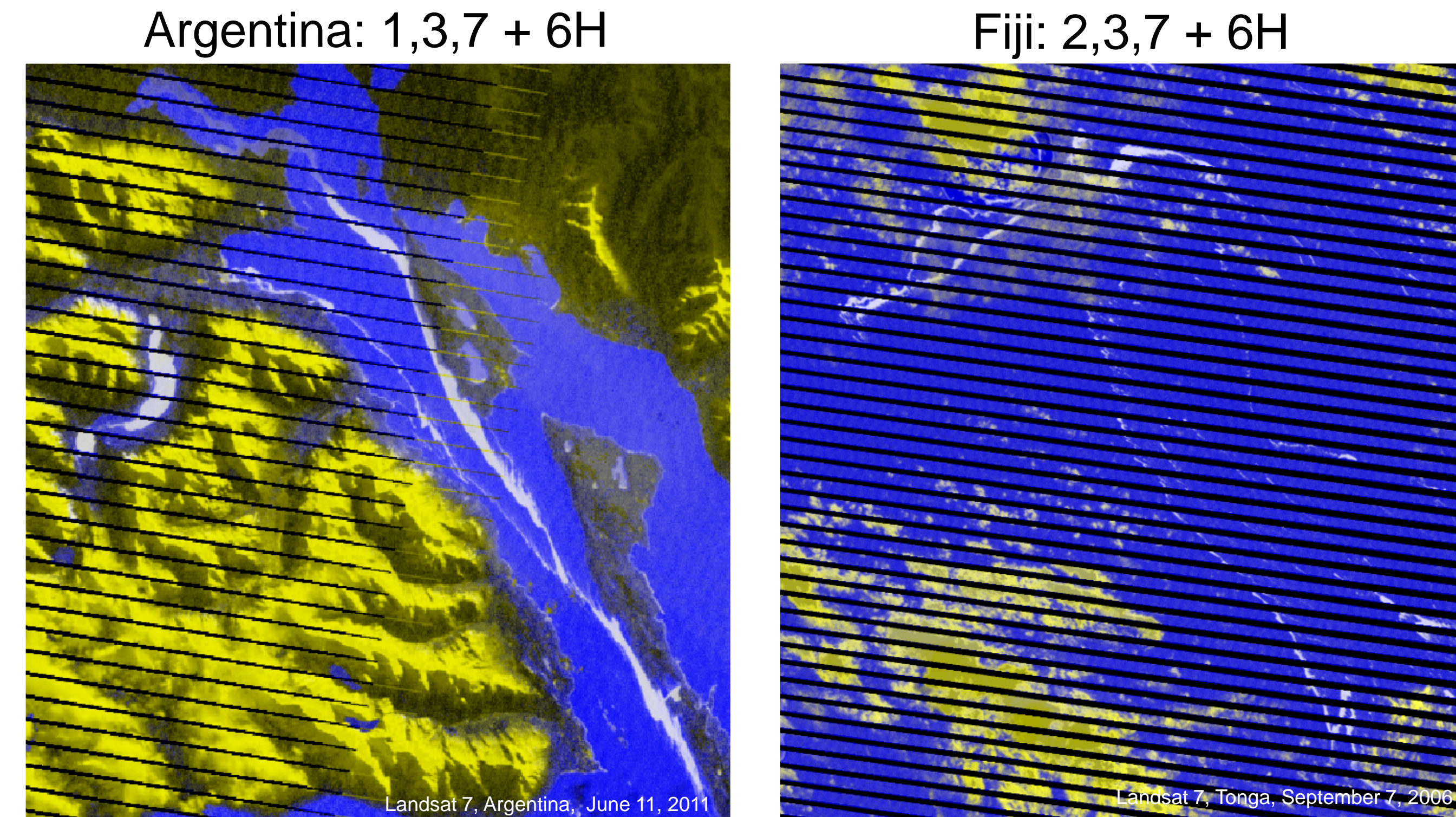
Chilean Eruption Event



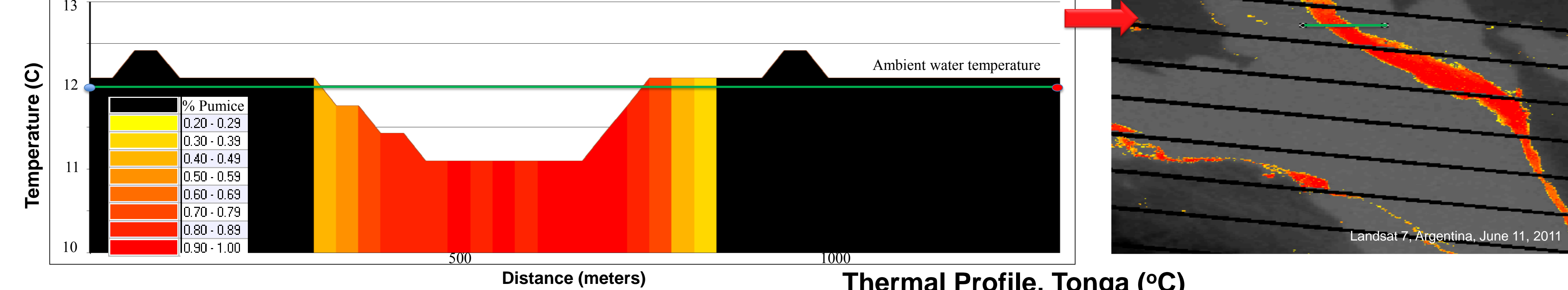
MOI Overlay Classification



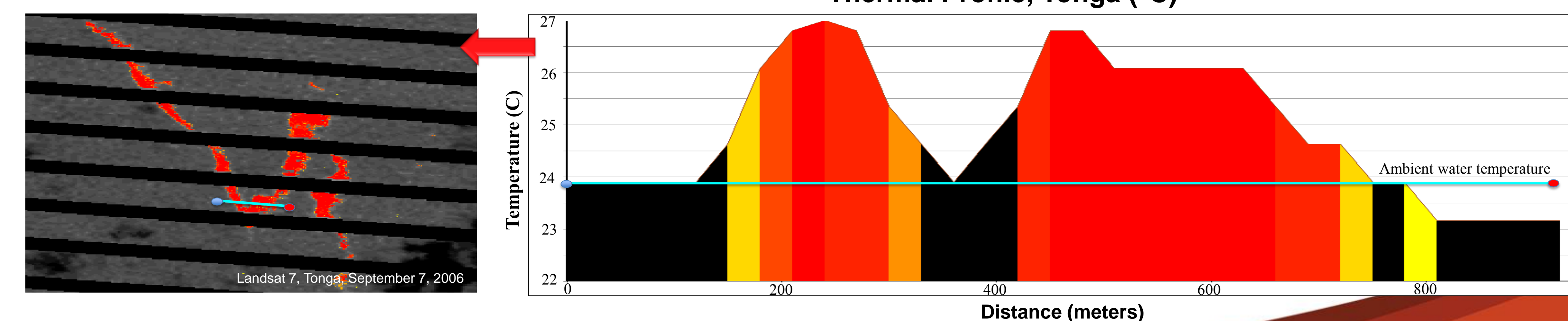
IHS False Color Composites



MOI Classification Overlay on Thermal Profile, Argentina (°C)



Thermal Profile, Tonga (°C)



TEAM MEMBERS



From Left: Conor Coady (UCSB), Quinten Geddes (UMT), William Lyddane (UVA), Josh Scott (Harvard), Lindsey Honaker (SWCC), Paula Chojnacki (UCSD), Jason McGilloway (PSU)

ACKNOWLEDGEMENTS

Peter Johnson, Lauren Childs, Malcolm Jones, and Nate Makar, Dr. Russell DeYoung, Ross Reahard, Greg Vaughan, Richard Wunderman, Vasco M. Mantas, NASA's WIST and GLOVIS data management sites

PROJECT PARTNERS



CONCLUSIONS

MODIS

- Useful for locating areas of pumice raft events

Landsat 5 & 7

- RGB to IHS + temperature as saturation aids in visual identification of pumice
- Pumice raft temperature generally lies between water temperature and ambient air temperature

- MOI classification effective in automatically classifying pumice using user-defined material signature