Applications of Hyperspectral Remote Sensing Observations of Geological Hazards

Florian M. Schwandner
Jet Propulsion Laboratory, California Institute of Technology

Applications of Hyperspectral Remote Sensing Observations of Geological Hazards

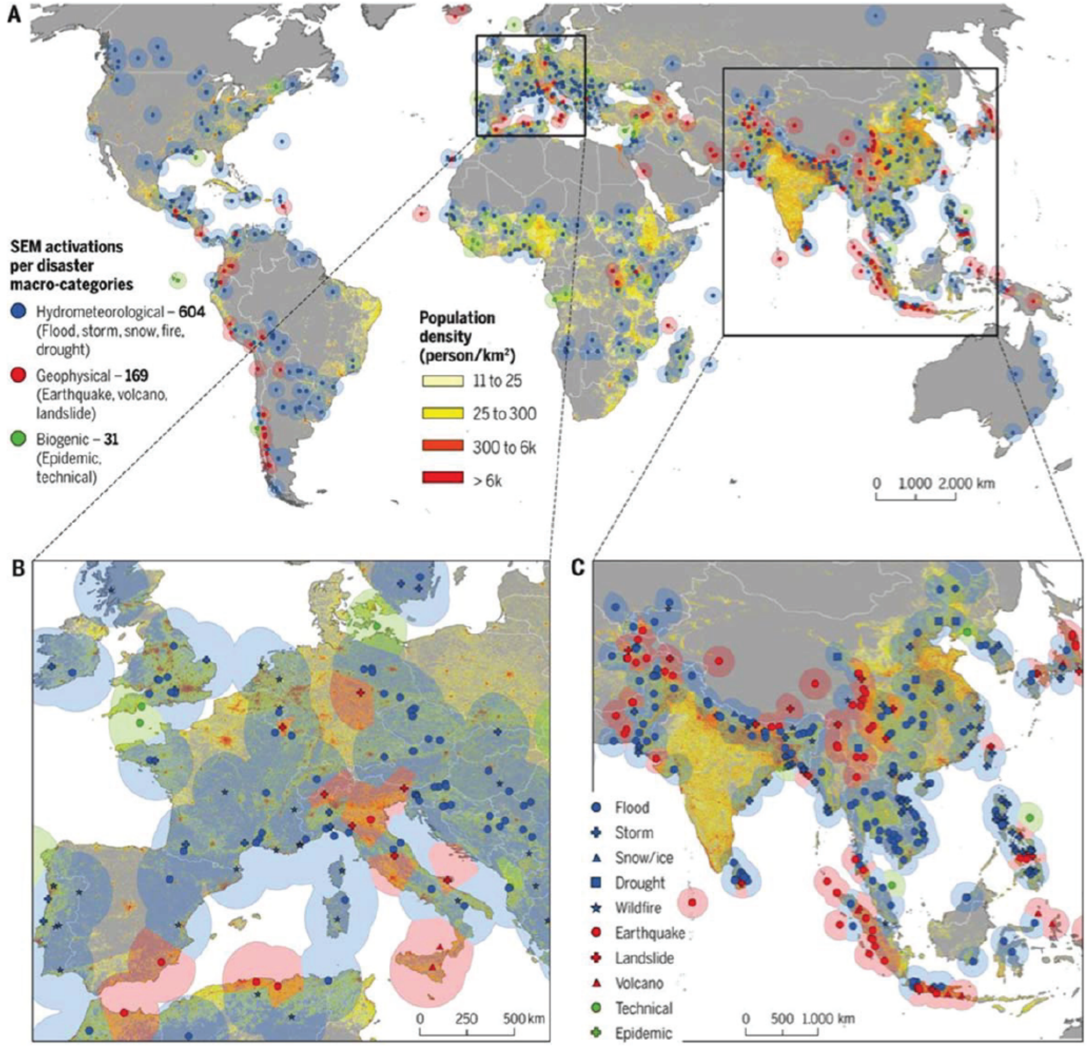


FIGURE 10.13 Recent satellite-based emergency mapping activations (SEM) at the global level (A) and regional level (B and C). Disaster categories are: (i) hydrometeorological, including flood, storm, snow, wildfire, and drought events (blue symbols); (ii) geophysical, including earthquake, volcano, and landslide events (red symbols); and (iii) biogenic, including epidemic outbreaks and technical accidents (green symbols). Polygons highlight clustering of activations for the various disaster categories. All three sections show population density in the background. SOURCE: Voigt et al. (2016).

Definitions

Hazard potential (%) x Vulnerability ($) = Risk

Natural Hazard: A *potential* occurrence of a natural system impulsive disturbance with potentially adverse effects.

Natural Disaster: An *actual* occurrence of a natural system impulsive disturbance that causes great damage or loss of life.

Applications (NASA): Project activities that enable innovative uses of NASA Earth science data in organizations' policy, business, and management decisions.

The project results and enhanced decision making improve the quality of life and strengthen the economy.

SBG Geological Hazards / Disasters in ESAS 2017

Understanding and predicting geological hazards.

Active surface geology (deformation, eruptions, landslides, and evolving landscapes).

DESIGNATED—***Targeted Observable:*** **Surface Biology and Geology** [**H-1c**, 2a, 2b, 3a, 3b, 3c, 4a, 4c, 4d; W-3a; **S-1a**, 1c, 2b, 4b, 4c, 7a; E-1a, **1c**, 1d, **2a**, **3a**, 5a, 5b, 5c; C-3a, 3c, 3d, 6b, 7e, 8f]

The **Surface Biology and Geology** Targeted Observable, corresponding to TO-18 in the Targeted Observables Table (Appendix C), enables improved measurements of Earth's surface characteristics that provide valuable information on a wide range of Earth System processes. Society is closely tied to the land surface for habitation, food, fiber and many other natural resources. The land surface, inland and near-coastal waters are changing rapidly due to direct human activities as well as natural climate variability and climate change. New opportunities arising from enhanced satellite remote sensing of Earth's surface provide multiple benefits for managing agriculture and natural habitats, water use and water quality, and urban development as well as understanding and predicting geological natural hazards. The Surface Biology and Geology observable is linked to one or more Most Important or Very Important science objectives from each panel and feeds into the three ESAS 2017 integrating themes: water and energy cycle, carbon cycle, and extreme event themes.

Science Considerations. This Targeted Observable will likely be addressed through hyperspectral measurements that support a multi-disciplinary set of science and applications objectives. Visible and shortwave infrared imagery addresses multiple objectives: active surface geology (e.g., surface deformation, eruptions, landslides, and evolving landscapes); snow and ice accumulation, melting, and albedo; hazard risks in rugged topography; effects of changing land-use on surface energy, water, momentum and carbon fluxes; physiology of primary producers; and functional traits of terrestrial vegetation and inland and near-coastal aquatic ecosystems. Thermal infrared imagery provides complementary information on ground, vegetation canopy, and water surface temperatures as well as ecosystem function and health. Depending on implementation specifics, the Targeted Observable may also contribute to hyperspectral ocean observation goals. However, such goals are met to a large degree by POR elements, in particular the hyperspectral PACE mission, and are not considered a priority for additional implementation (and thus are not recommended if they drive cost). Observations of the Earth's surface biology and geology, with the ability to detect detailed spectral signatures, provide a wide range of opportunities for Earth system science parameters across most of the panels and integrating themes. As such, this Targeted Observable maps to some of the highest panel priorities as well as the Integrating Themes.

SBG Geological Hazards / Disasters Objectives

EAS17 SBG TO-18: S-1a, 1c, 2b, 4b, 4c, 7a

QUESTION S-1	How can large-scale geological hazards be accurately forecast in a socially relevant timeframe?
QUESTION S-2	How do geological disasters directly impact the Earth system and society following an event?
QUESTION S-4	What processes and interactions determine the rates of landscape change?
QUESTION S-7	How do we improve discovery and management of energy, mineral, and soil resources?

Volcanic Eruptions

Calbuco eruption, Chile 2015

Landslides

Big Sur (California) 75-acre landslide May 2017. (image: CNN)

Other SBG geological hazards / disasters:

- Surface Deformation, Evolving Landscapes

Other program geological hazards / disasters:

- Earthquakes, Floods

Other related hazards / disasters:

- Oil Spills (ESAS 2017: 10-57 – multispectral)
- Mining Disasters, contaminant events

SBG Geological Hazards / Disasters Objectives

EAS17 SBG TO-18: S-1a, 1c, 2b, 4b, 4c, 7a

QUESTION S-1	How can large-scale geological hazards be accurately forecast in a socially relevant timeframe?
QUESTION S-2	How do geological disasters directly impact the Earth system and society following an event?
QUESTION S-4	What processes and interactions determine the rates of landscape change?
QUESTION S-7	How do we improve discovery and management of energy, mineral, and soil resources?

Volcanic Eruptions

SBG TO-18: **S-1a**, S-2b. Also: S-2a

S-1a. Measure the pre-, syn- and post-eruption surface deformation and products of Earth's entire active land volcano inventory with a time scale of days to weeks.

S-2b. Assess surface deformation (<10 mm), extent of surface change (<100 m spatial resolution) and atmospheric contamination, and the composition and temperature of volcanic products following a volcanic eruption (hourly to daily temporal sampling).

S-2a. Rapidly capture the transient processes following disasters for improved predictive modeling, as well as response and mitigation through optimal retasking and analysis of space data.

Landslides

SBG TO-18: S-1c, H-4b, H-4c. Also: H-4a

S-1c. Forecast and monitor landslides, especially those near population centers.

Changing Landscapes

SBG TO-18: S-4b, S-4c

S-4b. Quantify weather events, surface hydrology, and changes in ice/water content of near-surface materials that produce landscape change.

S-4c. Quantify ecosystem response to and causes of landscape change.

Geological Resources

SBG TO-18: S-7a

S-7a. Map topography, surface mineralogic composition/ distribution, thermal properties, soil properties/water content, and solar irradiance for improved development and management of energy, mineral, agricultural, and natural resources.

Landslides

Geological Hazards / Disasters: Landslides
Landslide Risk

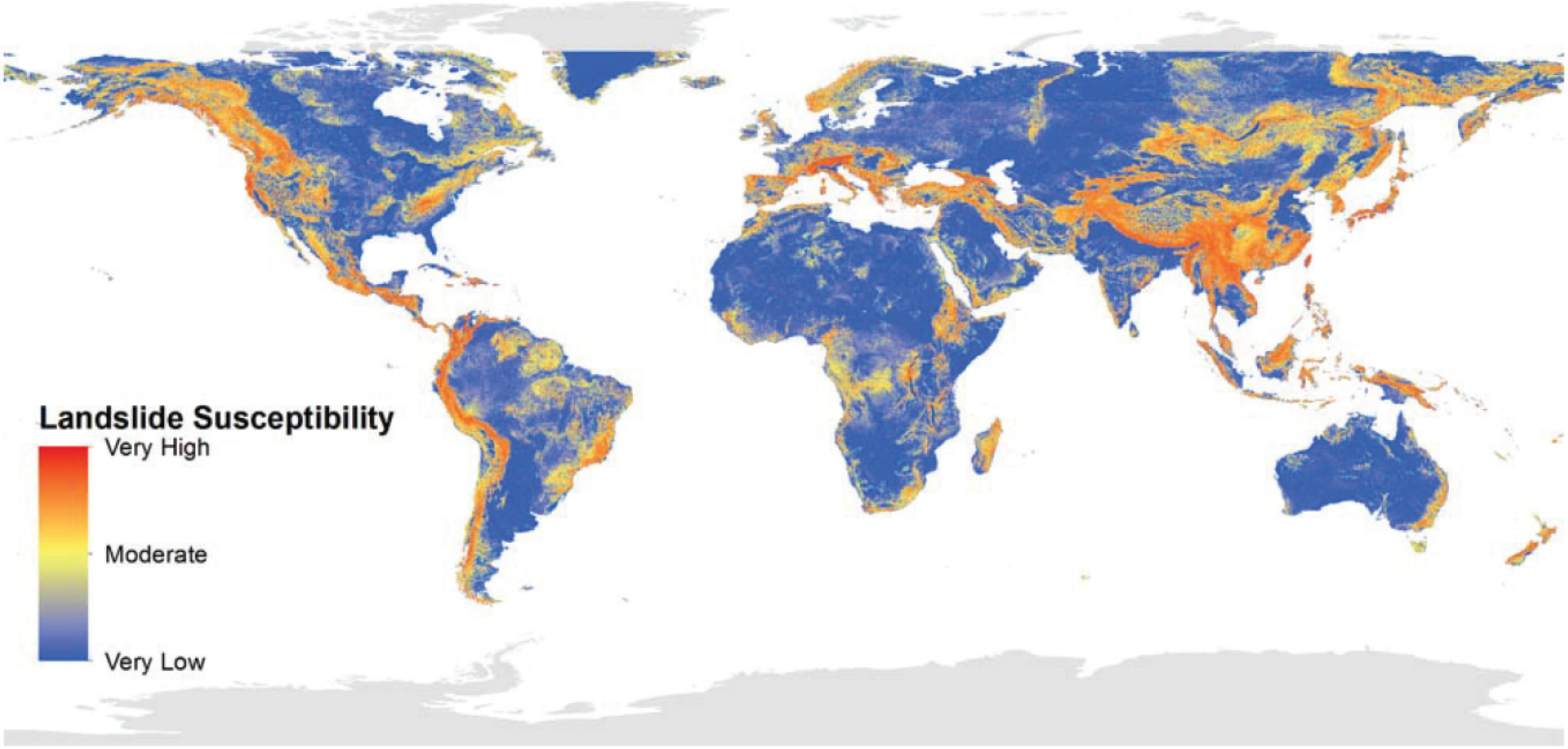
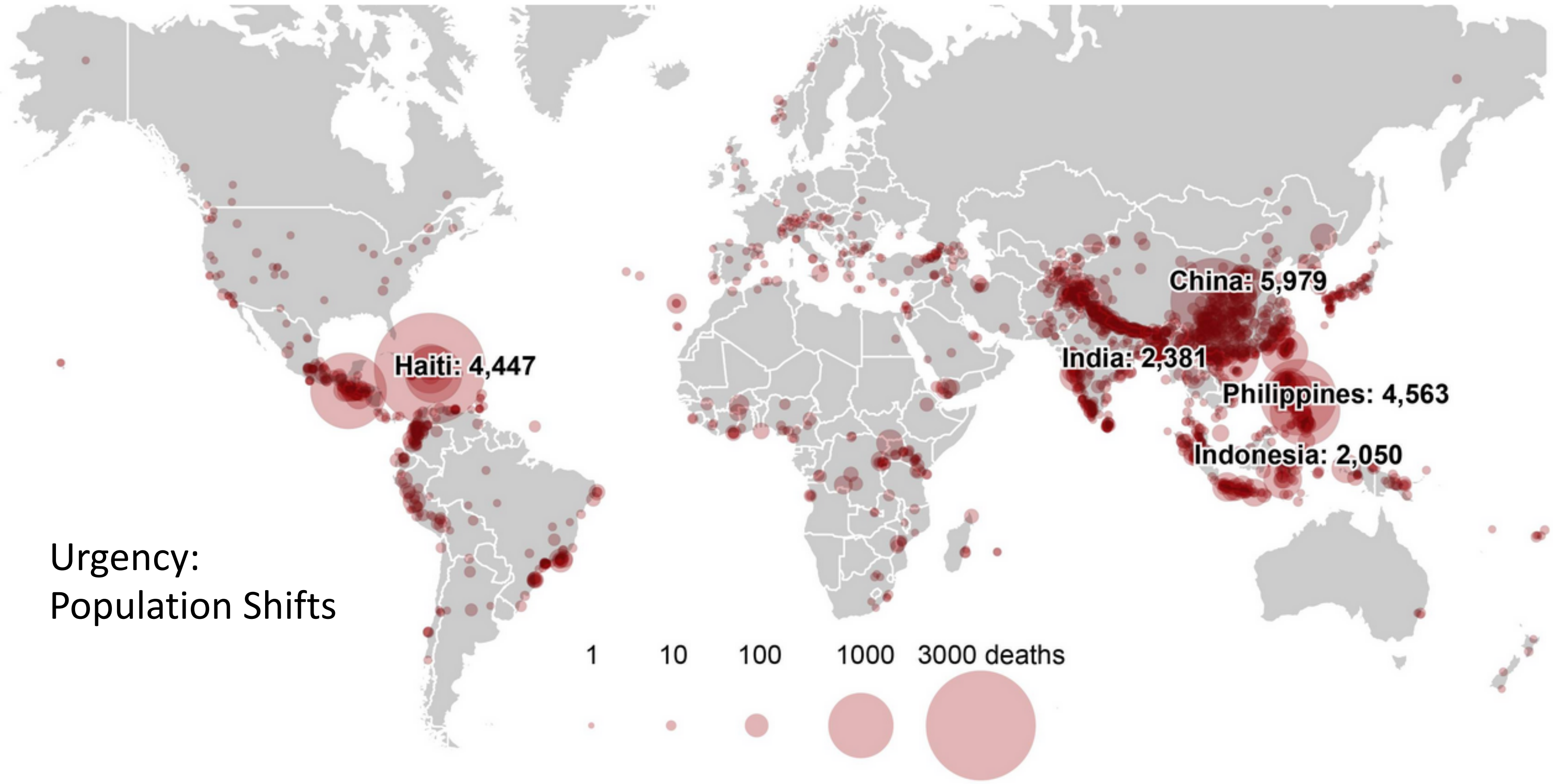


FIGURE 10.12 Global landslide susceptibility map developed using topography data from SRTM, forest loss information from Landsat, and other geophysical variables. SOURCE: Stanley and Kirschbaum (2017).

Geological Hazards / Disasters: Landslides Vulnerability and Disasters

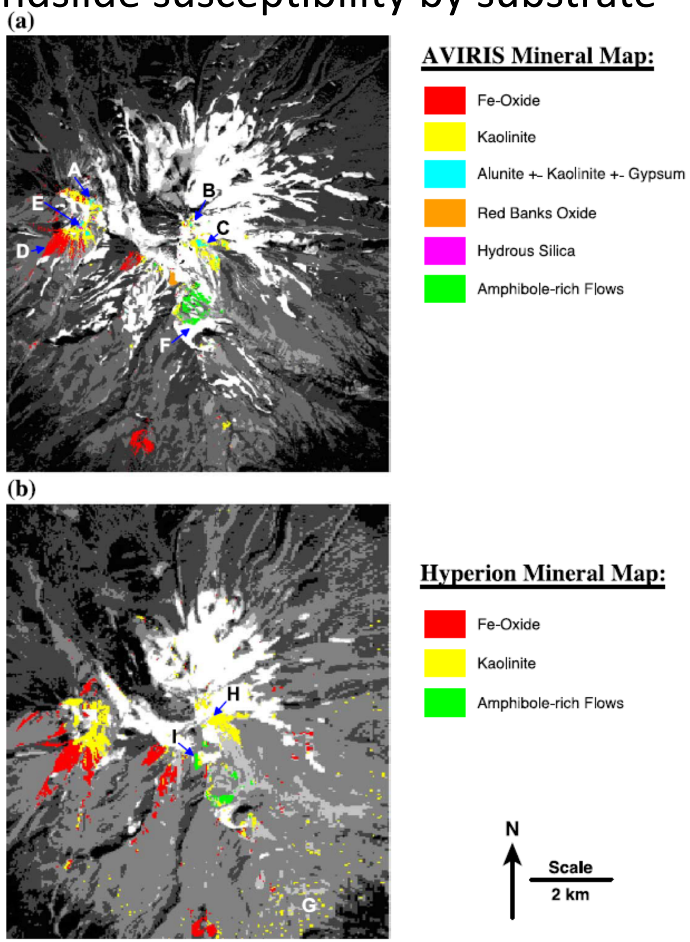


Urgency:
Population Shifts

2004-2007 data. Panko, B., Blogging the danger—and sometimes the art—of deadly landslides, Science, 2016.

Geological Hazards / Disasters: Landslides Remote Sensing

Landslide susceptibility by substrate



ELSEVIER

Available online at www.sciencedirect.com
SCIENCE DIRECT®

Remote Sensing of Environment 87 (2003) 345–358

Remote Sensing of Environment

www.elsevier.com/locate/rse

Analysis of potential debris flow source areas on Mount Shasta, California, by using airborne and satellite remote sensing data

J.K. Crowley*, B.E. Hubbard, J.C. Mars

M.S. 954, U.S. Geological Survey, 12201 Sunrise Valley Drive, Reston, VA 20192, USA

Received 16 December 2002; received in revised form 31 July 2003; accepted 3 August 2003

Abstract

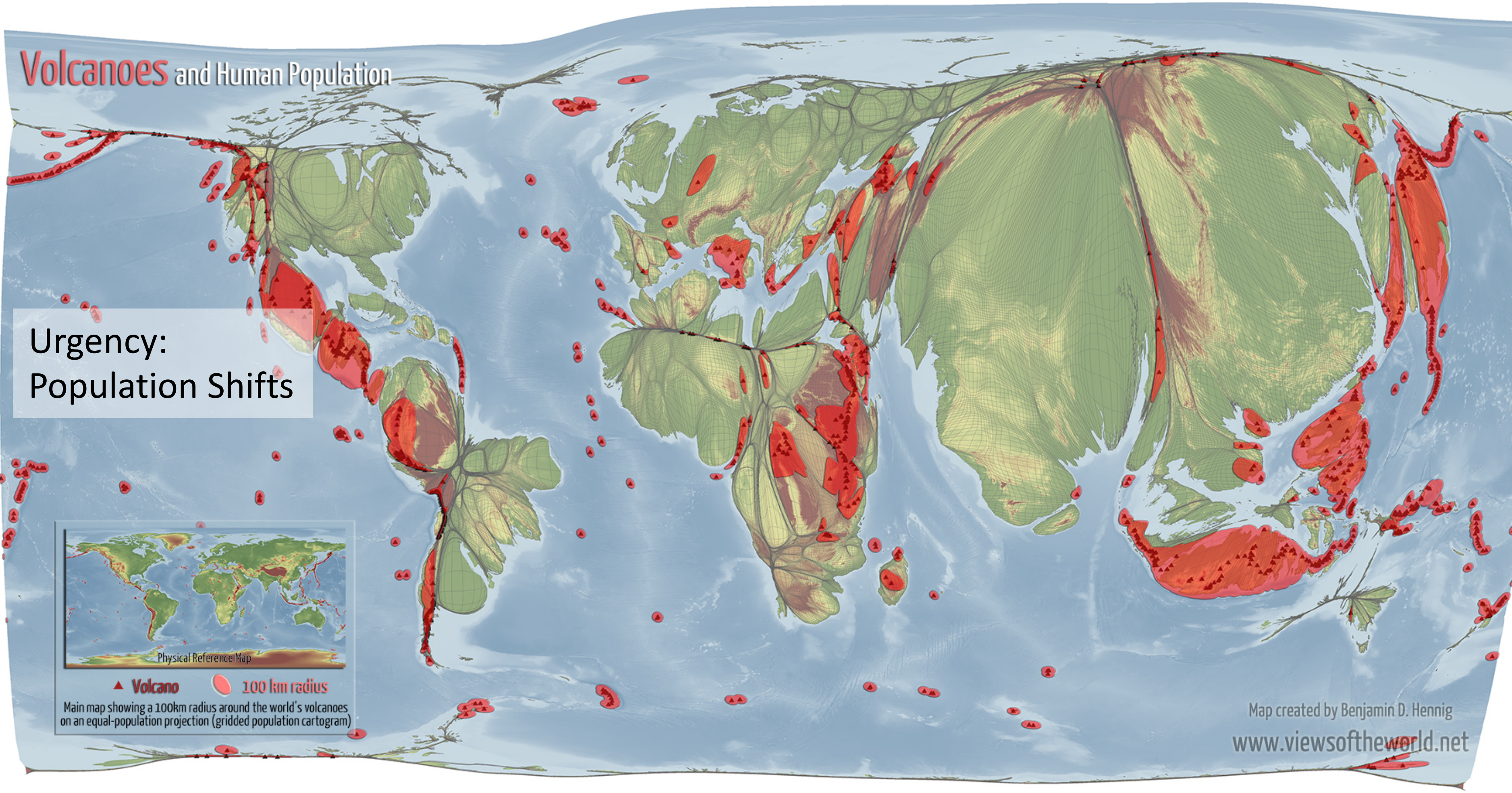
Remote sensing data from NASA's Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) and the first spaceborne imaging spectrometer, Hyperion, show hydrothermally altered rocks mainly composed of natroalunite, kaolinite, cristobalite, and gypsum on both the Mount Shasta and Shastina cones. Field observations indicate that much of the visible altered rock consists of talus material derived from fractured rock zones within and adjacent to dacitic domes and nearby lava flows. Digital elevation data were utilized to distinguish steeply sloping altered bedrock from more gently sloping talus materials. Volume modeling based on the imagery and digital elevation data indicate that Mount Shasta drainage systems contain moderate volumes of altered rock, a result that is consistent with Mount Shasta's Holocene record of mostly small to moderate debris flows. Similar modeling for selected areas at Mount Rainier and Mount Adams, Washington, indicates larger altered rock volumes consistent with the occurrence of much larger Holocene debris flows at those volcanoes. The availability of digital elevation and spectral data from spaceborne sensors, such as Hyperion and the Advanced Spaceborne Thermal Emission and Reflectance Radiometer (ASTER), greatly expands opportunities for studying potential debris flow source characteristics at stratovolcanoes around the world.

Keywords: Hydrothermal alteration; Debris flow; Volcanic hazards; Remote sensing; Mount Shasta; Mount Adams; Mount Rainier

Correlated with slopes from topography. Would be great to have hydrological and ecosystem structure & function information too, to get inundation probabilities. We can do it with combining VSWIR with TIR (and Lidar) data.

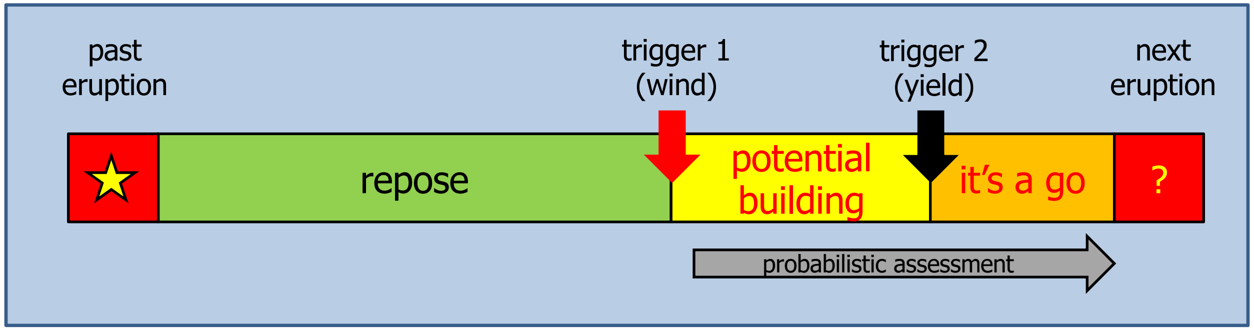
Volcanoes

Geological Hazards / Disasters : > 450 active Volcanoes



Henning, B. 2014: Gridded cartograms as a method for visualising earthquake risk at the global scale. Journal of Maps 10(2):186-194.

S-1a. Volcano applications: observations before, during, and after eruptions



(time scale not linear)

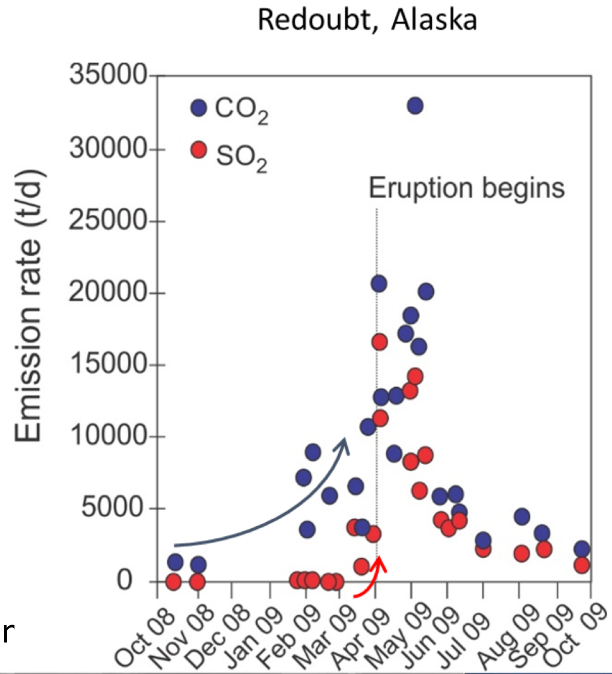
Syn- Post- = Pre- Syn-

Beyond direct hazards, additional volcano urgencies:
natural ecosystems and crops resiliency reduced in less diverse ecosystems -> increasing food security vulnerability to volcanic disasters

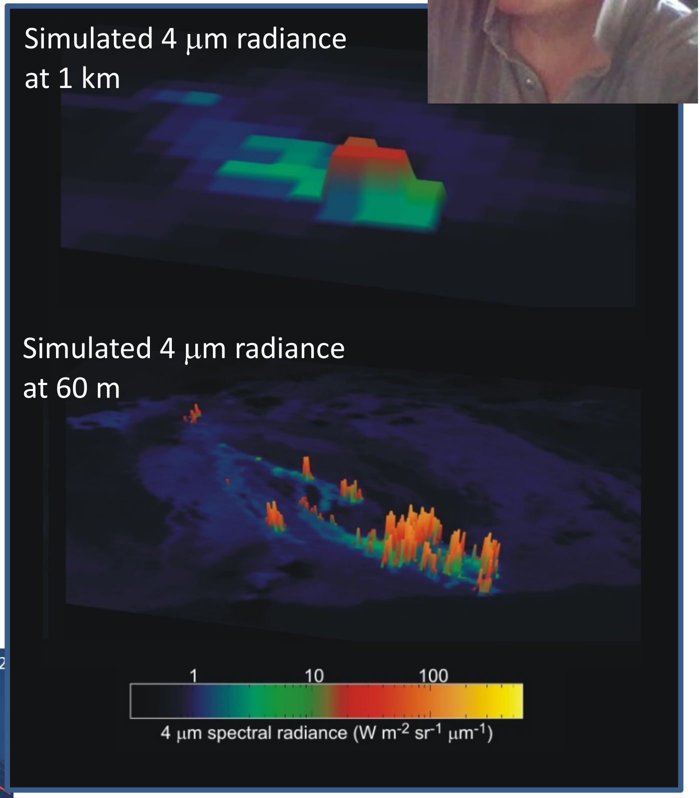
Lessons learned from HyspIRI

TIR imagery – Rob Wright

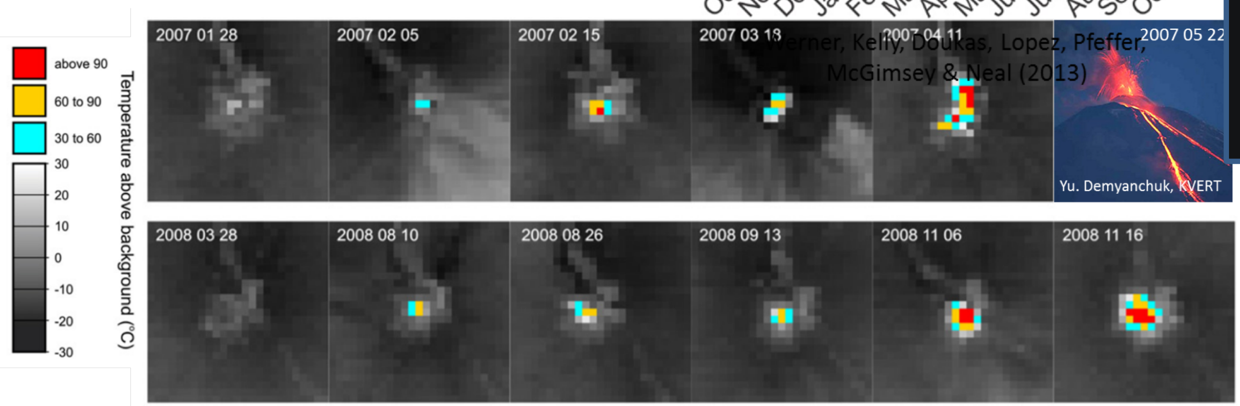
Gas tracking with combined VSWIR (CO_2) & TIR (SO_2) enables early precursor detection
→ actionable information for operational agencies, which may lead to evacuation and loss reduction. →



Werner, Kelly, Doukas, Lopez, Pfeffer, McGimsey & Neal (2013)



Low Cadence enables tracking of precursory ramping up of thermal sigr



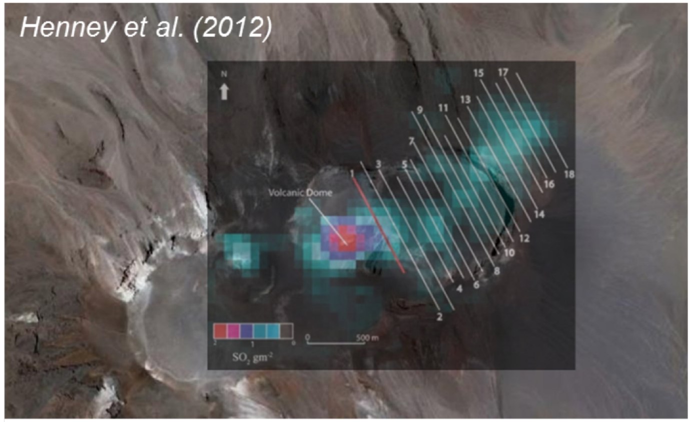
Gradual infilling of the summit crater at Kliuchevskoi, Russia, observed by ASTER, prior to overflow and emplacement of lava flows descending down the volcano's flanks

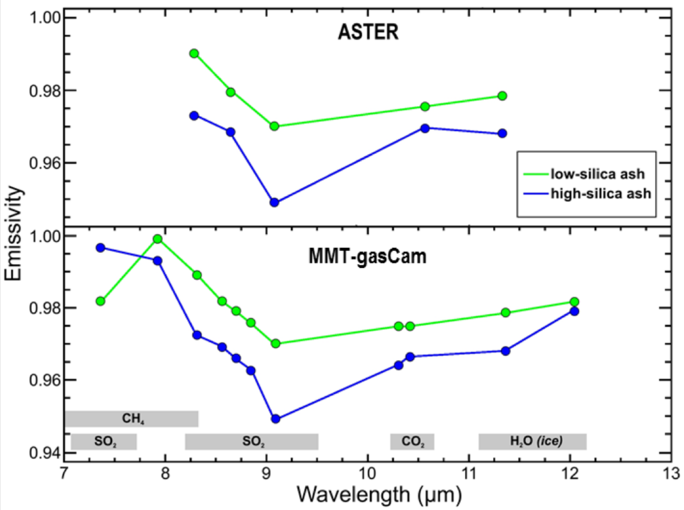
Murphy, Wright, Oppenheimer, & Souza-Filho, (2013)

Spatial Resolution constrains structure & flow character – gain lava flow extent, cooling rates, and prediction intel.
Also permits low enhancement thermal features monitoring (Greg Vaughan, USGS)

Lessons learned from HyspIRI

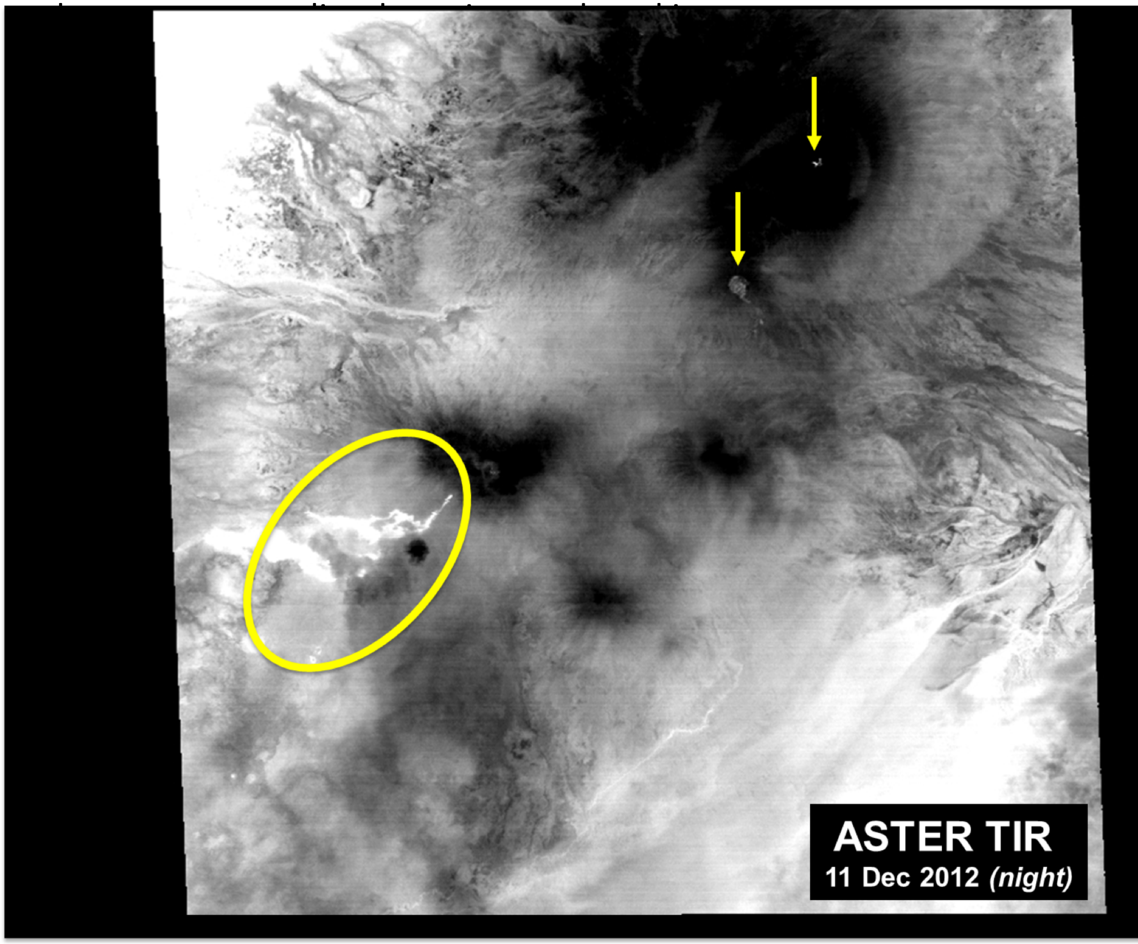
TIR imagery – Mike Ramsey





Hyperspectral TIR permits accurate gas & landslide precursor tracking during pre- and post- eruption times (**S-1a**, *Most Important*).

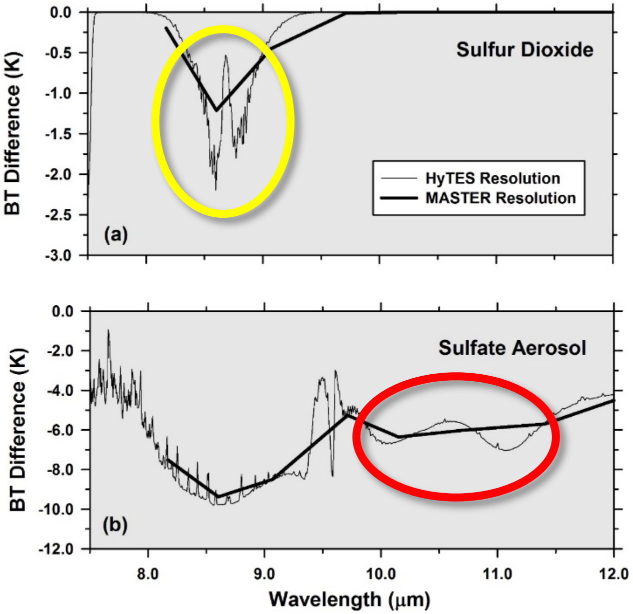
Higher spatial resolution permits detection of intense but small radius thermal



Lessons learned from HyspIRI

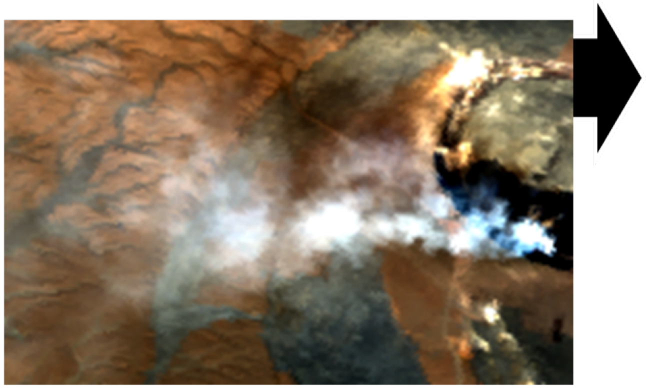
Gases via hyperspectral VSWIR & TIR – Vince Realmuto

Hyperspectral TIR permits accurate retrievals of SO_2 and sulfate aerosol, highly relevant to science and to respiratory health applications.

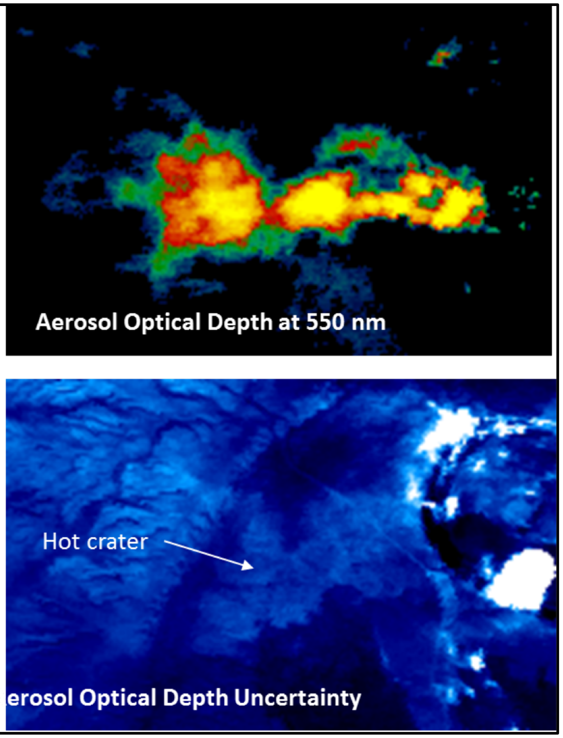


Simultaneous, fast-repeat, high-spatial resolution hyperspectral TIR & VSWIR necessary to constrain the dynamic, fast-evolving chemistry of volcanic emission plumes in the atmosphere.

Optimal Estimation for Iterative Fitting of Surface and Atmospheric Spectra. Allows Combined estimate of H_2O vapor, AOD, surface reflectance and temperature



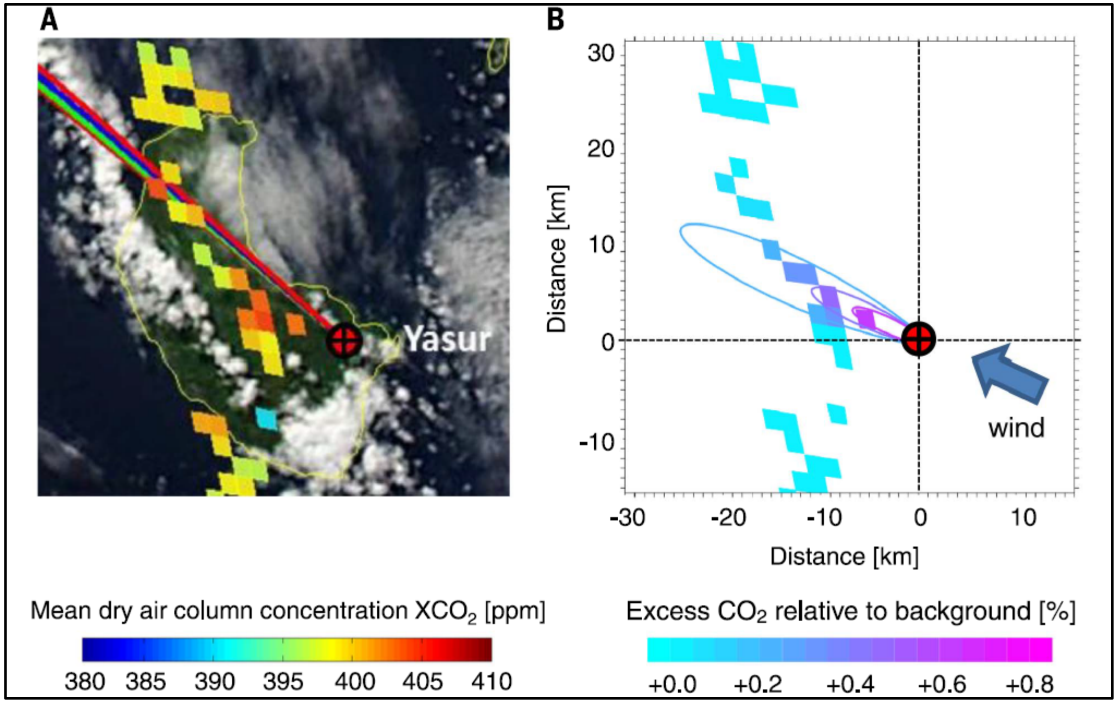
AVIRIS-C f170127t01p00r16 (subset, visible bands)



Lessons learned from HyspIRI

CO_2 gas via hyperspectral VSWIR – Florian Schwandner

Weeelll.. Not from HyspIRI but from OCO-2 (pre-SBG POR).



CO_2: most important EARLY precursor to eruptions.

Often simultaneous with weak thermal anomalies – <u>months</u> before eruptions.

RESEARCH | REMOTE SENSING

RESEARCH ARTICLE

CARBON CYCLE

Spaceborne detection of localized carbon dioxide sources

Florian M. Schwandner,[1,2]* Michael R. Gunson,[1] Charles E. Miller,[1] Simon A. Carn,[3] Annmarie Eldering,[1] Thomas Krings,[4] Kristal R. Verhulst,[1,2] David S. Schimel,[1] Hai M. Nguyen,[1] David Crisp,[1] Christopher W. O'Dell,[5] Gregory B. Osterman,[1] Laura T. Iraci,[6] James R. Podolske[6]

Spaceborne measurements by NASA's Orbiting Carbon Observatory-2 (OCO-2) at the kilometer scale reveal distinct structures of atmospheric carbon dioxide (CO_2) caused by known anthropogenic and natural point sources. OCO-2 transects across the Los Angeles megacity (USA) show that anthropogenic CO_2 enhancements peak over the urban core and decrease through suburban areas to rural background values more than ~100 kilometers away, varying seasonally from ~4.4 to 6.1 parts per million. A transect passing directly downwind of the persistent isolated natural CO_2 plume from Yasur volcano (Vanuatu) shows a narrow filament of enhanced CO_2 values (~3.4 parts per million), consistent with a CO_2 point source emitting 41.6 kilotons per day. These examples highlight the potential of the OCO-2 sensor, with its unprecedented resolution and sensitivity, to detect localized natural and anthropogenic CO_2 sources.

Atmos. Meas. Tech., 10, 3833–3850, 2017
https://doi.org/10.5194/amt-10-3833-2017

Atmospheric Measurement Techniques
Open Access
EGU

Airborne DOAS retrievals of methane, carbon dioxide, and water vapor concentrations at high spatial resolution: application to AVIRIS-NG

Andrew K. Thorpe[1], Christian Frankenberg[2,1], David R. Thompson[1], Riley M. Duren[1], Andrew D. Aubrey[1], Brian D. Bue[1], Robert O. Green[1], Konstantin Gerilowski[3], Thomas Krings[3], Jakob Borchardt[3], Eric A. Kort[4], Colm Sweeney[5], Stephen Conley[6,7], Dar A. Roberts[8], and Philip E. Dennison[9]

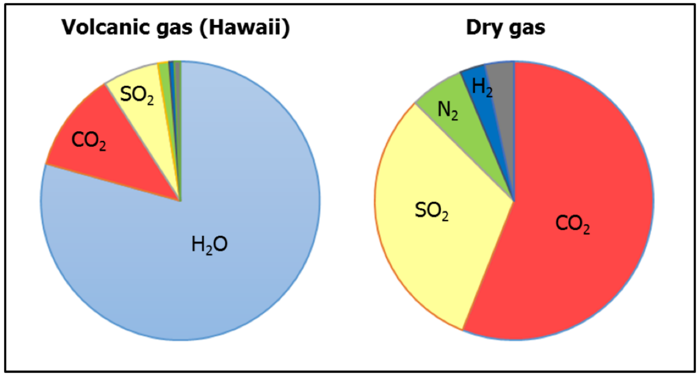
[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA
[2]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, California, USA
[3]Institute of Environmental Physics (IUP), University of Bremen, Bremen, Germany
[4]Department of Climate and Space Sciences and Engineering, University of Michigan, Ann Arbor, Michigan, USA
[5]Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, Colorado, USA
[6]Global Monitoring Division, NOAA Earth System Research Laboratory, Boulder, Colorado, USA
[7]Scientific Aviation, 3335 Airport Road, Boulder, Colorado, USA
[8]Department of Geography, University of California, Santa Barbara, Santa Barbara, California, USA
[9]Department of Geography, University of Utah, Salt Lake City, Utah, USA

Correspondence to: Andrew K. Thorpe (andrew.k.thorpe@jpl.nasa.gov)

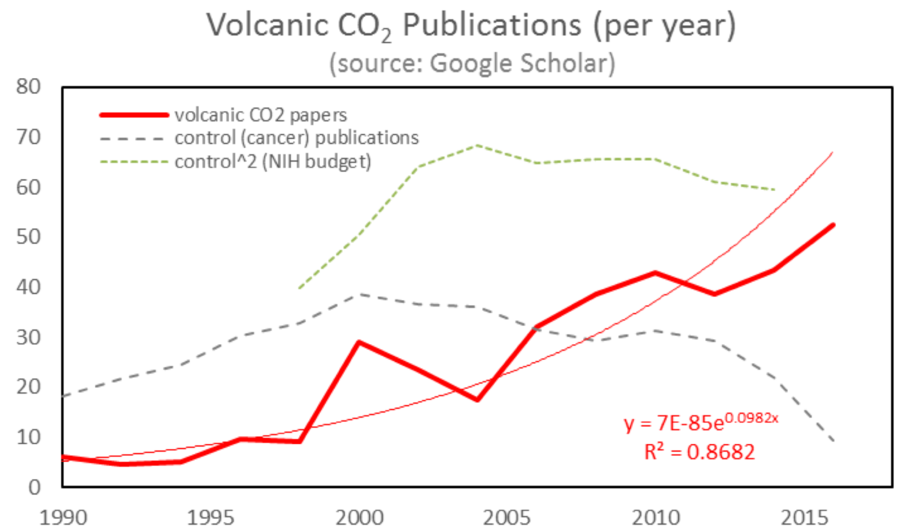
Received: 18 February 2017 – Discussion started: 9 May 2017
Revised: 29 August 2017 – Accepted: 5 September 2017 – Published: 19 October 2017

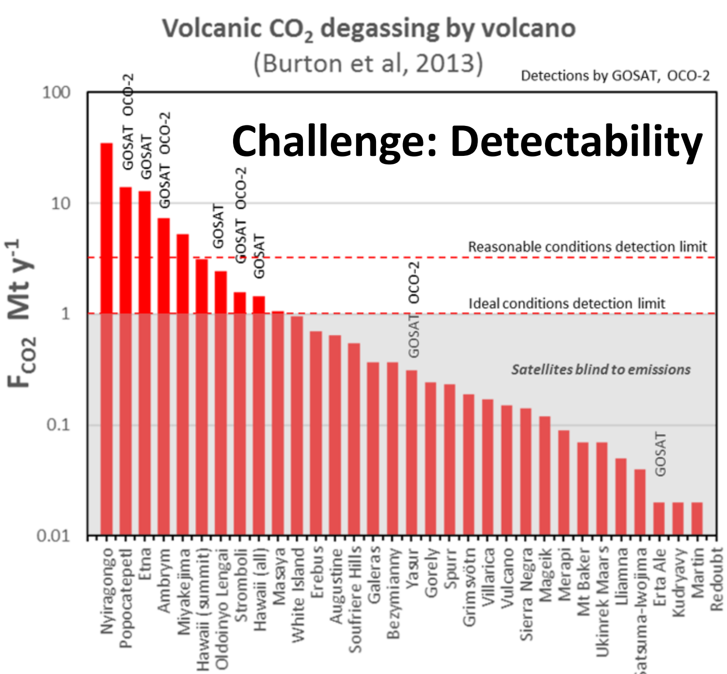
Lessons learned from HyspIRI

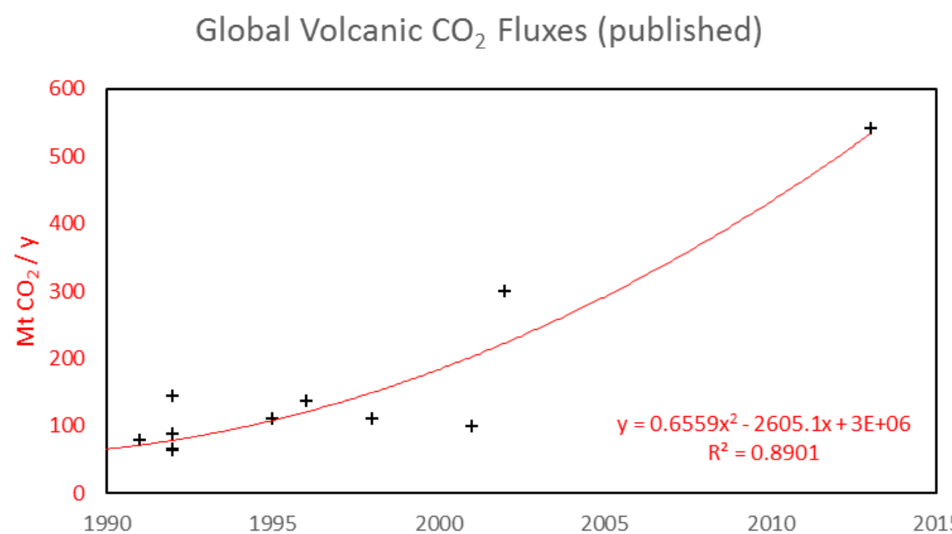
CO_2 gas via hyperspectral sensing



Volcanic CO_2 [S-1a "Most Important"]







Lessons learned from HyspIRI (JPL team, Chad Deering/MTU)

CO_2 via hyperspectral VSWIR & TIR sensing of plants as sensors of CO_2 enhancements

"trees as sensors"


Biogeosciences
An interactive open-access journal of the European Geosciences Union
| EGU.eu | EGU Journals | EGU Highlight Articles | Contact | Imprint |
Submit a manuscript
Manuscript tracking
About
Editorial board
Articles
Special issues
Highlight articles
Subscribe to alerts
Peer review
For authors
For reviewers
User ID
Password
https://doi.org/10.5194/bg-2018-100
© Author(s) 2018. This work is distributed under the Creative Commons Attribution 4.0 License.
Discussion papers
Abstract | Discussion | Metrics
Research article
05 Mar 2018
Plant responses to volcanically-elevated CO_2 in two Costa Rican forests
Robert R. Bogue[1,2], Florian M. Schwandner[1,3], Joshua B. Fisher[1], Ryan Pavlick[1], Troy S. Magney[1], Caroline A. Famiglietti[1], Kerry Cawse-Nicholson[1], Vineet Yadav[1], Justin P. Linick[1], Gretchen B. North[4], and Eliecer Duarte[5]
[1]Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, USA
[2]Geology Department, Occidental College, 1600 Campus Road, Los Angeles, CA 90041, USA
[3]Joint Institute for Regional Earth System Science and Engineering, University of California Los Angeles, Los Angeles, CA 90095, USA
[4]Biology Department, Occidental College, 1600 Campus Road, Los Angeles, CA 90041, USA
[5]OVSICORI-UNA, 2386-3000 Heredia, Costa Rica
Review status
This discussion paper is a preprint. It is a manuscript under review for the journal Biogeosciences (BG).
Copernicus Publications
The Innovative Open Access Publisher
Search articles
Search
Author
Download
Supplement (278 KB)
Short summary
We studied trees growing on the outer areas of two volcanoes in Costa Rica to

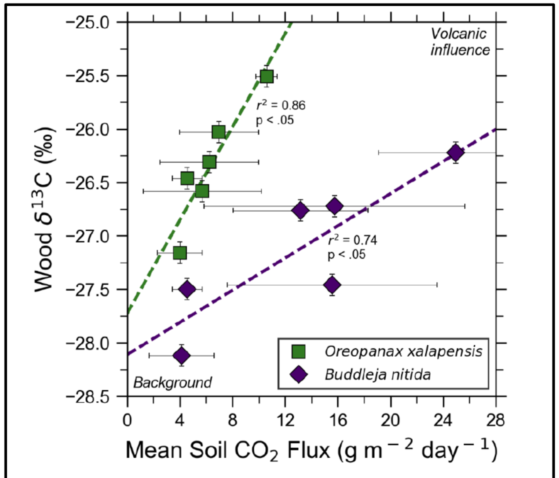
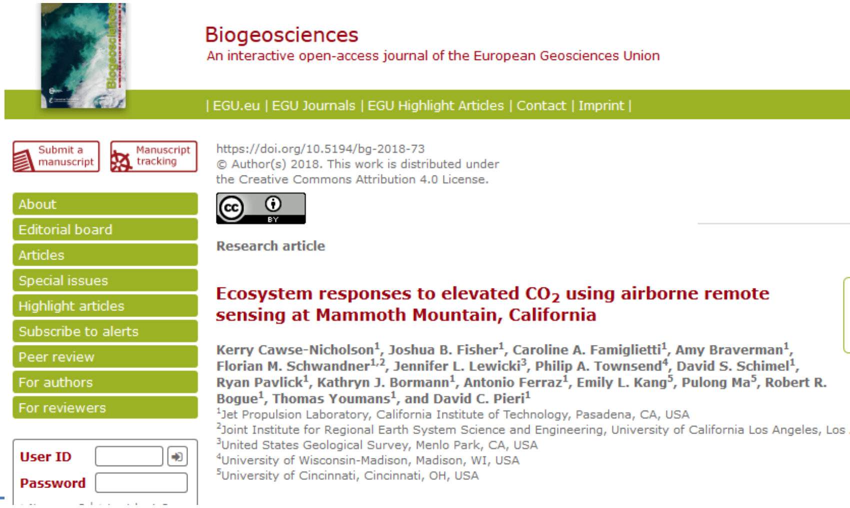
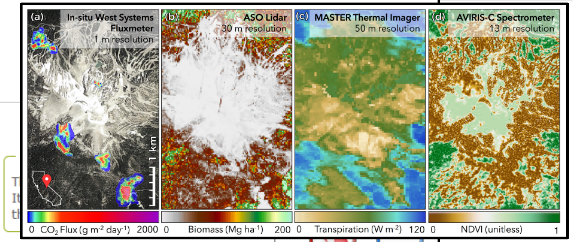


Fig 4: Bulk wood $\delta^{13}C$ of trees on Costa Rica's Turrialba volcano shows strong correlations with increasing volcanic CO_2 flux for two species, *O. xalapensis* and *B. nitida*, indicating long-term photosynthetic incorporation of isotopically heavy volcanic CO_2. Stable carbon isotope ratio ($\delta^{13}C$) of wood cores are plotted against soil CO_2 flux measured immediately adjacent to the tree that the core sample was taken from. Background and volcanic influence labels apply to both axes – higher CO_2 flux and heavier (less negative) $\delta^{13}C$ values are both characteristic of volcanic CO_2 emissions.


Biogeosciences
An interactive open-access journal of the European Geosciences Union
| EGU.eu | EGU Journals | EGU Highlight Articles | Contact | Imprint |
Submit a manuscript
Manuscript tracking
About
Editorial board
Articles
Special issues
Highlight articles
Subscribe to alerts
Peer review
For authors
For reviewers
User ID
Password
https://doi.org/10.5194/bg-2018-73
© Author(s) 2018. This work is distributed under the Creative Commons Attribution 4.0 License.
Research article
Ecosystem responses to elevated CO_2 using airborne remote sensing at Mammoth Mountain, California
Kerry Cawse-Nicholson[1], Joshua B. Fisher[1], Caroline A. Famiglietti[1], Amy Braverman[1], Florian M. Schwandner[1,2], Jennifer L. Lewicki[3], Philip A. Townsend[4], David S. Schimel[1], Ryan Pavlick[1], Kathryn J. Bormann[1], Antonio Ferraz[1], Emily L. Kang[5], Pulong Ma[5], Robert R. Bogue[1], Thomas Youmans[1], and David C. Pieri[1]
[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
[2]Joint Institute for Regional Earth System Science and Engineering, University of California Los Angeles, Los Angeles, CA, USA
[3]United States Geological Survey, Menlo Park, CA, USA
[4]University of Wisconsin-Madison, Madison, WI, USA
[5]University of Cincinnati, Cincinnati, OH, USA
Short summary
Carbon dioxide levels are rising globally, and it is important to understand how this rise will...
Read more



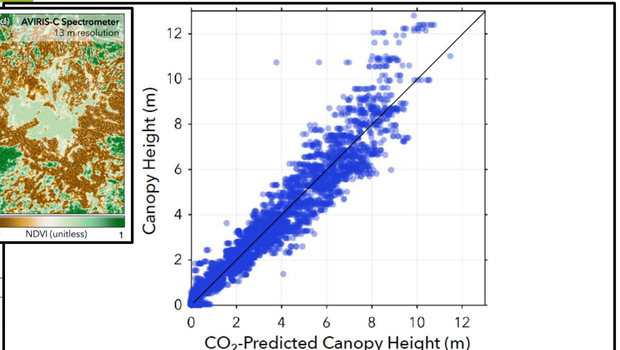
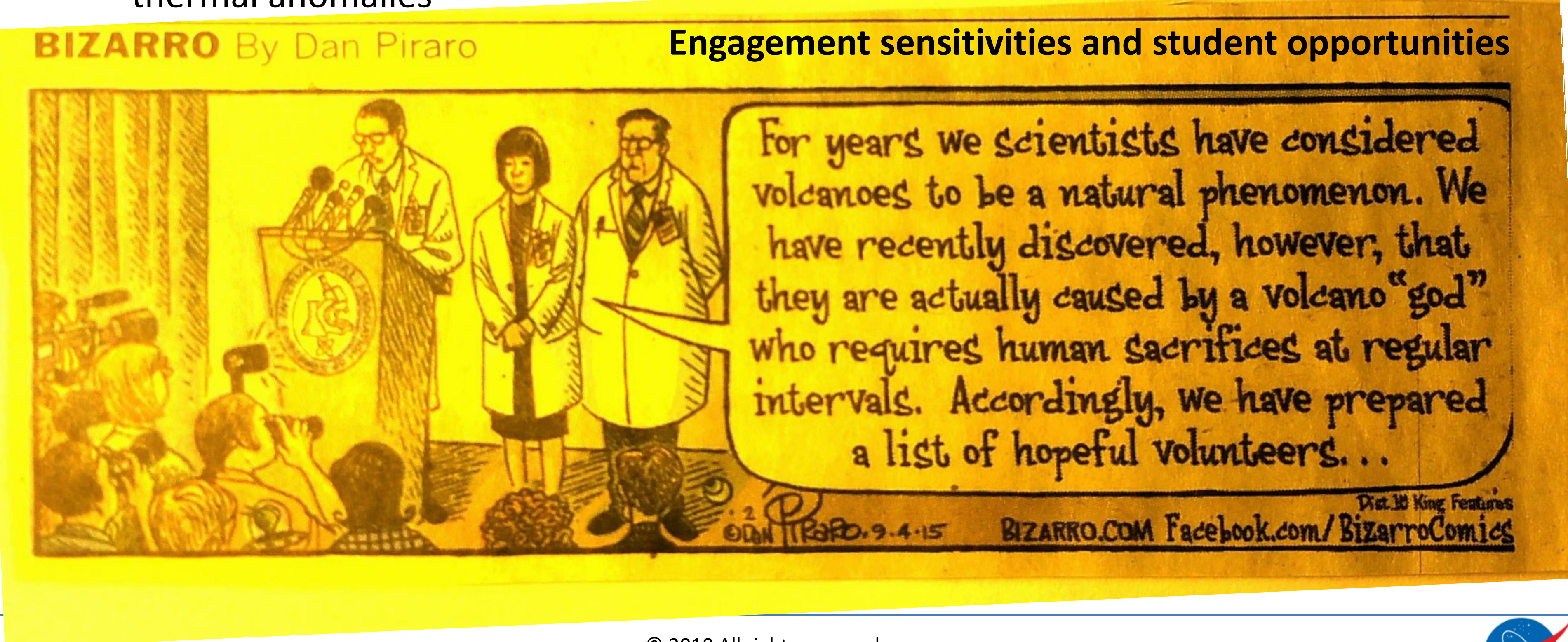


Figure 4: Canopy height is well modelled by the eCO_2 model, with an R^2=0.92, and the 1-1 line shown in black. However, the very tallest trees are not well captured.

Design considerations for geological hazards observing strategies with applications relevance

- Targeting: POR taught us that targeting is key to observe volcanoes
- Cadence: fast repeat cycle for frequent revisits (days to a week max.)
- VSWIR & TIR simultaneous ideal, contemporaneous if within <5 minutes.
- TIR multispectral acceptable, but hyperspectral desired, especially for less bright thermal anomalies

Engagement sensitivities and student opportunities



Applications:
Engagement

Some people's Science is other people's Applications

Geological Hazards Applications – where do we take guidance from?

NASA Applied Sciences Program https://appliedsciences.nasa.gov

- **2018 NASA ESD Directive** on Project Applications Program (Directed & EV Missions) https://science.gsfc.nasa.gov/610/applied-sciences/mission_applications_materials/FAS%20Directive_signed.pdf
- 2017 NASA ASP Annual Summary https://appliedsciences.nasa.gov/system/files/docs/2017_Disasters_Annual_Summary.pdf
- NASA ESD Disasters Program https://disasters.nasa.gov

NASA Earth Surface & Interior (ES&I) Focus Area

- 2015 CORE Report (Challenges and Opportunities for Research in ESI) https://smd-prod.s3.amazonaws.com/science-red/s3fs-public/atoms/files/CORE2016%20Updated%3DTAGGED.pdf
- 2002 SESWG Report "Living on a restless planet" https://solidearth.jpl.nasa.gov/PAGES/report.html

National Academies of Sciences, Engineering, Medicine http://www.nationalacademies.org

- **2017 ESAS Report** (Decadal Survey) https://www.nap.edu/catalog/24938
- 2017 ERUPT Report https://www.nap.edu/catalog/24650
- 2004 Partnerships for Reducing Landslide Risk Report https://www.nap.edu/catalog/10946/

National Science and Technology Council (NSTC): Subcommittee on Disaster Reduction (SDR)

- 2008 NSTC-SDR Volcano Disaster Reduction Challenge http://www.sdr.gov/docs/185820_Volcano_FINAL.pdf
- 2008 NSTC-SDR Landslide Disaster Reduction Challenge http://www.sdr.gov/docs/185820_Landslide_FINAL.pdf

Applications and SBG - How do we do this?

NASA HEADQUARTERS
SCIENCE MISSION DIRECTORATE (SMD)

EARTH SCIENCE DIVISION

DIRECTIVE ON PROJECT APPLICATIONS PROGRAM

Approved by:

Michael Freilich
Director, Earth Science Division
Science Mission Directorate, NASA Headquarters

29 June 2016
Date

2. PROJECT APPLICATIONS PROGRAM GOAL

The primary goal of the PAP is to maximize the benefit of the ESD's investment by enhancing the applications value and overall societal benefits of the project through:

- Scoping and developing applied research and applications as part of the overall mission concept;
- Demonstrating the project's benefit to society and contribution to the achievement of societal outcomes;
- Identifying specific product applications and Communities of Potential to better understand the impacts and benefit from using project products and models;
- Increasing the utility of data products; and
- Fostering a Community of Practice who can work with the project throughout the mission life cycle.

4.1 Pre-Phase A

Purpose: To enhance overall science objectives and societal benefits from the project's data, and establish characterization of the Communities of Practice and Potential. Initiate a team for the integration and inclusion of applications in the project concept review, and for articulation at the Key Decision Point for Phase A (KDP-A).

Focus: To determine and clarify the applications dimension of the overall project concept and initiation to amass the applications communities (Community of Potential and Community of Practice).

Implementation Activities: Perform assessments to determine what results techniques and products are useful to the applications community, as a result of associated research. A strong characterization of the Communities of Practice and Potential will enhance overall science objectives and societal benefits from the project's data. Produce a Community Assessment and Report.

Guidance: There are a number of people and organizations that may supply information or capabilities such as the Project Manager, the Project Scientists, the Science Team lead, the Project Science Data Systems Representative, the NASA Distributed Active Archive Centers (DAAC), and the Project Applications Coordinator (PAC). Additionally, it is expected that the Program Executive (PE), the Program Scientist (PS) and the Program Applications (PA) lead will be engaged in supporting the project's applications activities.

	Pre-Phase A
Project Life Cycle Phases	Concept Studies
Purpose	Scope the applications portion of the mission concept
Activities	Conduct Mission Studies
	Characterize the applications value of the mission
	Identify and characterize applications communities
	Support MCR and design trade-offs
	Consult with other projects to scope approaches to applications
	Develop information to inform the FAD and PLRA
	Inform concept discussions
Deliverables	Project Studies
	Community Assessment and Report
Events	MAR: Conduct a Mission Applications Review prior to MCR
	MCR: Articulate applications as part of the overall mission concept
	KDP-A

Application leads:
Jeff Luvall, Christine Lee

Application Communities of Practice :: Communities of Potential

US application relevant agencies (some)
- State agencies
- DOA incl. FS
- DHHS, incl. CDC
- EPA
- DOD

geological hazards relevant

US **AID, > VDAP, SERVIR**

DOI > **USGS** with VDAP & NVEWS, **NPS**, BLM

DOC > **NOAA**

DHS > **FEMA**

OSTP>NSTC > **SDR** (Subcommittee on Disaster Reduction)

Non-USG agencies (international, NGO, commercial)
- Committee on Earth Observation Satellites (CEOS)
- International Charter https://disasterscharter.org (125 countries, 17 members, 34 satellites, 583x)
- Intergovernmental Group on Earth Observations (GEO)
- World Meteorological Organization (WMO)
- World Organisation of Volcano Observatories (WOVO) http://www.wovo.org (>70 national agencies)
- Volcanic Ash Advisory Centers (VAAC)
- International Consortium on Landslides (ICL) http://icl.iplhq.org/
- UNESCO Geohazard Risk Reduction Program http://www.unesco.org/new/en/natural-sciences
- Commercial: Re-insurance sector, Technology sector (e.g., GIS, monitoring technology)
- NGOs:
  - National Emergency Management Association (NEMA, USA)
  - OXFAM International (formerly Oxford Committee for Famine Relief)
  - Red Cross, MSF/DWB, UNICEF
  - Disaster Preparedness and Emergency Response Association (DERA)

Applications of Hyperspectral Remote Sensing Observations of Geological Hazards

*initial scoping

	ESAS-17 SBG ES&I (S) Objectives	Relevant quantities	Likely Application Community Partners
S-1c	Forecast and monitor landslides, especially those near population centers.	Imaging of vegetation and rock/soil composition	USGS, BLM, NPS, FEMA, USAID, SDR, WOVO, FS, commercial partners (technology, re-insurance), NGOs Integrating Themes (objectives): H-3b; E-2c, E-5b; C-5a, C-5d, C-7b; W-5a, W-6a
S-1a	Measure the pre-, syn- and post-eruption surface deformation and products of Earth's entire active land volcano inventory with a time scale of days to weeks.	Temperature, composition and extent of erupted volcanic materials, including gases.	
S-2b	Assess surface deformation (<10 mm), extent of surface change (<100 m spatial resolution) and atmospheric contamination, and the composition and temperature of volcanic products following a volcanic eruption (hourly to daily temporal sampling).	Gases (CO2, SO2, H2S, H2O), ash, surface composition, lava flows & lakes, thermal emissions	USGS, BLM, NPS, FEMA, USAID, SDR, WOVO, NOAA, commercial partners (technology, re-insurance), NGOs Integrating Themes (objectives): H-4; E-1b, E-1d; W-2a, W-4a, W-5a, W-6a
S-2a	Rapidly capture the transient processes following disasters for improved predictive modeling, as well as response and mitigation through optimal retasking and analysis of space data. (not listed)		
S-4b	Quantify weather events, surface hydrology, and changes in ice/water content of near-surface materials that produce landscape change.	Spatial and temporal distribution of rainfall and snowfall. Snowcover duration & extent.	USGS, FEMA, NOAA, EPA, WMO, USDA Integrating Themes (objectives): H-1a, H-1c, H-2a, H-3b, H-4a-d; E-1b, E-1d-e, E-3a, E-4a, E-5a-c; C-2e; W-1a, W-3a, W-4a
S-4c	Quantify ecosystem response to and causes of landscape change.	Biomass extent, composition, health; species composition, carbon stocks, nutrient composition, wildfire history	
S-7a	Map topography, surface mineralogic composition/ distribution, thermal properties, soil properties/water content, and solar irradiance for improved development and management of energy, mineral, agricultural, and natural resources	30-m or better hyperspectral VSWIR imaging, and TIR data	USGS, BLM, USDA, NPS, EPA, USDA, commercial partners (resources). Integrating Themes (objectives): H-1ª, H-4a; E-1b, E-3a, E-5b

NASA Applications Program

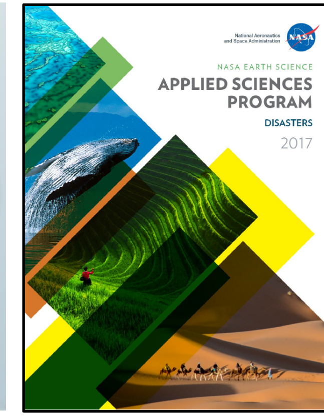
Activities supporting:

Disaster Research

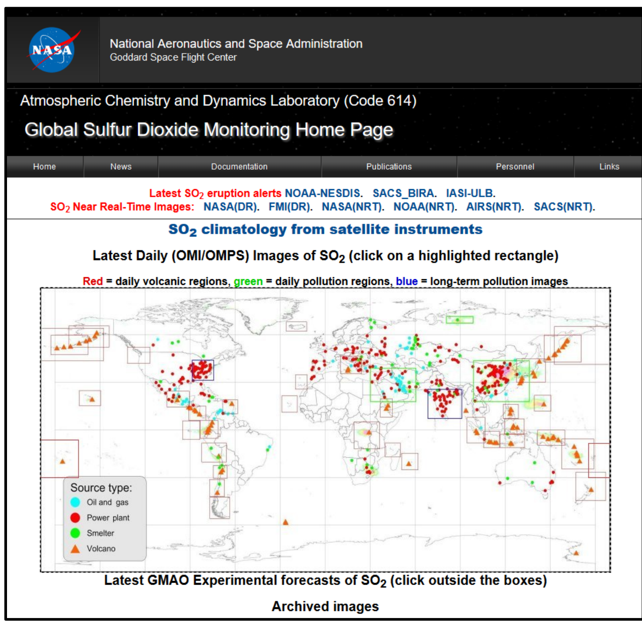
Disaster Response

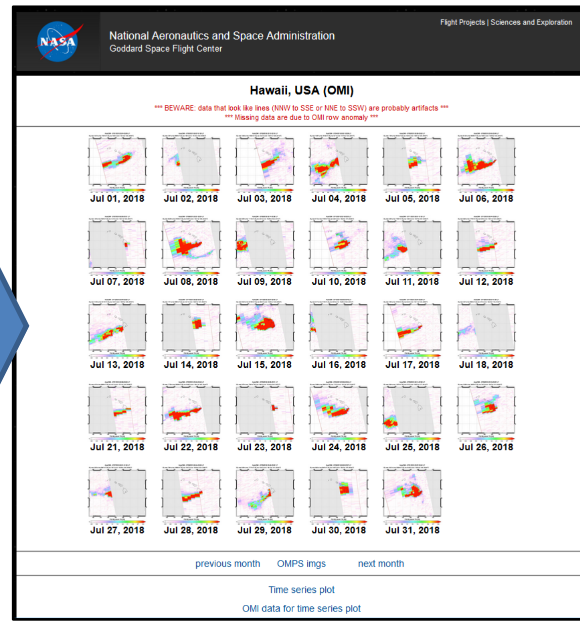
Disasters Resiliency (incl. Capacity Building Program)

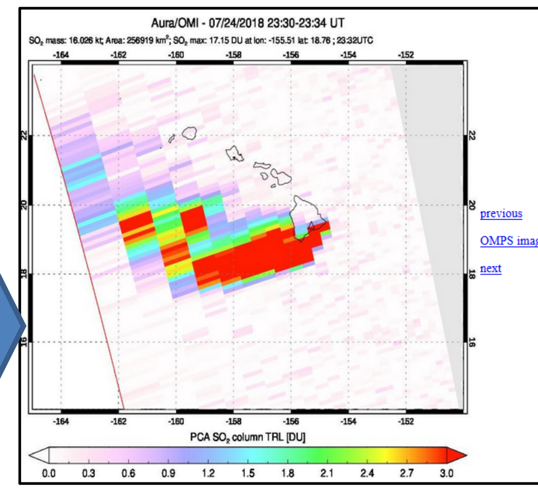
Disasters Mission Applications



One of many success stories in the NASA Applications Program: NASA SO_2 portal







Applications Project: Real-Time Volcanic Cloud Products and Predictions for Aviation Alerts

Used by >100 volcano observatories around the world. USAID/USGS uses it in training of scientists in affected countries. Multiple sensors & missions.

Applications:
Partner engagement examples

Applications: Volcanoes
Partner engagement example #1

- **2010** Singapore: Local observatory remote sensing training workshop
  Organized by USAID/VDAP/USGS/Earth Observatory
  Client group: Observatory Scientists from the Philippines, Papua New Guinea, Indonesia
- **2009** – ongoing: Partnership with PH, PNG, ID observatories – scientists exchange and field partnerships. Capacity building and training through their entire decision & support chain (from local population through gov and NGOs to provincial/state governor)
- **2012** operational monitoring & Cal/Val is live at Mayon volcano (PH)
- **2017/12** International Charter activated, satellites tasked
- **2018/01** evacuation >70,000, eruption follows.

Workshops
Workshops
Workshops
Workshops
Workshops
Workshops

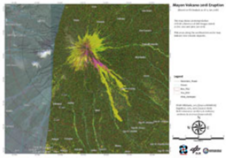
Partner uses sat. data

Products

Ash dispersion map of Mayon Volcano

Source: UK-DMC2
Acquired: 23/01/2018

Copyright: UK-DMC2 © DMCii 2018
Map produced by DOST PHIVOLCS



Mount Mayon eruption analysis

Source: RapidEye
Acquired: Pre-disaster: 22/12/2017
Post-disaster: 03 & 15/01/2018

Copyright: RapidEye © Planet (2018) - All rights reserved
Map produced by DOST PHIVOLCS

Volcano erupts


THE WALL STREET JOURNAL.

WEDNESDAY, JANUARY 24, 2018 - VOL. CCLXXI NO. 19 WSJ.com ★★★★ $4.00

Volcano Lights Up the Sky in the Philippines, as Fears Grow

What's News

Business & Finance

Price War Pressures Consumer Brands

Field & data training
Capacity building

Applications: Flood & Landslide Cal/Val
Partner engagement example #2 – citizen science Cal/Val

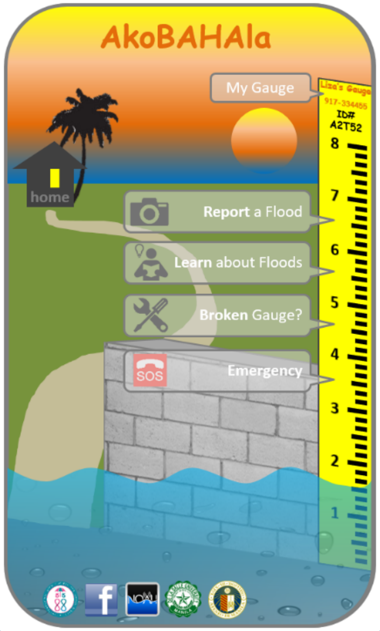
- **2015** Manila – conduct market surveys and establish partnerships in Manila (PH) at Project NOAH (remote sensing disasters center), affected communities, community NGOs, Universities, and National Police.
- **2015** Los Angeles - initiate Citizen Science project for flood gauges, to provide Cal/Val for Project NOAH, via an international NGO host (isshr.org)
- **2016** finalize app conceptual design and engineering studies, with USGS input
- **2017** implementation & programming (ongoing).

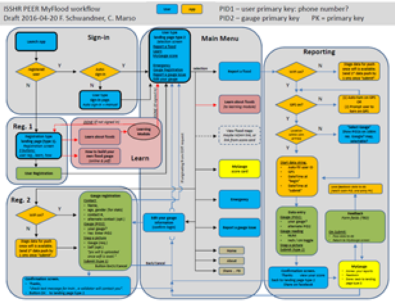
Planned: Project NOAH infusion (Cal/Val for flood & landslide data)
→ Feeds live map & inundation forecasts back to users

Market surveys and establish partnerships

Train univ. students to build, solicit, mentor local community gauges

CC user app final design. Enables Cal/Val data





Applications of Hyperspectral Remote Sensing Observations of Geological Hazards

*initial scoping

ESAS-17 SBG ES&I (S) Objectives		Relevant quantities	Likely Application Community Partners
S-1c	Forecast and monitor landslides, especially those near population centers.	Imaging of vegetation and rock/soil composition	USGS, BLM, NPS, FEMA, USAID, SDR, WOVO, FS, commercial partners (technology, re-insurance), NGOs Integrating Themes (objectives): H-3b; E-2c, E-5b; C-5a, C-5d, C-7b; W-5a, W-6a
S-1a	Measure the pre-, syn- and post-eruption surface deformation and products of Earth's entire active land volcano inventory with a time scale of days to weeks.	Temperature, composition and extent of erupted volcanic materials, including gases.	
S-2b	Assess surface deformation (<10 mm), extent of surface change (<100 m spatial resolution) and atmospheric contamination, and the composition and temperature of volcanic products following a volcanic eruption (hourly to daily temporal sampling).	Gases (CO_2, SO_2, H_2S, H_2O), ash, surface composition, lava flows & lakes, thermal emissions	USGS, BLM, NPS, FEMA, USAID, SDR, WOVO, NOAA, commercial partners (technology, re-insurance), NGOs Integrating Themes (objectives): H-4; E-1b, E-1d; W-2a, W-4a, W-5a, W-6a
S-2a	Rapidly capture the transient processes following disasters for improved predictive modeling, as well as response and mitigation through optimal retasking and analysis of space data. (not listed)		
S-4b	Quantify weather events, surface hydrology, and changes in ice/water content of near-surface materials that produce landscape change.	Spatial and temporal distribution of rainfall and snowfall. Snowcover duration & extent.	USGS, FEMA, NOAA, EPA, WMO, USDA Integrating Themes (objectives): H-1a, H-1c, H-2a, H-3b, H-4a-d; E-1b, E-1d-e, E-3a, E-4a, E-5a-c; C-2e; W-1a, W-3a, W-4a
S-4c	Quantify ecosystem response to and causes of landscape change.	Biomass extent, composition, health; species composition, carbon stocks, nutrient composition, wildfire history	
S-7a	Map topography, surface mineralogic composition/ distribution, thermal properties, soil properties/water content, and solar irradiance for improved development and management of energy, mineral, agricultural, and natural resources	30-m or better hyperspectral VSWIR imaging, and TIR data	USGS, BLM, USDA, NPS, EPA, USDA, commercial partners (resources). Integrating Themes (objectives): H-1ª, H-4a; E-1b, E-3a, E-5b

Trouble in Paradise

The next big U.S. eruption – Mauna Loa ?