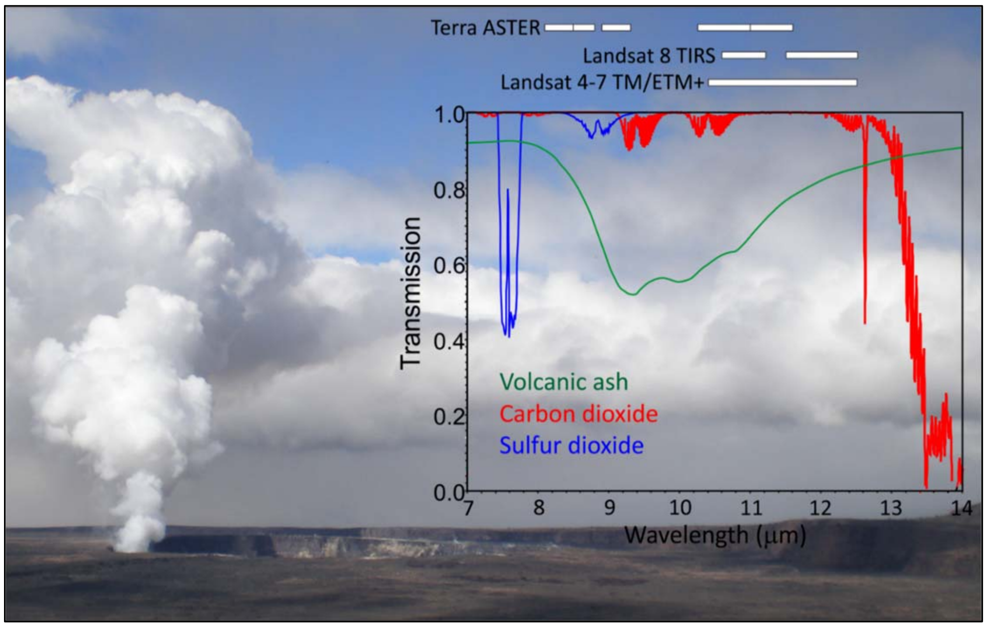
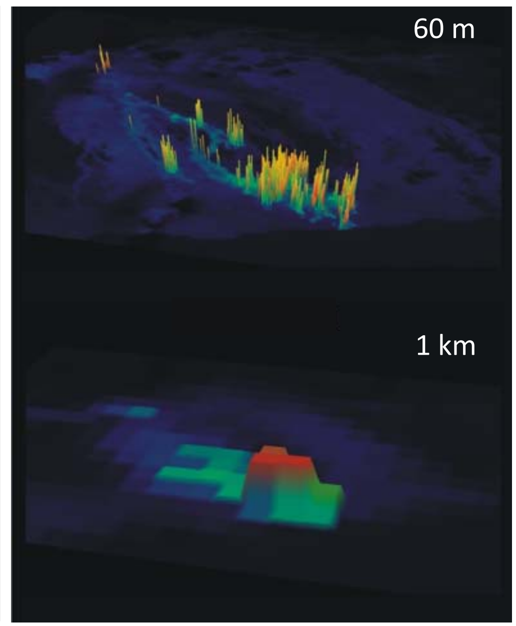
Future use of NASA airborne platforms to advance earth science priorities

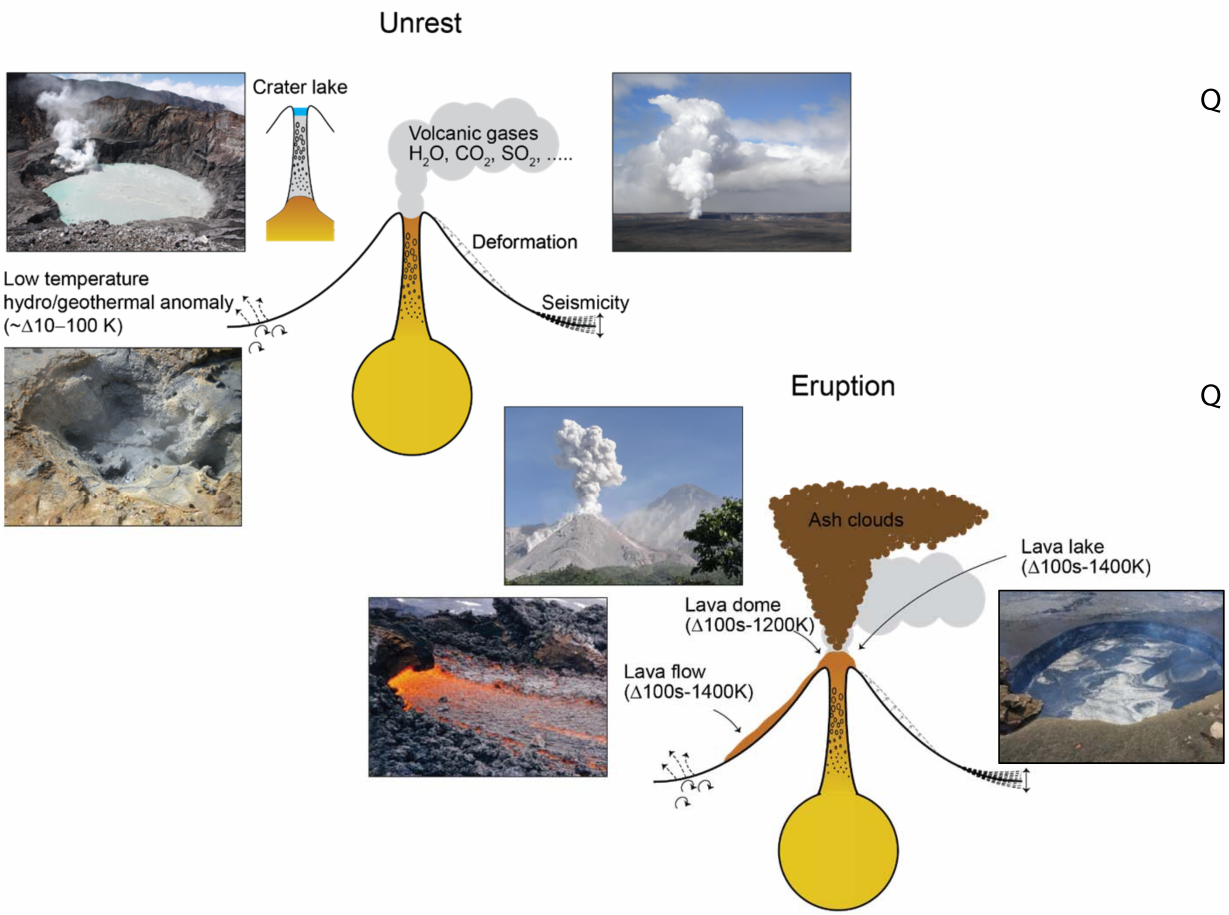
Surface dynamics, geological hazards, and disasters

Robert Wright
Hawai'i Institute of Geophysics and Planetology,
University of Hawai'i at Mānoa, HI, U.S.A.





What do volcanoes do that we can measure remotely?



Decadal Survey

Q S-1: How can large scale geological hazards be accurately forecast in a socially relevant time frame?

- 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 (Most important)

Q S-2: How do geological disasters directly impact the Earth system and society following an event?

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

How can airborne remote sensing support volcanologists and NASA?

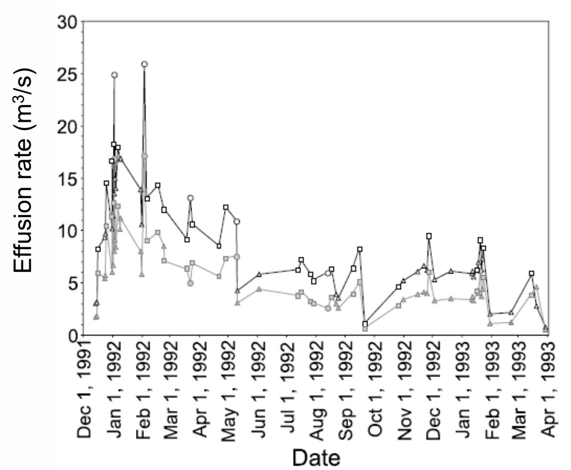
- Measuring volcanic processes and products requires observations that are generally limited to small geographic areas (gas clouds and eruption plumes being an exception):
    - *Traditional airborne campaigns provide important information, but quasi-static platforms (e.g. stratollites), and those with relatively short range (UAS) can also provide the required geographic coverage in many cases*

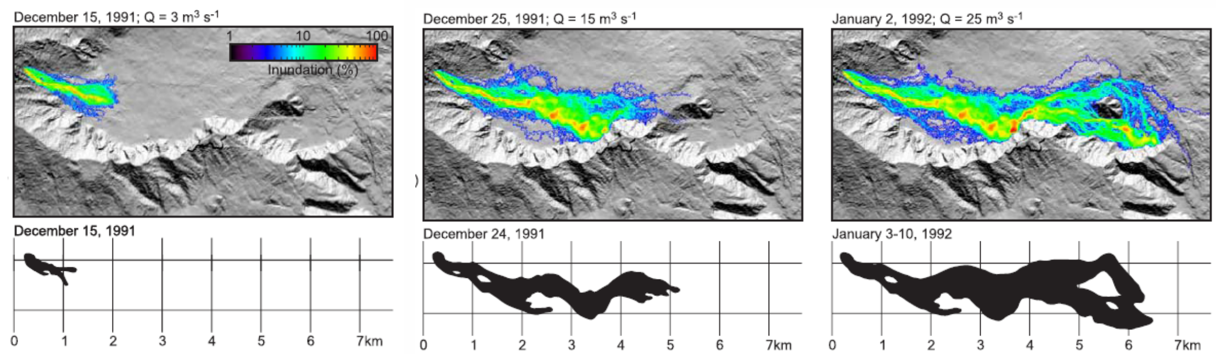
- Full spectrum measurements are required to measure all aspects of these processes and products:
  - VSWIR – crater lake color and composition; mineralogical mapping; lava surface temperature; MWIR – lava cooling; gas composition; LWIR – gas composition; mineraological composition; ash cloud analysis; Microwave – volcano deformation and volume changes
    - *Traditional facility instruments (e.g. AVIRISng; HyTES; MASTER) require traditional airborne platforms for deployment (due to mass and power requirements). Miniaturization of equivalent instruments will allow UAS and balloons to acquire equivalent data sets*

- Rapid deployment and high temporal sampling is a key requirements for volcanic disaster response:
    - *Traditional airborne platforms have been successfully deployed in response to volcanic crises (e.g. Kīlauea volcano, 2018). In the future, balloon and UAS platforms will allow rapid deployment, at lower cost, and the capability to provide hourly temporal sampling*

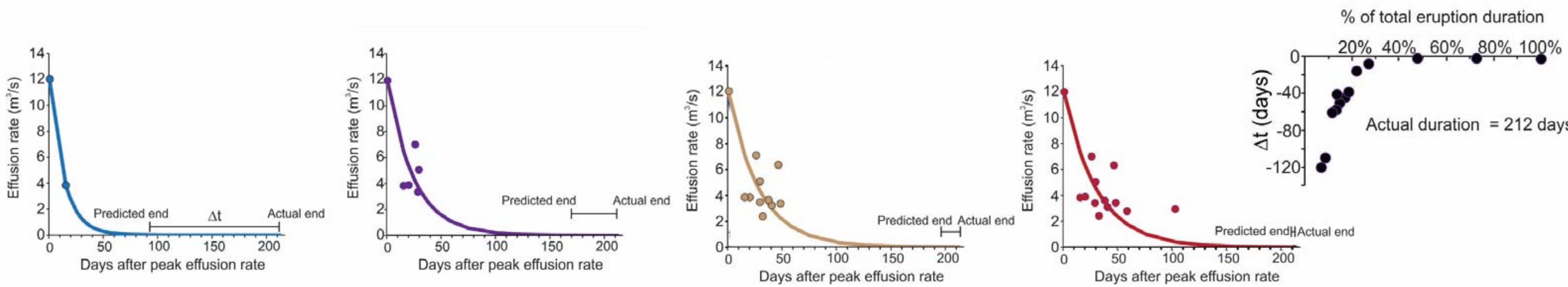
- Establishing science traceability for future orbital missions:
    - *Volcanic processes are spatially and temporally very dynamic. To answer the question of, for example, how gas emissions can be used to predict eruption onset, requires dense temporal sampling, at multiple volcanoes, to establish signal above noise, and drive requirements for spatial, temporal and spectral resolution of future missions. The flexibility to deploy the instruments of tomorrow, that will be designed to make measurements required by upcoming volcanological science advances, will be important for NASA to answer the questions posed by future decadal surveys. Prototyping these instruments benefits from a diversity of available platforms*

Eruption prediction: High spatial and temporal resolution measurements drive and validate model predictions





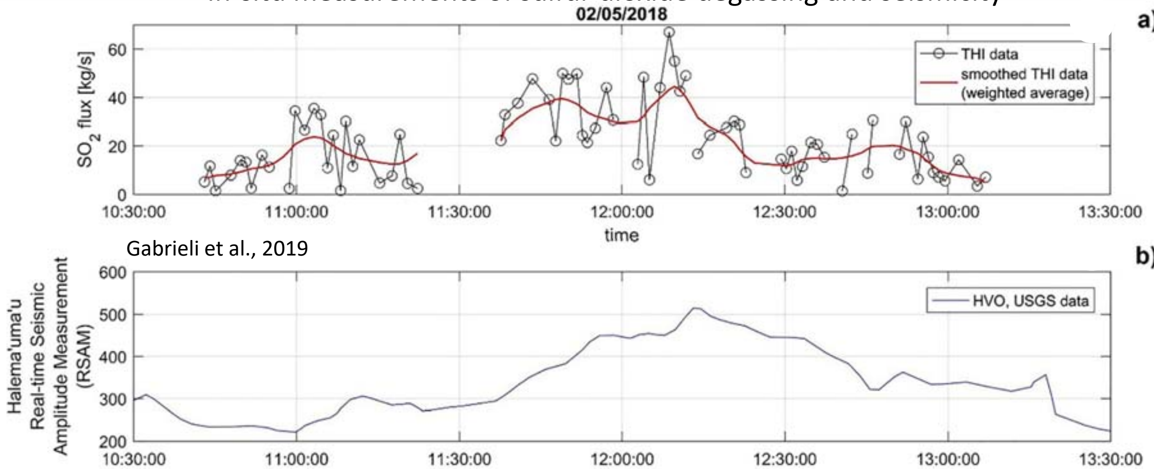
Wright et al., 2008



Bonny and Wright, 2017

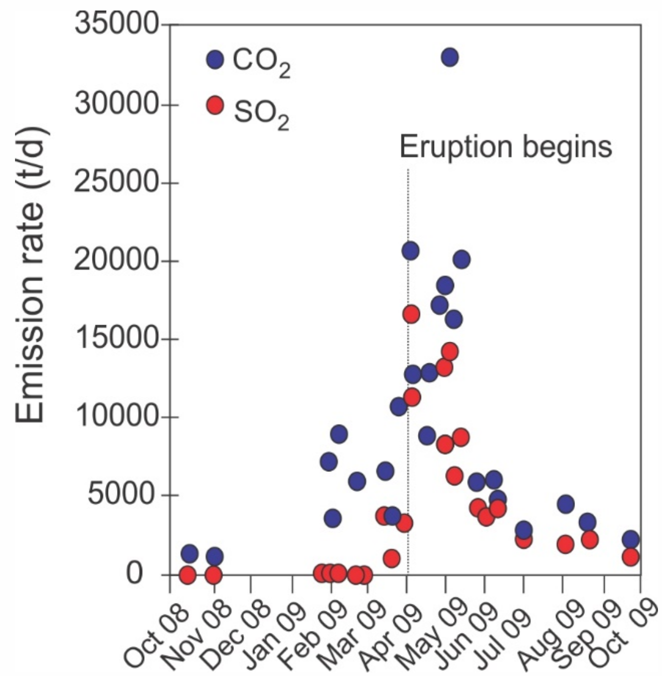
What remote measurements do we need to make to detect precursors to eruption onset, or significant changes in eruption intensity?

In-situ measurements of sulfur dioxide degassing and seismicity



Gabrieli et al., 2019

In-situ measurements of SO_2 and CO_2 degassing prior to 2009 eruption of Redoubt, AK



Werner et al., 2013