Autonomous forecasting of lava flow hazards using HyspIRI

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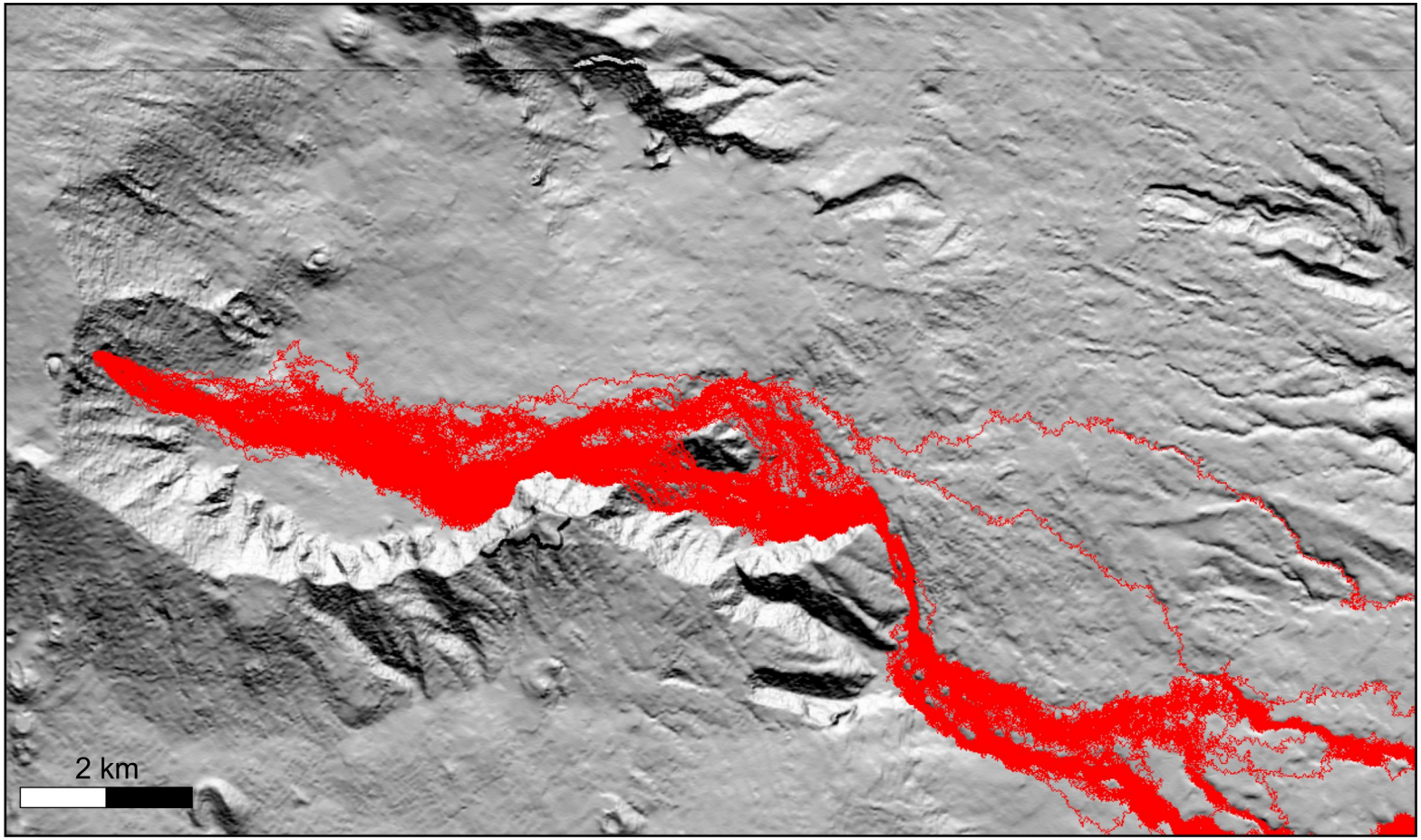
Forecasting lava flow hazards

- Along which paths, and to what distance from the vent, will lava flow, and how long will it take to get there?

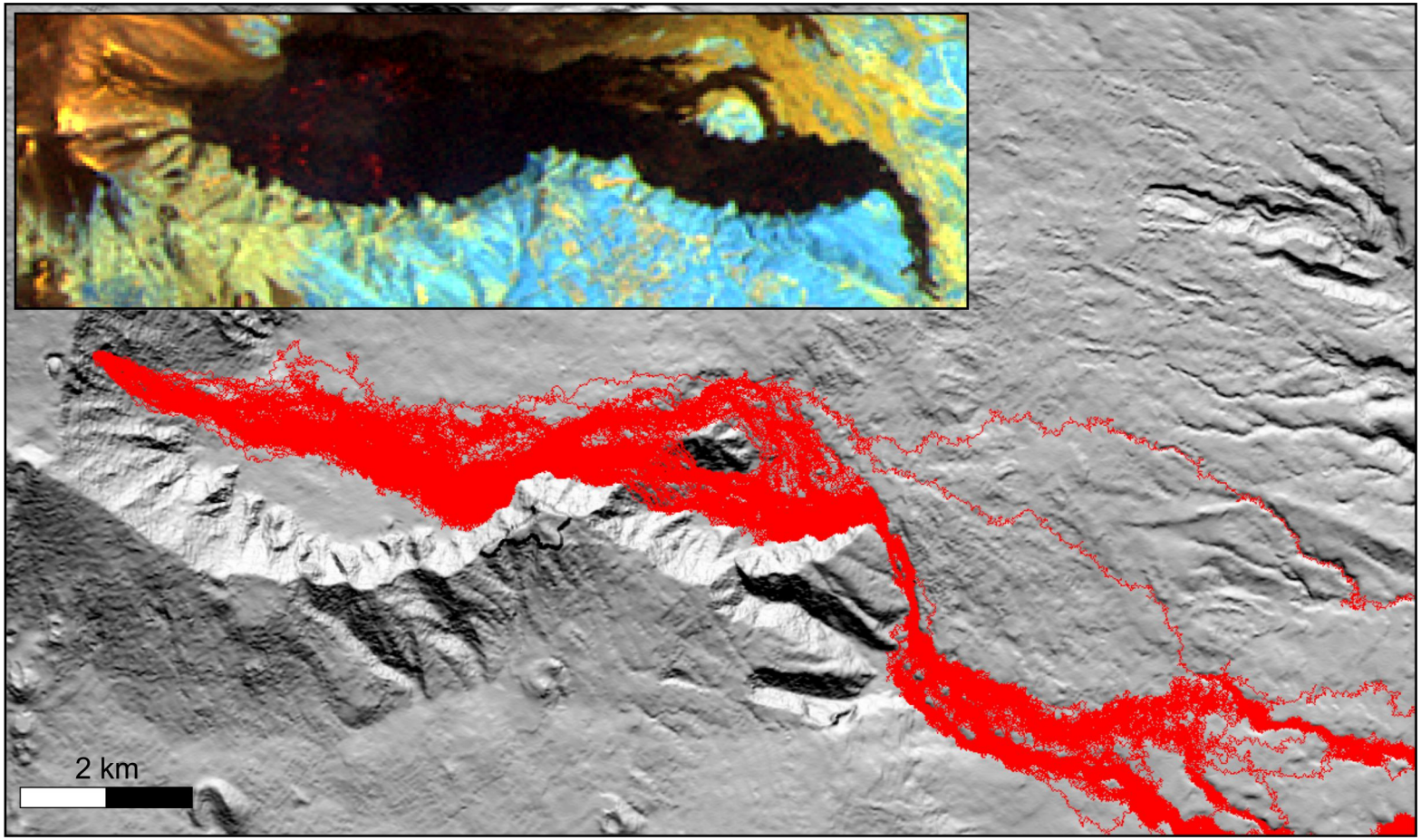
Predicting potential flow paths using a drainage model



Favalli et al., 2005

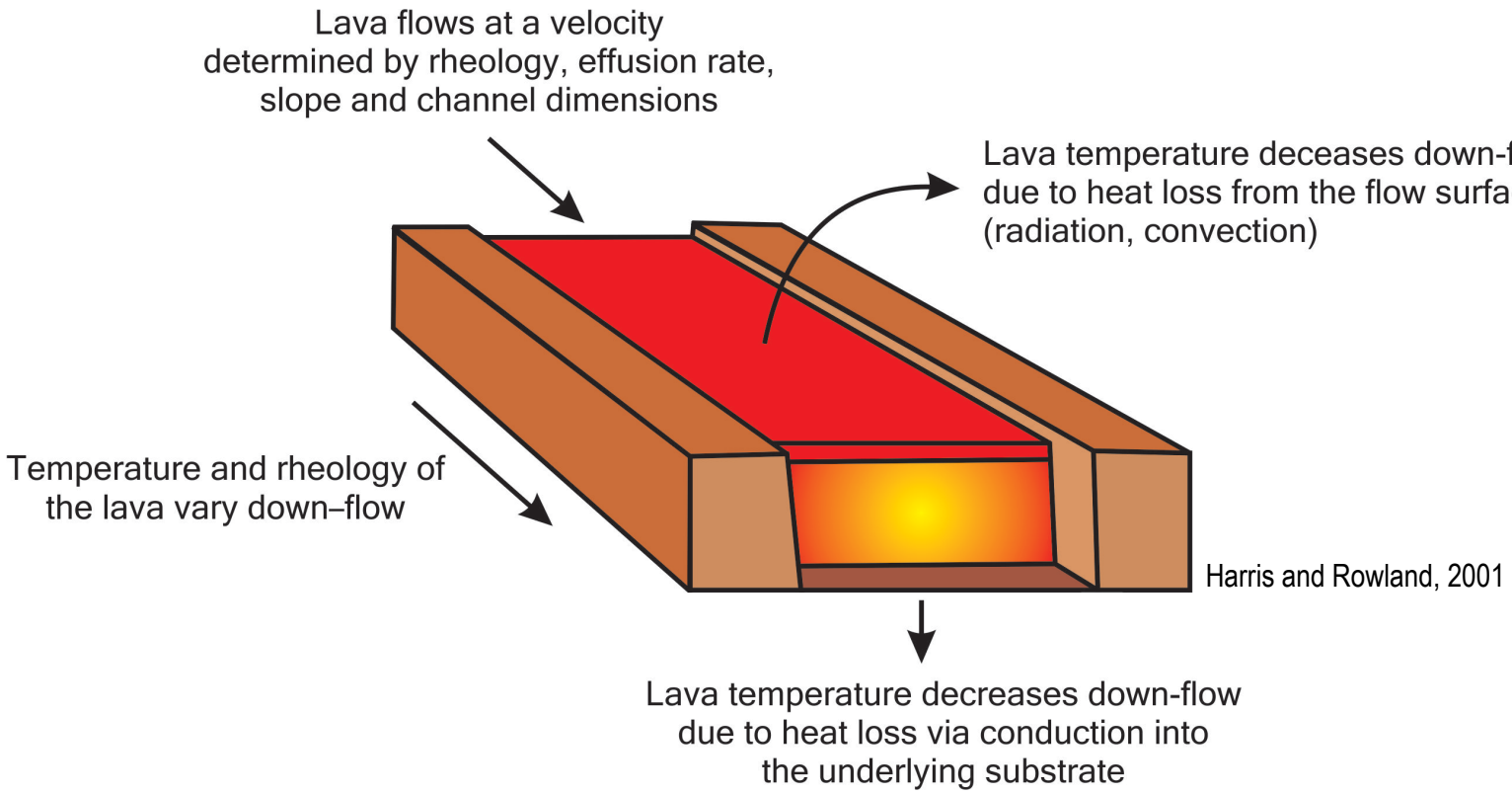
Lava flows downhill, but which way is downhill? A stochastic drainage model can be used with a DEM (SRTM, ASTER GDEM) to simulate the most likely paths a lava flow will take given a vent location

Predicting potential flow paths using a drainage model



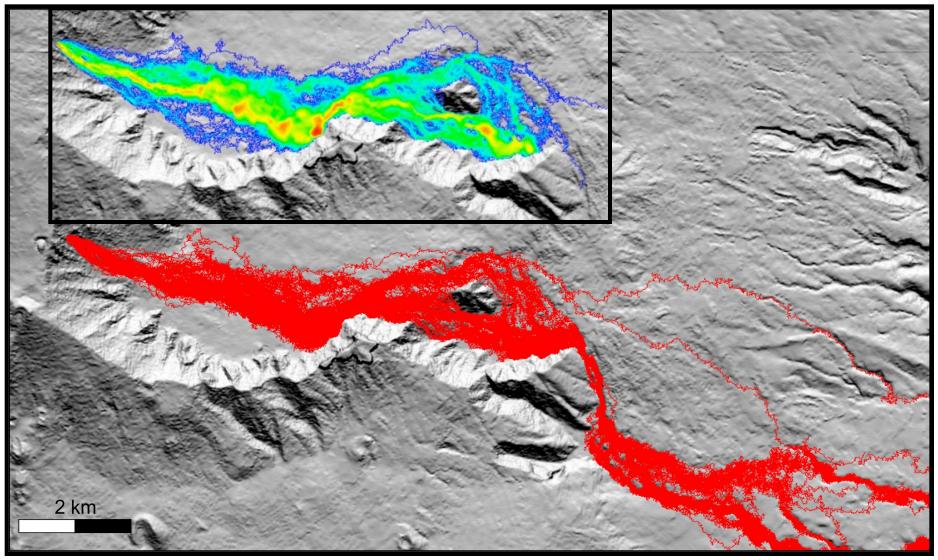
But, this approach does not predict the likely length a lava flow will attain

Predicting potential flow lengths using a thermo-rheological model

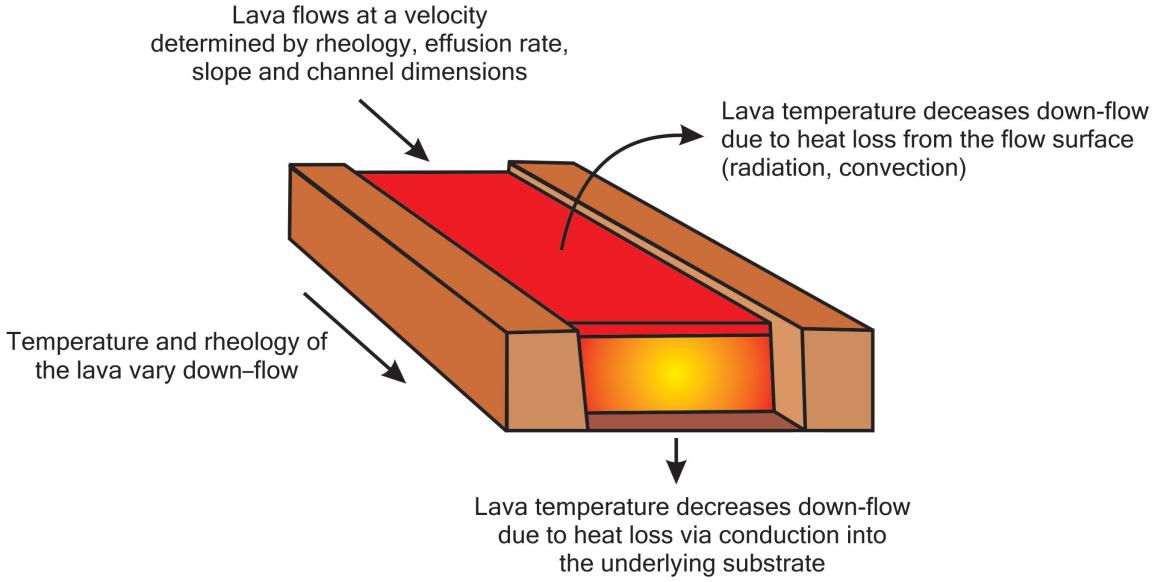


By modeling the stiffening of a control volume of lava flowing in a channel, the time (and hence distance) from the vent that the lava becomes too stiff to flow any further can be predicted using a numerical model

A thermo-rheological/stochastic approach for modeling lava flow hazards



Eruption intensity can change rapidly, and reliable lava flow hazard predictions rely on timely and accurate information regarding the nature and intensity of the eruption and how this varies

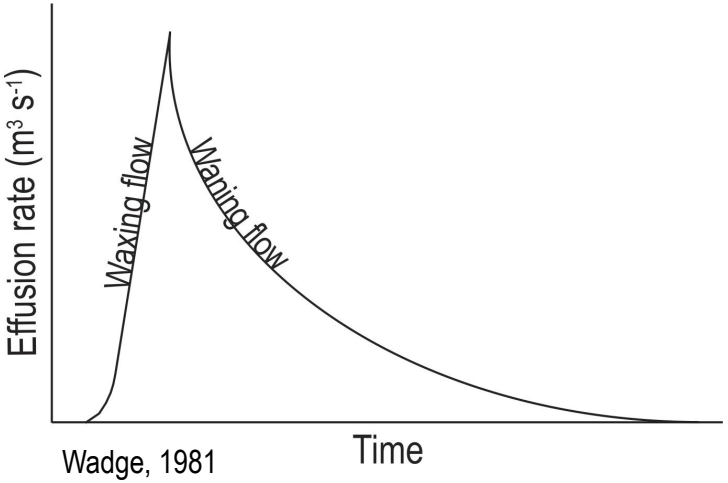


Much of the relevant information can be obtained from remote sensing data, in a manner not possible in the field

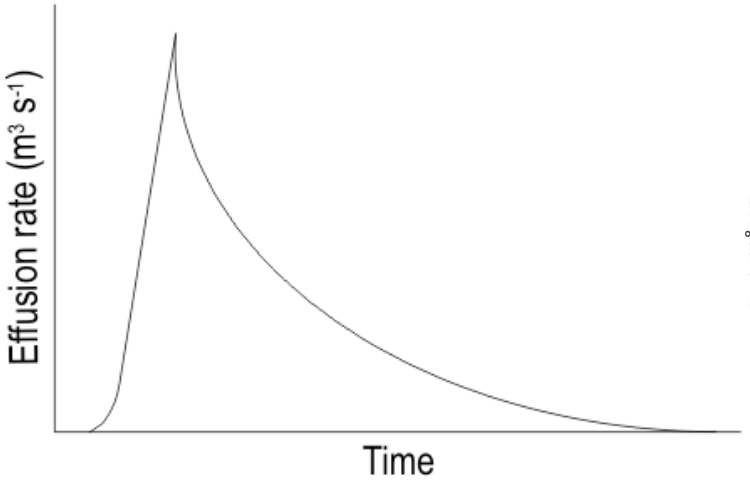
The importance of effusion rates

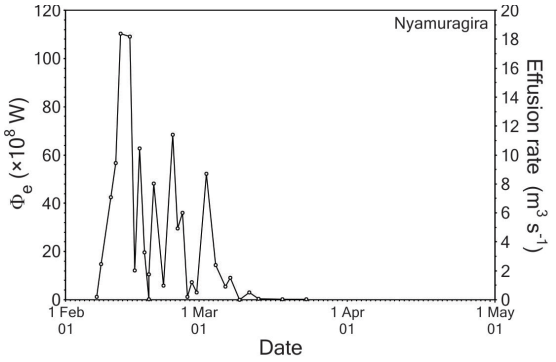
Effusion rates:

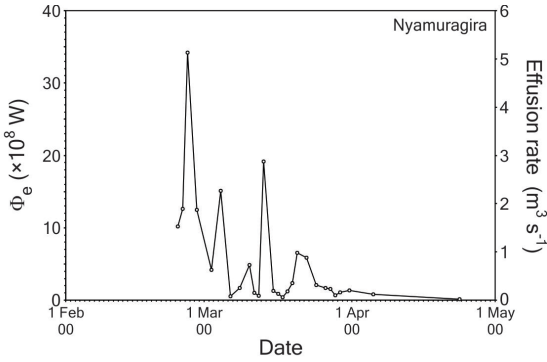
- Determine (largely) final flow length
- Vary during an eruption and between eruptions by1-2 o.o.m.
- Are difficult to estimate in the field

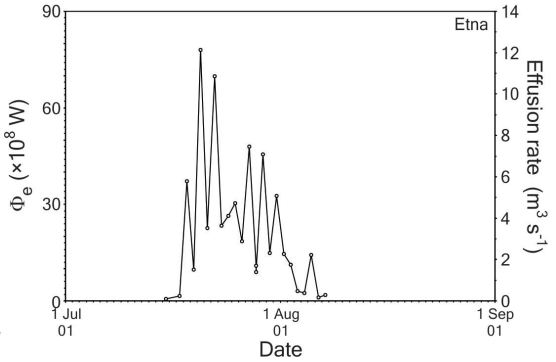


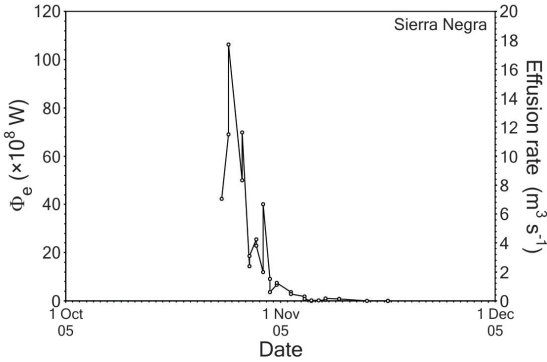
Wadge, 1981







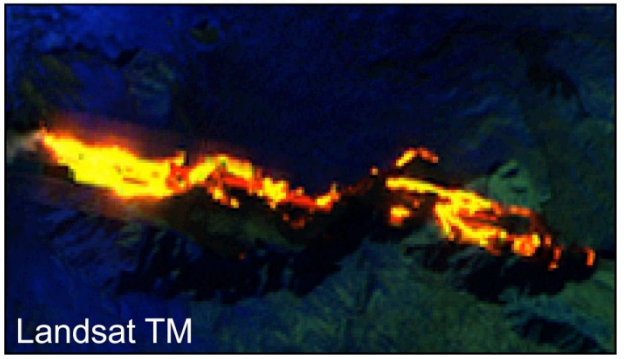


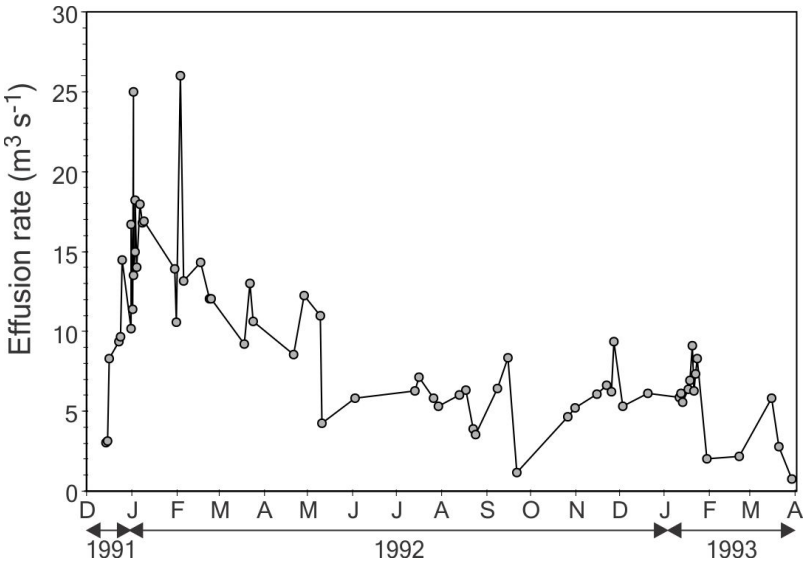


Calculating lava effusion rates from infrared satellite data

The higher the volumetric flux of lava from the vent, the greater the length (area) it can spread over before it solidifies

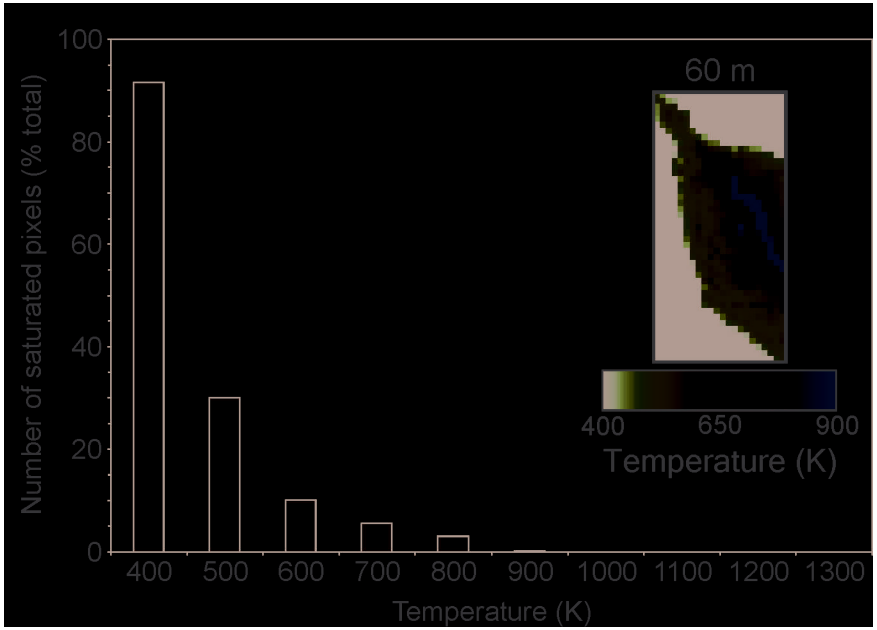
$$\text{Lava effusion rate} = \frac{\text{Heat loss from flow surface}}{\text{Enthalpy of the mass of lava}}$$

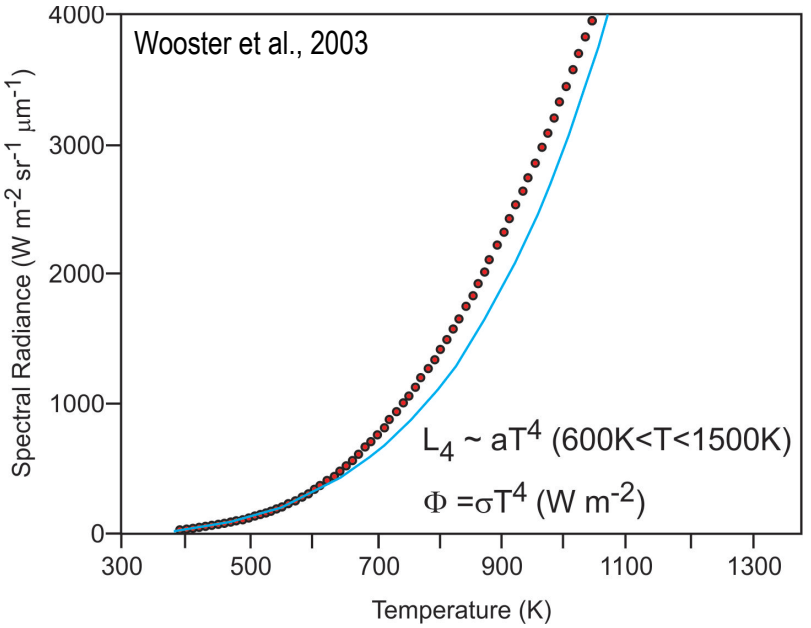


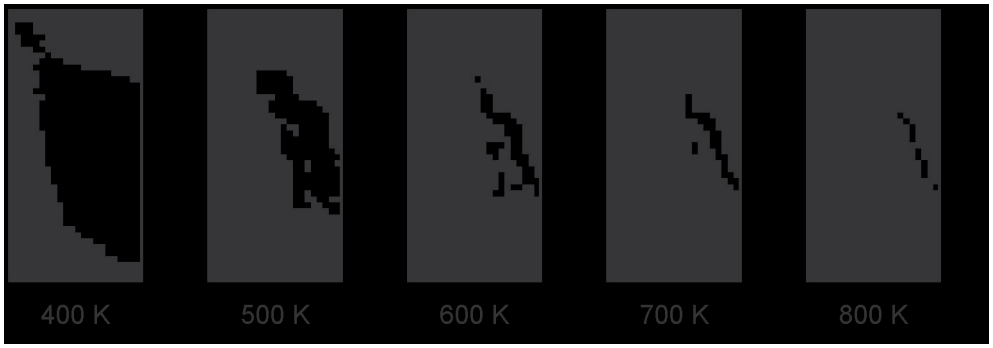


Walker, 1973; Pieri and Baloga, 1986; Harris et al., 1997; Wright et al., 2001

Calculating lava flow cooling from HyspIRI's 4 μm channel

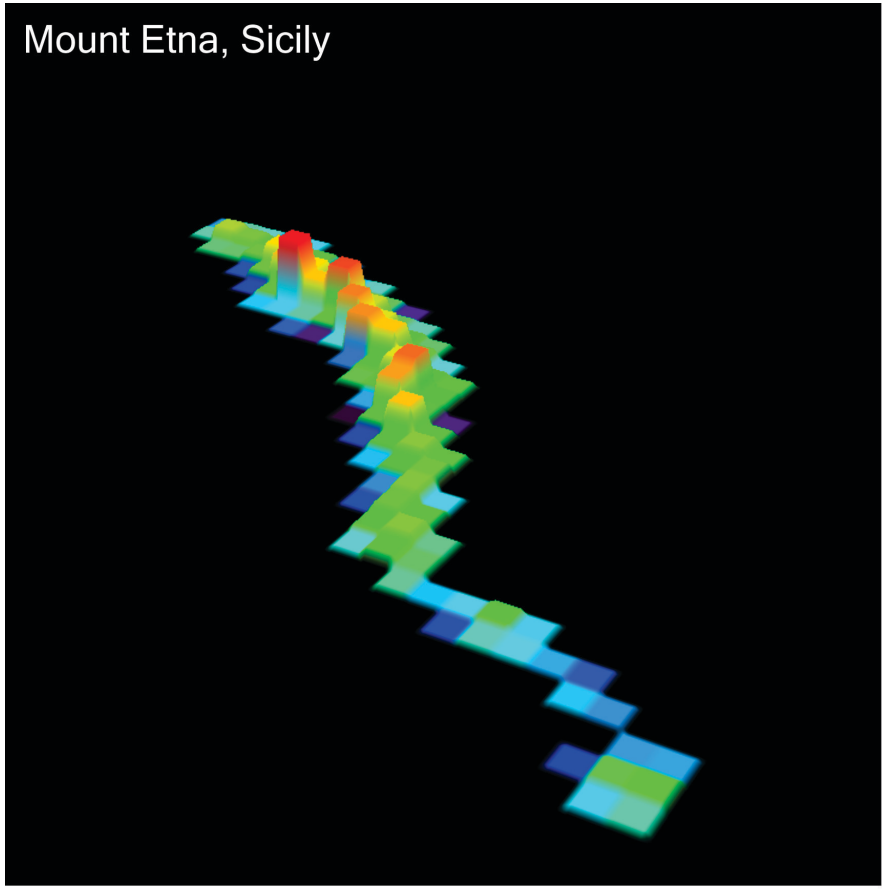


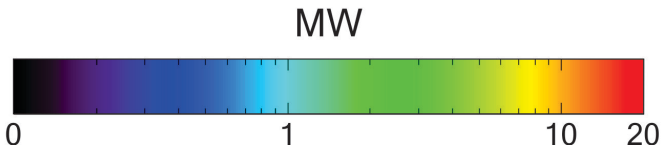




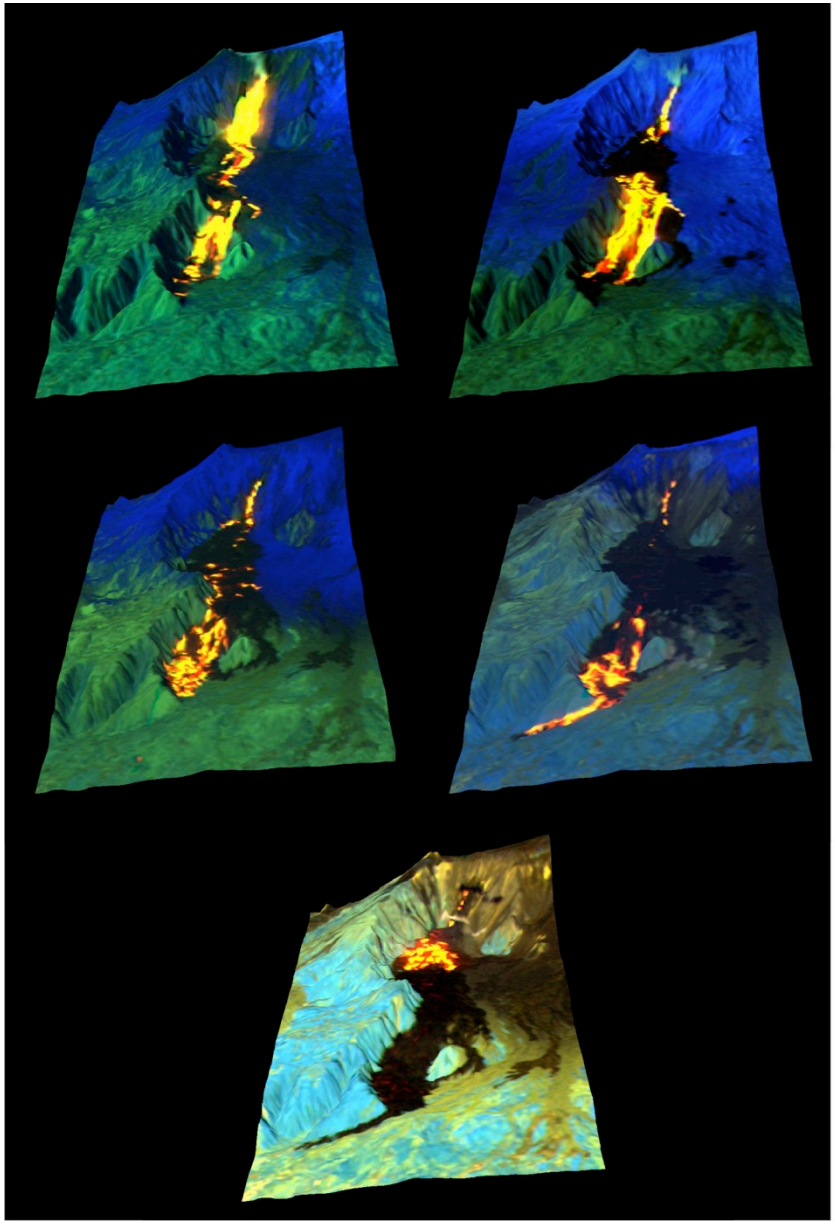
HyspIRI's high saturation temperature 4 μm channel will allow us to estimate lava flow cooling (and area) twice in each 5 day period

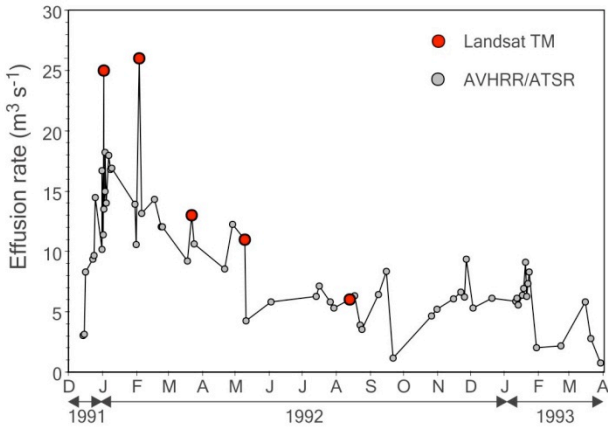
Surface heat loss along the length of an active lava channel





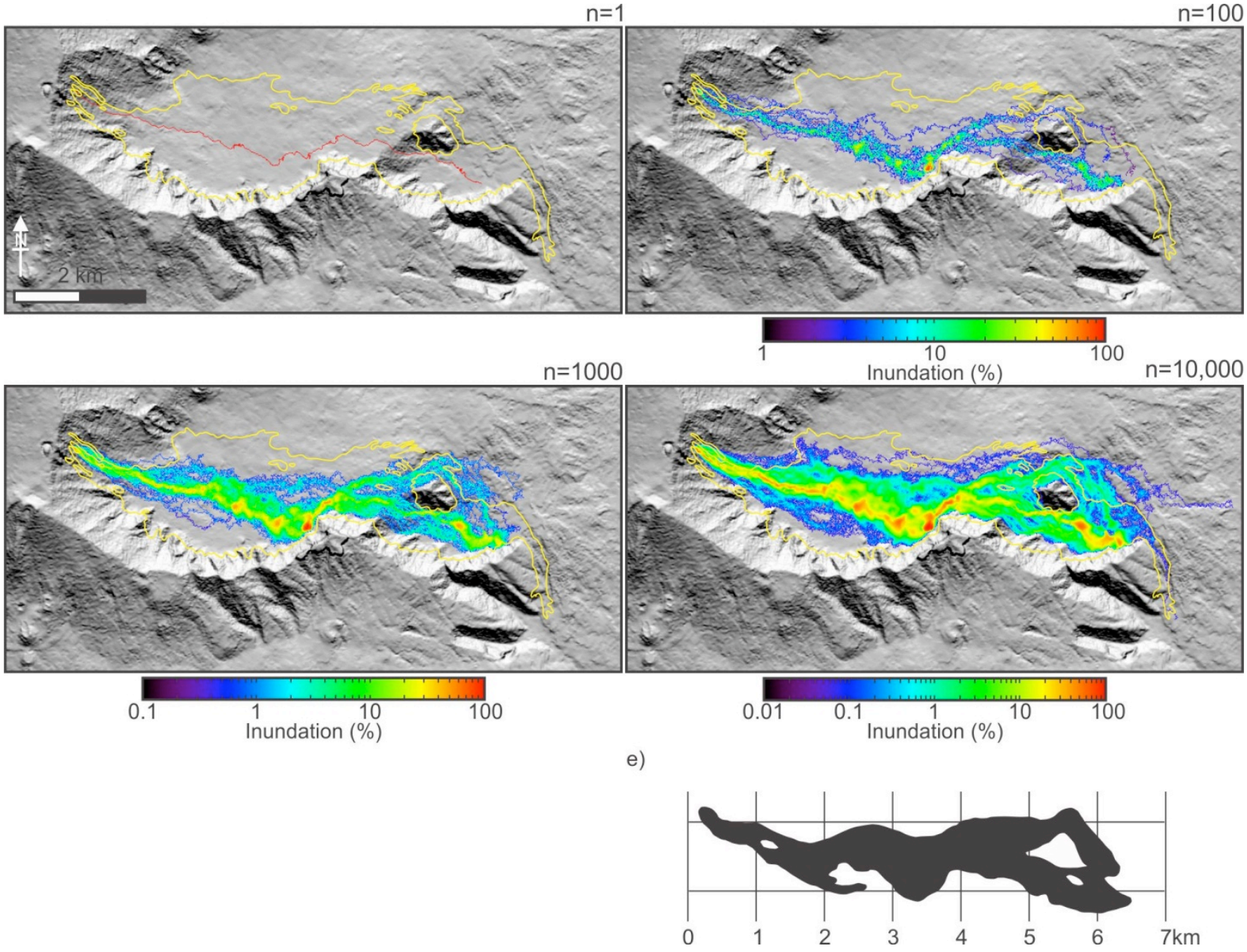
HyspIRI bridges the gap between high/low, spatial/temporal resolution sensors





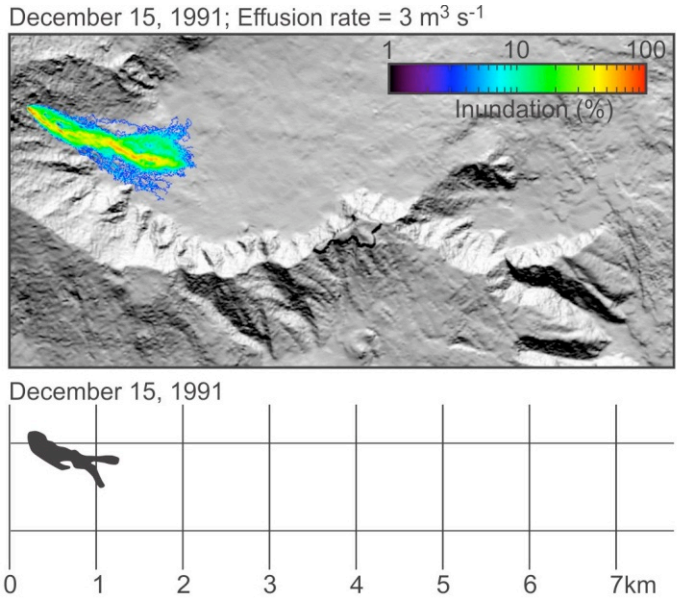
HyspIRI will give us MODIS-class temporal resolution with Landsat-class spatial resolution, allowing us to determine the important effusion rate parameter by day and night every five days

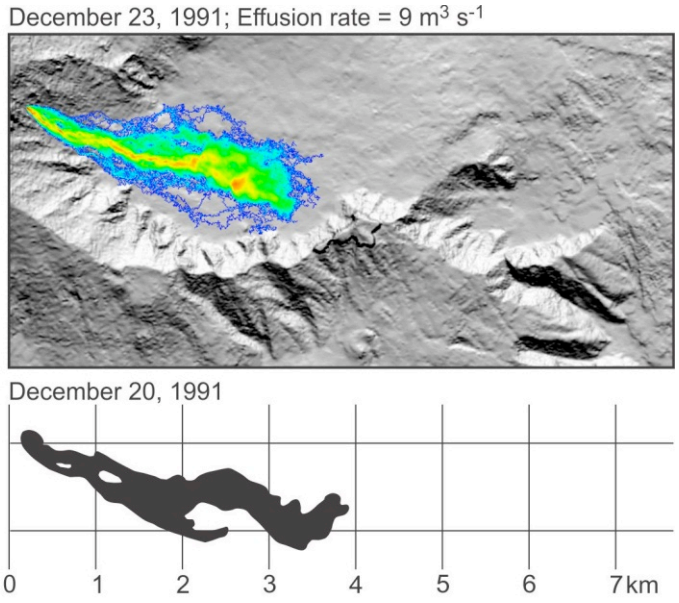
Driving numerical lava flow hazard models using satellite-derived effusion rates

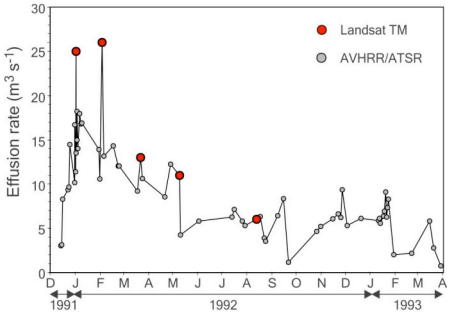


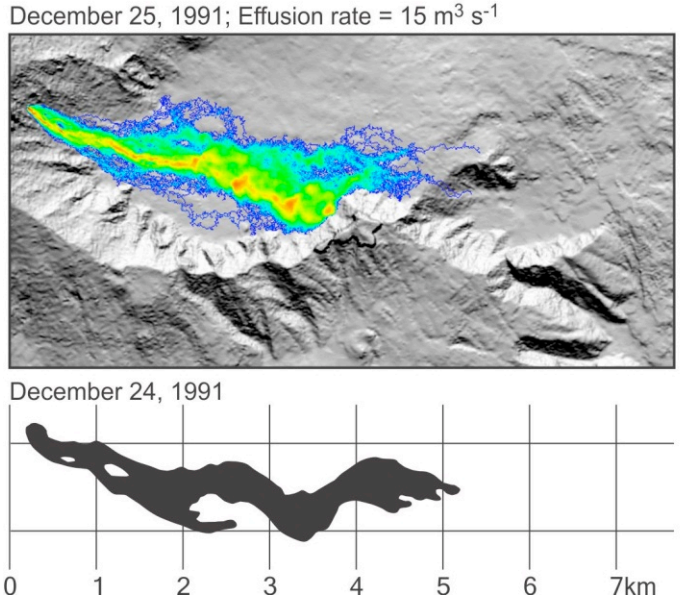
Wright et al., 2008

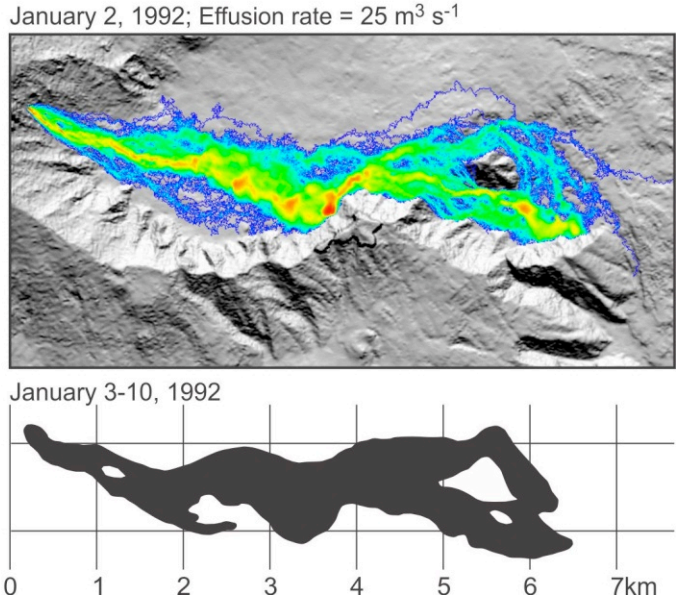
Driving numerical lava flow hazard models using satellite-derived effusion rates





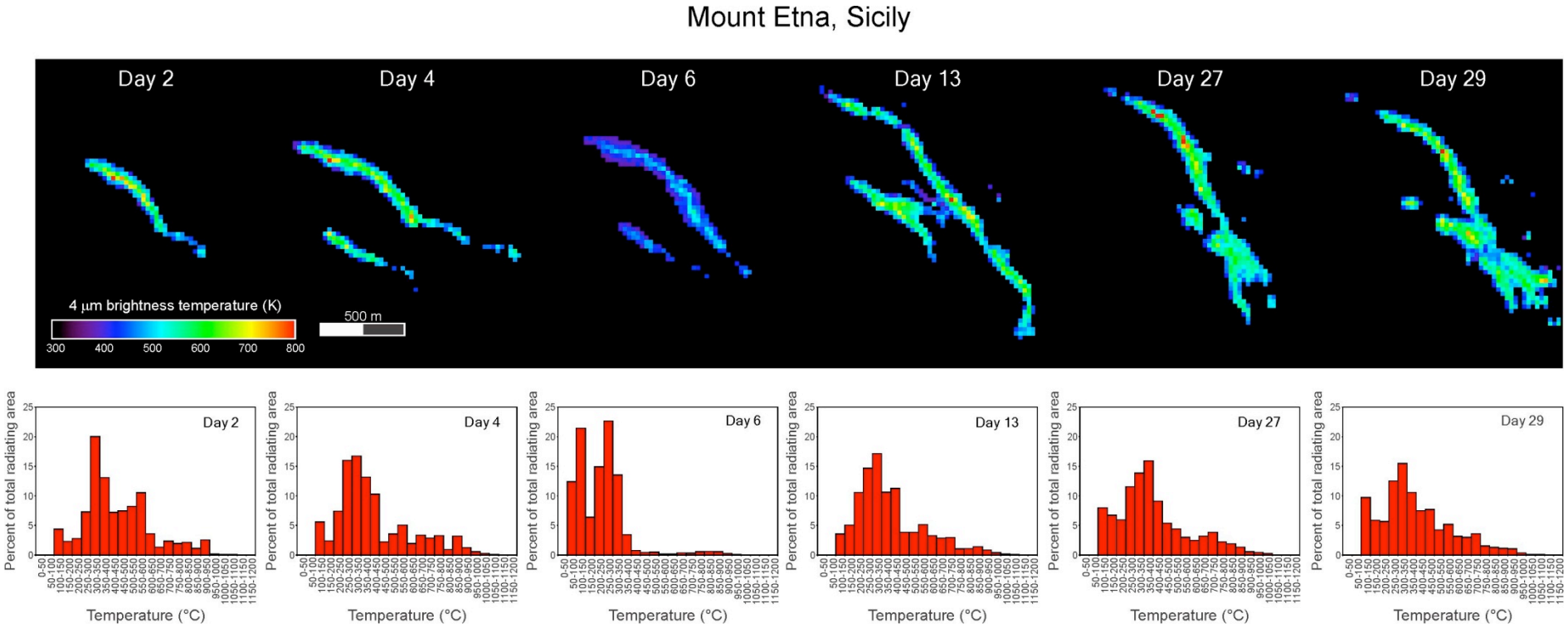






Wright et al., 2008

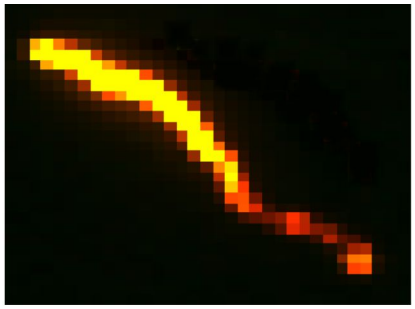
Parameterizing lava flow forecasting models using HyspIRI



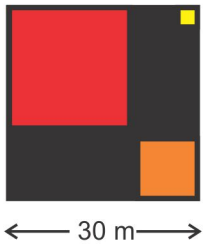
Wright, unpublished data

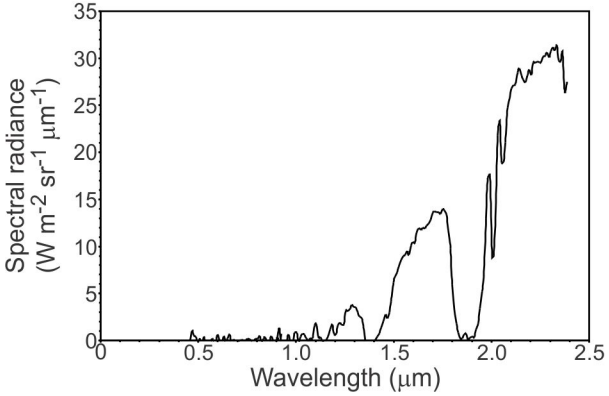
Lava flow surface temperature, and hence cooling rate, are important controls on how quickly lava solidifies. At present, these are poorly constrained inputs to numerical flow simulations. HyspIRI will allow us to fill this knowledge gap

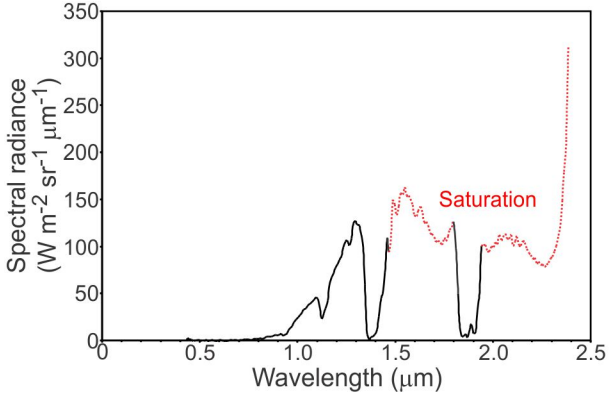
Lava surface temperatures can be retrieved from an imaging spectrometer

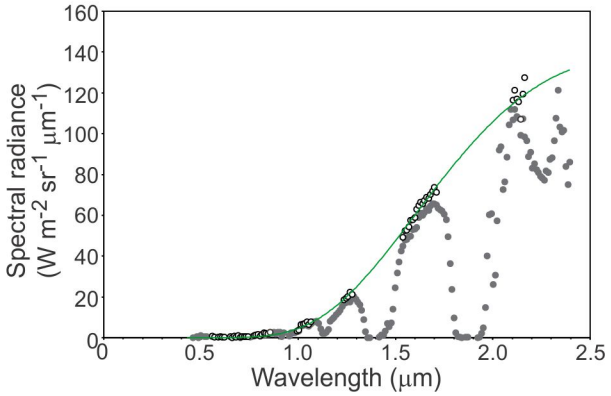


$$L_\lambda = \sum_{i=1}^{n} f_i(L, T_i)$$





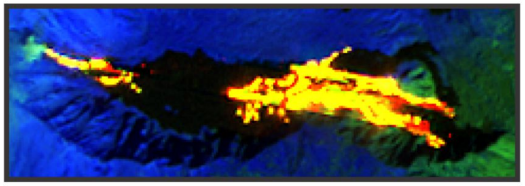




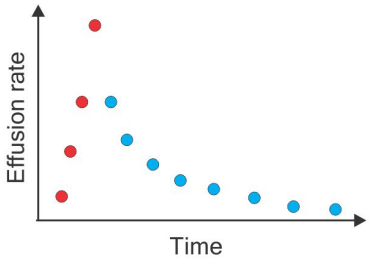
An imaging spectrometer always provides several tens of unsaturated spectral radiance measurements, at all points on the lava flow surface, from which lava surface temperatures can be determined

Autonomous forecasting of lava flow hazards using HyspIRI

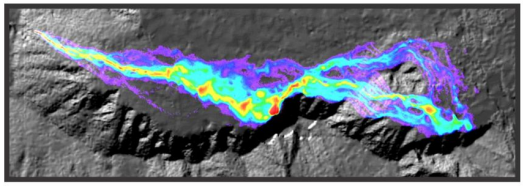
1. HyspIRI autonomously detects the onset of the eruption, pinpoints the vent location and acquires an image.....



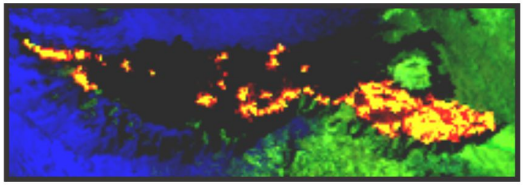
2. which allows us to compute the prevailing lava effusion rate.....



3. which we can use to drive a forecast of where the lava is likely to inundate.

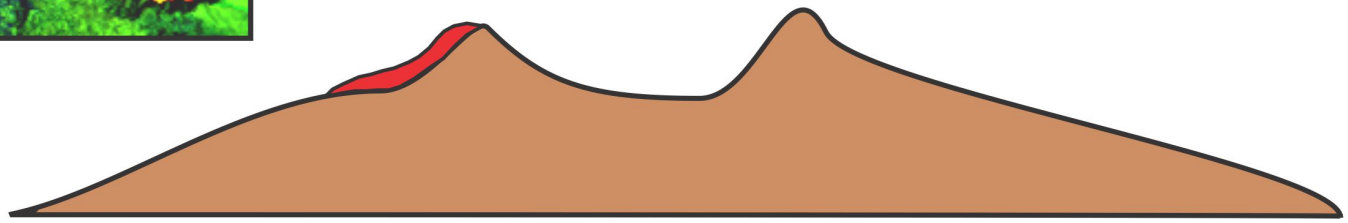


4. The next time HyspIRI passes over the target another image is acquired.....



5. which can be used to compute the new prevailing effusion rate.....

6. as well as calibrate and validate the model predictions



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