

Volcanoes are Hot: Thermal Precursors of Volcanic Eruptions



*2014 Ontake phreatic eruption
>60 fatalities*

[credit: BBC news]



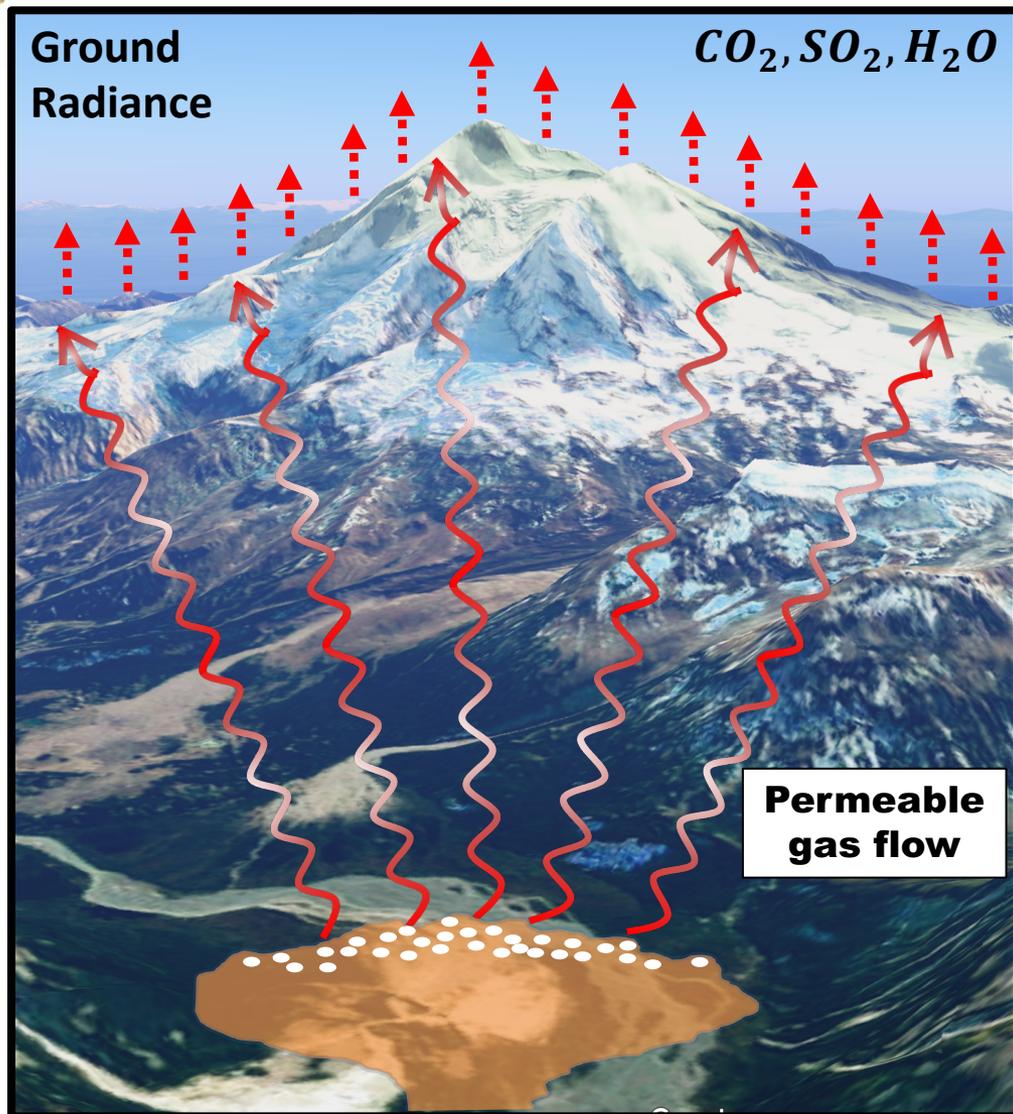
JPL Postdoc Seminar Series
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Jet Propulsion Laboratory
California Institute of Technology

HYPOTHESIS: radiance of volcanic edifices reflects subsurface processes



[credit: Google Earth, NASA]

- **Degassing magma reservoir**
[e.g., Stix and de Moor, 2018]
- **Diffuse outgassing**
- **Subsurface changes probably affect diffuse outgassing**
- **How to monitor diffuse outgassing?**

Difficult from the ground ...

[e.g., Chiodini et al., 1998; Hernández et al., 2001; Schwandner et al., 2004]

... even more difficult from space



Diffuse heat output

[e.g., Epiard et al., 2017; Melián et al., 2010]

RESEARCH QUESTION

- 1 Do diffuse heat emissions vary significantly before eruptions?
- 2 Can we forecast eruptions from space?

Method
Results
Discussion

Redoubt (USA) / 2009



Ontake (Japan) / 2007, 2014



Ruapehu (New Zealand) / 2006, 2007

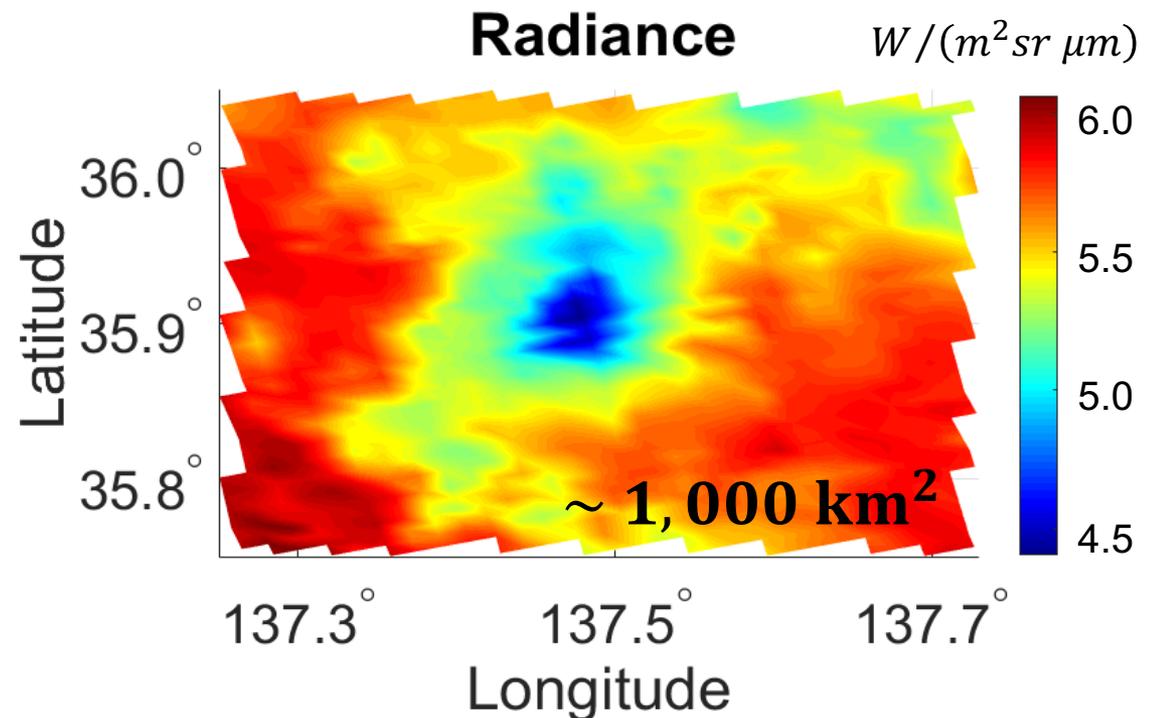


Domuyo (Argentina) / 2003, 2007, 2012



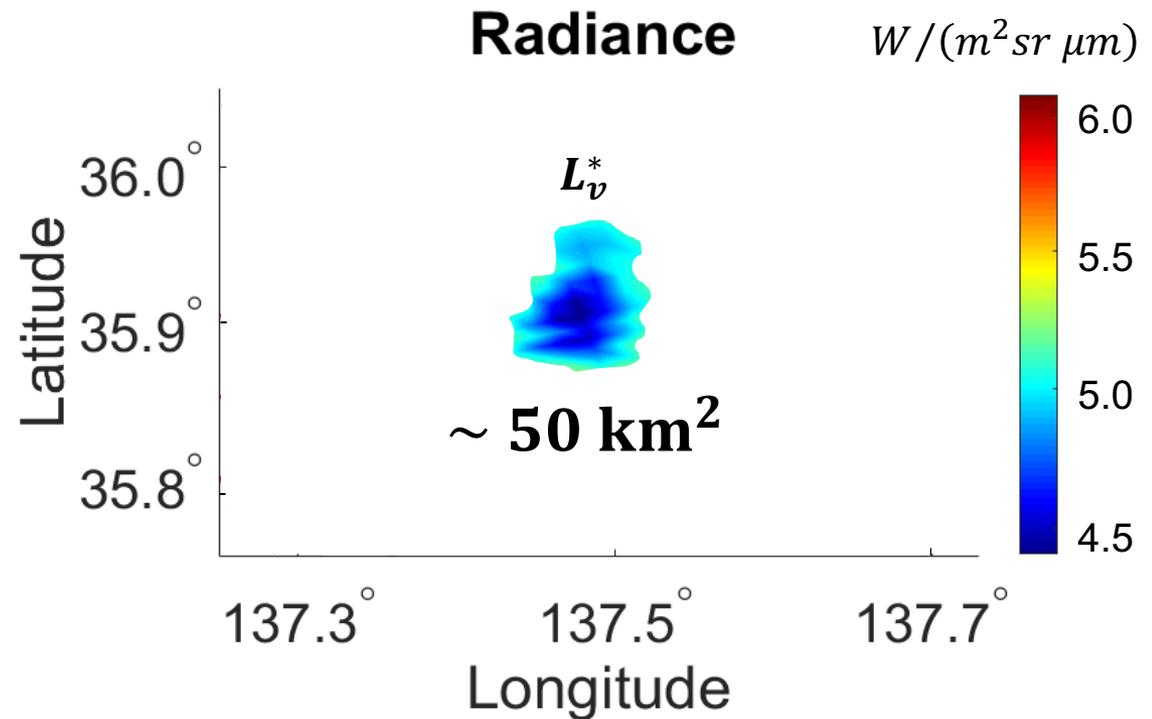
Median-of-median algorithm

- 1 Radiance data (Level 1B MODIS Terra/Aqua; band 31: 10.780-11.280 μm ; 1x1 km).
- 2 MEDIAN radiance of the volcanic edifice (L_v^*)



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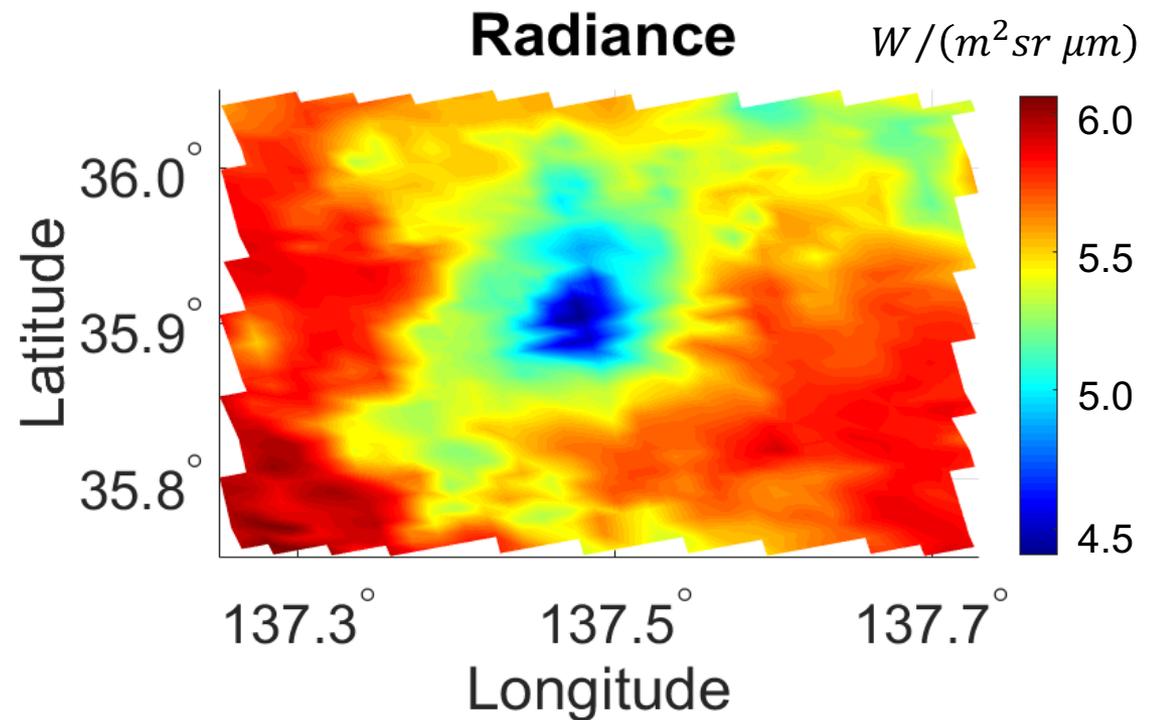
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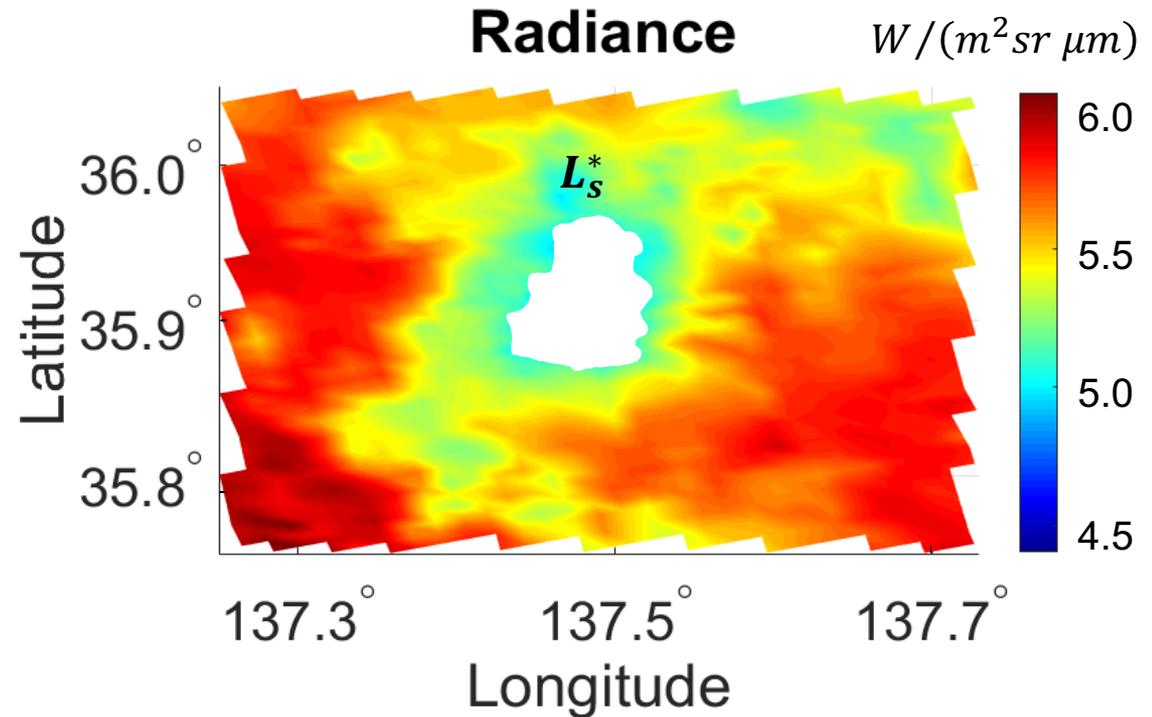
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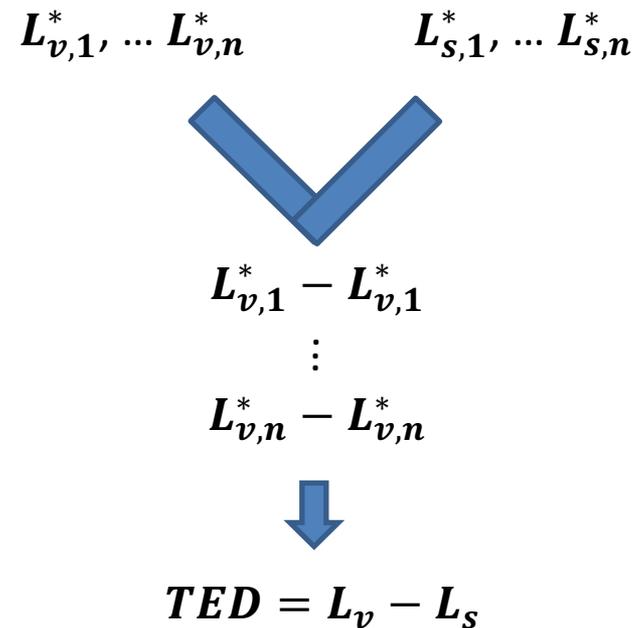
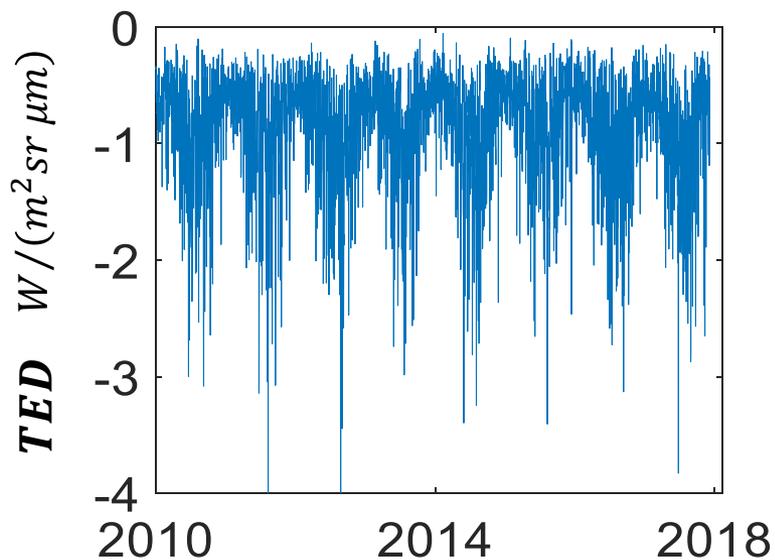
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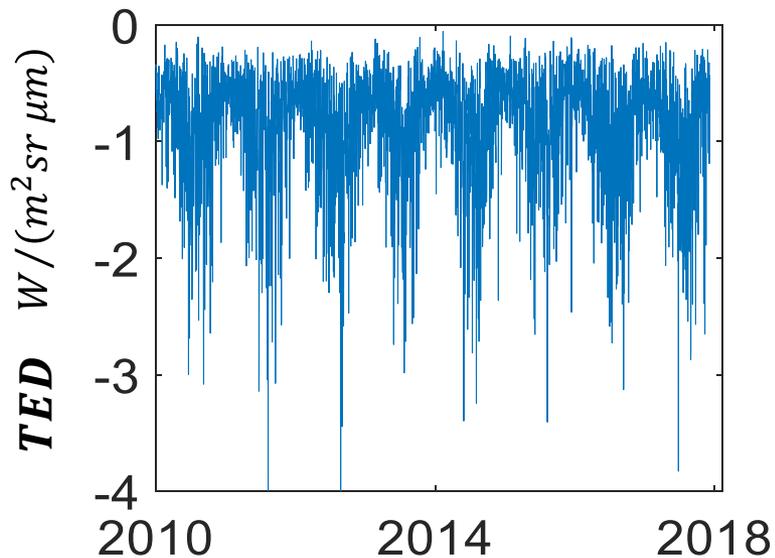
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- 4 DAILY MEDIAN of the difference [Thermal Emission Difference: TED].



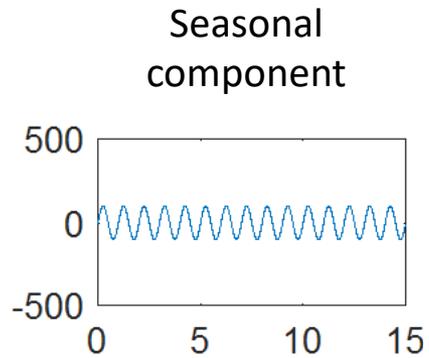
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Montecarlo experiments

- 1 Synthetic TED time series.
- 2 Test denoising techniques (moving mean, moving median, wavelet, Savitzky-Golay).



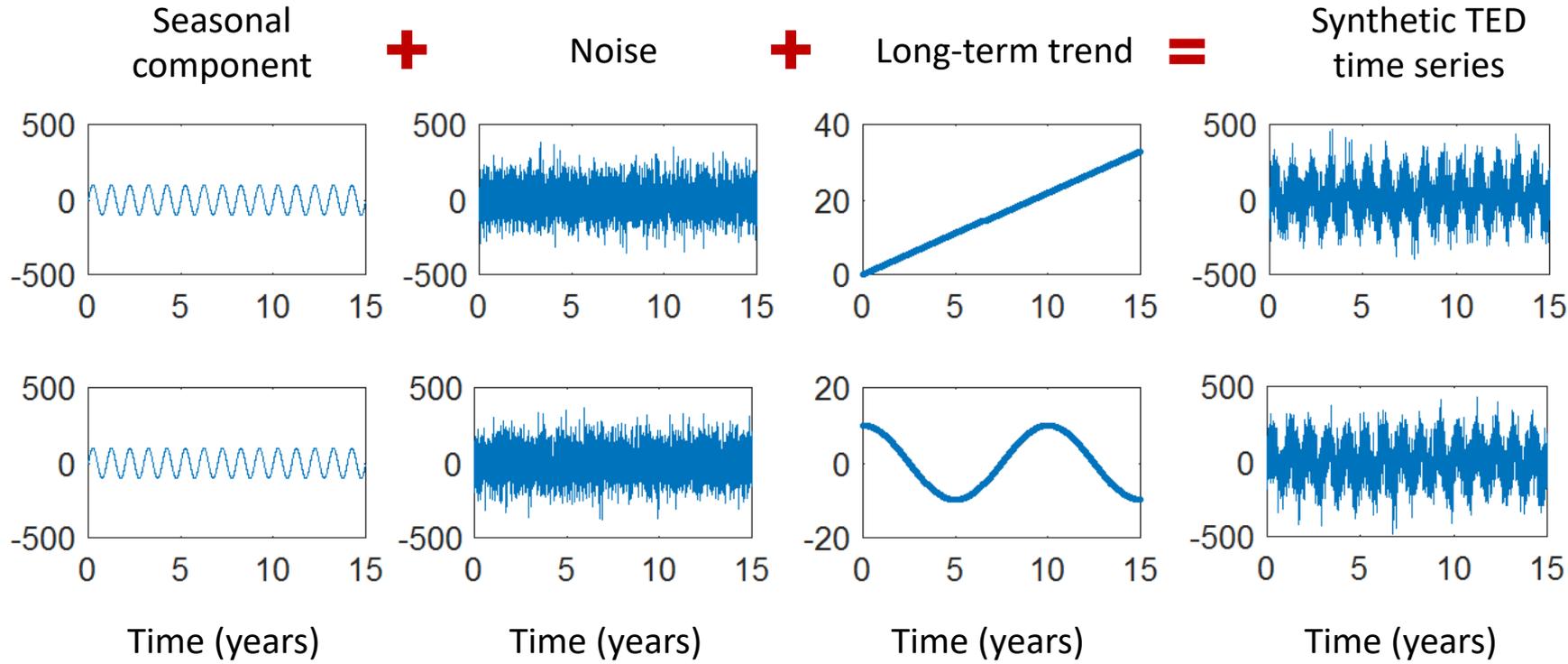
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A combination of **WAVELET and MEDIAN filters** is suitable to detect long-term trends

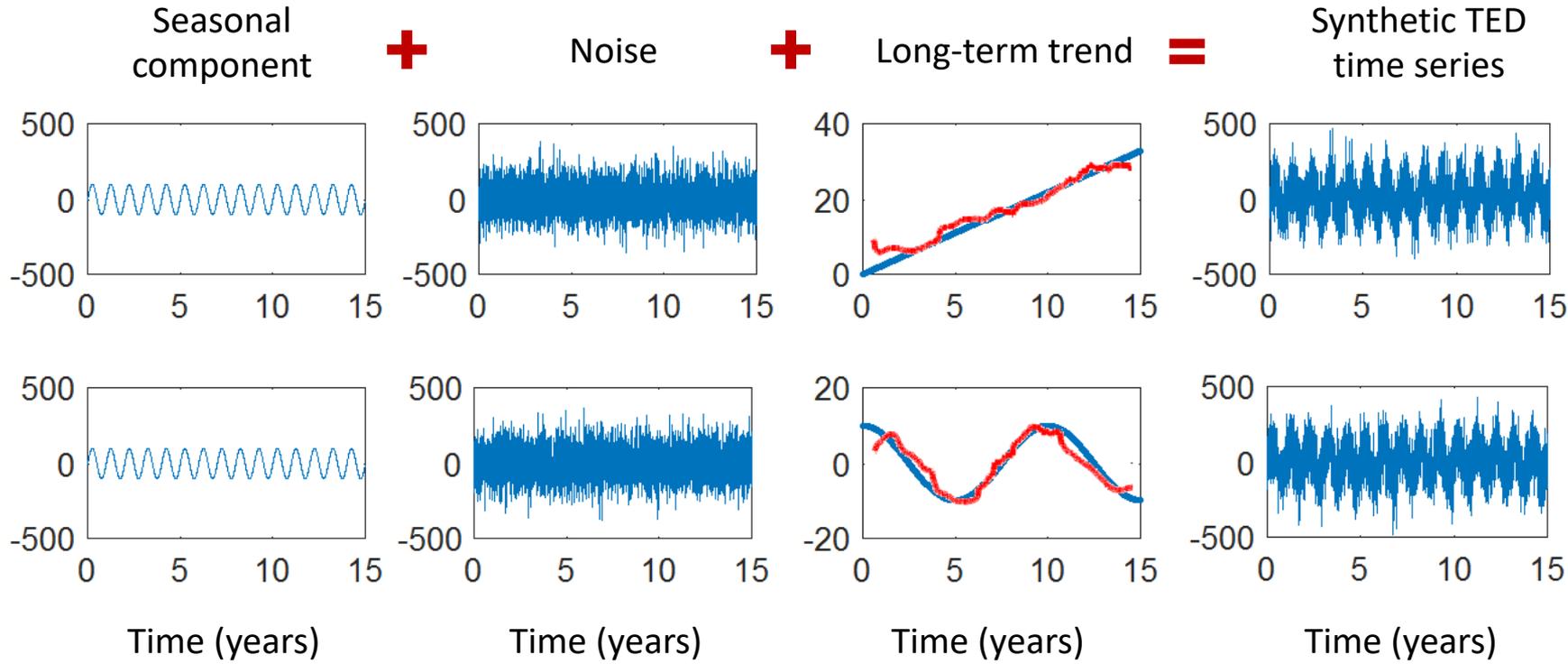
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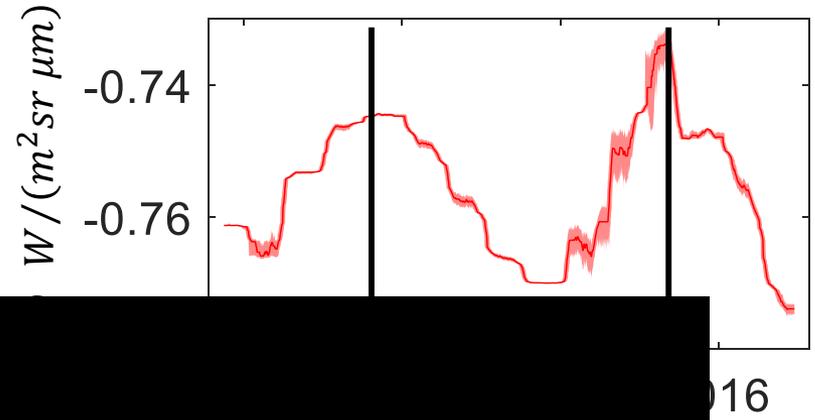
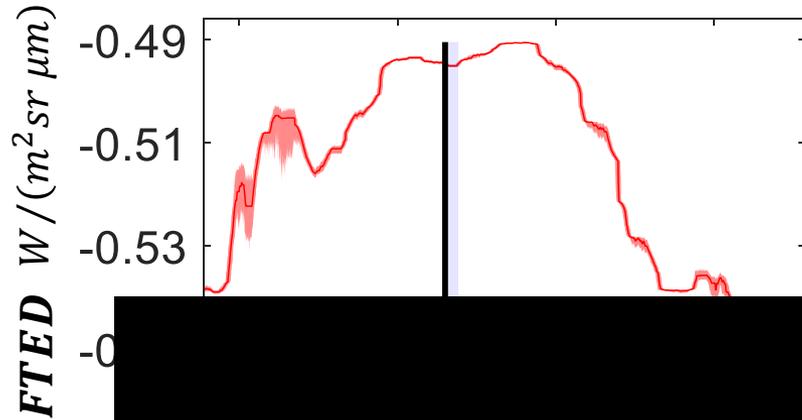
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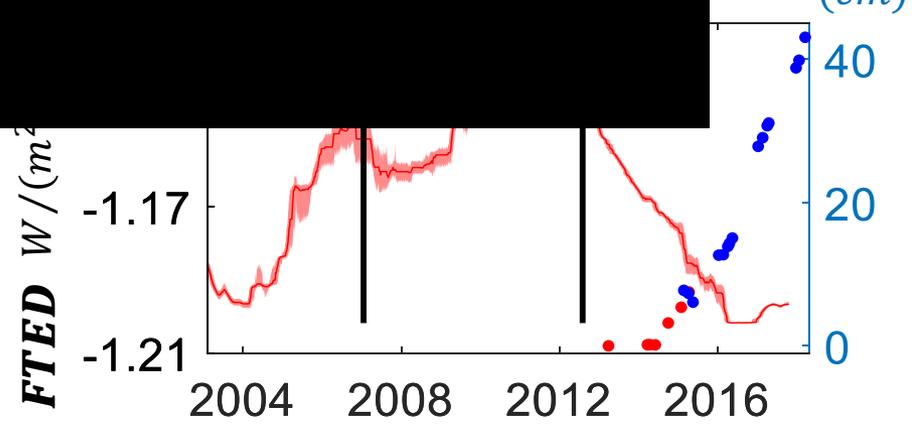
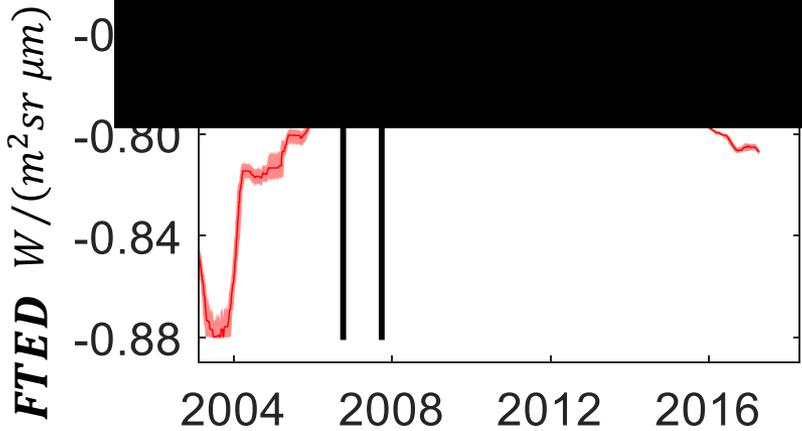


Redoubt (USA)

Ontake (Japan)



The radiance of the volcanic edifices increased before the eruptions



● RSAT-2

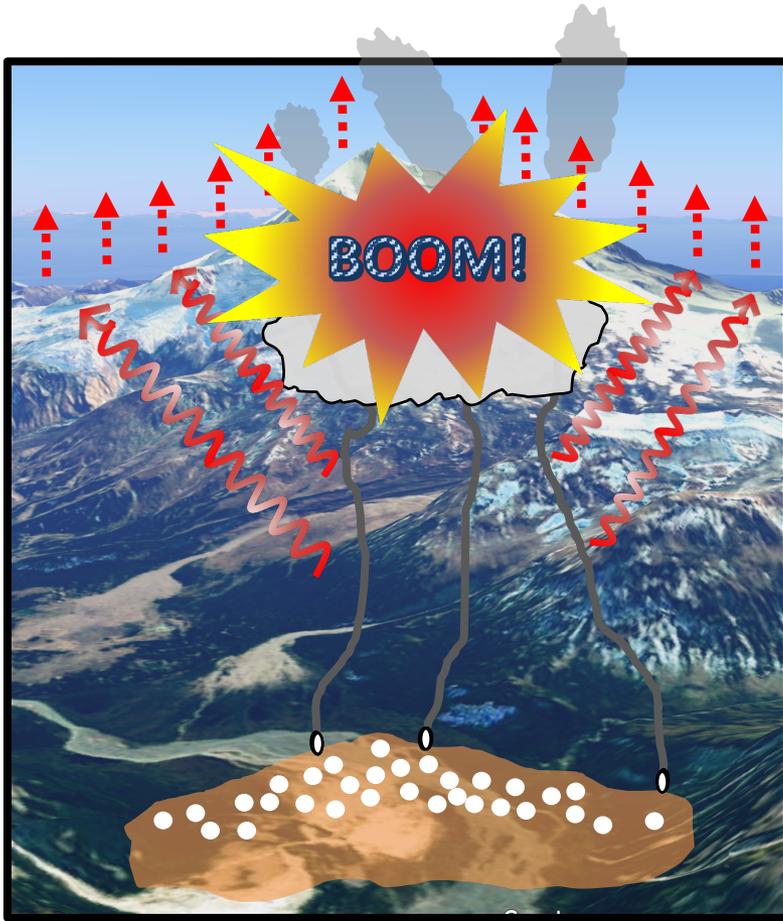
● ALOS-2

Why did the ground radiance increase prior to the eruptions?

1 Channelized VS diffuse degassing

[e.g., Notsu et al., 2006]

2



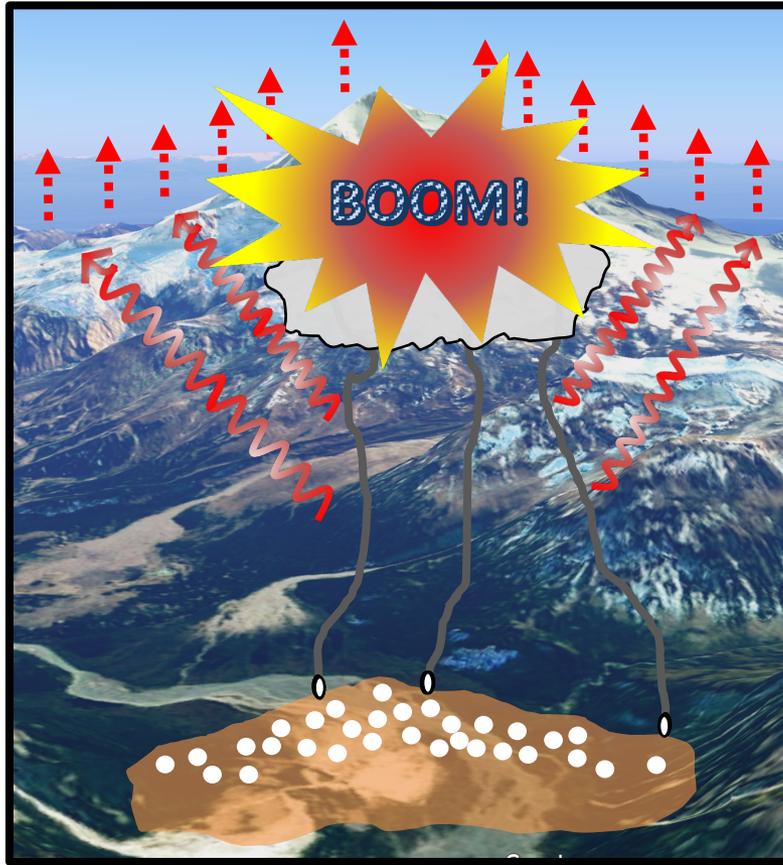
[credit: Google Earth]

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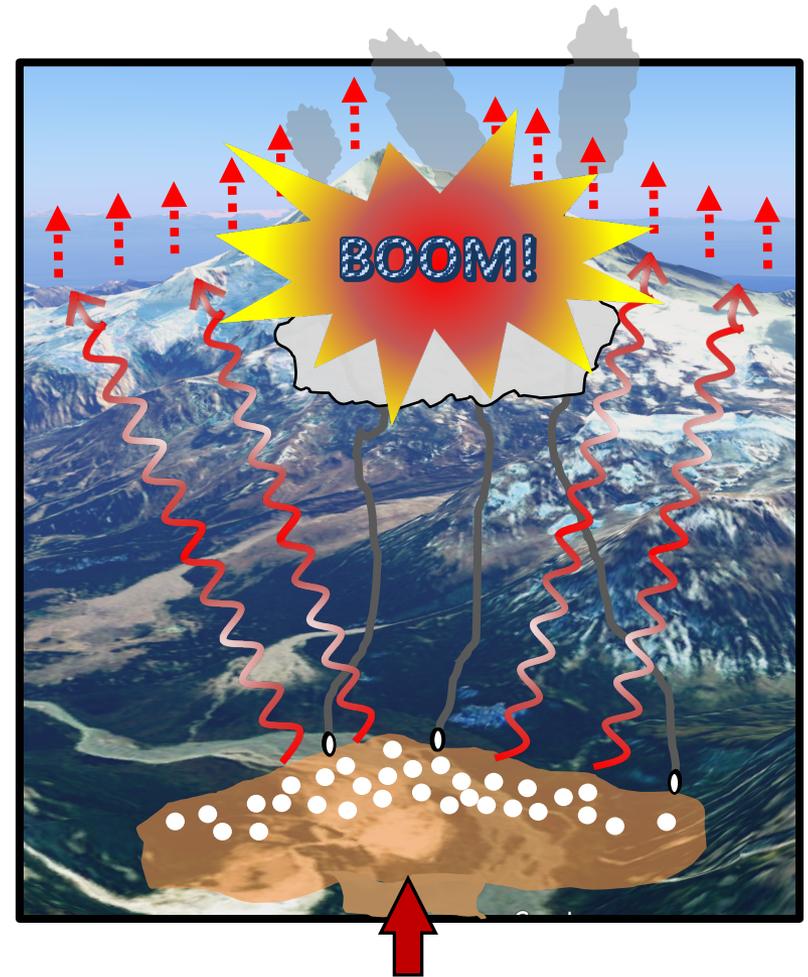
[e.g., Notsu et al., 2006]



[credit: Google Earth]

2 Magma ascent

[e.g., Hernández et al., 2001]



METHOD

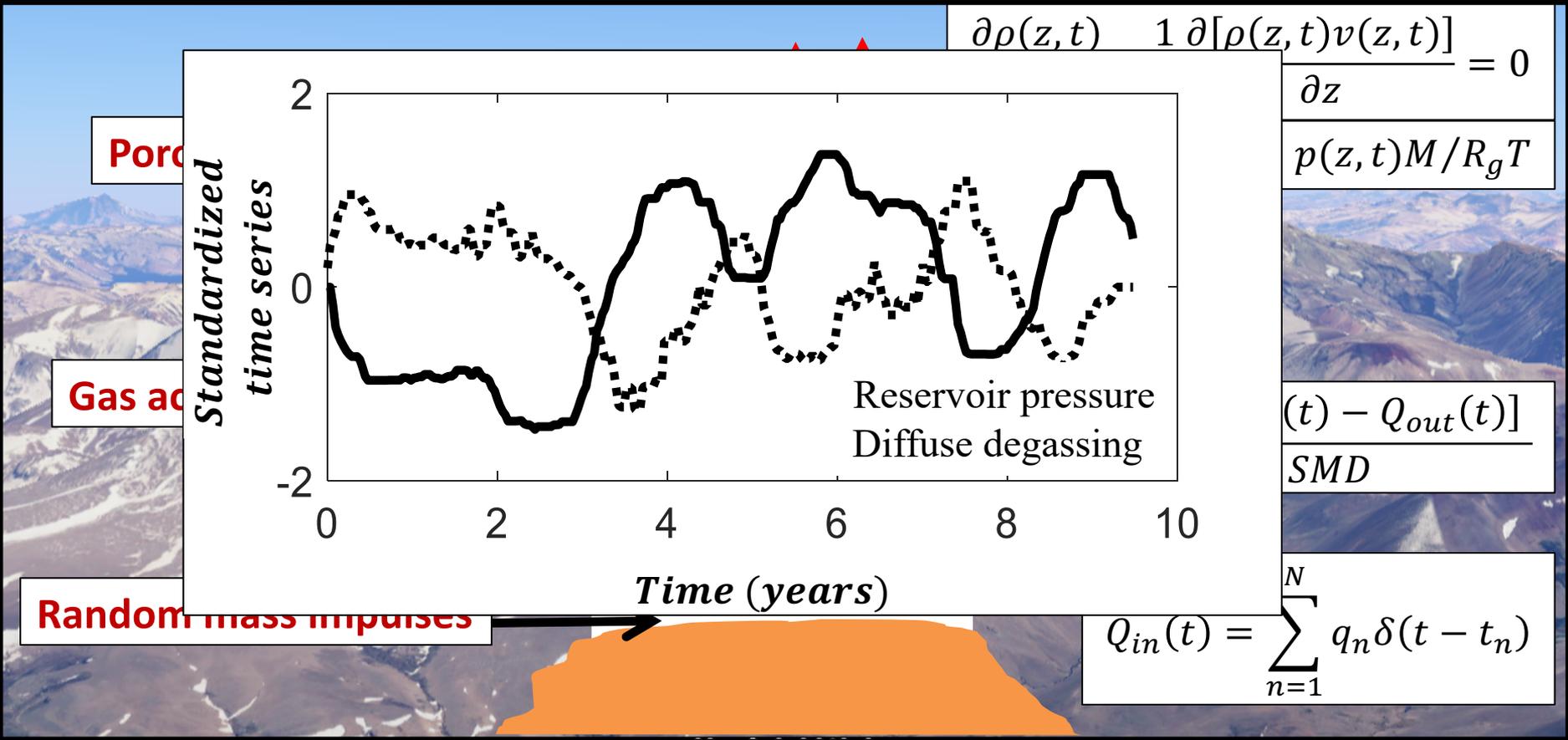
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Why did the ground radiance increase prior to the eruptions?

3 Spontaneous breathing [e.g., Girona et al., Submitted]

$$-\frac{\partial p(z,t)}{\partial z} = \frac{\mu}{\kappa} v(z,t) + \frac{\rho(z,t)}{\kappa^*} v(z,t)^2 + \frac{\rho(z,t)}{\varphi} \left(\frac{\partial v(z,t)}{\partial t} + \frac{v(z,t)}{\varphi} \frac{\partial v(z,t)}{\partial z} \right)$$



[credit: Google Earth]

[e.g., Girona et al., 2018; Girona et al., submitted]

RESEARCH QUESTIONS

1 Do diffuse heat emissions vary significantly before eruptions?

• R1:

YES. The overall radiance of the volcanic edifices increased prior to the most recent phreatic eruptions of Ontake and Ruapehu volcanoes.

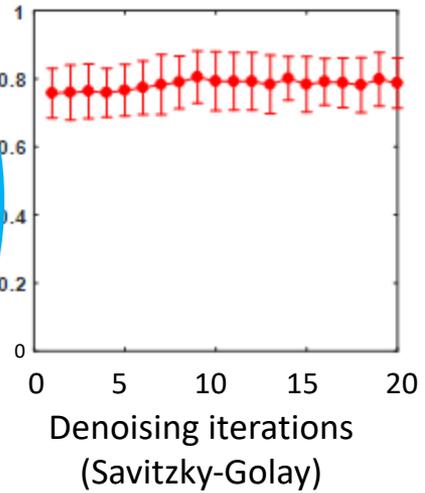
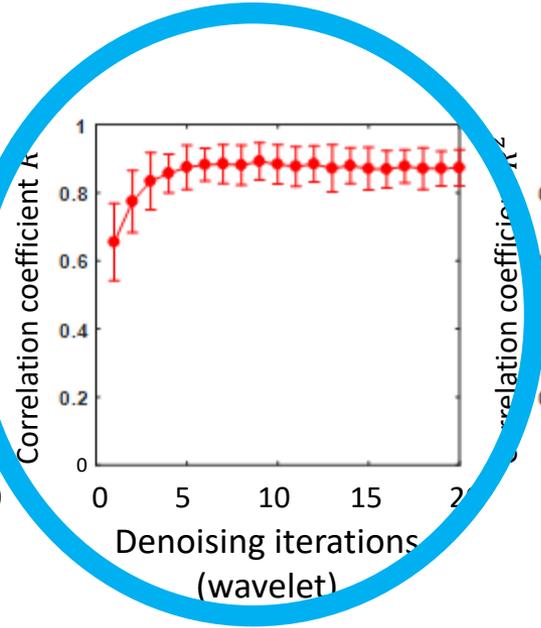
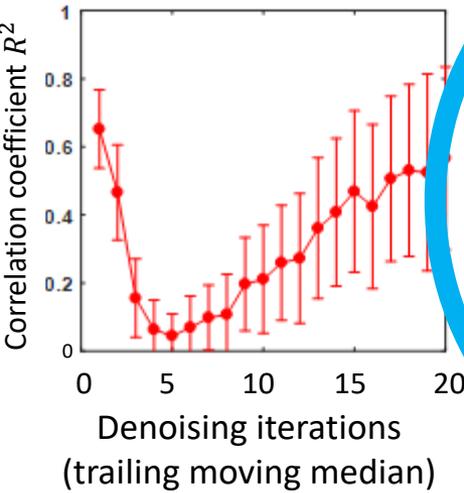
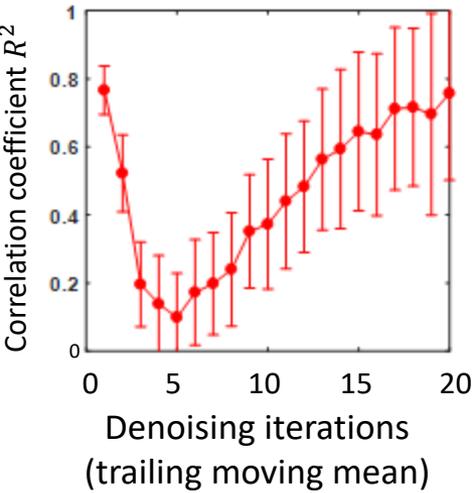
2 Can we forecast eruptions from space?

• R2:

Results are promising for long-term forecasting. Boundary effects related to filtering must be taken into account for real-time monitoring.

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A combination of **WAVELET** and **MEDIAN** filters is suitable to detect long-term trends

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RESEARCH QUESTION

1

Do diffuse heat emissions vary significantly before eruptions?

• R1:

YES. The overall radiance of the volcanic edifices increased prior to the most recent eruptions of Redoubt, Ontake, Ruapehu, and Domuyo volcanoes.

FORECASTING ?