The 2019 Raikoke eruption: Can smoke and Sulfuric acid aerosol be separated?
Raikoke Eruption

- Located on Kuril Archipelago (48.3 N, 153.3 E)
  - Means “hellmouth” in Ainu language

- Erupted in June 2019
  - VEI-4
  - Ash reached 13 – 17 km
  - Has a history of mid-sized eruptions
2019 NH Wildfires

- **Pyrocumulonimbus**
  - Product of intense burning events
  - Comparable to moderate-sized volcanic events (Peterson et al. 2018)
  - Inject smoke and BVOCs into stratosphere
  - Smoke composed of black and brown carbon of variable composition

- Capable of significantly impacting stratospheric chemistry and physics (Yu et al. 2019; Kablick et al. 2020)
2019 NH Wildfires

- Pyrocumulonimbus
  - Product of intense burning events
  - Comparable to moderate-sized volcanic events (Peterson et al. 2018)
  - Inject smoke and BVOCs into stratosphere
  - Smoke composed of black and brown carbon of variable composition

- Capable of significantly impacting stratospheric chemistry and physics (Yu et al. 2019; Kablick et al. 2020)

- 2019 northern hemisphere impacted by 2 major wildfires
  - Coincident with Raikoke eruption
  - Canada
  - Siberia
Did NH pyrocbs interact with Raikoke plume? (probably)
Can we see this interaction in the SAGE III/ISS data?
Observing Raikoke in SAGE 1020 nm Channel

Arrows indicate Raikoke latitude
Observing Raikoke in SAGE
1550 nm Channel

Arrows indicate Raikoke latitude
Smoke?

We'll come back to this.
Spectral Characteristics

Single Radius: 200 nm, Extinctions Ratioed to 1550 nm

- Spectral slope highly negative
- Spectral slope pretty flat
Breaking up SAGE data by event type
Breaking up SAGE data by event type

Extinction ratios collapse to $\sim 5$
Potential criteria for smoke identification

**Smoke**
- Spectral slope is flat
- Extinction ratios go to \(<~5\) regardless of wavelength

**Sulfuric Acid Aerosol**
- Spectral slope is negative
- Extinction ratios different for each wavelength combination
Can other events provide a guide?

- The Raikoke data is a mix of volcanic and fire emissions
- Do we have data of “non-mixed” events?
  - Ambae & Ulawun eruption (purely volcanic)
  - Australia (2020) and Canadian (2017) pyroCbs (purely wildfire)
Volcanic Events

Ambae Eruption

A: 23km
\[ y = 0.013x - 0.0012 \]

B: 24km
\[ y = 0.013x - 0.0012 \]

C: 21km
\[ y = 0.011x - 0.0012 \]

D: 22km
\[ y = 0.011x - 0.0012 \]

E: 19km
\[ y = 0.04x - 0.0012 \]

F: 20km
\[ y = 0.18x - 0.0013 \]

G: 17km
\[ y = 0.07x - 0.0013 \]

H: 18km
\[ y = 0.05x - 0.0013 \]

I: 15km
\[ y = 0.03x - 0.0013 \]

J: 16km
\[ y = 0.03x - 0.0013 \]

Ulawun Eruption

A: 23km
\[ y = 0.49x - 0.0012 \]

B: 24km
\[ y = 0.49x - 0.0012 \]

C: 21km
\[ y = 1.81x - 0.0015 \]

D: 22km
\[ y = 0.67x - 0.0012 \]

E: 19km
\[ y = 0.03x - 0.0012 \]

F: 20km
\[ y = 0.12x - 0.0011 \]

G: 17km
\[ y = -0.04x + 0.001 \]

H: 18km
\[ y = -0.04x + 0.0011 \]

I: 15km
\[ y = -0.04x + 0.0011 \]

J: 16km
\[ y = -0.04x + 0.0011 \]
PyroCb Events
Example Profiles Revisited

13-September 2019  Lat: 52.0 N Lon: 159.1 E

Extinction (km⁻¹)
Altitude (km, ASL)

520 nm
1020 nm

17-September 2019  Lat: 25.7 N Lon: 161.2 E

Extinction (km⁻¹)
Altitude (km, ASL)

520 nm
1020 nm

Smoke?
We’ll come back to this
Raikoke Event

Raikoke 50 N

Raikoke 25 N

10/16/2020
Example Profiles

17-September 2019  Lat: 25.7 N  Lon: 161.2 E

Smoke?

Seems to be the case.
The stratosphere has been impacted by multiple pyroCb and volcanic events since the launch of SAGE III/ISS.

SAGE III/ISS has proven capable of detecting these events, even for months afterward.

Smoke and sulfuric acid aerosol have different spectral characteristics.
- These characteristics may be exploited to differentiate effects/evolution of event types.
- May be useful for identifying “not sulfate” aerosol clouds.
  - Important for chemistry and PSC formation.

SAGE III/ISS data indicates the presence of smoke and sulfuric acid aerosol.
- Individual profiles may contain both aerosol types.
- Smoke tends to occupy the higher altitudes.
Questions
Observing Raikoke in SAGE 1550 nm Channel

Arrows indicate Raikoke latitude

Rises as moves south