Volcanic Ash Detection With Lidar: Minimizing False Positives and False Negatives
Mike Fromm
Naval Research Laboratory
Washington, DC, USA

Photo credit: Klaus Sievers, IFALPA

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Outline

1. Why does NRL care about volcanoes?
2. Motivation: a false-positive ash detection
3. Lidar depiction of co-resident particle types
4. Ash false positive and negative signatures
UTLS Pathways
1. Brewer-Dobson circulation
2. Quasi-isentropic exchange
3. Monsoon
4. Baroclinic cyclone
5. Volcano
6. pyroCb
7. xCb
Interpretation: all the particles are ash

PRESS RELEASE (April 22, 2010; 11:45 UTC)

Ash penetration over the Athens Basin (38°N, 23°E), Greece

Credit: National Technical University of Athens and EARLINET
Where did those high-altitude particles come from? The answer my friend, is blowing in the wind.

Volcano

Backward Trajectory

2-day calculation

19 April

Volcano

Athens 21 April

6 days
Forward trajectories from volcano on 19 April at 9 km do not pass near Greece.
The Big Picture: CALIPSO Lidar in Space

8 Particle Types at 1 Time in the UTLS

4 July 2011
Grimsvötn and Nabro sulfates

Smoke

Water cloud

Cirrus

BACKSCATTER
DEPOLARIZATION

Grimsvötn and Nabro sulfates

Smoke

Cirrus

Water cloud

Depolarization Ratio UTC: 2011-07-04 00:00:07.0 to 2011-07-04 00:22:40.2 Version: 3.01 Expedited
532 nm Total Attenuated Backscatter, km$^{-1}$ sr$^{-1}$  UTC: 2011-07-04 00:32:20.5 to 2011-07-04 00:45:49.2  Version: 3.01 Nominal Nighttime

- **BACKSCATTER**
  - NAT PSC
  - Ice PSC
  - Puyehue-Cordón Caulle Ash
Lidar Particle Phase Space: distinction, blurred lines

- **Backscatter (concentration)**
  - little
  - lots

- **Sulfate**
  - little
  - lots

- **Depolarization Ratio**
  - spherical → aspherical

- **Cloud Types**
  - Water Cloud
  - Smoke
  - Dust
  - Ash
  - Acidic PSC
  - Ice PSC
  - Cirrus
Fig. 1. Time-height cross section of the range-corrected signal (upper panel, log-scale, a.u.) and the volume linear depolarization ratio (lower panel) at 532 nm derived from MULIS lidar measurements at Malsach from 16 April 17 UTC to 17 April 24 UTC.
Kasatochi plume over Madison Wisconsin
532 nm Backscatter

Continuous volcanic layers for 13 days!

Lidar PI: Ed Eloranta

August                                             September
Aerosol backscatter cross section 23-Aug-2008

Backscatter cross section

Zoom to 23 August
Liquid on top, solids below?

Depolarization ratio

Zoom to 23 August
Volcanic ash (VA) signature in elastic, multi-wavelength, polarization lidar:
* backscatter range from detection limit to cloud-like
* depolarization ratio range, ~20-35%

VA false positive potential:
* mineral dust: similar backscatter and depolarization range
* ice cloud: overlapping backscatter & depolarization
* smoke: similar backscatter range as VA
* volcanic sulfate plume

VA false negative potential:
* cirrus/ash blend
* VA lost in particle mixtures
* weak signal, inhomogeneous plume
Conclusions

* Elastic lidar data: wunderbar! but under-constrained
  * overlap in backscatter and/or depolarization signal
  * assumptions and groupthink abound

* Critical issue: context awareness
  * real-time maps of extant plume types.
  * particle-type attribution must be an ongoing activity