GOES-R AWG Product Validation Tool Development

Aviation Application Team – Volcanic Ash

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OUTLINE

- **Products** (1-2 slides)
- **Validation Strategies** (3-4 slides)
- **Routine Validation Tools** (4-5 slides)
- **"Deep-Dive" Validation Tools** (4-5 slides)
- **Ideas for the Further Enhancement and Utility of Validation Tools** (1-2 slides)
- **Summary**

Products

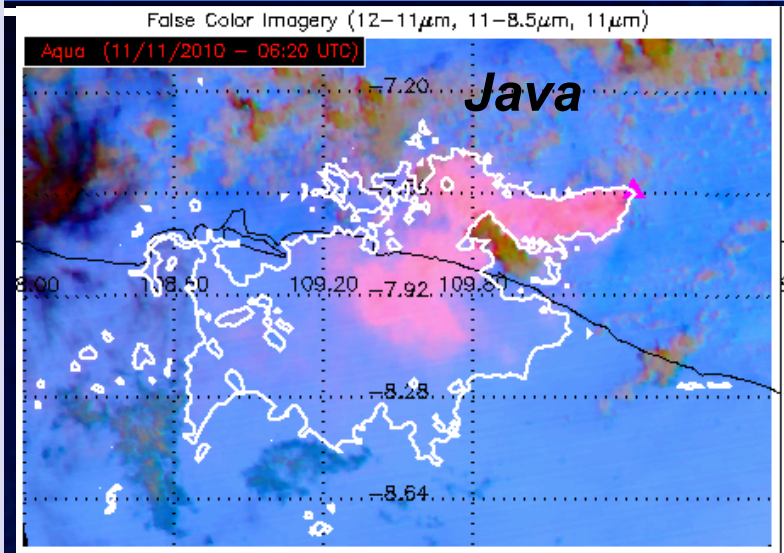
Volcanic Ash Requirements

Name	User & Priority	Geographic Coverage (G, H, C, M)	Vertical Resolution	Horizontal Resolution	Mapping Accuracy	Measurement Range	Measurement Accuracy	Product Refresh Rate/Coverage Time (Mode 3)	Product Refresh Rate/Coverage Time (Mode 4)	Vendor Allocated Ground Latency	Product Measurement Precision
Volcanic Ash: Detection and Height	GOES-R	Full Disk	3 km (top height)	2 km	1 km	0 - 50 tons/ km^2	2 tons/km^2	Full disk: 15 min	Full disk: 15 min	430 sec	2.5 tons/ km^2

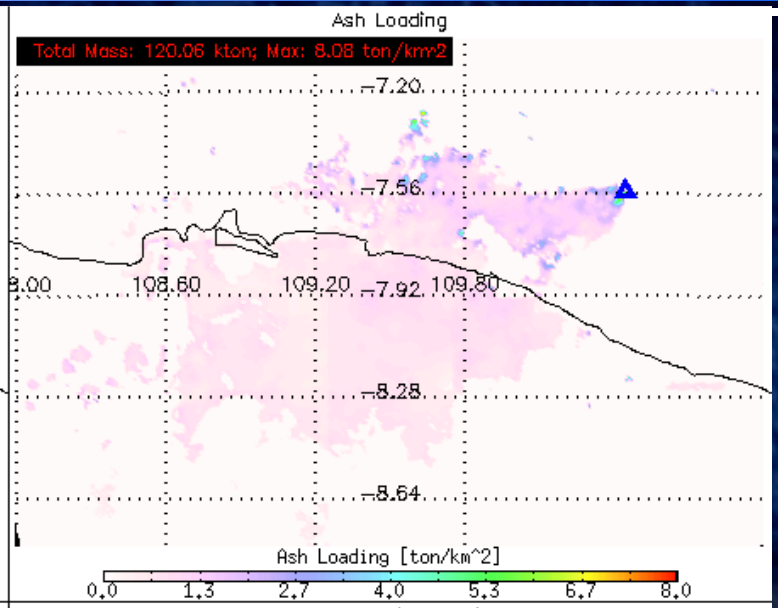
Name	User & Priority	Geographic Coverage (G, H, C, M)	Temporal Coverage Qualifiers	Product Extent Qualifier	Cloud Cover Conditions Qualifier	Product Statistics Qualifier
Volcanic Ash: Detection and Height	GOES-R	Full Disk	Day and night	Quantitative out to at least 60 degrees LZA and qualitative at larger LZA	Clear conditions down to feature of interest associated with threshold accuracy	Over volcanic ash cases

Products

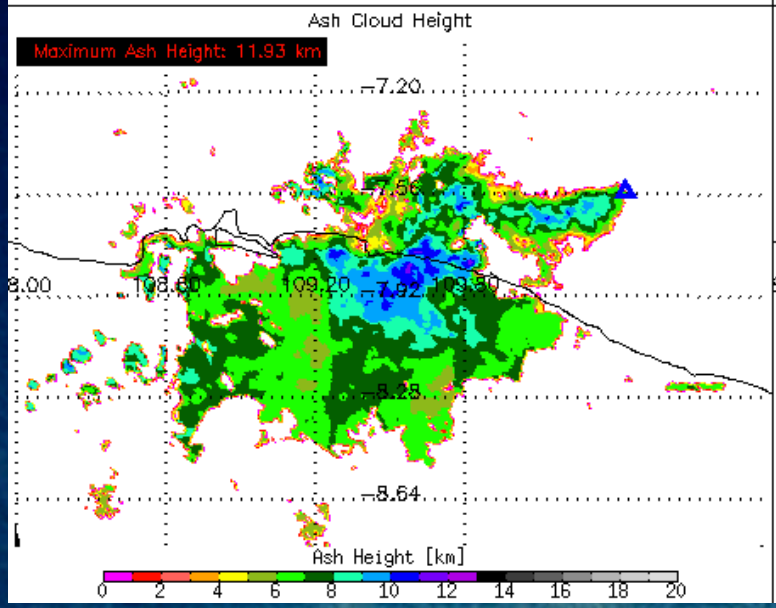
False Color Image (w/ ash detection results)



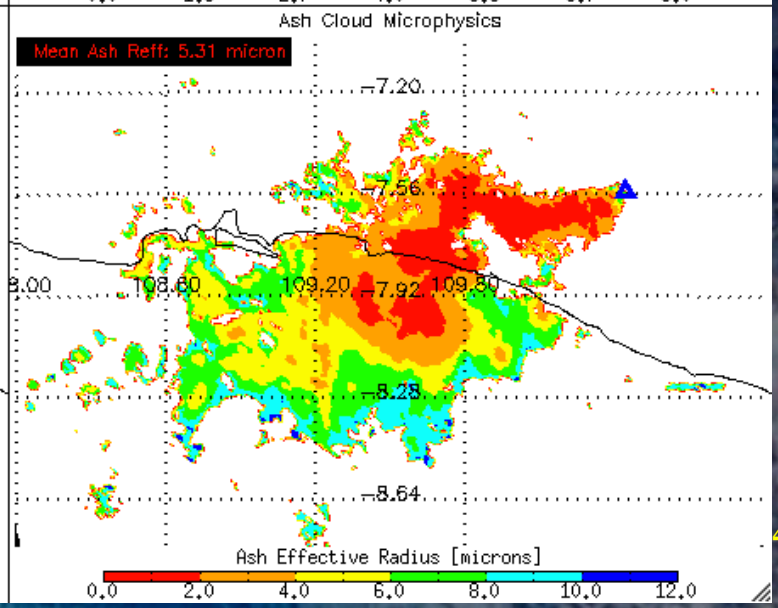
Ash Mass Loading



Ash Cloud Height



Ash Effective Radius

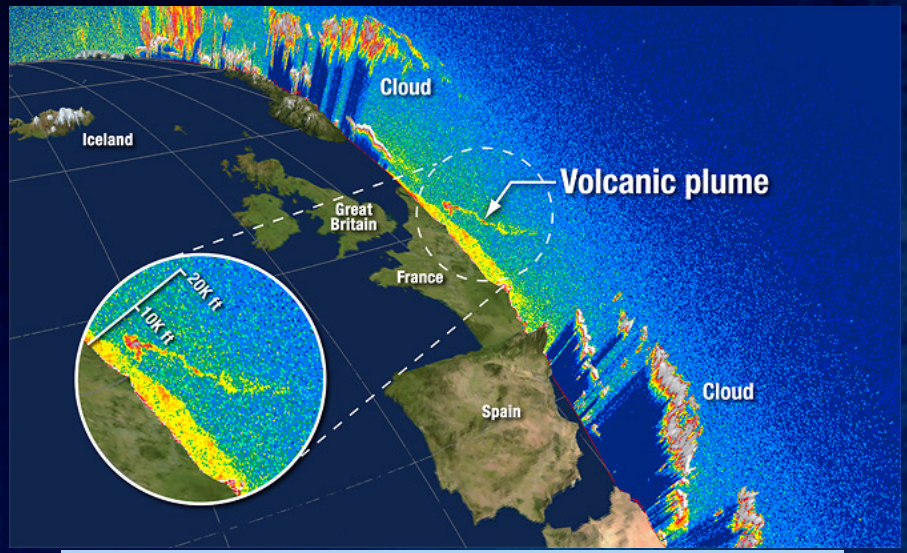


Validation Strategies

1. *Objectively identify which pixels contain volcanic ash*
   - A combination of infrared and lidar measurements are used to objectively identify satellite pixels that contain volcanic ash (as the highest cloud layer)
   - This step is needed since the GOES-R product will include false alarms
2. *Validate ash cloud height*
   - Directly validated using lidar measurements of ash clouds
   - Ash cloud validation is supplemented with lidar measurements of dust clouds which are spectrally similar, in the infrared, to volcanic ash
3. *Validate ash mass loading*
   - A combination of lidar and infrared measurements are used to compute a best estimate of mass loading
   - Aircraft measurements will also be used to validate the GOES-R ash mass loading product

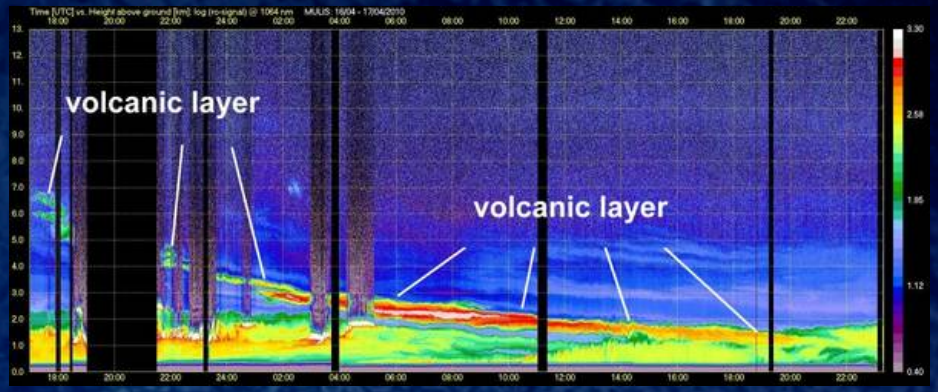
Validation Datasets

CALIOP lidar (freely available)



http://www-calipso.larc.nasa.gov/

EARLINET lidar network (freely available)



http://www.earlinet.org

DLR Aircraft Measurements
(soon to be available)

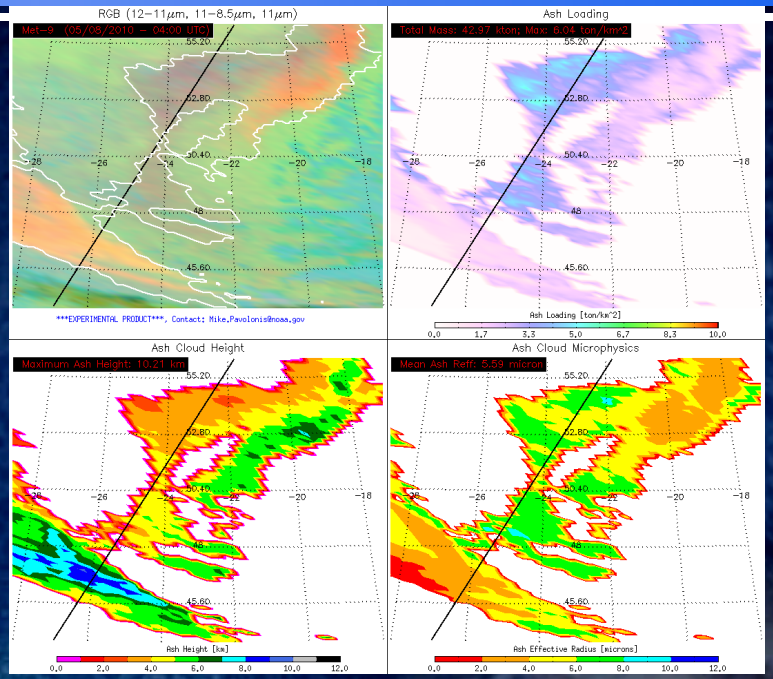
Schumann et al. (2011)

Validation Tool Major Requirements

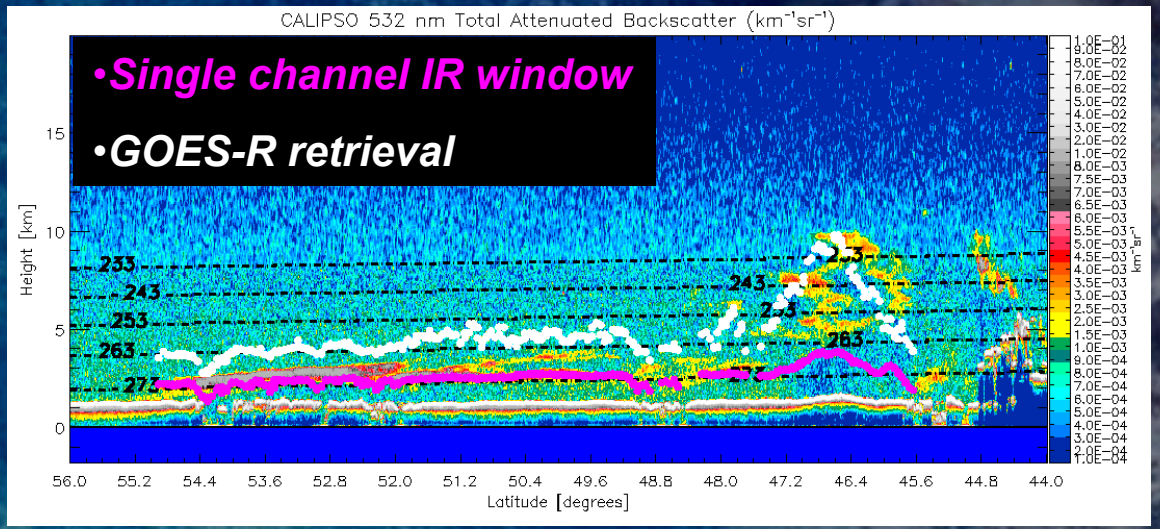
- Co-locate ABI (SEVIRI and MODIS) in space and time with spaceborne and ground-based lidars
- Compute cloud optical depth spectra using a combination of lidar cloud boundaries, infrared radiances, NWP model output, surface emissivity, SST data, and a fast clear sky radiative transfer model.
- Use cloud optical depth spectra to objectively identify satellite pixels that contain volcanic ash/dust
- Use cloud optical depth spectra to compute a “truth” ash mass loading
- Compute routine validation statistics
- A tool is needed to analyze aircraft measurements in detail
- Deep dive tools are needed to access various retrieval sensitivities (e.g. microphysical assumptions)
- Visualize results from every step of the process

Routine Validation Tools

1). An IDL tool was developed to co-locate ABI (proxy) data (SEVIRI and MODIS) and lidar data in space and time and extract relevant lidar information for each co-location.

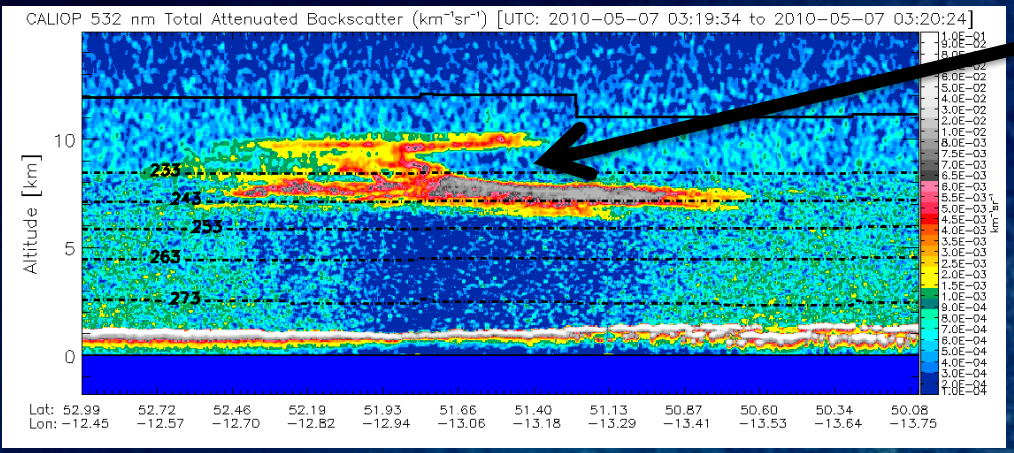


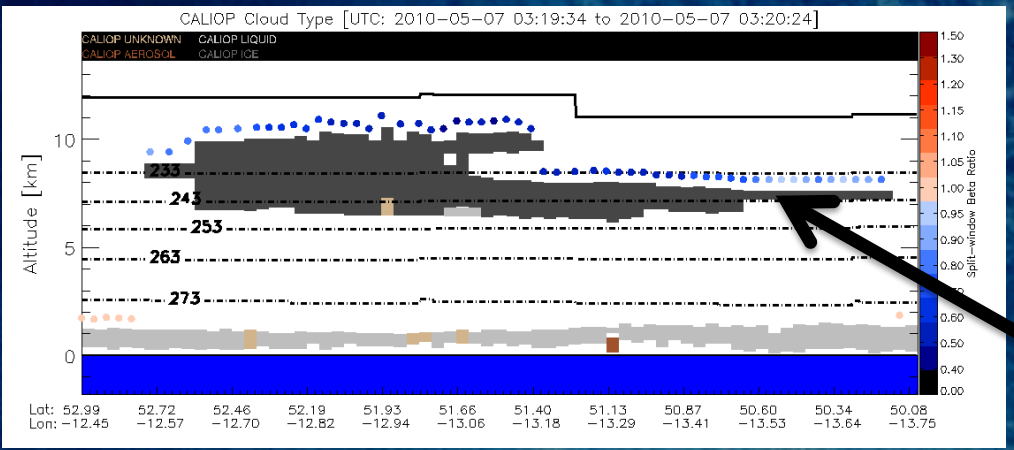
The results of the GOES-R algorithm can be displayed separately or overlaid onto the lidar data.



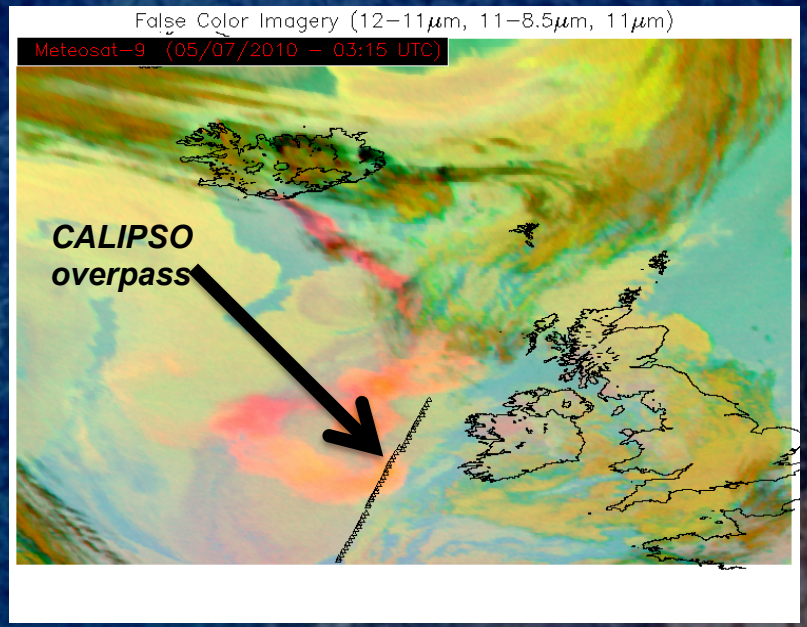
Routine Validation Tools

2). A combined GEOCAT and IDL tool was developed to compute infrared cloud optical depth spectra from the combination of lidar, IR radiances, and other ancillary data. The cloud optical depth spectra is first used to automatically and accurately identify ash and dust clouds.





Ash cloud

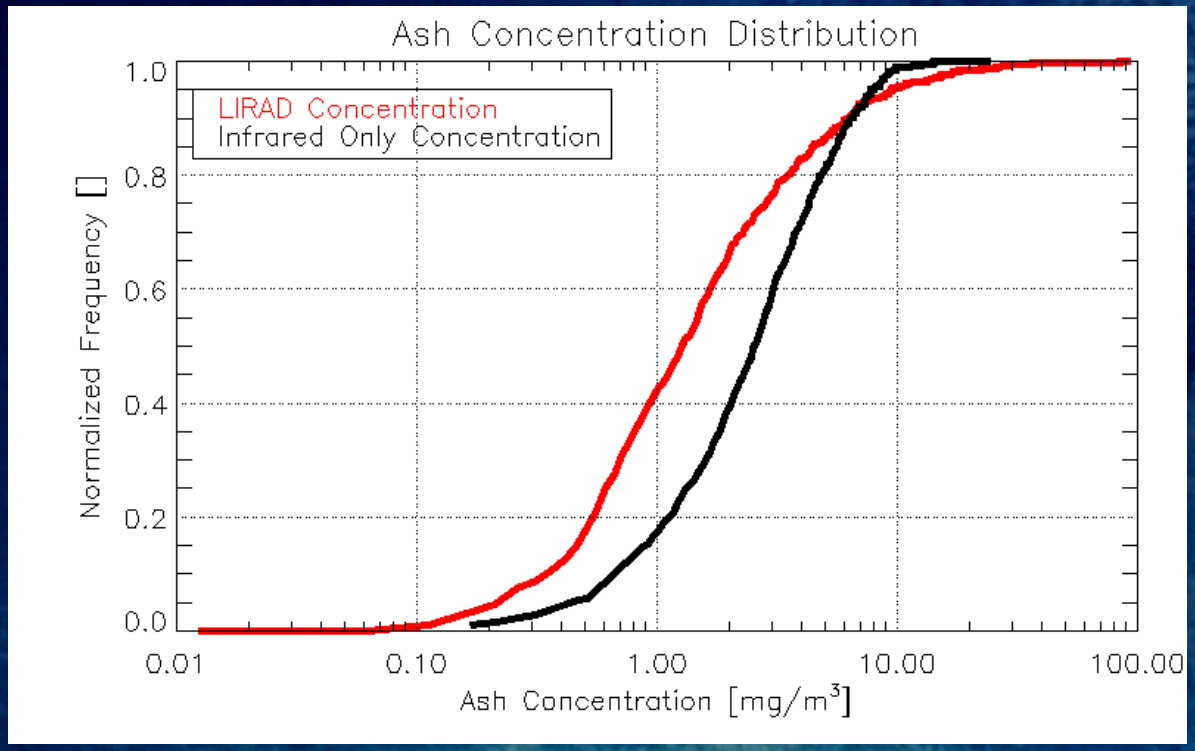


If the ratio of cloud optical depth at 11 and 12 μm is < 1.0; ash/dust is likely present.

Routine Validation Tools

3). An IDL tool was developed to compute ash mass loading and concentration from the lidar derived cloud optical depth spectra.

$$MC = \frac{4\pi\rho_{ash}\tau(\lambda)}{3(\Delta z)\sigma_{ext}(\lambda)} \int_{r1}^{r2} r^3 n(r) dr$$

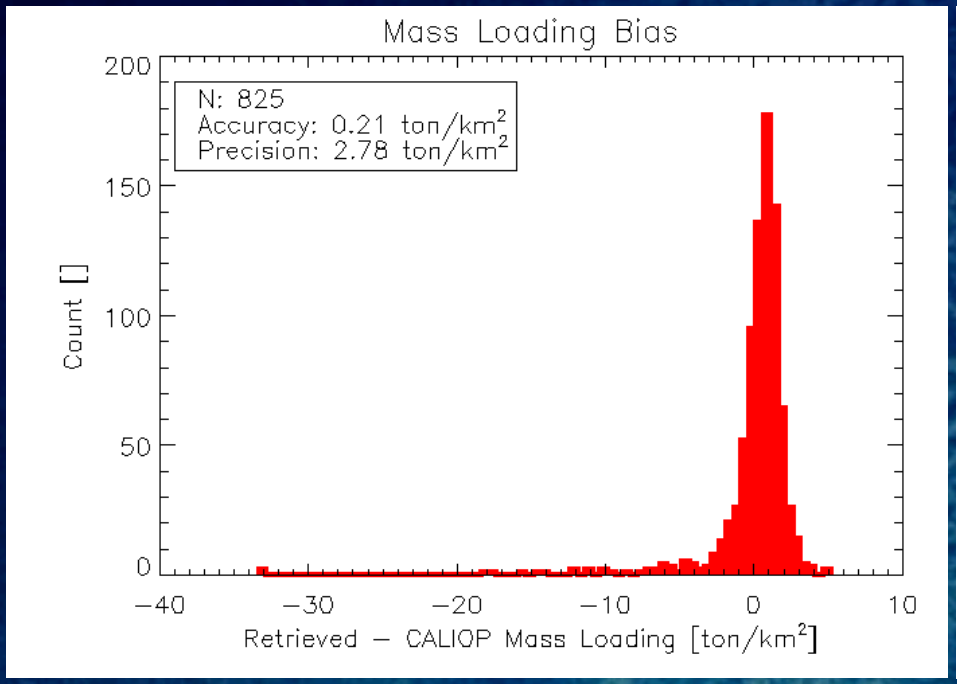


The mass loading routine is flexible, allowing for a variety of mineral compositions and particle distribution properties to be used (more on this in deep dive section)

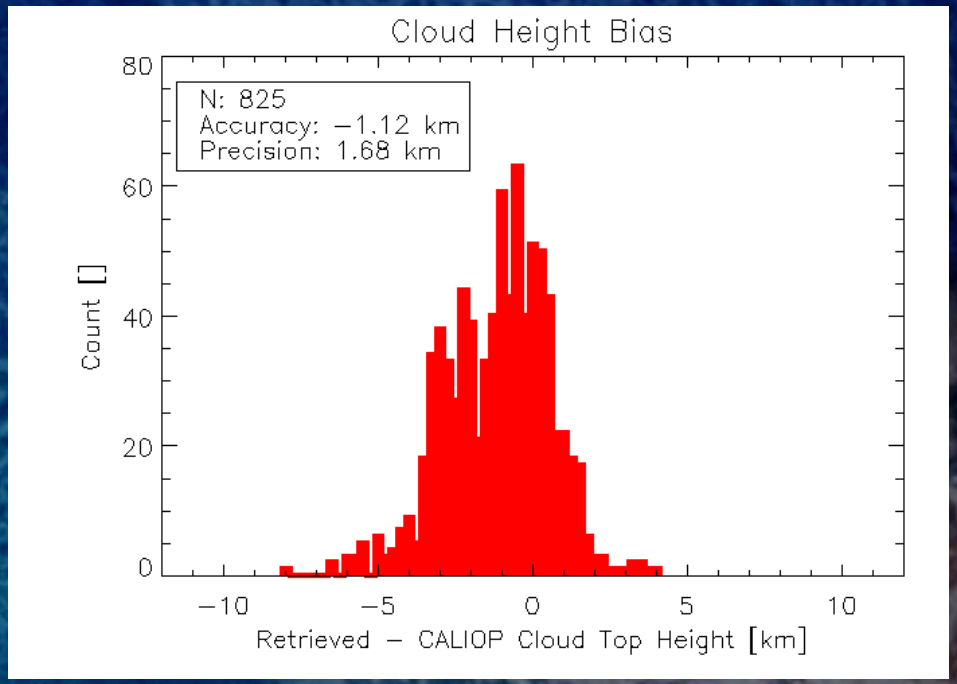
Routine Validation Tools

4). An IDL tool was developed to compute routine validation statistics compiled over any number of cases.

Mass Loading Bias and Precision Stats

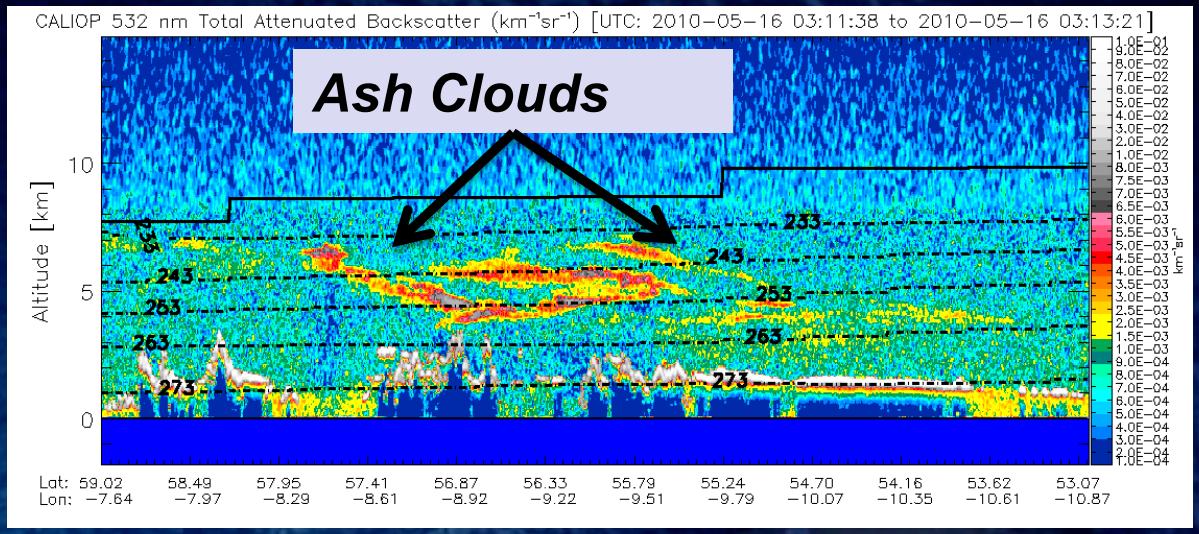


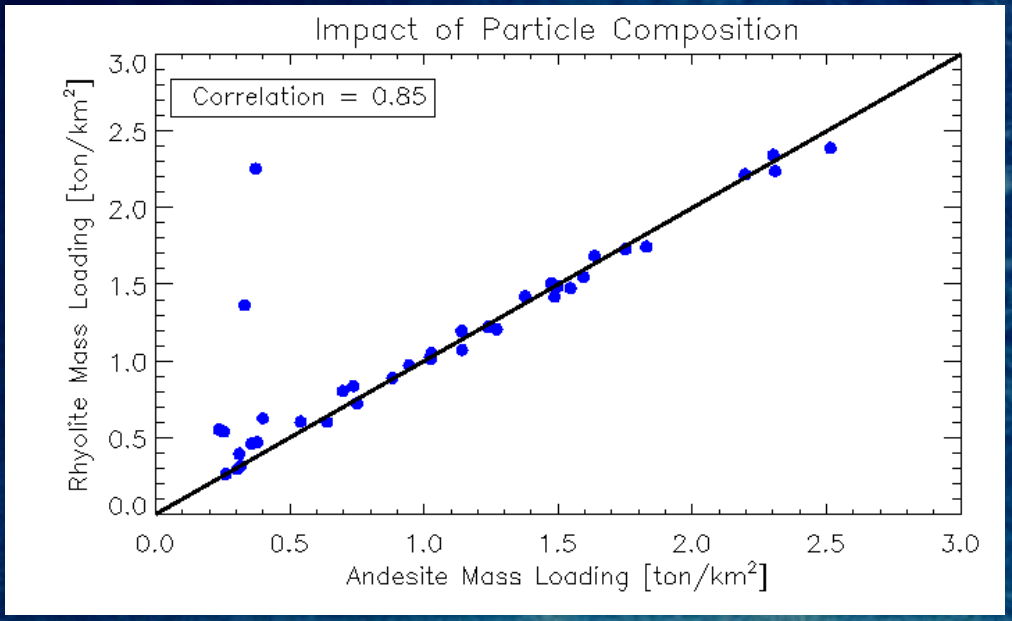
Ash Height Bias and Precision Stats



"Deep-Dive" Validation Tools

1). The sensitivity of the mass loading retrieval to the mineral composition and particle distribution attributes can be assessed on a case by case basis or on many cases.

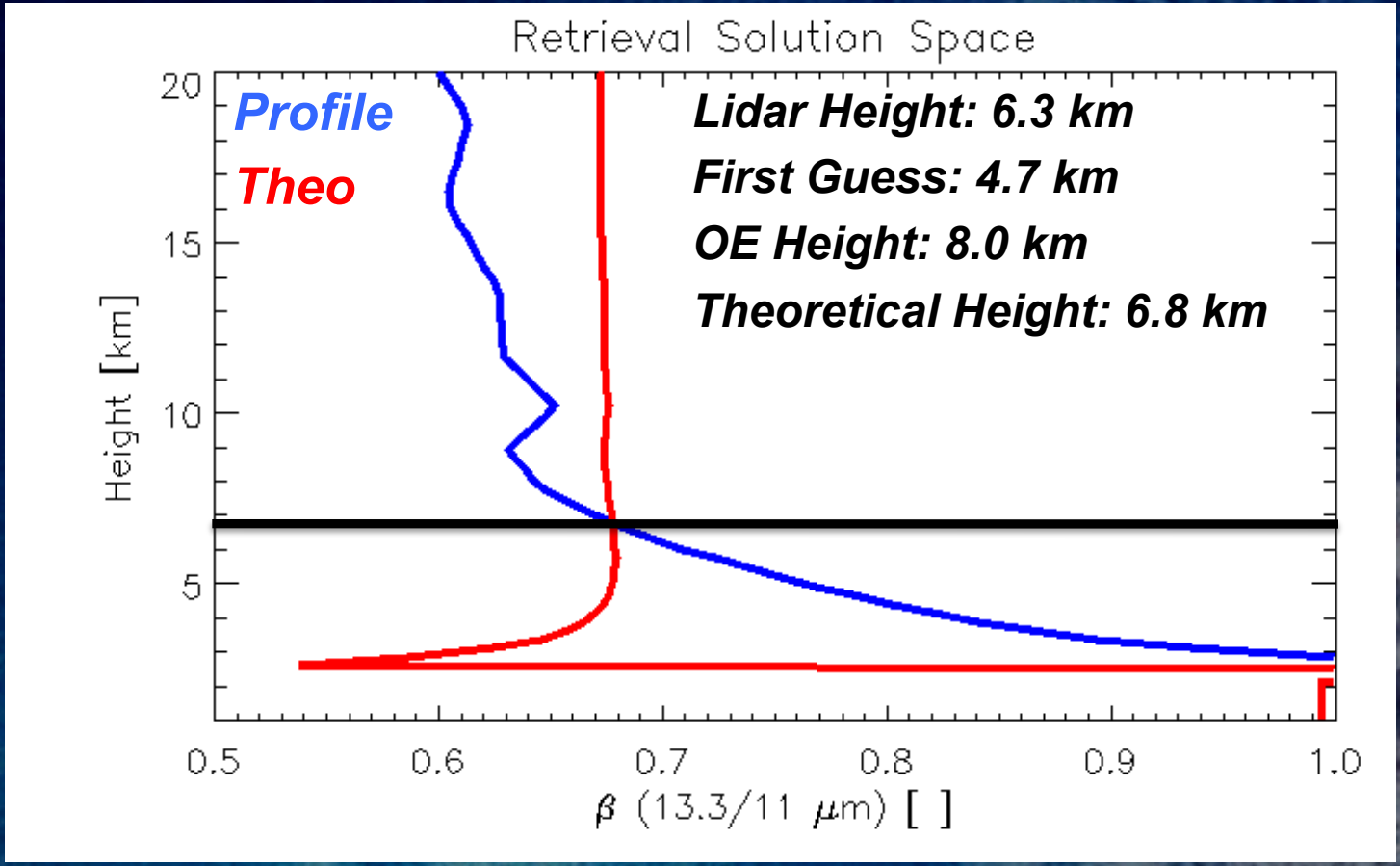




Mass loading using an andesite particle distribution versus a rhyolite particle distribution

"Deep-Dive" Validation Tools

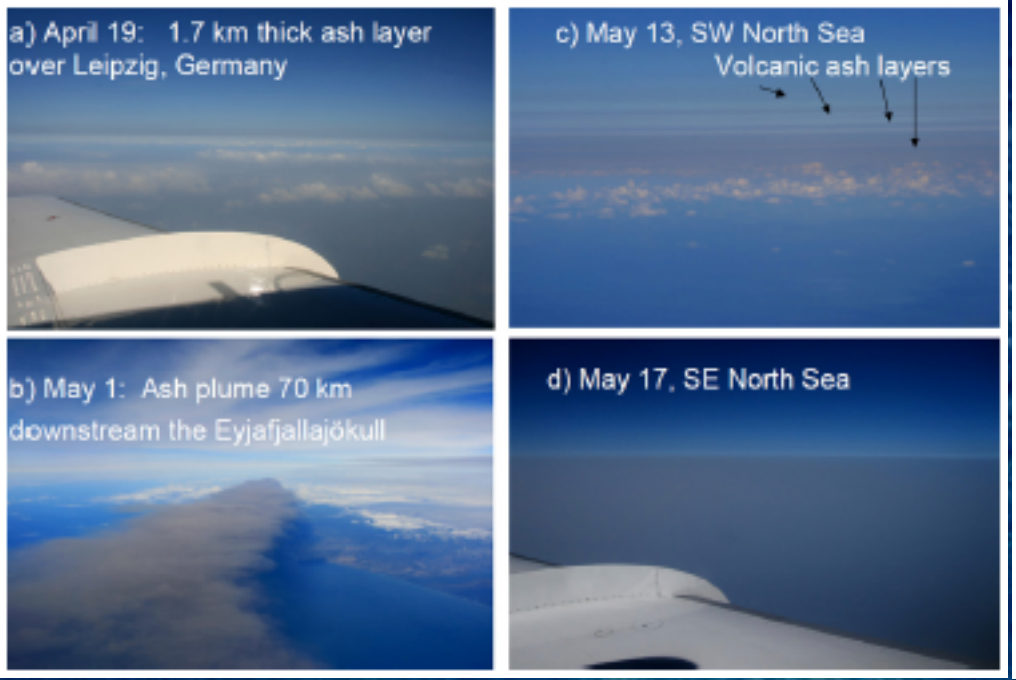
2). One of the deep dive tools is used to explore the retrieval solution space in detail.

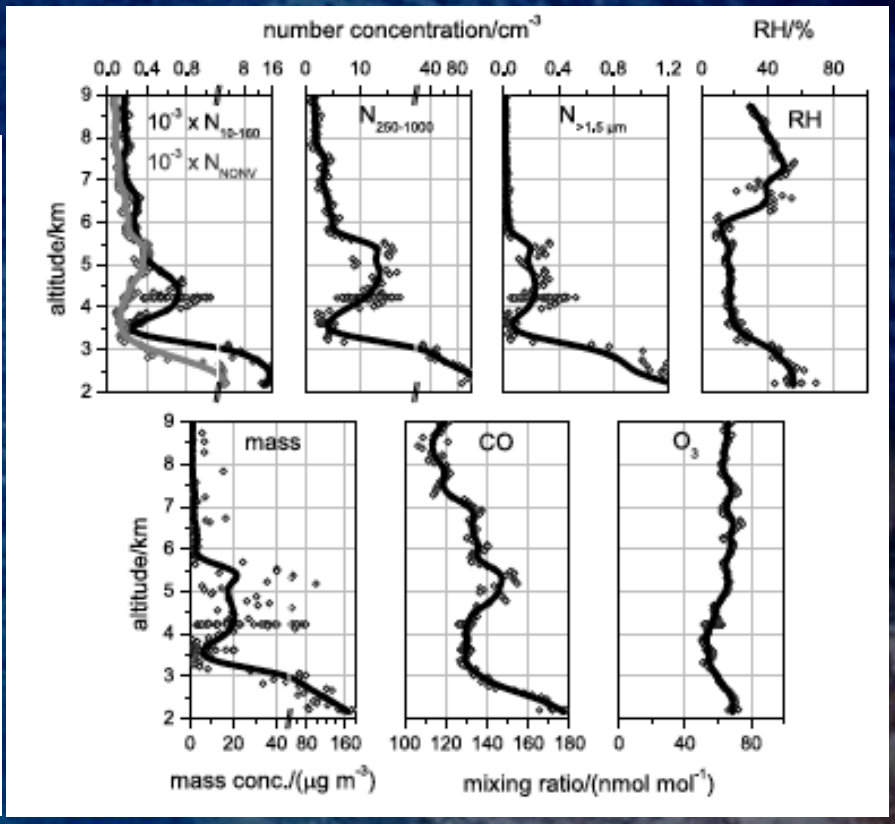


"Deep-Dive" Validation Tools

3). Another deep dive tool will be developed to perform detailed comparisons to a unique aircraft data set that will become available soon.

Schumann et al., 2011





Ideas for the Further Enhancement and Utility of Validation Tools

- The interface needed to use EARLINET lidar data is still under development
- Once the aircraft data are made available, the software needed to perform an analysis will be developed
- Develop the interfaces needed to use GLAS spaceborne lidar data (archived data sets from ICESat-1 and preparation for ICESat-2 2016 launch)
- A fully automated re-processing of the CALIPSO data record would be incredibly valuable, but may require extensive resources
- Develop a simulated retrieval capability
- Perform inter-comparisons with other groups (e.g. EUMETSAT, UKMet, etc…)
- Does it make sense to develop a near-realtime CALIPSO-based validation system and web interface?
- Prepare for EarthCARE?

Summary

- Geocat and IDL tools have been developed to validate and characterize the GOES-R volcanic ash products (height and mass loading) in detail
- While lidar is the primary means of assessing the accuracy of the GOES-R products, other methods (comparisons to unique aircraft data sets, inter-comparisons, and simulated retrievals) will also be used
- The GOES-R products have been demonstrated in real-time (http://cimss.ssec.wisc.edu/goes_r/proving-ground/geocat_ash/), but developing an objective real-time validation capability remains a challenge
- The GOES-R volcanic ash validation efforts will also benefit from feedback from the National Weather Service Alaska Region, who are receiving the products in near-real-time via the GOES-R Proving Ground