Validation of GOES-R volcanic ash products: Near real time operational decision support/hazard analysis

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Plan for 2011 - 2012 (Year 1)

Develop and enhance WRF-Chem and Puff models to deliver volcanic ash concentration forecasts

Analysis of GOES-R algorithm with other remote sensing methods for ash detection

Produce tool to allow model to satellite inter comparisons

Meetings with National Weather Service personnel

Overview of work done

Focused on two aspects:

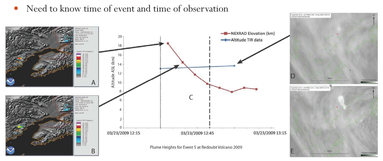
(1) Analysis of thermal infrared remote sensing of cloud top heights
(2) Volcanic ash modeling using WRF-Chem and comparison to volcanic ash retrievals.

We analyzed three of the major eruptions across the North Pacific and one in Europe
- Kasatochi in 2008
- Redoubt in 2009
- Sarychev Peak in 2009
- Eyjafjallajokull in 2010

Plume Heights

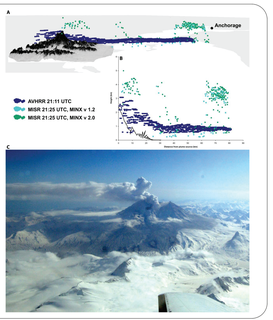
TIR (Timing of the data)

- Plume heights TIR versus radar
- Event lasted 20 Mins
- TIR from AVHRR ~ 55 Mins after start
- Event ended so dispersing cloud
- GOES-R ~ 15 mins so would still be over
- Need to know time of event and time of observation



TIR (MISR)

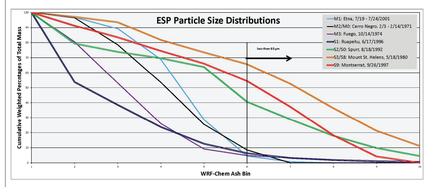
- Plume heights versus MISR
- Direct conversion of TIR to height
- MISR ~ 3.5-4.5 km
- TIR < 3km
- Airborne = 4-5 km
- Need to determine if cloud is 'translucent'



Model Intiailziation

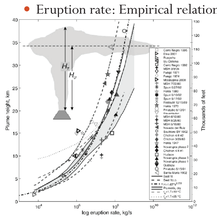
Model inputs: Particle size Distribution

- Use the assigned ESP PSD from Mastin et al. (2009)



Model inputs: Old Eruption rate

- Eruption rate: Empirical relationship



New method

Plumeria (Mastin, 2007) model examine effect of local atmosphere on plume rise

Model takes into account magma temperature, plume density, radius, upward velocity

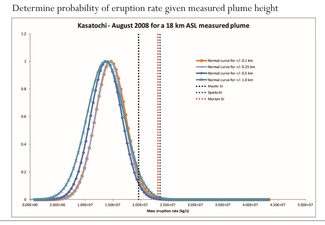
Use local radiosonde to get vertical profile of temperature, humidity, pressure

$H\,(km) = 1.69V^{0.259}$, where V=Volume flow rate (km^3/s). Use ash density to get eruption rate (kg/s)

Model inputs: New Eruption rate

- Eruption rate

Determine probability of eruption rate given measured plume height



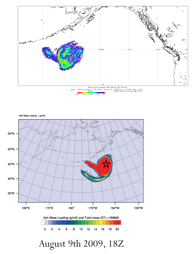
Kasatochi 2008: Satellite and WRF-Chem

Satellite signal (BTD < 0 K)

Total mass ~ 1400 KT

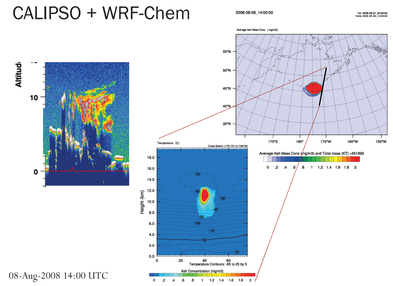
Mass Loading (WRF-Chem)

Total mass ~ 186,900 KT



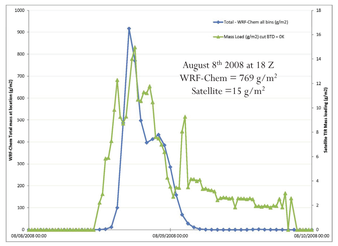
August 9th 2009, 18Z

CALIPSO + WRF-Chem



08-Aug-2008 14:00 UTC

Mass loading at 50N, 160W – Time Series

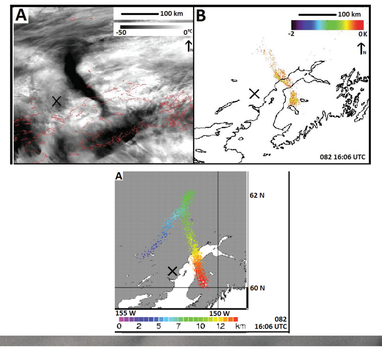


Redoubt 2009 : Events 5 and 19

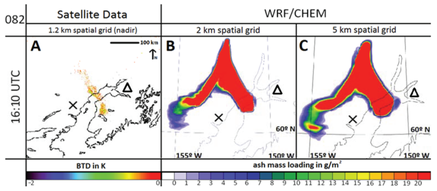
- Event 5
  - Explosive event
  - Start: March 23, 2009 12:31 Z
  - 20 minutes long
  - Plume moved to north-east
  - Plume to 14.9 km ASL
  - S2 type
- Event 19
  - Dome collapse
  - Start: April 4, 2009 13:58 Z
  - 30 minutes long
  - Plume moved to south-east
  - Plume to 15 km ASL
  - S2 type

	Rd 09	Rd 09
# events	19	19
event used	# 5 (best researched)	# 19
eruption time	Mar 23rd, 12:58 UTC	Apr 4th, 13:59 UTC
duration	0:20 h	0:31 h
height	14.9 km	15 km (averaged value)
eruption rate	$4.4x10^7$ kg/s	$4.4x10^7$ kg/s
volume	0.0017 km^3	0.0032 km^3
mass fraction <63 microns	0.4 (*)	0.4 (*)
isopachs	yes	yes

Redoubt 2009 Satellite data v Puff: March 23

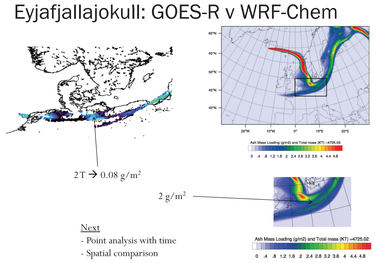


Satellite data v WRF-Chem: March 23 2009



Initial PSD had too much fine (used default ESP of S2)
Initial Eruption rate too high (used Sparks Er)
Lack of BTD to the north-north-east due to local cloud cover

Eyjafjallajokull: GOES-R v WRF-Chem



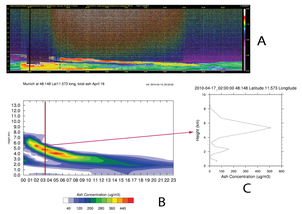
Next
- Point analysis with time
- Spatial comparison

Model Assessment Eyjafjallajökull 2010

Munich LIDAR

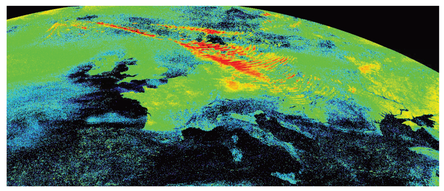
03Z
4 – 5 km
500 ug/m³

Gasteiger et al. (2011)
5 km ASL
650 – 1800 ug/m³



Eyjafjallajökull 2010: Volcanic ash composite

- Raw Composite of Ash Concentrations
- 15 April – 20 April 2010
- SEVIRI Data, each band represents an hour



What is next? – Year 2

Continue

Provide GOES-R height product analysis capability compared to other methods
Analysis of GOES-R algorithm with other remote sensing methods for ash detection
Continue tool developed to compare satellite to model products
Add in additional volcanic events

New

Assess and validate VATD model results compared to GOES-R ash algorithm products

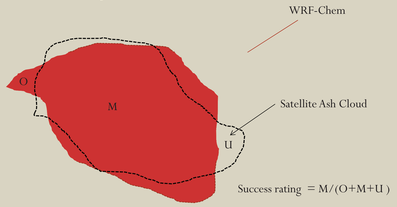
Display the VATD model products and statistical accuracy within AWIPS architecture

Develop new model inputs to improve ESP

'statistical coefficient of the space analysis'

Figure of Merit in Space (FMS)

Take satellite as 'truth' – How good is the match?



Success rating = M/(O+M+U)

M = WRF-Chem matches satellite
O = WRF-Chem overestimates as seen from satellite
U = WRF-Chem underestimates as seen from satellite