The eruption of Mt. Tongariro on August 6th 2012: Operational response and dispersion modelling challenges.

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November 16, 2013

Outline

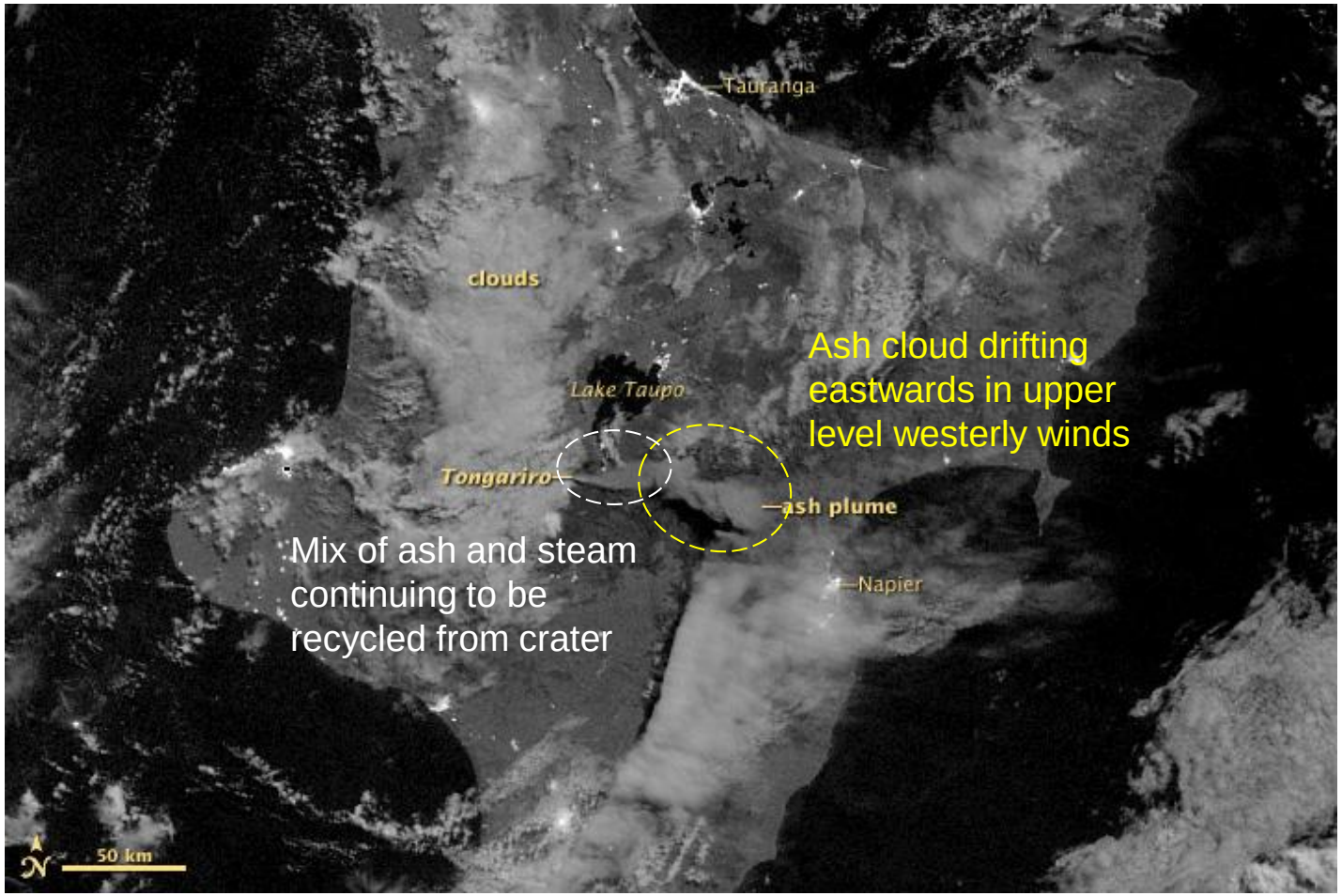
Tongariro (Te Maari) Eruption 06 August 2012
- Wellington VAAC response
- Radar observations
- Developing our use of weather radar for VAAC purposes
- How did our dispersion model do?

VAAC modelling programme

Tongariro (Te Maari) Eruption 06 August 2012

- Eruption time: 11:52:18 UTC.
- Source: Upper Te Maari Crater (1485m amsl); last eruption 1897.
- Eruption sequence:
  - Landslide
  - 2 pyroclastic surges, first east then west, to 2.5km from vent
  - Large vertical plume generating pulse, angled to northeast
  - Second smaller vertical pulse 2.5 minutes later
  - Continued ash recycling and re- emission from crater produced third smaller vertical pulse.
- Ash cloud drifted eastwards to offshore Hawkes Bay producing estimated 231,000 m^3 ash.

Tongariro (Te Maari) Eruption – 06 August 2012

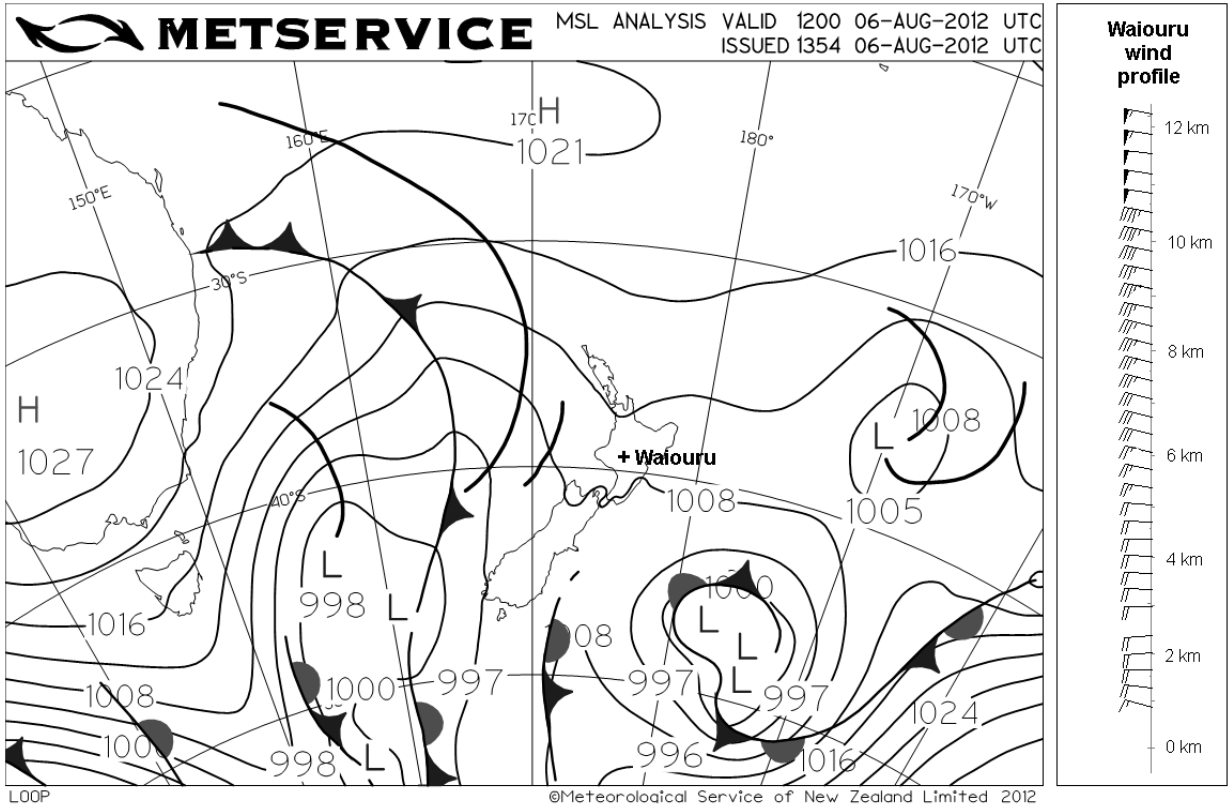


Suomi NPP Satellite, Visible Infrared Imaging Radiometer (VIIRS) day-night band Image

1255 UTC 6 August 2012 (1 hour after eruption)

Image Source: NASA Earth Observatory, Image of the Day

Tongariro (Te Maari) Eruption – 06 August 2012



Meteorological conditions:

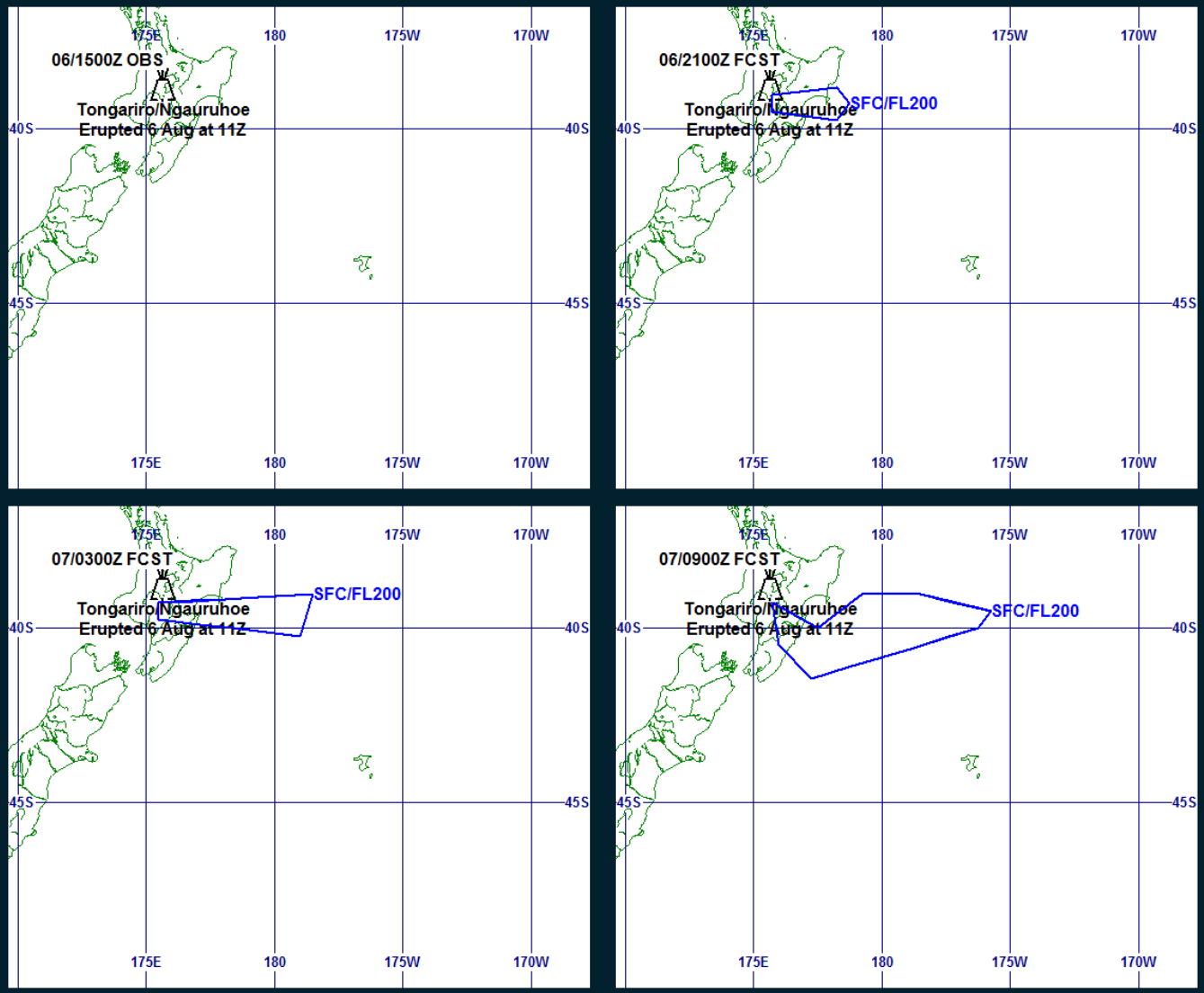
Situation: Weak ridge of high pressure over New Zealand with generally clear skies over the central North Island (few showers moving onto North Island west coast).

Winds: Westerly 20 kt at 2km (amsl), increasing to west-northwest 45 kt at 10km (amsl) over Mt Tongariro at the time of the eruption.

Wellington VAAC response

- 11:52 pm (NZDT) August 6: Eruption
- GNS
  - 12:25 am August 7: VAB - aviation colour code red
  - 12:30 am: VONA - *Volcanic Cloud Height unknown*
  - No camera at Te Maari craters at the time
- 2:32 am: first VAA issued - SFC/FL200; source of information GNS/PIREP. Last VAA issued: 5:26 am August 9.
- The initial lack of a good plume height estimate will have decreased the confidence in dispersion model runs and dependent VAA/VAGs.
- Some time later Severe Weather Forecaster John Crouch discovered that the eruption was captured well by dual-pol C-band weather radar...

Wellington VAAC response



Weather radar coverage of central North Island volcanoes

Tongariro/Ngauruhoe/Ruapehu volcanoes covered by 3 radars

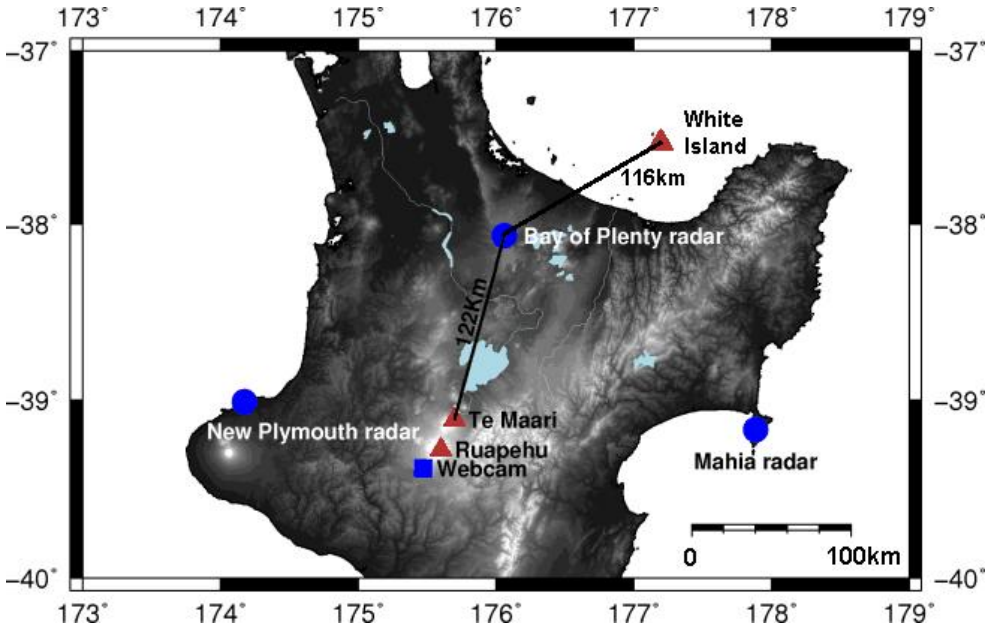
- Bay of Plenty (dual pol C-band)
- Mahia (dual polarisation C-band)
- New Plymouth (single pol C-band)

White Island (and Rotorua area) covered by Bay of Plenty and Mahia radars.

Bay of Plenty radar provides 'best' unobstructed data for both volcanic areas.

Bay of Plenty radar specifications:

- 7.5 minutes task cycle,
- 200 metres range bin spacing,
- 0.95 degree beam width,
- 15 beam elevations - 0.5 to 20 degrees,
- Horizontal Reflectivity (Z_H), Radial Velocity (V), Differential Reflectivity (ZDR), Correlation Coefficient (RhoHV), Differential Phase (PhiDP), Specific Differential Phase (Kdp).

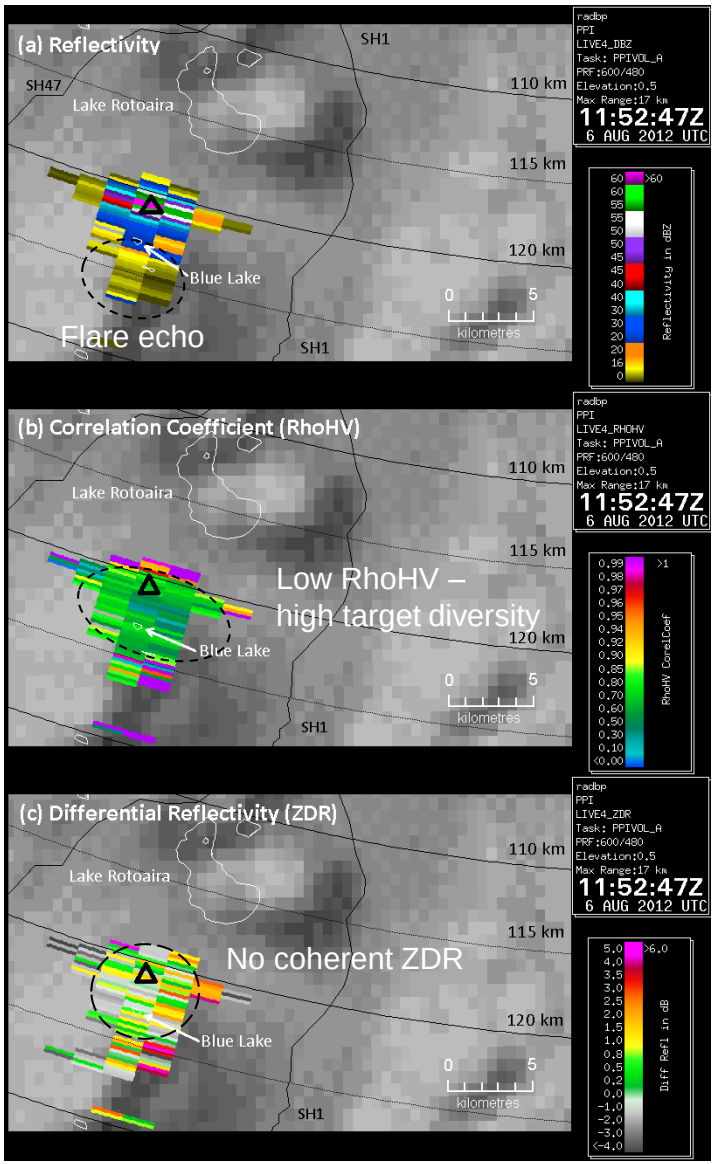


Bay of Plenty C-band Weather Radar	Distance from radar	0.5° Beam Centre Height	0.5° Beam Centre Height above crater
Upper Te Maari Crater (1485m)	122 km	2.6 km (amsl)	1.1 km
White Island (30m)	116 km	2.4 km (amsl)	2.4 km

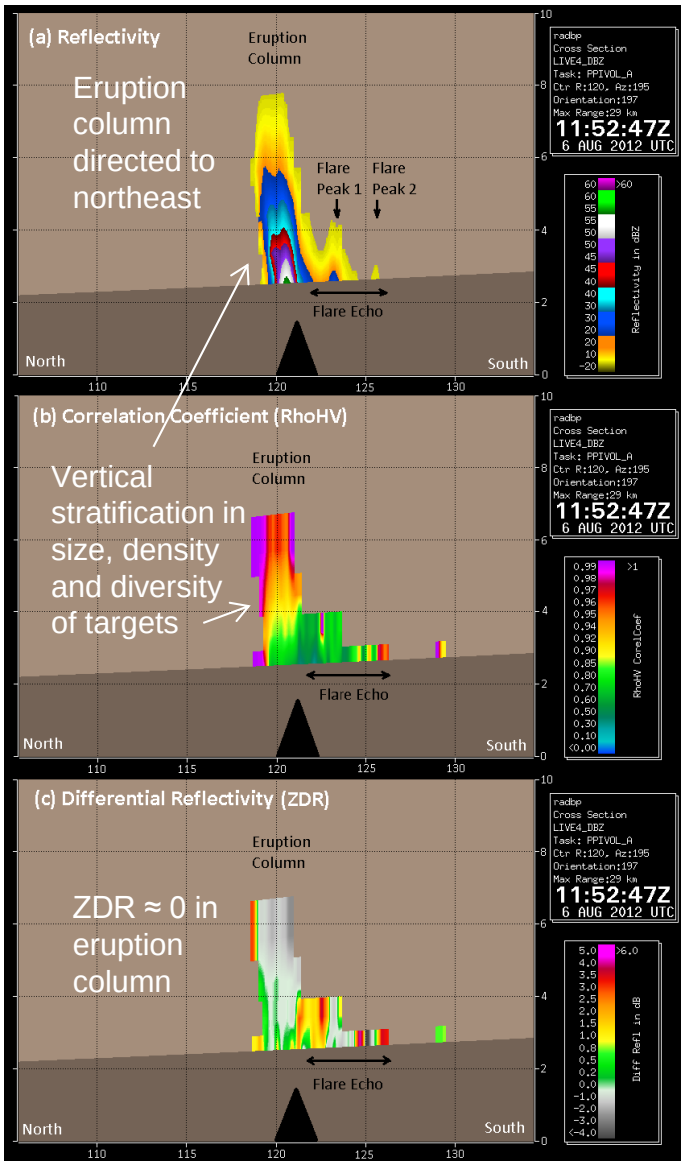
slide courtesy of John Crouch

Tongariro (Te Maari) Eruption – 06 August 2012 – 11:52 UTC

0.5 degree PPI



North-South cross-section



Eruption!

Initial scan within 1 minute of the eruption.

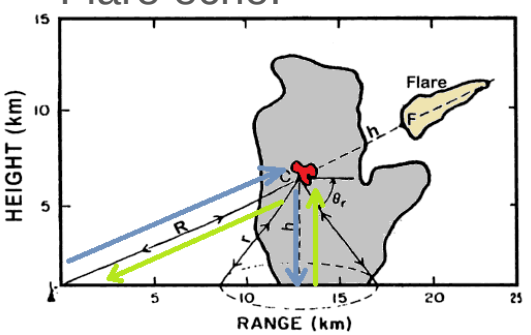
Vertical cross-section shows first 2.5 minutes of eruption.

Max reflectivity 61dBZ

Decreasing dBZ and increasing RhoHV with height in eruption column.

Flare peaks about twice beam-ground distance.

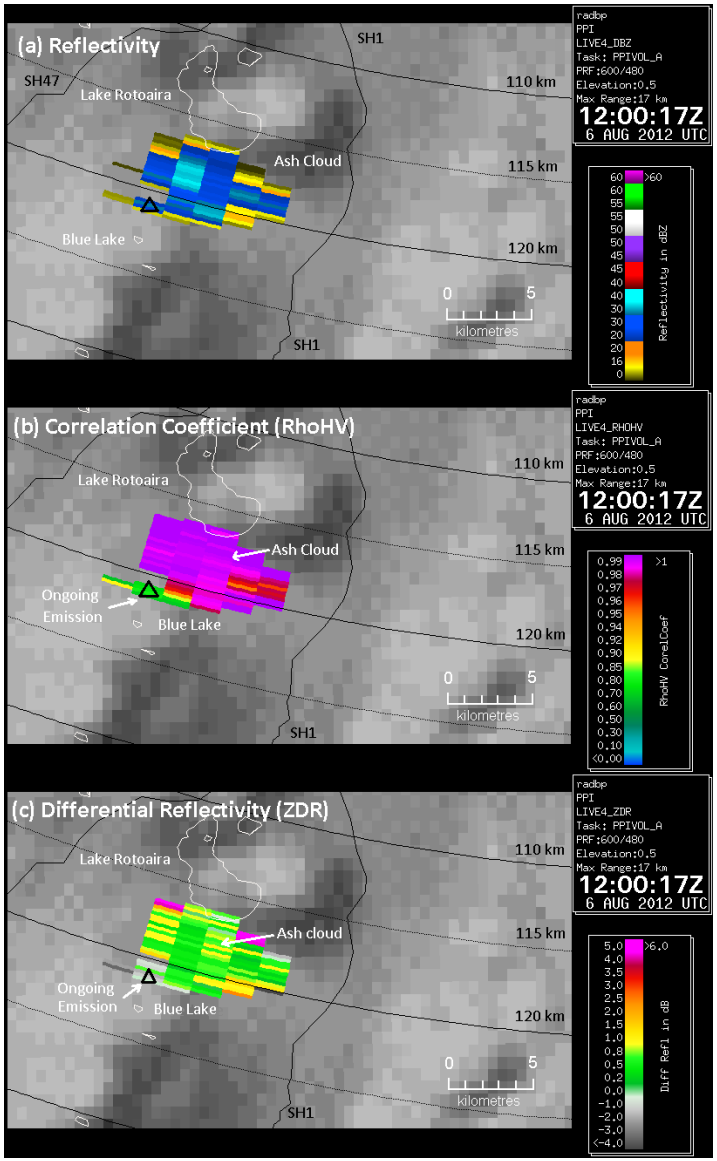
Flare echo:



slide courtesy of John Crouch

Tongariro (Te Maari) Eruption – 06 August 2012 – 12:00 UTC

0.5 degree PPI



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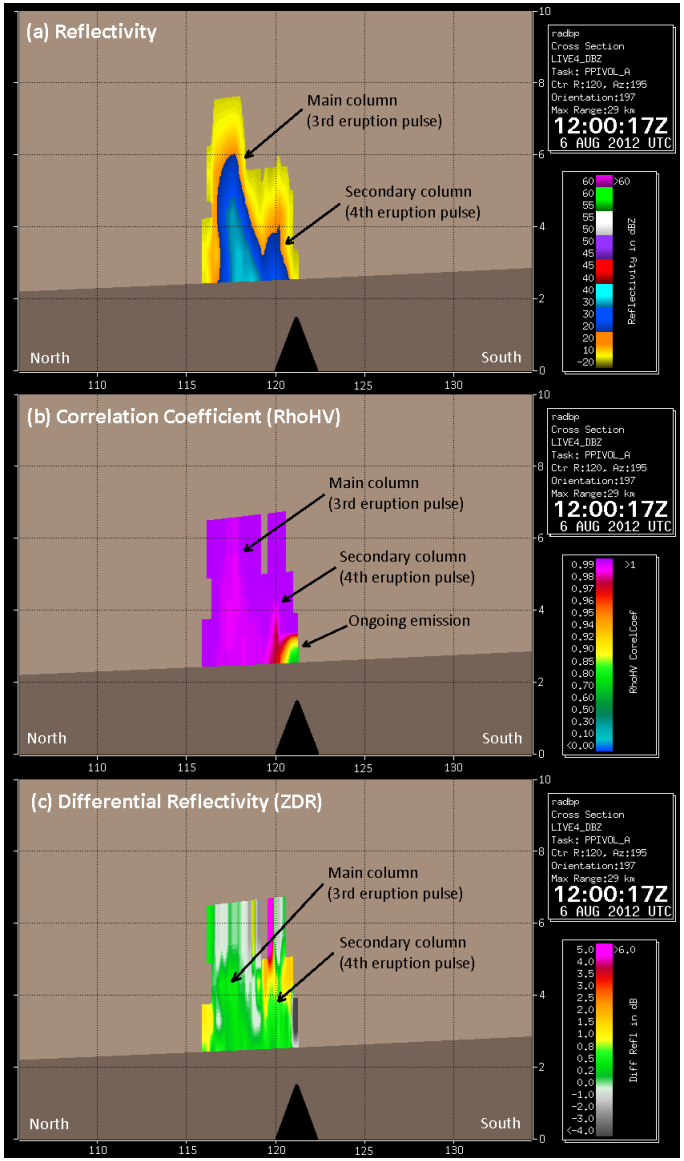


Higher reflectivities associated with larger falling ash particles.

High values of RhoHV associated with ash cloud (small target diversity).

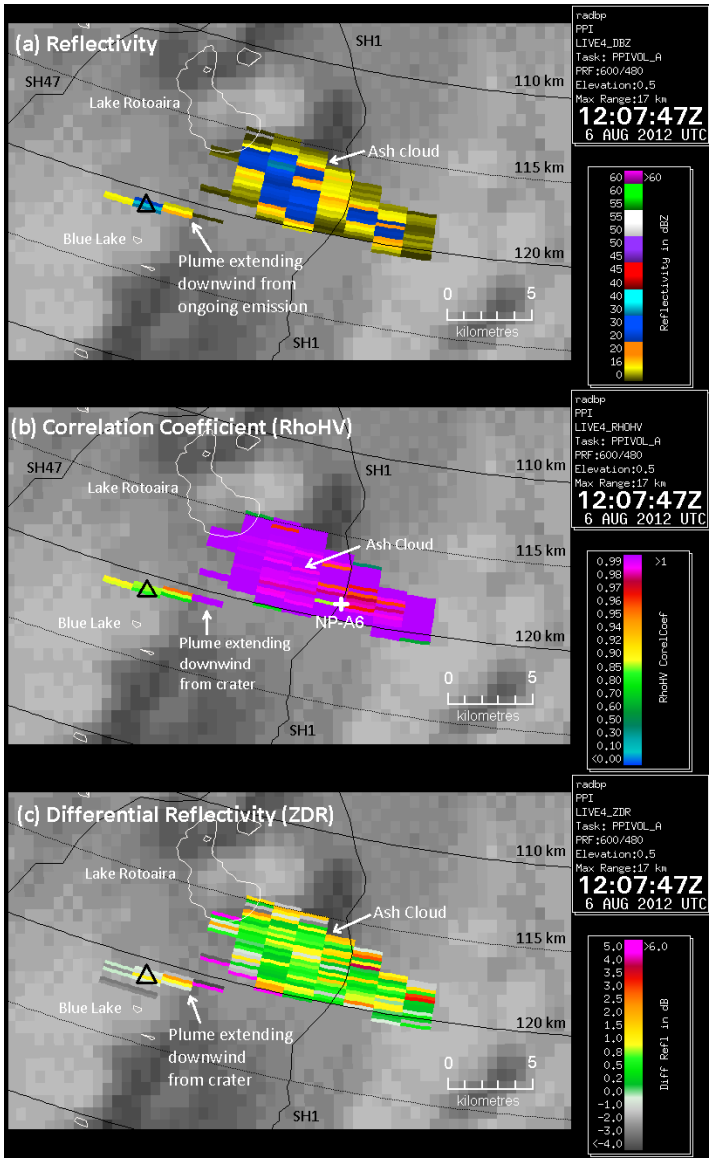
Low values of RhoHV associated with ongoing emissions from crater (high target diversity).

Positive values of ZDR (0 to 1 dB) associated with higher values of reflectivity in ash cloud (larger ash particles falling with preferred horizontal orientation).

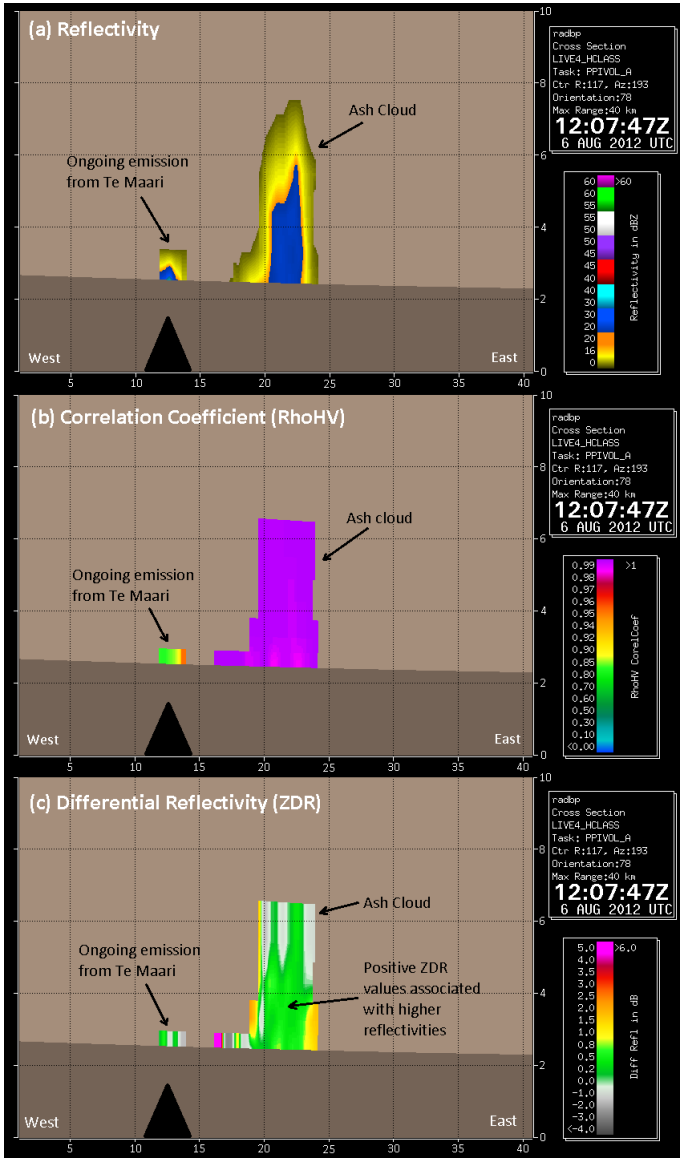
slide courtesy of John Crouch

Tongariro (Te Maari) Eruption – 06 August 2012 – 12:07 UTC

0.5 degree PPI



West-East cross-section



Ash cloud detached from vent and drifting away, but emissions ongoing from Upper Te Maari crater (recycling).

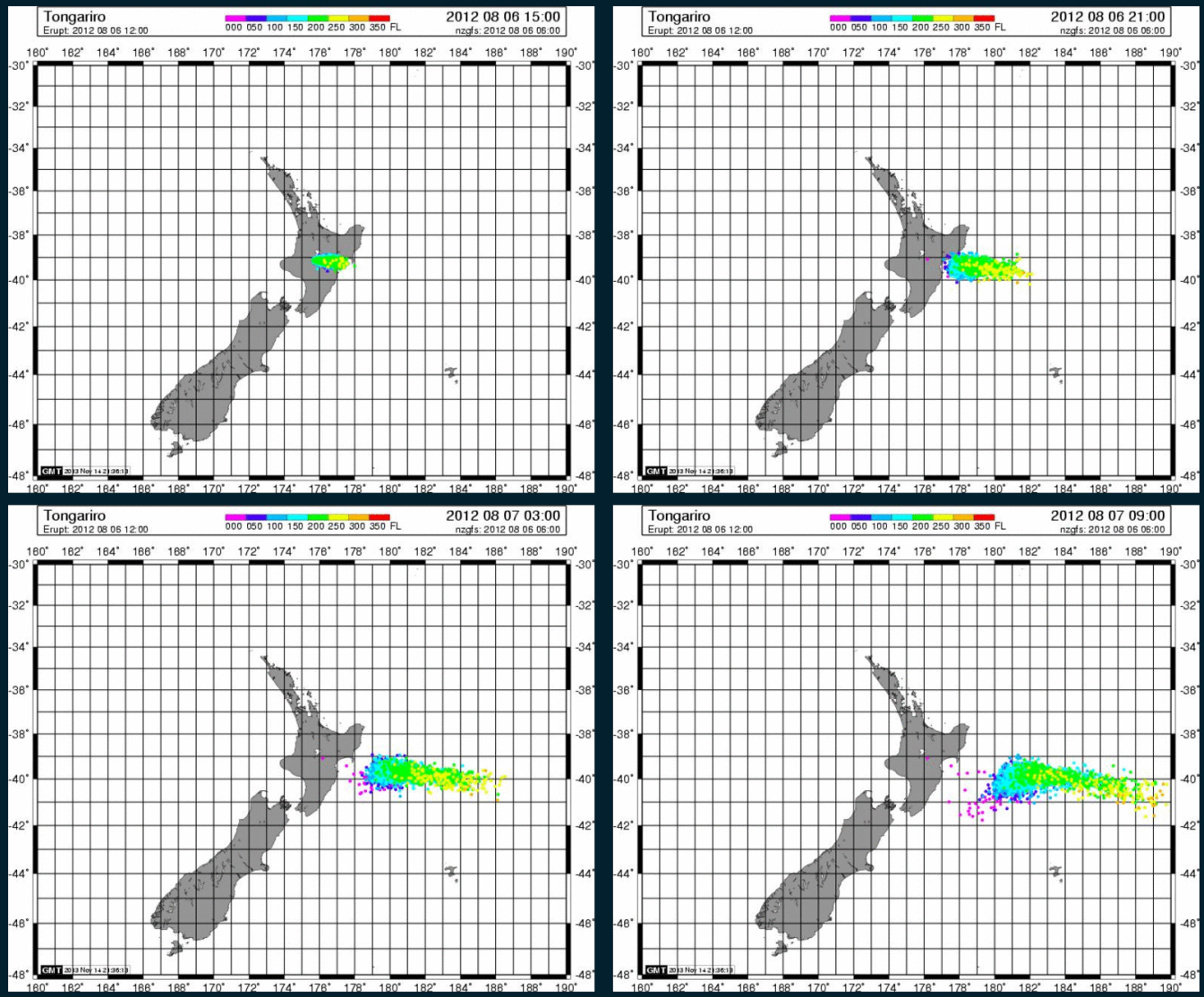
RhoHV values high in ash cloud, but some variation at low levels (higher reflectivities).

RhoHV values remain low in ongoing emission from Te Maari.

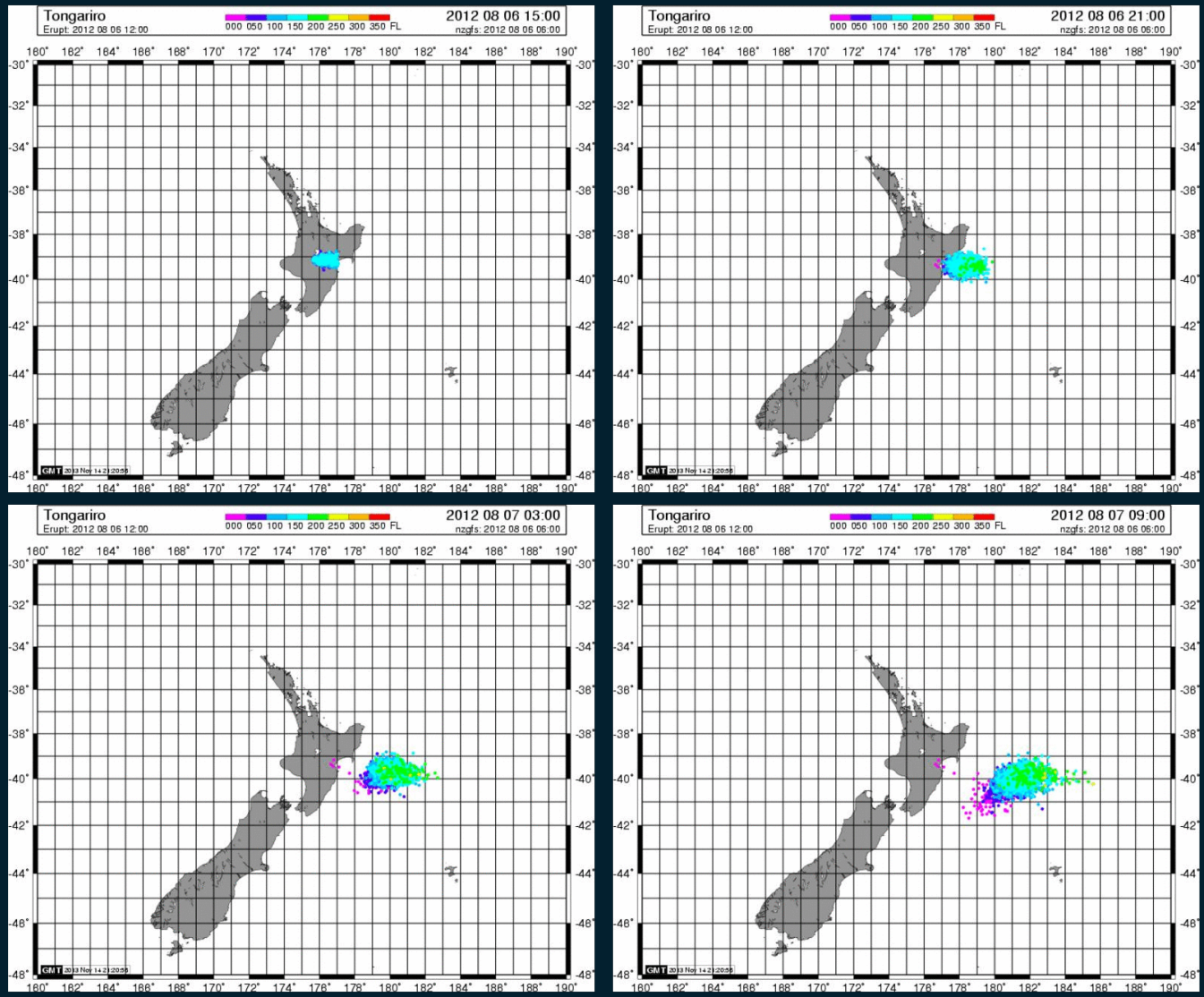
Positive ZDR values (0 to 1) associated with higher reflectivities (larger ash particles falling with preferred horizontal orientation).

slide courtesy of John Crouch

PUFF re-run with 8km plume height



Original PUFF run (16000 ft plume height)



Developing our use of weather radar for VAAC purposes

- Three smaller recent eruptions have also been observed by Metservice weather radar
  - the second eruption of Upper Te Maari crater (21 November 2012).
  - two small eruptions at White Island (20 August, 11 October 2013)
- Training for VAAC forecasters on interpretting radar imagery.
- John Crouch is working with the IRIS system on automatic eruption detection by dual-pol radars. Currently enabled for Bay of Plenty radar.

How did our dispersion model do?

- PUFF-UAF (version 2.1.2), driven by GFS (1 degree, 12 pressure levels) only
- From forecaster feedback: Good agreement with satellite observations for the first 6 hours, but after this the areal extent of the forecast ash cloud became progressively too large.
    - this is a frequent complaint of our dispersion modelling system, which may be largely due to the way output is plotted.

VAAC modelling programme

Key recommendations from WMO best practices Inputs/Outputs workshop that we do not yet follow:

- VAAC model output should be quantitative
  - mass loading
  - ash cloud top height
  - both of these are observable by satellite
- models should include wet deposition
- various sources of driving NWP should be available
- adequate vertical/temporal/horizontal resolution of driving NWP

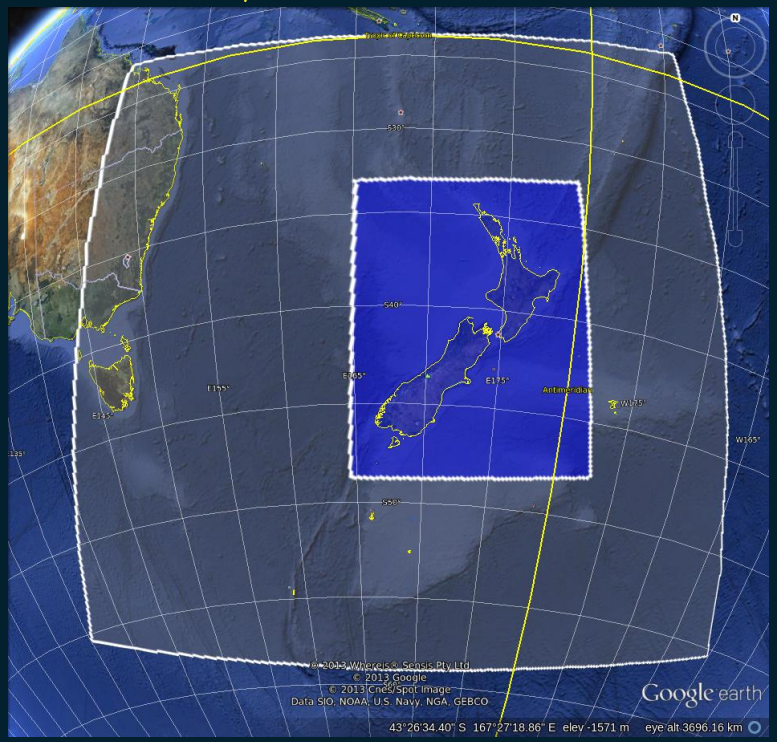
How our new system might look

- HYSPLIT
- quantitative outputs
- multiple NWP sources
  - 8km WRF over NZ (driven by at least GFS and ECMWF, 51 vertical levels, hourly data)
  - GFS 0.5 degree 3 hourly 25 vertical levels
  - ECMWF 0.125 degree data (preferrably on sigma levels)
  - this set can be easily expanded if deemed worthwhile

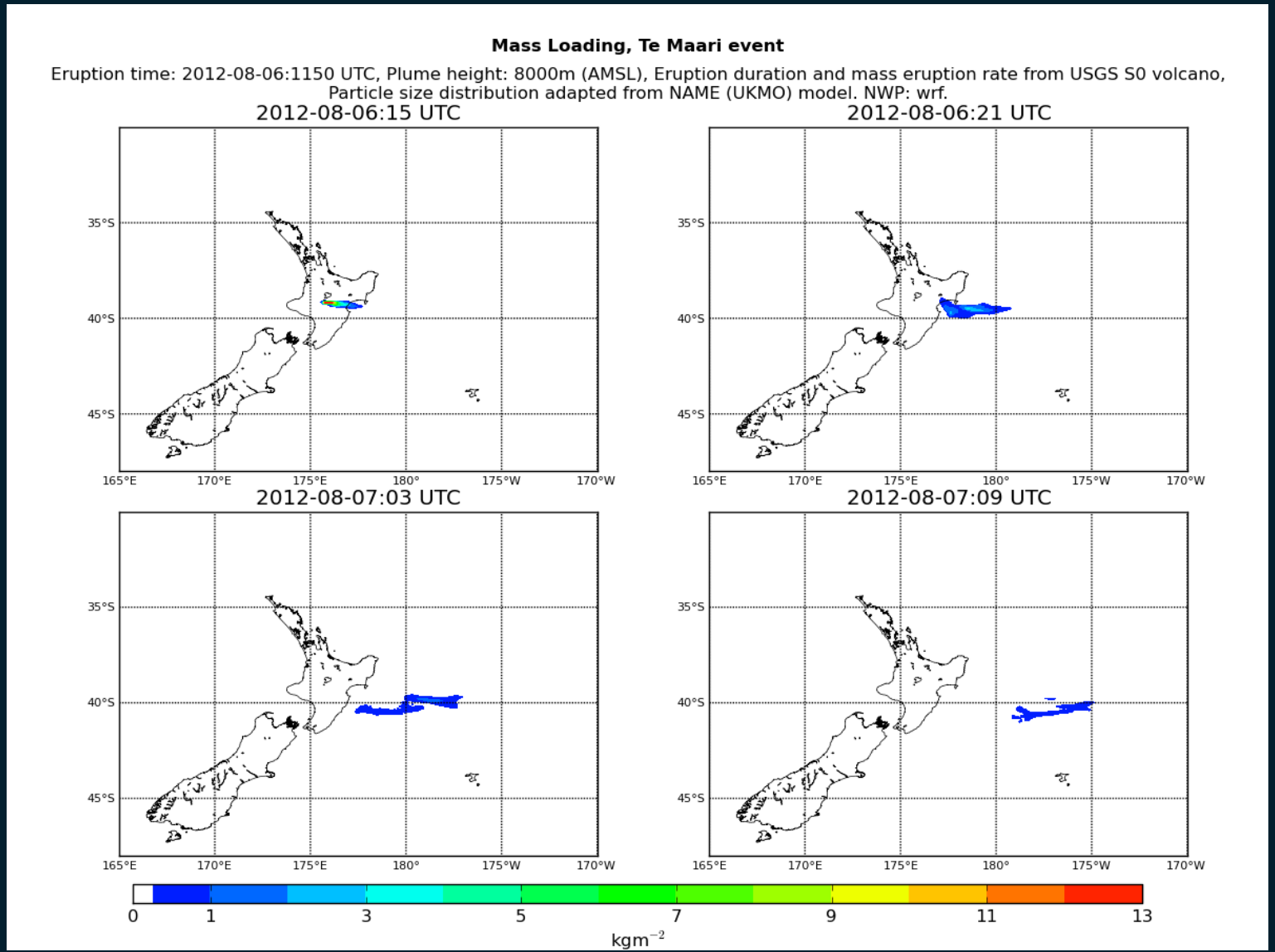
How our new system might look

HYSPLIT can take several NWP grids and pass pollutants from global to local area models, using the highest resolution available at a given location.

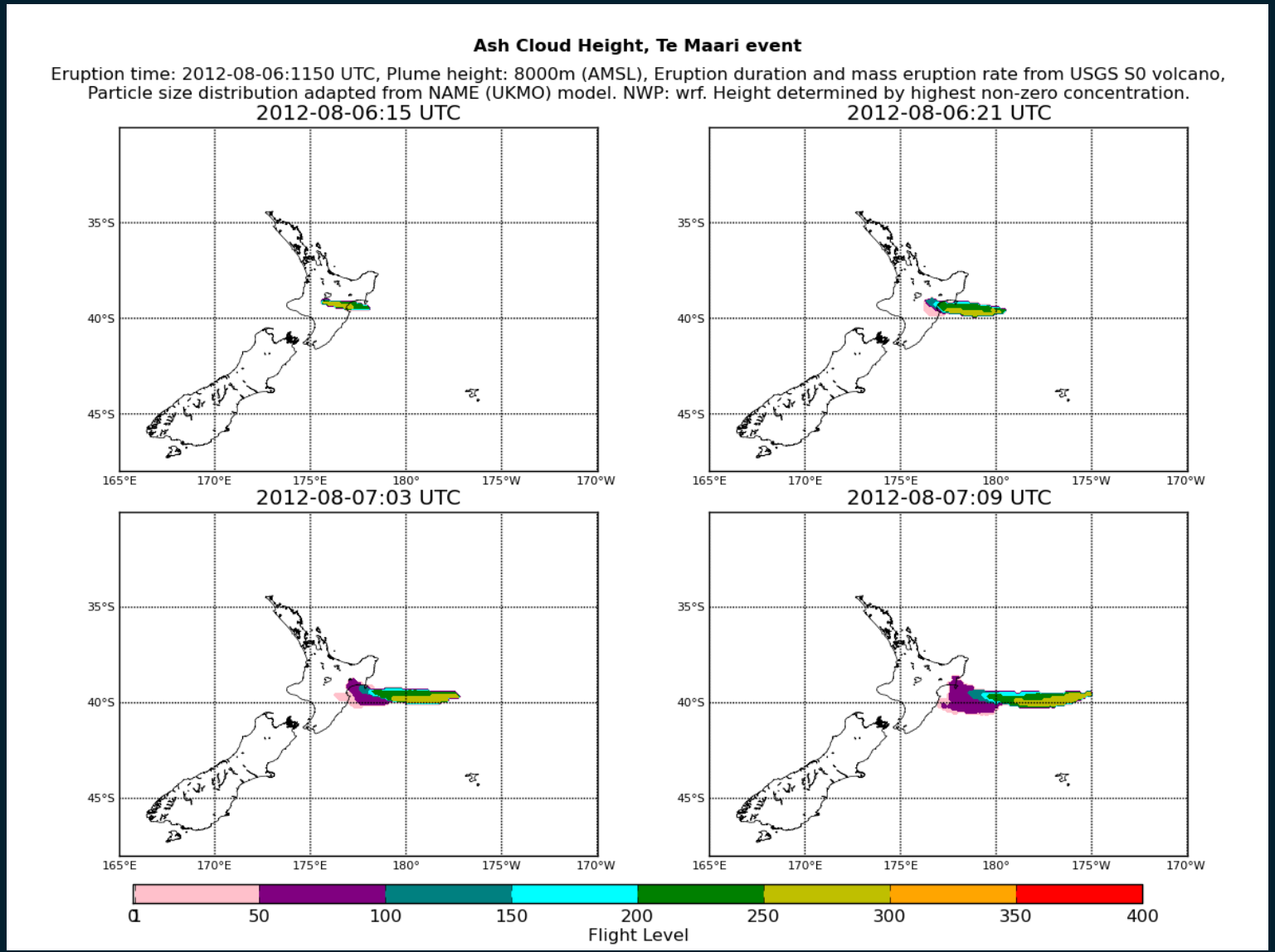
24km/8km WRF nests



Example output



Example output



First project - underway

- Along with VAAC forecasters, define requirements for pilot system
- using case studies, establish value of
  - multiple NWP sources
  - vertical resolution
- default eruption parameter specification: Mastin curve (plume height to MER) or or USGS categorized eruptions?
- alternative particle size distributions
- desired output, graphics specification, temporal resolution, and averaging.
- How many parameters should be settable by forecasters?

Thankyou for your attention!