A-train Observations of Volcanic Cloud-Top Height and Thickness for the 2008 Chaitén Eruption

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1. Introduction

Chaitén experienced three major eruptions on 2, 6 and 8 May 2008 (Carn et al., 2009). The ash clouds were long-lived and were subject to long range (4000 km) transport, putting aircraft at risk. The A-train passed over the event several times during 2-10 May and captured the synoptic scale movement of the ash clouds. The need for accurate ash detection and high resolution measurements of Volcanic Cloud-Top Height (VCTH) was highlighted by this event.

1. (a) Hyperspectral infrared ash detection

- Natural extension to traditional broadband ash detection algorithms (e.g. Prata et al., 1989b).

1. (b) Ash detection algorithm

- From the available AIRS channels, 12 are selected and averaged to form 4 “ash” channels.

\[ BT_1 = \sum_{i} w_i BT_i \]

- The ash channels are combined to give a single brightness temperature difference, as follows.

\[ \Delta BT_{c} = BT_1 - BT_2 + BT_3 - BT_4 \]

- Criteria (1) and (2) must be met before the AIRS pixel is deemed ash affected.

\[ \Delta BT_{c} > \Delta T_{c} \quad (1) \]

\[ BT_{c} < T_h \quad (2) \]

where, \( \Delta T_{c} \) is a threshold set to eliminate noise and false detections from clear scenes and \( T_h \) is a threshold set to eliminate false detections due to low elevation dust aerosol over land.

1. (c) 5 May 2008 at 15:17 UTC

2. Data and methods

- **AIRS**
  - Hyperspectral infrared brightness temperature difference algorithm applied to AIRS for ash detection.

- **CALIOP**
  - Collocation of CALIOP profile to allow ash detection within 532 nm backscatter profiles.

- **Thresholding algorithm** used to extract height information at high resolution.

- **HYSPLIT**
  - Back trajectories used to verify heights and to estimate initial VCTHs.
  - Forward trajectories used to generate a dummy forecast.

3. Results and discussion

- Setting, \( \Delta T_{c} = 2 \) K and \( T_h = 290 \) K, was best compromise between false detections and clear ash signal.

- 12 VCTHs and thicknesses recorded. Heights ranged from 3.68-16.56 km with an average height of 7.74 km.

- Thicknesses ranged from 270-670 m with over 80% of thicknesses being less than 400 m.

- Volcanic ash detected and tracked for 72 h at distances of up to 4000 km from the source.

- Back trajectories allowed determination of volcanic ash when two or more features were present in the vertical but at the same location in the horizontal.

- Initial plume heights of 4, 4.5 and 5 km estimated from back trajectory analysis, were used to create a dummy forecast.

- Dummy forecast agreed well with observations.

3. (b) 5 May 2008 at 18:29 UTC

4. Conclusions and future work

- **Ash detection algorithm** is simple, fast and effective.
- **AIRS/CALIOP method** is able to detect and quantify thin ash layers.
- **Back trajectories** initialised with CALIOP heights were useful in estimating initial VCTHs.
- Long-lived ash clouds that were transported large distances were likely to have travelled through the mid-troposphere (4-5 km).
- Intend to apply method to different eruptions (test robustness) and use different meteorological datasets to test sensitivity of HYSPLIT.

References
