A stereoscopic Approach to obtain Volcanic Ash Cloud Top Heights

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1 Objective

Considering the volcanic eruption of Eyjafjallajökull in 2010, which affected air traffic, a stereoscopic approach to obtain information on ash cloud top heights using data from Meteosat-8 and Meteosat-9, is analyzed. Ash plume height is the major parameter for atmospheric dispersion modelling and therefore a major factor in air traffic management.

The main objective is to evaluate if a stereoscopic analysis of Meteosat-8 and Meteosat-9 images is suitable for this purpose.

2 Process Chain

The emitting characteristic of ash clouds in the atmospheric window region between 10 µm and 12 µm wavelength is different to water clouds. Therefore this split-window brightness temperature difference is useful in reliably locating plumes of ash from volcanic eruptions.

A pre-processing of the data in time is neccessary, as Meteosat-8 and Meteosat-9 scan the Earth displaced in time. Furthermore a spatial mapping transforming the dataset of Meteosat-8 into the grid system of Meteosat-9, is applied. Afterward, a pair of images from both satellites can be combined to a 3D stereo image.

The depth information of this stereo-pair is represented by points, that show the same spot of an ash cloud in both images. Those matching points are located using a pyramid-based correlation as suggested by Zakšek at al, 2013. Once the matching points are found, their positions are converted to the 3D coordinate system of the Earth (Fig. 1).

The next step is to determine the actual spot of the ash cloud represented by the intersection point between the corresponding points and the satellites. There are two methods suited to find the location of the intersection point: a geometric-based approach (Aschwanden, 2011) and an approach using vector algebra (Zašek et al, 2013). Only the vector algebra-based method is used for the following calculations because in contrast to the geometrical approach, it can be easily adjusted to the slightly changing positions of the satellites. Finally, the Volcanic Ash Cloud Height (VACH) is obtained by substracting the earth radius from the located point of intersection.

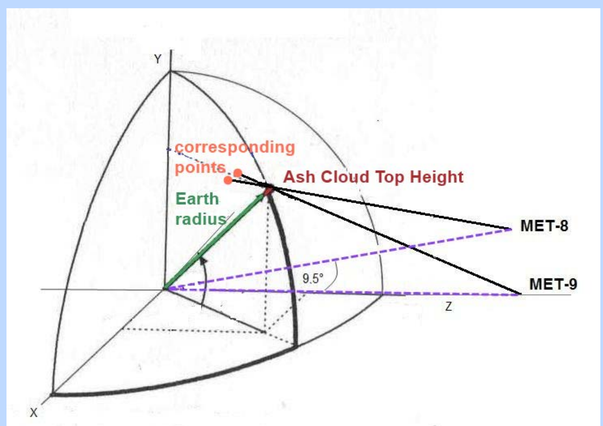


Fig. 1. Illustration of corresponding points, ash cloud top height, earth radius and positions of the Meteosat satellites.

3 Accuracy of Height Assignment for Europe

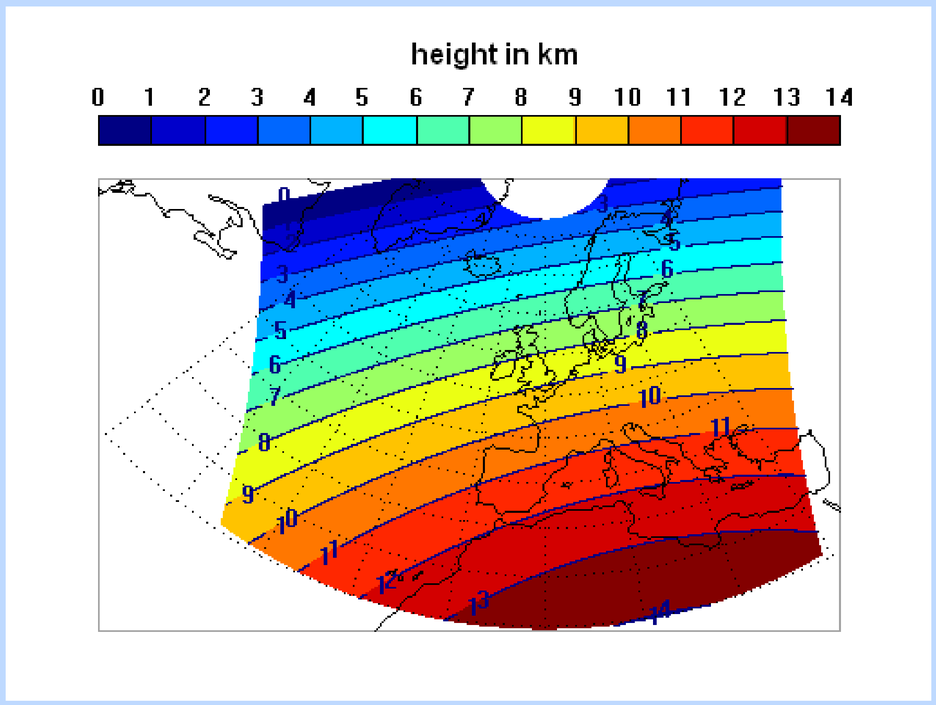
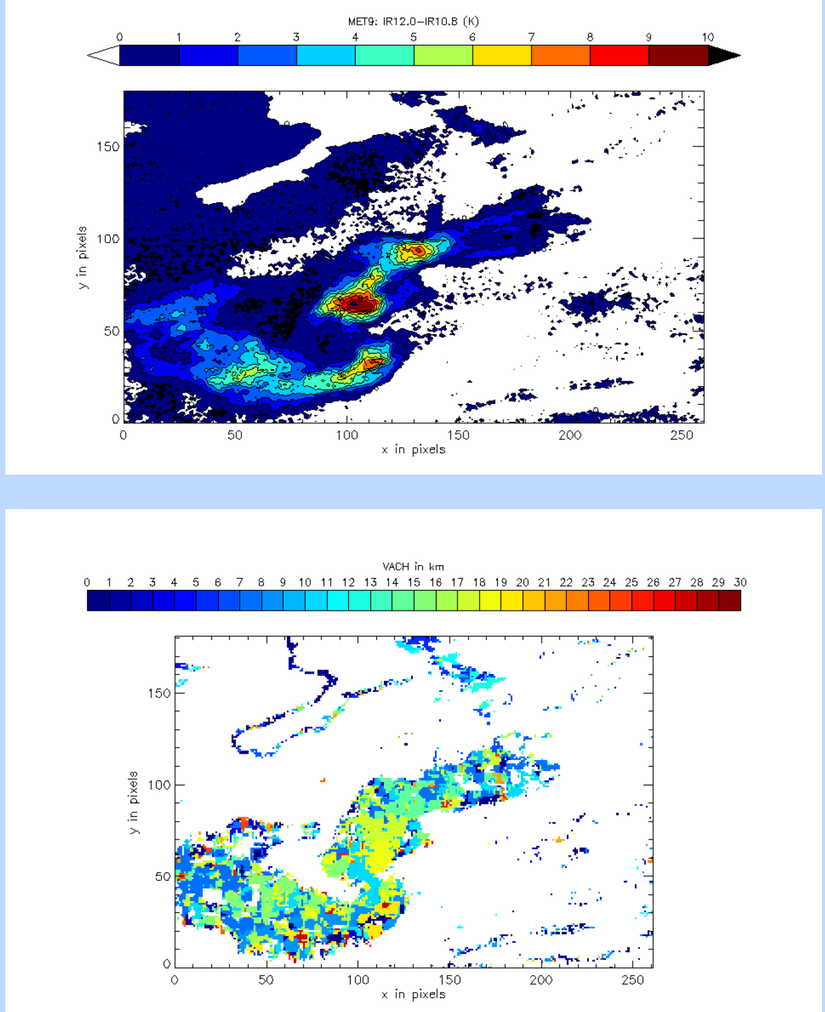


Fig. 2. The height assignment for a constant shift in x-direction between both Meteosat datasets of one pixel shows that the possible accuracy of calculation of VACH mainly depends on the poor spatial resolution of the Meteosat images and the scan angle.

4 Case Study: Eyjafjallajökull Eruption in 2010

07 May 2010 03:00 UTC | **12 May 2010 03:15 UTC**



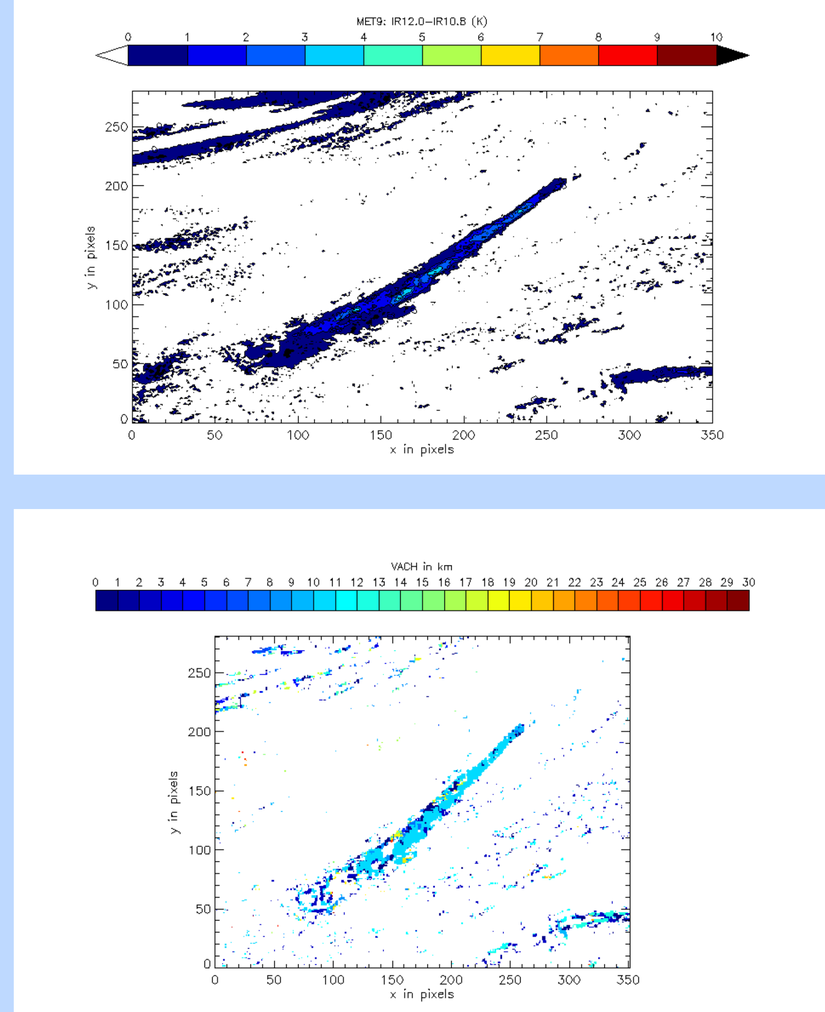


Fig. 3. Ash cloud top heights obtained by using the described process chain. Two cases of volcanic ash events within the Meteosat fields of view have been selected: 07 May 2010, 03:00 UTC (left) and 12 May 2010, 03:15 UTC (right). Region of Interest (ROI): about 10° to the south of Iceland. Top: Brightness temperature differences IR12.0 – IR10.8 (K) of Meteosat 9 data for the ROI. Bottom: Calculated VACH (km) for the ROI.

For the two cases VACH up to 20 km (left) respectively around 10 km (right) are assigned. Compared to measurements these obtained values are overestimated. The difference is caused by the poor resolution of Meteosat data and due to the small angle of the steroscopic view of the Meteosat satellites.

References:
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