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Assimilating Aircraft-based measurements to improve the State of Distal Volcanic Ash Cloud

Guangliang Fu (1), Hai Xiang Lin (1), Arnold Heemink (1), Arjo Segers (2), Sha Lu (1), and Thorgeir Palsson (3)

(1) Dept. of Applied Mathematics, Delft University of technology, Mekelweg 4, 2628 CD Delft, The Netherlands (g.fu@tudelft.nl), (2) TNO, Dept. of Climate, Air and Sustainability, P.O. Box 80015, 3508 TA Utrecht, the Netherlands (arjo.segers@tno.nl), (3) School of Science and Engineering, Reykjavik University, 101 Reykjavik, Iceland (tpalsson@ru.is)

The sudden eruption at the 1666 m high, ice-capped Eyjafjallajökull volcano, in south Iceland during 14 April to 23 May 2010, had caused an unprecedented closure of the European and North Atlantic airspace resulting in global economic losses of US$5 billion. This has initiated a lot of research on how to improve aviation advice after eruption onset. Good estimation of both the state of volcanic ash cloud and the emission of volcano are crucial for providing a successful aviation advice.

Currently most of the approaches, employing satellite-based and ground-based measurements, are in the focus of improving the definition of Eruption Source Parameters (ESPs) such as plume height and mass eruption rate, which are certainly very important for estimating volcano emission and state of volcanic ash cloud near to the volcano. However, for ash cloud state in a far field, these approaches can hardly make improvements. This is mainly because the influence of ESPs on the ash plume becomes weaker as the distance to the volcano is getting farther, thus for a distal plume the information of ESPs will have little influence.

This study aims to find an efficient way to improve the state of distal volcanic ash cloud. We use real-life aircraft-based observations, measured along Dutch border between Borken and Twist during the 2010 Eyjafjallajökull eruption, in an data assimilation system combining with a transport model to identify the potential benefit of this kind of observations and the influence on the ash state around Dutch border. We show that assimilating aircraft-based measurements can significantly improve the state of distal ash clouds, and further provide an improved aviation advice on distal ash plume. We compare the performances of different sequential data assimilation methods. The results show standard Ensemble Kalman Filter (EnKF) works better than others, which is because of the strong nonlinearity of the dynamics and the EnKF's resampling Gaussianity nature. Furthermore, another important aspect of data assimilation methodology related to time-correlated errors is also investigated. The result shows for assimilating aircraft-based timely measurements in a far field, time-correlation of model errors on the state is critical to the performance of the assimilation system.