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Estimating volcanic ash emissions by a chemical "Sequential Importance Resampling Smoother"

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The 2010 eruption of the Icelandic volcano Eyjafjallajökull instigated interest in the ability to increase the forecast skills of ash concentrations, which is of special interest for air traffic control, amongst others. To date, it is not possible for forecast models to make quantitative predictions of ash concentrations.
The objective of this work is to develop a novel method to significantly reduce this problem by improving the emission parameters of volcanic eruptions. The method generalizes the Sequential Importance Resampling Filter algorithm to a smoother method to deal with time reversed observation–emission–relationships. For this reason, the EURAD-IM model is extended to an ensemble system. To handle the large requirements of computer power, this ensemble system is implemented on the JUQUEEN supercomputer at Forschungszentrum Jülich.
The algorithm spawns the ensemble members according to their weights, which are proportional to the conditional probability of the observations given the model state. The smoother property is realized by adjoint integration back to the volcanic source and serves to combine multiple observations.
The Sequential Importance Resampling Smoother was tested for April 14, 2010, which is the first eruption day of the Icelandic volcano Eyjafjallajökull. The test was performed with artificial observations, which were arranged according to the CALIPSO satellite, in an identical twin context.
The system proofs to perform remarkably well. For the *biased* test case, which uses different emission heights as were used for the nature run, the RMSE of the weighted ensemble mean as well as the ensemble spread were reduced by 60 % and 95 %, respectively. The total emitted mass concentration of the a posteriori run differs slightly from the emitted mass concentrations of the nature run. The rank histograms of the a posteriori estimate show a flattened shape compared to a priori estimate, which indicates a reliable system for the test case.
By applying the results from this work, the Sequential Importance Resampling Smoother appears to provide a critical step forward toward quantitatively forecast ash concentrations. Although the algorithm was tested for volcanic eruptions, it is applicably for other emission scenarios as forest fires or see-salt uplift event as well as initial value issues.