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WORKING PAPER

INTERNATIONAL VOLCANIC ASH TASK FORCE (IVATF)

FIRST MEETING

Montréal, 27 to 30 July 2010

Agenda Item 7: Improvement and harmonization of dispersion models and their visual presentation (IAVW Coordination Group)
7.1: Need for additional work on dispersion models

VOLCANIC ASH TRANSPORT AND DISPERSION MODELING

(Presented by the United States)

SUMMARY

The quality of output from volcanic ash transport and dispersion models depend on the accuracy of the input meteorology, the eruption source parameters, the simulation of the atmospheric processes affecting the ash, and other factors. This paper addresses the need for improvements in model performance, in particular to meet the needs for levels of concentration. .

1. INTRODUCTION

1.1 Accuracy of volcanic ash transport and dispersion models depend on the accuracy of the input meteorology, the eruption source parameters, the simulation of the atmospheric processes affecting the ash, and other factors. Due to high uncertainties of the model output, forecasters use the model output only as guidance, and along with observations and other information, develop Volcanic Ash Advisories and SIGMETs. More evaluation of model output with respect to observations is needed, both in terms of spatial ash patterns and ash concentrations. Additional evaluation of ash tolerance concentration levels are needed to assess their uncertainty before using them as a basis to interpret model output. Since model output drives the forecast portion of Volcanic Ash Advisory Center (VAAC) / Meteorological Watch Office (MWO) for large eruption, international harmonization of model output is needed.

1.2 Discussion in this paper focuses on the use of dispersion models with proposed recommendations for improvements in model performances. These recommendations are based on the experiences by the U.S.

2. DISCUSSION

2.1 Given the recent WMO workshop on volcanic ash (Santiago, Chile, 2010) there is a need for the VAACs to further evaluate the numerical models within the constraints that no one meteorological model, transport and dispersion model, observation, forecaster, etc. is perfect.

2.2 The following contribute to the model output concentration uncertainty and are described briefly below: source term, meteorology, and physical processes. The model starts from the eruption column; dynamics of the column itself are not modeled.

Source term, also called eruption source parameters:

a) Model output concentration is proportional to the initial mass. For example, if the initial mass is 100 milligrams, and the calculated concentration is 1 mg/m^3, then if the initial mass is 1000 mg (ten times greater), the concentration will be 10 mg/m^3 (ten times greater);

b) Particle mass-size range distribution and particle distribution in vertical (including specifying the top and bottom. Temporal variability of mass eruption rate, mass distribution in the vertical, and ash column top/bottom height can contribute to the model output uncertainty. With common change in wind speed and/or direction with height (wind shear), knowing the top height and layer depth is important;

c) Start and stop time of eruption. Can affect total mass of ash being modeled. Variability of the 3-d meteorology with time can affect the output uncertainty especially if the start and stop time(s) are uncertain;

d) Knowing these values in real-time can be a challenge

Meteorology:

a) Accuracy of the driving/underlying meteorology. In some regions of the area of responsibility of the Washington VAAC, especially South and Central America, sometimes the meteorological model winds have differed from that inferred by the observed volcanic ash cloud location, possibly because of more uncertainty in the data initializing the model in those regions. In addition, recent studies have shown that the impact of environmental winds have a controlling influence on plume height and therefore transport patterns especially in high shear environments (Bursik, 2001); hence it is critical to properly initialize the plume column top and bottom, or account for their uncertainty;

b) Meteorological conditions. For example in a spatially uniform, time invariant, 3-d flow field, uncertainty of the meteorology will be relatively low, but in a spatially varying, and time varying, 3-d flow field, the uncertainty will be higher.

Physical processes:

a) Gravitational settling;

b) Aggregation. Causes more ashfall, hence less airborne ash. This is not currently simulated by U.S. VAAC-issued model output;

c) Wet deposition can also increase ashfall. This is currently not included in U.S. output to provide a more "conservative" estimate of the amount of ash remaining airborne because precipitation forecasts generally are more uncertain that other parameters forecast by meteorological models. Wet deposition is currently being added to the model output guidance.

2.3 An ensemble approach is one way to account for some of the uncertainty. For instance, the model can be run many times, each time with a realistic variant of one of the uncertain parameters (e.g. ash amount, ash column height, eruption start time and duration, input meteorology dataset, with and without wet deposition, etc.). Taken as a whole, the variability of the ensemble members' output gives an indication of the uncertainty associated with that particular ash forecast. For instance, maps showing the 90th percentile concentration or number of ensemble members with ash concentration greater than zero, particularly if they are run in a coarse mode to minimize computer run time, may be useful in interpreting the output from the single traditional deterministic run.

2.4 Limited model evaluation has been done with respect to observations, e.g. current operational satellite products showing ash spatial extent and top height and other observations. Unfortunately, there are uncertainties and limitations to observational capabilities. For example, differentiating ash and meteorological clouds and identifying multiple ash cloud layers (tops and bottoms) through remote sensing can be difficult. Pilots sometimes see a particulate sulfate layer and may call it "ash", when there may be little to no ash present. For model evaluation use, pilots need to estimate as well as possible, the location/time of the ash sightings. Clearly, the most accurate 3-d observations are needed for model evaluation, or uncertainties of the observations should be included in the evaluation.

2.5 Numerical models are currently used as guidance by the forecaster to identify and forecast the location of the ash cloud, regardless of ash concentration levels. One of the principle reasons to use the model in that manor is due to the uncertainty of the output from the model. However, there is a need for the models to be improved to identify ash concentration levels. We are concerned whether the state of the science is mature to provide this level of accuracy for ash concentration levels.

2.6 Given that the VAAC tend to use different dispersion models driven by different meteorological models; that the ICAO products, the Advisories and SIGMETs, need to be consistent among the VAAC; the models which contribute toward the forecast portion of the Advisories and SIGMETs, especially for large eruptions, need to be generally consistent. Currently there is no agreed world-wide source term for numerical models. Without a standardized source term there can be differences in output which can lead to differences in identifying the location of the ash as well as forecasts of ash concentration levels.

3. CONCLUSION

3.1 In consideration of the above discussion the meeting is invited to consider the following action:

Action Agreed 1/… — Transport and Dispersion Model Evaluation

That, the IAVW coordination group, in coordination with WMO, be tasked to:

a) perform a model evaluation with respect to observations, ideally using a common set of observations and eruption source term parameters;

b) address the accuracy and levels of uncertainty for ash concentration levels provided by the model; and

c) promote the standardization, as necessary, the dispersion models used by the VAACs, particularly regarding default source terms.

4. ACTION BY THE IVATF

a) note the information in this paper; and

b) decide on the draft action:

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