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Using weather regimes to efficiently model tephra dispersion

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Countries without volcanoes may still be affected by volcanic ash from regional explosive eruptions. Better understanding of the potential impacts in such areas requires a site-specific ash hazard and risk assessment that accounts for multiple sources. Such an assessment requires a probabilistic modelling approach in order to capture the variability in source parameters and wind conditions. Where the assessed area is more than a few hundred kilometres from the eruption, a three-dimensional numerical ash dispersal model must be implemented so that temporal and spatial variations in meteorological conditions can be accounted for. Such models are significantly more computationally expensive than simplified numerical or analytical models. In a stochastic hazard assessment with random sampling of individual instantaneous wind fields, the large numbers of simulations required to assess multiple volcanic sources, eruptions and meteorological conditions can be prohibitive. Here, we propose the use of synoptic weather regimes as an alternative approach for incorporating the variability in meteorological conditions, as one of the most important influences on ash dispersion. Synoptic weather regimes categorise the main weather configurations experienced across an area into a manageable number of patterns, allowing us to carry out targeted sampling of meteorological records. Synoptic weather regimes are available for a wide range of regions globally. For a study of long-range ash dispersion over Europe, the use of synoptic patterns reduced the number of meteorological records that otherwise needed to be sampled by a factor of 200. Significant improvements in modelling efficiency permitted the use of more sophisticated models and higher-resolution inputs and outputs.