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From Determinism to Probability in Numerical Weather Prediction

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Over the last 25 years there has been a radical change in the way weather forecasts are made, from deterministic predictions based on best-guess models integrated from best-guess initial conditions, to probabilistic predictions based on stochastic models integrated from distributions of initial conditions consistent with available observations. Such a change was necessary because the climate system is chaotic and hence nonlinear – a consequence of which is that the growth of small forecast uncertainties will vary from one set of initial conditions to another. The operational implementation of the Ensemble Prediction System at ECMWF in 1992 resulted in the development of two particular techniques needed to make a reliable probabilistic forecast system: singular vectors and stochastic parametrisation. A description of and justification for these techniques will be given.

What can ensemble-based forecasts achieve in the coming 25 years? It is argued that by being able to provide quantitative risk-based predictions of extreme weather, ensemble forecasts will provide the means for Disaster Preparedness Agencies to decide when to be proactive in helping mitigate the effects of such weather. In this way, it is anticipated that ensemble weather prediction will become a major tool in helping society achieve one of the key targets of the UN Sendai Framework for Disaster Risk Reductions: to substantially reduce global disaster mortality.

The development of probabilistic ensemble-based forecasts illustrates the importance of basic mathematical concepts, including chaos, stochastic processes and non-self-adjoint dynamics, for the benefit of society worldwide, especially those in developing countries who are particularly exposed and vulnerable to extreme weather.