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## **Assimilating and forecasting precipitation at global scales**

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Numerical weather prediction (NWP) is the process of assessing the current state of the atmosphere, then using this to initialise a physical forecast model to make predictions over timescales from hours to weeks. The current state of the atmosphere is reconstructed using data assimilation, mainly using satellite and ground-based observations. In particular, all-sky data assimilation is used to extract information on cloud and precipitation from passive microwave radiances, currently at frequencies from 6 GHz to 325 GHz. Active observations are assimilated directly as reflectivities at some centres, mainly from ground-based radar and hopefully soon also from space radars such as EarthCARE. However, the full reconstruction of precipitation also depends on the forecast model and on the many other observations that are indirectly sensitive to precipitation. Going into the forecast, precipitation is increasingly controlled by the physical forecast model and by the evolving synoptic situation. Hence, to best improve precipitation forecasts, we need to find ways to use precipitation observations to improve the forecast models themselves, and not just the initial conditions. Alternatively, data-driven (AI) based forecasts can be trained directly on the analyses or even on the observations (end-to-end forecasting) which may sidestep this completely. However, it may be that a combination physical equations and machine learning will ultimately generate the highest quality precipitation forecasts. In all scenarios, widespread availability of direct and indirect precipitation observations is critical.