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Northern Hemisphere extratropical cyclone biases in ECMWF sub-seasonal forecasts

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Extratropical cyclones influence midlatitude surface weather directly via precipitation and wind and indirectly via upscale feedbacks on the large-scale flow. Biases in cyclone frequency and characteristics in medium-range to sub-seasonal numerical weather prediction might therefore hinder exploiting the potential predictability on these timescales. We thus, for the first time, identify and track extratropical cyclones in 21 years (2000 – 2020) of sub-seasonal ensemble reforecasts from the European Centre for Medium-Range Weather Forecasts (ECMWF) in the Northern Hemisphere in all seasons. Overall, the reforecasts reproduce the climatology of cyclone frequency and life-cycle characteristics qualitatively well up to six weeks ahead. However, there are significant regional biases in cyclone frequency, which can result from a complex combination of biases in cyclone genesis (locally and upstream), size, location, lifetime, and propagation speed. Their magnitude is largest in summer, with the strongest deficit of cyclones of up to 15% in the North Atlantic, relatively large in spring, and smallest in winter and autumn. Moreover, the reforecast cyclones are too deep in both ocean basins during most seasons, although intensification rates are captured well. An overestimation of cyclone lifetime and differences between the native spatial resolutions of the reforecasts and the verification dataset might explain this intensity bias in some cases, but there are likely further so far unidentified processes involved. While the patterns of cyclone frequency and life cycle biases often appear in lead time weeks 1 and 2, their magnitudes typically grow further at sub-seasonal lead times and, in some cases, saturate in weeks 5 and 6 only. Most of the dynamical sources of these biases thus likely appear in the early medium range, but biases on longer timescales probably contribute to their further increase with lead time. Our study provides a useful basis to identify, better understand, and ultimately reduce biases in the large-scale flow and in surface weather in sub-seasonal weather forecasts. Given the considerable biases during summer, when sub-seasonal predictions of precipitation and surface temperature will become increasingly important, this season deserves particular attention for future research.