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The role of cyclones and PV cutoffs for the occurrence of unusually long wet spells in Europe

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The synoptic dynamics leading to the longest wet spells in Europe are so far poorly investigated, despite these events' potentially large societal impacts. In this study we examine the role of cyclones and PV cutoffs for unusually long wet spells in Europe, defined as the 20 longest uninterrupted periods with at least 5 mm daily accumulated precipitation at each ERA-Interim grid point in Europe (this set of spells is hereafter referred to as S_{20}). The S_{20} occur predominantly in summer over the eastern continent, in winter over the North Atlantic, in winter or fall over the Atlantic, and in fall over the Mediterranean and European inland seas. Four case studies reveal archetypal synoptic storylines for long wet spells: (a) A seven-day wet spell near Moscow, Russia, is associated with a single slow-moving cutoff-cyclone couple; (b) a 15-day wet spell in Norway features a total of nine rapidly passing extratropical cyclones and illustrates serial cyclone clustering as a second storyline; (c) a 12-day wet spell in Tuscany, Italy, is associated with a single but very large cutoff-complex, which is replenished multiple times by a sequence of recurrent anticyclonic wave breaking events over the North Atlantic and western Europe; and (d) a 17-day wet spell in the Balkans features intermittent periods of diurnal convective precipitation in an environment of weak synoptic forcing and recurrent passages of upper-level troughs and PV cutoffs and thus also highlights the role of diurnal convection for long wet spells over land. A systematic analysis of cyclone and cutoff occurrences during the S_{20} reveals considerable spatial variability in their respective role for the S_{20}. For instance, cyclones and cutoffs are present anywhere between 10% and 90%, and 20% and 70% of the S_{20} time steps, respectively, depending on the geographical region. However, overall both cyclones and cutoffs, appear in larger number and at a higher rate during the S_{20} compared to climatology. Furthermore, in the Mediterranean, the PV cutoffs and cyclones are significantly slower moving and/or longer-lived during the S_{20} compared to climatology. Our study thus documents for the first time the palette of synoptic storylines accompanying unusually long wet spells across Europe, which is a prerequisite for developing an understanding of how these events might change in a warming climate and for evaluating the ability of climate models to realistically simulate the synoptic processes relevant to these events.