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The role of large-scale atmospheric flow and Rossby wave breaking in the evolution of extreme wind storms over Europe

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We investigate the relationship between large-scale atmospheric flow and the evolution of the most extreme windstorms affecting Continental Europe. Using a cyclone identification and tracking algorithm we generate a 40-year climatology of winter cyclones and focus on the top 25 most destructive Continental European wind storms. We subjectively group 22 of the top 25 storms as having a similar trajectory and evolution. A sea-level pressure composite over the selected storms shows that these storms typically occur during particularly strong and persistent positive NAO anomalies which peak about 2 days before the storms' peak intensity; the NAO pattern then shifts eastward such that the low-high dipole is centered over the European continent when the storms strike Europe. A temporal composite of potential temperature on the 2-PVU surface suggests that this NAO shift is the result of cyclonic wave-breaking to the north and anti-cyclonic wave-breaking to the south penetrating further to the east than during a typical high-NAO event. This creates an extremely intense, zonally-oriented jet over the North Atlantic and Europe whose baroclinicity favours explosive intensification of storms as they make landfall while steering them into the heart of the continent. We develop and index which captures the gross features of this scenario and use to study the decadal variability in the frequency with such conditions have been encountered in the past. We also compare the skill of this index as a statistical predictor of extreme European windstorms compared to using a threshold value of the daily NAO index.