The North Atlantic jet stream: a look at preferred positions, paths and transitions

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Preferred jet stream positions and their link to regional circulation patterns over the winter North Atlantic/European sector are investigated to corroborate findings of multimodal behaviour of the jet positions and to analyse patterns of preferred paths and transition probabilities between jet regimes using ERA-40 data. Besides the multivariate Gaussian mixture model, hierarchical clustering and data image techniques are used for this purpose. The different approaches all yield circulation patterns that correspond to the preferred jet regimes, namely the southern, central and the northern positions associated respectively with the Greenland anticyclone or blocking, and two opposite phases of an East Atlantic-like flow pattern. Growth and decay patterns as well as preferred paths of the system trajectory are studied using the mixture model within the delay space. The analysis shows that the most preferred paths are associated with central to north and north to south jet stream transitions with a typical time-scale of about 5 days, and with life cycles of 1–2 weeks. The transition paths are found to be consistent with transition probabilities. The analysis also shows that wave breaking seems to be the dominant mechanism behind Greenland blocking. Copyright © 2011 Royal Meteorological Society

Key Words: jet stream; circulation patterns; Greenland blocking; preferred paths; transition probability

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1. Introduction

The North Atlantic and North Pacific are the two main Northern Hemispheric (NH) storm track regions with active synoptic weather systems. In addition, large-scale preferred flow structures that persist longer than typical midlatitude synoptic weather systems have been identified over the North Pacific and the North Atlantic sectors (e.g. Dole and Gordon, 1983). It is known in fact that the midlatitude North Atlantic/Europe and North Pacific are the main regions of significant departure from normality (Christiansen, 2009; Hannachi et al., 2009). This non-normality is associated with (i) local high skewness over the Aleutians and Greenland, respectively, observed in the low-frequency part of 500 hPa geopotential height (Z500) and sea-level pressure (SLP) (Nakamura and Wallace, 1991; Rennert and Wallace, 2009), and (ii) local large negative excess kurtosis, or platykurtosis (sub-Gaussianity) over the northern parts of both basins (Sardeshmukh and Sura, 2009). These regions, in particular, are locations of frequent blocking events (Pelly and Hoskins, 2003; Woollings and Hoskins, 2008; Woollings et al., 2008).

Hannachi (2007, H07 hereafter) investigated preferred structures of planetary wave dynamics using the multivariate Gaussian mixture model applied to daily winter 500 hPa height from the National Center for Environmental Prediction and the National Center for Atmospheric Research (NCEP/NCAR) reanalyses. He identified two preferred planetary flow structures, namely a positive