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On horizontal wind gradient variability from the stratosphere to the surface over Arctic sea ice

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Previous studies have demonstrated changes in vertical wind shear in recent decades, with implications for upward-propagating planetary waves, the stratospheric polar vortex, and tracer transport. Changes in vertical wind shear combined with horizontal gradients have also been shown to contribute to an increase in vertical gradients in tracer fields, with important implications for vertical transport. In order to explore the extent to which changes in vertical wind shear are reflected in changes to horizontal stirring, we examine horizontal wind gradient fields from the stratosphere to the surface from 1979 to 2000. Studied in particular are the spatial and temporal properties and trends for relative vorticity, divergence, strain and the Weiss criterion (which monitors the competition between strain- and vorticity-dominated fields), to illustrate how horizontal wind gradients have changed over the last several decades. The results from this investigation show increased cyclonic activity in the middle stratosphere to 1998 during winter and positive strain anomalies during spring from 1990 to 1998, in support of the now well understood phenomenon of a strengthened polar vortex associated with increased vertical shear in the 1990s. Spatial distributions for seasonal relative vorticity fields exhibit spatially coincident large- and small-scale coherent features near the surface and in the middle stratosphere during fall and winter. Trend analyses highlight statistically significant trends in strain and relative vorticity fields during fall and winter, which are reflected in coherent features in relative vorticity trends at the surface during winter months, strain trends over Fram Strait near the tropopause during summer, and in all trends in wind gradient fields in the middle stratosphere during fall. The results from this investigation suggest that despite significant variability in wind

gradient fields, statistically significant trends exist from the stratosphere to the surface and exhibit spatial coincidence with sea ice concentration anomaly patterns. This coupling from the surface to the upper atmosphere is important in the development of our understanding of the response of sea ice concentrations to climate variability and change.