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INFERENCES OF EFFECTS OF GLOBAL CLIMATE CHANGE ON MESOSCALE CLIMATE OVER THE CENTRAL U.S.

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1. INTRODUCTION

The inability of general circulation models (GCMs) to represent regional-scale climate has become increasingly recognized as a limitation in the analysis of potential impacts of climate change on human activities. While present-day GCMs cannot *directly* provide reliable regional-scale predictions of such variables as precipitation, it may be possible *indirectly* to infer changes in regional climate by extracting information from trends in large-scale fields related to these variables. The assumption that large-scale fields can be processed in some way to provide information on smaller scales is the basis of "downscaling" techniques (see e.g., the review by Wilby and Wigley 1998).

In the present study we use GCM output to examine possible changes in the occurrence of summertime low-level jets (LLJs) over the central U.S. for a climate influenced by increased concentrations of greenhouse gases. The importance of LLJs for precipitation in this region has been established in previous studies (e.g., Stensrud 1996; Arritt et al. 1997). Ghan et al. (1996) evaluated current-climate predictions of the LLJ by two GCMs and found that the models produced LLJs that agreed reasonably well with observed climatologies. If GCMs can provide credible indications of changes in of LLJs, we may be able to infer changes in the quantity and character of regional precipitation over the central U.S.

2. DATA SOURCE

We have examined output from the second generation coupled atmosphere–ocean general circulation model developed by the Hadley Centre of the U.K. Meteorological Office (HadCM2), described by Johns et al. (1997). We compared two 10-year records of 6-hourly sigma level output for June, July and August (JJA), one for a control climate and another for the years 2040-2049 from a run with increased greenhouse gas (GHG) concentrations. It is important to keep in mind that GCM results are realizations based on assumed scenarios and are not predictions of climate at a specific date.

The sigma level wind fields were analyzed to detect LLJs using the criteria first proposed by Bonner (1968). For brevity we focus here on criterion 1 LLJs, which have maximum low-level wind speeds of at least 12 m s^{-1} decreasing by at least 6 m s^{-1} aloft.

3. RESULTS

Results for the control climate (Figure 1) indicate that LLJs as depicted in HadCM2 closely resemble observed climatologies of the LLJ. Both the frequency of occurrence (about 30%) and the location of maximum occurrence (western Oklahoma) agree remarkably closely with the climatology presented by Bonner (1968). The diurnal variability of LLJ occurrence also agrees with observed climatology, with LLJs occurring most often at 06 UTC (not shown).

The GHG scenario indicates a modest increase in the occurrence of low-level jets (Figure 2). Of particular interest is a dipole pattern in the GHG scenario such that LLJs are more frequent in the southern part of the region and less frequent in the northern part. Previous studies have shown that such a dipole pattern is associated with enhanced low-level convergence and increased regional precipitation (Pan et al. 1999).

Upper-level height fields during JJA in the GHG climate are characterized by more zonal flow over most of the continental U.S. with a slightly weaker summertime mid-level ridge over the central U.S. (not shown). Since the presence of a subtropical ridge has been shown to suppress the development of LLJs (Mitchell et al. 1995), weakening of the ridge may be the reason for increased incidence of LLJs in the GHG results.

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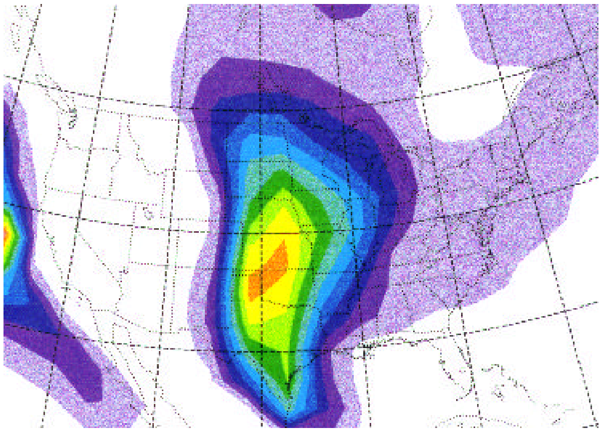

Figure 1: Incidence of criterion 1 low-level jets in the HadCM2 control climate. Frequency of occurrence is shaded in bands of 3%.

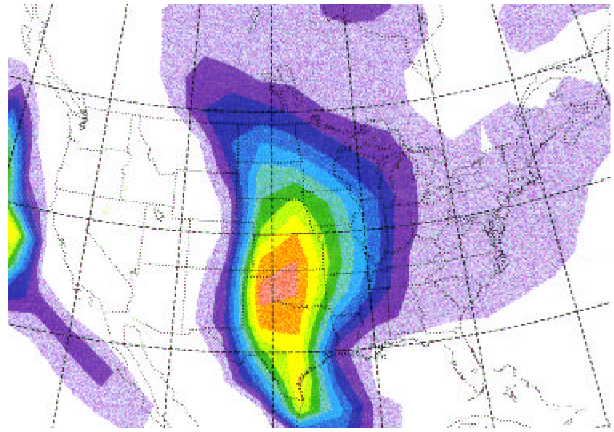

Figure 2: Incidence of criterion 1 low-level jets in the HadCM2 GHG scenario. Frequency of occurrence is shaded in bands of 3%.

4. SUMMARY AND FUTURE STUDY

Examination of 6-hourly output from a coupled ocean-atmosphere general circulation model indicates that predicted LLJs for the control climate compare favorably to observations, giving some confidence in the ability of the model to predict this dynamical feature which is important for regional hydrology. Results from a scenario with enhanced greenhouse gases indicate a dipole pattern with more frequent LLJs in the south-central U.S. and less frequent LLJs to the north.

Ongoing work includes analysis of 6-hourly HadCM2 precipitation to determine whether observed relationships between LLJs and precipitation can be detected in the model output, and in particular whether the dipole change in LLJ occurrence for the GHG scenario is associated with increased precipitation. Ghan et al. (1996) found that the relationship between LLJs and precipitation was not well represented in the GCMs they examined. Given the importance of mesoscale convective systems for warm-season precipitation in the central U.S., it may be necessary to use mesoscale resolution if climate change over the central U.S. is to be depicted realistically.

5. ACKNOWLEDGMENTS

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