1. INTRODUCTION

Cloud-to-ground (CG) lightning from thunderstorms initiating forest fires is a typical summer hazard in the rugged terrain of the Yukon Territory of northern Canada. The lightning season usually starts in May, peaks during July and is usually over in September. This region typically experiences 141 wildfires annually which burn over 160,000 hectares between June and August. An annual average of over 20 thousand CG flashes account for about 54% of these ignitions. During the summer of 2004, a persistent upper level ridge dominated throughout the Yukon. Maximum temperatures were above normal for much of the season and precipitation amounts were about 60% of normal. The number of CG flashes, lightning-initiated forest fires and extent of the area burned surpassed historic records. Specifically, over 40 thousand CG flashes accounted for 88% of the 282 wildfires consuming over 1.7 million hectares of the territory. (Green, 2004; WFRP, 2005). The 2004 fire season in Alaska burned about 2.7 million hectares.

Several studies have previously investigated the influence of smoke from fires on CG polarity and peak current characteristics. Large increases in the percentage and peak currents of positive CG lightning were found in thunderstorms in the central US ingesting smoke from fires in Central America (Lyons et al. 1988). Murray et al. (2000) reported peak current decreases in the negative CG flashes for the same study area. Increases in the percentage of positive CG lightning were found in the Mackenzie Basin of Canada during the 1995 fire season (Kochtubajda et al. 2002). Recently, Fernandes et al, (2006) reported decreases in negative peak currents, and increases in the peak currents and percentage of positive CG flashes in the Amazon area of Brazil.

The objective of this study is to advance our understanding of the nature of lightning during an extreme fire season. Our analyses will focus on the lightning activity during the month of July and address the following questions. What were the polarity and peak current lightning characteristics in Yukon during this extreme fire period? How different or similar were they from less extreme periods? How similar or different are the Yukon findings from those reported in southerly latitudes?

2. DATA and ANALYSIS

Cloud-to-ground lightning flash data were obtained from the Canadian Lightning Detection Network (CLDN) for the period 2002 to 2006. These data describe the location, time, polarity, first-stroke peak current and multiplicity (number of strokes) of the flash and are subject to a variety of uncertainties including measurement and calibration errors, and model limitations.
(Cummins and Murphy, 2009). Figure 1 shows the location of the 7 CLDN sensors and the topography of Yukon. This 482,443 square kilometre area is a complex mixture of mountains, plateaus and river valleys. The mountain ranges run in a variety of orientations that not only border the plateaus, but sometimes cross them. There is a wide range of elevations to these mountains. The Saint Elias Mountains in south-western Yukon are the highest in Canada and have extensive icefields, while the Richardson Mountains in the northeast are low and often rounded at the peaks. Between these two ranges are numerous other ranges.

Positive flashes were reclassified according to guidelines discussed in Cummins and Murphy (2009) as a result of field campaigns described in Biagi et al. (2007). Specifically, positive events with current strength below 15 kA that were classified as CG previous to April 2006 were now classified as cloud discharges, and positive flashes with current strengths greater than 20 kA that had been classified as cloud discharges were likely to be CG discharges.

First-stroke peak positive and negative currents and percentage positive polarity characteristics during July 2004 were compared to the characteristics archived for July 2002-03 and July 2005-06. Spatial patterns were derived using equal-area square grid cells with 20 km sides (Burrows et al. 2002). Current strength anomaly maps were produced by subtracting the average of the July 2002-03 and 2005-06 data from the July 2004 data for each 20 km by 20 km grid cell. Difference values less than/greater than zero would show a decrease/increase in 2004, respectively. The spatial analyses were undertaken in ARCGIS and included the Spatial Analyst toolbox.
3. RESULTS

a. Percent positive CG flashes

The spatial pattern of the average percentage of positive CG lightning for July 2002, 2003, 2005 and 2006 is shown in Figure 2. The Yukon typically detects about 20-30% positive flashes. However, there are some areas that experience more positive flashes. The band of positive CG flashes >80% along the St. Elias Mountains in the south west corner of the Yukon may reflect sensor bias or topographic influences as weaker flashes may not be detected due to the distance or range from the nearest sensor. The spatial pattern of percentage positive CG lightning detected in July 2004 (figure 3) is significantly different from the 4-year average. A large area of the Yukon Plateau was found to have 2 to 5 times more positive lightning.
Figure 2. The spatial distribution of the percentage of positive flashes in July [averaged for 2002, 2003, 2004, 2005]. The locations of the CLDN sites are superimposed.
b. First-stroke peak current

The first-stroke mean peak current strength anomaly maps for negative and positive CG flashes are shown in Figures 4 and 5, respectively. Negative mean peak current strengths during July 2004 were generally weaker over much of the Yukon. The peak-current strengths decreased by as much as 20 kA in some regions of the Yukon. Conversely, positive mean peak current strengths were generally stronger over the area. In some areas, the peak-current strengths increased by 40 to 50 kA.
Figure 4. Anomaly map of negative flash peak current. Difference was determined by subtracting the mean of July 2002, 2003, 2005 and 2006 data from the July 2004 data for each bin.
4. DISCUSSION

The 2004 wildfire season and associated lightning activity in the Yukon Territory of northern Canada was unusual in many aspects. Our preliminary observations of the CG flash characteristics during July 2004 in the Yukon appear to confirm the previous findings of Lyons et al. (1998), Murray et al. (2000) and Fernandez et al. (2006). We found increases in the peak currents and percentage of positive CG flashes and decreases in negative peak currents.

Smoke transported from the fires in Alaska is also likely to have influenced the electrical characteristics of CG lightning in the Yukon. It would be interesting to examine how aerosols might affect lightning. Although there is no known source of direct aerosols data for the Yukon, an inter-comparison of satellite-derived aerosol optical depths from the MODIS instrument onboard the EOS -Terra satellite and CG lighting may provide additional insight. Recently, Lang and Rutledge (2006) have suggested that changes in +CG production in thunderstorms may be linked to drought environments. Further studies will also be undertaken to determine whether/how...
these changes in lightning characteristics may be related to the drought conditions prevalent in 2004.

5. ACKNOWLEDGEMENTS

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6. REFERENCES


