Lightning, Storms and Precipitation
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The primary objective of this research is to quantify and improve our understanding of the determination of precipitation rates from lightning frequency measurements, which would enhance the prospect of forecasting the occurrence and magnitude of flooding. The problem of forecasting convective precipitation is important because of the increasing amounts of damage being caused by flooding.

Various workers (e.g. Goodman et al. 1988; Goodman and Buechler 1990; Williams et al. 1990) have speculated and to some limited degree demonstrated that quantitatively definable relationships exist between lightning frequency **F** and thunderstorm parameters such as precipitation rate, updraught speed, radar reflectivity, etc. If such relationships can be established quantitatively, then measurements made with the Lightning Imaging Sensor (LIS) (Christian and Goodman 1987; Christian et al. 1992), on the TRMM satellite or ground-based systems such as the Met Office's Arrival Time Difference (ATD) lightning location system can be used to derive values of these and/or and other parameters. Thus the instruments could have significant forecasting or nowcasting importance.

This project is concerned primarily with relationships between lightning activity and characteristics of two types of ice hydrometeors in thunderstorms, precipitating graupel particles and non-precipitating ice crystals. Since graupel particles and ice crystals are believed to be the hydrometeors whose interactions give rise to charge transfer and electric field growth in thunderstorms, culminating in lightning, it would be natural to find strong relationships between lightning activity and the vertical fluxes of graupel and ice crystals. Our objective is to explore such possible relationships with a detailed cloud model. New evidence has been found recently that such relationships do exist. An important part of the project is to compare the model results with these observations that are currently being analysed and synthesised by other collaborator colleagues from NASA/MSFC (Marshall Space Flight Center).

Lightning frequency and its interrelation with precipitation, is now becoming an increasingly important tool in Numerical Weather Prediction data assimilation techniques. Alexander et al.\ (1999) demonstrated that error skills are improved significantly if even simple lightning-derived precipitation estimates for a sub-tropical convective storm system are included in the data assimilation. Thus the outcome of this proposed work will also have a significant impact on the development of data assimilation tools.

The student will employ our model to identify the limiting conditions for specified observations for which data exists, while our NASA collaborators address the same questions by examining these data.