

The GLOBE Contrail Protocol: Initial analysis of results

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Introduction

The GLOBE contrail protocol was launched in March 2003 to obtain surface observer reports of contrail occurrence to complement satellite and model studies underway at NASA Langley, among others. During the first year, more than 30,000 ground observations of contrails were submitted to GLOBE. An initial analysis comparing the GLOBE observations to weather prediction model results for relative humidity at flight altitudes is in progress. This paper reports on the findings to date from this effort.

Background

The temperature and humidity in the atmosphere govern the formation of persistent contrails by jet aircraft exhaust. If the temperature is cold enough, and the humidity is high enough, then aircraft can produce contrails that can last for several minutes or even hours. Scientists gather information on temperature and humidity at aircraft cruise altitudes (between 27,000 and 39,000 feet – about 8 to 12 km) using weather balloons, also called soundings. However, the amount of moisture at flight altitudes is difficult to measure due to instrument issues, and the balloon observations are too sparse and inaccurate to allow an exact estimate of the amount of contrail formation across the US; and even less so around the world. Atmospheric scientists at NASA Langley are using temperature and humidity information from numerical weather prediction models to supplement the weather balloon measurements and to improve forecasts of contrail formation across the country (Ref. 1). Student ground observations of contrails and clouds through the GLOBE program (and the Earth Day 2004 Contrail Count-a-Thon; Ref. 2) are helping NASA Langley scientists to determine the quality and consistency of the humidity data used in numerical weather prediction models. It is important to note that GLOBE, and another student program called S'COOL (<http://scool.larc.nasa.gov>), are currently the only programs for surface observations of contrails in existence.

Method

Results from two high-resolution numerical weather model analyses, the Rapid Update Cycle (RUC; Refs. 3-4) and the Advanced Regional Prediction System (ARPS; Ref. 5), are being analyzed. The comparison between the observations and model results will also be used to create an empirical contrail formation parameterization that can be applied to the two numerical weather forecast models. Nearly 1500 GLOBE observations of clouds and contrails across the continental US during April 2004 were compared to relative humidity calculations from RUC and ARPS model analyses. The

model results were sorted according to whether the GLOBE surface observation for that time and location reported short-lived contrails only or persistent spreading contrails.

Results

Figures 1 and 2 show how the relative humidity with respect to ice (RHI) at aircraft cruise levels compares from each model based on the contrail surface observation criteria. Figure 1 shows that the RHI over schools that observed only short-lived contrails ranged widely from low to high values but averaged 54 and 62 percent for the RUC and ARPS models respectively. The distribution of RHI in the RUC model is generally dryer than that in the ARPS model.

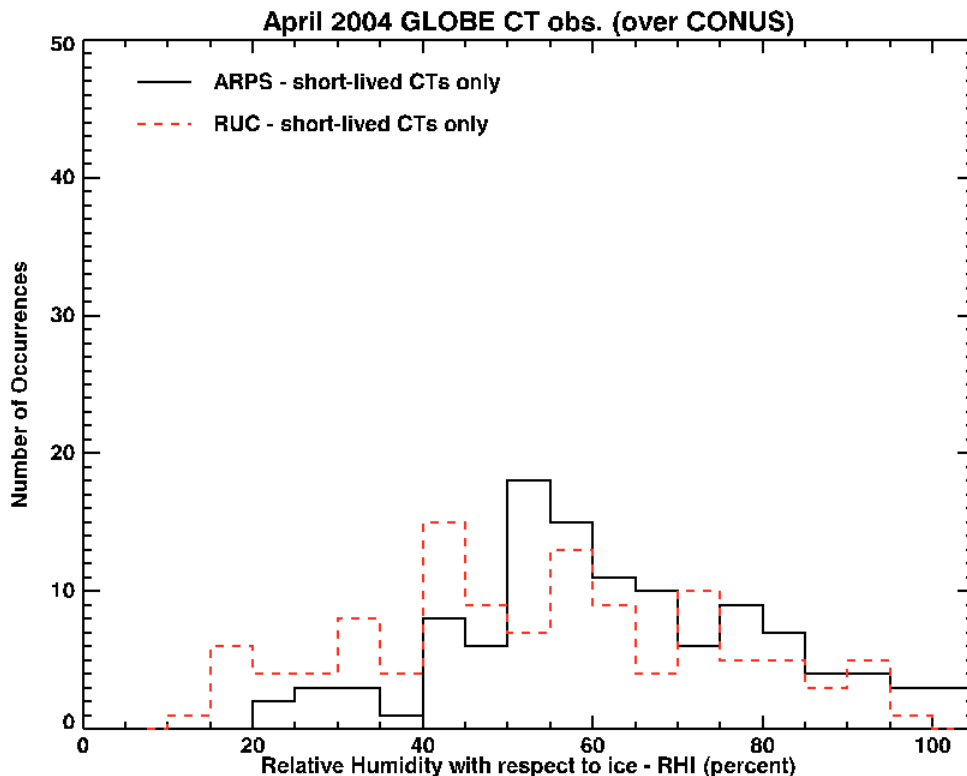


Figure 1. Histogram of model relative humidity with respect to ice at flight levels for cases when GLOBE surface observers in the Continental US (CONUS) report only short-lived contrails.

Figure 2 shows that the average RHI from the models when persistent spreading contrails were observed over the school again varied broadly but with a histogram of occurrence weighted much more strongly toward high values. The average RHI was 67 percent for RUC and 77 percent for ARPS. In each case the RHI values are broadly distributed, but the models are correctly indicating higher average relative humidity for situations where GLOBE students report persistent spreading contrails.

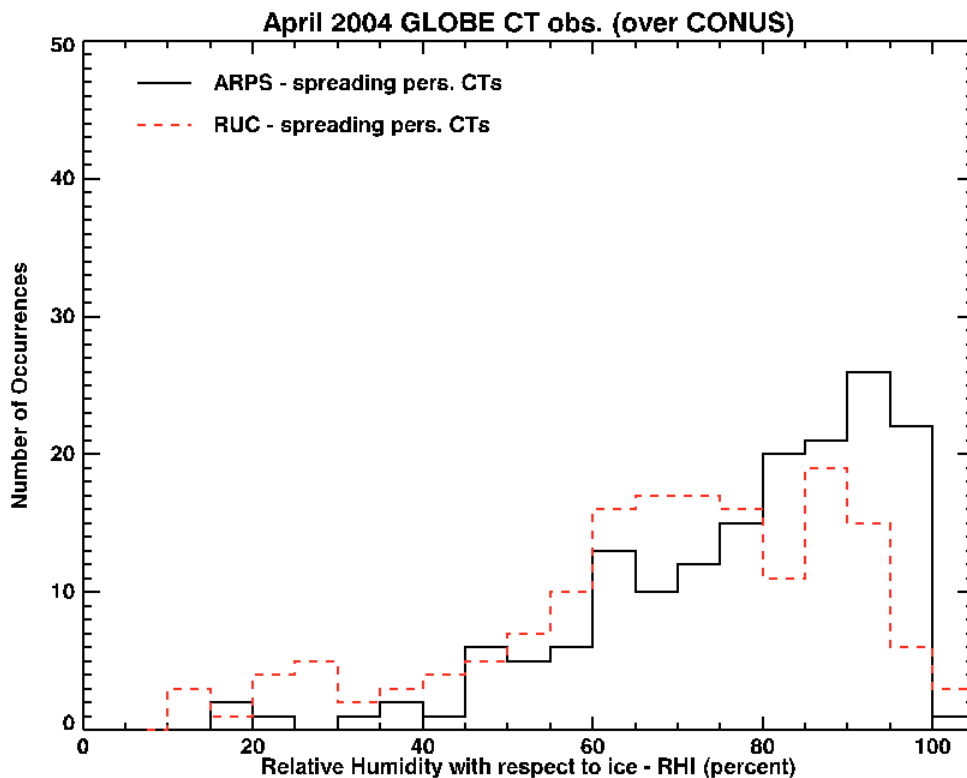


Figure 2. Histogram of model relative humidity with respect to ice at flight levels for cases when GLOBE surface observers report persistent spreading contrails.

Discussion

Comparisons like these between weather prediction model and GLOBE data will allow atmospheric scientists to improve estimates of the current and future cloud coverage caused by persistent contrails. There are currently more than 88,000 contrail reports in the GLOBE database, and new reports are coming at a rapid rate. To facilitate use of these data in analysis, a process has been set up to maintain a database at NASA Langley containing the contrail observations for each month. This database will be updated weekly through an ftp connection to GLOBE, which will provide all new observations reported that week. It is hoped that this more easily accessible database of observations will enable comparison to on-going satellite cloud detection and property retrieval efforts at NASA Langley, as well as further contrail studies.

References

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