Towards Improved Contrail Parameterizations for Climate-scale Models

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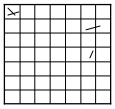
Introduction

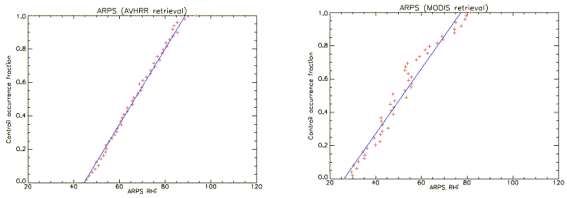
Contrails remain one of the most uncertain impacts of aviation on climate. Most previous attempts to simulate contrail climate effects on the global scale have estimated contrail cirrus coverage as a function of the model's relative humidity. Although the atmospheric conditions necessary for contrail formation are well defined, the diagnosis or prediction of such clouds is still complicated by uncertainties in modeling the atmospheric state in the upper troposphere. Considerable uncertainty remains in the coverage by climate-model-scale contrail simulations.

This study assesses the use of relative humidity with respect to ice (RHI) derived from high-resolution numerical weather prediction models, including the RUC (Rapid Update Cycle) model (Benjamin et al., 2004) and the ARPS (Advanced Regional Prediction System) model (Xue et al., 2003.)



We use the automated contrail detection algorithm of Mannstein et al, (1999) with 1-km resolution **AVHRR** and **MODIS** data. The contrail detection results are sorted into 0.5 by 0.5 degree grid boxes. The grid boxes are grouped into 7×7 arrays of boxes, and a **CONTRAIL OCCURRENCE FRACTION** within each array is computed. The example at the left has an occurrence fraction of 4/49 = 0.08.

Plots of the contrail occurrence fraction versus the mean 200 to 300 hPa RHI computed from each model for each corresponding array show a strong correlation between model humidity and the probability of contrail occurrence within a region. This relationship suggests that layer mean upper tropospheric humidity may be used as a proxy for contrail occurrence fraction. Thus, it may be possible to reconstruct the climatological contrail occurrence fraction over a region from RUC or ARPS relative humidity climatologies.



We test this hypothesis by comparing the contrail occurrence fraction derived directly from the AVHRR and MODIS imagery with the occurrence fraction fields derived from the ARPS and RUC RHI data. In addition to the relative humidity data, the reconstructions use estimates of flight track data (Garber et al, 2004) and cloud coverage data from the GOES 0.5 deg gridded cloud product dataset (Minnis et al, 2005) to mask out regions of no air traffic and/or thick cloud cover that would block the automated contrail detection method.

Reconstructed from RHI

Observed

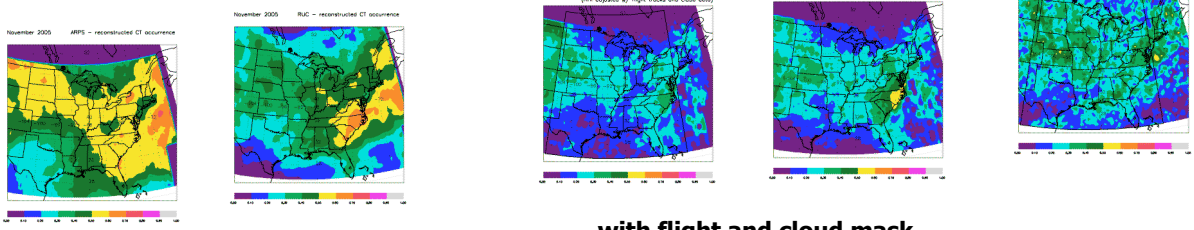
RHI only

with flight and cloud mask

ARPS **RUC** **ARPS** **RUC**

NOAA-16 AVHRR

(49 overpasses from November 2005)



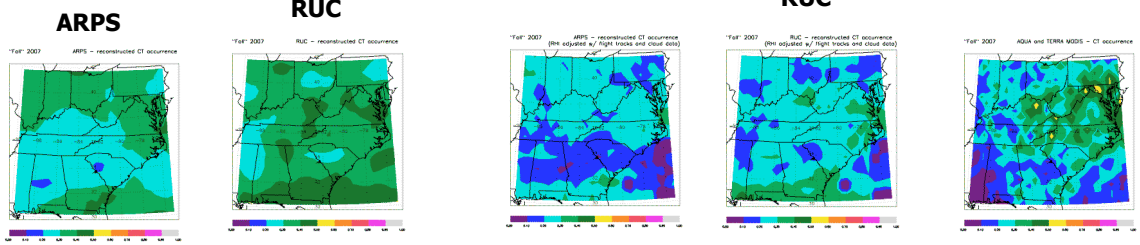
RHI only

with flight and cloud mask

ARPS **RUC** **ARPS** **RUC**

AQUA and TERRA MODIS

(23 overpassess From late September To December 2007)



Future Work

Improve contrail detection algorithm and make it more consistent between different satellites.

Compare method using AIRS humidities to RUC/ARPS results.