PH28:
EMS2011-716

Contrail Retrievals from MODIS for ACCRI

Patrick Minnis[1], David P. Duda[2], Rabindra Palikonda[2], Konstantin Khlopenkov[2], Sarah Bedka[2], Robyn Boeke[2], Thad Chee[2], J. Kirk Ayers[2], and Kris Bedka[2]

1 NASA Langley Research Center, Hampton VA
2 Science Systems and Applications Inc., Hampton VA

Abstract

To improve our understanding of contrail impacts on climate, a consistent contrail climatology is being developed at NASA Langley based on measurements from the MODerate-resolution Imaging Spectroradiometer (MODIS) on the Terra and Aqua satellites. Data taken over the Northern Hemisphere from 2 different years are being analyzed using several different algorithms to detect linear contrails and compute their radiative forcings in context of the environment. Both clouds and contrails are retrieved and the radiative forcing is computed using both theoretical and empirical approaches. This poster provides an overview of the approach, processing system, and the initial results of the project, which is supported by the FAA Aviation Climate Change Research Initiative (ACCRI).

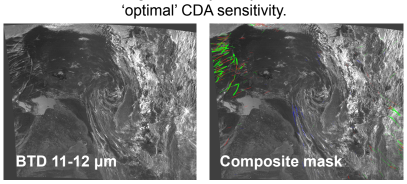
Approach

- Refine contrail detection & retrieval algorithms
- Develop improved radiative forcing estimation methods
- Retrieve NH contrails & clouds from Terra & Aqua MODIS data
- Make results available to modelers (climate, mesoscale, etc.)

Contrail Detection Algorithm (CDA)

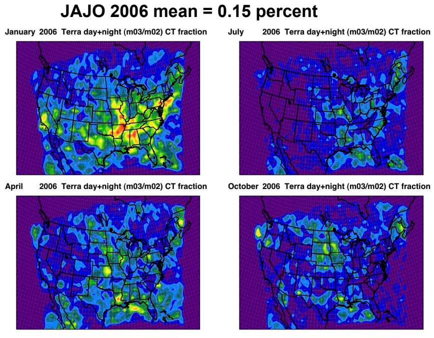
Current method is a **modification** of the Mannstein et al. (1999) technique. This CDA uses two thermal infrared channels, 10.8 and 12 µm on MODIS, and applies a scene-invariant brightness temperature difference threshold to identify linear features that may be contrails. Non-contrail cloud edge features are then removed by applying six binary masks that use additional information from other MODIS IR channels. Three of these masks were included in the Mannstein algorithm, and three are modifications to the original algorithm.

Contrail Detection Error Analysis from Interactive Program
44 MODIS images visually analyzed to determine 'optimal' CDA sensitivity.

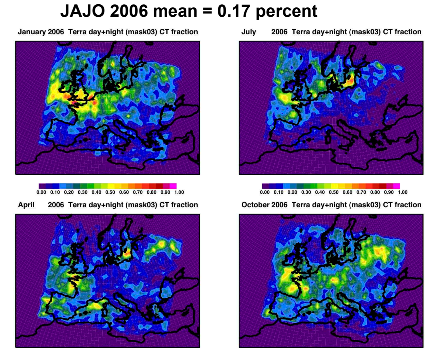


Contrails identified by the CDA are shown in red, contrails deleted by analyst are shown in blue, and the contrails added by analyst are shown in green.

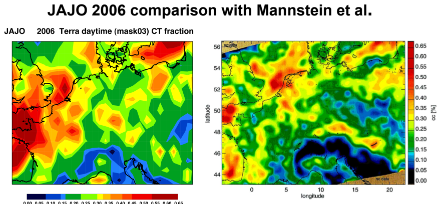
Uncorrected CONUS CT Fraction:
JAJO 2006 mean = 0.15 percent



Uncorrected Europe CT Fraction:
JAJO 2006 mean = 0.17 percent



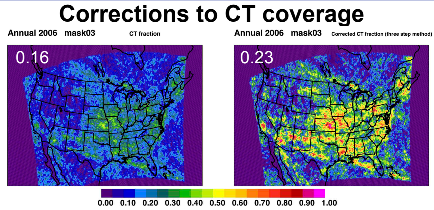
Uncorrected Central Europe CT Fraction:
JAJO 2006 comparison with Mannstein et al.



1030 LT (JAJO 2006)
mean CT fraction: 0.23%

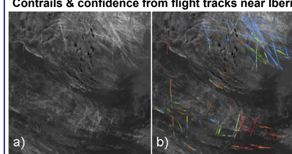
1200 LT (Annual 1996)
mean CT fraction:~ 0.23%

Corrections to CT coverage



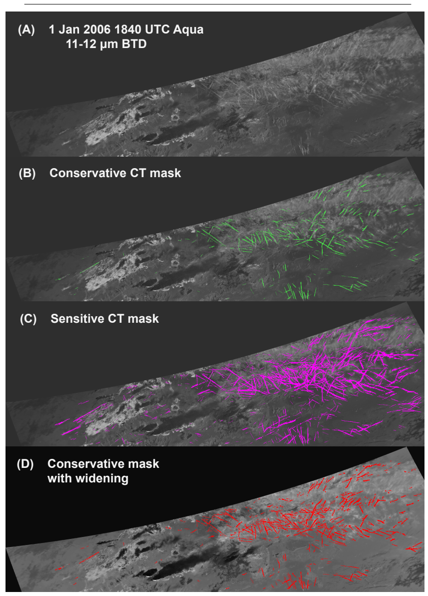
Thermal inhomogeneity correction

Contrails & confidence from flight tracks near Iberia, 1135 UTC, 12 March 2006,



Light blue	DC = >75-100
Green	DC = >50-75
Yellow	DC = > 25-50
Orange	DC = 0

Waypoint data to determine detection confidence (DC)



Dealing with spreading contrails: Increase CDA sensitivity (C) or widen detected contrails (D)

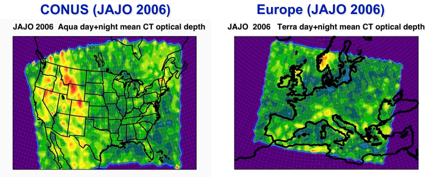
Contrail Optical Property Retrieval

Direct Method

MODIS pixel radiances are used to infer contrail optical properties (contrail optical depth (COD), and radiative forcing). In this method, the contrail temperature (220 K) and contrail particle size (Re = 10 µm symmetric hexagonal crystal) are fixed.

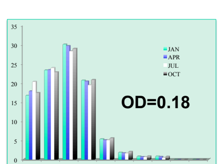
Contrail Optical Depth (COD)

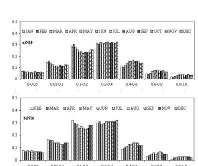
CONUS (JAJO 2006) | Europe (JAJO 2006)



JAJO 2006 mean: 0.200 | JAJO 2006 mean: 0.176

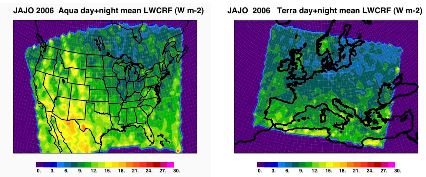
CONUS: Terra MODIS 2006 | CONUS: AVHRR 2001





Longwave Contrail Radiative Forcing (LWCRF)

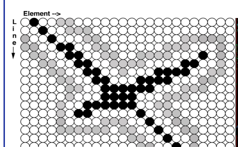
CONUS (JAJO 2006) | Europe (JAJO 2006)

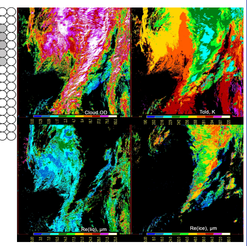


JAJO 2006 mean: 11.2 W m^{-2} | JAJO 2006 mean: 9.0 W m^{-2}

Indirect Method

Refined retrievals will be based on algorithm developed at NASA LaRC (Minnis et al., 2008, 2011) that includes COD and contrail effective particle size (r_e).





Compute M_{SW} & M_{LW} for gray pixels using cloud optical depth, T_{cld}, Re & Z_{cld} in RTM
- **use Sfc albedo**
- **T_{sfc}**
- **MERRA reanalysis**

Add contrail layer with Re, T_{con}, Z_{con} and derived contrail optical depth to gray pixels mean and recompute M_{SW} & M_{LW} => Net Contrail Radiative Forcing

Summary

- Initial optimal CDA developed
- Interactive contrail evaluation tool developed
- Prototype methods for using waypoint data & dealing with spreading contrails developed
- Cloud code being tested in contrail processing framework
- Methods for estimating both Re and COD being evaluated

Preliminary Results

- Contrail coverage over CONUS < AVHRR results
- Contrail optical depths & LWCRF different than earlier results
  - CONUS: COD = 0.19 vs. 0.26 from AVHRR *(Palikonda et al.)*
  - Europe: COD = 0.18 vs. 0.11 from AVHRR *(Meyer et al.)*

Future Work

- Decide on CDA using waypoints, apply to 2006 NH MODIS data
- Reprocess CONUS & analyze NH data
- Refine estimates of COD, Re, SW & LW forcing
  - –utilize SIST to retrieve COD & Re
  - –incorporate knowledge of surrounding clouds
  - –break contrail statistics in term of clear & cloudy backgrounds
- Finish construction of system to estimate 24-h contrail forcing

=> Should lead to more accurate assessment of contrail climate impact

Acknowledgments

Research supported under the FAA Aviation Climate Change Research Initiative (ACCRI) program and the American Recovery and Reinvestment Act (ARRA).

References

- Mannstein, H., R. Meyer and P. Wendling, 1999: Operational detection of contrails from NOAA-AVHRR-data. *Int. J. Remote Sensing*, **20**, 1641-1660.
- Meyer. R., H. Mannstein, R. Meekötter, U. Schumann, and P. Wendling, 2002: Regional radiative forcing by line-shaped contrails derived from satellite data. *J. Geophys. Res.* **107**, doi: 10.1029/2001JD000426.
- Minnis, P., and Co-authors, 2008: Cloud detection in non-polar regions for CERES using TRMM VIRS and Terra and Aqua MODIS data. *IEEE Trans. Geosci. Remote Sens.*, **46**, 3857-3884.
- Minnis, P., and Co-authors, 2011: CERES Edition-2 cloud property retrievals using TRMM VIRS and Terra and Aqua MODIS data. *IEEE Trans. Geosci. Remote Sens.*, **49**, doi:10.1029/TGRS2011.2144601.
- Palikonda, R., P. Minni D. P. Duda, and H. Mannstein, 2005: Contrail coverage derived from 2011 AVHRR data over the United States and southern Canada. *Meteorol. Z.*, **14**, 525-536.

Contact: Patrick Minnis, p.minnis@nasa.gov
http://www-pm.larc.nasa.gov