Linear contrail detection over the eastern United States from MODIS data

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Introduction

The automated linear contrail detection algorithm of *Mannstein et al. 1999* provides the ability to establish a global climatology of contrail coverage from satellite imagery. The algorithm exploits the linear structure of contrails and the brightness temperature difference between the 11.0 and 12.0 µm channels. Often this method will misclassify natural cirrus and other cloud 'streamers' as contrails leading to an overestimation of contrail coverage (*Minnis et al., 2005*). Here, additional contrail discriminators are tested in the detection algorithm using physical and optical properties of the true linear contrails. Terra and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) data over the eastern United States were analyzed for cloud-top pressure, cloud effective temperature, cloud optical depth, cloud effective diameter using the visible IR solar-infrared split-window technique (VISST) (*Minnis et al., 1995*).

Contrail and Cloud 'Streamers' Properties

- Typically, contrails differ from misidentified cloud 'streamers' by (Table 1b):
  - Lower cloud-top pressures
  - Lower cloud effective temperatures
  - Smaller optical depths
  - Smaller effective diameters

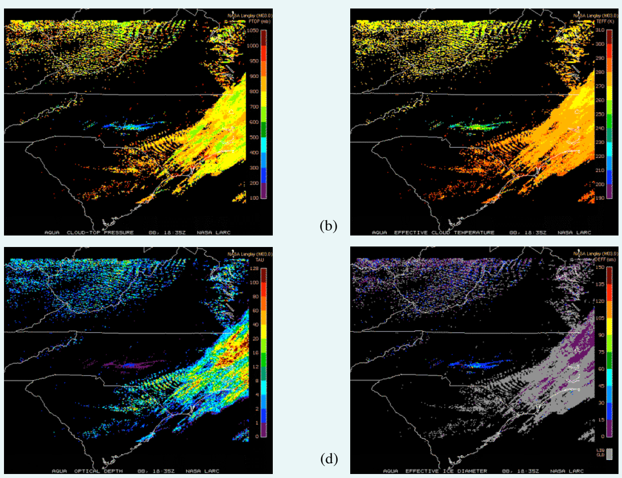

Fig. 1. VISST retrieval for Aqua MODIS from 1835 UTC, 06 November 2007 of (a) cloud-top pressure, (b) cloud effective temperature, (c) optical depth, and (d) effective diameter.

Cloud Property Thresholds

- Any pixels identified as a contrail will considered be a 'streamer' and eliminated if:
  - Cloud-top pressure > 754.1 mb
  - Cloud effective temperature > 272.9 K
  - Cloud optical depth > 1.66
  - Effective diameter > 117.8 µm
- Using the Max value of the true contrail properties as the thresholds will ensure no true contrails will be eliminated.

(a)

	Contrail		'Streamers'	
	Max	Mean	Max	Mean
Cloud-top pressure (mb)	754.1	299.6	882.2	486.3
Cloud effective temperature (K)	272.9	234.7	273.0	249.6
Cloud optical depth	1.66	0.44	109.1	3.84
Effective diameter (µm)	117.4	23.3	119.1	29.7

(b)

	Cloud-top pressure < 400 mb	Cloud effective temperature < 250 K	Cloud optical depth < 1.0	Cloud effective diameter < 30 µm
Contrail	84 %	82 %	95 %	78 %
'Streamers'	46 %	43 %	33 %	62 %

Table 1. (a) The max and mean values for both contrail and cloud 'streamers' for numerous MODIS overpasses over the eastern U.S. and (b) the percentage of contrail and cloud 'streamer' pixels less than a cloud-top pressure of 400 mb, a effective temperature of 250 K, an optical depth of 1, and an effective diameter of 30 µm.

Contrail Detection

- Contrail outbreak over North Carolina can be seen in the 11 - 12 µm temperature difference MODIS image.
- Both the linear contrails over N.C. and cloud 'streamers' over West Virginia and South Carolina are flagged as contrails by the detection algorithm.
- Using thresholds in the cloud properties (Table 1a), most of the misclassified cloud streamers are eliminated.
- The total contrail coverage for the MODIS scene decreases from 3.6% (Fig. 2b) to 0.9% (Fig. 2b) when the additional cloud property discriminators are applied.

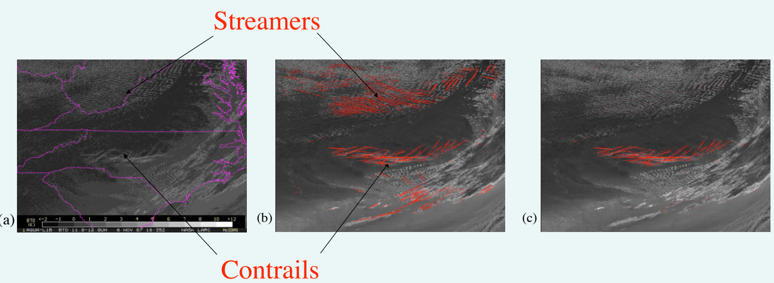

Fig. 2. (a) Aqua MODIS 11 - 12 µm temperature difference from 1835 UTC, 06 November 2007, (b) 11 - 12 µm image with contrails selected by the detection algorithm (in red), and (c) with the additional cloud properties discriminators from Table 1a.

Summary

❑Incorporating cloud physical and optical properties as additional discriminators into the automated detection algorithm of *Mannstein et al. 1999* can eliminate many of the low-level cloud 'streamers' that are often misidentified as contrails.

❑Problems still arise when the the 'cloud streamers' are high cirrus and exhibit similar properties of true contrails.

❑Improved detection of contrails in satellite imagery will lead to more accurate global climatology of contrail coverage and a better assessment of their impact on climate.

References

Mannstein, H., R. Meyer, P. Wendling, 1999: Operational detection of contrails from NOAA AVHRR data. Int. J. Remote Sens. **20**, 1641-1660.

Minnis, P., Palikondra, R., Walter, B. J., Ayers, J. K., Mannstein, H., 2005: Contrail properties over the eastern North Pacific from AVHRR data. Meteorol. Z. **14**, 515-523.

Minnis, P., D. P. Kratz, J. A. Coakley, Jr., M. D. King, D. Garber, P. Heck, S. Mayor, D. F. Young, and R. Arduini,Cloud Optical Property Retrieval (Subsystem 4.3), Clouds and the Earth's Radiant Energy System (CERES) Algorithm Theoretical Basi Document Volume III: Cloud Analyses and Radiance Inversions (Subsystem 4). NASA RP 1376 Vol. 3, edited by CERES Science Team, pp. 135-176, 1995.