Atmos. Meas. Tech. Discuss., 3, C868–C871, 2010
www.atmos-meas-tech-discuss.net/3/C868/2010/

Atmospheric Measurement Techniques Discussions

Interactive comment on "An automatic contrail tracking algorithm" *by* M. Vazquez-Navarro et al.

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Received and published: 9 July 2010

We thank Bernd Kaercher for his constructive comments. The points he addresses are very important, but some are beyond the scope of the current manuscript. They will be taken into consideration in future studies.

Unluckily, the high variability of contrails makes impossible to assess which part of the lifetime is observed. The method provides an insight better than previous methods but we are aware that it is not complete. Due to the sensor limitations (discussed in paper) some parts of the lifetime are and will remain unidentified. The unknown span between contrail formation behind the aircraft and first detection in the SEVIRI IR data cannot have much relevance for their radiative forcing, as the contrail is confined to a small width and does not produce a detectable signal in the radiances. More problematic is the termination of the tracking, which is often not the end of the impact on net radiation,

as a certain contrast to the surrounding is necessary for the detection. This point will be adressed in future studies, for instance, combining results of ACTA with ground based observations or by a statistical evaluation of a large set of tracked contrails. Nevertheless the design goal is, to cover the whole life cycle - of course as far as possible with satellite observations. We tried to account for the difference between design goal and reality of measurements also in the other parts of the paper.

p.1440, line 16 "The term aircraft-induced cloudiness is not used according to its IPCC definition."

Yes - we modified the first sentence of the introduction accordingly

p.1440, line 20 "young contrails are easy to identify. How shall the reader interpret the term easy in that statement? There are a number of false alarm issues in detecting line-shaped contrails passively from space-borne sensors. It may (or may not) be true that contrails remain linear, but unless the authors convincingly demonstrate that the tracked, short segments can safely be identified by the remote sensing method (in terms of width, optical depth, and other detectability parameters such as underlying surface or nearby cloud), the assertion (p.1442, lines 19ff) is not useful as an argument in support of the tracking method and affects the discussion in Sect.2, which heavily relies on the tracking of the linear segments."

Even an untrained observer (and I tested this with pre-school children) is able to identify linear contrails both in satellite images and by observing them in the sky above. In this sense the identification of linear contrails is 'easy'. In later stages of the development the linearity criterion becomes more and more unreliable as the contrails become wider and their boundaries become fuzzy. The identification of such an cirrus cloud as contrail or contrail cirrus is only possible, if the development in time is considered. This is the main principle of ACTA. The analysis of the properties of these 'special' cirrus clouds will be subject of a follow-on paper, but not of the description of the method here. The inclusion of 'width, optical depth, and other detectability parameters' into the

detection method would prohibit the further statistical evaluation of these parameters.

p.1449, lines 1+2 "Contrail age and linearity are not necessarily connected."

The term 'linear contrails' was coined in order to highlight the fact, that in satellite images only a (small) fraction of those cirrus clouds, which are directly initiated from aircraft can be identified by a linearity criterion, which includes the length to width ratio and also a certain 'sharpness' of the boundaries. Except from some unusual cases (military aircraft, changes of heading due to the airway structure) aircraft fly long distances in straight lines and are much faster then the variation of wind speed and direction. Thus there is no reason to assume, that fresh contrails are not linear. This changes in time as the ambient atmosphere with their inherent variations influences the development of the contrail. The reverse direction - i.e. the development from a bent and fuzzy structure into a linear shape is not very likely. So I conclude: Contrail age and linearity are connected.

"Relating to the life cycle issue from above: How long and wide are the contrail line segments mentioned in Sect.2.1?"

The tests that define the width and length of the accepted contrail region are described in Sect 2.2, the statistics of results will be presented in the follow-on paper.

"What about false alarms?"

The original CDA was tuned to give a low false alarm rate (see Sect, 1 in the revised version). For the test studies the result of the CDA has been verified by eye. We are aware that such a data screening is also necessary for a 'mass data production'. A second version of false alarms is the possibility, that pixels from the undisturbed surrounding are included into the contrail cirrus. The tests in sect. 2.2 are designed to reduce them to an - still not quantified - minimum.

"I suppose contrails merging into a thin cirrus cloud system or simply older strongly spreading contrails cannot be tracked for a long time with the method, even if the previ-

ous history of contrail evolution was known. What would happen if a tracked contrail or contrail segment is concealed/obscured by a cloud underneath or above or becomes optically to thin to be detected for a little while?"

Such situations terminate the tracking, as the contrail (or contrail cirrus) does no longer exist as an object, which can be discriminated radiometrically from the surrounding. This is one of the limitations of ACTA.

"What is the estimated optical depth detection threshold for contrails inherent in the applied method?"

ACTA is not based on an optical depth related radiance. Statistics on the temporal evolution of optical depth including an estimate of the thresholds will be a topic of the follow on paper.

The aim of the paper is to describe a method that provides a useful tool when studying the life cycle of contrails and provides a contrail mask, that allows to discriminate between contrails and natural cirrus. We are aware that the algorithm does not solve all the problems (discussed in pg 1460, line 15 and ss.). It takes the available tools for contrail studies by observation a step further as it allows to study the life cycle of a large number of contrails to be performed automatically..

Interactive comment on Atmos. Meas. Tech. Discuss., 3, 1439, 2010.