Analysis of the optical depth evolution in a spiral contrail using AVHRR data

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Spiral contrail

There is an increasing interest in contrails that support cirrus cloud formation and that modify the heating of the atmosphere. As a consequence, they may have an impact on our climate.

A case study shows a spectacular spiral contrail over the North Sea near the Danish coast. The multi-channel AVHRR Processing Scheme Over cLouds, Land and Ocean (APOLLO) is used to derive the optical depth of a long persistant contrail which presumably was formed by a military AWACS aircraft. The contrail has an age up to 3 hours. Favourably, the contrail exists in a homogeneous cold air mass covering only a small geographical area with its eye-catching shape (Figs. 1 and 2). The upper air wind blew away the contrail circles along the coast.

Method

The contrail pixel were manually identified by applying seven objective criteria based on thresholds and texture features in the calibrated data of the five AVHRR channels. The identified spiral pixel were rolled up from the North to the South along a time axis (500 pixel = 1 h) in order to study the temporal evolution of the contrail. The contrail is about 1500 km long, it consists of nine circles with a diameter of 60 km. The contrail pixel outside of clouds (Fig. 3) are used to determine the optical depth from R1 with the APOLLO algorithm assuming that each contrail pixel is totally filled by the contrail. First, the optical depth of the contrail pixel is derived, second, the optical depth of neighbouring cloudfree pixel over water, and the difference of both is shown along a time axis (Fig

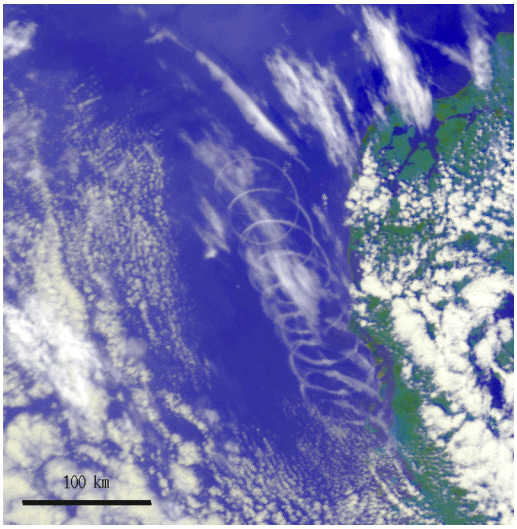
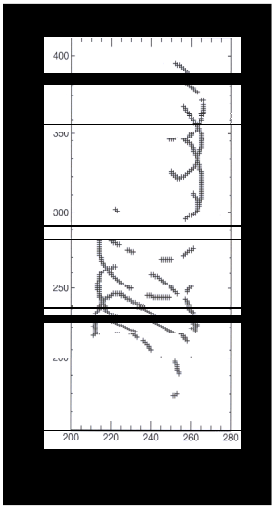


Fig. 2: Photograph of spiral contrail from ground (by courtesy of Arne

⇦ Fig. 1: AVHRR scene (ch. 1, 2, 4) of the North Sea: 22 May 1998, 14:45 UTC (remapped)

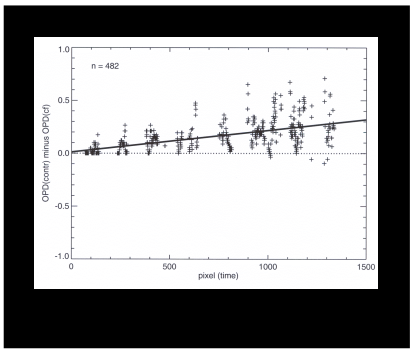


Results

The optical depth of the contrail is found to increase linearly from 0.5 to 0.9 in three hours, and the optical depth of the cloudfree pixel increases also for 0.1, thus, the temporal increase of the contrail's optical depth is in the order of 0.1 per hour at 0.63 μm.

This greater optical depth of the older parts of the contrail should lead to higher T4-T5 values. This is not the case, probably this effect is masked by the growth of ice particles with time, which was often measured in the contrails in-situ.

This pixel dataset of the curvilinear contrail may be used as a reference for new contrail detection algorithms.



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