

## ***Interactive comment on “A climatology of formation conditions for aerodynamic contrails” by K. Gierens and F. Dilger***

**K. Gierens and F. Dilger**

klaus.gierens@dlr.de

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### **Reply to the reviewer’s comments on Manuscript No. ACP-2013-344 A climatology of formation conditions for aerodynamic contrails by K. Gierens and F. Dilger**

We thank the reviewers for their friendly and constructive comments and hope to have met their expectations in our revised version.

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#### **1 Reply to reviewer No. 1**

##### 1.1 General comments

The reviewer mentions critical viewpoints that rate exhaust contrails too unimportant (for climate change, I assume) to be of any interest. The same line of arguments must then consequently rate aerodynamic contrails as even less interesting. I do not at all share such attitudes. Even if contrails (both types) would play no role at all for climate change (a point not to be discussed in this reply!), they would be of interest *per se* simply because they exist as natural (or not purely natural) phenomena. Neither rainbows nor glories (and a myriad of other phenomena) have any impact on climate change but probably nobody would say they are too unimportant to be of any interest.

Character sizes of the figures have been increased by 50% and colours in Figure 3 have been changed.

##### 1.2 Specific comments

###### 1.2.1 Page 14669

At 230 K and assuming ice saturation, the contribution of ambient water vapour to the water vapour at engine exit (i.e. ambient vapour plus vapour from burning kerosene) is of the order one percent, or equivalently the vapour resulting from burning kerosene contributes about 99% of all water at engine exit. (For a similar argument see: Gierens, K., 2012: Selected topics on the interaction between cirrus clouds and embedded contrails. Atmos. Chem. Phys., 12, 11943-11949, section 2). This shows the importance of the water added from the kerosene combustion for the initial visibility of exhaust contrails. In contrast, for aerodynamic contrails it is the ambient water vapour alone that must condense into visible ice crystals.

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A few lines on this have been added together with additional new text at the end of the first paragraph of section 2 in the revised version.

### 1.2.2 Figures

Figures have been redrawn with larger letters.

### 1.2.3 Typographical errors and minor objections

All corrections done.

## 2 Reply to reviewer No. 2

### 2.1 General comments

I have tried to improve the presentation and style along the recommendations provided by the reviewer, for details see below.

### 2.2 Specific comments

#### 2.2.1 Abstract

A short paragraph has been added at the beginning of the abstract explaining shortly the purpose of the current paper in terms of the potential climate impact of aerodynamic contrails. I hope this will rise interest for reading the paper. The word "belief" has been deleted from the last sentence (and changed into "deem" in the conclusion section).

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The word "currently" has been de-emphasized.

#### 2.2.2 Introduction

The introduction has been changed quite a bit in order to better meet the reviewer's requirements. A new paragraph has been added at the beginning that sets the stage, introduces climate impacts of exhaust contrails and contrail cirrus and relates what we know about such contrails to what we know and know not so far about aerodynamic contrails.

Ugly enumerations in the original text have been replaced by alternative text throughout the introduction. I hope this new text improves the English style sufficiently.

#### 2.2.3 Page 14672 (meant was 14671)

I removed some words and the sentence reads now: "This latter quantity can simply be calculated by dividing the aircraft weight by its wing area". Now it should be clear how the pressure drop on the wings is calculated.

#### 2.2.4 Page 14678

Sorry, I forgot this reference. Now added.

#### 2.2.5 Figure 5

There is a summer maximum in the northern hemisphere over the polar latitudes at the 350 hPa level, that is, at about 8000 m altitude. At the same altitude such a maximum is missing over Antarctica in southern summer, but there is a similar summer maximum

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at 450 hpa, that is, in about 6500 m altitude. I think, this kind of asymmetry can be explained by the different vertical distribution of temperatures in northern versus southern polar latitudes. The air over Antarctica is typically colder than the air over the Arctic in corresponding seasons (see for instance Figure 10.11 in J.R. Holton, 1979: An introduction to dynamic meteorology (2nd Ed.), Academic Press, New York, USA). This observation is reflected in the ERA-Interim data and thus in our analysis as well.

### 2.3 Technical comments

#### 2.3.1 Page 14670, line 3

The correct sentence is: "ice clouds that cannot without doubt be traced back to an aerodynamic effect are excluded". This has been replaced now anyway.

#### 2.3.2 Page 14670, lines 15 and 16

Text in line 15 changed as suggested. Text in line 16 unchanged, but text four lines above changed in order to avoid repetition of "when and where".

#### 2.3.3 Page 14671

Sentence changed into: "An example might be useful to explain the figure".

#### 2.3.4 Page 14674

Numbers less than ten spelled out here and elsewhere (three occasions).

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#### 2.3.5 Page 14674, line 29

corrected.

#### 2.3.6 Page 14675

BADA is now spelled out and cited.

#### 2.3.7 Page 14679

"are a bit randomly distributed" changed into "appear randomly distributed". I prefer to retain the structure of the figure for consistency with the structure of the other figures. In order to find out what is significant and what not, it would be required to analyse more years and to consider the variation from year to year. The small effect that we see indicates that it is not worth the effort to calculate a statistical significance in this case.

#### 2.3.8 Page 14680

The sentence has been changed into: "Persistent aerodynamic contrails are rare. Generally they occur with less than 10% probability, but more typically this probability is of the order 1%."

#### 2.3.9 Page 14681, lines 11 and 12

Corrected.

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#### 2.3.10 Figures

Figures have been redrawn.

### **3 Additional changes**

A colleague asked me about the significance of the 230 K visibility threshold. A few explanatory sentences are now given at the end of the first paragraph of Section 2.

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Interactive comment on Atmos. Chem. Phys. Discuss., 13, 14667, 2013.