FORECAST OF CONTRAILS

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This paper contains brief information about prediction of aircraft produced contrails in the ISSR. Most importantly it points on why it is necessary to forecast contrails and induced cloudiness. Mentioned inn this paper are few possibilities of improving the current situation .

K e y w o r d s: Contrails, Prediction, EU ETS

1 INTRODUCTION

Aviation has three important influences on condensation in atmosphere. The three aspects are: exhaust contrails, aerodynamics contrails, and ice particles production. Despite aerodynamics contrails may appear quite often is the most important condensation of exhaust contrails. Its importance lays in fact that these contrails and even more induced cloudiness which shape from them, have negative impact on Earth´s radiative balance. As contrails are not any danger for air transport there is no need to predict them and therefore is their future occurrence only rarely forecast. But with rising emphasis on problematic of changing climate and Earth´s radiative imbalance, there shall be efforts for improvement of scientific understanding and for better forecast systems.

2 CONTRAILS

The existence of contrails existence can be expressed using the Schmitt-Appleman criterium. It can be written in a simple equation, which consist of elements which are well known. Thus contrails as such can be easily predicted for each flight depending on the actual weather situation. But problem lies in estimate of persistence. The contrails without persistence becomes unstable and disappear in about 120 seconds. These non-persistent contrails although have some negative impact on Earth´s radiative force but the impact is by multiple smaller than the impact of persistent contrails. Persistency of contrails depends on fact if the ambient air is supersaturated with respect to ice. Such regions have been termed "ice-supersaturated regions" (ISSR). Super-saturation occurs very frequently in higher troposphere. ISSR can be connected with clouds free airspace or with ice crystal based cloudiness. Soot produced by incomplete combustion in aircraft engines supports the creation of the contrails and because burning 1kg of jet fuel produces 10^{14} soot particles it is technically impossible to reduce production of soot under level which would lead to stop occurring of contrails behind aircraft flying in ISSR. Important, but not indispensable is sulphur. Fuel with higher sulphur addition makes the soot particles more able to serve as condensation nuclei in aircraft, what is another reason why to decease % of sulphur in fuel. [1]

3 ISSR PREDICTION

As mentioned before ice supersaturated regions are indispensable condition for contrails formation. Important data were claimed from MOZAIC (Measurement of Ozone and Water Vapour by Airbus In-Service Aircraft) project. Mosaic project started in 1993 and there were five commercial aircraft of Lufthansa equipped with additional measuring devices to improve scientific information about atmosphere in altitudes where most part of commercial flight are made. One of most important outputs of this program was information about ISSR. It seems that average thickness of ISSR is not more than 1,5 km, what is important for avoiding of these zones by flying below or over. Another important conclusions of this study pointed on fact that some particles persist in atmosphere for more than 24 hours (although that average life cycle is significantly shorter), what makes contrails very important part in radiative forcing equations. Prediction of exact location and vertical position of ISSR shall be very important part of aviation meteorological forecast in near future. As mentioned before, ISSR are not important from safety of flight point of view, but they are of extreme importance from the aspect of aviation impact on atmosphere. In the time of MOZAIC experiment the data form only five aircrafts were evaluated after landing of aircraft but today technologies make real time evaluation from much larger aggregate possible. Effective tool for real time data obtaining and distribution is the MODE S SSR. Namely the BDS registers 44 Routine meteorological data, and 45 hazardous meteorological data are very important. These two registers contains meteorological data sufficient for ISSR regions prediction and so they can serve as input for atmospheric model which will predict air space segments where there is high risk of the contrails creation. The problem is that only a very small number of aircraft in worldwide, or at least in Europe region, is equipped with on board humidity measuring device. Reason why are aircraft not equipped with humidity measuring devices is that they don't need it for any meteorological measuring important for flight safety and so it is not used.

4 SUGGESTION FOR FUTURE

4.1 Further research

Level of scientific understanding of phenomenon contrail production is not high enough. For example there is no model or equation sufficiently enough to estimate

the time of how long contrails will stay in the atmosphere until they disappear. Also, there is no model for exact cirrus clouds creation in dependency on contrails. We know that there is a strong correlation but exact equation is still to be found.

4.2 Equipping of aircraft

With every aircraft equipped with humidity measuring equipment which would transfer the data via SSR mode S, we will gather more data from wider area of the world. The data received from radio probes can never have such as wide mesh than data from even only small a percent of commercial flight. Thanks to SSR, we have an adequate way how to gather important scientific data, but we can´t use it now because there are no aircrafts with such equipment.

4.3 Legislative Frame

With the implementation of air transport in EU ETS there is now strong and usable tool how to force aviation companies to participate on further research in this field. EU ETS made them pay for burdening of Earth´s atmosphere with CO_2 and other glasshouse gases, which negatively impacts radiative balance. All former initiatives such as [2], faced fact that aviation company has no obligation to fly in such way to minimize the impacts on Earth´s climate, their only target is to minimize the costs.

With existence of EU ETS and its liability for most of aviation companies in EU, there is for first time legislative tool how to encourage aviation companies, producers of aircraft or ATM to find new solutions for reducing of negative impact of aviation on radiative forcing balance. Contrails forecast system could be viable way how to achieve it. For example if we would mark out some parts of air space, where is high risk of contrails production, we may remove airplanes which avoid this zone from obligation of buying EU ETS allowances for this trip. It shall be a "win-win" scenario. Aviation companies spare some financial funds for not have to buy allowances and flying in zone without contrails, even with fact that there will be higher fuel consumption, we shall have lesser negative impact on Earth´s radiative balance.

5 CONCLUSION

Forecast of area of ISSR is important for increasing the possibility of reducing aviation impact on Earth´s radiative balance despite the fact that there are still many unknown. The existence of EU ETS makes it possible for the first time and there should be further research.

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