EMS Annual Meeting Abstracts
Vol. 12, EMS2015-638, 2015
15th EMS / 12th ECAM

Probing the upper troposphere by watching aircraft

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Contrails (a short word for "condensation trails") are linear clouds that sometimes form behind aircraft. Their formation is triggered when the hot and humid air in the exhaust of aircraft engines mixes with sufficiently cold air in the upper atmosphere. Depending on the temperature and humidity at the flight altitude, contrails may not form at all, form and evaporate within a few seconds or minutes, or persist for a longer time, possibly spreading into cirrus clouds. Contrails and induced cirrus are studied as one component of aviation's impact on the climate system, but simulating contrails remains very difficult because the variations in upper-tropospheric humidity are insufficiently documented and understood.

We propose to think in reverse mode. Sky cameras now have enough resolution to resolve persistent and non-persistent contrails. So-called "flight radars" can listen to automatic signals broadcasted by air planes every few seconds, thus providing the exact position of the planes. As contrail formation and evolution are well understood, detecting and observing contrails forming behind identified air planes offer an indirect measurement of temperature and humidity in the upper troposphere in clear-sky conditions. Drifting contrails can also be used to derive atmospheric motion vectors by comparing successive images. As part of the Harry Otten prize for innovation in meteorology, we propose to use off-the-shelf instrumentation to fully automate such observations, thus providing unique high-frequency and low-cost information on the upper troposphere.

Such measurements are expected to be of high value not only for quantifying the climate impact of contrails but also for numerical weather prediction that relies on real-time availability of numerous measurements from in situ and remote sensing observations. Our proposal is also in line with a general trend in meteorology towards fully automated instrumentation. The measurement system may offer interesting synergies with existing and future programs of sky monitoring that can deliver other pieces of information on the atmosphere. This talk will present qualitative and quantitative aspects of our observation method, highlighting its potential and feasibility but also the remaining difficulties.