Thunderstorm *Hector* north of Darwin, Australia. (Photo: Hans Schlager)

Lightning and nitrogen oxides in the most intense thunderstorms on Earth -

New research results from IPA now published

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Thunderstorms are not only spectacular weather phenomena but also have an important influence on atmospheric chemistry and climate. In the last years, the DLR-Institut für Physik der Atmosphäre (IPA) focussed on this topic and performed a number of field experiments in Europe, Brazil, Africa and Australia. The research was part of several European research programs (e.g. EULINOX, TROCCINOX, AMMA, SCOUT-O3) with a number of international partners. The measurements are now evaluated and recently published in international research journals. Important new results were achieved.

In the hot lightning channel the available oxygen and nitrogen in the atmosphere can produce large amounts of nitrogen oxides (NO). According to global estimates, see review article of IPA scientists on this topic (*Schumann and Huntrieser*, 2007), the NO emissions from lightning are distinctly higher than NO emissions from aircraft.

In the last years, IPA performed field experiments in the tropics to investigate thunderstorms in areas with the highest global lightning frequency. Research aircraft performed in-situ measurements of nitrogen oxides in the thunderstorms and the new German lightning detection network LINET was installed at the ground (*Höller et al*., 2009). The present knowledge on lightning was summarised in a book (*Betz*, *Schumann and Laroche*, 2009). In the years 2004 and 2005, the DLR research aircraft *Falcon* performed many research flights in Brazil (*Huntrieser et al*., 2007, 2008). Field experiments in Australia and West-Africa followed in the years 2005 and 2006. In Darwin, at the northern top end of Australia, one of the most intense and well-known thunderstorm on Earth (*Hector*) was investigated in detail.

The results are surprising. Though tropical thunderstorms produce a lot of lightning, the observed amount of nitrogen oxides was not as large as expected. Detailed investigations show, that not only the number of flashes is of importance, but also the length of the flashes. In typical short-lived tropical thunderstorms the flashes are on average shorter than in thunderstorms at our latitudes. This is mainly caused by the higher wind shear in our latitudes. The elevated wind shear causes a stronger change of wind speed and direction with altitude. As a result, the up- and downdraft areas in the thunderstorm are separated and the thunderstorm intensifies, spread and may persist for a longer time. These recently published results from IPA-scientists (*Huntrieser et al.*, 2009) are now also explicitly confirmed by U.S. scientists at NASA (*Bucsela et al.*, 2009).

Simulations with the global climate model *ECHAM* of the IPA give further interesting results. Nitrogen oxides from lightning produce ozone and ozone is an important greenhouse gas. Up to now, it was assumed that more thunderstorms can develop in a warmer world. Therefore, it was expected that more nitrogen oxides and ozone are produced, which further contribute to global warming. However, according to the new IPA studies the opposite is the case. In a warmer climate the number of thunderstorms will decrease, however the thunderstorms themselves will intensify. Overall, it is expected that the number of flashes around the globe will decrease. This result agrees well with observed long-term trends of lightning occurrence. The actual climate impact of thunderstorms may therefore be the opposite of what was assumed up to now (*Grewe*, 2009).

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