Measurements of HO_x in the outflow of convective systems

Atmospheric Chemistry – AG Harder

Roland Rohloff[1], Daniel Marno[1], Monica Martinez[1], Dirk Dienhart[1], Ivan Tadic[1], Horst Fischer[1], Jos Lelieveld[1,2], Hartwig Harder[1,]

[1]Max Planck Institute for Chemistry, Mainz, Germany
[2]Energy, Environment and Water Research Center, The Cyprus Institute, Nicosia, Cyprus

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CAFE-Africa campaign

The CAFE-Africa-Campaign (Chemistry of the Atmosphere Field Experiment) aims to study the impact of the convective outflow during the 2018 West African Monsoon on the chemistry and composition in the upper troposphere. The HALO (High Altitude and Long Range Research) aircraft had been equipped with a comprehensive set of gas phase and aerosol instruments. Based from the Cape Verde Islands HALO probed the convective outflow from electrified and non-electrified systems with marine or continental inflow during 14 measurement flights.

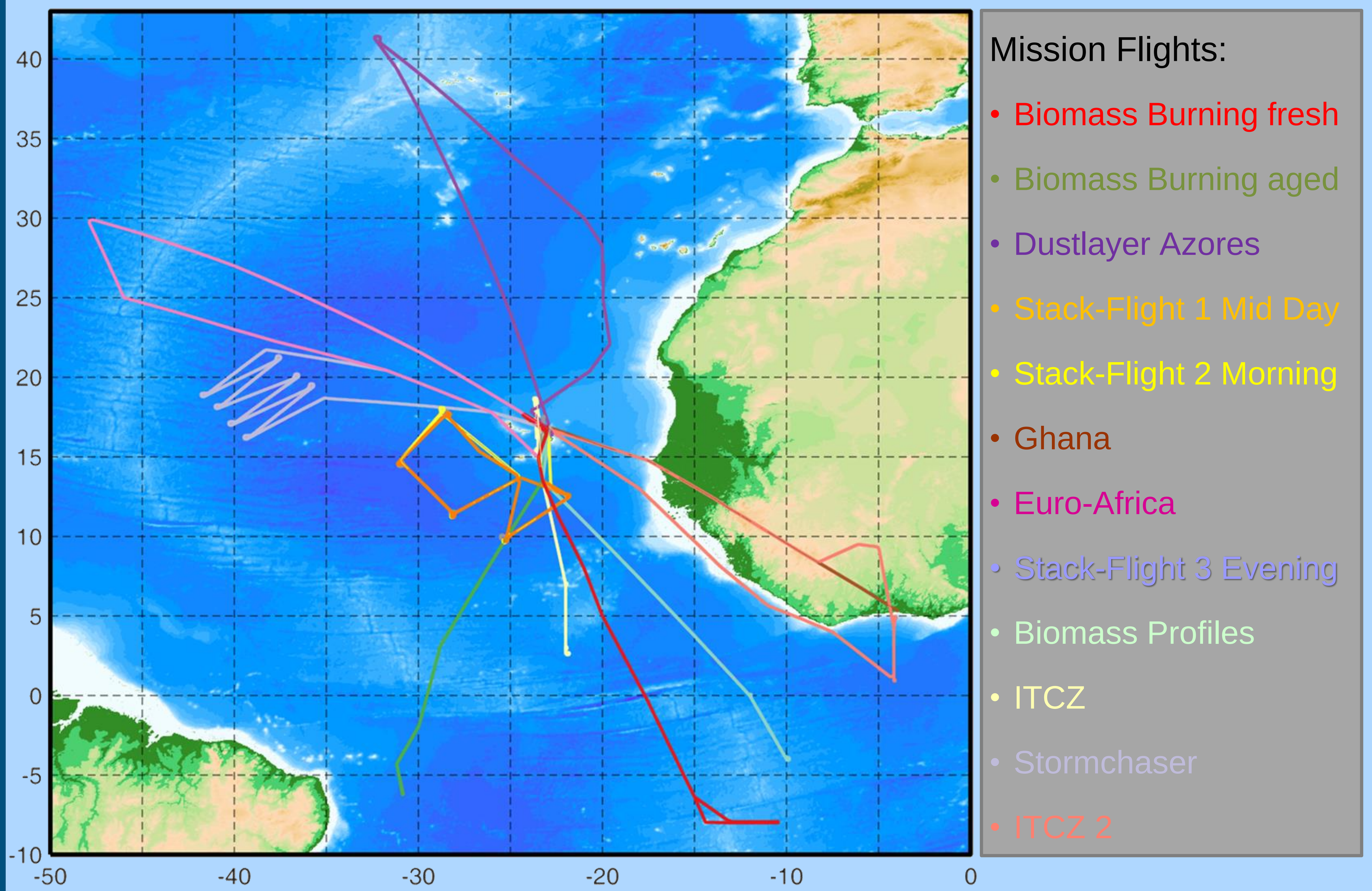


Fig 1 : Flight-tracks for scientific mission flights of the Cafe-Africa Campaign, that took place during the West African Monsoon 2018

Detection of atmospheric OH / HO2 with the HORUS-Instrument

To minimize wall loss and optimize calibration capability the sampled air is decelerated in a shrouded inlet (fig 2a). The air is drawn into a prechamber close to ambient pressure and periodically exposed to an OH scavenger (fig 2b) to quantify the chemical OH background. In the following detection volume, at low pressure (1.5-15 hPa), the OH-radicals are exposed to Laser radiation on and off resonance of Q12 transition around 308nm (fig 2c). The emitted fluorescence light is detected by a micro-channel-plate PMT.

Detection of HO_2-radicals is achieved by chemical conversion of HO_2 to OH. Possible interferences originating from RO_2+NO are quantified by periodic variation of the NO-addition.

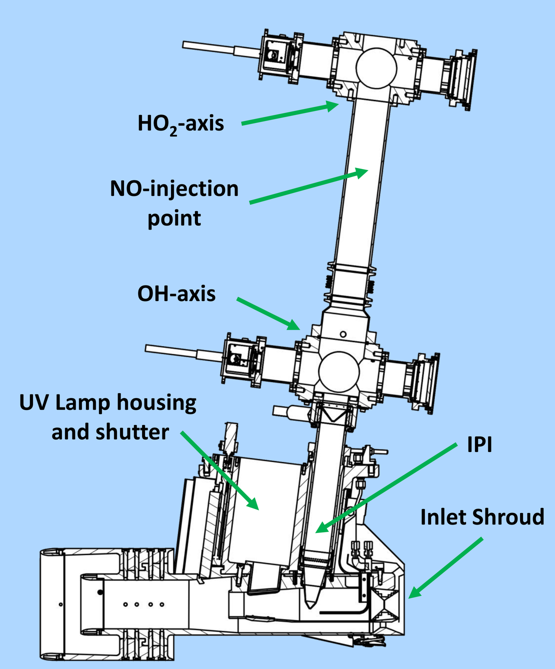


Fig 2a : Drawing of the Inlet Shroud and HORUS-Instrument

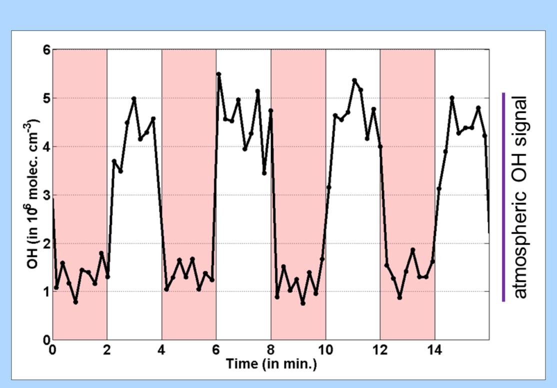


Fig 2b: Determination of chemical background by periodic scavenger addition

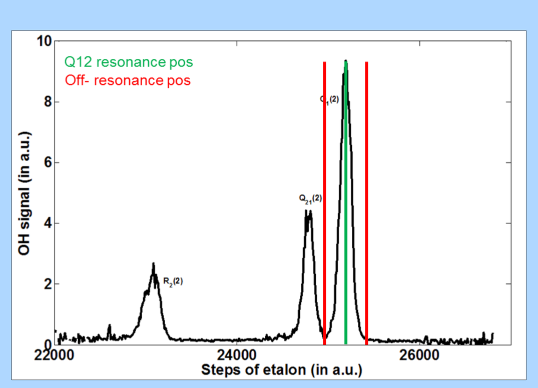


Fig 2c: Determination of physical background by wavelength toggling on and off the resonance position

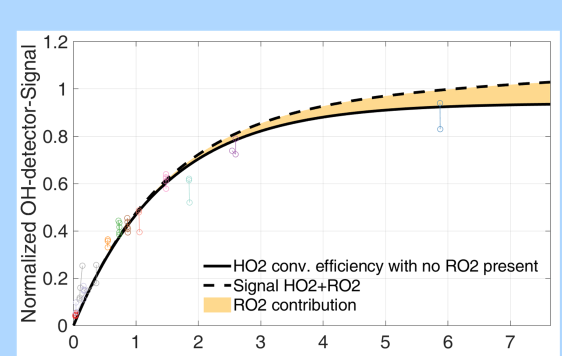


Fig 2d: HO_2 conversion efficiency for different NO additions

Mission Flight – ITCZ

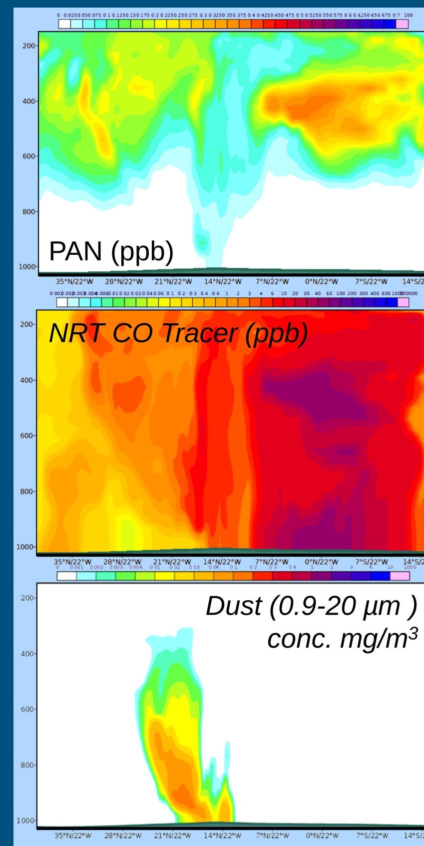


Fig 3b: CAMS forecast 31 Aug 2018 vertical cross section at 22°W ª

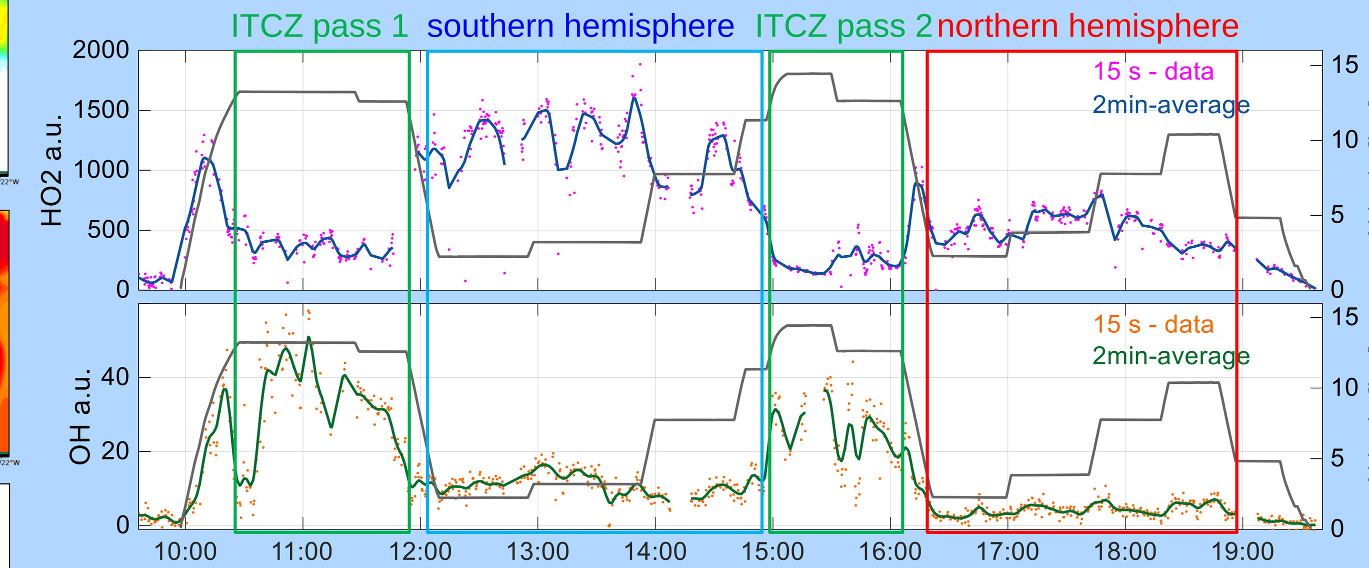


Fig 3a: Preliminary OH and HO2 fluorescence data, for mission flight 13, boxes indicate areas of interest

- *Monitor differences in air masses of both hemispheres at 4 legs each*
- *Northern hemisphere influenced by Saharan dust event*
- *Southern hemisphere Biomass Burning (BB) impact predicted by CAMS*
- *Two ITCZ passes at Flight-level 410 and 450*

Findings based on preliminary data:

- Southern hemisphere enhanced HO_2* signals in the BB-Plume compared to signals in the northern hemisphere.
- Southern hemisphere : Strong shifts in HO_2*, that could indicate convective outflow events.
- Encountered cumulonimbus clouds (PIC-1) during ITCZ passes, flybys are accompanied by increase in OH, possibly due to lightning NO_x in outflow.
- Lower OH and HO2* in later stage of the flight due to lower j(O¹D)
- increase in OH, after passing the cloud layer, driven by increased j(O¹D) as well as HO_x sources transported by the cloud on thin layer above the clouds.

Mission Flight – Stormchaser

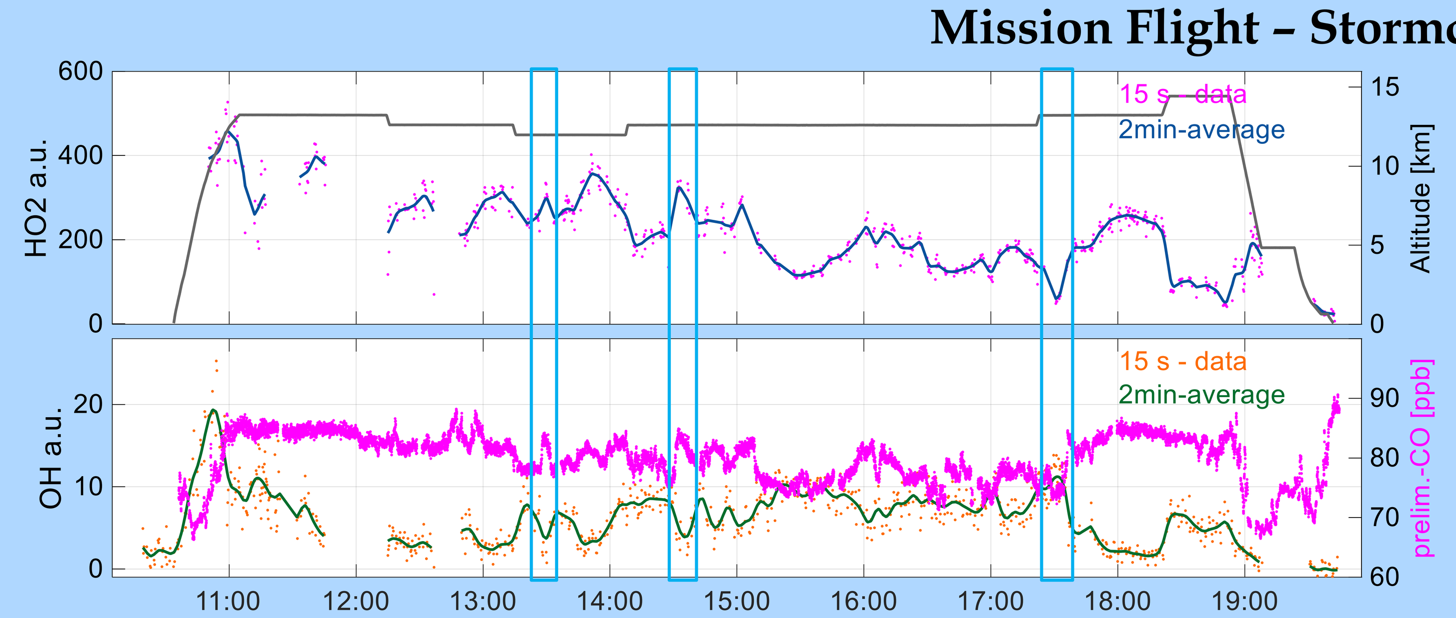


Fig 4a: Preliminary OH and HO2 data, for mission flight 14, boxes indicate areas of interest

- *sample outflow of the early stage of hurricane Florence utilizing traversing maneuvers to cross the outflow*

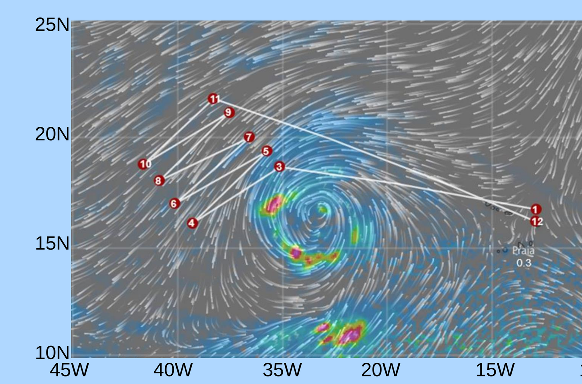


Fig 4b: Windy.com Air-Profile used in flight planning, provided by Horst Fischer, MPIC; prediction for 02 Aug 2018 14:00 UTC

Findings based on preliminary data

- initial climb: increase in OH* above the cloud layer
- HO_2 signal follows CO signal shape
- OH* mirrors the CO signal

Mission Flight – Biomass profiles

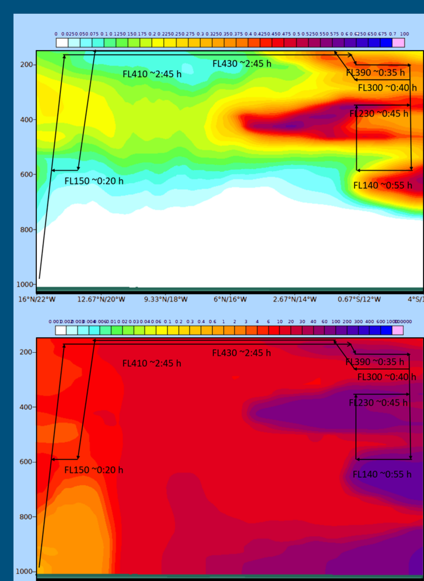


Fig 5b: CAMS forecast 29 Aug 2018 vertical cross section from 16°N/22°W to 4°S/10°W ª
(top) CO-tracer (ppb)
(bottom) PAN (ppb)

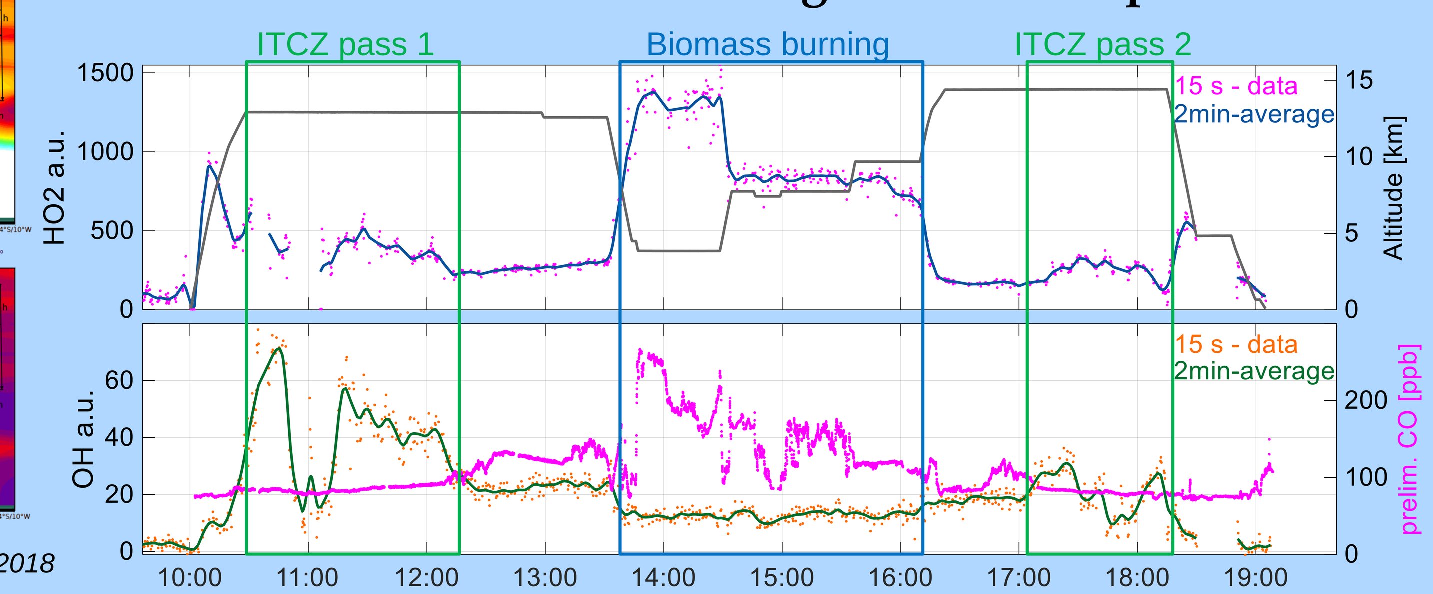


Fig 5a: Preliminary OH and HO2*, for mission flight 12, boxes indicate areas of interest*

- *Fly a southbound route and descend into biomass burning plume, predicted by CAMS*
- *Sample outflow of the ITCZ while flying to BB-plume*
- *Sample BB- air at various PAN / CO layers predicted by CAMS around -15/-10.*
- *Sample outflow of the ITCZ while flying back*

Findings based on preliminary data

- initial climb: strong increase in OH* above cloud layer.
- ITCZ Fly-over: cumulonimbus clouds - accompanied by increase in OH*
- BB-plume: CO and HO_2* increase whilst OH-signal declines.
- First BB-leg FL120: HO_2* at max. value for the flight
- Following BB-legs: HO_2* lower compared to FL120, but still elevated
- HO2-signal dropping / OH increasing whilst increasing in altitude
- 2nd ITCZ-Flyover, quick OH* shifts, but smaller, since decreased j(O¹D)-rate

Data level presented in plots

- Fluorescence data presented with off resonance background subtracted
- OH-data : OH* without subtraction of chemical background
- HO2-data: Data shown at 90% conversion efficiency, background due to RO2-conversion to be determined by frequent low conversion measurements.

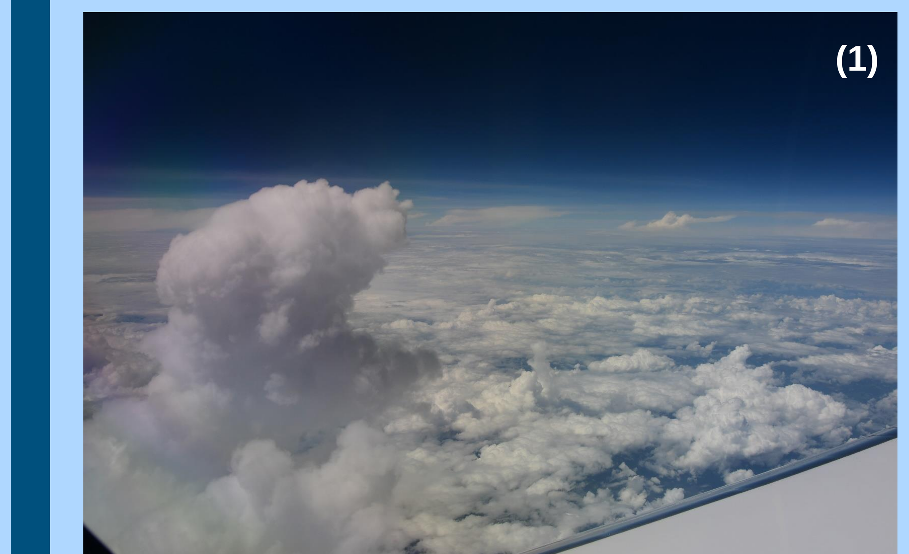
Conclusions from preliminary data

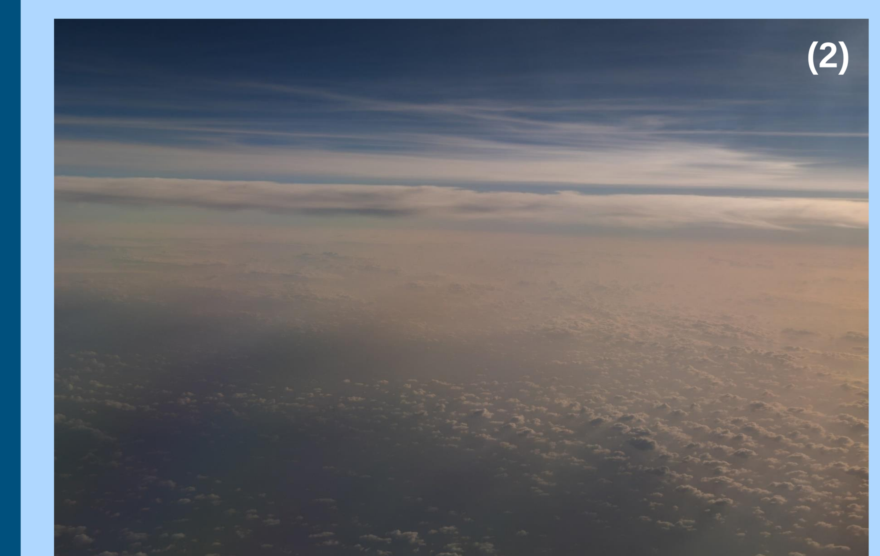
- elevated HO_2* has been observed in biomass burning plumes
- elevated OH* in outflow of convective systems, due to presence of lightning NO_x
- elevated OH above the cloud deck due to increase of j(O¹D) and HO_x sources

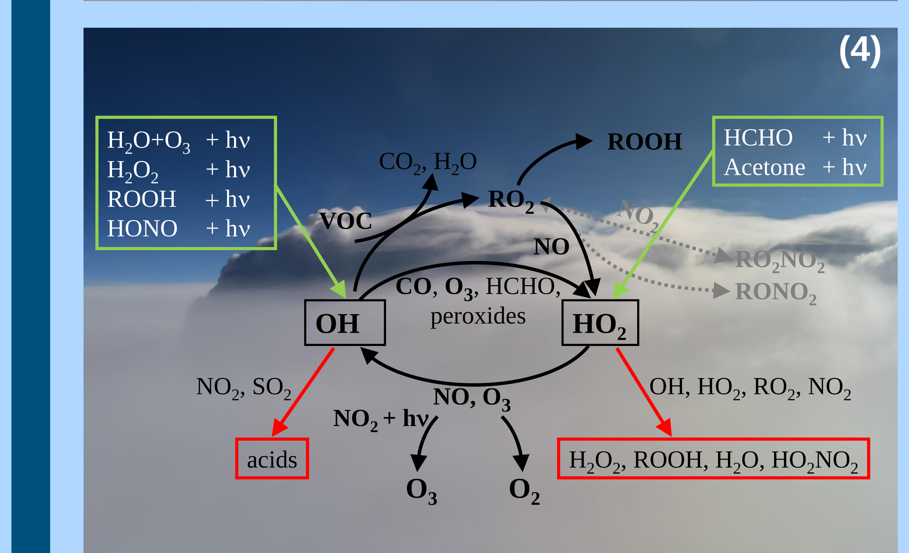
Scientific questions to address

- Radical recycling efficiency under different convective outflows and background air
- New particle formation in outflow of clouds
- Potential vs actual Particle growth depending on inflow into convective system (marine/continental)

ªContains modified Copernicus Atmosphere Monitoring Service Information 2018







(1) cumulonimbus clouds at the ITCZ during Mission flight 13
(2) Dust layer North of the ITCZ Mission flight 13
(3) HALO aircraft after take off
(4) cumulonimbus cloud / with HO_x-Cycle super-imposed
(5) Group Picture at SAL-Airport with present Scientific crew
(1)–(4) pictures by Dirk Dienhart, MPIC
(5) picture by Susanne Benner, MPIC