Ozone and water vapour sonde measurements at Bhola Island, Bangladesh

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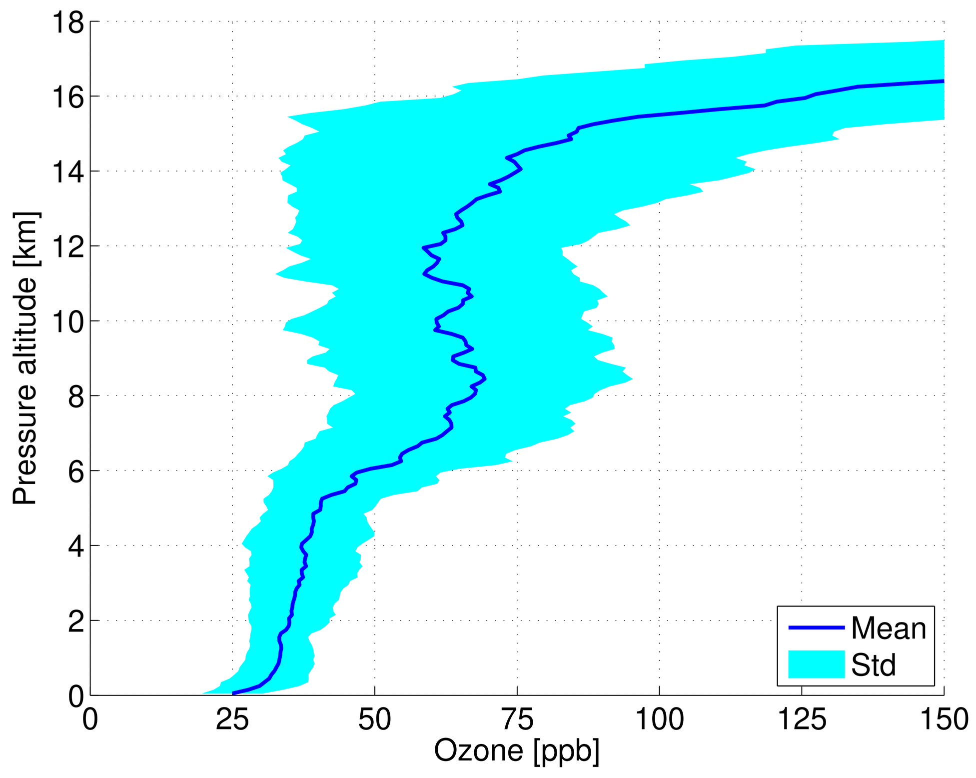
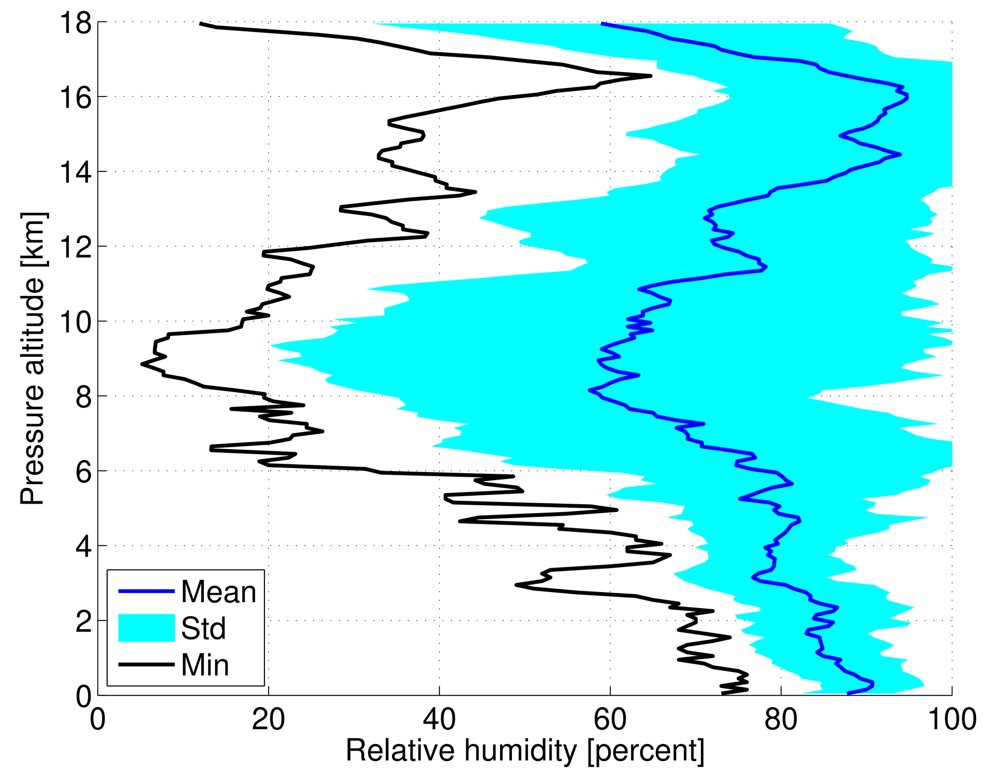
- 14 sonde launches from Bhola Island, Bangladesh
- As part of the StratoClim campaign
- Asian Summer Monsoon season
- Jul–Aug 2016 and Jul–Aug 2017

Sonde launch at Bhola Island: J. "Egon" Graeser (AWI) and local collaborators

Mean profiles



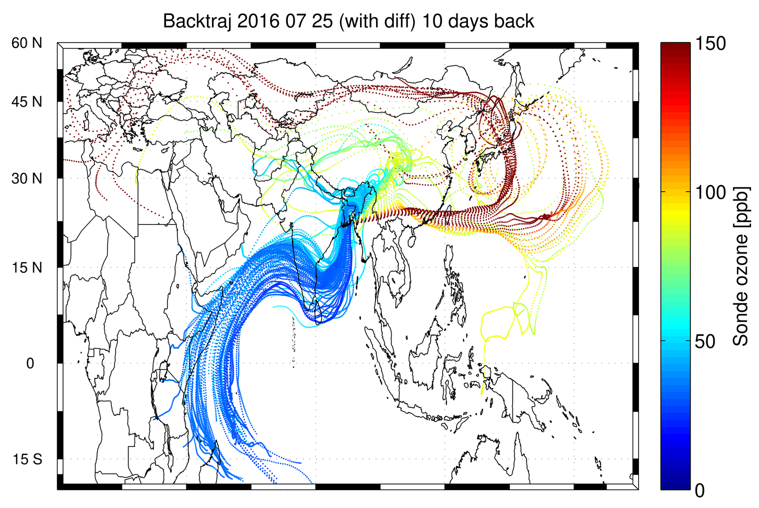
Mean ozone profile averaged over all soundings and standard deviation over all soundings

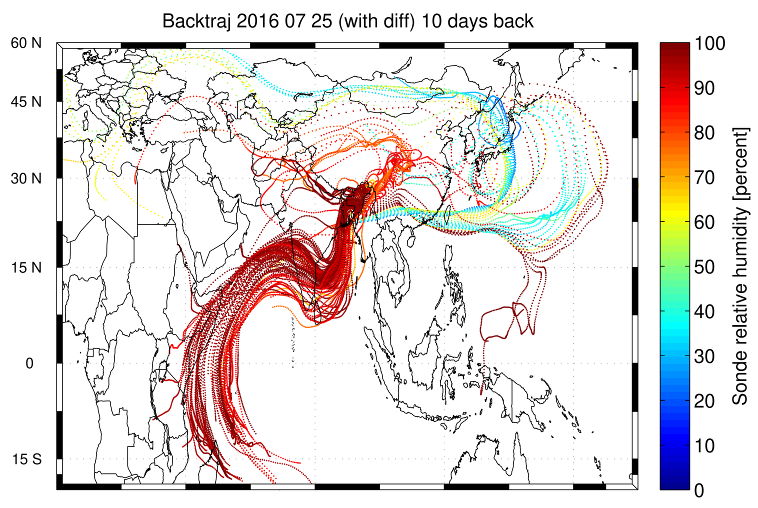


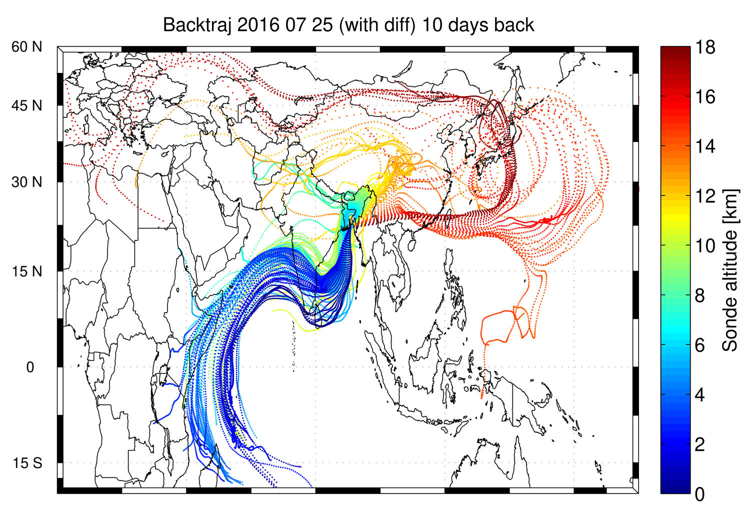
Mean relative humidity profile averaged over all soundings. Relative humidity over water vapour for $T > 0^\circ$ C and over ice for $T < 0^\circ$ C

- Large variability both in O_3 and H_2O
- Pronounced relative humidity minimum somewhere between 6–12 km in many sondes (at least 8 of 14)
- Ozone maximum somewhere between 6–12 km in many sondes (at least 7 of 14)
- Most sondes show a pronounced increase in ozone and decrease in relative humidity around 6 km

Back trajectories: Origin of air matters for O_3 and H_2O
(Example 25 Jul 2016)





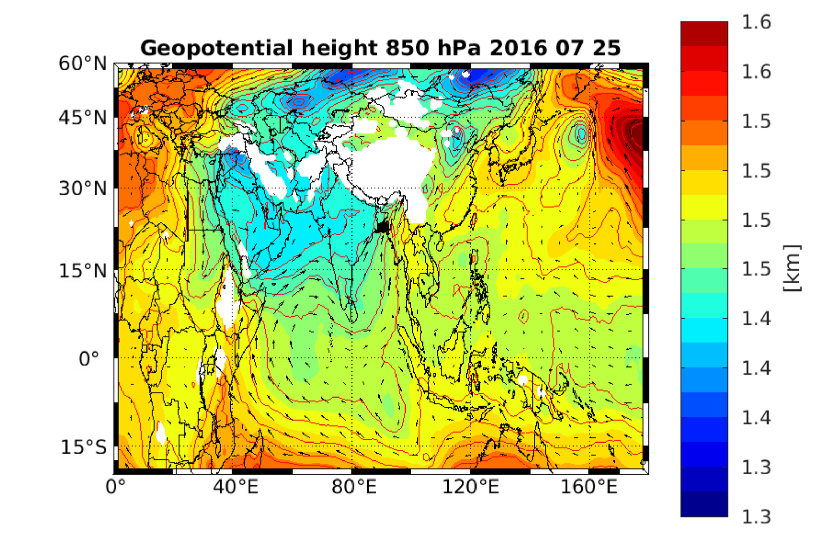


- 10 day back trajectories driven by ERA Interim starting every 100 m along sonde ascent
- Color coded by: Ozone (upper left), altitude (lower left), relative humidity (upper right)

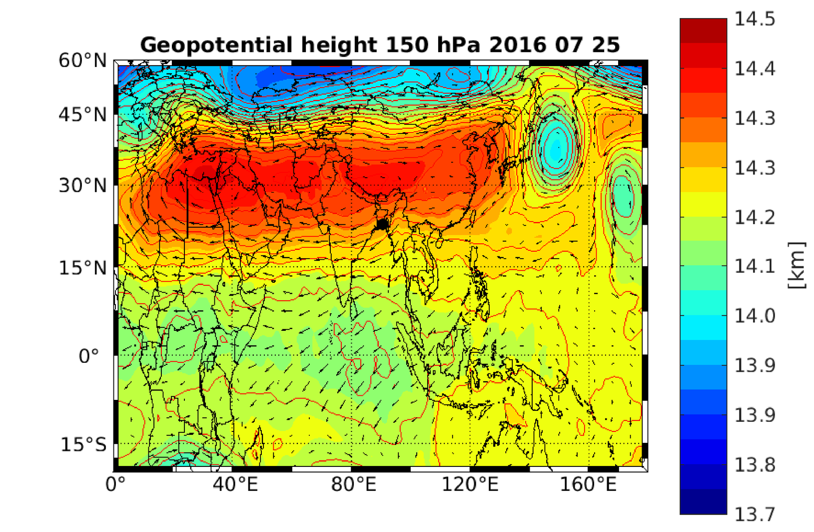
Conclusions

- Clear correlation between origin of air and O_3 and H_2O
- True for all measurements, not only for example
- Up to 6 km: Asian summer monsoon circulation
  - Advection from southwest
  - Air originates over Indian Ocean
  - Extremely moist
  - Poor in ozone (clean)
- Between 6–12 km: Transitional area
  - Relatively low wind speeds
  - Different origins: E.g. Tibet, Phillipines
  - Location of O_3 maxima and H_2O minima
  - Most "interesting" region
- Above 12 km: Monsoon anticyclone
  - Advection in large loop: Eastward above Inner Asia, southward above East of China, westward above South China and India
  - Dry
  - Increased ozone

Weather conditions

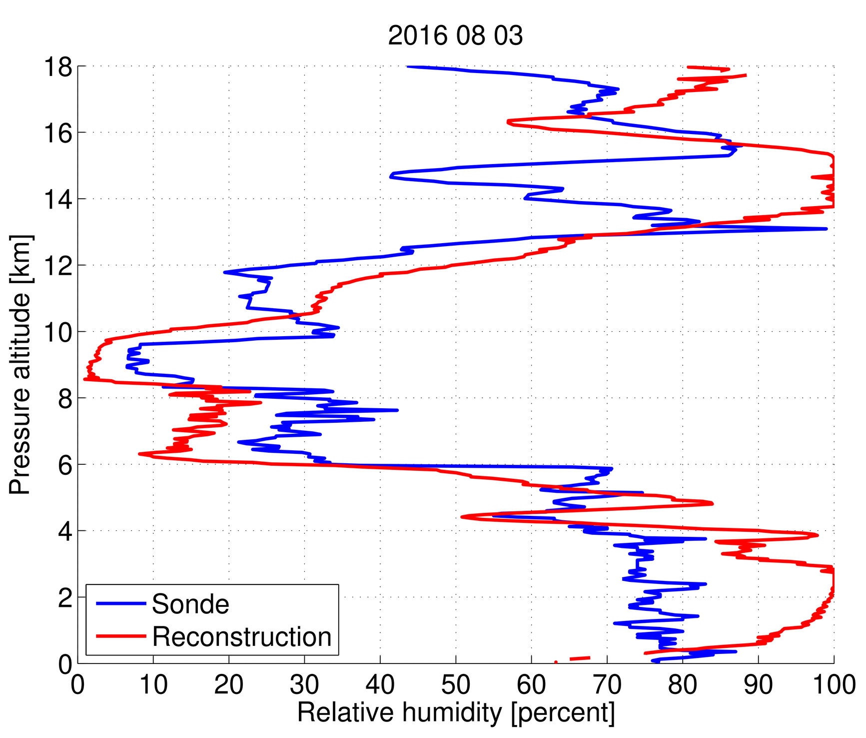


Geopotential height and wind (850 hPa, 25 Jul 2016)



Geopotential height and wind (150 hPa, 25 Jul 2016)

Water vapour minima explained: Air saturated in convection gets drier by subsidence
(Example 3 Aug 2016)



Relative humidity measured on 3 Aug 2016 (blue) and reconstruction from minimum temperatures along statistical ensembles of trajectories including convection (red)

Statistical ensemble trajectories with convection

- In addition to "normal" trajectory, 50 statistical ensemble trajectories at every starting point (every 100m)
  - Statistical convection driven by ERA Interim convective mass fluxes and detrainment rates
  - Statistical vertical diffusion of 0.1 $m^2 s^{-1}$

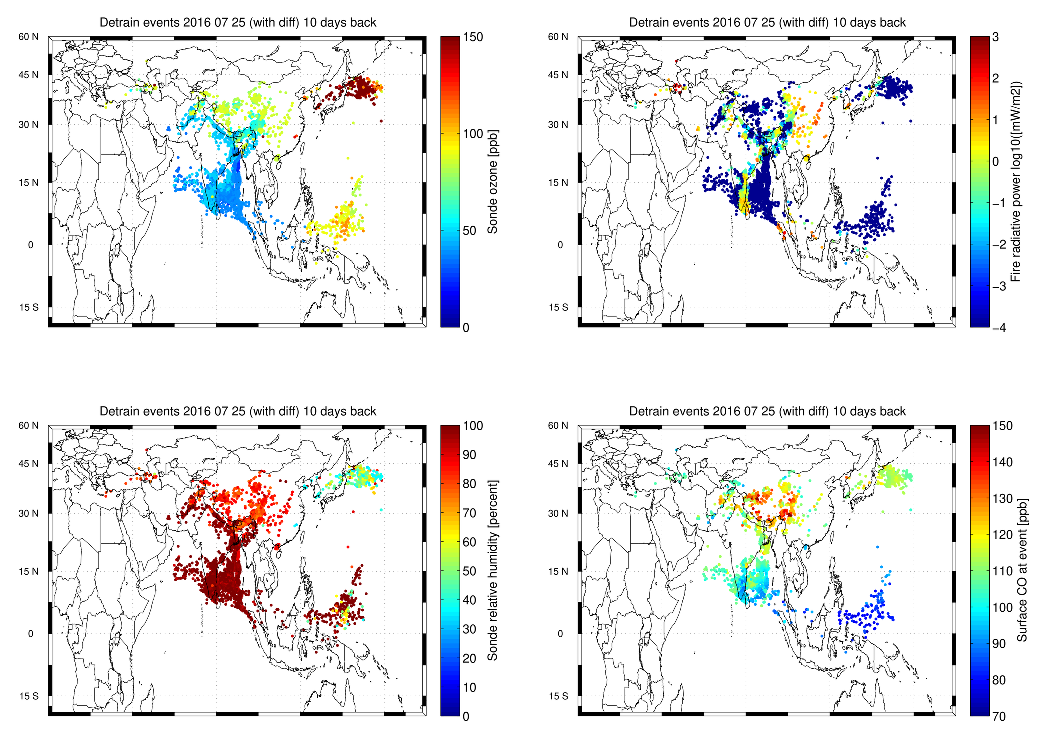
A simple model for predicting water vapour:
Assumptions:

- Trajectory leaves convection with 100 % relative humidity
- Slow subsidence and adiabatic warming outside cloud
- Absolute water vapour is conserved (relative humidity decreases)

Realisation of model:

- Take coldest temperature of each ensemble trajectory after last convective event
- Divide saturation pressure of coldest temperature by saturation pressure of measured temperature to obtain relative humidity
- Average over the 50 ensemble trajectories to obtain one value per altitude

CO and biomass burning at detrainment locations
(Example 25 Jul 2016)

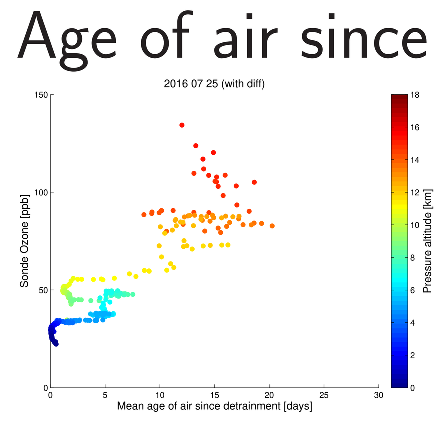


- Locations of last convective event for all ensemble trajectories
- Sonde ozone (upper left), Sonde relative humidity (lower left), Fire intensity from MODIS satellite measurements (upper right), Surface CO from AIRS satellite measurements (lower right)

Conclusion

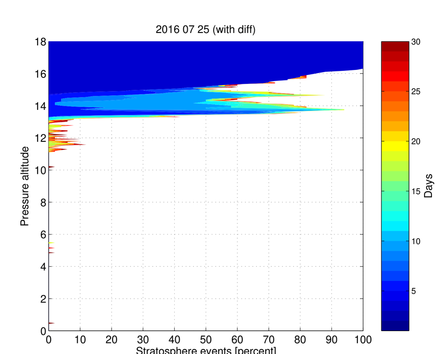
- No very clear relationship between maxima/filaments in sonde ozone at Bhola and measured quantities at the location of the convective events (CO, fire intensity) (for all soundings)

Age of air since convection



- No clear relation between mean age of air since last convective event and measured ozone (Figure shows example 25 Jul 2016)

Minor stratospheric influence



- Most profiles show no significant influence of stratospheric air below 12–14 km (Figure shows percentage of ensemble backward trajectories ending in stratosphere after n days, 25 Jul 2016)

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