Comparing RD94 dropsonde and aircraft temperature and humidity measurements based on data from arctic field studies

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Introduction

Dropsondes are launched from research aircraft to measure vertical profiles of temperature, humidity, pressure and wind in the atmosphere while descending to the ground. Onboard the aircraft Polar 5 of the Alfred Wegener Institute for Polar and Marine Research (AWI), they are deployed on arctic and antarctic campaigns.

Here we compare dropsonde and aircraft temperature and humidity sensors to assess their performance under arctic conditions.

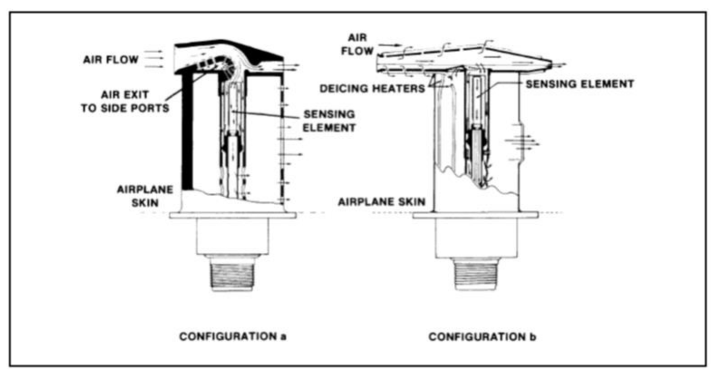
Dropsonde

- Commercial Vaisala RD94 dropsondes (Hock and Franklin, 1999)
- Launched from the aircraft on a parachute, dropping at $v_z \approx -10\ m/s$

Temperature:	Pt 100 sensor
Relative humidity:	Humicap (capacitive)
Wind vector:	GPS

Polar 5 aircraft sensors

- Permanently installed in commercial Rosemount aviation housings (Stickney and Shedlov, 1994)



Temperature:	Pt 100 sensor
Relative humidity:	Humicap (capacitive)
	Dewpoint mirror

Field measurements

- Flights over different regions of the arctic ocean
- Temperatures between $-35℃$ and $+5℃$
- Dense, low stratus clouds (mostly liquid phase)
- Dropsonde launches next to vertical profile flights
- AMALi aerosol lidar (Stachlewska et al., 2010) identifies cloud top

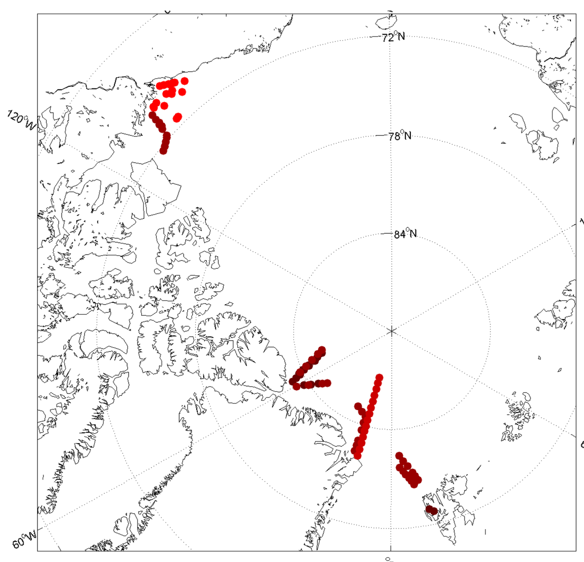


Fig 1: Measurement locations

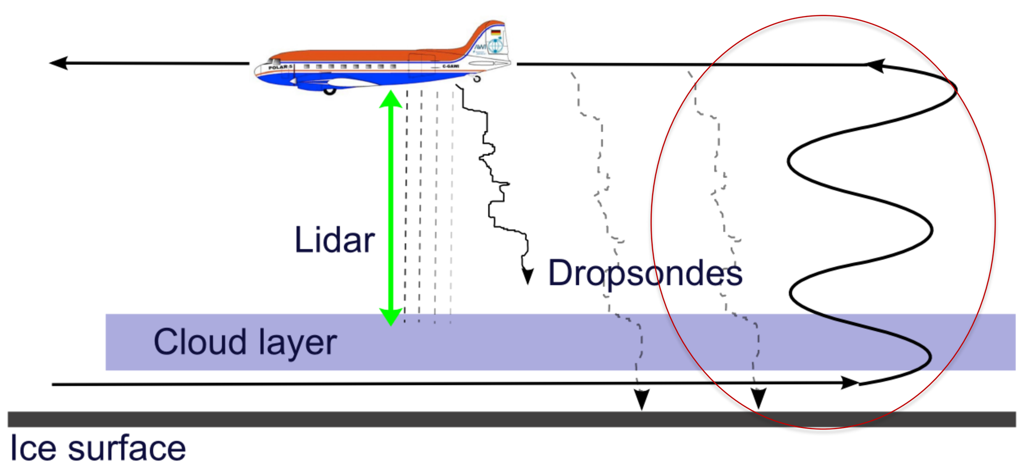


Fig 2: Measurement pattern

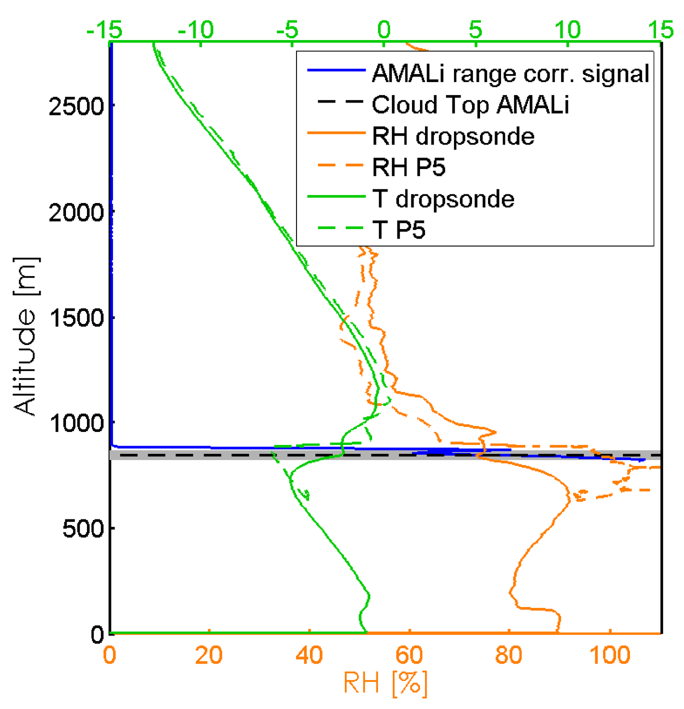


Fig 3: Example of profiles measured by dropsonde and Polar 5 aircraft. The top of a stratus cloud at $850\ m$ can be seen in temperatures and humidities and by the AMALi lidar backscatter. Aircraft humidity shows a vertical extent of the cloud of about $250\ m$.

Data evaluation and results

Dropsonde – aircraft comparison:

- Dropsonde profiles located near aircraft descents or ascents in space and time are chosen
- Data are averaged over common altitude bins of $20\ m$
- Data are separated into bins inside and outside cloud using additional information from atmospheric lidar for cloud top altitude

Relative humidity

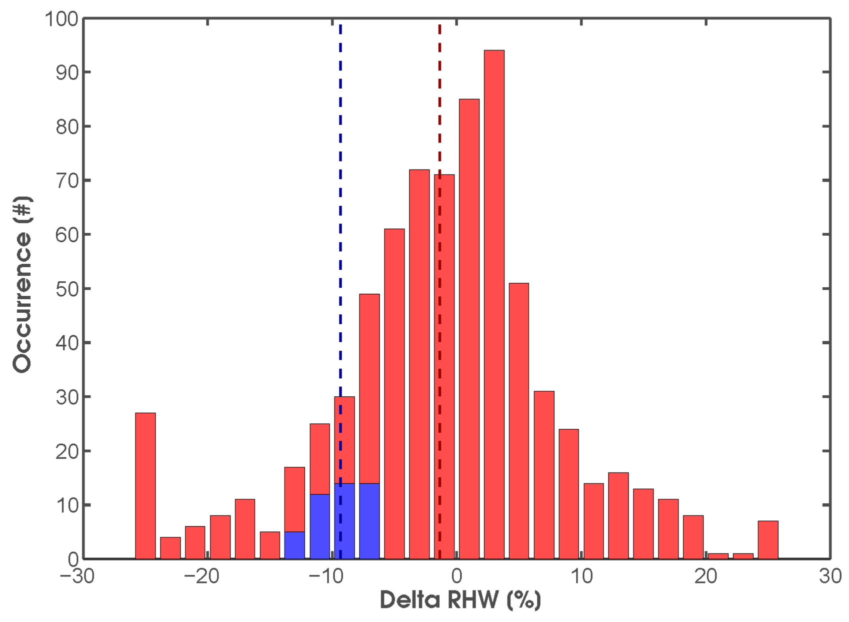


Fig 4: Dropsonde minus aircraft for measurements in cloud free air (red) and dropsonde compared to $100\ \%$ inside clouds (blue). Mean values agree within $2\ \%$ RH in cloud free air. Inside clouds, the mean bias is almost $-10\ \%$.

Temperature

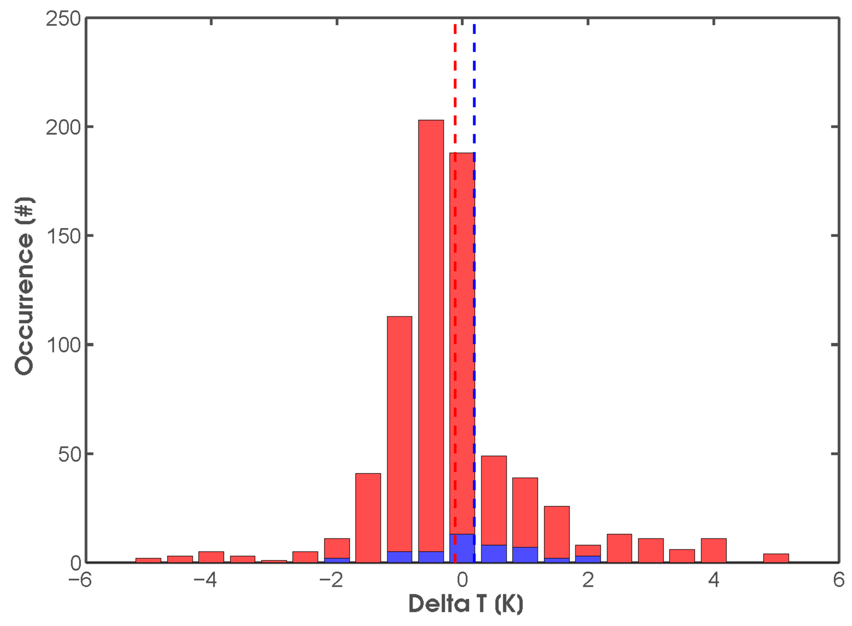


Fig 6: Dropsonde minus aircraft for measurements in cloud free air (red) and inside clouds (blue). Mean values agree within $\pm 0.1\ K$ in cloud free and cloudy air.

Dropsonde max. humidity

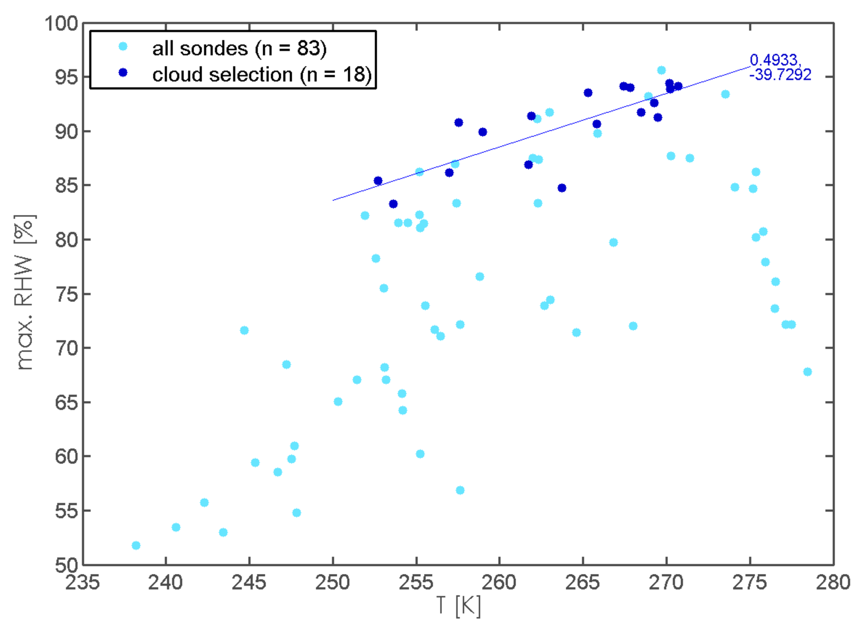


Fig 5: Maximum dropsonde humidity per profile within and out of clouds.

- Theoretical 100% within clouds is not reached at any temperature
- Temperature dependency of about $-0.5\ \%RH/K$

Dropsonde time lag

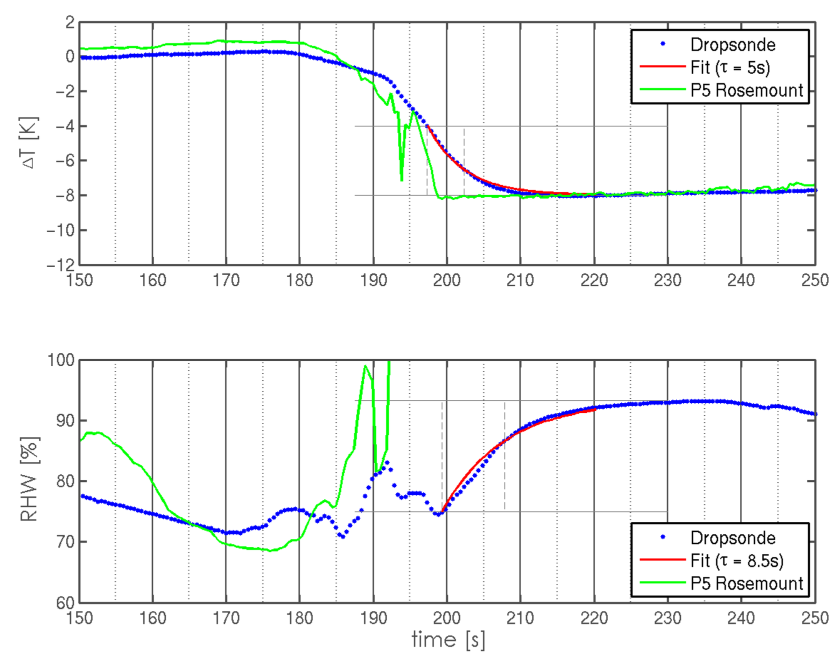


Fig 7: Example for dropsonde time constant estimation at cloud top transitions.

- T: $\tau_{mean} = 4.5s(\pm 2s) \rightarrow 45\ m$
- RH: $\tau_{mean} = 8s(\pm 2s) \rightarrow 80\ m$

- Overall agreement dropsonde – aircraft is good outside of clouds
- Dropsonde humidity within clouds shows a dry bias of almost 10 %
- Data indicate a temperature dependency of the humidity bias
- Threshold for cloud detection from dropsondes needs to be adjusted below 100% depending on temperature

References: Stachlewska, I. S. , Neuber, R. , Lampert, A. , Ritter, C. and Wehrle, G. (2010). AMALi the Airborne Mobile Aerosol Lidar for Arctic research. Atmos. Chem. Phys., 10 , pp. 2947-2963.
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