Peltier Cooled Frost point Hygrometer: PCFH
Future instrument for balloon borne water vapor measurements in the UTLS

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For the past two years, an optimally controlled Peltier-cooled frost point hygrometer for balloon borne water vapor measurements in the upper troposphere and lower stratosphere (UTLS) has been under development at ETH Zürich. Considering what was accomplished so far in dew/frost point hygrometry, lessons learnt from SnowWhite [Vömel et al, 2003], CFH [Vömel et al., 2016] and FPH [Hall et al., 2016] and new approaches to the open problems are used to implement a more reliable water vapor measurements in the UTLS, hopefully suited as a long term solution. With the PCFH we address the long-standing problems with the cryogenically cooled frost point hygrometers, by replacing the inconvenient logistics of its handling and insecure perspective of future use by a plug-in solution. The Peltier element cooling range is maximized by a careful study of its limitations, behavior and response to its environment. A good development of SnowWhite was the replacement of the thermistor by thermocouples, more demanding but with better accuracy and versatility. These were characterized traceable to the national standard provided by METAS, the Swiss Federal Institute of Metrology. Further improvements are in the feedback control loop and the instrument housing, which is prone to self-pollution. In spite of the PID (proportional/ integral /derivative) control parameters tuned to different operating frost point temperatures and updated regularly during a flight, CFH and FPH still show instabilities that were only being addressed by a statistical treatment. Substantial progress is expected from introducing a Linear Quadratic Regulator scheme as state of the art optimal control method. Reduction of self-contamination interferences and improved data quality checks are also expected by designing a double instrument – with two independent sensor heads and inlets and optimization of the inlet tubes.

Key words: frost point hygrometer, water vapor, upper troposphere, lower stratosphere, instrument development

References

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