

## **Use of Computational Fluid Dynamics for improvement of Balloon Borne Frost Point Hygrometer**

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In the StratoClim 2016 Balloon Campaign in Nainital (India) during the Asian Summer Monsoon, balloon born payloads containing the EN-SCI CFH – Cryogenic Frost point Hygrometer – were flown to observe water vapor and cloud formation processes in the Upper Troposphere and Lower Stratosphere. Some of the recorded atmospheric water vapor profiles showed unexpected values above the tropopause and were considered contaminated. To interpret these contaminated results and in the scope of the development of a new frost point hygrometer – the Peltier Cooled Frost point Hygrometer (PCFH) - computational fluid dynamic (CFD) simulations with ANSYS Fluent software have been carried out. These simulations incorporate the fluid and thermodynamic characteristics of stratospheric air to predict airflow in the inlet tube of the instrument. An ice wall boundary layer based on the Murphy and Koop 2005 ice-vapor parametrization was created as a cause of the unexpected water vapor. Sensitivity was tested in relation to the CFD mesh, ice wall surface, inlet flow, inlet tube dimension, sensor head location and variation of atmospheric conditions.

The development of the PCFH uses the results of this study and other computational fluid dynamic studies concerning the whole instrument boundary layer and heat exchanger design to improve on previous realizations of frost point hygrometers. As a novelty in the field of frost point hygrometry, Optimal Control Theory will be used to optimize the cooling of the mirror by the Peltier element, which will be described in a physical “plant model”, since the cooling capacity of a cryogenic liquid will no longer be available in the new instrument.