Investigating water vapor, clouds, and aerosol in the tropical tropopause layer with in situ and profiling measurements from long duration Strateole-2 balloons.

Developing RACHuTS (Reeldown Aerosol Cloud Humidity and Temperature Sensor) and LPC, the LASP (Laboratory for Atmospheric and Space Physics) Particle Counter

Overview: The tropopause forms a boundary for many vertical atmospheric mixing processes. Above the tropopause the air is much drier than below, but still water vapor plays a significant role in cooling the stratosphere and in ozone chemistry, with additional radiative effects. This importance motivates efforts to measure and to model stratospheric water vapor. Still there are significant areas where our knowledge is limited by measurements. One of these is the tropical tropopause layer (TTL), the primary pathway for tropospheric water vapor and other trace gases to enter the stratosphere. This proposal seeks support to significantly expand our observational coverage of this important and poorly sampled region of the atmosphere by making multiple nightly measurements of water vapor, cloud occurrence, and temperature across the TTL for up to three months. The proposal takes advantage of an opportunity to participate in the French funded Stratéole 2 campaign. This is a French initiated campaign to study stratospheric dynamics and ozone chemistry in the southern hemisphere by a set of instrumented drifting balloons. The opportunity to US investigators is to deploy instruments on a subset of the Stratéole 2 gondolas, through collaboration with the Centre National d'Etudes Spatiales (CNES) in Toulouse and the Laboratoire de Métérologie Dynamique (LMD) in Paris. The instruments proposed to be deployed here will be on long range quasi-Lagrangian balloons drifting at ~18 km, near the top of the TTL, between ±10º of the equator for up to three months in the October – February time frame. An engineering test campaign is planned for 2018-2019 to deploy one example of each of the 6 scientific gondolas: 4 *in situ* gondolas at ~18 km, and two remote sensing gondolas at ~20 km. The scientific campaign is planned for 2020-2021 to deploy 20 balloons, including 3 balloons with the instruments proposed here. The *in situ* instruments to be prepared and deployed with this proposal consist of: 1) An instrument assembly to measure profiles of water vapor, cloud occurrence, and temperature on 10 profiles each night across the TTL. The assembly will extend to 2 km below the drifting balloon. 2) An optical particle counter to make hourly day and night aerosol size distribution measurements at the location of the drifting balloon near the top of the TTL.

Intellectual Merit: While the fundamental instruments required for these measurements are available through collaborating scientific institutes or commercially, the integration and application of these instruments for deployment during the Stratéole 2 campaign will require a significant engineering effort to meet the following objectives. 1) Develop the instrument assembly containing a Lyman alpha hygrometer (FLASH-B), a backscattersonde (COBALD), and two temperature sensors prepared for deployment on a 2000 meter line from the base of a drifting balloon. 2) Develop the reel down device, a docking station to collect data, recharge batteries, and clear memories, an interface for remote control of each instrument, and a small gondola to carry the instruments. 3) Develop the interfaces to control and communicate with the optical particle counter and to possibly increase the instrument size resolution. The scientific challenges are to: 1) Complete water vapor, backscattersonde, and temperature profiles over a distance of 2 km across

the TTL during the engineering and science campaigns. 2) Collect hourly measurements of aerosol size distribution at the top of the TTL. 3) Improve, if necessary, the instrumental capability or sampling strategy between the engineering and scientific campaigns. 4) Use the profiles of water vapor and cloud presence in the TTL to understand the transport of water into the lower stratosphere. 5) Use aerosol size distribution measurements at the top of the TTL to improve assessments of the flux of primary aerosol into the stratosphere.

Broader Impacts: Insights gained into processes controlling transport of water vapor and particles across the TTL will have impacts on understanding the impact of these constituents on the chemistry of the stratosphere and ultimately on climate. There will be subsequent impacts on climate model predictions using an improved understanding of these important climate variables. Engineers at LASP will gain experience with balloon-borne measurement systems. A post-doctoral scholar will gain hands on experience with preparation and deployment of field instruments within a larger scientific campaign. Both Co-Is will gain valuable experience as part of an international scientific campaign.

***Instrument Collaborators*:**

Frank Wienhold, ETH - Institute for Atmospheric and Climate Science, Zurich, Switzerland, will provide the COBALD (Compact Optical Backscatter Aerosol Detector) instrument for cloud detection.

Vladimir Yushkov, SBC ATTEX Ltd., Moscow, Russia, will provide the FLASH-B (Fluorescence Advanced Stratospheric Hygrometer for Balloon) instrument for water vapor measurements.

Albert Hertzog, Laboratoire de Météorologie Dynamique, Paris, France, will provide the Thermodynamic SENsor (TSEN) for high resolution temperature measurements.

Correlative measurement collaborators, for water vapor soundings:

Henry Selkirk, Universities Space Research Association, Columbia, Maryland, USA,

Masatomo Fugiwara, Faculty of Environmental Earth Science, Hokaido University, Sapporo, Japan.