PROJECT SUMMARY

Overview:

This project proposes to build and deploy fiber optic temperature profilers (called FLOATS) to investigate the thermal structure of the Tropical Tropopause Layer (TTL) using high resolution in situ temperature profiles from aboard a constellation of long duration balloons. FLOATS instruments will be deployed as part of the Strateole 2 campaign, on balloons launched, operated and funded by the Centre National d'Etudes Spatiales (CNES in Toulouse, France) under the scientific lead of the Laboratoire de Meteorologie Dynamique (LMD in Paris, France). FLOATS measures the intrinsic temperature of 2000m of optical fiber that is suspended from a balloon gondola using Raman scattering of laser light pulses injected into the fiber. The Strateole 2 balloons will fly at an altitude of approximately 17.5km, and thus FLOATS will measure the temperature between 15.5 and 17.5km spanning the upper TTL and cold point tropopause, with a temperature precision of 0.3C and a vertical resolution of 3m, at a 2 minute cadence. Each balloon will fly for a minimum of three months, with a flight domain spanning the tropical belt from 20S to 15N. From this platform, FLOATS will collect tens of thousands of profiles that together will form a 'curtain' of temperature measurements with unprecedented accuracy, resolution and density.

A prototype FLOATS instrument has been successfully flown, and this prototype will be refined and adapted to for long duration measurements. The first instrument will be flown on a validation campaign that is scheduled to launch from the Seychelles in late 2018. Instrument performance during the validation campaign will be assessed and based on this data; any minor modifications to the design can be performed. Three more instruments will be fabricated for the first full science campaign in the boreal winter of 2020-2021. The PI, Dr. Kalnajs, will oversee development, testing, fabrication and calibration of the FLOATS instrument and will also mentor a post doctoral researcher who will gain experience as an instrument scientist through their involvement with the full cycle from instrument development through deployment and analysis. Dr. Alexander, will contribute to the experimental design, and take a leading role in the analysis of the data from both field missions.

Intellectual Merit :

The FLOATS instruments will measure the thermal structure of the TTL with vertical resolution that far exceeds satellite-based instruments, and will provide many thousands more temperature profiles in a broader area than the tropical radiosonde network. This thermal structure is the dominant factor controlling the transport of water vapor across the TTL and has a significant influence on the composition of the global stratosphere. Furthermore, water vapor and cirrus in the TTL and lower stratosphere have a disproportionately large influence on the radiative balance of the atmosphere and on surface temperatures. The small-scale temperature perturbations resolved by FLOATS can depress the cold point temperature by several degrees, can induce the formation of cirrus clouds in the TTL, and drive additional dehydration beyond that expected based on the mean cold-point temperature. The high vertical resolution and measurement density of FLOATS will capture the evolution, vertical propagation, and frequency/phase speed spectra of waves in the TTL. The Quasi Biennial Oscillation (QBO), is driven by a broad spectrum of waves, and a large fraction of waves that drive the QBO are thought to occur at small scales that are unresolvable in global models, but will be resolved by FLOATS.

Broader Impacts :

Both the Strateole 2 concept and the FLOATS instruments represent an innovative new way of observing the TTL and will produce the highest resolution, highest density and most widely distributed measurements of TTL temperature profiles ever collected. This unprecedented data set has the potential to have an impact across multiple fields of study. These measurements will provide a unique data set for constraining sub-grid scale wave induced variability, and thereby contribute to the modeling community through development of improved gravity wave parameterizations and validation studies. The application of fiber optic temperature sensing to atmospheric research in general is relatively rare, and the development of FLOATS has already led to interest from researchers in other atmospheric disciplines. Continued instrument development and demonstration of the technique on a larger scale should spur the use of the technique in the broader community.