Tropical waves and their effects on circulation from 3D GPS radio occultation sampling from stratospheric balloons in Strateole-2

Overview: The interactions of waves and precipitating clouds dominate tropical dynamics and hydrological variability. However, the fine vertical scales of waves and cirrus in the upper troposphere/lower stratosphere region create observational challenges that cannot be addressed by either satellite or sparse radiosonde methods, and modeling challenges persist due to the high resolution required and gaps in physical process understanding. The objectives of the proposed work are to design and deploy next generation GPS receivers for Radio OCcultation (ROC) on board long-duration stratospheric balloons and execute a continuous sequence of temperature profiles on either side of the balloon trajectory to sample the equatorial wave field in three dimensions. The ROC observations will make it possible to achieve the following:

1) Quantify relationships between upper troposphere to lower stratosphere wave properties and tropical convection needed to improve model representations of wave driving of the quasi-biannual oscillation (QBO);

2)Determine the relationship of upper troposphere waves to the presence of cirrus clouds that can be used for improving model representations of these clouds;

3) Quantify global characteristics of waves that determine tropical cold point temperature variability for use in improving models of stratospheric dehydration.

The new superpressure balloon instrumentation, including the ROC and a new French micro-lidar for detecting cirrus and convective cloud tops, will be deployed during the Strateole-2 campaign, with balloon infrastructure provided by French collaborators, for 4 balloon flights of expected 80 day duration. The field campaign data analysis will include multiple approaches for 3-D wave analysis to capture consistent descriptions of the horizontal and vertical structure of tropical waves that impact cirrus formation and relationships to convective clouds.

Intellectual Merit: The proposed campaign will provide a wealth of new knowledge on upper tropospheric and lower stratospheric waves across the broad range of spatial and temporal wave scales: global to hundreds of kilometers, and seasonal to hours, that modulate these UTLS processes. The high vertical resolution will give new knowledge on the fine-scale wave-mean flow interaction that is unresolved in global models and will provide direct observations of the spatial structure of waves that will be critical for developing the next generation of global models that are moving towards resolving fine-scale waves and the QBO. Because stratospheric water vapor plays an important role in the radiative budget of the stratosphere as well as in modulating surface warming, quantifying wave properties in the equatorial region is important for improving climate models. Slow upwelling, rapid transport by penetrating deep convection, thin cirrus precipitation, and horizontal transport and cooling by waves combine to give the observed variability in water vapor on timescales ranging from very short to decadal. The key to achieving these objectives is the unique combination of the GPS ROC instrument and BeCOOL micro-lidar cloud observations from the stratospheric balloon platform that enable these systematic observations of the instantaneous description of 3-D wavefields.

Broader impacts: A UCSD undergraduate research class will deploy a ROC instrument unit on a commercial stratospheric balloon flight with WorldView.com in Tucson, AZ. In a one semester research class, students will plan a measurement campaign, in combination with ground based GPS water vapor measurement sites in the southwestern US and Mexico as part of the NSF supported TLALOCNET. Students will be recruited from latin@ communities in AZ and CA for in depth analysis during summer undergraduate research fellowships in the SIO SURF,

UNAVCO RESESS, and UCAR SOARS programs. Video will be collected during balloon flights for the SIO youtube.com channel and will be provided along with teacher professional development material. Two female PIs will provide diverse role models for the young students. Two graduate students will be supported for Strateole-2 field operations and data analysis.