A Viable Stratospheric Transport Monitoring Program; Tracking & Improving Our Understanding of Climate Change

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Climate change drives change in tropospheric weather. This in turn modifies the generation of wave activity, the major driver of stratospheric circulation. Coupled chemistry-climate models predict that stratospheric circulation will increase in strength with increased greenhouse gases [e.g. *Butchart et al*., 2010]. Knowledge of change in stratospheric circulation is of significant importance. This was highlighted in a recent model study (*Scaife et al.*, 2011) that shows how changes in stratospheric circulation can play a significant role in predictions of future climate change. These stratospheric changes "induce change in the baroclinic eddy growth rate across the depth of the troposphere," altering predictions of regional rainfall, mean winds, and troposphere storm tracks. Other related examples are the recovery of ozone [*Butchart, et al*., 2010], the concentration of stratospheric water vapor [Solomon *et al*., 2010], and tropopause height. Climate-monitoring programs will benefit substantially by having a stratospheric circulation-monitoring component to track the coupling of these two regimes.

To validate model predictions of change in stratospheric circulation requires high quality, long-term measurements. The trace gases SF_6, N_2O, CFC-12, CFC-113, CFC-11, and halon-1211 are uniquely influenced by stratospheric circulation time scales, through changes in the "age" of stratospheric air [*Waugh and Hall*, 2002], and stratospheric path and recirculation which manifests in both age distributions, and the "maximum path height" distributions [*Hall*, 2000] through photolytic loss. A recent study by *Engel et al.* [2009] and extended by *Ray et al.* [2010] pieced together available balloon based SF_6 and CO_2 measurements over the past three decades to show that the mean age of stratospheric air has increased, in apparent opposition to the decreased mean age predicted by models that show stratospheric circulation strengthening. This study highlighted the role long-lived trace gas measurements can play in helping to understand model predictions, but also clearly reveals the limitations of the currently available stratospheric measurements. Recent laboratory studies have proven the feasibility of using the low cost AirCore techniques of *Tans* [2009] coupled with our fast chromatograph, *Moore et al.* [2003], to acquire such stratospheric data. We outline a series of technically feasible measurements that would substantially improve our ability to monitor most of the relevant aspects of stratospheric circulation change.

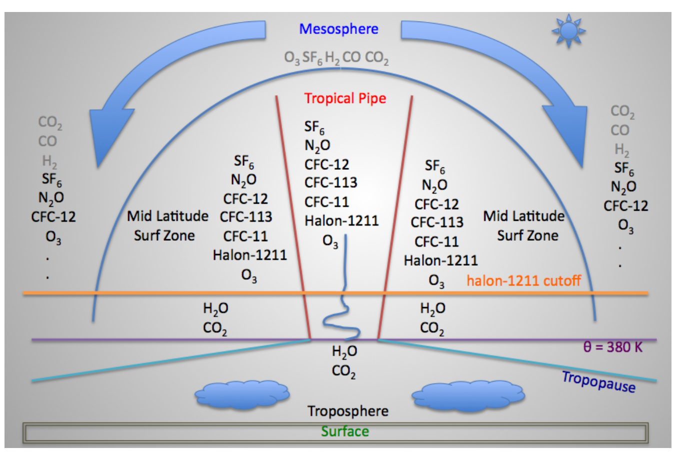

Figure 1. A monitoring program based on technically and financially feasible trace gas measurements, with the seasonal data acquired using inexpensive hand launched balloons descending from 30 km.