A novel analytical method for measuring high-resolution vertical profile of stratospheric trace gas mole fractions using a GC-ECD

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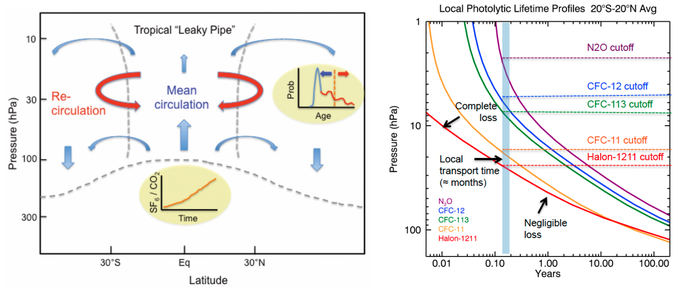
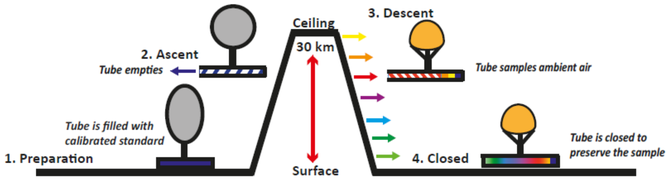
Introduction

- Understanding how increasing greenhouse gases in the stratosphere impact stratospheric circulation and associated climate feedbacks is important;
- Direct observation of stratospheric circulation is difficult, but dynamical change can be inferred from stratospheric mean age of air;
- A combination of "age tracers" (CO_2, SF_6) and photochemical reactive trace gases (CFC-11, CFC-12, CFC-113, H-1211, N_2O) is a great tool for investigating stratospheric mean age and changes in circulation;



Left: sketch of stratospheric circulation. Right: photochemical lifetime of various trace gases. Both figures are from Moore et al. (2013).

- Direct stratospheric observations are rare due to the high cost of aircraft campaigns;
- **AirCore** (Tans 2009, Karion et al., 2010) provides a novel approach for stratospheric observation;
- NOAA/GML brought AirCore technique to operational level with a 10+ year observational record of stratospheric trace gases;
- AirCore samples are analyzed by continuous analyzer for mole fractions of CO_2, CH_4, and CO

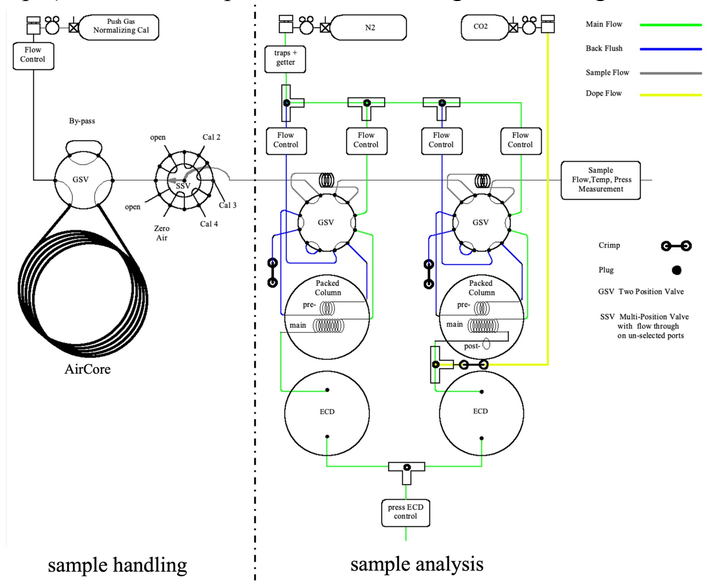


Schematic description of the five steps of the AirCore sampling method. From Membrive et al. (2017).

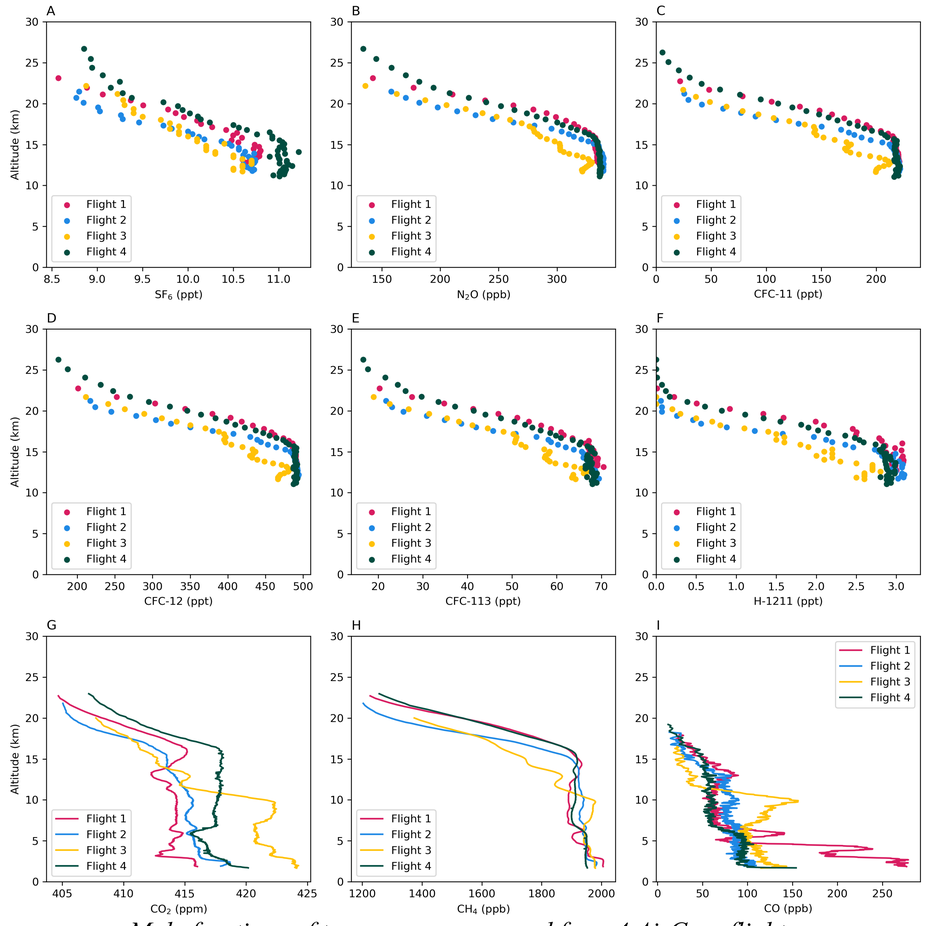
A new method for measuring more trace gas species (SF_6, N_2O, CFC-11, CFC-12, CFC-113, and H-1211) in AirCore is needed to better study stratospheric dynamics.

Methods

- A Gas Chromatography – Electron Capture Detector is adapted for analyzing mole fractions of SF_6, N_2O, CFC-11, CFC-12, CFC-113, and H-1211 from the stratospheric portion of AirCores (called StratoCore-GC-ECD);
- The system separates one AirCore sample into ~3.5-5 mL (4 hPa per sample) of discrete aliquqts without inducing extra mixing;



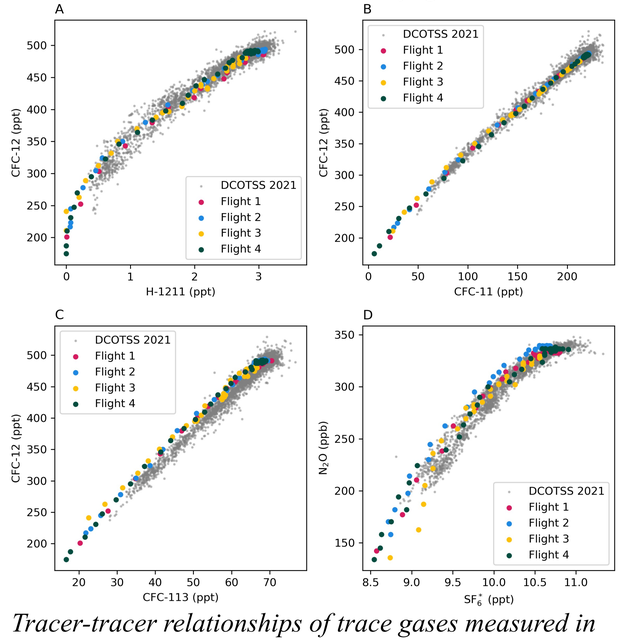
Simplified sketch of the StratoCore-GC-ECD system.



Mole fractions of trace gases measured from 4 AirCore flights.

Results

- Four AirCore flights (each with 2 AirCore samples) were conducted in northeastern Colorado from 2021-2022;
- In each flight, one AirCore sample was analyzed on StratoCore-GC-ECD and the other was analyzed by a Picarro CRDS analyzer;
- 35-45 StratoCore-GC-ECD measurements were made in the stratospheric portion of each AirCore;
- Results display expected dynamic ranges of each trace gas;
- Agreement on tracer-tracer relationships with aircraft *in situ* measurements during the NASA Dynamics and Chemistry of the Summer Stratosphere (DCOTSS) campaign.



Tracer-tracer relationships of trace gases measured in AirCores compared with DCOTSS measurements.

Conclusion and outlook

- The novel method provides a promising, low-cost approach to directly observe the mole fractions of trace gases well into the mid-stratosphere beyond current technology;
- Routine deployment of this low-cost observation platform will advance our understanding of stratospheric dynamics and its response to changes in climate.

References

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Acknowledgement

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