1. Introduction
A new flask-air analysis system (Magicc-3) has been developed for measurement of CO₂, CH₄, N₂O, CO, SF₆, and H₂ from discrete air samples collected as part of the NOAA ESRL GMD Global Greenhouse Gas Reference Network (GGRN). Magicc-3 uses laser spectroscopic instruments for CO₂, CH₄, N₂O, and CO along with gas chromatography for SF₆ and H₂. The new system offers several improvements over the current system (Magicc-1) which has been in use since 1997.

Key improvements:

- N₂O repeatability: 0.03 ppb vs. 0.4 ppb on Magicc-1
- Sample gas usage: 325 mL vs. 525 mL on Magicc-1
- Measurement over larger mole fraction ranges
- Efficient operator interface and dual sample manifolds improve capacity

2. Instrumentation / Calibration

- **CO₂ / CH₄ - Picarro CRDS (G2301)**
  - Picarro pulls gas through the system (~60 mL/min)

- **N₂O / CO - Aerodyne QC-TILDAS**
  - Stop flow measurement (100 mL cell at 50 Torr)

- **SF₆ / H₂ - Gas Chromatography (ECD / PDD)**
  - New SF₆ chromatography
   - 5-µL injection valve (heart cut of)
     - Column:
       1) 1/8 OD x 0.25 m, alumina FT, 60/30 mesh
       2) 1/8 OD x 1.5 m, alumina FT, 60/30 mesh
       3) 1/8 OD x 0.45 m, 5A molecular sieve, 60/30 mesh

- **Multi-point calibrations for all species**
  - Off-line relative to a reference tank, approximately bi-weekly
  - Single set of 11 standards allows identical treatment of standards / samples

Dry air mole fraction ranges covered by Magicc-3 standards:

- CO₂: 340 – 550 ppm
- CH₄: 1500 – 4200 ppm
- N₂O: 275 – 415 ppm
- SF₆: 5 – 17 ppt
- H₂: 200 – 600 ppm

3. Magicc-3 Plumbing Diagram

4. Magicc-3 Sample / Standard Measurement Sequence

5. Target Tank Results for Different Gas Usage / Sample Volumes

6. Global Network Flask Analysis: Same Air Comparison with Magicc-1

- **Flasks filled from a calibrated cylinder**
  - Two PFPs filled from a calibrated cylinder are used to compare Magicc-3 (red squares) to Magicc-1 (black circles). Flasks were measured first on Magicc-3 (using 360 mL of sample gas) and then on Magicc-1. Issues with the technique used to fill test flasks can cause offsets from the assigned values of the cylinder, especially for CO₂. The difference in the offsets for N₂O and CO may be related to assigned values of the test gas cylinder and / or the standards used to calibrate the analysis systems. This is under investigation.

7. Global Network PFP Analysis: Co-Located Comparison with Magicc-1

- Two PFPs filled from a calibrated cylinder are used to compare Magicc-3 (red squares) to Magicc-1 (black circles). Known issues with filling a PFP from a cylinder lead to the apparent drift in both results for CO₂. A significant improvement in N₂O repeatability is observed.

8. Conclusions

Magicc-3 offers a significant improvement in N₂O repeatability (±0.03 ppb), CH₄ and CO measurements of discrete air samples (other species are comparable to Magicc-1) and can routinely measure samples over a wider mole fraction range for all species while using less sample gas. A slightly faster cycle time and the flexibility of the operator interface will improve the measurement capacity of the system.