New Volumetric Flow Rate Tests of Ozonesonde Pumps at Reduced Pressures

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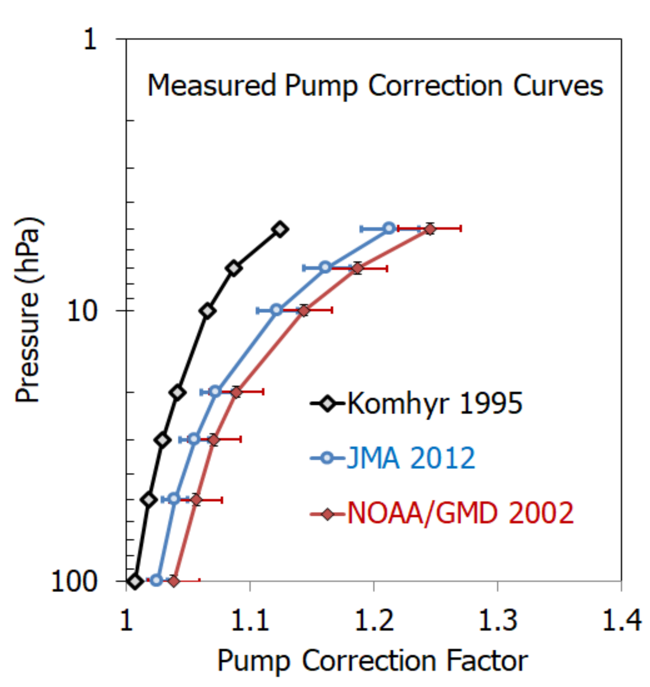
INTRODUCTION

Balloonborne electrochemical concentration cell (ECC) ozonesondes measure high-resolution profiles of ozone concentration from the surface to 35 km (5 hectopascals) altitude. Regular ECC ozonesonde performance tests are carried out at the world calibration center in Jülich, Germany. However, measuring the ozonesonde pump efficiency (Pump Correction Factor – PCF) at low pressures is not done for the calibration center experiments; PCF values are measured by a few individual laboratories.

The ozonesonde volumetric flow rate is constant at surface pressure and steadily decreases with altitude (lower pressure) due to the greater effect of resistance from pumping against the cathode solution fluid head and pump leakage.
Processing the ozone profile data includes multiplying the ground-measured flow rate by a pump correction factor (PCF) - which is a function of pressure. The most widely used PCF curves are based on experimental measurements by Komhyr (1986, 1995). The only two methods in use at this time are the bag deflation method by the Japanese Meteorological Agency (JMA) and the oil bubble flow meter by NOAA/GMD. Figure 1 shows and example of the averaged PCF curves for each method. The NOAA oil bubble flow method has recently been modified to allow measuring flow rate PCF curves with added head pressure to simulate realistic conditions during a balloon flight.
Unfortunately, JMA has significantly cut their ozonesonde program and may discontinue the measurements. The NOAA method will be the only remaining method to measure PCFs, which is essential for quality control tracking.



Ozonesonde with Teflon piston pump

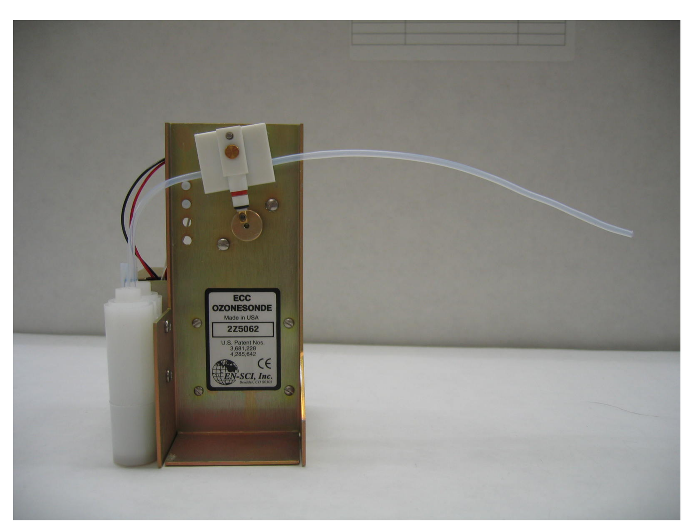


Figure 1. The standard Pump Correction Factor (PCF) curve from Komhyr (1995) and the average values (±1 standard deviation) of the other two methods by the Japanese Meteorological Agency (JMA) and the NOAA ozonesonde groups.

New Pump Correction Factor Measurements

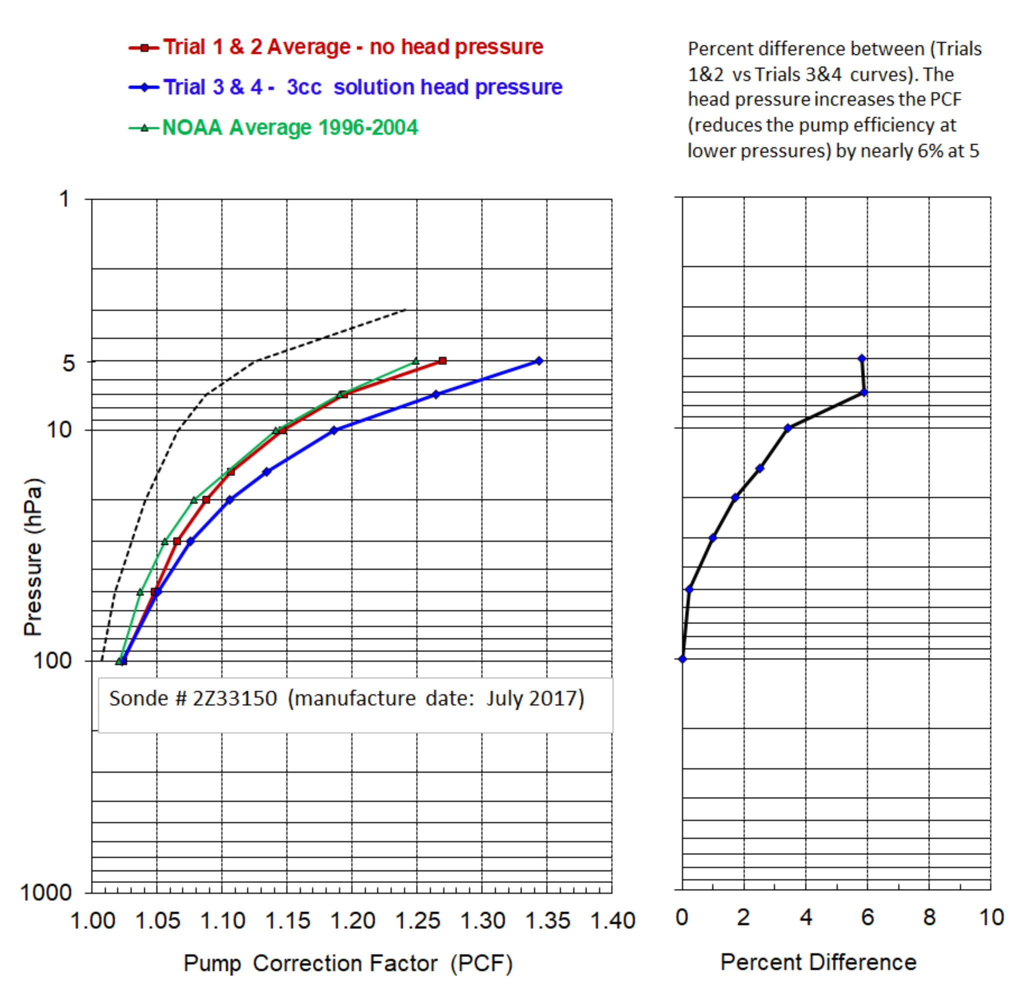


Figure 2. 4 measurements of the Pump Correction Factor (PCF) curve for sonde serial number 2Z33150. Adding head pressure for the pump to push against decreases the PCF by nearly 6% at the top of the profile as shown in figure to the right. The Komhyr-1995 curve (International Standard Operating Procedures) is also shown.

Can The Sudden Drop (2015-2018) in Hilo Ozonesonde Total Column Comparison with the Mauna Loa Dobson Be Due to Ozonesonde Pump Efficiency?

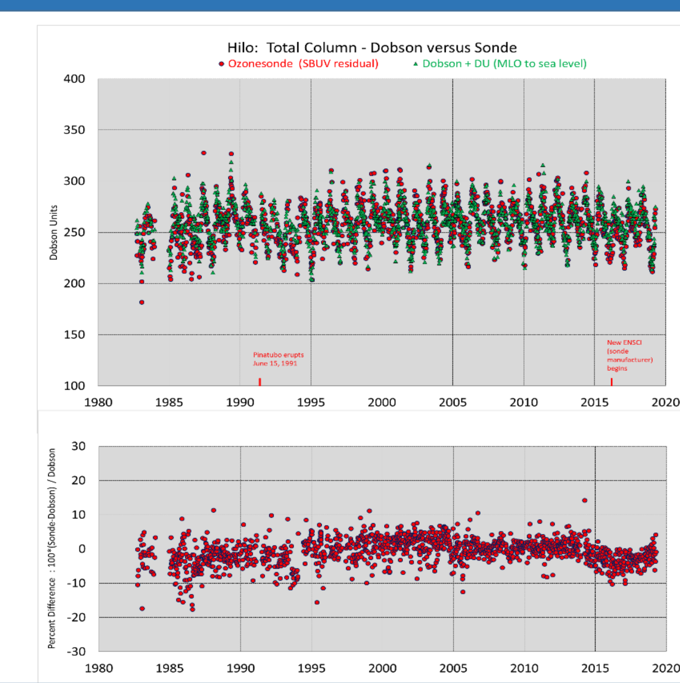


Figure 3. Ozonesonde total column (Dobson Units) compared to the Mauna Loa Dobson measurements. Sudden Drop of around 5% low begins in 2015.

Samoa and Costa Rica sites have also reported a similar drop in total column ozone.

Comparing Hilo Ozonesonde Climatology Before and After the Decline

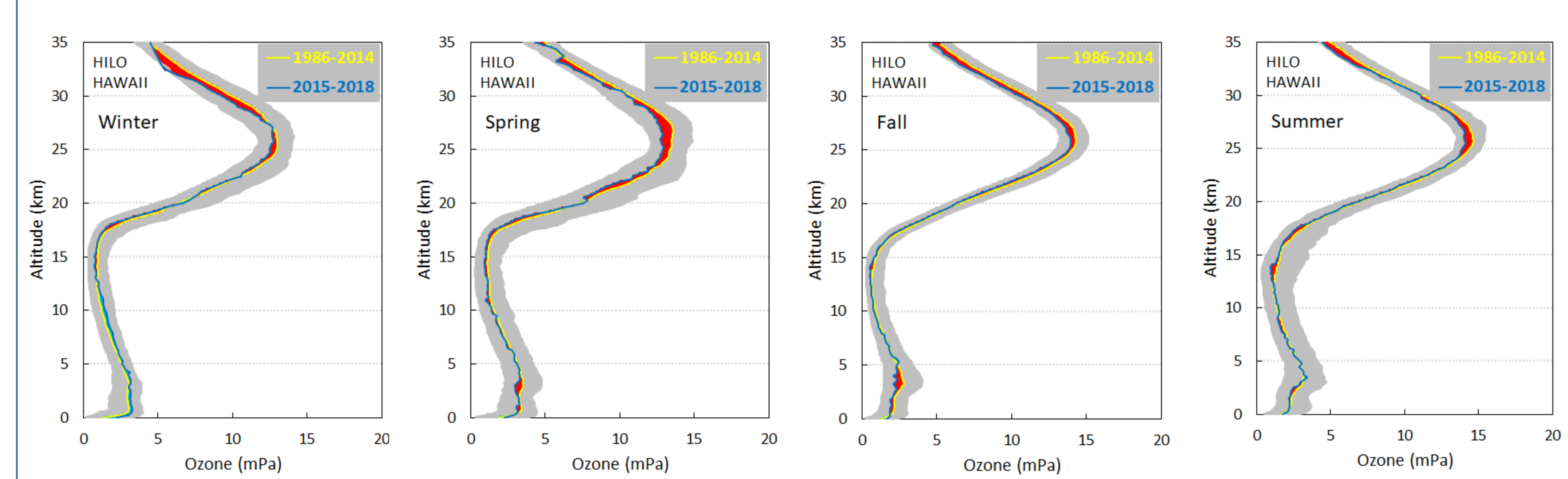


Figure 4. Red shading shows the altitude profile regions where the 2015-2018 period is reading low compared to the long-term 1986-2014 period. The seasonal periods all show that the major drop in ozone is near or above the ozone peak at 25 km (about 25 hPa).

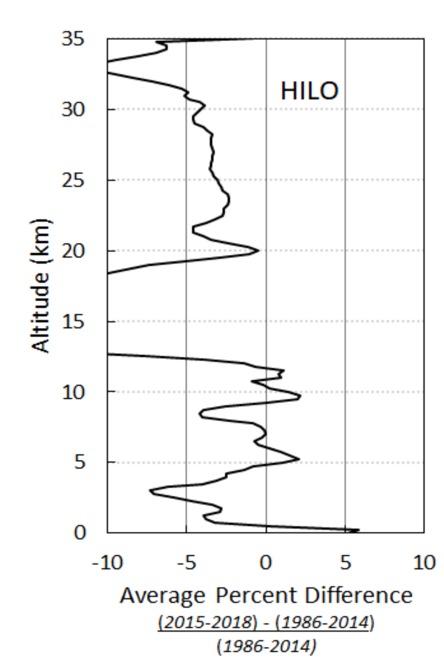


Figure 5. Average % difference for all 4 seasons shown in Fig 4. The decline of 3 to 5% above 20 km indicates that pump efficiency may be responsible for the decline. Ozonesondes manufactured in 2015-2018 possibly have a greater average PCF value than the older averages. More tests will need to be completed.

FUTURE WORK

- Compare different series of ozonesondes averaged profiles (same as Figure 4) for Hilo and several other global ozonesonde sites.
- Begin routine selection of new series of ozonesondes for Pump Flow Correction Factor (PCF) measurements in the NOAA environmental chamber as a routine quality check. Also track down pre-2015 ozonesonde series for chamber measurements to see if there have been pump performance changes.