3 March 2015

TO: WINTER data-processing file
FROM: Al Cooper
SUBJECT: recalibration of PSF/QCF

A problem with the WINTER measurements has been that there has been a consistent offset between corrected values of ambient pressure represented by PSFDC and PSFC, and an offset of the opposite sign between QCFC and QCFRC. These are the corrected values based respectively on PSFD, PSFRD, QCF, and QCFR. Circle maneuvers indicate that the results from QCFRC/PSFC produce valid wind measurements while QCFC/PSFDC produce wind measurements with an error of about 1 m/s in the longitudinal component (i.e., in TAS). Both pairs of sensors were calibrated previously using LAMS, and appropriate correction factors are being applied, but it appears that some aspect of the static defect associated with PSFD changed since that calibration. The sum QCF+PSFD matches the sum QCFR+PSFRD to within about 0.1 hPa, so the problem is not the dynamic pressure but rather the static pressure, with as measured by the transducer or as delivered by the static buttons.

Rather than produce known erroneous values from PSFD/QCF, it seems preferable to recalibrate in some way. Repeating the LAMS-based calibration would be best, but that is not practical for some time. An alternative is to treat the measurements from PSFRD/QCFR as a transfer standard, previously calibrated by LAMS, and now calibrate the suspect pair PSFD/QCF by reference to the reliable pair PSFRD/QCFR. These then remain independent measuring systems and will produce differences in measurement consistent with the standard error characterizing the calibration. In case of failure of either system, the other would provided a fully characterized alternative. Also, values included in the output files will then be ones that we consider accurate within our uncertainty estimates, which clearly is not the case now.

The recalibration proceeds as follows:

1. A corrected ambient pressure measurement PSFC is available and is thought to be a valid measurement. It therefore can be used as a standard (or, perhaps better, as a "transfer standard" transferring the LAMS-based calibration into a calibration standard) for this new calibration.

2. The equation used to represent the LAMS-based calibration for the C-130 was

$$\frac{\delta p}{p} = c_0 + c_1\alpha + c_2 M \tag{1}$$

where $p$ is the uncorrected pressure measurement, $\delta p$ is the error in that measurement, $\alpha$ is the angle of attack and $M$ is the Mach number calculated from the uncorrected pressures $p$ and $q$ where $q$ is the dynamic pressure. For this calibration, $p$ is PSFD, $q$ is QCF, $\alpha$ is AKRD (calculated on the basis of ADIFR and QCFR), and $M$ is based on PSFD, QCF, and EWX, the latter to account for the minor humidity dependence. However, adding another coefficient leads to significant improvement in the case of refitting:

$$\frac{\delta p}{p} = c_0 + c_1\alpha + c_2 M + c_3 M^2 \tag{2}$$

3. Because in the available data files from the field AKRD is based on QCF and PSFD, a recalibration will be used here. An appropriate calibration was developed for FRAPPE and should still apply: AKRD = 4.860 + 14.1416 * ADIFR / QCFR.

4. The fit is then performed by identifying $\delta p$ with PSFD - PSFC and then finding the coefficients $\{c_i\}$ providing the best fit to (2). The code for this minimization is embedded in this routine, in the "minimization" chunk. The fit results are listed below, and Fig. 1 shows the distribution of the difference between the reference standard PSFC and the corrected pressure $p_c$ from this fit:

$$p_c = p\left(1 - c_0 - c_1\alpha - c_2 M - c_3 M^2\right) \tag{3}$$

This is then the replacement for PSFDC.

```
## lm(formula = PCOR ~ AKRD + Mach + I(Mach^2), data = DataC)
## [1] "Coefficients:"
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.021004  4.383e-05   479.2        0
## AKRD        -0.001306  1.128e-06 -1158.1        0
## Mach        -0.108492  2.310e-04  -469.6        0
## I(Mach^2)    0.137813  2.963e-04   465.1        0
## [1] "Residual standard error: 0.00025, dof=152222"
## [1] "R-squared 0.934"
```

The result of this fit, applied to data from flights 1–8 of WINTER, is $\{c\}$={0.0210, −0.0013, −0.1085, 0.1378}. Fit restrictions were TASX > 90, |ROLL| < 5, and |GGVSPD| < 3. The mean error in $p_c$ relative to PSFC is −0.004 hPa and the standard error is 0.17 hPa. The same correction as given in (3) should be applied, with opposite sign, to QCF to get QCFC; i.e.,

$$q_c = q + p\left(c_0 + c_1\alpha + c_2 M + c_3 M^2\right) \ , \tag{4}$$

and the mirror image of the histogram as shown in Fig. 1 applies to the difference between QCFRC and new QCFC. In particular, the same standard deviation applies to the difference between QCFRC and QCFC after this correction is applied.

– End of Memo –

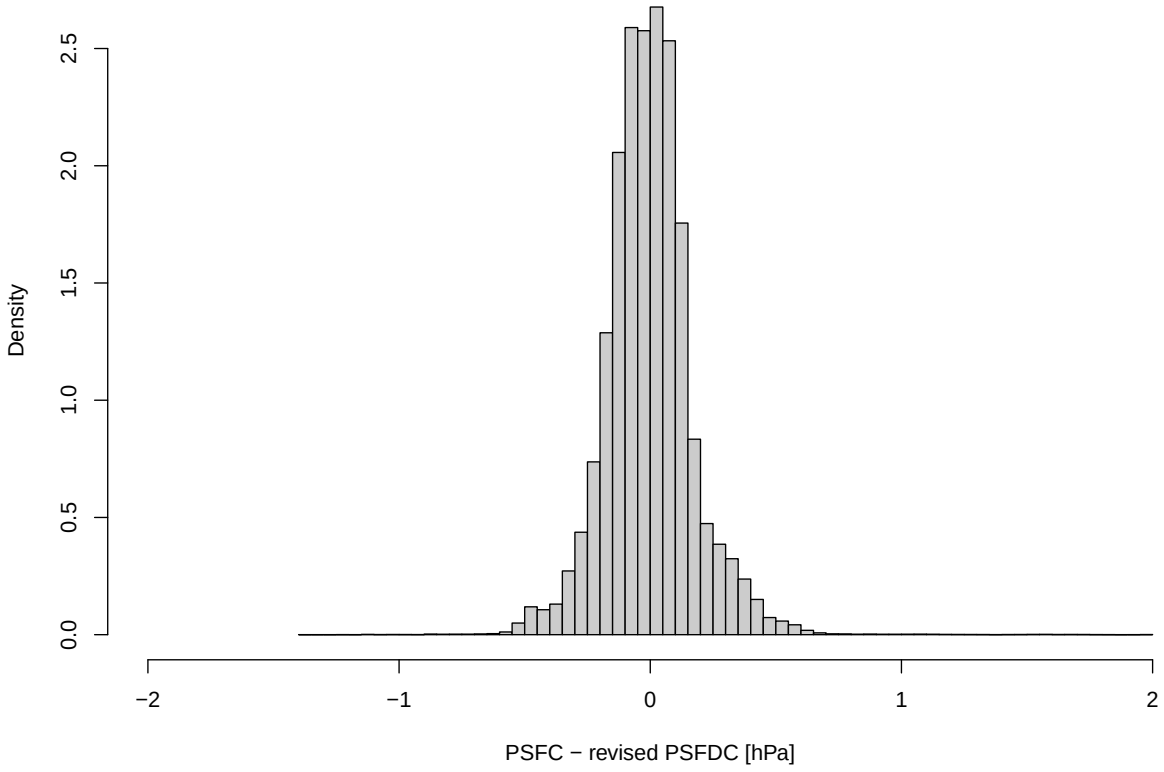


Figure 1: Distribution showing the fraction of measurements per unit interval in the difference between PSFC and PSFD corrected by (3).

Reproducibility:

| | |
|---|---|
| PROJECT: | recalQCF |
| ARCHIVE PACKAGE: | recalQCF.zip |
| CONTAINS: | attachment list below |
| PROGRAM: | recalQCF.Rnw |
| ORIGINAL DATA: | /scr/raf_data/WINTER/{rf01–rf08}.nc as processed in the field project |
| GIT: | https://github.com/WilliamCooper/WINTER.git (archive includes this project) |

Attachments: recalQCF.Rnw
recalQCF.pdf
SessionInfo