Review of "Calibration of 3D wind measurements on a single engine research aircraft"
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General Comments: New methods for calibrating 3-D wind measurements on a small research aircraft are tested. Unfortunately, the new algorithms use unrealistic simplifying assumptions, inconsistent and/or poorly explained methodology, and do not provide a useful comparison with established approaches to calibrating similar aircraft data. The calibrated winds appear to exhibit minimal aircraft motion errors and high fidelity, but it is unclear what accuracy is achieved and what corrections are most needed to produce these results. The error analysis which propagates white noise through the data reduction presents a novel approach, but incorrect application leads to underestimation of errors. Major revision is needed before publication.

Specific Comments (by line number):

121: Earth fixed coordinates are oriented with the x-axis East, y-axis North, and z-axis upward.

131: These equations aren't new; see Lenschow, D.H.: Aircraft measurements in the boundary layer. Probing the Atmospheric Boundary Layer, D.H. Lenschow, ed., American Meteor. Soc., 29-38, 1986. Suggest, "The simplified wind equations (Lenschow, 1986) give an estimation of the first order terms during straight horizontal flight." Delete similar sentence at lines 137-138.

186: Not necessarily true. Equations (4) show that if there is a wind shift, but heading angle, ground speed and true airspeed are maintained, there must also be a shift in β. If you observe that there is no correlation in your data, simply state as much without drawing broad conclusions.

226: Equation (6) won't give you the right answer. For one thing, mean attack angle is typically nonzero and varies over the course of a flight, and even if sideslip angle is close to zero, there is usually a small bias. Sensitivity coefficients are needed to scale the raw measurements from the nose boom (see eqns. 6 & 8 of Khelif, Burns, and Friehe, 1999) before it is possible to determine angular offsets using the resulting winds. Also, while changing an attack angle offset will move $\langle w \rangle$ to the desired zero average, so will other adjustments such as the sensitivity coefficient, or the pitch angle from the IRS. Which one is correct?

238: Why should only the vertical wind component be independent of aircraft attitude? How does limiting your approach in this way impact your methodology?

258-271: This procedure corrects for angular differences between the nose boom and the IRS inside the cabin, but have you considered the possibility of non-orthogonal axes on the nose boom itself? In other words, could you have a little bit of yawing incorporated into attack angle fluctuations, and vice-versa? How would you correct for that?

297: Is there evidence of compression and flow distortion impacting these results? If yes, then you must describe the problem and find a method to reduce it. If no, why do mention it here?

575: If equation 13 provides local indicated flow angles, what transformation equation accounts for the "dynamical effects" mentioned here, yielding α_{NB} and β_{NB} of equation 5?

602: How can the Cessna be "perfectly stabilized" so as to eliminate vertical aircraft velocity? Show a time series plot of the vertical velocity and provide statistics of the typical variability during tower flybys and racetrack flight segments. Assuming vertical wind is zero, a relatively small 0.3 ms^{-1} vertical drift in an airplane traveling at 80 ms^{-1} will produce an offset between pitch and attack angle of 0.2°. That's not particularly good for a small aircraft such as this.

620: If you prefer to use quasi-level flight rather than pitching maneuvers, I would suggest removing the assumption that pitch and attack angles are equal. Instead, calculate the vertical winds as in section 5 of Khelif, Burns, and Friehe (1999) and use these to calibrate attack angle. To do so, tune the linear coefficient to minimize vertical wind oscillations induced by the non-zero vertical aircraft velocities. Can you improve on the scatter in figure 6b with this approach?

624: I don't think you are correcting both effects. What range of Mach number is represented in the racetrack and flyby data? If it only makes <0.1% difference in K value across the range, other analysis errors are likely much larger and you could simply average Mach across all maneuvers and apply a constant K in Equation (13). Otherwise, you can only correct both effects with one step using linear regression analysis, thus fitting $\alpha_{ref} - \alpha_{ind} = f(\text{Mach}, \alpha_{ind})$.

665: Add the height-corrected static pressure trace to the top panel of figure 7a. Reference the data to the right axis and zoom in, i.e., reduce the pressure range relative to the bottom panel so that the pressure variation fills the frame and allows easy comparison to the sideslip angle trace.

775: Unless you have a valid reason to omit data with high wind variability, you have to accept the scatter as is. Delete the sentence beginning with "Therefore the scatter is too pessimistic…"

782: I believe there is another source of error in addition to the bias η_b and the relative error due to small sample statistics. Suppose the data set comprised of an infinite sample that fit ideally with slope = 1 and no offset (η_b= 0°), but the scatter standard deviation was the same as yours (σ = 0.3°) despite negligible uncertainty in the slope due to huge sample size. The scatter statistic describing ($\beta_{ref} - \beta_{ind}$) would in fact have to contribute to the error in β; in fact, it is the uncertainty in determining η_b. The same reasoning would apply to attack angle data.

809: If this is the uncertainty in the correction angles due to their variability, the uncertainty of ε_b should be 0.2° as stated on line 632, and for η_b it should be 0.3° (see comment, line 782). It should be clearly explained that relative flow angle error which scales with flow angle results from measurement uncertainty rather than the offset calibration.

847: To Figure 10 please add the horizontal wind components with uncalibrated attack and yaw angle and uncalibrated static/dynamic pressure data. Label the right axis if needed to place data on the same scale. Estimate the error in the uncalibrated cross-wind component, and describe which calibration procedure is most responsible for removing the yawing motion from the winds.

876: To Figure 11 please add the vertical wind with uncalibrated attack and yaw angles and uncalibrated static/dynamic pressure data. Label the right axis if needed to place data on the same scale. Estimate the error in the uncalibrated vertical winds, and describe which calibration procedure is most responsible for removing the pitching motion from the vertical winds.

980: In this alternative method of error analysis, white noise should be added to ALL the parameters that are used in the calculation of the target data product (e.g., static temperature). Accordingly, I would modify the sentence to read, "the error of a single measurement parameter can be represented by a white noise contribution which is applied to each of the original data time series which impact that measurement."

1036: To what data are you adding the white noise signal to? Total air temperature? What about adding white noise to static (and dynamic) pressure also, which are used to convert total to static temperature in the processing algorithm? Isn't that the whole point of using this method?

1094: What other parameters were involved in the calculation? These are never mentioned!

1120: Shouldn't overall uncertainties for α and β increase a bit? If the uncertainty of α is equally divided between the offset and relative terms, shouldn't the total sum (in quadrature) to ~0.3°? Likewise if the relative error for β is negligible, shouldn't the offset error be $\geq$0.3°?

1135-1139: I believe this is faulty reasoning. Why should horizontal wind measurement uncertainty of the along-wind component only come from true airspeed, or the cross-wind component only come from sideslip angle? Why should vertical wind measurement uncertainty be limited to attack angle calibration errors? Just with respect to vertical wind, what about true air speed errors (with all the attendant uncertainties associated with static and dynamic pressures, and total temperature), pitch angle errors (IRS units don't measure perfectly), and vertical aircraft velocity errors? All these sources of uncertainty should be included in an error analysis, not just the cherry picked ones mentioned here. You can't just isolate noise to a particular channel and conveniently turn all the others off.

Technical Comments (by line number):

48: Begin new paragraph.

171: Begin new paragraph.

182: Suggest, "The bigger and heavier the aircraft, the slower it usually reacts to changes in the wind signal. The magnitude of β fluctuations correspond to the strength of turbulence and inertia of the aircraft."

199: Suggest, "As usually an aircraft navigation system does not measure the flow angles…"

265: Suggest "Eq. 5."

351: Suggest "hand side".

749-755: Delete sentences beginning with "To understand…" and "An important step…"

764: Suggest: "will perturb and increase the scatter of the results."

864: This is backwards. It should read, "While the former would indicate any deficiencies in the TAS calibration, the latter would be sensitive to error in the β calibration."

1029: Suggest "processed" rather than "unprocessed". Use of the word "original" already indicates that this data has not been recomputed with added white noise.

1033: End parentheses after "Fig. 13b".

1150: Should be "dependent" rather than "depending".

1219: Begin new paragraph with "We calculated…"