Gill-ATI Sonic Comparison at Sherman Island, West Pond, and Tonzi Ranch

Cove Sturtevant

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Synopsis

An ATI sonic was placed next to each of the Gill sonics at Sherman Island, West Pond, and Tonzi Ranch for comparison. The Gills at Sherman Island and Tonzi are the 'older' models while the Gill at West Pond is the 'newer' models. The ATI was placed at Sherman Island from 27 September to 18 October 2012, at West Pond from 18 October to 8 November 2012, and at Tonzi Ranch from 15 November to 11 December 2012.

The average wind speeds from the ATI and both Gill sonics are very comparable, only a few percent different. The older Gill at Sherman shows a non-linear sonic virtual temperature (ts) response compared to the Vaisala, while the newer Gill at West Pond, the older Gill at Tonzi, and the ATI sonic show nearly linear responses. The temperature responses of the older Gills appear to change slightly at higher sensible heat flux.

Examining turbulence statistics and net fluxes between the ATI and the Gill sonics reveals that there are notable differences between the Gill sonics and the ATI. While the Gills show similar patterns of difference, these differences vary by degree. The most important difference between the ATI and Gill sonics is the vertical wind speed (w), and of secondary importance is the sonic temperature (ts) variance. The w variance for the ATI is substantially higher than the w variances from the Gill sonics (16% higher than the older Gills at Sherman and Tonzi, 32% higher than the newer Gill at West Pond). However, the ts variance of the ATI tends to be lower than the Gills (9% lower than the Sherman Gill, 17% lower than the West Pond Gill, but no different from the Tonzi Gill). Differences in fluxes (H, LE, CO_2, CH_4) tend to follow the differences in w variance, although at about half the effect. Additionally, the effect of lower w variance on sensible heat flux (H) from the Gills appears to be partially offset by higher ts variance where present. The net effect: the ATI measured H 4% higher than the Sherman Gill, 8% higher than the West Pond Gill, and 6% higher than the Tonzi Gill. For the other fluxes (LE, CO_2, CH_4), ATI fluxes are ~4-8% higher than the Sherman and Tonzi Gills and ~16% higher than the West Pond Gill.

On the daily timescale, the relationships are a little more obscure due to lower sample size, but different flux responses between the Gills and ATI tend to average out for fluxes that span both positive and negative values (H and CO_2 flux). This is because although the Gill measures significantly lower w variance than the ATI, the effect is similar for both positive and negative fluxes, leading to an underestimation of positive fluxes and an overestimation (less negative) of negative fluxes (see plots). However, for fluxes which are heavily weighted toward positive values (LE and CH_4 flux), the effects on the daily average fluxes are similar to those at the half-hourly time scale.

The following figures show relevant comparisons and more in-depth discussion of results. Note: all regressions are 'robust regressions' that minimize the influence of outliers. All plots show half-hourly averages unless specified.

Sherman Island (27 September – 18 October, 2012)

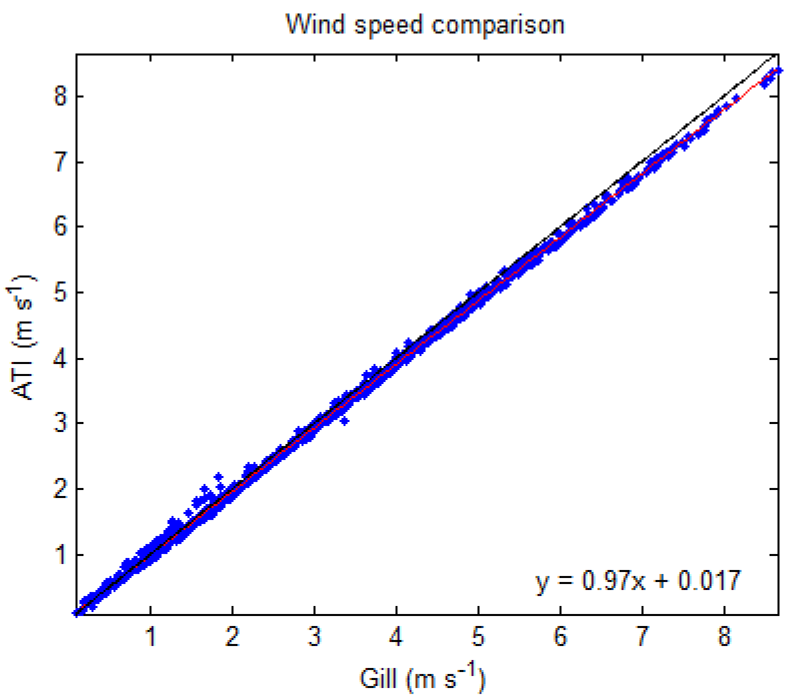

Figure SI-1. Wind speed comparison between the ATI and Gill sonics at Sherman Island. The relationship is linear and almost 1:1, the ATI sonic showing a slightly lower response compared to the Gill.

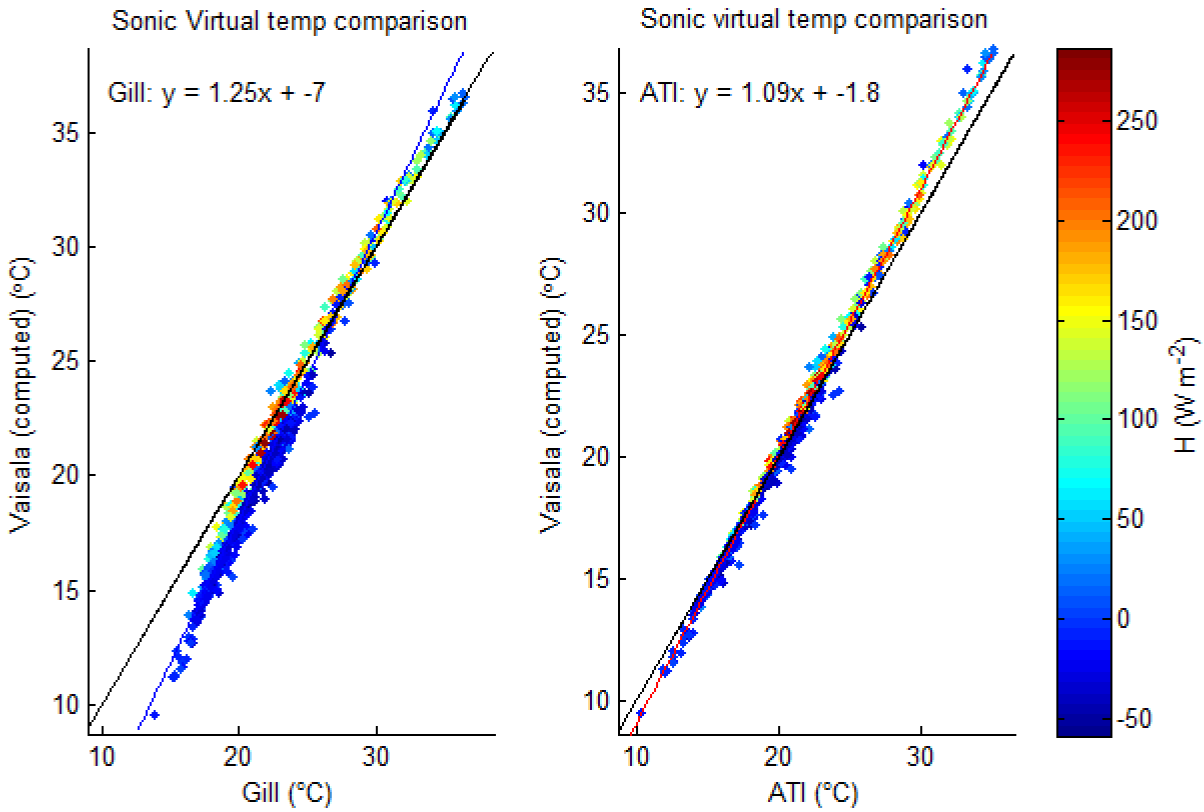

Figure SI-2. Sonic virtual temperature responses (Gill on the left, ATI on the right) compared to that computed from the Vaisala at Sherman Island. Color shows sensible heat flux. The Gill shows a non-linear response that is overestimated at lower temperature but becomes linear and nearly 1:1, although slightly underestimated, after 25 °C. The Gill relationship also changes slightly at higher sensible heat flux. The ATI shows a linear, but ~10% lower response than the Vaisala. The ATI overestimates below about 20 °C and underestimates above about 20 °C.

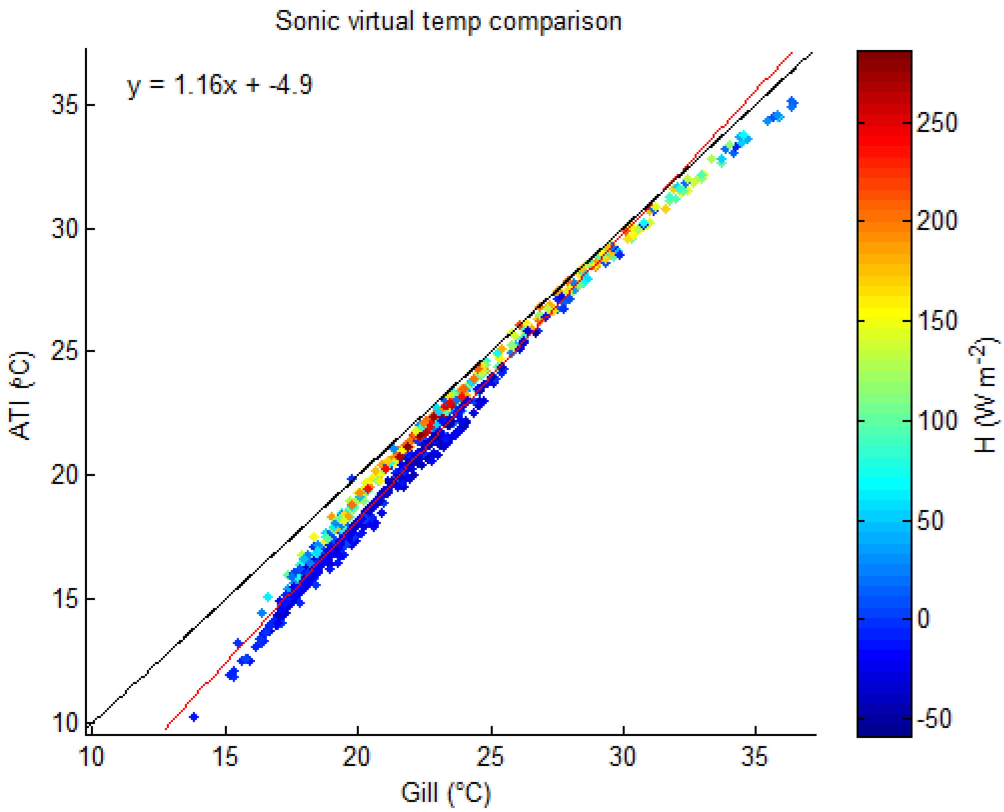

Figure SI-3. Comparison of the ATI and Gill sonic temperature responses at Sherman against each other. As expected, the relationship is curved. The Gill response is lower than the ATI at low temperature, about 1:1 from about 22-27 °C, and higher than the ATI above that range. The Gill sonic shows a positive offset from the ATI that grows at high and low temperature. The Gill's slightly variable response at higher heat flux is also apparent.

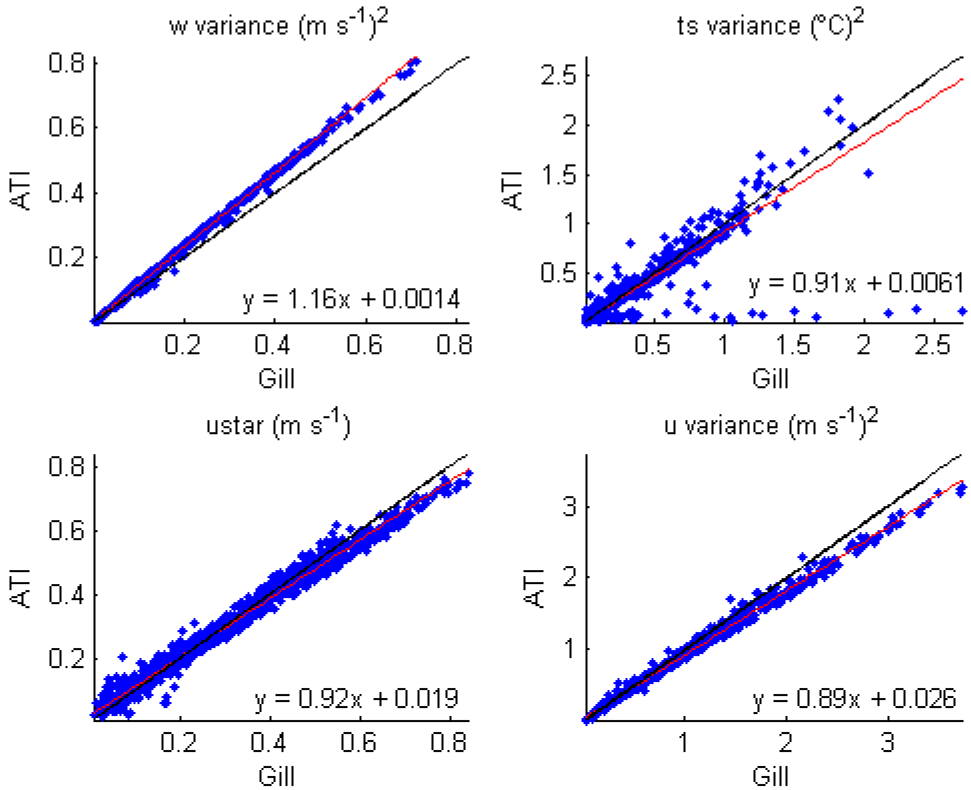

Figure SI-4. Comparison of Sherman Island turbulence statistics between the Gill and ATI sonics. The ATI sonic shows greater variance than the Gill for w, but lower variance for u. The net effect on ustar is mostly controlled by the lower variance for u, the ATI sonic showing lower values. Sonic temperature variance is more noisy in comparison, but aside from a smattering of points at the top end the ATI shows a 9% lower response than the Gill sonic. From the time series, this effect is evident at midday when the temperatures are hottest, and is therefore likely linked to the lower sonic temperature response of the ATI compared to the Gill at high temperature (Figure SI-3).

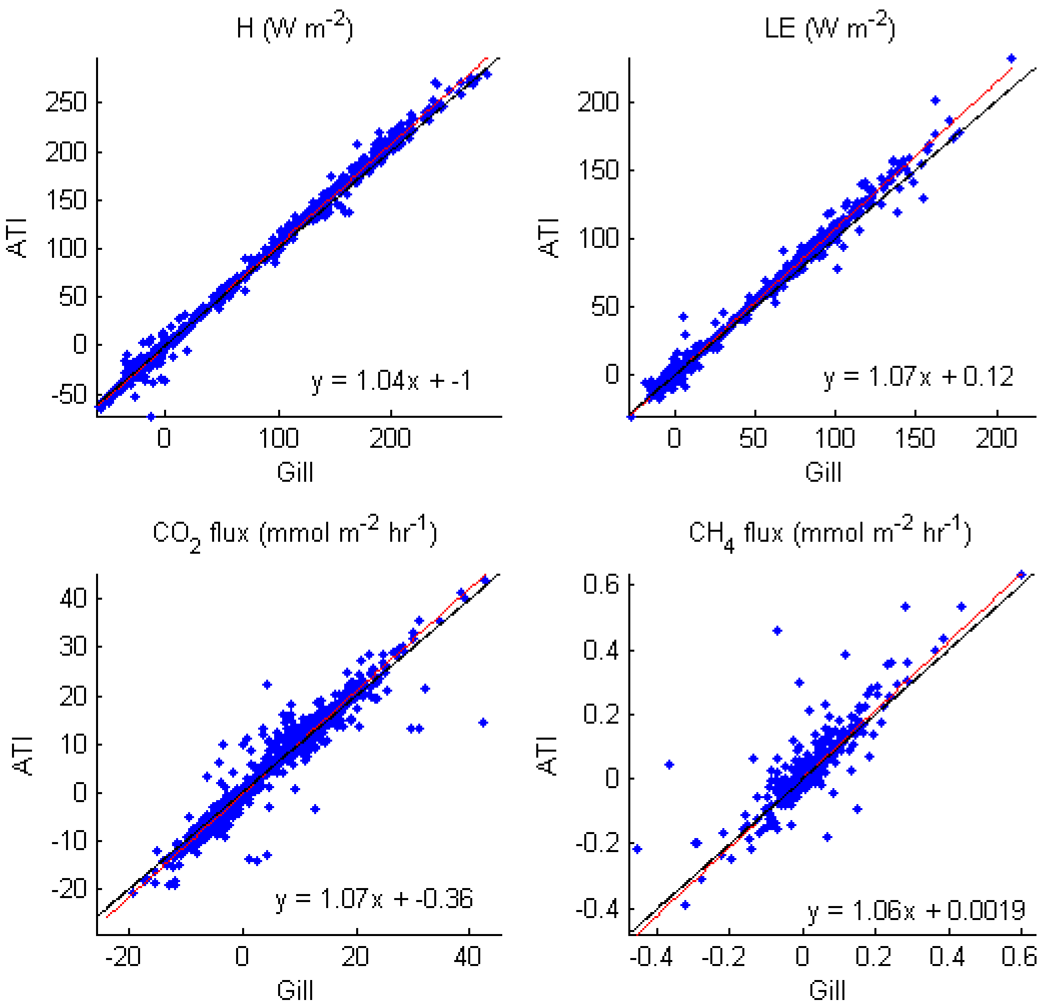

Figure SI-5. Half-hourly flux comparison at Sherman (including WPL correction and forcing the mean scalar values from the fast sensors to those available from the slow sensors). H, LE, CO_2 flux, and CH_4 flux all show greater responses for the ATI sonic, most likely a result of the greater w variance observed for the ATI sonic. H shows the closest correspondence between the two sonics due to the cancelling out of the higher w variance and lower ts variance for the ATI sonic. The other three fluxes all show about a 7% greater response for the ATI sonic, which is lower than the 16% greater w variance, suggesting that some of the increased w variance of the ATI sonic may be noise.

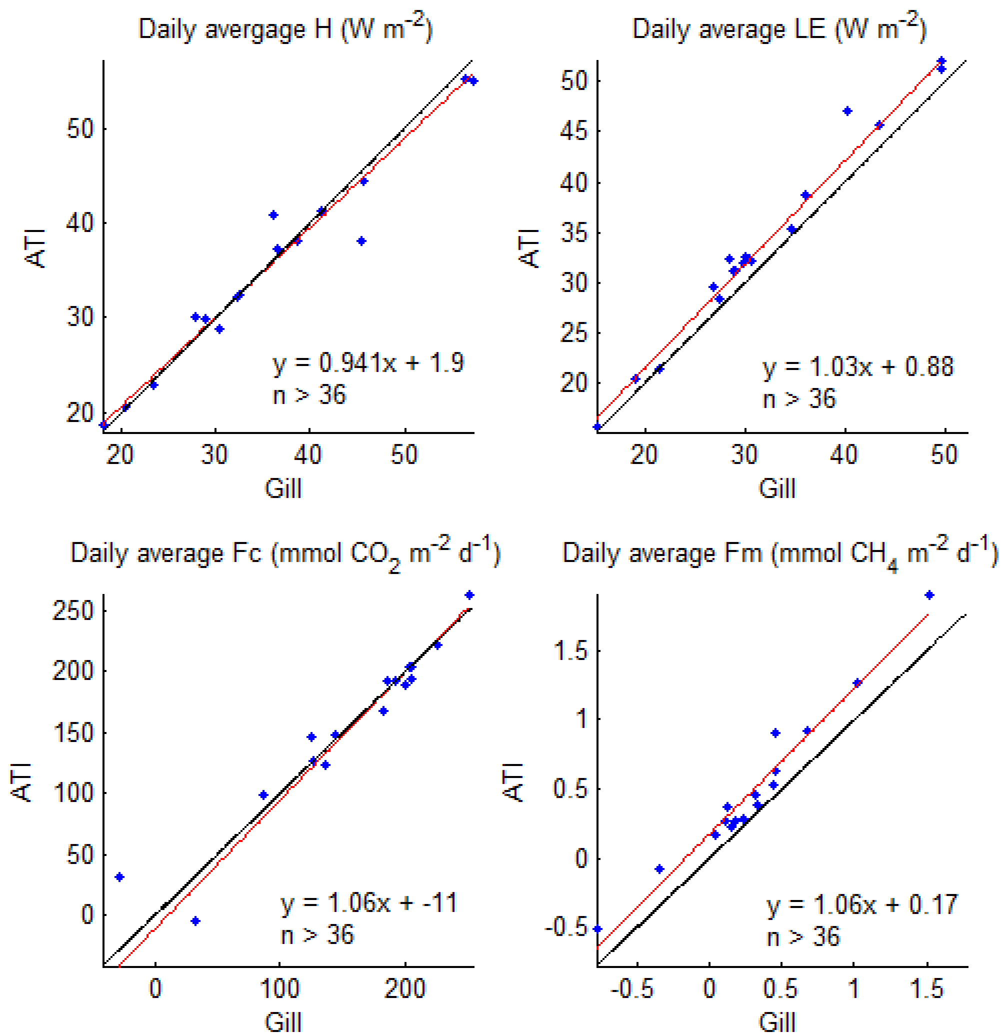

Figure SI-6. Daily average fluxes computed with available data from Sherman (no gap filling, accepted the average as long as a threshold number of half-hourly fluxes were available). Despite the computed departure from a 1:1 relationship, H and CO_2 flux show scatter right around the 1:1 line. For these two fluxes, the overestimation at positive values and underestimation at negative values or vice versa tend to cancel out on the daily average. For LE and CH_4 flux, however, there is a clear offset between the two sonics (ATI higher) due to the fact that these fluxes are usually positive or close to zero at night.

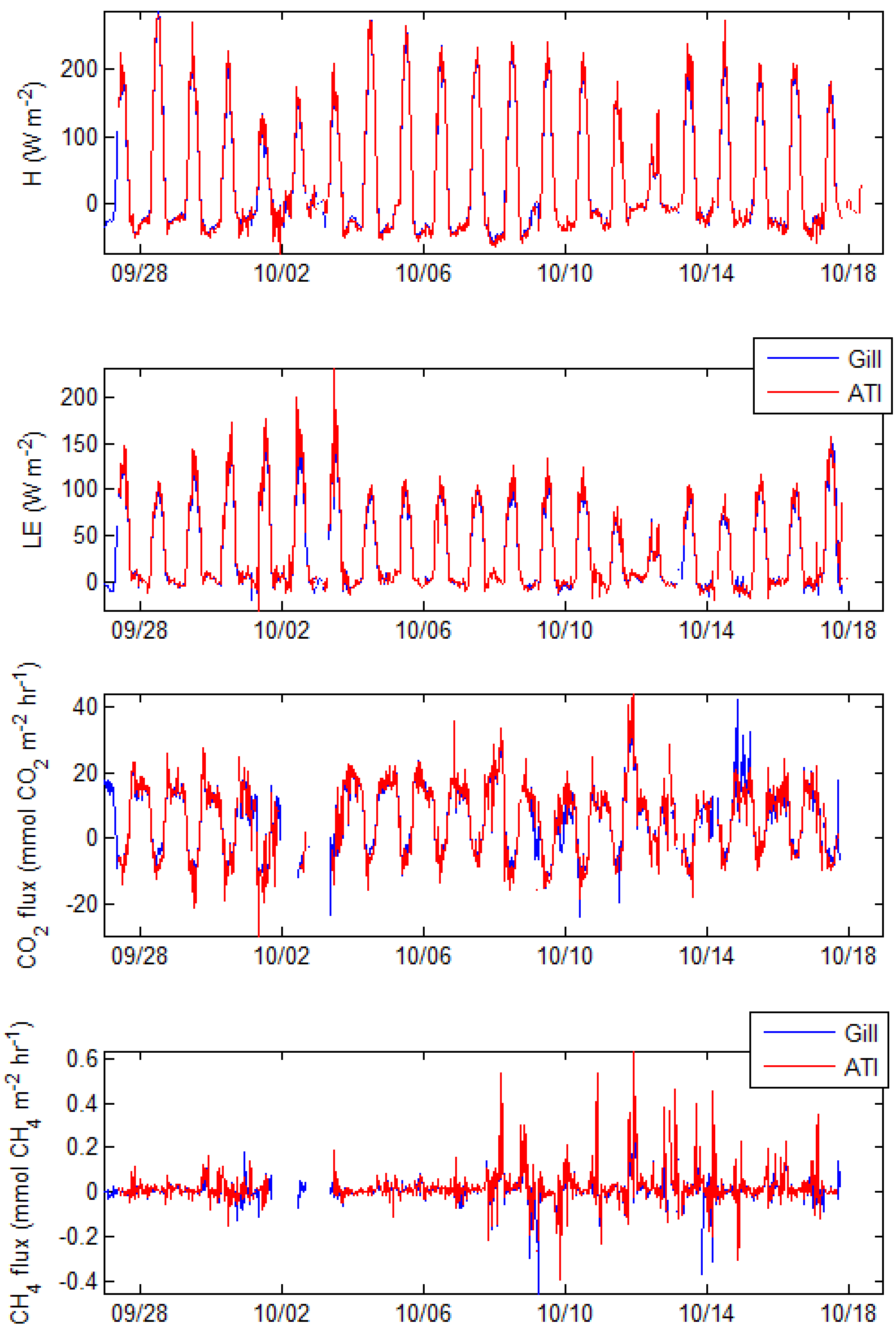

Figure SI-7. Flux time series at Sherman Island for general reference.

West Pond (18 October - 8 November, 2012)

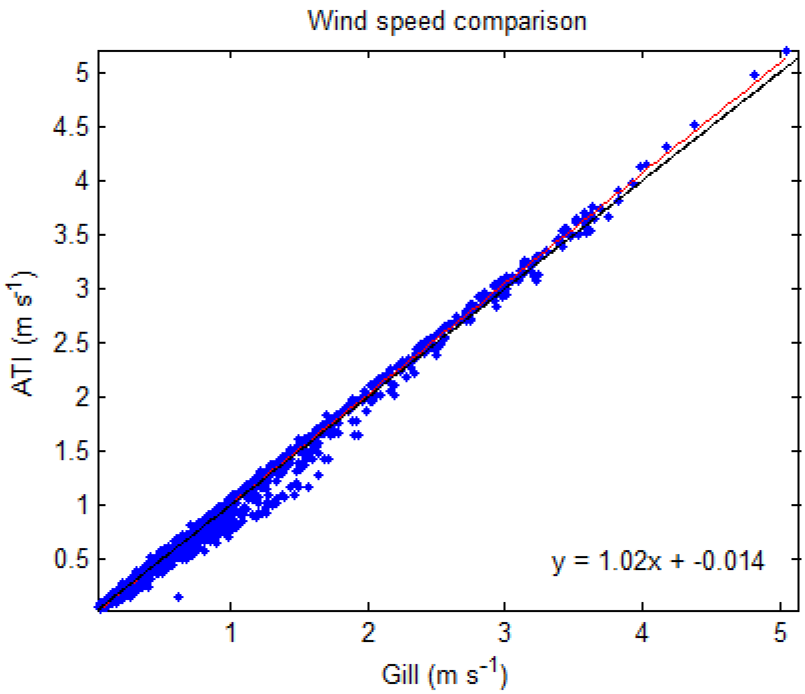

Figure WP-1. Wind speed comparison between the ATI and Gill sonics at West Pond. The relationship is linear and almost 1:1, the ATI sonic showing a slightly higher response compared to the Gill.

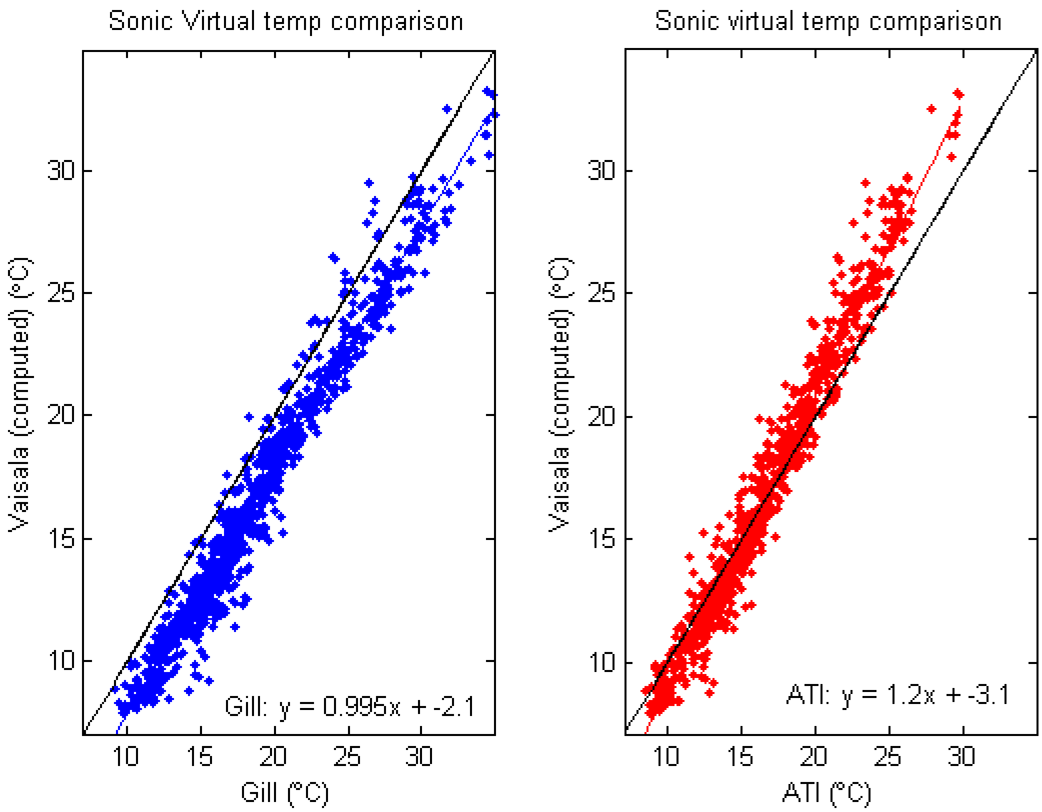

Figure WP-2. Sonic virtual temperature responses (Gill on the left, ATI on the right) compared to that computed from the Vaisala at West Pond. Both relationships are somewhat noisier than Sherman, and since the ATI-Gill comparison plot below (Figure WP-3) is smoother it is probably the Vaisala that is noisier here. The noise in this plot is not attributed to relative humidity or sensible heat flux. Unlike the Sherman Gill, the West Pond Gill shows a near-linear response, nearly 1:1, but always overestimated by about 2 °C. The ATI shows a linear response about 20% lower than the Vaisala (which is 10 percentage points lower than the response it showed at Sherman), that is overestimated below about 15 °C and underestimated above about 15 °C. Since the ATI sonic likely didn't change its response between Sherman and West Pond, the lower response of the ATI at Sherman likely reflects a different response of the Vaisala.

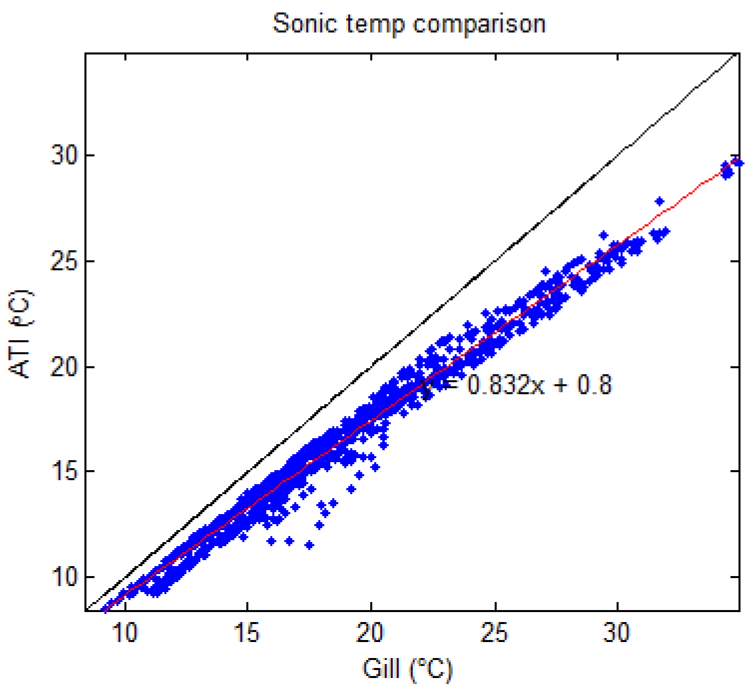

Figure WP3. Comparison of the ATI and Gill sonic virtual temperature responses at West Pond against each other. As expected, the relationship is more linear than that at Sherman due to the more linear response of the Gill at West Pond. The Gill shows about a 17% higher response to temperature than the ATI. The Gill sonic also shows a positive offset from the ATI that grows with higher temperature.

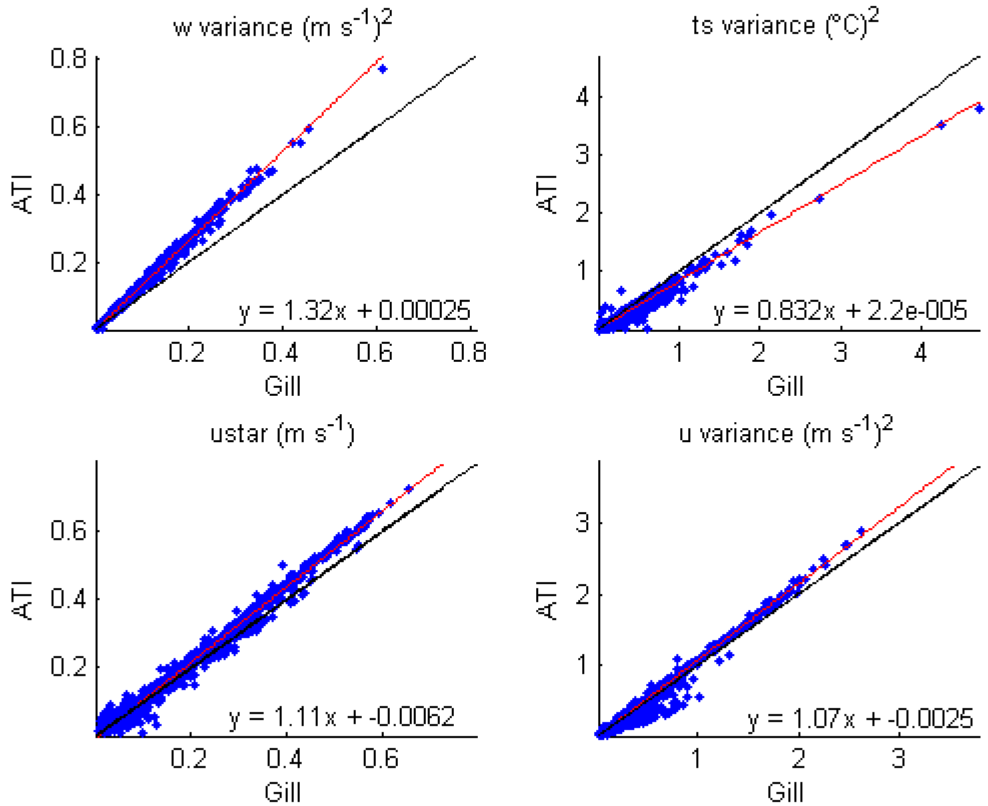

Figure WP-4. Comparison of West Pond turbulence statistics between the Gill and ATI sonics. The ATI sonic shows substantially greater w variance than the Gill, and somewhat greater for u. This is in contrast to the higher u variance observed for the Gill at Sherman. Similar to Sherman, the net effect on ustar is mostly controlled by the u variance, the ATI sonic showing higher values. Sonic temperature variance mirrors the mean value response in Figure WP-3, the ATI showing about a 17% lower response in temperature variance than the Gill. This effect is seen at all times in the time series, similar to the linear effect observed in Figure WP-3.

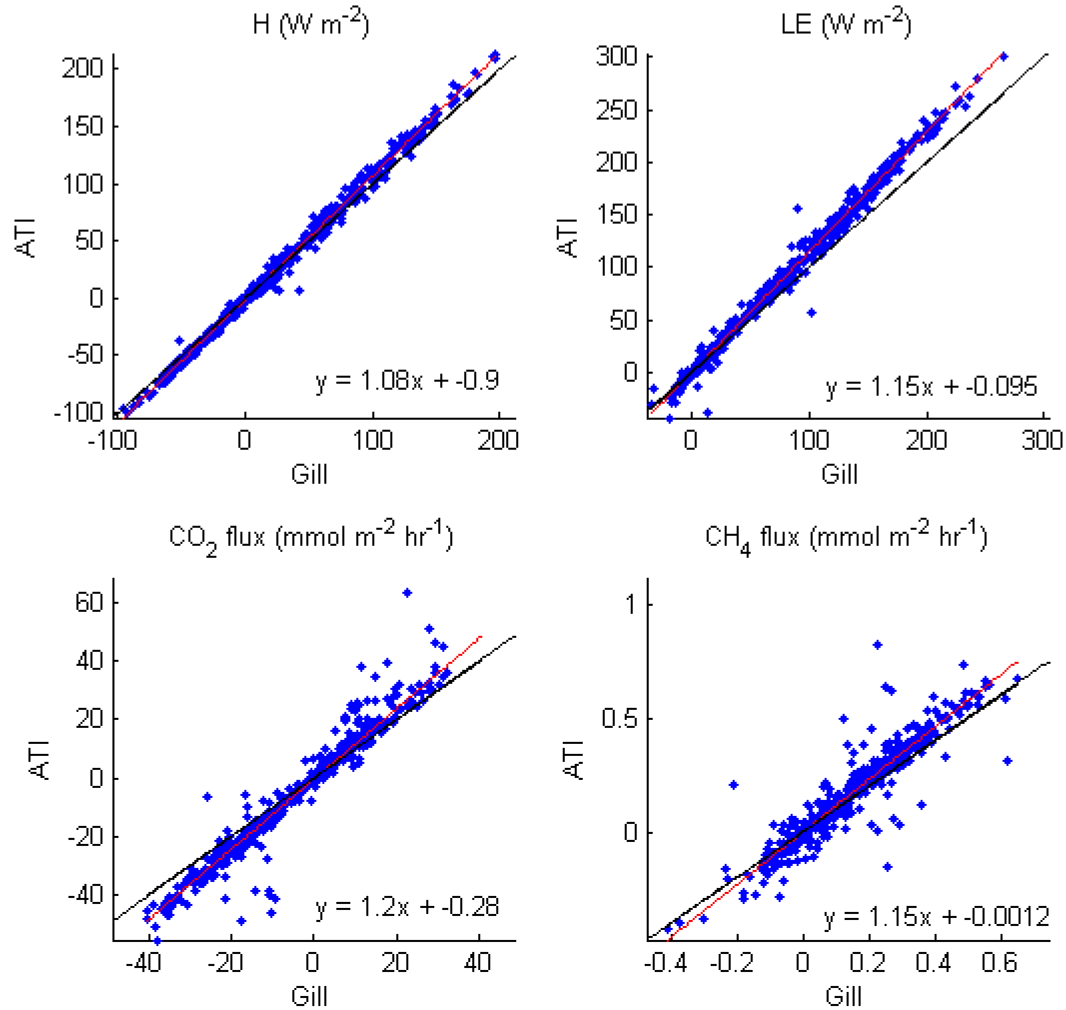

Figure WP-5. Half-hourly flux comparison at West Pond (including WPL correction and forcing the mean scalar values from the fast sensors to those available from the slow sensors). H, LE, CO_2 flux, and CH_4 flux all show greater responses for the ATI sonic, but about double those seen for Sherman as a result of the ~double response in w variance for the ATI versus the Gill here. Again, H shows the closest correspondence between the two sonics due to the cancelling out of the higher w variance and lower ts variance for the ATI sonic. The other three fluxes all show about a 15-20% greater response for the ATI sonic, which is again about half the 32% greater w variance.

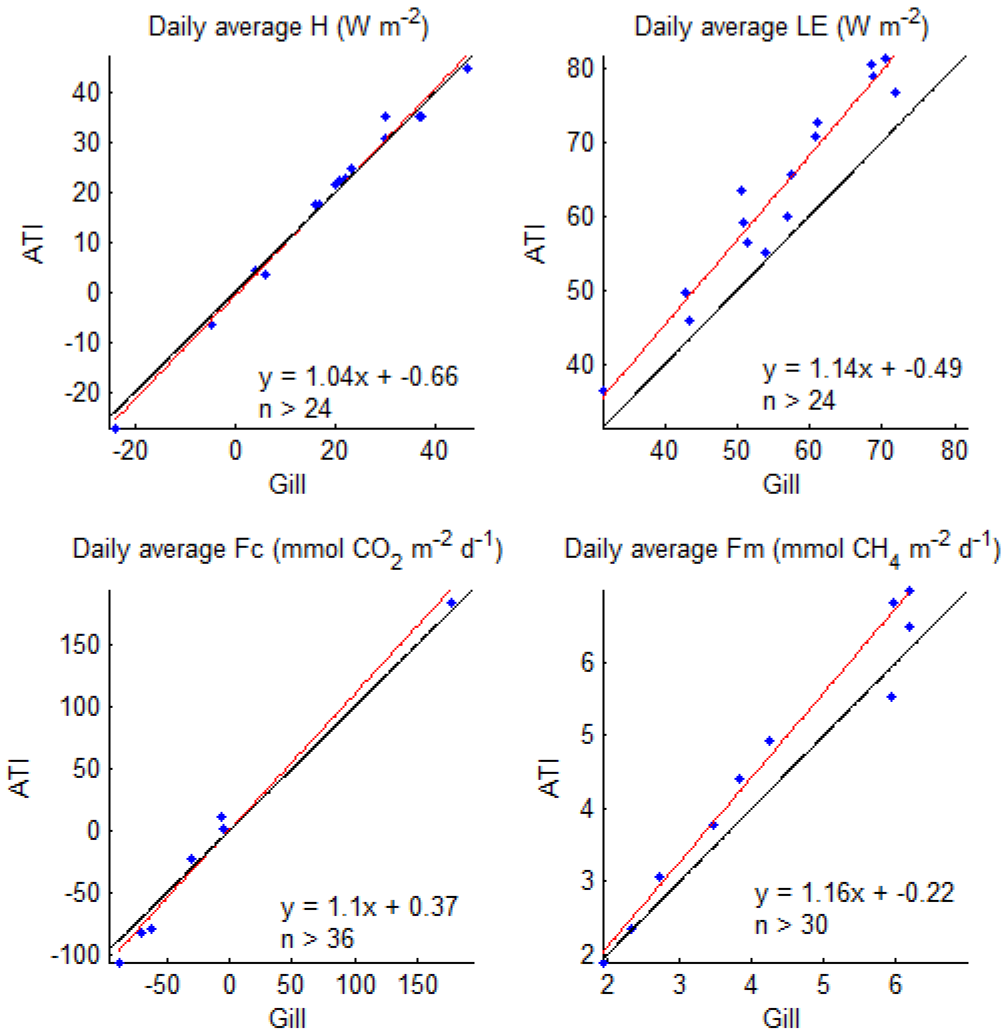

Figure WP-6. Daily average fluxes computed with available data from West Pond (no gap filling, accepted the average as long as a threshold number of half-hourly fluxes were available). H and CO_2 flux again show scatter right around the 1:1 line due to the cancelling out of over/underestimation for positive/negative values. Due to the greater CO_2 sink at West Pond versus Sherman, there starts to be some underestimation of the ATI sink on days with greater sinks. For LE and CH_4 flux, there are again more defined and increasing offsets (underestimation of the Gill) due to the fact that these fluxes are positive most of the time.

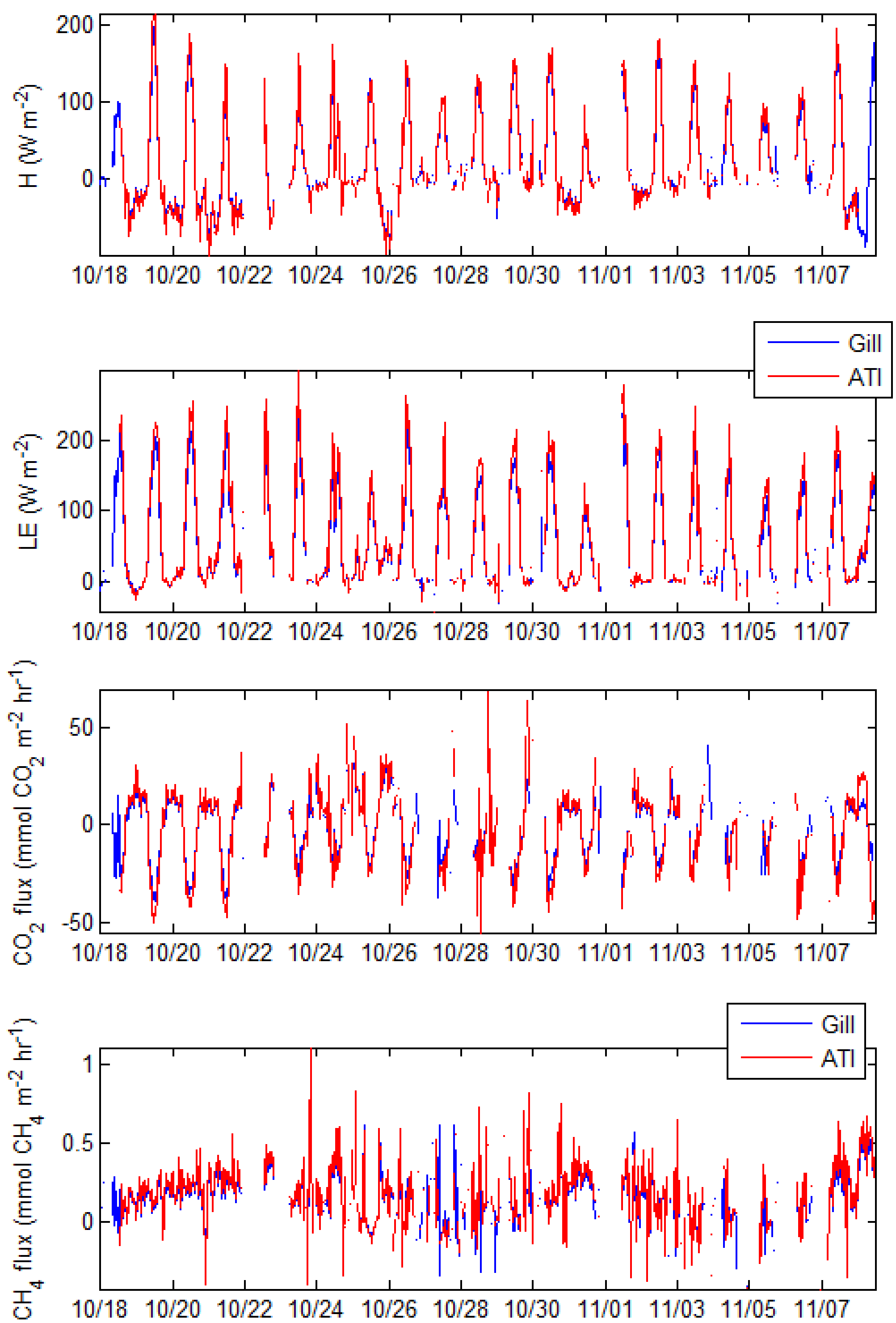

Figure WP-7. Flux time series at West Pond for general reference.

Tonzi Ranch (15 November – 11 December, 2012)

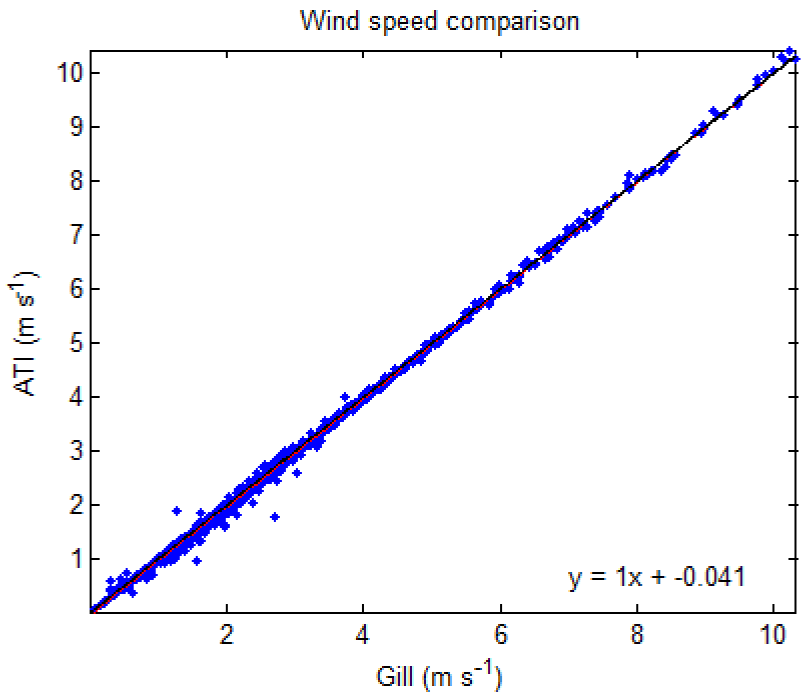

Figure TT-1. Wind speed comparison between the ATI and Gill sonics at Tonzi Ranch. The relationship is linear and 1:1.

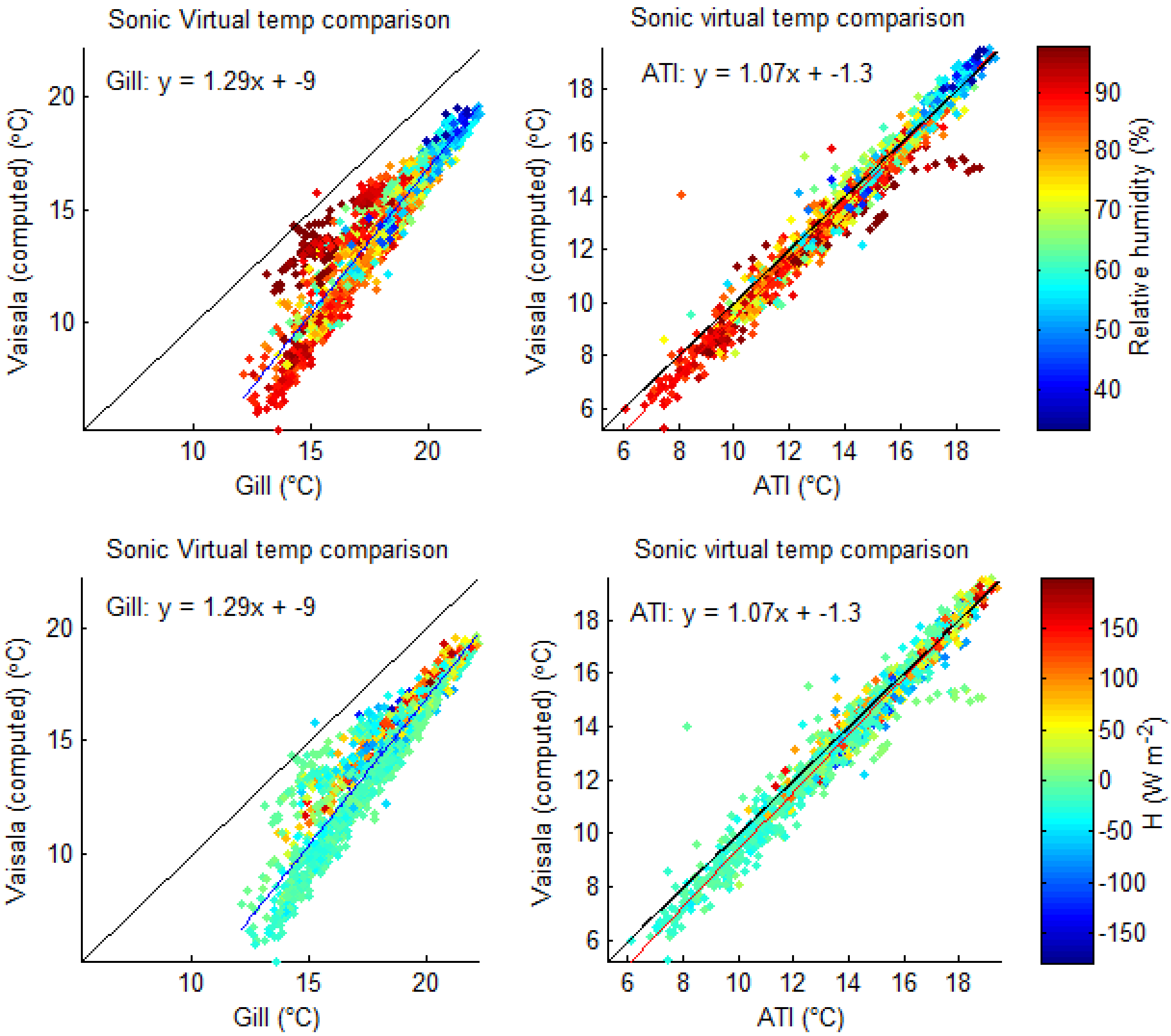

Figure TT-2. Sonic virtual temperature responses (Gill on the left, ATI on the right) compared to that computed from the Vaisala at Tonzi. In the top two plots, the color of the points indicates relative humidity. In the bottom two plots, the color of the points indicates the sensible heat flux. Similar to the West Pond Gill, the Tonzi Gill shows a near-linear response, but with a much smaller response than the Vaisala and always overestimated. The ATI shows a linear response about 7% lower than the Vaisala, that is overestimated below about 15 °C and underestimated above about 15 °C, very similar to the relationship at Sherman. Both the Gill and ATI relationships are relatively noisy, but the Gill relationship more so. The noisiest points for the Gill are associated with very high relative humidity (most red points), likely due to dew droplets collecting on the transducer heads. This phenomenon isn't seen in the ATI. There is also a secondary relationship present in the Gill sonic associated with very high or very low sensible heat flux. This phenomenon is not present for the ATI sonic.

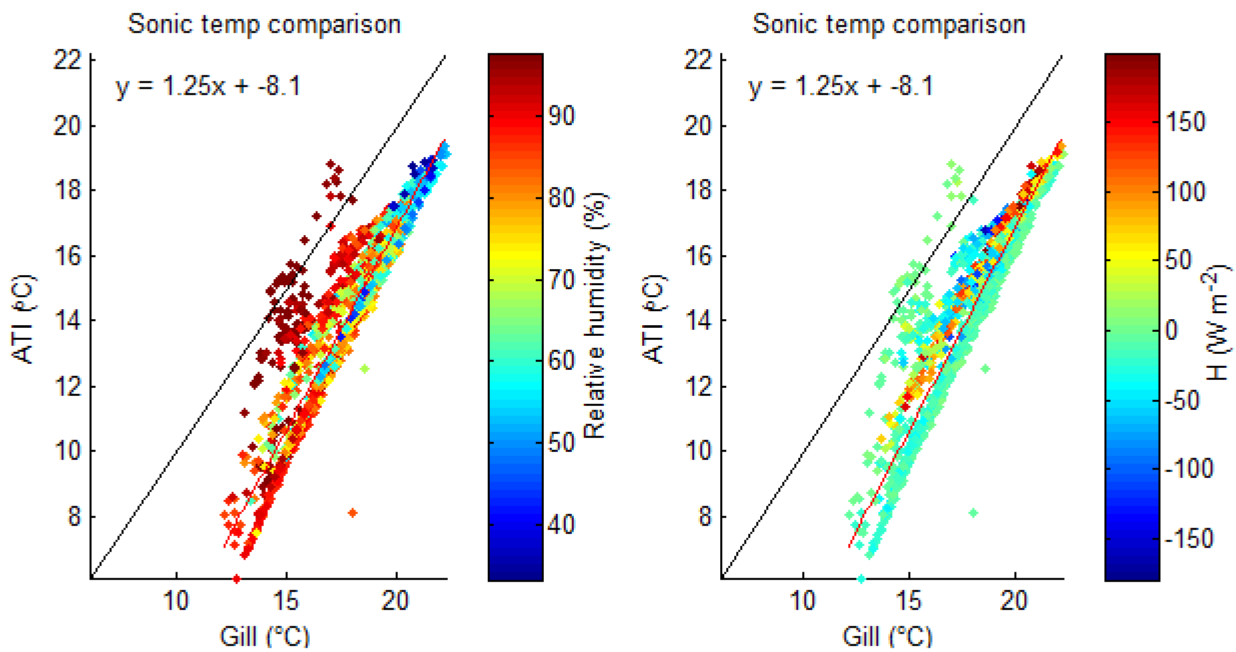

Figure TT-3. Comparison of the ATI and Gill sonic virtual temperature responses at Tonzi against each other. In the left plot, color indicates relative humidity. In the right plot, color indicates sensible heat flux. The relationship appears relatively linear. However, the effect from high relative humidity on the Gill is apparent (left plot) as well as the more subtle dual relationship due to high magnitudes of sensible heat flux in the Gill (right plot). Overall, the Gill shows about a 25% higher response to temperature than the ATI along with a positive offset that diminishes with higher temperature.

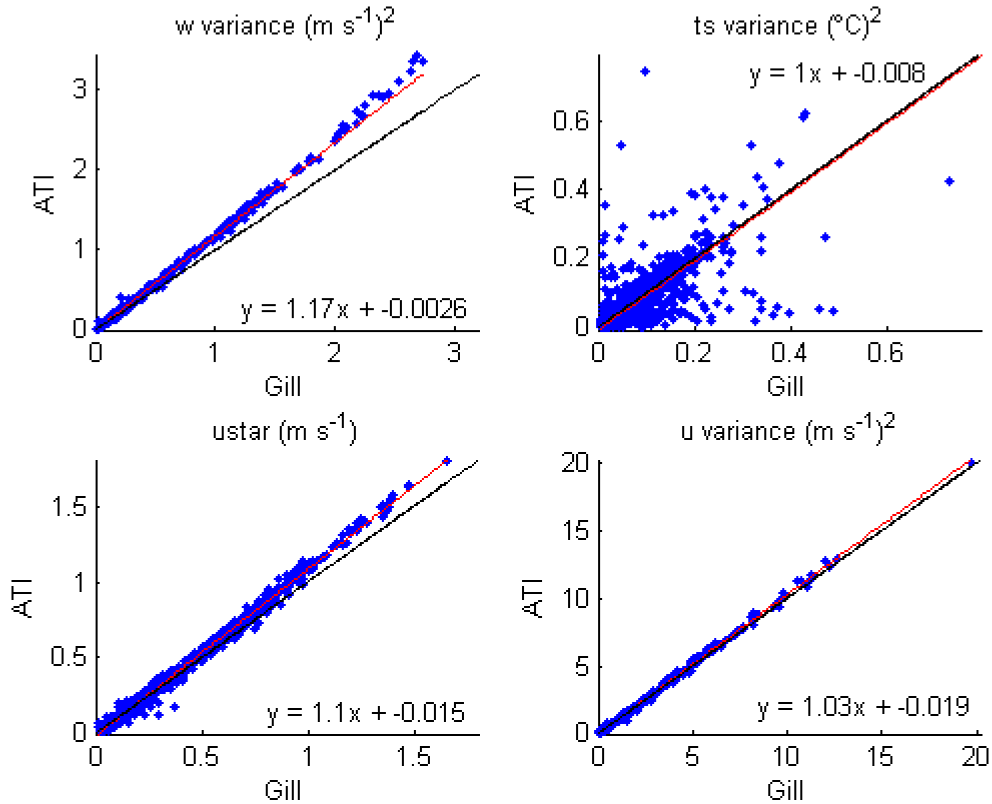

Figure TT-4. Comparison of Tonzi turbulence statistics between the Gill and ATI sonics. The ATI sonic shows substantially greater w variance than the Gill, very similar to Sherman comparison. There is a very slightly higher u variance for the ATI, more similar to the West Pond comparison than the Sherman comparison. The effect on ustar seems to split the difference in w and u variances. Although rather noisy, the sonic temperature variances are similar between the ATI and Gill. This lack of difference departs from the Sherman and West Pond comparisons, where the Gill ts variances trend higher than the ATI.

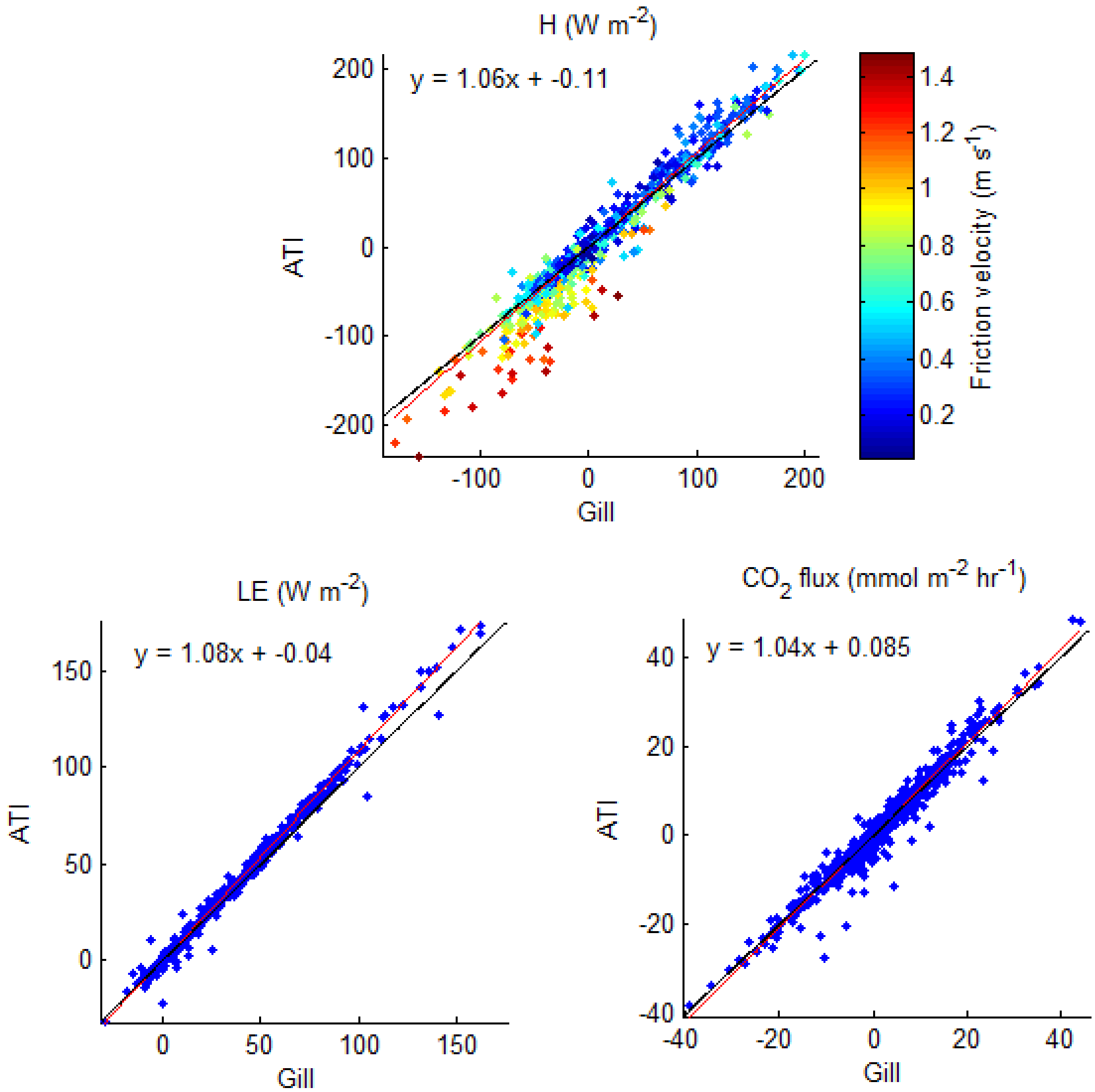

Figure TT-5. Half-hourly flux comparison at Tonzi (including WPL correction and forcing the mean scalar values from the fast sensors to those available from the slow sensors). H, LE, and CO_2 flux all show greater responses for the ATI sonic, very similar to the effect at Sherman (the Sherman Gill showed a very similar w variance comparison). In comparison to Sherman, the higher w variance of the ATI results in a comparatively stronger effect on H (although only 2% points), perhaps due to the lack of offset from lower ts in the ATI. The H comparison at Tonzi also shows some strong scatter and a steeper relationship at lower H values. This occurrence is perhaps due to a steeper w variance relationship at very high friction velocity (indicated by colors in the H plot and also seen in the w variance plot in Fig. TT-4). The odd scatter in the Gill ts relationship (Fig. TT-2) at higher RH doesn't appear to effect H, perhaps because higher RH values were associated with very small sensible heat flux. The slight differences in ts relationship at high magnitudes of H (Fig. TT-3) also don't appear to have a large effect. The other two fluxes (LE and CO_2) show a 4-8% greater response for the ATI sonic, which is roughly similar to half the w variance relationship.

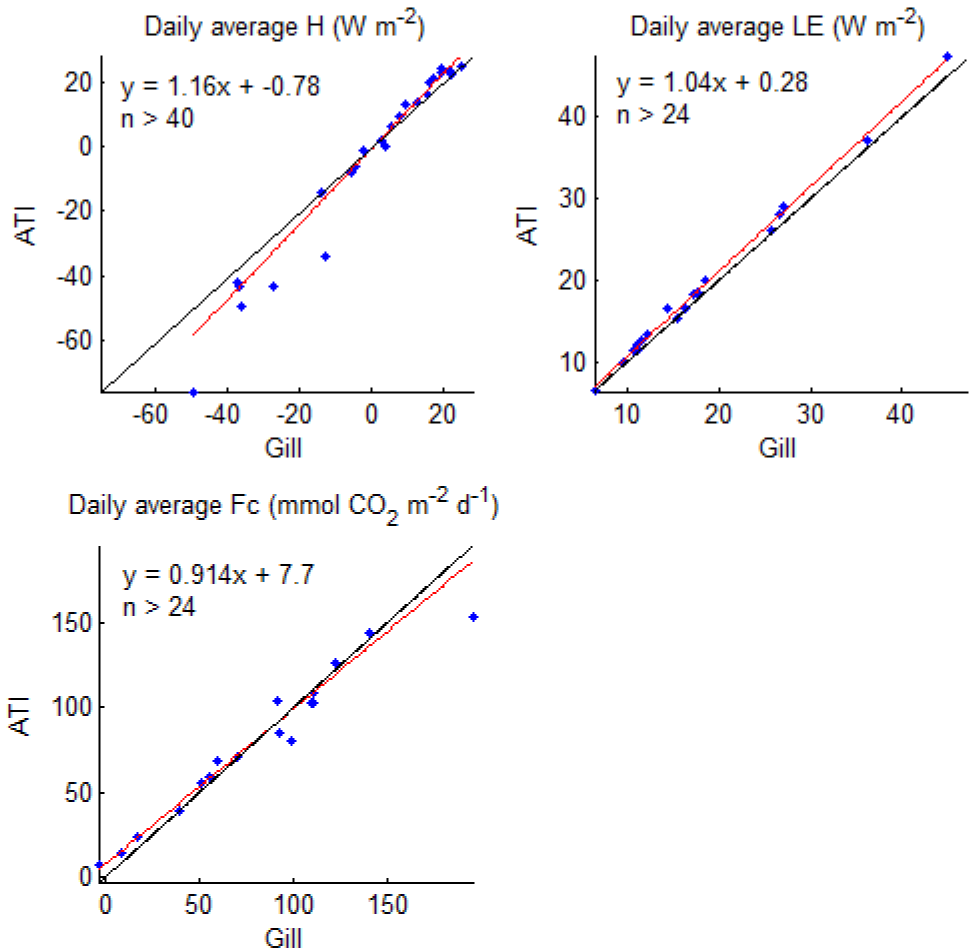

Figure TT-6. Daily average fluxes computed with available data from Tonzi (no gap filling, accepted the average as long as a threshold number of half-hourly fluxes were available). Although CO_2 flux again shows scatter right around the 1:1 line (despite the regression equation) due to the cancelling out of over/underestimation for positive/negative values, H this time shows an interesting relationship. The pattern is heavily influenced by the strongly negative H values during the days in which the friction velocity was very high and H very negative for a large part of the day, which is why the pattern more mimics the half-hourly relationship. For LE, there is again a relationship similar to the half-hourly plot.

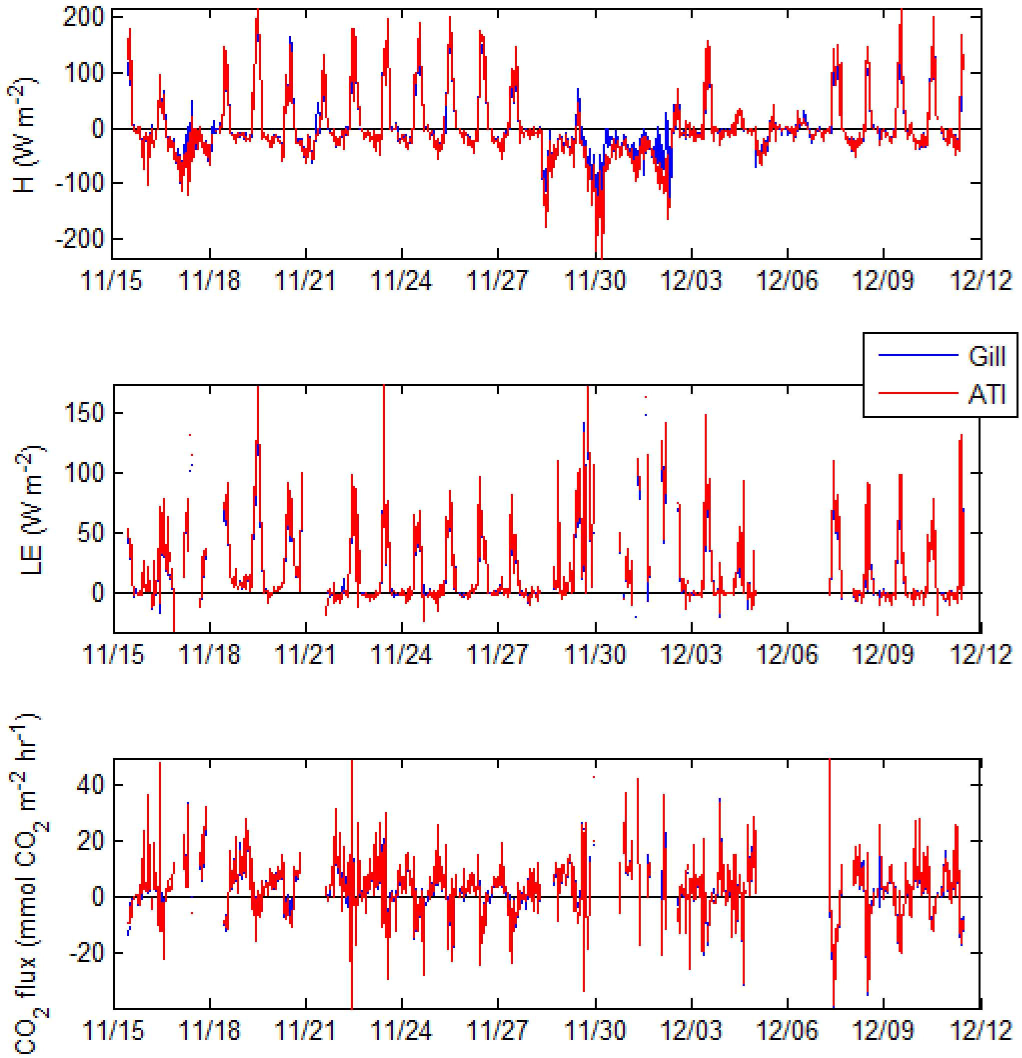

Figure TT-7. Flux time series at Tonzi for general reference.