

Summary

The potential for biases in filter-based light absorption has been recognized. This calls into question the quality of long-term baseline absorption observations that are important to evaluate climate models. To resolve this problem we report long term direct filter free observations of optical properties with a 3-wavelength photo-acoustic spectrometer (PASS-3) of both light absorption and scattering at 781, 532 & 405 nm at SGP in 2013 and 2015. We compare our results with absorption measurements made by baseline filter-based measurements (PSAP at 660, 530 & 467 nm) and the direct scattering observations made with a nephelometer (at 700, 550 & 450 nm). All instruments were located on the same inlet and the optical observations were compared at the same wavelength using extrapolations with measured Angstrom exponents. One hour averaging was used for our comparison to gain sufficient signal/noise for the PASS. Our analysis shows that while the absorption measured by the PASS and PSAP are well correlated the PSAP is biased high by a factor of 2.2, 1.9 and 1.8 in 2013 and by 2.8, 2.4, and 4.1 in 2015 at 781, 532 and 405nm respectively. The PASS was upgraded with a high power green laser and deployed at SGP in 2015. We find that the signal/noise of absorption at 532nm improved significantly in 2015 but the biases persisted. The PASS scattering measurements are noisy but agree with those measured by the nephelometer. We find that the PSAP high absorption bias increased with aerosol organic content in 2013 consistent with earlier results but not in 2015. Our results can be used to empirically scale the historic PSAP record at SGP for more reliable climate model evaluation.

PASS-3, PSAP, Neph. & ACSM at SGP

- Direct, online measurement of aerosol absorption & scattering
 - 781, 532, 405 nm
 - Absorption (β_{abs})
 - Scattering (β_{sca})
 - Angstrom Exponent (AE)
 - 2013 & 2015 SGP deployment
 - 2015 upgrade 532 nm laser power increased by factor of 4.
- PSAP Absorption measurements
 - 660, 530, 467 nm
- ACSM chemical composition data
- Nephelometer scattering data
 - 700, 530, 467 nm
- 1 hour averages used in analysis



Figure 1. : Aerosol Observing System at SGP where all measurements were made in the same inlet and conditions.

References

- Subramaniam et al. AS&T 41, 630–637, 2007
- Lack et al. AS&T, 42, 1033–1041, 2008.
- Cappa et. al. AS&T, 42, 1022–1032, 2008
- Cross, E.S. et al., AS&T, 44, 592-611, 2010.
- Flowers, B.F. et al., ACP, 10,10387-98, 2010.

Acknowledgement

This research is funded by DOE ASR grant F265 to LANL and instrument mentoring and data archiving funded by DOE ARM program. MKD also thanks NSF Atmospheric Chemistry for support.

PASS-3, PSAP & Neph. Comparison

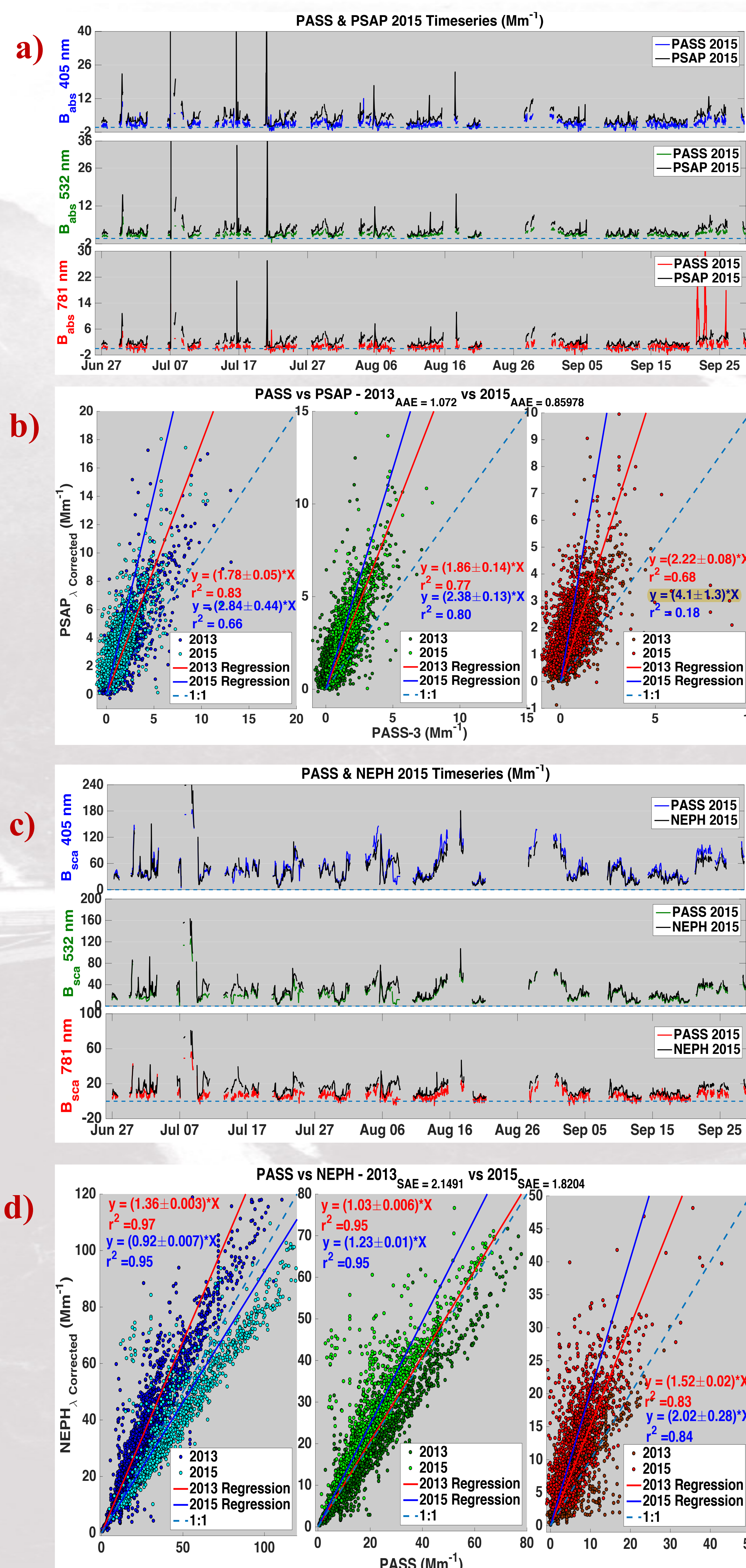


Figure 2: a) Time series of PASS-3 and PSAP absorption data. b) Correlations of PASS-3 and PSAP absorption extrapolated using AE to PASS-3 wavelengths and fits for 2013 and 2015. c) Time series of PASS-3 and Nephelometer scattering data. d) Correlation of PASS-3 and Nephelometer scattering extrapolated using AE to PASS-3 wavelengths and fits for 2013 and 2015.

PSAP/PASS-3 versus OA

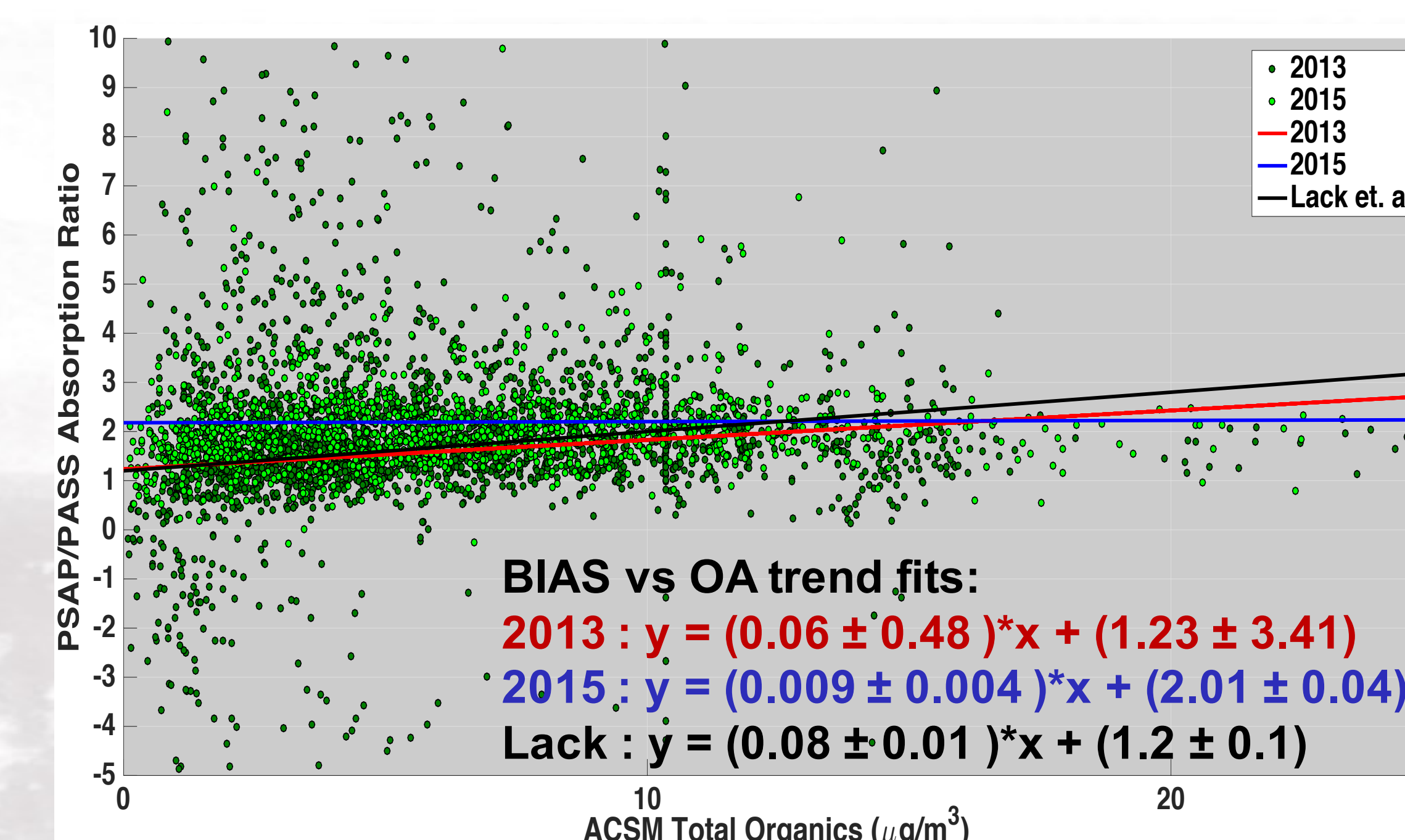


Figure 3 : PSAP/PASS Ratio vs Organic Aerosols at 532 nm. Lack et. al. and 2013 show increasing bias with organic loading in contrast to 2015.

	<u>2013</u>		<u>2015</u>	
	B_{abs}	$B_{scatter}$	B_{abs}	$B_{scatter}$
405 nm:	1.57 ± 1.58	25.87 ± 18.54	1.61 ± 1.60	51.85 ± 31.32
532 nm:	1.02 ± 0.99	16.83 ± 12.33	1.48 ± 0.95	23.05 ± 16.68
781 nm:	0.58 ± 0.67	4.79 ± 3.87	0.80 ± 2.29	7.31 ± 6.89

- PSAP and PASS-3 are well correlated
- PSAP is biased high relative to PASS-3
- PSAP bias persists in 2015
- PSAP bias correlates with OA in 2013
- Retroactive corrections of PSAP record at SGP

532nm PASS-3 Laser Upgrade

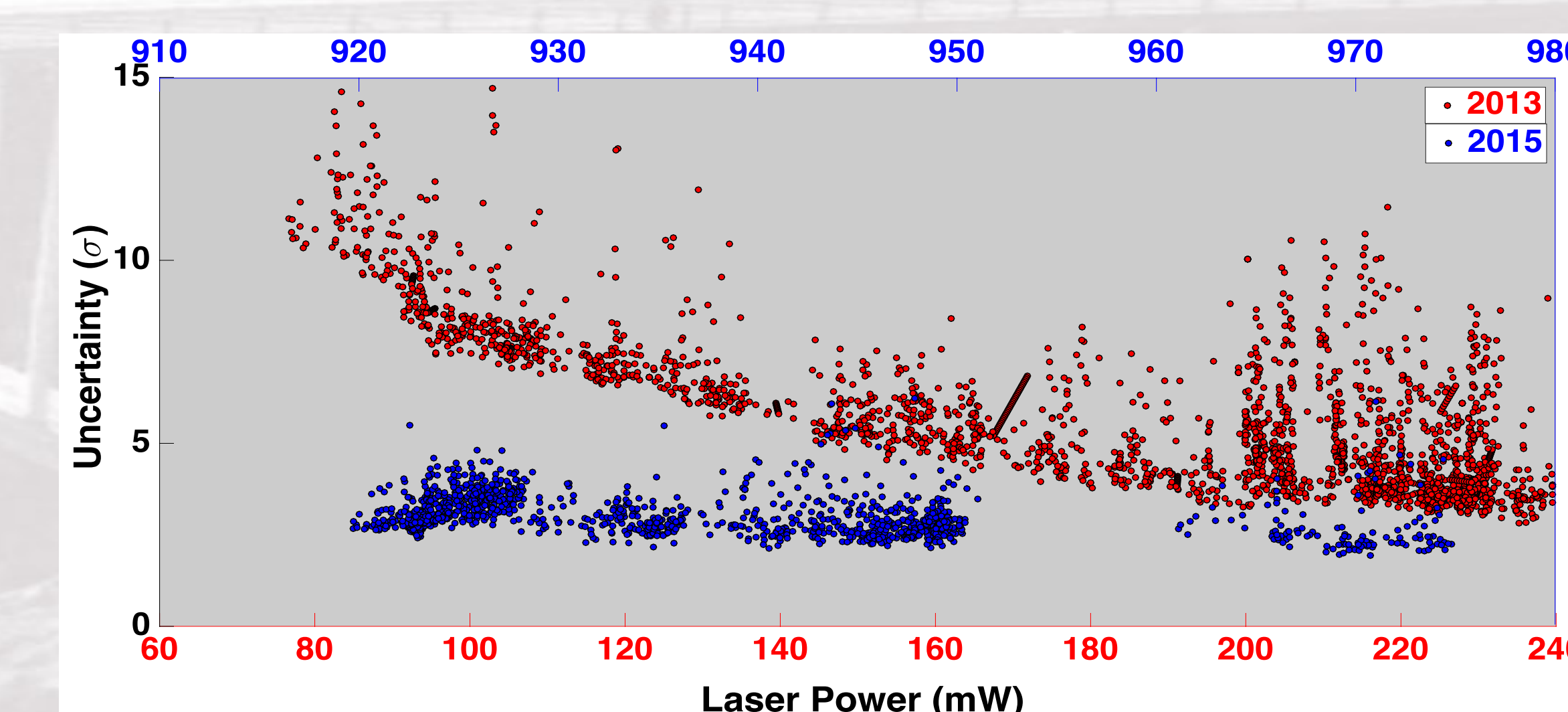


Figure 4: (Above) Uncertainty in 532 absorption as measured by variability (1 sigma) in signal versus laser power, 2013 in red, 2015 in blue. Uncertainty and scatter are both reduced by a factor of 2-5 in 2015.

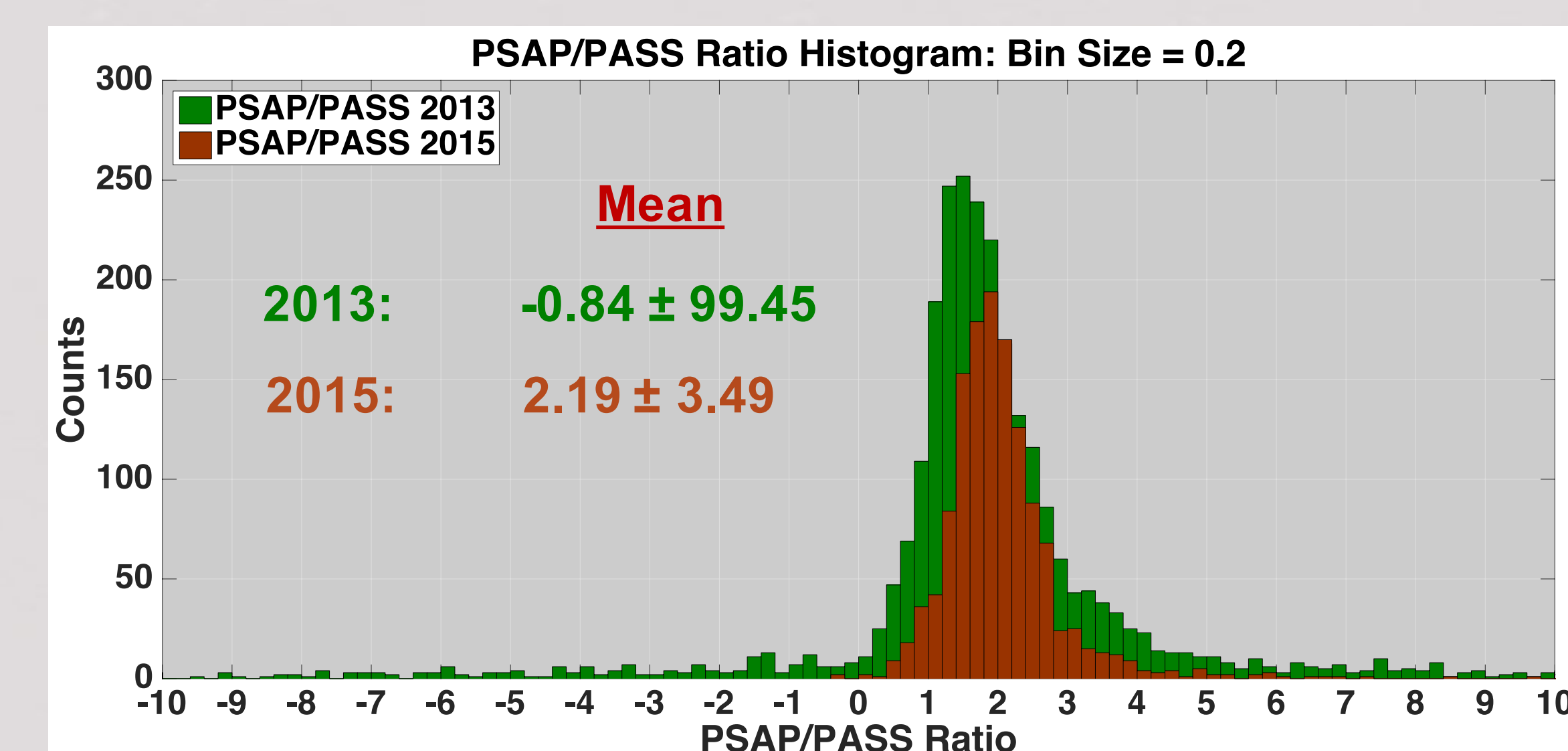


Figure 5:) Histogram PSAP/PASS3 ratio measured in 2013 (green) and 2015 (red) show a bias of 2 in the 532 nm absorption. 2015 bias is less variable due to lower noise at higher power.

- Lower uncertainty and noise in 532 nm absorption at higher laser power in 2015.
- PASS-3 performance is much improved