



## **VLASS Project Memo #10**

### **Phase Stability and Ionospheric Variations in VLASS1.1**

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#### **1. Context**

This document summarizes for all observations of VLASS1.1:

- ionospheric total electron content variations
- phase stability
- variability of rms phases observed by VLA's atmospheric phase interferometer (API)

This document aims to help with the selection of VLASS1.1 datasets to recalibrate applying ionospheric corrections and provide valuable information of data quality for all VLASS1.1 datasets.

#### **2. Ionosphere**

The standard CASA ionospheric calibration tasks were used to generate an ionospheric calibration table for each VLASS1.1 dataset. This provides an estimate of the total electron content TEC of the ionosphere for a given pointing, taking Earth's magnetic field, path lengths through the ionosphere, and knowledge of the absolute vertical TEC into account. From these calibration tables the minimum, maximum, and mean were obtained and tabulated for all VLASS1.1 datasets. A full table in chronological order can be found in Table 1 in the Appendix. To visualize the value ranges, the distributions of minimum, maximum, mean, and maximum-minimum (delta) values are plotted in Fig. 1. In Fig. 2 the derived delta TEC values are plotted in chronological order. It clearly illustrates that in general delta TEC values were higher during BnA configuration where observations were conducted at lower elevations thus passing through more ionosphere. For VLASS1.1 the mean dTEC was 16 TECU, with a median of 12 TECU and min/max of 1.6/75 TECU.

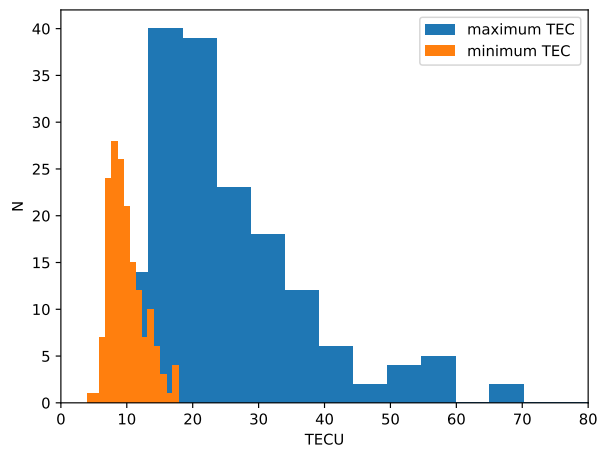
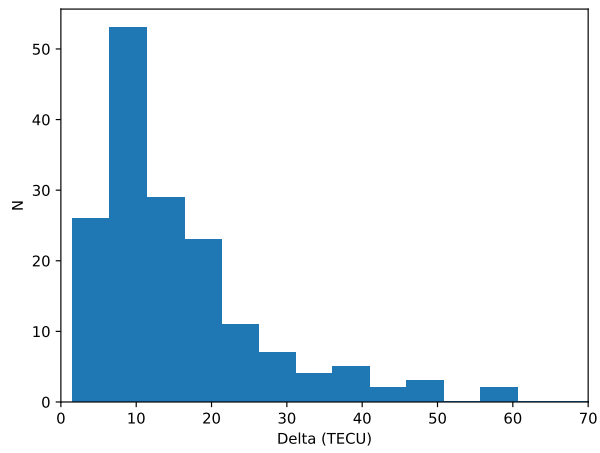
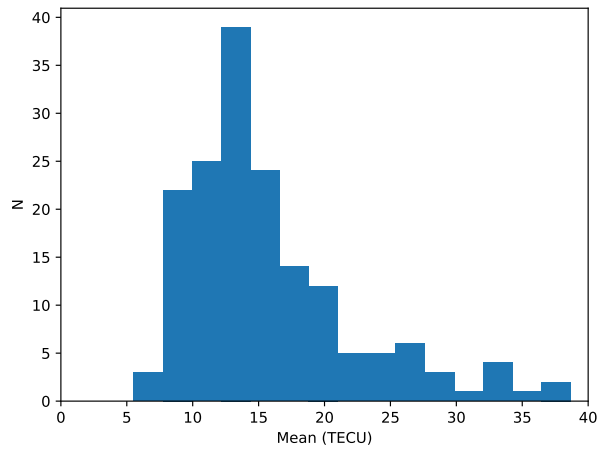


Figure 1: From top to bottom: Average TEC value distribution, Max-Min TEC distribution, maximum and minimum TEC value distribution.

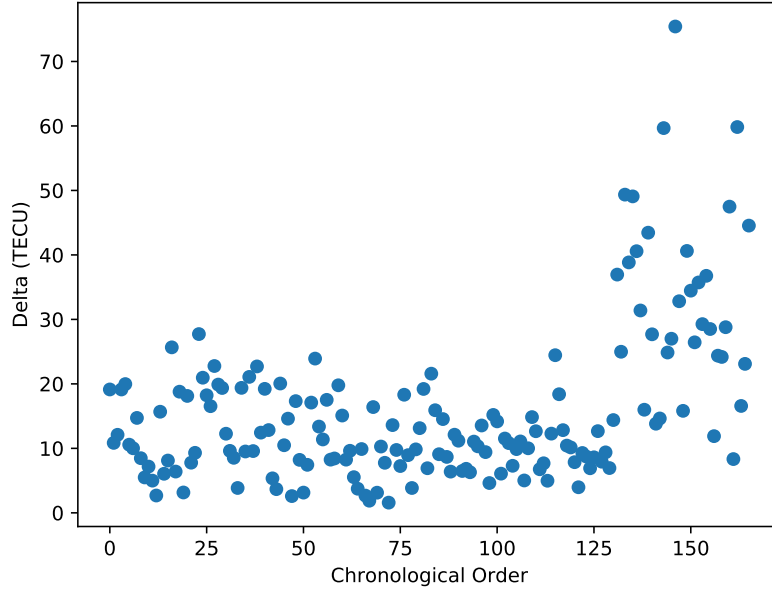


Figure 2: Delta TEC for each VCLASS1.1 observation plotted in chronological order.

### 3. Phase Stability

To obtain an estimate on the phase stability of VCLASS1.1 observations, the solutions from the finalphasegaincal gaintable of the quicklook calibration pipeline are used. To facilitate comparison, values from both polarizations are averaged for each scan and antenna after which the standard deviations are derived on a per antenna basis. From this the mean and maximum standard deviations are obtained. These values are listed in Table 2. In Fig. 3 the distribution of values for the maximum and mean standard deviations are shown. More interesting when plotting the mean standard deviations against the chronological order of observations it seems that during the beginning of VCLASS1.1 phases were less stable, while through the bulk of observing phase stability was good and only worsened once observing began in BnA configuration where observations were at primarily low elevations. This is expected due to path length effects. The mean phase standard deviation for VCLASS1.1 was  $9.7^\circ$ , with a median of  $7.5^\circ$  and min/max values of  $3.6/38^\circ$ .

### 4. Impact of Ionosphere/Atmosphere on Phase Stability

In Section 2 the ionospheric changes are described for VCLASS1.1 observations. To gauge water vapor conditions during the VCLASS1.1 observations, rms phases from the API observing at 11 GHz are used (data provided by Bryan Butler). The collected data contain a

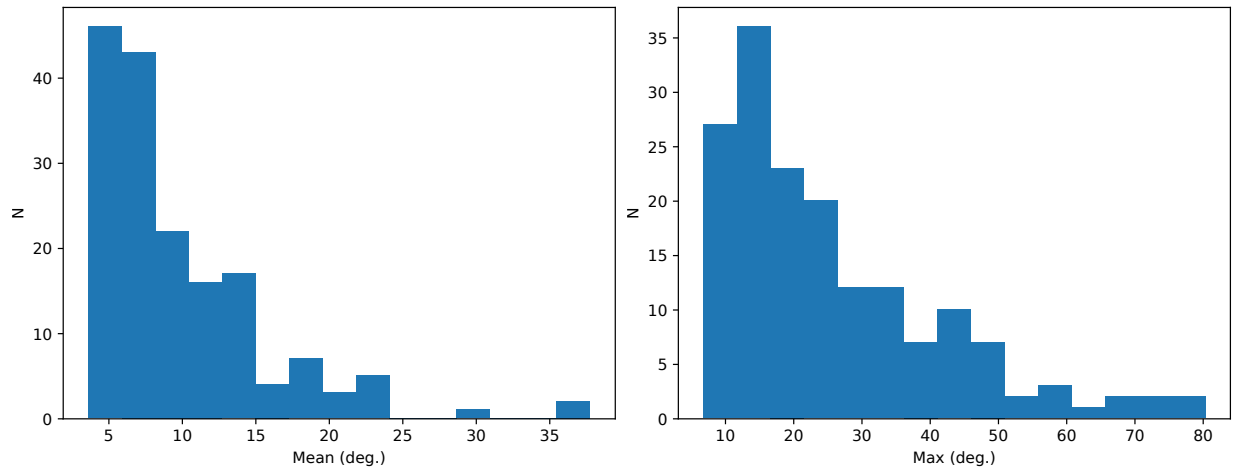


Figure 3: From left to right: Mean standard deviation of final phase calibration, Maximum standard deviation from final phase calibration.

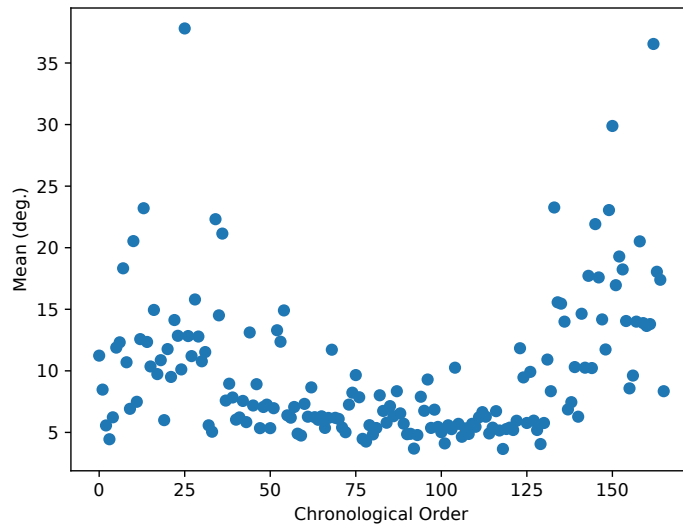


Figure 4: Mean standard deviation of final phase calibration plotted in chronological order.

datapoint every 10 min which are matched to times of phase calibrator scans. From this the mean and maximum API rms phase were extracted. The derived values are listed in Table 3. Similar to the previous section in Fig. 5 and 6 the distribution and chronological order of the observed API rms phases are illustrated.

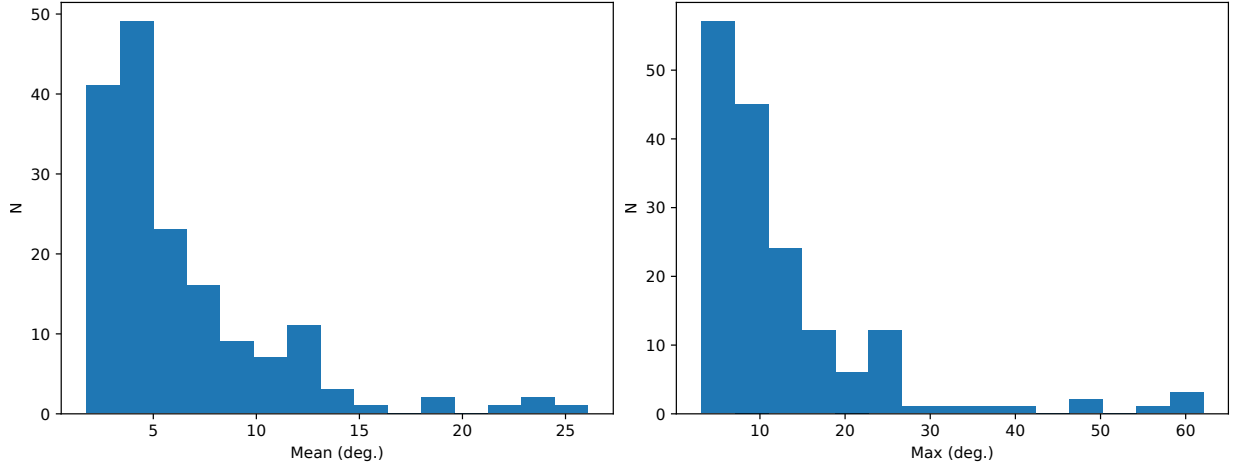


Figure 5: From left to right: Mean of API rms phases, Maximum API rms phases during given observation.

To ensure that times of high delta TEC values and high API rms phases are not correlated the Pearson product-moment correlation coefficient  $\rho$  was calculated. It was determined to be  $1.5 \cdot 10^{-5}$ , thus indicating no evidence for a significant linear correlation between TEC and API values. The correlation coefficient comparing the mean standard deviation from VLASS1.1 final phase calibration against dTEC and mean API rms phases only show weak correlation. This is also visualized in Figs. 7 and 8. The final Figure illustrates the relationship between API phases, dTEC and the observed phase variability. The mean API phase rms for VLASS1.1 was  $6.2^\circ$  with a median of  $4.7^\circ$  and a min/max value of  $1.8/26^\circ$ .

## 5. Conclusion

From the above analysis we can conclude that observed instability in derived residual phases from calibrator scans in VLASS1.1 arise both from atmospheric as well as from ionospheric effects. Where primarily above  $10^\circ$  rms phase observed by the API phase stability slowly worsens. However, the ionosphere seems to play a more significant role regarding introduced phase instabilities above dTEC of 25–35 TECU. Given a limited number of observations with high dTEC and high API rms phases this analysis needs to be revisited in the future.

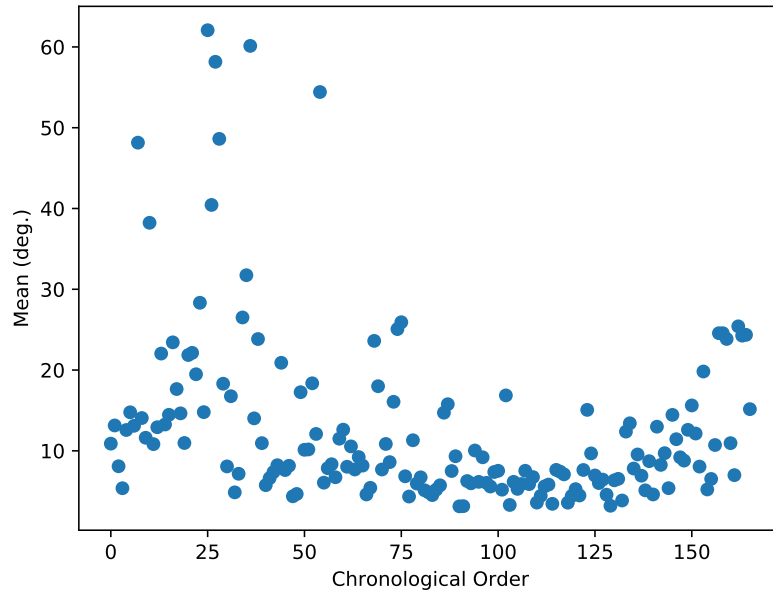


Figure 6: Mean of API rms phases plotted in chronological order.

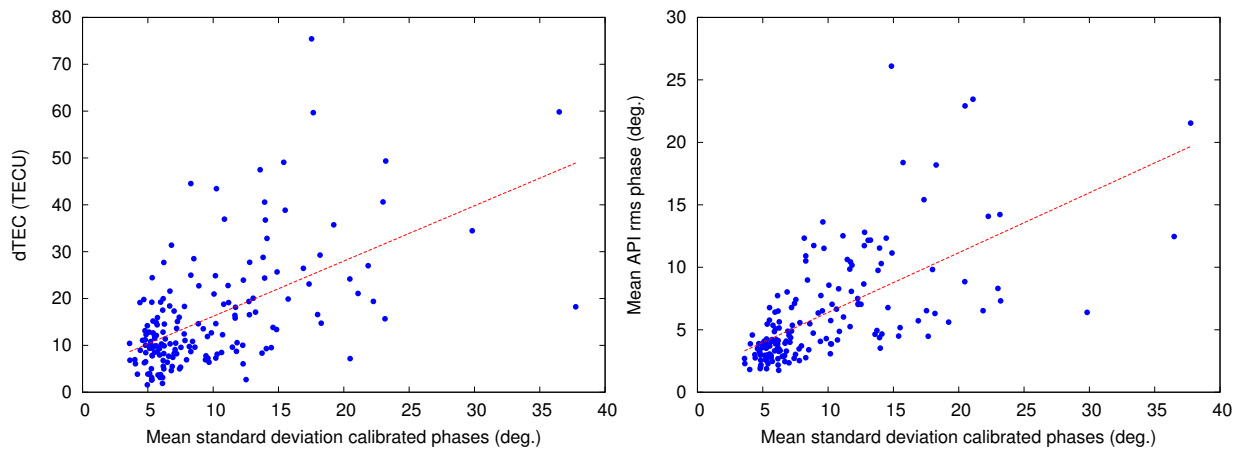


Figure 7: Left: Mean standard deviation of the calibrated phases is plotted against dTEC. A linear fit provides a visual guideline to gauge any potential linear correlation. Right: Mean standard deviation of the calibrated phases is plotted against dTEC. A linear fit provides a visual guideline to gauge any potential linear correlation.

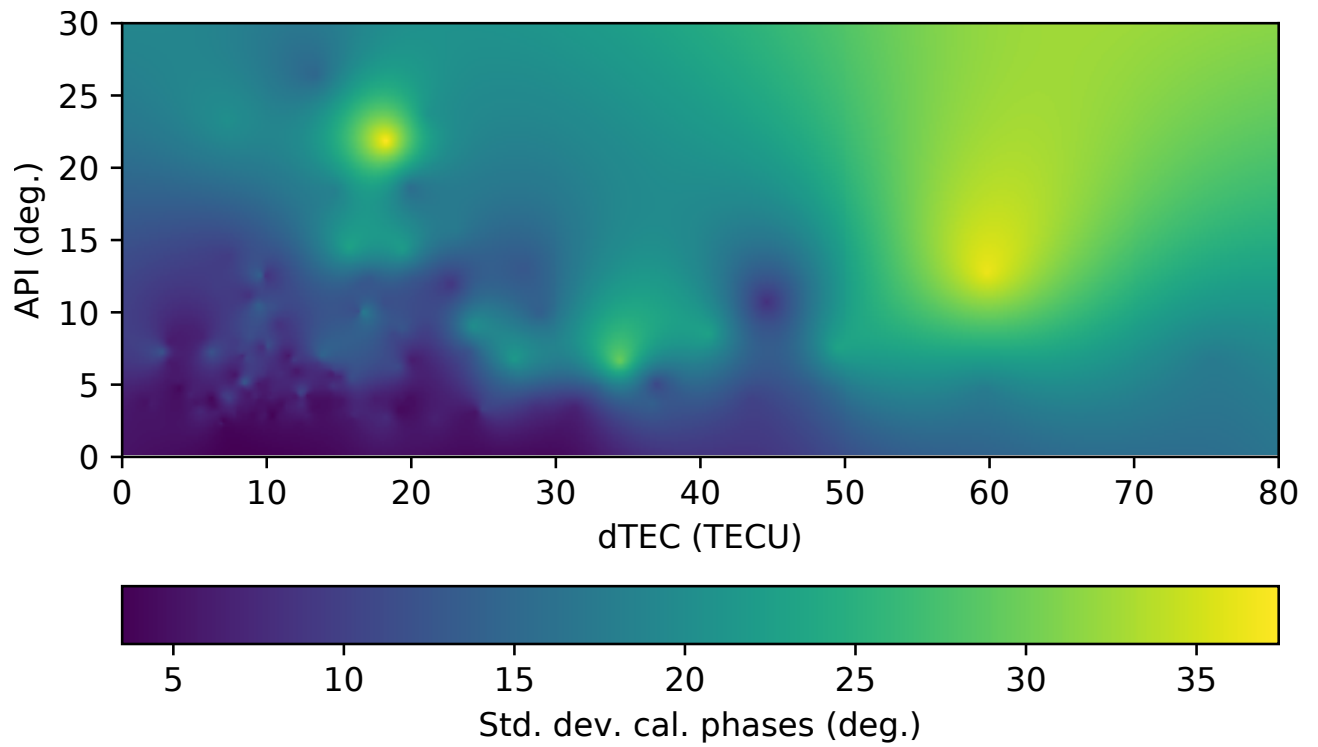


Figure 8: Map of calibrated phase variability plotted against rms phases from the API and dTEC. The map was generated by linearly interpolating the data.

## A. Tables

Table 1: Derived TEC values for all VLASS1.1 observations.

filename	min (TECU)	max (TECU)	mean (TECU)	delta (TECU)
VLASS1.1.sb34346984.eb34356943.58004.0160307176	14.309453	33.444495	20.154483	19.135041
VLASS1.1.sb34361741.eb34367683.58005.085977442126	4.041596	14.891834	5.542069	10.850237
VLASS1.1.sb34356210.eb34369329.58006.08368738426	6.245384	18.349208	7.956669	12.103825
VLASS1.1.sb34361043.eb34371004.58007.1075228588	9.235266	28.367890	13.050263	19.132623
VLASS1.1.sb34382472.eb34389458.58009.054277766205	9.631736	29.602296	13.929828	19.970559
VLASS1.1.sb34395681.eb34403276.58010.036995381946	7.774493	18.345279	10.850978	10.570786
VLASS1.1.sb34418989.eb34425056.58011.2817505787	7.517959	17.532467	9.541126	10.014508
VLASS1.1.sb34421723.eb34429827.58011.82889114584	12.344941	27.066403	20.507345	14.721462
VLASS1.1.sb34402674.eb34433625.58014.15711049769	7.032471	15.508952	7.824822	8.476480
VLASS1.1.sb34417859.eb34434020.58014.453630601856	7.081074	12.573553	9.427240	5.492479
VLASS1.1.sb34397357.eb34435512.58014.72557283565	12.737863	19.913542	14.469227	7.175679
VLASS1.1.sb34420672.eb34448755.58015.27887172454	6.511323	11.507642	7.957535	4.996318
VLASS1.1.sb34461205.eb34469117.58017.220875416664	7.074291	9.762376	7.926168	2.688085
VLASS1.1.sb34441820.eb34483341.58017.956089363426	10.033051	25.714254	16.526275	15.681203
VLASS1.1.sb34434950.eb34484414.58018.13499180556	8.039731	14.097608	8.978655	6.057877
VLASS1.1.sb34422762.eb34486846.58018.47191952546	8.183205	16.294075	11.415933	8.110870
VLASS1.1.sb34446513.eb34497773.58018.931944780095	9.086508	34.752669	15.485129	25.666162
VLASS1.1.sb34401997.eb34497870.58019.45873091435	9.141265	15.543325	12.508923	6.402060
VLASS1.1.sb34475744.eb34497997.58020.06194271991	9.477390	28.266336	12.737100	18.788946
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VLASS1.1.sb34499142.eb34512738.58022.410128460644	9.827255	17.606009	13.655218	7.778754
VLASS1.1.sb34510386.eb34526547.58023.125750694446	10.917370	20.224937	13.702255	9.307567
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filename	min	max	mean	delta
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VLASS1.1.sb34607978.eb34635523.58053.05546966435	8.544401	16.795521	11.619115	8.251120
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VLASS1.1.sb34738258.eb34756362.58088.29786020833	8.245527	22.431106	14.446537	14.185579
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VLASS1.1.sb34518430.eb34756479.58089.71818545139	13.370826	24.895591	16.848141	11.524765
VLASS1.1.sb34731735.eb34756489.58090.122307233796	6.857628	17.673638	12.776654	10.816010
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VLASS1.1.sb34517306.eb34782681.58097.74992206019	12.021474	23.097077	14.435564	11.075602
VLASS1.1.sb34613920.eb34787246.58098.73782822917	15.956245	20.978055	17.938861	5.021810
VLASS1.1.sb34787846.eb34789515.58100.03466122685	8.517083	18.530745	12.771923	10.013661
VLASS1.1.sb34761173.eb34797849.58102.982940497684	11.877078	26.725537	15.293850	14.848460
VLASS1.1.sb34768661.eb34797855.58103.322425844905	10.698504	23.355331	15.089104	12.656827
VLASS1.1.sb34641006.eb34808190.58115.235410231486	8.201968	14.962541	10.894558	6.760573
VLASS1.1.sb34747564.eb34810829.58116.160714247686	7.339626	15.025957	10.799932	7.686331
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VLASS1.1.sb34804404.eb34810911.58118.545018310186	8.104874	32.552231	18.093151	24.447357
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filename	min	max	mean	delta
VLASS1.1.sb34749299.eb34811010.58120.34588865741	8.911065	21.736427	10.939585	12.825362
VLASS1.1.sb34692336.eb34811412.58121.33896026621	7.633400	18.061356	9.517808	10.427956
VLASS1.1.sb34812068.eb34812594.58122.954574675925	9.123528	19.267990	12.490858	10.144461
VLASS1.1.sb34746916.eb34812604.58123.11002827546	6.515330	14.372670	10.336903	7.857340
VLASS1.1.sb34739674.eb34813174.58124.37509868055	8.644914	12.613273	9.469753	3.968359
VLASS1.1.sb34773813.eb34819682.58127.102012013886	7.896890	17.180137	13.890772	9.283247
VLASS1.1.sb34766890.eb34821128.58128.20474726852	9.591727	18.325926	14.190301	8.734199
VLASS1.1.sb34748147.eb34823345.58130.14045111111	7.441720	14.356030	9.994084	6.914310
VLASS1.1.sb34752093.eb34823539.58130.440413715274	9.024755	17.638268	10.897118	8.613513
VLASS1.1.sb34772249.eb34824245.58131.128517708334	8.016337	20.687605	13.603346	12.671268
VLASS1.1.sb34940218.eb34825732.58132.15545319444	11.347510	19.281245	16.506248	7.933736
VLASS1.1.sb34762611.eb34828612.58134.27350804398	9.666613	19.047628	11.783571	9.381015
VLASS1.1.sb34894726.eb34973224.58148.30825349537	13.093612	20.039914	15.350808	6.946301
VLASS1.1.sb34984786.eb34985738.58150.33651579861	14.586769	28.976481	18.084555	14.389712
VLASS1.1.sb34940218.eb34992438.58151.92216394676	10.430069	47.379853	33.404257	36.949784
VLASS1.1.sb34919742.eb34993475.58152.22067622685	8.606312	33.588383	24.559234	24.982071
VLASS1.1.sb34924077.eb34993493.58152.55778096065	8.418614	57.767722	34.089593	49.349109
VLASS1.1.sb34917571.eb34994250.58152.889074189814	12.393482	51.233854	28.977632	38.840372
VLASS1.1.sb34925152.eb34995045.58153.57609369213	7.613452	56.691469	34.953158	49.078017
VLASS1.1.sb34918656.eb34995118.58153.94350954861	11.251519	51.828071	32.048960	40.576552
VLASS1.1.sb34901451.eb34995355.58154.327259618054	11.652270	43.035583	19.175231	31.383312
VLASS1.1.sb34920826.eb35001824.58155.24291935185	15.460073	31.451111	23.154711	15.991038
VLASS1.1.sb34916486.eb35006898.58156.86241219907	13.855412	57.302962	33.198642	43.447550
VLASS1.1.sb34902511.eb35008344.58157.34584716435	10.013780	37.701890	16.335759	27.688110
VLASS1.1.sb34915423.eb35019637.58158.66329216435	17.789457	31.610647	23.896150	13.821189
VLASS1.1.sb34912231.eb35025904.58159.00888243056	8.919638	23.555822	15.048295	14.636184
VLASS1.1.sb34926227.eb35032384.58159.58002181713	8.391534	68.061639	38.664989	59.670105
VLASS1.1.sb34910088.eb35032971.58159.93049569444	10.648447	35.513133	18.701400	24.864686
VLASS1.1.sb34922993.eb35033647.58160.26137790509	11.848989	38.849336	25.846360	27.000347
VLASS1.1.sb34927307.eb35033887.58160.5989258912	10.238644	85.662539	38.630552	75.423895
VLASS1.1.sb34903570.eb35034891.58160.909213252315	10.865279	43.682635	19.855624	32.817355
VLASS1.1.sb34897149.eb35035193.58161.27141606482	10.571312	26.388647	17.006441	15.817335
VLASS1.1.sb34907929.eb35038477.58161.62935980324	14.651283	55.268203	26.938474	40.616920
VLASS1.1.sb34940544.eb35040203.58161.99305538194	9.337592	43.795864	25.586464	34.458272
VLASS1.1.sb34898226.eb35042893.58162.29820586806	8.359157	34.803786	16.027849	26.444629
VLASS1.1.sb35045706.eb35051188.58162.78700490741	16.765334	52.494386	25.114435	35.729051
VLASS1.1.sb34921909.eb35065962.58163.23824550926	12.409026	41.675848	24.027060	29.266822
VLASS1.1.sb35049291.eb35069720.58164.000153773144	9.712232	46.469732	26.536932	36.757500
VLASS1.1.sb34899305.eb35070592.58164.31599563657	8.590040	37.099120	18.215363	28.509080
VLASS1.1.sb34900388.eb35074823.58165.26784681713	10.584310	22.478168	15.972511	11.893858
VLASS1.1.sb34914360.eb35075355.58165.623772928244	14.169460	38.542339	26.624309	24.372879
VLASS1.1.sb34904669.eb35076619.58165.98193083333	12.143106	36.321058	21.242100	24.177951
VLASS1.1.sb34913301.eb35082677.58166.59343417824	11.741521	40.532060	26.685962	28.790538
VLASS1.1.sb34905760.eb35113377.58166.981752928245	11.517822	59.005807	19.127578	47.487985
VLASS1.1.sb34896437.eb35113379.58167.31986631945	8.805516	17.144047	12.667170	8.338531
VLASS1.1.sb34906851.eb35113389.58167.585474039355	10.061927	69.894676	29.216988	59.832749
VLASS1.1.sb34911154.eb35113630.58167.94820277778	12.141691	28.719204	17.290118	16.577513
VLASS1.1.sb35116607.eb35119115.58168.767963136575	17.487236	40.589547	29.369075	23.102311
VLASS1.1.sb35118798.eb35120996.58169.55511674768	9.115627	53.660916	30.885820	44.545289

Table 2: Derived standard deviations of phases for all VLASS1.1 observations.

filename	max (deg.)	mean (deg.)
VLASS1.1.sb34346984.eb34356943.58004.0160307176	23.12	11.18
VLASS1.1.sb34361741.eb34367683.58005.085977442126	17.51	8.42
VLASS1.1.sb34356210.eb34369329.58006.08368738426	11.90	5.51
VLASS1.1.sb34361043.eb34371004.58007.1075228588	8.26	4.39
VLASS1.1.sb34382472.eb34389458.58009.054277766205	10.88	6.17
VLASS1.1.sb34395681.eb34403276.58010.036995381946	22.41	11.83

filename	max	mean
VLASS1.1.sb34418989.eb34425056.58011.2817505787	28.99	12.26
VLASS1.1.sb34421723.eb34429827.58011.82889114584	35.51	18.27
VLASS1.1.sb34402674.eb34433625.58014.15711049769	43.61	10.64
VLASS1.1.sb34417859.eb34434020.58014.453630601856	14.88	6.86
VLASS1.1.sb34397357.eb34435512.58014.72557283565	35.99	20.48
VLASS1.1.sb34420672.eb34448755.58015.27887172454	26.57	7.43
VLASS1.1.sb34461205.eb34469117.58017.220875416664	44.49	12.52
VLASS1.1.sb34441820.eb34483341.58017.956089363426	46.19	23.15
VLASS1.1.sb34434950.eb34484414.58018.13499180556	49.36	12.29
VLASS1.1.sb34422762.eb34486846.58018.47191952546	20.72	10.30
VLASS1.1.sb34446513.eb34497773.58018.931944780095	25.13	14.89
VLASS1.1.sb34401997.eb34497870.58019.45873091435	25.09	9.68
VLASS1.1.sb34475744.eb34497997.58020.06194271991	20.99	10.81
VLASS1.1.sb34398871.eb34498197.58021.421088125004	20.06	5.94
VLASS1.1.sb34441254.eb34502953.58021.896690486115	22.81	11.71
VLASS1.1.sb34499142.eb34512738.58022.410128460644	18.55	9.45
VLASS1.1.sb34510386.eb34526547.58023.125750694446	27.10	14.07
VLASS1.1.sb34483343.eb34534527.58023.96684016204	49.52	12.79
VLASS1.1.sb34476823.eb34548285.58025.047613229166	37.96	10.06
VLASS1.1.sb34535845.eb34554723.58025.888074629635	71.97	37.75
VLASS1.1.sb34505092.eb34556840.58026.368332048616	24.85	12.77
VLASS1.1.sb34481252.eb34557673.58027.0348240625	21.03	11.14
VLASS1.1.sb34504025.eb34557675.58027.36083796296	28.30	15.74
VLASS1.1.sb34523741.eb34557765.58027.86045872685	26.97	12.73
VLASS1.1.sb34551246.eb34557773.58028.35913222222	19.51	10.72
VLASS1.1.sb34516171.eb34560849.58028.92610690973	21.17	11.47
VLASS1.1.sb34523166.eb34560853.58029.136930451394	11.42	5.52
VLASS1.1.sb34500420.eb34560860.58029.36441232639	9.04	5.00
VLASS1.1.sb34544228.eb34567550.58030.97564148148	70.54	22.26
VLASS1.1.sb34466515.eb34567552.58031.1574071412	26.28	14.45
VLASS1.1.sb34516741.eb34573529.58031.90910875	49.00	21.09
VLASS1.1.sb34513906.eb34574667.58032.44399570602	14.77	7.53
VLASS1.1.sb34520623.eb34574778.58032.849138969905	14.32	8.90
VLASS1.1.sb34460103.eb34575144.58033.08475238426	14.90	7.78
VLASS1.1.sb34538006.eb34575228.58034.00227542824	19.13	5.98
VLASS1.1.sb34464356.eb34575230.58034.17006068287	21.33	6.16
VLASS1.1.sb34459038.eb34579917.58037.11761364584	77.19	7.50
VLASS1.1.sb34501162.eb34586596.58038.35304930556	11.22	5.78
VLASS1.1.sb34538714.eb34596436.58039.97741366898	32.06	13.06
VLASS1.1.sb34595851.eb34597070.58040.24579836805	13.88	7.13
VLASS1.1.sb34451818.eb34599612.58040.92692017361	13.40	8.86
VLASS1.1.sb34589996.eb34600351.58041.24583186343	11.27	5.29
VLASS1.1.sb34477887.eb34601198.58042.00525377315	41.29	7.01
VLASS1.1.sb34596438.eb34603649.58042.87761814815	12.52	7.20
VLASS1.1.sb34605640.eb34613345.58044.21898310185	12.22	5.29
VLASS1.1.sb34612269.eb34618429.58046.08591032407	15.70	6.91
VLASS1.1.sb34437482.eb34619856.58046.81455576389	26.95	13.24
VLASS1.1.sb34614479.eb34620102.58046.99344417824	30.39	12.31
VLASS1.1.sb34401340.eb34620284.58047.7253216088	24.74	14.85
VLASS1.1.sb34611199.eb34620981.58049.042559525464	11.73	6.33
VLASS1.1.sb34609053.eb34623434.58051.07626767361	12.97	6.14
VLASS1.1.sb34607978.eb34635523.58053.05546966435	14.01	7.01
VLASS1.1.sb34514521.eb34635770.58054.42706077546	13.34	4.84
VLASS1.1.sb34450715.eb34635774.58054.85418905092	6.77	4.69
VLASS1.1.sb34545702.eb34635788.58055.86366935185	14.34	7.26
VLASS1.1.sb34617180.eb34646687.58058.06139675926	11.11	6.22
VLASS1.1.sb34638721.eb34661415.58062.02459759259	20.41	8.60
VLASS1.1.sb34646980.eb34662839.58063.1139615625	12.26	6.18
VLASS1.1.sb34638143.eb34669310.58064.18296799768	9.73	5.97
VLASS1.1.sb34639297.eb34672679.58065.06301421297	12.57	6.25
VLASS1.1.sb34640437.eb34680548.58066.26112458333	12.89	5.31
VLASS1.1.sb34667861.eb34684334.58067.0700902199	10.65	6.12

filename	max	mean
VLASS1.1.sb34555518.eb34684966.58067.79193422454	20.72	11.66
VLASS1.1.sb34539903.eb34684984.58068.81223880787	17.74	6.13
VLASS1.1.sb34642889.eb34684986.58068.98737954861	12.34	6.04
VLASS1.1.sb34442902.eb34685006.58069.77234059028	10.68	5.34
VLASS1.1.sb34670411.eb34685012.58070.0894284838	12.60	4.96
VLASS1.1.sb34674058.eb34686456.58070.889693784724	10.96	7.20
VLASS1.1.sb34552309.eb34700380.58074.807198912036	21.55	8.17
VLASS1.1.sb34647560.eb34700758.58075.26425702547	16.00	9.60
VLASS1.1.sb34671004.eb34701330.58075.89221989583	40.18	7.80
VLASS1.1.sb34682599.eb34701332.58076.227281388885	15.75	4.42
VLASS1.1.sb34541153.eb34701340.58076.63468844908	13.47	4.20
VLASS1.1.sb34541777.eb34701358.58077.63418230324	9.58	5.53
VLASS1.1.sb34683177.eb34701350.58077.22767572917	36.99	4.78
VLASS1.1.sb34672112.eb34701485.58077.90941222222	9.22	5.30
VLASS1.1.sb34689495.eb34703149.58078.35454543981	17.55	7.96
VLASS1.1.sb34694546.eb34722302.58079.14187313657	25.11	6.69
VLASS1.1.sb34691777.eb34722670.58079.44965504629	47.61	5.73
VLASS1.1.sb34725237.eb34739672.58079.98035050926	11.37	7.08
VLASS1.1.sb34396276.eb34742211.58081.44143899306	16.52	6.26
VLASS1.1.sb34613347.eb34742769.58081.77578660879	16.18	8.29
VLASS1.1.sb34688925.eb34742786.58082.275898692125	45.32	6.49
VLASS1.1.sb34487023.eb34742790.58082.46979534722	8.39	5.65
VLASS1.1.sb34721714.eb34742798.58083.12232637731	8.83	4.80
VLASS1.1.sb34691207.eb34742806.58083.396391030095	10.58	4.83
VLASS1.1.sb34697045.eb34742816.58084.0767340625	6.85	3.63
VLASS1.1.sb34394839.eb34742822.58084.37348608796	12.43	4.73
VLASS1.1.sb34552882.eb34748145.58084.833168136574	15.51	7.84
VLASS1.1.sb34729422.eb34752663.58085.08270920139	12.26	6.70
VLASS1.1.sb34734941.eb34752668.58085.27215615741	20.02	9.24
VLASS1.1.sb34721120.eb34752706.58086.306814780095	44.91	5.31
VLASS1.1.sb34743887.eb34753042.58087.08123225694	62.94	6.79
VLASS1.1.sb34733139.eb34753044.58087.252424861115	25.21	5.39
VLASS1.1.sb34738258.eb34756362.58088.29786020833	35.72	4.96
VLASS1.1.sb34540529.eb34756370.58088.69021324074	19.67	4.05
VLASS1.1.sb34518430.eb34756479.58089.71818545139	10.74	5.52
VLASS1.1.sb34731735.eb34756489.58090.122307233796	25.46	5.21
VLASS1.1.sb34688349.eb34756507.58091.09663136574	53.90	10.20
VLASS1.1.sb34762399.eb34782669.58096.94457474537	11.29	5.64
VLASS1.1.sb34517306.eb34782681.58097.74992206019	24.73	4.59
VLASS1.1.sb34613920.eb34787246.58098.73782822917	19.89	5.27
VLASS1.1.sb34787846.eb34789515.58100.03466122685	11.40	4.82
VLASS1.1.sb34761173.eb34797849.58102.982940497684	20.26	5.64
VLASS1.1.sb34768661.eb34797855.58103.322425844905	12.75	5.40
VLASS1.1.sb34641006.eb34808190.58115.235410231486	38.38	6.17
VLASS1.1.sb34747564.eb34810829.58116.160714247686	68.99	6.59
VLASS1.1.sb34746335.eb34810881.58117.1772871412	35.24	6.22
VLASS1.1.sb34751533.eb34810907.58118.339736064816	43.96	4.86
VLASS1.1.sb34804404.eb34810911.58118.545018310186	29.55	5.33
VLASS1.1.sb34801109.eb34810929.58119.504280277775	36.32	6.67
VLASS1.1.sb34749299.eb34811010.58120.34588865741	22.00	5.10
VLASS1.1.sb34692336.eb34811412.58121.33896026621	22.23	3.60
VLASS1.1.sb34812068.eb34812594.58122.954574675925	10.74	5.22
VLASS1.1.sb34746916.eb34812604.58123.11002827546	19.35	5.33
VLASS1.1.sb34739674.eb34813174.58124.37509868055	11.48	5.14
VLASS1.1.sb34773813.eb34819682.58127.102012013886	13.18	5.89
VLASS1.1.sb34766890.eb34821128.58128.20474726852	25.36	11.78
VLASS1.1.sb34748147.eb34823345.58130.14045111111	13.99	9.41
VLASS1.1.sb34752093.eb34823539.58130.440413715274	10.78	5.71
VLASS1.1.sb34772249.eb34824245.58131.128517708334	20.04	9.86
VLASS1.1.sb34769249.eb34825732.58132.15545319444	14.44	5.90
VLASS1.1.sb34762611.eb34828612.58134.27350804398	13.55	5.14
VLASS1.1.sb34894726.eb34973224.58148.30825349537	15.78	4.00

filename	max	mean
VLASS1.1.sb34984786.eb34985738.58150.33651579861	11.82	5.71
VLASS1.1.sb34940218.eb34992438.58151.92216394676	69.32	10.86
VLASS1.1.sb34919742.eb34993475.58152.22067622685	29.65	8.29
VLASS1.1.sb34924077.eb34993493.58152.55778096065	45.61	23.21
VLASS1.1.sb34917571.eb34994250.58152.889074189814	29.19	15.51
VLASS1.1.sb34925152.eb34995045.58153.57609369213	41.93	15.40
VLASS1.1.sb34918656.eb34995118.58153.94350954861	31.39	13.94
VLASS1.1.sb34901451.eb34995355.58154.327259618054	10.94	6.81
VLASS1.1.sb34920826.eb35001824.58155.24291935185	12.59	7.40
VLASS1.1.sb34916486.eb35006898.58156.86241219907	26.35	10.25
VLASS1.1.sb34902511.eb35008344.58157.34584716435	11.62	6.22
VLASS1.1.sb34915423.eb35019637.58158.66329216435	45.25	14.58
VLASS1.1.sb34912231.eb35025904.58159.00888243056	35.39	10.20
VLASS1.1.sb34926227.eb35032384.58159.58002181713	49.60	17.66
VLASS1.1.sb34910088.eb35032971.58159.93049569444	22.60	10.17
VLASS1.1.sb34922993.eb35033647.58160.26137790509	48.75	21.86
VLASS1.1.sb34927307.eb35033887.58160.5989258912	57.50	17.53
VLASS1.1.sb34903570.eb35034891.58160.909213252315	28.15	14.12
VLASS1.1.sb34897149.eb35035193.58161.27141606482	20.91	11.68
VLASS1.1.sb34907929.eb35038477.58161.62935980324	52.74	23.00
VLASS1.1.sb34940544.eb35040203.58161.99305538194	80.31	29.83
VLASS1.1.sb34898226.eb35042893.58162.29820586806	34.49	16.90
VLASS1.1.sb35045706.eb35051188.58162.78700490741	38.72	19.23
VLASS1.1.sb34921909.eb35065962.58163.23824550926	28.80	18.18
VLASS1.1.sb35049291.eb35069720.58164.000153773144	31.62	13.99
VLASS1.1.sb34899305.eb35070592.58164.31599563657	19.37	8.52
VLASS1.1.sb34900388.eb35074823.58165.26784681713	21.67	9.56
VLASS1.1.sb34914360.eb35075355.58165.623772928244	34.00	13.94
VLASS1.1.sb34904669.eb35076619.58165.98193083333	60.18	20.46
VLASS1.1.sb34913301.eb35082677.58166.59343417824	37.43	13.82
VLASS1.1.sb34905760.eb35113377.58166.981752928245	25.17	13.59
VLASS1.1.sb34896437.eb35113379.58167.31986631945	35.87	13.74
VLASS1.1.sb34906851.eb35113389.58167.585474039355	60.42	36.49
VLASS1.1.sb34911154.eb35113630.58167.94820277778	32.20	17.99
VLASS1.1.sb35116607.eb35119115.58168.767963136575	44.36	17.34
VLASS1.1.sb35118798.eb35120996.58169.55511674768	16.91	8.29

Table 3: Derived API mean and maximum rms phases for all VLASS1.1 observations.

filename	mean (deg.)	max (deg.)
VLASS1.1.sb34346984.eb34356943.58004.0160307176	6.02	10.89
VLASS1.1.sb34361741.eb34367683.58005.085977442126	8.98	13.14
VLASS1.1.sb34356210.eb34369329.58006.08368738426	5.77	8.09
VLASS1.1.sb34361043.eb34371004.58007.1075228588	3.01	5.37
VLASS1.1.sb34382472.eb34389458.58009.054277766205	6.50	12.58
VLASS1.1.sb34395681.eb34403276.58010.036995381946	10.17	14.77
VLASS1.1.sb34418989.eb34425056.58011.2817505787	7.50	13.10
VLASS1.1.sb34421723.eb34429827.58011.82889114584	18.19	48.15
VLASS1.1.sb34402674.eb34433625.58014.15711049769	6.65	14.06
VLASS1.1.sb34417859.eb34434020.58014.453630601856	8.03	11.62
VLASS1.1.sb34397357.eb34435512.58014.72557283565	22.92	38.23
VLASS1.1.sb34420672.eb34448755.58015.27887172454	7.10	10.83
VLASS1.1.sb34461205.eb34469117.58017.220875416664	7.04	12.92
VLASS1.1.sb34441820.eb34483341.58017.956089363426	14.22	22.04
VLASS1.1.sb34434950.eb34484414.58018.13499180556	7.03	13.26
VLASS1.1.sb34422762.eb34486846.58018.47191952546	7.04	14.46
VLASS1.1.sb34446513.eb34497773.58018.931944780095	11.14	23.43
VLASS1.1.sb34401997.eb34497870.58019.45873091435	11.52	17.65
VLASS1.1.sb34475744.eb34497997.58020.06194271991	8.28	14.64

filename	mean	max
VLASS1.1.sb34398871.eb34498197.58021.421088125004	6.41	10.97
VLASS1.1.sb34441254.eb34502953.58021.896690486115	10.43	21.86
VLASS1.1.sb34499142.eb34512738.58022.410128460644	7.74	22.13
VLASS1.1.sb34510386.eb34526547.58023.125750694446	10.30	19.48
VLASS1.1.sb34483343.eb34534527.58023.96684016204	12.80	28.33
VLASS1.1.sb34476823.eb34548285.58025.047613229166	8.57	14.79
VLASS1.1.sb34535845.eb34554723.58025.888074629635	21.54	62.07
VLASS1.1.sb34505092.eb34556840.58026.368332048616	11.73	40.44
VLASS1.1.sb34481252.eb34557673.58027.0348240625	12.52	58.16
VLASS1.1.sb34504025.eb34557675.58027.36083796296	18.38	48.62
VLASS1.1.sb34523741.eb34557765.58027.86045872685	8.66	18.31
VLASS1.1.sb34551246.eb34557773.58028.3591322222	4.18	8.07
VLASS1.1.sb34516171.eb34560849.58028.92610690973	10.62	16.76
VLASS1.1.sb34523166.eb34560853.58029.136930451394	3.06	4.86
VLASS1.1.sb34500420.eb34560860.58029.36441232639	3.61	7.16
VLASS1.1.sb34544228.eb34567550.58030.97564148148	14.08	26.51
VLASS1.1.sb34466515.eb34567552.58031.1574071412	12.33	31.74
VLASS1.1.sb34516741.eb34573529.58031.90910875	23.45	60.13
VLASS1.1.sb34513906.eb34574667.58032.44399570602	7.41	14.02
VLASS1.1.sb34520623.eb34574778.58032.849138969905	11.74	23.84
VLASS1.1.sb34460103.eb34575144.58033.08475238426	3.47	10.95
VLASS1.1.sb34538006.eb34575228.58034.00227542824	3.87	5.75
VLASS1.1.sb34464356.eb34575230.58034.17006068287	2.68	6.62
VLASS1.1.sb34459038.eb34579917.58037.11761364584	3.03	7.37
VLASS1.1.sb34501162.eb34586596.58038.35304930556	5.36	8.22
VLASS1.1.sb34538714.eb34596436.58039.97741366898	12.16	20.90
VLASS1.1.sb34595851.eb34597070.58040.24579836805	4.37	7.62
VLASS1.1.sb34451818.eb34599612.58040.92692017361	4.73	8.15
VLASS1.1.sb34589996.eb34600351.58041.24583186343	1.88	4.37
VLASS1.1.sb34477887.eb34601198.58042.00525377315	2.35	4.66
VLASS1.1.sb34596438.eb34603649.58042.87761814815	6.78	17.26
VLASS1.1.sb34605640.eb34613345.58044.21898310185	4.26	10.13
VLASS1.1.sb34612269.eb34618429.58046.08591032407	4.88	10.17
VLASS1.1.sb34437482.eb34619856.58046.81455576389	12.17	18.36
VLASS1.1.sb34614479.eb34620102.58046.99344417824	7.10	12.09
VLASS1.1.sb34401340.eb34620284.58047.7253216088	26.10	54.42
VLASS1.1.sb34611199.eb34620981.58049.042559525464	3.33	6.06
VLASS1.1.sb34609053.eb34623434.58051.07626767361	3.85	7.85
VLASS1.1.sb34607978.eb34635523.58053.05546966435	4.56	8.34
VLASS1.1.sb34514521.eb34635770.58054.42706077546	2.56	6.73
VLASS1.1.sb34450715.eb34635774.58054.85418905092	3.89	11.50
VLASS1.1.sb34545702.eb34635788.58055.86366935185	5.36	12.62
VLASS1.1.sb34617180.eb34646687.58058.06139675926	3.49	8.03
VLASS1.1.sb34638721.eb34661415.58062.02459759259	5.48	10.55
VLASS1.1.sb34646980.eb34662839.58063.1139615625	4.13	7.69
VLASS1.1.sb34638143.eb34669310.58064.18296799768	5.07	9.23
VLASS1.1.sb34639297.eb34672679.58065.06301421297	5.14	8.17
VLASS1.1.sb34640437.eb34680548.58066.26112458333	2.97	4.60
VLASS1.1.sb34667861.eb34684334.58067.0700902199	3.48	5.42
VLASS1.1.sb34555518.eb34684966.58067.79193422454	9.85	23.61
VLASS1.1.sb34539903.eb34684984.58068.81223880787	7.73	18.00
VLASS1.1.sb34642889.eb34684986.58068.98737954861	4.20	7.69
VLASS1.1.sb34442902.eb34685006.58069.77234059028	5.45	10.85
VLASS1.1.sb34670411.eb34685012.58070.0894284838	3.56	8.60
VLASS1.1.sb34674058.eb34686456.58070.889693784724	4.90	16.07
VLASS1.1.sb34552309.eb34700380.58074.807198912036	12.33	25.07
VLASS1.1.sb34647560.eb34700758.58075.26425702547	13.63	25.92
VLASS1.1.sb34671004.eb34701330.58075.89221989583	2.53	6.85
VLASS1.1.sb34682599.eb34701332.58076.227281388885	2.75	4.34
VLASS1.1.sb34541153.eb34701340.58076.63468844908	4.58	11.31
VLASS1.1.sb34541777.eb34701358.58077.63418230324	3.70	5.95
VLASS1.1.sb34683177.eb34701350.58077.22767572917	3.18	6.72

filename	mean	max
VLASS1.1.sb34672112.eb34701485.58077.90941222222	3.87	5.12
VLASS1.1.sb34689495.eb34703149.58078.35454543981	3.71	4.87
VLASS1.1.sb34694546.eb34722302.58079.14187313657	2.45	4.52
VLASS1.1.sb34691777.eb34722670.58079.44965504629	2.47	5.19
VLASS1.1.sb34725237.eb34739672.58079.98035050926	4.00	5.73
VLASS1.1.sb34396276.eb34742211.58081.44143899306	5.63	14.72
VLASS1.1.sb34613347.eb34742769.58081.77578660879	10.91	15.77
VLASS1.1.sb34688925.eb34742786.58082.275898692125	2.87	7.50
VLASS1.1.sb34487023.eb34742790.58082.46979534722	4.06	9.33
VLASS1.1.sb34721714.eb34742798.58083.12232637731	1.89	3.13
VLASS1.1.sb34691207.eb34742806.58083.396391030095	2.04	3.15
VLASS1.1.sb34697045.eb34742816.58084.0767340625	2.29	6.26
VLASS1.1.sb34394839.eb34742822.58084.37348608796	3.31	5.98
VLASS1.1.sb34552882.eb34748145.58084.833168136574	5.57	10.04
VLASS1.1.sb34729422.eb34752663.58085.08270920139	3.92	6.16
VLASS1.1.sb34734941.eb34752668.58085.27215615741	6.34	9.20
VLASS1.1.sb34721120.eb34752706.58086.306814780095	2.54	6.04
VLASS1.1.sb34743887.eb34753042.58087.08123225694	4.09	5.58
VLASS1.1.sb34733139.eb34753044.58087.252424861115	3.73	7.38
VLASS1.1.sb34738258.eb34756362.58088.29786020833	3.88	7.53
VLASS1.1.sb34540529.eb34756370.58088.69021324074	3.87	5.19
VLASS1.1.sb34518430.eb34756479.58089.71818545139	6.77	16.86
VLASS1.1.sb34731735.eb34756489.58090.122307233796	2.59	3.30
VLASS1.1.sb34688349.eb34756507.58091.09663136574	3.87	6.16
VLASS1.1.sb34762399.eb34782669.58096.94457474537	2.79	5.29
VLASS1.1.sb34517306.eb34782681.58097.74992206019	3.49	5.89
VLASS1.1.sb34613920.eb34787246.58098.73782822917	3.53	7.53
VLASS1.1.sb34787846.eb34789515.58100.03466122685	2.97	5.88
VLASS1.1.sb34761173.eb34797849.58102.982940497684	2.93	6.75
VLASS1.1.sb34768661.eb34797855.58103.322425844905	2.28	3.59
VLASS1.1.sb34641006.eb34808190.58115.235410231486	2.18	4.43
VLASS1.1.sb34747564.eb34810829.58116.160714247686	2.86	5.60
VLASS1.1.sb34746335.eb34810881.58117.1772871412	3.27	5.82
VLASS1.1.sb34751533.eb34810907.58118.339736064816	2.19	3.44
VLASS1.1.sb34804404.eb34810911.58118.545018310186	2.94	7.64
VLASS1.1.sb34801109.eb34810929.58119.504280277775	2.93	7.42
VLASS1.1.sb34749299.eb34811010.58120.34588865741	4.08	7.09
VLASS1.1.sb34692336.eb34811412.58121.33896026621	2.70	3.58
VLASS1.1.sb34812068.eb34812594.58122.954574675925	3.57	4.42
VLASS1.1.sb34746916.eb34812604.58123.11002827546	2.88	5.26
VLASS1.1.sb34739674.eb34813174.58124.37509868055	2.95	4.47
VLASS1.1.sb34773813.eb34819682.58127.102012013886	4.85	7.63
VLASS1.1.sb34766890.eb34821128.58128.20474726852	8.07	15.07
VLASS1.1.sb34748147.eb34823345.58130.14045111111	4.07	9.68
VLASS1.1.sb34752093.eb34823539.58130.440413715274	4.18	6.95
VLASS1.1.sb34772249.eb34824245.58131.128517708334	4.29	6.01
VLASS1.1.sb34769249.eb34825732.58132.15545319444	3.31	6.44
VLASS1.1.sb34762611.eb34828612.58134.27350804398	3.71	4.57
VLASS1.1.sb34894726.eb34973224.58148.30825349537	1.82	3.20
VLASS1.1.sb34984786.eb34985738.58150.33651579861	4.21	6.35
VLASS1.1.sb34940218.eb34992438.58151.92216394676	4.87	6.53
VLASS1.1.sb34919742.eb34993475.58152.22067622685	2.76	3.85
VLASS1.1.sb34924077.eb34993493.58152.55778096065	7.31	12.38
VLASS1.1.sb34917571.eb34994250.58152.889074189814	5.17	13.41
VLASS1.1.sb34925152.eb34995045.58153.57609369213	4.49	7.81
VLASS1.1.sb34918656.eb34995118.58153.94350954861	4.37	9.55
VLASS1.1.sb34901451.eb34995355.58154.327259618054	3.29	6.92
VLASS1.1.sb34920826.eb35001824.58155.24291935185	2.71	5.11
VLASS1.1.sb34916486.eb35006898.58156.86241219907	3.86	8.72
VLASS1.1.sb34902511.eb35008344.58157.34584716435	1.75	4.60
VLASS1.1.sb34915423.eb35019637.58158.66329216435	6.77	12.99
VLASS1.1.sb34912231.eb35025904.58159.00888243056	5.73	8.26

filename	mean	max
VLASS1.1.sb34926227.eb35032384.58159.58002181713	4.48	9.71
VLASS1.1.sb34910088.eb35032971.58159.93049569444	3.08	5.38
VLASS1.1.sb34922993.eb35033647.58160.26137790509	6.53	14.45
VLASS1.1.sb34927307.eb35033887.58160.5989258912	6.53	11.44
VLASS1.1.sb34903570.eb35034891.58160.909213252315	4.66	9.20
VLASS1.1.sb34897149.eb35035193.58161.27141606482	5.25	8.79
VLASS1.1.sb34907929.eb35038477.58161.62935980324	8.31	12.60
VLASS1.1.sb34940544.eb35040203.58161.99305538194	6.39	15.62
VLASS1.1.sb34898226.eb35042893.58162.29820586806	5.72	12.14
VLASS1.1.sb35045706.eb35051188.58162.78700490741	5.61	8.05
VLASS1.1.sb34921909.eb35065962.58163.23824550926	6.30	19.82
VLASS1.1.sb35049291.eb35069720.58164.000153773144	3.53	5.22
VLASS1.1.sb34899305.eb35070592.58164.31599563657	3.40	6.52
VLASS1.1.sb34900388.eb35074823.58165.26784681713	6.51	10.72
VLASS1.1.sb34914360.eb35075355.58165.623772928244	11.54	24.56
VLASS1.1.sb34904669.eb35076619.58165.98193083333	8.85	24.56
VLASS1.1.sb34913301.eb35082677.58166.59343417824	9.75	23.85
VLASS1.1.sb34905760.eb35113377.58166.981752928245	4.64	10.95
VLASS1.1.sb34896437.eb35113379.58167.31986631945	4.94	6.99
VLASS1.1.sb34906851.eb35113389.58167.585474039355	12.46	25.41
VLASS1.1.sb34911154.eb35113630.58167.94820277778	9.82	24.26
VLASS1.1.sb35116607.eb35119115.58168.767963136575	15.41	24.36
VLASS1.1.sb35118798.eb35120996.58169.55511674768	10.51	15.16

## ***Revision History***

Revision	Date	Author(s)	Description
1.0	2018-05-07	Frank Schinzel	Original