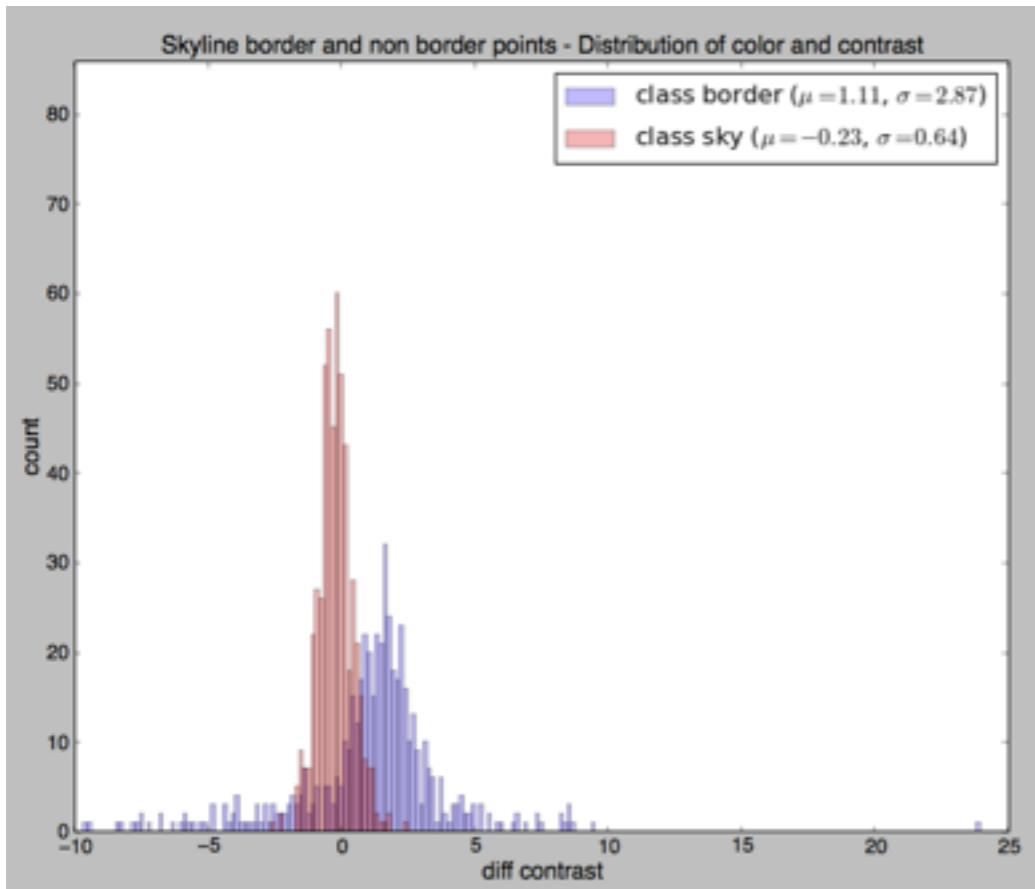


LDA look at difference in contrast, hue, blue or red, and CIE theta, all divided by their respective standard deviations.

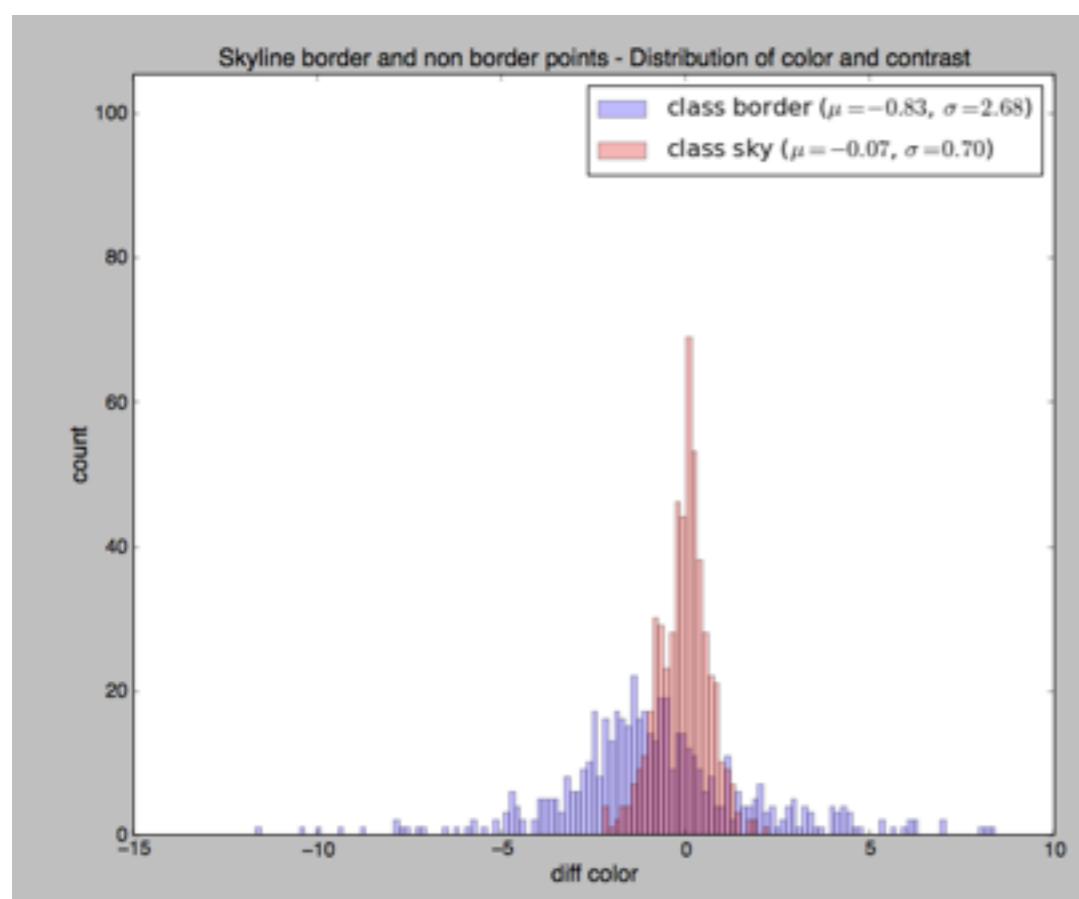
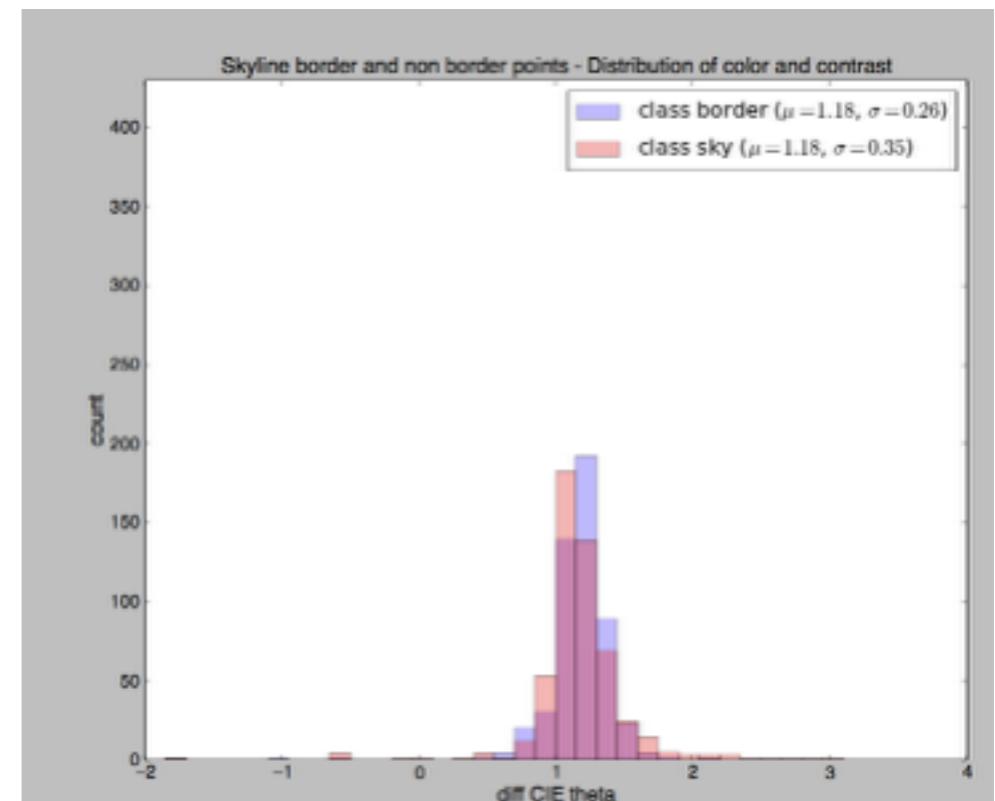
Brown & Lowe 2003, image 1



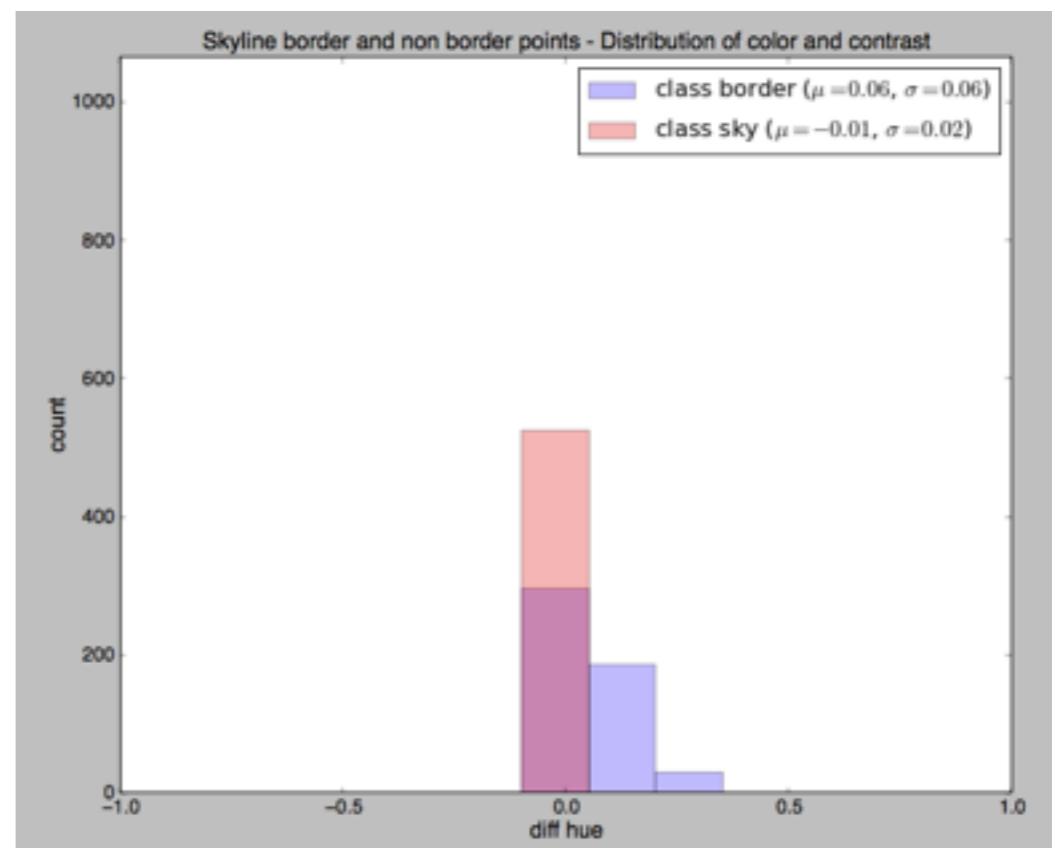
Brown & Lowe 2003, image 1



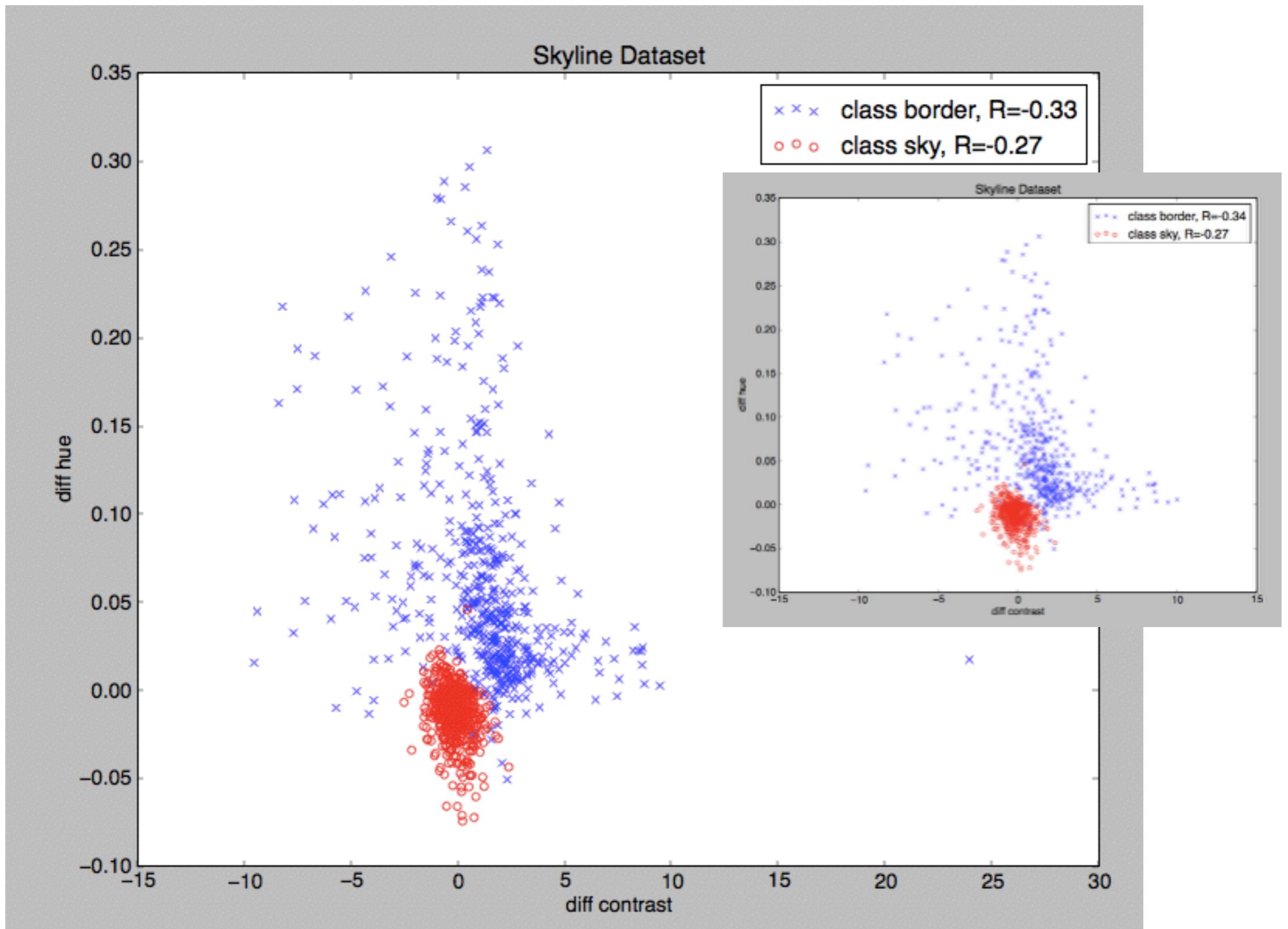
*note: the largest contrasts were removed from analysis for plot visibility



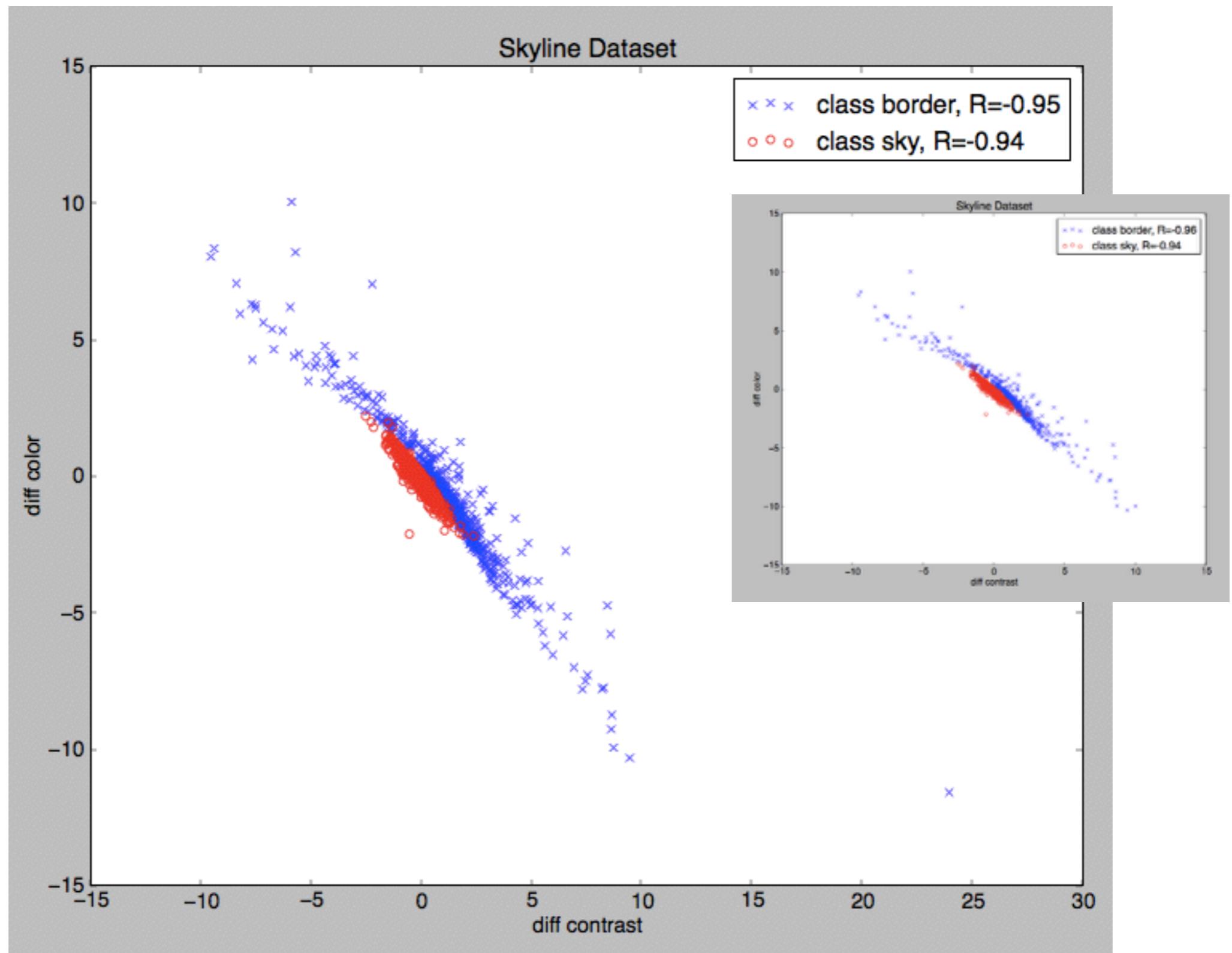
stats using 24 neighbors



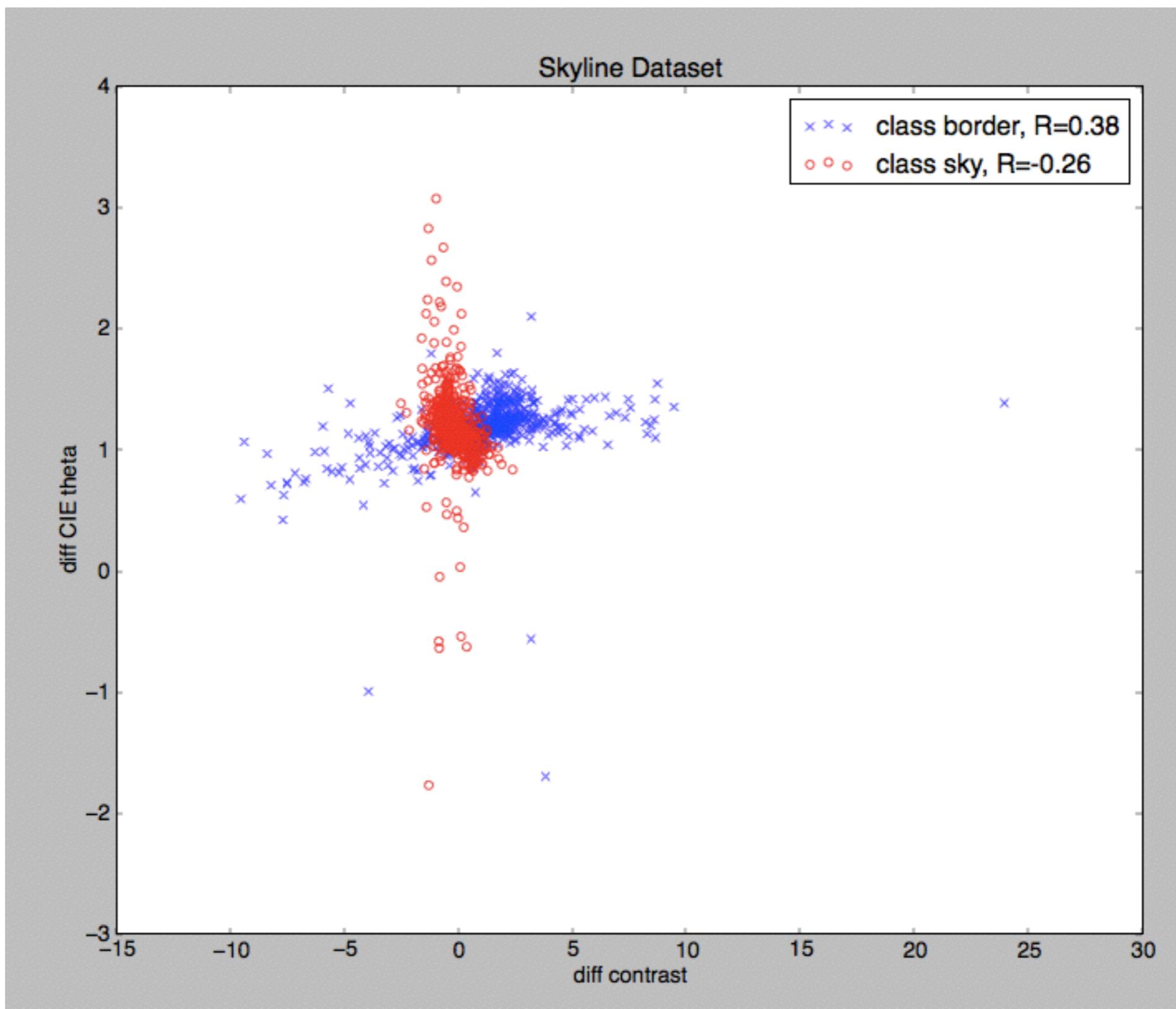
Brown & Lowe 2003, image 1



Brown & Lowe 2003, image 1

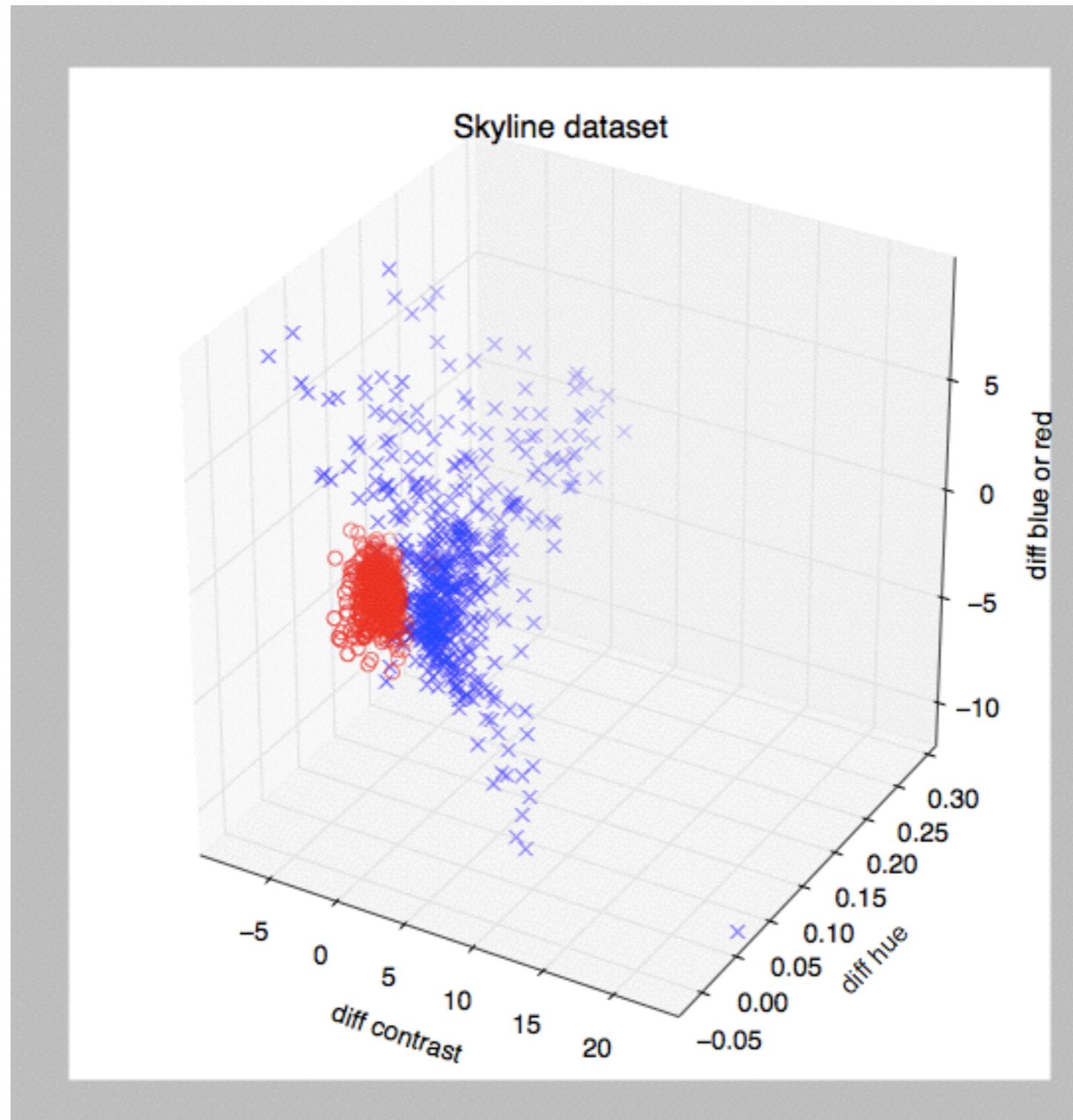


Brown & Lowe 2003, image 1



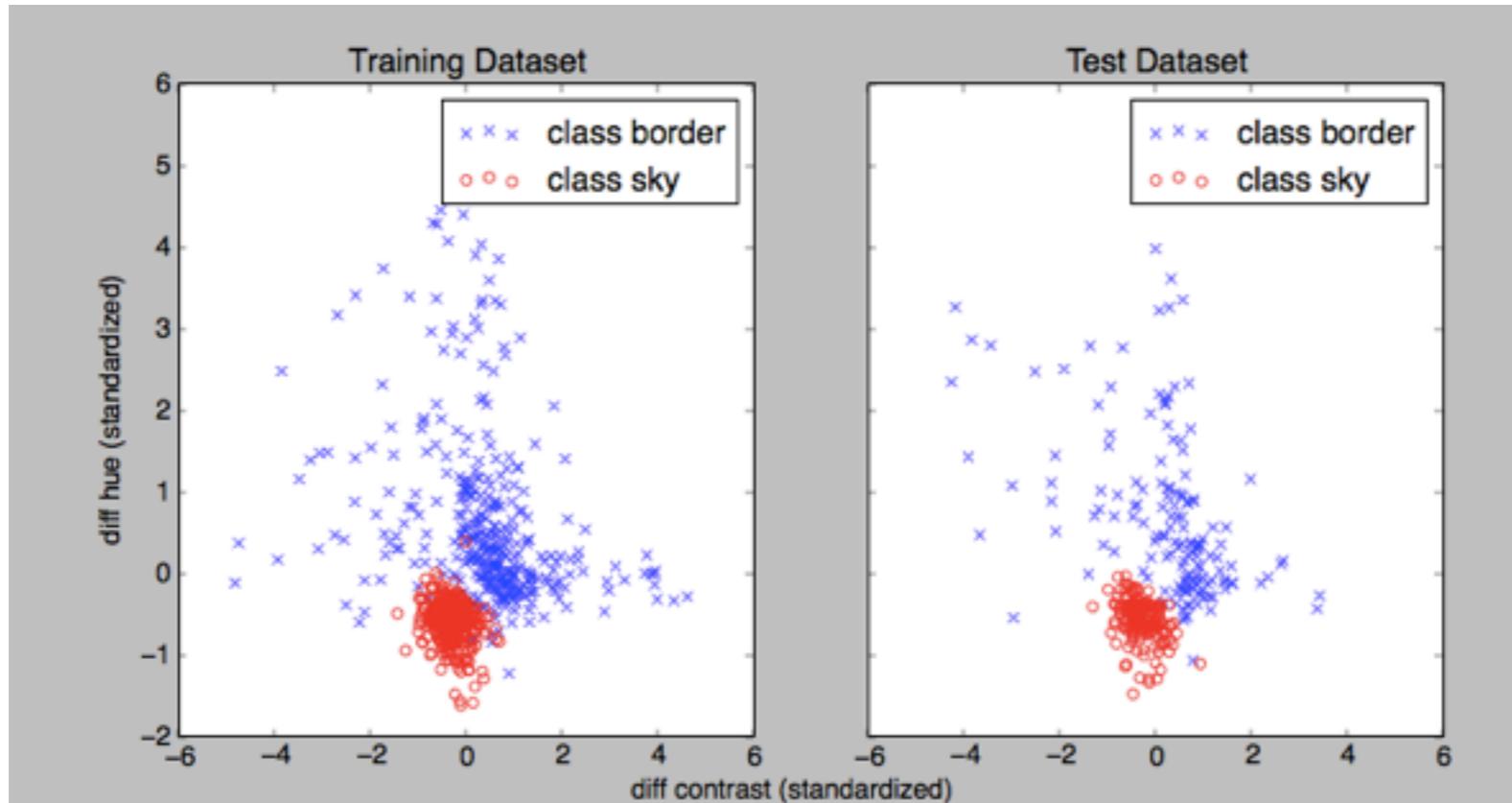
stats using 24 neighbors

Brown & Lowe 2003, image 1

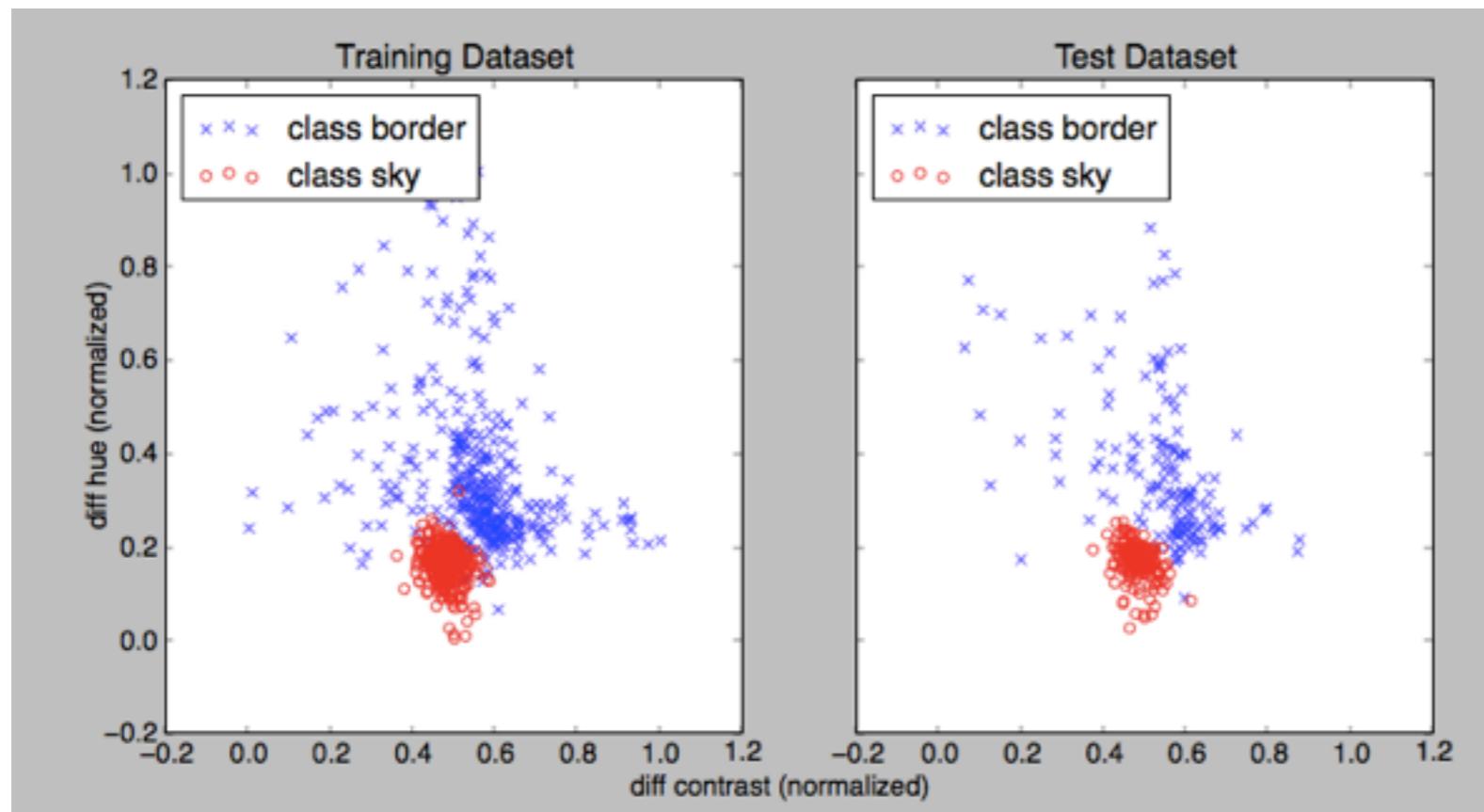


stats using 24 neighbors

Brown & Lowe 2003, image 1



Z-score normalization:
rescaled to mean $\mu = 0$
and standard deviation
 $\sigma = 1$

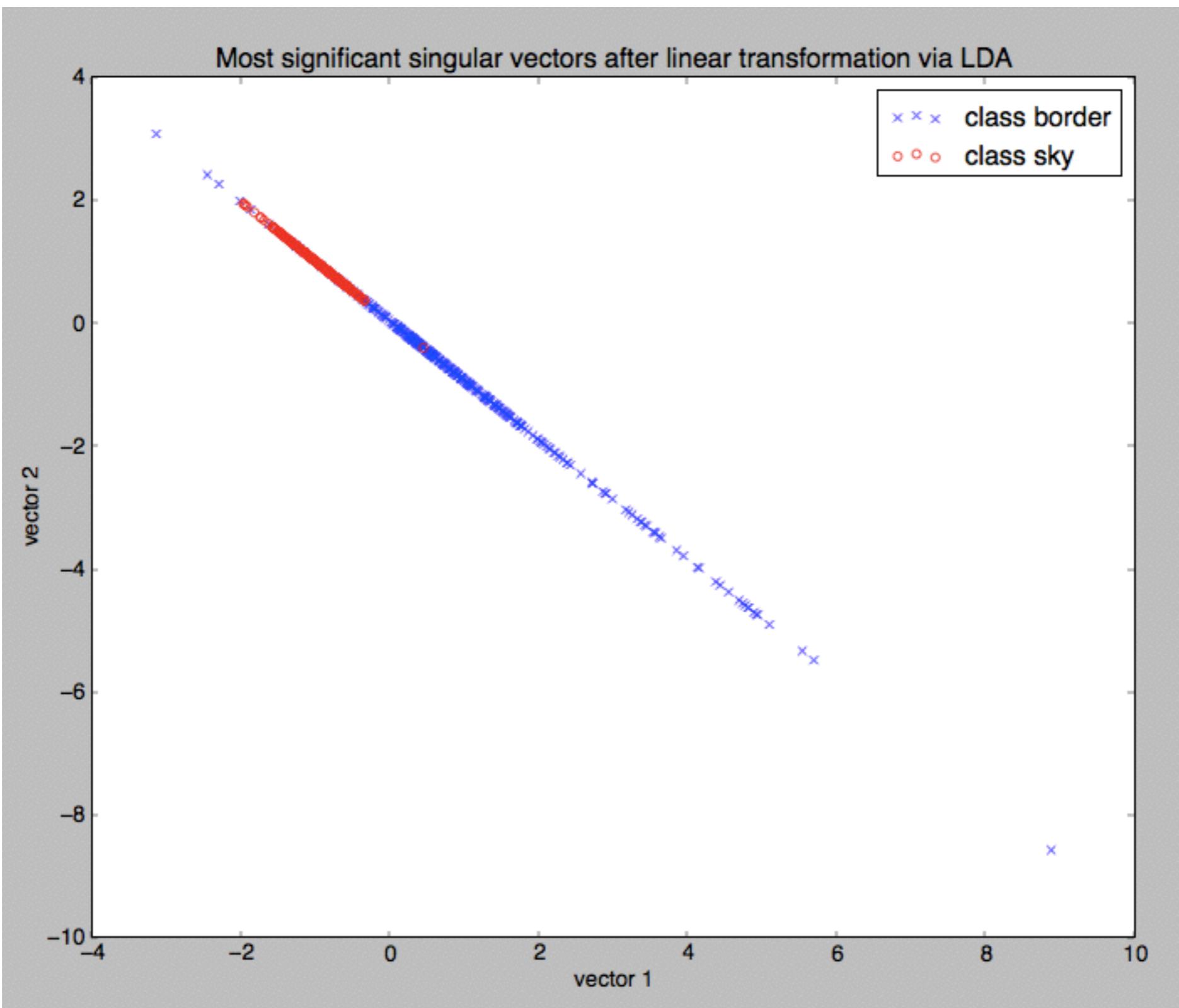


Min-max normalization:
rescaled to a fixed
range of 0 to 1 using:

$$X' = \frac{(X - X_{\min})}{(X_{\max} - X_{\min})}$$

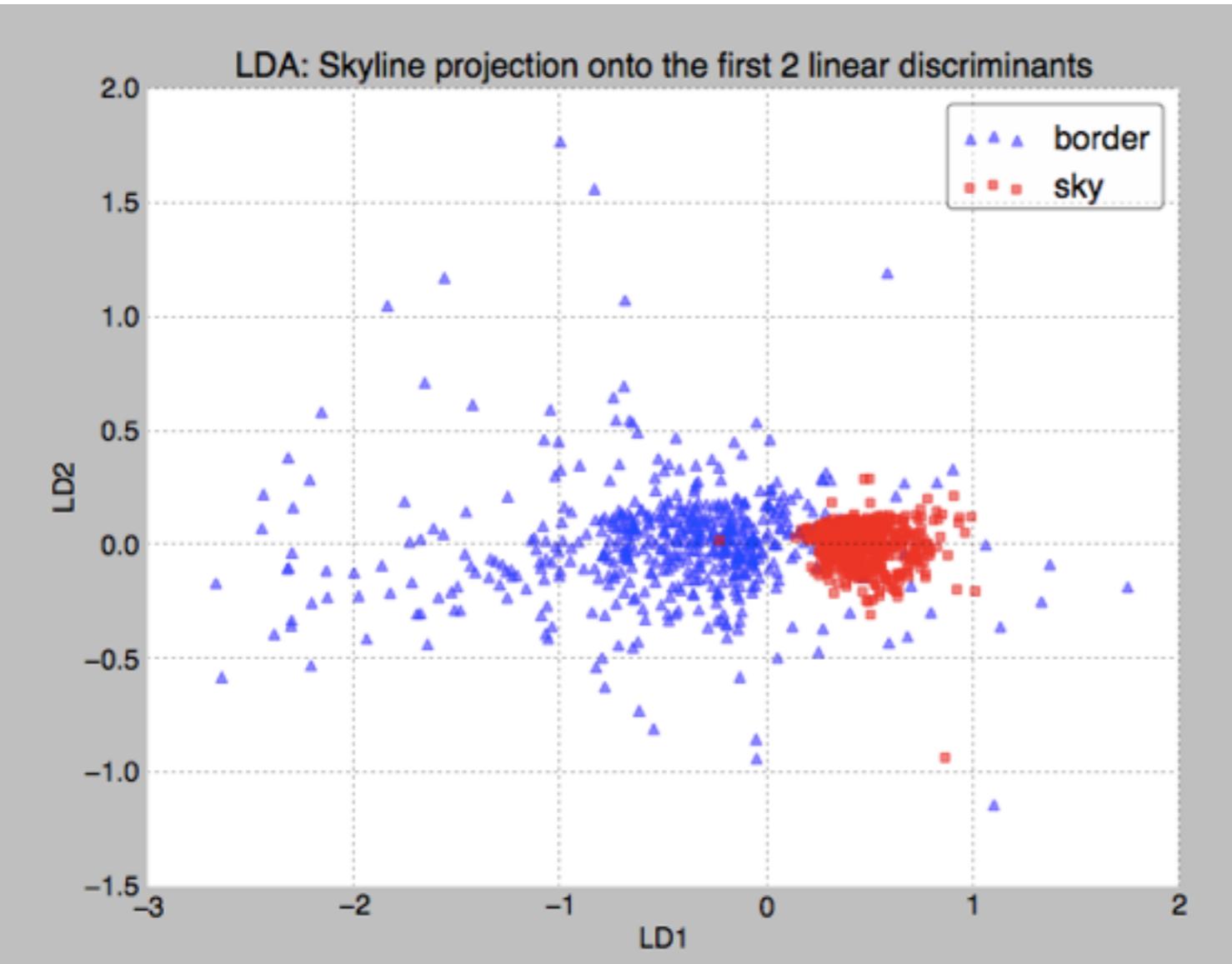
stats using 24 neighbors

Brown & Lowe 2003, image 1



stats using 24 neighbors

Brown & Lowe 2003, image 1



http://sebastianraschka.com/Articles/2014_python_lda.html

"within-class scattering matrix": for each class i: $S_i = \sum_{x \in \text{data}} (x - m_i)(x - m_i)^T$
where $m_i = (1/n_i) * \sum_{x \in \text{data}} x$

$\Rightarrow S_w = \sum_i S_i$

"between-class scattering matrix":

$\Rightarrow S_B = \sum_i N_i (m_i - m)(m_i - m)^T$
where m is the overall mean, and m_i and N_i are the sample mean and sizes

Solving for $A^T \nu = \lambda \nu$ where $A = S_w^{-1} \cdot S_B$, ν is eigenvector, and λ is eigenvalue
 \Rightarrow LD1 and LD2 are diff contrast and diff hue transformed by $y = W^T \cdot X$ ($= W \cdot T \cdot \text{dot}(X \cdot T) \cdot T$)

```

contrast  hue    BorR
Mean Vector class 1: [ 0.3219  0.6334 -0.1949]
Mean Vector class 2: [-0.3127 -0.6153  0.1894]

('within-class Scatter Matrix:\n',
array([[ 929.0412, -256.3866, -924.4859],
       [-256.3866,  630.4283,  296.2583],
       [-924.4859,  296.2583,  994.8667]]))

('between-class Scatter Matrix:\n',
array([[ 311.9914,   613.8395,  -188.773 ],
       [ 613.8395,  1207.8298,  -371.5872],
       [-188.773 ,  -371.5872,  114.5147]]))

Eigenvector 1:
[[-0.7296]
 [-0.5264]
 [-0.4365]]
Eigenvalue 1: 3.36e+00

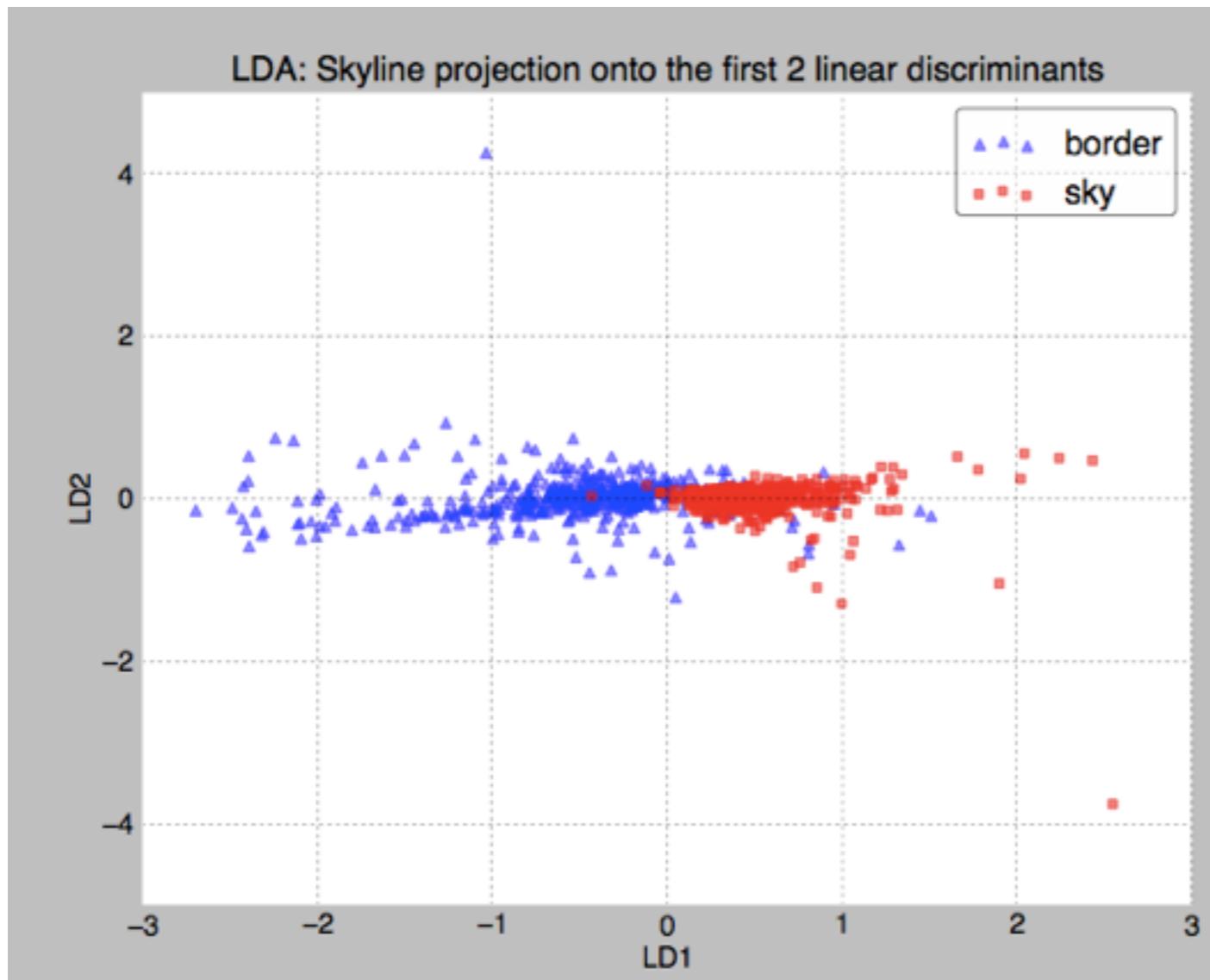
Eigenvector 2:
[[-0.8083]
 [ 0.5043]
 [ 0.304 ]]
Eigenvalue 2: -1.78e-17

Eigenvector 3:
[[ 0.6804]
 [-0.1237]
 [ 0.7224]]
Eigenvalue 3: 4.66e-03
ok
Eigenvalues in decreasing order:
3.36159544502
0.00466279798653
1.7822517108e-17
Variance explained:
eigenvalue 1: 99.86%
eigenvalue 2: 0.14%
eigenvalue 3: 0.00%
('Matrix W:\n', array([[-0.7296, -0.5264, -0.4365],
       [ 0.6804, -0.1237,  0.7224]]))

```

[Brown & Lowe 2003, image 1](#)

same analysis, except the neighborhood for stats is 8 pixels instead of 24.



Mean Vector class 1: [0.332 0.6717 -0.158]

Mean Vector class 2: [-0.3124 -0.6319 0.1486]

('within-class Scatter Matrix:\n',
array([[911.5281, -190.6089, -889.5255],
[-190.6089, 585.3437, 218.0827],
[-889.5255, 218.0827, 993.1179]]))
('between-class Scatter Matrix:\n',
array([[316.9373, 640.6376, -150.044],
[640.6376, 1295.4907, -304.0761],
[-150.044 , -304.0761, 72.1681]]))

Eigenvector 1:

[[-0.7012]
[-0.5647]
[-0.4353]]

Eigenvalue 1: 3.59e+00

Eigenvector 2:

[[-0.8121]
[0.4796]
[0.3325]]

Eigenvalue 2: 3.52e-16

Eigenvector 3:

[[0.6703]
[-0.162]
[0.7242]]

Eigenvalue 3: 1.10e-02

ok

Eigenvalues in decreasing order:

3.59292475827

0.0109669690478

3.5237701844e-16

Variance explained:

eigenvalue 1: 99.70%

eigenvalue 2: 0.30%

eigenvalue 3: 0.00%

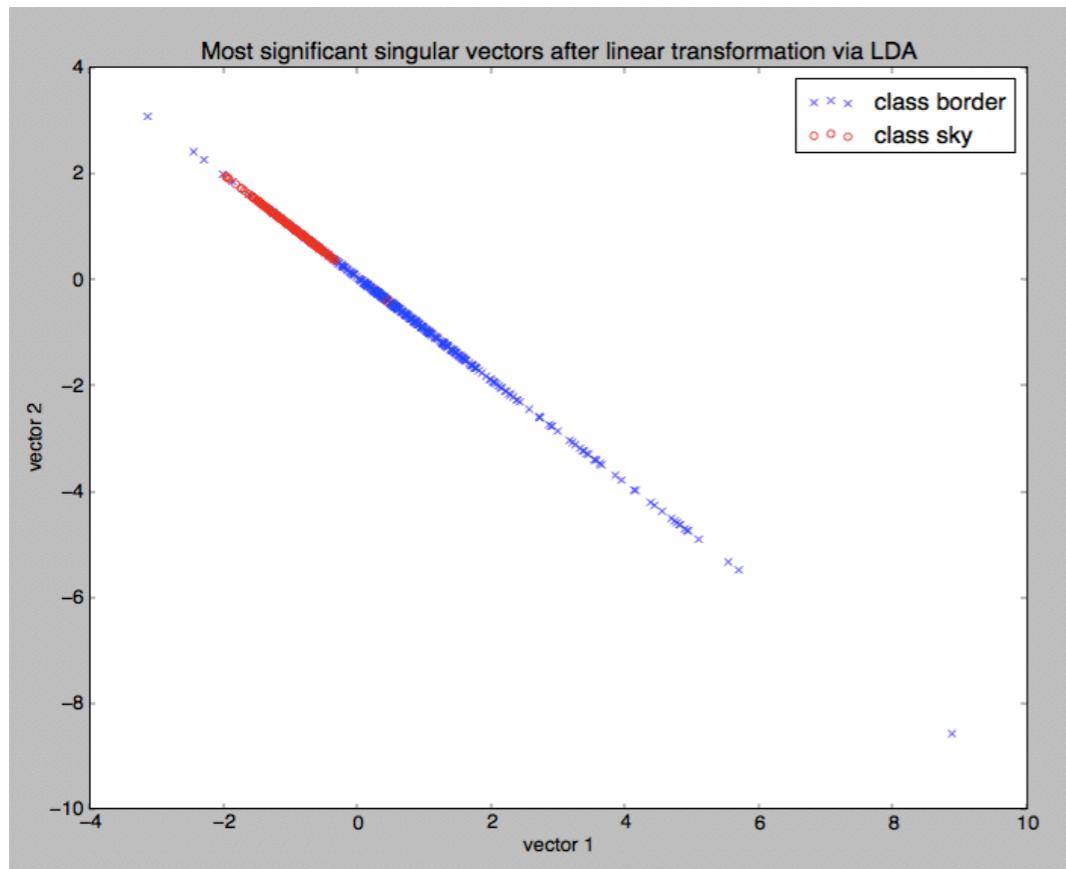
('Matrix W:\n', array([[-0.7012, -0.5647, -0.4353],
[0.6703, -0.162 , 0.7242]]))

LDA look at difference in contrast, hue, blue or red, and CIE theta, all divided by their respective standard deviations.

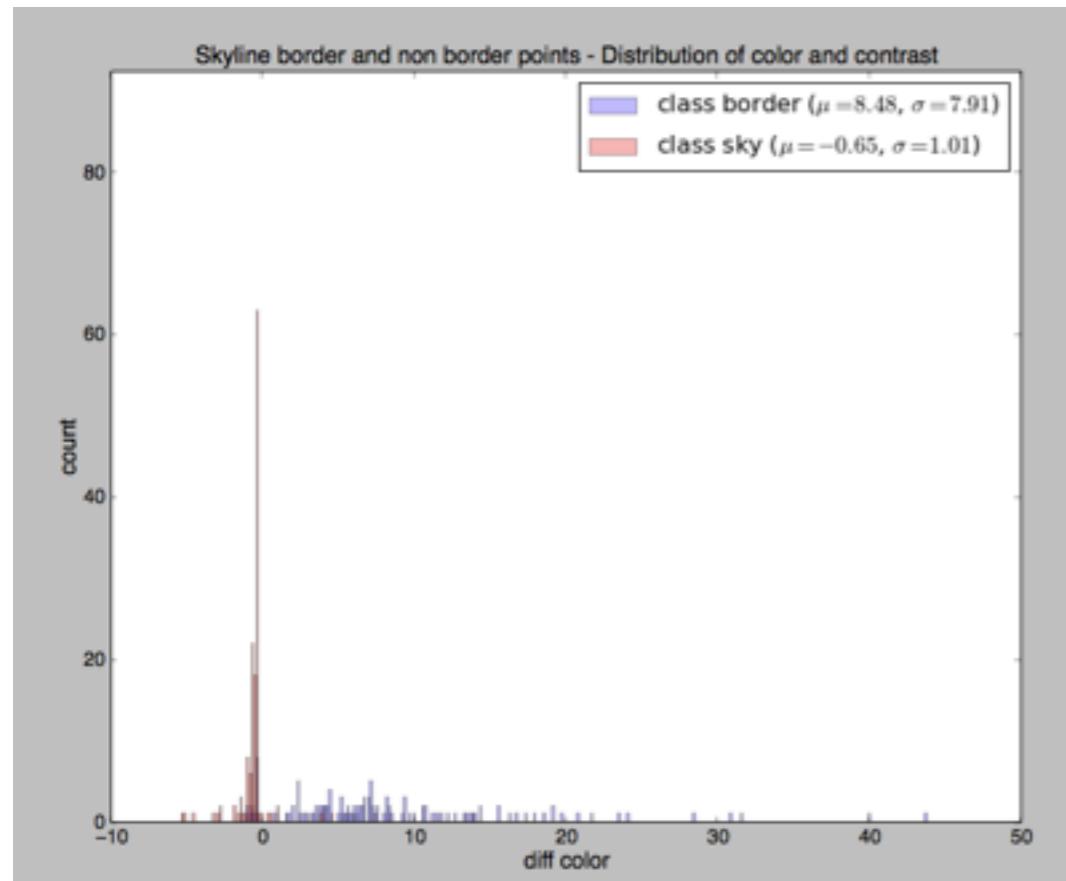
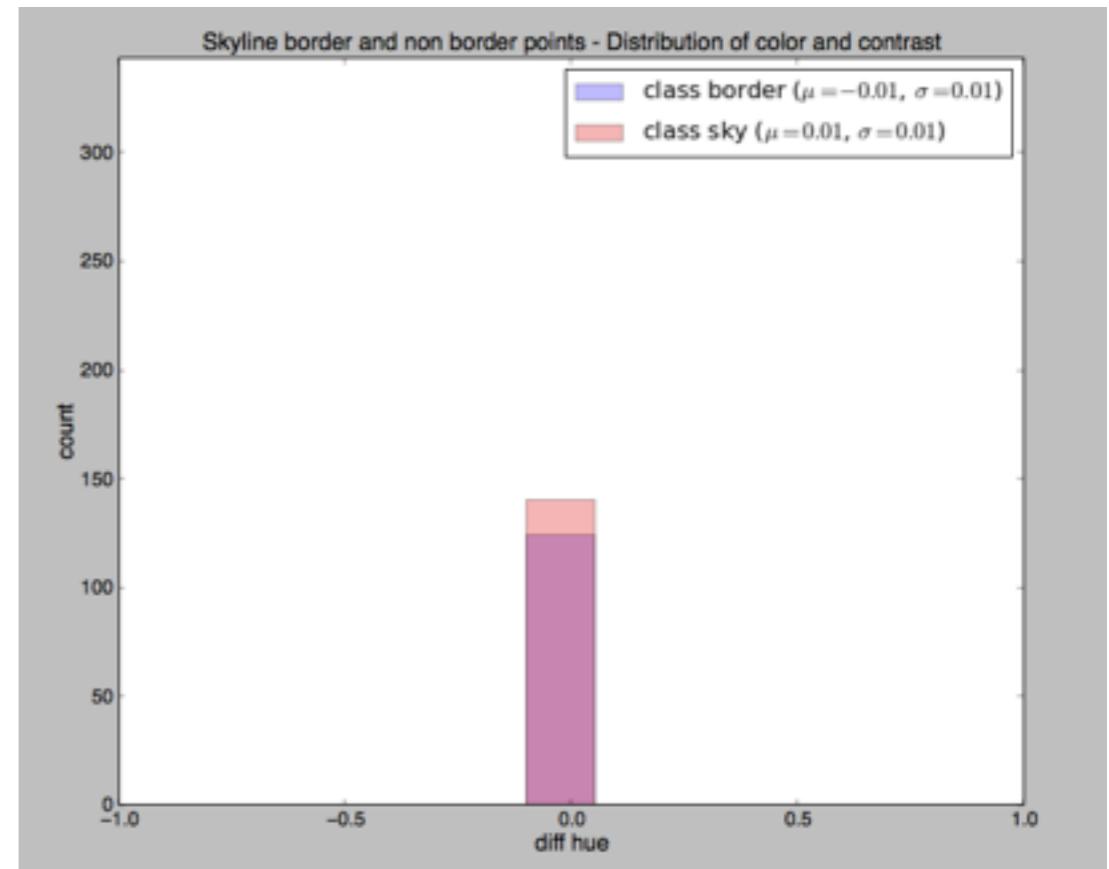
Venturi mtn range, image 1



Venturi mtn range, image 1

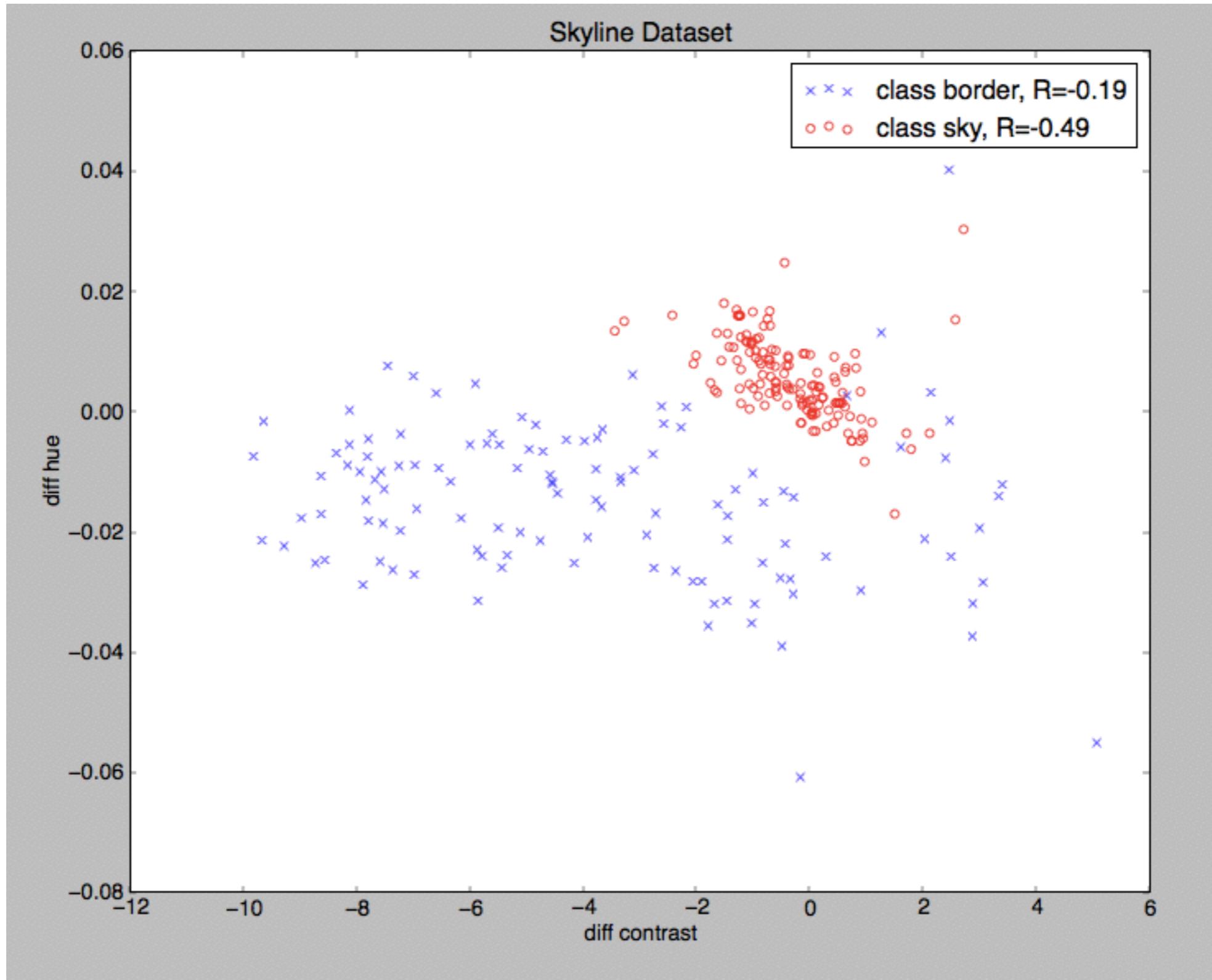


*note: the largest contrasts were removed from analysis for plot visibility



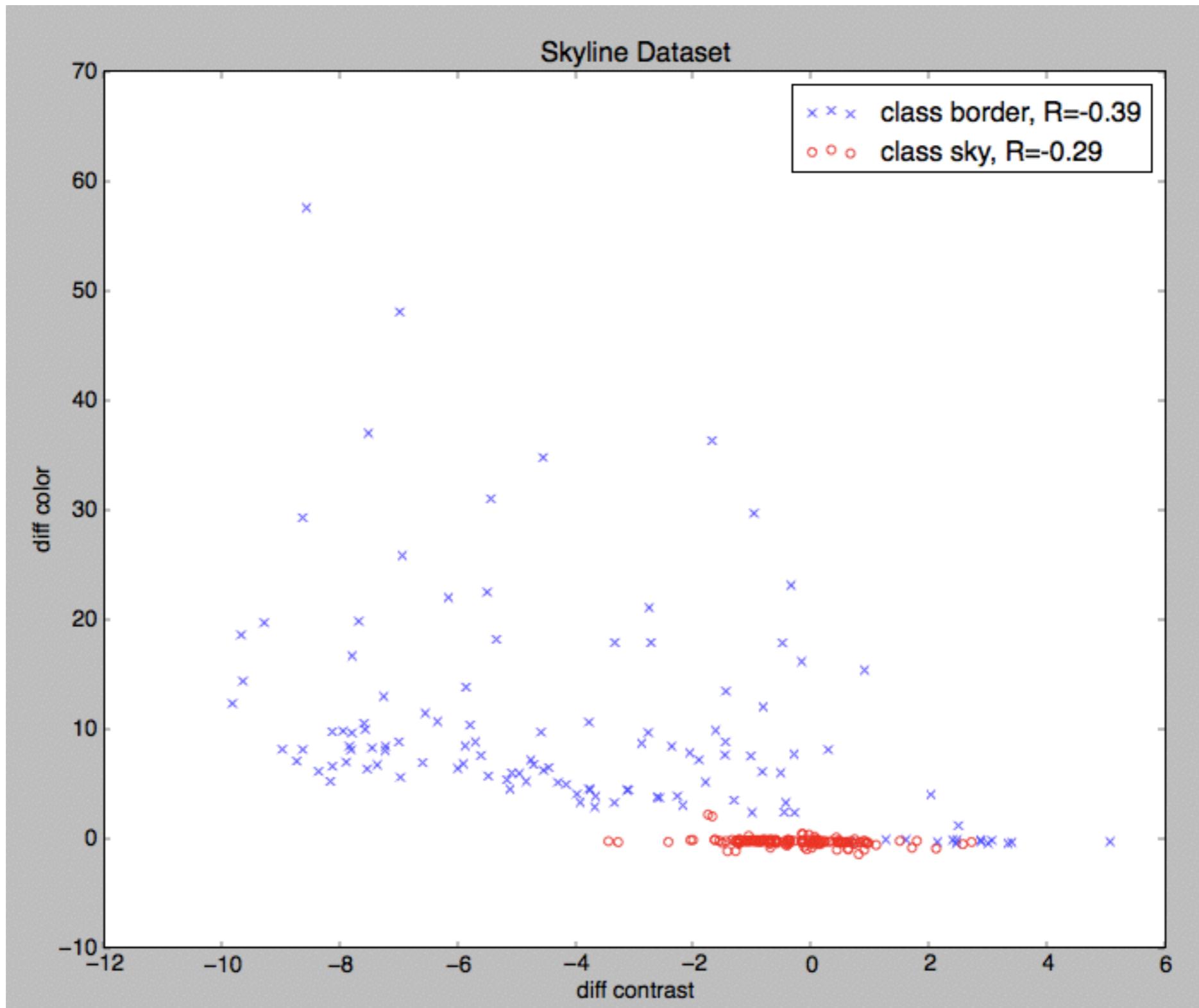
stats using 24 neighbors

Venturi mtn range, image 1



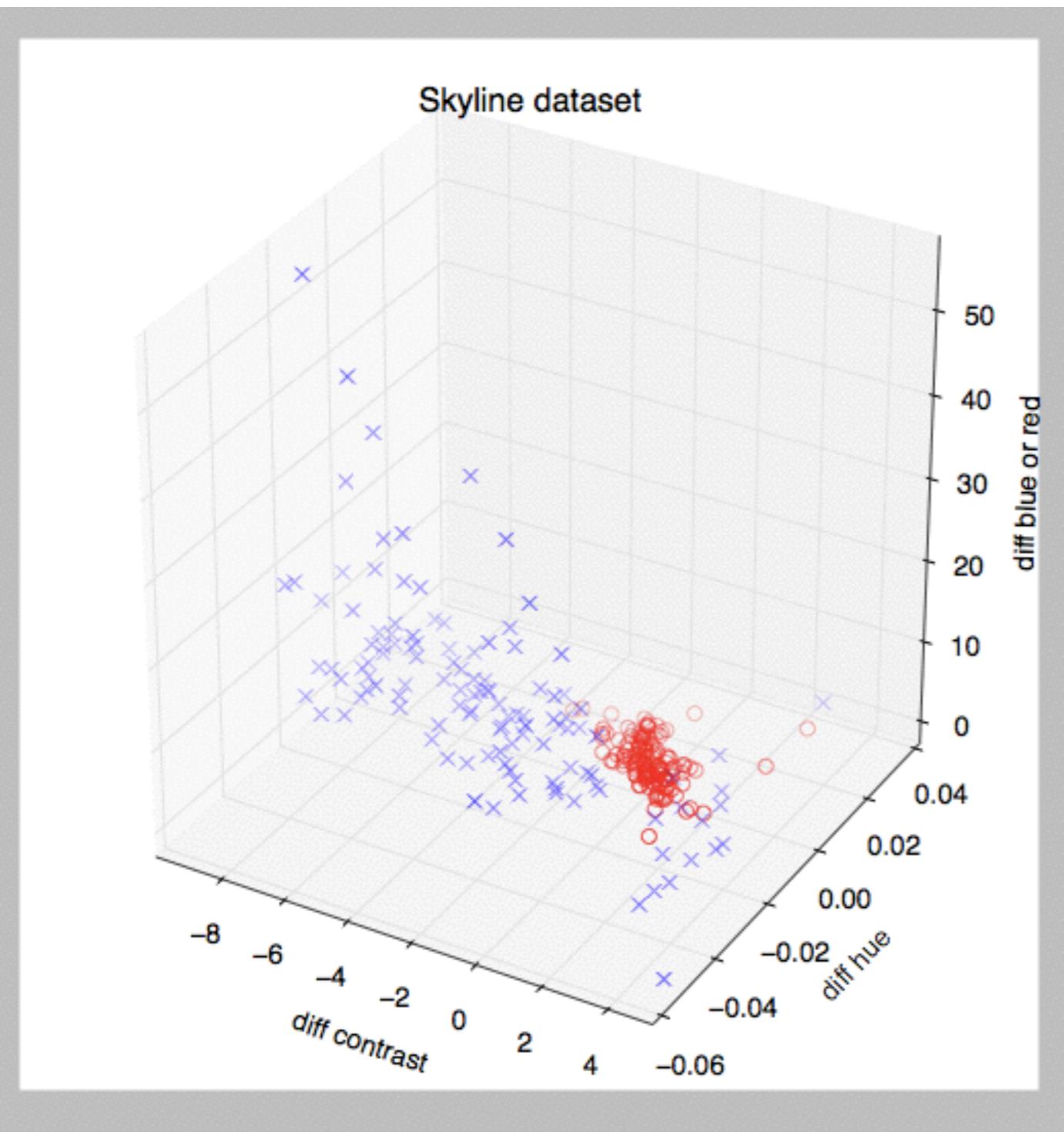
stats using 24 neighbors

Venturi mtn range, image 1

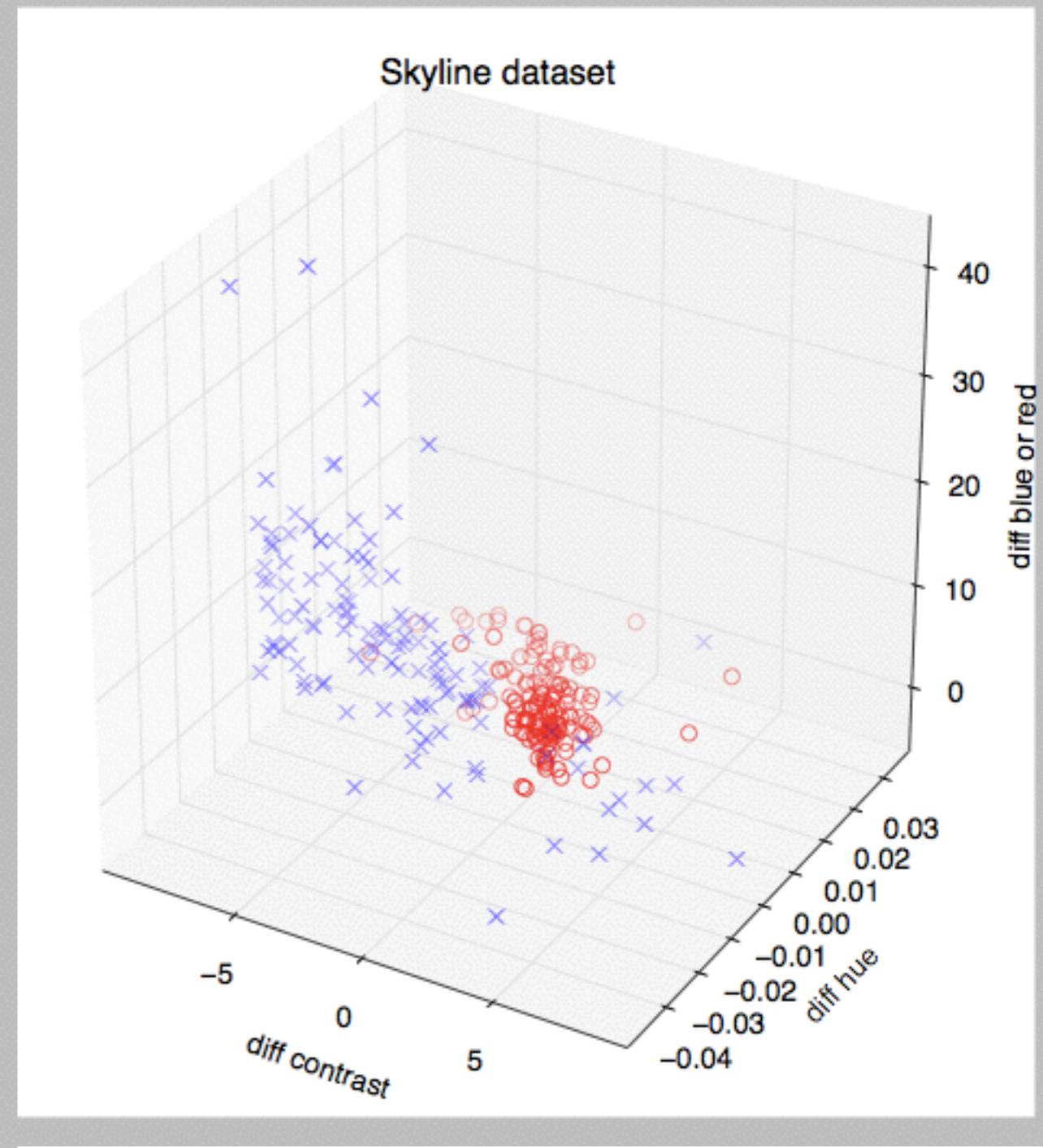


stats using 24 neighbors

Venturi mtn range, image 1

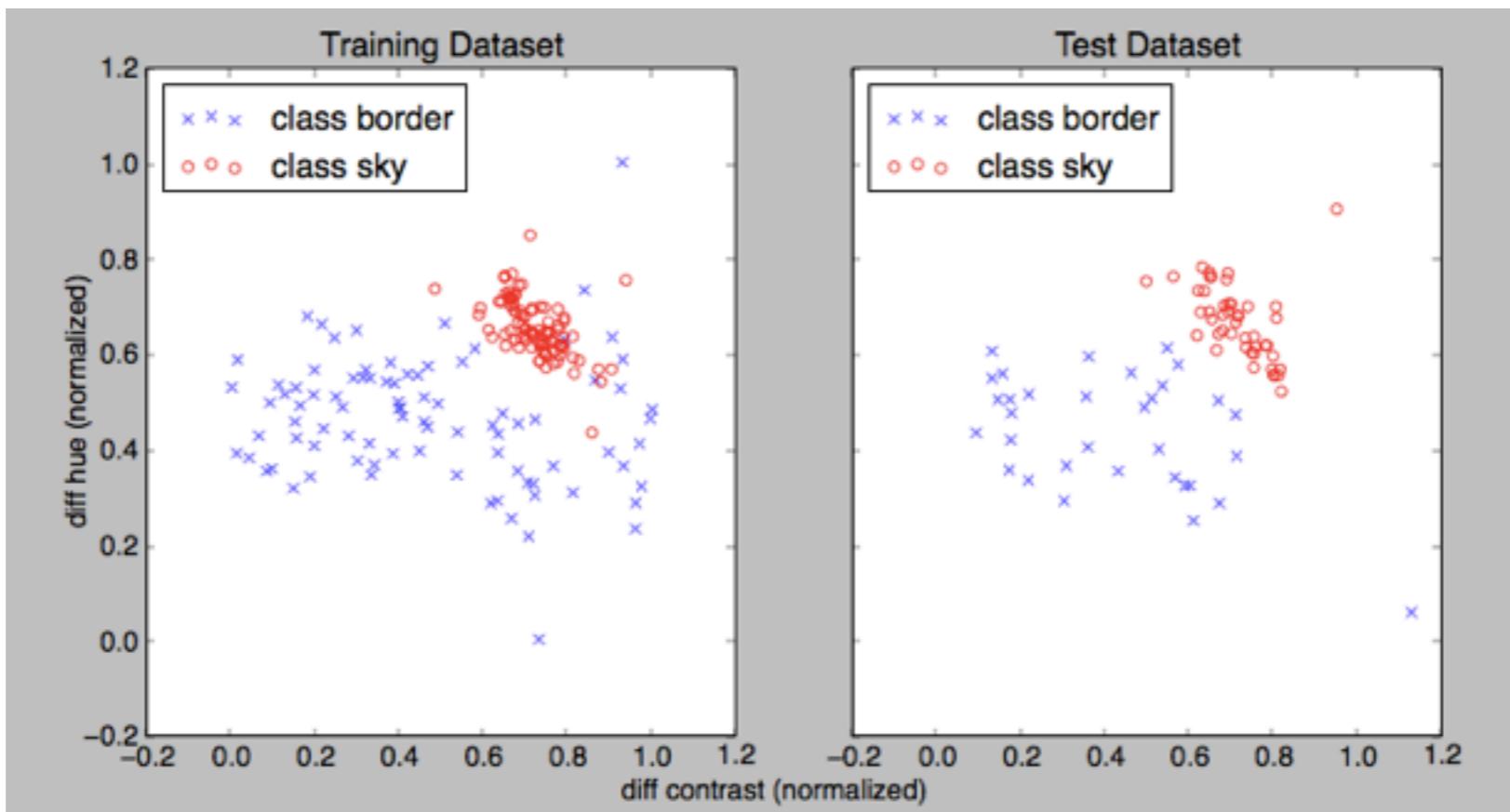
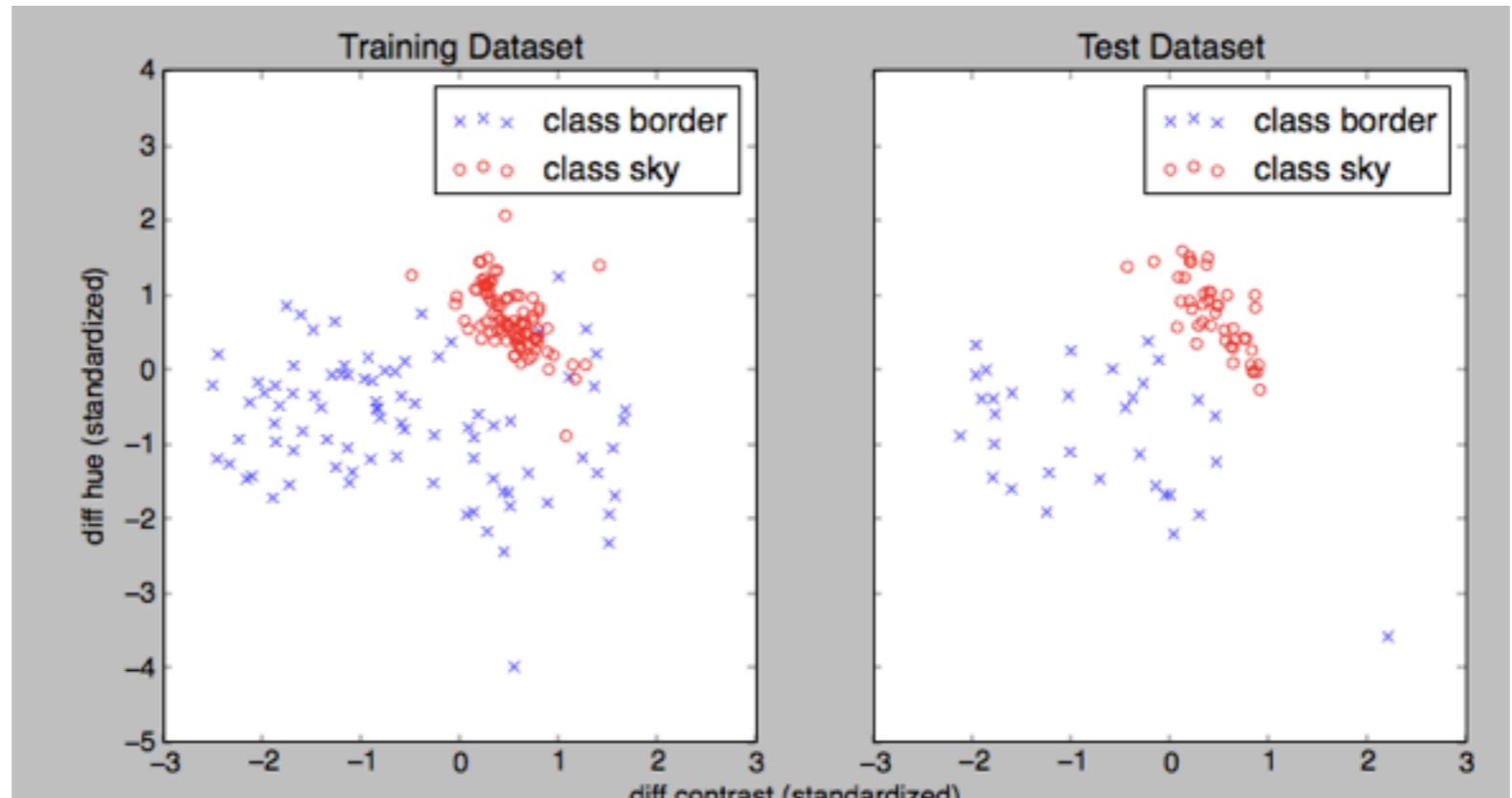


stats using 24 neighbors



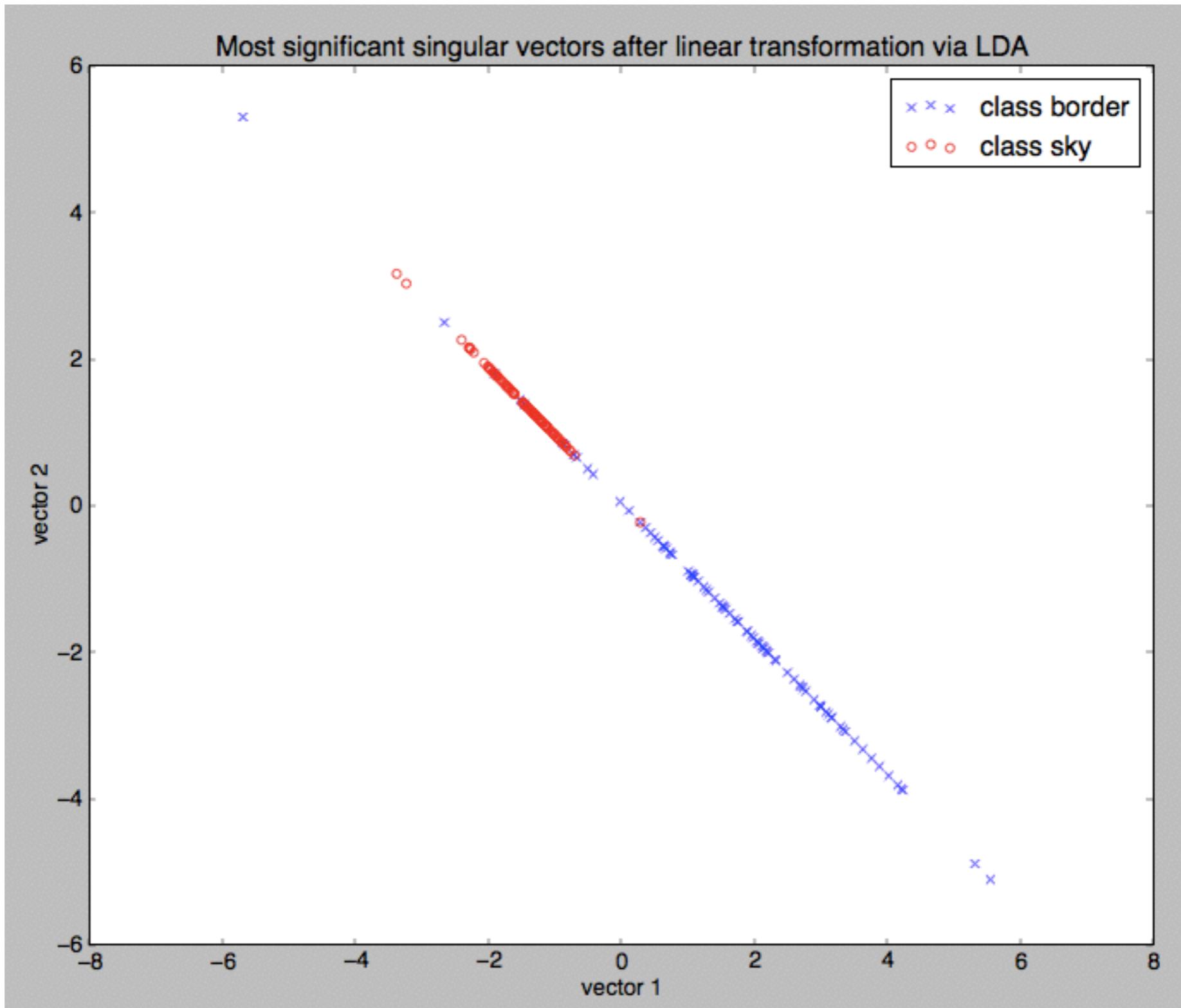
stats using 8 neighbors

Venturi mtn range, image 1



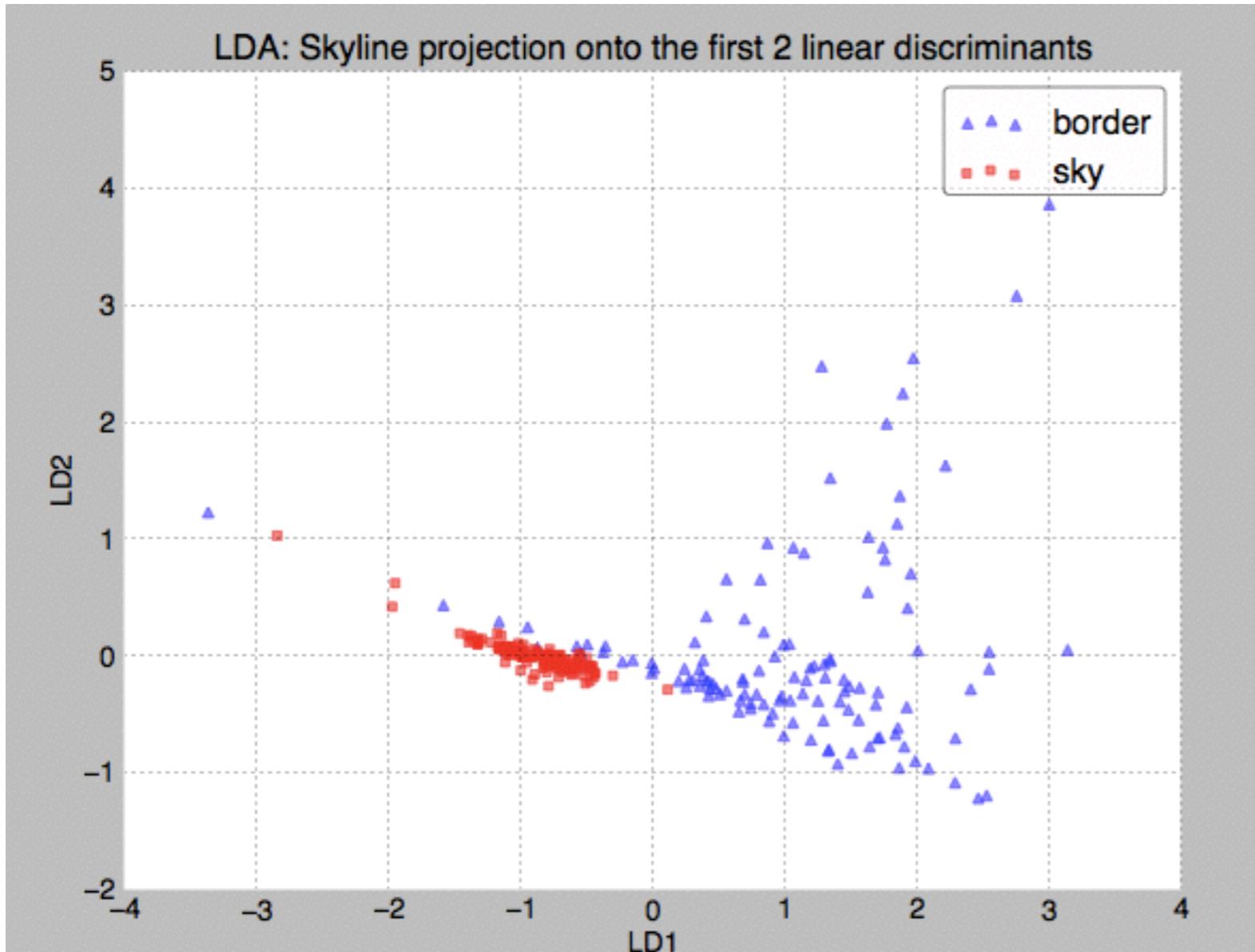
stats using 24
neighbors

Venturi mtn range, image 1



stats using 24 neighbors

Venturi mtn range, image 1



contrast	hue	BorR
-0.6022	-0.7636	0.6539
0.5168	0.6553	-0.5612

Mean Vector class 1: [-0.6022 -0.7636 0.6539]

Mean Vector class 2: [0.5168 0.6553 -0.5612]

('within-class Scatter Matrix:\n',
array([[180.4607, -34.2094, -65.7596],
[-34.2094, 130.9027, -34.346],
[-65.7596, -34.346 , 165.8548]]))

('between-class Scatter Matrix:\n',
array([[246.4277, 311.9811, -263.8149],
[311.9811, 395.1018, -334.9979],
[-263.8149, -334.9979, 290.2456]]))

Eigenvector 1:
[[-0.5373]
[-0.8377]
[0.0975]]

Eigenvalue 1: 5.61e+00

Eigenvector 2:
[[-0.7457]
[0.6608]
[0.0849]]

Eigenvalue 2: -3.83e-16

Eigenvector 3:
[[0.441]
[0.3521]
[0.8255]]

Eigenvalue 3: 5.54e-02

ok

Eigenvalues in decreasing order:

5.61435797825
0.0554408654804
3.82727650849e-16

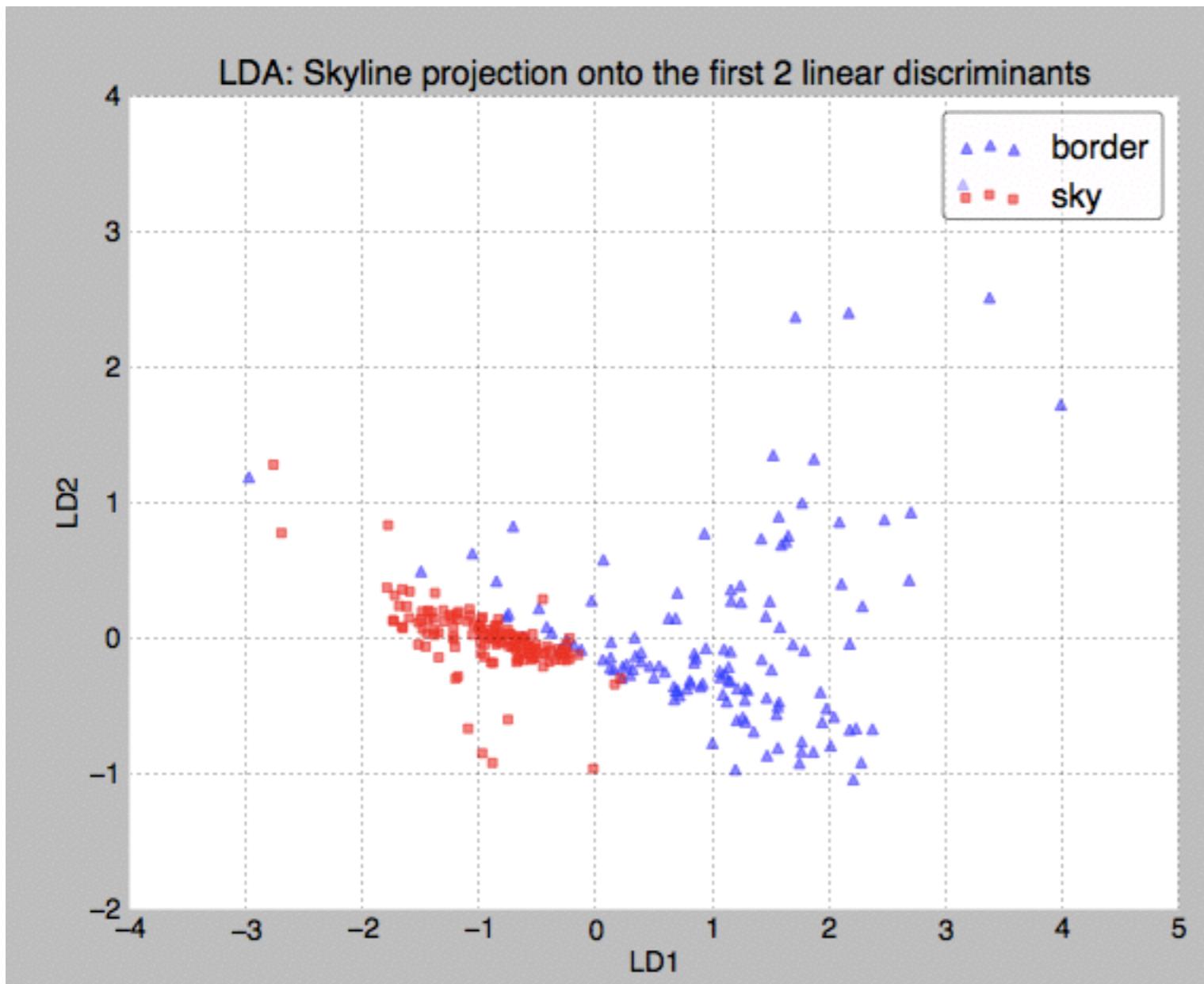
Variance explained:

eigenvalue 1: 99.02%
eigenvalue 2: 0.98%
eigenvalue 3: 0.00%

('Matrix W:\n', array([[-0.5373, -0.8377, 0.0975],
[0.441 , 0.3521, 0.8255]]))

stats using 24 neighbors

Venturi mtn range, image 1



```
contrast  hue   BorR
Mean Vector class 1: [-0.4823 -0.7366  0.6801]
Mean Vector class 2: [ 0.4272  0.6525 -0.6023]

('within-class Scatter Matrix:\n',
array([[ 209.6069, -38.8914, -78.5168],
       [-38.8914,  137.1159, -29.6406],
       [-78.5168, -29.6406, 155.8602]]))
('between-class Scatter Matrix:\n',
array([[ 164.2464, 250.295 , -229.0169],
       [ 250.295 , 381.7193, -350.3459],
       [-229.0169, -350.3459, 325.4864]]))

Eigenvector 1:
[[ -0.4013]
 [ -0.8675]
 [  0.2939]]
Eigenvalue 1: 4.77e+00

Eigenvector 2:
[[ -0.7657]
 [  0.6283]
 [  0.1375]]
Eigenvalue 2: -8.22e-16

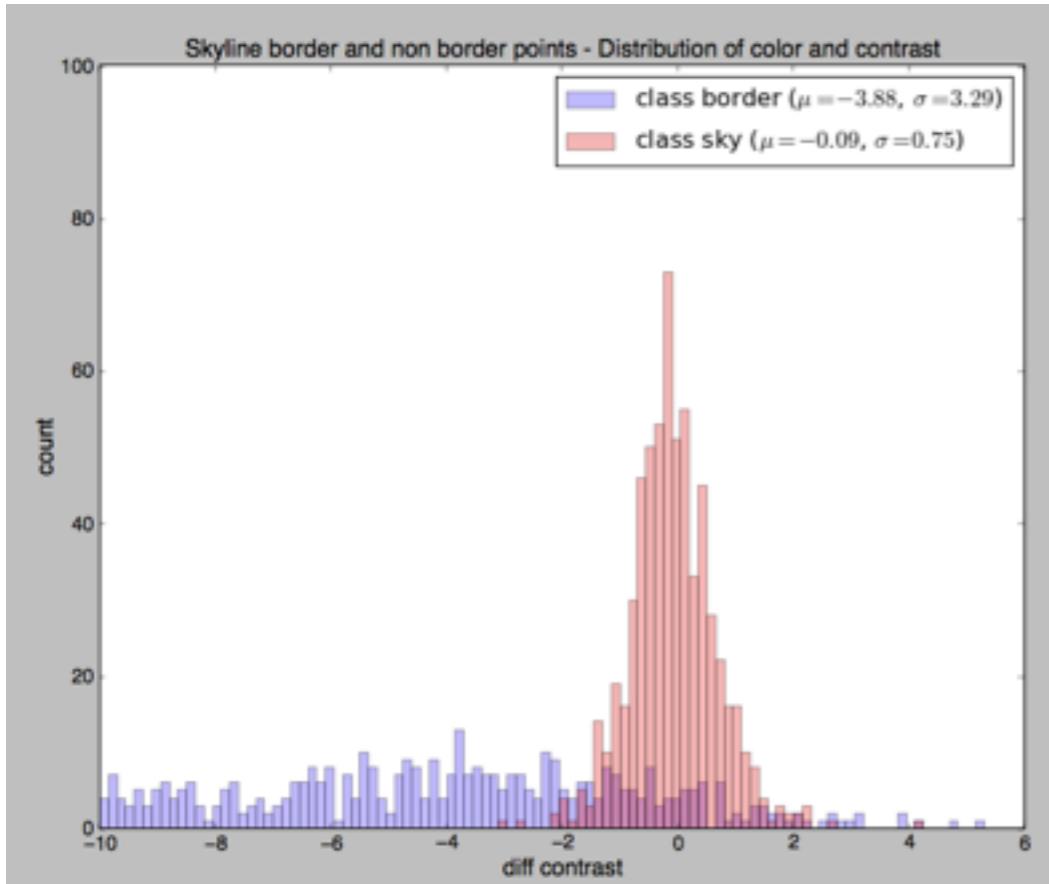
Eigenvector 3:
[[  0.4803]
 [  0.402 ]
 [  0.7796]]
Eigenvalue 3: 4.05e-02
ok
Eigenvalues in decreasing order:
4.77036733009
0.0405101484074
8.22079194997e-16
Variance explained:
eigenvalue 1: 99.16%
eigenvalue 2: 0.84%
eigenvalue 3: 0.00%
('Matrix W:\n', array([[-0.4013, -0.8675,  0.2939],
       [ 0.4803,  0.402 ,  0.7796]]))
```

stats using 24 neighbors

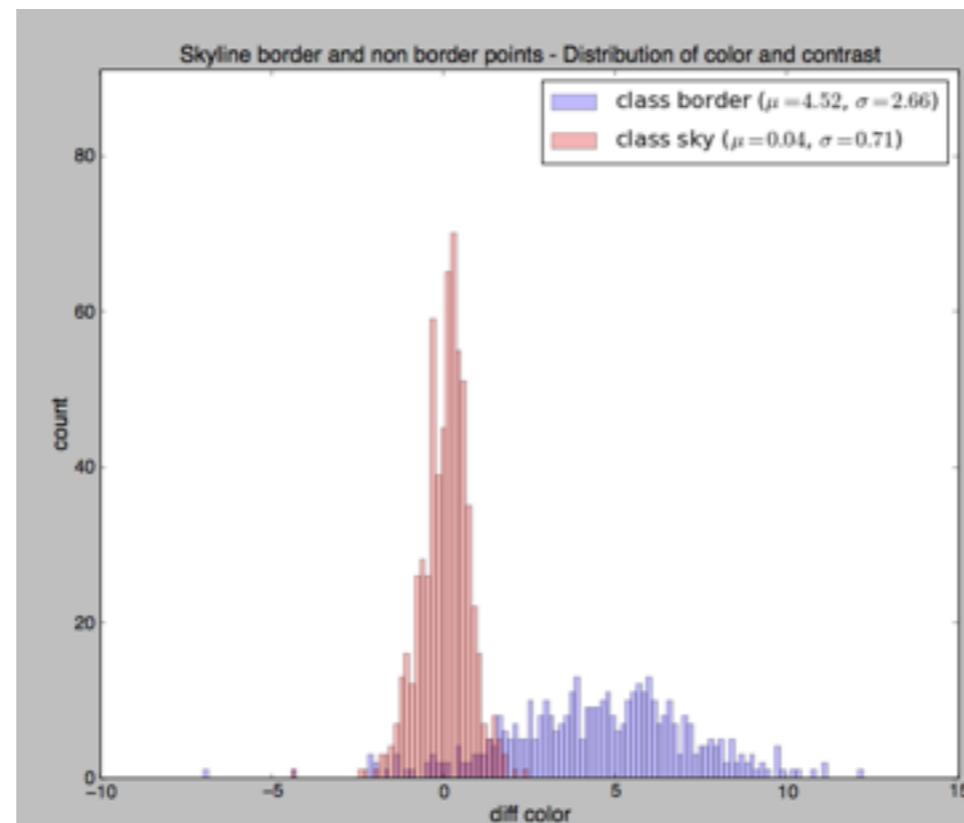
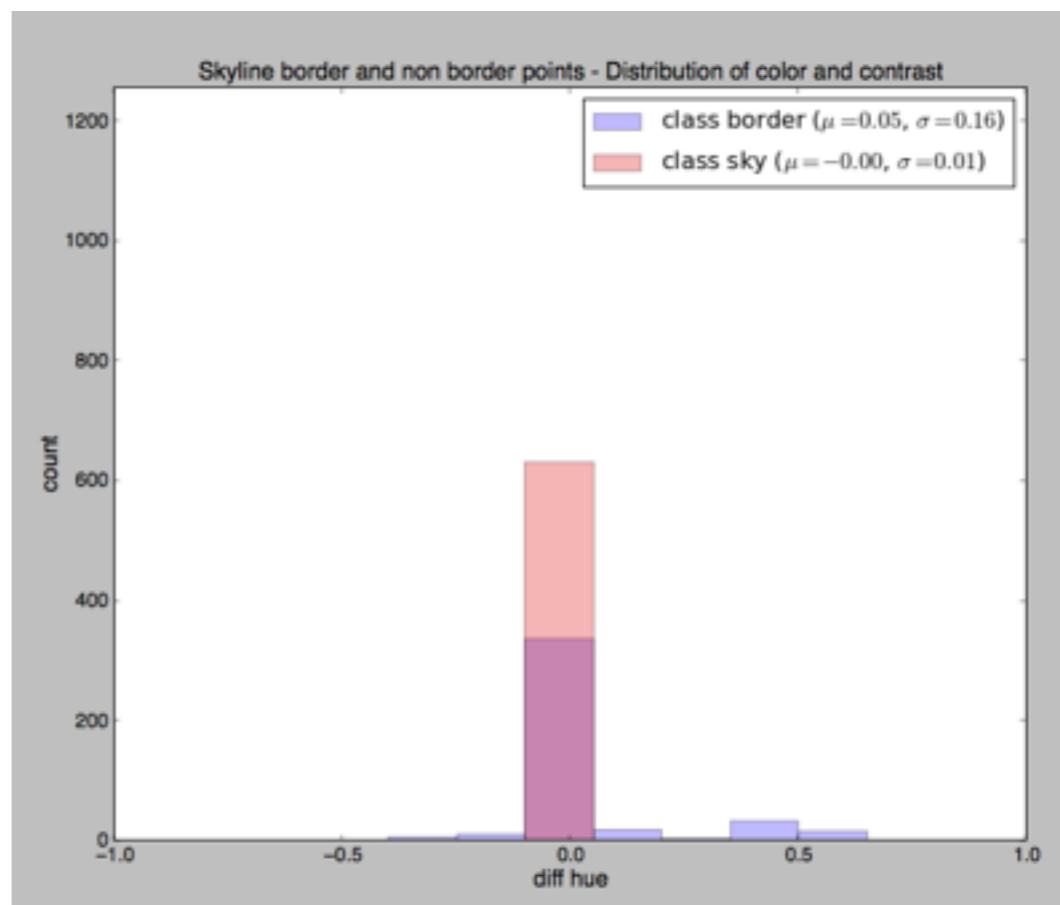
seattle test image



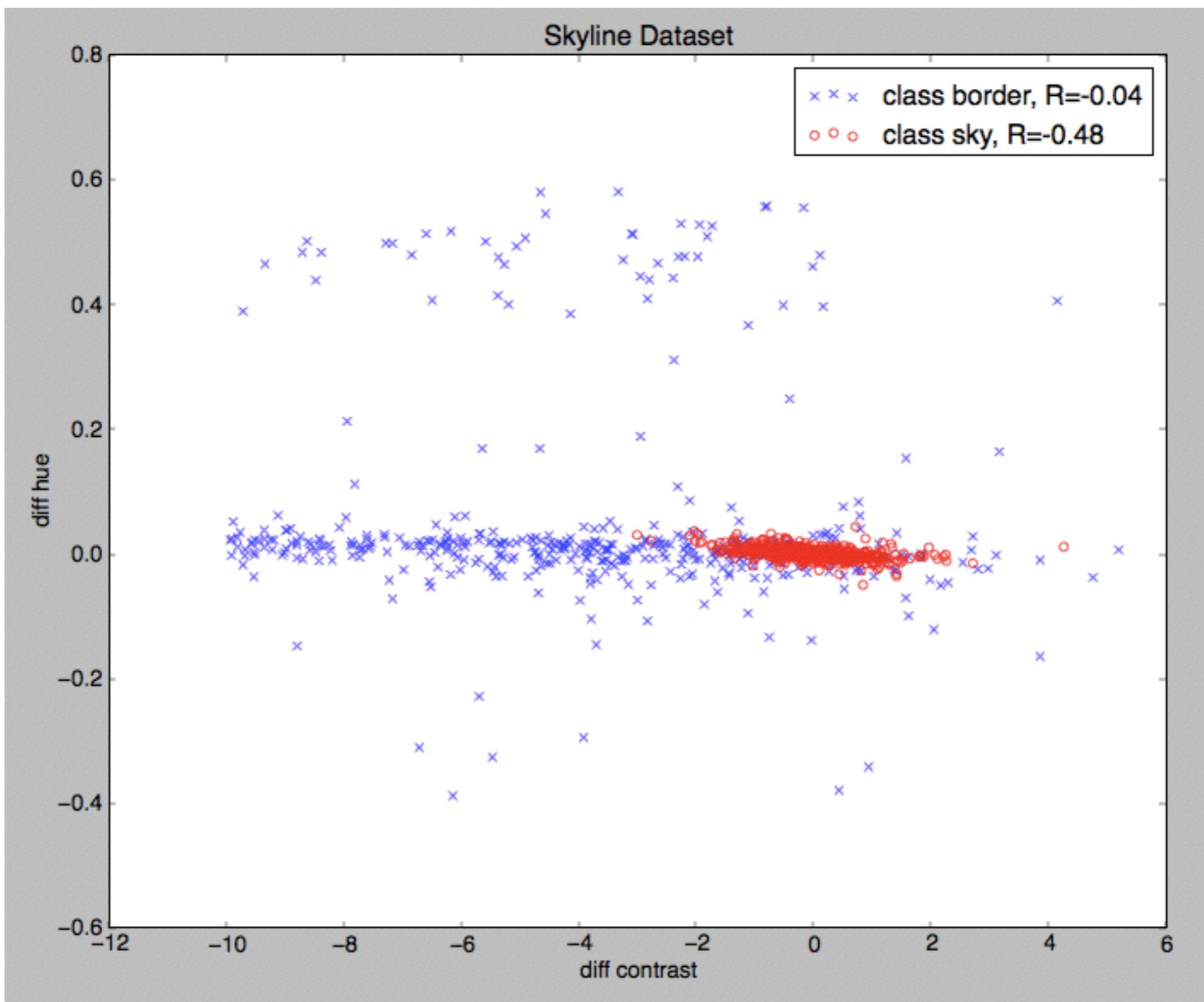
seattle test image



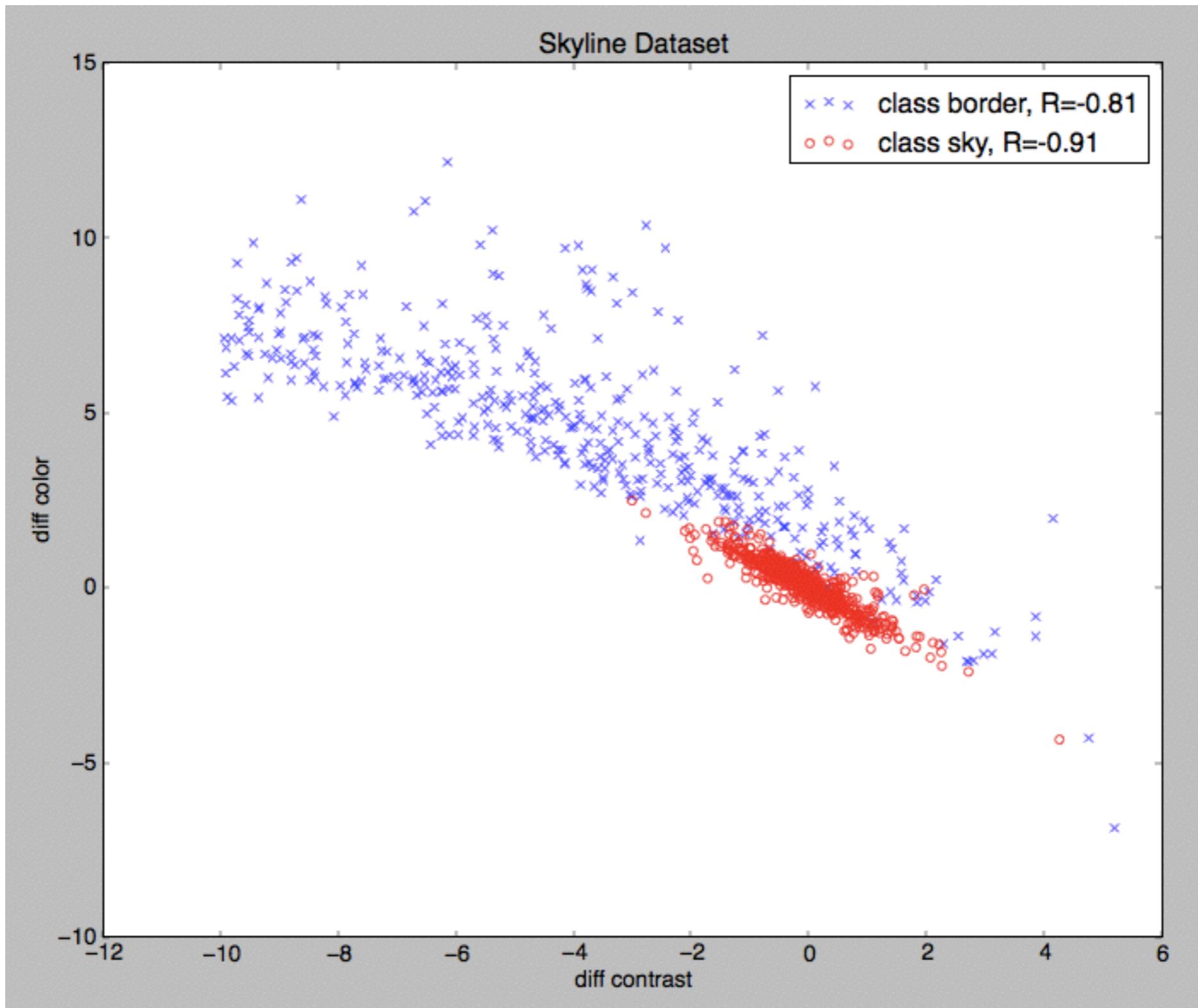
*note: the largest contrasts were removed from analysis for plot visibility



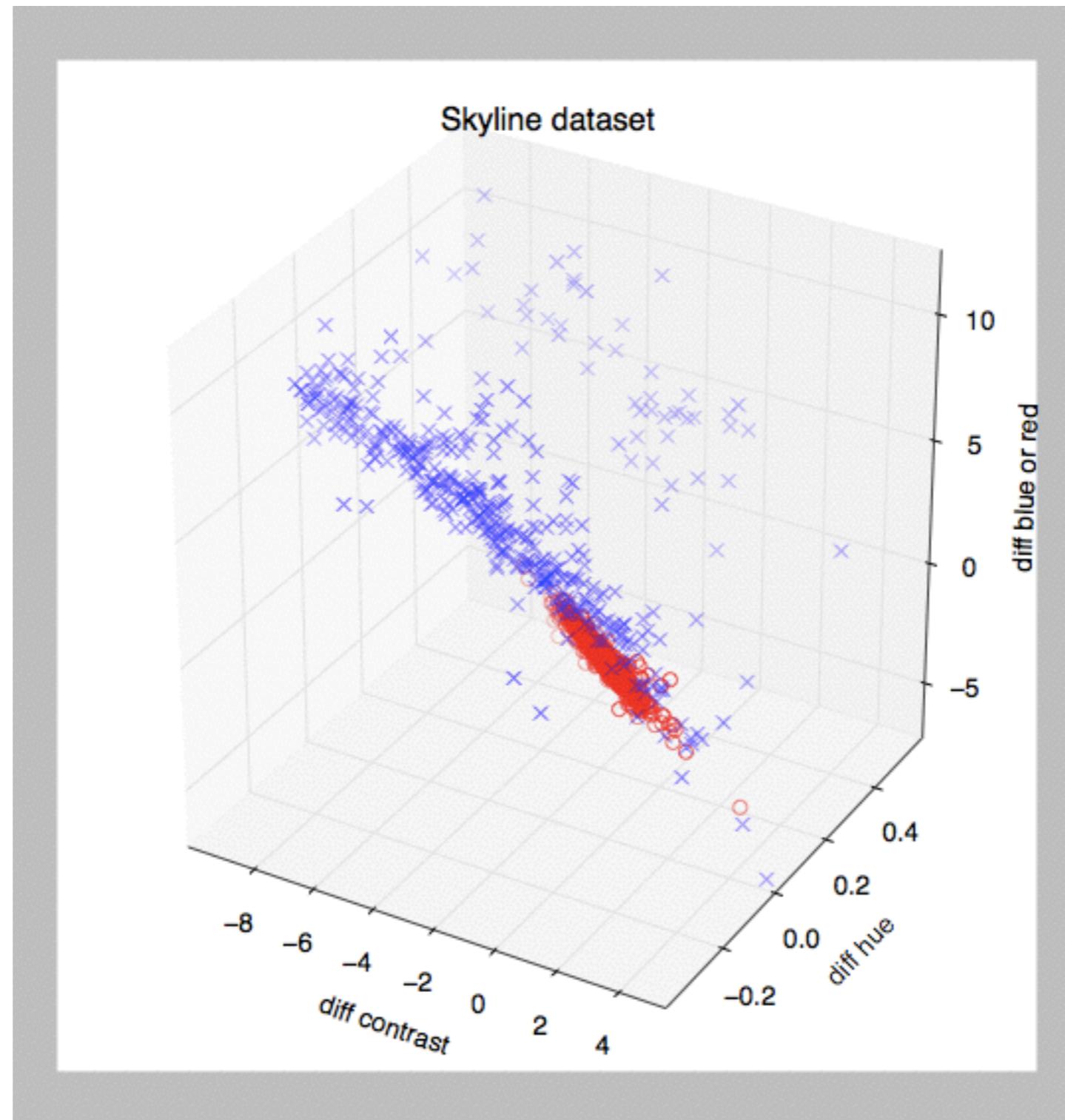
seattle test image



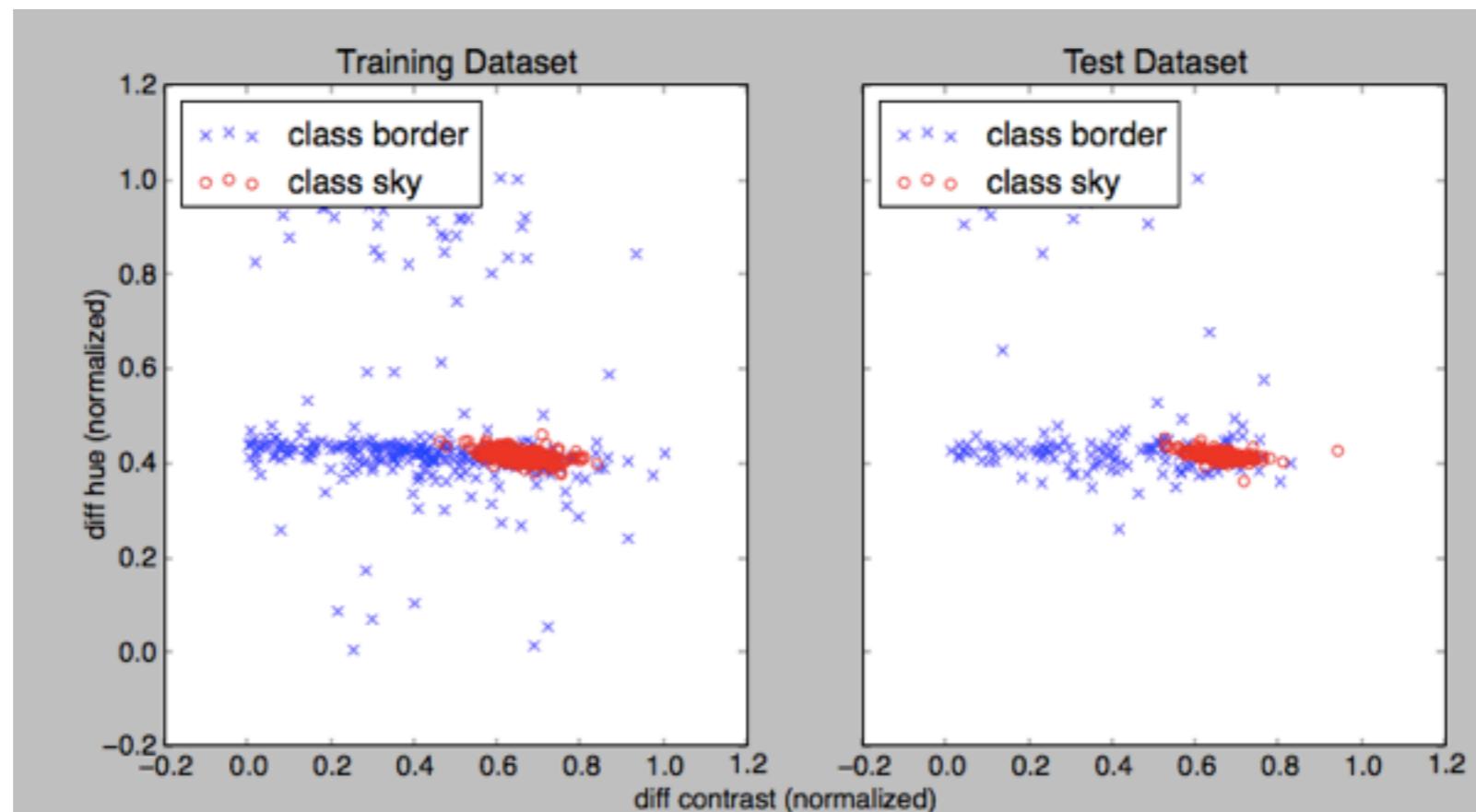
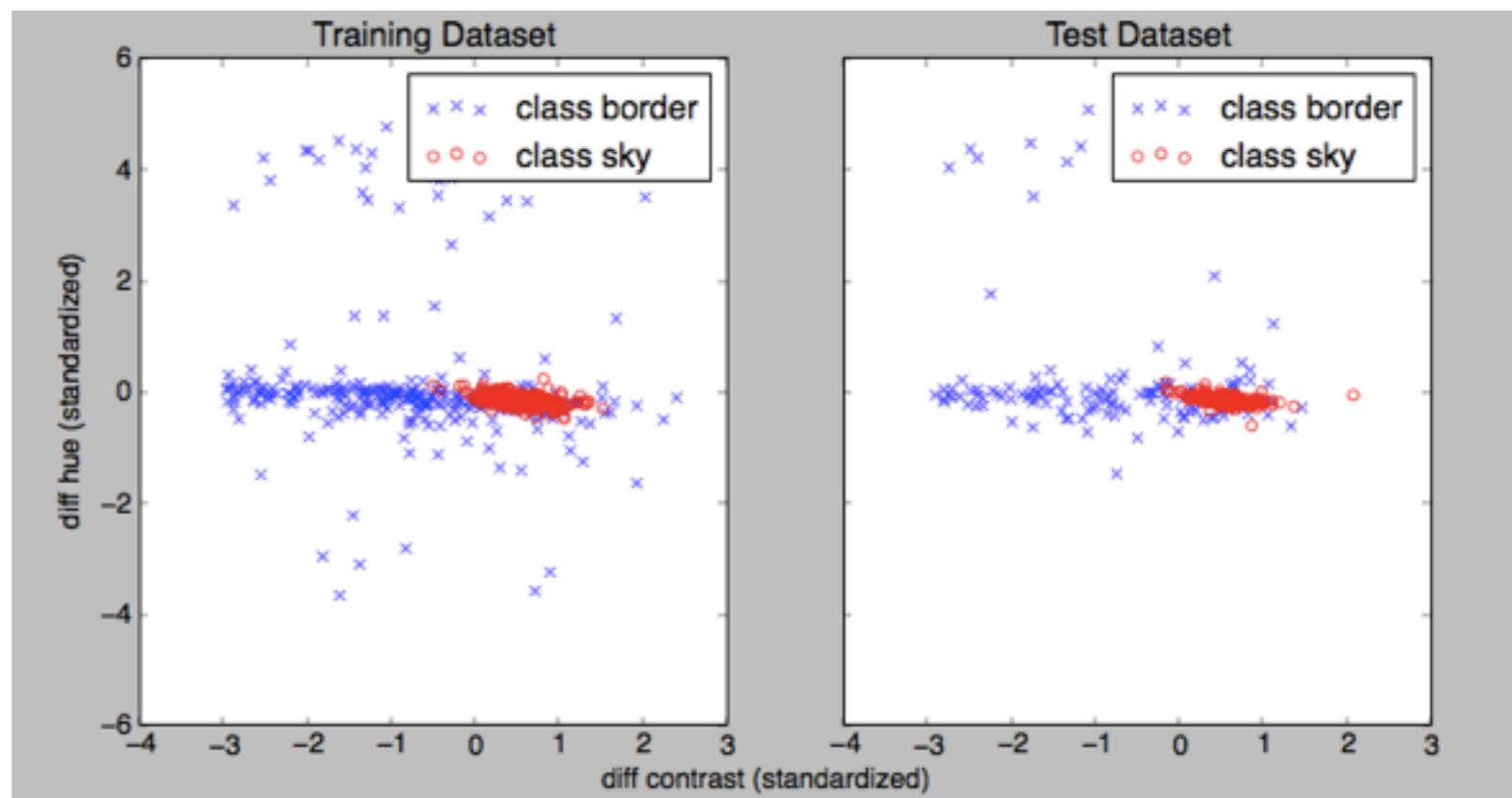
seattle test image



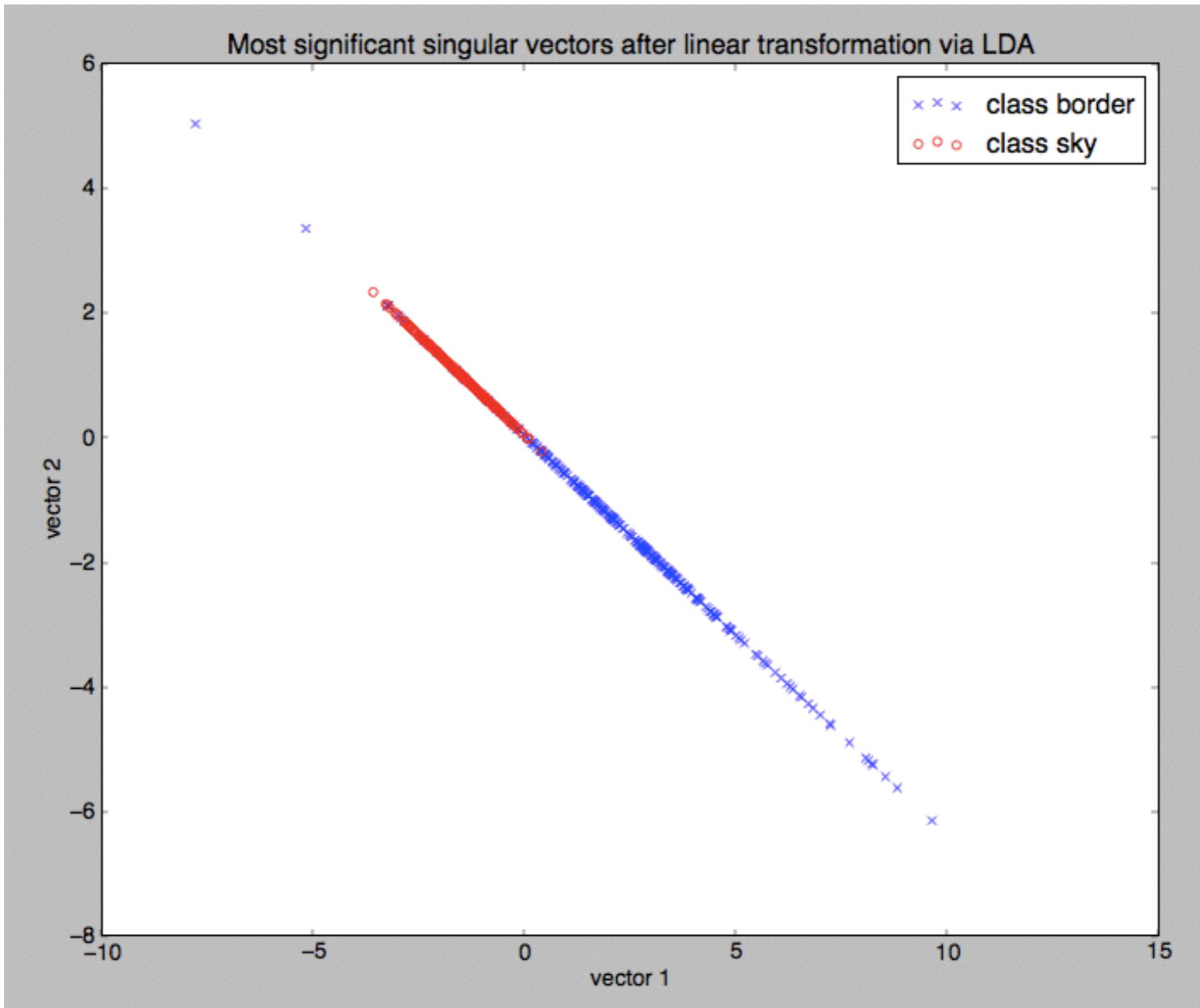
seattle test image



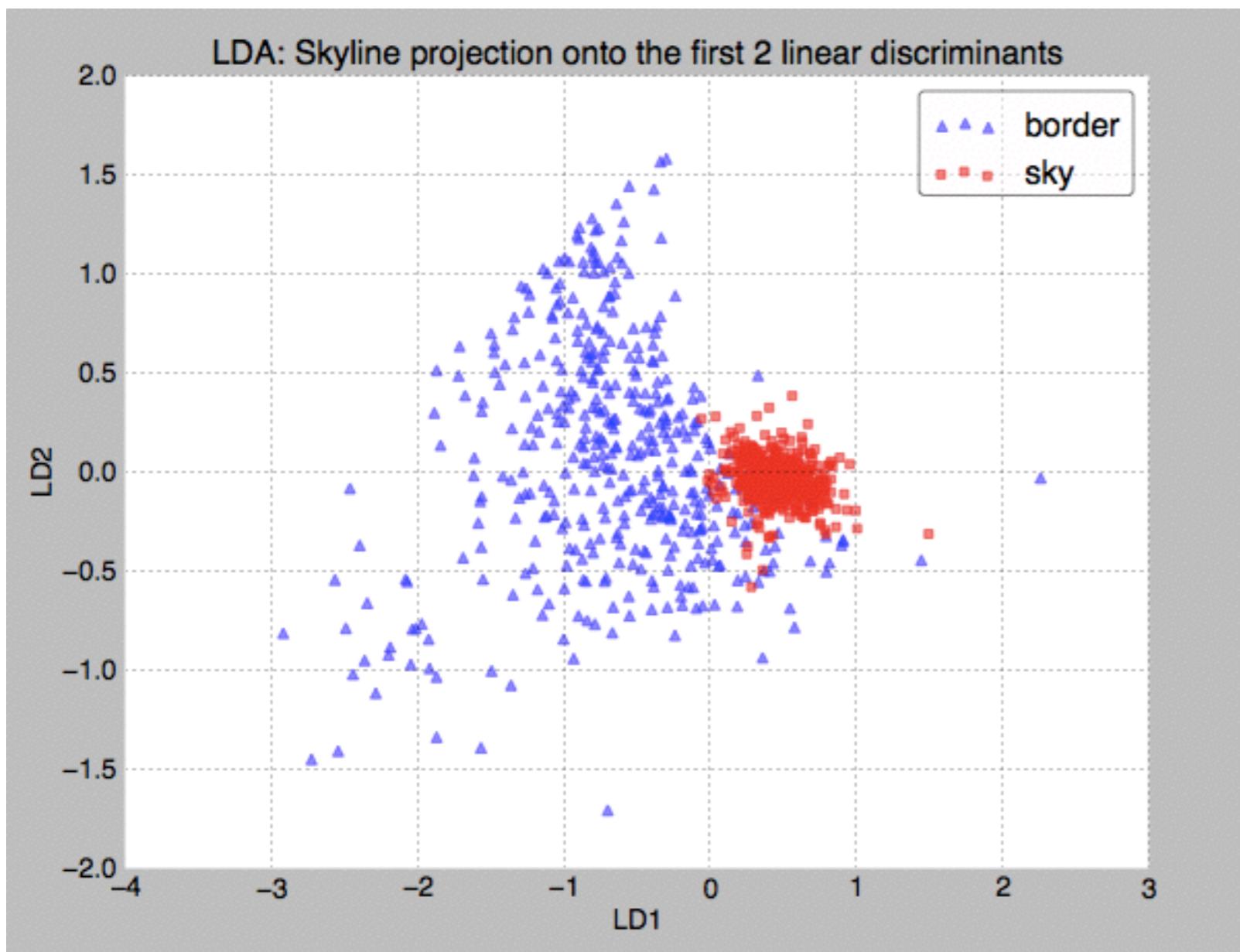
seattle test image



seattle test image



seattle test image



contrast	hue	BorR
-0.7979	0.2884	0.9527
0.5328	-0.1926	-0.6362

('within-class Scatter Matrix:\n',
array([[603.0896, -40.0089, -406.6303],
[-40.0089, 990.742 , 87.2074],
[-406.6303, 87.2074, 413.2026]]))
('between-class Scatter Matrix:\n',
array([[1384.8533, -436.4072, -1550.2439],
[-436.4072, 221.8961, 624.4976],
[-1550.2439, 624.4976, 1954.5143]]))

Eigenvector 1:
[[-0.2991]
[-0.0201]
[-0.954]]
Eigenvalue 1: 5.15e+00

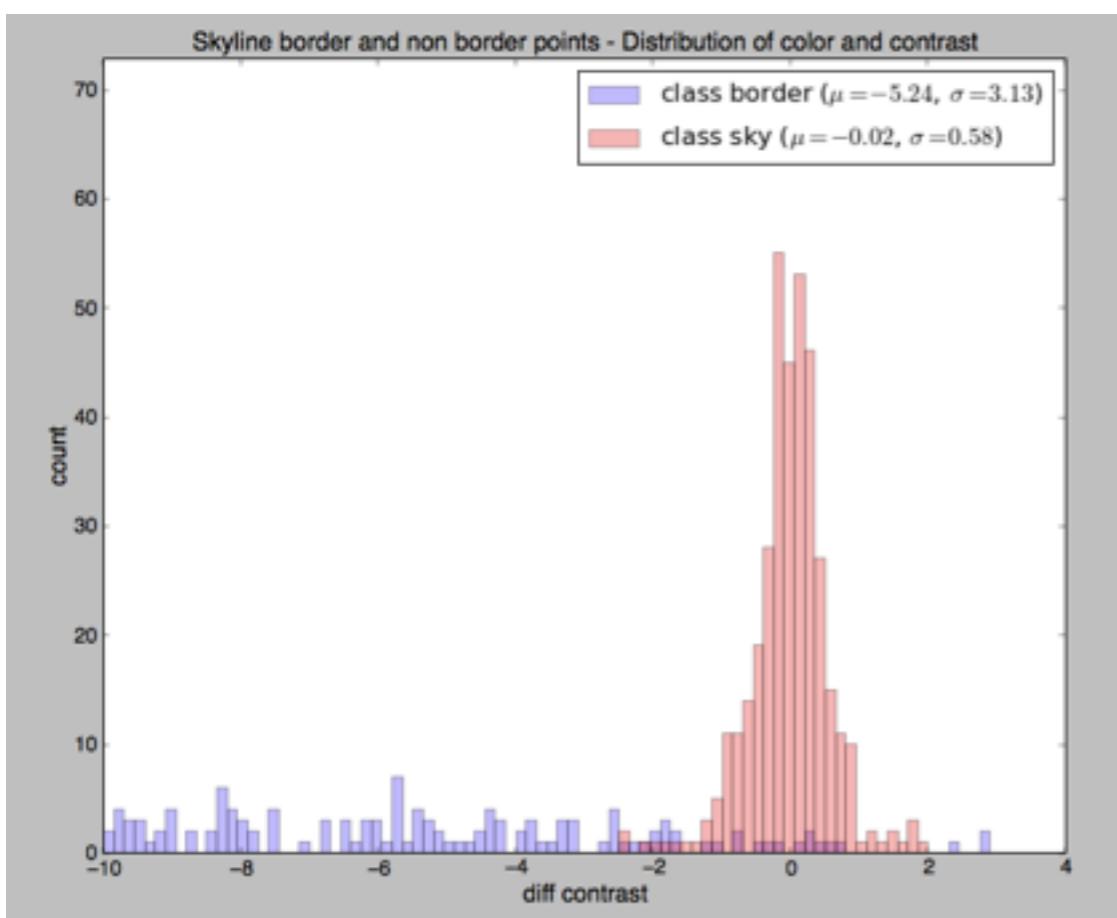
Eigenvector 2:
[[-0.7999]
[-0.0233]
[-0.5997]]
Eigenvalue 2: 7.06e-01

Eigenvector 3:
[[0.3069]
[-0.8087]
[0.5018]]
Eigenvalue 3: -1.46e-16
ok
Eigenvalues in decreasing order:
5.15261790736
0.706269126932
1.45634103903e-16
Variance explained:
eigenvalue 1: 87.95%
eigenvalue 2: 12.05%
eigenvalue 3: 0.00%
('Matrix W:\n', array([[-0.2991, -0.0201, -0.954],
[-0.7999, -0.0233, -0.5997]]))

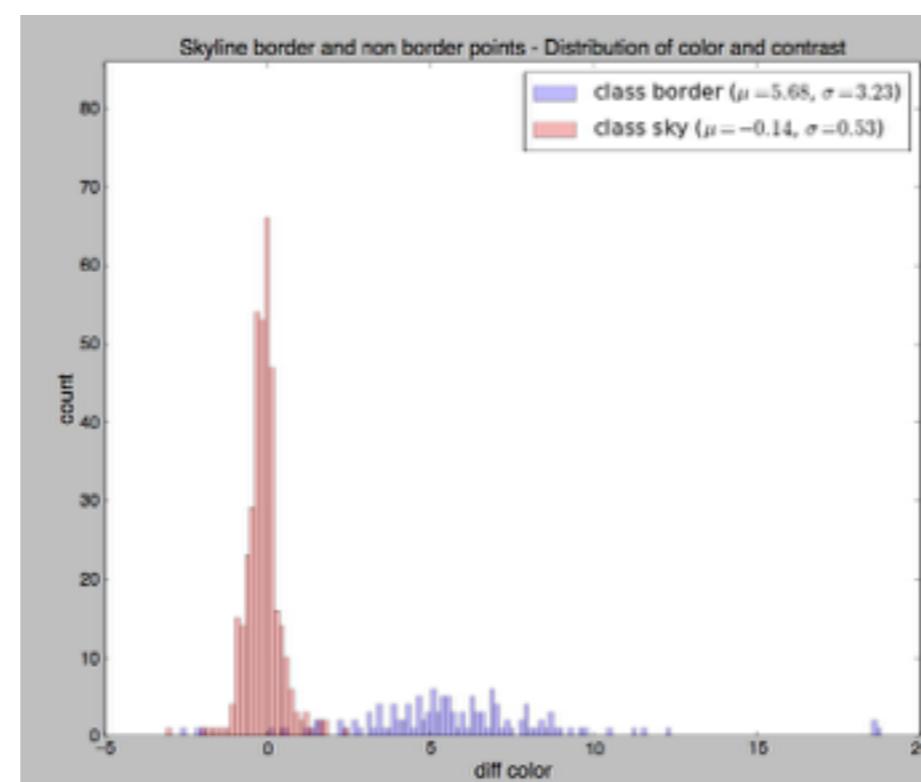
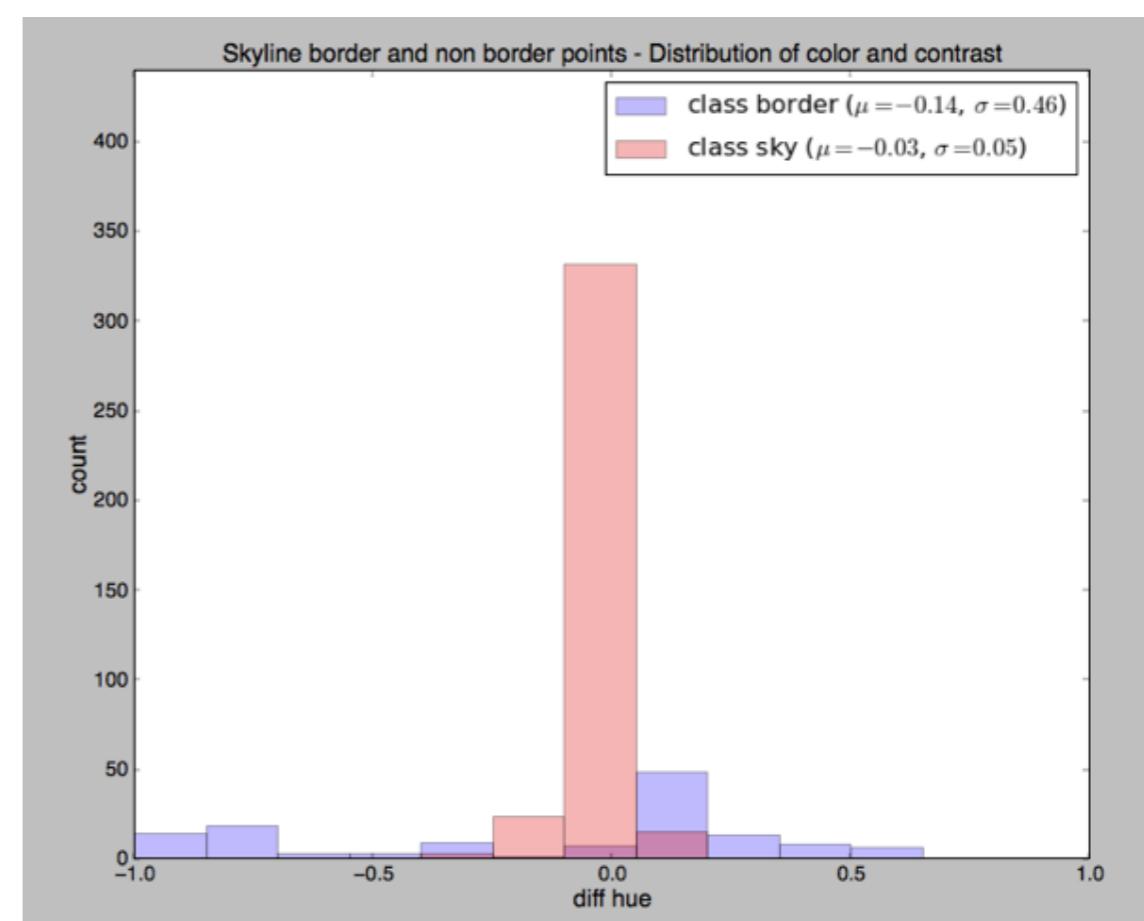
arches test image



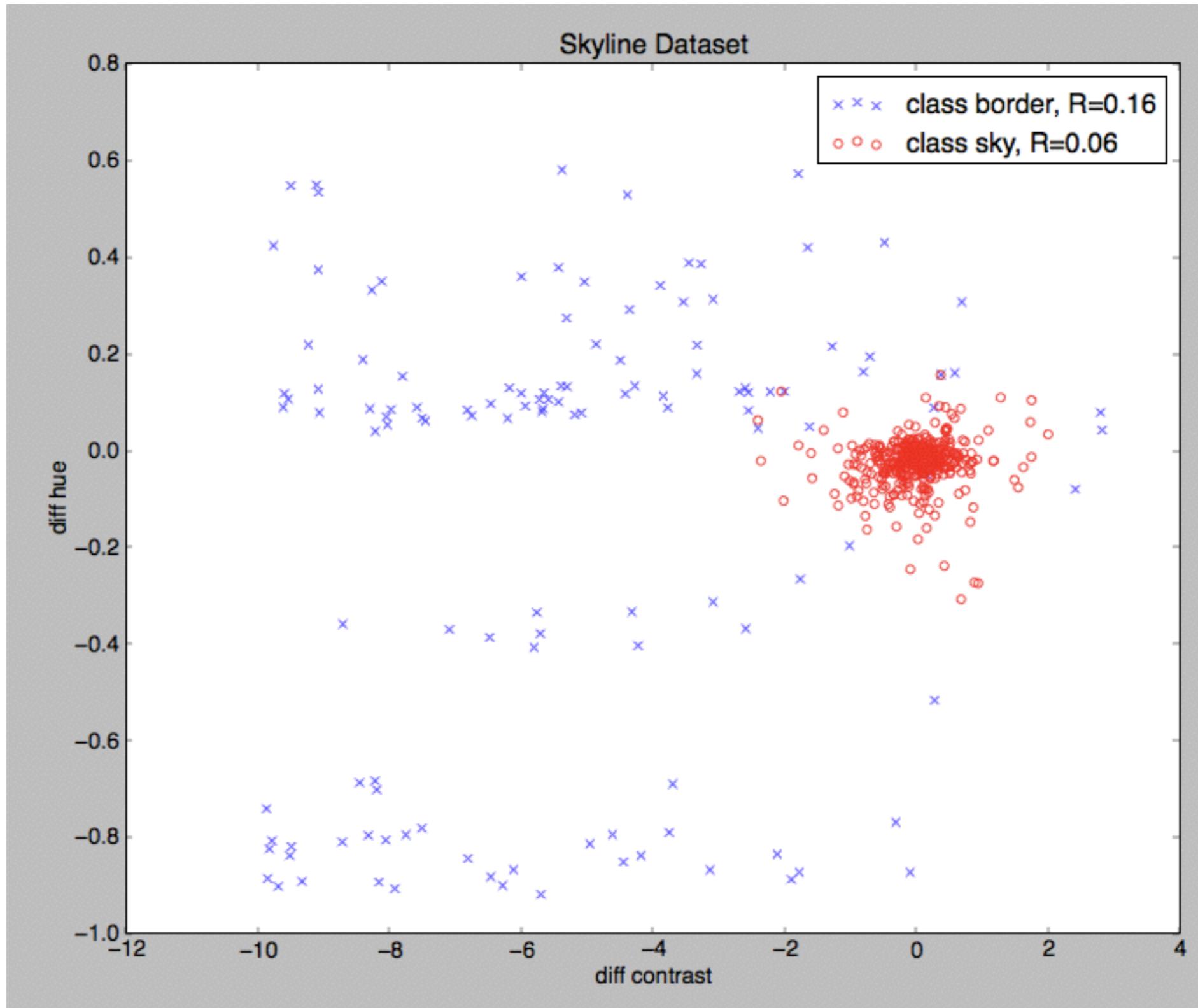
arches test image



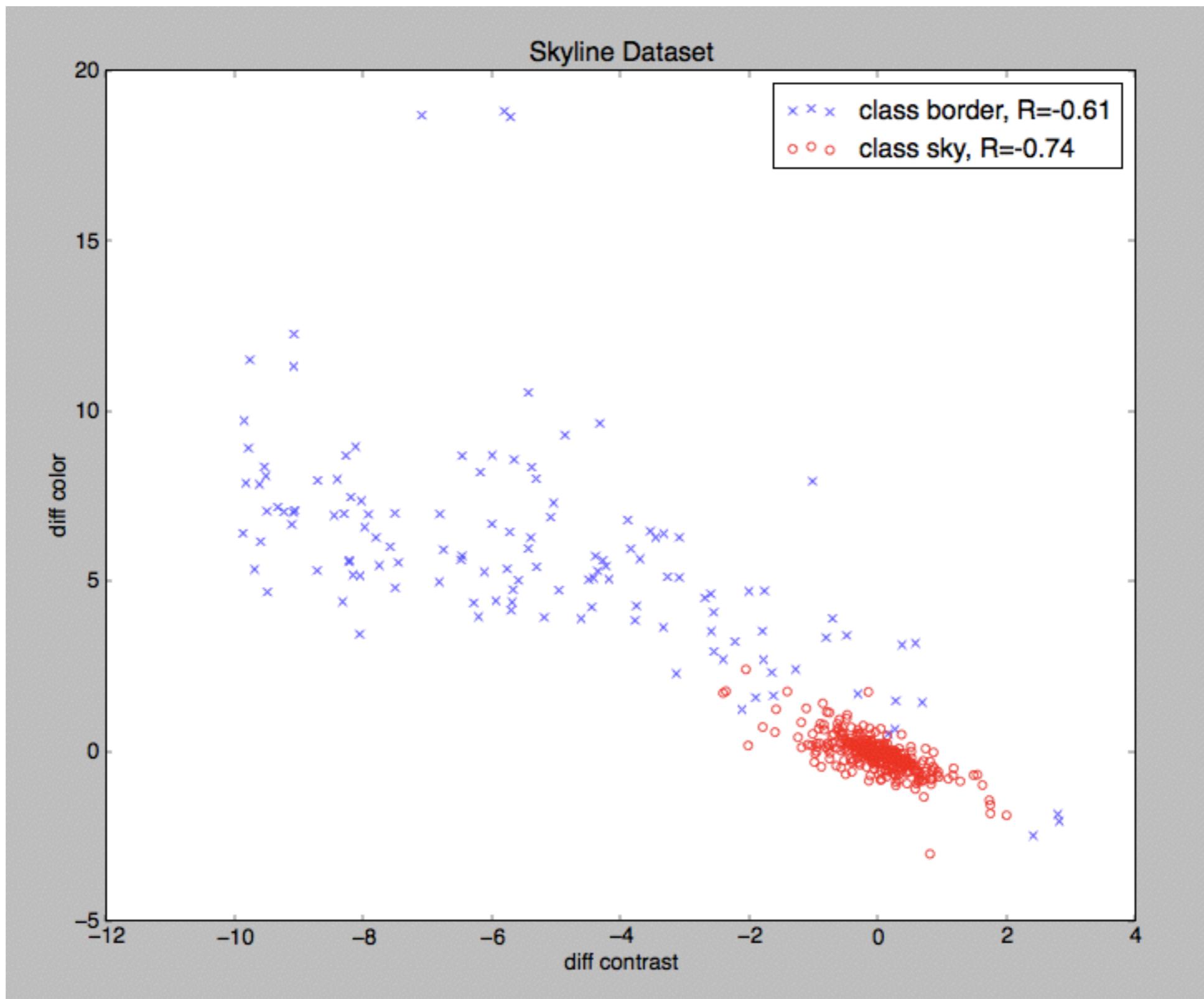
*note: the largest contrasts were removed from analysis for plot visibility



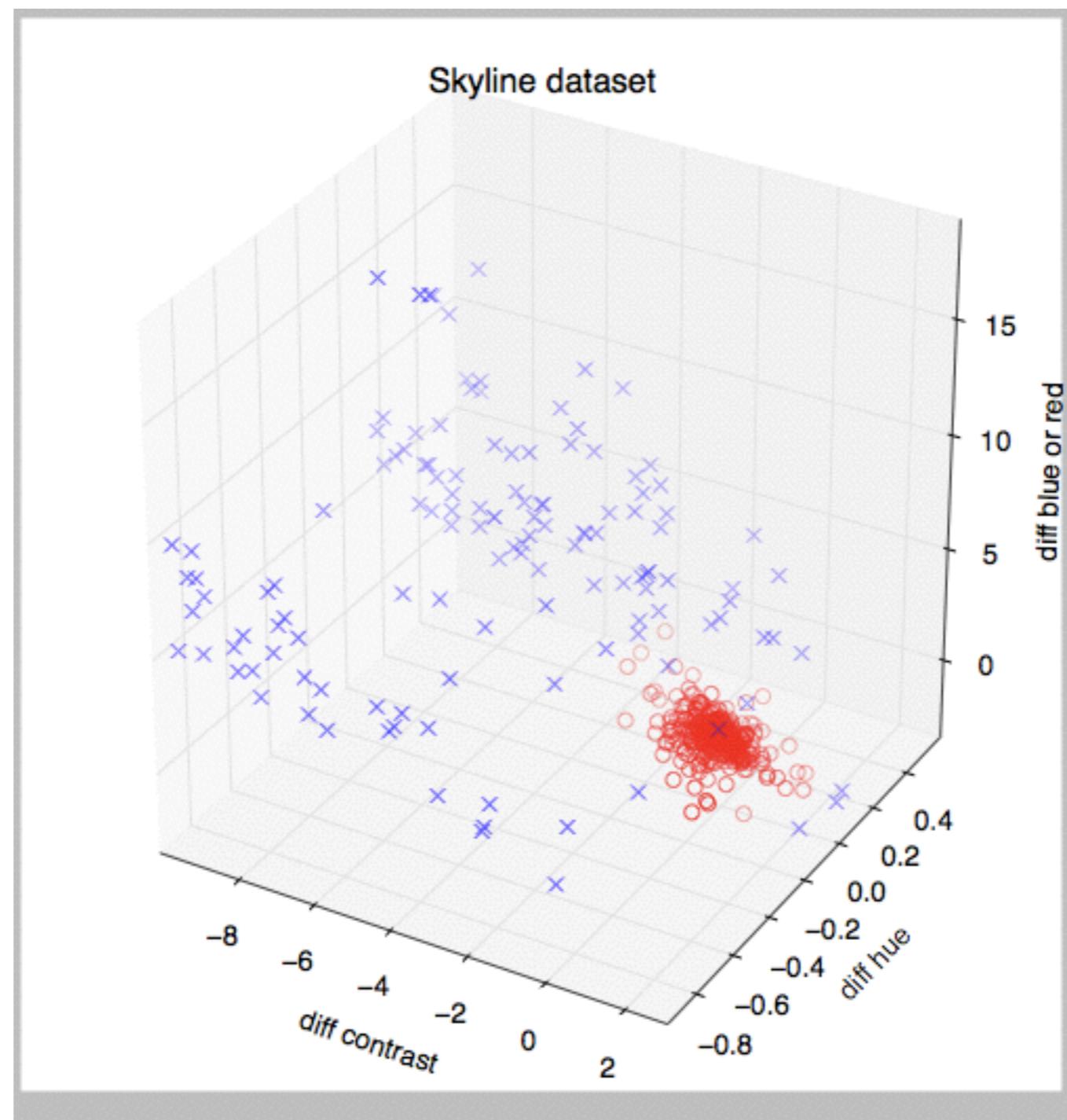
arches test image



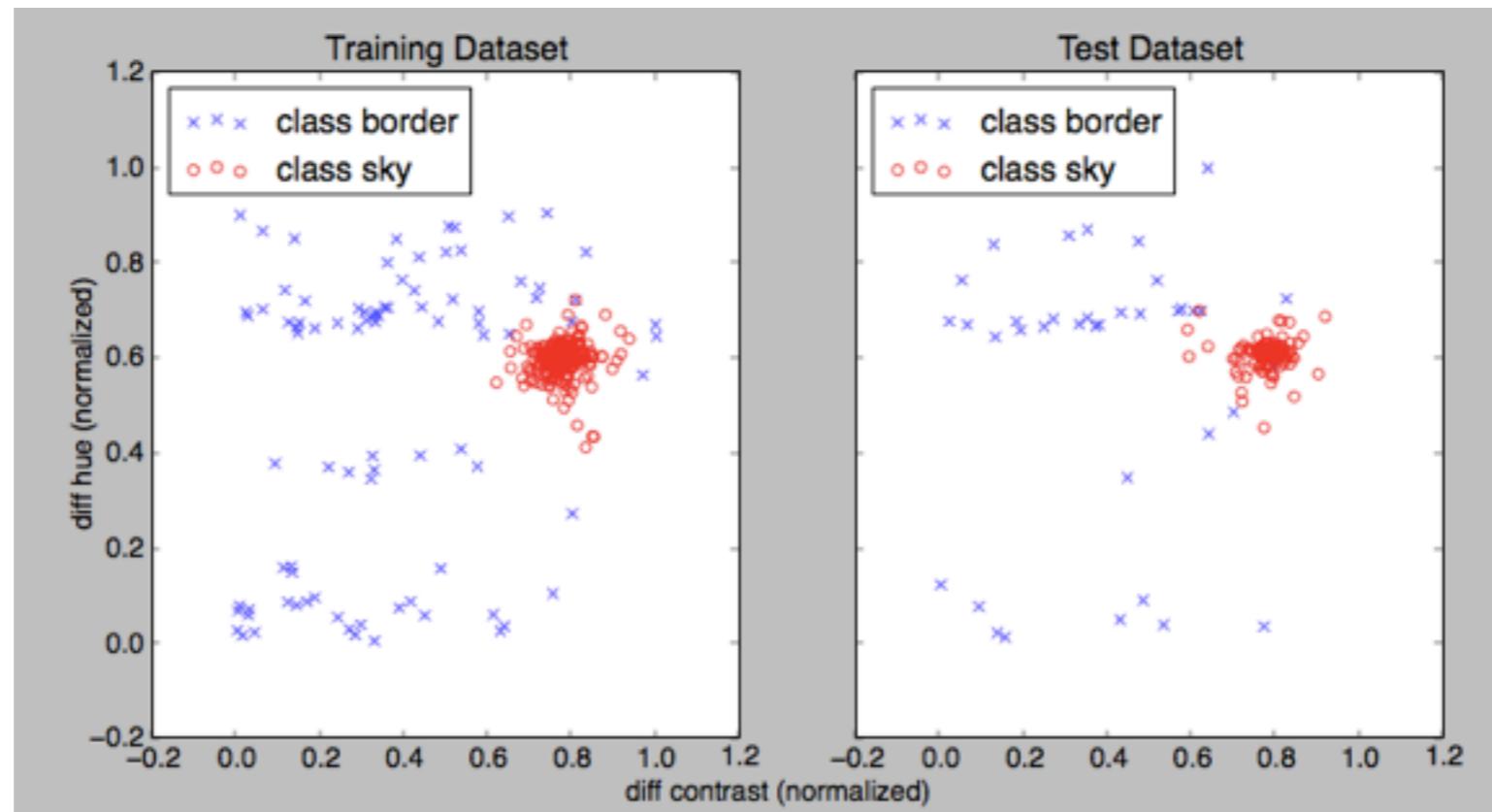
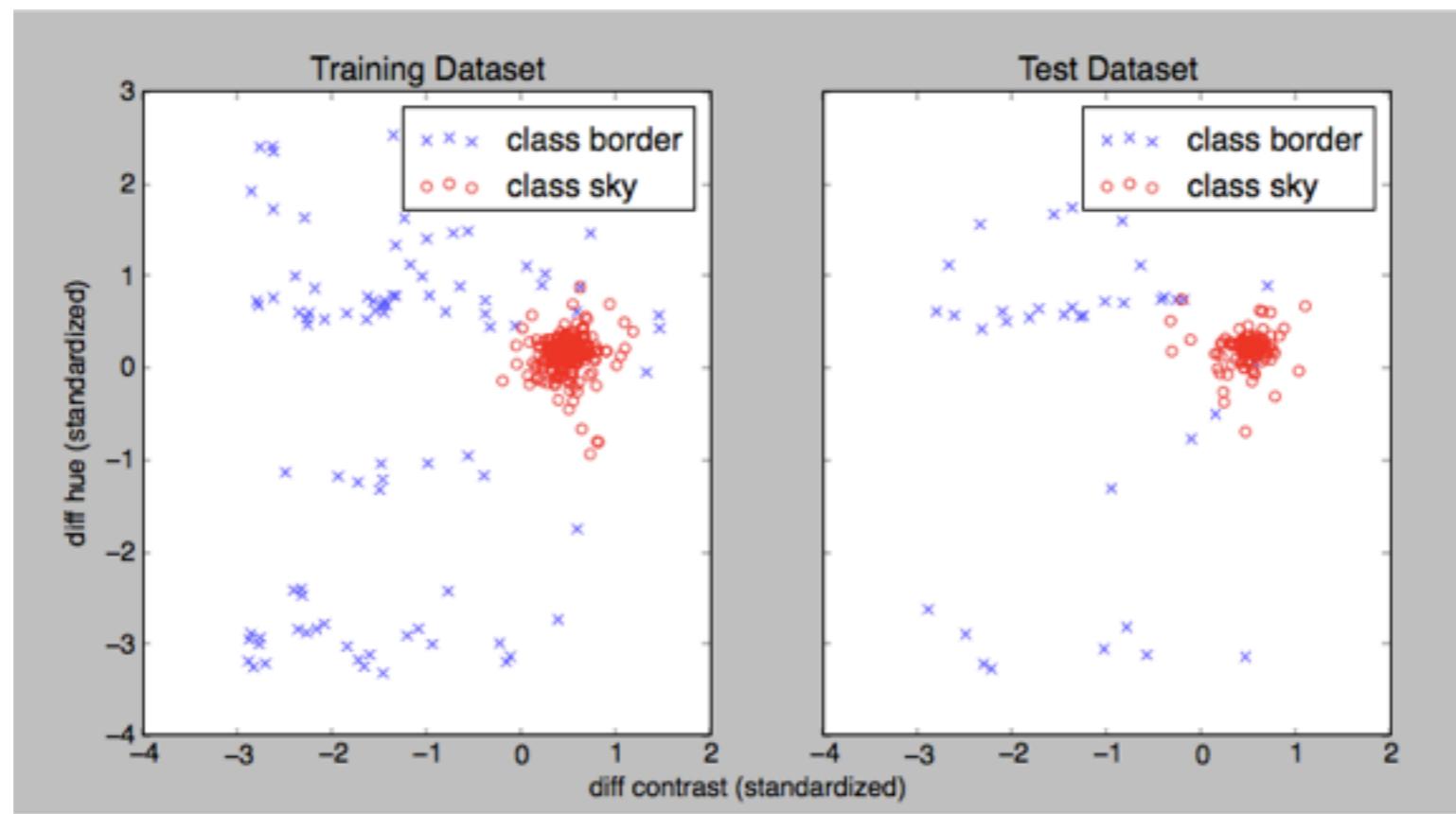
arches test image



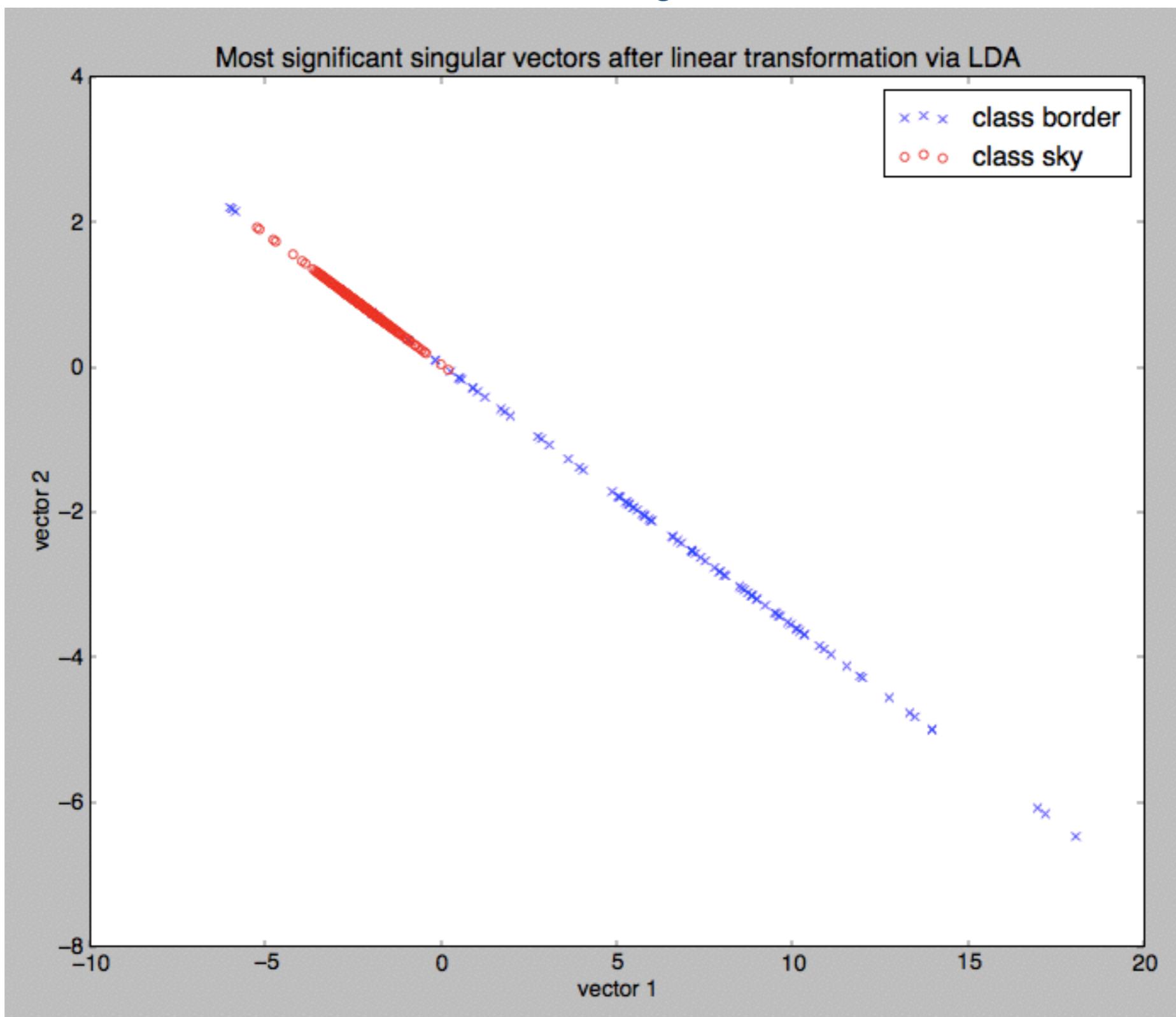
arches test image



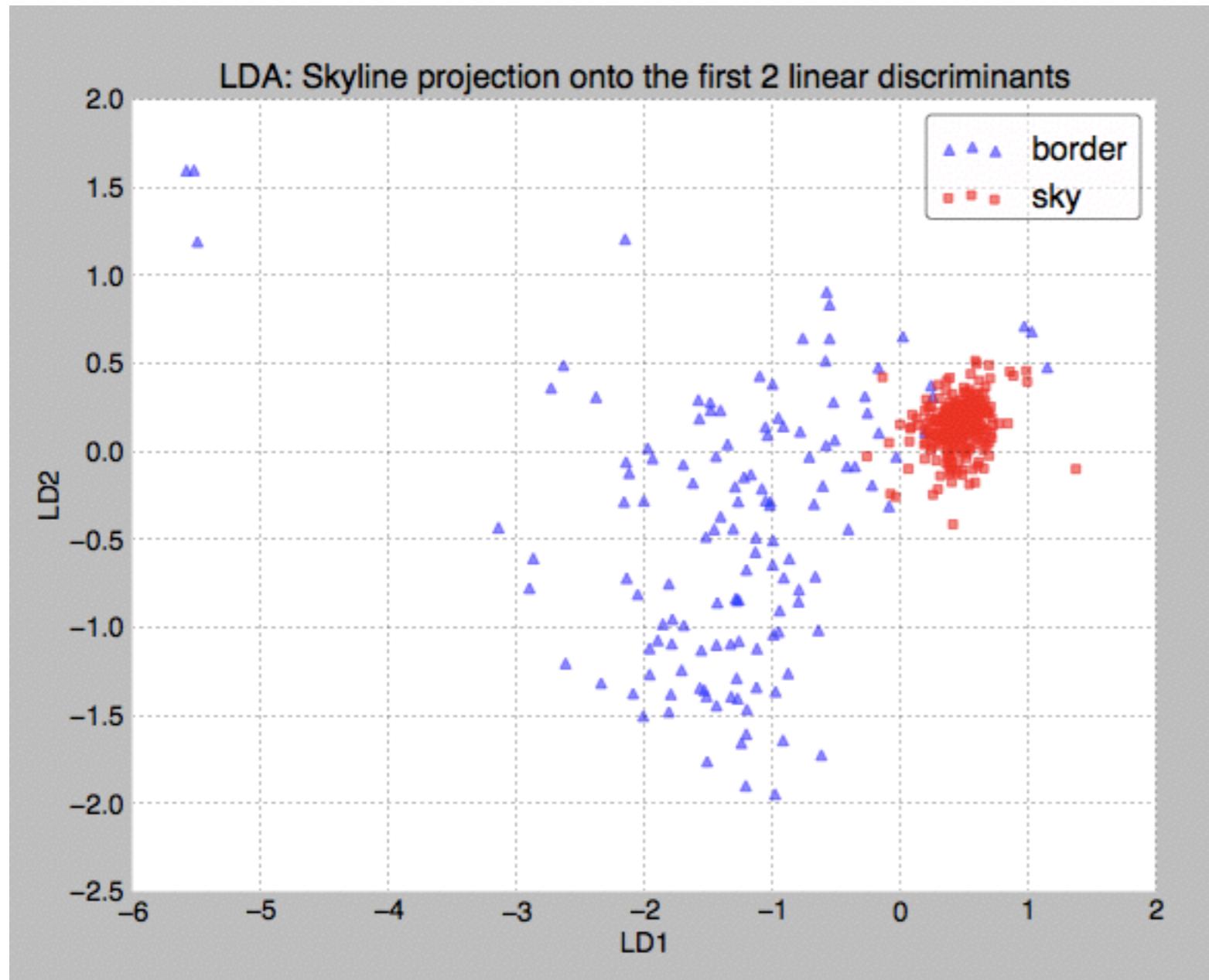
arches test image



arches test image



arches test image



contrast	hue	BorR
-1.367	-0.3369	1.406

Mean Vector class 1: [-1.367 -0.3369 1.406]

Mean Vector class 2: [0.4777 0.1177 -0.4914]

('within-class Scatter Matrix:\n',
array([[174.1759, 45.5446, -101.2847],
[45.5446, 482.0853, 21.4294],
[-101.2847, 21.4294, 155.194]]))

('between-class Scatter Matrix:\n',
array([[1193.746 , 452.6714, -801.2709],
[452.6714, 270.0177, -39.0431],
[-801.2709, -39.0431, 1250.6914]]))

Eigenvector 1:
[[-0.0864]
[0.0562]
[-0.9947]]

Eigenvalue 1: 8.15e+00

Eigenvector 2:
[[0.853]
[0.0182]
[0.5215]]

Eigenvalue 2: 6.30e+00

Eigenvector 3:
[[-0.5076]
[0.8076]
[-0.3]]

Eigenvalue 3: 4.17e-16

ok

Eigenvalues in decreasing order:

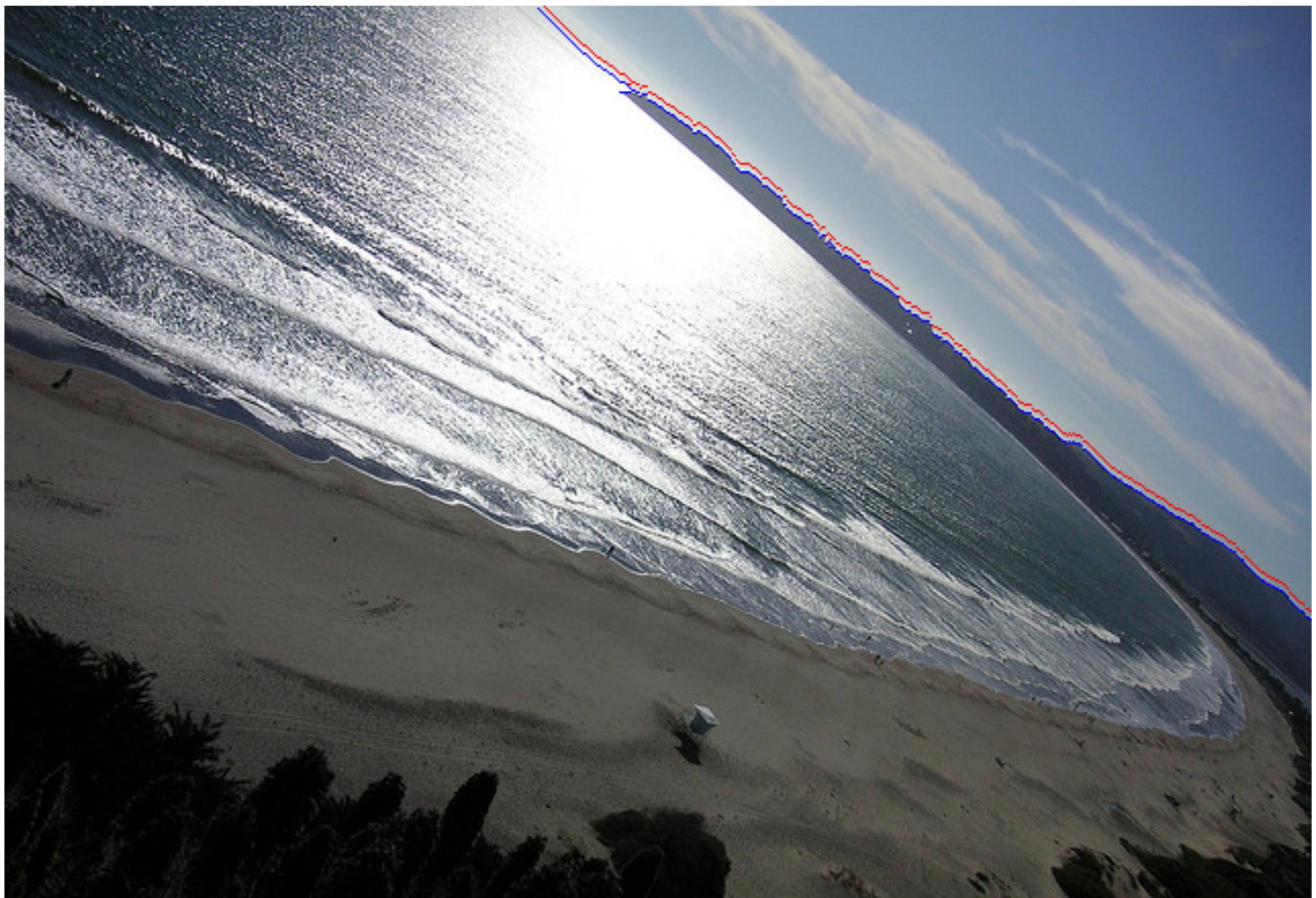
8.15019949428
6.30193750399
4.16985115178e-16

Variance explained:

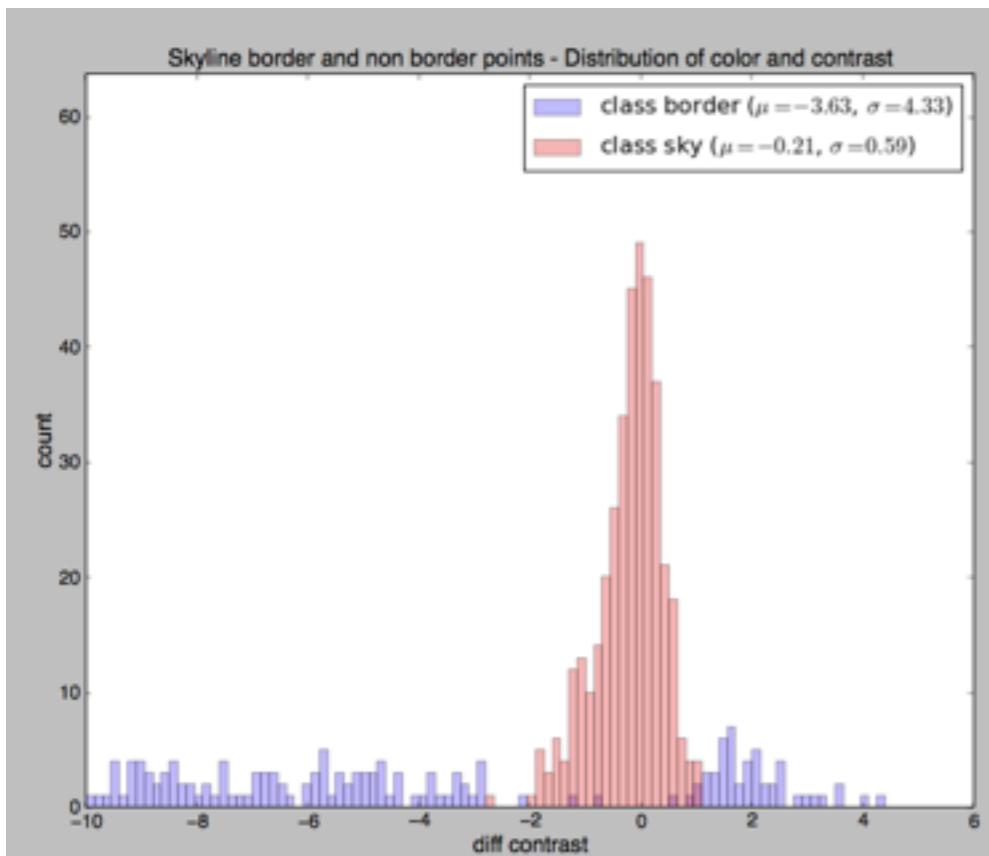
eigenvalue 1: 56.39%
eigenvalue 2: 43.61%
eigenvalue 3: 0.00%

('Matrix W:\n', array([[-0.0864, 0.0562, -0.9947],
[0.853 , 0.0182, 0.5215]]))

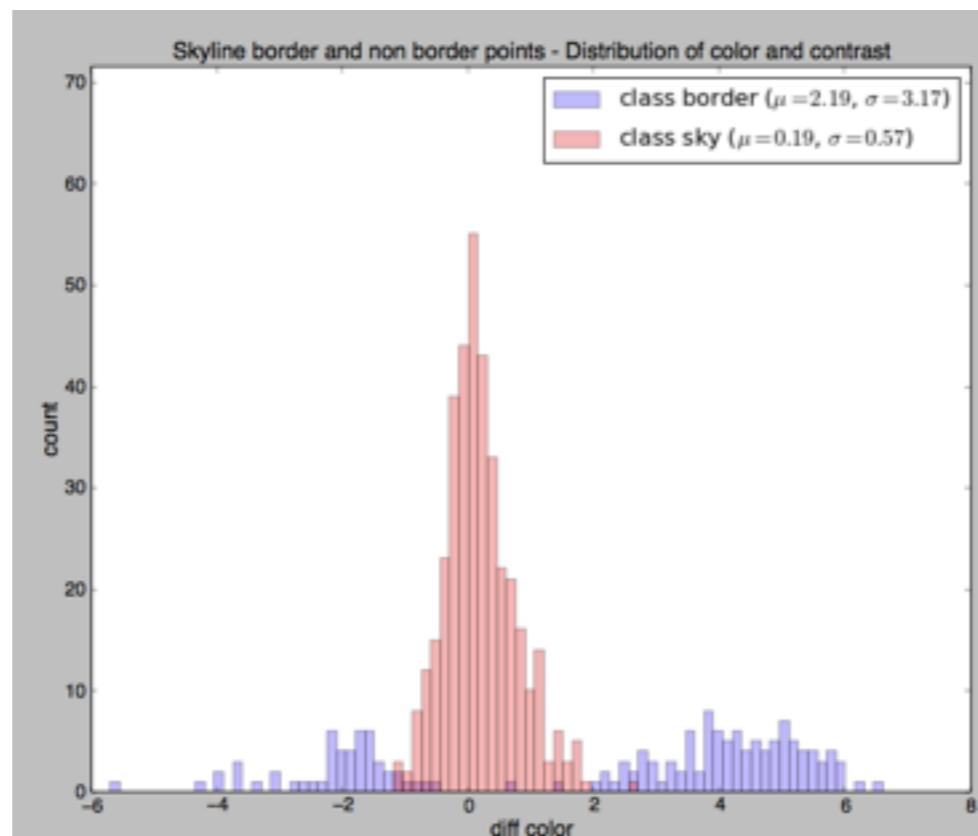
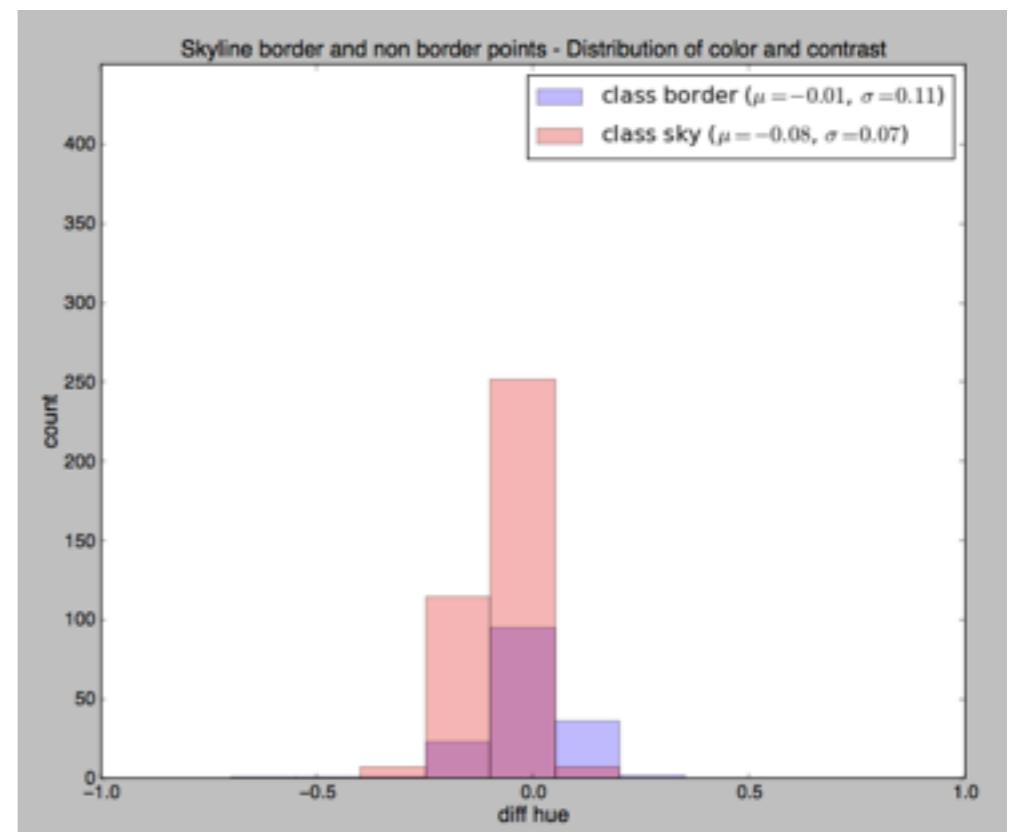
stinson test image



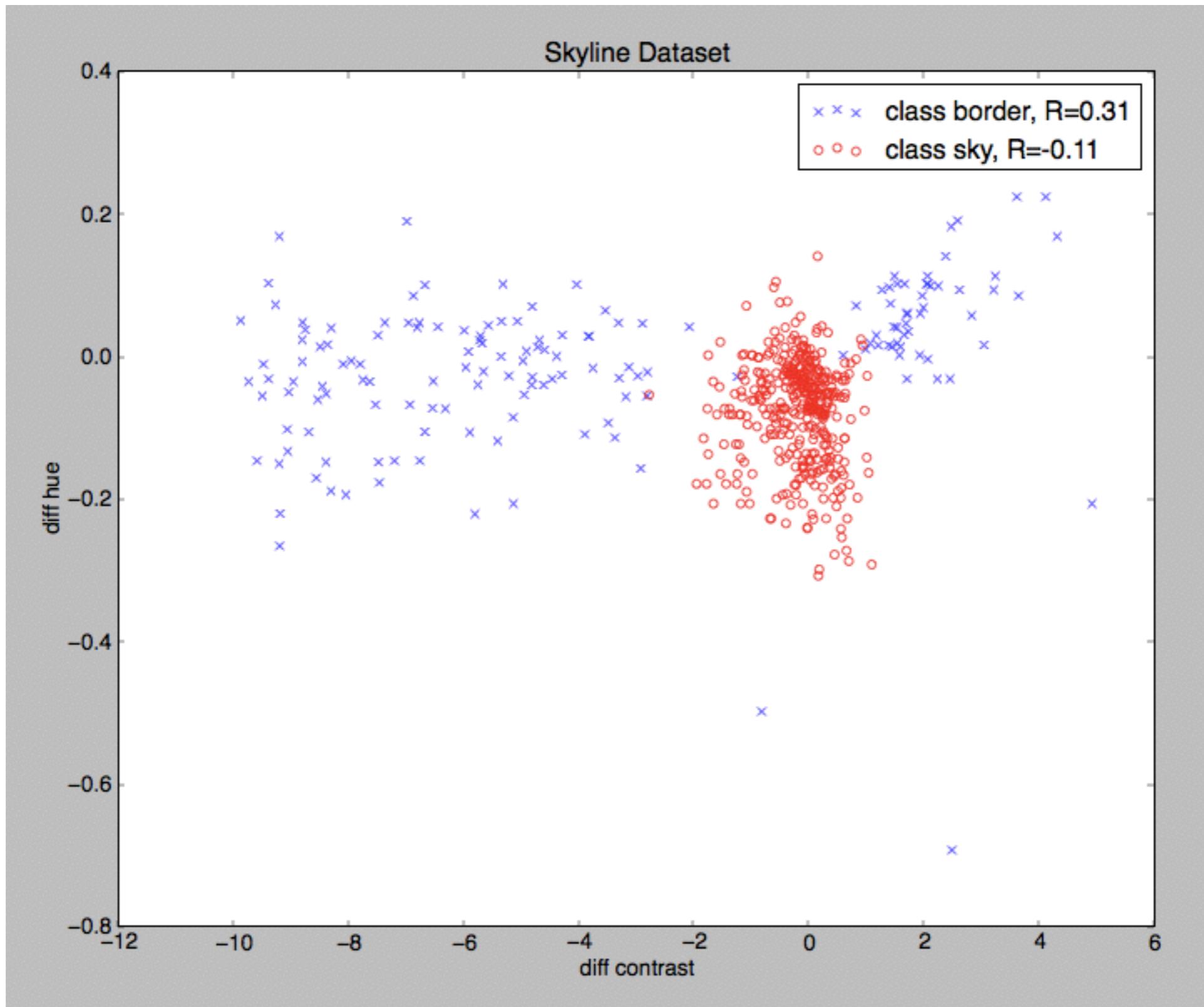
stinson test image



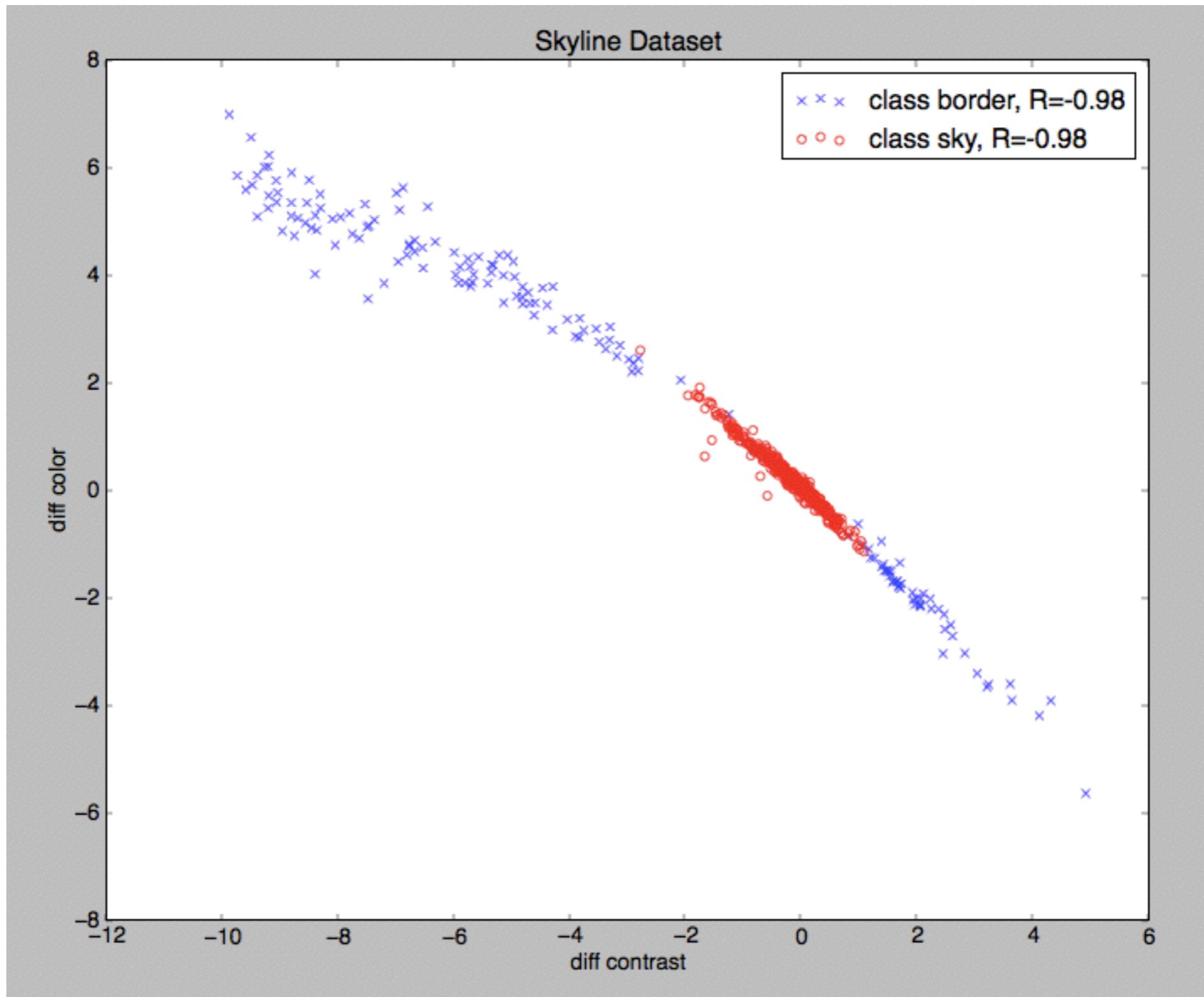
*note: the largest contrasts were removed from analysis for plot visibility



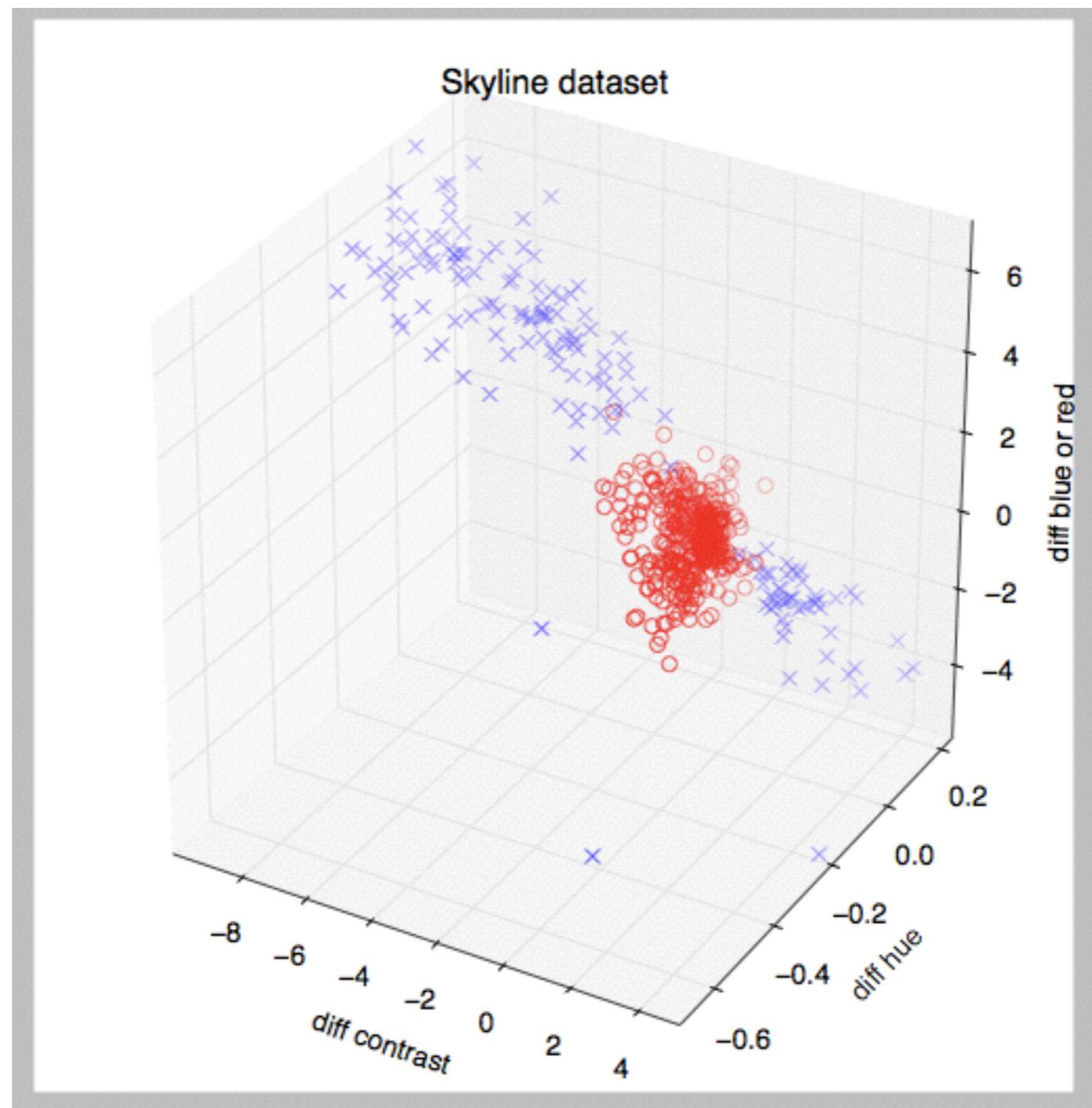
stinson test image



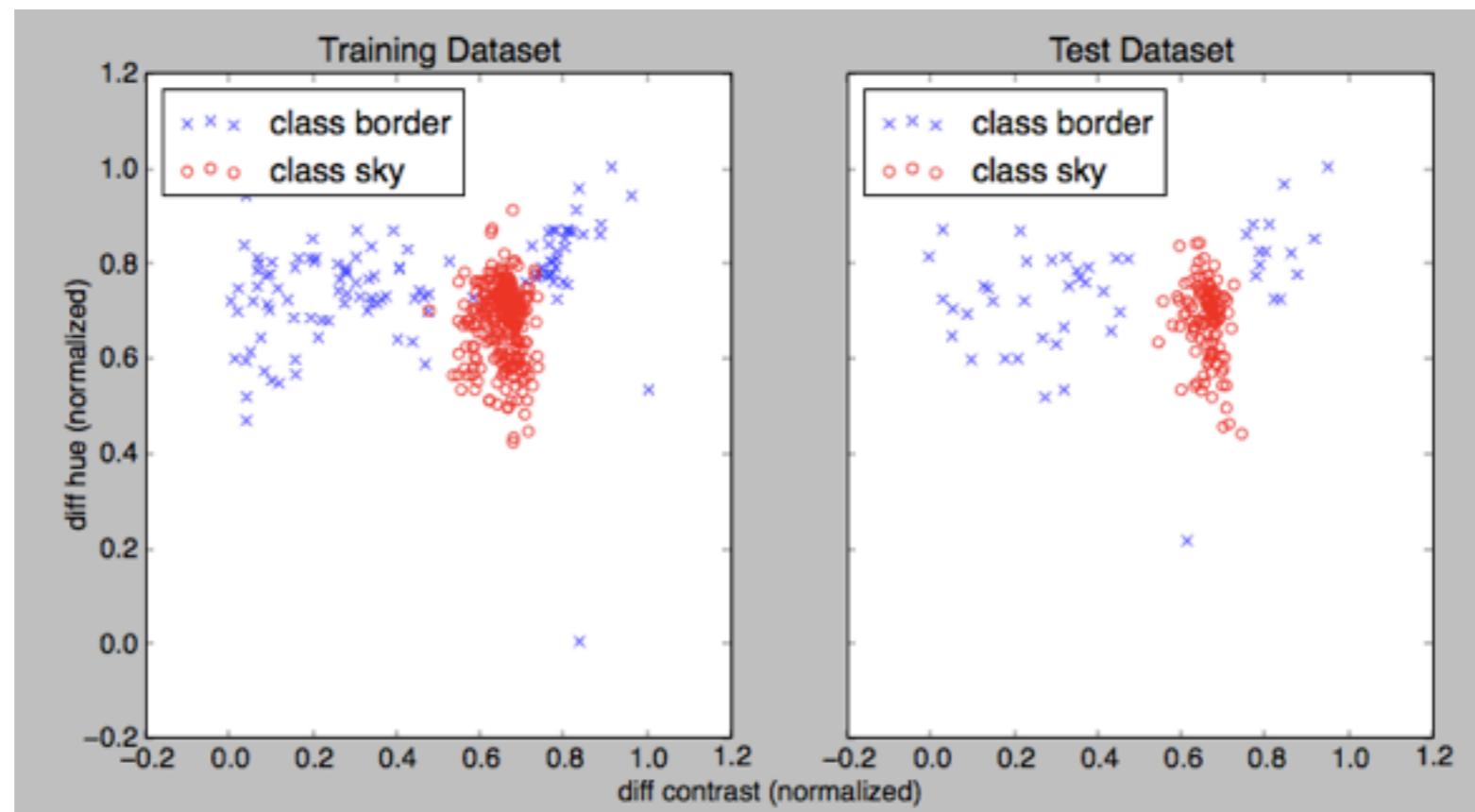
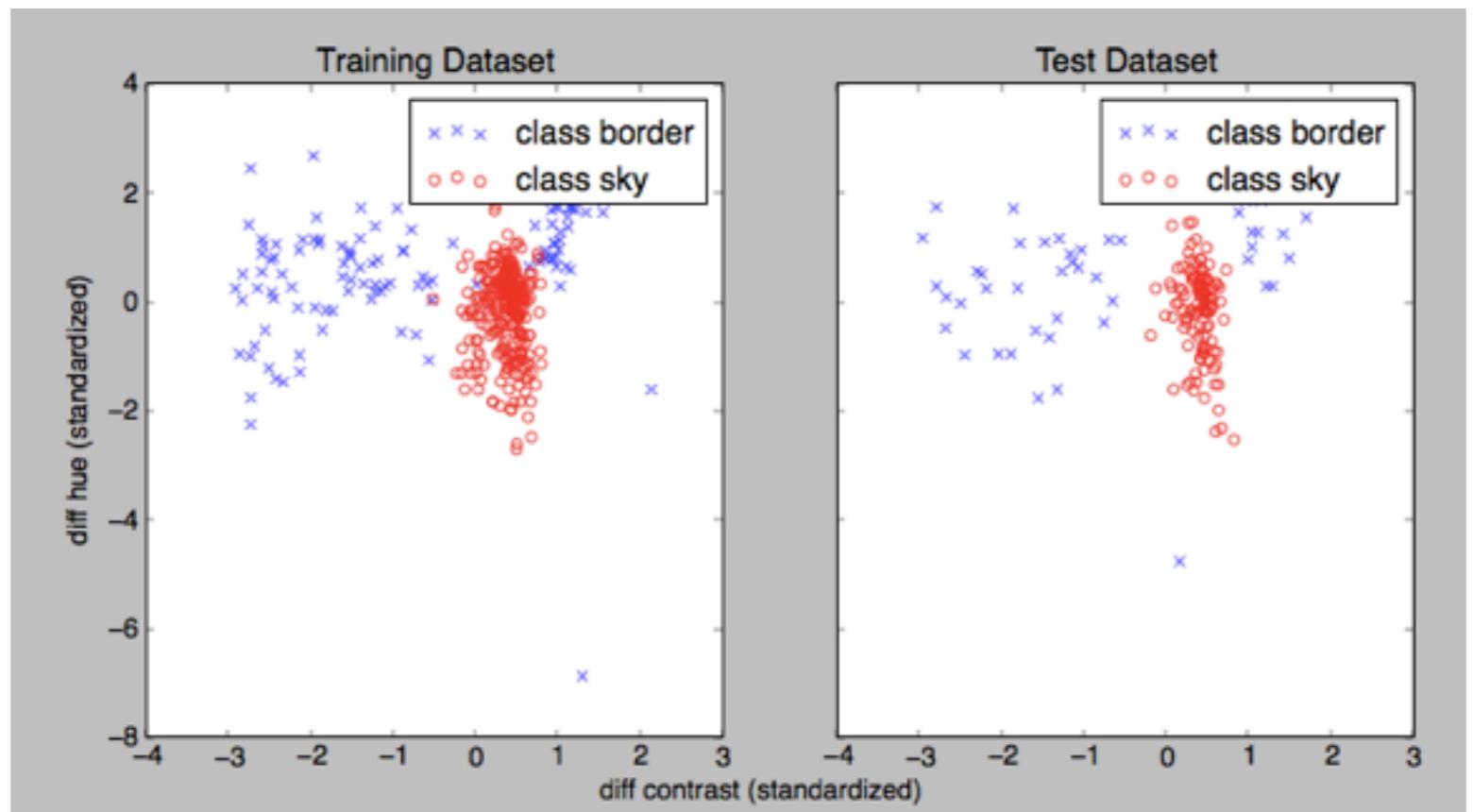
stinson test image



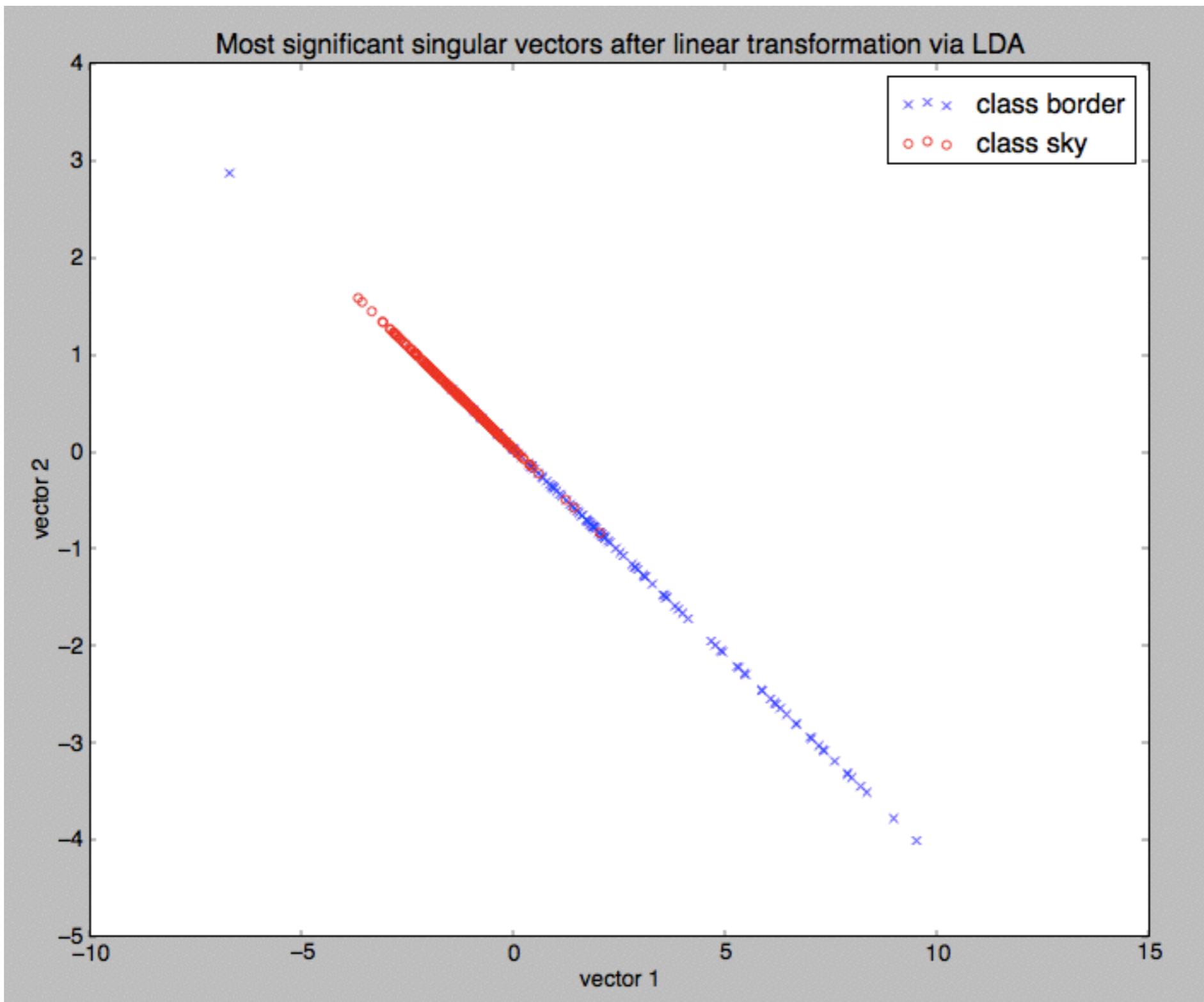
stinson test image



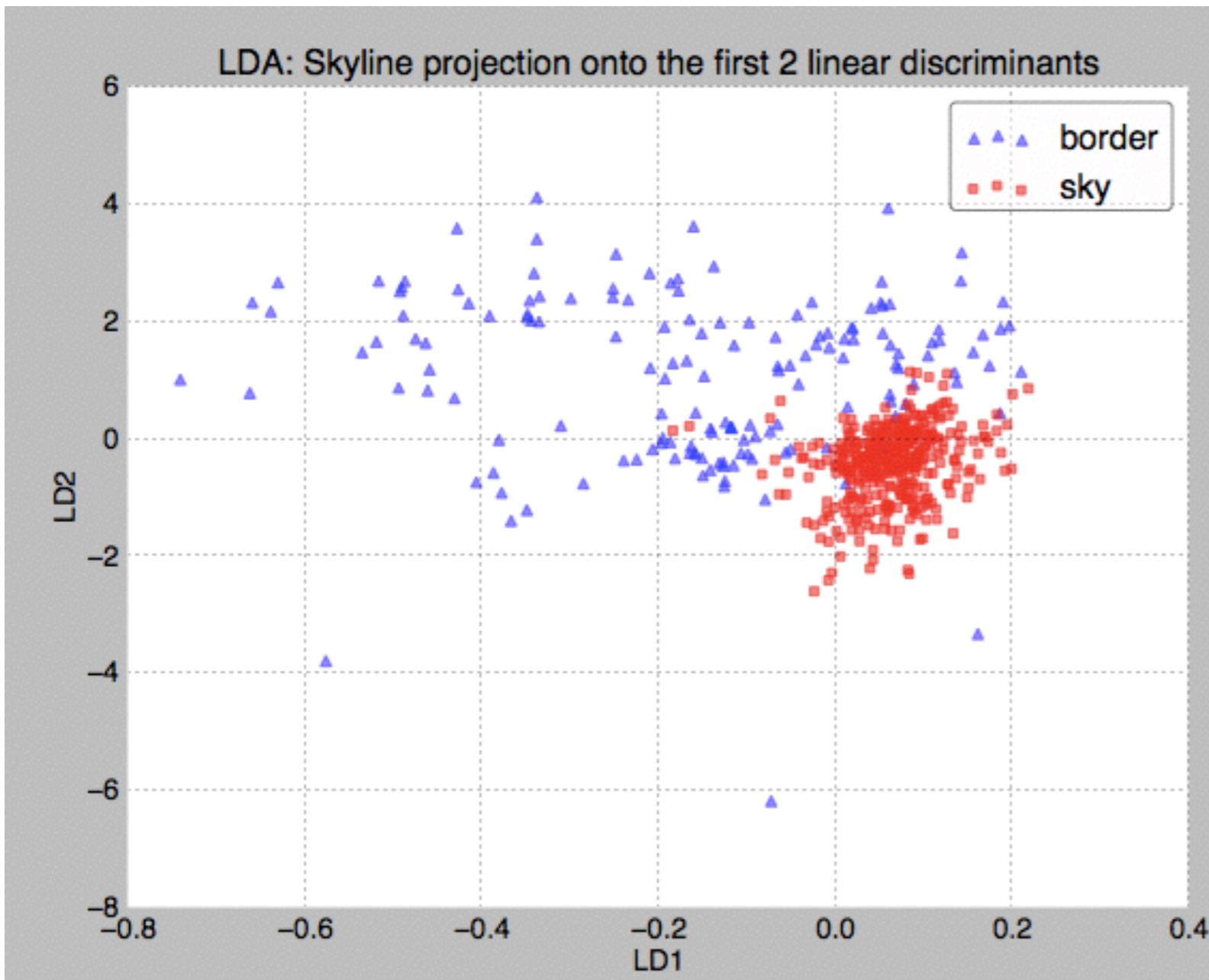
stinson test image



stinson test image



stinson test image



contrast	hue	BorR
-0.84	0.5231	0.7013

Mean Vector class 1: [-0.84 0.5231 0.7013]

Mean Vector class 2: [0.3524 -0.2195 -0.2942]

('within-class Scatter Matrix:\n',
array([[378.7388, 83.016 , -393.9848],
[83.016 , 476.2382, -73.8294],
[-393.9848, -73.8294, 426.9915]]))

('between-class Scatter Matrix:\n',
array([[544.4533, -230.8641, -332.2215],
[-230.8641, 251.9551, 315.0741],
[-332.2215, 315.0741, 399.6952]]))

Eigenvector 1:
[[0.7351]
[-0.0186]
[0.6777]]

Eigenvalue 1: 1.82e+01

Eigenvector 2:
[[-0.2304]
[0.6909]
[0.6853]]

Eigenvalue 2: 1.71e+00

Eigenvector 3:
[[-0.0863]
[0.7463]
[-0.66]]

Eigenvalue 3: 7.15e-16

ok

Eigenvalues in decreasing order:

18.2106532786
1.70921681581
7.14804521187e-16

Variance explained:

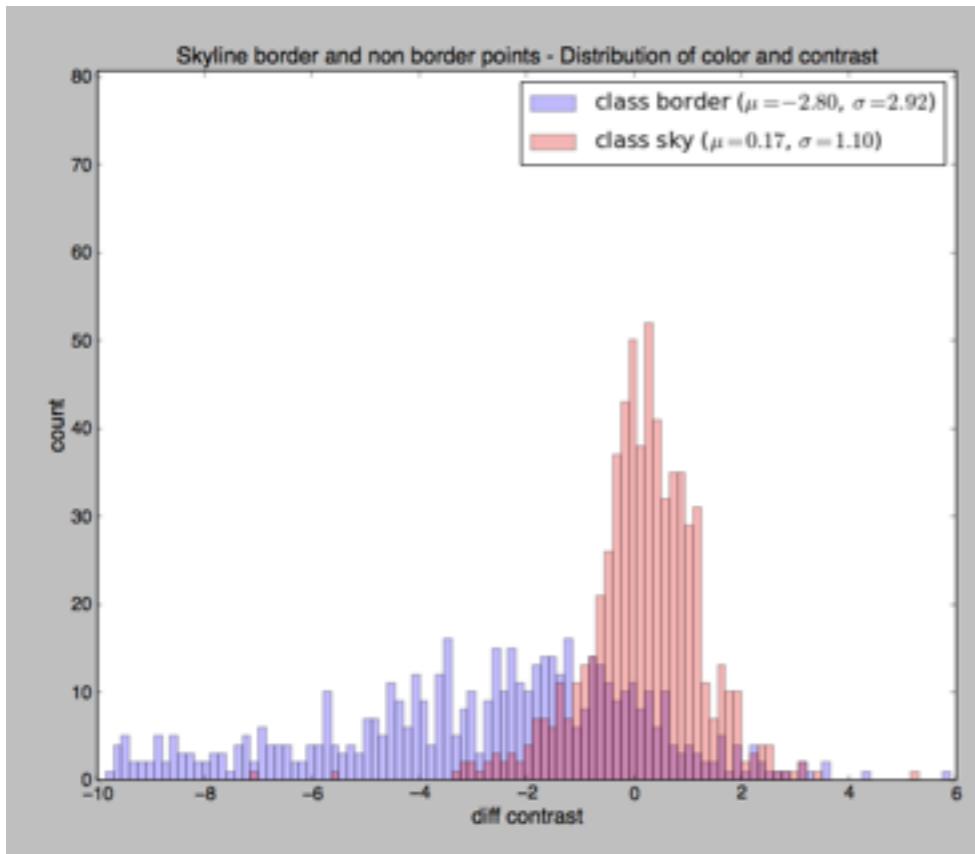
eigenvalue 1: 91.42%
eigenvalue 2: 8.58%
eigenvalue 3: 0.00%

('Matrix W:\n', array([[0.7351, -0.0186, 0.6777],
[-0.2304, 0.6909, 0.6853]]))

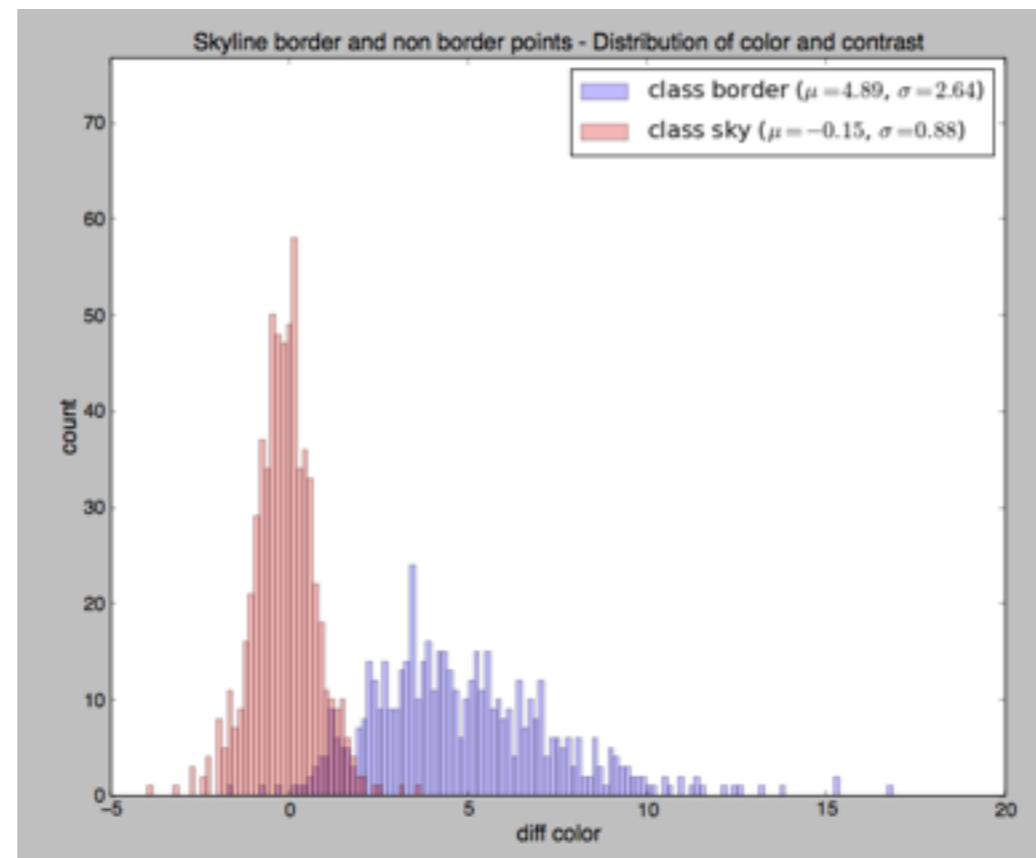
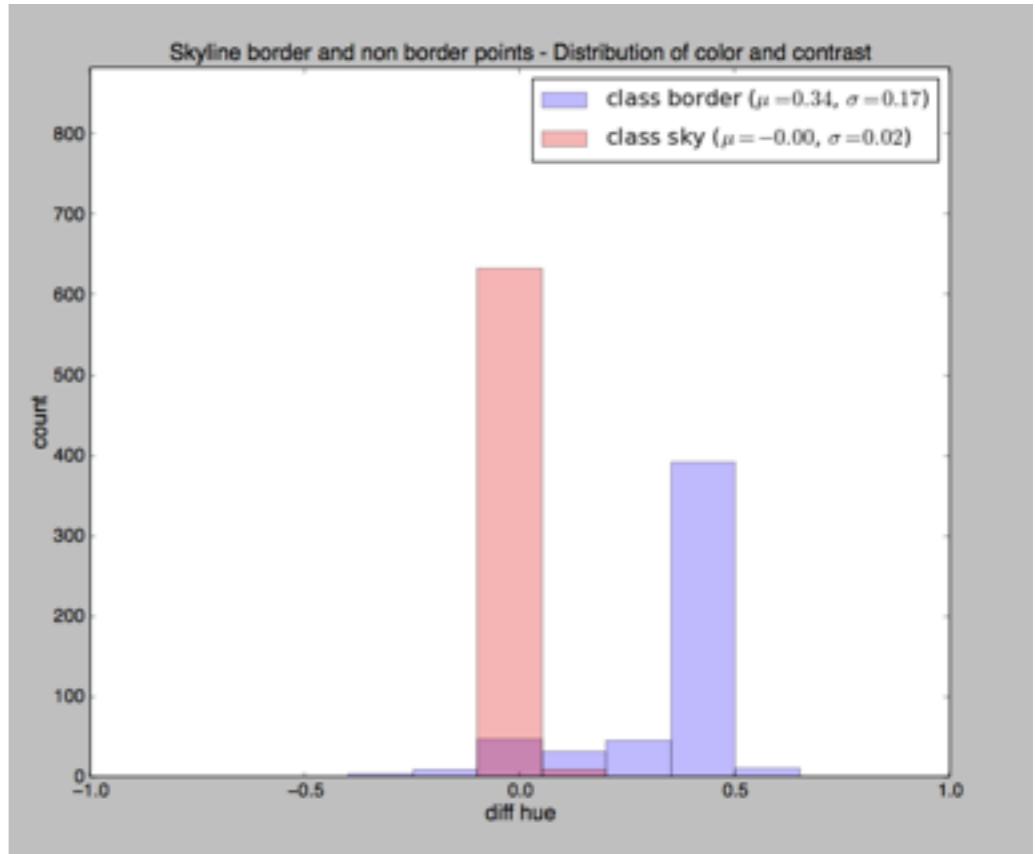
cloudy san jose test image



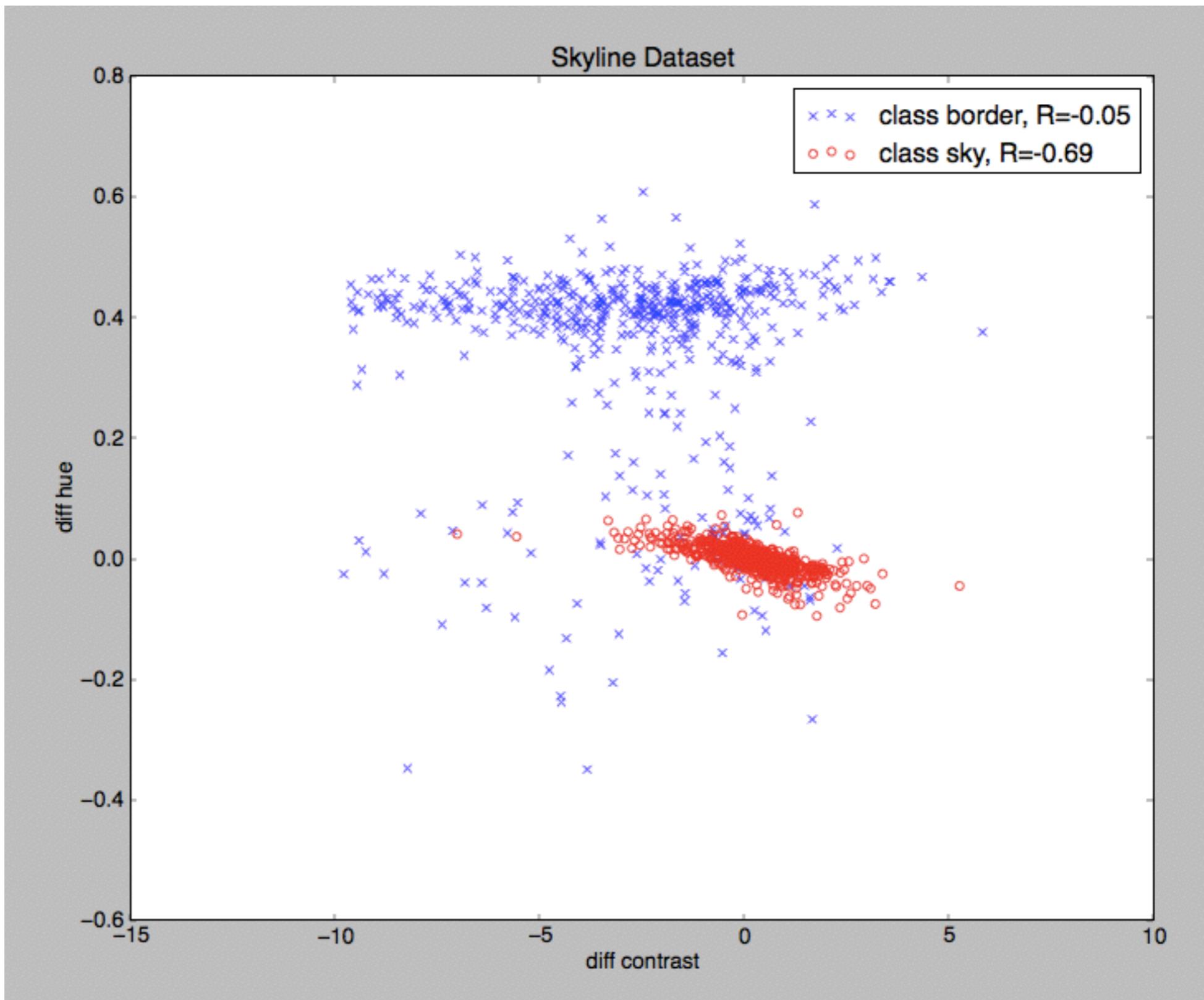
cloudy san jose test image



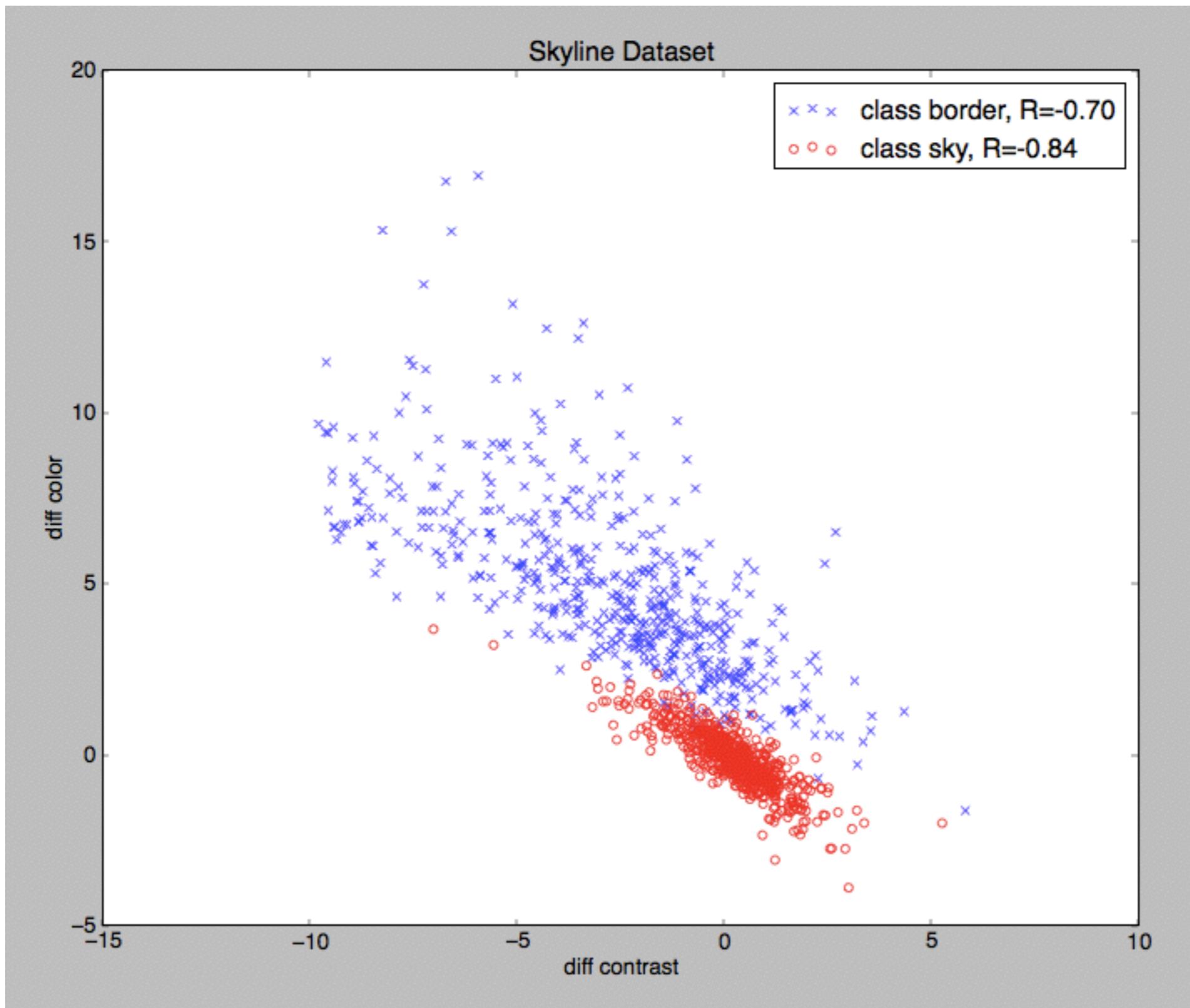
*note: the largest contrasts were removed from analysis for plot visibility



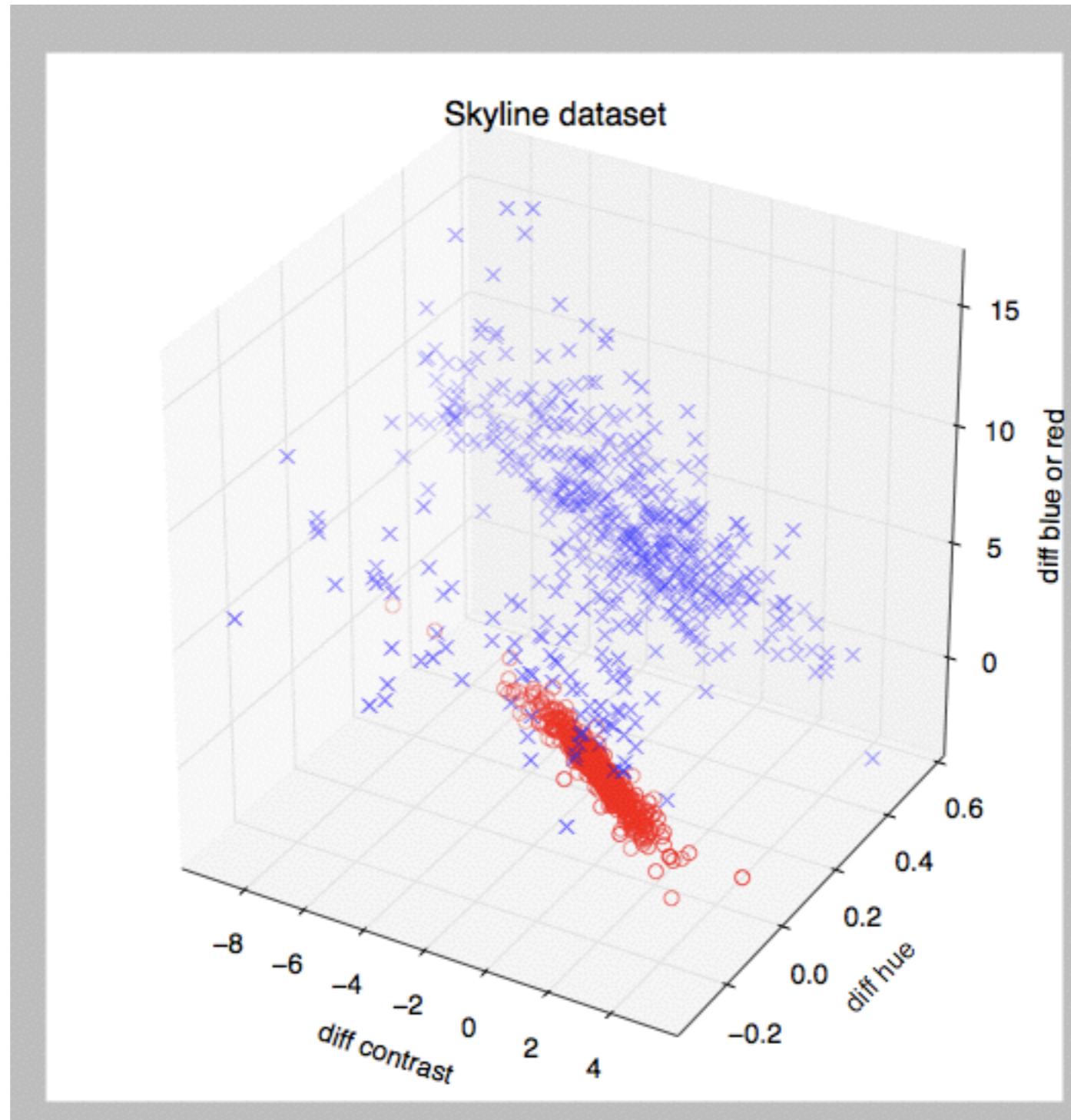
cloudy san jose test image



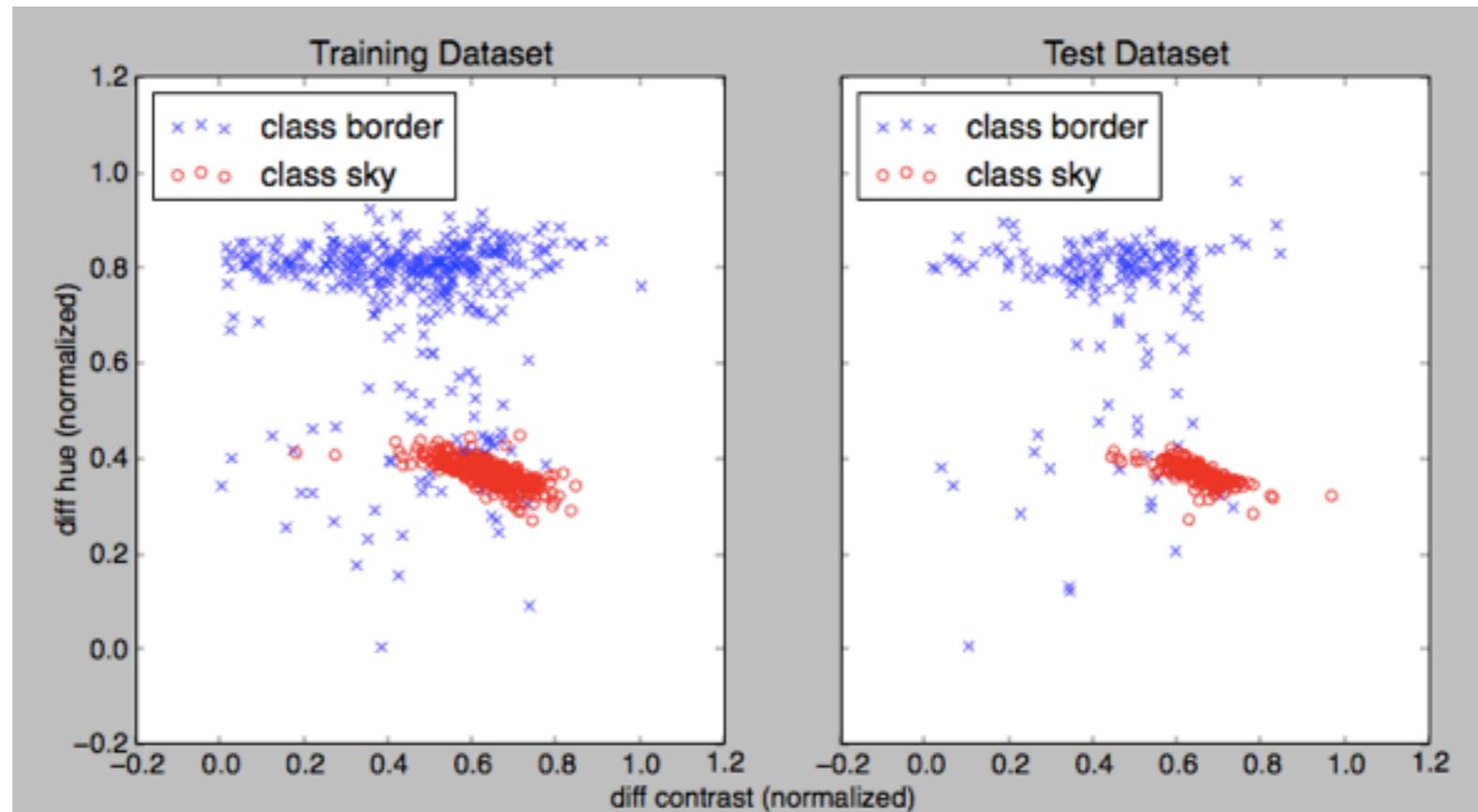
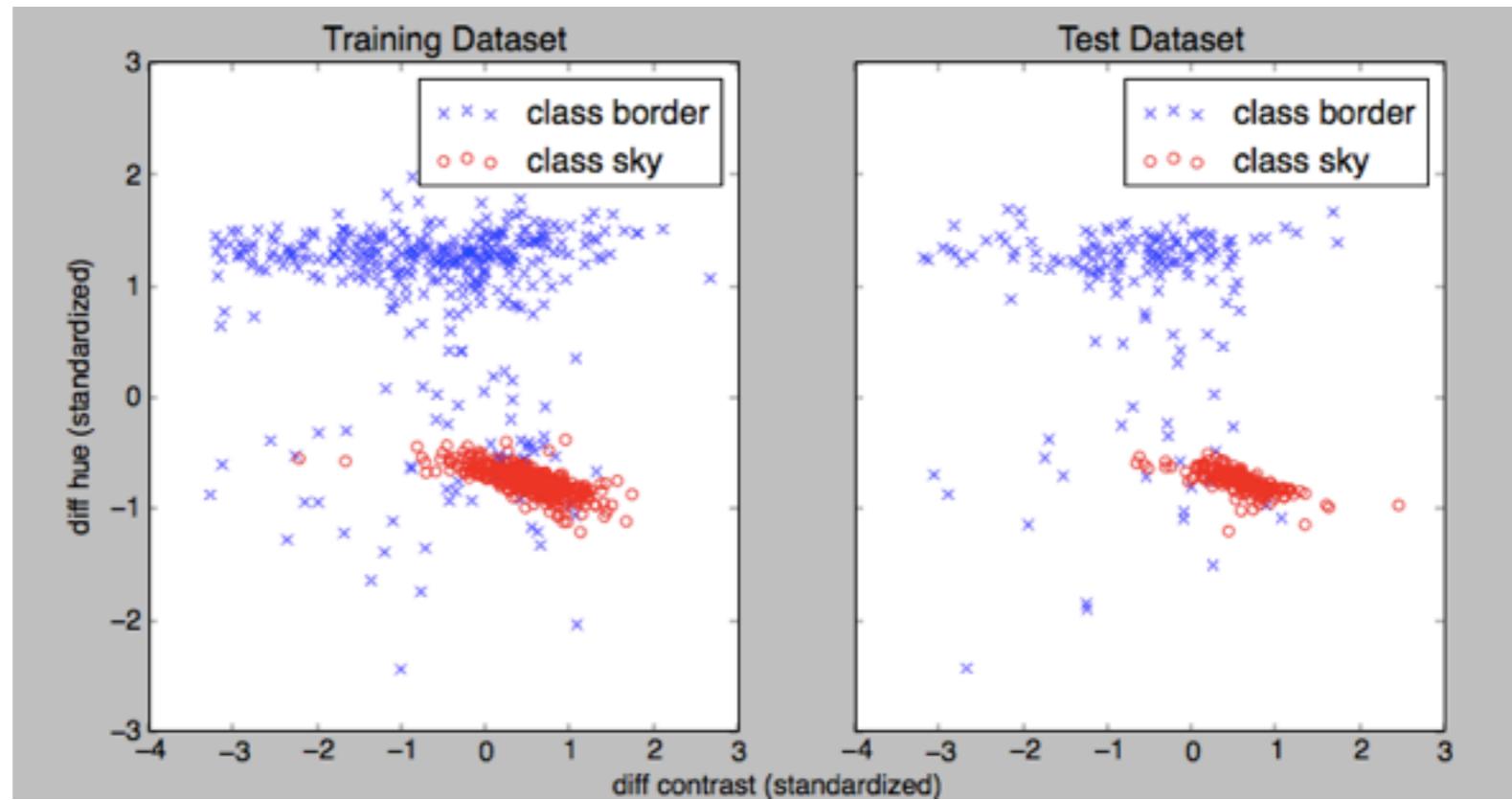
cloudy san jose test image



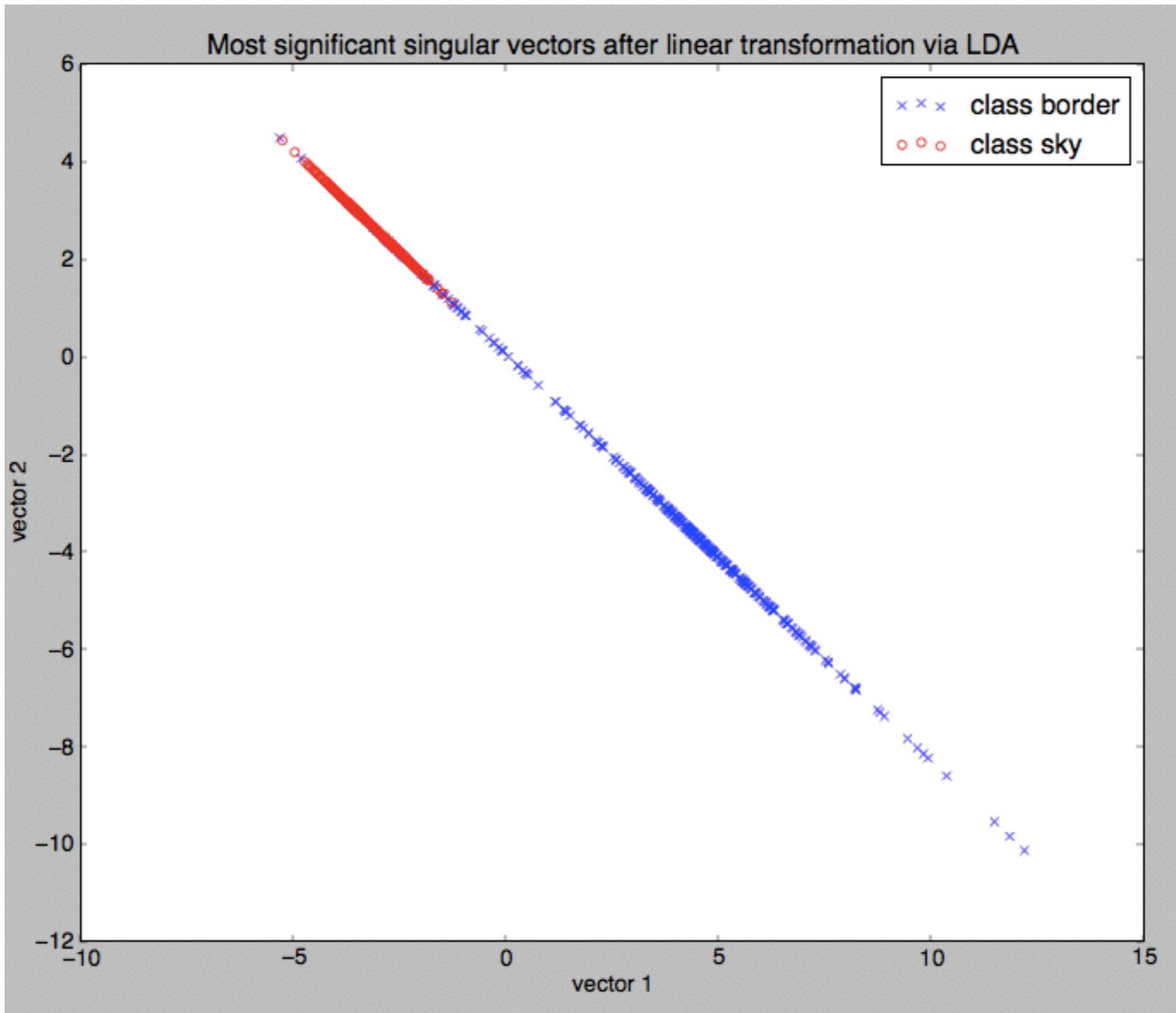
cloudy san jose test image



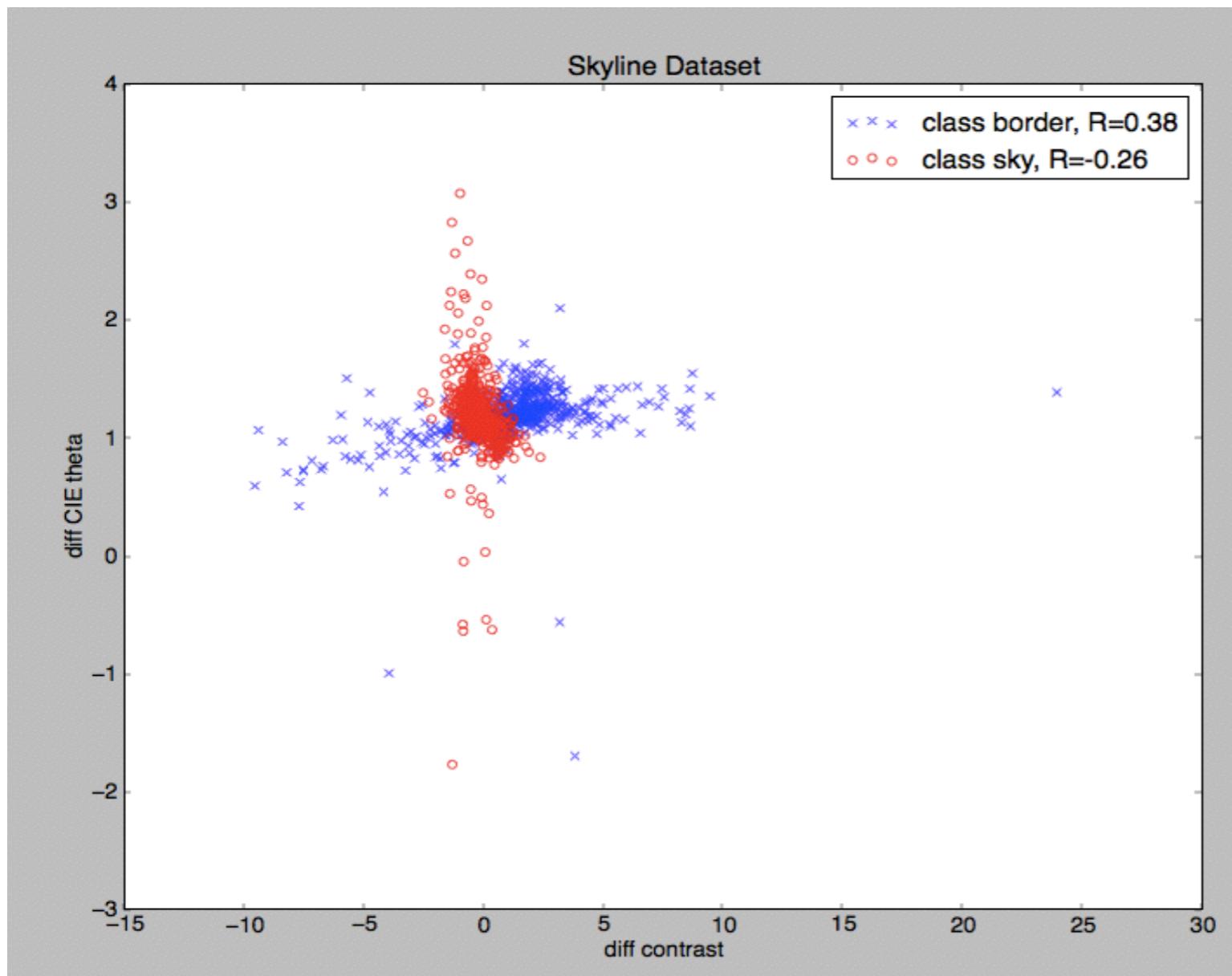
cloudy san jose test image



cloudy san jose test image



cloudy san jose test image



contrast	hue	BorR
-0.6249	0.915	0.8745

Mean Vector class 1: [0.5206 -0.7623 -0.7285]

('within-class Scatter Matrix:\n',
array([[792.7025, -45.451 , -419.4417],
[-45.451 , 355.4534, 103.9867],
[-419.4417, 103.9867, 426.4421]]))

('between-class Scatter Matrix:\n',
array([[1163.2016, -1662.9155, -1588.5417],
[-1662.9155, 2474.949 , 2366.0545],
[-1588.5417, 2366.0545, 2261.9829]]))

Eigenvector 1:
[[0.1214]
[0.7336]
[0.6686]]

Eigenvalue 1: 9.84e+00

Eigenvector 2:
[[0.6999]
[-0.1895]
[0.6886]]

Eigenvalue 2: 1.29e-01

Eigenvector 3:
[[-0.0189]
[-0.6975]
[0.7163]]

Eigenvalue 3: 1.85e-15

ok

Eigenvalues in decreasing order:

9.84005195578
0.128680128928
1.85202129573e-15

Variance explained:

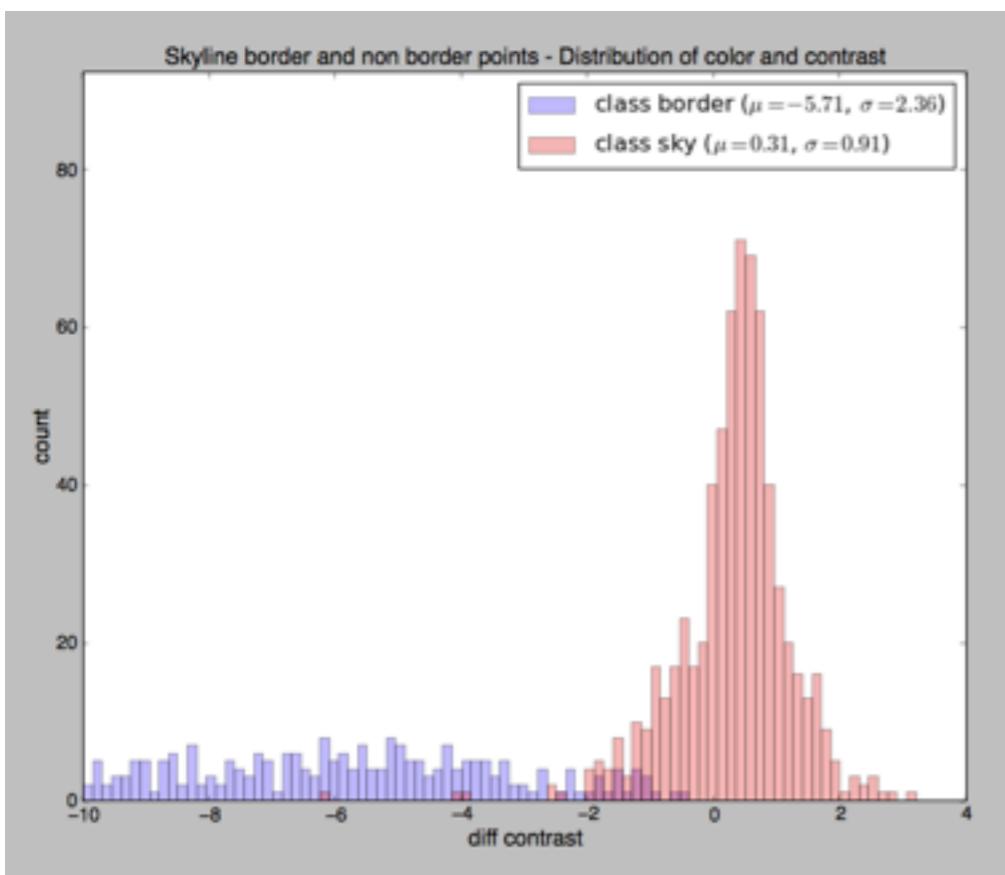
eigenvalue 1: 98.71%
eigenvalue 2: 1.29%
eigenvalue 3: 0.00%

('Matrix W:\n', array([[0.1214, 0.7336, 0.6686],
[0.6999, -0.1895, 0.6886]]))

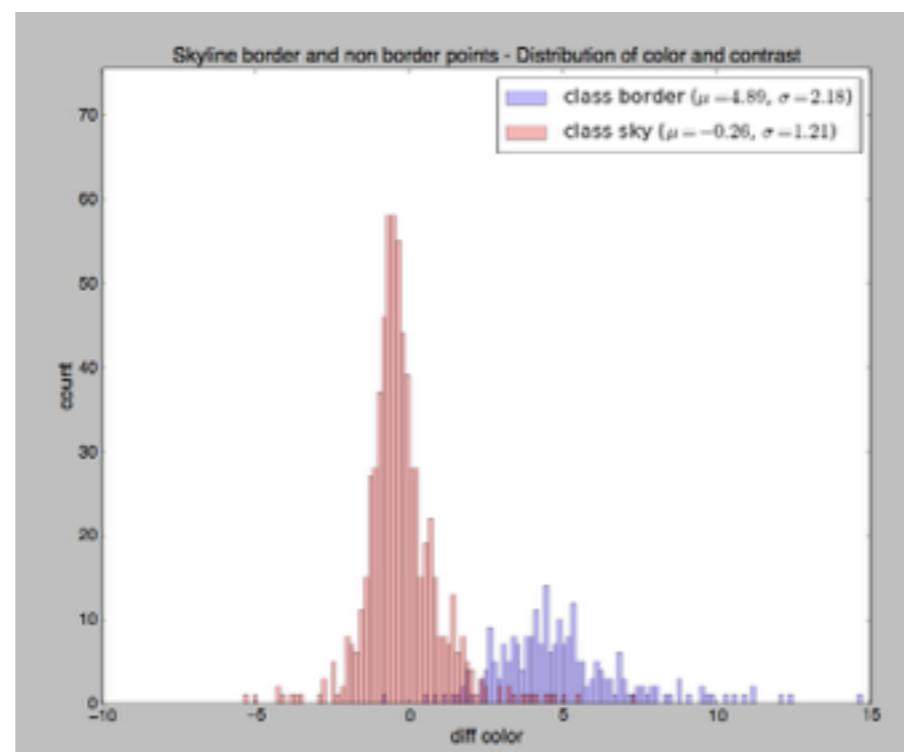
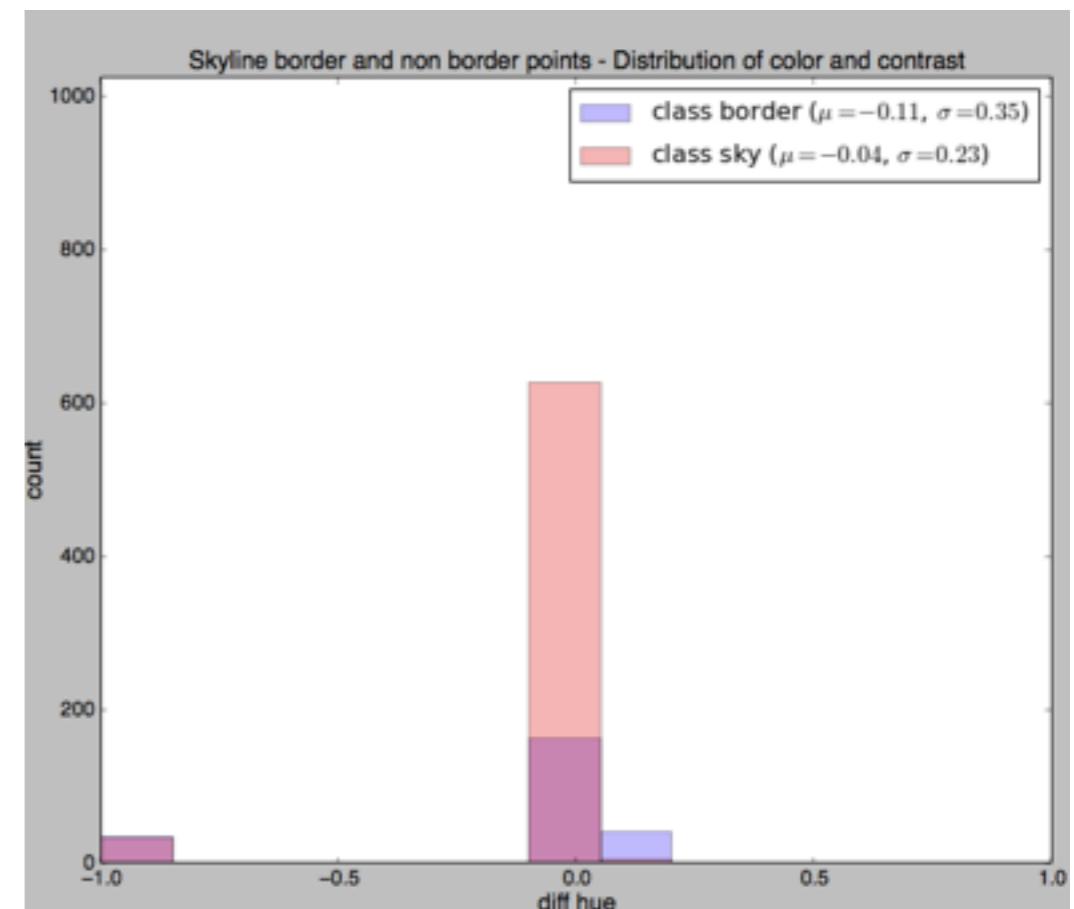
stonehenge test image



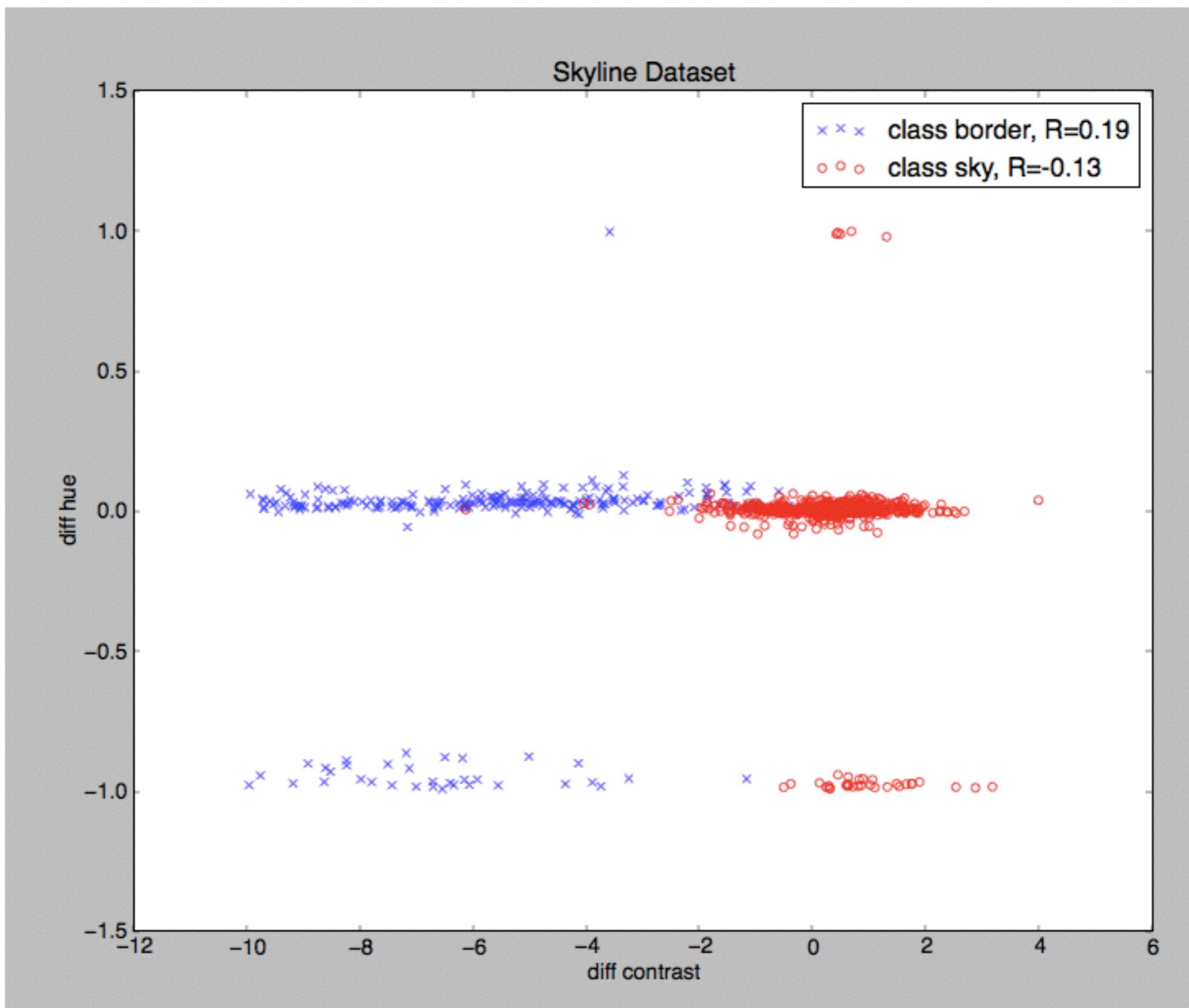
stonehenge test image



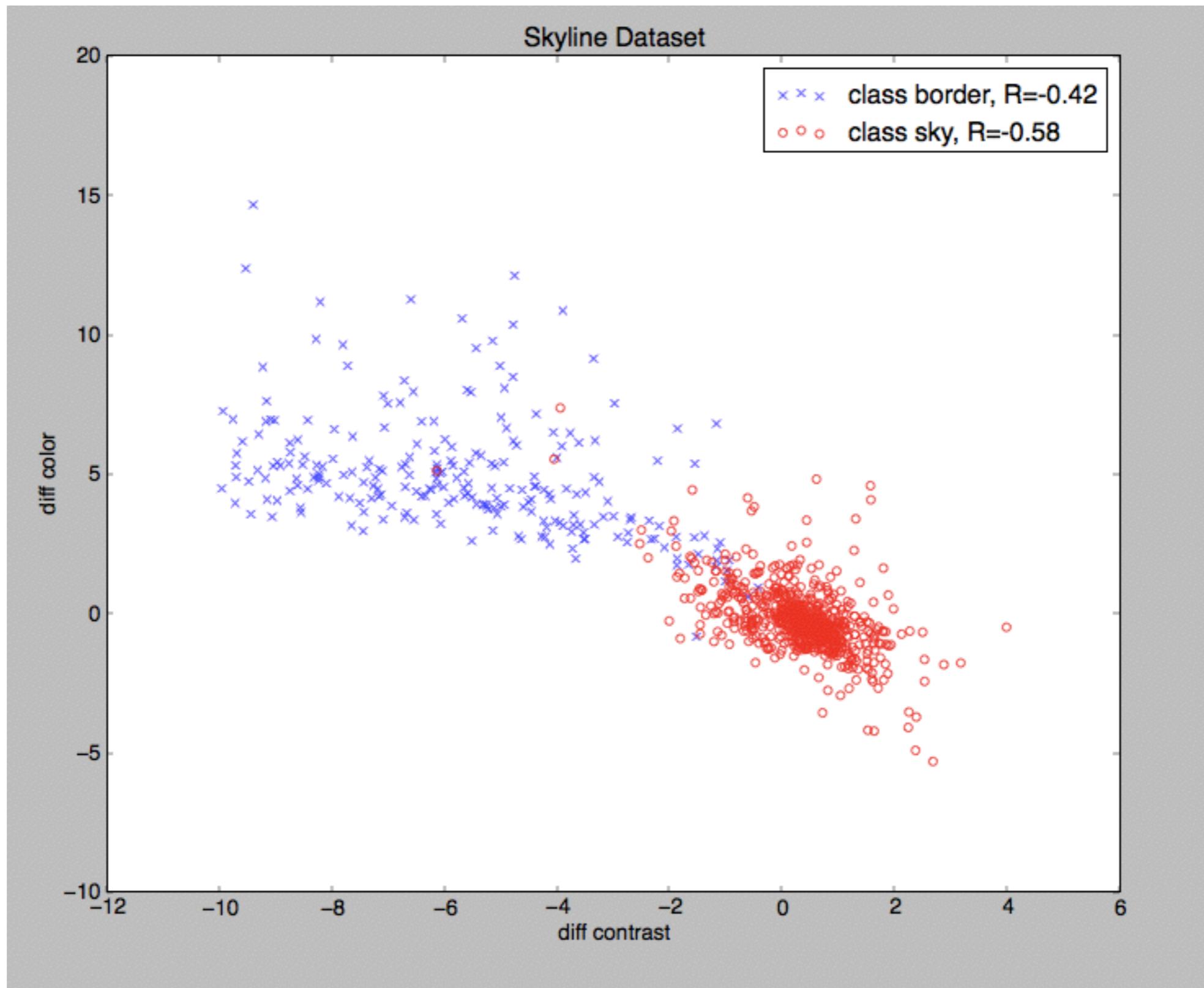
*note: the largest contrasts were removed from analysis for plot visibility



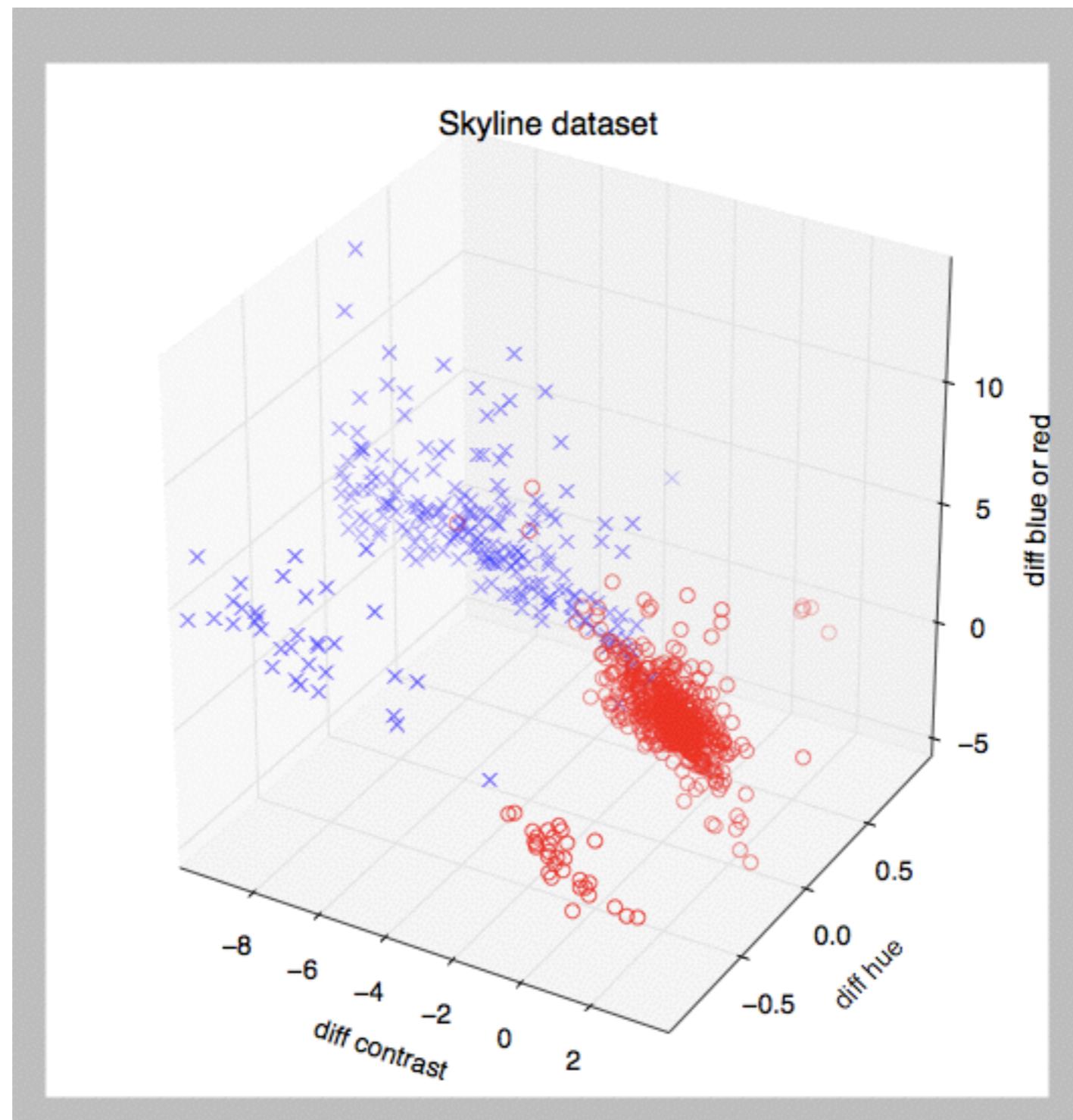
stonehenge test image



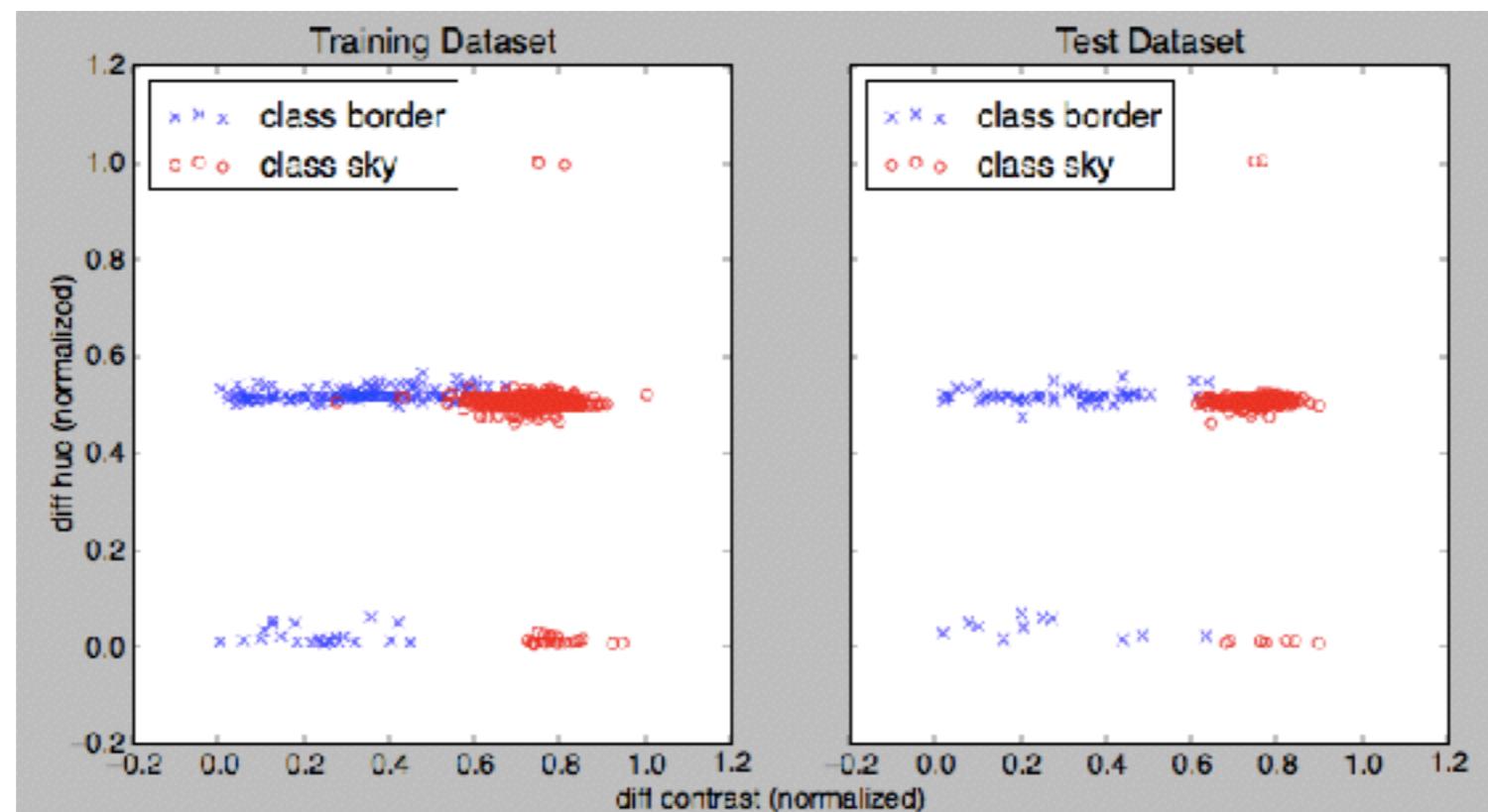
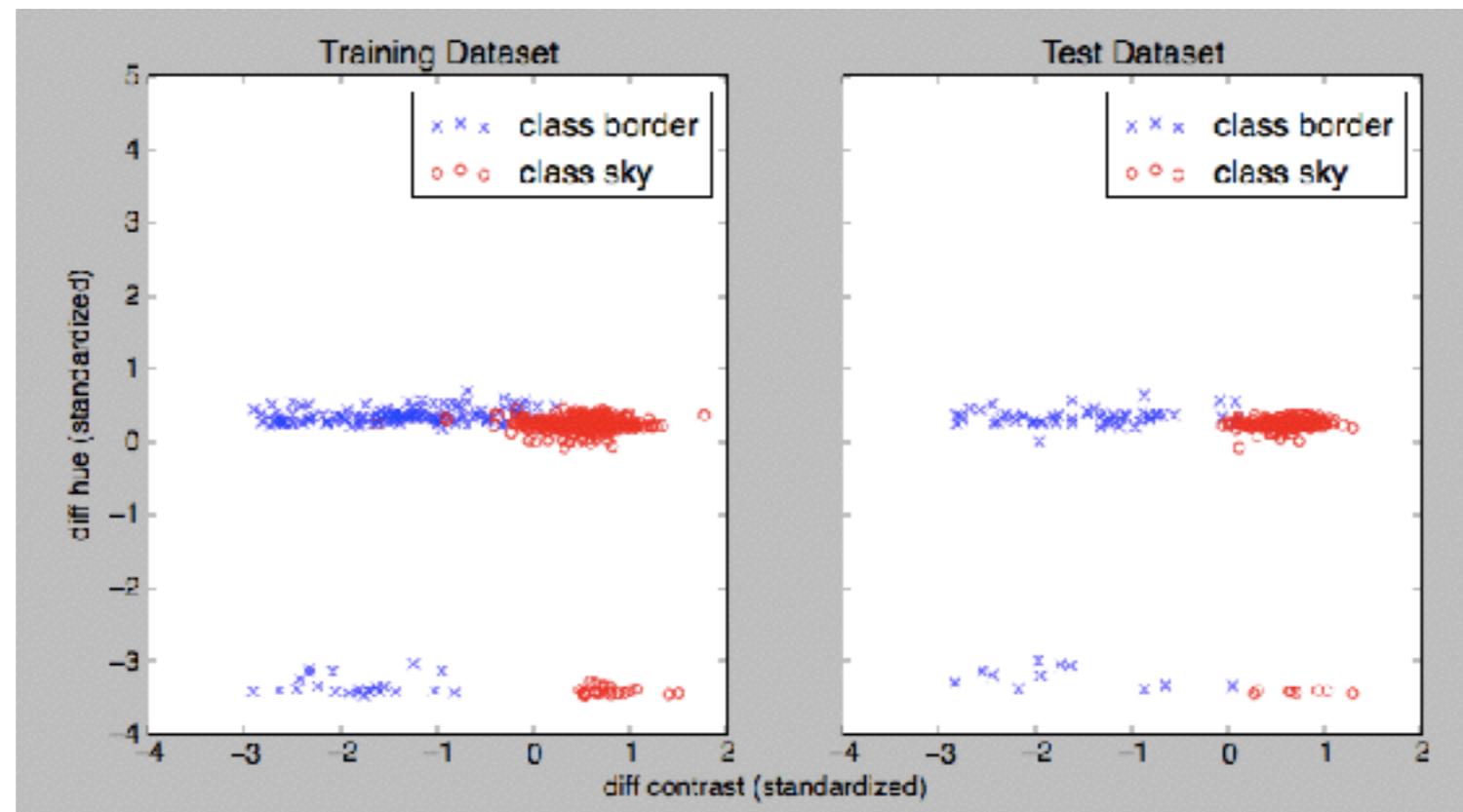
stonehenge test image



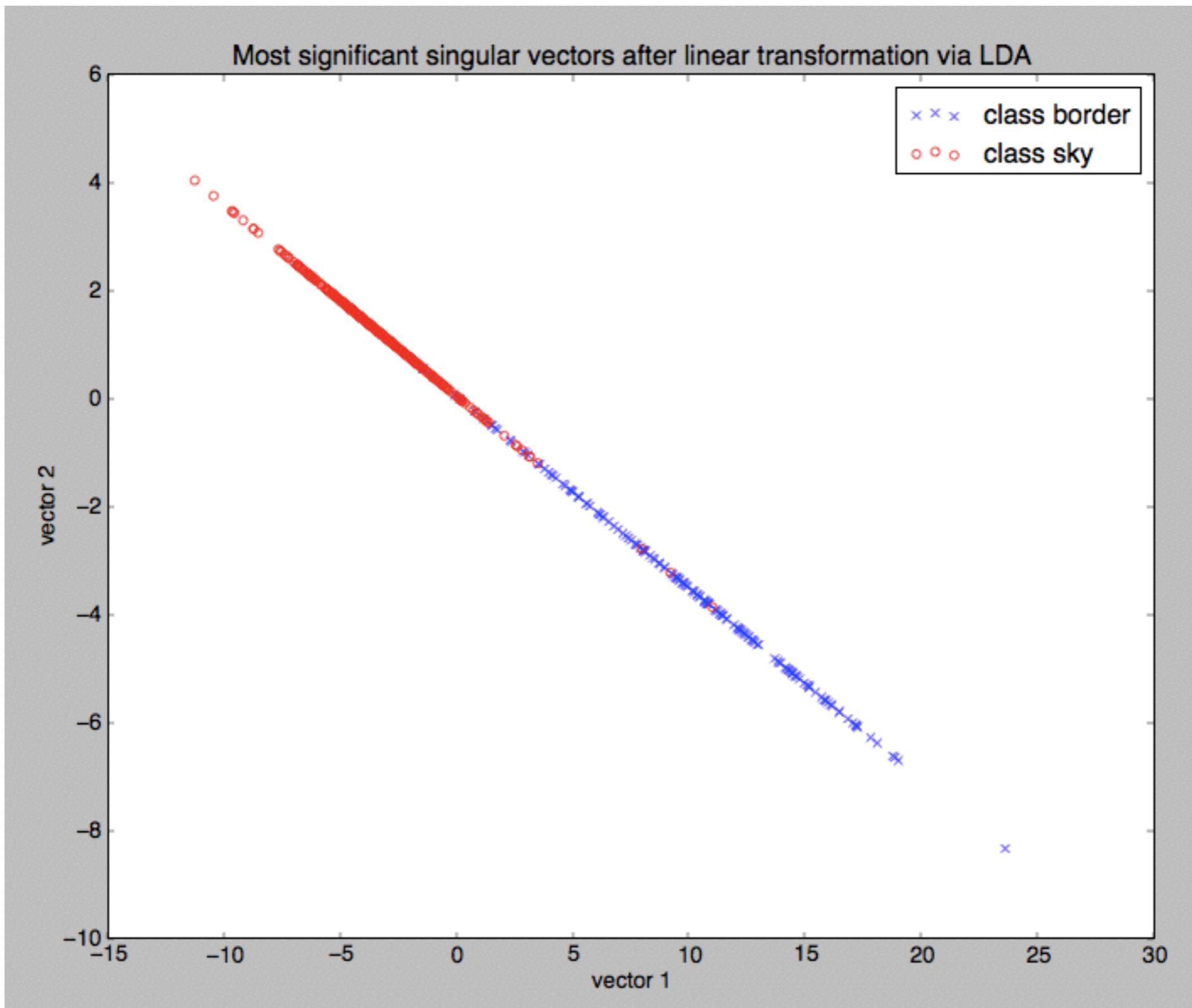
stonehenge test image



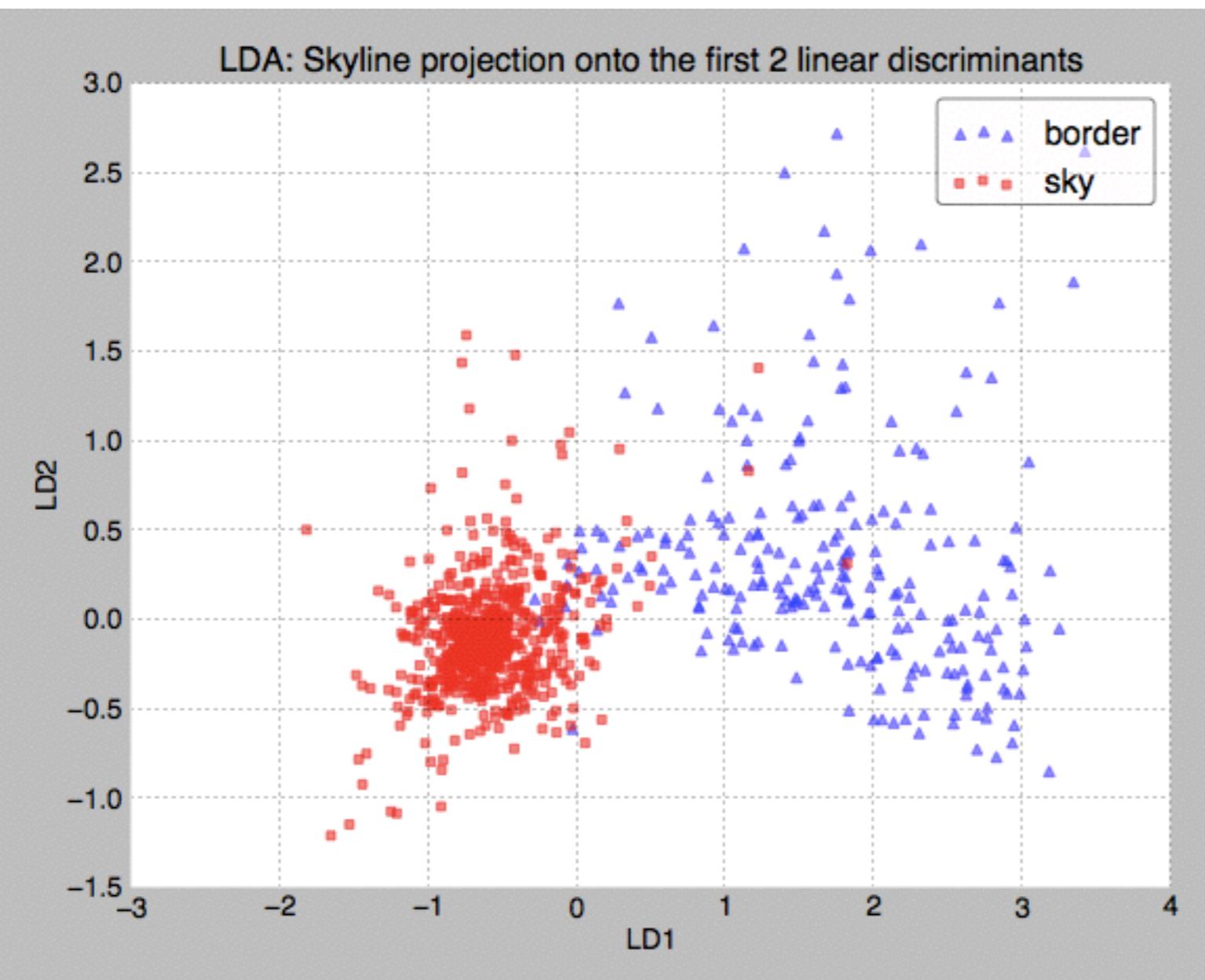
stonehenge test image



stonehenge test image



cloudy san jose test image



contrast	hue	BorR
-1.4794	-0.1936	1.3958
0.522	0.0683	-0.4925

('within-class Scatter Matrix:\n',
array([[205.145 , 23.1388, -112.9972],
[23.1388, 889.0816, 14.9999],
[-112.9972, 14.9999, 281.5866]]))

('between-class Scatter Matrix:\n',
array([[2481.3731, 667.0138, -1575.7598],
[667.0138, 429.5633, 136.0448],
[-1575.7598, 136.0448, 2252.0482]]))

Eigenvector 1:
[[-0.9876]
[-0.0366]
[0.1525]]

Eigenvalue 1: 1.23e+01

Eigenvector 2:
[[-0.4505]
[0.815]
[-0.3645]]

Eigenvalue 2: 0.00e+00

Eigenvector 3:
[[0.5591]
[0.0716]
[0.826]]

Eigenvalue 3: 5.80e+00

ok

Eigenvalues in decreasing order:

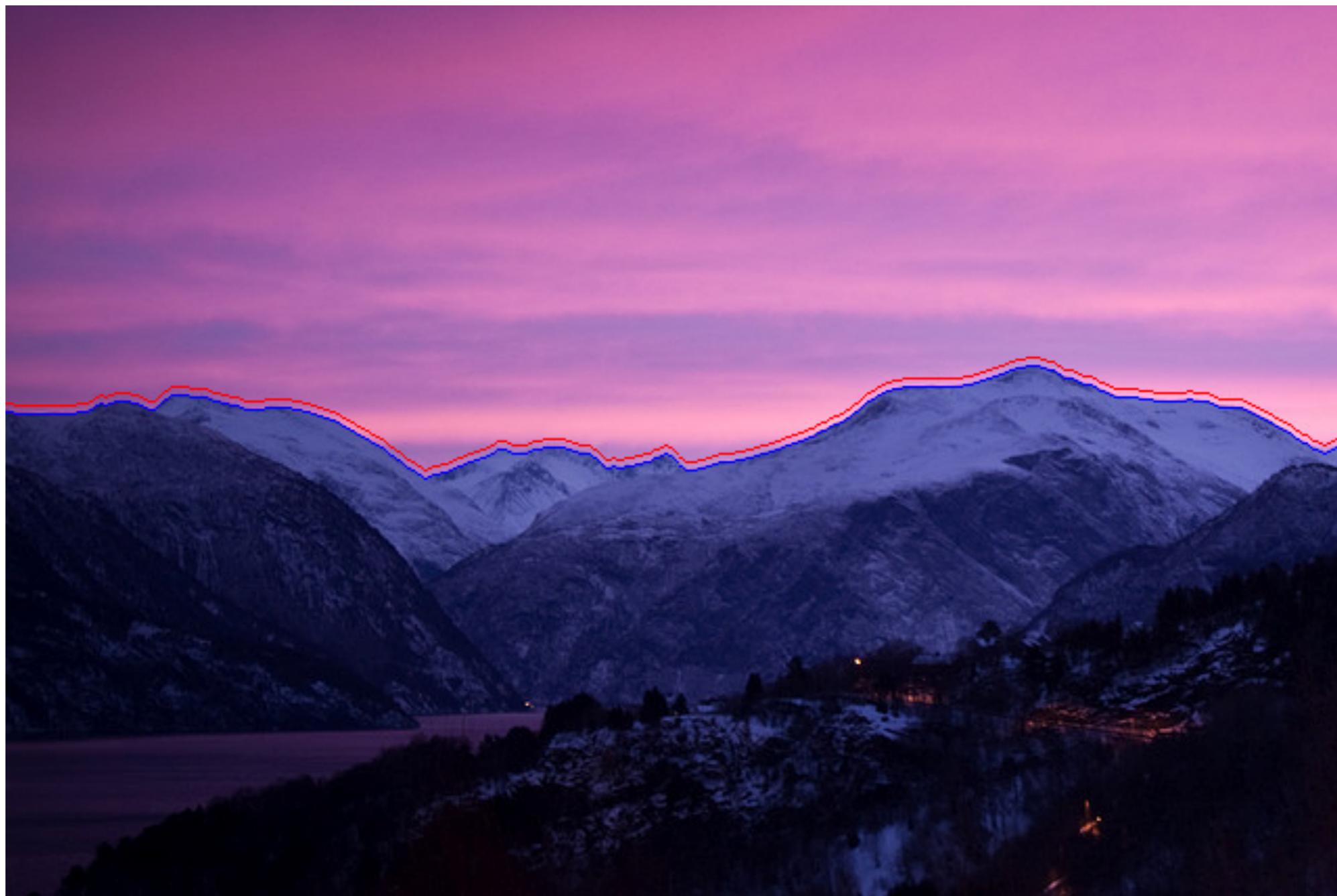
12.3043384159
5.80051974387
0.0

Variance explained:

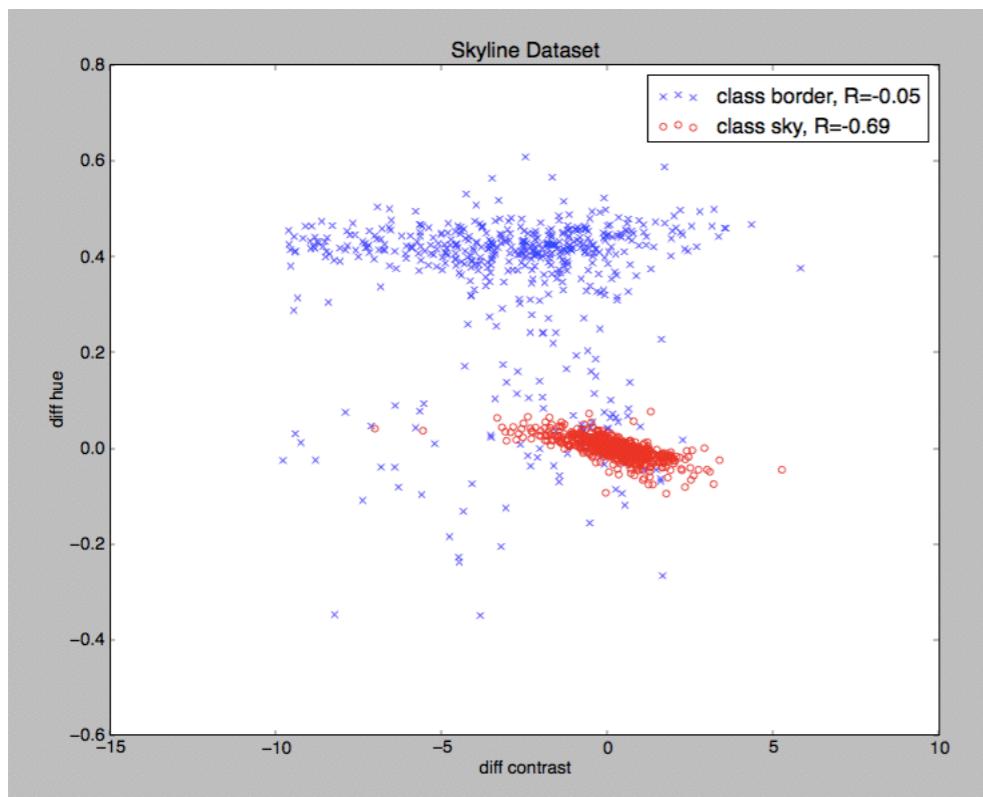
eigenvalue 1: 67.96%
eigenvalue 2: 32.04%
eigenvalue 3: 0.00%

('Matrix W:\n', array([[-0.9876, -0.0366, 0.1525],
[0.5591, 0.0716, 0.826]]))

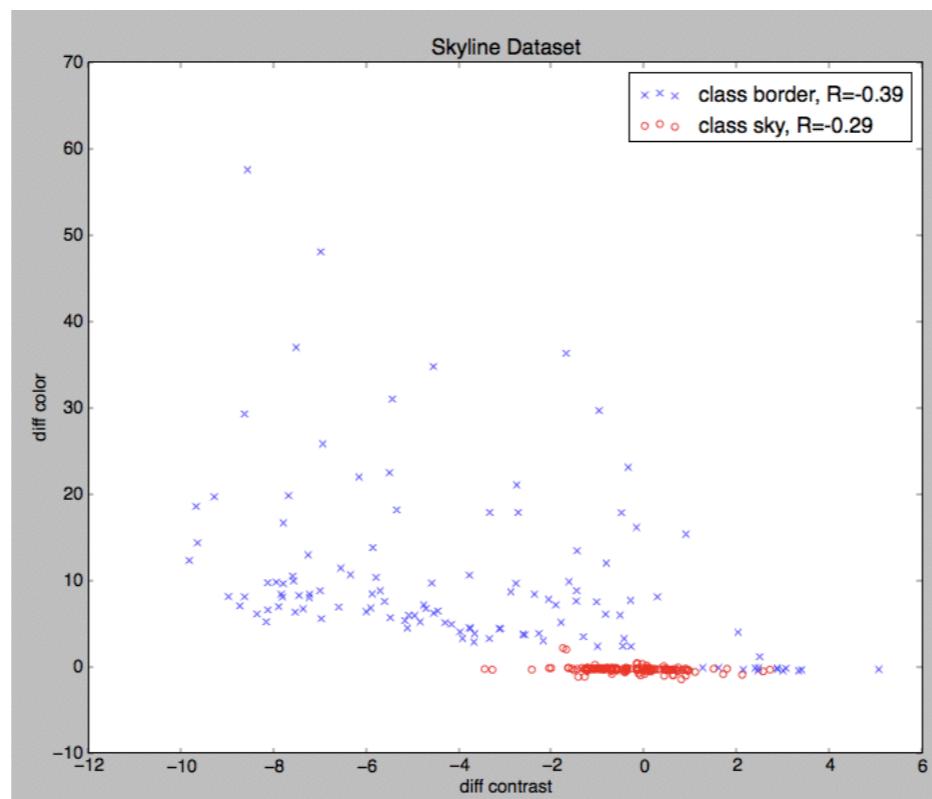
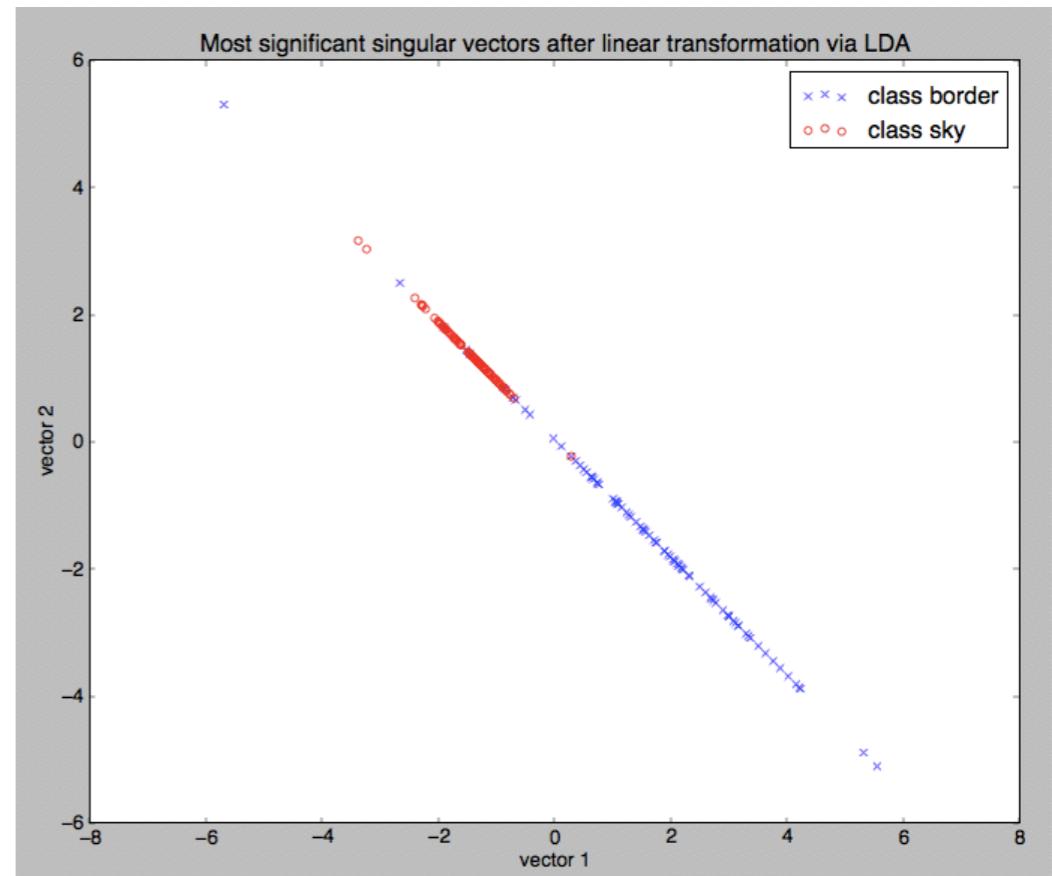
norwegian mtn range test image



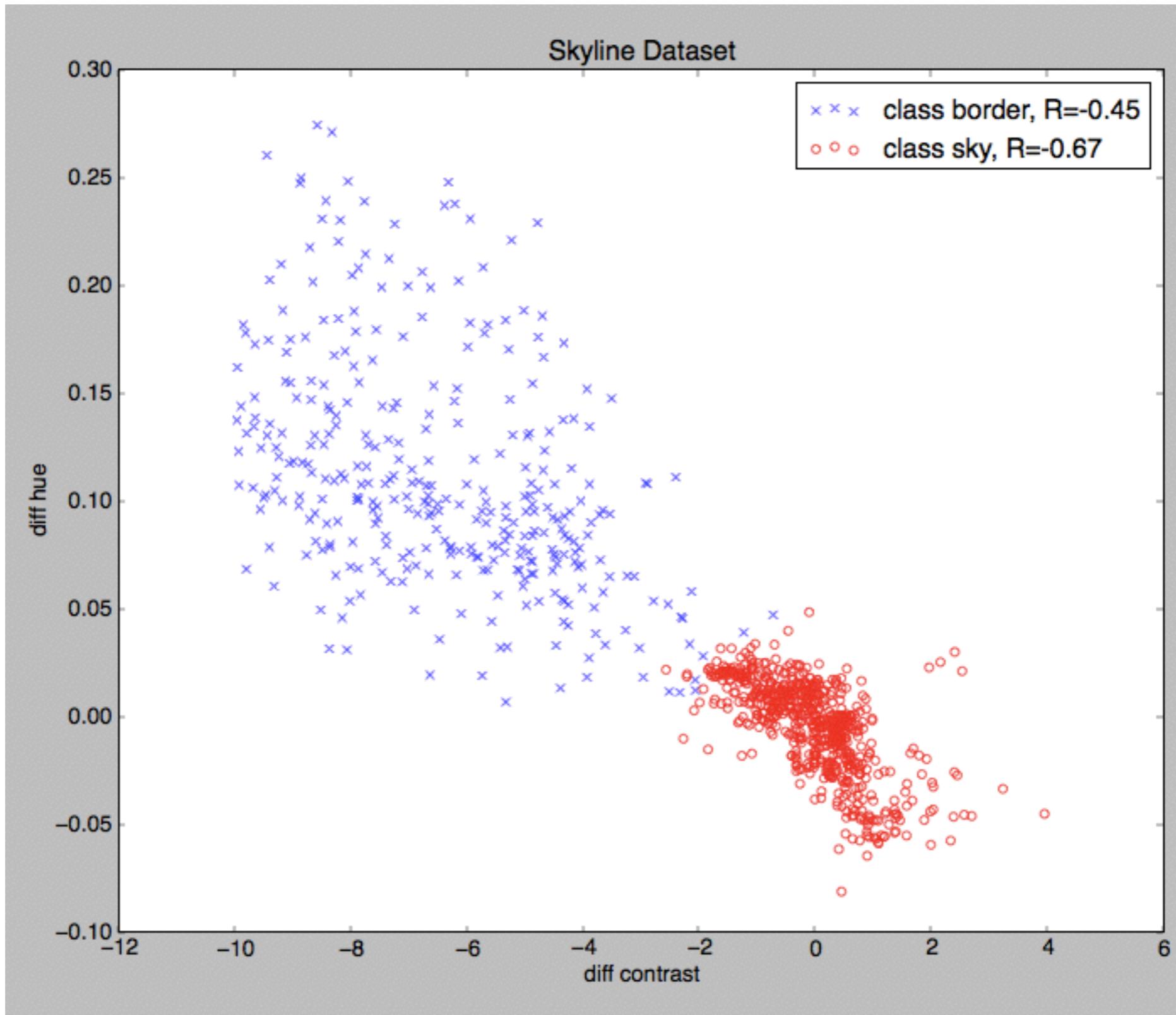
norwegian mtn range test image



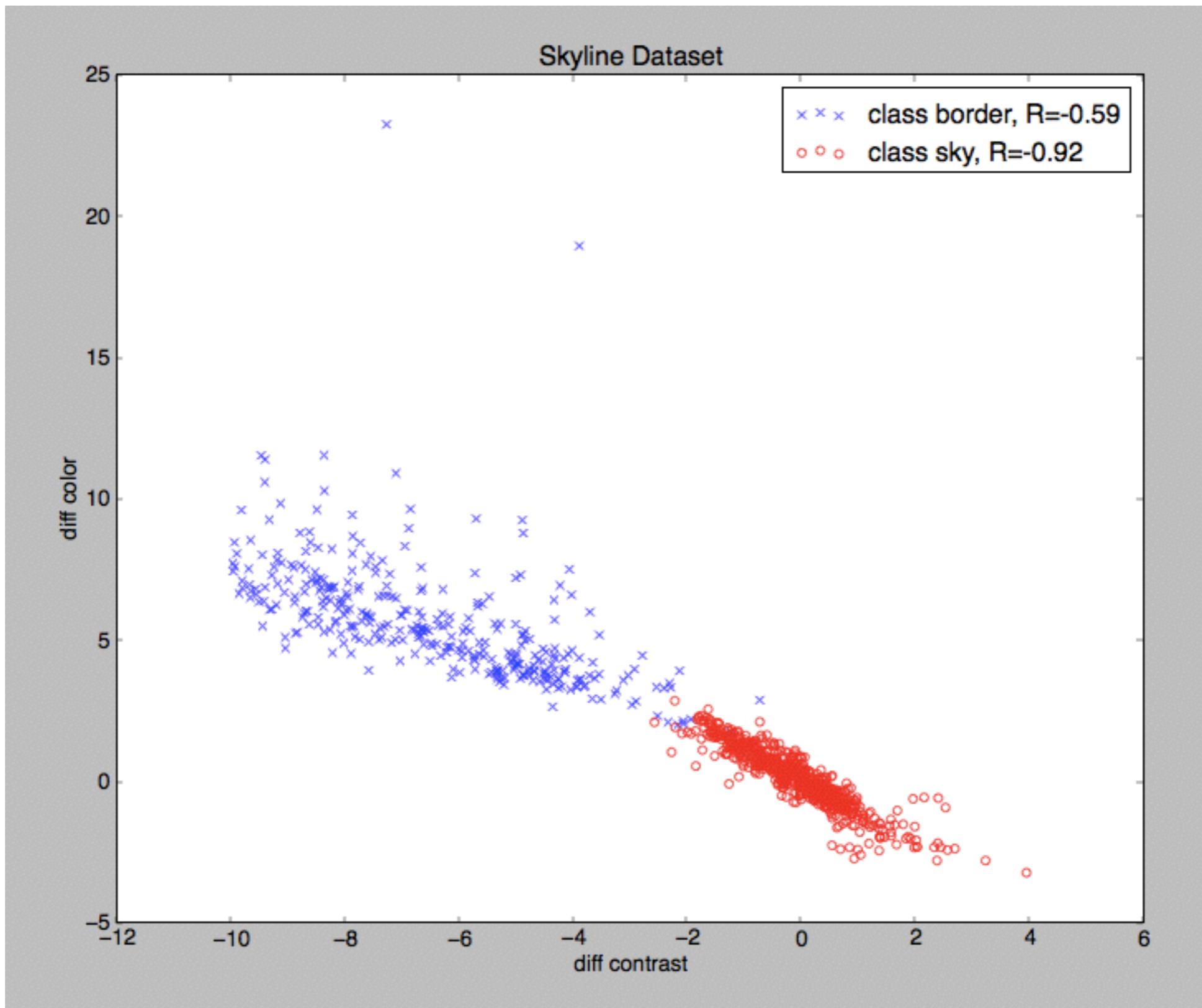
*note: the largest contrasts were removed from analysis for plot visibility



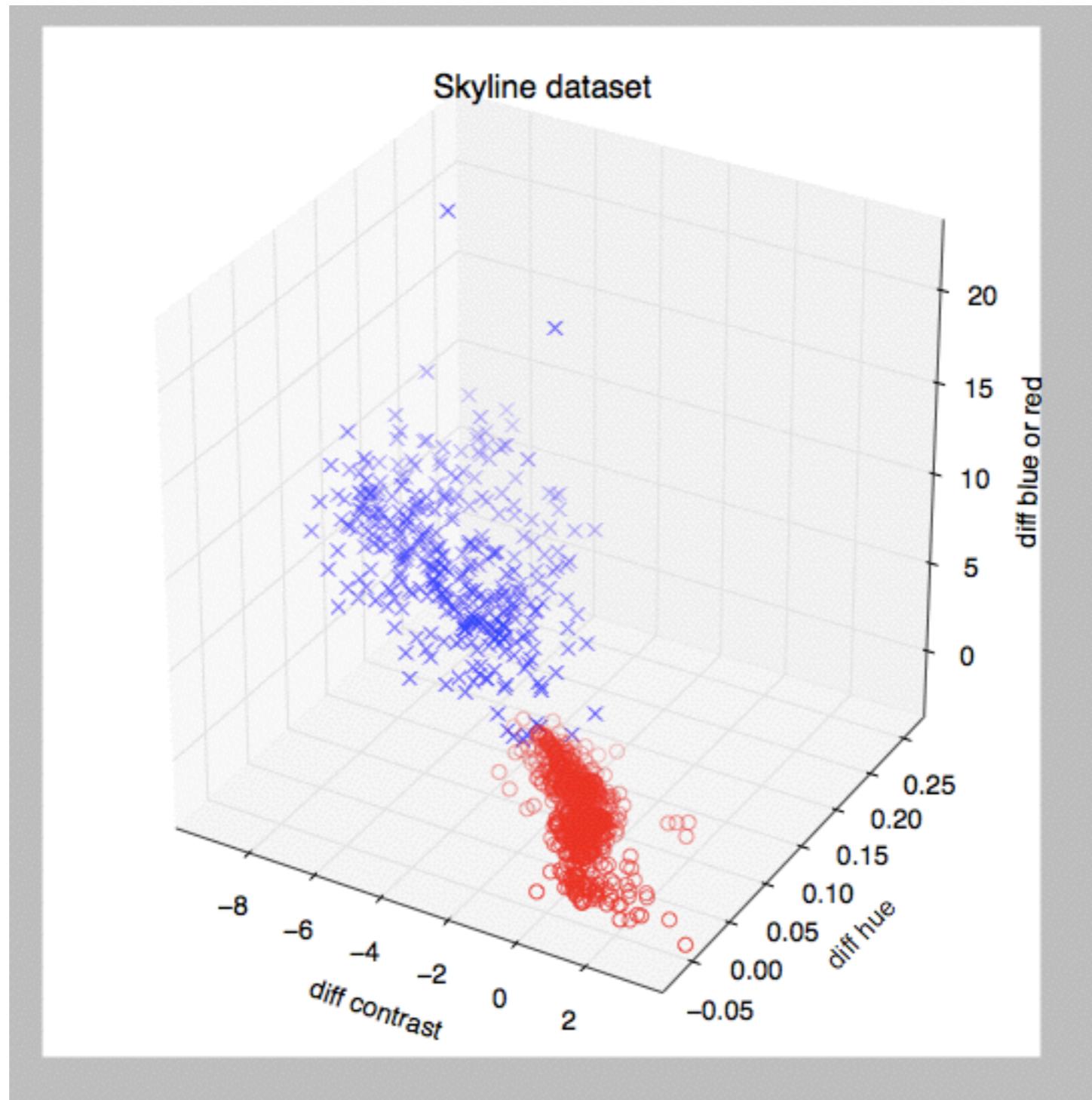
norwegian mtn range test image



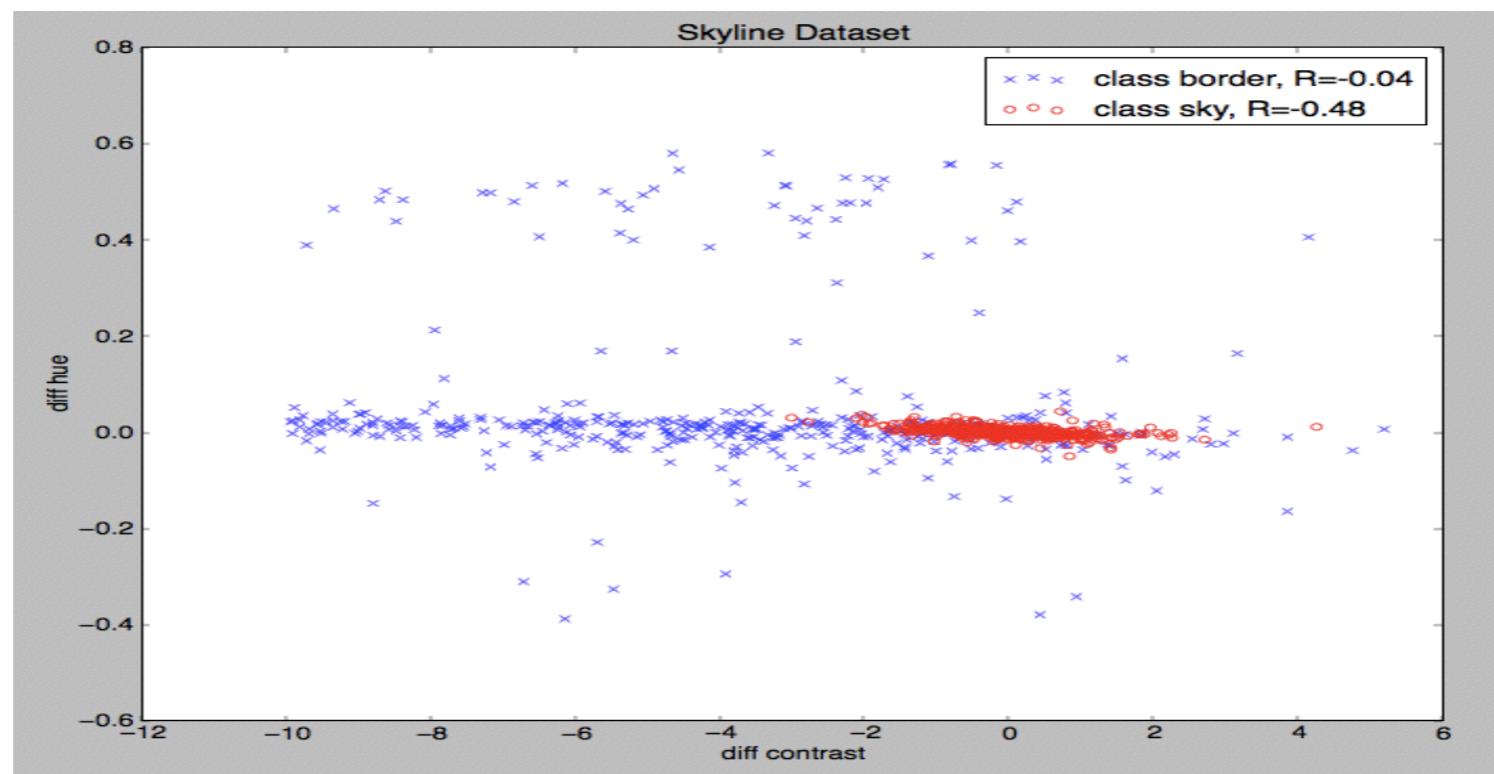
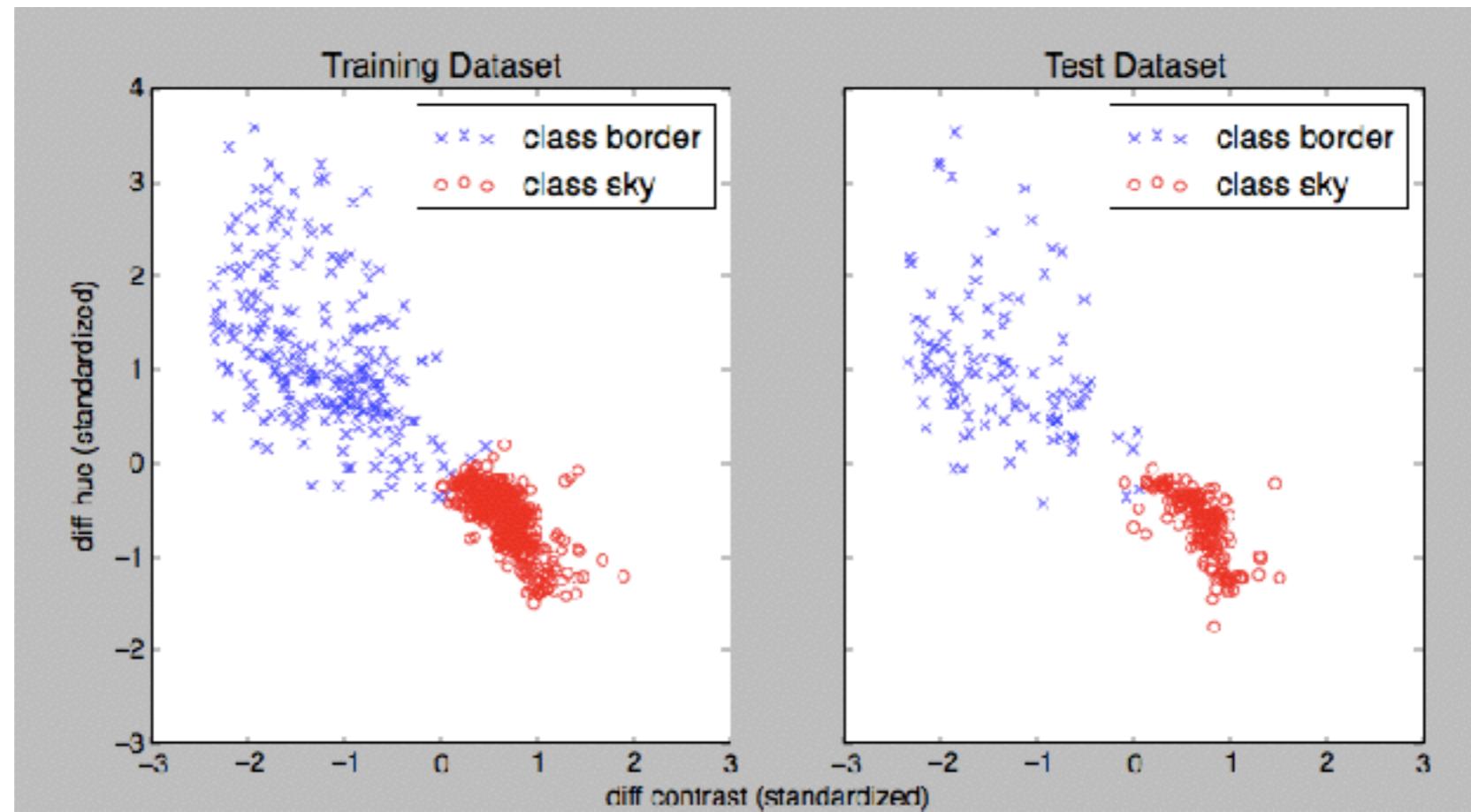
norwegian mtn range test image



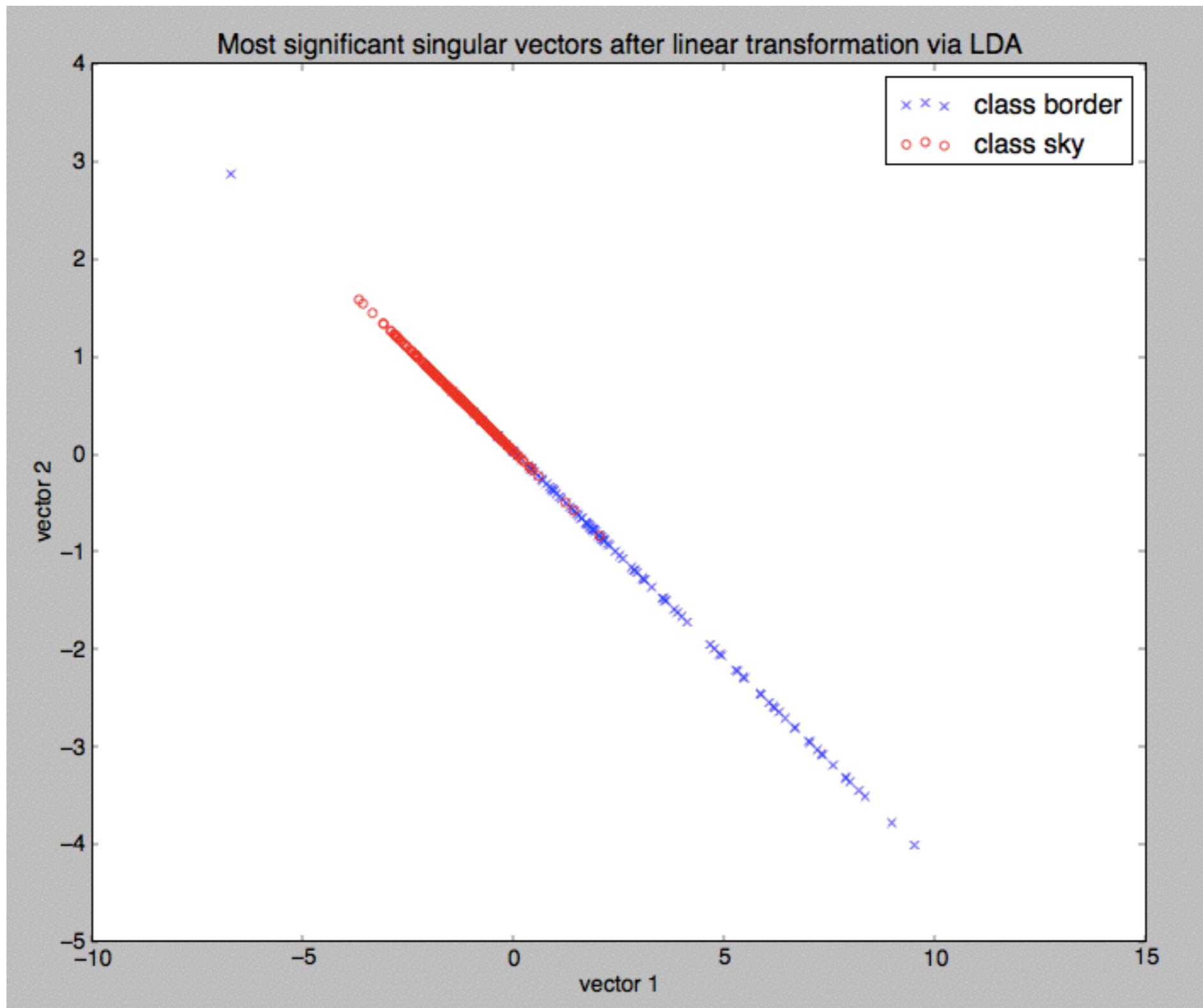
norwegian mtn range test image



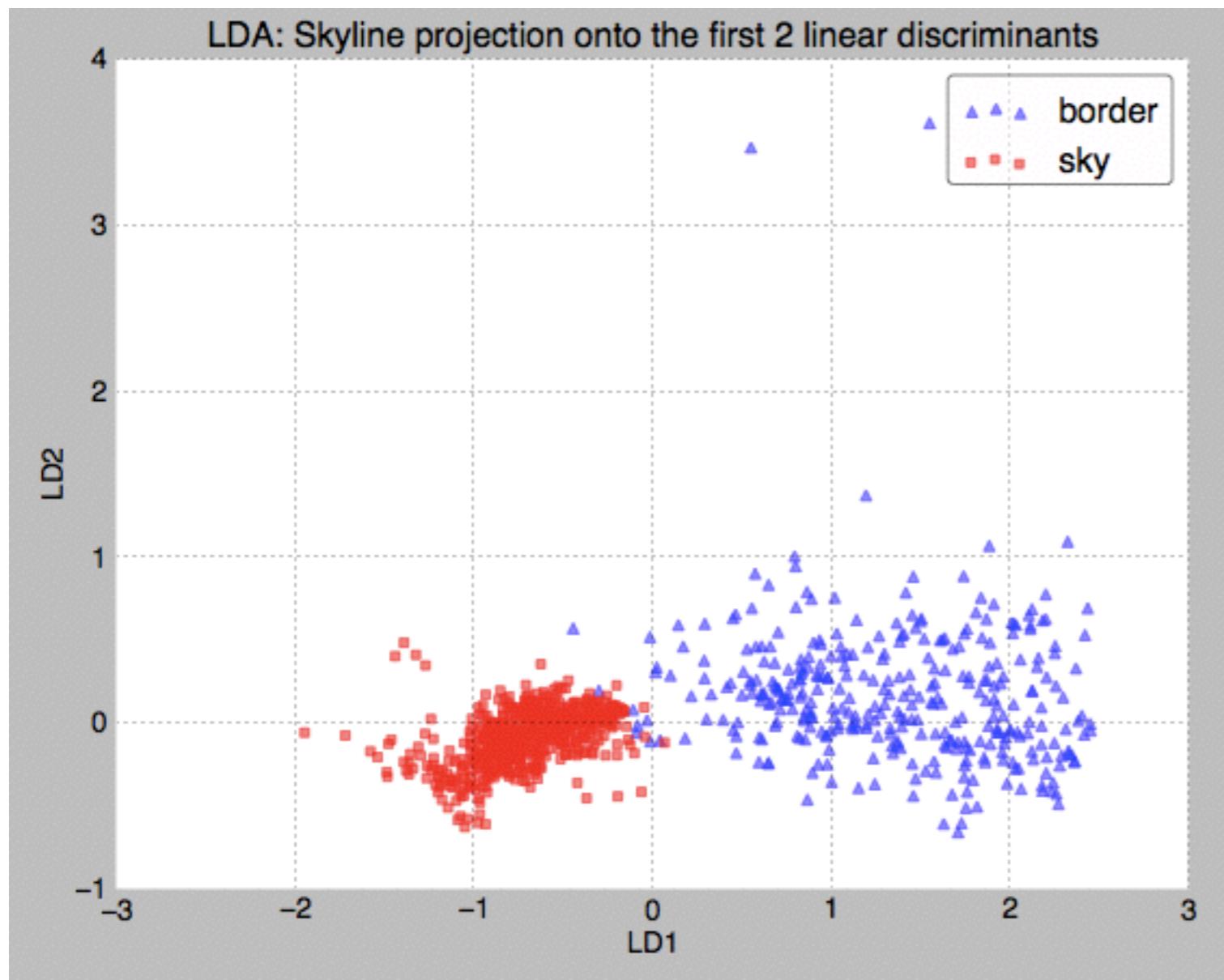
norwegian mtn range test image



norwegian mtn range test image



norwegian mtn range test image



contrast	hue	BorR
-1.2421	1.1407	1.1862
0.6638	-0.6096	-0.6339

Mean Vector class 1: [-1.2421 1.1407 1.1862]

Mean Vector class 2: [0.6638 -0.6096 -0.6339]

('within-class Scatter Matrix:\n',
array([[172.341 , -113.9692, -139.7582],
[-113.9692, 299.1902, 110.5439],
[-139.7582, 110.5439, 243.642]]))

('between-class Scatter Matrix:\n',
array([[2655.2496, -2004.3297, -2093.2883],
[-2004.3297, 2274.702 , 2356.3953],
[-2093.2883, 2356.3953, 2441.3467]]))

Eigenvector 1:
[[-0.9955]
[0.0941]
[-0.0136]]

Eigenvalue 1: 1.55e+01

Eigenvector 2:
[[-0.0134]
[0.7137]
[-0.7003]]

Eigenvalue 2: 8.88e-16

Eigenvector 3:
[[0.7335]
[0.3168]
[0.6014]]

Eigenvalue 3: 8.59e+00

ok

Eigenvalues in decreasing order:

15.5410055133
8.59498303985
8.881784197e-16

Variance explained:

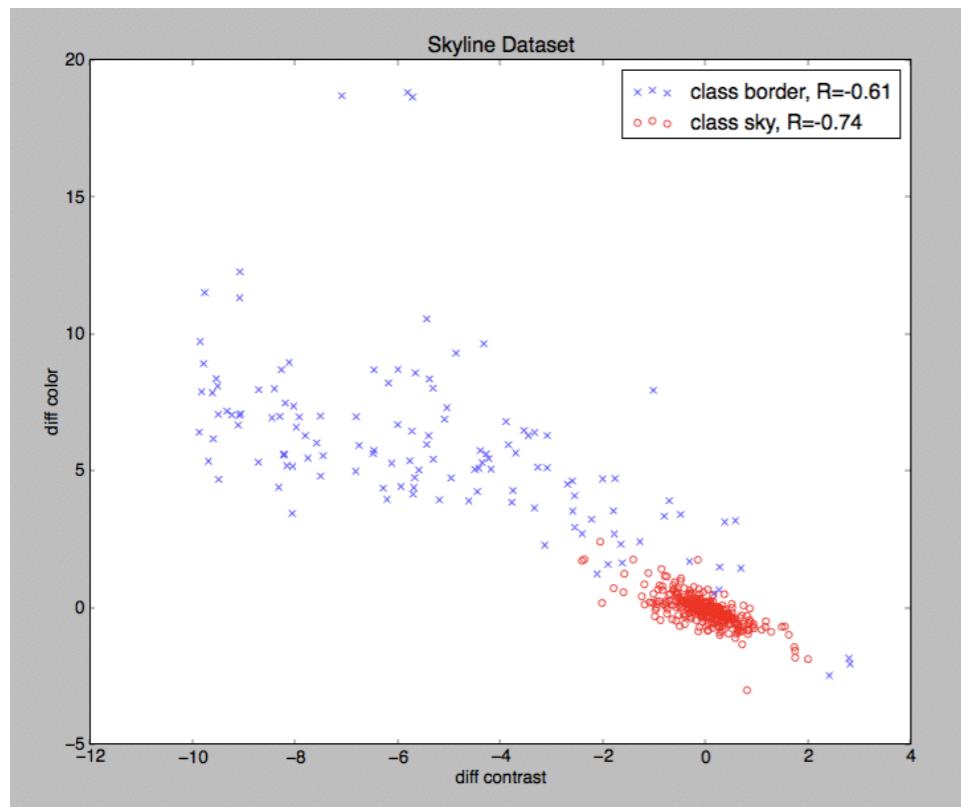
eigenvalue 1: 64.39%
eigenvalue 2: 35.61%
eigenvalue 3: 0.00%

('Matrix W:\n', array([[-0.9955, 0.0941, -0.0136],
[0.7335, 0.3168, 0.6014]]))

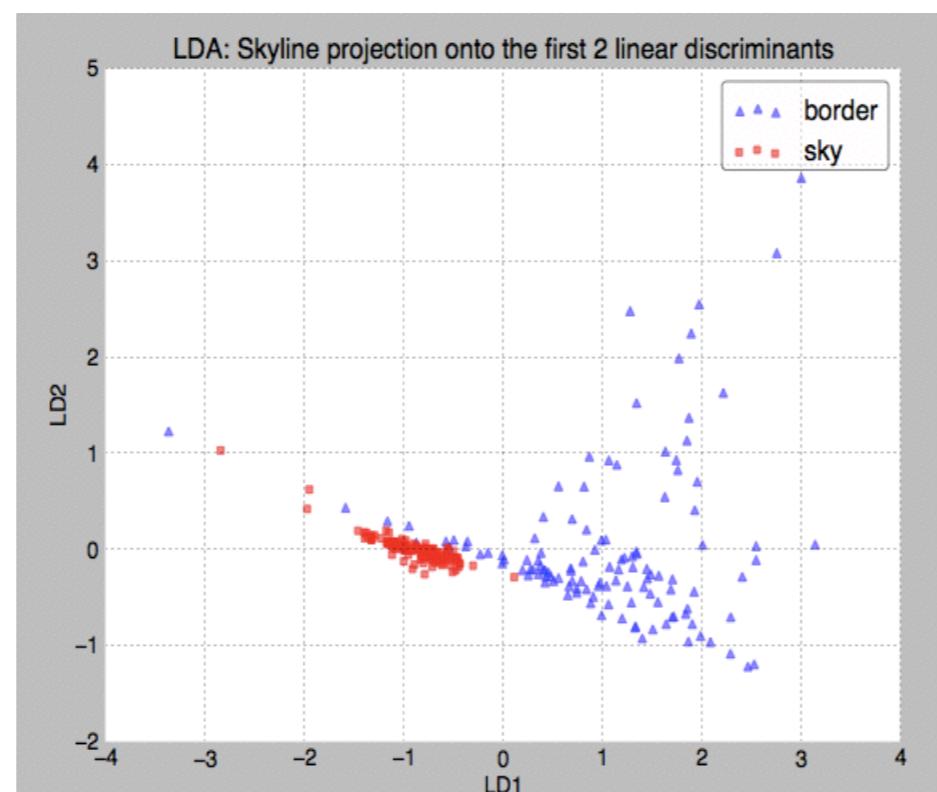
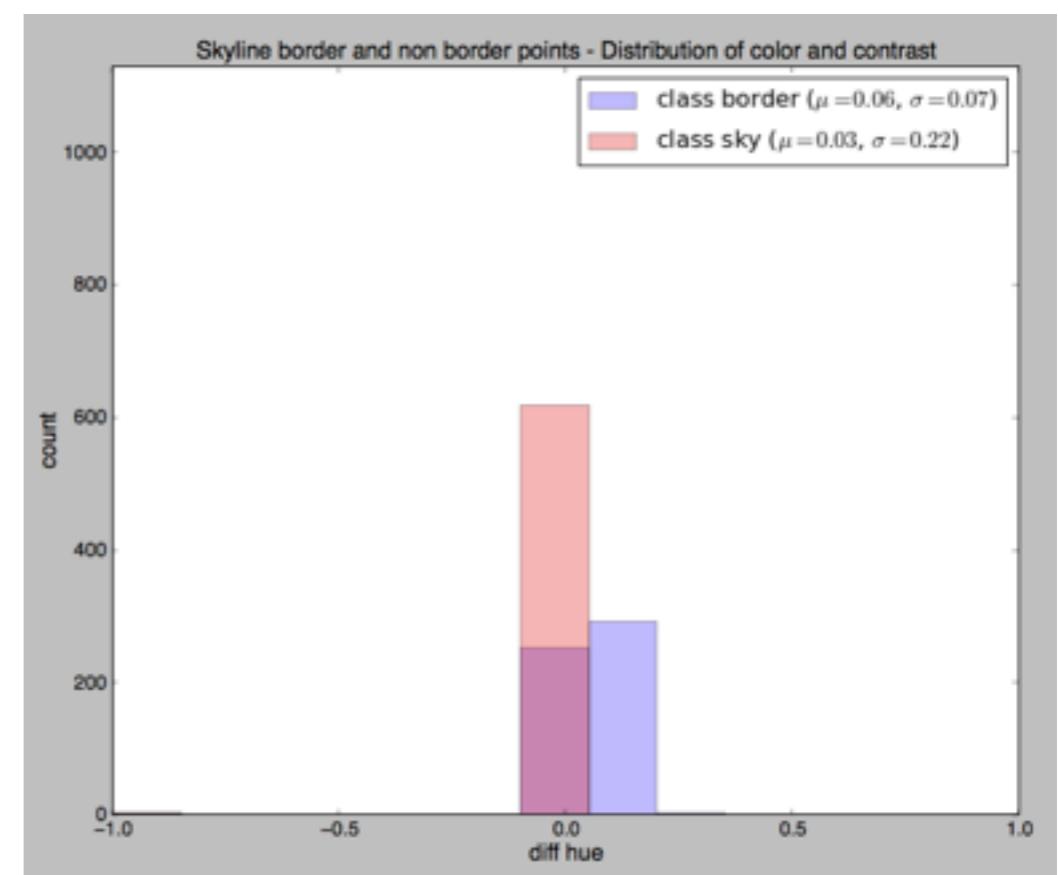
half dome test image



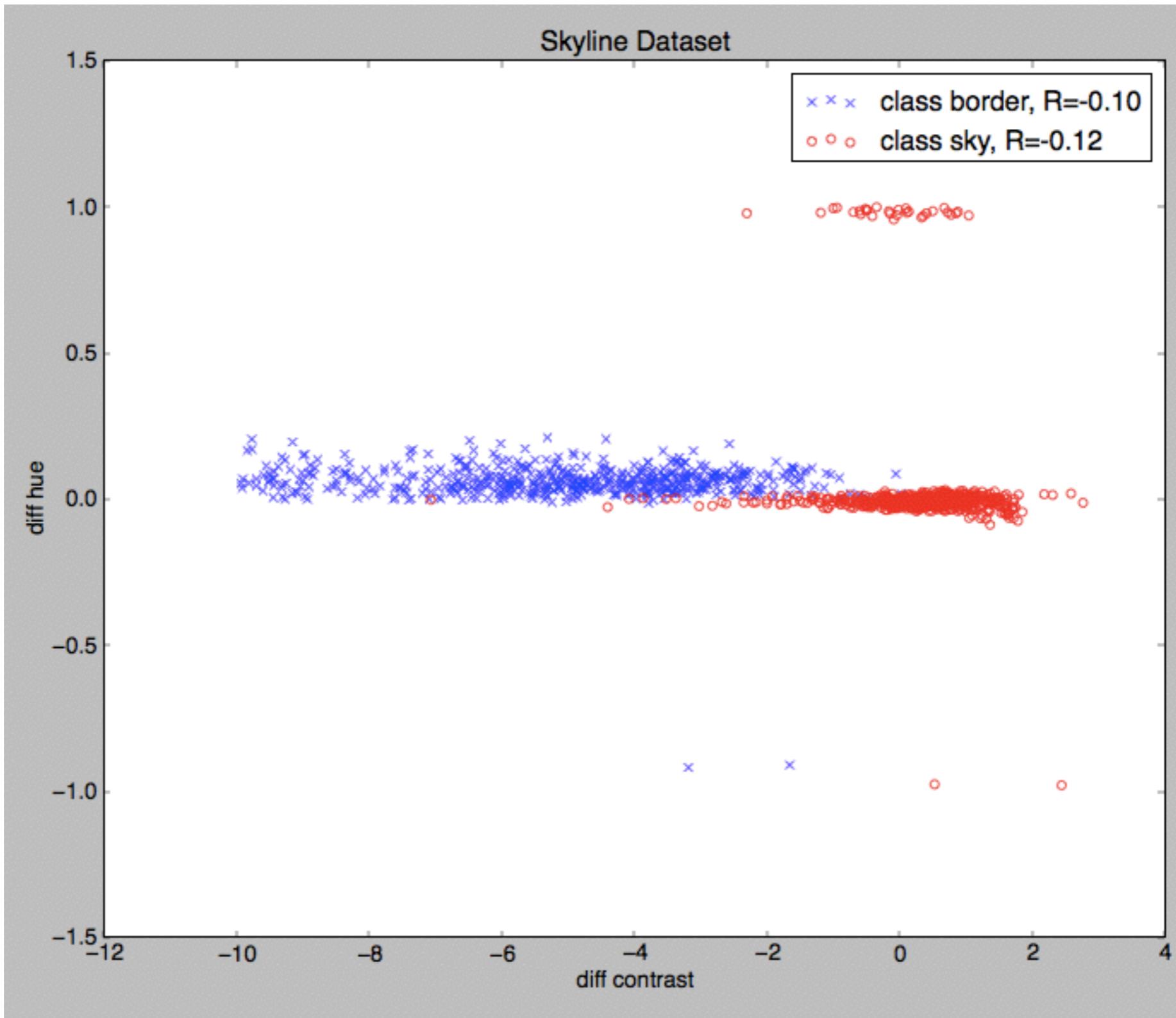
half dome test image



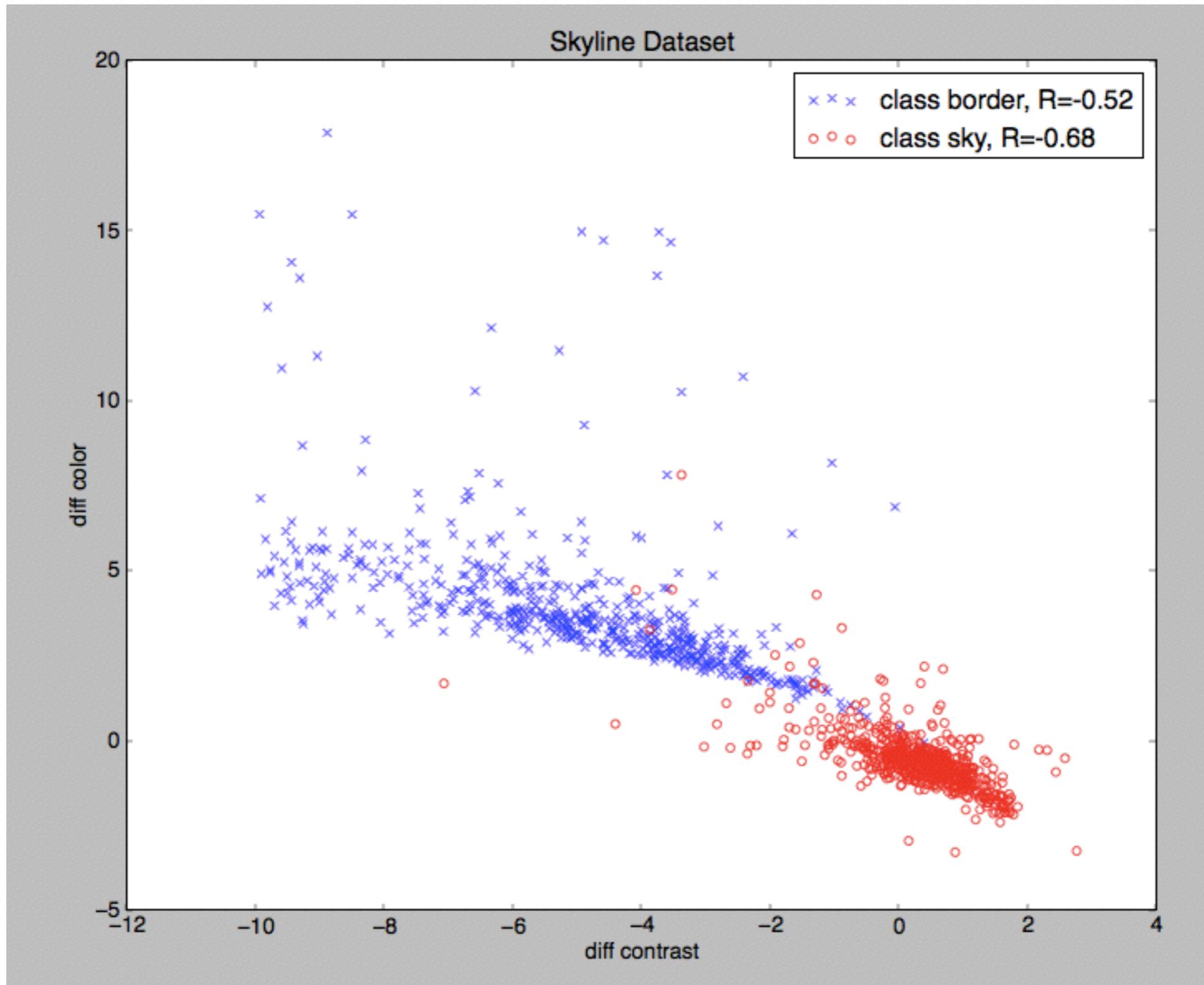
*note: the largest contrasts were removed from analysis for plot visibility



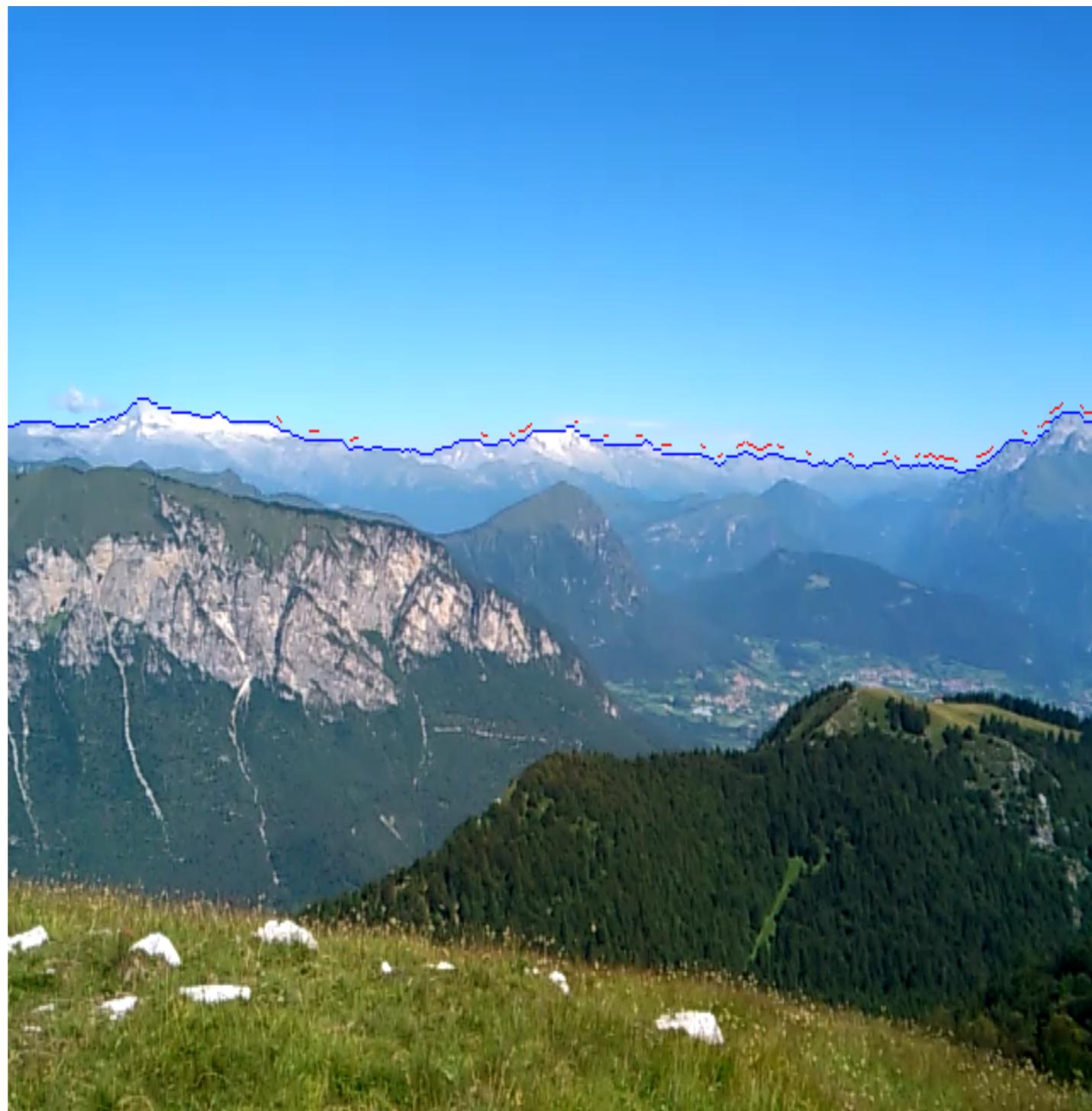
half dome test image



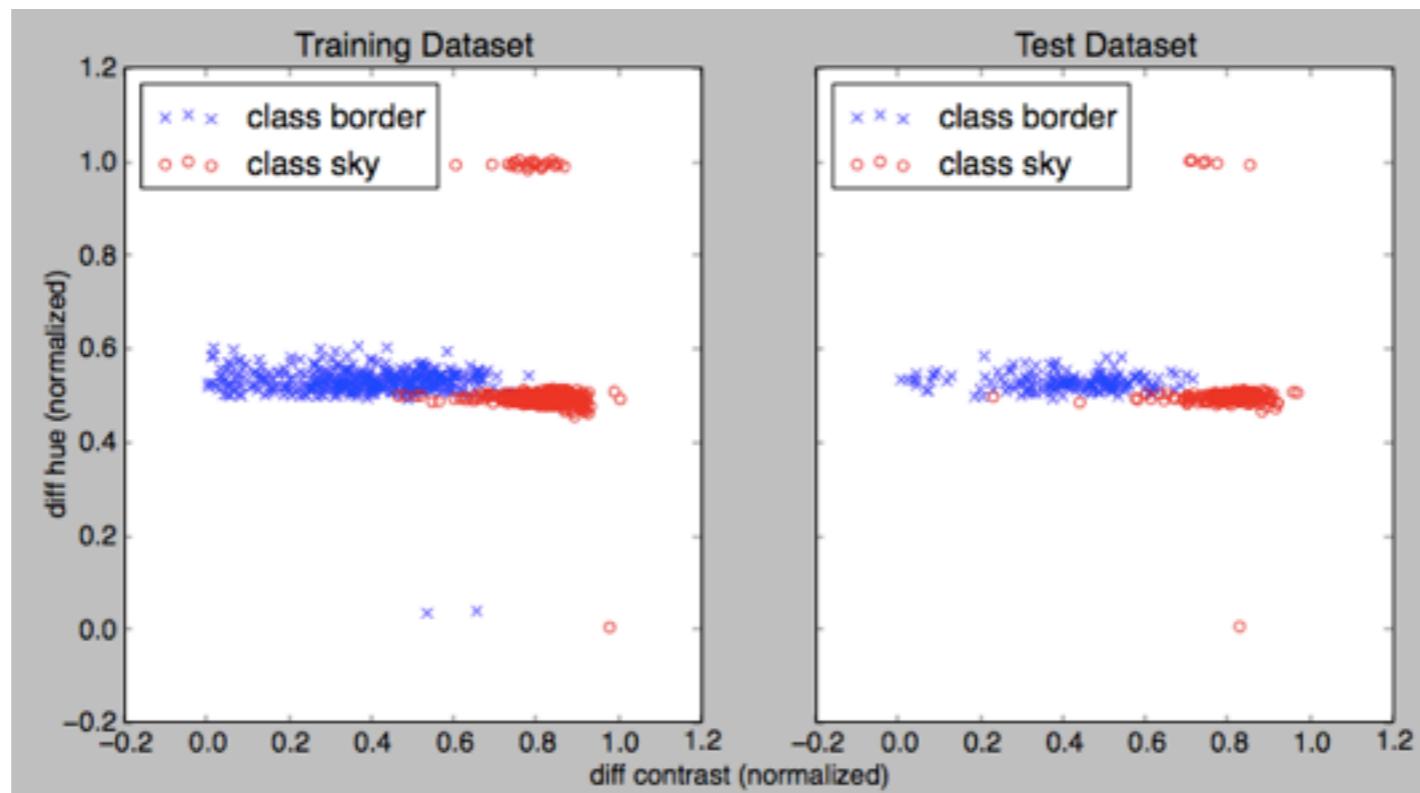
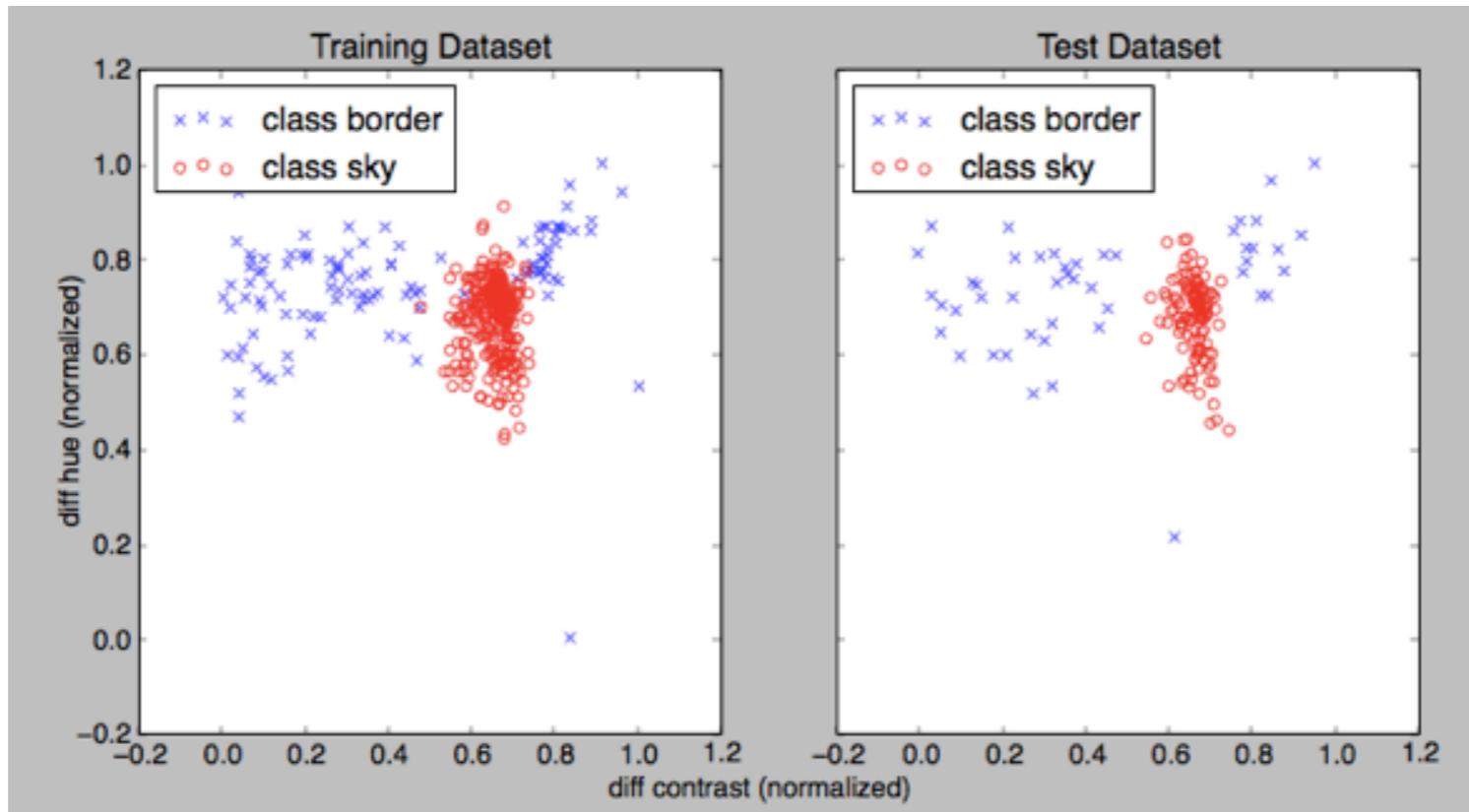
half dome test image



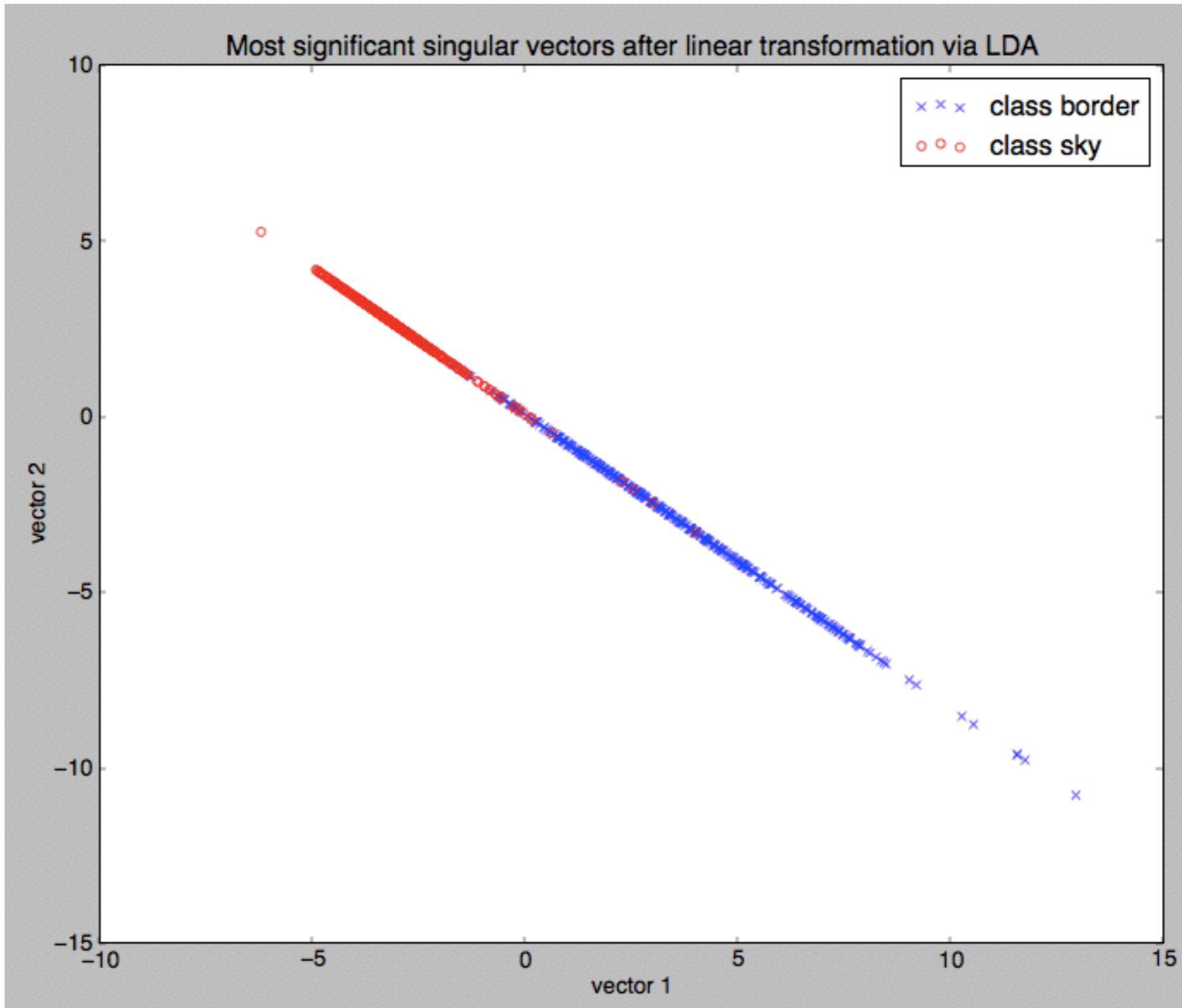
half dome test image



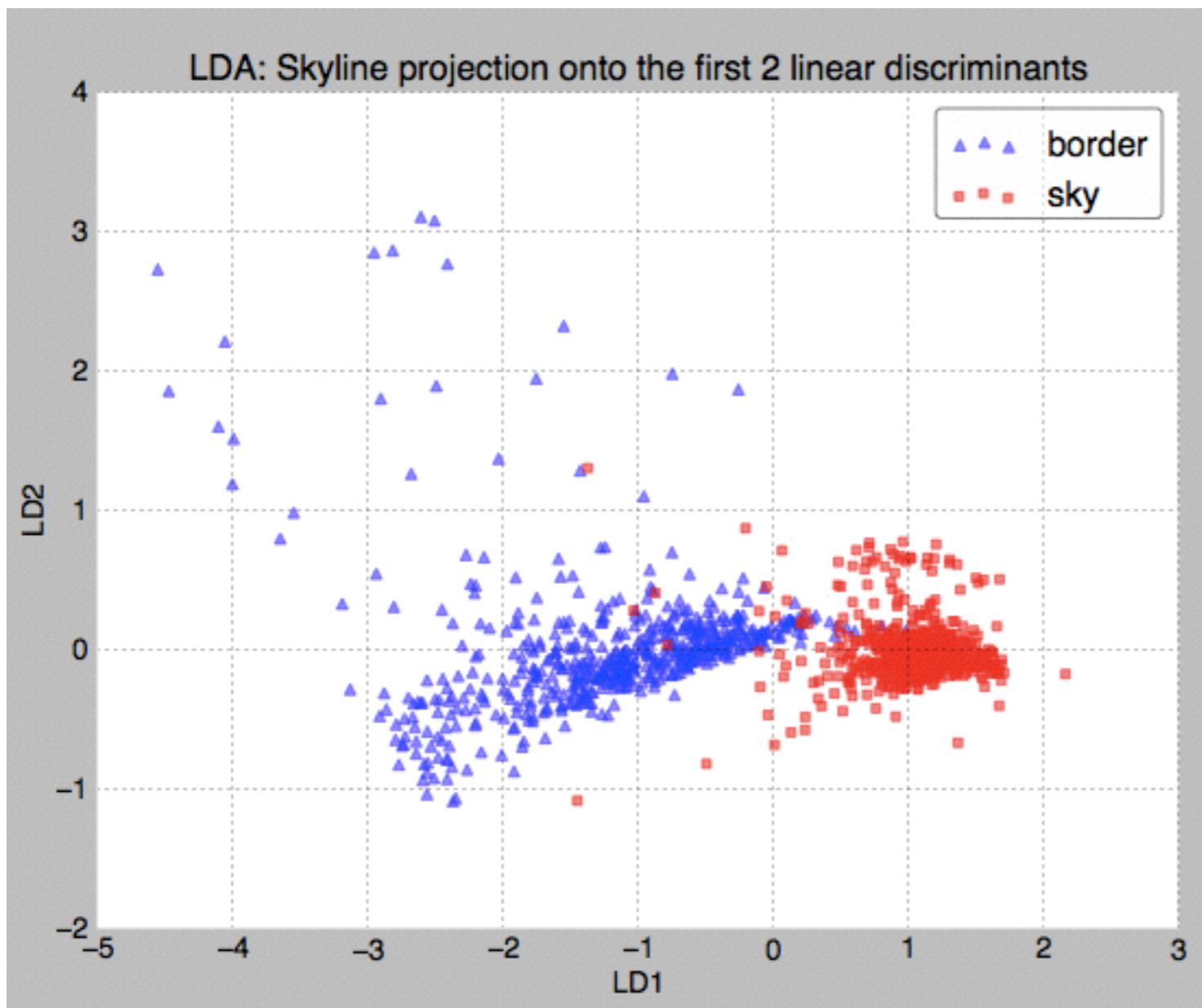
half dome test image



half dome test image



half dome test image



```
contrast  hue   BorR
Mean Vector class 1: [-0.9293  0.0847  0.8842]
Mean Vector class 2: [ 0.7818 -0.0713 -0.7439]

('within-class Scatter Matrix:\n',
array([[ 326.8775, -45.5975, -199.7885],
       [-45.5975, 1187.7852, -2.7804],
       [-199.7885, -2.7804, 408.9613]]))
('between-class Scatter Matrix:\n',
array([[ 2616.8026, -224.988 , -2465.7501],
       [-224.988 , 34.0793, 238.3547],
       [-2465.7501, 238.3547, 2370.5511]]))

Eigenvector 1:
[[ 0.894 ]
 [ 0.0046]
 [-0.448 ]]
Eigenvalue 1: 9.02e+00

Eigenvector 2:
[[ 0.6884]
 [ 0.129 ]
 [ 0.7137]]
Eigenvalue 2: 1.64e-01

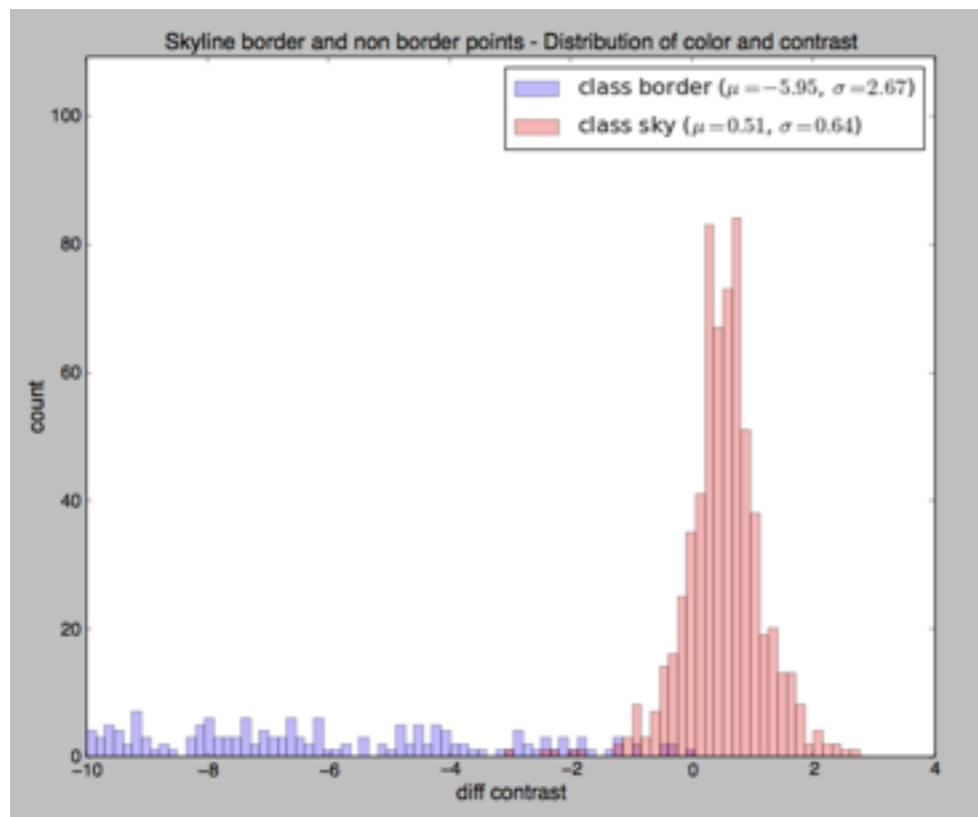
Eigenvector 3:
[[-0.3591]
 [ 0.8146]
 [-0.4555]]
Eigenvalue 3: -9.09e-17
ok
Eigenvalues in decreasing order:
9.02435451732
0.163807646534
9.08927734888e-17
Variance explained:

eigenvalue 1: 98.22%
eigenvalue 2: 1.78%
eigenvalue 3: 0.00%
('Matrix W:\n', array([[ 0.894 , 0.0046, -0.448 ],
       [ 0.6884, 0.129 , 0.7137]]))
```

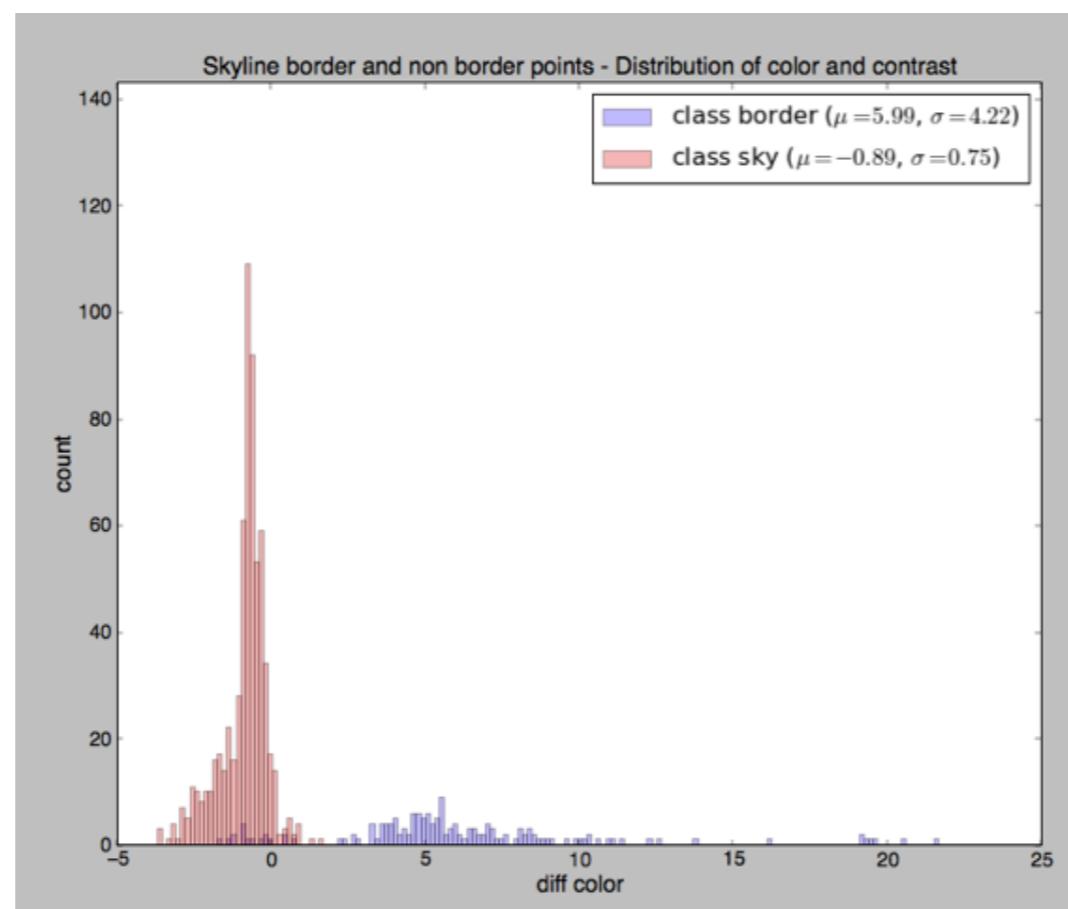
costa rica test image



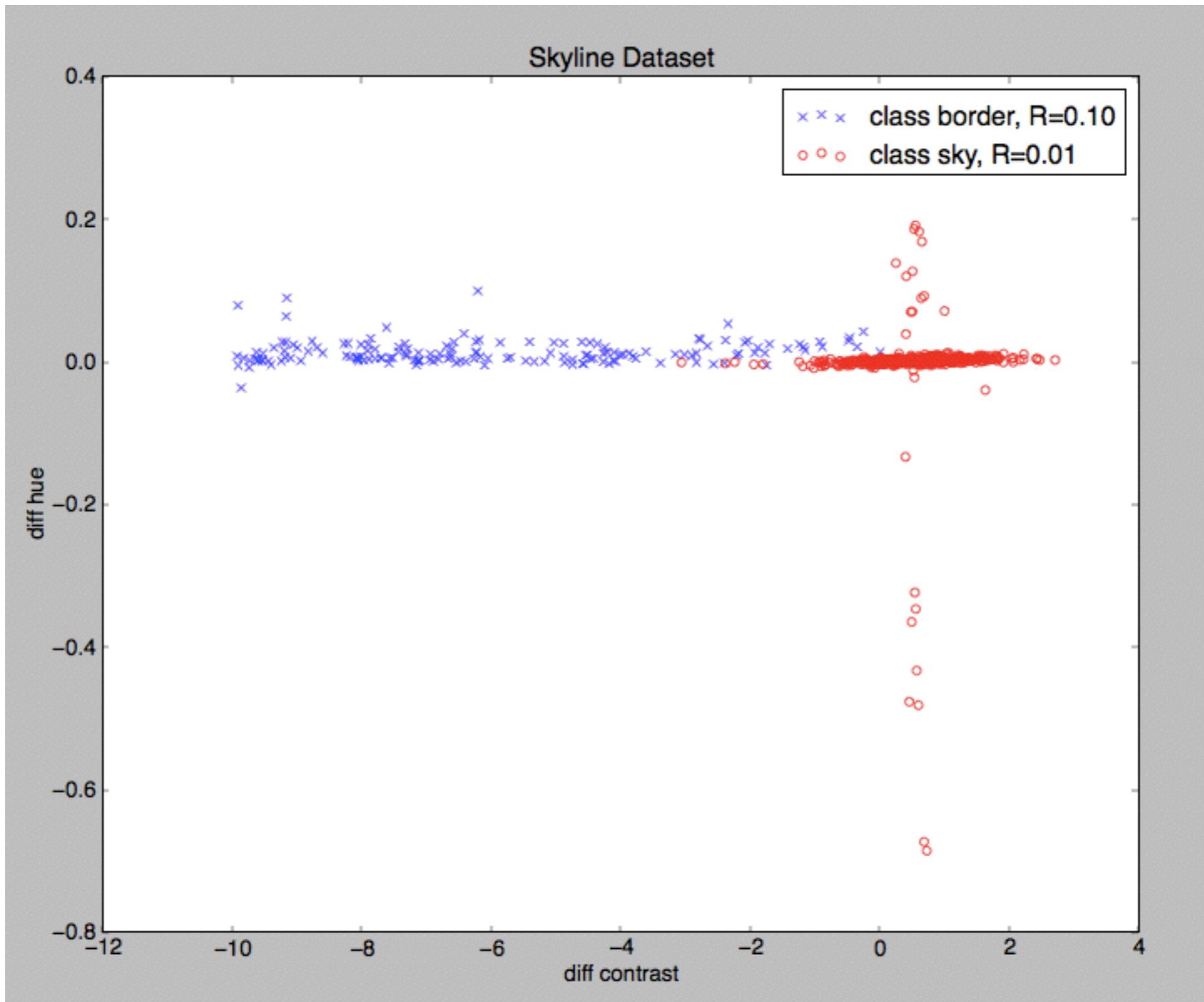
costa rica test image



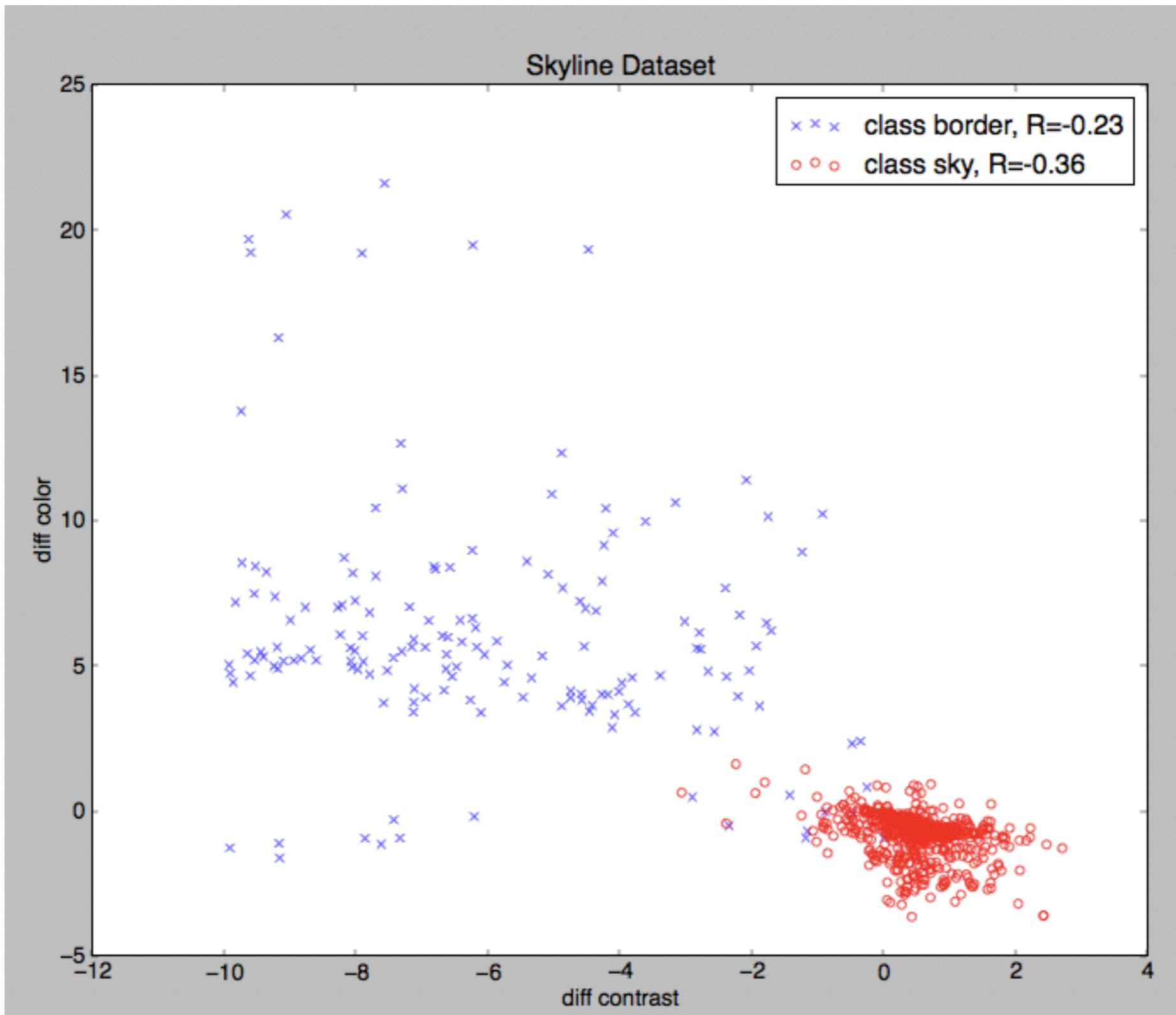
*note: the largest contrasts were removed from analysis for plot visibility



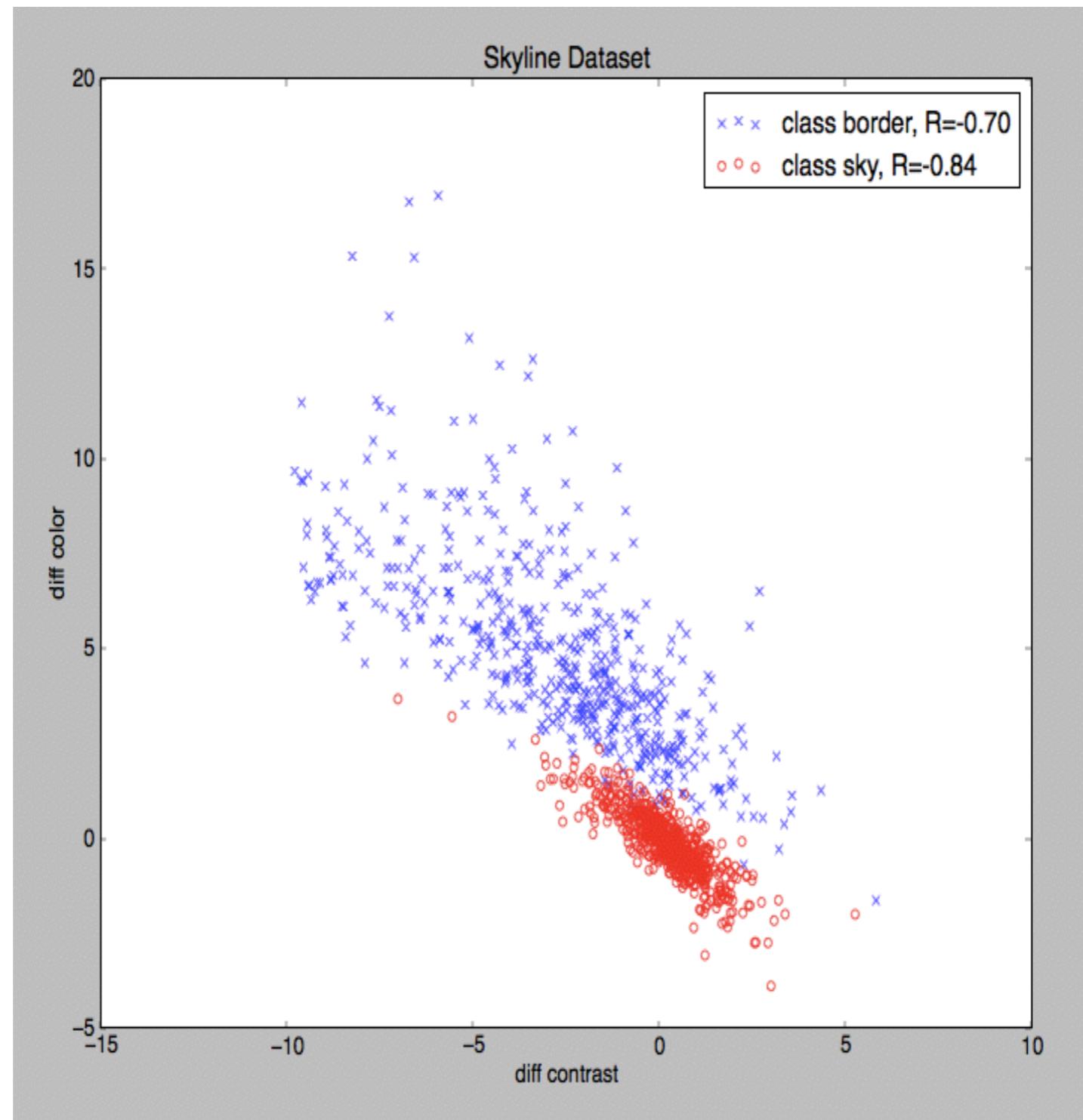
costa rica test image



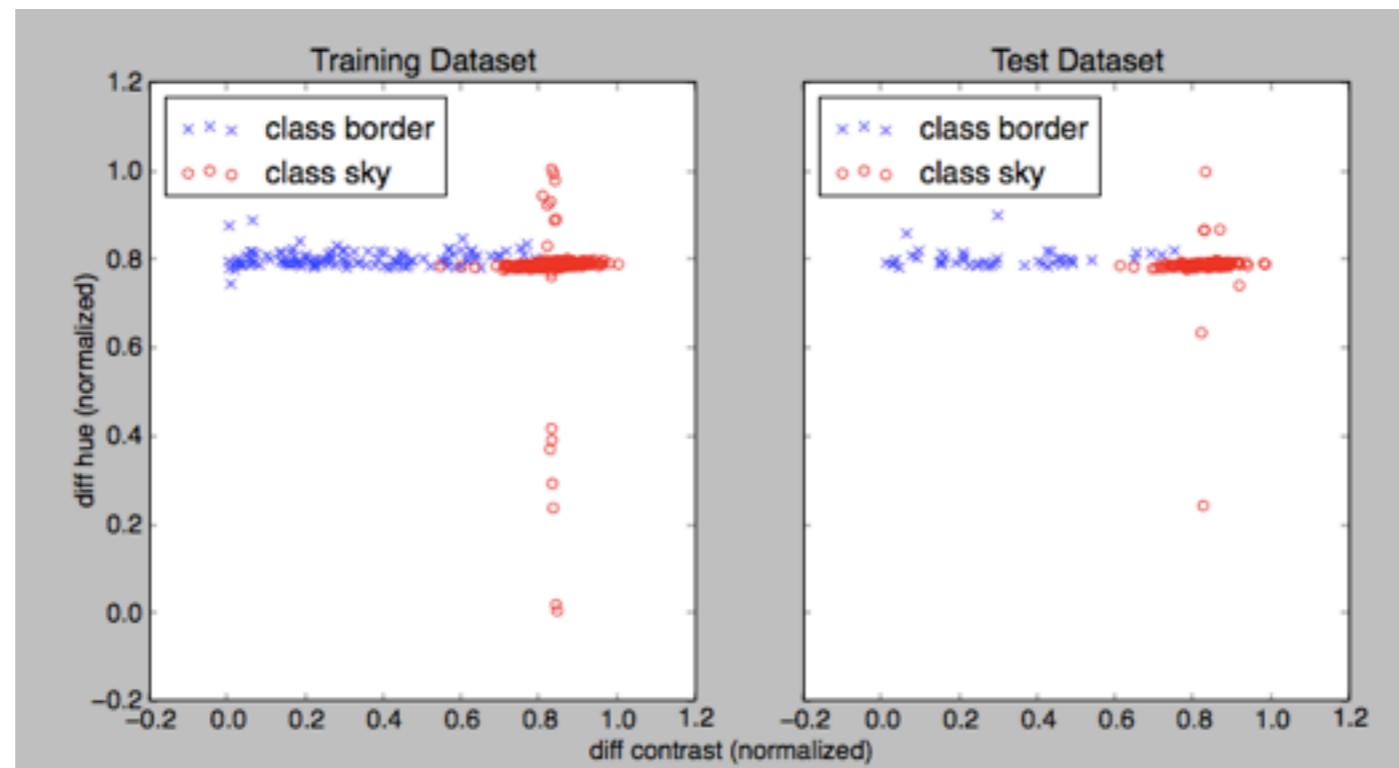
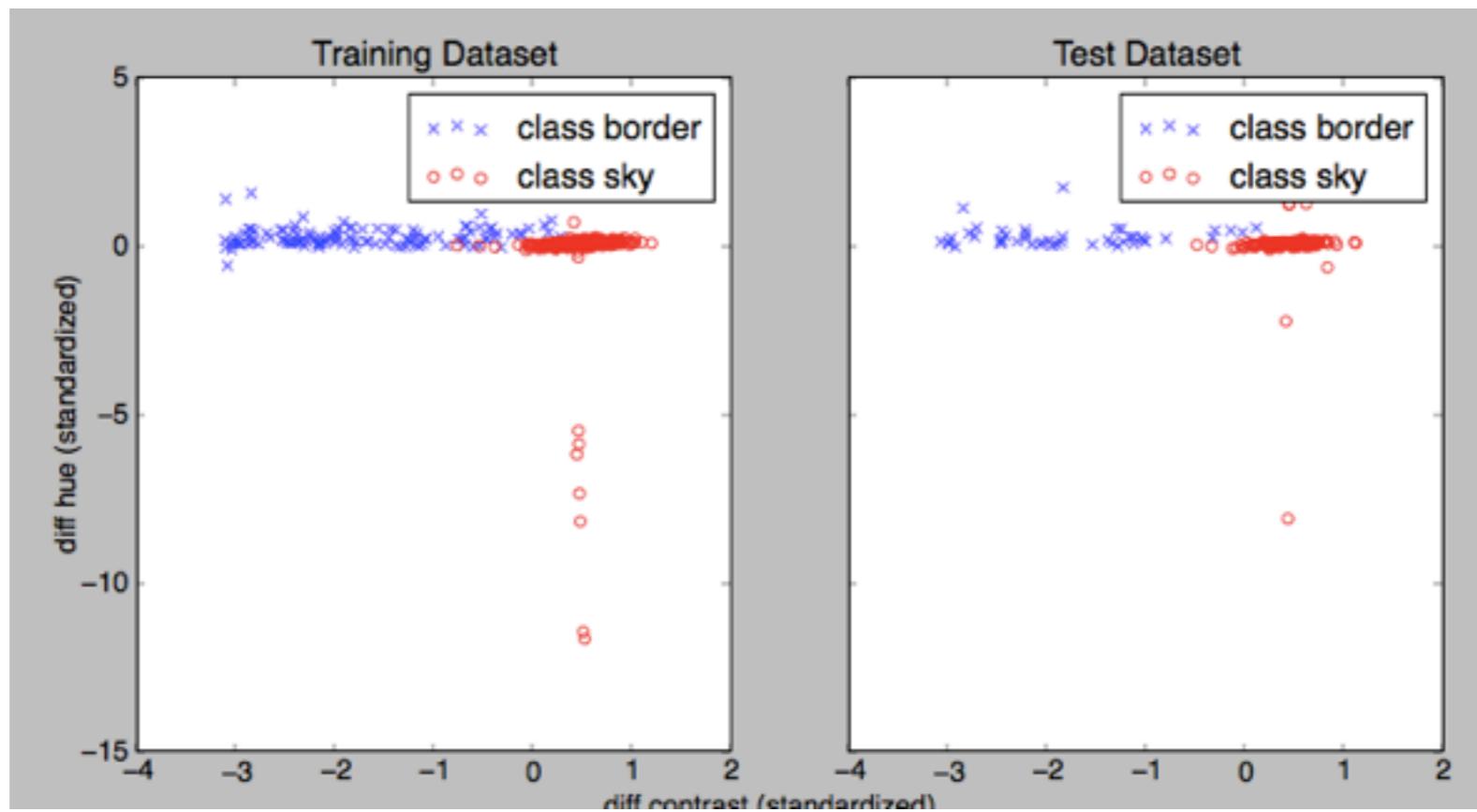
costa rica test image



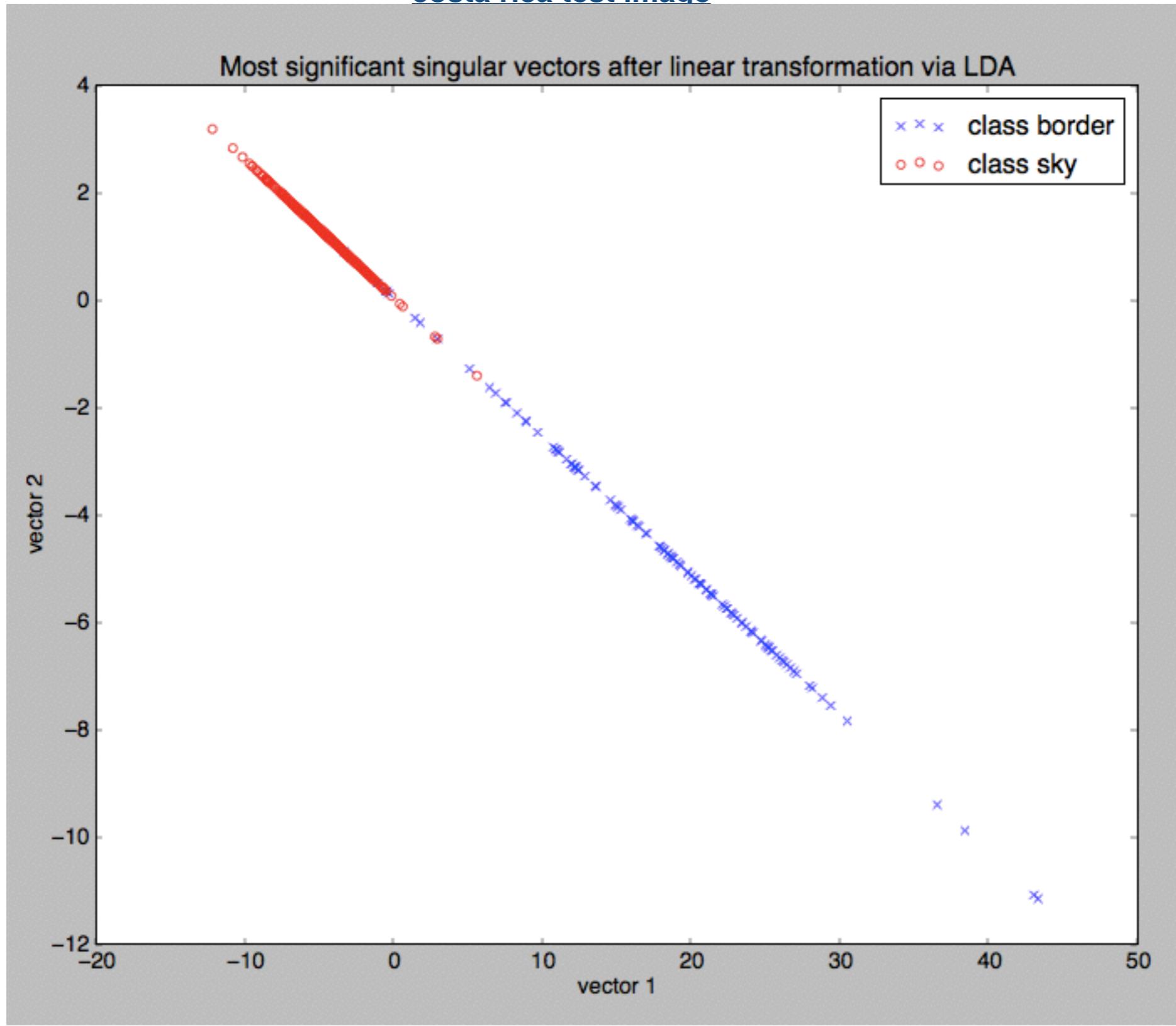
costa rica test image



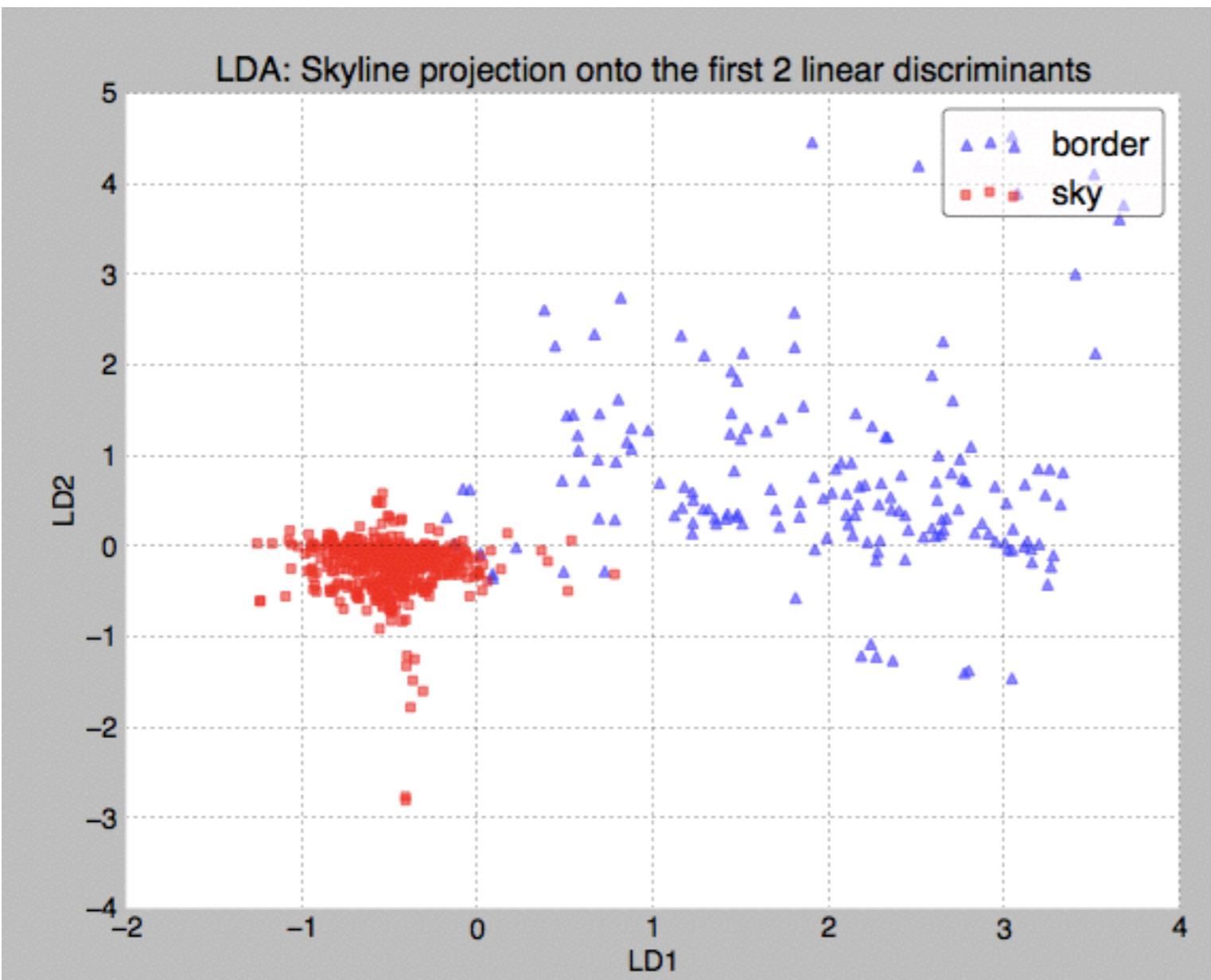
costa rica test image



costa rica test image



costa rica test image



contrast	hue	BorR
-1.7744	0.2375	1.6116
0.4464	-0.0597	-0.4054

('within-class Scatter Matrix:\n',
array([[166.5698, 6.8544, -52.5003],
[6.8544, 789.6358, -30.2555],
[-52.5003, -30.2555, 277.6674]]))

('between-class Scatter Matrix:\n',
array([[2554.1195, 396.0976, -1077.8011],
[396.0976, 684.9215, 882.1842],
[-1077.8011, 882.1842, 2220.8267]]))

Eigenvector 1:
[[-0.9931]
[-0.0112]
[0.1171]]

Eigenvalue 1: 1.55e+01

Eigenvector 2:
[[-0.3294]
[0.8117]
[-0.4823]]

Eigenvalue 2: 1.17e-15

Eigenvector 3:
[[0.4155]
[0.2067]
[0.8858]]

Eigenvalue 3: 7.81e+00

ok

Eigenvalues in decreasing order:

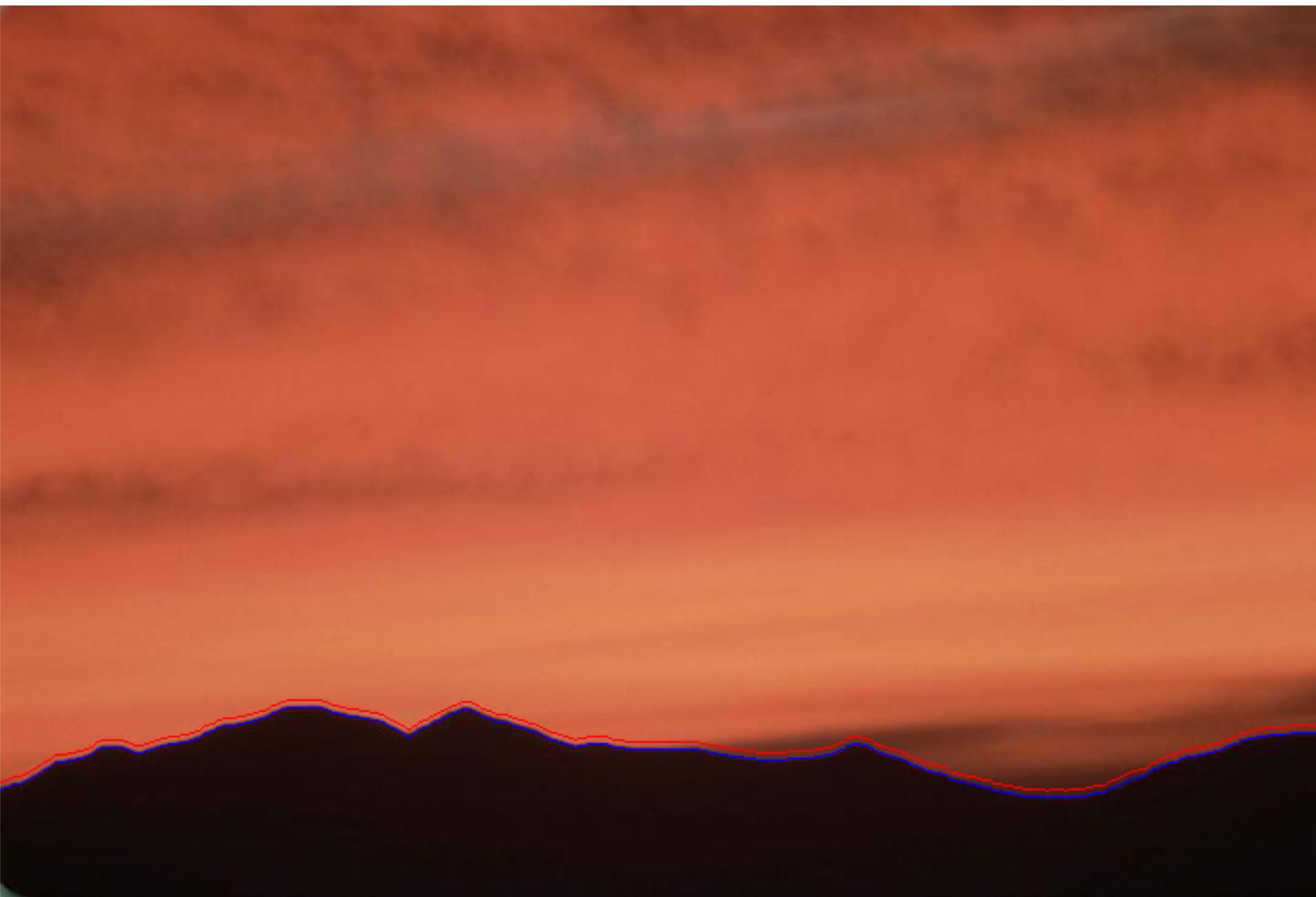
15.5386024436
7.80996914968
1.16573417586e-15

Variance explained:

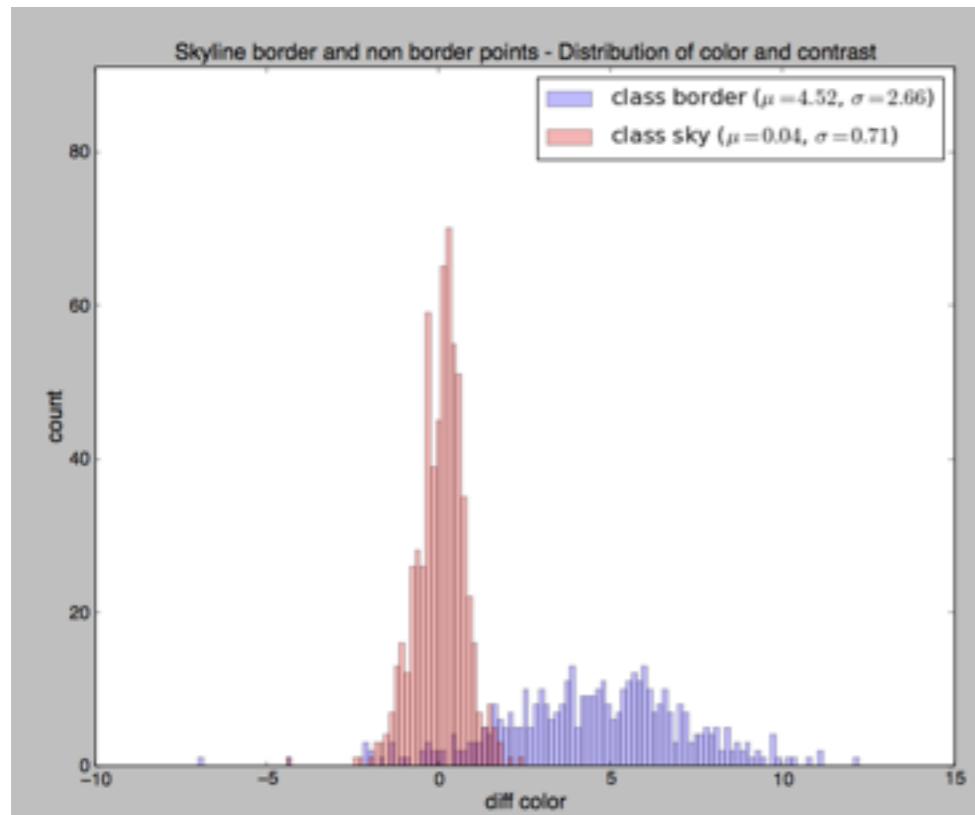
eigenvalue 1: 66.55%
eigenvalue 2: 33.45%
eigenvalue 3: 0.00%

('Matrix W:\n', array([[-0.9931, -0.0112, 0.1171],
[0.4155, 0.2067, 0.8858]]))

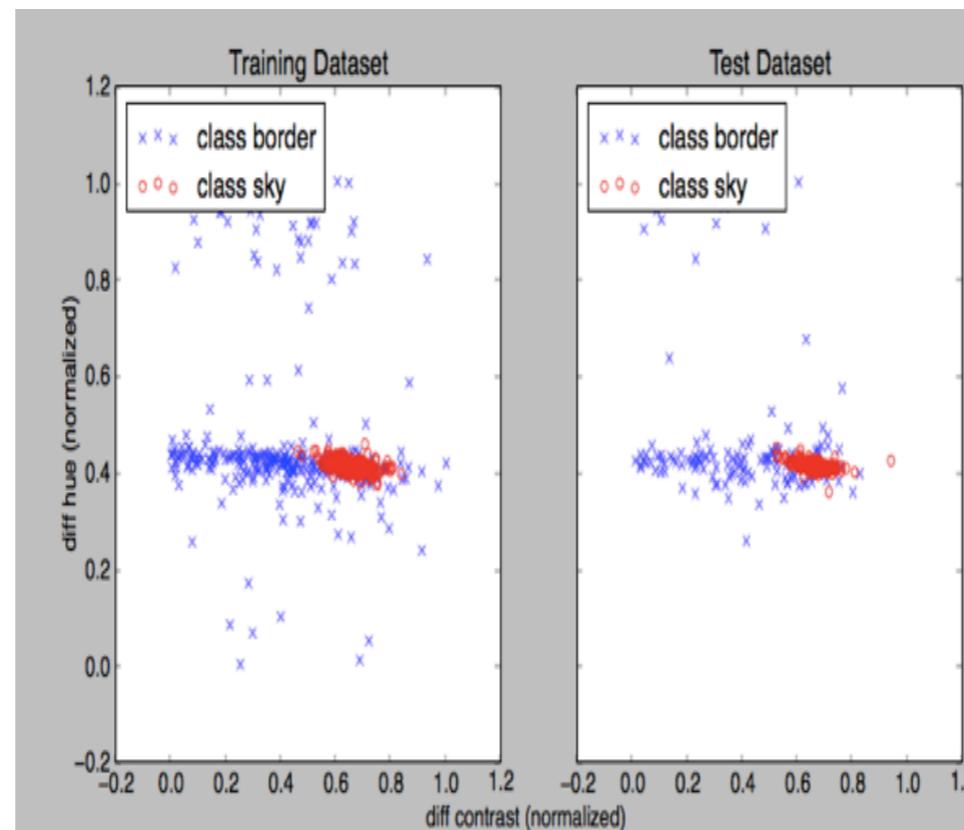
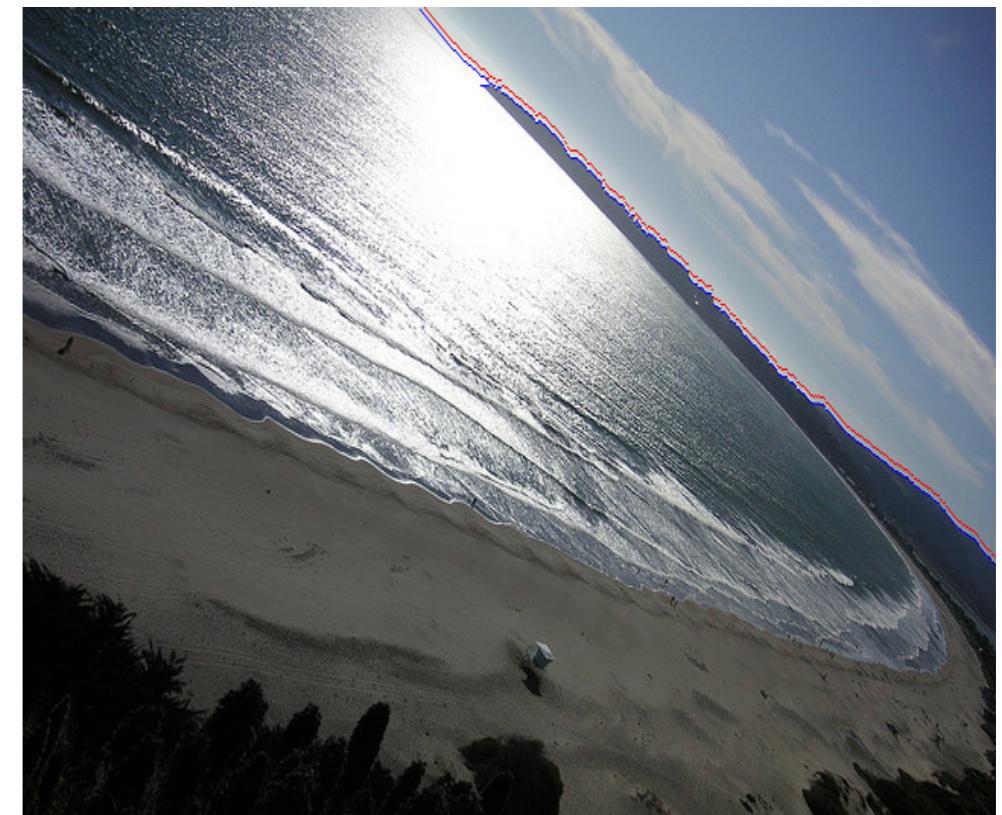
new mexico test image



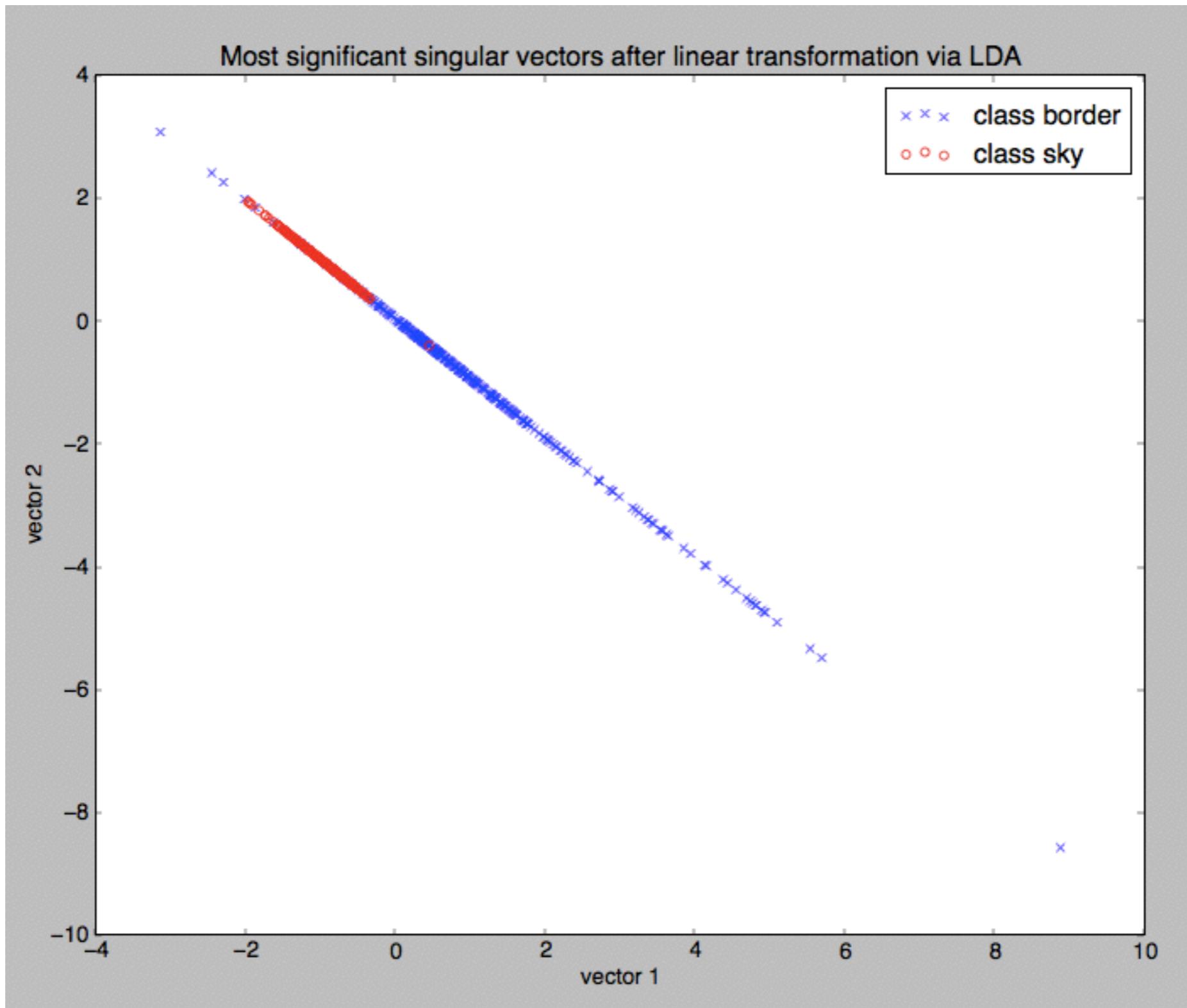
new mexico test image



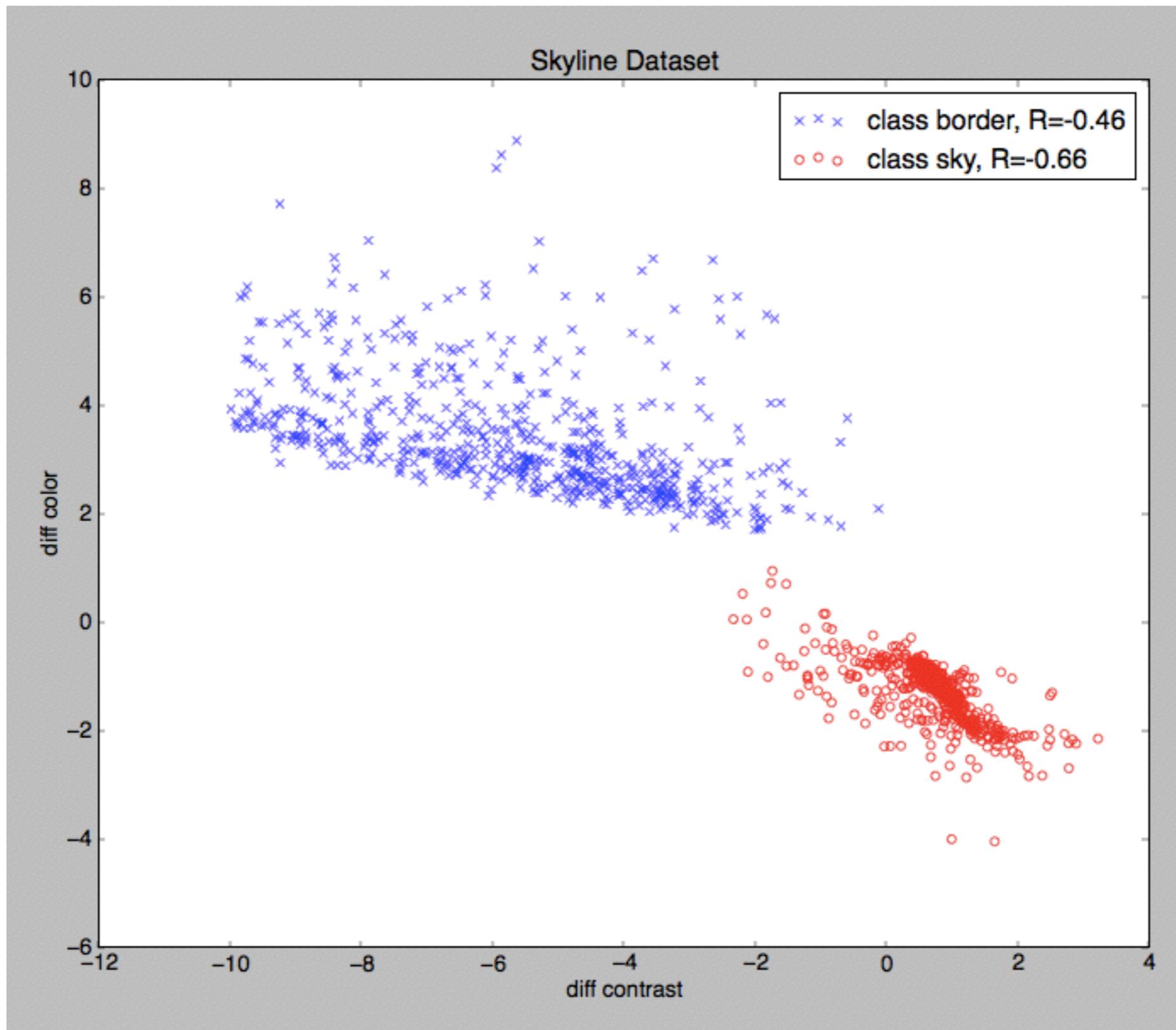
*note: the largest contrasts were removed from analysis for plot visibility



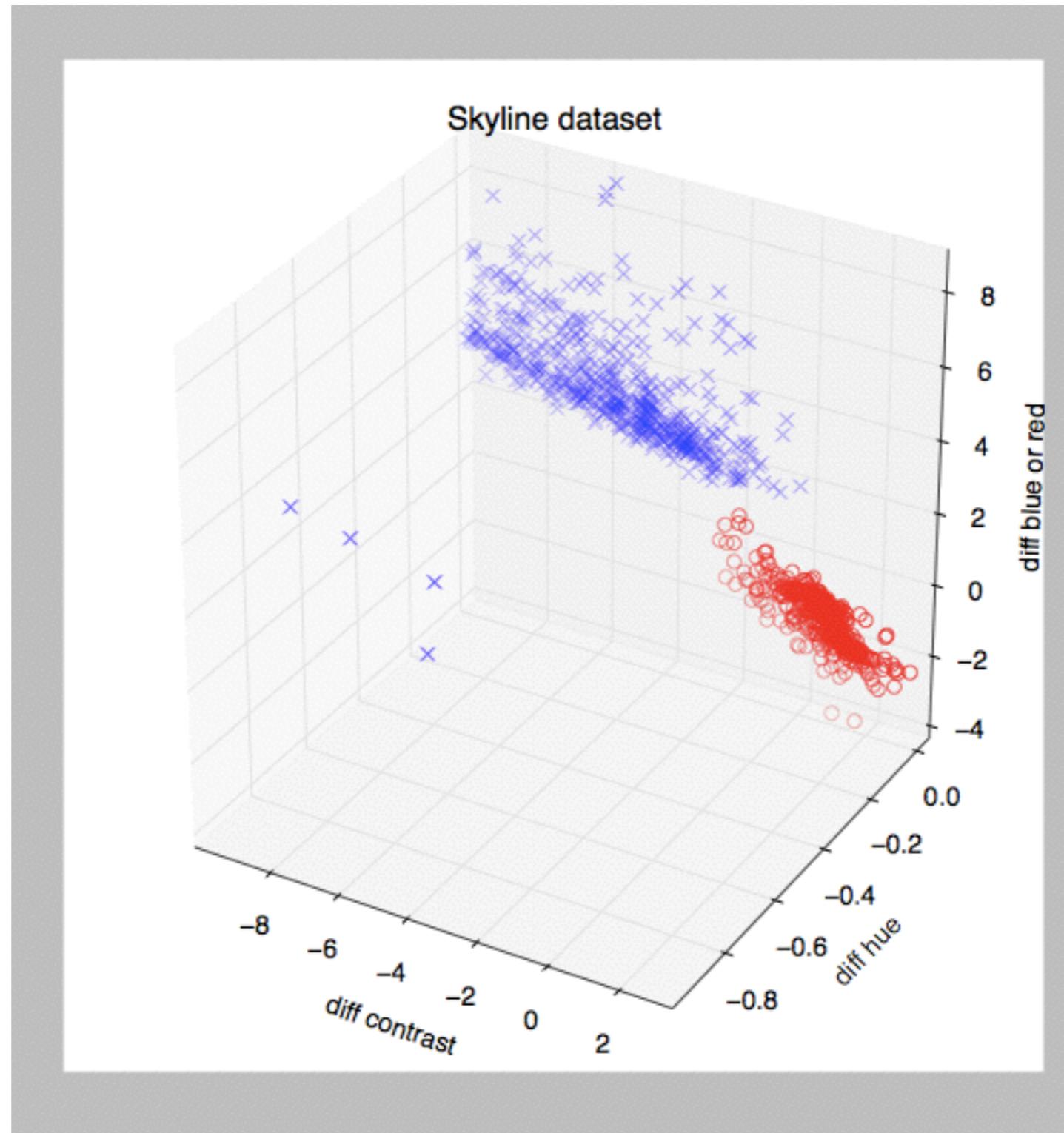
new mexico test image



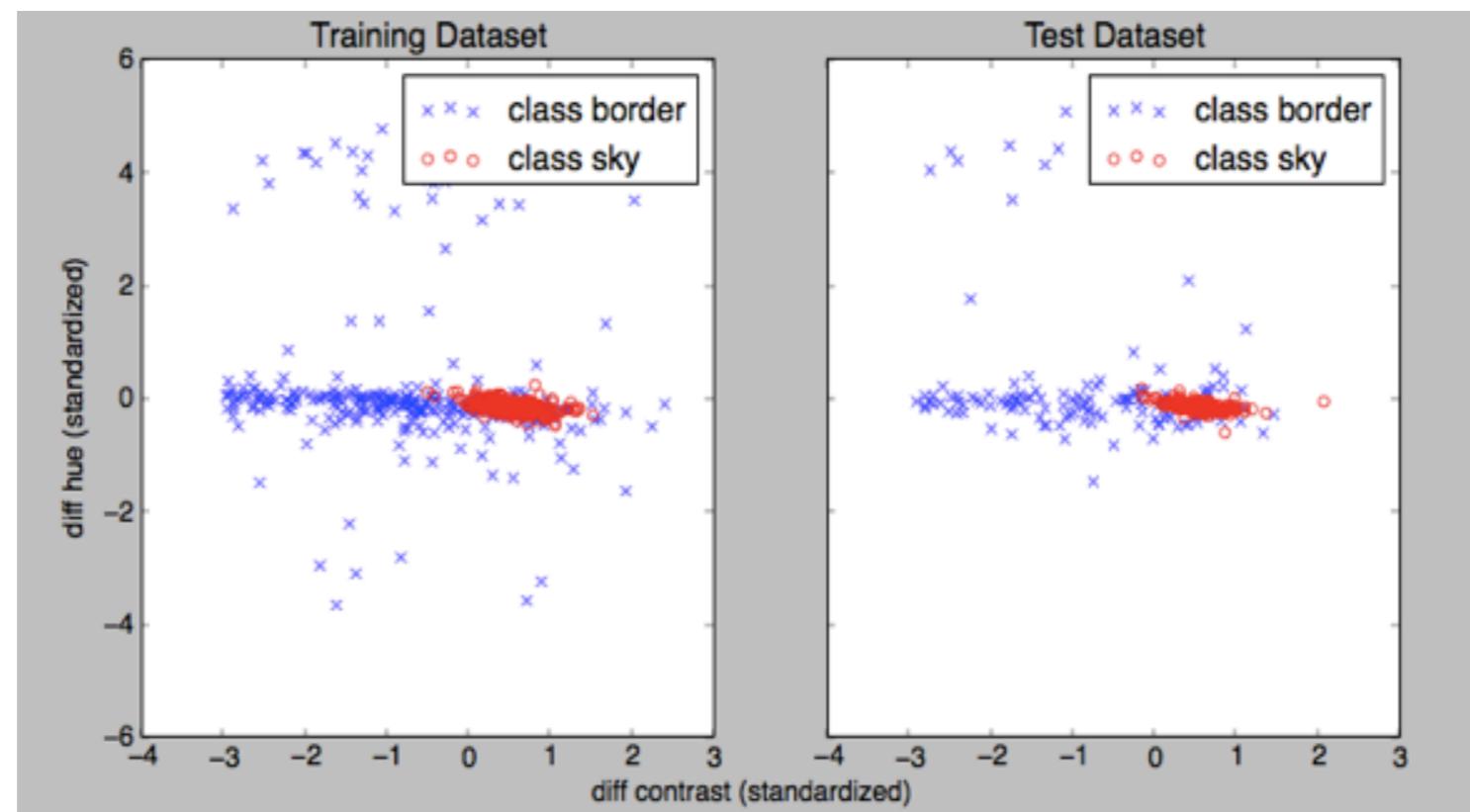
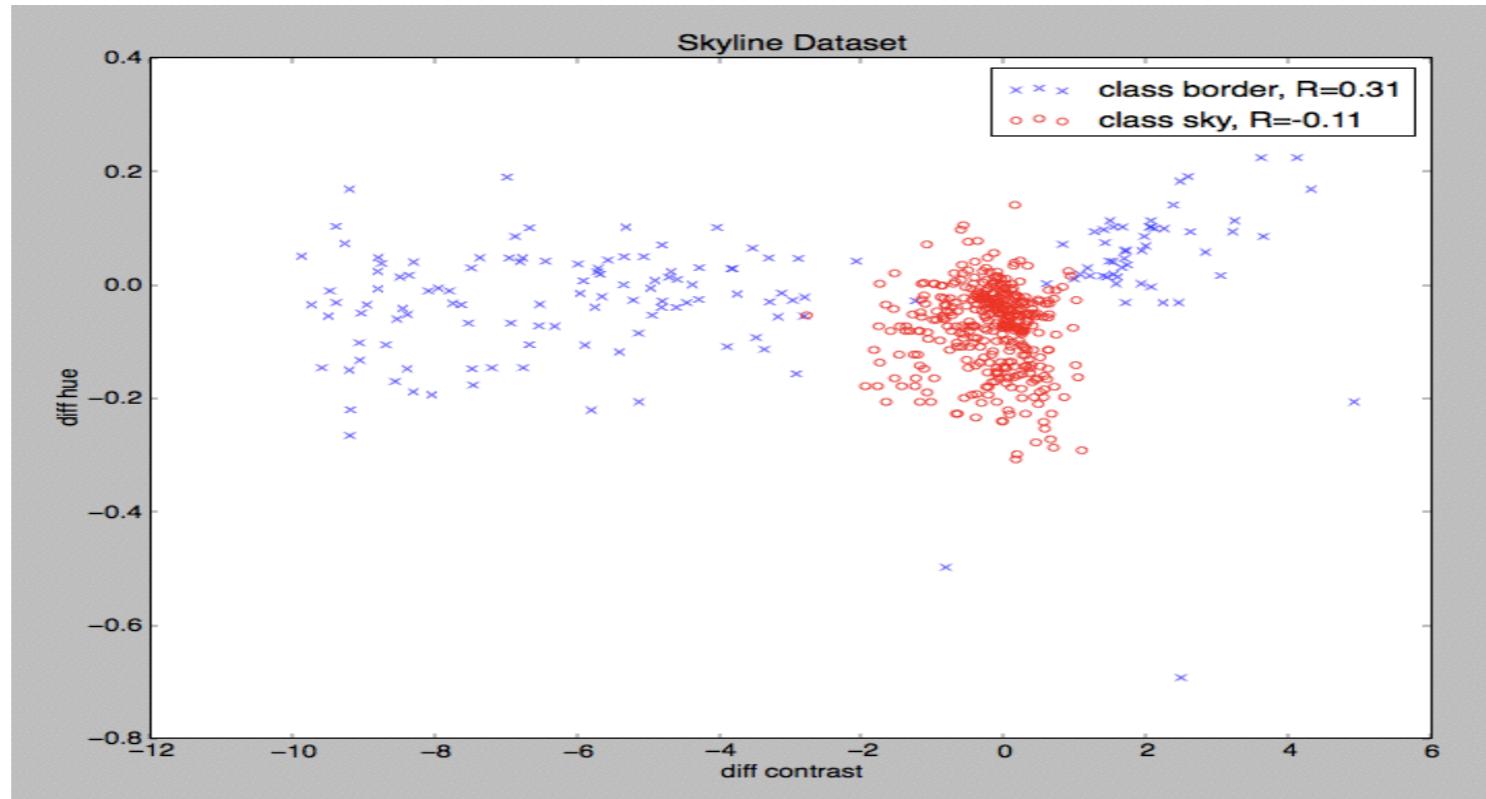
new mexico test image



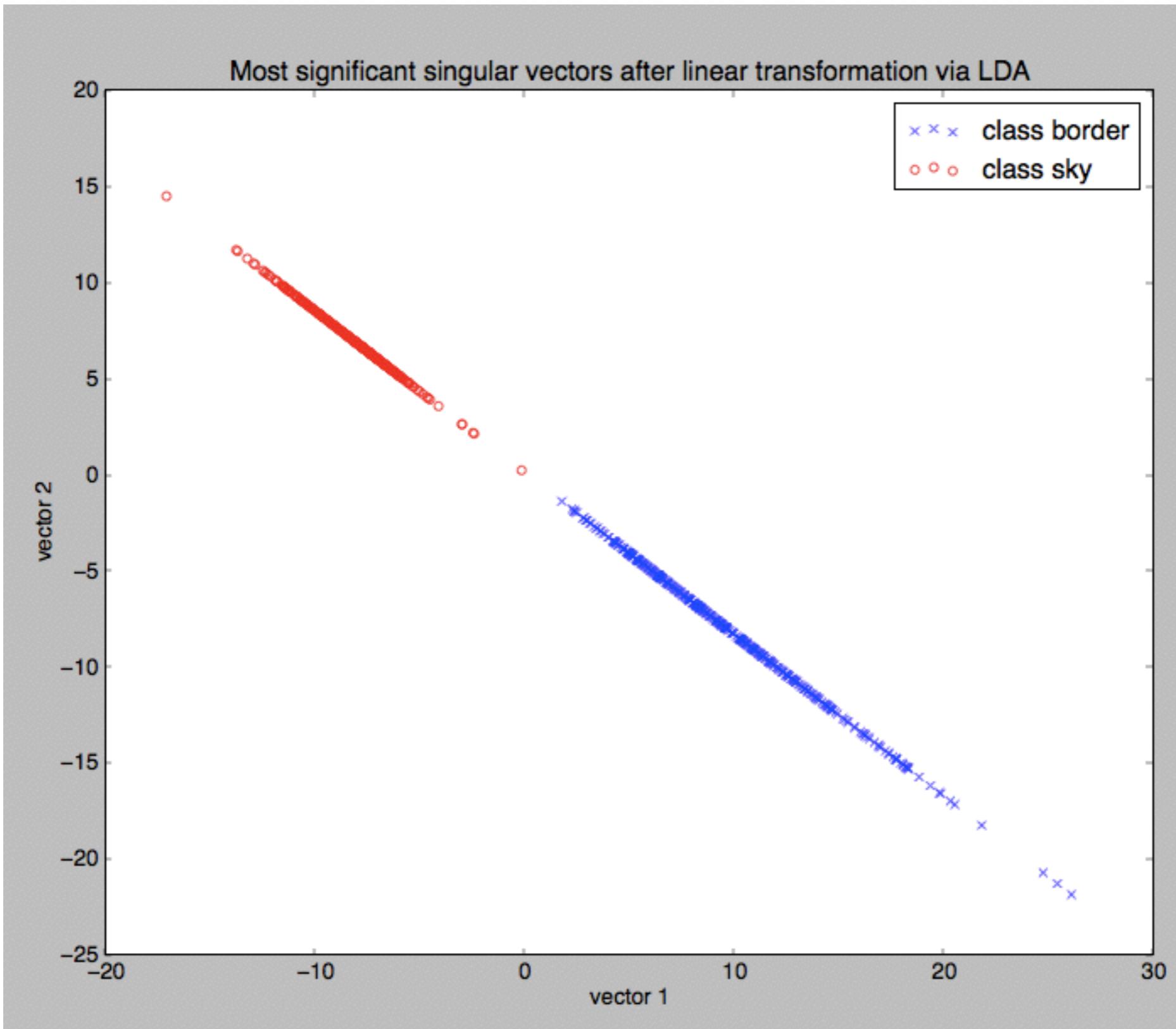
new mexico test image



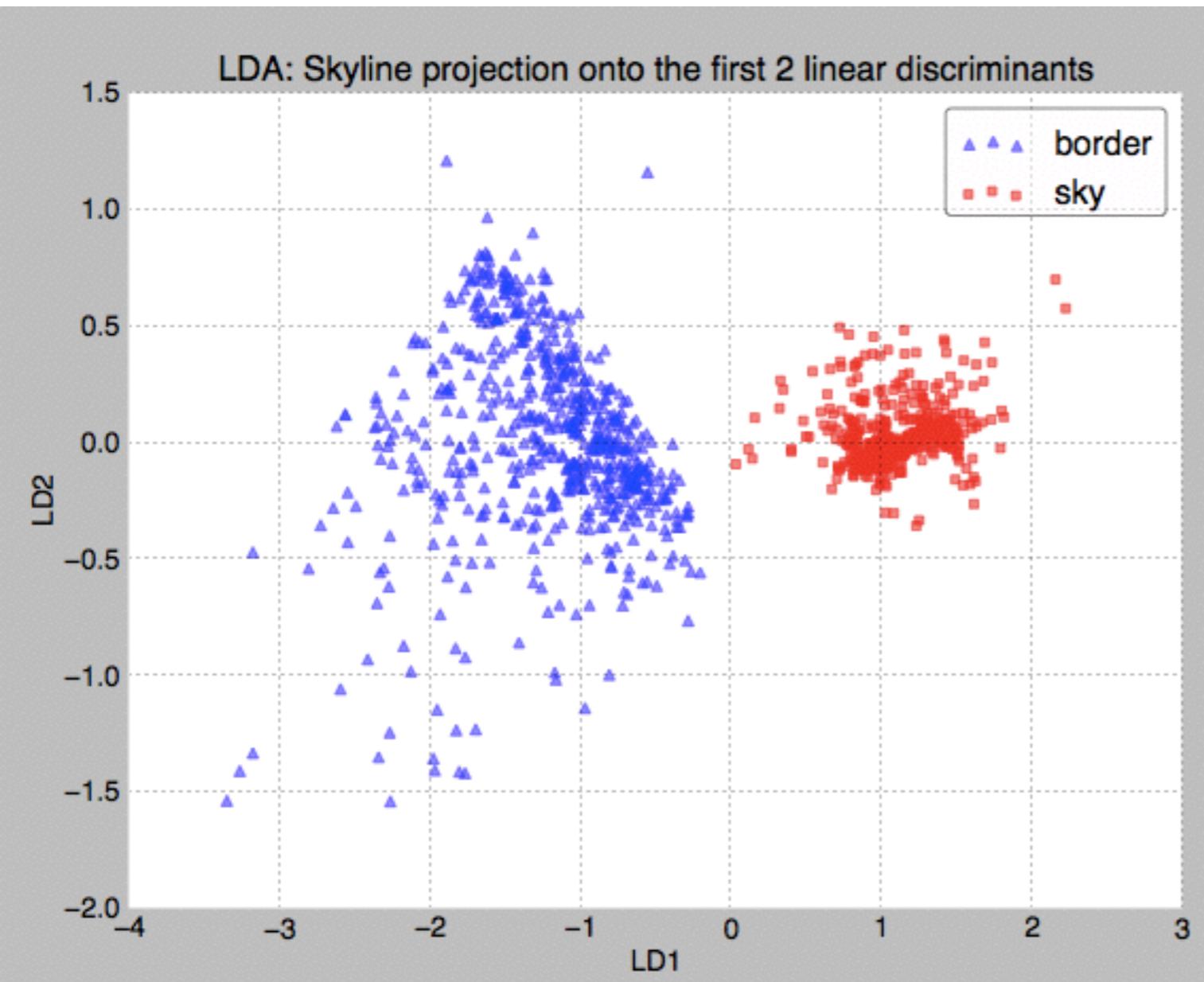
new mexico test image



new mexico test image



new mexico test image



```
contrast  hue   BorR
Mean Vector class 1: [-0.9673 -0.0244  1.0153]
Mean Vector class 2: [ 0.8272  0.0209 -0.8683]

('within-class Scatter Matrix:\n',
array([[ 268.8979,   -6.2717,  -99.9184],
       [-6.2717,  1344.3154,  -29.6696],
       [-99.9184,  -29.6696,  159.2336]]))
('between-class Scatter Matrix:\n',
array([[ 3242.1798,    95.2984, -3374.9391],
       [ 95.2984,   15.9273,  -71.5997],
       [-3374.9391, -71.5997,  3571.1727]]))

Eigenvector 1:
[[ 0.2783]
 [-0.017 ]
 [-0.9603]]
Eigenvalue 1: 2.42e+01

Eigenvector 2:
[[-0.7224]
 [-0.0797]
 [-0.6868]]
Eigenvalue 2: 2.55e-01

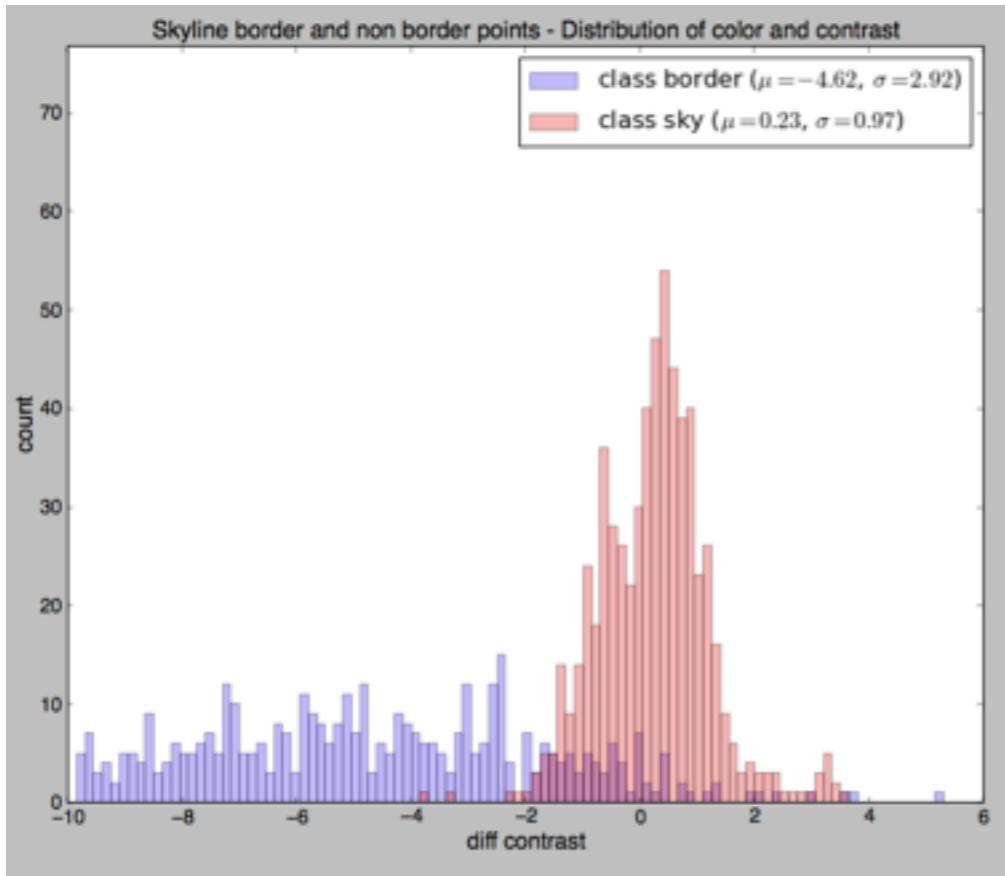
Eigenvector 3:
[[ 0.428 ]
 [-0.8162]
 [ 0.3881]]
Eigenvalue 3: 8.18e-16
ok
Eigenvalues in decreasing order:
24.2346515941
0.254794059977
8.17964421251e-16
Variance explained:

eigenvalue 1: 98.96%
eigenvalue 2: 1.04%
eigenvalue 3: 0.00%
('Matrix W:\n', array([[ 0.2783, -0.017 , -0.9603],
       [-0.7224, -0.0797, -0.6868]]))
```

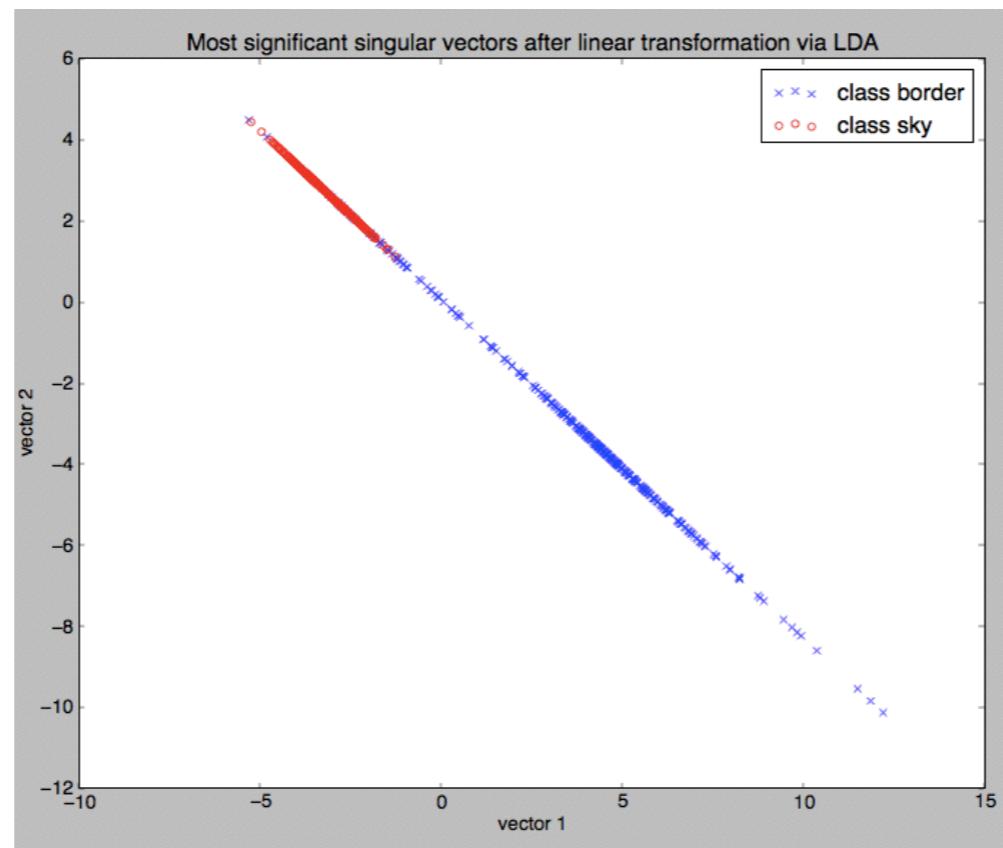
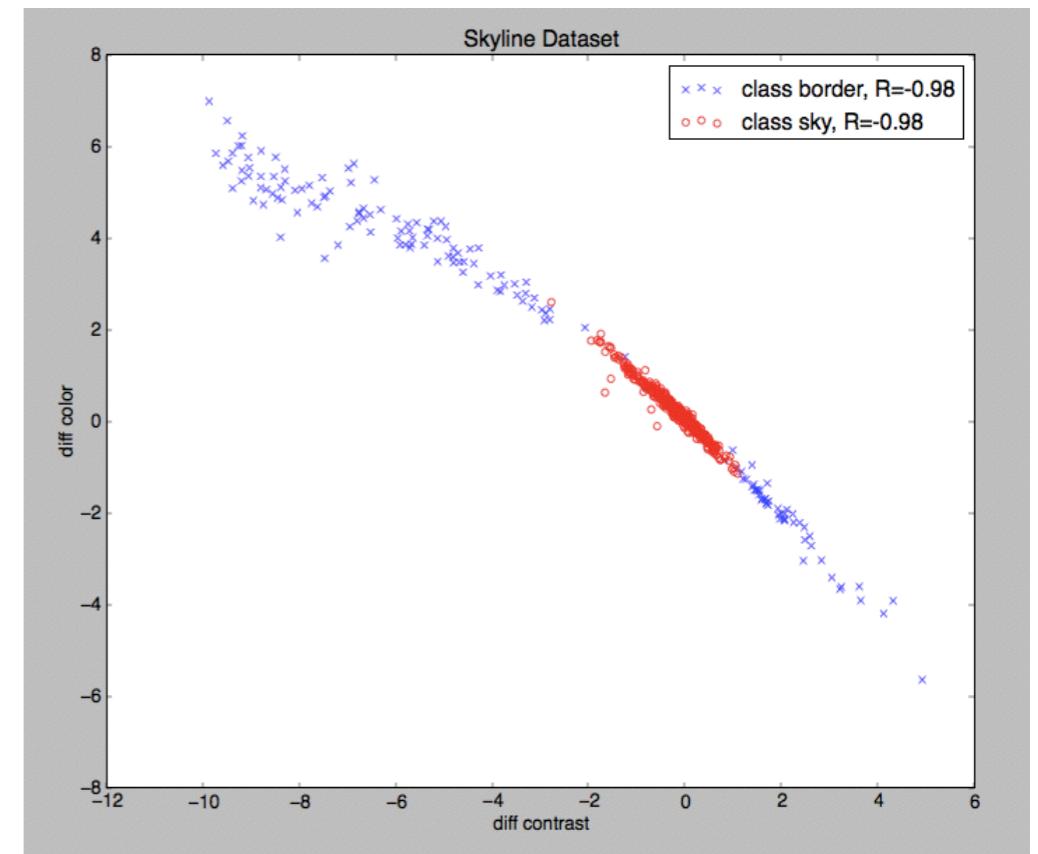
arizona test image



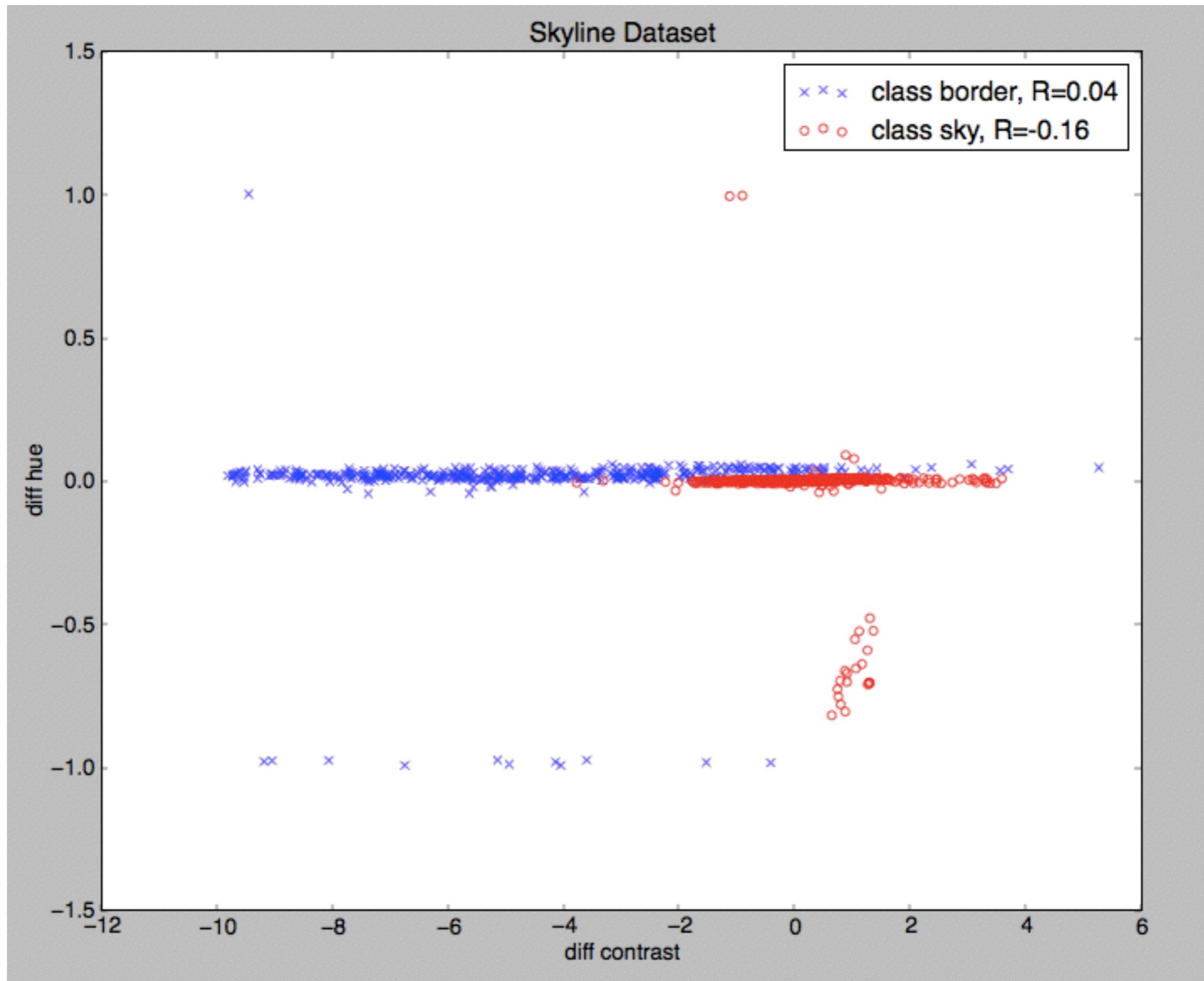
arizona test image



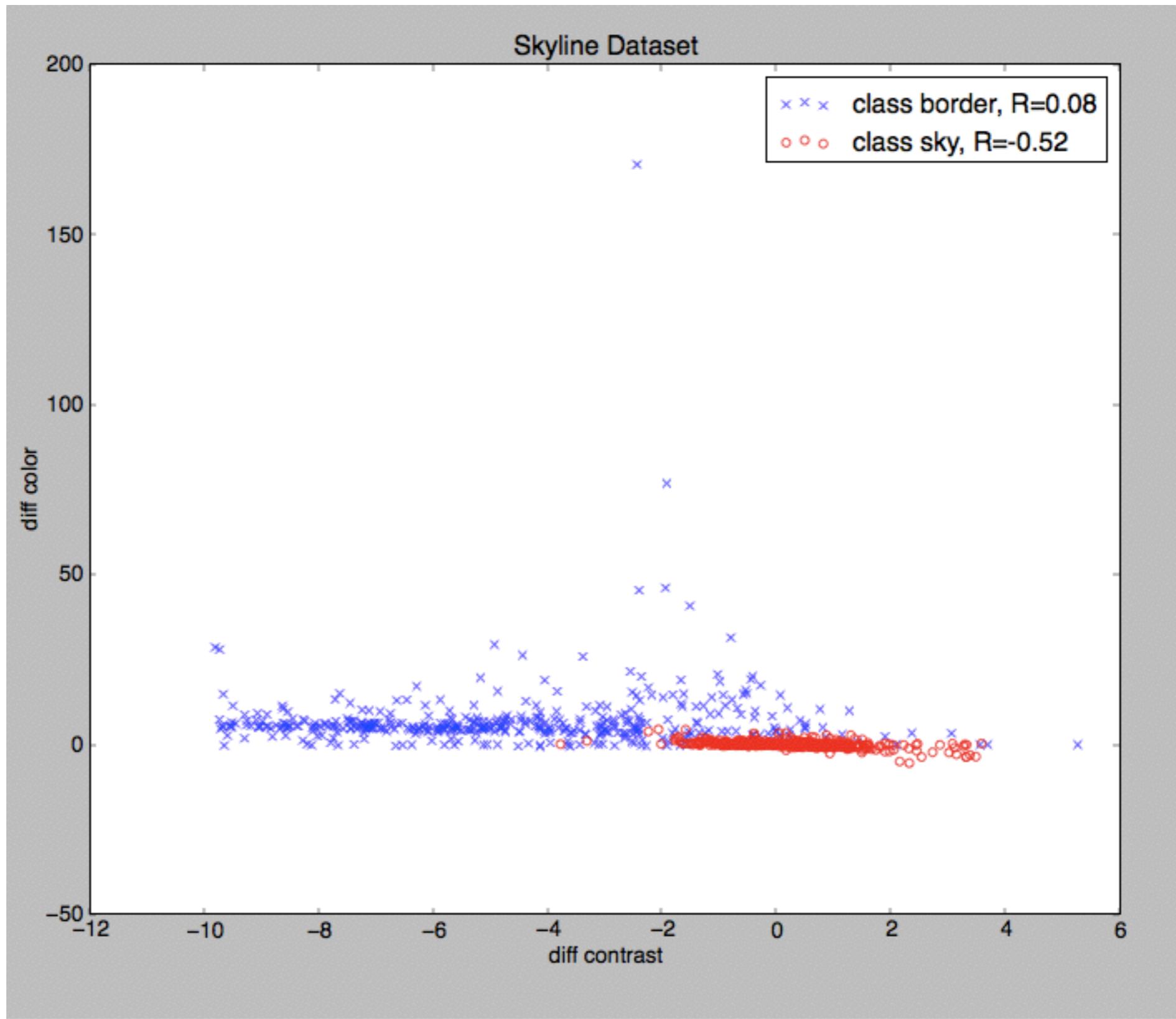
*note: the largest contrasts were removed from analysis for plot visibility



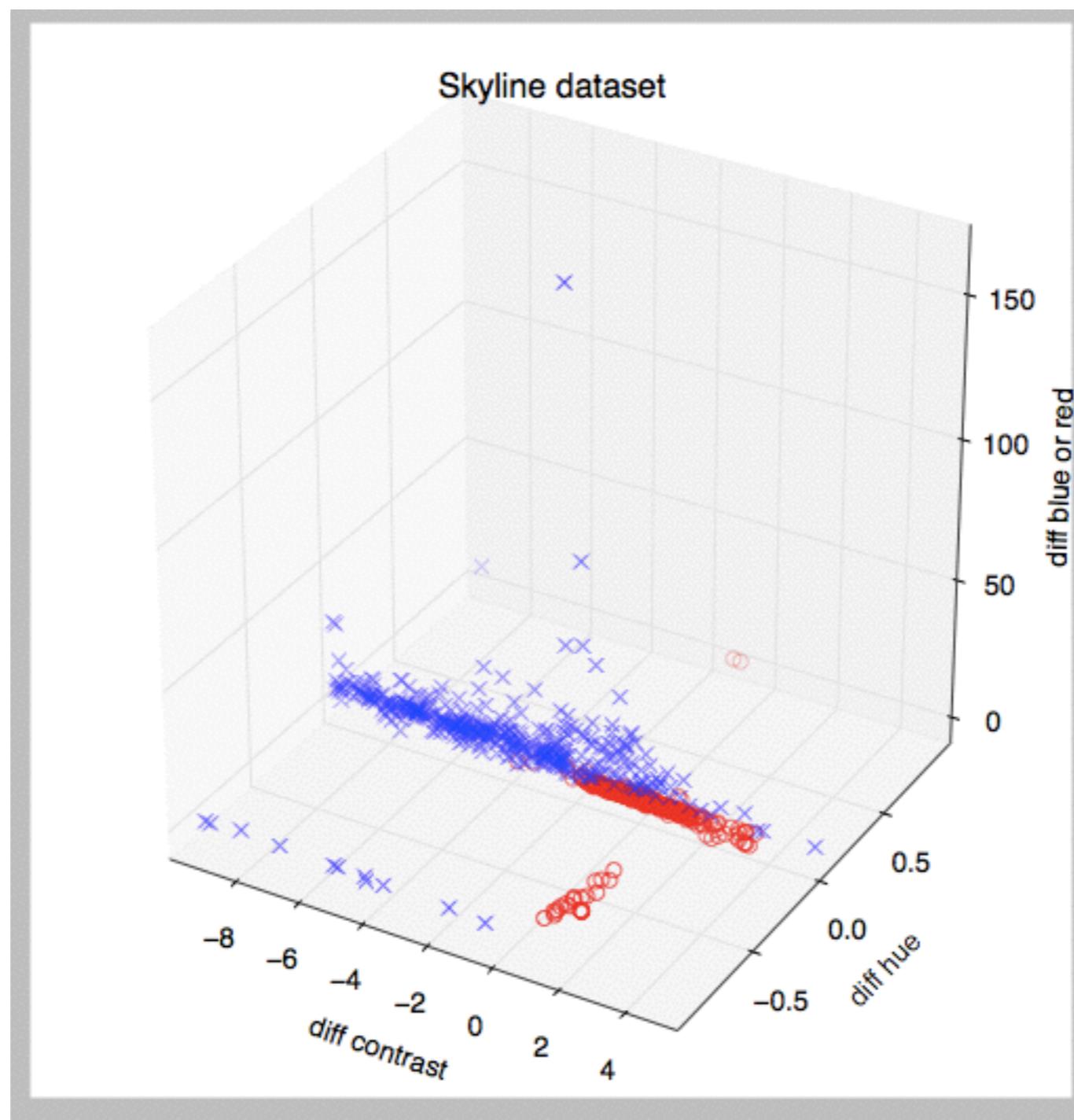
arizona test image



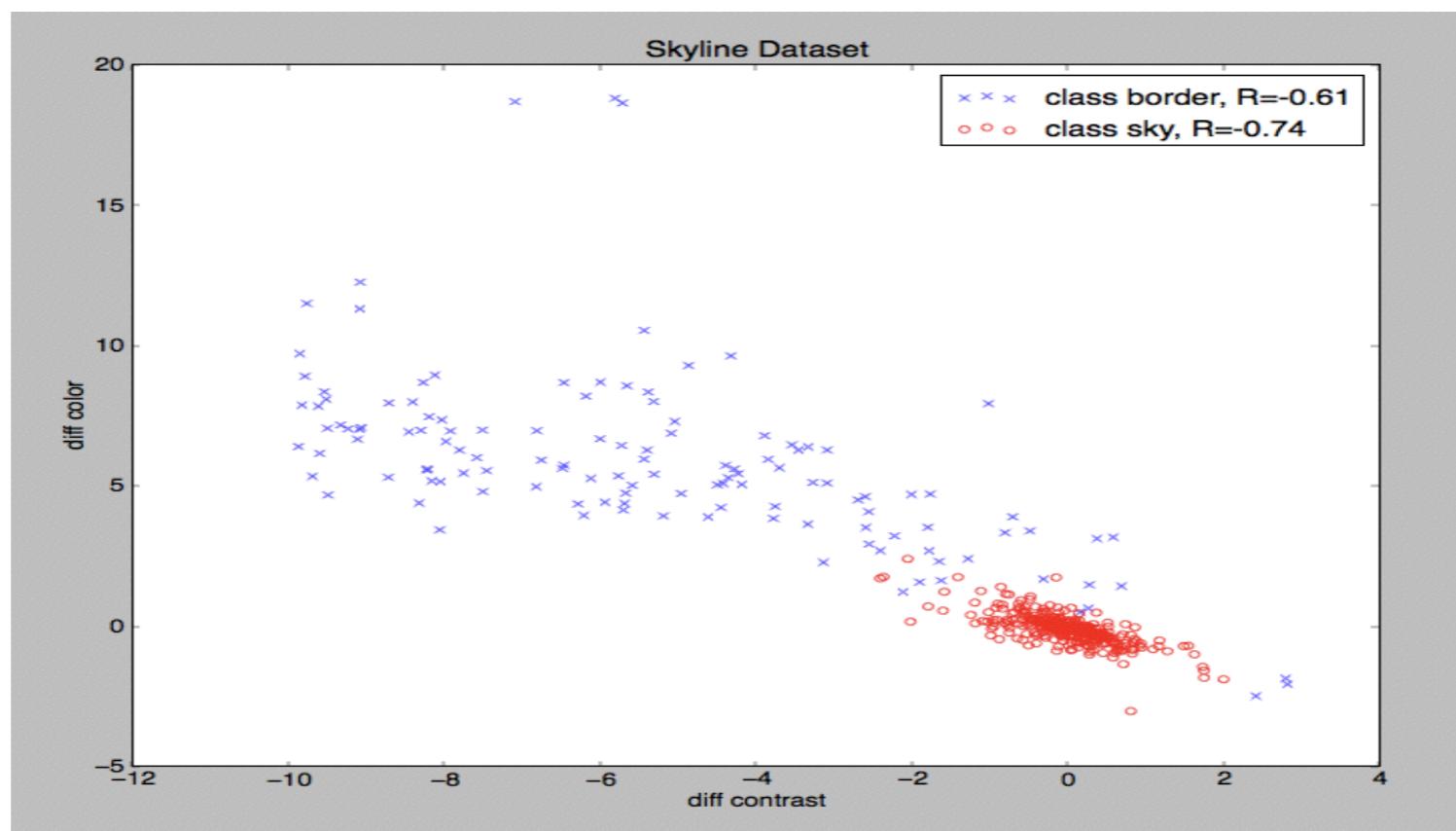
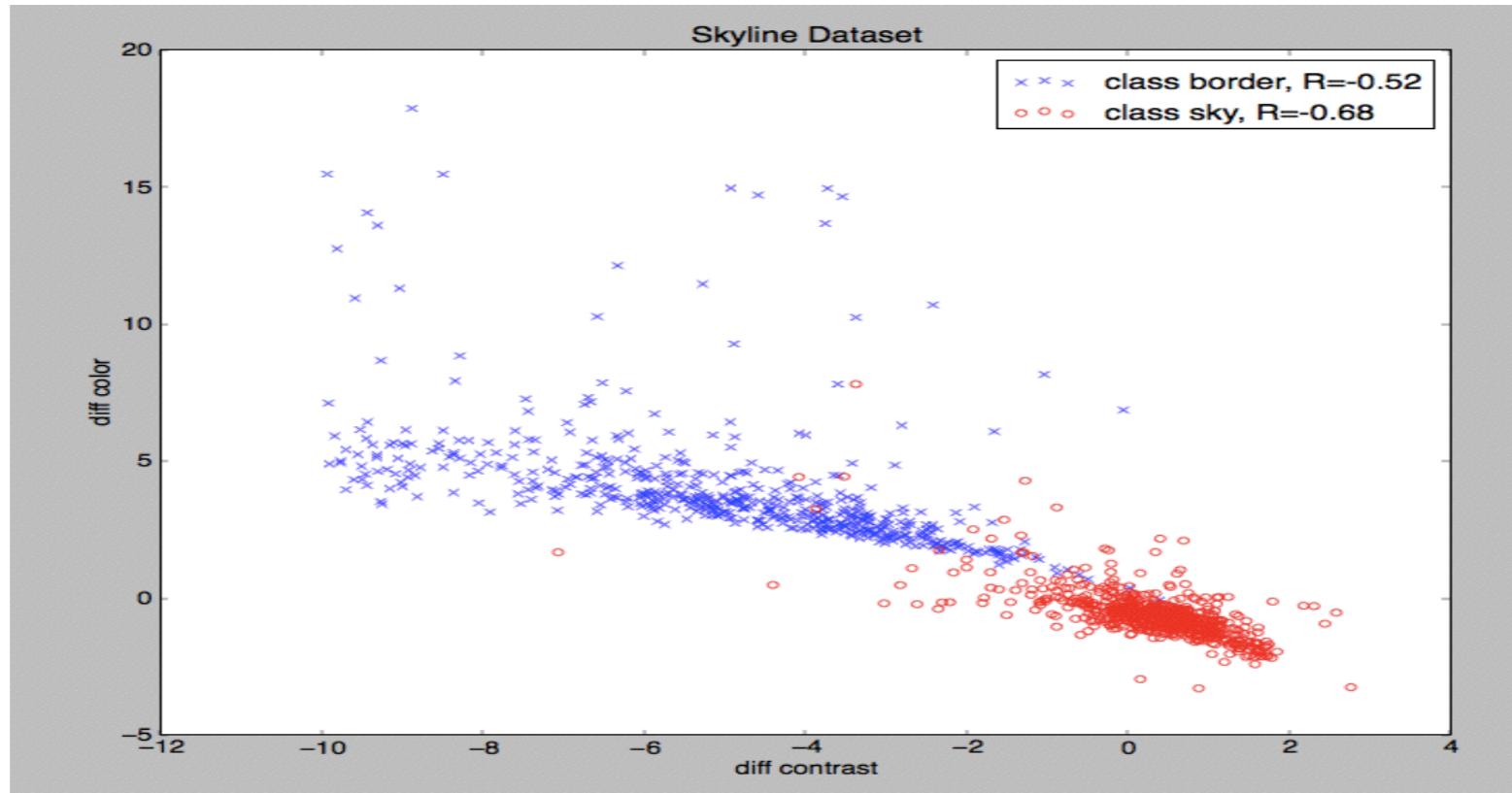
arizona test image



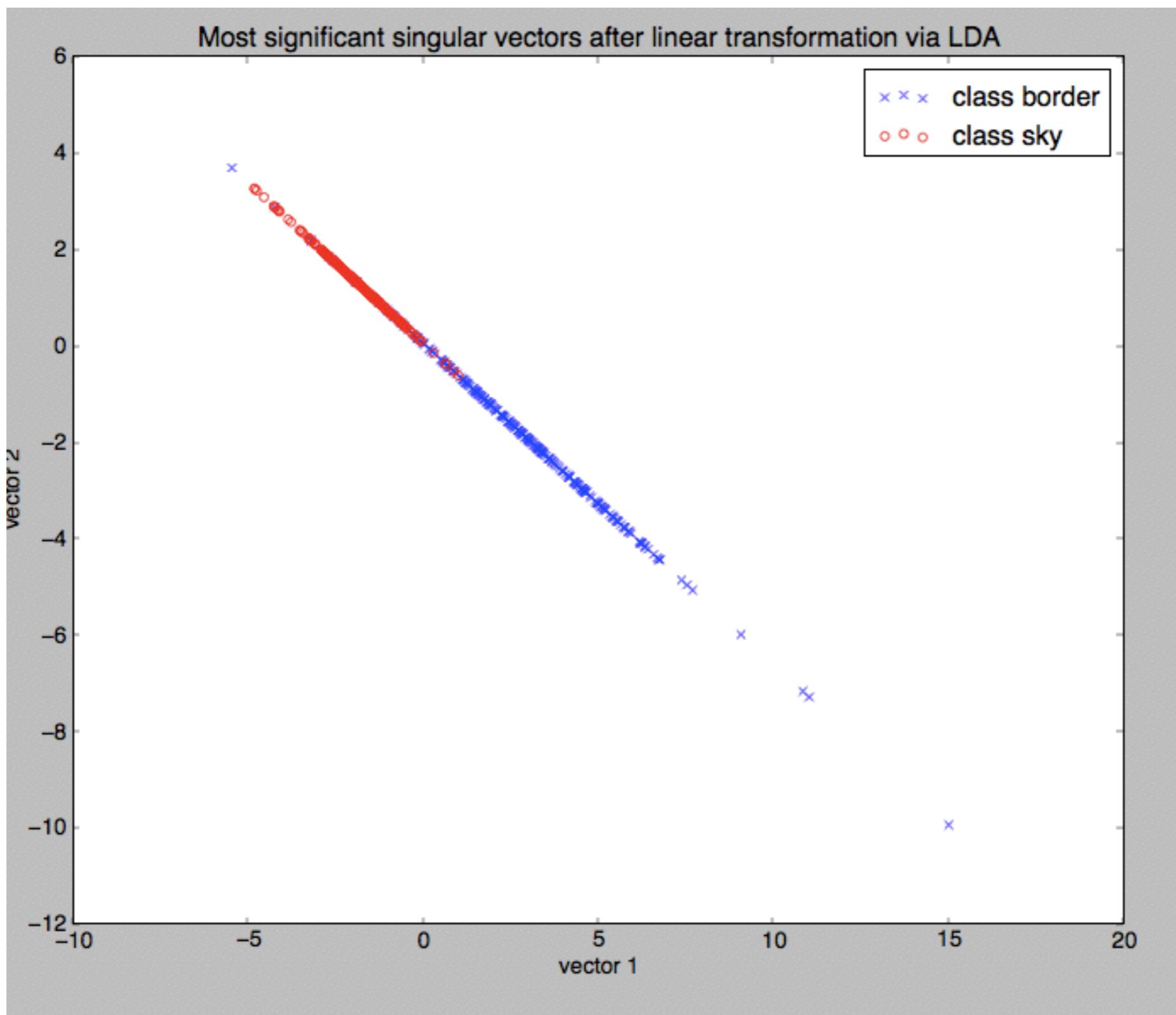
arizona test image



arizona test image



arizona test image



arizona test image

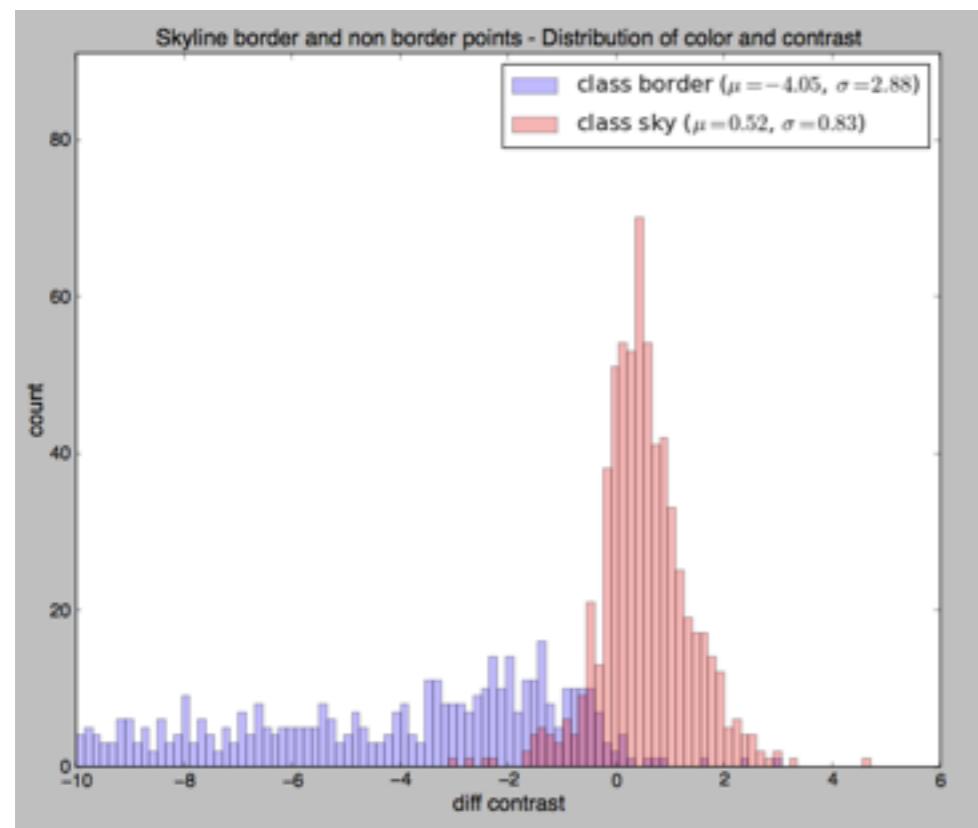


contrast	hue	BorR
Mean Vector class 1: [-0.9274	0.0676	0.5582]
Mean Vector class 2: [0.6329	-0.0462	-0.3809]
('within-class Scatter Matrix:\n',		
array([[426.6628, -9.4933, 32.1831],		
[-9.4933, 1029.7744, 30.872],		
[32.1831, 30.872 , 813.3243]]))		
('between-class Scatter Matrix:\n',		
array([[1849.6528, -102.0323, -1064.2459],		
[-102.0323, 40.3181, 110.4992],		
[-1064.2459, 110.4992, 689.6683]]))		
Eigenvalue 1:		
[[0.9469]		
[-0.0058]		
[-0.3216]]		
Eigenvalue 1: 5.32e+00		
Eigenvalue 2:		
[[-0.4694]		
[-0.4678]		
[-0.7489]]		
Eigenvalue 2: 1.07e-01		
Eigenvalue 3:		
[[0.2646]		
[-0.8012]		
[0.5367]]		
Eigenvalue 3: -5.80e-17		
ok		
Eigenvalues in decreasing order:		
5.31932034283		
0.107340722064		
5.80177595038e-17		
Variance explained:		
eigenvalue 1: 98.02%		
eigenvalue 2: 1.98%		
eigenvalue 3: 0.00%		
('Matrix W:\n', array([[0.9469, -0.0058, -0.3216],		
[-0.4694, -0.4678, -0.7489]]))		

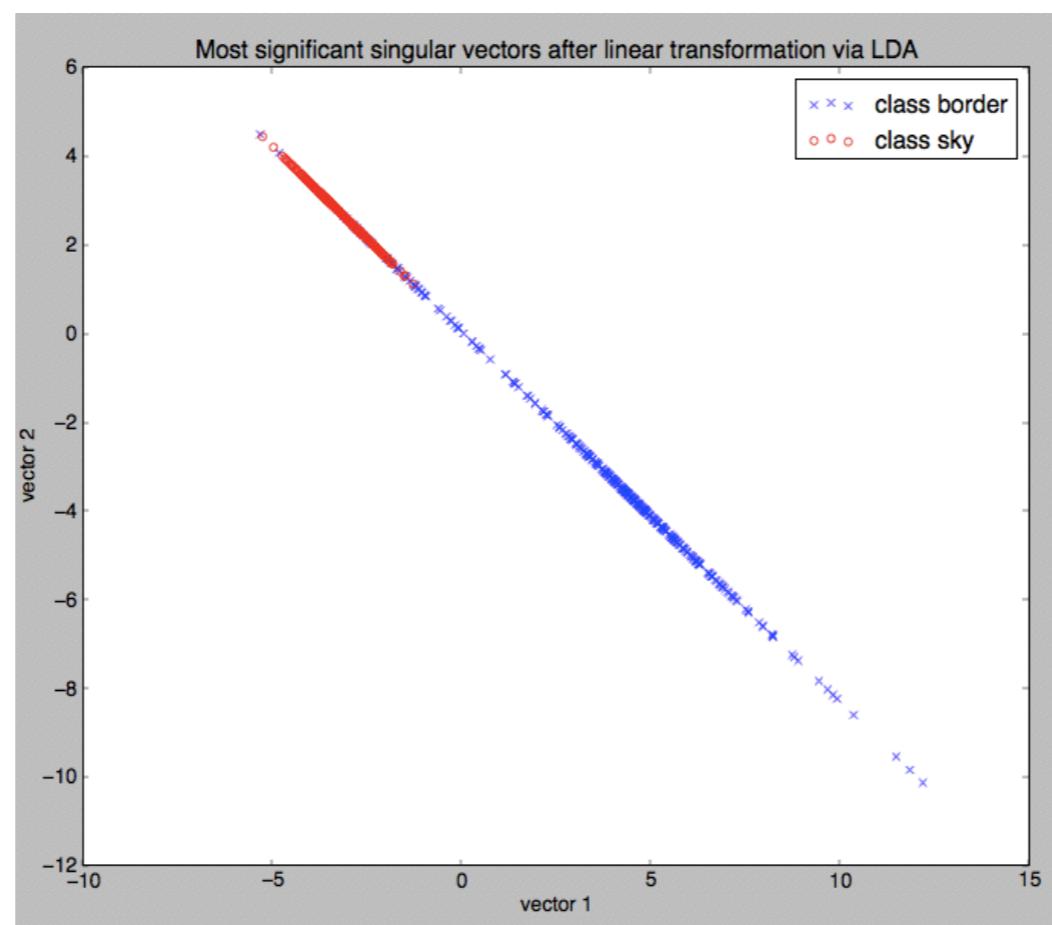
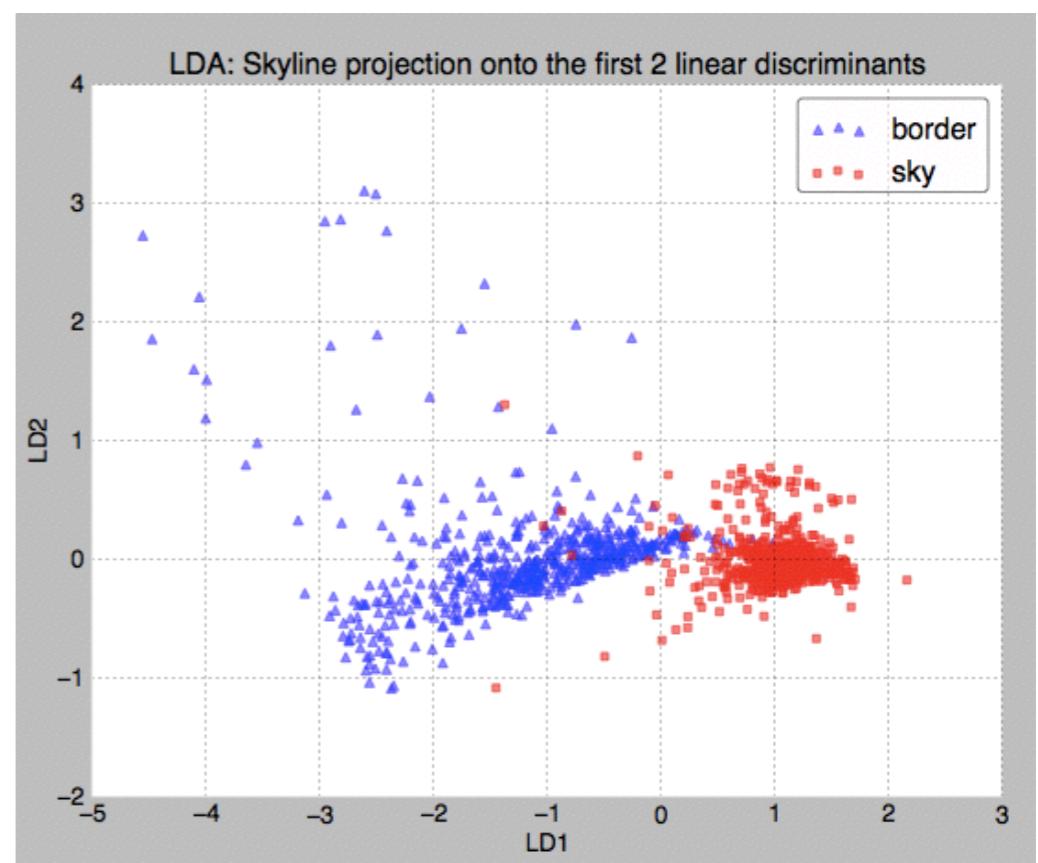
rainbow test image



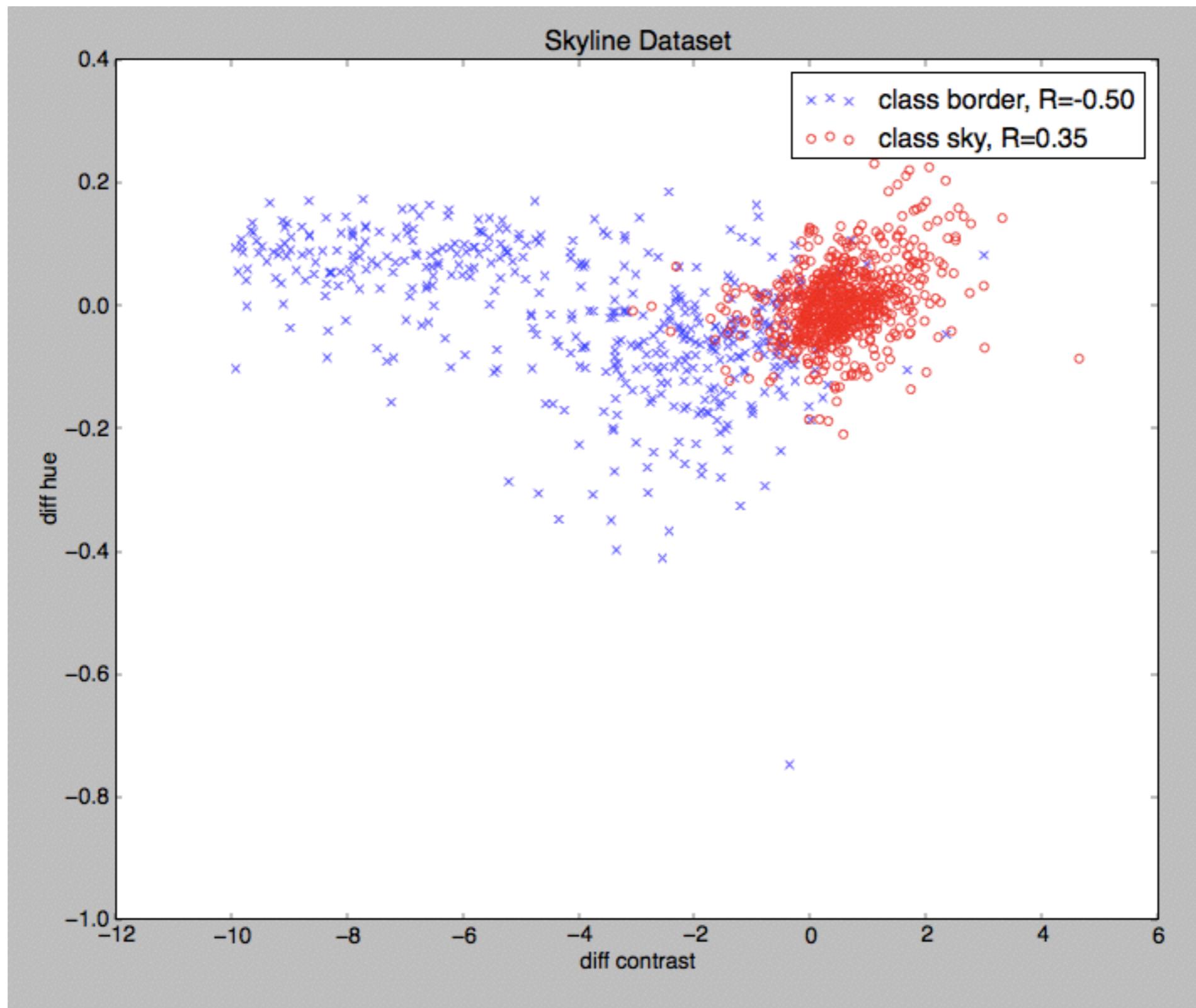
rainbow test image



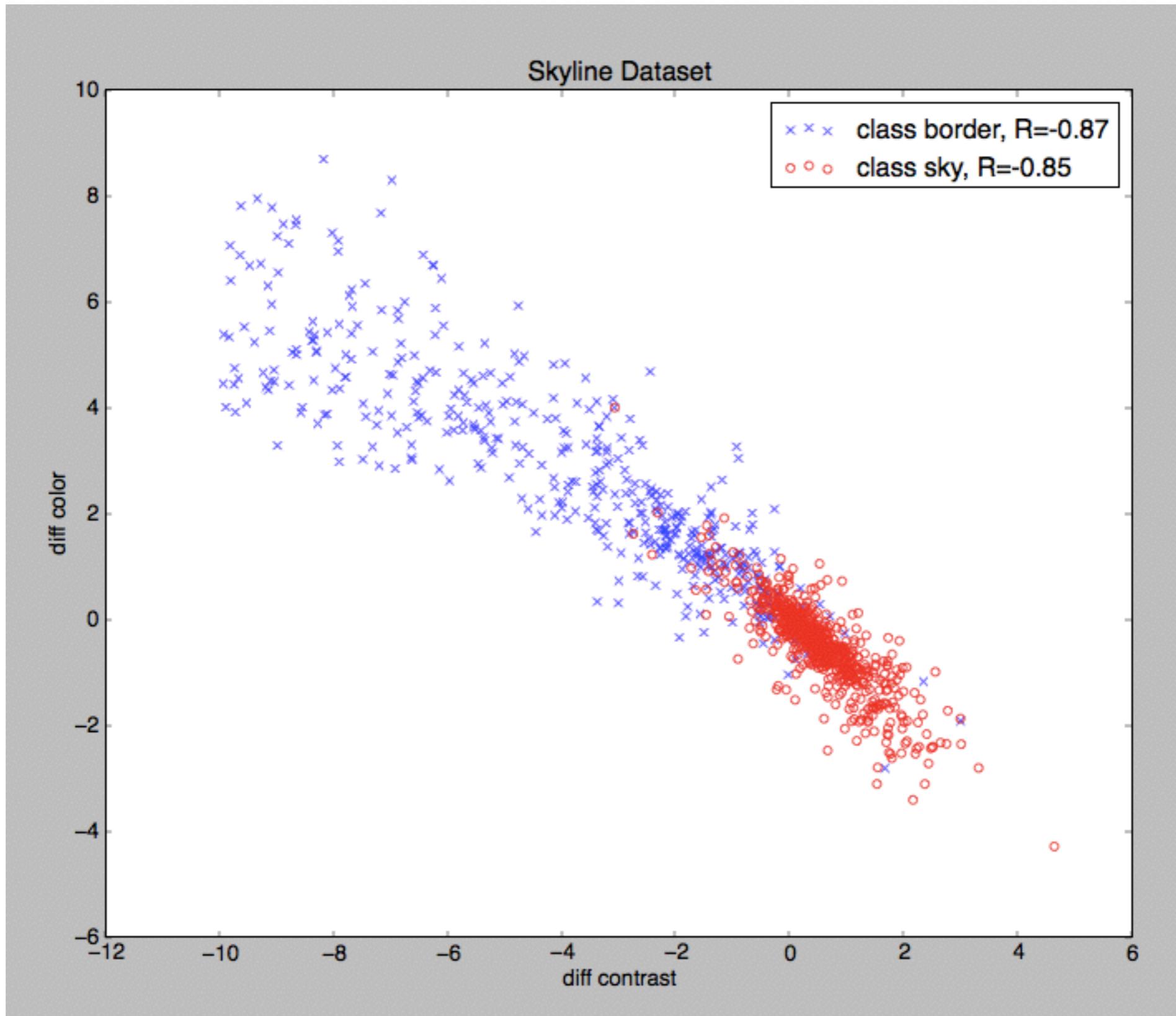
*note: the largest contrasts were removed from analysis for plot visibility



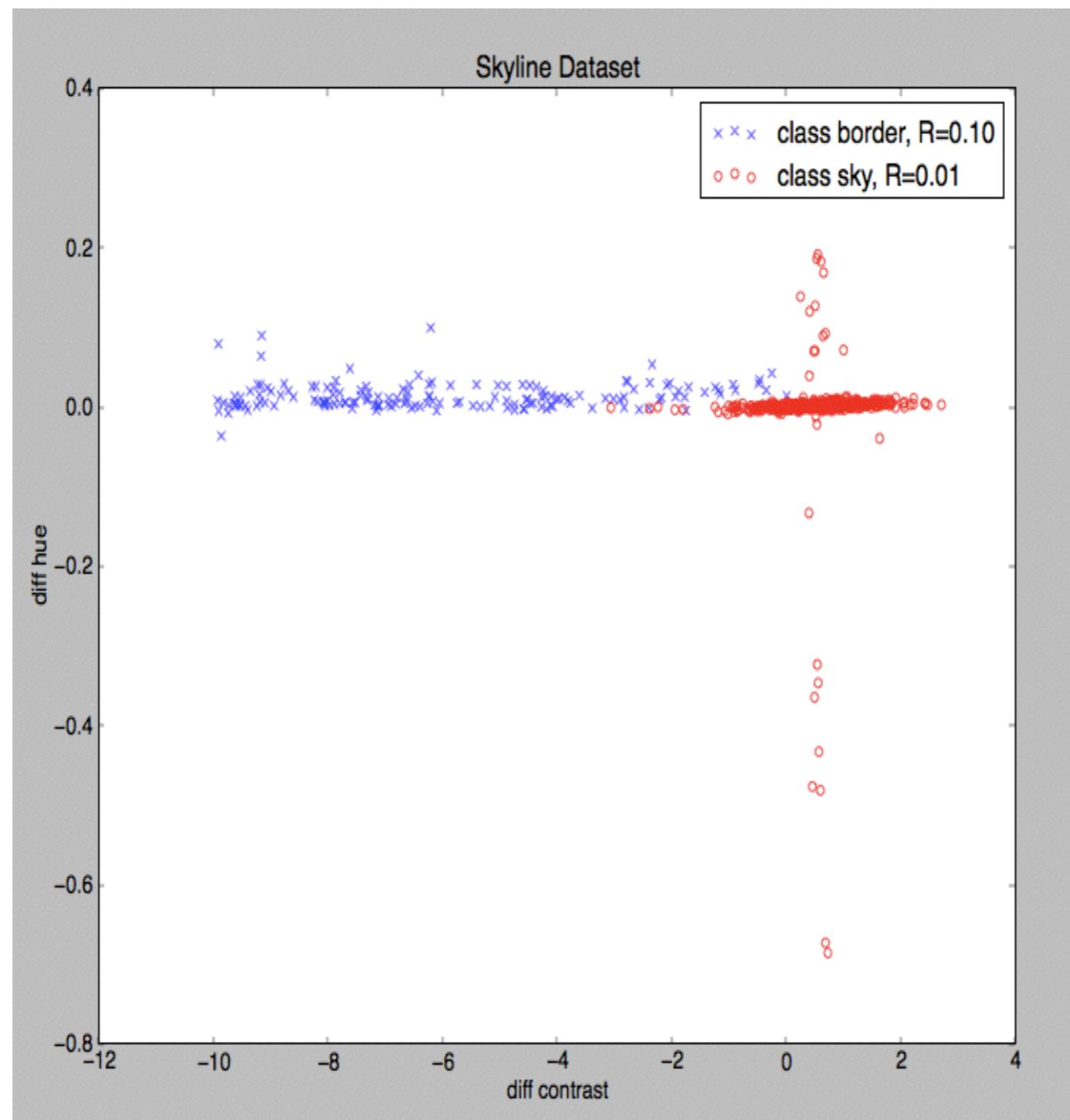
rainbow test image



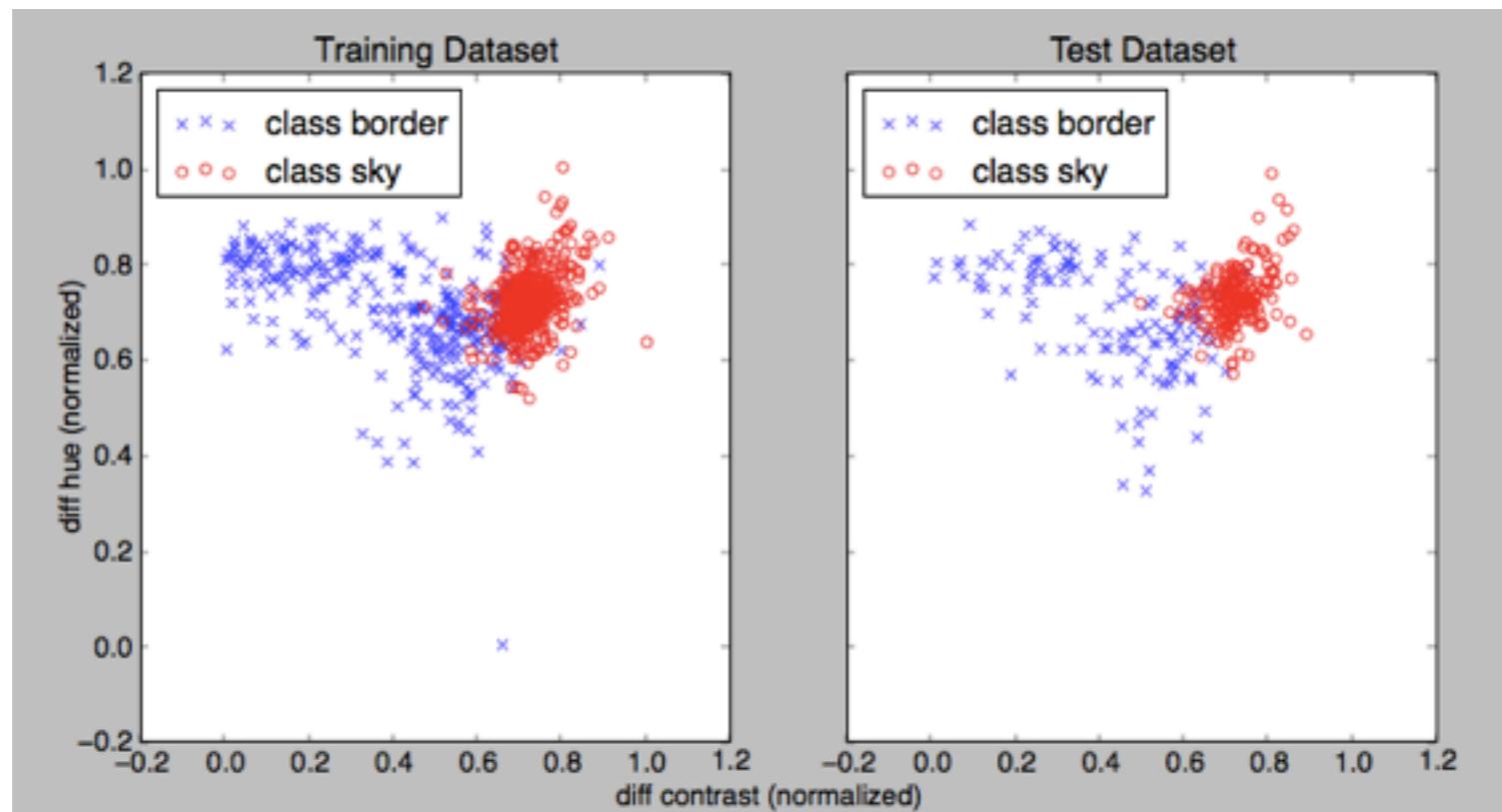
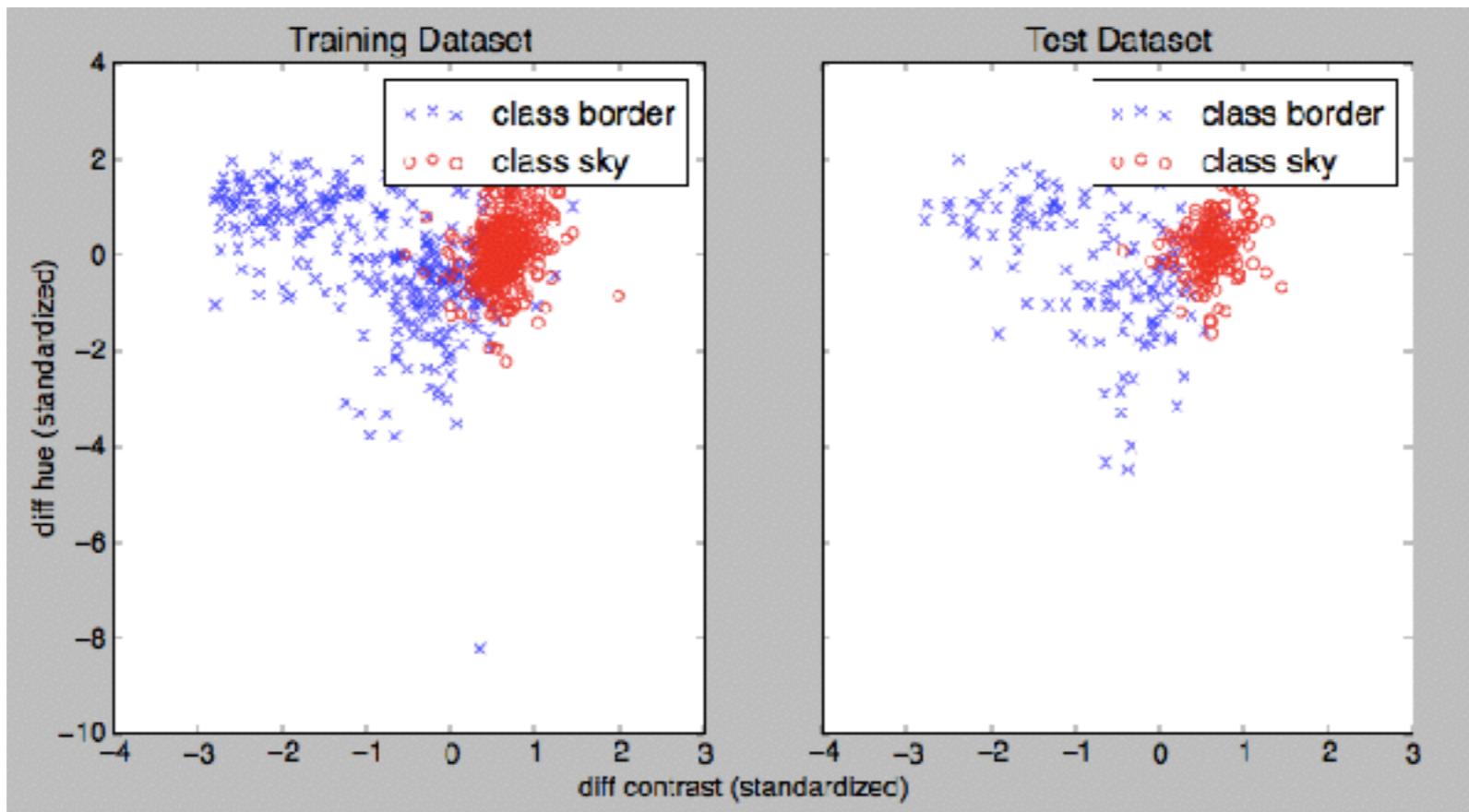
rainbow test image



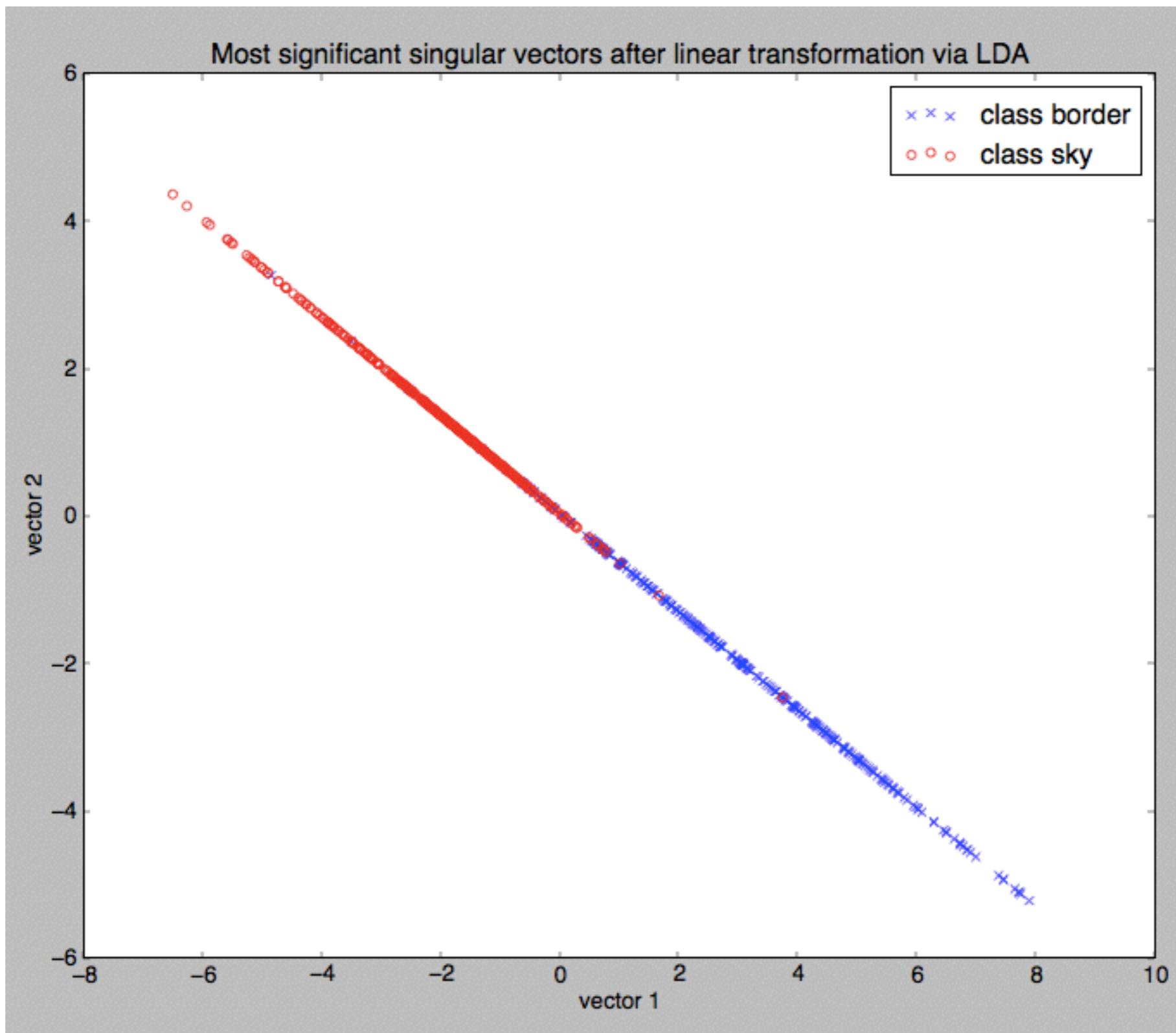
rainbow test image



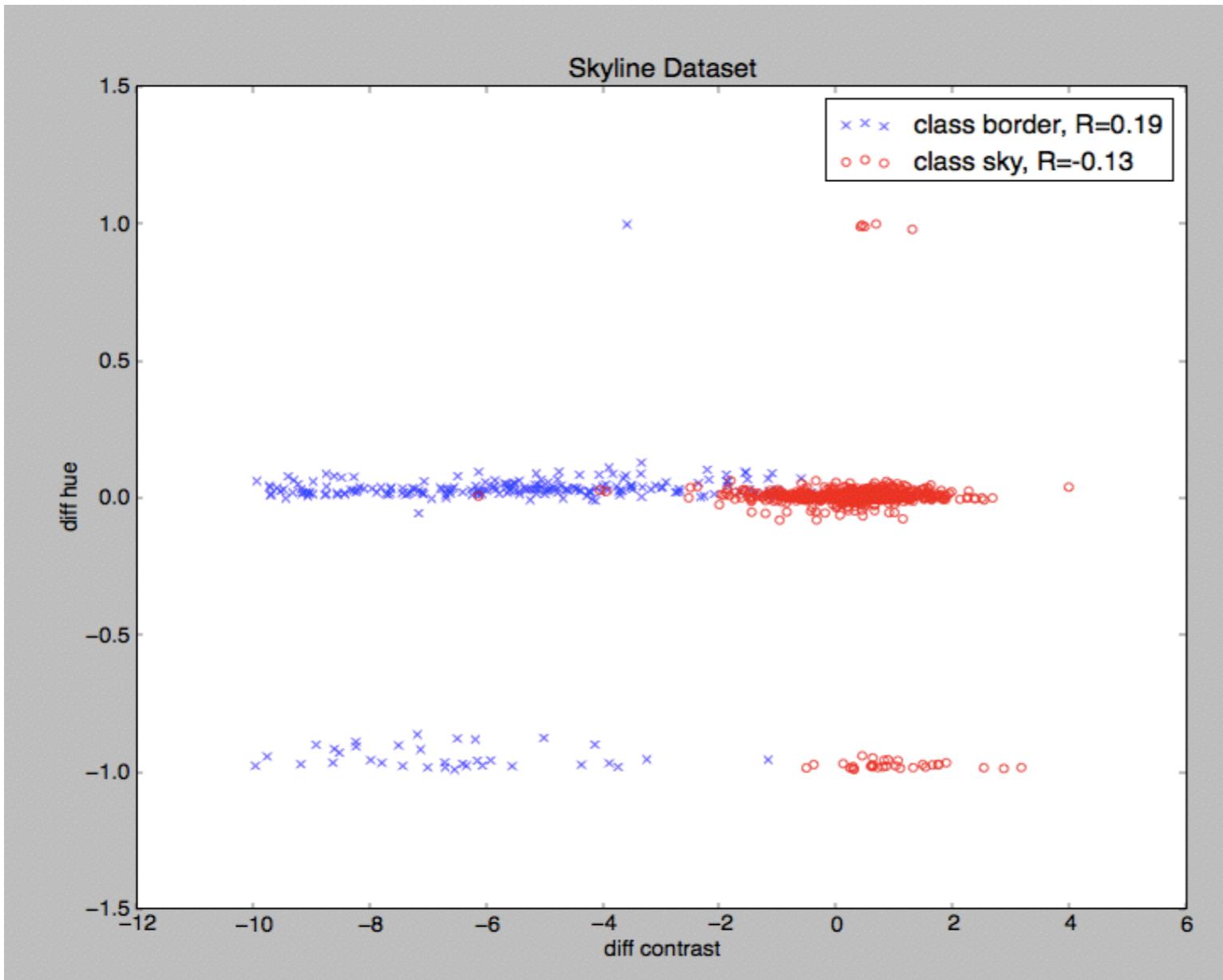
rainbow test image



rainbow test image



rainbow test image



contrast	hue	BorR
-0.9182	-0.1511	0.925
0.6231	0.1025	-0.6277

Mean Vector class 1: [-0.9182 -0.1511 0.925]

Mean Vector class 2: [0.6231 0.1025 -0.6277]

('within-class Scatter Matrix:\n',
array([[460.4303, -229.9637, -390.5265],
[-229.9637, 1059.3262, 310.4501],
[-390.5265, 310.4501, 451.1894]]))

('between-class Scatter Matrix:\n',
array([[1894.5371, 351.7602, -1812.6911],
[351.7602, 97.8492, -258.3772],
[-1812.6911, -258.3772, 1922.2598]]))

Eigenvector 1:
[[0.2433]
[0.372]
[-0.8958]]

Eigenvalue 1: 5.89e+00

Eigenvector 2:
[[0.7143]
[-0.0049]
[0.6998]]

Eigenvalue 2: 1.46e+00

Eigenvector 3:
[[-0.4745]
[0.8127]
[-0.3382]]

Eigenvalue 3: -2.42e-16

ok

Eigenvalues in decreasing order:

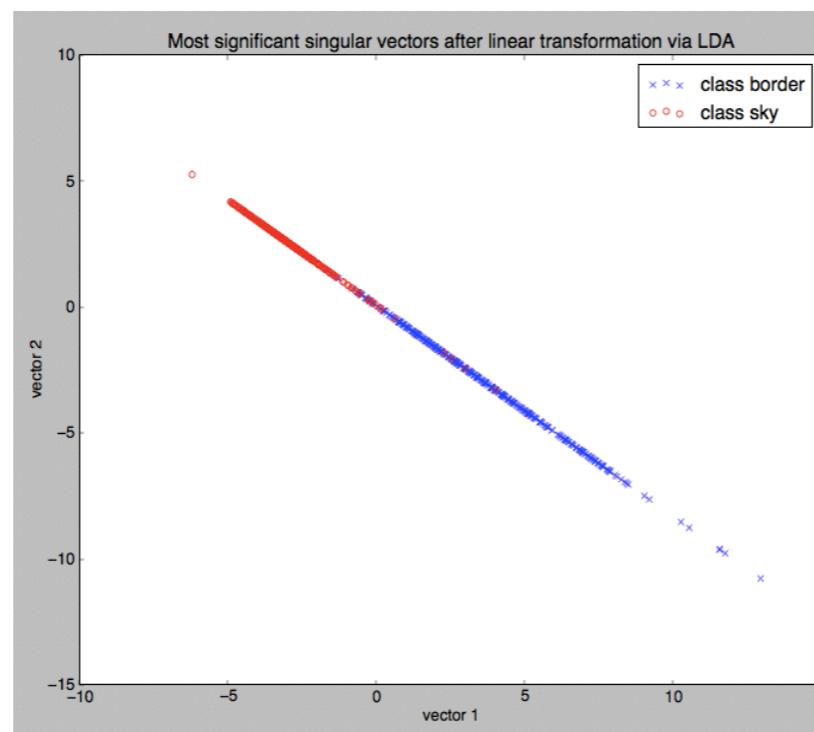
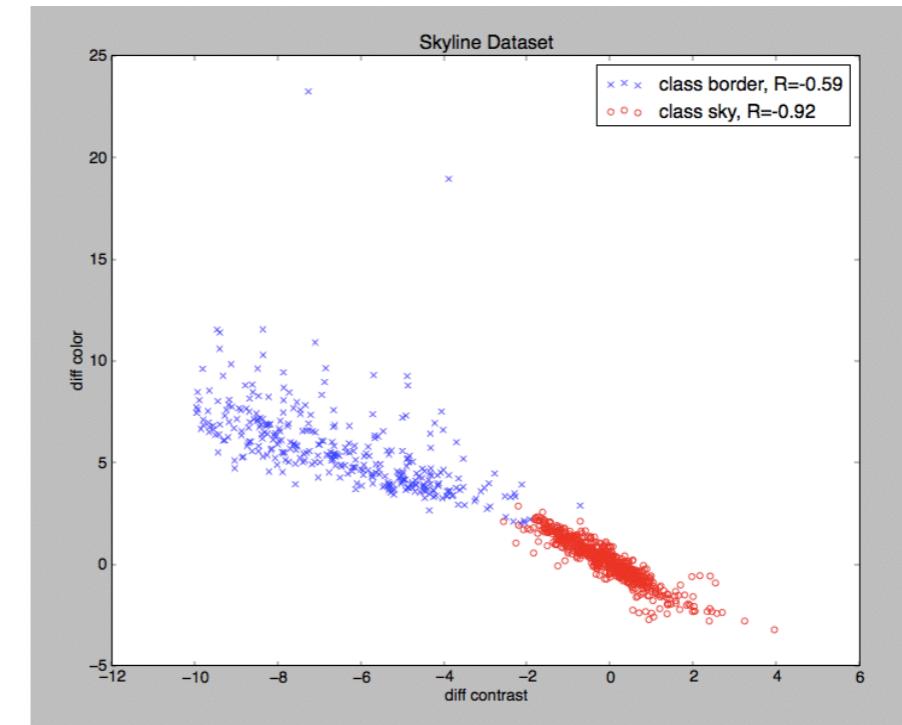
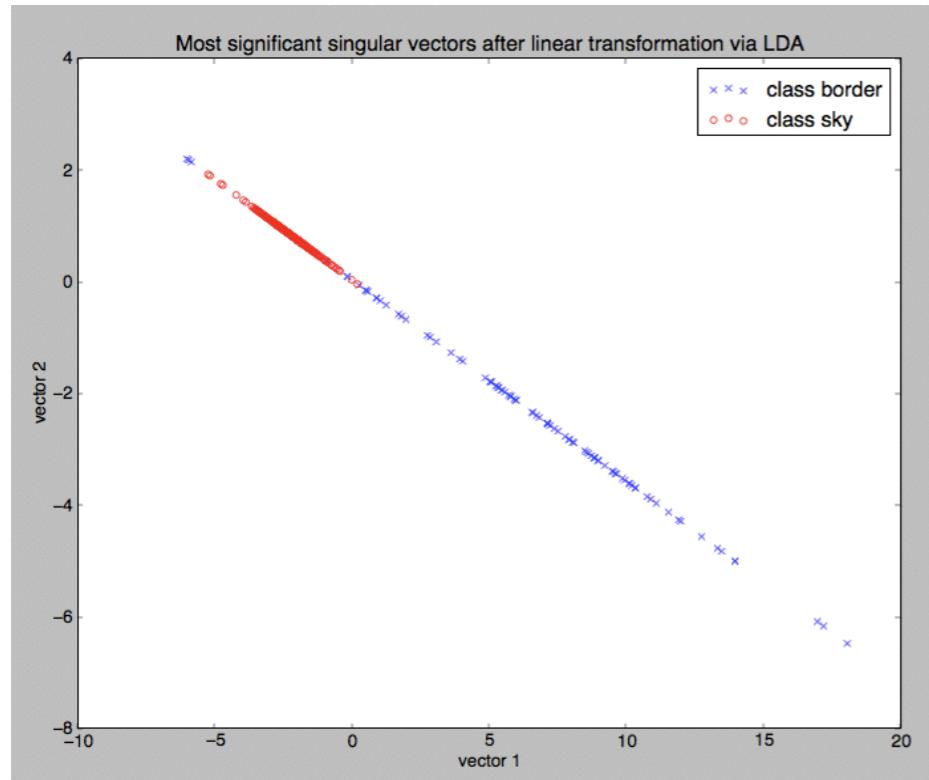
5.88771162291
1.46408665497
2.41960351699e-16

Variance explained:

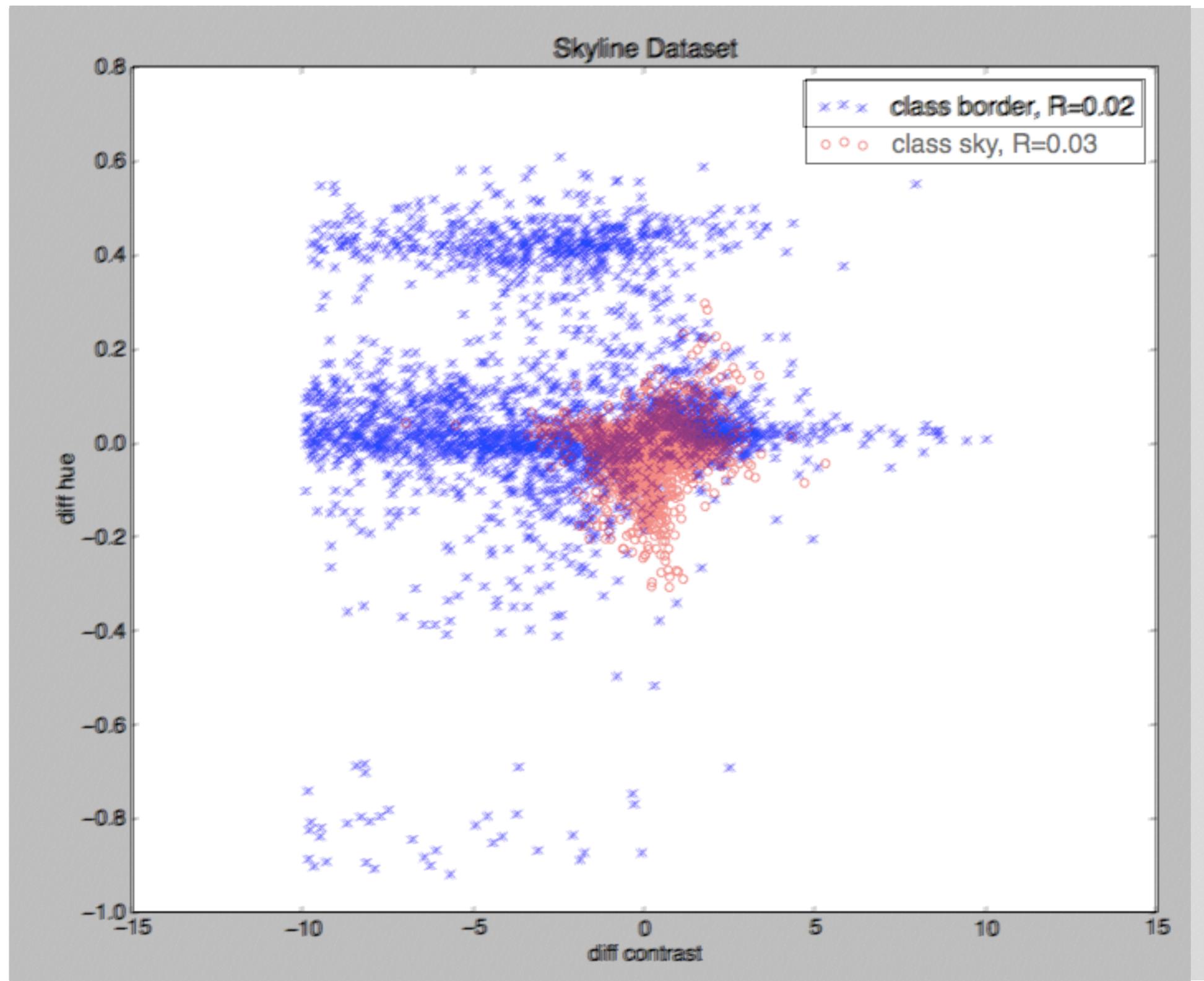
eigenvalue 1: 80.09%
eigenvalue 2: 19.91%
eigenvalue 3: 0.00%

('Matrix W:\n', array([[0.2433, 0.372 , -0.8958],
[0.7143, -0.0049, 0.6998]]))

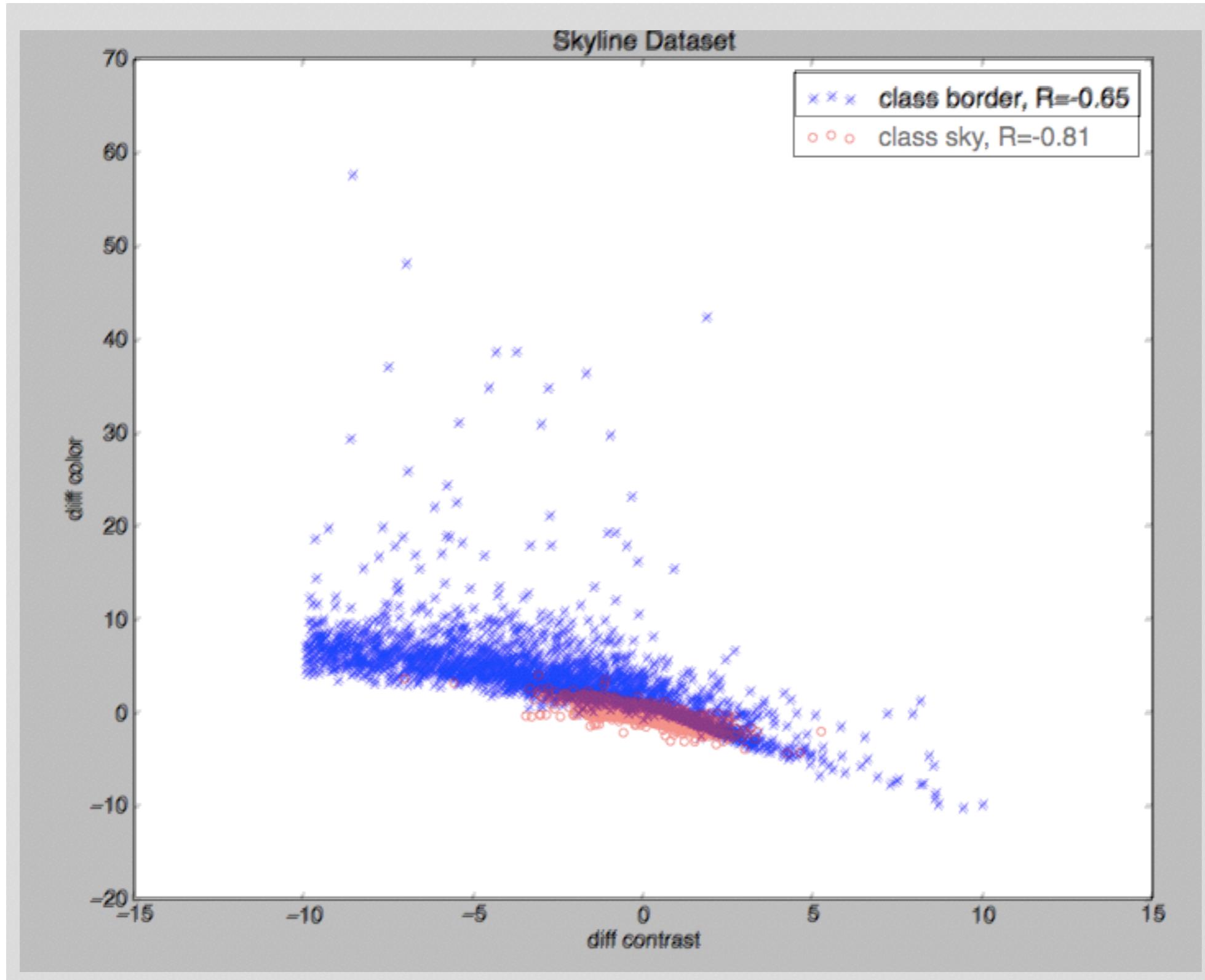
All BLUE SKY data in one:



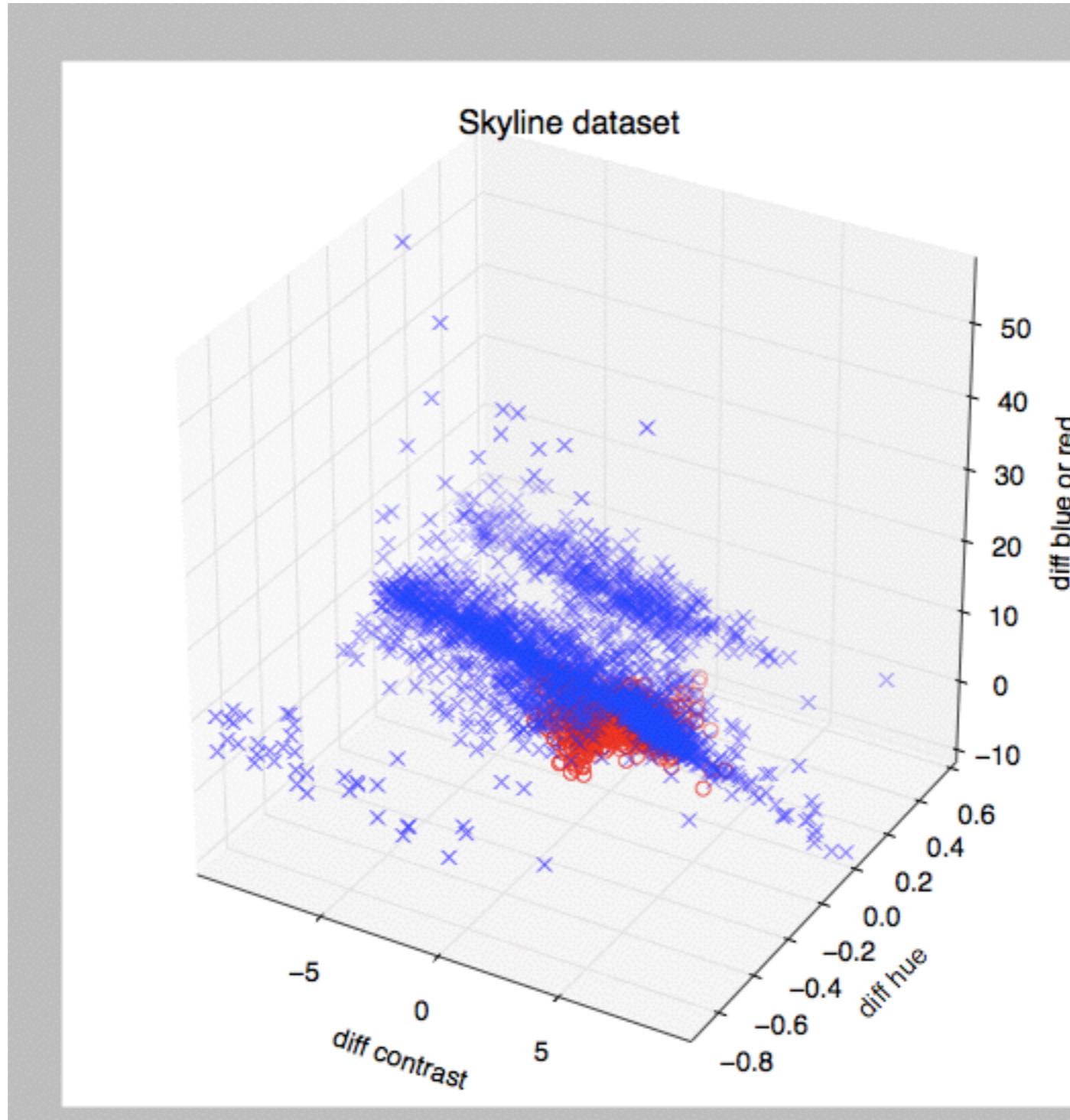
All BLUE SKY data in one:



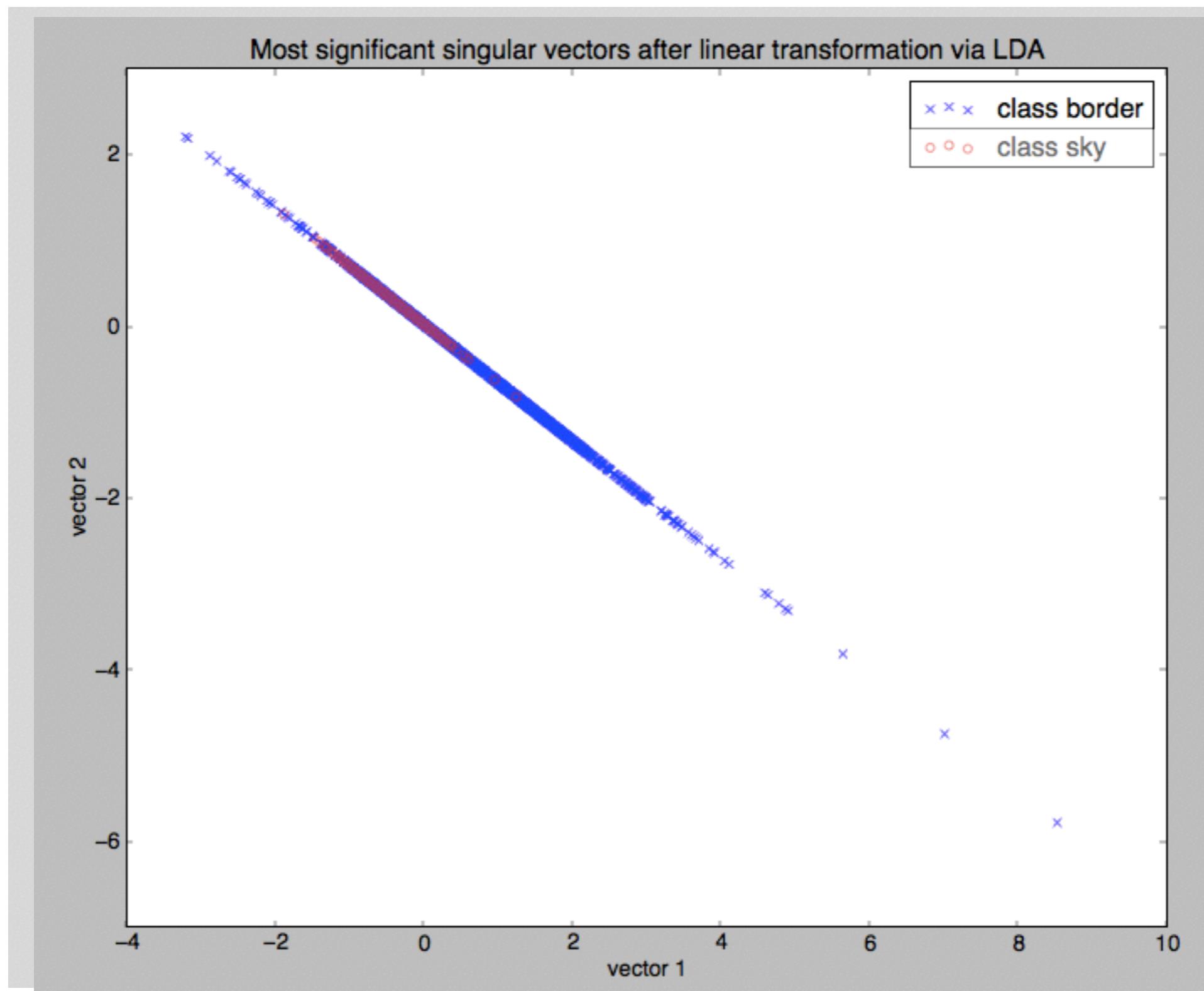
All BLUE SKY data in one:



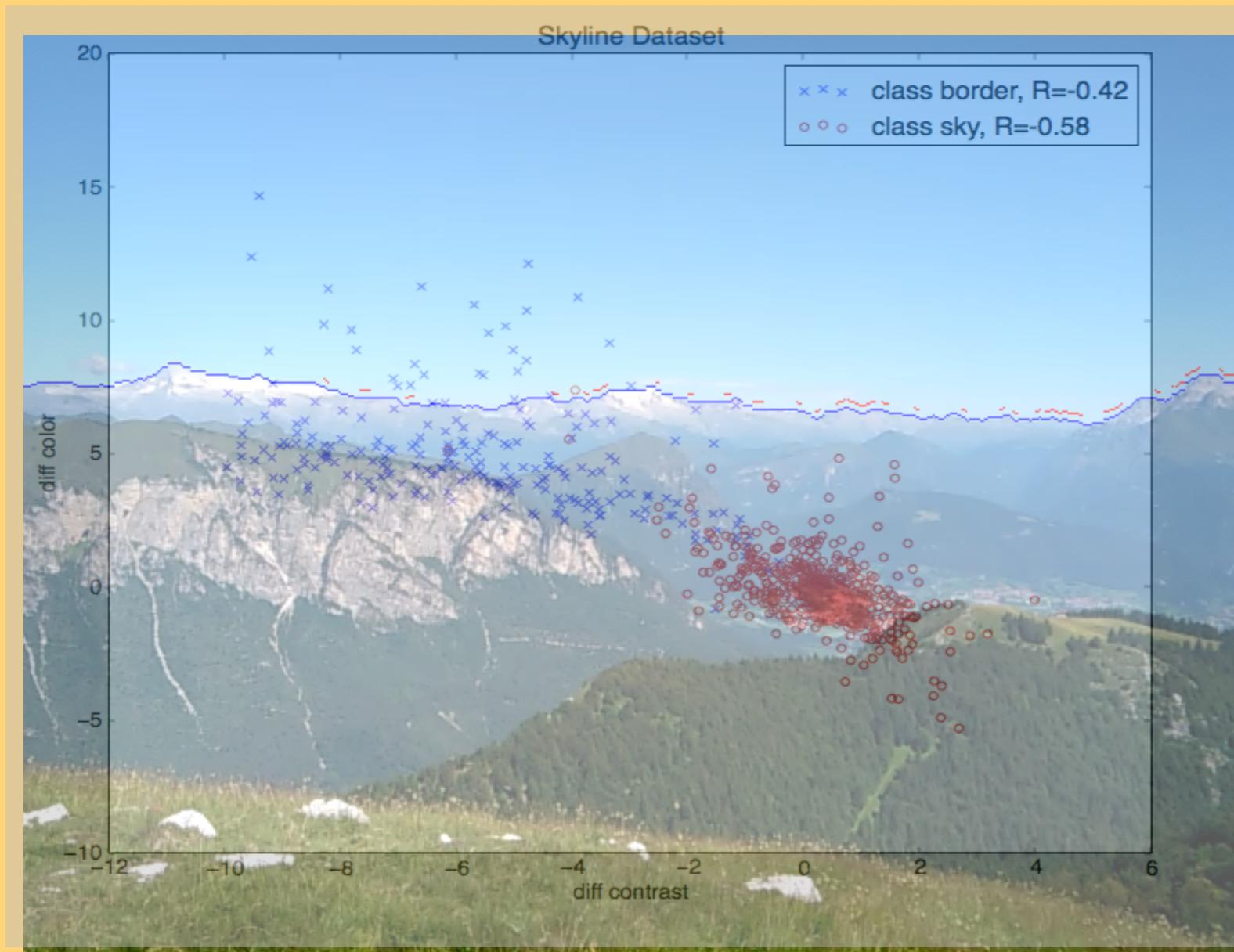
All BLUE SKY data in one:



All BLUE SKY data in one:



All BLUE SKY data in one:

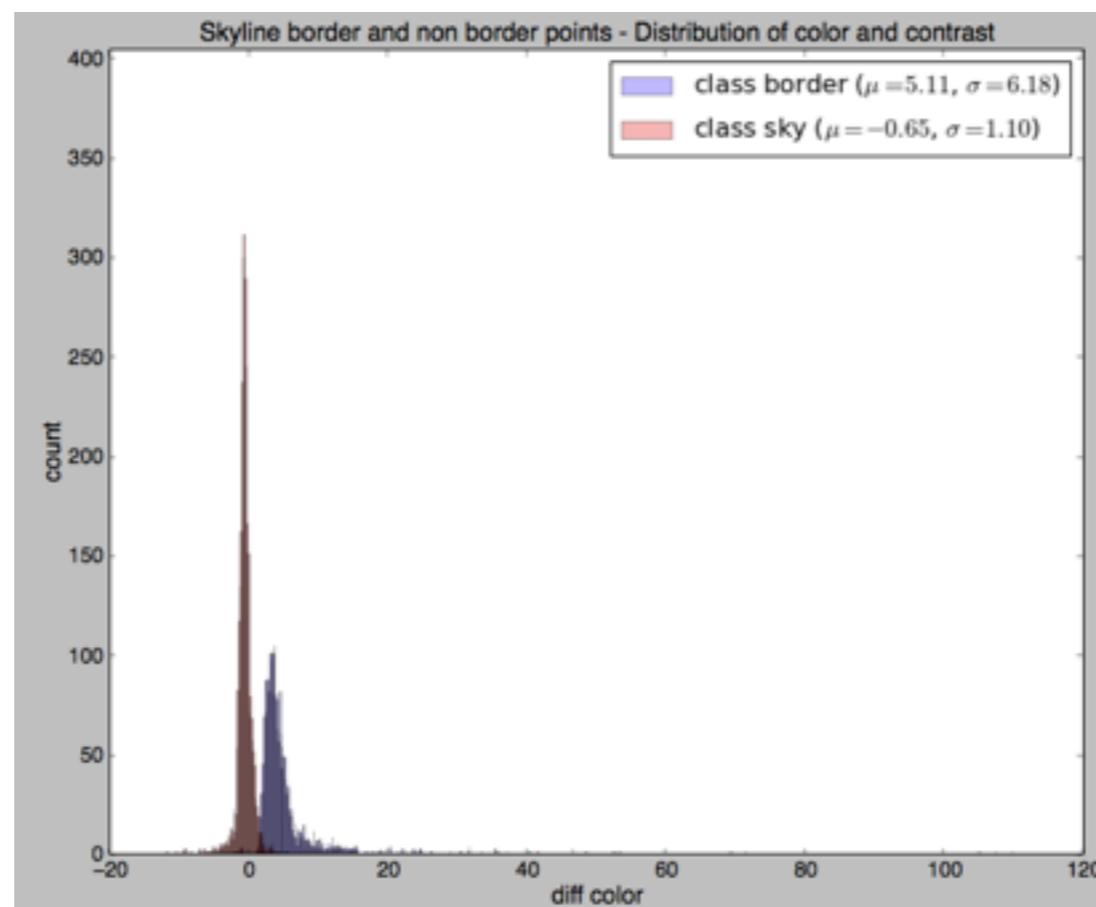
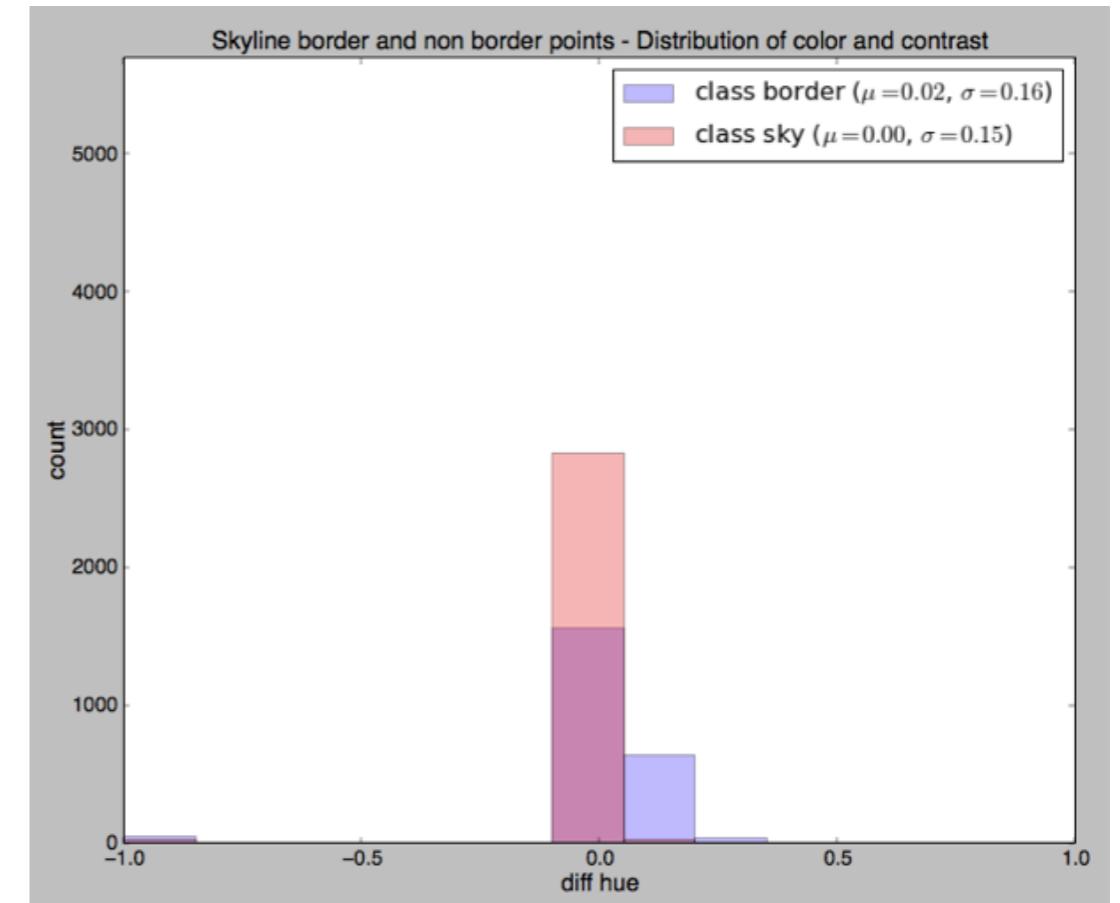
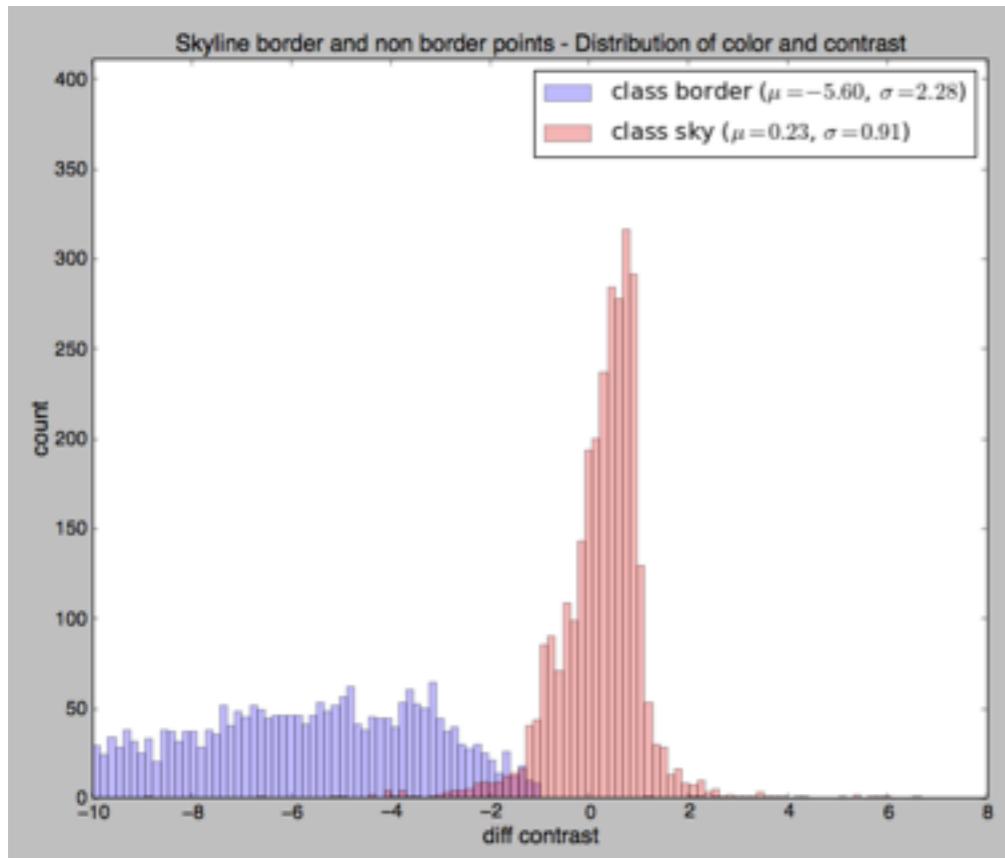


unfortunately, not separable when all blue sky image data is combined

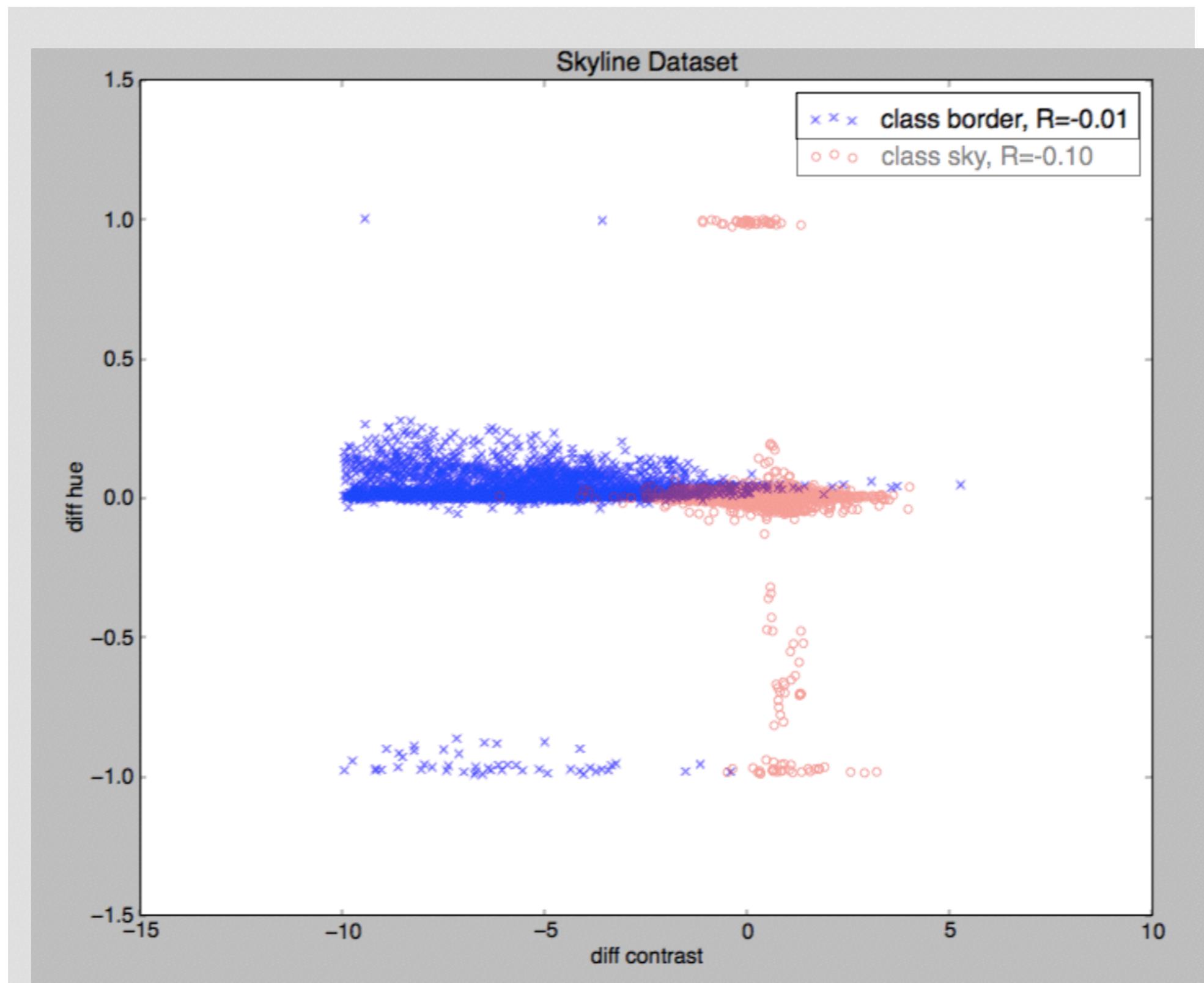
contrast	hue	BorR
Mean Vector class 1: [-0.5522]	0.3844	0.5999]
Mean Vector class 2: [0.3835	-0.267	-0.4166]

```
('within-class Scatter Matrix:\n',
array([[ 4519.8975,   112.627 , -2883.6326],
       [ 112.627 ,  5145.5562,  528.4881],
       [-2883.6326,  528.4881,  4301.0599]]))\n('between-class Scatter Matrix:\n',
array([[ 3751.0559, -2426.9726, -3848.2235],
       [-2426.9726,  1874.0798,  2863.5337],
       [-3848.2235,  2863.5337,  4407.5685]]))\n\nEigenvector 1:\n[[ 0.5059]\n[-0.527 ]\n[-0.6829]]\nEigenvalue 1: 1.38e+00\n\nEigenvector 2:\n[[-0.7642]\n[-0.0694]\n[-0.6413]]\nEigenvalue 2: 1.43e-01\n\nEigenvector 3:\n[[ 0.1436]\n[-0.7679]\n[ 0.6243]]\nEigenvalue 3: -8.84e-17\nok\nEigenvalues in decreasing order:\n1.38318243685\n0.14281235715\n8.83944604139e-17\nVariance explained:\neigenvalue 1: 90.64%\neigenvalue 2: 9.36%\neigenvalue 3: 0.00%\n('Matrix W:\n', array([[ 0.5059, -0.527 , -0.6829],
       [-0.7642, -0.0694, -0.6413]]))
```

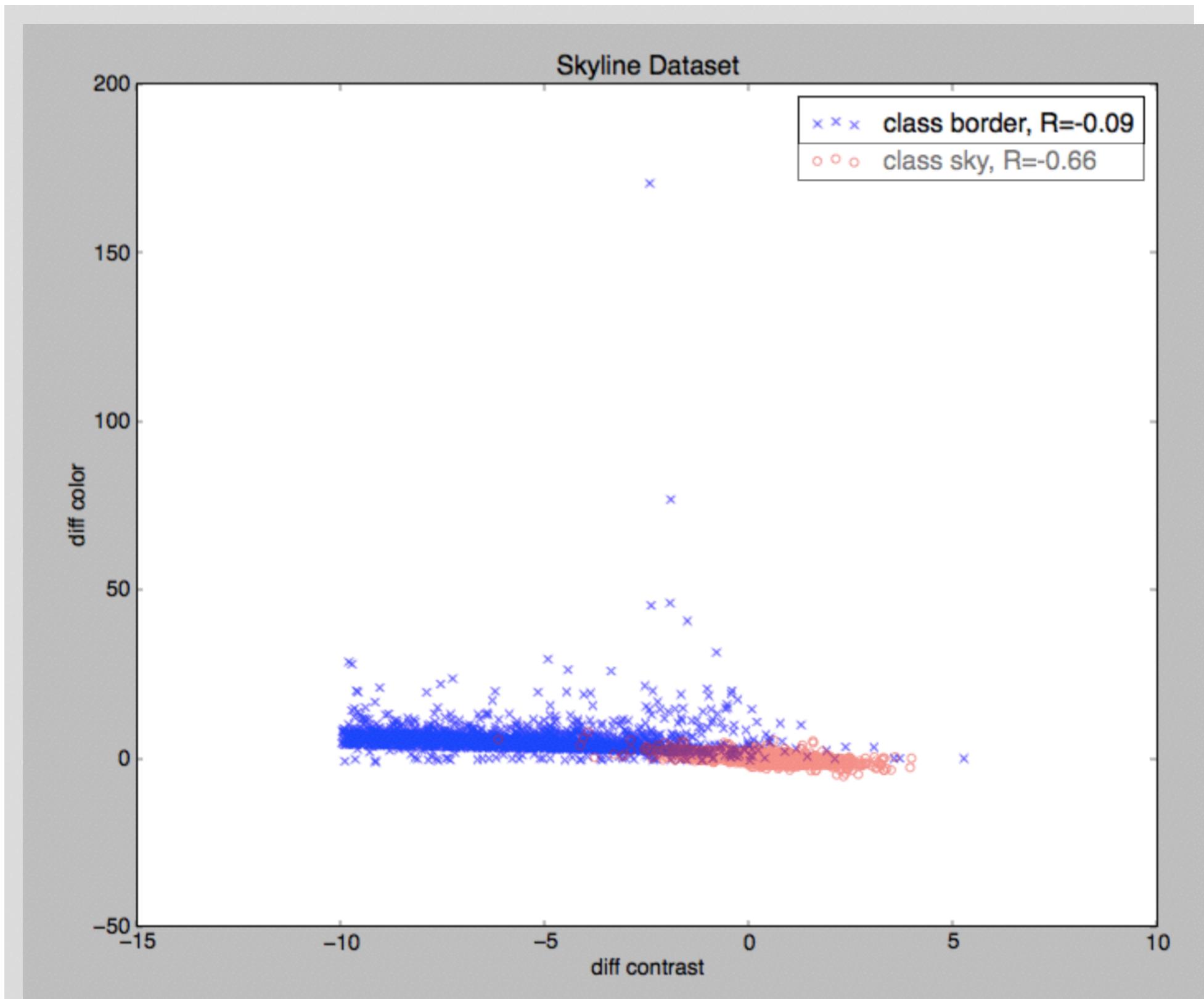
All RED SKY data in one



All RED SKY data in one



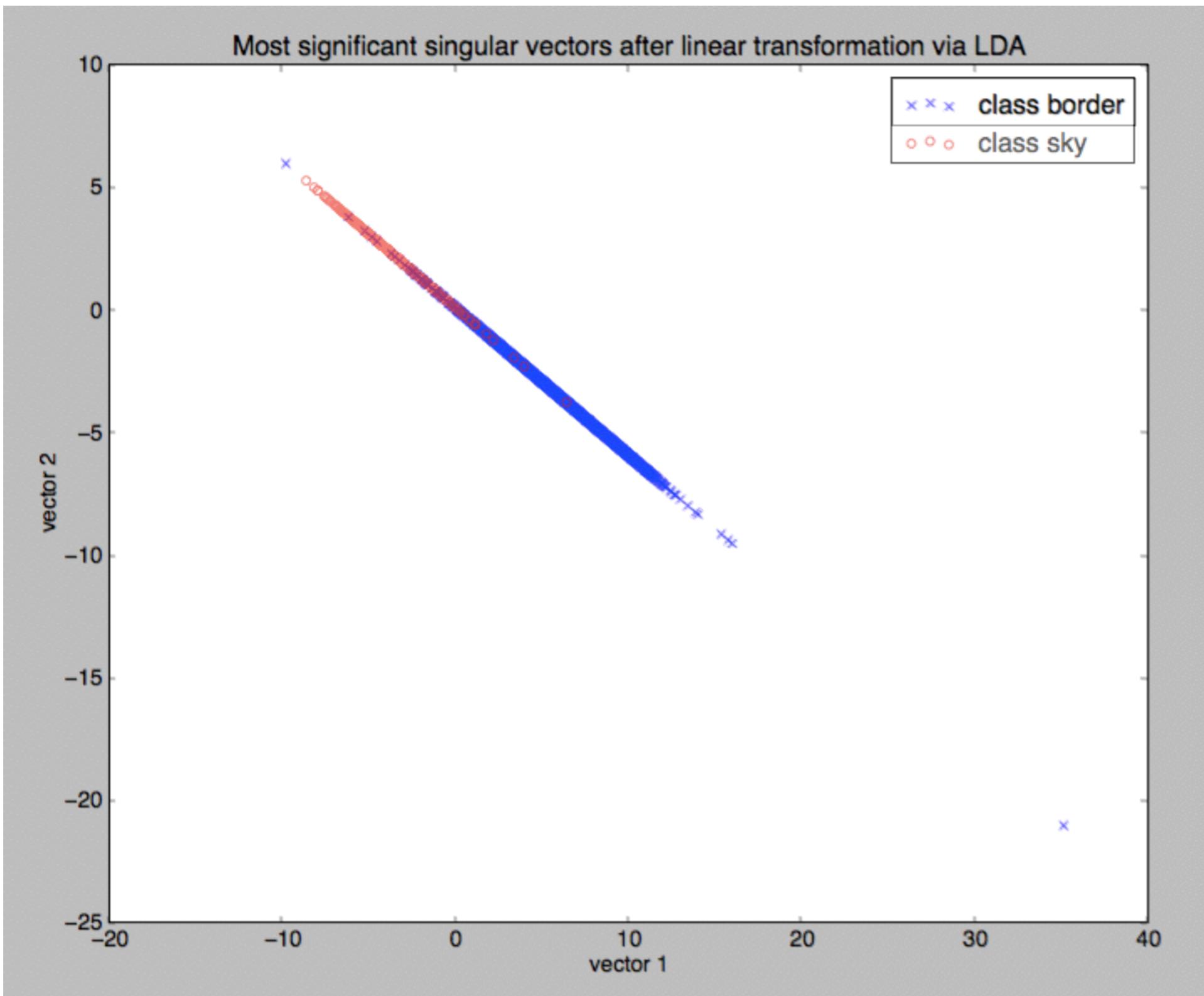
All RED SKY data in one



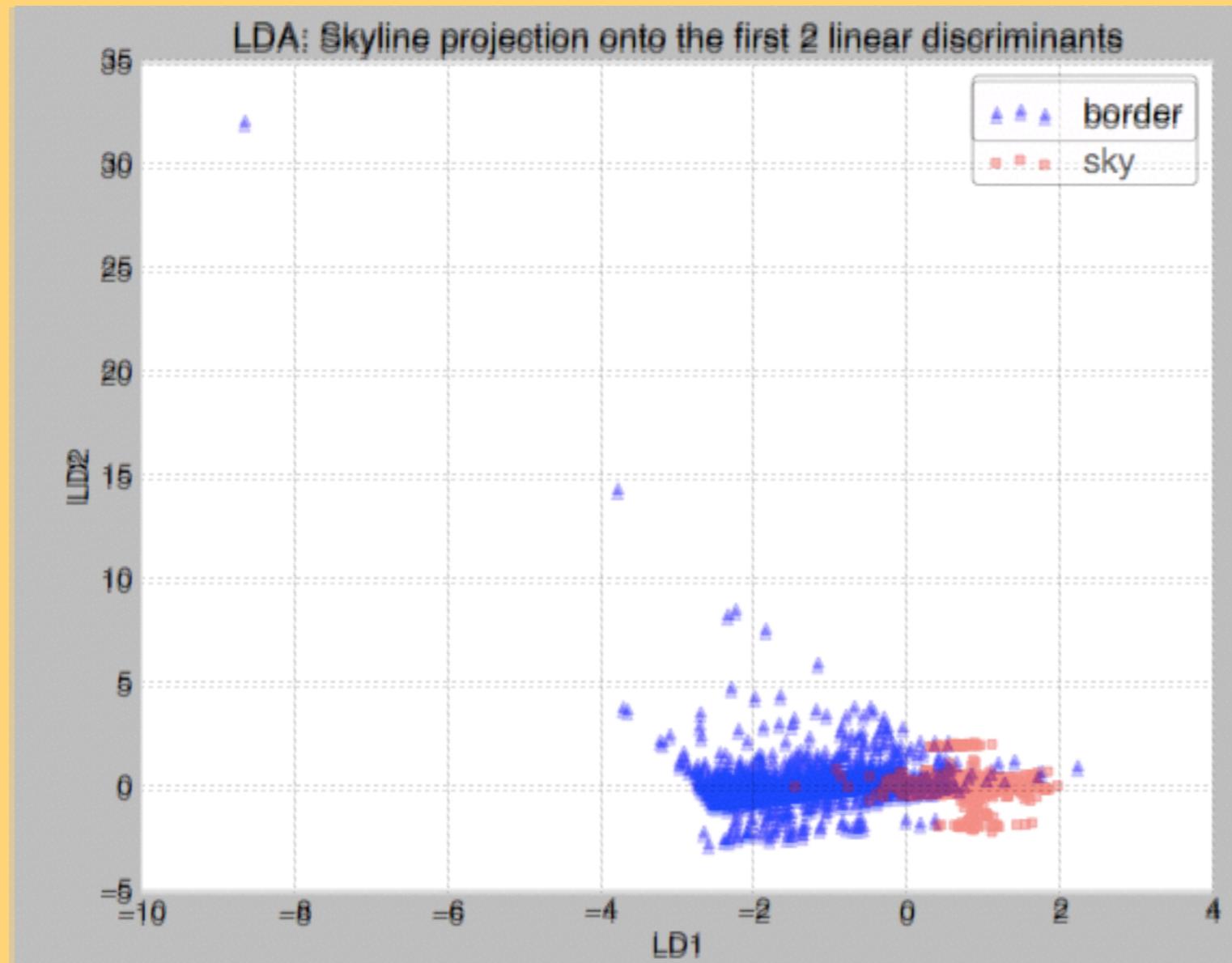
All RED SKY data in one



All RED SKY data in one,



All RED SKY data in one, filtered for $\text{math.abs}(\text{contrastDiff}) > 1$ AND $\text{math.abs}(\text{blueOrRedDiff}) > 1$ for border points and the opposite for sky points:



unfortunately, not separable when all blue sky image data is combined

contrast	hue	BorR
Mean Vector class 1: [-1.133]	0.1035	0.8367
Mean Vector class 2: [0.6664	-0.0609	-0.4921]
('within-class Scatter Matrix:\n', array([[1530.2186, -107.1163, -344.4298], [-107.1163, 6208.6289, 105.1825], [-344.4298, 105.1825, 3675.4423]]))		
('between-class Scatter Matrix:\n', array([[14681.618 , -764.6675, -9923.0841], [-764.6675, 646.3871, 1483.0301], [-9923.0841, 1483.0301, 8245.947]]))		
Eigenvector 1:	[[0.9788]	[0.0042]
	[-0.2048]]	
Eigenvalue 1:	1.05e+01	
Eigenvector 2:	[[0.5571]	[0.3011]
	[0.774]]	
Eigenvalue 2:	4.85e-01	
Eigenvector 3:	[[-0.3007]	[0.8078]
	[-0.5071]]	
Eigenvalue 3:	2.67e-16	
ok		
Eigenvalues in decreasing order:		
10.4597223426		
0.484576956832		
2.66600425266e-16		
Variance explained:		
eigenvalue 1: 95.57%		
eigenvalue 2: 4.43%		
eigenvalue 3: 0.00%		
('Matrix W:\n', array([[0.9788, 0.0042, -0.2048], [0.5571, 0.3011, 0.774]]))		