

Lab Notebook

Photonic Lantern Information Determination

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Parte I

Normalized Mutual Information Analysis

1. The data

1.1. Zernike coefficients dataset

8 datasets of zernike coefficients are created, each of the dataset contain 5000 data-points

- **2 mode dataset:** 2 Zernike modes coefficients, their RMSE in the range [-1,1]
- **5 mode dataset:** 5 Zernike modes coefficients, their RMSE in the range:
 - Modes 2 and 3: [-0.4, 0.4]
 - Modes 4, 5 and 6: [-0.4, 0.4]
- **9 mode dataset:** 9 Zernike mode coefficients, their RMSE in the range:
 - Modes 2 and 3: [-0.22, 0.22]
 - Modes 4, 5 and 6: [-0.22, 0.22]
 - Modes 7, 8, 9 and 10: [-0.22, 0.22]
- **14 mode dataset:** 14 Zernike mode coefficients, their RMSE in the range:
 - Modes 2 and 3: [-0.142, 0.142]
 - Modes 4, 5 and 6: [-0.142, 0.142]
 - Modes 7, 8, 9 and 10: [-0.142, 0.142]
 - Modes 11, 12, 13, 14 and 15: [-0.142, 0.142]

- **20 mode dataset:** 20 Zernike mode coefficients, their RMSE in the range:

- Modes 2 and 3: [-0.1, 0.1]
- Modes 4, 5 and 6: [-0.1, 0.1]
- Modes 7, 8, 9 and 10: [-0.1, 0.1]
- Modes 11, 12, 13, 14 and 15: [-0.1, 0.1]
- Modes 16, 17, 18, 19, 20 and 21: [-0.1, 0.1]

- **27 mode dataset:** 27 Zernike mode coefficients, their RMSE in the range:

- Modes 2 and 3: [-0.07, 0.07]
- Modes 4, 5 and 6: [-0.07, 0.07]
- Modes 7, 8, 9 and 10: [-0.07, 0.07]
- Modes 11, 12, 13, 14 and 15: [-0.07, 0.07]
- Modes 16, 17, 18, 19, 20 and 21: [-0.07, 0.07]
- Modes 22, 23, 24, 25, 26, 27 and 28: [-0.07, 0.07]

- **35 mode dataset:** 35 Zernike mode coefficients, their RMSE in the range:

- Modes 2 and 3: [-0.05, 0.05]
- Modes 4, 5 and 6: [-0.05, 0.05]
- Modes 7, 8, 9 and 10: [-0.05, 0.05]
- Modes 11, 12, 13, 14 and 15: [-0.05, 0.05]
- Modes 16, 17, 18, 19, 20 and 21: [-0.05, 0.05]
- Modes 22, 23, 24, 25, 26, 27 and 28: [-0.05, 0.05]
- Modes 29, 30, 31, 32, 33, 34, 35 and 36: [-0.05, 0.05]

- **44 mode dataset:** 44 Zernike mode coefficients, their RMSE in the range:

- Modes 2 and 3: [-0.04, 0.04]
- Modes 4, 5 and 6: [-0.04, 0.04]
- Modes 7, 8, 9 and 10: [-0.04, 0.04]
- Modes 11, 12, 13, 14 and 15: [-0.04, 0.04]
- Modes 16, 17, 18, 19, 20 and 21: [-0.04, 0.04]
- Modes 22, 23, 24, 25, 26, 27 and 28: [-0.04, 0.04]
- Modes 29, 30, 31, 32, 33, 34, 35 and 36: [-0.04, 0.04]
- Modes 37, 38, 39, 40, 41, 42, 43, 44 and 45: [-0.04, 0.04]

1.2. PSFs intensities dataset

8 datasets of 5000 PSF intensities are created from the 5 zernike coefficients dataset, each datapoint being a 128x128 matrix

1.3. LP mode coefficients dataset

8 datasets of 5000 LP coefficients are created from the 5 zernike coefficients dataset, each datapoint being a 19x2 matrix dividing the real and imaginary part of the LP coefficients

1.4. Output fluxes dataset

The output fluxes are obtained using the 19 mode PL transfer matrix. 8 datasets of 5000 Output fluxes are created from the 5 zernike coefficients dataset, each datapoint being a 19x1 vector

2. Preprocessing

2.1. PSF Intensities

The 5000x128x128 PSF intensities datasets are dimensionally reduced using UMAP giving an array of 5000x19 projections of the PSF Intensities for each dataset.

Number of neighbors	Min distance	Number of components
15	0.3	19

Cuadro 1: UMAP hyperparameter configurations for PSF Intensities dimensionality reduction

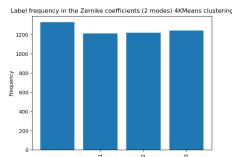
2.2. Clustering

K-Means is used to find clusters in all the datasets. KMeans is set to produce the following number of clusters:

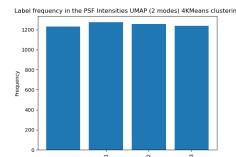
- 4
- 8
- 16
- 32
- 64
- 100
- 250
- 500
- 1000

The results are the following:

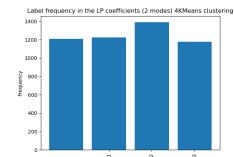
2.2.1. 2 Zernike modes datasets clusters densities



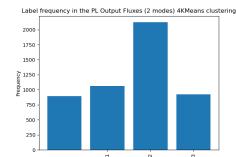
(a) 4KMeans for Zernike coefficients



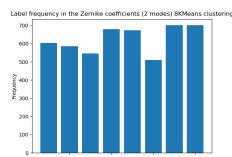
(b) 4KMeans PSF Intensities UMAP



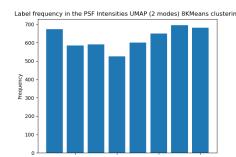
(c) 4KMeans LP coefficients



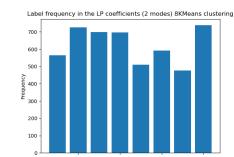
(d) 4KMeans Output Fluxes



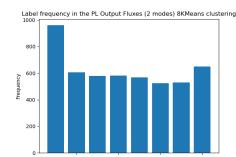
(a) 8KMeans for Zernike coefficients



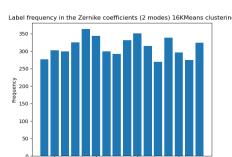
(b) 8KMeans PSF Intensities UMAP



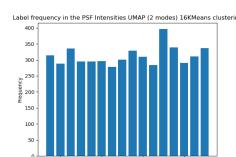
(c) 8KMeans LP coefficients



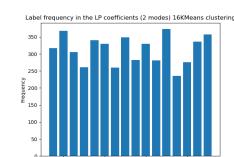
(d) 8KMeans Output Fluxes



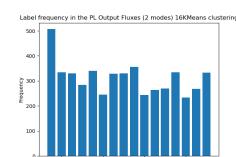
(a) 16KMeans for Zernike coefficients



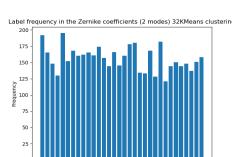
(b) 16KMeans PSF Intensities UMAP



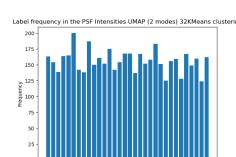
(c) 16KMeans LP coefficients



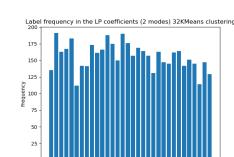
(d) 16KMeans Output Fluxes



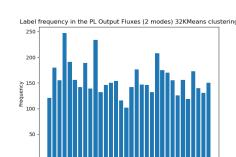
(a) 32KMeans for Zernike coefficients



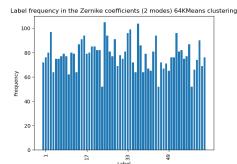
(b) 32KMeans PSF Intensities UMAP



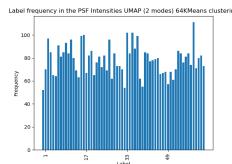
(c) 32KMeans LP coefficients



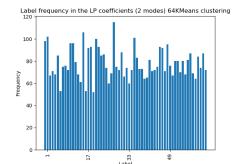
(d) 32KMeans Output Fluxes



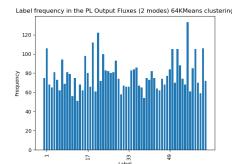
(a) 64KMeans for Zernike coefficients



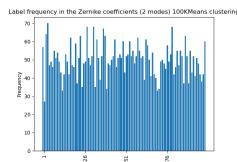
(b) 64KMeans PSF Intensities UMAP



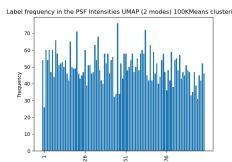
(c) 64KMeans LP coefficients



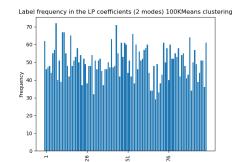
(d) 64KMeans Output Fluxes



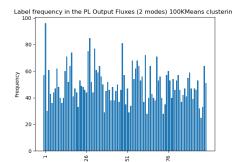
(a) 100KMeans for Zernike coefficients



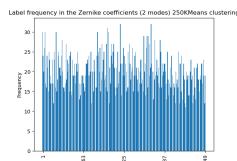
(b) 100KMeans PSF Intensities UMAP



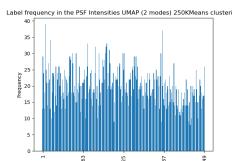
(c) 100KMeans LP coefficients



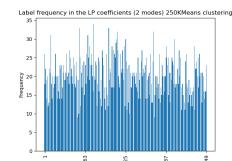
(d) 100KMeans Output Fluxes



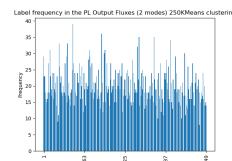
(a) 250KMeans for Zernike coefficients



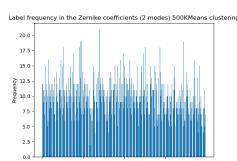
(b) 250KMeans PSF Intensities UMAP



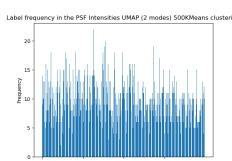
(c) 250KMeans LP coefficients



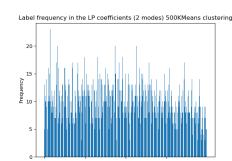
(d) 250KMeans Output Fluxes



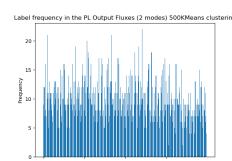
(a) 500KMeans for Zernike coefficients



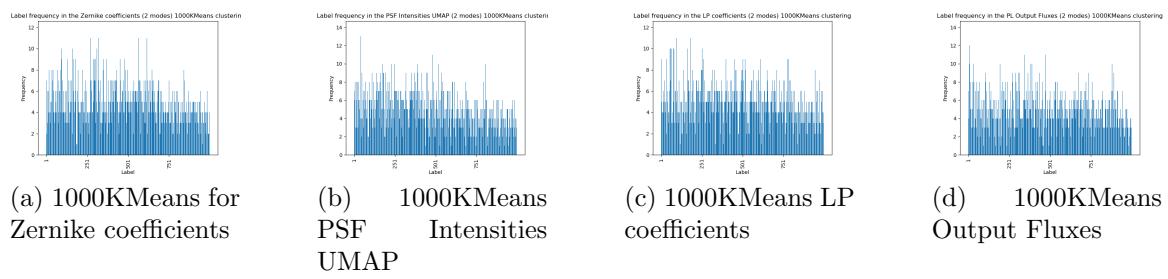
(b) 500KMeans PSF Intensities UMAP



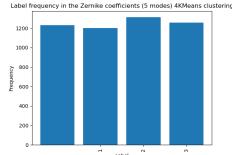
(c) 500KMeans LP coefficients



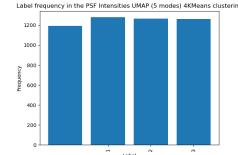
(d) 500KMeans Output Fluxes



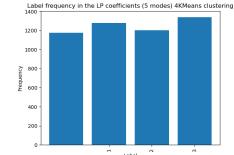
2.2.2. 5 Zernike modes datasets clusters densities



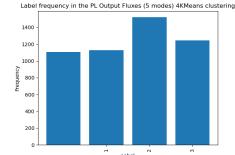
(a) 4KMeans for Zernike coefficients



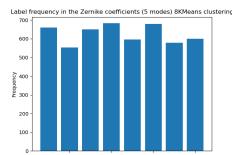
(b) 4KMeans PSF Intensities UMAP



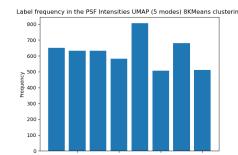
(c) 4KMeans LP coefficients



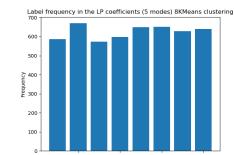
(d) 4KMeans Output Fluxes



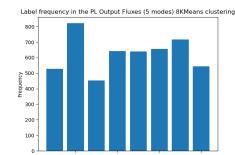
(a) 8KMeans for Zernike coefficients



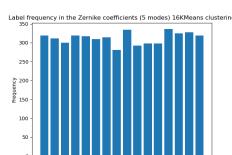
(b) 8KMeans PSF Intensities UMAP



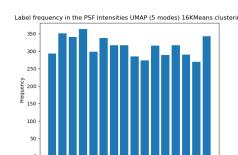
(c) 8KMeans LP coefficients



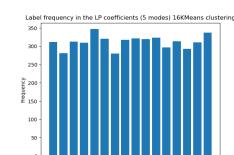
(d) 8KMeans Output Fluxes



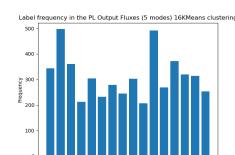
(a) 16KMeans for Zernike coefficients



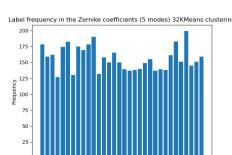
(b) 16KMeans PSF Intensities UMAP



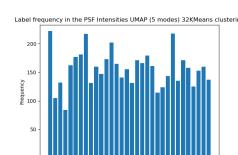
(c) 16KMeans LP coefficients



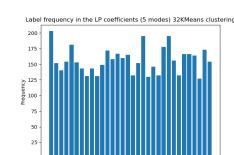
(d) 16KMeans Output Fluxes



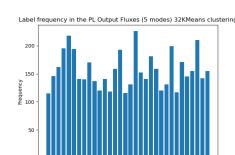
(a) 32KMeans for Zernike coefficients



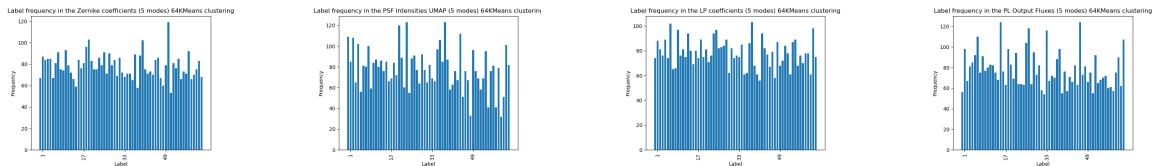
(b) 32KMeans PSF Intensities UMAP



(c) 32KMeans LP coefficients



(d) 32KMeans Output Fluxes

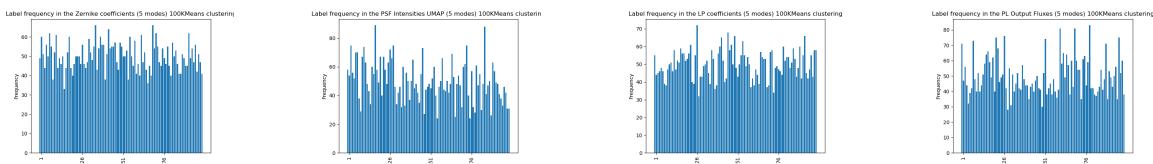


(a) 64KMeans for Zernike coefficients

(b) 64KMeans PSF
Intensities UMAP

(c) 64KMeans LP
coefficients

(d) 64KMeans Output Fluxes

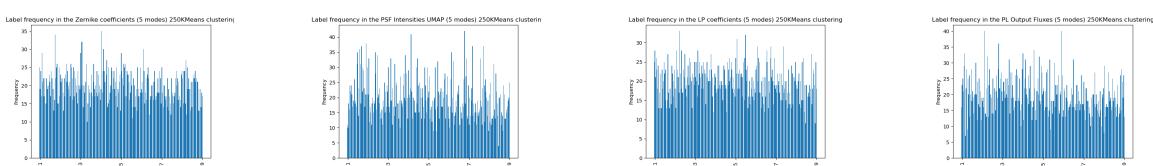


(a) 100KMeans for Zernike coefficients

(b) 100KMeans
PSF Intensities
UMAP

(c) 100KMeans LP
coefficients

(d) 100KMeans
Output Fluxes

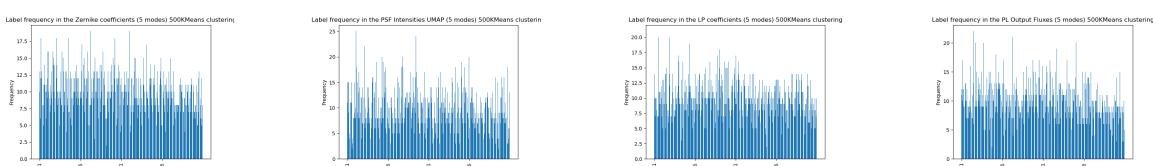


(a) 250KMeans for Zernike coefficients

(b) 250KMeans
PSF Intensities
UMAP

(c) 250KMeans LP
coefficients

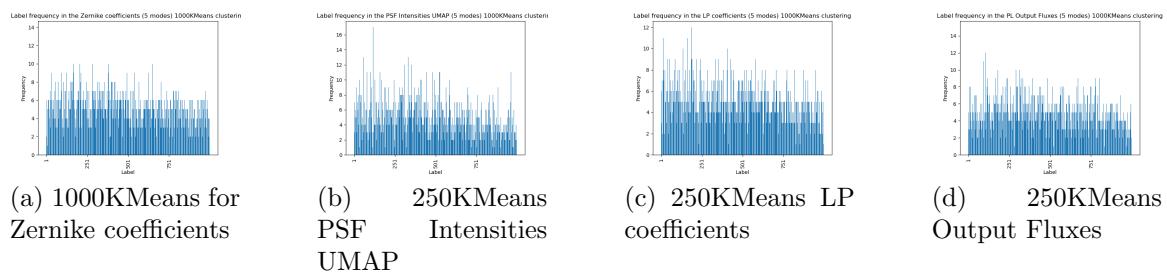
(d) 250KMeans
Output Fluxes



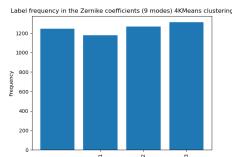
(a) 500KMeans for Zernike coefficients

(b) 500KMeans
PSF Intensities
UMAP

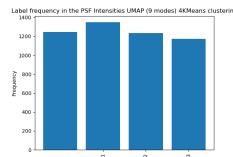
(c) 500KMeans LP coefficients



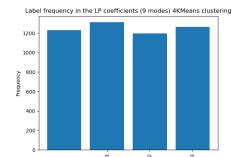
2.2.3. 9 Zernike modes datasets clusters densities



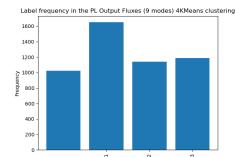
(a) 4KMeans for Zernike coefficients



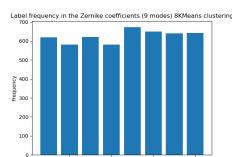
(b) 4KMeans PSF Intensities UMAP



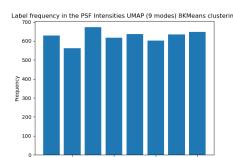
(c) 4KMeans LP coefficients



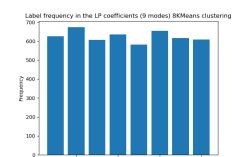
(d) 4KMeans Output Fluxes



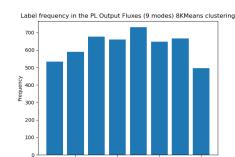
(a) 8KMeans for Zernike coefficients



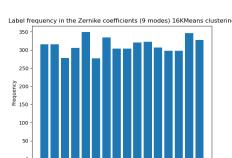
(b) 8KMeans PSF Intensities UMAP



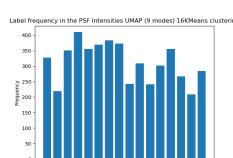
(c) 8KMeans LP coefficients



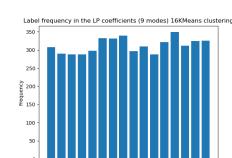
(d) 8KMeans Output Fluxes



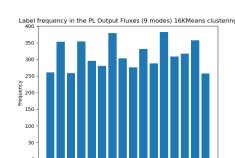
(a) 16KMeans for Zernike coefficients



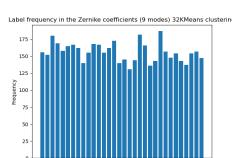
(b) 16KMeans PSF Intensities UMAP



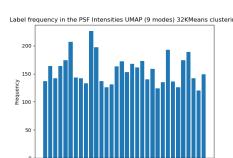
(c) 16KMeans LP coefficients



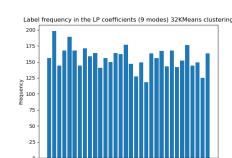
(d) 16KMeans Output Fluxes



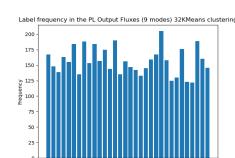
(a) 32KMeans for Zernike coefficients



(b) 32KMeans PSF Intensities UMAP

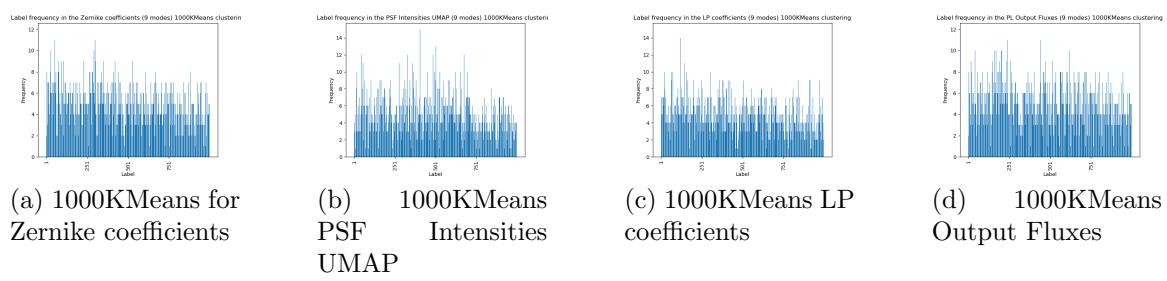


(c) 32KMeans LP coefficients



(d) 32KMeans Output Fluxes





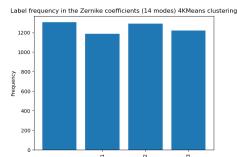
(a) 1000KMeans for
Zernike coefficients

(b) 1000KMeans
PSF Intensities
UMAP

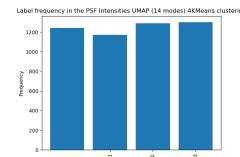
(c) 1000KMeans LP
coefficients

(d) 1000KMeans
Output Fluxes

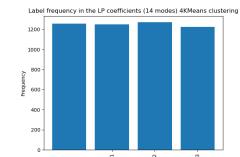
2.2.4. 14 Zernike modes datasets clusters densities



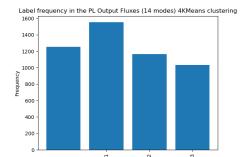
(a) 4KMeans for Zernike coefficients



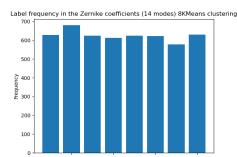
(b) 4KMeans PSF Intensities UMAP



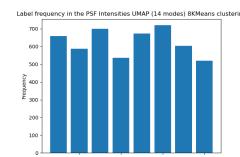
(c) 4KMeans LP coefficients



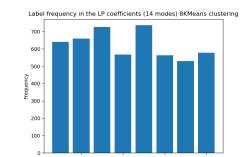
(d) 4KMeans Output Fluxes



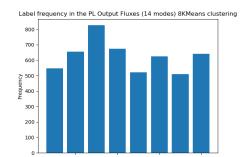
(a) 8KMeans for Zernike coefficients



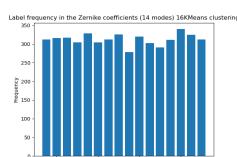
(b) 8KMeans PSF Intensities UMAP



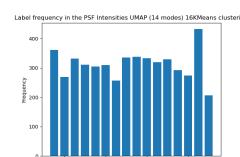
(c) 8KMeans LP coefficients



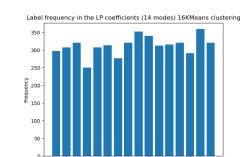
(d) 8KMeans Output Fluxes



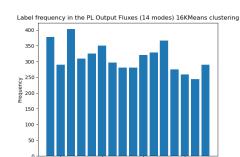
(a) 16KMeans for Zernike coefficients



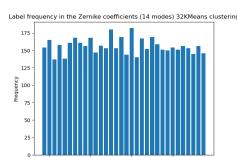
(b) 16KMeans PSF Intensities UMAP



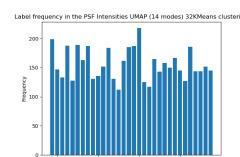
(c) 16KMeans LP coefficients



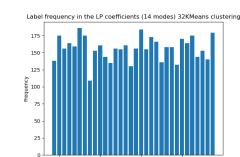
(d) 16KMeans Output Fluxes



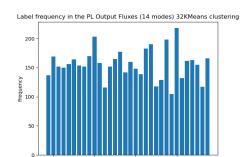
(a) 32KMeans for Zernike coefficients



(b) 32KMeans PSF Intensities UMAP

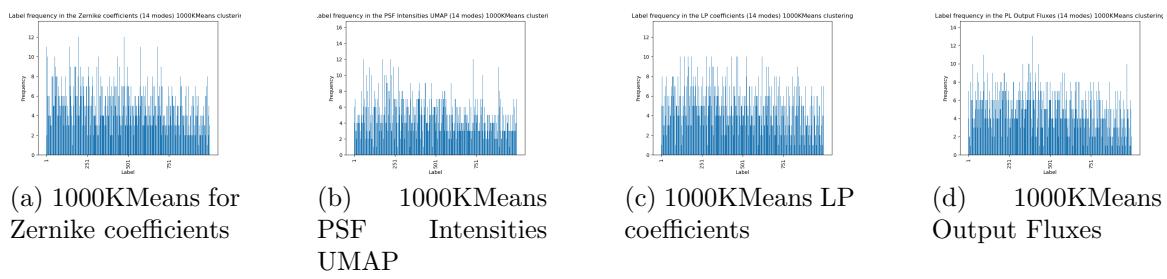


(c) 32KMeans LP coefficients

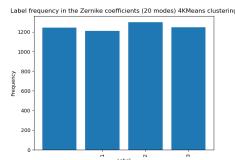


(d) 32KMeans Output Fluxes

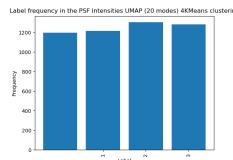




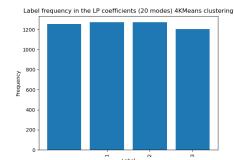
2.2.5. 20 Zernike modes datasets clusters densities



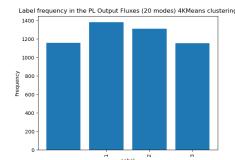
(a) 4KMeans for Zernike coefficients



(b) 4KMeans PSF Intensities UMAP



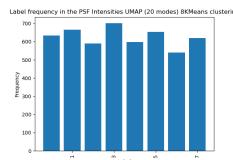
(c) 4KMeans LP coefficients



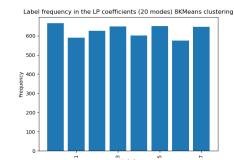
(d) 4KMeans Output Fluxes



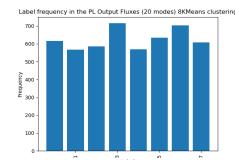
(a) 8KMeans for Zernike coefficients



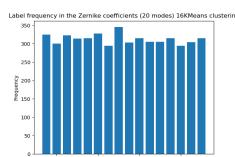
(b) 8KMeans PSF Intensities UMAP



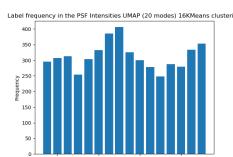
(c) 8KMeans LP coefficients



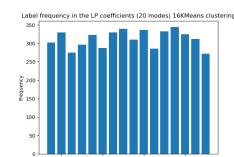
(d) 8KMeans Output Fluxes



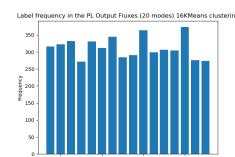
(a) 16KMeans for Zernike coefficients



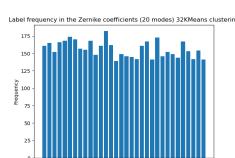
(b) 16KMeans PSF Intensities UMAP



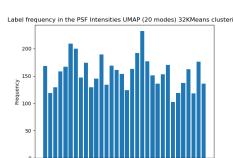
(c) 16KMeans LP coefficients



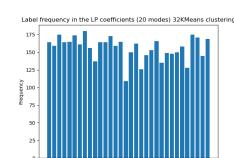
(d) 16KMeans Output Fluxes



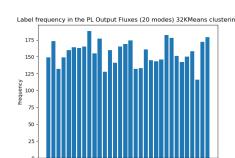
(a) 32KMeans for Zernike coefficients



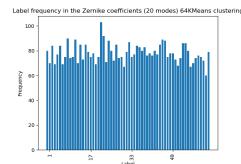
(b) 32KMeans PSF Intensities UMAP



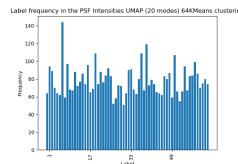
(c) 32KMeans LP coefficients



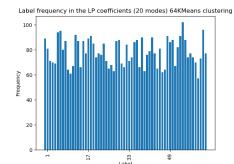
(d) 32KMeans Output Fluxes



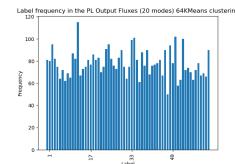
(a) 64KMeans for Zernike coefficients



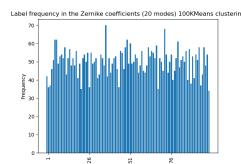
(b) 64KMeans PSF Intensities UMAP



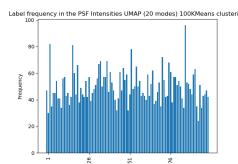
(c) 64KMeans LP coefficients



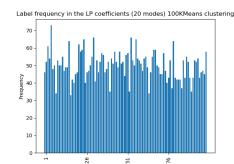
(d) 64KMeans Output Fluxes



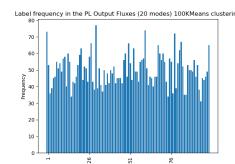
(a) 100KMeans for Zernike coefficients



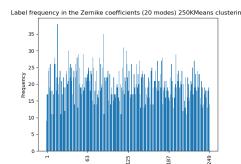
(b) 100KMeans PSF Intensities UMAP



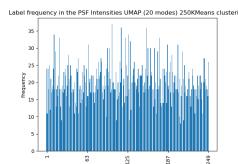
(c) 100KMeans LP coefficients



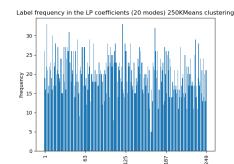
(d) 100KMeans Output Fluxes



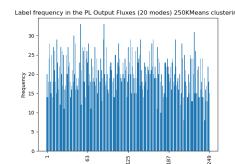
(a) 250KMeans for Zernike coefficients



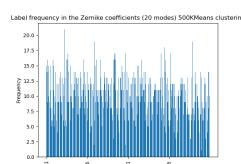
(b) 250KMeans PSF Intensities UMAP



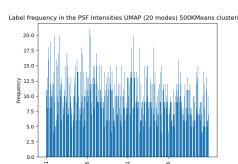
(c) 250KMeans LP coefficients



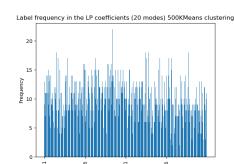
(d) 250KMeans Output Fluxes



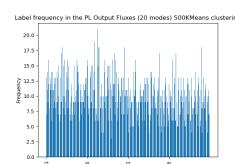
(a) 500KMeans for Zernike coefficients



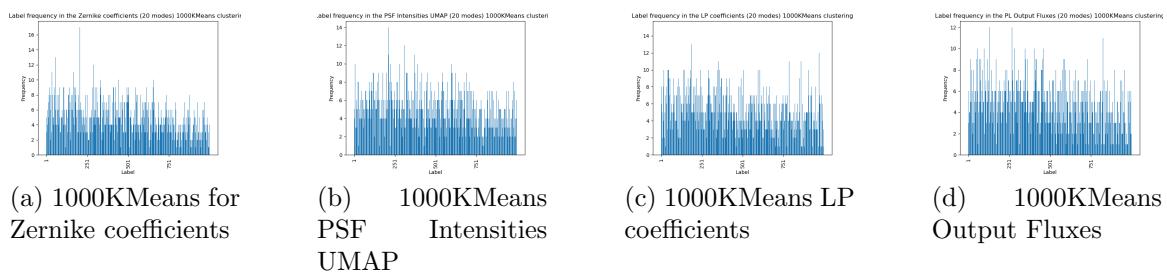
(b) 500KMeans PSF Intensities UMAP



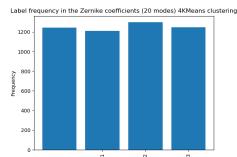
(c) 500KMeans LP coefficients



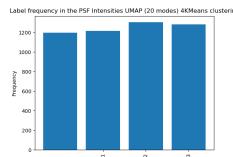
(d) 500KMeans Output Fluxes



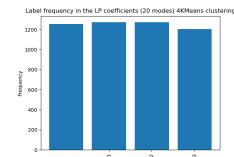
2.2.6. 27 Zernike modes datasets clusters densities



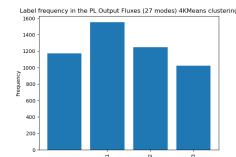
(a) 4KMeans for Zernike coefficients



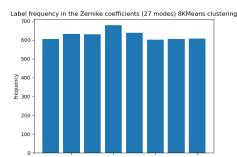
(b) 4KMeans PSF Intensities UMAP



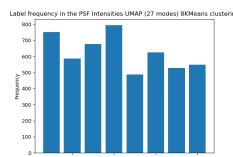
(c) 4KMeans LP coefficients



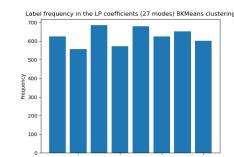
(d) 4KMeans Output Fluxes



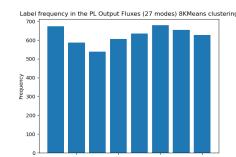
(a) 8KMeans for Zernike coefficients



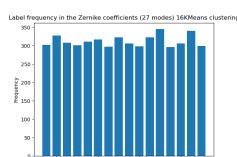
(b) 8KMeans PSF Intensities UMAP



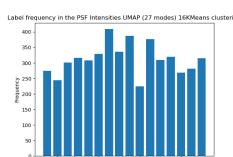
(c) 8KMeans LP coefficients



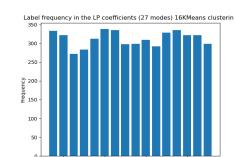
(d) 8KMeans Output Fluxes



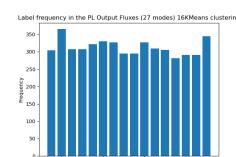
(a) 16KMeans for Zernike coefficients



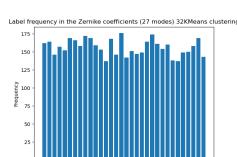
(b) 16KMeans PSF Intensities UMAP



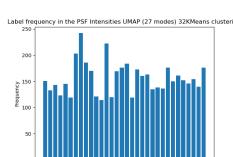
(c) 16KMeans LP coefficients



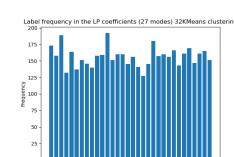
(d) 16KMeans Output Fluxes



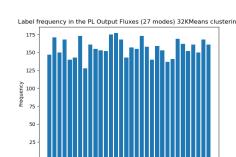
(a) 32KMeans for Zernike coefficients



(b) 32KMeans PSF Intensities UMAP

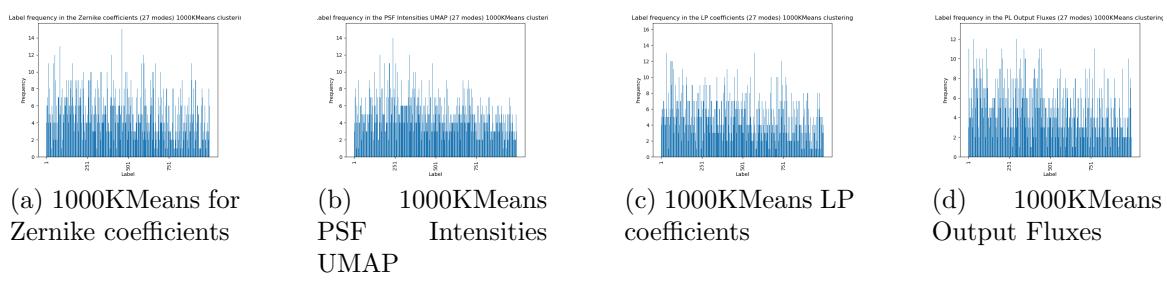


(c) 32KMeans LP coefficients

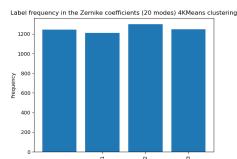


(d) 32KMeans Output Fluxes

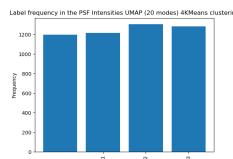




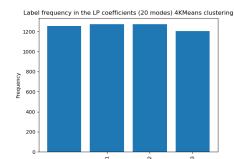
2.2.7. 35 Zernike modes datasets clusters densities



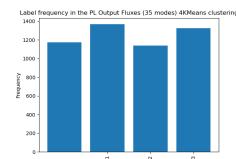
(a) 4KMeans for Zernike coefficients



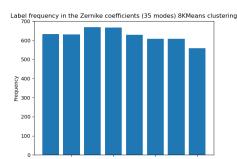
(b) 4KMeans PSF Intensities UMAP



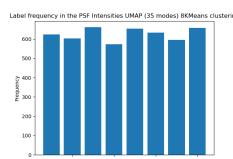
(c) 4KMeans LP coefficients



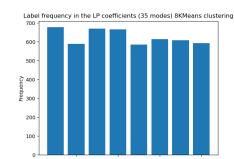
(d) 4KMeans Output Fluxes



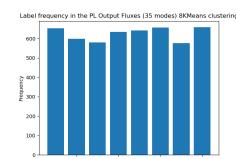
(a) 8KMeans for Zernike coefficients



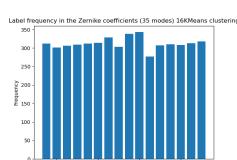
(b) 8KMeans PSF Intensities UMAP



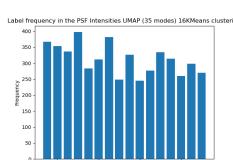
(c) 8KMeans LP coefficients



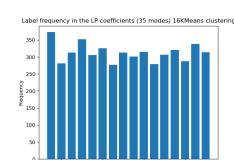
(d) 8KMeans Output Fluxes



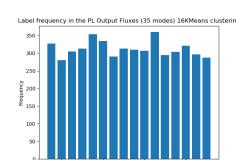
(a) 16KMeans for Zernike coefficients



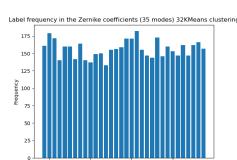
(b) 16KMeans PSF Intensities UMAP



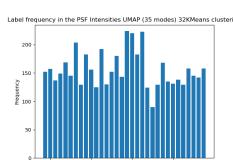
(c) 16KMeans LP coefficients



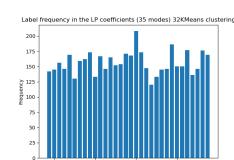
(d) 16KMeans Output Fluxes



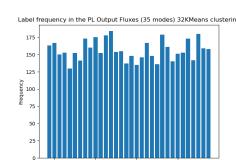
(a) 32KMeans for Zernike coefficients



(b) 32KMeans PSF Intensities UMAP

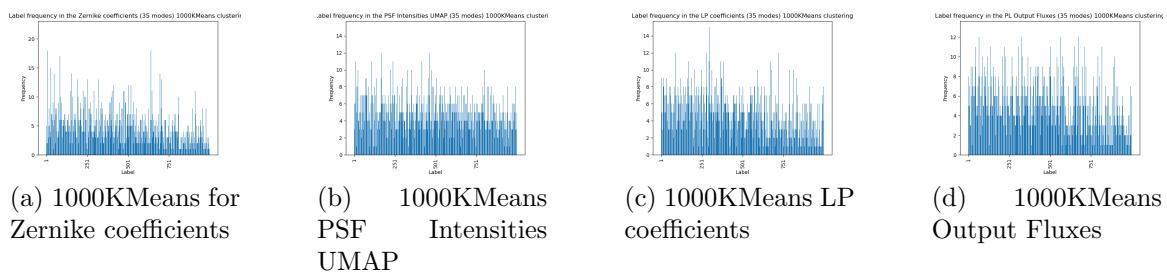


(c) 32KMeans LP coefficients

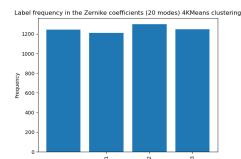


(d) 32KMeans Output Fluxes

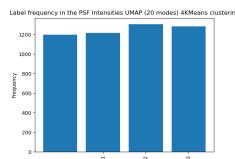




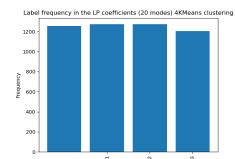
2.2.8. 44 Zernike modes datasets clusters densities



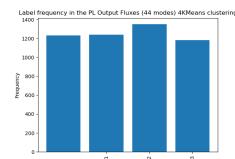
(a) 4KMeans for Zernike coefficients



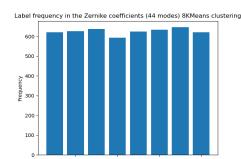
(b) 4KMeans PSF Intensities UMAP



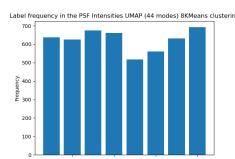
(c) 4KMeans LP coefficients



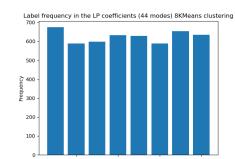
(d) 4KMeans Output Fluxes



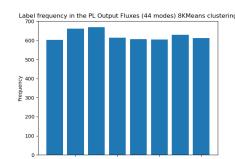
(a) 8KMeans for Zernike coefficients



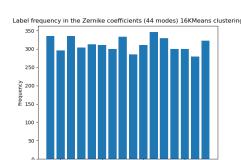
(b) 8KMeans PSF Intensities UMAP



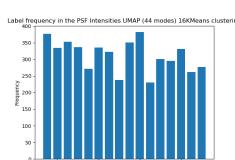
(c) 8KMeans LP coefficients



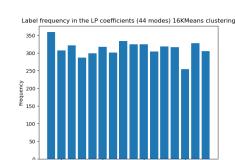
(d) 8KMeans Output Fluxes



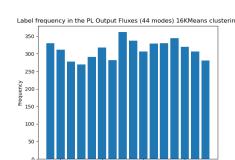
(a) 16KMeans for Zernike coefficients



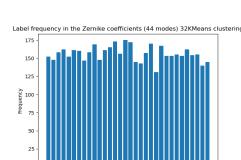
(b) 16KMeans PSF Intensities UMAP



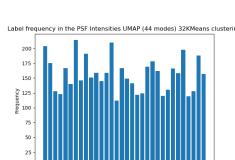
(c) 16KMeans LP coefficients



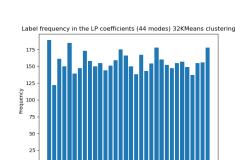
(d) 16KMeans Output Fluxes



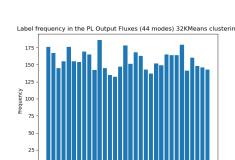
(a) 32KMeans for Zernike coefficients



(b) 32KMeans PSF Intensities UMAP

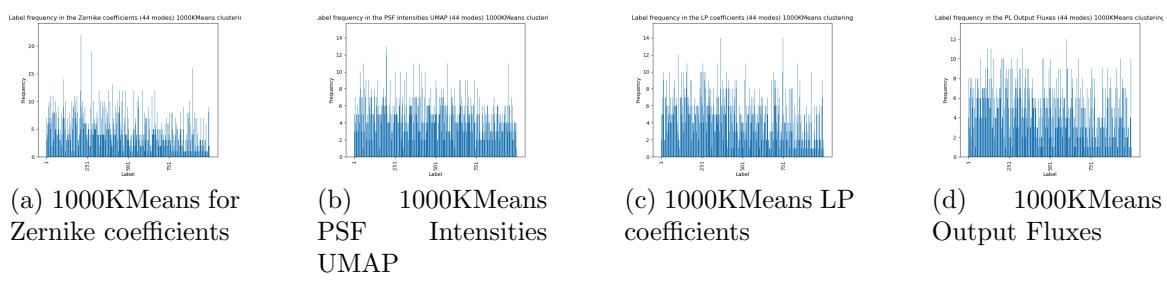


(c) 32KMeans LP coefficients



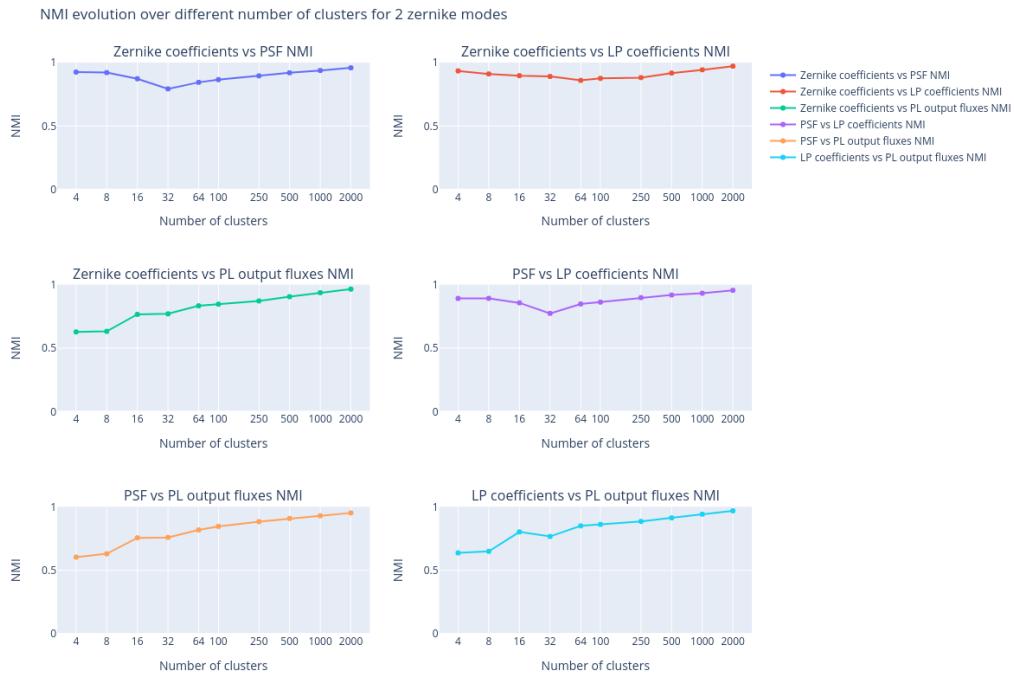
(d) 32KMeans Output Fluxes





2.3. Normalized Mutual Information evolution

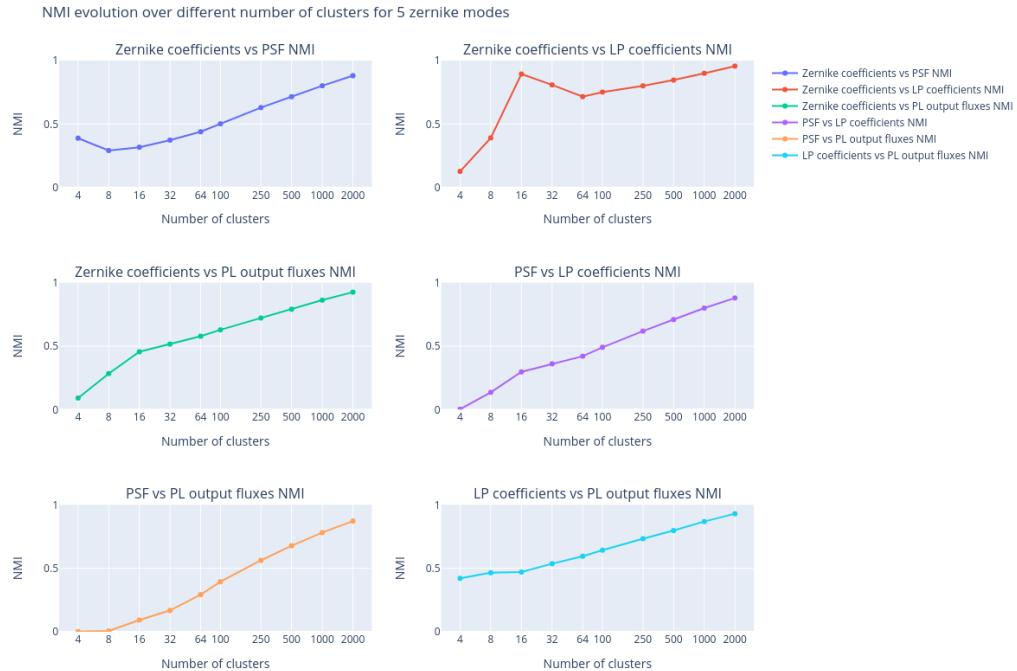
2.3.1. NMI evolution over number of clusters for 2 zernike mode related datasets



Clusters	Z vs PSF	Z vs LP	Z vs PL	PSF vs LP	PSF vs PL	LP vs PL
4	0.925	0.934	0.628	0.892	0.604	0.637
8	0.921	0.910	0.633	0.892	0.630	0.649
16	0.872	0.897	0.766	0.857	0.756	0.802
32	0.793	0.891	0.770	0.774	0.759	0.766
64	0.844	0.860	0.834	0.848	0.818	0.850
100	0.865	0.875	0.846	0.863	0.846	0.861
250	0.895	0.881	0.872	0.898	0.883	0.885
500	0.919	0.917	0.905	0.919	0.908	0.913
1000	0.937	0.943	0.937	0.933	0.930	0.942
2000	0.959	0.972	0.965	0.956	0.952	0.969

Cuadro 2: NMI Analysis for Different Numbers of Clusters

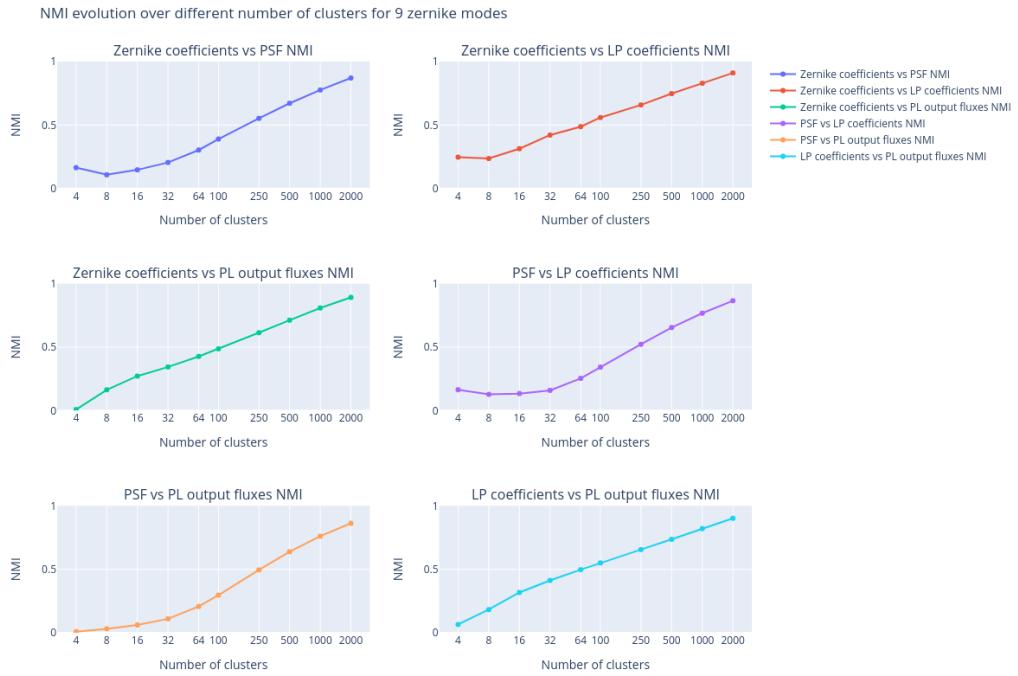
2.3.2. NMI evolution over number of clusters for 5 zernike mode related datasets



Clusters	Z vs PSF	Z vs LP	Z vs PL	PSF vs LP	PSF vs PL	LP vs PL
4	0.3884	0.1268	0.0914	0.0033	0.0016	0.4207
8	0.2913	0.3905	0.2838	0.1361	0.0064	0.4649
16	0.3172	0.8939	0.4555	0.2970	0.0925	0.4705
32	0.3731	0.8080	0.5162	0.3606	0.1683	0.5361
64	0.4390	0.7155	0.5783	0.4208	0.2927	0.5950
100	0.5018	0.7515	0.6286	0.4911	0.3940	0.6427
250	0.6296	0.8008	0.7217	0.6187	0.5626	0.7328
500	0.7151	0.8462	0.7910	0.7095	0.6774	0.7972
1000	0.8012	0.8996	0.8626	0.7995	0.7812	0.8683
2000	0.8807	0.9562	0.9255	0.8795	0.8723	0.9299

Cuadro 3: NMI Analysis for Different Numbers of Clusters

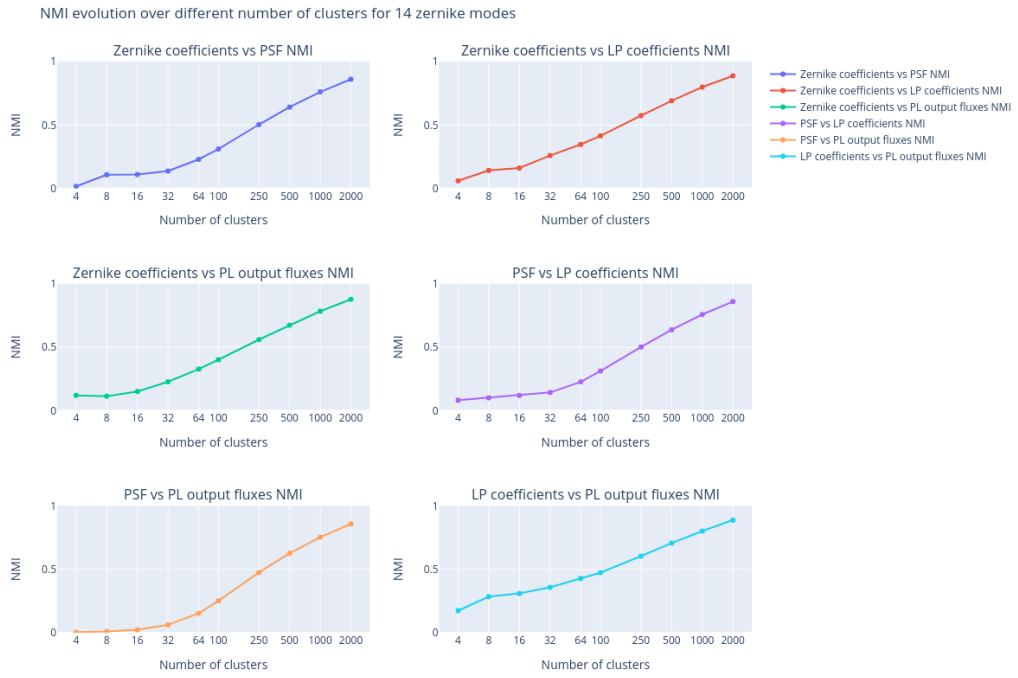
2.3.3. NMI evolution over number of clusters for 9 zernike mode related datasets



Clusters	Z vs PSF	Z vs LP	Z vs PL	PSF vs LP	PSF vs PL	LP vs PL
4	0.164	0.247	0.009	0.165	0.009	0.065
8	0.108	0.236	0.164	0.128	0.031	0.183
16	0.147	0.313	0.272	0.134	0.061	0.317
32	0.205	0.421	0.344	0.160	0.110	0.413
64	0.303	0.487	0.427	0.254	0.207	0.497
100	0.389	0.559	0.487	0.343	0.296	0.550
250	0.552	0.658	0.614	0.522	0.495	0.655
500	0.671	0.747	0.712	0.655	0.638	0.736
1000	0.776	0.829	0.809	0.768	0.761	0.820
2000	0.870	0.910	0.892	0.866	0.862	0.902

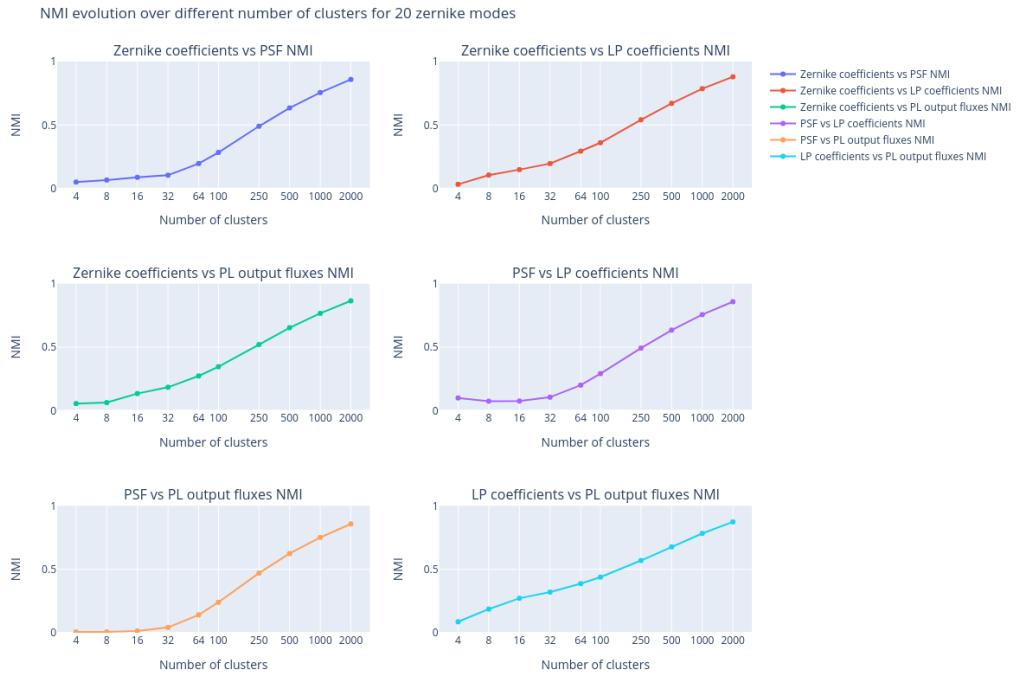
Cuadro 4: NMI Analysis for Different Numbers of Clusters

2.3.4. NMI evolution over number of clusters for 14 zernike mode related datasets



Cuadro 5: NMI Analysis for Different Numbers of Clusters

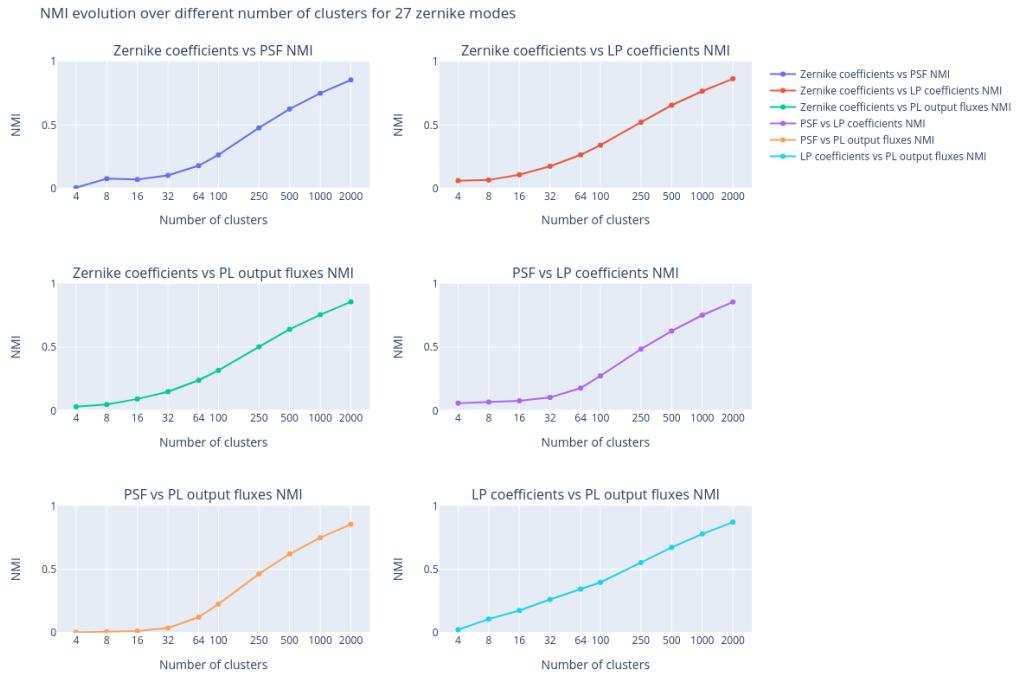
2.3.5. NMI evolution over number of clusters for 20 zernike mode related datasets



Clusters	Z vs PSF	Z vs LP	Z vs PL	PSF vs LP	PSF vs PL	LP vs PL
4	0.051	0.033	0.056	0.100	0.007	0.087
8	0.067	0.106	0.063	0.074	0.007	0.186
16	0.088	0.149	0.134	0.075	0.014	0.272
32	0.105	0.196	0.184	0.106	0.042	0.320
64	0.196	0.294	0.273	0.201	0.141	0.387
100	0.284	0.361	0.346	0.292	0.240	0.438
250	0.490	0.541	0.520	0.492	0.470	0.569
500	0.635	0.671	0.653	0.635	0.624	0.676
1000	0.756	0.786	0.766	0.757	0.752	0.783
2000	0.859	0.879	0.865	0.858	0.857	0.873

Cuadro 6: NMI Analysis for Different Numbers of Clusters

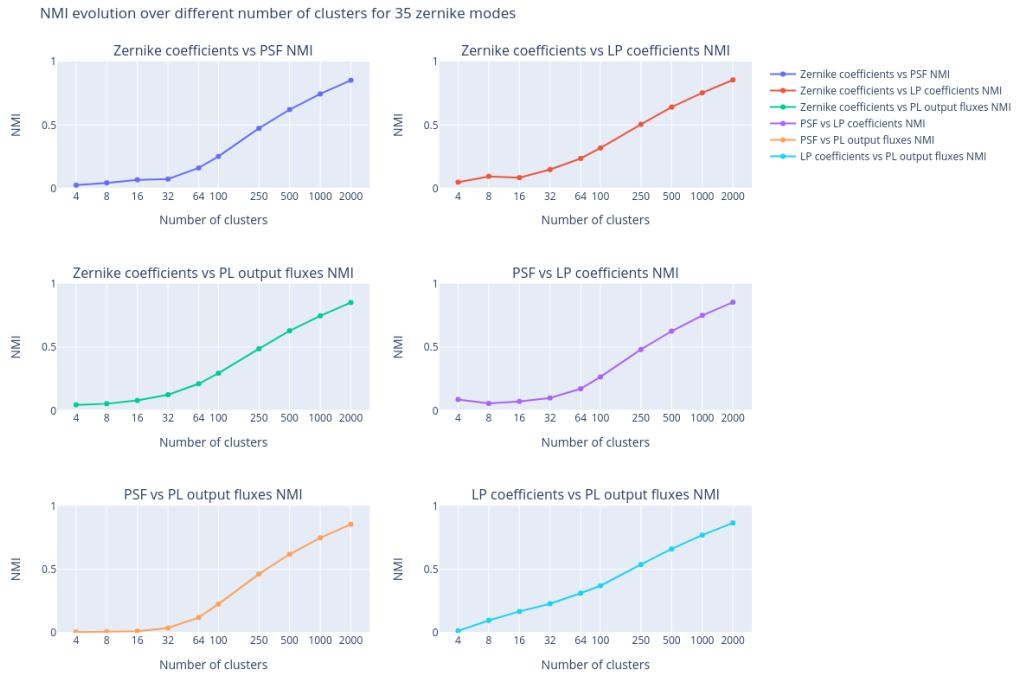
2.3.6. NMI evolution over number of clusters for 27 zernike mode related datasets



Clusters	Z vs PSF	Z vs LP	Z vs PL	PSF vs LP	PSF vs PL	LP vs PL
4	0.006	0.062	0.030	0.059	0.004	0.024
8	0.077	0.067	0.048	0.067	0.007	0.108
16	0.071	0.108	0.092	0.077	0.014	0.175
32	0.104	0.175	0.149	0.104	0.037	0.263
64	0.180	0.265	0.239	0.177	0.123	0.344
100	0.264	0.341	0.317	0.274	0.226	0.397
250	0.477	0.522	0.503	0.485	0.463	0.552
500	0.626	0.656	0.640	0.627	0.620	0.672
1000	0.750	0.767	0.755	0.752	0.749	0.778
2000	0.855	0.865	0.857	0.856	0.855	0.872

Cuadro 7: NMI Analysis for Different Numbers of Clusters

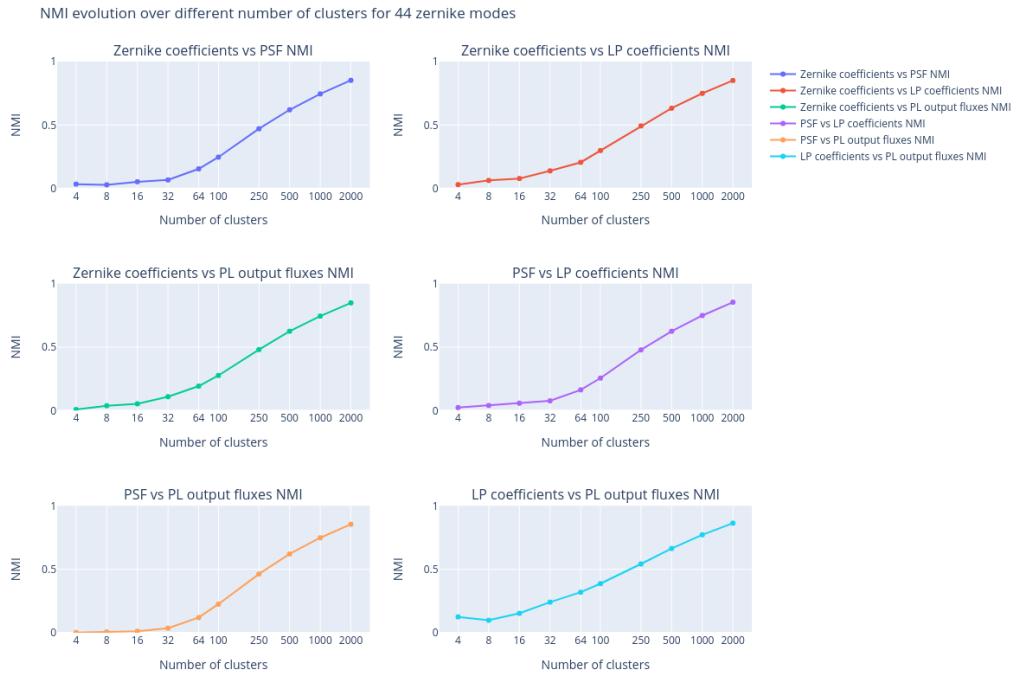
2.3.7. NMI evolution over number of clusters for 35 zernike mode related datasets



Clusters	Z vs PSF	Z vs LP	Z vs PL	PSF vs LP	PSF vs PL	LP vs PL
4	0.026	0.049	0.046	0.088	0.006	0.015
8	0.045	0.095	0.054	0.056	0.009	0.097
16	0.068	0.085	0.080	0.073	0.013	0.168
32	0.074	0.149	0.125	0.100	0.037	0.229
64	0.162	0.236	0.212	0.172	0.120	0.312
100	0.253	0.319	0.295	0.265	0.226	0.370
250	0.474	0.506	0.487	0.482	0.462	0.538
500	0.622	0.641	0.629	0.626	0.619	0.660
1000	0.745	0.754	0.747	0.750	0.748	0.769
2000	0.853	0.855	0.852	0.854	0.855	0.865

Cuadro 8: NMI Analysis for Different Numbers of Clusters

2.3.8. NMI evolution over number of clusters for 44 zernike mode related datasets

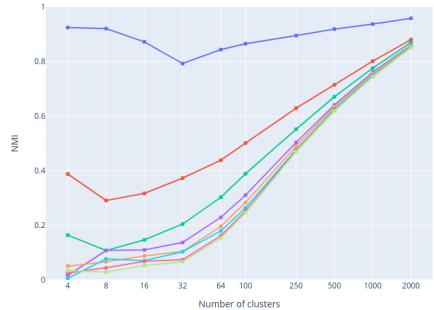


Clusters	Z vs PSF	Z vs LP	Z vs PL	PSF vs LP	PSF vs PL	LP vs PL
4	0.034	0.031	0.009	0.024	0.002	0.125
8	0.029	0.064	0.039	0.040	0.006	0.098
16	0.053	0.079	0.054	0.058	0.012	0.153
32	0.067	0.139	0.110	0.077	0.036	0.241
64	0.155	0.206	0.193	0.164	0.120	0.320
100	0.247	0.299	0.277	0.256	0.225	0.387
250	0.470	0.493	0.481	0.478	0.463	0.542
500	0.620	0.632	0.625	0.625	0.621	0.664
1000	0.745	0.749	0.745	0.749	0.749	0.772
2000	0.852	0.851	0.849	0.854	0.855	0.864

Cuadro 9: NMI Analysis for Different Numbers of Clusters

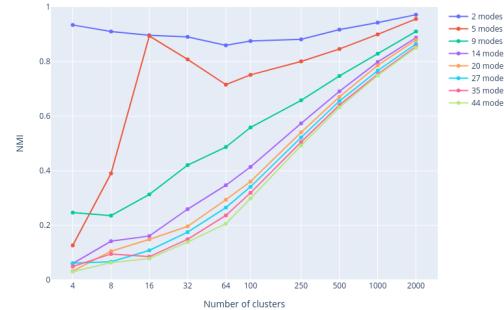
2.3.9. NMI evolution over number of zernike modes

Zernike coefficients vs PSF NMI



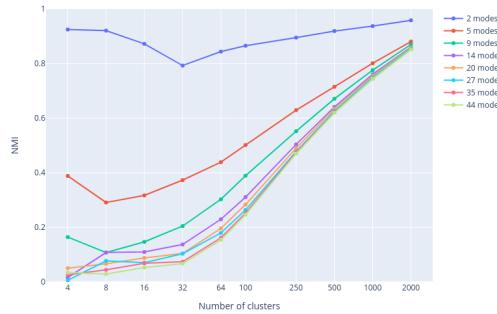
(a) NMI evolution over number of clusters for Zernike coefficients vs PSF

Zernike coefficients vs LP coefficients NMI



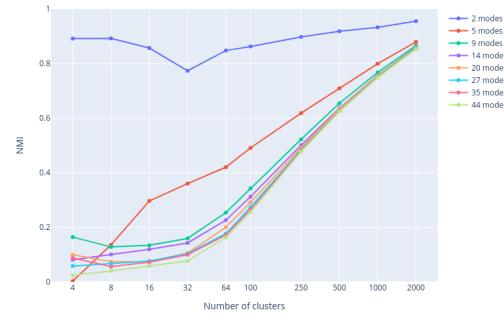
(b) NMI evolution over number of clusters for Zernike coefficients vs LP coefficients

Zernike coefficients vs PL output fluxes NMI



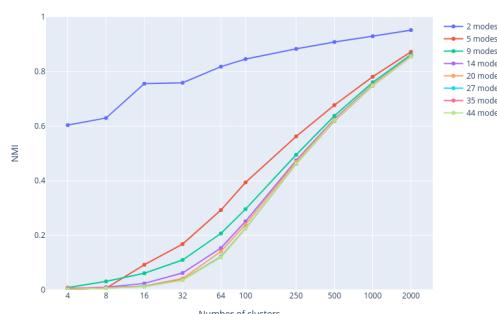
(c) NMI evolution over number of clusters for Zernike coefficients vs PL output fluxes

PSF vs LP coefficients NMI



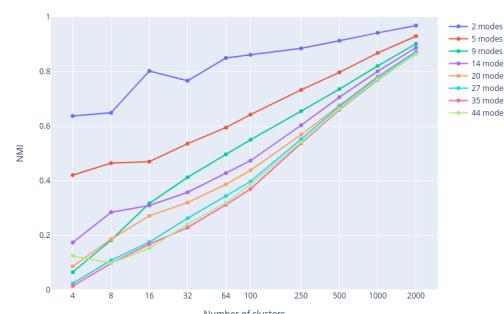
(d) NMI evolution over number of clusters for PSF vs LP coefficients

PSF vs PL output fluxes NMI



(e) NMI evolution over number of clusters for PSF vs PL output fluxes

LP coefficients vs PL output fluxes NMI



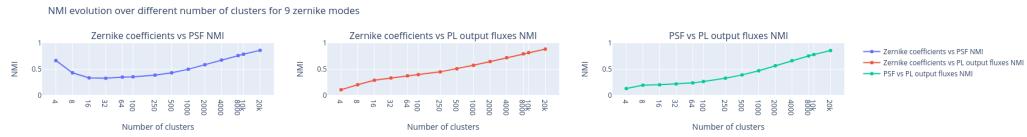
(f) NMI evolution over number of clusters for LP coefficients vs PL output fluxes

2.4. Normalized Mutual Information evolution for a big dataset

This dataset is made from 75000 combinations of 9 zernike modes their RMSE ranging from:

- Modes 2,3 between [-0.8, 0.8]
- Modes 4,5,6 between [-0.6, 0.6]
- Modes 7,8,9,10 between [-0.4, 0.4]

2.4.1. NMI evolution over number of clusters for 9 zernike mode related datasets



Clusters	Z vs PSF	Z vs PL	PSF vs PL
4	0.667	0.109	0.133
8	0.433	0.205	0.196
16	0.336	0.291	0.205
32	0.329	0.334	0.220
64	0.351	0.375	0.240
100	0.356	0.399	0.267
250	0.389	0.452	0.331
500	0.433	0.510	0.393
1000	0.501	0.577	0.472
2000	0.588	0.648	0.567
4000	0.677	0.722	0.664
8000	0.763	0.796	0.755
10000	0.789	0.819	0.782
20000	0.863	0.886	0.859

Cuadro 10: NMI Analysis for Different Numbers of Clusters