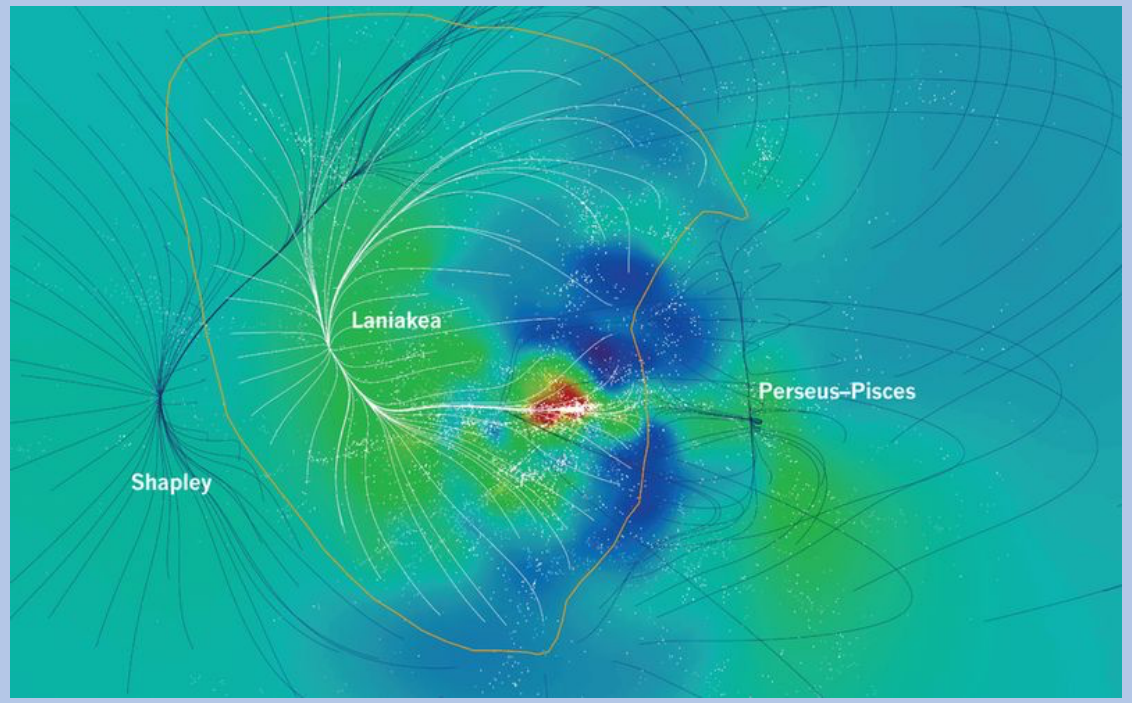
Quantifying Clustering Environment of the 2MRS Galaxies in the Pisces-Perseus Supercluster



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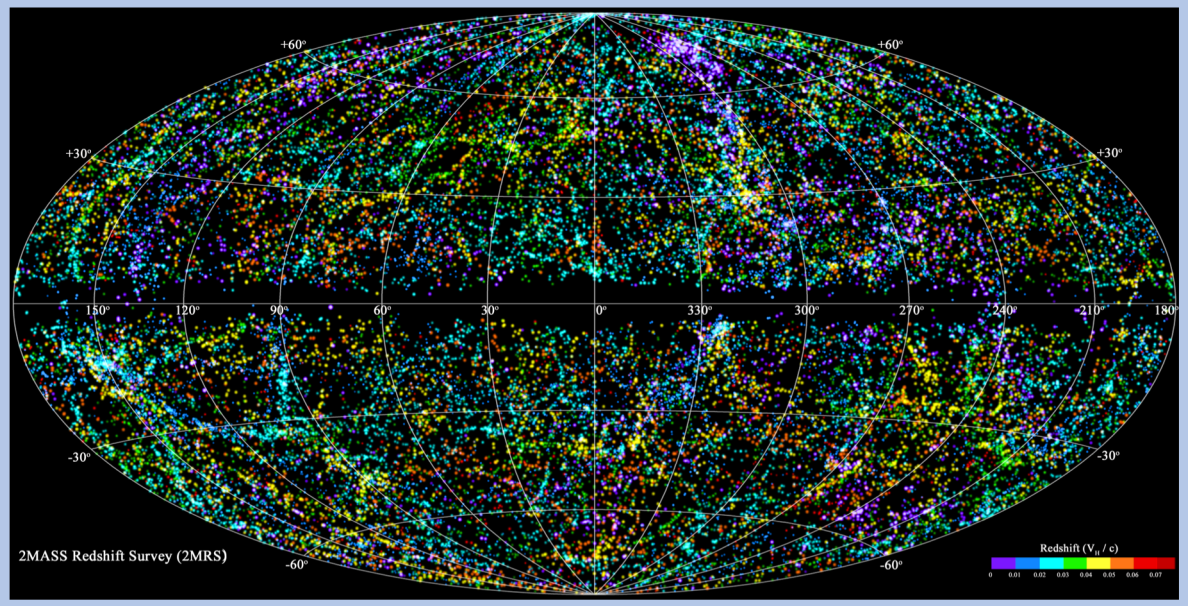
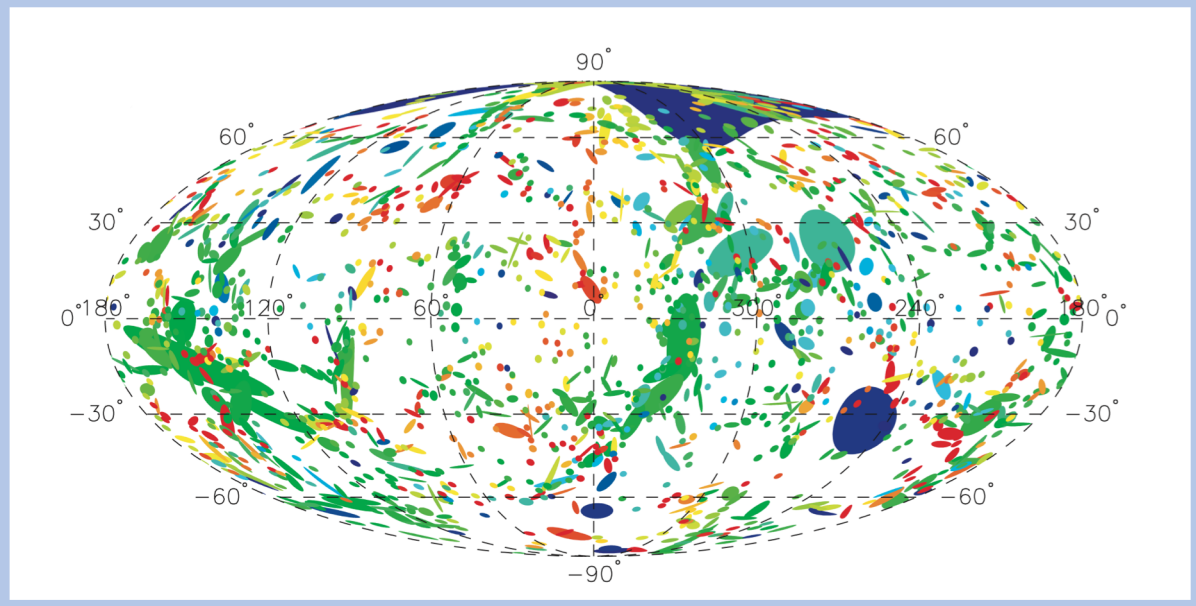
The 2MRS (2MASS Redshift Survey)

- Is the spectroscopic extension to the 2 Micron All Sky Survey (2MASS) to map the nearby universe up to a completeness of $K_s < 11.75$ mag (1.990-2.310 μm)
- contains 4.3×10^4 galaxies with associated redshifts
- used over the Sloan Digital Sky Survey (SDSS) because of SDSS's lack of sky coverage in the southern galactic hemisphere.
- Essential use is to give first order description of the local volume

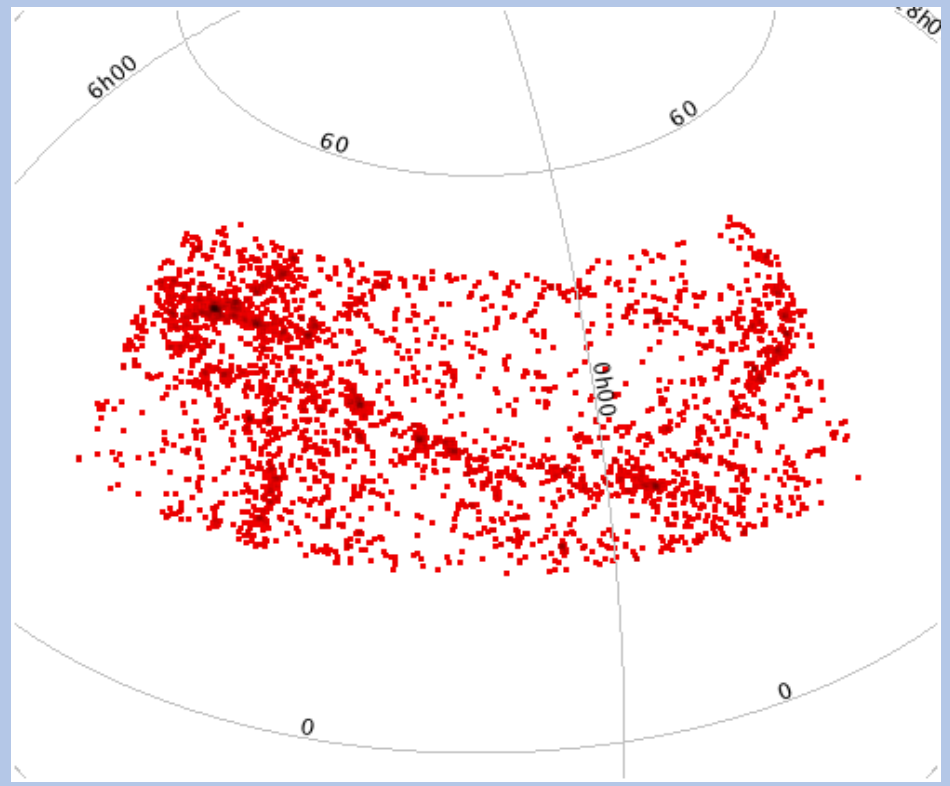


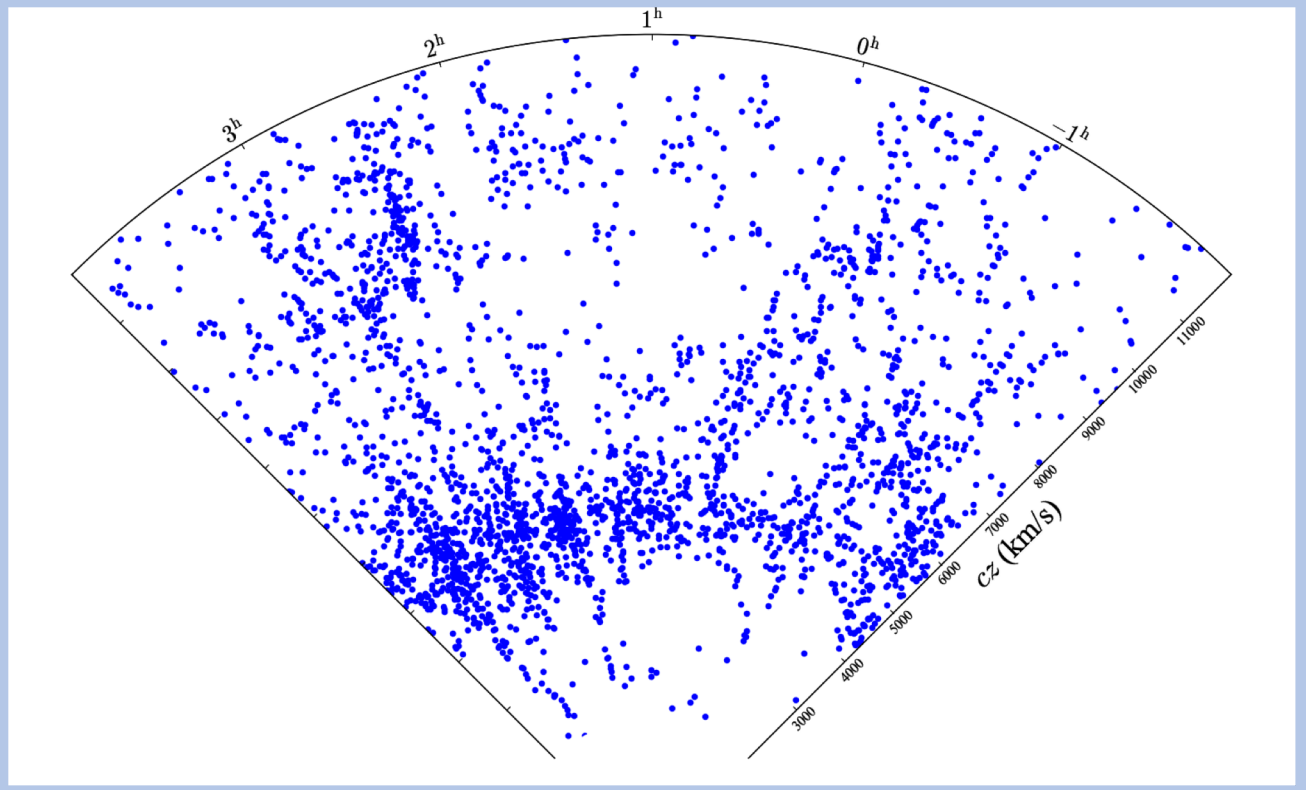


The Pisces-Perseus Region

- Our interest takes place in the Pisces-Perseus Supercluster, which we'll roughly define in the sky as:
  - $2000 < cz < 12000$ km/s
  - $-30 < RA < 60$
  - $20 < DEC < 50$

*Note the sample from 2MRS includes interlopers of galaxies up to 25000 km/s





Creating the Mock Catalog Environment

- To first order, comparing to mock catalogs gains insight to degree of clustering
- We assume a magnitude limit at $K_s < 11.75$ mag and that the Supercluster follows a Schechter Luminosity function distribution:

$$\Phi(M) = \phi_* 10^{.4(\alpha+1)(M-M_*)} e^{10^{.4(M-M_*)}}$$

- At farther distances, we see only the brightest galaxies at larger volumes (Malmquist Bias), so to assign a probability for a certain M to be chosen, we create a "selection function" s(M):

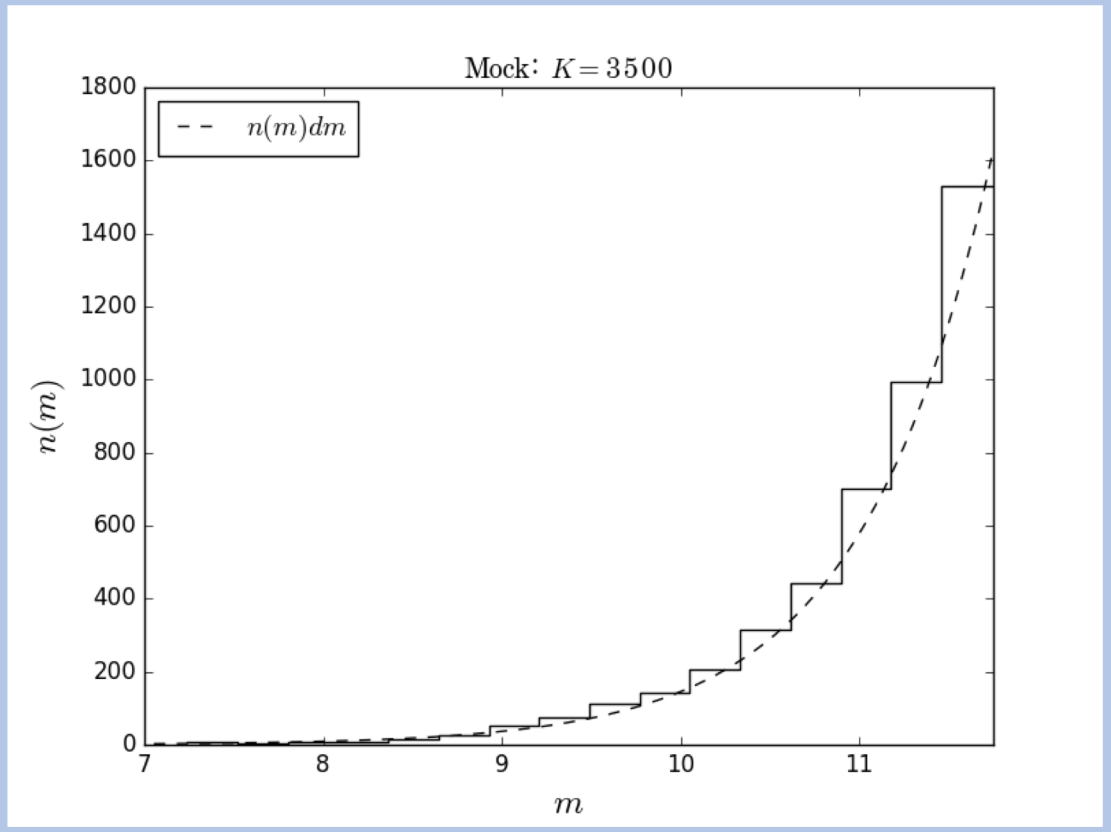
$$s(M) = \left[\frac{\int_{-\infty}^{M} \Phi(M')\, dM'}{\int_{-\infty}^{M_{lim}} \Phi(M') dM'} \right]^{\gamma}$$

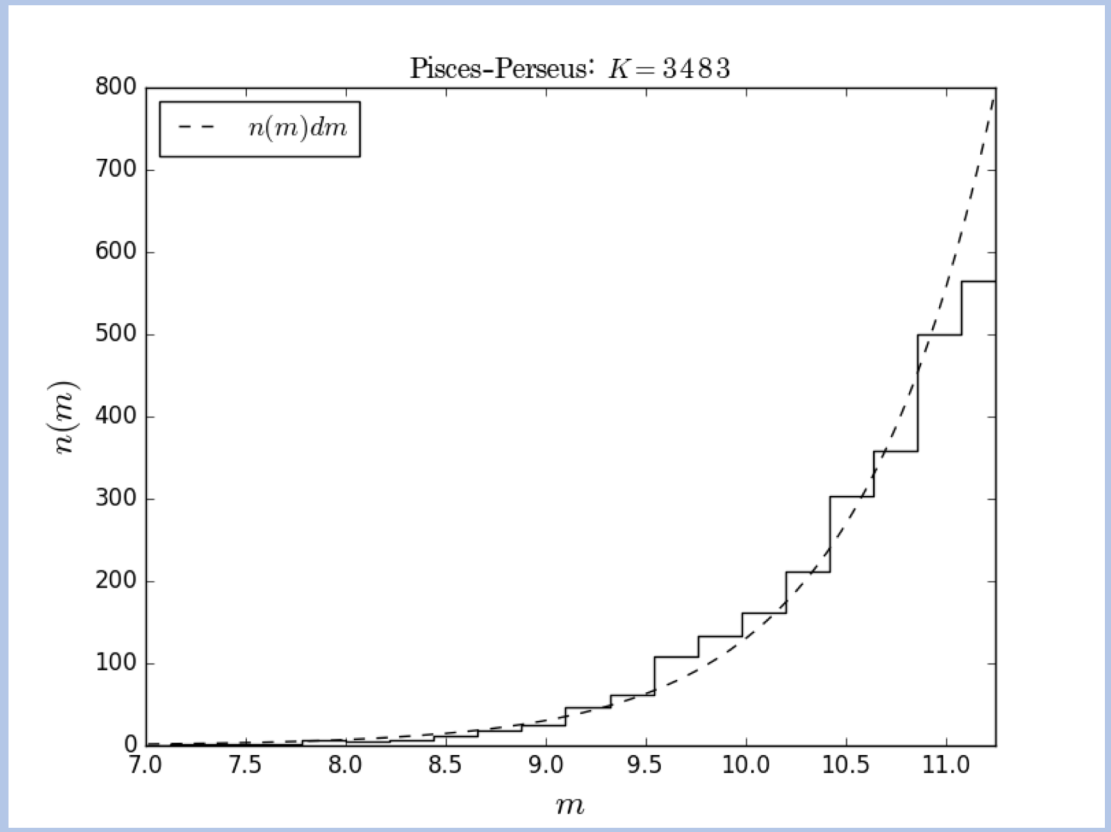
- For a random distribution, RA and DEC are randomly assigned

Creating the Mock Catalog Environment

- We check that the population is plausible by comparing it to the expected magnitude distribution for a complete, magnitude-limited sample:

$$n(m)dm = n_0 \int_0^\infty \Phi(M) r^2 dr\, dm \quad \text{Where } M = m - 5\log(r/10)$$





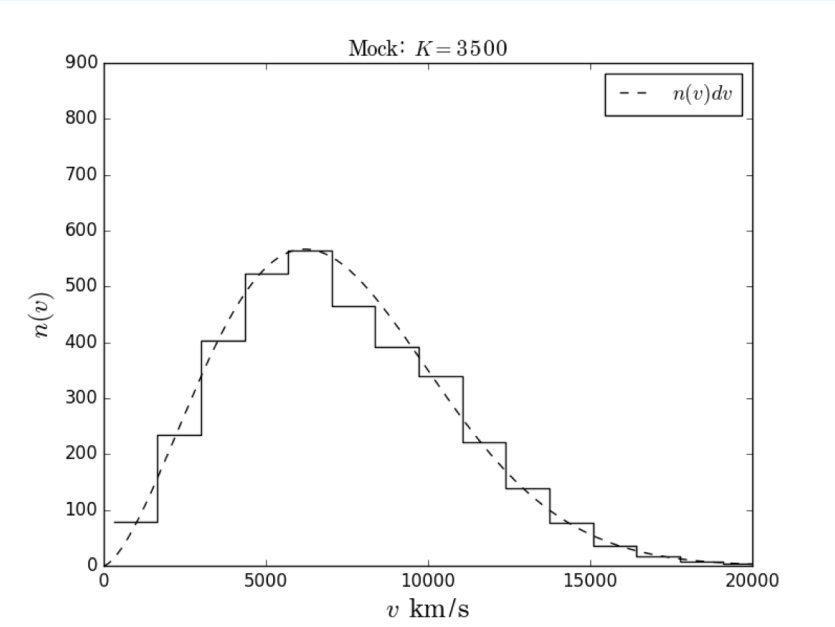
Creating the Mock Catalog Environment

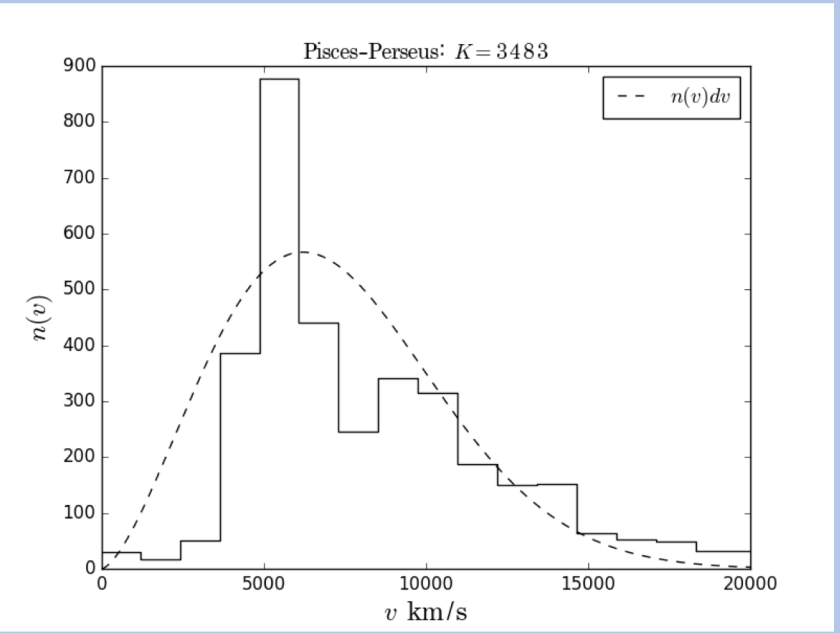
- Similarly, we assign redshifts based on the expected redshift distribution for a incomplete, magnitude-limited sample:

$$N(v,m)dv\,dm = \Phi(M)\left(\frac{v}{H}\right)^2 dv\,dm$$

- Since our sample is has a magnitude limit, we multiply this by our selection function and integrate to M_{lim}:

$$N(v)dv = v_0 \int N(v,m)s(M)dm\,dv \quad \text{Where } M = m - 5\log(v/10H)$$





Nth Nearest Neighbor

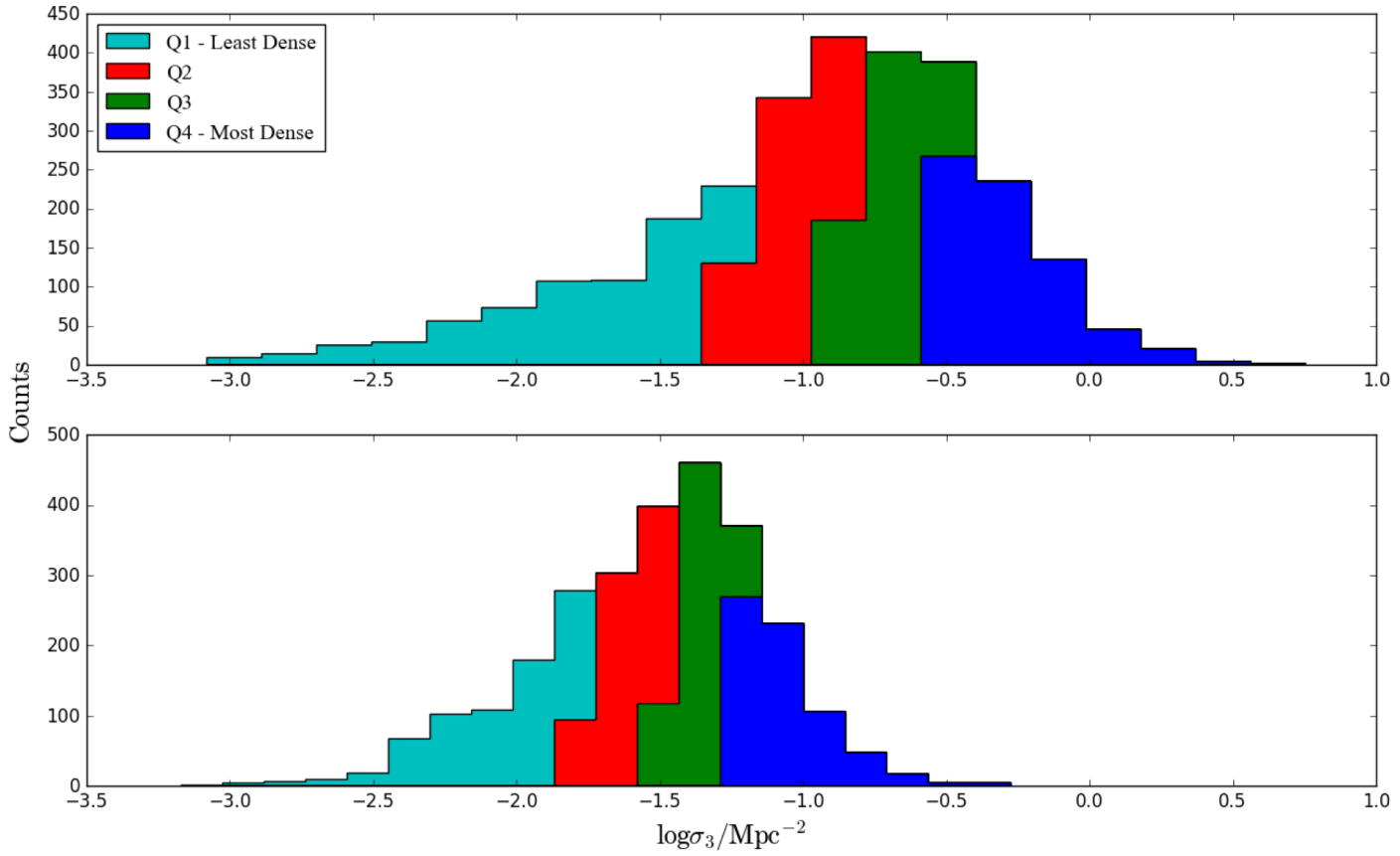
- Method of quantifying environment is finding a galaxy's Nth nearest neighbor, in principle galaxies with closer neighbors are in denser environments
- Identify galaxies within a redshift range (radial distance) and spatial coordinates (tangential distance) to solve for the total nth-nearest neighbor distance
- To avoid edge effects, we add an additional 32.5% of galaxies within a region outlining our test region

Projected nth-neighbor surface density:

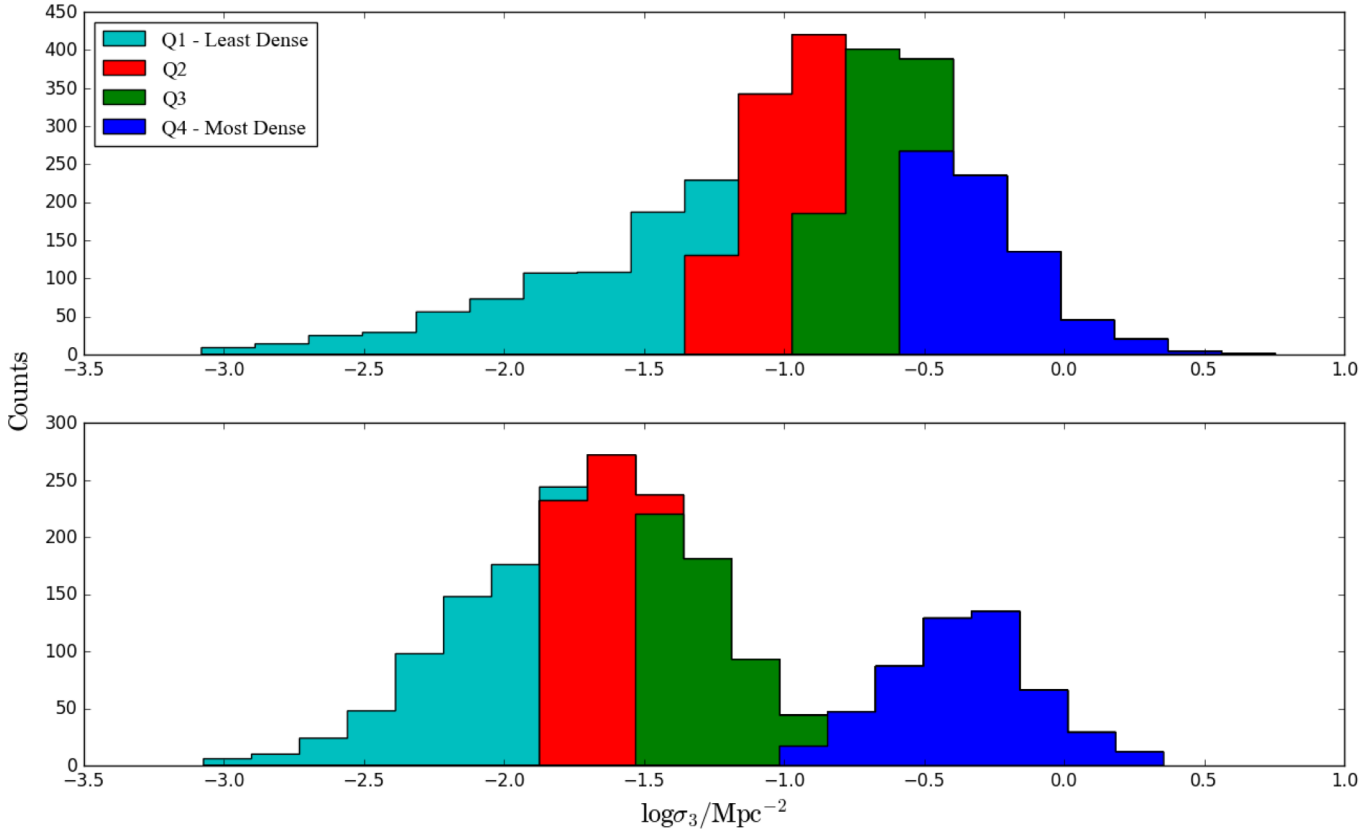
$$\sigma_N = \frac{N}{\pi r_N^2}$$

Projected nth-neighbor volume density:

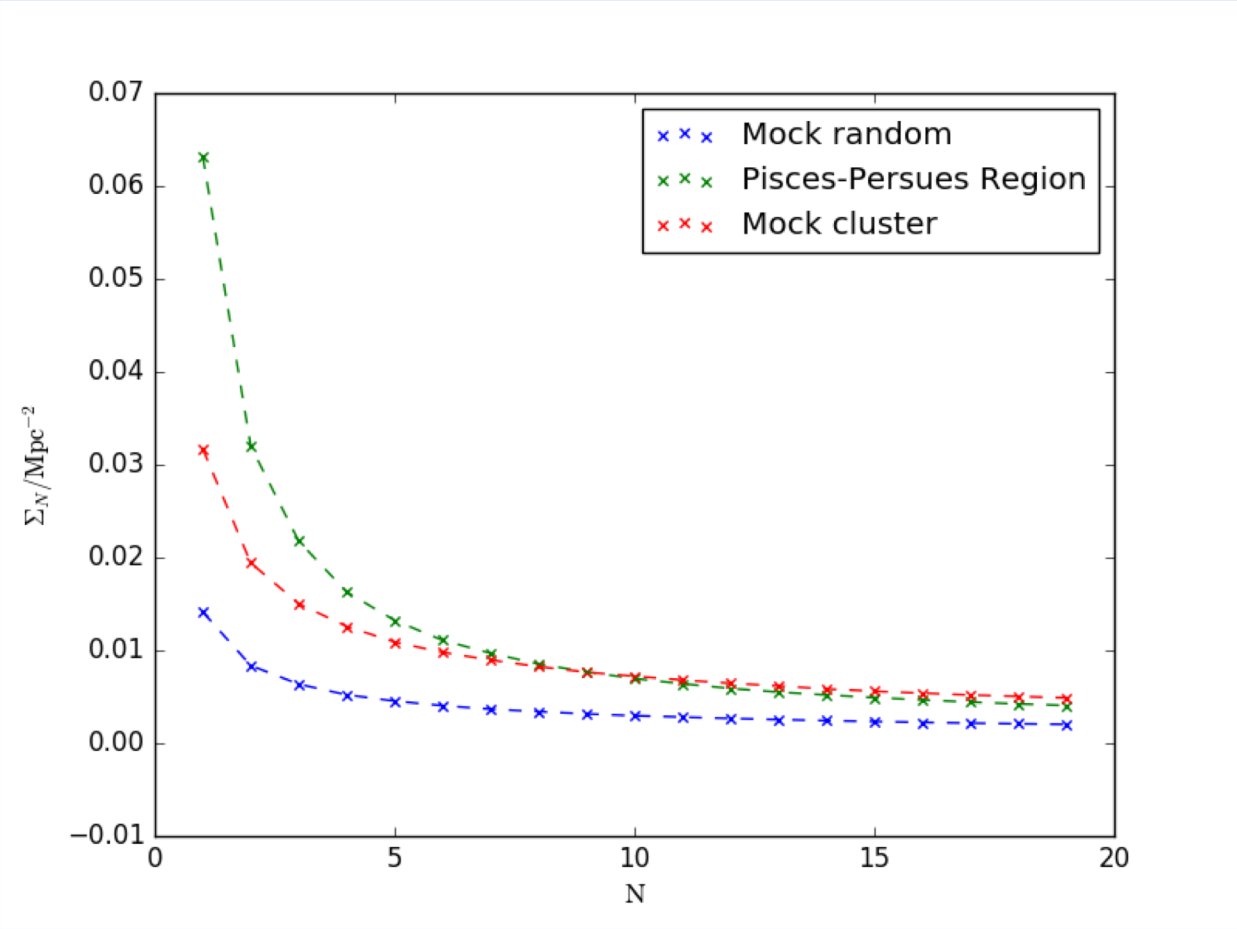
$$\Sigma_N = \frac{N}{(4/3)\pi r_N^3}$$

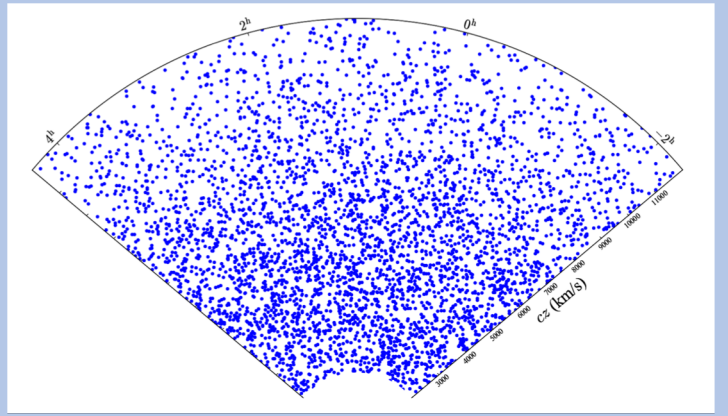


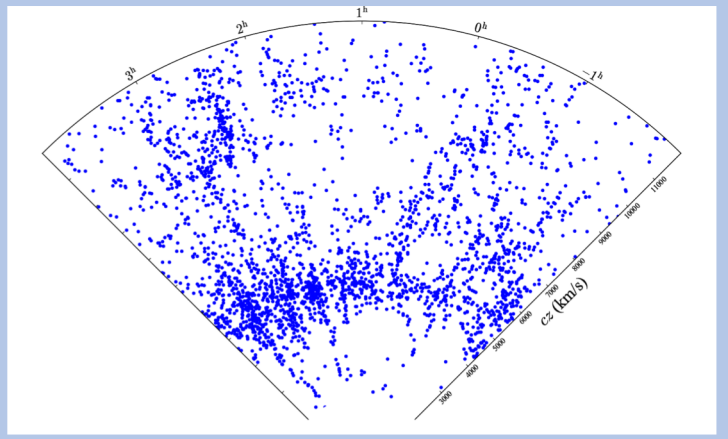
Similar to Jones et al., we create a histogram of σ_3 and can visualize the clustering environment of the Pisces-Perseus region (Top) by noting the skew towards progressively denser environments, while the mock distribution (Bottom) retains a normal shape.

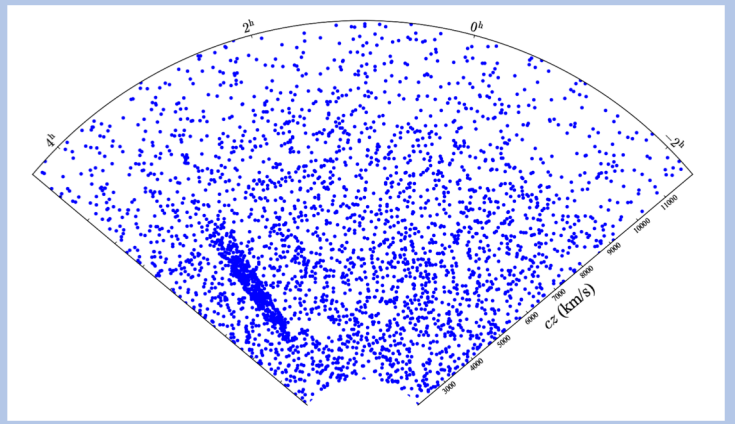


We impose a cluster of 500 galaxies (Bottom) at a group distance of 5500 km/s and compare that clustering distribution to the Pisces-Perseus Region (Top). Note of the bimodal distribution of the ”mock cluster” is apparent because no voids are caused as a result of the cluster.









As N increases, we see the progressive drop off in σ_N for a random mock distribution (Blue), the Pisces-Perseus Region (Green), and a mock distribution with a cluster centered at 5500 km/s (Red). The steep drop-off near lower values of N for Pisces-Perseus implies a dense core of clustering, while the mock catalog's cluster is not as dense.

Comments on Redshift distances

- On large distances, Hubble Flow is an effective means for determining distances. However, on the local scale we begin to see deviations from Hubble Flow.
- To first order, the 2MRS produces a helpful mapping of the local universe, but cannot tell the whole story.
- Redshift-independent distances and assigning galaxies to pre-determined clusters/groups can effectively reduce concerns in peculiar velocities misrepresenting distances.
- This mock catalog assumes pure Hubble Flow and treats each galaxy individually, rather than determining galaxies' inclusion in groups with a single distance.

Motivation and Going Forward

- Goal is to compare quantitatively the degree of observed clustering with that evident in mock catalogs generated under different input constraints.
- Future work part of Arecibo Pisces-Perseus Supercluster Survey (APPSS), trying to look at expectations for clustering, so we can test different models v. observed regions.
- Next step is to take into account more clustering and redshift space to improve our distance assignments by fitting local velocity fields for density inhomogeneities.

References

- Huchra et al. 2012, ApJ, 199, 26
- Crook et al. 2007, ApJ, 655, 790
- Giovanelli & Haynes 1982, AJ, 87, 1355
- Jones et al. 2015, MNRAS, 457, 4393