AUGMENTING MACHINE LEARNING PHOTOMETRIC REDSHIFTS WITH GAUSSIAN MIXTURE MODELS

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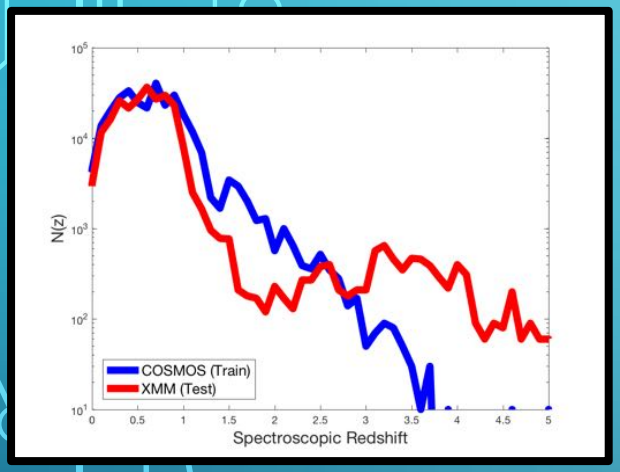
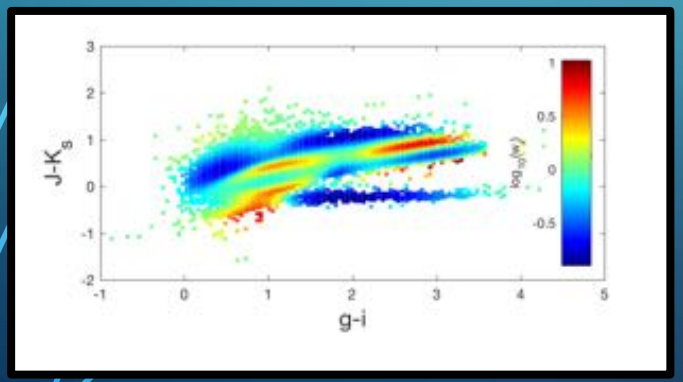


Training (COSMOS) and test (XMM-LSS) data constructed to have different redshift (left) and colour (below) distributions

We used Gaussian Mixture Models to model the differences in colour-magnitude space

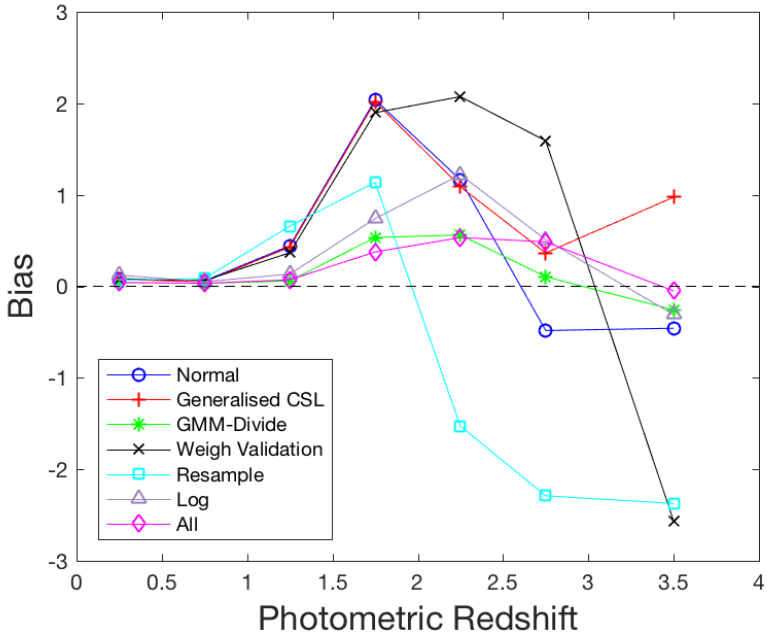


- Measuring the redshifts of large numbers (10^5-10^9) of galaxies is essential for many problems in galaxy physics and cosmology. Spectroscopic redshifts can unfortunately only be obtained for a small number of these galaxies; photometry must be used
- Photometric redshifts (photo-z) can be calculated in two main ways: a) fitting model galaxy spectra templates, or b) using machine learning (ML), trained on galaxies for which we do know the redshift
- GPz is a machine learning code for photo-z developed in Almosallam+2016, applied in Gomes+2018 , Duncan+2018
- We seek to develop ways to account for training and test data having different distributions in parameter space - traditionally challenging for ML methods
- In COSMOS and XMM-LSS uGRIZYJHK data we find bias on predictions can be moderately reduced with no additional data if the differences in the colour distributions are taken into account, Hatfield+2020

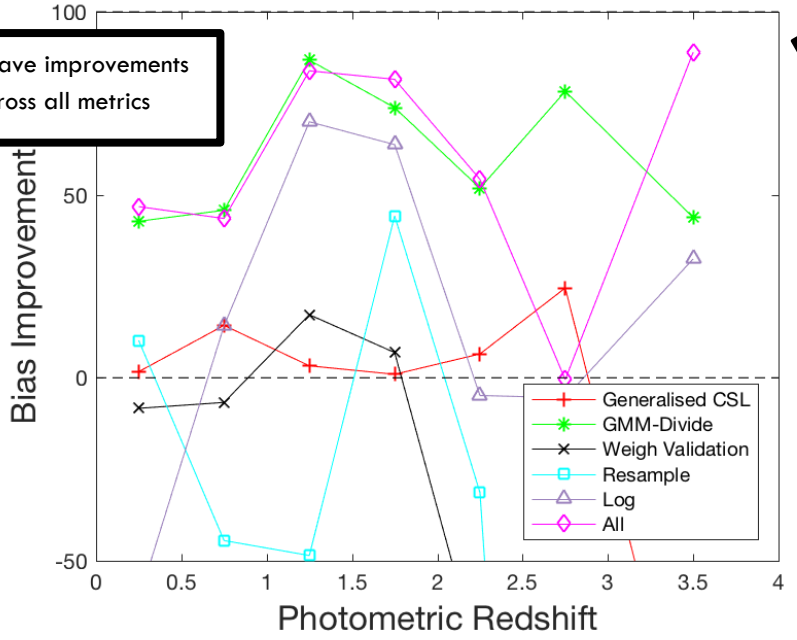
METHODS CONSIDERED & RESULTING IMPACT ON PHOTO-Z METRICS

Bias on predictions (mean prediction minus true redshift): zero means predictions are unbiased)

Improvement in bias (100%=complete removal of bias)



`All' gave improvements across all metrics



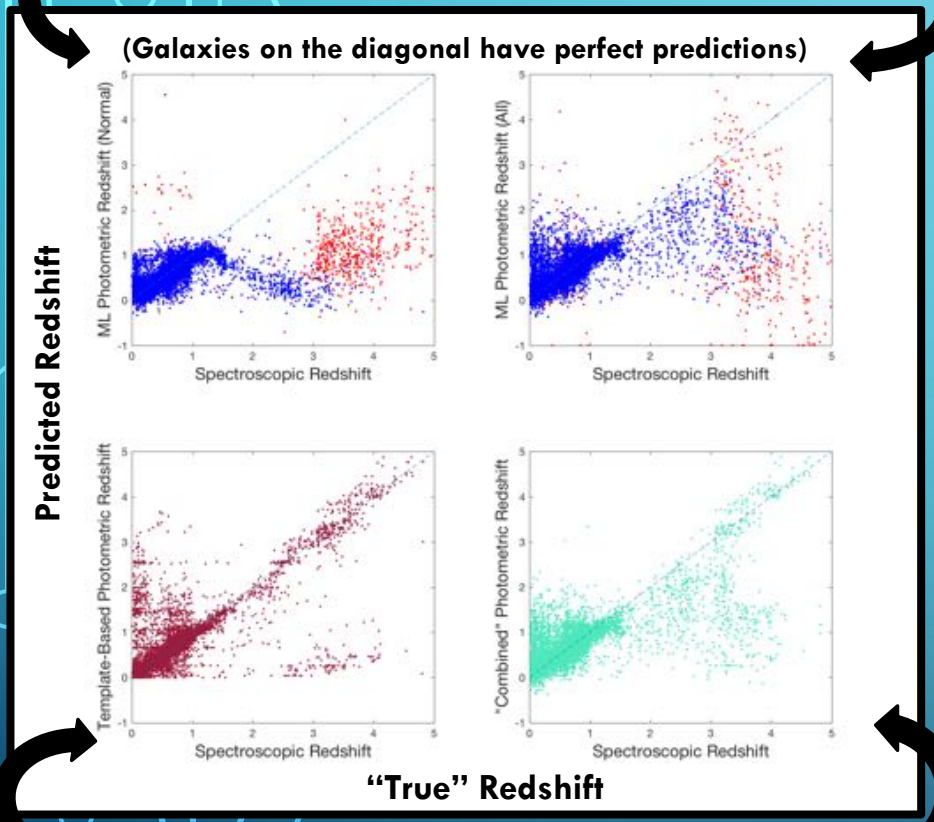
Methods Considered

- **Normal:** base use of GPz
- **GCSL:** Upweighting parts of colour space common in the test data but rare in the training data
- **GMM-Divide:** Using a GMM to divide parameter space into smaller segments in an unsupervised way, and then training on them separately
- **Weigh Validation:** Making the validation data look more like the test data
- **Resample:** Retrain the algorithm multiple times, each time resampling new photometry values based on the photometry uncertainty
- **Log:** Modelling log(z) rather than z
- **All:** Using Weigh Validation, Resample and GMM-Divide simultaneously

COMBINING ML AND TEMPLATE FITTING

Conventional Application of ML

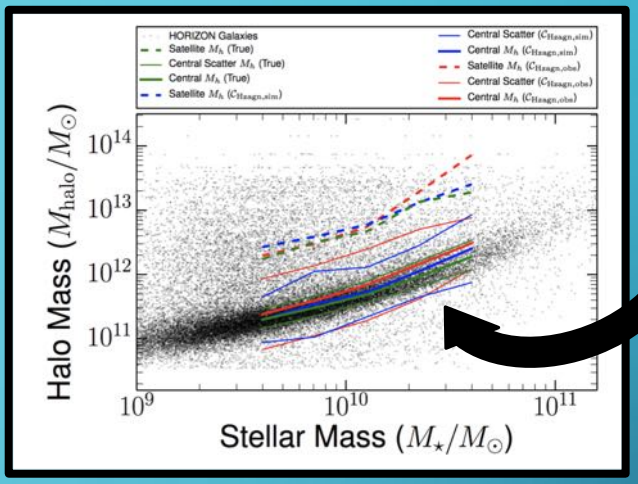
ML with the modifications described in this poster



Template based photo-z (from Adams+2020)

Hybrid combination of ML and Template methods – for overall better predictions

RELATED WORK



TRUE PHYSICS
ESTIMATE FROM CLUSTERING
ESTIMATE BASED ON PHOTO-Z

In Hatfield+2019 we looked at how measurements of the relationship between galaxies and their host dark matter halo are biased if photo-z are used rather than the true redshifts, for the hydrodynamical cosmological simulation Horizon-AGN

Have applied methods here to the Rubin DESC Tomography Challenge