Predicting Galactic Redshift from Apparent Magnitude

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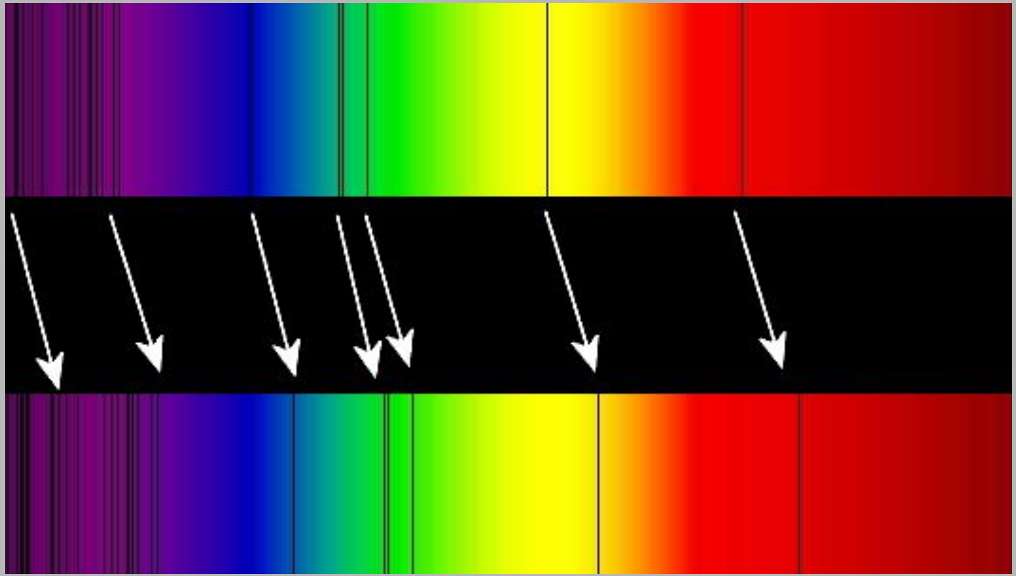
What is redshift?

- Measurement of how “red” the light from a distant object appears
- Higher redshift: object appears to be moving away at greater speed
- Caused by actual motion, gravitation and the expansion of space

What is apparent magnitude?

- Measures how bright an object appears in at a certain wavelength (“color”)
- Inverted logarithmic scale: higher apparent magnitude = fainter object
- Difference of 5 magnitudes corresponds to a brightness difference of 100 times



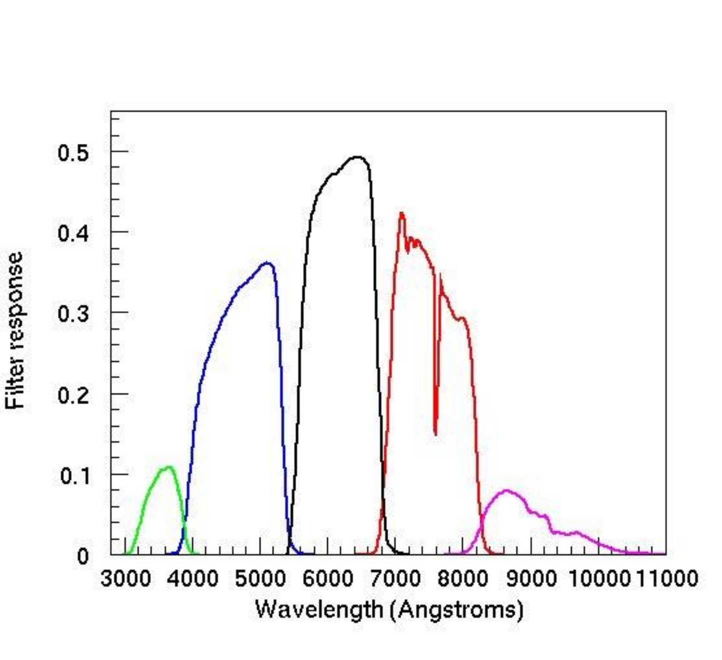
Left: original and redshifted spectrum (image from WikiBooks)

Why do we care?

- Redshift can be used to estimate distances to extremely far away objects (galaxies, star clusters, quasars)
- This gives us a better idea of how large the universe is
- This in turn allows us to theorize about its origins and evolution
- **Goal of this project: create a model that amateur astronomers can use to predict redshift values with their own magnitude measurements**

The data

- Gathered from the Sloan Digital Sky Survey (https://www.sdss.org/)
- Apparent magnitudes and redshifts for 100k galaxies
- 5 wavelength bands: U, G, R, I, Z
- U - ultraviolet; G - green; R - red; I, Z - infrared

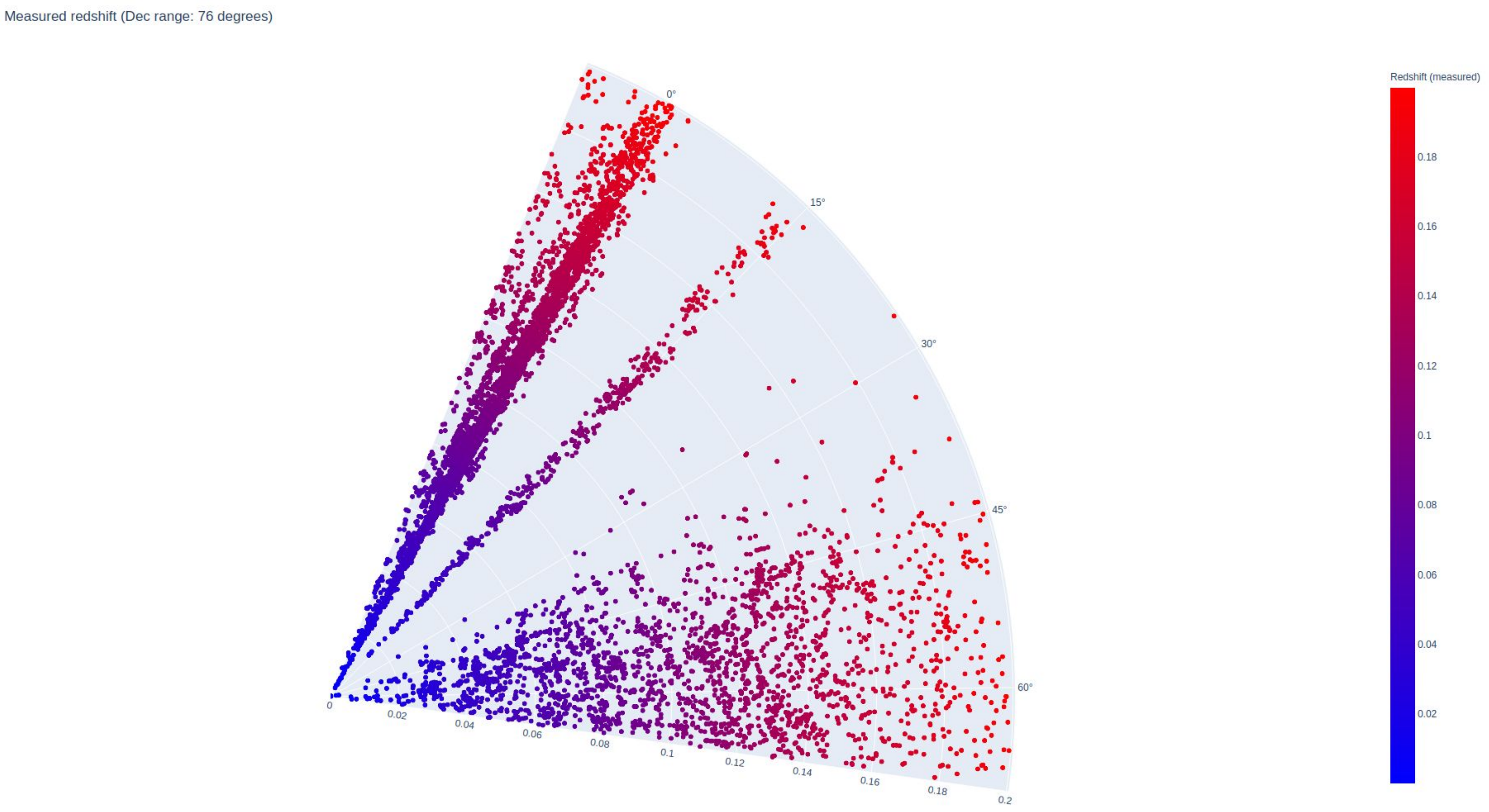


Right: filter response in 5 wavelength bands (image from SDSS)

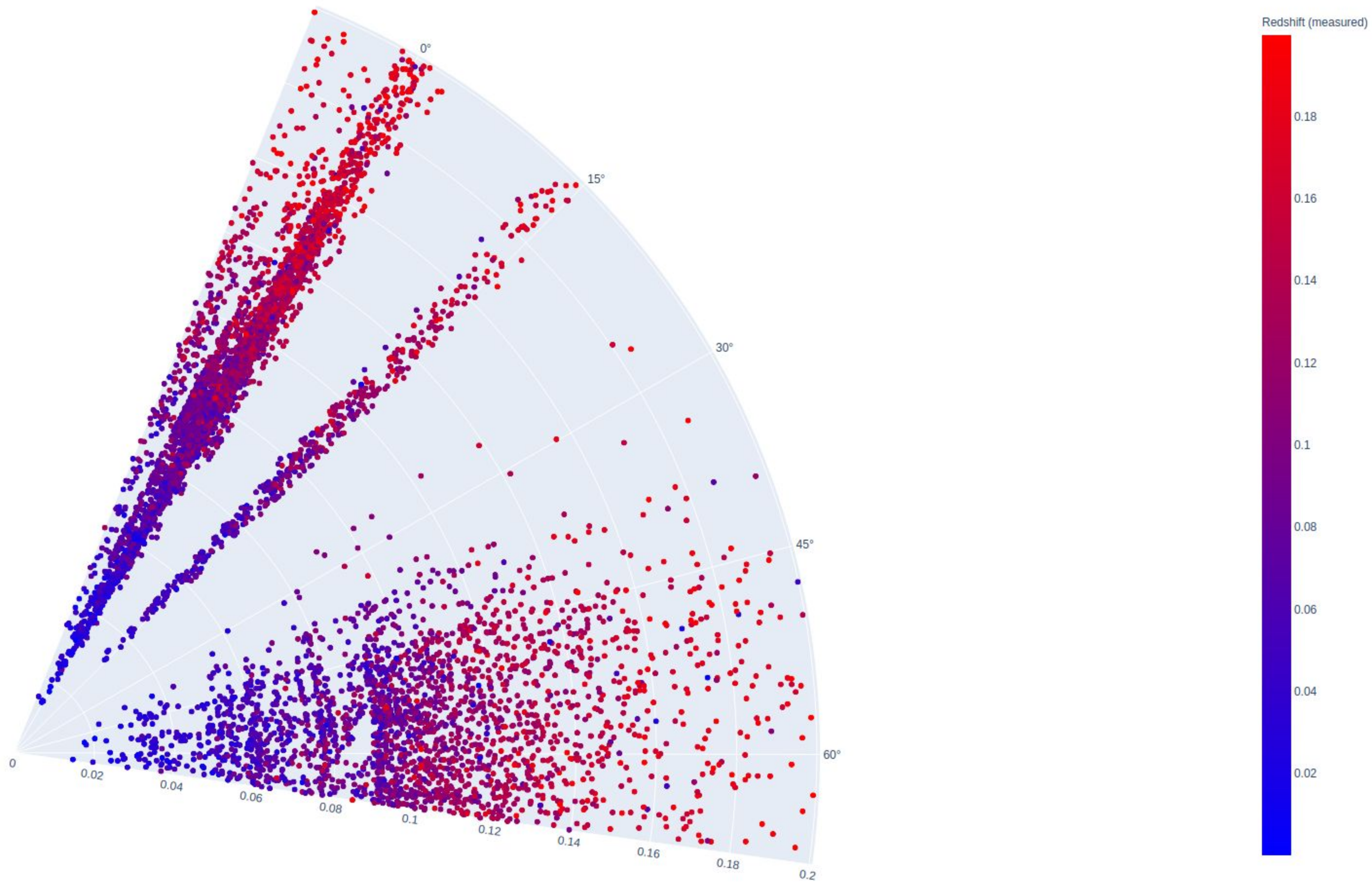
The models

- 5 regression models were tested: linear, quadratic, cubic, K-nearest neighbors, random forest
- Evaluated using R^2 and root-mean-square error
- Highest performance on test data: **random forest regression**

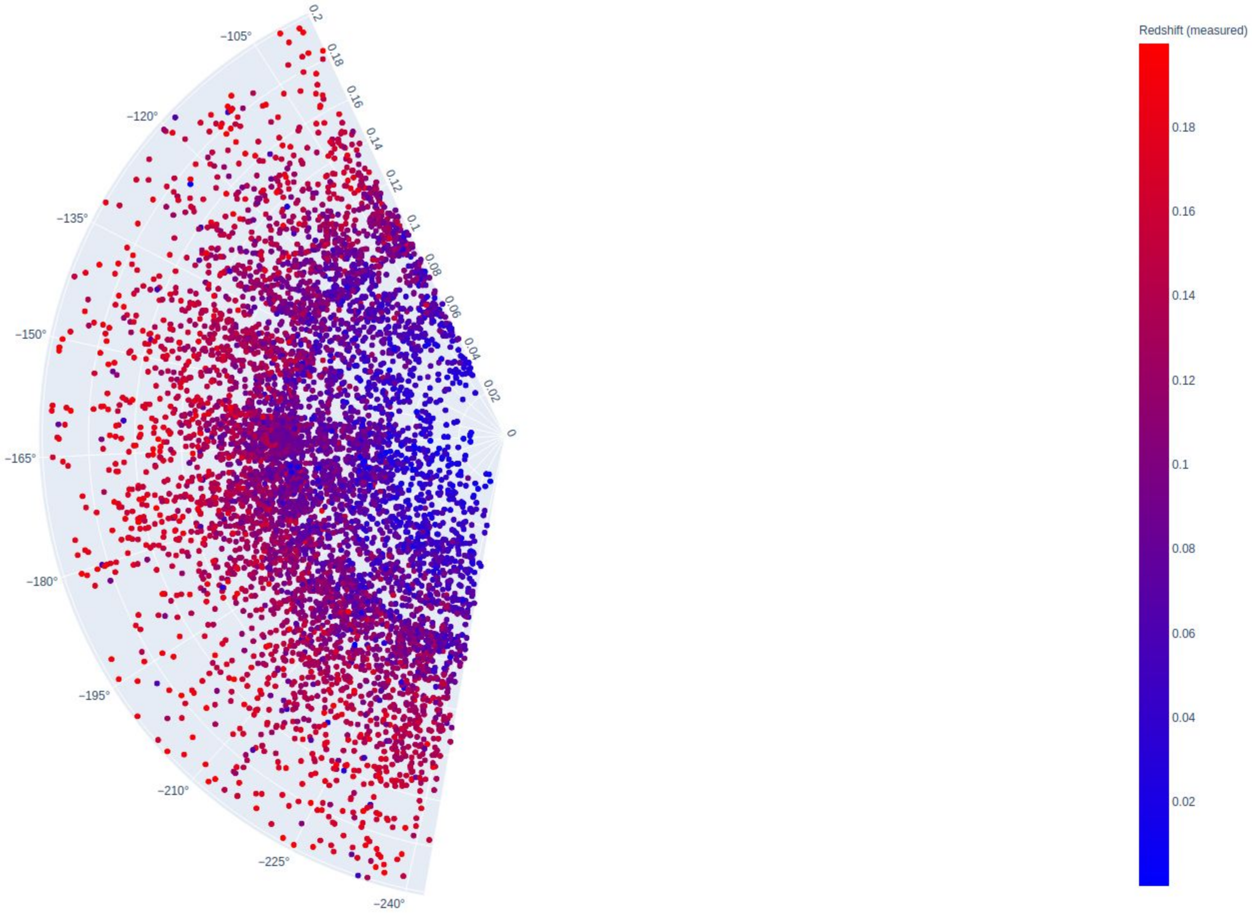
Model	R^2 (test data)	RMSE (test data)
Multiple Linear Regression	0.832	0.092
Degree 2 Polynomial Regression	0.854	0.086
Degree 3 Polynomial Regression	0.838	0.085
K-Nearest Neighbors	0.859	0.080
Random Forest	0.879	0.080


Measured redshift (Dec range: 76 degrees)
0°
15°
30°
45°
60°
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
Redshift (measured)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02

Predicted redshift (Dec range: 76 degrees)

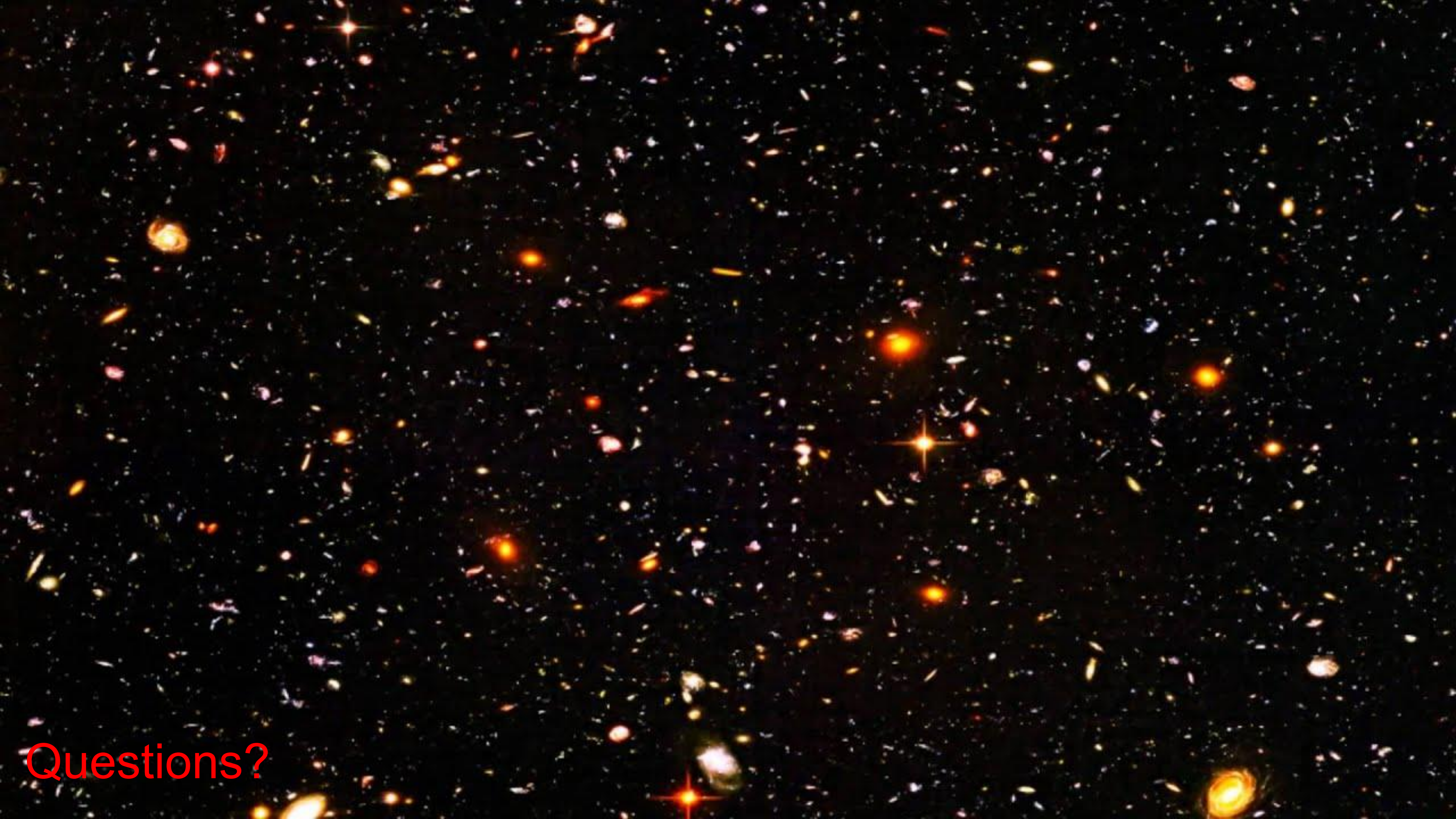


Predicted redshift (RA range: 145 degrees)



Conclusions, recommendations, next steps

- The results of the random forest regressor were not perfect, but adequate
- A **more specialized model** could yield better predictions in a narrower range of magnitudes or redshifts
- Next steps: **create a model optimized for lower magnitudes** since these bright galaxies are accessible to amateur scientists, **test redshift predictors on nearby stars** for the purpose of measuring velocities, **provide easy online access to models and source code**


Questions?