HARNESSING ML FOR ATMOSPHERIC RETRIEVAL OF EXOPLANETS

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TARGETS ACHIEVED :

- Reading of Radiative Transfer equation. (POSEIDON Radiative transfer.)
- Training and testing the already existing Models (HELA (uses Random forest) , POSEIDON(Non ML-nested sampling method)).

LITERATURE REVIEW:

- Radiative Transfer Equation :

$$t_{\lambda,i} = \mathrm{EXP}\left(-\sum_{i=1}^{N_{\mathrm{lay}}} \alpha_{\lambda,j}\mathcal{P}_{i,j}\Delta h_j\right) = \mathrm{EXP}\left(-\sum_{i=1}^{N_{\mathrm{lay}}} \Delta\tau_{\lambda,j}\mathcal{P}_{i,j}\right),$$

$$\left(\frac{R_{\mathrm{p},\lambda}}{R_{\mathrm{s}}}\right)^2 = \frac{1}{R_{\mathrm{s}}^2}\left(R_{\mathrm{p}}^2 + 2\sum_{i=1}^{N_r}[1 - t_{\lambda,i}]b_i\Delta b_i\right),$$

Robinson, T. D. (2017, February 20). A Theory of Exoplanet Transits with Light Scattering. The Astrophysical Journal, 836(2), 236.

- HELA : Random forest

Márquez-Neila, P., Fisher, C., Sznitman, R., & Heng, K. (2018, June 25). Supervised machine learning for analysing spectra of exoplanetary atmospheres *Nature Astronomy*, *2*(9), 719–724.

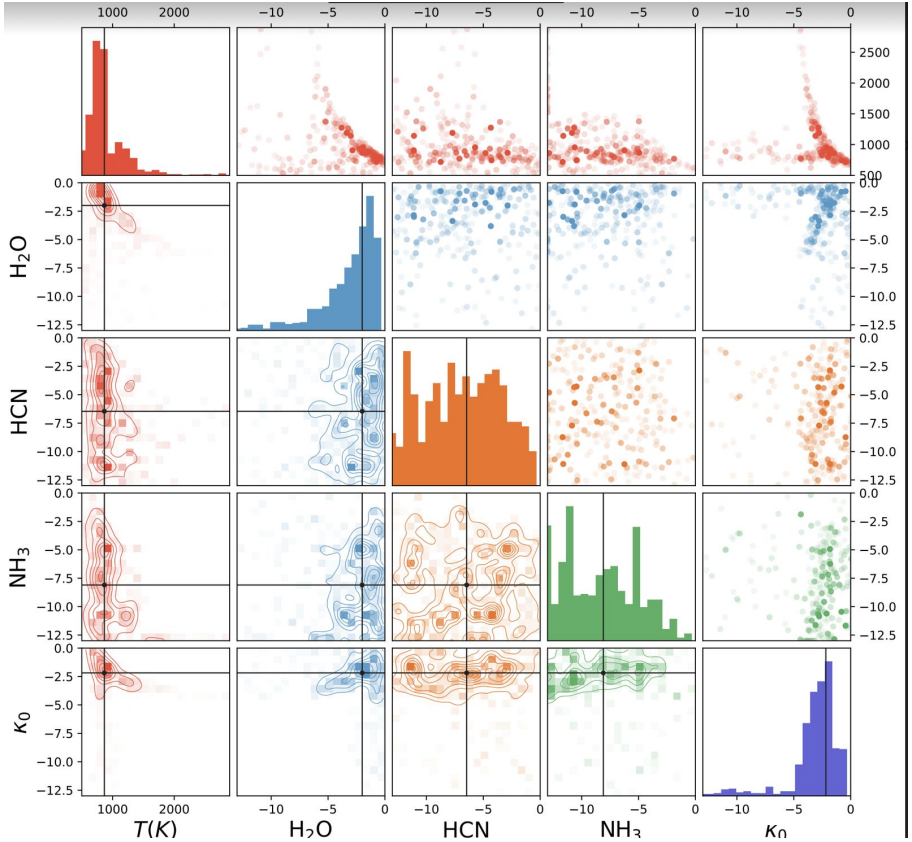
- POSEIDON

MacDonald, R. J. (2023, January 13). POSEIDON: A Multidimensional Atmospheric Retrieval Codefor Exoplanet Spectra. *Journal of Open Source Software*, *8*(81), 4873.

- Nested Samplig

Hayes, J. J. C., Kerins, E., Awiphan, S., McDonald, I., Morgan, J. S., Chuanraksasat, P., Komonjinda, S., Sanguansak, N., & Kittara, P. (2020, April 14). Optimizing exoplanet atmosphere retrieval using unsupervised machine-learning classification. *Monthly Notices of the Royal Astronomical Society*, *494*(3), 4492–4508. https://doi.org/10.1093/mnras/staa978

RESULTS of RETRIEVAL From HELA



Corner plot : HELA after training and testing

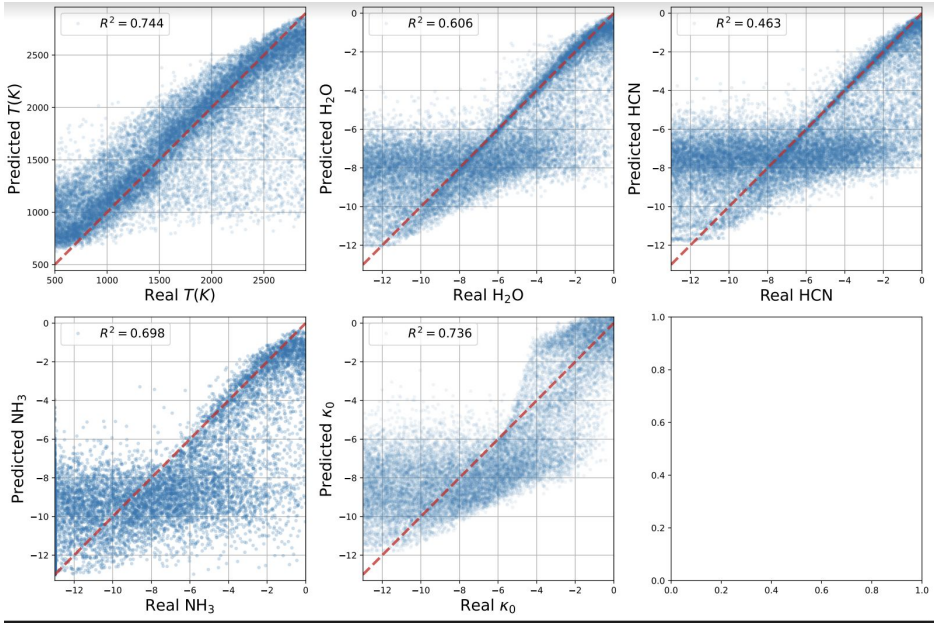


Fig : Tested R^(2) Score

COMPARISON BETWEEN DIFFERENT METHODS

Using already processed data (HELA Dataset)

Machine Learning Technique	**R^{2} Score**
1. Random Forest	0.6394
2.XGBRegressor	0.5925
3. SVR	0.5668
4. Neural Networks	0.1456

FURTHER PLANS

- Data Set would be taken from HELA DATA SET (80,000 2. WFC3

  transmission spectra for training and 20,000 dataset for testing.) + Data Synthesized in NISER + Data Self - Generated from NASA Psg.

- Creating a Comparative Model of various ML techniques which gives user option to compare the accuracy of respective Atmospheric Retrievals.