MACHINE LEARNING FOR ASTROPHYSICS
2ND EDITION
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INAF
ISTITUTO NAZIONALE DI ASTROFISICA
OSSERVATORIO ASTROFISICO DI ARCETRI

OssicoNN: Inferring stellar parameters and their uncertainties from high-resolution spectroscopy using conditional Invertible Neural Networks

OssicoNN
a MALSPEC Project from INAF Arcetri

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Motivation

News instruments => 10 x more spectra

Problem : classical algorithm = slow and weak with SNR

Solution : Machine Learning Algorithm

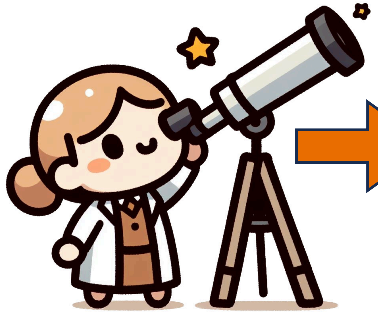
Training:

=> Spectra: GAIA-ESO Survey (GES), ***Randich et al. 2022***
spectral range 5330-5610Å & 8480-8980Å

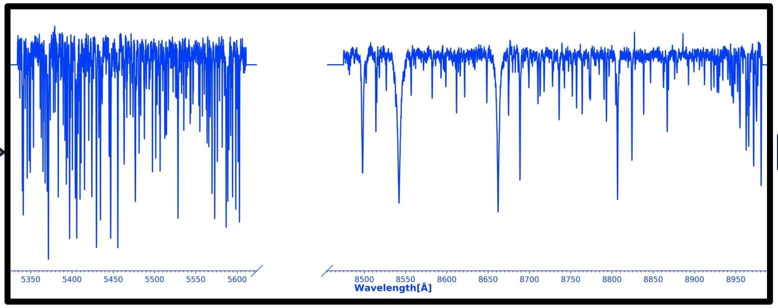
=> Parameters (targets): ***Hourihane et al. (2022)***

Training size = 6,969 stars
Full dataset = 52,841 stars

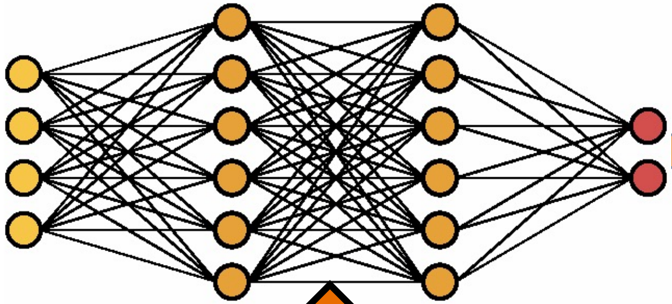
Observation



Reduction



Analysis

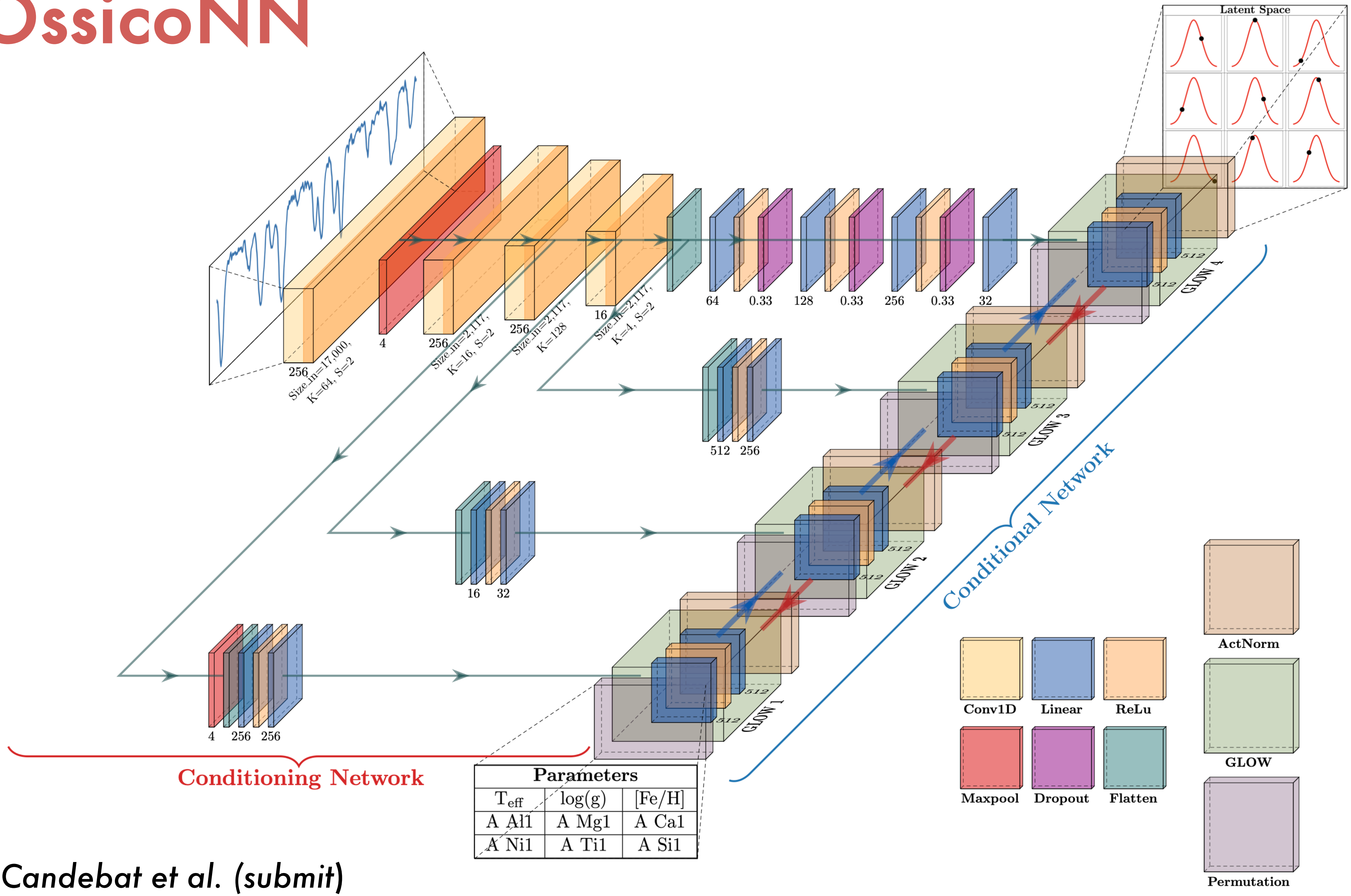


OssicoNN

Parameters:

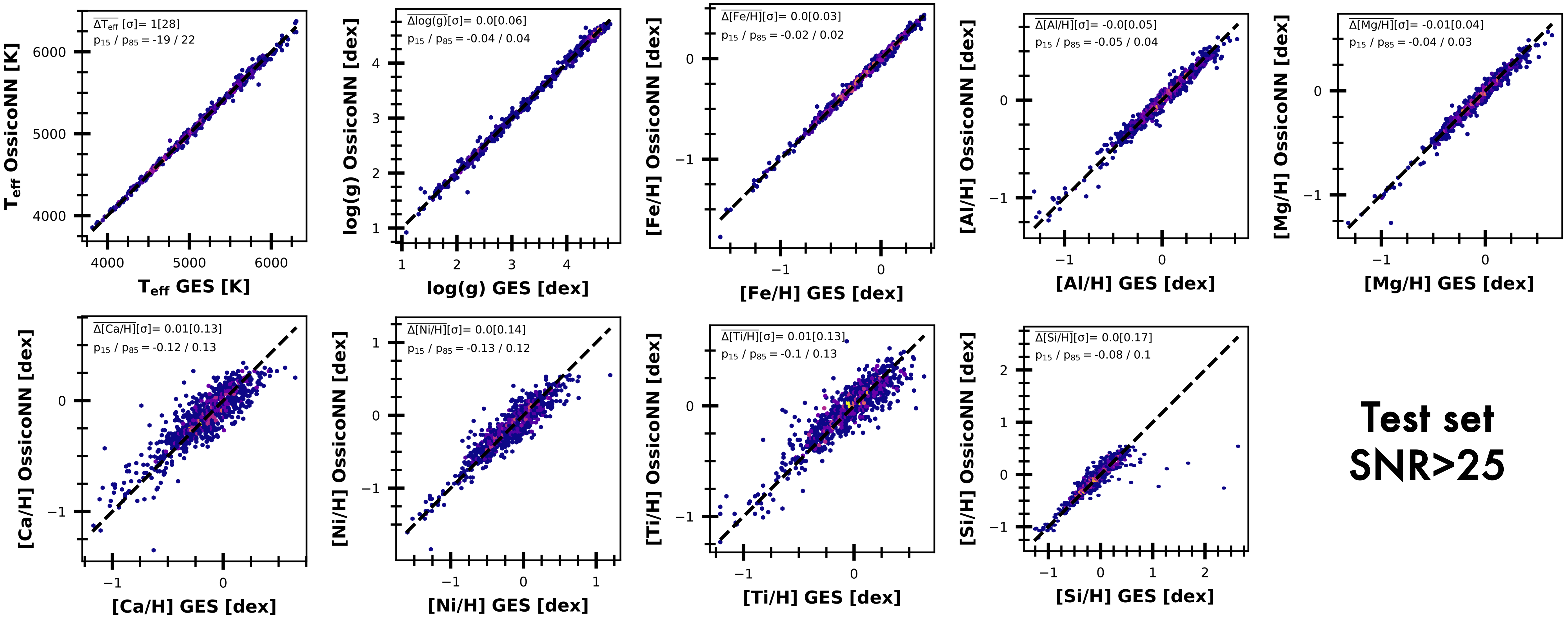
- Temperature
- Surface Gravity
- Metalicity [Fe/H]
- Abundances

OssicoNN



Candebat et al. (submit)

Results



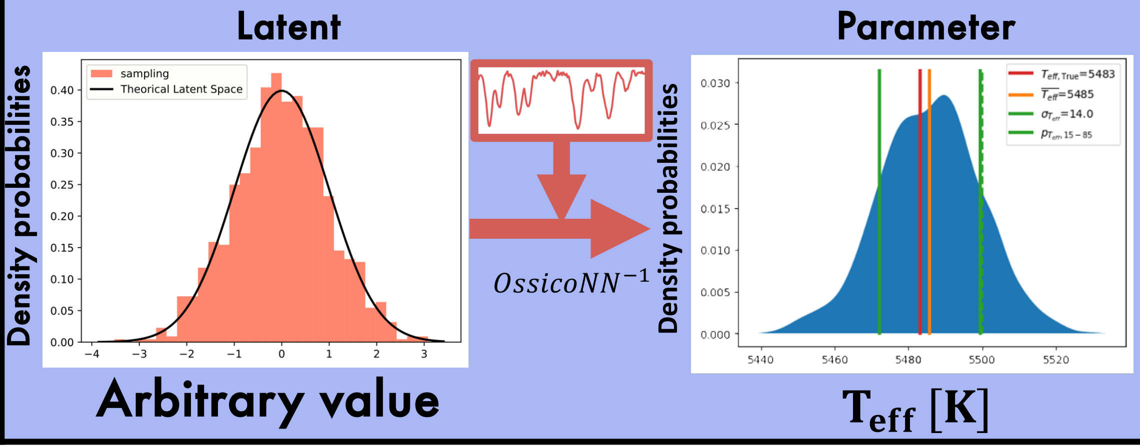
Test set
SNR>25

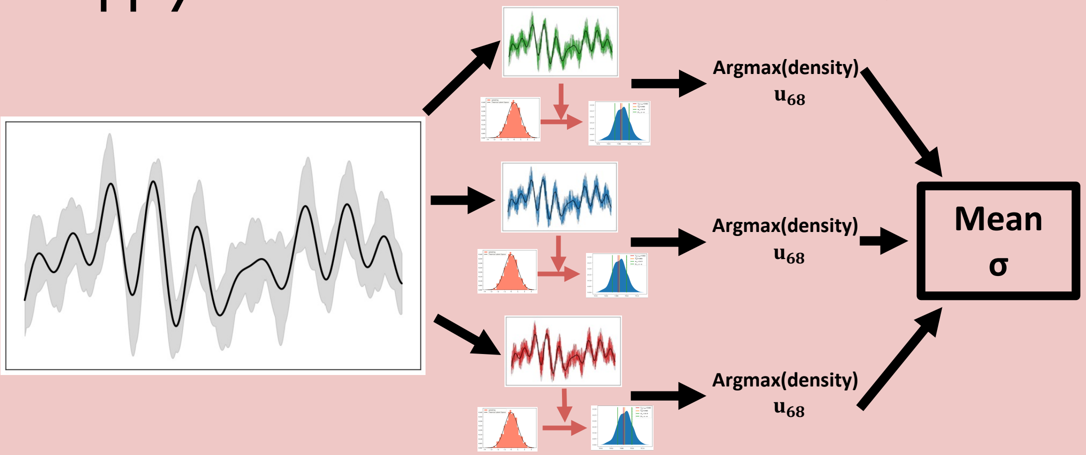
Candebat et al. (submit)

Uncertainty

Two types

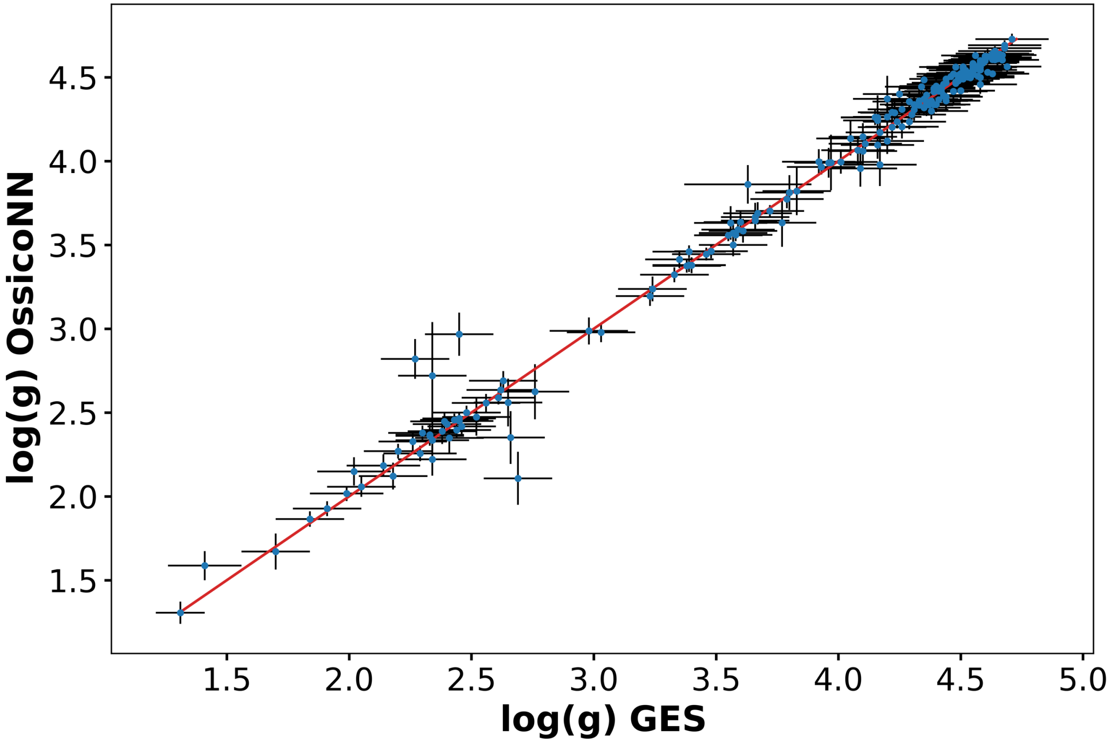
ε	Epistemic	Aleatoric
Origin	From the Neural Network itself	From the Data
Problem	lack of knowledge / loss ≠ 0	Randomness/ Noise in data
Computation	1- Sample all the latent space (reservoir of diversity) 2- Choose one spectrum 3- look all the possible values for parameters	1- Add noise between [−std , +std] 2- Compute epistemic uncertainty and value 3- Apply the mean and the standart deviation

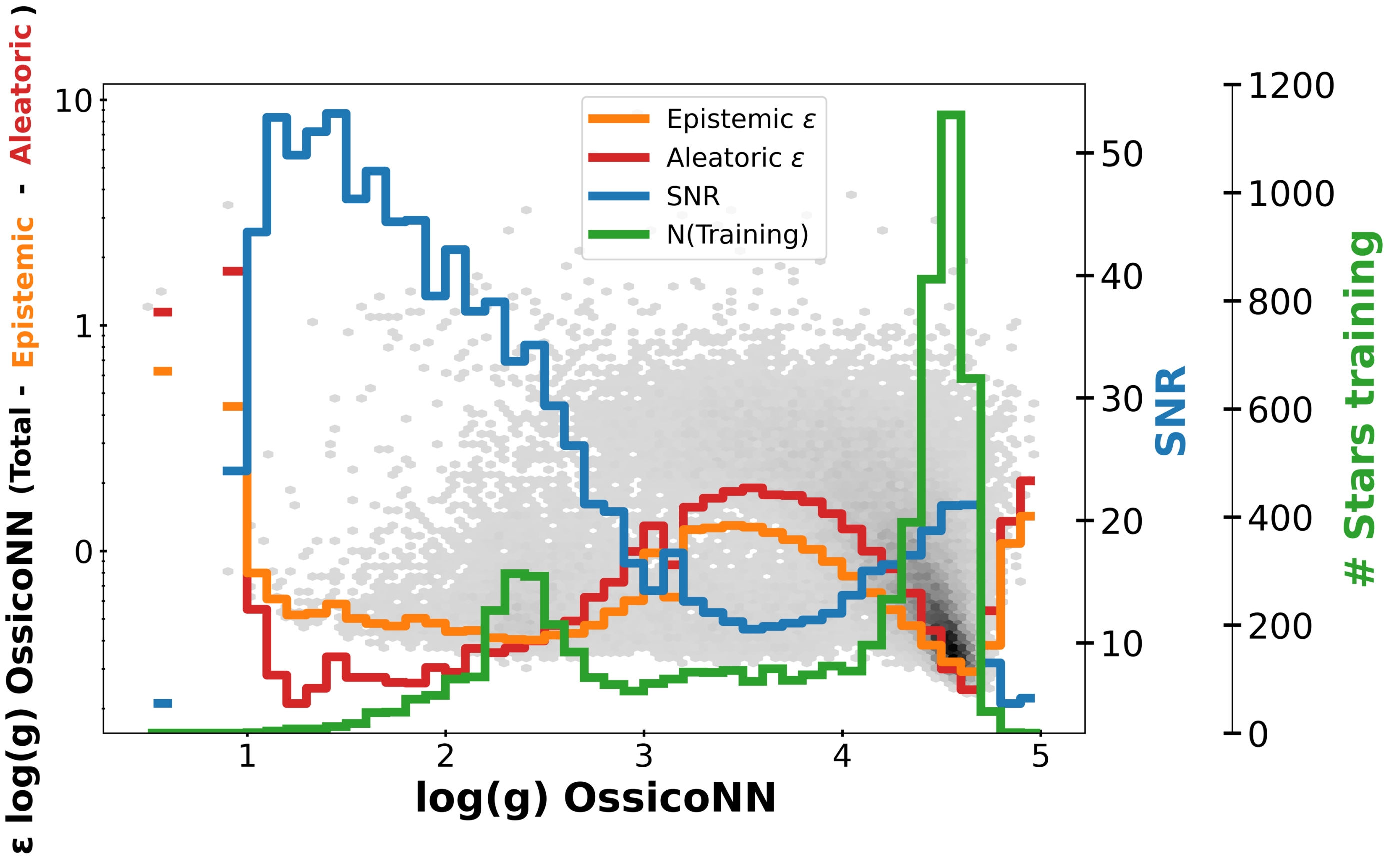




$$\Rightarrow \epsilon_{total} = \sqrt{\epsilon^2_{epistemic} + \epsilon^2_{aleatoric}}$$

Uncertainty
Measurement





Candebat et al. (submit)

Conclusion

- cINNs are interesting tools for computing Bayesian posteriors.
- OssicoNN accurately estimates the parameters of stars from spectra, with a small but consistent error.
- These estimates are in line with astrophysical validation.
- The uncertainties are consistent with the knowledge.
- This doesn't solve the other problems of supervised machine learning: dependence on the dataset, the need to have a complete dataset, the impossibility of predicting the unknown...

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