Notes on work up to week 7:

Models have been created on GPFlow and Tensorflow Probability (TFP).

GPFlow:

GPflow.GPR was the first library used to create a model with 1 dimensional input (rotation) ang age as the output. The result met expectations with the model predicting the data and, using a linear mean function, reasonable estimates for regions without data. The model seemed to be more confident than it should have been as only 75% of the data points fell into the 95% confidence interval.

GPflow.GPR was then used to create a model with a 2 dimensional input (rotation and B-V index). Although the library run extremely fast (on colab using GPU: a few minutes per run as opposed to approx. 4hrs for pymc) the results were not satisfactory. Lack of understandable documentation made issues hard to resolve. Figure 1 shows the Data against the predictions. It should follow along the y=x (red) straight line but it has a different slope. Changing this manually was possible by removing any optimization parameters but introduced extreme uncertainties. Optimization parameters (using gradient decent and adaptive Hamiltonian Monte Carlo (HMC)) yielded lengthscales in the millions which is not reasonable given that the B-V index ranged between 0. and 0.4, ages from 0 to 14 and periods from 0 to 100. The problem is thought to be the Zero prior but the lack of documentation resulted in very slow progress in changing the mean function. This reasons resulted in considering tensorflow as the library of choice.

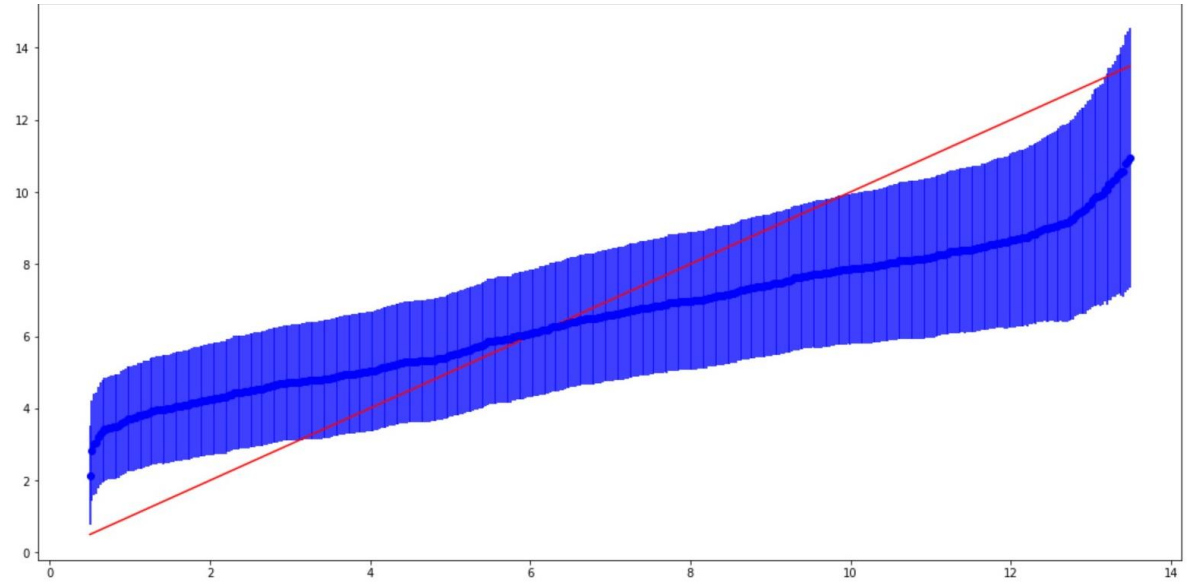

Figure 1:Data against Predictions using GPflow

Tensorflow Probability:

TFP was tested and the results so far look promising. This is largely due to the extensive documentation. The same inputs used in the GPFlow model, were used here and Figure 2 shows the results. The model used stochastic gradient decent to find the parameters. As expected the predictions (blue) follow the y=x line for the largest part of the graph. The region 0<x<2 is not on the line and the region 12<x<14 has extreme uncertainty. For the first region, the problem is identified to be the use of a zero mean function. For the second region, the large uncertainties are though to occur because of the lack of data in that region, a non-zero mean function might help.

TFP seems to be as fast as GPflow however, colab.research.google.com runs out of run when all the points are attempted to be run.

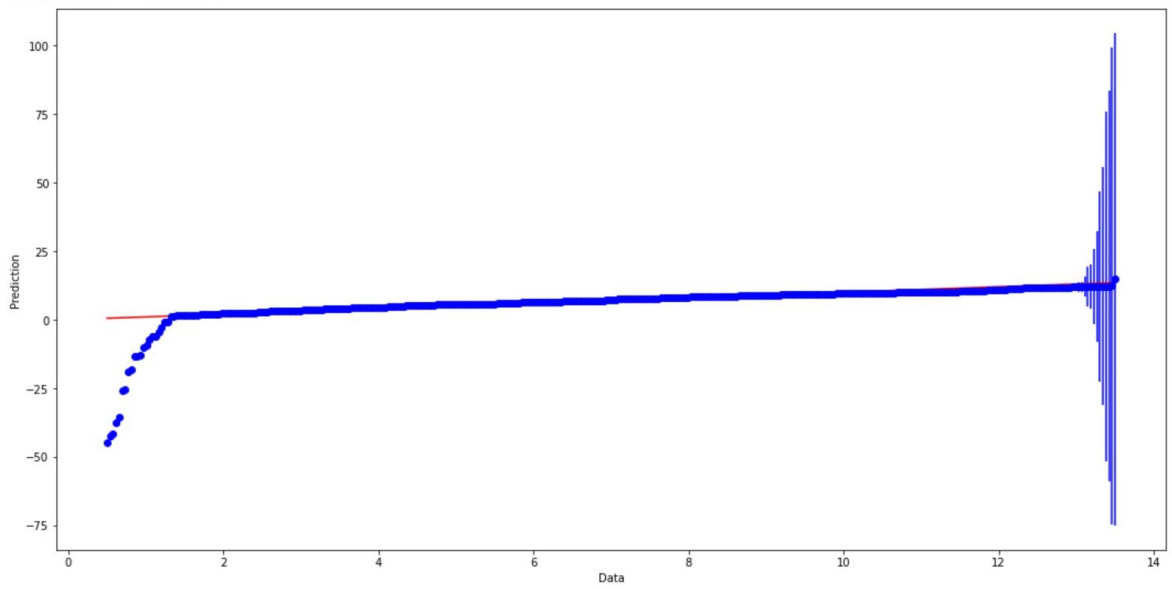

Figure 2: Data against prediction using TFP

Literature Review:

[1] James F. Kasting. When methane made climate.Scientific American, 291(1):78–85, July 2004.

[2] Jennifer L. van Saders, Tugdual Ceillier, Travis S. Metcalfe, Victor Silva Aguirre, Marc H. Pinsonneault,Rafael A. Garcı́a, Savita Mathur, and Guy R. Davies. Weakened magnetic braking as the origin of anoma-lously rapid rotation in old field stars.Nature, 529(7585):181–184, Jan 2016.

[3] Søren Meibom, Sydney A. Barnes, Imants Platais, Ronald L. Gilliland, David W. Latham, and Robert D.Mathieu. A spin-down clock for cool stars from observations of a 2.5-billion-year-old cluster.Nature,517(7536):589–591, Jan 2015.

[4] Sydney Barnes. A simple nonlinear model for the rotation of main-sequence cool stars. i. introduction,implications for gyrochronology, and color-period diagrams.The Astrophysical Journal, 722:222, 09 2010.

[5] Sydney A. Barnes and Yong-Cheol Kim. Angular Momentum Loss from Cool Stars: An Empirical Expres-sion and Connection to Stellar Activity. , 721(1):675–685, September 2010.

[6] Robert P. Kraft. Studies of Stellar Rotation. V. The Dependence of Rotation on Age among Solar-TypeStars. , 150:551, November 1967.

[7] Carl Edward Rasmussen.Gaussian Processes in Machine Learning, pages 63–71. Springer Berlin Heidel-berg, Berlin, Heidelberg, 2004.

[8] Carl Edward Rasmussen and C. K. I. Williams.Gaussian Processes for Machine Learning. MIT Press,Berlin, Heidelberg, 2006

[9] Andrew Gelman, John Carlin, Hal Stern, David Dunson, Aki Vehtari, and Donald Rubin, Bayesian Data Analysis, Chapter 2, Columbia University

Conclusions:

TFP seems to be more appropriate than GPFlow for the current use. The model shown in Figure 2 looks promising and could be improved to create an ideal model.

Plans for the coming weeks:

- Introduce a non-zero mean function to the second model
- Optimize the parameters using HMC for the second model
- More in depth review of [9] Bayesian Data Analysis