Inference of atomic line parameters from quiet-sun observations at 1.56 microns

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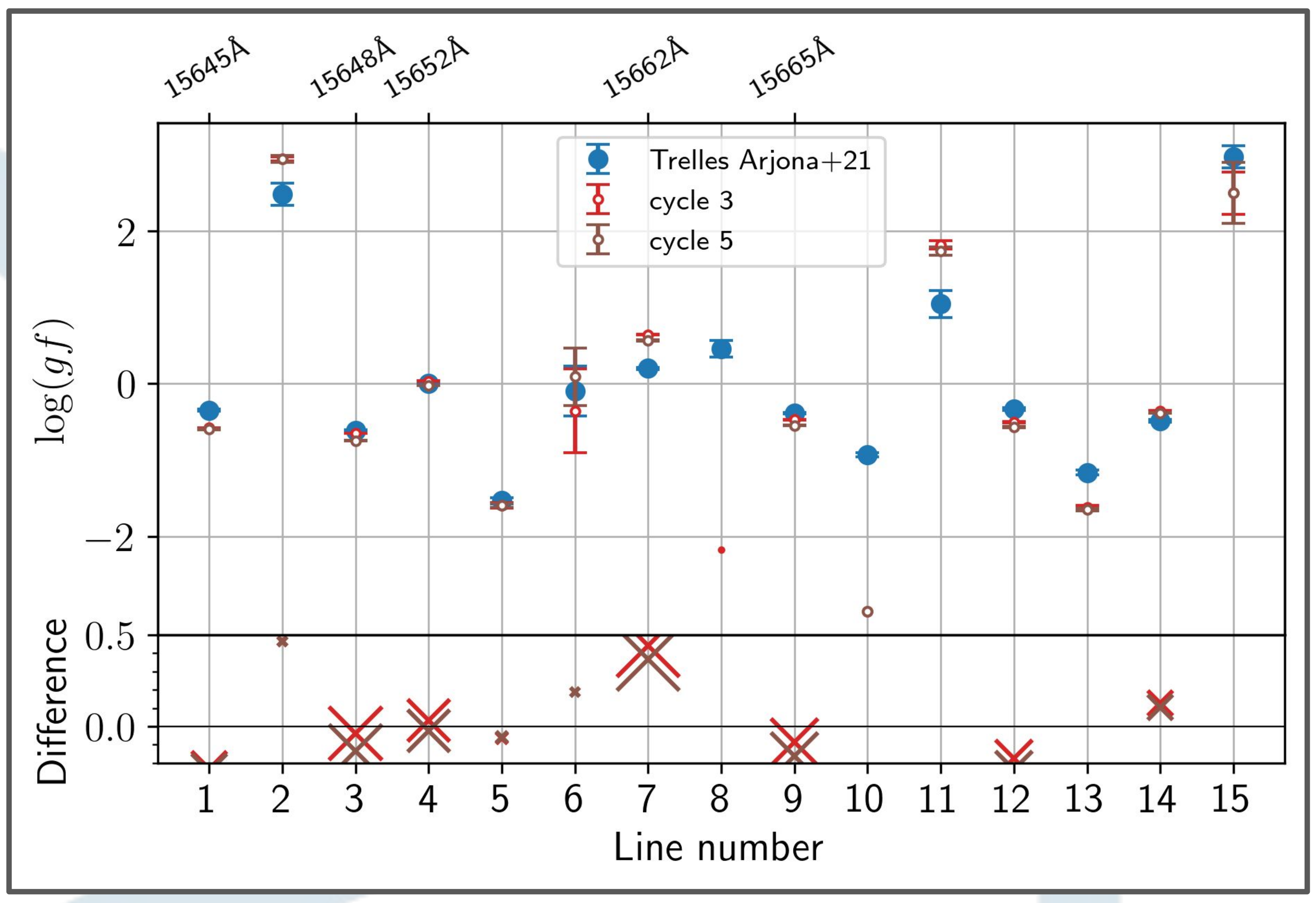
Introduction

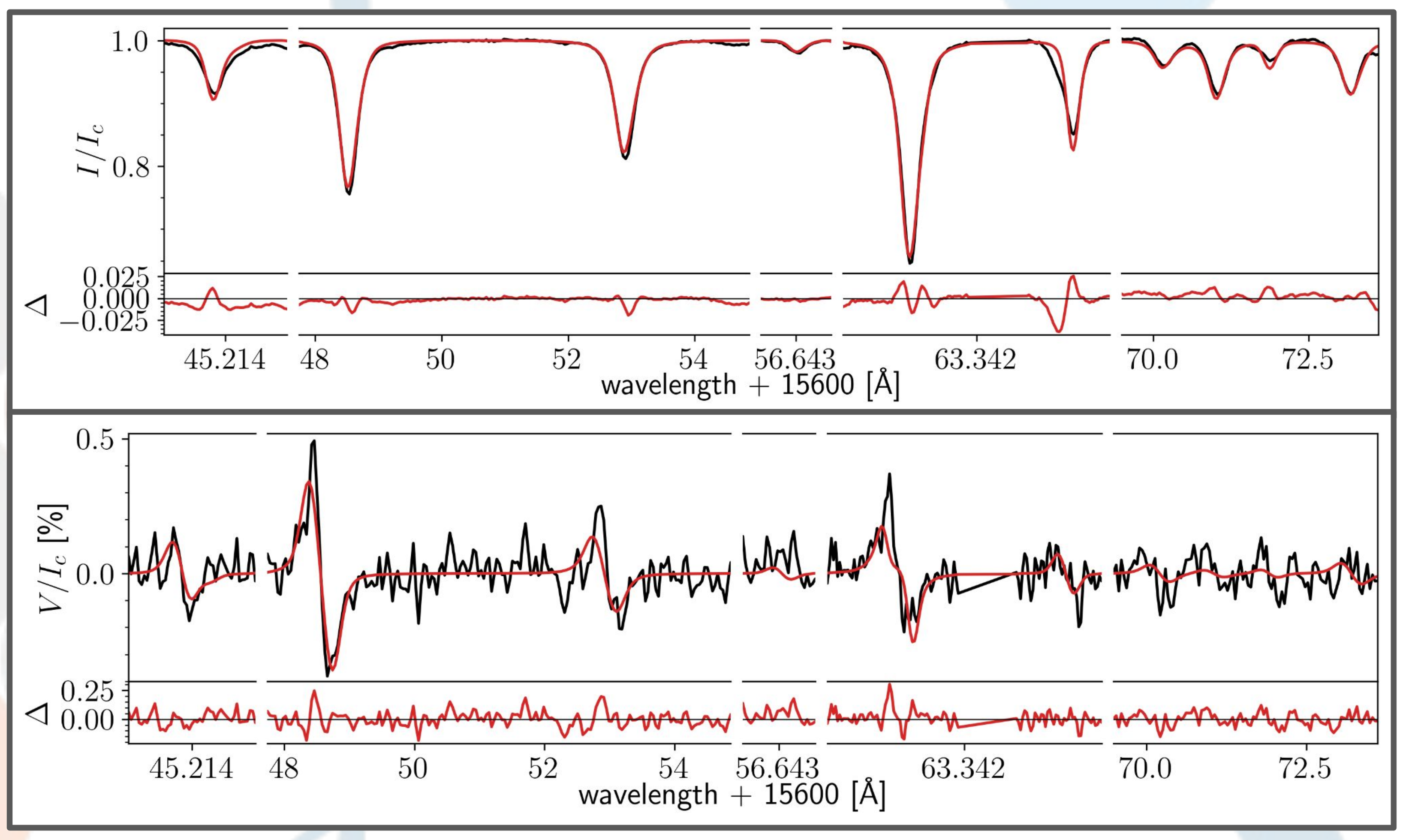
The accuracy of inferred physical parameters of the solar atmosphere through inversions of the radiative transfer equation depends on the quality of atomic line parameters used to model the spectral line profiles. The transition probability of a spectral line, regularly indicated as log(gf), characterises the strength of a line. For many spectral lines it is a very poorly constrained parameter with experimental measurements available only for a handful of spectral lines observed in the solar spectrum. In this work, our aim is to **infer the log(gf) parameter of iron lines at 1.56 micron through an inversion of observed solar spectra**.



Comparison of the log(gf) values retrieved from 3rd and 5th inversion cycles to those from Trelles Arjona et al. (2021).

Inversion method

We apply the coupled method implemented in *globin* inversion code (Vukadinović et al. 2024). The method relies on a simultaneous fit of all spectra from observed field of view inferring atmospheric and atomic parameters by imposing a spatial coupling in the latter. This coupling limits the cross-talk between atomic and atmospheric parameters and ensures reliable retrieval of both. The strongest cross-talk is between the temperature and the log(gf) parameter.



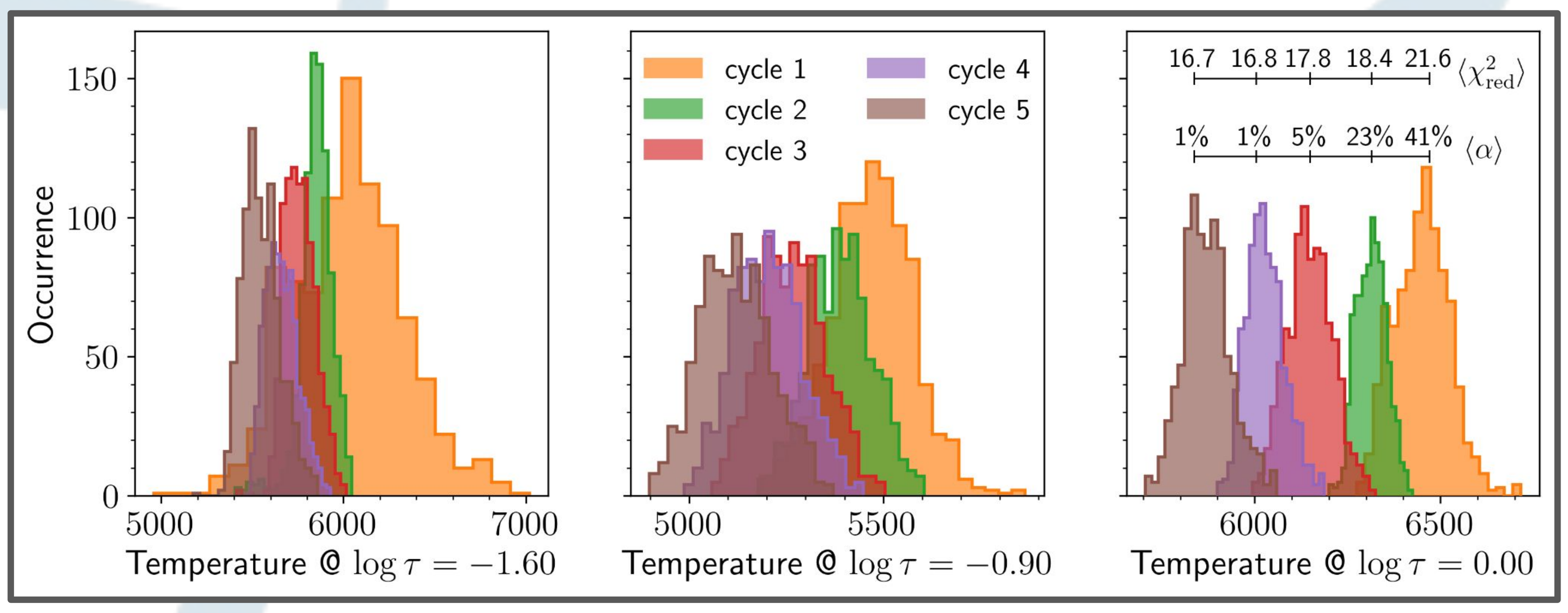
Example of the best fit to the Stokes I and V spectra in a single pixel from the 5th inversion cycle.

Observations

We use GRIS/GREGOR quiet-sun disc-center observations from the 29th of August 2018. The same data were used in Trelles Arjona et al. (2021) for inferring the log(gf) parameter of each spectral line in each individual pixel. We selected a small, 30x30 pixel, region with low polarisation signals.

Results

We run inversion in multiple cycles with intermediate smoothing of free parameters to remove the optimisation algorithm from the local minimum and improve the fit quality. We assume a two-component atmospheric model taking the Harvard atmospheric model (Gingerich et al. 1971) for the second component.



Temperature distribution in three nodes for each inversion cycle. The average filling factor, α, decreases over cycles lowering down the average temperature of atmospheres and improving the fit quality.

Conclusions

- retrieved log(gf) values are comparable to the results reported in Trelles Arjona et al. (2021)
- large deviations in log(gf) only for very weak lines; they have less significant impact on fit quality
- relative log(gf) values are more reliably determined than the absolute ones

References

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