APOGEE

TECHNICAL NOTE

An analysis of ASPCAP and QASPCAP results on the Pleiades

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Abstract

We perform a series of basic test using three visits for APOGEE plate 5534, pointing towards the Pleiades. This plate is atypical in that it gathers mainly spectra of dwarfs, but the data have a fairly good quality and the cluster's members provide a useful reference to compare against ASPCAP results. We use these plates to perform a sanity check of the newly built *apstar* libraries, to be used with the *apstar* files, and for which the (individual visit and combined) observations, as well as the models, have been sampled on a common frequency grid. We also perform a sanity check on QASPCAP, a compact and flexible script with modest functionality, but which allows a quick and effective testing of critical parts of the IDL wrapper for ASPCAP. Both tests are successfully passed.

We find a significant number of spectra that correspond to stars near the edges of the grid in effective temperature and gravity. We show that, if included, these results can easily distort any statistics derived from these tests. By restricting the analysis to Pleiades members we find that the metallicities inferred from the analysis of the combined visits included in apstar files are significantly better than those inferred from the analysis of individual files.

1 Introduction

After a number of versions of ASPCAP have been run on data and a tagged version is on the svn repository, we are now in position to make further checks. Szabolcs Mészáros reports somewhere else on the preliminary analysis of over a dozen of open and globular clusters: differences between mean ASPCAP metallicity for the clusters and literature values, trends of abundances with effective temperature and gravity, star-to-star scatter, etc. A set of tests aimed at characterizing the interpolation errors over the parameter space is also underway.

Here we report on a number of tests based on three visits (plate 5534, MJD 55847, 55851, and 55854) to a field of the Pleiades open cluster (100 Myr old, solar metallicity). The density of members, identified through their radial velocity, in the APOGEE plates is modest, about 150 of a total of about 265 fibers with stellar spectra, but sufficient. The spectra are in general of good quality, but it is important to bear in mind that these stars are dwarfs, not giants.

Our tests are mainly aimed at exploring the potential of apstar files, which have not been used so far in ASPCAP. We also test a small version of the ASPCAP IDL wrapper (Quick-ASPCAP or QASPCAP) – much more simple in terms of book-keeping abilities than ASPCAP, and developed mainly to allow an easy optimization of the free parameters involved in the pre-processing of the APOGEE data, such as those related to continuum normalization, selection of spectral windows, and identification of data points with large systematic errors that leak through the reduction pipeline.

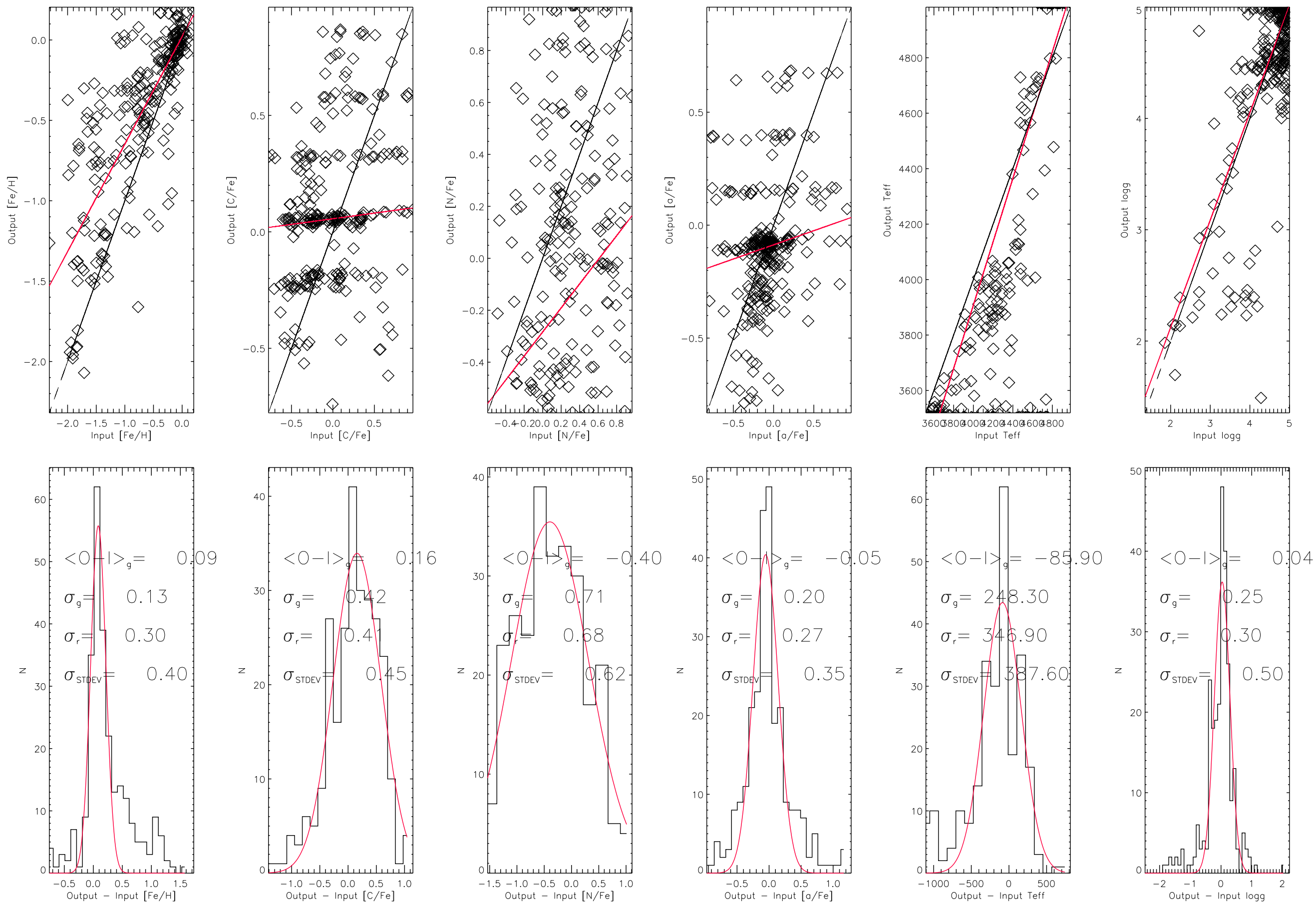

Figure 1: Comparison between ASPCAP (xaxis in the top panels), and QASPCAP (y-axis in the top panels) for plate 5534 observed on MJD 55847. The red lines in the upper panels show a least-squares fit to the data – which in some cases is meaningless. The bottom panels show the residuals (QASPCAP-ASPCAP), and the red curve is a Gaussian fit to them. Each panel on the lower row shows three estimates of the spread of the distribution of residuals: that from a Gaussian fit (σ_g), from a robust algorithm (the width of the distribution excluding the higher and lower 15% of the sample, σ_r), and a straight rms value ($\sigma_{\rm STDEV}$).

QASPCAP, with its simple design, works the same with apvisit and apstar files. In this note we perform a number of tests to validate this piece of software, and then use it to compare results from apstar and apvisit files.

2 ASPCAP vs. QASPCAP

We have by now a fairly good confidence on the basic parameters extracted by ASPCAP for high quality spectra. QASPCAP is identical, but replaces the IDL wrapper by a simpler code that allows to explore different aspects – in fact, qasp-

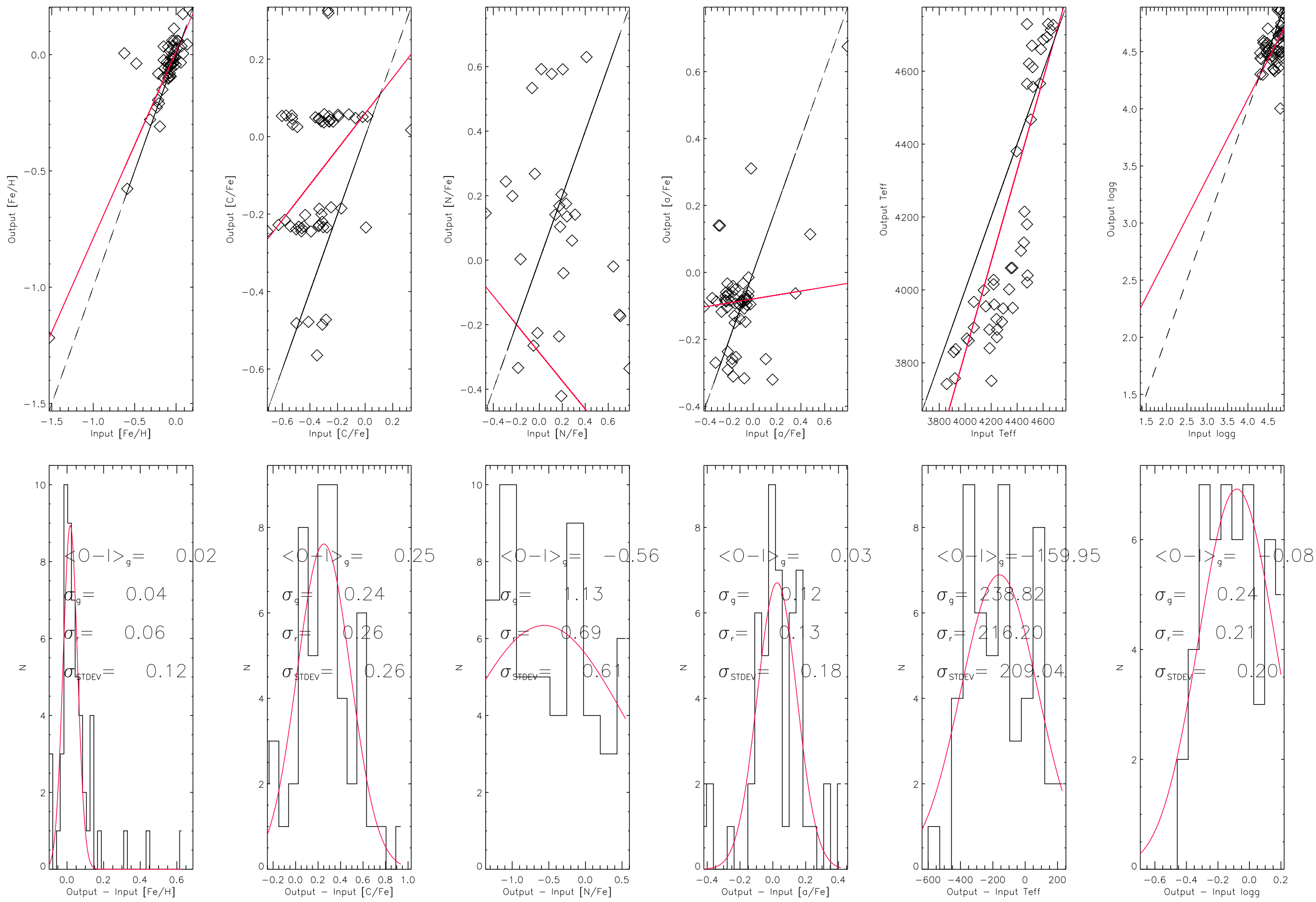

Figure 2: Similar to Fig. 1, but excluding data points close to the grid edges.

cap.pro is a single routine that does all the data preparation for FERRE. Obviously, before using it for various explorations, we need to validate QASPCAP against the standard ASPCAP, the version using the full-blown IDL wrapper.

The fist test performed consists of running the three visits on the Pleiades, that is, the apvisit spectra (one spectrum per visit), through both the standard ASPCAP and QASPCAP, and comparing the results. These tests are run with a 6-parameter PCA-compressed grid (psd0121). Fig. 1 shows the results for one of the visits (MJD=55847). The top panels plot the ASPCAP (v0.3) results in the abcissae, and the QASPCAP results in the ordinates for each of the 6 parameters involved in the psd0121 grids ($3500 < T_{\rm eff} < 5000$ K). Neither the stars that are not members of of the Pleiades, nor those that are too close to the grid edges to be trusted have been removed. While the first ones are useful in this case, the latter distort significantly the level of agreement, as it has been pointed out in the telecons by Mészáros.

A much more clear picture of the agreement level can be obtained if we exclude points that are dangerously close to the edges of the grid. Leaving out those points closer than 0.1 dex in abundances or $\log g$,and 20 K in $T_{\rm eff}$, which represent a non-

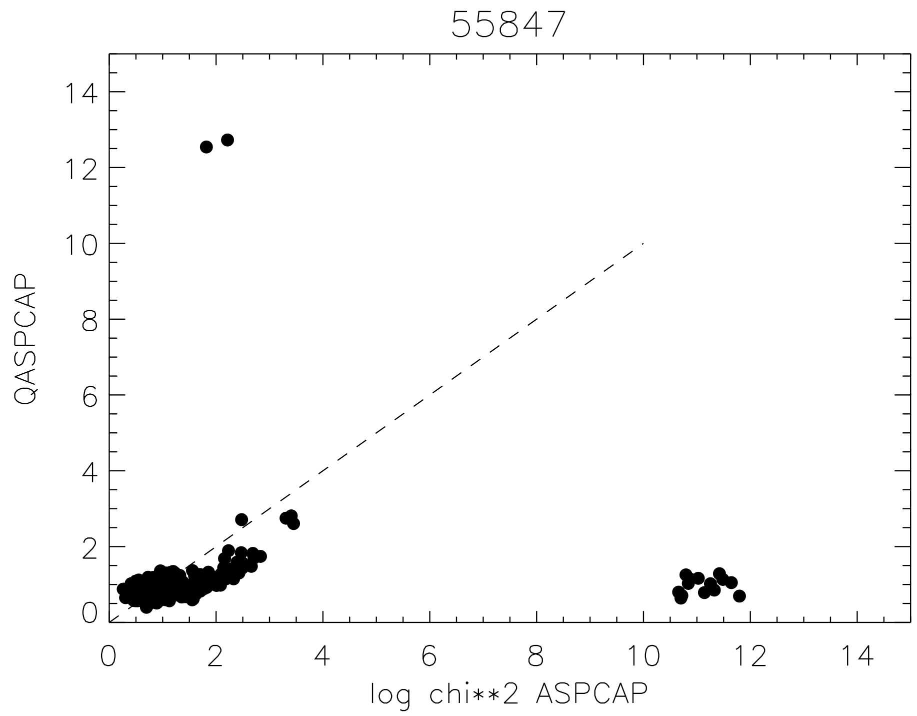

Figure 3: χ^2 for the results of ASPCAP (x-axis) and QASPCAP on 55034-55847. The dashed line corresponds to a straight line with a slope of one.

neglible fraction of the sample, the statistics (Fig. 2) indicate that the agreement is fair: 0.06 dex in [Fe/H], about 0.3 dex in [C/Fe], 0.1 in [α/Fe] , about 0.7 dex in [N/Fe], 220 K in $T_{\rm eff}$, and 0.2 dex in $\log g$ (using the robust estimate of the spread – see the caption of Fig. 1 for more details). A strong concentration of the data points in [C/Fe] ('noding') is obvious for QASPCAP but less so for ASPCAP. Fig. 3 shows that χ^2 is typically smaller for QASPCAP than for ASPCAP.

The results for plate 5534 mjd 55851 are quite similar with σs of 0.1 dex for iron, 0.2 dex for C/Fe, α/Fe and $\log g$, and 0.6 dex for N/Fe, and again the χ^2 values are lower for QASPCAP. Since the basic pre-processing in ASPCAP and QASPCAP is the same and the main difference is related to the masking of residual emission lines and problematic parts of the spectrum, these values illustrate the sensitivity of the results to such changes. The scatter in the N/Fe ratios is significantly larger than for previous analysis (see, e.g., Tech. notes dated May 2011 and February 2012) but this is without a doubt related to the fact that these stars, unlike the bulk of the APOGEE sample, are dwarfs, and CN lines, which carry the information about the N abundance, are much weaker in dwarfs than in giants of the same temperature and metallicity.

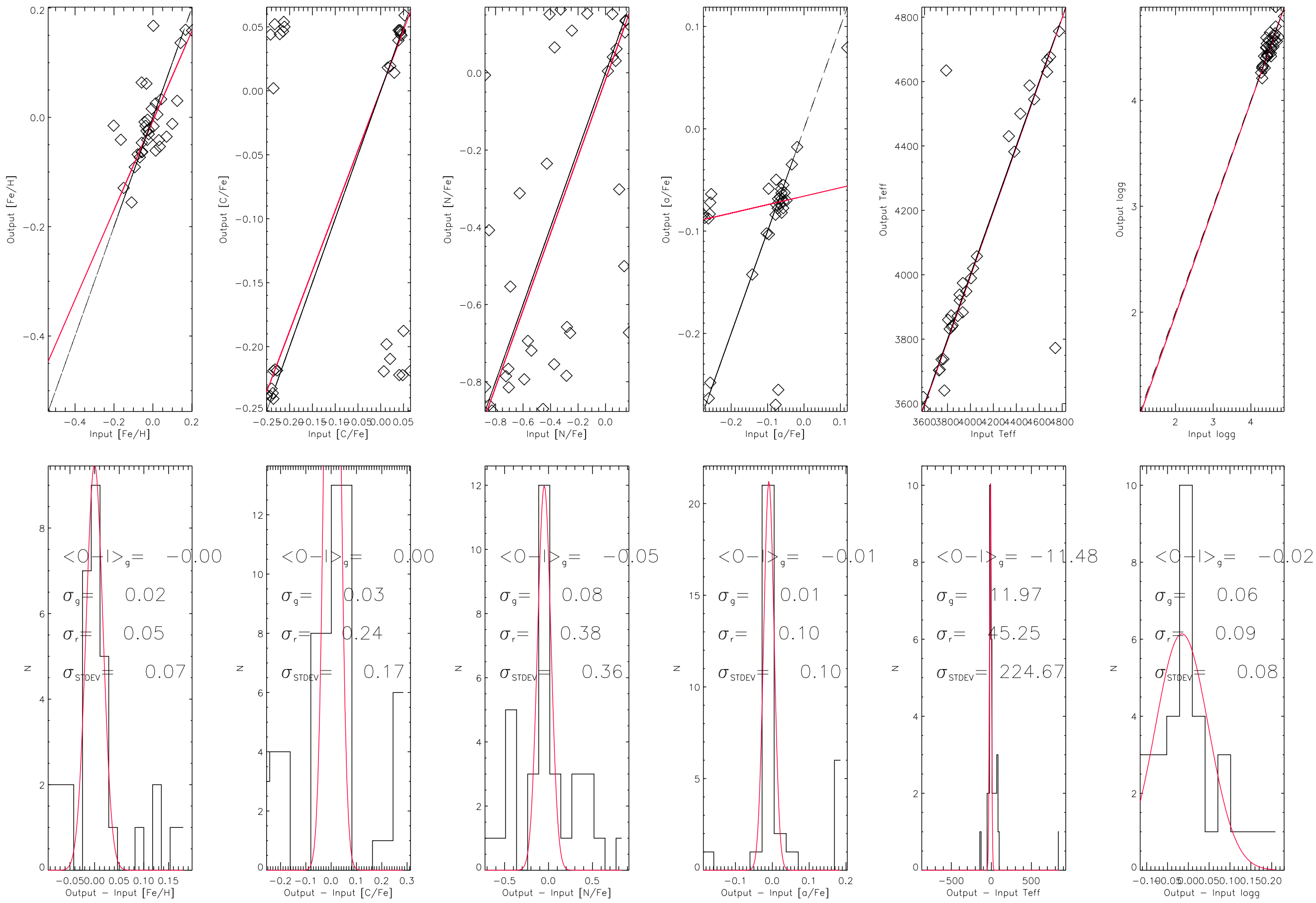

Figure 4: Similar to Figs. 1, and 3, comparing QASPCAP results for 6 (x-axis in upper panels) and 7 (y-axis) parameters.

3 QASPCAP consistency

Our next test examines variations within QASPCAP runs in which 6 (23k0421, with a microturbulence equal to $0.24 - 0.3 \log g$) or 7 parameters (microturbulence as a free parameter) are searched for. The main result is illustrated in Fig. 4, where the spectra have been filtered to avoid those too close to the edges. The agreement is excellent, with $1{-}\sigma$ spreads of 0.05 dex in iron, 0.2 for C/Fe, 0.4 for N/Fe, 0.1 for α/Fe, 45 K in $T_{\rm eff}$, and 0.1 dex in $\log g$. The fact that N is loosely constrained is most likely related to the fact that these stars are dwarfs, as mentioned earlier, so CN lines are not as strong as in giants.

We have also examined the level of agreement for QASPCAP between runs on apvisit and apstar data. Again we filter our the objects that end up dangerously close to the edges of the grid, and the results are displayed in Fig. 5. The upper set of 6 figures corresponds to the case of 7 parameters,and the lower set to 6 parameters. Note that there is a slight inconsistency for the case of 6 parameters, since for apvisit results the micro is fixed to 2 km/s, while for apstar results the micro adopted follows the $0.24 - 0.3 \log g$ recipe.

The agreement is modest for Fe and the α/Fe ratio (about 0.1 dex) and for the gravity (about 0.2 dex), but the scatter is sizable for C/Fe (0.4 dex) and even more for N/Fe (0.5–0.7 dex), as well as for the effective temperature (about 300–400 K). Since the apstar spectra analyzed have a signal-to-noise ratio about $\sqrt{3}$ higher, our preliminary conclusion is that either the apvisit spectra do not have enough signal-to-noise or that there are issues (bugs?) with the analysis of apstar files. Fig. 6 shows part of the spectrum of the same star in a single visit, and after combining the three visits. Clearly the input data, and the model fitting, are of higher quality for the apstar case.

4 Metallicity spread

Finally, we compare the spread in metallicity we find for RV-defined Pleiades members for three different runs using apstar files analyzed with 7 or 6 free parameters, and results found with apvisit files (just one MJD, 55847) – all processed with QASPCAP.

The results are shown in Fig. 7. We have made no attempt to drop spectra with low signal-to-noise, fast rotators, etc. The rms scatter we find is 0.11 dex for a 7-parameter run on apstar files, and a very similar value (0.13) dex is obtained for a 6-parameter run. The scatter is obviously increased to about 0.3 dex when the lower signal-to-noise apvisit files are analyzed. The average metallicity is all cases about solar, and no significant variations are observed with effective temperature

5 Conclusions

Briefly, QASPCAP seems to work fine. The fact that it gives a lower χ^2 than ASPCAP could simply reflect the different weights (or weight reductions) that applies, and this is easy to check by simply running ASPCAP with the same filters as those implemented in QASPCAP.

We find evidence in the metallicity spread for the Pleiades members that the performance for apstar files is substantially bettter than for lower signal-to-noise ratio singe visit (apvisit) observations.

There are plenty of opportunities for introducing errors in the construction of the grids used with ASPCAP, and in particular for the apstar libraries, which involve freshly developed (i.e. untested) code. The experiments with these Pleiades test suggest that any mistakes present are unlikely to induce gross errors in the results. We also find that a careful cleanup of results for stars close to the edges of the parameter range of the libraries is necessary in order to obtain a clear picture from any tests with real data.

From these tests, we identify a few items to explore: the results from ASPCAP and QASPCAP should be easily reconciled by making sure the same criteria for weighting the different frequencies are applied (this is just a few lines of code).

The spread in metallicity for the Pleaides and other clusters can be explored as a function of the signal-to-noise of the spectra, which will provide an empirical constraint on the error bars for metallicity. This value can be compared with the internal (inverse of curvature matrix) errors from FERRE and with those from Montecarlo (also coded in FERRE) runs. If default and Montecarlo errors in FERRE agree, the discrepancy with the empirical estimates is likely due to the error bars in the input spectra. At the very least such experiment will provide zeroth-order corrections to our internal error bars.

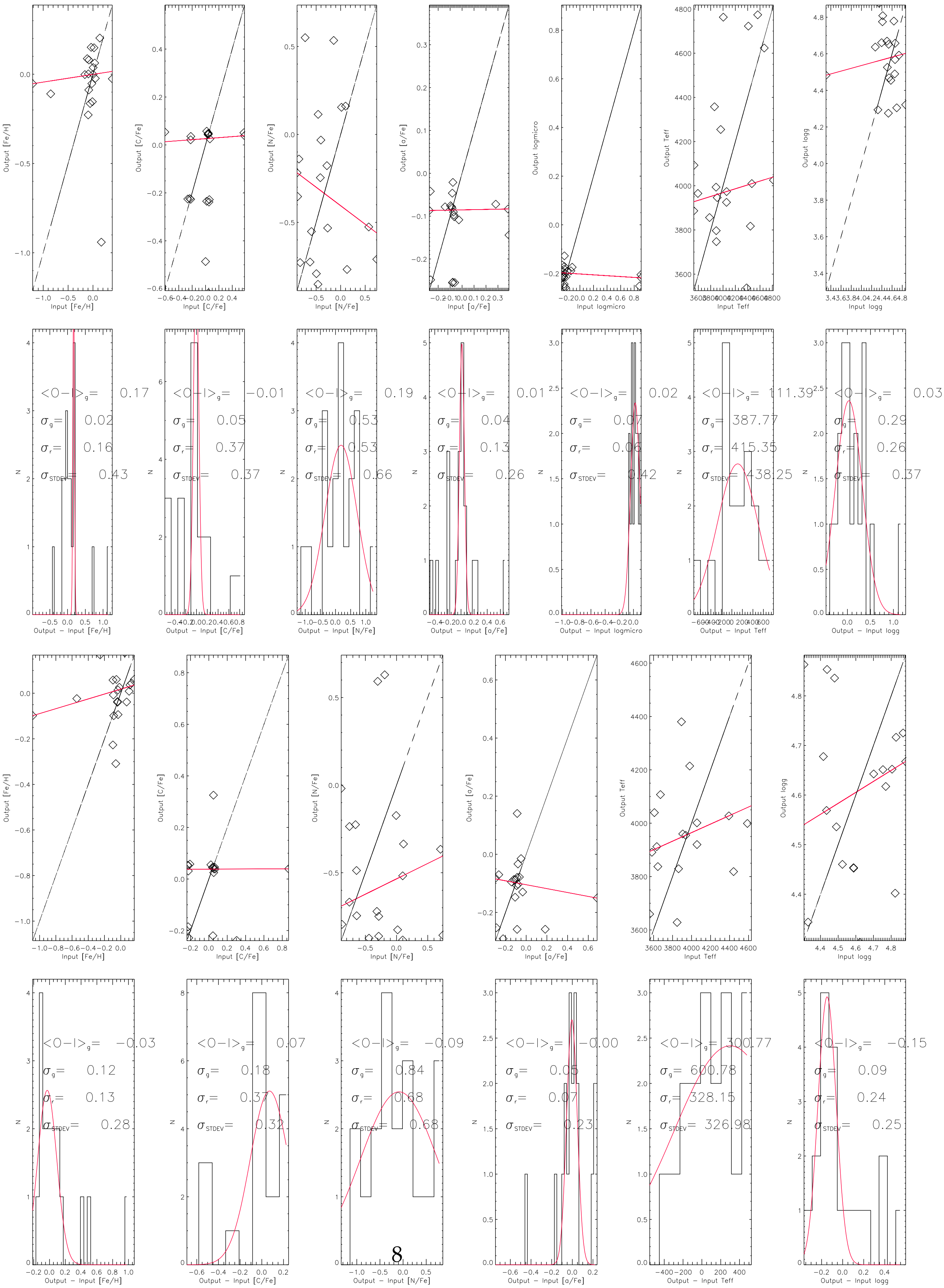

Figure 5: Similar to Fig. 1, 3 and 4, comparing QASPCAP results for apvisit (x-axis) and apstar (y-axis). The upper set of graphs corresponds to an analysis with 6 parameters, and the lower set to a analysis with a free microturbulence.

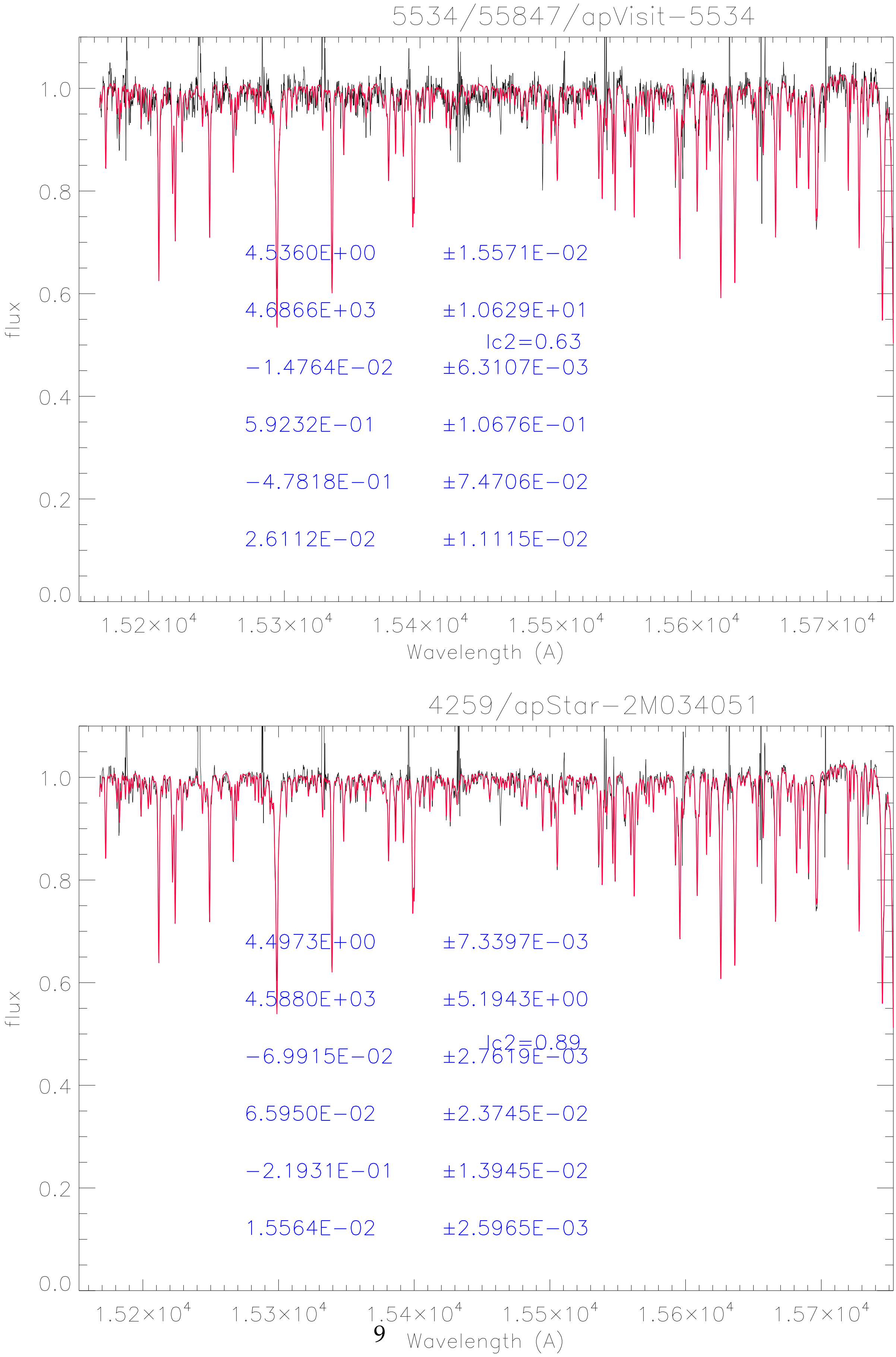

Figure 6: Part of the spectrum of $2M03405126+2335544$ in one of the of the visits (upper panel; apVisit-5534-55847-026) and in the combined apstar spectrum (bottom).

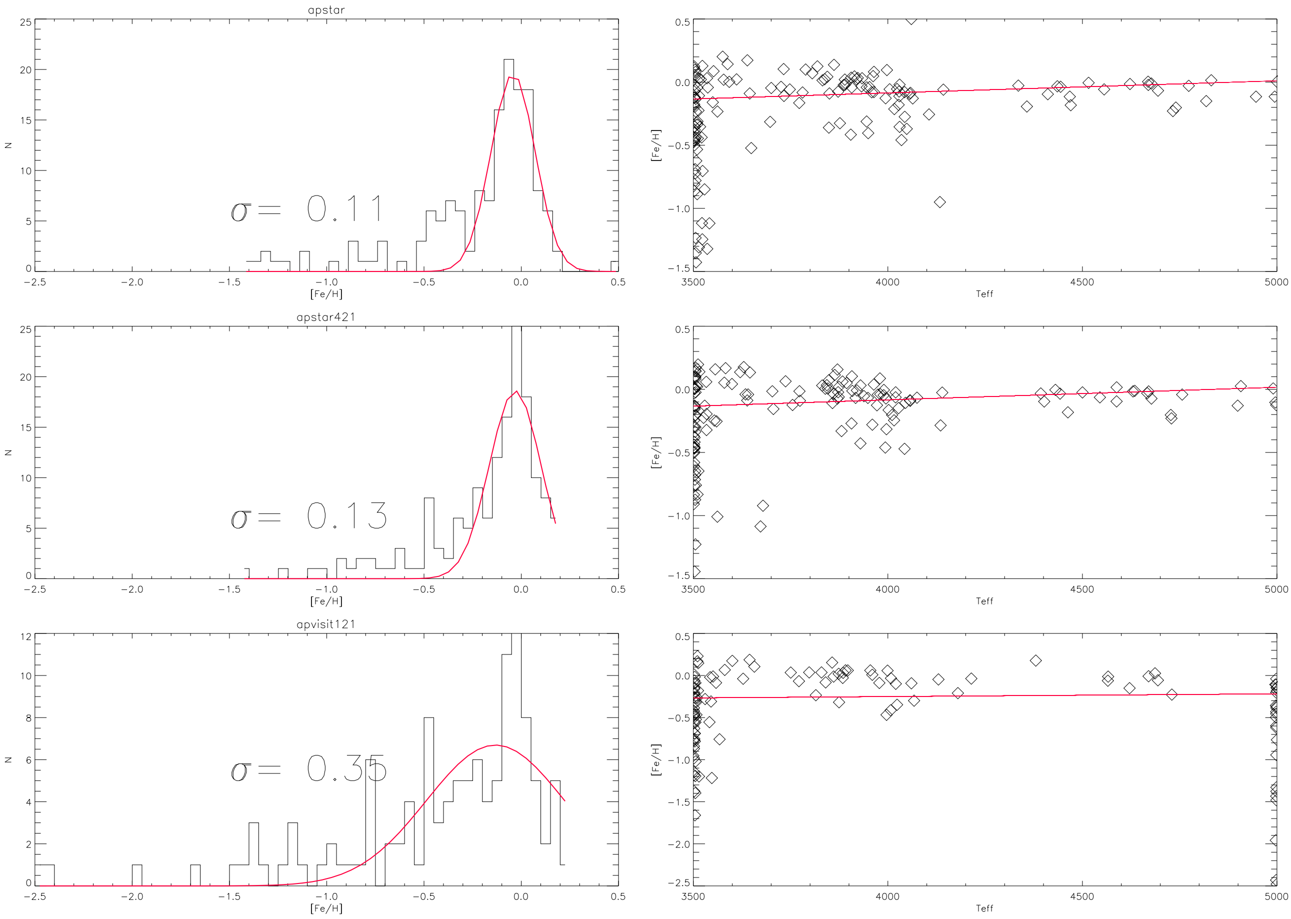

Figure 7: [Fe/H] results for apstar files and a 7-parameter (aps23k0221_w123) analysis (top), the same data with a 6-parameter analysis (aps23k0421_w123; middle panels), and a 6-parameter analysis of a single visit (apvisit files – pds0121_w123; bottom panels). The left-hand panels show the metallicity distribution and a Gaussian fit in red, and the right-hand panels show the metallicity as a function of effective temperature for each case. Only radial-velocity members are included in this plot.