EFFECTS OF TELLURICS IN PRVS AND EFFECTIVENESS OF MITIGATION STRATEGIES

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George Mason University | March 18th, 2019 | EPRV IV
EarthFinder

PI: Peter Plavchan

Gautam Vasisht, Chas Beichman (Instrument)
Xavier Dumusque, Heather Cegla (Stellar Activity)
Peter Gao, Courtney Dressing (Ancillary)
Sharon Xuesong Wang (Tellurics)
Goals

What’s the RV precision floor set by tellurics?
How well can we mitigate tellurics in various bands?
Simulated Observed Spectra

Kurucz Solar Model, also used as input template

TAPAS, tailored to atm., condition of the month. Varying airmass and PWV nightly.

Shifting tellurics with barycentric motion over a year. No photon noise.

Convolved each “order”, $R = 120,000$. Perfectly known PSF and wavelength solution
230 orders

365 nights

RV Extraction

2 methods x 3 conditions

CCF & Forward Modeling
- No correction of tellurics
- Perfectly known tellurics
- Lack of knowledge of tellurics
RMS of RVs ~ errors added by tellurics for this order

365 nights

230 orders
RMS of RVs ~ errors added by tellurics for this order

Combine RVs from all orders to derive nightly RV

365 nights

230 orders
RMS of RVs ~ errors added by tellurics for this order

Combine RVs from all orders to derive nightly RV

365 nights

230 orders

200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350

-30000 -20000 -10000 0 10000 20000 30000

Barycentric Velocity (m/s)

RMS of RVs ~

Combine RVs from all
orders to derive nightly
RV
No Division + CCF
No Division + CCF Smoothed
Division + CCF
Forward Modeling
Adding Realism

- Using Mauna Kea lines to fit Kitt Peak observations
- No prior knowledge on line depths and PWV
Reality is more than a mismatched line profile

Oxygen lines in Keck data from RVxK2
Forward Modeling + Realistic Conditions
270 orders

365 nights

RMS of RVs ~ errors added by tellurics for this order

Combine RVs from all orders to derive nightly RV
Combined RV vs Time
What is the RV precision floor set by tellurics?

<table>
<thead>
<tr>
<th>Instrument</th>
<th>No Correction (m/s)</th>
<th>CCF + Division (m/s)</th>
<th>Modeling (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EarthFinder Opt</td>
<td>0.035</td>
<td>0.021</td>
<td>0.067</td>
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<tr>
<td>EarthFinder NIR</td>
<td>2.432</td>
<td>0.761</td>
<td>0.321</td>
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<tr>
<td>ESPRESSO</td>
<td>0.034</td>
<td>0.020</td>
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<tr>
<td>CARMENES NIR</td>
<td>2.359</td>
<td>0.659</td>
<td>0.442</td>
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</tbody>
</table>
Thank You!

**Take-Home Message**

In the optical, tellurics are adding at least 2 cm/s.

In the NIR, tellurics are adding about 30 cm/s.

**Collaborators:**
Cullen Blake, Sharon Xuesong Wang, Peter Plavchan, Bryson Cale

Report, code and all synthesized spectra will be public, and **available now upon request.**