EFFECTS OF TELLURICS IN PRVS AND EFFECTIVENESS OF MITIGATION STRATEGIES

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

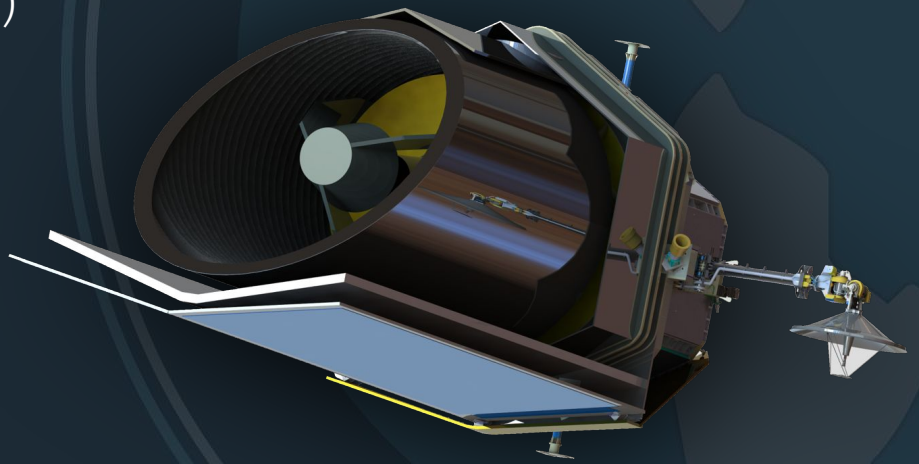
CARNEGIE SCIENCE

GEORGE MASON UNIVERSITY

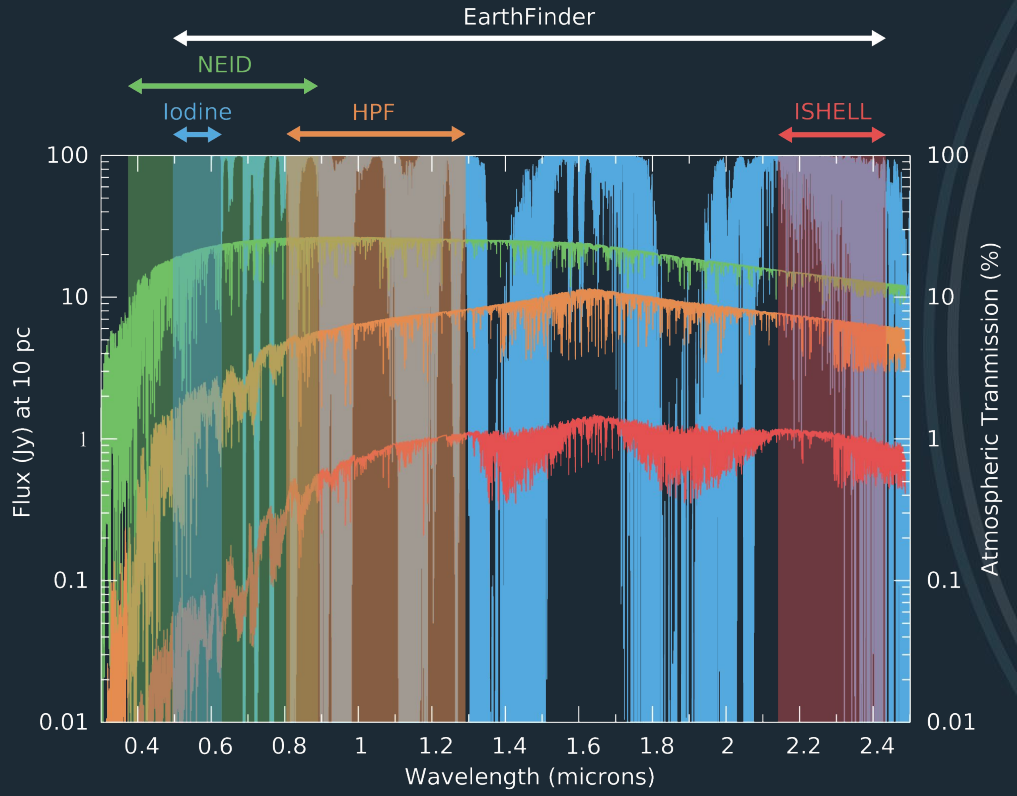
EarthFinder

PI: Peter Plavchan

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

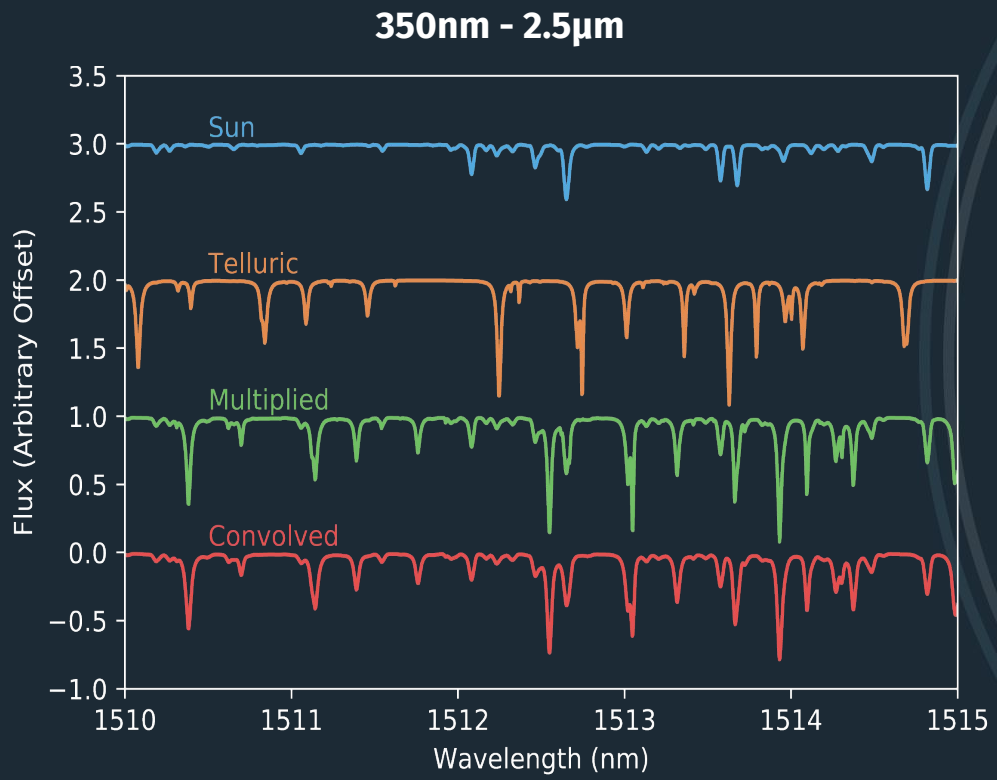


Goals



What's the RV precision floor set by tellurics?
How well can we mitigate tellurics in various bands?

Simulated Observed Spectra

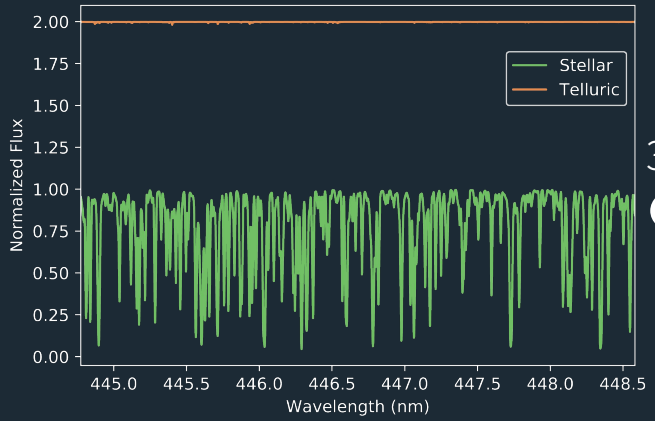


Kurucz Solar Model, also used as input template

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

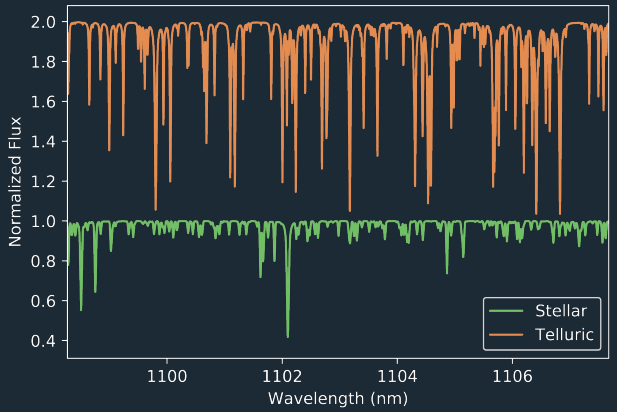
Shifting tellurics with barycentric motion over a year. **No photon noise**.

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



365 nights

230 orders

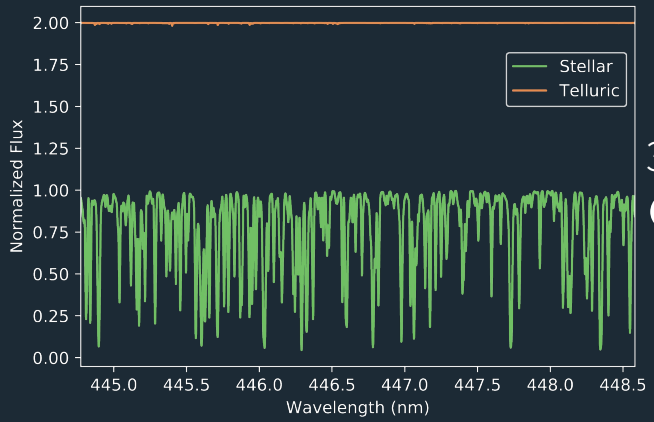


RV Extraction

2 methods x 3 conditions

CCF & Forward Modeling

- No correction of tellurics
- Perfectly known tellurics
- Lack of knowledge of tellurics



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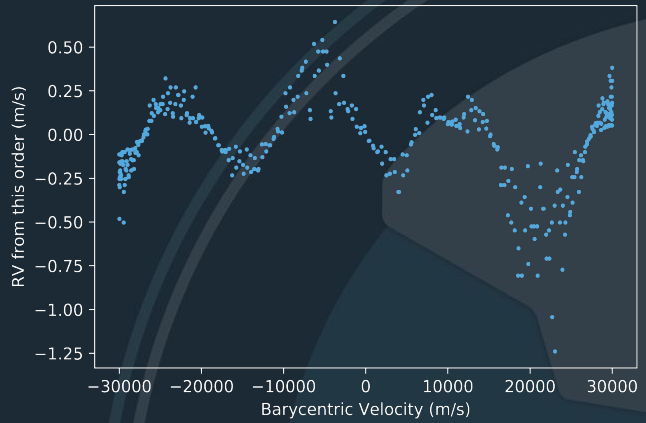
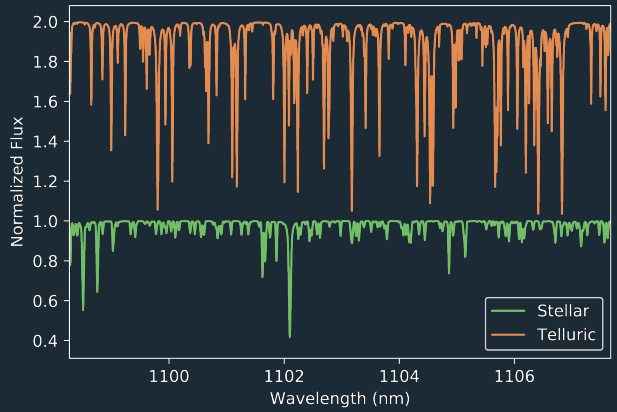
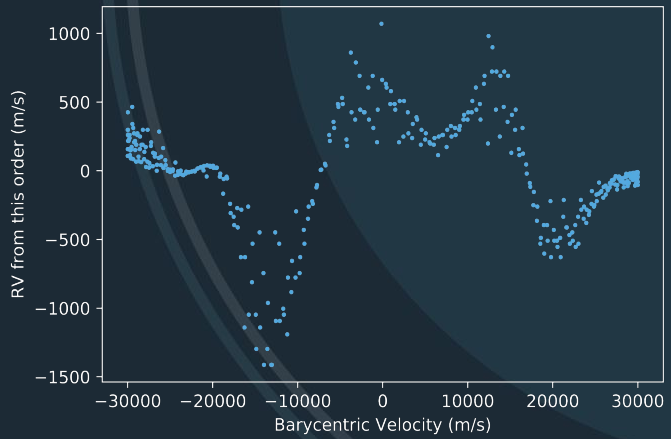
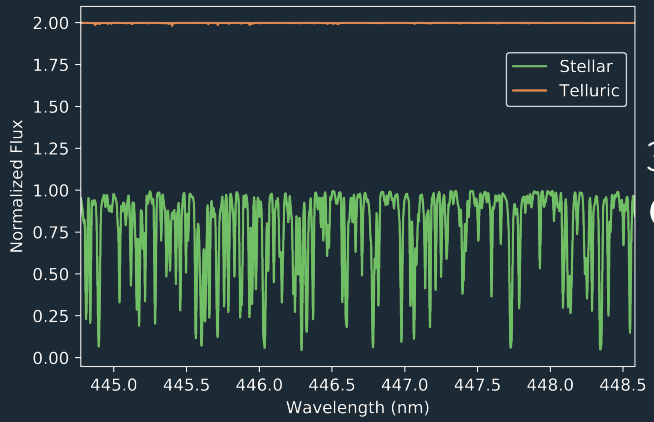


RMS of RVs ~ **errors added by tellurics** for this order

230 orders







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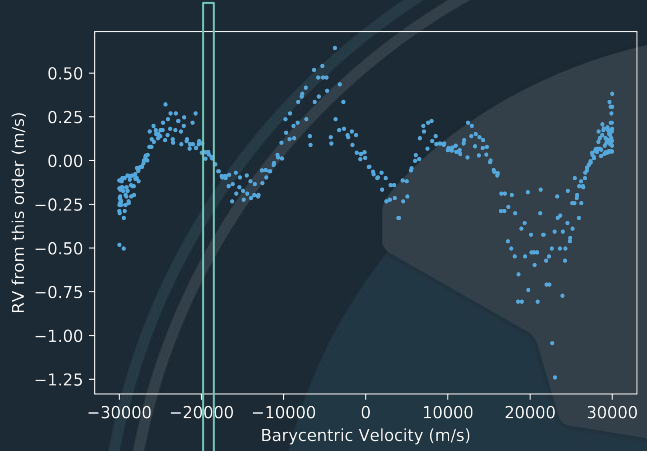

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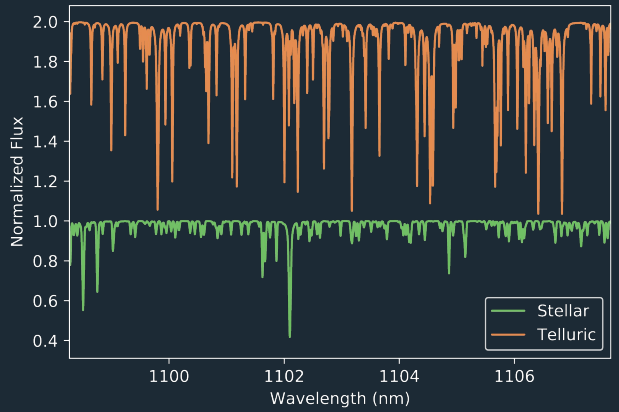
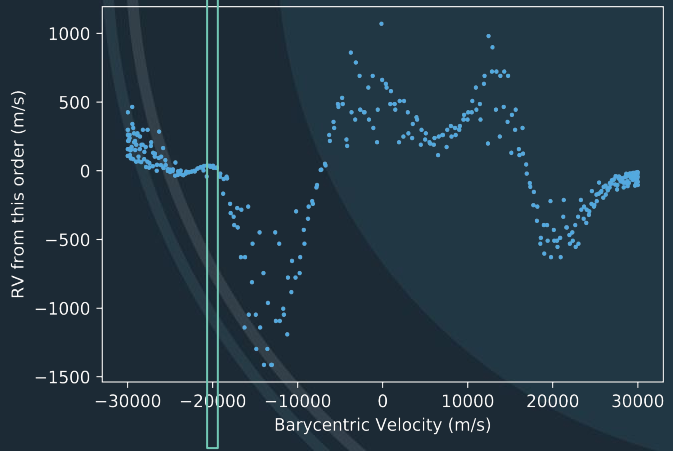
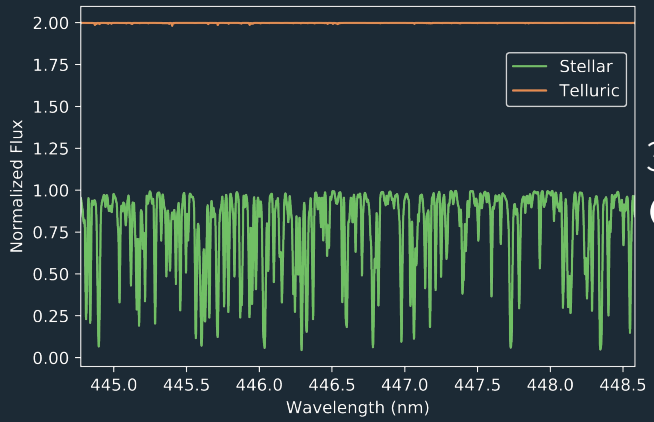




Combine RVs from all orders to derive nightly RV



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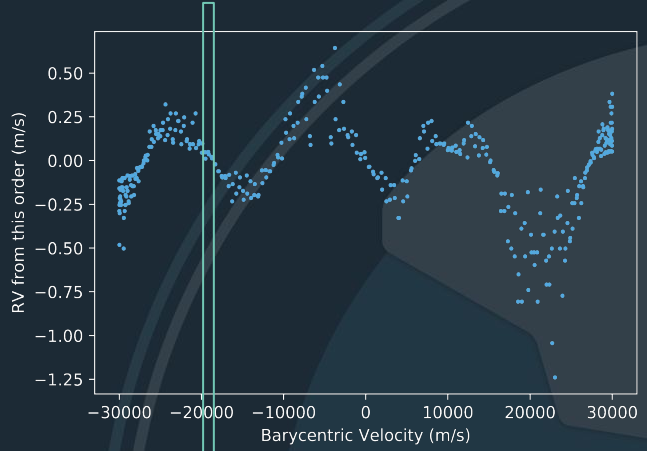

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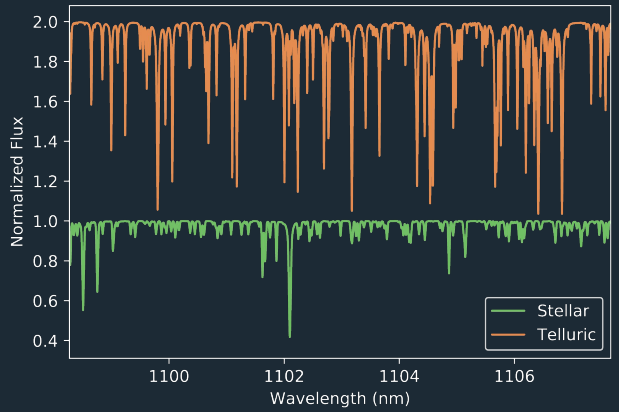

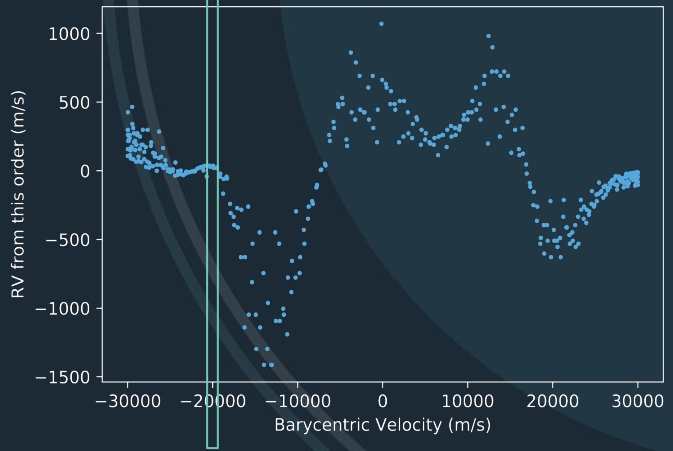

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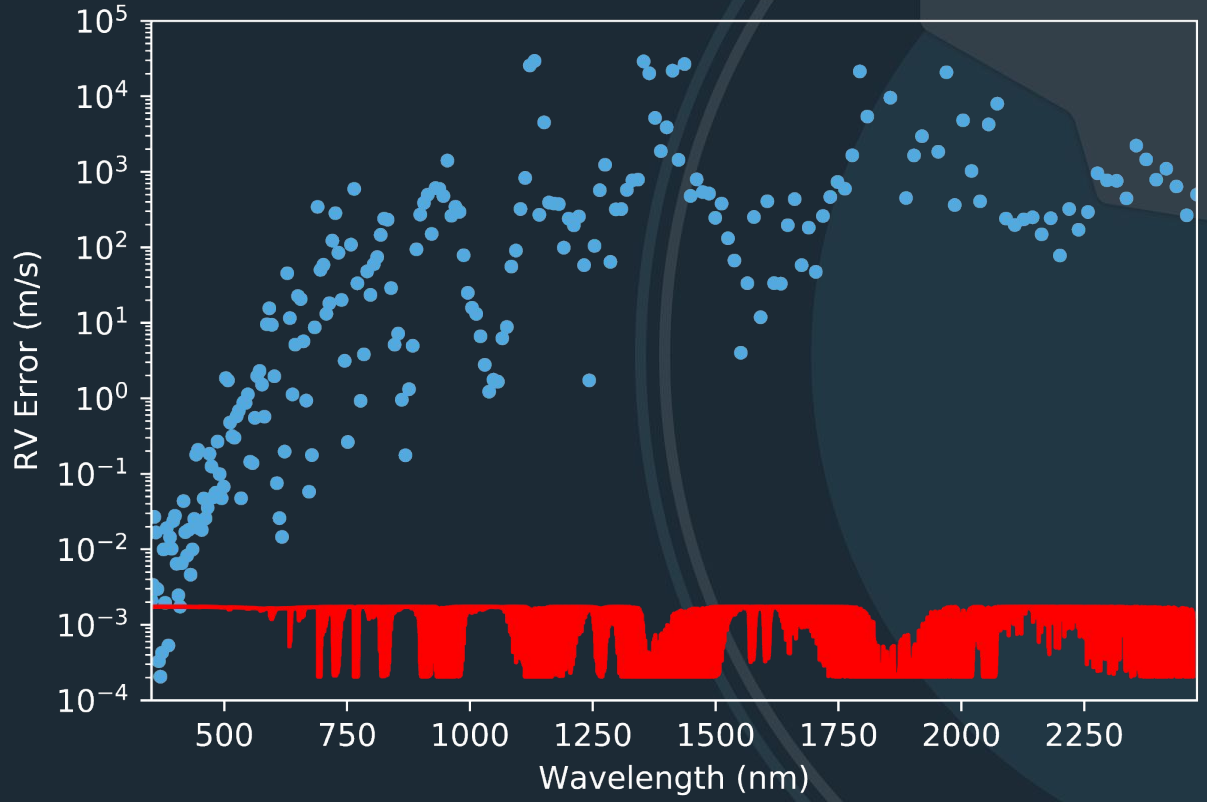
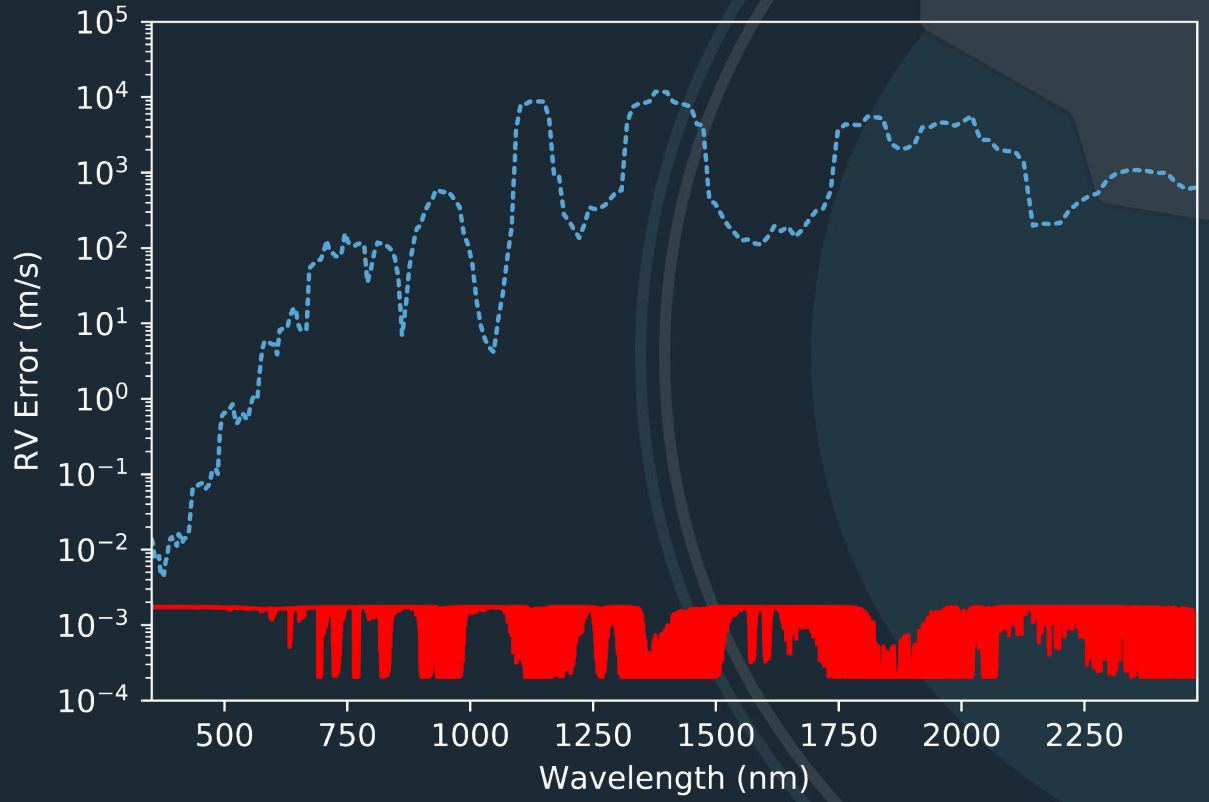
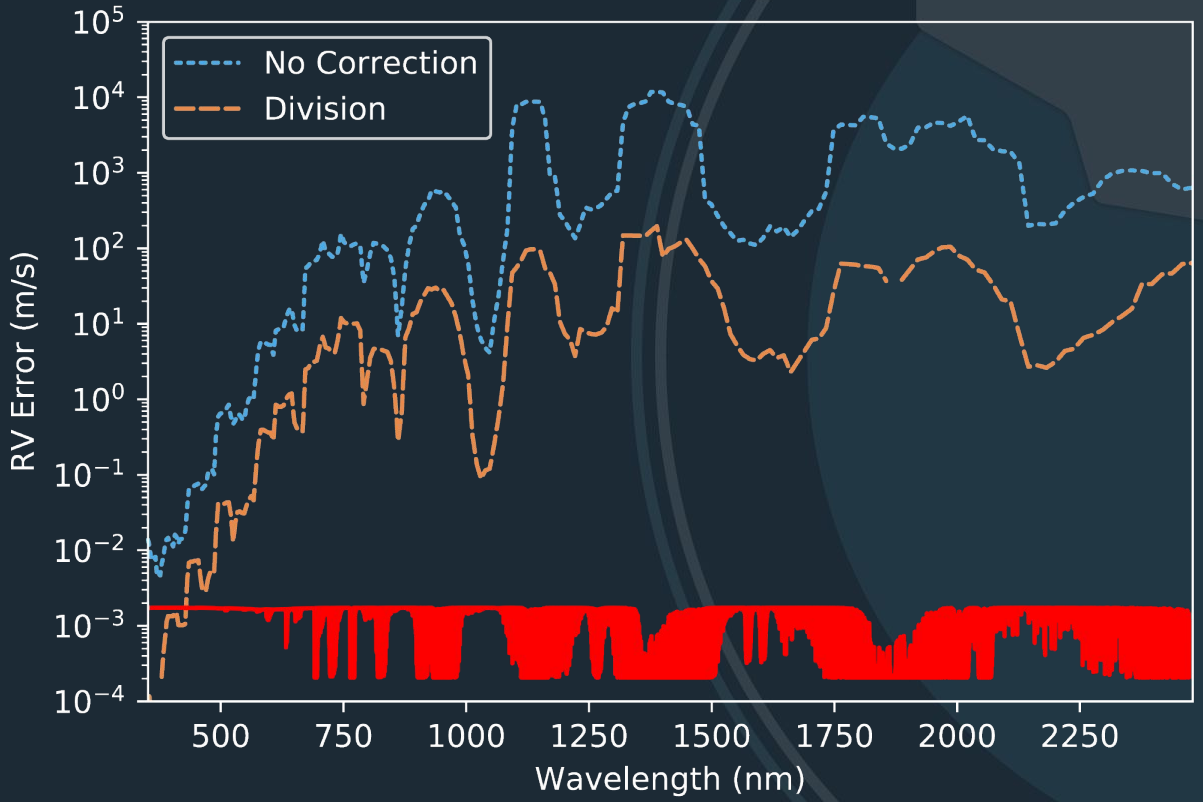
No Division + CCF



No Division + CCF Smoothed

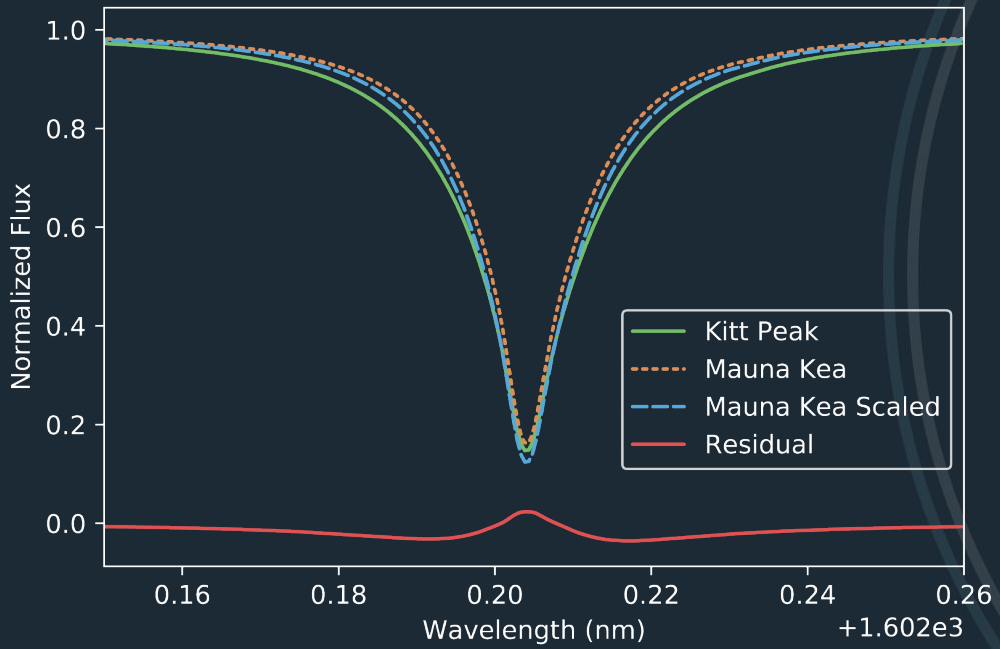


Division + CCF



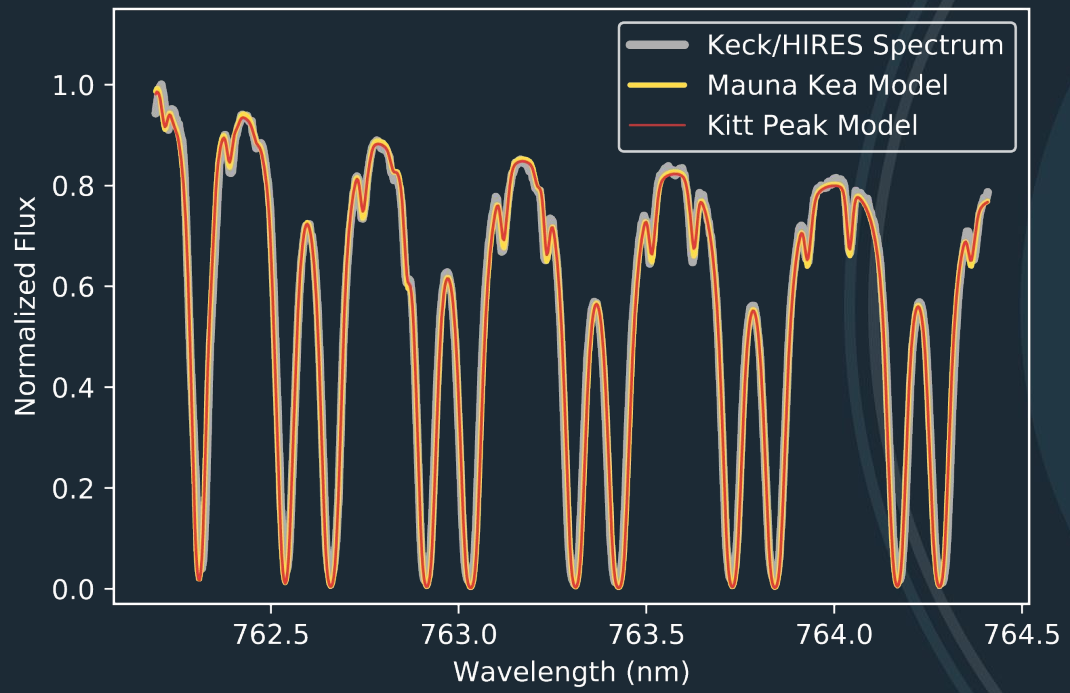
Forward Modeling

Adding Realism



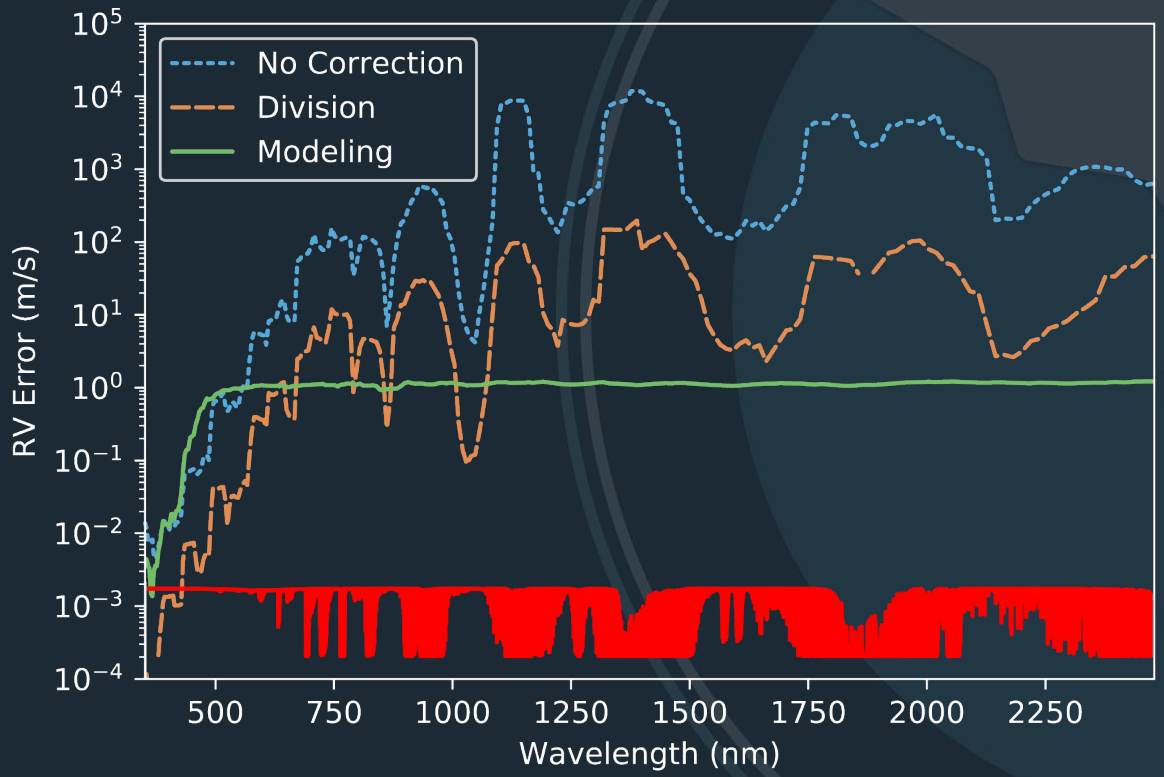
- Using Mauna Kea lines to fit Kitt Peak observations
- No prior knowledge on line depths and PWV

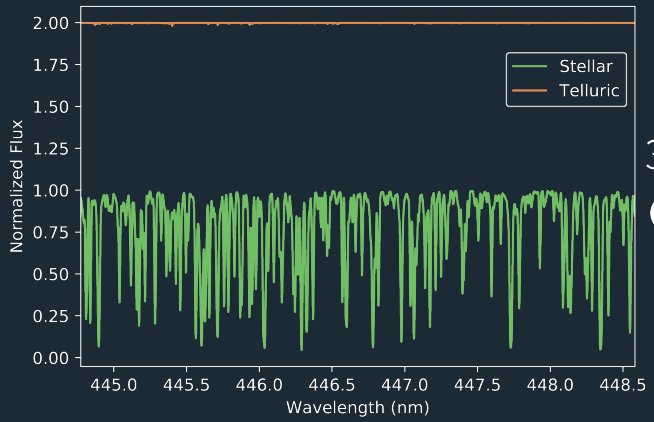
Reality is more than a mismatched line profile



Oxygen lines in Keck data from RVxK2

Forward Modeling + Realistic Conditions





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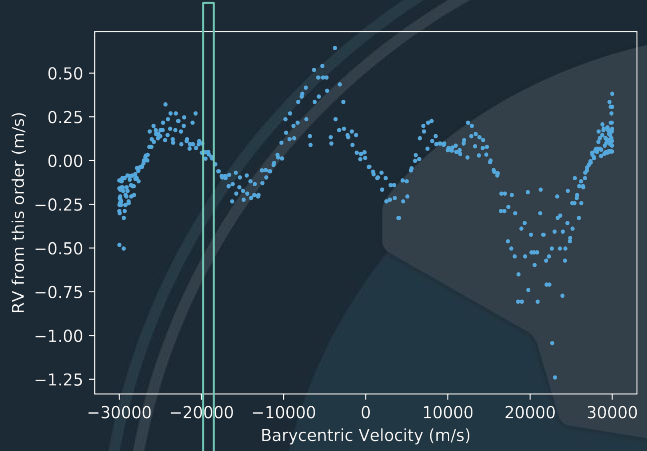

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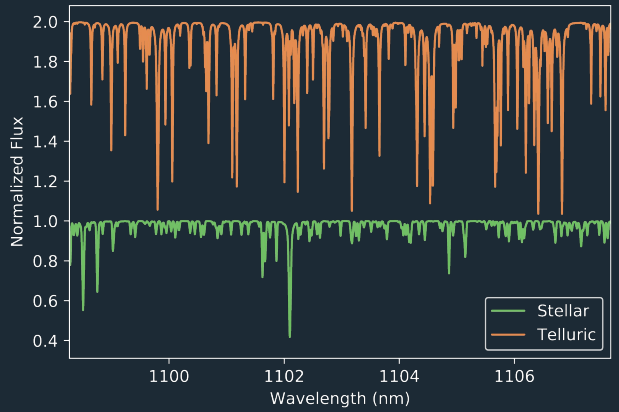
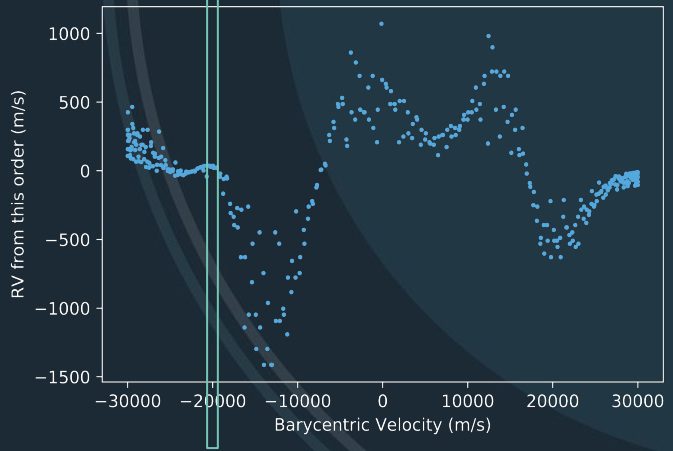
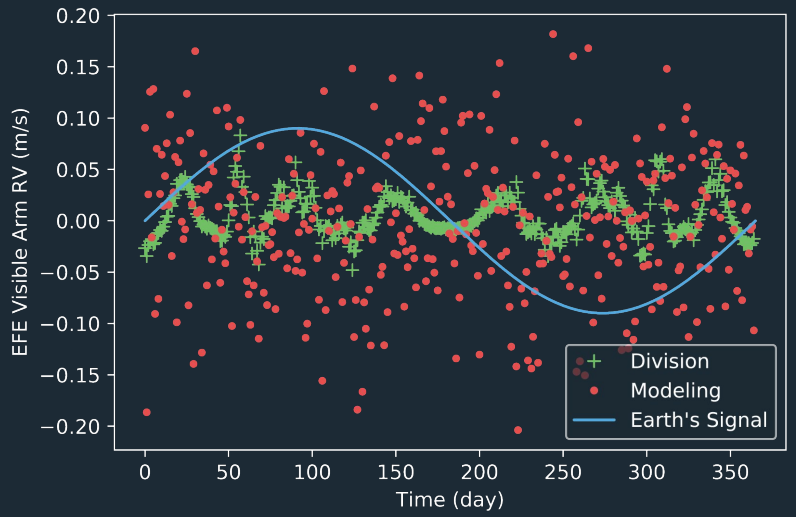
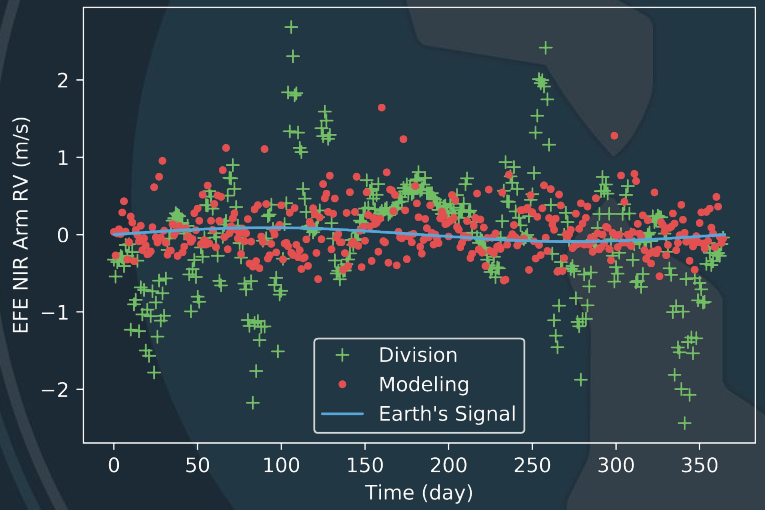




Combine RVs from all orders to derive nightly RV

Combined RV vs Time





What is the RV precision floor set by tellurics?

Instrument	No Correction (m/s)	CCF + Division (m/s)	Modeling (m/s)
EarthFinder Opt	0.035	**0.021**	0.067
EarthFinder NIR	2.432	0.761	**0.321**
ESPRESSO	0.034	**0.020**	0.069
CARMENES NIR	2.359	0.659	**0.442**

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.**