The UV SSI of the Sun Compared to Cooler Stars, Similarities and Differences

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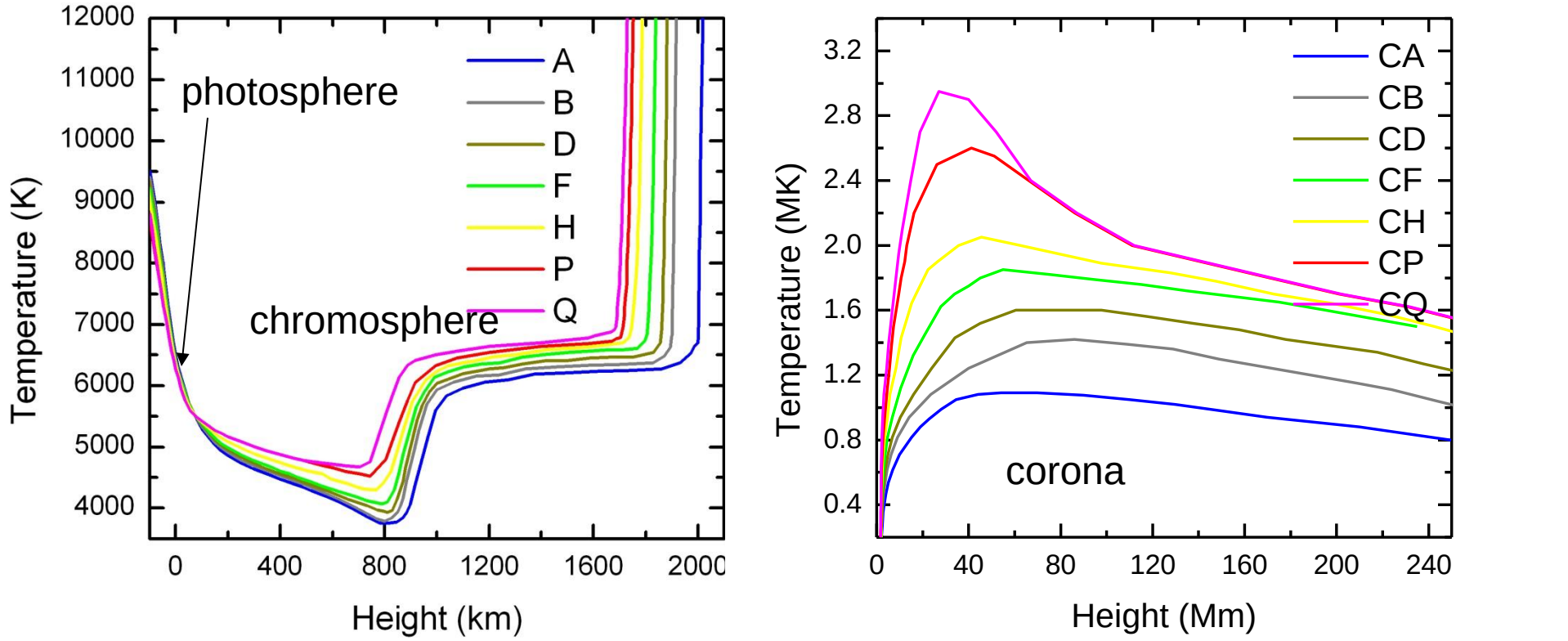
Solar Radiation Physical Modeling

(SRPM) *Fontenla et al. 2011, JGR, 116, D20108*

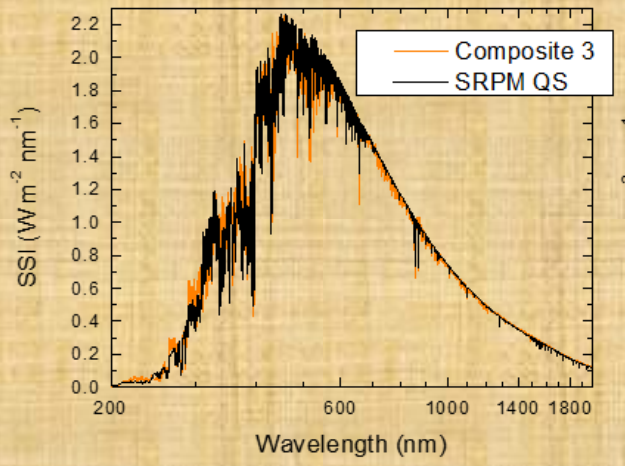


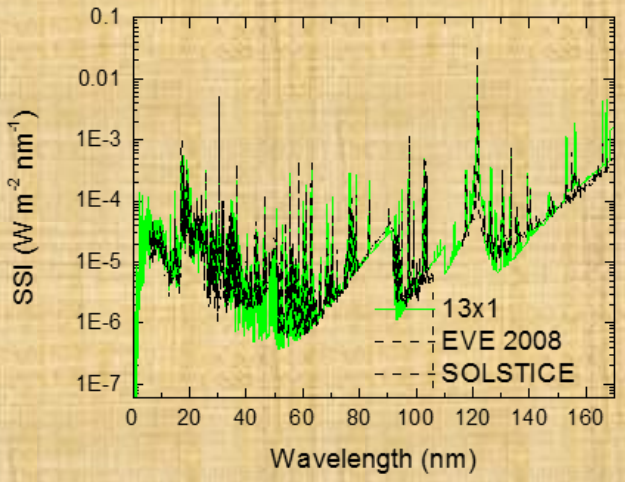
Contributions to quiet-Sun TSI (1360 W m^{-2}, Δ~+1 W m^{-2}):

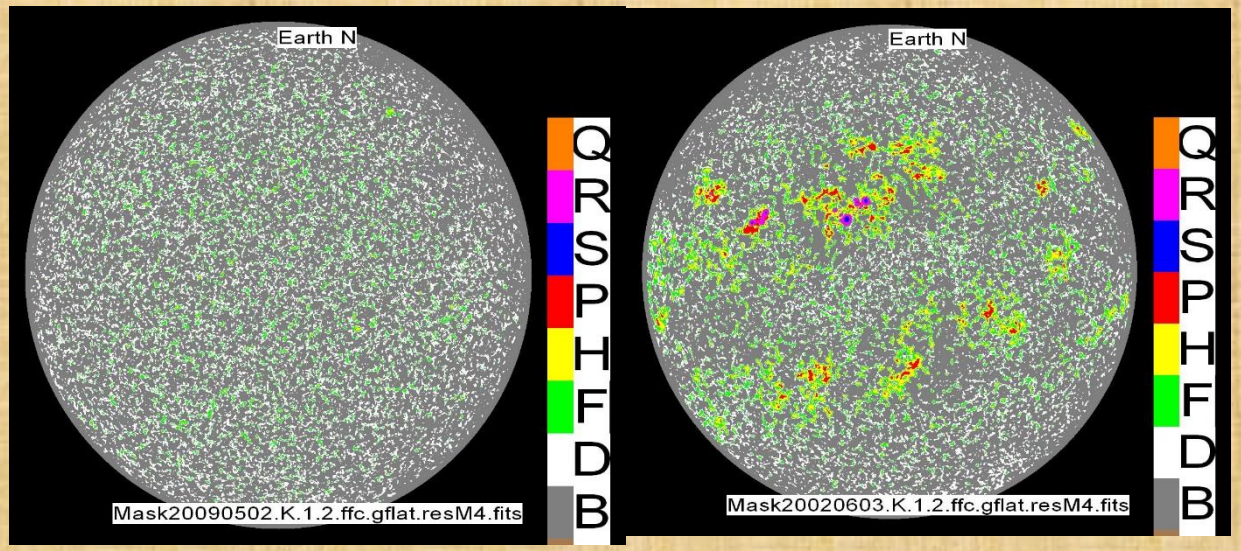
- Photosphere: ~1350 W m^{-2} (Δ~-1 W m-2)
- Chromosphere: ~10 W m^{-2} (Δ~+2 W m^{-2})
- Corona+Transition-region: ~70 mW m^{-2} (Δ~+100 mW m^{-2})

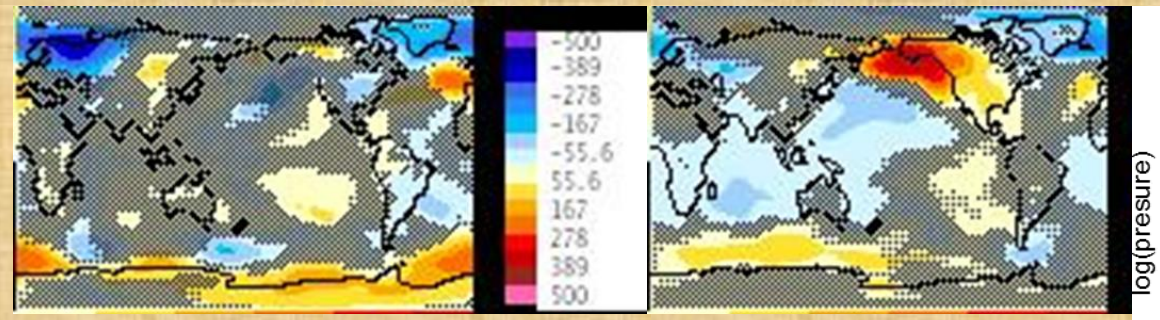
Reminder: 2011 results of SRPMv2

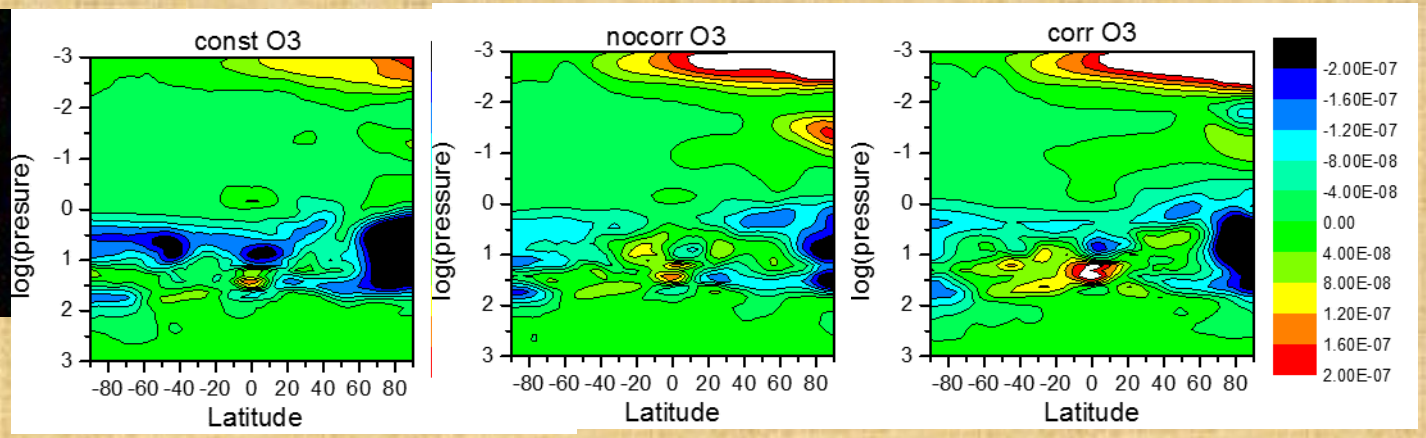
- Fontenla, J. M., J. Harder, W. Livingston, M. Snow, and T. Woods, “High-resolution solar spectral irradiance from extreme ultraviolet to far infrared”, JGRA., 116, D20108, doi:10.1029/2011JD016032 (2011)



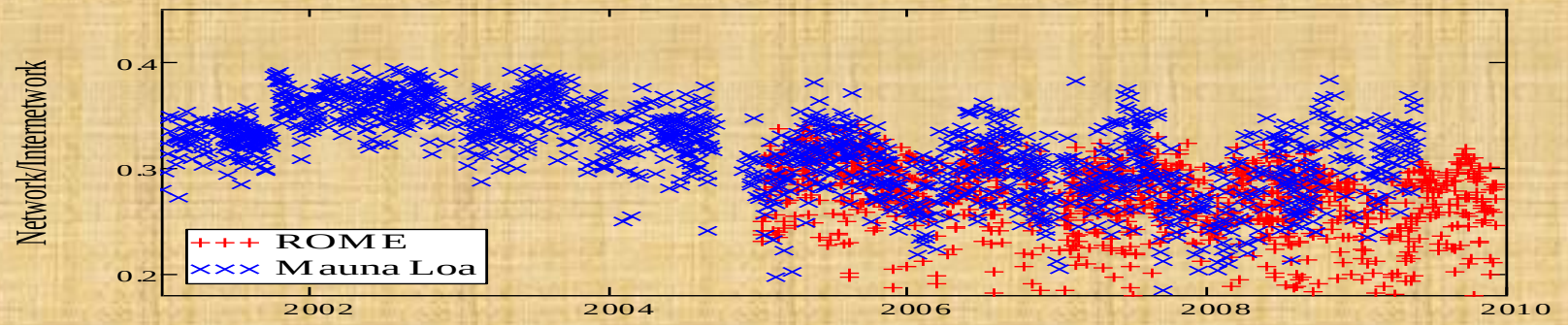


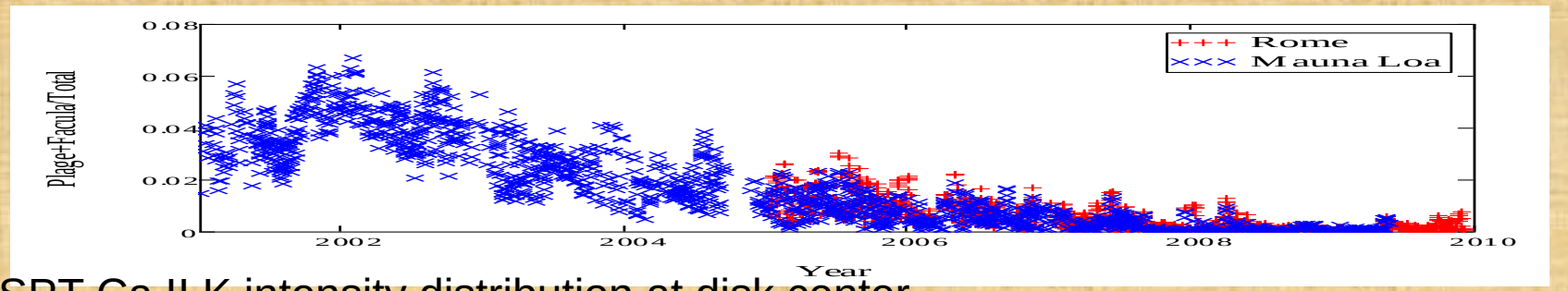




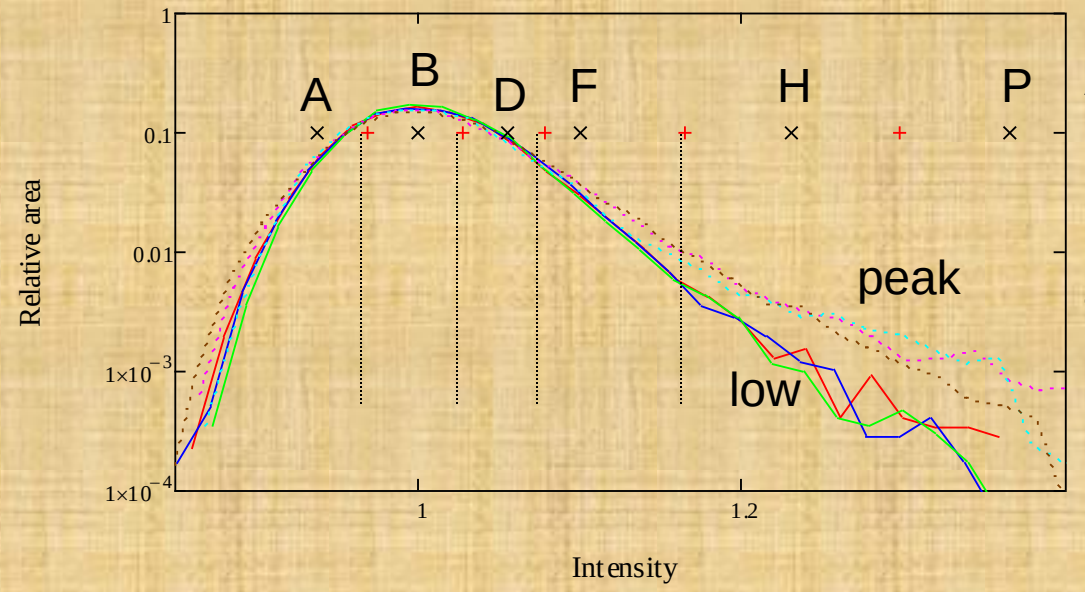


2012: SRPM matching of TSI by network changes





- PSPT Ca II K intensity distribution at disk center



Available ground images lack reliable absolute calibration. Day to day matching is done either by median (nocorr) or by TSI (corr).

TSI before -1.6 % scale

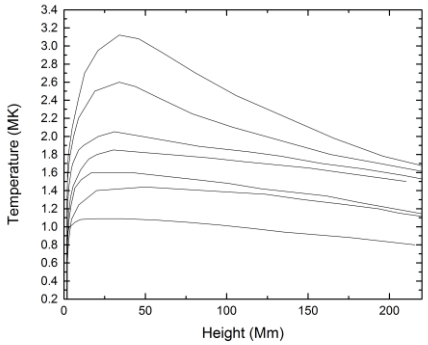
A	1101	1374.60
B	1001	1382.19
D	1002	1388.15
F	1003	1391.44
H	1004	1400.86
P	1005	1419.14
S	1006	265.97
R	1007	1103.82
Q	1008	1428.82

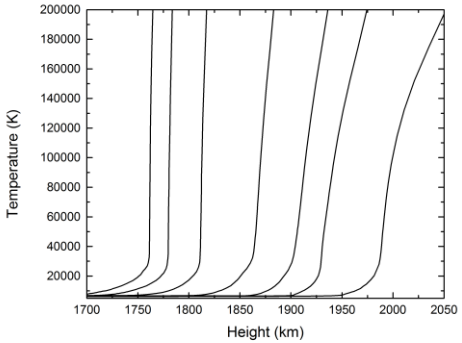
2013 results of SRPMv2

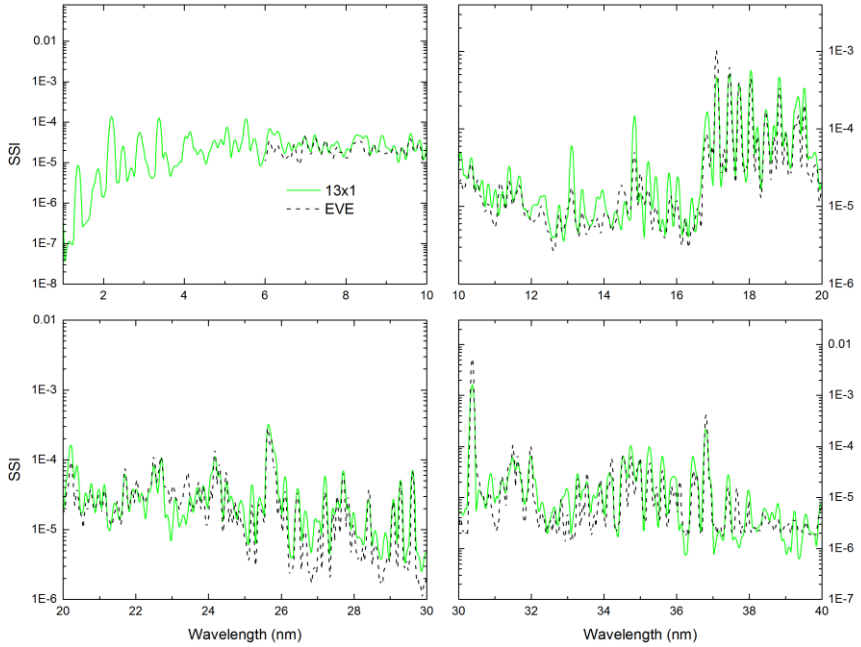
Vieytes, M. C.; Fontenla, J. M., “Improving the Ni I Atomic Model for Solar and Stellar Atmospheric Models”, ApJ, 769, article id. 103, DOI: 10.1088/0004-637X/769/2/103 (2013)

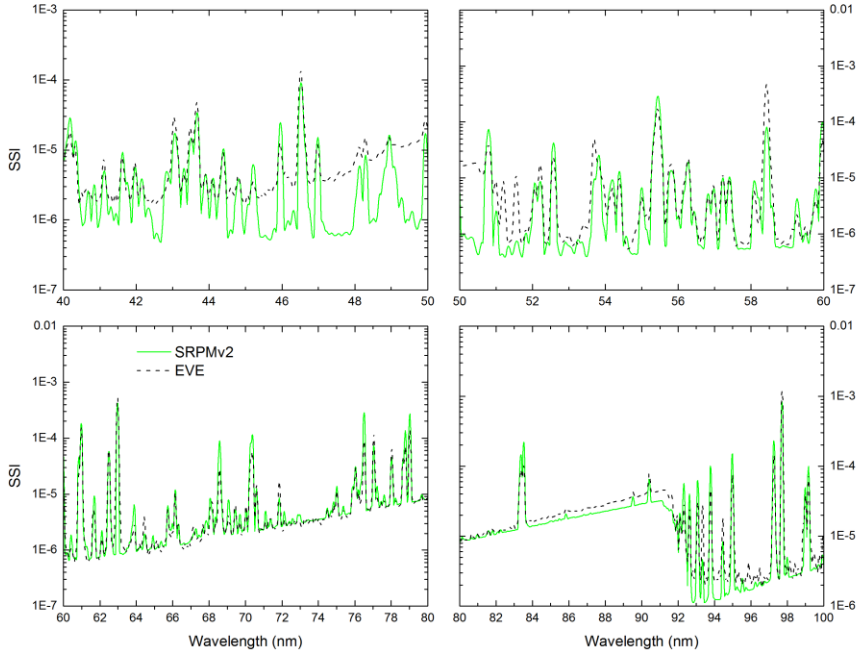
FUV/EUV/XUV: Fontenla, J.M., Landi, E., Snow, M., and Woods, T., “Far- and Extreme-UV Solar Spectral Irradiance and Radiance from Simplified Atmospheric Physical Models”, Solar Phys., 289, 515-544, DOI 10.1007/s11207-013-0431-4 (2014)

New website: http://www.galactitech.net/John/SRPMv2/ and http://www.galactitech.net/John/SERFS/Images has recent masks from SDO/AIA.



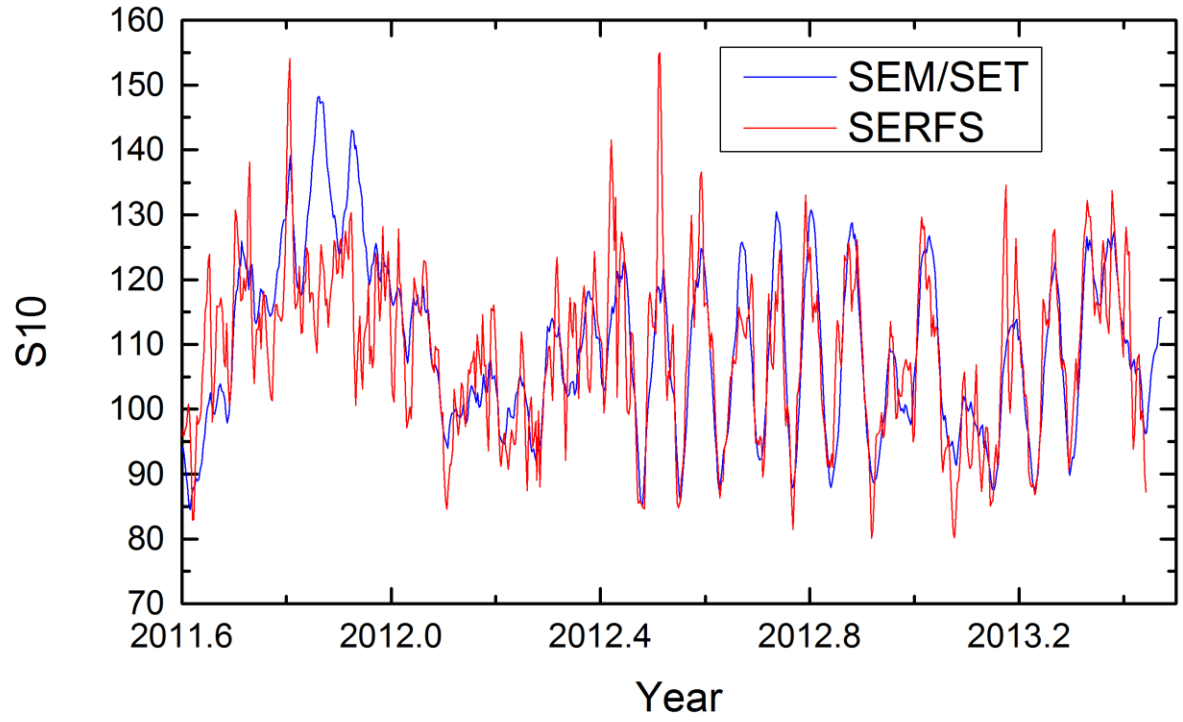




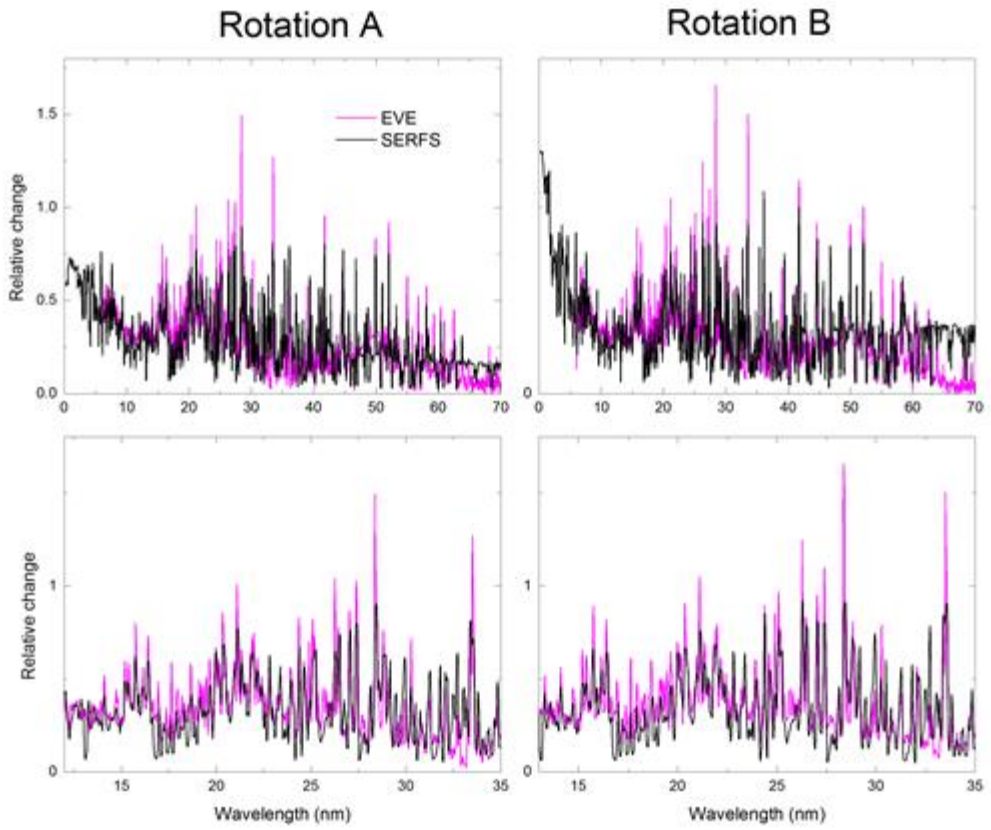


2013 results of SRPMv2 – UV SSI variability

Time evolution during 2012 of the commonly used S10 index

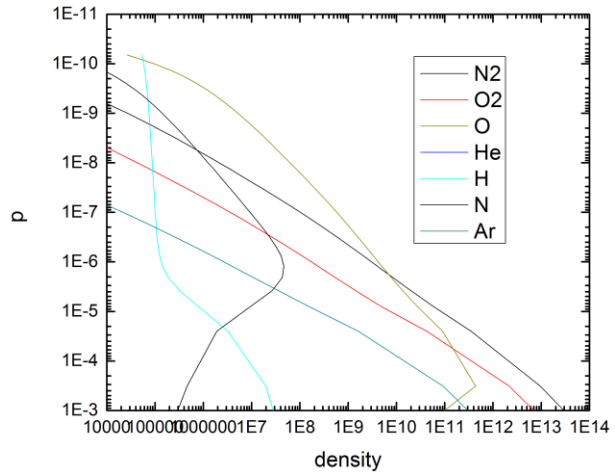


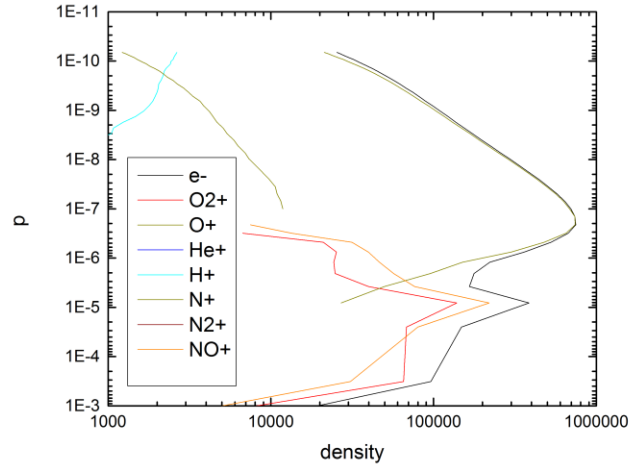
EUV spectra of rotational modulations



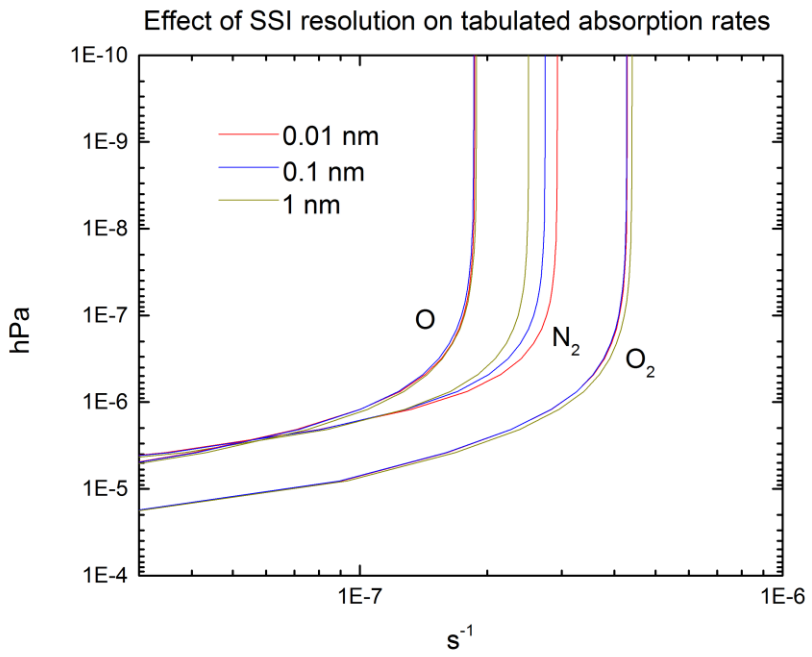
Thermospheric Modeling

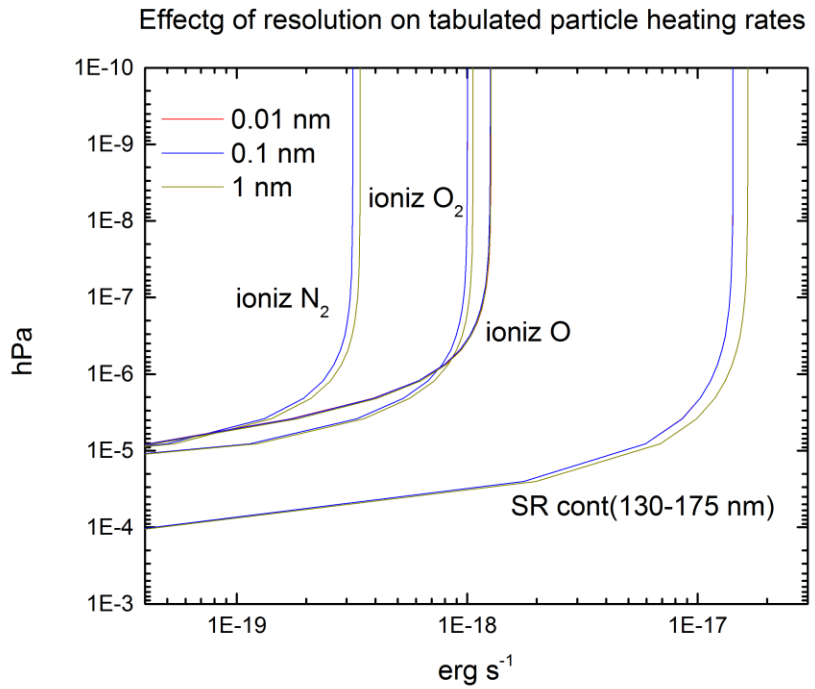
These results are now starting to be used for calculating thermospheric rates at various spectral resolutions and comparing with the 37 bands often used.





The graphs show the effect of the input SSI resolution on some rates, but in all cases the absorbers cross-sections were measured at ~0.2 nm resolution or less and have an important continuous part for the processes below. The most important resolution effect arises due to presence of lines and is not well known.

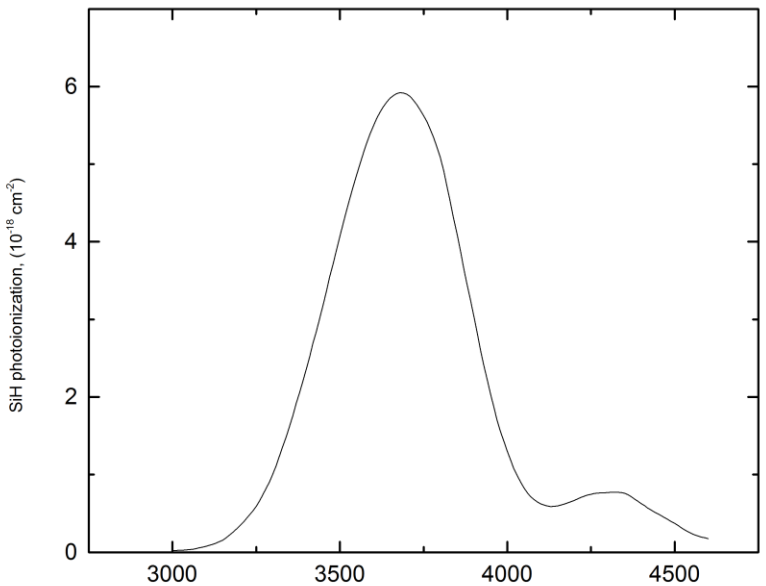




Molecular Photodissociation Effects

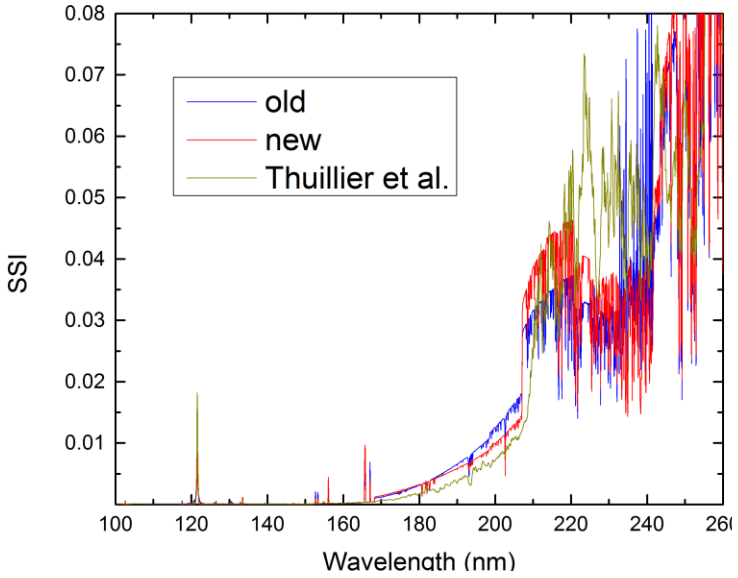
- Issue in the range ~170-200 nm, excessive SSI results from SRPMv2-2011-2013. It was proposed by Avrett & Loeser 2008 that transitions to excited electronic states of CO and SiO could cover that. However, the spectrum they calculate shows very abundant and large intensity fluctuations that have not been observed (e.g. SORCE/SOLSTICE). Thus, a larger opacity than they considered and of more continuous nature would be hiding these lines.

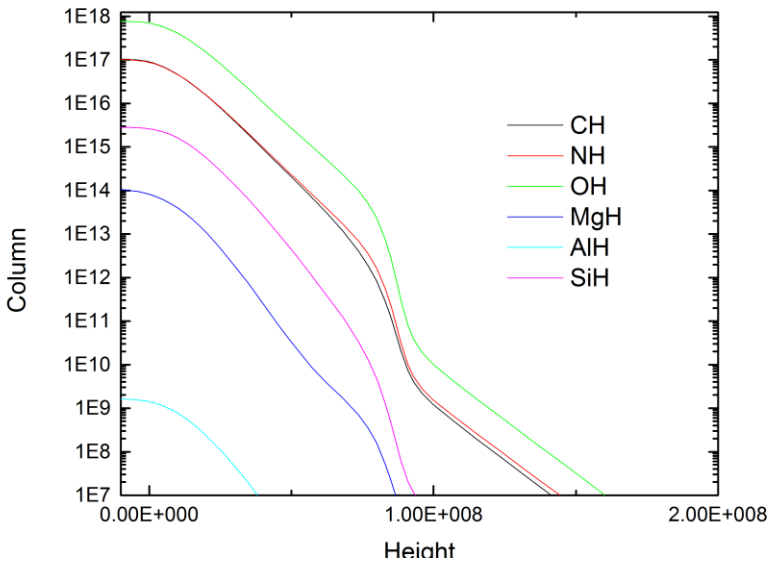
- SiH photodissociation opacity was recently introduced from Stancil et al. (in preparation). Has a small effect the NUV spectrum at wavelengths ~360 nm. However, it has very significant effects on Cr I and V I non-LTE and thereby affects other wavelengths.

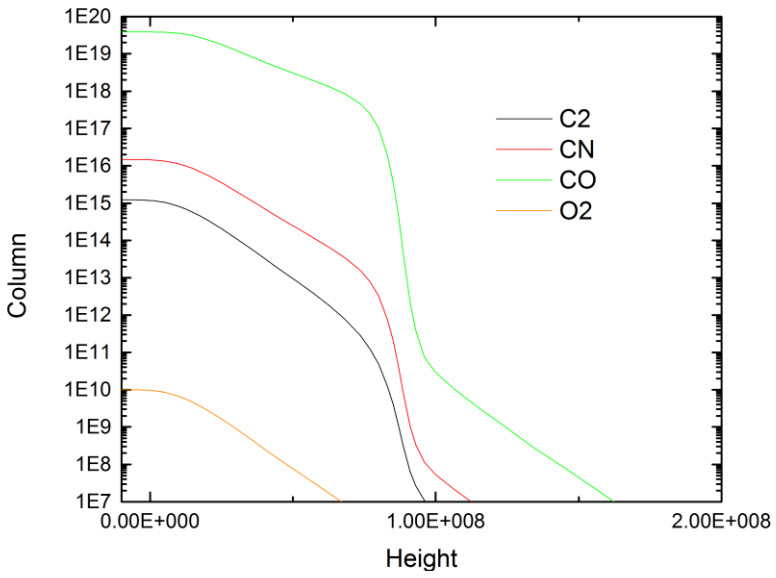


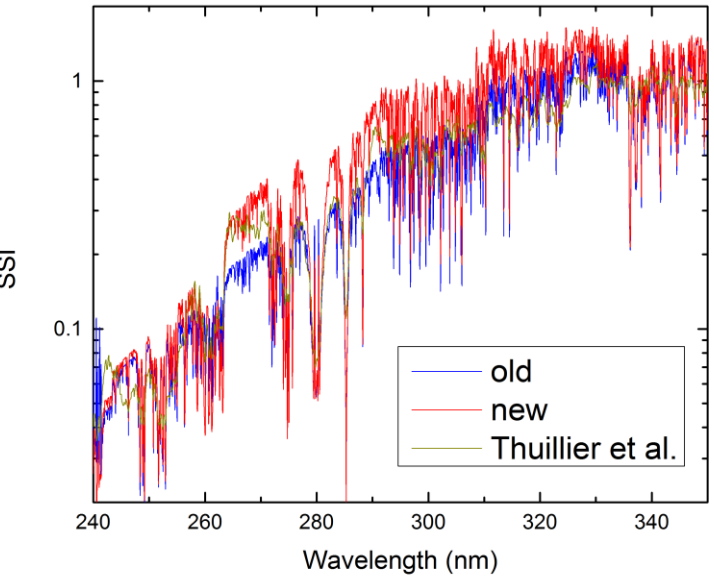
;From Stancil et al. ApJ 1997 (;5000K)

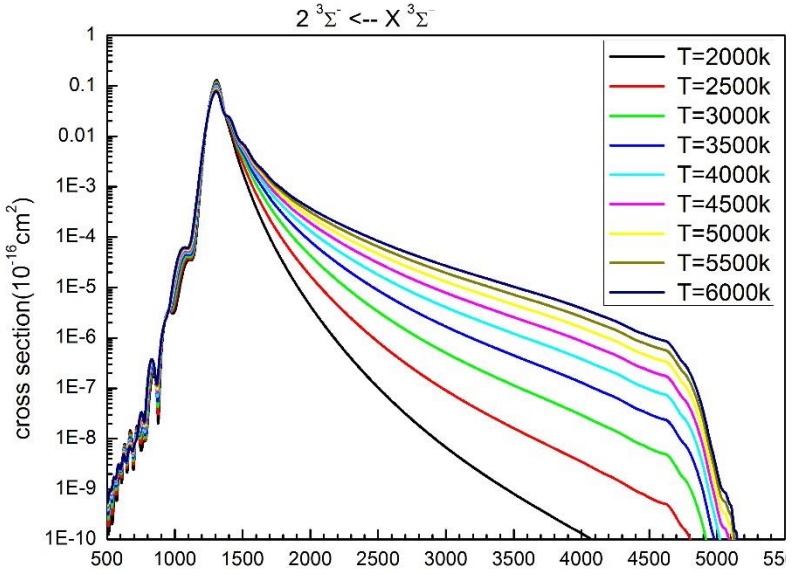
Effects of molecular continuum opacities on the near-UV SSI

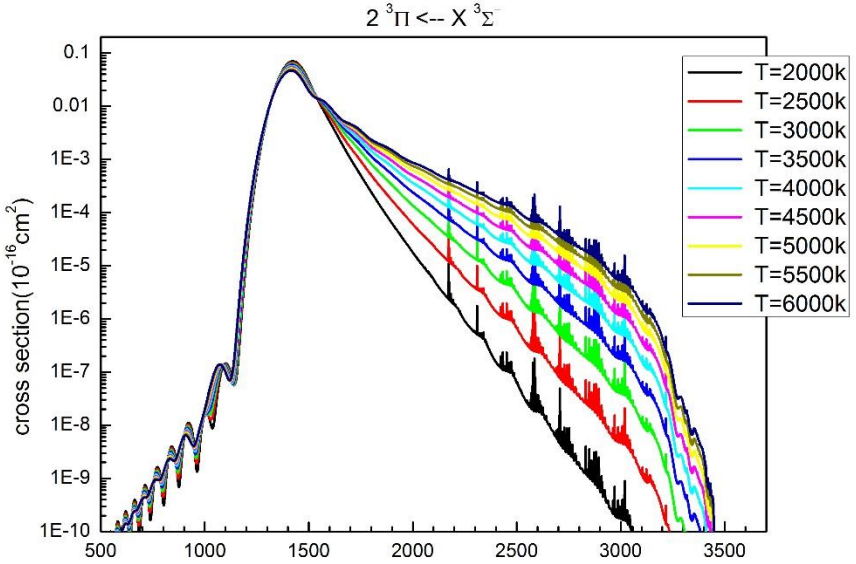






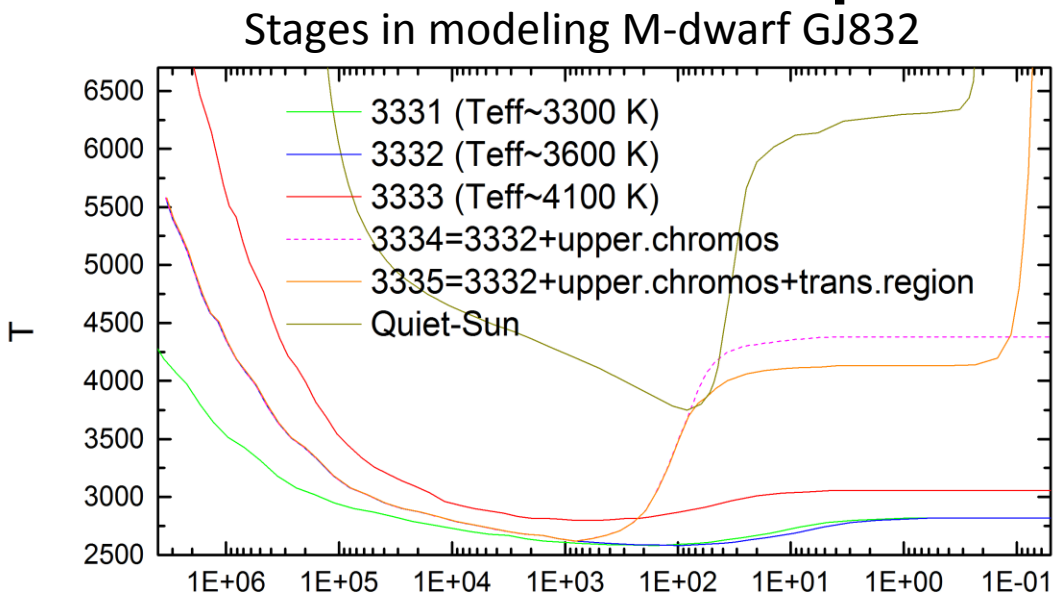


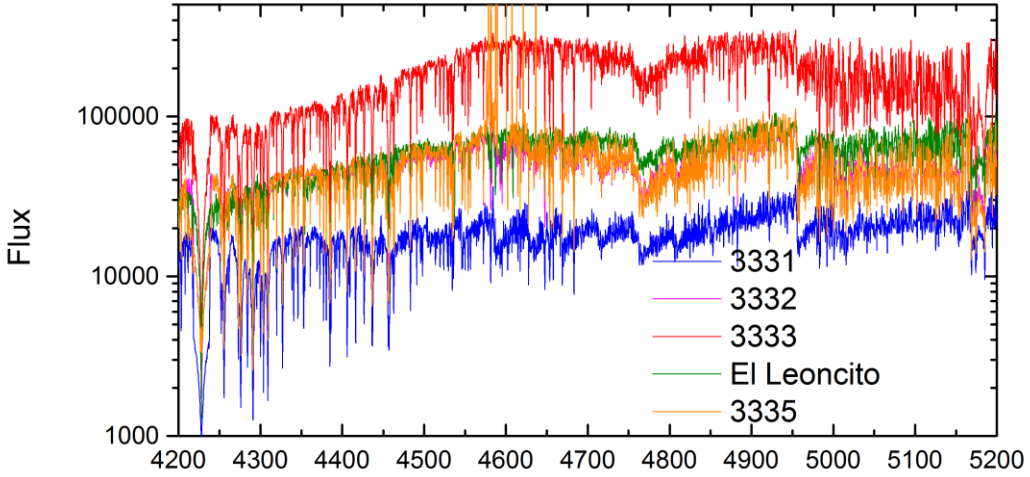


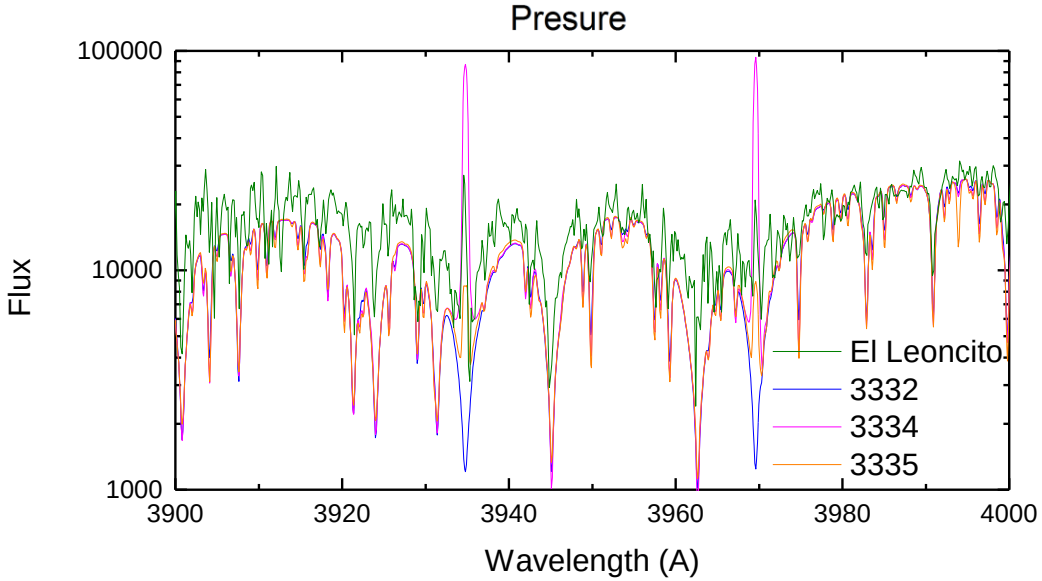


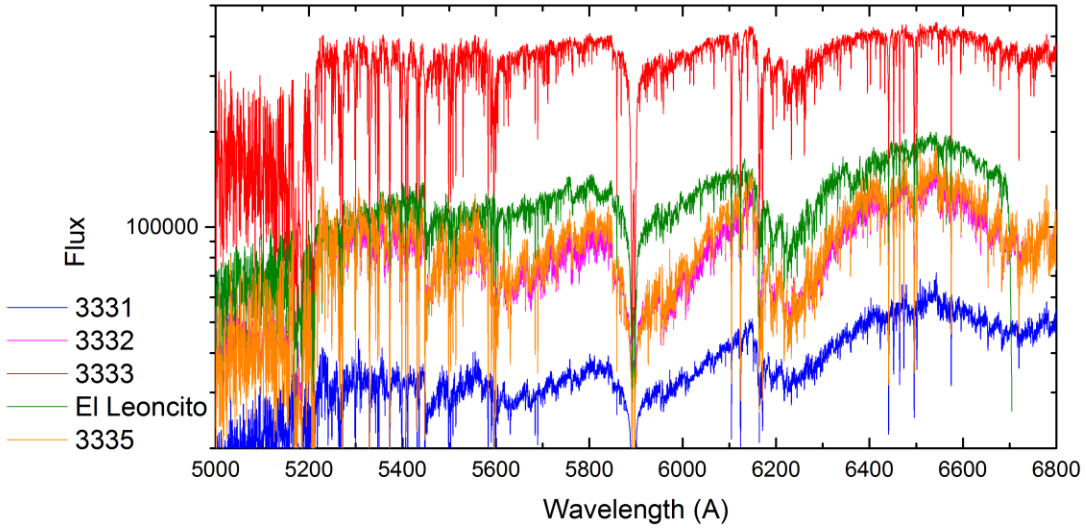
G. Shen, A. Kuri, J. M. Fontenla, P. C. Stancil, and J. G. Wang in preparation

Cool stars, GJ832, semi-empirical-model atmospheres and observations





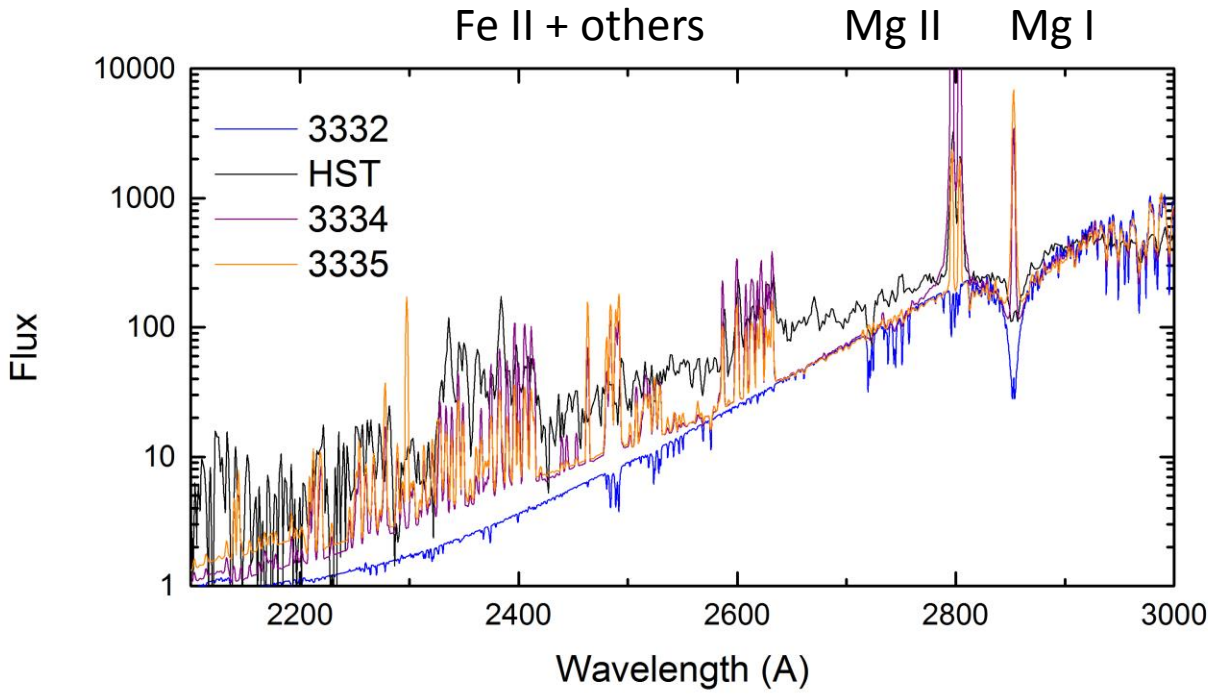


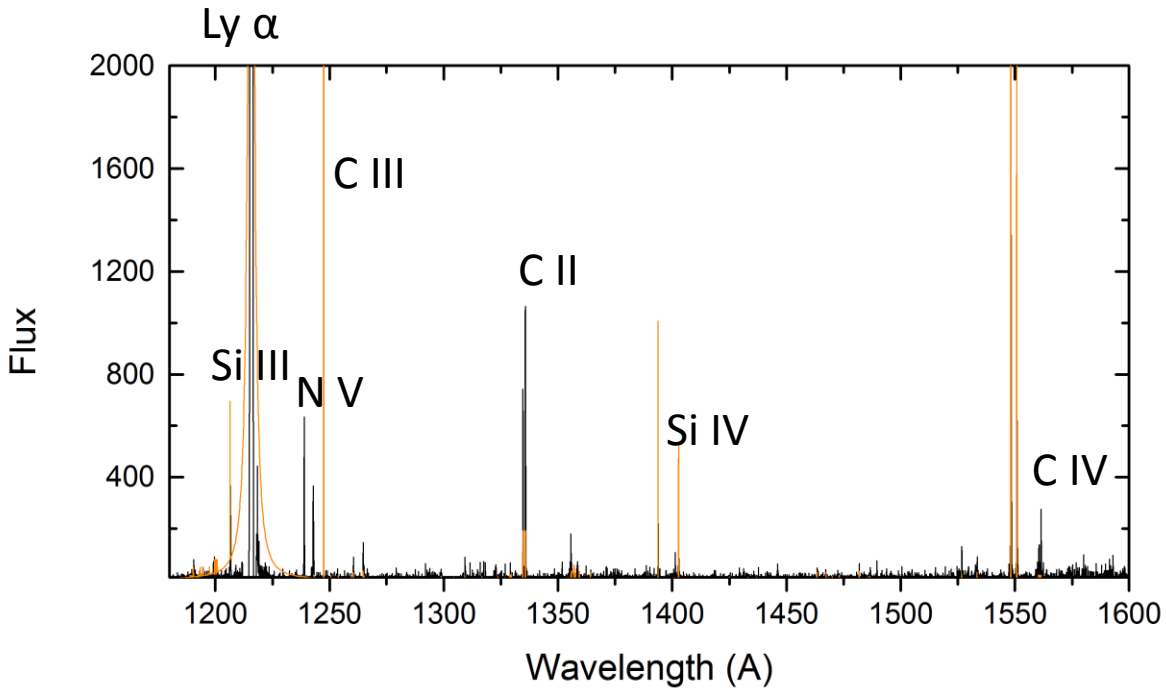


Cool stars UV -> chromosphere and transition-region

NUV background continuum is very low, although shorter than 2600 A is not as low as if there was no chromosphere. Lines from Fe + etc. are in emission instead of the absorption lines in the Sun.

Ly alpha and chromospheric FUV lines, e.g. O I, cannot be observed due to interstellar absorption. Transition-region lines are there but the intensity ratios between them are very different from the Sun.





Lines from other species, and 3D in sunspots

- For cooler stars, and also on sunspots umbrae, TiO lines are now included in SRPMv2 database (~1.4 million of them are the important ones). These improve dramatically the agreement of computed and observed visible spectrum of M type stars. Other relevant cool lines from VO will be included, especially for cooler stars.

- The inclusion of these lines slows down the line-by-line calculation of the spectrum. For molecules in LTE a version of the correlated-k method can speed it up. For now SRPM does line-by line and have switches to turn off molecular lines for some models and on when calculating the cooler stars spectra.

- 3D NLTE model of sunspot is just started, to include illumination from above by the surrounding penumbra.

Pending issues on cool stars

- Important issue is the computation of molecular concentrations. Currently SRPMv2 can calculate sequestration of elements into diatomic molecules, and this can be turned on/off depending on the case.

- However, except for H2, it currently uses LTE formulation. Detailed simulation of molecular reactions is the next step needed, and may lead to some non-LTE effects similar to the well known in H2.

- Other non-LTE effects regarding population of excited vibrational and electronic-states may occur, although are probably less important.

- Interesting differences seem to exist between the FUV line-ratios, that correspond to the transition-region, in the Sun and in various cool stars. These just started to be investigated.