Solar prominence diagnostics from non-LTE modelling of Mg II h&k line profiles

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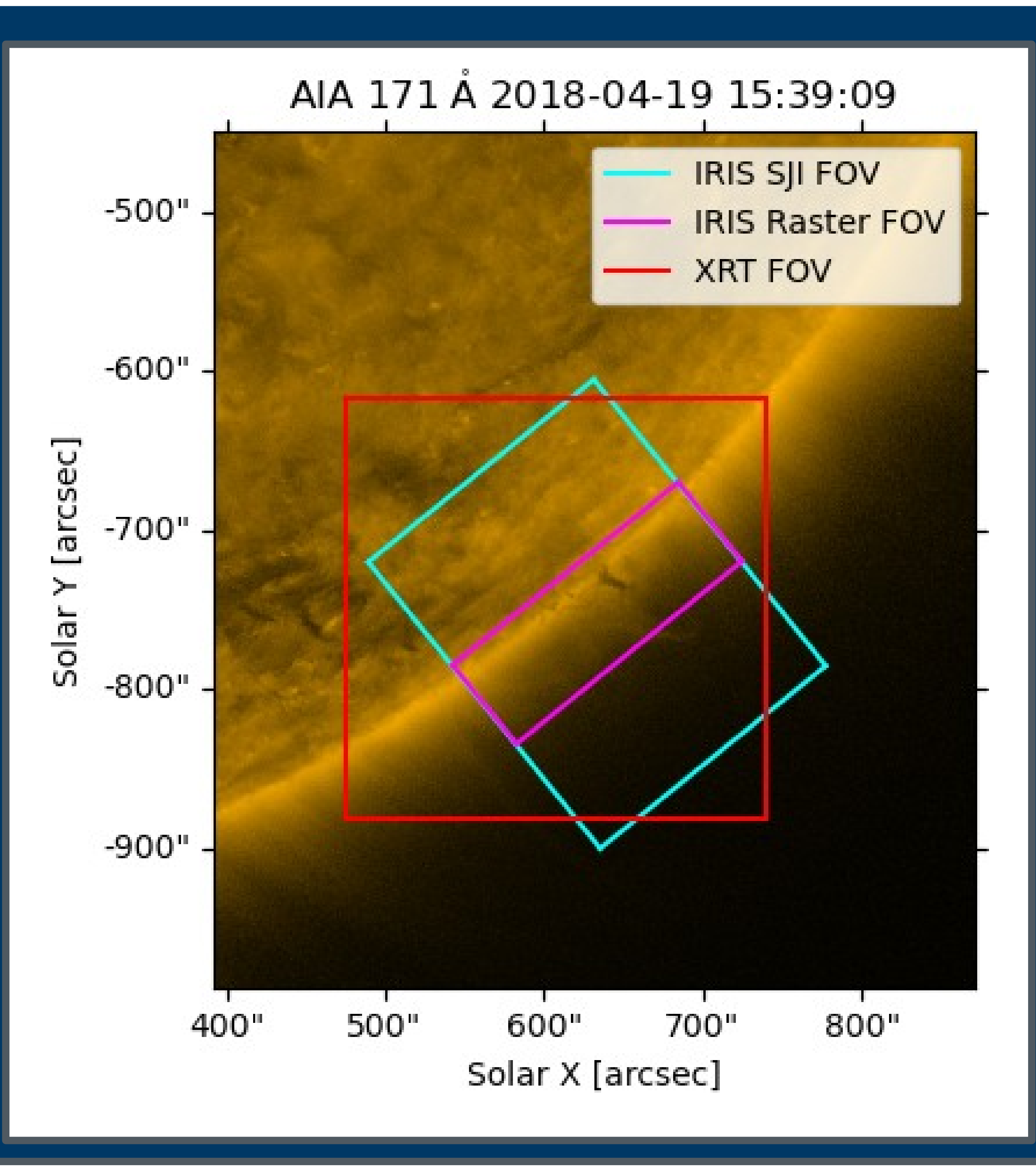
We investigate a new method to for obtaining the plasma parameters of solar prominences observed in the Mg II h&k spectrallines by comparing line profiles from the IRIS satellite to a bank of profiles computed with a one-dimensional non-local thermody-namic equilibrium (non-LTE) radiative transfer code.

A prominence appeared off the south-western solar limb on 19 April 2018. It was observed with IRIS, and Hinode as part of a coordinated observation with MSDP and other ground-based observatories. The IRIS and Hinode observations start from 14:14 and end at 19:15 UTC. The IRIS observations comprise of a set of 18 very large coarse 32-step rasters of the C II , Si IV, and Mg II filters, with their complimentary SJI observations. The Hinode observations consisted of XRT observations with three filter combinations, Al poly/Open, Open/Gband, and Open/Ti. .



Using a one-dimensional NLTE radiative transfer code, PROM, we generated 1007 MgII model profiles, 252 of which are isothermal and isobaric, where the remaining 755 include a PCTR. The parameters of these atmospheres can be seen right table. All of these combinations amount to 1008 models; however, one model did not converge, so we only consider the 1007 that did. The PCTR models adopt the same parametric description of the PCTR as in Anzer and Heinzel (1999). The pressure profile is given as a function of the column mass *m*, by

$$p(m) = 4p_c \frac{m}{M}\left(1 - \frac{m}{M}\right) + p_{\rm tr} \qquad \text{where,} \qquad p_{\rm cen} = p_c + p_{\rm tr}$$

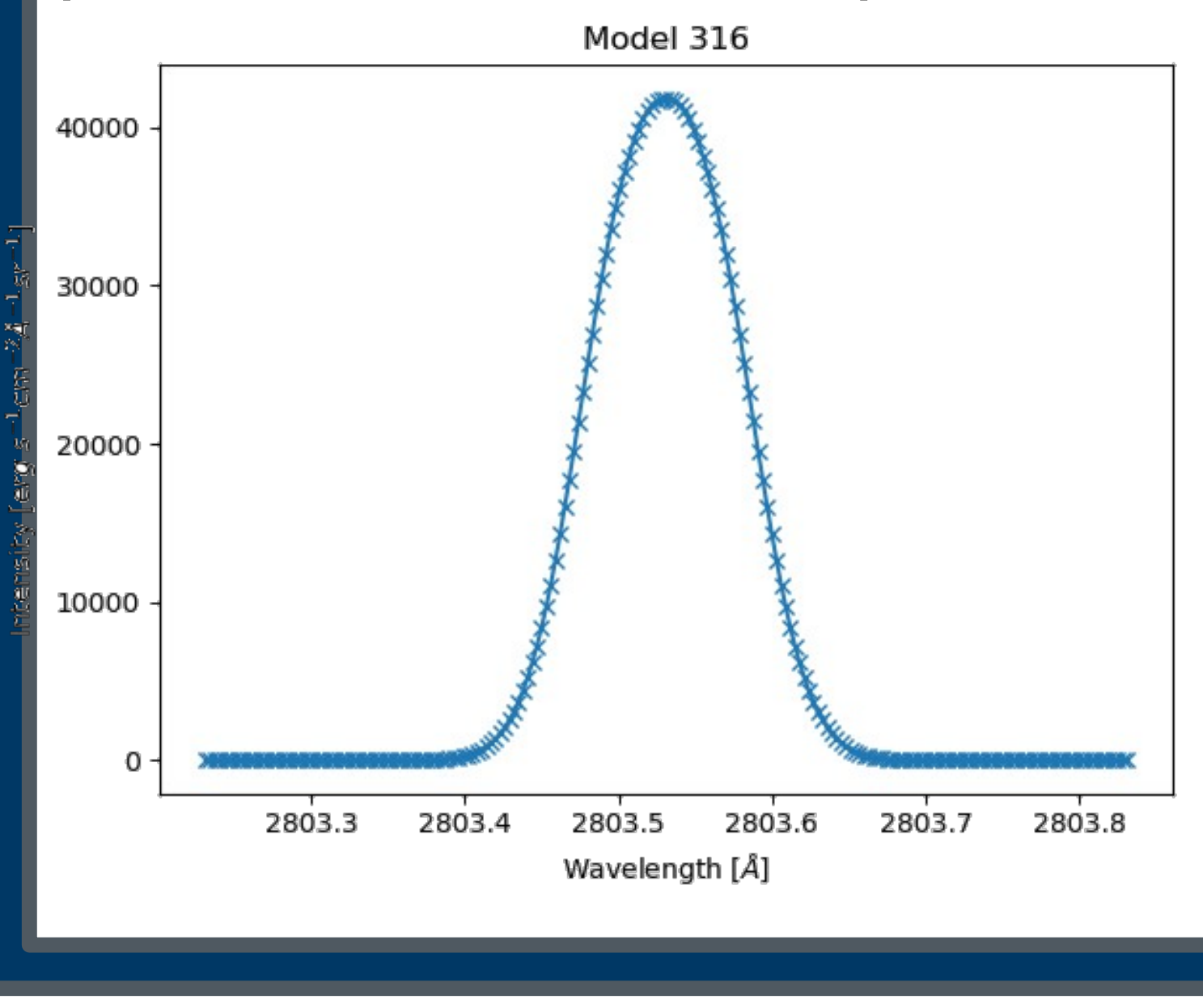
The temperature profile is taken to be,

$$T(m) = T_{\rm cen} + (T_{\rm tr} - T_{\rm cen})\left(1 - 4\frac{m}{M}\left(1 - \frac{m}{M}\right)\right)^{\gamma}$$

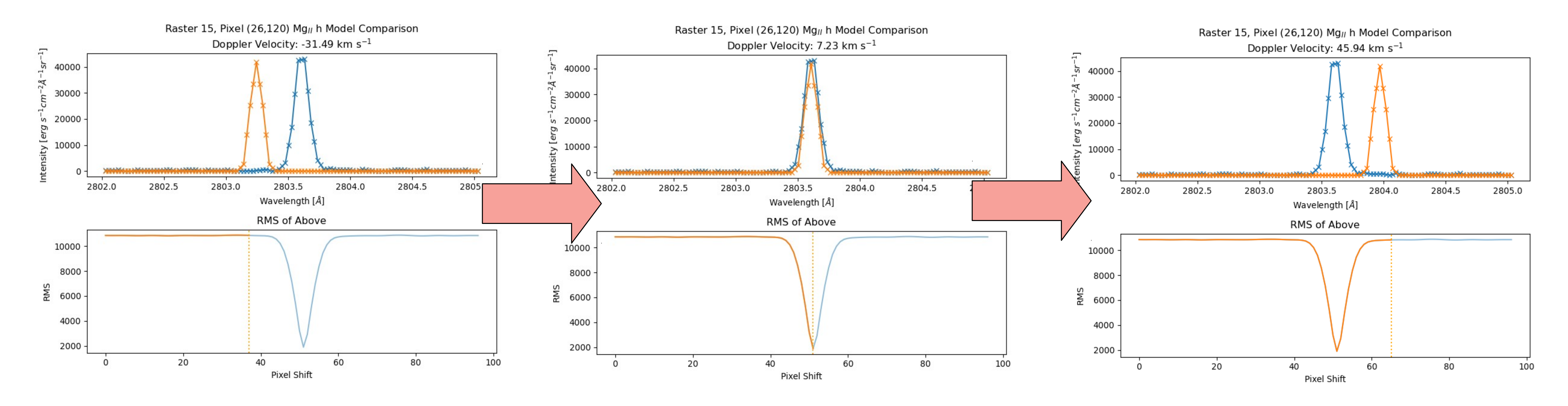
γ is a dimensionless number that dictates the extent of the PCTR. A γ value of 0 indicates the model is isothermal and isobaric – with no PCTR. γ, however, cannot physically be zero, it is a placeholder.

Parameter	Unit	Value
$T_{\rm cen}$	K	6000, 8000, 10000, 15000, 20000, 25000, 30000, 35000, 40000
$T_{\rm tr}$	K	100000
$p_{\rm cen}$	dyne cm^{-2}	0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1
$p_{\rm tr}$	dyne cm^{-2}	0.01
Slab Width	km	200 – 124100
M	g cm^{-2}	3.7×10^{-8}–5.1×10^{-4}
v_T	km s^{-1}	5
H	km	1000
γ		0, 2, 5, 10

To match these line profiles directly with IRIS observations, we must first degrade the line profiles to match the spectral resolution of IRIS.

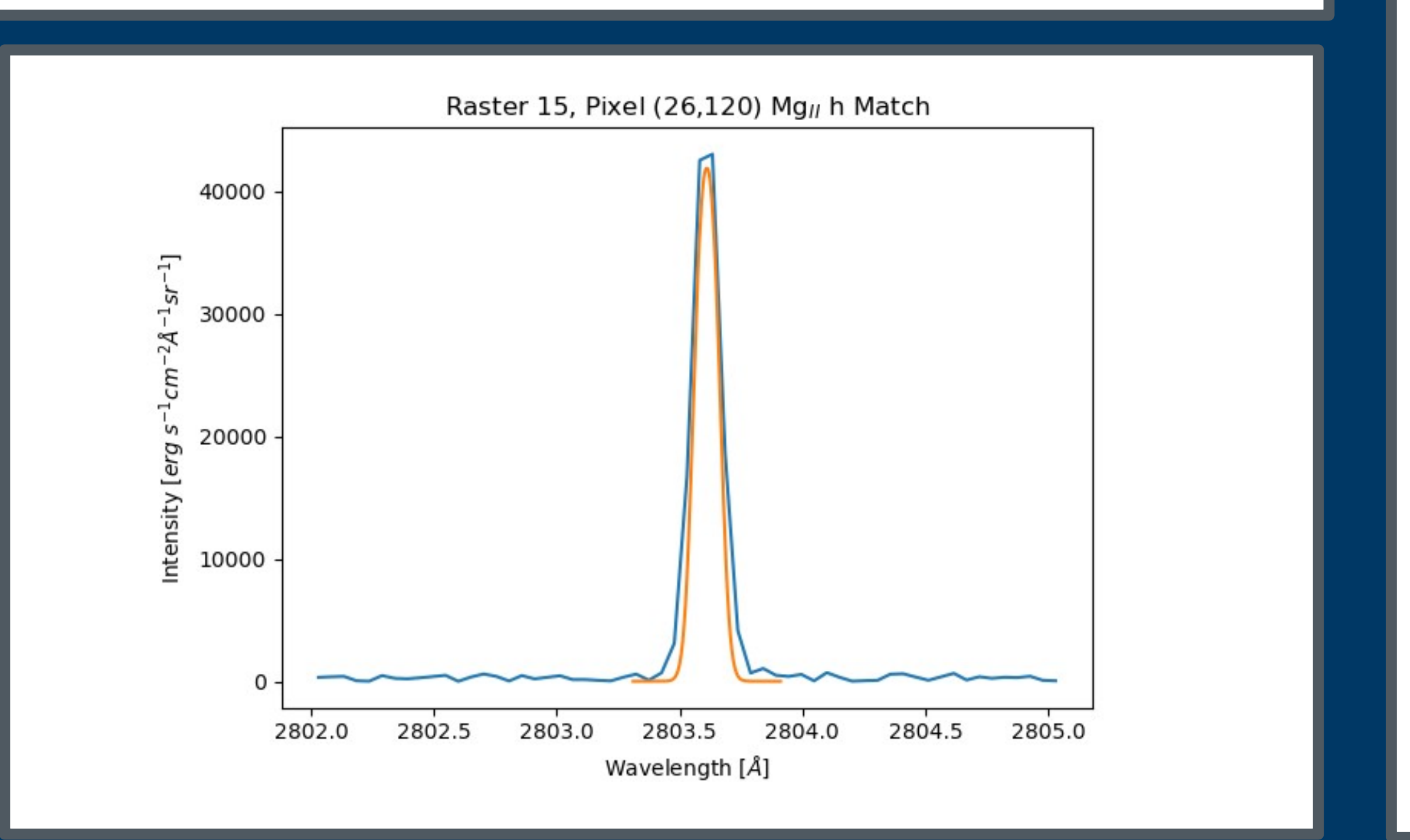


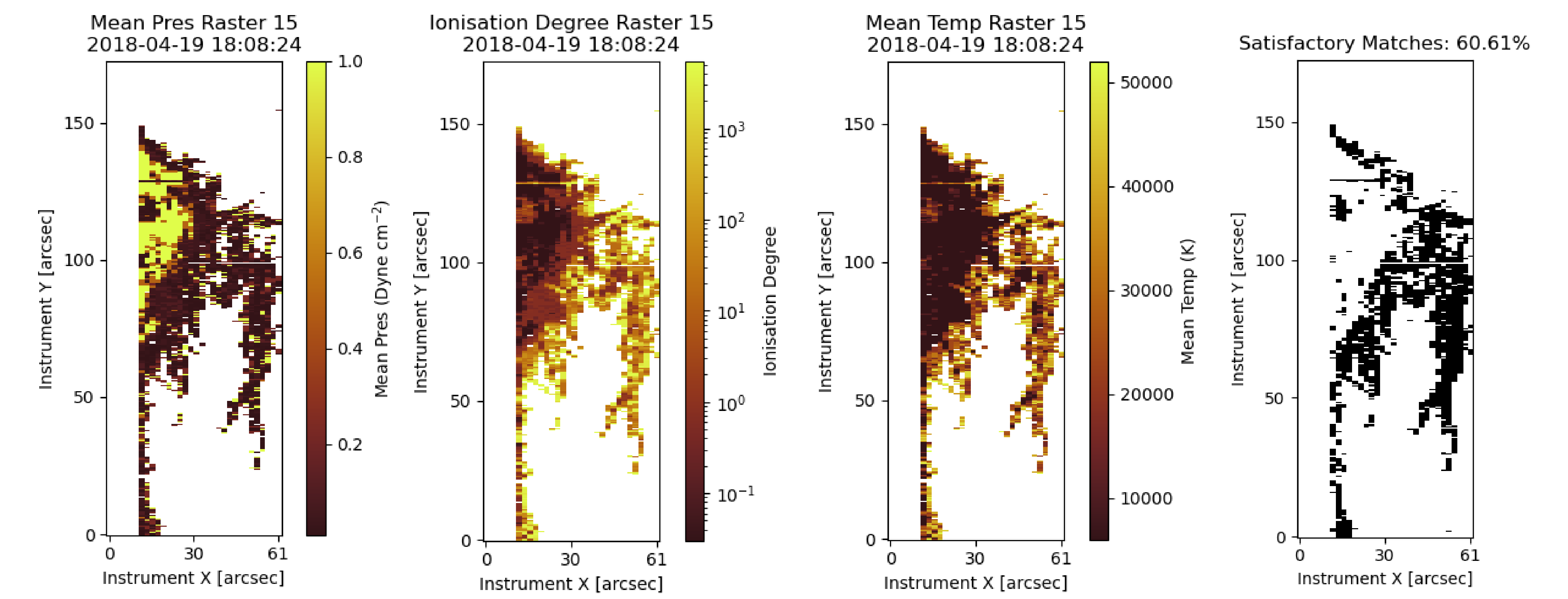
We also employ sub-pixel interpolation to allow us to get better matches. As many observed peak seem to be "in between" pixels.



We wish to match these synthesized line profiles with observations. However, these synthesized profiles are formed at exactly the rest wavelength of the line(s). This is rarely (if at all) seen in reality. To account for this, we "roll" the synthesized line profiles through some window (here, 3Å) centred on the rest wavelength of the lines, measuring the RMS at every position.

This allows us to find the "best fitting" line, independent of doppler velocity. As we measure RMS, we also have a statistic to determine how well a synthesized profile fits the observations.





In total, 49%, (35617/72536 pixels) were found to have satisfactory fits. Sections closer to the centre of the prominence did not yield any satisfcatory matches. This suggests that the grid of models was used was not diverse enough and/or complex lines profiles are found in this area. Mean pressure and temperature appear to remain stable during the observation, fluctuating on average between 0.18 and 0.26 dyne cm^{-2} and between 7800K and 11500K. Past studies show that the ionisation degree (nHII/nHI) is within 0 to 10. However, these past studies never considered temperatures above 15000K. Above these temperatures, the ionisation degree increases exponentially. The higher temperatures that we recover lead to a higher ionisation degree.