Optical observations of thermospheric neutral temperature in aurora

Daniel Whiter and David Price, University of Southampton, UK

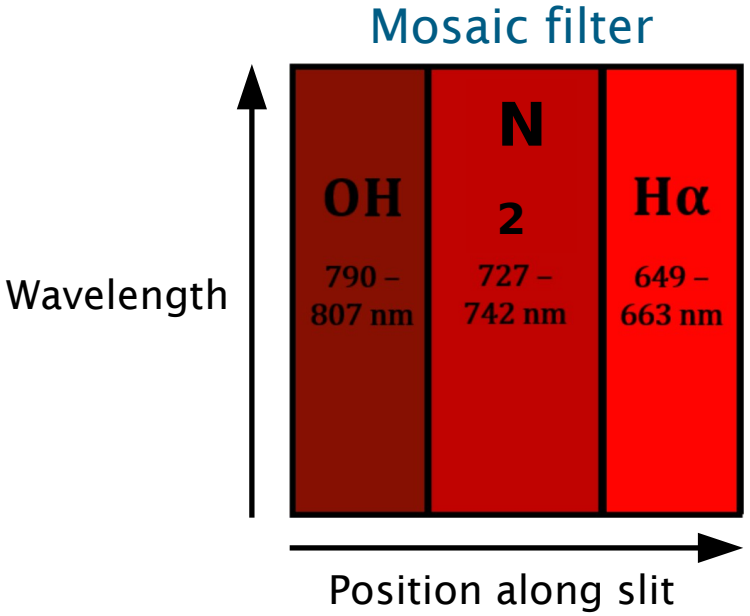
Key points

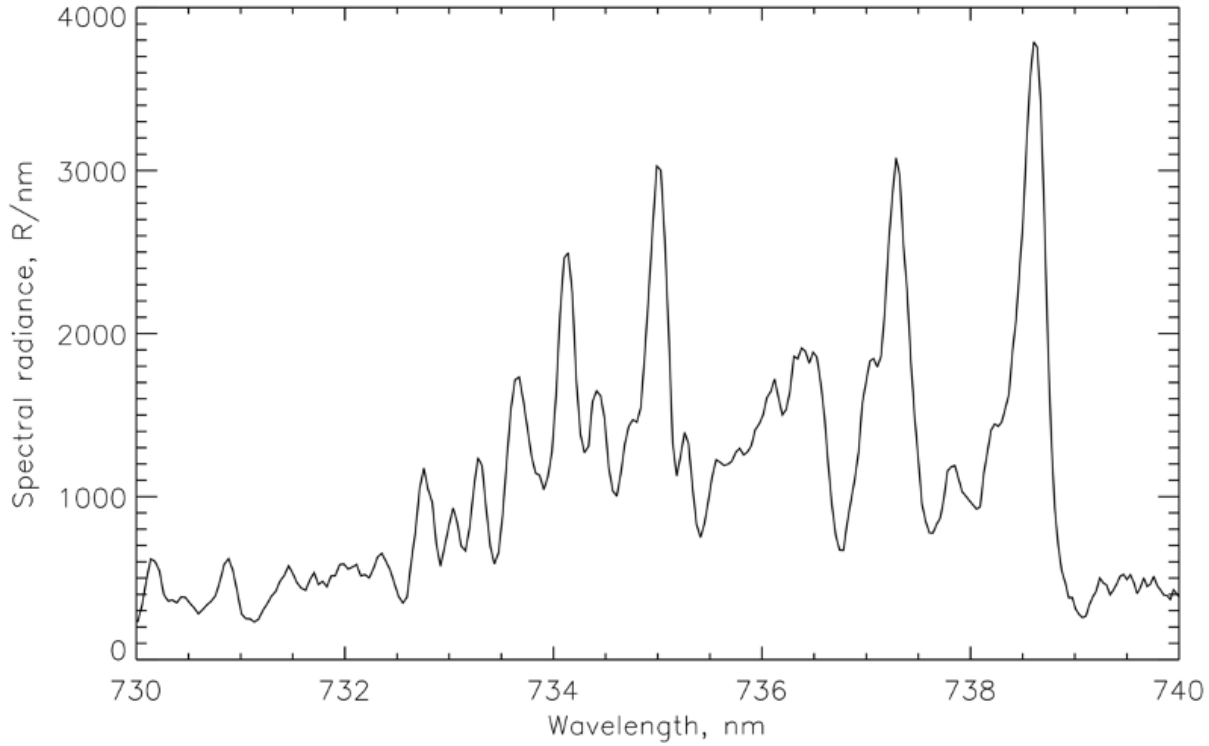
- Aurora is substantial energy source in polar upper atmosphere through heating
- Spatial and temporal variability of heating not yet well quantified
- New technique to measure neutral temperature altitude profile in aurora at high cadence (0.5s)
- Event study shows Joule heating adjacent to an arc, and heating embedded within auroral curls

d.whiter@soton.ac.uk

Spectrographic measurements of N_2 ^1P aurora

- High Throughput Imaging Echelle Spectrograph (HiTIES)
- Svalbard, high Arctic (78ºN)
- ~0.1nm resolution, 0.5s cadence
- Imaging detector, so spatial information along slit



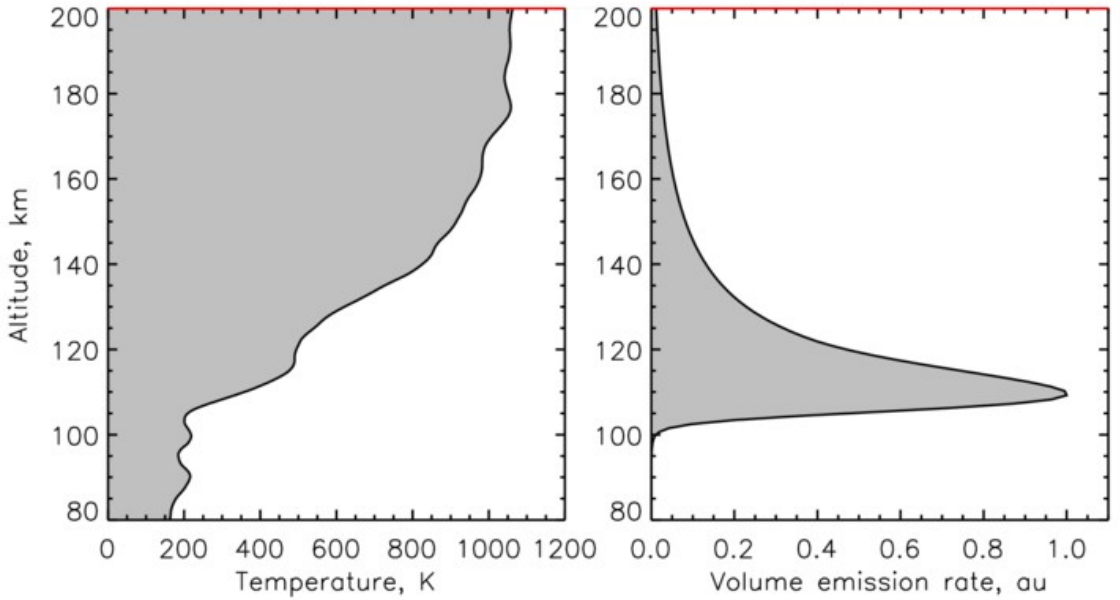


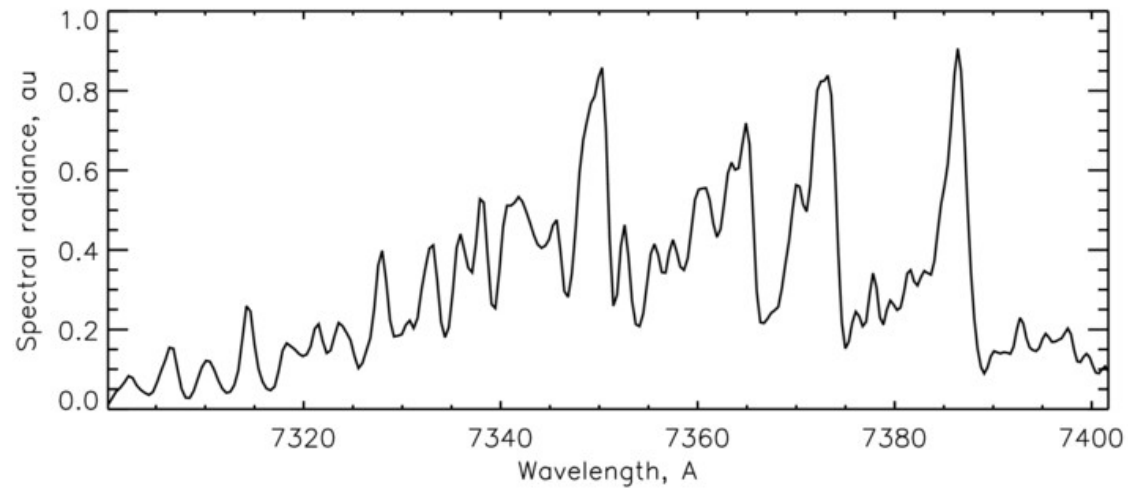
Example observed N_2 spectrum, shape is temperature dependent

d.whiter@soton.ac.uk

Inversion to neutral temperature profile

- Measured N_2 spectrum represents a height-integrated temperature profile
- Volume emission rate (VER) profile obtained from model + optical/radar observations
- "Simulated annealing" technique finds neutral temperature profile which best matches observed spectrum

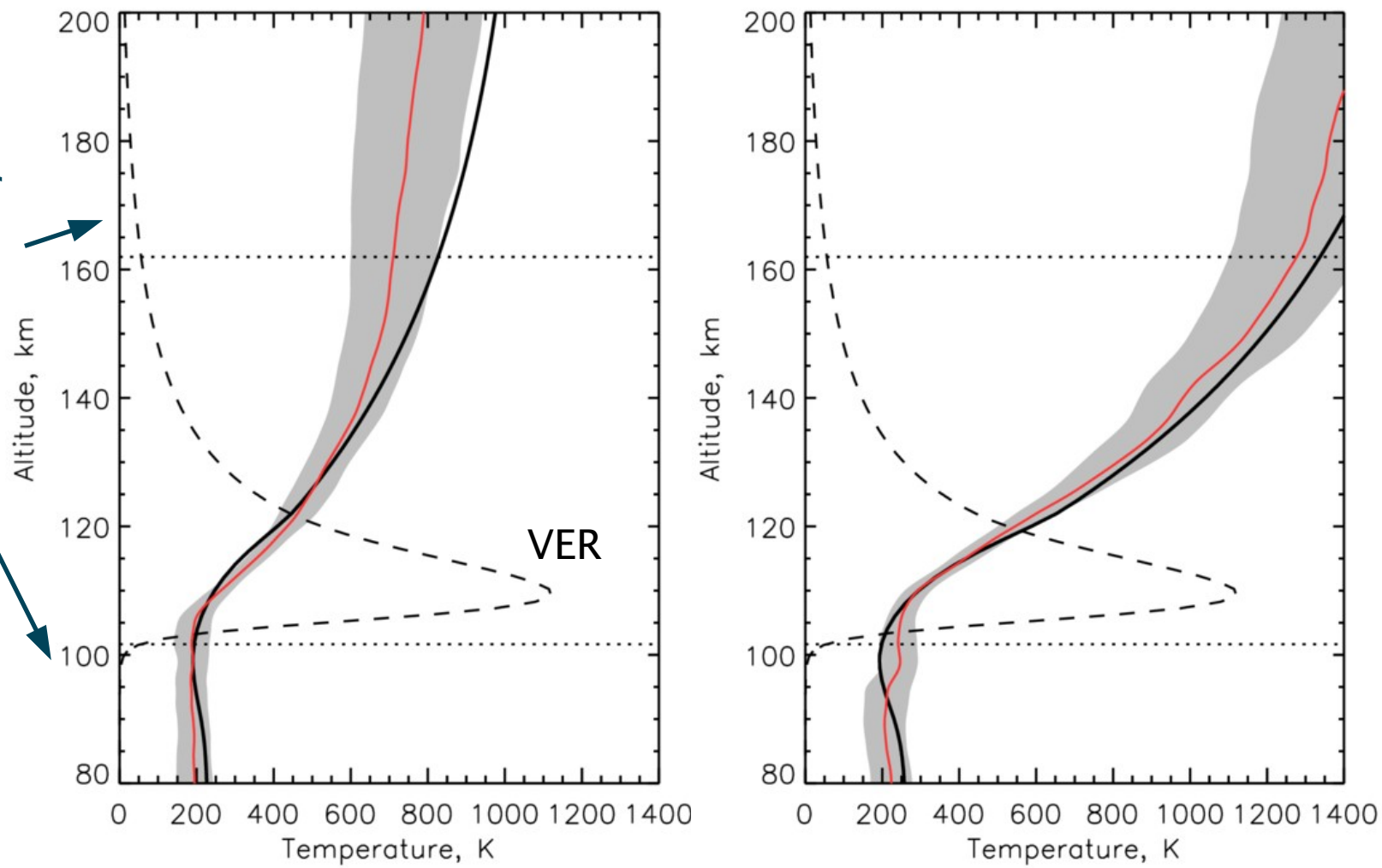




d.whiter@soton.ac.uk

Validation

- Best results near VER peak
- Where VER < 5% of maximum, results ignored
- Peaks are smoothed out
- Inversion does a good job overall!

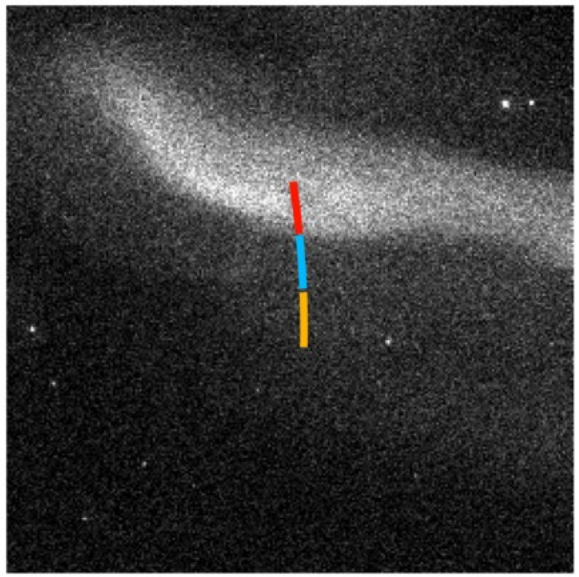


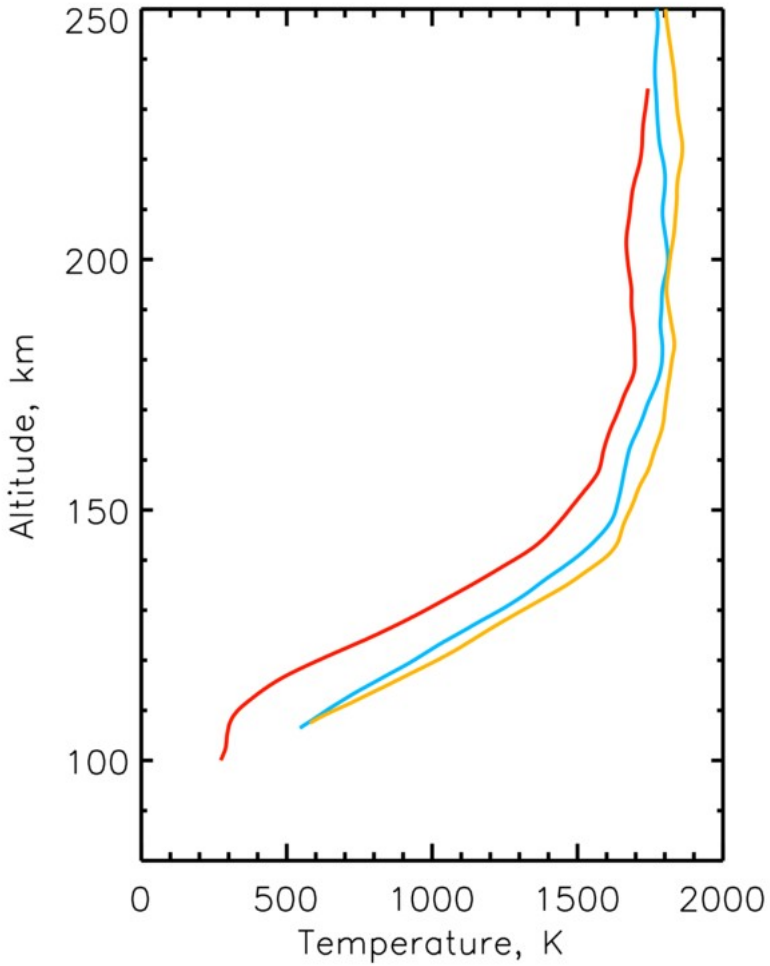
d.whiter@soton.ac.uk

Results: Joule heating adjacent to arc

= spectrograph slit, divided in 3 parts

6°
~10 km in E-region





Neutral temperature profiles from the 3 parts of the slit

Hotter adjacent to the bright arc (yellow and blue)

d.whiter@soton.ac.uk

Results: Joule heating adjacent to arc

= spectrograph slit, divided in 3 parts

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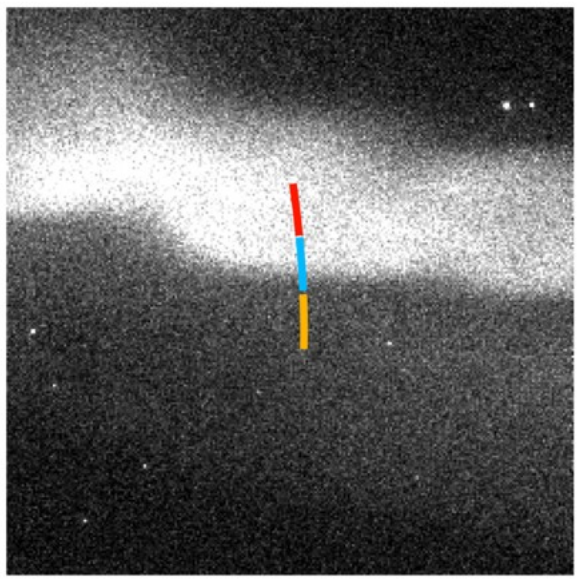

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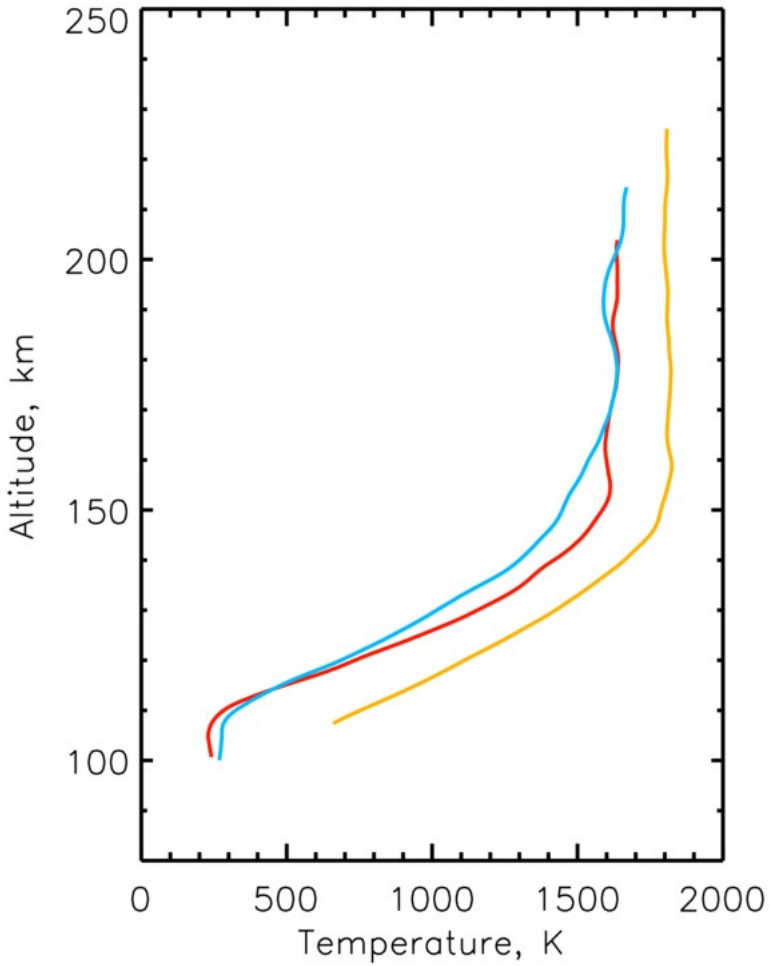


E-field strongest next to an arc

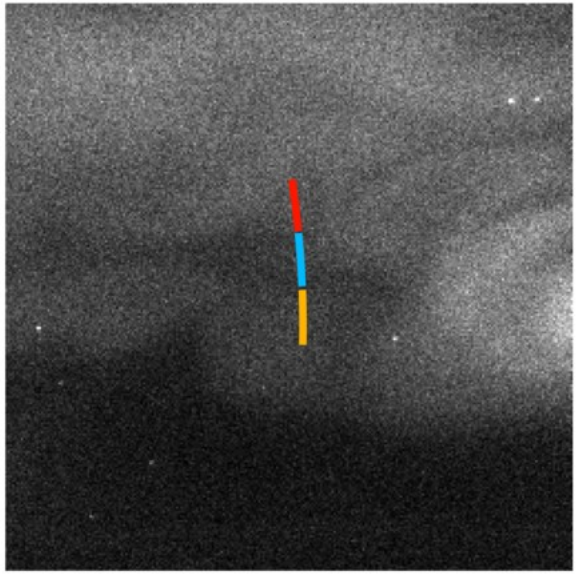
Joule (frictional) heating from velocity difference between ions and neutrals, where E-field is strong

Hotter adjacent to the bright arc (yellow and blue)

d.whiter@soton.ac.uk

Results: Heating in auroral curls

A. Before curl



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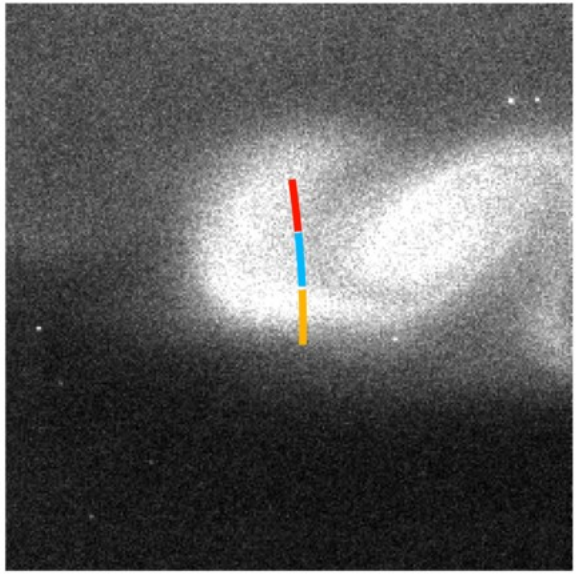
B. Curl in slit



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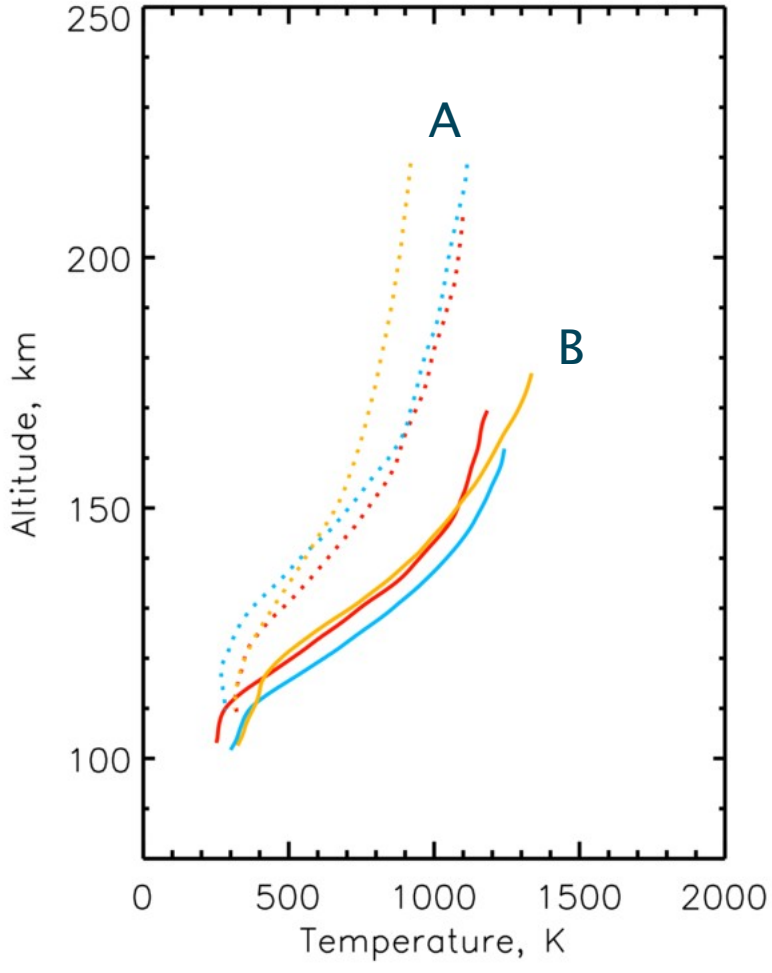

- Hottest in the bright curl
- Strong field-aligned current
- Cools following curl (not shown)

d.whiter@soton.ac.uk

Further information

- D. J. Price et al., High-Resolution Optical Observations of Neutral Heating Associated With the Electrodynamics of an Auroral Arc, JGR, 2019, doi:10.1029/2019JA027345
- David Price, Observations of thermospheric heating signatures associated with sub-kilometer scale auroral electrodynamics, PhD Thesis, University of Southampton, UK, 2021, https://eprints.soton.ac.uk/455066/

d.whiter@soton.ac.uk