

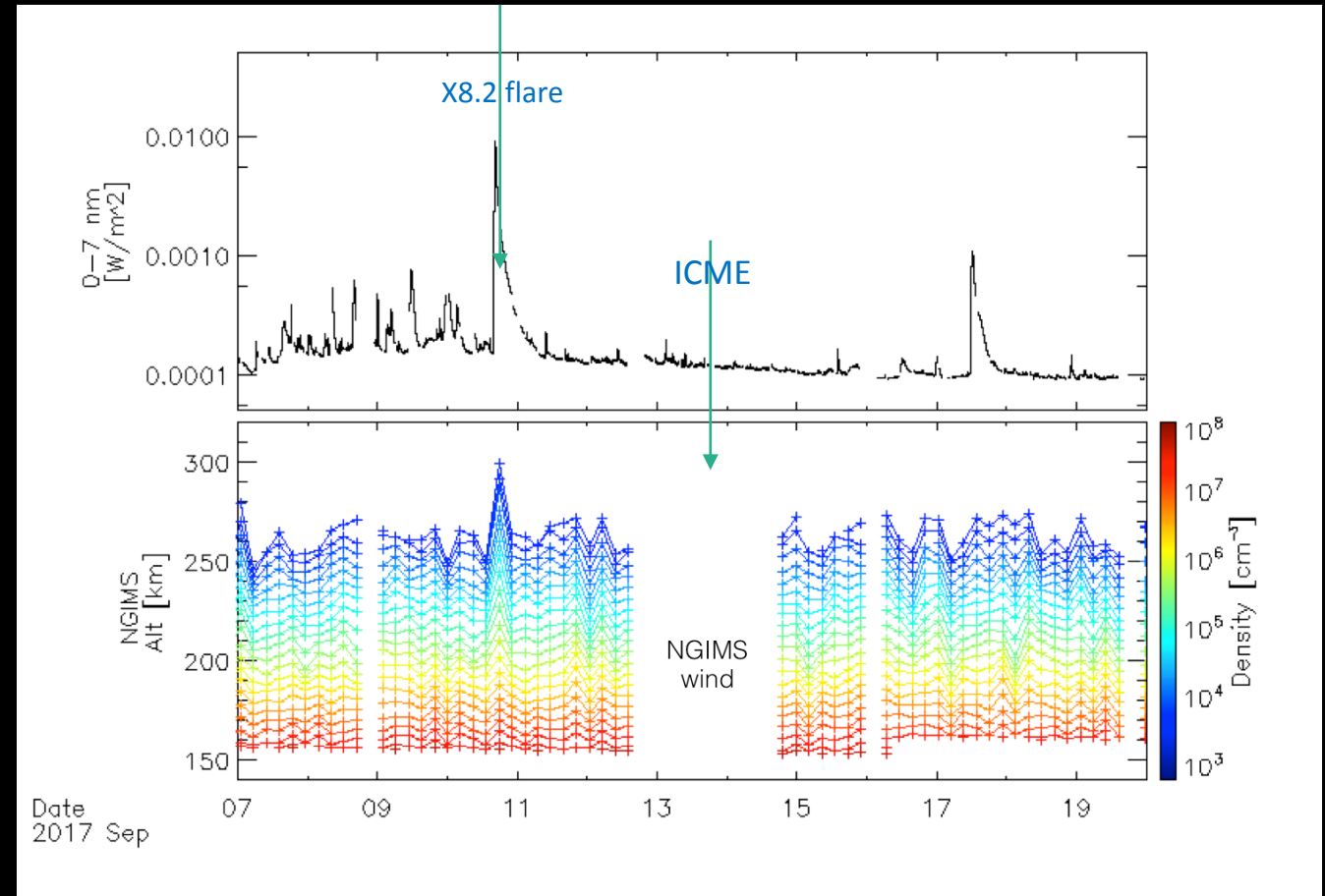


**September 2017 Solar Flare Event:
Rapid Heating of the Martian
Neutral Upper Atmosphere from
the X-class Flare as observed by
MAVEN**

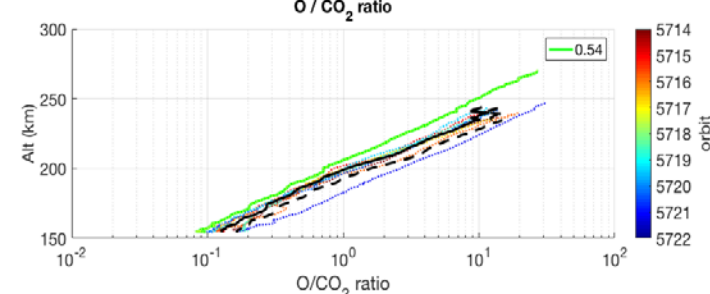
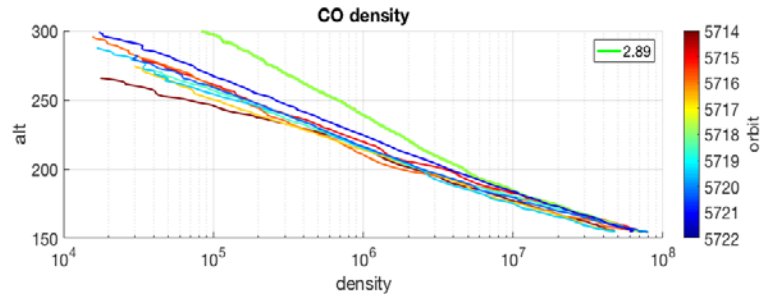
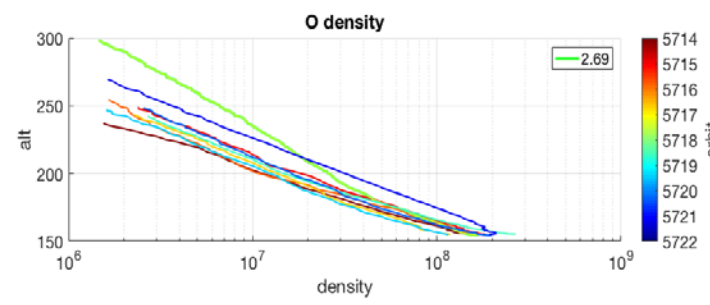
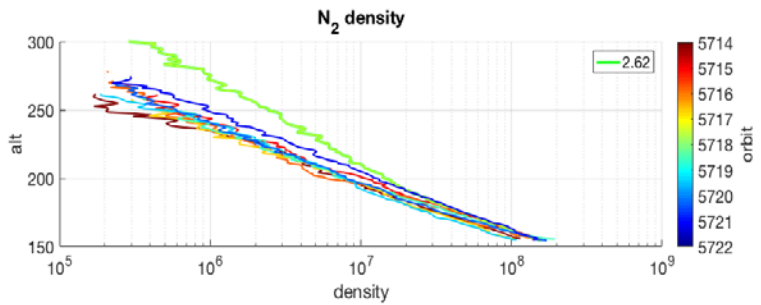
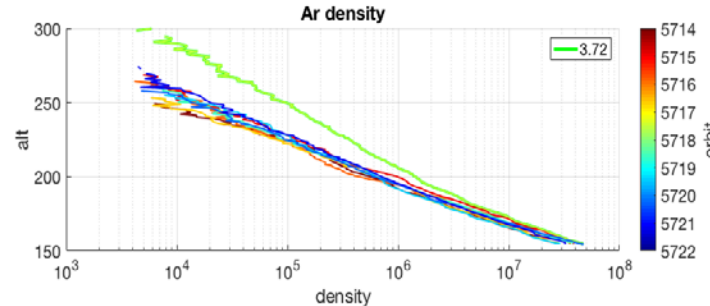
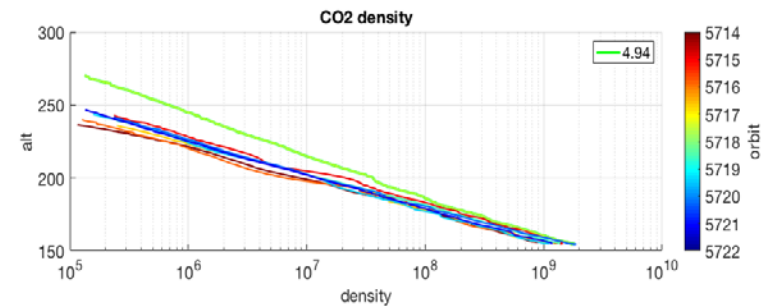
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Solar flare event 10-11 Sept 2017

- X-class flare (8.5 strength) detected 10 Sept peaking at UTC 16:39
- MAVEN periapsis inbound began UTC 17:30
- ICME followed flare 13-14 September
- NGIMS Observed a peak in the upper atmospheric densities of Ar, CO₂, N₂, CO, and O
- Steep change in the scale height of Ar and N₂ indicate a dramatic increase in atmospheric temperature that dropped immediately after the flare passed



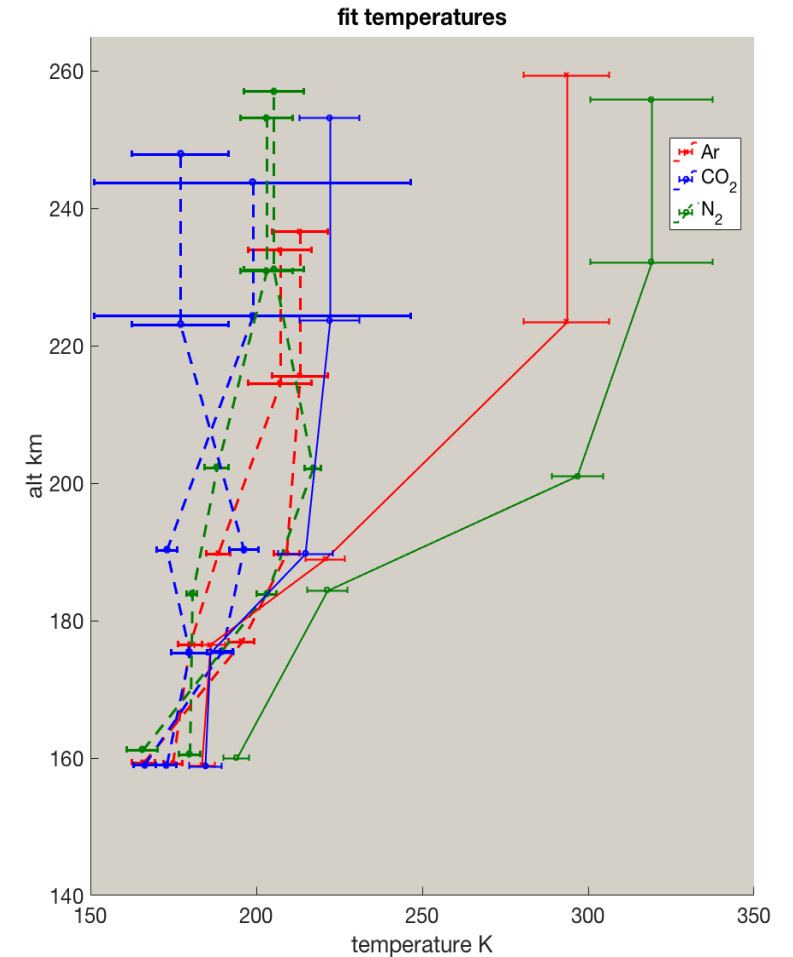
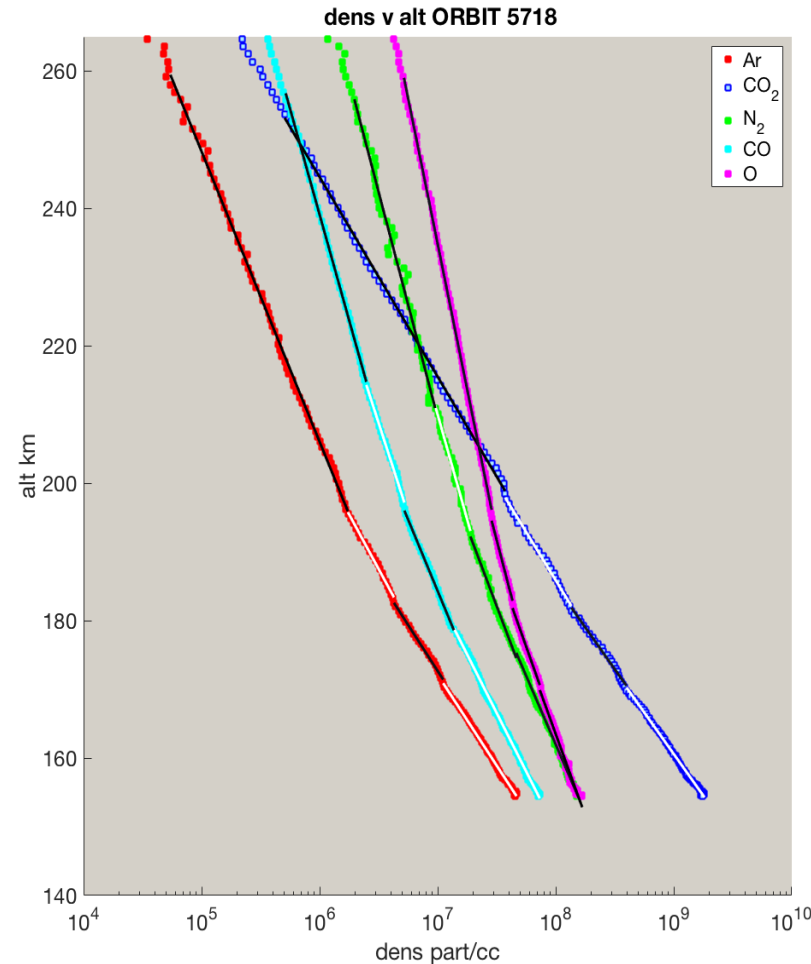
NGIMS atmospheric response to EUV heating



Inbound NGIMS density plots for CO₂, Ar, N₂, O, and CO. red – yellow are pre-flare orbits, green is orbit 5718, the flare orbit, and blue to violet are the post flare orbits. Each orbit is 4.5 hours. The relaxation of the atmosphere within 1 orbit of the end of the flare indicates that the heating of the atmosphere lasts approximately the length of the flare.

Neutral Scale Height and Temperature

Left: Ar (red), CO₂ (blue), N₂ (green), CO (cyan), and O (magenta) from orbit 5718 (flare orbit) and scale height fits at 4 ranges along the inbound profile. Right: Temperature derived from the scale height fits ($H = mg/kt$). Dashed lines indicate before and after the flare, solid is the flare orbit. Ar (red), N₂(green), CO₂(blue)



Species	Scale Height (km)	Temperature (K)
Ar	11.9841	191.62
	Lower: 11.4820 Middle: 11.6313 Upper: 13.8056 Top: 18.3535	Lower: 183.59 Middle: 185.97 Upper: 220.74 Top: 293.46
	12.5323	200.38
N ₂	17.0880	191.26
	Lower: 17.3343 Middle: 19.7742 Upper: 26.5137 Top: 28.5043	Lower: 194.01 Middle: 221.32 Upper: 296.75 Top: 319.03
	17.8332	199.60
CO ₂	10.1968	179.34
	Lower 10.4984 Middle: 10.5796 Upper: 12.2129 Top: 12.6252	Lower: 184.65 Middle: 186.07 Upper: 214.80 Top: 222.05
	10.2678	180.60

Conclusions & summary

- While CO₂ had a large increase in density in the upper atmosphere, had the smallest scale height change, likely because CO₂ can cool at certain vibrational modes generally excited at these EUV energies.
- O and CO had steep scale height changes (11-15 km) during the flare most likely as a result of photochemistry from the EUV interaction in the top side ionosphere (Thiemann et al., 2018)
- Best measurement of the atmospheric heating from the non-reactive species N₂ and Ar indicating a 100 – 130 k heating due to the flare. The slightly higher temperature exhibited by N₂ is something to still be modeled.