Is the He abundance of the slow wind regulated by collisions in the solar atmosphere?

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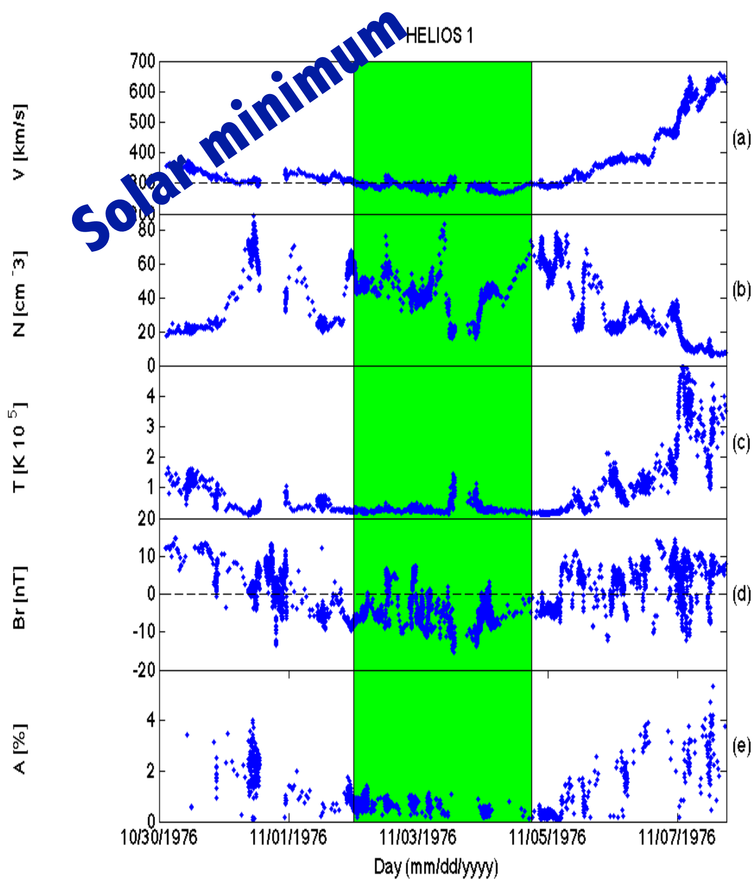
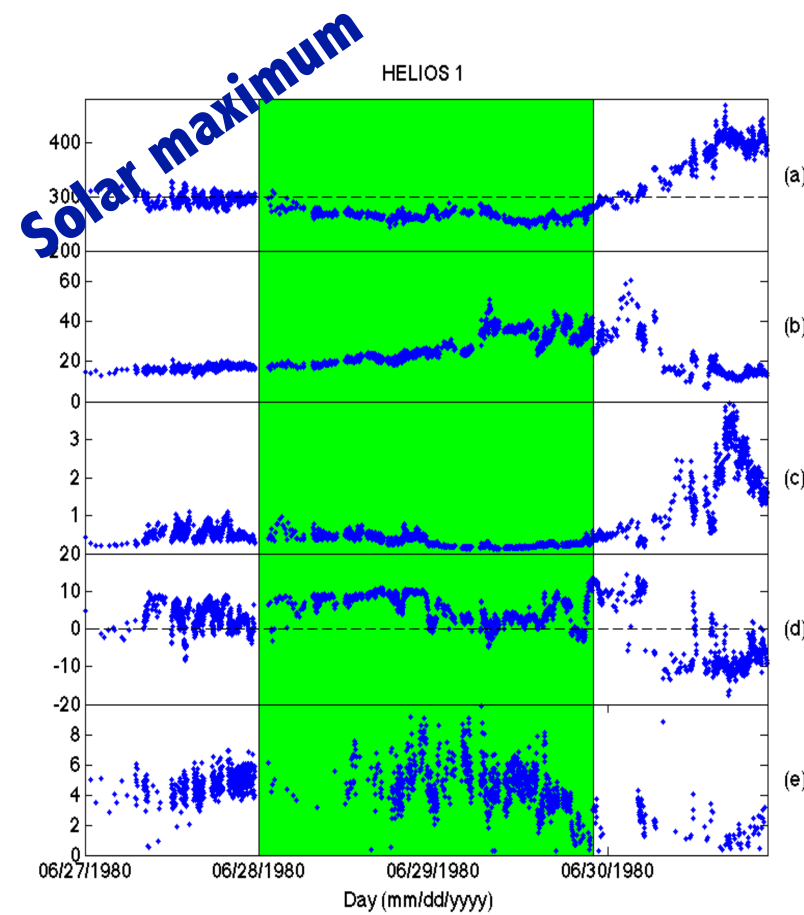
Two VSSW events in solar minimum and maximum





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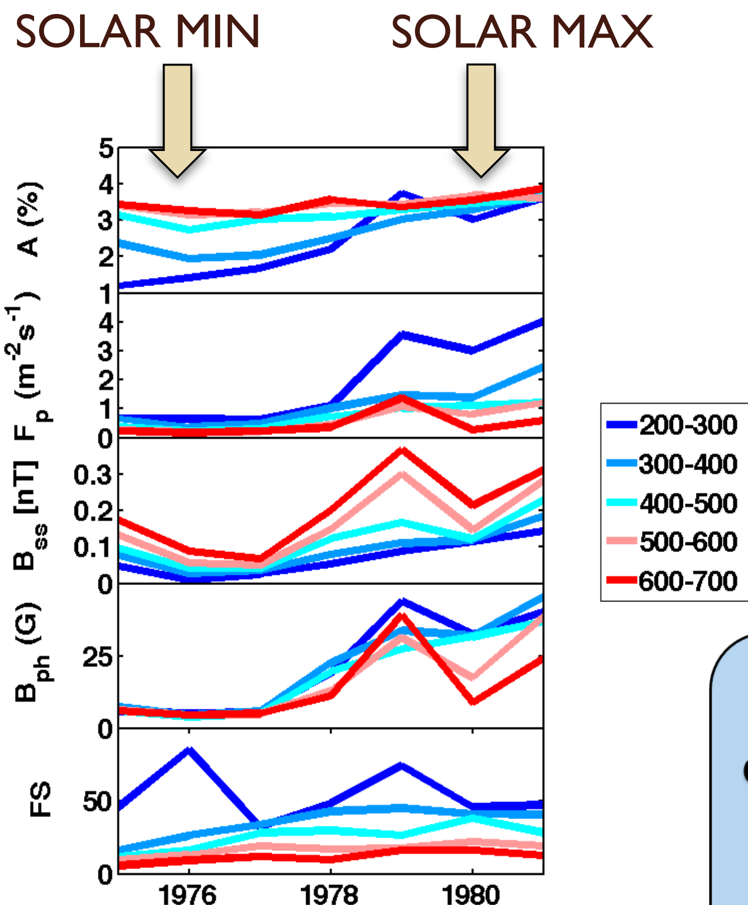
Solar cycle variability



Sanchez-Diaz et al. (2016)

very slow wind (blue), same trend for:

-He abundance

-$n_p v_p$(photosphere)

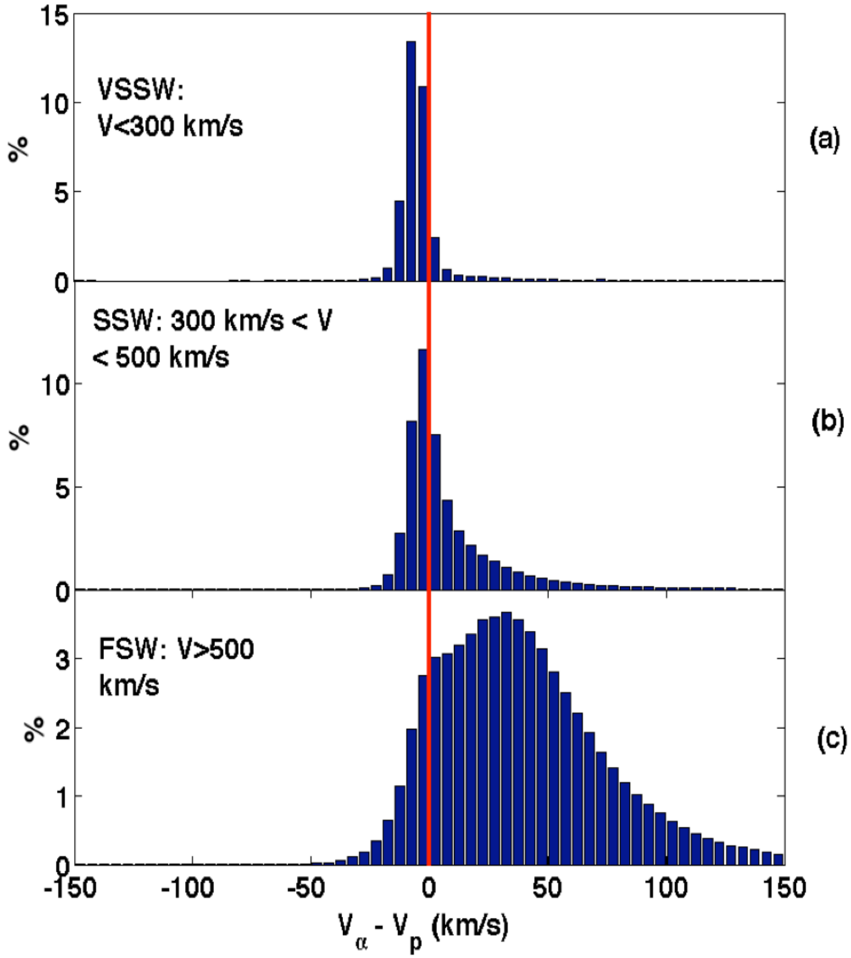
-B(photosphere)

$n_p v_p$ → collision rate → He flux

OR

B(phot.) → $n_{He} v_{He}$

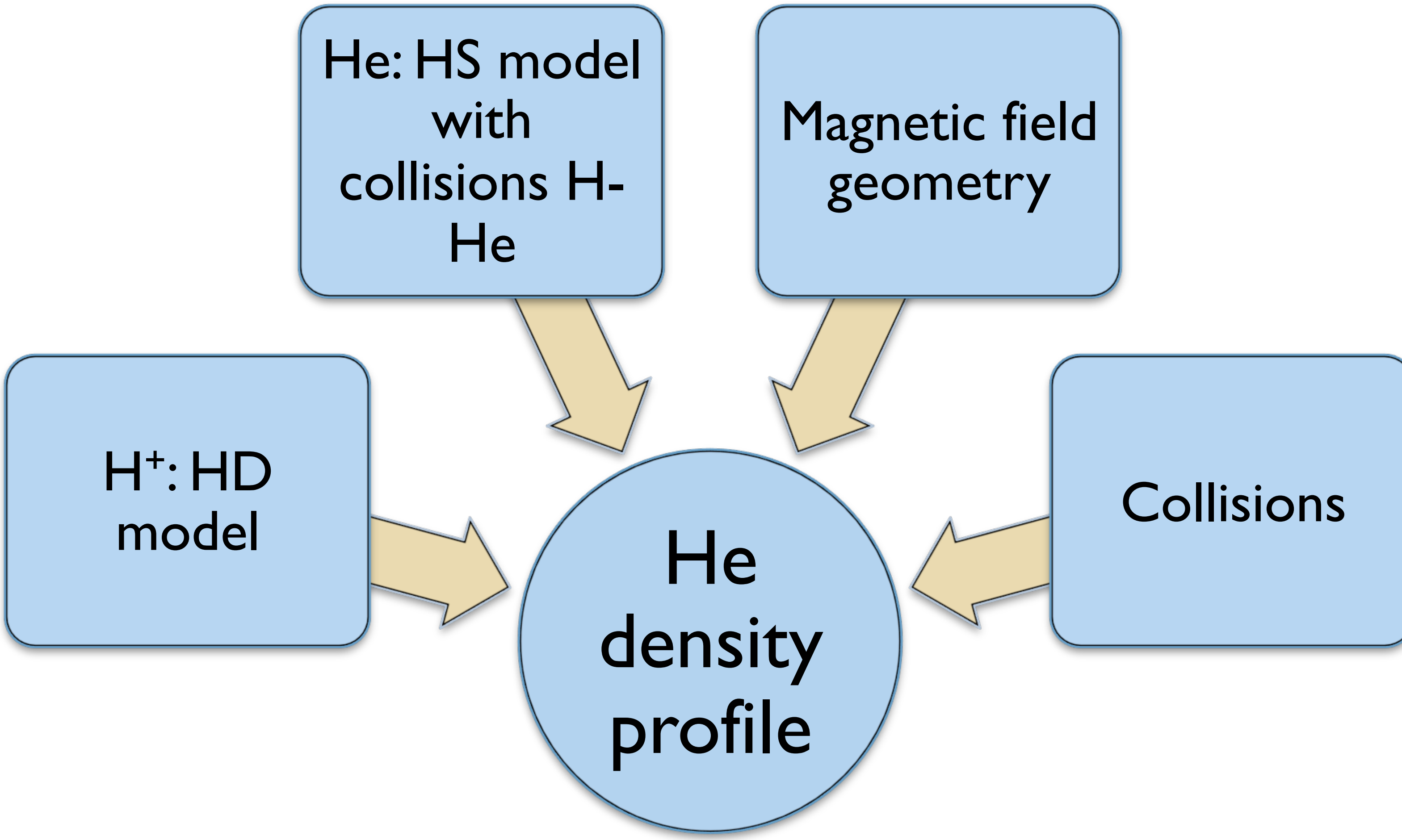
Relative alpha to proton velocity



Sanchez-Diaz et al. (2016)

- **Very Slow Solar Wind: narrow distribution. Small relative velocities ➔ Coming from a collisional region?**
- **Fast wind: wide distribution**

Model


He: HS model with collisions H-He
Magnetic field geometry
H+: HD model
Collisions
He density profile

H^+: HD model

Description

→1D HD solution projected on a field line with any geometry

→Phenomenological heating flux

Applicability

→Chromosphere

→Transition region

→Corona

Described in *Pinto et al.* (2009), *Grappin et al.* (2010), *Verdini et al.* (2012)

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He: HS model

$$\begin{cases} k_B T_\alpha \dfrac{\partial n_\alpha}{\partial r} + n_\alpha m_\alpha g = -\nu m_\alpha \Phi_\alpha \\ \dfrac{\partial \Phi_\alpha}{\partial r} + \dfrac{\beta \phi}{r} = 0 \end{cases}$$

Momentum equation

Continuity equation

$$n_\alpha(r) = C_g e^{-\frac{r}{H_g(r)}} + C_d e^{-\frac{r}{H_d(r)}}$$

Local solution for layers of ~constant temperature, height

$$H_d(r) = \frac{1}{\dfrac{1}{H_p(T_p(r))} + \dfrac{\beta}{r}}$$

Diffusive scale height

$$H_g(r) = H_\alpha(T_\alpha(r))$$

Gravitational scale height

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Boundary conditions: scale heights

$$C_g + C_d = n_\alpha(r = R_0)$$

$$C_d = \frac{\phi_\alpha(r = R_0)}{D_\alpha}\left(\frac{1}{H_d} - \frac{1}{H_g}\right)$$

$C_d<0$ ($H_g<H_d$)

➔Momentum transfer H←He

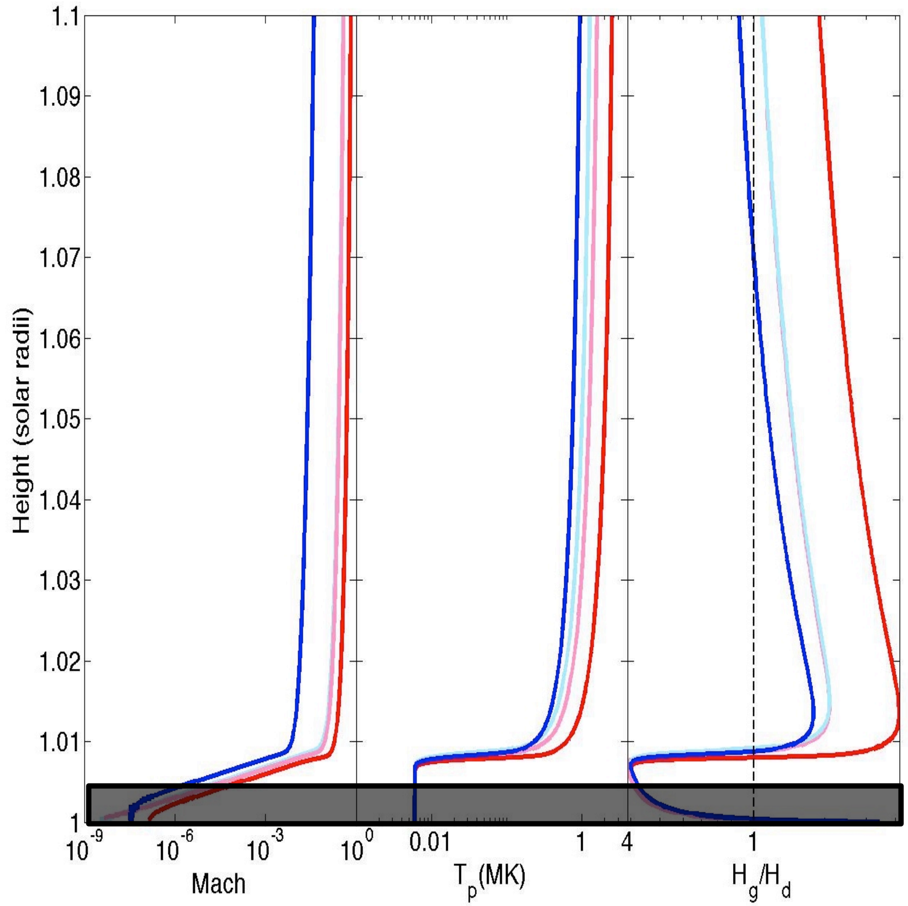
➔ collisions slow He down

$C_d>0$ ($H_g>H_d$)

➔Momentum transfer H→He

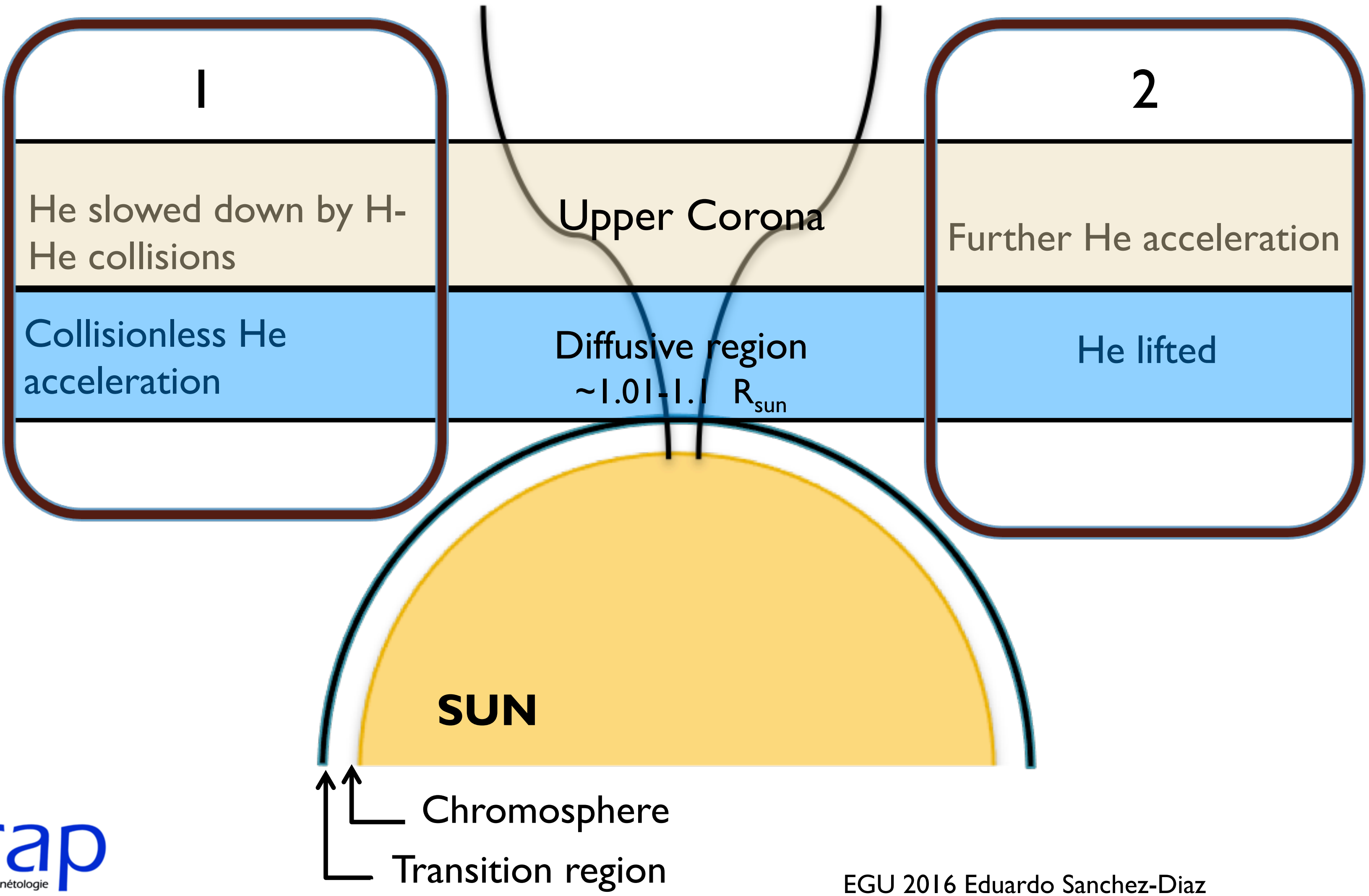
➔ collisions accelerate He

Profiles of relative scale heights

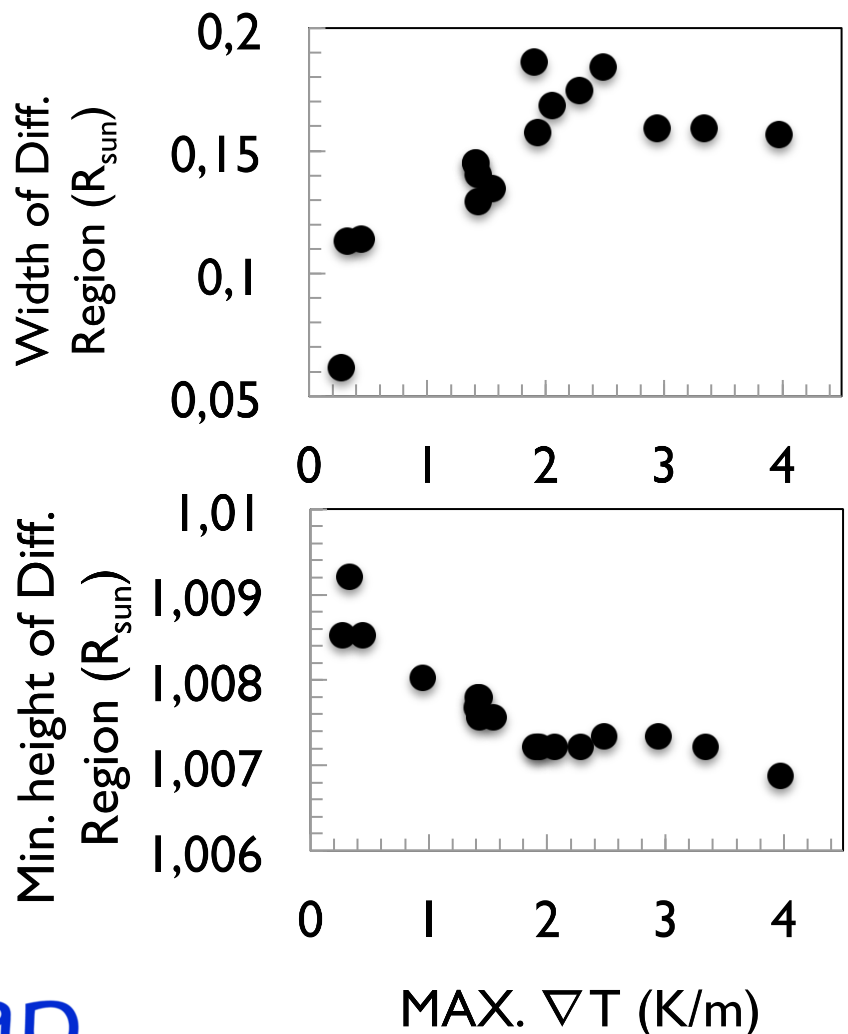


- **Above Transition Region: diffusion region with $H_g > H_d$ ➔ He lifting by diffusion is possible**
- **Higher up in the corona $H_g < H_d$: He^{++} might be slowed down by collisions with H^+**

Two possible scenarios



Diffusive region: dependence with heating rate



Higher ∇T (= higher B_{ph}) ➔ The He diffusion region is the:

- Lower down (denser ➔ more collisional)
- Wider

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Summary

Diffusive region ~1.01-1.1 R_{sun}:

- Momentum transfer H→He
- Wider & lower for higher heating rate (solar max) ➔ Scenario 2 (He uplifting) more likely

Above ~1.1 R_{sun}:

- He slowed down if collisions enough