Thermal Modeling of the Solar Corona

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Layout of the talk

- Existing models of the ambient corona and their limitations
- The temperature profiles derived by the models

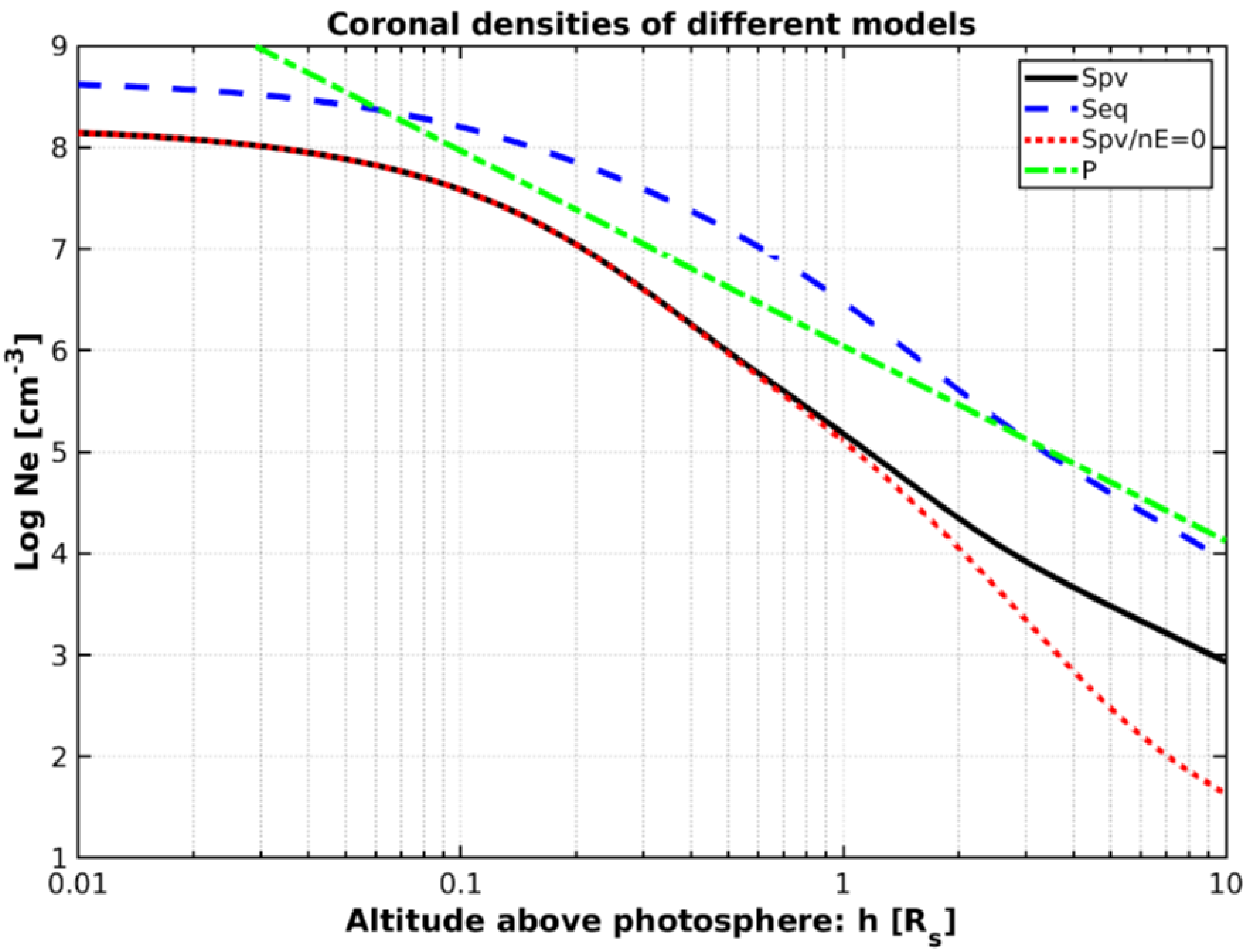
The Scale-Height model

- $H = K*T / \mu*m_H*g = - [d(\ln n_e)/dr]^{-1}$

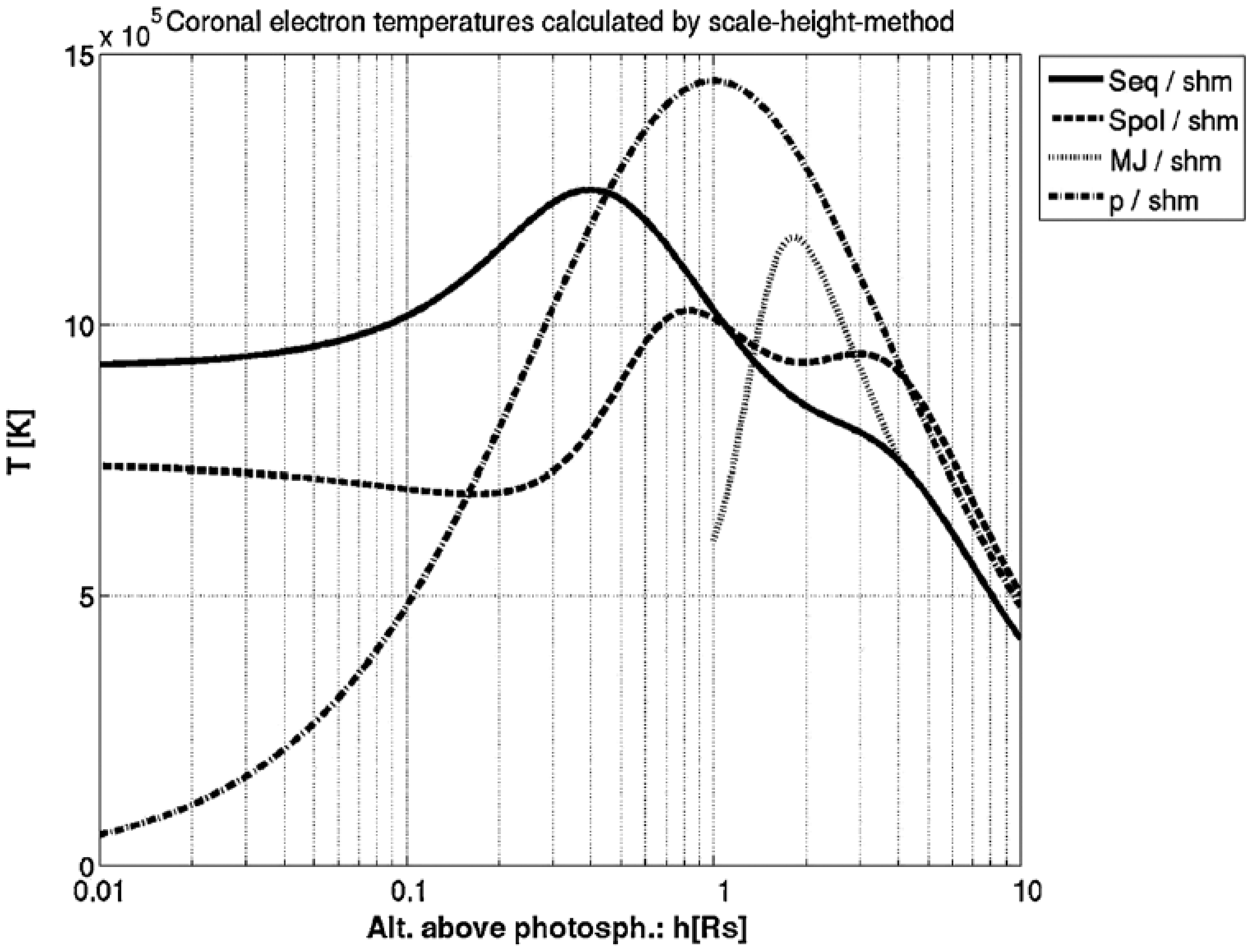
- 1st problem: $g = g(r) = g_0 * R_S^2 / r^2$ (Chapman 1957)

- 2nd problem: H not constant, i.e. corona not isothermal

- H not quasi-isothermal either (i.e. $d(\ln n_e)/dr$ not approximately exponential). Saito (1970)'s fit doesn't satisfy $p_e \approx n_e * k * T$



Lemaire and Katsiyannis (2021)



Lemaire and Stegen (2016)

The HST model

- Adds the dT/dr factor:

  $dT(r)/dr + [d(\ln n_e)/dr]^{-1} = - \mu * m_H * g * R_S^2 / (k\ r^2)$

- Alfven (1941) had already solved equations numerically.

- Problem: No solar wind!!

Parker's model

- Adds the ρ du/dt factor:

  $dT(r)/dr + [d(\ln n_e)/dr]^{-1} + \mu * m_H * g * R_S^2 / (k\ r^2) + \rho\, du/dt = 0,$

where $\rho = m_H\, n_e(r)$ and $n_e(r)$ decreases exponentially.

- 1st problem: Needs precise assumptions for the boundary condition of u_0 so u(r) is continuous and passes through a saddle point at the distance where the bulk speed becomes supersonic (Parker 1963).

- 2nd problem: It only diverges for T(∞)=0. Pottach (1960), Brandt et al (1965), and Gibson et al (1999) used T(∞)=0 and P(∞)=0. Even slightly different boundary conditions will produce divering steady state solutions.

The DYN model

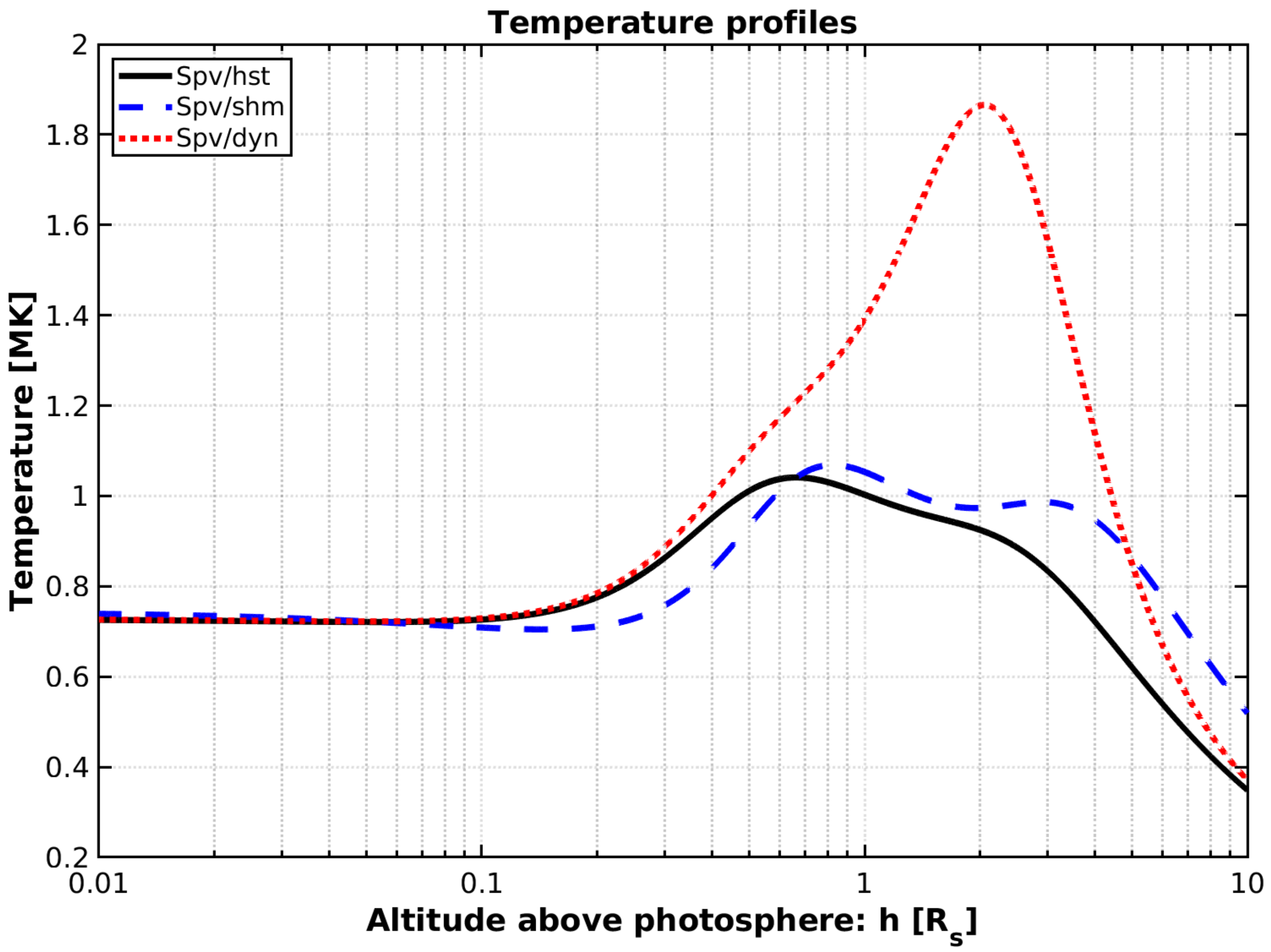
- Lemaire & Stegen (2016) also added at term to Saito (1970)'s fit. This was to correct for n_e(1AU). Saito (1970)'s fit up to 4 R_S:

$$n_e(r)= 10^8 [3.09\ r^{-16}\ (1-0.5\ \sin(\varphi)) + 1.58\ r^{-6}\ (1-0.95\ \sin(\varphi)) + 0.0251\ r^{-2.5}\ (1-\sqrt{\sin(\varphi)})] + n_e(1AU)\ (215/r)^2$$

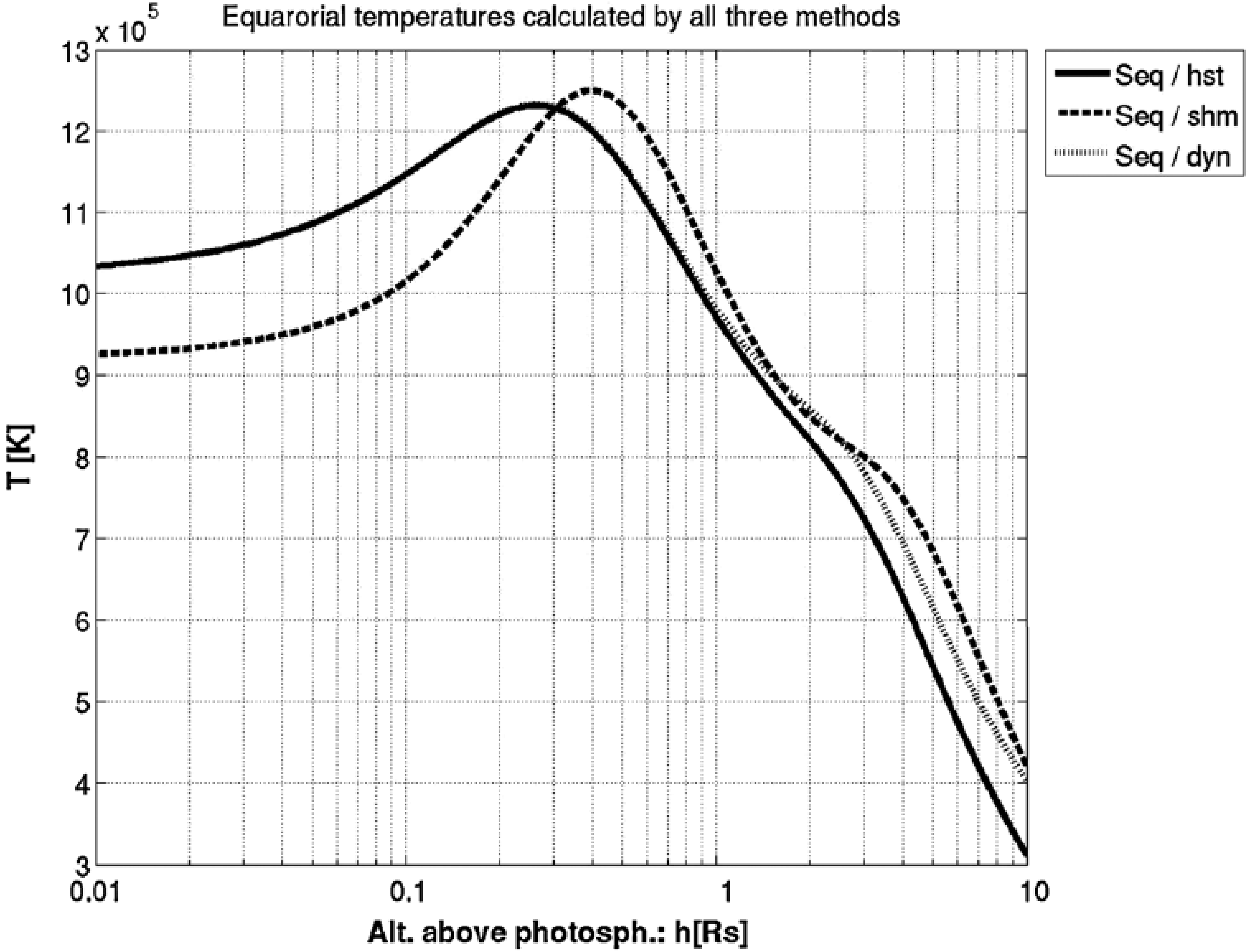
- Boundary conditions (n_E and u_E) are set at 1 AU.

- $u(r,\varphi)= u_E\ A_E/A(r)\ n_E / n_e(r,\varphi)$,

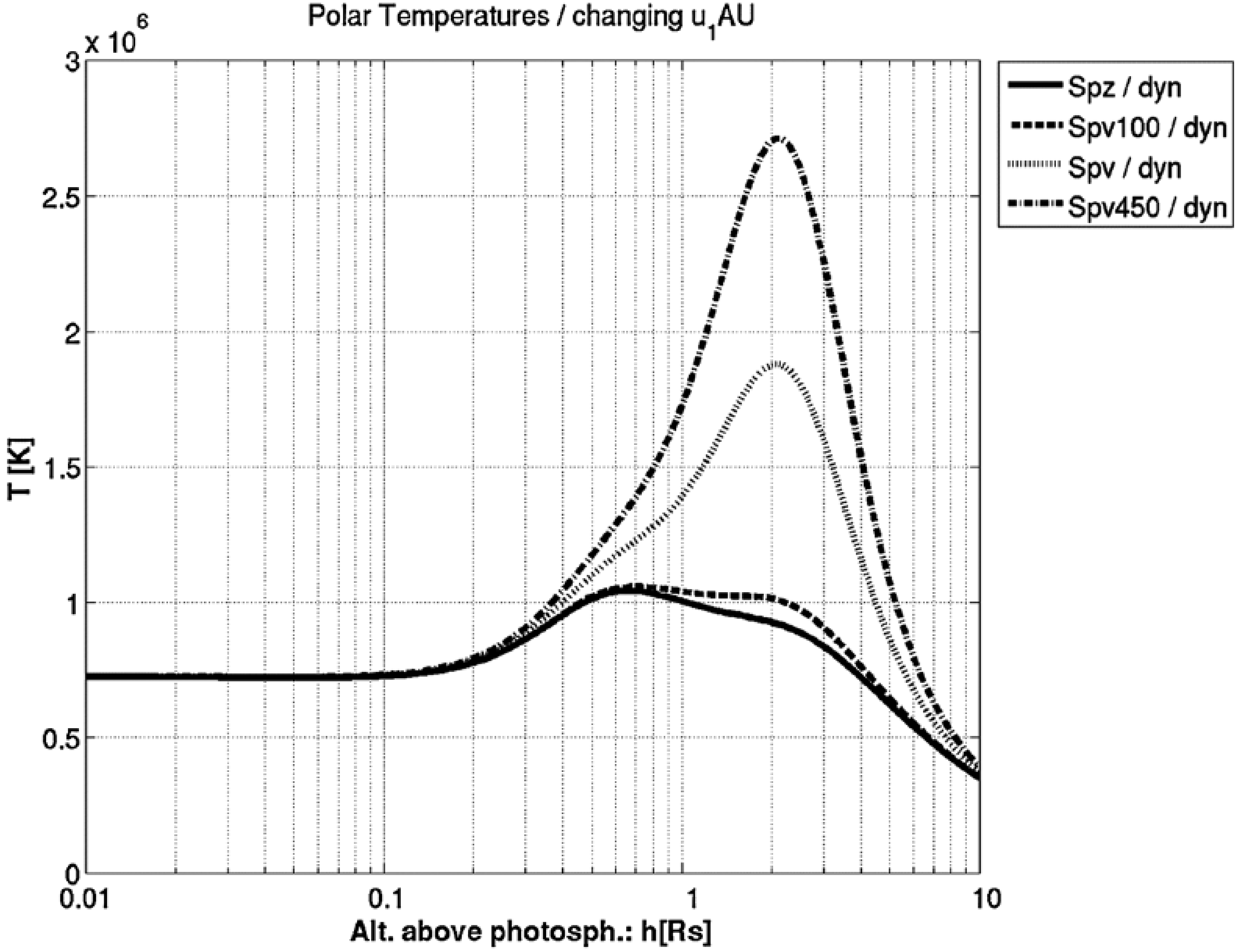
where A is the cross sectionof the flow tubes.



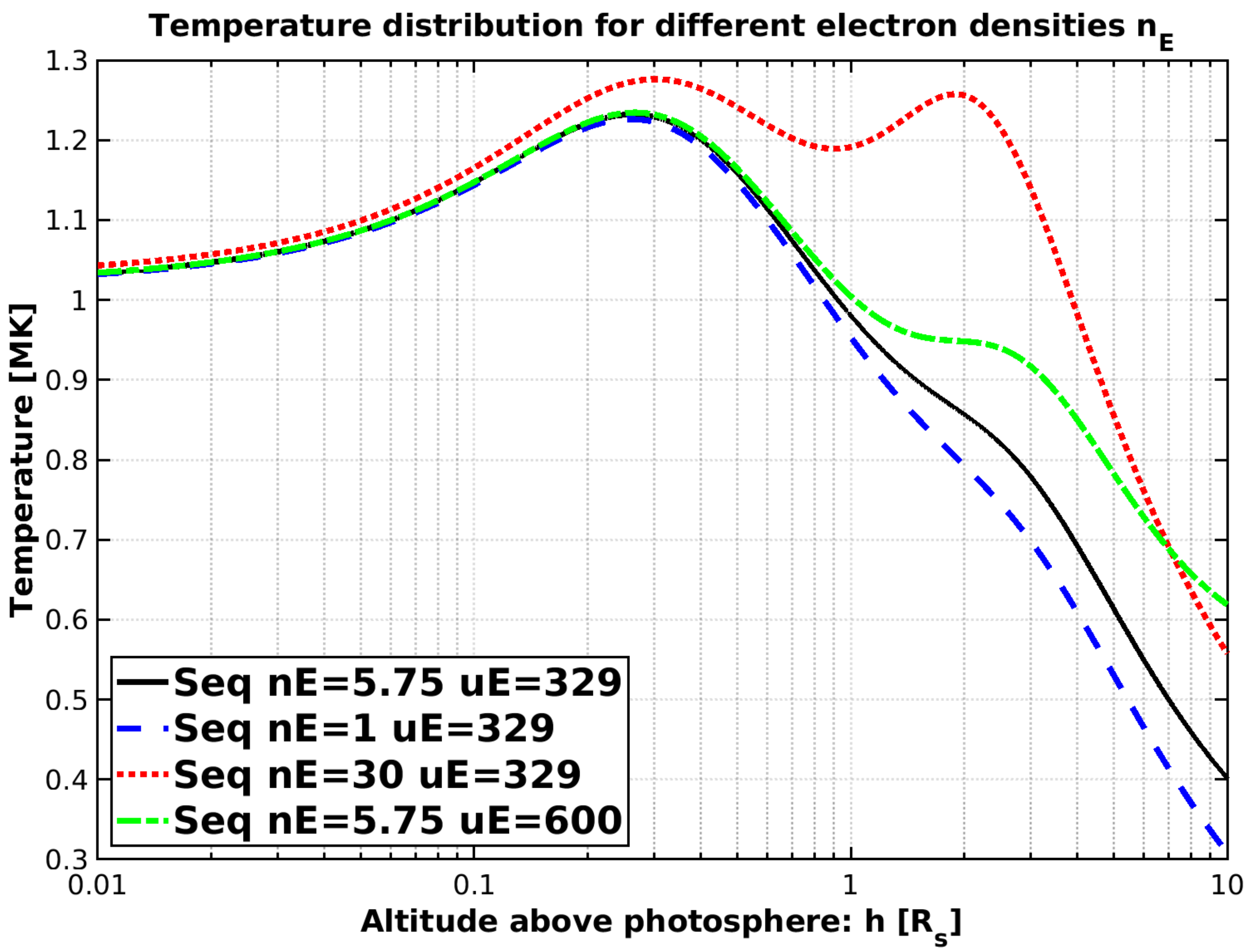
Lemaire and Katsiyannis (2021)



Lemaire and Stegen (2016)



Lemaire and Stegen (2016)



Lemaire and Katsiyannis (2021)