Large Aperture [O I] 6300 Å Observations of Comet Hyakutake: Implications for the Photochemistry of OH and [O I] Production in Comet Hale-Bopp

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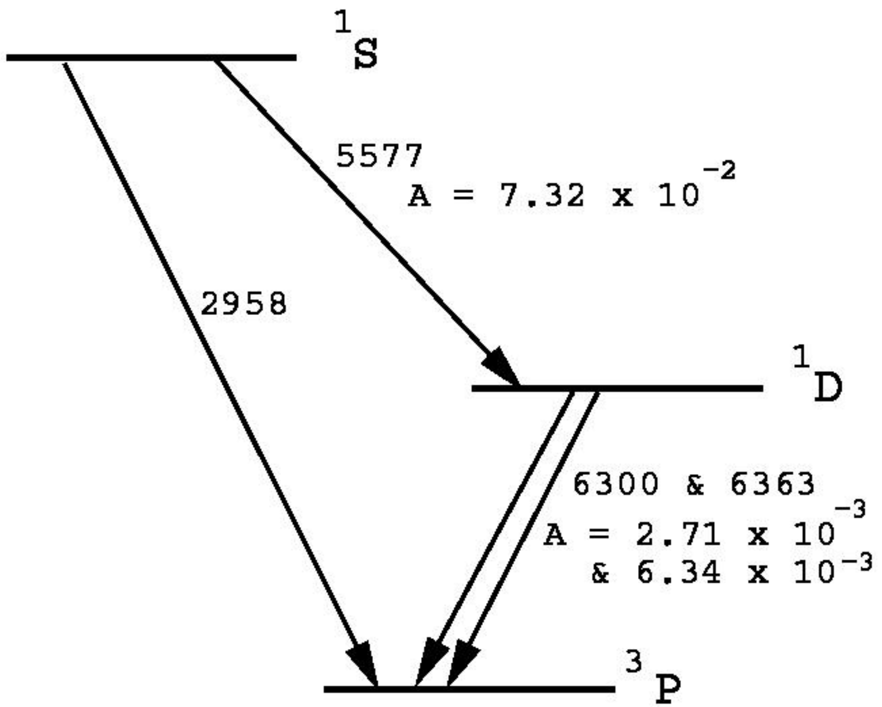
What is [O I] 6300 Å?

- Emission line from a metastable state of oxygen
- O(^{1}D) difficult to get to with photon excitation
- Product of electron excitation or molecular dissociation
- 110 s lifetime



Hale-Bopp had “too much” [O I]

- By a factor of 3—4
  - Assuming standard H_2O and OH photochemistry
- 4 instruments on 3 telescopes
- Morgenthaler et al., Ap.J., 2001 asked: is photochemistry correct?
  - OH in particular

Likely Answer

- Glinski et al. (2004): Hale-Bopp coma dense enough for gas phase chemistry:

$$O + OH \rightarrow O_2 + H$$

  - Simple coma model with 14 concentric shells
  - Complex chemical model with 55 reactions
  - O_2 efficient at producing [O I]
- OH → [O I] branching ratio still needed to be raised to match Hale-Bopp data

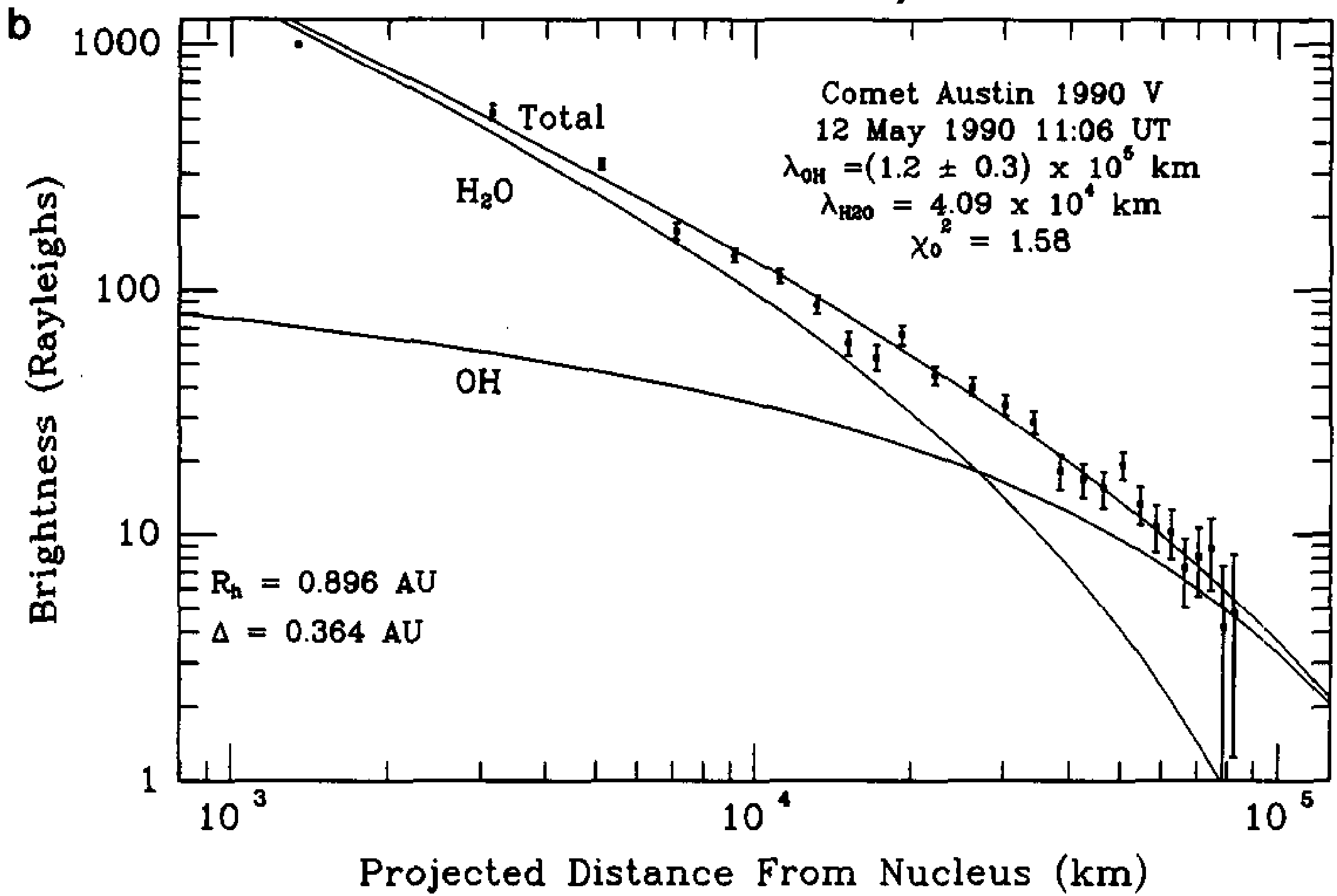
Do [O I] observations of other comets support any change in OH branching ratios?

- Uwe Fink [O I] profiles of many comets consistent with standard H_2O and OH photochemistry
  - Fink et al. do not cleanly separate airglow and NH_2
  - Sensitivity of long-slit spectrometers to extended sources is low compared to wide-field Fabry-Pérots
  - OH does dominates [O I] >10^4 km
- Fink sensitivity to [O I] from OH may be too low to address this issue

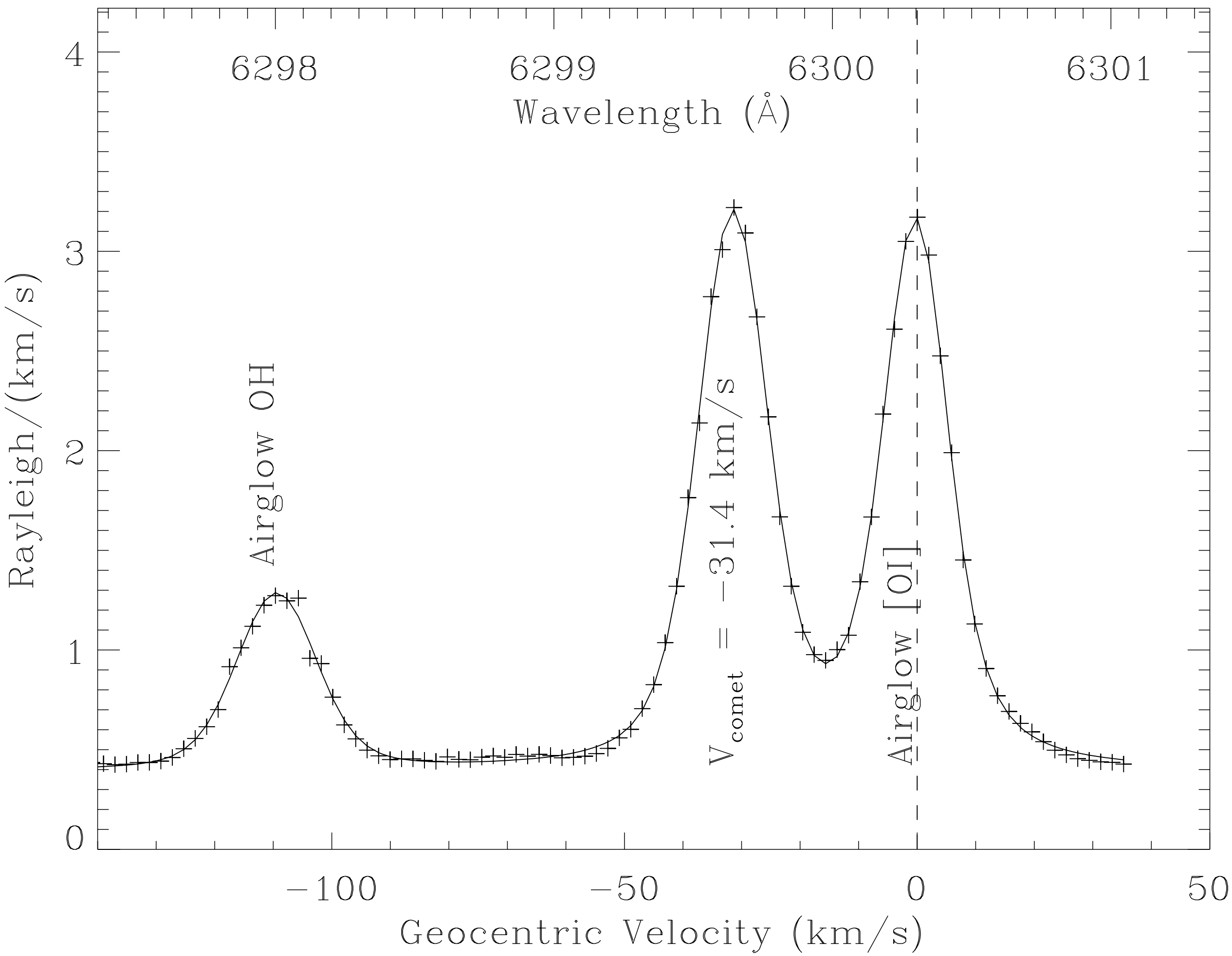
Fabry-Pérot Observations

- Solar minimum comets:
  - Hale-Bopp (Morgenthaler et al. 2001)
    - “Too much” [O I]
  - Halley (Magee-Sauer et al. 1988, 1990), Hyakutake (this work)
    - Highly variable production rates
- Solar max comet: Austin
  - Good agreement with standard photochemistry (Schultz et al. 1993)

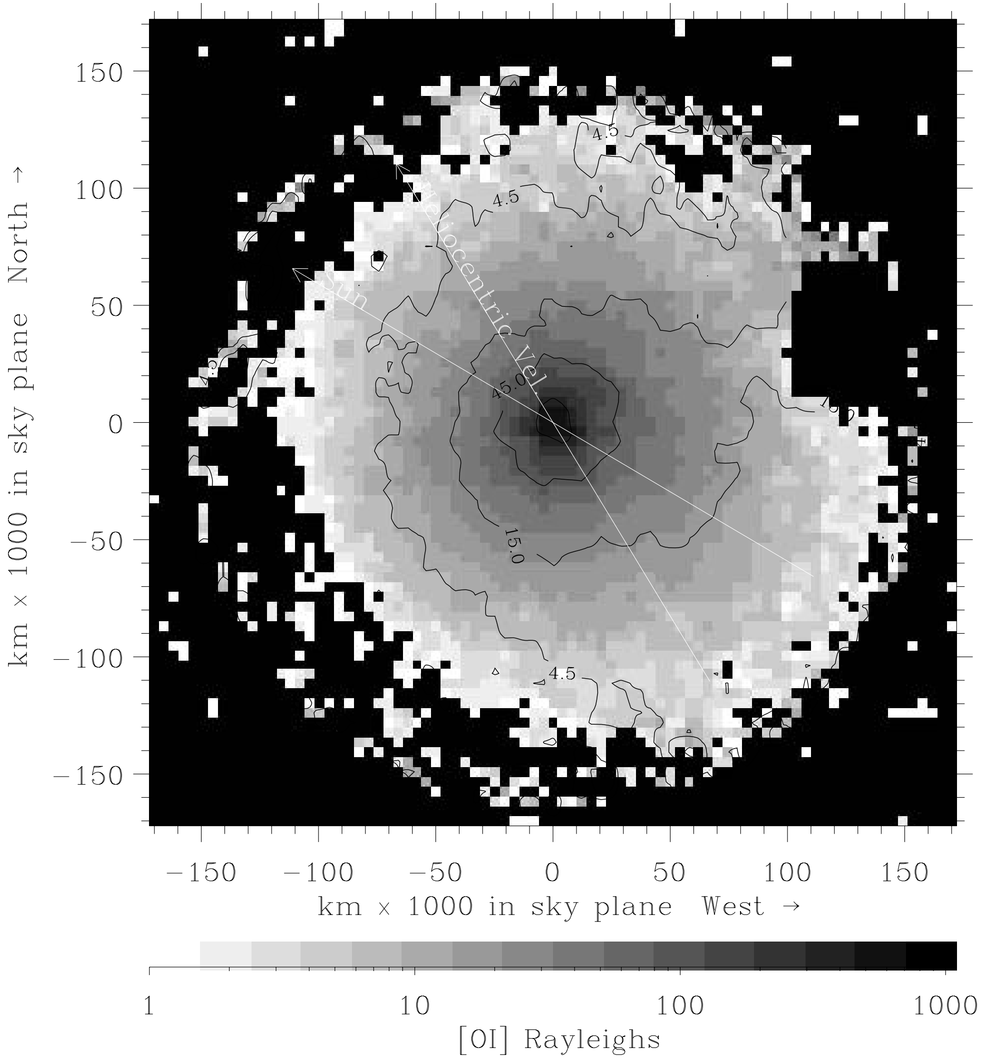
Comet Austin [O I] Profile (Schultz et al. 1993)



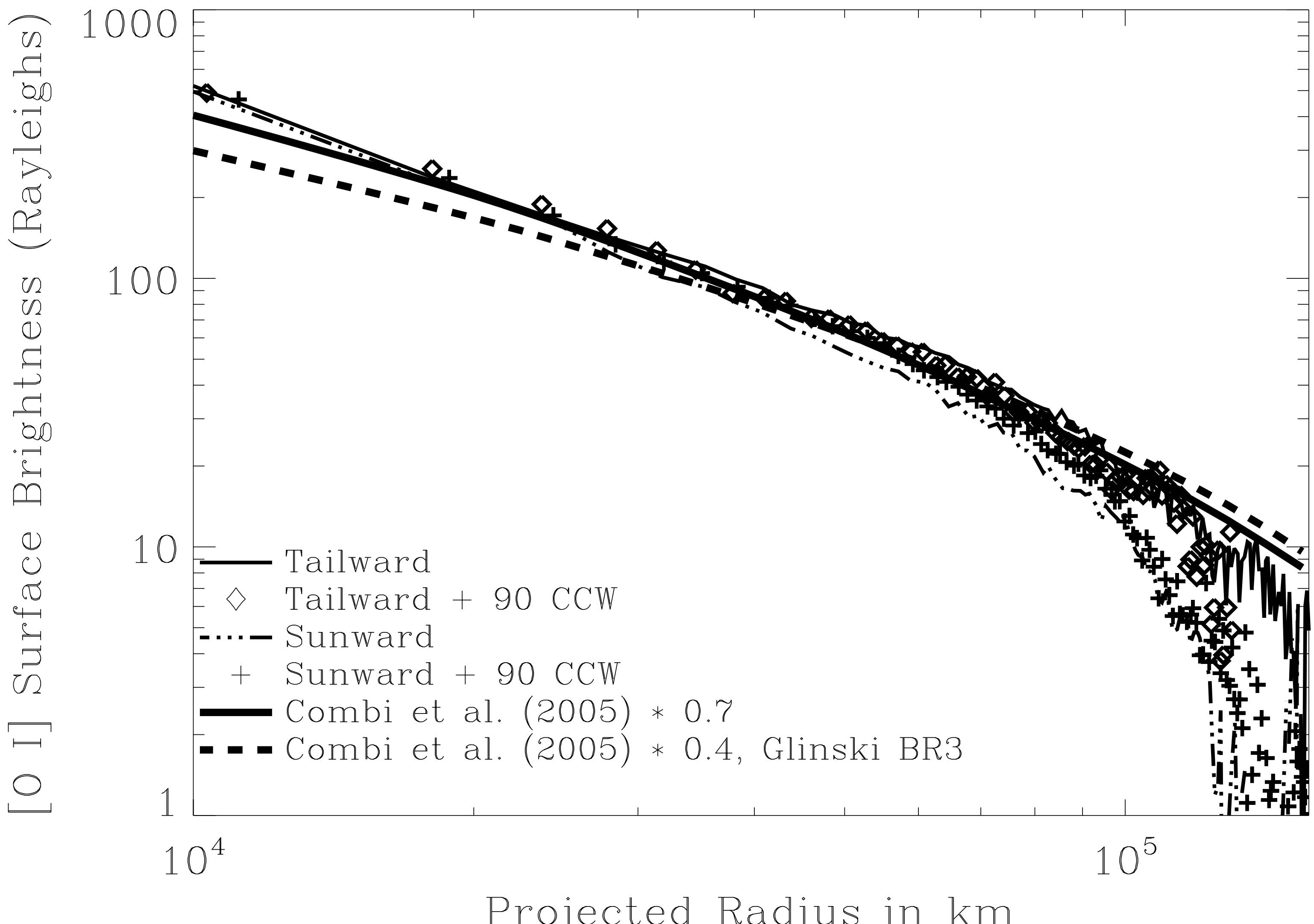
Hyakutake (2006 March 23)



Hyakutake (2006 March 23)



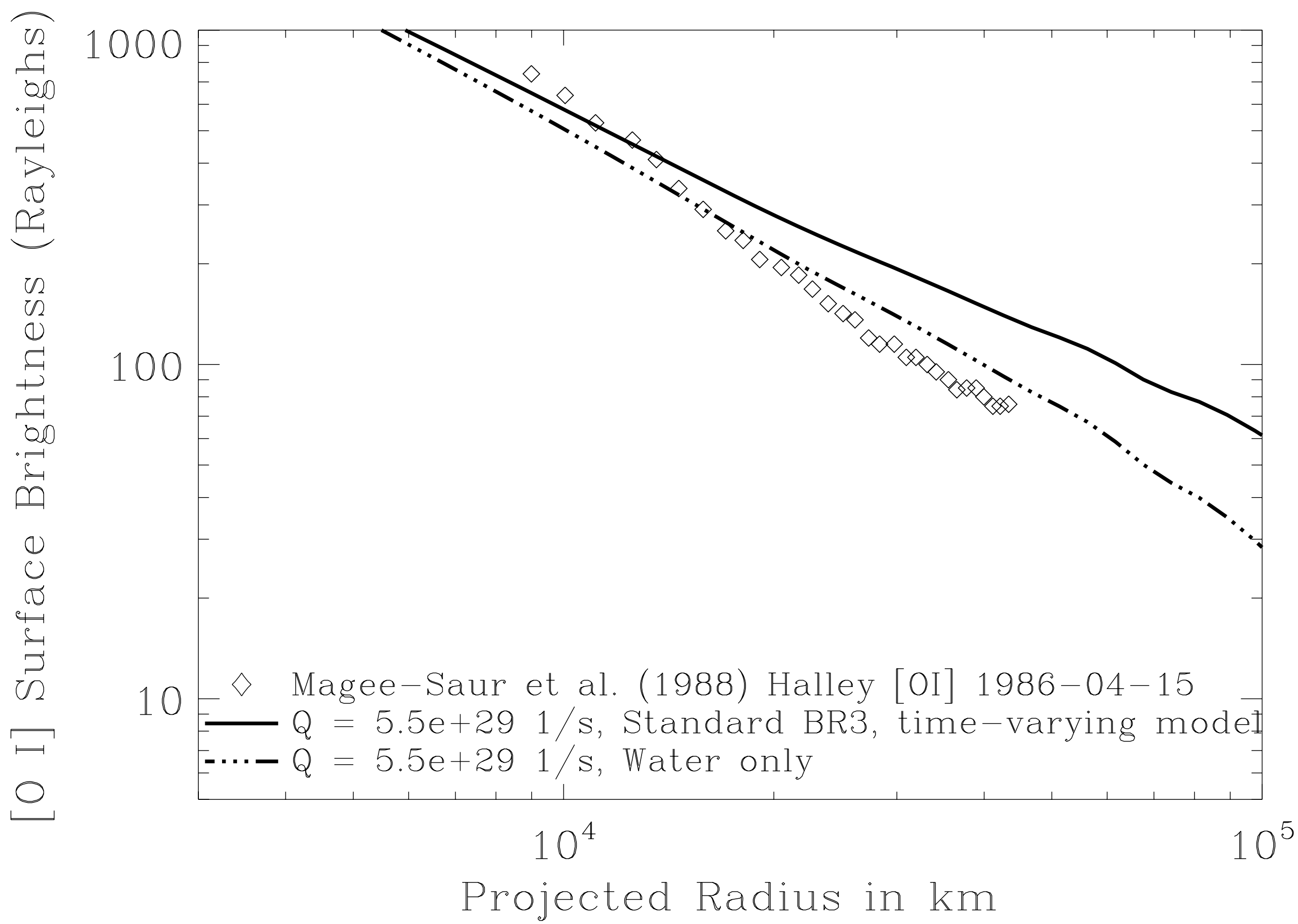
Hyakutake (2006 March 23)



Hyakutake (2006 March 23)

- Time-varying Haser model based on Combi et al. (2005) $Q(H_2O)$ values
- Glinski et al. (2004) modified OH → [O I] branching ratio ($BR3_G$) not compatible
- Model fits data best with standard photochemistry
- Let's stick with standard H_2O and OH photochemistry

Halley measured profiles steeper than model



Halley measured profiles steeper than model

- Hyakutake model based on actual $Q(H_2O)$ values (Combi et al. 2005) fits well
- Halley time-varying model based on $Q(C_2)$ values (Schleicher et al. 1990)
  - CN and NH_2 profiles match C_2 well (Combi et al. 1993)
- Does H_2O have a different inner coma or outgassing or behavior than CN, NH_2, and C_2?