PHOTOCHEMISTRY AND DIFFUSION IN JUPITER'S STRATOSPHERE. J. I. Moses[1], T. Fouchet[2], B. Bézard[3], E. Lellouch[3], and G. R. Gladstone[4], [1]Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston TX 77058-1113 (moses@lpi.usra.edu), [2]Atmospheric, Oceanic and Planetary Physics, Oxford University, Oxford OX1 3PU, England, [3]Observatoire de Paris-Meudon, F-92195 Meudon, France, [4]Space Sciences Dept., Southwest Research Institute, San Antonio TX 78228-0510, USA.

Introduction: Infrared spectra from Jupiter exhibit numerous emission features due to higher-order hydrocarbons produced from methane photolysis in the upper stratosphere. Photochemical models to date [e.g., 1,2,3] have done a poor job of reproducing the observed hydrocarbon abundances, especially if one considers the new high-quality observational constraints provided by ISO, the Infrared Space Observatory [see 4,5,6,7]. Recent advances in our knowledge of the stratospheric temperature profile, species abundances, and chemical kinetics data have provided important new model constraints and input parameters, and updated photochemical models are needed in order to explain the observed composition. We use the observational constraints provided by ISO to construct new one-dimensional steady-state models of Jovian stratospheric photochemistry. The models include coupled hydrocarbon and oxygen photochemistry, vertical eddy and molecular diffusion, and radiative transport (including multiple Rayleigh scattering by H_2, He, and CH_4). We focus on determining the eddy diffusion coefficient profile in the stratosphere, as this information is currently poorly constrained or contradictory [e.g., 8,9, and Fig. 1]. We also discuss the implications with regard to hydrocarbon photochemistry on all the giant planets.

Results: The upper-stratospheric eddy diffusion coefficient derived from observations of Jupiter's 584 Å brightness [e.g., 10] is inconsistent with that derived from the *Voyager* ultraviolet stellar occultation experiment [8] or infrared CH_4 ν_3-band florescence data [11]. Therefore, we have created two models (A & B) with very different high-altitude diffusion profiles (see Fig. 1). We also test the eddy diffusion profile used by [1] (Model C). The resulting mixing-ratio profiles for several observed constituents are shown in Fig. 2. Our main conclusions are as follows:

(a) Models A and B both provide a good fit to the ISO C_2H_2, C_2H_6, CH_3C_2H, C_4H_2, and C_6H_6 data. The He profile from Model B is consistent the 584 Å data, but the Model B CH_4 profile is inconsistent with the methane observations of [8,11]. The Model A CH_4 profile is consistent with [8,11], but the He profile is inconsistent with [10]. A reanalysis of all the above data sets [8,10,11], new UV occultation data (i.e., the *Cassini* flyby), and/or a better determination of the upper atmospheric temperature profile as a function of latitude are needed before this issue can be resolved.

(b) Model C and the model of [1] are inconsistent with the C_4H_2 upper limit and the C_2H_6/C_2H_2 ratio inferred from ISO data [4], suggesting that the eddy diffusion coefficient adopted in these models is too large at pressures of 1-100 mbar and/or the hydrocarbon chemistry from [1] is incorrect or incomplete.

(c) The large abundance of benzene on Jupiter and the other giant planets [e.g., 5] most probably results from the long dissociation lifetime of the C_6H_6 molecule. Upon absorption of a UV photon, electronically excited C_6H_6 can be collisionally quenched at lower stratospheric pressures before it dissociates.

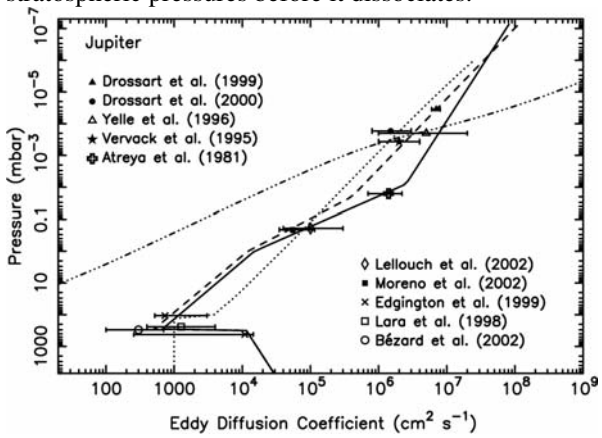
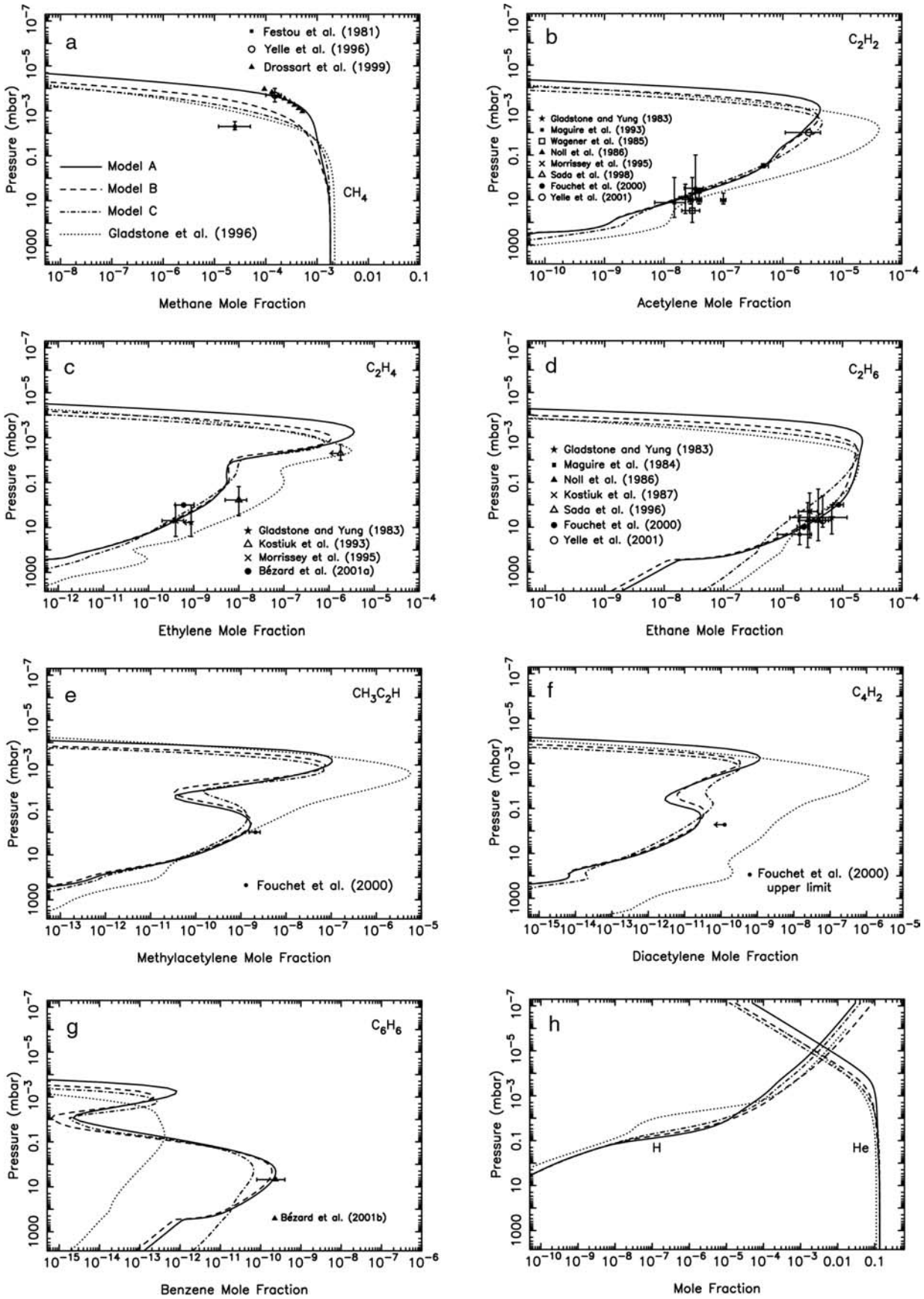


Figure 1. The eddy diffusion coefficients adopted for Model A (solid line), Model B (dashed line), and Gladstone *et al.* [1] and Model C (dotted line) compared with various observational constraints (individual data points).

Figure 2 (next page): Mixing ratio profiles from our models compared with various infrared and ultraviolet observations (line styles as labeled in Fig. 2a).

References: [1] Gladstone, G. R. *et al.* (1996) *Icarus* **119**, 1. [2] Romani, P. N. (1996) *Icarus* **122**, 233. [3] Lee, A. Y. T. *et al.* (2000) *JGR* **105**, 20207. [4] Fouchet, T. *et al.* (2000) *Astron. Astrophys.* **355**, L13. [5] Bézard, B. *et al.* (2001) *Icarus* **154**, 492. [6] Drossart, P. *et al.* (1999) [7] Encrenaz, T. *et al.* (1996) *Astron. Astrophys.* **315**, L397. [8] Yelle, R. V. *et al.* (1996) *JGR* **101**, 2149. [9] Festou, M. C. *et al.* (1981) *JGR* **86**, 5715. [10] Vervack, R. J., Jr. *et al.* (1995). *Icarus* **114**, 163. [11] Drossart, P. *et al.* (1999), *In The Universe as Seen by ISO*, p. 169, ESA SP-427.


a
Festou et al. (1981)
Yelle et al. (1996)
Drossart et al. (1999)
Model A
Model B
Model C
Gladstone et al. (1996)
CH4
Pressure (mbar)
Methane Mole Fraction
b
C2H2
Gladstone and Yung (1983)
Maguire et al. (1993)
Wagener et al. (1985)
Noll et al. (1986)
Morrissey et al. (1995)
Sada et al. (1998)
Fouchet et al. (2000)
Yelle et al. (2001)
Acetylene Mole Fraction
c
C2H4
Gladstone and Yung (1983)
Kostiuk et al. (1993)
Morrissey et al. (1995)
Bézard et al. (2001a)
Ethylene Mole Fraction
d
C2H6
Gladstone and Yung (1983)
Maguire et al. (1984)
Noll et al. (1986)
Kostiuk et al. (1987)
Sada et al. (1996)
Fouchet et al. (2000)
Yelle et al. (2001)
Ethane Mole Fraction
e
CH3C2H
Fouchet et al. (2000)
Methylacetylene Mole Fraction
f
C4H2
Fouchet et al. (2000)
upper limit
Diacetylene Mole Fraction
g
C6H6
Bézard et al. (2001b)
Benzene Mole Fraction
h
H
He
Mole Fraction