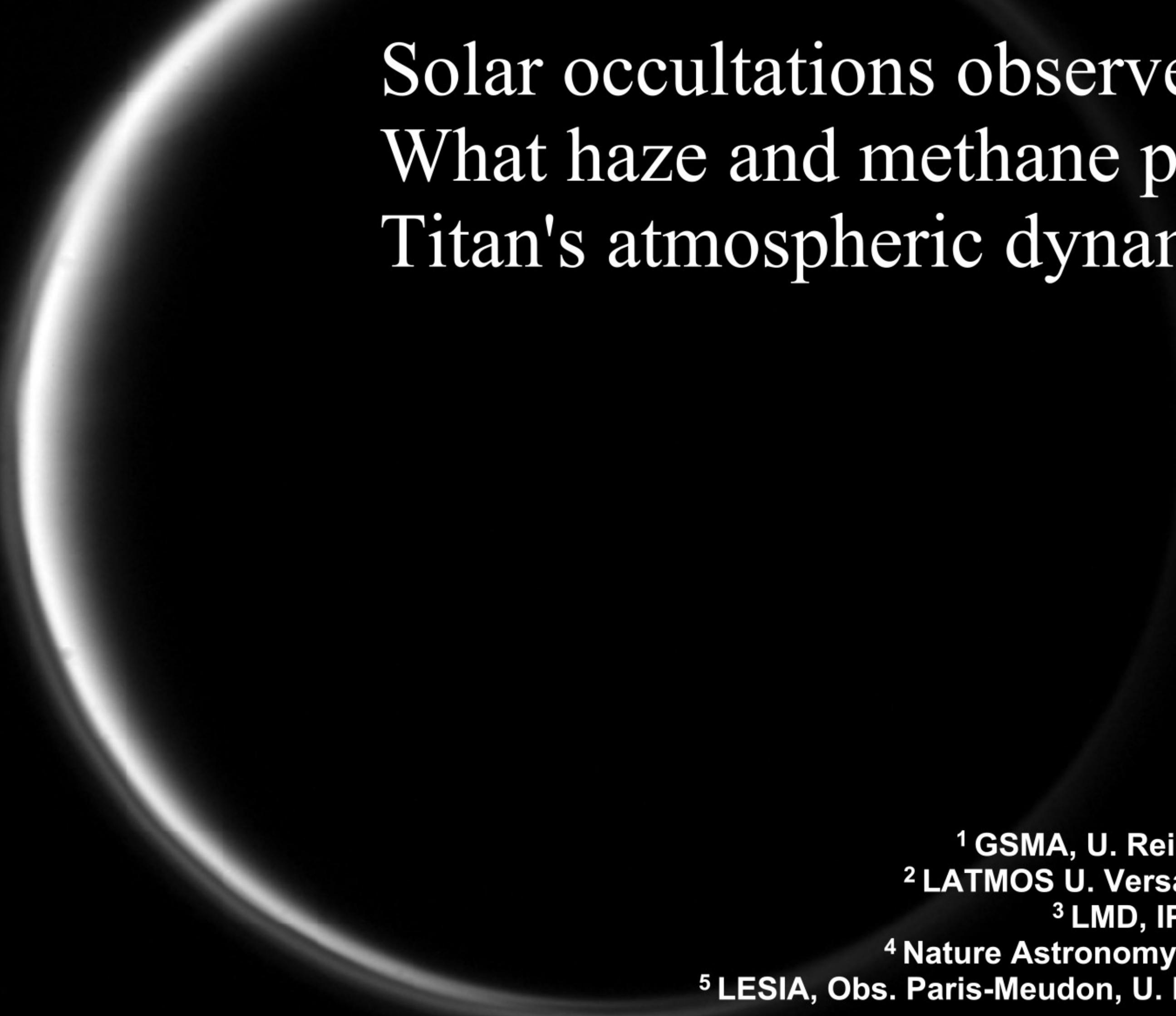

Solar occultations observed by VIMS-IR: What haze and methane profiles reveal about Titan's atmospheric dynamics and climate.

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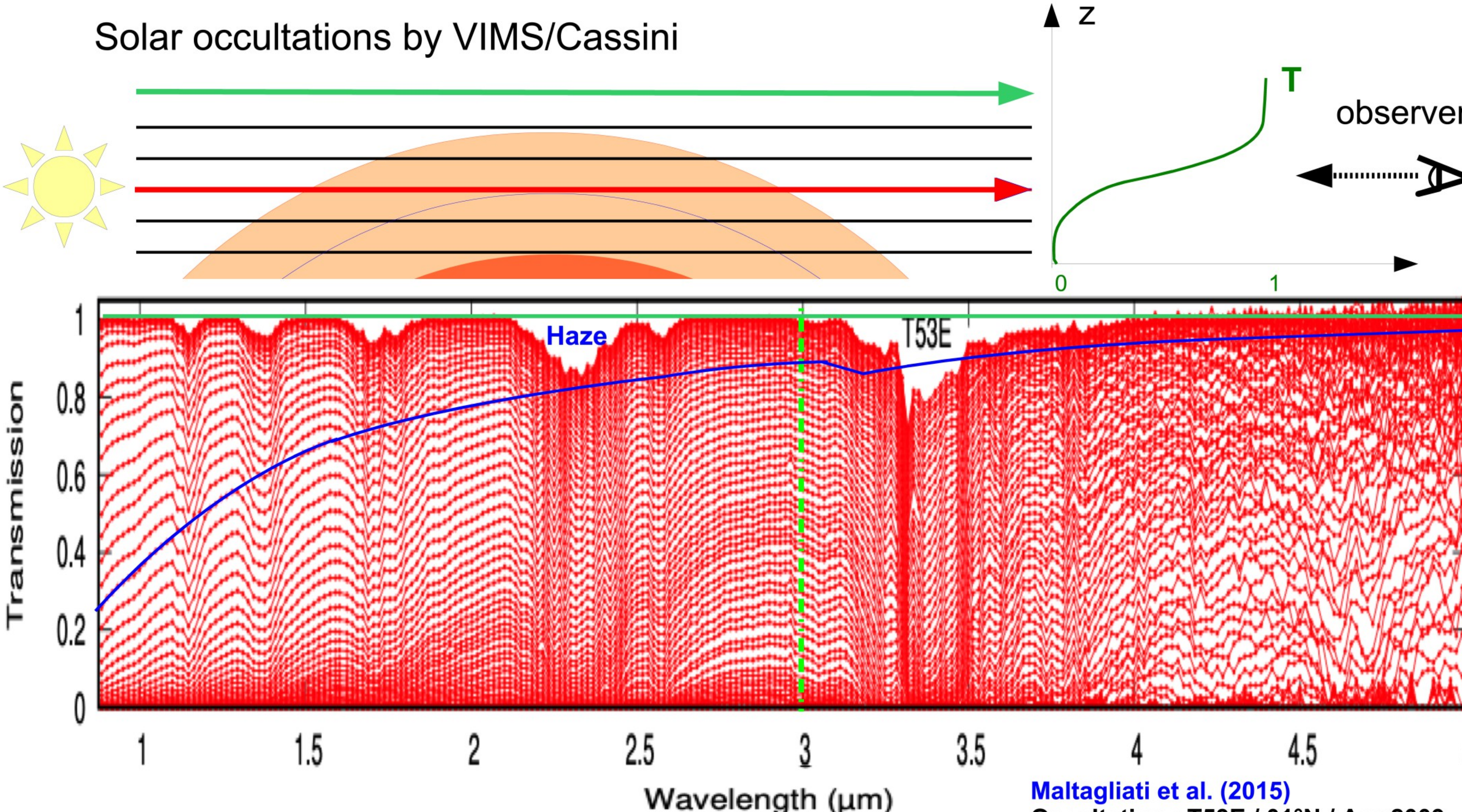
Solar occultations by VIMS/Cassini



Maltagliati et al. (2015)
Occultation : T53E / 01°N / Apr 2009

➔ Why redo it after Bellucci et al., 2009 and Maltagliati et al., 2015 ?

- New spectroscopic data : project CH4@Titan + ab-initio calculations (Rey et al., 2018)
- Retrieval of haze properties (profiles and spectral slopes)

Table 1 Main information about occultation data

# Flyby	Side	Date	Latitude	Distance† (km)	Shift‡ (nm)
T10	Egress	15 Jan 2006	70°S	8300	$2.64^{+0.16}_{-0.21}$
T53	Egress	20 Apr 2009	01°N	6300	$9.40^{+0.10}_{-0.09}$
T78	Egress	12 Sep 2011	27°N	8400	$10.63^{+0.11}_{-0.11}$
T78	Ingress	12 Sep 2011	40°N	9700	$10.44^{+0.12}_{-0.15}$

† Distance between Cassini and Titan during the observation

‡ Wavelength shift applied to nominal wavelengths of VIMS-IR channels evaluated with absorption of methane between 0.88 and 2.05μm

Steady state circulation ~12 yrs

North spring Equinox (30.7.2009)

Post-equinoctial transition ~3 yrs

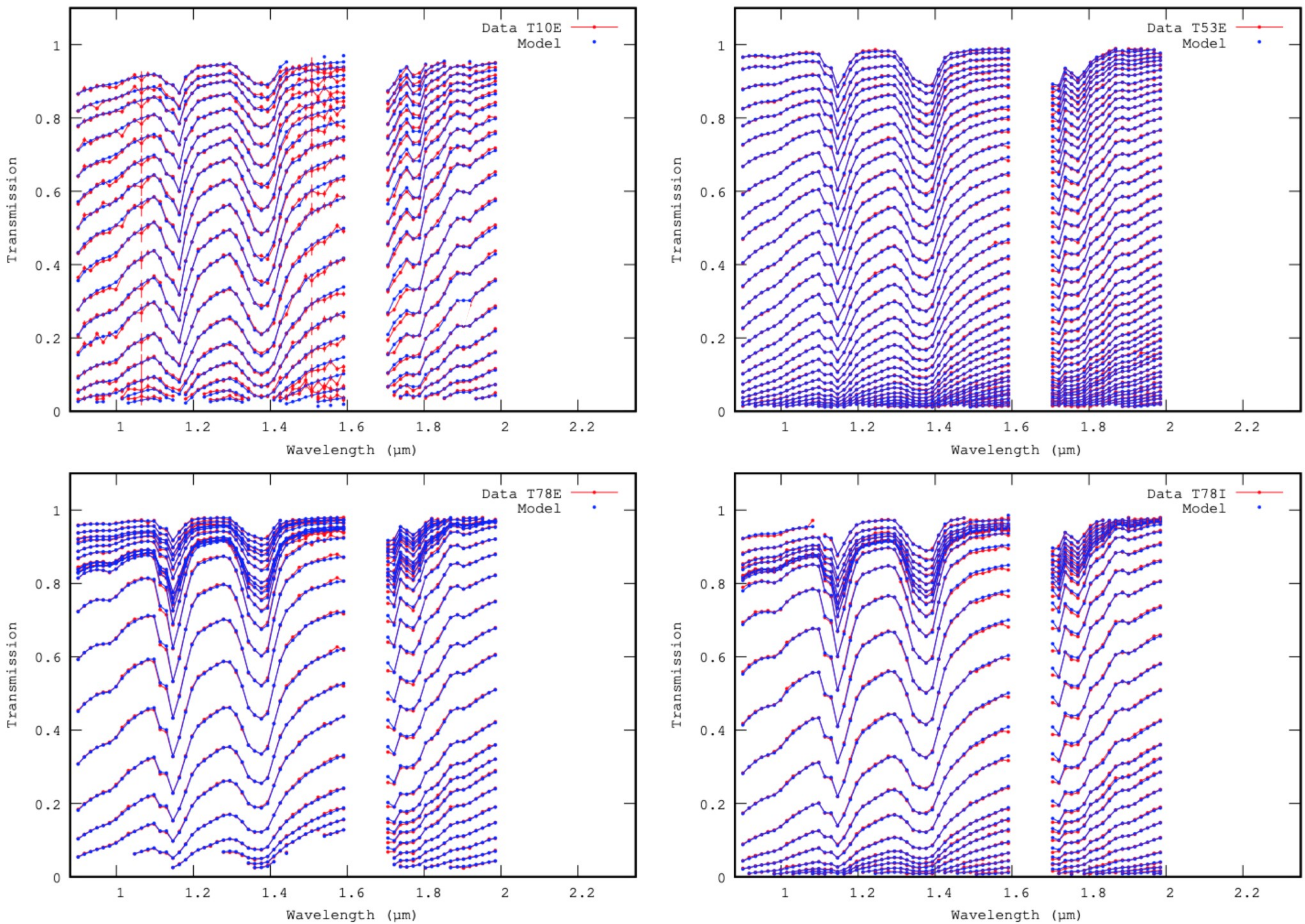
$$K_{ij} = \partial y_i / \partial x_j \big|_{x_0}$$

$$\bar{x} = x_0 + \left(K^T S_\epsilon^{-1} K\right)^{-1} K^T S_\epsilon^{-1} \left(y - y(x_0)\right)$$

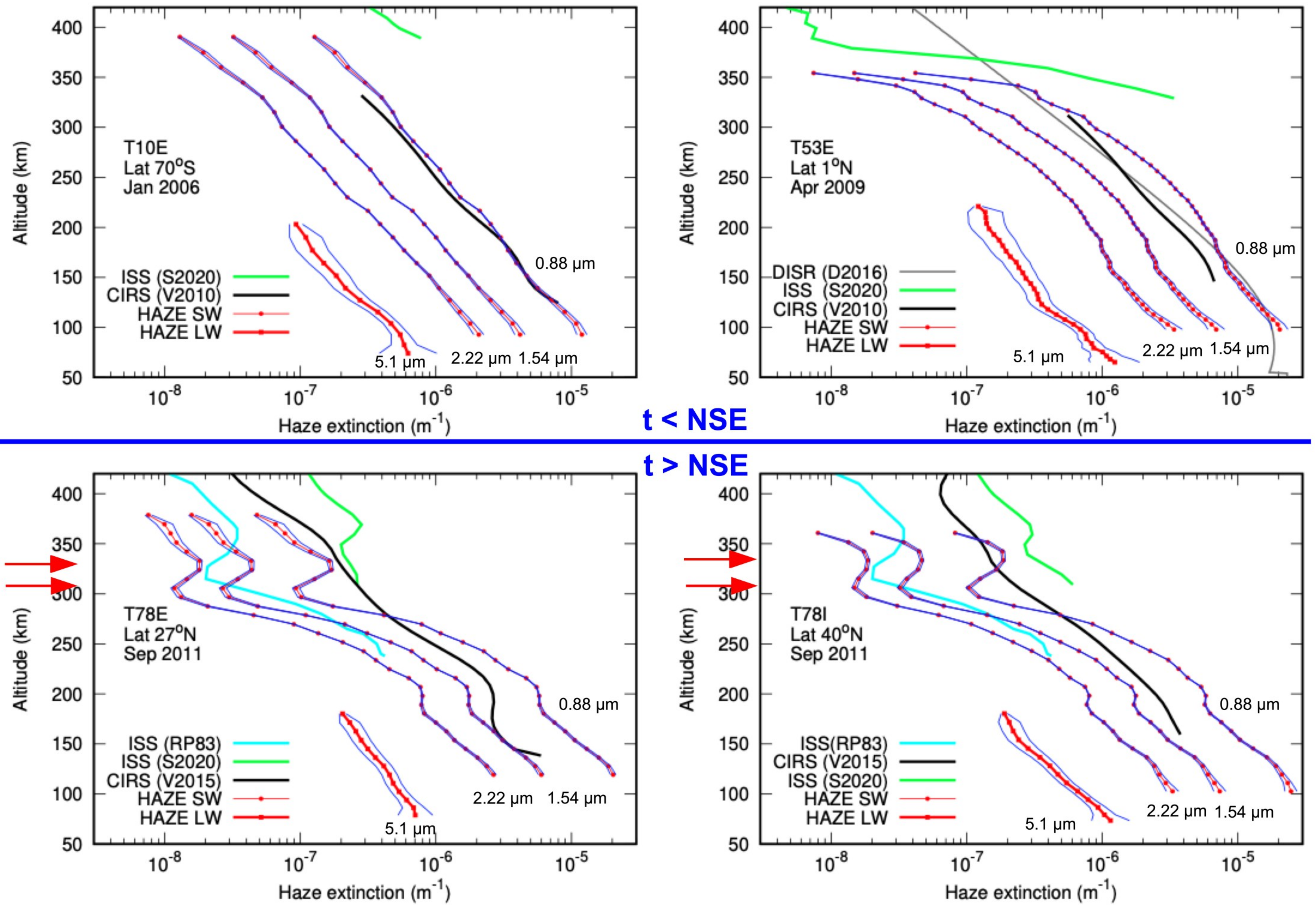
$$S^\dagger = \left(K^T S_\epsilon^{-1} K + \beta H\right)^{-1} = \left(S^{-1} + \beta H\right)^{-1}$$

Rodger 2000

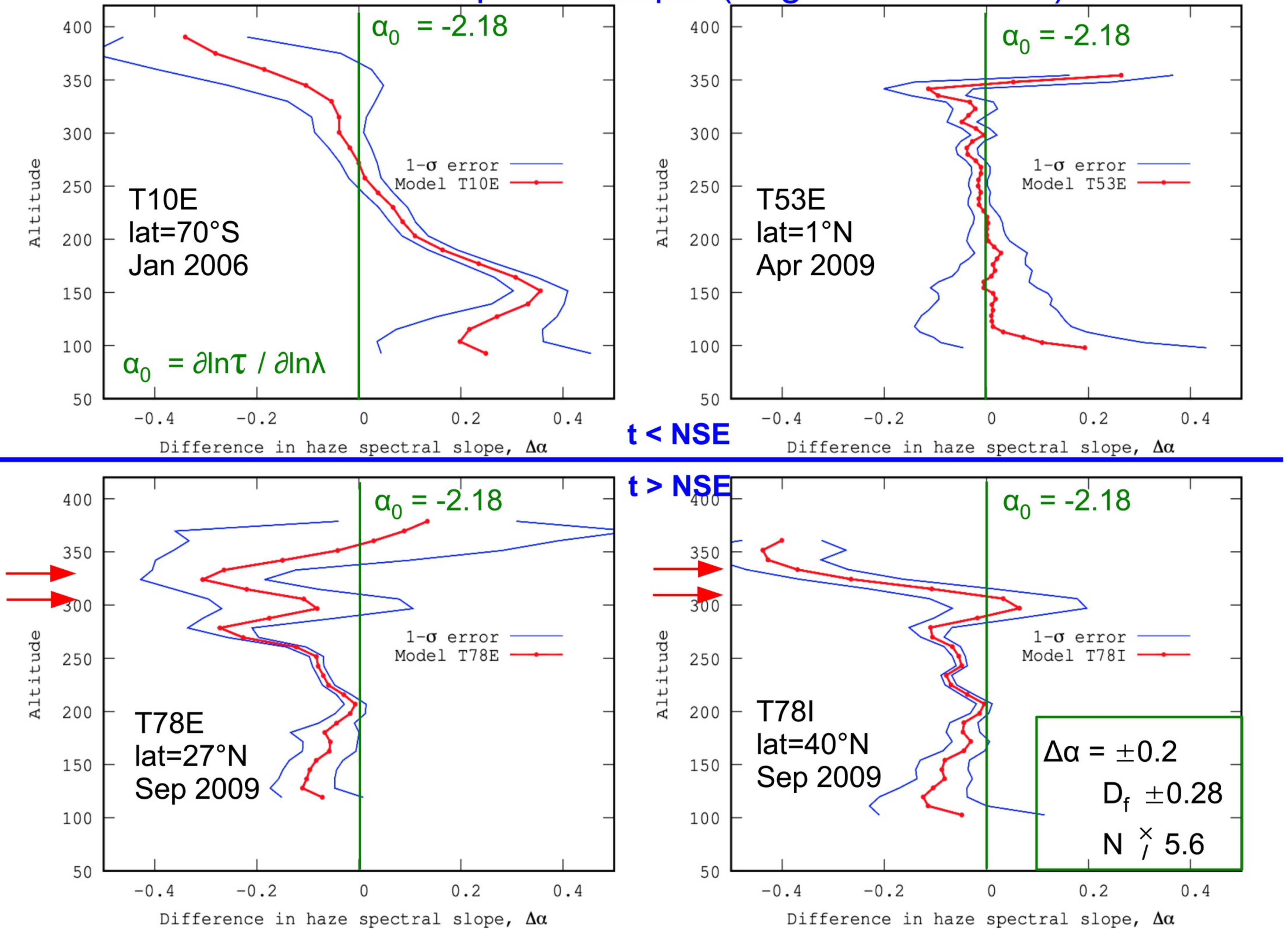
Haze + CH_4

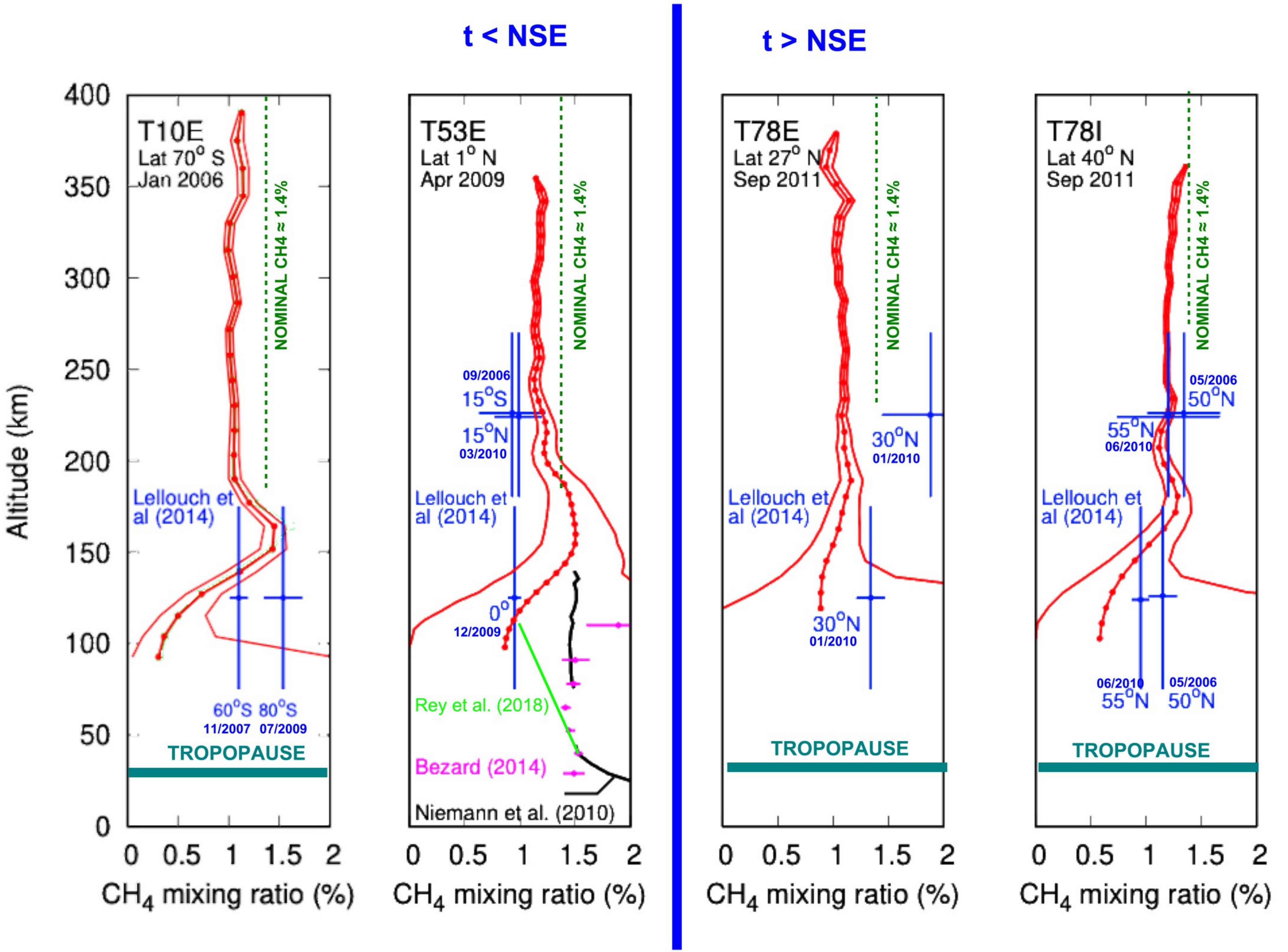

Data T10E
Model
Transmission
Wavelength (µm)
Data T53E
Model
Transmission
Wavelength (µm)
Data T78E
Model
Transmission
Wavelength (µm)
Data T78I
Model
Transmission
Wavelength (µm)

Haze extinction profiles

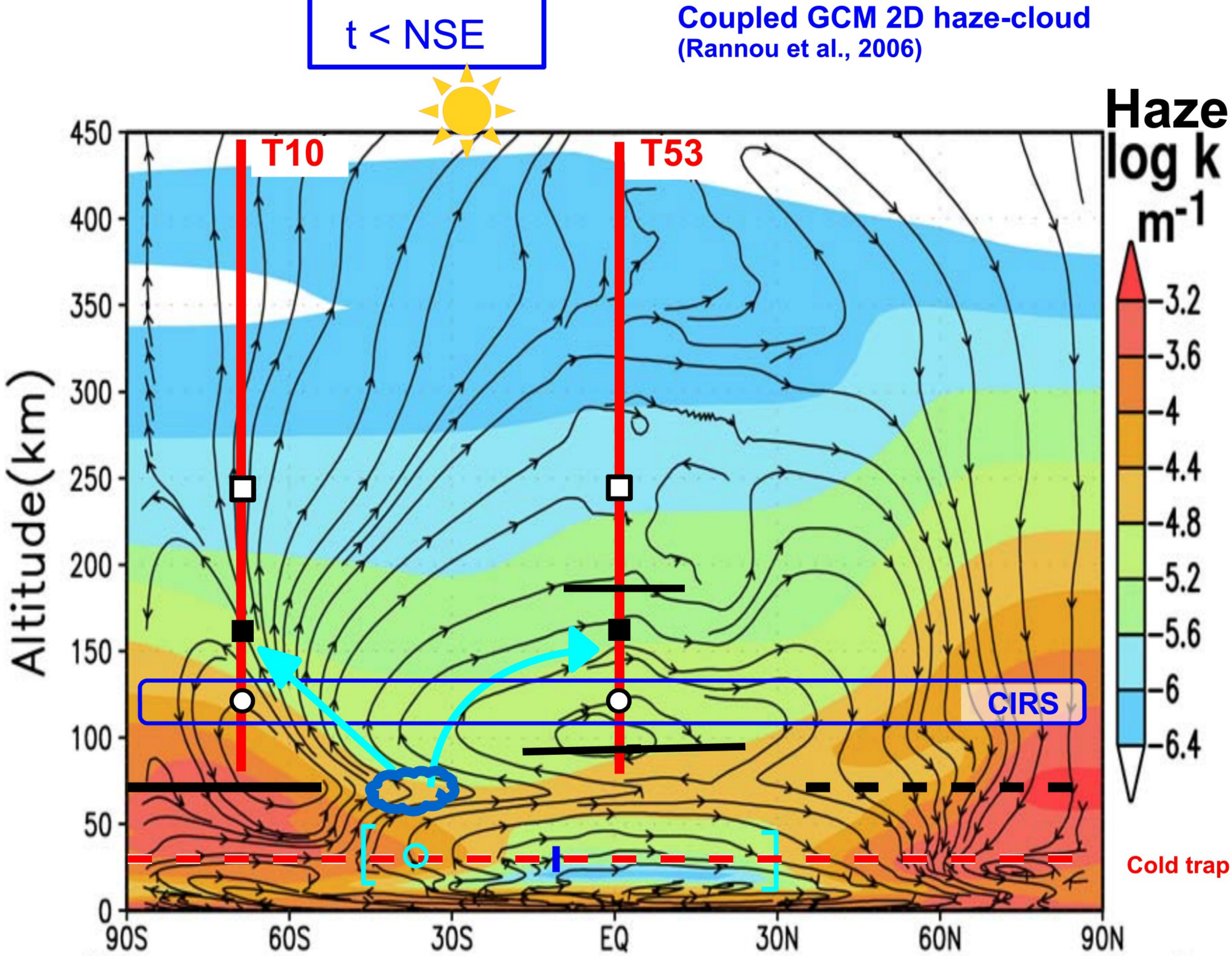


Haze spectral slope (Angström factor α)





t < NSE
t > NSE
T10E
Lat 70° S
Jan 2006
T53E
Lat 1° N
Apr 2009
T78E
Lat 27° N
Sep 2011
T78I
Lat 40° N
Sep 2011
NOMINAL CH4 ≈ 1.4%
Lellouch et al (2014)
60°S 11/2007
80°S 07/2009
09/2006 15°S
15°N 03/2010
0° 12/2009
30°N 01/2010
05/2006 50°N
55°N 06/2010
Rey et al. (2018)
Bezard (2014)
Niemann et al. (2010)
TROPOPAUSE
Altitude (km)
CH4 mixing ratio (%)



t < NSE
Coupled GCM 2D haze-cloud
(Rannou et al., 2006)
Haze
log k
m-1
T10
T53
CIRS
Cold trap
Altitude(km)
450
400
350
300
250
200
150
100
50
0
90S
60S
30S
EQ
30N
60N
90N
-3.2
-3.6
-4
-4.4
-4.8
-5.2
-5.6
-6
-6.4

4 occultations (Maltagliati et al., 2015) + new methane linelist (now in Hitran)

* Lower stratospheric value (1 – 1.15%) variable in time and space

* Haze extinction profile + spectral slopes

* Methane intrusion at the south pole from tropics (with convection ?)
Inhibited transport at the equator and summer pole

→ Tropo-strato connection

What else ?

* Morphology of fractal aerosols Df ~2.3 ± 0.1 / 3000 x 50 nm (⚠ if $m(\lambda) = n_0 + i\kappa_0$)

* CH_3D, CO

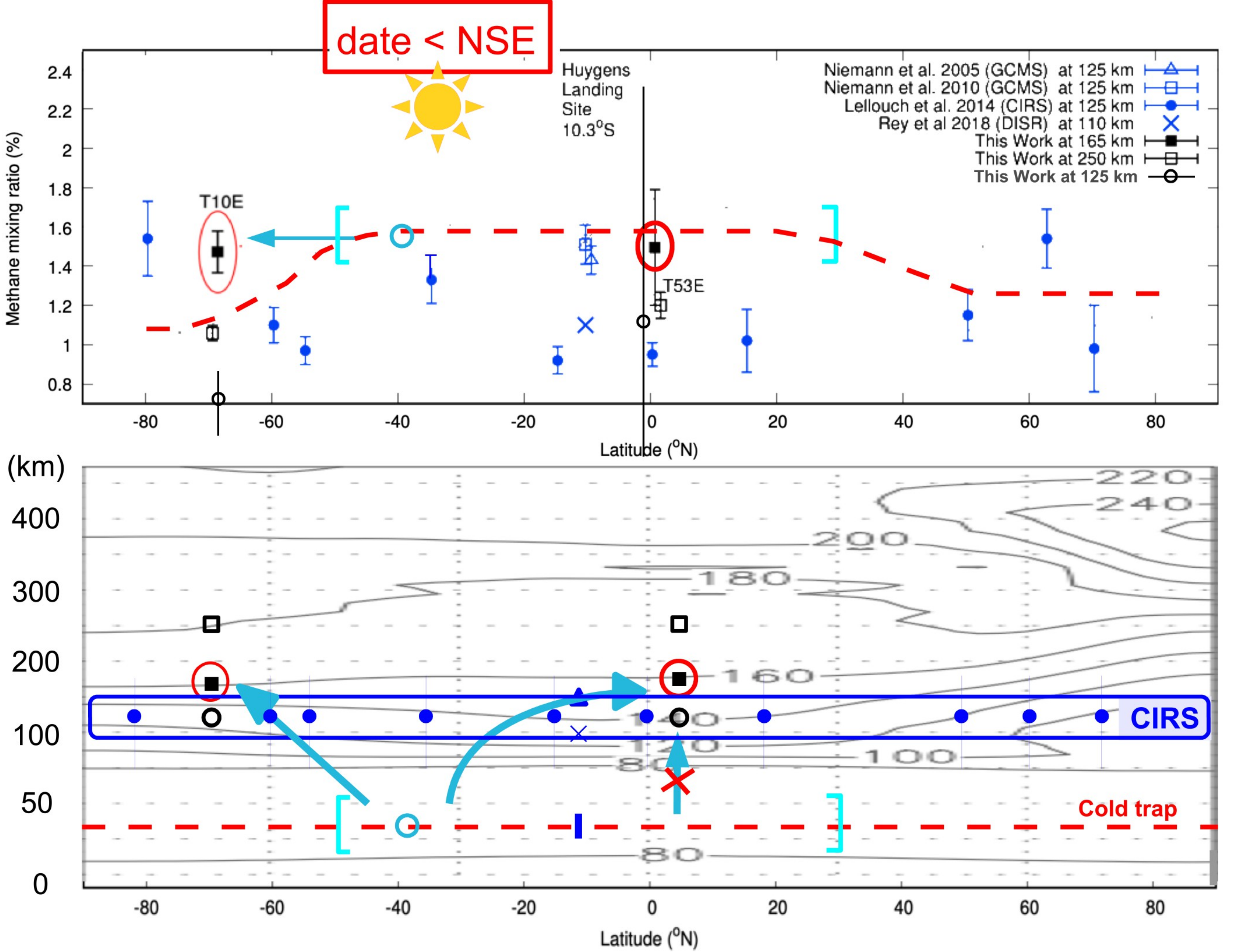
* (Huge) missing absorption at 2.3 µm (→ 3.2 – 3.4 µm)

What Next ?

* Ethane absorption = other objectives

↳ HCN, C_2H_2, C_2H_6 + haze absorption (refractive index) around 3.0 µm

* Constraint for 3D-GCMs (with cloud, haze and feedbacks) → See talk by B de Batz



date < NSE
Huygens Landing Site 10.3°S
Niemann et al. 2005 (GCMS) at 125 km
Niemann et al. 2010 (GCMS) at 125 km
Lellouch et al. 2014 (CIRS) at 125 km
Rey et al 2018 (DISR) at 110 km
This Work at 165 km
This Work at 250 km
This Work at 125 km
Methane mixing ratio (%)
T10E
T53E
Latitude (°N)
(km)
CIRS
Cold trap
Latitude (°N)

Ethane missing !!