

Dynamics and chemistry in the Amazonian region



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METEOROLOGY AND AIR QUALITY



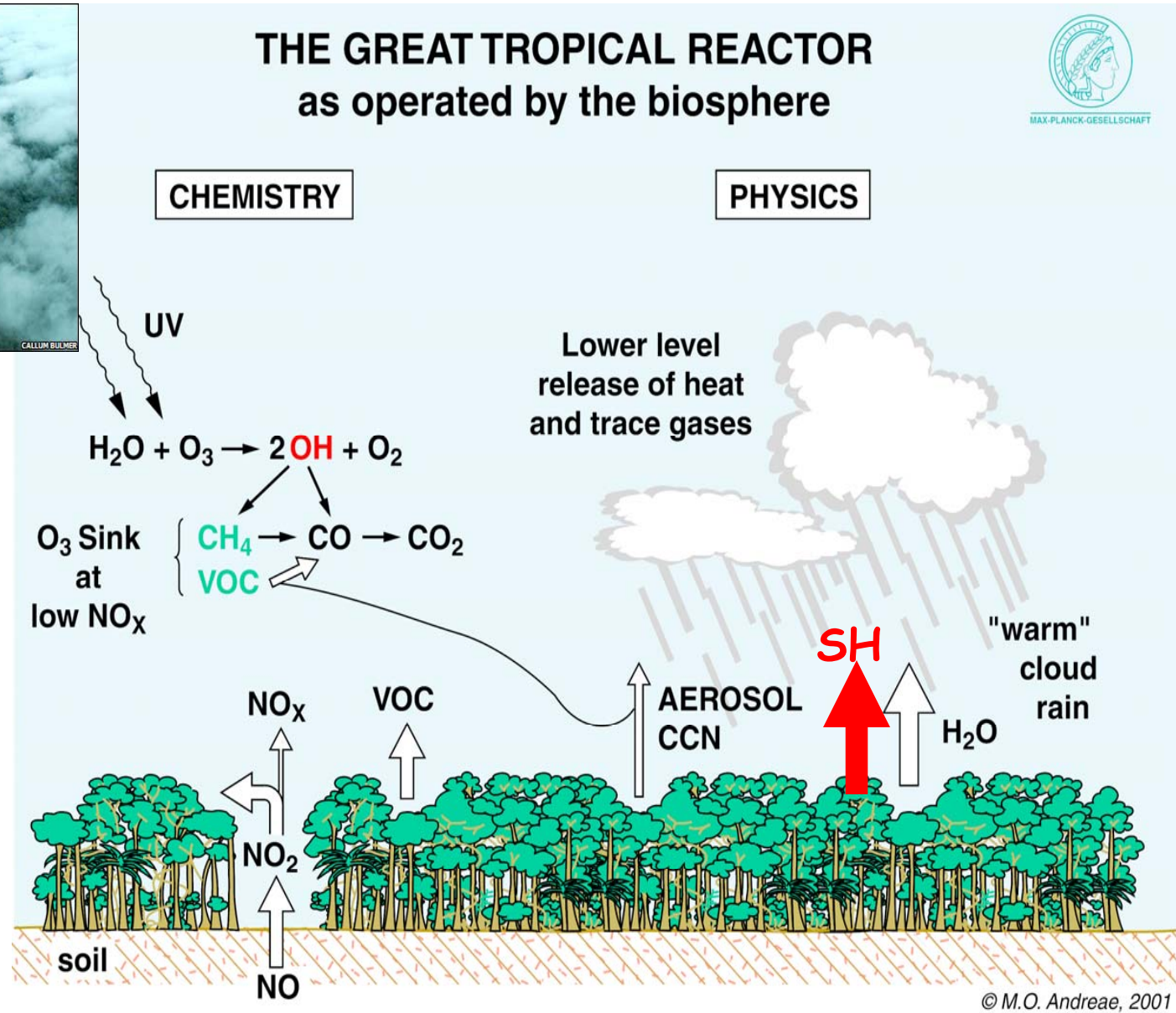
MAX-PLANCK-GESellschaft

Why do we study it?

Dynamics: importance in regulating the heat and water exchange at all the spatial scales

Chemistry: controlling the oxidizing capacity of the atmosphere

The broader perspective

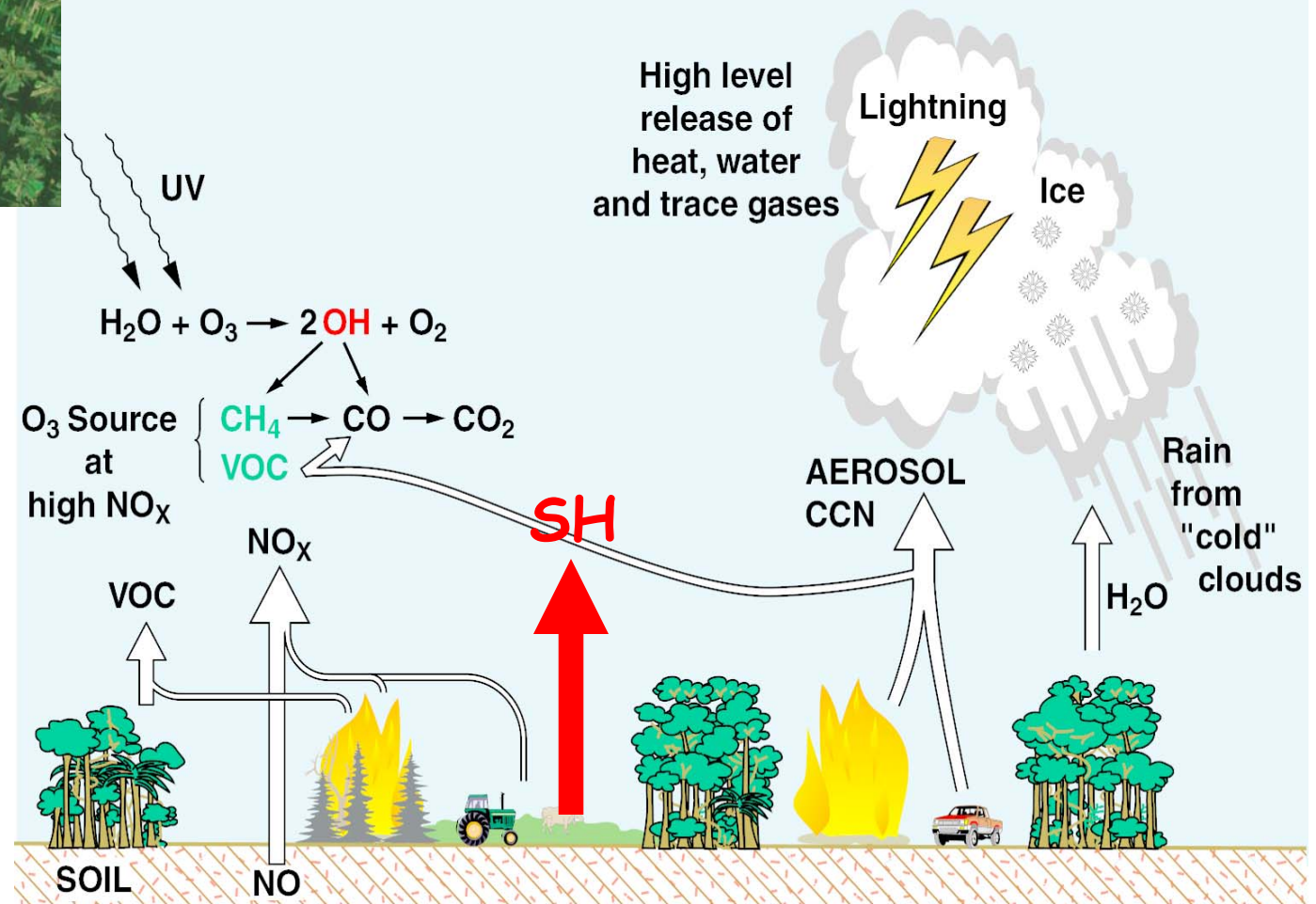


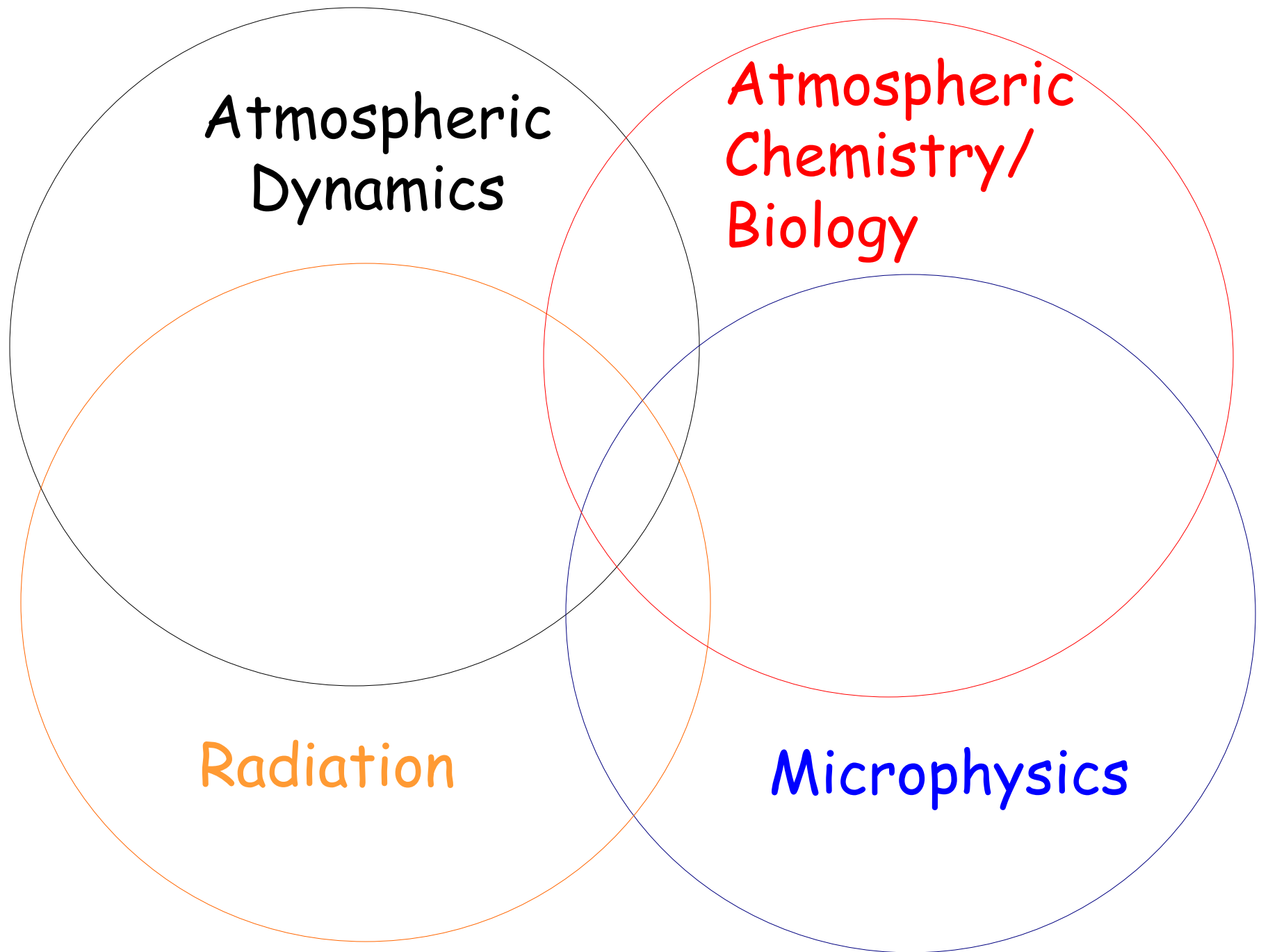
(Courtesy M. Andreae, MPI)

Larger land-use modification affecting dynamics and chemistry

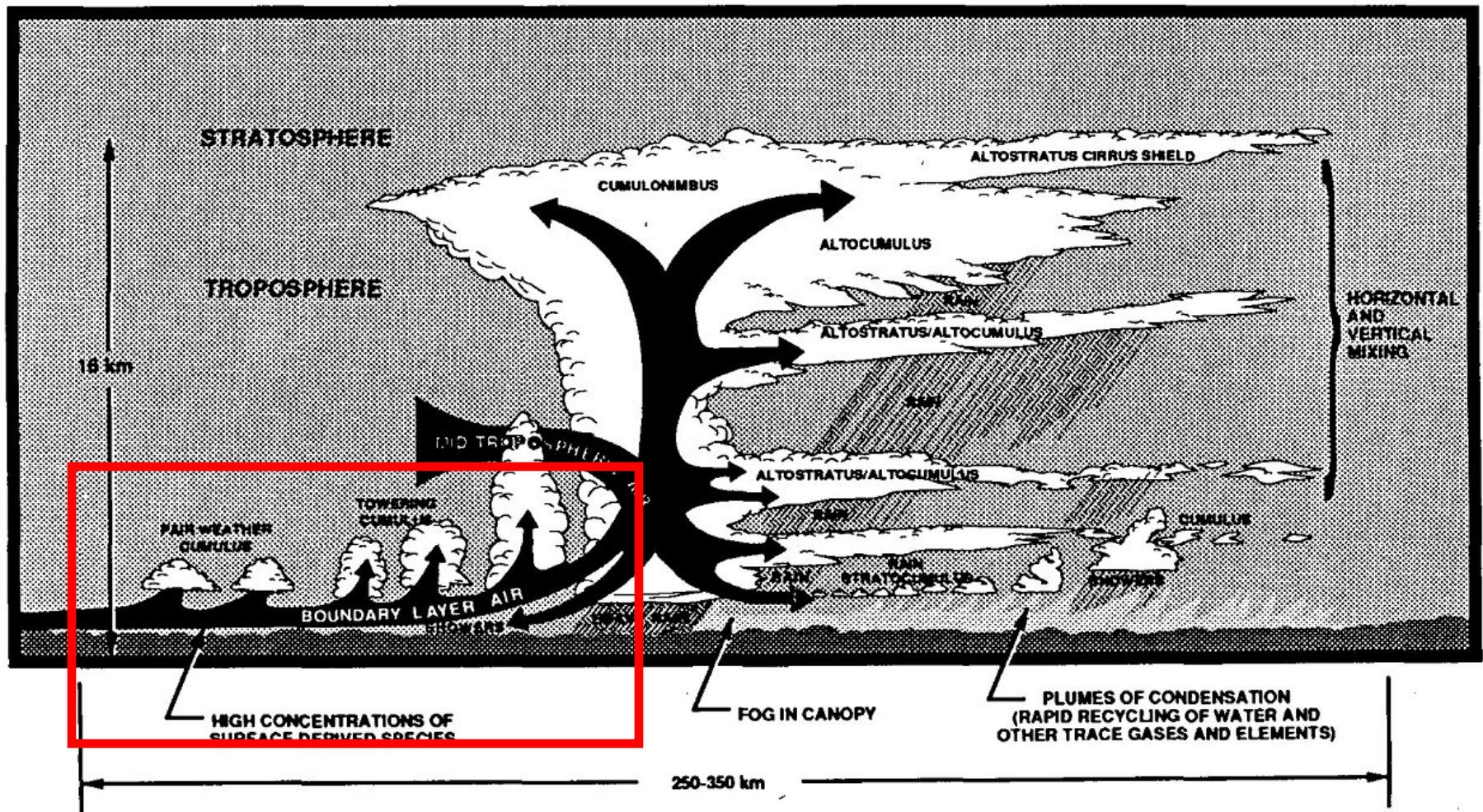


THE GREAT TROPICAL REACTOR as perturbed by deforestation and pollution



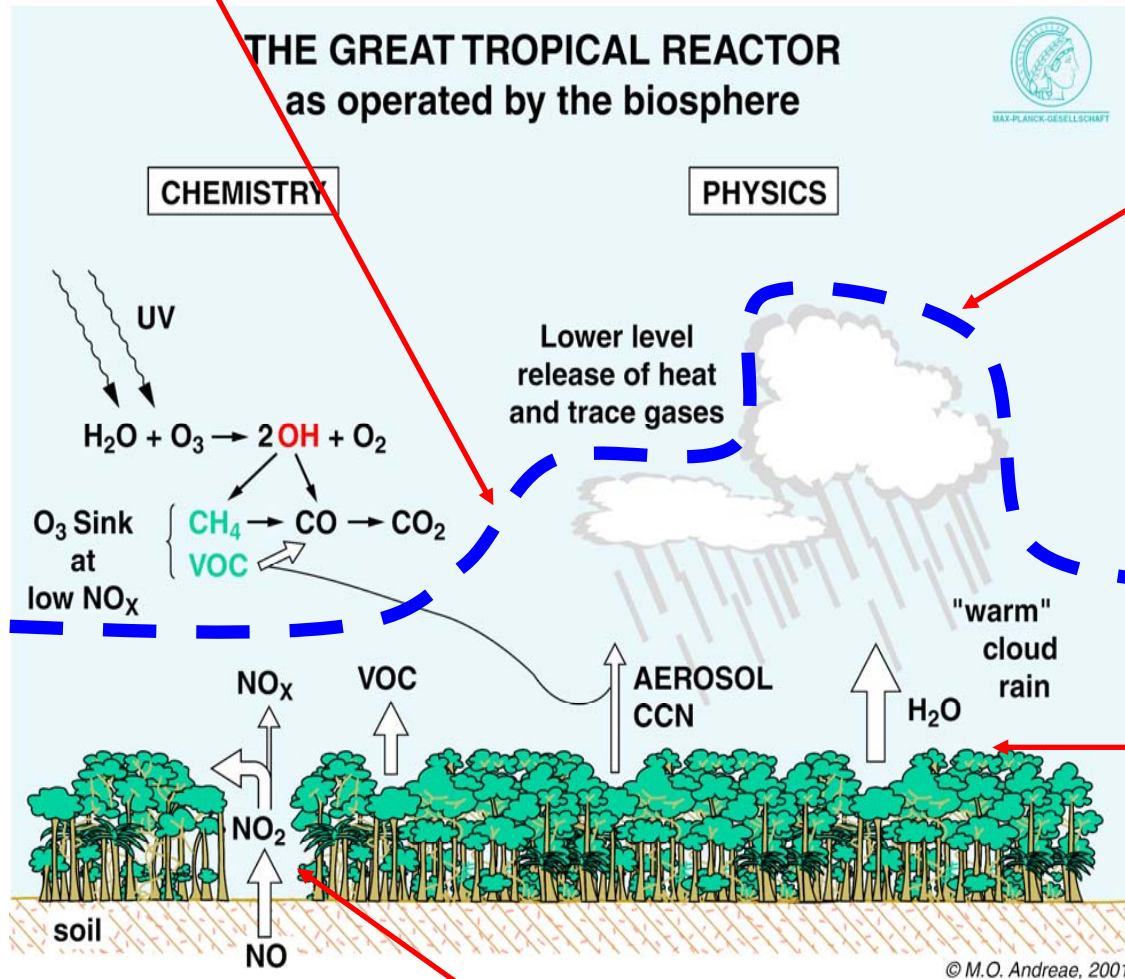


Complexity of dynamics: interaction of spatial scales and physical processes



(Garstang et al., 1990)

Exchange free troposphere and boundary layer



Boundary-layer development
Cloud formation=>
dilution factors
aerosol formation

Turbulence and canopy

Surface heterogeneity

Breaking down the complexity of this system to study

First the individual components

Second the interaction between the physical/chemical processes

How sensitive is the atmospheric compound diurnal variability to boundary layer dynamics?

Study of the diurnal variability of isoprene and related compounds

Observational/modelling
in the Amazonian region

Method

Available observations, but the observational evidence is most of the times far from complete

Design modeling tools with different degrees of complexity and detail

Two modelling tools:

Large-eddy simulation (DALES)

Explicitly resolving the most relevant turbulent scales of the CBL

Mixed-layer theory (conceptual model)

Compounds are well mixed, but there is a specific treatment of entrainment: boundary layer growth and exchange FT-ABL

Designing a conceptual model (mixed-layer theory in CBL)

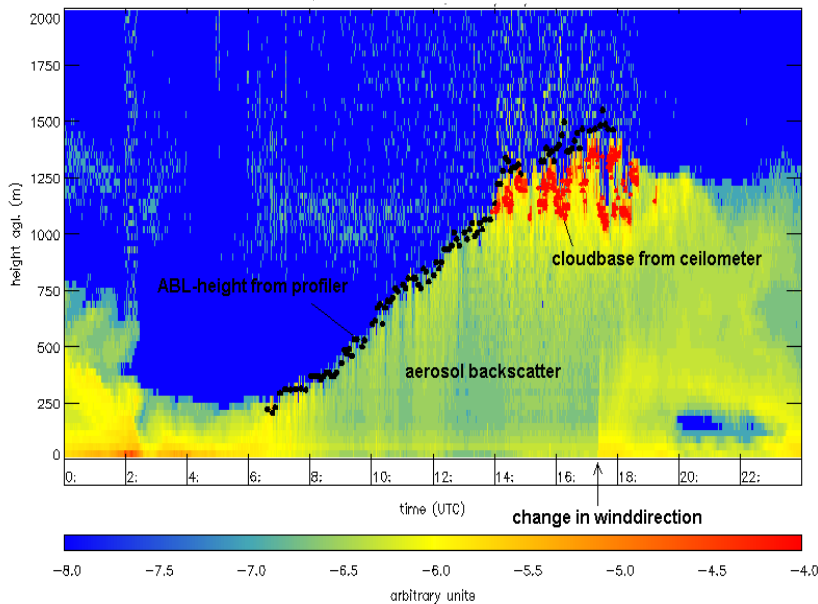
- Reproduce the essential features of the diurnal boundary layer development and evolution of the thermodynamic variables and atmospheric compounds
- Prescribing initial and surface conditions (although it is possible to couple it to a soil-vegetation model)

Pros:

- Reproduce adequately clear boundary layers
- Conceptuality and simplicity
- Enable us to study space range variability
- Close to the boundary-layer schemes implemented in large scale models

Cons:

- Limitations in cloudy boundary layers or surface heterogeneity
- Absence of gradients near surface and entrainment zone



$$\frac{\partial \bar{\psi}}{\partial t} + \bar{u}_i \frac{\partial \bar{\psi}}{\partial x_i} + \frac{\partial (\overline{w' \psi'})}{\partial z} = R$$

Free troposphere

Boundary layer

FT/BL exchange
and dilution

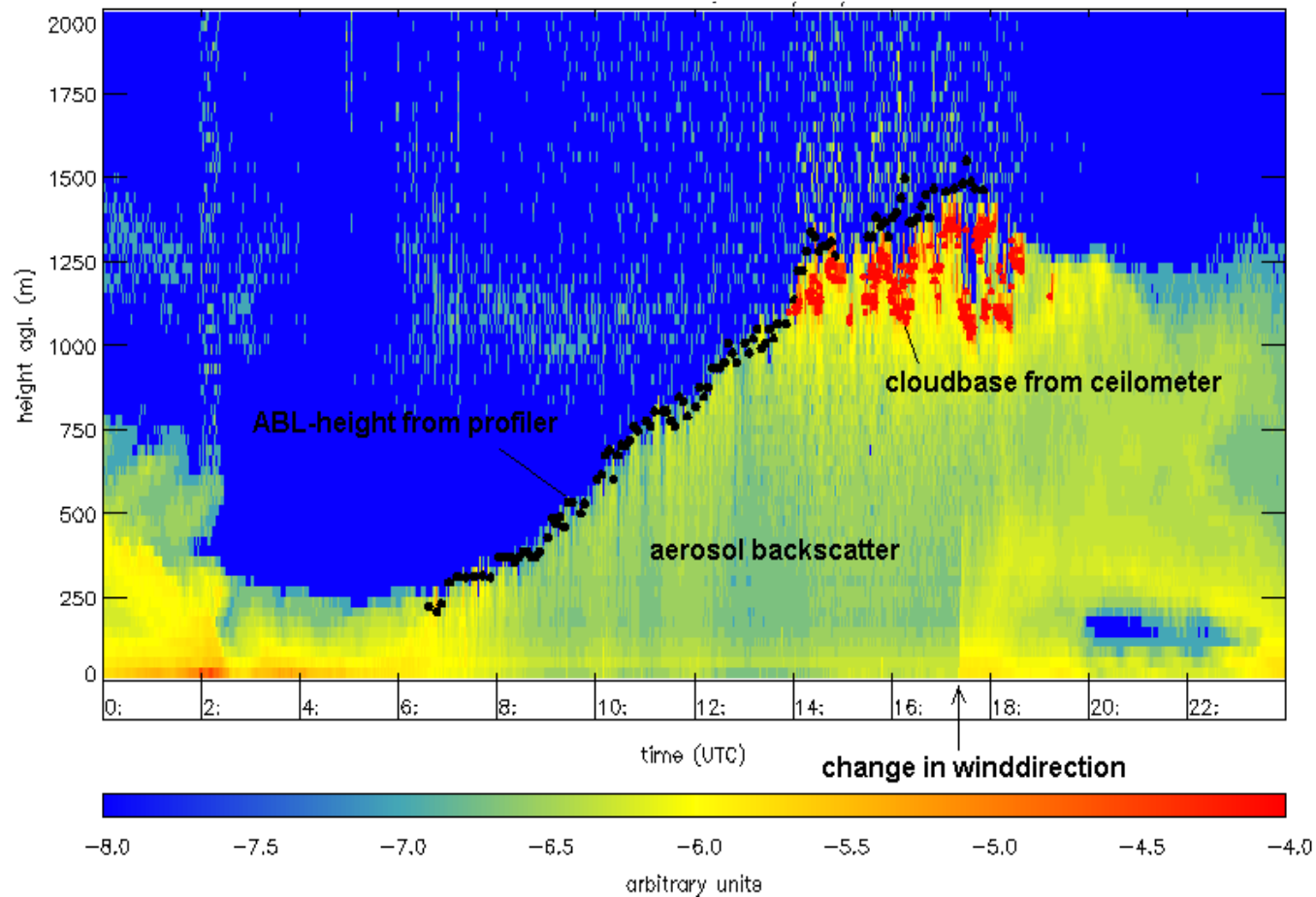
Reactivity

Surface/Vegetation exchange

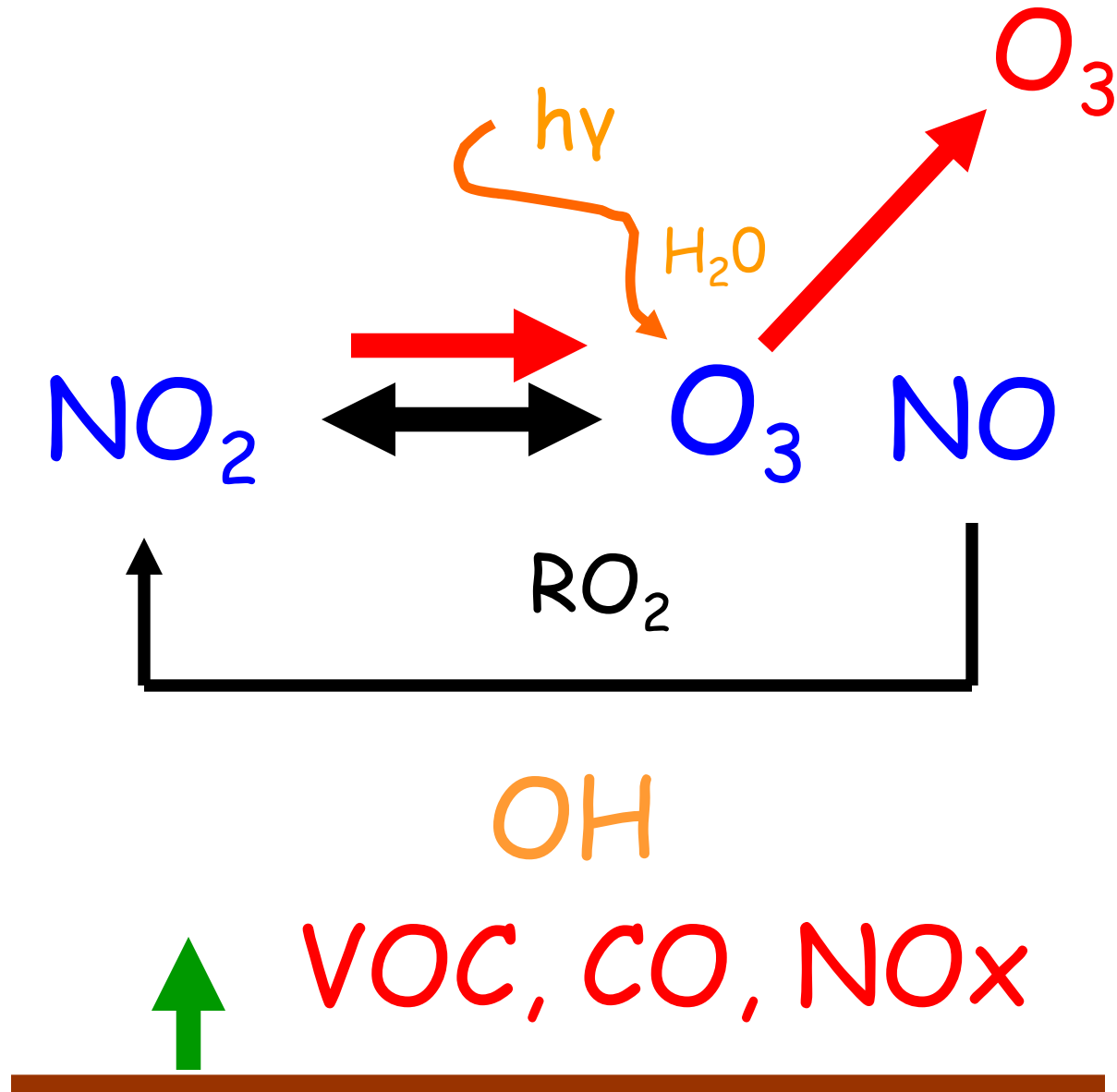
$h(t)$

Numerical experiments: large-eddy simulation and mixed-layer model

Dynamics



Chemistry



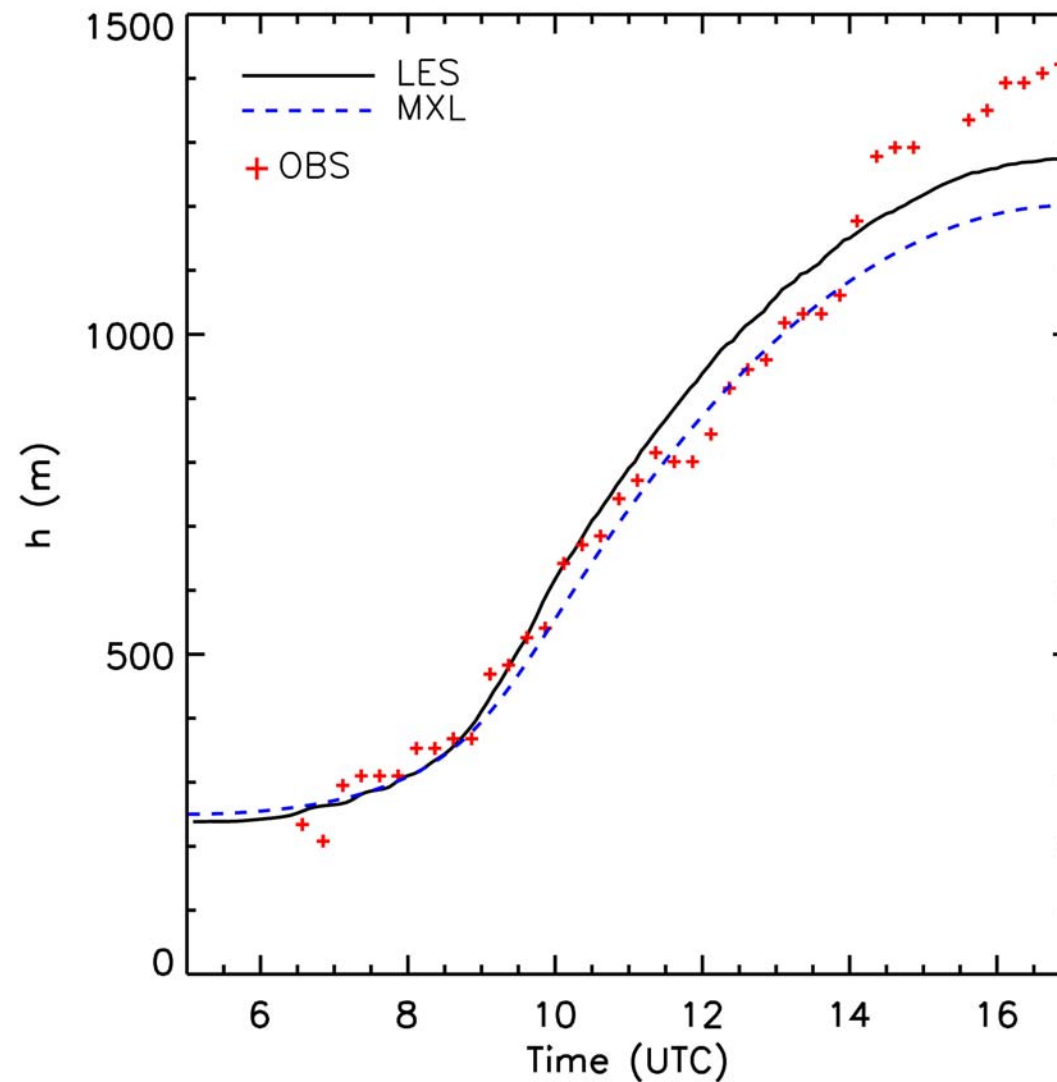
How do measurements,
DALES and MXL model compare?

Boundary layer height growth (dynamics)

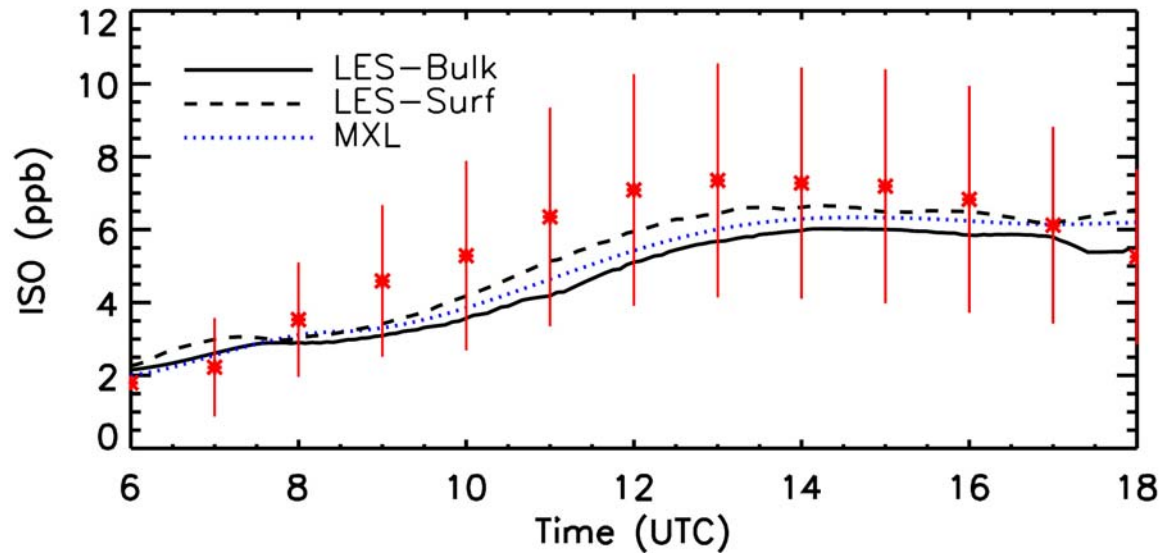
Temporal evolution isoprene and MVK
(chemistry and dynamics)

Vertical profiles isoprene
(chemistry and dynamics)

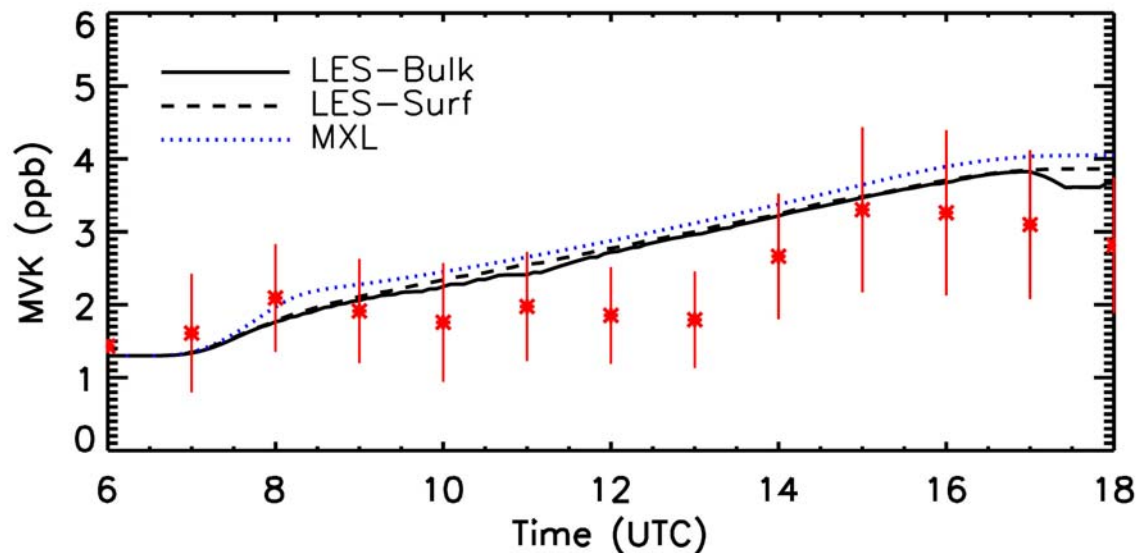
Boundary layer height evolution compared to observations (wind profiler)



Isoprene and MVK diurnal variation

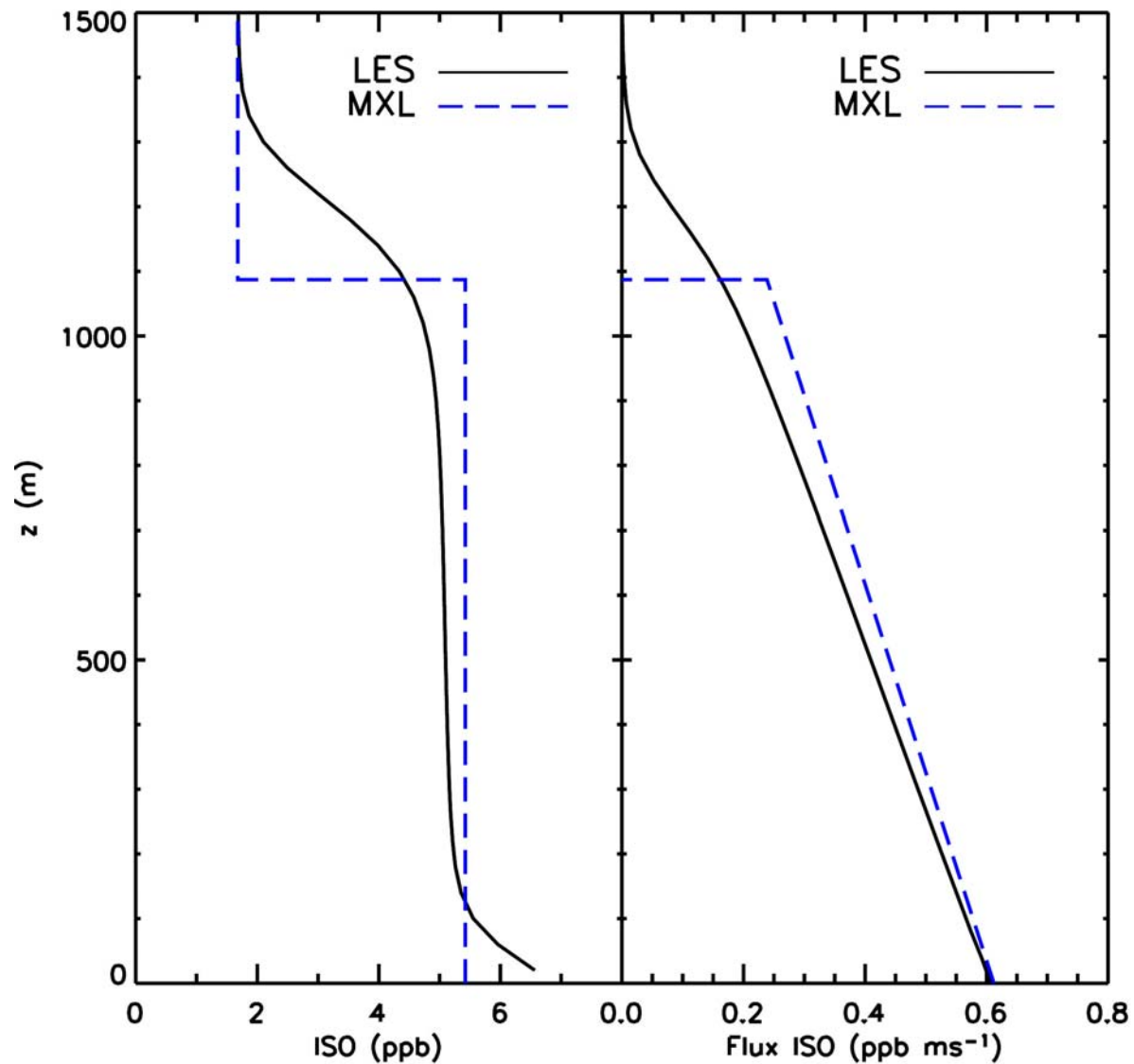


Observations were taken at the Amazonian region (TROFEE, Karl et al. 2007)



In passant: LES reactant evolutions very similar to MXL results

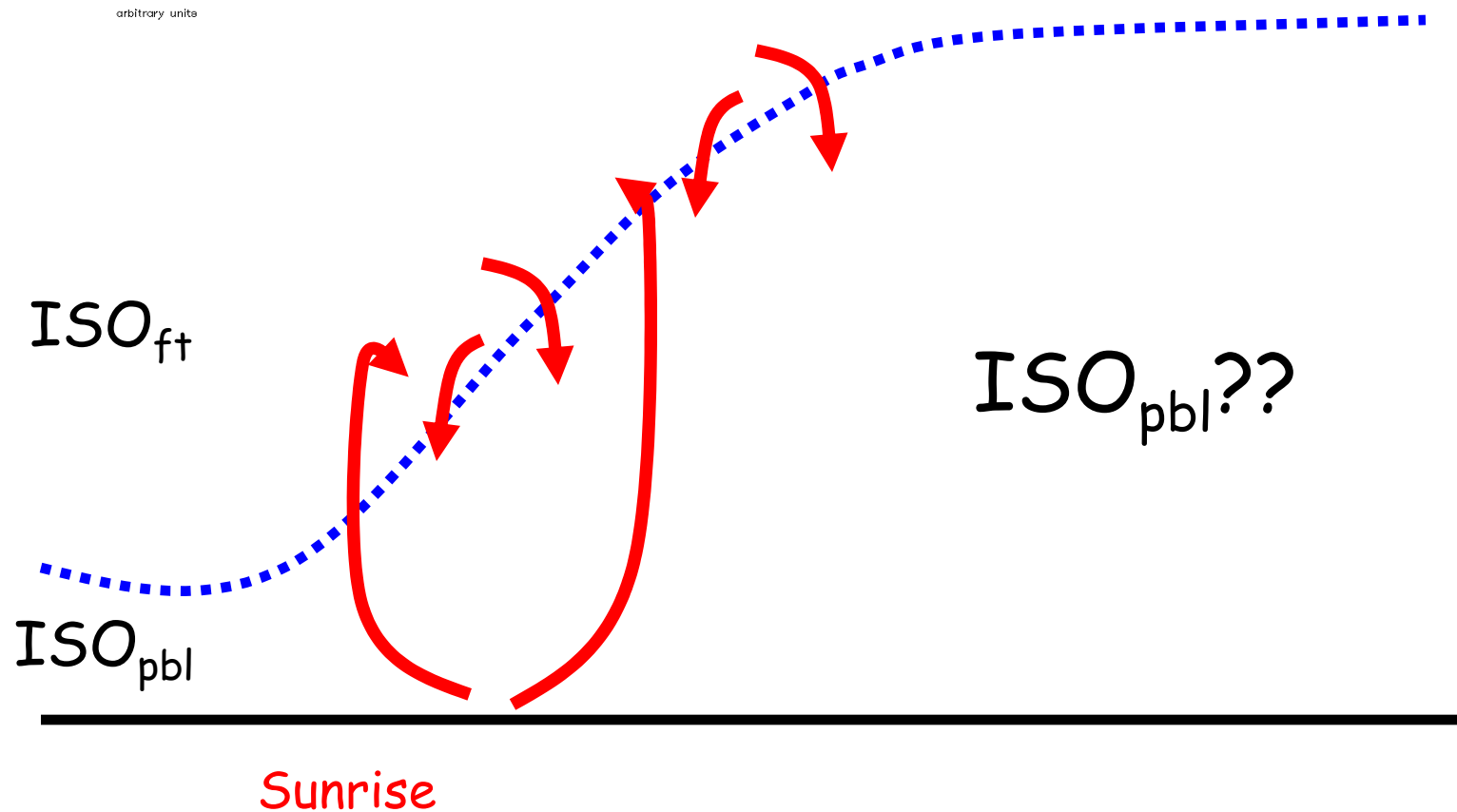
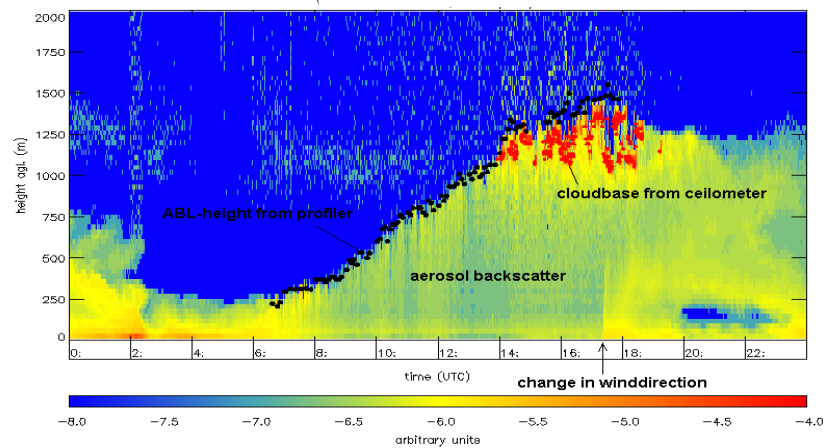
Vertical profiles LES and MXL at 12 UTC



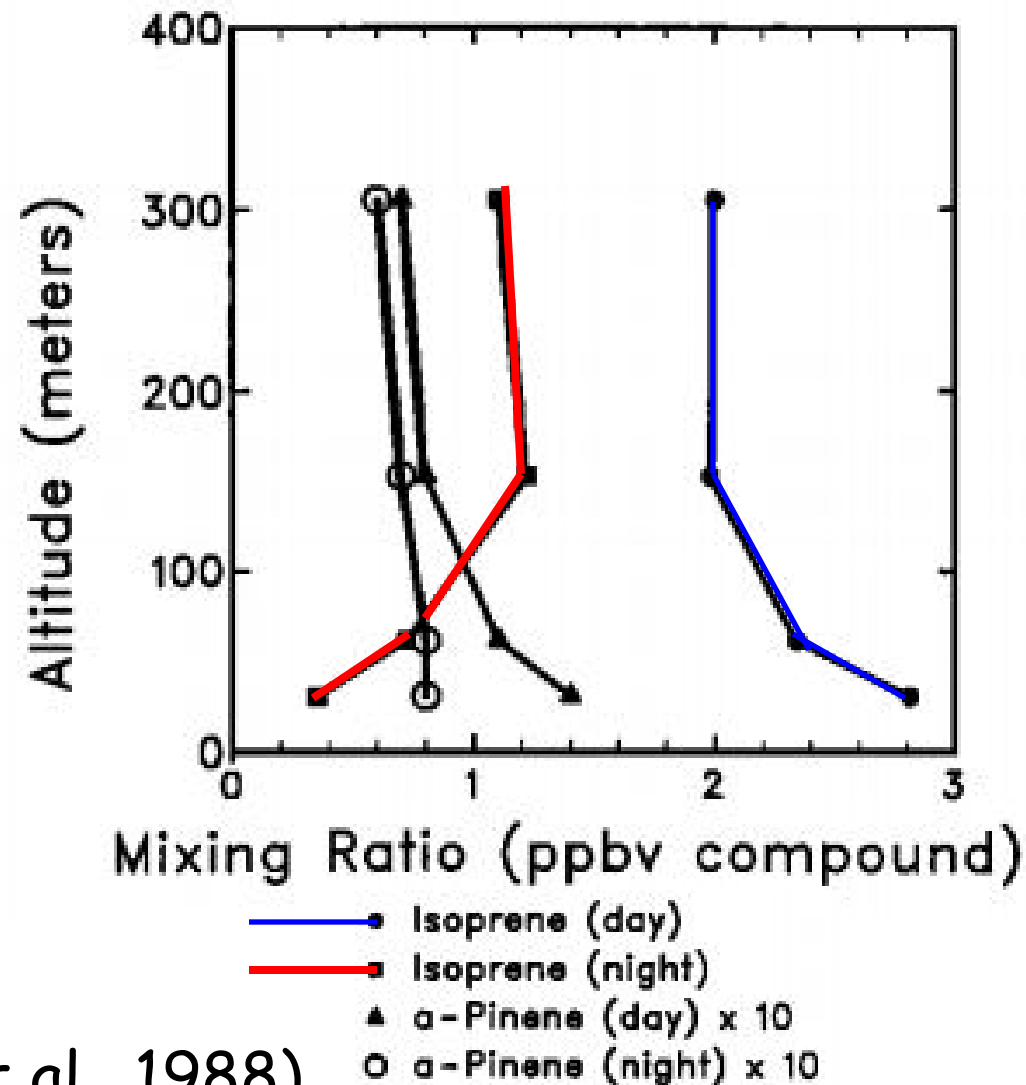
Numerical experiments allows us to do sensitivity analysis and determine uncertainties due to boundary layer development and isoprene conditions

Role of entrainment versus surface

Isoprene initial conditions in the free troposphere (nocturnal diurnal conditions)



Very few experimental evidence
isoprene vertical profiles



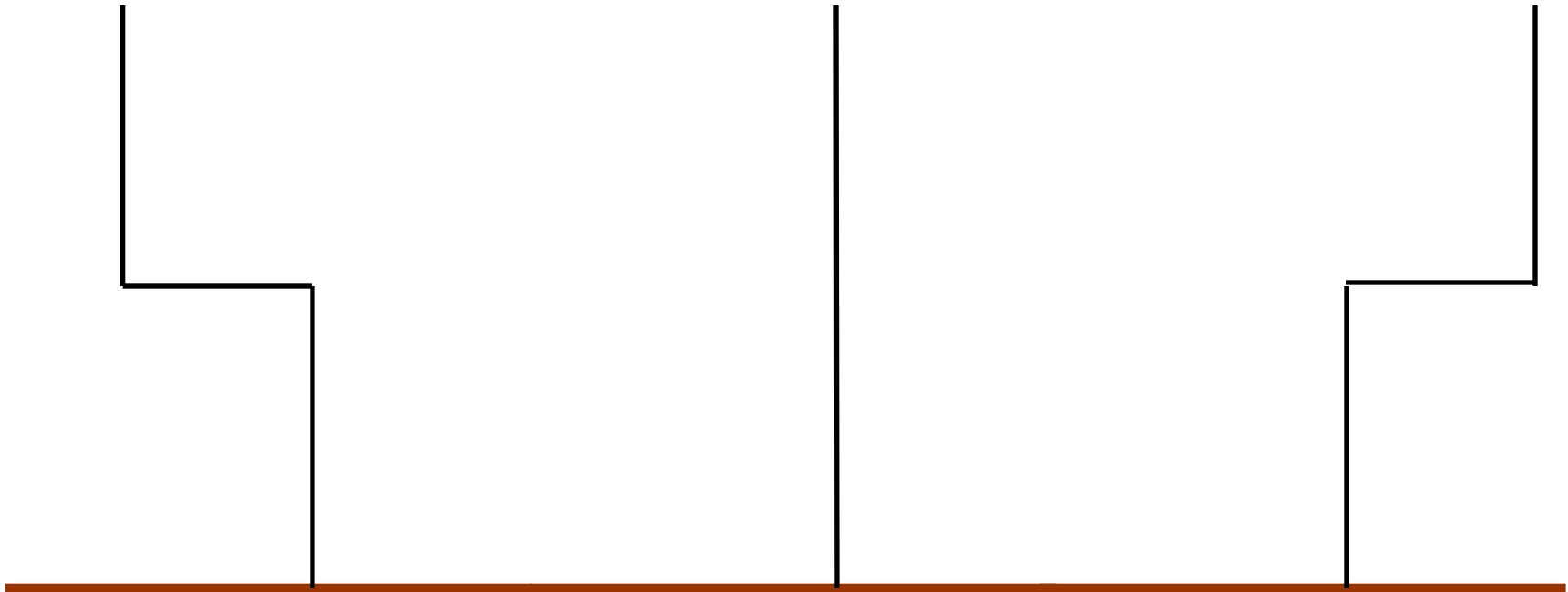
Sensitivity to entrainment:

Three different initial isoprene and MVK profiles at the night-day transition

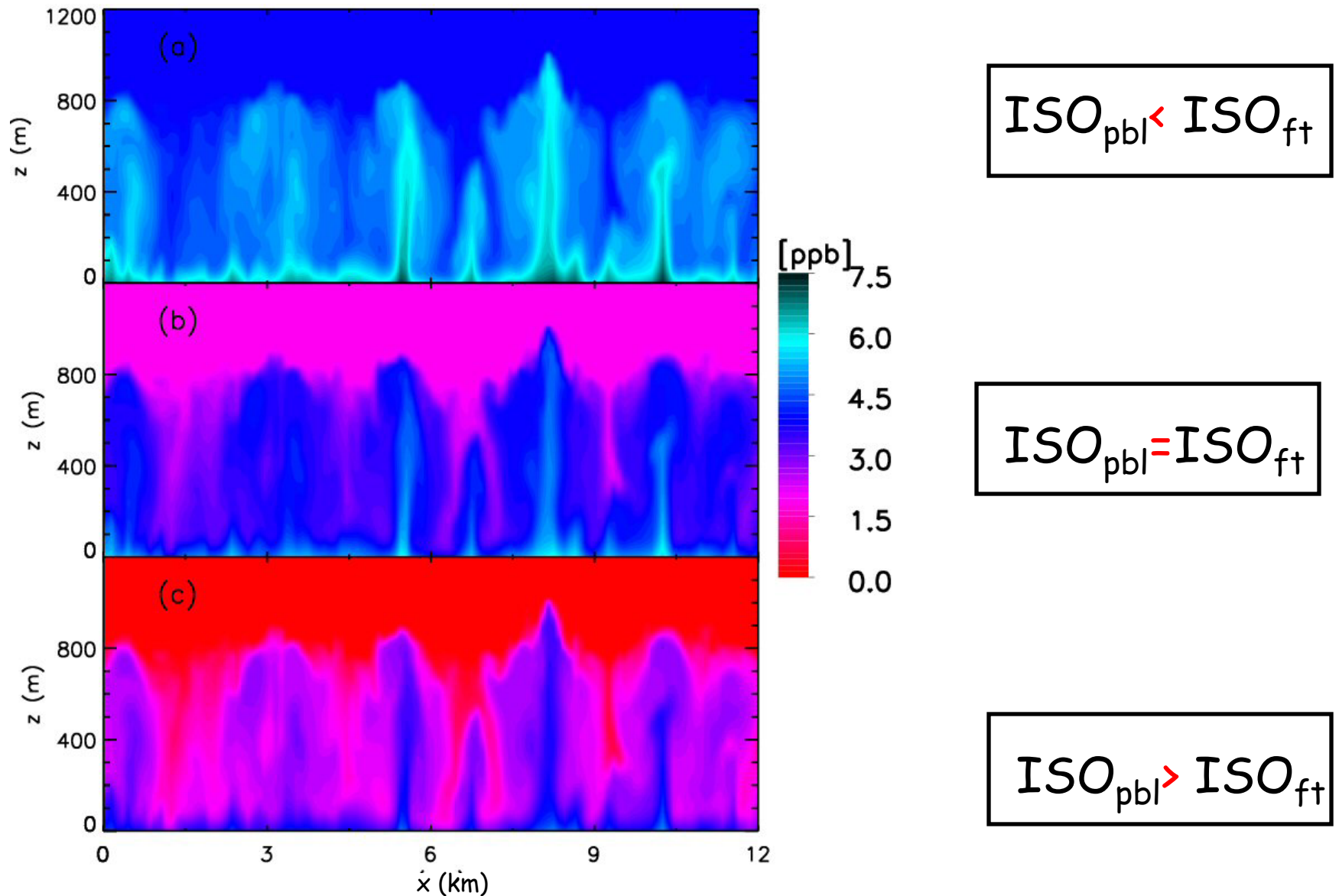
Lower ISO and MVK
in the residual layer

Same ISO and MVK
in RL and ABL

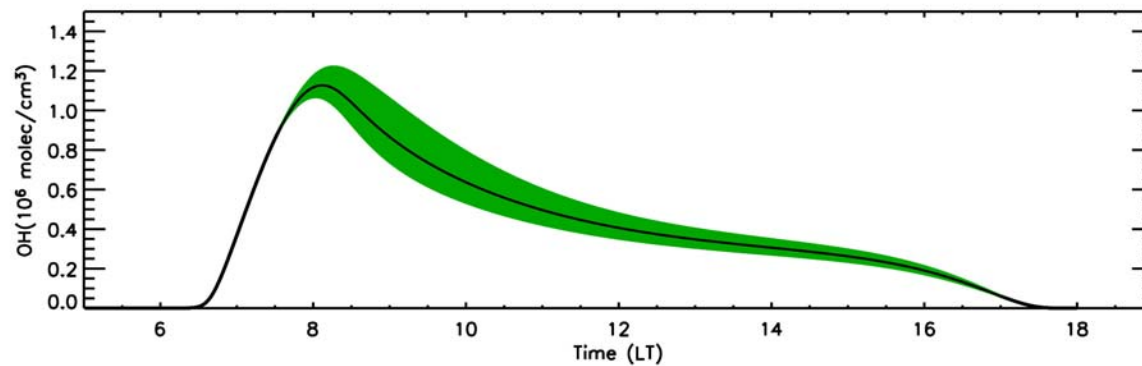
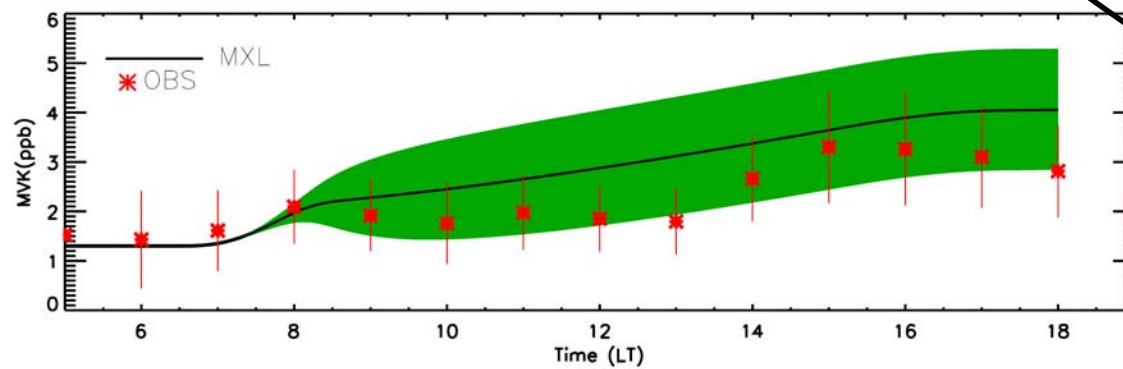
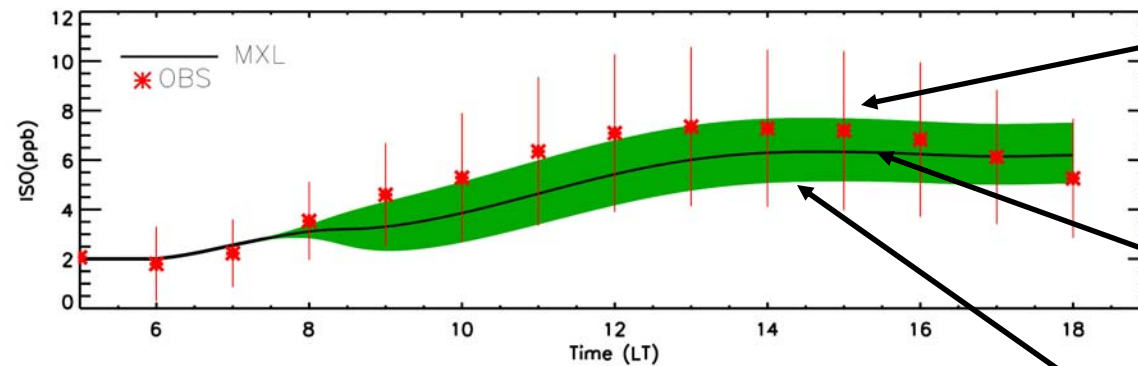
Higher ISO and MVK
in residual layer



Instantaneous vertical cross section ISO taken in the mid-morning (LES)



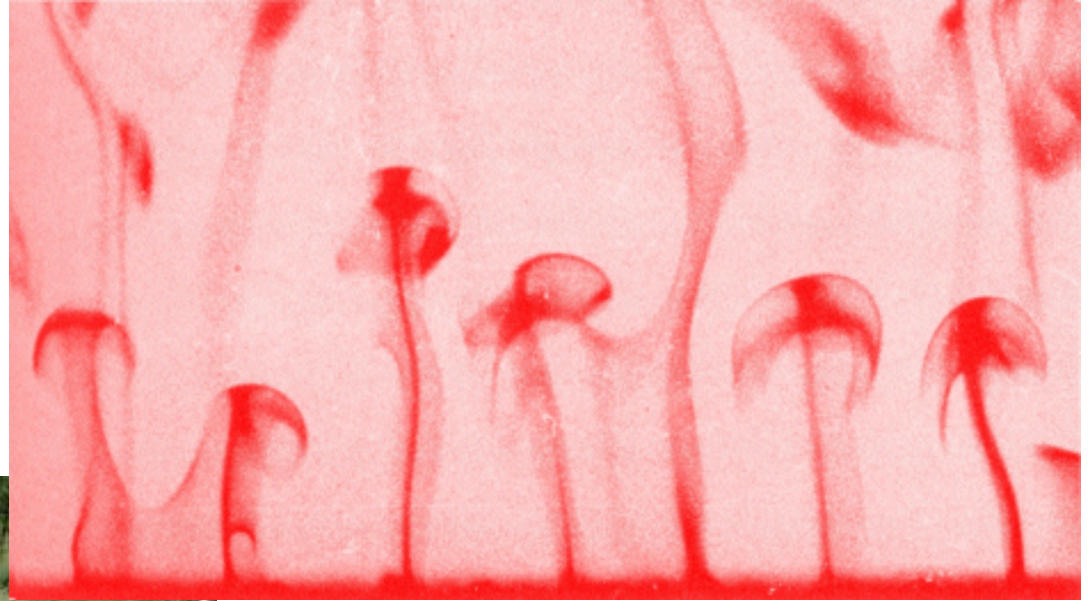
Sensitivity to entrainment isoprene



Is the surface emission more important than the FT-ABL exchange?

Turbulent mixing
and FT-ABL
exchange

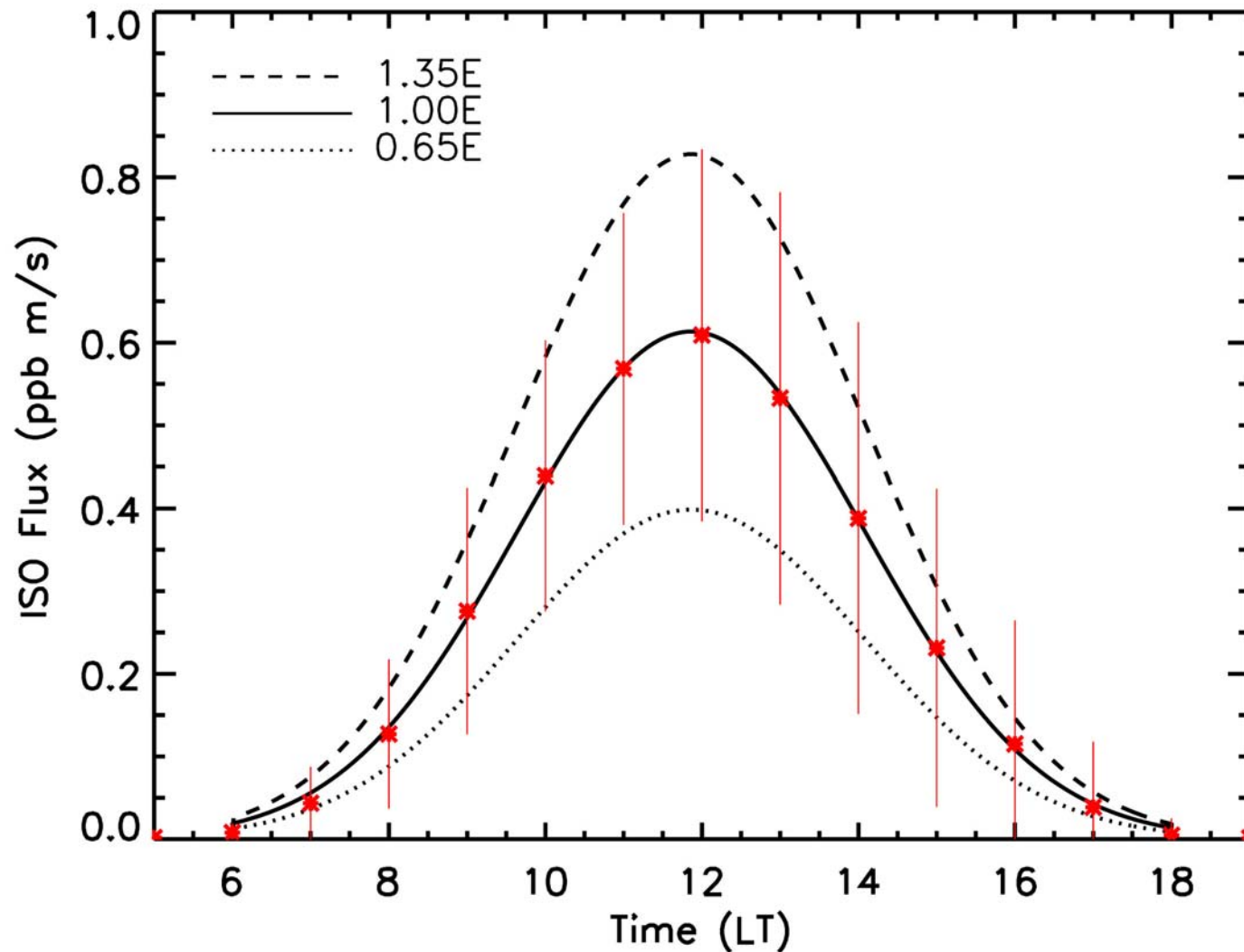
Surface emission



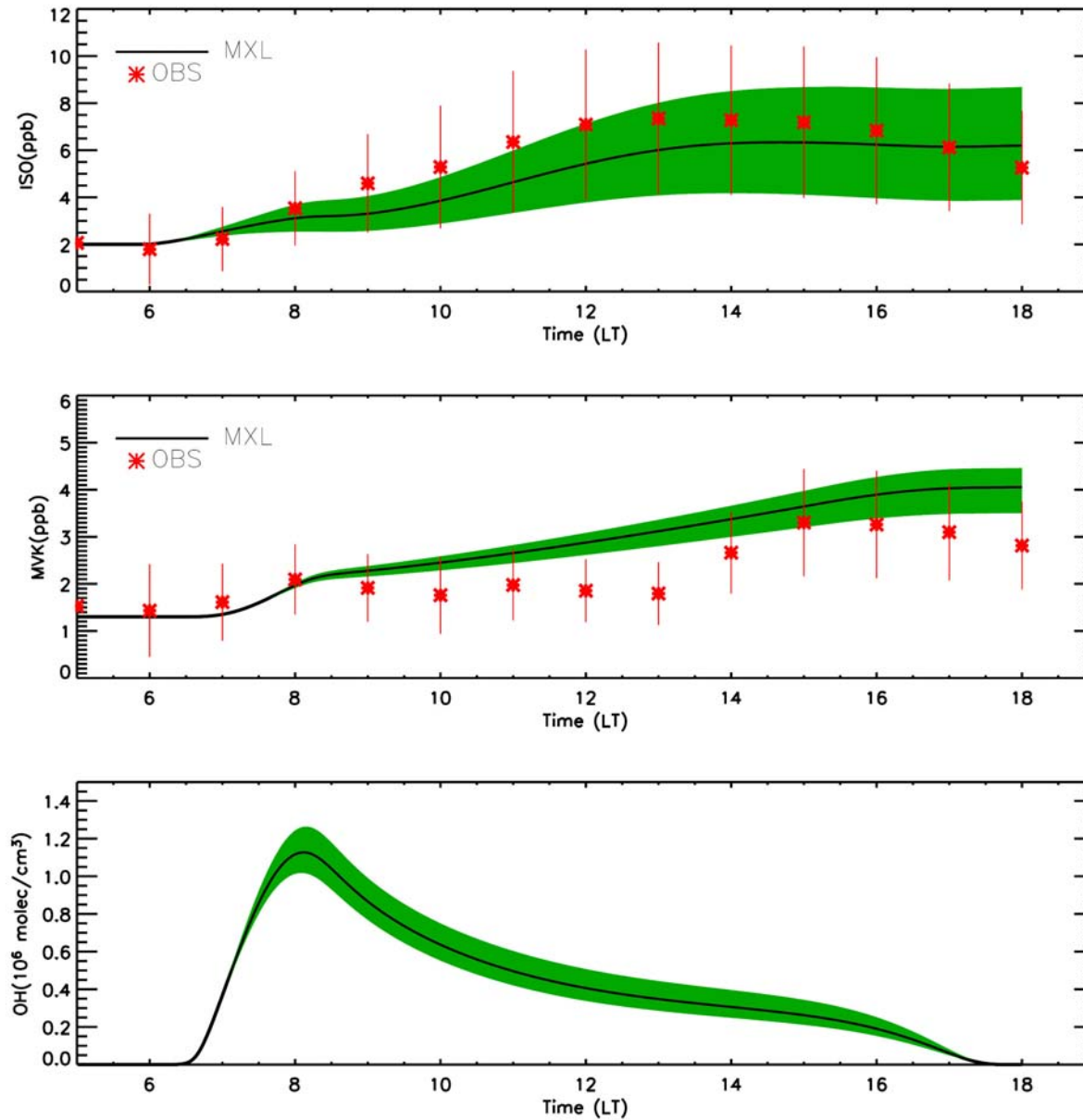
(Madronich, 2009)

Sensitivity to surface fluxes:

Three different initial emission flux for isoprene



Sensitivity to surface emission



In concluding:

Challenging coupling of physical, chemistry and biological processes to understand the dynamics and chemistry in the Amazonian region

Important of the atmospheric boundary layer as a buffer region between the surface and the free troposphere conditions