

Role of saturation in the water vapor diurnal cycle in the South American Tropical Tropopause Layer

CT3LS 2015



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Motivation

How does overshooting convection affect the water vapor variability in the tropical tropopause layer and lower stratosphere?

TRO-pico project

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Co-coordinator J.-P. Pommereau
www.univ-reims.fr/TRO-pico

Involves field campaigns in Bauru (southern Brazil), ground-based, space and balloon-borne observations, and modelling.



Content

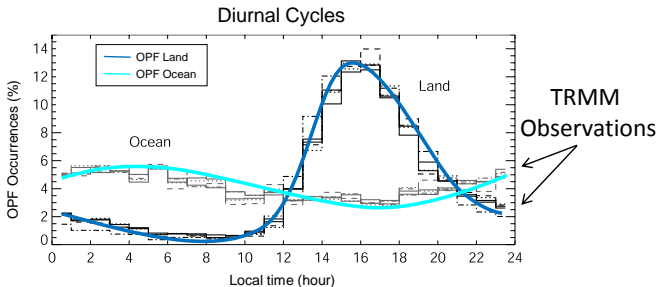
1. **Baseline and global scale overview**
2. **Regional scale case study: South America**
 - **Impact of overshooting convection**
 - **Role of the saturation in H₂O diurnal cycle**
3. **Conclusion**



Section 1

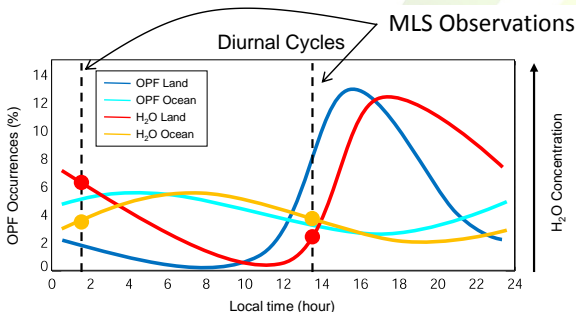
Baseline studies & Overview of large scale impact of overshooting convection on the TTL/LS H₂O

Baseline study 1: Liu and Zipser, JGR, 2005



The Overshooting Precipitation Features (OPF) diurnal cycle above land, which peaks at 1600 LT with large amplitude, is different from that above ocean, which peaks at 0400 LT with small amplitude.

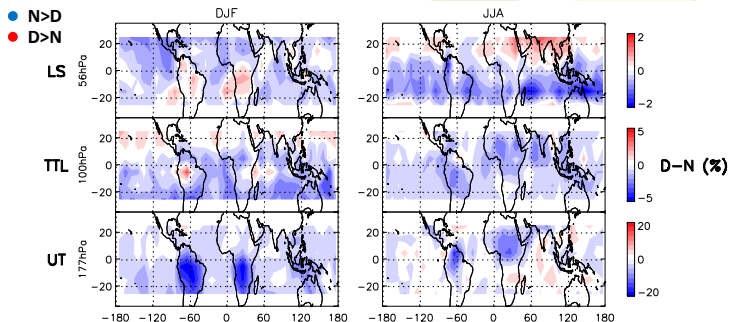
Baseline study 2: Liu and Zipser, JGR, 2009



The UT Microwave Limb Sounder (MLS) H₂O daytime sampling (1330 LT) is on average smaller than the night-time sampling (0130 LT) over land ($D-N < 0$), and the opposite over ocean ($D-N > 0$).

Baseline study 3: Carminati et al., ACP, 2014

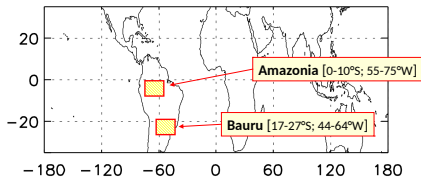
MLS relative D-N H₂O (%) 2005-2012 solstitial seasons



- UT **negative** D-N in continental most convective regions.
- TTL/LS **positive** D-N in continental most convective regions.

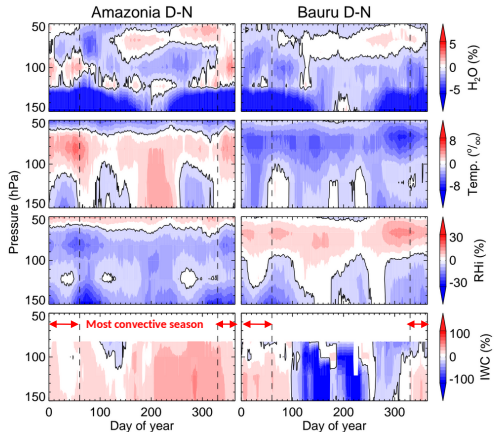
Section 2

Regional scale case study: South America Impact of overshooting convection & Role of TTL saturation



MLS 10-year (2004-2014) daily averaged D-N

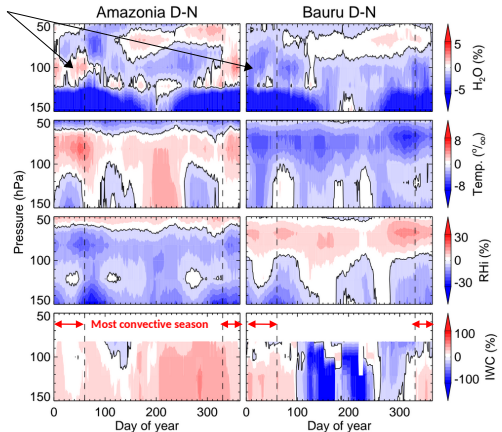
D-N H₂O, temperature, RH_i, and IWC ±16 days running mean



MLS 10-year (2004-2014) daily averaged D-N

- Daytime moistening in Amazonia vs night-time moistening in Bauru at 100 hPa in convective season.

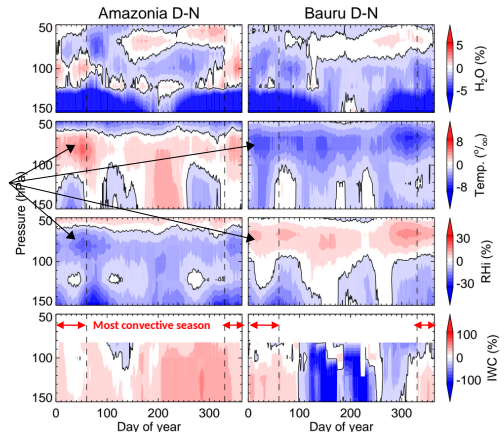
D-N H_2O , temperature, RH_i, and IWC ± 16 days running mean



MLS 10-year (2004-2014) daily averaged D-N

- Daytime moistening in Amazonia vs night-time moistening in Bauru at 100 hPa in convective season.
- Opposite sign of D-N in T and RH_i linked to MLS sampling times in phase with the convective cooling in Amazonia but not in Bauru.

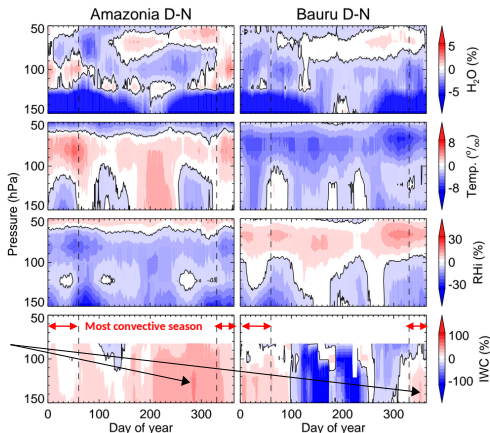
D-N H₂O, temperature, RH_i, and IWC ±16 days running mean



MLS 10-year (2004-2014) daily averaged D-N

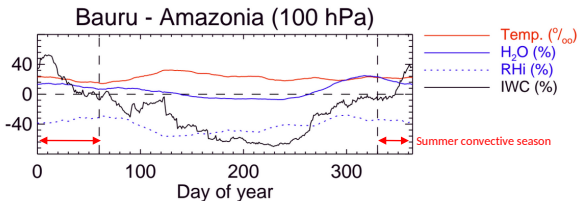
- Daytime moistening in Amazonia vs night-time moistening in Bauru at 100 hPa in convective season.
- Opposite sign of D-N in T and RH_i linked to MLS sampling times in phase with the convective cooling in Amazonia but not in Bauru.
- Daytime increase of IWC almost year-round near the equator, but only during the convective season in the tropics.

D-N H₂O, temperature, RH_i, and IWC ±16 days running mean



Differences in the TTL

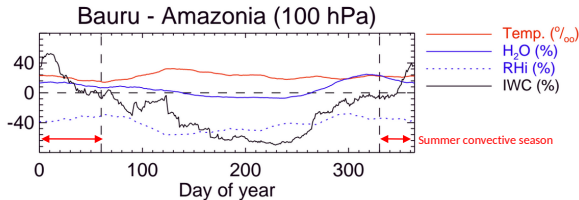
Relative difference between Bauru and Amazonia of MLS 10-year (2004-2014) daily averaged H₂O, temperature, RH_i, and IWC ± 16 days running mean.



- Bauru is warmer and has a lower RH_i than Amazonia year-round.
- H₂O and IWC present a seasonal cycle of large amplitude.
- Wet and ice-charged summer TTL in Bauru is the sign of a convective moistening with ice injection/sublimation.

Differences in the TTL

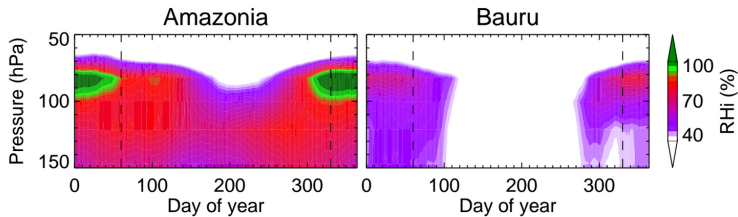
Relative difference between Bauru and Amazonia of MLS 10-year (2004-2014) daily averaged H_2O , temperature, RH_i, and IWC ± 16 days running mean.



But, it does not explain the difference in D-N between Bauru and Amazonia!

Hypothesis: The residence time of ice crystals

MLS (2004-2014) daily averaged $RH_i \pm 16$ days running mean.



In a **super-saturated** TTL, ice crystals must sediment to sub-saturated levels or perdure until the saturation is no longer sustained to sublimate, which should **require more time** than if they were injected in a sub-saturated TTL.

How to verify this hypothesis?

MOCAGE-VALENTINA assimilation tool

→ MOCAGE CTM

- Horizontal resolution: global ($2^{\circ} \times 2^{\circ}$)
- Vertical resolution: 47 levels from surface to 5 hPa in σ coordinates
- Dynamical/Met. forcing provided by ARPEGE analyses
- Time step: 15 min for chem/phy processes & 60 min for dynamics
- 140 hPa: Limit between ARPEGE constraints and chemical species

→ VALENTINA (PALM coupler)

- 3D-Var method
- Model error has been fixed to be 45%
- Assimilation with hourly frequency
- Covered period: Nov 2011 to Mar 2012 (to be extended to Mar 2013)
- MLS water vapor is used from 316 to 5 hPa
- Validated with MIPAS data sets

(Payra et al., AMTD, in prep.)

A 24-h resolved cycle for H₂O

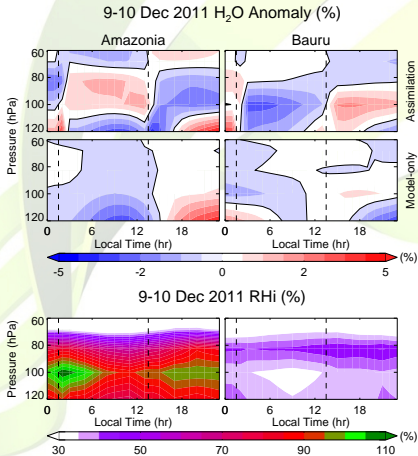
MLS observations assimilated in MOCAGE-VALENTINA

Amazonia_{100hPa}

Daytime moistening, consistent with delayed sublimation of ice crystals in super-saturated TTL. Not seen in the CTM!

Bauru_{100hPa}

Night-time moistening, consistent with rapid sublimation of ice crystals in sub-saturated TTL.



Conclusion


At large scale

- Impact of convection in function of the season and of the surface.
- Dehydrating Cold Trap processes in oceanic regions.
- Hydrating overshooting injection of ice crystals in continental regions.

At regional scale in South America

- Overshooting injection of ice crystals both in tropical and equatorial regions, but the time scale for sublimation (and thus moistening) differs.
 - ⇒ In sub-saturated tropical TTL, rapid sublimation and late afternoon/night-time moistening.
 - ⇒ In super-saturated equatorial TTL, delayed sublimation and late night-time/morning moistening (not seen in the CTM!).

Thank you.

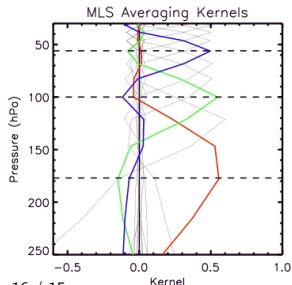


Supplementary material

MLS characteristics

4 operational products relevant for this study:

- **H₂O** (190 GHz) ([Read et al., 2007](#))
- **Temperature** (118 GHz) ([Schwartz et al., 2008](#))
- **RHi** (from H₂O and Temperature products) ([Read et al., 2007](#))
- **Cloud Ice Water Content** (IWC) (240 GHz) ([Wu et al., 2008](#))



3 layers of interest

56 hPa → LS
100 hPa → TTL
177 hPa → UT

3 independent pieces of information

Resolution (VxH) ~3x220 km

Precision 6-25%

Accuracy 4-20%

(in 177-56 hPa pressure range)

Supplementary material

Assimilation

