Why so few observations of enhanced water vapor in the lower stratosphere at Houston in SEAC4RS?

or

How uniform is the lowermost stratosphere in the North American monsoon?

Rennie Selkirk, GESTAR/NASA GSFC
Anne M. Thompson, NASA GSFC
Lenny Pfister, NASA Ames Research Center
Melody Avery, NASA Langley Research Center
Bob Herman, Jet Propulsion Lab
Jessica Smith, Harvard University
Ryan Stauffer, Penn State University

with contributions from NOAA ozone and MMS teams
Talk Outline

• Motivations
• UT/LS water vapor at Ellington versus rest of SEAC4RS region
  • SEACIONS CFH ascents
  • Aircraft descents: HWV Lyman-α and HHH and JPL JLH
  • Elsewhere combination of ER-2 level legs and dips
• Large-scale meteorological context – 300 hPa evolution
• Convective influence
• Summary and conclusions
Motivating questions

- How do trace constituents find their way to the UTLS?
- What is the contribution of tropical air to the UTLS in the North American monsoon?
- How do convective and horizontal transport processes interact to condition the trace constituent structures in the UTLS?
- What are the horizontal and spatial scales of mixing in the anticyclonic regime over summertime North America?
Water vapor vs. ozone

Compact relationship with clear stratosphere and troposphere branches
- Very pronounced “knee” at 380 K
- Coldpoints (red dots) in lower stratosphere branch of diagram
- Conspicuous narrowing of water vapor range in 400-600 ppbv ozone
- Widening range below shows history of strat-trop exchange
SEACIONS
Cryogenic Frostpoint Hygrometer
18 launches at Ellington Field

KEY FEATURES

- Transition to undisturbed stratosphere from 415 K to 440 K
- Mixing region from 365 K to 415 – with sub-layer of enhancements from 380 K to 395 K
- Sharp throttling down of variability seen in the UT at 365 K – the tropopause cold trap

How do these layers look outside of the immediate region around Houston?

SEAC4RS STM 2015
Pasadena, CA
29 April 2015
Ly-\(\alpha\) (Harvard)

Separate 2-deg box around Houston from rest of SEAC4RS theater of flight operations

- Overall, similar layering and transitions
- Enhancement layer 380-395K, but somewhat less distinct than in sondes
- Enhancements spread throughout mixing layer from 365 K to 415 K
- Cold trap “throttle” evident in std dev
Higher level of variability than LYA, but main features of the two regions very similar.

JLH (JPL)
Separate 2-deg box around Houston from rest of SEAC4RS theater of flight operations.
Ly-α (Harvard)

Water vapor scattered versus ozone

- Variability reduced above 200 ppb/390 K
- “Heel” feature with low WV below
- Enhancements evident to 600 ppbv
- Heel acquires an “Achilles tendon”
Water vapor scattered versus ozone

Bigger spreads in water vapor evident, but otherwise similar to Ly-α
Meteorological context
MERRA 300 hPa charts
(all 18 UT)
Convective Influence along ER-2 flight track

Time to most recent convection (<10 days)
(all flights except Aug 12-21)

- Convective influence evenly scattered throughout SEAC4RS operational region
- But distribution of convective influence times is very heterogeneous
Convective Influence Source Locations

- FRESHEST INFLUENCES: Gulf Coast, south Texas, Caribbean
- MIXED AGES: mid-continental MCS’s
- FARTHER UPSTREAM: western Mexico, Pacific ITCZ and tropical cyclones, central America
Like times since convective influence, source latitudes are literally all over the map.

No region in SEAC4RS region is clearly associated with a source latitude.

Rather, the pattern is consistent with overall anti-cyclonic flow.
Houston very similar to rest of SEAC4RS in both source locations (latitude) and age of air since convection

- A slight preponderence at Houston for local convection (red peak at 30°).
- Convective influence suggests that air sampled over Houston is representative of SEAC4RS – differences due to sampling
Summary and conclusions

- **Water vapor enhancements**
  - Limited over Houston, copious over rest of SEAC4RS region
  - Underlying vertical structure consistent in both regions

- **Meteorological context**
  - Strong ridging mid-continent emblematic of anticyclonic flow
  - This pattern flowed air parcels from the eastern Tropical Pacific and even Central America into the continental flow regime

- **Convective Influence**
  - Uniform but fine-grained distribution over SEAC4RS region UTLS
  - Houston indistinguishable from rest of SEAC4RS

**Conclusion:** The lower frequency and magnitudes of LMS water vapor enhancements over Houston vis-à-vis the larger SEAC4RS region are a result of sampling and consistent with large-scale uniformity of fine-grained tracer structure of UT/LS in the anticyclonic North American monsoon regime.