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?

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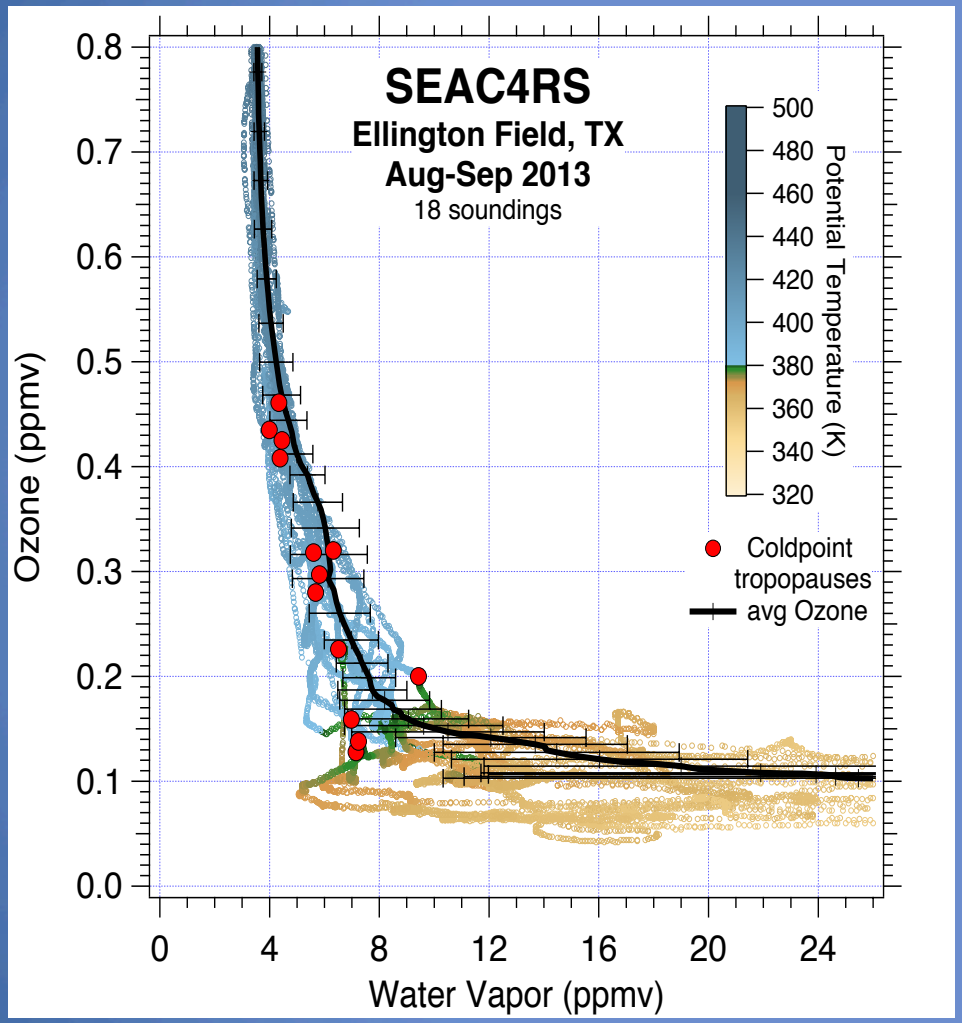
Talk Outline

- 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?

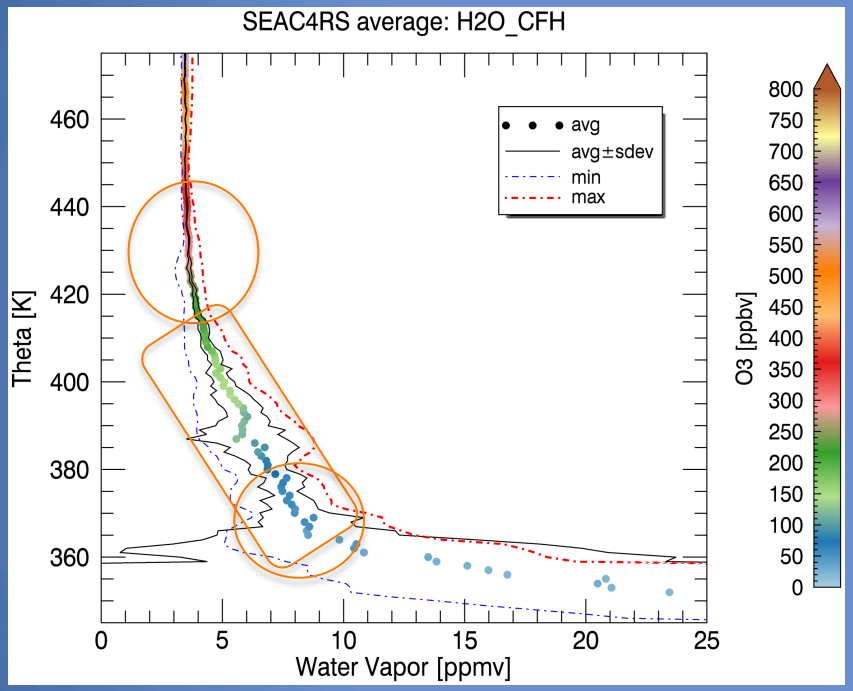
Water vapor vs. ozone



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



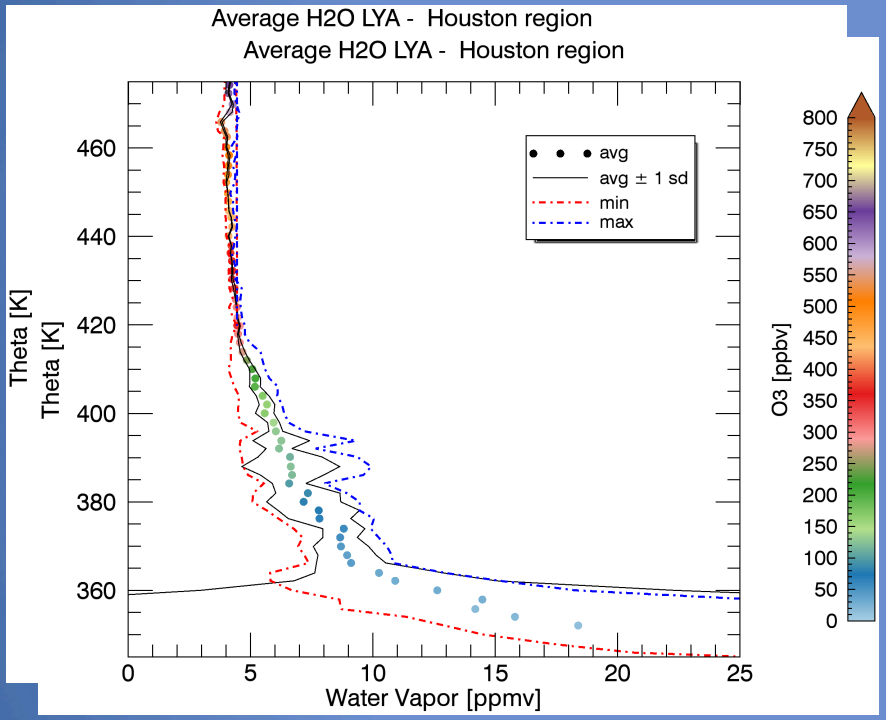
KEY FEATURES

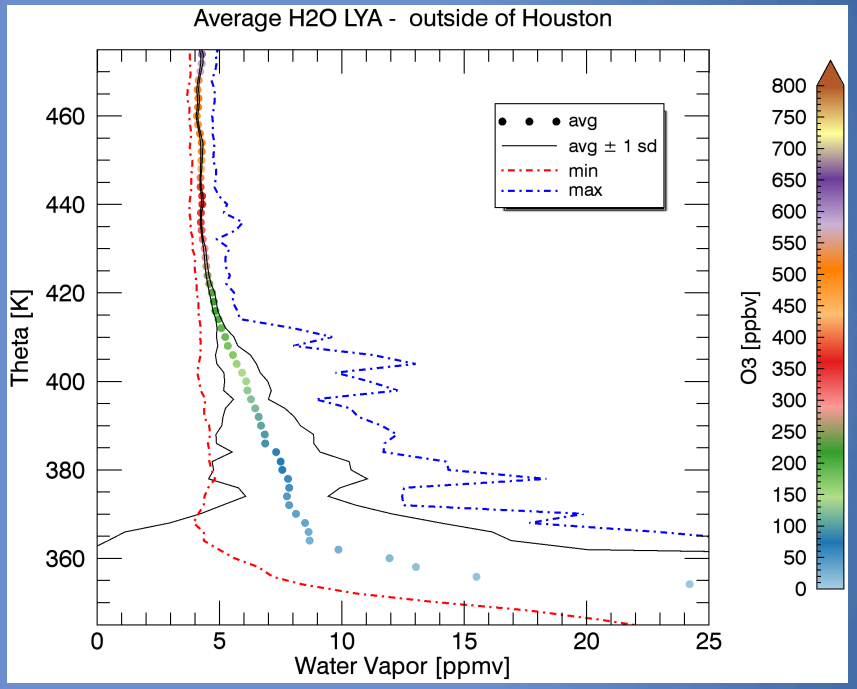
- Transition to undisturbed stratosphere from 415 K to 440 K
- Mixing region from 365 K to 415 – with sub-layer of enhancements from 380 K to 395 K
- Sharp throttling down of variability seen in the UT at 365 K – the tropopause cold trap

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

Ly-α (Harvard)

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



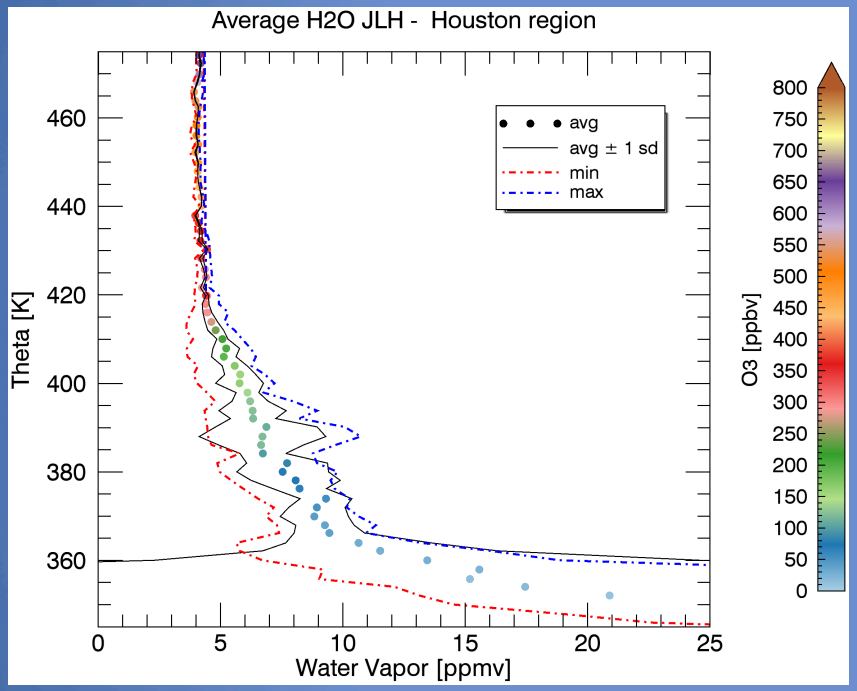


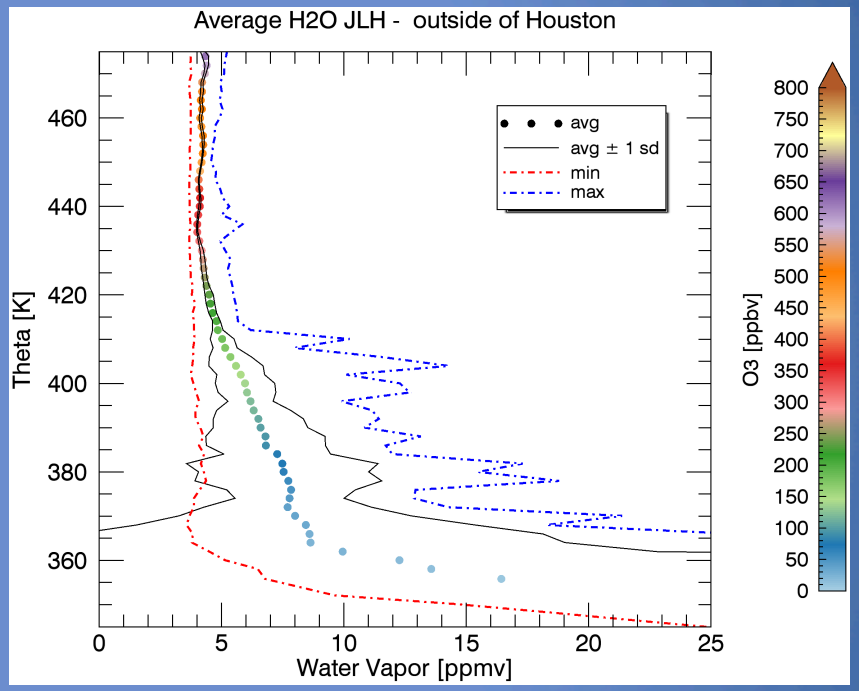
- Overall, similar layering and transitions
- Enhancement layer 380-395K, but somewhat less distinct than in sondes

- Enhancements spread throughout mixing layer from 365 K to 415 K
- Cold trap "throttle" evident in std dev

JLH (JPL)

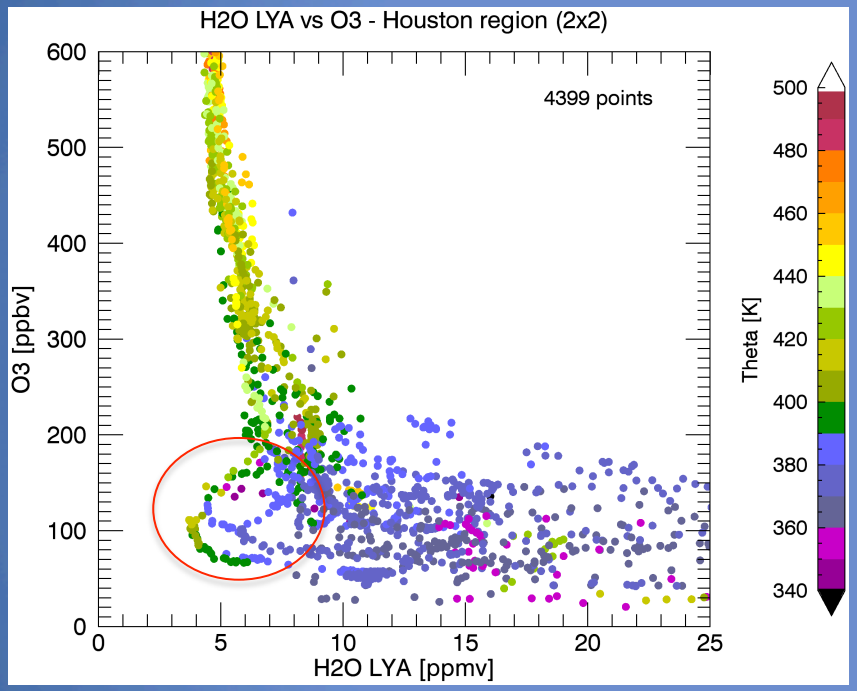
Separate 2-deg box around Houston from rest of SEAC4RS theater of flight operations

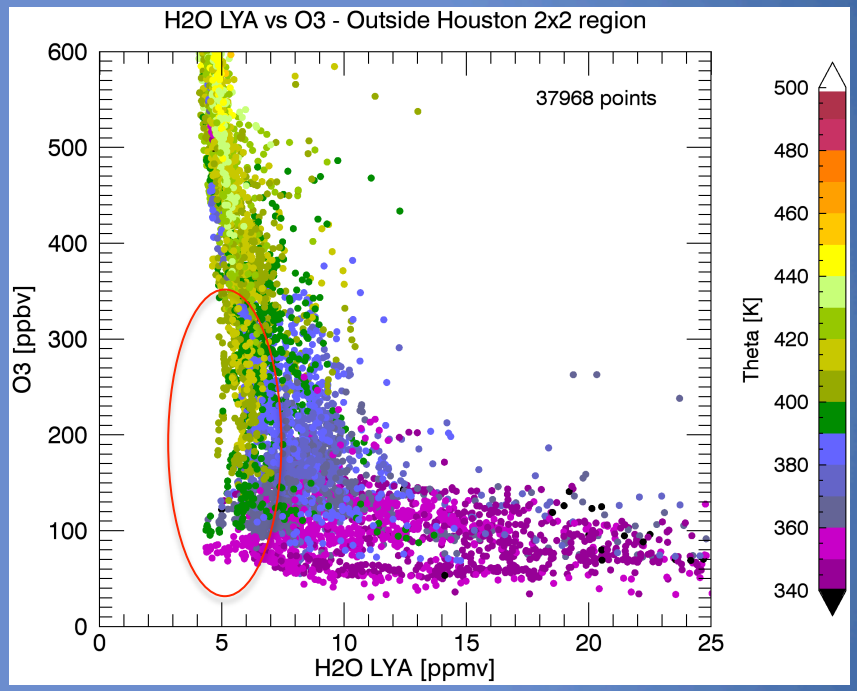




Higher level of variability than LYA, but main features of the two regions very similar

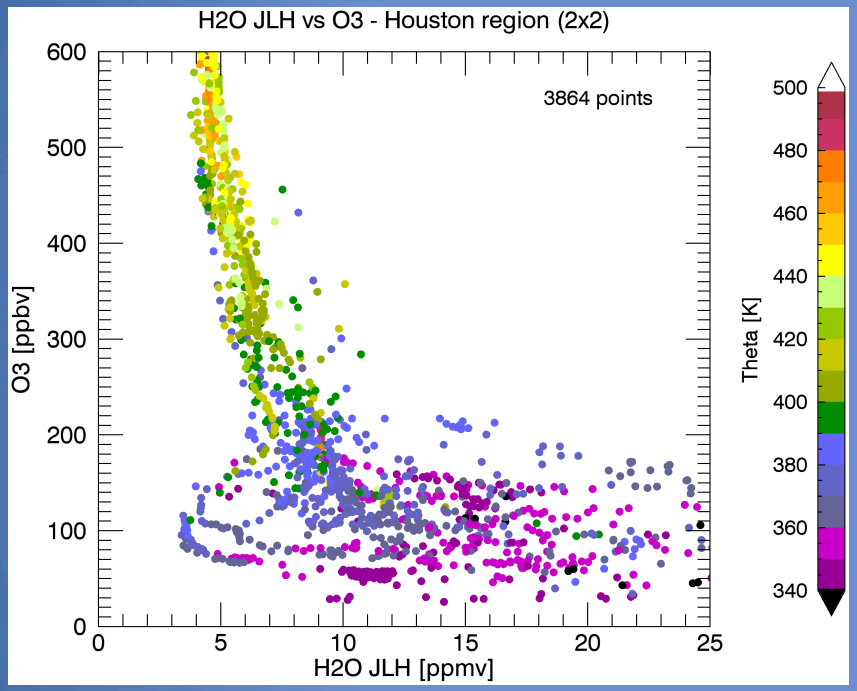
Ly-α (Harvard)
Water vapor scattered versus ozone

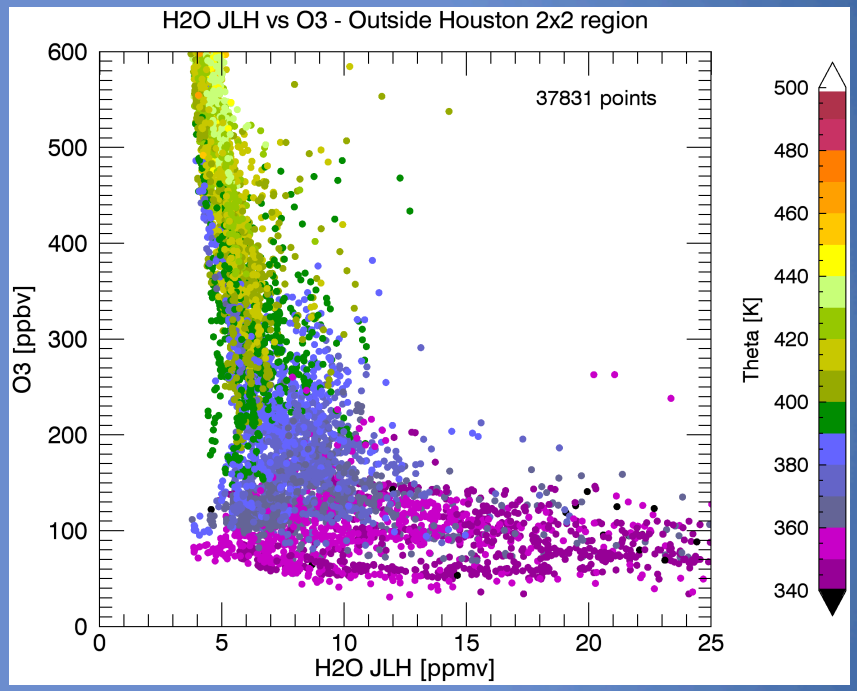




- Variability reduced above 200 ppb/390 K
- "Heel" feature with low WV below
- Enhancements evident to 600 ppbv
- Heel acquires an "Achilles tendon"

JLH (JPL)
Water vapor scattered versus ozone



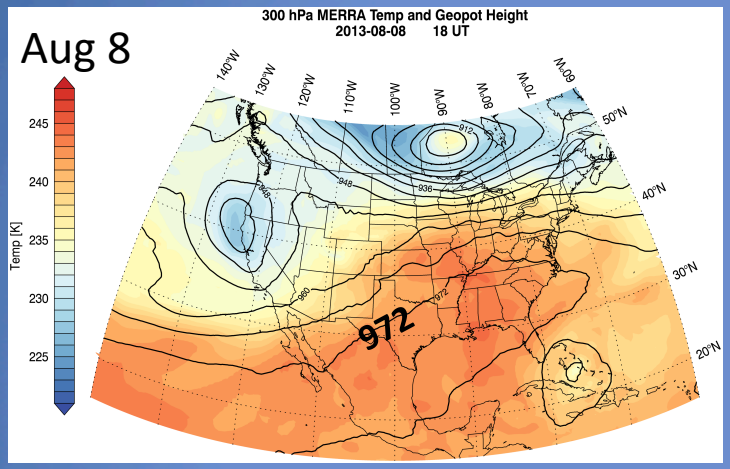


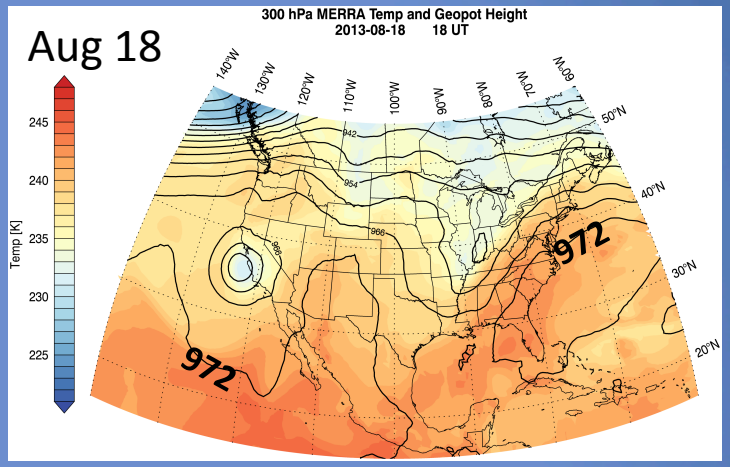
Bigger spreads in water vapor evident, but otherwise similar to Ly-α

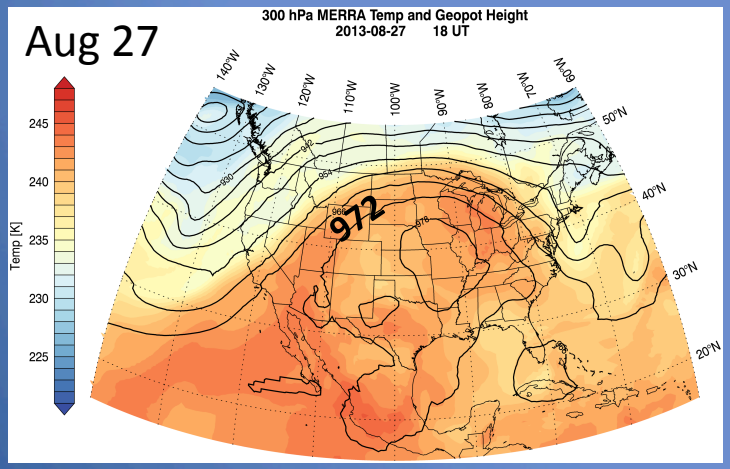
Meteorological context

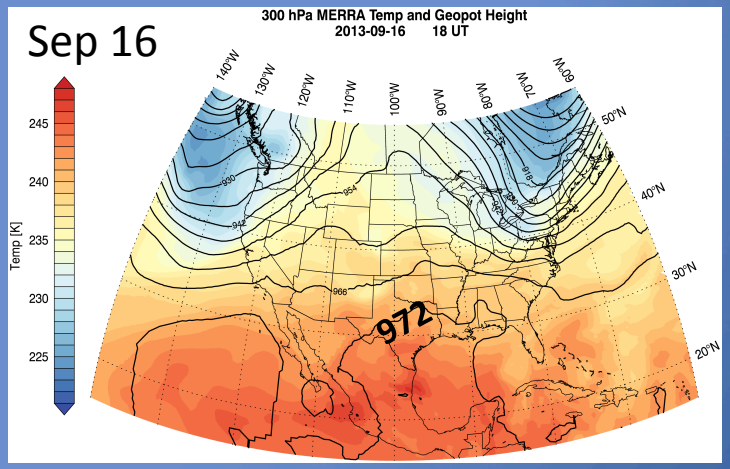
MERRA 300 hPa charts

(all 18 UT)

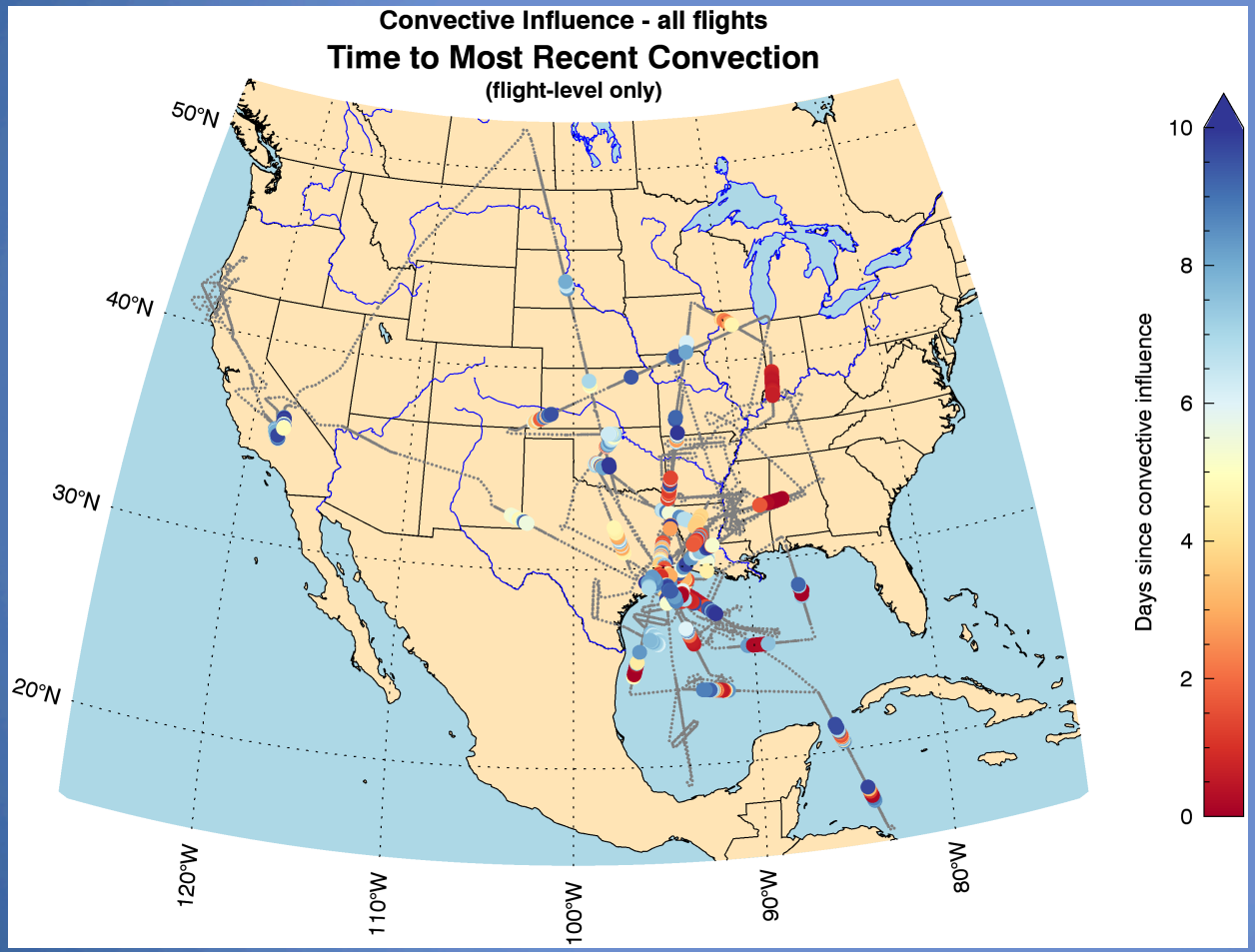






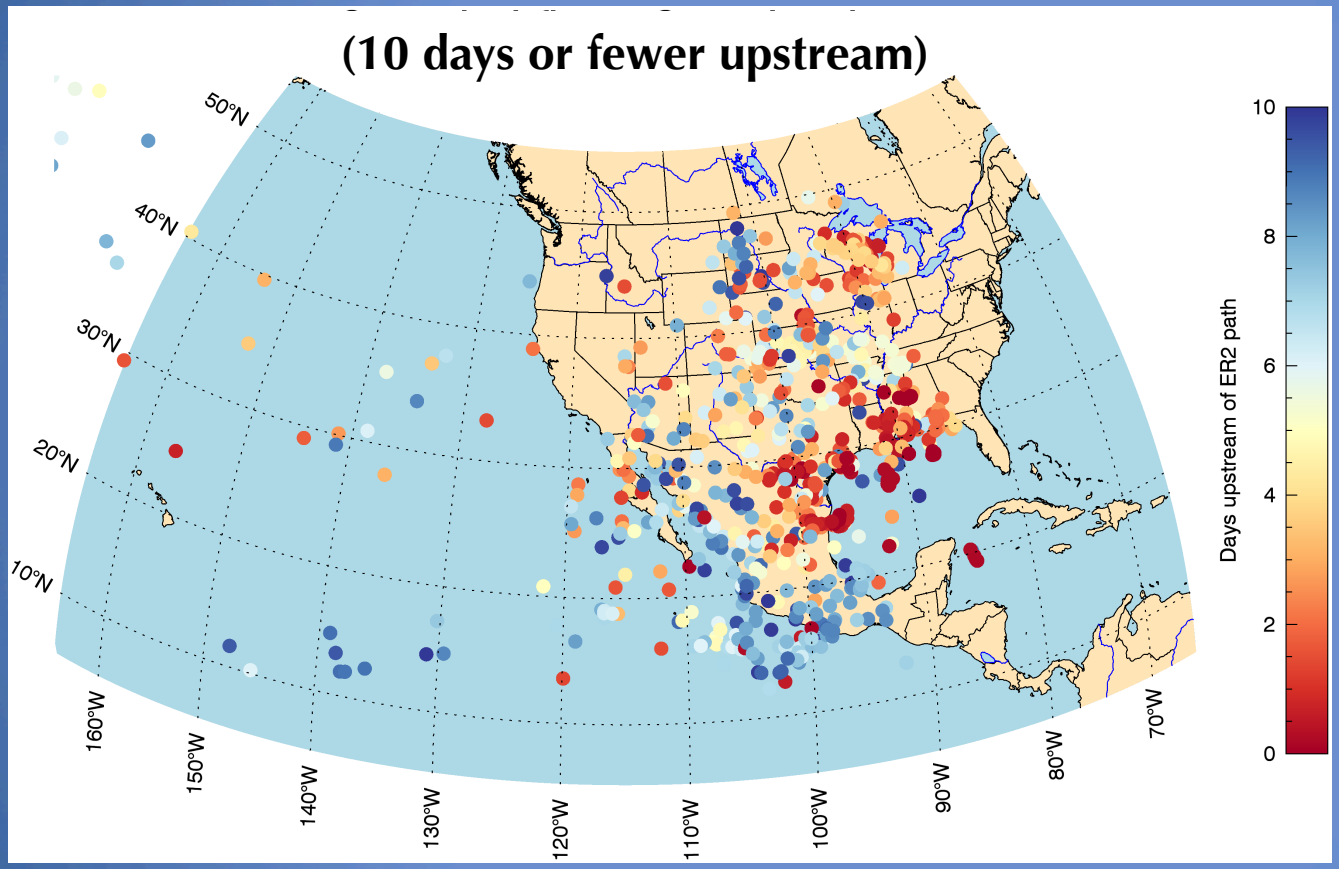


Convective Influence along ER-2 flight track
Time to most recent convection (<10 days)
(all flights except Aug 12-21)



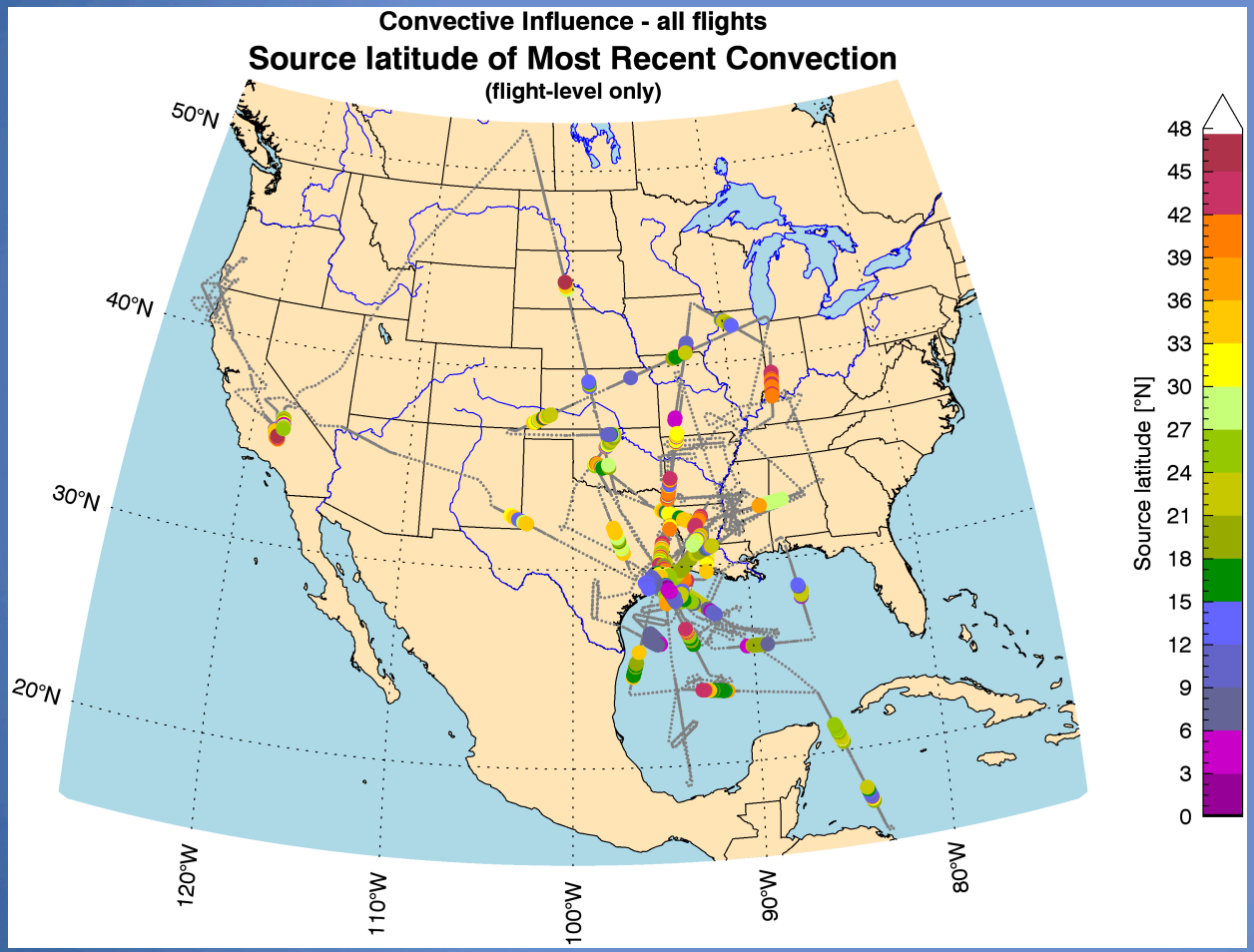
- Convective influence evenly scattered throughout SEAC4RS operational region
- But distribution of convective influence times is very heterogeneous

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

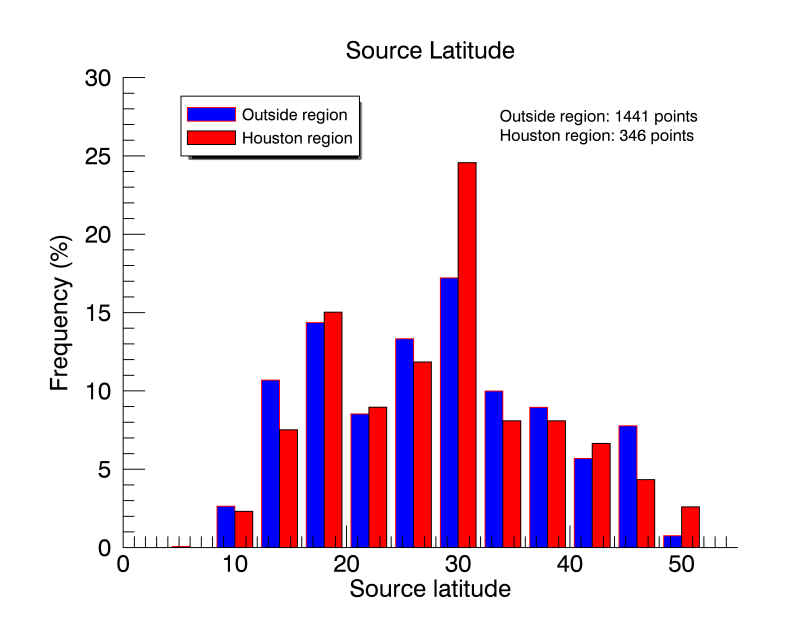
Convective Influence along ER-2 flight track
Latitude of most recent convection
(all flights except Aug 12-21)

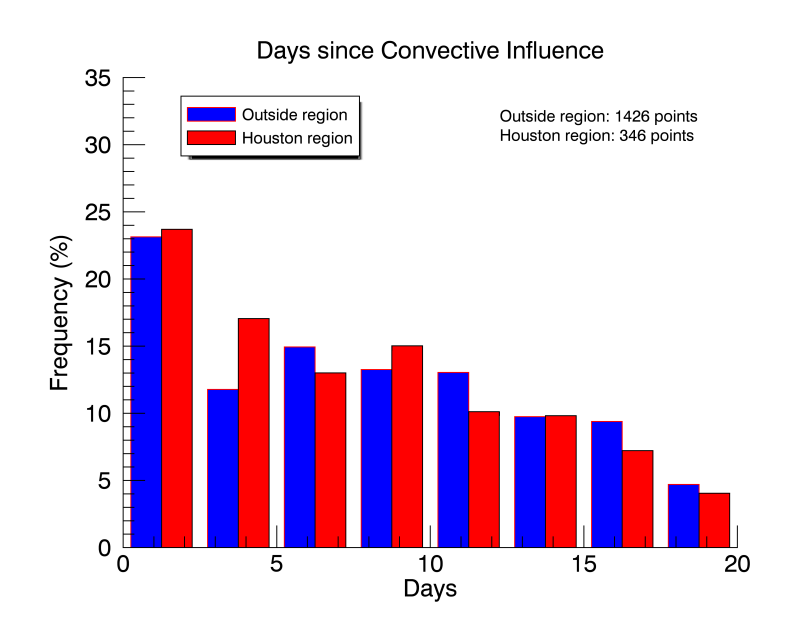


KEY FEATURES

- 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

Convective Influence along ER-2 flight track
Houston region vs. SEAC4RS ops regions
(all flights except Aug 12-21)





- 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 convectio (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 anticylconic 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 a 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