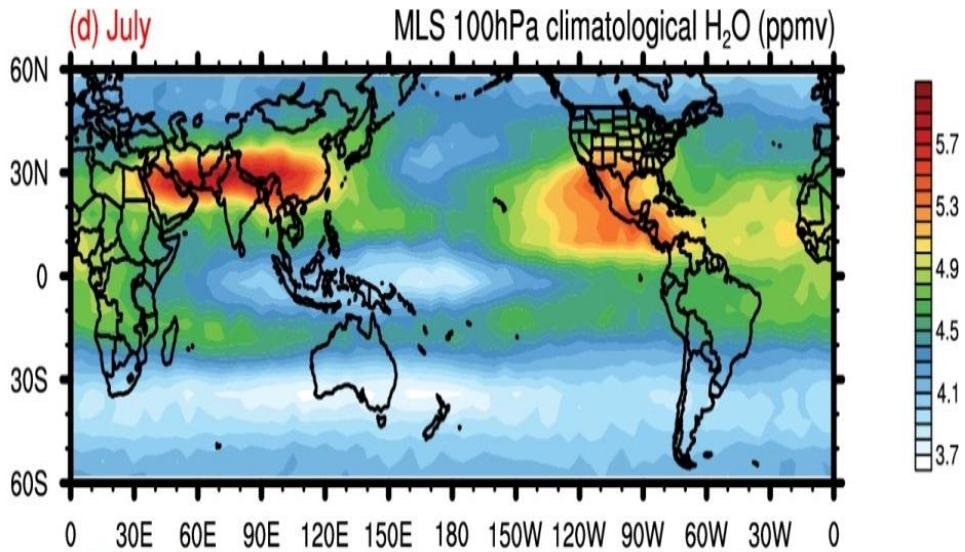
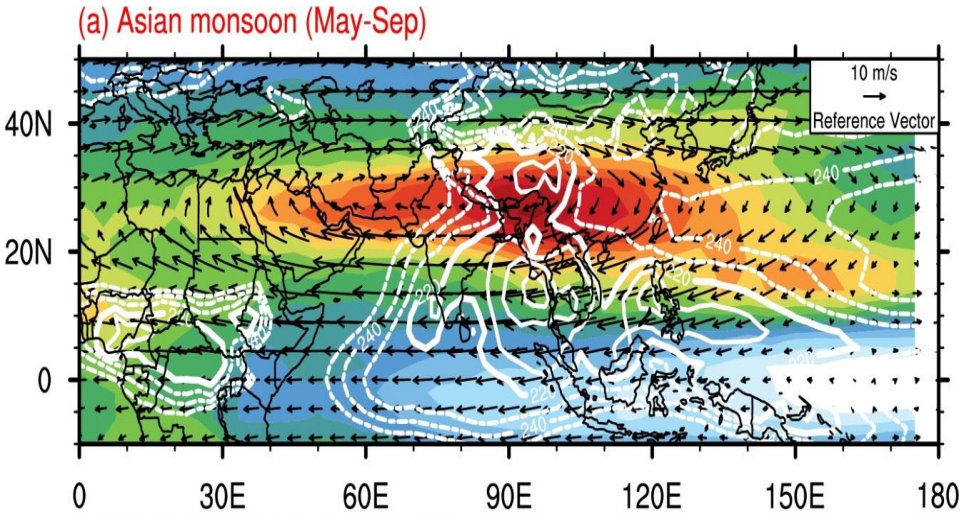
What controls stratospheric water vapor in the NH summer monsoon regions?

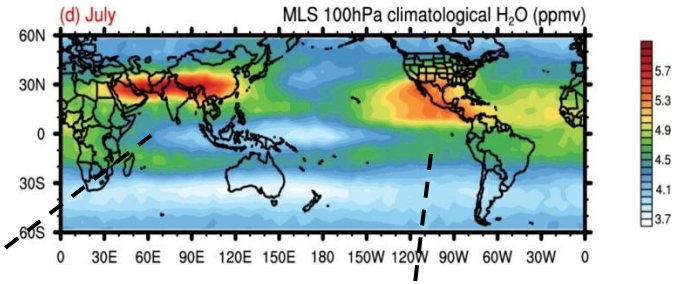
Bill Randel, NCAR
Kai Zhang and Rong Fu, U. Texas, Austin

Aura
MLS H_2O

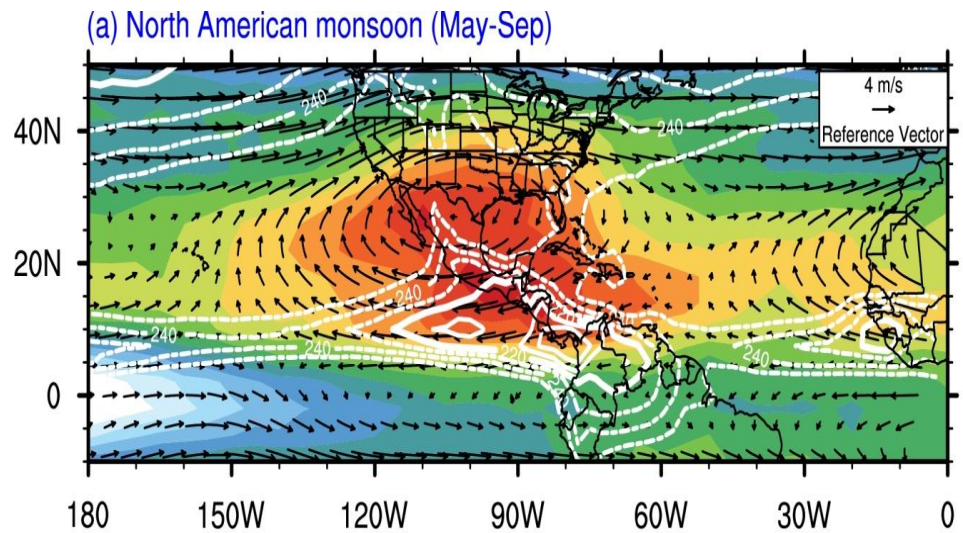


Climatological circulation and OLR





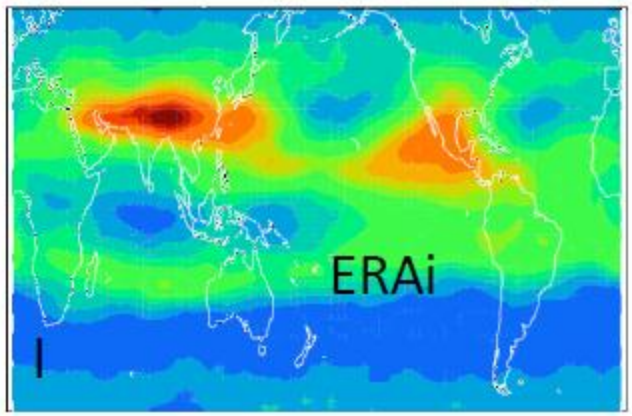
monsoon anticyclones,
much stronger over Asia



100 hPa H_2O aligned
more with circulation
than with deep convection

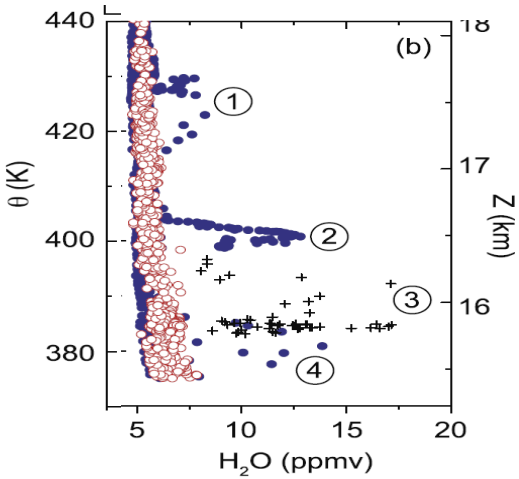
What processes maintain the monsoon H_2O maxima?

Large-scale circulation/temperatures



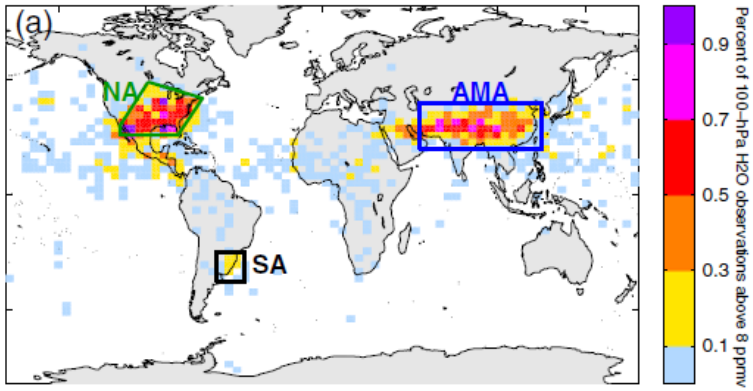
Domain filling trajectory calculations, no explicit convection
Schoeberl et al, 2013

Overshooting deep convection



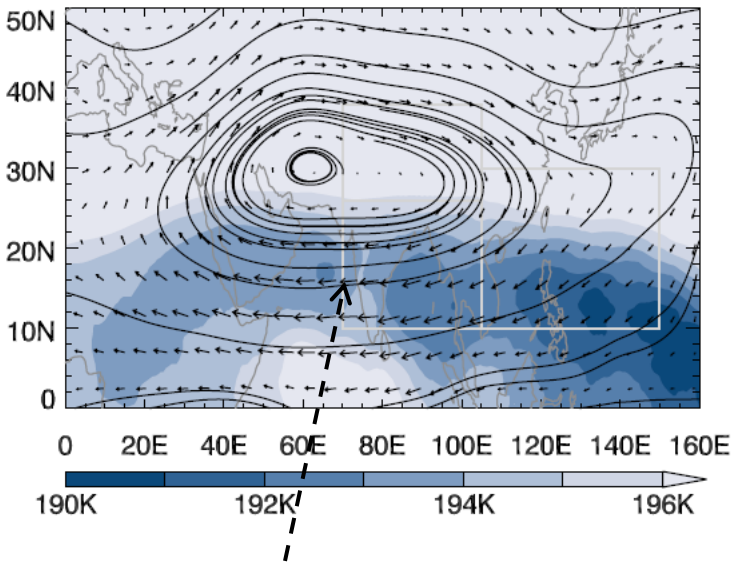
aircraft measurements, Hanisco et al, 2007

MLS satellite
Schwartz et al, 2013



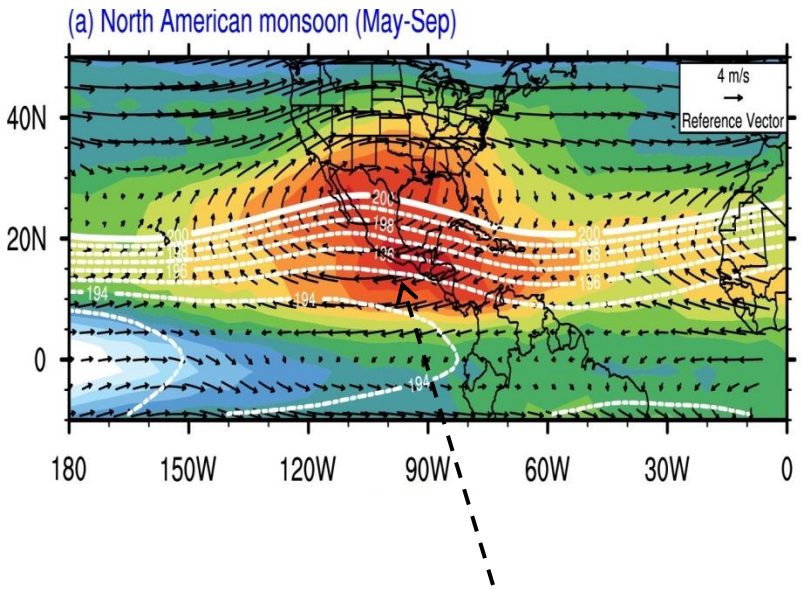
Monsoonal circulation and 100 hPa temps

Asian monsoon



Dehydration occurs mainly on equatorward (cold) side

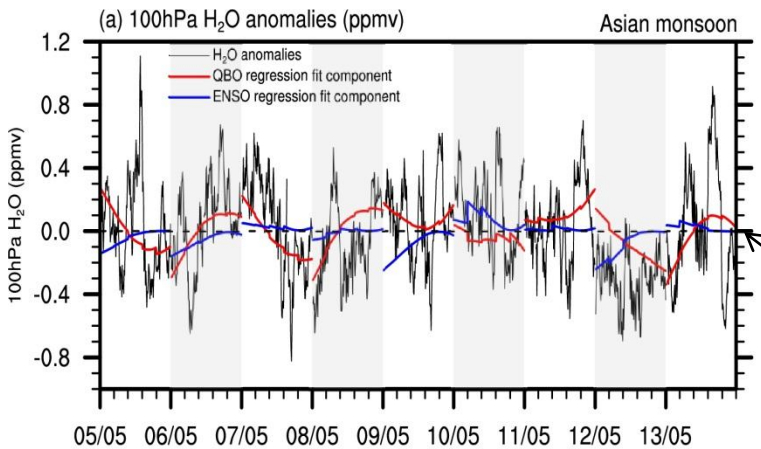
Wright et al, JGR, 2011

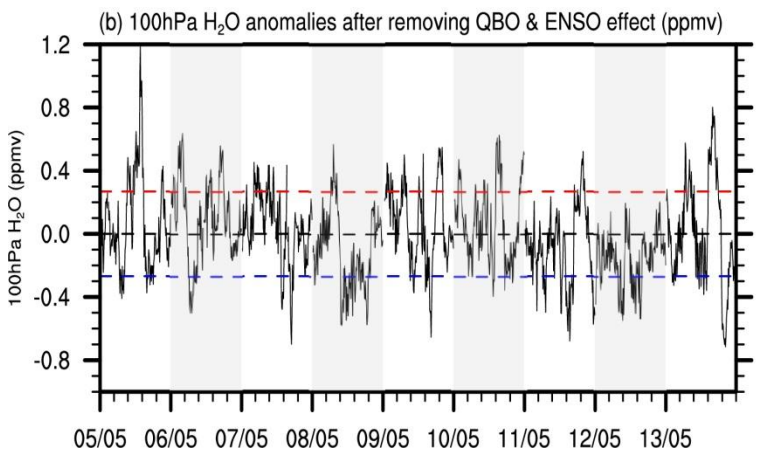


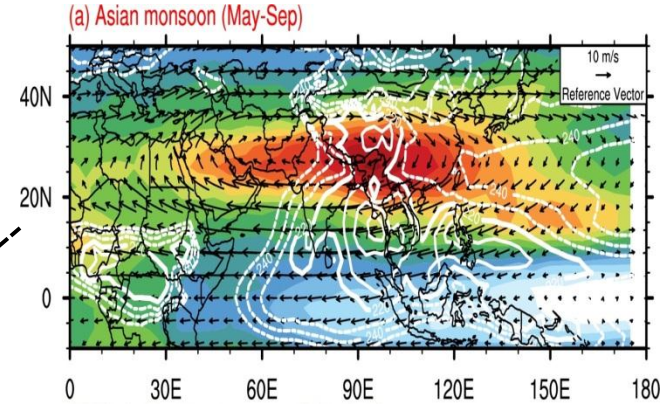
coldest temps on equatorward side of anticyclone

variability in Asian monsoon

9 years of MLS observations

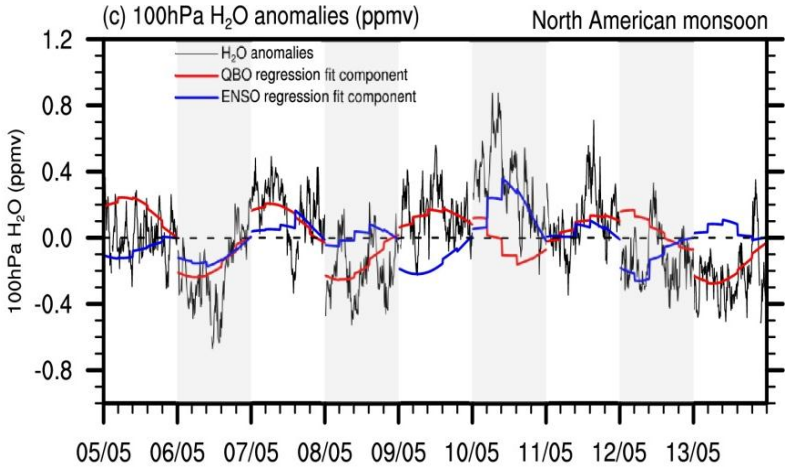


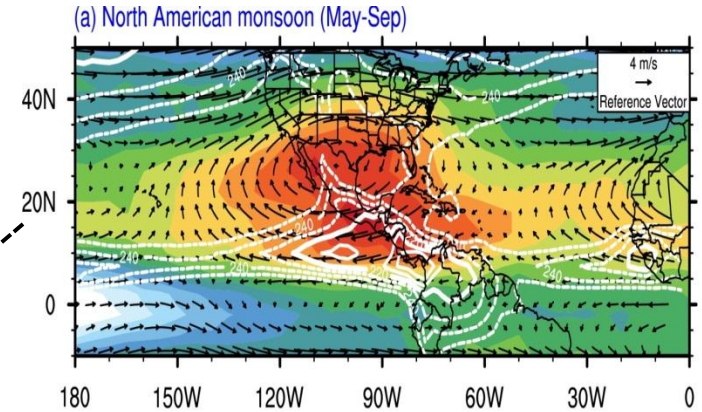


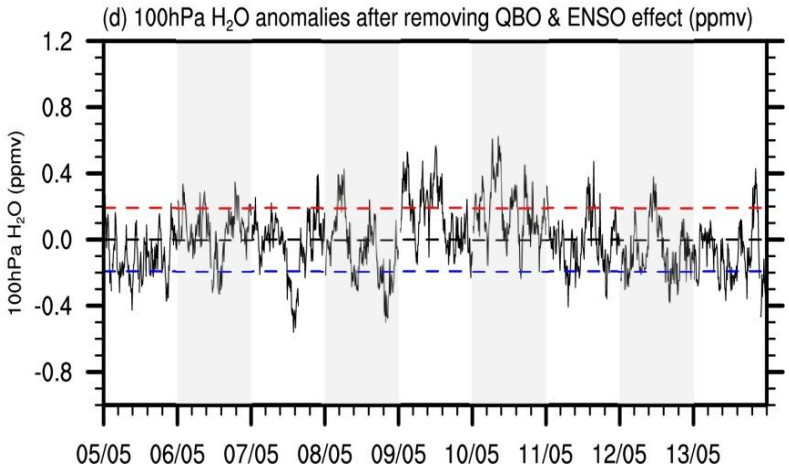


interannual QBO and ENSO fits
(empirical; not well understood)

N American monsoon

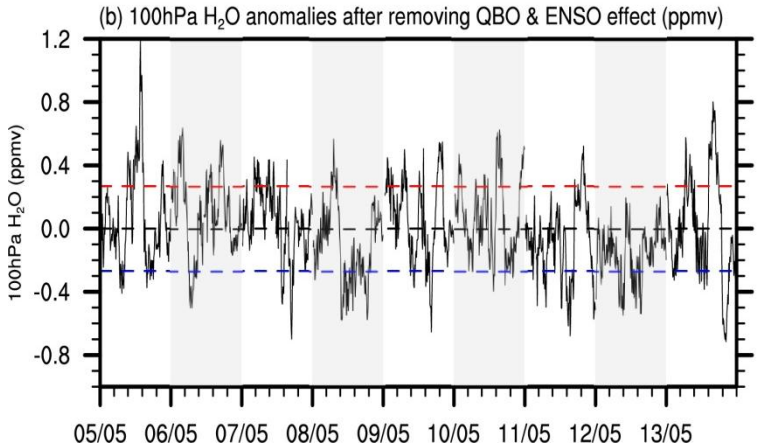




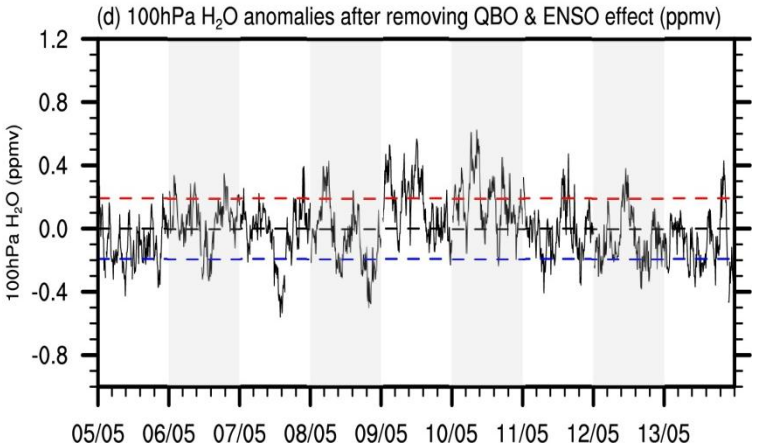


100 hPa H_2O anomalies with QBO, ENSO removed

Asia

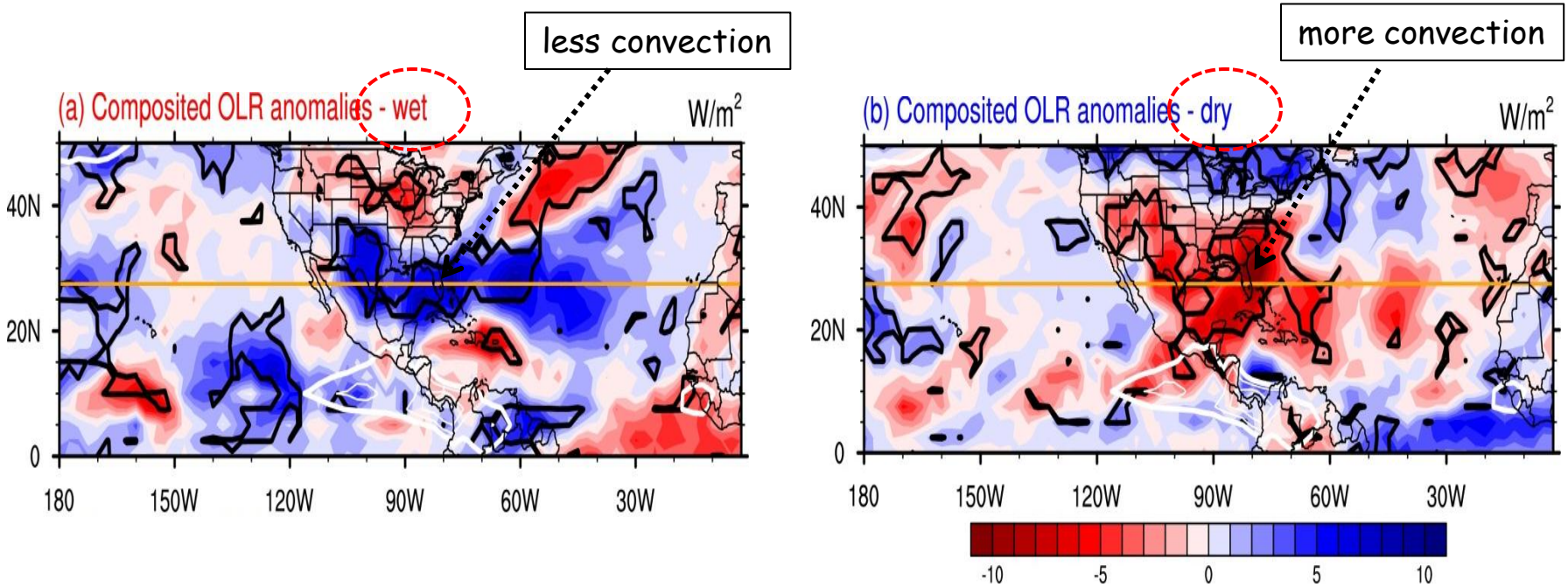


N America



How is this variability related to deep convection and circulation/temperature ?

Composites over N America wrt 100 hPa H_2O



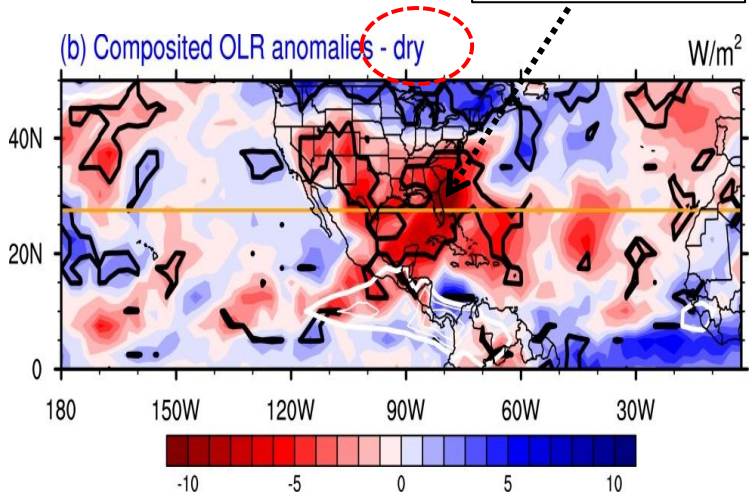
<u>Surprising result</u>: less (more) convection

↕

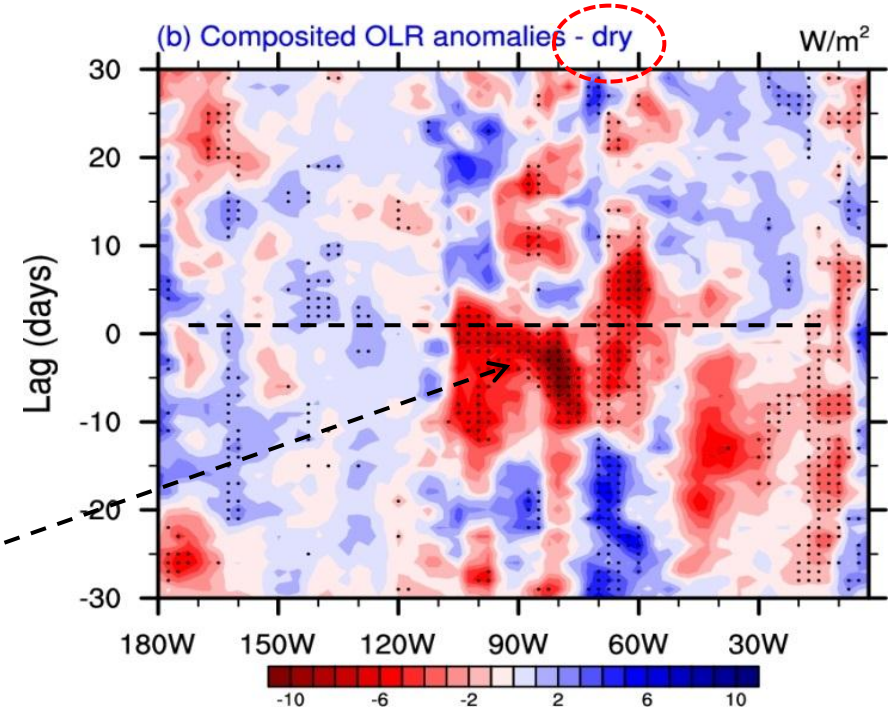
more (less) lower stratosphere H_2O

N. America

more convection



time lag variation

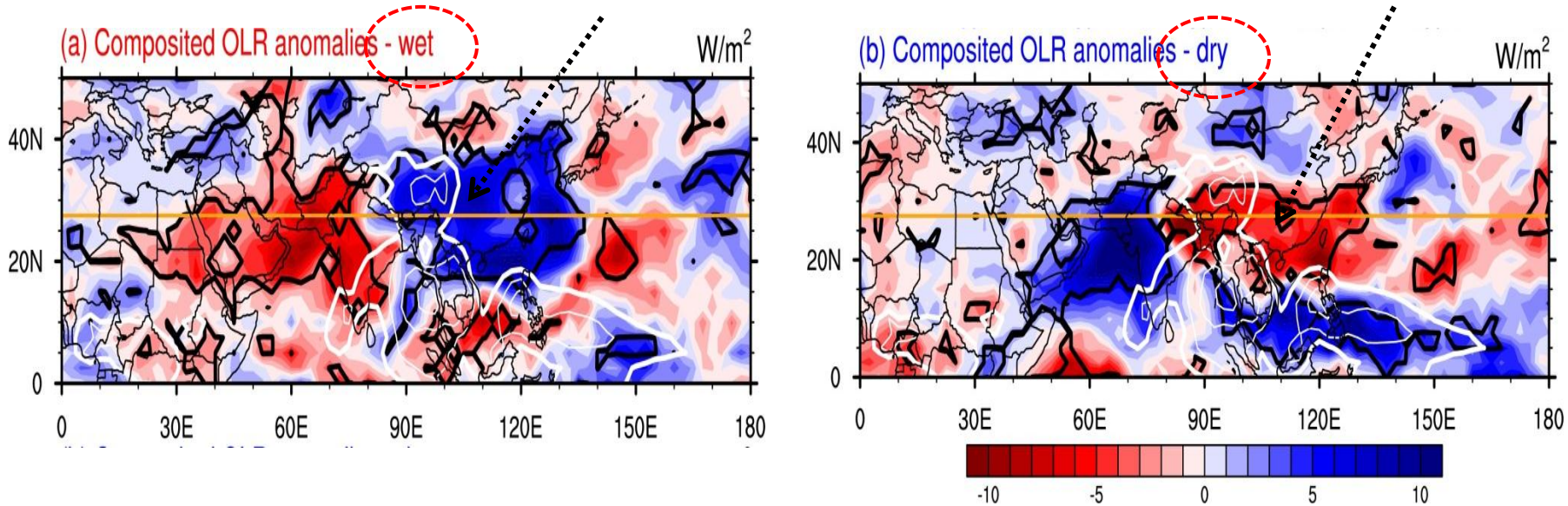


enhanced convection preceeds dry stratosphere H_2O by ~5 days

Composites over Asia wrt 100 hPa H_2O

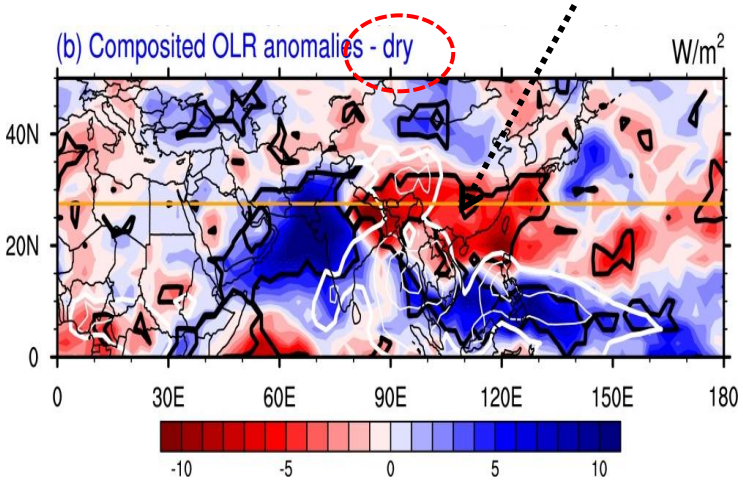
less convection

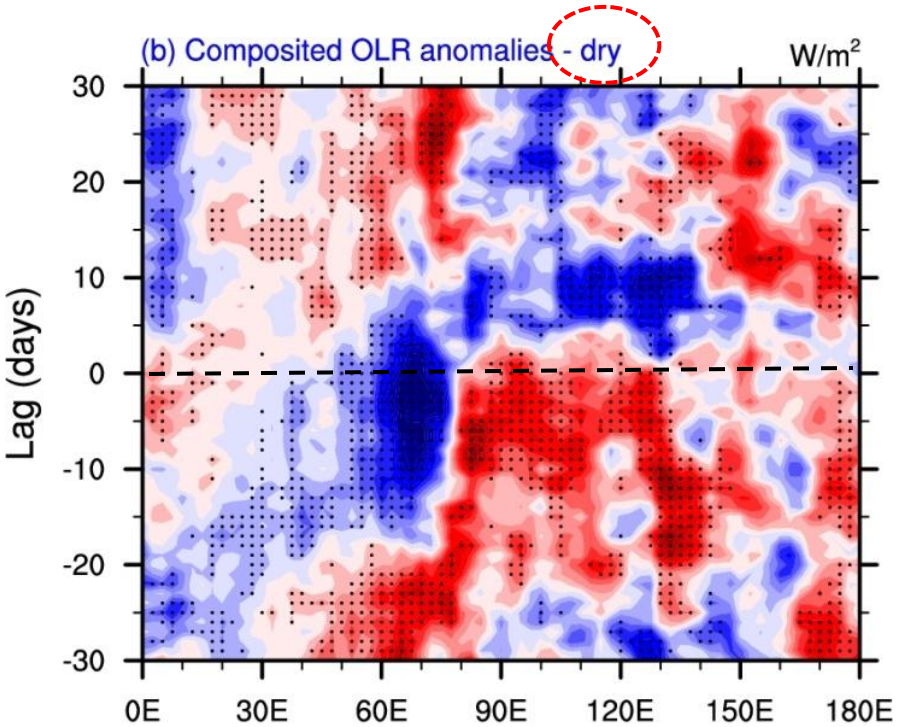
more convection



Asia

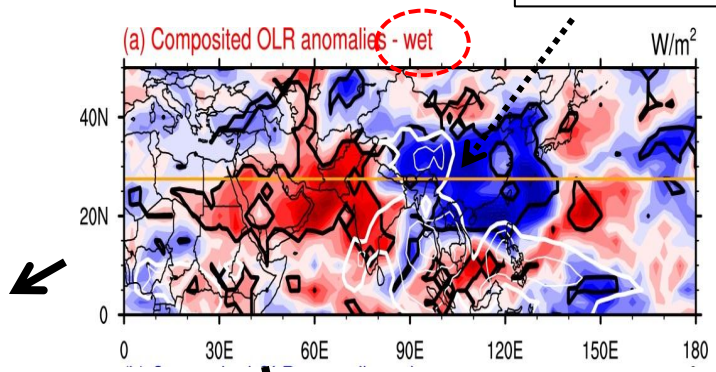
more convection

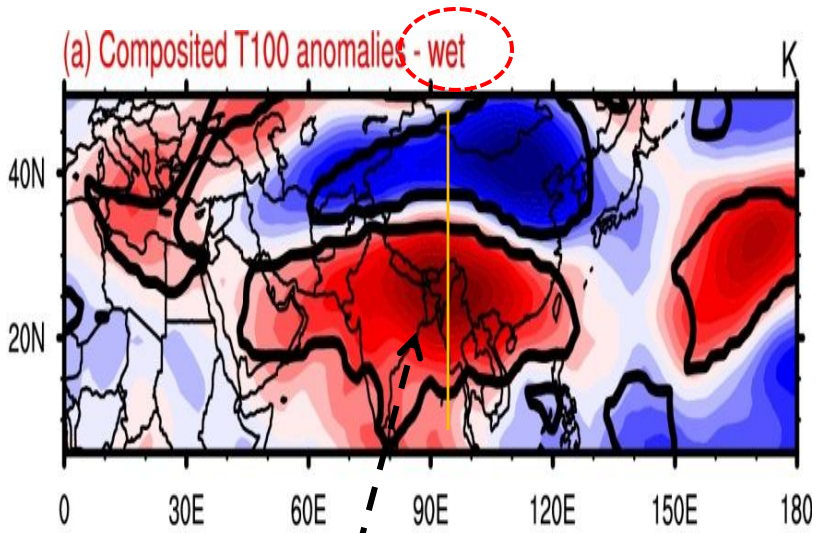




Asian monsoon:
links to temperatures at 100 hPa

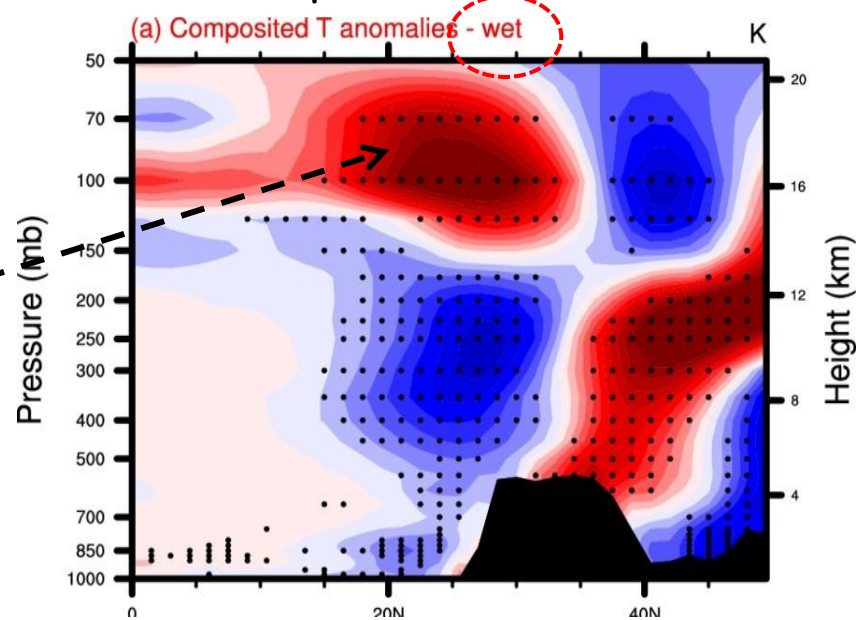
less convection



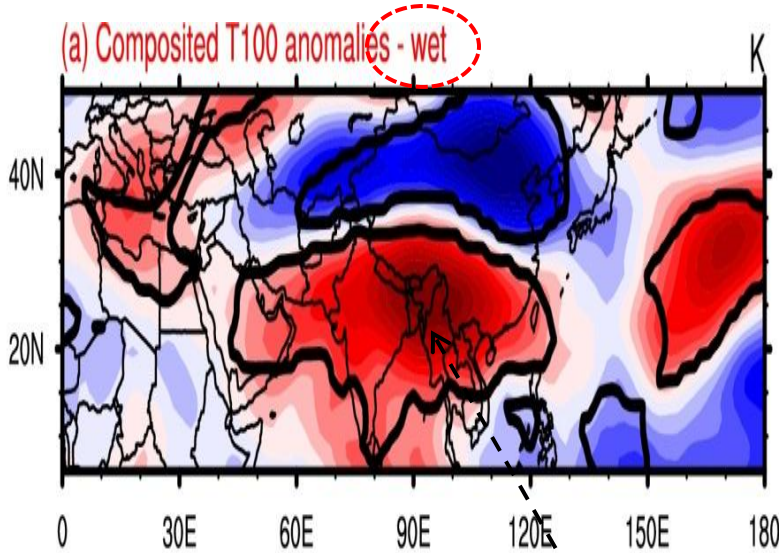


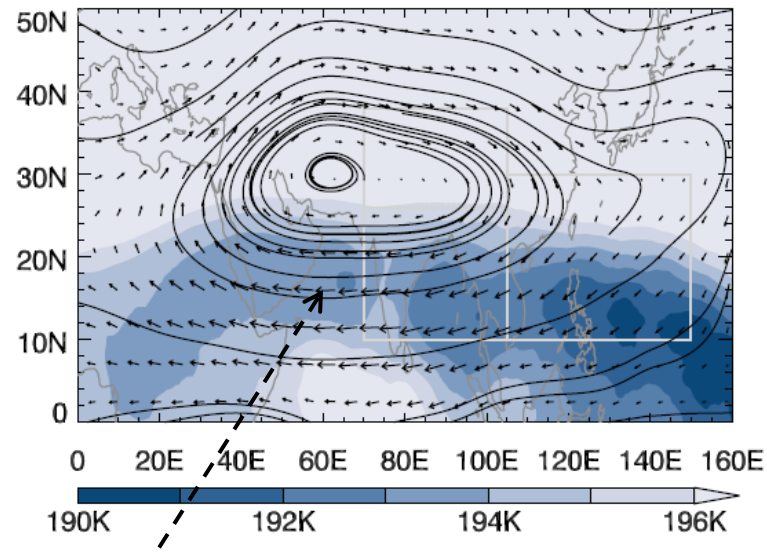
warm temps in low latitude stratosphere

Temp anomalies near 90 E



Wright et al, 2011





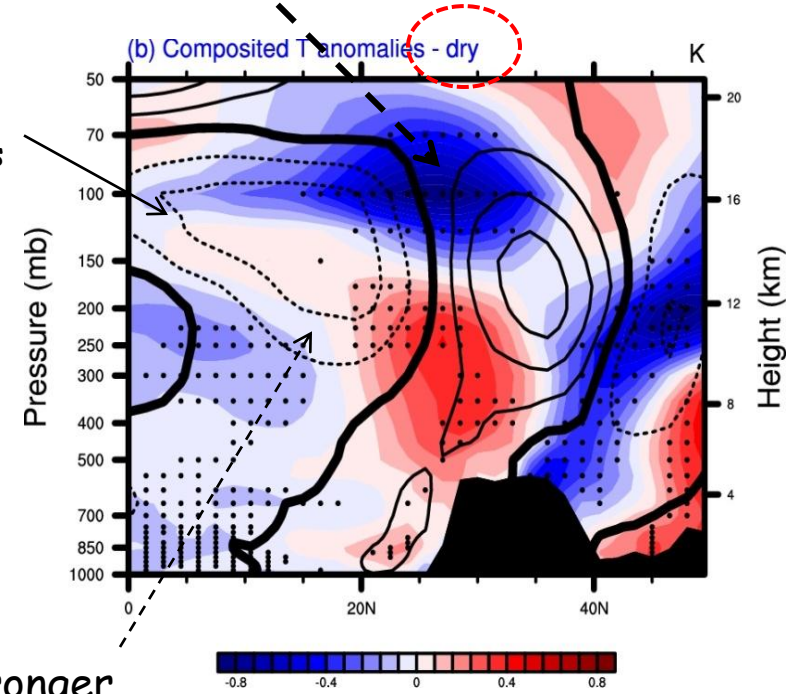
subtropics: most important region for dehydration

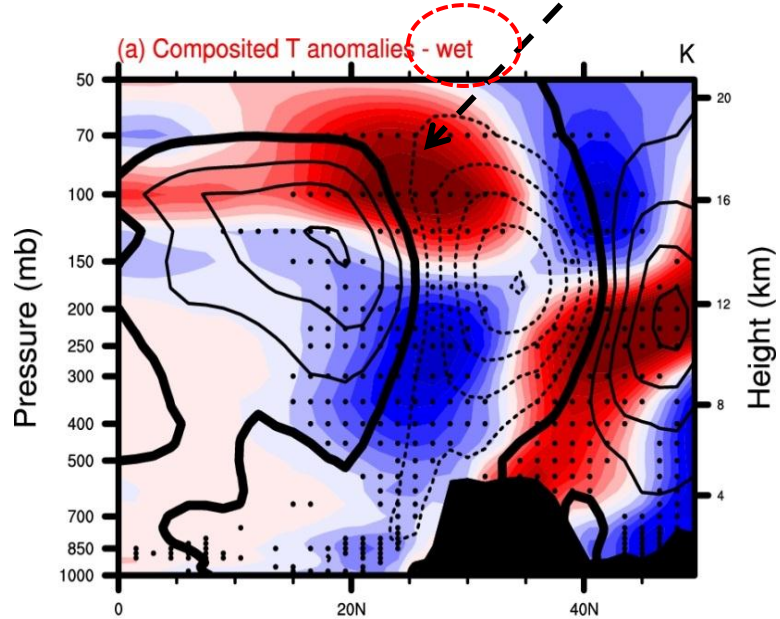
Mirror images for dry, wet composites

more convection
cold, dry stratosphere

less convection
warm, wet stratosphere

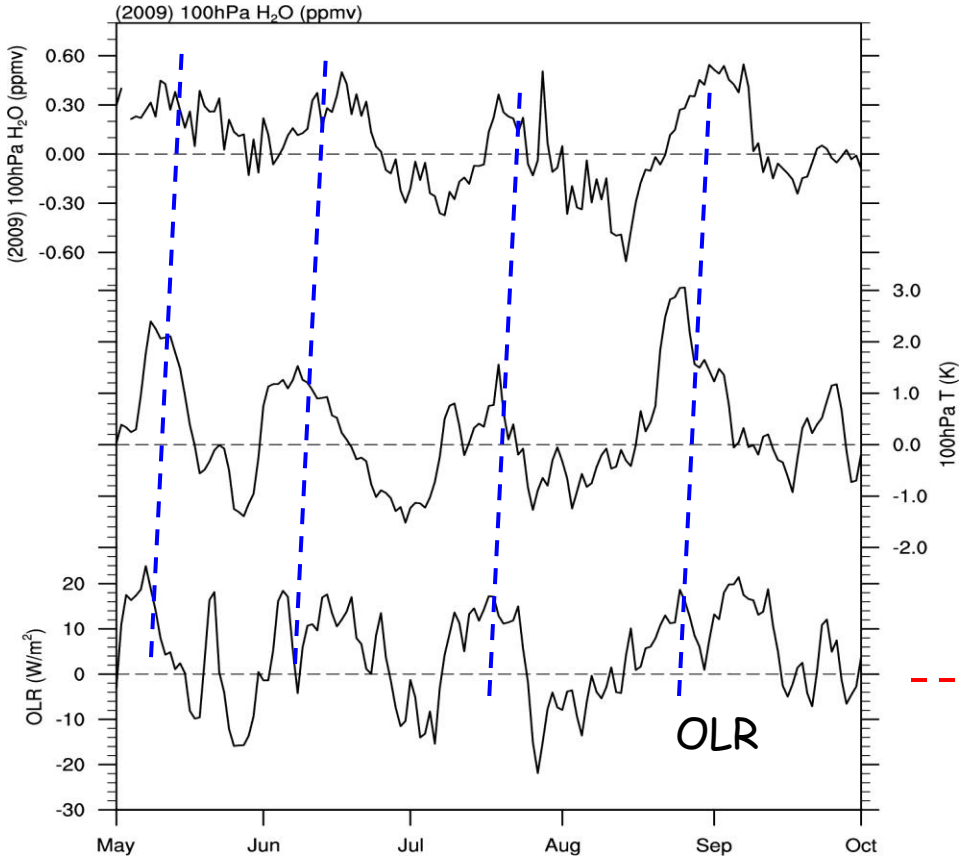
zonal winds





stronger anticyclone

time series over Asia during summer 2009



H_2O in monsoon

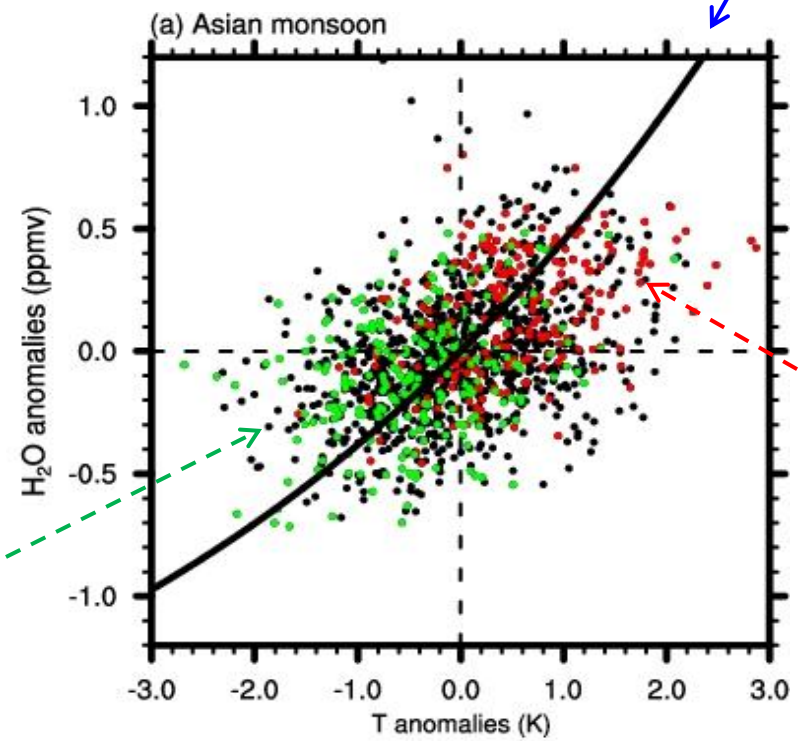
100 hPa temps, 10-30 N

less convection

more convection

How does observed
H_2O agree with temp?

Clausius Clapeyron



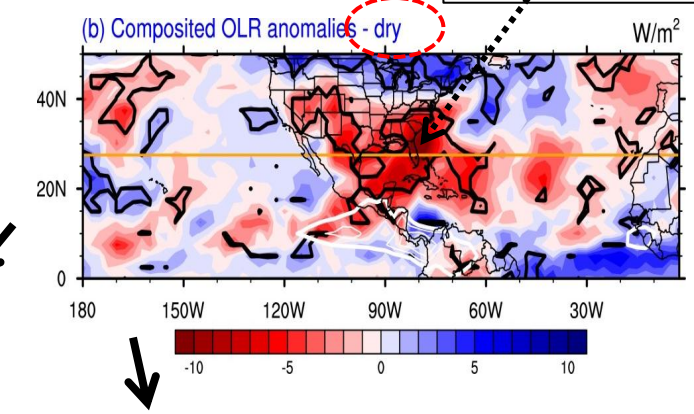
red: 15% extreme
weak convection

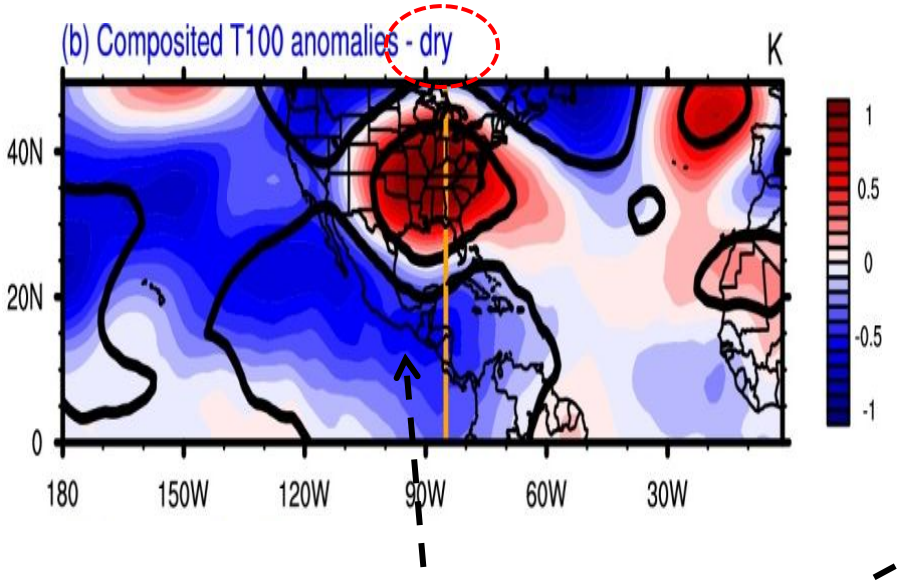
green: 15% extreme
strong convection

100 hPa, 10-30 N

North American monsoon:
links to temperatures at 100 hPa

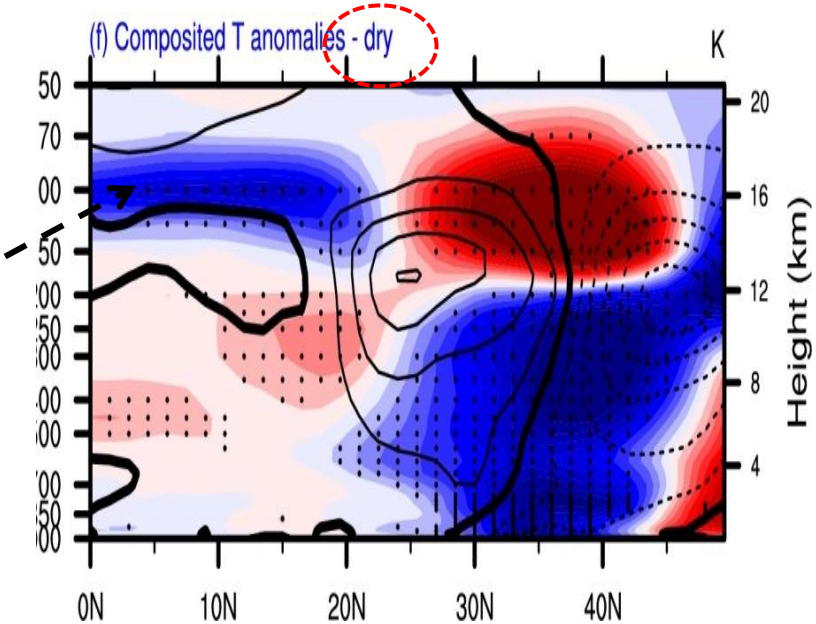
more convection



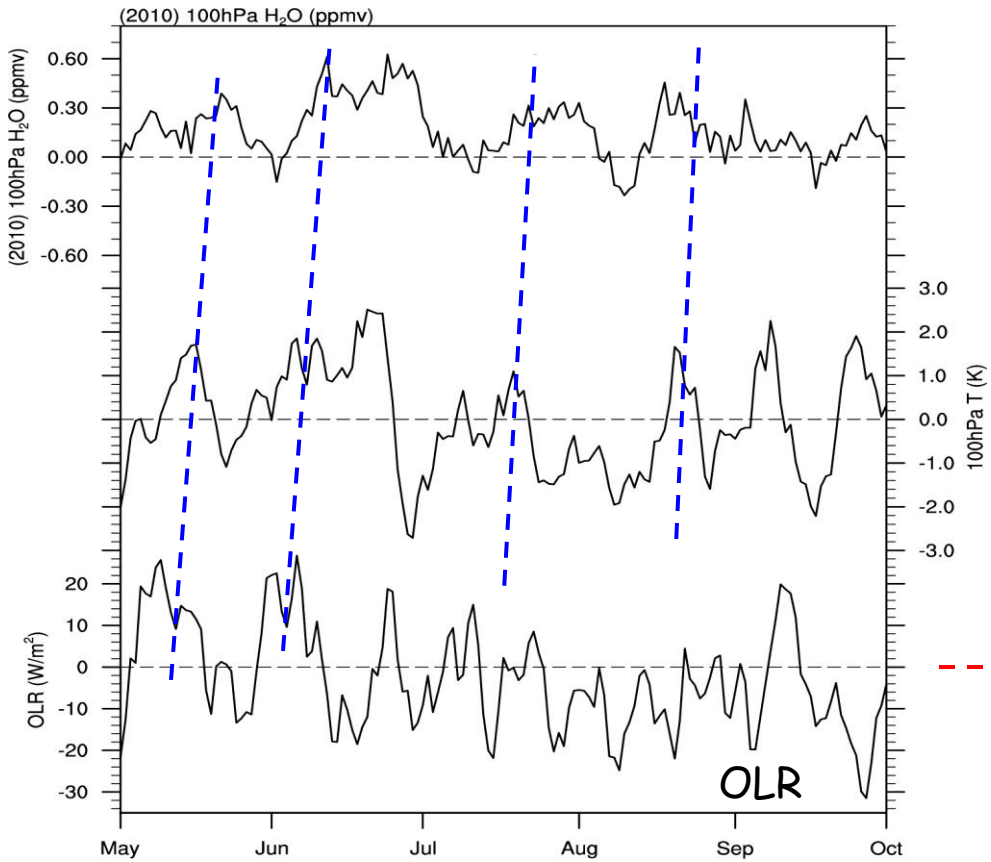


colder temps in low latitude stratosphere

Temp and zonal wind anomalies near 90 W



time series over N. America during summer 2010



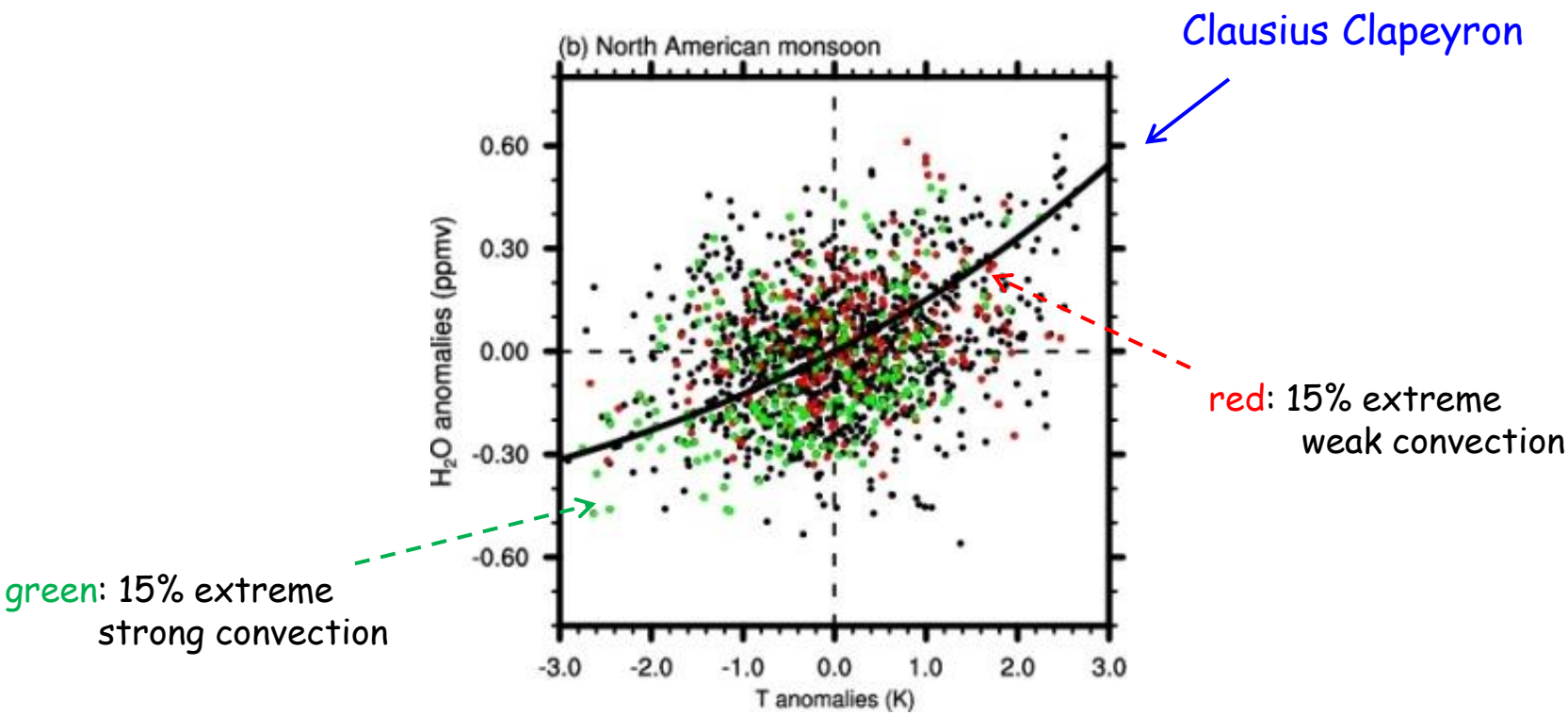
H_2O in monsoon

100 hPa temps, 5-20 N

less convection

more convection

How does observed
H_2O agree with temp?



100 hPa, 5-20 N

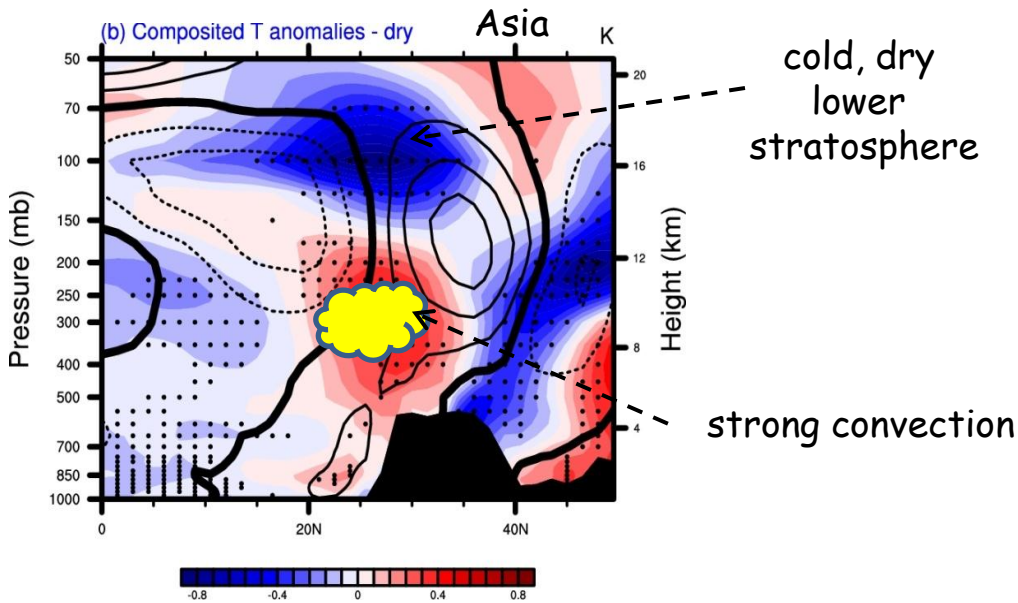
Key points:

- Surprising result: strong (weak) convection associated with

  ⇕

  dry (wet) lower stratosphere

- Physical link: temperatures in the subtropical stratosphere



John Gille Symposium

A celebration of John's distinguished career

Stratospheric dynamics and chemistry, tropospheric composition

Invited speakers including: Clive Rodgers, Reinhard Beer, Masato Shiotani, Jim Drummond, Anne Douglass, Peternel Levelt, …

November 21, 2014
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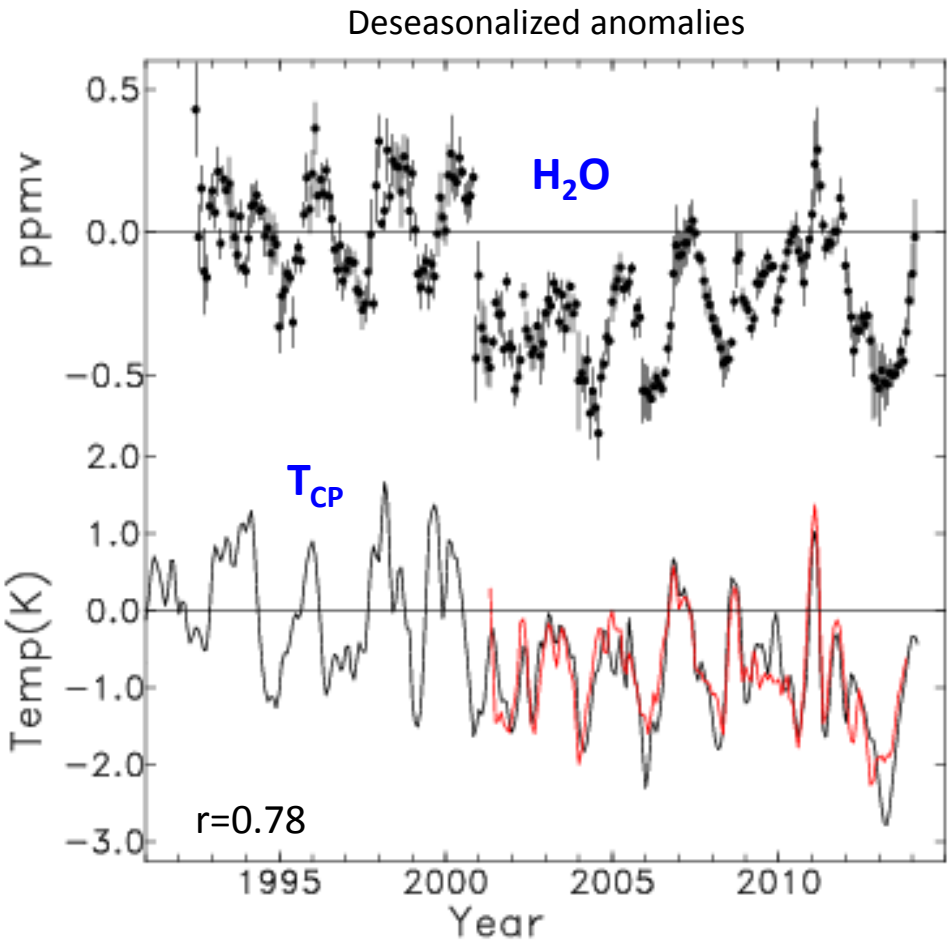
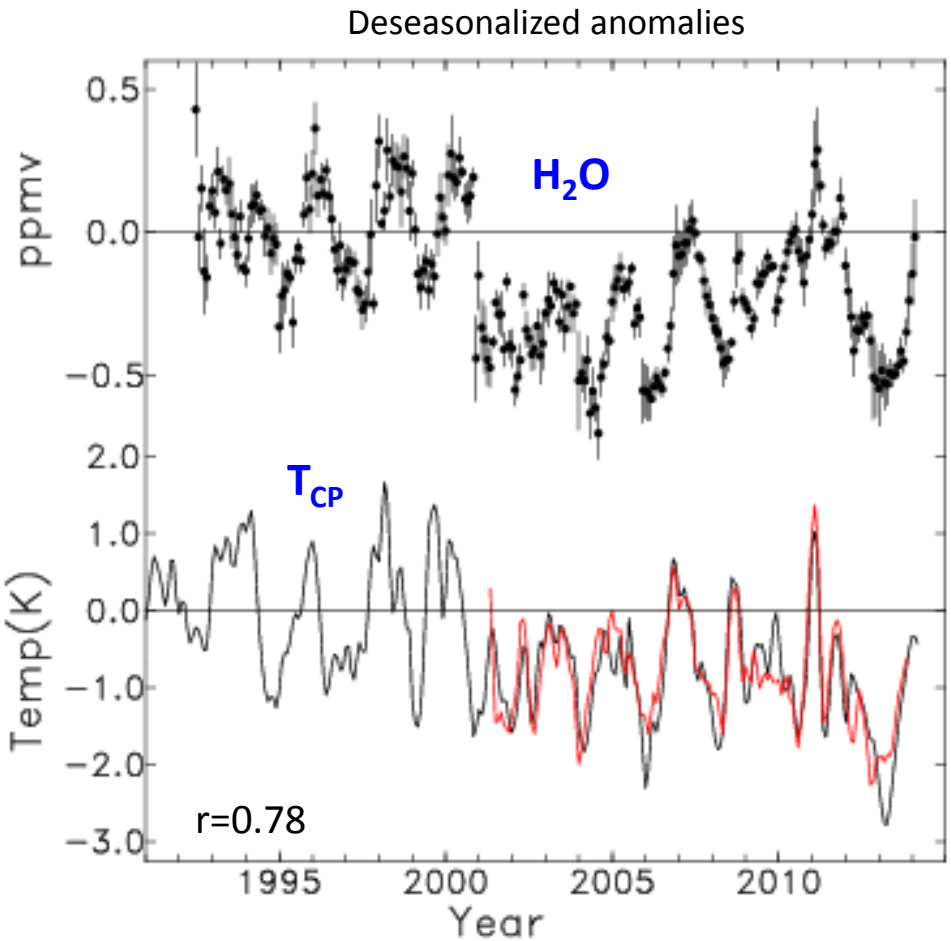
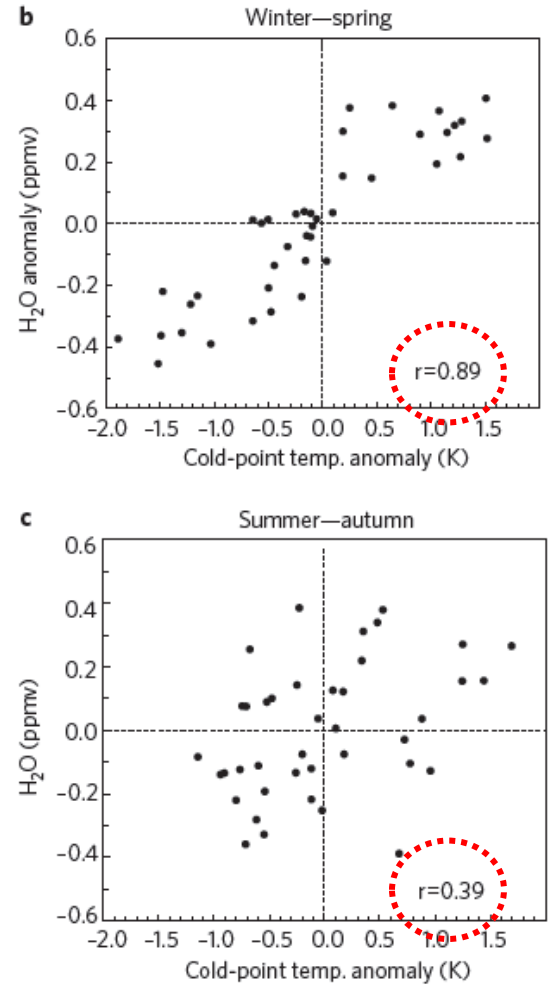
Correlated variations in stratospheric H_2O and cold point temperatures



near-global mean (60° N-S)
water vapor at 82 hPa
from combined HALOE-MLS data

cold-point tropical
tropopause temperatures

black: radiosondes
red: GPS (after 2001)

Correlated variations in stratospheric H_2O and cold point temperatures