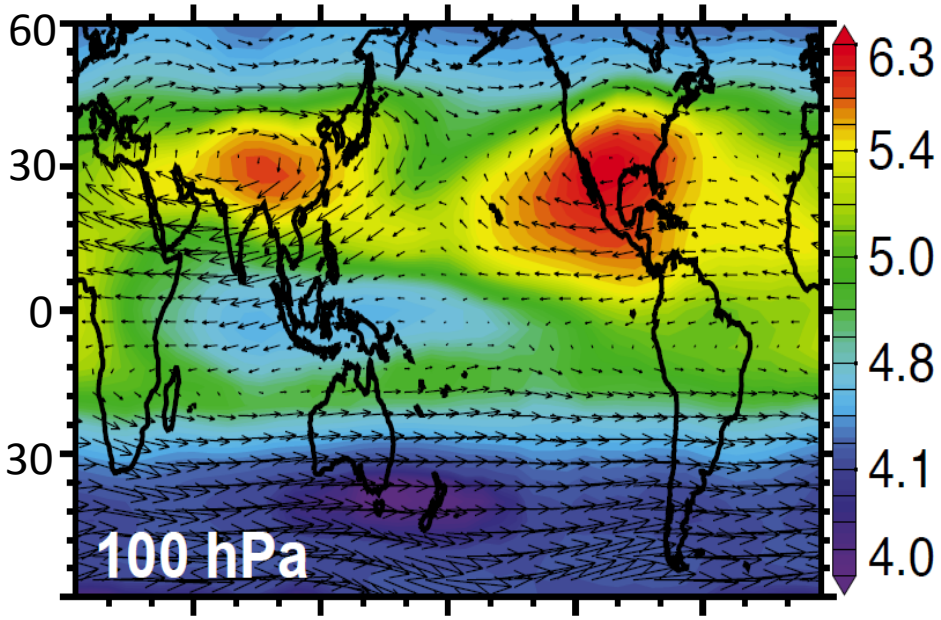
Control and influence of NH summer monsoons on stratospheric water vapor

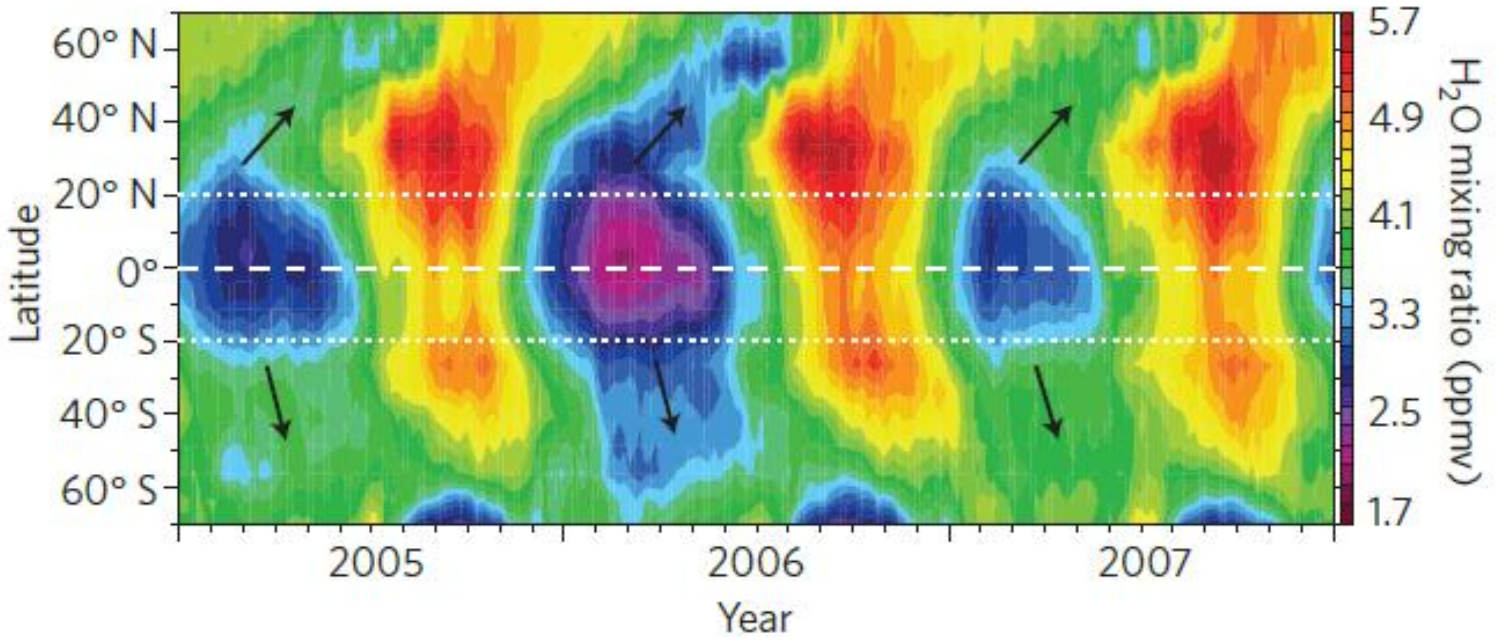
Bill Randel, NCAR
Kai Zhang and Rong Fu, U. Texas, Austin
Tao Wang, JPL

August
MLS H_2O



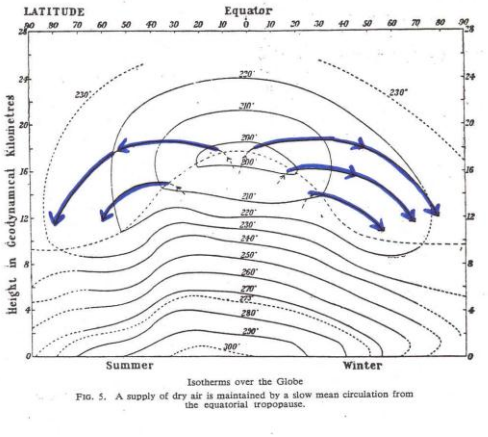
Well-known seasonal cycle of water vapor in lower stratosphere

Aura MLS 100 hPa

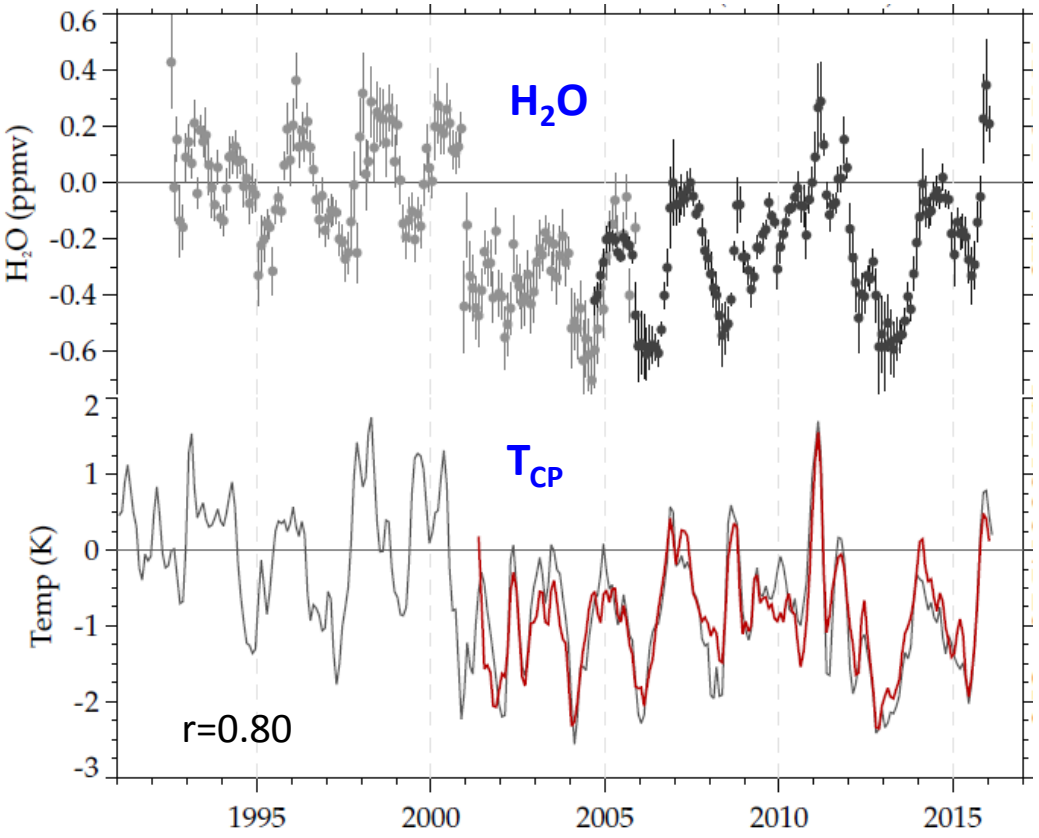


Stratospheric H_2O is controlled by tropical cold point temperatures

Brewer, 1949



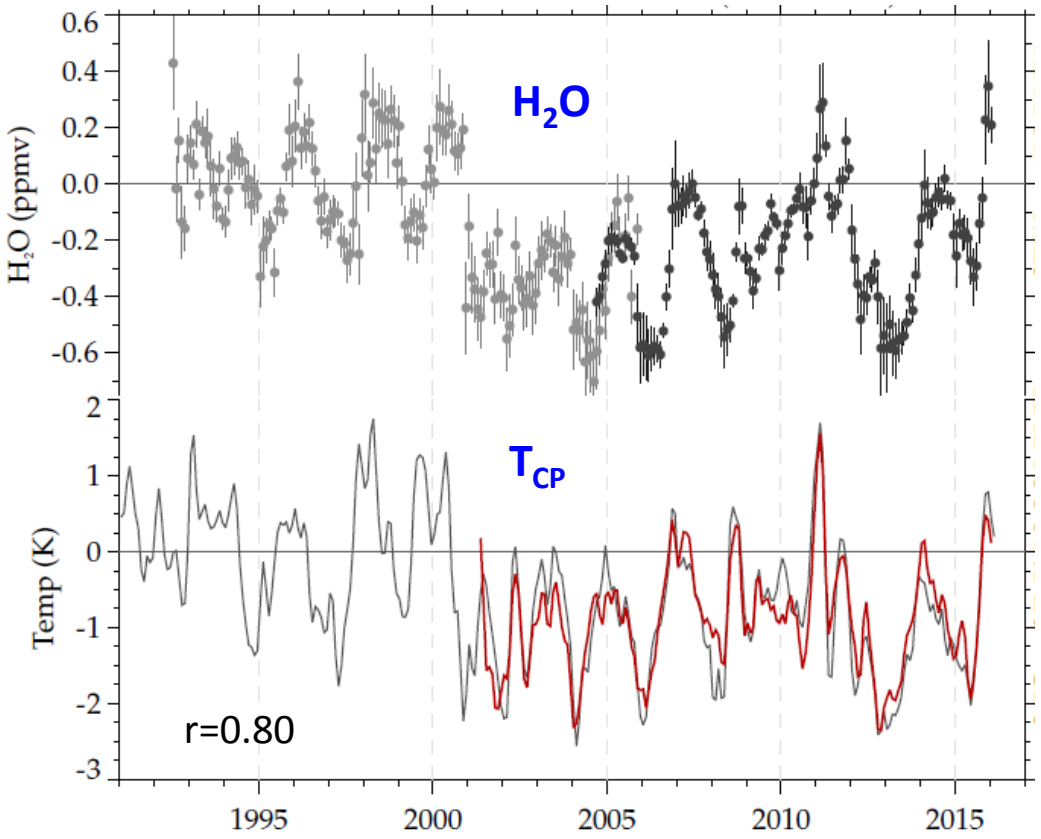
Deseasonalized anomalies

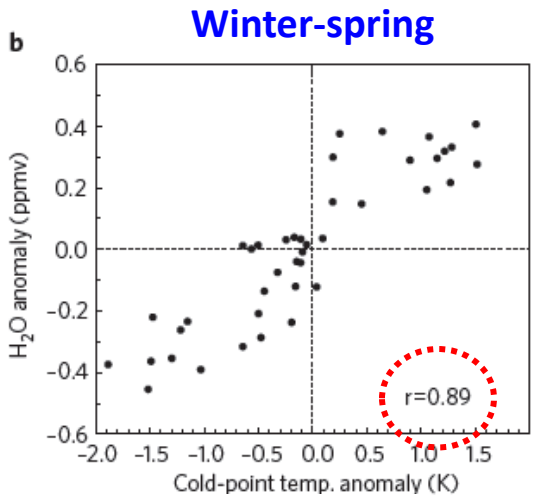


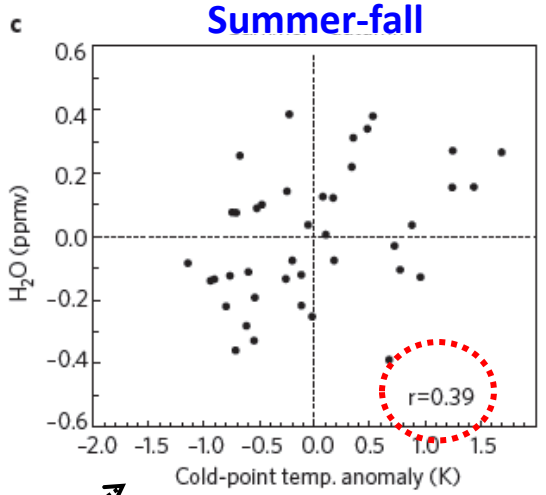
near-global mean (60° N-S)
water vapor at 82 hPa
from combined HALOE-MLS data

cold-point tropical
tropopause temperatures
10° N-S

black: radiosondes
red: GPS (after 2001)



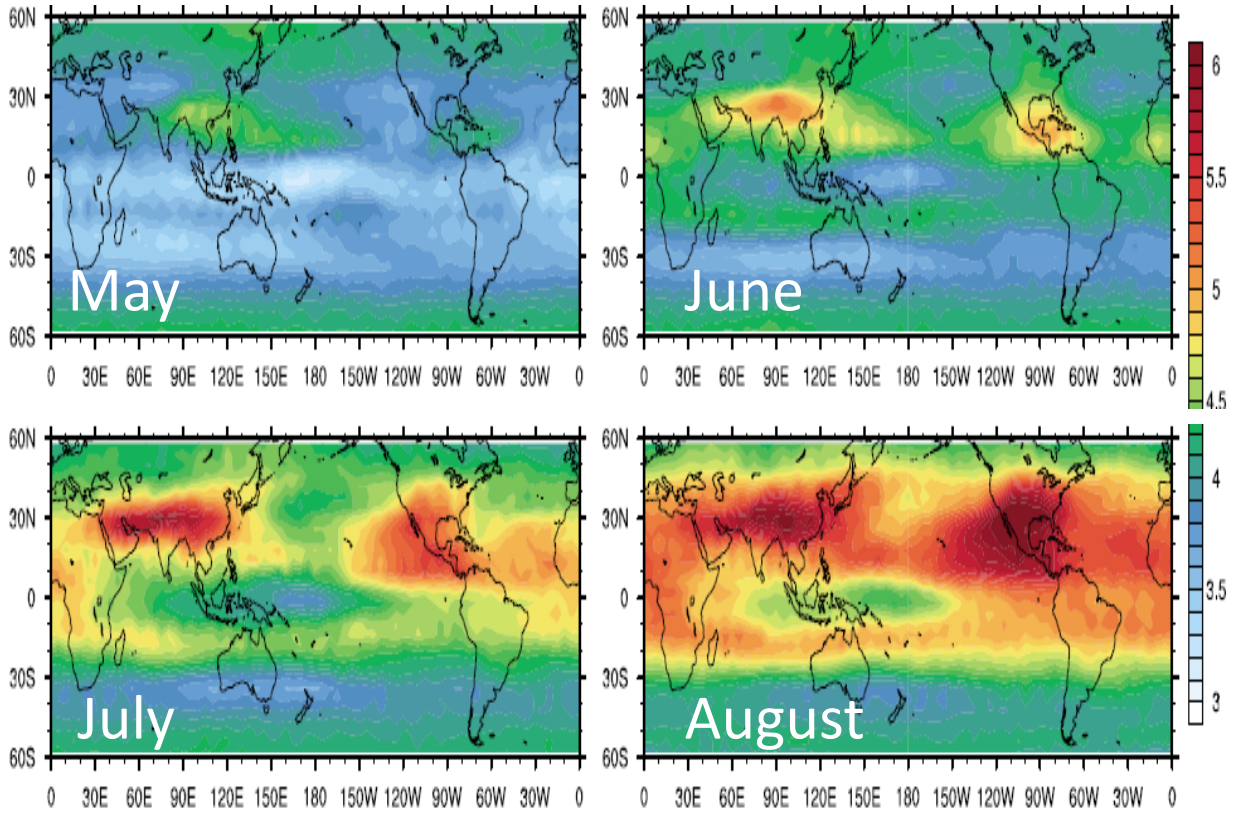




weaker correlations during summer

what else is controlling H_2O during summer?

100 hPa water vapor climatology from MLS



2 questions:

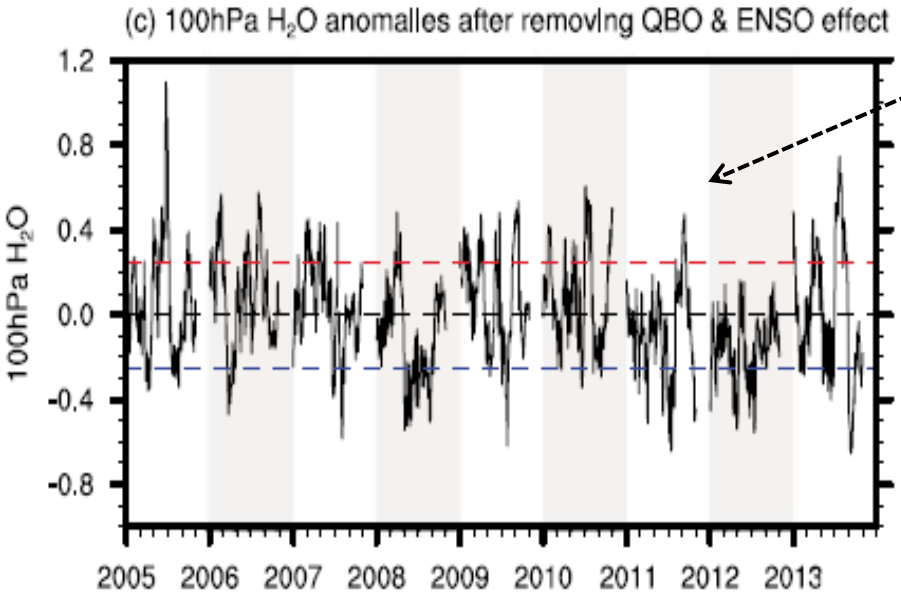
- What controls monsoon water vapor
- What is the monsoon influence on the globe?

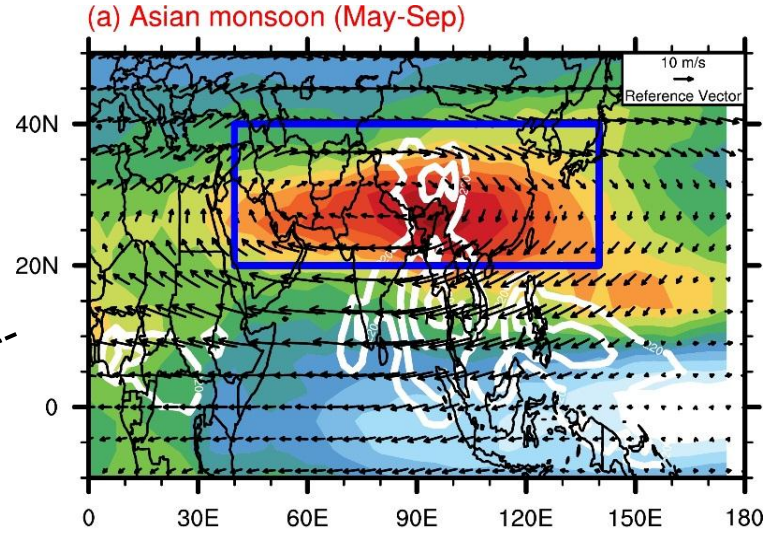
What controls stratospheric water vapor in the NH summer monsoon regions?

JGR 2015

William J. Randel[1], Kai Zhang[2], and Rong Fu[2]

9 years of MLS observations
deseasonalized anomalies



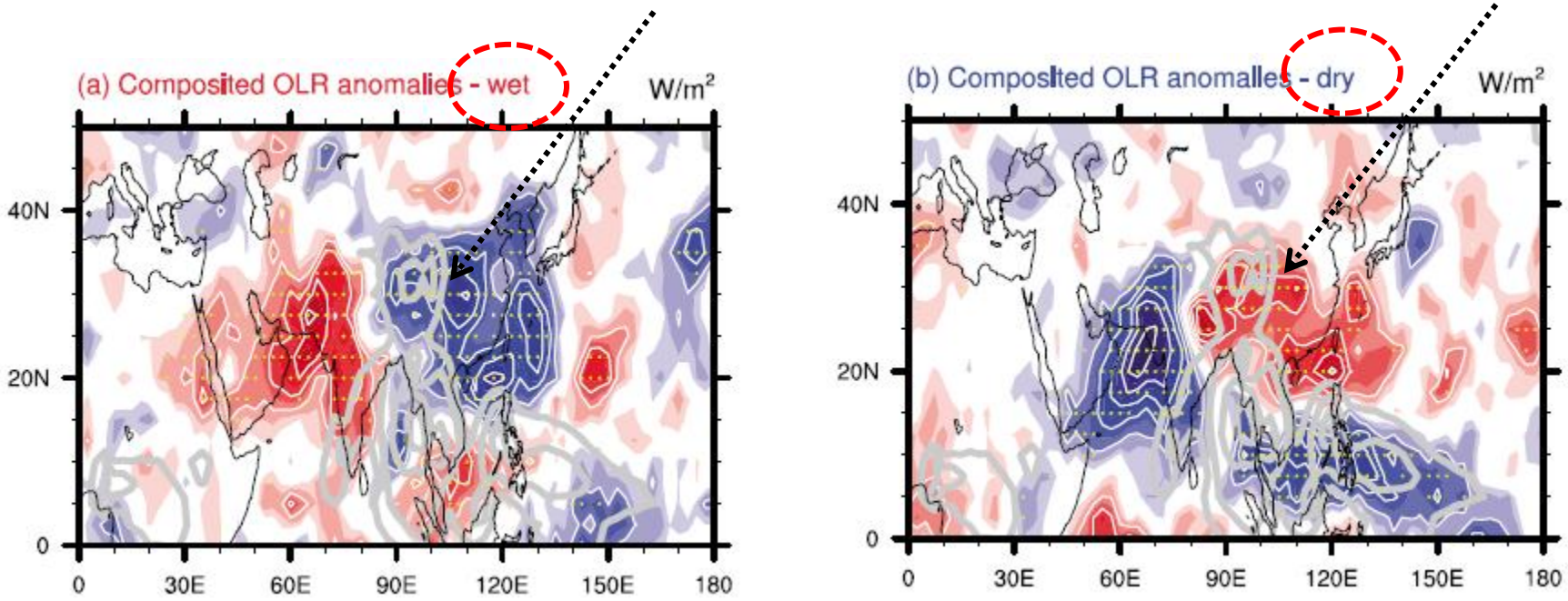


How is this variability related
to deep convection
and circulation/temperature ?

OLR composites over Asia wrt 100 hPa H_2O

less convection

more convection



Surprising result: less (more) convection

↕

more (less) lower stratosphere H_2O

Aspects of the 40–50 Day Oscillation during the Northern Summer as Inferred from Outgoing Longwave Radiation

MWR, 1986

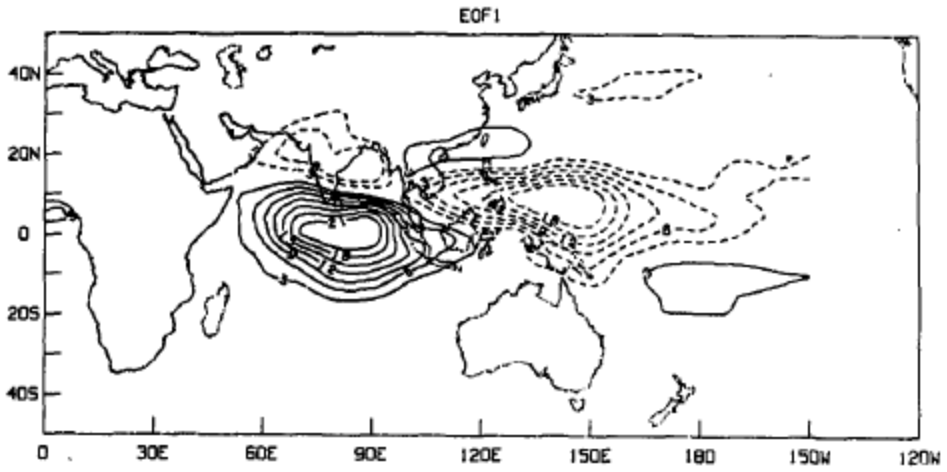
KA-MING LAU

Goddard Laboratory for Atmospheres, NASA/Goddard Space Flight Center, Greenbelt, MD 20771

P. H. CHAN

Applied Research Corporation, Landover, MD 20785

1st EOF of OLR over monsoon region



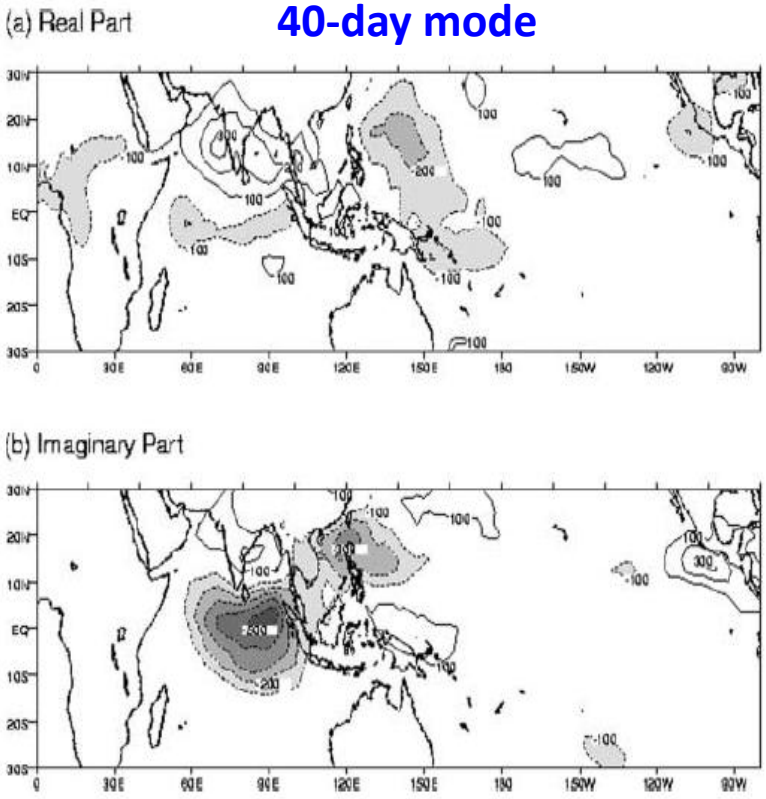
Climate Dynamics (2001) 18: 85–102

H. Annamalai · J. M. Slingo

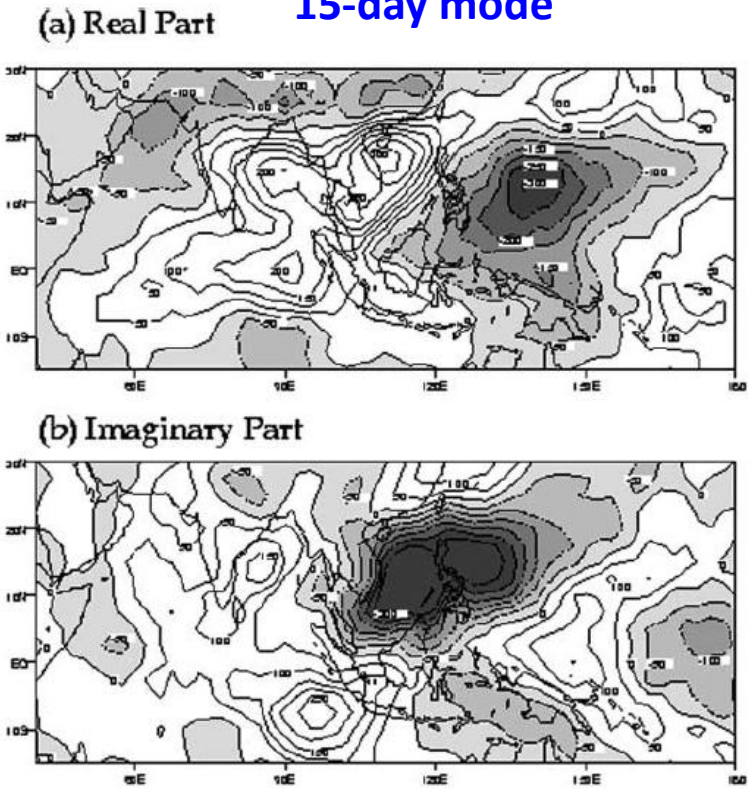
Active/break cycles: diagnosis of the intraseasonal variability of the Asian Summer Monsoon#

Principal Oscillation Patterns (POP)

40-day mode

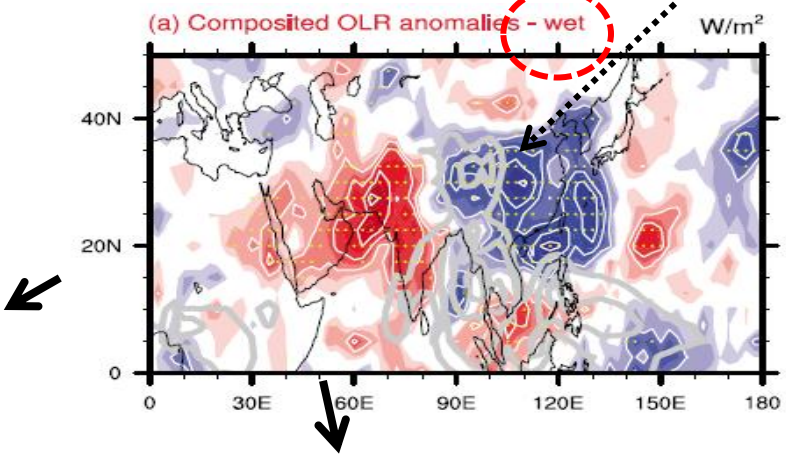


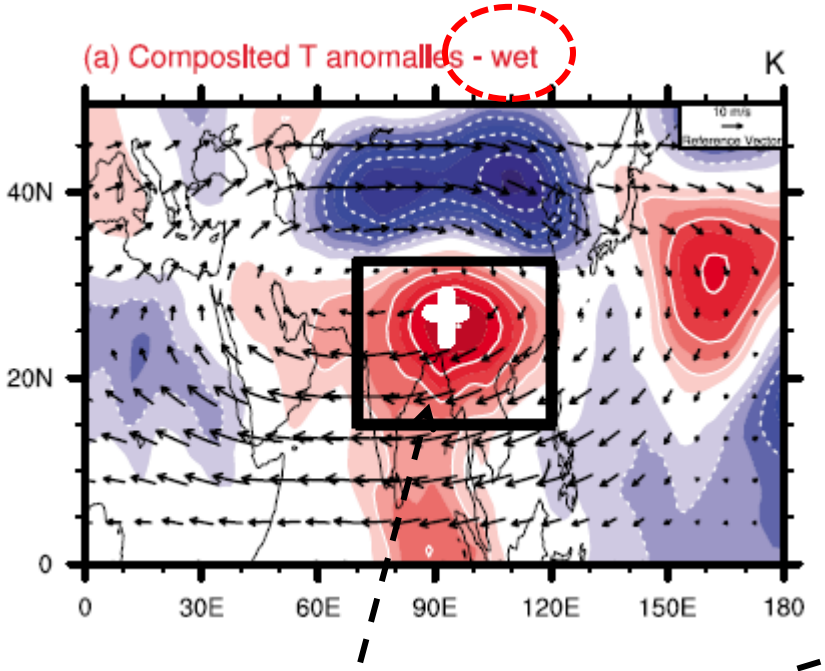
15-day mode



Asian monsoon:
links to temperatures at 100 hPa

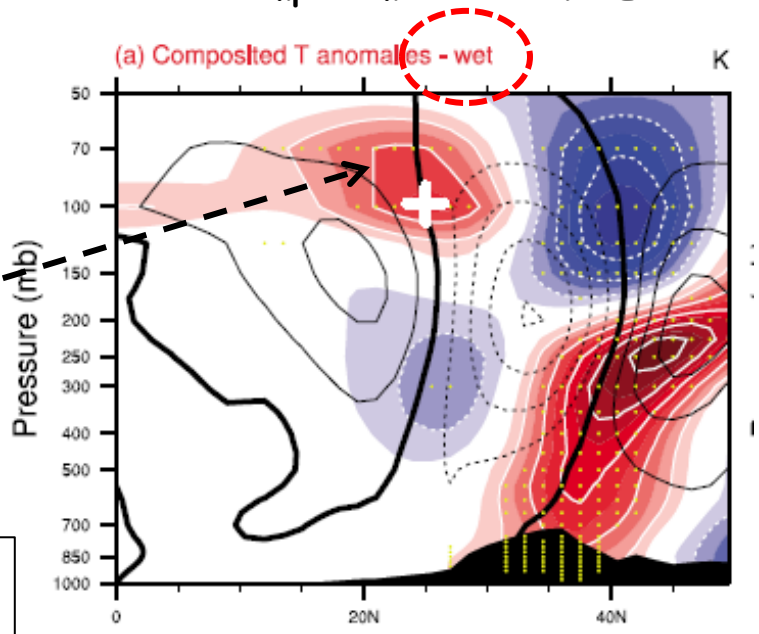
less convection





warm temps in low latitude stratosphere

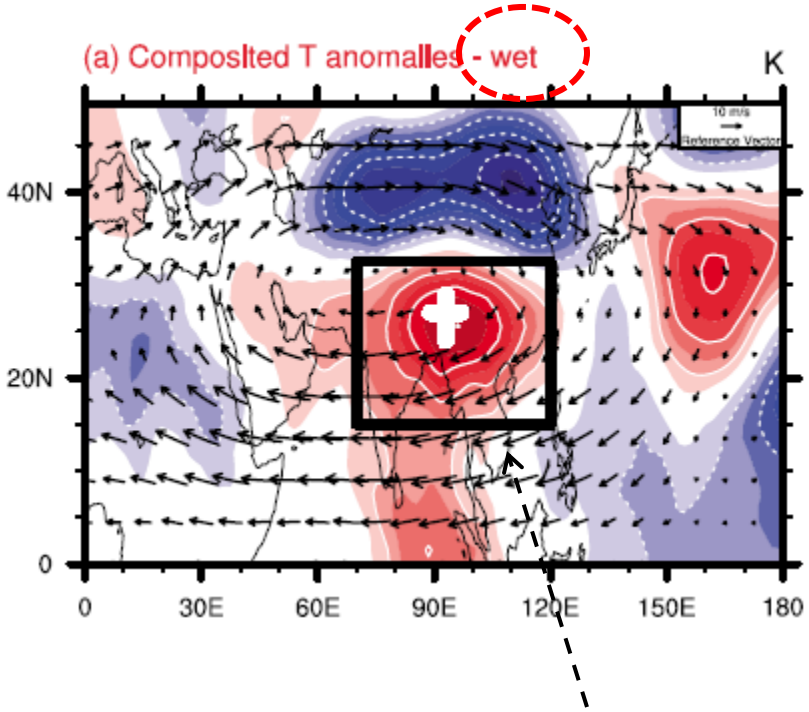
Temp anomalies near 90 E



balanced dynamical response to change in convection

JGR 2011

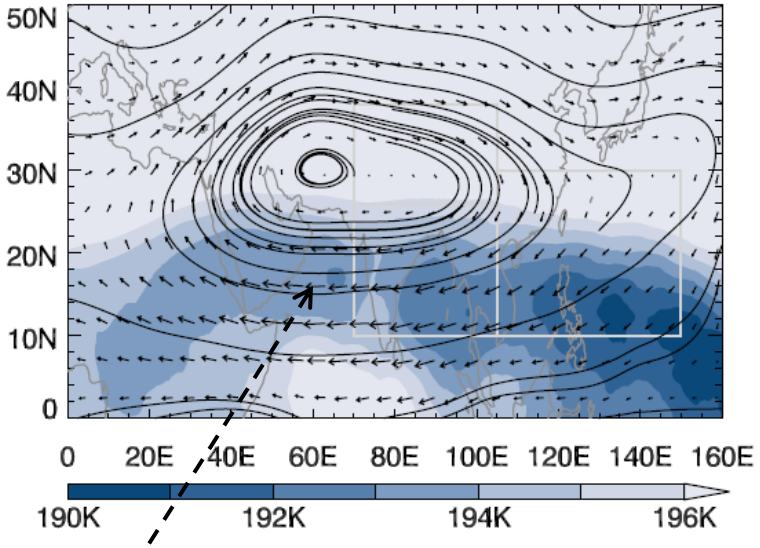
temp anomalies for wet composites



The influence of summertime convection over Southeast Asia on water vapor in the tropical stratosphere

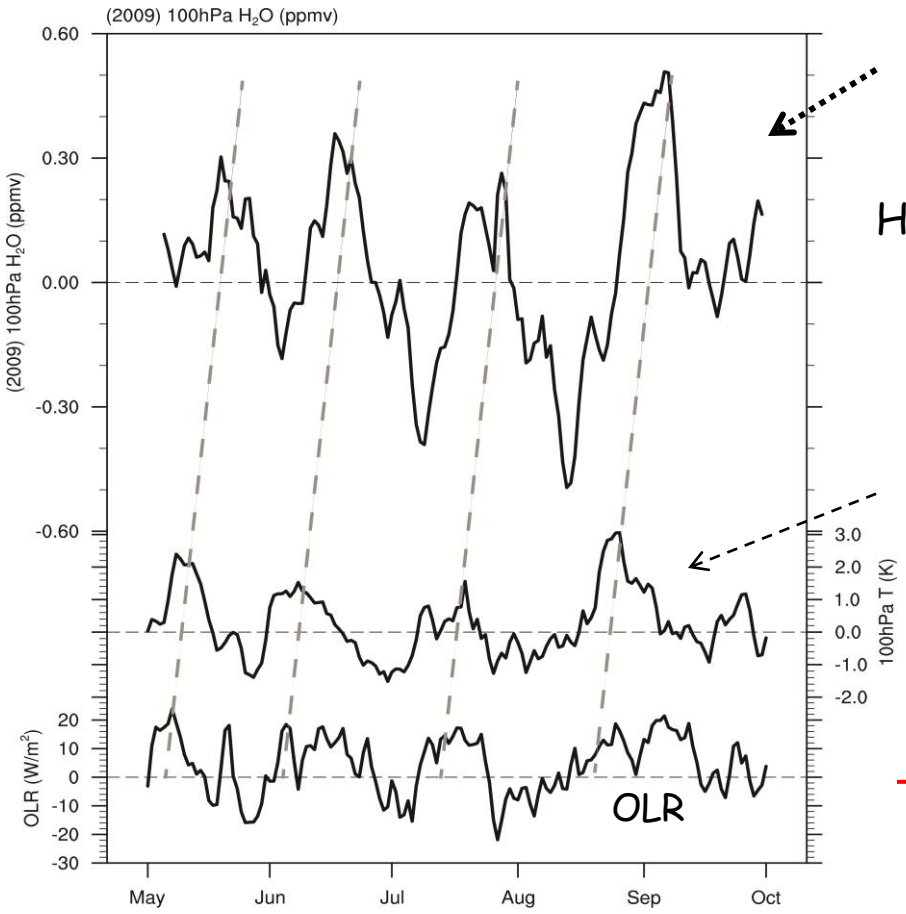
J. S. Wright,[1] R. Fu,[2] S. Fueglistaler,[3] Y. S. Liu,[4] and Y. Zhang[5]

Received 1 December 2010; revised 3 March 2011; accepted 28 March 2011; published 17 June 2011.



subtropics: most important region for dehydration

time series over Asia during summer 2009



30-40 day oscillations

H_2O in monsoon

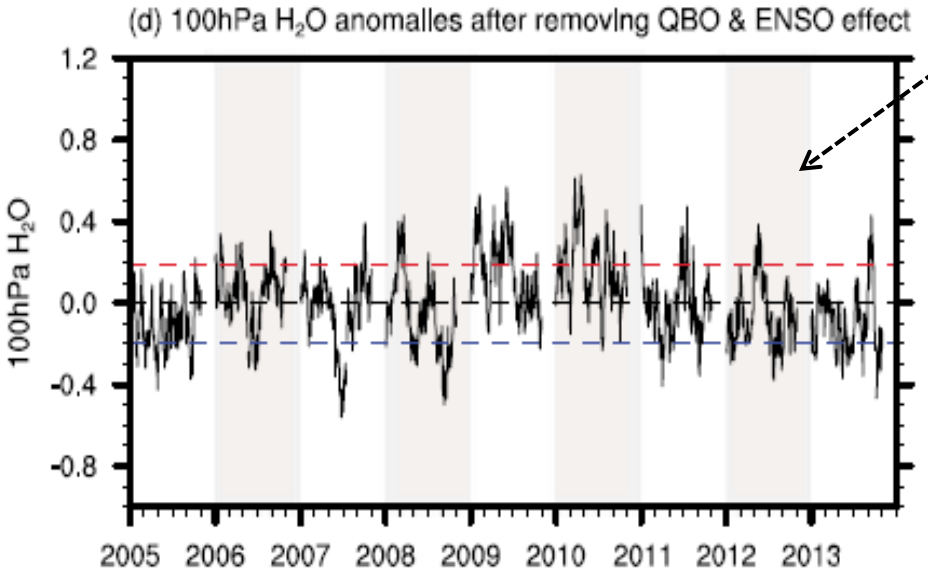
100 hPa temps, 10-30 N

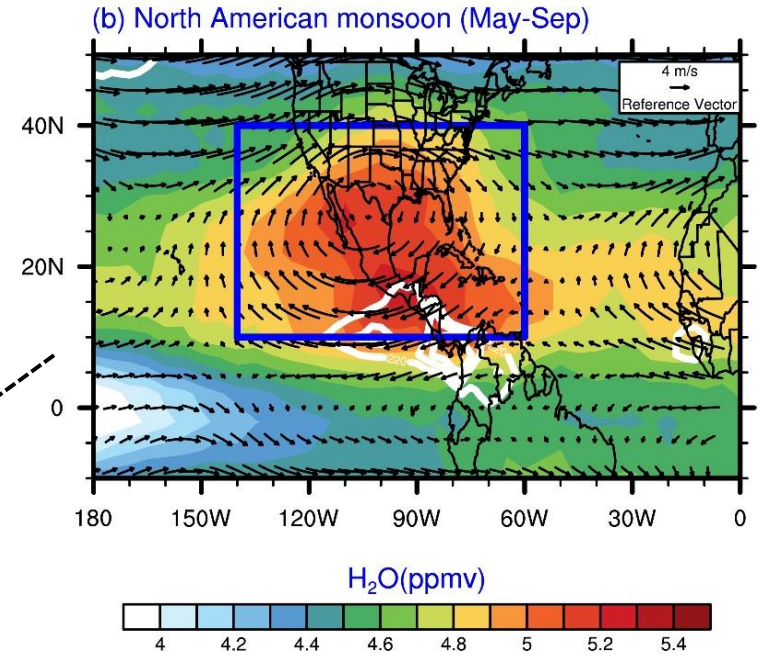
less convection

more convection

N American monsoon

9 years of MLS observations
deseasonalized anomalies

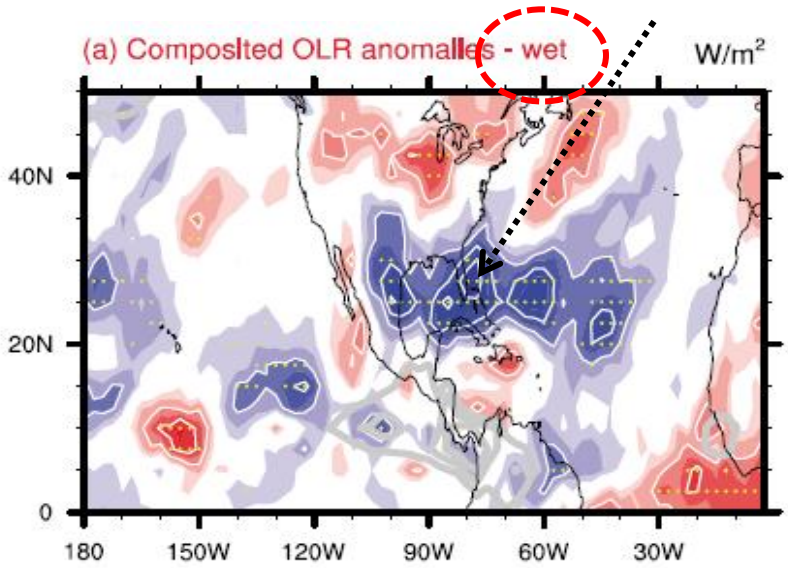


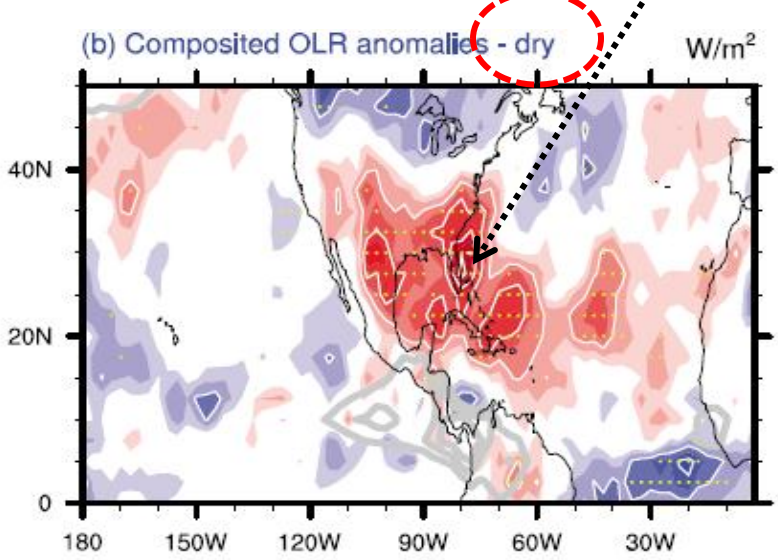


Composites over N America wrt 100 hPa H_2O

less convection

more convection

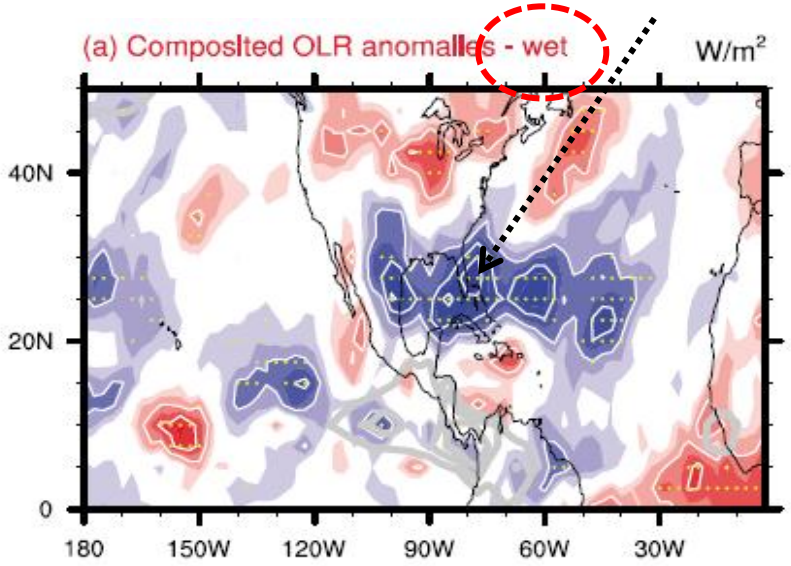


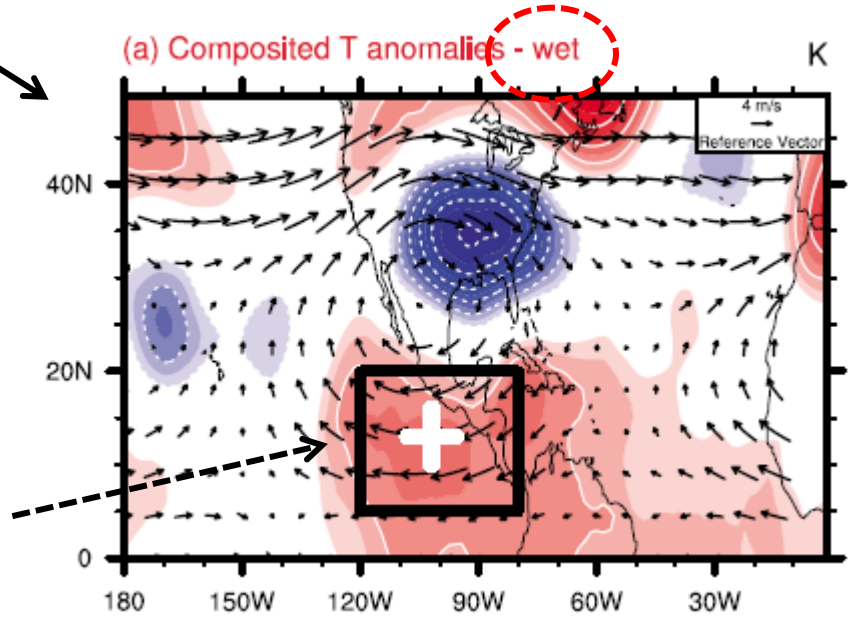


Same result: less convection ~ wet lower stratosphere

temp anomalies for wet composites

less convection





Similar connection:
<u>subtropical temps at 100 hPa</u>

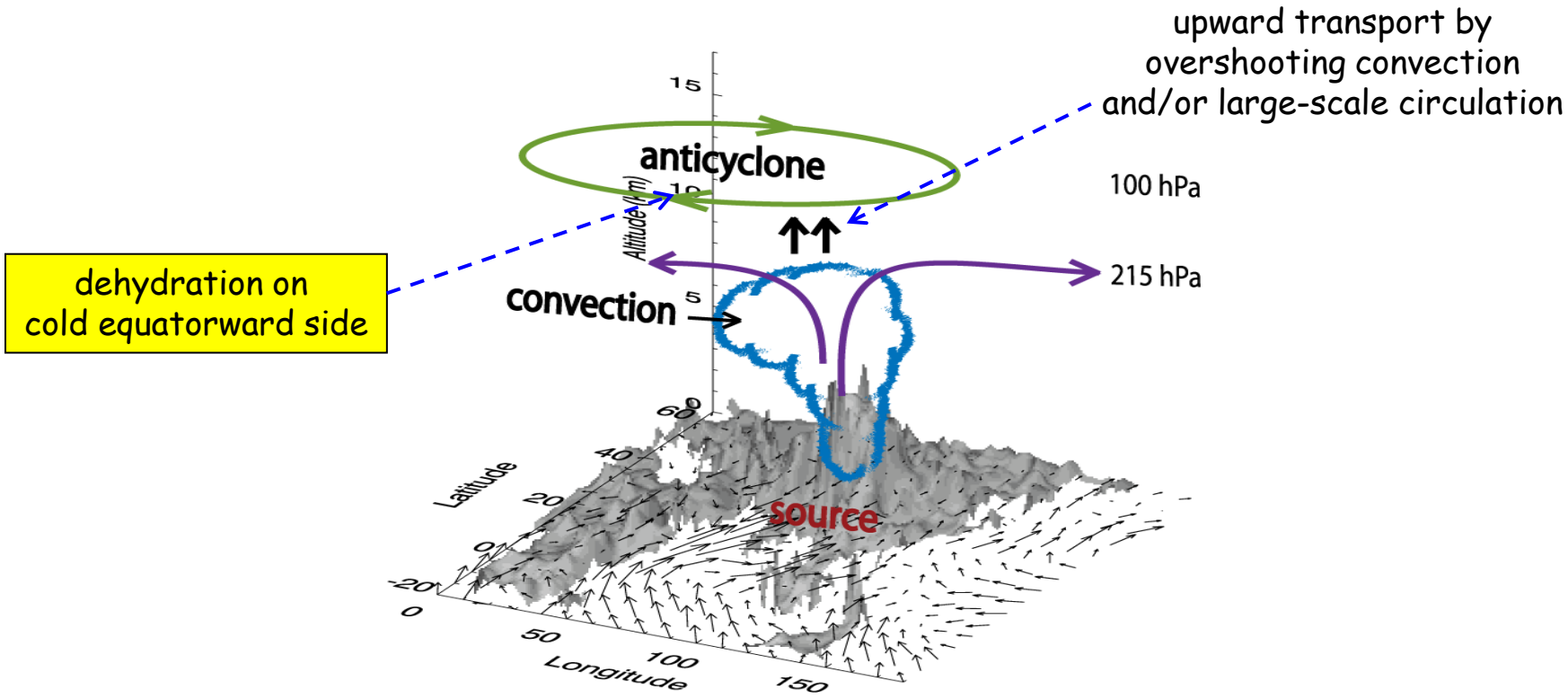
Key points:

- Surprising result: strong (weak) convection associated with

  dry (wet) lower stratosphere

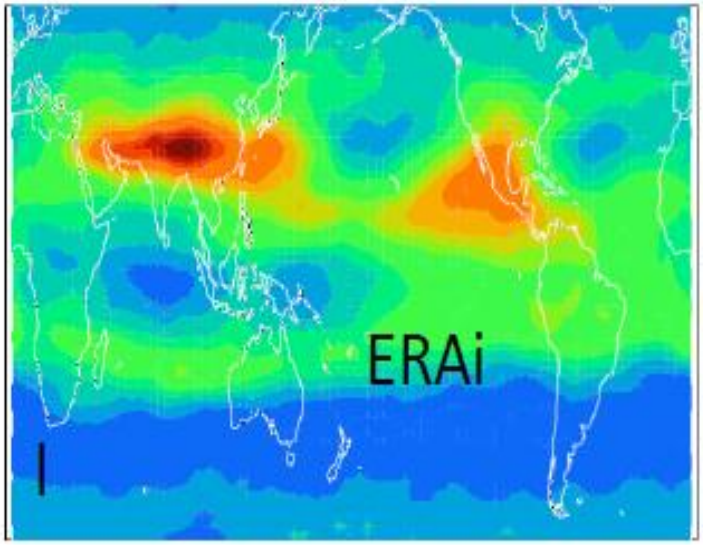
- Monsoon H_2O controlled by temperatures in the subtropical stratosphere

- Coherent links to oscillations of the 'tropospheric' monsoon



What is the influence of the monsoons on global stratospheic H_2O ?

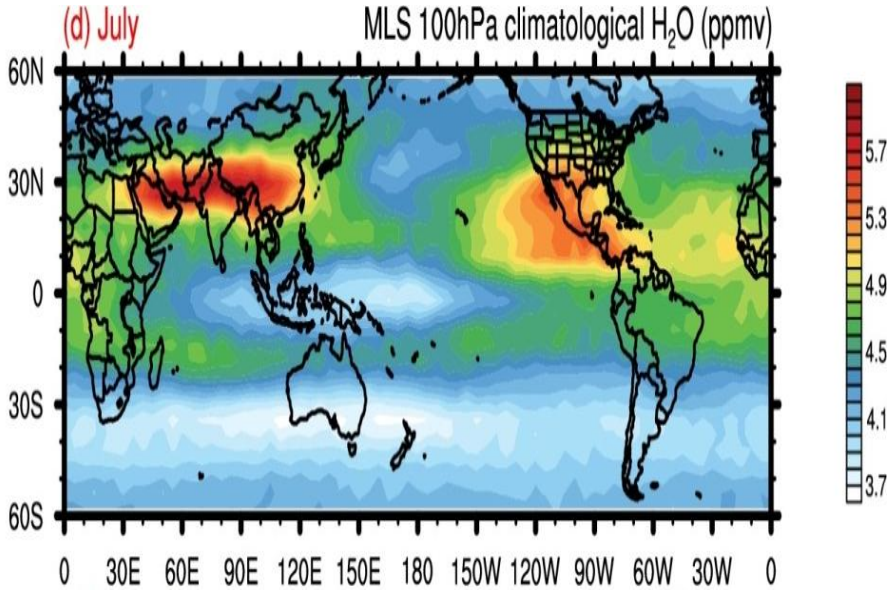
trajectory model



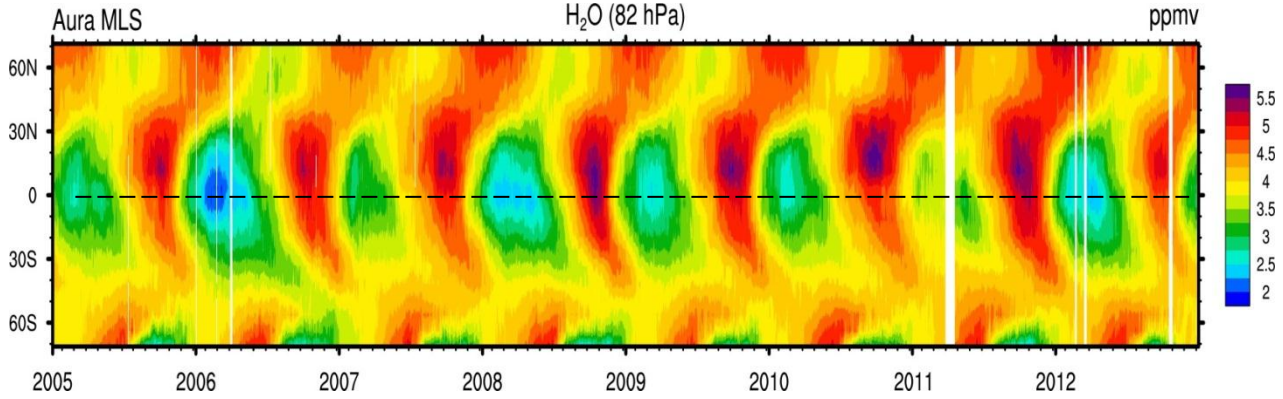
Schoeberl et al 2013
Domain-filling trajectory model

Large-scale circulation and temps;
no parameterized convection

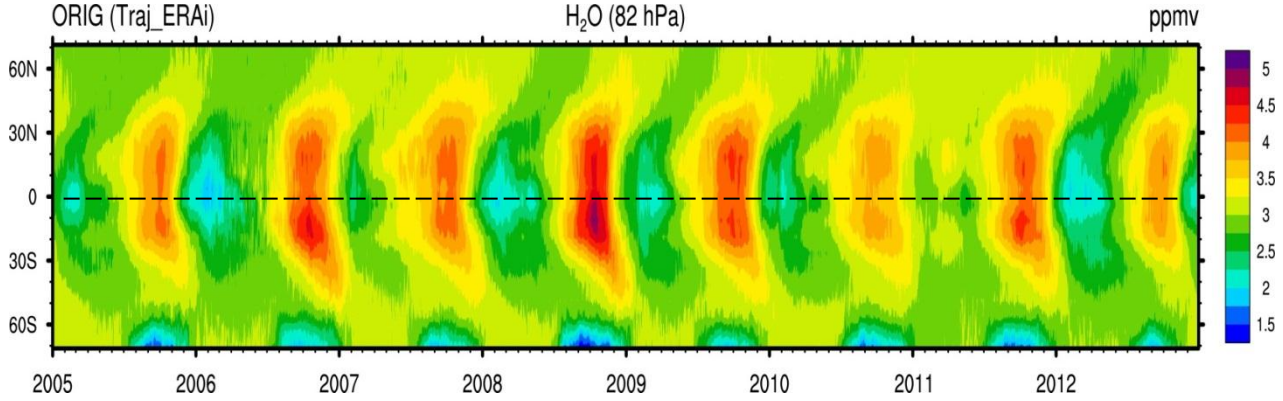
observations



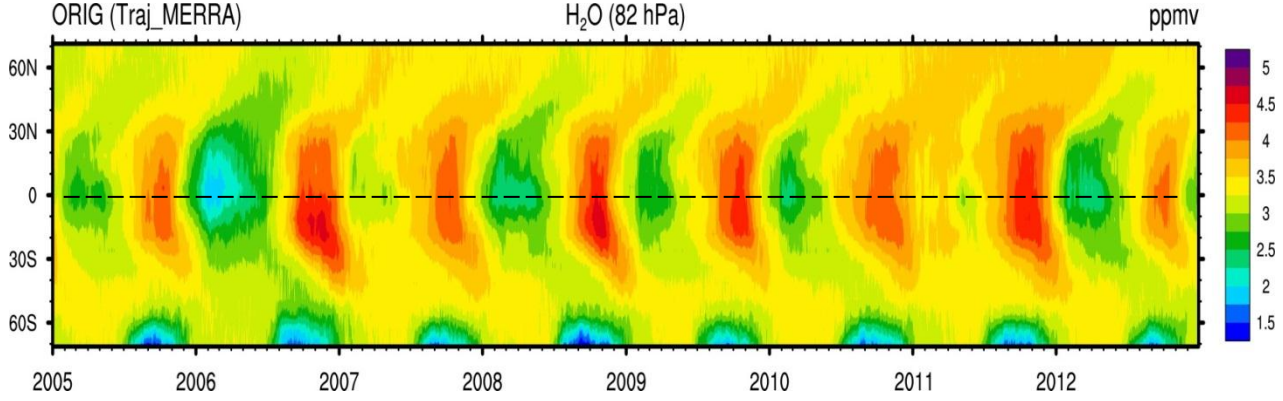
82 hPa



MLS

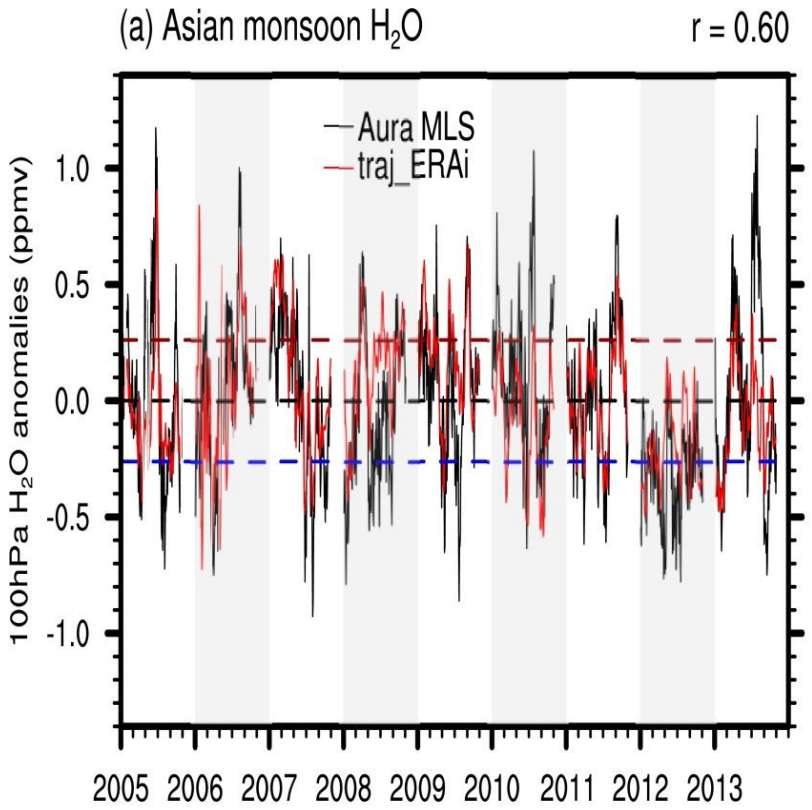


ERAi calculations



MERRA calculations

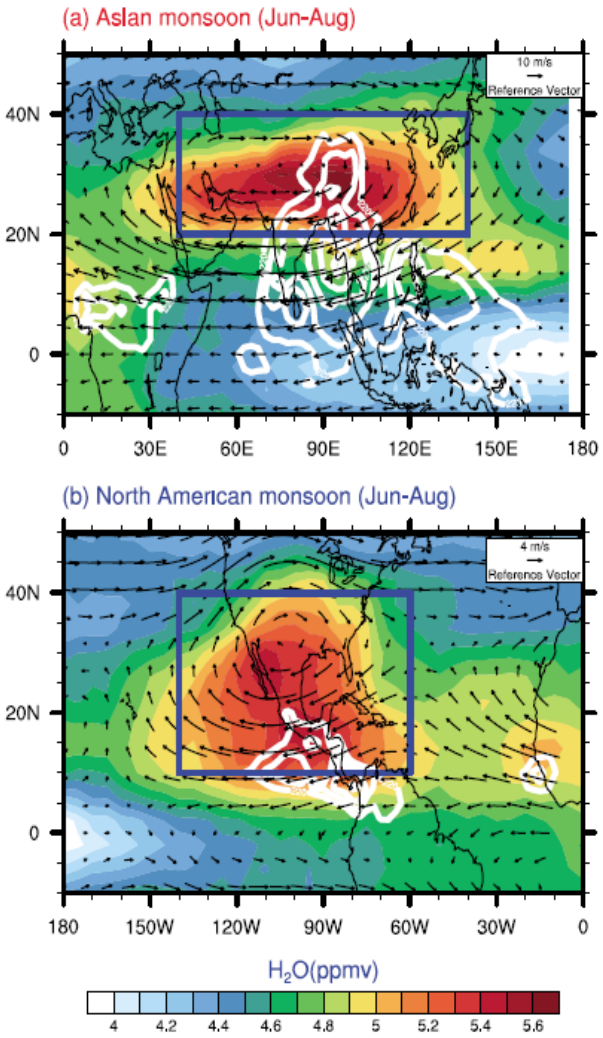
100 hPa anomalies in Asian monsoon water vapor



Overall, the trajectory model does a good job at large-scale variability

Experiments

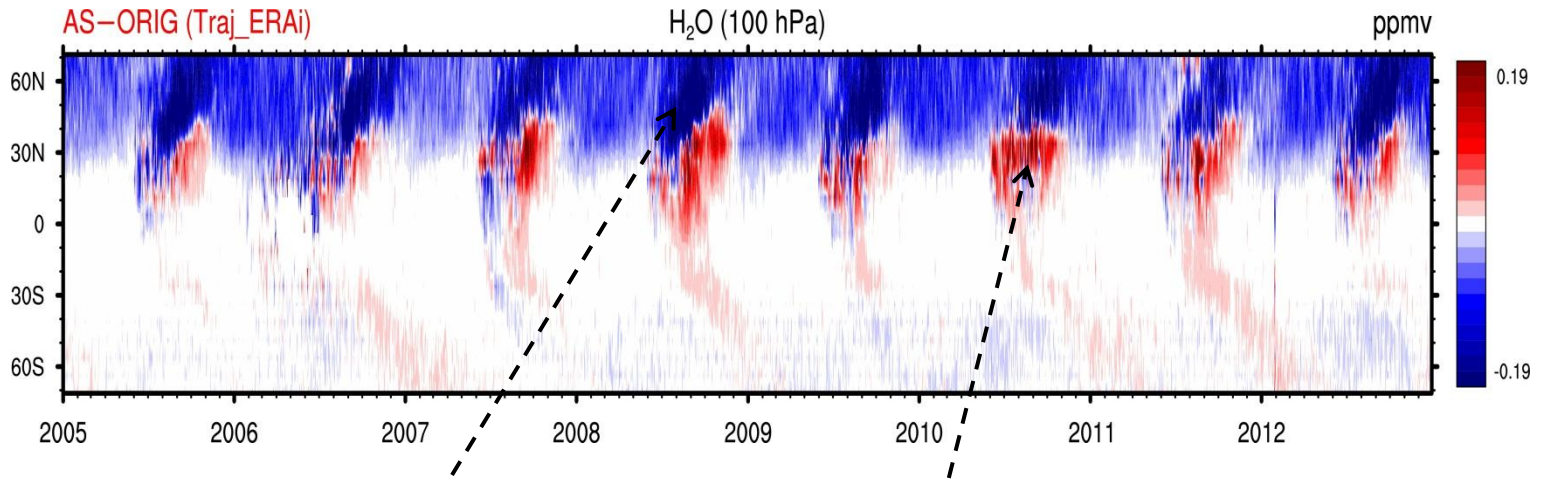
- **1. ASIA:** remove parcels that ever meet Asian monsoon region 370K-420K during JJA.
- **2. NA:** remove parcels that ever meet NA monsoon region 370K-420K during JJA.
- **3. ASIA&NA:** remove parcels that ever meet either Asian or NA monsoon region 370K-420K during JJA.



ASIA experiment

100 hPa differences

ERAi



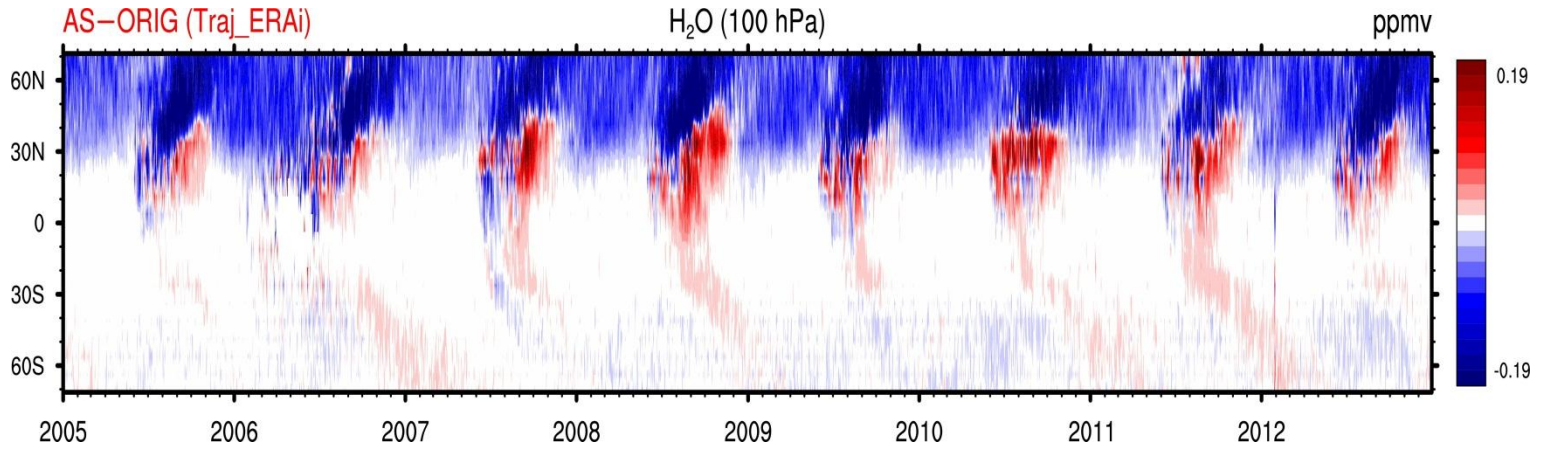
blue: monsoon moistens

red: monsoon dries

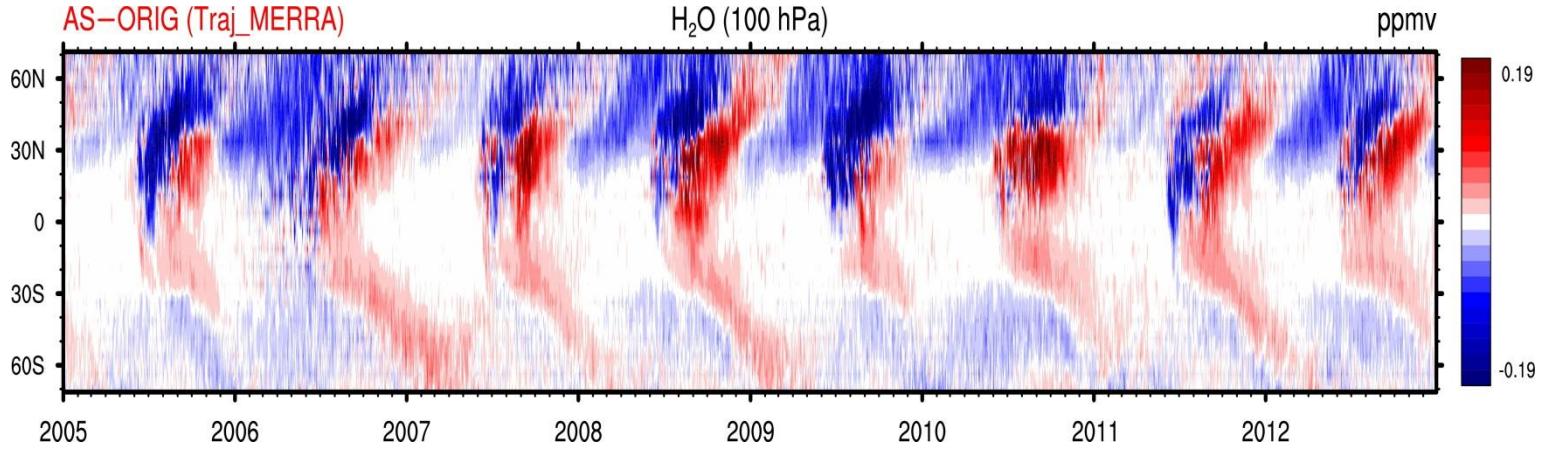
ASIA experiment

100 hPa differences

ERAi



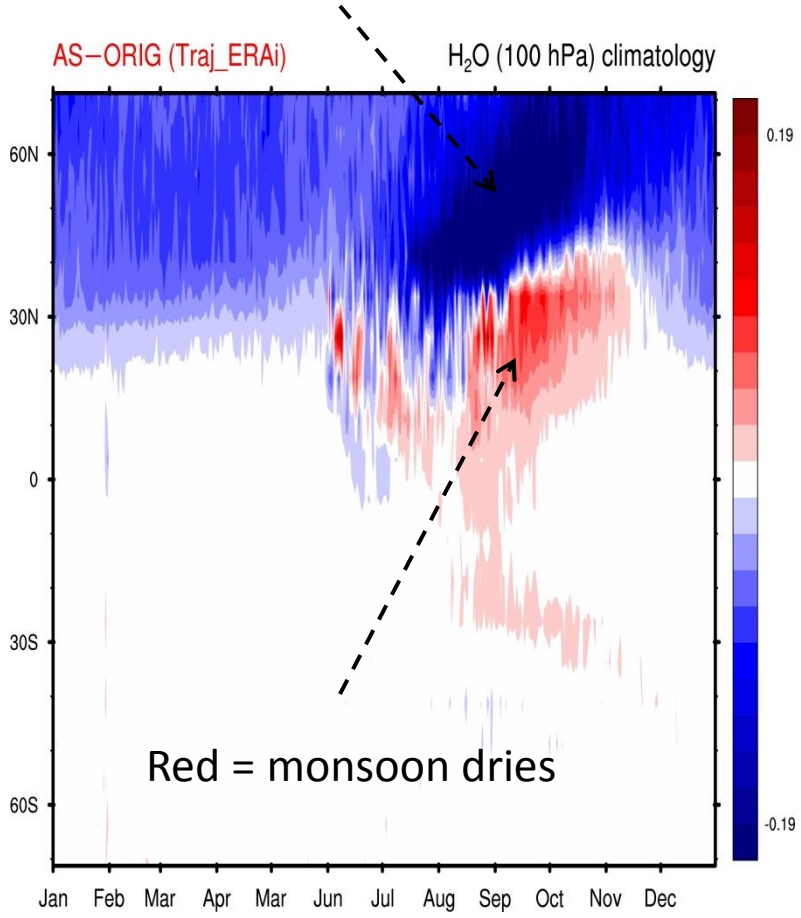
MERRA

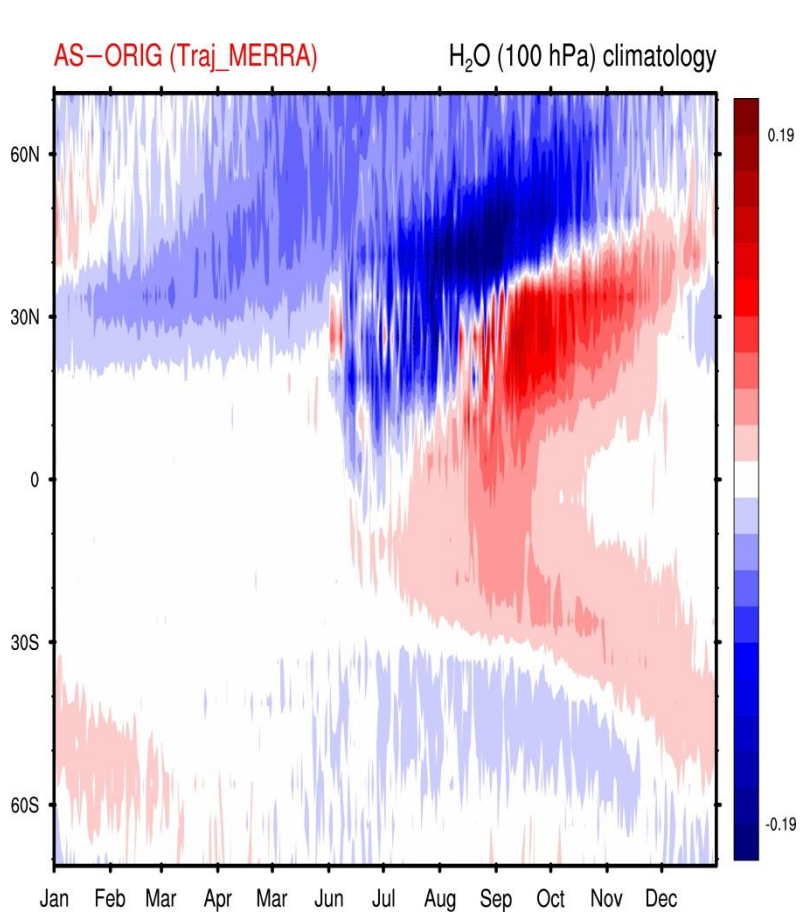


ASIA experiment

100 hPa differences

Blue = monsoon moistens





ASIA experiment

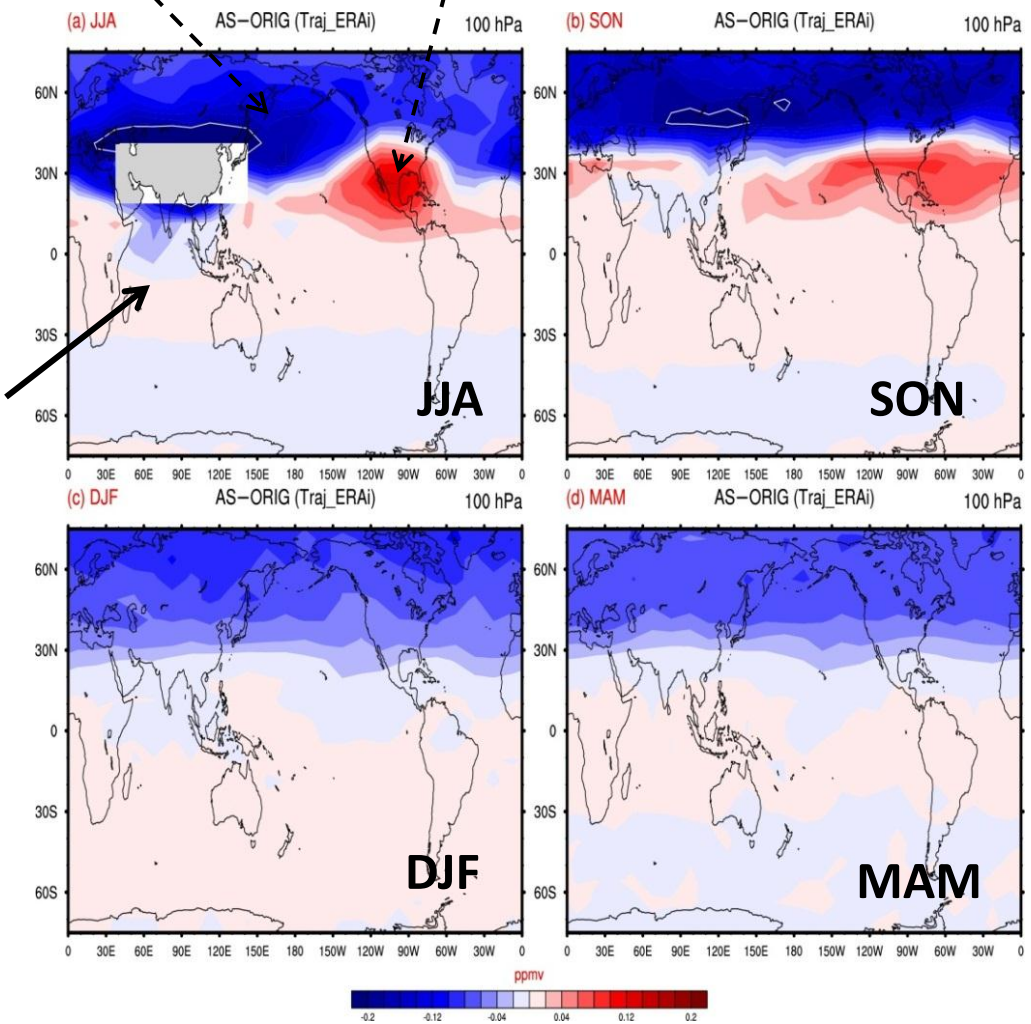
Traj_ERAi

difference maps

100 hPa

moistening

drying



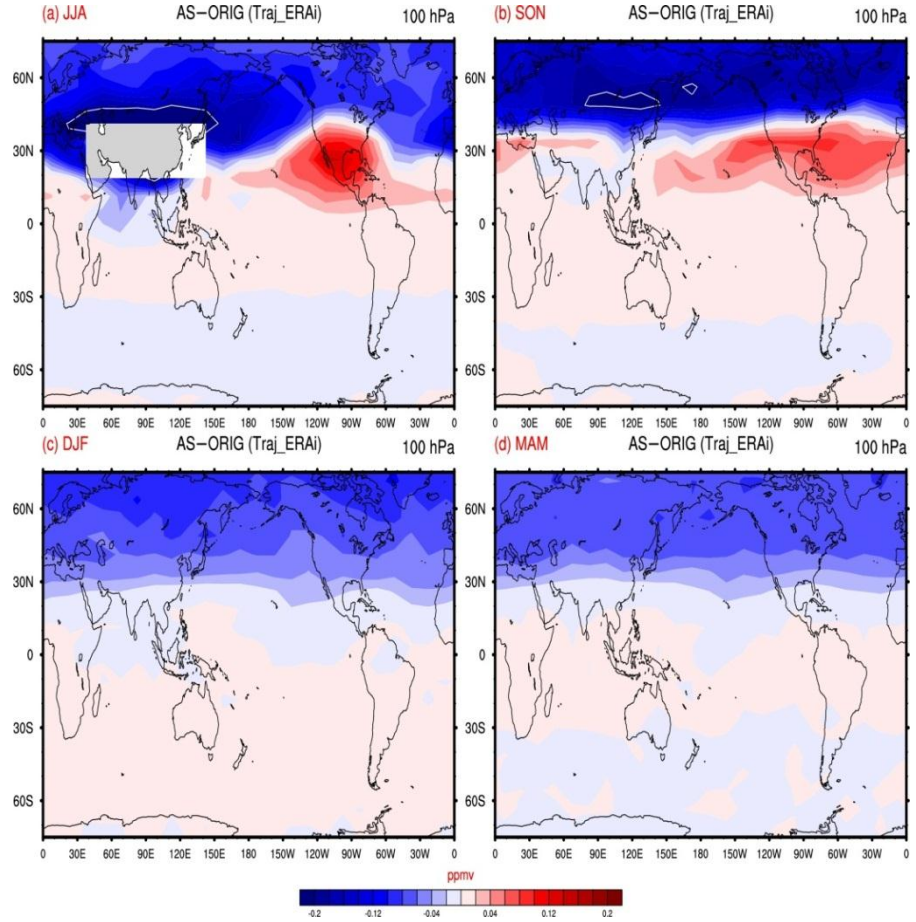
Communication between Asian and NA monsoons !

ASIA experiment

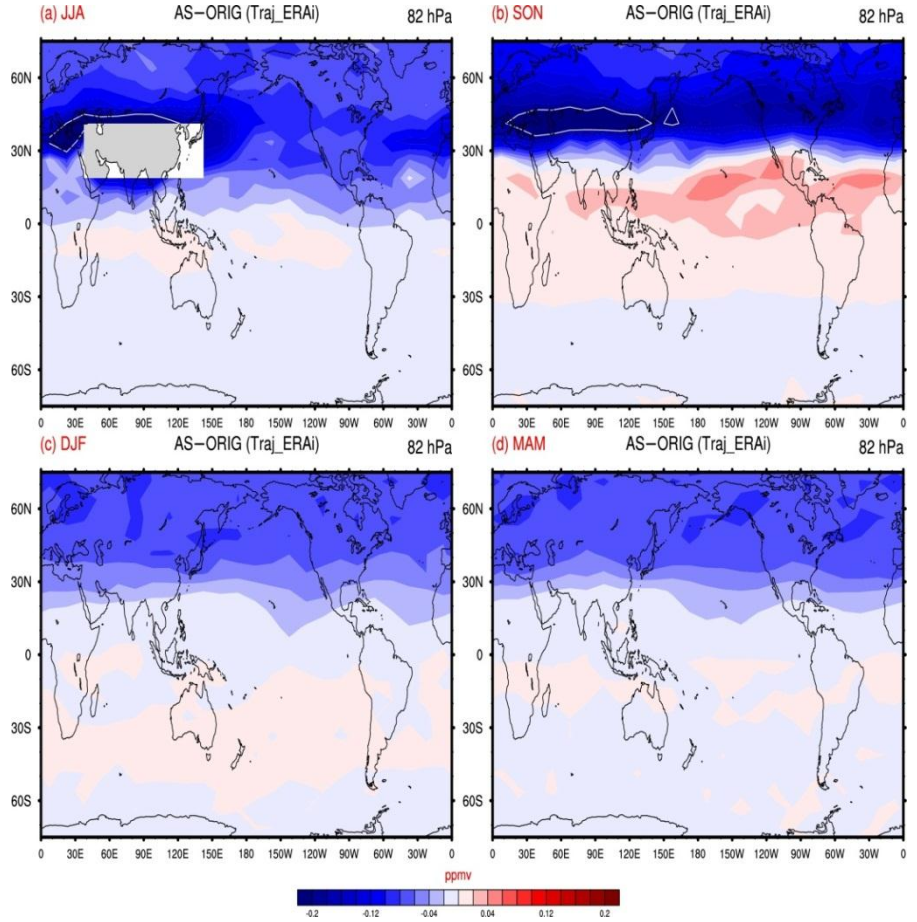
Traj_ERAi

difference maps

100 hPa



82 hPa

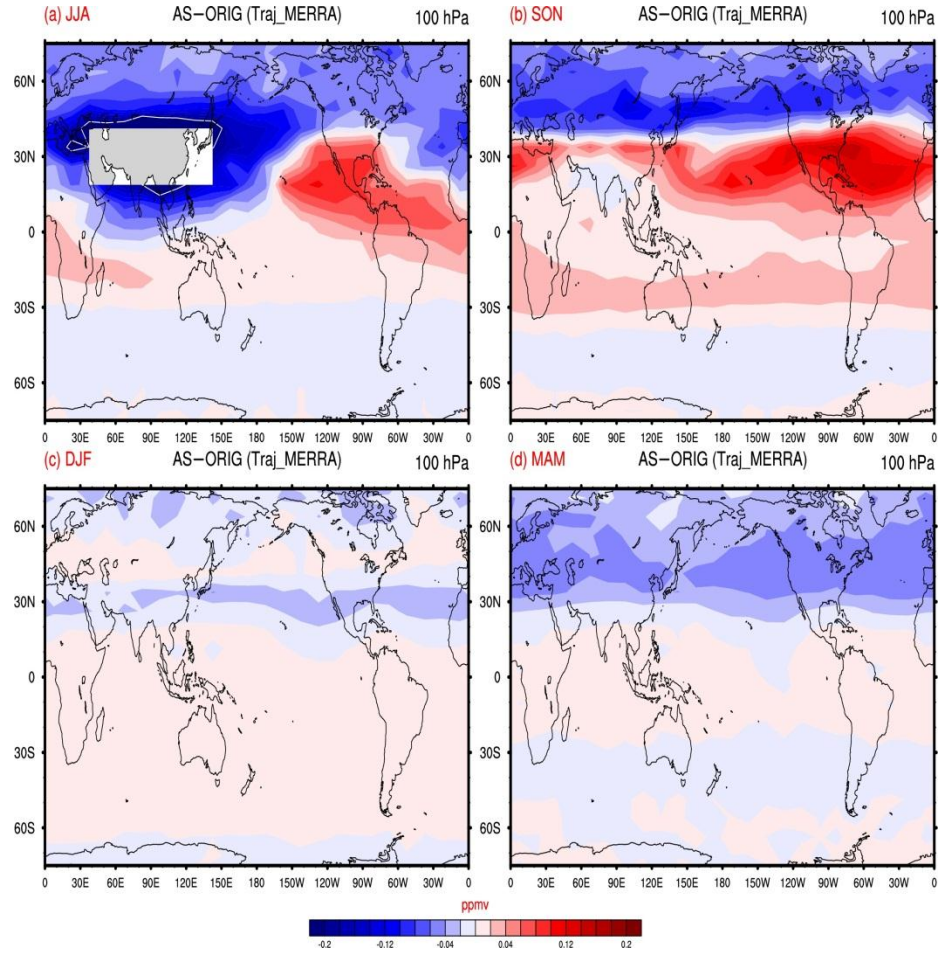


ASIA experiment

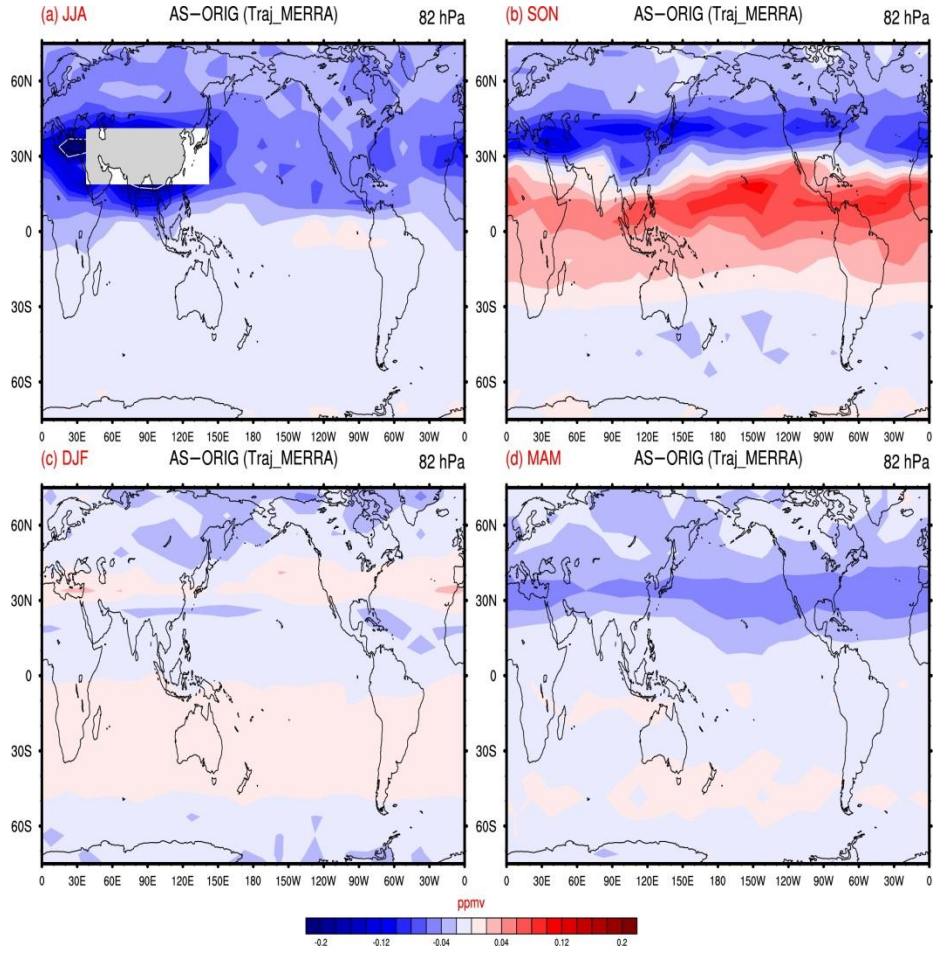
Traj_MERRA

difference maps

100 hPa



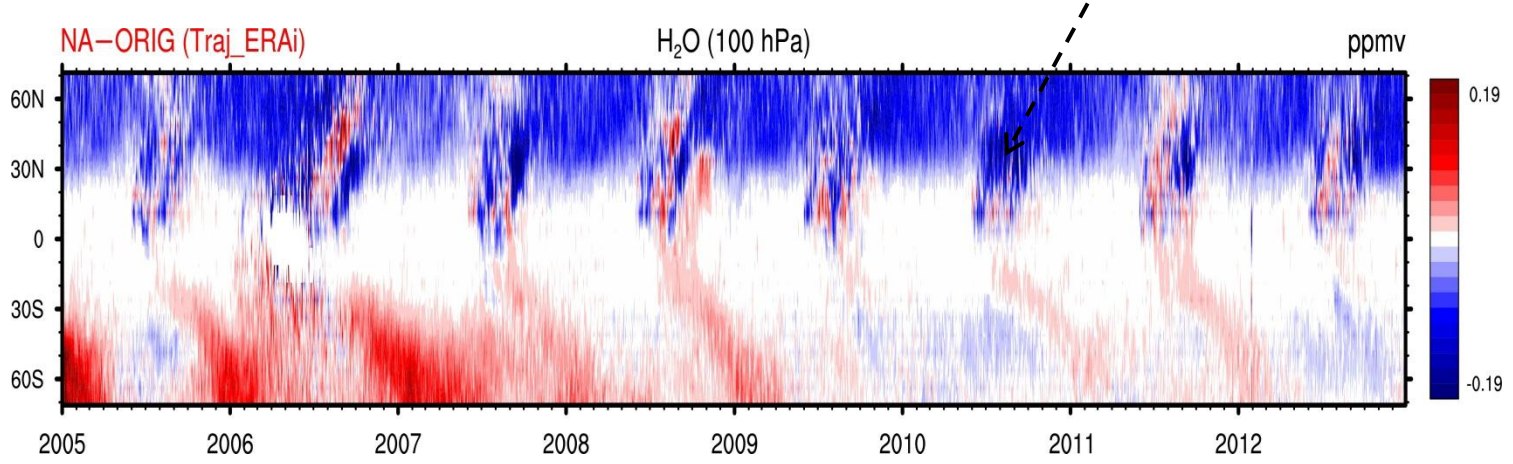
82 hPa

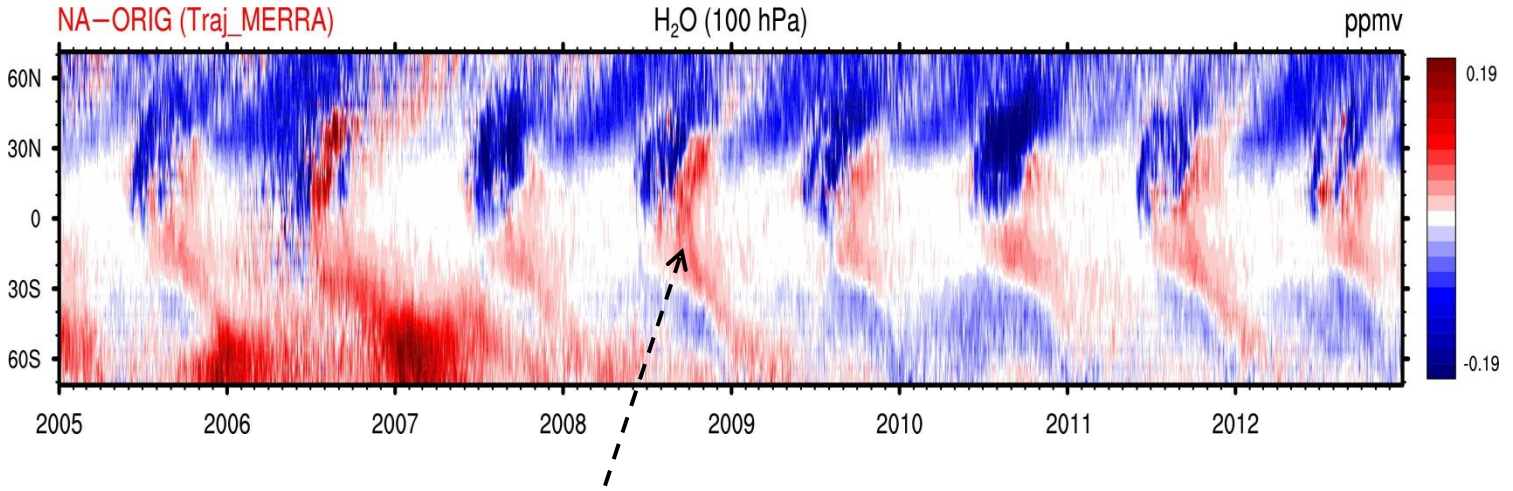


NA experiment

100 hPa

Blue = monsoon moistens

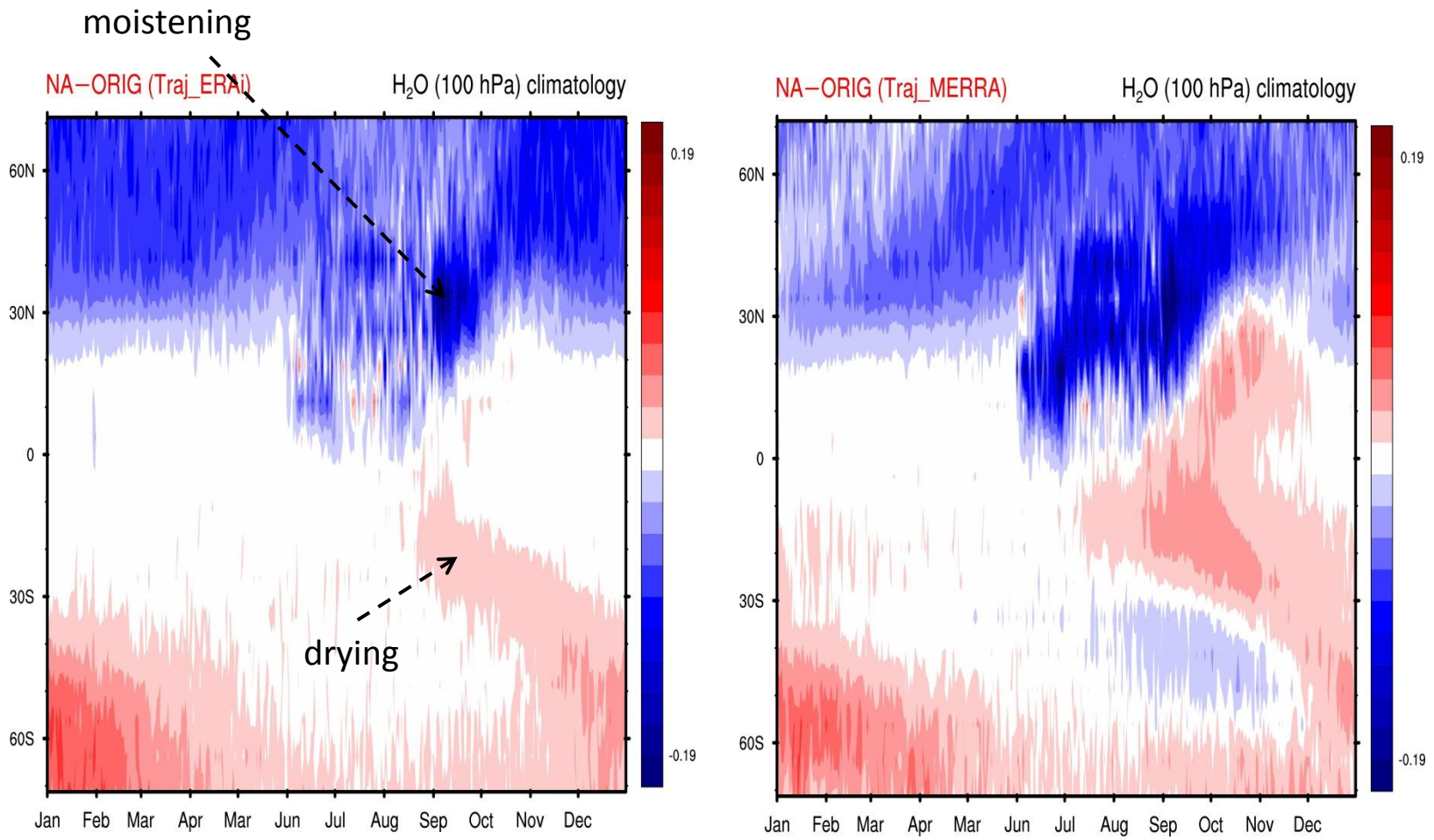




red = monsoon dries

NA experiment

100 hPa climatology

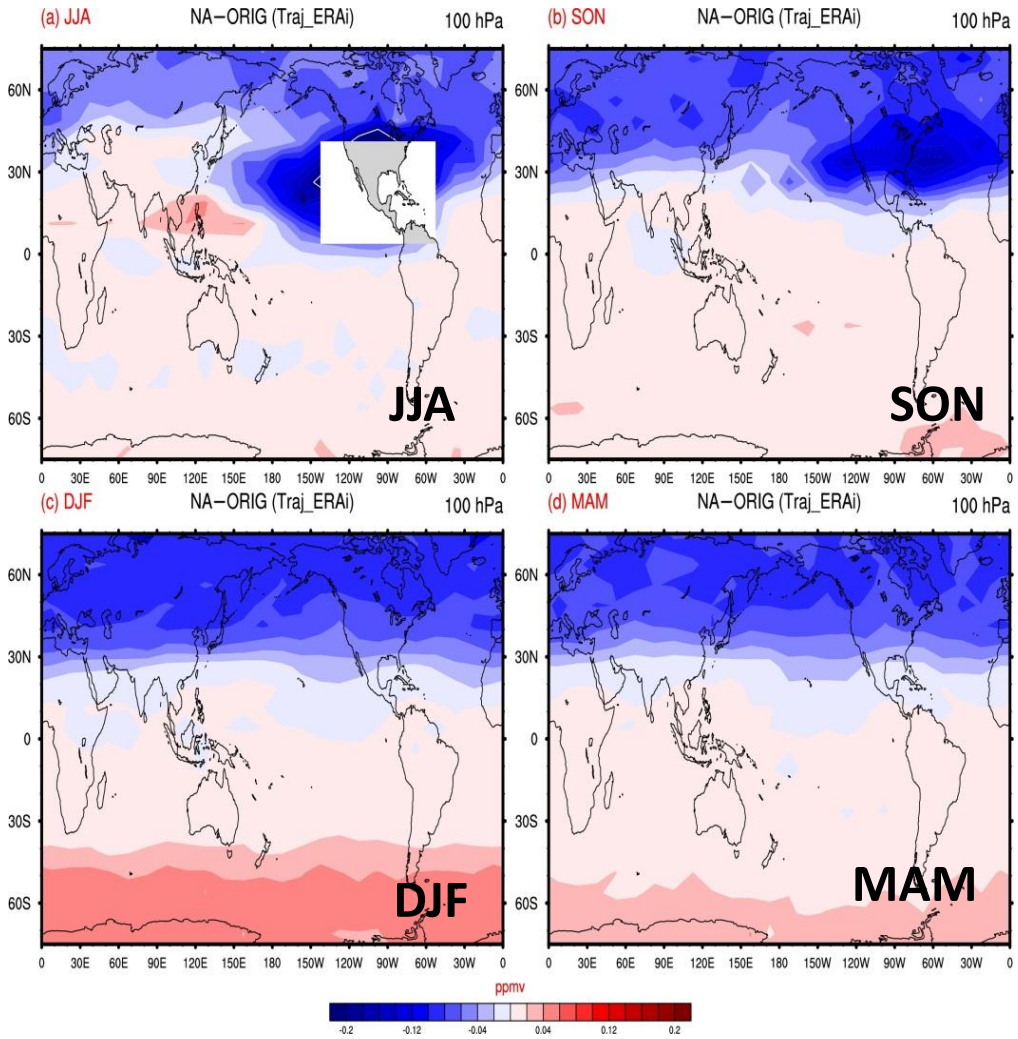


NA experiment

Traj_ERAi

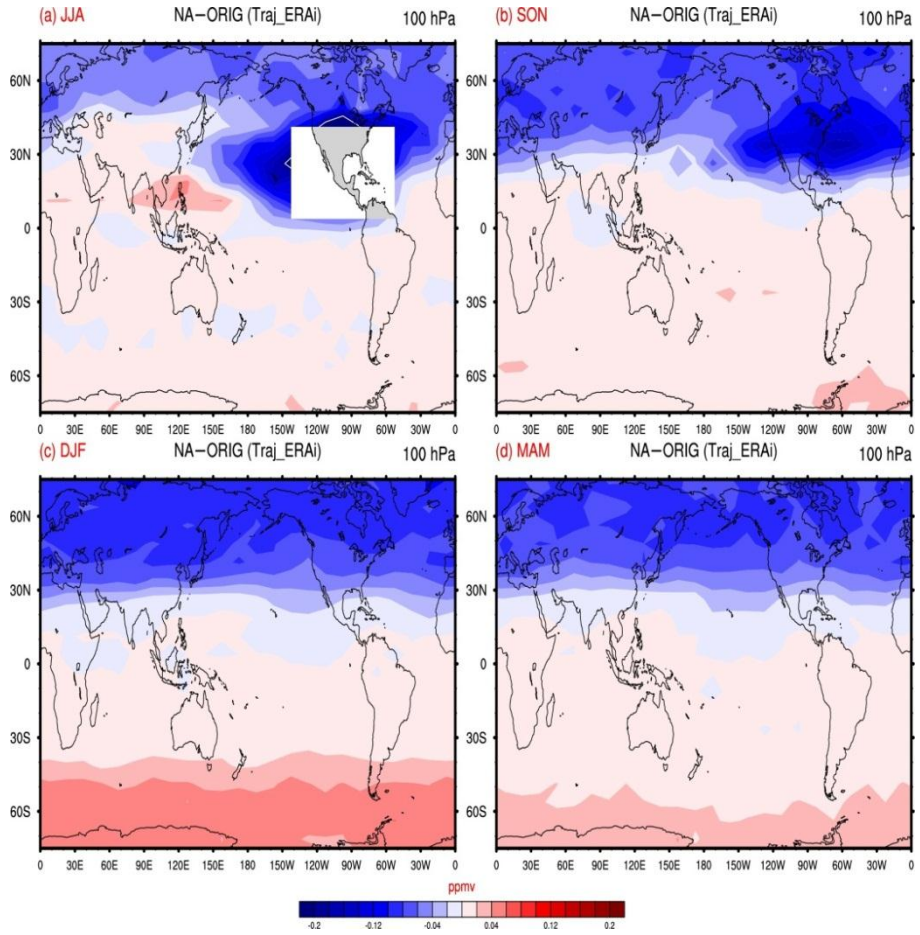
difference maps

100 hPa

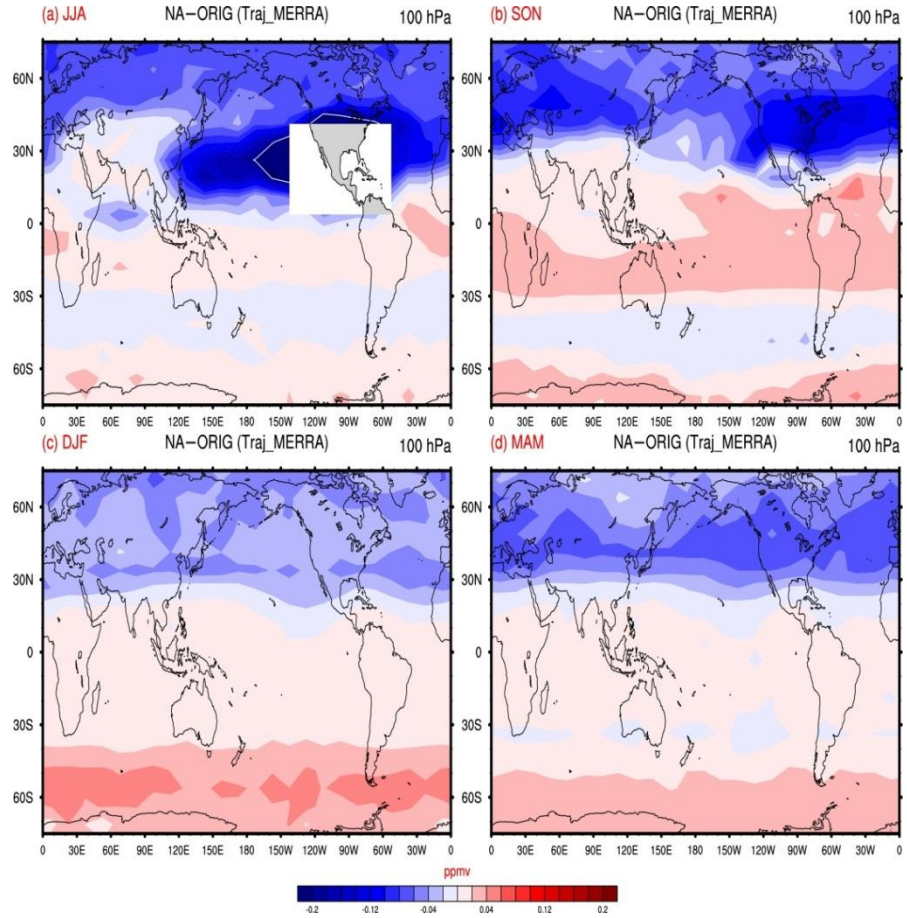


NA experiment **100 hPa difference maps**

Traj_ERAi



Traj_MERRA



Notes:

- Work in progress and we don't understand it very well yet.
- These are interesting results, but how should we interpret them?
- Do monsoons both moisten and dry lower stratosphere?
- Thanks for any suggestions.