The response of East Asian monsoon to the precessional cycle

Cross-section of a stalagmite

Observation: 3-5‰ of ΔΔ^{18}O change following the precessional cycle

- High insolation → low isotope values → stronger monsoon
- Coherent pattern among different cave sites over Asia

Data from Wang et al., 2008
Redrawn by Chiang et al., 2015

Observation: 3-5‰ of ΔΔ^{18}O change following the precessional cycle Existing hypotheses and problems:

Hypotheses Problems

(1) Local precip change: e.g. Wang et al., 2000

Previous model results show little precipitation change

Battisti et al., 2014

Observation: 3-5‰ of ΔΔ^{18}O change following the precessional cycle Existing hypotheses and problems:

Hypotheses Problems

Upstream precip change:

(1) Local precip change: (2)

Previous model results show

little precipitation change

Too small ‘‘ ^{18}O change

Pausata et al., 2011, Lee et al., 2009; 2012 Battisti et al., 2014

Observation: 3-5‰ of Observation: 3-5‰ of ‘‘ ^{18} ^{18}O change

following the precessional cycle O change following the precessional

cycleExisting hypotheses and problems:

Hypotheses Problems

Upstream precip change:

(1) Local precip change: (2)

(3) Precip seasonality change:

Chiang et al. 2015

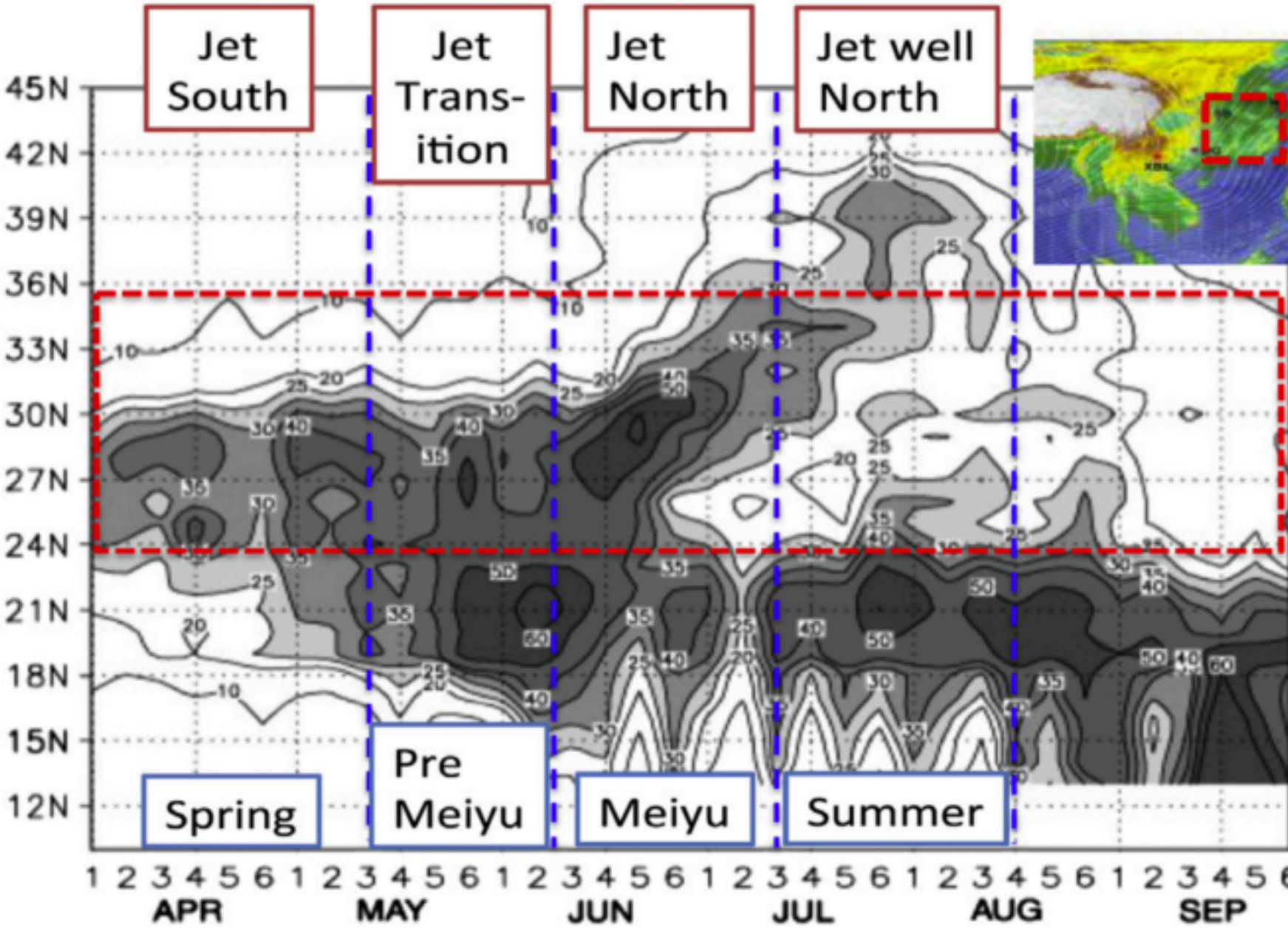
change Not yet

Previous model results show
little precipitation change

proven

Too small ⍰⍰ ^{18}O

Precipitation belt south of the jet **East Asian**



High ‰ ^{18}O Low ‰ ^{18}O

monsoon regio Chiang et al. 2015

Observation: 3-5‰ of ΔΔ^{18}O change following the precessional cycle

Existing hypotheses and problems:

Hypotheses	Problems
(1) Local precip change: (2)	**Upstream precip change: (3)**

Precip seasonality change: change Not yet

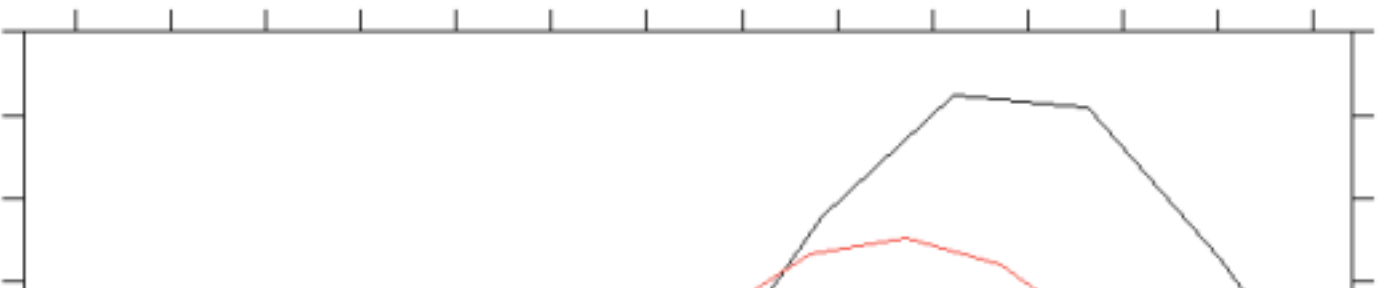
Previous model results show little precipitation change

proven

Too small ◆◆ ^{18}O

Which is the most reasonable hypothesis and why?

Previous model study



Modeled location of Jets in June too north

NCEP

NCAR CAM2

Longitude avg between 100E and 135E

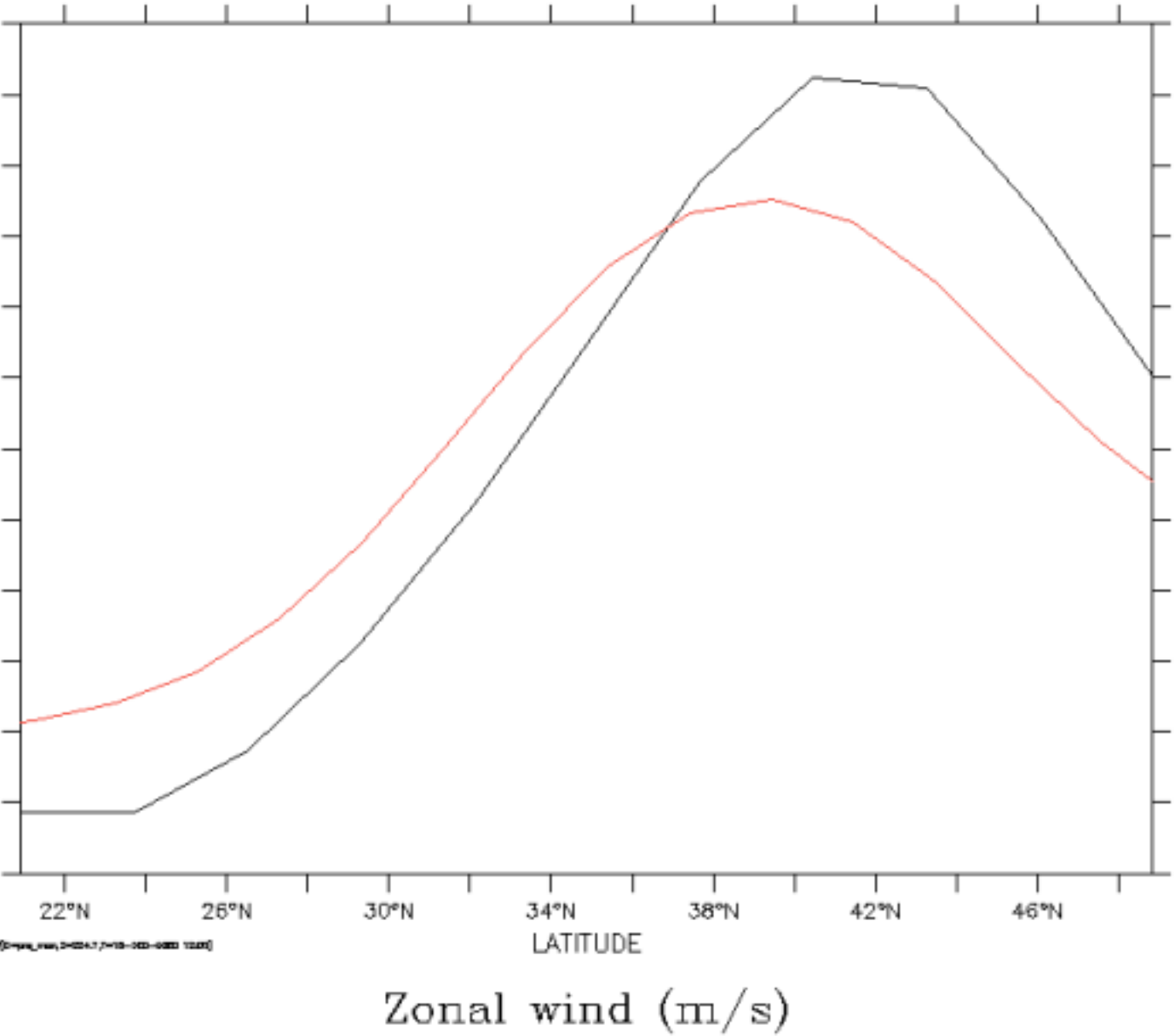
U at 200 hPa in June

Little summer precip

New model study

Modeled location of Jets in June too north

NCEP
NCAR
CAM2



GFDL AM2

Longitude avg between 100E and 135E

U at 200 hPa in June

GFDL model jets are still north of the Tibet, but not too much.

Summer precip is still not very good, but a little better.

Results JJA

Precip June perihelion - December perihelion

GFDL CM1.2 Max eccentricity: 0.05

CM1.2

Lee et al., 2019

A large (up to 50%) increase in precipitation during the June perihelion case in the coupled ocean-atm simulations

Results

A large (up to 50%) increase in precipitation during the June perihelion case in the coupled ocean-atm simulations

But, not in the slab ocean simulations

Precip June perihelion - December perihelion

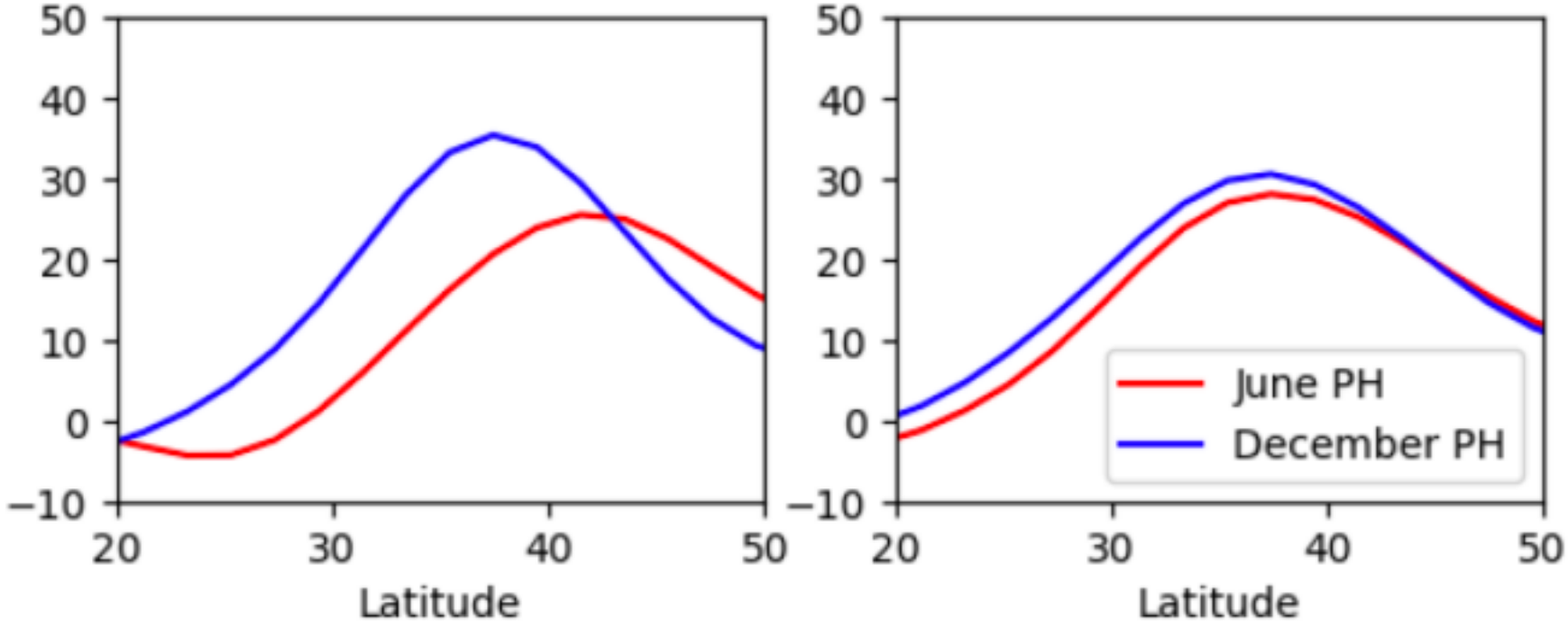
CM1.2 SOM

Lee et al., 2019

U at 200hPa in June

Longitude avg between 100E and 135E

SOM CM1.2



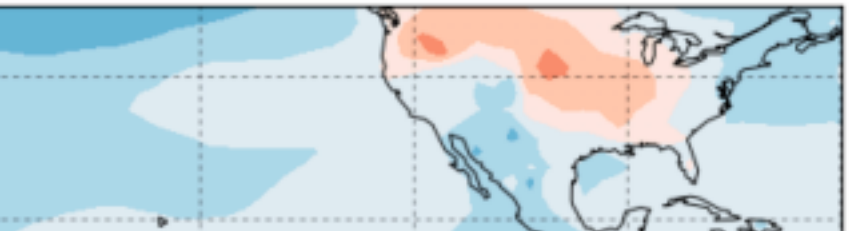
Weakening and northward

shift of the jet Location and strength not changing significantly

Substantial cooling in the northwestern Pacific

Annual mean surface temperature

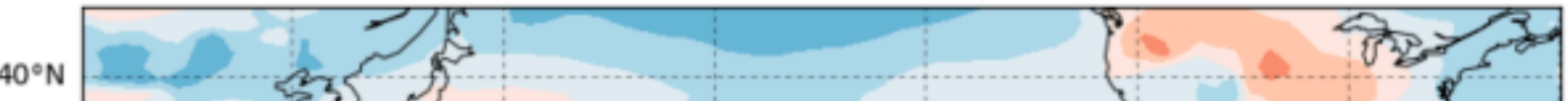
SOM



CM1.2

K

Sub-surface temperature is set by the cold season SST



SOM

CM1.2

K

Observation: 3-5‰ of ΔΔ^{18}O change following the precessional cycle Existing hypotheses and problems:

Hypotheses	Problems
(1) Local precip change: (2)	little precipitation change Too small ▯▯^{18}O
Upstream precip change: (3)	change Not yet
Precip seasonality change:	proven

Previous model results show

A large (up to 50%) increase in precipitation during the June perihelion case

Observation: 3-5‰ of ▯▯^{18}O change following the precessional cycle Existing hypotheses and problems:

Hypotheses Problems

little precipitation change

(1) Local precip change: (2)

Too small ^{18}O

Upstream precip change: (3)

change Not yet

Precip seasonality change:

proven

Previous model results show

A large (up to 50%) increase in precipitation during the June perihelion case

Research questions:

What would be the isotope response?

Precip June perihelion - December perihelion

Model results with iCESM forced by GFDL CM2.1 SST

differences. However, the model shows a large change in precipitation is necessary to explain the observed isotopic change.

Symbol: cave sites

Model precipitation results are opposite to the observed

couple_main

flux_ocn_to_ice

flux_ice_to_ocean

atmos_tracer_gather_data sfc_boundary_layer

update_atmos_model_dynamics update_atmos_model_down

flux_down_from_atmos

update_land_model_fast

update_ice_model_fast

atm_land_ice_flux_exchange flux_up_to_atmos

GFDL model structure

Adding isotopes into GFDL

model

Start with AM2 with a simpler convective scheme.

Difficulties: handling small values, if statements, mass not conserving, not knowing explicit sources and sinks of water vapor