Twitter: @coralsncaves

Getting too hot out there?

The cool kids hang in the pre-industrial.

"Climate of the Common Era" session PP010

AGU 100 ADVANCING EARTH AND SPACE SCIENCE | FALL MEETING
Washington, D.C. | 10–14 Dec 2018

PP029: Paleoclimatic history of the El Niño-Southern Oscillation

observations, theory, modeling

Tom Marchitto (CU-Boulder)
Kim Cobb (Georgia Tech)
Diane Thompson (Boston University)

Orbital controls on Western Pacific hydrology

Kim Cobb (Georgia Tech)

@coralsncaves

Stacy Carolin (Oxford)
Shelby Ellis (Georgia Tech)
Sang Chen (Caltech)
David Lund (U. Connecticut)
Nele Meckler (U. Bergen)
Ian Orland (U. Wisconsin)
Jess F. Adkins (Caltech)
Jud W. Partin (UT-Austin)
Sharon Hoffmann (UNC-Wilmington)
Julien Emile-Geay (U. Southern California)
Andrew A. Tuen (U. Sans Malaysia)
Brian Clark, Syria Lejau, Jenny Malang
(Gunung Mulu National Park)
Jean Lynch-Stieglitz (Georgia Tech)
Jessica Moerman (Smithsonian)

#fiercefemalefieldphoto

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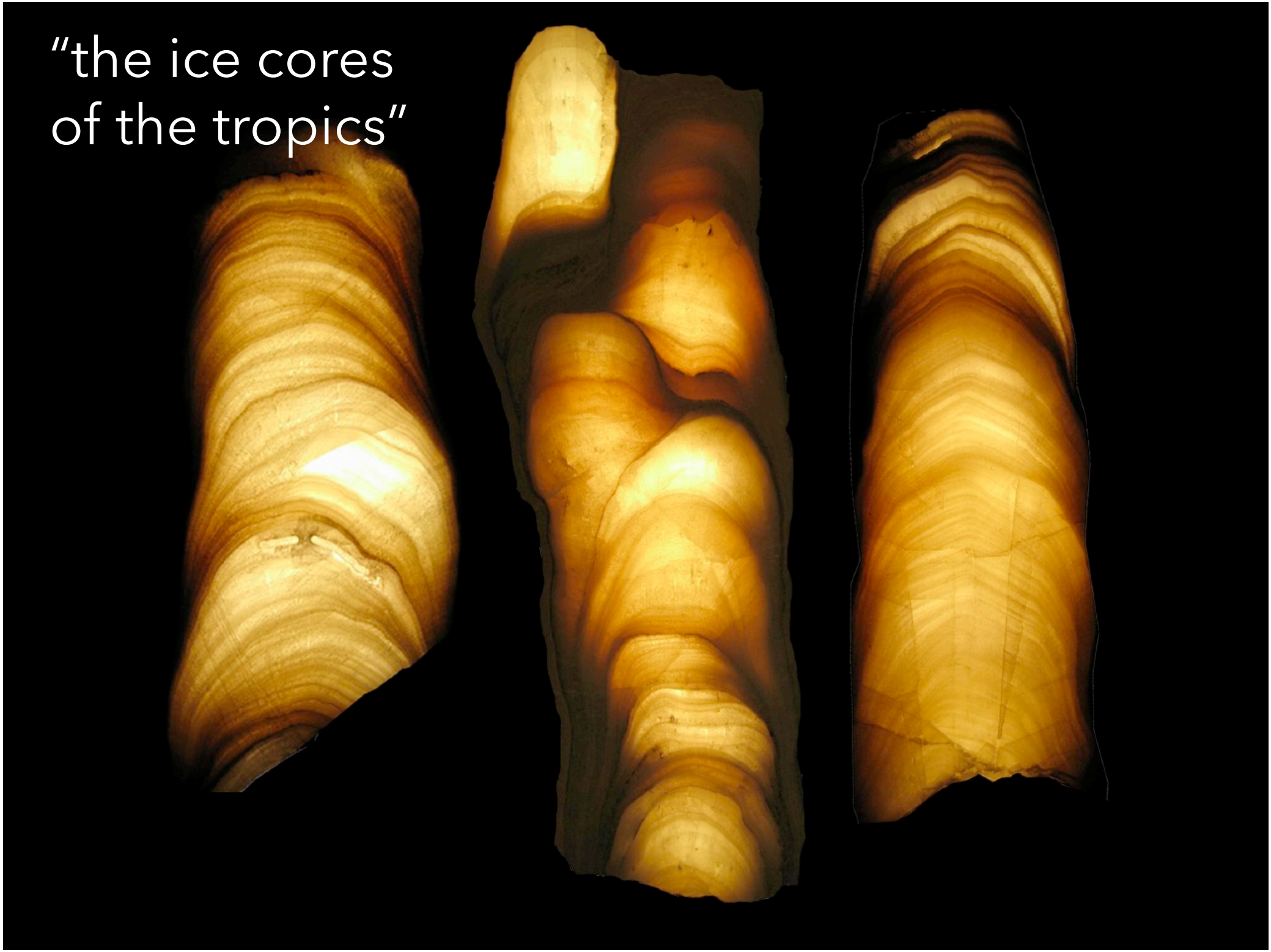
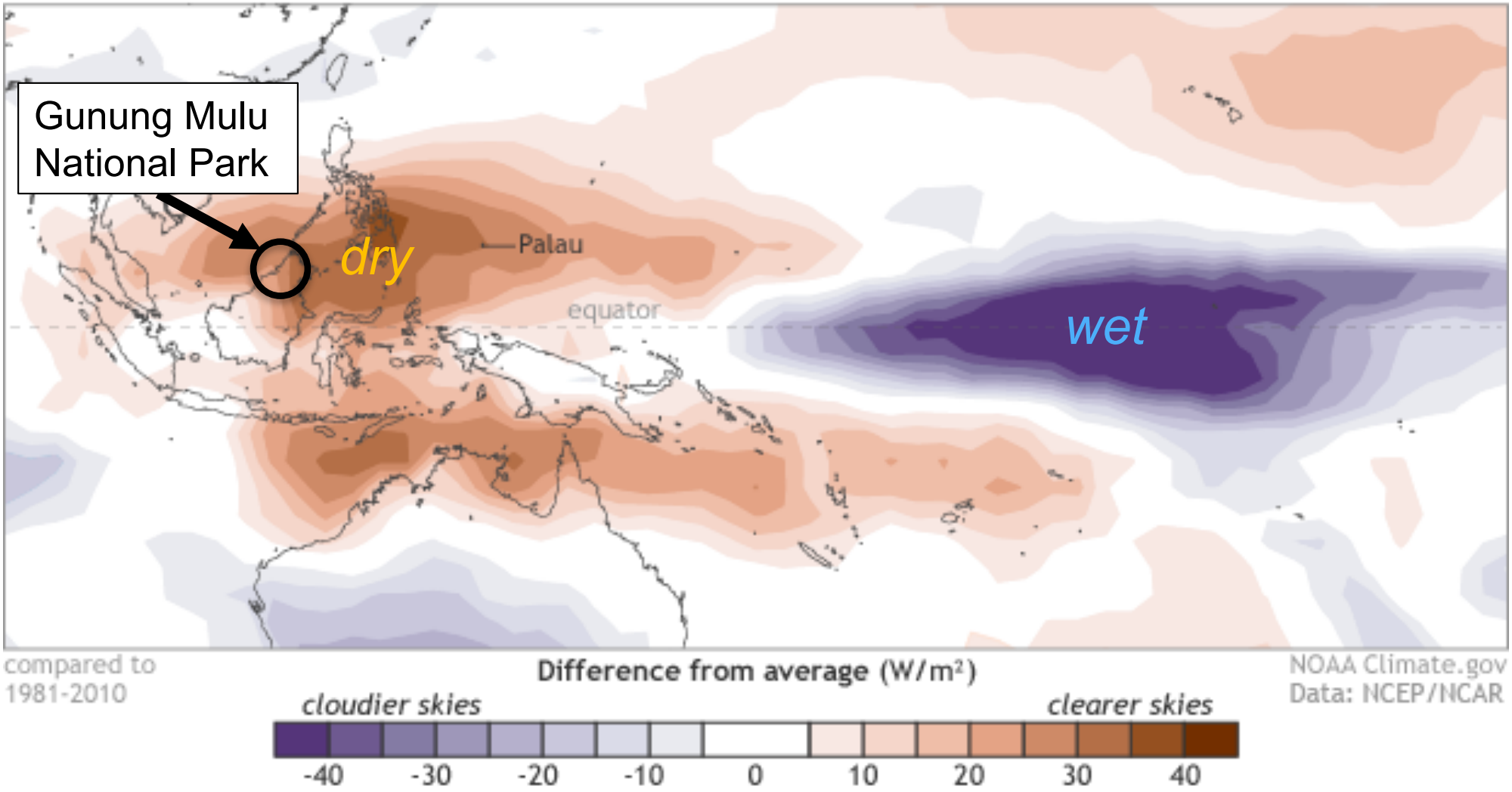
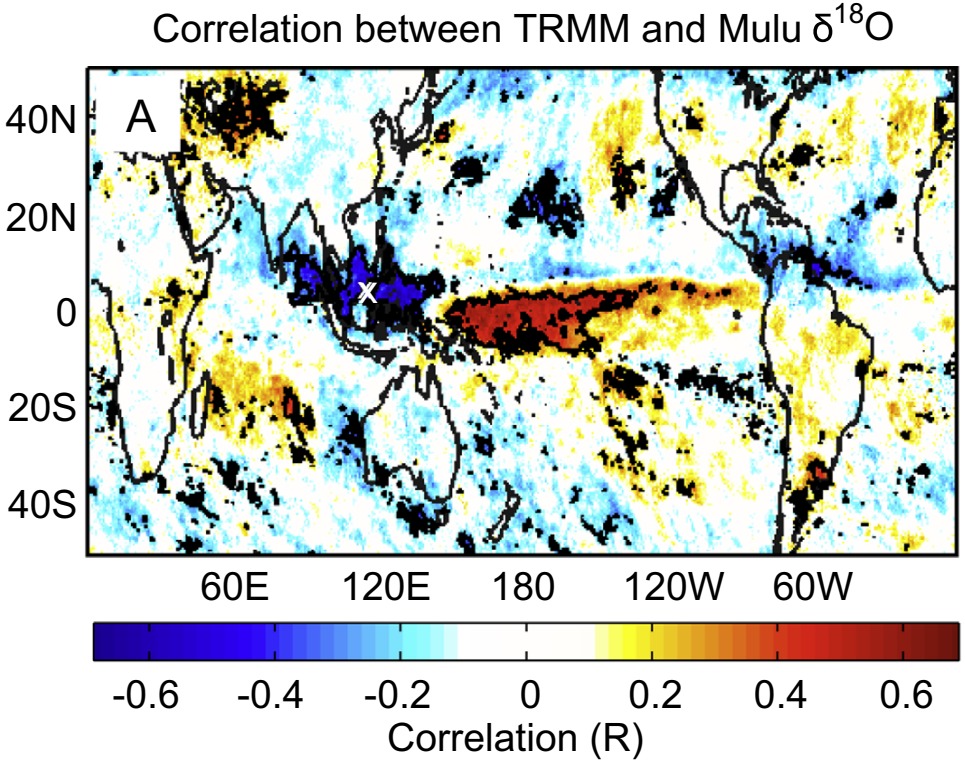

"the ice cores
of the tropics"

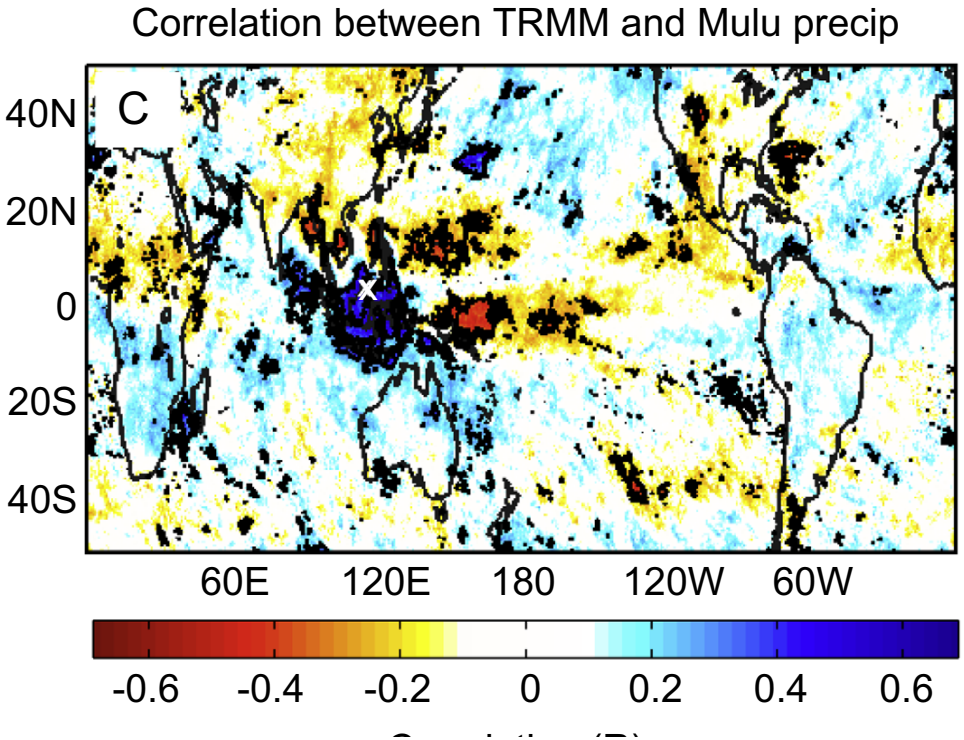
2015/16 El Niño event
Outgoing Longwave Radiation (OLR)





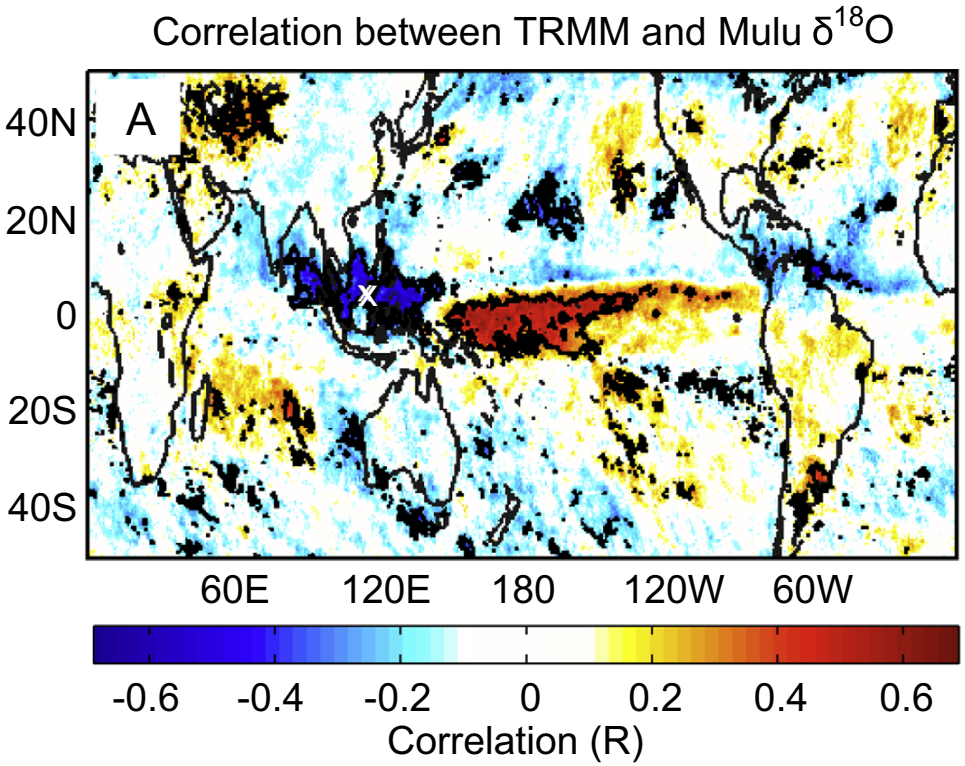
R(Mulu $\delta^{18}O$,TRMM)

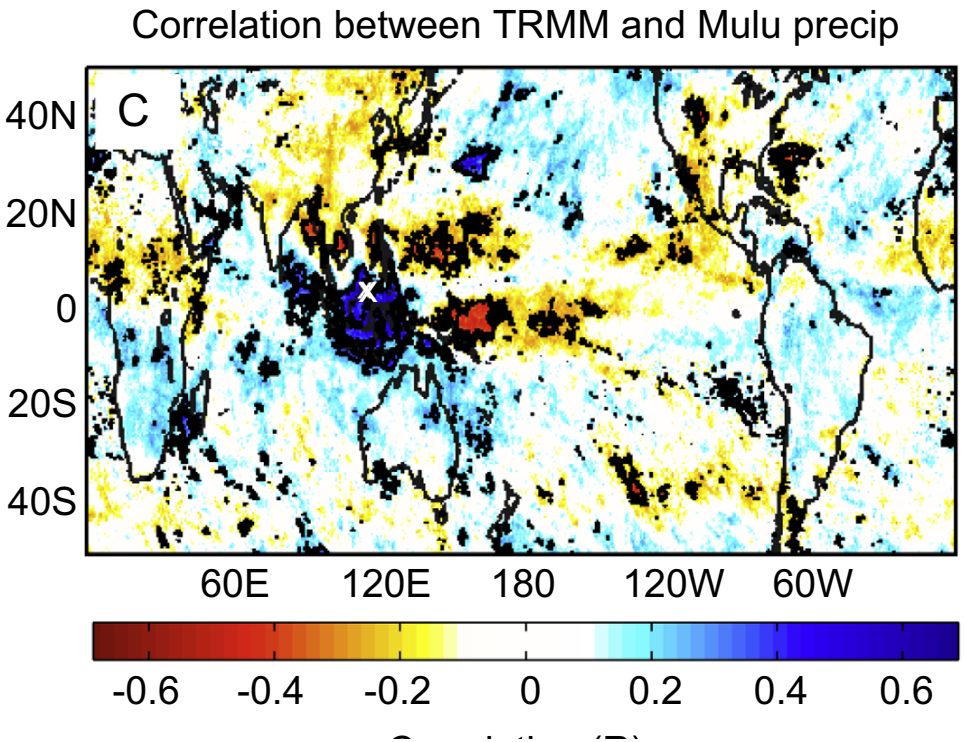
Rainfall oxygen isotopes at Mulu are better than a rain gauge!



R(Mulu precip,TRMM)

Moerman et al., 2013

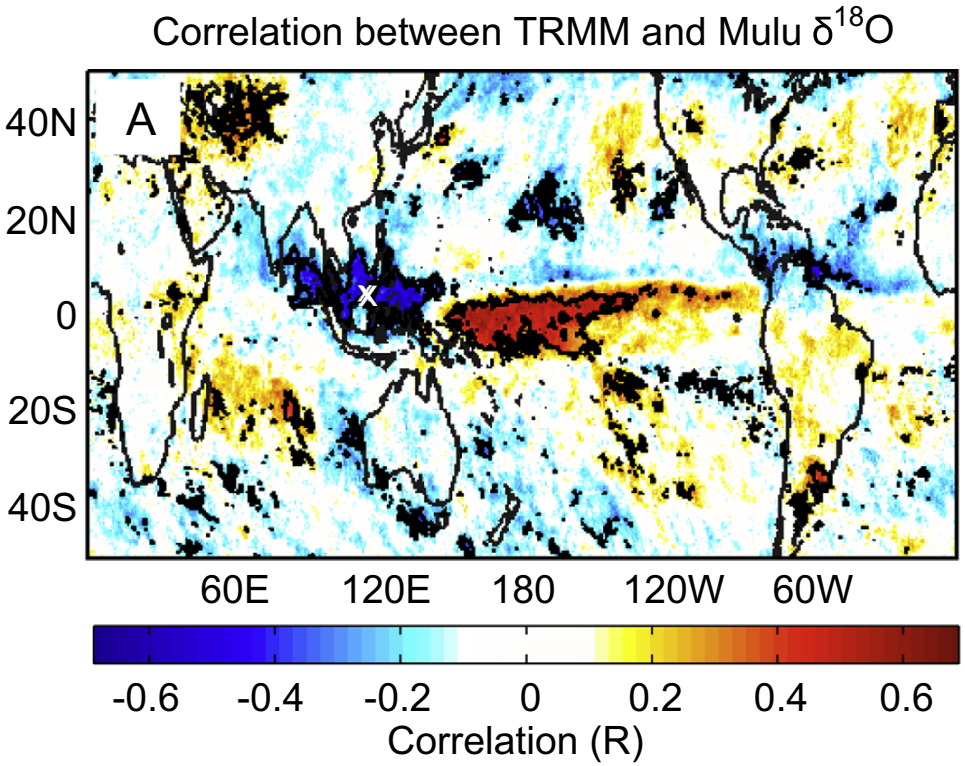


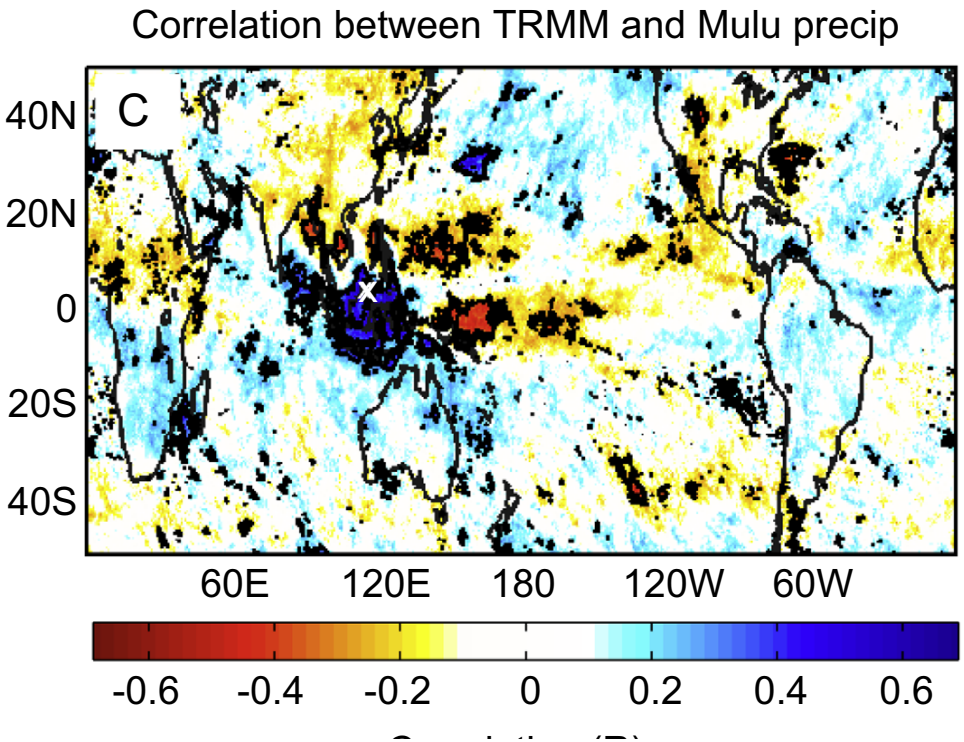


Why?

Rainfall isotopes integrate through space and time.

Moerman et al., 2013

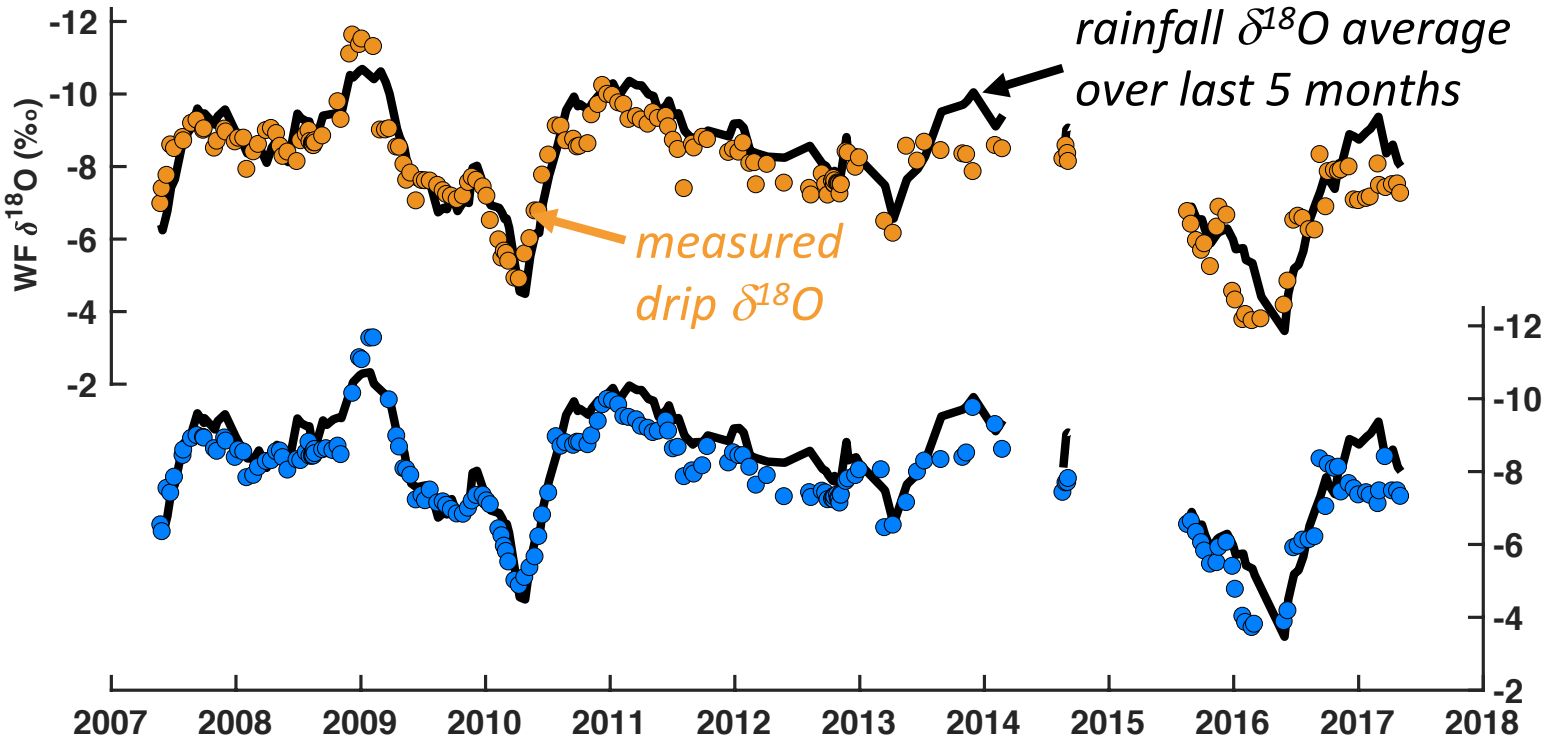


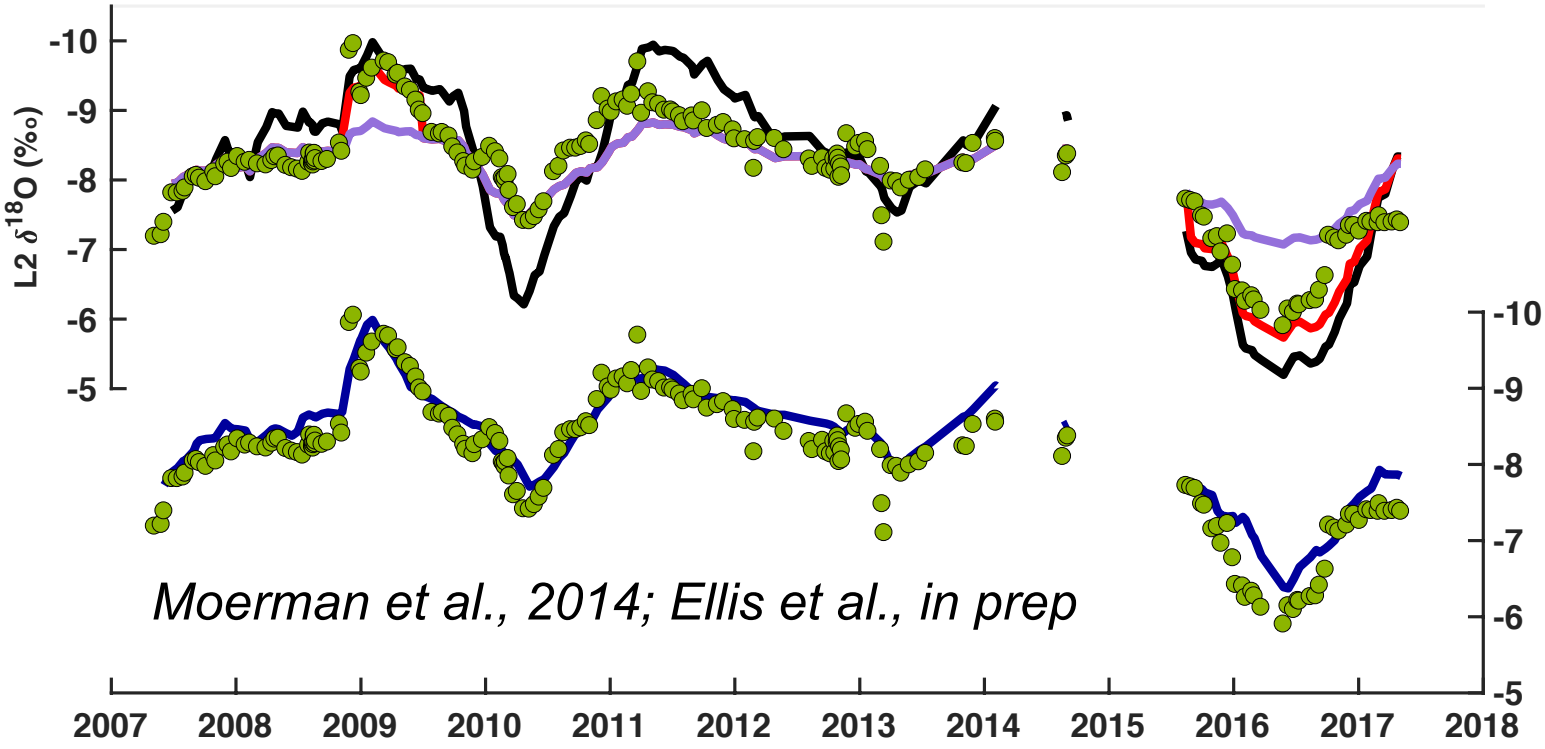


40% of Mulu $\delta^{18}O_R$ variance controlled by ENSO

20% by seasonal variability

Moerman et al., 2013

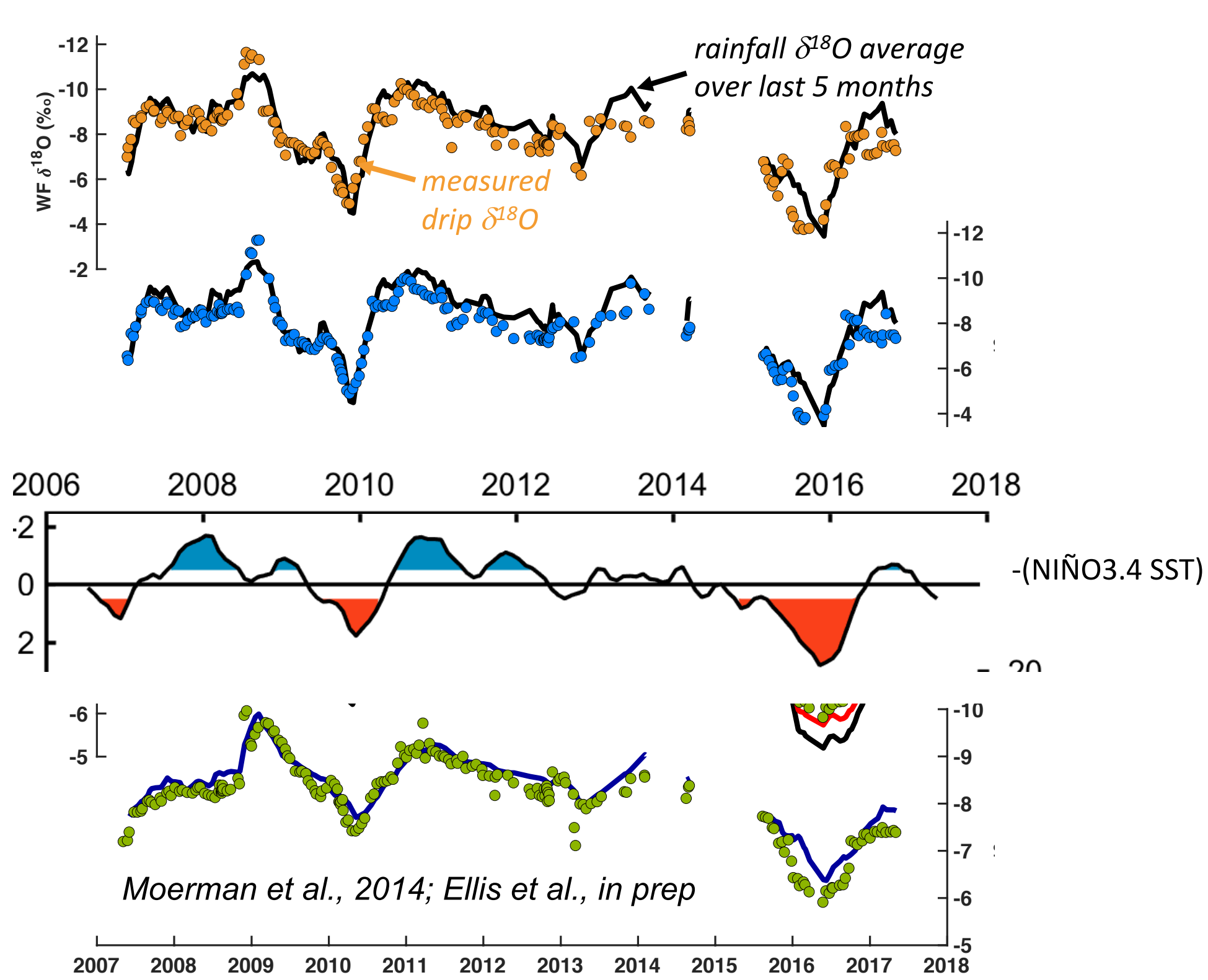




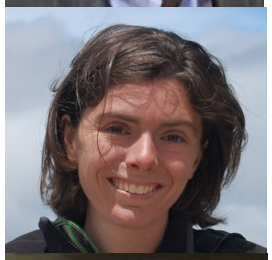
Moerman et al., 2014; Ellis et al., in prep

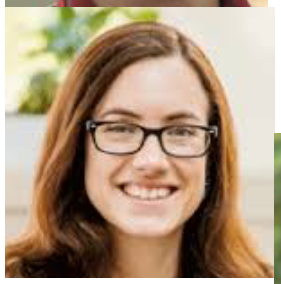
Mulu $\delta^{18}O_R$ variations reflected in cave dripwater $\delta^{18}O$ variations

5-10 month residence times


rainfall $\delta^{18}O$ average over last 5 months
measured drip $\delta^{18}O$
WF $\delta^{18}O$ (‰)
-12
-10
-8
-6
-4
-2
2006
2008
2010
2012
2014
2016
2018
-(NIÑO3.4 SST)
2
0
2
20
-6
-5
-10
-9
-8
-7
-6
-5
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Moerman et al., 2014; Ellis et al., in prep







Observations and Modeling of Water Isotopes in the Climate System (funded 2018-2021)

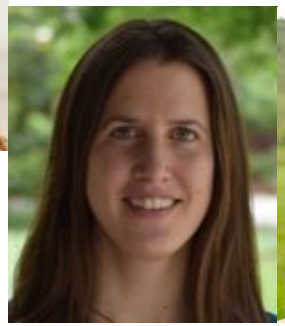
<u>Working group members</u>:
Kim Cobb (Co-Chair) – Georgia Tech
David Noone (Co-Chair) – U. Oregon
Samantha Stevenson – UCSB
Gabe Bowen – U. Utah
Jess Conroy – U. Illinois C-U
Alyssa Atwood – UC-Berkeley, GA Tech
Bronwen Konecky – Washington Univ.
Allegra Legrande – NASA-GISS
Adrianna Bailey – NCAR
Jesse Nusbaumer – NASA-GISS
Natalie Burls – George Mason

<u>Key goals</u>
water isotopes as essential ocean and climate variable?

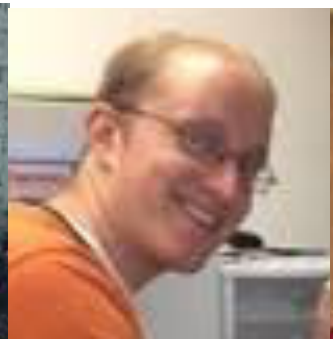
design 21st century obs network

data archive for all water isotope obs & model data

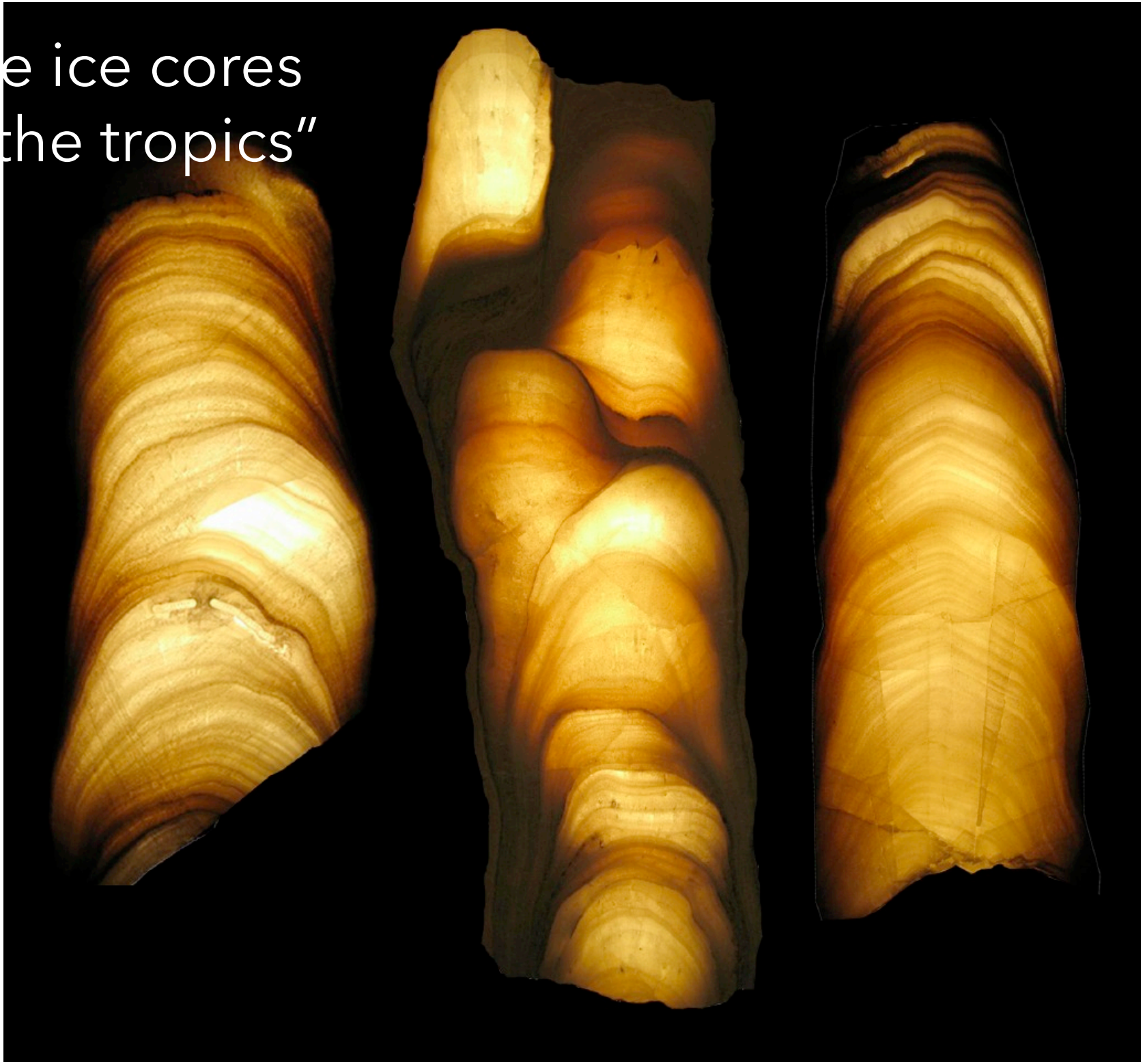
coordinating modeling efforts → CMIP7?





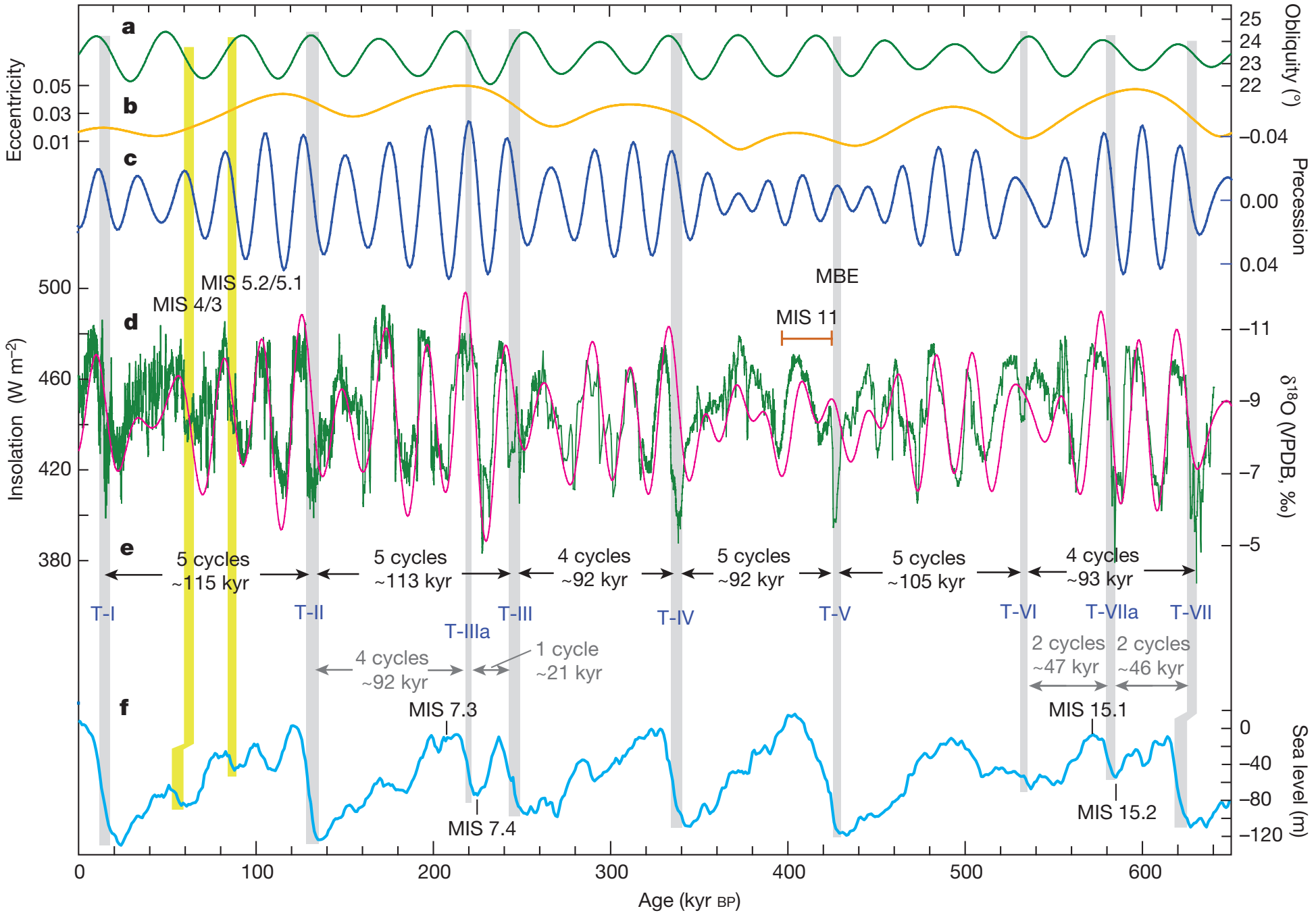



e ice cores
the tropics”

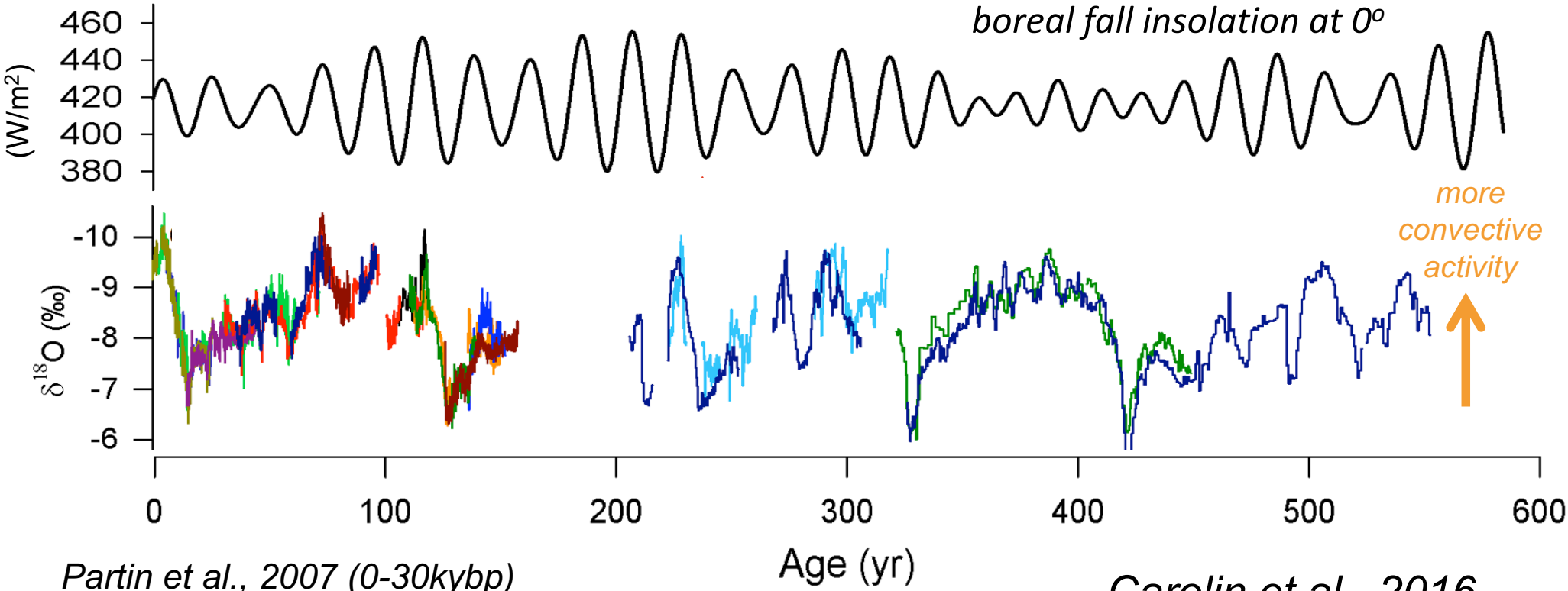


What is the sensitivity of western tropical Pacific hydroclimate to orbital forcing?

Hulu/Sanbao, *Cheng et al., Nature 2016*



Mulu stalagmite $\delta^{18}O$

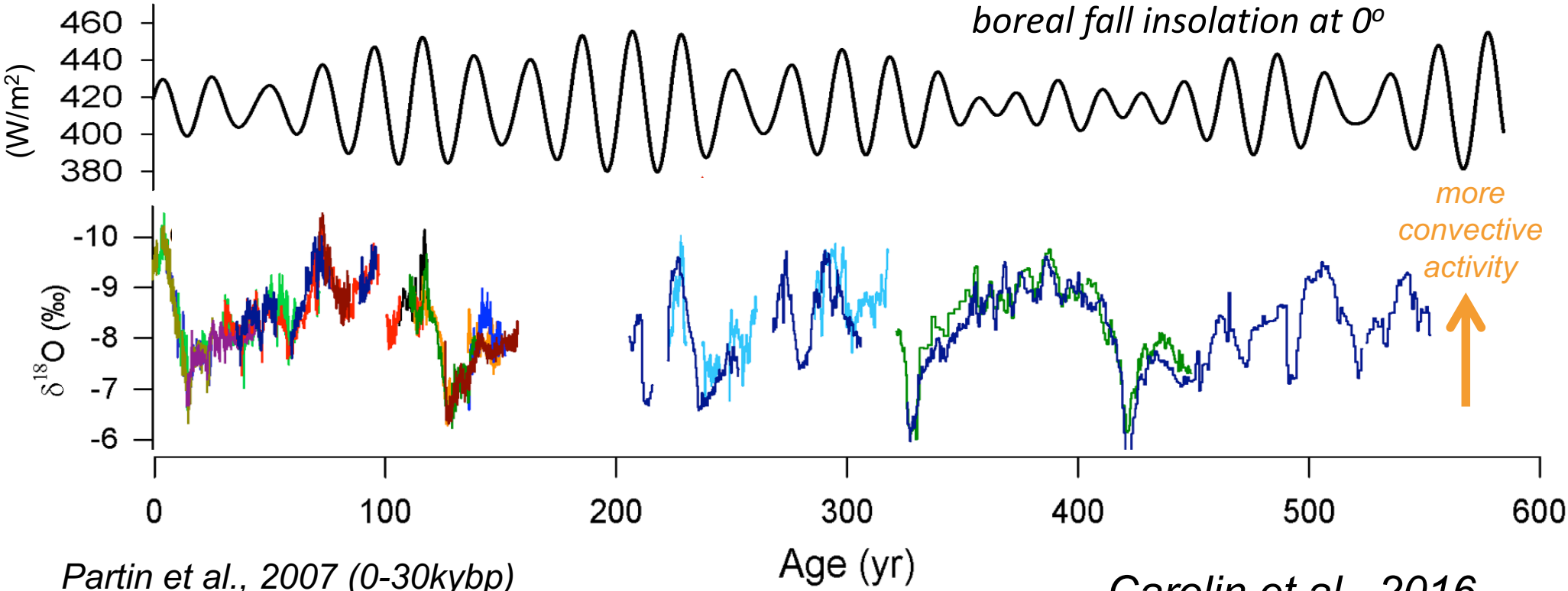


Partin et al., 2007 (0-30kybp)
Meckler et al., 2012 (200-550kybp)
Carolin et al., 2013 (30-100kybp)
Carolin et al., 2016 (100-160kybp)

Carolin et al., 2016

strong precessional signal tied to boreal fall insolation

Mulu stalagmite $\delta^{18}O$



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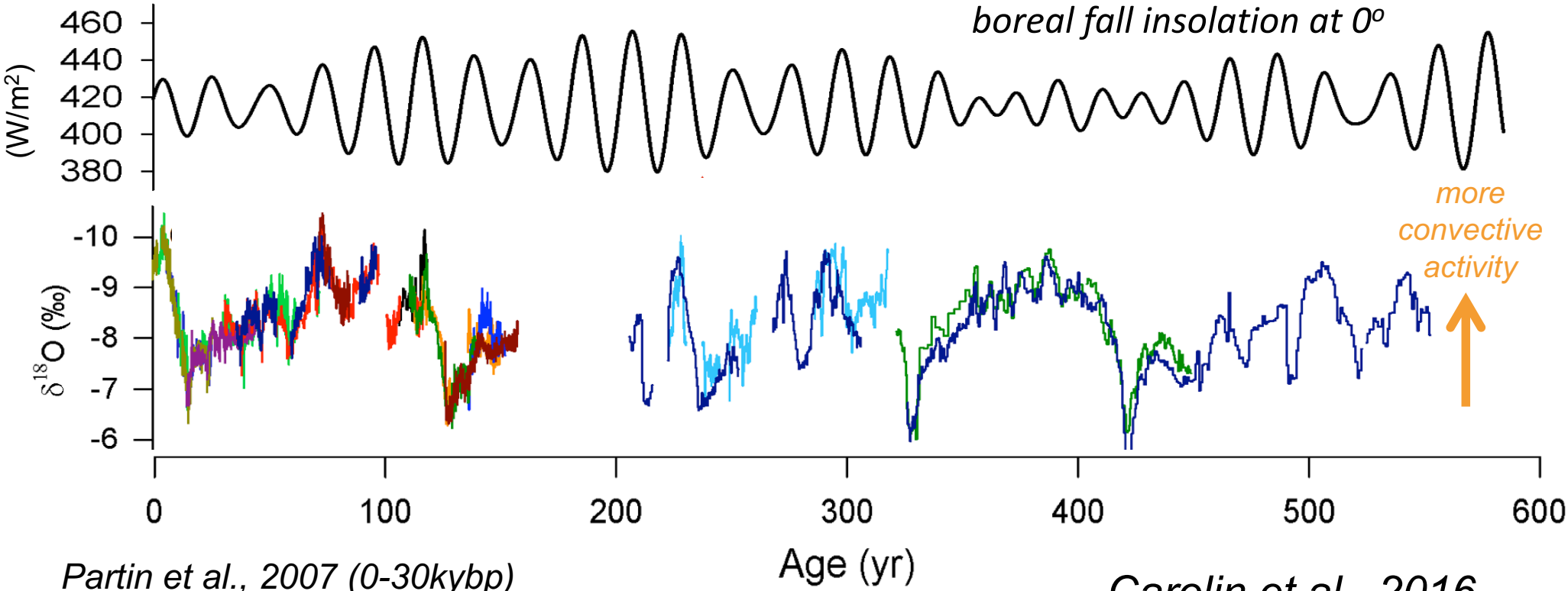
clear influence of glacial boundary conditions

Mulu stalagmite $\delta^{18}O$



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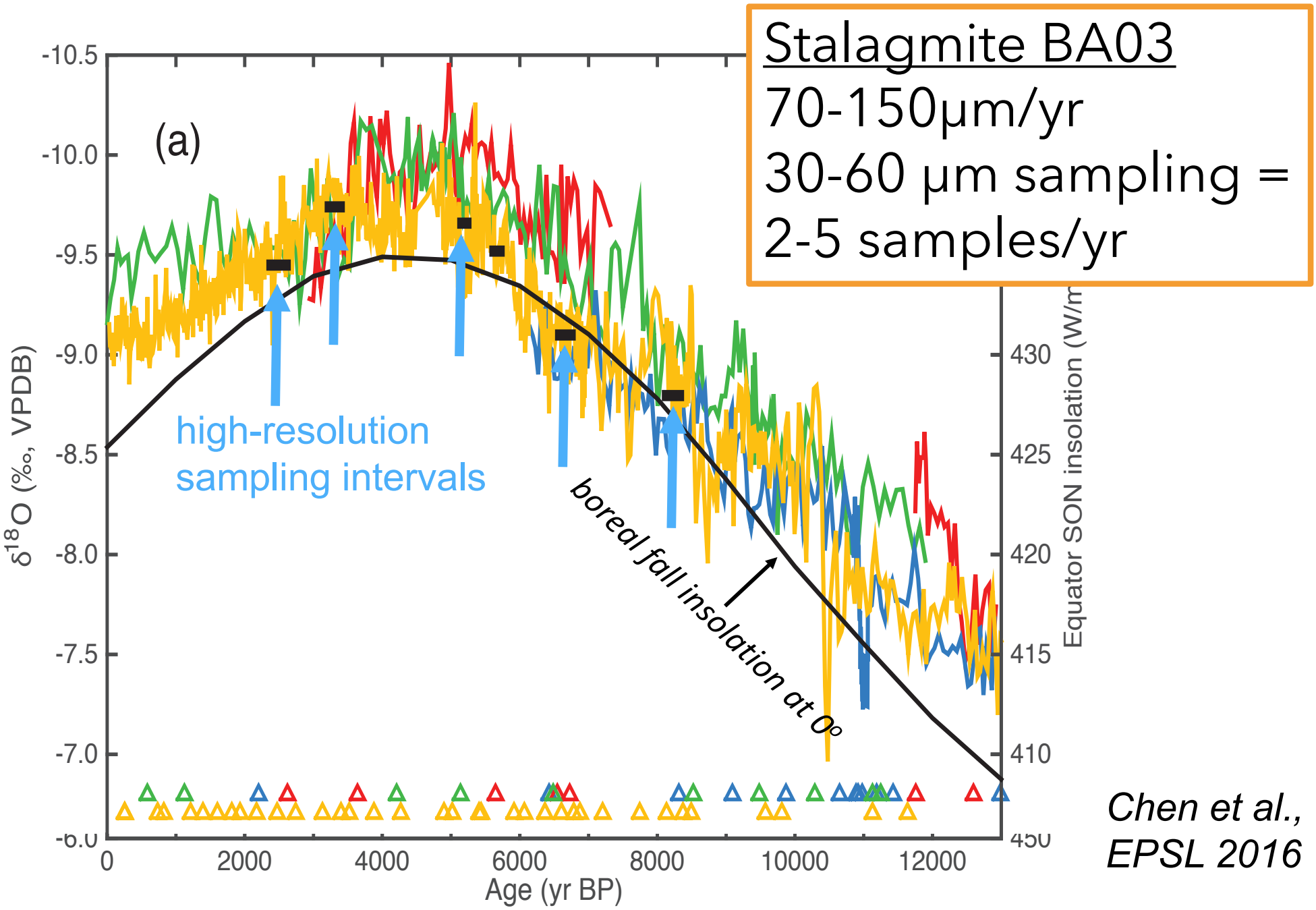
Carolin et al., 2016

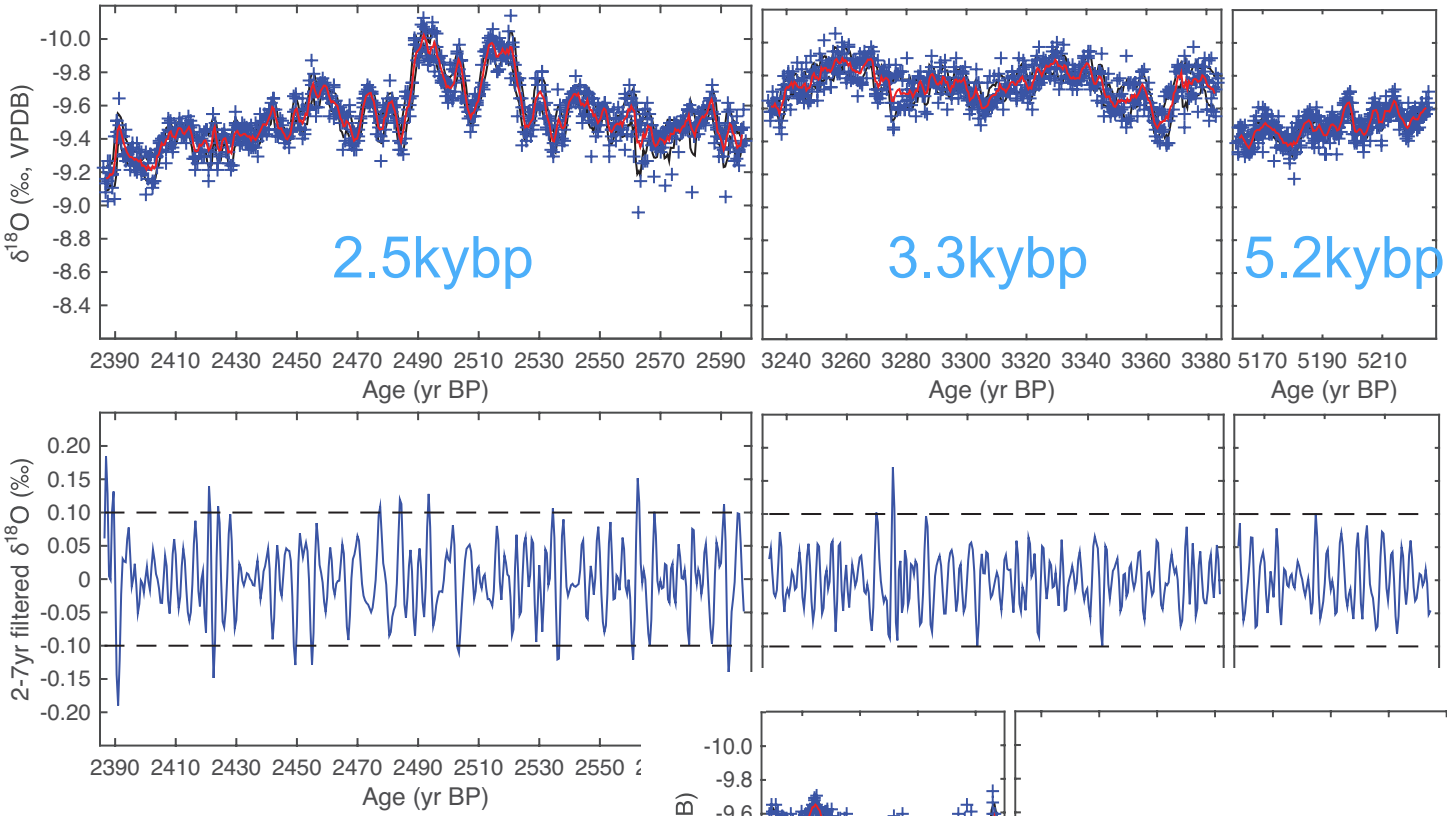
clear influence of glacial boundary conditions
($\delta^{18}O_{sw}$ +/- Sunda Shelf +/- temp +/- ΔENSO, ENSO-like)

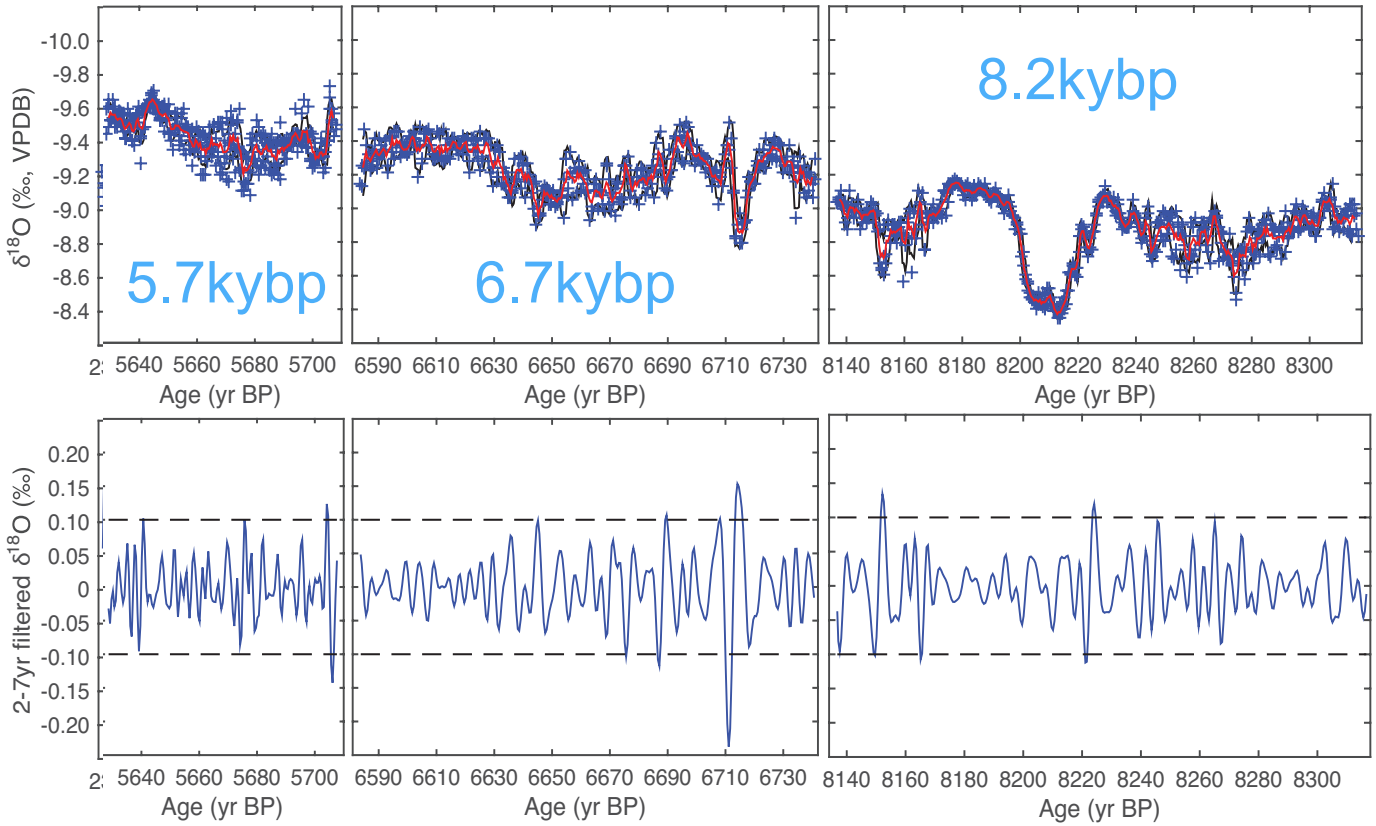
What dynamical processes underlie the strong response of Borneo stalagmite $\delta^{18}O$ to boreal fall insolation?

Our Holocene Playground



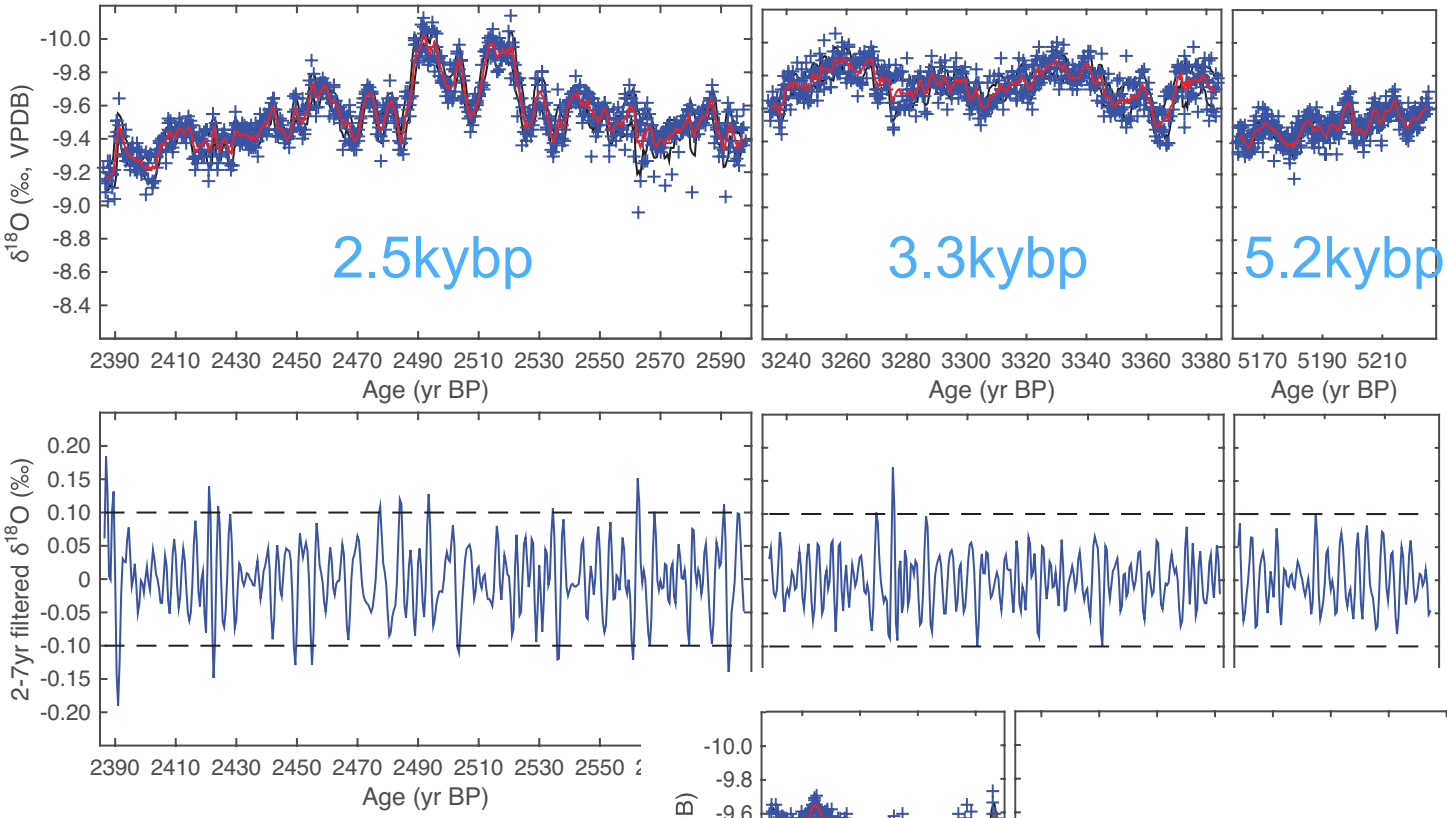
Chen et al., EPSL 2016

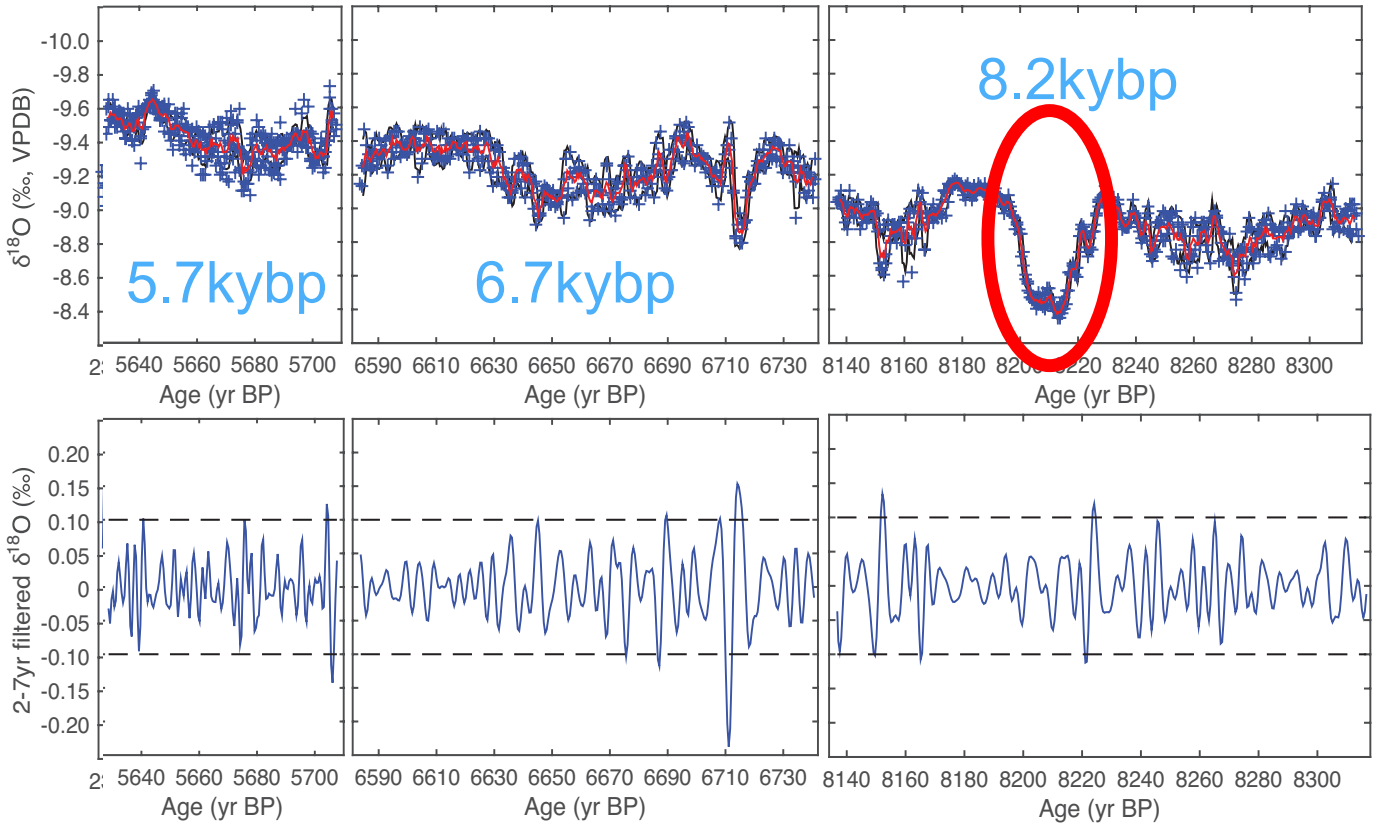




sub-annually resolved stalagmite d^{18}O records, 50-200yrs long

Chen et al,. 2016





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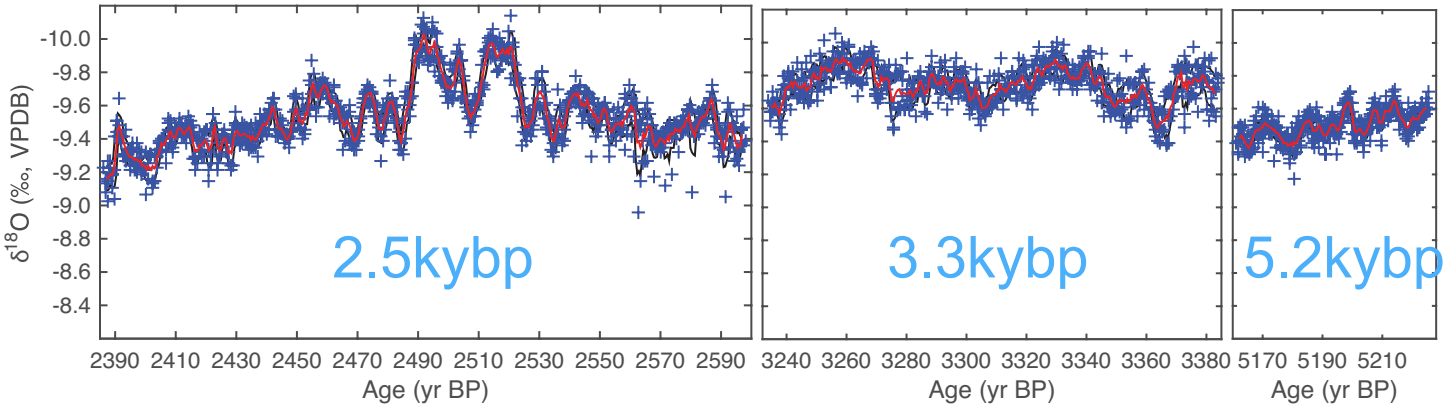
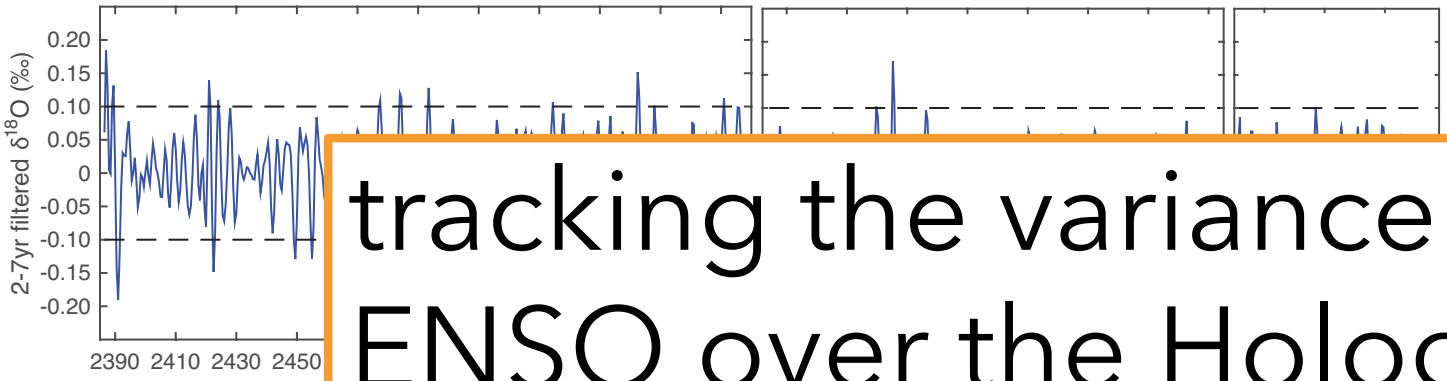
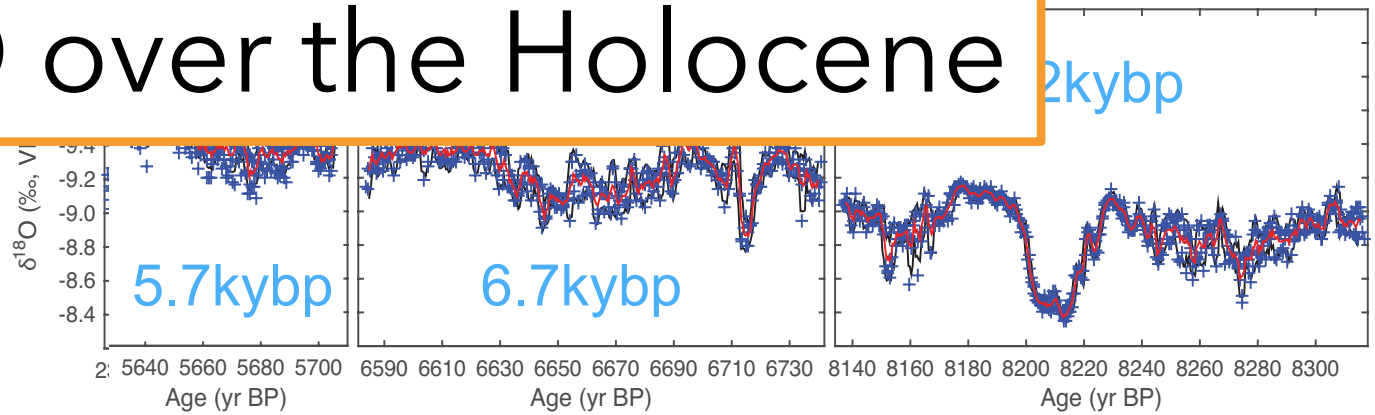
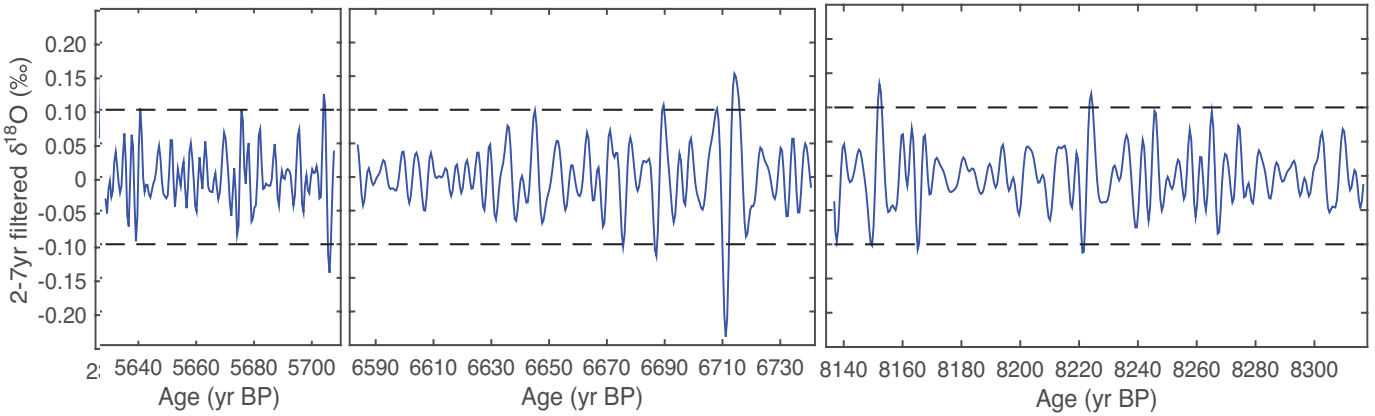
Chen et al,. 2016





tracking the variance of ENSO over the Holocene

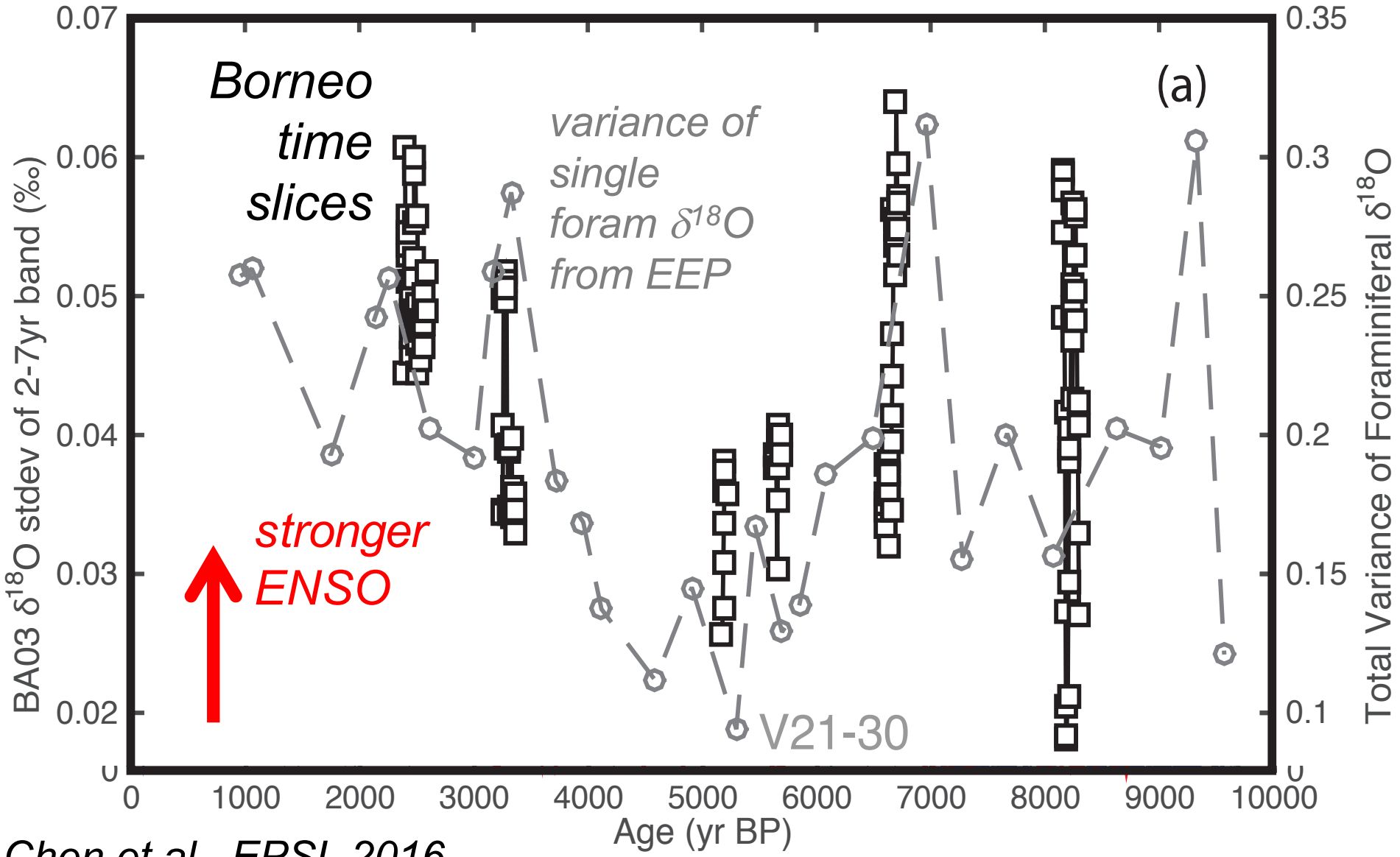




sub-annually resolved stalagmite d^{18}O records, 50-200yrs long

Chen et al,. 2016

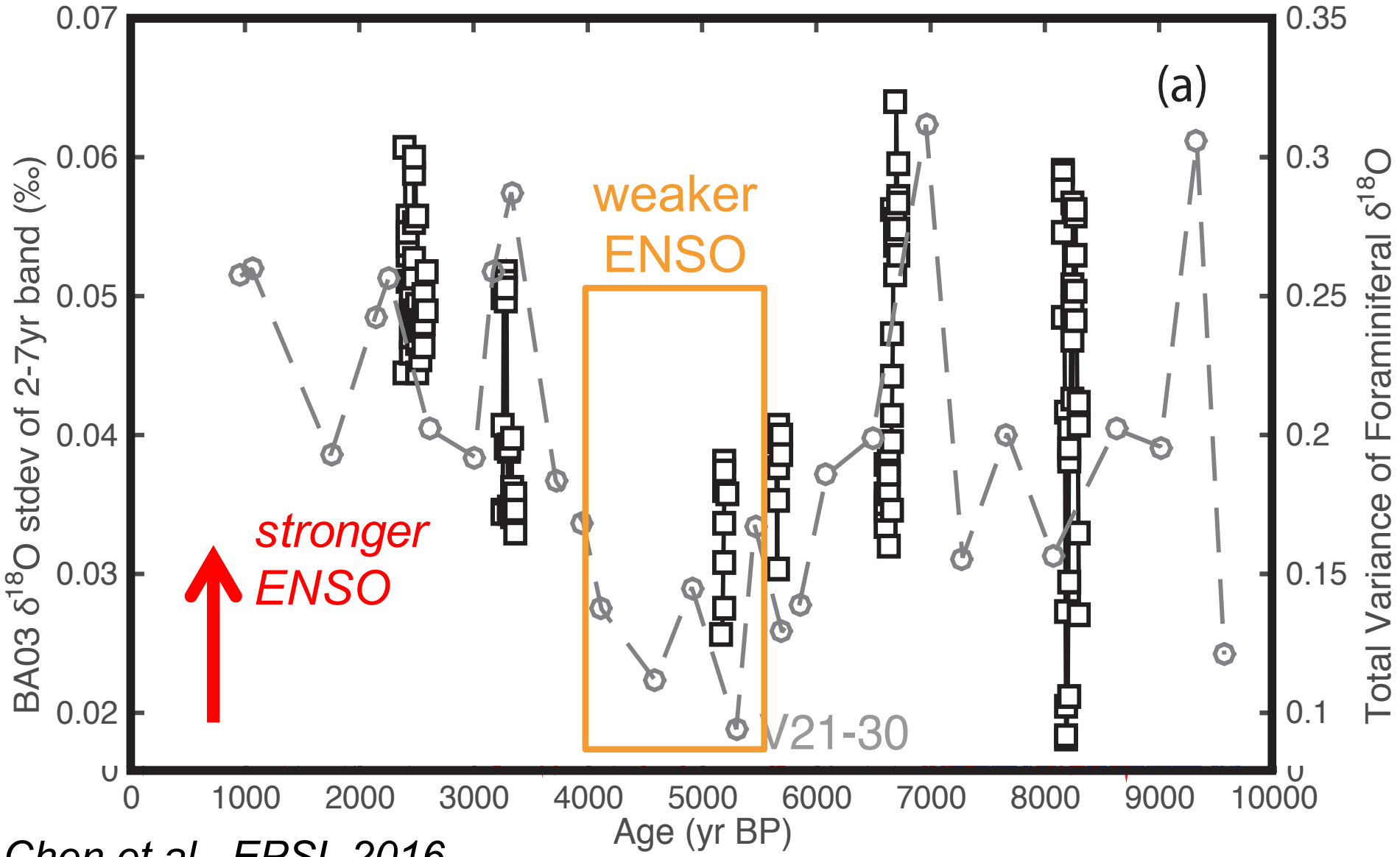
Borneo stalagmite interannual $\delta^{18}O$ variance



Chen et al., EPSL 2016

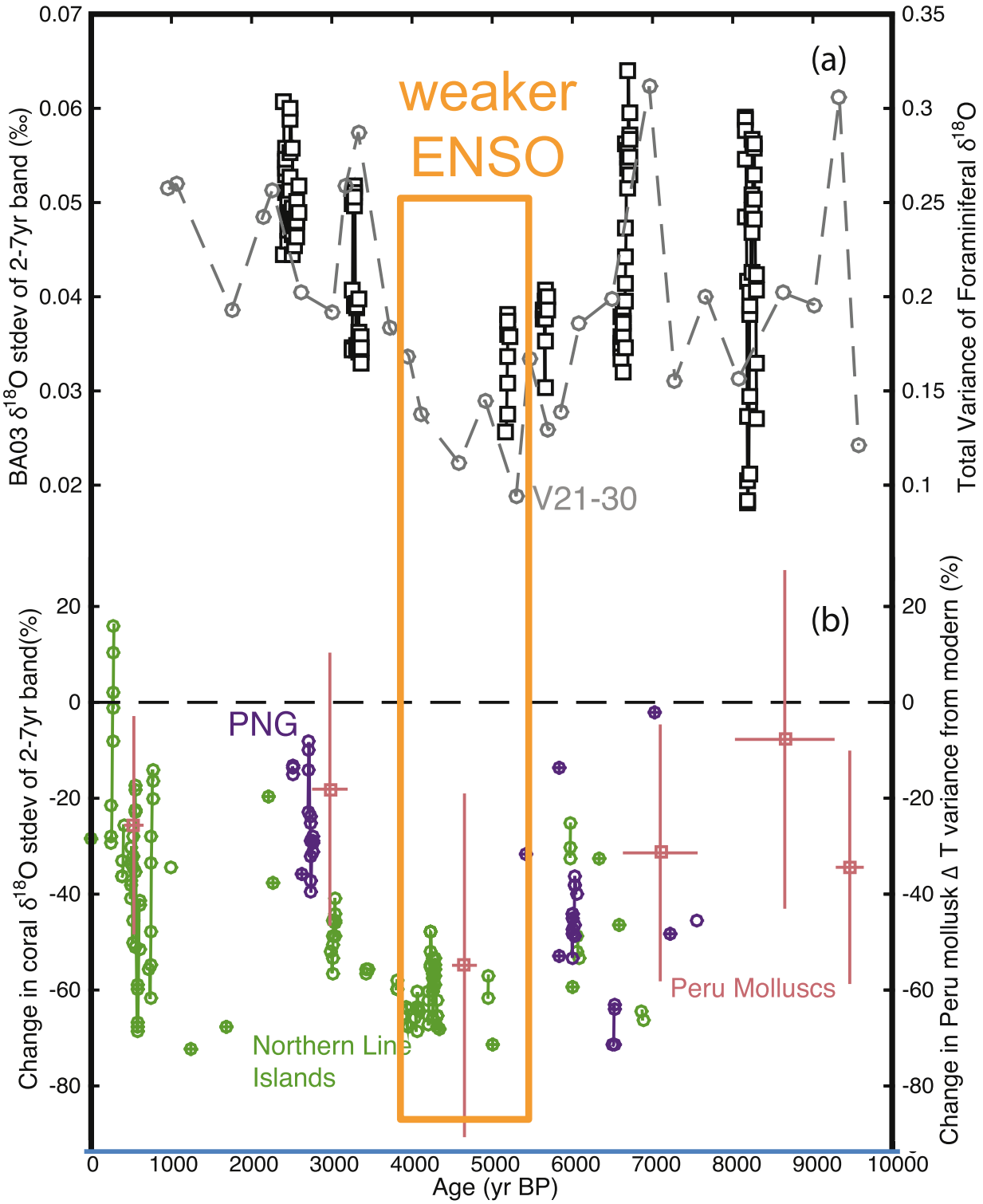
Joanides & Koutavas, 2012

Borneo stalagmite interannual $\delta^{18}O$ variance



Chen et al., EPSL 2016

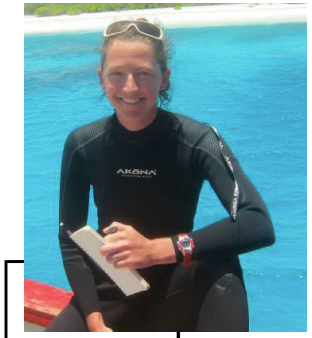
Joanides & Koutavas, 2012

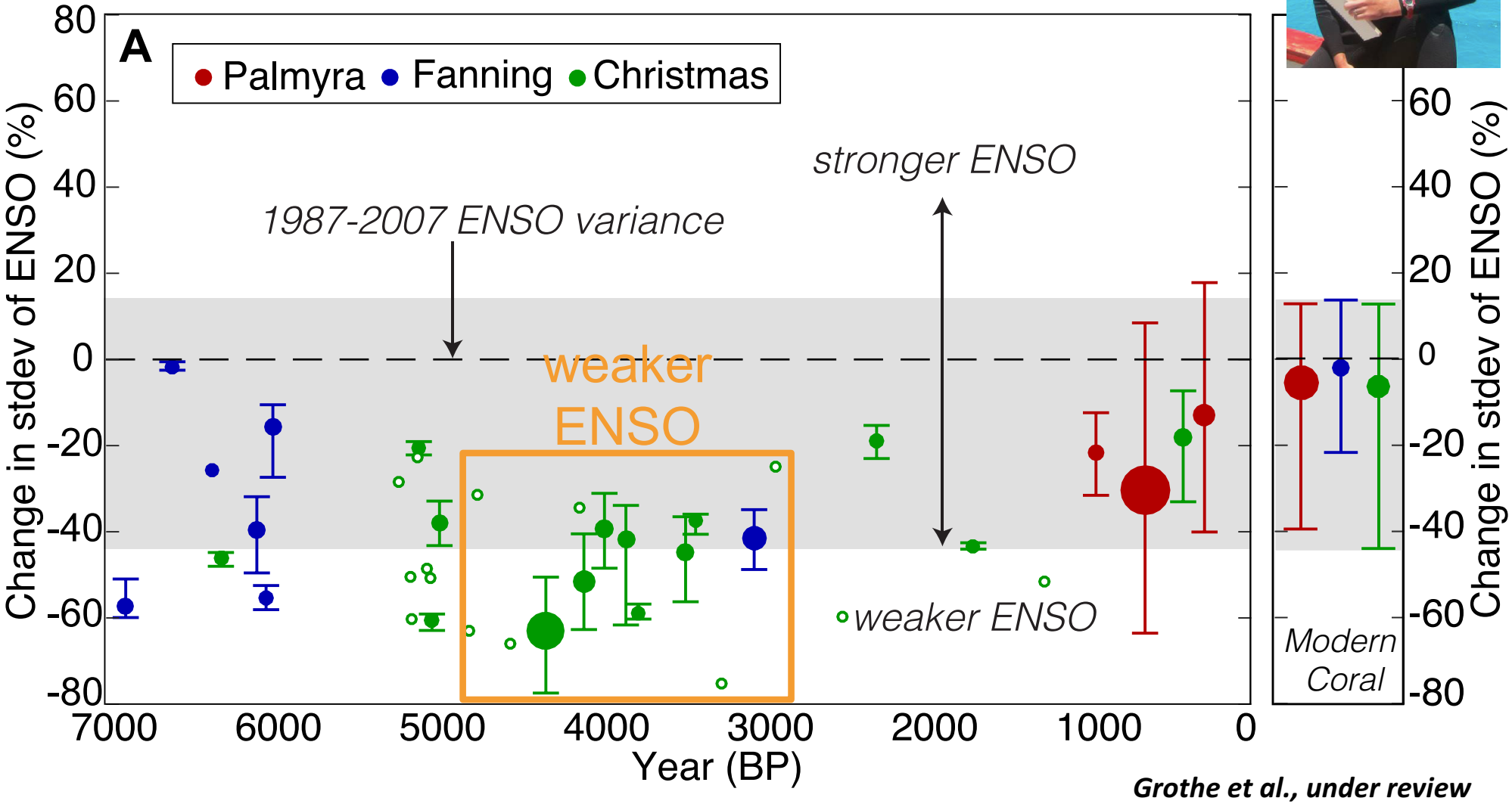


Borneo data consistent with other ENSO proxies

Cobb et al., 2013;
Carre et al., 2014;
McGregor et al., 2013

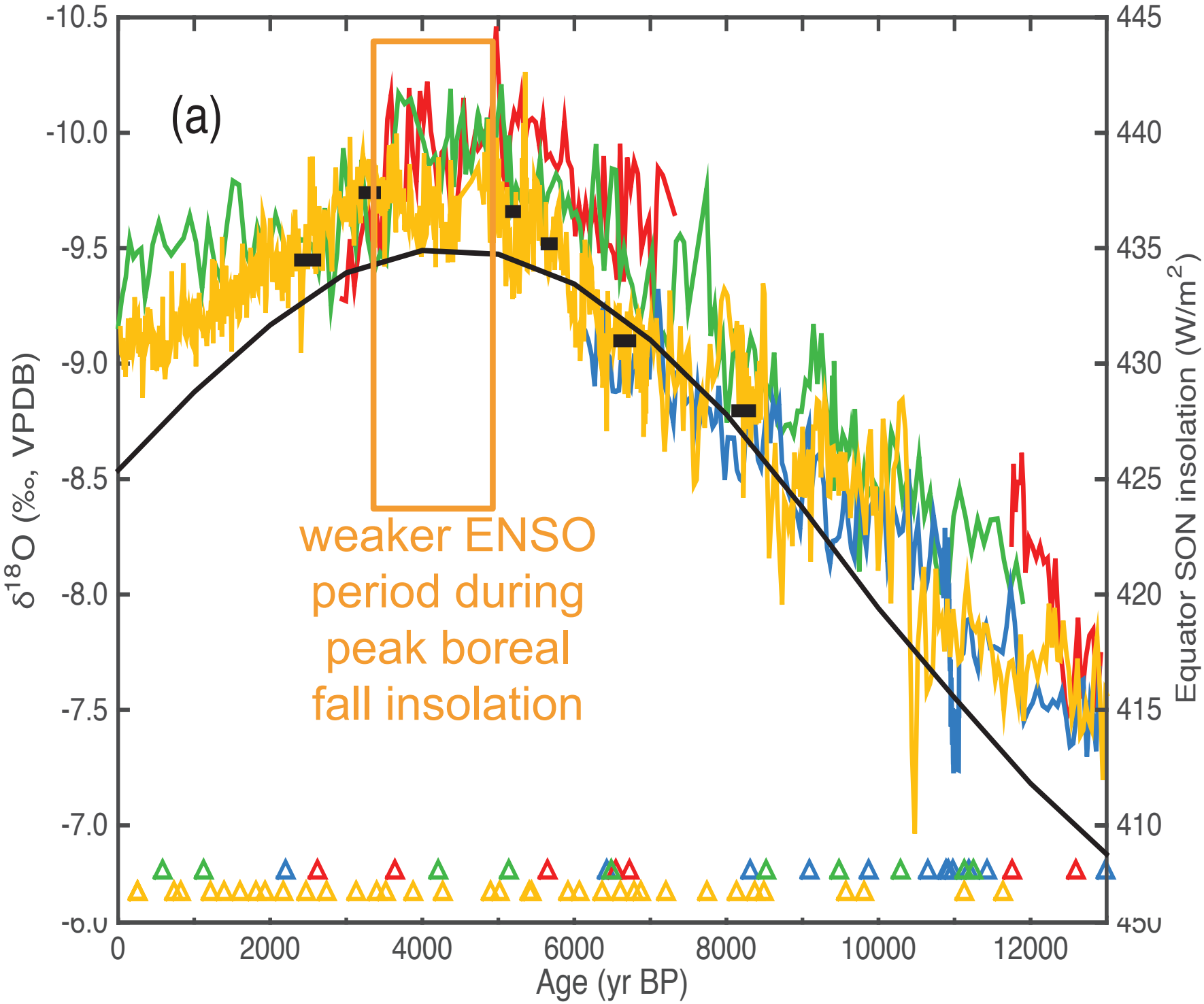
Year-to-year variability over 7,000yrs

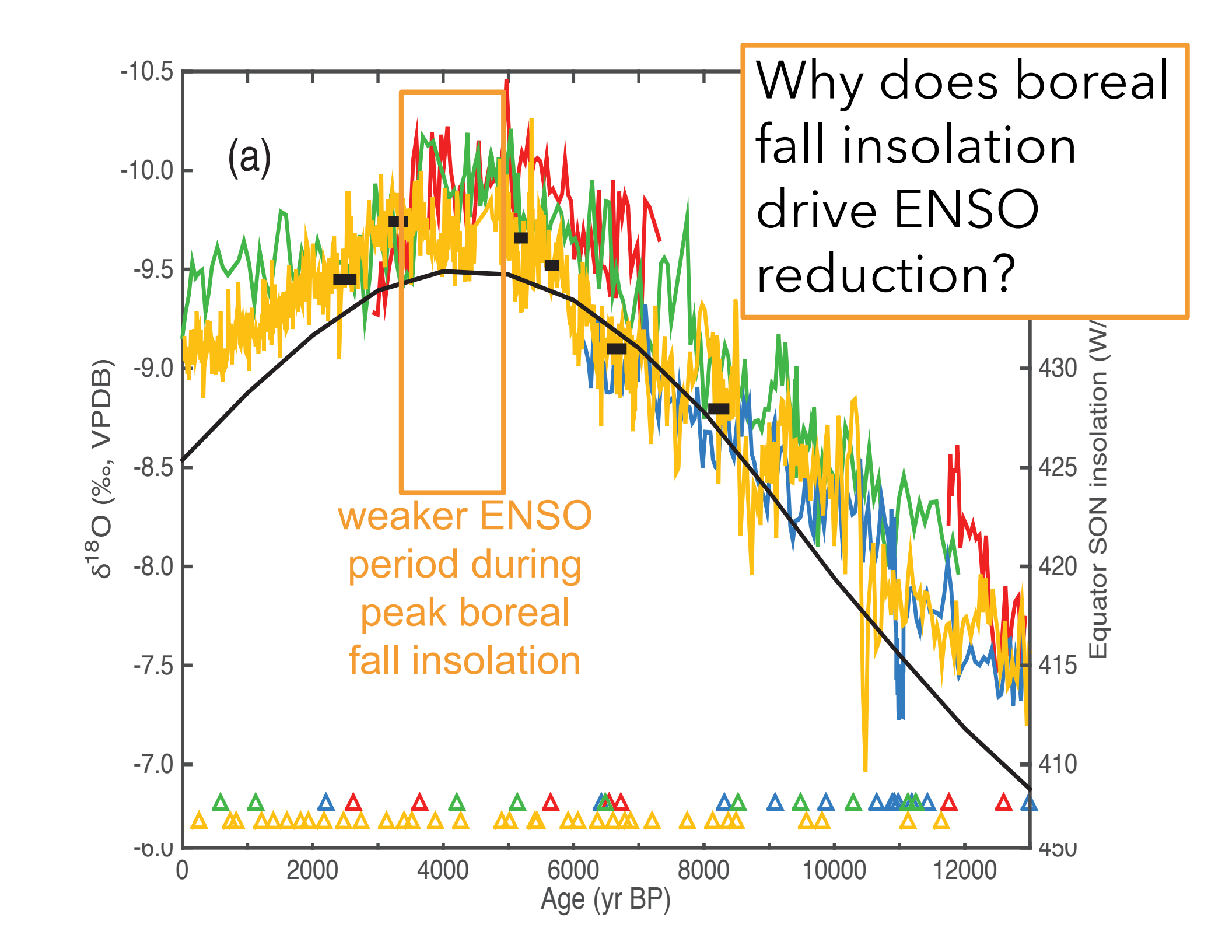




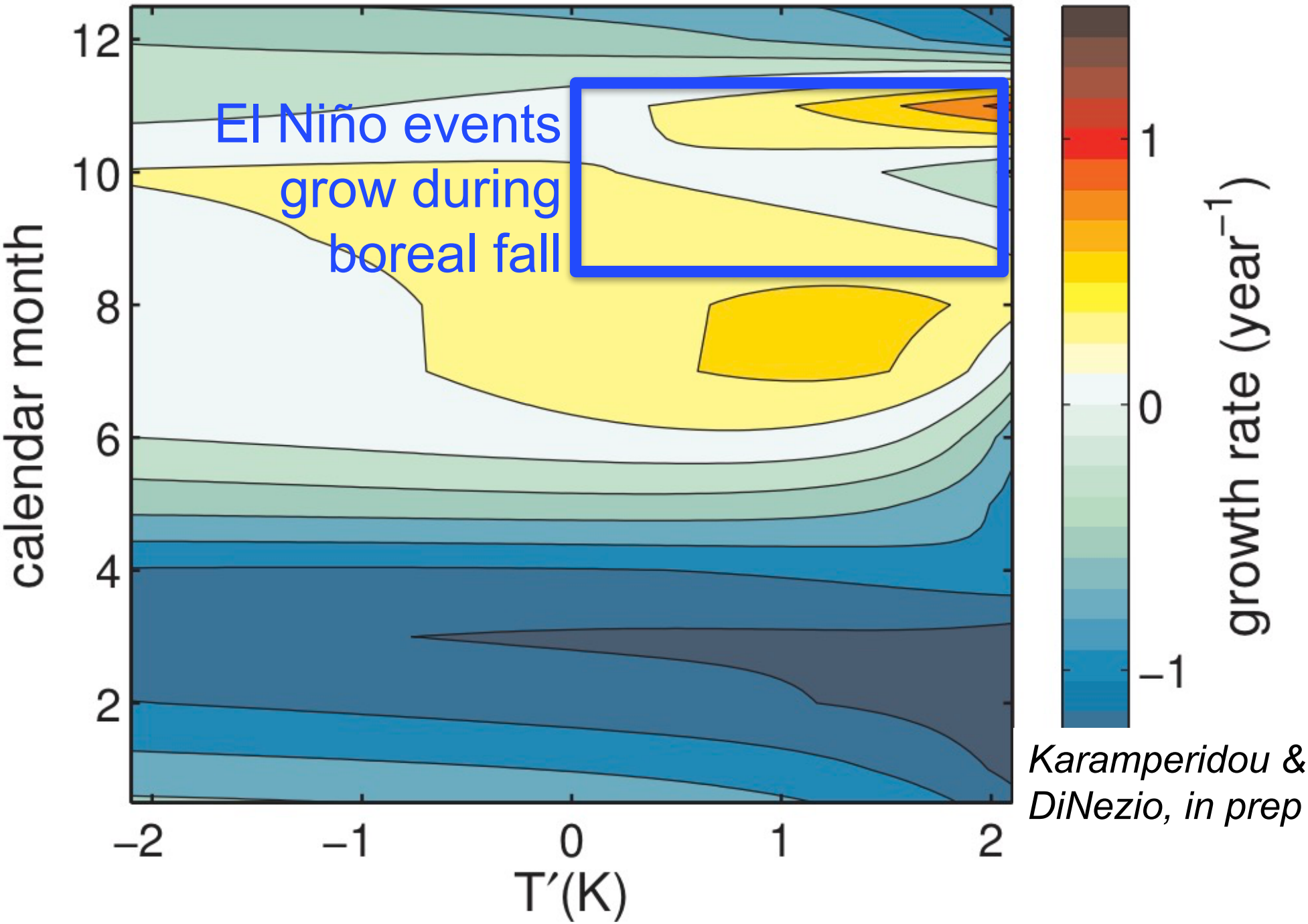
Most data fall below the late 20th century benchmark.

Grothe et al., under review
Cobb et al, 2013
Cobb et al., 2003
McGregor et al., 2013
Grothe et al., in prep
Woodroffe et al., 2003


(a)
weaker ENSO
period during
peak boreal
fall insolation
δ18O (‰, VPDB)
Equator SON insolation (W/m2)
Age (yr BP)
-10.5
-10.0
-9.5
-9.0
-8.5
-8.0
-7.5
-7.0
-6.5
445
440
435
430
425
420
415
410
405
0
2000
4000
6000
8000
10000
12000

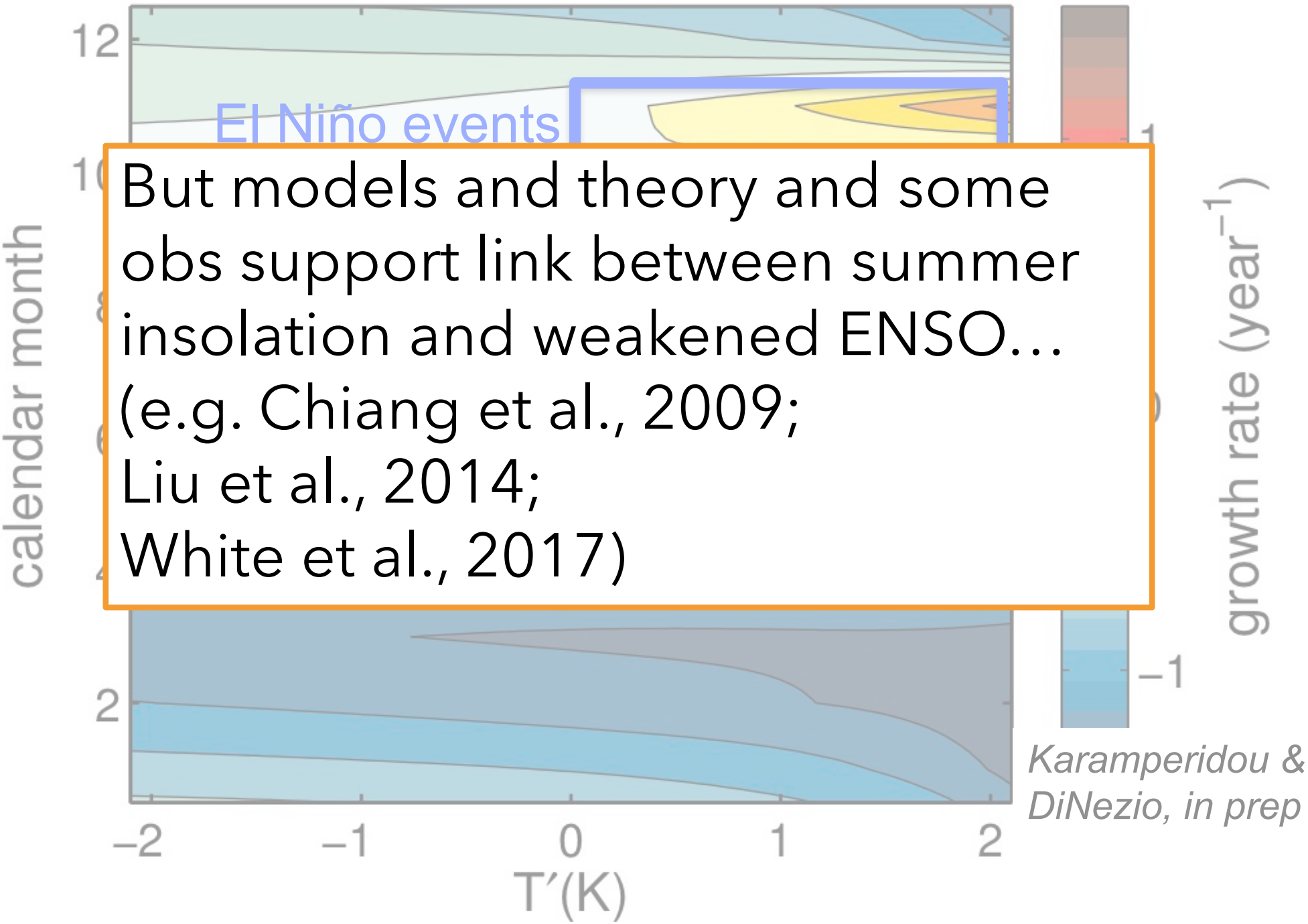

Why does boreal fall insolation drive ENSO reduction?
(a)
weaker ENSO period during peak boreal fall insolation
δ18O (‰, VPDB)
Equator SON insolation (W/
Age (yr BP)
-10.5
-10.0
-9.5
-9.0
-8.5
-8.0
-7.5
-7.0
-6.5
430
425
420
415
410
405
0
2000
4000
6000
8000
10000
12000

ENSO growth rate as a function of season



Karamperidou & DiNezio, in prep

ENSO growth rate as a function of season



But models and theory and some obs support link between summer insolation and weakened ENSO… (e.g. Chiang et al., 2009; Liu et al., 2014; White et al., 2017)

Karamperidou & DiNezio, in prep

Tropical Pacific coupled system sensitive to external radiative forcing, especially to changes in the seasonal cycle, but full dynamical picture still unclear.

Tropical Pacific coupled system sensitive to external radiative forcing, especially to changes in the seasonal cycle, but full dynamical picture still unclear.

Key roles for modeling community:

1) explore isotope-enabled simulations to provide dynamical context for key reconstruction sites (Hulu, Mulu, central Pacific Galapagos, East Africa)

Tropical Pacific coupled system sensitive to external radiative forcing, especially to changes in the seasonal cycle, but full dynamical picture still unclear.

Key roles for modeling community:
1) explore isotope-enabled simulations to provide dynamical context for key reconstruction sites (Hulu, Mulu, central Pacific Galapagos, East Africa)

2) combine a hierarchy of models in novel ways to explore interactions between mean state, seasonal cycle, & ENSO (Atwood et al., in prep)