CLIMATE VARIABILITY AND CHANGE DURING THE LAST MILLENNIUM

李時雨, 林冠慧, 廖怡君, 王寶貫
RCEC, Academia Sinica

Acknowledgement: NCAR LME project

HUNTER IN THE SNOW

1565 by Pieter Bruegel the Elder

One of the "common & severe" winter during the 16th century

WINTER LANDSCAPE WITH A BIRD TRAP

in Netherlands

1601 by Pieter Bruegel the Younger

Freeze over Dutch canal in winter; nowadays ice free

LITTLE ICE AGE (1450-1850) & MEDIEVAL WARM PERIOD (950-1250)

- *With colder/warmer than normal temperature*
- *Due proposed to solar variability (Lean, 2010), tropical volcanic eruptions (LIA, Schurer, 2014), declining NH summer insolation (Kaufman, 2009), land cover/use (He, 2014)*
- *Conventionally a "more European" climate phenomenon*
- *Medieval warm period (climate anomaly) often has more heterogeneity*

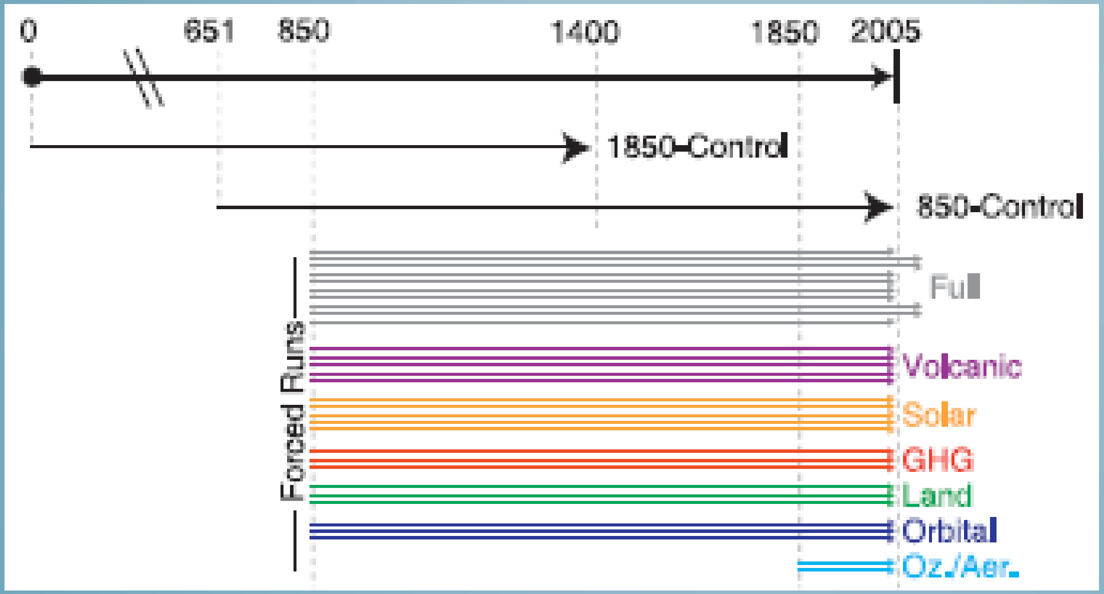
WHY THEN AND WHY US

- *High data density and the ability to quantify the relative importance of forcings with downside of smaller changes*
- *CMIP5 Last Millennium simulations organized by PMIP3*
- *Test the ability of state-of-the-art climate models in explaining climate changes*
- *NCAR-CESM-LME expands from CMIP5 LM that provides full and single forcing member*

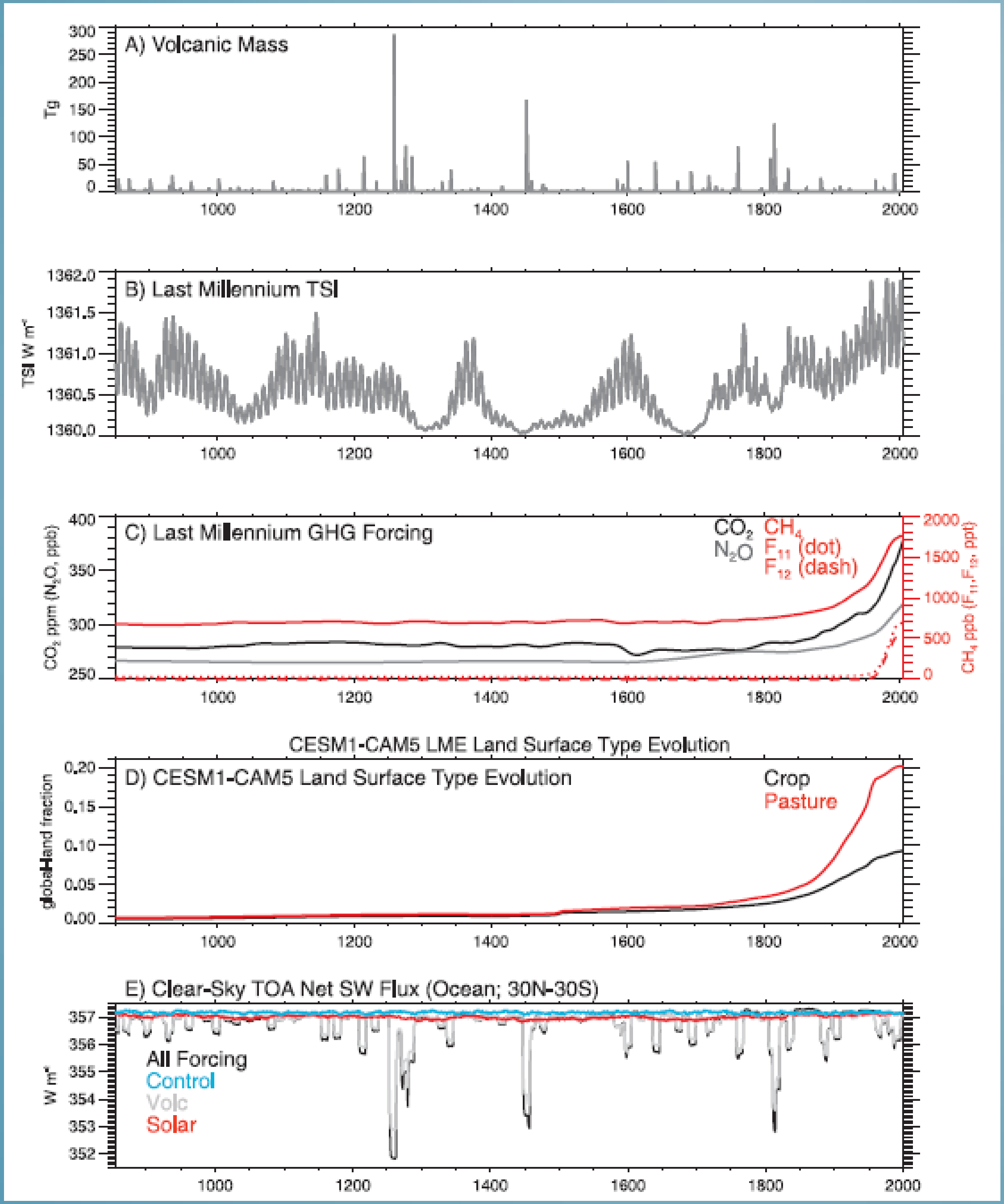
MODEL & DESIGN

	CESM-LME	CCSM-TraCE21k
Model	CESM1 (CAM5)	CCSM3_LPJ
Resolution	2-degree (atm, clm) 1-degree (pop, csim) F19-g16	4-degree (atm,clm) 3-1 degree (pop) T31_gx3v5
Purpose	Since 850CE	Since LGM
Transient	YES	YES but no really for LM
Forcings	Solar, orbital, volcanic, LCLU, GHG, (ozone-aerosol)	Orbital, GHG, Ice-5G, paleography, meltwater

MODEL & DESIGN



-- Spin-up from 1850 control
-- 850 control branched out
-- Started from year 850



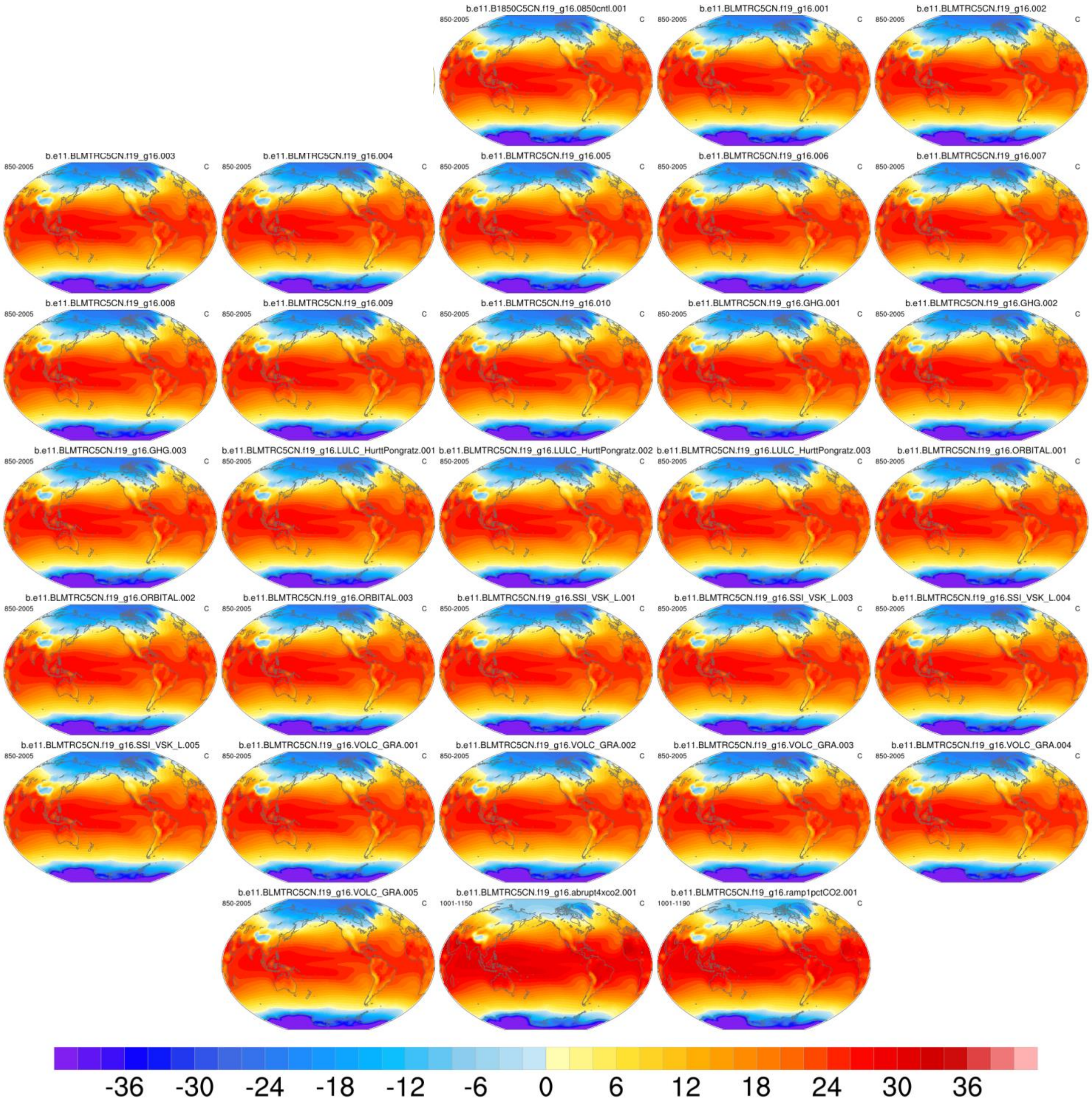
From NCAR-LME project

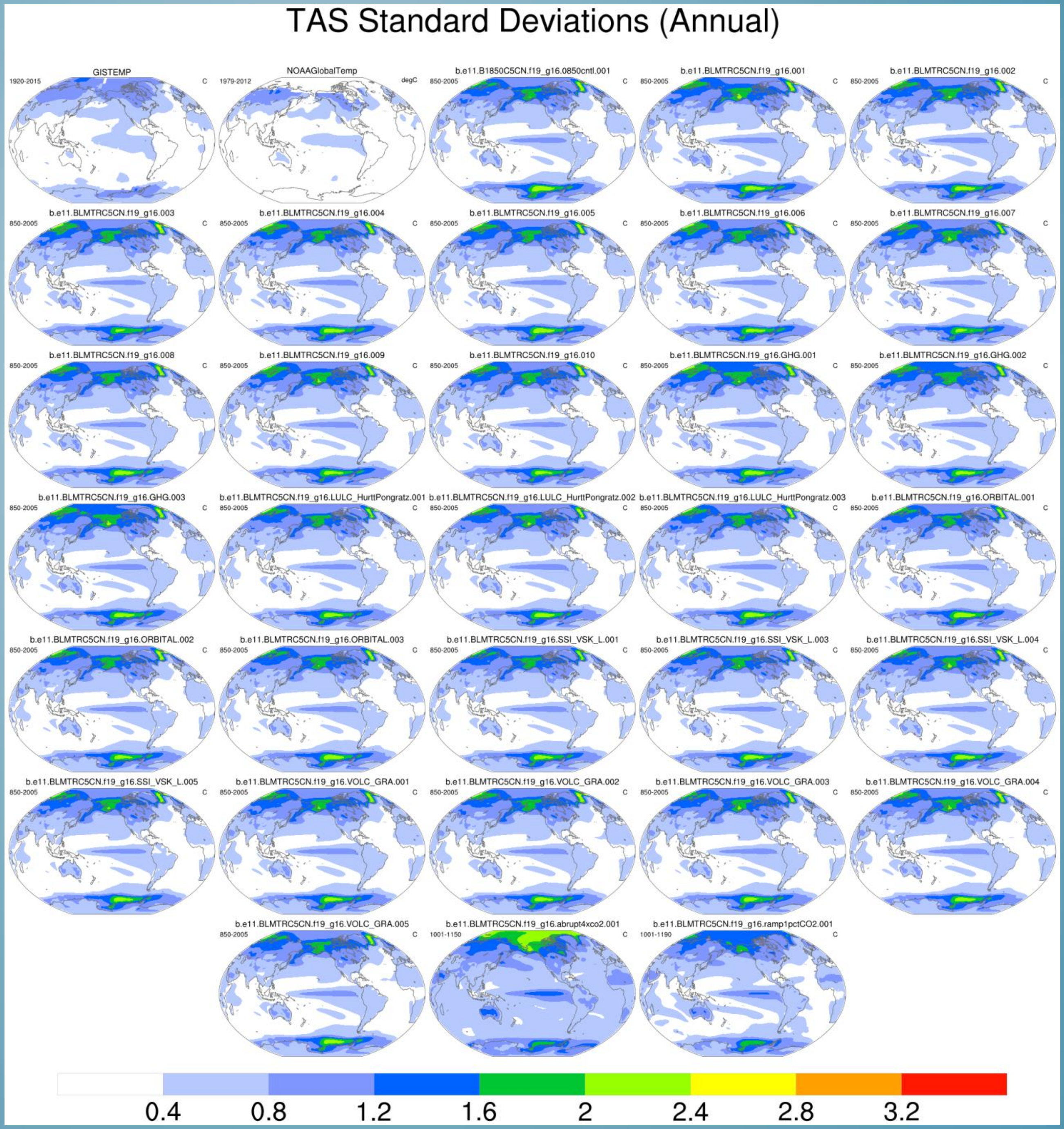
HOW DOES IT GO?

… In a global sense

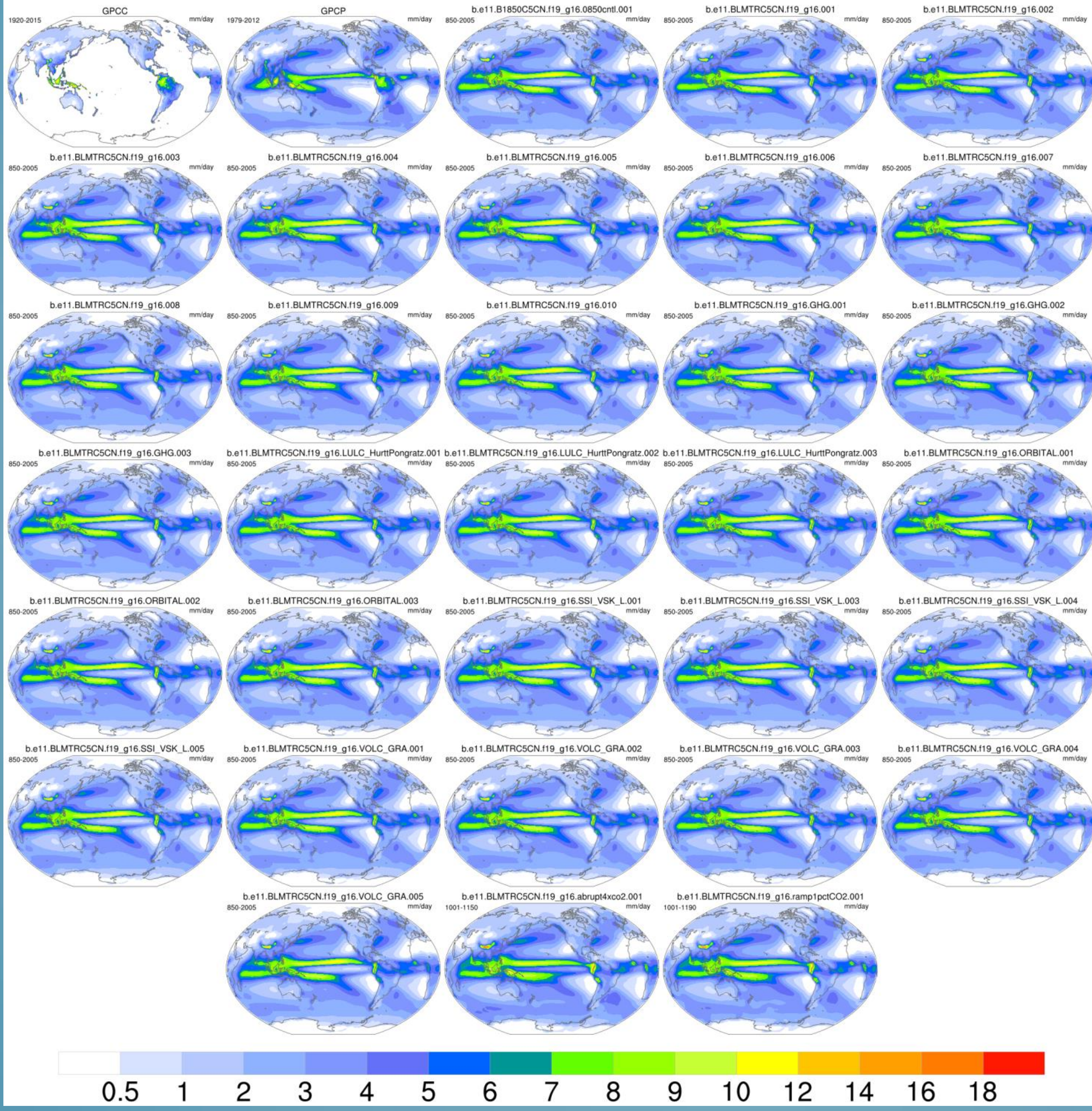
From 850-1850

TAS Means (Annual)

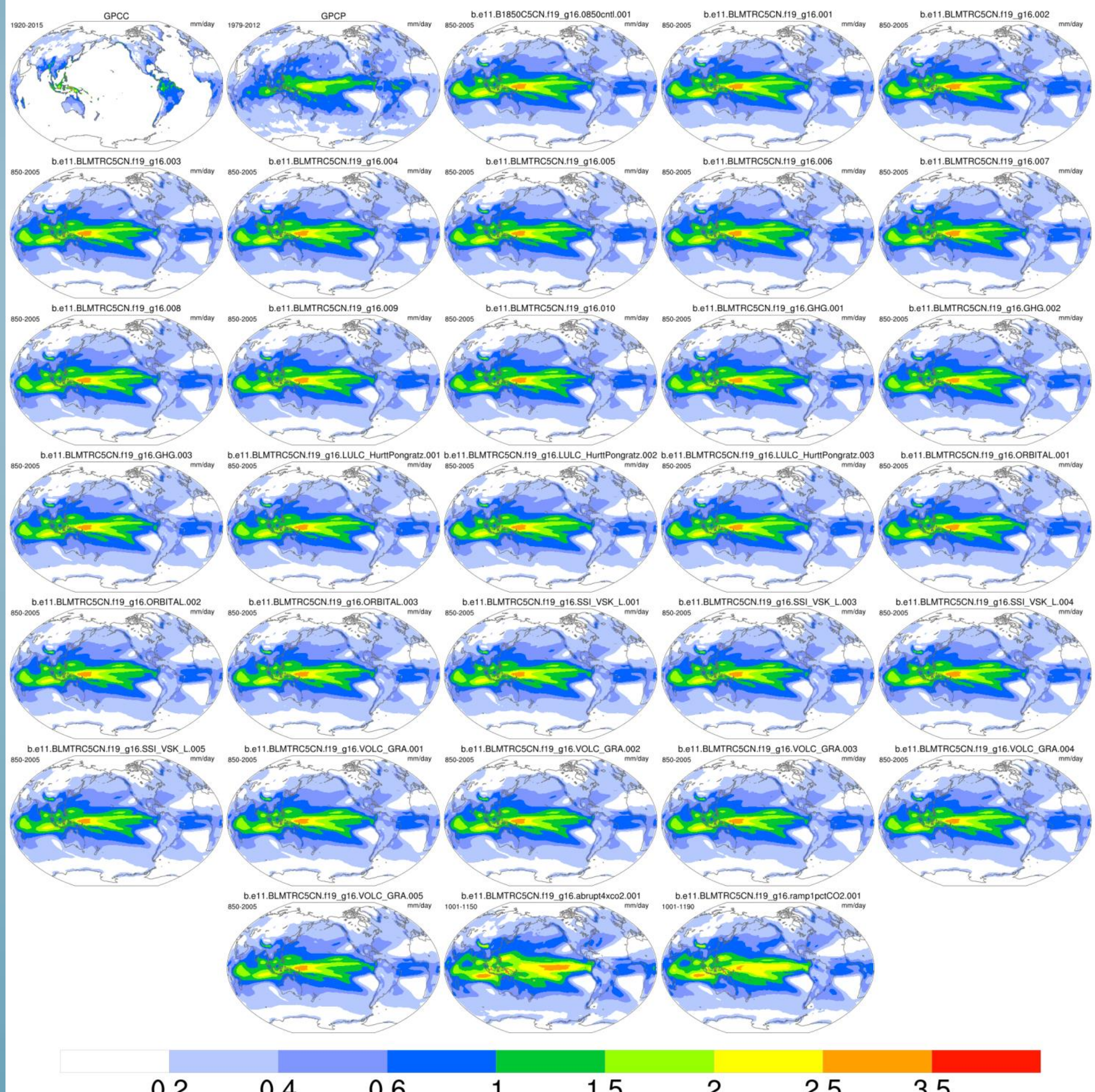



TAS Standard Deviations (Annual)
GISTEMP
1920-2015
NOAAGlobalTemp
1979-2012
degC
b.e11.B1850C5CN.f19_g16.0850cntl.001
b.e11.BLMTRC5CN.f19_g16.001
b.e11.BLMTRC5CN.f19_g16.002
b.e11.BLMTRC5CN.f19_g16.003
b.e11.BLMTRC5CN.f19_g16.004
b.e11.BLMTRC5CN.f19_g16.005
b.e11.BLMTRC5CN.f19_g16.006
b.e11.BLMTRC5CN.f19_g16.007
b.e11.BLMTRC5CN.f19_g16.008
b.e11.BLMTRC5CN.f19_g16.009
b.e11.BLMTRC5CN.f19_g16.010
b.e11.BLMTRC5CN.f19_g16.GHG.001
b.e11.BLMTRC5CN.f19_g16.GHG.002
b.e11.BLMTRC5CN.f19_g16.GHG.003
b.e11.BLMTRC5CN.f19_g16.LULC_HurttPongratz.001
b.e11.BLMTRC5CN.f19_g16.LULC_HurttPongratz.002
b.e11.BLMTRC5CN.f19_g16.LULC_HurttPongratz.003
b.e11.BLMTRC5CN.f19_g16.ORBITAL.001
b.e11.BLMTRC5CN.f19_g16.ORBITAL.002
b.e11.BLMTRC5CN.f19_g16.ORBITAL.003
b.e11.BLMTRC5CN.f19_g16.SSI_VSK_L.001
b.e11.BLMTRC5CN.f19_g16.SSI_VSK_L.003
b.e11.BLMTRC5CN.f19_g16.SSI_VSK_L.004
b.e11.BLMTRC5CN.f19_g16.SSI_VSK_L.005
b.e11.BLMTRC5CN.f19_g16.VOLC_GRA.001
b.e11.BLMTRC5CN.f19_g16.VOLC_GRA.002
b.e11.BLMTRC5CN.f19_g16.VOLC_GRA.003
b.e11.BLMTRC5CN.f19_g16.VOLC_GRA.004
b.e11.BLMTRC5CN.f19_g16.VOLC_GRA.005
b.e11.BLMTRC5CN.f19_g16.abrupt4xco2.001
1001-1150
b.e11.BLMTRC5CN.f19_g16.ramp1pctCO2.001
1001-1190
850-2005
C
0.4
0.8
1.2
1.6
2
2.4
2.8
3.2

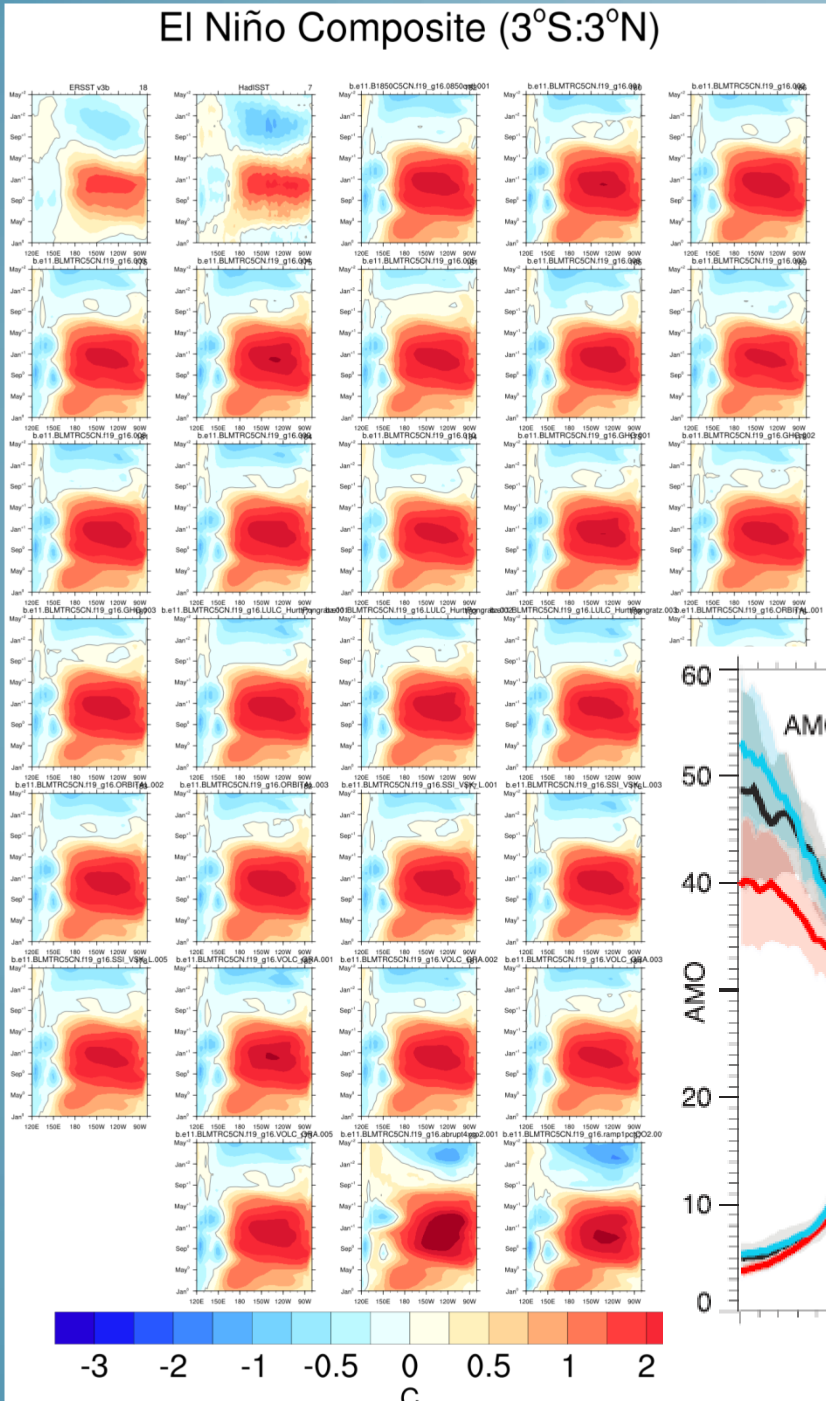
PR Means (Annual)

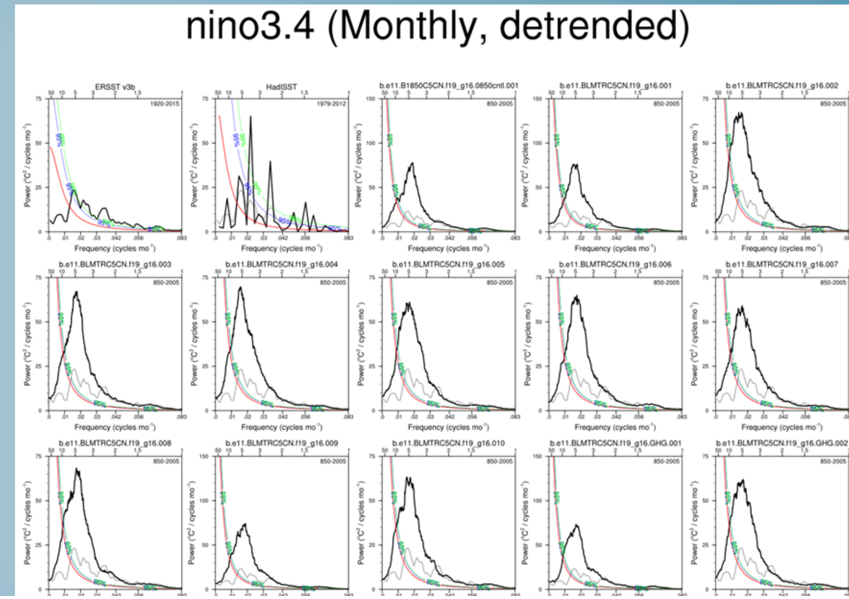


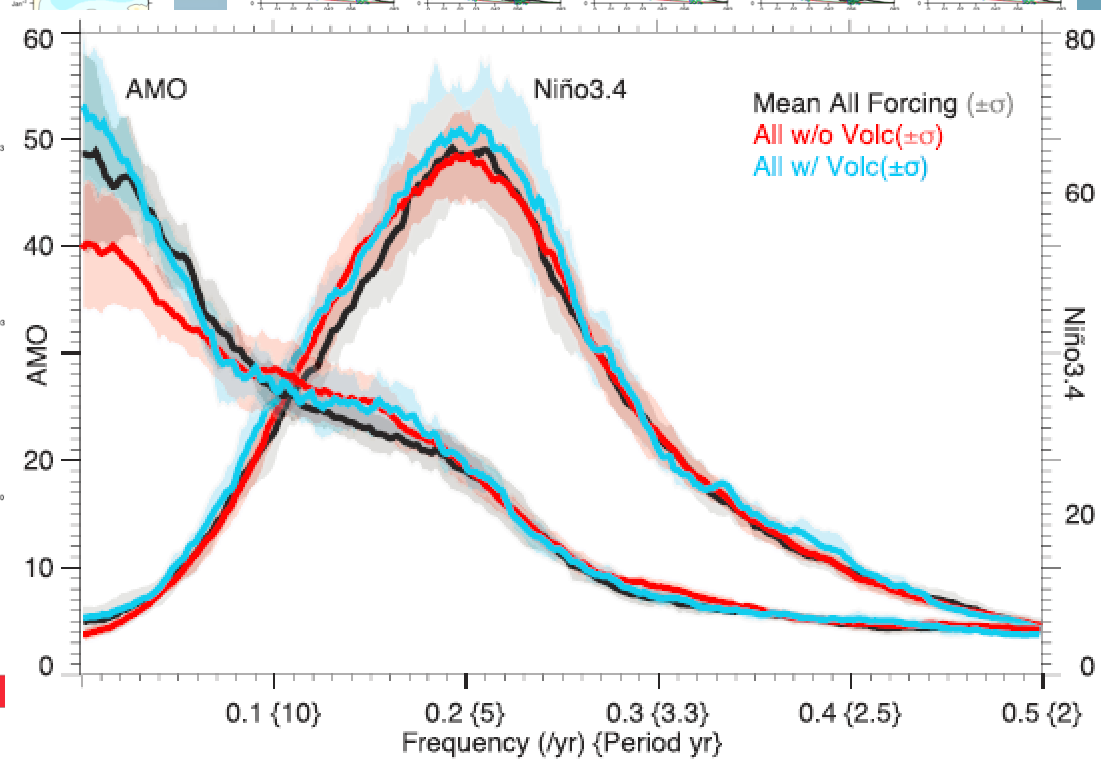
PR Standard Deviations (Annual)



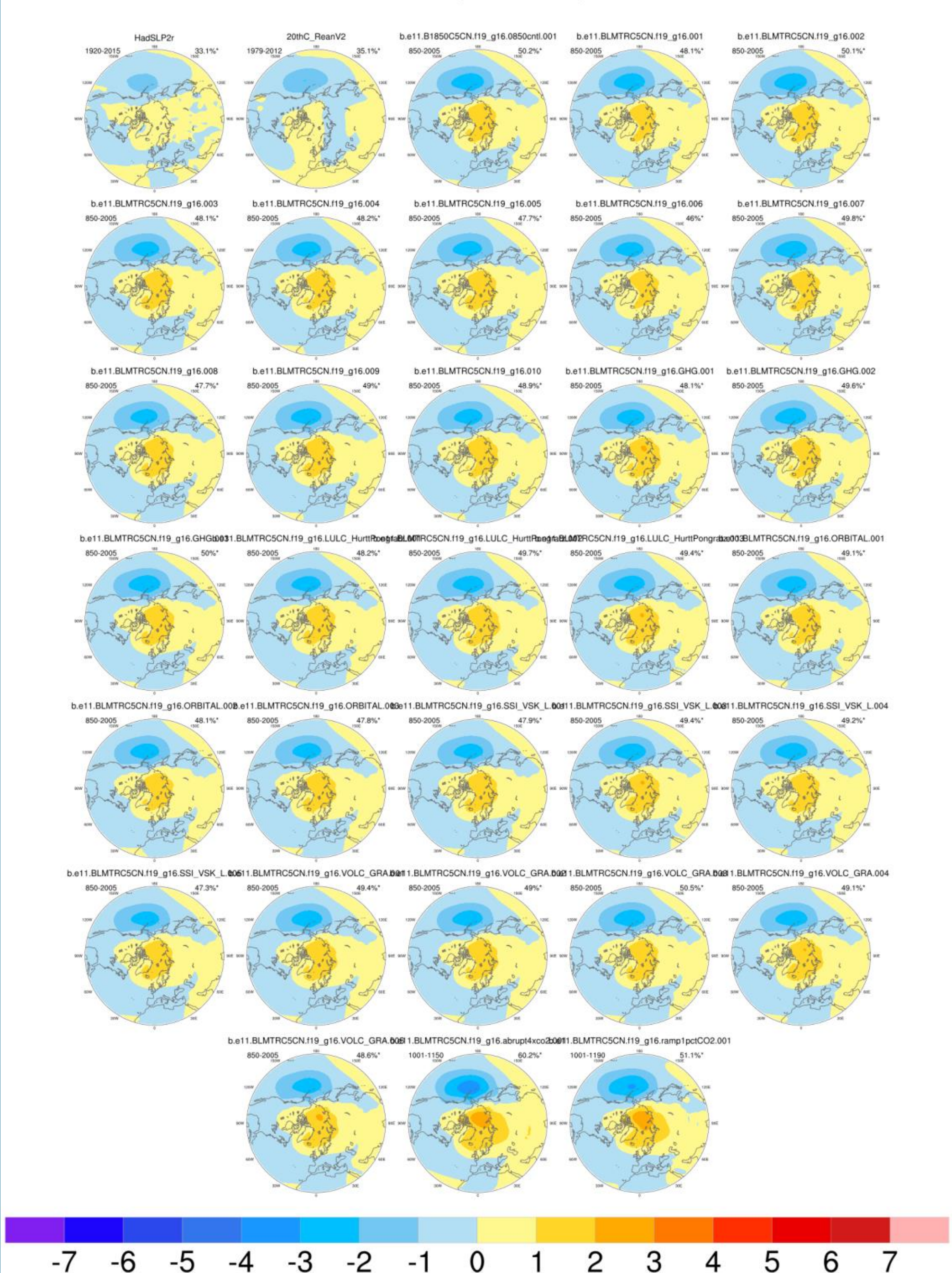
15915915

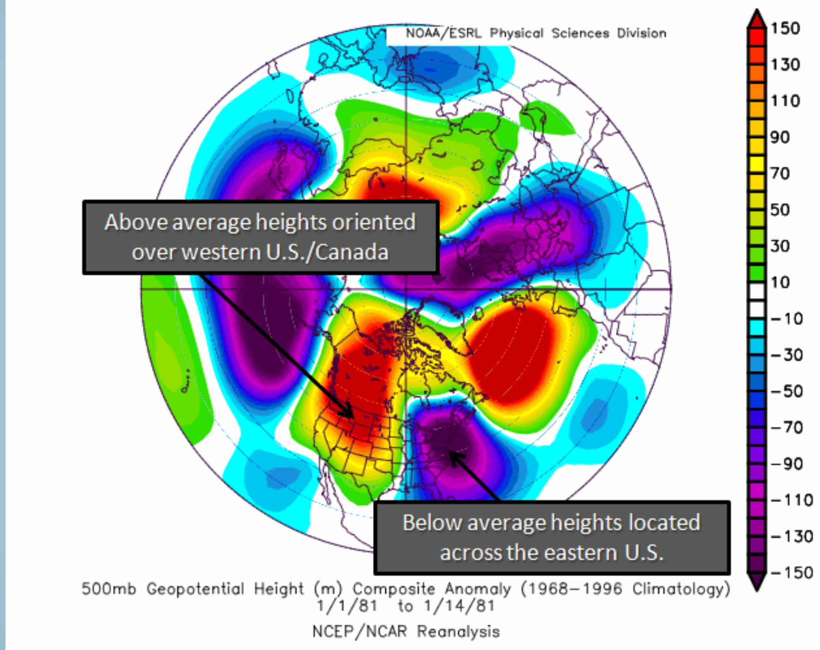

El Niño Composite (3°S:3°N)
-3
-2
-1
-0.5
0
0.5
1
2
C

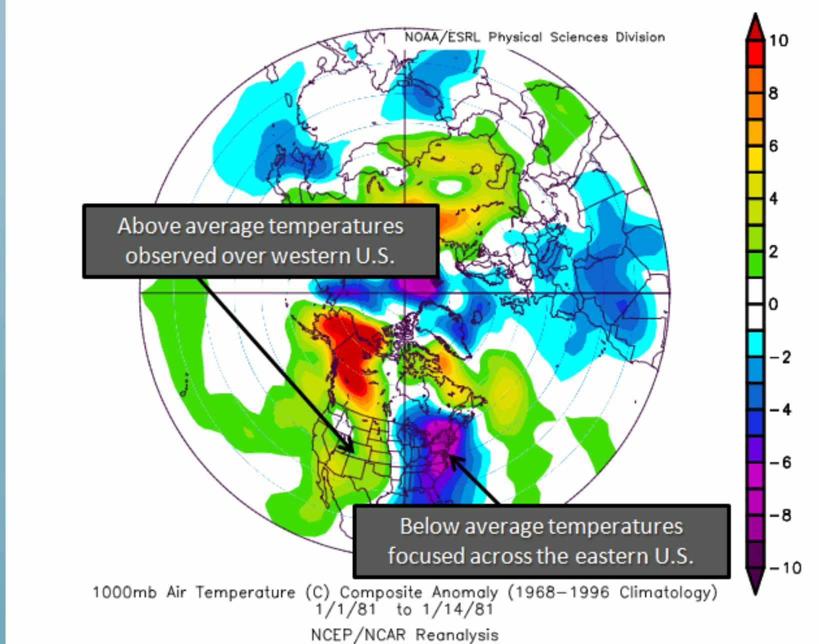

nino3.4 (Monthly, detrended)


AMO
Niño3.4
Mean All Forcing (±σ)
All w/o Volc(±σ)
All w/ Volc(±σ)
AMO
Niño3.4
Frequency (/yr) {Period yr}
0.1 {10}
0.2 {5}
0.3 {3.3}
0.4 {2.5}
0.5 {2}

PNA (Annual)







From NCEP website

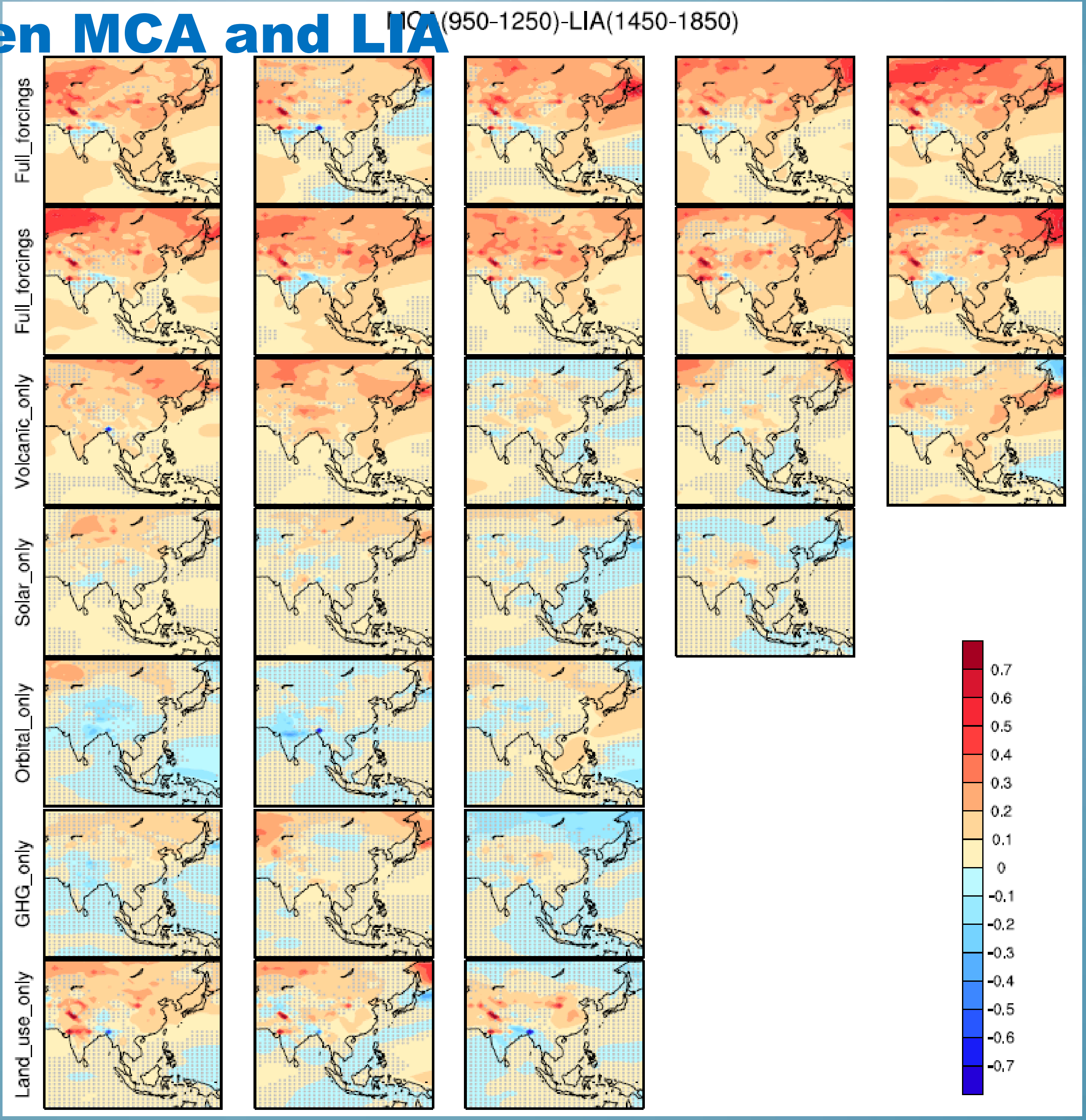
HOW DOES IT GO?

… In our yard

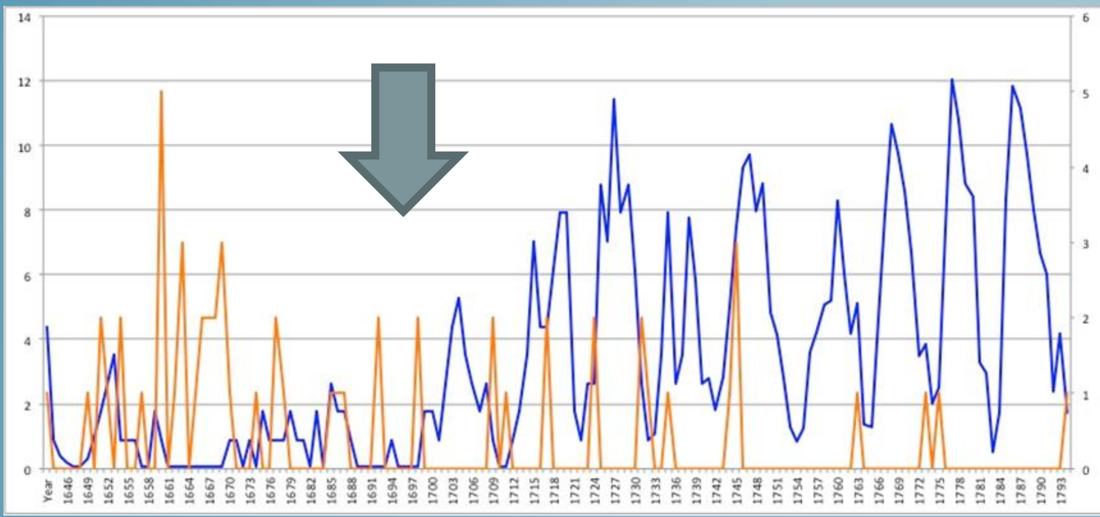
HOW DIFFERENT?
Changes between MCA and LIA

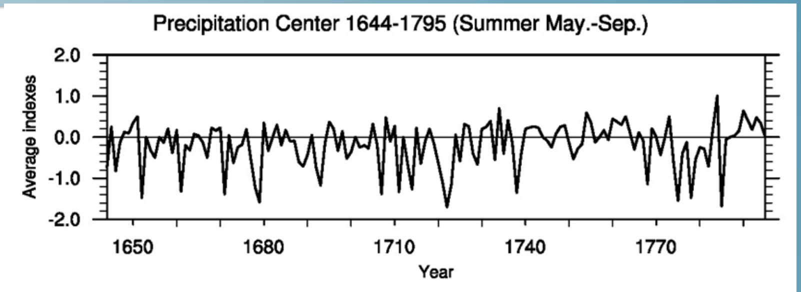
-- Anomalies from two phase as a test

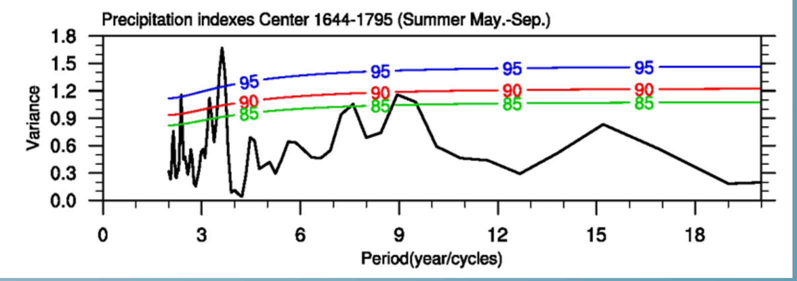
-- LME results shows mostly significant but not the TraCE-21k

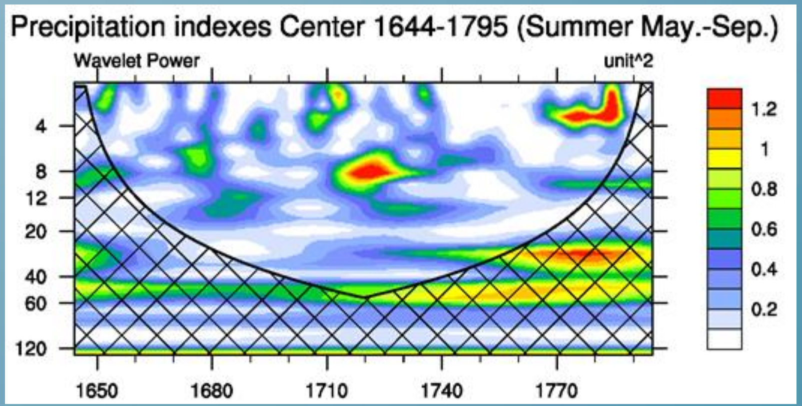


Working with reconstruction







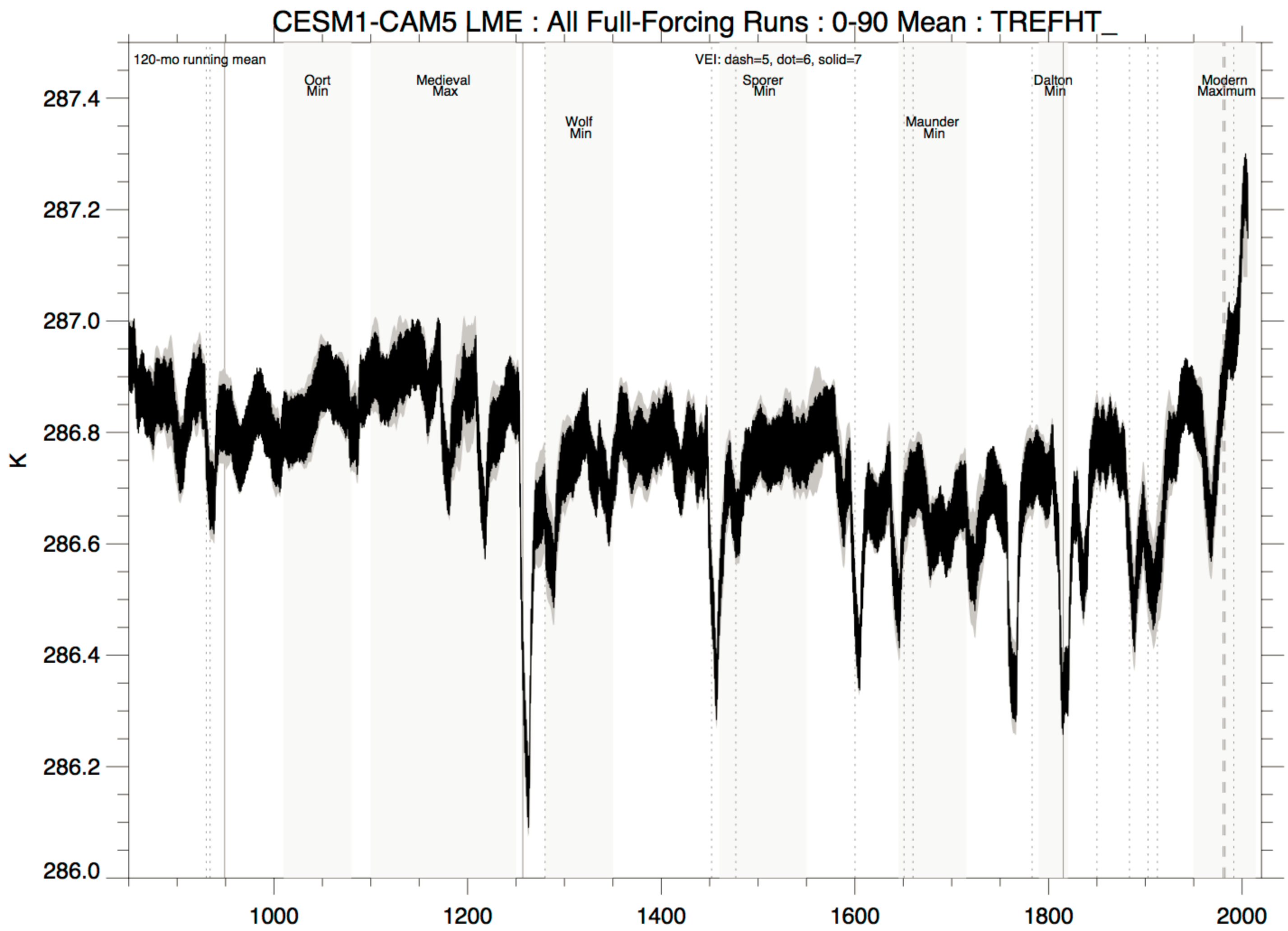


-- Wei shows speleothem isotopic data suggest precipitation in southern China correlate with Be-10 solar activity (sunspot)

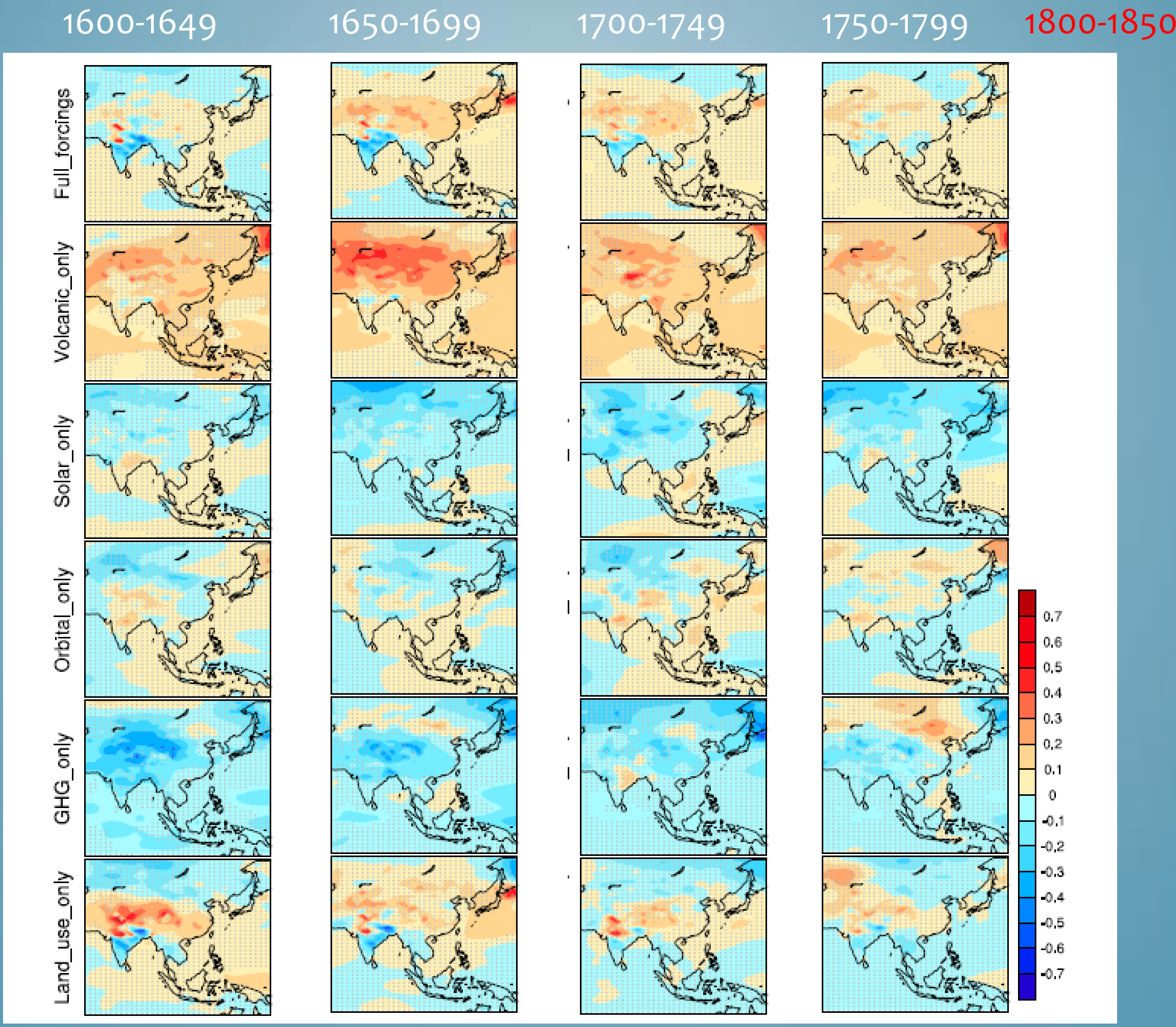
-- REACHS reconstruction also shows summer snow in Eastern China correlate with group sunspot number

-- precipitation follows solar 11-year cycles

Surface temperature

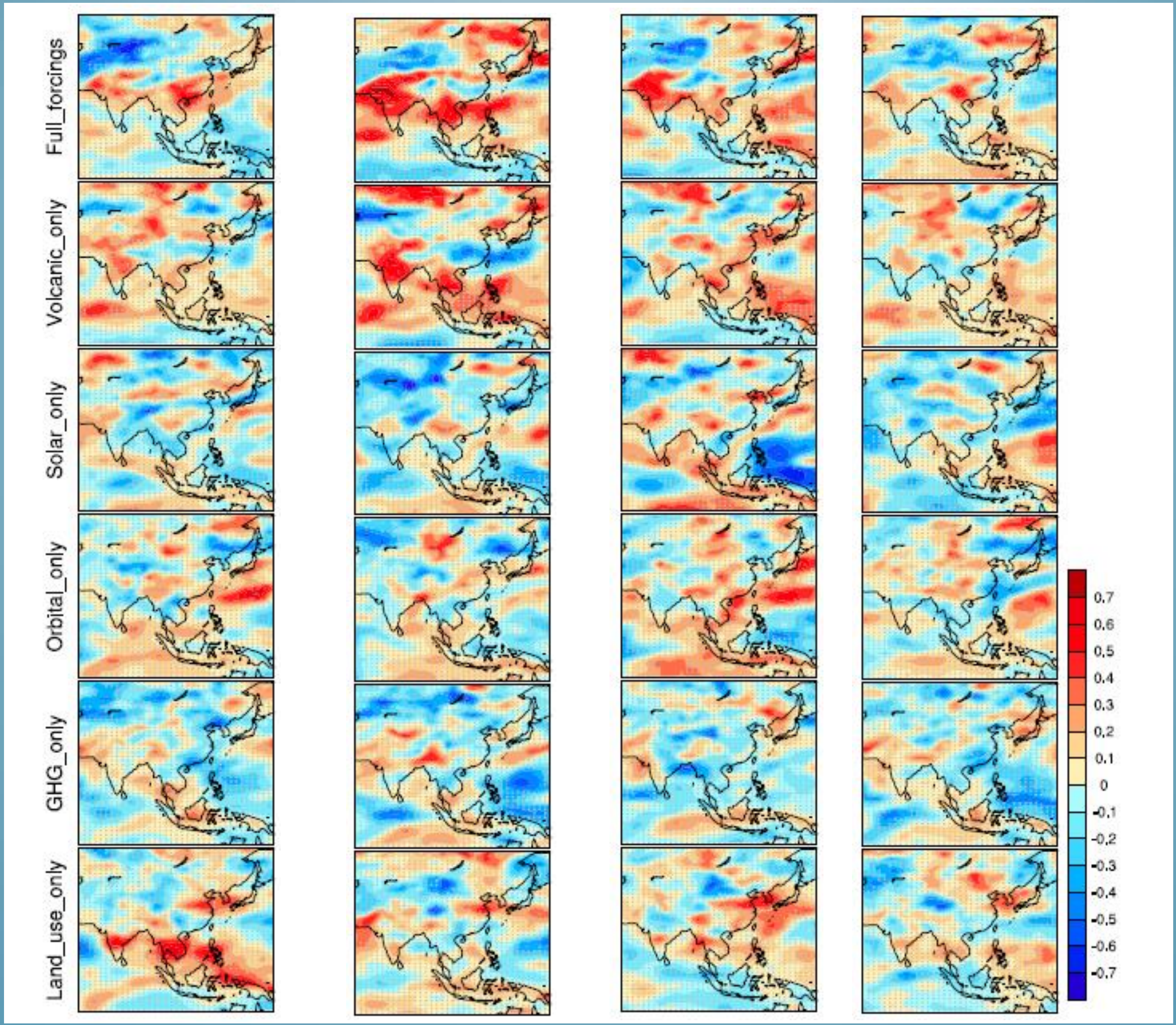


From 1644 - 1795 TS

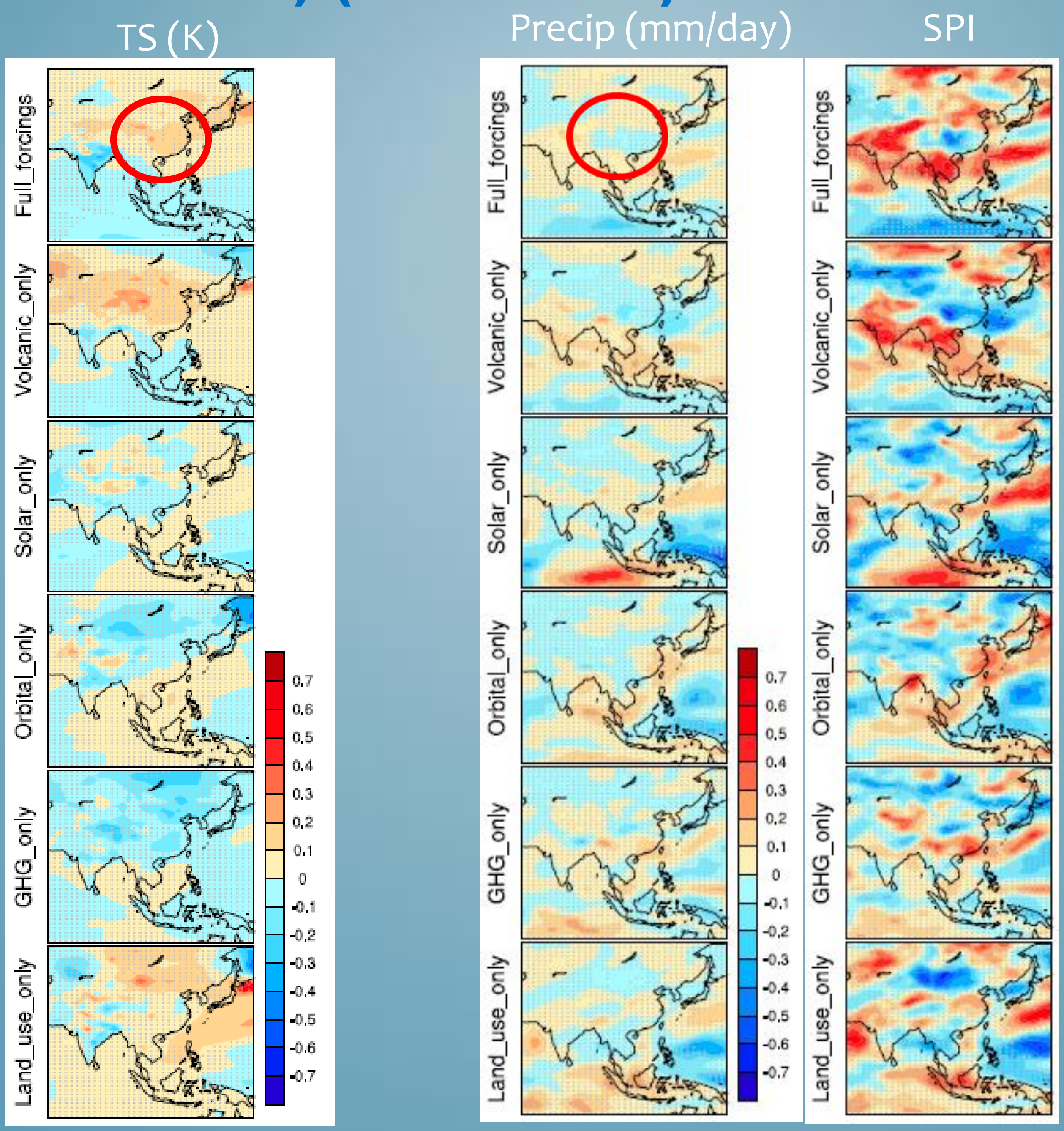


From 1644 - 1795 std precipitation index

1600-1649 1650-1699 1700-1749 1750-1799 1800-1850



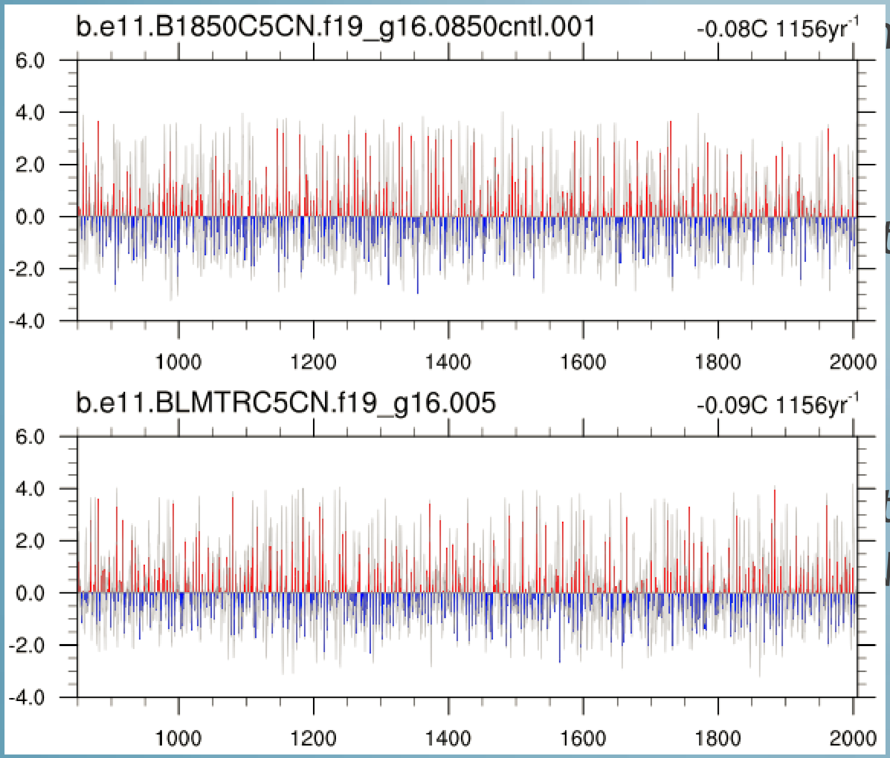
For (1650-1699)-(1750-1799)

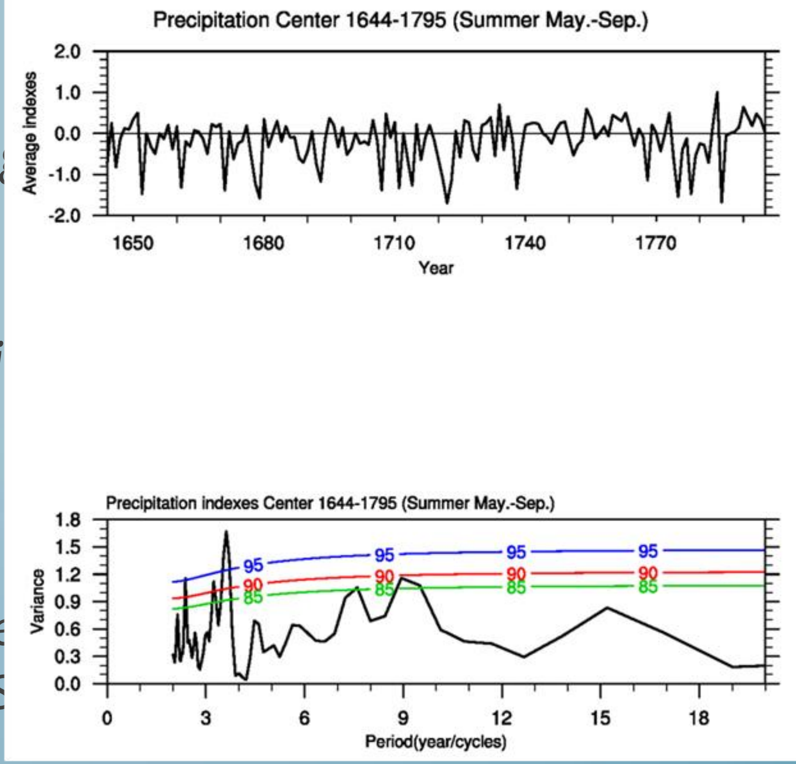


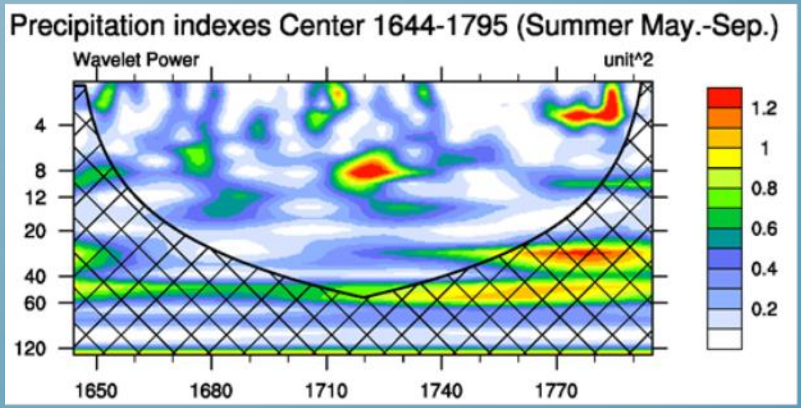
PROSPECTIVE

- *Continue on diagnostic analysis on global and regional time scales with a focus on East Asia*
- *Model-data (literature reconstruction) comparison and historical events*
- *Ongoing:*
  -- Characterizing precipitation pattern over monsoon Asia
  -- How does that associate with ENSO activity?

PROSPECTIVE







PROSPECTIVE

- *Continue on diagnostic analysis on global and regional time scales with a focus on East Asia*
- *Model-data (literature reconstruction) comparison and historical events*
- *Ongoing:*
  -- Characterizing precipitation pattern over monsoon Asia
  -- How does that associate with ENSO activity?
  -- LIA and MCA in China (Asia)
  -- Monsoon/Maiyu front evolution

Data Driven & Thank you