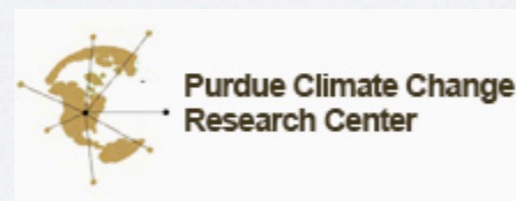


HEAT STRESS BIASES IN COMMUNITY LAND MODEL WITHIN CESM

Jonathan R. Buzan, Matthew Huber, and Keith Oleson



Motivation

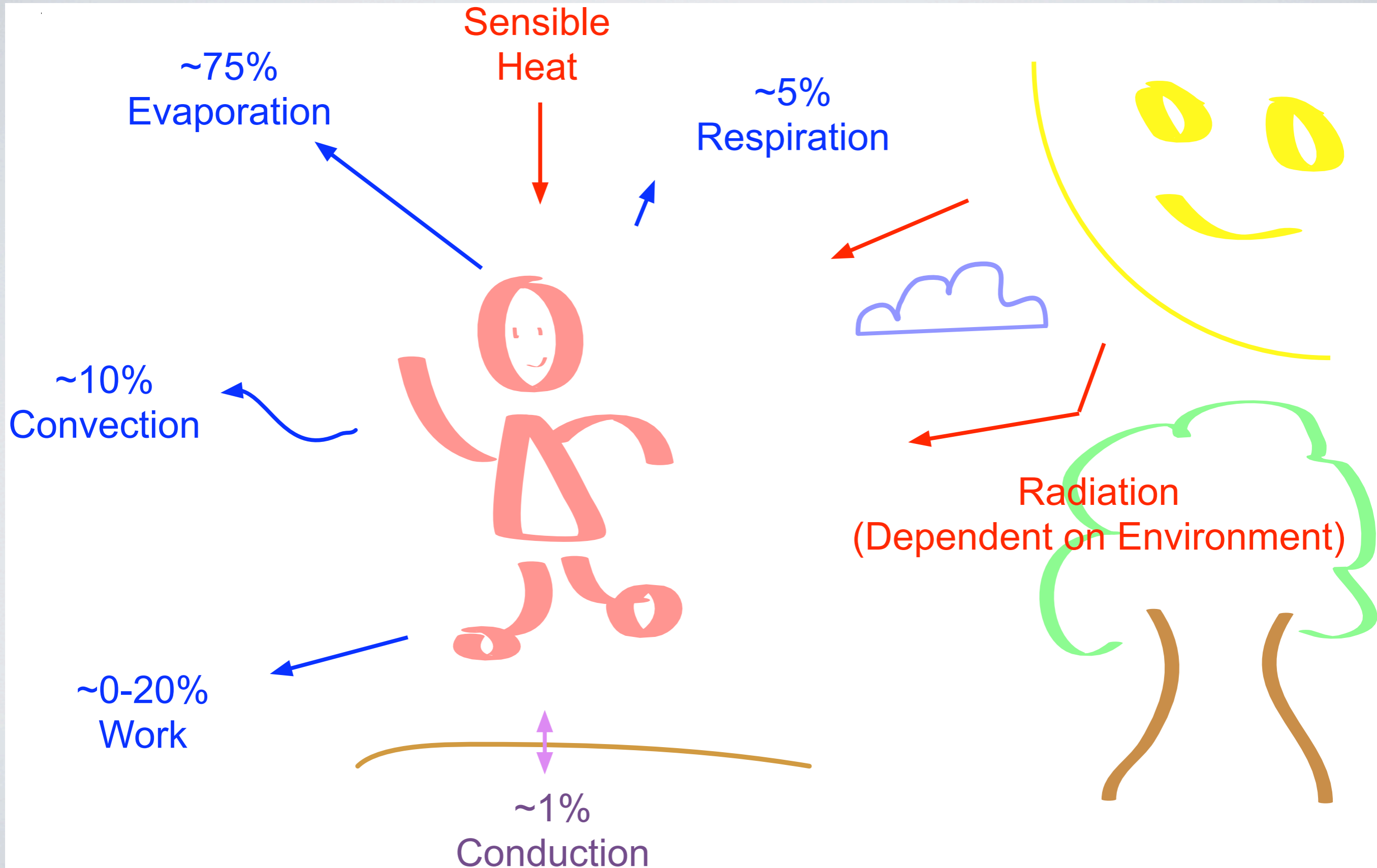
WHAT IS HEAT STRESS?

Heat stress occurs when the human body loses the ability to internally regulate heat balance (hyperthermia).

This is opposed to a fever, where the human body is the cause of heat stress (Simon 1993).

Motivation

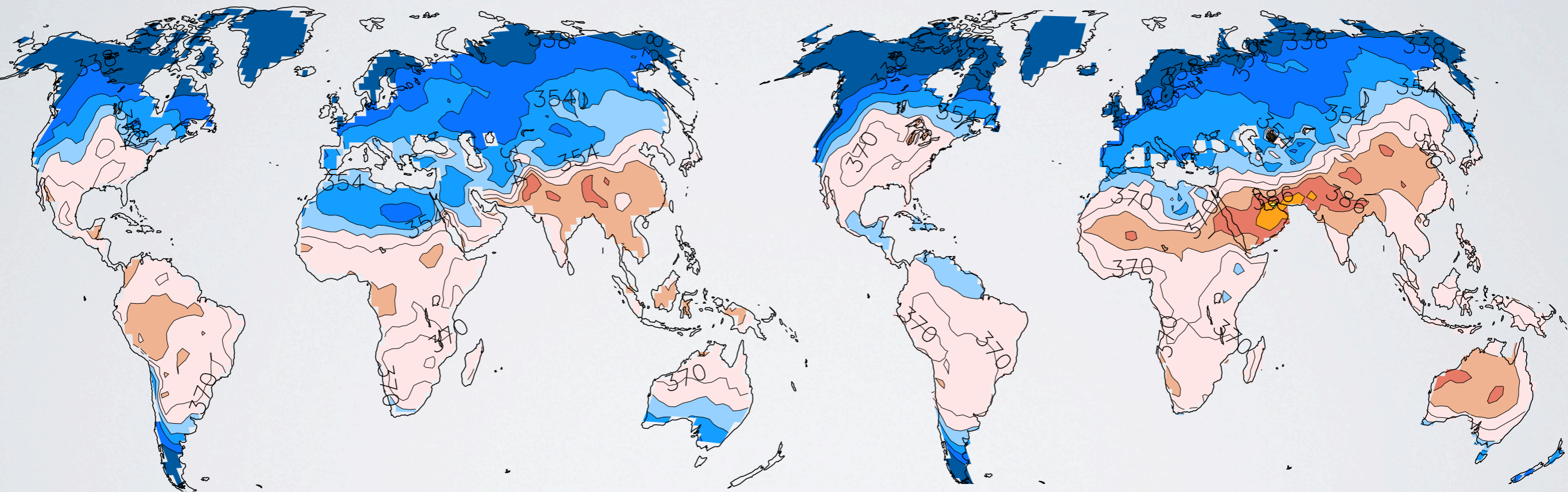
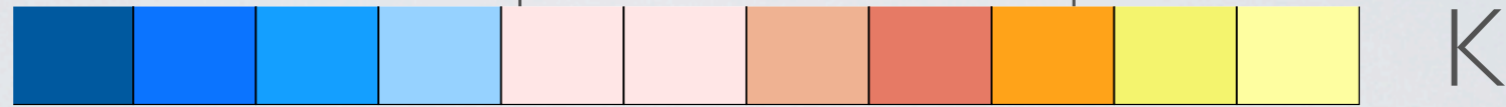
- Normal Core temperature $\sim 37.5^{\circ}\text{C}$
- Heat Exhaustion Core temperature 38.5°C
- Heat Stroke Core temperature $+42^{\circ}\text{C}$



Problem

CESM Modern Day vs ERA Interim

Absolute Max Equivalent Potential Temperature



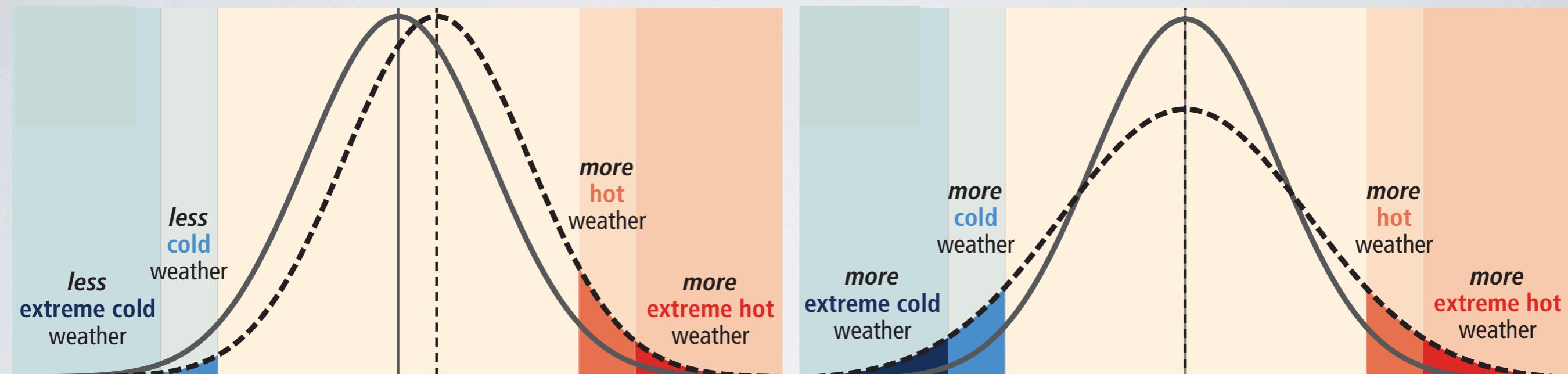
ERA Interim 2002-2011

CESM Slab Ocean Modern

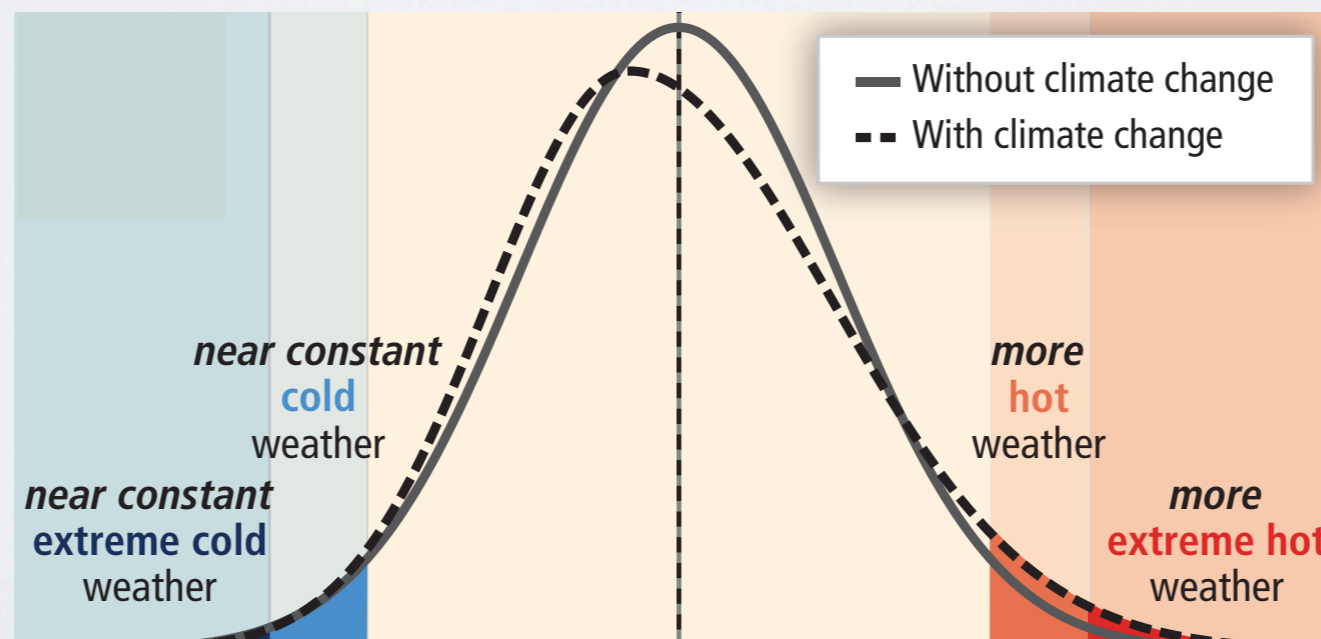
Terminology: Probability Density Functions and 99th and 95th Percentiles

Shift in Mean

Increased Variability

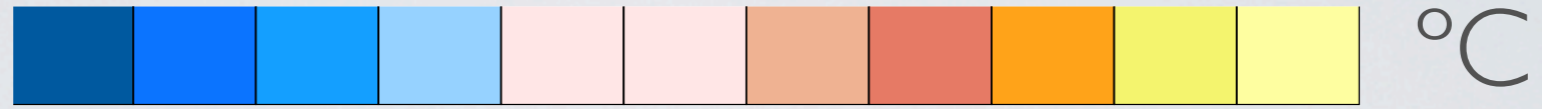


Changed Symmetry



IPCC SREX, 2012

Heat Index 95th Percentile



23

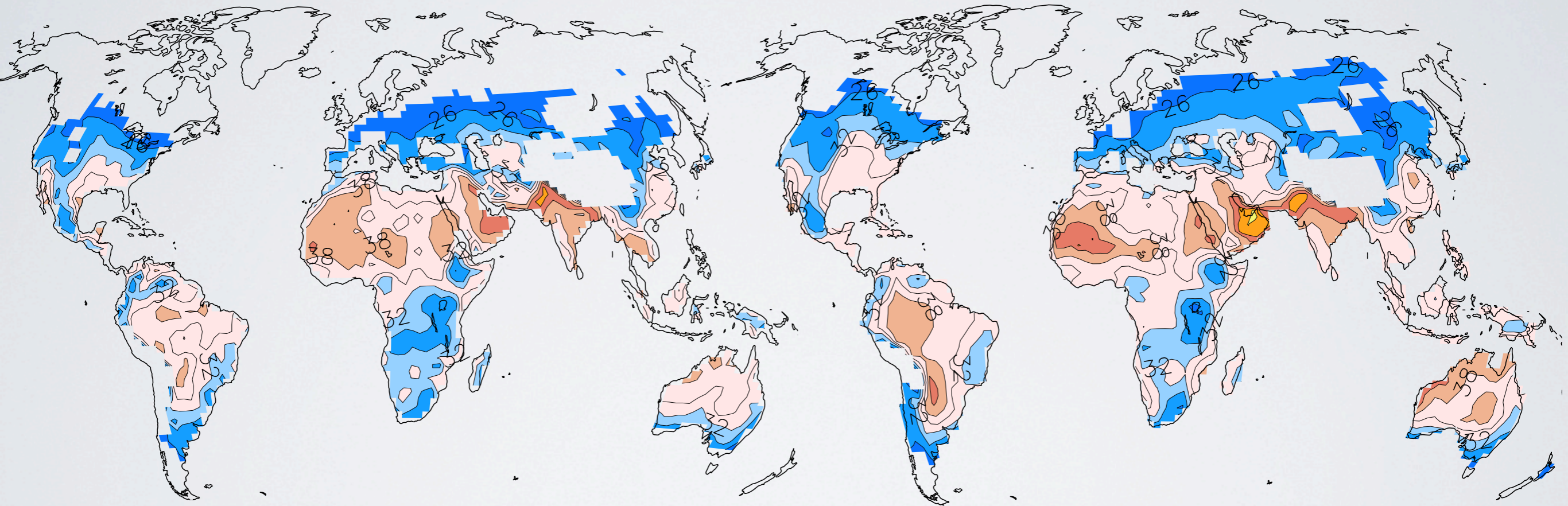
29

35

41

47

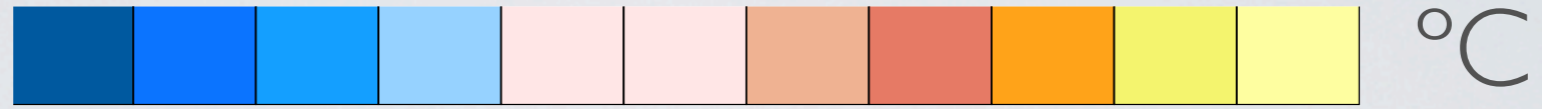
°C



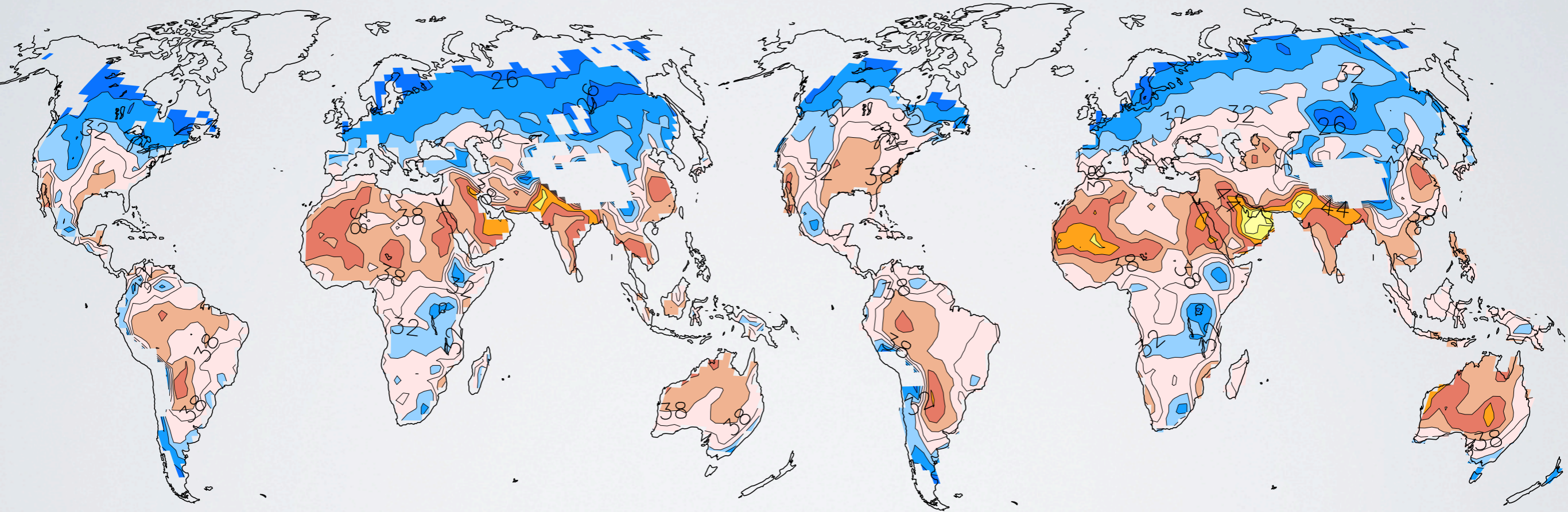
ERA Interim

CESM Slab Ocean Modern

Heat Index 99th Percentile



23 29 35 41 47



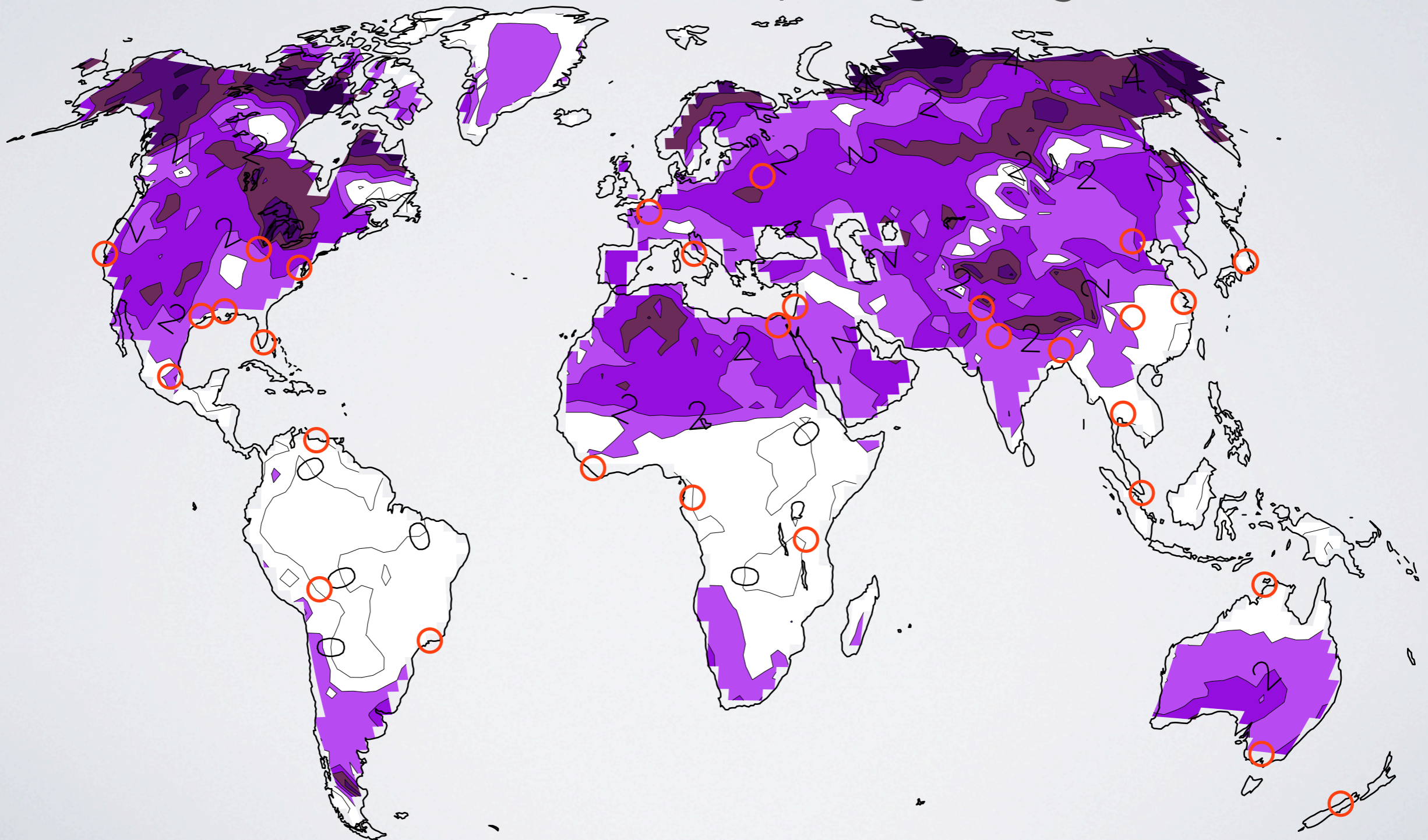
ERA Interim

CESM Slab Ocean Modern

Heat Index

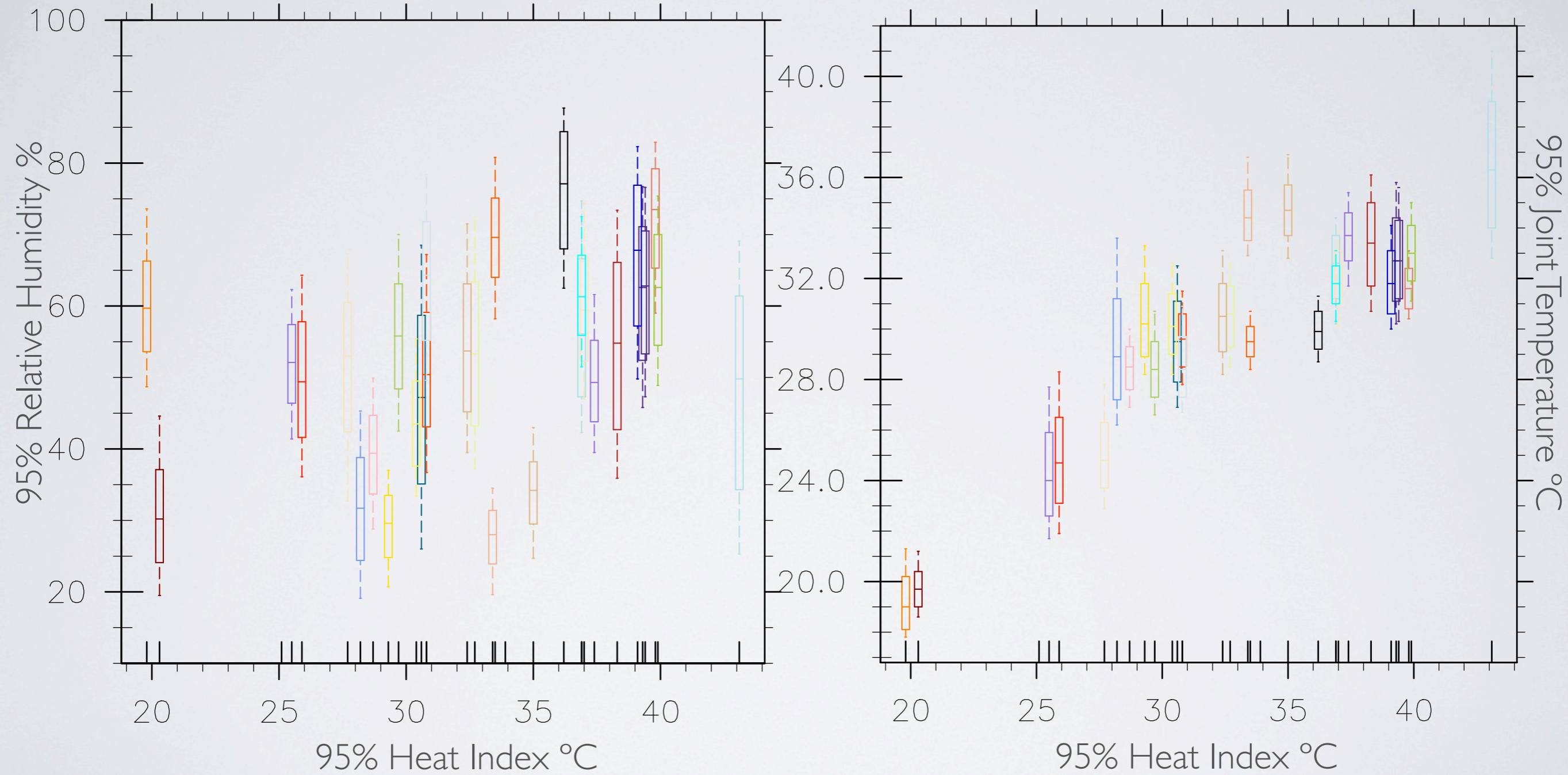
99th - 95th Percentile Change

CESM Slab Ocean Modern - ERA Interim



Heat Index

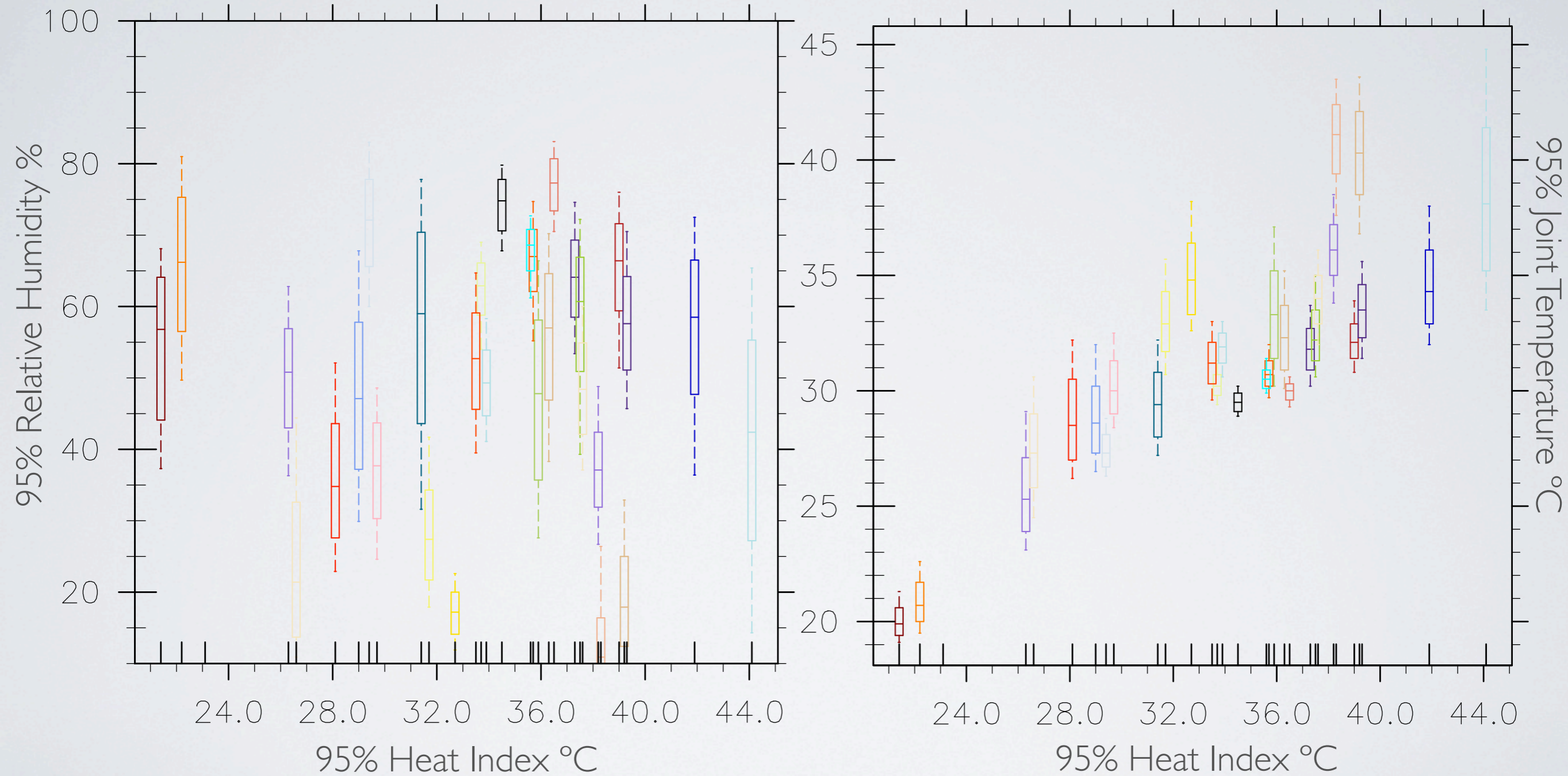
95th Percentile Joint Distributions



ERA Interim

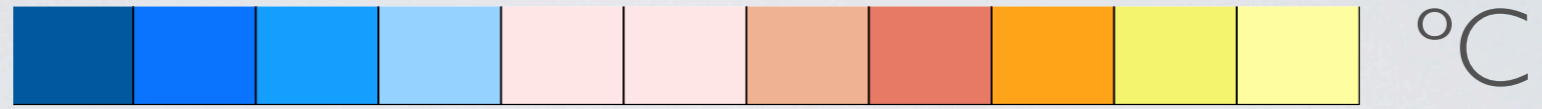
Heat Index

95th Percentile Joint Distributions

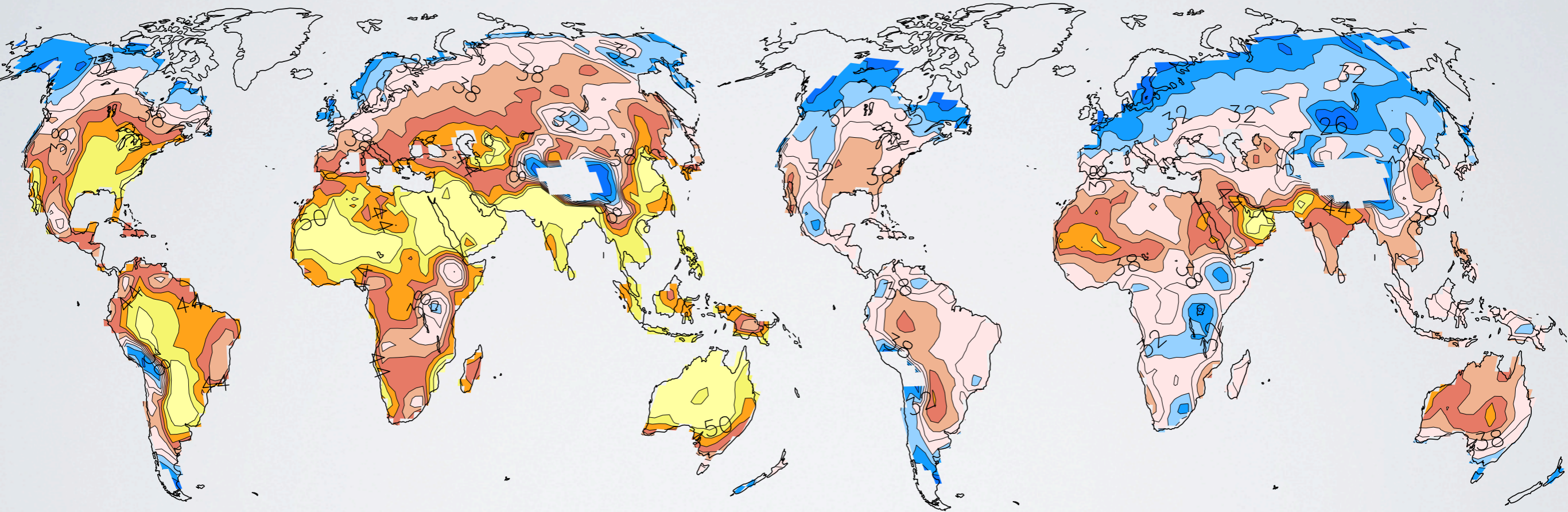


CESM Slab Ocean Modern

Heat Index 99th Percentile



23 29 35 41 47



CESM Slab Ocean | 20 ppmv CO₂

CESM Slab Ocean Modern

DISCUSSION

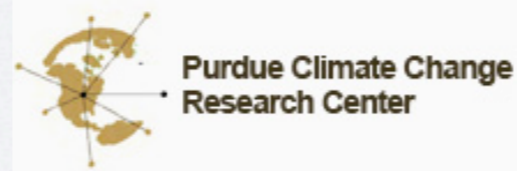
- Using Heat Stress metrics for model data comparisons are a robust method for predicting extremes (Fischer and Knutti, 2012)
- Wide spread use of air conditioning will be necessary (Barreca et al, 2013)
- Occupational Health and Safety Administration (OSHA.gov) standards will be violated world wide in a warmer climate

CONCLUSIONS

- CESM can replicate modern extreme heat stress patterns
- Spatial patterns of extreme heat stress in CESM are similar to ERA Interim, however CESM is warmer worldwide
- Variability of heat stress from 95th to the 99th percentile is greater in CESM than in ERA Interim
- In a warmer climate, extreme heat stress at low latitudes rise above the calibration of Heat Index

THANK YOU!

QUESTIONS?



SUPPLEMENTAL MATERIAL



History of Thermal Indices

- Heat Index = $(-42.379) + (2.04901523)*Tf + (10.14333127)*RH + ((-0.22475541)*Tf*RH) + ((-6.83783e-3)*Tf^2.) + ((-5.481717e-2)*RH^2.) + (1.22874e-3)*(Tf^2.)*RH + (8.5282e-4)*Tf*RH^2. + ((-1.99e-6)*(Tf^2.)*(RH^2.))$
- Polynomial fit to a empirical human thermal comfort model (Rothfus, 1990)
- Used by the National Weather Service

NOAA's National Weather Service

Heat Index

Temperature (°F)

	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

NOAA

<http://www.nws.noaa.gov/om/heat/index.shtml>

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

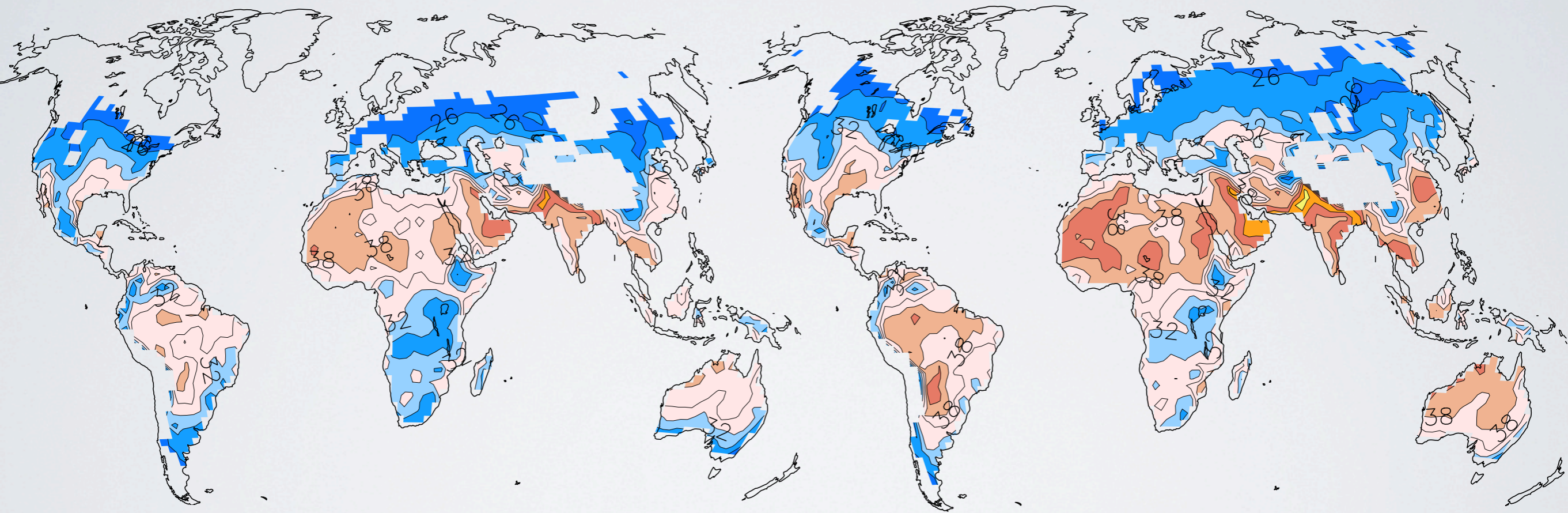
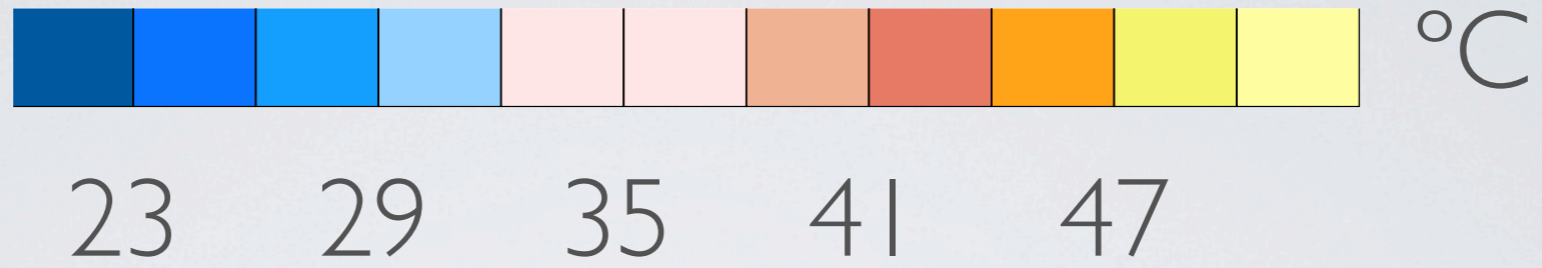
Caution

Extreme Caution

Danger

Extreme Danger

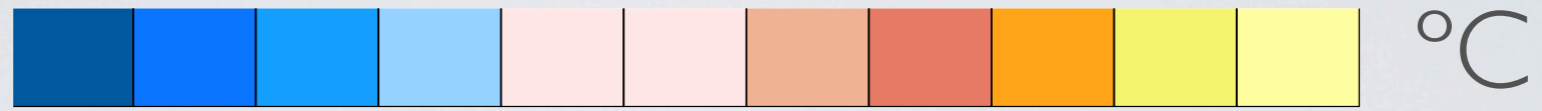
Heat Index ERA Interim 2002-2011



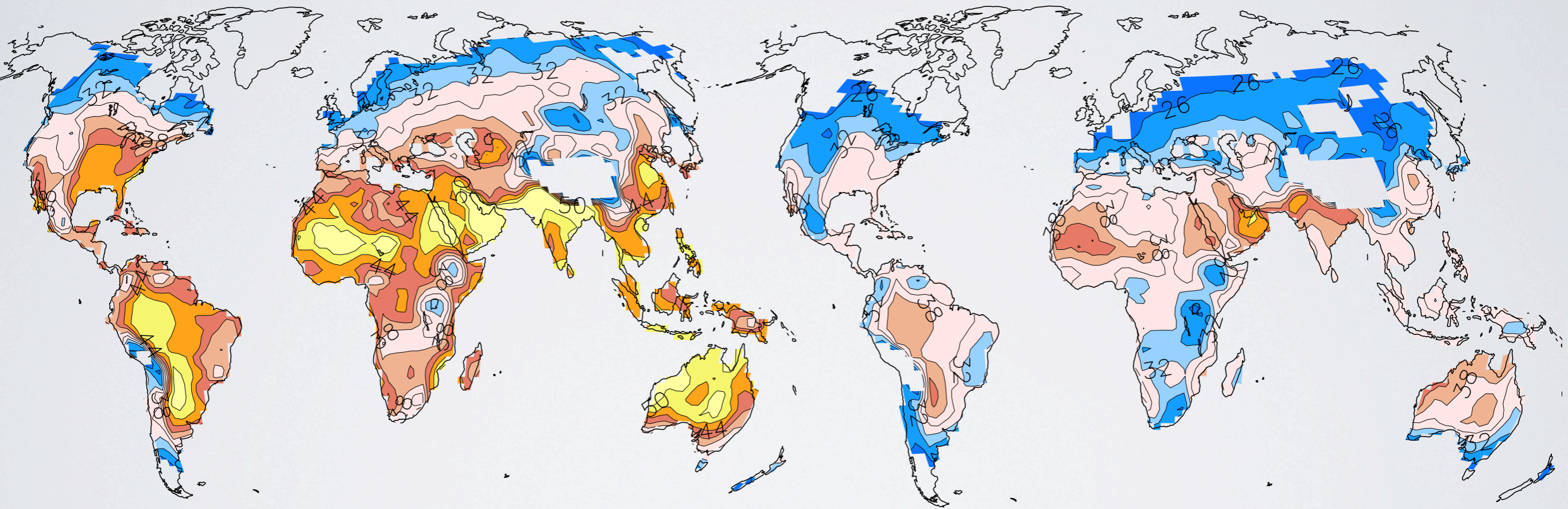
95th Percentile

99th Percentile

Heat Index 95th Percentile



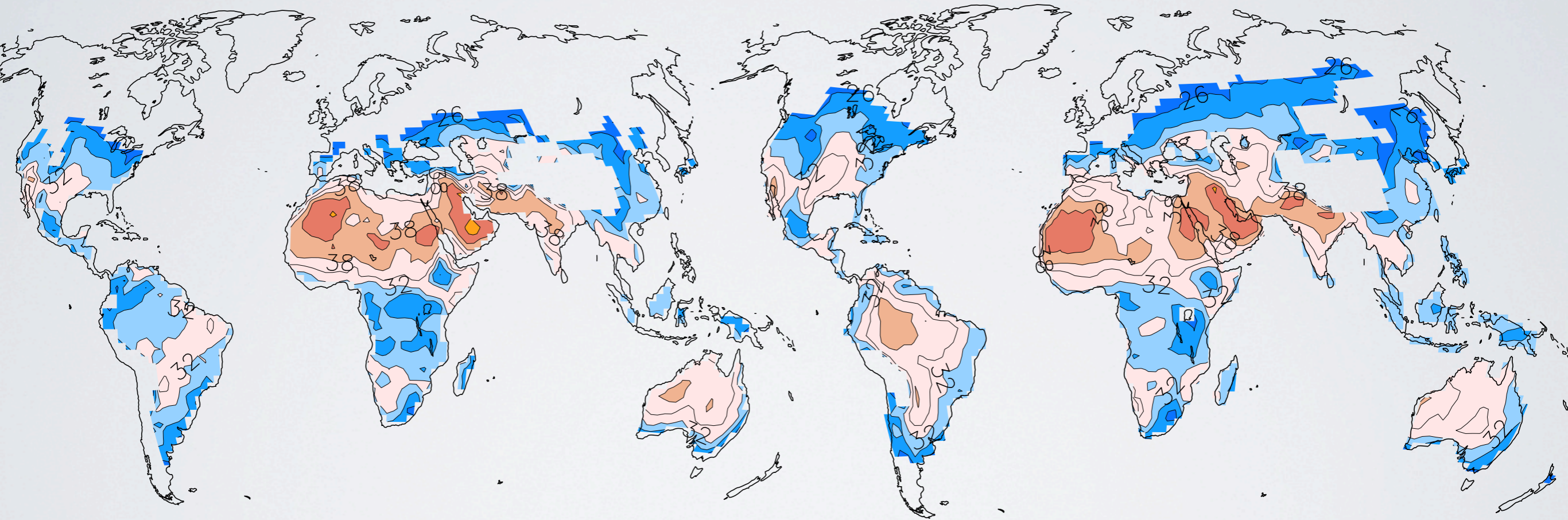
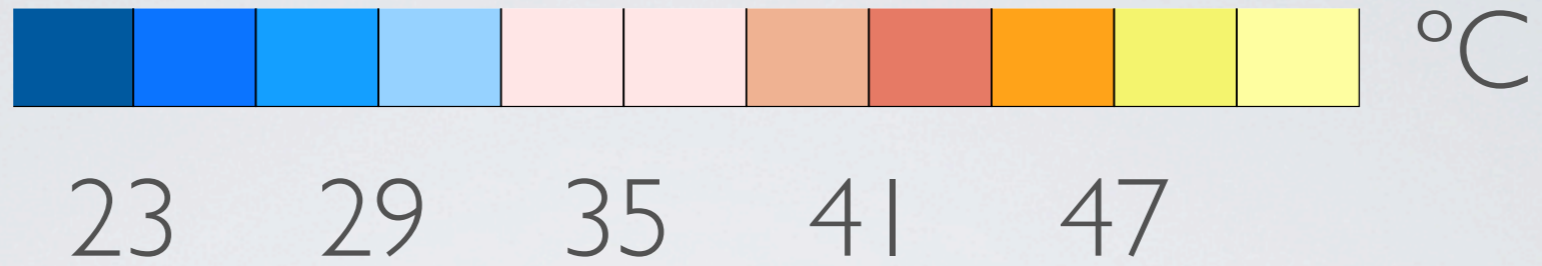
23 29 35 41 47



CESM Slab Ocean | 120 ppmv CO₂

CESM Slab Ocean Modern

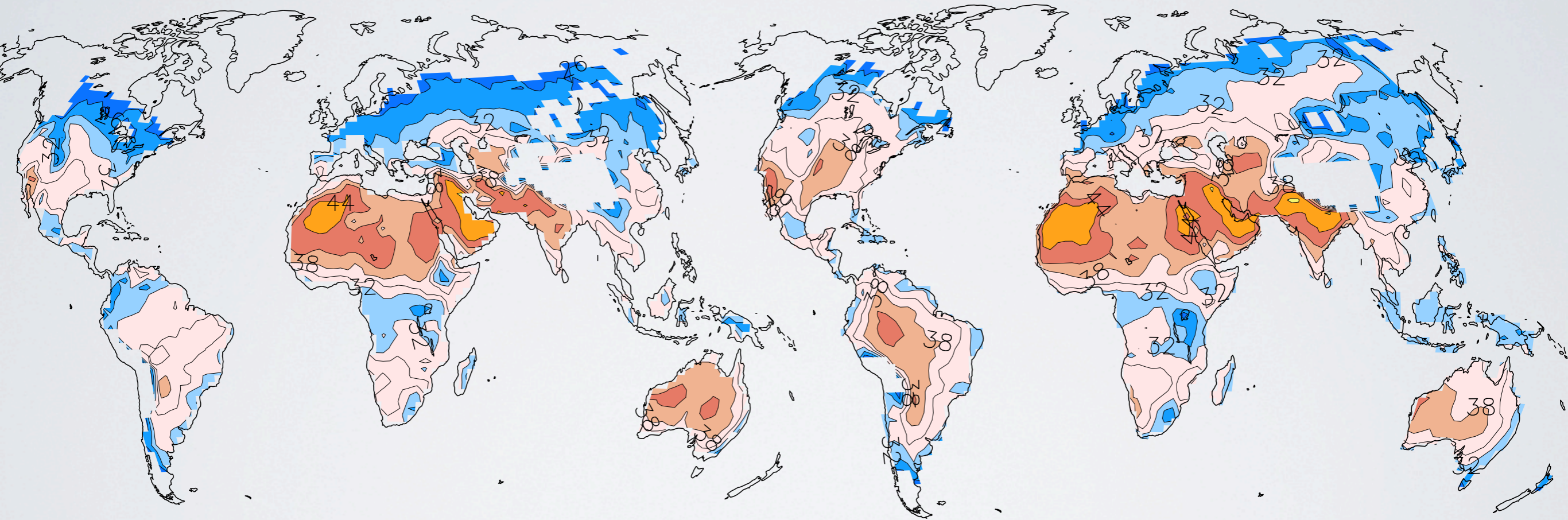
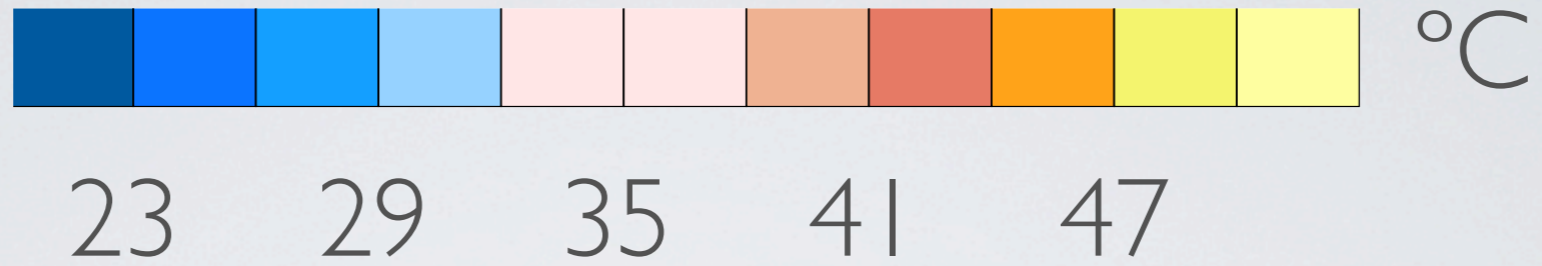
Temperature 95th Percentile



ERA Interim

CESM Slab Ocean Modern

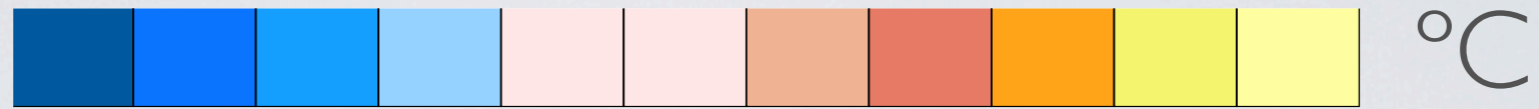
Temperature 99th Percentile



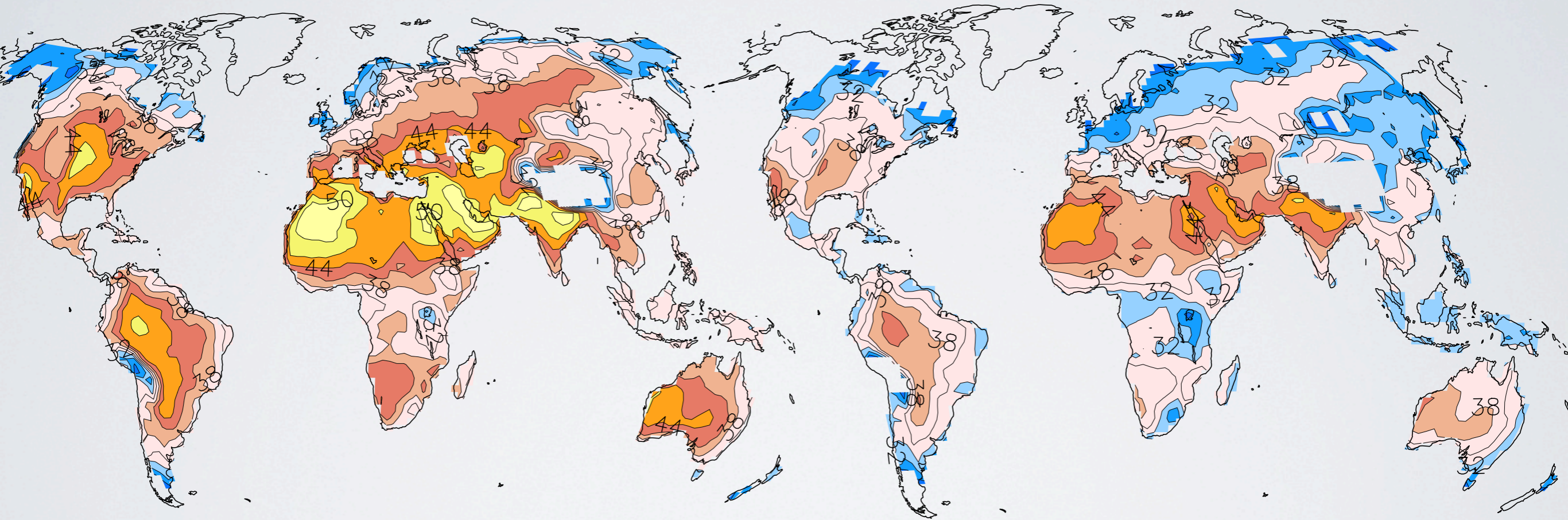
ERA Interim

CESM Slab Ocean Modern

Temperature 99th Percentile



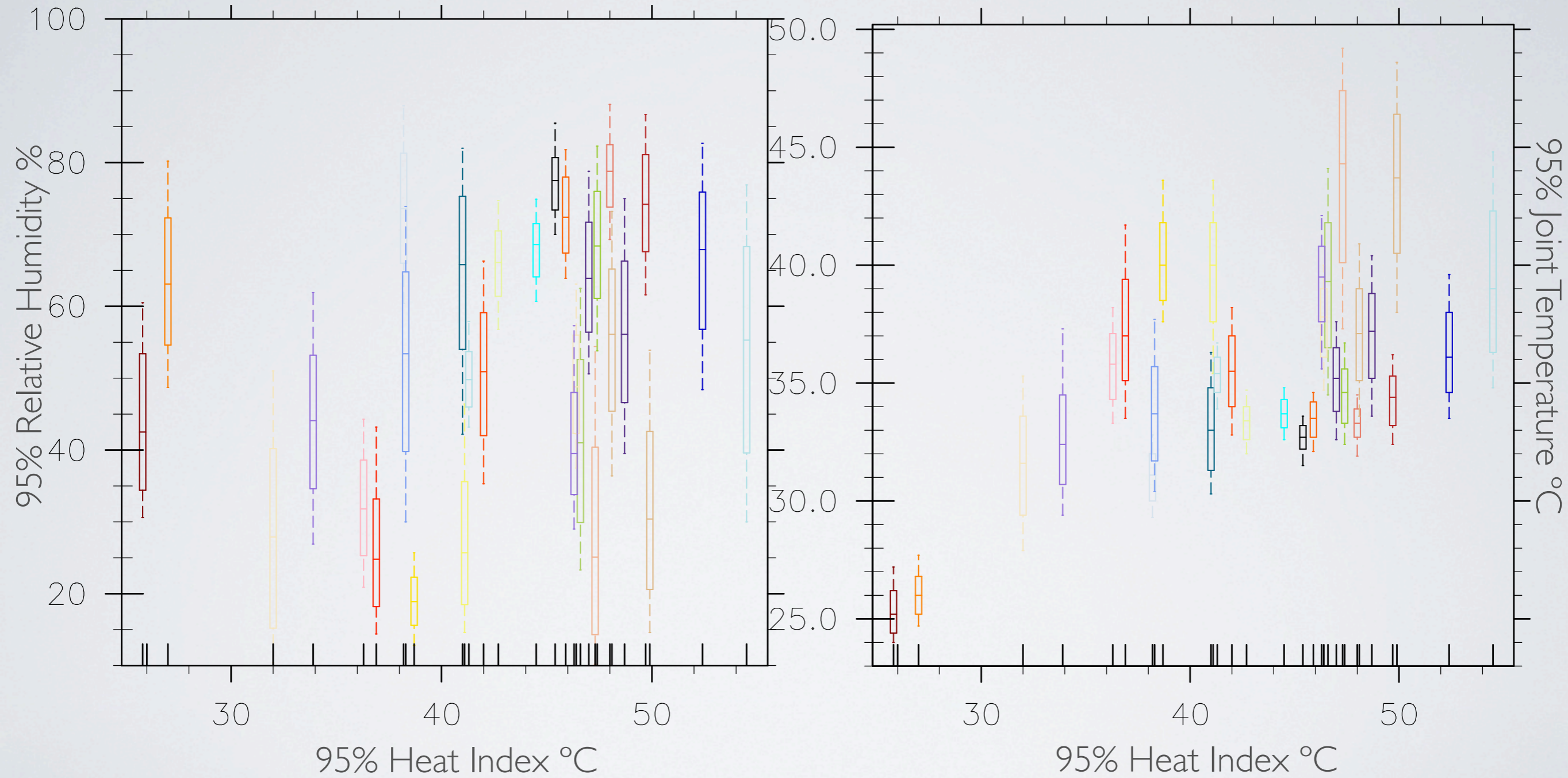
23 29 35 41 47



CESM Slab Ocean | 20 ppmv CO₂

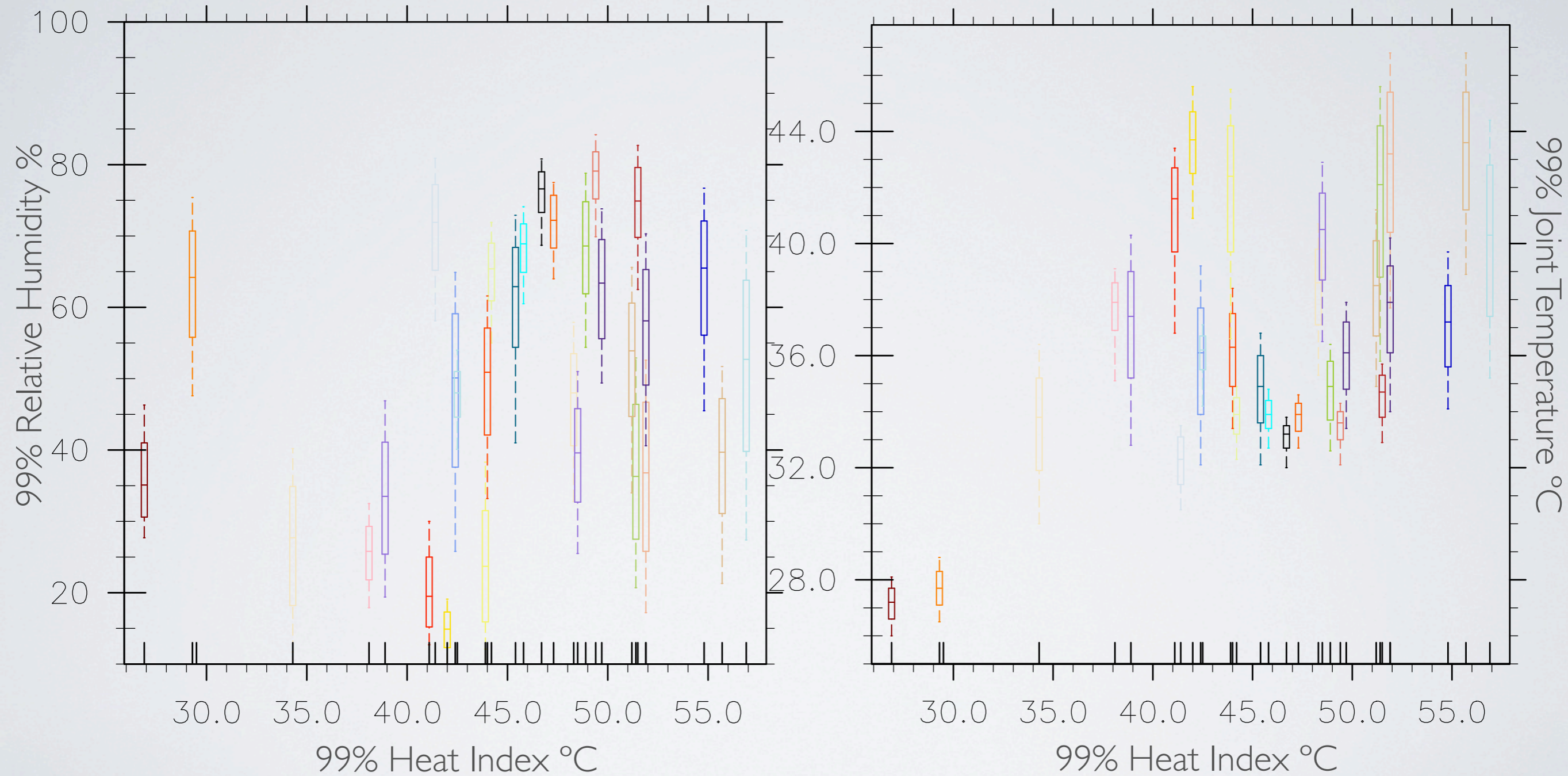
CESM Slab Ocean Modern

Heat Index Joint Distributions **95th Percentile**



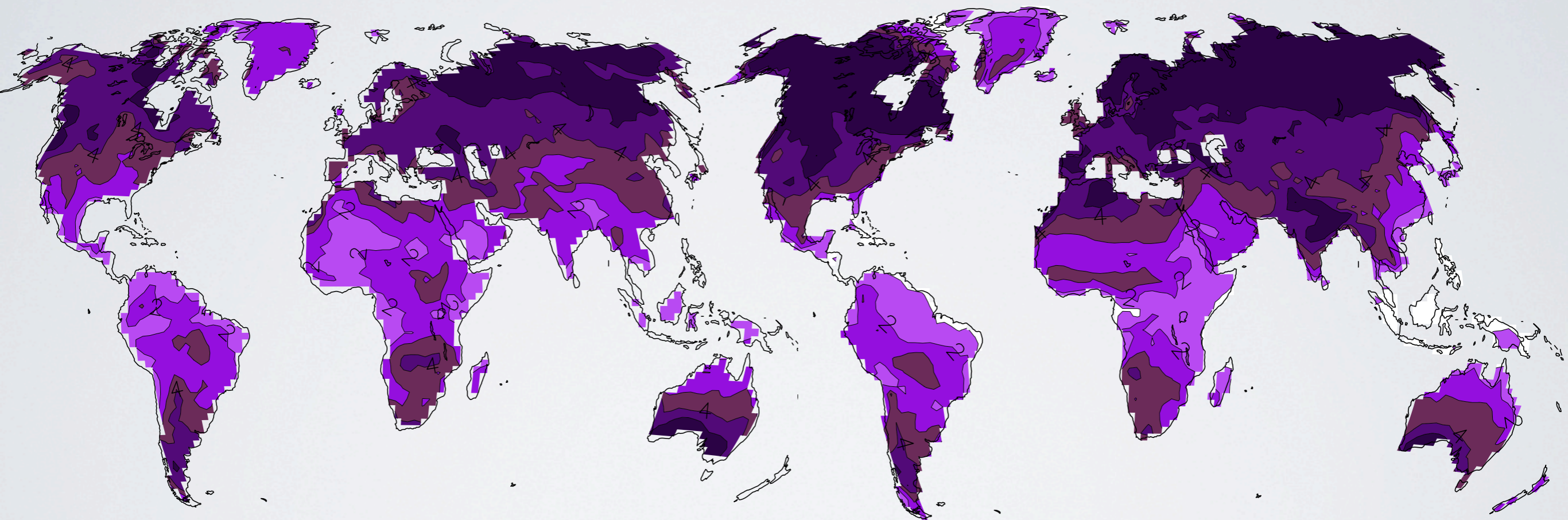
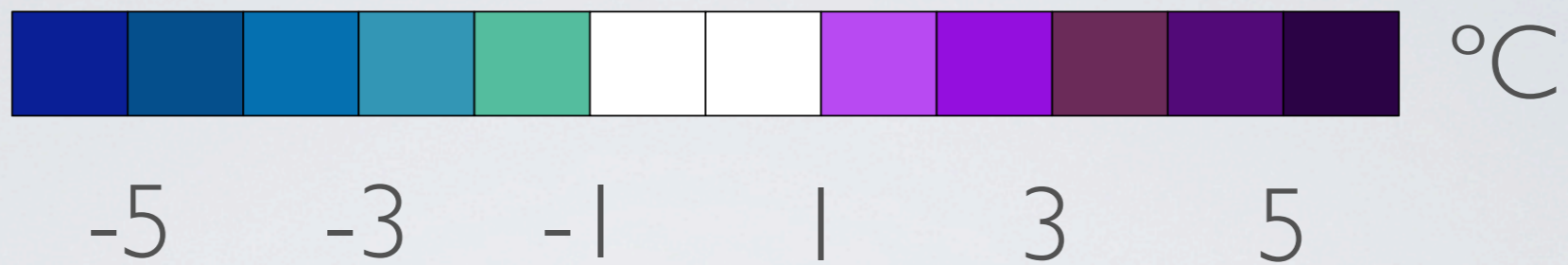
CESM Slab Ocean 1120 ppmv CO₂

Heat Index Joint Distributions **99th Percentile**



CESM Slab Ocean 1120 ppmv CO₂

Temperature 99th - 95th Percentile Change



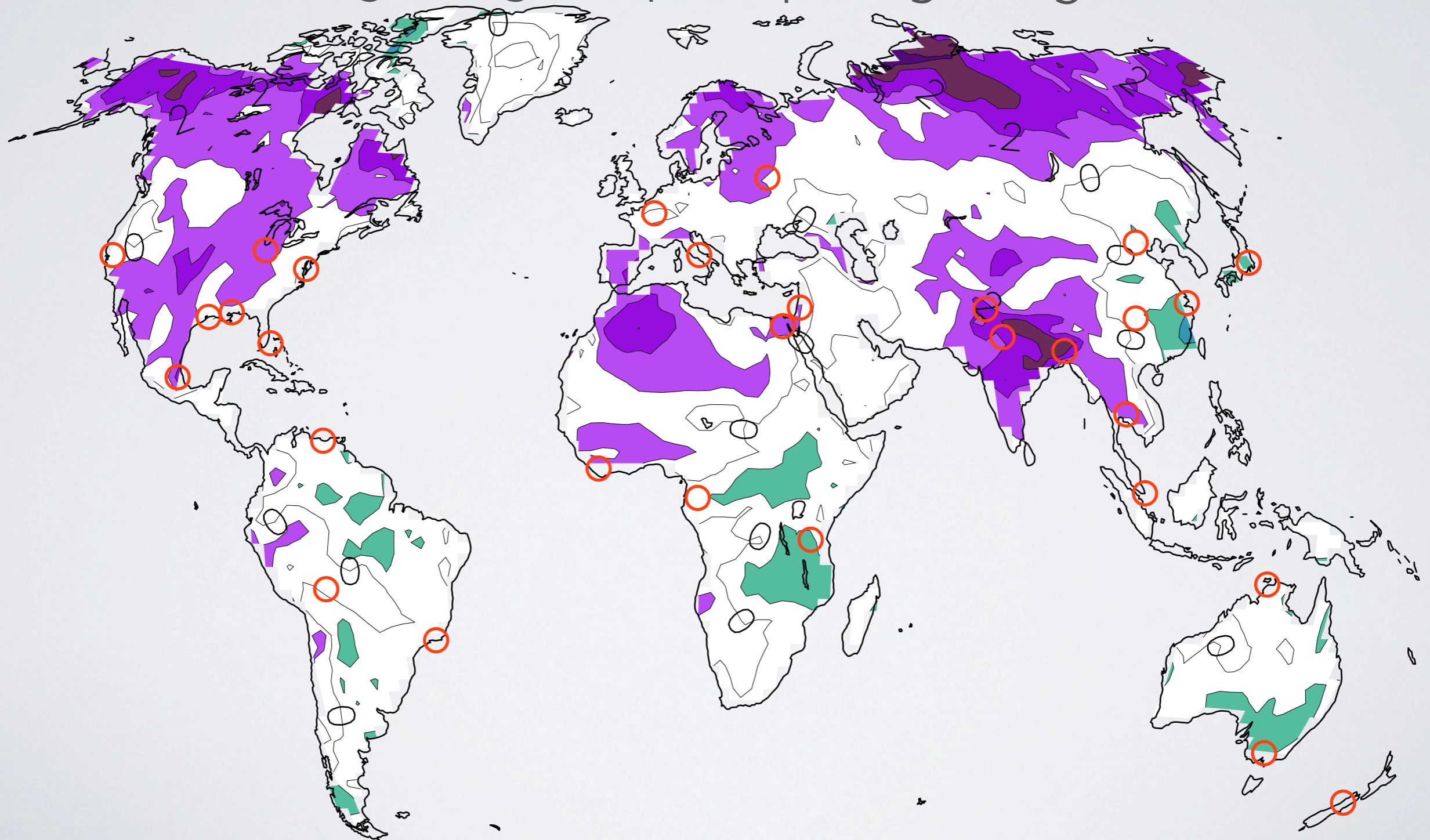
ERA Interim

CESM Slab Ocean Modern

Temperature

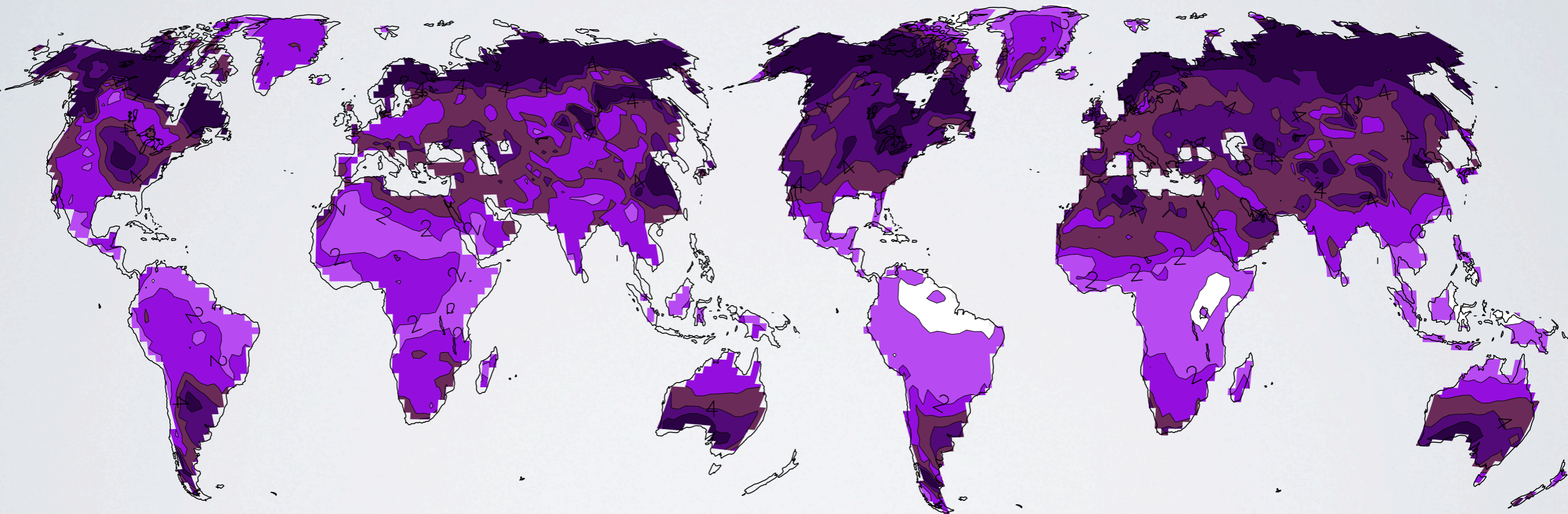
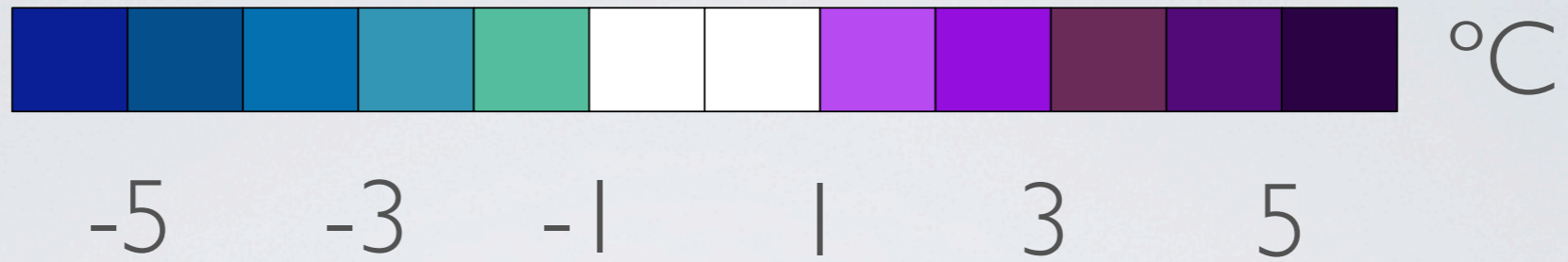
99th - 95th Percentile Change

CESM Slab Ocean Modern - ERA Interim



Heat Index

99th - 95th Percentile Change

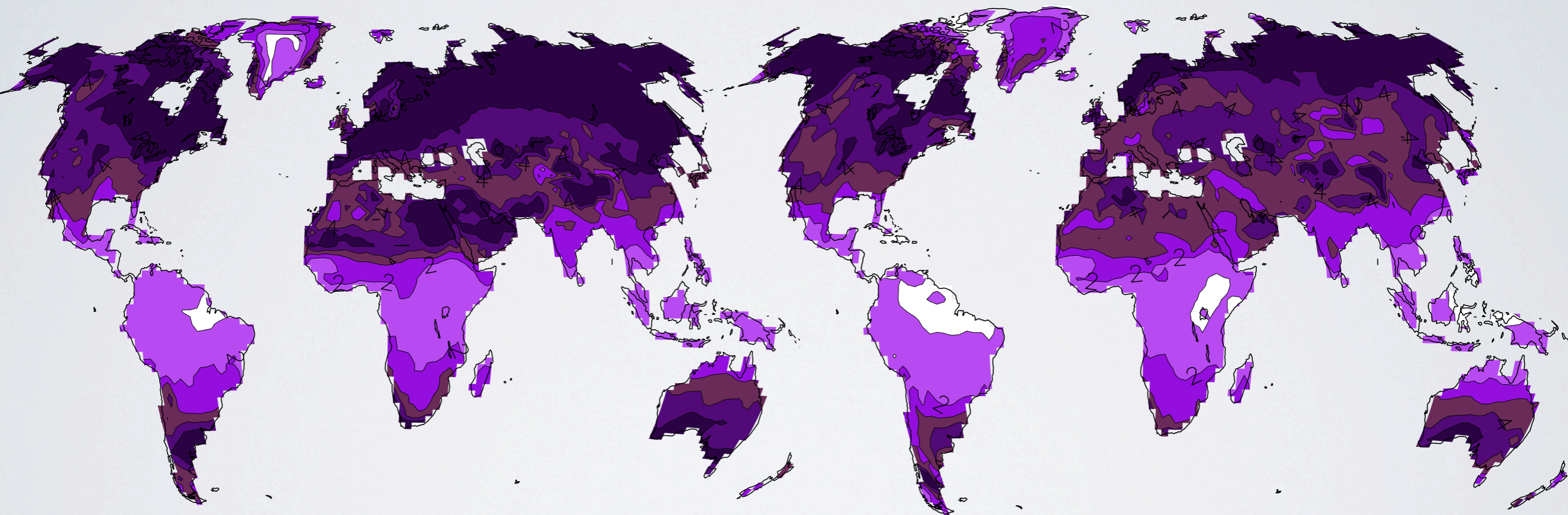
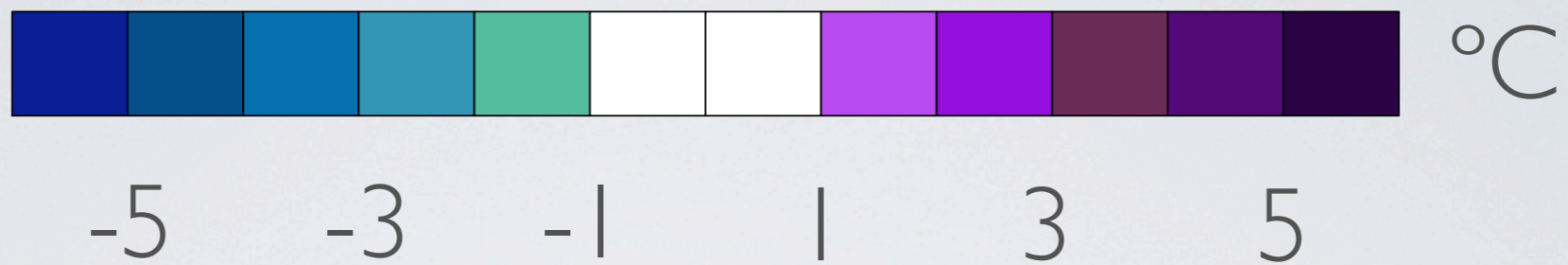


ERA Interim

CESM Slab Ocean Modern

Heat Index

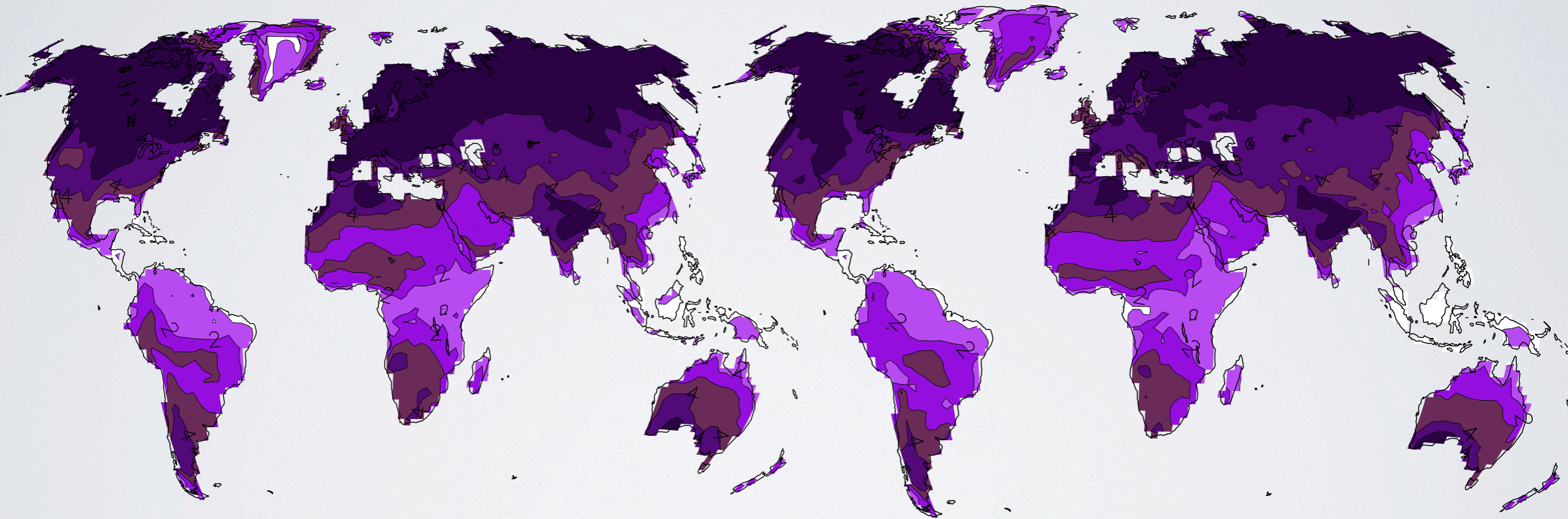
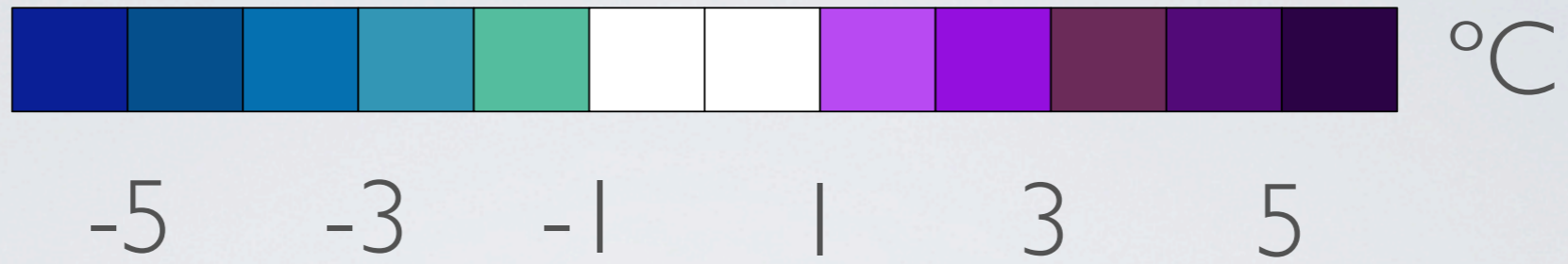
99th - 95th Percentile Change



CESM Slab Ocean | 20 ppmv CO₂

CESM Slab Ocean Modern

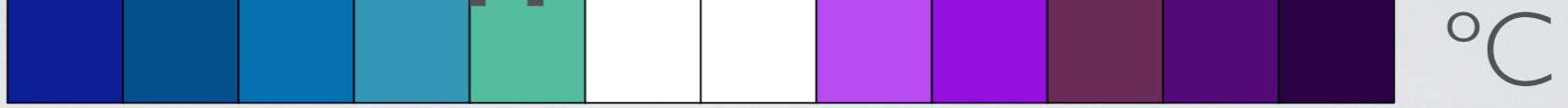
Temperature
99th - 95th Percentile Change



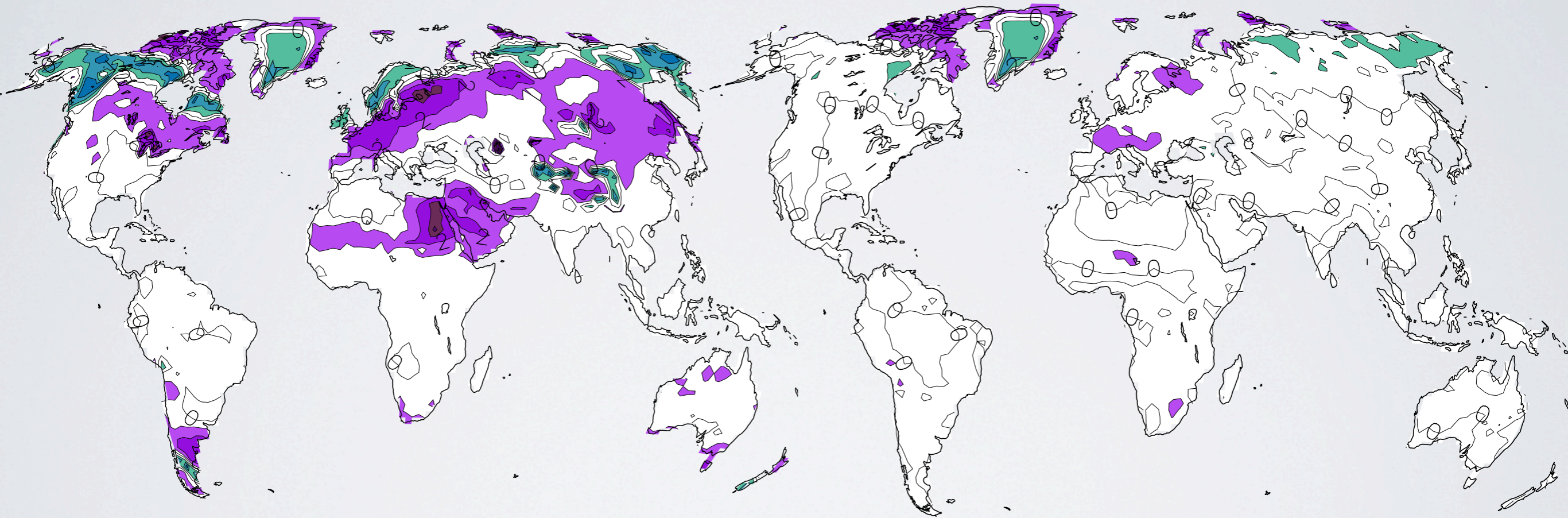
CESM Slab Ocean | 20 ppmv CO₂

CESM Slab Ocean Modern

Heat Index vs Temperature
99th - 95th Percentile Change
CESM I120 ppmv - CESM Modern



-5 -3 -1 1 3 5 °C



Heat Index

Temperature