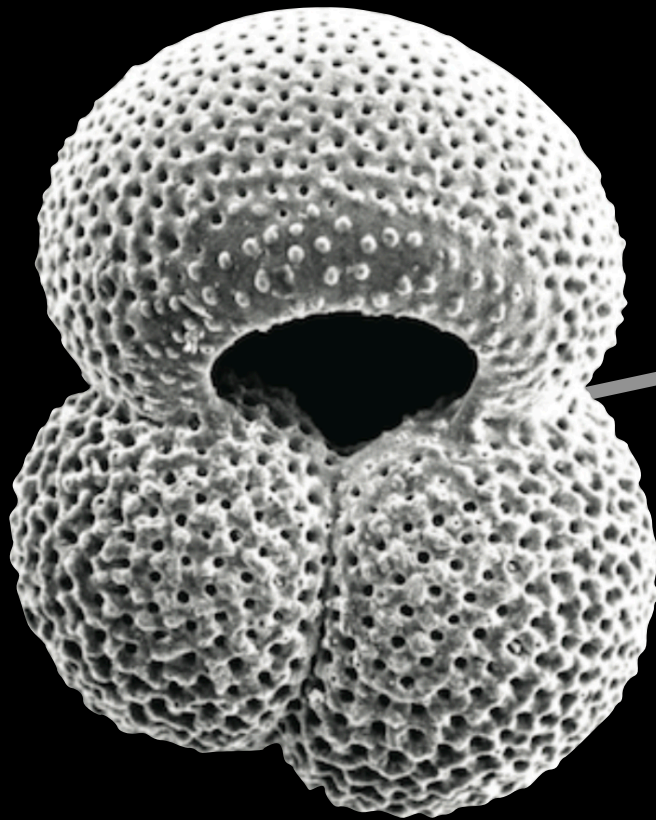


# Combining and contextualizing foraminiferal reconstructions and climate models

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**Kaustubh Thirumalai**  
University of Arizona



# Combining and contextualizing foraminiferal reconstructions and climate models

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**Kaustubh Thirumalai**  
University of Arizona



# Foraminiferal Reconstructions



# Foraminiferal Reconstructions

Section & Sample



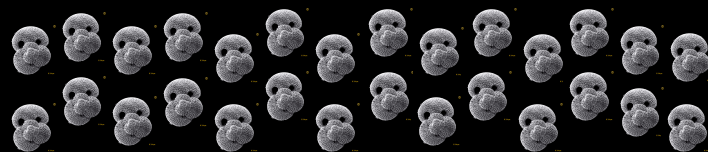


# Foraminiferal Reconstructions

Section & Sample



*Globigerinoides ruber*



$n$  forams = 1 sample

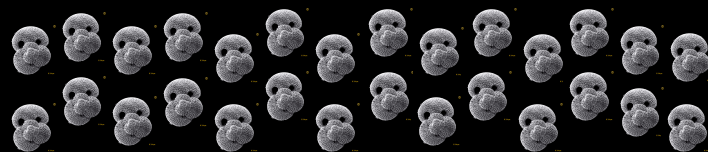


# Foraminiferal Reconstructions

Section & Sample



*Globigerinoides ruber*



$n$  forams = 1 sample

$$\delta^{18}\text{O} = f(T, \delta^{18}\text{O}_{\text{sw}})$$



Isotope Machine

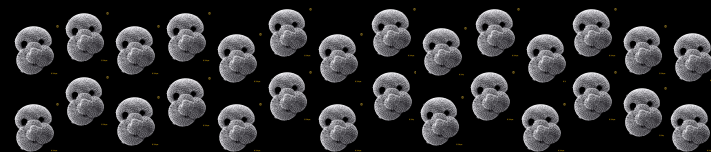


# Foraminiferal Reconstructions

Section & Sample



*Globigerinoides ruber*

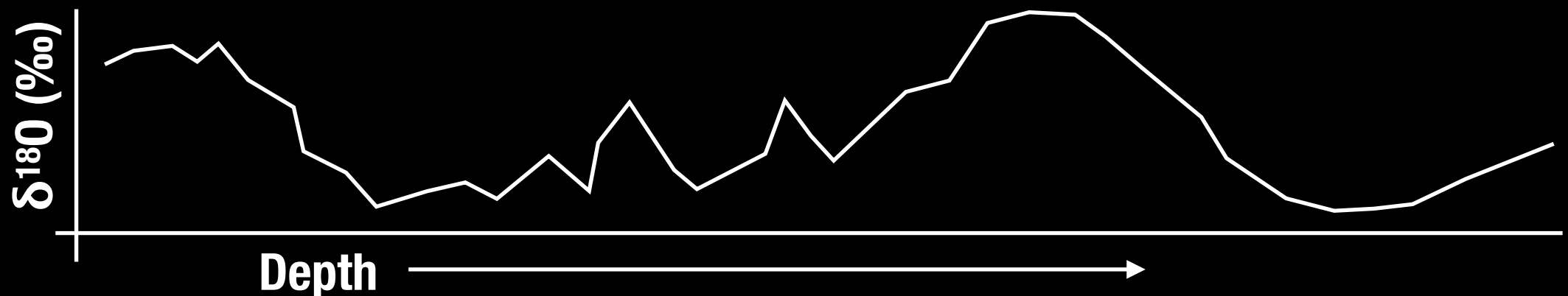


$n$  forams = 1 sample

$$\delta^{18}\text{O} = f(T, \delta^{18}\text{O}_{\text{sw}})$$



Isotope Machine

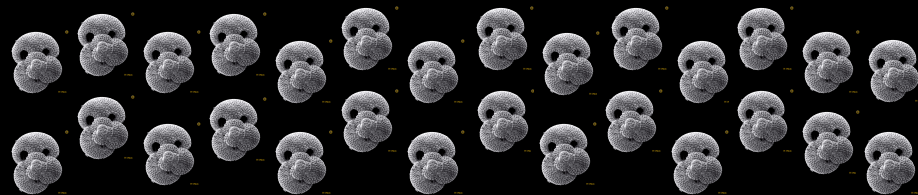




# Individual Foraminiferal Analyses

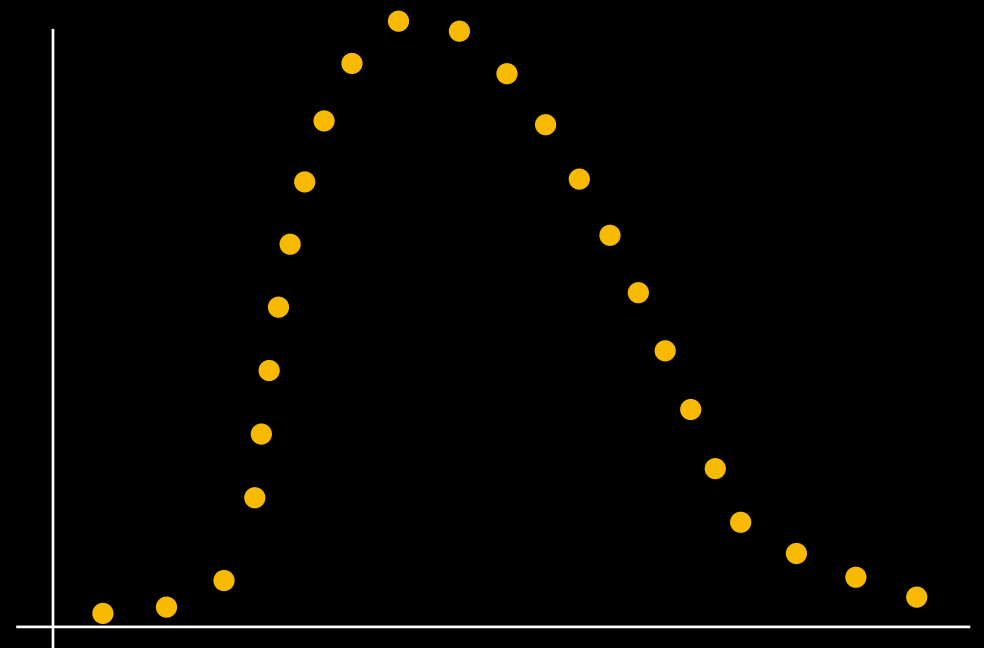
Modern Core-Top

$n$  forams =  $n$  "months" sampled



$\delta^{18}O$  (‰)

Frequency

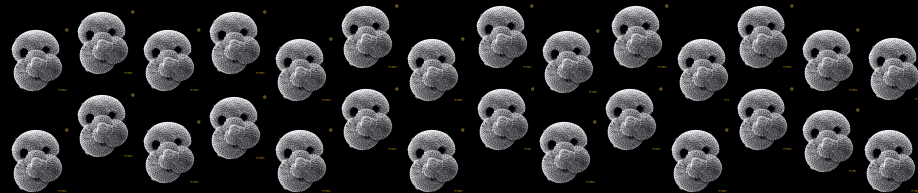




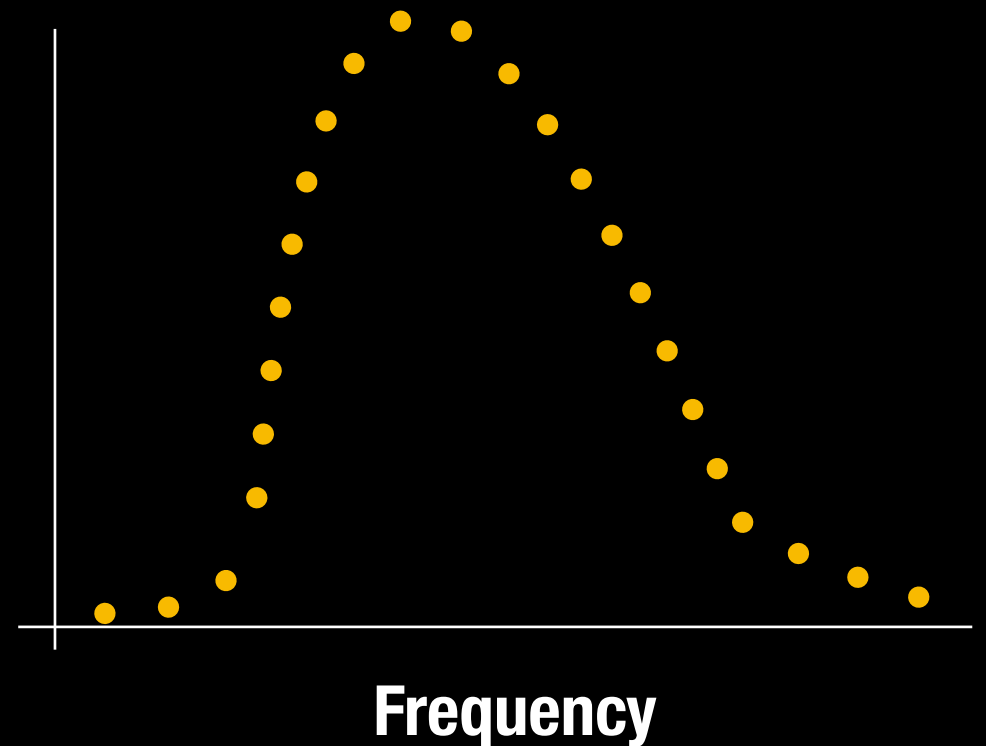
# Individual Foraminiferal Analyses

Modern Core-Top

$n$  forams =  $n$  "months" sampled



$\delta^{18}O$  (‰)

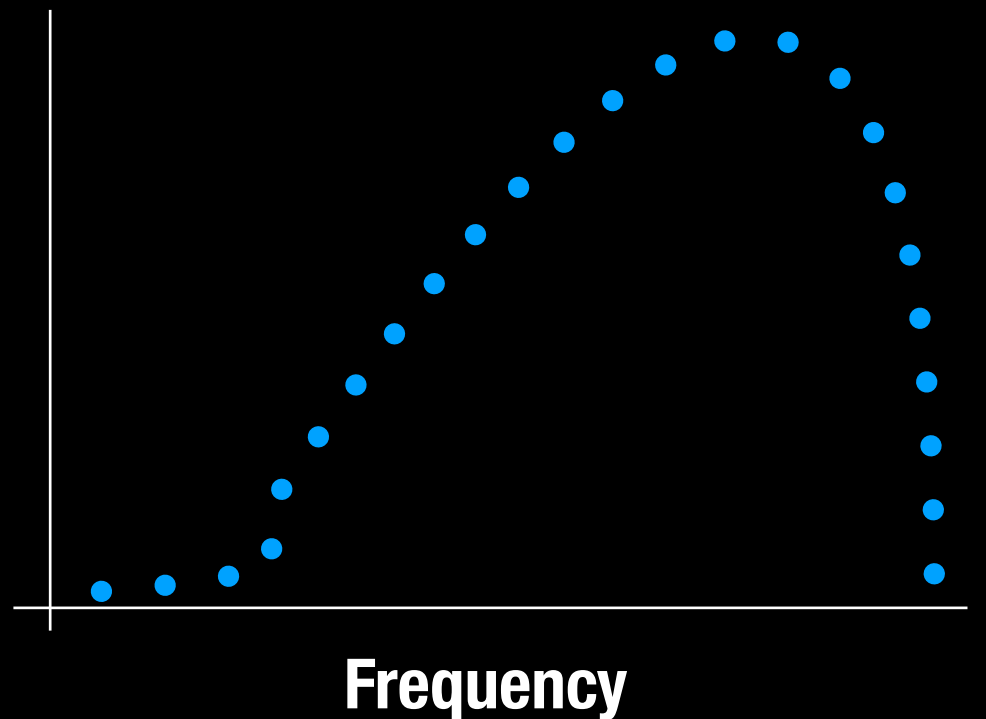


Downcore Sample

$n$  forams =  $n$  samples



$\delta^{18}O$  (‰)

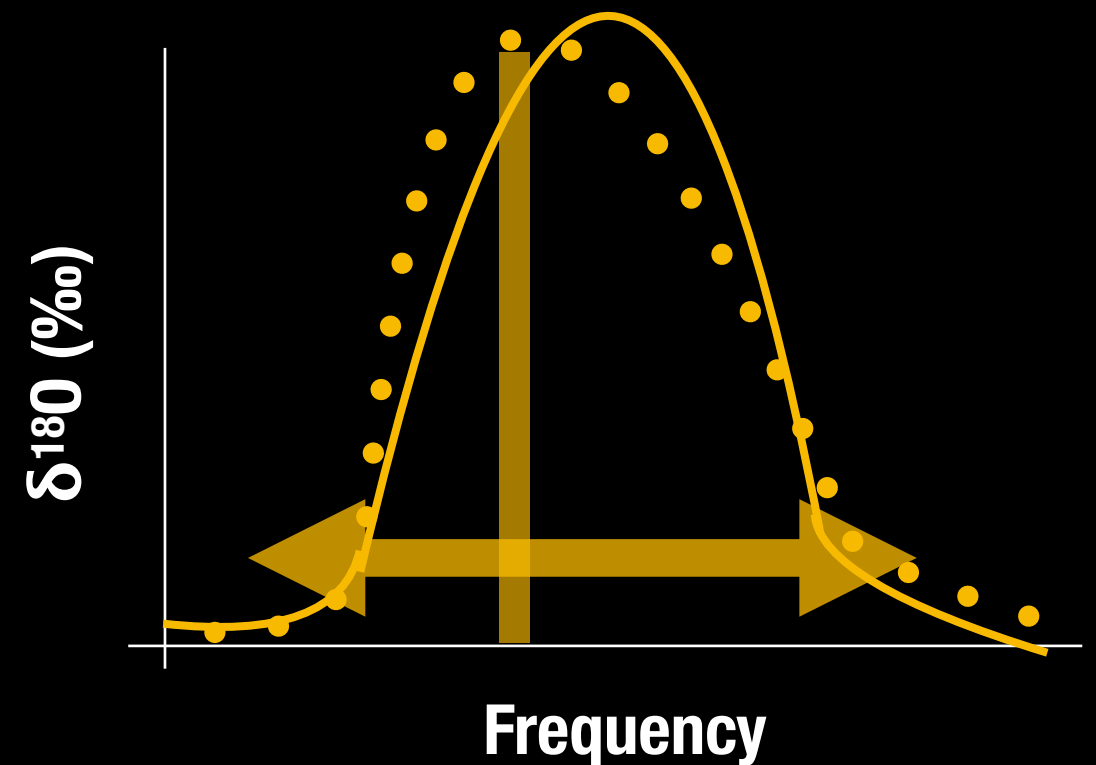
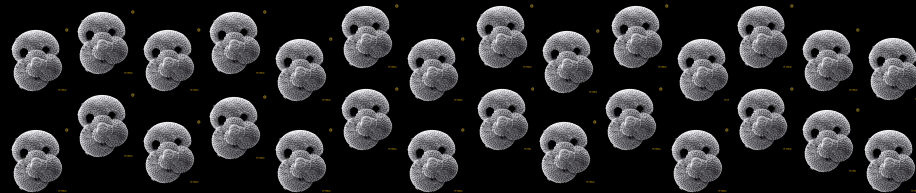




# Individual Foraminiferal Analyses

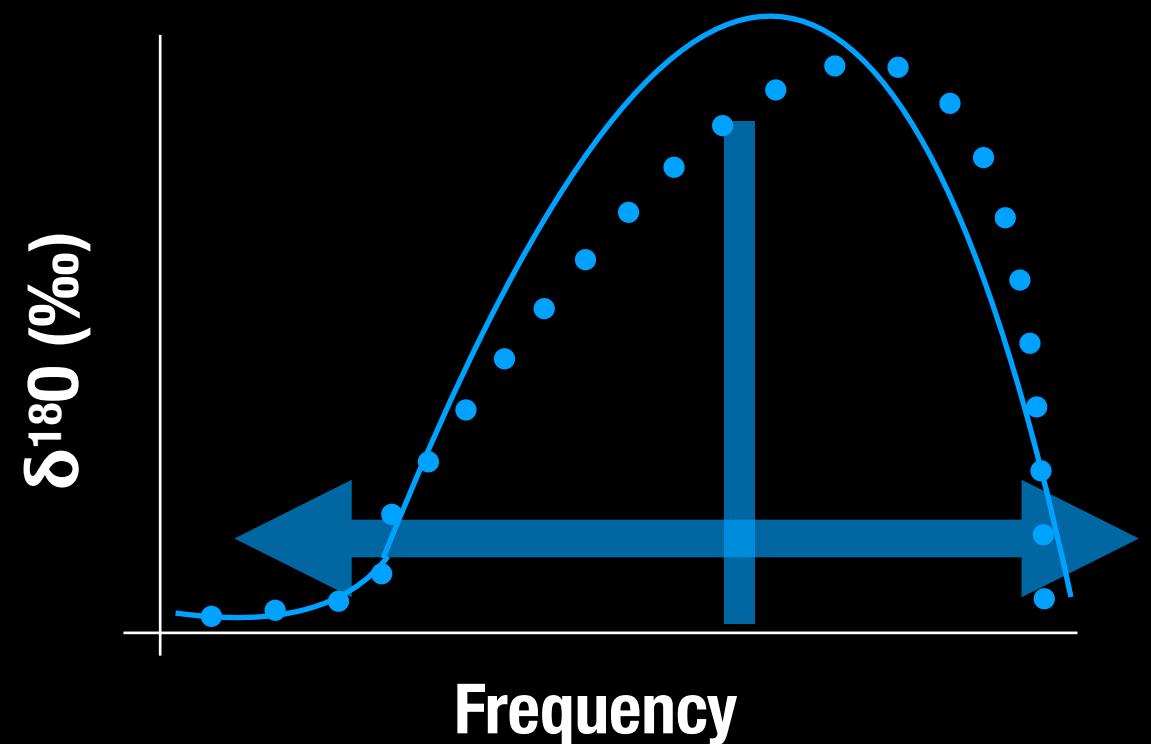
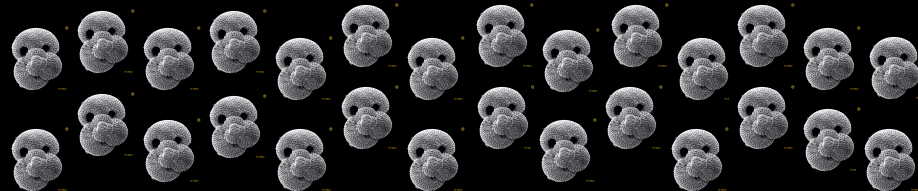
Modern Core-Top

$n$  forams =  $n$  "months" sampled

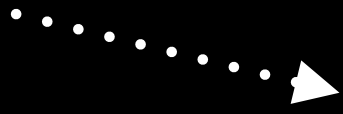


Downcore Sample

$n$  forams =  $n$  samples





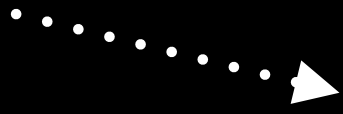


$$\delta^{18}\text{O} = f(T, \delta^{18}\text{O}_{\text{sw}})$$

Lifespan=1 month

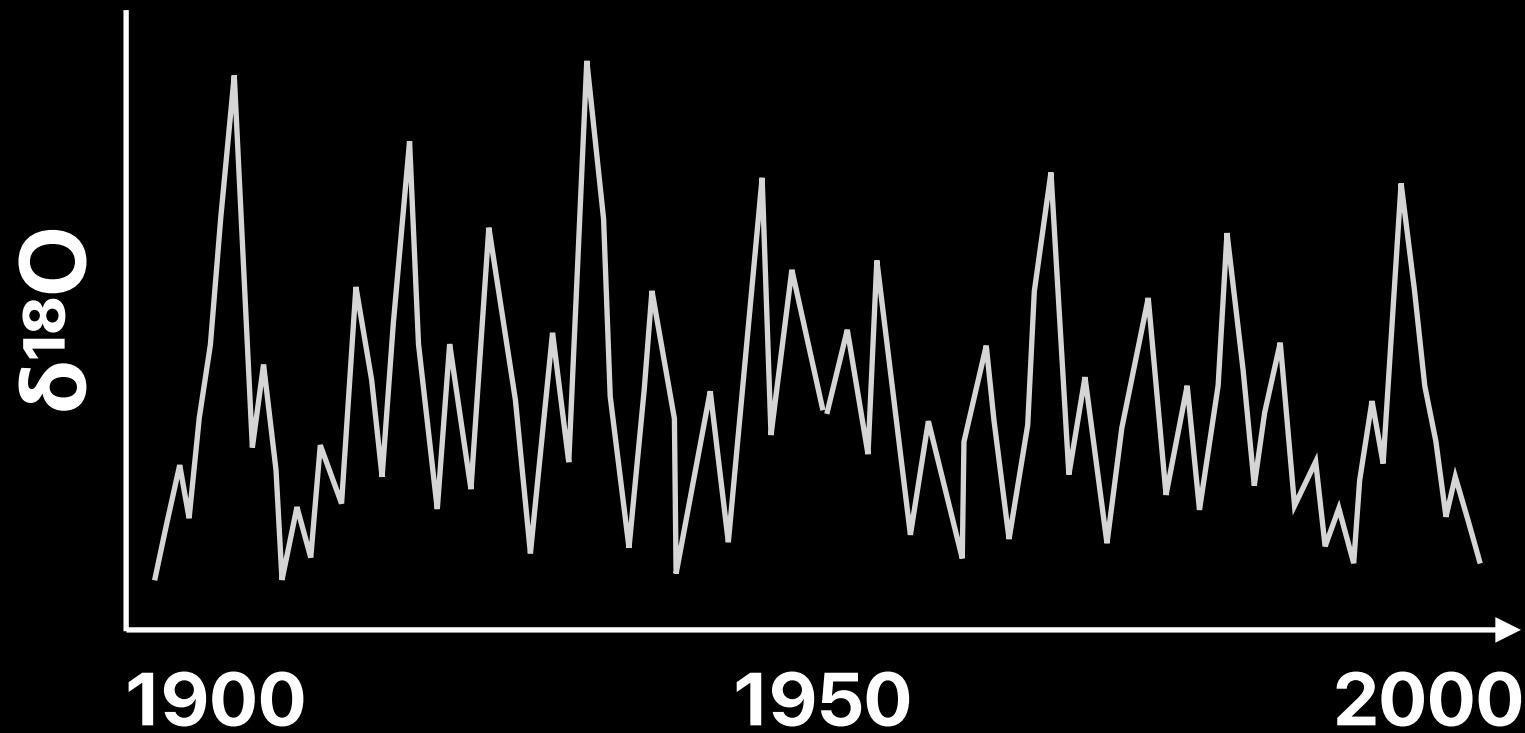
# Forward Modeling Foraminifera



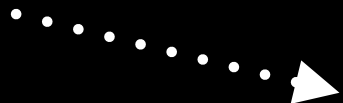


$$\delta^{18}\text{O} = f(T, \delta^{18}\text{O}_{\text{sw}})$$

Lifespan=1 month

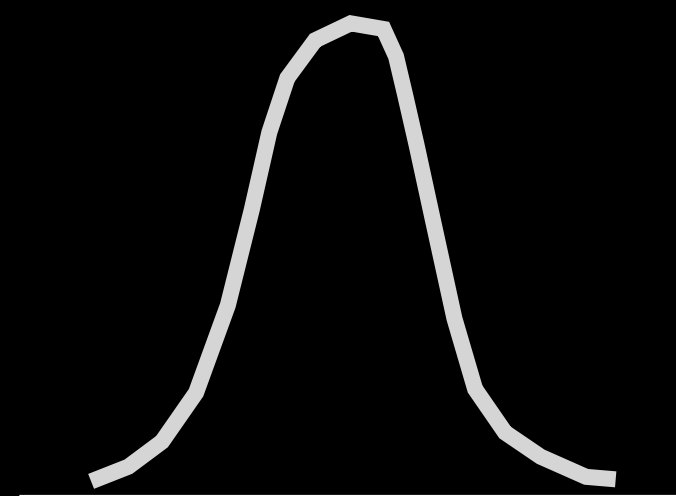
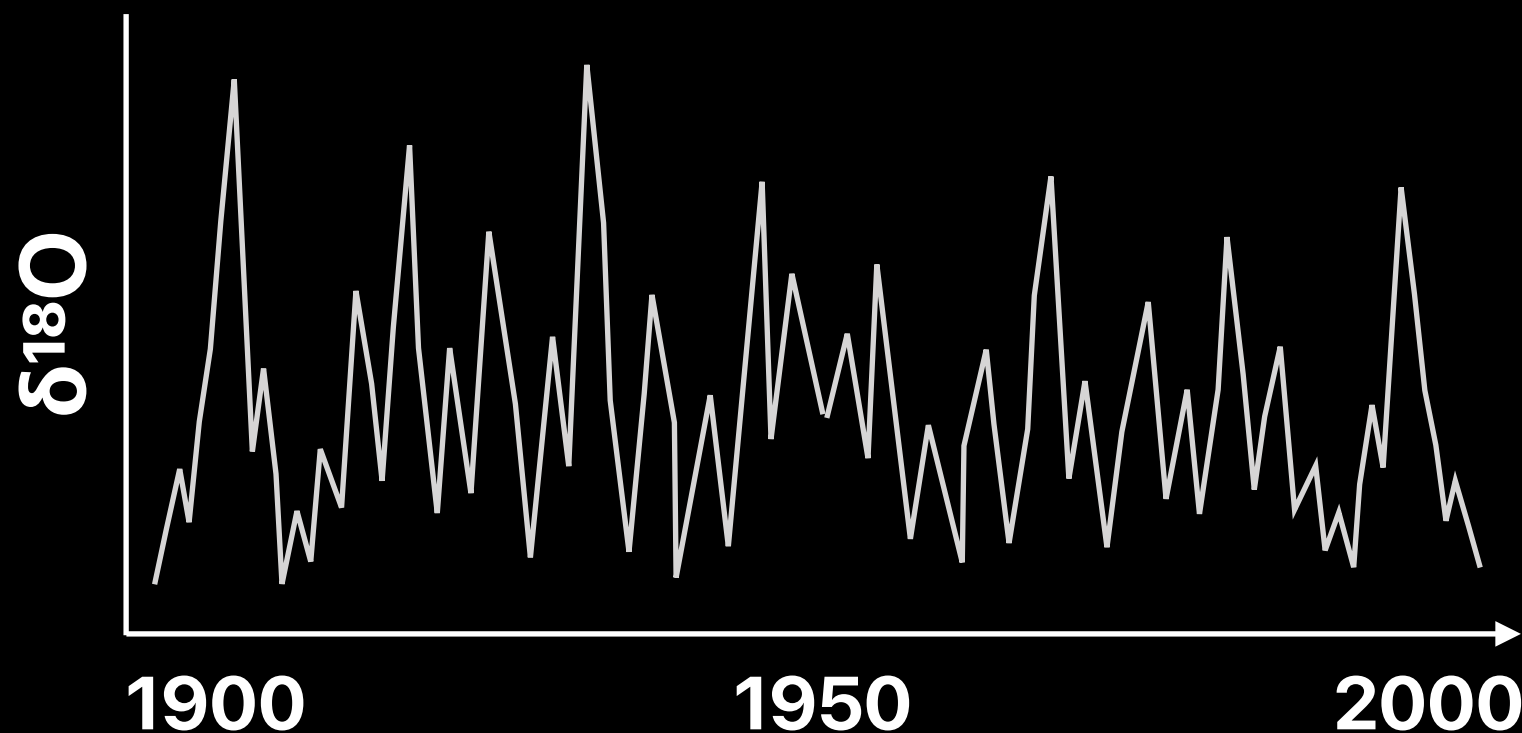


# Forward Modeling Foraminifera



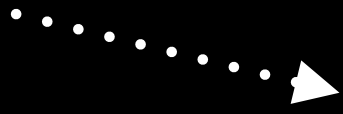
$$\delta^{18}\text{O} = f(T, \delta^{18}\text{O}_{\text{sw}})$$

Lifespan=1 month



# Forward Modeling Foraminifera

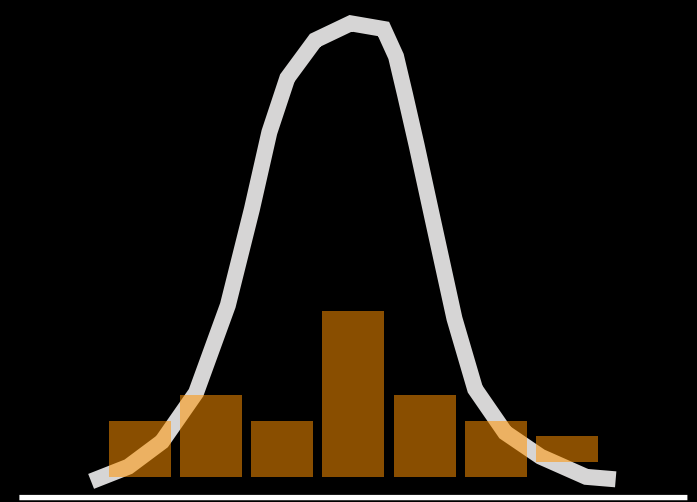
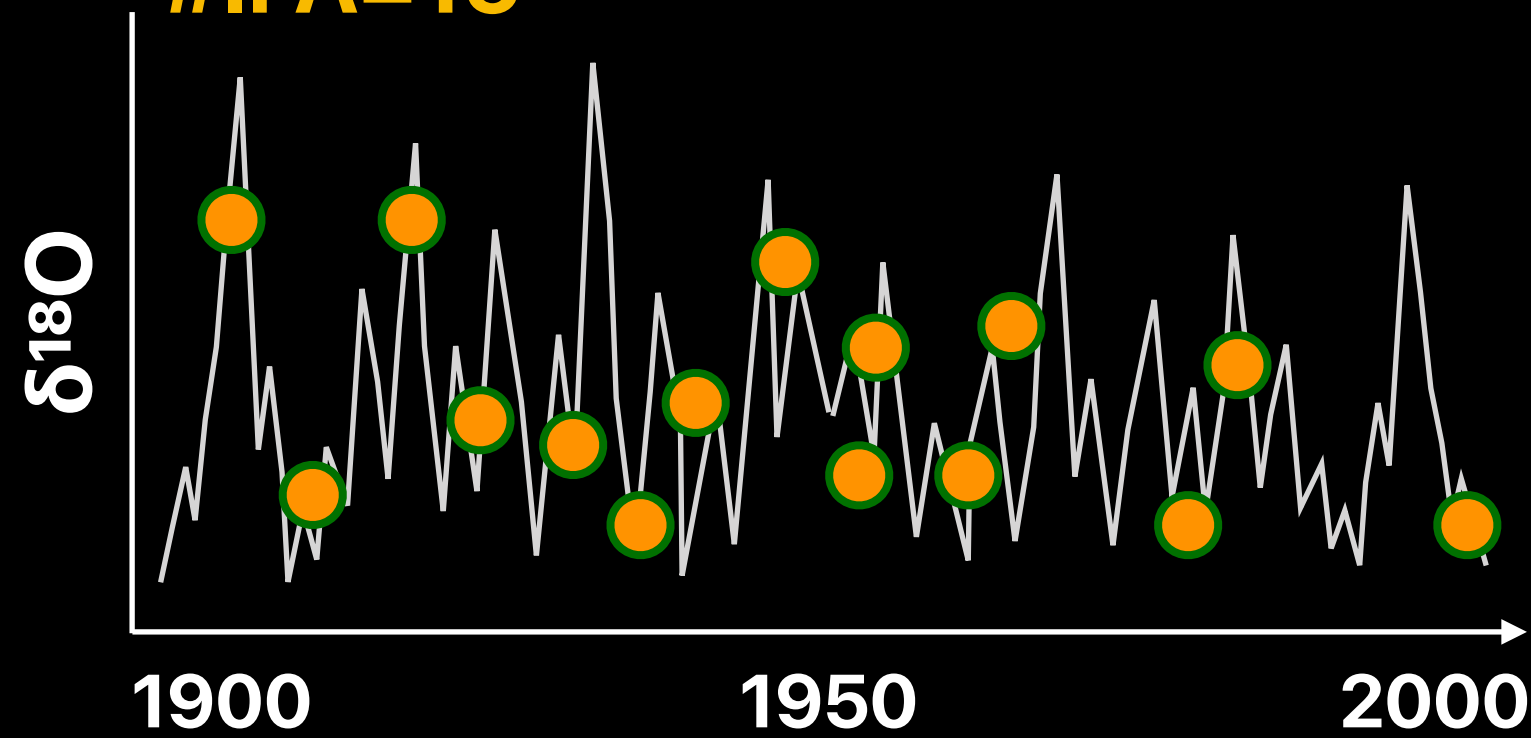




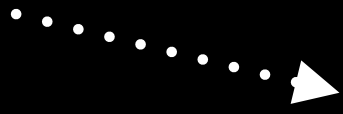
$$\delta^{18}\text{O} = f(T, \delta^{18}\text{O}_{\text{sw}})$$

Lifespan=1 month

#IFA=15



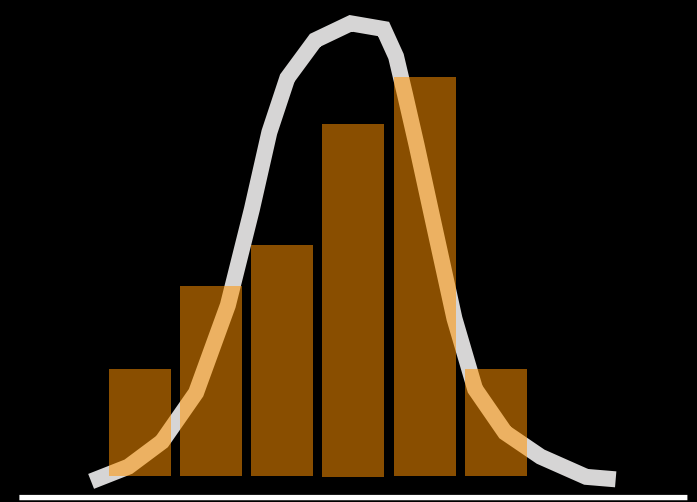
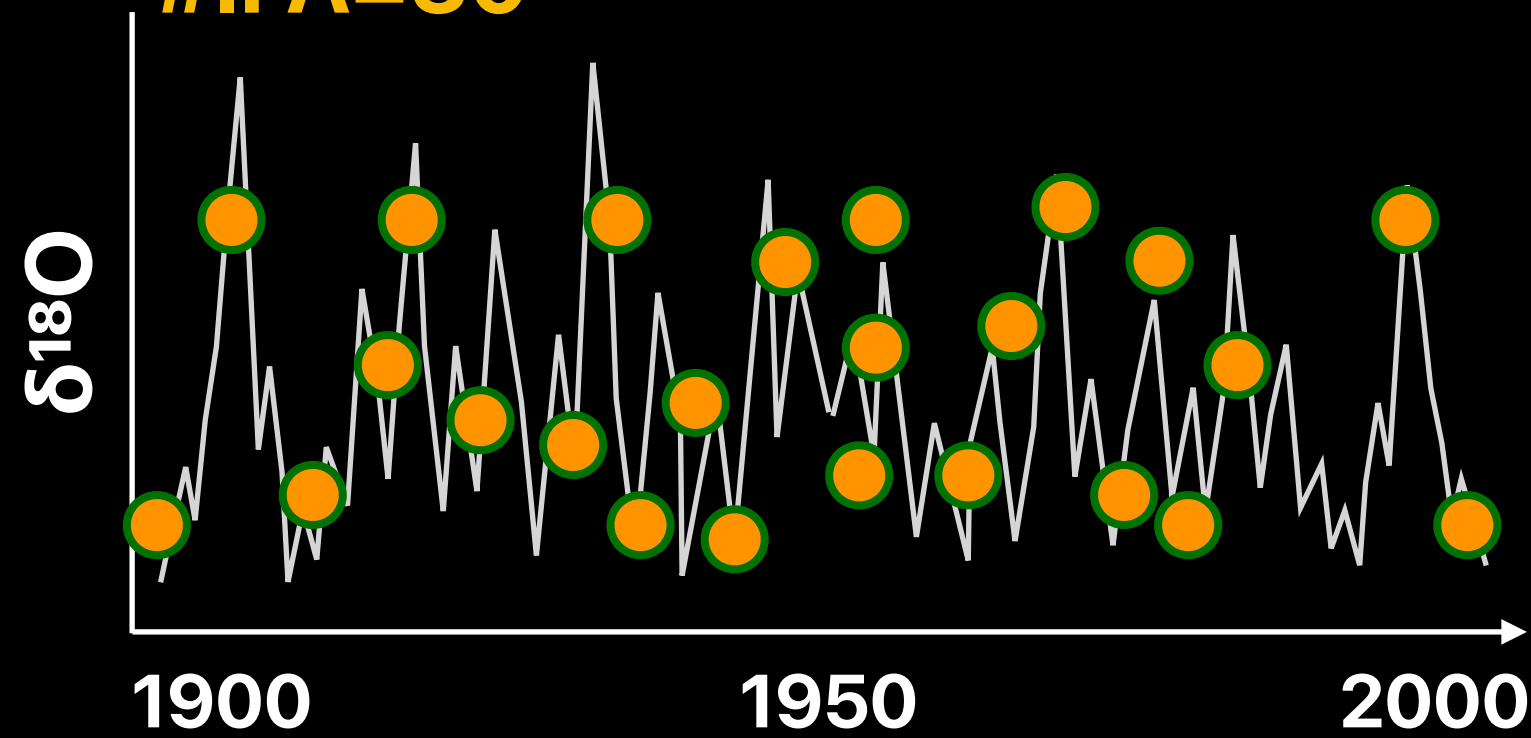
# Forward Modeling Foraminifera



$$\delta^{18}\text{O} = f(T, \delta^{18}\text{O}_{\text{sw}})$$

Lifespan=1 month

#IFA=30

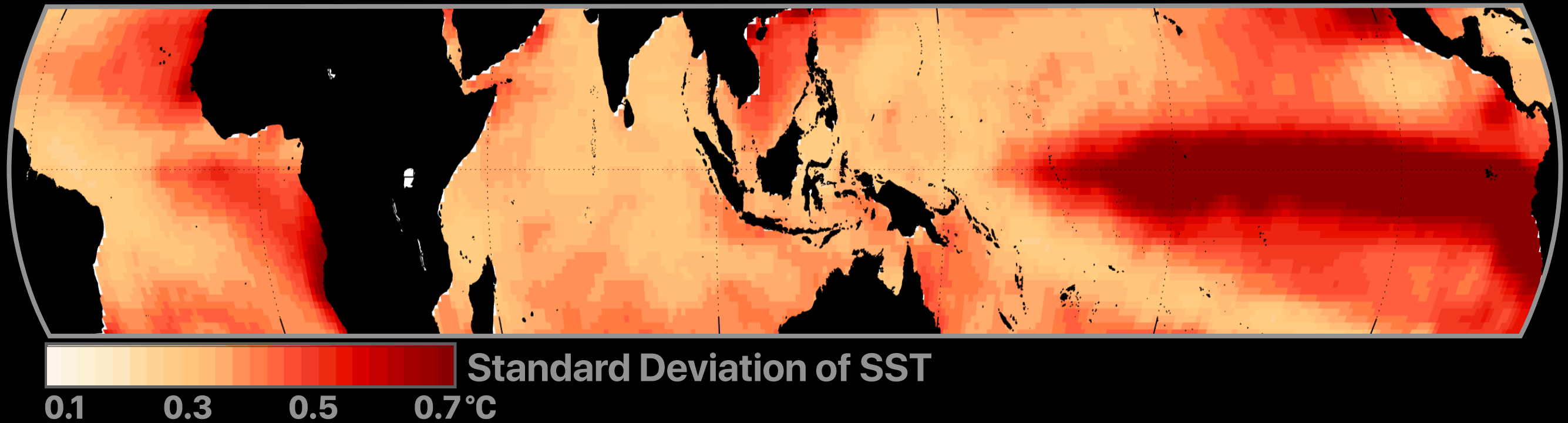


# Forward Modeling Foraminifera

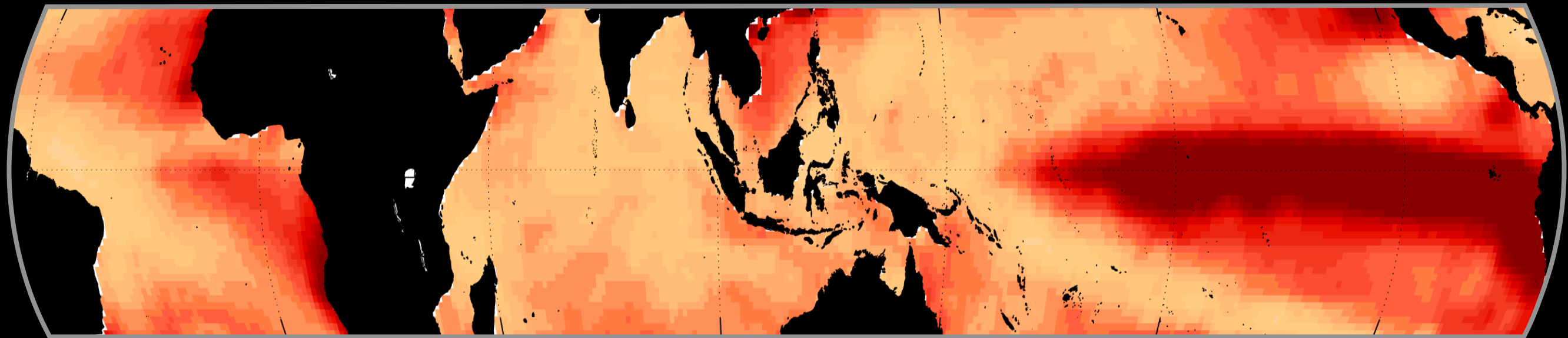


# Climate Variability in the Indian Ocean

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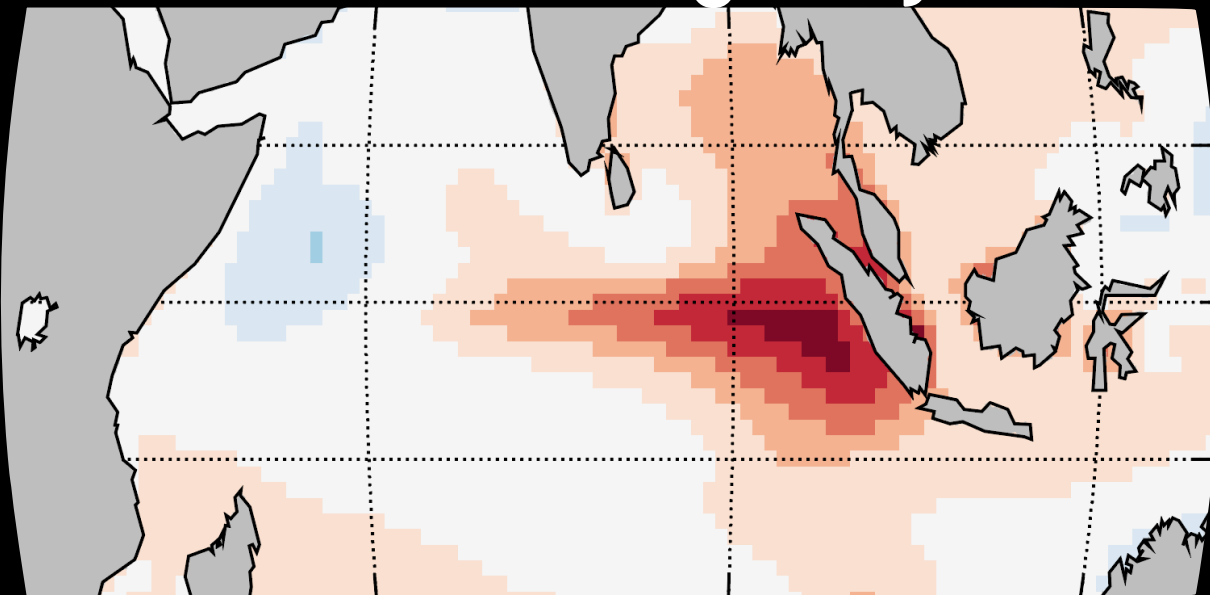


# Climate Variability in the Indian Ocean

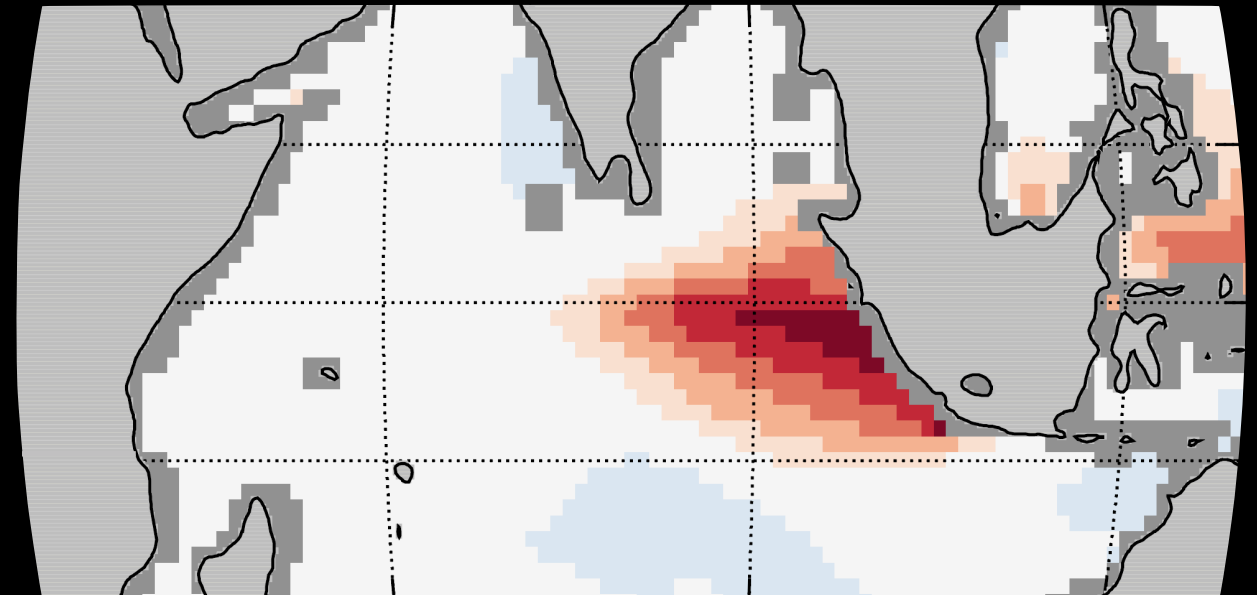


Standard Deviation of SST  
0.1 0.3 0.5 0.7°C

## Global Warming Projection



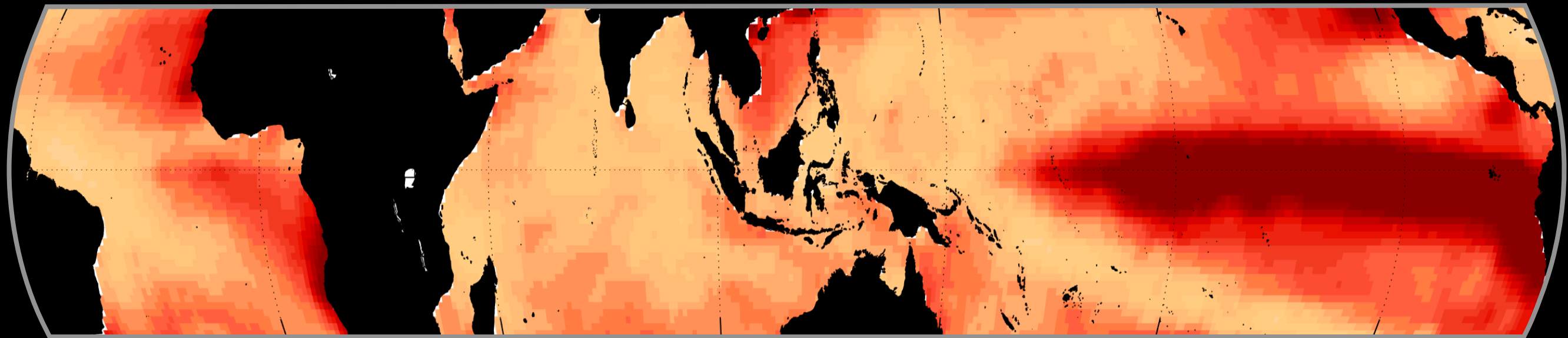
## Last Glacial Maximum



$\Delta 1\sigma$ -SST (%)  
100% -80% -40% 0 40% 80% 100%

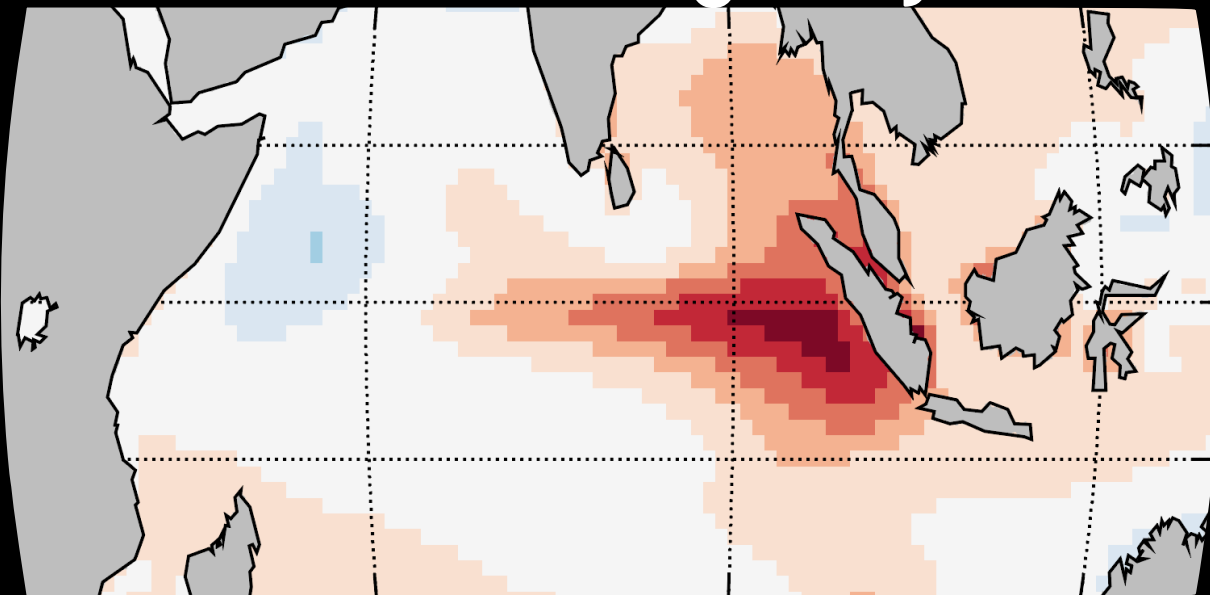


# Climate Variability in the Indian Ocean

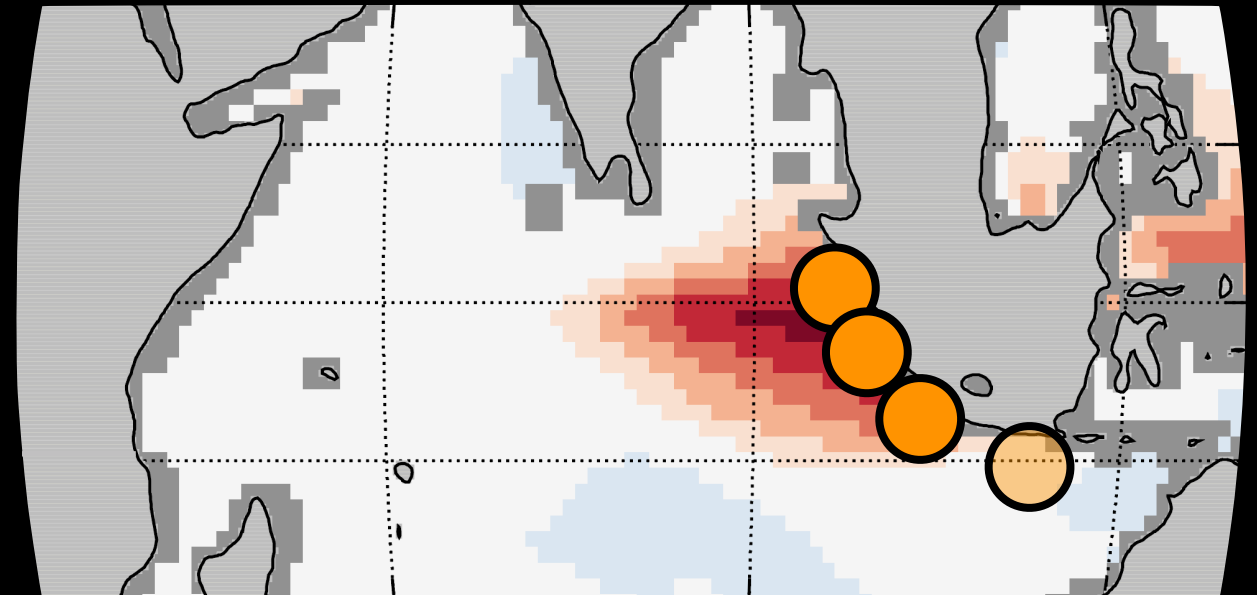


Standard Deviation of SST  
0.1 0.3 0.5 0.7°C

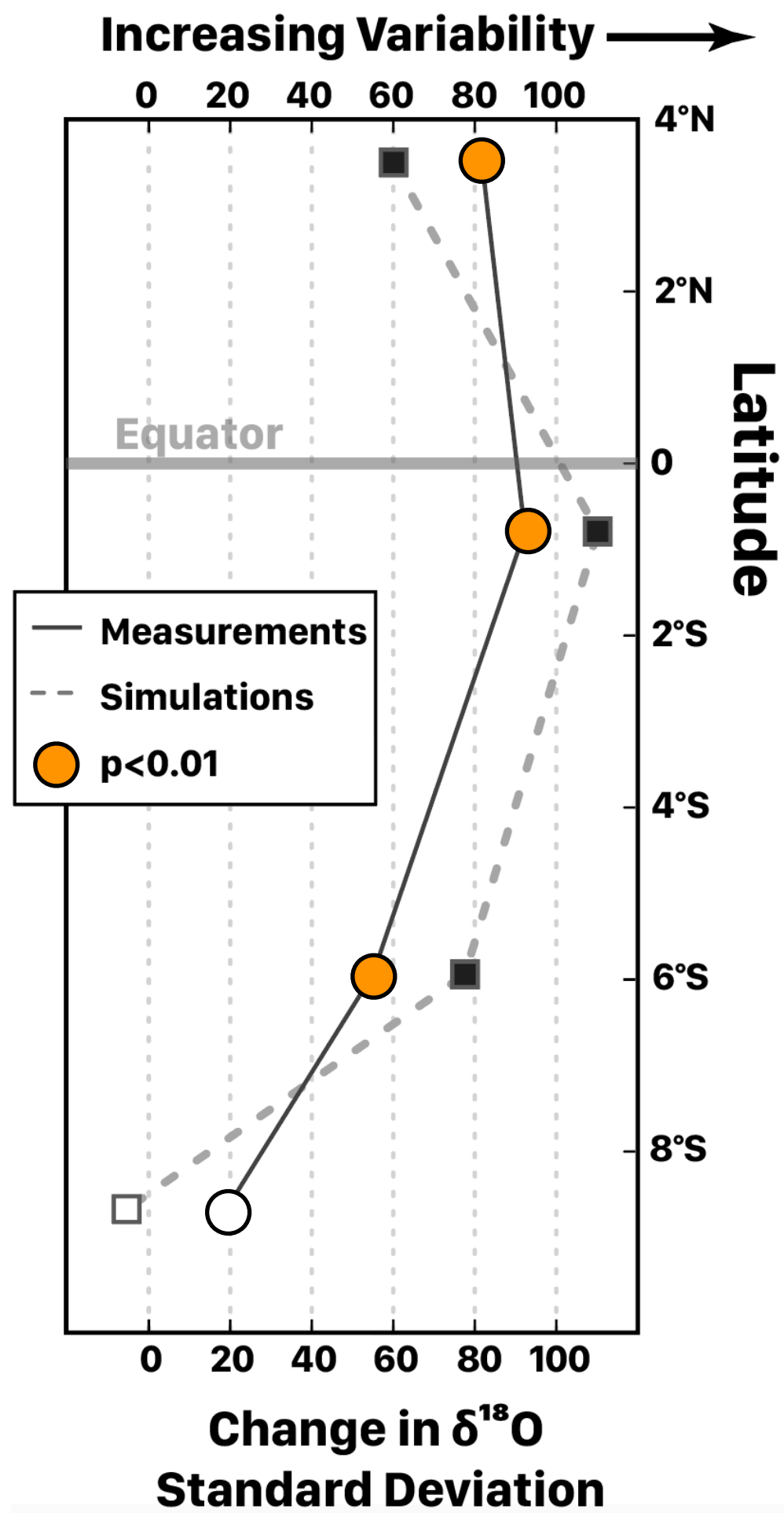
## Global Warming Projection



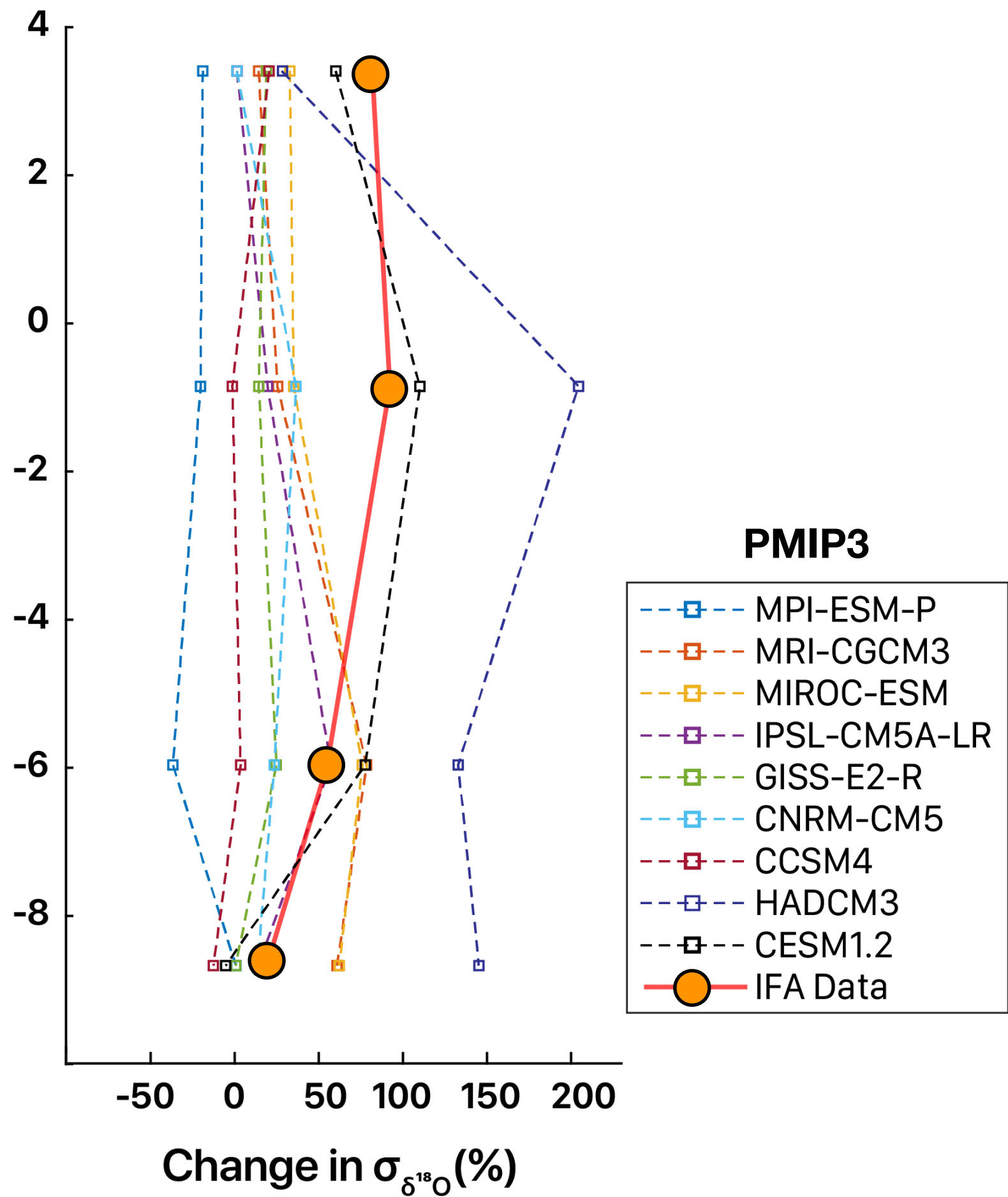
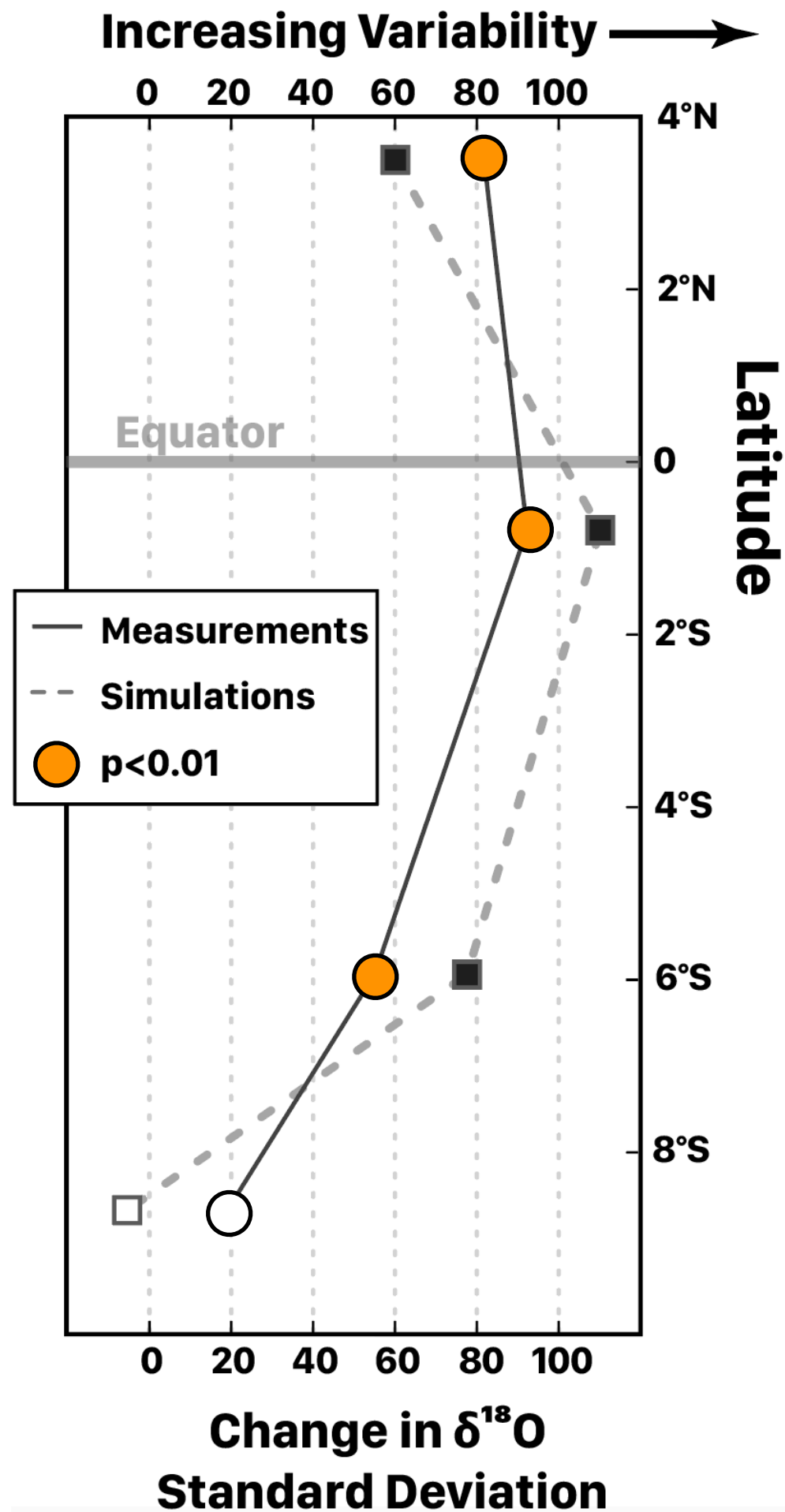
## Last Glacial Maximum



100% -80% -40% 0 40% 80% 100%  $\Delta 1\sigma$ -SST (%)







Foraminifera can provide key constraints on ocean-atmosphere processes

Forward-modeling can test simulations of subdecadal variability under different mean states

Foraminiferal forward models set expectations for future drilling/sampling

Hypothesis testing can be refined with isotope-enabled models, biogeochemical models etc.