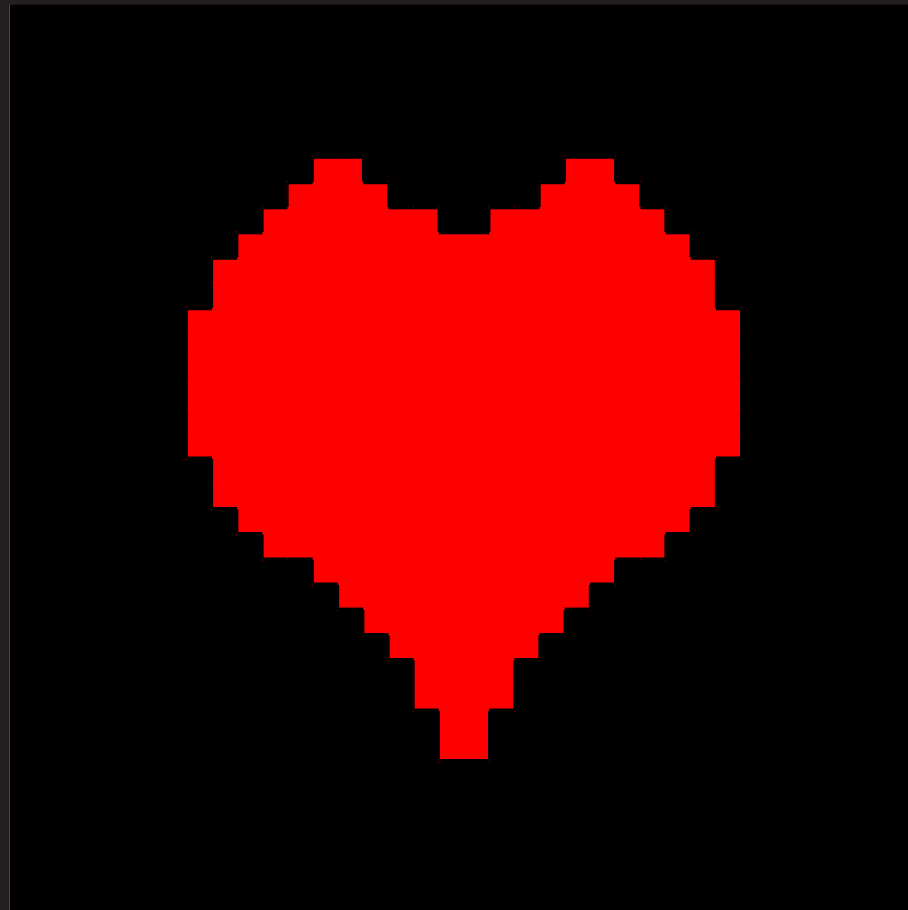


Global Meridional Overturning Circulation in Real and Fake Worlds

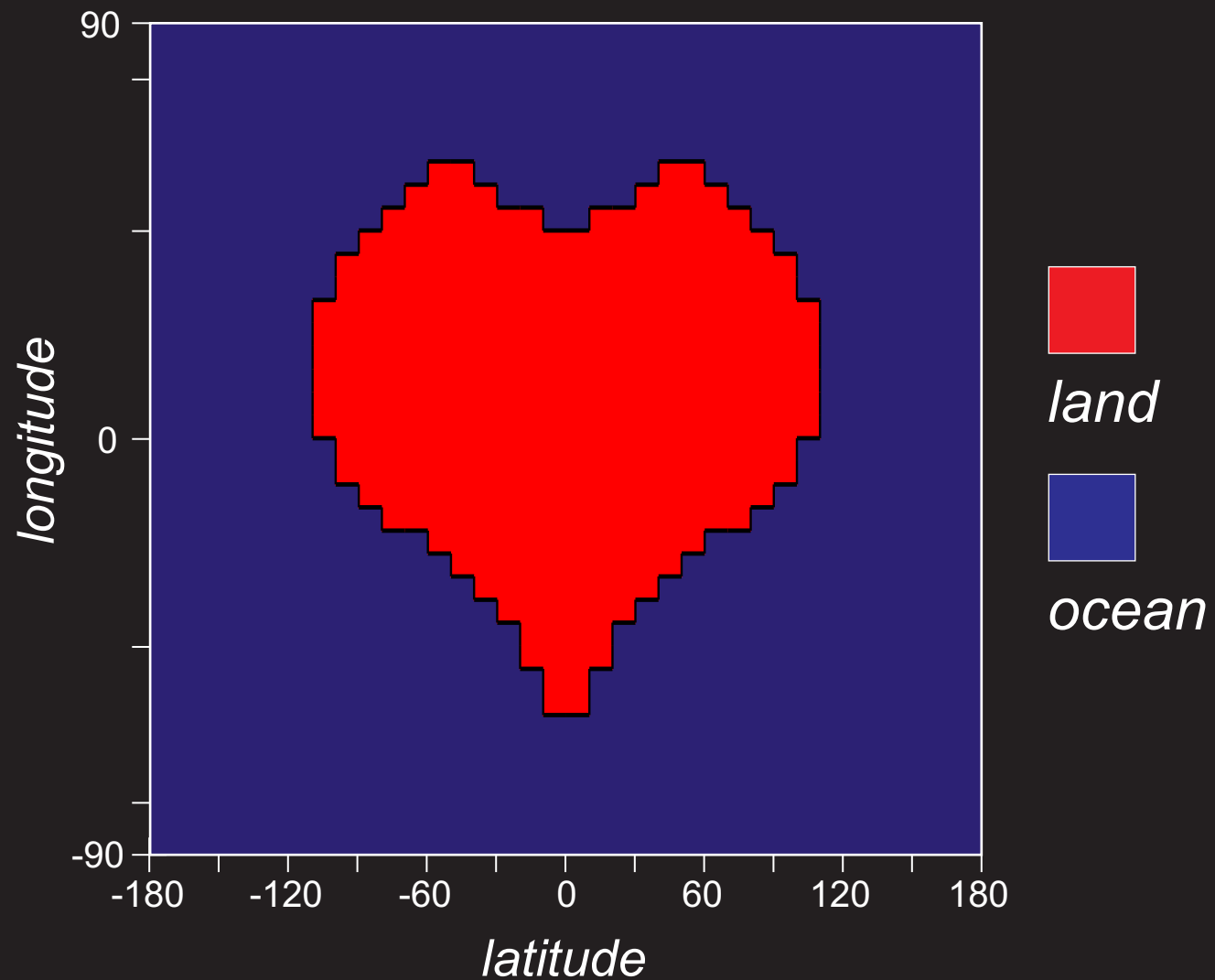
Andy Ridgwell

Sandy Kirtland Turner





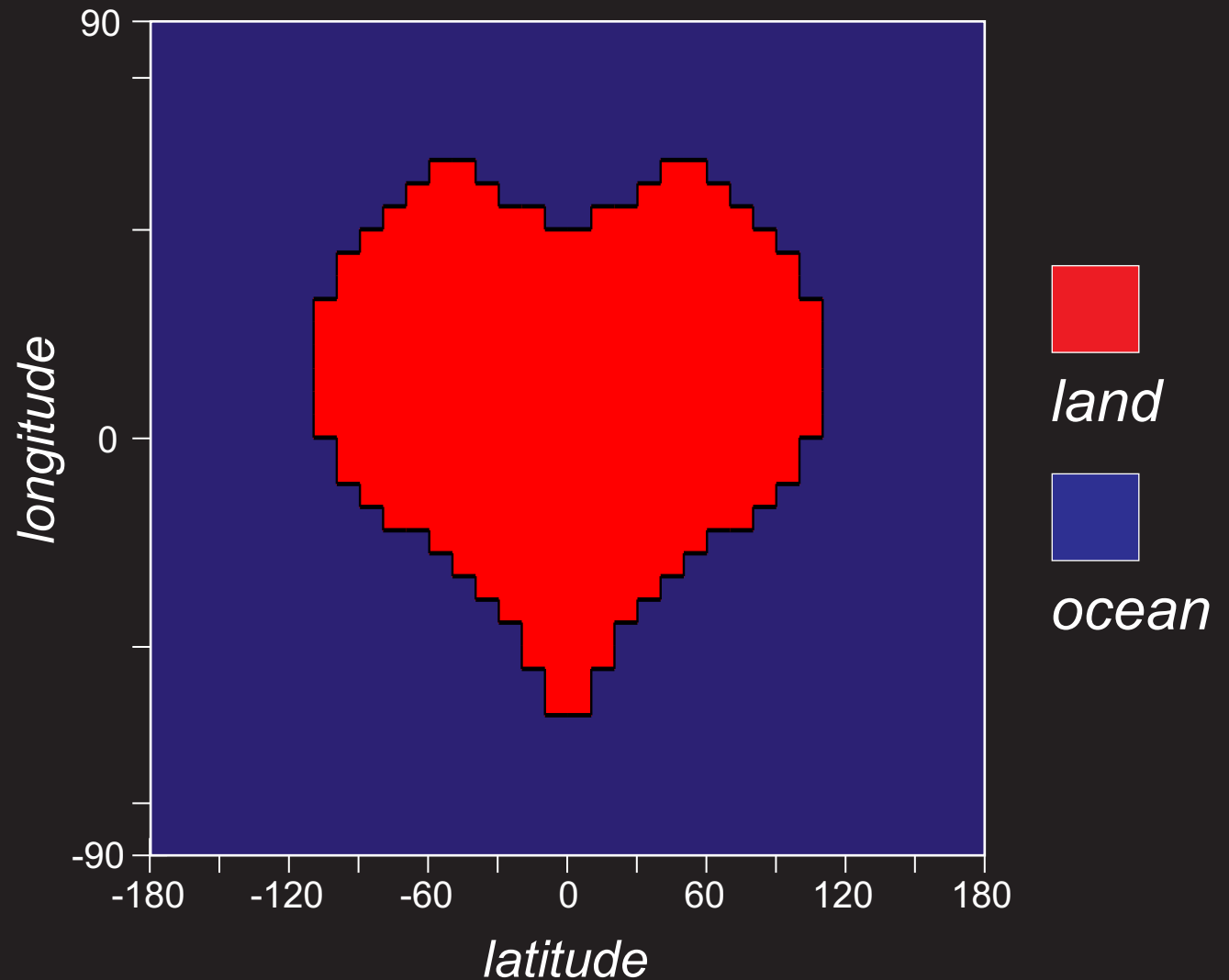
super-continent *Valentinea* @ xxx Ma (equal area projection)





what is the associated circulation pattern (and strength),
and why?

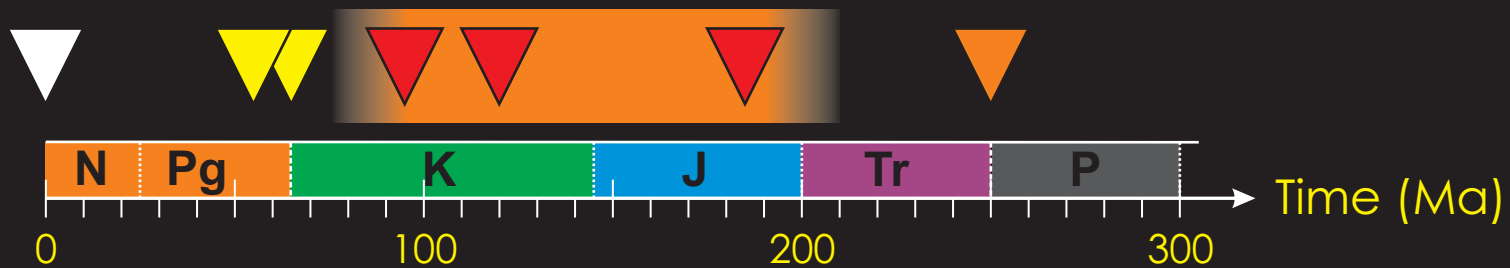
super-continent *Valentinea*
@ xxx Ma (equal area projection)



Introduction



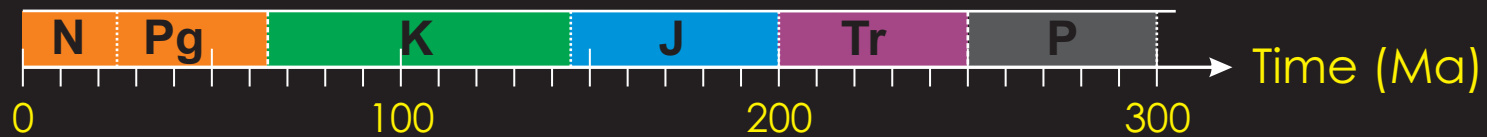
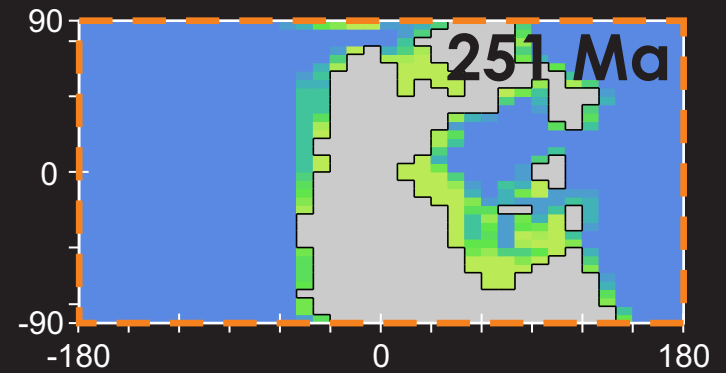
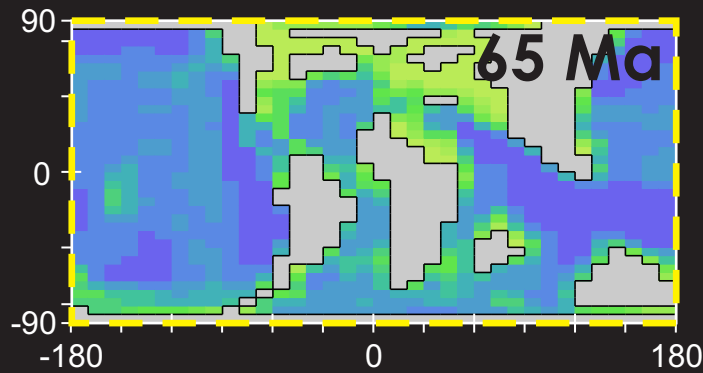
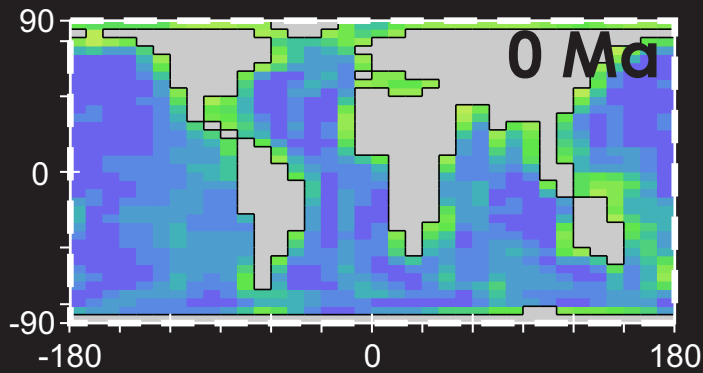
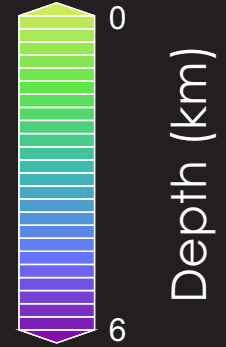
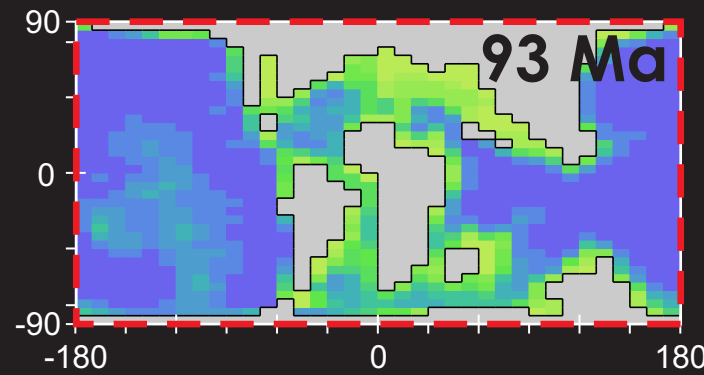
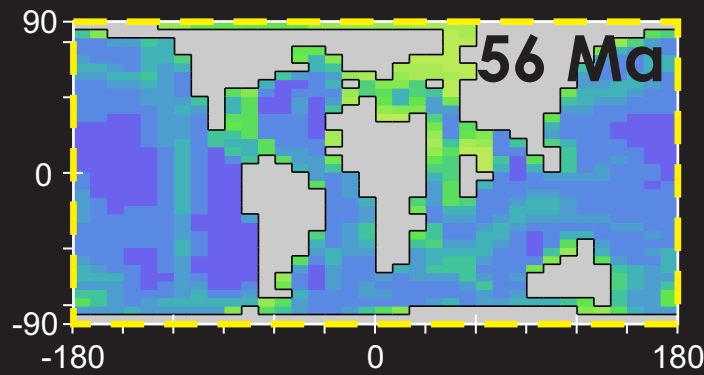
disp('the ocean as a cradle/nexus of ...
extreme environmental change, evolution and extinction')



Introduction



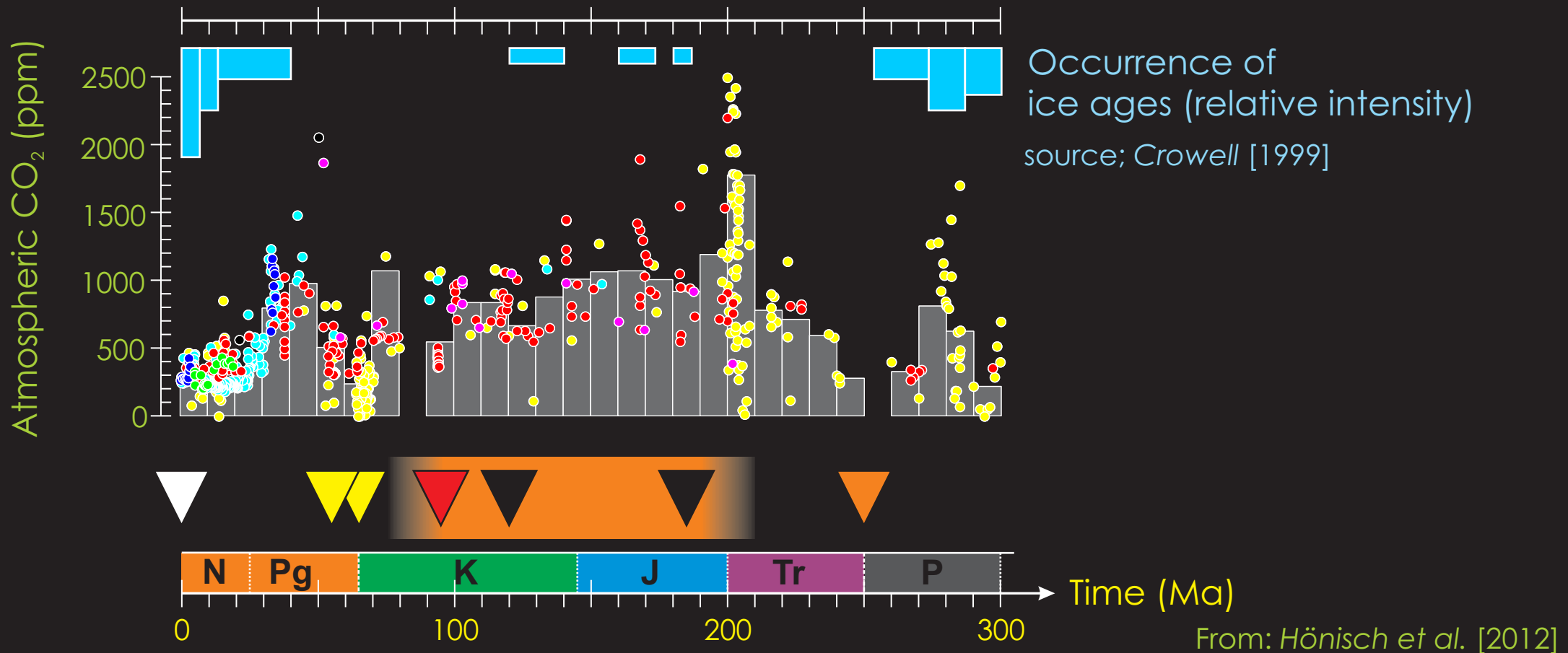
disp('varying continental configuration & sea-level')

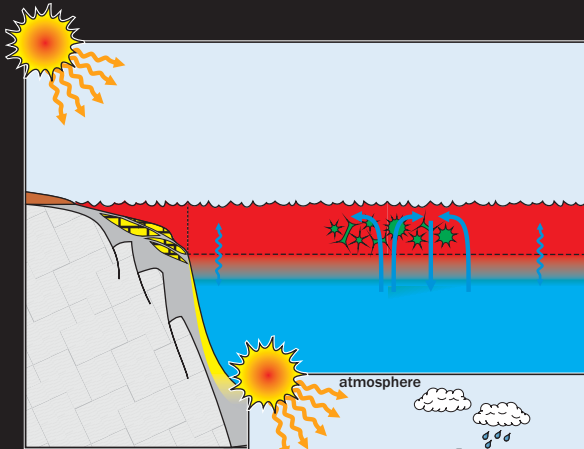


Introduction

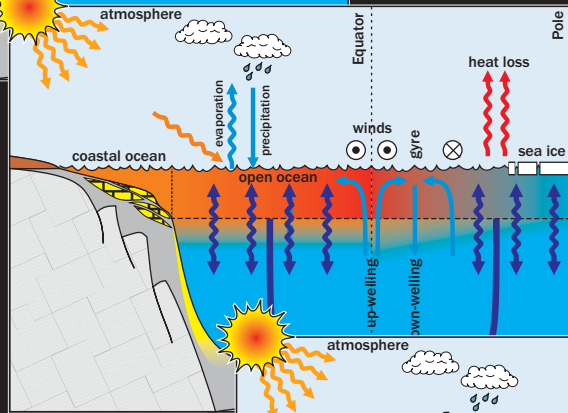


disp('varying greenhouse gas concentrations & climate')

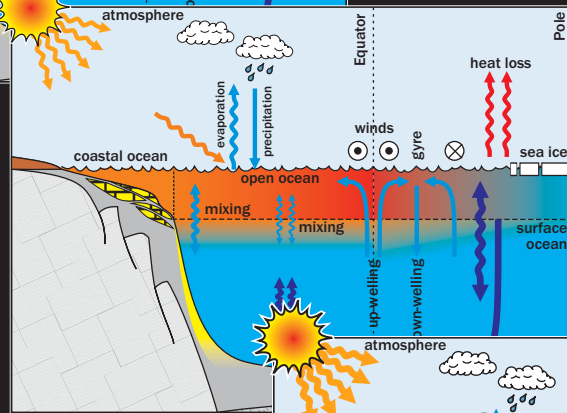




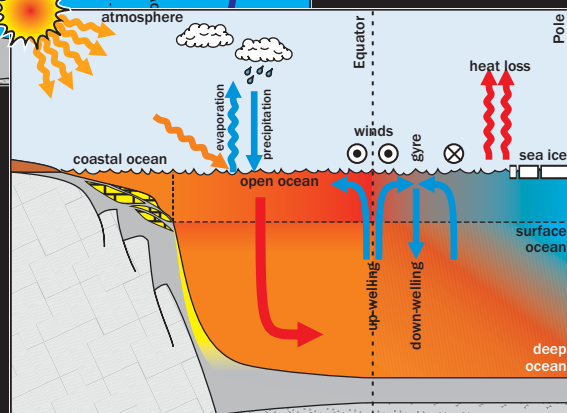
stagnant ocean
(no significant sources of deepwater)



'completely mixed' ocean
(large number of sources of deepwater spanning all latitudes)



modern-like ocean
(deepwater formation dominated by high latitude sources)



'Mediterranean on speed'
(deepwater formation at low latitudes)

Introduction

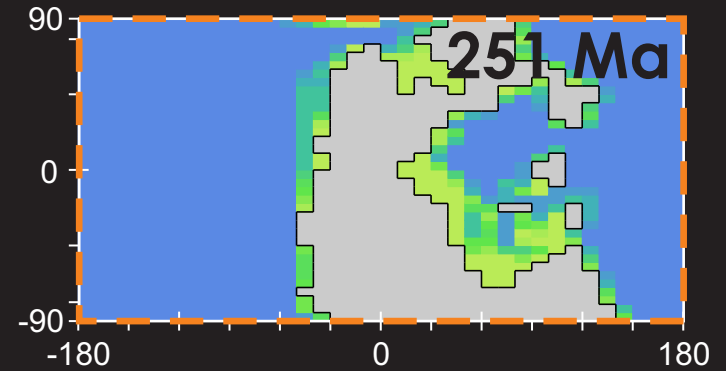
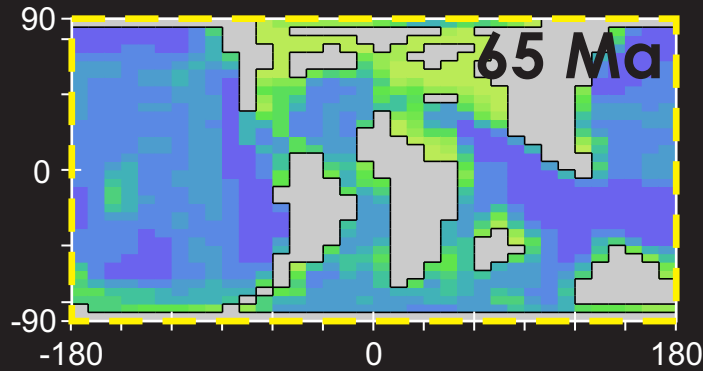
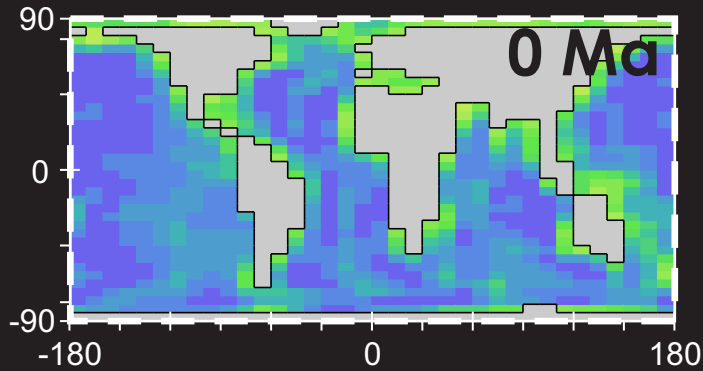
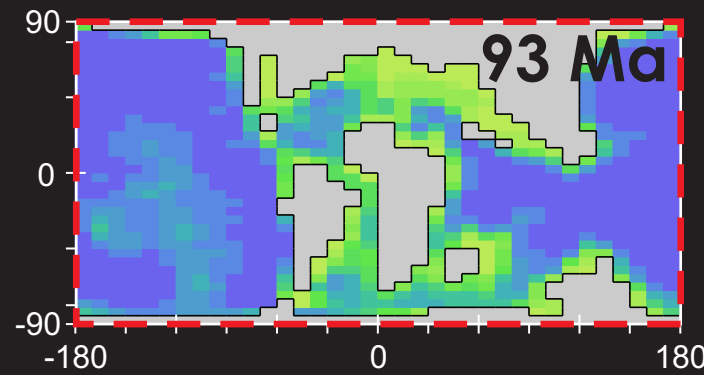
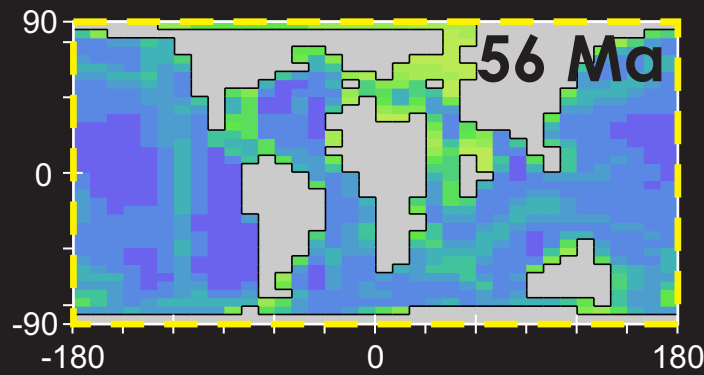


```
if (numerical_simulation == understanding)
```

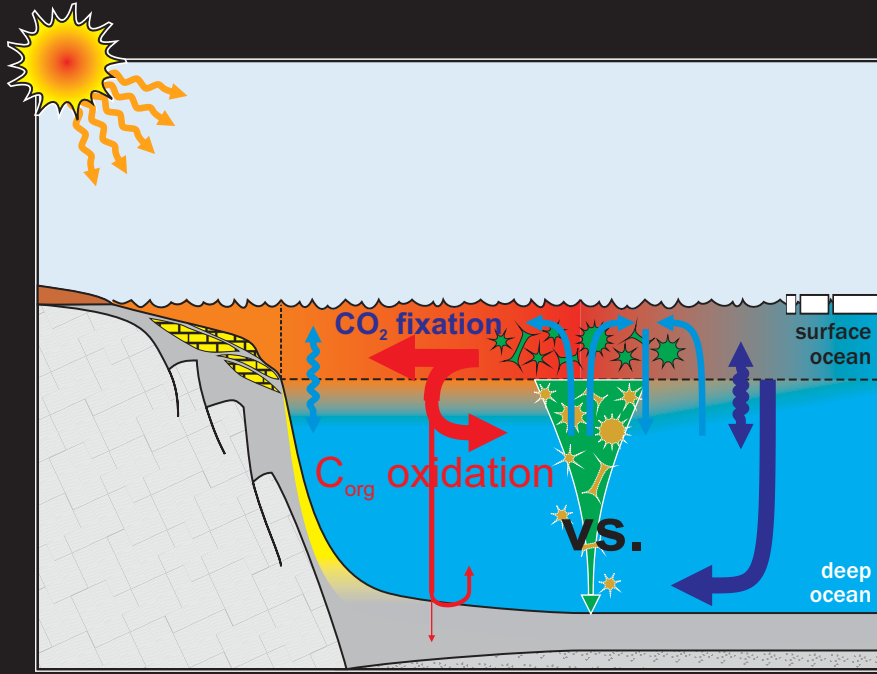
...

```
else
```

...



Introduction

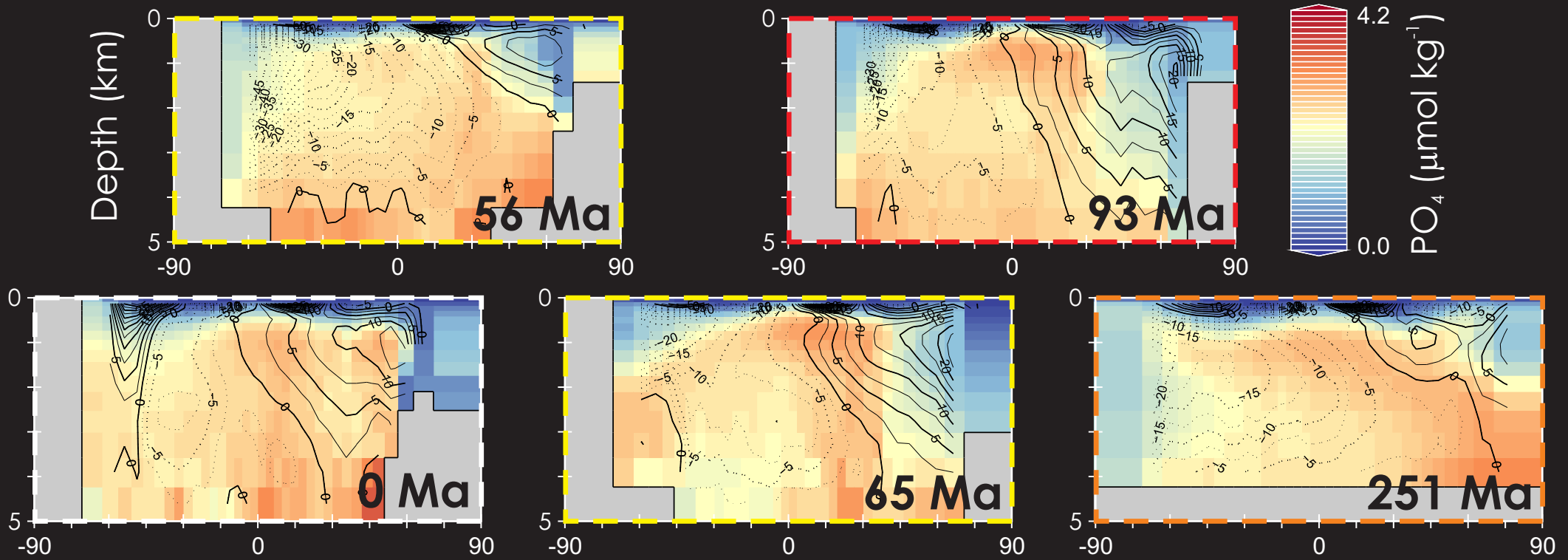


What controls the e.g. $[O_2]$ distribution in the ocean?

(1) The biological (soft tissue) pump and associated oxygen demand (with more minor contributions from dissolved organic matter and inputs of reduced species e.g. at hydrothermal vents).

(2) Ocean circulation and the transport of $[O_2]$ in near equilibrium with the atmosphere, into the ocean interior.

(Although a circulation that strongly transports O_2 to depth most likely also returns nutrients to the surface.)





switch time

```
case { 'modern', 'future' }
```

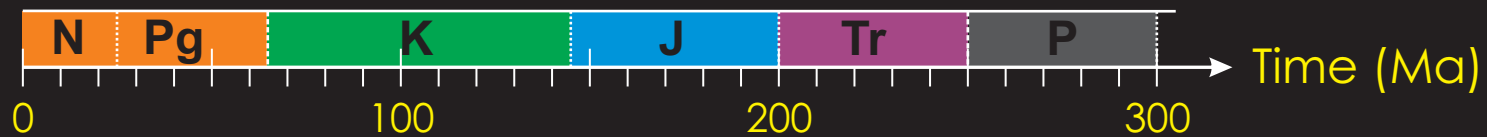
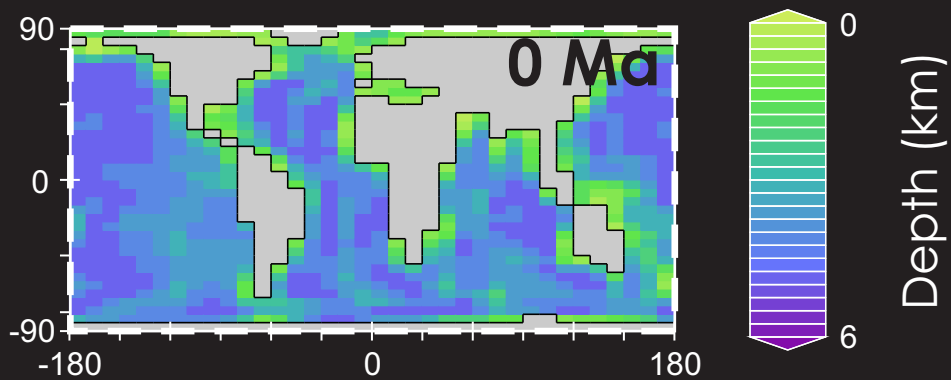
...

```
case { 'LGM' }
```

...

```
otherwise
```

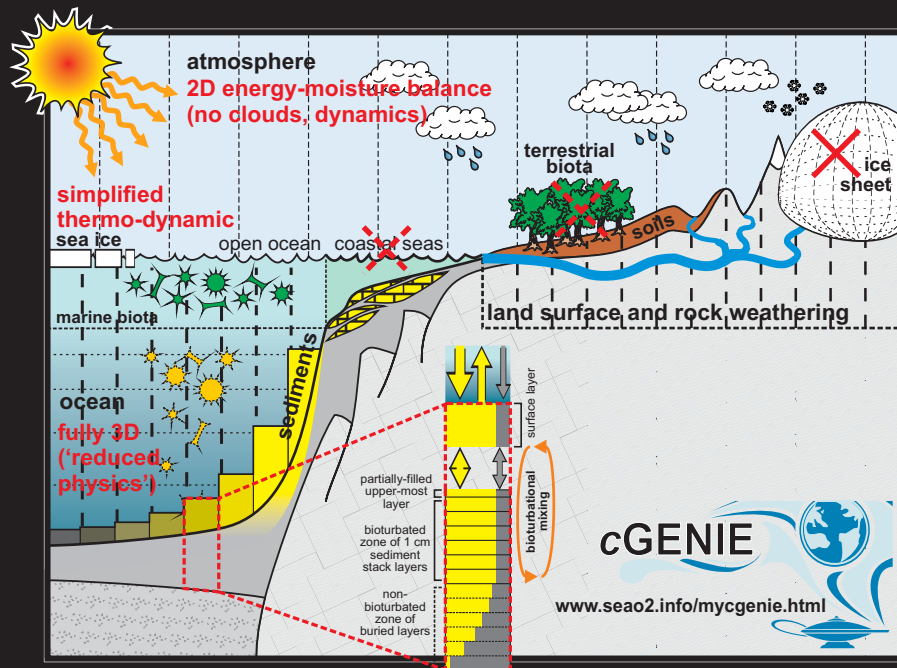
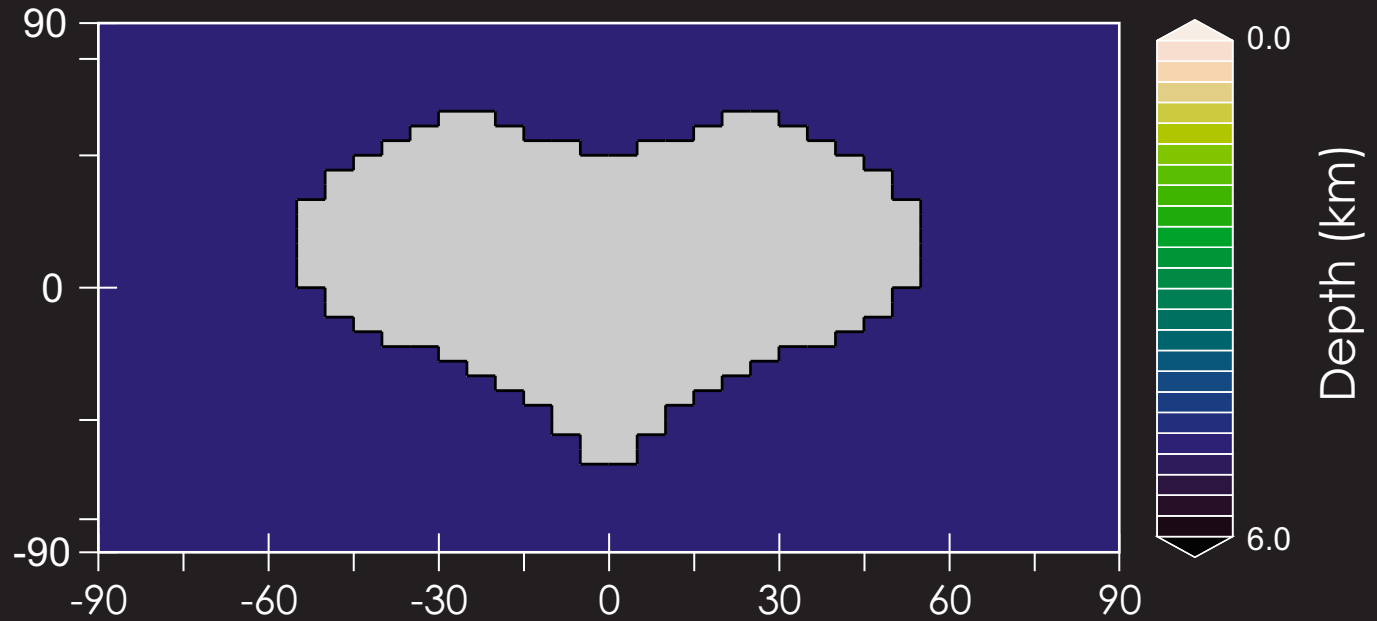
...



Ocean circulation in fake worlds



'flat bottom' bathymetry (and no mountains on land)
simple 'roofing' run-off scheme



'cGENIE' Earth system model
('of Intermediate Complexity')
www.seao2.info/mycgenie.html

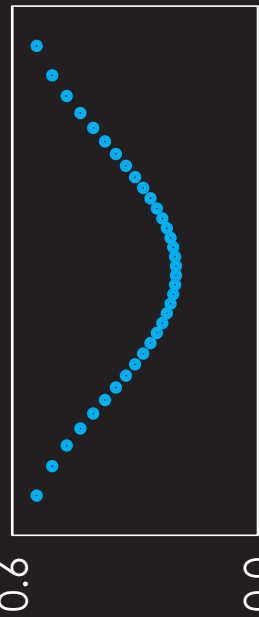
Ocean circulation in fake worlds



zonal
wind stress

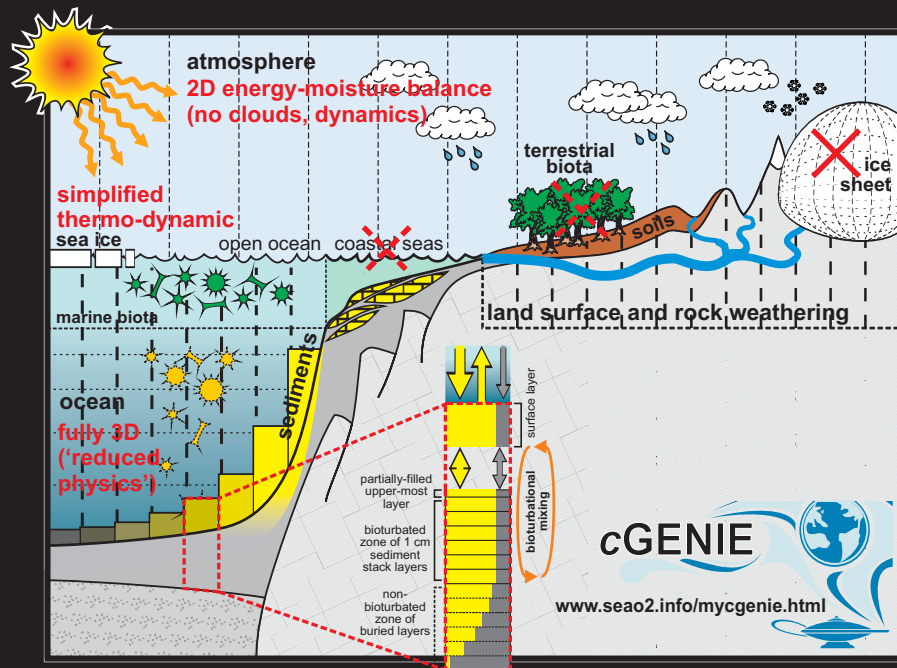
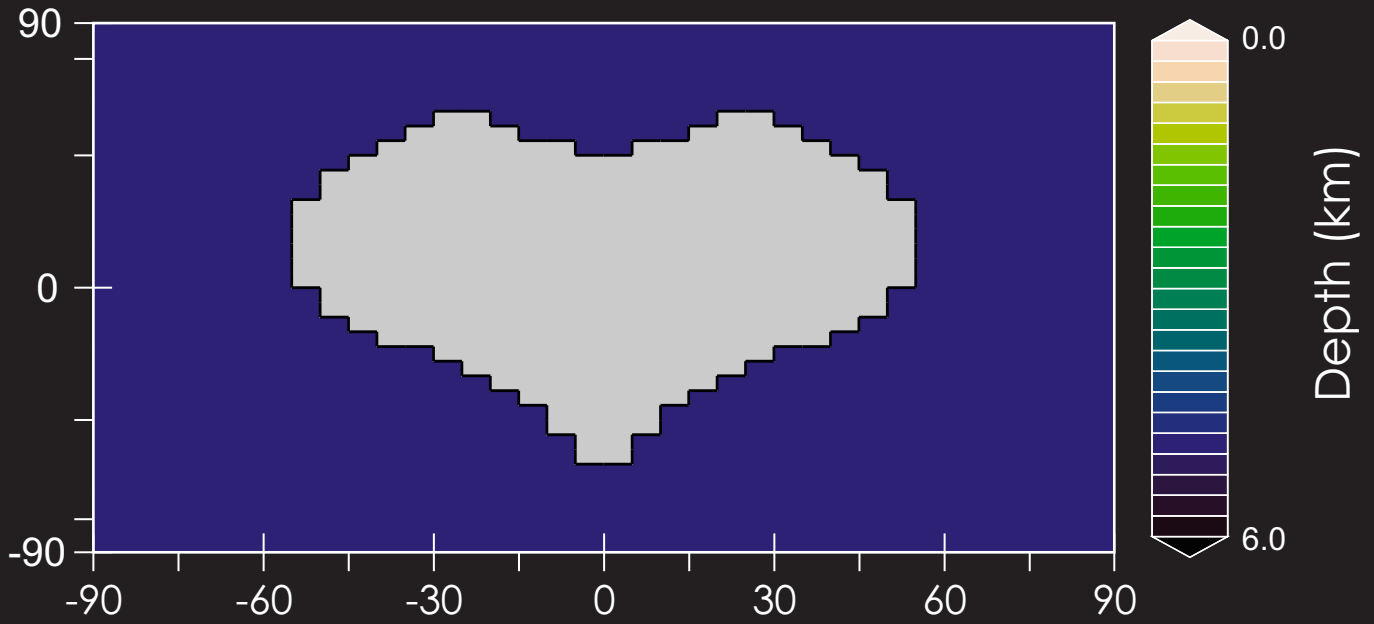


planetary
albedo



+ $\times 1\text{CO}_2$

+ seasonal insolation forcing & modern orbit



'cGENIE' Earth system model
('of Intermediate Complexity')

www.seao2.info/mycgenie.html

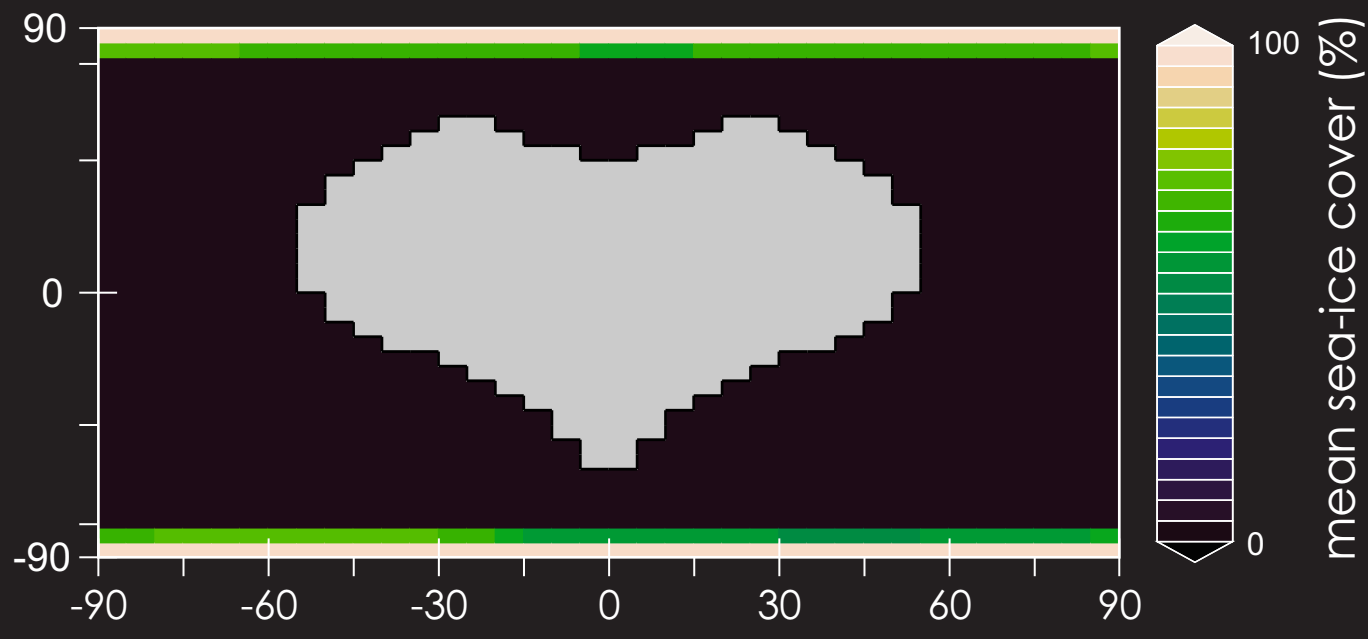
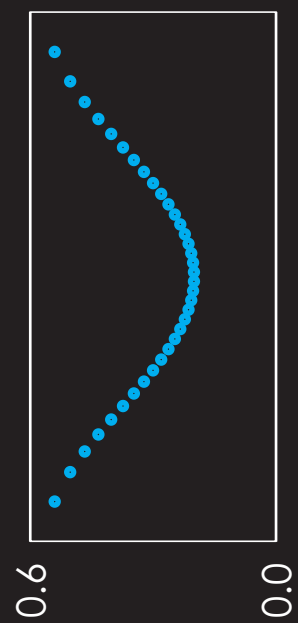
Ocean circulation in fake worlds



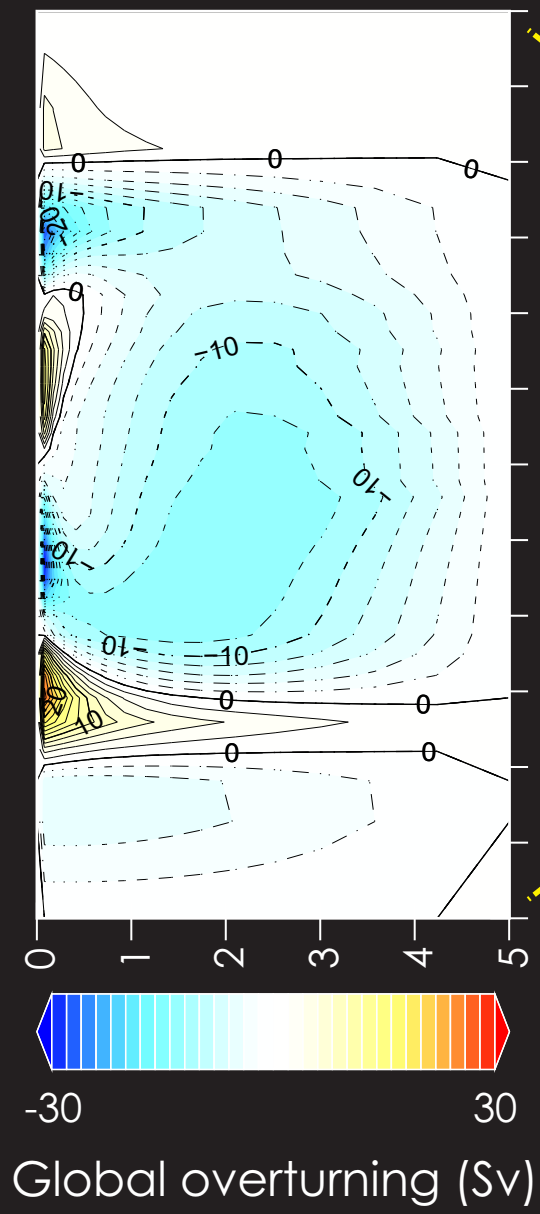
zonal
wind stress

planetary
albedo

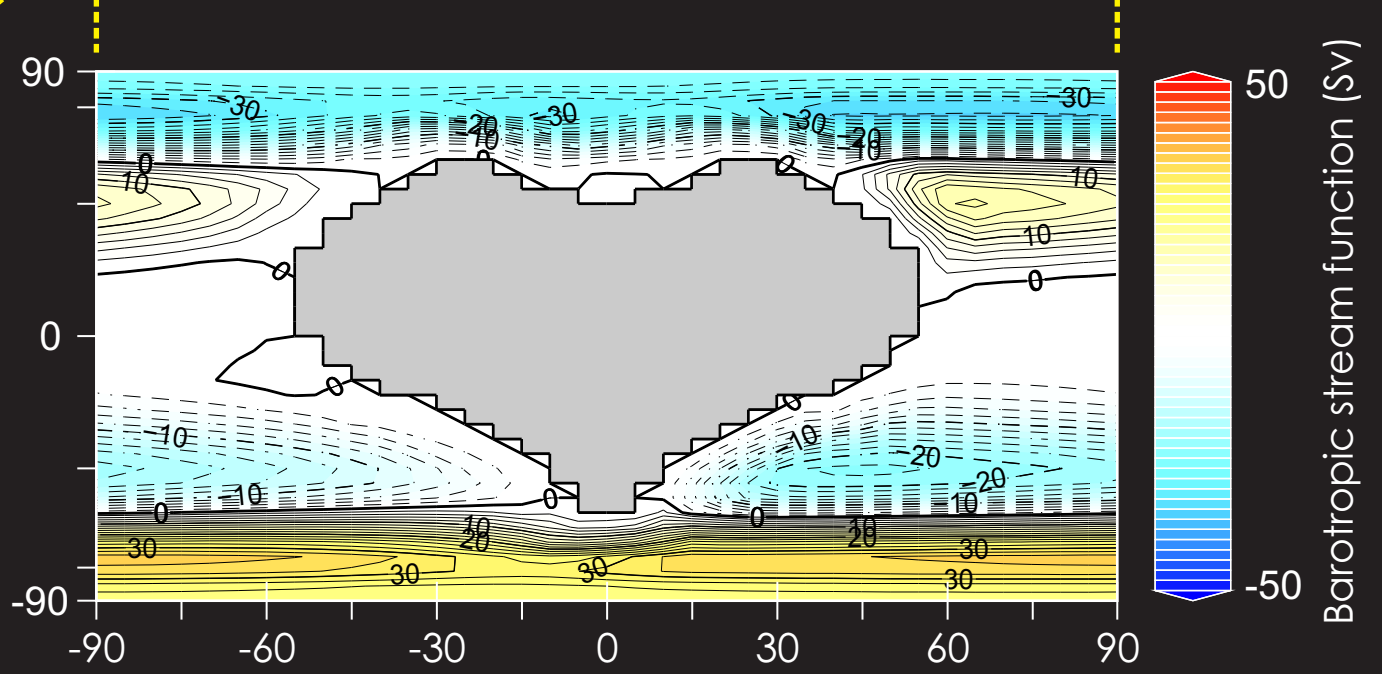
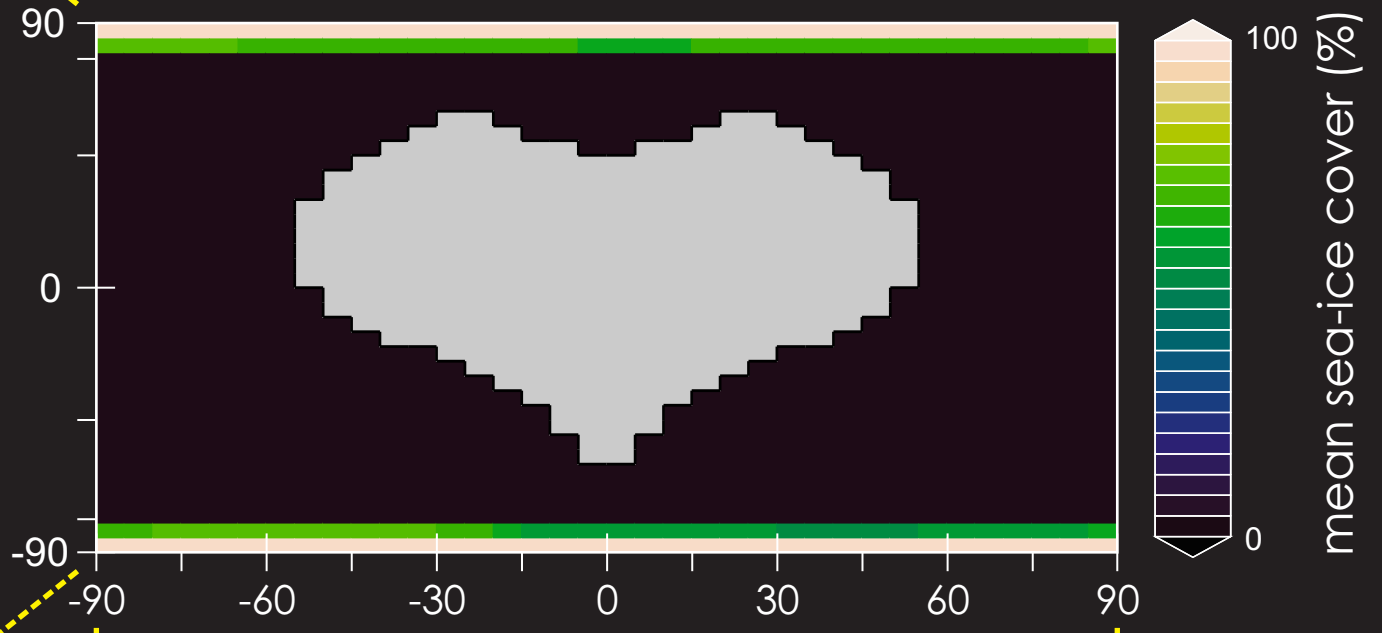
5000 year spin-up from 'cold'



Ocean circulation in fake worlds

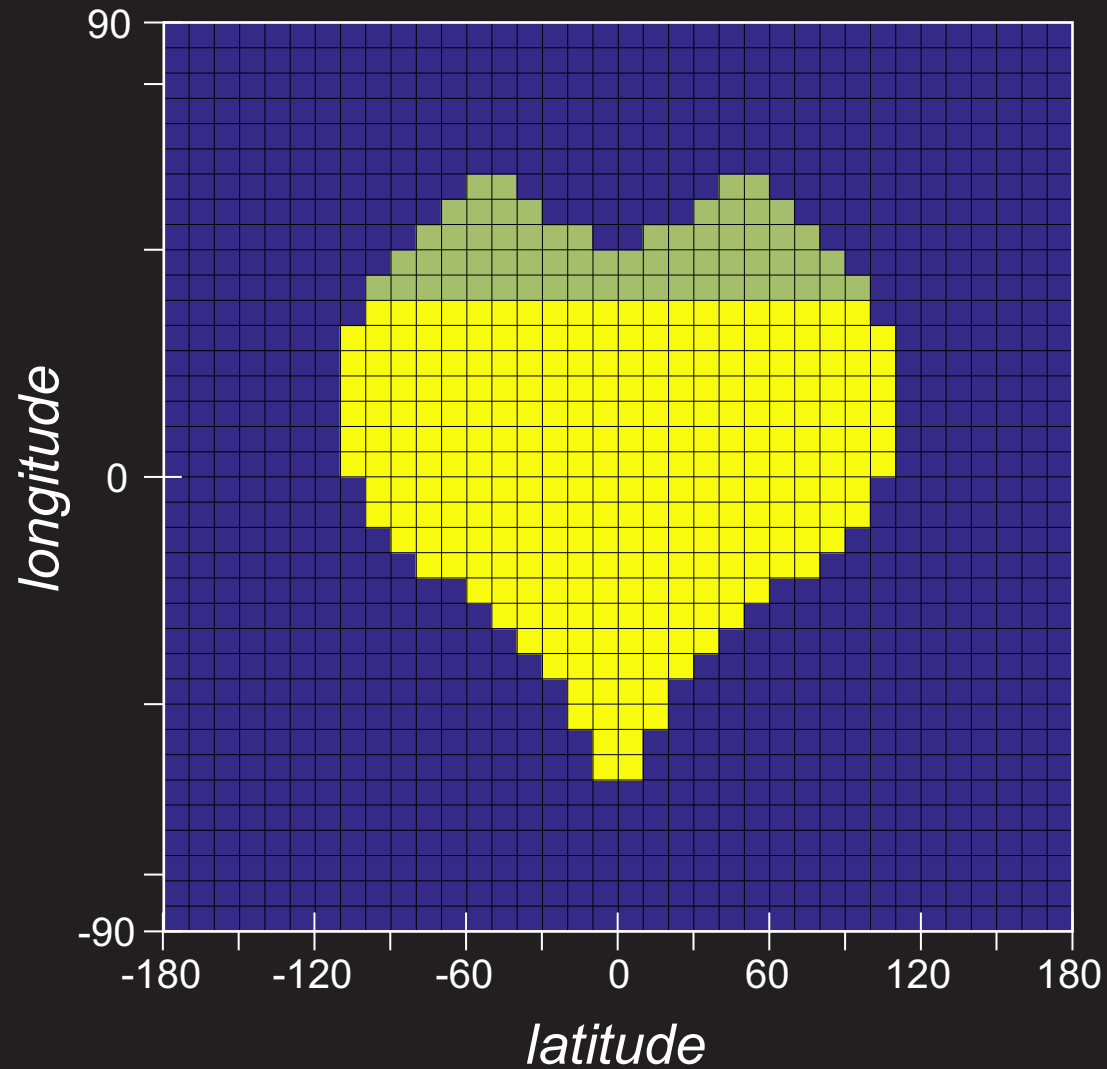


5000 year spin-up from 'cold'



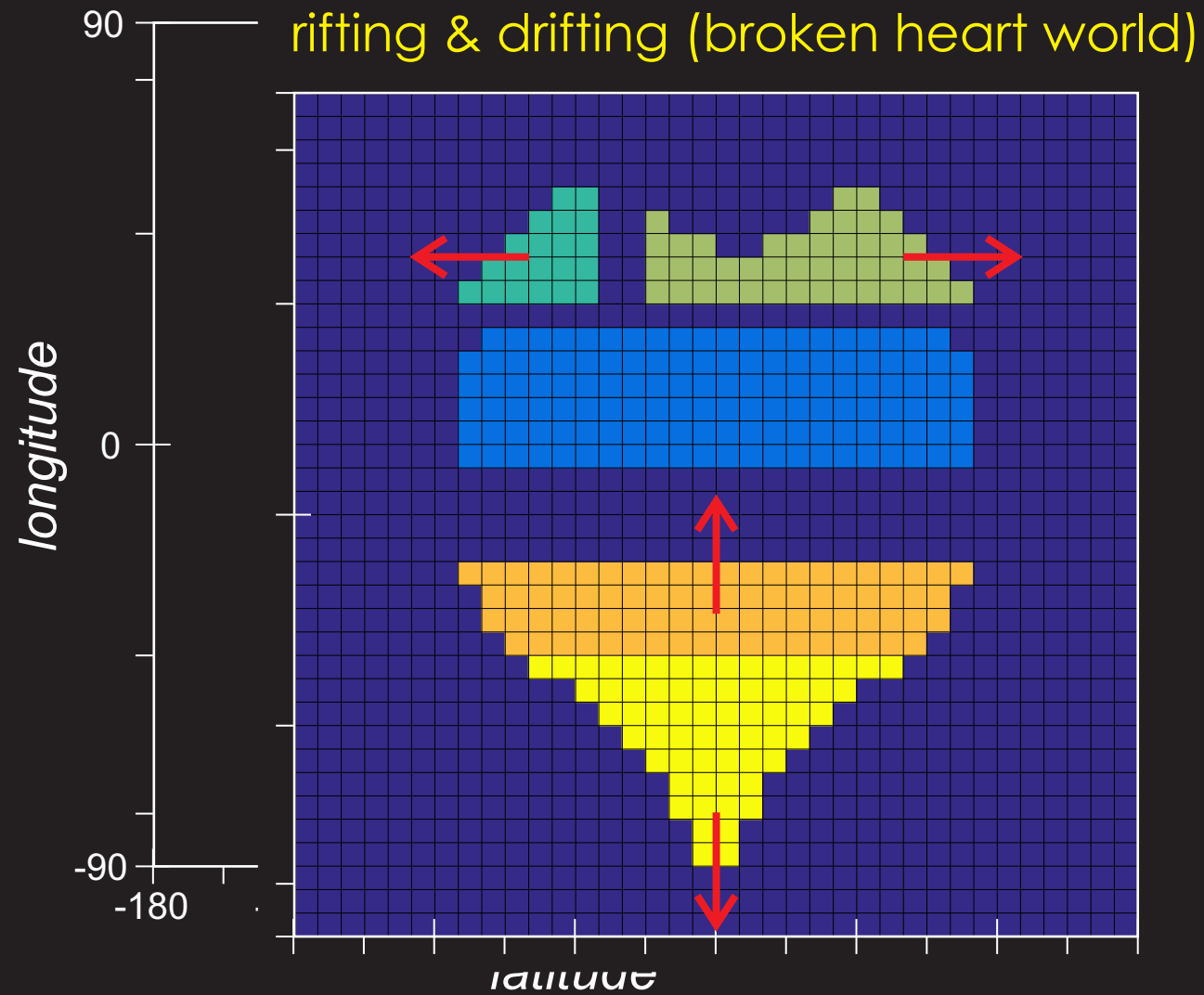


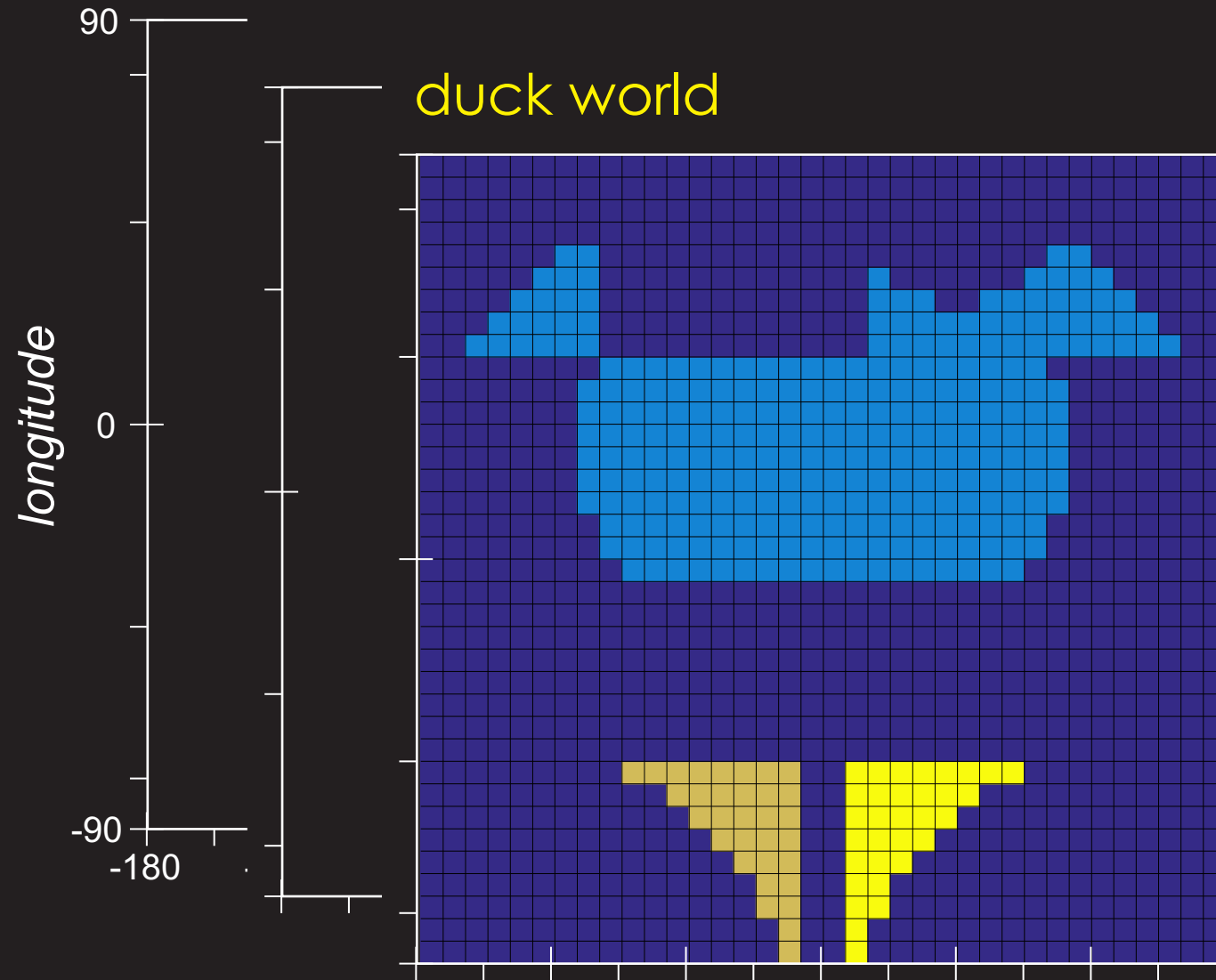
fragmentation (rifting)



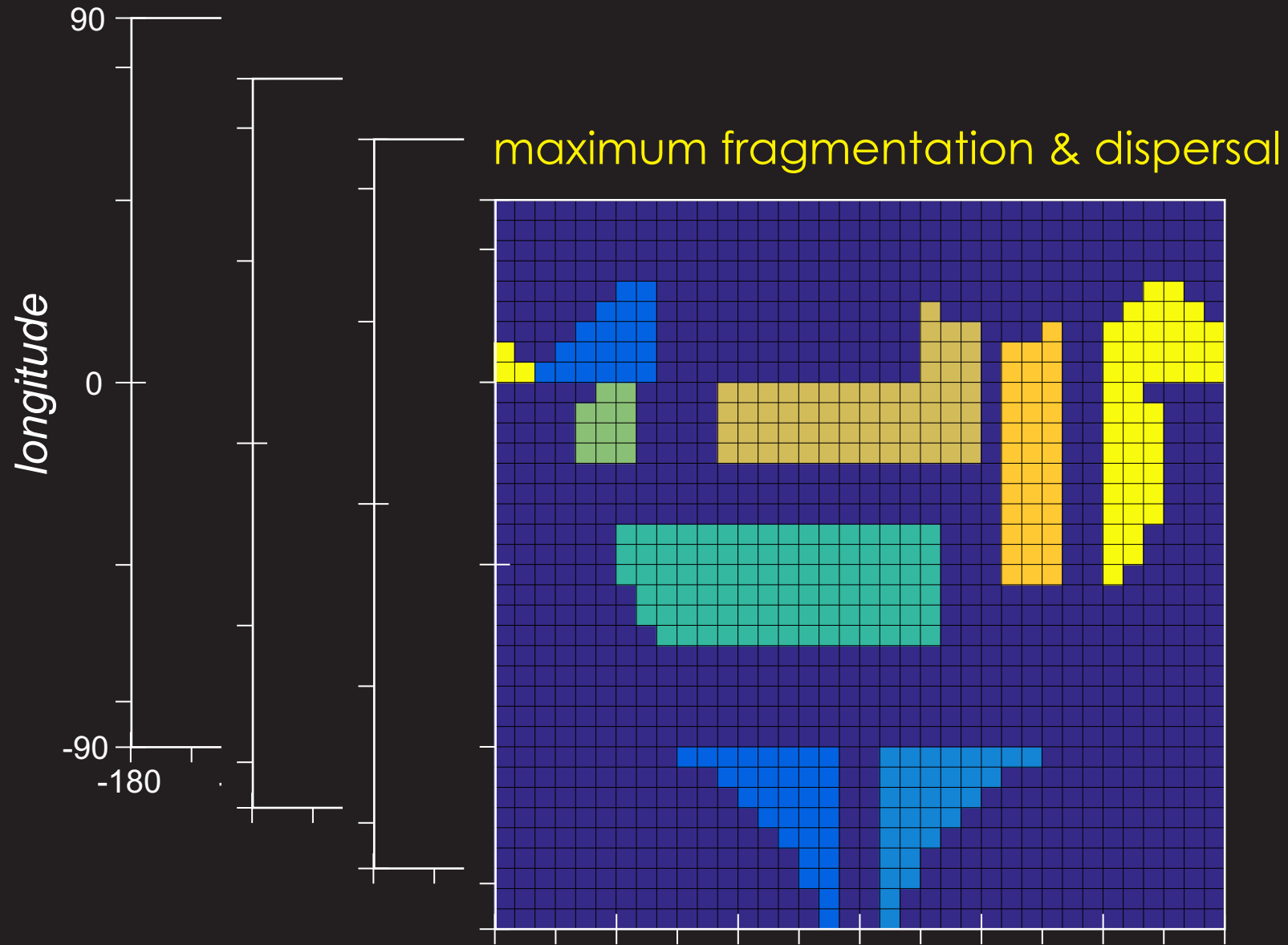
random number of rifting events initiated

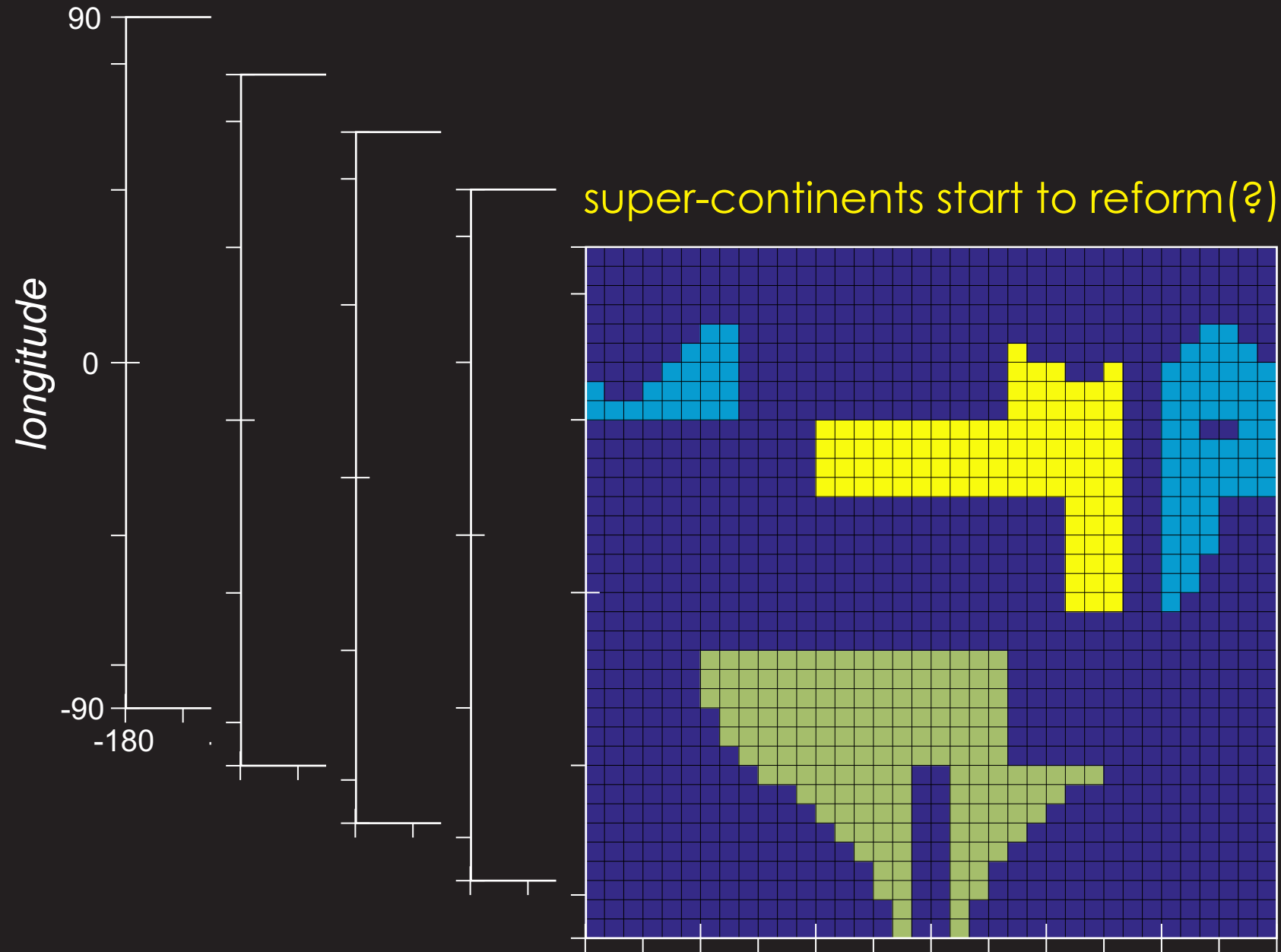
random location for rift initiation + random direction of rift propagation





continental fragments can re-combine
(and then re-rift apart)





Fake results of fake worlds analysis



16 initial experiments ... ultimately ca. 10^2 or 10^3

measure of continental fragmentation (total edges/cells) →

measure of low/high latitude asymmetry ↓

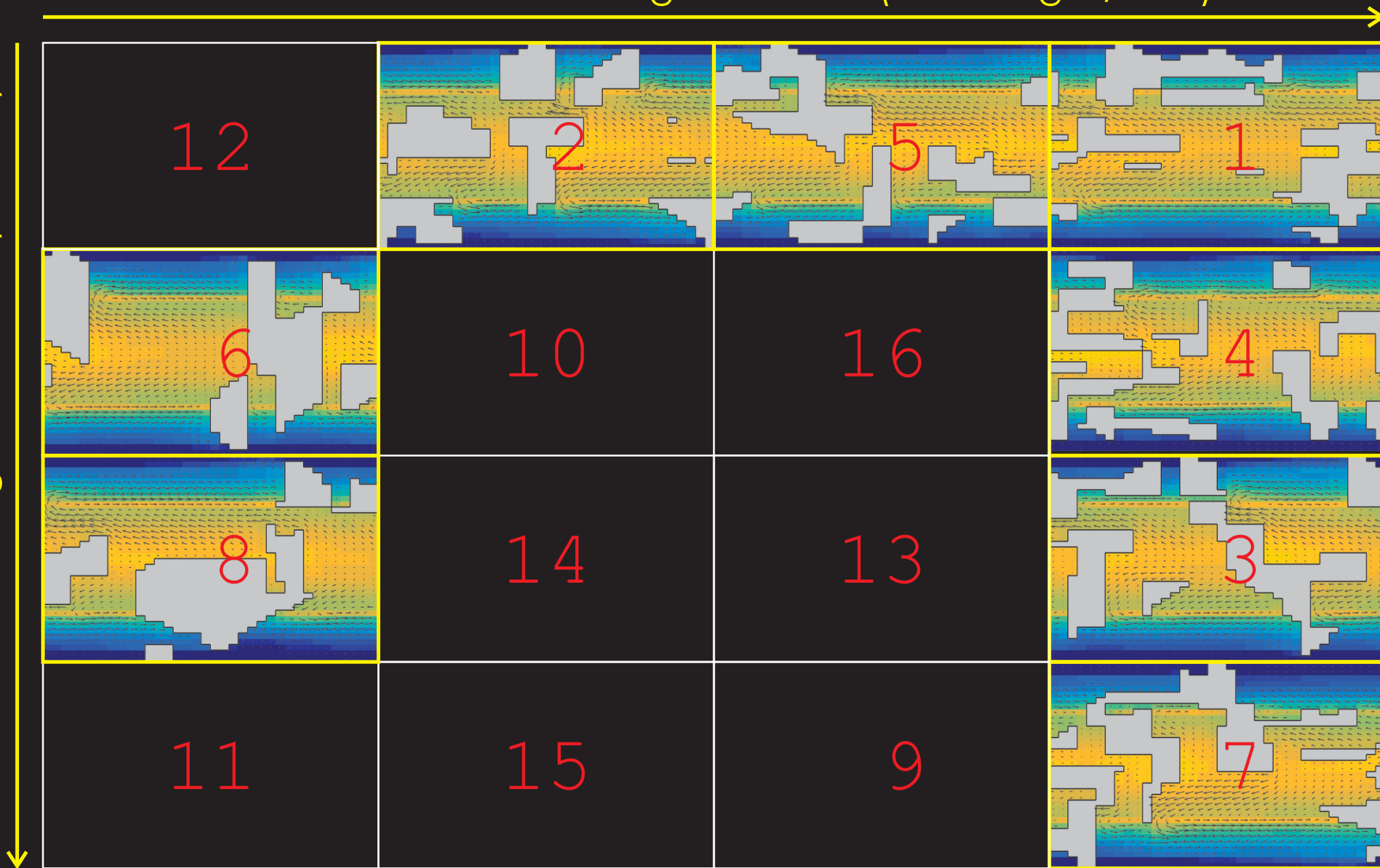
12	2	5	1
6	10	16	4
8	14	13	3
11	15	9	7



sufficiently 'random'?

measure of continental fragmentation (total edges/cells)

measure of low/high latitude asymmetry



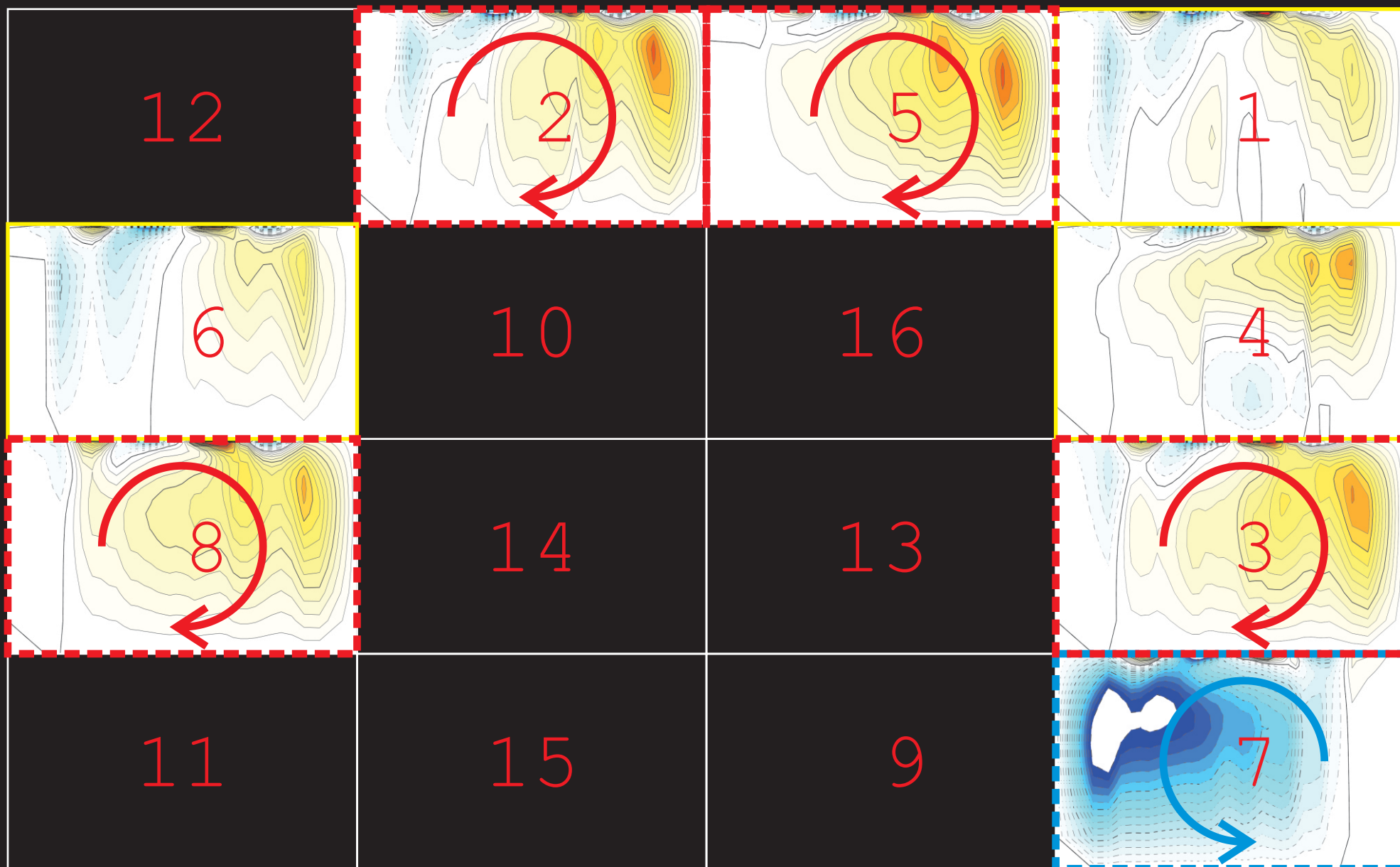
Fake results of fake worlds analysis



N vs. S source bias? (modern orbit? fragmentation algorithm?)

measure of continental fragmentation (total edges/cells) →

measure of low/high latitude asymmetry ↓



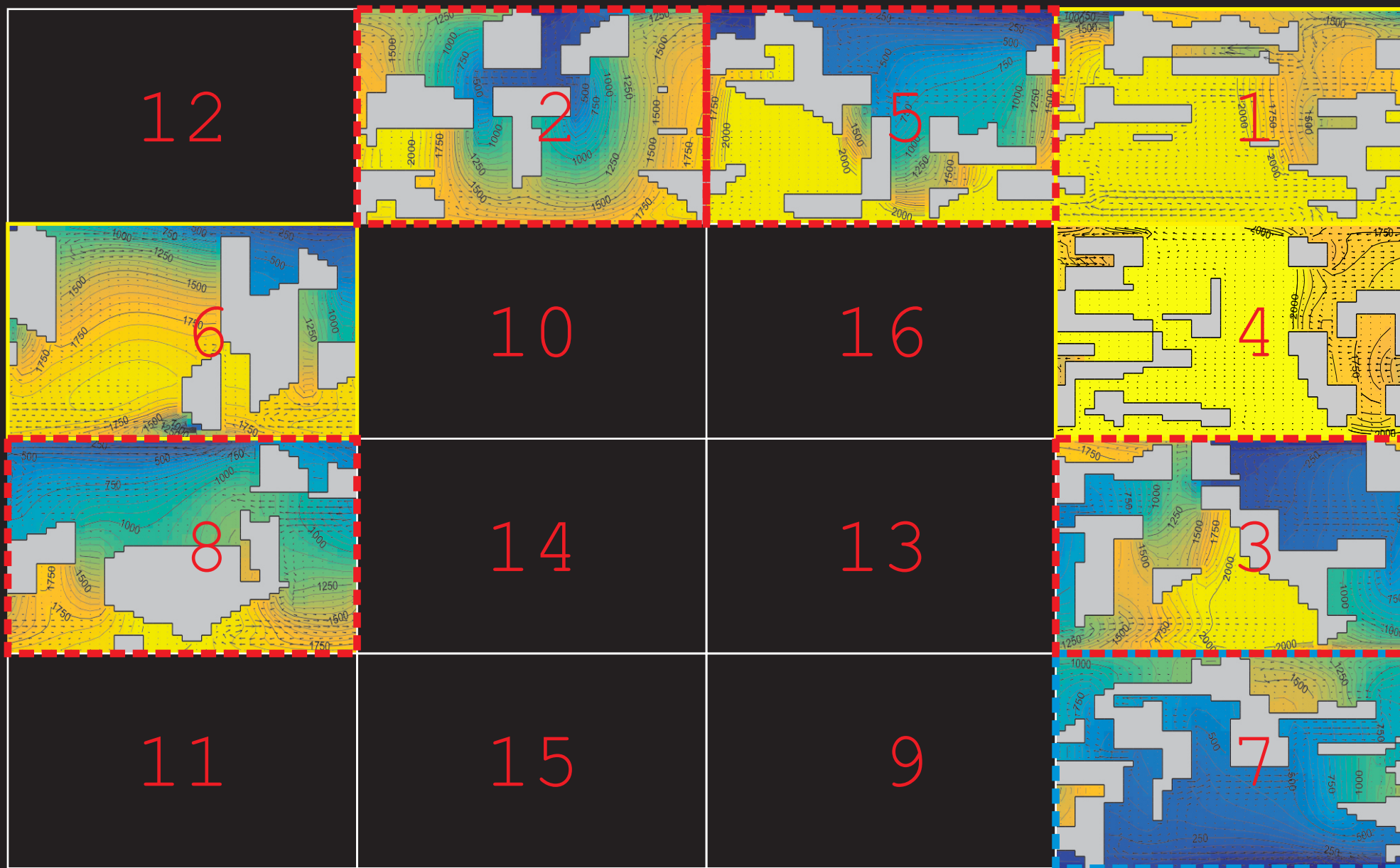
Fake results of fake worlds analysis



abyssal ventillation age (yellow == >2000 years)

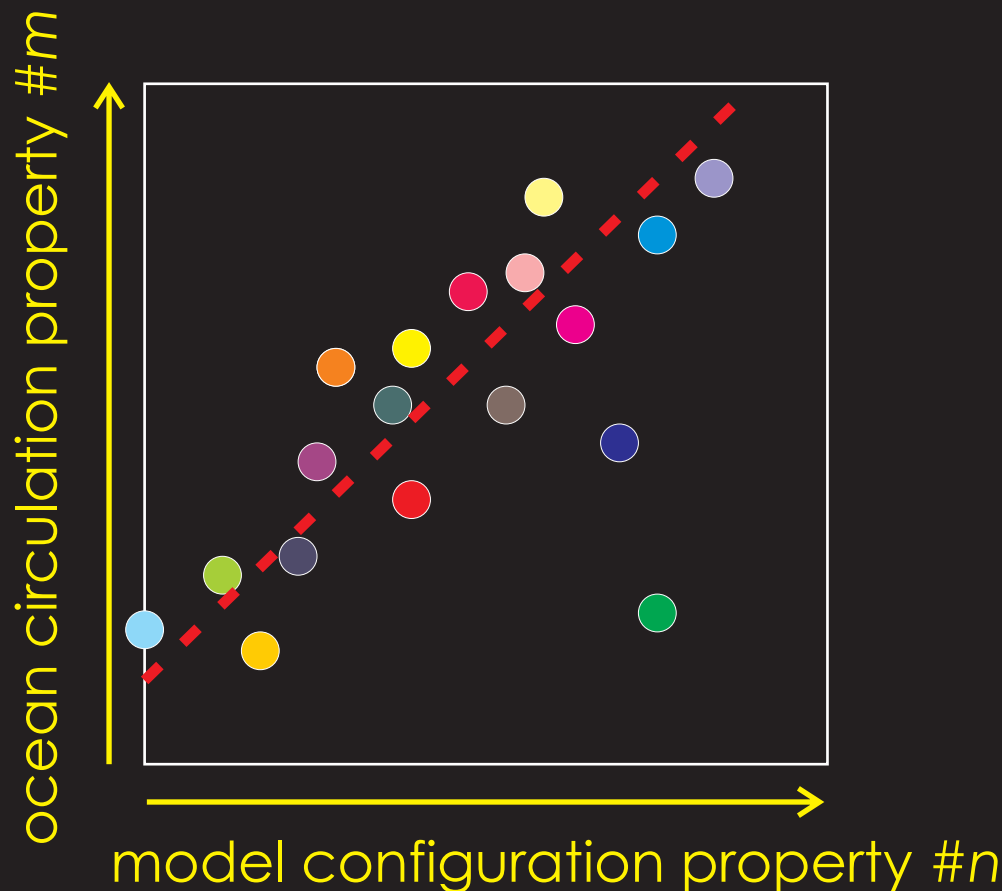
measure of continental fragmentation (total edges/cells)

measure of low/high latitude asymmetry





1. How to analyse – metrics for ocean circulation?
(vs. metrics for continental fragmentation and distribution and climate forcing)
2. Remove biases in world randomization(?)
3. How critically sensitive is global MOC to 'small' details?
(cf. modern AMOC and lack of PMOC)



mean deep ocean ventilation age
min/max MOC
(depth of min/max MOC)

total edge (coast) length/area
N/S hemisphere asymmetry
low/high latitude asymmetry
meridional SST gradient /
mean global sea-ice fraction

