



# ALL DEGLACIAL MODEL-DATA COMPARISONS ARE WRONG SOME MAY BE USEFUL

Andy Ridgwell

University of Bristol / University of California, Riverside

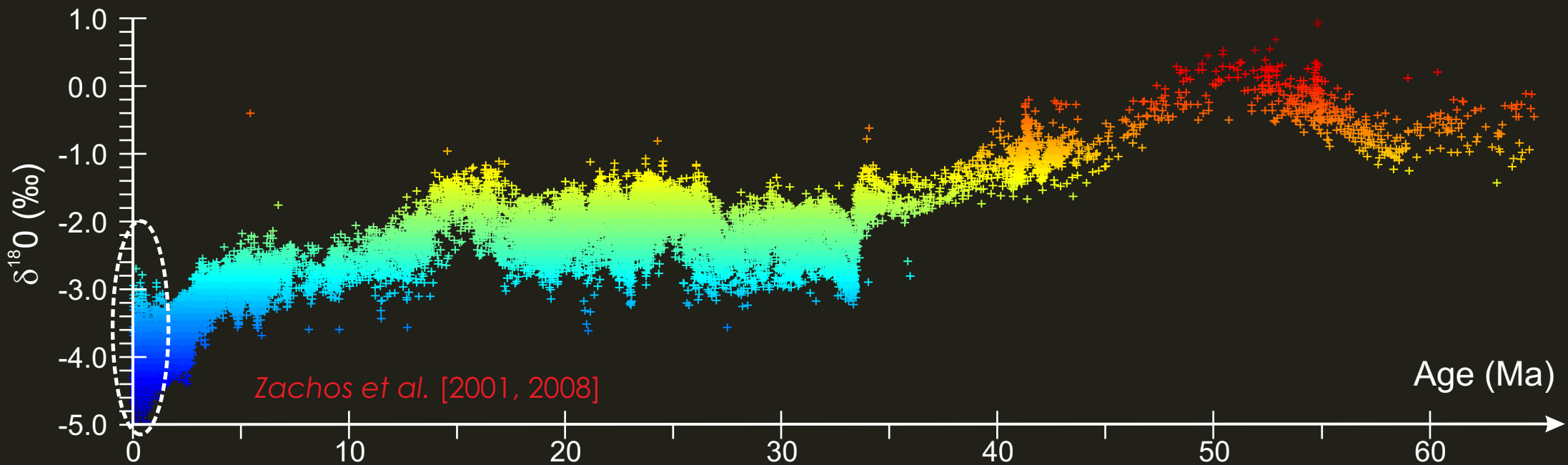
European Research Council

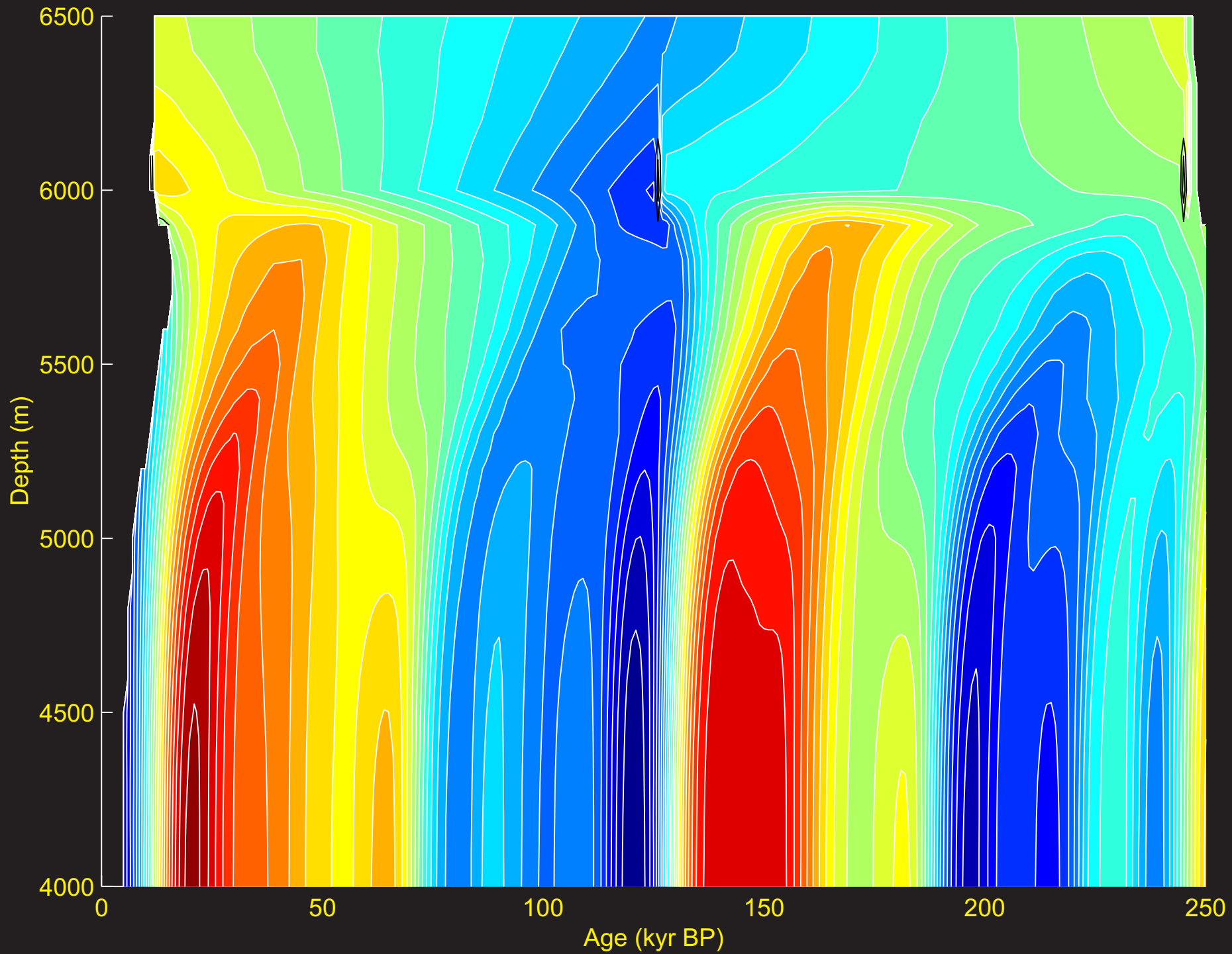
Established by the European Commission



University of  
BRISTOL

UCR





One (or more) of the following:

- \* This is not relevant at all.
- \* Too late – this was relevant 15 years ago.
- \* There are potentially important implications for bulk carbonate and low sedimentation rate records. But no-one in their right mind uses these any more.
- \* There are important implications for data-data (wiggle matching) and model-data analysis.
- \* There are important questions raised of where in the sediments, and what fraction, of carbonate dissolves.
- \* Meh

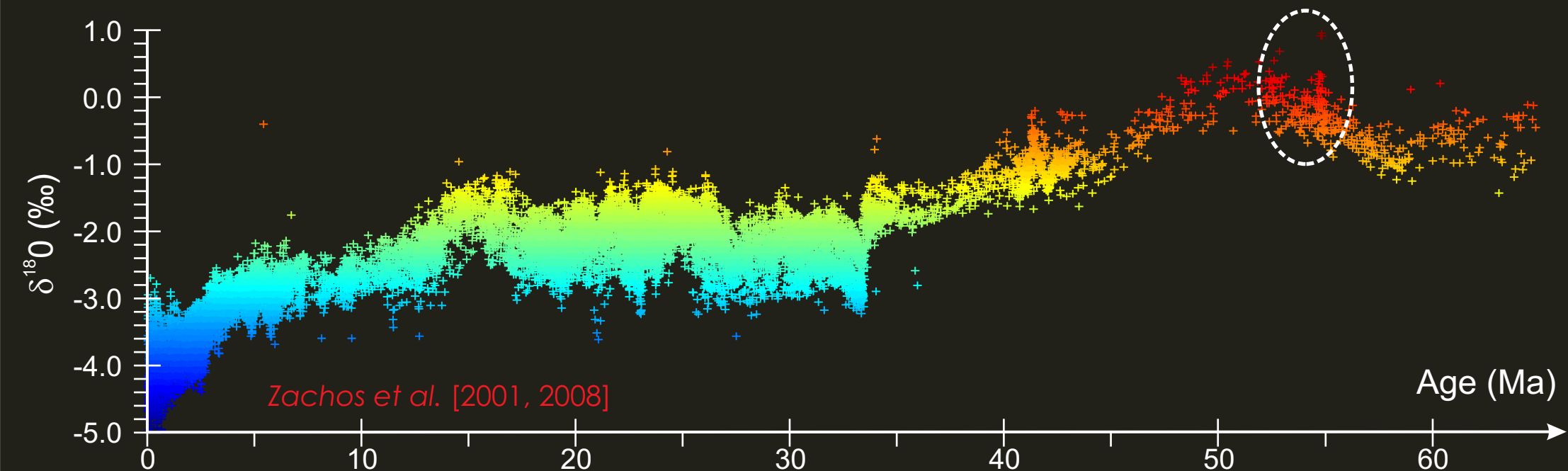
forget about it  
drink beer  
be happy

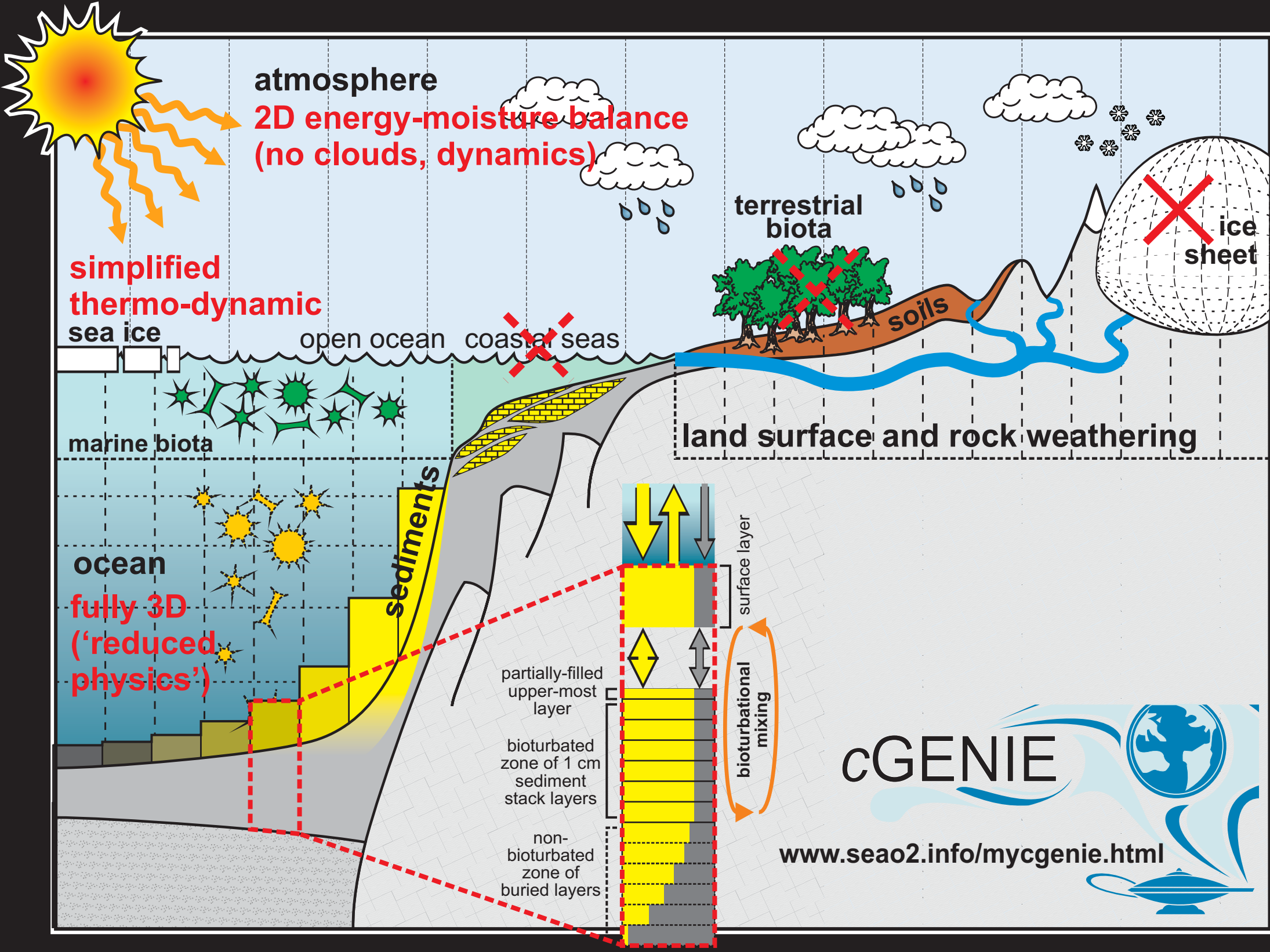
keep going

meh

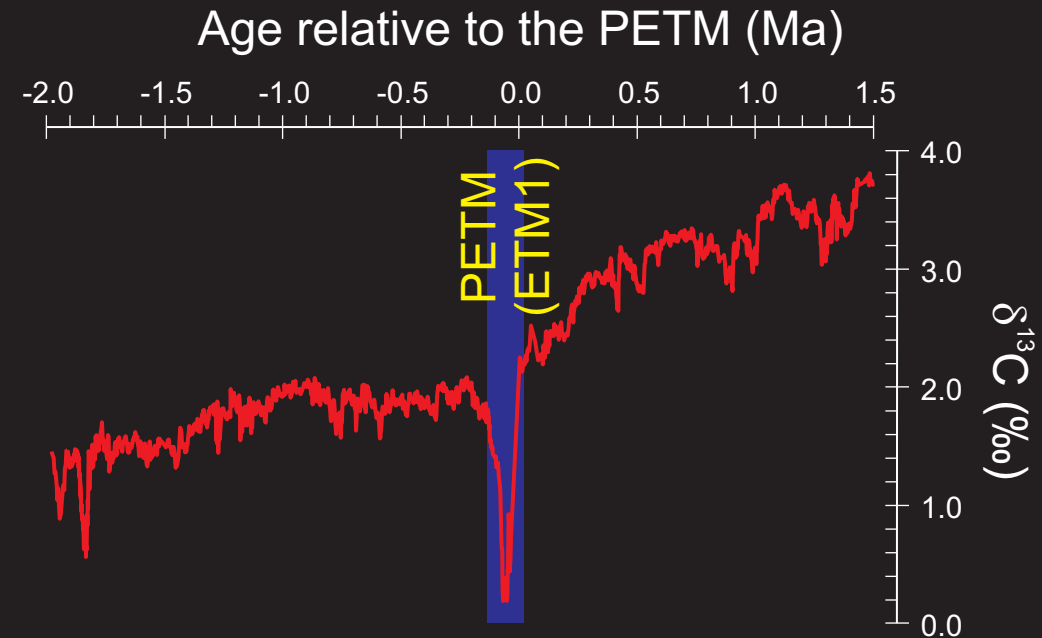
# A deep time perspective on shallow time, time

Quantifying 'time' in models and data

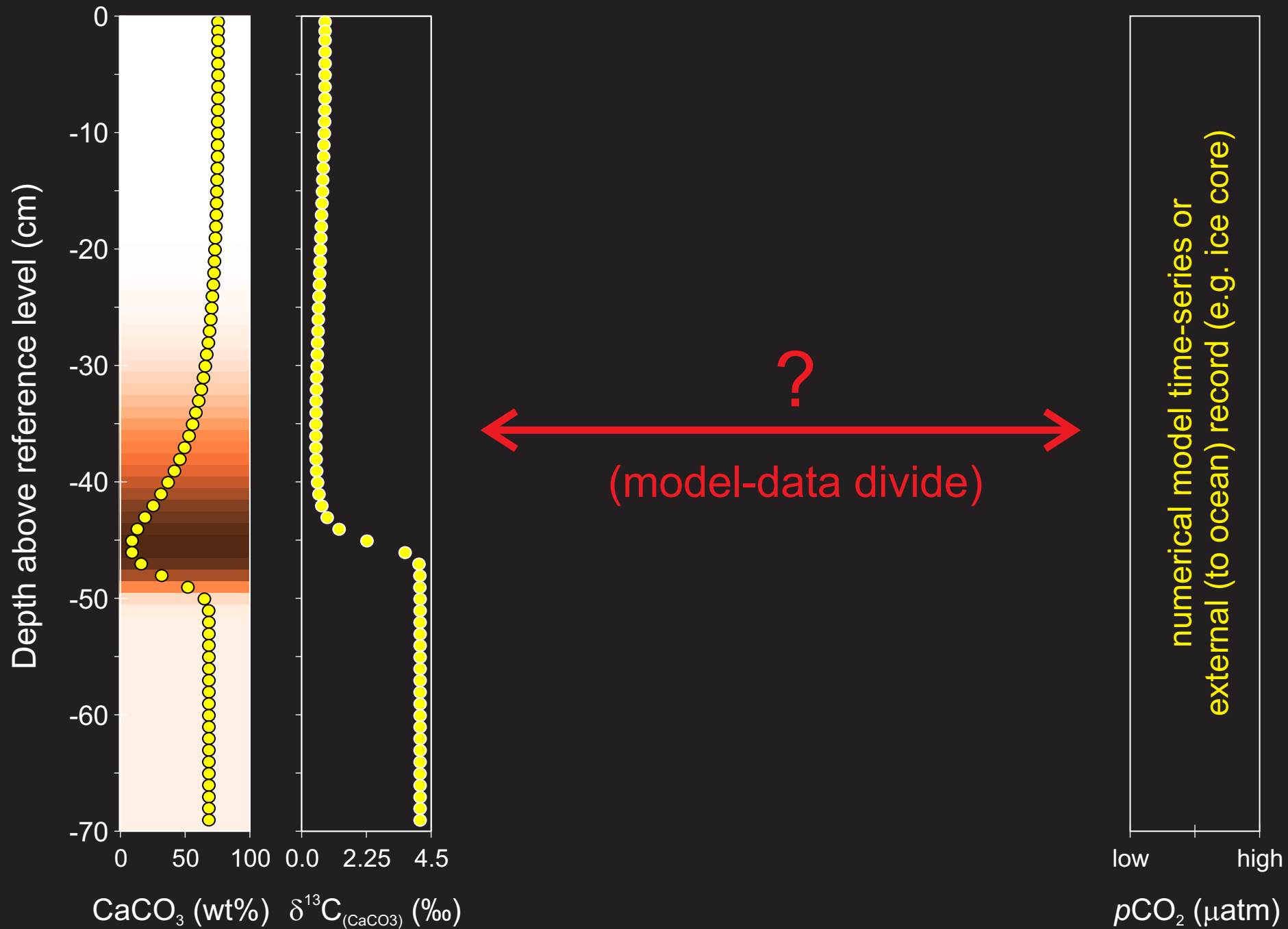




Consider: An event characterized by a (severe) reduction in carbonate preservation

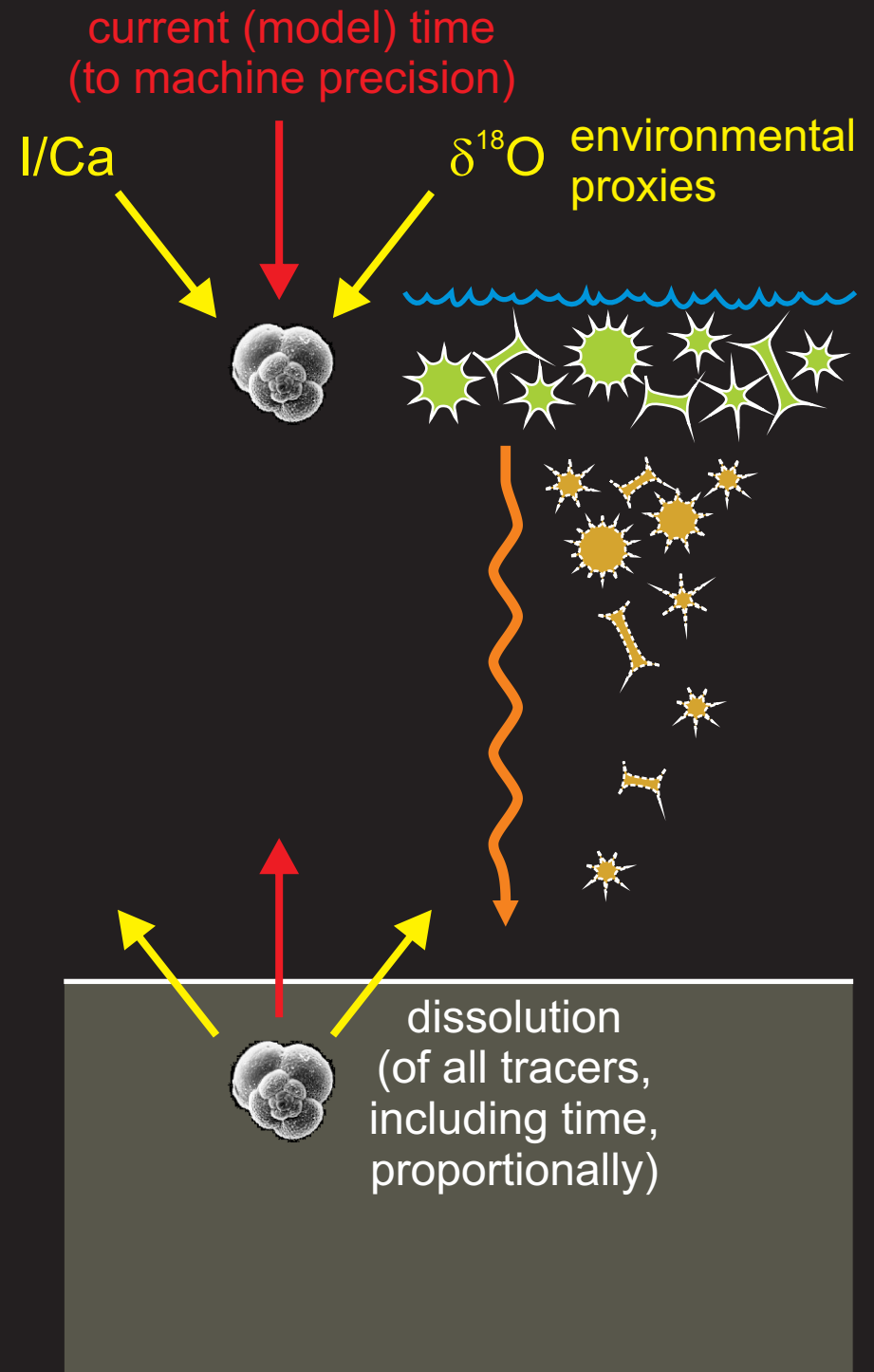
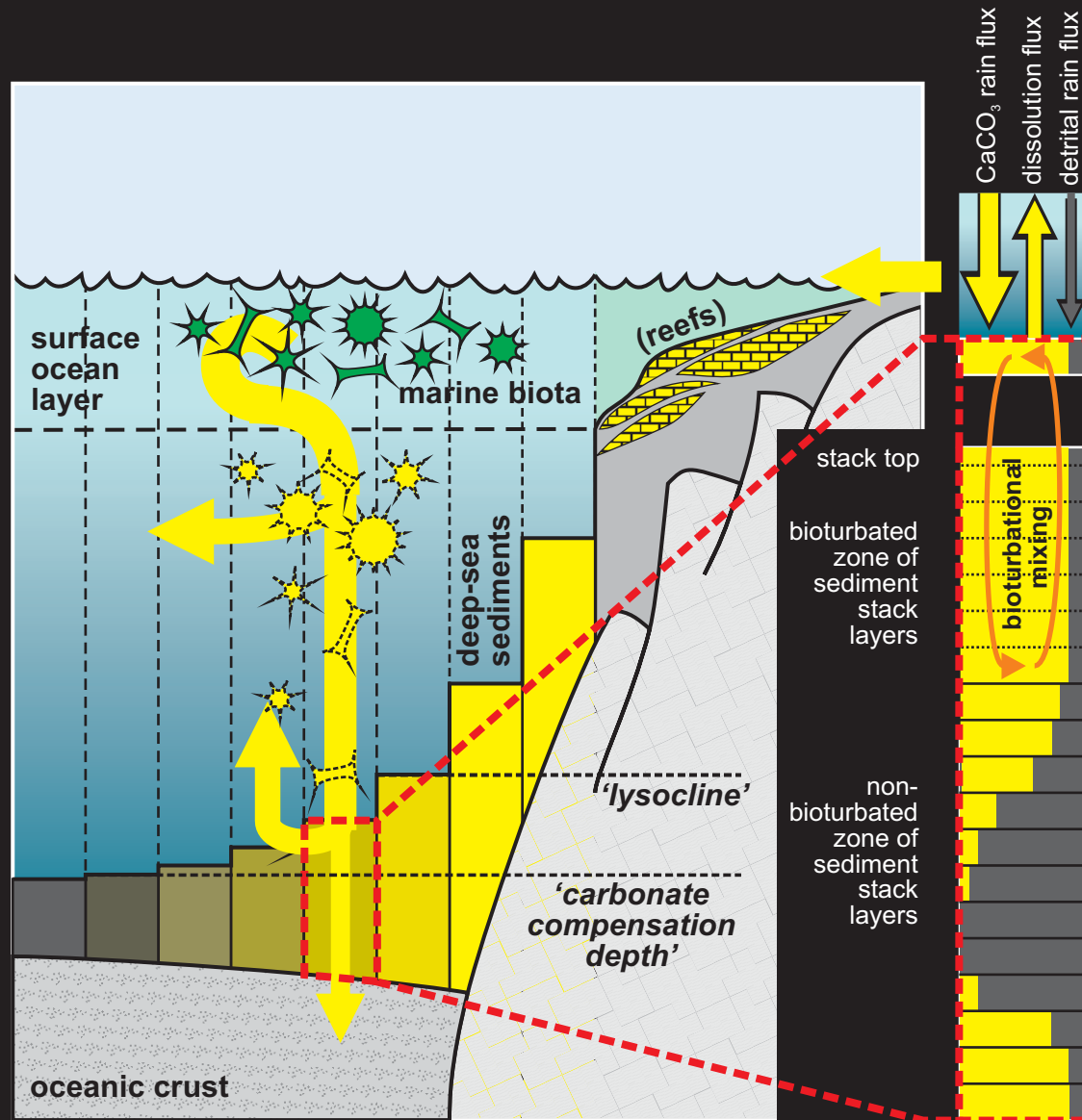






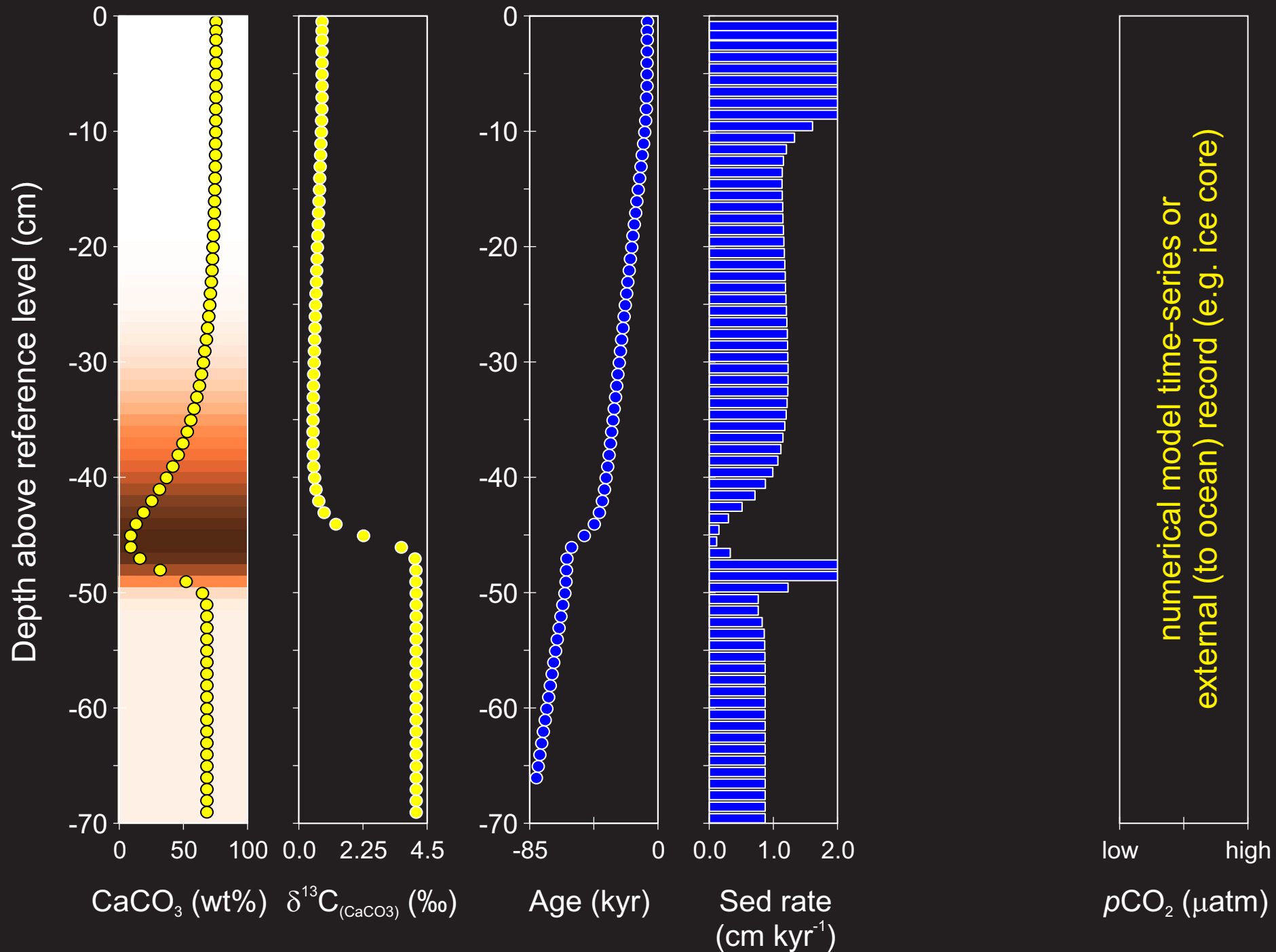
# Age model artifacts -- lessons from deeper-time (1)

Quantifying 'time' in models and data



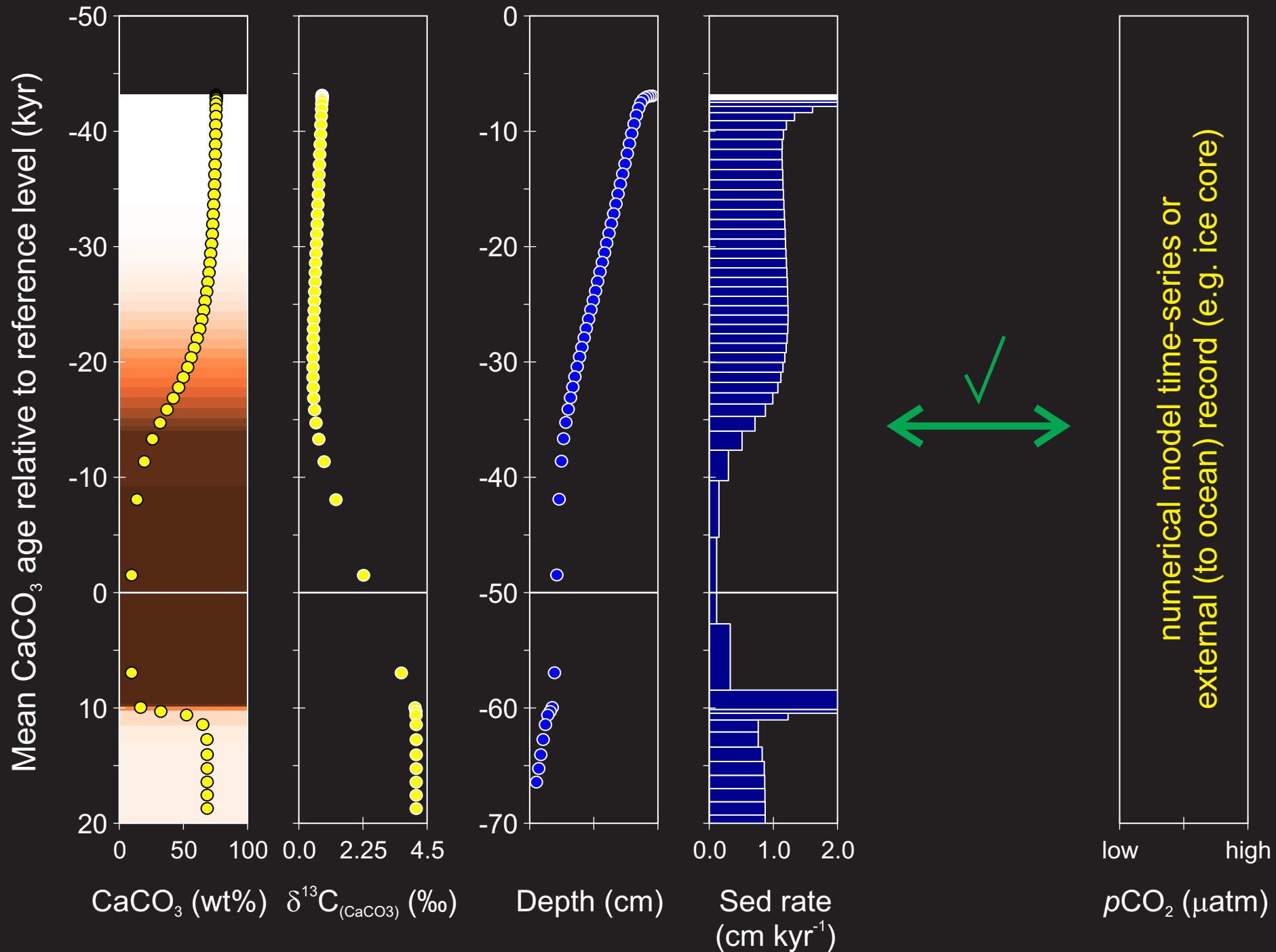
# Age model artifacts -- lessons from deeper-time (1)

Quantifying 'time' in models and data



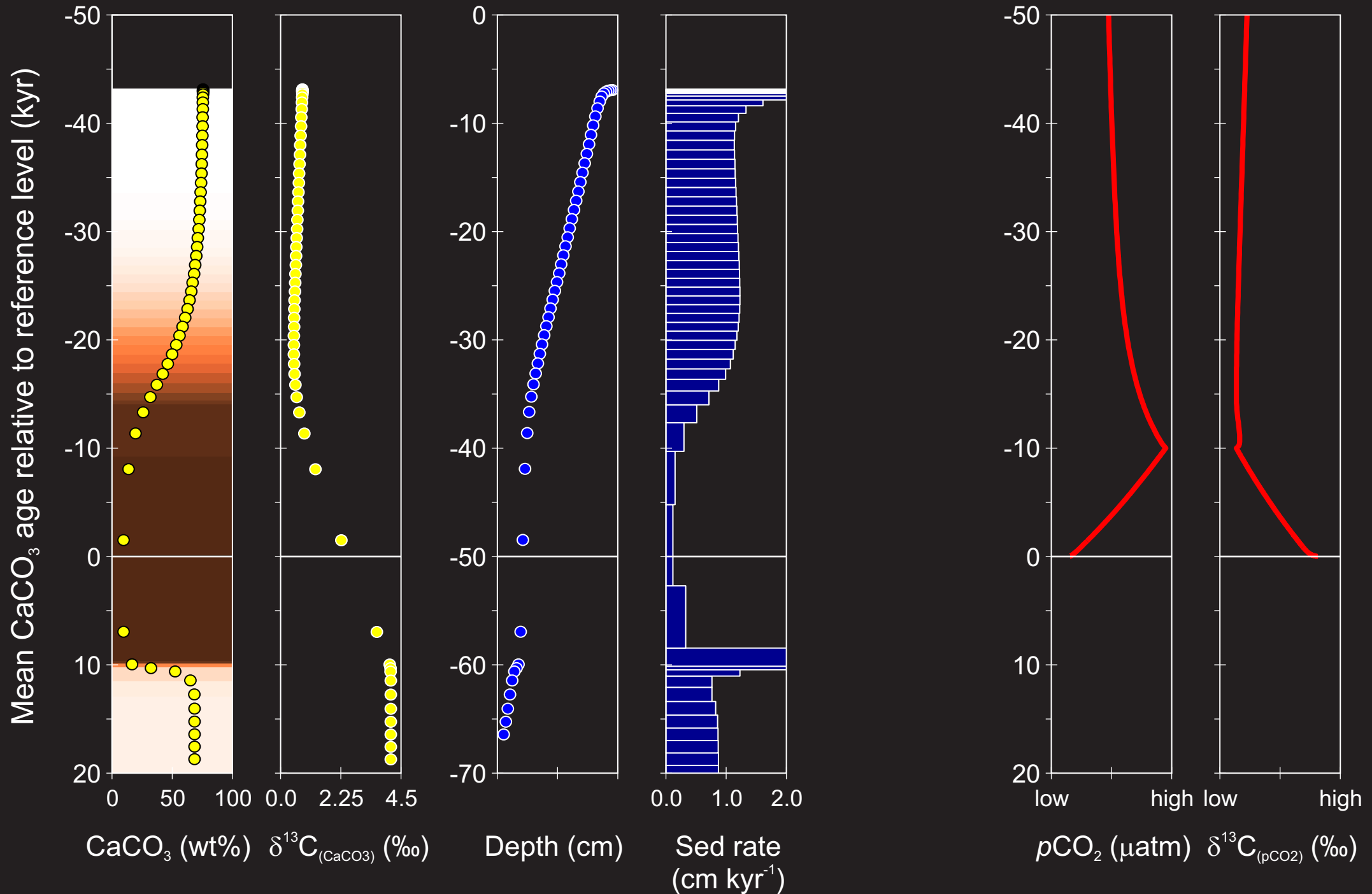
# Age model artifacts -- lessons from deeper-time (1)

Quantifying 'time' in models and data

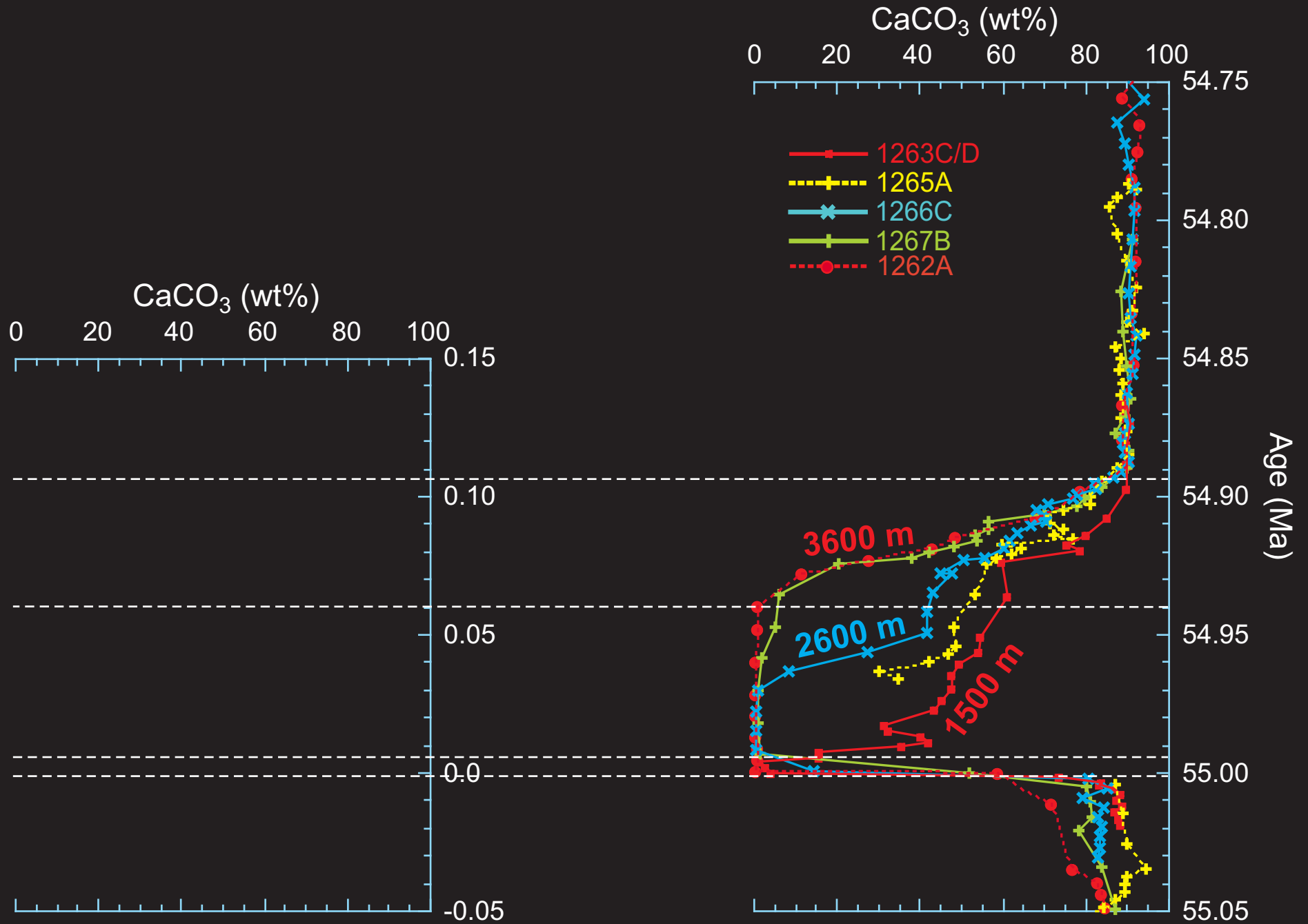


# Age model artifacts -- lessons from deeper-time (1)

Quantifying 'time' in models and data



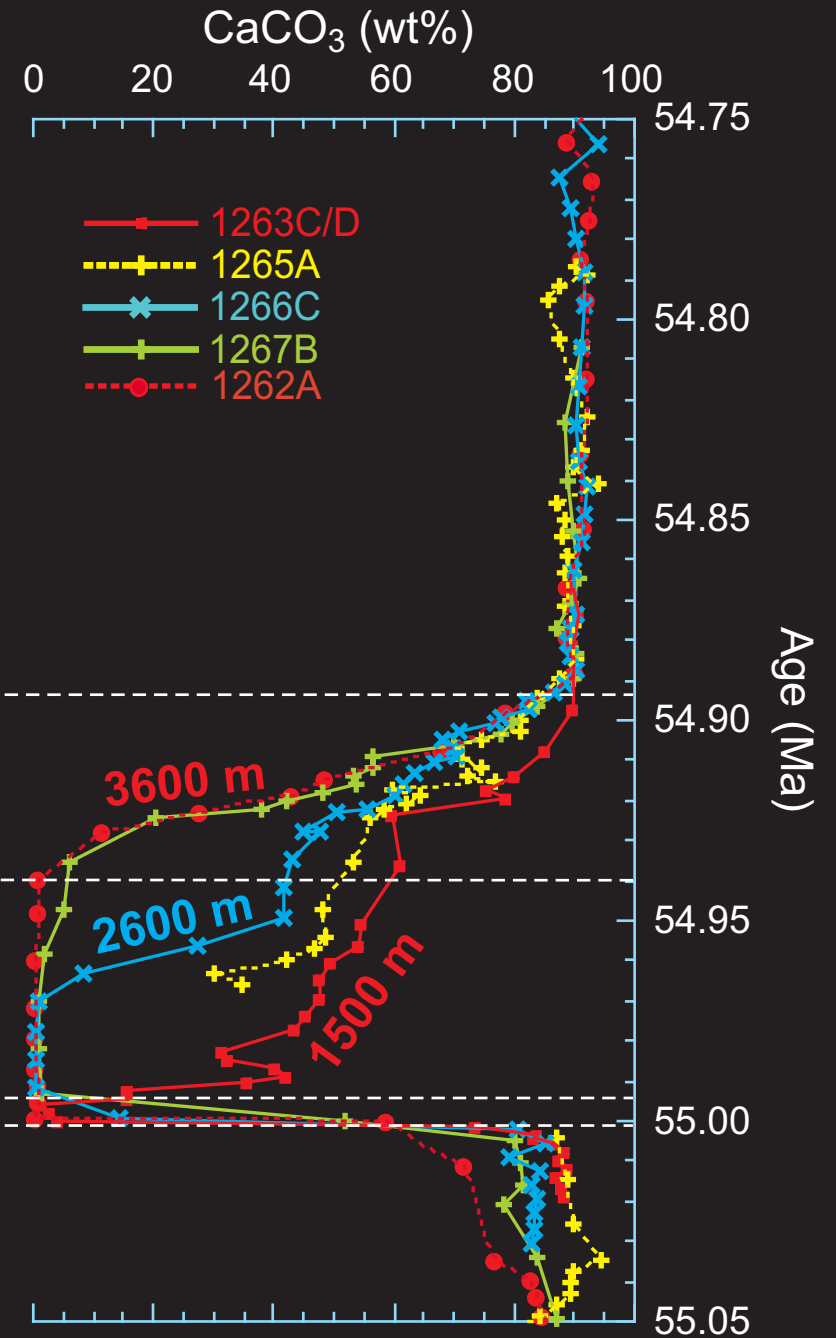
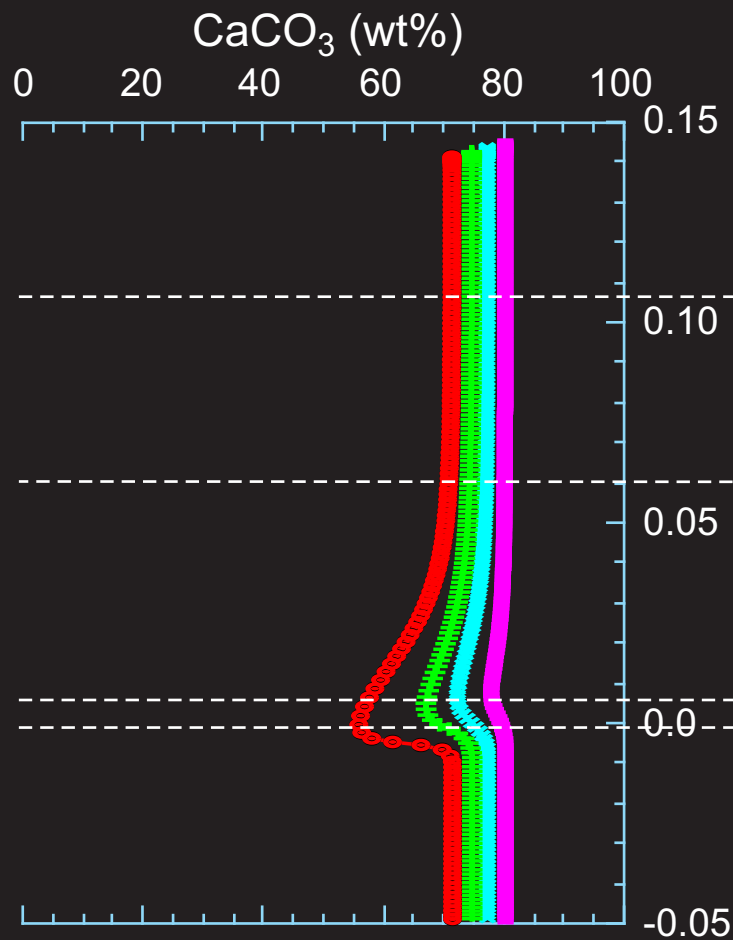
Model-generated synthetic sediment core response [Ridgwell, 2007]



Bulk sediment wt% CaCO<sub>3</sub> content [Zachos et al., 2005]

2000 PgC CO<sub>2</sub> perturbation

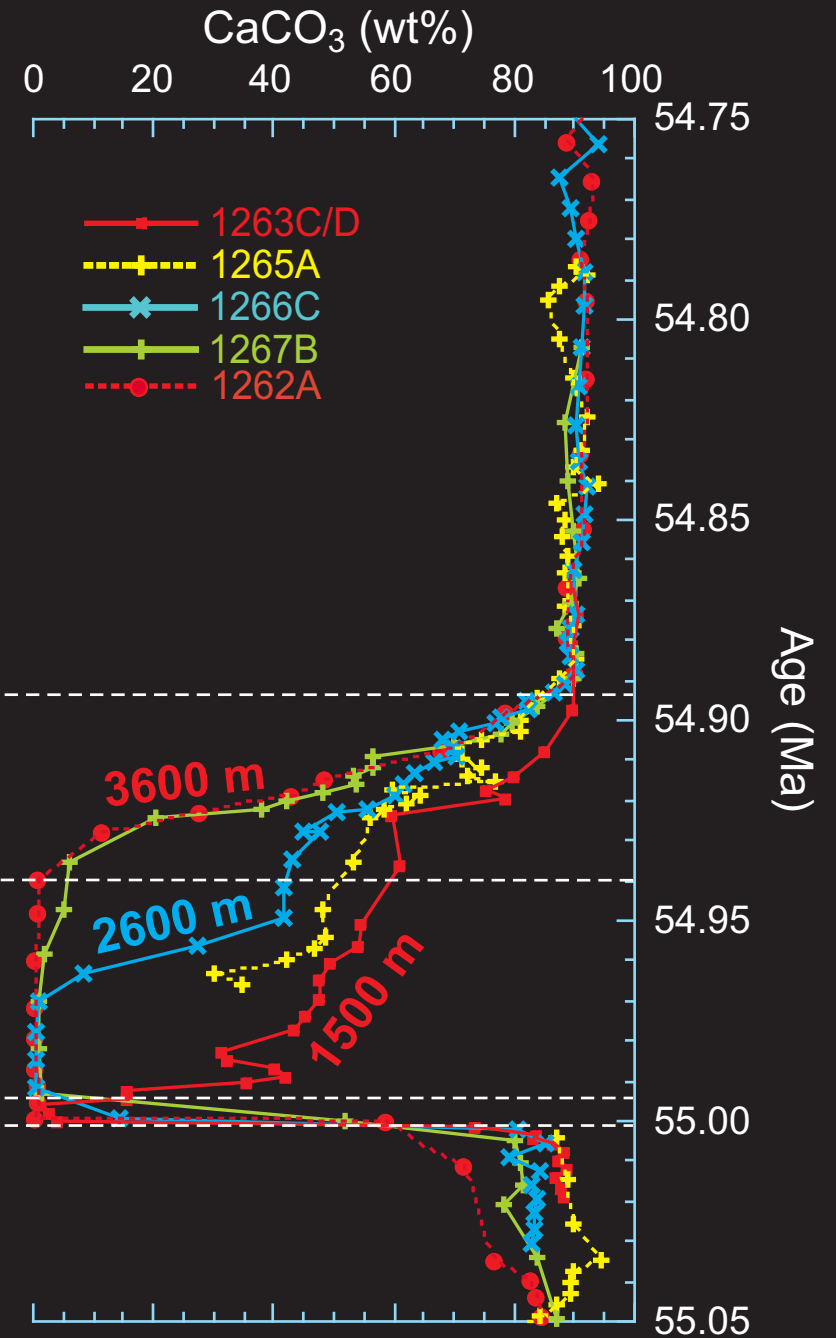
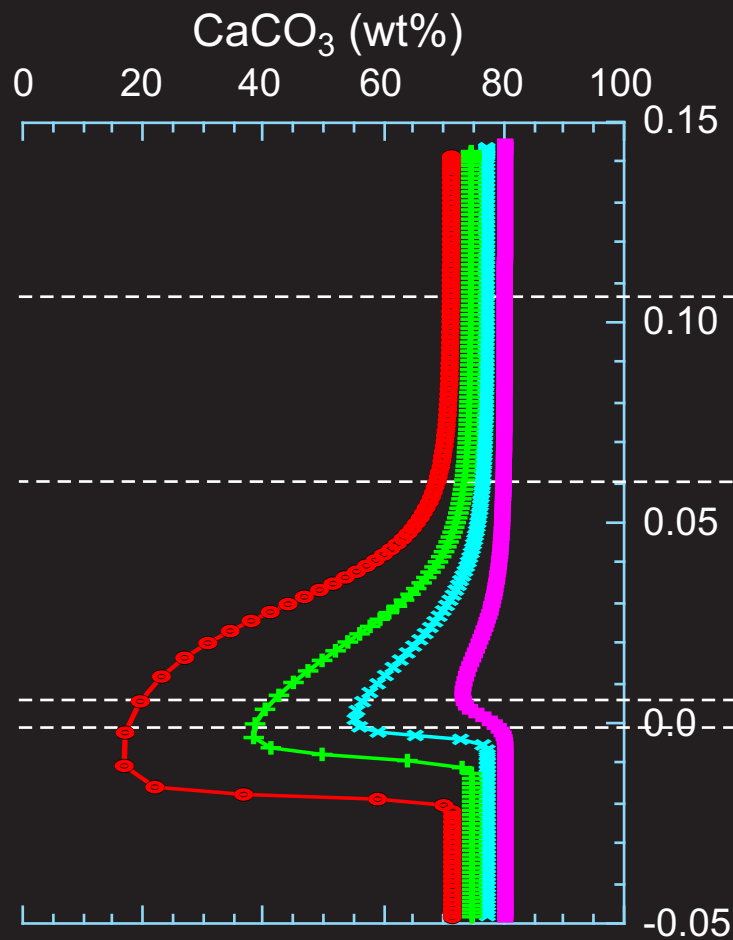
Model-generated synthetic sediment core response [Ridgwell, 2007]



Bulk sediment wt% CaCO<sub>3</sub> content [Zachos et al., 2005]

4000 PgC CO<sub>2</sub> perturbation

Model-generated synthetic sediment core response [Ridgwell, 2007]

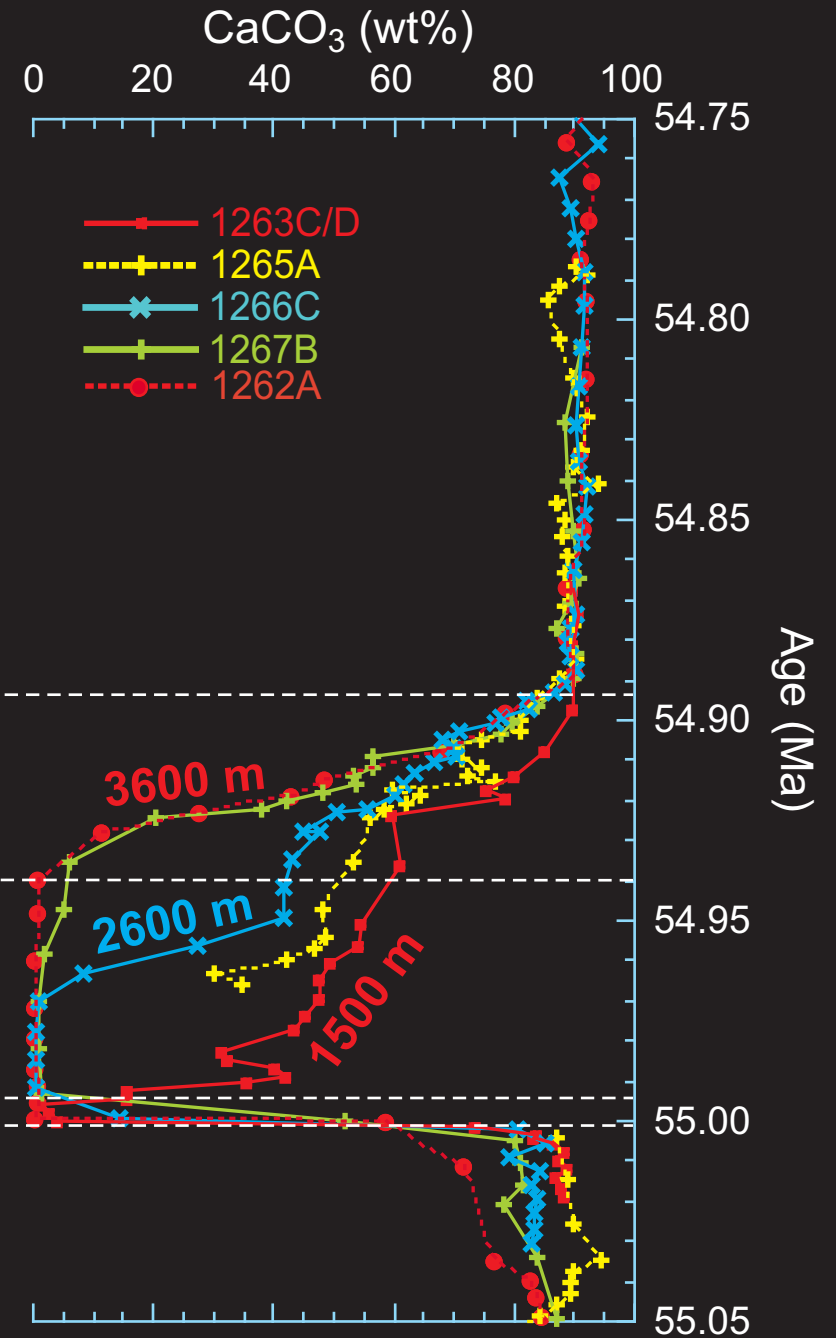
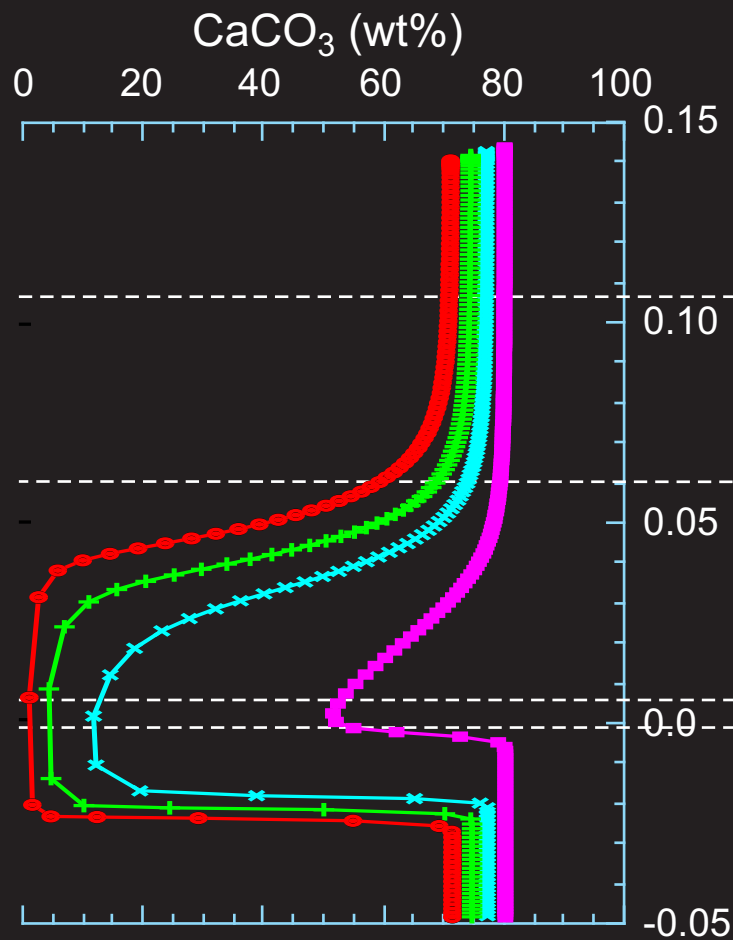


Bulk sediment wt% CaCO<sub>3</sub> content [Zachos et al., 2005]



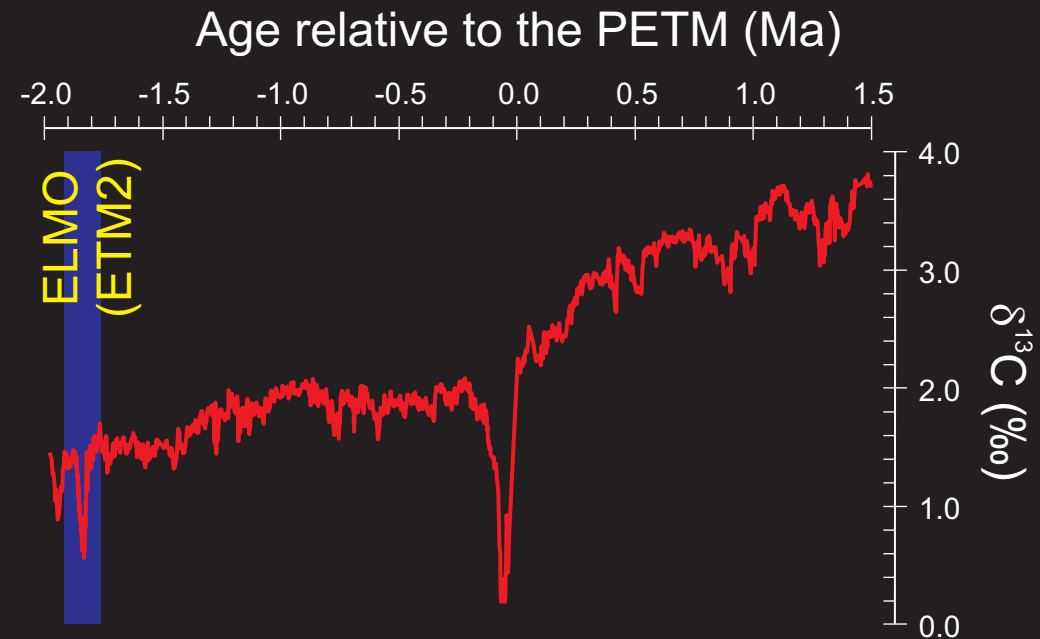
6000 PgC CO<sub>2</sub> perturbation

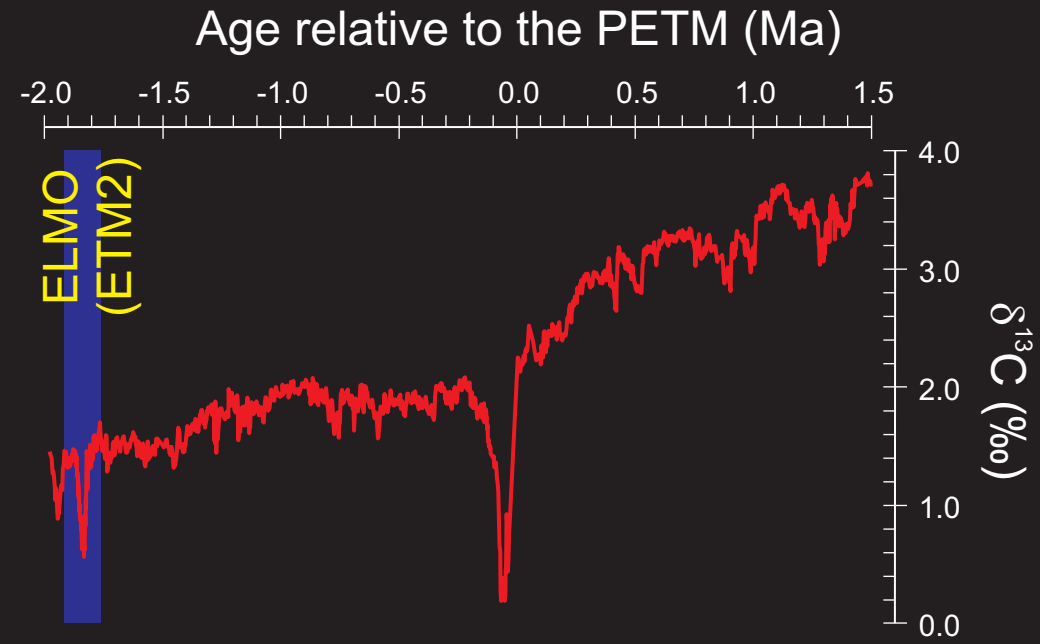
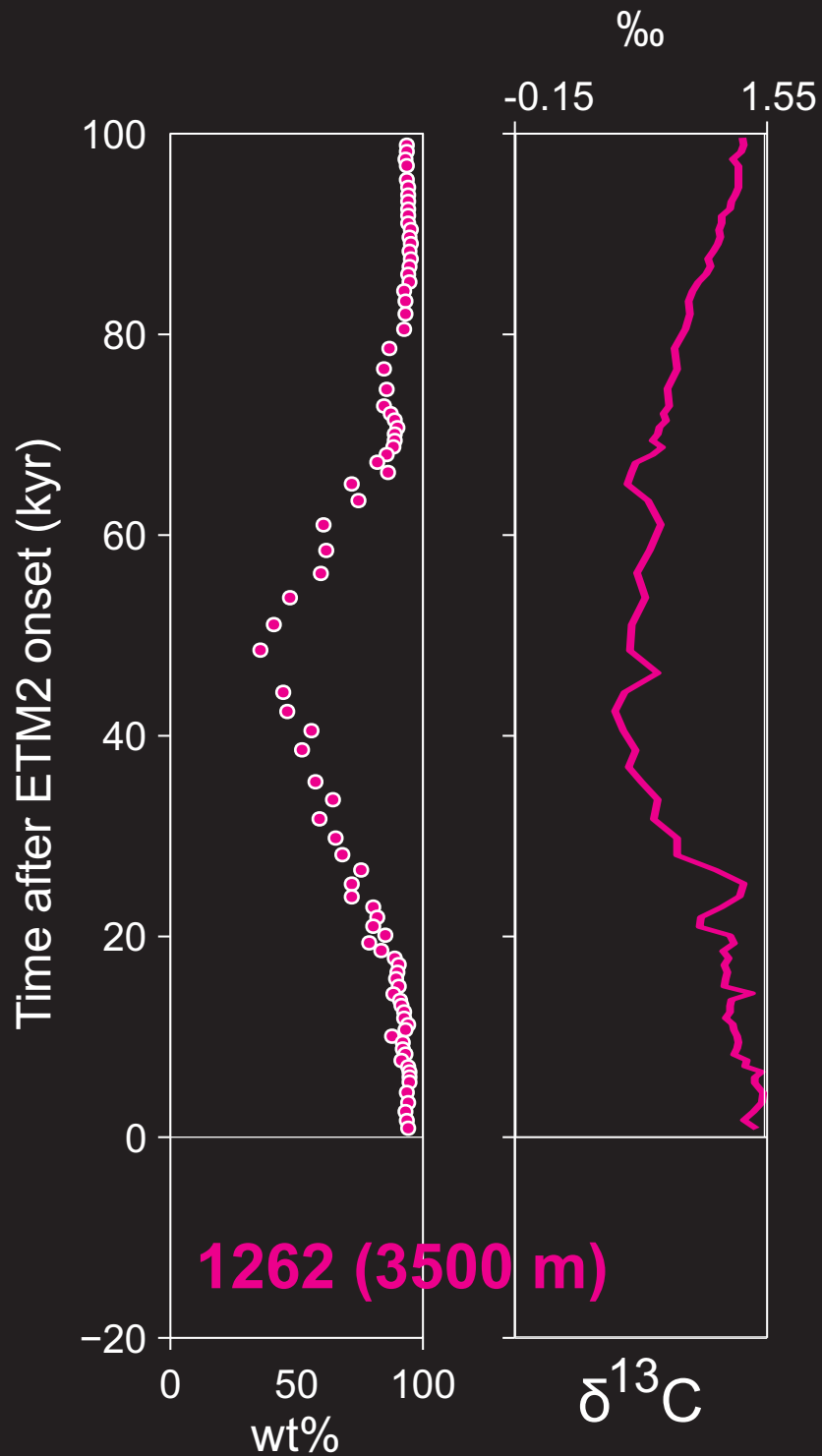
Model-generated synthetic sediment core response [Ridgwell, 2007]



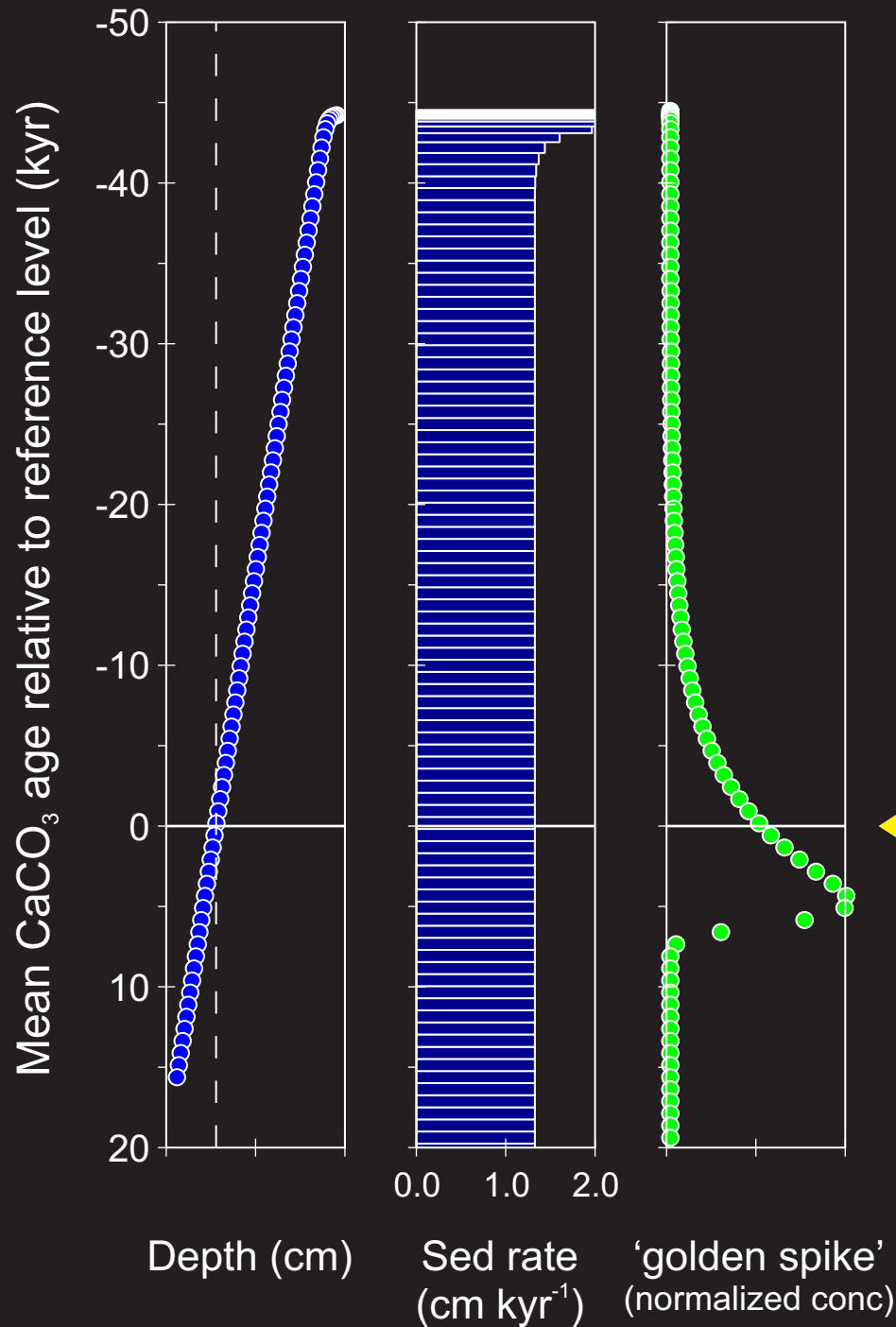
Bulk sediment wt% CaCO<sub>3</sub> content [Zachos et al., 2005]

Consider: An event characterized by a (mild) reduction in carbonate preservation





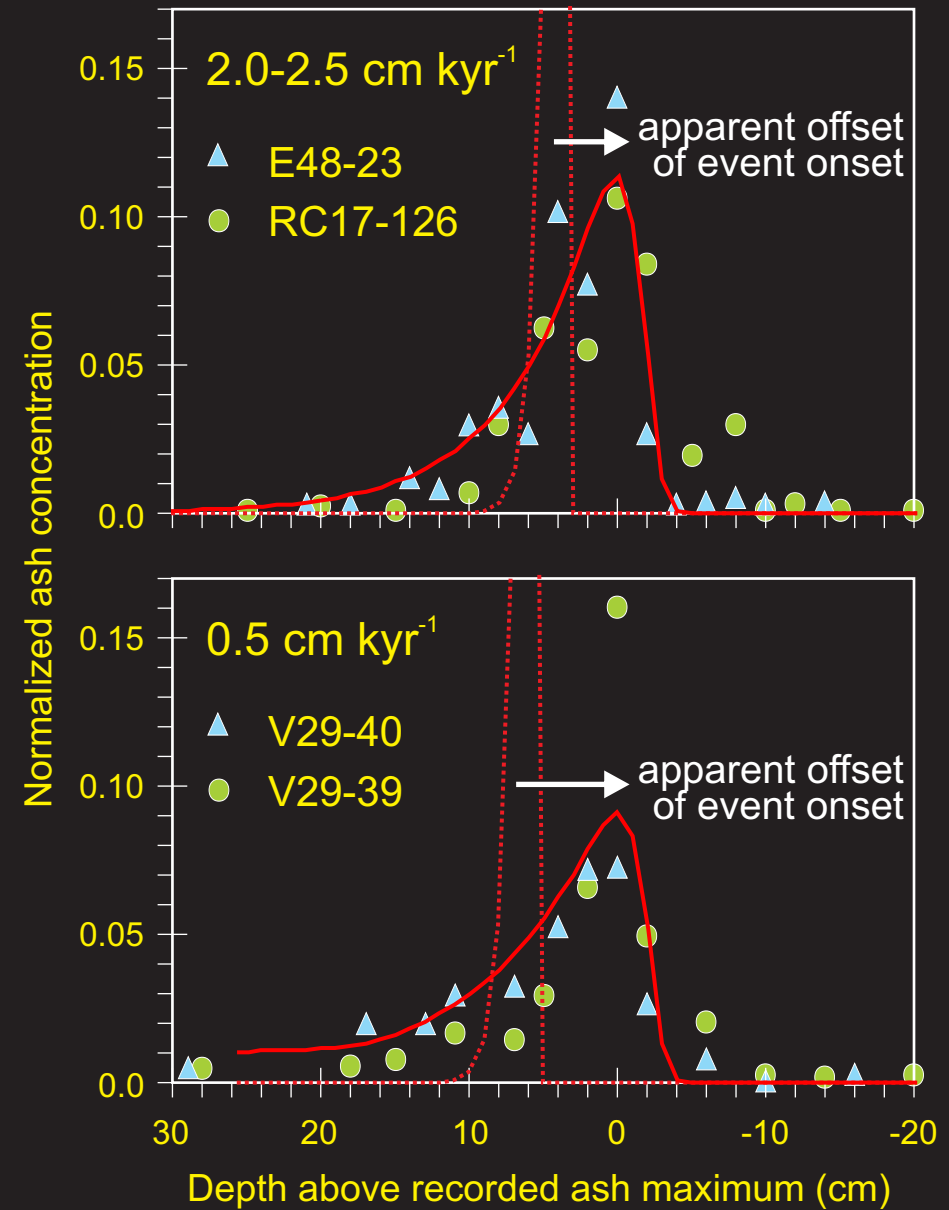
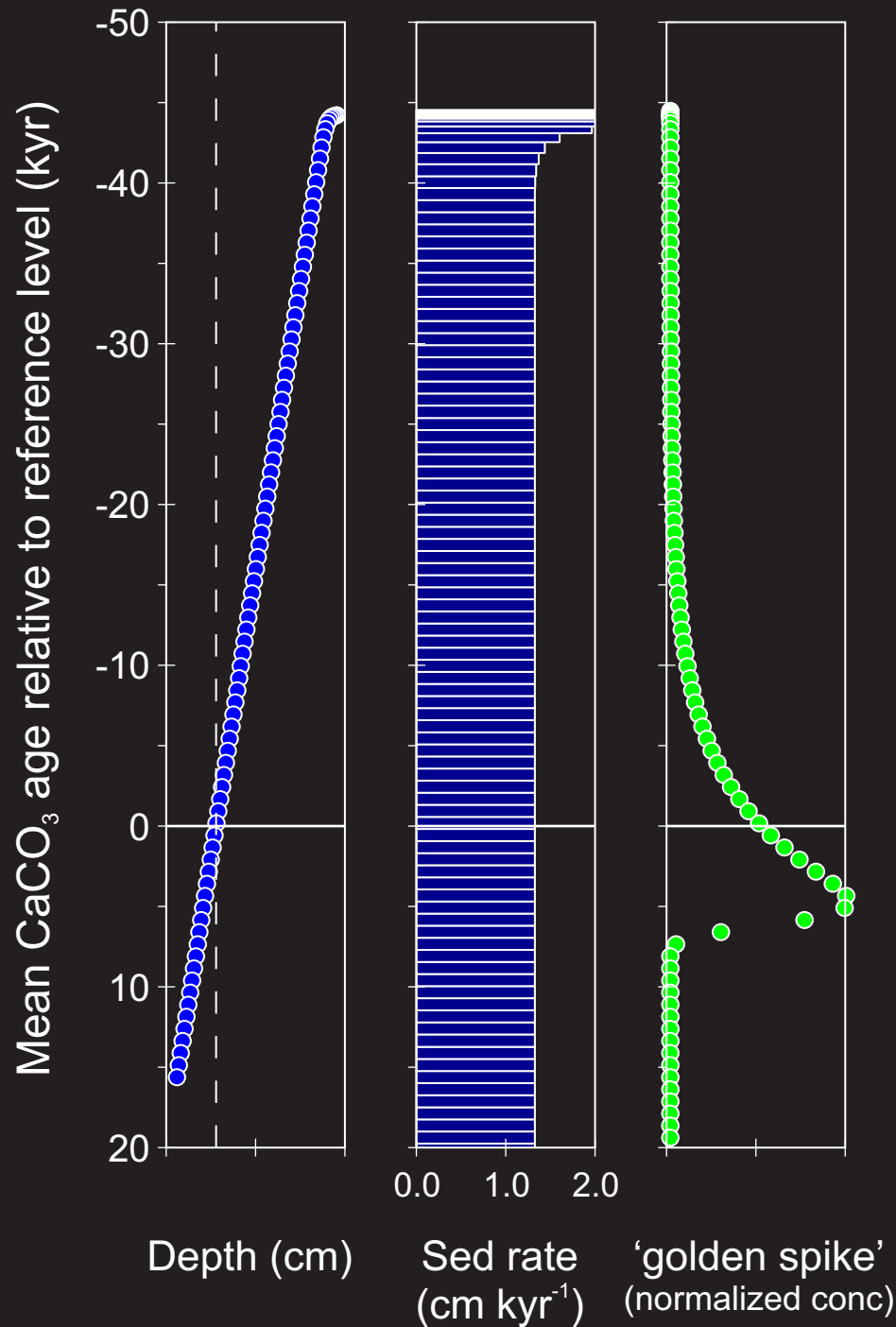
# Age model artifact lessons from deeper-time (2)



← model experiment starts, surface sediments 'tagged' (instantaneous pulse of inert, conservative, numerical tracer)

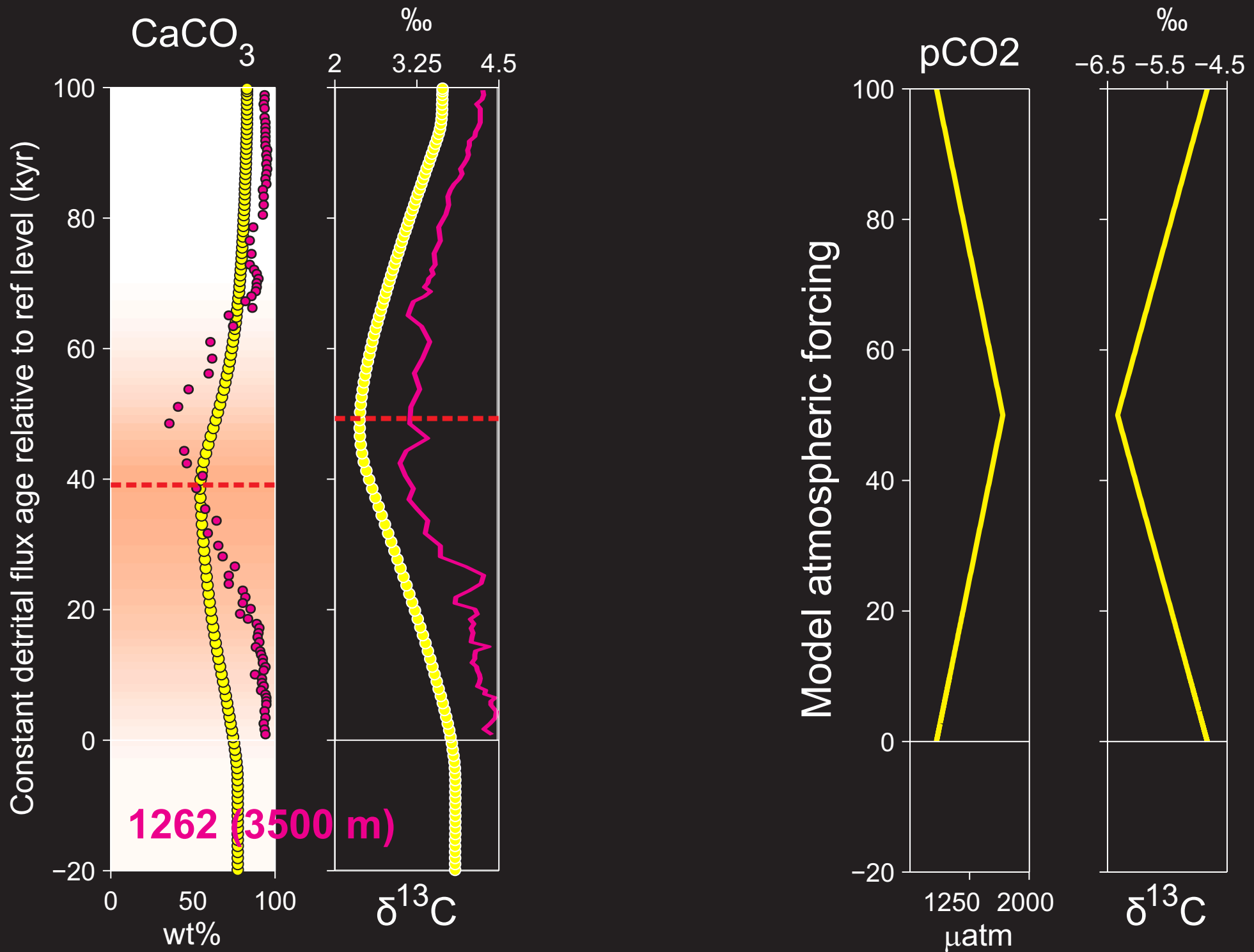
# Age model artifact lessons from deeper-time (2)

Quantifying 'time' in models and data



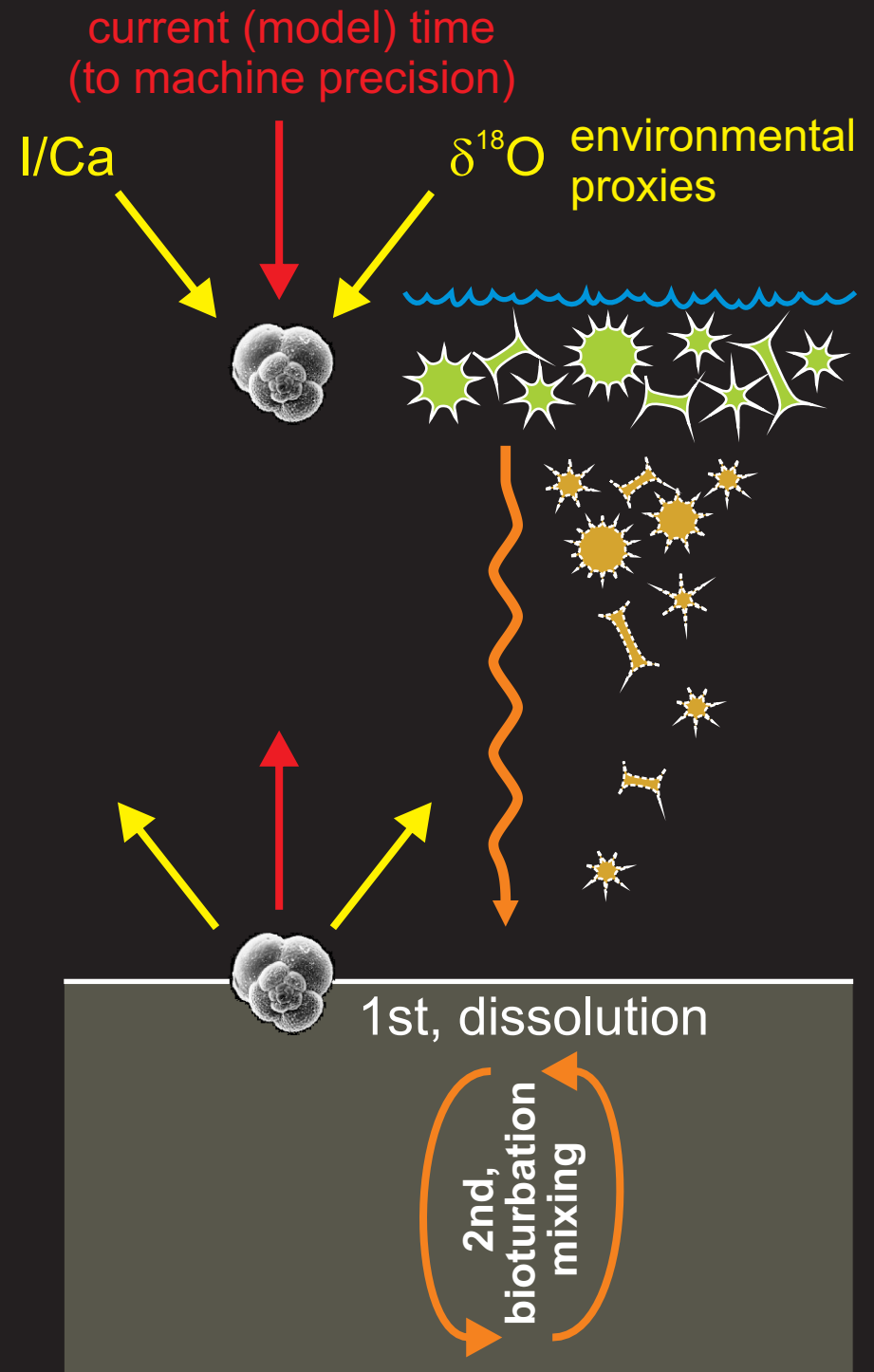
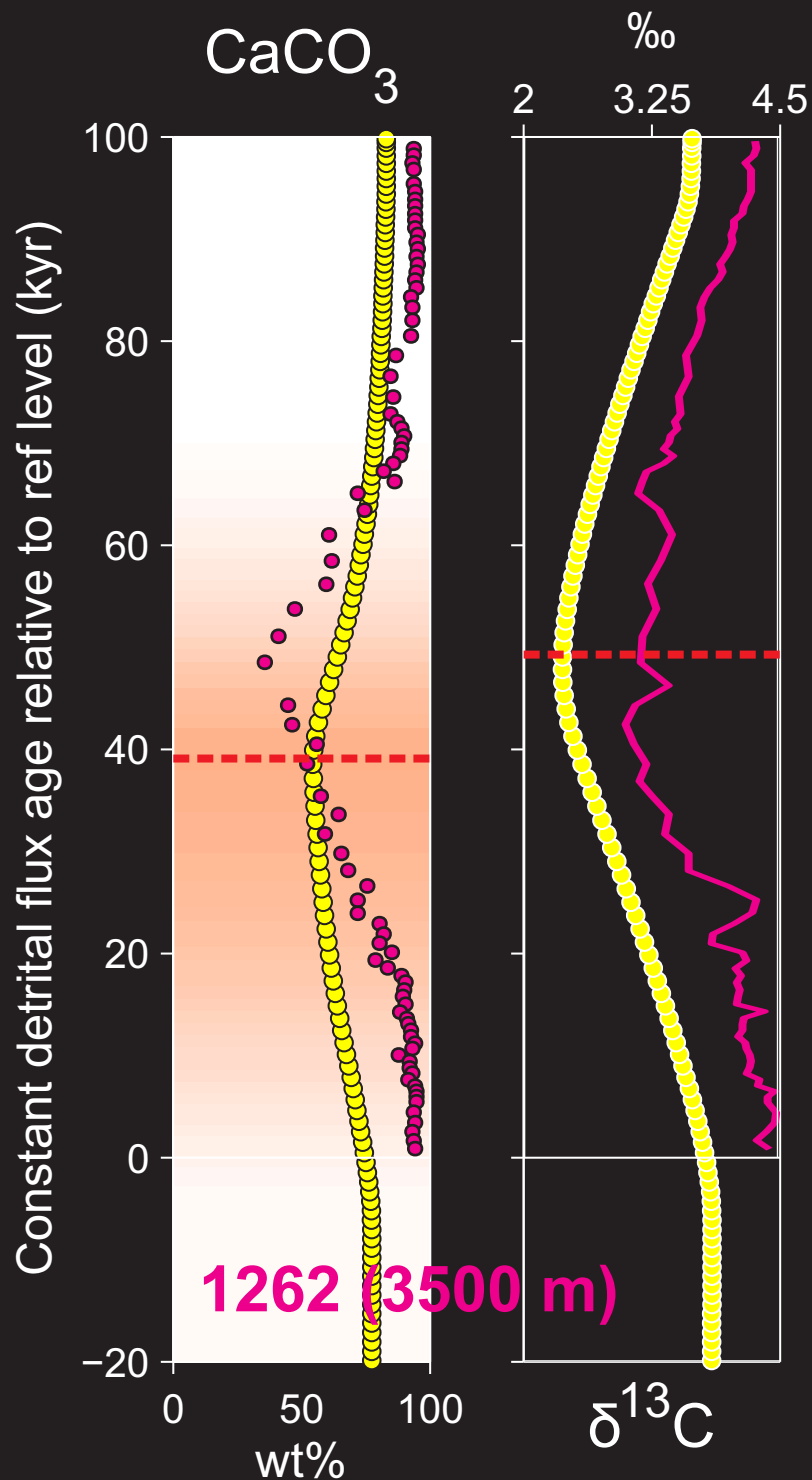
# Age model artifact lessons from deeper-time (2)

Quantifying 'time' in models and data



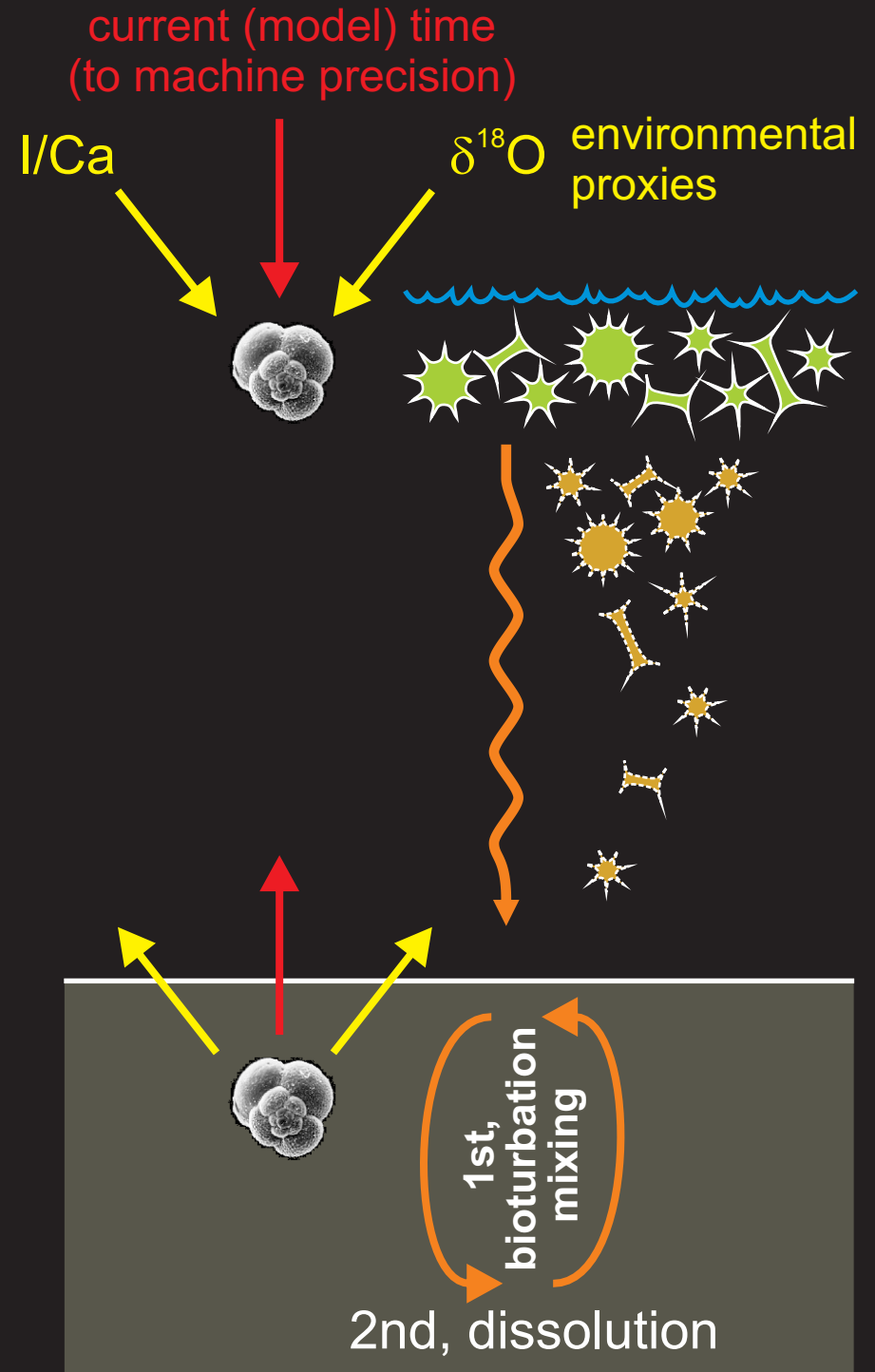
# 'Interface' $\text{CaCO}_3$ dissolution

Quantifying 'time' in models and data



# 'Homogeneous' $\text{CaCO}_3$ dissolution

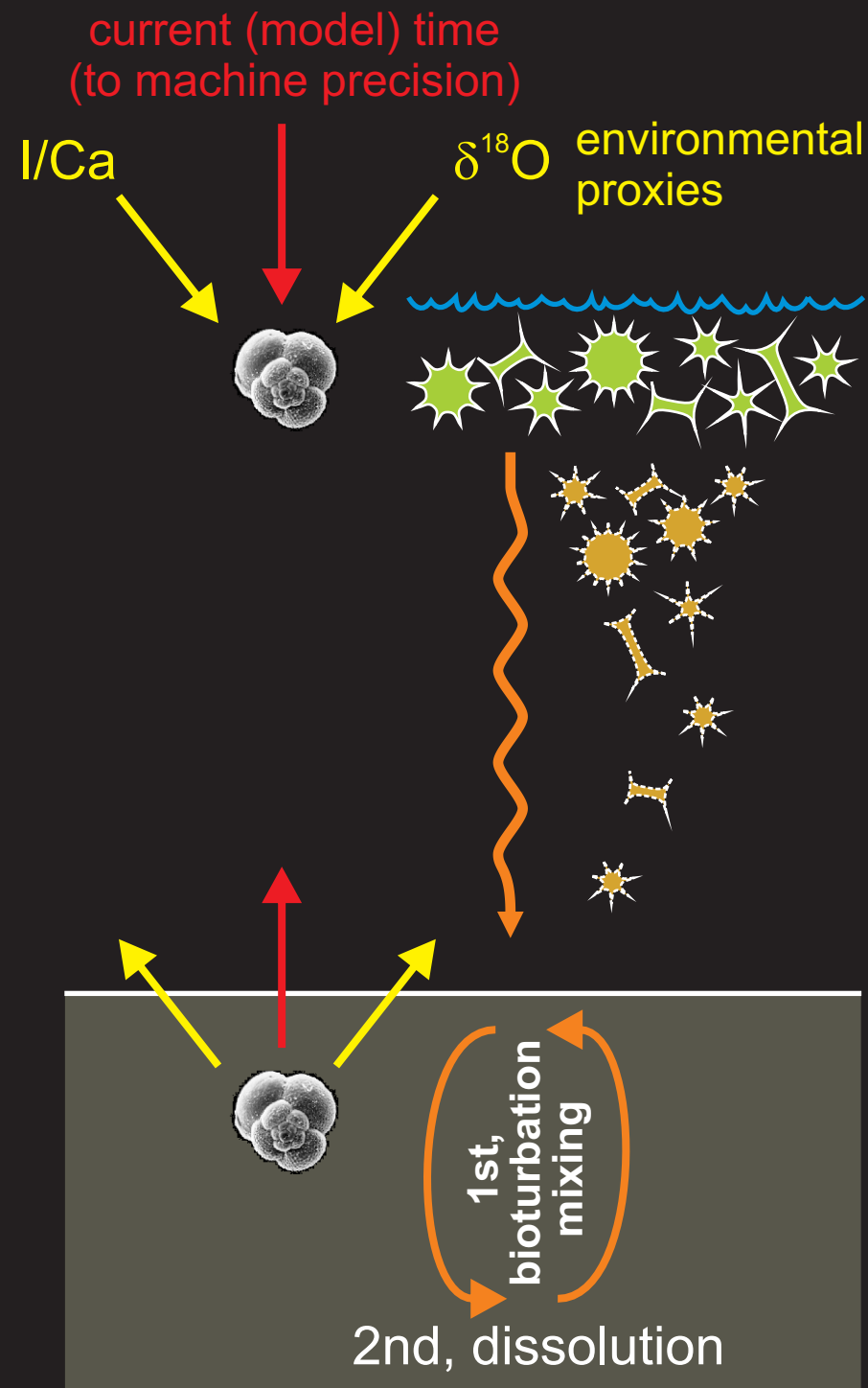
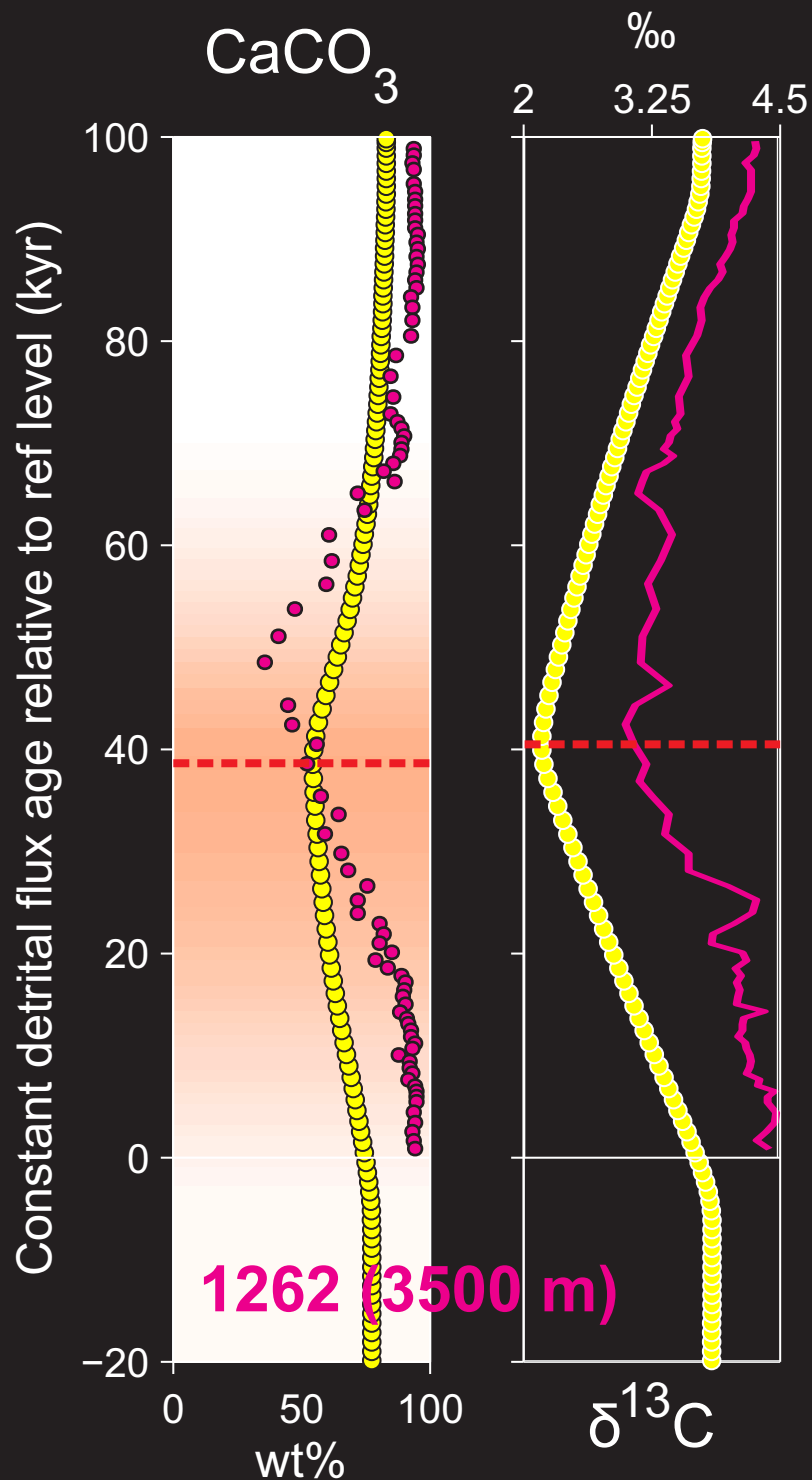
Quantifying 'time' in models and data





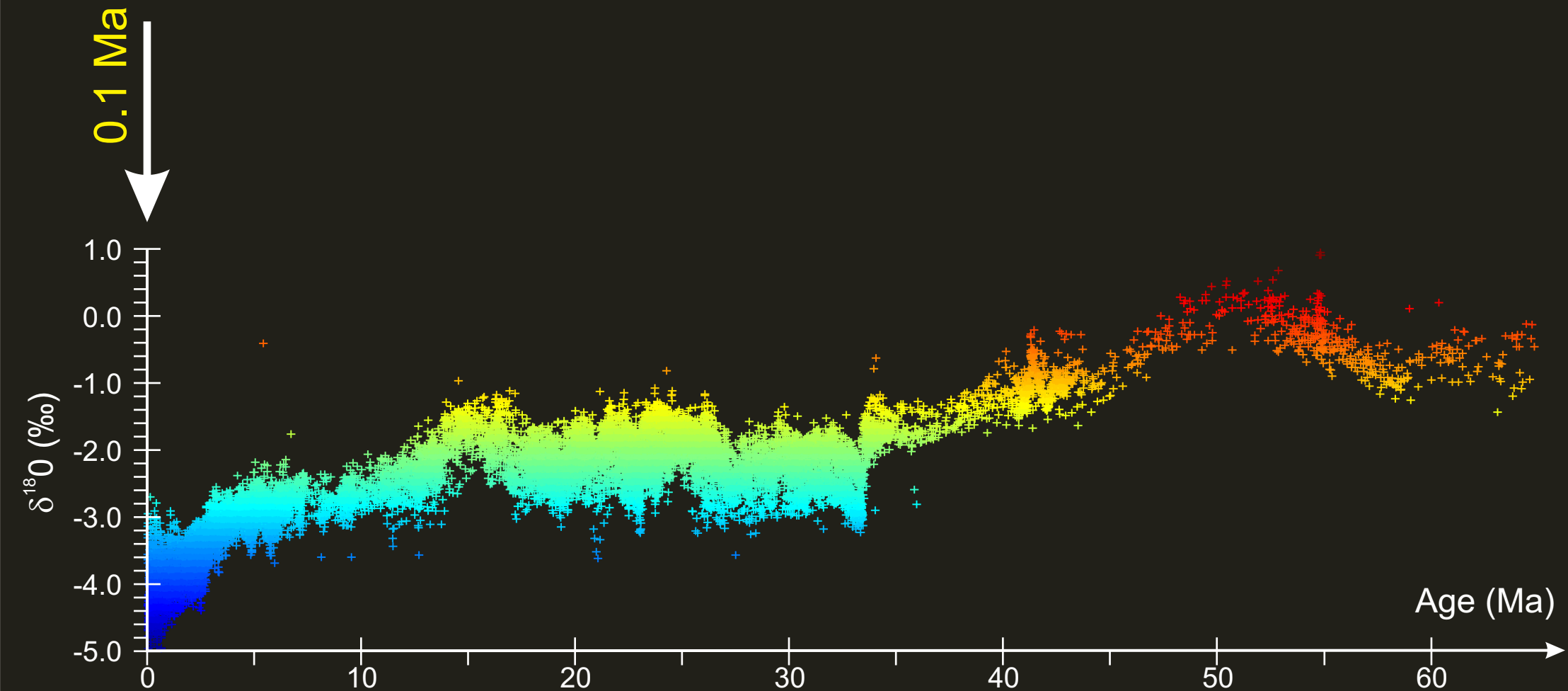
# 'Homogeneous' $\text{CaCO}_3$ dissolution

Quantifying 'time' in models and data



# Shallow time, time (i.e. time in shallow time)

Quantifying 'time' in models and data

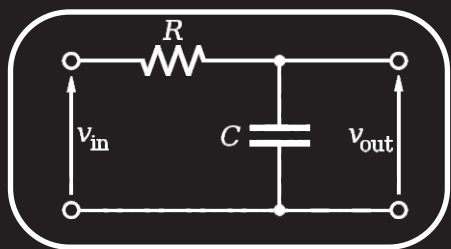


# Shallow time, time (i.e. time in shallow time)

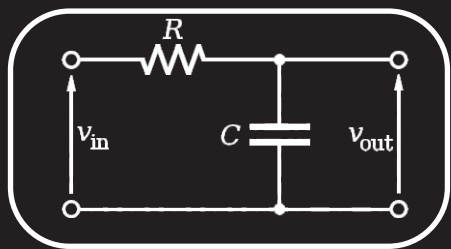
Quantifying 'time' in models and data



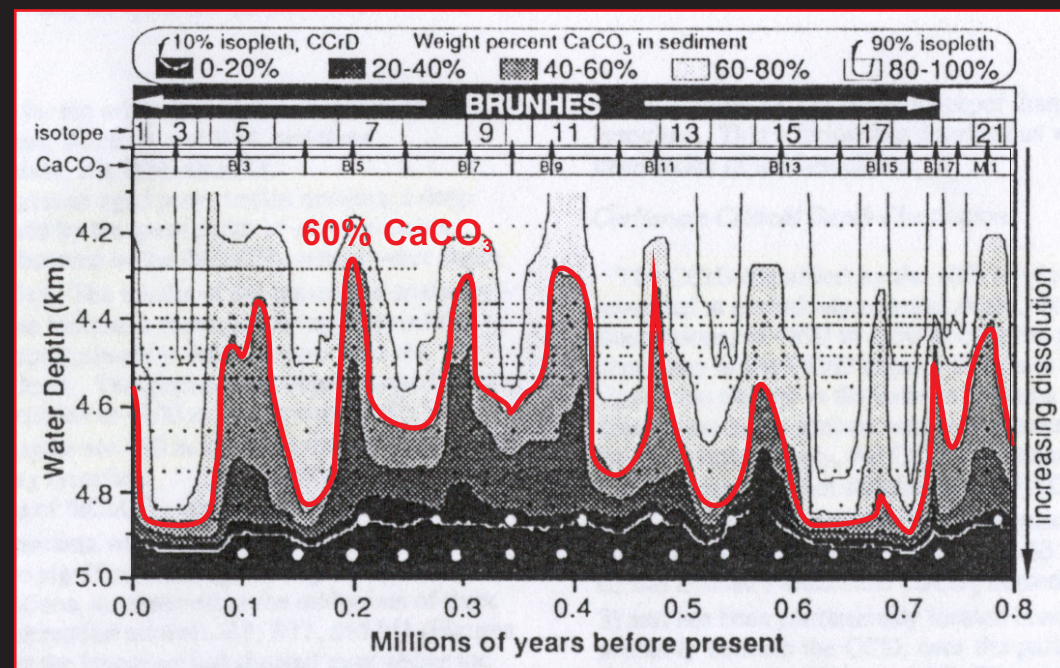
dissolution  
(preservation)



mixing  
(bioturbation)



Farrell and Prell [1989]



*Consider: Co-varying (glacial-interglacial)  $\text{CaCO}_3$  dissolution cycles and how a (varying) stable isotope is recorded*

*Methodology:  $\delta^{18}\text{O}$  of planktic carbonate follows the LR04 stack, plus atmospheric  $\text{pCO}_2$  is forced to follow the EPICA Dome C record, providing a varying preservation forcing on  $\text{CaCO}_3$  in marine sediments.*

# Shallow time, time (i.e. time in shallow time)

Quantifying 'time' in models and data

```
1: sprout.ggy.bris.ac.uk - mushroom@sprout - SSH Secure Shell
File Edit View Window Help
Quick Connect Profiles

all.q@compute-0-2.local BIP 0/6/24 6.00 1x26-amd64
4192 0.55500 runmuffin. mushroom r 03/08/2015 13:46:20 1
4291 0.55500 runmuffin. mushroom r 03/16/2015 22:01:35 1
4302 0.55500 runmuffin. mushroom r 03/18/2015 08:19:50 1
4303 0.55500 runmuffin. mushroom r 03/18/2015 08:20:05 1
4304 0.55500 runmuffin. mushroom r 03/18/2015 08:20:20 1

all.q@compute-0-3.local BIP 0/5/24 5.00 1x26-amd64
4121 0.55500 runmuffin. mushroom r 02/16/2015 20:11:50 1
4202 0.55500 runmuffin. mushroom r 03/08/2015 14:08:05 1

all.q@compute-0-4.local BIP 0/4/24 4.02 1x26-amd64
4215 0.55500 runmuffin. mushroom r 03/10/2015 19:55:20 1
4305 0.55500 runmuffin. mushroom r 03/18/2015 17:12:20 1
4307 0.55500 runmuffin. mushroom r 03/18/2015 17:13:05 1

all.q@compute-0-5.local BIP 0/4/24 4.00 1x26-amd64
4191 0.55500 runmuffin. mushroom r 03/08/2015 13:46:05 1
4204 0.55500 runmuffin. mushroom r 03/08/2015 18:00:05 1
4246 0.55500 runmuffin. mushroom r 03/13/2015 10:52:50 1

[mushroom@sprout genie-main] $ ls
assumedgood.log GENIEconf.py genie_ini_wrappers.dep initialise_genie.o runmuffin.sh
compare-basic.sh genie_control.dep genie_ini_wrappers.f90 inputdata runmuffin.t100.sh
comparelong.sh genie_control.f90 genie_ini_wrappers.mod local_netcdf.dep sro
config2xml.py genie_control.mod genie_ini_wrappers.o local_netcdf.f90 testbiogem.out
configs genie_control.o genie.job local_netcdf.mod testebgogs.out
current_config.dat genie.dep genie_loop_wrappers.dep local_netcdf.o testing.mak
data genie_end_wrappers.dep genie_loop_wrappers.f90 local_output.dep translate_config.py
doc genie_end_wrappers.f90 genie_loop_wrappers.mod local_output.f90 user.mak
end_genie.dep genie_end_wrappers.mod genie_loop_wrappers.o local_output.mod user.sh
end_genie.f genie_end_wrappers.o genie.o local_output.o WindowsCompilation.txt
end_genie.o genie_example.job genie_util.dep makefile write_netcdf_genie.dep
extract-basic.sh genie.exe genie_util.f90 makefile.arc write_netcdf_genie.f90
extractvars.sh genie.F genie_util.mod nccomp.py write_netcdf_genie.o
extrap.dep genie_global.dep genie_util.o netcdf.inc write_netcdf.mod
extrap.f genie_global.f90 include README
extrap.o genie_global.mod initialise_genie.dep README.changes
fine.py genie_global.o initialise_genie.F runmuffin.ensemble.sh

[mushroom@sprout genie-main] $
[mushroom@sprout genie-main] $
[mushroom@sprout genie-main] $ qstat -f
queue name qtype resv/used/tot. load_avg arch states
-----
all.q@compute-0-1.local BIP 0/3/24 3.00 1x26-amd64
4295 0.55500 runmuffin. mushroom r 03/16/2015 22:07:50 1
4312 0.55500 runmuffin. mushroom r 03/20/2015 09:45:20 1
4313 0.55500 runmuffin. mushroom r 03/20/2015 09:48:50 1

all.q@compute-0-1.local BIP 0/9/24 9.02 1x26-amd64
4123 0.55500 runmuffin. mushroom r 02/16/2015 20:12:20 1
4201 0.55500 runmuffin. mushroom r 03/08/2015 14:07:50 1
4214 0.55500 runmuffin. mushroom r 03/10/2015 19:54:50 1
4261 0.55500 runmuffin. mushroom r 03/15/2015 14:07:50 1
4270 0.55500 runmuffin. mushroom r 03/15/2015 14:13:50 1
4272 0.55500 runmuffin. mushroom r 03/15/2015 14:14:05 1
4308 0.55500 runmuffin. mushroom r 03/18/2015 17:15:20 1
4311 0.55500 runmuffin. mushroom r 03/18/2015 17:35:05 1

all.q@compute-0-2.local BIP 0/6/24 6.00 1x26-amd64
4192 0.55500 runmuffin. mushroom r 03/08/2015 13:46:20 1
4291 0.55500 runmuffin. mushroom r 03/16/2015 22:01:35 1
4302 0.55500 runmuffin. mushroom r 03/18/2015 08:19:50 1
4303 0.55500 runmuffin. mushroom r 03/18/2015 08:20:05 1
4304 0.55500 runmuffin. mushroom r 03/18/2015 08:20:20 1

all.q@compute-0-3.local BIP 0/5/24 5.02 1x26-amd64
4121 0.55500 runmuffin. mushroom r 02/16/2015 20:11:50 1
4202 0.55500 runmuffin. mushroom r 03/08/2015 14:08:05 1

all.q@compute-0-4.local BIP 0/4/24 4.00 1x26-amd64
4215 0.55500 runmuffin. mushroom r 03/10/2015 19:55:20 1
4305 0.55500 runmuffin. mushroom r 03/18/2015 17:12:20 1
4307 0.55500 runmuffin. mushroom r 03/18/2015 17:13:05 1

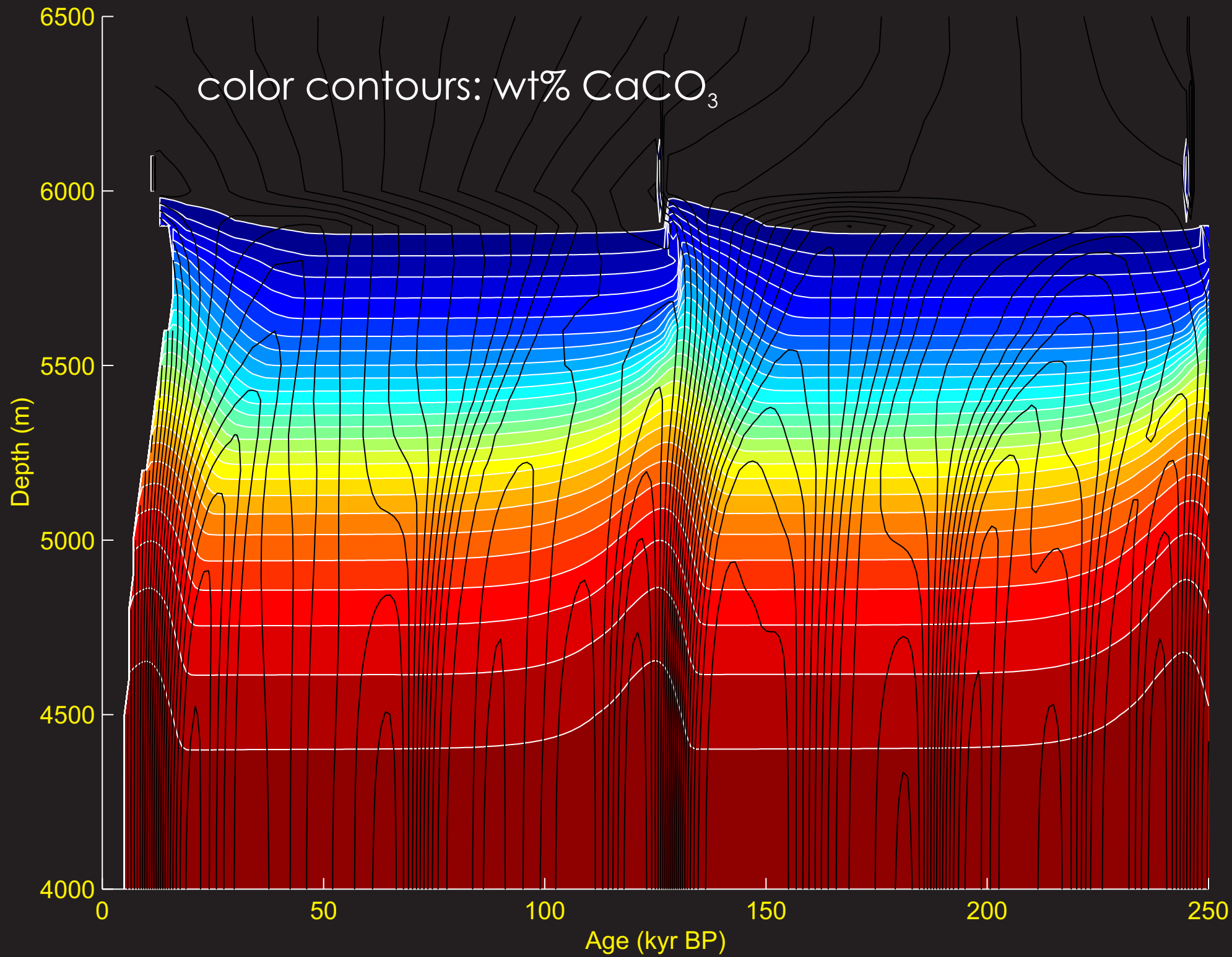
all.q@compute-0-5.local BIP 0/4/24 4.00 1x26-amd64
4191 0.55500 runmuffin. mushroom r 03/08/2015 13:46:05 1
4204 0.55500 runmuffin. mushroom r 03/08/2015 18:00:05 1
4246 0.55500 runmuffin. mushroom r 03/13/2015 10:52:50 1

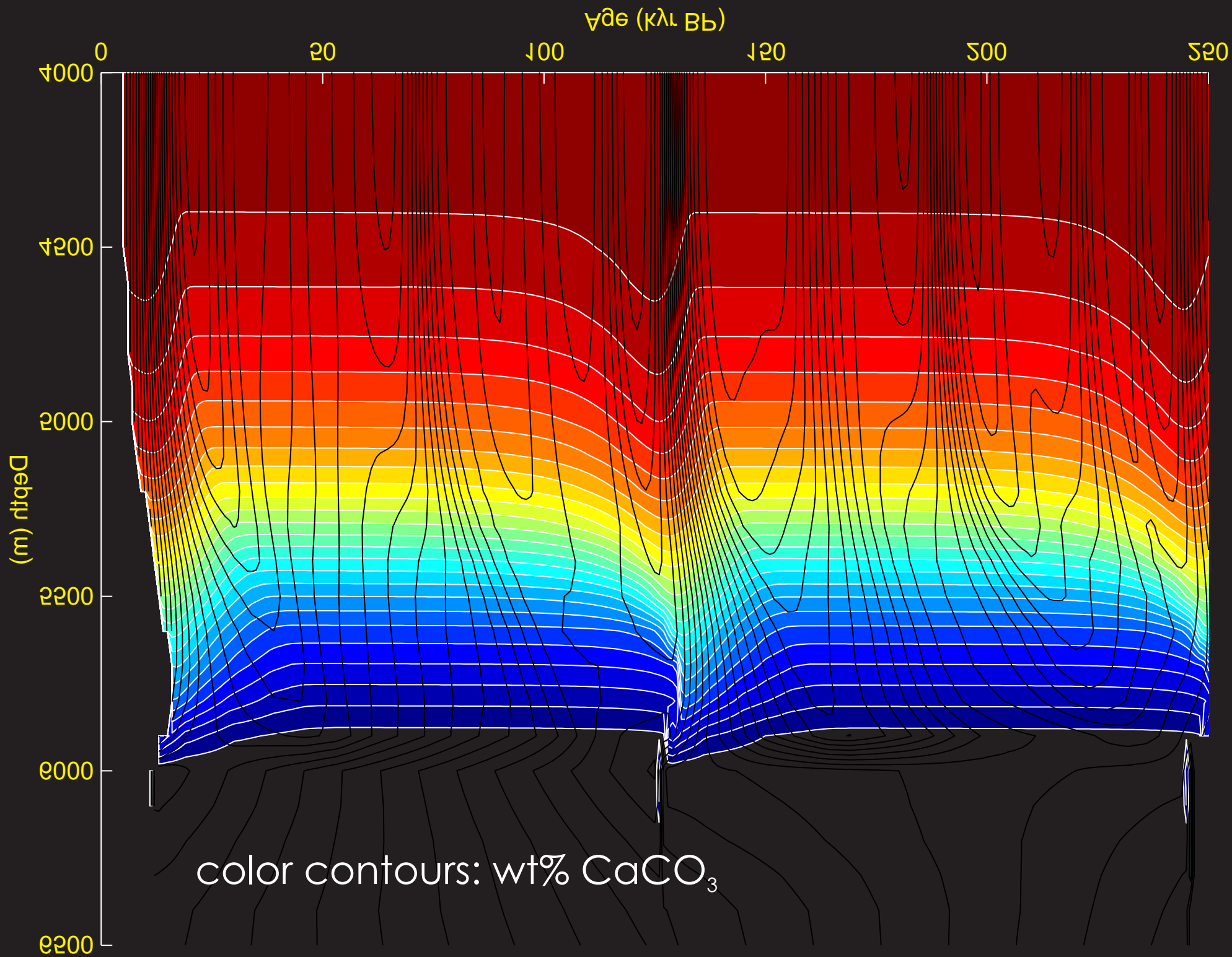
[mushroom@sprout genie-main] $
```

Consider: Co-varying (glacial-interglacial)  $\text{CaCO}_3$  dissolution cycles and how a (varying) stable isotope is recorded

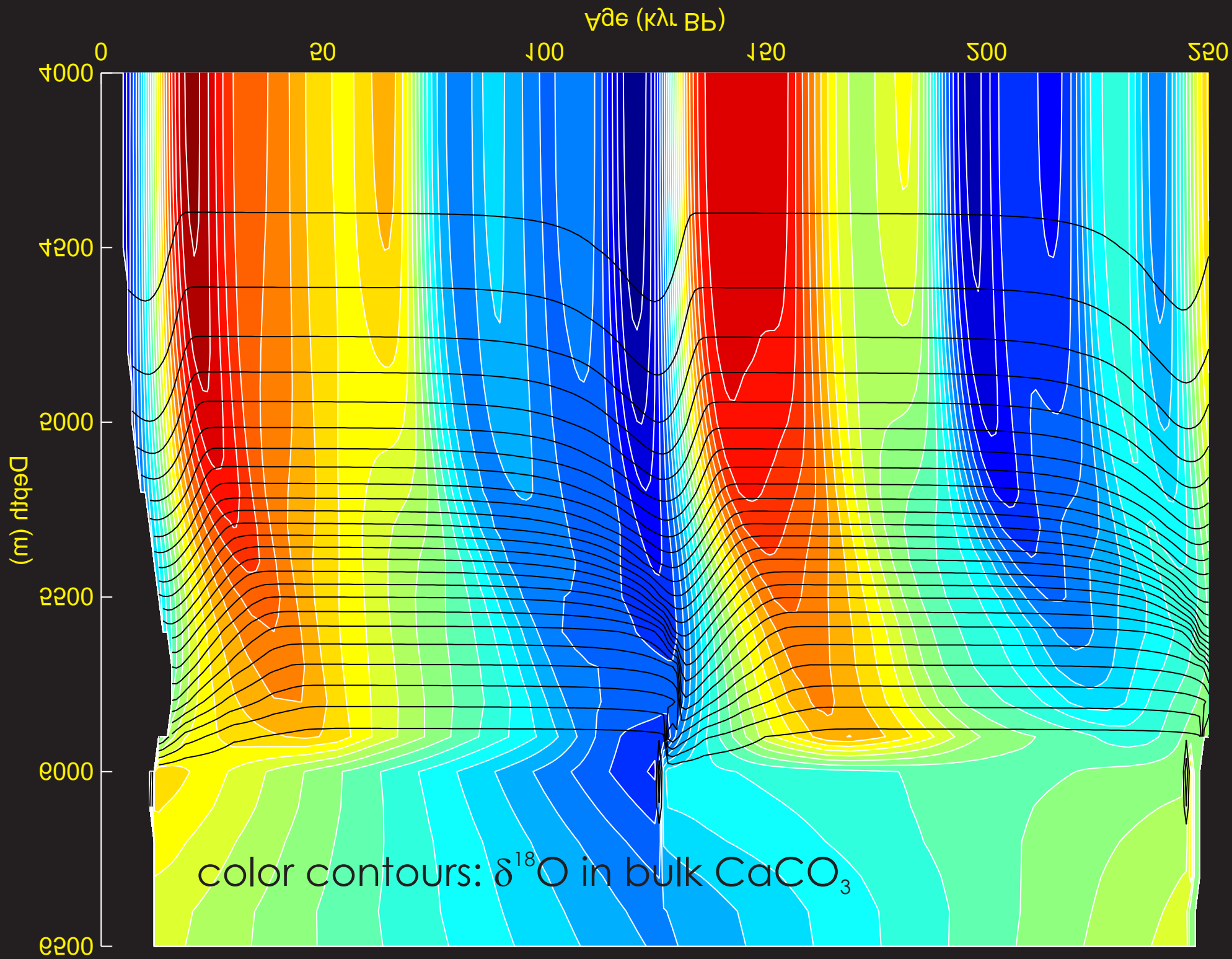
~~Methodology:  $\delta^{18}\text{O}$  of planktic carbonate follows the LR04 stack, plus atmospheric  $\text{pCO}_2$  is forced to follow the EPICA Dome C record, providing a varying preservation forcing on  $\text{CaCO}_3$  in marine sediments.~~

Instead:  $\delta^{18}\text{O}$  of planktic carbonate follows SPECMAP while 500 PgC  $\text{CO}_2$  removed from the atmosphere (to the terrestrial biosphere) across the deglacial transition (and then gradually added back again in a sawtooth shape).









## Implications

- ★ Once again, it matters 'where'  $\text{CaCO}_3$  dissolution occurs (and what carbonate fraction) in accumulating sediments. Distortion of time-varying signals is likely minimized if a 'homogeneous' mode of dissolution dominates.
- ★ Use of multiple benthic individuals (even if single species) will avoid bulk sediment artifacts (other proxies will be differentially affected though), but give rise to an entertaining convolution of benthic foram population dynamics (driven by  $[\text{O}_2]$  and Corg flux variability), with a time-varying G-I environmental signal. (This would be an 'interface' like situation.)
- ★ Single foram analyses in which both age-scale and environmental proxy are simultaneously measured, is ideal. But e.g.  $\delta^{18}\text{O}$  would be adequate ( $^{14}\text{C}$  not essential).
- ★ Modellers should learn some marine geology.

One (or more) of the following:

- \* This is not relevant at all.
- \* Too late – this was relevant 15 years ago.
- \* There are potentially important implications for bulk carbonate and low sedimentation rate records. But no-one in their right mind uses these any more.
- \* There are important implications for data-data (wiggle matching) and model-data analysis.
- \* There are important questions raised of where in the sediments, and what fraction, of carbonate dissolves.
- \* Meh

forget about it  
drink beer  
be happy

keep going

meh

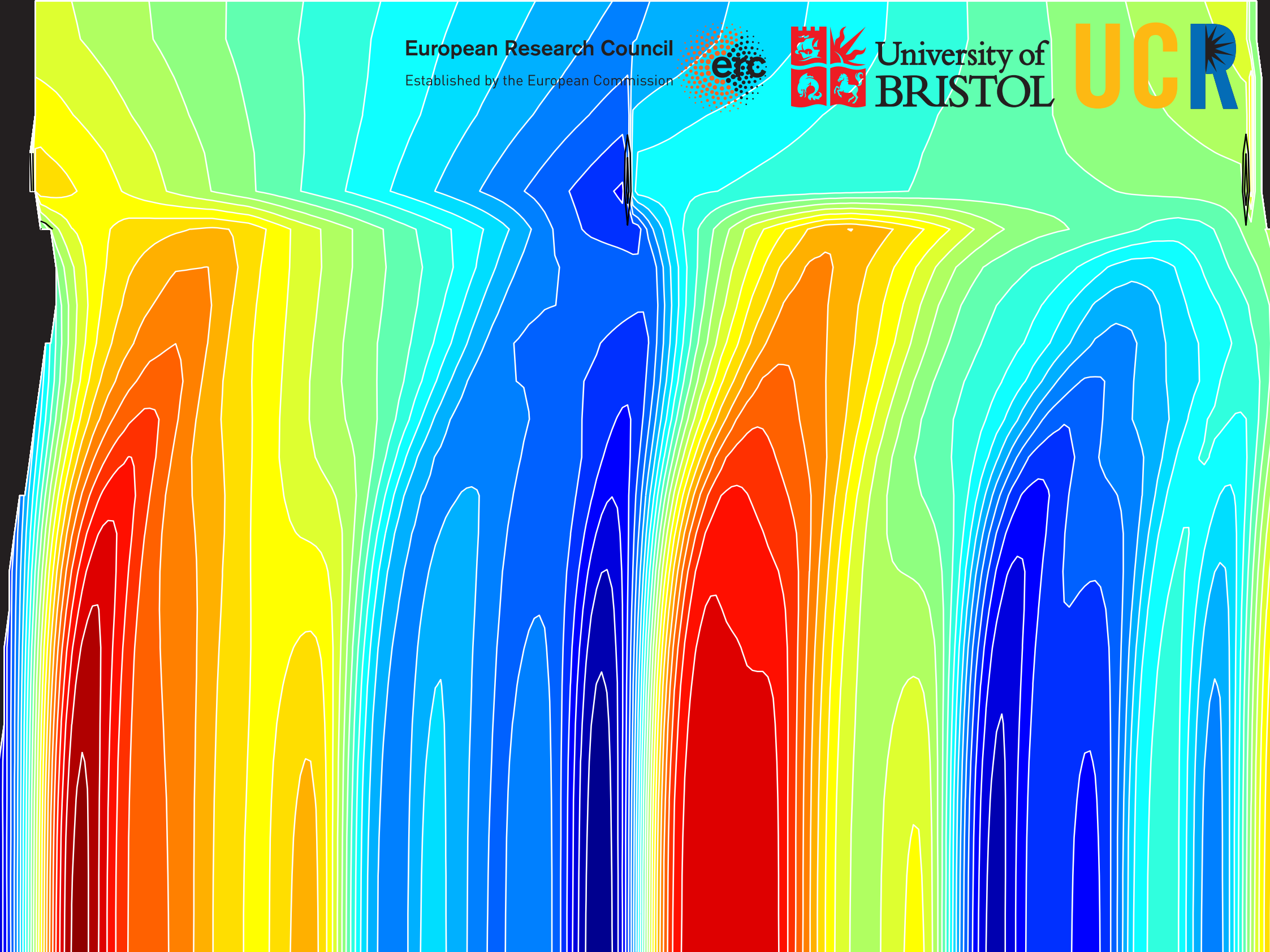
European Research Council

Established by the European Commission



University of  
BRISTOL

UCR



# Answers to questions

Quantifying 'time' in models and data

```
1: sprout.ggy.bris.ac.uk - mushroom@sprout - SSH Secure Shell
File Edit View Window Help
Quick Connect Profiles

-----
all.q@compute-0-2.local      BIP 0/6/24      6.00 1x26-amd64
4192 0.55500 runmuffin. mushroom r 03/08/2015 13:46:20 1
4291 0.55500 runmuffin. mushroom r 03/16/2015 22:01:35 1
4302 0.55500 runmuffin. mushroom r 03/18/2015 08:19:50 1
4303 0.55500 runmuffin. mushroom r 03/18/2015 08:20:05 1
4304 0.55500 runmuffin. mushroom r 03/18/2015 08:20:20 1
-----
all.q@compute-0-3.local      BIP 0/5/24      5.00 1x26-amd64
4121 0.55500 runmuffin. mushroom r 02/16/2015 20:11:50 1
4202 0.55500 runmuffin. mushroom r 03/08/2015 14:08:05 1
-----
all.q@compute-0-4.local      BIP 0/4/24      4.02 1x26-amd64
4215 0.55500 runmuffin. mushroom r 03/10/2015 19:55:20 1
4305 0.55500 runmuffin. mushroom r 03/18/2015 17:12:20 1
4307 0.55500 runmuffin. mushroom r 03/18/2015 17:13:05 1
-----
all.q@compute-0-5.local      BIP 0/4/24      4.00 1x26-amd64
4191 0.55500 runmuffin. mushroom r 03/08/2015 13:46:05 1
4204 0.55500 runmuffin. mushroom r 03/08/2015 18:00:05 1
4246 0.55500 runmuffin. mushroom r 03/13/2015 10:52:50 1
-----
[mushroom@sprout genie-main] $ ls
assumedgood.log      GENIEconf.py      genie_ini_wrappers.dep  initialise_genie.o      runmuffin.sh
compare-basic.sh     genie_control.dep  genie_ini_wrappers.f90  inputdata              runmuffin.t100.sh
comparelong.sh       genie_control.f90  genie_ini_wrappers.mod  local_netcdf.dep       src
config2xml.py        genie_control.mod  genie_ini_wrappers.o    local_netcdf.f90       testbiogem.out
configs              genie_control.o    genie.job                local_netcdf.mod       testbiogogs.out
current_config.dat   genie.dep           genie_loop_wrappers.dep  local_netcdf.o         testing.mak
data                 genie_end_wrappers.dep  genie_loop_wrappers.f90  local_output.dep       translate_config.py
doc                  genie_end_wrappers.f90  genie_loop_wrappers.mod  local_output.f90       user.mak
end_genie.dep        genie_end_wrappers.mod  genie_loop_wrappers.o    local_output.mod       user.sh
end_genie.f          genie_end_wrappers.o   genie.o                  local_output.o         WindowsCompilation.txt
end_genie.o          genie_example.job     genie_util.dep           makefile                write_netcdf_genie.dep
extract-basic.sh     genie.exe            genie_util.f90           makefile.arc            write_netcdf_genie.f90
extractvars.sh       genie.F              genie_util.mod           nccomp.py               write_netcdf_genie.o
extrap.dep           genie_global.dep     genie_util.o             netcdf.inc              write_netcdf.mod
extrap.f             genie_global.f90     include                  README                  README.changes
extrap.o             genie_global.mod     initialise_genie.dep     README.changes
finc.py              genie_global.o       initialise_genie.F       runmuffin.ensemble.sh
-----
[mushroom@sprout genie-main] $
[mushroom@sprout genie-main] $
[mushroom@sprout genie-main] $ qstat -f
-----
queueName      qtype  resv/used/tot.  load_avg  arch      states
-----
all.q@compute-0-1.local      BIP 0/3/24      3.00 1x26-amd64
4295 0.55500 runmuffin. mushroom r 03/16/2015 22:07:50 1
4312 0.55500 runmuffin. mushroom r 03/20/2015 09:45:20 1
4313 0.55500 runmuffin. mushroom r 03/20/2015 09:48:50 1
-----
all.q@compute-0-1.local      BIP 0/9/24      9.02 1x26-amd64
4123 0.55500 runmuffin. mushroom r 02/16/2015 20:12:20 1
4201 0.55500 runmuffin. mushroom r 03/08/2015 14:07:50 1
4214 0.55500 runmuffin. mushroom r 03/10/2015 19:54:50 1
4261 0.55500 runmuffin. mushroom r 03/15/2015 14:07:50 1
4270 0.55500 runmuffin. mushroom r 03/15/2015 14:13:50 1
4272 0.55500 runmuffin. mushroom r 03/15/2015 14:14:05 1
4308 0.55500 runmuffin. mushroom r 03/18/2015 17:15:20 1
4311 0.55500 runmuffin. mushroom r 03/18/2015 17:35:05 1
-----
all.q@compute-0-2.local      BIP 0/6/24      6.00 1x26-amd64
4192 0.55500 runmuffin. mushroom r 03/08/2015 13:46:20 1
4291 0.55500 runmuffin. mushroom r 03/16/2015 22:01:35 1
4302 0.55500 runmuffin. mushroom r 03/18/2015 08:19:50 1
4303 0.55500 runmuffin. mushroom r 03/18/2015 08:20:05 1
4304 0.55500 runmuffin. mushroom r 03/18/2015 08:20:20 1
-----
all.q@compute-0-3.local      BIP 0/5/24      5.02 1x26-amd64
4121 0.55500 runmuffin. mushroom r 02/16/2015 20:11:50 1
4202 0.55500 runmuffin. mushroom r 03/08/2015 14:08:05 1
-----
all.q@compute-0-4.local      BIP 0/4/24      4.00 1x26-amd64
4215 0.55500 runmuffin. mushroom r 03/10/2015 19:55:20 1
4305 0.55500 runmuffin. mushroom r 03/18/2015 17:12:20 1
4307 0.55500 runmuffin. mushroom r 03/18/2015 17:13:05 1
-----
all.q@compute-0-5.local      BIP 0/4/24      4.00 1x26-amd64
4191 0.55500 runmuffin. mushroom r 03/08/2015 13:46:05 1
4204 0.55500 runmuffin. mushroom r 03/08/2015 18:00:05 1
4246 0.55500 runmuffin. mushroom r 03/13/2015 10:52:50 1
-----
[mushroom@sprout genie-main] $
```