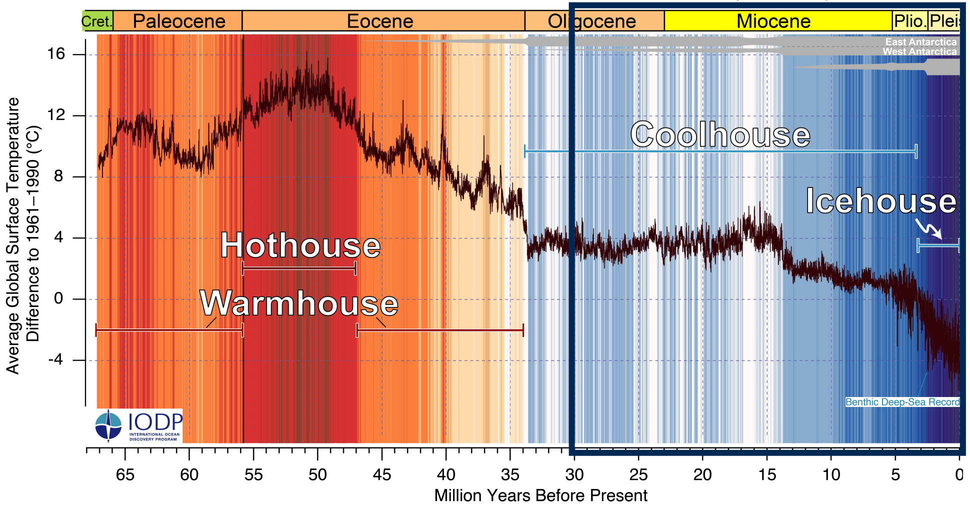
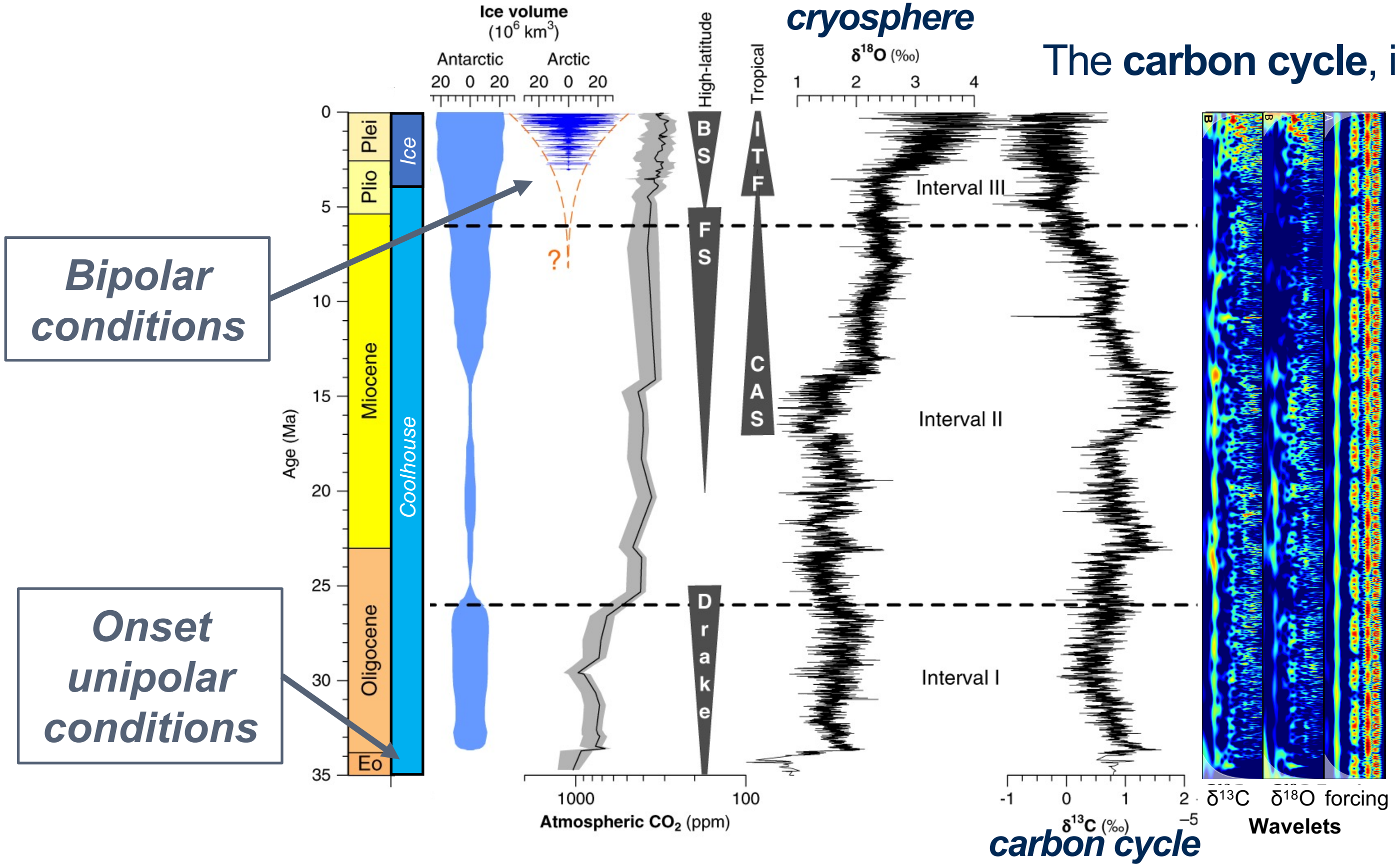
Disentangling controls and orbital pacing of Southeast Atlantic carbonate deposition since the Oligocene (30-0 Ma)

Westerhold et al., 2020, Science



Anna Joy Drury, Diederik Liebrand, Thomas Westerhold, Helen Beddow, David Hodell, Nina Rohlfs, Roy Wilkens, Mitchell Lyle, David De Vleeschouwer, Maximilian Vahlenkamp, Fiona Rochholz, Heiko Palike, Lucas Lourens

The last 34 Myr documents the evolution from a unipolar to bipolar world



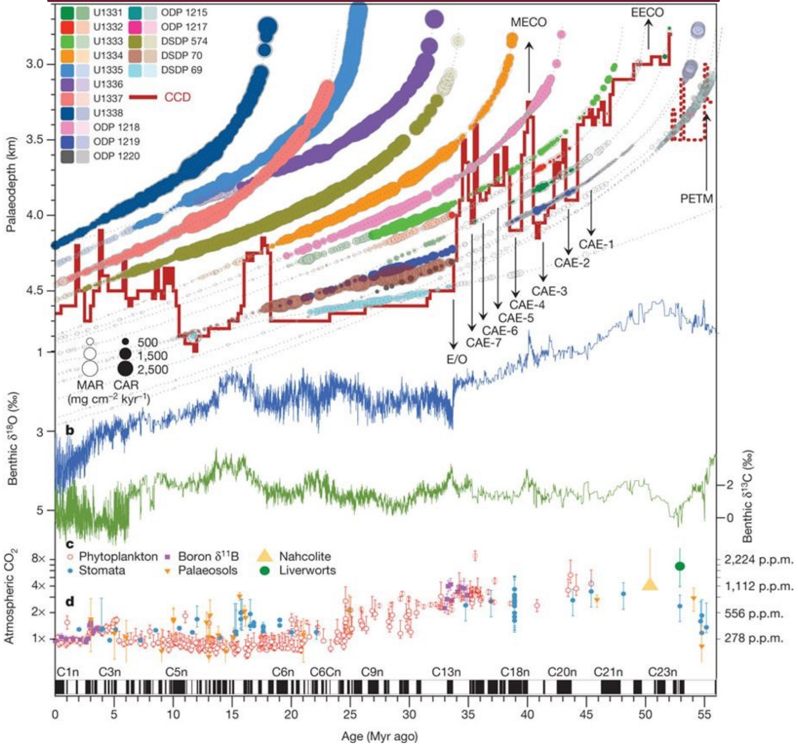
The **carbon cycle**, including atmospheric CO_2, is an important driver of the **cryosphere** in this Coolhouse to Icehouse development

De Vleeschouwer, Drury et al., 2020
Nature Communications

with info from
Westerhold et al., 2020, Science
De Vleeschouwer et al., 2017, Geology

Carbonate deposition is an important part of the carbon cycle

Pälike et al., 2012: detailed view of the CCD from Pacific carbonate data

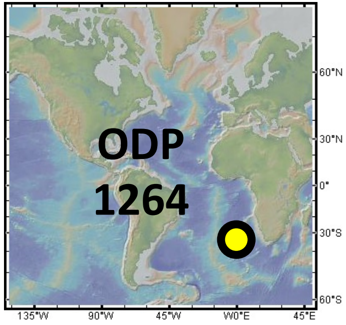


Carbonate ($CaCO_3$) in the ocean is an important regulator of atmospheric CO_2 thanks to its role in buffering atmospheric CO_2 variations.

Deep-sea carbonate deposition itself controlled by productivity and dissolution

Pacific – OK!

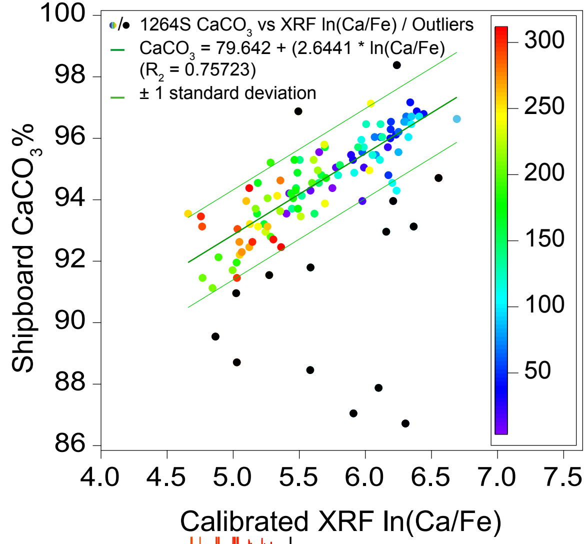
No equivalent Atlantic records existed ⇒ until now…

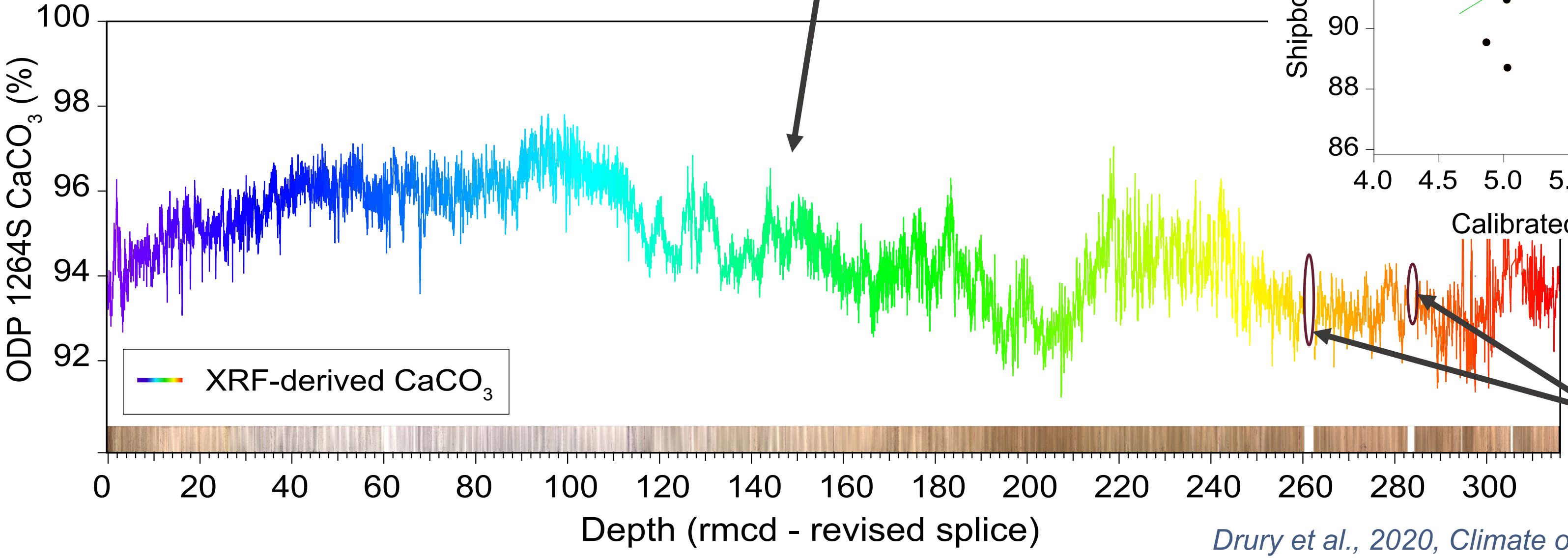


We estimated Southeast Atlantic $CaCO_3$ deposition using XRF ln(Ca/Fe)

At Site 1264:

The ln(Ca/Fe) ratio of X-ray fluorescence core scanning data was calibrated to discrete shipboard %$CaCO_3$ data to obtain a near-continuous ~316 m %$CaCO_3$ record





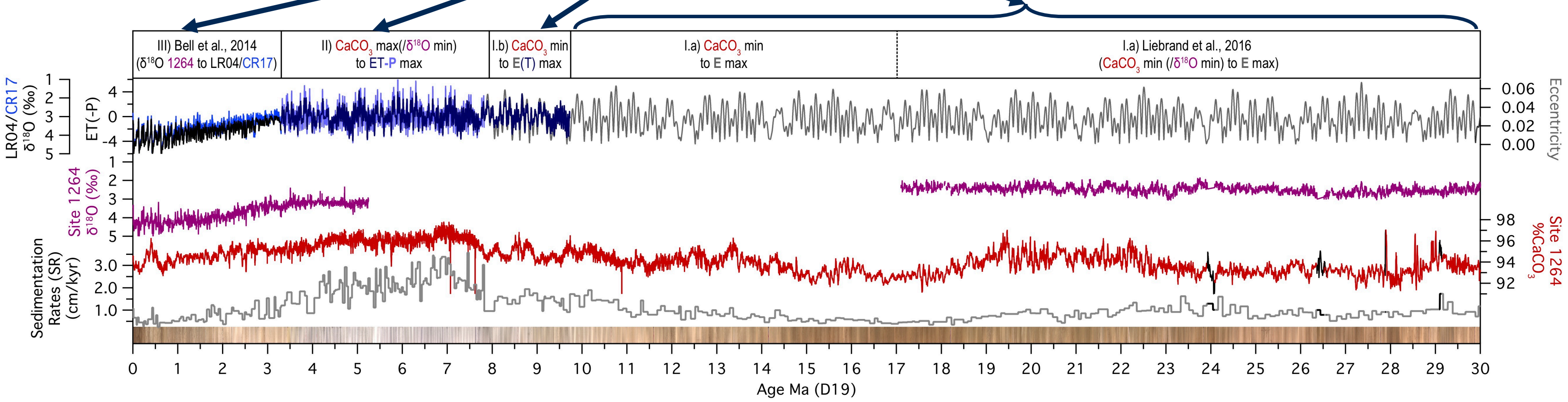
Small gaps were filled with data from Site 1265

Drury et al., 2020, Climate of the Past Discussion

We accurately dated 30 million year old sequence by identifying orbital beats

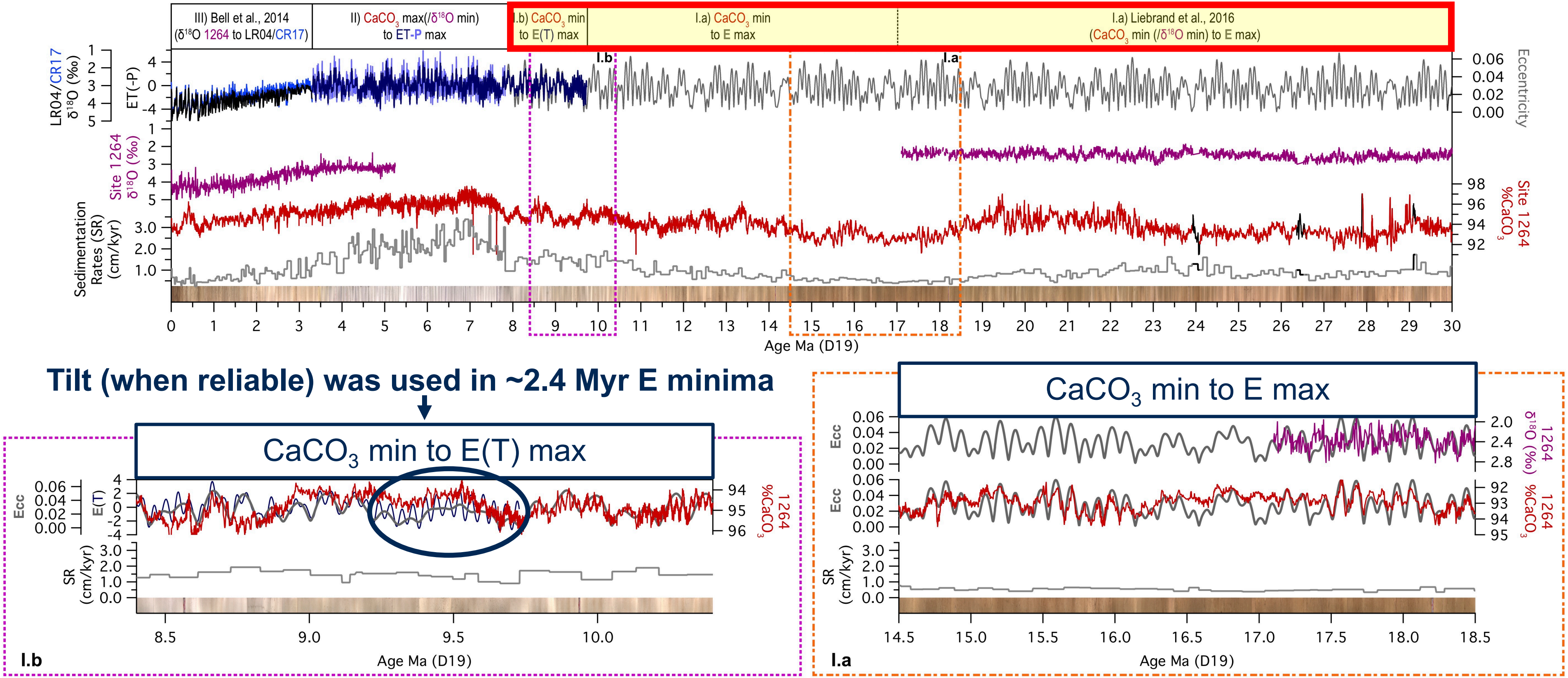
3 different tuning approaches were needed across the entire record

because the dominant beat was not constant



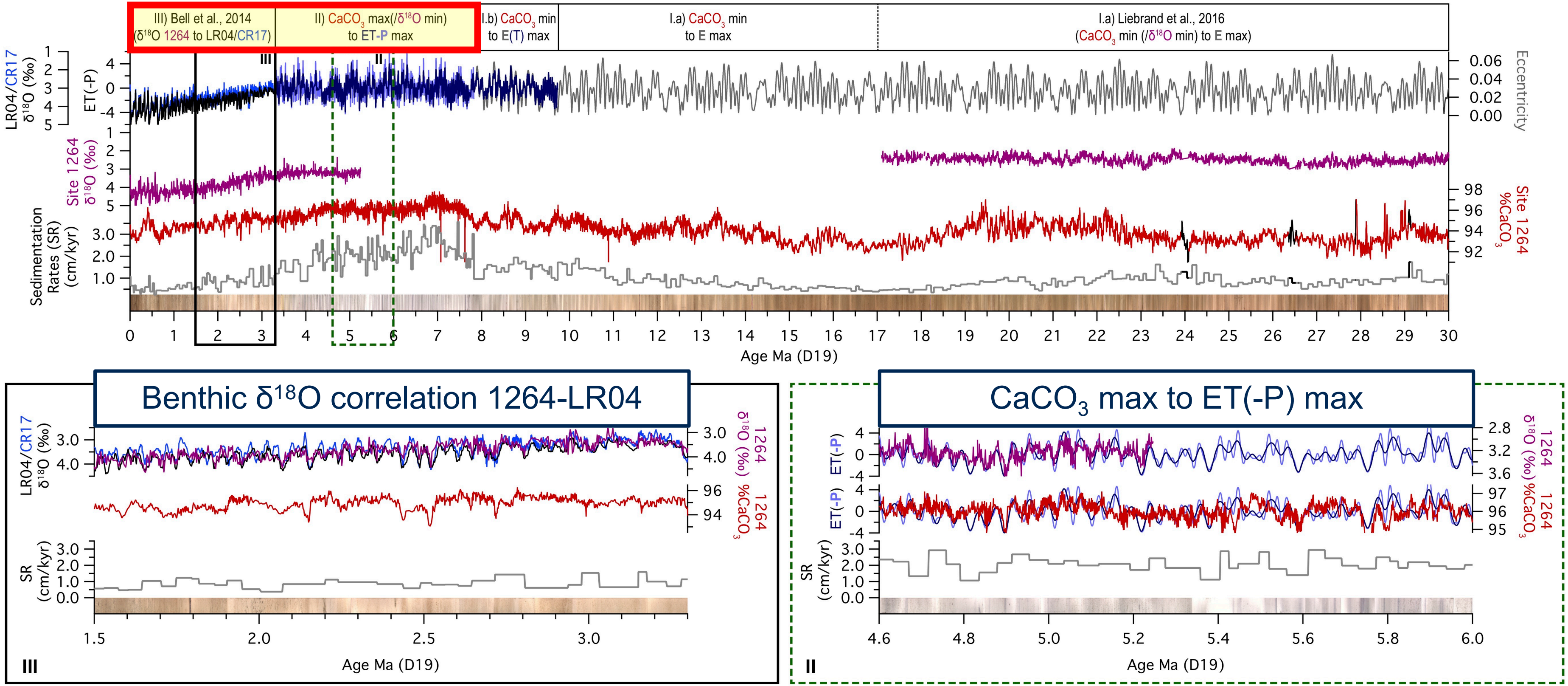
Drury et al., 2020, CPD; Bell et al., 2014, G-cubed; Liebrand et al., 2016, EPSL

$CaCO_3$ minima were tuned to eccentricity(-tilt) maxima from 30-8 Ma



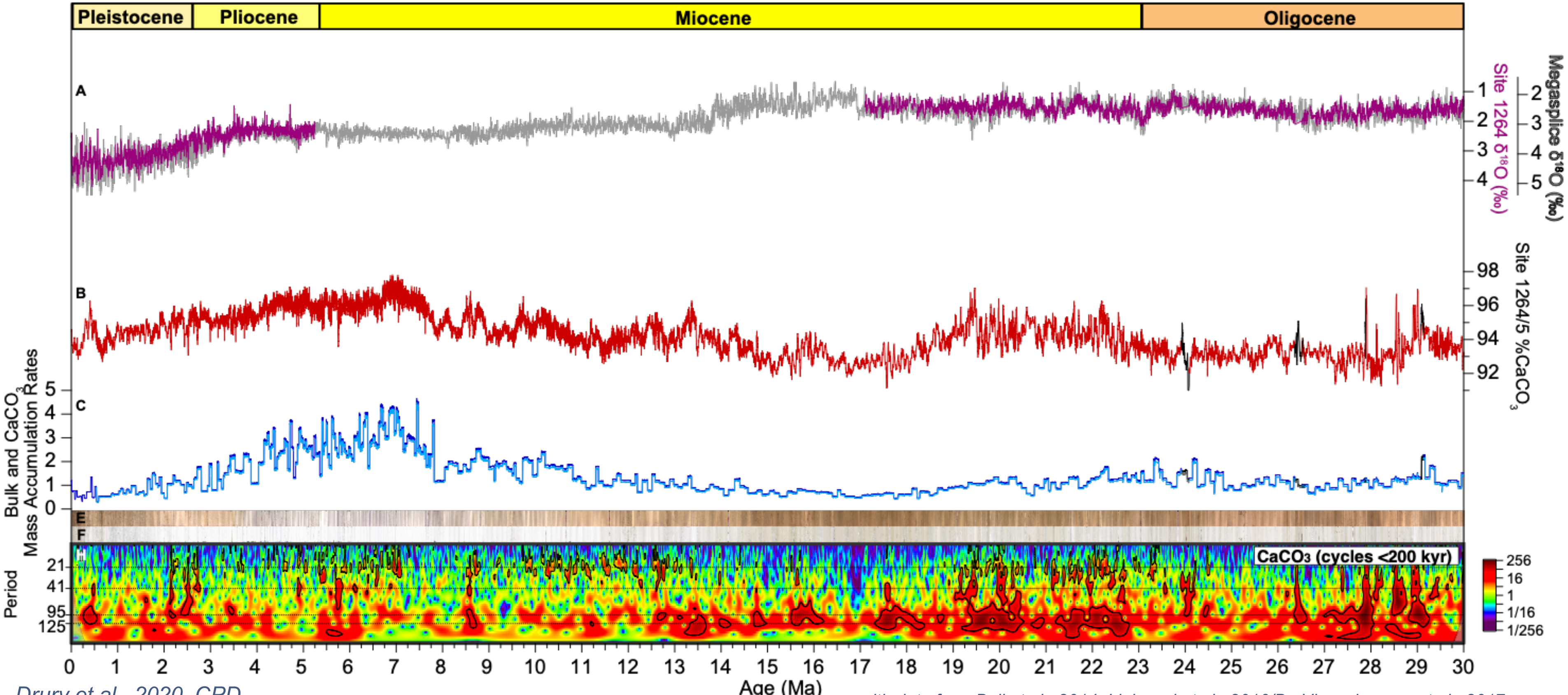
Drury et al., 2020, CPD; Bell et al., 2014, G-cubed; Liebrand et al., 2016, EPSL

We used different tuning approaches from 8-0 Ma because eccentricity was weaker



Drury et al., 2020, CPD; Bell et al., 2014, G-cubed; Liebrand et al., 2016, EPSL

The orbital imprint on $CaCO_3$ deposition shows three distinct phases



Drury et al., 2020, CPD

with data from Bell et al., 2014, Liebrand et al., 2016/De Vleeschouwer et al., 2017

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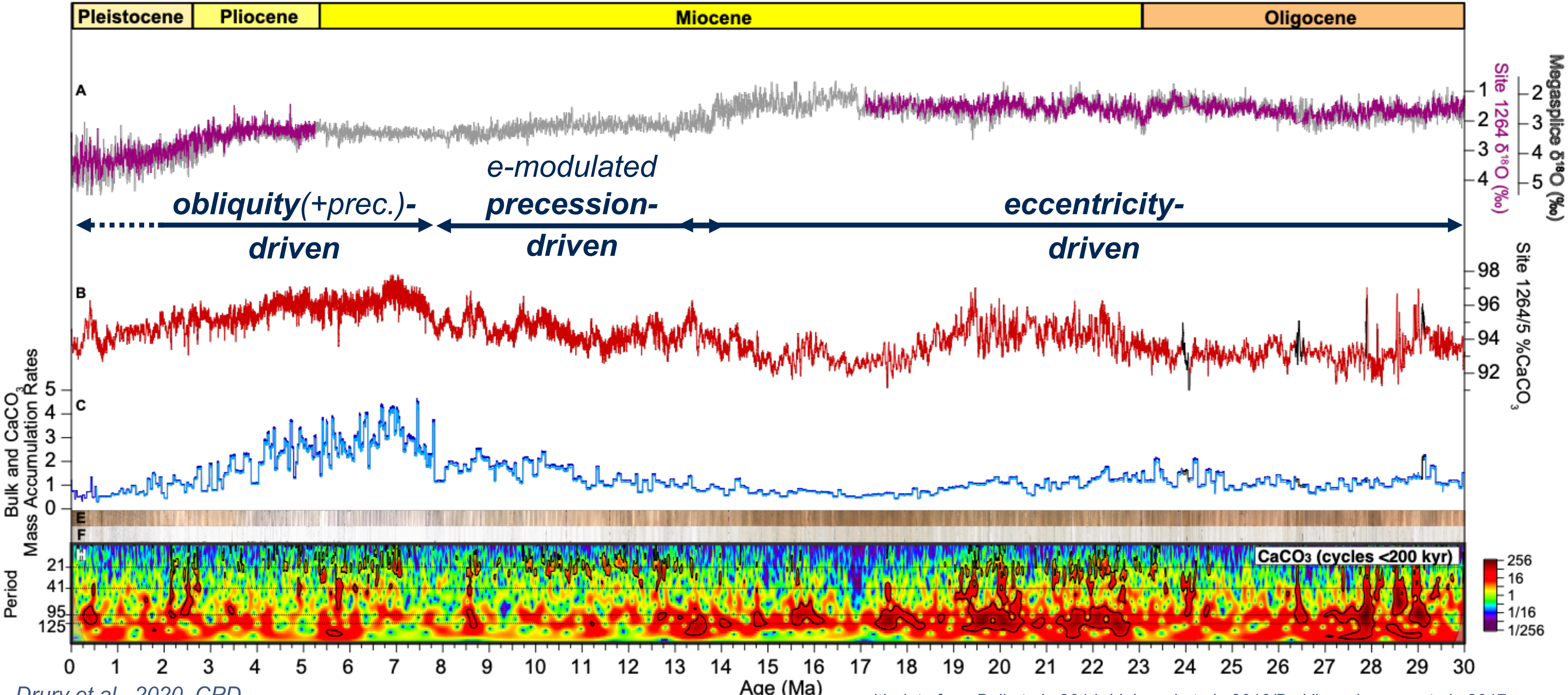

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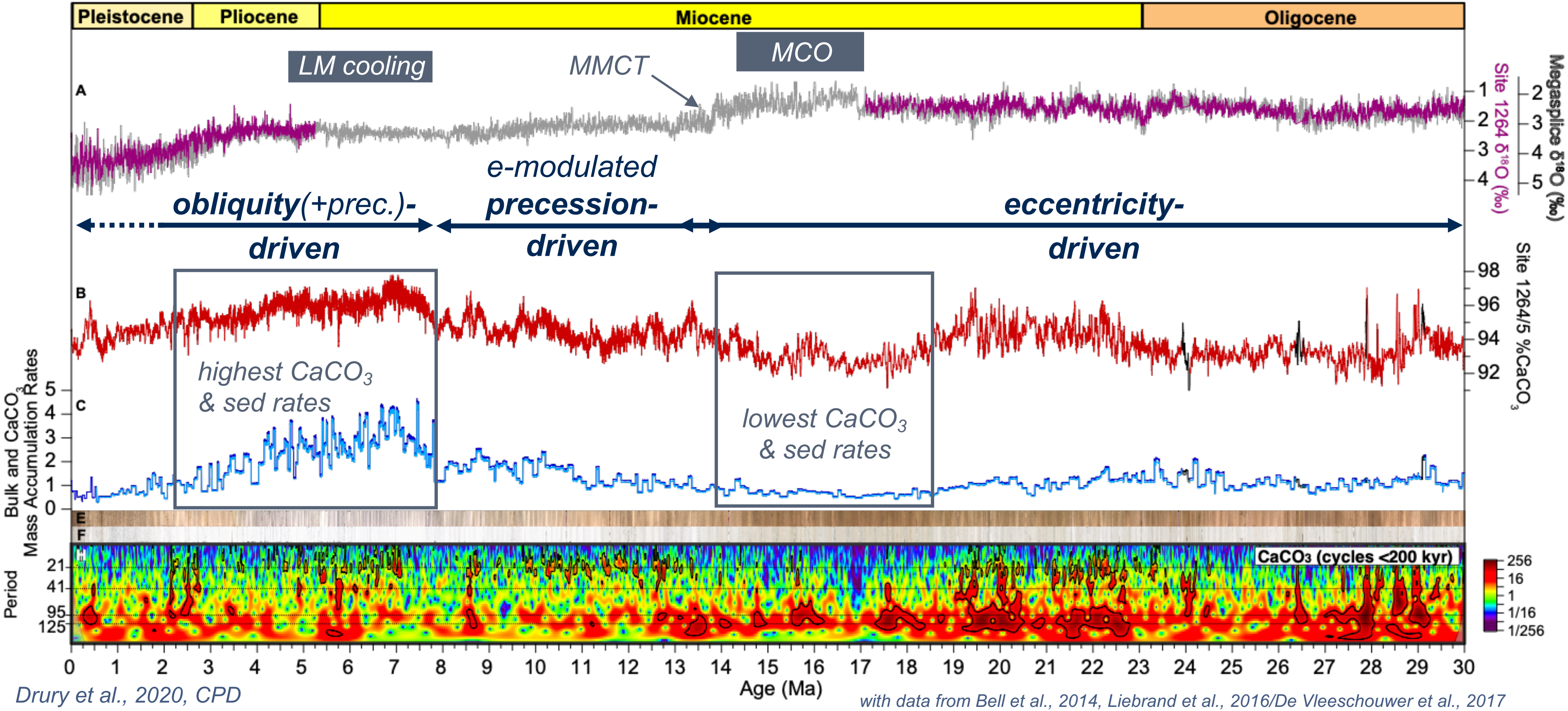


Drury et al., 2020, CPD

with data from Bell et al., 2014, Liebrand et al., 2016/De Vleeschouwer et al., 2017

Eccentricity-paced cyclicity (dissolution?) dominates during Miocene warmth

UCL

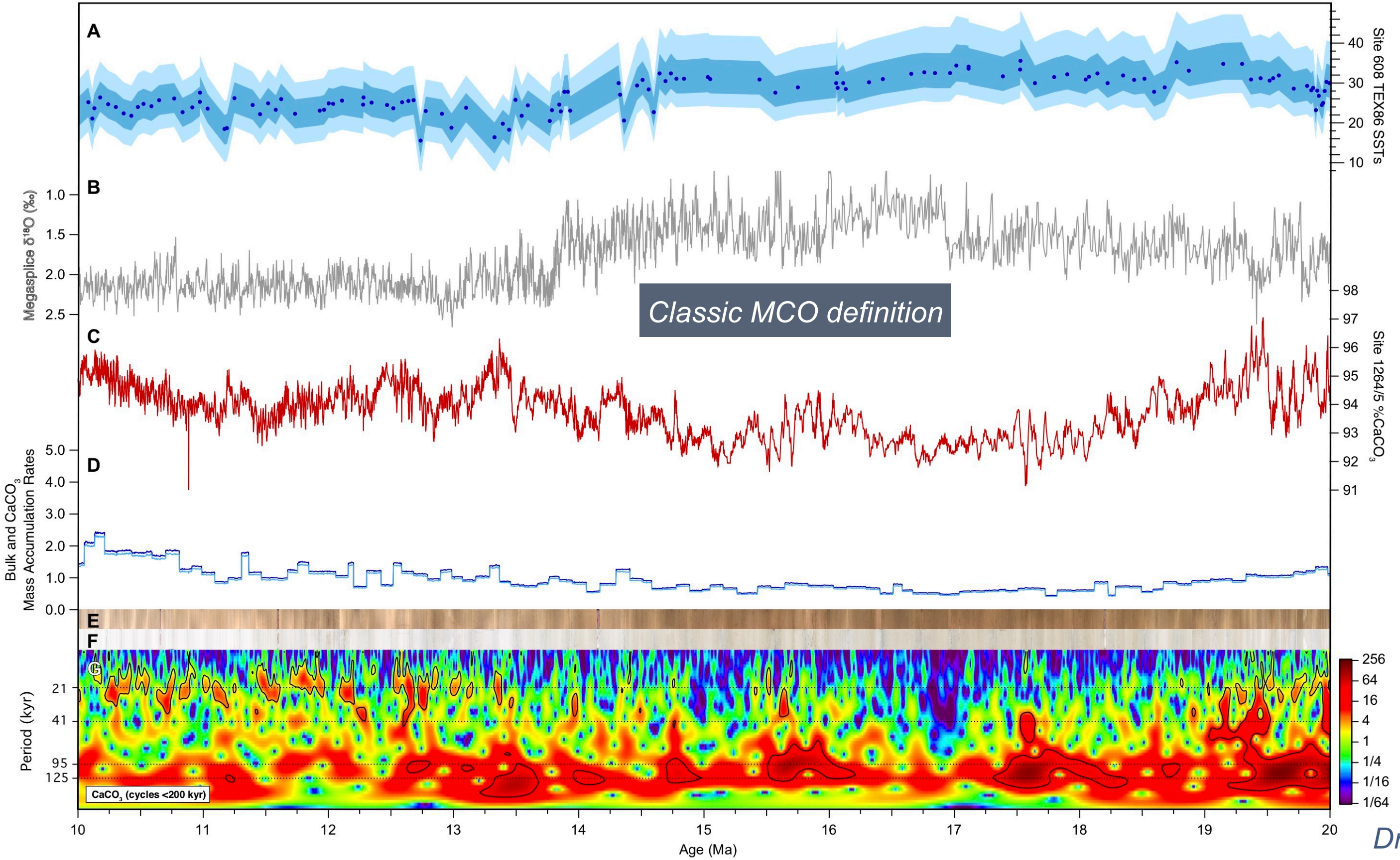
TEX86 SSTs
Super et al., 2018

$\delta^{18}O$ megasplice
De Vleeschouwer et al., 2017

$\%CaCO_3$

Mass accumulation rates

$CaCO_3$ wavelet analysis



Drury et al., 2020, CPD

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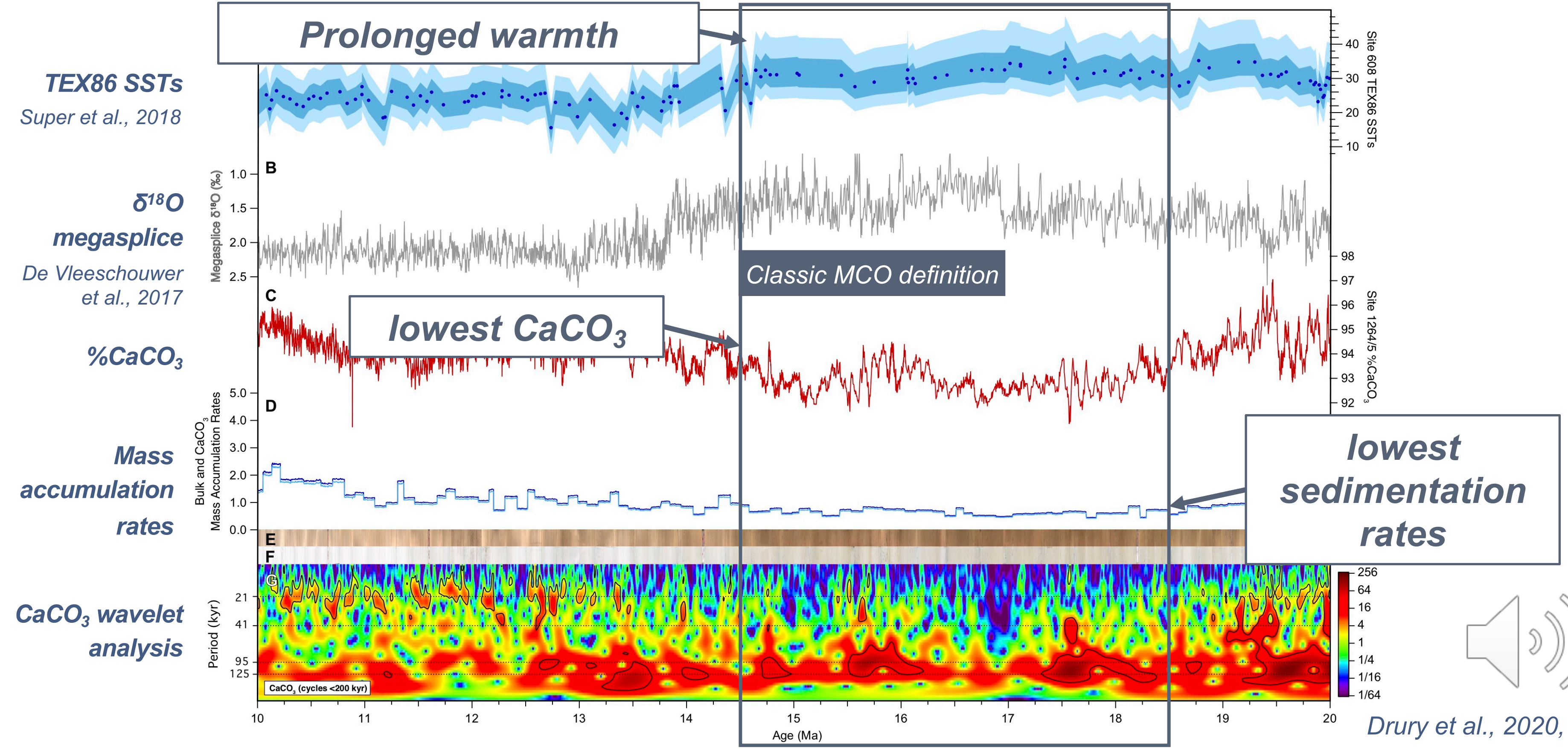

Drury et al., 2020, CPD

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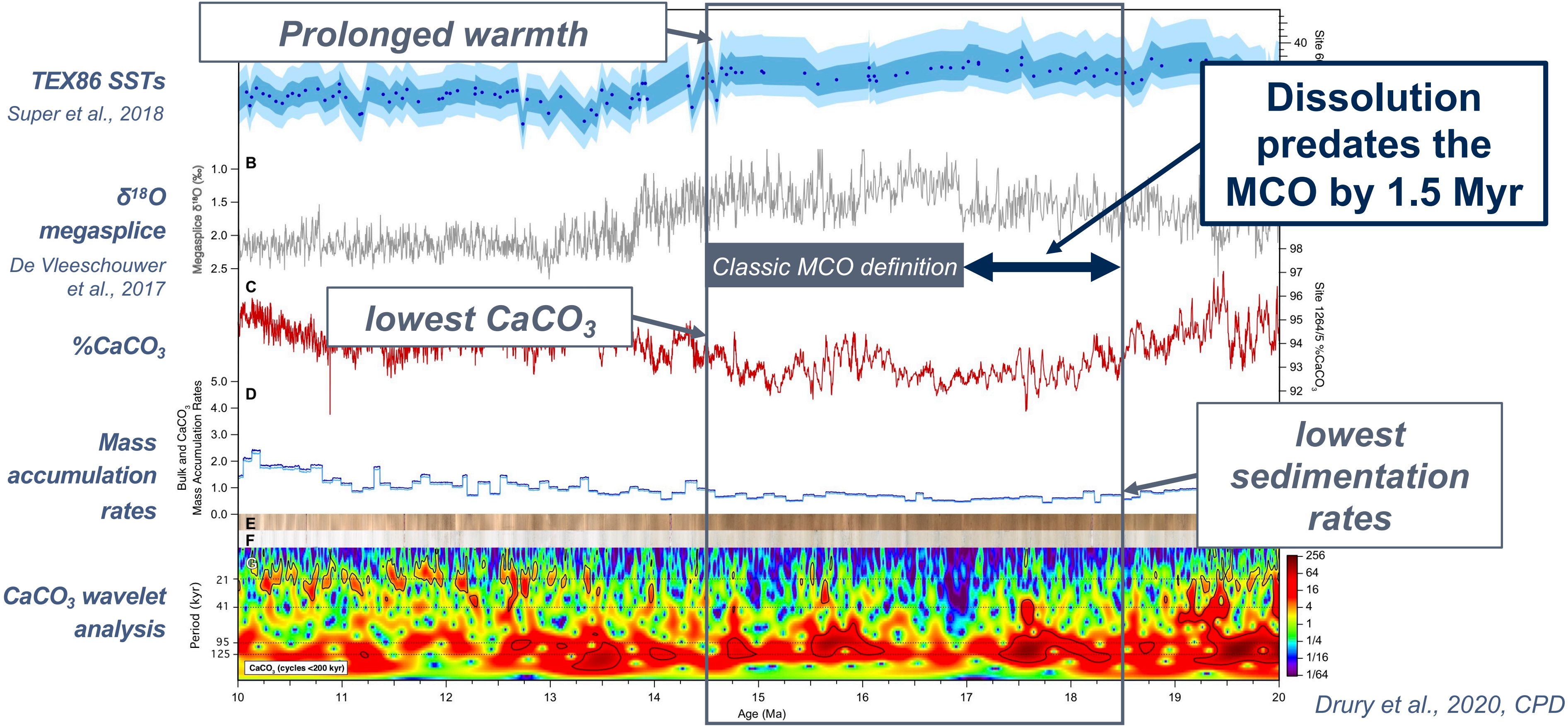


Drury et al., 2020, CPD

Precession-driven deposition prevails after the mid Miocene climate transition

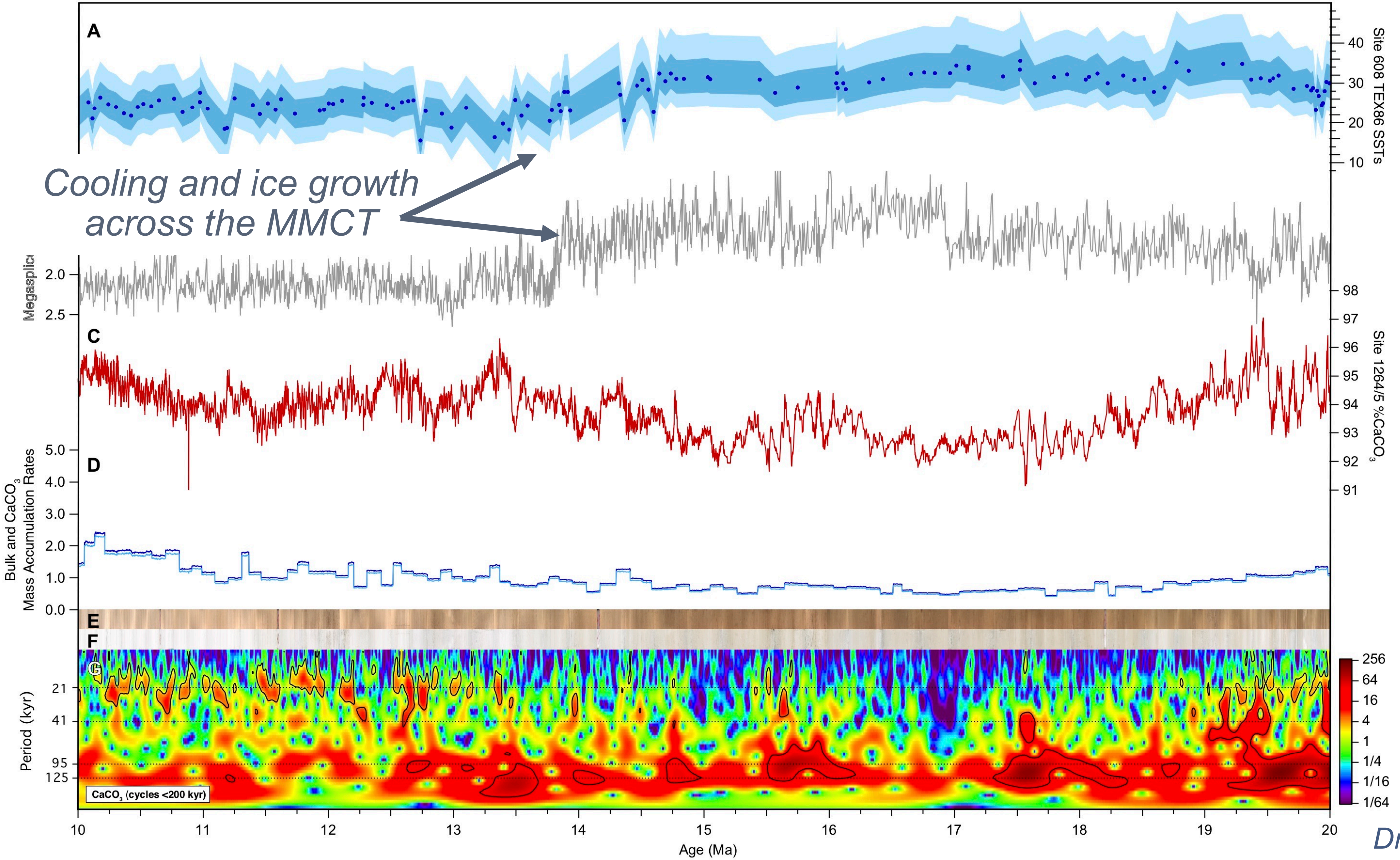
TEX86 SSTs
Super et al., 2018

δ¹⁸O megasplice
De Vleeschouwer et al., 2017

%CaCO₃

Mass accumulation rates

CaCO₃ wavelet analysis



Drury et al., 2020, CPD

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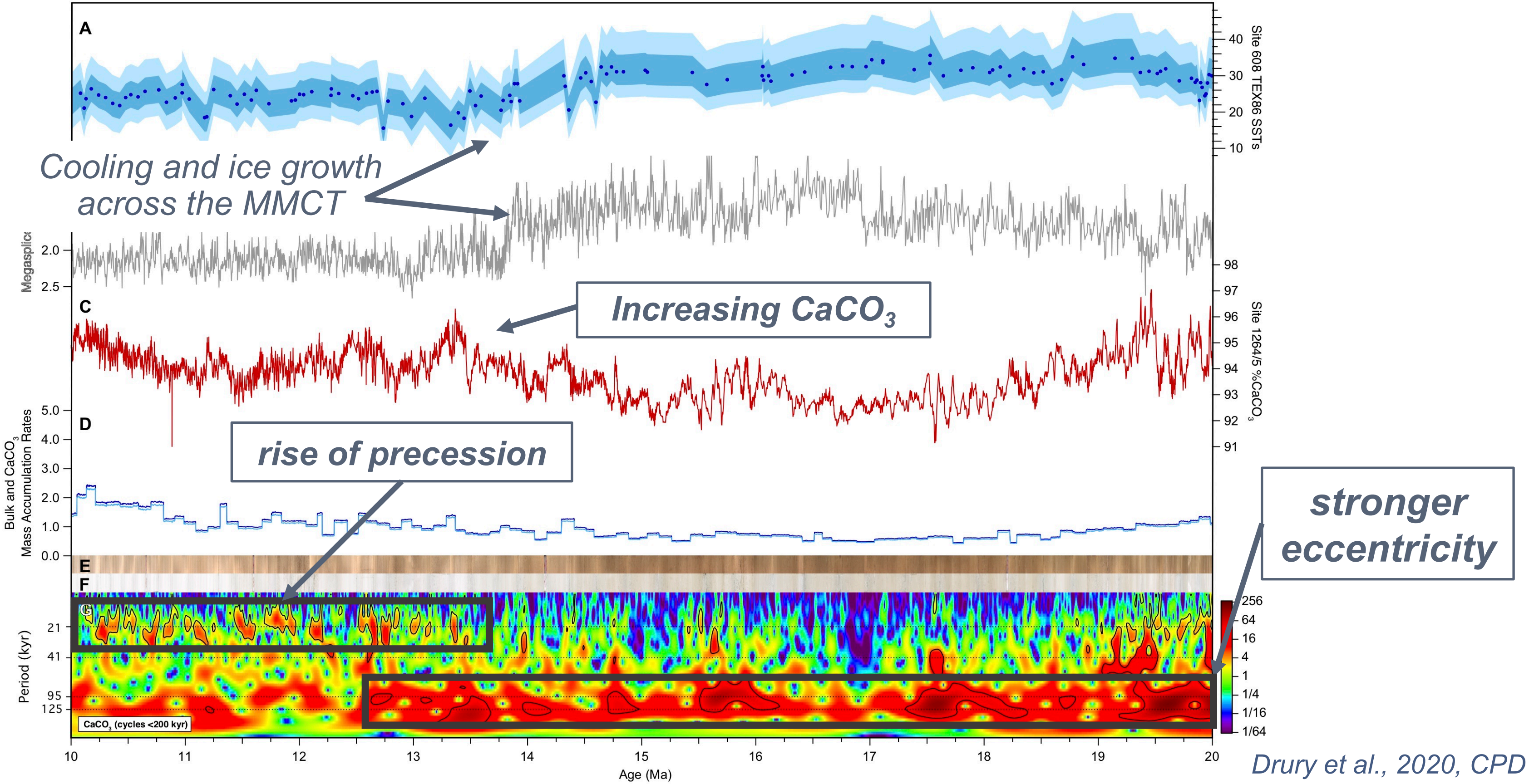

Drury et al., 2020, CPD

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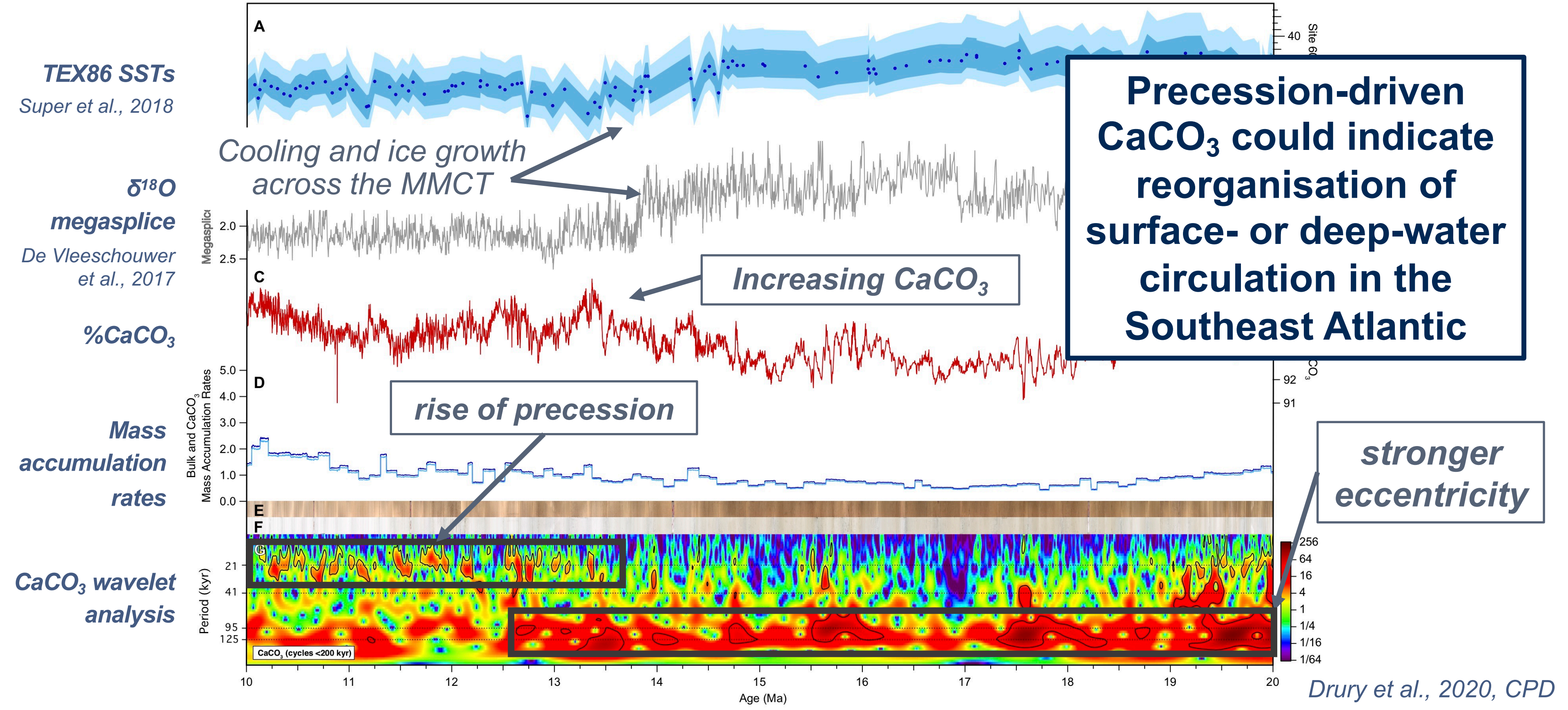
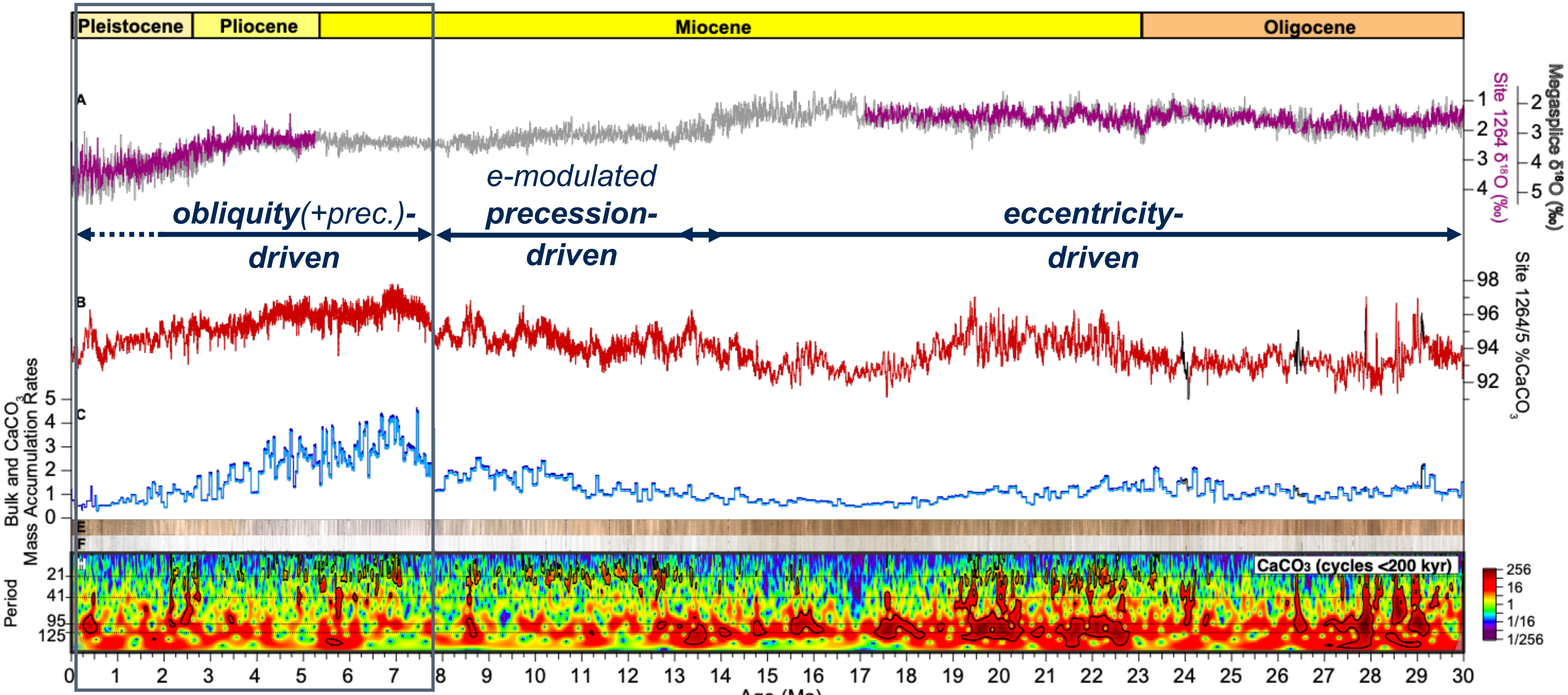


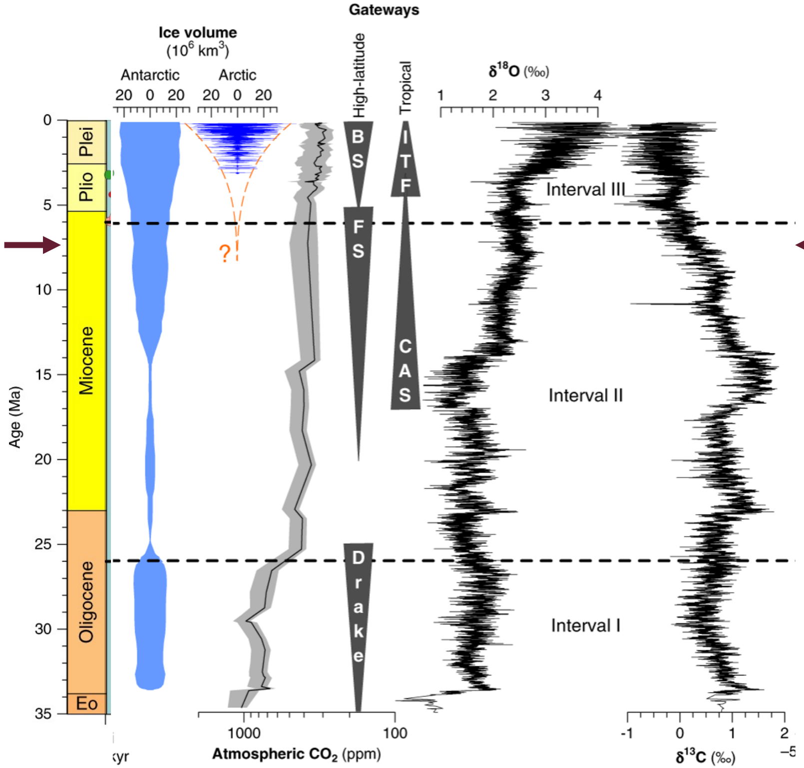
Obliquity-precession driven $CaCO_3$ dynamics arise after 8 Ma



Drury et al., 2020, CPD

with data from Bell et al., 2014, Liebrand et al., 2016/De Vleeschouwer et al., 2017

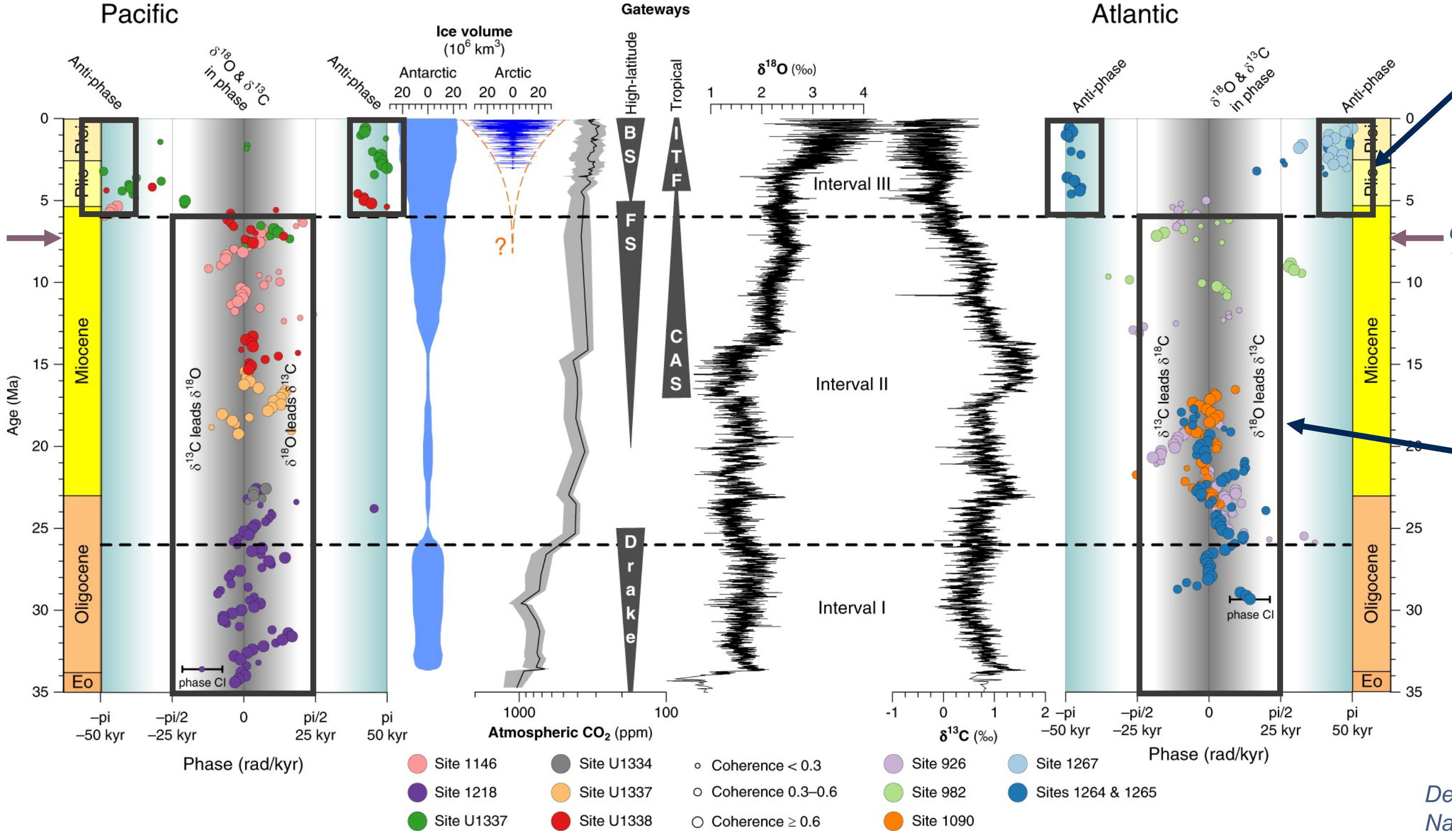
Late Miocene switch from in- to anti-phase eccentricity δ18O-δ13C relationship



Site 1264 %CaCO$_3$ rise of obliquity (+precession)

De Vleeschouwer, Drury et al., 2020
Nature Communications

Late Miocene switch from in- to anti-phase eccentricity $\delta^{18}O$-$\delta^{13}C$ relationship



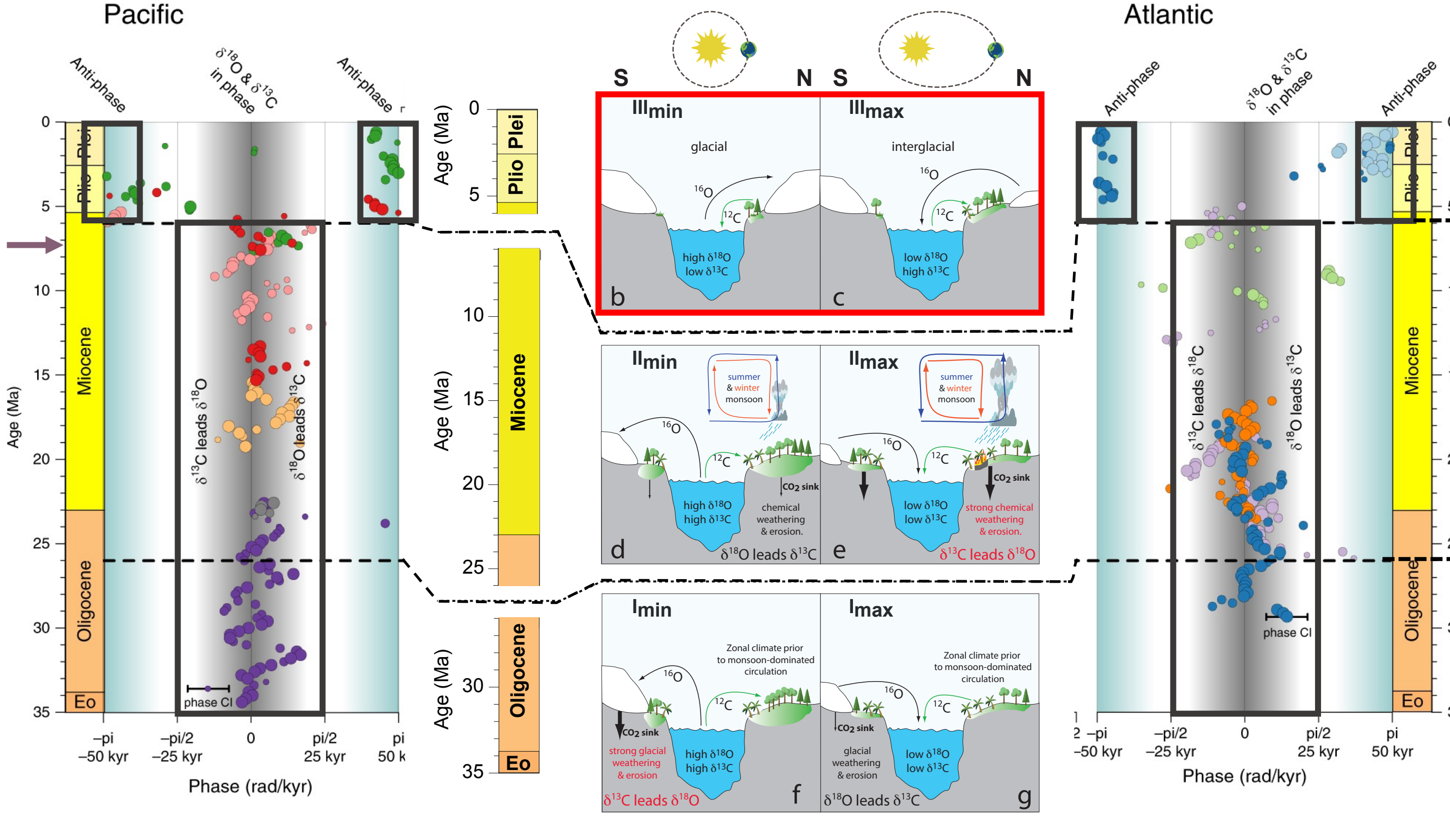
*Eccentricity $\delta^{13}C$ & $\delta^{18}O$ are **anti-phase***

%$CaCO_3$ obliquity

*Eccentricity carbon cycle ($\delta^{13}C$) & cryosphere ($\delta^{18}O$) are **in-phase***

De Vleeschouwer, Drury et al., 2020 Nature Communications

High-latitude biomes drove this late Miocene in- to anti-phase switch



Arctic cooling:
Less continental carbon storage ($\downarrow\downarrow$ δ^{13}C) during cool spells ($\uparrow\uparrow$ δ^{18}O)

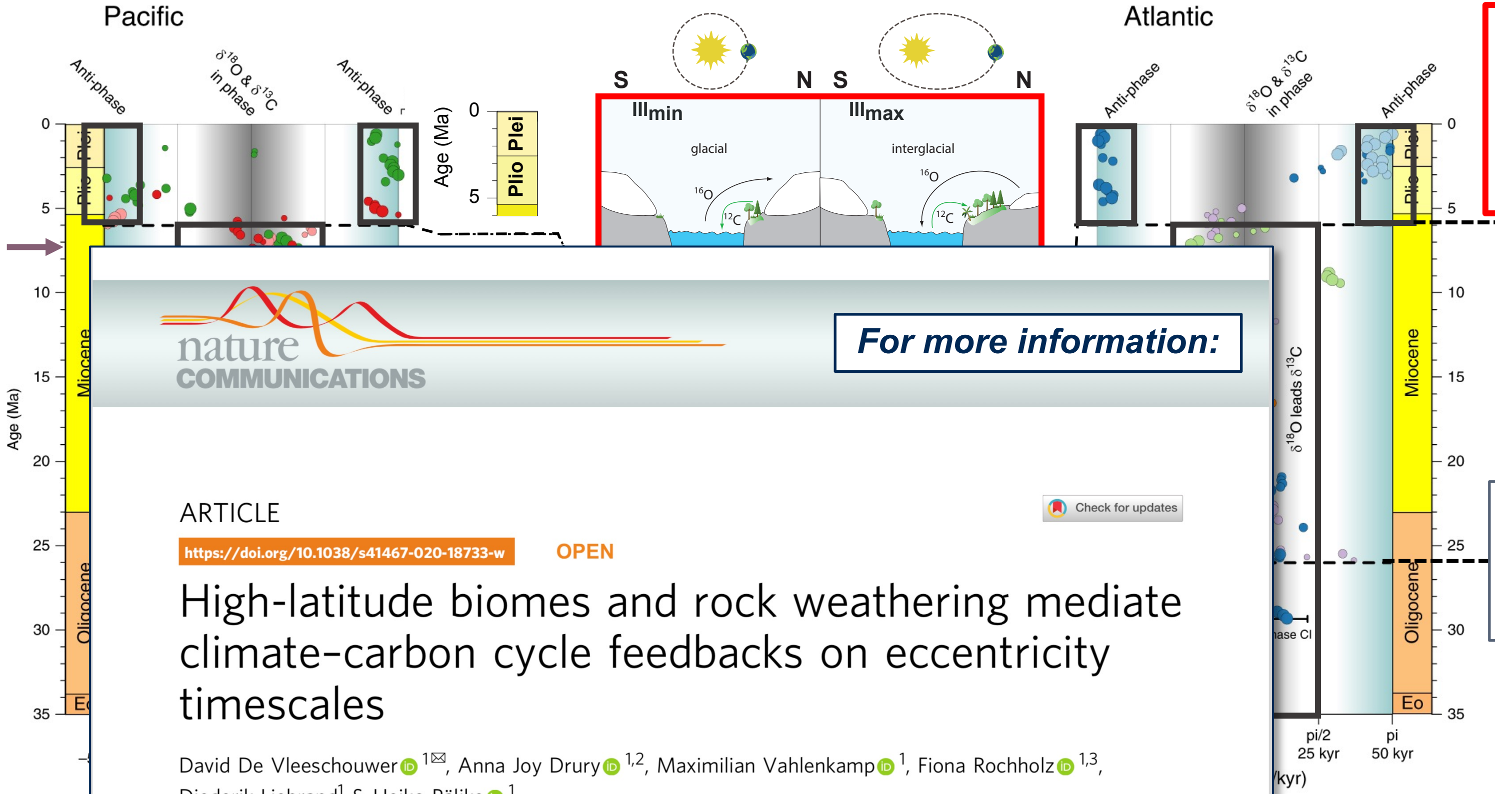
Monsoon-driven continental weathering

More continental carbon storage ($\uparrow\uparrow$ δ^{13}C) during cool spells ($\uparrow\uparrow$ δ^{18}O)

Glacial-driven continental weathering

De Vleeschouwer, Drury et al., 2020
Nature Communications

High-latitude processes drove this late Miocene in- to anti-phase switch



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For more information:

ARTICLE

https://doi.org/10.1038/s41467-020-18733-w OPEN

High-latitude biomes and rock weathering mediate climate–carbon cycle feedbacks on eccentricity timescales

David De Vleeschouwer[1✉], Anna Joy Drury[1,2], Maximilian Vahlenkamp[1], Fiona Rochholz[1,3], Diederik Liebrand[1] & Heiko Pälike[1]

Arctic cooling:
Less continental carbon storage (⇊ δ^{13}C) during cool spells (⇈ δ^{18}O)

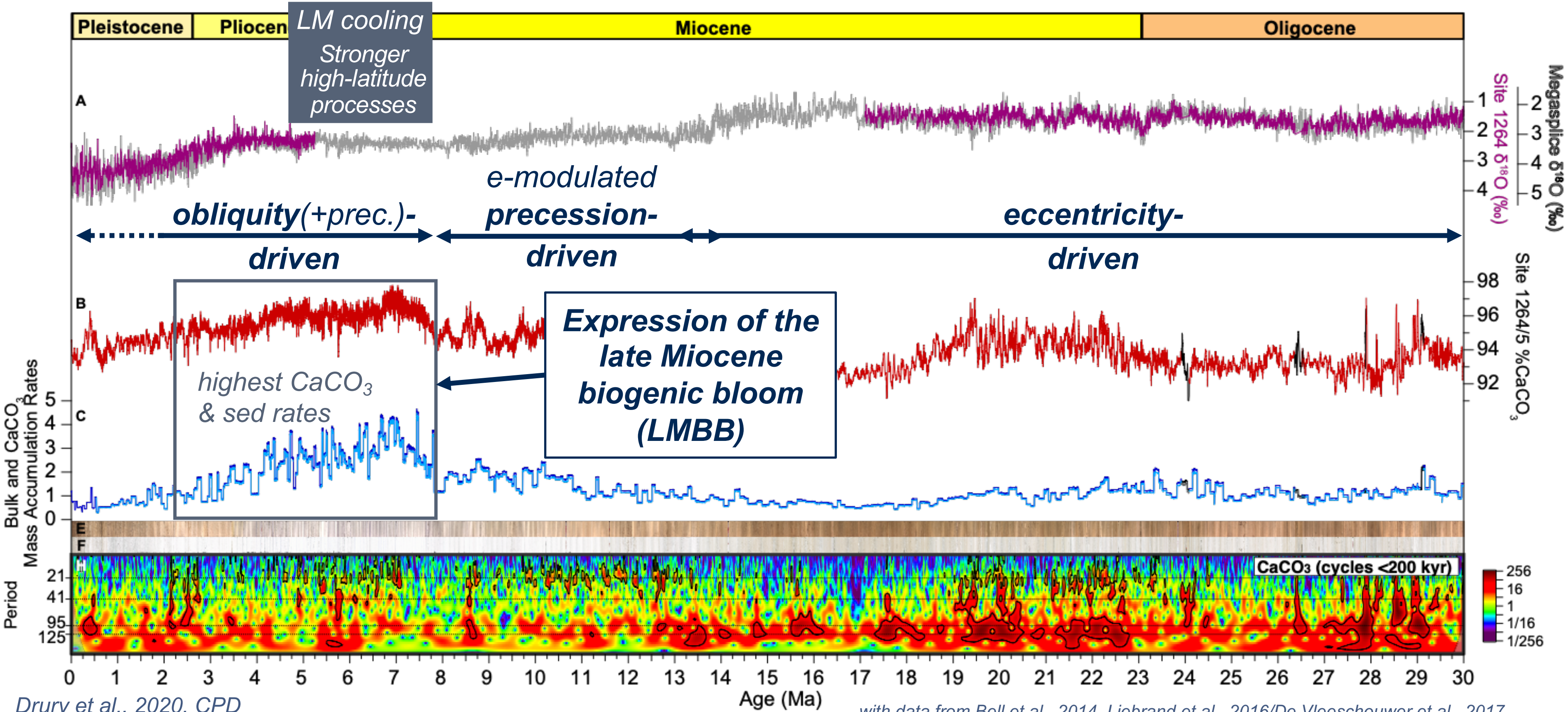
Monsoon-driven continental weathering

More continental carbon storage (⇈ δ^{13}C) during cool spells (⇈ δ^{18}O)

Glacial-driven continental weathering

De Vleeschouwer, Drury et al., 2020
Nature Communications

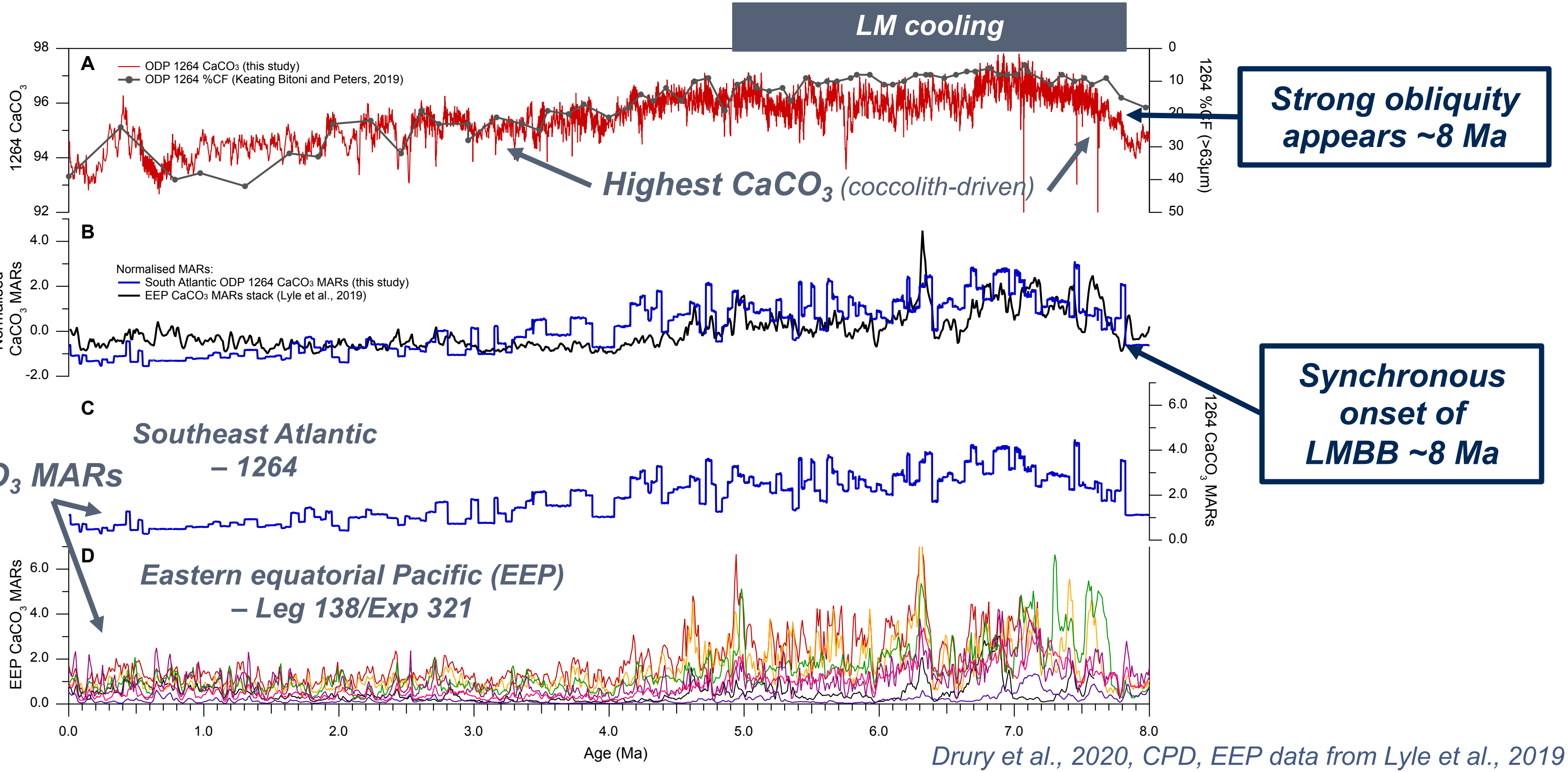
Increased high-latitude forcing could cause the ~8 Ma onset of the LMBB



Drury et al., 2020, CPD

with data from Bell et al., 2014, Liebrand et al., 2016/De Vleeschouwer et al., 2017

High-latitude processes may also drive the late Miocene biogenic bloom onset



Drury et al., 2020, CPD, EEP data from Lyle et al., 2019

For more information about this research:

https://doi.org/10.5194/cp-2020-108
Preprint. Discussion started: 4 September 2020

Climate of the Past
Discussions
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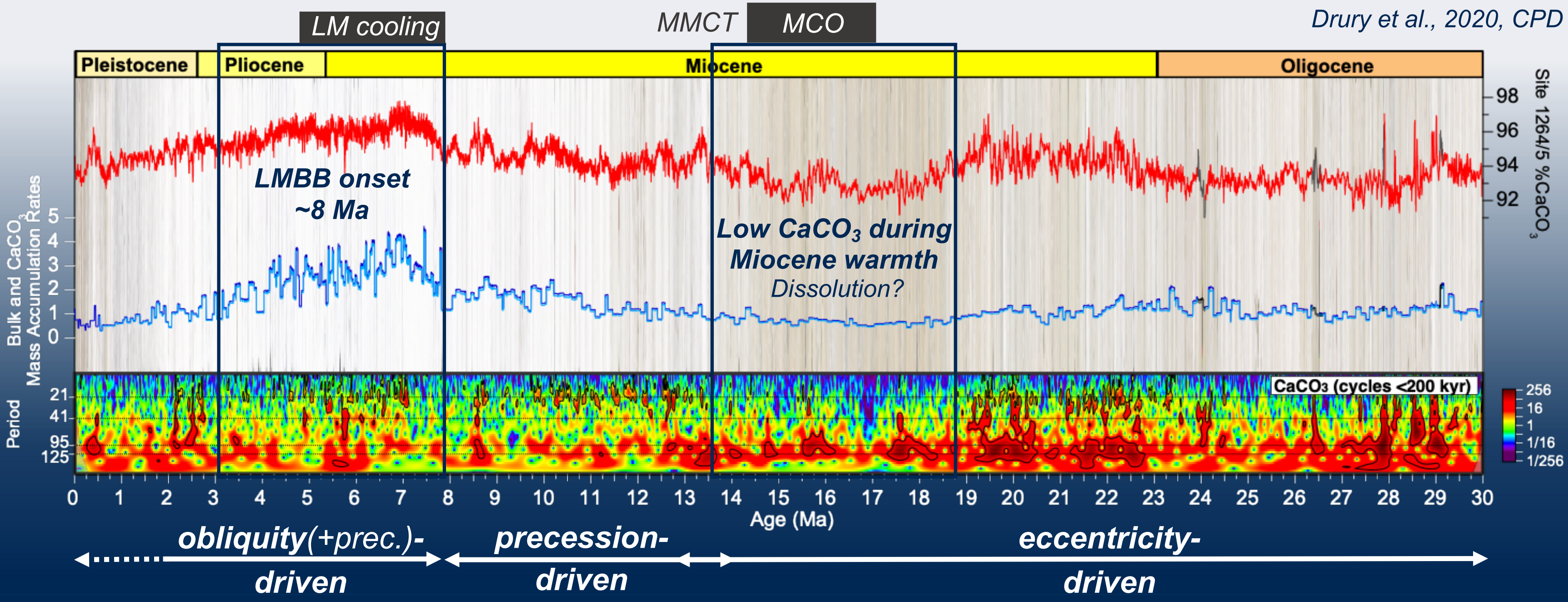
Climate, cryosphere and carbon cycle controls on Southeast Atlantic orbital-scale carbonate deposition since the Oligocene (30-0 Ma)

Anna Joy Drury[1,2*], Diederik Liebrand[1], Thomas Westerhold[1], Helen M. Beddow[3], David A. Hodell[4], Nina Rohlfs[1], Roy H. Wilkens[5], Mitch Lyle[6], David B. Bell[7], Dick Kroon[7], Heiko Pälike[1], Lucas J. Lourens[3]

A 30 million year $CaCO_3$ view of climate, cryosphere and carbon cycle interactions

Drury et al., 2020, CPD



Increased high-latitude processes

UCL