Drivers of Global and Regional Fire activity
What we know from the different GCD syntheses

Anne-Laure Daniau
CNRS, UMR EPOC, Bordeaux, France
Changes in fire regimes since the Last Glacial Maximum: an assessment based on a global synthesis and analysis of charcoal data

(Power et al. 2008 Clim Dyn)
Data treatment

Extraction of raw data from the database

Individual record standardisation
- Box–Cox transformation
- Z-scores rescaling

Composite curve

Z-scores by site
- Lowess curve fitted to the pooled transformed data

Common mean and variance for all sites

(Protocol in Marlon et al. 2008; Power et al. 2010)
Transition from cold glacial to warm Holocene climates was marked by a global increase in fire - climate controls via temperature and biomass level -

(Power et al. 2008 Clim Dyn)
Results from GCD version 2

Daniau and 61 collaborators, 2012 Global Biogeochemical Cycle

Predictability of biomass burning in response to climate changes

(Daniau et al. 2012, GBC)
Increase in global biomass burning from glacial to interglacial

Different trends in biomass burning between northern and southern hemispheres

(Daniau et al. 2012, GBC)
Different trends between northern and southern hemispheres ....

And also between northern and southern tropics and extratropics

→ How to explain these different latitudinal trends in fire and what are the drivers?

(Daniau et al. 2012, GBC)
66% of the variance in biomass burning is explained by a single global function of simulated temperature and moisture. Mean annual temperature and Precipitation minus Evaporation (moisture index) are the key climatic variables. Simulations obtained from the ECBILT-CLIO model v3 run by changing orbital forcing, ice sheet, topography and greenhouse gas concentrations (Timm and Timmermann, 2007 J. of Climate).

Results from GCD version 2

Statistical regression model between biomass burning and simulated climatic variables.

- Mean annual temperature
- Precipitation minus Evaporation (moisture index)

Simulations obtained from the ECBILT-CLIO model v3 run by changing orbital forcing, ice sheet, topography and greenhouse gas concentrations (Timm and Timmermann, 2007 J. of Climate)

66% of the variance in biomass burning is explained by a single global function of simulated temperature and moisture.

Warmer temperatures and intermediate P-E increase fire.

(Daniau et al. 2012, GBC)
Results from GCD version 3

Marlon and 16 collaborators, submitted to Biogeosciences

Reconstructions of biomass burning from sediment charcoal records to improve data-model comparisons

GCDv3 - Number of Samples (since 22 ka)

V2 + 56 sites
736 sites

Number of Samples:
- < 10
- 10-100
- 100-1000
- > 1000

(Marlon et al. submitted)
Results from GCD version 3

Product:

Spatially gridded version of GCDv3 using dot maps

- Each dot on the map represents a composite charcoal series constructed from all records within a fixed distance of the dot
- All GCD sites contribute to at least one dot -- radius used to identify sites contributing to a dot as half the distance between diagonally adjacent dots at the equator (e.g., ~395 km for a 5° x 5° grid)
- Gridding approach prevents interpolation into areas that are not represented in the GCD, which is desirable given the great spatial heterogeneity of fire regimes

(Marlon et al. submitted)
Results from GCD version 3

Base period: 21,000-200 cal yr BP

(Plotted on a 5° grid, e.g., ~395 km)

(Marlon et al. submitted)
Results from GCD version 3

Base period: 1,000-1,800 CE (200 cal yr BP)
Results from GCD version 3

Example: Gridded-map of simulated area-burned and charcoal anomalies (6ky – 0 BP)

Data and Model:
- Agree
- Disagree

Simulated area-burned from CLIMBA model (Brücher et al. 2014)
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Colhoun Eric
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Daniau Anne-Laure
Daniels Mark
Davis Basil
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Eshetu Zewdu
ECD-UK
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IMPD
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Jones Claire
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Kaltenrieder Petra
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Niinemets Eve
Norstrom Elin
Notti Roland
Ogura Akira
Olsson Fredrik
Oswald Wyatt
Pierce Jen
Poska Anneli
Power Mitchell
Prentice Colin
Richard Pierre
Ri us Damien
Roberts Neil
Robinson Guy
Rösch Manfred
Rowe Cassandra
Sasaki Naoko
Scharf Elizabeth
Shuman Bryan
Simard Isabella
Stevenson Janelle
Takahara Hikaru
Taylor Zack
Terwilliger Valery
Tierney Jessica
Toney Jaime
Turner Rebecca
Turney Chris
Umbanhowar Charles
Urregón Dunia
Valsecchi Verushka
Vandergoes Marcus
Vannière Boris
Vedrova Estella
Vescovi Elisa
Walsh Megan
Wang Xuan
Whitlock Cathy
Wick Lucia
Williams Nicola
Wilmshurst Janet
Yu Shiyong
Zewdu Esthetu
Zhang Jia Hua
Zhang Yun
Zhao Yan
Zong Yongqiang
Simulated climatic variables obtained from Timm and Timmermann (2007, J. of Climate)

- Mean annual temperature
- Precipitation minus Evaporation
Results from GCD version 2

Paleo GAM
Charcoal vs. EcBilt Transient Data
21 – 0 kya

Modern GAM
GFED Area burned vs. CRU Data
1996-2009
1961-1990

Warmer temperatures and intermediate P-E increase fire

MAT Anomalies P-E Anomalies

MAT (°C) Annual P-E (mm)