The Rules of Fire

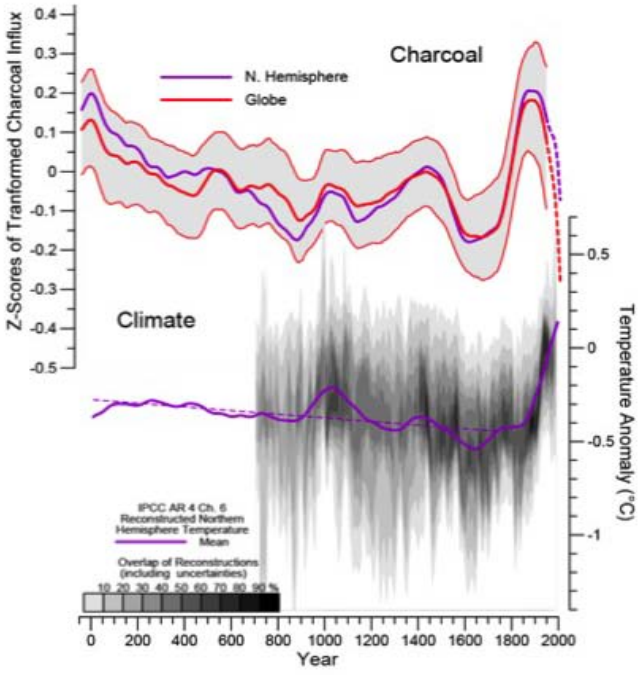
Fire is a complex but predictable function of climate and land use

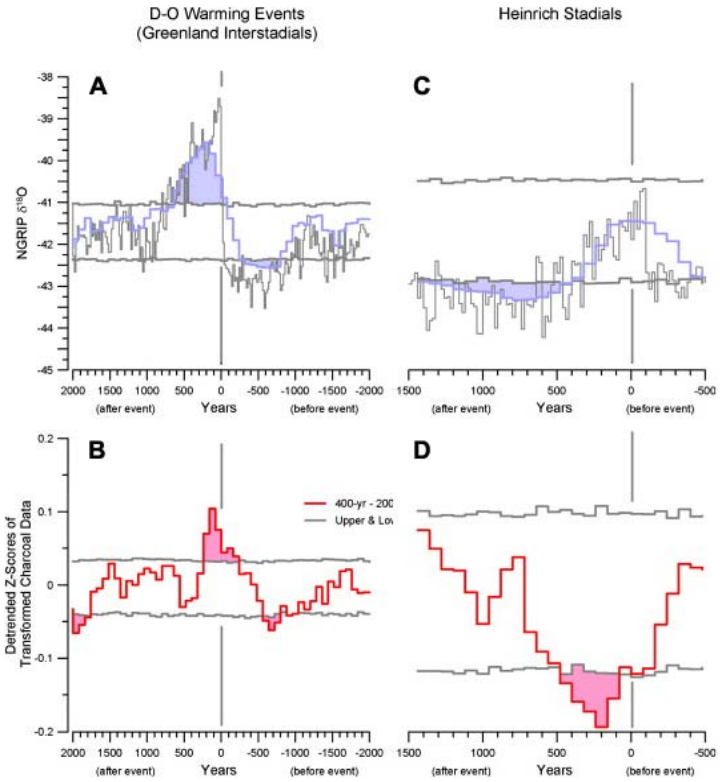
QUEST Activites on fire

- A wildfire prediction module has been built and included in the QUEST Earth System Model Satellite observations have improved it.
- A unique global data base of sedimentary charcoal records has been created, and has contributed new insights about the controls of fire.

Fig. 1 (right). Temperature changes (blue) and global biomass burning changes (red) linked to rapid warming (left) and cooling (right) events during the last ice age (Arneth et al. 2010)

Fig. 2 (below). Biomass burning during the past 2000 years, compared with northern hemisphere temperature reconstructions (Marlon et al. 2008)





New Insights

- Abrupt climate changes evoke fire responses within decades. Warming leads to more fire, cooling to less (Figure 1).
- Biomass burning is highly sensitive to temperature, tracking shifts of a few tenths of a degree. But burning declined after the 1870s due to intensified land use, and is now at a historic low (Fig. 2).
- Burnt area increases with temperature but peaks at intermediate rainfall. These relationships are captured in models (Fig. 3).
- Palaeoclimate modelling can accurately simulate burning trends at different latitudes from the last glacial maximum onwards (Fig. 4).

QUEST Research

The topic of fire surfaced late in QUEST, but an explosion of research followed involving all three QUEST Themes and several Working Groups. A detailed fire module is being integrated into the QUEST Earth System Model, giving it greater capability in fire modelling than many other Earth System Models. This is expected to lead to better projections of vegetation change, emissions and feedbacks and fire risks. FireMAFS exploited new satellite products to improve fire modelling.

QUEST explored the Earth System consequences of fire. The Global Palaeofire Working Group (GPWG) worked in collaboration with the QUEST Deglaciation project to create a unique global data base (Fig 1).

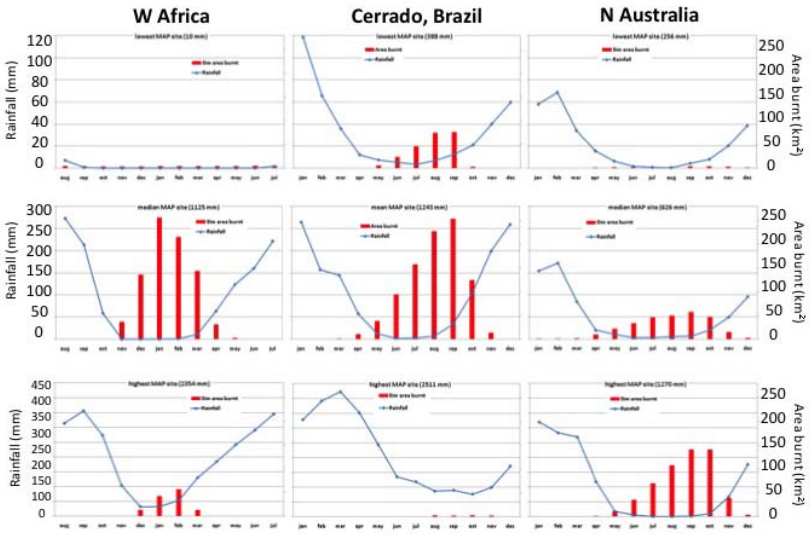
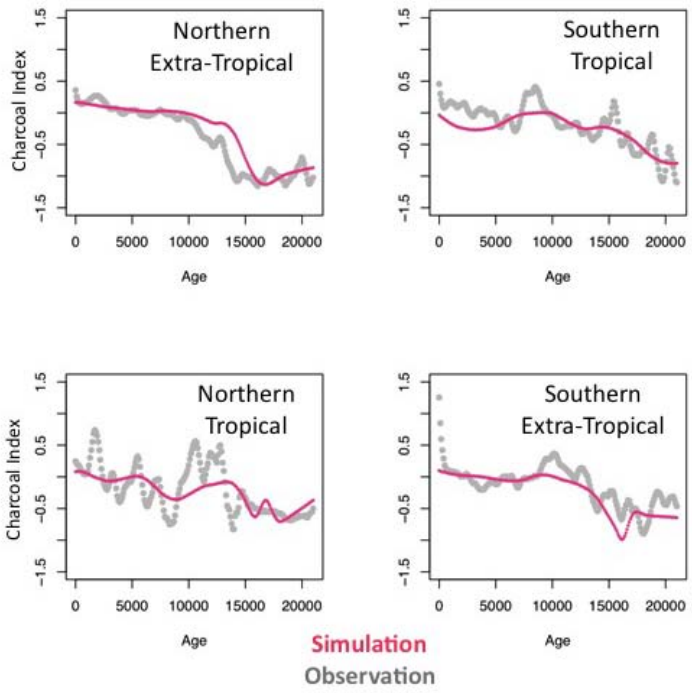


Fig. 3. (above) Seasonal cycles of rainfall and modelled biomass burning at different locations (Spessa et al. in prep.) (matches observed system behaviour, e.g. Spessa et al. 2005)

Fig. 4. (below) Observed and simulated postglacial trends of biomass burning in the northern and southern extratropics and tropics (Daniau et al. in prep.)



Several lines of evidence recently developed both in and beyond QUEST have led to a surprising conclusion regarding the role of human ignitions in fire regimes. It has been found that the main effect of nearby human population is a reduction in burnt area. This effect can be seen both in space (using satellite observations of fire-prone regions) and time. It is counterintuitive, because most fires today, except in areas remote from population, are started by people. It seems that these fires are substituting for fires that would have started anyway.

The reduction in fire with human population is not due to fire-fighting, which mainly protects lives and property. Rather, the data suggest intensive land use—reducing fuel availability and connectivity—as the cause. There is also evidence that abandoning land leads to a resurgence of fire. Whatever the cause, this finding means that even if individual fires are not predictable, nevertheless, fire risk is predictable, and driven (directly or indirectly) by climate. QUEST has explored this predictability through both modelling and data analysis.

Projects Involved: FireMAFS, QESM, Global Palaeofire Working Group

Publications

Arneth A et al. (2010) Terrestrial biogeochemical feedbacks in the climate system. *Nat Geo* 3: 525–532.

Bowman DMJS, 21 others (2009) Fire in the Earth System. *Science* 324: 481-484.

Daniau A-L, Harrison SP, Bartlein PJ (2009) Fire regimes during the last glacial. *Quat Sci Rev* 29: 2918-2930.

Gomez-Dans J, et al (2009) Probabilistic calibration of a coupled vegetation and fire model using satellite data. *Proceedings of IGARSS*. 1: 0-1

Marlon JR, 8 others (2008) Climate and human influences on biomass burning over the past two millennia. *Nature Geoscience* 1: 697-702.

Power MJ, 64 others (2008) Changes in fire regimes since the LGM: an assessment based on a global synthesis and analysis of charcoal data. *Climate Dynamics* 30: 887-907

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Spessa A, Fisher R (2010) On the relative role of fire and rainfall in determining vegetation patterns in tropical savannas: a simulation study. *Geophysical Research Abstracts* 12, EGU2010-7142-6.

Spessa A, et al (in prep) Modelling vegetation fires and emissions. *Fire and Global Change.*

QUEST Quantifying and Understanding the Earth System

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