Discipline of Statistics

Reconstructing Palaeoclimate

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The world's climate is entering into a period of change described by the IPCC (Nov, 2007) as potentially `abrupt'. Yet we know pitifully little about such changes. The instrumental record on past climates is limited to about two centuries and shows no abrupt changes. The general circulation models (GCMs) used to explore future climates are essentially equilibrium models: given assumed `forcing scenarios', we can learn something about future `steady states' but very little about transitions. The palaeoclimate provides a complementary source of information. For example, in Jan 2007, Working Group 1 of the IPCC reported: `During the last glacial period, abrupt regional warmings (probably up to 16 degrees C within decades over Greenland) occurred repeatedly over the North Atlantic region'. Yet inference on the palaeoclimate is indirect and uncertain. Our research focuses on Bayesian space-time inference; a first attempt was reported in Haslett et al (2006), Bayesian Palaeoclimate Reconstruction - with discussion, JRSS(A). Our focus now is on Europe for the period since the onset of rapid deglaciation towards the end of the last glacial stage, a little

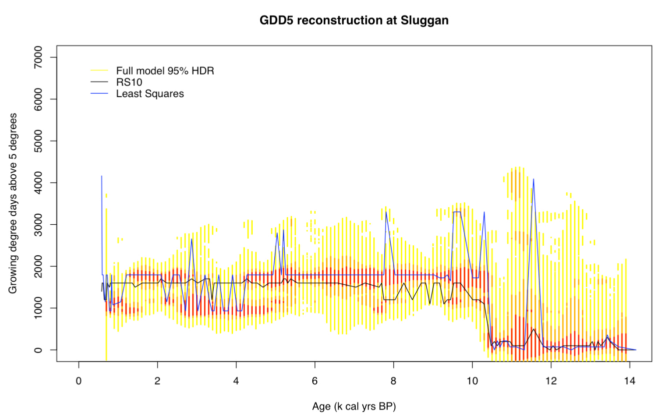

Figure 3. Reconstruction of the growing degree days above 5 degrees (GDD5, a measure of the length of the growing season) at Sluggan Moss in Northern Ireland over the last 14 thousand years. The yellow indicate the interval of GDD5 values with 95% probability. Red and orange indicate areas of highest probability. The black and blue lines are alternative 'point' reconstructions that do not attempt to measure the uncertainty in the reconstruction. Note that time is going 'backwards' on the x-axis.

less than 15,000 calendar years ago. This research runs concurrently with the study of methodological challenges for Bayesian space-time modelling. For the palaeoclimate, what information we have is mostly available via biological and chemical proxies. Examples include: changes in pollen composition as found in sediments, for this reflect

s changes in vegetation and hence in climate; changes in the composition of oxygen isotopes in Greenland ice, for this reflects past evaporation. Our main focus is on pollen, although in principle the methodology is capable of application to many compositional proxies. Such data derive from counts of pollen, from different types of plant (known as taxa), that have been preserved in sedimentary records, in lakes and in bogs. Inference relies on the `modern analogue' hypothesis: the climate 8,000 years ago in, eg Glendalough in Ireland, is like the modern climate somewhere in the Northern Hemisphere. More abstractly, useful information is contained in models of the relationship between climate and pollen composition in the modern world. The key advance is in joint analysis of the many sources of uncertainty. This permits: (a) borrowing strength across multiple sites, and indeed multiple proxies, by a reliance on a degree of spatio-temporal smoothness in climate change; (b) a modular approach, separately focussed on the climate responses of individual taxa and on radiocarbon dating uncertainties, coherently linked by Monte Carlo methods; and (c) the subsequent sampling of joint space-time climate histories. This latter is of great importance; it directly addresses the need for detailed information on space-time changes, and it does so in the context a careful analysis of the many uncertainties.