INTIMATE event definition

Below is a summary of feedback in response to a discussion paper I promulgated in early August about definition of events for the INTIMATE event stratigraphy. Comments were received from David Barrell, Pat Suggate and Marcus Vandergoes.

Summary and comments on feedback

A common thread to Pat's and David's comments was that trends of average value of a continuous but noisy curve (continuous record) are the basis on which events should be defined. In relation to a curve like the one in Fig. 1, Pat suggested defining a first order event (though he preferred the term episode) that covers the transition from low to high. Pat's first order event is esentially the same as the 'transition' event I proposed.

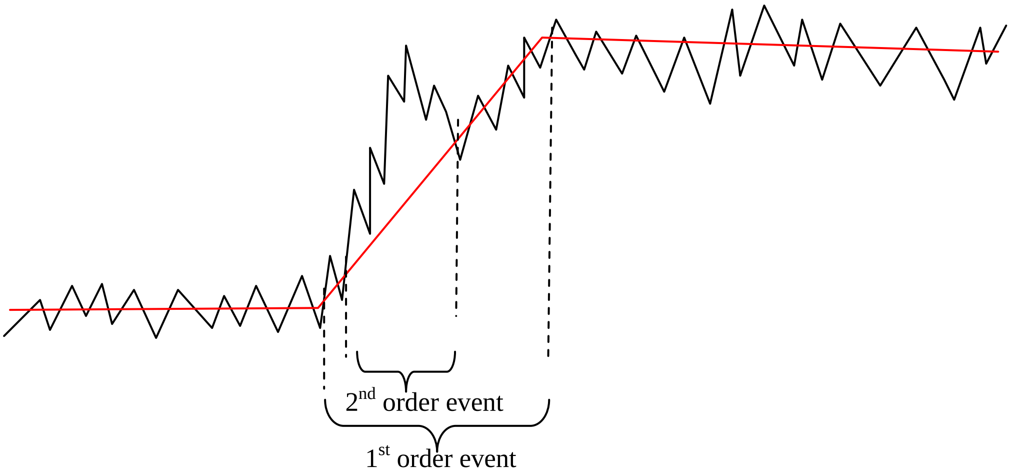

Figure 1 First and second order events, equivalent to transition and excursion events respectively

Pat went further to suggest we define second order events on the basis of excursions from a trend, whether that be a trend of change as in the diagram above, or a trend of constancy. This equivalent to my "excursion" event.

David argued the importance of the envelope of behaviour about the average for defining the beginning and end of events.

In the example in Fig. 2 the transition event begins when the curve exceeds the upper bound of the pre-transition envelope and ends when the curve exceeds the lower bound of the post-transition event envelope. The same approach can be used to define the bounds on excursion events. David noted that using this approach, the ACR event as recognised in the EPICA core has a shorter duration than currently defined and the beginning and end of the event very closely coincide in time with evidence of cooling from NW South Island speleothems, and from Kaipo bog pollen. *Perhaps the ACR excursion event is not defined conservatively enough.*

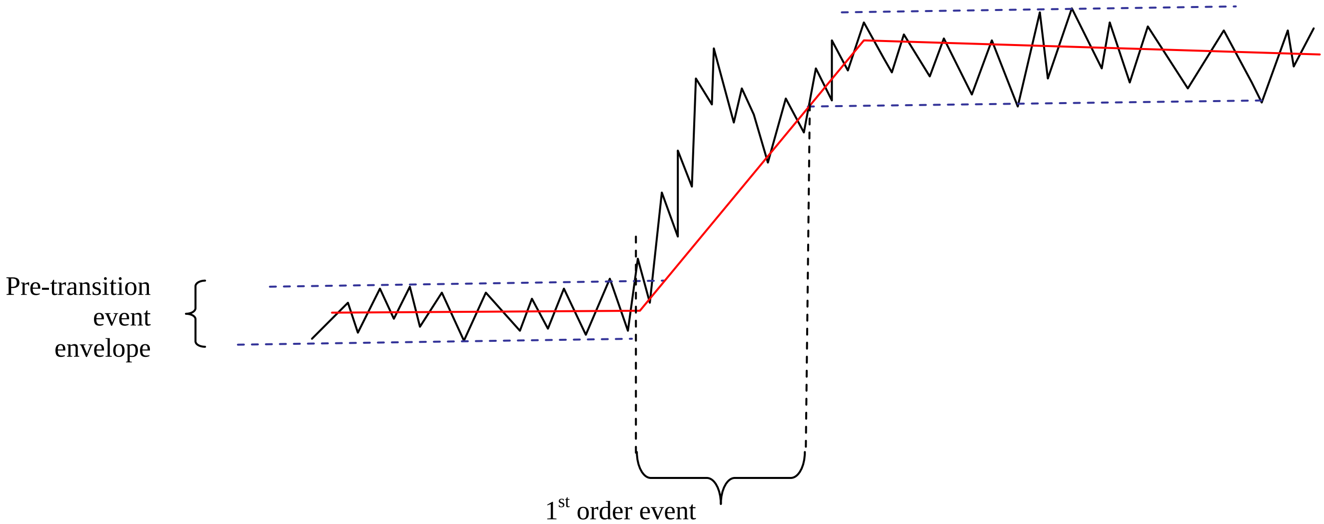

Figure 2 Barrell's suggestion of defining events as when curves depart from envelopes of behaviour determined by noise.

In identifying events he advocated a rigorous and explicit approach. He adopted the approach of defining start, culmination and end parameters of events where it is appropriate, but argued that each has uncertainty due to the noise in the records, as illustrated in his figure reproduced below (Fig. 3). An additional uncertainty is also introduced by any errors in the age model used for the curve. In this context he discussed his concerns about the implied precison of some of the continuous records presented on the poster. He noted that the late-glacial period sections of Pukaki Maar pollen and Otamangakau pollen, above the Waiohau tephra horizon, and the Onaero aeolian quartz andisols were light on age control. Marcus Vandergoes suggested the point of infection of a curve as could be used to define a start or end, or indeed a culmination. Points of inflection can only be applied to a smoothed curve since noise essentially represents multiple inflection points, and then we return to the question of what level of deviation of a smooth curve in relation to the noise is sufficient to recognise a change.

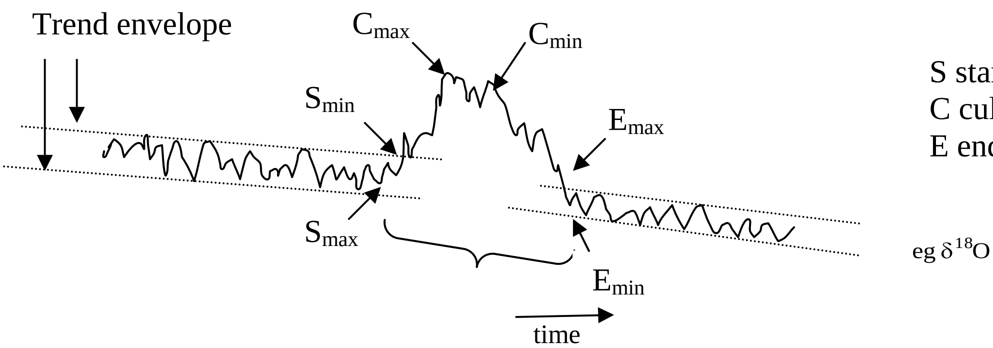

Figure 3 Barrel's event parameters

From Fig. 3 it is clear how Smin and Emax can be defined; they correspond to the times when the curve meets the upper bound of the trend envelope on its rise and fall, respectively. There seems to be no objective way of defining Emin and Smax, however.

David provided an example of event definition using the late glacial advance from the (fragmentory) glacial record (Table 1).

Table 1 Barrell's exemplar for event definition (glacial record)

EVENT	Parameter	Age determination method	Age	Assessed reliability	Comments
Late glacial ice advance	Start(max)	Trend estimate			Not clearly defined
		Maximum numeric age			Not clearly defined
		Minimum numeric age			Not clearly defined
	Start(min)	Trend estimate	c. 14,100	Poor	
		Maximum numeric age	14,150	Moderate	14C (Canavan Knob) on soil overlain by till close to maximum advance position
		Minimum numeric age	13,850	Poor	14C (Canavan Knob) on wood within till close to maximum advance position
	Cul(max)	Trend estimate			Not clearly defined
		Maximum numeric age			Not clearly defined
		Minimum numeric age			Not clearly defined
	Cul(min)	Trend estimate	c. 12,000	Poor	
		Maximum numeric age	12,700	Moderate	14C (Cropp River) on wood within till close to maximum advance position
		Minimum numeric age	11,100	Poor	10Be (Arthur's Pass) on boulders on terminal moraine
	End(max)	Trend estimate			Not clearly defined
		Maximum numeric age			Not clearly defined
		Minimum numeric age			Not clearly defined
	End(min)	Trend estimate	c. 11,600	Poor	
		Maximum numeric age	12,700	Moderate	14C (Cropp River) on wood within till close to maximum advance position
		Minimum numeric age	11,100	Poor	10Be (Arthur's Pass) on boulders on terminal moraine

This is a useful model, especially in that it is explicit about the reliability of limiting ages. I was left unsure, however, on how trend estimates are derived. You'll note how the 'max' parameters are not defined for the Start, Culmination and End. I think this reflects a misapplication of the concepts developed for a continuous record to a fragmentary record – I elaborate below.

If, hypothetically, we had a continuous record of valley ice volume in the Waiho and Cropp catchments from ca. 30 ka to ca. 5 ka it may look like Fig. 4. The deglaciation from ca. 19 ka to ca. 16 ka is a transition event (Suggate's 1st order event) from high to low ice volumes. The late glacial readvance manifested as the Waiho Loop and Cropp Valley moraines is an excursion (2nd order) event during this transition event.

The numeric (radiocarbon and cosmo) ages we have are associated with the terminal moraines, and therefore make the most precise statements about the culmination of the event: samples from beneath the moraine provide a maximum age; samples from within the moraine are probably slight overestimates, ignoring inherited age effects; and samples on top of the moraine provide minimum ages. The uncertainties in establishing the timing of the culmination stem from the stratigraphic context and the uncertainties in the dating techniques, not from interpretations of the variations of a continuous curve as are Smin, Smax, Cmin, Cmax etc. in Fig. 3. These parameters as defined are clearly inappropriate for a fragmentary record. We know very little about the start and end of this event other than what is provided by the ages associated with the culmination. The event started before the oldest age underestimate of the culmination(hence Smin=oldest Cmin), and ended after the youngest age overestimate of the culmination(hence Emax=youngest Cmax)). Once again, however, these Smin and Emax are not the same as the Smin and Emax depicted in Fig. 3; they are brought about by stratigraphic context, not from uncertainty about how to interpret a curve's wiggles.

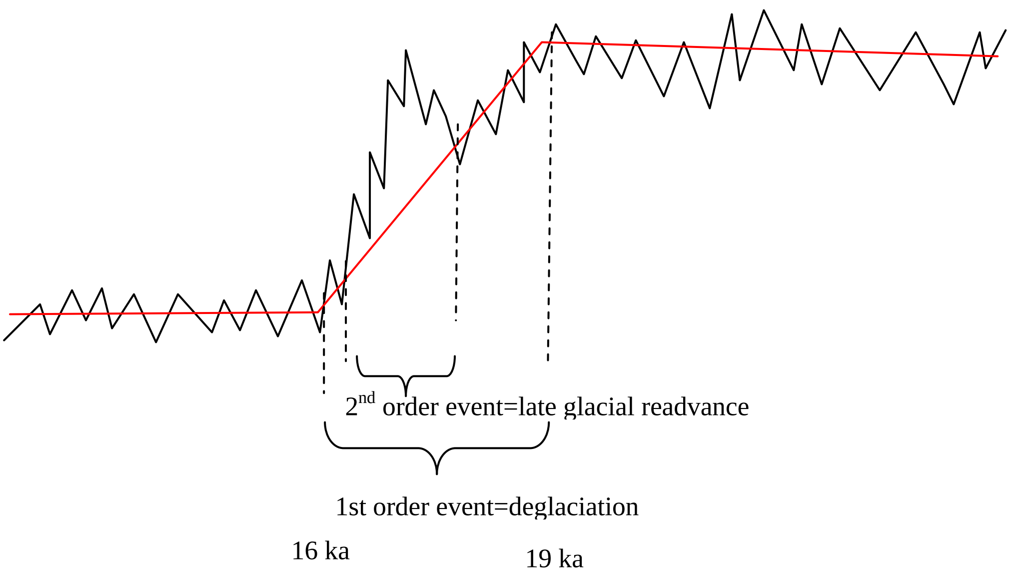

Figure 4. Hypothetical variation of ice volume in valley glaciers before, during and after the last deglaciation. The late glacial readvance shows as an excursion (2nd order) event on the deglaciation transition (1st order) event.

Where to from here

In general it appears that defining two kinds of events has met some approval. We need to decide whether we adopt the initial ‘transition/excursion’ event terminology or the ‘1st order/2nd order’ terminology – I have no strong feelings either way. The 1st/2nd order system is more flexible and addresses a concern of Marcus Vandergoes’ in that it allows finer scale events (excursions within excursions) to be recognised using a 3rd, 4th order etc notation, but it does not express as well the characteristics of events, e.g. changes from one metastable state to another is connoted in the term ‘transition’.

The proposal for recognising a start, culmination and an end to events also received support, although it needs to be recognised that a culmination is undefinable for a transition event. Uncertainty in quantifying these parameters arises in both continuous and fragmentary records. In the first, uncertainty results from deciphering signal from noise, and from errors in age models. In the second, it arises from errors associated with dating, and limitations imposed by stratigraphic context of dated samples. We need to be explicit about how uncertainty arises in the parameters we define.

Perhaps from here an executive decision is made on a protocol for defining events, and that whatever is decided upon is improved iteratively.

Peter Almond