Response to Referee 1:

General remark: We will extend the paper in order to explain the model in more detail as suggested by the referee.

Specific comments:

1) General references will be added.
2) The quantities mentioned will be explicitly explained.
3) Further references will be added.
4) The exponential is simply a consequence of the assumption that local 'melting events' appear randomly and uncorrelated. All 'waiting times' between random uncorrelated events have an exponential distribution. This is a fundamental law of statistical physics. The assumption is probably not perfect, but as a reasonable approximation it has strong support from statistical physics. This will be briefly explained in the revised text. The probability of the melting events can also be derived the other way around. I.e. by asking what distribution is required for Glen's flow law. This leads to the exponential distribution we use.
5) For any 'melting event' (could perhaps also be called a microscopic viscous deformation event) the local deformation will be proportional to the local strain in the material (strain is locally relaxed during the event). I.e. deformation is proportional to σ/E. The occurrence frequency per unit volume of such events is proportional to λ. Thus the overall viscous deformation rate of the material is proportional to $(\sigma/E)\lambda$. Specific answer to the "Am I right?" question: Yes, if you by 'asymptotically' means 'averaged over time'. The symbol '≈' is a standard mathematical symbol for 'approximately equal to'. This will be better explained in revised manuscript. The derivation is presented with approximate equalities since it

is exact only at the level of a single beam, and approximate at the 'macroscopic' level, when deformations of the full lattice are considered.

6) This relation comes from the fact that the energy of a beam U is approximately proportional to the elastic energy density σƐ/2 multiplied by the lattice unit area a^2. We will add this to the text.
7) This comment is confusing: What does the referee mean by "accounted for", and what does iterations for continuum models have to do with it? Here we start with a very general, physically relevant, microscopic description of irreversible viscous deformations events and derive the density of such events which is needed to reproduce the macroscopic Glen's flow as function of the local energy density, stiffness and the temperature dependent factor A. After we introduced this dependence in the particle model we verified that the macroscopic behavior of the model reproduced Glen's flow accurately. If the exponent in the flow law was something else than approximately 3 then it would require a different form for λ. A figure with a numerical test of the model viscosity as function of shear stress is attached. For computational reasons the pre-factor is lower than for ice, but the exponent have the correct value. We could simulate also the correct pre-factor, but that would take months of computations
8) Once we are able to reproduce the stress exponent of Glen's flow we can adjust the viscosity through the pre-factor A. For ice this corresponds to the temperature dependence of viscosity. I.e. we can adjust the temperature of the ice in the model.
9) This refers to a practical computational problem. Calving is a rapid event with high velocities and large energy release over a few seconds. This sets strict limits on the maximum time step length (~10^{-4}sec). Viscous ice flow is, in contrast, a slow process with significant deformation only over weeks or months. It would demand extremely long computations (in practice impossibly long) to cover both phenomena simultaneously.
10) We will add references to relevant papers here. This makes it possible for readers interested in technical details of models related to this one. A more detailed description in text would probably just cause confusion.

11) Details of the computational implementation will be added to the revised manuscript.

12) This will be added in the revised manuscript.

13) I suppose the referee here means the kinetic energy (the word 'kinematic' does not appear in the text). Kinetic energy is the 'motion energy' , $1/2mv^2$ for translations (a half times mass times velocity squared) and $1/2I\omega^2$ for rotational (a half times moment of inertia times angular velocity squared).

14) The block in this figure is supported from the left. The referee is right in that this is likely to cause confusion since it is not mentioned in the text. This will be revised. The amount of randomness can be freely adjusted. With no randomness there are no fluctuations, and with a lot of randomness there are a lot. It is not clear how this should be implemented to best represent glacier ice. So far we have used a small amount of randomly broken bonds as initial condition. This mimics pre-existing small cracks in the ice.

15) This is explained in the figure caption. We will also add the explanation in the text. The markers represent the kinetic energy of the 'surging' simulations for which the ice-block is either in the surging or the quiescent phase all the time. The lines represent the cases when a 'phase transition' takes place during simulation. I.e. an onset of surging is detected during the simulation.

16) The model is inherently scale invariant. This means that the parameters of the model can be rescaled in whatever fashion as long as the equations-of-motion remain the same. For example. The length scale can be rescaled. Obviously, the particle size sets a lower boundary for the smallest fragment size, and it is in practice impossible to get exactly the same fragmentation for any two simulations that are not identical, but the functional form of the FSD (Fragment Size Distribution) is not sensitive to the particle size. Only when the particles become very large and very few does the FSD change form.

Technical comments:

Typos will be fixed. The detailed deformation…means that we do not calculate the exact change of shape for particles pressed against each other. The notation n(s) means numbers of fragments of size s, and it has no unit. 'fish-symbol' indeed means proportional to, and 'of the order'. I hesitate to put in too much units for a scale-invariant model. It does not really serve any purpose and is usually only confusing. Times are added to Fig.4. The time and viscosity can be rescaled as long as viscosity/time remains constant.