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Interactive comment on "Event-driven deposition: a new paradigm for snow-cover modelling in Antarctica based on surface measurements" *by* C. D. Groot Zwaaftink et al.

E. Morris (Referee)

emm36@cam.ac.uk

Received and published: 19 October 2012

tc-2012-133

Event driven deposition: a new paradigm for snow-cover modelling in Antarctica based on surface measurements

C.D. Groot Zwaaftink et al.

General comments

This paper describes modifications made to the SNOWPACK model to enable it to be used in on the Antarctic Plateau where wind-transport modifies the timing and char-

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acteristics of new snow inputs to the snow pack. The revised model has been tested using data from Dome C. The modifications are interesting and potentially useful. In summary the authors propose:

(1) a time delay between precipitation and input of snow to the snow pack depending on wind speed. (2) a new snow density at the upper boundary of the snow pack depending on wind speed (3) a revised expression for wind-compaction in the upper 7 cm of the snow pack (4) a revised expression for the temperature dependence of snow viscosity

With these changes the model produces good simulations of surface temperature and of temperature at 10 cm depth over a 6-week period. The simulated surface height over 3 years is somewhat under-estimated, although the changes in height follow the changes measured at a nearby stake farm reasonably well. Simulations of snow stratigraphy produce depth hoar layers, as would be expected, although such layers were not actually recorded in the observed stratigraphy.

The authors show clearly that it is not a good idea to use a constant density of 83 kg m-3 for the new snow input at the upper boundary over a 3-year period. This is hardly surprising, since periods of calm when snow is added to the pack at this density are limited. Previous studies have used new snow densities of 300-400 kg m-3. The authors really need to show that equation (1) produces better simulations than an optimised constant density – which will probably lie in the 300-400 kg m-3 range.

The paper would be much improved if the effect of each modification to the basic "Alpine" SNOWPACK model was demonstrated in turn, and quantified using an expression for goodness-of-fit of the simulated to the observed data. In particular, it seems important to separate modifications (1) and (2) – is there really evidence that the time delay is important? Or is the correct choice of input density the critical factor in improving simulations? How important is the new expression for viscosity compared to the other changes?

Structure It would help the reader to follow the argument if observations made by pre-

vious workers appeared either in the introduction or as part of a discussion section and observations made at Dome C were described all together in a "field observations" section. Descriptions of processes crop up in different sections and would be better gathered together in one place – the Introduction is an obvious choice. The main difficulty in following the paper arises because the authors spend a lot of time discussing the surface-board measurements, which, in the end, are not used in the modelling. Clearly the measurements were made in the hope that they would show the input to the snow surface. Did they? If they are not useful to drive the model, did they at least contribute to deriving equation (1)? The reader needs to be guided through a structured exposition that explains why each bit of data is introduced.

Nomenclature The paper would greatly benefit from a revision in which key terms (accumulation, deposition, precipitation etc) were defined and used precisely and consistently. For example, in the Abstract the authors refer to "precipitation measured 1 m above the surface" whereas later (section 4.1) they state " After subtracting the amount of hoar deposition from the observed daily total deposition on a table 1 m above the surface one obtains the estimated precipitation". In other words, precipitation is derived from measurements of snow depth on the table. Another example comes later in the Abstract where the authors write "We then used the snow cover model SNOWPACK to simulate the snow cover evolution for different deposition parameterisations. The main adaptation of the model described here is a new event-driven accumulation scheme." The reader will suppose that "deposition" and "accumulation" are different – but it is not clear how. An extra difficulty arises in that "deposition" is commonly used to mean the opposite of "sublimation" whereas in this paper the term seems to be reserved for advection of ice particles to the upper surface of the snow pack.

Specific Comments

Title I think it would be helpful to re-think the title of the paper: (1) I do not really think that the authors are introducing a new paradigm or that the model necessarily applies to the whole of Antarctica. (2) The phrase "event-driven" is defined to have a specific

meaning in the text, but for the reader who just reads the title the meaning is not at all clear and could refer for example to precipitation events.

p.3577 l.1 If the conditions are found across the whole Plateau they are "extreme" rather than "extraordinary" l.4 If the paragraph is about the whole Plateau area then you need to say "for example . . ... at Dome C " p.3578 l.25 why "snow grains" here? Do you mean snow flakes? p.3582 l.7 what is meant by "if necessary " here? p.3583 1.11 how about using the term stratigraphic profile to make clear what is meant? l.23 snow structure is not the same as metamorphism l.27 Antarctic Plateau environment p.3584 l.6 Why are the observations not shown? l.10 dune formation does not necessarily mean snow is immobile l.20 Presumably the "original mechanism" is a reference to the original version of SNOWPACK, but this makes no sense to the reader at this stage p.3585 l.5 How is this calculated? l.7 which daily average? l.9 What is the justification for using a 100 hour moving average? l.10 "lies in the range 4-7 m s-1 " implies 7 m s-1 is the upper bound. Do you mean "exceeds 4-7 m s-1"? p.3586 Equation (1). The variable Uevent should be made dimensionless. log (x) has a singularity at x=0 so the lower limit on Uevent needs to be discussed. p.3588 l.9 Is "toughness" the right word here? Equation (4): need to show how f(T) relates to strain rate (as you do with equation (2)) p.3589 l.21 Strainrate at 10m can be estimated if you know the mean annual accumulation and the density p.3591 l.17 This is rather confusing. Why not say that the effects of wind transport are larger at the surface than at 1 m height? l.25 Large spatial heterogeneity in what? p.3592 l.5 Need to stae error isn 13.7 kg m-2 This is significant since densit is only estimated from snow crystal form. Note that you have not explained how Frezzoti et al determined the mean annual accumulation or what the variability might be. This whole section needs clarification – and it is worth considering why it is included. p.3593 l.25 Last three sentences are misplaced here p.3954 l.12 Would it not be better to compare equations than to compare your simulated results with filed results from areas with different climatological condition? p.3595 l.8 Need to be careful here. The surface temperature is determined via the longwave energy, and if this also plays a major part in the energy budget the predicted surface temperature

may not be independent of the measured value. Figures A location map of stations referred to in the text would be useful Generally the figures could do with better titles with more explanation of what is shown. Contours and prevailing wind would be useful in Fig 2 Why not use conventional symbols in Fig. 7?

Technical corrections

Suggested revisions to the English: p.3576 l.2 "has been studied" p.3577 l.8 "This not only affects…" l.12 "sastrugi" l.19 "we lack a quantitative description" p.3578 l.1 "are found" l.20 "For example, Frezzoti et al tried to estimate…" p.3579 l.10 delete "yet" l.18 "However, over such a short period" l.20 delete "though" l.20 "reproduces temperatures quite well" l.28 "The means of each series averaged…. p.3582 l.13 "allow accumulation…. to be assessed" l.19 "are only available" l.22 "snow board Sbclear is cleared daily; snowboard SB acc is not. Thus Sbclear gives the daily deposition and Sbacc the difference between deposition and erosion" p.3583 l.4 depths of 5,10,50 and 100 cm (at a location….) and 150, …. 100 cm (at 5-7 m from the shelter) p.3584 l.9 Kohnen Station l.27 threshold depends on surface properties these were not measured at Dome C" p.3585 l.1 "more" requires "than…." l.2 "average 3m wind speed" l.17 "overcome" not clear. Should this be "explained"? "It has been shown by many authors…" l.12 "we expect that there will be an upper limit on …" p.3586 l.7 "of the change in density between precipitation and surface snow" l.20 "adaptation" does not seem to be the right word here. How about "the impact of using equation (1) will be discussed further…"? p. 3587 l. 1 "The overburden pressure on surface snow is minimal and will therefore produce little compaction. Low temperatures will not lead…. However, as Brun pointed out, wind…." 1.10 "if" and "else" not needed in equation (2) l.15 "has already reached" l.16 "this study" p.3588 l.7 "barely compressible" l.22 "previous temperature expression" p.3591 l.22 "the difference between …. is interesting" l.28 "from 18 Nov…. to 3 July.." p.3593 l.10 "overburden" l.11 "cannot" l.24 " Indeed it would only take a little sublimation to saturate the air" p.3596 l.8 "It is important for such a comparison" l.9 "the observed profile" l.14 "profile observed near Concordia…"

p.3598 l.3 "representative of" l.26 "the performance of the model to be tested"

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