Firn densification and ice sheet surface elevation changes

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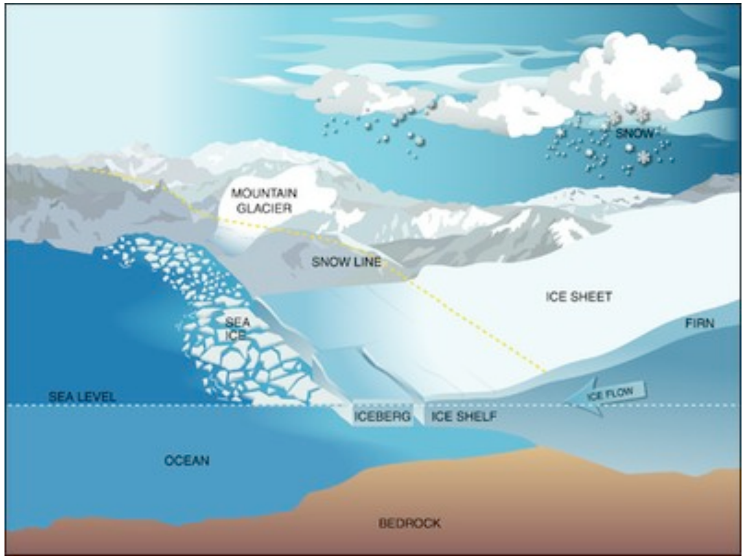
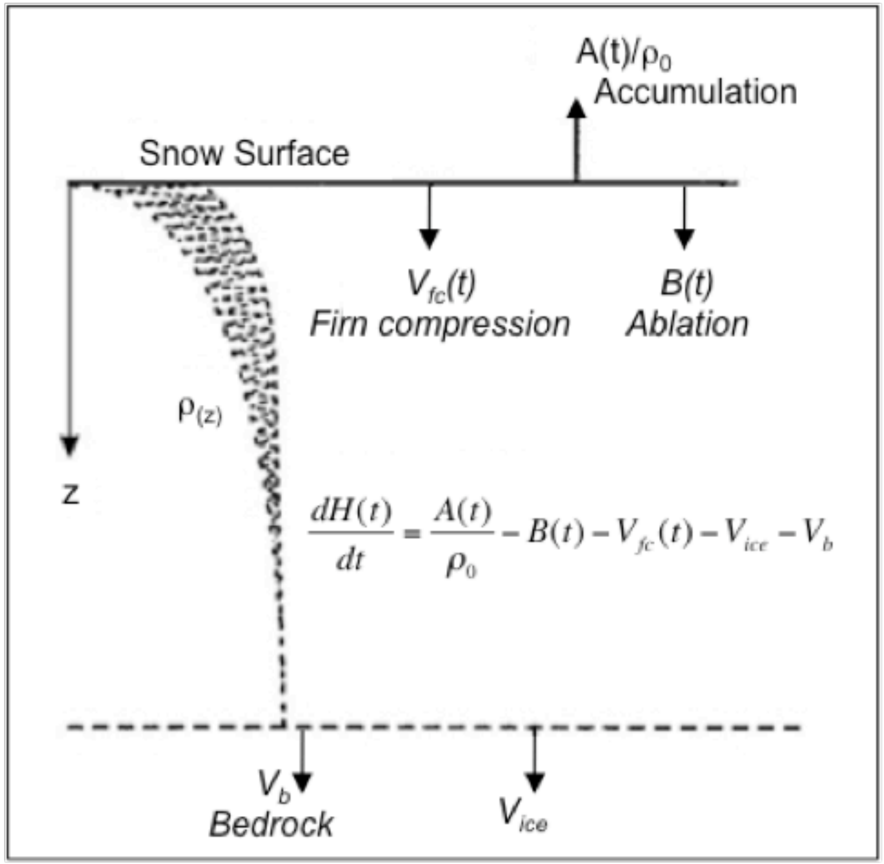
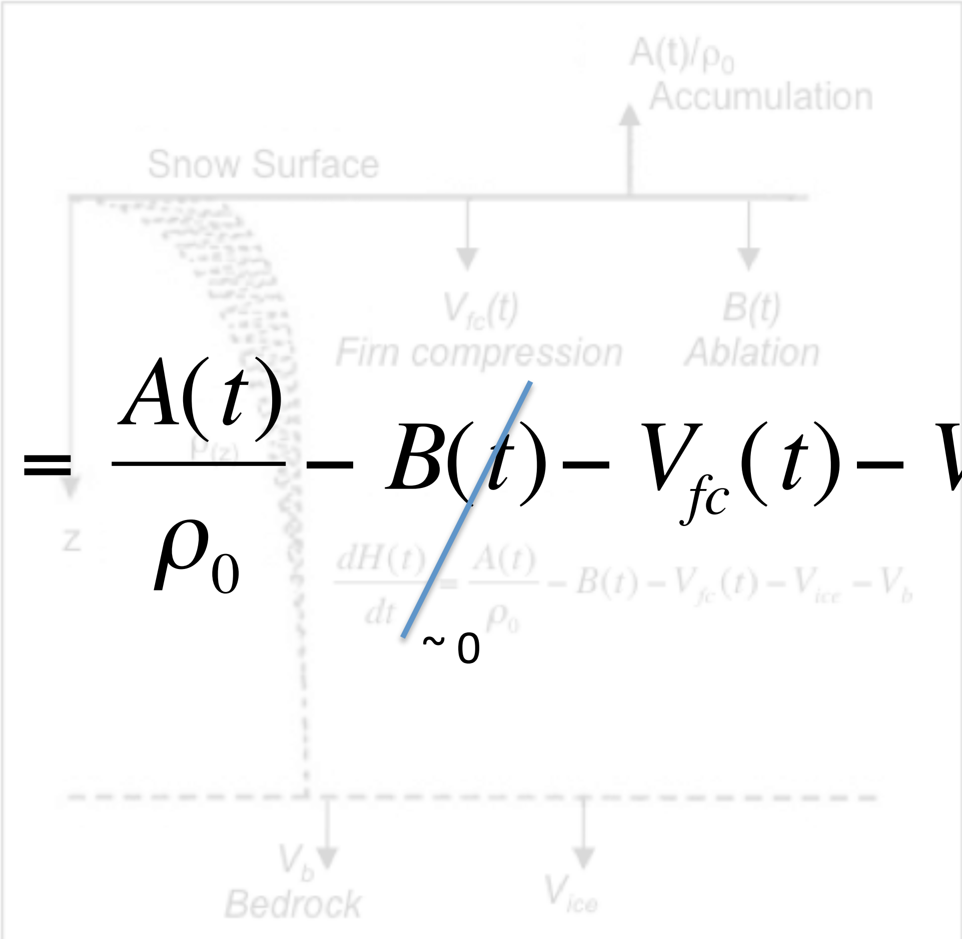
Total Elevation Change





Total Elevation Change



$$\frac{dH(t)}{dt} = \frac{A(t)}{\rho_0} - B(t) - V_{fc}(t) - V_{ice} - V_b$$

$B(t)$ ~ 0, V_b ~0

Model of Elevation Change

2D flowline model → V_{ice}

Firn densification model → V_{fc}

Model of Elevation Change

2D flowline model → V_{ice}

accumulation

Firn densification model → V_{fc}

Firn Densification Model

$$V_{fc}(z,t) = \int_{z_i}^{z} \frac{1}{\rho(z)} \frac{d\rho(z)}{dt} dz$$

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SIMPLE Firn Densification Model

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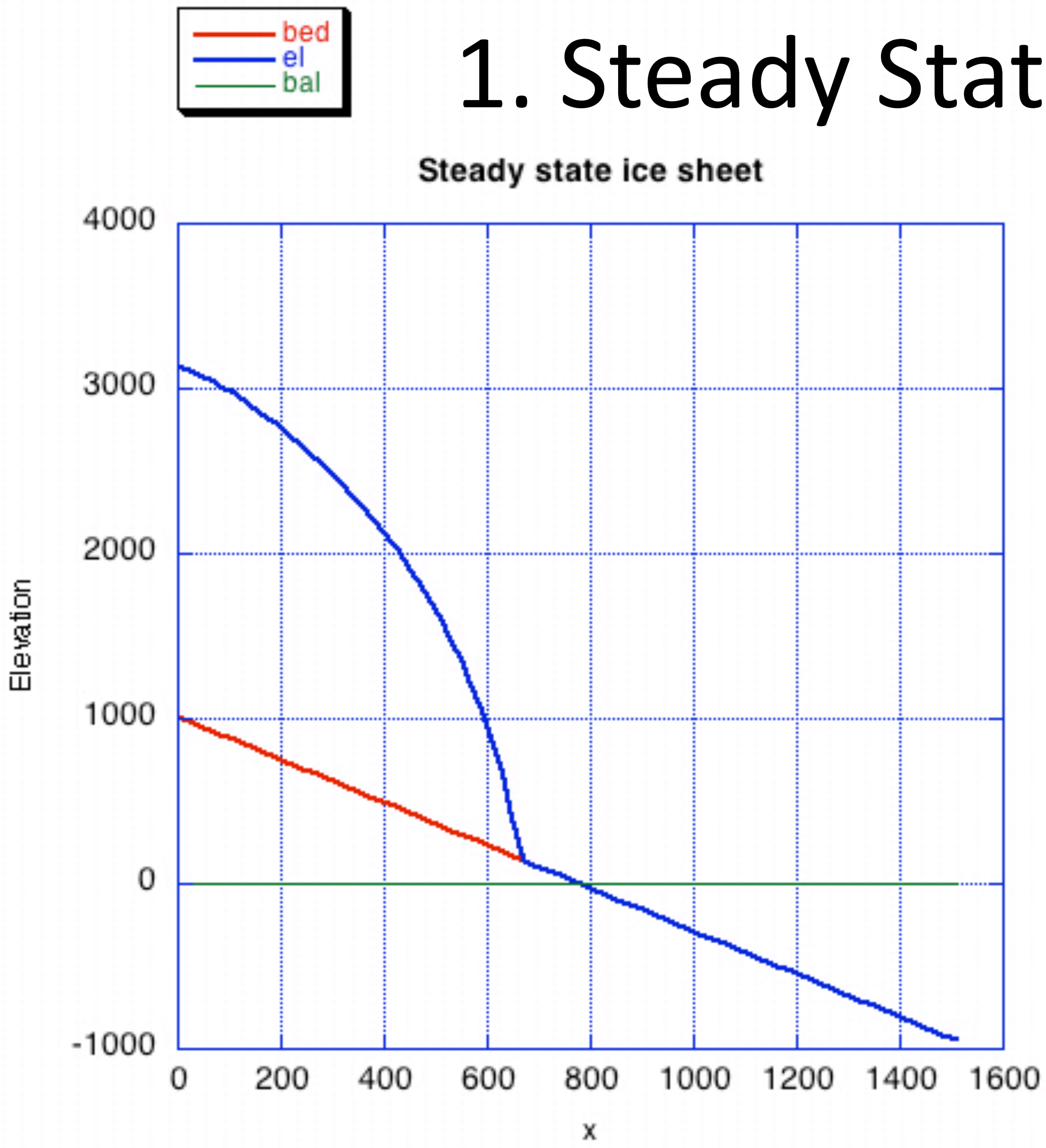
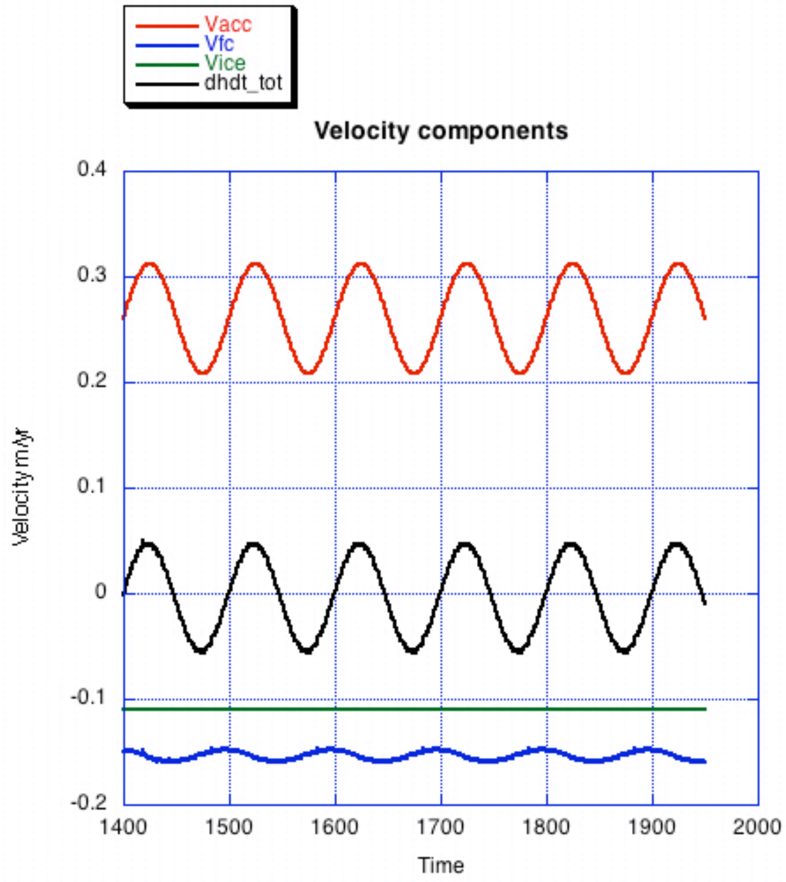
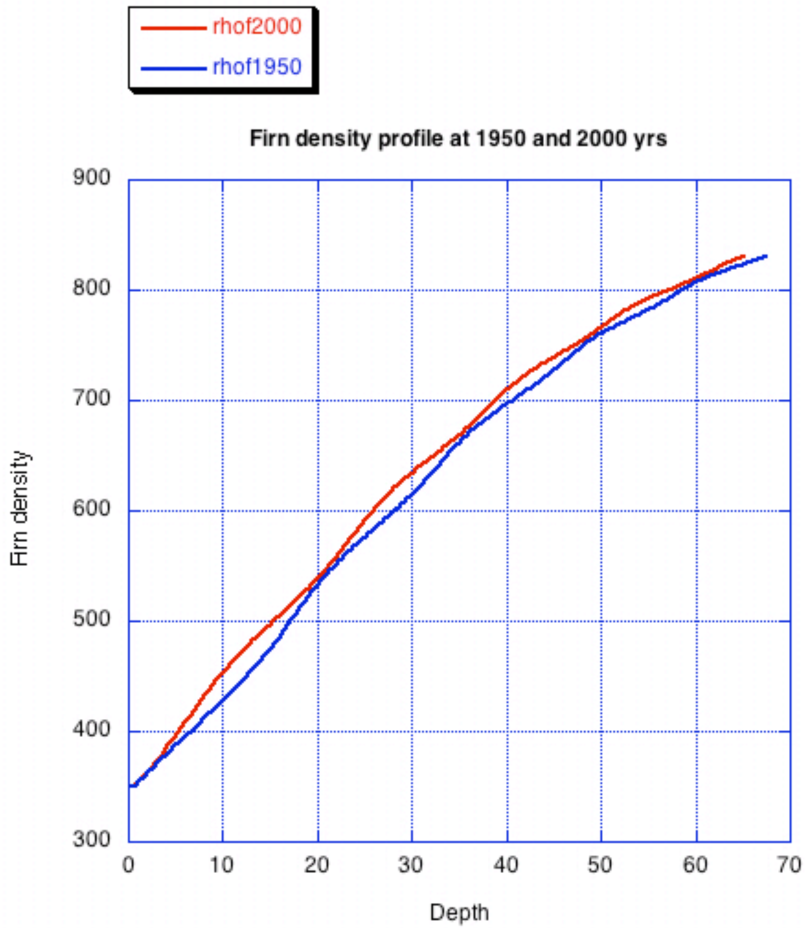
$$\rho(t) = (\rho_0 - \rho_i)e^{-\frac{KA}{\rho_i}t} + \rho_i$$

1. Steady State



2. Sinusoidal Accumulation





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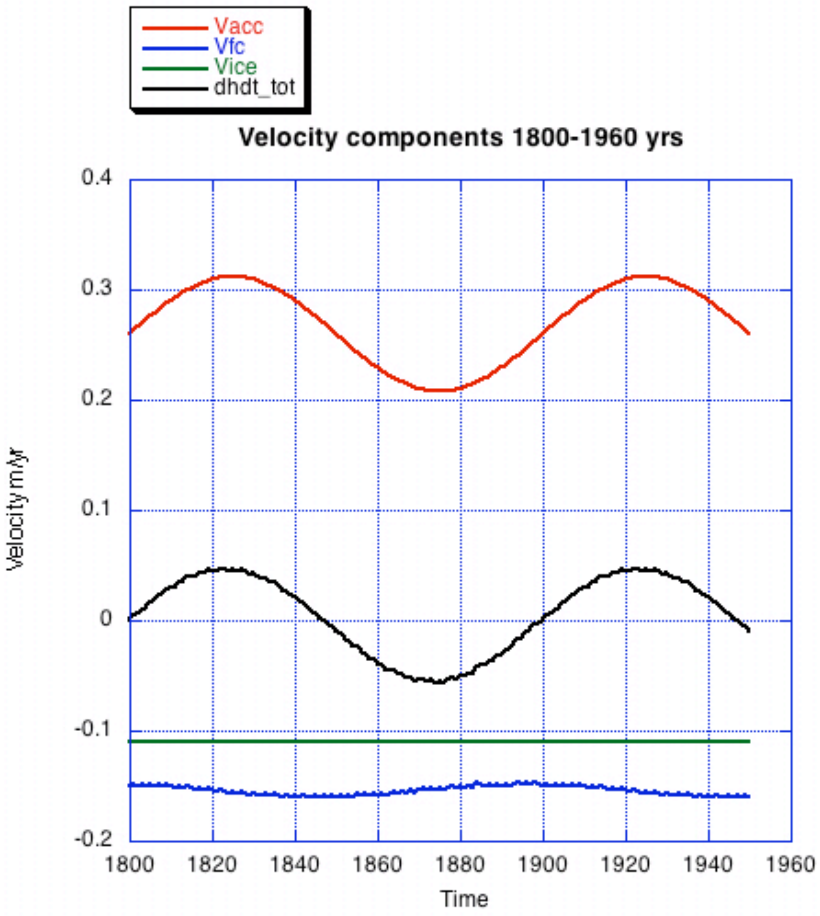
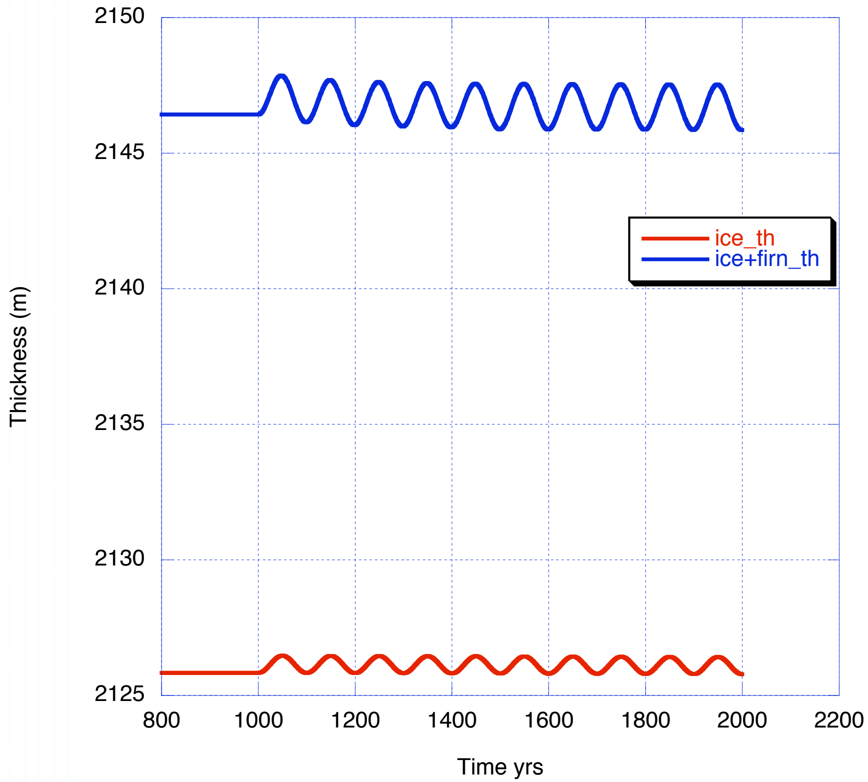
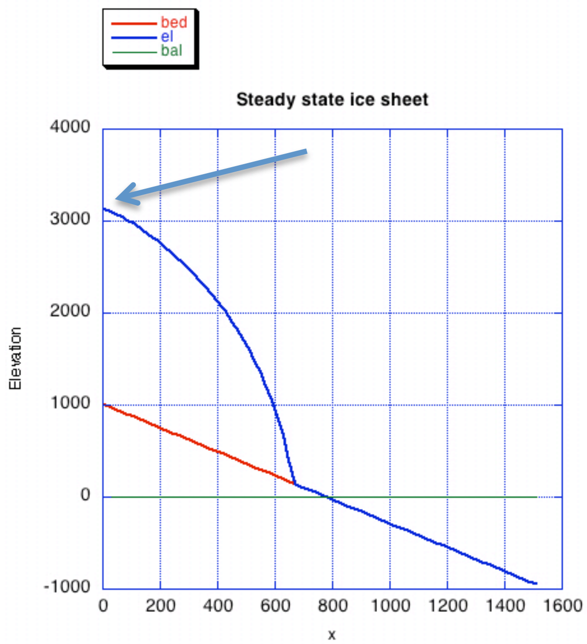
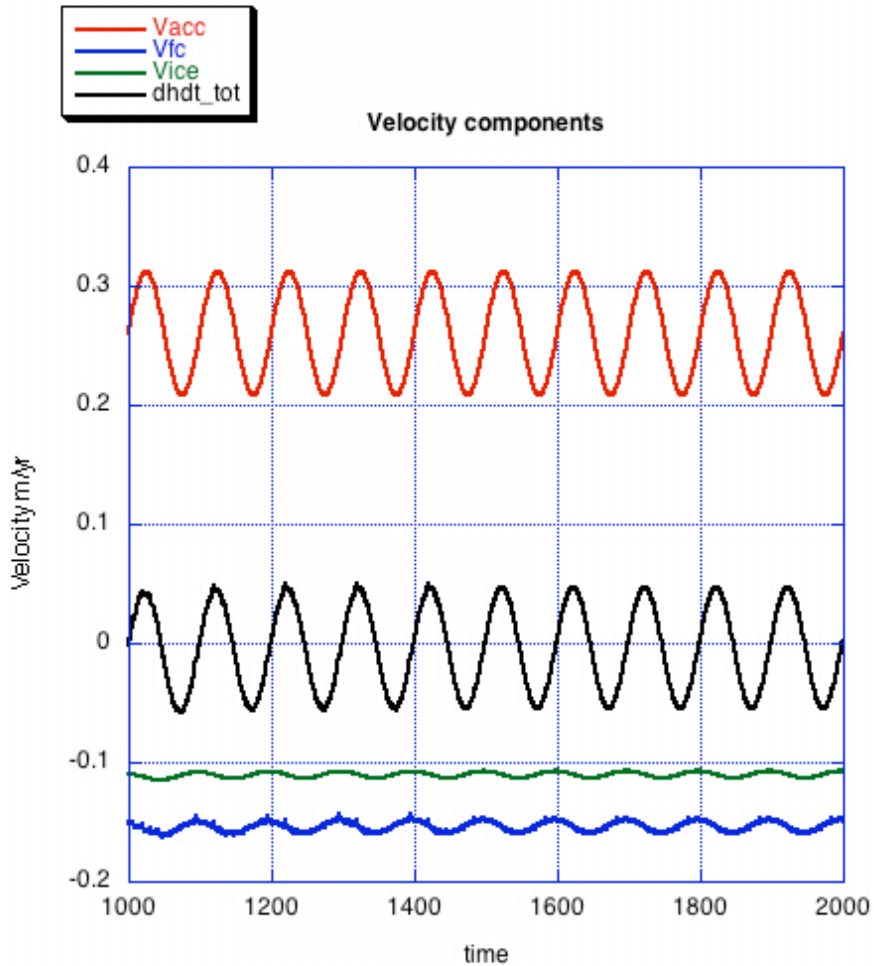




3. Local Accumulation





Summary

dhdt is dominated by accumulation change, however firn densification rate also has an effect

Firn densification rate is a function of past accumulation rate (when temperature is excluded)

Where accumulation changes occur over the whole modelled ice sheet ice velocity is almost constant, whereas an accumulation change at one point only will cause noticeable velocity fluctuations

Inclusion of a firn model amplifies the response to short term accumulation changes – this has implications for satellite remote sensing

Acknowledgements - Michiel Helsen