Supplement of The Cryosphere, 9, 2271–2293, 2015
http://www.the-cryosphere.net/9/2271/2015/
doi:10.5194/tc-9-2271-2015-supplement
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Supplement of

Verification of the multi-layer SNOWPACK model with different water transport schemes

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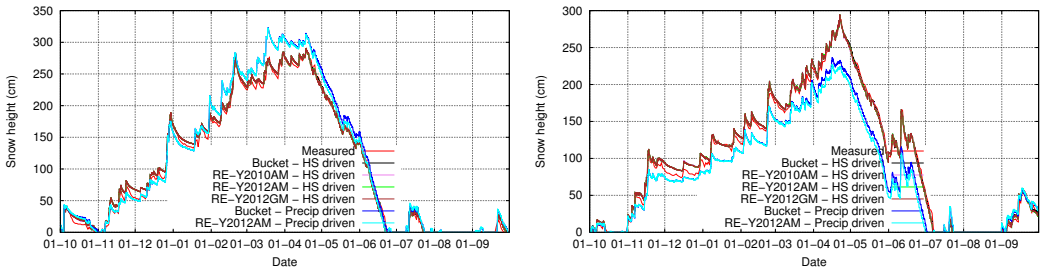

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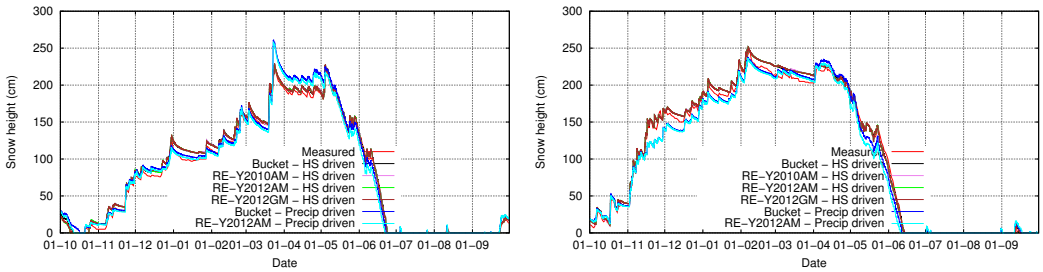

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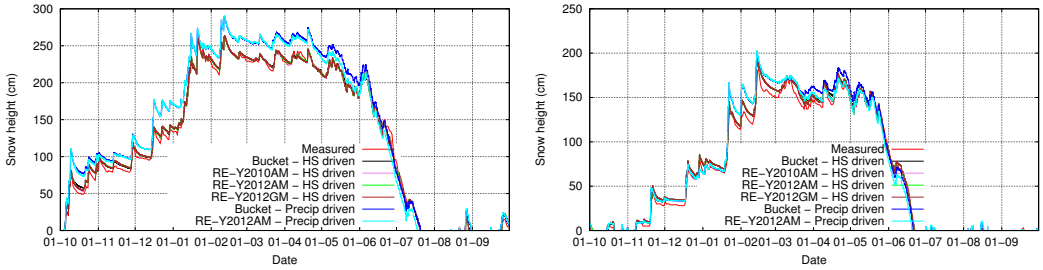

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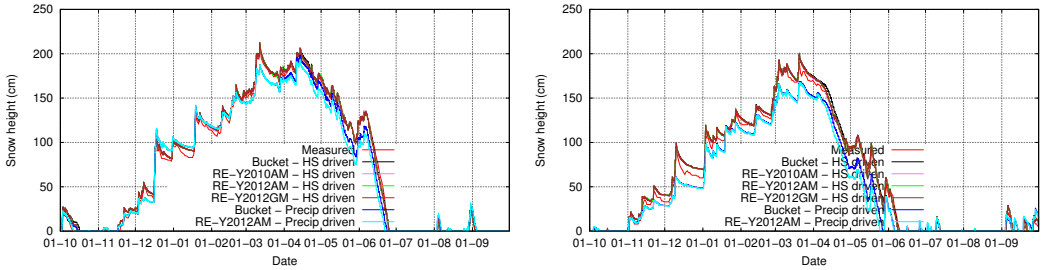
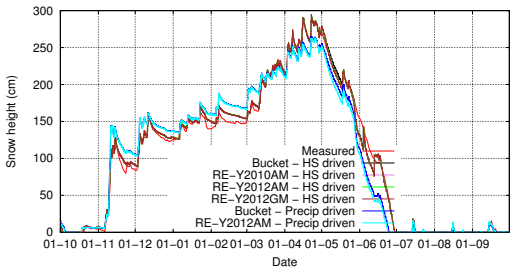
(f) 2004-2005



(g) 2005-2006

(h) 2006-2007

Figure S1: Measured and modelled snow height for different model setups.



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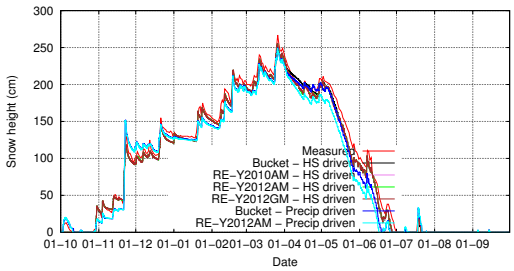
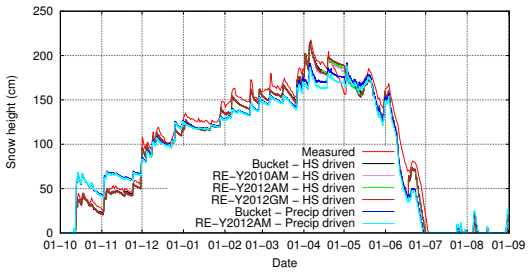
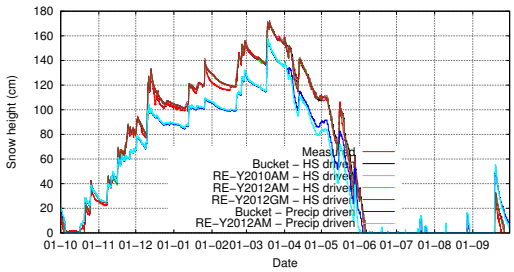


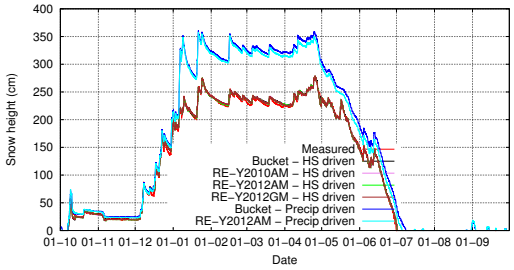
(b) 2008-2009



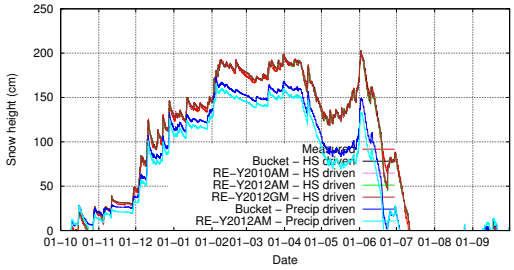
(c) 2009-2010



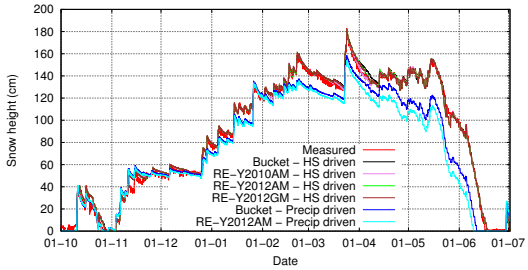
(d) 2010-2011



(e) 2011-2012



(f) 2012-2013



(g) 2013-2014

Figure S2: Measured and modelled snow height for different model setups, continued.

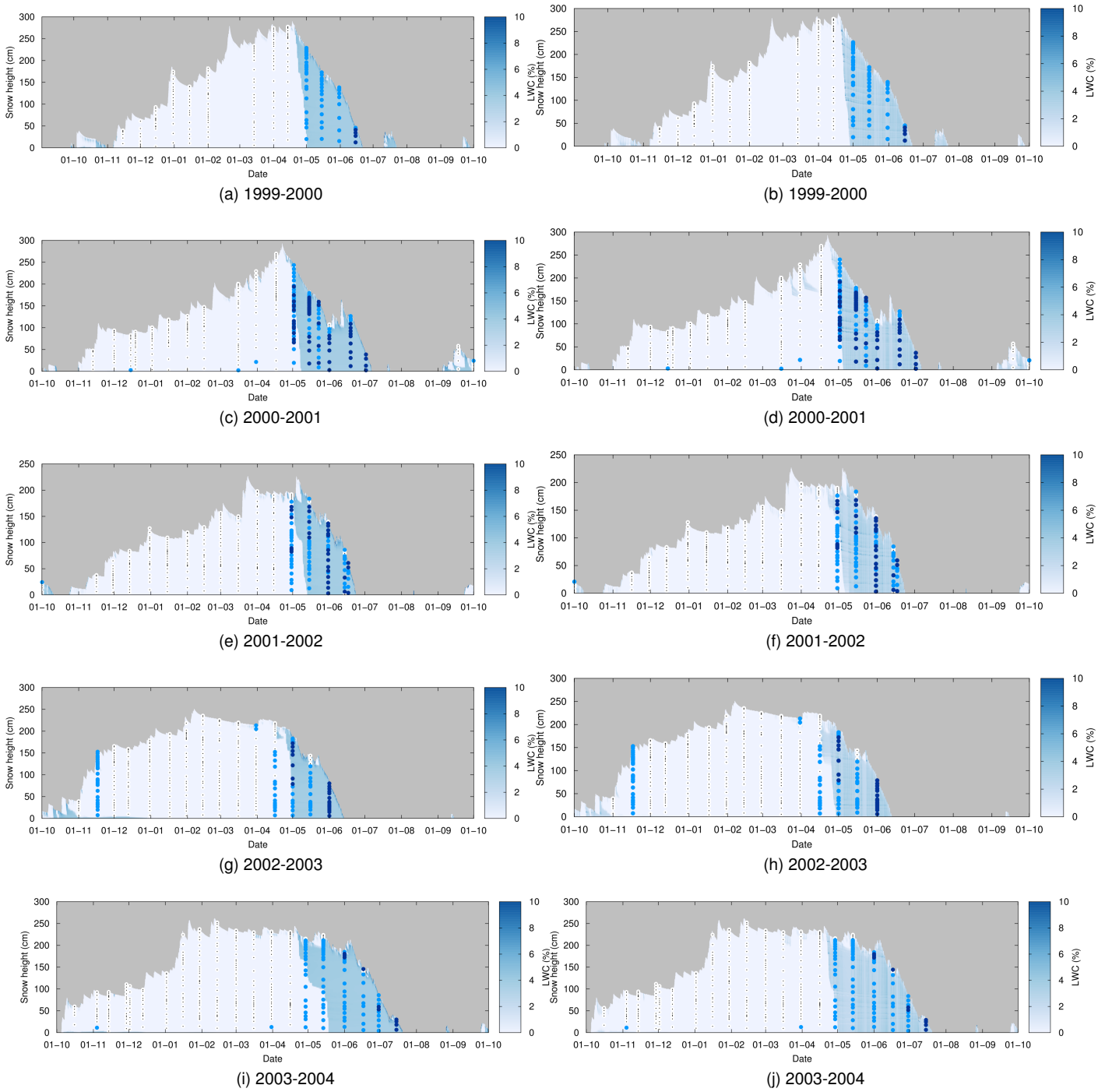


Figure S3: LWC (%) for the snow height-driven simulations with the bucket scheme (left), and with RE-Y2012AM (right). Dots denote layers that have been reported as dry (0% LWC, white with black center dot), moist (0-3% LWC, light blue) or wet, very wet or soaked ($\geq$3% LWC, dark blue) from the biweekly snow profiles. When layers are reported as "1-2" (dry-moist), it is considered moist.

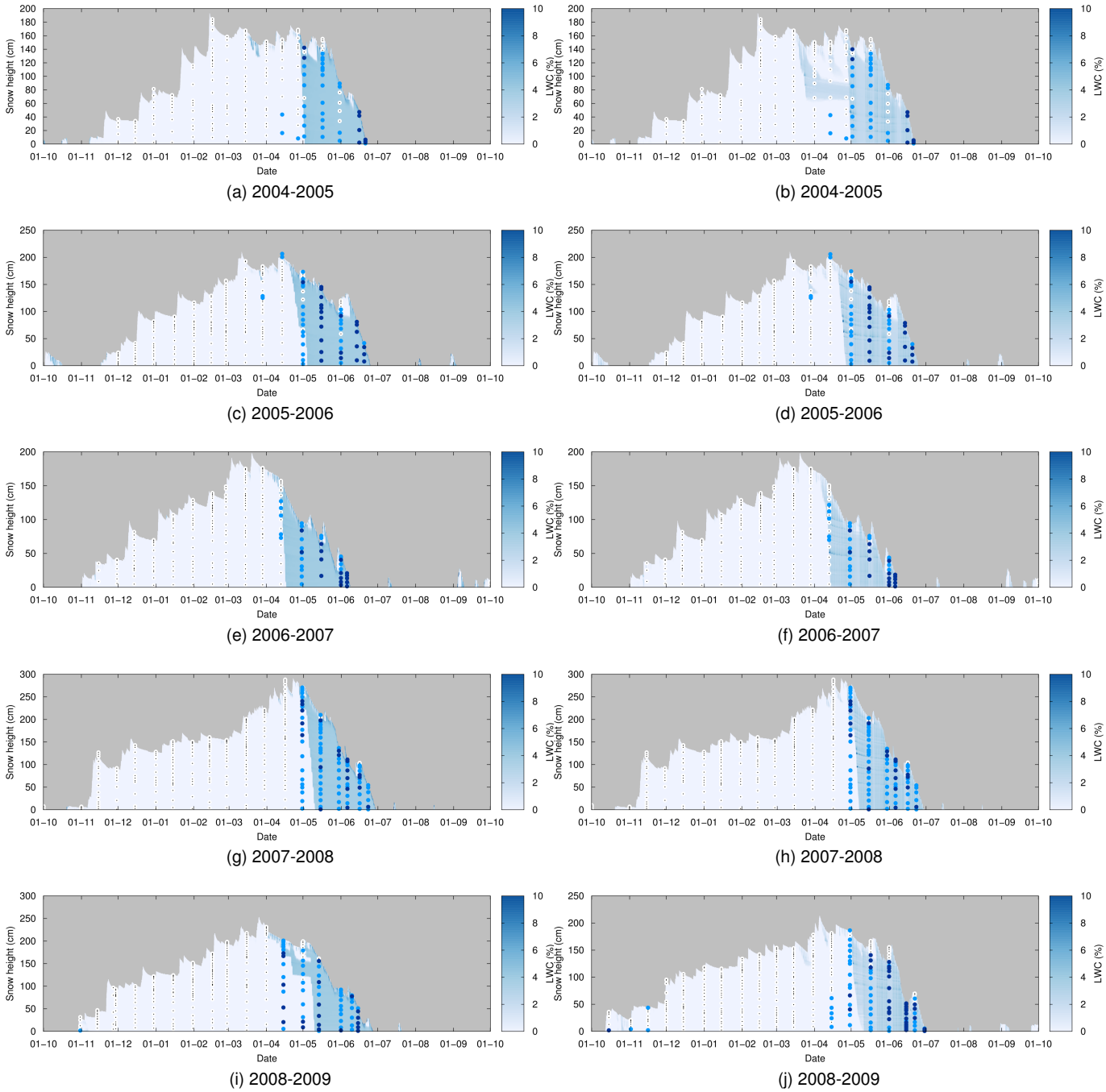


Figure S4: LWC (%) for the snow height-driven simulations with the bucket scheme (left), and with RE-Y2012AM (right), continued. Dots denote layers that have been reported as dry (0% LWC, white with black center dot), moist (0-3% LWC, light blue) or wet, very wet or soaked (≥3% LWC, dark blue) from the biweekly snow profiles. When layers are reported as "1-2" (dry-moist), it is considered moist.

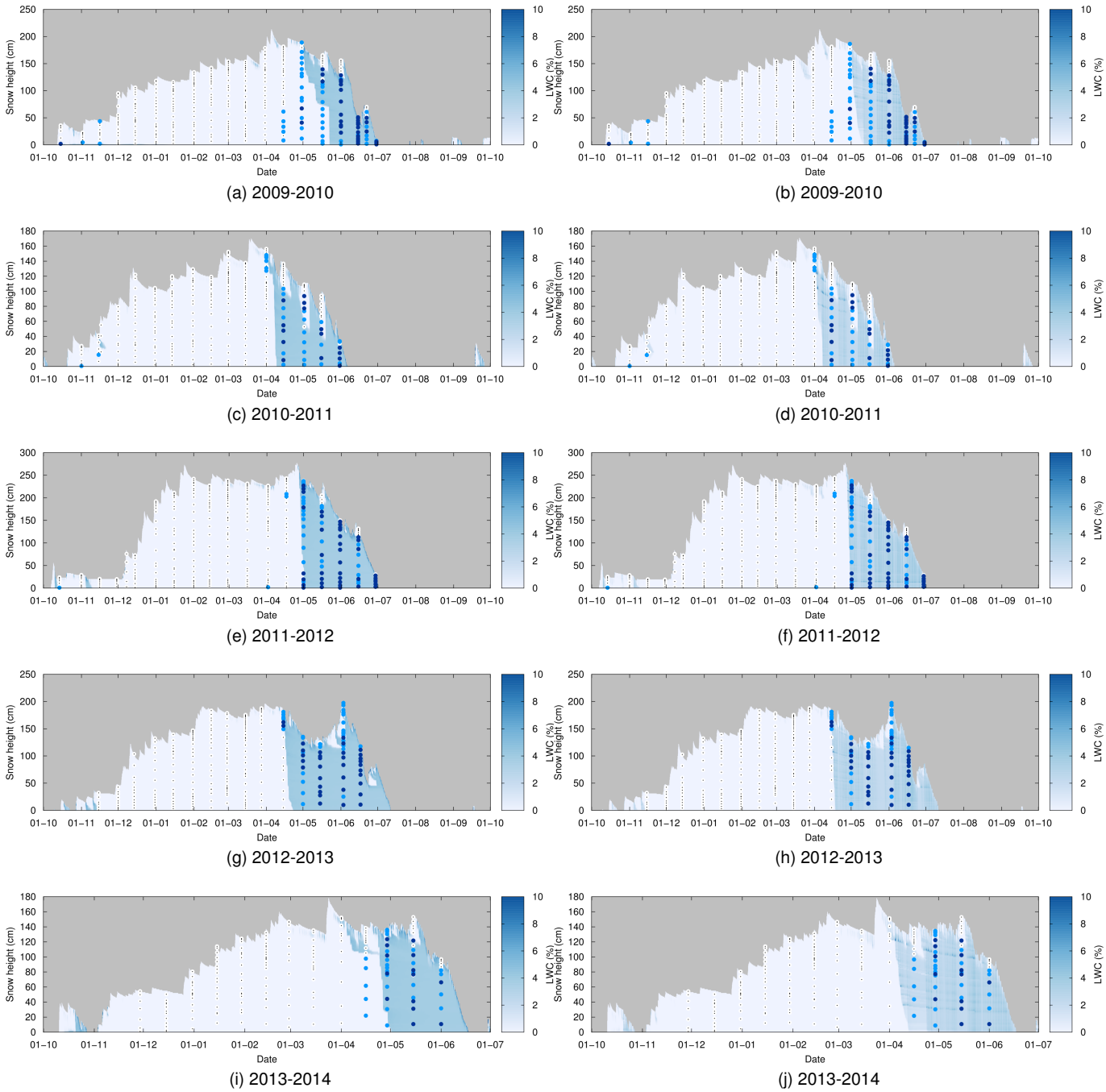
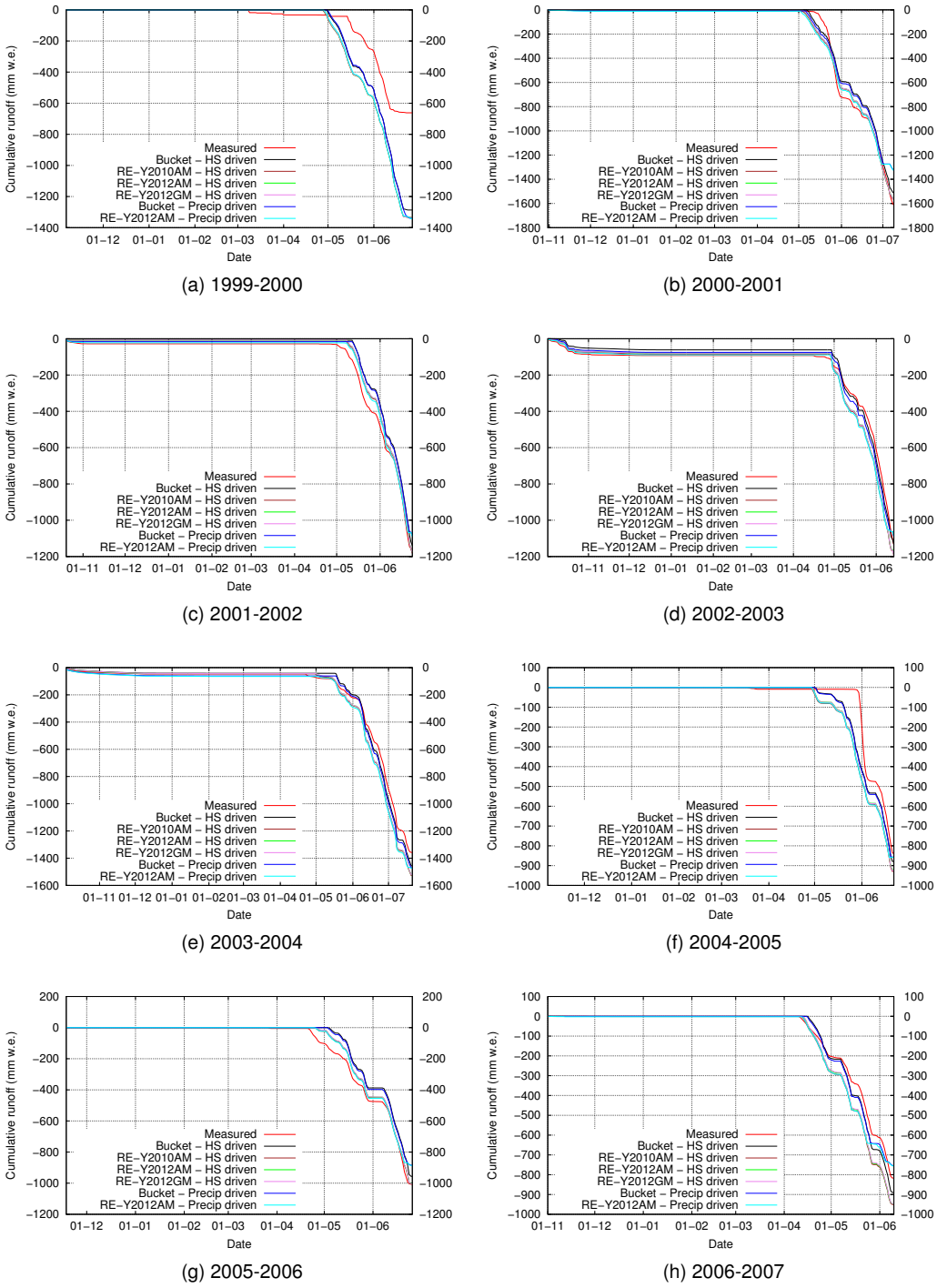


Figure S5: LWC (%) for the simulations with the bucket scheme (left), and with RE-Y2012AM (right), continued. Dots denote layers that have been reported as dry (0% LWC, white with black center dot), moist (0-3% LWC, light blue) or wet, very wet or soaked ($\geq$3% LWC, dark blue) from the biweekly snow profiles. When layers are reported as "1-2" (dry-moist), it is considered moist.



(a) 1999-2000

(b) 2000-2001

(c) 2001-2002

(d) 2002-2003

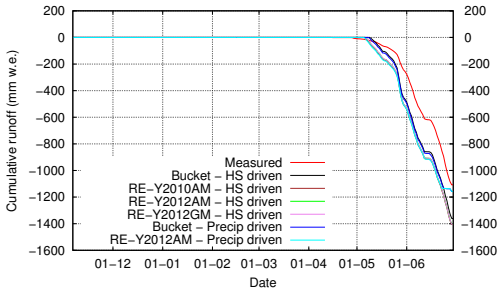
(e) 2003-2004

(f) 2004-2005

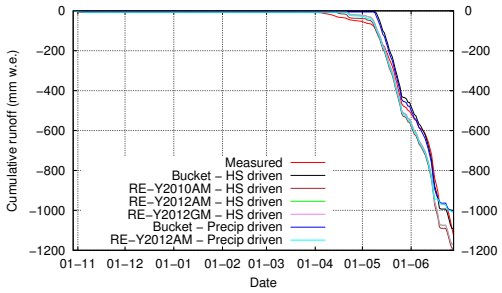
(g) 2005-2006

(h) 2006-2007

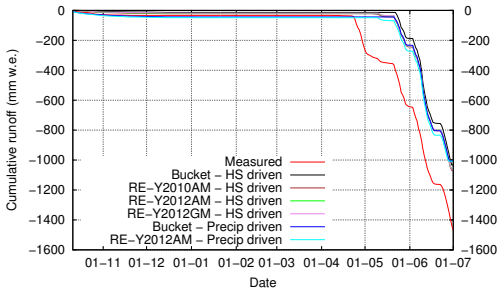
Figure S6: Cumulative runoff (mm).



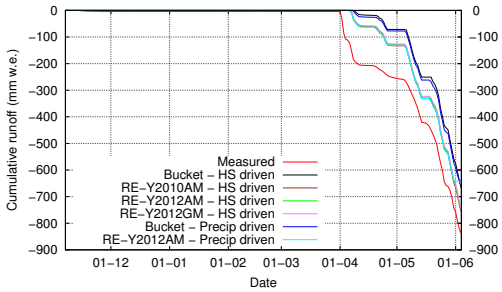
(a) 2007-2008



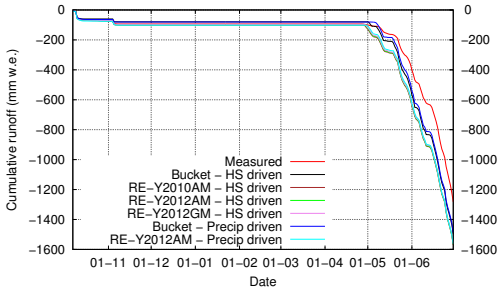
(b) 2008-2009



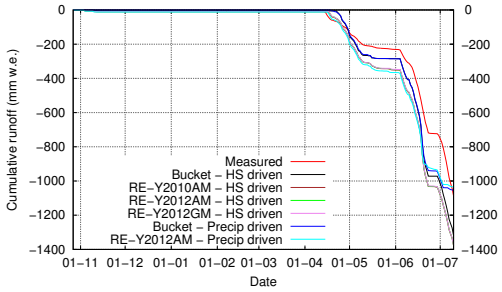
(c) 2009-2010



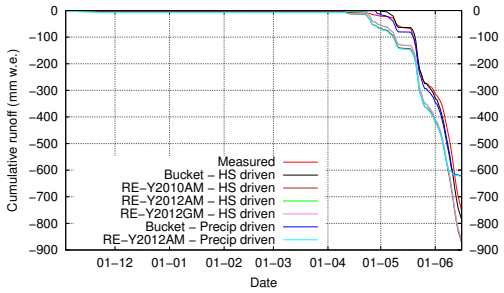
(d) 2010-2011



(e) 2011-2012



(f) 2012-2013



(g) 2013-2014

Figure S7: Cumulative runoff (mm), continued.

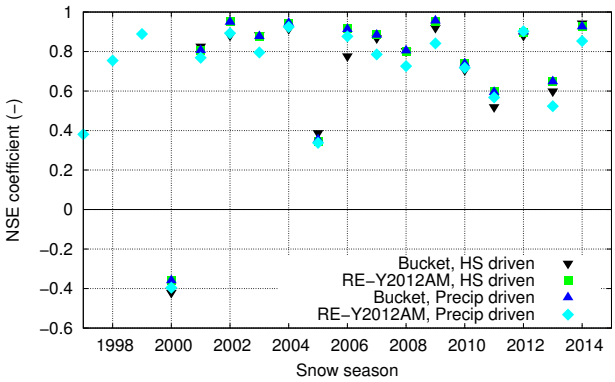


Figure S8: Nash-Sutcliffe model efficiency coefficients for daily runoff sums.

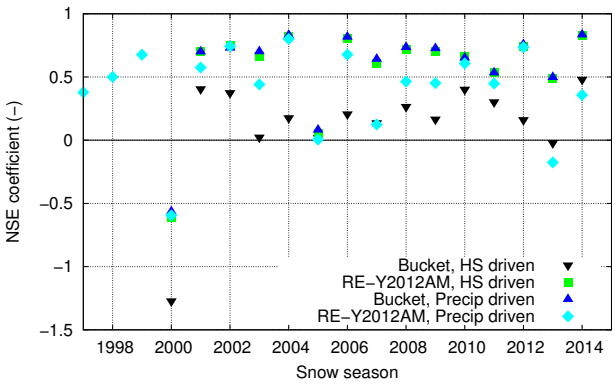


Figure S9: Nash-Sutcliffe model efficiency coefficients for hourly runoff sums.

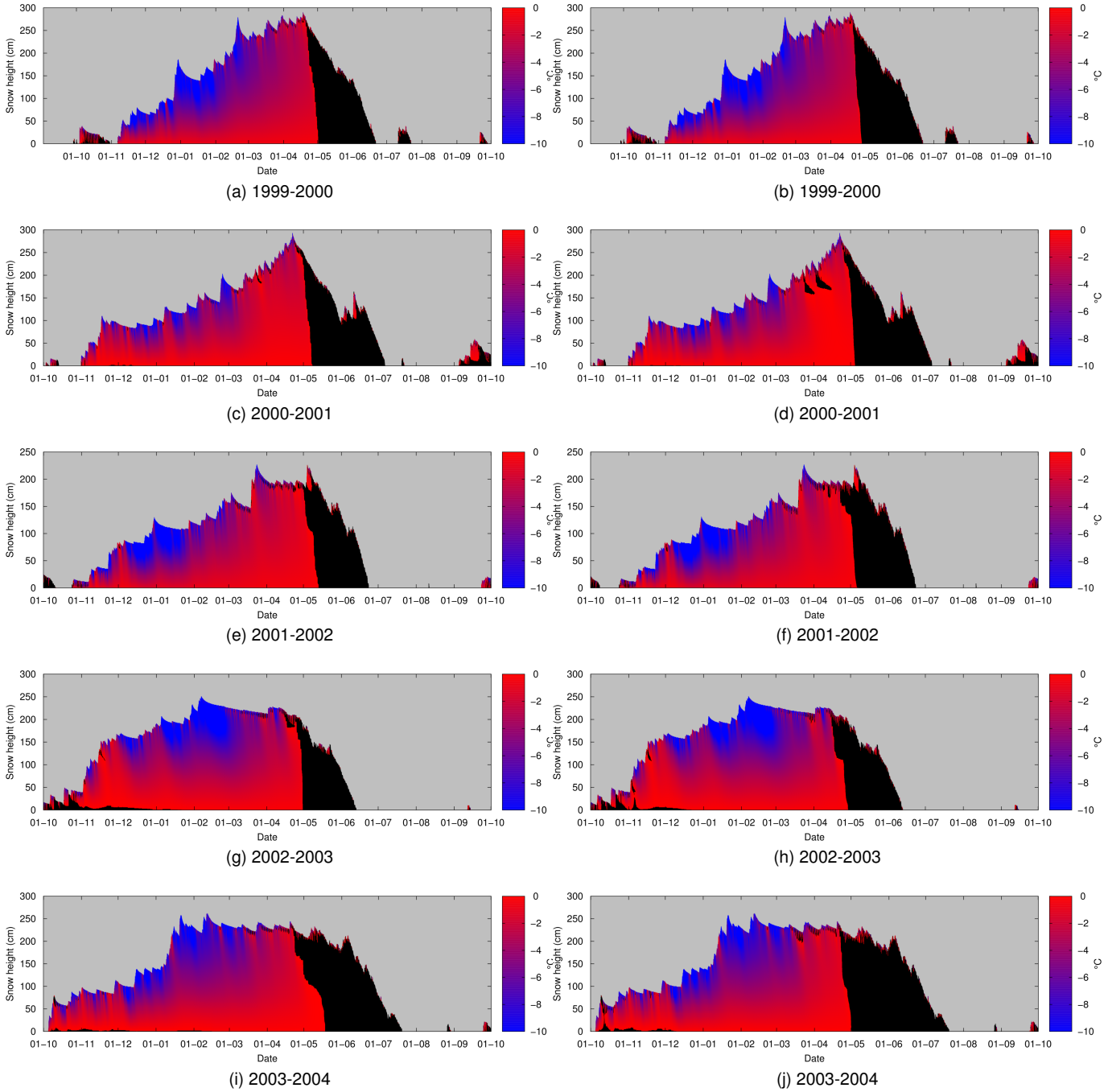


Figure S10: Snow temperature (°C) for the snow height-driven simulations with the bucket scheme (left), and with RE-Y2012AM (right). Snow at exactly 0 °C coloured black to mark areas of the snowpack that are melting or freezing.

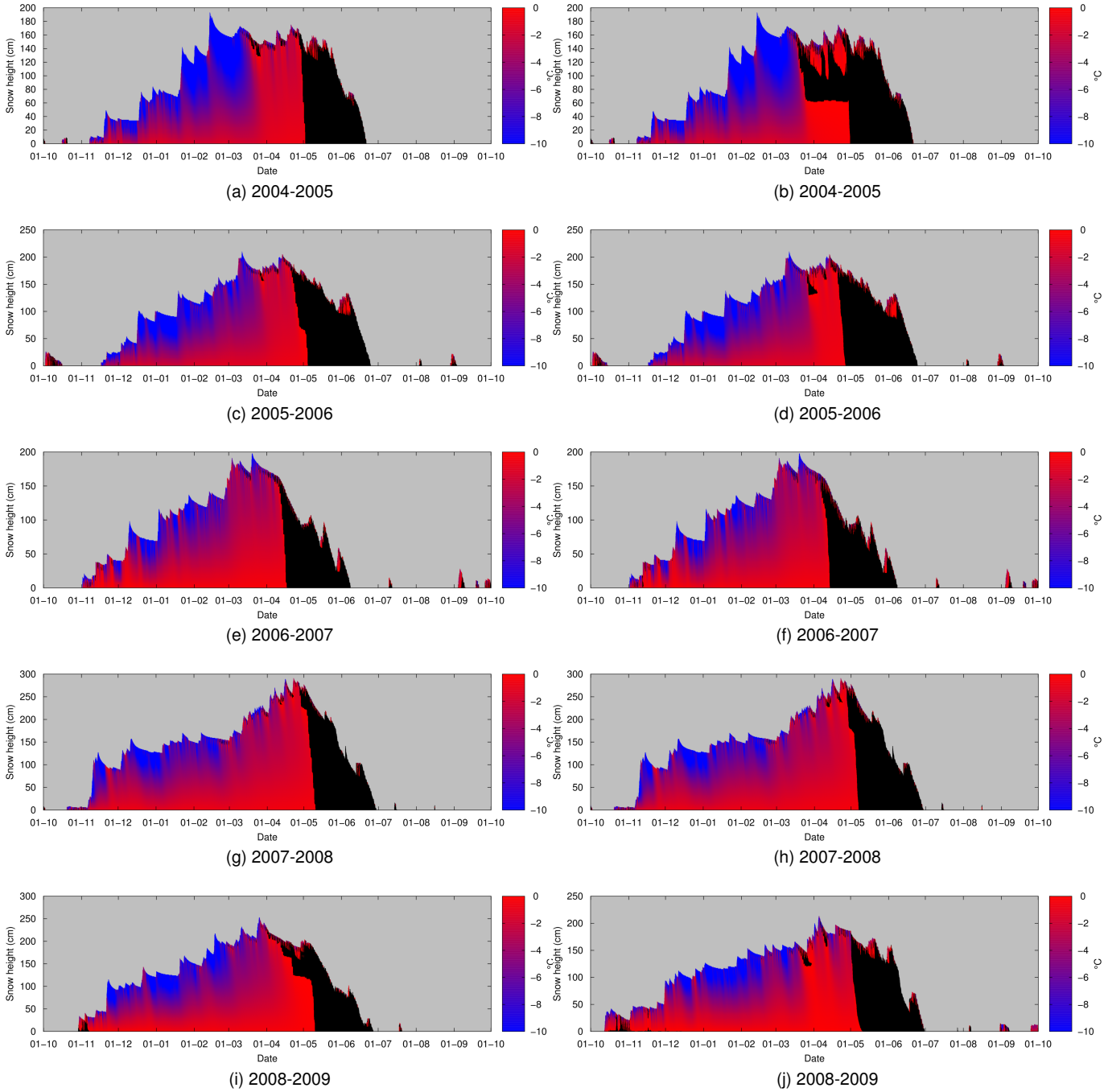


Figure S11: Snow temperature (°C) for the snow height-driven simulations with the bucket scheme (left), and with RE-Y2012AM (right), continued. Snow at exactly 0 °C coloured black to mark areas of the snowpack that are melting or freezing.

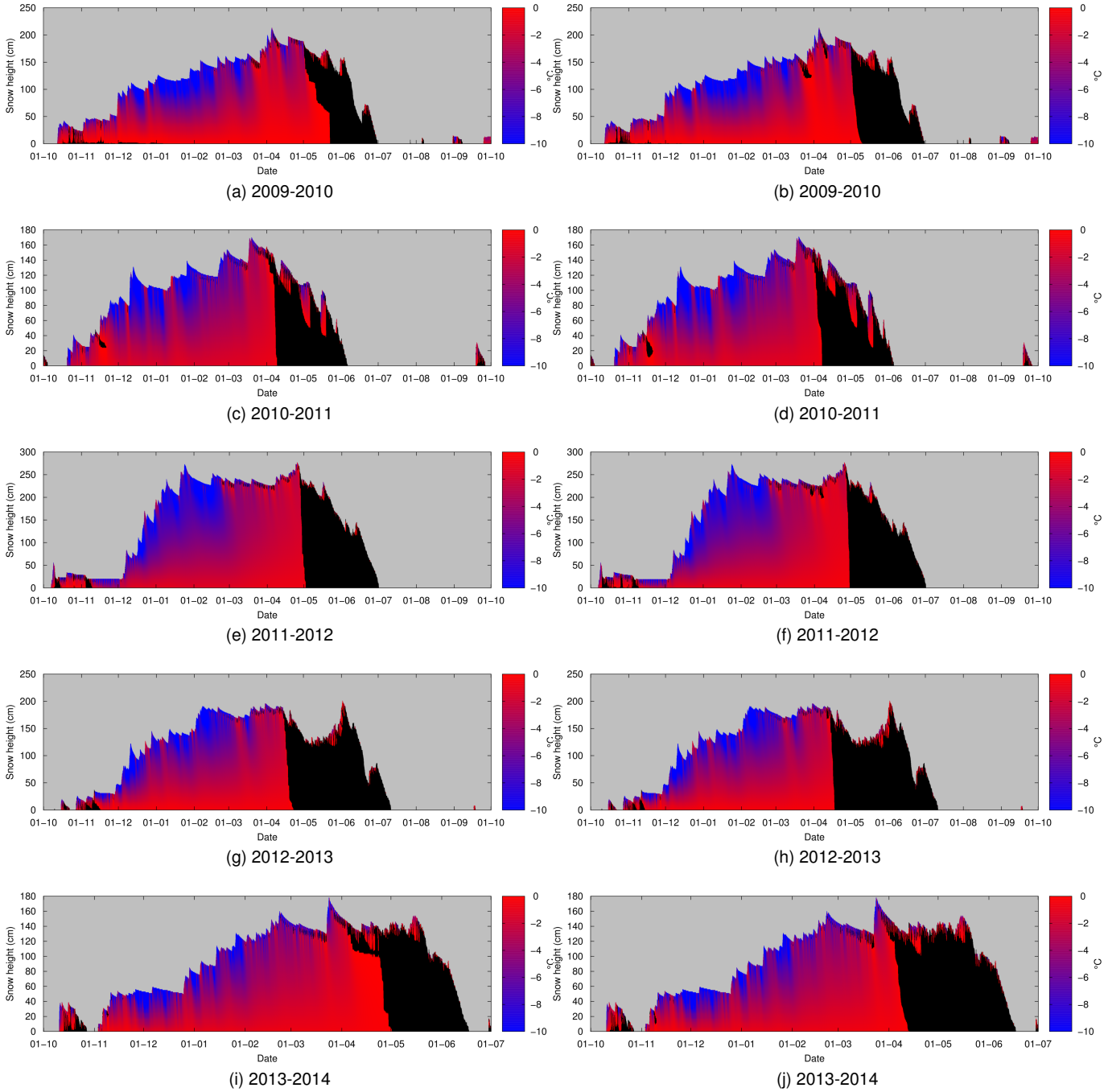
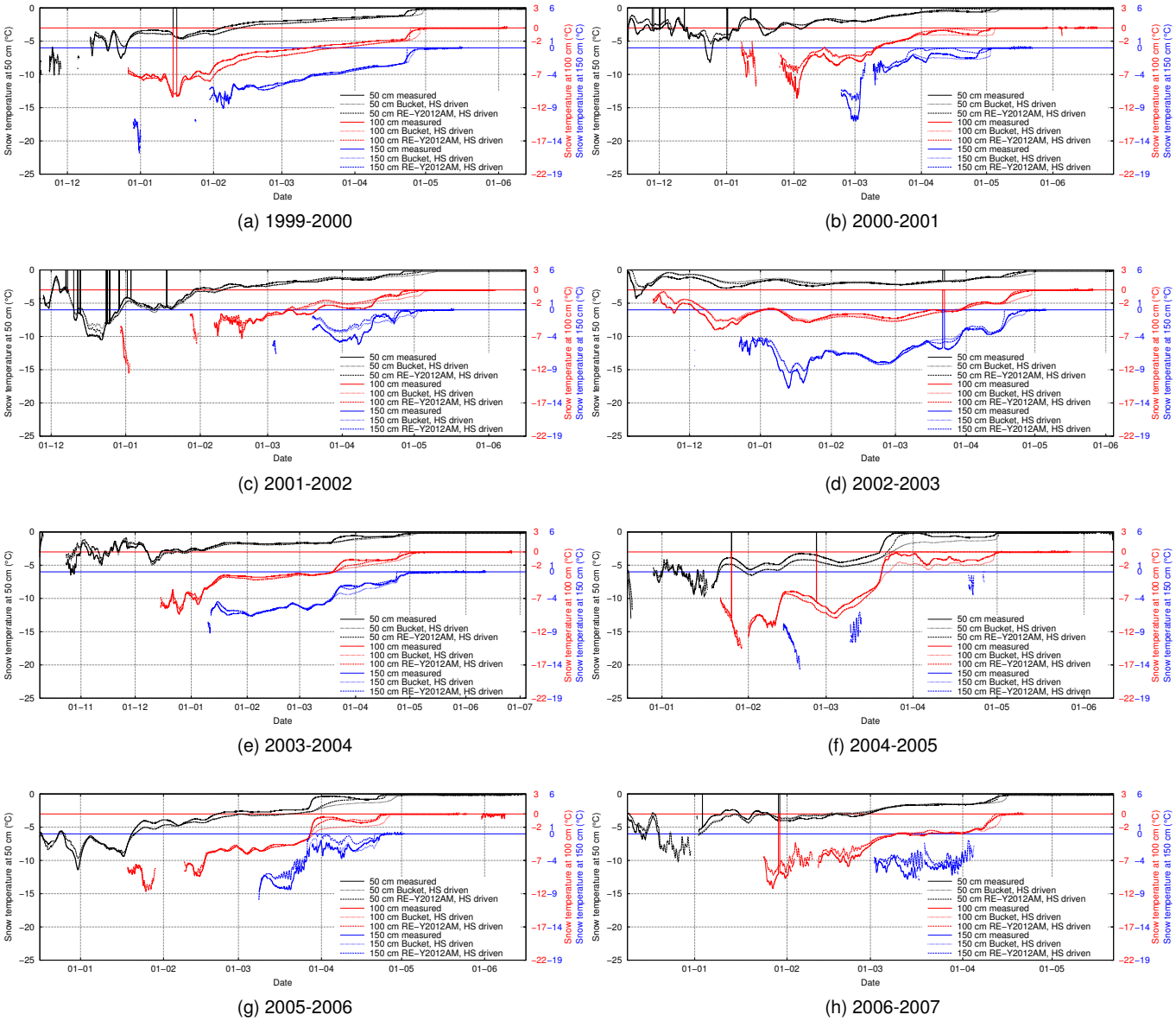


Figure S12: Snow temperature (°C) for the snow height-driven simulations with the bucket scheme (left), and with RE-Y2012AM (right), continued. Snow at exactly 0 °C coloured black to mark areas of the snowpack that are melting or freezing.



(a) 1999-2000

(b) 2000-2001

(c) 2001-2002

(d) 2002-2003

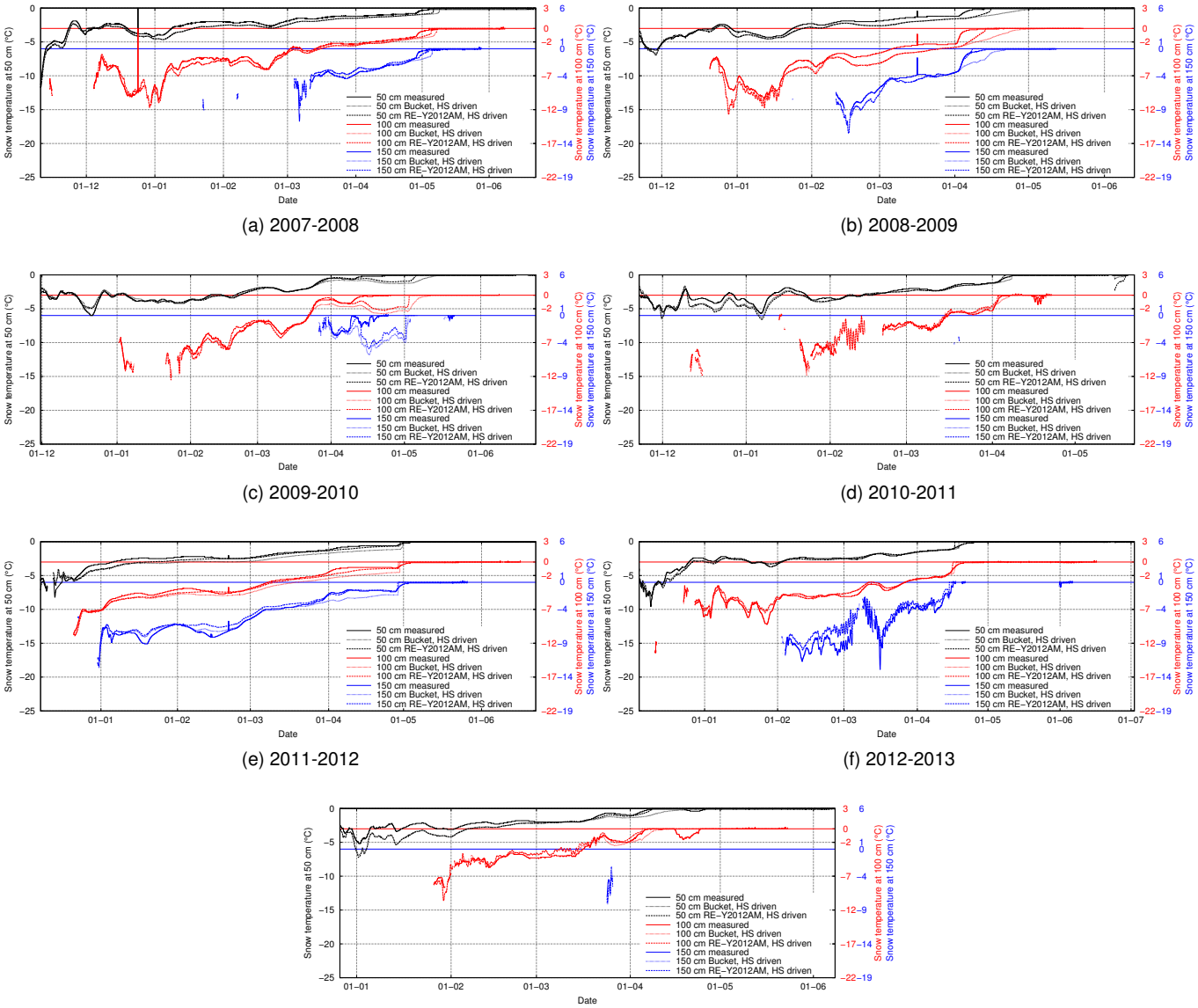
(e) 2003-2004

(f) 2004-2005

(g) 2005-2006

(h) 2006-2007

Figure S13: Measured and modelled snow temperatures at 50, 100 and 150 cm above the surface. Values are only plotted when the snow height was at least 20 cm more than the height of the temperature sensor.



(a) 2007-2008

(b) 2008-2009

(c) 2009-2010

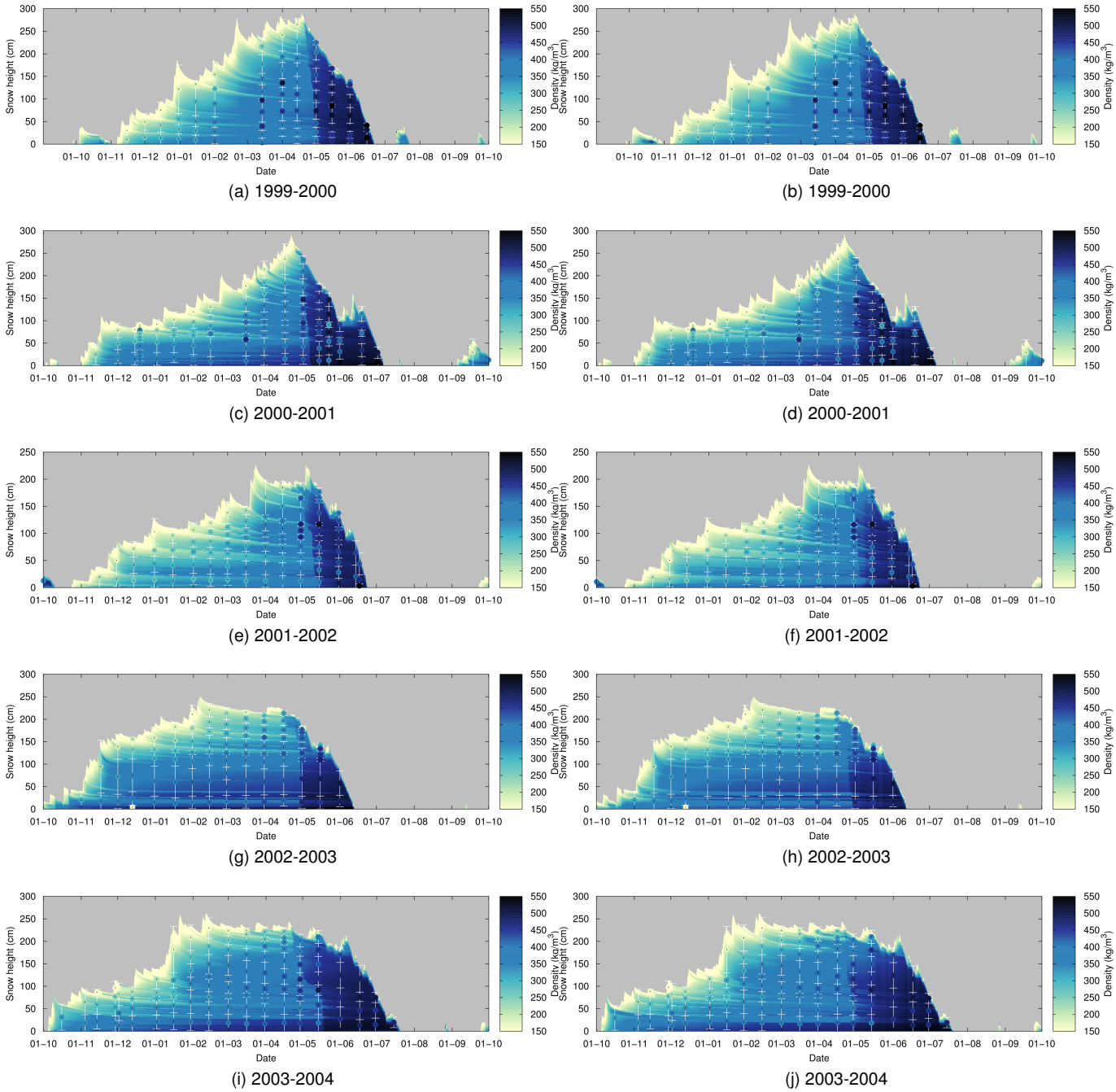
(d) 2010-2011

(e) 2011-2012

(f) 2012-2013

(g) 2013-2014

Figure S14: Measured and modelled snow temperatures at 50, 100 and 150 cm above the surface, continued. Values are only plotted when the snow height was at least 20 cm more than the height of the temperature sensor.



(a) 1999-2000 (b) 1999-2000

(c) 2000-2001 (d) 2000-2001

(e) 2001-2002 (f) 2001-2002

(g) 2002-2003 (h) 2002-2003

(i) 2003-2004 (j) 2003-2004

Figure S15: Snow density (kg m^{-3}) for the snow height-driven simulations with the bucket scheme (left), and with RE-Y2012AM (right). Dots with a black center point indicate measured snow density reported from the biweekly snow profiles, where the black center point is located in the middle of the observed layer.

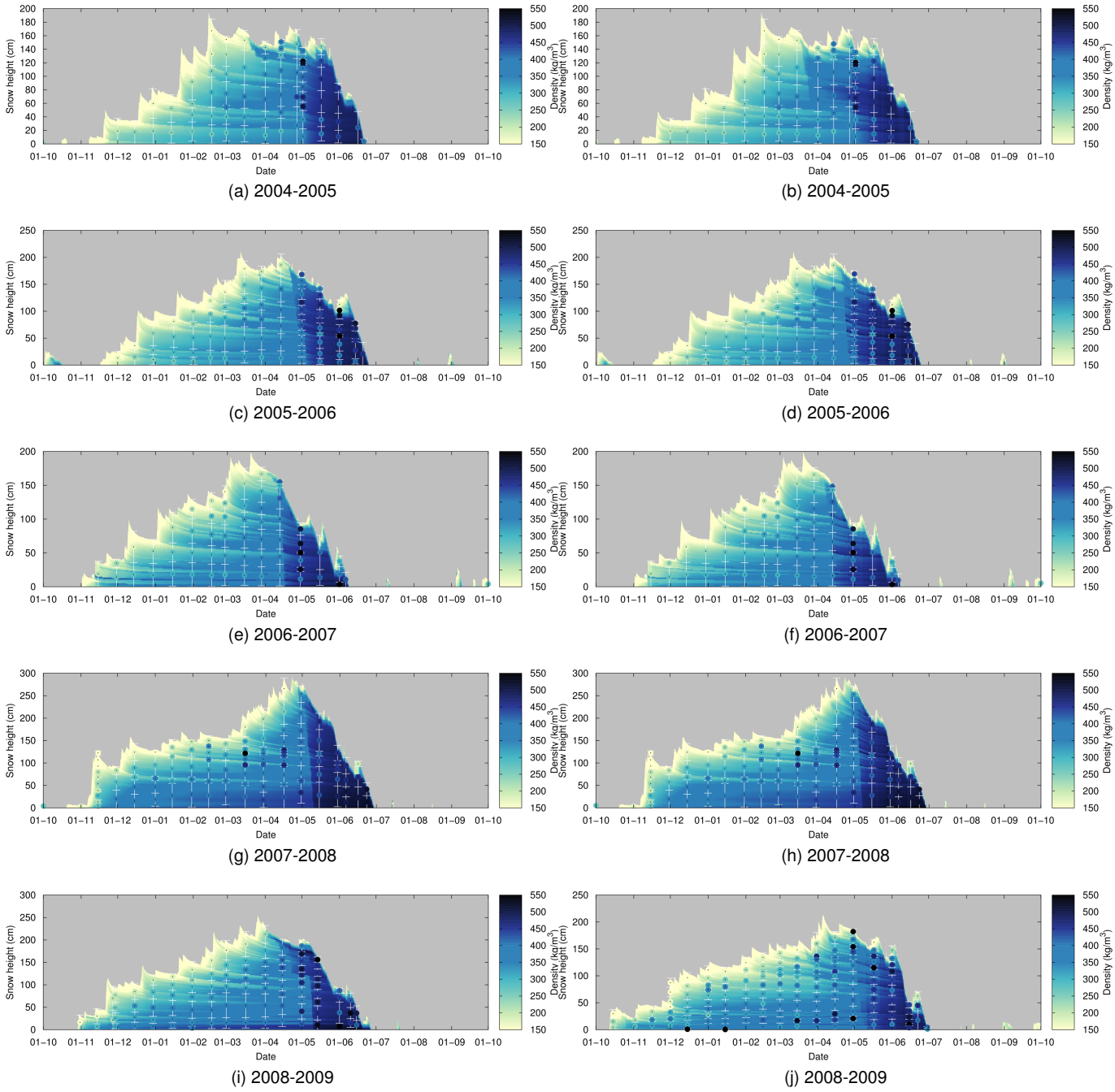
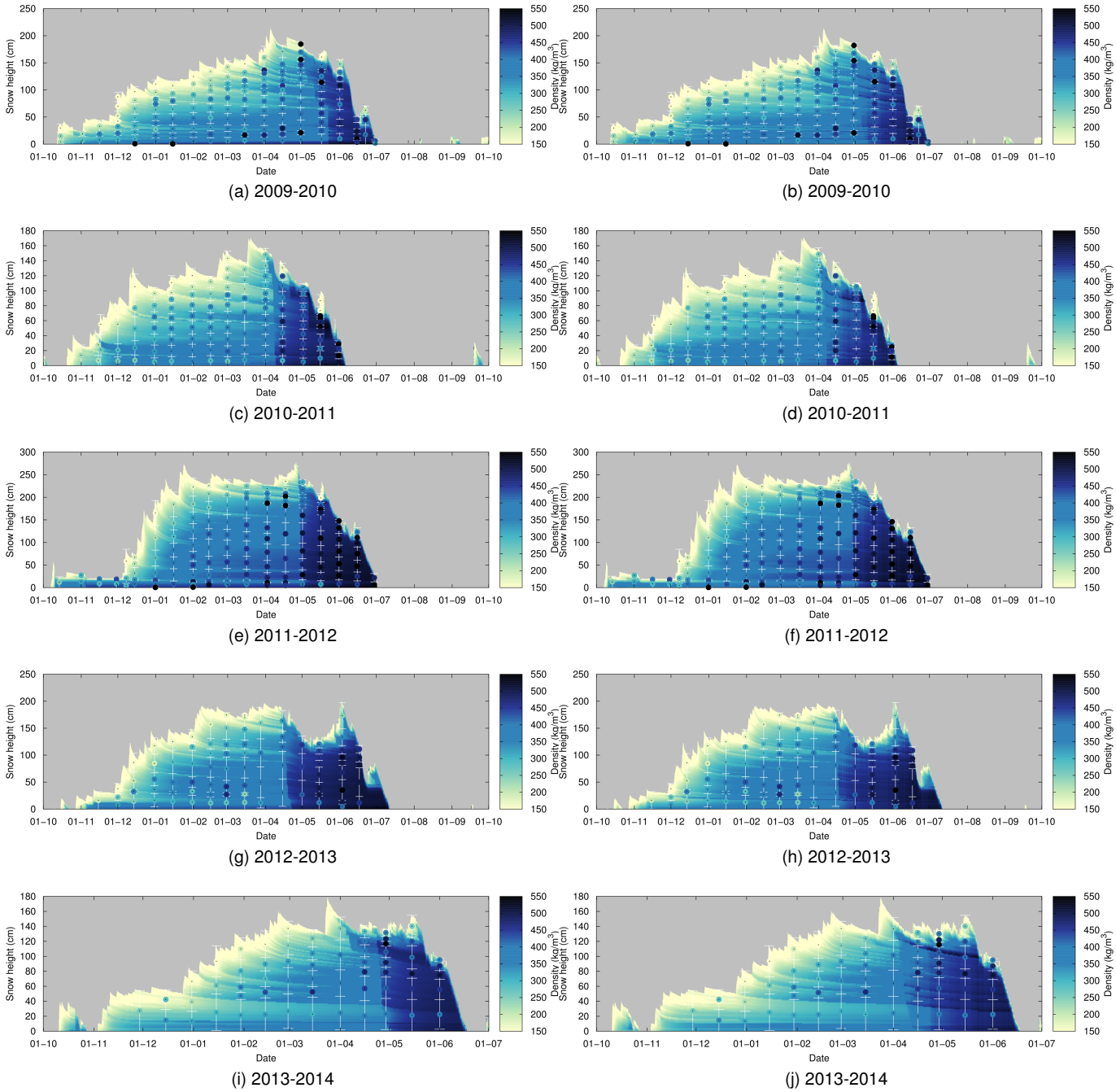


Figure S16: Snow density (kg m^{-3}) for the snow height-driven simulations with the bucket scheme (left), and with RE-Y2012AM (right), continued. Dots with a black center point indicate measured snow density reported from the biweekly snow profiles, where the black center point is located in the middle of the observed layer.



(a) 2009-2010 (b) 2009-2010

(c) 2010-2011 (d) 2010-2011

(e) 2011-2012 (f) 2011-2012

(g) 2012-2013 (h) 2012-2013

(i) 2013-2014 (j) 2013-2014

Figure S17: Snow density (kg m^{-3}) for the snow height-driven simulations with the bucket scheme (left), and with RE-Y2012AM (right), continued. Dots with a black center point indicate measured snow density reported from the biweekly snow profiles, where the black center point is located in the middle of the observed layer.

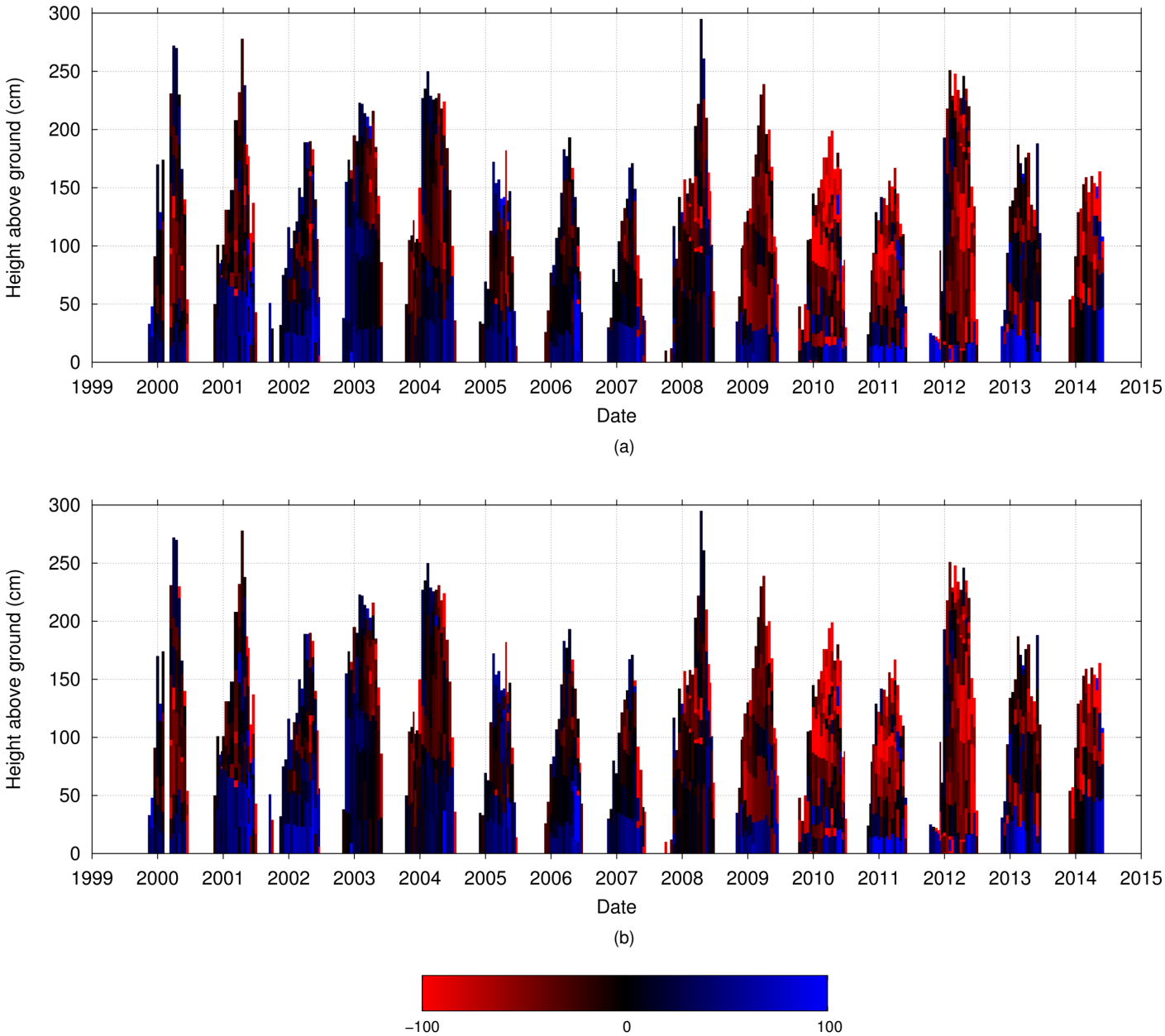


Figure S18: Difference between modelled and measured density (kg m^{-3}) for snow height driven simulations with the bucket scheme (a) and RE-Y2012AM (b).

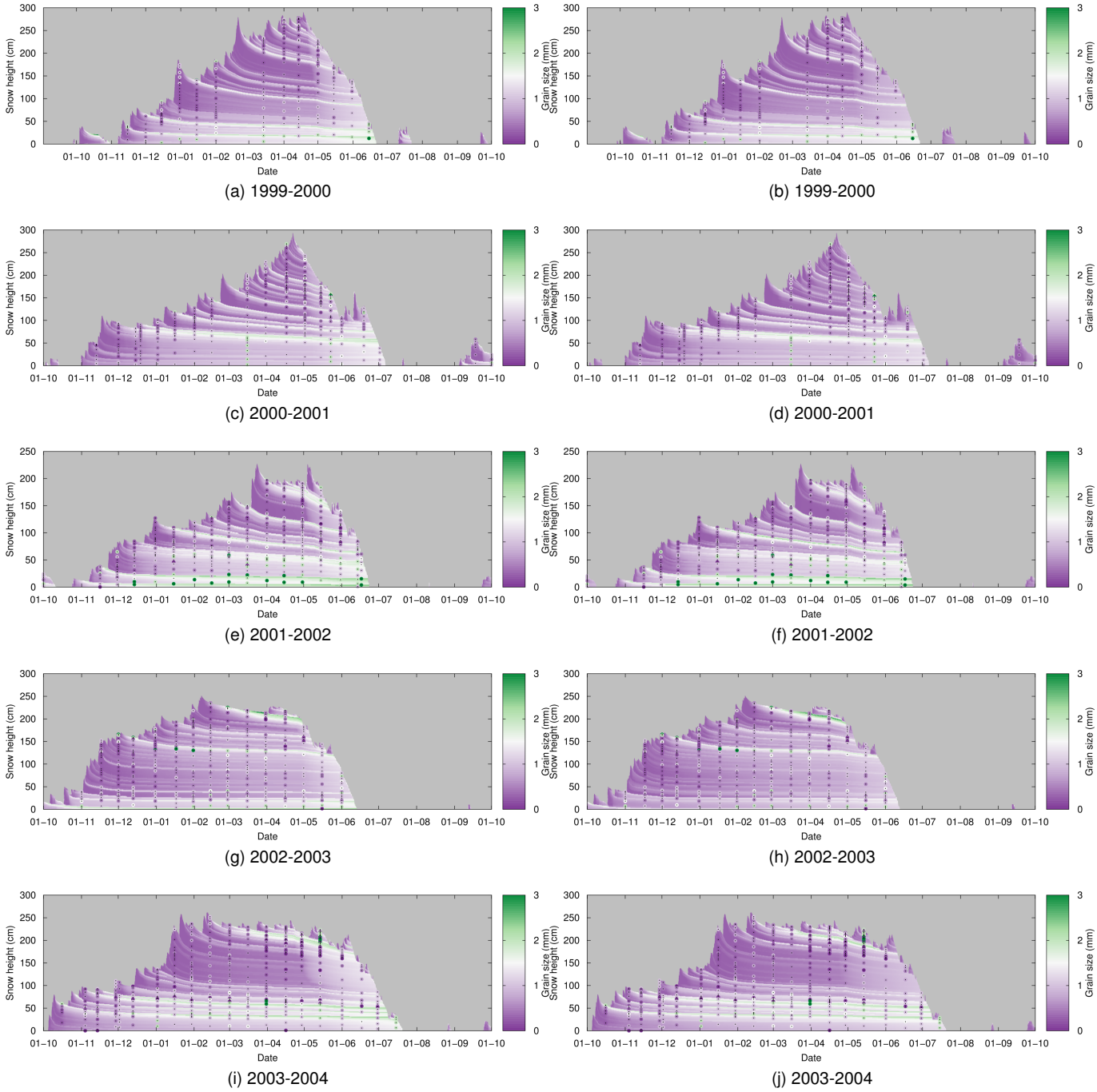
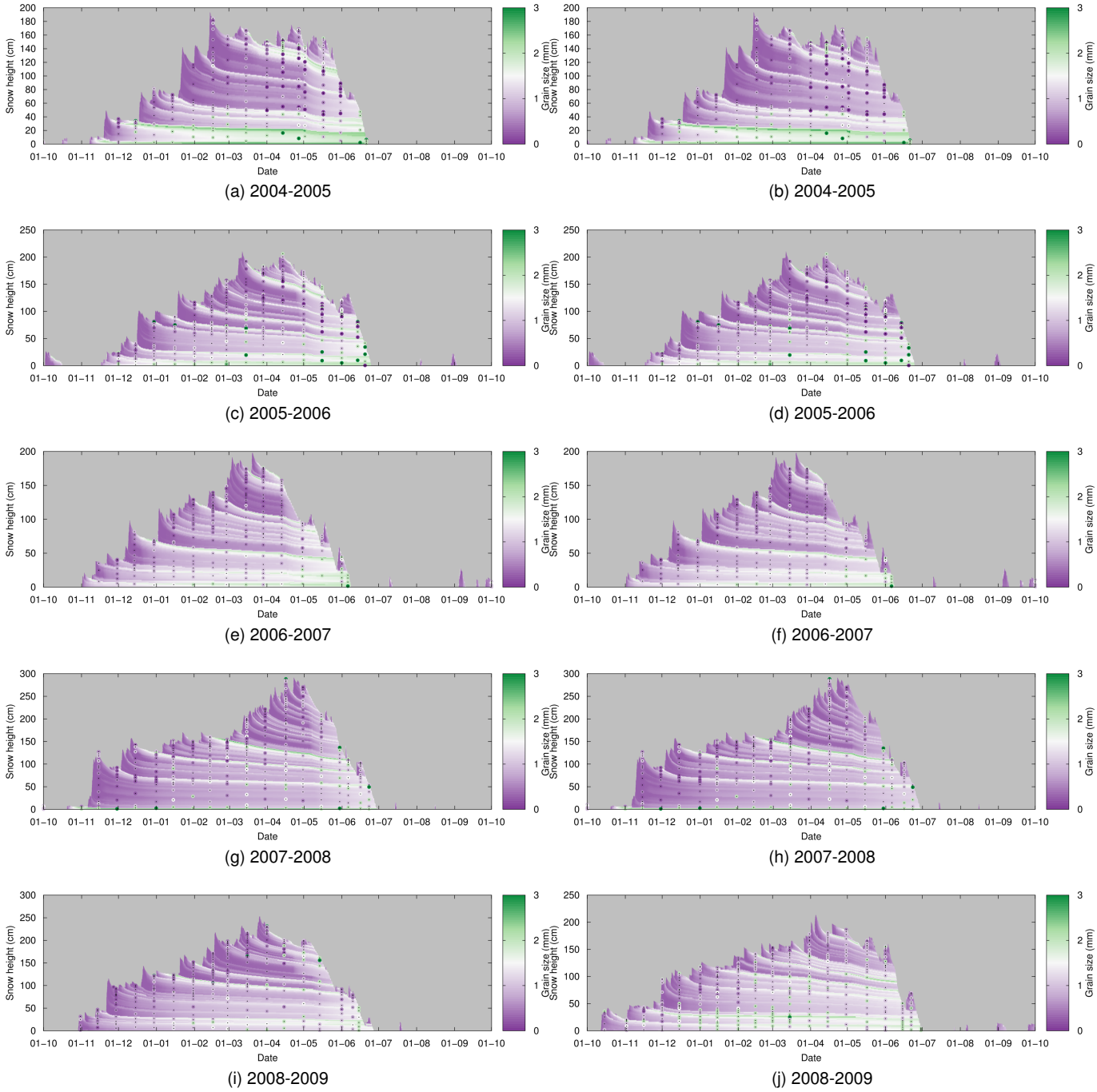


Figure S19: Grain size (mm) for the snow height-driven simulations with the bucket scheme (left), and with RE-Y2012AM (right). Dots with a black center point indicate observed grain sizes reported from the biweekly snow profiles, where the black center point is located in the middle of the observed layer.



(a) 2004-2005 (b) 2004-2005

(c) 2005-2006 (d) 2005-2006

(e) 2006-2007 (f) 2006-2007

(g) 2007-2008 (h) 2007-2008

(i) 2008-2009 (j) 2008-2009

Figure S20: Grain size (mm) for the snow height-driven simulations with the bucket scheme (left), and with RE-Y2012AM (right), continued. Dots with a black center point indicate observed grain sizes reported from the biweekly snow profiles, where the black center point is located in the middle of the observed layer.

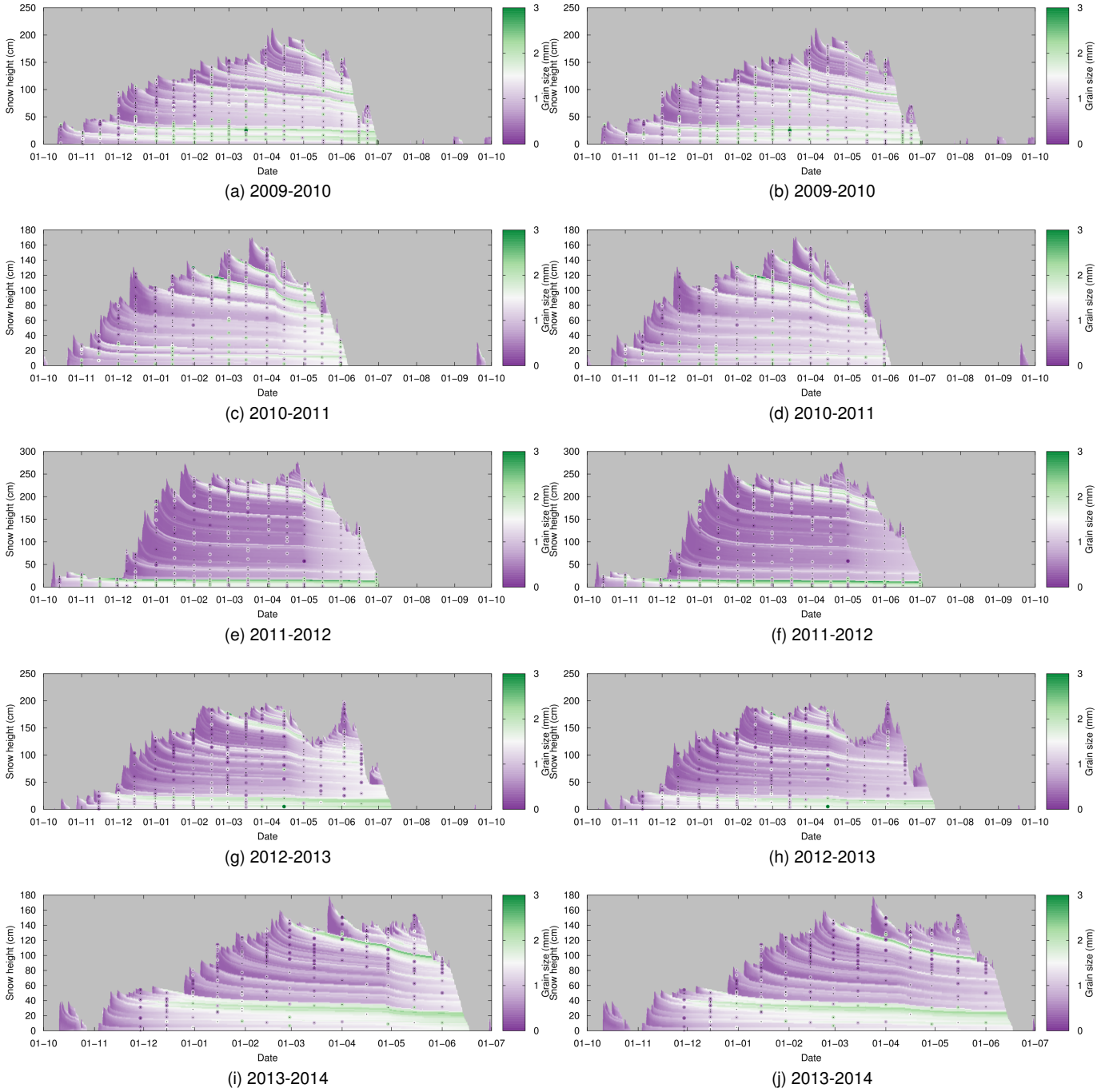


Figure S21: Grain size (mm) for the snow height-driven simulations with the bucket scheme (left), and with RE-Y2012AM (right), continued. Dots with a black center point indicate observed grain sizes reported from the biweekly snow profiles, where the black center point is located in the middle of the observed layer.

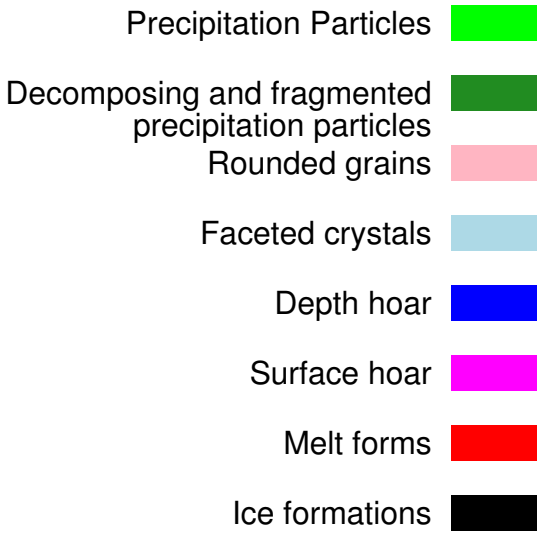
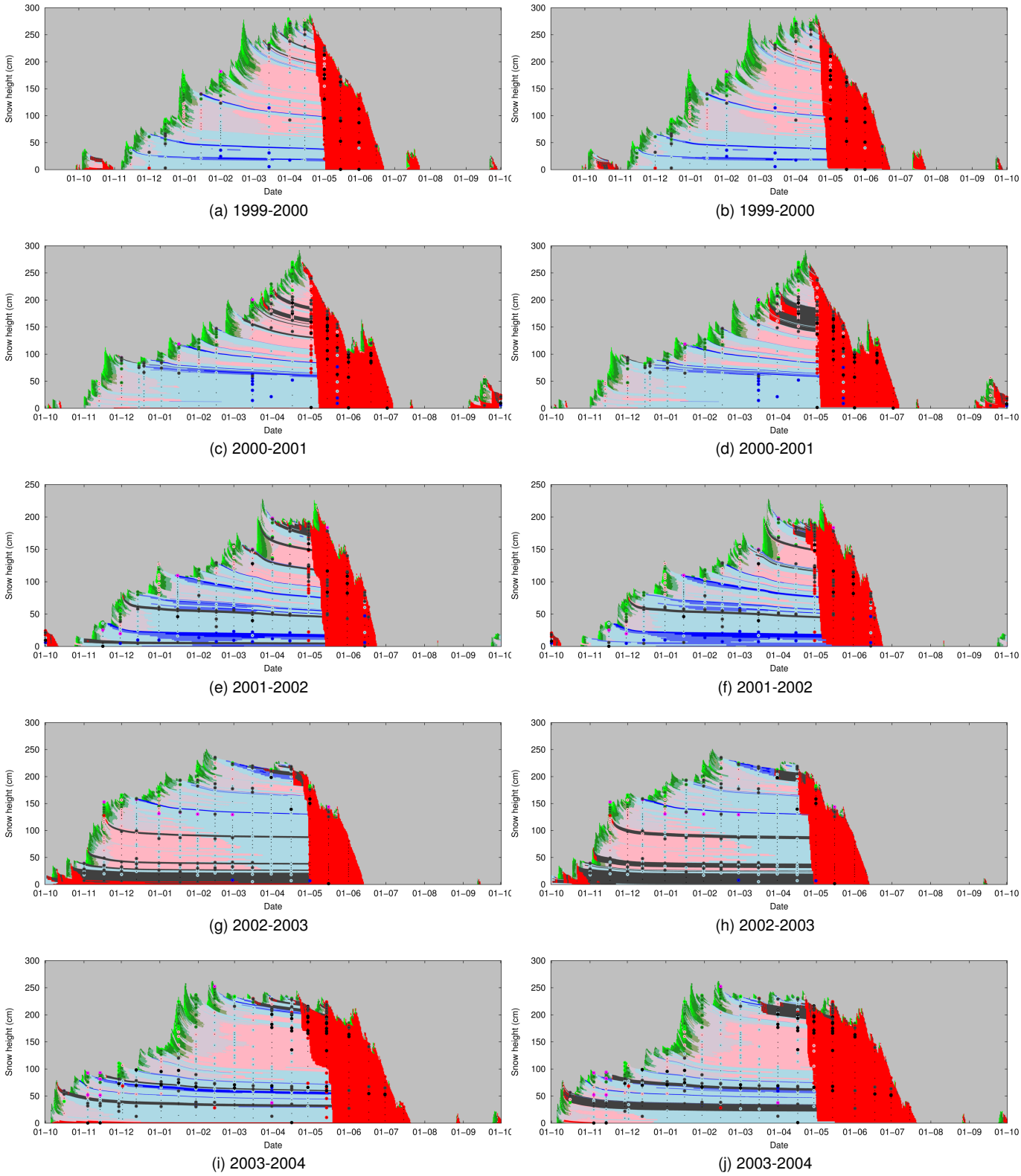


Figure S22: Grain shapes and associated colours. Crusts and ice lenses are summarized as *Ice formations*.



(a) 1999-2000 (b) 1999-2000

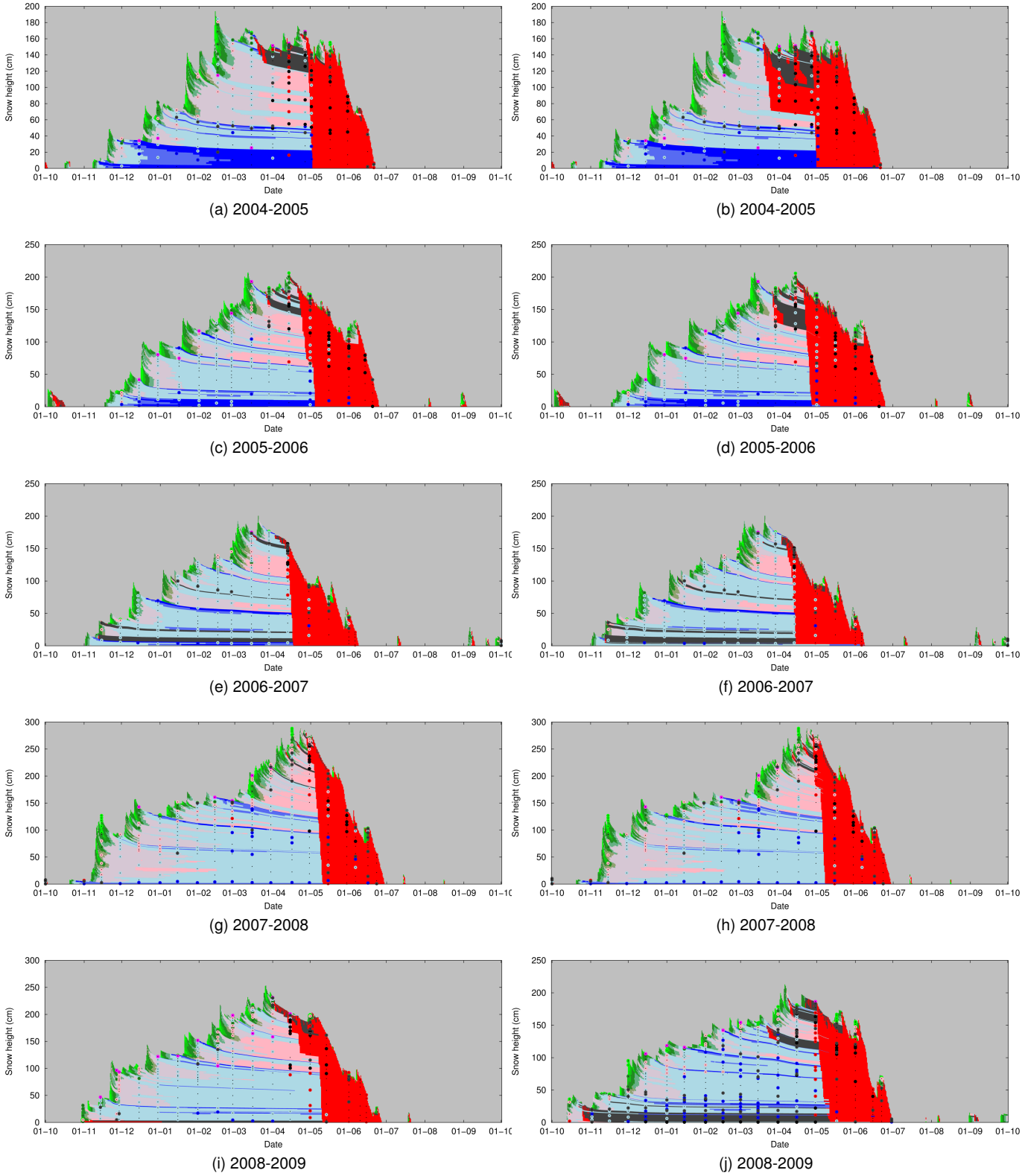
(c) 2000-2001 (d) 2000-2001

(e) 2001-2002 (f) 2001-2002

(g) 2002-2003 (h) 2002-2003

(i) 2003-2004 (j) 2003-2004

Figure S23: Grain shapes for the simulations with the bucket scheme (left), and with RE-Y2012AM (right). Dots indicate observed grain types reported from the biweekly snow profiles, where the dots are located in the middle of the observed layer. A legend is provided in Figure S22.



(a) 2004-2005 (b) 2004-2005

(c) 2005-2006 (d) 2005-2006

(e) 2006-2007 (f) 2006-2007

(g) 2007-2008 (h) 2007-2008

(i) 2008-2009 (j) 2008-2009

Figure S24: Grain shapes for the simulations with the bucket scheme (left), and with RE-Y2012AM (right), continued. Dots indicate observed grain types reported from the biweekly snow profiles, where the dots are located in the middle of the observed layer. A legend is provided in Figure S22.

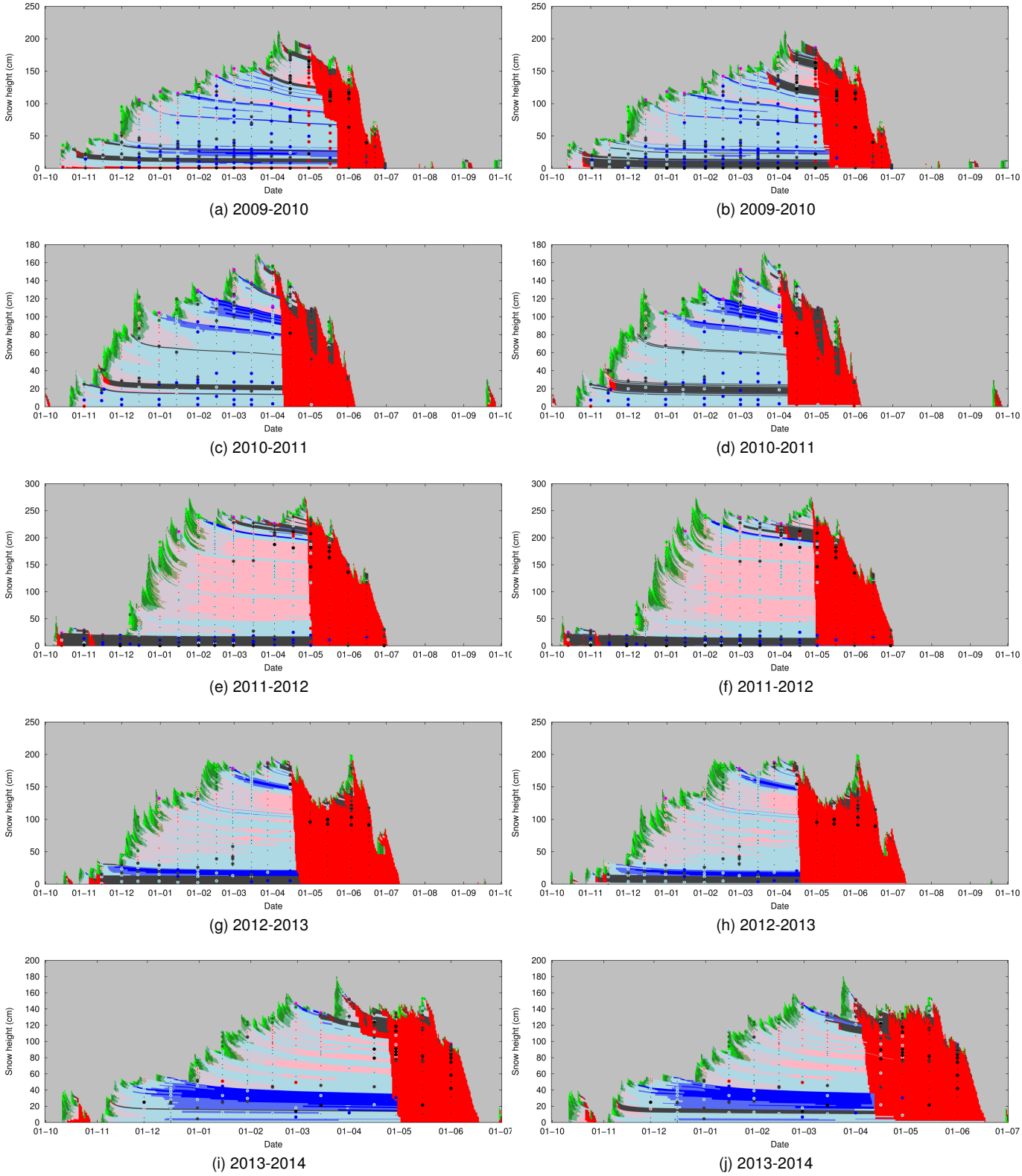


Figure S25: Grain shapes for the simulations with the bucket scheme (left), and with RE-Y2012AM (right), continued. Dots indicate observed grain types reported from the biweekly snow profiles, where the dots are located in the middle of the observed layer. A legend is provided in Figure S22.