Sensitivity of snow albedo and radiative forcing with respect to light-absorbing impurities in snow

Hans-Werner Jacobi (Hans-Werner.Jacobi@ujf-grenoble.fr)**, Martin Ménégoz**
Laboratoire de Glaciologie et Géophysique de l'Environnement (LGGE), CNRS / University Grenoble Alpes, France

Neige et Impuretés, Réunion OSUG Atelier Neige
Grenoble, 2 October 2015

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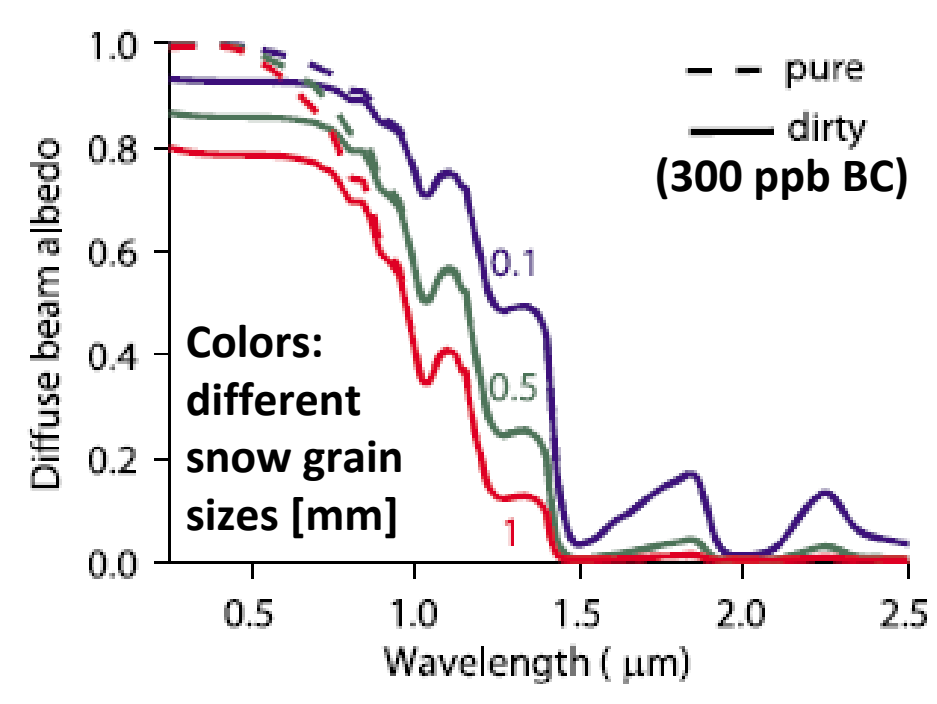
Effect of BC in snow on albedo and radiative forcing



Gardner and Sharp, JGR 2010

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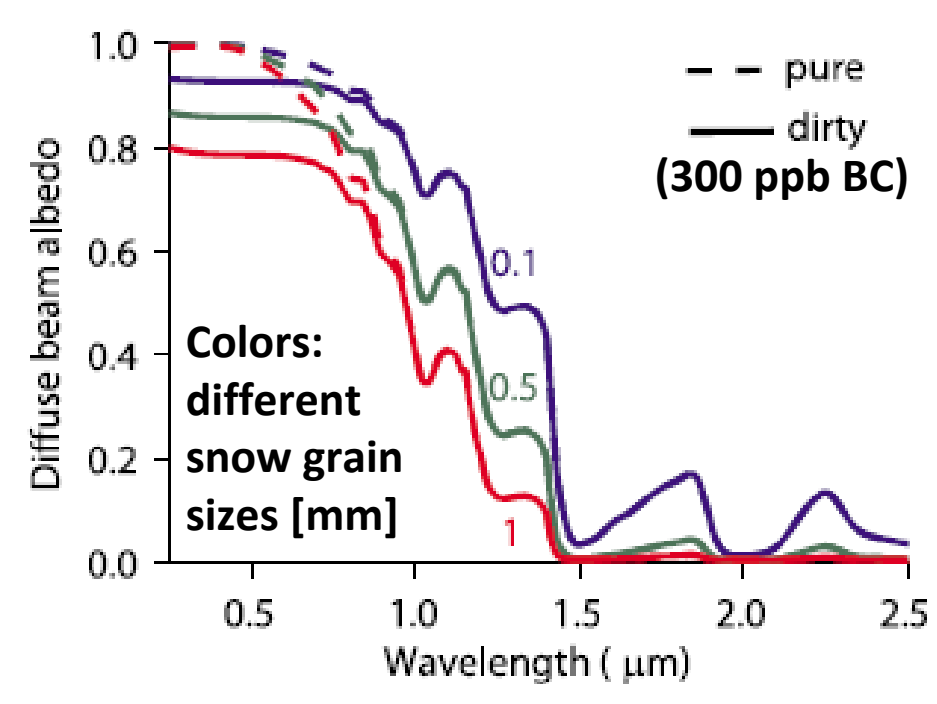

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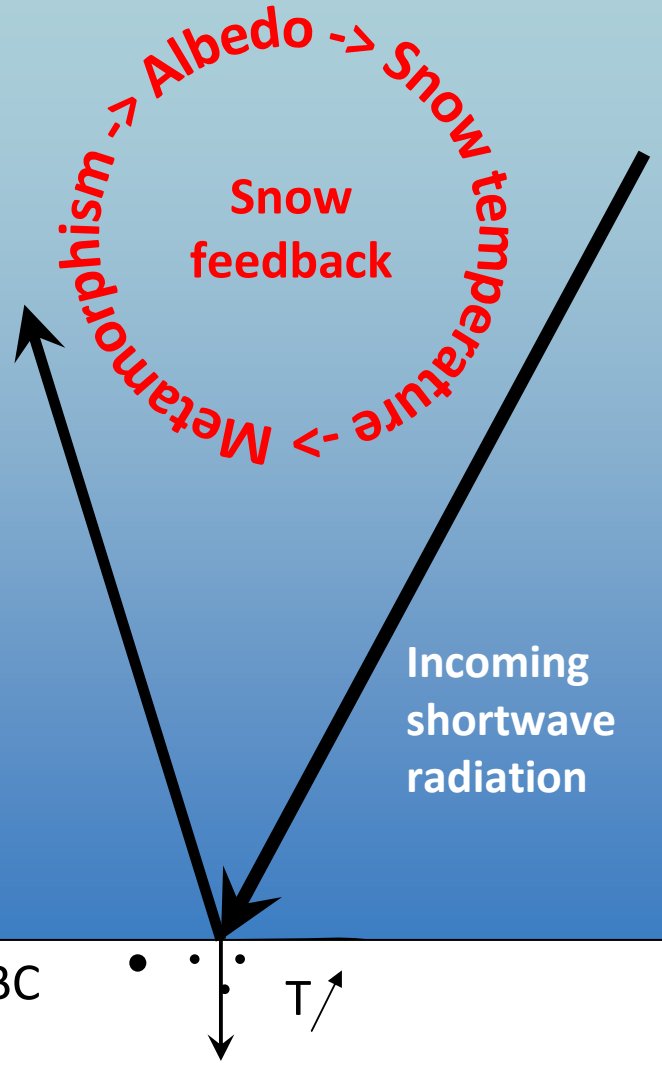

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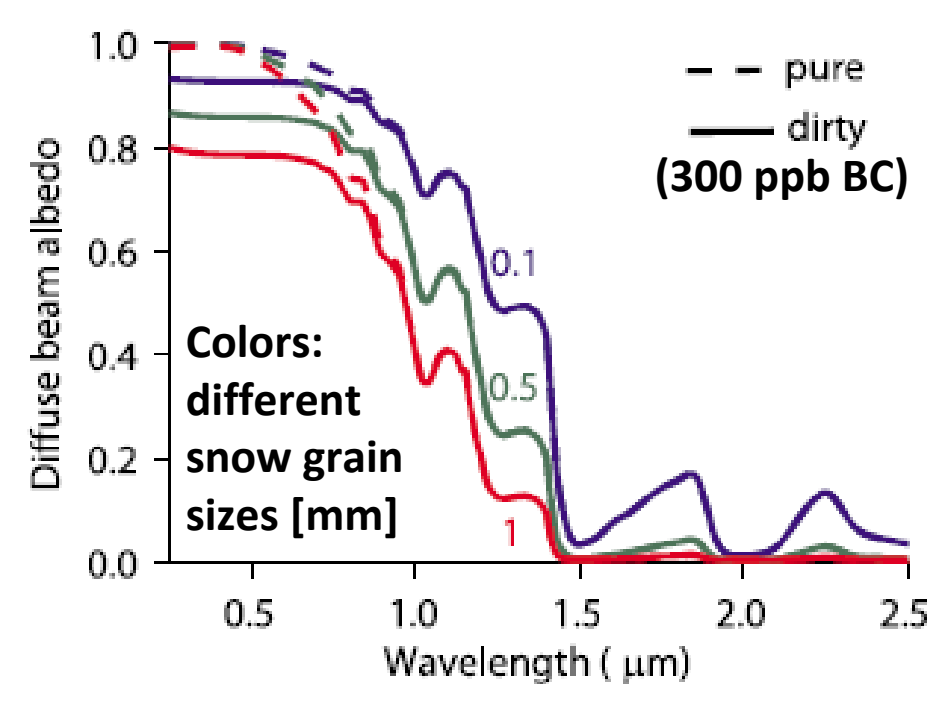
Effect of BC in snow on albedo and radiative forcing



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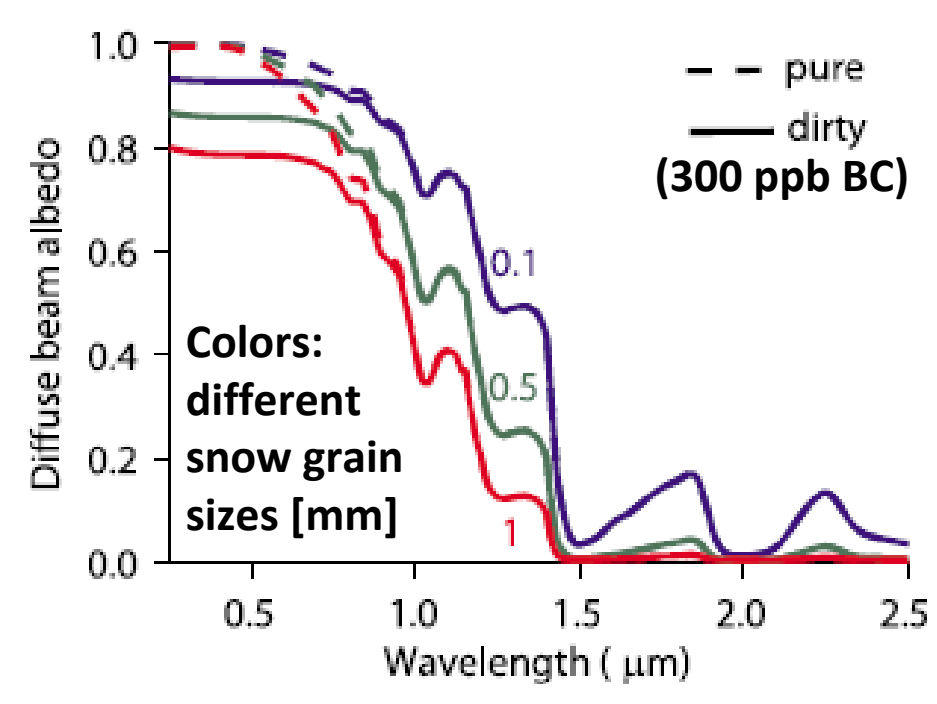

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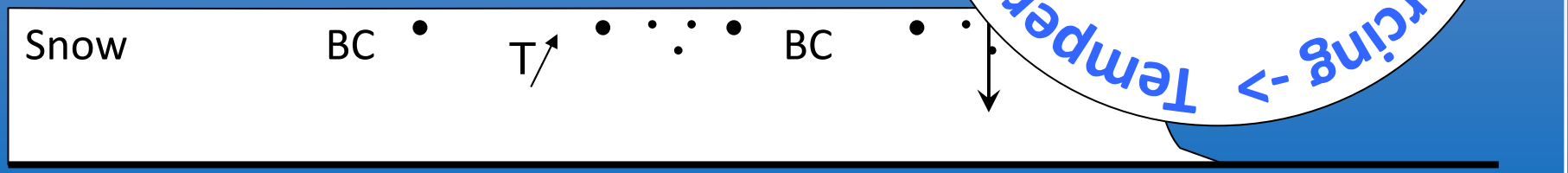

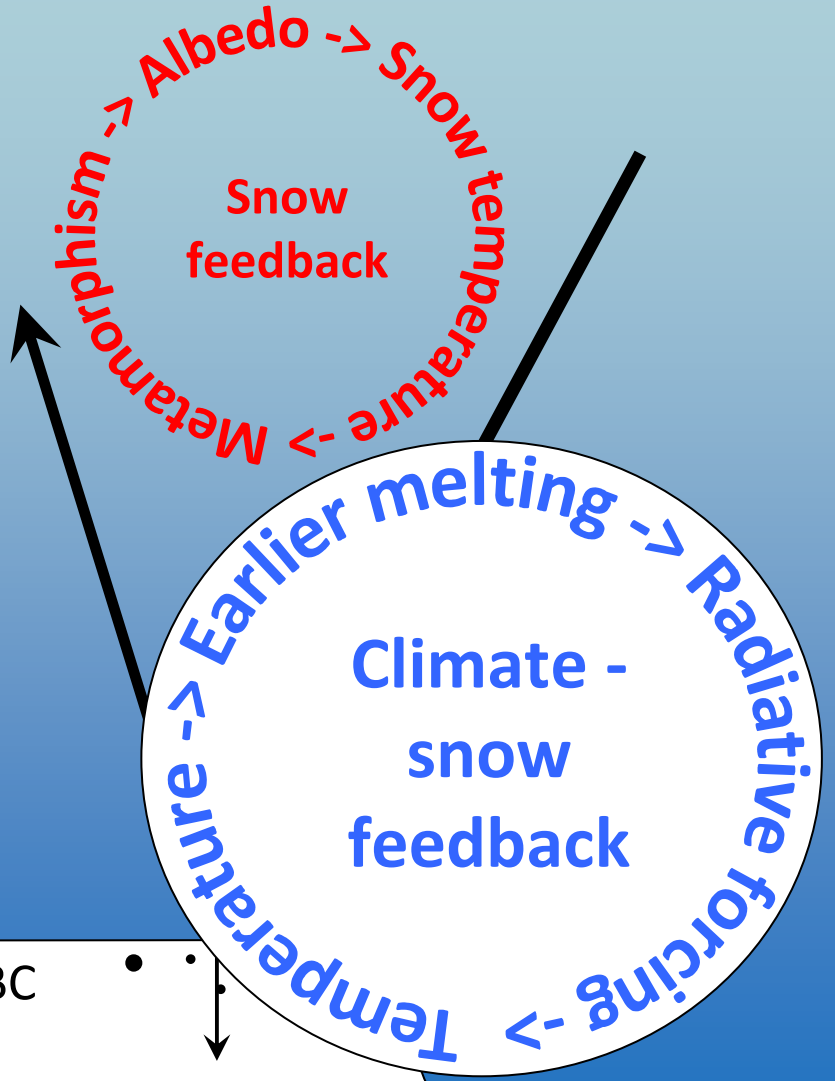

Winter — Spring — Summer

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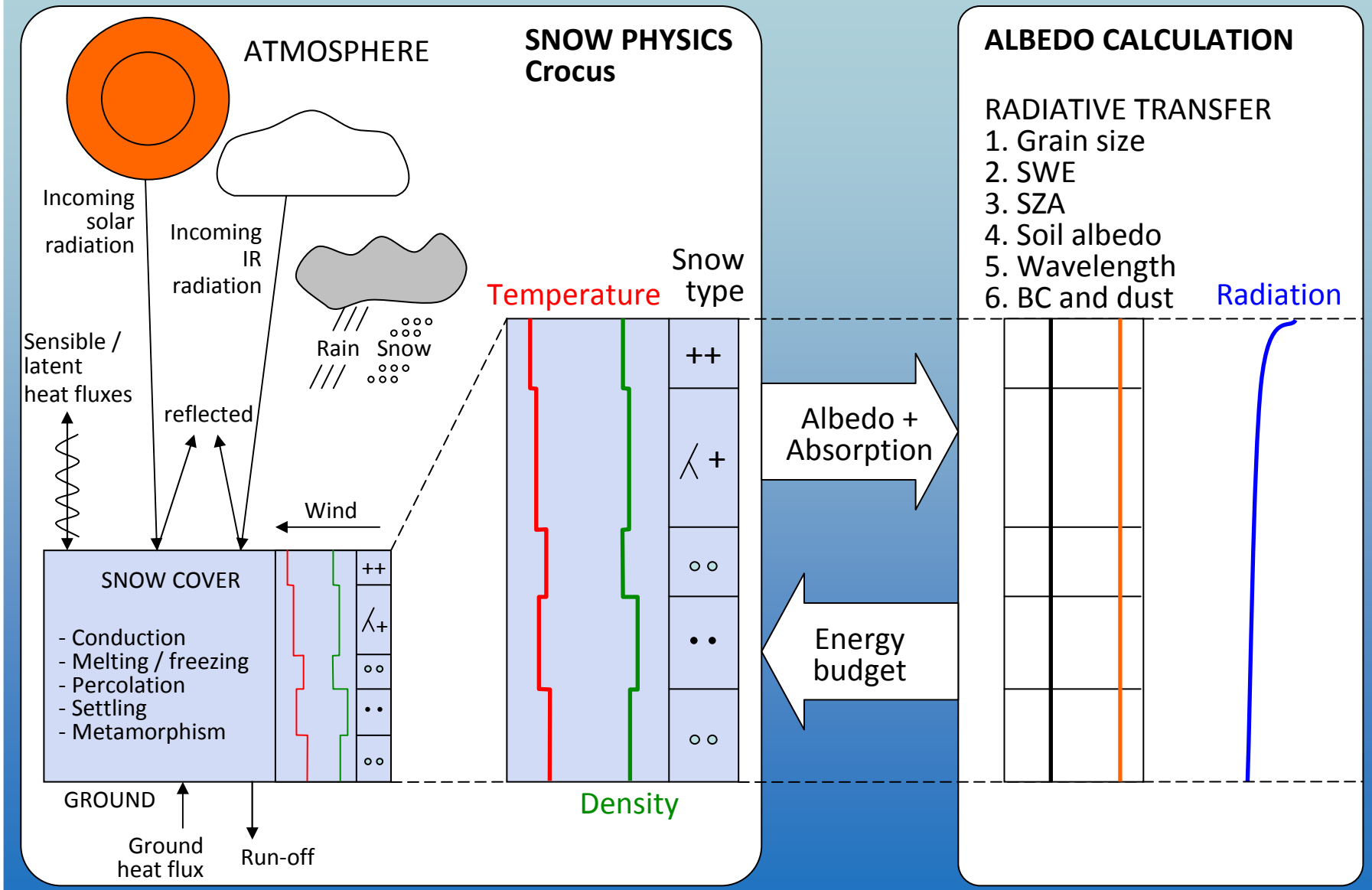
Albedo in the CROCUS snowpack model



Warren+Wiscombe, J.Atmos.Sci. 1980; Jacobi et al., Cryosphere

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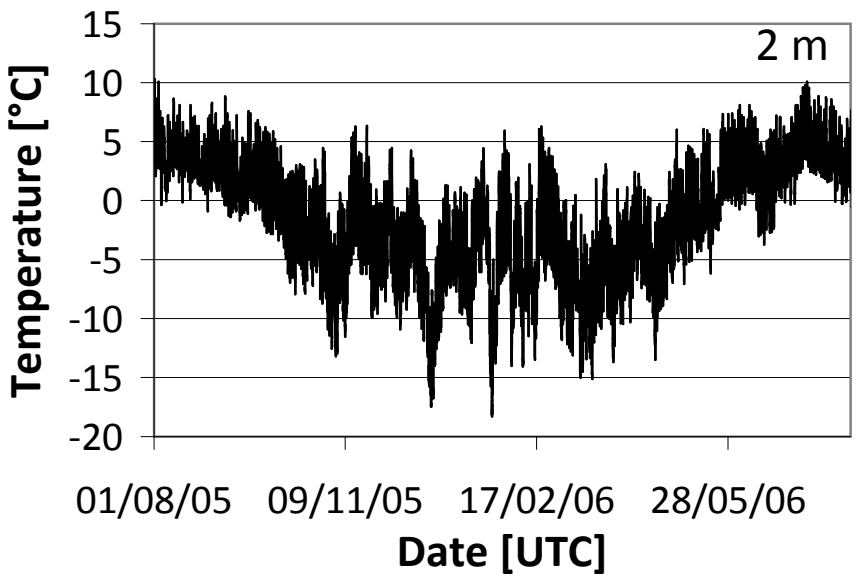
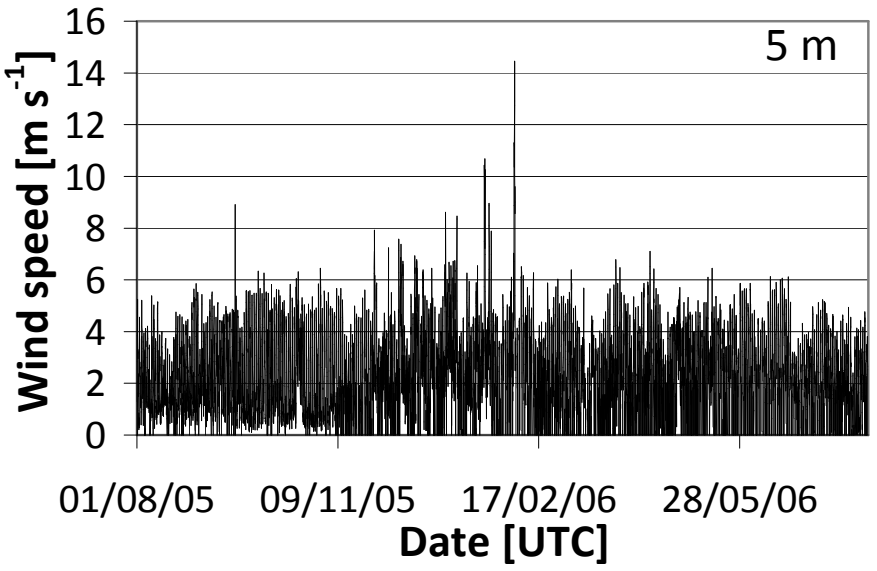
Snowpack simulations using observations at Pyramid at 28° N (2004 – 2007)





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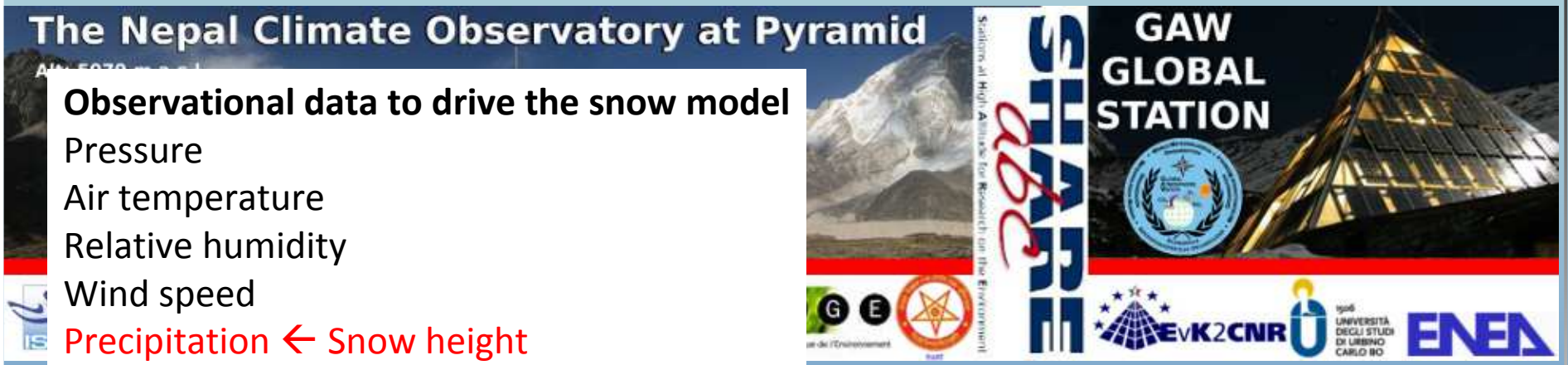
Snowpack simulations using observations at Pyramid (2004 – 2007)



Observational data to drive the snow model

Pressure

Air temperature

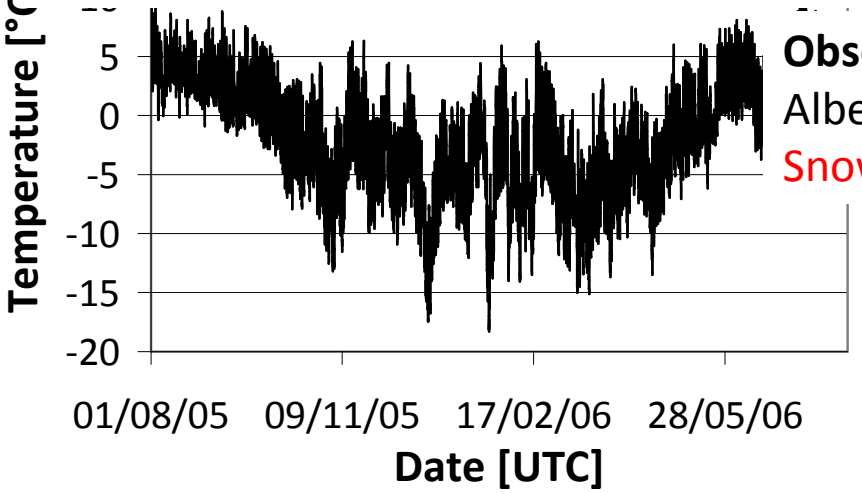
Relative humidity

Wind speed

Precipitation ← Snow height

Incoming short-wave radiation

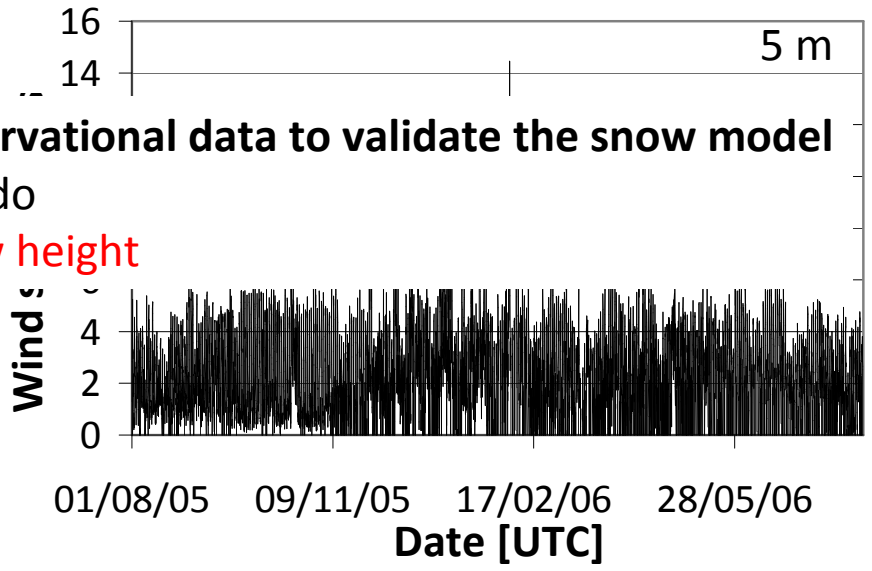
Incoming long-wave radiation



Observational data to validate the snow model

Albedo

Snow height



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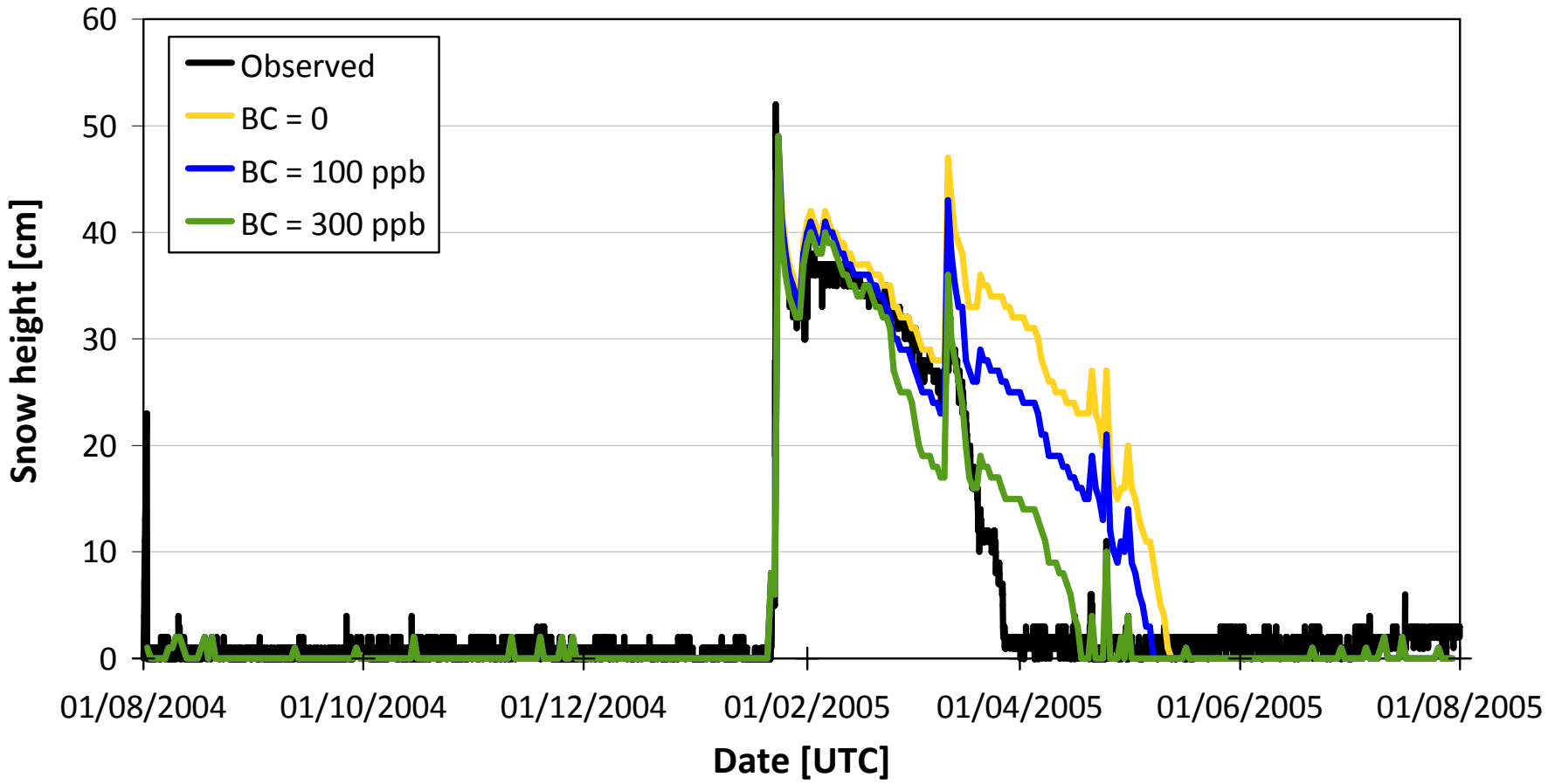
Comparison of observed and simulated snow height at Pyramid using estimated precipitation (2004–2005)



Jacobi et al., Cryosphere 2015

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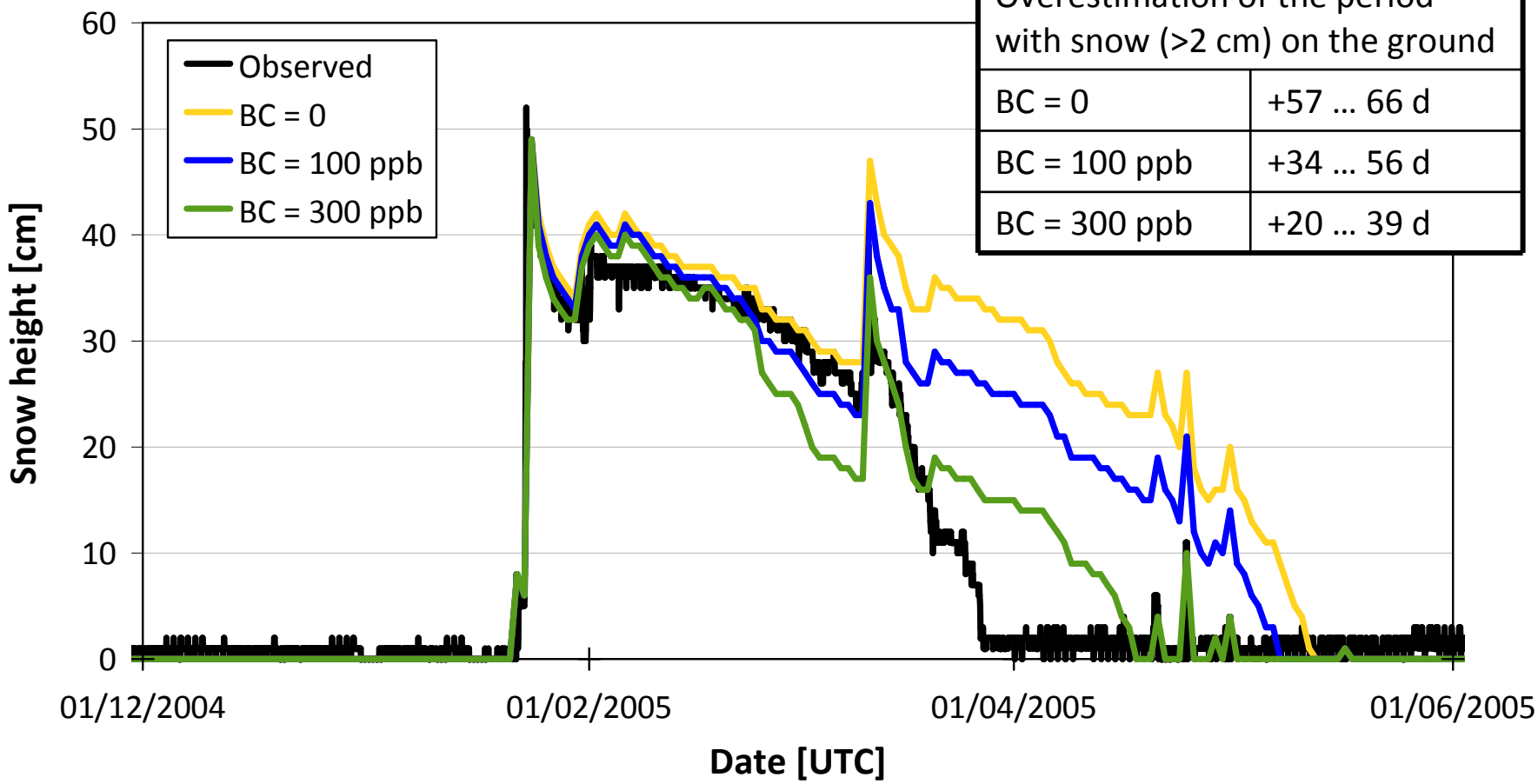

Overestimation of the period with snow (>2 cm) on the ground	
BC = 0	+57 … 66 d
BC = 100 ppb	+34 … 56 d
BC = 300 ppb	+20 … 39 d

Jacobi et al., Cryosphere 2015

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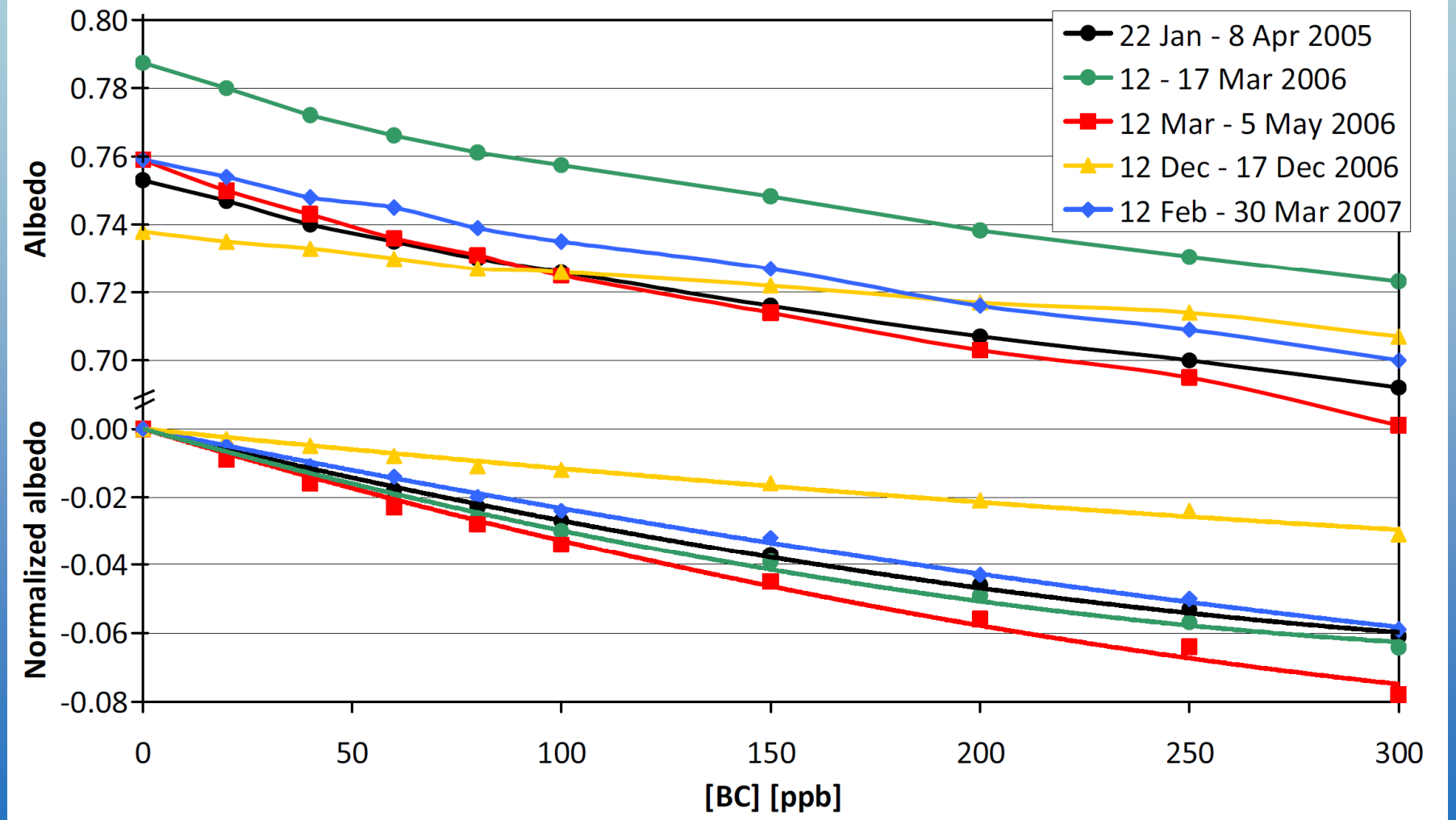
Reduction of the snowpack albedo as a function of BC concentration for snow heights larger than 10 cm



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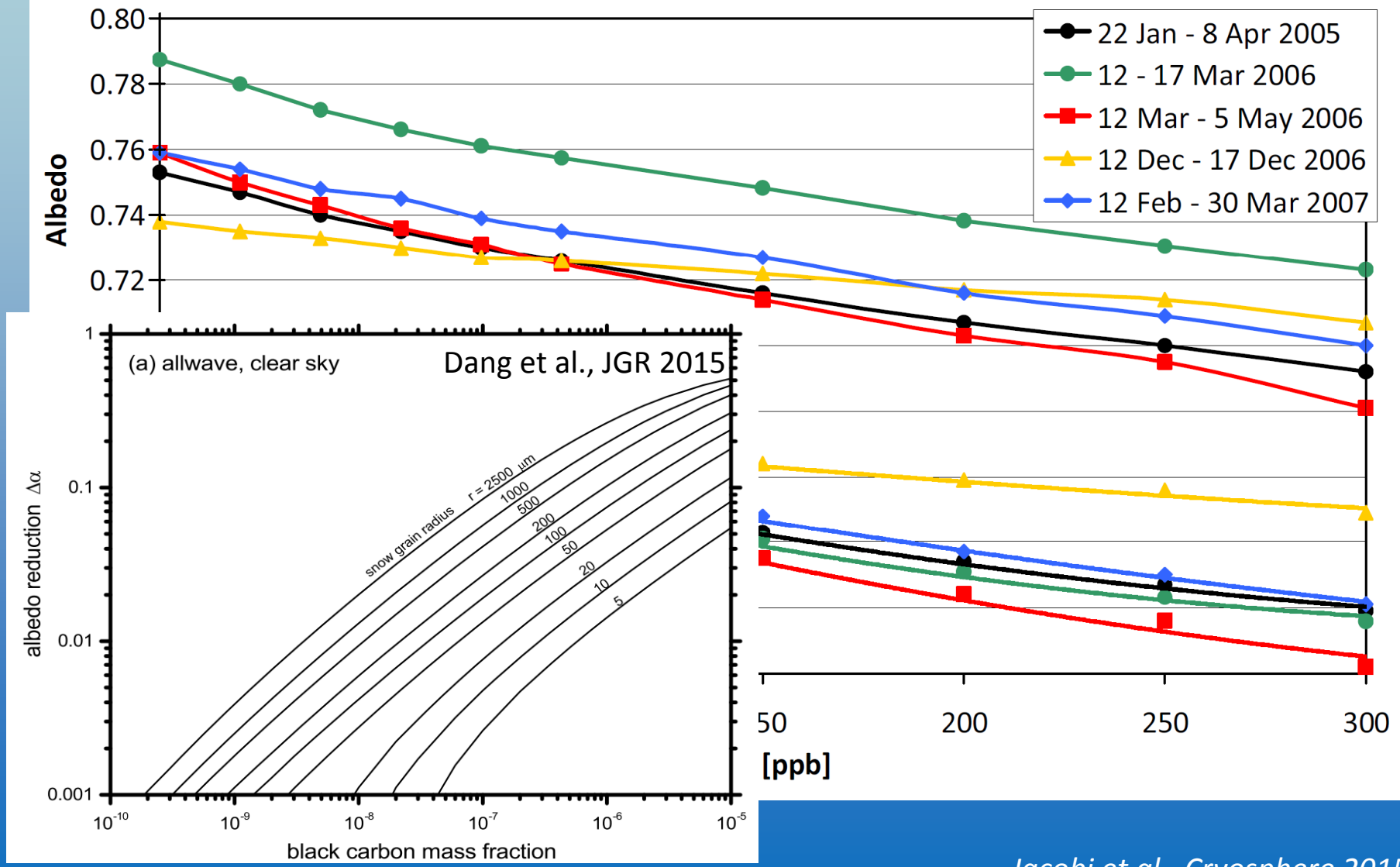

Jacobi et al., Cryosphere 2015

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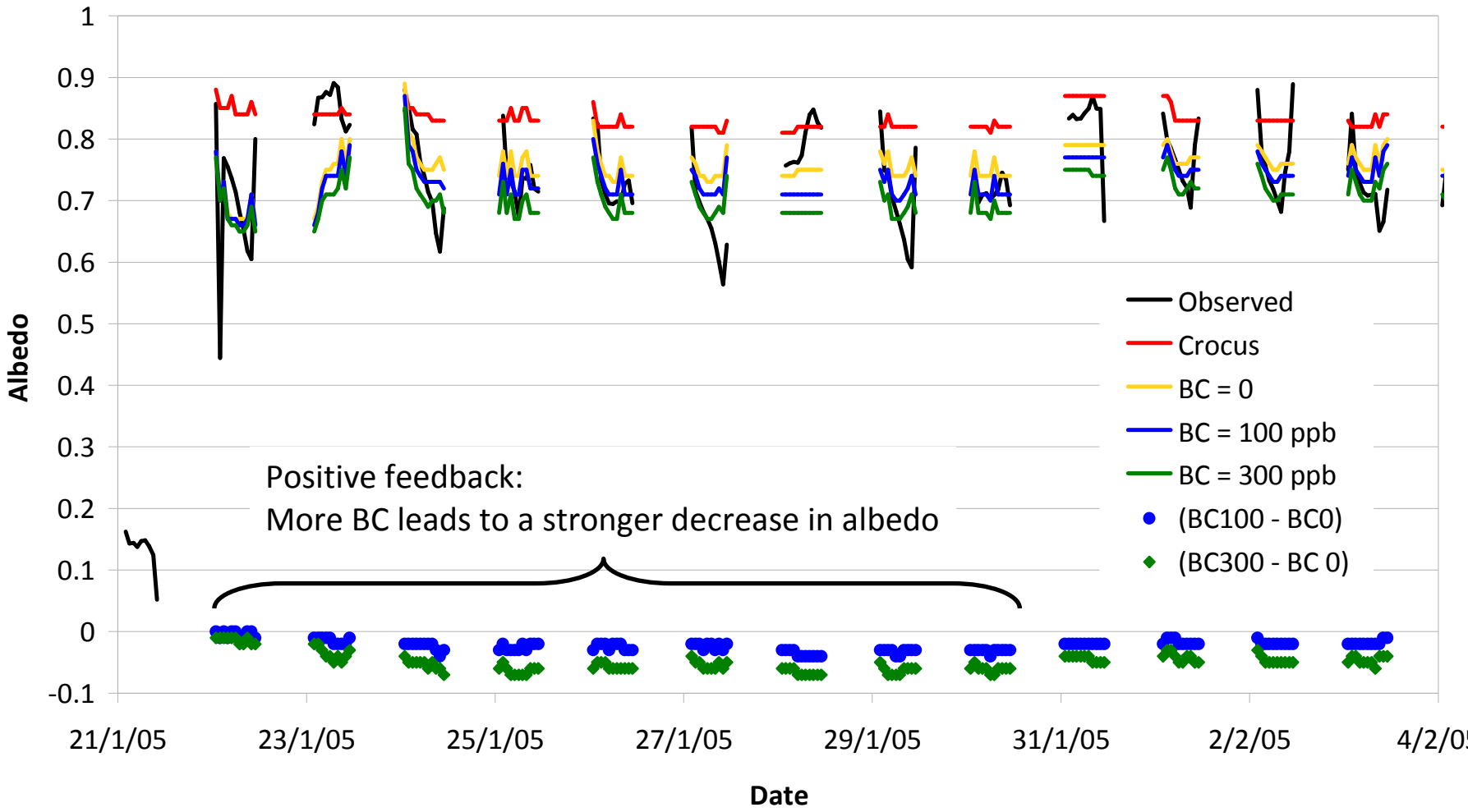
Positive feedback mechanism between BC and albedo



Jacobi et al., Cryosphere 2015

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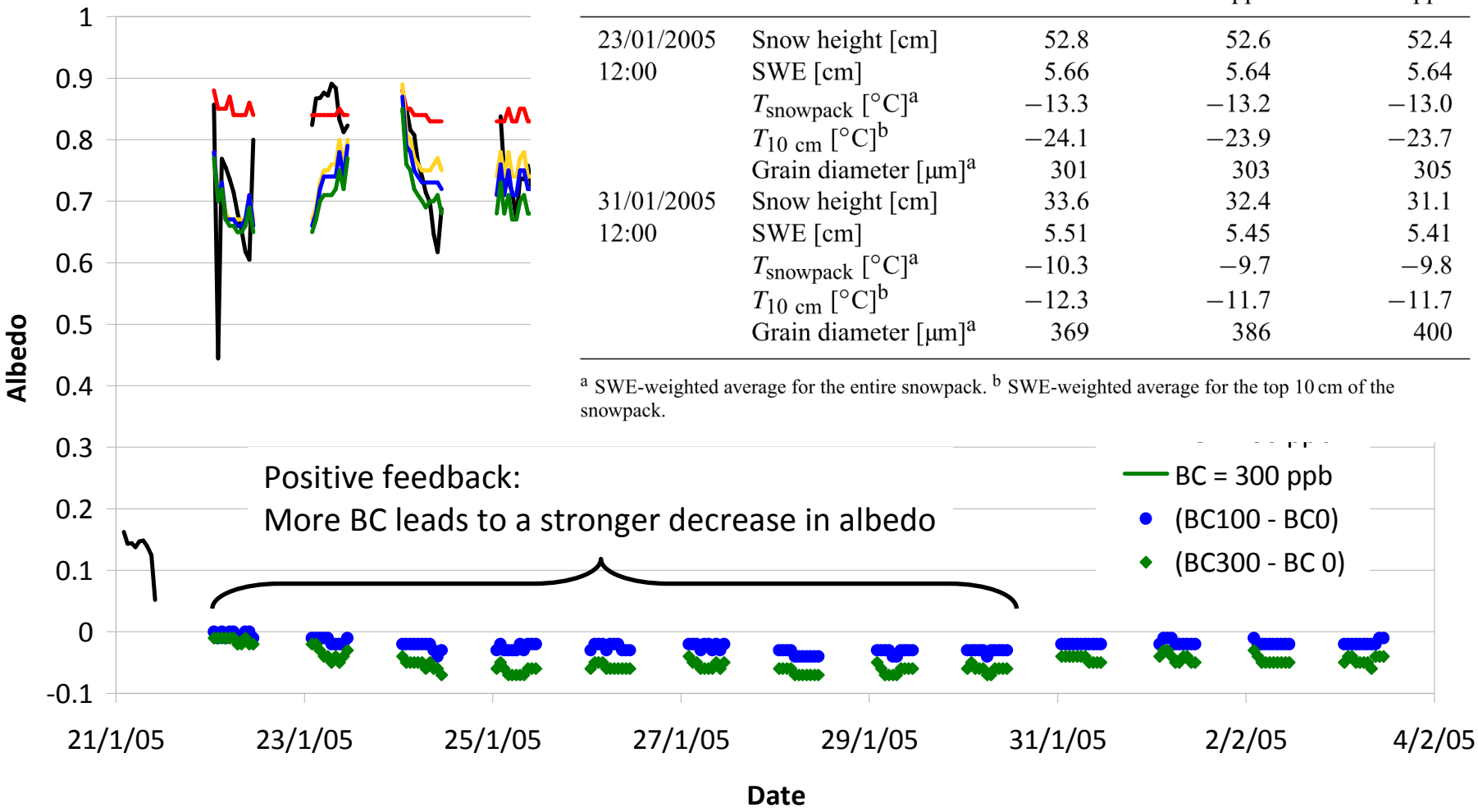
Positive feedback mechanism between BC and albedo

		BC = 0	BC = 100 ppb	BC = 300 ppb
23/01/2005 12:00	Snow height [cm]	52.8	52.6	52.4
	SWE [cm]	5.66	5.64	5.64
	$T_{snowpack}$ [°C][a]	−13.3	−13.2	−13.0
	$T_{10\ cm}$ [°C][b]	−24.1	−23.9	−23.7
	Grain diameter [μm][a]	301	303	305
31/01/2005 12:00	Snow height [cm]	33.6	32.4	31.1
	SWE [cm]	5.51	5.45	5.41
	$T_{snowpack}$ [°C][a]	−10.3	−9.7	−9.8
	$T_{10\ cm}$ [°C][b]	−12.3	−11.7	−11.7
	Grain diameter [μm][a]	369	386	400

[a] SWE-weighted average for the entire snowpack. [b] SWE-weighted average for the top 10 cm of the snowpack.



Jacobi et al., Cryosphere 2015

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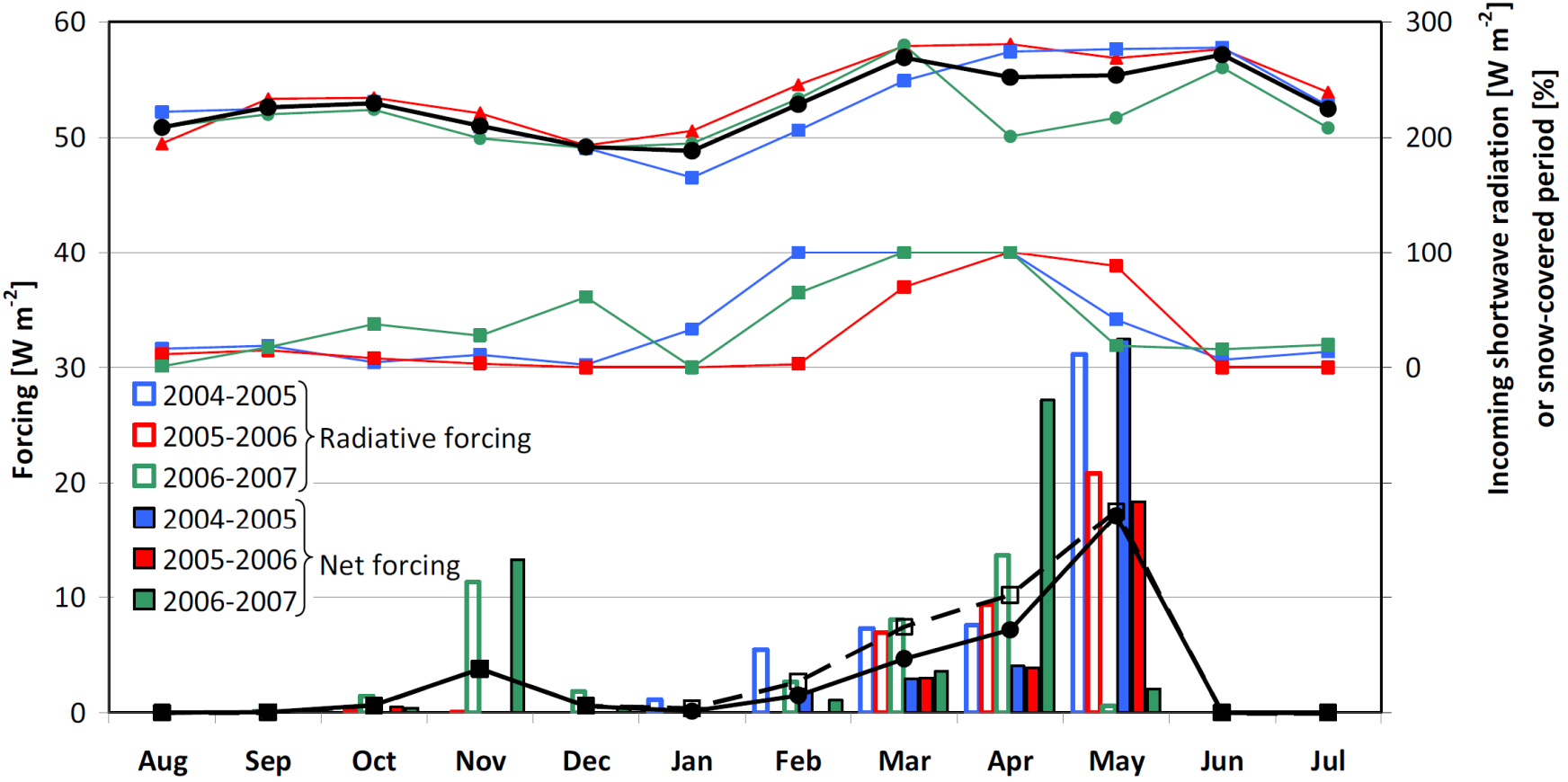
Seasonality of incoming SW radiation, period with snow cover, and simulated radiative forcing



Jacobi et al., Cryosphere 2015

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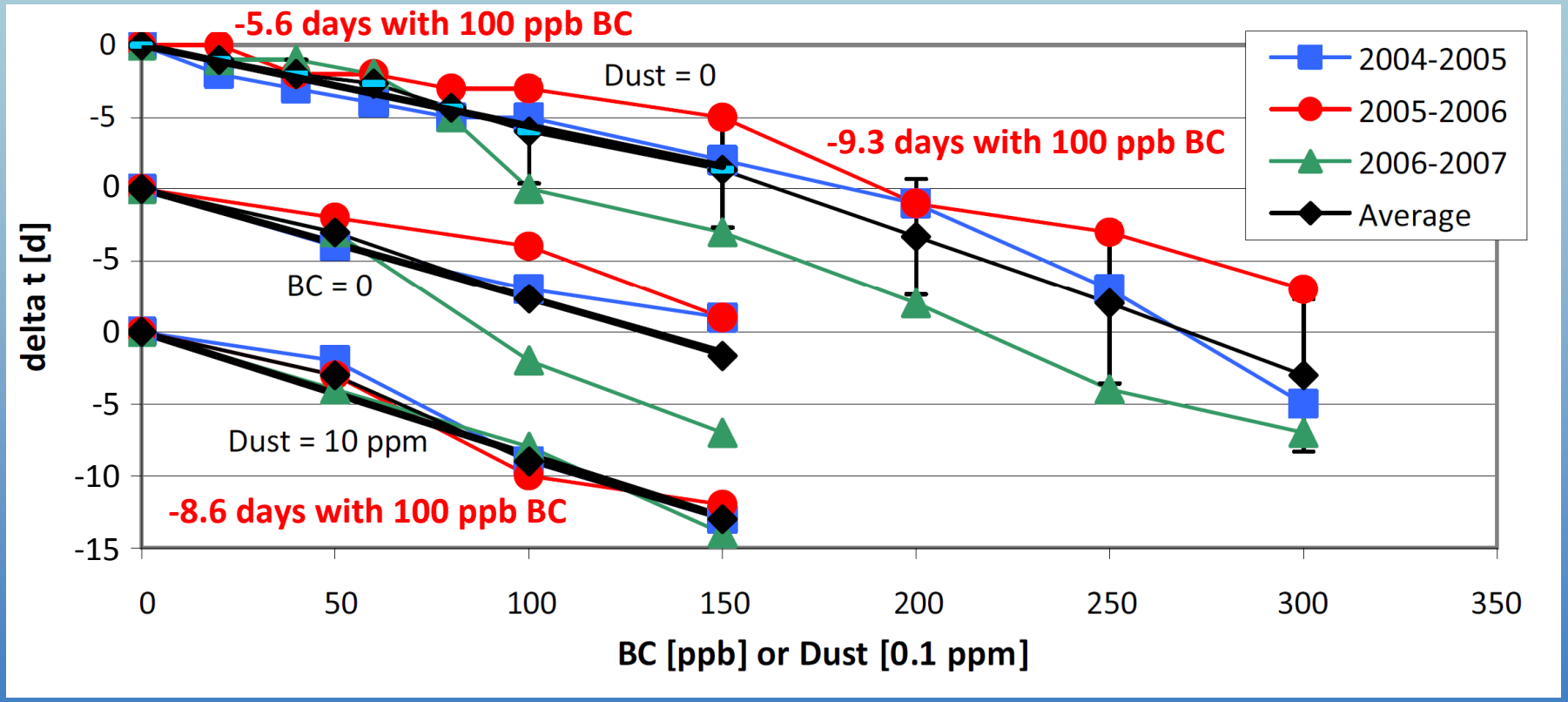
Simulated average reduction in the snow-covered period as a function of BC and dust



Jacobi et al., Cryosphere 2015

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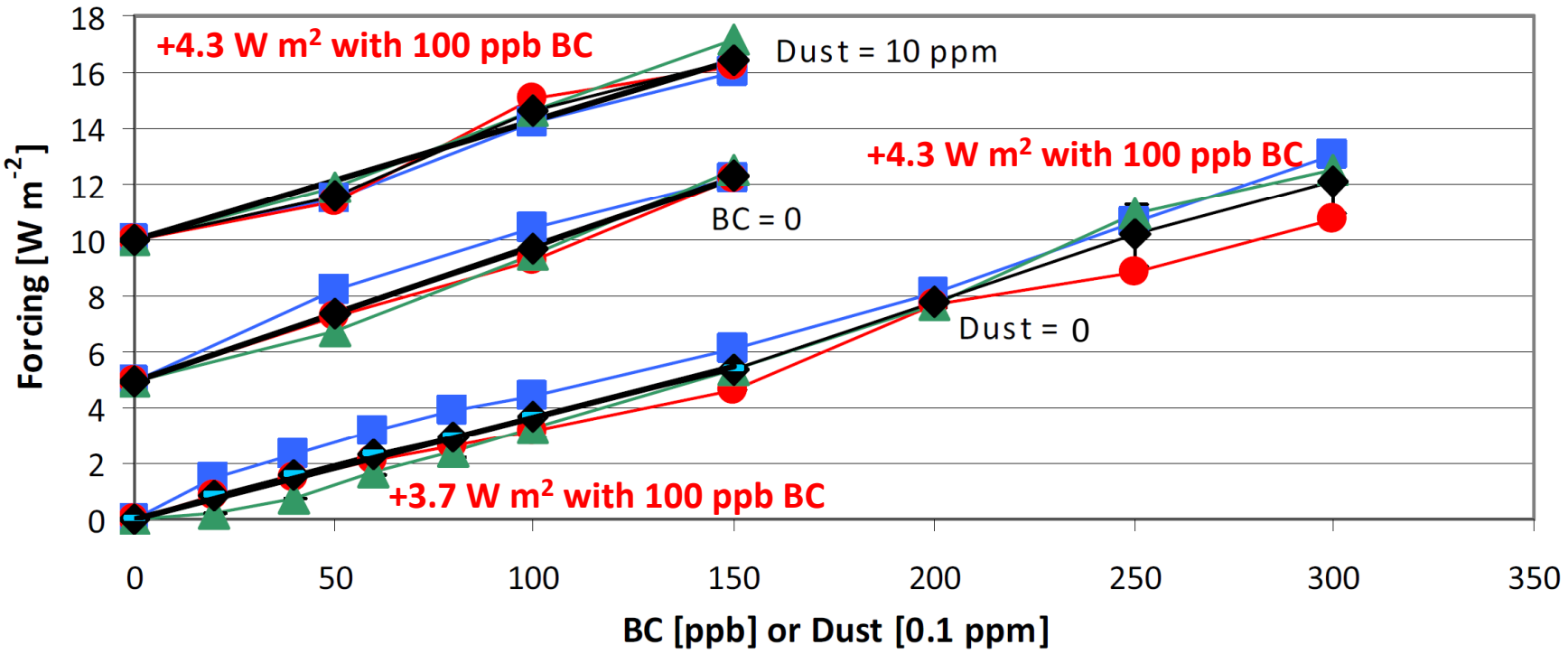
Simulated radiative forcing as a function of BC and dust concentrations



Jacobi et al., Cryosphere 2015

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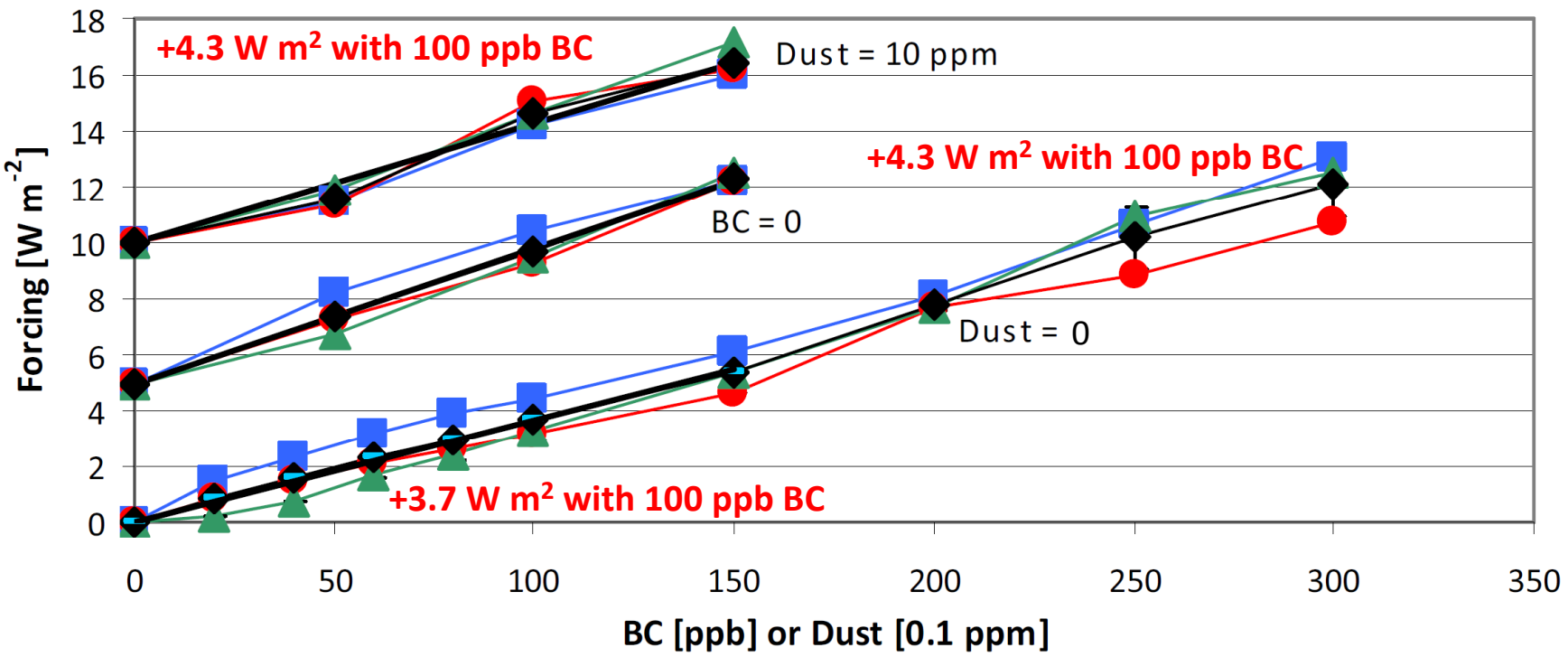
Simulated radiative forcing as a function of BC and dust concentrations



The sensitivity of the radiative fording and snow melt regarding BC is larger for dirty snow!

Jacobi et al., Cryosphere 2015

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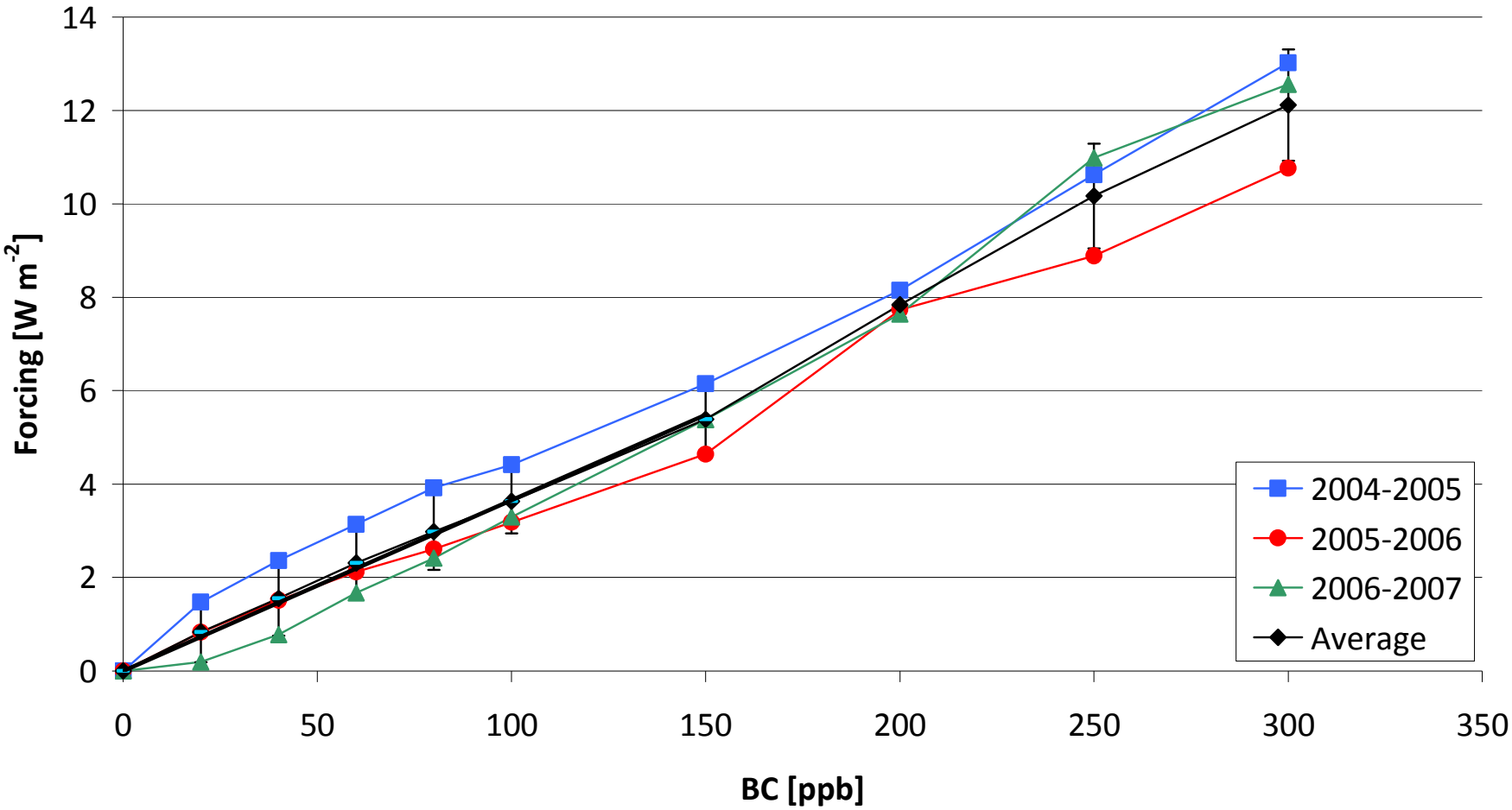
Comparison of the simulated sensitivity of the radiative forcing for BC in snow with global models



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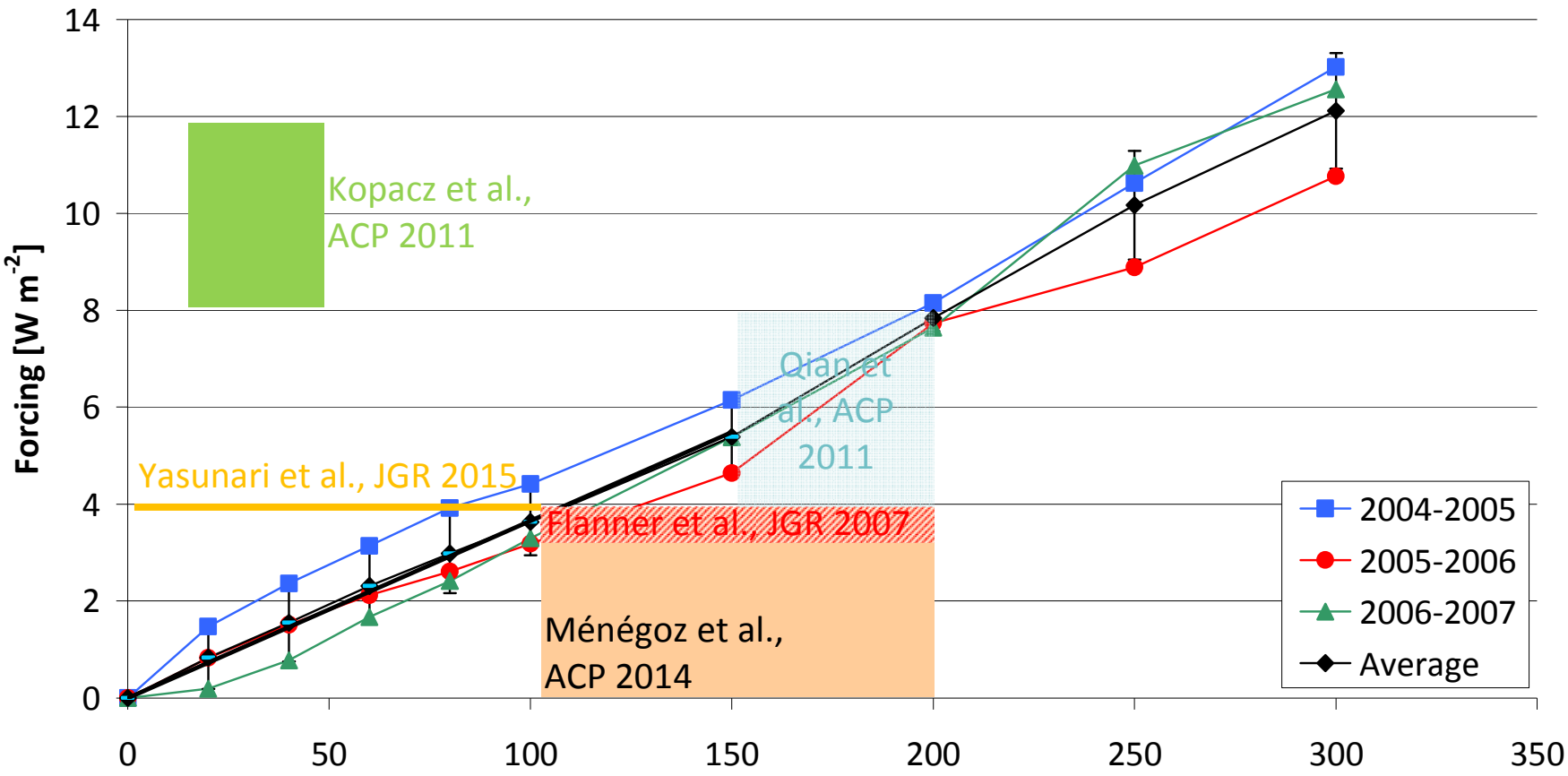
Comparison of the simulated sensitivity of the radiative forcing for BC in snow with global models



B **Sensitivity of radiative forcing regarding BC in snow not consistent in different models!**

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Conclusions

1. Sensitivity of radiative forcing and snow melt regarding BC and dust appears larger for dirty snow.
2. We need to know all light-absorbing impurities to quantify the impact of BC.
3. Sensitivity of radiative forcing regarding BC in snow not consistent in different models!

Paprika

PRESHINE (Pressures on Water and Soil Resources in Nepal Himalaya)

EvK2CNR

AGENCE NATIONALE DE LA RECHERCHE ANR

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Conclusions

1. Sensitivity of radiative forcing and snow melt regarding BC and dust appears larger for dirty snow **(in the Himalayas)**.
2. We need to know all light-absorbing impurities to quantify the impact of BC.
3. Sensitivity of radiative forcing regarding BC in snow not consistent in different models!

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EvK2CNR

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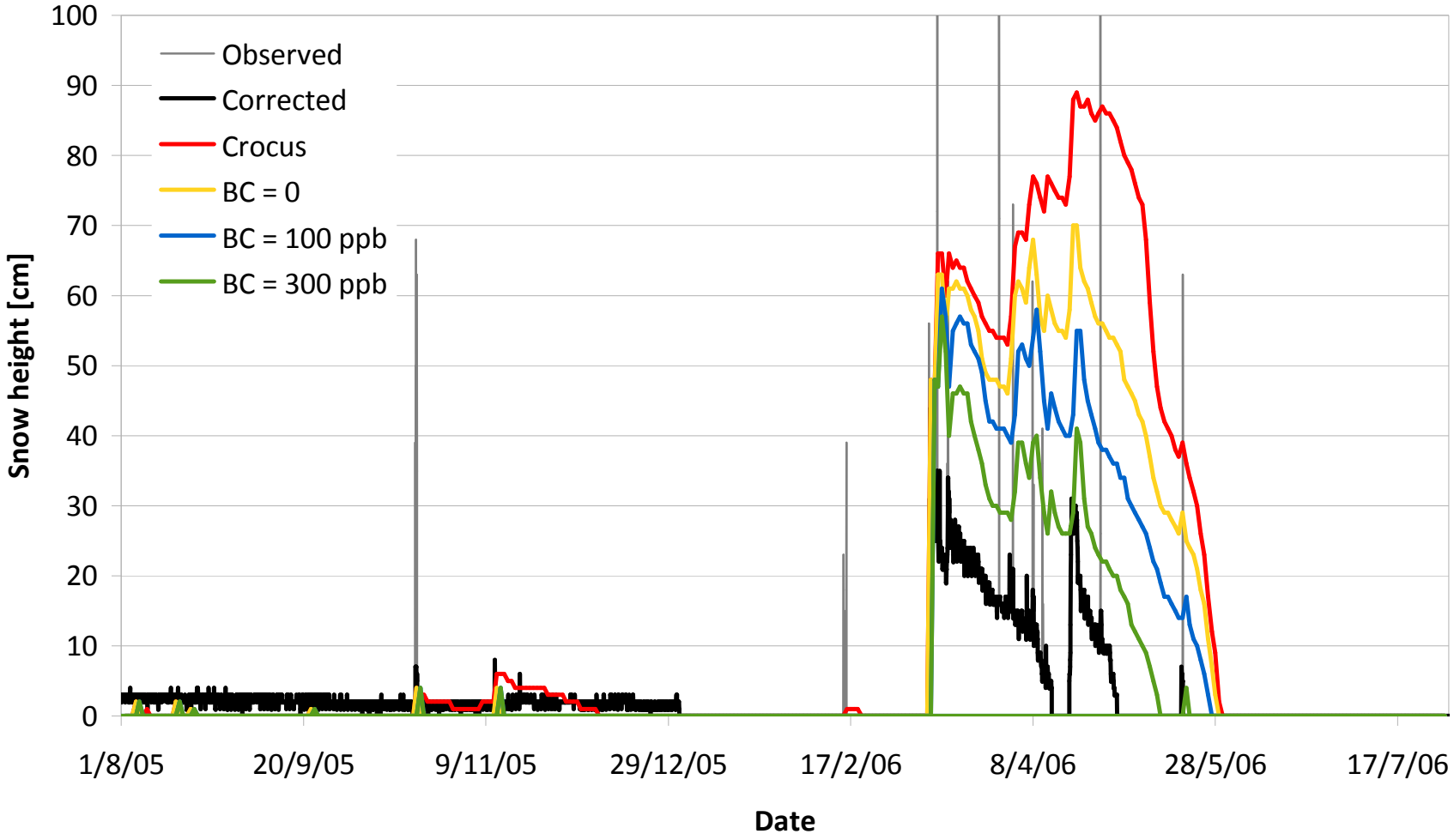
Comparison of observed and simulated snow height at Pyramid using estimated precipitation (2005–2006)



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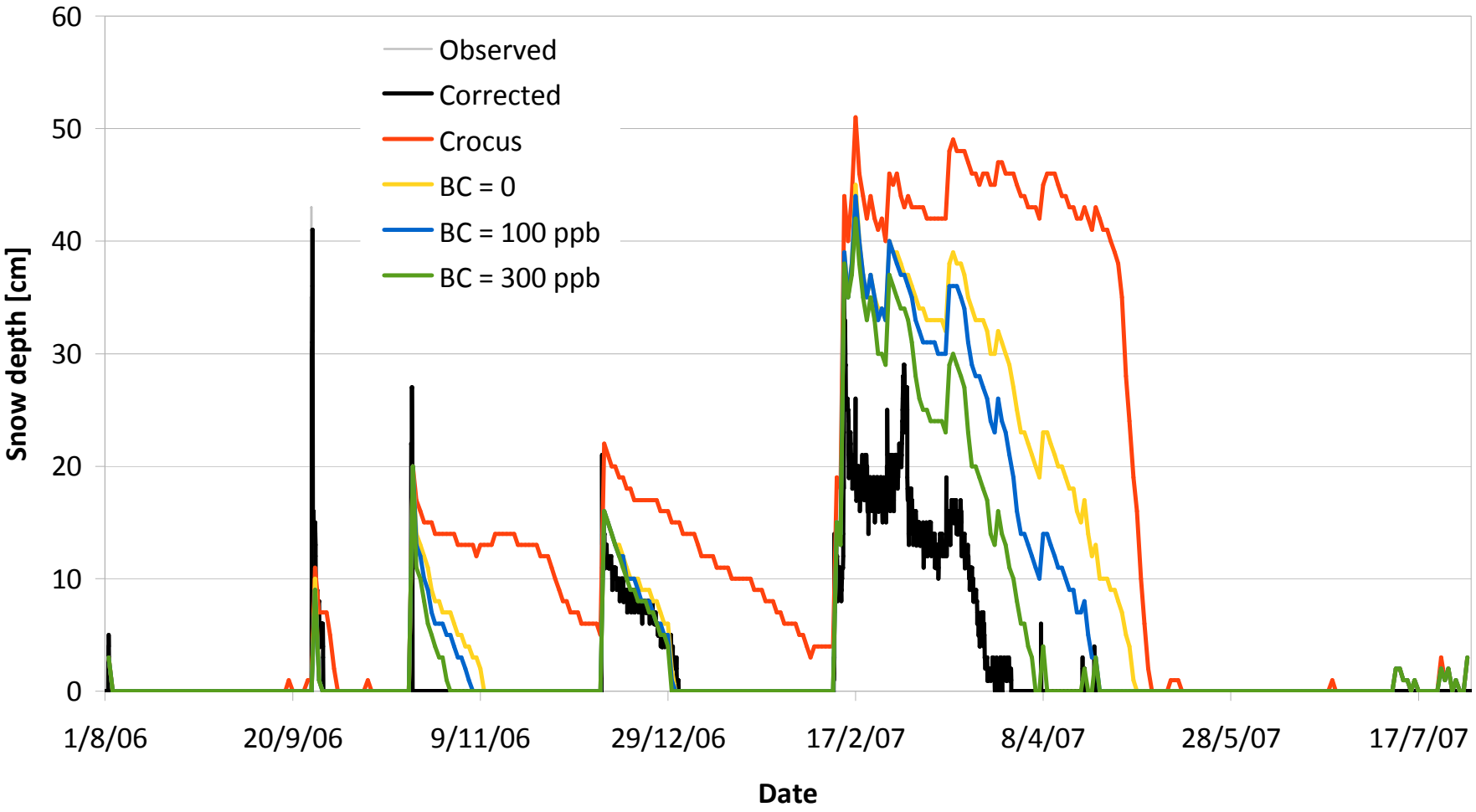

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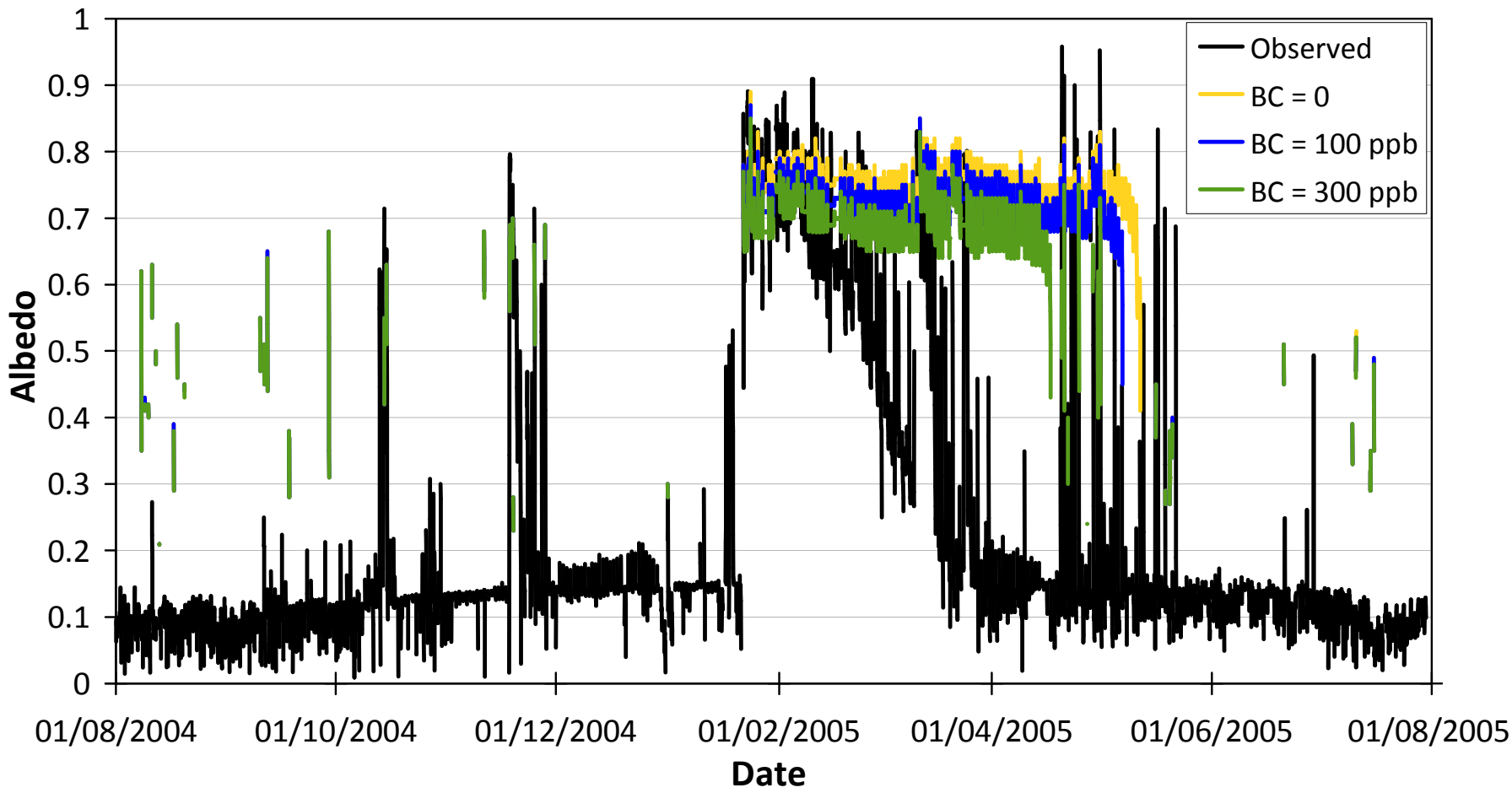
Comparison of observed and simulated albedo at Pyramid (2004 – 2005)



Jacobi et al., Cryos.Discuss. 2014

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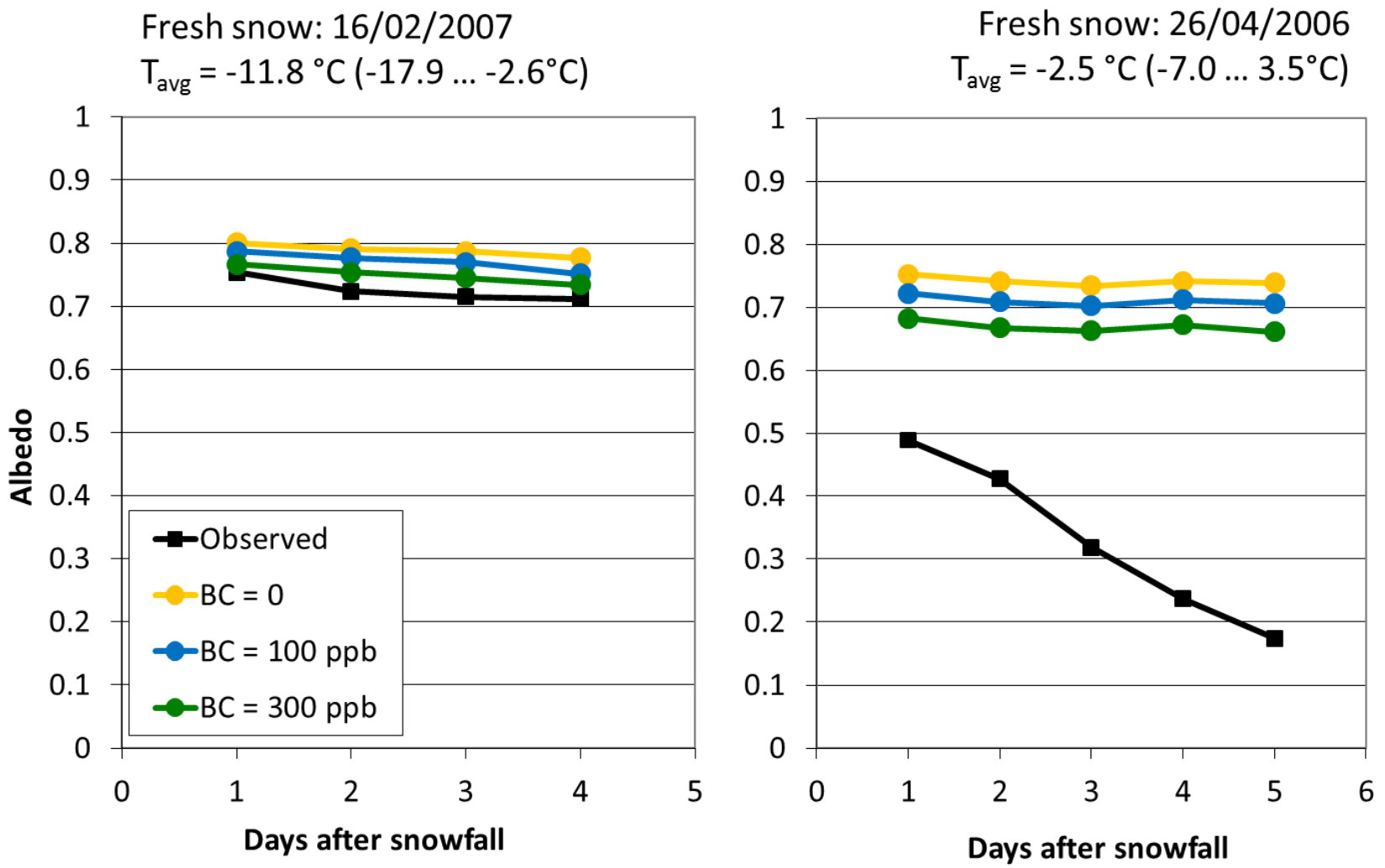
Comparison of observed and simulated albedo at Pyramid during periods without fresh snow



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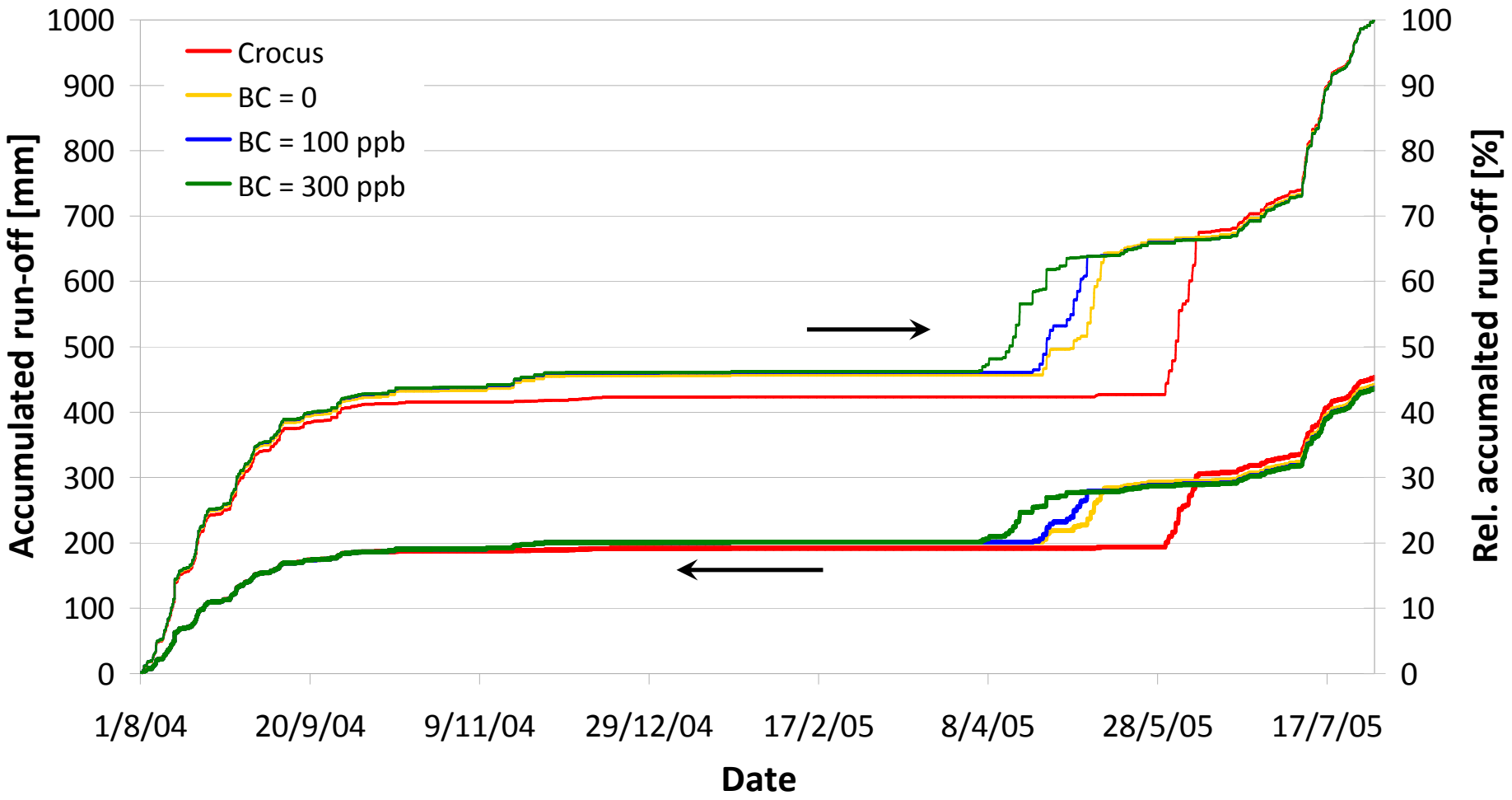
Comparison of simulated accumulated run-off (snow + rain) for Pyramid (2004–2005)



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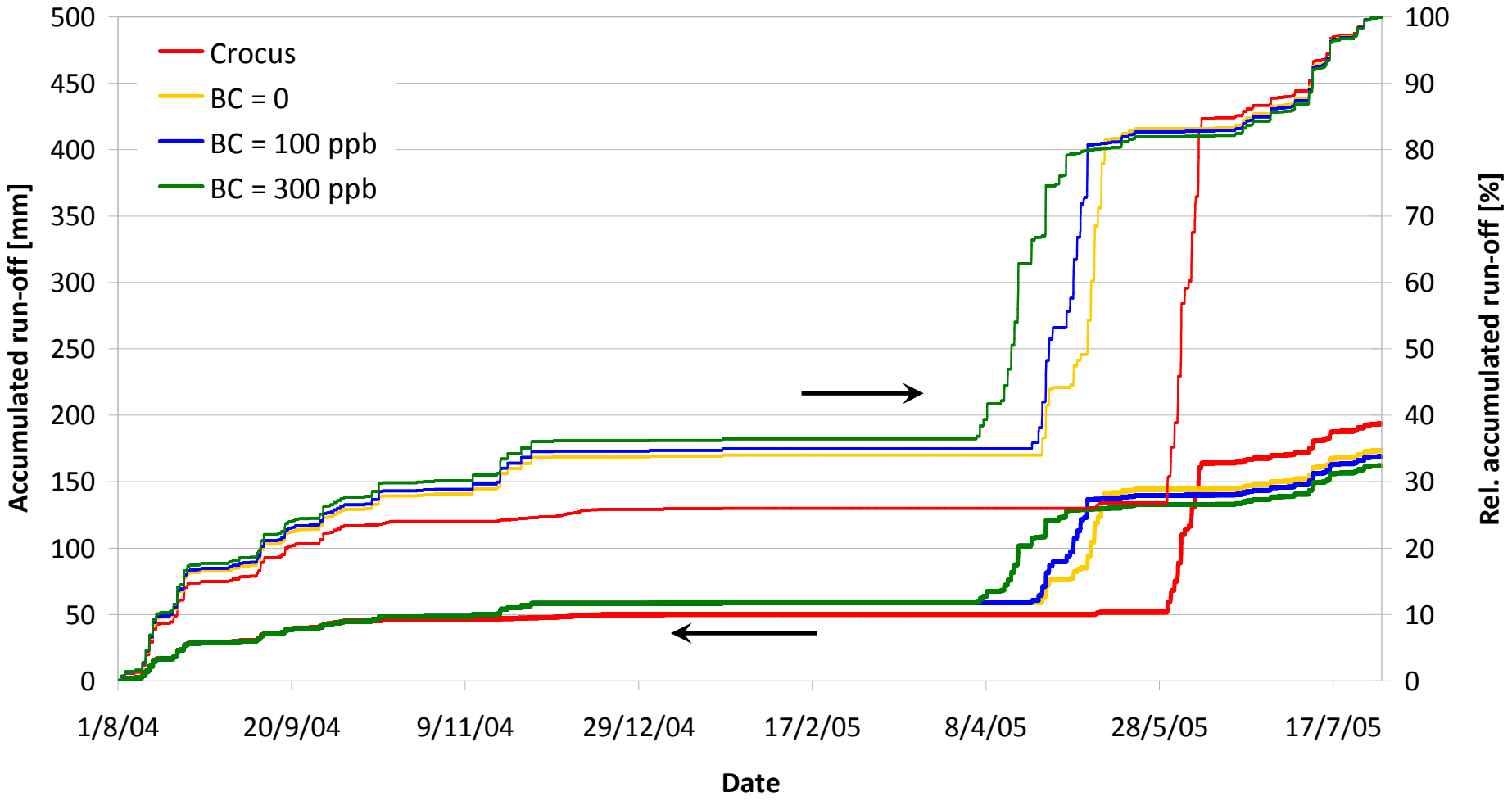
Comparison of simulated accumulated run-off (only snow) for Pyramid (2004–2005)



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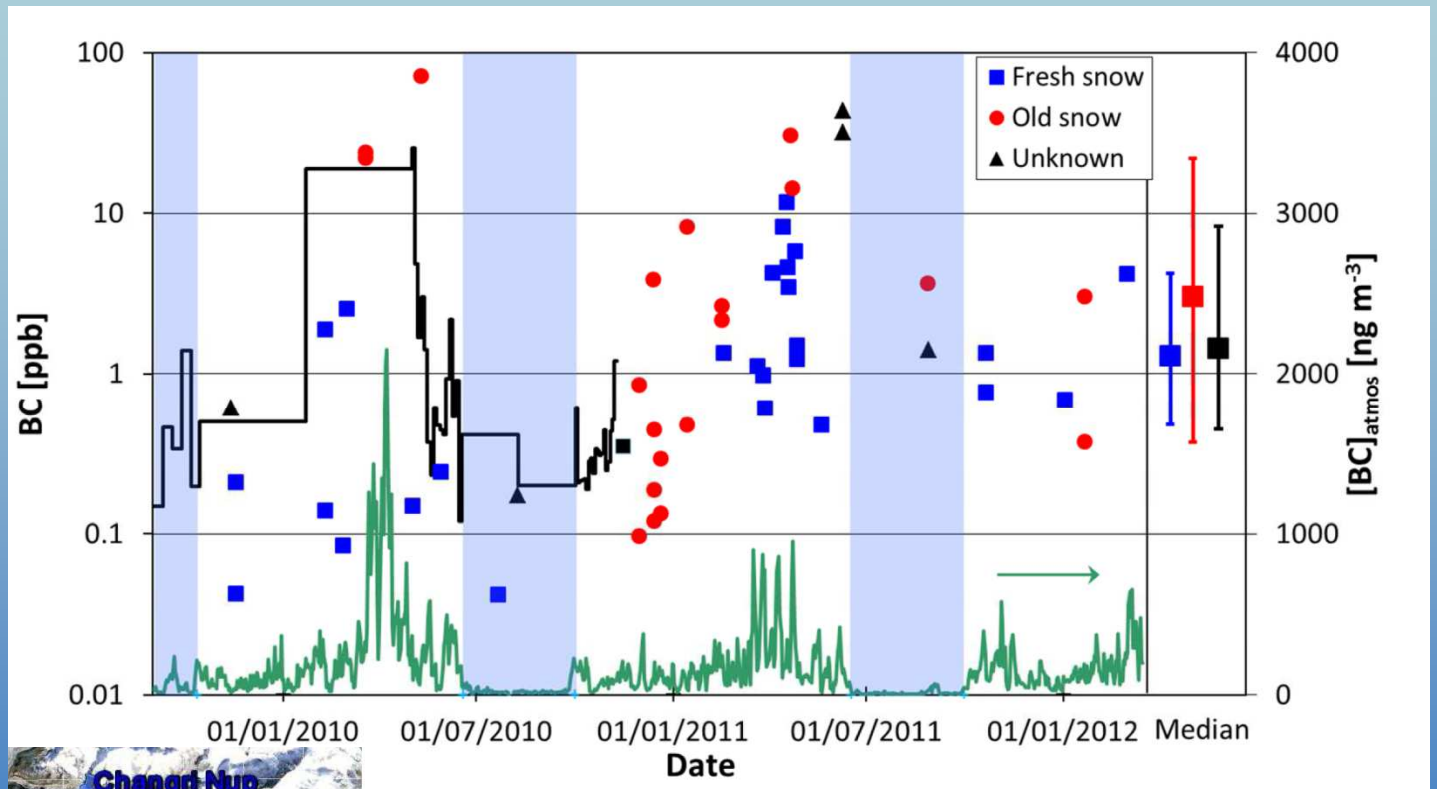
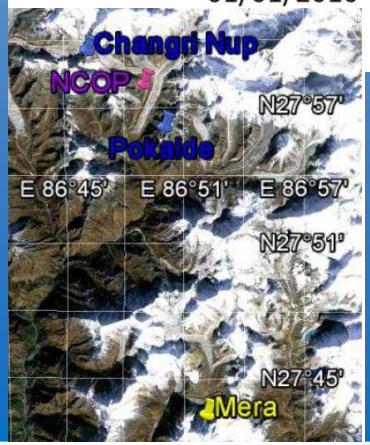
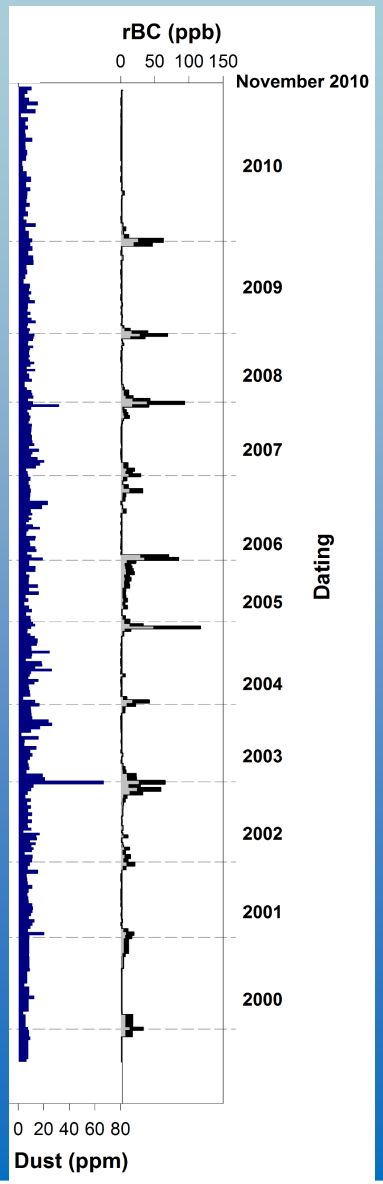
Observed BC and dust concentrations in snow (Pyramid) and in an ice core (Mera glacier)





BC: variable, 0.1 … 100 ppb
Dust: constant, ~10 ppm

Ginot et al., Cryos. 2014; Jacobi et al., Cryos.Discuss. 2014



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