Bayerisches Landesamt für
Umwelt

What’s new at the wetting front?

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Réunion Atelier Neige – Grenoble

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Foto: J. Schweizer

Wet-snow avalanche
Flüelapass ~16 h
Planned opening of
the road 17 h

Foto: J. Rocco

Reasons for bad predictability

- Formation processes are not fully understood.
- Timing is extremely short.
- Small differences in forcing (e.g. infiltration rate, snow stratigraphy) seem to be important.
- High potential for feed-back mechanisms exist.

Schneebeli (2004)

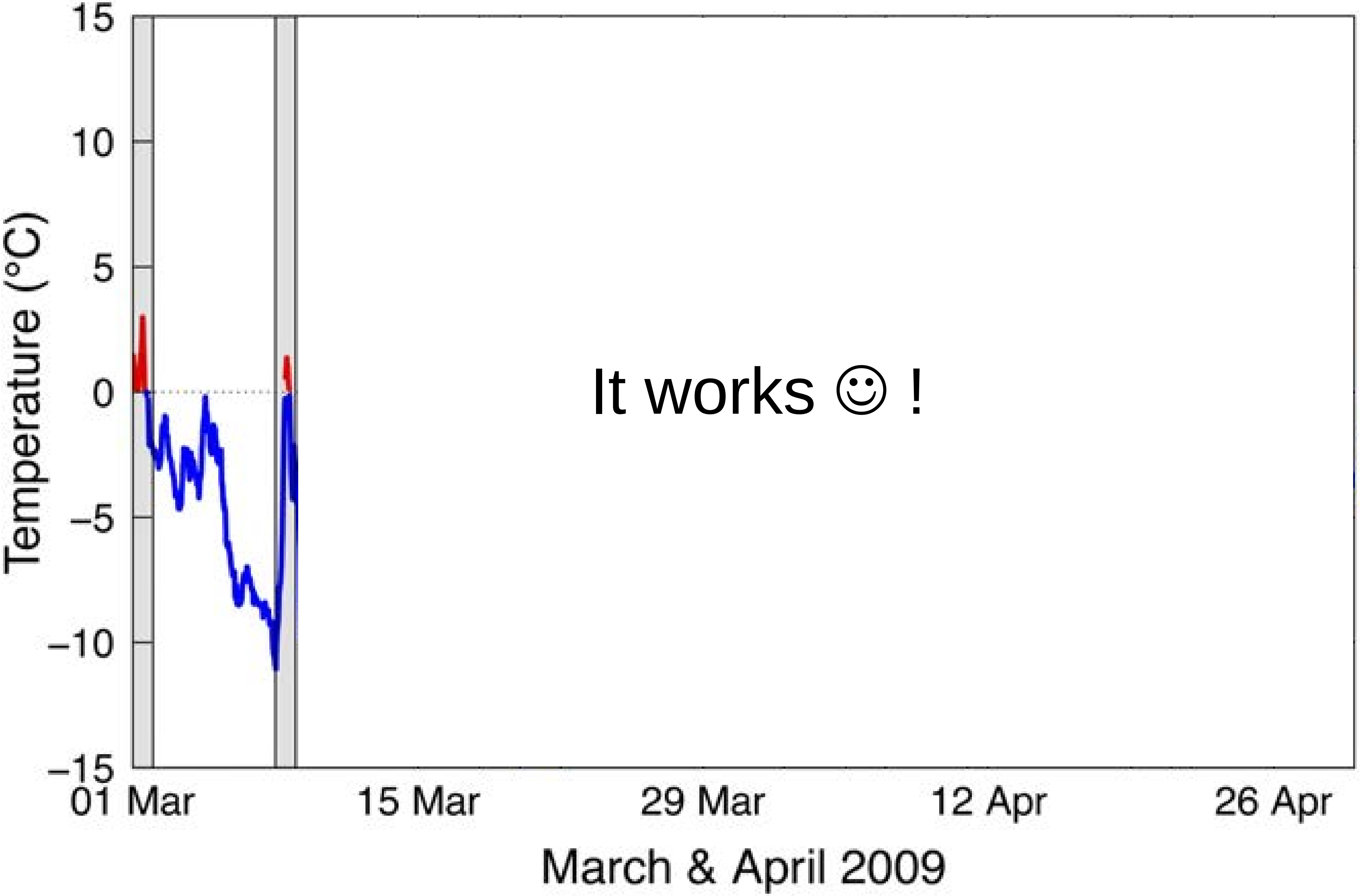
Problems stated by avalanche professionals

- No established procedure to assess wet-snow instability
  - No best-practice stability test
  - No evident meteorological parameter (air temperature?)
  - Indicator avalanches (only reliable parameter?)

- Major forecasting problem concerns the correct onset of avalanche activity.

Techel and Pielmeier (2009)

Air temperature as a proxy?



It works ☺ !

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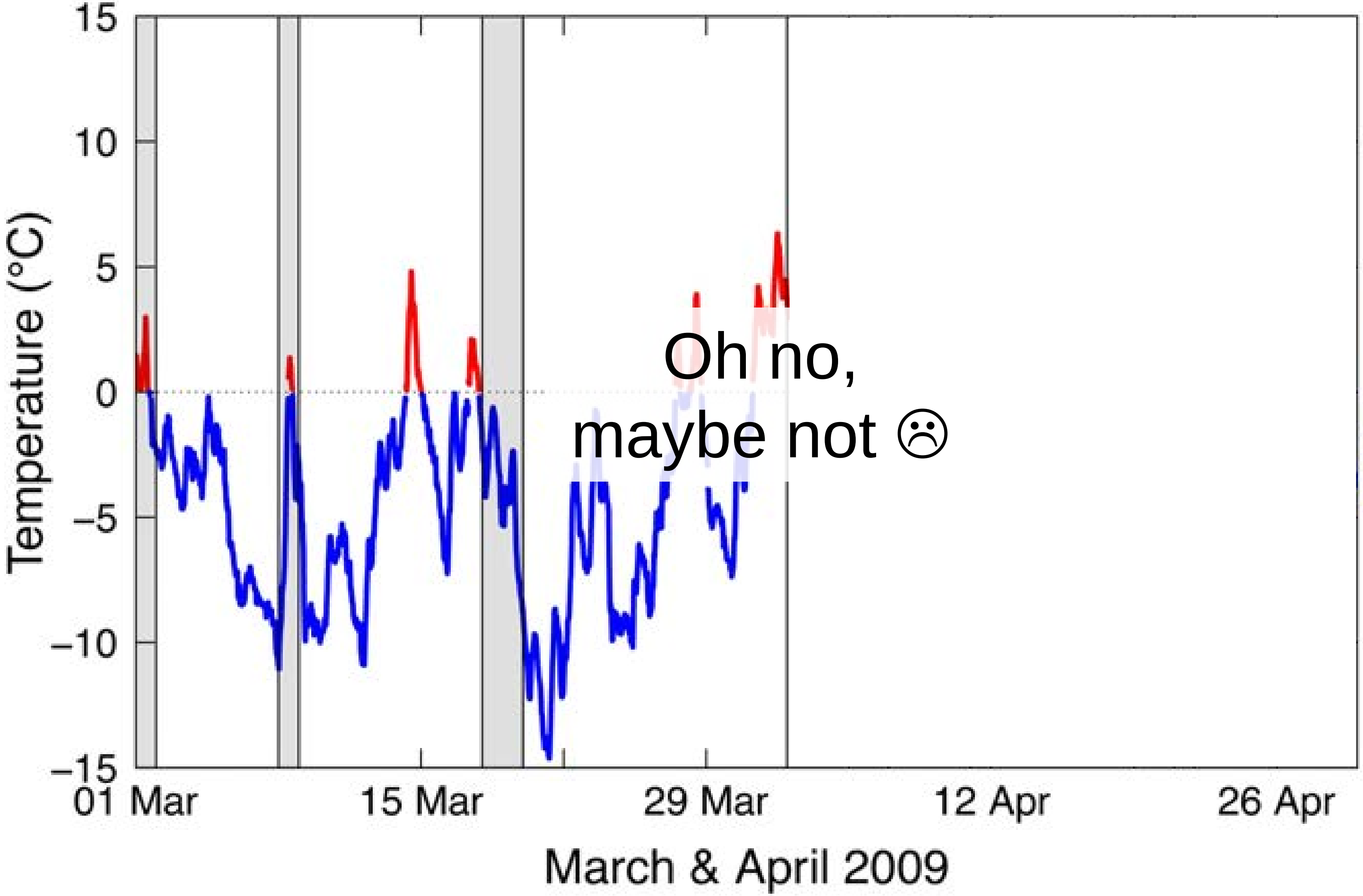
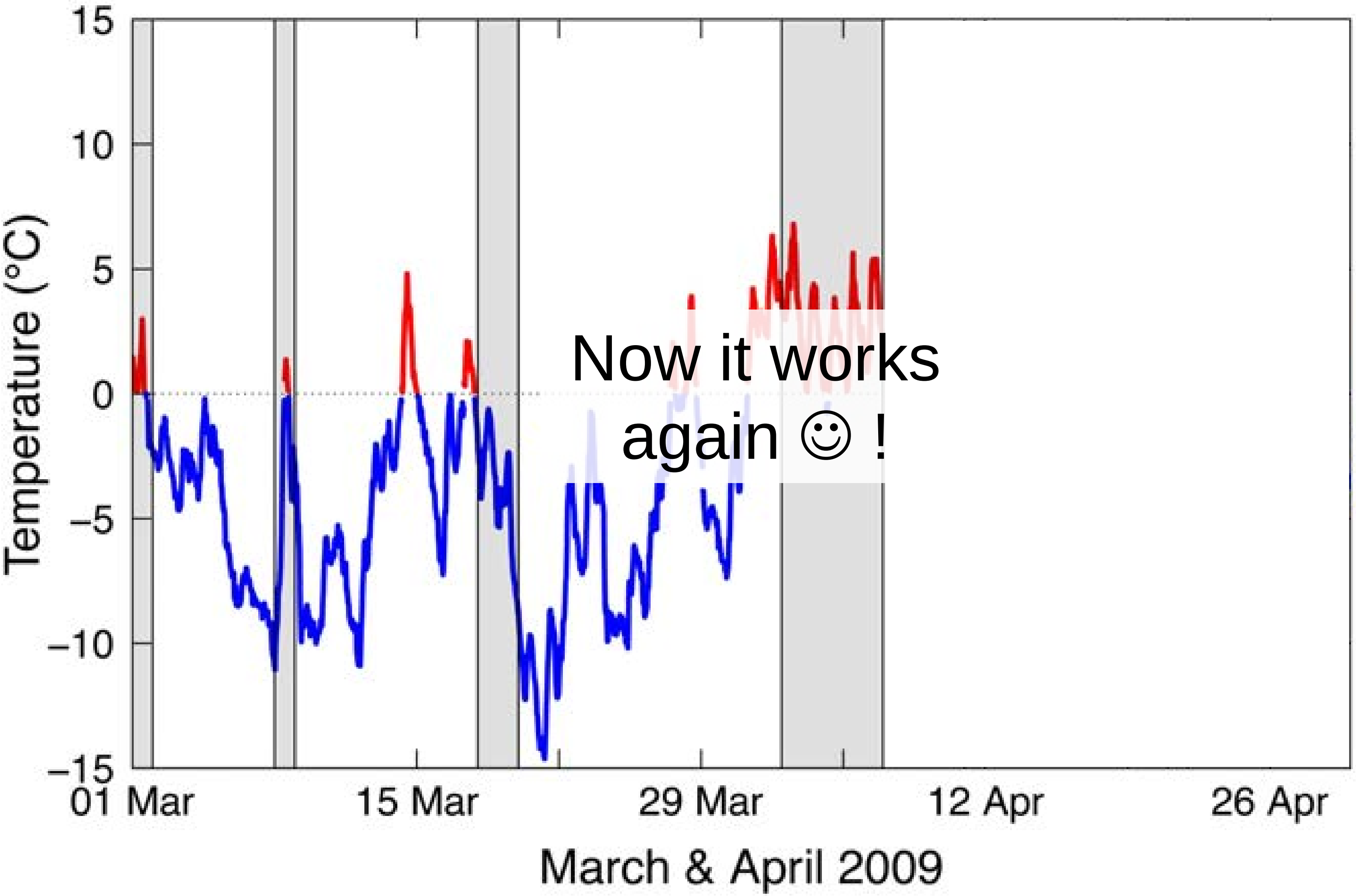


Oh no,
maybe not ☹

Air temperature as a proxy?



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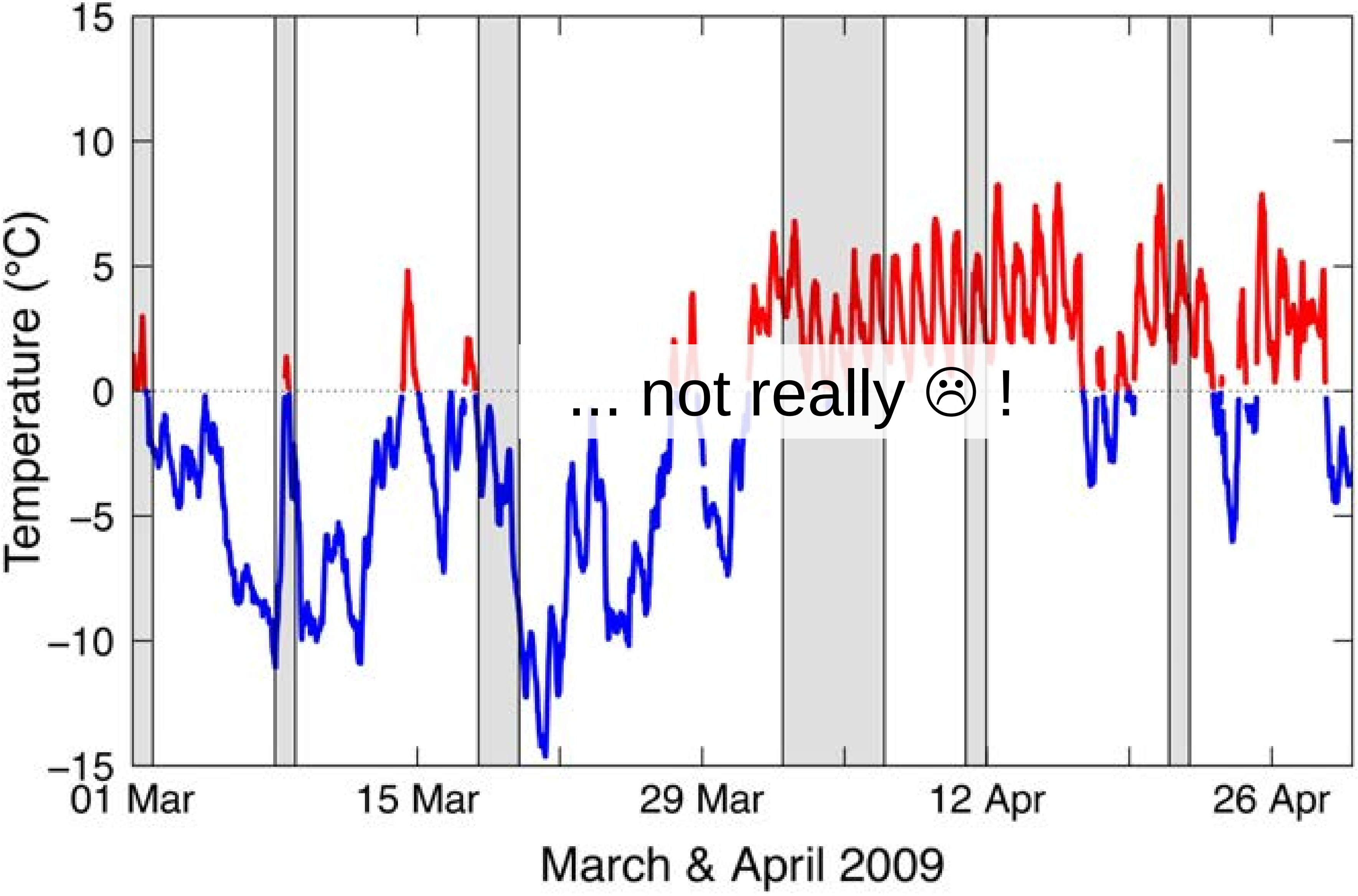

What is the deal?

*Do physically **more complex model** settings provide **better predictions** of wet-snow avalanche occurrence than **simpler ones**?*

Models describing wet-snow avalanches

- Baggi and Schweizer (2009)
  - 3d-sum of positive TA, days since isothermal state, capillary barrier index (BAG)
- Peitzsch et al. (2012)
  - Mean TA, maximum TA, decrease in HS (PEI)
- Mitterer and Schweizer (2013)
  - 5d-sum of positive TA (MIT1)
  - 3d-sum of positive TA, mean TSS (MIT2)
- Mitterer et al. (2013)
  - Modelled / measured energy and mass balance (MIT3)

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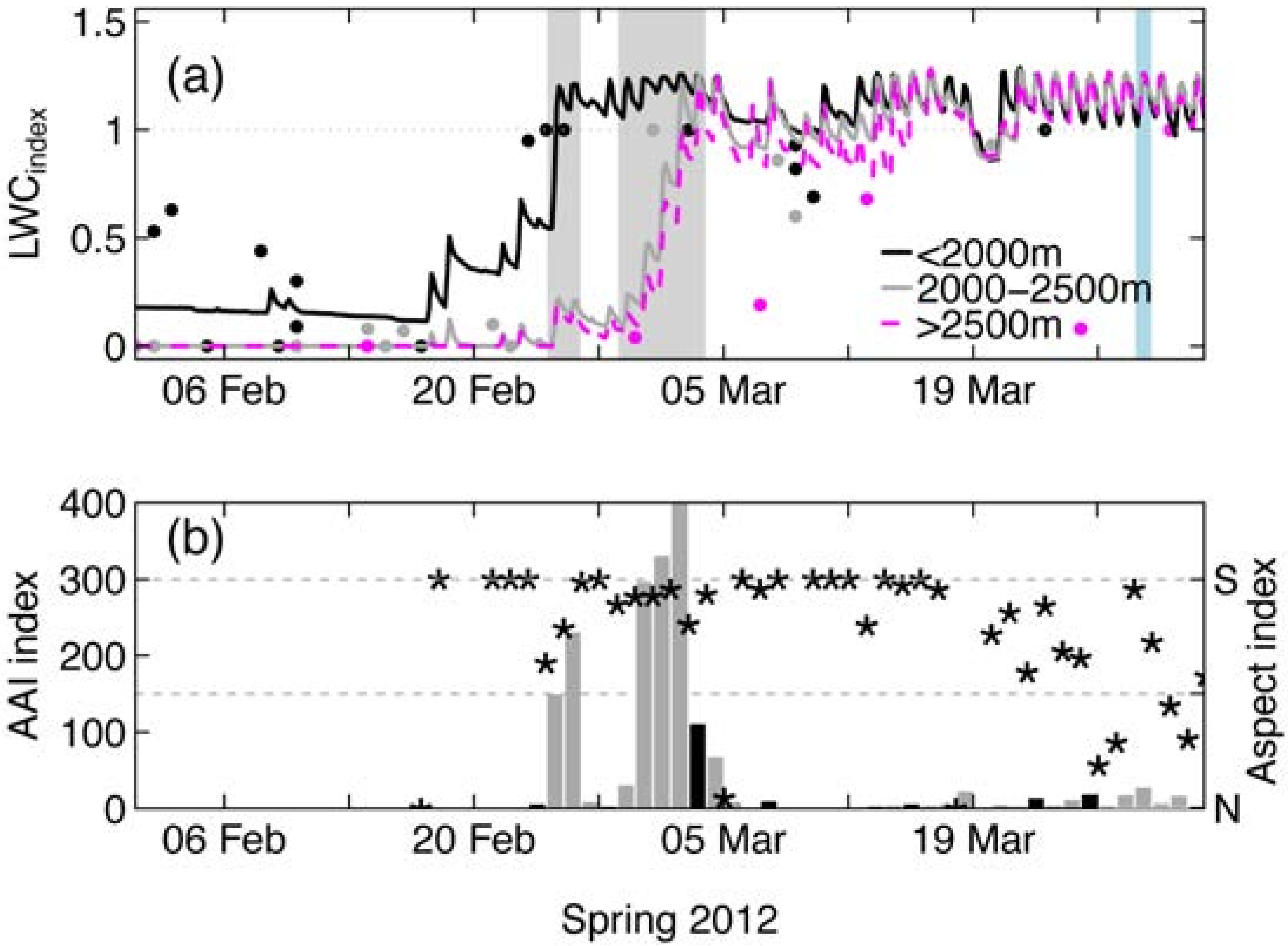
Energy balanced based index (LWC_{index})

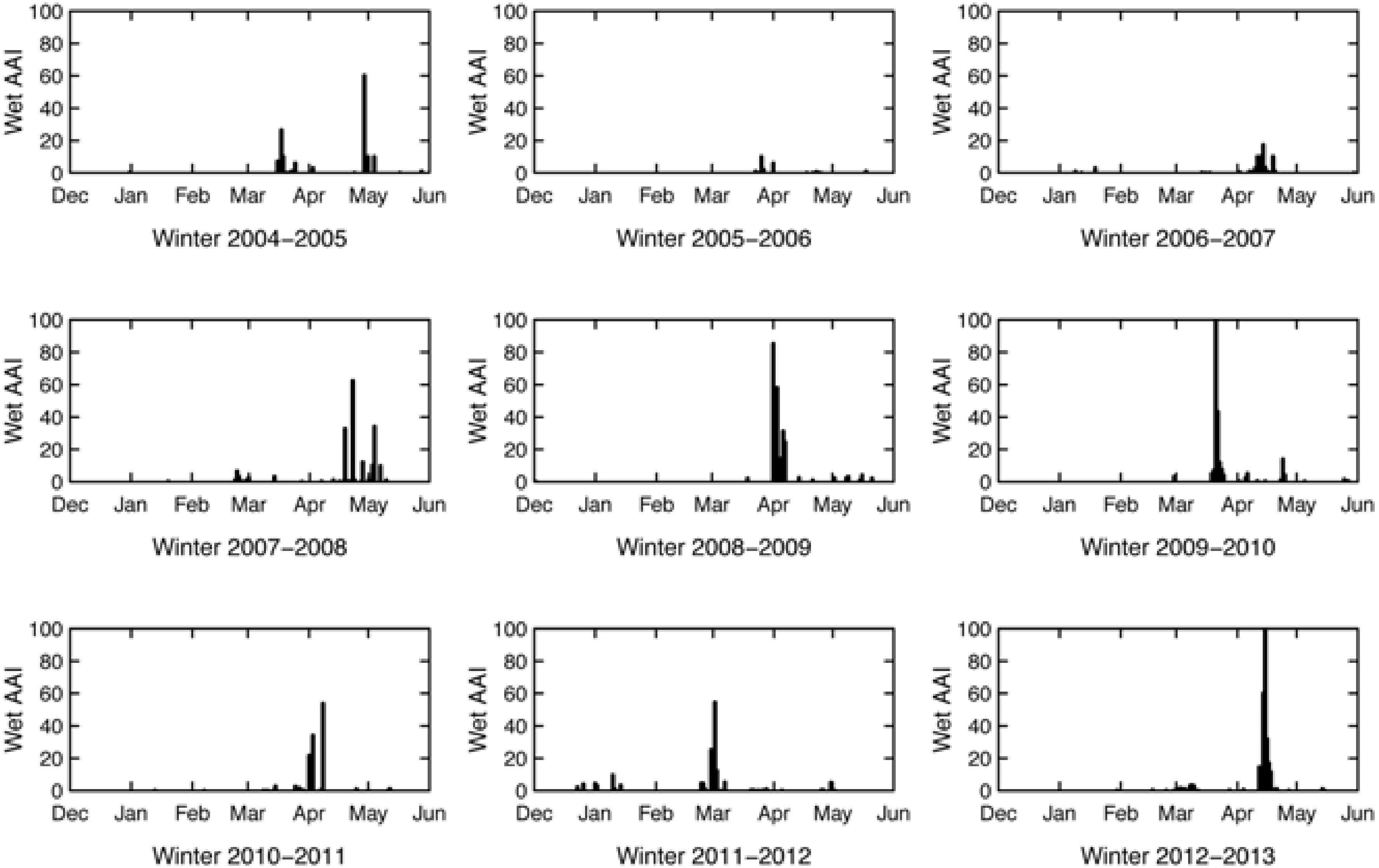
- At low liquid water content (θ_w), capillary forces dominate the water flow in snow (pendular regime).
- If θ_w increases, water will start to flow downwards due to gravity (funicular regime).
- The transition from the pendular to the funicular regime was experimentally observed at a volumetric liquid water content ($\theta_{w,v}$) of 3-8%.

$$\Rightarrow \quad LWC_{index} = \bar{\theta}_{w,v} / 0.03$$

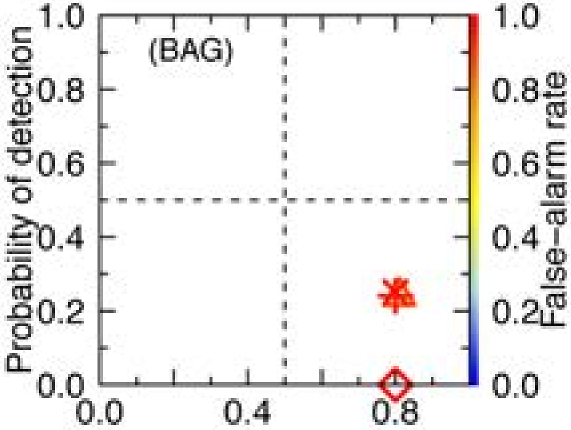
Energy balanced based index (LWC_{index})



Verification with avalanche activity data



Predictive performance of models



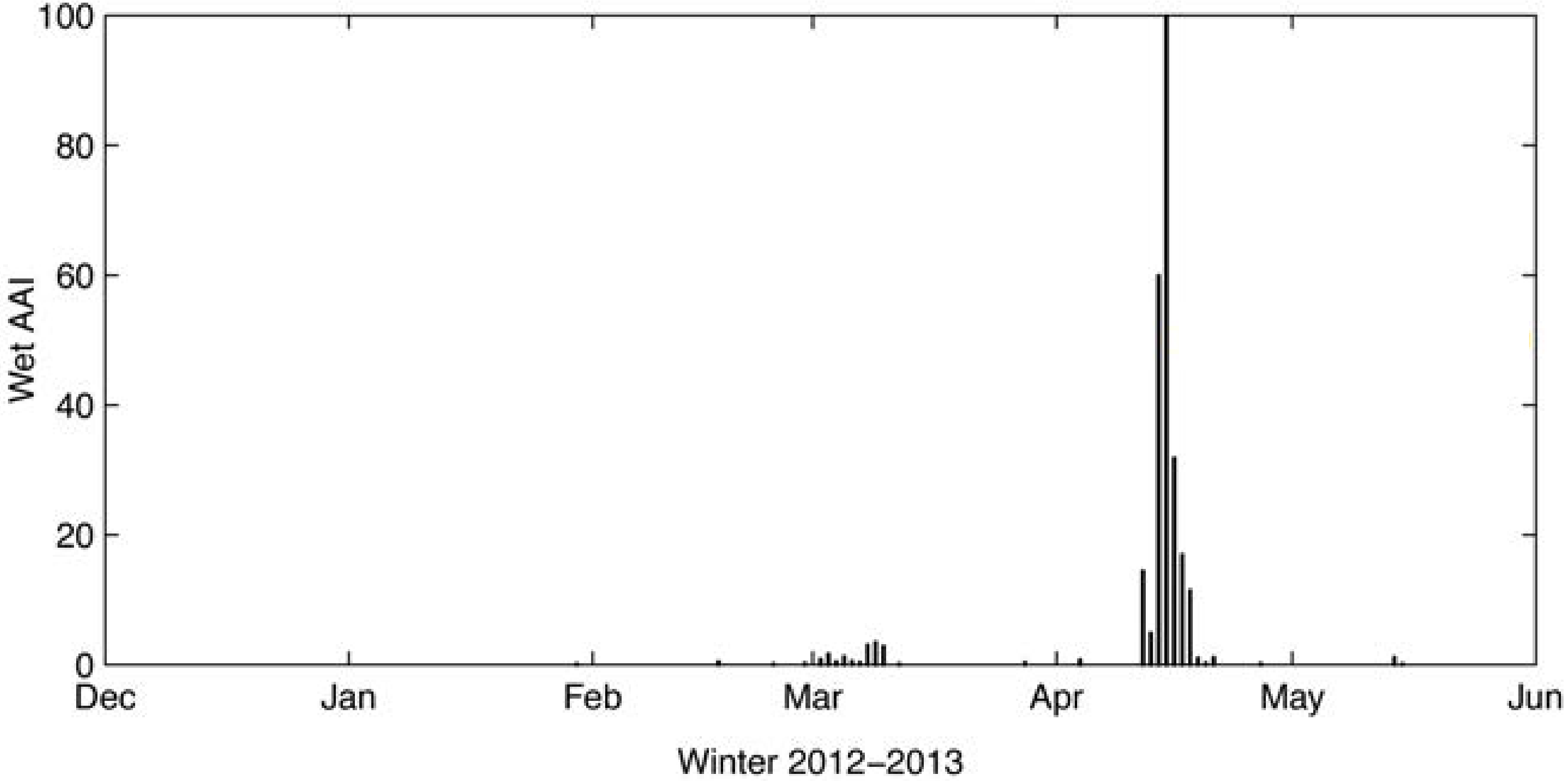
What's the story with the performance?

MIT2 and **MIT3**

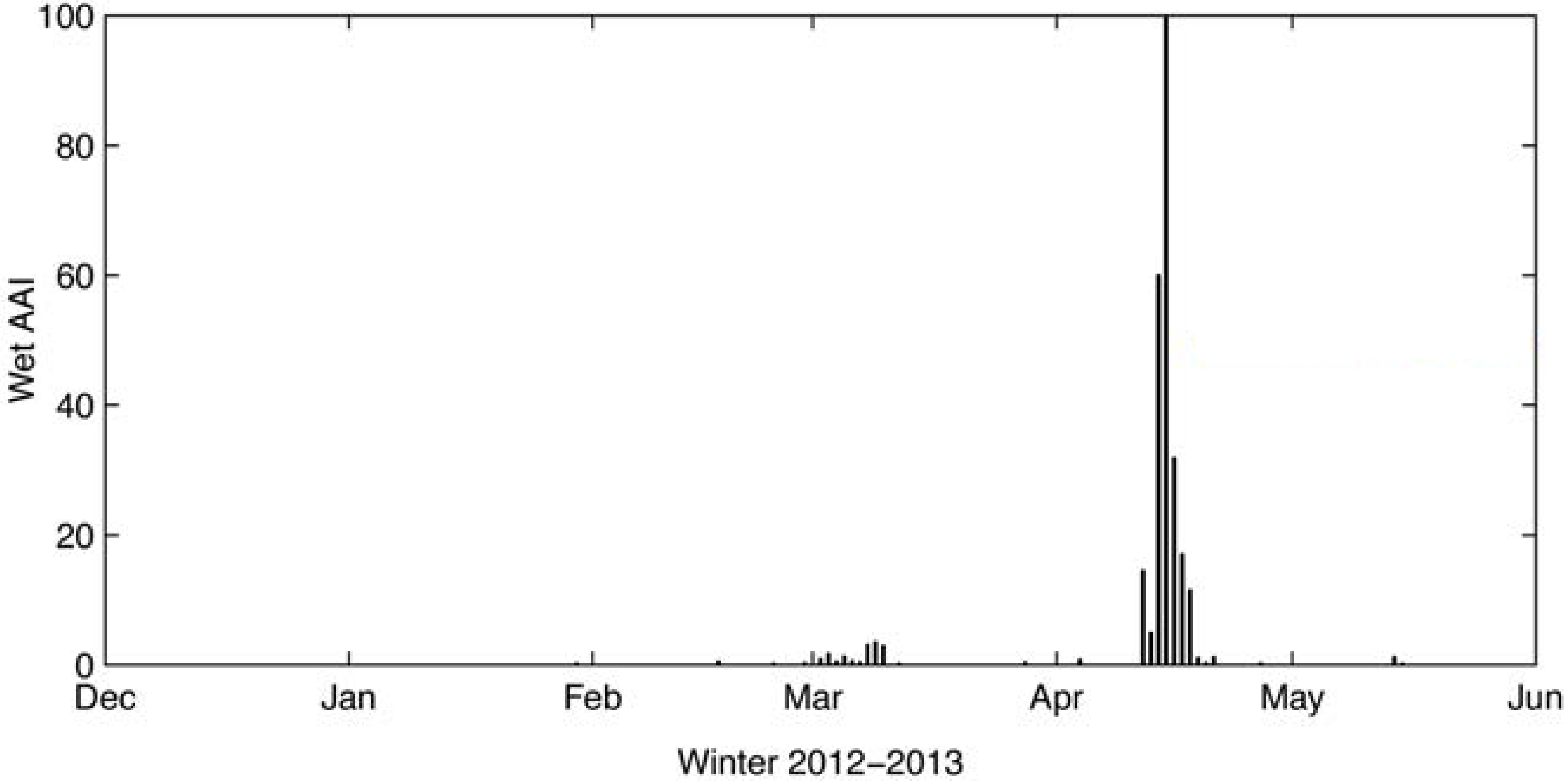
- Hit 8-9 out of 10 avalanche days
- Low rate of misses, but still there
- Recognise only 2/3 of the non-avalanche day
- With both models you predict 7-9 times an avalanche day although no one occurs (high false alarm rate).

⇨ *Makes the models not really suitable for operational use.*

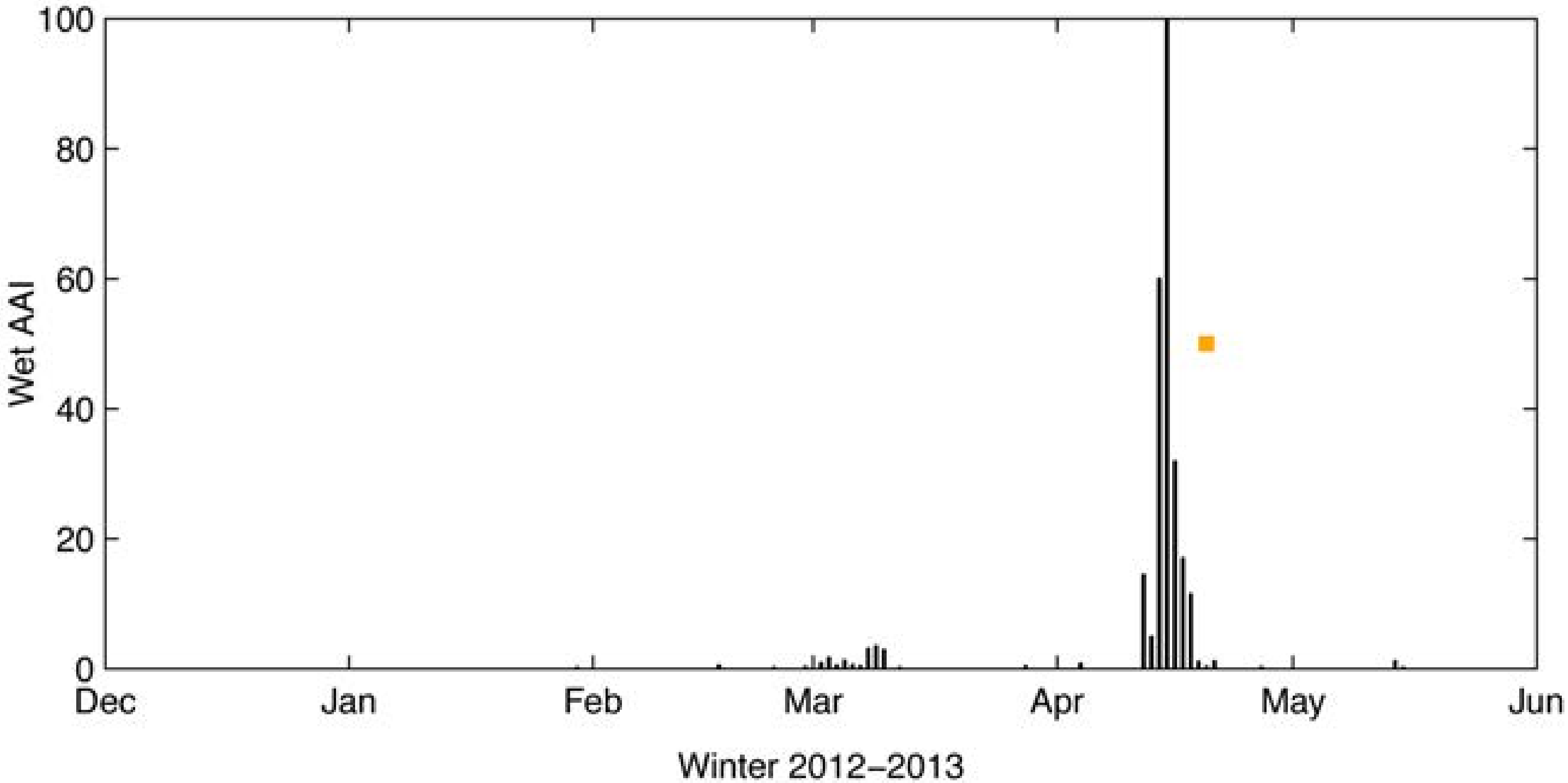
Where do the false alarms occur for MIT2?



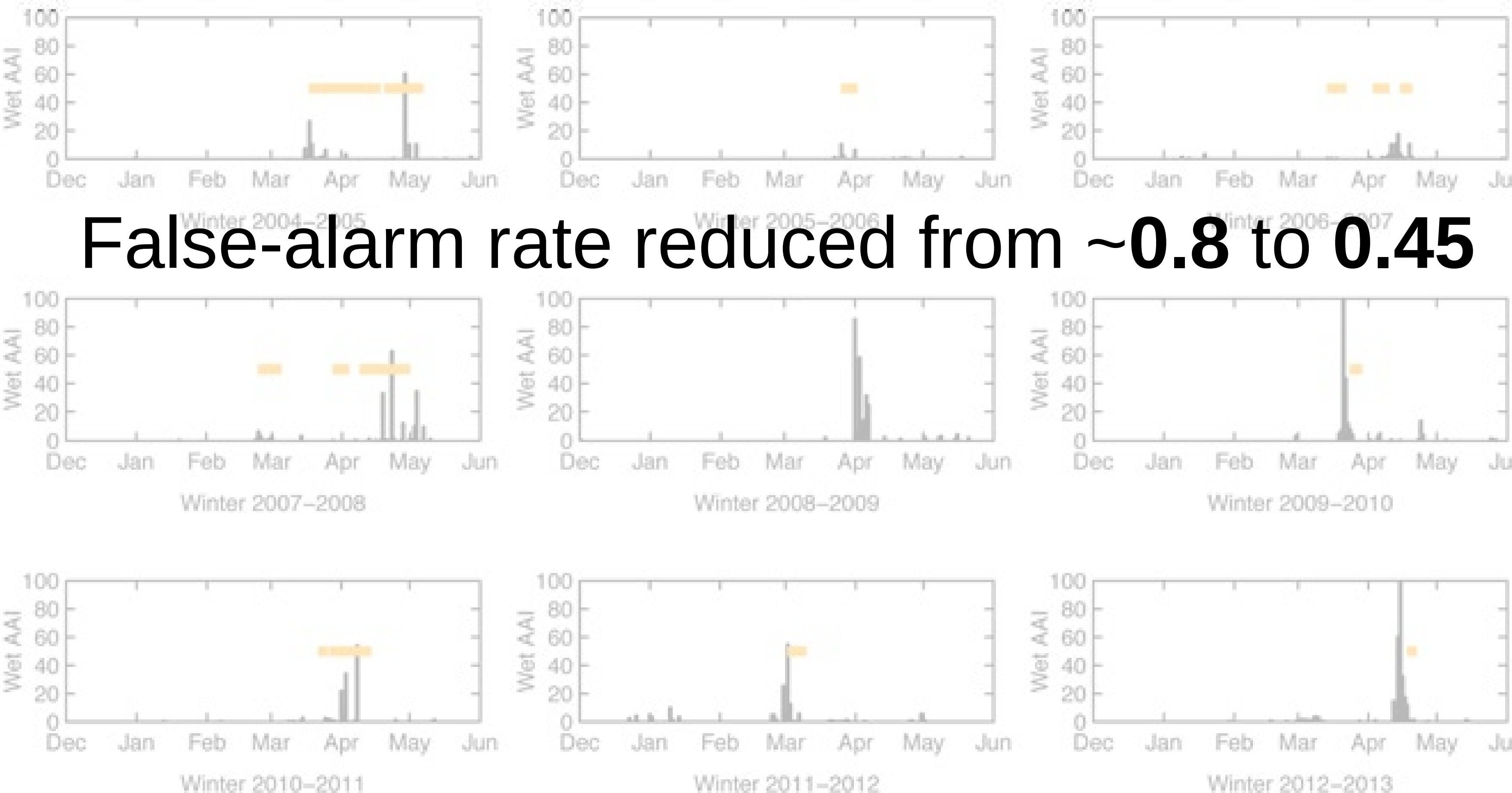
Where do the false alarms occur for MIT3?



Introducing days since isothermal state (MIT3)



Introducing days since isothermal state (MIT3)

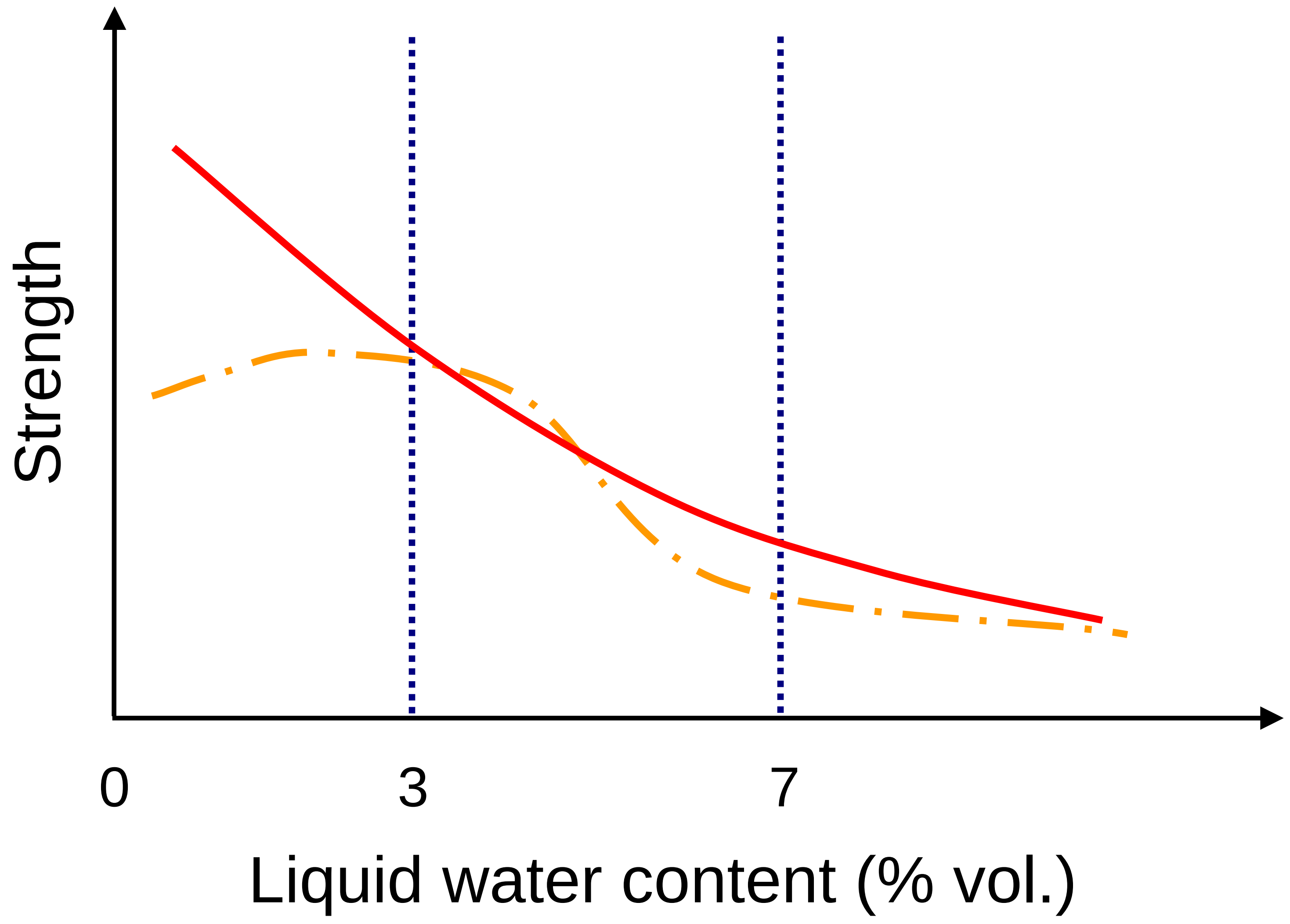


False-alarm rate reduced from ~**0.8** to **0.45**

Conclusions

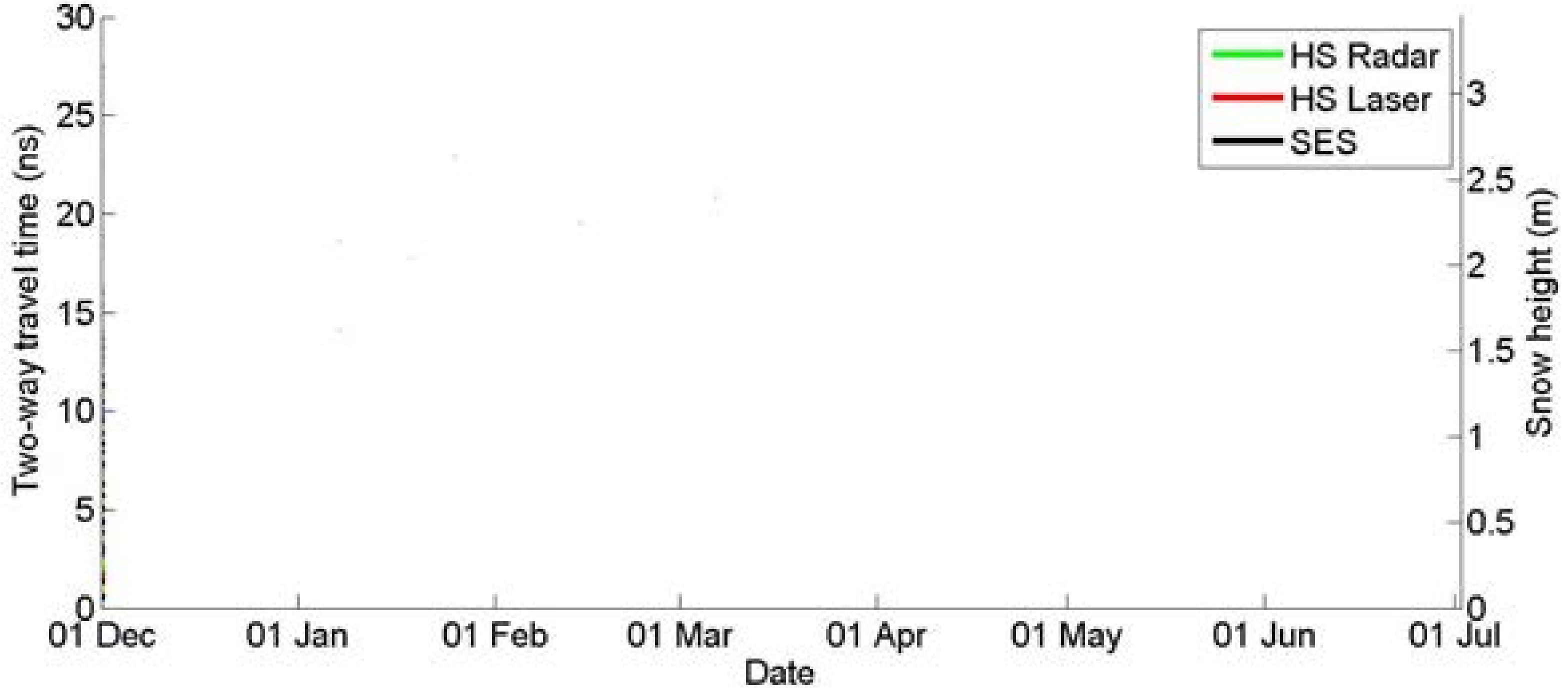
- Knowing energy input (e.g. 3d-sum of TA) and energetic state of the snowpack (e.g. TSS) provides best footing for forecasting models.
- Not all higher complexity models do necessarily provide better predictions.
- More complex models offer better options to tackle false alarms.
- False alarms are governing the performance of the forecasts.
- Forecasters are happy with the energy balance based index.

Why is measuring water so important?

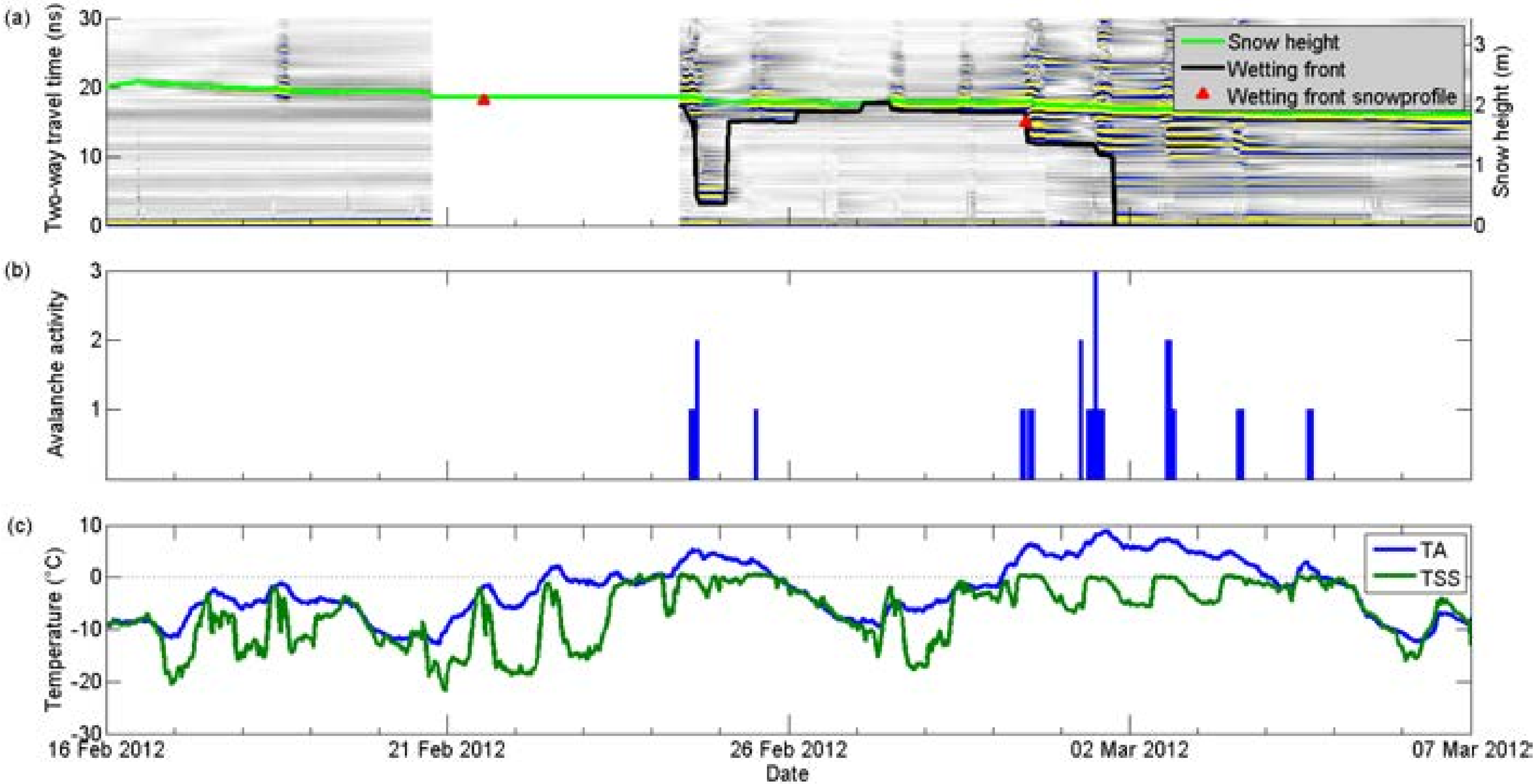


upGPR: Setup in the field

Schmid et al. (2014)

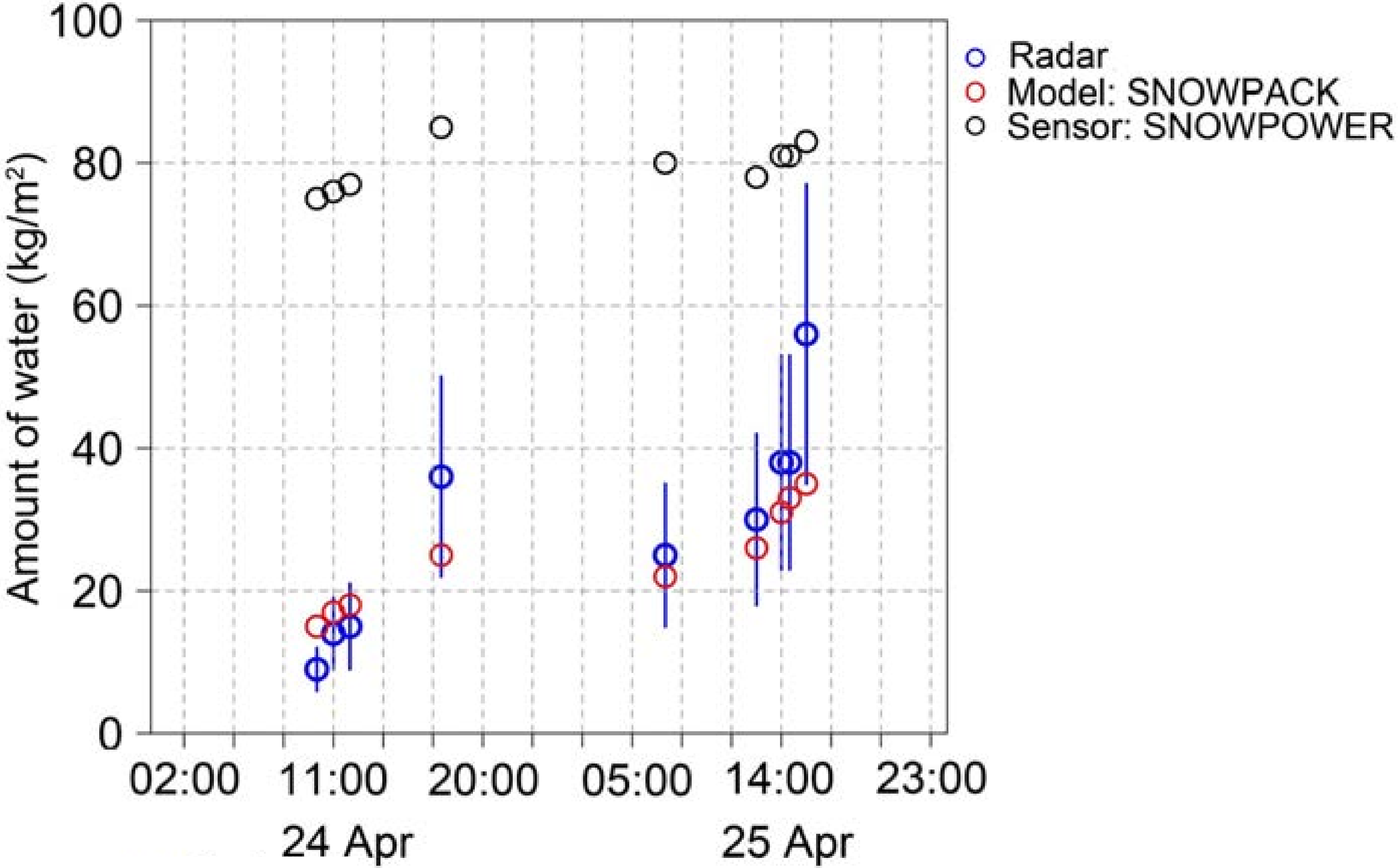


Tracking water in radar signal

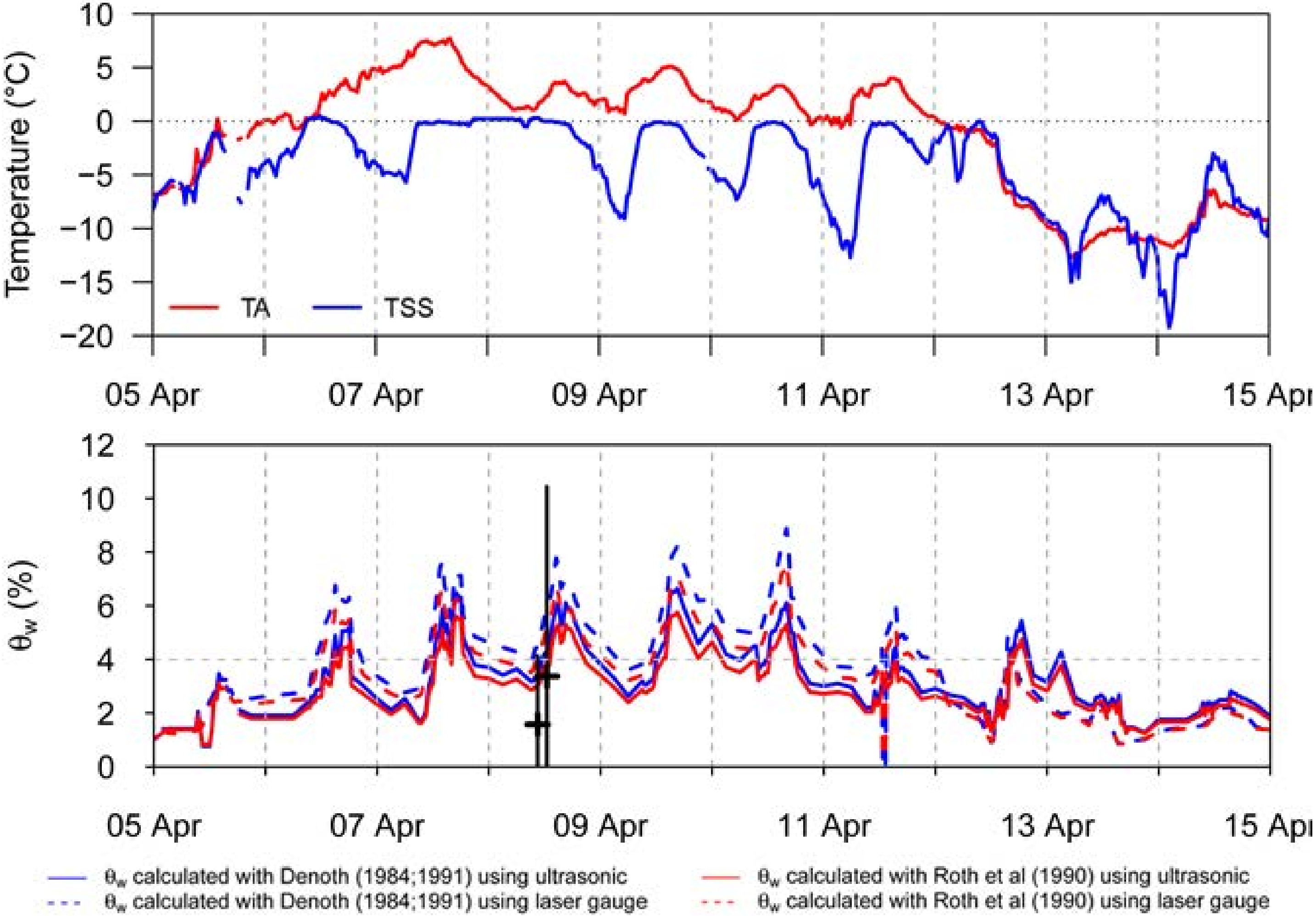


Schmid et al. (2012)

Amount of water within snowpack



Calculating liquid water content



Schmid et al. (2014)

Conclusions

- Moving water can be tracked.
- Average liquid water content for the entire snow-pack can be calculated – but not for single layers.
- Multiple reflections hint to parts of the snowpack with high liquid water content.
- Flow patterns cannot be determined.
- In the future, analysis of frequency content of the multiple reflections and other sensor setups may allow determining liquid water content for single layers.


- Thank you for your attention -