

Snowload – Past, Present and Future

User workshop – Report

Brief overview

Date: 09.04.2024

Time: 9:00 to 12:30 (UTC+2)

Place: Online (WebEx)

Number of participants: 31

Purpose of workshop:

- Introduction of the project FPCUP SNOWLOADS;
- Presentation of the first version of snowload information system for Bavaria;
- User dialogue;

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Introduction

Snow loads have a significant impact on structures, especially buildings, and can have profound effects, especially during intense or extreme snow events. These loads can cause widespread environmental damage, such as impacts on forests, as well as damage to infrastructure and people. It is therefore crucial to accurately characterize the spatial distribution of expected snow loads in each European country.

The FPCUP initiative, in collaboration with partners such as the German Weather Service (DWD), the Centre national de la recherche scientifique (CNRS), the Finnish Meteorological Institute (FMI), and the Politecnico di Milano (POLIMI), aims to develop a Copernicus Climate Change Service (C3S) app on the Climate Data Store (CDS). This app will provide Europe-wide climatological information on snow loads for civil engineering, hazard mitigation and damage prevention. In three pilot regions - Bavaria (Germany), Uusimaa (Finland), and Lombardia (Italy) - three downstream services will use the C3S App data as a basis and enrich it with up-to-date snow load information.

For Bavaria, a pilot downstream service for snow load information is developed, tested, and shared in cooperation with local and municipal authorities as well as disaster response teams. This pilot downstream system aims not only to provide current snow load data for responding to potential high snow load events, but also to contextualize it in the context of climate change using the C3S application.

The project aims to have close communication with stakeholders in order to develop services that users actually want and that are as user-friendly as possible. A first user survey was conducted in autumn 2023, which will be analyzed in a separate report (see [here](#)).

In April 2024, the DWD and its partners organized the first German-language FPCUP SNOWLOAD workshop. This online event represented an important milestone in the development of the snow load information system tailored to the Bavarian region, while also providing insights into the broader objectives of the FPCUP SNOWLOADS project.

With a primary focus on Bavaria, the workshop served as a platform for stakeholders to engage in discussions with developers of the snow load information service for Bavaria. While the discussions and presentations were mainly held in German to address local concerns, English presentations by project partners ensured a broader representation of the European scope of the project.

The workshop attracted considerable interest, with 31 participants. An effective promotion campaign, including email and website promotion, resulted in 28 registrations during the month of March, demonstrating the strong stakeholder engagement.

With a dynamic format of presentations, discussions, and interactive sessions, the workshop facilitated an open exchange of ideas, needs, and expectations. The user dialogue session, supplemented by tools such as word clouds and polls, provided a structured platform for participants to provide feedback and suggestions.

This report aims to distill the insights and outcomes of the workshop, shedding light on the collaborative efforts driving the advancement of the snowload information system in Bavaria and beyond.

Program and overview of the workshop

Uhrzeit	Thema	Sprache	Referent / Referentin
9:00-9:10	Greeting and introduction	German	Bodo Wichura (DWD) Penelope Gehring (DWD)
9:10-9:30	Introduction to snow load and snow load maps	German	Bodo Wichura
9:30-10:15	Introduction to FPCUP SNOWLOADS	English	Ali Nadir Arslan (FMI) Elisa Kamir (CNRS)
10:15-10:30	Break		
10:30-11:15	Snow load information system Bavaria	German	Penelope Gehring
11:15-12:15	User dialogue / discussion	German	Bodo Wichura Penelope Gehring
12:15-12:30	Conclusion & Goodbye	German	Penelope Gehring Bodo Wichura

DWD Deutscher Wetterdienst

FMI Finnish Meteorological Institute

CNRS Centre National de la Recherche Scientifique

The workshop began with Bodo Wichura's presentation on snow load and snow load maps. He provided a solid grounding in snow load fundamentals, including insights into snow load standards and the evolution of snow load zones. Furthermore, he shared findings from a project to refine snow load maps for Germany with practical implications for future snow load standards.

After that, the workshop moved on to discuss the different parts of the project (see also *Introduction*).

Ali Nadir Arslan then presented FPCUP SNOWLOAD and the snow load tools developed by FMI. He also discussed the plans to compare the data from these tools with the C3S snow load app. Moreover, he presented the plans for the pilot downstream service for the pilot region Lombardia.

Elisa Kamir then presented one of the main parts of FPCUP SNOWLOADS, the C3S snow load app, outlining its development strategy and sharing preliminary data analysis results. She also provided a sneak peek of the C3S app prototype, highlighting the ongoing progress in its development.

After a short break, Penelope Gehring presented the pilot downstream service currently under development for the pilot region of Bavaria. She also showed the first version of the system and gave the participants a hands-on demonstration of its functionality. Additionally, she gave a short outlook on how the development will continue and how the data of the C3S app will be used.

For reference, slides from all presentations have been included in the *Appendix* of the report to ensure a comprehensive record of the workshop.

The following section of this report delves into the user dialogue that concluded the workshop, capturing valuable insights and feedback from participants in a straightforward manner.

User dialogue

The user dialogue part of the workshop used polls and word clouds to facilitate interactive engagement and ensured that all participants could contribute their insights, even if they were not comfortable speaking directly online. This section of the report presents the outcomes of

the user dialogue, organized into three parts: polls, word clouds, and comments from the WebEx chat or verbal input.

Polls

The initial poll (see *Figure 1*) revealed that the majority of participants, 70%, were from civil protection departments. Another significant portion, 15%, represented the property management sector. Notably, 20% of participants selected "other," with individuals using the chat feature to elaborate on their specific sector providing additional clarity on their backgrounds and affiliations. For example, road maintenance and construction consulting were mentioned, as well as participants involved in the development of the DWD's national hazards portal.

The consistency between the results of the workshop survey and the findings from the user survey conducted in the fall of 2023 is noteworthy. In both cases, there is a predominant representation from civil protection departments, indicating a continued and significant interest from this sector in snowload information services. This alignment underscores the importance of considering the needs and requirements of civil protection departments in the ongoing development of snowload-related initiatives.

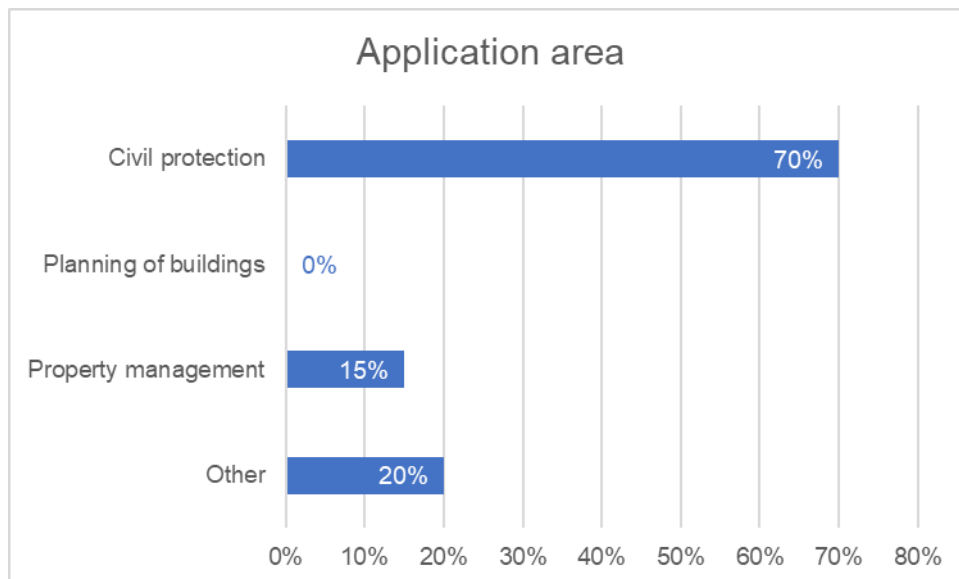


Figure 1: What is your application area (multiple-choice) Respondent: 20

Reflecting on earlier feedback gathered during the user survey, it was noted that the terms "grid" and "point data" may not have been adequately defined, potentially leading to misunderstandings. To address this, participants were again asked to express their preference between these two data formats during the workshop.

Following the poll, it was revealed that all 17 participants unanimously voted in favor of the "grid" data format. This broad consensus underscores a clear preference within the audience for grid-based data representation.

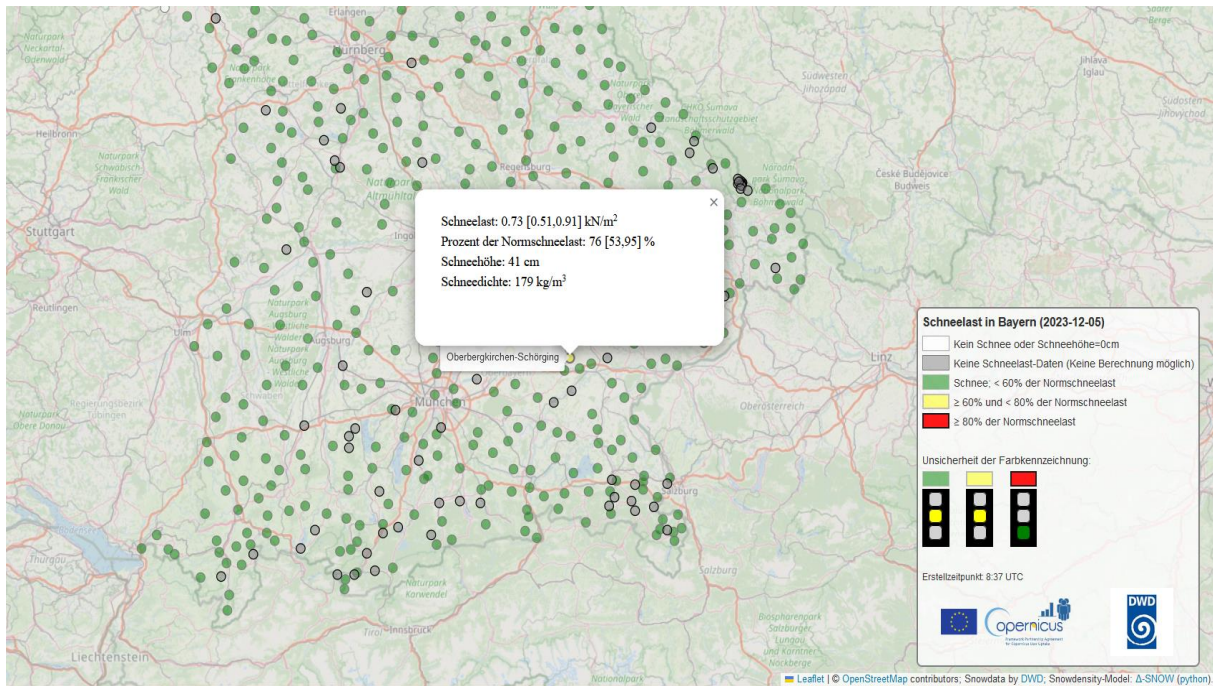


Figure 2: Example of a snow load map showed during the user workshop

The workshop then turned to user feedback on the first version of the snow load information system (see Figure 2), focusing initially on the markers on the map and the accompanying legend. Two separate polls were conducted to gather insights: the first asked for ratings on a scale of 1 to 5 stars, while the second used a multiple-choice question to assess the perceived helpfulness, practicality, and understandability of the markers and legend.

The initial poll (see Figure 3) showed that the majority of respondents rated the markers and legend favorably, with a significant proportion assigning a rating of 4 stars or above. This indicates a generally positive reception of these components within the snow load information system.

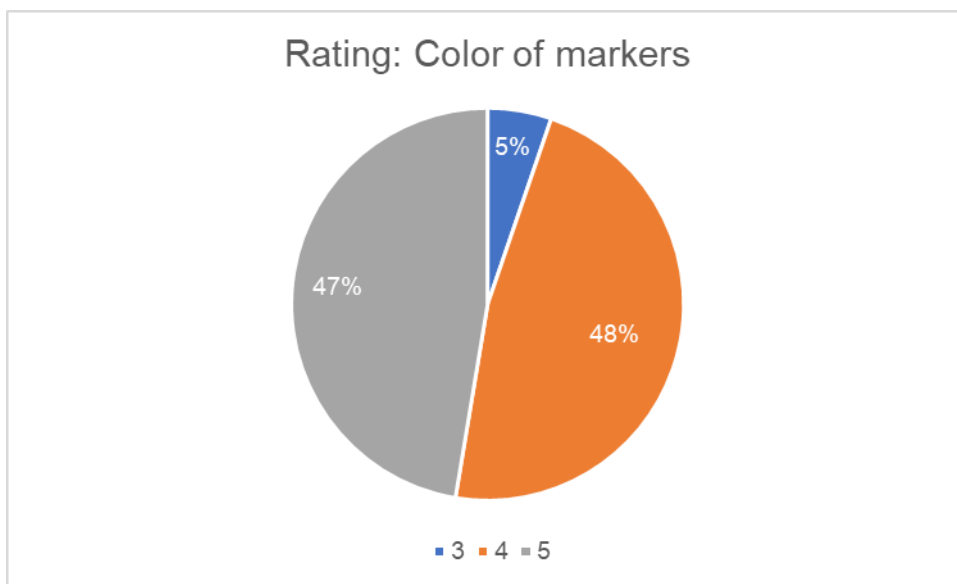


Figure 3: Do you like the color of the markers and the corresponding legend? Respondent: 19 Score: 4.4

However, the subsequent multiple-choice question (see Figure 4) highlighted some nuances in participant’s perceptions. While about 86% of participants found the markers to be

understandable, only 20-30% found them to be practical and helpful. This discrepancy suggests that while users may comprehend the markers, they may not find them sufficiently actionable or informative in their current form.

Given these findings, further research is warranted to explore ways to improve the markers to increase their practicality and usefulness from the user perspective.

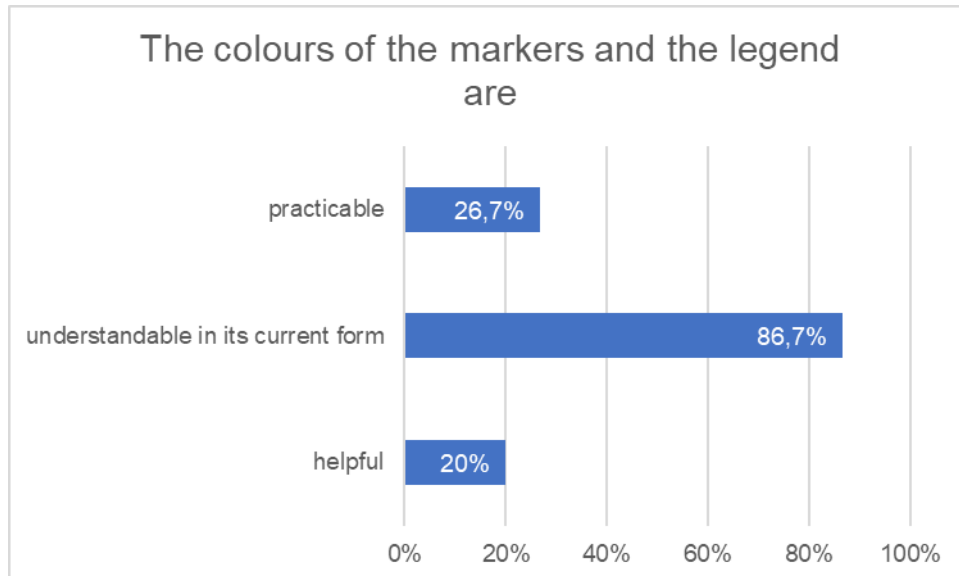


Figure 4: How are the colours of the markers and the legend? (multiple-choice) Respondent: 15

The discussion then moved to the incorporation of traffic lights into the snow load information system to provide insight into the certainty of the model predictions. The participants were again asked two questions, one about their rating of the traffic lights, and another about their understandability, helpfulness and practicality.

Although the majority of respondents gave ratings of four stars or higher, a notable 5% of respondents rated the traffic lights with only one star (see Figure 5). This suggests potential challenges in understanding the current format of the traffic light system. In fact, while 75% of participants found the traffic lights helpful, only about 37% found them understandable, and an even smaller proportion found them practical (see Figure 6).

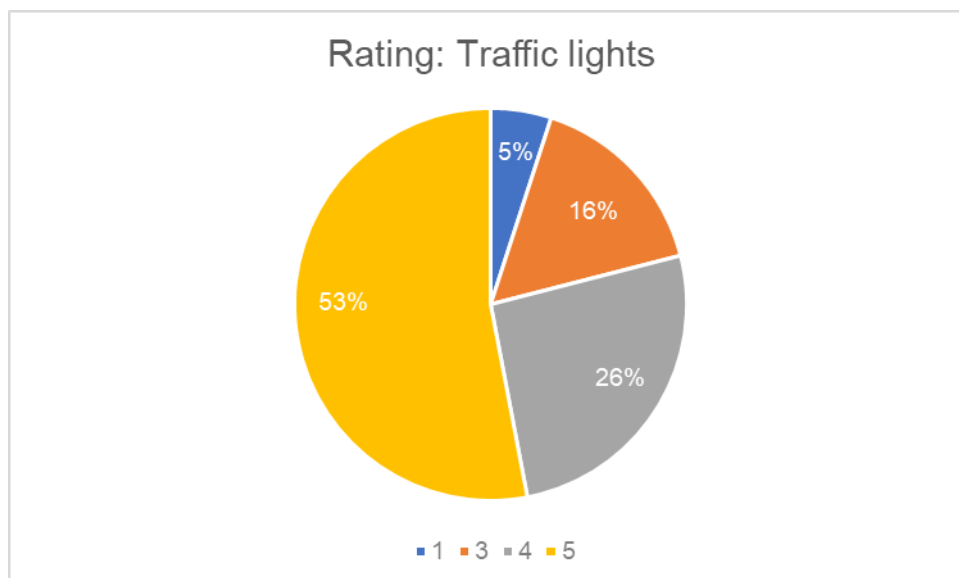


Figure 5: Do you like the traffic lights? Respondent: 19 (Score: 4.2)

One participant noted a potential source of confusion: the integration of the traffic lights within the legend. This led to uncertainty about whether the traffic lights were part of the legend or provided additional information. In addition, the lack of visible changes in the traffic light colors unless there is a significant snow load further complicated understanding for some participants.

These findings highlight the need for clarity and refinement in the presentation of the traffic light system within the snow load information system. Addressing these concerns is essential to ensure that users can effectively interpret and use the information provided by the traffic lights in their decision-making processes.

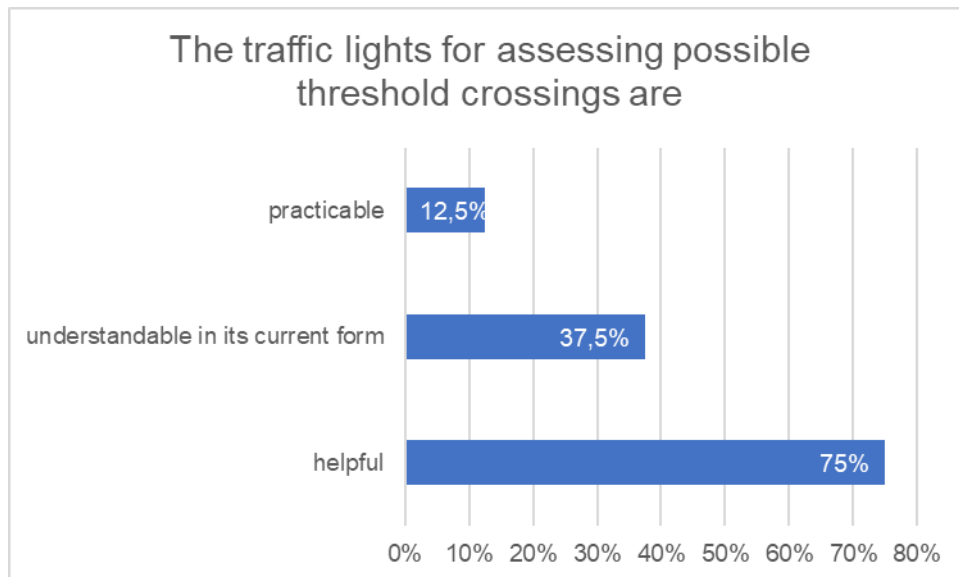


Figure 6: How are the traffic lights for assessing possible threshold crossings? (multiple-choice) Respondents: 16

The discussion then moved to the presentation of error intervals, where the estimated mode error was depicted in terms of upper and lower limits for snow loads. Participants were again asked to provide ratings, along with assessing the helpfulness, understandability and practicality of the error intervals.

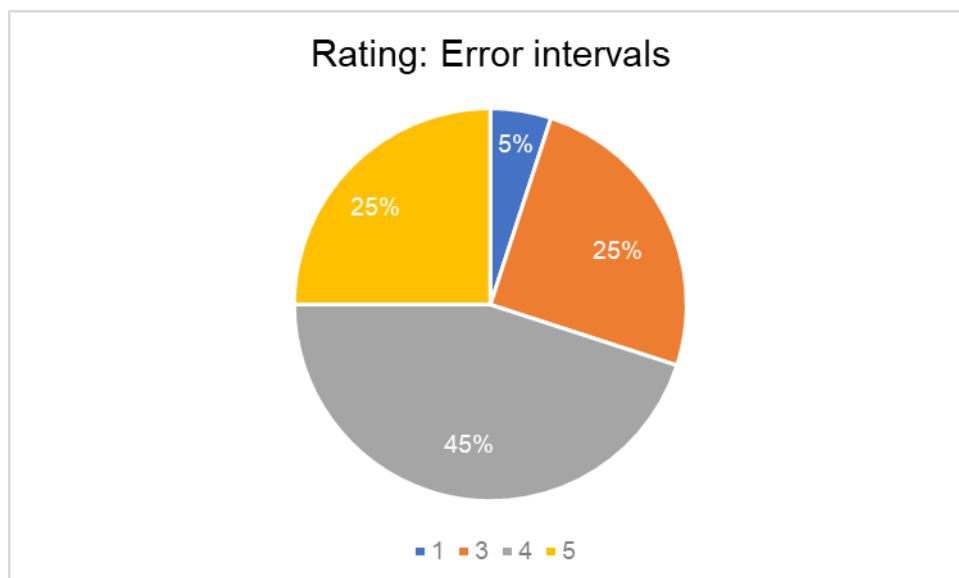


Figure 7: Do you like the error intervals? Respondent: 20 (Score 3.9)

Analysis of participants' responses (see Figure 7) revealed that 25% of the respondents rated the error intervals as three stars, while 5% gave it only one star. In addition, 25% rated it four

stars, indicating that the majority rated it with four stars or lower. This suggests a consensus among participants that while the information provided by the error intervals is considered helpful, the display method may not be easily understandable or practical (see also *Figure 8*).

One participant highlighted a potential source of confusion: the notation used for the error intervals. They noted that, at first glance, the format resembled a decimal number in parentheses, leading to initial misunderstanding. They suggested using words instead of mathematical notation to improve clarity and comprehension for users.

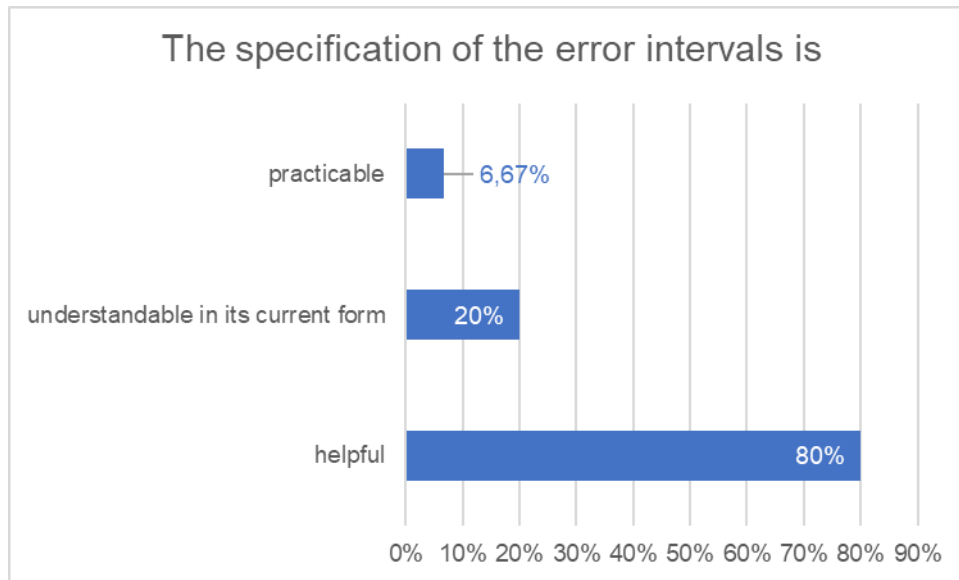


Figure 8: How is the specification of the error intervals? (multiple-choice) Respondent: 15

The feedback section concluded with an overall rating of the snowload maps, which showed a high level of satisfaction among respondents (see *Figure 9*). An overwhelming 85% of respondents gave the maps five stars, while the remaining 15% gave them four stars.

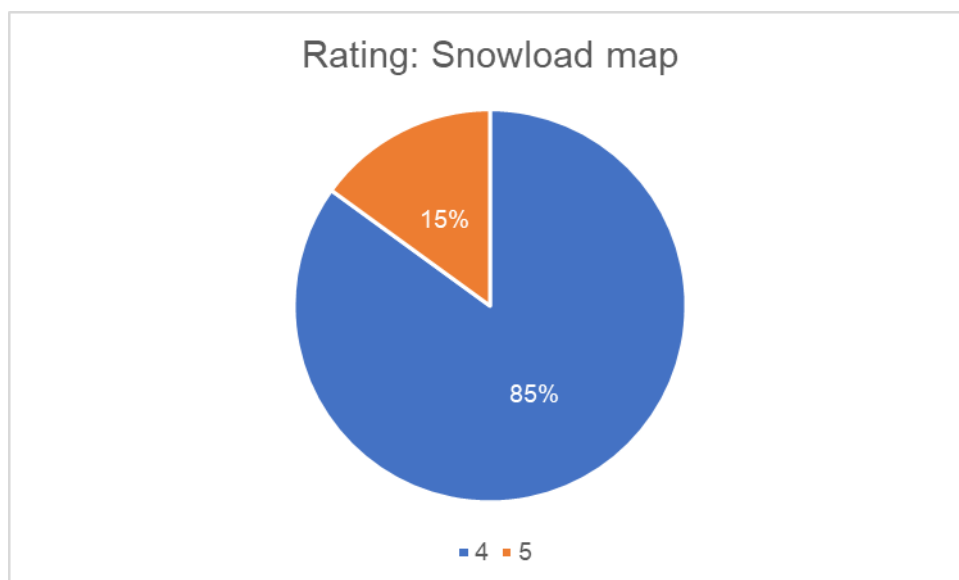


Figure 9: Overall evaluation of the snow load maps (Score 4.2) Respondent: 13

Despite specific criticisms raised regarding certain aspects of the maps, such as the markers, legend, traffic lights, and error intervals, the collective sentiment indicates overall satisfaction with the first version of the snowload maps.

Continuing the discussion, the participants were asked about their requirements for the further development of the snow load information system, especially with regard to the data displayed on the maps. The results (see *Figure 10*) indicate that both snow load and snow depth were strongly desired by more than 75% of respondents. However, there was less enthusiasm for snow density, with only about 38% of respondents expressing a strong desire for its inclusion on the maps.

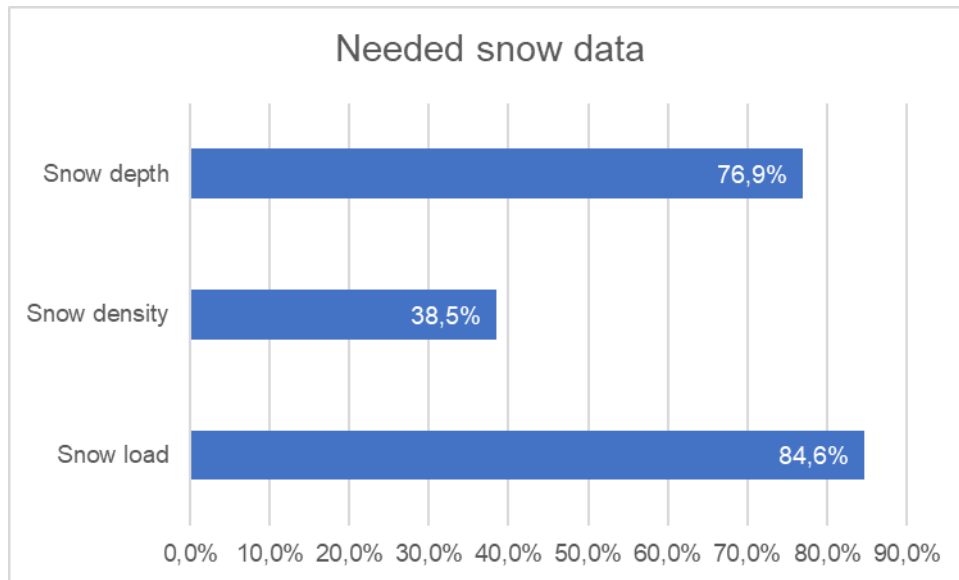


Figure 10: What snow information do you need that is shown on the map? (multiple-choice) Respondent: 13

In the final poll, participants were asked about their preferences for the spatial resolution of the snow load information system. Options ranged from 1 km x 1 km to county or district level. The results (see *Figure 11*) indicated that a majority (53%) favored a spatial resolution of 1 km x 1 km.

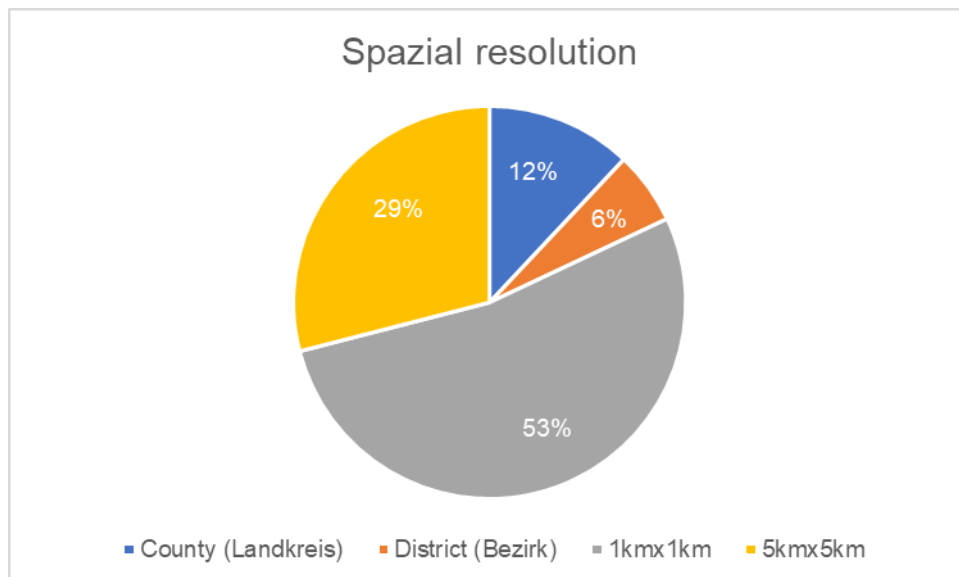


Figure 11: What kind of spatial resolution would be most useful for you? Respondent: 17

However, there was also considerable interest in other resolution possibilities, with varying degrees of support for 5 km x 5 km and county or district level resolutions. The least preferred option was 10 km x 10 km, suggesting a preference for finer spatial resolution among participants.

Word cloud

This section focuses on the input gathered through word clouds, where the participants' responses to two key questions provided valuable insight into their wishes and priorities regarding the further development of the snow load information system.

In response to the question about general wishes for a snow load system (see *Figure 12*), participants overwhelmingly emphasized the importance of usability, expressing a desire for simple and quick access to the system. In addition, there was significant interest in features related to monitoring trends in snow load and accessing forecasts.

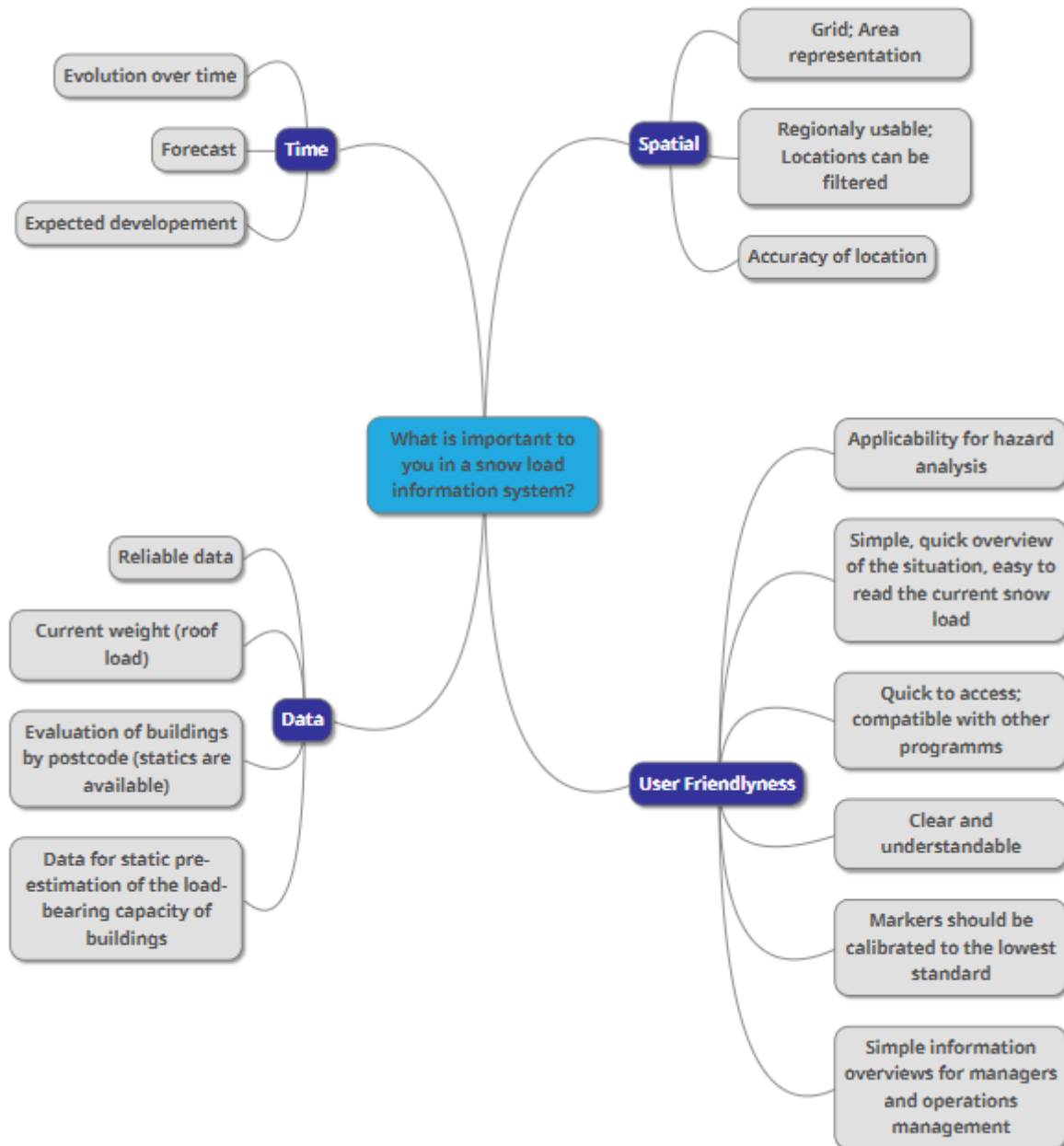


Figure 12: Input of the word cloud regarding the question "What is important to you in a snow load information system?" (Respondent: 15)

In terms of ideas for improvement of the snow load information system during the development of the new version, participants reiterated the importance of forecasting capabilities, highlighting the value of being able to predict snow load conditions. Furthermore, participants expressed a desire for different layers within the system, including one with grid-based data

and another with station points, indicating a need for diverse and customizable data visualization options to meet various user needs and preferences. These insights gleaned from the word clouds provide valuable guidance for prioritizing development efforts and enhancing the functionality and usability of the snow load information system.

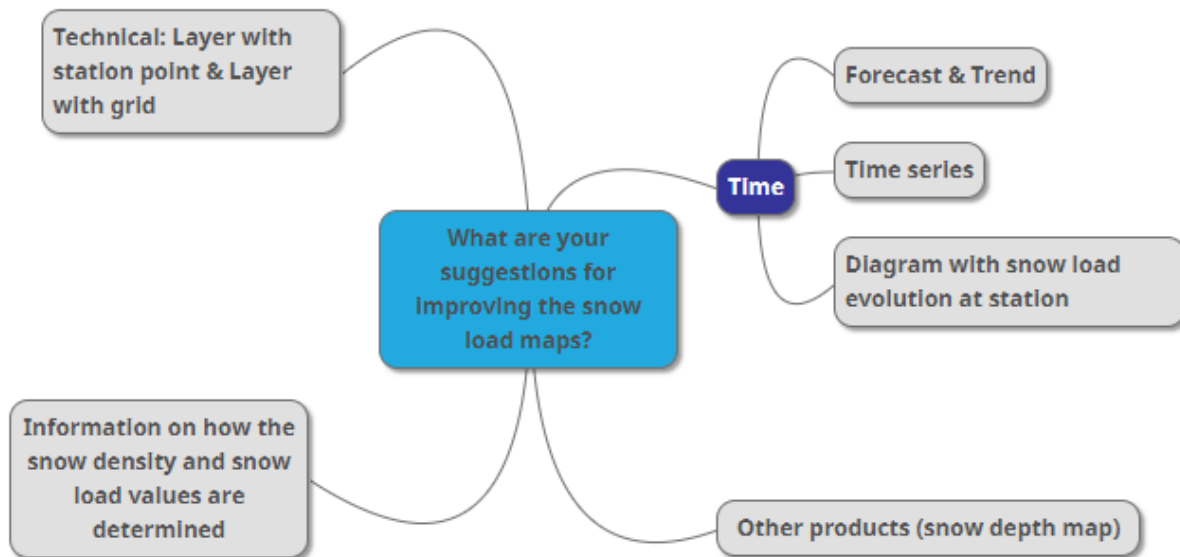


Figure 13: Input of the word cloud regarding the question "What are your suggestions for improving the snow load maps?" (Respondent: 7)

Comments & Discussion

Participants expressed several specific suggestions and interests for improving the snow load information system. There was a notable interest in access historical snow load standards, particularly regarding worst-case scenarios, suggesting the need for comprehensive documentation to facilitate informed decision-making.

In addition, participants highlighted the importance of including roof load statistics, underscoring the relevance of this data for building maintenance and safety. Some participants stressed the importance of including warnings in the system to alert users to potential risks.

Participants also recommended making the used snow load standards directly visible within the legend of the map for enhanced clarity and usability. Furthermore, there was interest in offering user-generated data to augment the system's accuracy.

Finally, participants mentioned the need for legally compliant and reliable information. Particularly in relation to building closure decisions based on comparisons between roof load and snow load in specific areas, the discussion highlighted the importance of operator responsibility for service properties on the basis of reliable information. It was pointed out by DWD that the app can provide as reliable information as possible at the time of its release. The subsequent decisions must be made on the basis of all available information (including building specific information); in this respect, the basic data on snow loads are not legally binding.

Conclusion

In conclusion, we are pleased with the wealth of input and constructive discussions with stakeholders during the workshop. Through engaging dialogues, we successfully addressed open questions and received invaluable feedback and ideas for the further development of the snow load information system. In addition, the increased interest of participants in trying out the test version indicates a growing enthusiasm with the project. Overall, this workshop proved

to be a resounding success and laid a solid foundation for continued collaboration and progress in refining and enhancing the snow load system to better meet the needs of its users.

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Contact information


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Appendix


Presentation I: Introduction to snow load and snow load maps



Deutscher Wetterdienst
Wetter und Klima aus einer Hand




Zone I
Zone II
Zone III
Zone IV
Zone V
Zone VI
Zone VII



Zone I
Zone II
Zone III
Zone IV
Zone V
Zone VI
Zone VII
Zone VIII
Zone IX
Zone X
Zone XI
Zone XII
Zone XIII
Zone XIV
Zone XV
Zone XVI
Zone XVII
Zone XVIII
Zone XIX
Zone XX
Zone XXI
Zone XXII
Zone XXIII
Zone XXIV
Zone XXV
Zone XXVI
Zone XXVII
Zone XXVIII
Zone XXIX
Zone XXX

Einführung Schneelast und Schneelastkarten

Bodo Wichura, Fabiana Castino, Penelope Gehring





Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Motivation

- ab 09.01.2019 wurde für die Landkreise
 - Berchtesgaden, Traunstein, Miesbach, Bad Tölz/Wolfratshausen und Garmisch-Partenkirchen
 der Katastrophenfall ausgerufen



<https://www.ingenieurbau-online.de/deutsches-ingenieurblatt/archiv/berchtesgaden/bad-toelz/ein-jahr-danach>



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Motivation

→ ab 09.01.2019 wurde für die Landkreise

- Berchtesgaden, Traunstein, Miesbach, Bad Tölz/Wolfratshausen und Garmisch-Partenkirchen der Katastrophenfall ausgerufen

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

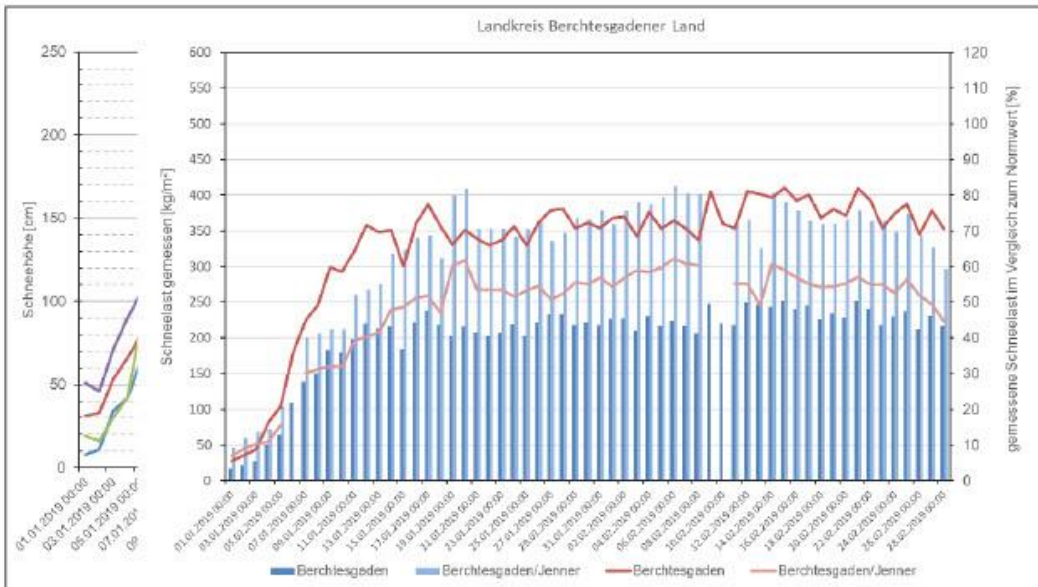
Ortsdaten	Berchtesgaden			Kain			Mitterschwand (Buchhornsweg)		
	Schneehöhe cm	Schneelast kg/m²	Dichte kg/m³	Schneehöhe cm	Schneelast kg/m²	Dichte kg/m³	Schneehöhe cm	Schneelast kg/m²	Dichte kg/m³
01.01.19	6	17	250	11	10	170	12	20	210
02.01.19	11	22	290	17	20	120	18	30	160
03.01.19	24	27	80	20	21	70	28	40	160
04.01.19	42	58	120	24	24	100	25	44	170
05.01.19	64	64	180	27	26	130	27	46	170
06.01.19	55	110	200	25	238	160	29	91	130
07.01.19	60	128	220	26	220	140	28	104	130
08.01.19	52	151	290	28	229	170	25	106	140
09.01.19	68	184	270	33	230	160	28	132	150
10.01.19	209	180	180	241	269	120	130	242	110
11.01.19	115	168	180	143	172	120	137	151	110
12.01.19	106	220	220	162	220	120	130	148	140
13.01.19	88	216	240	140	226	140	112	150	130
14.01.19	90	210	270	109	228	160	89	138	200
15.01.19	98	185	210	108	240	120	103	134	180
16.01.19	82	221	270	100	262	160	89	156	160
17.01.19	70	228	340	102	284	190	88	209	200
größte Schneehöhe									
erforderliche Schneelastensätze nach jeweils gültiger Norm (am Boden)									
Ortsdaten	Berchtesgaden			Kain			Mitterschwand (Buchhornsweg)		
vor 1972	200			200			100		
1972 - 1978	200			200			100		
1978 - 2007	300			300			150		
2007 - 2018	300			300			150		
ab 2018	300			300			150		
	kg/m²			kg/m²			kg/m²		

Schneehöhen und Schneelasten vom 01.01. bis 17.01.2019 (Zeitraum der „Schneekatastrophe 17“ Tabelle: Schwind)

<https://www.noenergiebau-online.de/deutsches-noenergiebau-archiv/fachartikel/elektro-ein-jahr-danach>

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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Motivation

- „Zusammenfassung und Fazit:
- ...
- Anfang 2019 ist kurzzeitig eine große Menge an Schnee in den Alpen und dem Bayerischen Alpenrand gefallen. Der Artikel belegt dies durch Zahlen und Fakten des Deutschen Wetterdienstes.
- Es zeigte sich jedoch, dass die höchste Schneelast im Februar auftrat, als die „Schneekatastrophe“ längst aus der öffentlichen Wahrnehmung und der Berichterstattung der Medien verschwunden war.
- Es war von Vorteil, dass bedenkliche Dächer bereits im Januar abgeräumt wurden. Die größeren Schneelasten im Februar konnten dadurch schadensfrei aufgenommen werden. ...“



Artikel von Ingenieur-Senator (e.h.) Wolfgang Schwind

Ein Jahr danach

Schneekatastrophe in Bayern


Deutscher Wetterdienst (DWD) | 10.02.2020 | [Schneelast](#) | [Drucken](#)

<https://www.ingenieurbau-online.de/deutsches-ingenieurblatt/archiv/fachartikel/ein-jahr-danach>



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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Schneelast

→ Schneelast auf dem Boden: Von einer Schneedecke aufgrund ihrer Masse ausgeübte Kraft auf dem Boden

$SL = mA_{\text{Schnee}} * g$	g	Fallbeschleunigung	$\left[\frac{m}{s^2} \right]$
$SL = W\ddot{A} * g$	$W\ddot{A}$	Wasseräquivalent	$[mm] = \left[\frac{l}{m^3} \right] = \left[\frac{kg}{m^3} \right]$
$SL = SW * SH$	mA_{Schnee}	flächenbezogene Masse der Schneedecke	$\left[\frac{kg}{m^2} \right]$
$SW = SD * g$	SW	Schneewichte	$\left[\frac{N}{m^2} \right]$
	SD	Schneedichte	$\left[\frac{kg}{m^3} \right]$
	SH	Schneehöhe	$[m]$
	SL	Schneelast	$\left[\frac{N}{m^2} \right]$



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Deutscher Wetterdienst
Wetter und Klima aus einer Hand 

Messung der Schneehöhe und des Wasseräquivalents



kdg fdt, picture alliance/dpa, Klaus-Dietmar Gabbert



Schneehöhenmesser SHM 30 (Foto: )



Schneehöhenmesser SHM 30 

Schneehöhenmessung mit Schneepegel und Laseroptischem-Schneehöhensensor

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Deutscher Wetterdienst
Wetter und Klima aus einer Hand 

Messung der Schneehöhe und des Wasseräquivalents



300764820 10510 40 000400000 181 000 0000 



Schneewaage SSG (Foto: Fa. Sommer) 



Schneelastwächter PP313 in Einsatz (Foto: Fa. Messkolle GmbH) 

Wasseräquivalentmessung mit Schneesonde, Schneewaage und Schneelastwächter

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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Schneelastannahmen bei der Planung von Bauwerken

- ➔ Nach der DIN 1055, Teil 5 (2005) wird der „... Rechenwert der Schneelast s auf der Grundlage des charakteristischen Wertes der Schneelast s_k am Boden ermittelt.
- ➔ Der charakteristische Wert entspricht der 98%- Fraktile der Jahresmaxima und hat somit eine jährliche Überschreitenswahrscheinlichkeit von 0,02. Dies entspricht einer mittleren Wiederkehrperiode von 50 Jahren. ...“
- ➔ „... Charakteristische Werte für Schneelasten werden für regionale Zonen (Schneelastzonen) mit unterschiedlichen Intensitäten der Schneelast ermittelt. ...“


Schneelastzonenkarte der DIN 1055, Teil 5 (2005)*
*Aktuell: DIN EN 1991-1-4/NA:2010-12





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Deutscher Wetterdienst
Wetter und Klima aus einer Hand



DIBt-Forschungsvorhaben: Bereitstellung von Schneelastwerten für das Bauwesen durch den DWD

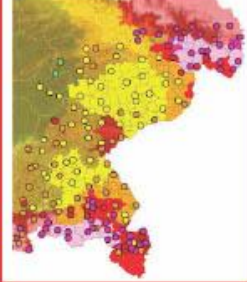
1975


2005


2016

2023







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Wetter und Klima aus einer Hand

Pilotuntersuchung (DIBt)


- Pilotuntersuchung „Flächenhafte Analyse von Schneelastmesswerten in fünf Landkreisen und ihr Vergleich mit den Schneelastzonenendaten der DIN 1055-5:2005“, 2017
- eine Überarbeitung der Schneelastzonenkarte für eine realistischere Darstellung der Schneelasten im Gesamtgebiet der Bundesrepublik Deutschland ist möglich durch:
 - Erweiterung der Datenbasis der Schneedecke mit allen verfügbaren DWD-Zeitreihen (Ergänzung mit weiteren Daten des Wasseräquivalents, Einbeziehung der Daten der Schneehöhe)
 - Analysen zur **Schneedichte** aus Schneehöhe und Wasseräquivalent
 - **Berechnung der Wasseräquivalente** an allen Standorten mit **Schneehöhenmessungen**
 - Ermittlung der **charakteristischen Schneelasten** am Boden mit Extremwertanalysen an allen Standorte mit Werten des Wasseräquivalents
 - **Räumliche Interpolation** der charakteristischen Schneelasten mit Hilfe eines geostatistischen Verfahrens





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Wetter und Klima aus einer Hand


DIBt-Forschungsvorhaben: Bereitstellung von Schneelastwerten für das Bauwesen durch den DWD (Fabiana Castino, 2019-2022)


1975

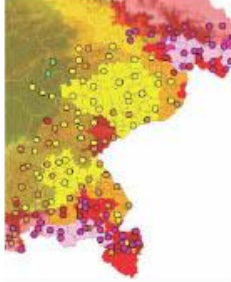
2005


2016


2023












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Wetter und Klima aus einer Hand


Bereitstellung von Schneelastwerten für das Bauwesen

1. Vorbereitung des Schneedatensatzes
2. Wasseräquivalent- Modellierung
3. Raster der Schneedecke (1950-2020)
4. Schneelastkarte



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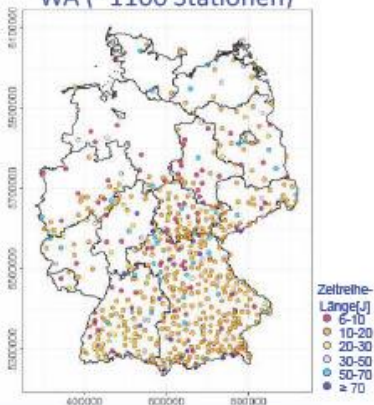
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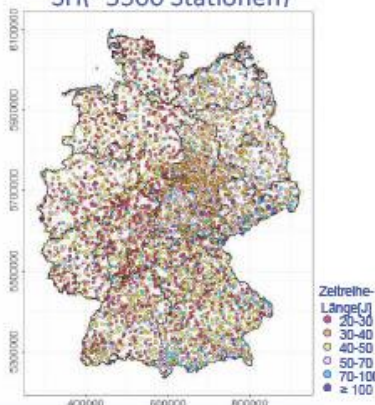
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Schneedatensatz

WÄ (~1100 Stationen)



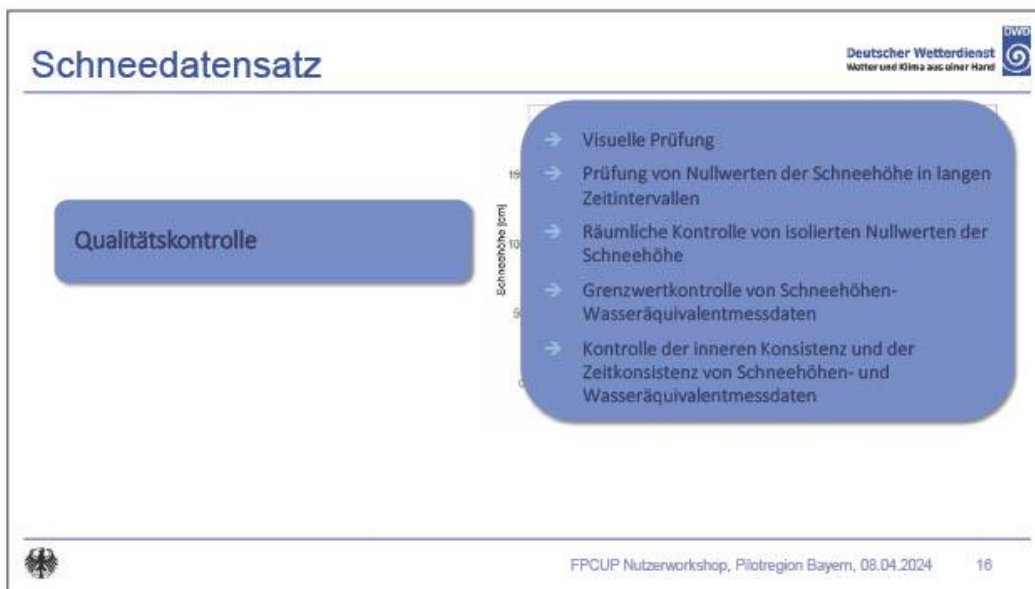
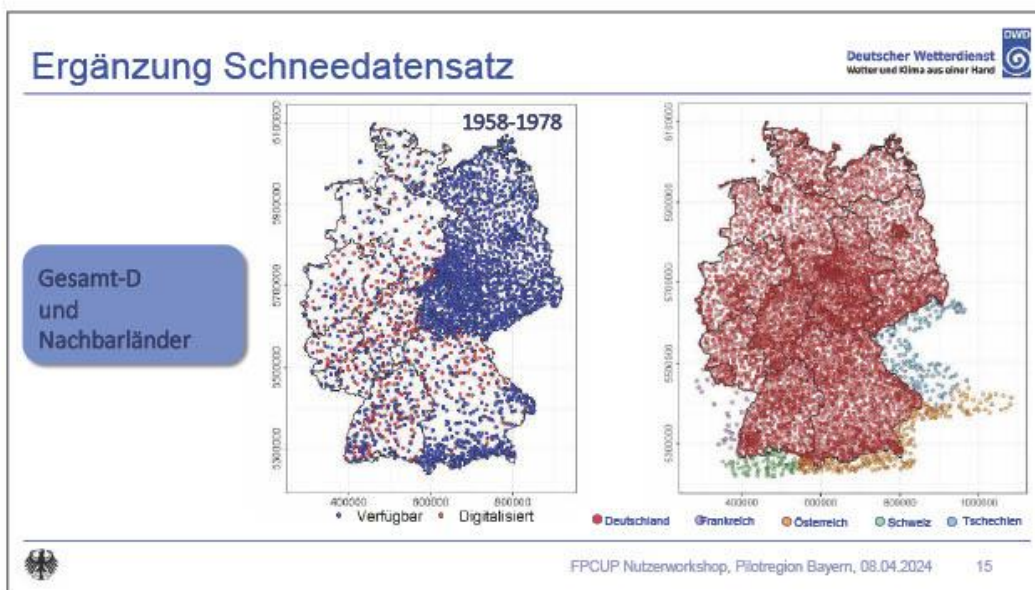
SH (~5500 Stationen)





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Schneedatensatz

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Qualitätskontrolle

Homogenitätstest

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Wasseräquivalent Modellierung

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1. Thermodynamische Schnee-Modelle (Snow4, Crocus, SNOWPACK, SNOWBAL)
Zusätzlich (zu SH, WÄ) Messungen verschiedener meteorologischer Parameter notwendig
2. Empirische Regressionsmodelle (ERM) der Schneedichte ($\rho \approx \rho(\text{SH}, H, \text{Region}, \dots)$)
 - Jonas et al. (2009) – Schweizer Alpen
 - Sturm et al. (2010) – Canada und Schweizer Alpen
 - Pistocchi et al. (2016) – Südtiroler Alpen
 - McCreight and Small (2014) – USA
3. Semi-empirisches Multi-Ebenen Modell Δ_{SNOW} , Winkler et al. (2021), ZAMG
 - Winkler et al. (2021), Österreich

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Raster der Schneedecke (1950-2020)

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Datensatz: gemessene SH / modelliertes WÄ

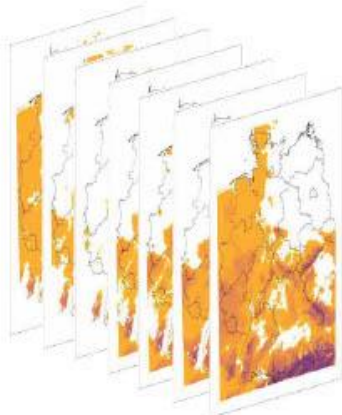
- 6000 Zeitreihen
- Gesamt-Deutschland + Nachbarländer (FR, CH, AT, CZ)
- 1950-2020

Tool: Interpolationsmodul des Modells SNOW4
→ Statistische Interpolation
(Universal Kriging auf ~1km² Gitter)

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Raster der Schneedecke (1950-2020)

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70 Jahre (1950-2020)
Tägliche Raster
1km² Auflösung

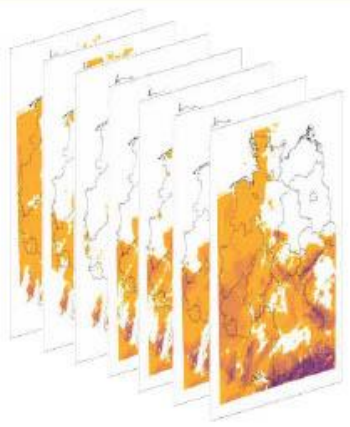
- Schneehöhe
- Wasseräquivalent
- Schneelast

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Raster der Schneedecke (1950-2020)



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S_k charakteristischer Wert der Schneelast am Boden

Extremwertanalyse (EWA)

Methoden


- **Ansatz**
(„Block Maxima“ oder „Peaks over Threshold“)
- **Verteilungsmodell der Extremwerte**
(Gumbel, GEV, Pareto, ...)
- **Schätzfunktion zur Bestimmung der Verteilungsparameter der Extremwerte**
(Maximum Likelihood, Moments, ...)




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Schneelastkarte




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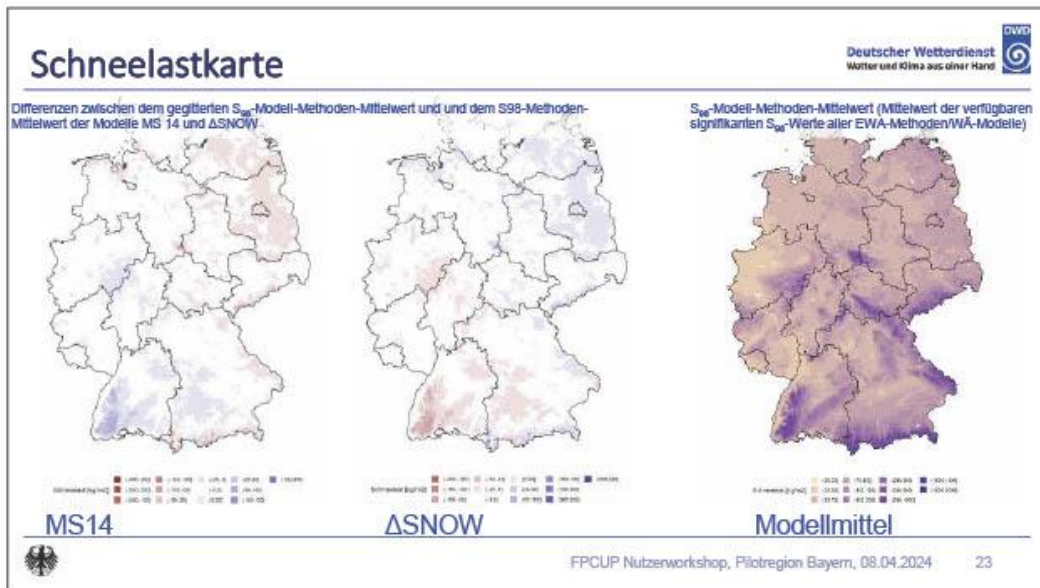
```

graph TD
    WÄModell[WÄ-Modell] --> HM[WÄ-Hybrides Modell (HM)]
    WÄModell --> DS[WÄ-ΔSNOW (DS)]
    HM --> EWA[Extremwertanalyse]
    DS --> EWA
    EWA --> S98[Insgesamt 10 Werte für das 98%-Perzentil der Jahresmaxima der Schneelast (S_98)]
    S98 --> S98HM[S_98^HM - Methoden-Mittel für HM]
    S98 --> S98DS[S_98^DS - Methoden-Mittel für DS]
    S98HM --> Sk[charakteristischer Wert der Schneelast S_k]
    S98DS --> Sk
    Sk --- Note[abgeleitet aus dem S_98-Modell-Methoden-Mittel]
    
```



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Vielen Dank für die Aufmerksamkeit!
Fragen?

Dr. Fabiana Castino
Dr. Penelope Gehring
Dr. Bodo Wichura

Deutscher Wetterdienst
Abteilung Klima- und Umweltberatung (KU1)
Regionales Klimabüro Potsdam
Michendorfer Chaussee 23
14473 Potsdam

techlim.potsdam@dwd.de
www.dwd.de/lastgutachten





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Presentation II: FPCUP SNOWLOAD



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METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

FPCUP SnowLoad

**User Workshop
Bavaria**

Ali Nadir Arslan
Finnish Meteorological Institute
&
Carlo de Michele
Politecnico di Milano

09 April 2024

ali.nadir.arslan@fmi.fi

European Union logo and Copernicus FPCUP logo are present in the top right and bottom right corners.



CONTENT

- Background
- FPCUP SnowLoad Pilot in Uusimaa / Finland
- FPCUP SnowLoad Pilot in Lombardia / Italy

Ilmatieteen laitos
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

European Union logo and Copernicus FPCUP logo are present in the bottom left and bottom right corners.

Background

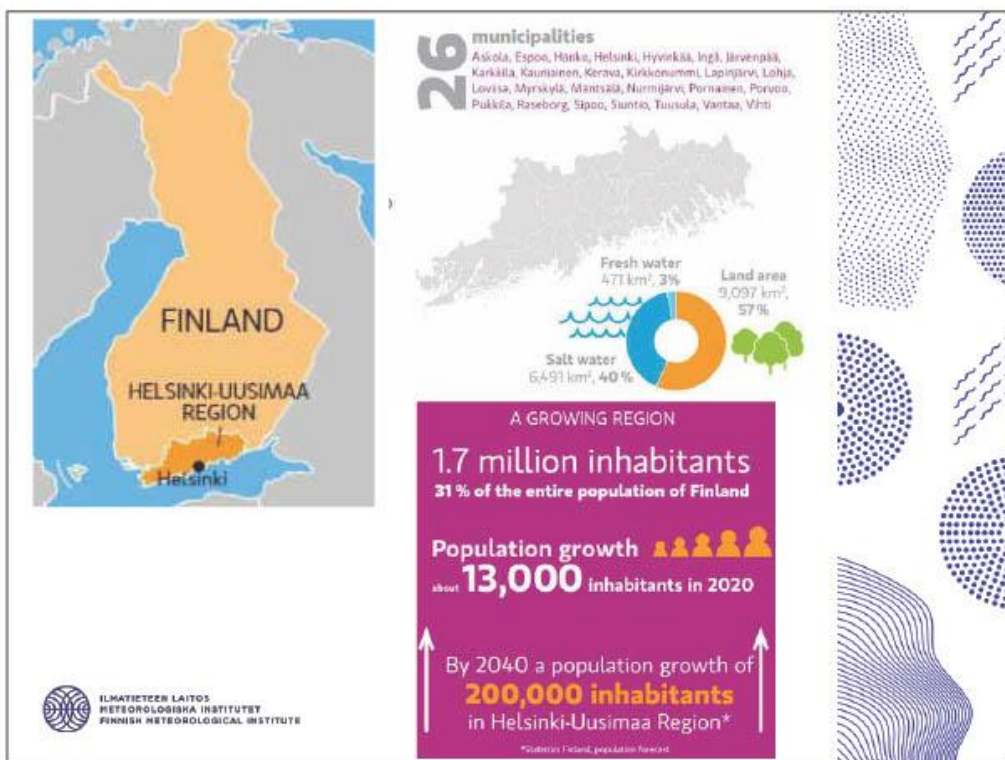
- The C3S App will provide Europe-wide maps of snow load related parameters (i.e., 50 years return values of snow loads; in addition, maximum values of snow depth, snow water equivalent, depending on user requirements) and will make available a basic dataset of snow load information under past and future climate.
- Pilot downstream services will use the data of the C3S core App as basic and background information on snow loads and will enrich them with current snow load information, delivered from National Weather Services, for instance.
- The C3S App and the additional pilot downstream services will be delivered in the context of delivery events (workshops).



FPCUP SnowLoad Pilot

Uusimaa / Finland

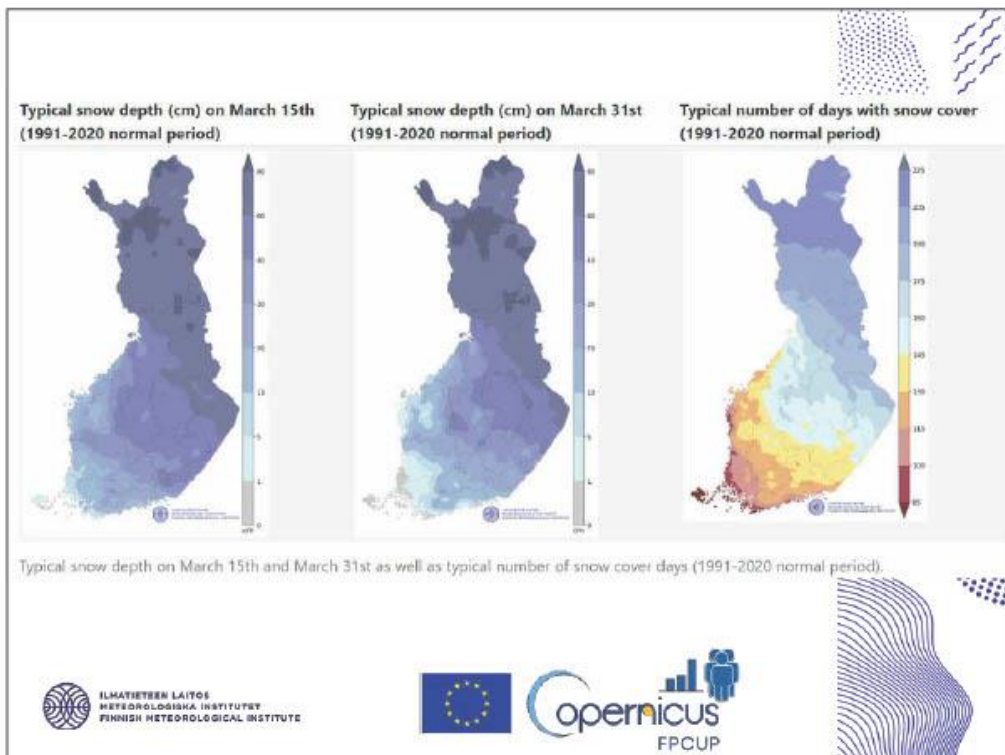
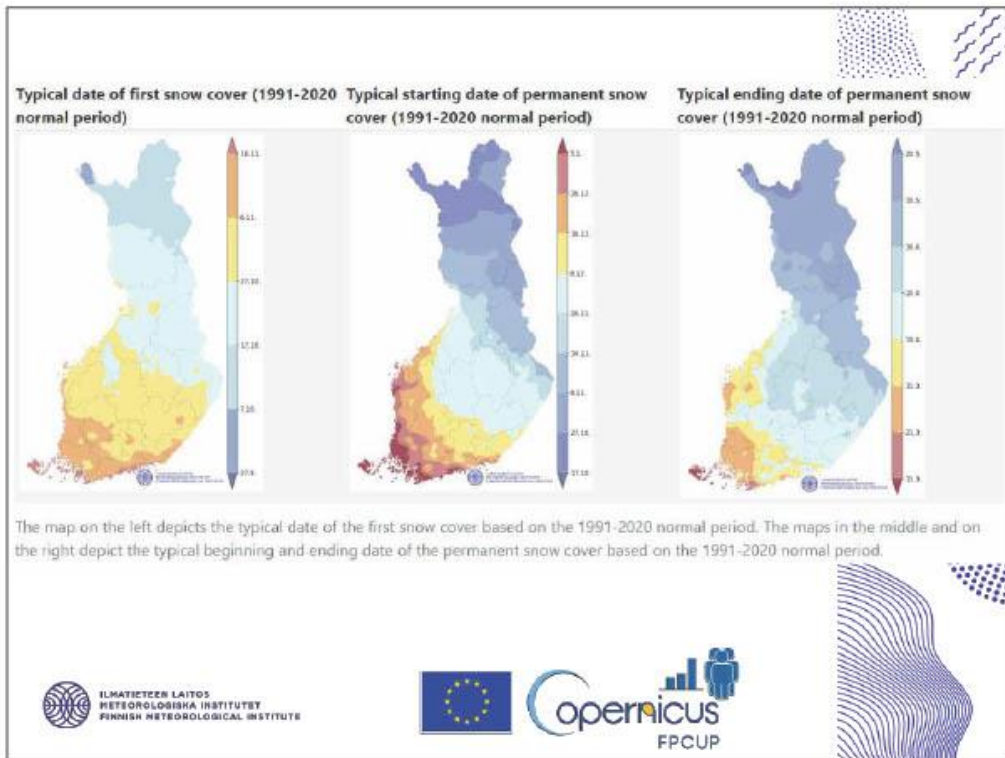


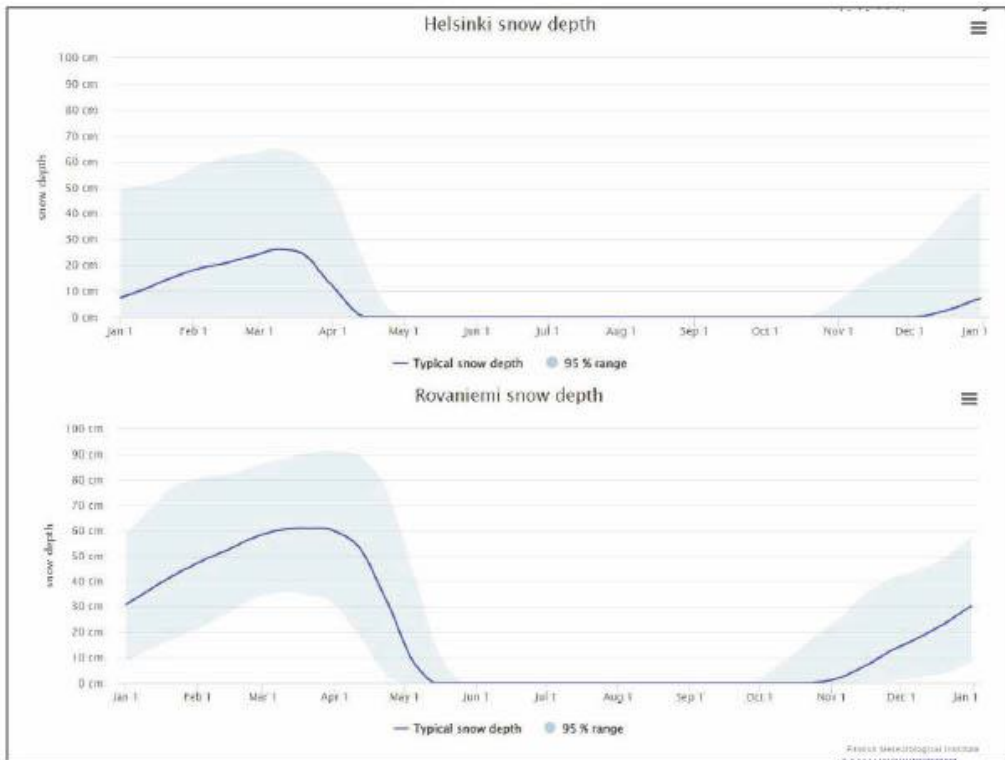


Snow Statistics

- ❑ In Finland the first snow cover is considered to have happened on the day when there is measurable snow in the morning observation (06 UTC). The permanent snow cover is defined as the longest period with consecutive snow cover days.
- ❑ The very first snowflakes fall to the ground in late August or early September over the higher peaks in Lapland. The first ground-covering snow and permanent snow cover arrive at different times in different parts of the country. In Lapland the winter is long (approximately seven months) and the permanent snow cover comes significantly earlier than in southern Finland.
- ❑ The snow cover is usually thickest in mid March, in Lapland often as late as early April. Soon after that the snow cover starts to melt fast.
- ❑ The maximum snow depth is usually found around March (most of the country) or early April (Lapland). Typically, the ground is covered with snow over half a year in Lapland.

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 FINNISH METEOROLOGICAL INSTITUTE





Finnish Meteorological Institute observation stations include a total of about **400 different types of observation stations**. Snow depths are available from 175 observation stations starting from **1961**.



Snow load

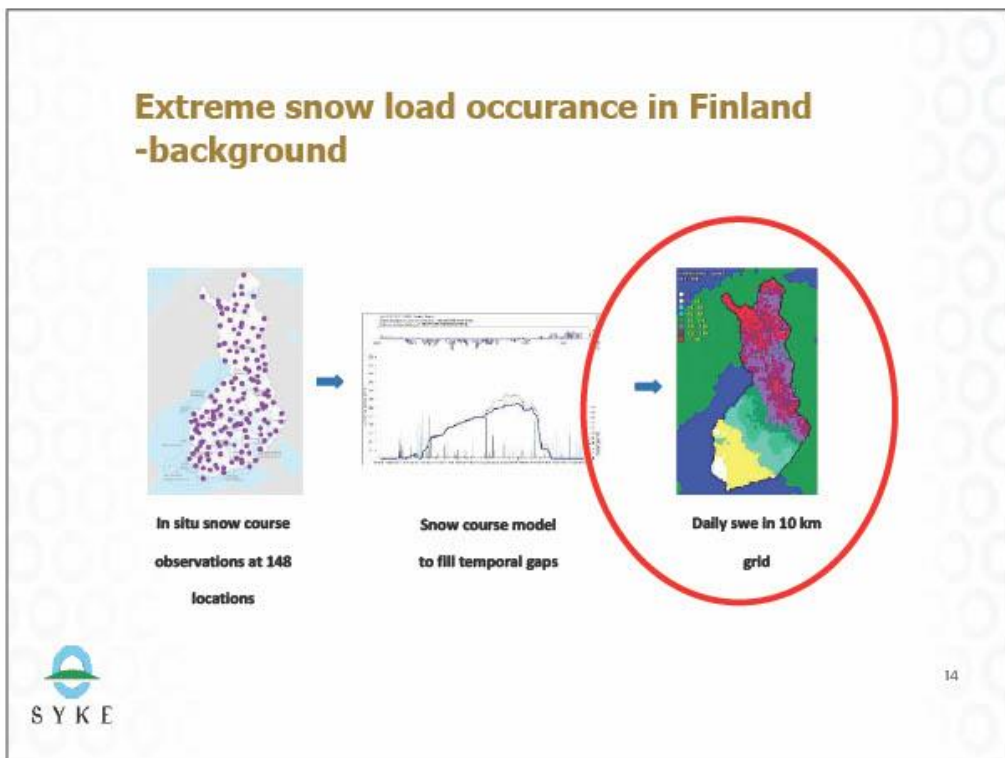
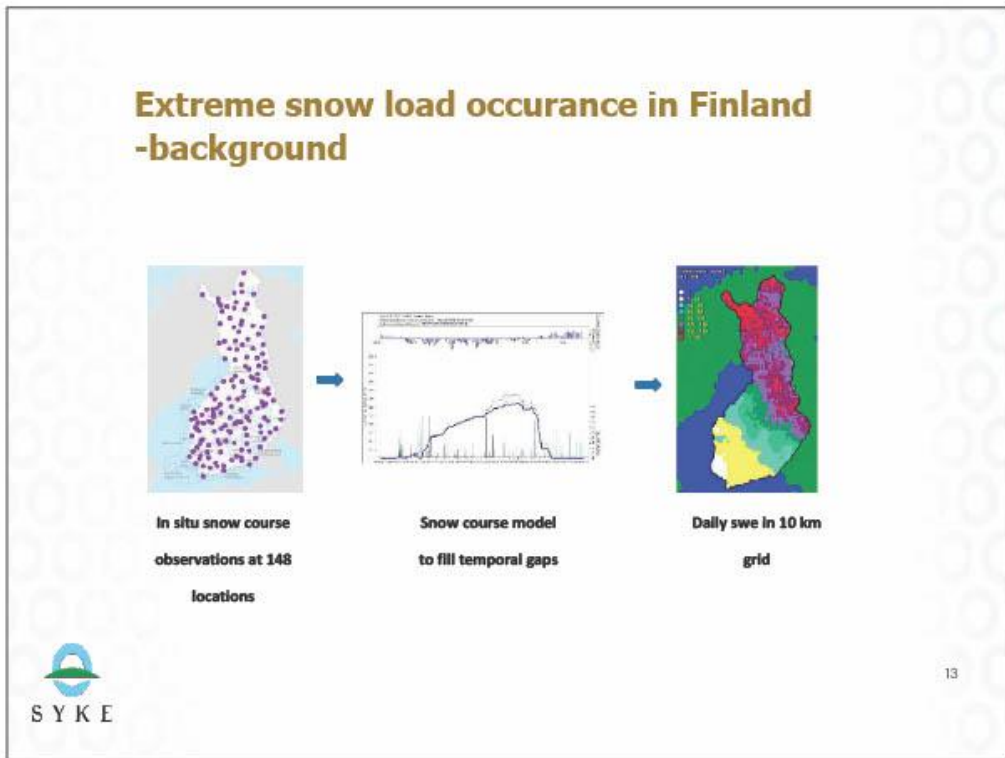
- Snow load:
 - the weight of the snow on ground (kg/m^2)
- Snow water equivalent:
 - Depth of water layer if snow melted (mm)
- Snow load = snow water equivalent
- Snow load \neq roof load

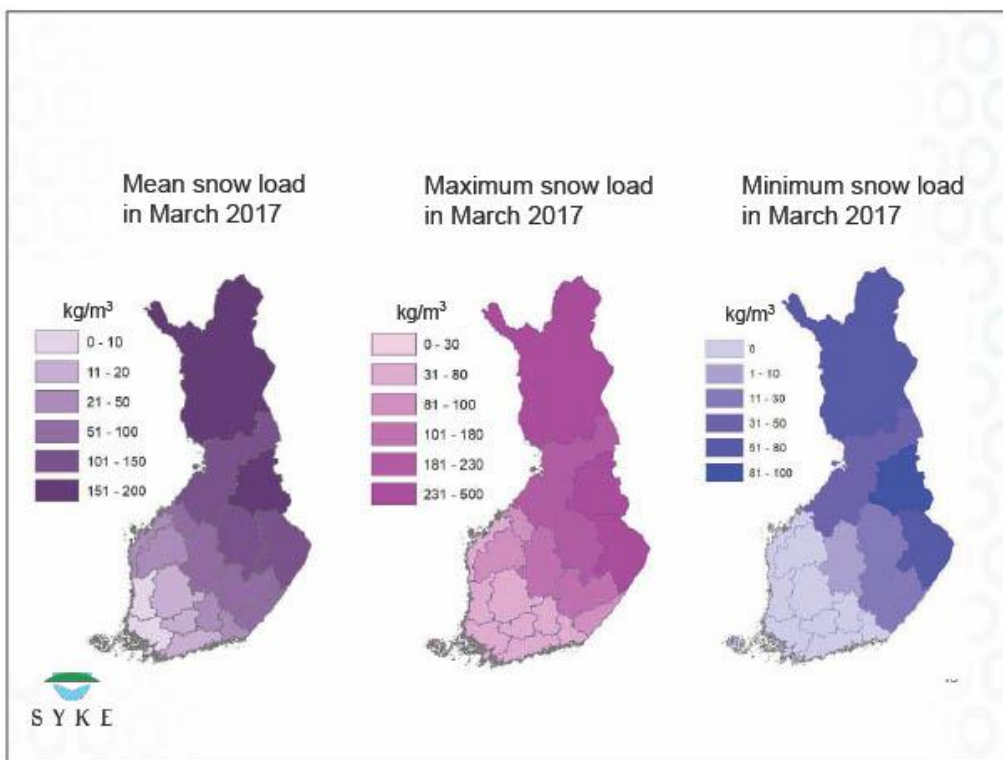


What kind of statistics would describe the snow situation in Finland in different years

- Describe the whole country
 - Regional differences
 - Describing larger areas
- Statistics on annual differences?
- Pointing out extreme cases and years?





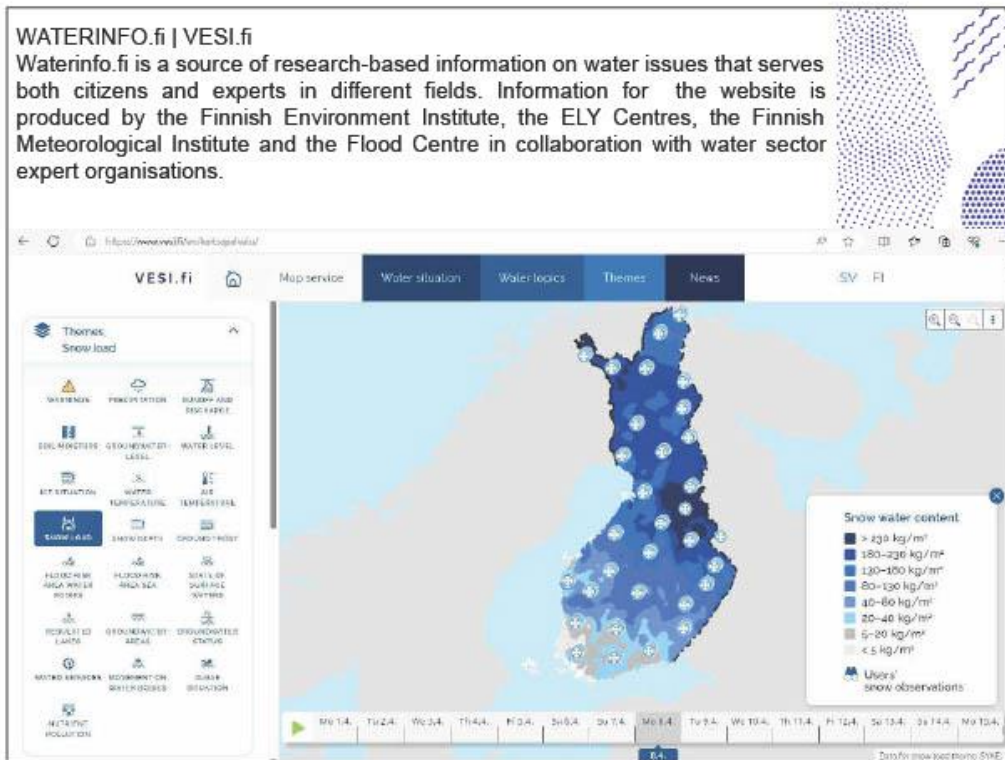


Extreme snow load occurrence in Finland

- Spatial analysis done at County level
 - Also other spatial groupings possible
- Occurrence of heavy snow load (> 100 kg/m²)
 - Number of days at least in one grid point?
 - Number of days at percentage of County area
 - At least n grid points required to count

Number of days when snow load over 100 kg/m² in January 2017





FPCUP SnowLoad Pilot

Lombardia / Italy




The bottom section of the slide features a large title 'FPCUP SnowLoad Pilot' and a subtitle 'Lombardia / Italy'. Below the title, there are two logos: the logo of the Finnish Meteorological Institute (Ilmatieteen laitos) on the left and the Copernicus FPCUP logo on the right. The Copernicus logo includes a stylized globe and the text 'Copernicus FPCUP'. The background of the slide has a decorative pattern of blue dots and wavy lines on the right side.

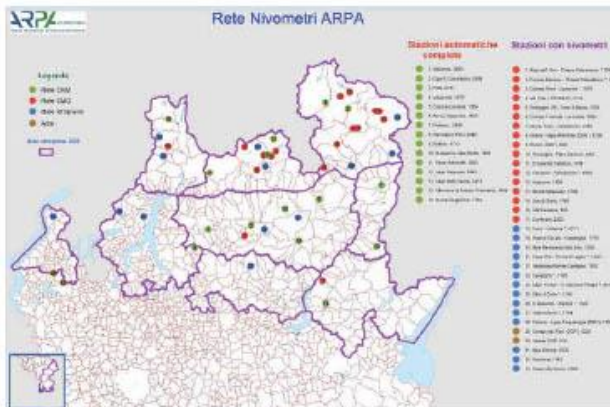
Pilot Region Lombardia

Lombardia region: 23.844 km²

Flat part is 47%
 Hilly part is 12
 Mountain part is 41%

Snow loads are ruled by normativa NTC2018 (2018)
<https://www.gazzettaufficiale.it/eli/qu/2018/02/20/42/so/8/sq/pdf>

Pilot Region Lombardia: data



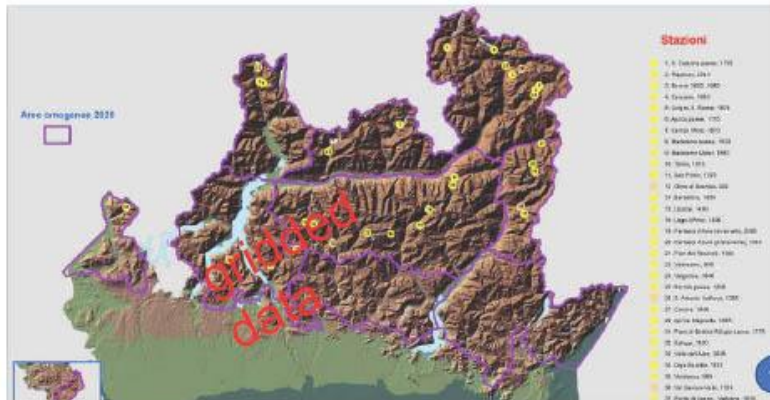
Station data:
Automatic stations

Pilot Region Lombardia: **data**



Manual stations

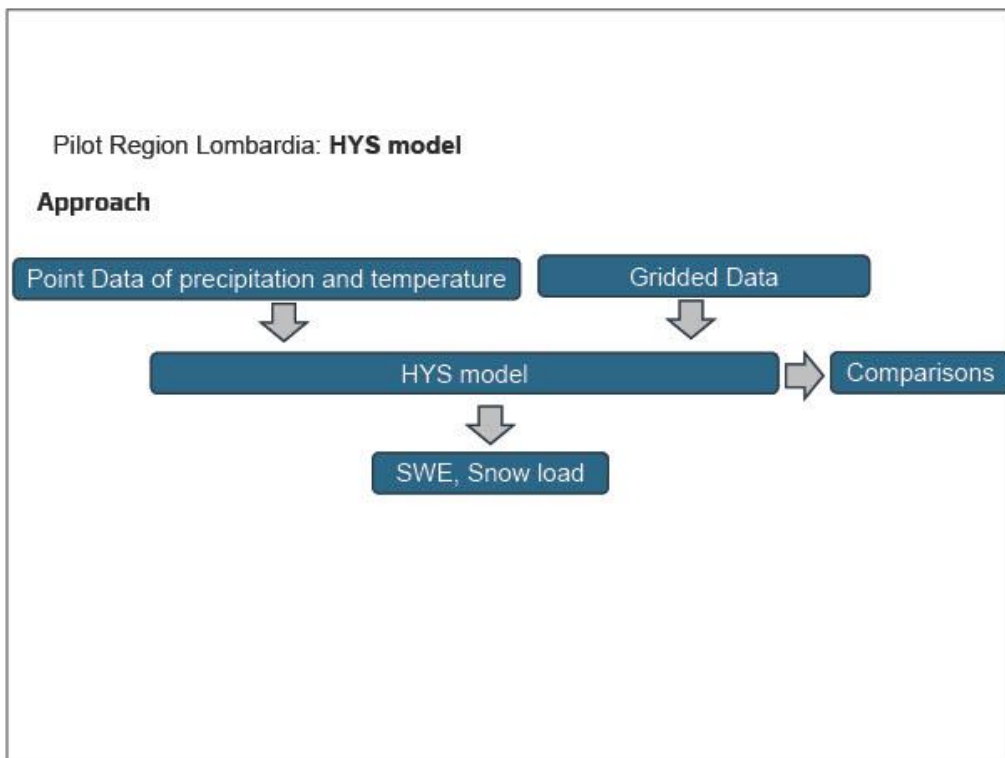
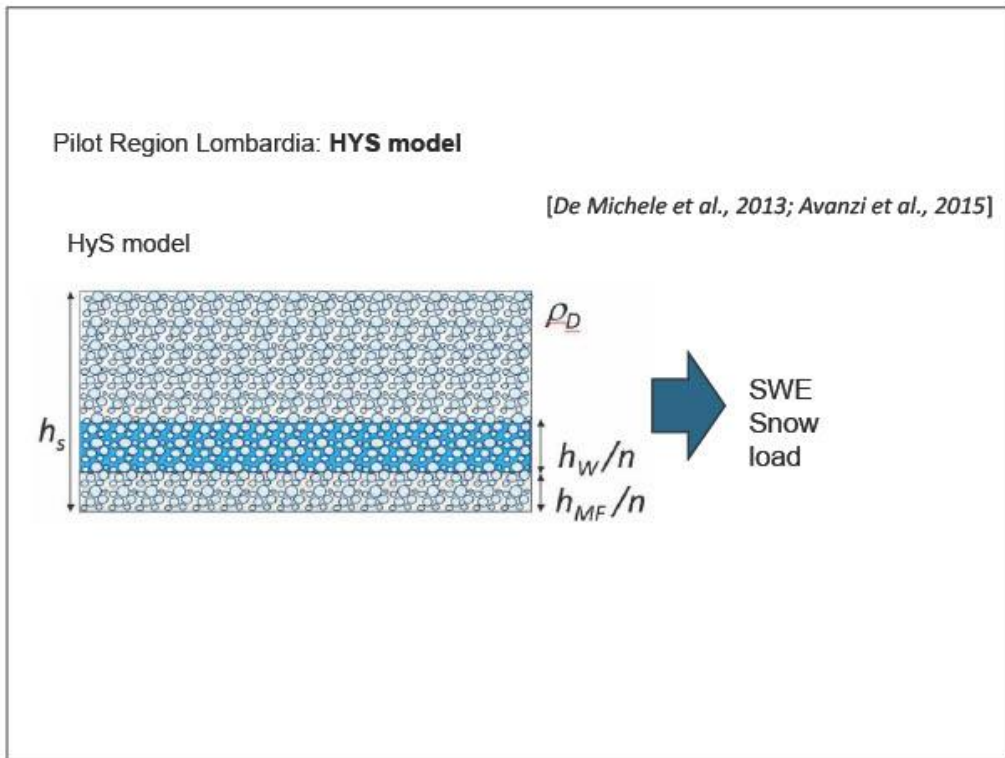
Pilot Region Lombardia: **data**

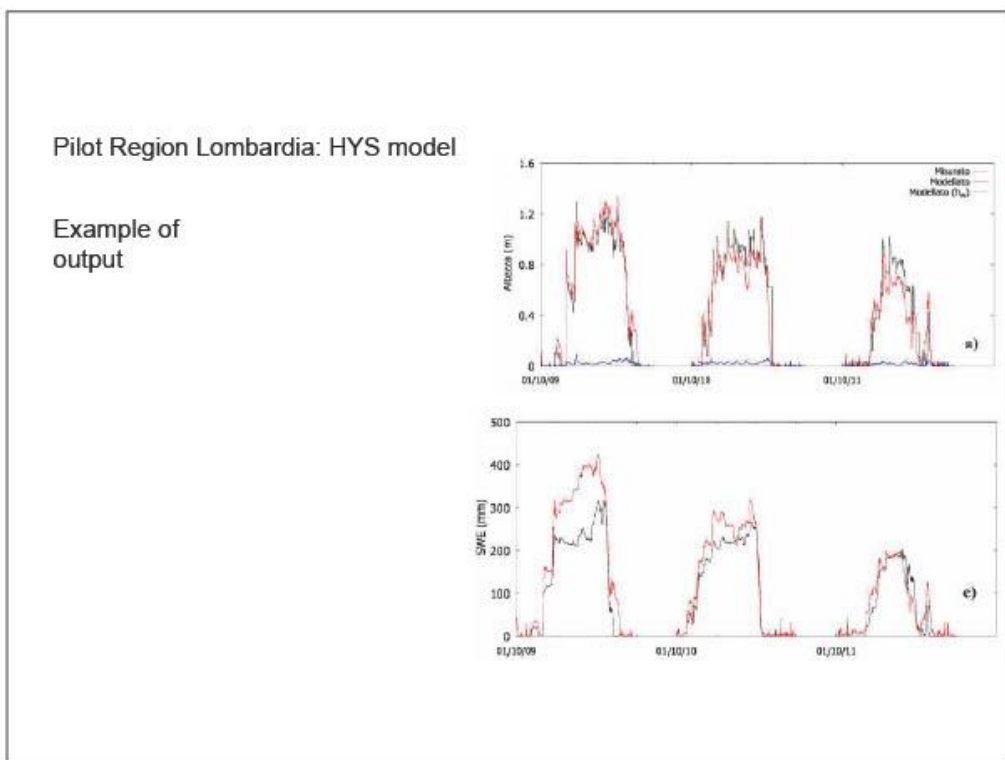


SENTINEL data

ERA5 –land data
9 x 9 km²
Hourly time scale

CMCC-CLM data
2.2 x 2.2 km²
Hourly time scale









THANK YOU!

More information:
Ali Nadir Arslan - ali_nadir_arslan@fmi.fi

8.4.2024 Ali Nadir Arslan

Presentation III: Estimation of snow load data using Copernicus and in-situ data

Caroline Herschel Framework Partnership


Agreement on Copernicus User Uptake

User uptake of Copernicus data into applications and services for snow loads : Towards a "SnowLoads" C3S App

Estimation of snow load data using Copernicus and in-situ data

Samuel Morin¹, Guillaume Evin², Elisa Kamir^{1,2}, Ali Nadir Arslan³, Bodo Wichura⁴, Gehring Penelope⁴

1. Météo-France – CNRS, CNRM, Toulouse and Grenoble, France
2. Univ. Grenoble Alpes, INRAE, CNRS, IGE, Grenoble, France
3. DWD
4. FMI



Introduction	Evaluation of MTMSI reference	Return levels from MTMSI projections
 <p style="font-size: small; margin-top: 5px;">Crédit: Météo France 2018/2019</p> <p>A9 Montpellier (France) Feb. 2018 <u>People stuck for hours as number of snowplow had not been planned for such snow fall event.</u></p>	 <p style="font-size: small; margin-top: 5px;">Crédit: DWD 2023/2024</p> <p>Munich (Germany) Dec. 2023 <u>Transports were suspended in Munich due to 44 cm of snow, heaviest snowfall since records started in 1933.</u></p>	
<ul style="list-style-type: none"> • While both winter and summer are projected to become warmer throughout Europe, extreme precipitation is projected to increase throughout the entire European territory • Could extreme events of snow falls become more frequent and/or more intense? 		

Introduction	Evaluation of MTMSI reference	Return levels from MTMSI projections
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OUR QUESTIONS

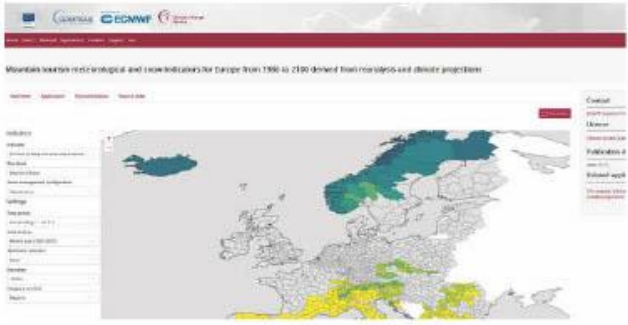
- How **intense** could future snowfall extremes become ?
- How **reliable** is the data set we use?

3

Introduction	Evaluation of MTMSI reference	Return levels from MTMSI projections
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MTMSI data set

- The **MTMSI reanalysis (1962-2020) data set** result from **MESCAN-SURFEX** model chain fed with **UERRA**
- On each **NUTS-3**, representative **grid points** were selected and used to run **CROCUS** model on the whole **NUTS-3** area



MTMSI

UERRA - MESCAN SURFEX -33km	Grid points selection	Crocus 10 km geometry
--------------------------------	-----------------------	--------------------------

4

Introduction Evaluation of MTMSI reference Return levels from MTMSI projections

MTMSI data set

- Case-by-case identification of “**mountain**” and “**plain**” NUTS-3
- On “**mountain**” NUTS-3 grid points were selected to provide results by steps of **100 meters elevation**
- On “**plain**” NUTS-3 grid points were selected to provide a **single elevation**




Figure 1. Spatial coverage of MTMSI data set.

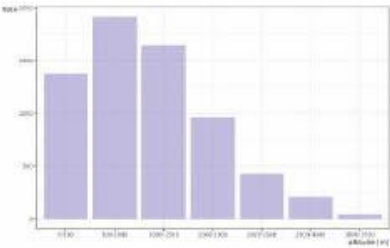


Figure 2. Altitude coverage of MTMSI data set.

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Introduction Evaluation of MTMSI reference Return levels from MTMSI projections

In situ data set

Alpine station observations:

- Monthly max of snow depth
- From 1962 to 2015
- 2893 stations

German station observations:

- Yearly max of snow depth
- From 1970 to 2020
- 5388 stations


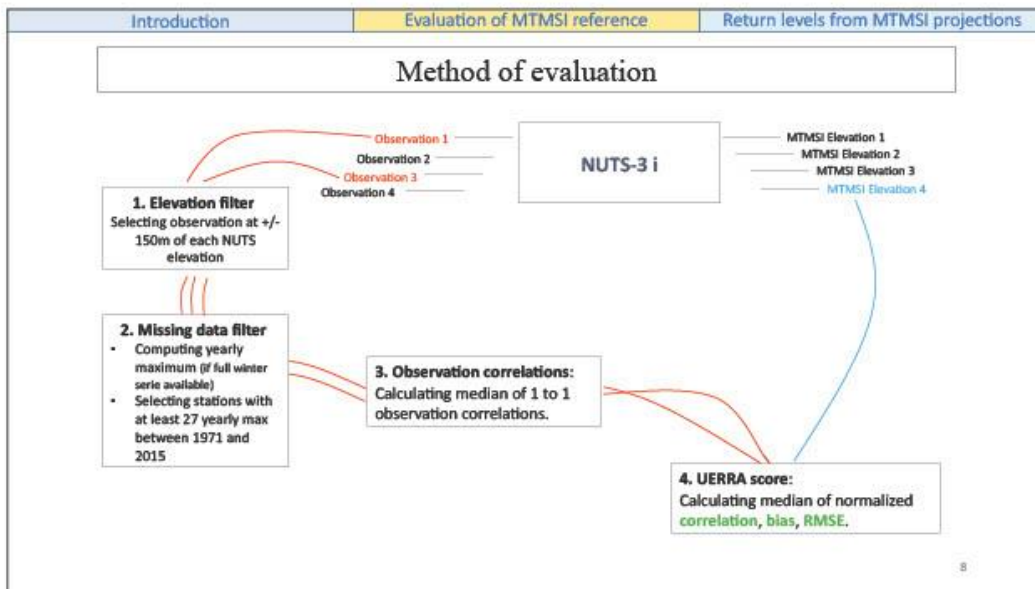
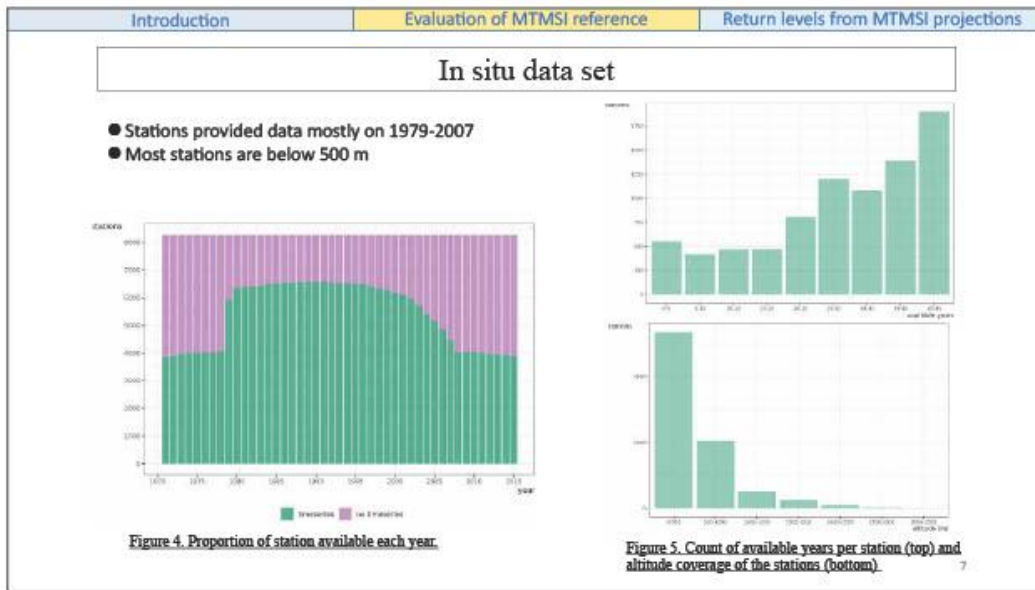
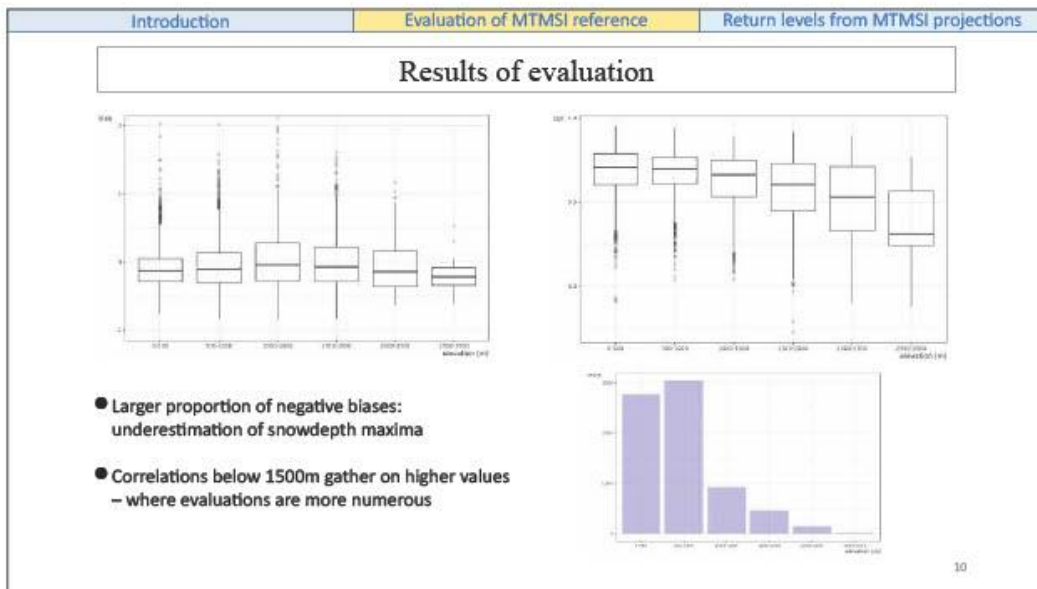
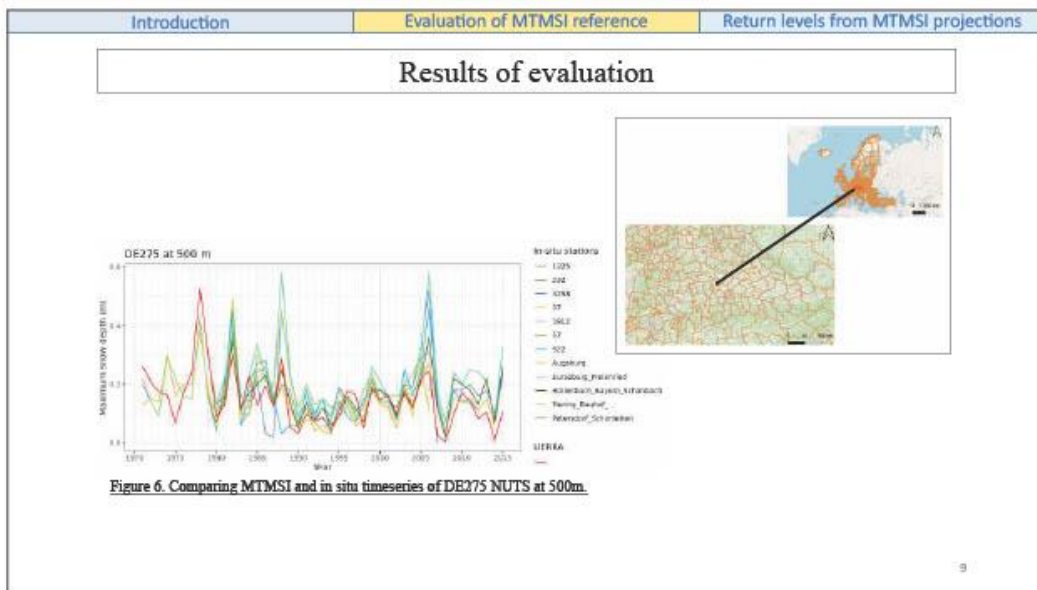
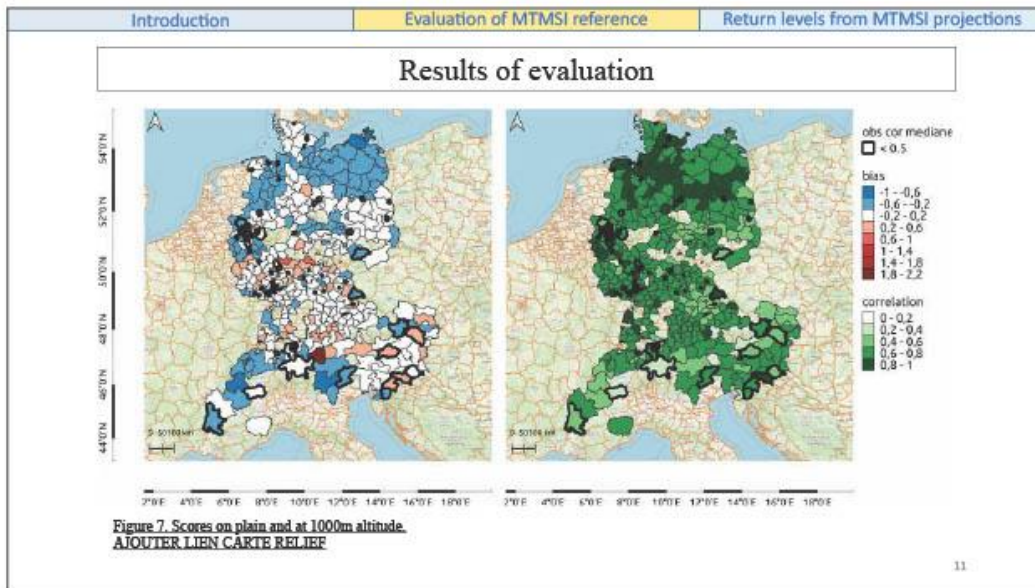


Figure 3. In situ station location.

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Introduction Evaluation of MTMSI reference Return levels from MTMSI projections

Generalized Extreme Value distribution : theory

- The distribution of the maximum of repeated samples of a homogeneous population converge to **Generalized Extreme Value Distribution (GEV)**:

$$P(Y \leq y) = \begin{cases} \exp \left[- \left(1 + \xi \frac{y - u_+}{\sigma} \right)_+^{-\frac{1}{\xi}} \right] & \text{if } \xi \neq 0 \text{ and} \\ \text{where } u_+ \text{ denotes } \max(u, 0), \\ \exp \left[- \exp \left(- \frac{y - u}{\sigma} \right) \right] & \text{if } \xi = 0. \end{cases}$$
- The quantiles of the GEV are of particular interest because of their interpretation as return levels; the value expected to be exceeded on average once every $1/p$ periods, where $1 - p$ is the specific probability associated with the quantile.
50-year return level \Leftrightarrow quantile 0,98

Stationary GEV: for each ensemble member, annual maxima are assumed stationary for time periods of 20-30 years.

Multi-model ensemble

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Introduction	Evaluation of MTMSI reference	Return levels from MTMSI projections
--------------	-------------------------------	--------------------------------------

Estimating return level with GEV

- 1. We adjust GEV on SWE maxima of 2071-2100 period**
 - On each simulation chain (GCM-RCM) :
 - a. If less than 10 non null SWE maxima, no adjustment
 - b. Otherwise, if at least one null SWE maxima, adjustment with exponential and gamma functions
 - c. Otherwise, adjustment with Gumbel
 - If one chain of RCP/NUTS/altitude ensemble with less than 10 non null SWE, we go through step b->d with all members of the ensemble
- 2. We estimate 50-year return level of SWE based on adjusted GEV parameters**

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Introduction	Evaluation of MTMSI reference	Return levels from MTMSI projections
--------------	-------------------------------	--------------------------------------

Results

SWE 50-year RL relative differences between 1975-2005 and 2070-2100

Elevation:

Climate scenario:

Figure 8. 50 years return level relative differences at NUTS-3 level on 600m altitude (application screenshot).

<http://127.0.0.1:6792/>

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Presentation IV: A snow load information system for Bavaria




Ein Schneelast-Informationssystem für Bayern

FPCUP SNOWLOADS

**Penelope Gehring¹, Bodo Wichura¹, Samuel Morin², Elisa Kamir^{2,3}, Guillaume Evin³,
Ali Nadir Arslan⁴, Carlo De Michele⁵**

¹Deutscher Wetterdienst, Regionales Klimabüro Potsdam
²Météo-France, Centre National de la Recherche Scientifique (CNRS), Centre National de Recherches Météorologiques (CNRM)
³Université Grenoble Alpes, Institut national de la recherche agronomique (INRAE), CNRS
⁴Finnish Meteorological Institute (FMI)
⁵Politecnico di Milano (POLIMI)












Nutzenworkshop Schneelast 2024




Überblick & Ziele



Schneelastinformationssystem für Bayern:

- **Schwerpunkt: Reaktion auf aktuelle hohe Schneelasten**
- Basiert bzw. verweist auf die C3S App für Hintergrundinformationen zu Schneelasten (z.B. für Planungszwecke)
- Potentielle Nutzer:
 - Katastrophenschutz (z.B. Feuerwehr, Bergwacht, DRK, etc.),
 - Gebäudeverwaltungen,
 - Etc.
- Ziele:
 - Bereitstellung der Schneelast-Daten **so früh wie möglich**,
 - **Nutzerfreundliche** interaktive Karten,
 - Möglichkeit zum Herunterladen bestimmter Daten,
 - Einzelheiten hängen auch von den Ergebnissen des Nutzerdialogs ab



Nutzenworkshop Schneelast 2024

Nutzerumfrage

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Dauer: 01.08.2023 – 19.11.2023

Region: Bayern

Teilnehmer: 74

Ziele:

- Erstes Verständnis der Nutzergruppen und deren Anforderungen;
- Bewerbung des Projekts;
- Kontaktfindung;

Nutzerworkshop Schneelast 2024

Potentielle Nutzer

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

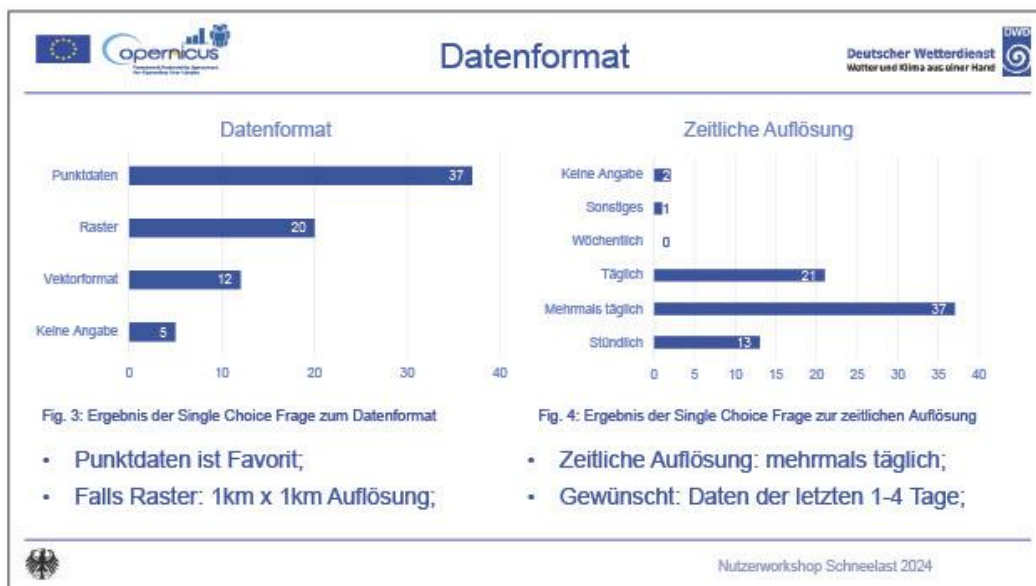
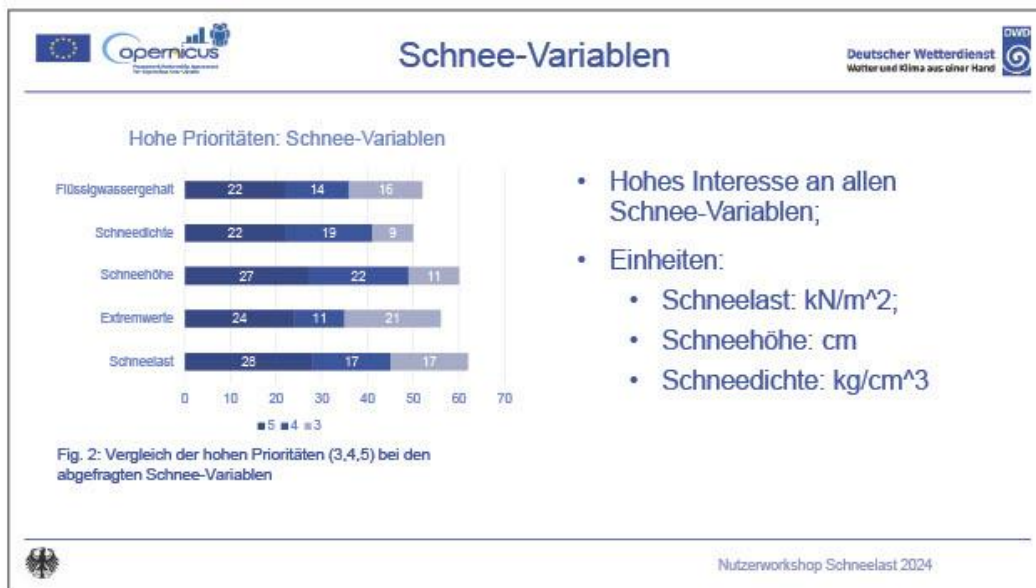
Anwendungsgebiete

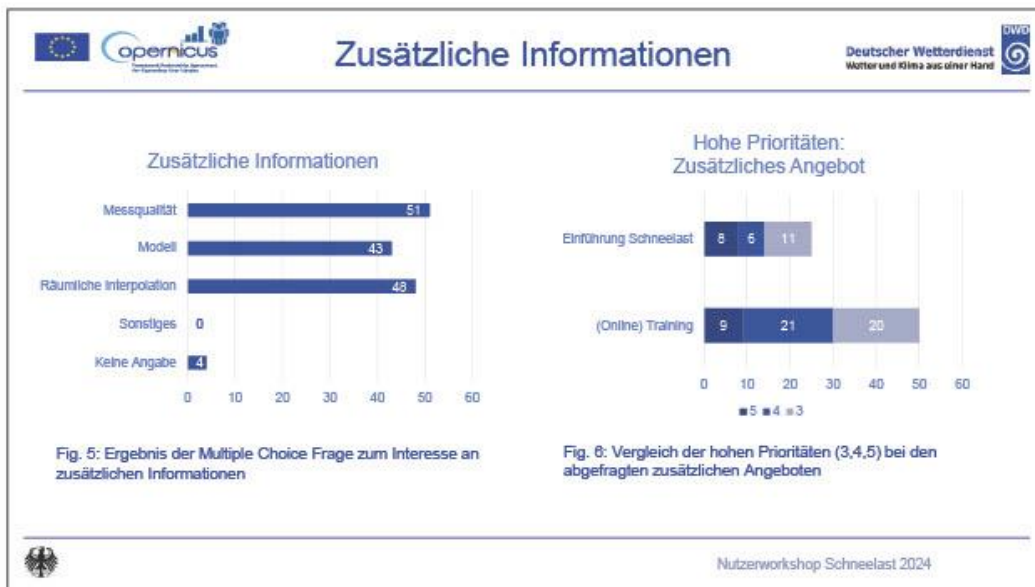
Anwendungsgebiet	Anzahl
Allgemeiner Katastrophenschutz	67
Schutz der Infrastruktur	52
Überschwemmungen	34
Forstschutz	13
Allgemeiner Umweltschutz	13
Lawnen	13
Sonstiges	1

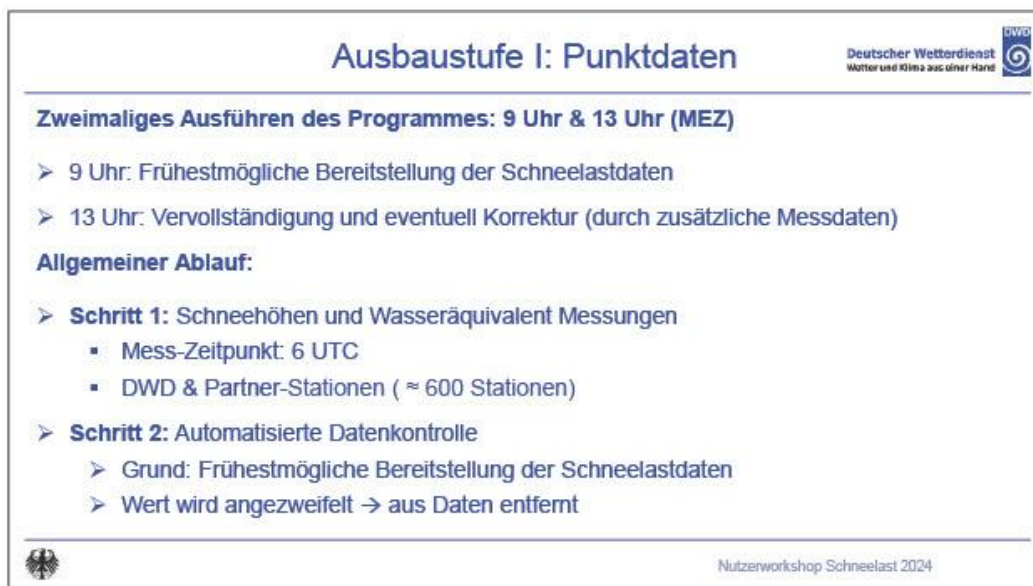
- Fokussiert auf Bayern;
- nur ein ganz kleiner Teil interessiert an DE, DACH bzw. EU;
- Haupt-Nutzergruppe: Katastrophenschutz;

Fig. 1: Ergebnis der Multiple Choice Frage zu Anwendungsgebieten


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Ausbaustufe I: Punktdaten



Deutscher Wetterdienst
 Wetter und Klima aus einer Hand

- **Schritt 3: Modellierung der Schneedichte mit Δ Snow (Winkler et al. 2020)**
 - Grund: Nur ein Bruchteil der Schneehöhe-Stationen misst auch Wasseräquivalent
 - Basiert auf Prozessen der Schneedeckenalterung und der Massenänderung im Verlauf des Winterjahres (Input: Jahres-Zeitreihe von täglichen Schneehöhen)
 - Regionale Kalibrierung von sieben Modellparametern ersetzt Input von meteorologischen oder geographischen Daten
- **Schritt 4: Modellkontrolle**
 - Ist der Modellwert realistisch? → Intervall-Test
 - Was ist die mögliche Modellabweichung? → Vergleich Wasseräquivalent-Messungen im Umkreis
- **Schritt 5: Erstellung HTML-Karte**


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Ausbaustufe I: Punktdaten



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- Für Testnutzer verfügbar, siehe https://www.dwd.de/DE/leistungen/schneelast_info_bayern/testversion_schneelastinfo.html

Testversion des Schneelast-Informationssystems

Framework Partnership Agreement on Copernicus User Uptake

Eine Testversion des Schneelast-Informationssystems für Bayern ist ab sofort unter data.dwd.de verfügbar.

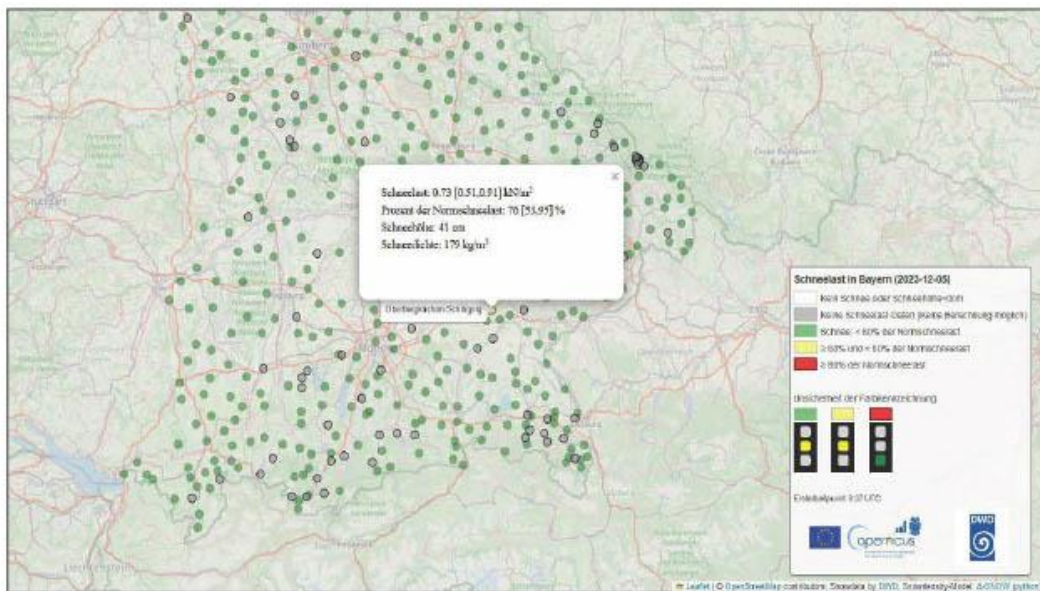
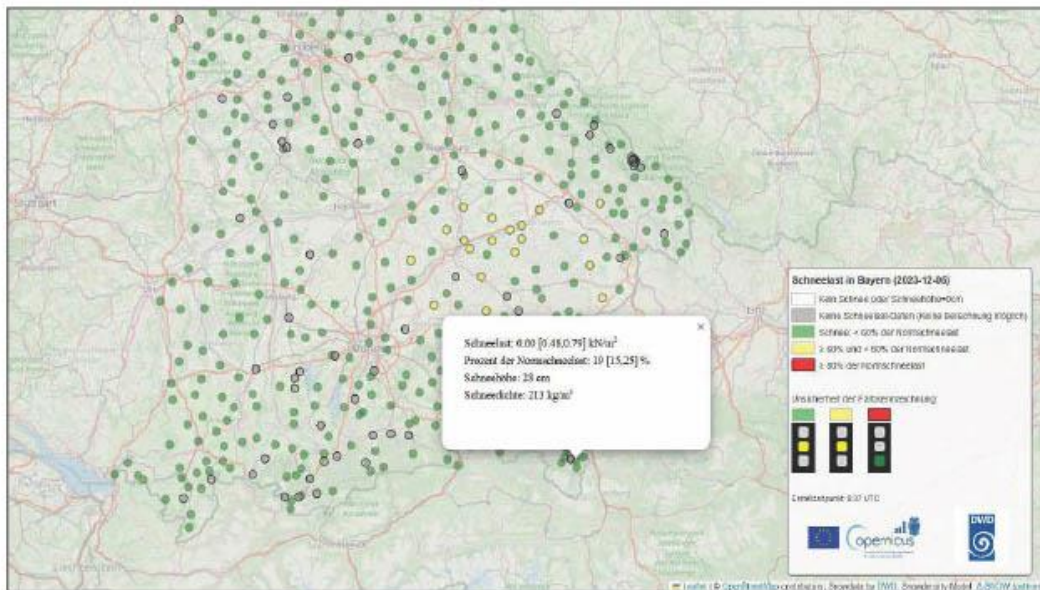
Die erste Version des Schneelast-Informationssystems stellt täglich Schneelast-Karten bereit, welche gemessene Schneehöhen und modellierte Schneelasten für Stationen in Bayern beinhalten. Diese Daten werden auf einer interaktiven Karte übersichtlich dargestellt.

Die HTML-Datei kann in jedem Browser geöffnet werden, zur Darstellung eines Hintergrund-Layers (topographische Karte) wird eine Internet-Verbindung benötigt (zur reinen Datendarstellung nicht unbedingt erforderlich).

In zukünftigen Ausbaustufen sollen die räumliche Auflösung verbessert und die Schneelastdaten mithilfe der C3S SNOWLOAD App in den einen klimatologischen Kontext gesetzt werden.

W möchten Sie das Schneelast-Informationssystem für Bayern testen?
 Schicken Sie bitte eine E-Mail an techiklim.potsdam@dwd.de um die Zugangsdaten zum Nutzerbereich unter data.dwd.de zu erhalten!


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Nächste Schritte




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- **Modell:**
 - Genauere Leistungsanalyse;
 - Implementierung zusätzlicher Ausgleichsmethoden;
 - Vergleich anderer Schneedichte-Modelle;
- **Räumliche Interpolation:**
 - Erstellung von Rastern;
 - Weiterführender Nutzerdialog;

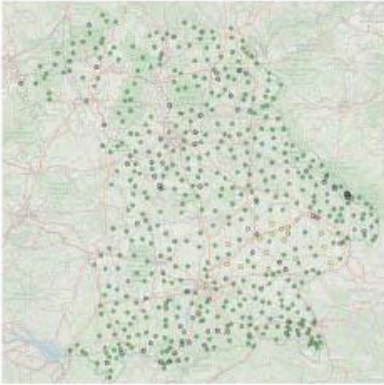


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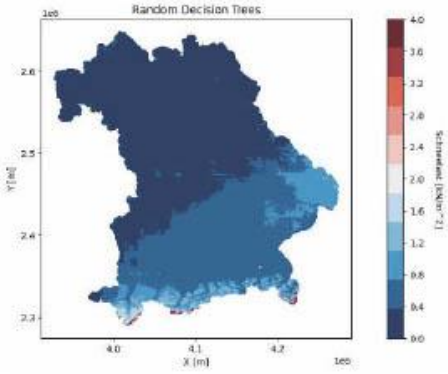
Nächste Schritte




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Schneelastkarte mit Punktdaten



Plot eines Rasters



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Ausblick Veranstaltungen

- **Fachtagung Katastrophenvorsorge 2024**
- **Nutzerworkshop Bayern:**
 - Inhalt: Ausbaustufe II & Vorbereitung Wintermonate
 - Ort: Voraussichtlich München (RKB München)
 - Zeit: Oktober/November
- **Nutzerworkshop EU:**
 - Inhalt: Projekt-Ergebnisse (EU Schneelastkarten; Pilotgebiete); Externe Redner;
 - Ort: Hybrid (?)
 - Zeit: Oktober/November

Nutzerworkshop Schneelast 2024


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Wetter und Klima aus einer Hand

Vielen Dank für die Aufmerksamkeit!
Fragen?

Dr. Fabiana Castino
Dr. Penelope Gehring
Dr. Bodo Wichura

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https://www.dwd.de/DE/leistungen/schneelast_info_bayern/schneelast.html


Dreisessel (Bayrischer Wald)

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