



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

Services across time scales and components at MeteoSwiss

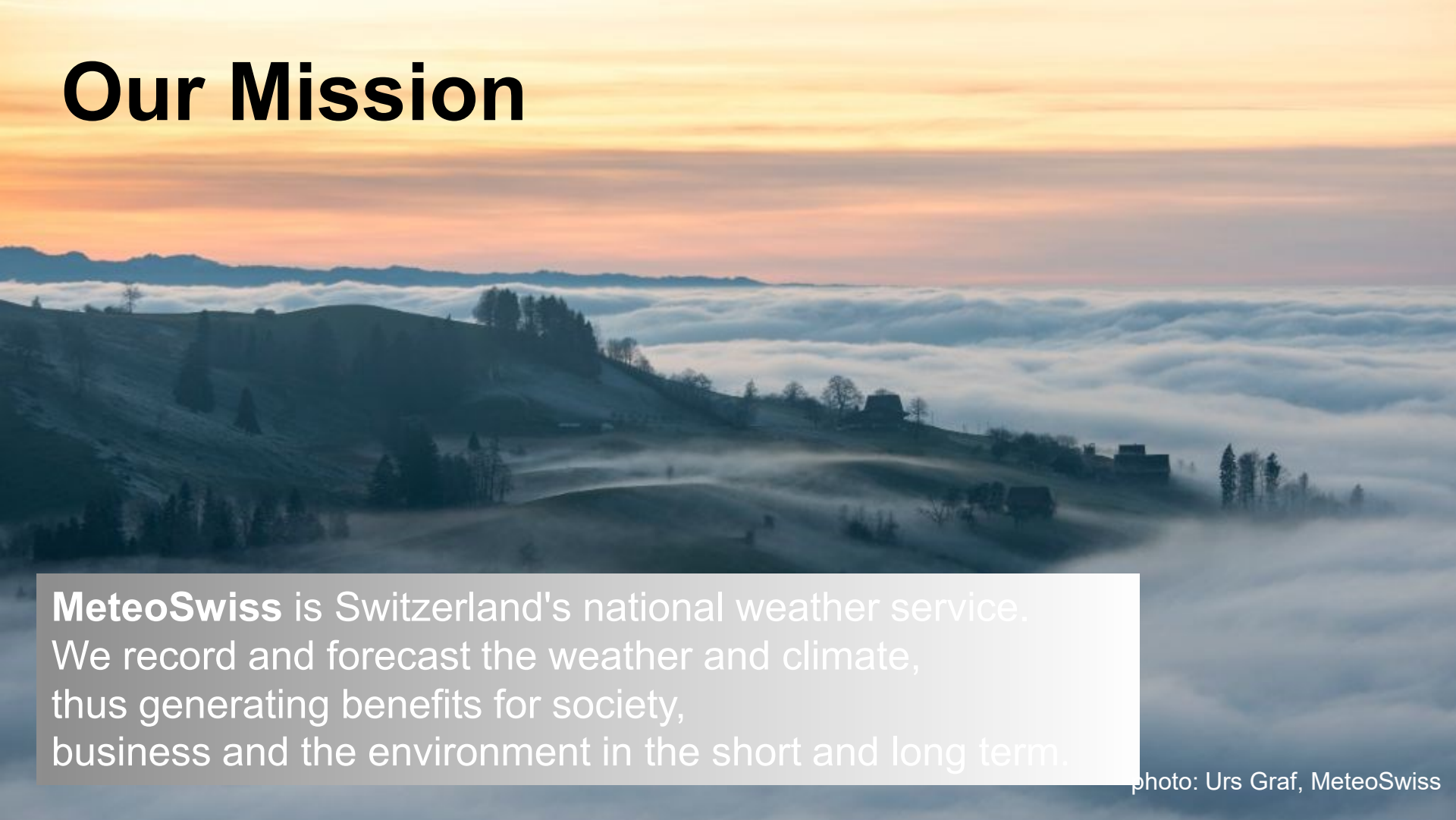
- examples from the climate division

ECMWF annual seminar 2025 – 50th anniversary celebration

Christian Grams with contributions from Michael Begert, Vincent Humphrey, Icíar Lloréns Jover, Christoph Spirig, Anke Tetzlaff and many MeteoSwiss colleagues

Climate Division – Federal Office of Meteorology and Climatology MeteoSwiss

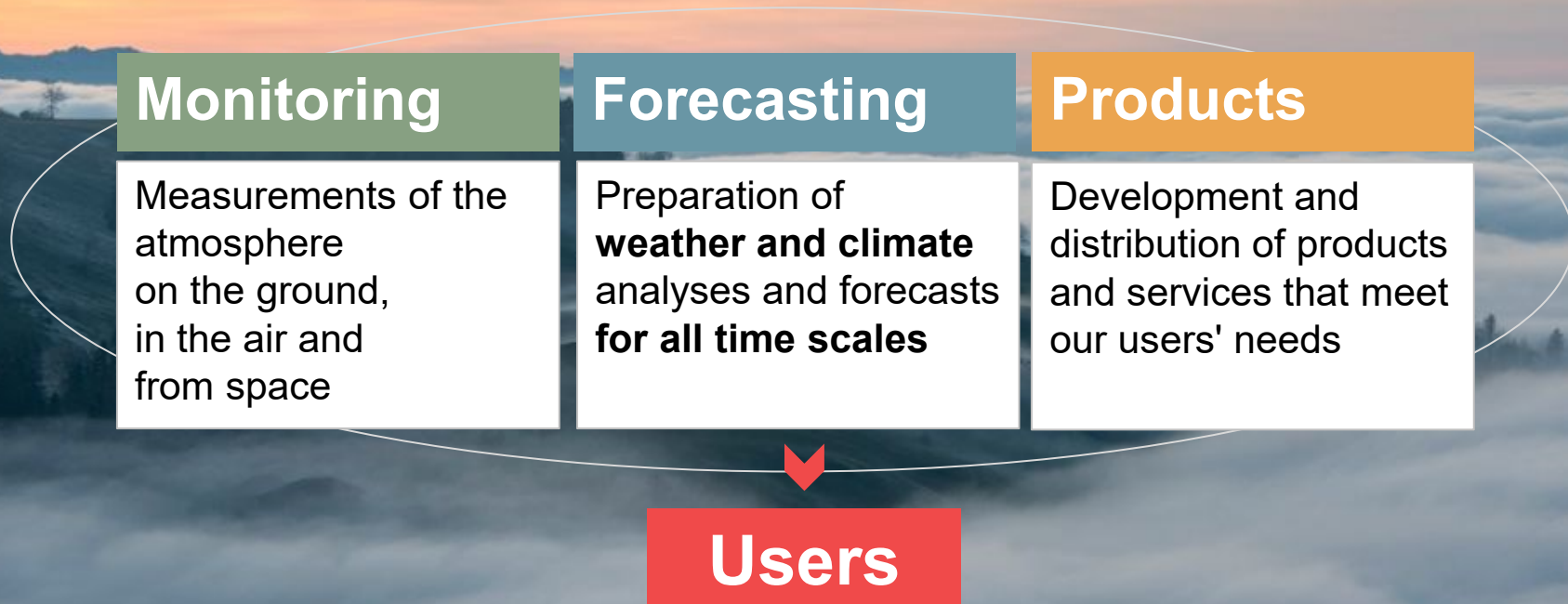
Our Mission



MeteoSwiss is Switzerland's national weather service. We record and forecast the weather and climate, thus generating benefits for society, business and the environment in the short and long term.

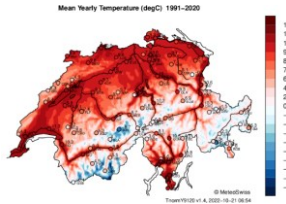
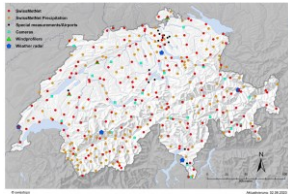
photo: Urs Graf, MeteoSwiss

Our core tasks



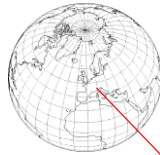
seamless weather and climate data

Monitoring



Forecasting

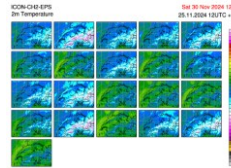
Lateral boundary conditions:
IFS ENS, 9 km
4x per day



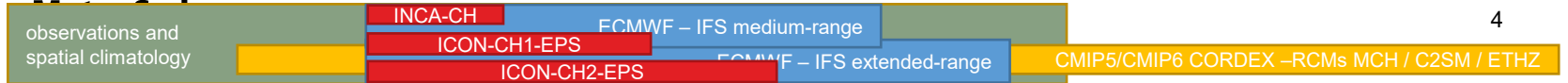
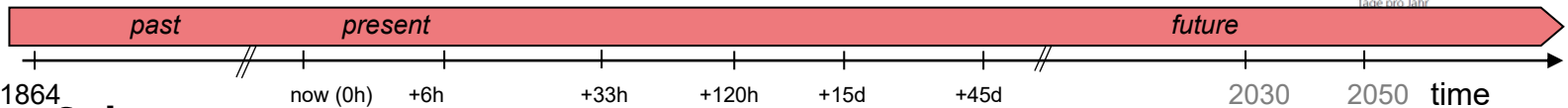
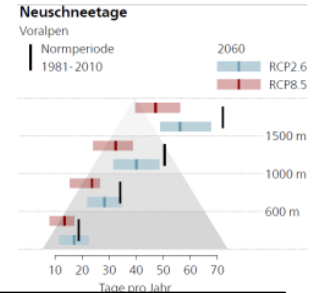
ECMWF

ICON

ICON-CH1/
CH2-EPS
1.0 / 2.1 km,
11 / 21 mem.



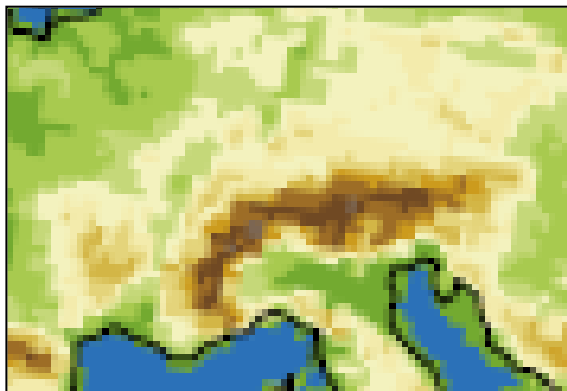
Climate Scenarios





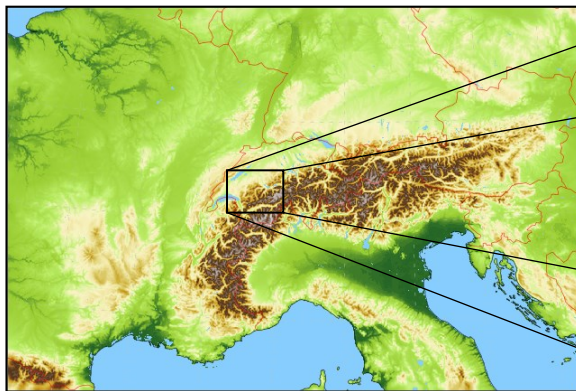
Challenges – complex orography

$\Delta x \sim 30\text{km}$



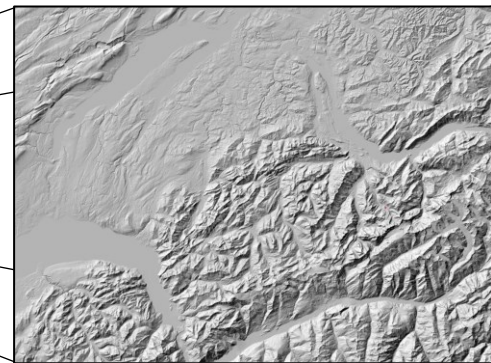
e.g. ERA5 or RCM

$\Delta x \sim 1\text{km}$



ICON-CH1-EPS

$\Delta x \sim 100\text{m}$



DEM – users' need



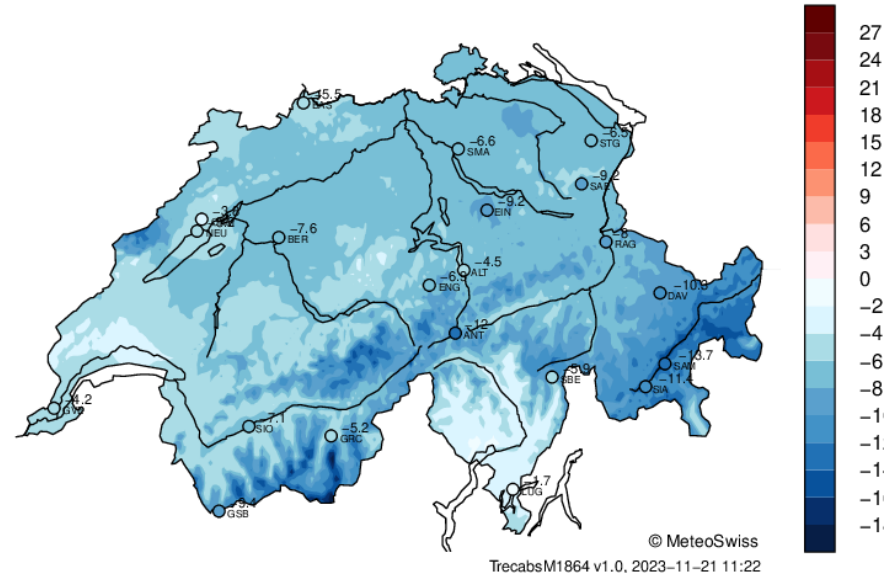
Challenges – temporal consistency

- few station records date back < 1900
- changes in sites and instrumentations

Jan 1864

→ requires **homogenization** and
sophisticated **spatial climate analyses**

Monthly Mean Temperature (degC) Jan 1864 (Reconstr.)



Literature: F. Isotta, M. Begert, C. Frei, JGR-A, 2019, . [doi:10.1029/2018JD029910](https://doi.org/10.1029/2018JD029910)



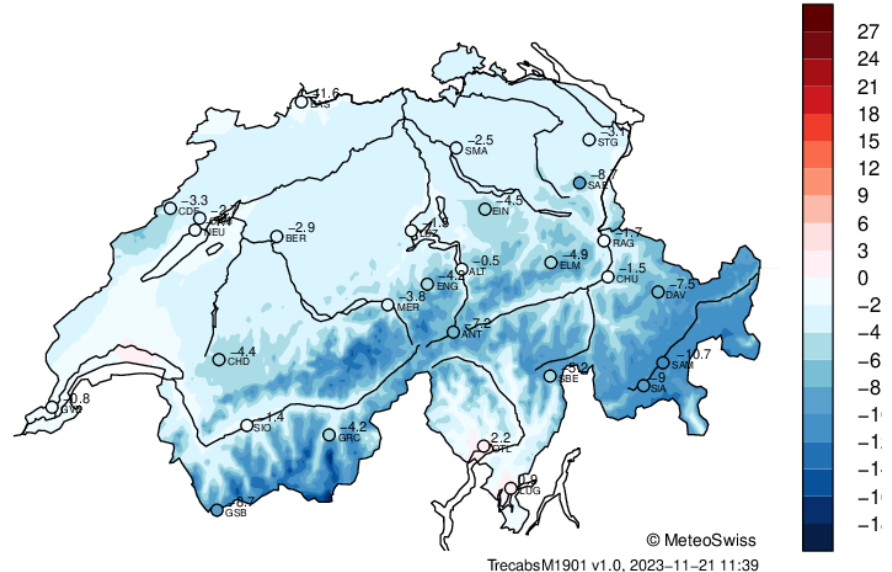
Challenges – temporal consistency

- few station records date back < 1900
- changes in sites and instrumentations

Jan 1901

→ requires **homogenization** and sophisticated **spatial climate analyses**

Monthly Mean Temperature (degC) Jan 1901 (Reconstr.)



Literature: F. Isotta, M. Begert, C. Frei, JGR-A, 2019, . [doi:10.1029/2018JD029910](https://doi.org/10.1029/2018JD029910)



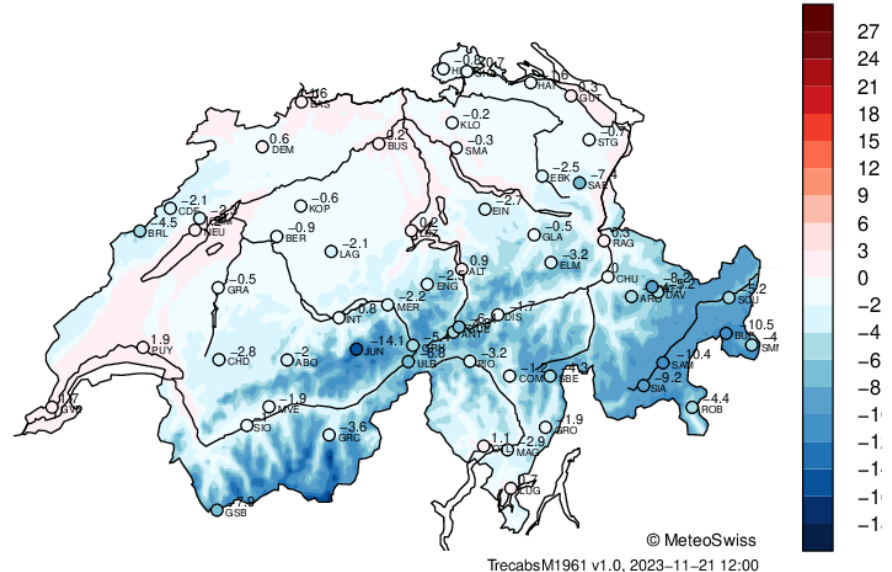
Challenges – temporal consistency

- few station records date back < 1900
- changes in sites and instrumentations

Jan 1961

→ requires **homogenization** and
sophisticated **spatial climate analyses**

Monthly Mean Temperature (degC) Jan 1961 (Reconstr.)



Literature: F. Isotta, M. Begert, C. Frei, JGR-A, 2019, . [doi:10.1029/2018JD029910](https://doi.org/10.1029/2018JD029910)

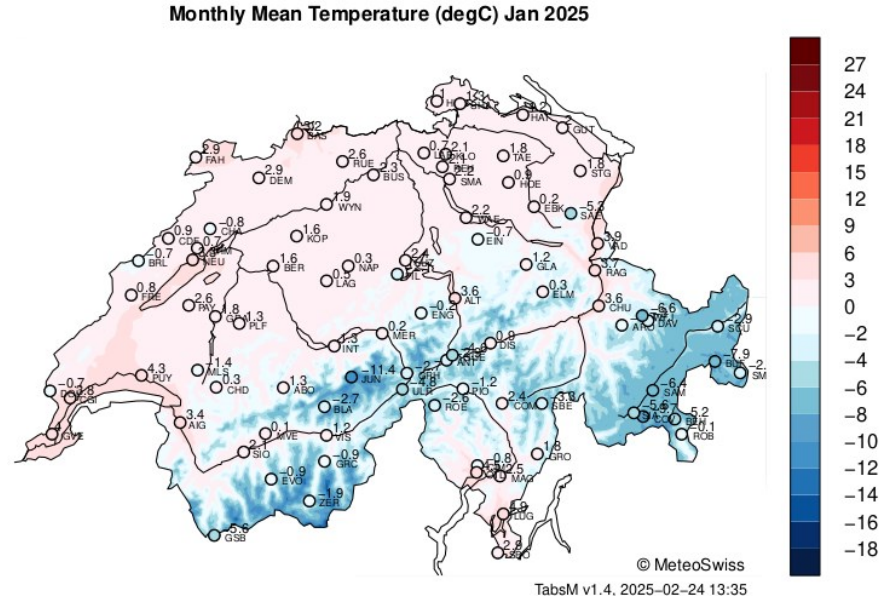


Challenges – temporal consistency

- few station records date back < 1900
- changes in sites and instrumentations

Jan 2025

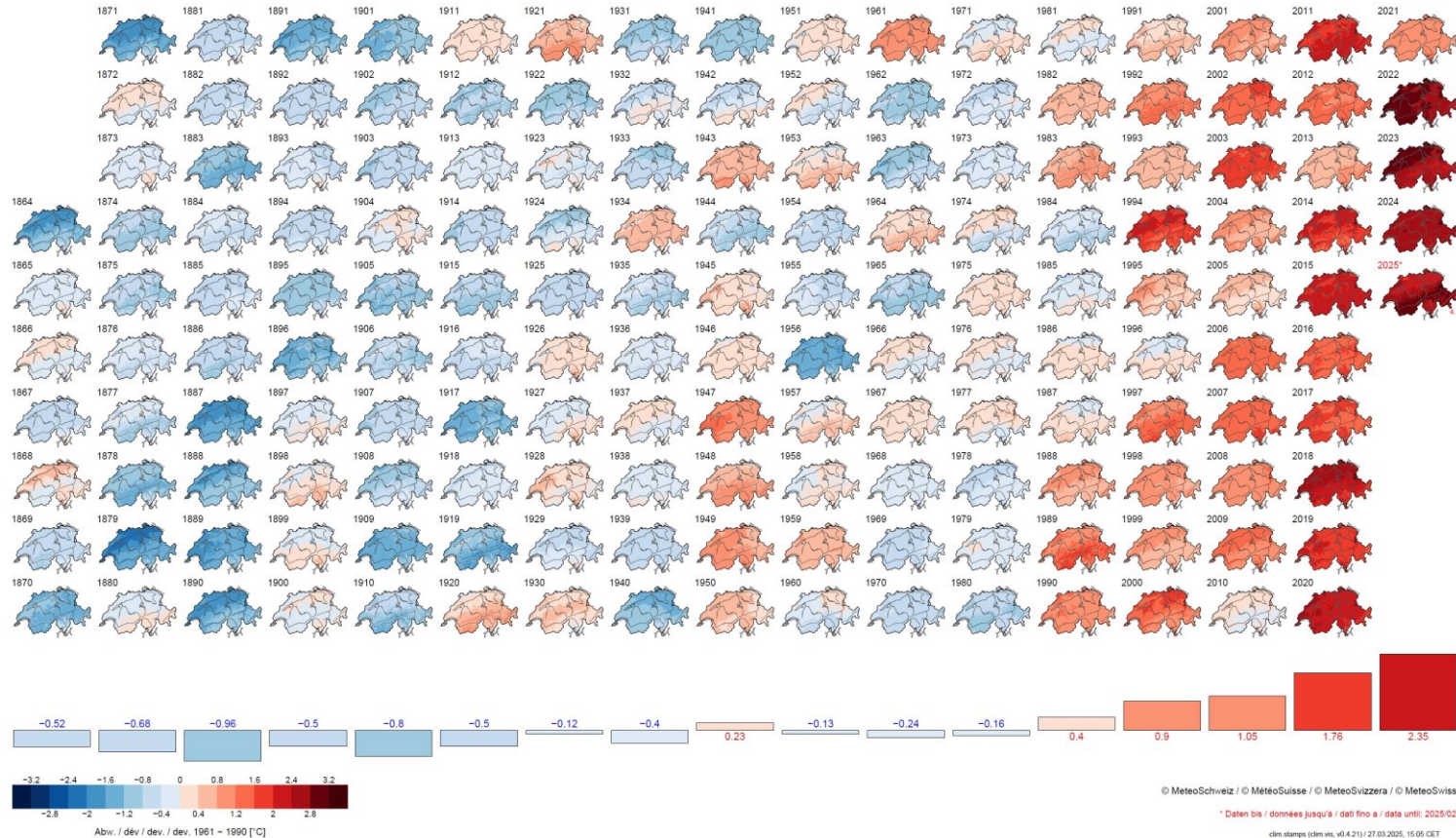
→ requires **homogenization** and
sophisticated **spatial climate analyses**



Literature: F. Isotta, M. Begert, C. Frei, JGR-A, 2019, . [doi:10.1029/2018JD029910](https://doi.org/10.1029/2018JD029910)



Long-term trend in temperature



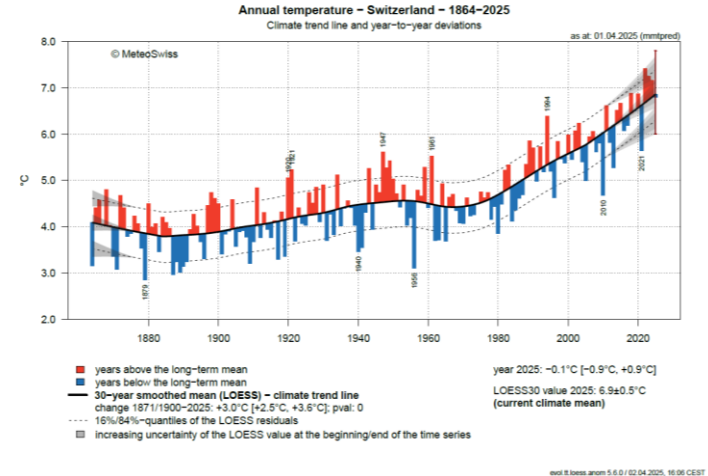


Long-term trend and outlook

- What is the climatological reference in a changing climate?
- What is the internal climate variability in a non-stationary background state?
- How anomalous will the current year be with respect to pre-industrial climate?

→ LOESS filter for current climate mean

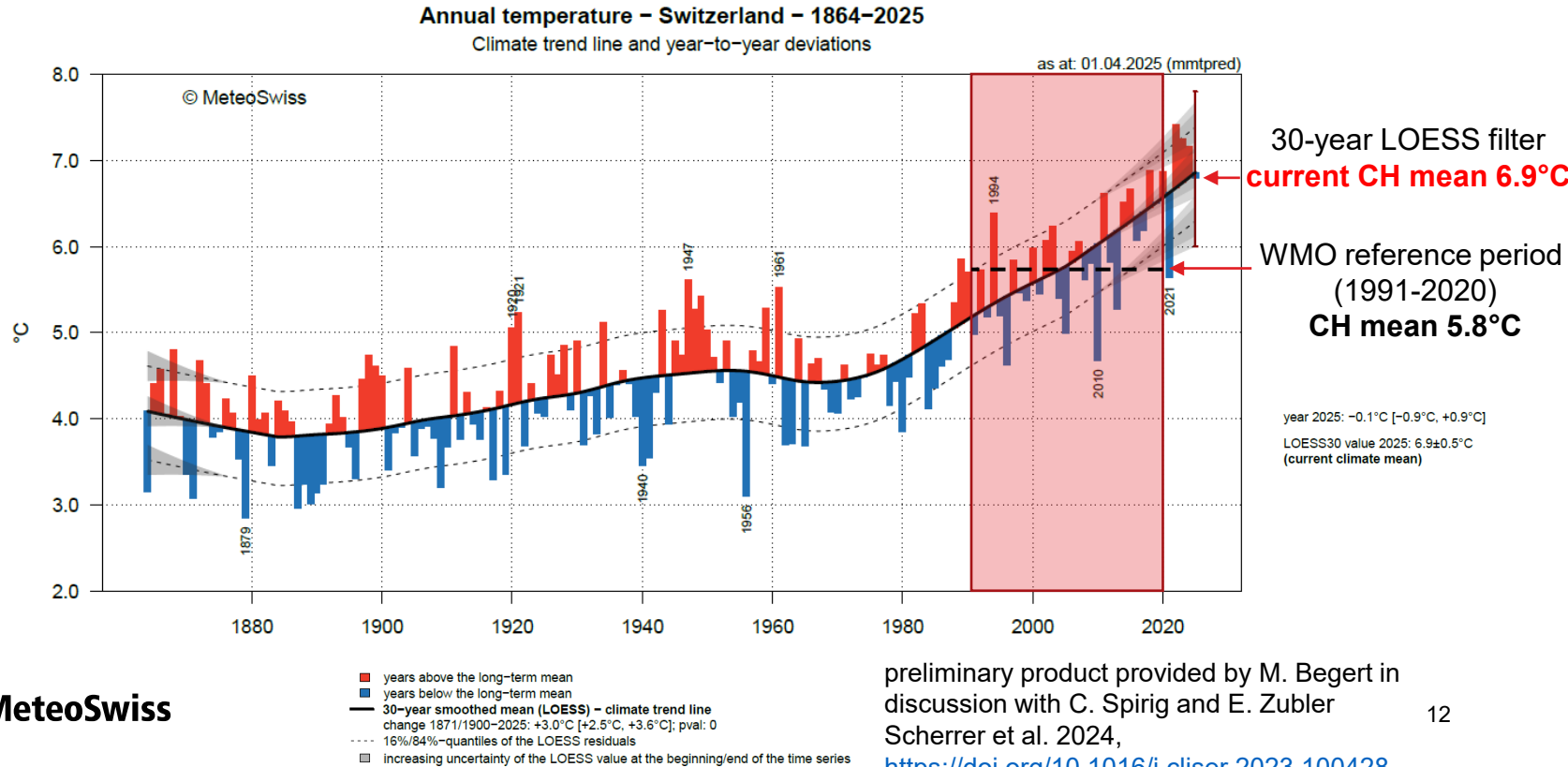
Scherrer et al. 2024, <https://doi.org/10.1016/j.cliser.2023.100428>



preliminary product provided by M. Begert
in discussion with C. Spirig and E. Zubler



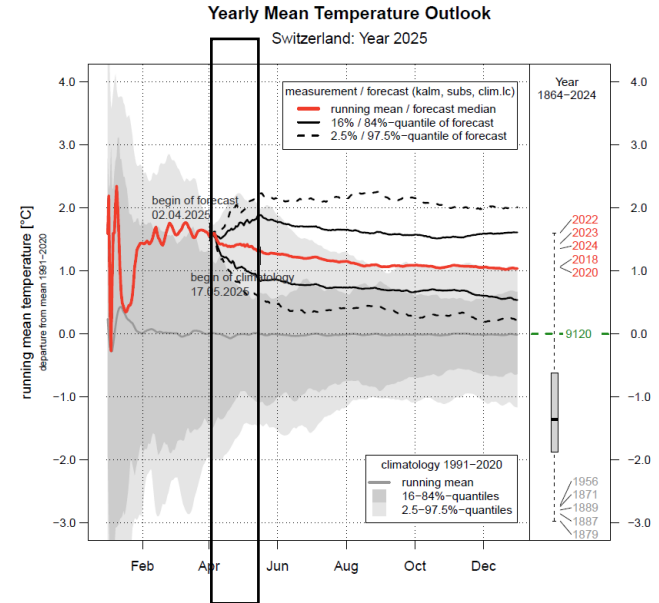
Long-term trend and outlook





Long-term trend and outlook

- What is the climatological reference in a changing climate?
 - What is the internal climate variability in a non-stationary background state?
 - **How anomalous will the current year be with respect to pre-industrial climate?**
- LOESS filter for current climate mean
- combine post-processed ECMWF extended-range with LOESS trend-adjusted climatology **yields simple, yet accurate, seasonal forecast**



yearly departure outlook

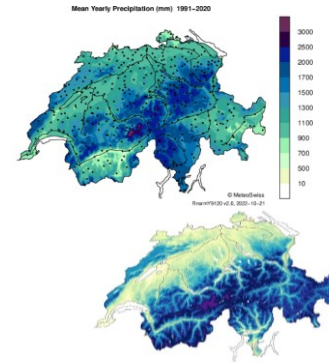
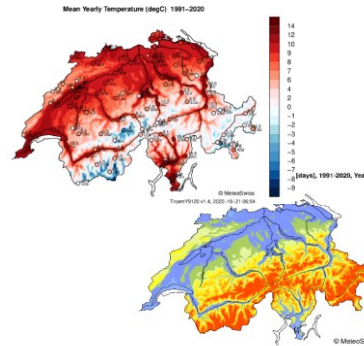
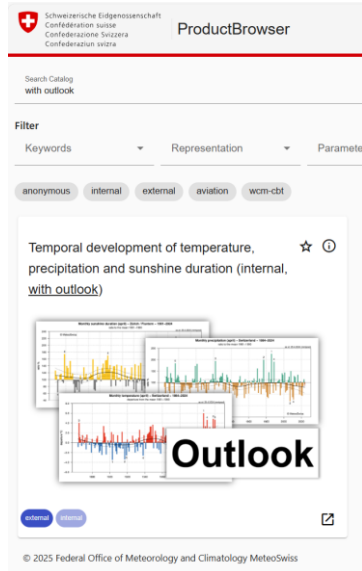
97.5% - q: 2.0°C rank 1
84% - q: 1.6°C rank 2
50% - q: 1.0°C rank 6 (of 162)
16% - q: 0.5°C rank 11
2.5% - q: 0.2°C rank 16

probabilities rank 1 to 5 (from above)

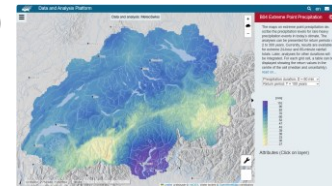
rank 1: 16%
rank 2: 25%
rank 3: 28%
rank 4: 48%
rank 5: 49%

preliminary product provided by M. Begert
in discussion with C. Spirig and E. Zubler

Examples of further spatial and long-term climate analyses



- temperature, precipitation, sunshine, radiation (MTG)
- derived quantities: e.g. heating days, frost days...
- daily, monthly, yearly, climate mean
- extreme value statistics (e.g. hydromaps.ch)
- special observations: pollen & phenology, snow

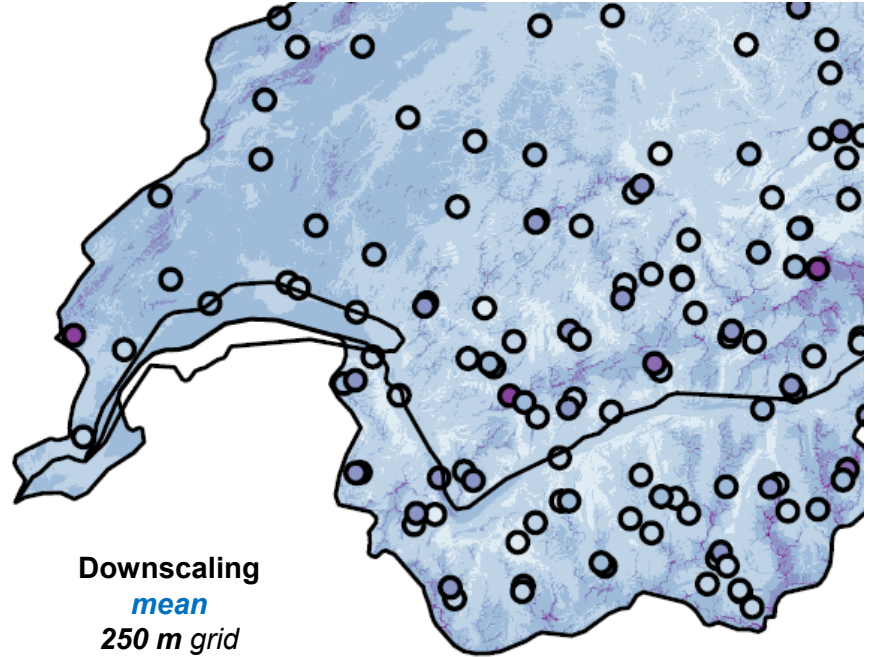




Seamless wind climatology

Yearly climatology for the period 2021 to 2023

- **ML approach combining**
 - **model** background from COSMO / ICON analysis or downscaled ERA5
 - **observations**
 - **static fields** (mainly hyper-resolution topography at x=25m)
- seamless approach for climate analysis, nowcasting and downscaling of ICON forecasts



Downscaling
mean
250 m grid

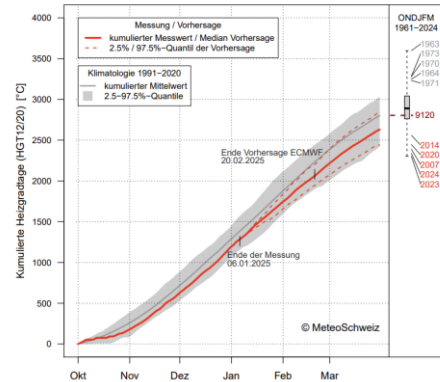
user-specific climate products: energy

- meteorological input and outlook for national energy dashboard
- weekly energy weather outlook
- climatological data for planning (norming, estimates of renewables...)
- climate scenarios

Aktueller Stand und Abschätzung der Heizgradtage für den Winter 2024/2025

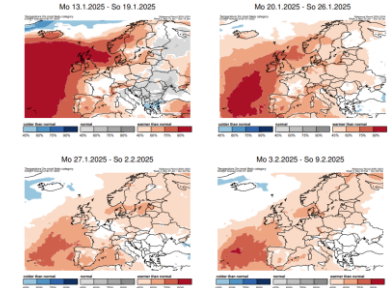
Halbjahres-Vorhersage – Heizgradtag-Summe (HGT12/20)

Zürich / Fluntern: ONDJFM 2025



Temperaturvorhersage (Europa)

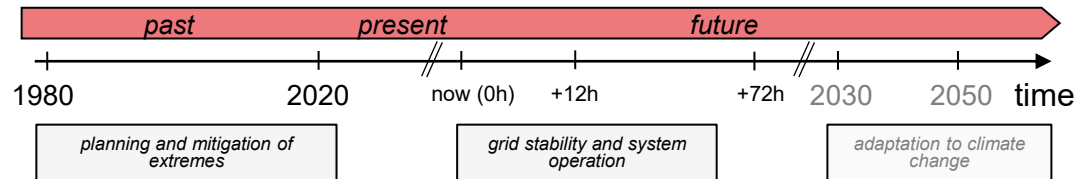
für die nächsten vier Wochen vom 13.1.2025 bis 9.2.2025



<https://www.energieschweiz.admin.ch/wetter/aktuell>

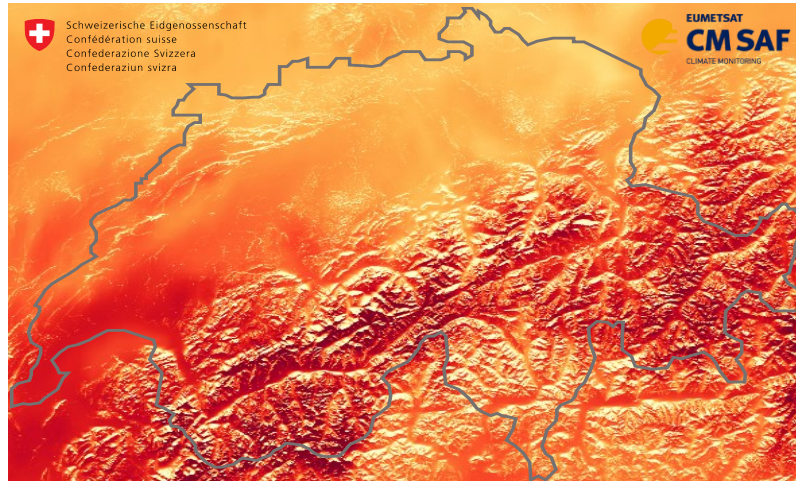
<https://www.meteoschweiz.admin.ch/wetter/spezialprognosen/spezialbulletin-fuer-das-energiemanagement.html>

Vision: seamless climate and weather data for enabling a renewable power system





energy: Solar potential of all roofs in Switzerland – a free climate service



MeteoSwiss



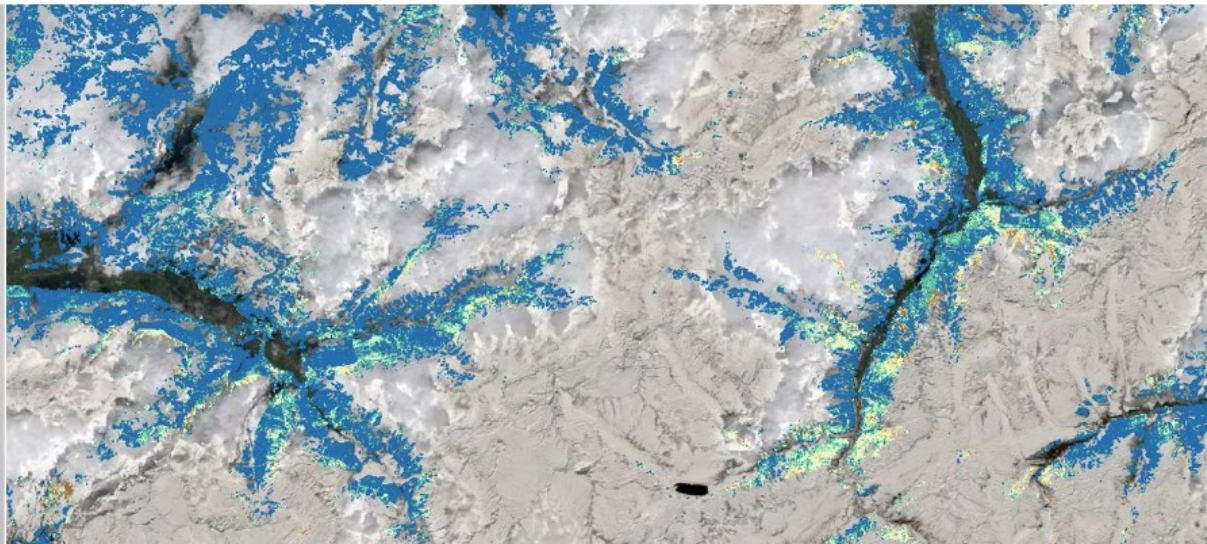
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Energie BFE
Bundesamt für Meteorologie und Klimatologie MeteoSchweiz
Bundesamt für Landestopografie swisstopo





Climate Service on Drought using CM SAF Land Surface Temperature – vegetation health index



Combining the CM SAF Land Surface Temperature climate and real-time data with high resolution Sentinel vegetation data





Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

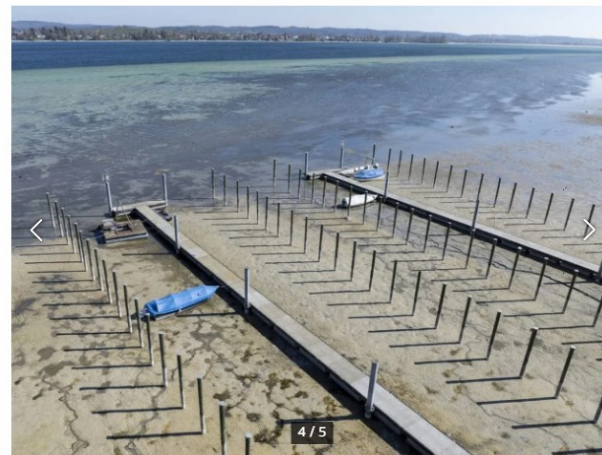
Project Drought



SRF

Play SRF Audio

Tiefer Wasserstand am Bodensee



Und die kommenden Tage geben wenig Hoffnung auf mehr Wasser. (2.4.2025)

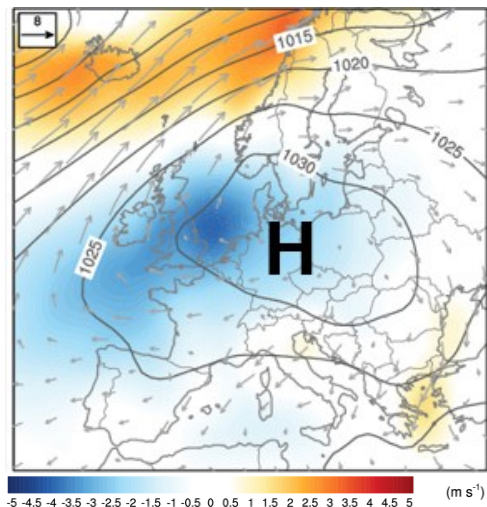
KEYSTONE/ENNO LEANZA

<https://www.srf.ch/news/schweiz/booten-liegen-auf-dem-trockenen-schweizer-seen-fuehren-extrem-wenig-wasser-die-hintergruende> retrieved at 8.4.2025

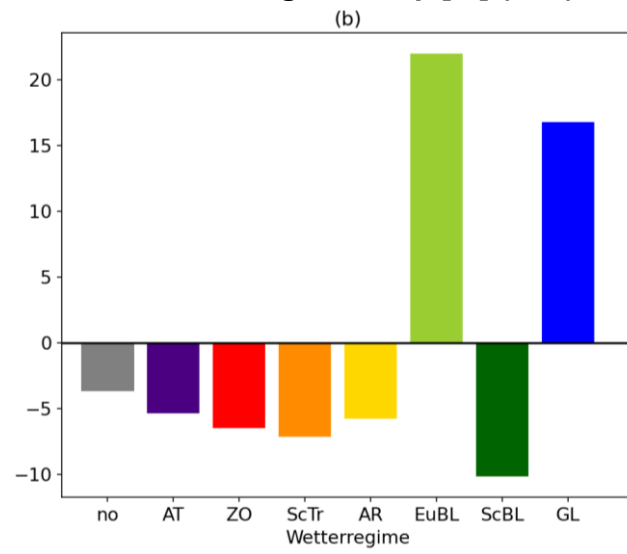


repeated blocking during the last 6 months

MSLP and W100m during EuBL



anomalous regime freq. [%] (abs) in 2024/25



anomalous regime frequency in winter half year 2024/25 1.9.2024-8.2.2025
3x more EuBL and 2x more GL than climatology



Drought monitoring and early warnings

Monitoring

Forecasts

Warnings

Information



Warnings via official
channels of the federal

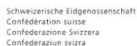
web-based drought
information platform

Go-Live
8. May 2025



MeteoSwiss

provided by V. Humphrey, S. Bircher, and A. Imamovic



[Kontakt](#) [Newsletter](#) [Medien](#)

[Startseite](#)
[Einflussfaktoren](#)
[Über Trockenheit](#)
[Weitere Informationen](#)
[Über die Plattform](#)



Copyright © 2009 by Thieme Medical Publishers, Inc., 381 Park Avenue, New York, NY 10017
All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or by any information storage or retrieval system, without prior written permission from Thieme Medical Publishers, Inc.

© 2006 Pearson Education, Inc. All rights reserved. This publication is protected by copyright. Any unauthorized distribution or reproduction of this work is prohibited. For more information, contact Pearson Education, Inc., 501 Boylston Street, Boston, MA 02116.

Michigan State University

[illegible]

Das Unternehmen ist ein 100-prozentiges Tochterunternehmen der Siemens AG. Die Siemens AG ist ein börsennotiertes Unternehmen. Die Siemens AG ist ein börsennotiertes Unternehmen. Die Siemens AG ist ein börsennotiertes Unternehmen.

[illegible]

Abstract

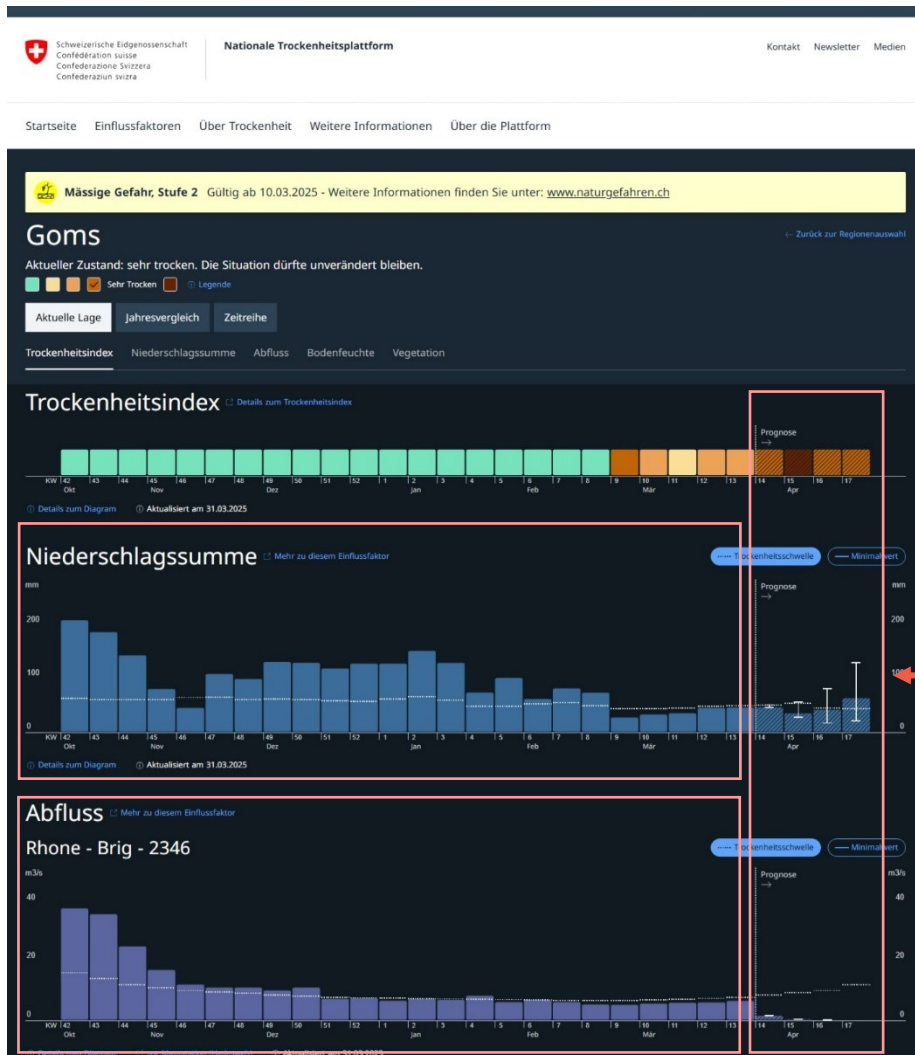
© 2006 The Authors
Journal compilation © 2006 Blackwell Publishing Ltd

Author's page:
<http://www.thomson.com> & <http://www.thomson.com> (all copyright 2001-2002)

Figure 10.10: A 3D plot of the function $f(x, y, z) = x^2 + y^2 + z^2$ over the domain $[0, 1] \times [0, 1] \times [0, 1]$. The surface is a paraboloid opening upwards from the origin.

MeteoSwiss

provided by V. Humphrey, S. Bircher, and A. Imamovic



current
warning level

weekly
aggregation

IFS ENS EXT

provided by V. Humphrey, S. Bircher,
and A. Imamovic

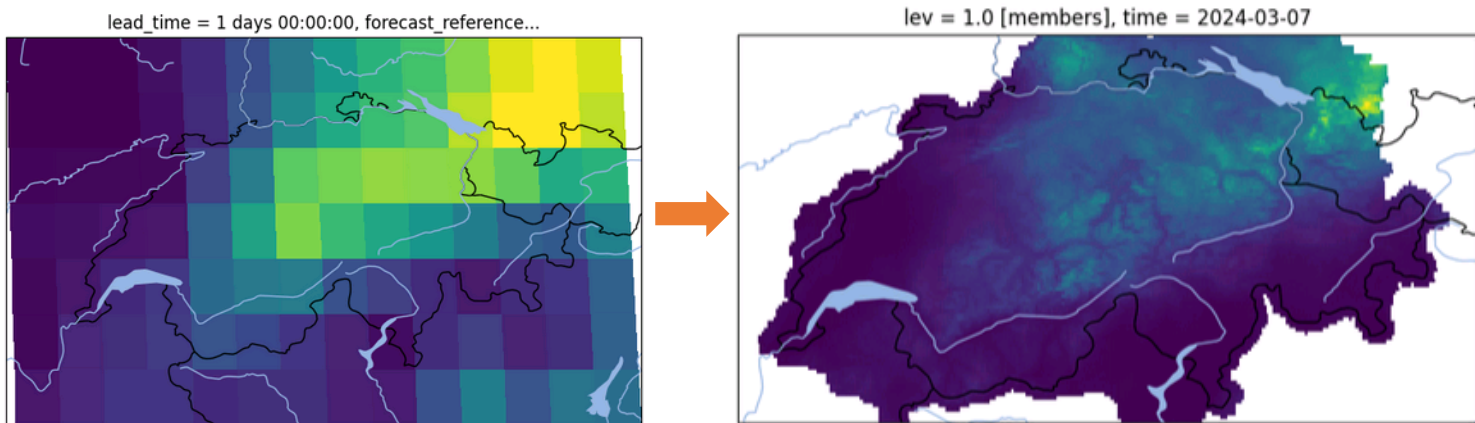
interpolated
stationdata

point
measurements
MeteoSwiss



Downscaling ECMWF ENS-EXT

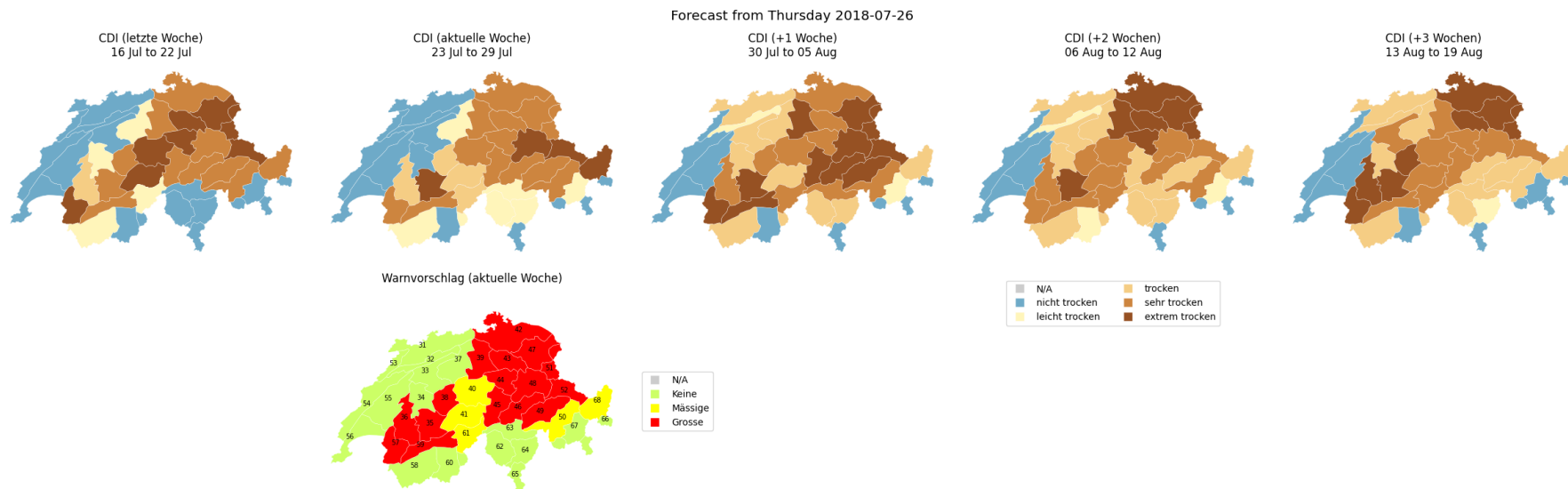
forecast



Downscaling (Quantile-Mapping) of precipitation forecast (raw IFS extended range at 9km) using climatological information available at 2km grids (RhiresD), which are based on stations measurements



Forecast is a basis for warnings



Warnprodukte Trockenheit
Credit: MeteoSchweiz

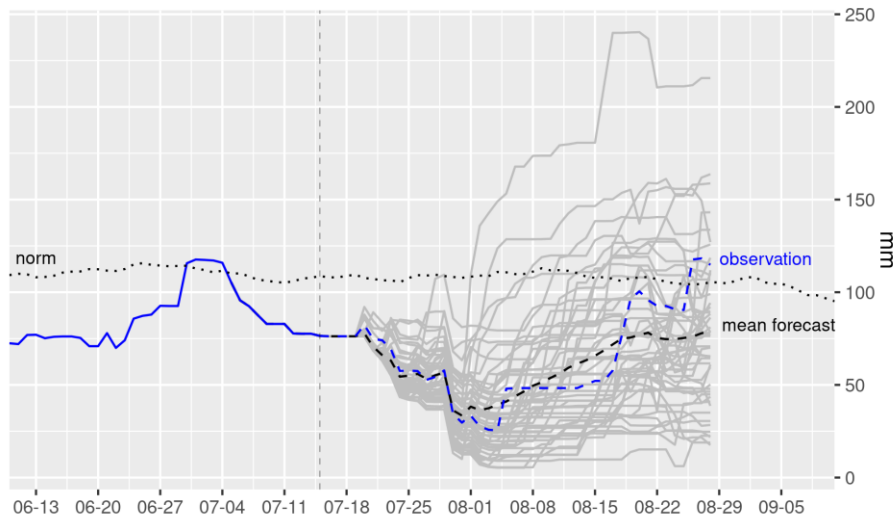
MeteoSwiss

provided by V. Humphrey, S. Bircher, and A. Imamovic



Skill

Niederschlagssumme der letzten 30 Tagen - östliches Mittelland
Bias-corrected 6-week forecast from 2022/07/15 (51 members)



MeteoSwiss

Take-home

- No skill in weekly sums after W2
- Useful skill until W4 for hydro variables & indices (inherits skill from observations)
- Downscaling does not massively improve skill (only bias) but facilitates «seamless» integration with high-res observations



Outlook Drought

Two equally important questions in drought management:

✓ **Predict drought onset** «*do I need to take measures now already?*»

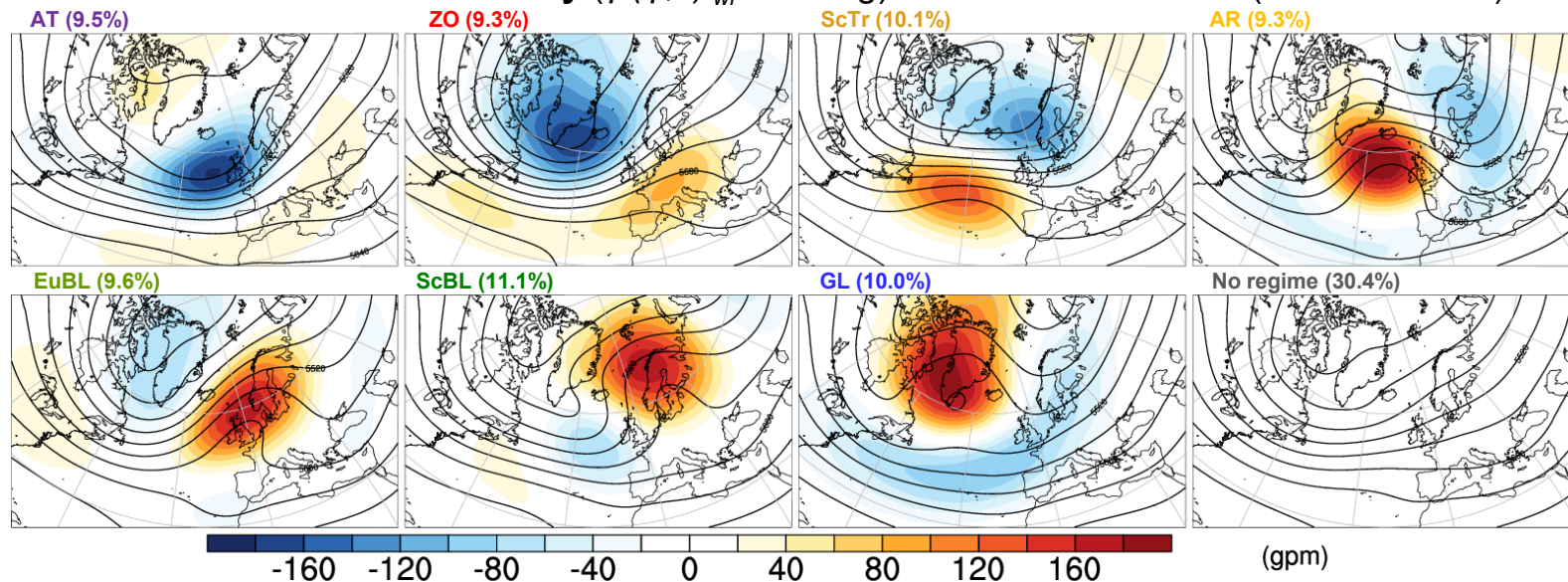
- Good observations + IFS ENS EXT

× **Predict drought end** «*can I lift some measures now already?*»

- Short-range high-res forecast (ICON-1&2) not used in current setup

Outlook year-round weather regimes

cluster mean Z500 anomaly ($\phi'(\varphi, \lambda)_{wr}$ shading) and absolute values (black contours)



Grams et al. 2017 doi:[10.1038/nclimate3338](https://doi.org/10.1038/nclimate3338).

Cyclonic regimes:

- Atlantic trough
- Zonal Regime
- Scandinavian trough

Blocked regimes:

- Atlantic ridge
- European blocking
- Scandinavian blocking
- Greenland blocking



Low stratus Swiss plateau and regimes



MeteoSchweiz-Blog | 25.02.2025

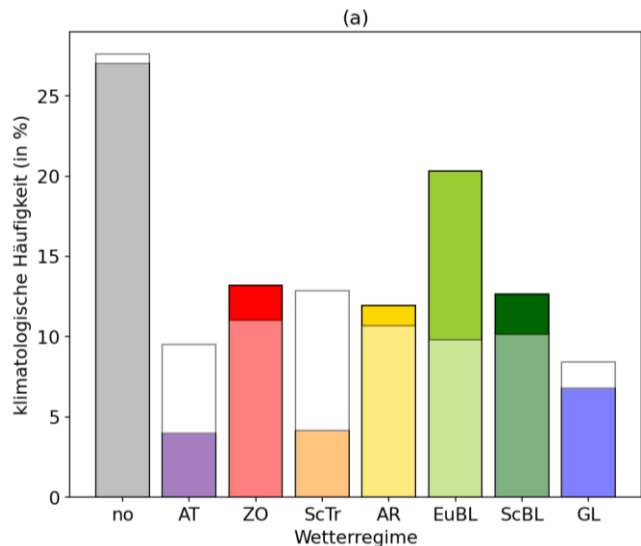
Das letzte Halbjahr zeigte sich bisher sehr neblig

Zahlreiche Mittellandbewohner auf der Alpennordseite dürften sich im vergangenen Halbjahr mindestens einmal über die anhaltenden Nebel- oder Hochnebelperioden gewundert haben...

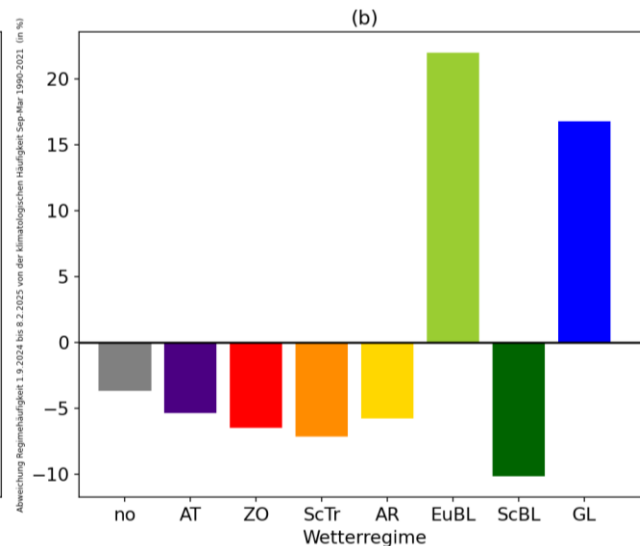
Klima



climatology regime freq. during fog



anomalous regime freq. in 2024/25



Klimablog 25.2.2025 <https://www.meteoschweiz.admin.ch/ueber-uns/meteoschweiz-blog/de/2025/02/nebliges-halbjahr.html>

bold: regime frequency during fog days
SONDJFM 1981-2025

white/pale: climatological regime
frequency SONDJFM 1990/91-2020/21

current anomalous regime frequency from
1.9.2024-8.2.2025

3x more EuBL and 2x more GL than climatology

MeteoSwiss

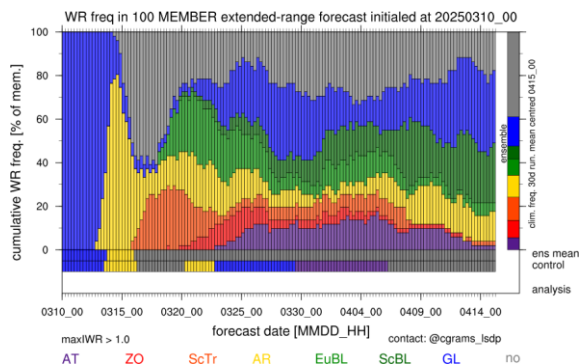
© Zurich, April 2025, Christian M. Grams

29

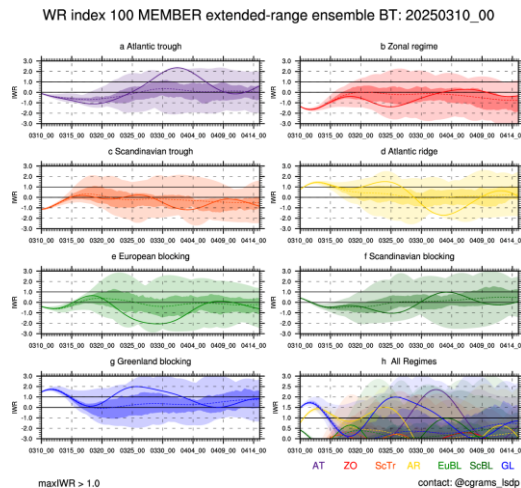


Examples regime subseasonal outlooks

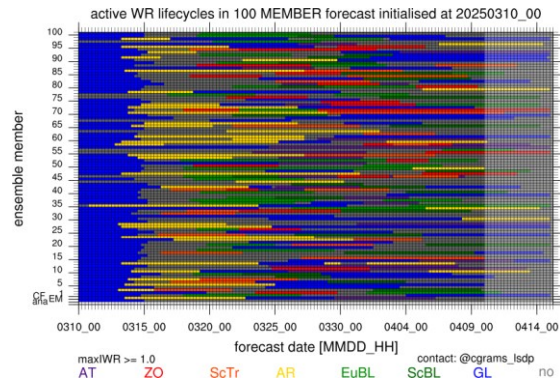
(a) overview regime forecast



(b) detailed regime forecasts



(c) details on members



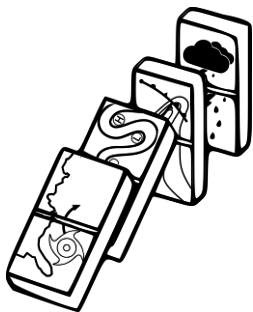
daily ECMWF **extended-range 100 member ensemble**

Event-prone (weather) regimes (EPR)

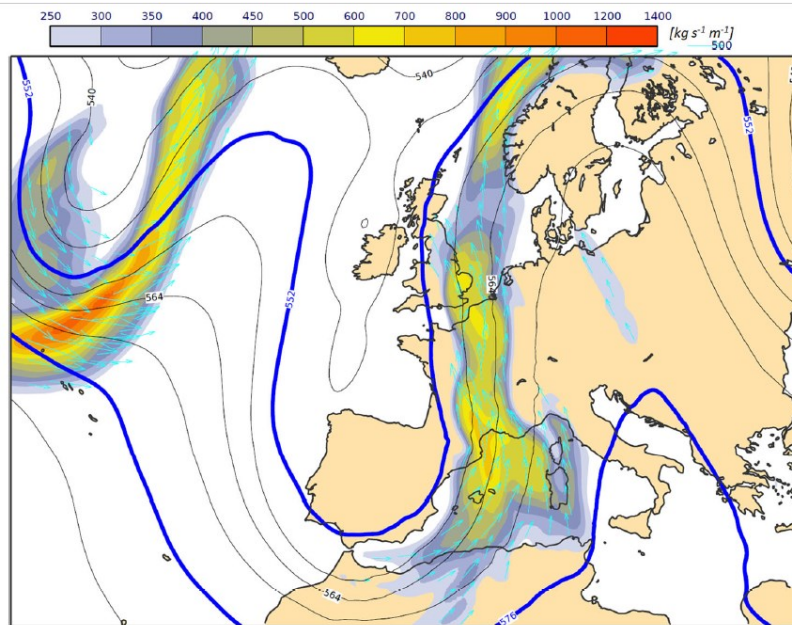
Zivildienst Jannis Portmann 2024-2025

Example Northern Italy / Southern Alps HPE

- Z500 (Geopotential height @ 500hPa)
- IVT (Integrated water-vapor transport)



MeteoSwiss



Grazzini et al. 2020, doi:[10.1007/s42865-020-00018-1](https://doi.org/10.1007/s42865-020-00018-1)

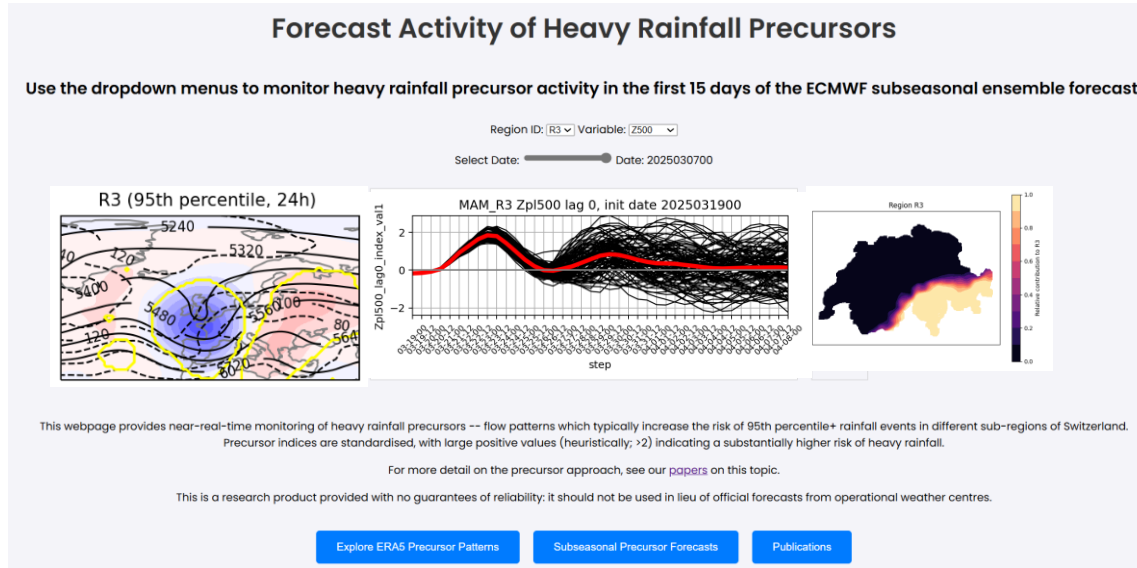


EPR: realtime precursor index forecasts

courtesy Josh Dorrington (Uni Bergen) and Jannis Portmann (MCH)

https://joshdorrington.github.io/DominoWeb/s2s_forecast.html

https://joshdorrington.github.io/DominoWeb/ch_s2s.html



Further reading:

ECMWF Newsletter autumn 2024:

<https://www.ecmwf.int/en/newsletter/181/news/increasing-lead-time-early-warnings>

Dorrington, J., et al. NHESS, <https://doi.org/10.5194/nhess-24-2995-2024>

Dorrington, J., et al. QJRMS, <https://doi.org/10.1002/qj.4622>

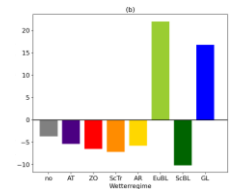
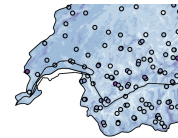
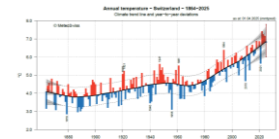
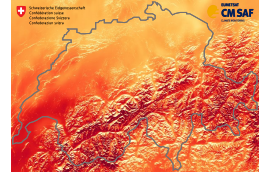
Grazzini, F., et al.

QJRMS: <https://doi.org/10.1002/qj.4755>



Summary

- climate services in complex terrain require (very) high resolution gridded data $O(1\text{km}-100\text{m})$
- non-stationary climate challenges disentangling internal variability and trends
- seamless weather and climate services enabled through blending observations, ECMWF & high-resolution model data, and spatial statistics
- ML allow new ways of generating hyper-resolution climate data
- weather regimes give dynamical context to climate monitoring



christian.grams@meteoswiss.ch



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

MeteoSchweiz

Operation Center 1
CH-8058 Zürich-Flughafen
T +41 58 460 91 11
www.meteoschweiz.ch

christian.grams@meteoswiss.ch

MeteoSvizzera

Via ai Monti 146
CH-6605 Locarno-Monti
T +41 58 460 92 22
www.meteosvizzera.ch

MétéoSuisse

7bis, av. de la Paix
CH-1211 Genève 2
T +41 58 460 98 88
www.meteosuisse.ch

MétéoSuisse

Chemin de l'Aérologie
CH-1530 Payerne
T +41 58 460 94 44
www.meteosuisse.ch

MeteoSwiss

© Zurich, April 2025, Christian M. Grams