Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

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

MeteoSwiss

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

A centennial climate-consistent spatial analysis of precipitation for the European Alps

Climate Change

Francesco Isotta*, Barbara Chimani+, Johann Hiebl+ and Christoph Frei*

* Federal Office of Meteorology and Climatology MeteoSwiss

+ Zentralanstalt für Meteorologie und Geodynamik

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COPERNICUS Project C3S_311a-Lot4 (C3Surf)

Collection and Processing of In Situ Observations

- Lot 4: Climate monitoring products for Europe based on in situ observations
- Consortium: KNMI (NL, lead), EUMETNET, DWD (D), MeteoSwiss (CH), MetNorway (N), OMSZ (H), UEA-CRU (UK), GCRI (CZ), ZAMG (A)
  - collect station data across Europe
  - develop ensemble pan-European dataset → climate indices
  - regional datasets involved (Fennoscandia, Alps, Carpathian Region)
  - data delivery and information systems
- 2017-2021

Contribution of MeteoSwiss

- With ZAMG: centennial monthly spatial analysis of precipitation
- Comparison (Fennoscandia, the Carpathian region and the Alpine region)

https://surfobs.climate.copernicus.eu/

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Alpine Reconstruction

Alpine spatial analysis (monthly precipitation)

- European Alps
- monthly precipitation
- centennial (~150y)
- high standards in climate consistency
- targeted for long-term climate monitoring
- operational updating every 2 years

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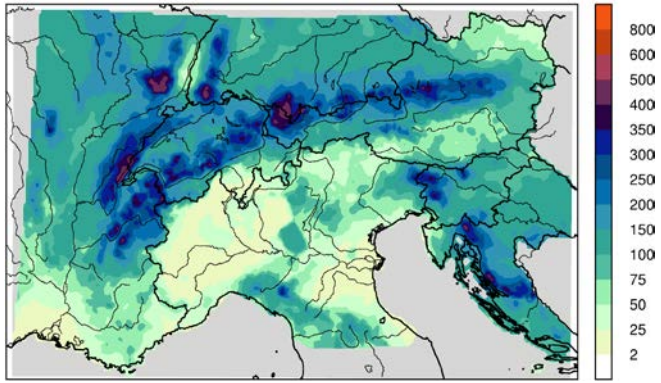
Method - Introduction

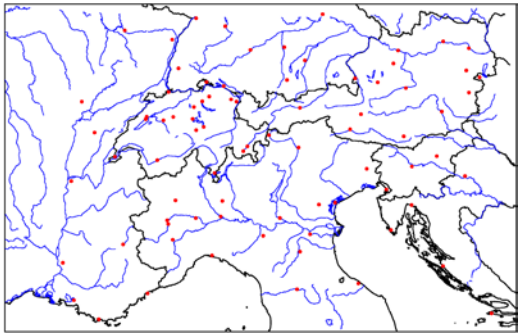
Climate Change

High-resolution component



+

Long-term component



Homogenised station data
No gaps

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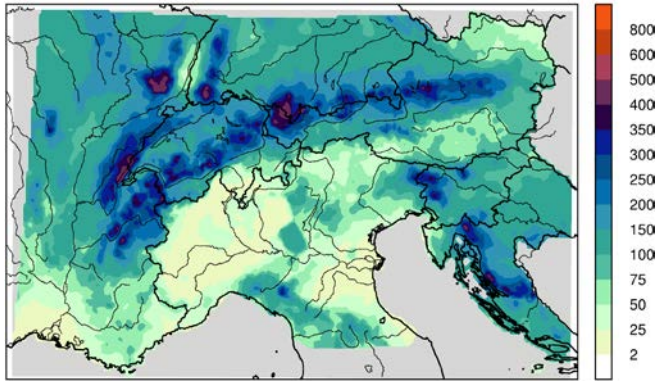
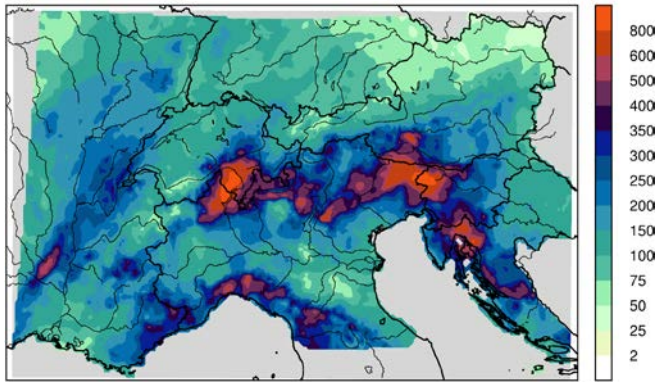
High-resolution component: APGD

Climate Change

November 1992



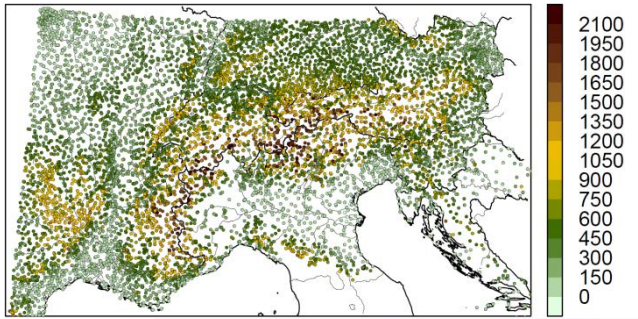
October 1993



Alpine Precipitation Grid Dataset (APGD)

1971 – 2008 (daily)
monthly precipitation totals
>5500 stations each month
grid spacing 5-km (ETRS-LAEA)
23574 non-NA grid points

Isotta et al. 2014
meteoswiss.ch → search for APGD
DOI: http://dx.doi.org/10.18751/Climate/Griddata/APGD/1.0



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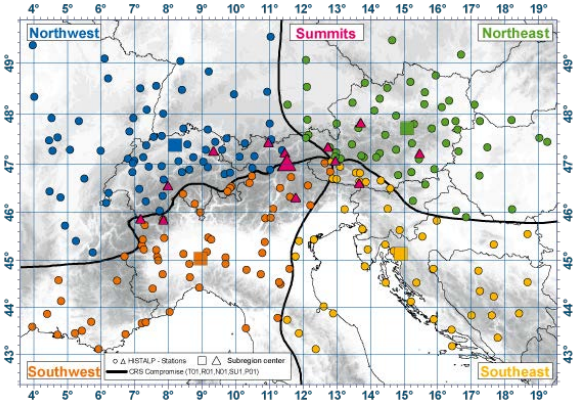
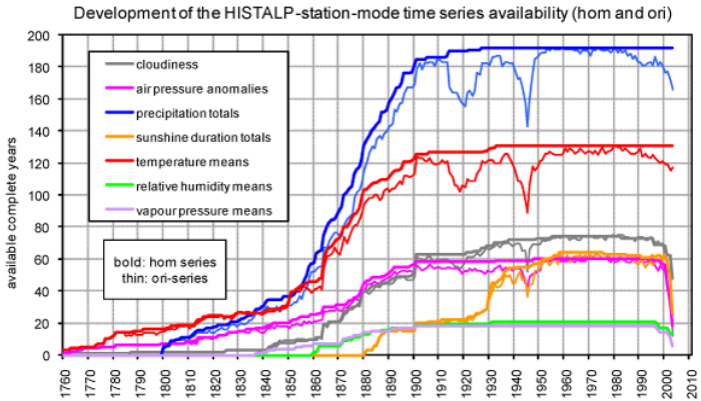
Long-term component: HISTALP

Historical **I**nstrumental Climatological **S**urface **T**ime Series Of The Greater A**lp**ine Region





- → **LONGTERM**
- → **DENSE**
- → **QUALITY IMPROVED** (outliers removed, gaps filled)
- → **HOMOGENISED**
- → **MULTIPLE** (more than one climate element)
- → **USER FRIENDLY** (well described, different modes for different applications)

Recent/current improvements:

- → New original time series (BIH, F, I, SLO,)
- → Additional stations (BIH, F, SLO)
- → New station set (improved density, CH)

Total >200 stations for precipitation

http://www.zamg.ac.at/histalp/

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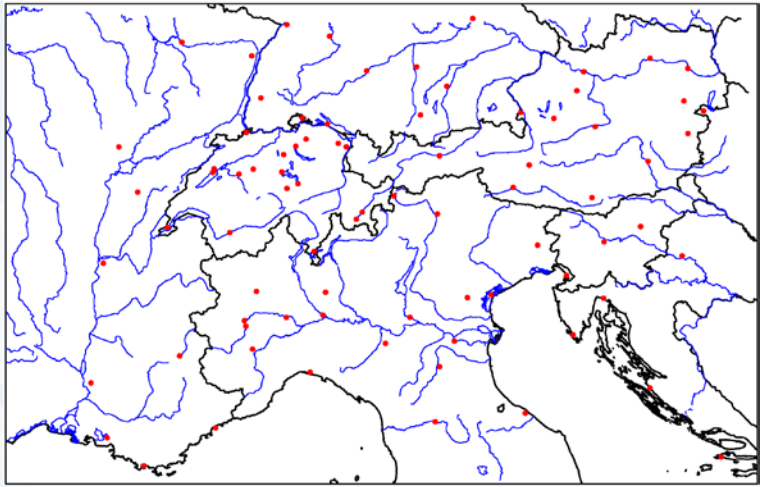
Station Data: HISTALP

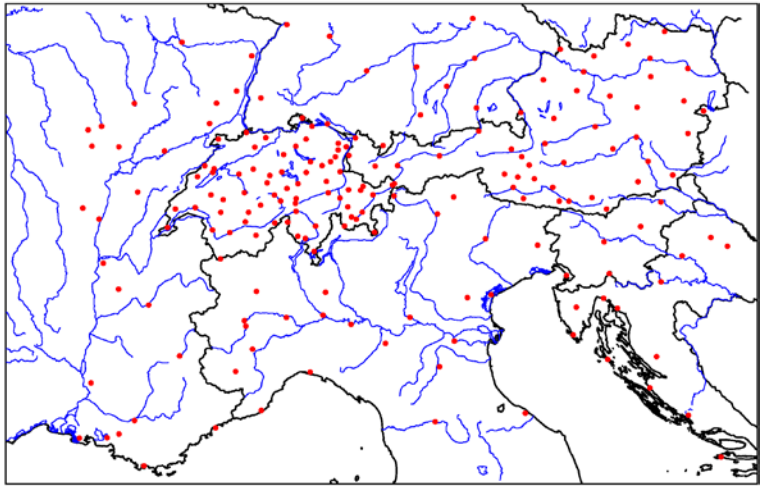
Two Subsets

"very long"



Period: 1870 – actual
Stations: 80
Calibration period: 1971 – 2008
Reduced effective resolution

"long"



Period: 1901 – actual
Stations: 192
Calibration period: 1971 – 2008
Meso-scale resolving

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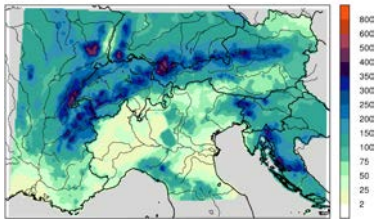
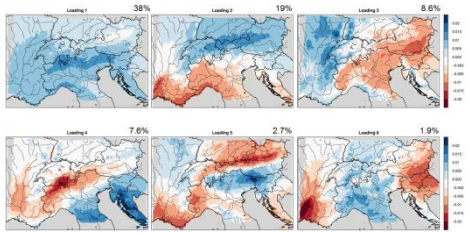
RSOI - Overview

- **R**educed **S**pace **O**ptimal **I**nterpolation (Kaplan et al., 1997; Schmidli et al. 2001, 2002; Schiemann et al., 2010; Masson and Frei, 2015)



High-resolution component
CALIBRATION PERIOD
(data transformation for precipitation)

PCA →



PC loadings
Dimensionality reduction (truncation)

+

$data

	station	time	value
1	ALT	200203010000	2.43
2	ANT	200203010000	1.60
3	BAS	200203010000	1.59
4	BER	200203010000	1.52
5	CDF	200203010000	1.88
6	CHD	200203010000	2.18
7	CHM	200203010000	1.98
8	CHU	200203010000	2.46
9	DAV	200203010000	1.71
10	EIN	200203010000	2.28
11	ELM	200203010000	2.36
12	ENG	200203010000	2.07
13	GRC	200203010000	2.00
14	GSB	200203010000	1.41
15	GVE	200203010000	1.27
16	LUG	200203010000	1.85
17	LUZ	200203010000	1.85

Station data (sparse network)
CALIBRATION PERIOD

Station data (sparse network)
RECONSTRUCTION PERIOD

$data

	station	time	value
1	ALT	200203010000	2.43
2	ANT	200203010000	1.60
3	BAS	200203010000	1.59
4	BER	200203010000	1.52
5	CDF	200203010000	1.88
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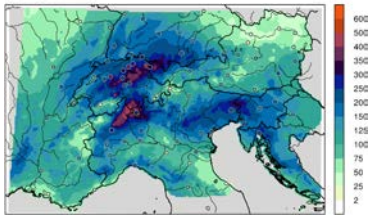
15	GVE	200203010000	1.27
16	LUG	200203010000	1.85
17	LUZ	200203010000	1.85

→ OI →



Reconstruction (sparse network)
RECONSTRUCTION PERIOD

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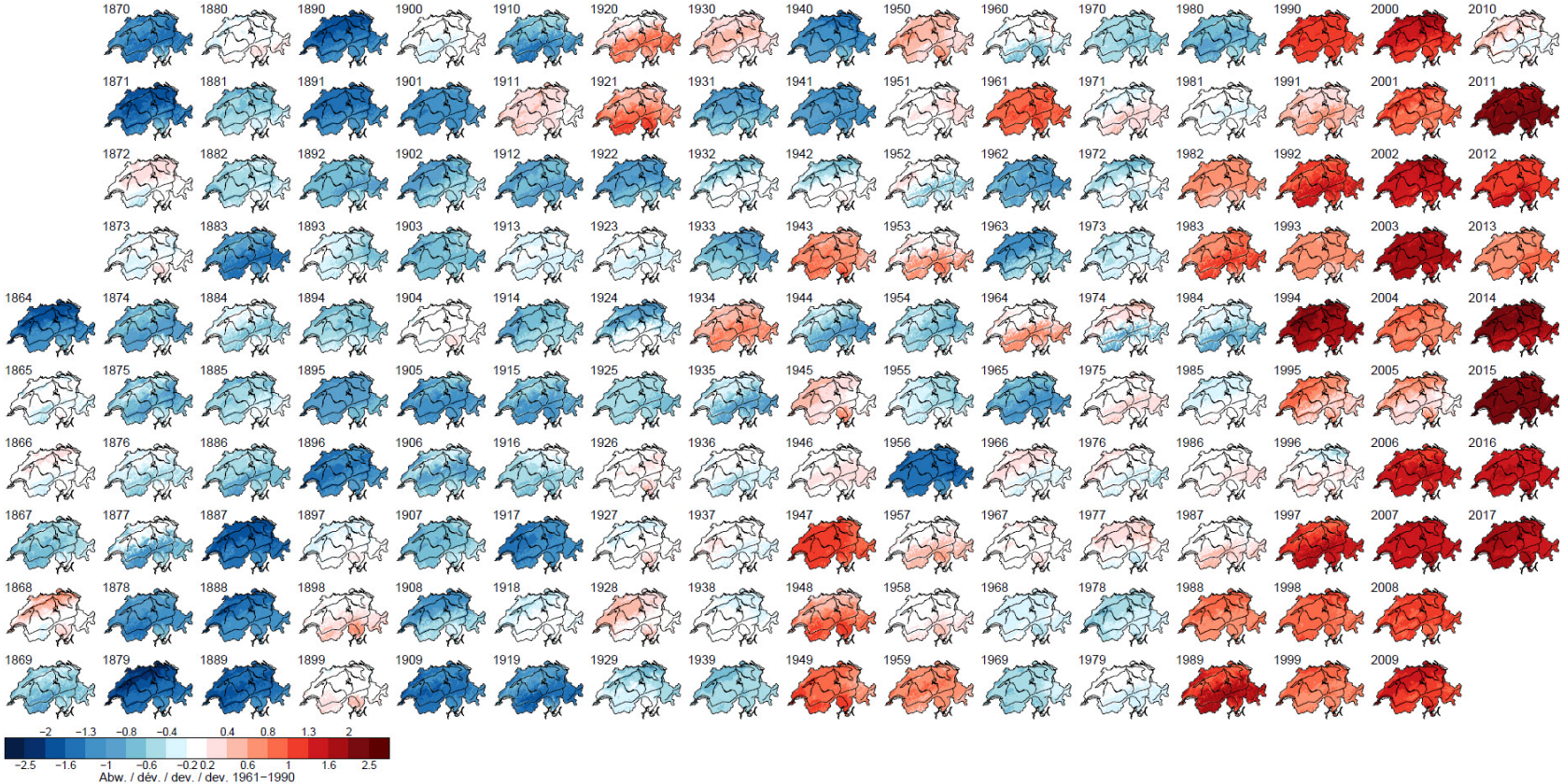
Reconstructions in Switzerland



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PCA: Loadings

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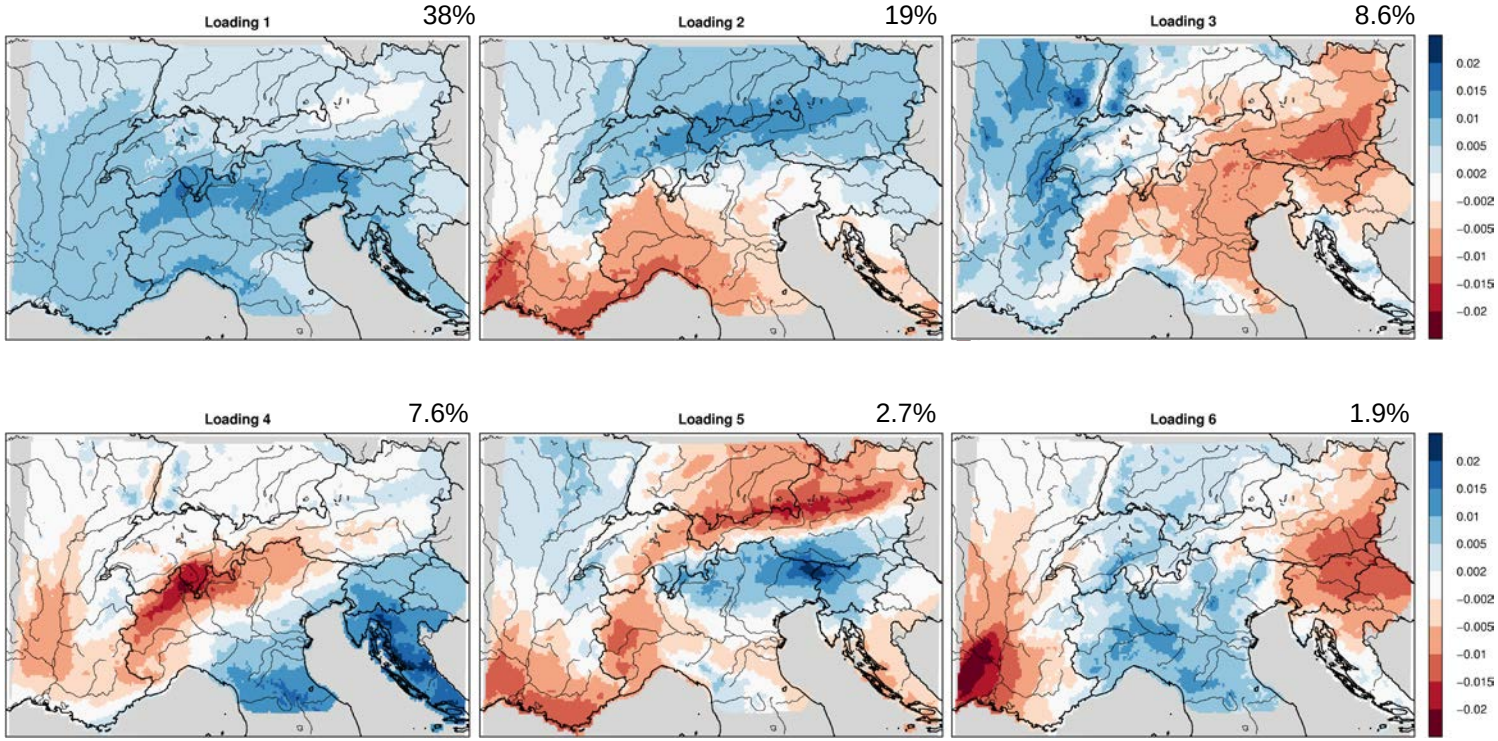

...

The phasespace coordinate system in terms of mutually uncorrelated contrasts

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PCA: Rotated loadings

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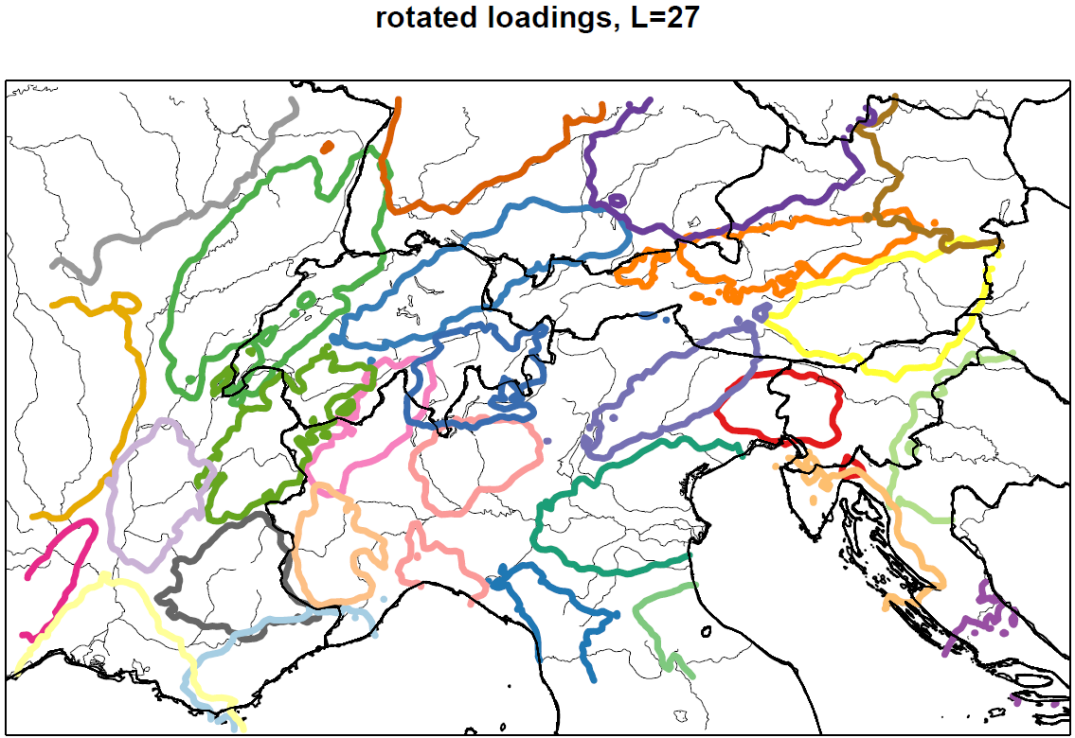

The phasespace coordinate system in terms of core regions (mutually correlated)

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Evaluation: Example Months

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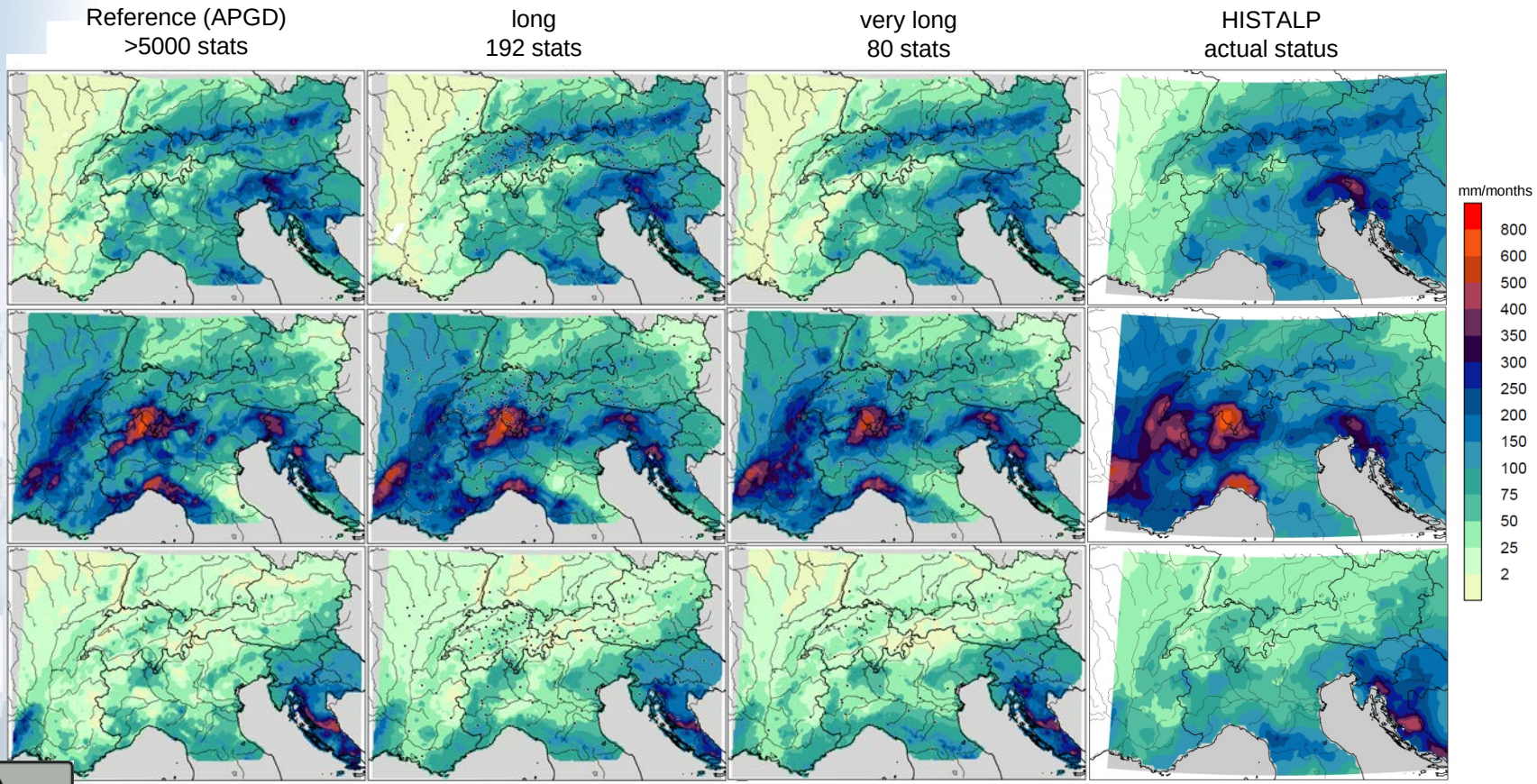

s-validation: reconstruction calibrated with target month excluded

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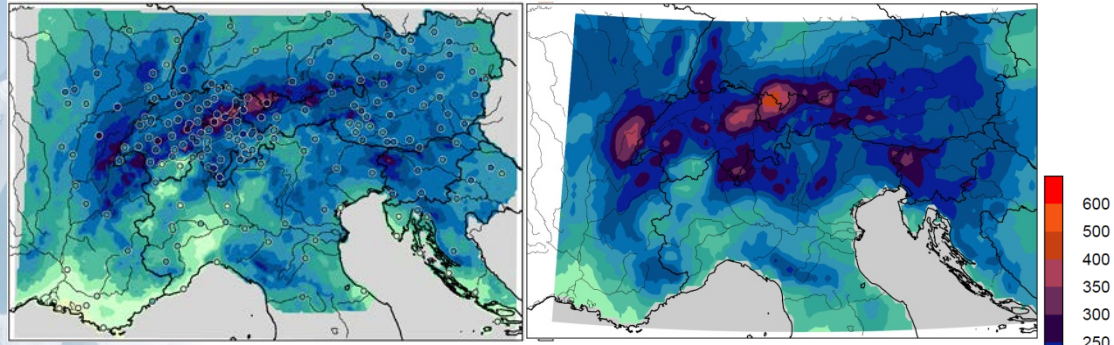
Reconstruction: Example Months

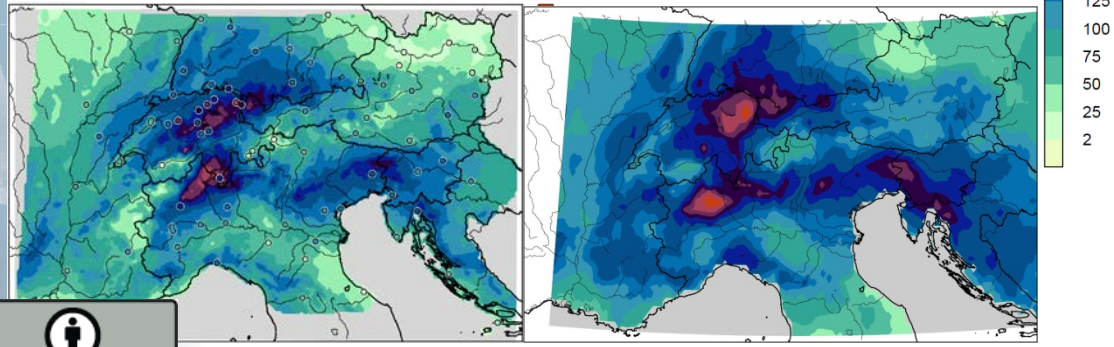
Prominent floods of river Rhine

Long reconstruction June 1910 HISTALP



Schaffhausen (www.schaffhausen-foto-archiv.ch)

Very long reconstruction June 1876 HISTALP



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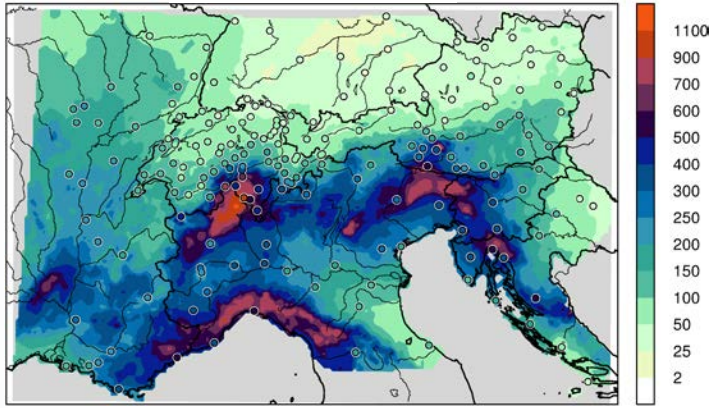
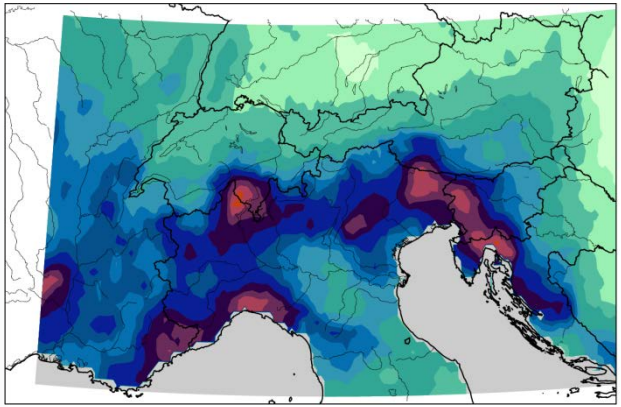
Reconstruction: Example Months

Climate Change

Long reconstruction



HISTALP



Heavy floods along Southern Alps

October 1907

Piacenza, Po (www.ilpiacenza.it)

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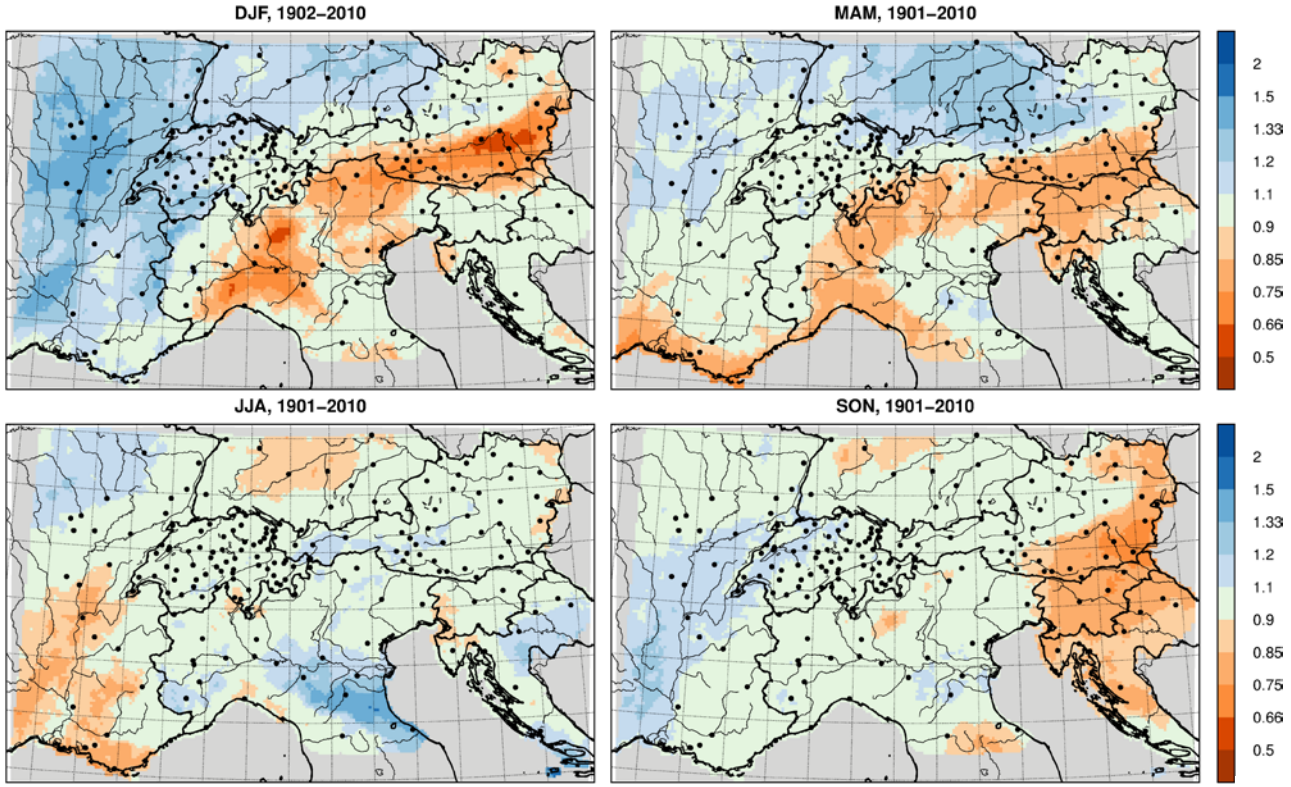
Precipitation Trend



1901–2010

Trend: relative change (end / beginning)
Sig. level: $\alpha_{FDR} = 0.05$ (bold contours),
family-wise testing (Benjamini & Hochberg 1995)

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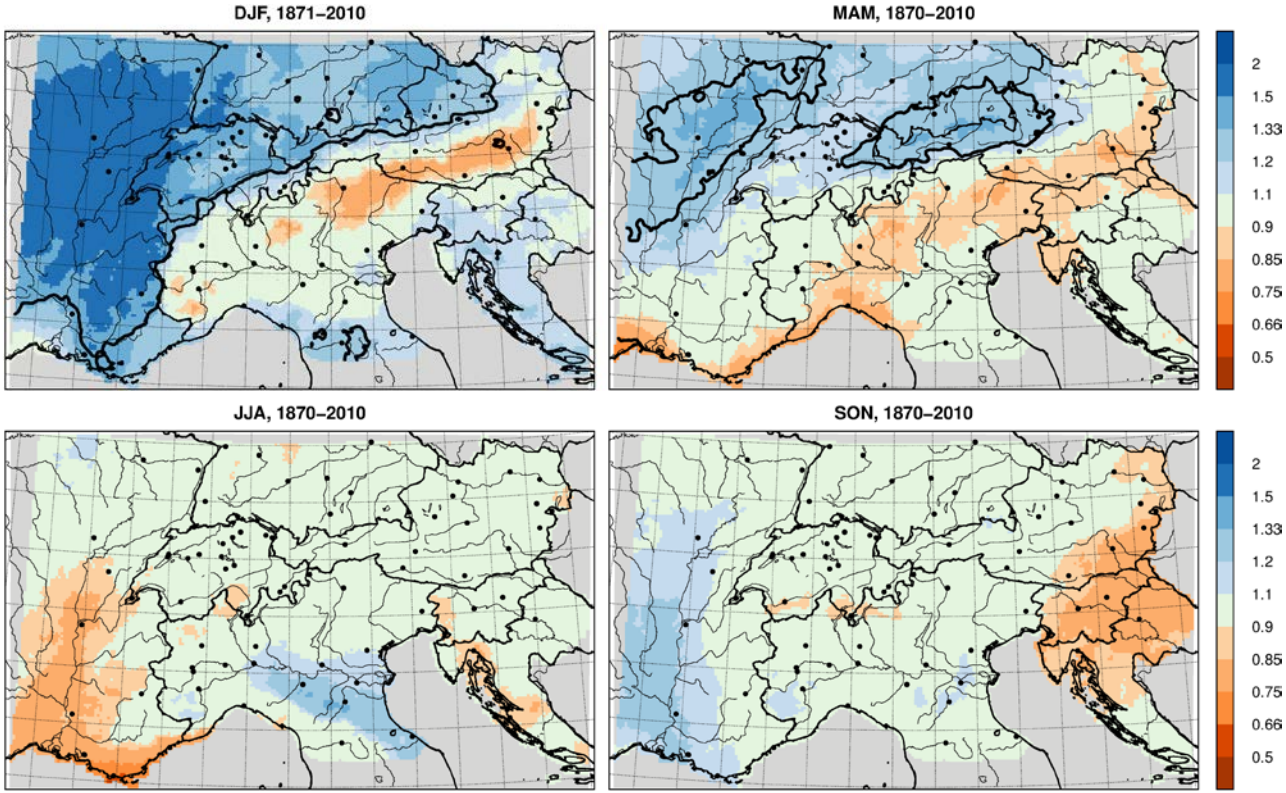
Precipitation Trend



1870–2010

Trend: relative change (end / beginning)
Sig. level: $\alpha_{FDR} = 0.05$ (bold contours),
family-wise testing (Benjamini & Hochberg 1995)

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Summary

- Prototype of the HISTALP reconstruction look promising
- HISTALP station dataset covers region evenly
  - allows dataset to extend back as far as 1870
  - higher accuracy than earlier attempts (Masson & Frei 2014)
- Reconstruction dataset ...
  - ... delivers fields with rich mesoscale structures
  - ... is more plausible than interpolation from stations alone
  - ... satisfies high standards in climate consistency
  - ... ideal to compare decadal variations in other datasets
- Future work: use newest HISTALP dataset, in depth evaluation

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