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Circulation Type Classifications and Precipitation Variability in the Alps

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Themes

- How to measure the resolution of surface climate by circulation types (CTs)? (“Provide tools for comparison and evaluation of different CTs”)
- How well do COST733 CTs resolve mesoscale precipitation (heavy events) in the Alps?
- How does the relationship look like?

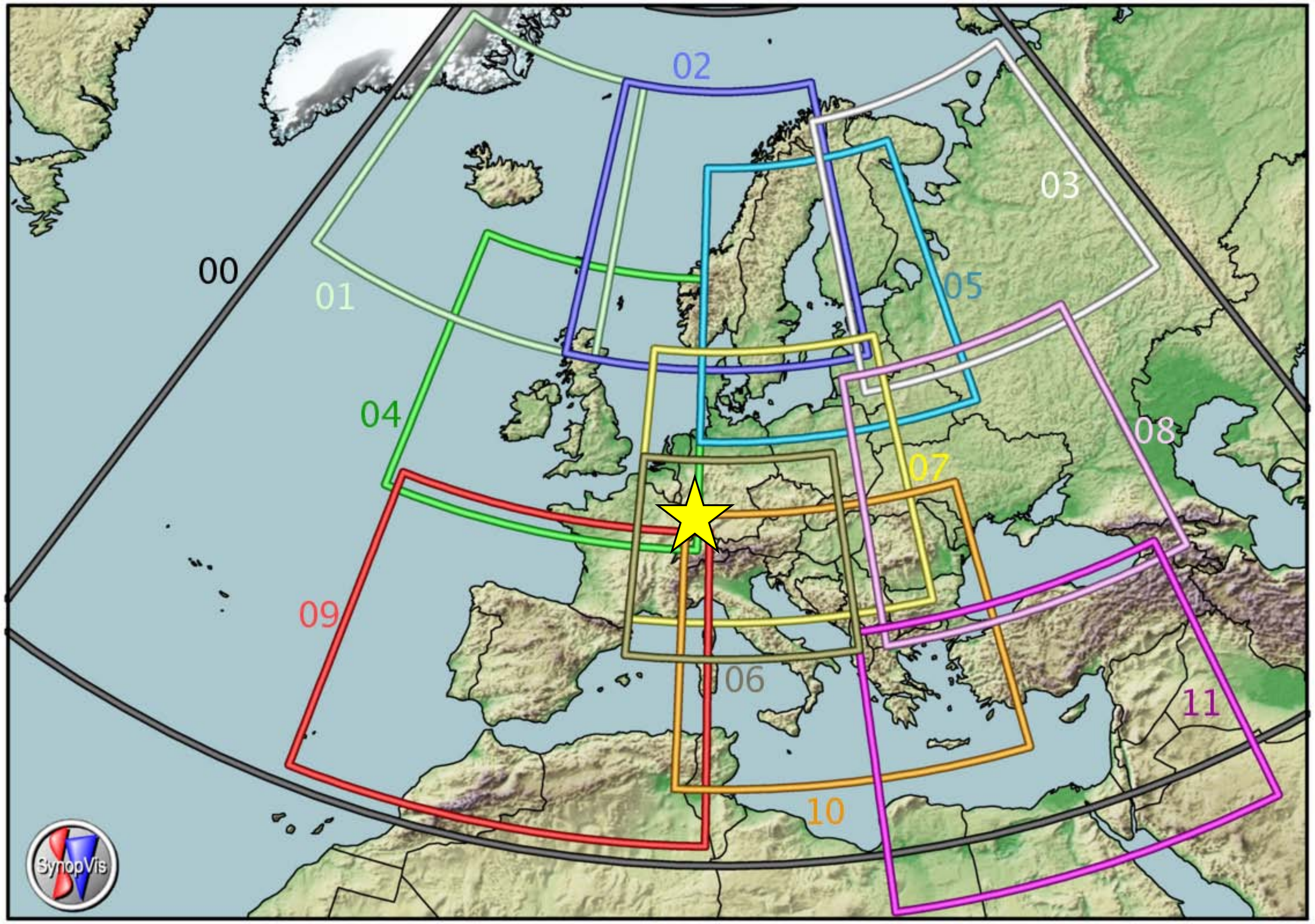
Circulation Type Classifications

- COST 733 catalogue v1.2 (status mid 2008)

- 22 methods (objective and subjective/manual)
- alltogether 71 catalogs (incl. 9, 18, 27 types)

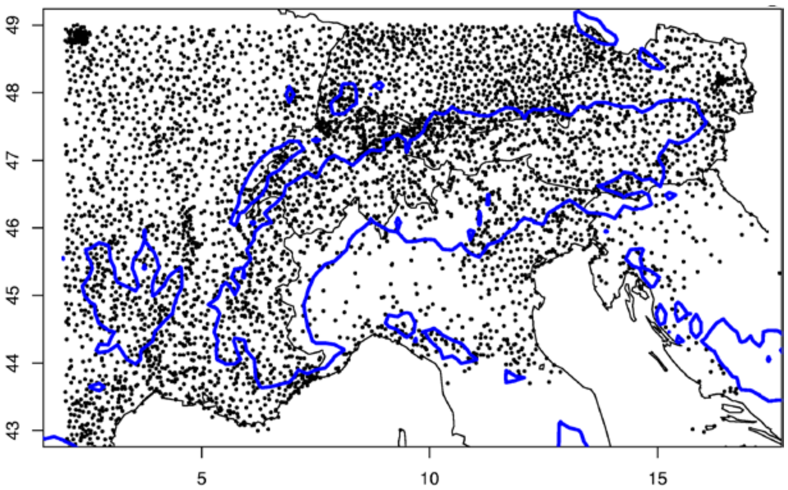
- Classification parameter: SLP, ECMWF ERA40, daily, (excpt subj.)
- No time sequencing, no seasonal classification
- Period: 1971-2000

Circulation Type Classifications

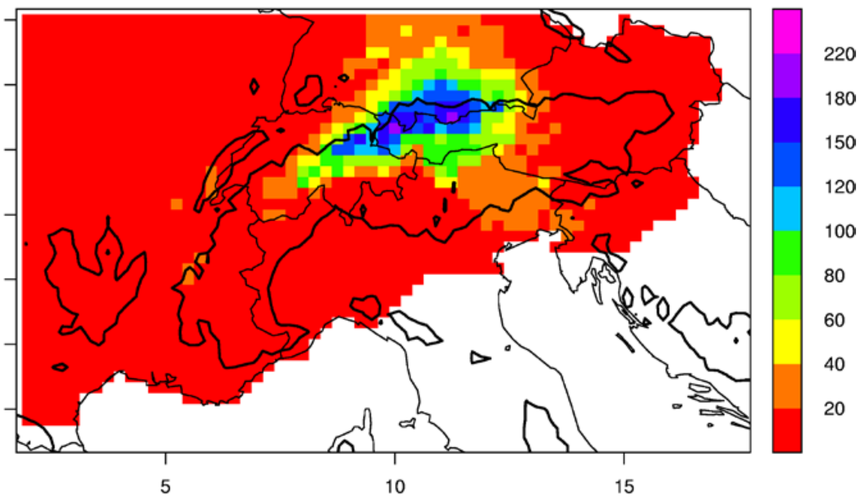


Alpine Precipitation

Station Network



Example: 1999.05.21



Daily gridded precipitation

- Alpine region
- 20 km resolution
- approx 7000 rain-gauges
- 1971-2000

Events

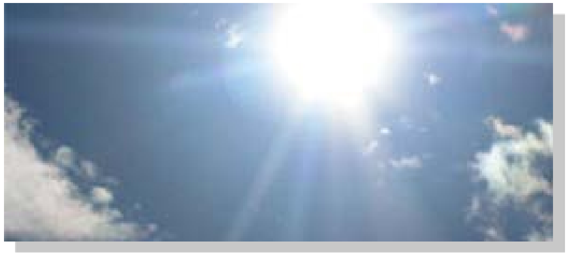
- wet days (> 1 mm per day, OCC)
- quantile exceedence (Q60, Q80, Q95)

medium   intense   heavy

Frei & Schär 1998, Frei et al. 2006

CT-Classification and Prob. Prediction

- CT-Classification can be viewed as probabilistic prediction
  - E.g. empirical PDF of temperature within CT_k is forecast PDF for days belonging to CT_k .
- For binary events:
  - E.g. O_3 –days: if day t in CT_k, prob(O_3-day @ t) = prob(O_3-day | CT_k)



- Use concepts of probabilistic forecast evaluation to assess/compare CT-classifications.
  - Continuous → Rank Probability Skill Score (RPSS)
  - Binary → Brier Skill Score (BSS)
  - Added value over climatological fcst (no classification)

Schiemann and Frei 2010

The Brier Skill-Score

$$BSS = \frac{\frac{1}{N}\sum_{i=1}^{l} N_i \left(p_i - \overline{p}\right)^2}{\overline{p}\left(1-\overline{p}\right)}$$

p_i	probability of event in CT i
l	number of CTs
N_i	number of days, classified as CT i
$\overline{p}$	climatological frequency of event

BSS = 1: perfect resolution of events by CT

BSS = 0: event probability equals climatology in all CTs

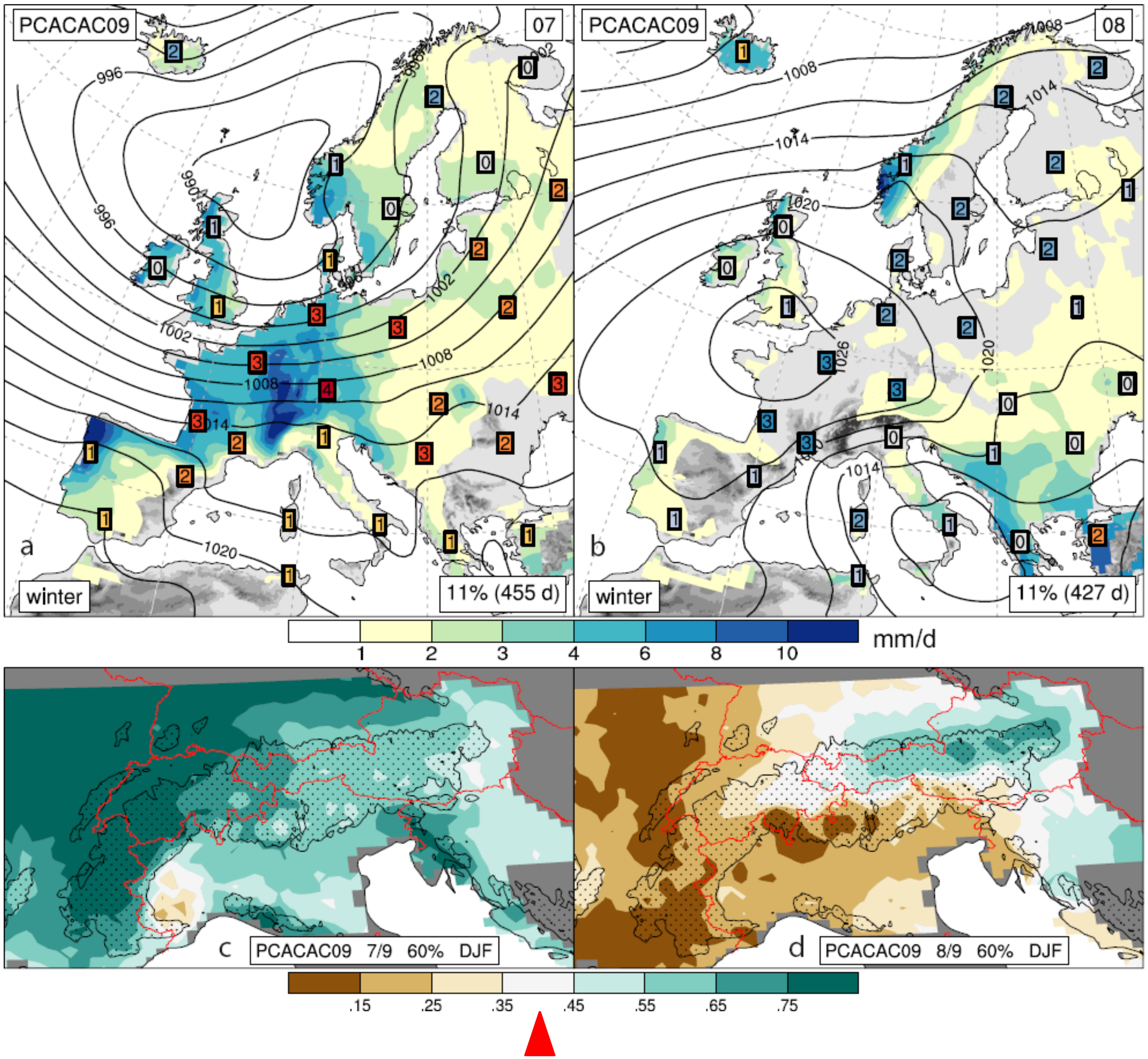
BSS in [0,1]; the better the larger, sort of „explained variance“ in prob.

Note: BSS simplifies to „resolution“ only.

Note: Sampling errors may pretend skill! Need statistical test!

Schiemann and Frei 2010

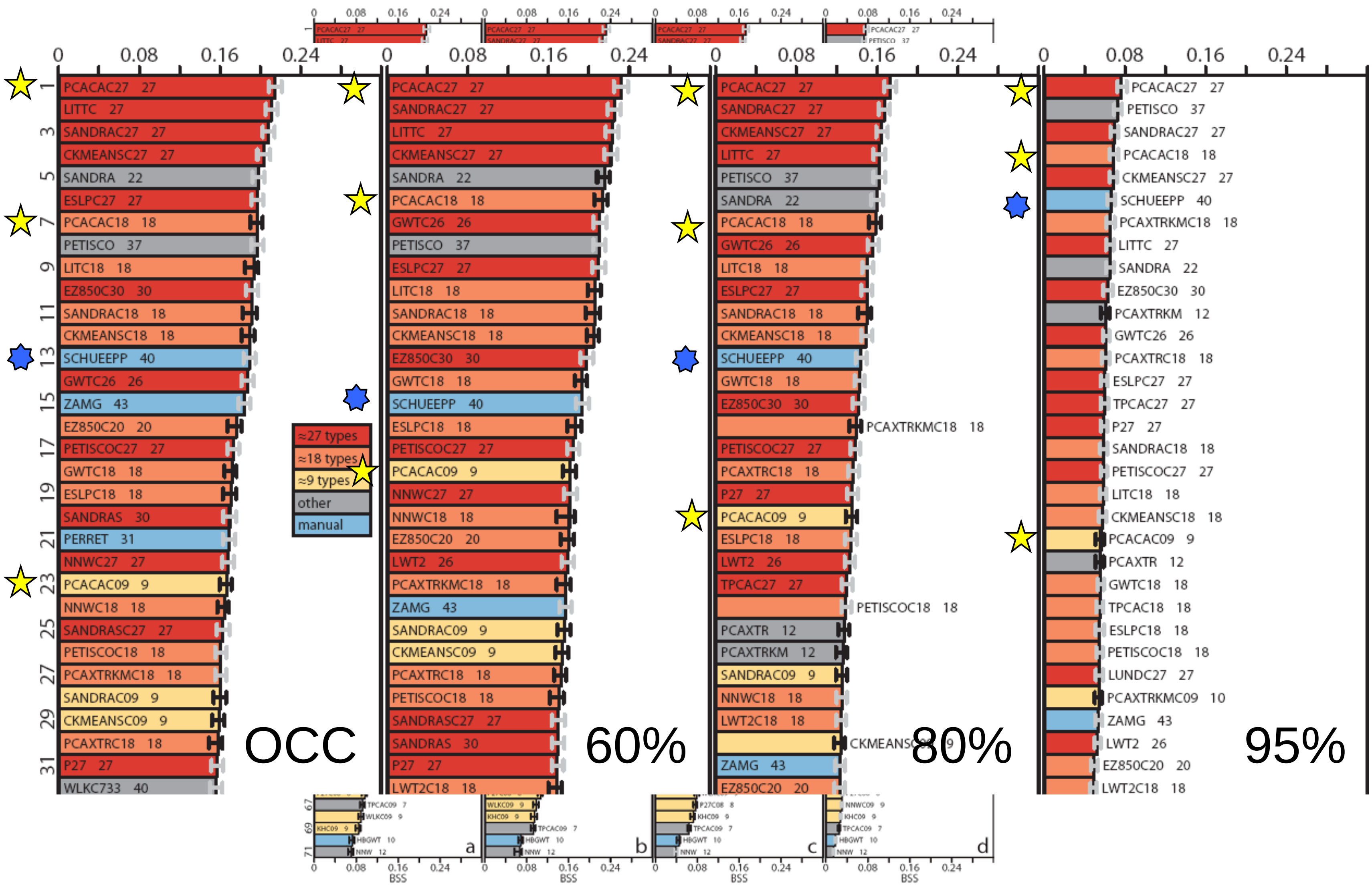
Brier skill score (BSS) - Motivation



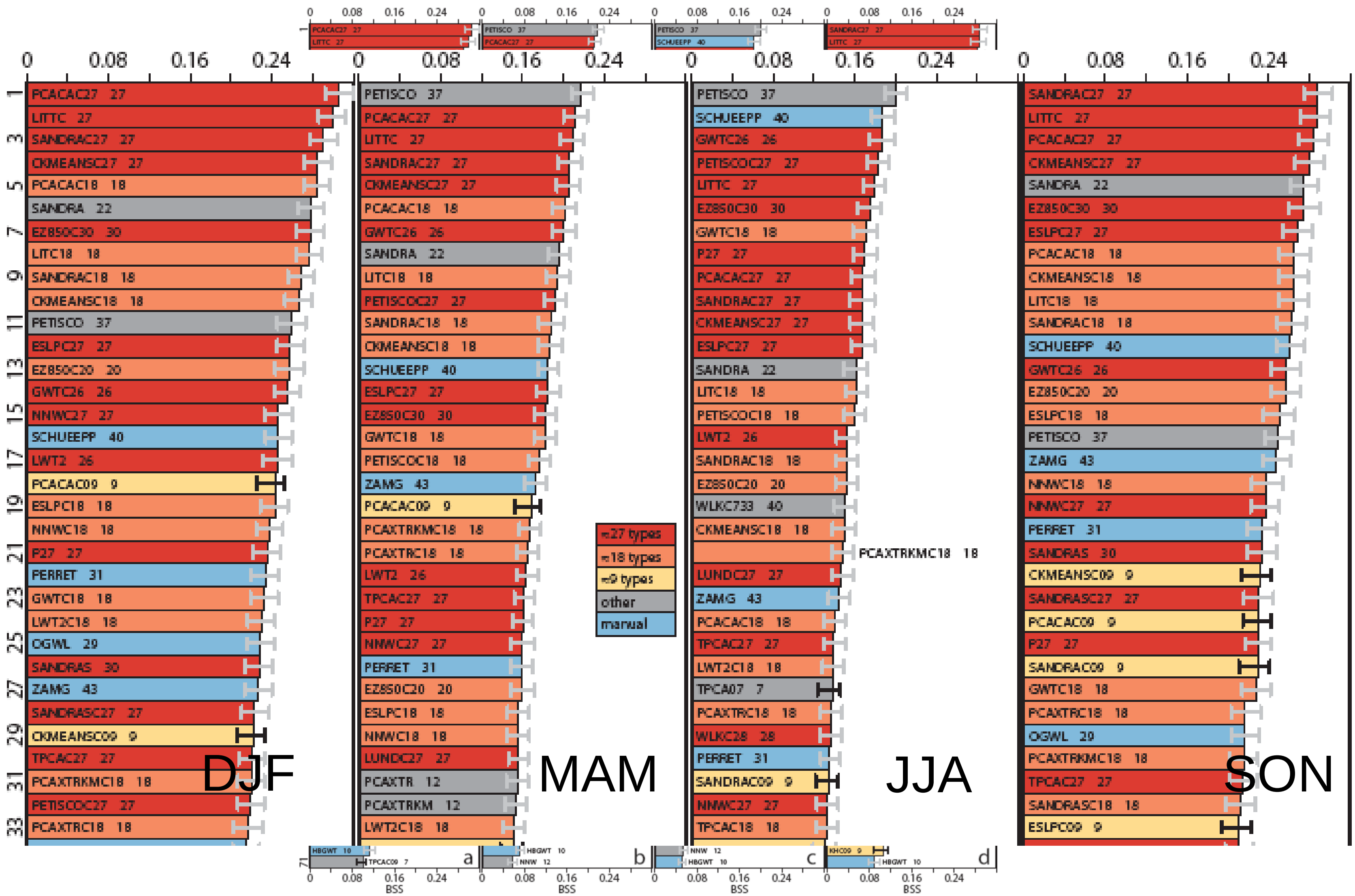
Mean SLP

Prob. R>Q60

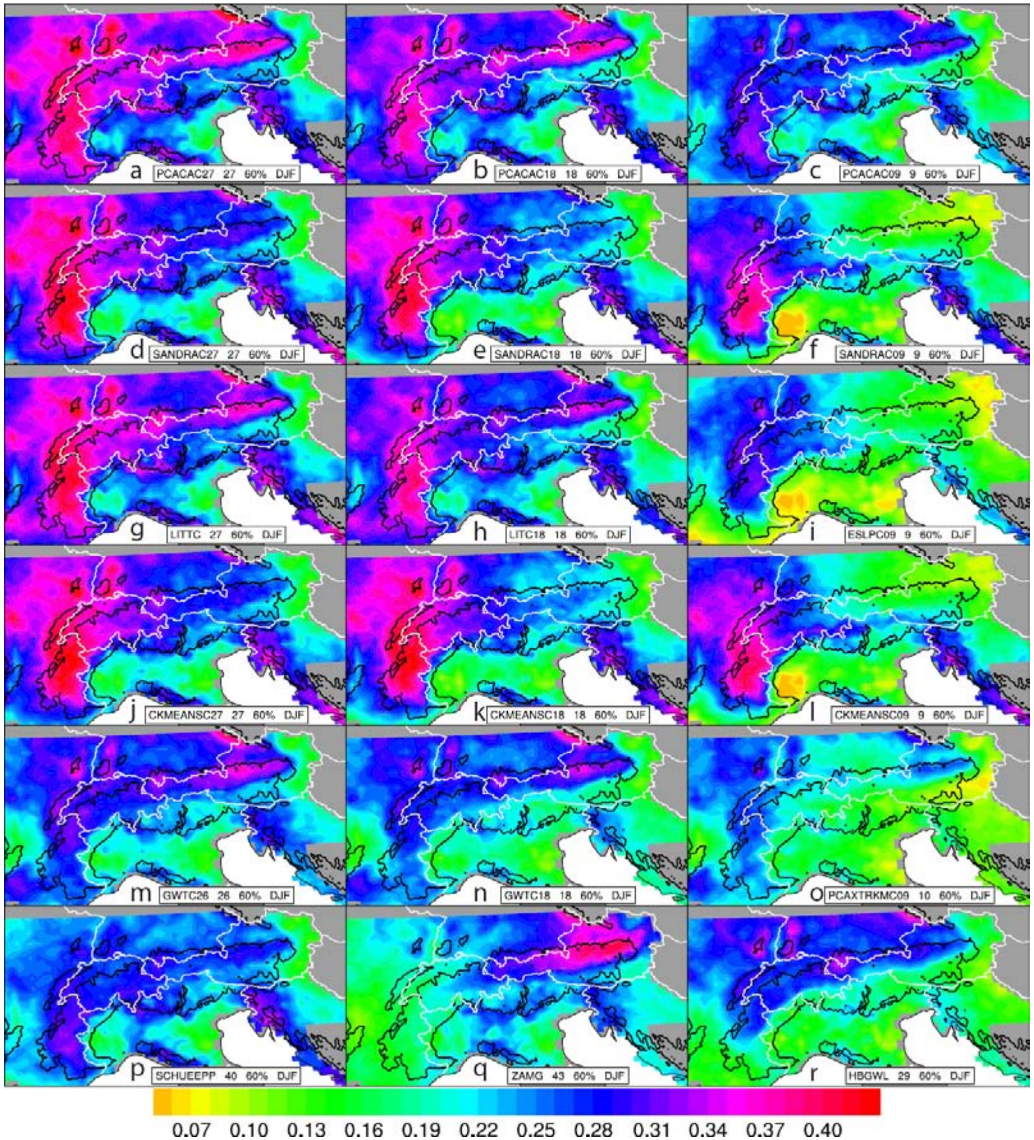
BSS (annual mean, entire Alps)



BSS (Q60, seasonality, entire Alps)



BSS: Q60 (DJF)



PCACA

SANDRAC

LITTC

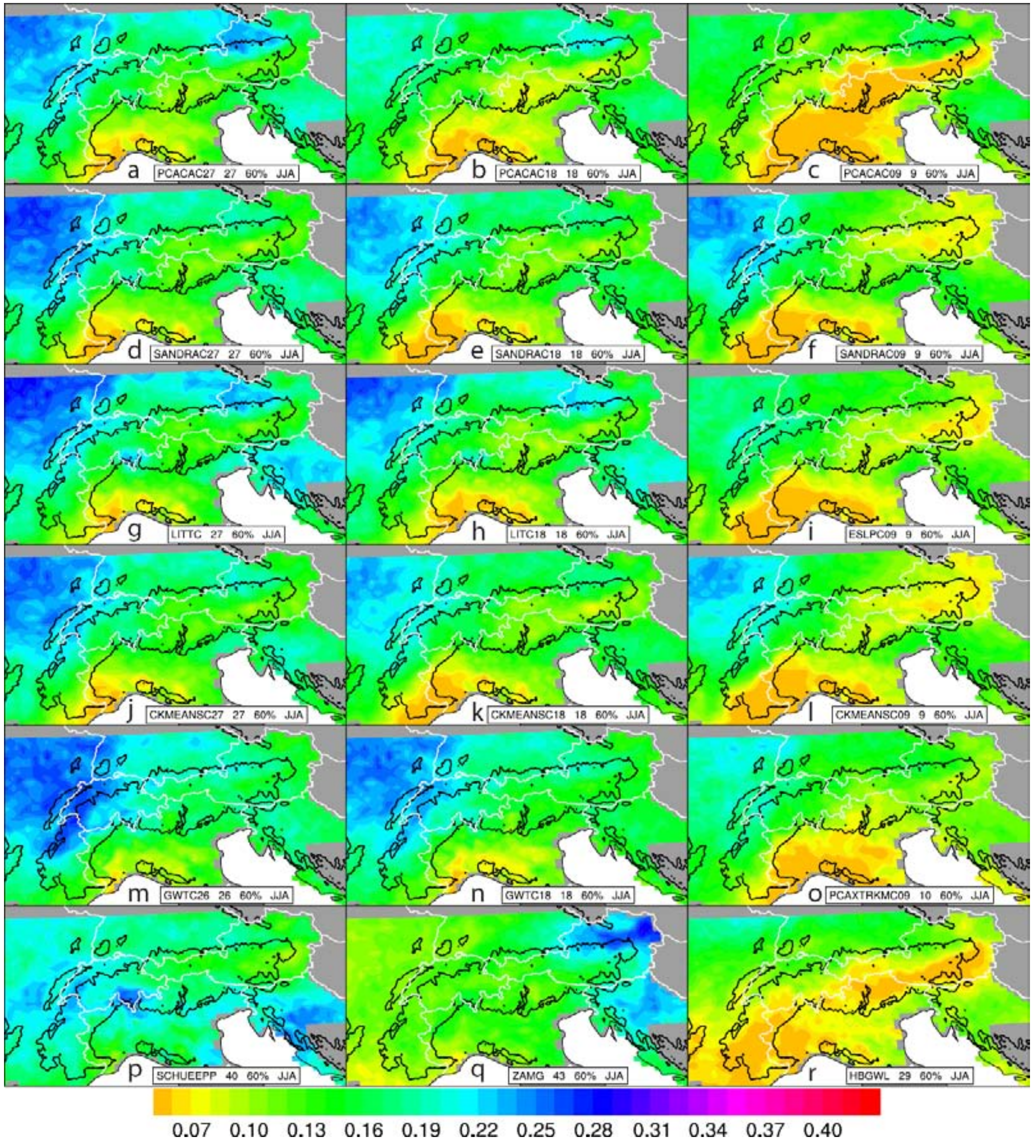
CKMEANSC

GWTC

5 „better“ automatic (27, 18, 9)

others (SCHUEPP, ZAMG, HB)

BSS: Q60 (JJA)



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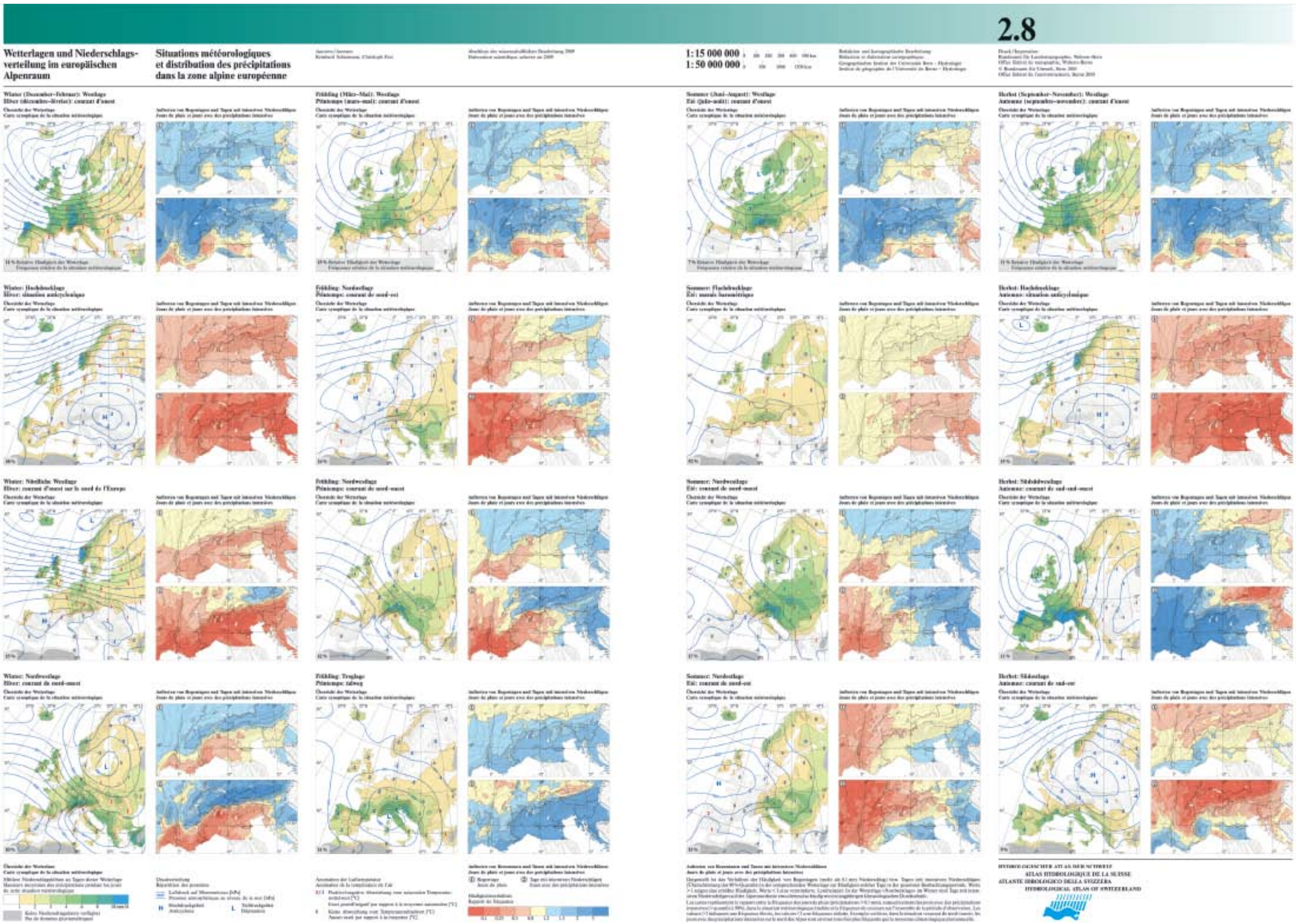
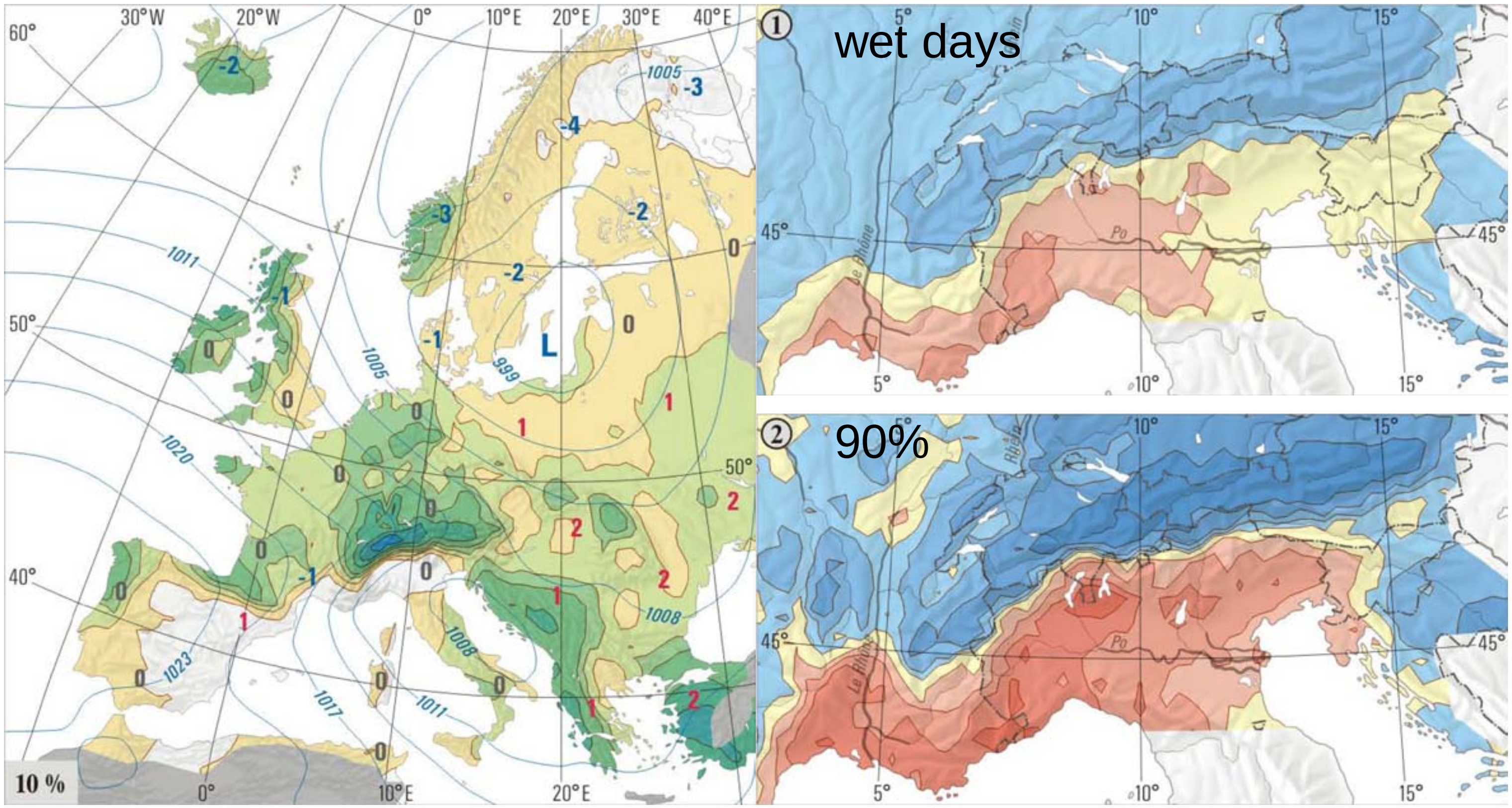
Hydrological Atlas of Switzerland



Example: Northwesterly type (winter)



1 | 2 | 3 | 4 | 6 | 8 | 10 mm/d

Luftdruck auf Meeresniveau [hPa]
Pression atmosphérique au niveau de la mer [hPa]

Anomalien der Lufttemperatur
Anomalies de la température de l'air

2/-1 Positive/negative Abweichung vom saisonalen Temperatur-mittelwert [°C]
Ecart positif/négatif par rapport à la moyenne saisonnière [°C]

① Regentage
Jours de pluie

② Tage mit intensiven Niederschlägen
Jours avec des précipitations intensives

Häufigkeitsverhältnis
Rapport de fréquence

0.1 | 0.25 | 0.5 | 0.8 | 1.2 | 1.5 | 2 | 3

$$p_i / \overline{p}$$

Conclusions

- Concepts of probabilistic forecast evaluation for assessment of CTCs. E.g. BSS for precipitation event categories.
- For Alpine precipitation:
  - few classifications with high skill (OPT, THR), no single “best”
  - Ranking *fairly* consistent between type number, precipitation threshold and (to some degree) season.
  - Several automatic classifications superior/comparable to manual “Alpine” classifications, despite smaller type numbers.
- Conditional probability of intense rainfall deviates by factor of 2-4 from climatology in certain classes/ares. Rich mesoscale structure.
- Explained probability variance for heavy events is low (less 10%).
- While of limited value for prediction, CTCs are valuable as …
  - … a building block of more complex prediction system.
  - … a benchmark for other probability forecasts. BSS as framework.

Publications

Schiemann & Frei 2010, Phys. Chem. Earth, 35

Schiemann & Frei 2010, Hydr. Atlas of Switzerland

Schiemann et al. 2010, J. Geophys. Res., 115