Drought assessment for climate services

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Part A

Assessing the contribution of moisture and temperature to VHI

A Application of LST CDRs for drought monitoring

$$VCI = \frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}$$ Vegetation Condition Index

$$TCI = \frac{LST_{max} - LST}{LST_{max} - LST_{min}}$$ Thermal Condition Index

$$\mathbf{VHI = \alpha VCI + (1 - \alpha) TCI}$$ Vegetation Health Index

Usually taken as 0.5!
Traditional VHI

(Kogan et al., 1997)

Methodology to estimate the contributions of VCI and TCI

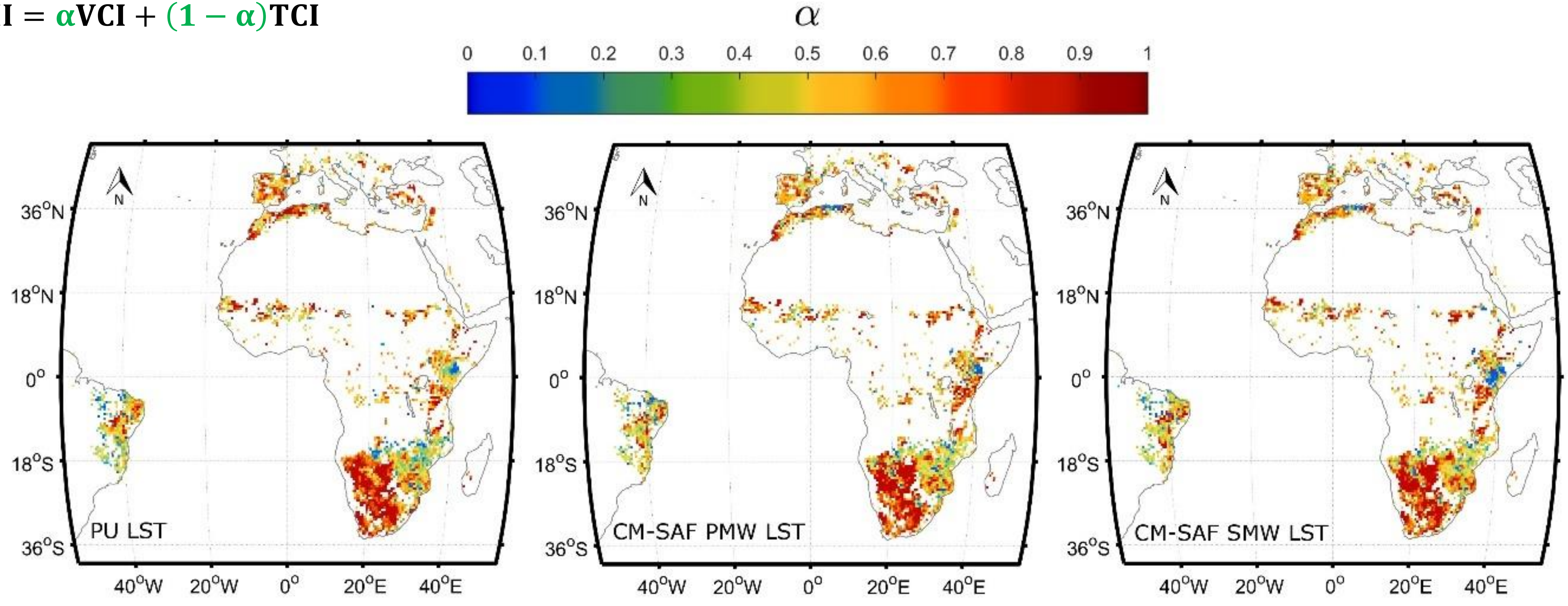
1. For each pixel the month of maximum NDVI is assumed
2. VHI is estimated with α=0.5 for that pixel and month
3. VHI is then correlated with the previous month SPEI at different time-scales
4. The SPEI time-scale of maximum correlation is chosen
5. For that time-scale **the SPEI-VHI correlation is maximised through an iterative process**

(Bento et al., 2018a)

A Application of LST CDRs for drought monitoring

(Bento et al., 2018b)

$$\mathbf{VHI} = \alpha\mathbf{VCI} + (1-\alpha)\mathbf{TCI}$$



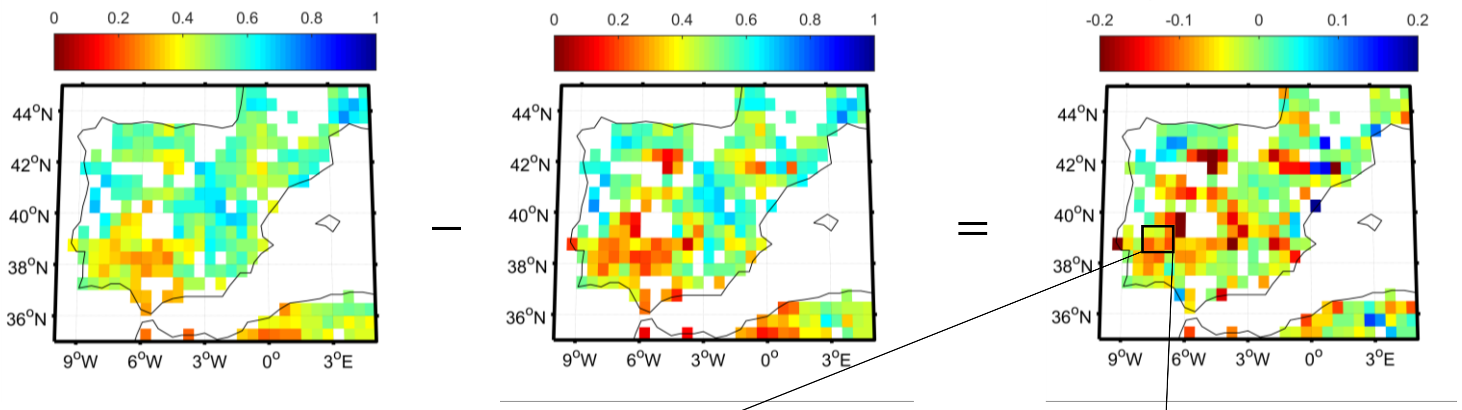
PU LST= Princeton University LST

CM-SAF PMW LST = Clim Saf Physical Mono-Window LST

CM-SAF SMW LST = Clim Saf Statistical Mono-Window LST

A Application of LST CDRs for drought monitoring

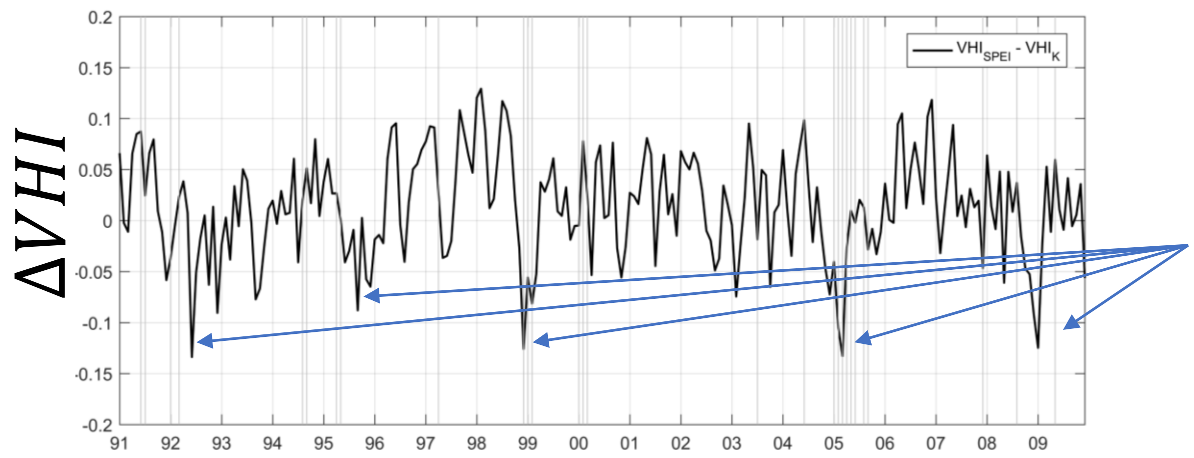
Traditional VHI | SPEI-based VHI | **SPEI-based − Traditional VHI**



Case study on Iberia

Winter 1998/99

SPEI-based − Traditional VHI time series



Larger differences occur in years characterised by known droughts in the region!

(Bento et al., 2018b)

Courtesy of
MeteoSwiss

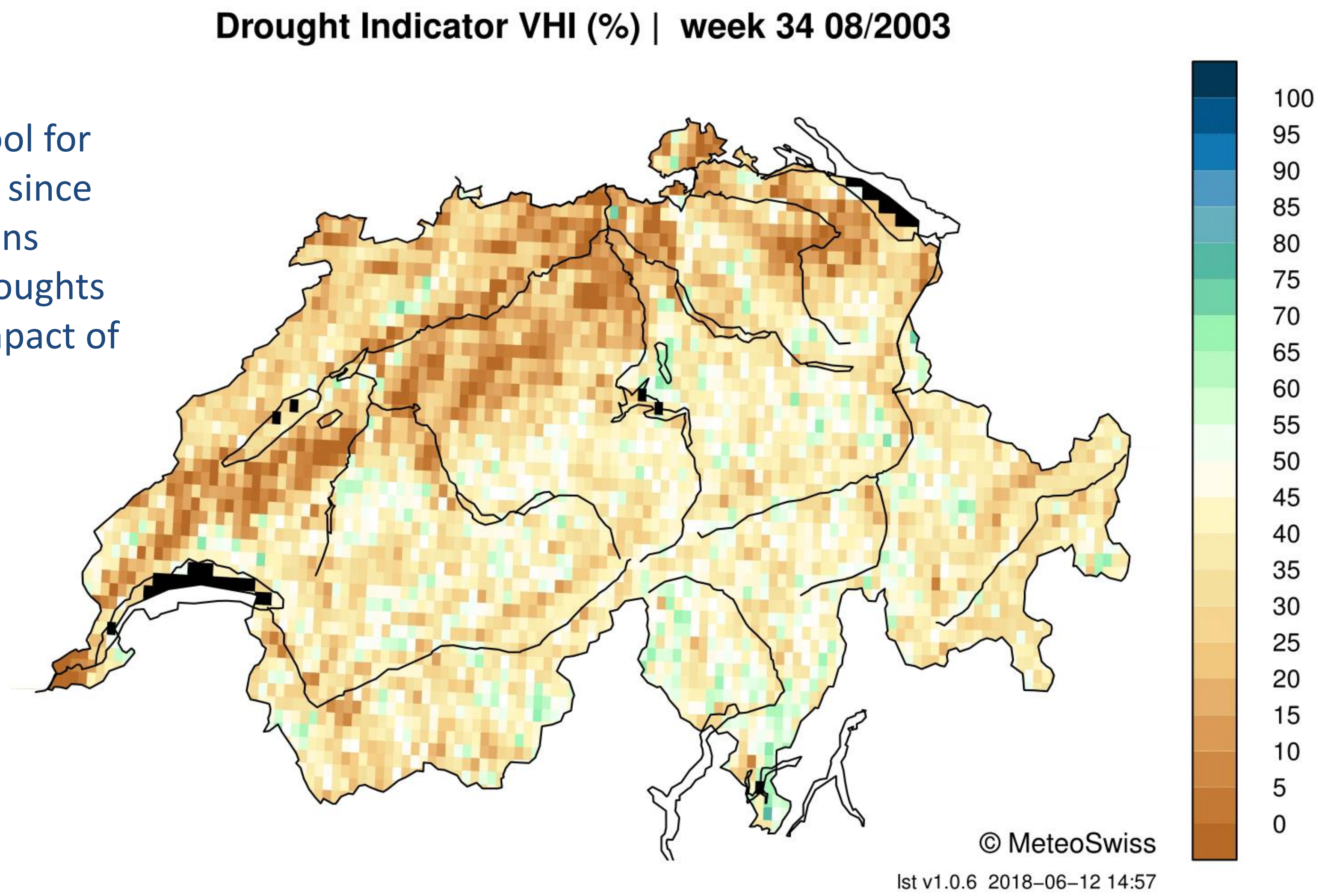
Part B

VHI as a risk assessment tool in Switzerland

B VHI as a risk assessment tool in Switzerland

Courtesy of MeteoSwiss

VHI is a great tool for risk assessment since we see regions vulnerable to droughts i.e. we see the impact of droughts



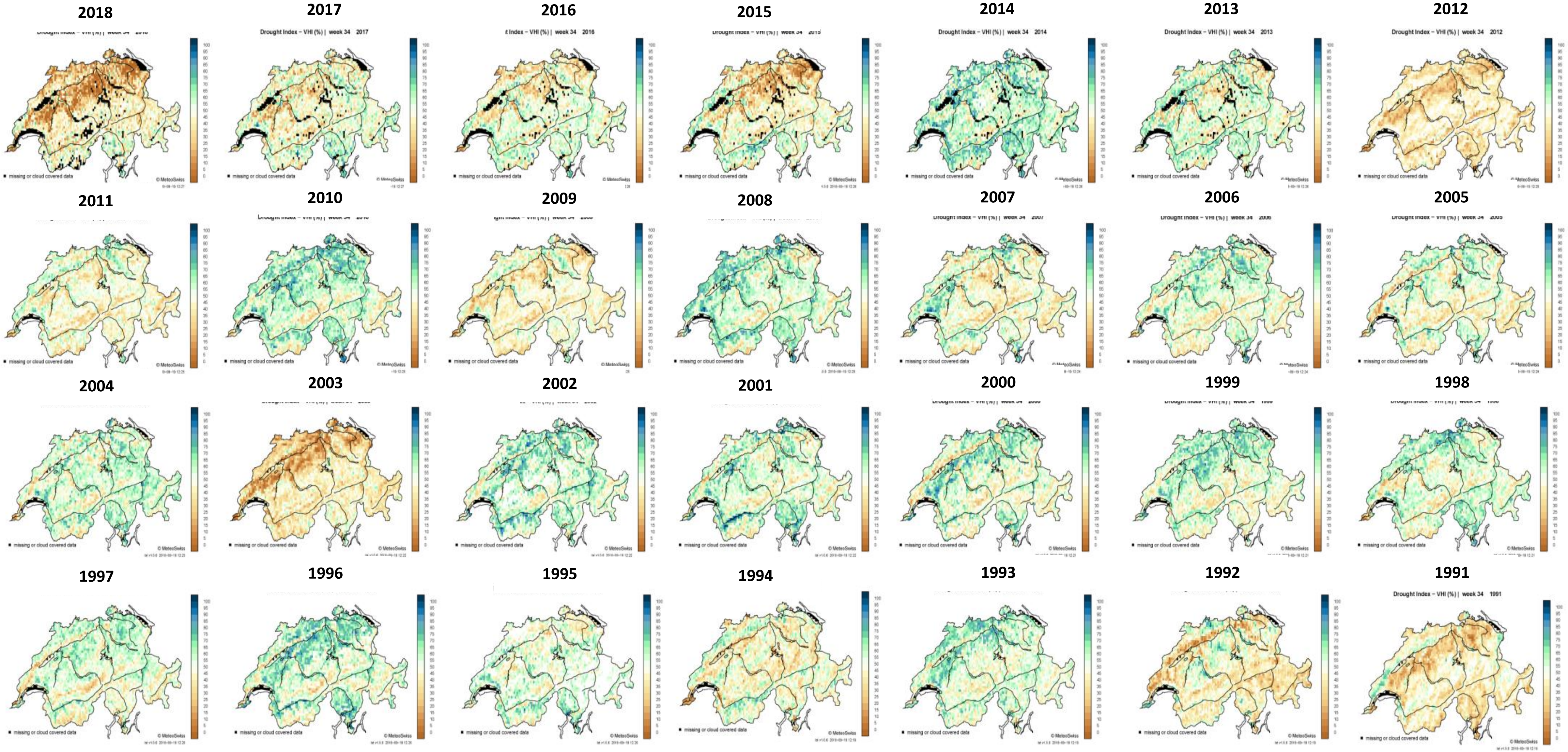
WMO VHI

Combination of CM SAF Land Surface Temperature & Vegetation Maps

B VHI as a risk assessment tool in Switzerland

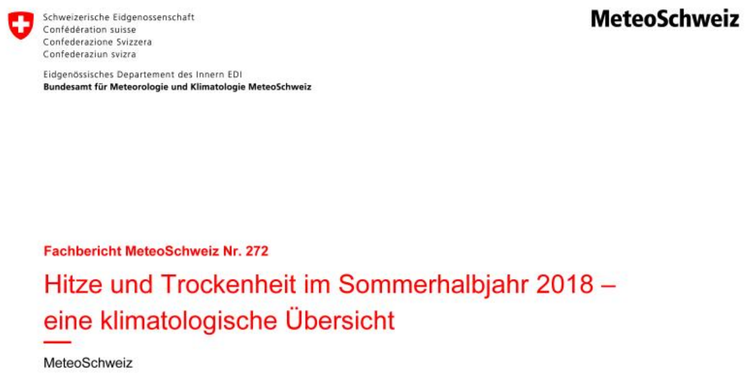
Courtesy of MeteoSwiss

Satellite-based Drought Index VHI (August, Week 34)



B VHI as a risk assessment tool in Switzerland

Courtesy of MeteoSwiss


Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement des Innern EDI
Bundesamt für Meteorologie und Klimatologie MeteoSchweiz

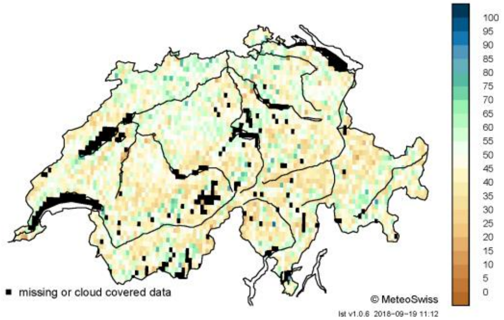
MeteoSchweiz

Fachbericht MeteoSchweiz Nr. 272

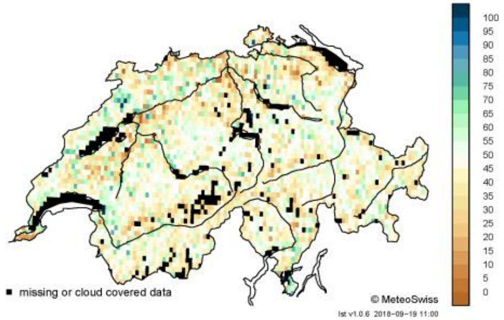
Hitze und Trockenheit im Sommerhalbjahr 2018 – eine klimatologische Übersicht

MeteoSchweiz

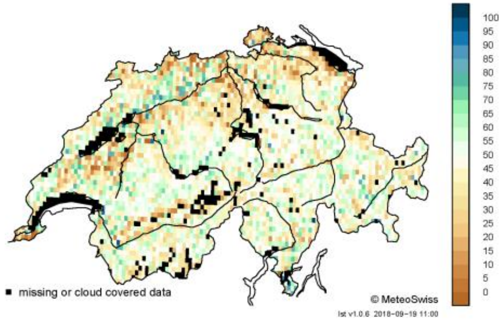
9.-15. April 2018



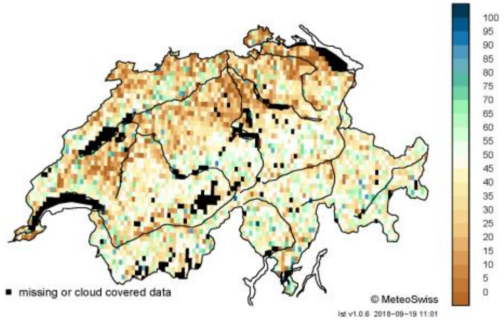
21.-27. Mai 2018



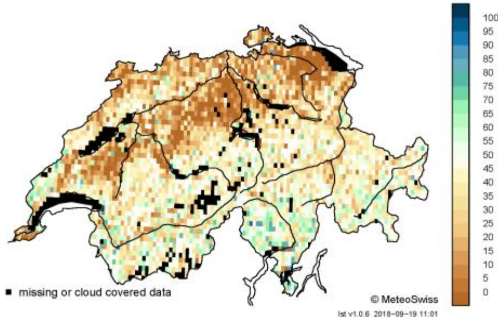
25. Juni - 1. Juli 2018



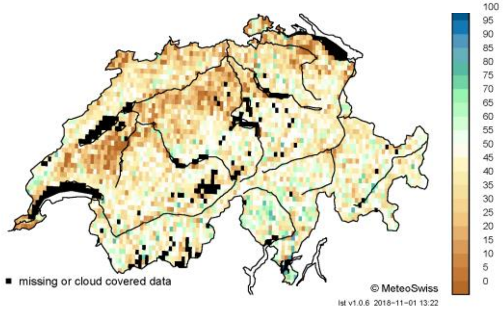
23. Juli - 29. Juli 2018



20. – 26. August 2018



17.-23. September 2018



Part C

Application of Copulas to agricultural drought risk management

C Drought and Crop data

(Ribeiro et al., under review)

Drought impacts are assessed by wheat and barley yield anomalies (t/ha) during 1986-2016

Drought hazard is evaluated based on:

- **VCI** (Vegetation Condition Index)
- **TCI** (Temperature Condition Index)
- **SPEI** (Standardized Precipitation Evapotranspiration Index)

The rationale here is that it is possible to assess the probability of drought related wheat and barley crop losses

Characterization of drought conditions

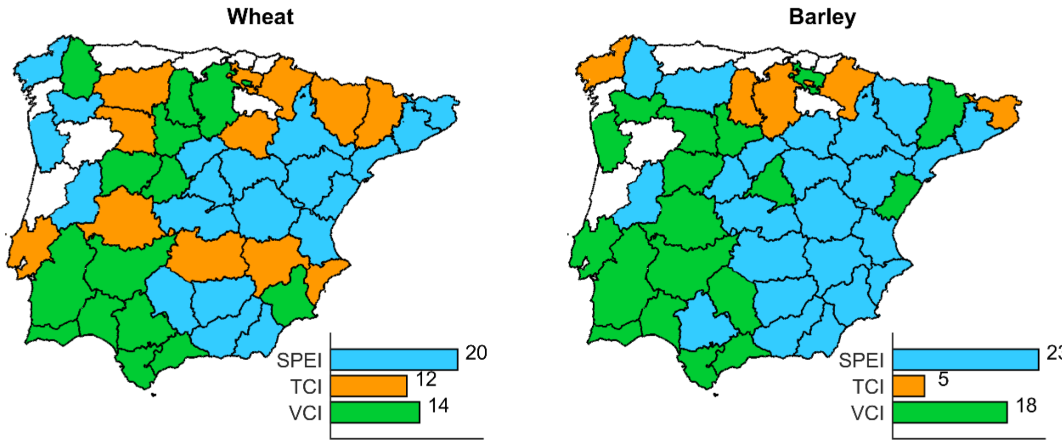


Fig. 2 - Type of drought indicator (VCI, TCI, SPEI) selected for each cereal and province and the respective nº of provinces using each drought indicator (small bar graphs).

C Copula-based approach

A bivariate copula is a joint distribution of two variables X (e.g. SPEI, VCI or TCI) and Y (e.g. crop yield anomalies) expressed as

$$F_{XY}(x,y) = C\big(F_X(x)\,, F_Y(y)\big)$$

where $F_X(x)$ and $F_Y(y)$ are the marginal distributions and C is the copula describing the amount of dependence between the variables.

This study makes use of 5 popular bivariate copula families (Fig. 3) which have been used to assess the adverse impacts of climate extremes on agricultural systems

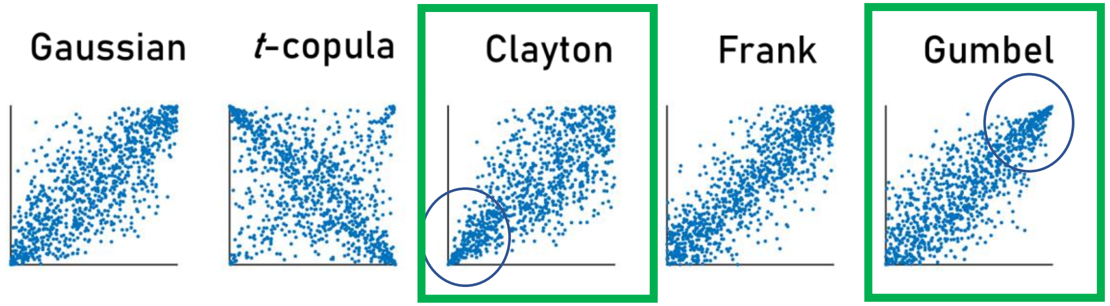


Fig. 3 – Schematic overview of the different copulas employed illustrating the associated dependence structures.

Step 1. Fit the copula functions (Fig. 3) and select the more adequate copula function based on the values of the Akaike's Information Criteria (AIC)

Describe the dependence structures between the drought conditions and the crop yields

Step 2. Generation of larger samples preserving the dependence structures

Step 3. Estimate the conditional probability of crop-loss under different drought severity levels using the copula simulations

$$Pr(X \leq crop - loss\ threshold \mid \mathrm{Y} \leq \mathrm{drought\ threshold})$$

C Agricultural drought risk

(Ribeiro et al., under review)

Maps of selected copula models

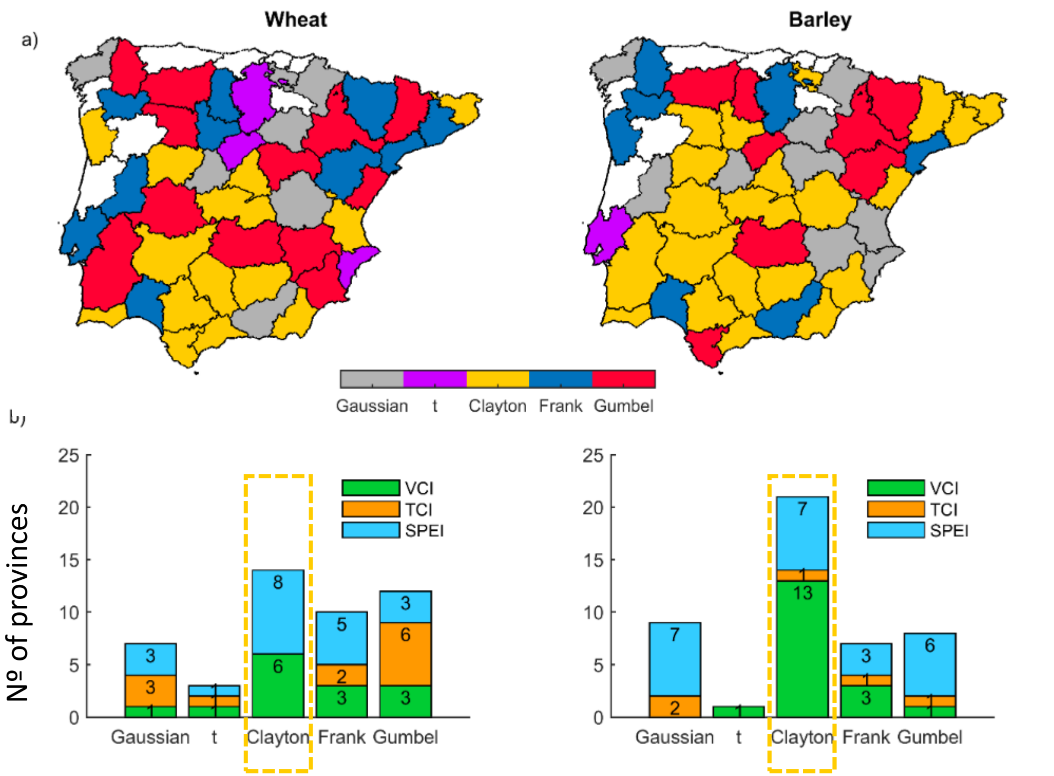


Fig. 4 – Selected copulas according to the values of AIC and respective nº of provinces adopting each type of copula and drought indicator.

- **Clayton is the most selected type of copula** (Fig. 4a) suggesting stronger dependence between the low extremes values of yield anomalies and drought conditions mainly characterized by VCI and SPEI (Fig. 4b).

Probability of drought-related crop-loss

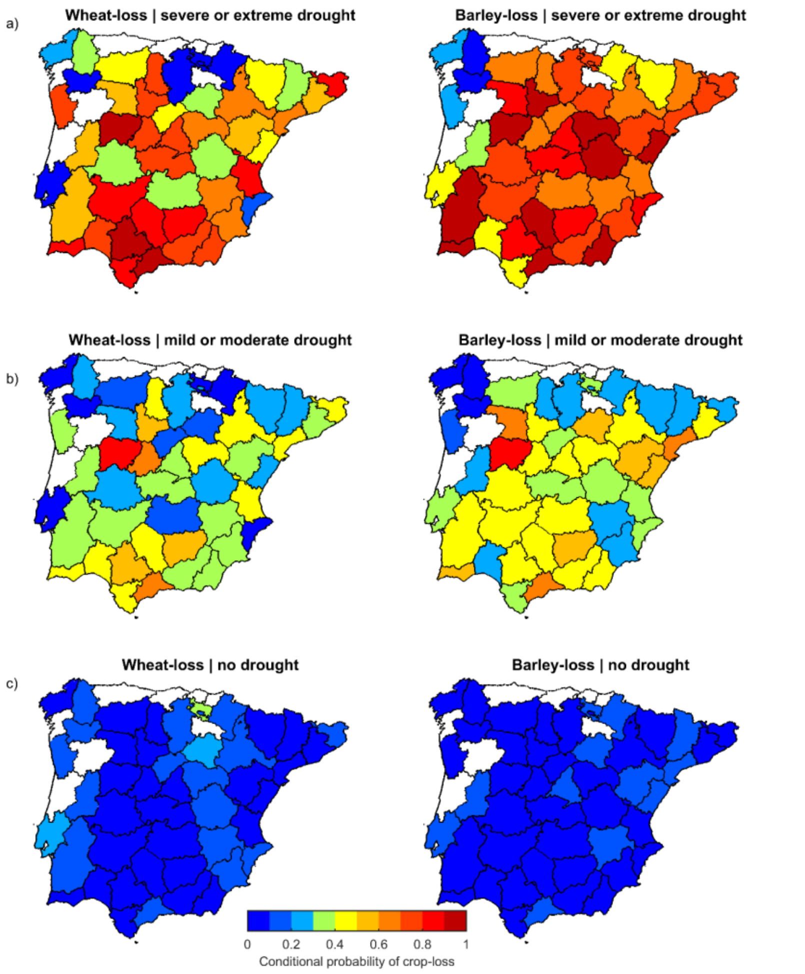


Fig. 5 - Agricultural drought risk during a) severe or extreme droughts; b) mild or moderate drought; c) no-drought.

- Barley shows a larger number of provinces with greater agricultural drought risk
- Probability of crop-loss increases with drought severity in most of the provinces
- Some losses are still expected under non-drought conditions

Part D

Overall Conclusions and Final Remarks

D Final Remarks

Part A

VHI is typically estimated as a plain average between VCI and TCI

i.e.

$$\boldsymbol{VHI = \alpha VCI + (1 - \alpha)TCI}$$

~~With $\alpha = 0.5$~~

With α variable

A methodology is developed with the aim of inferring different contributions to VCI and TCI for different regions.

=

Helps addressing operational drought risk faster

Part B

Using VHI as traditionally estimated in Switzerland is a very good tool for drought risk assessment since regions most vulnerable to droughts are very well distinguished.

Southern Switzerland

Well established water structures

Vegetation **less** vulnerable

Northern Switzerland

No water structures

Vegetation **more** vulnerable

Part C

Using statistical tools like Stepwise Regression and Copula Theory:

VCI and **SPEI**: Joint Low Extremes (Wheat and Barley)

TCI: Joint High Extremes (Just for Wheat)

Probability of Crop-Loss

↓ Increases with

Drought Severity

Barley-loss more likely than wheat-loss

Drought assessment for climate services

Acknowledgements

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