

# The Central European droughts of 2018 and 2019 observed with GRACE Follow-On

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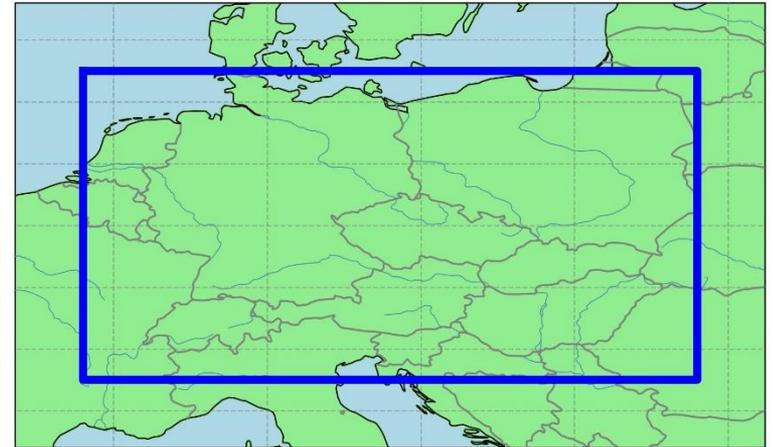
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# Introduction

- Central Europe exhibited severe droughts in 2018 and 2019
- With GRACE-FO the mass deficit in these years can be quantified
- 18 years of GRACE and GRACE-FO data allow joint assessment of Central European droughts in 2003, 2015, 2018, and 2019
- Comparison with drought indices derived from soil moisture and lake levels relates GRACE/GRACE-FO data to other hydrological observations

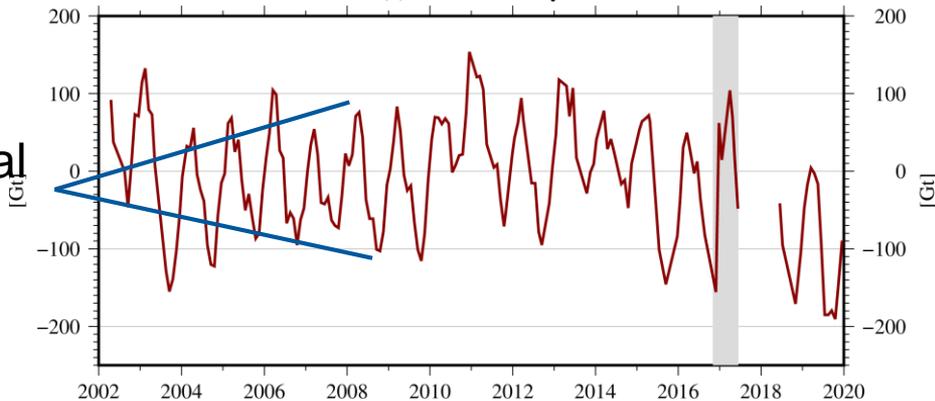
# Data

- GRACE and GRACE-FO monthly gravity fields from the GFZ RL06 time series (Dahle et al., 2019)
- Gridded terrestrial water storage (TWS) are available at GFZ's GravIS portal ([gravis.gfz-potsdam.de](http://gravis.gfz-potsdam.de))
- Central Europe: 4°-24° E, 45°-55°N

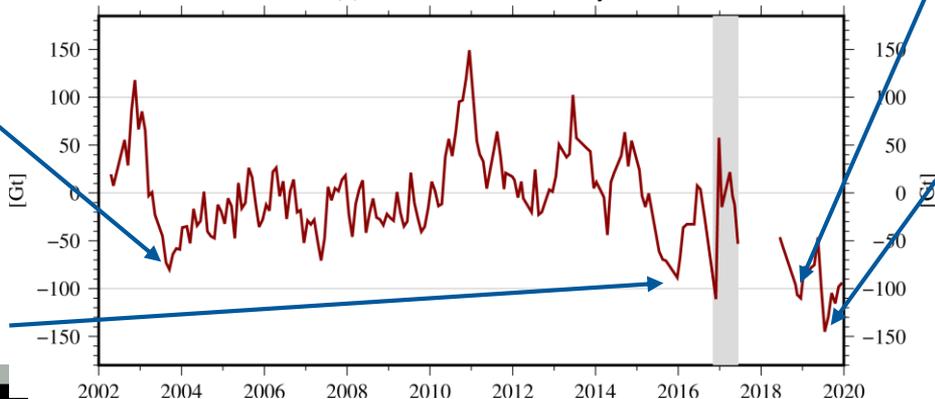


# GRACE/GRACE-FO mass deficit

(a) Mass Anomaly



(b) Residual Mass Anomaly



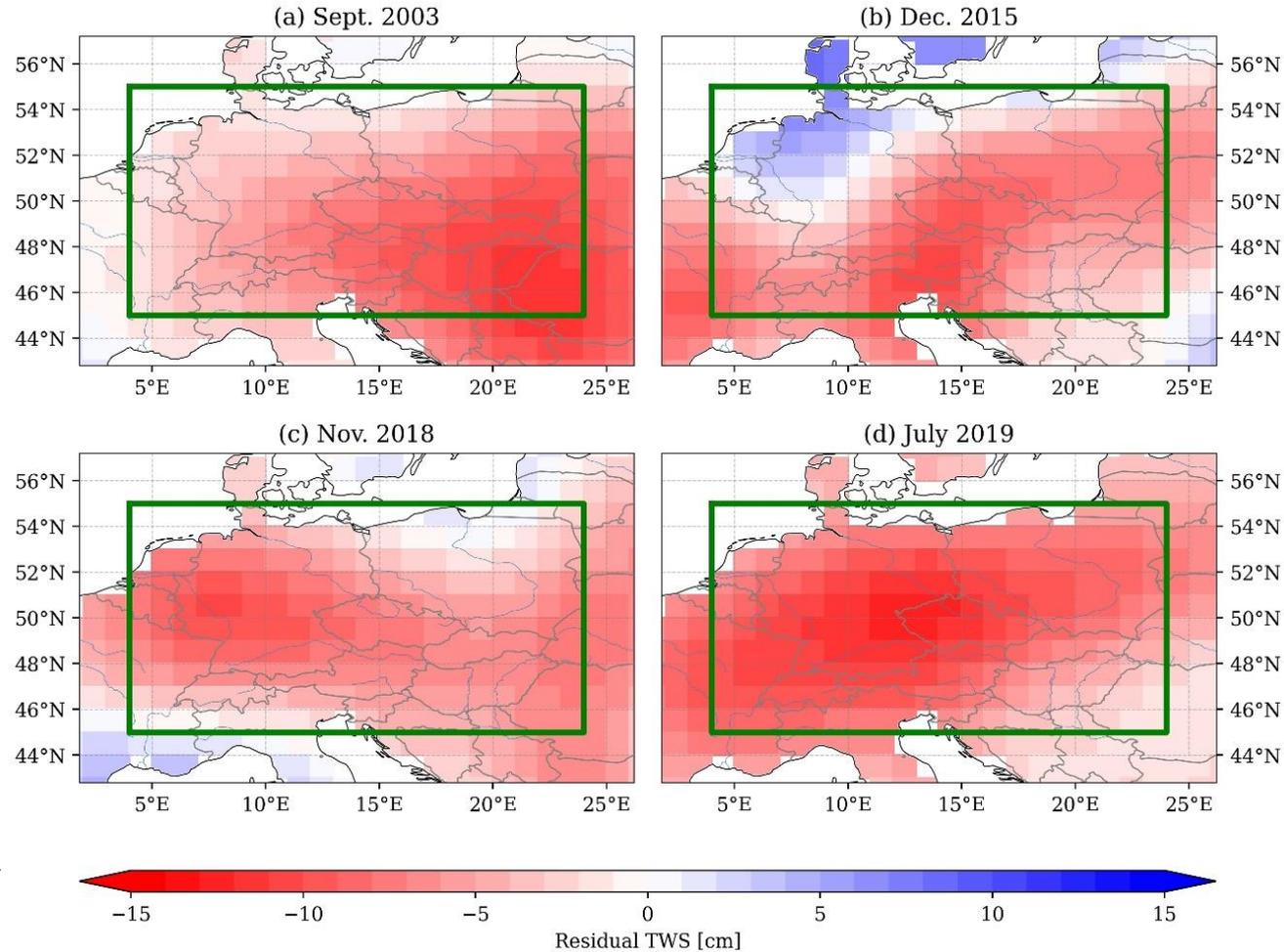
2018: -113 Gt  
→ 73% annual variation

2019: -146 Gt  
→ 95% annual variation

2003: -80 Gt

2015: -83 Gt

# Spatial Pattern of mass deficit



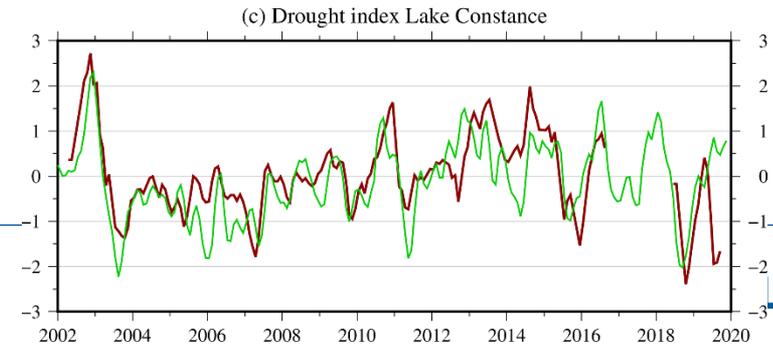
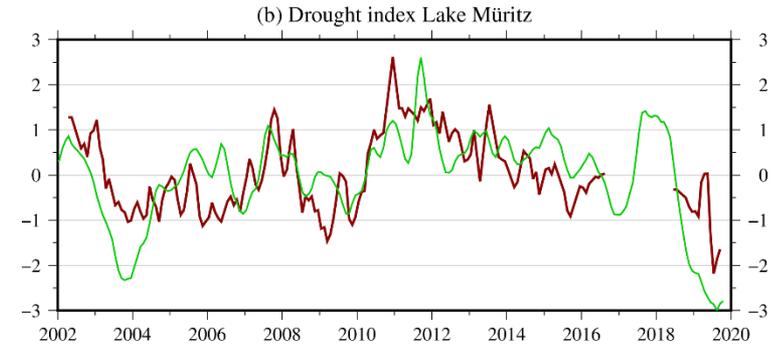
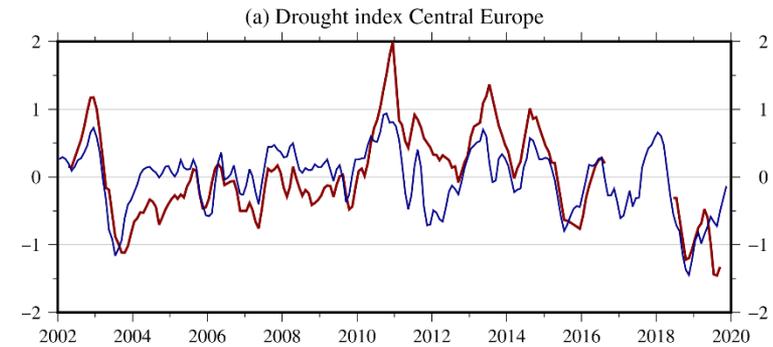
# Comparison with Drought Indices

Used drought indices:

- GRACE/GRACE-FO mass anomaly is converted to drought index DI-TWS
  - Drought index as standardised anomaly:
  - $DI - TWS_{i,j} = \frac{TWS_{i,j} - \mu_i}{\sigma_i}$ ,  $\mu_i$ ,  $\sigma_i$ , mean and standard deviation of month  $i$
- European Drought Observatory (EDO) soil moisture drought index (Horion et al., 2012), DI-SM
- Lake levels of Lake Constance and Lake Müritz converted to drought index similar to TWS, DI-LL

# Comparison with Drought Indices

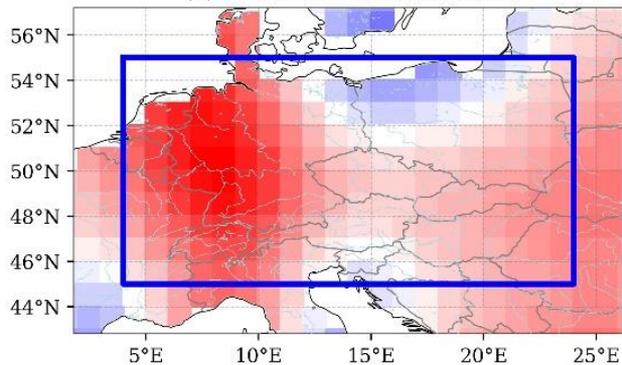
- Soil moisture shows recovery in 2019, not seen with DI-TWS
- High water level of Lake Constance are due to snow-rich winter in the Alps feeding into the lake



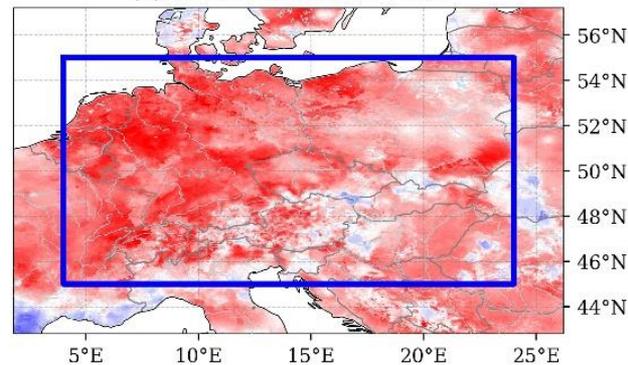
Red: DI-TWS  
Blue: DI-SM  
Green: DI-LL

# Comparison of Spatial Patterns

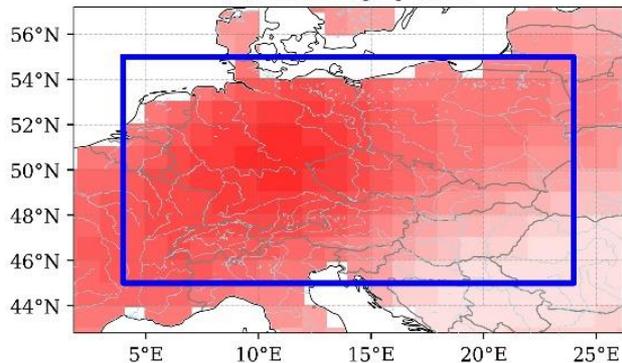
(a) DI-TWS: November 2018



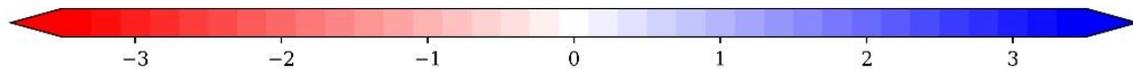
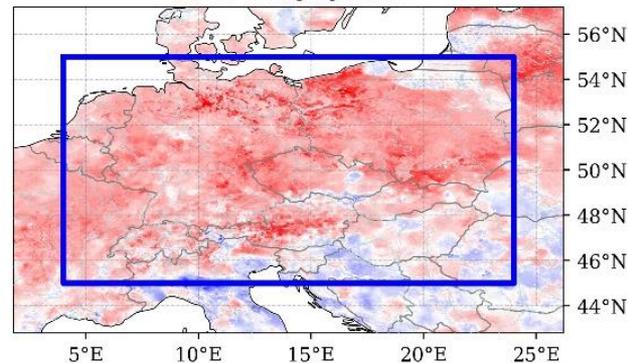
(b) DI-SM: November 2018



(c) DI-TWS: July 2019



(d) DI-SM: July 2019



# Conclusion

- GRACE-FO continues the GRACE mission in quantifying the continental water mass anomalies
- 2018 and 2019 were the driest years in the whole GRACE/GRACE-FO time series in Central Europe with a water storage deficit of 112 Gt and 145 Gt, respectively
- Only GRACE/GRACE-FO can observe the total water mass deficit whereas soil moisture or lake level observations observe only parts and can be governed by regional effects

# References

- Dahle, C. et al. (2019). The GFZ GRACE RL06 Monthly Gravity Field Time Series: Processing Details and Quality Assessment. *Remote Sensing*, 11 (18). doi: 10.3390/rs11182116
- Horion, S., et al. (2012). JRC Experience on the Development of Drought Information Systems (Vol. 25235; Tech. Rep.). Publications Office of the European Union. doi: 10.2788/15761