

## GRACE & GNSS



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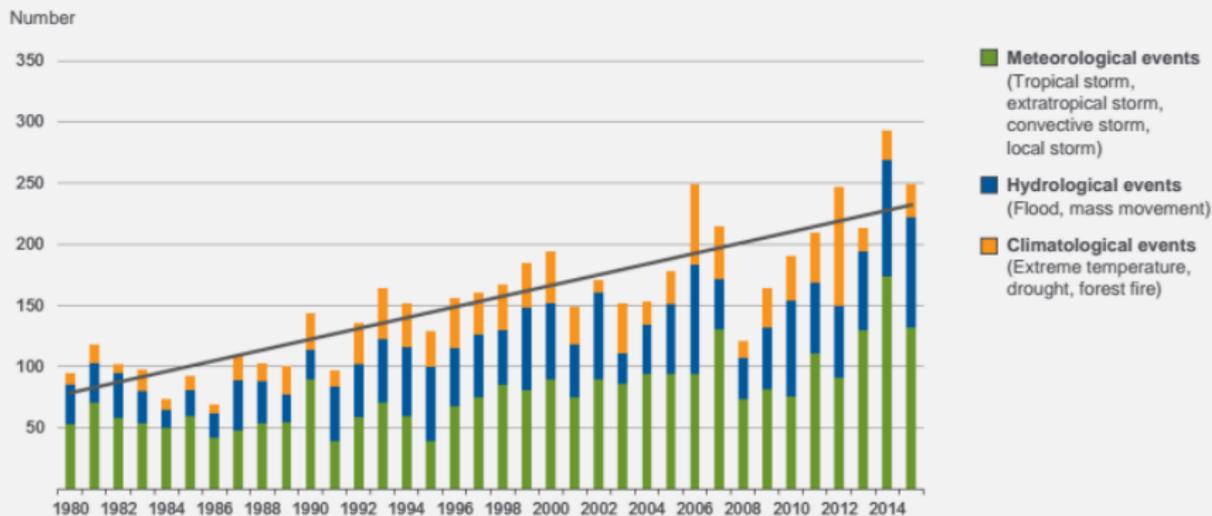
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4th scientific seminar "Physics and chemistry of the Earth System"  
9-11 October, 2022, Banya

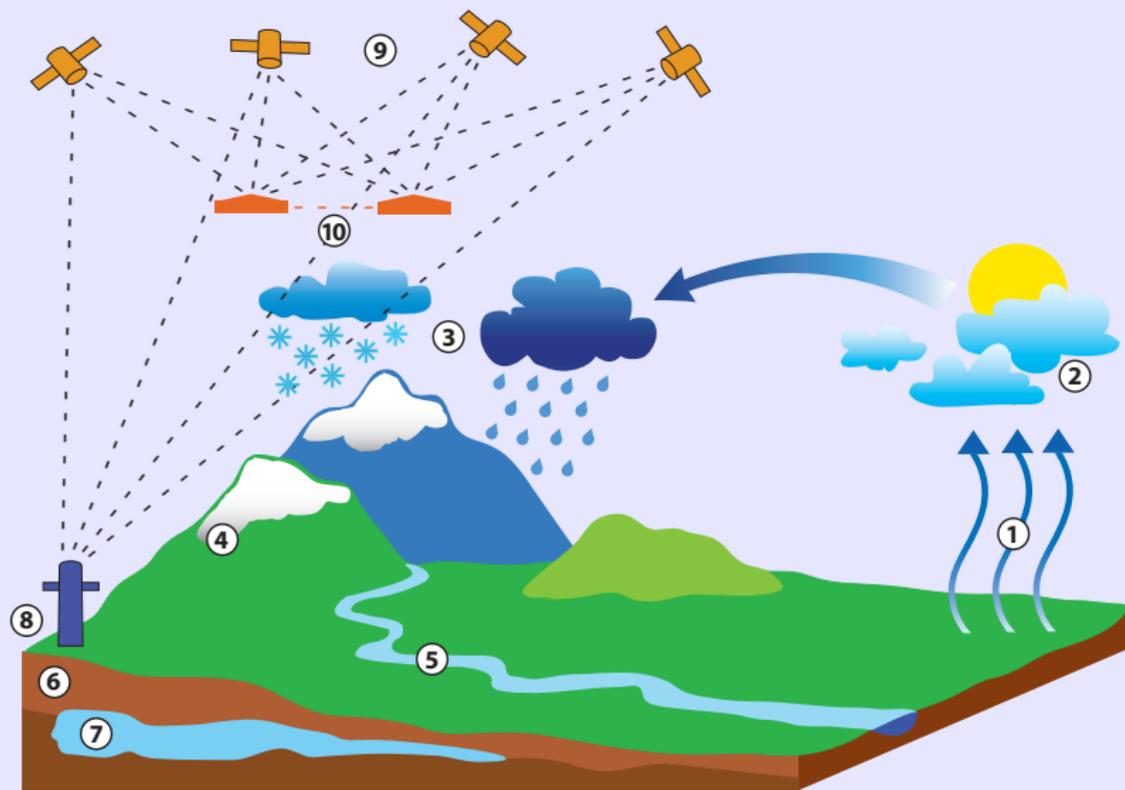
NatCatSERVICE

## Weather-related loss events in Europe 1980 – 2015 Number of events



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# Hydrological cycle



# SYNOP, GRACE and GNSS data sets: 2003-2014

## Data

- temperature and precipitation 2003-2014 SYNOP Station Sofia
- GNSS Integrated Water Vapour 2003-2013 IGS repro1 GNSS SOFI station
- Terrestrial Water Storage Anomaly- GRACE Level 2 monthly gravity variations (AIUB-RL02) and 2003-2014-EGSIEM (CSR, GFZ and JPL)

## Method

- extreme dry and wet periods in Bulgaria - 2007 and 2014 case studies
- monthly mean anomalies
- Seasonal-trend decomposition of time series<sup>1</sup>

$$X_{ts} = X_{long} + X_{seas} + X_{res} \quad (1)$$

- Drought Severity Index<sup>2</sup> and Standardized Precipitation Index<sup>3</sup>

$$DSI_{i,j} = \frac{TWSA_{i,j} - TWSA_j}{\sigma_j}, SPI_{i,j} = \frac{P_{i,j} - P_j}{\sigma_j} \quad (2)$$

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<sup>1</sup> Cleveland et al., 1990

<sup>2</sup> Zhao et al., 2017

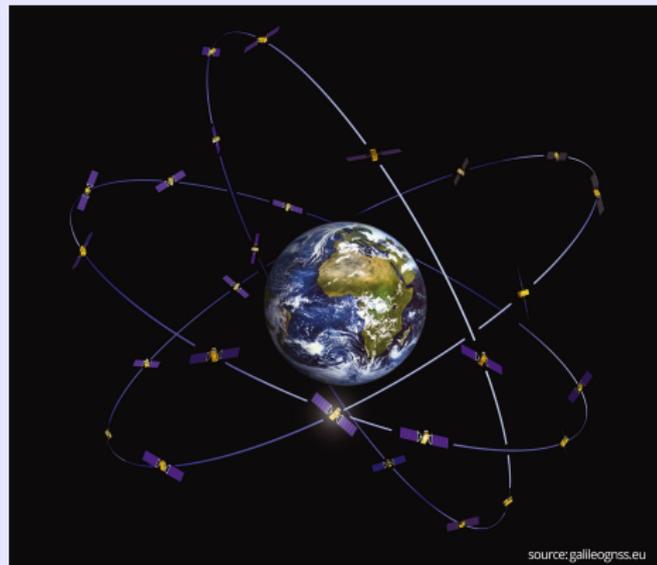
<sup>3</sup> McKee et al., 1993

# GNSS tropospheric product - IWV from SOFI GNSS Station

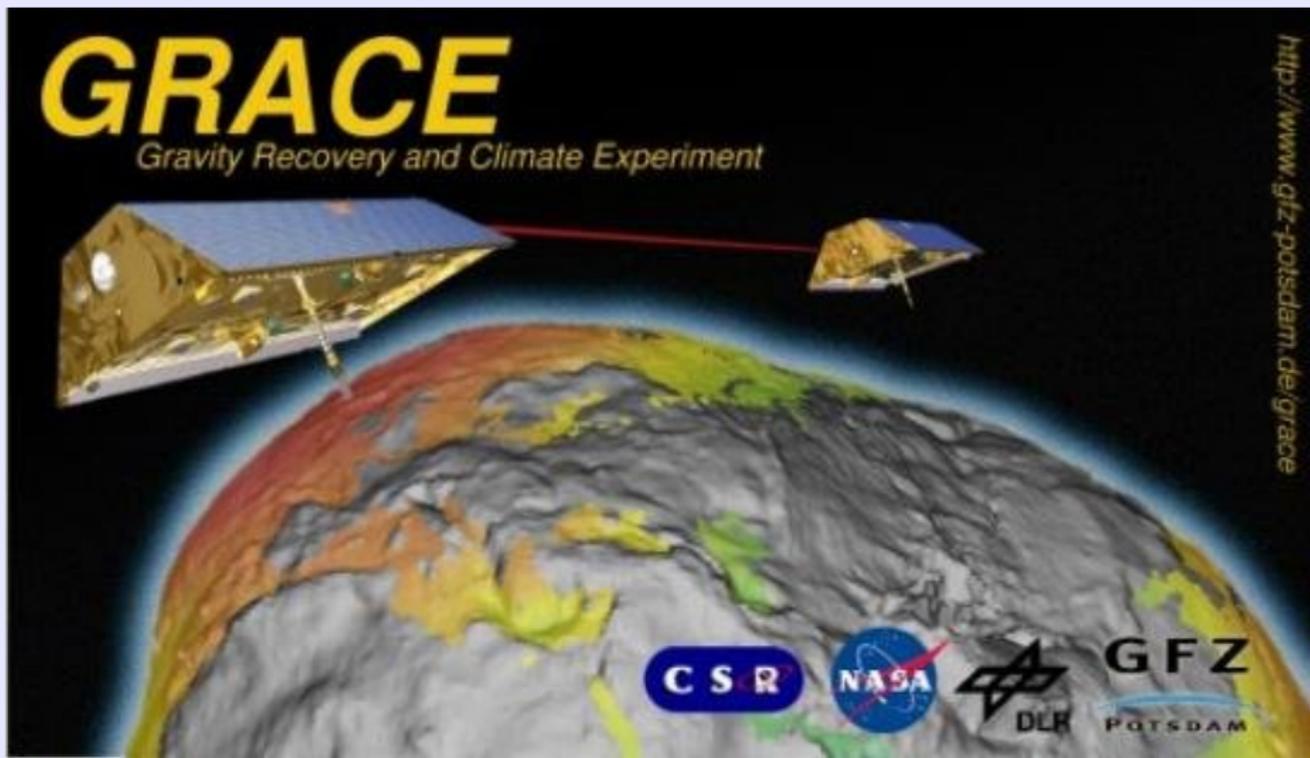
- first reprocessing campaign of the International GNSS Service (IGS repro1)

$$ZWD = ZTD - ZHD \quad (3)$$

$$IWV = k \cdot ZWD \quad (4)$$

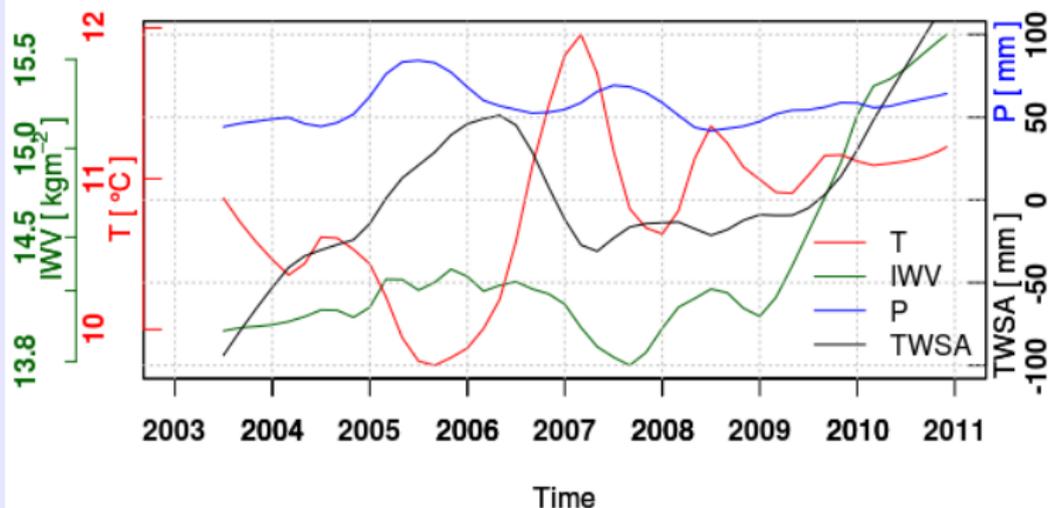


# Gravity Recovery And Climate Experiment (GRACE)

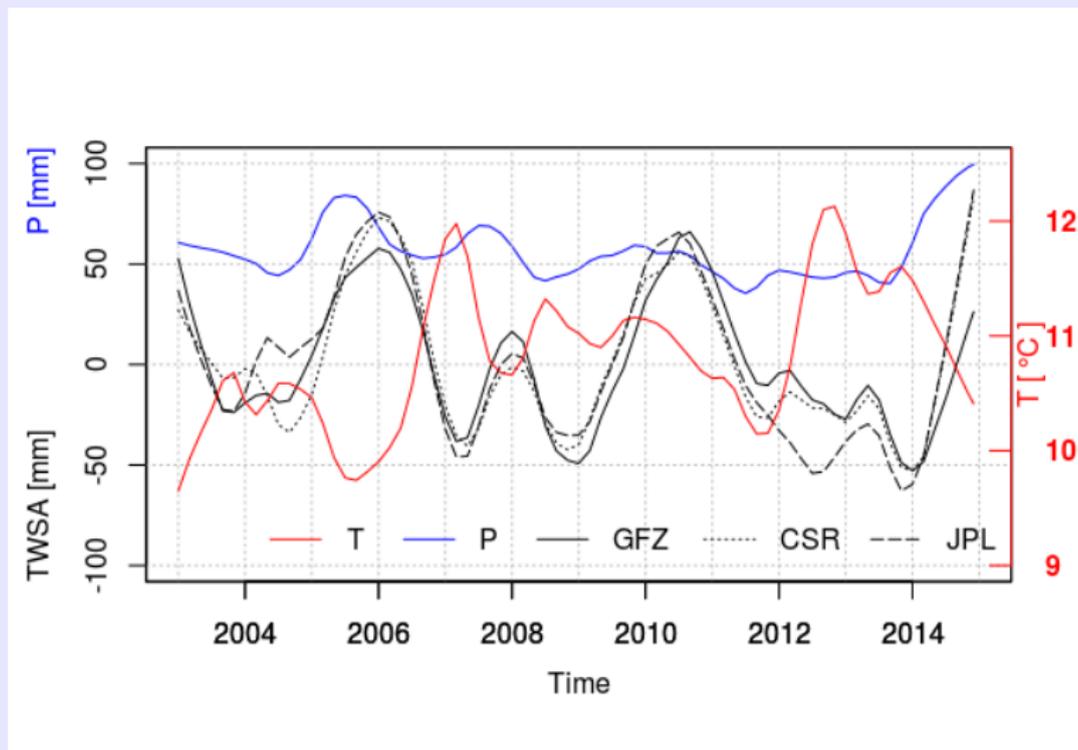


## Results - 2007 anomalies and long-term trends

2007	J	F	M	A	M	J	J	A	S	O	N	D
T	5	3	+	+	+	+	2	+	-	-	-	-
P	-	-	-	+	+	+	-56	+	+	+	+	-
IWV	+	+	-	-	+	+	-2.7	+	-	+	-	-
TWSA	-64	+	-	-	-	-	-	-82	-	+	+	+

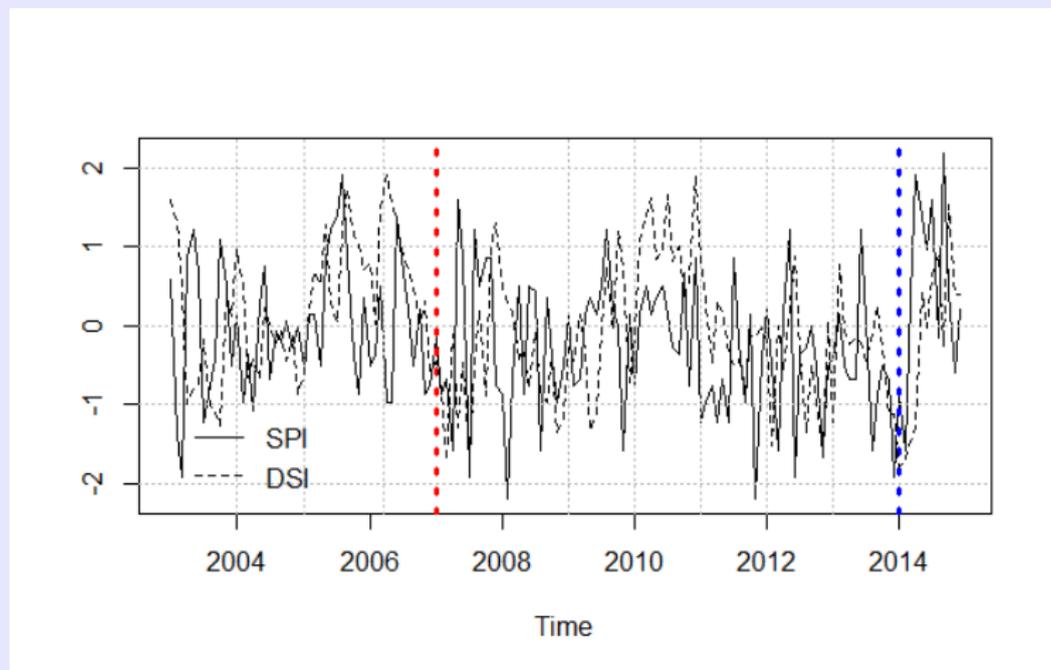


## Results - long-term trends ( $X_{long} = X_{ts} - X_{seas} - X_{res}$ )



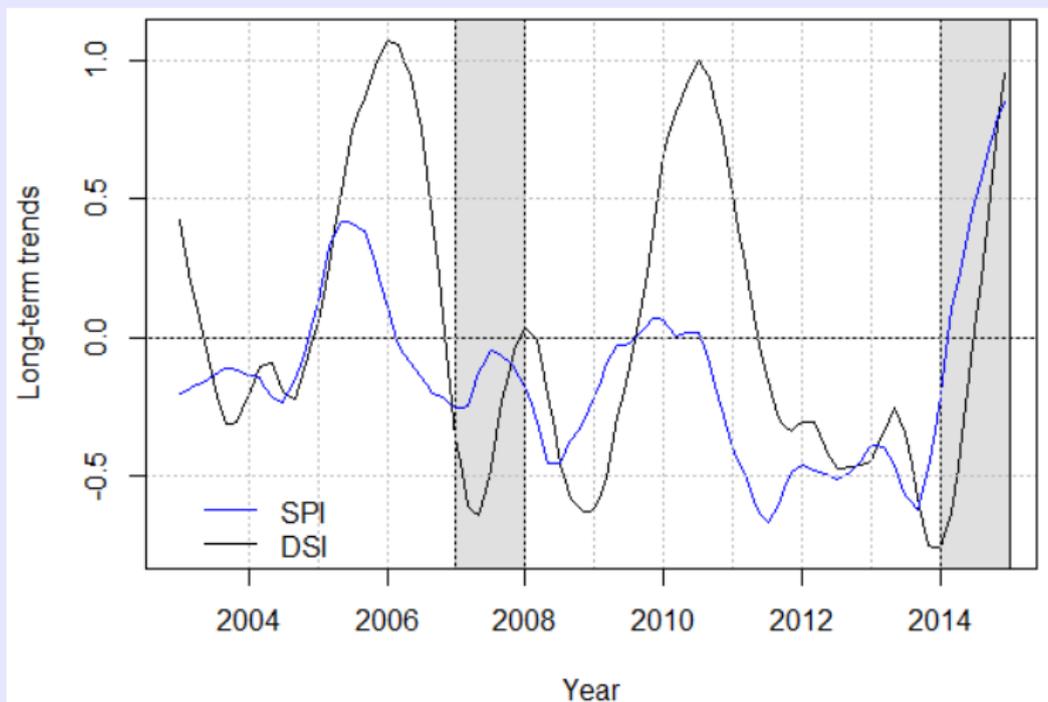
- Moderate negative correlation between T and P (-0.4), T and TWSA (-0.6)
- Moderate to high positive lagged correlation between P and TWSA (0.7, lag=4)

# Drought Severity Index (DSI) and Standardized Precipitation Index (SPI)



- Moderate cross-correlation coefficient between DSI and SPI (0.4, lag=3)

## Results - long-term trends



# Conclusion

- synergy between surface and satellite observations used to study extreme wet and dry periods in Bulgaria
- demonstrate the potential of IWV and TWSA time series in studying the regional characteristics of hydrological cycle
- 2007 positive T and negative IWV, P and TWSA. 2014 negative T and positive P and TWSA
- observed time step between precipitation and TWSA
- DSI vs SPI moderate cross-correlation coefficient of 0.36 (lag=3)

## *Reference:*

- 1) *Mircheva et al., 2017, Anomalies of hydrological cycle components during the 2007 heat wave in Bulgaria, Journal of Atmospheric and Solar Terrestrial Physics, 165-166, 1-9, 10.1016/j.jastp.2017.10.005.*
- 2) *Mircheva et al., 2020. Analysis of the 2014 Wet Extreme in Bulgaria: Anomalies of Temperature, Precipitation and Terrestrial Water Storage, Hydrology, 7(3), 66, <https://doi.org/10.3390/hydrology7030066>.*

THANK YOU!

