

Drought Trends and Projections

(Drought trends over 1951-2016 and projections until 2100)

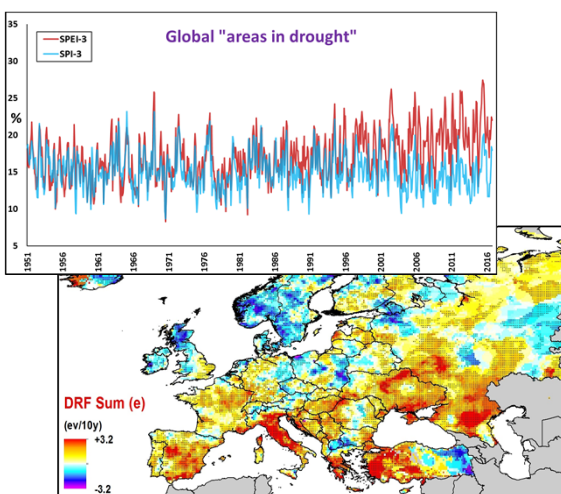
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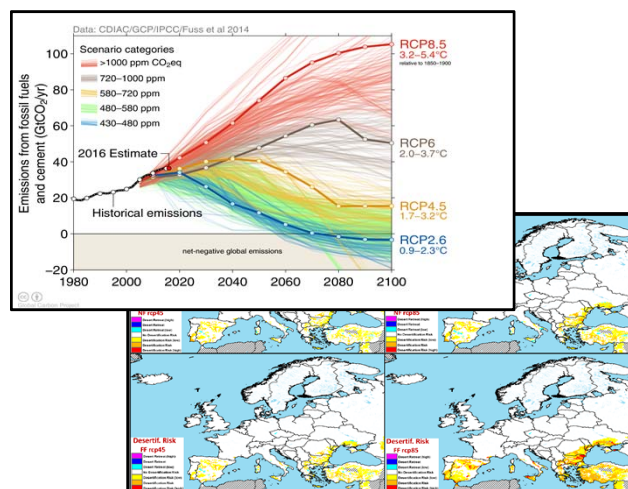
Context and Motivations



PAST

Moderate global drought increase in the last decades

Decreasing drought tendency in Northern Europe, increasing in Southern Europe in the last 50-60y



FUTURE

Climate change is expected to foster more frequent and severe drought events as the century passes

But to what extent? And where?

BEWARE

We here discuss only one type of droughts, namely:

METEOROLOGICAL DROUGHTS

However, some results could also apply to agricultural and hydrological droughts, due to multiple time-scales investigated

Objectives and Goals

- Investigate European drought trends in the last six-seven decades
- Analyze meteorological drought trends and events at global scale
- Improve the spatial resolution of past and future drought outputs
- Use new data/simulations to study drought projections over Europe
- Complete the first global drought analysis using CORDEX data/runs
- Investigate the relation between drought and future desertification

Data and Methods (1)

EUROPE

Input Data

- Homog. ECA&D E-OBS v10-v16 (**PAST**)

Monthly precipitation // 1950-2012/16 // 0.25°

Monthly temperature // 1950-2012/16 // 0.25°

- Bias-adj. EURO-CORDEX (**FUTURE**)

Monthly precipitation // 1981-2100 // 0.11°

Monthly temperature // 1981-2100 // 0.11°

2 scenarios (RCP4.5 and RCP8.5), 11 simulations

Drought Indicators

- **Standardized Precipitation Index (SPI)**

Underlying distribution: Gamma function

Used for: past trends and future projections

- **Standardized Precipitation-Evapotranspiration Index (SPEI)**

Underlying distribution: Log-logistic function

Used for: past trends and future projections

- **Reconnaissance Drought Indicator (RDI)**

Underlying distribution: Log-normal function

Used for: past trends

- **Composite drought indicator (SPI-SPEI-RDI)**

Used for: past trends

Baseline for all the indicators: the entire period analyzed

Time-scales for all the indicators: 3 and 12 months

PET: Thornthwaite or Hargreaves-Samani

Data and Methods (2)

GLOBAL

Input Data

- **GPCCv5-v7 (PAST)**

Monthly precipitation // 1951-2010/13 // 0.5°

- **CRUTSv3.24-4.01 (PAST)**

Monthly PET_{Penman-Monteith} // 1951-2016 // 0.5°

Monthly precipitation // 2014-2016 // 0.5°

- **CORDEX (FUTURE)**

Monthly precipitation // 1981-2100 // 0.44°

Monthly temperature // 1981-2100 // 0.44°

2 scenarios (RCP4.5 & RCP8.5), >85 simulations for 11 regions

Drought Indicators

- **Standardized Precipitation Index (SPI)**

Underlying distribution: Gamma function

Used for: past trends and future projections

- **Standardized Precipitation-Evapotranspiration Index (SPEI)**

Underlying distribution: Log-logistic function

Used for: past trends and future projections

Baseline for all the indicators: the entire period analyzed

Time-scales for all the indicators: 3 and 12 months

PET: Thornthwaite, Hargreaves-Samani, or Penman-Monteith

More than 45 scientists contributed to provide us with CORDEX data for the 11 (+3) regions.

The analyses for global drought projections based on CORDEX data are currently ongoing. Results are expected by spring 2018

Data and Methods (3)

Event-based approach

We focus on the drought events, not on cumulated variables

Consequently we analyze the drought trends and projections of drought quantities related to drought events.

Following this approach, we try to answer these questions:

- *Did the frequency of drought events increase in the last decades? Will it increase in 21st century?*
- *Did the drought events last longer, become more severe and/or intense in the last decades? Will they do in 21st century?*

Key point: *all the results are “compared” to a reference period (1951-1980 for the past and 1981-2010 for the future)*

Drought quantities

- **Drought Frequency (DF)**

Usually computed as number of events per decade (10 years)

- **Extreme Drought Frequency (ExDF)**

An extreme drought event is a drought event which has at least two consecutive months in extreme drought conditions

- **Drought Duration (DD)**

Expressed in months, including the start and the end month of the drought

- **Drought Severity (DS)**

Sum of the indicator value during the drought event

If computed per country or region, it is normalized by dividing DS for the drought event threshold (which depends on the country or region and is always -1 at grid point scale)

Exceptionally, we computed TDS (total drought severity), which is the sum of DS of each event for that period

- **Drought Intensity (DI)**

Obtained as the ratio between drought severity and drought intensity

- **Area in drought (DA)**

Average area in drought conditions during the drought event

Results (1)

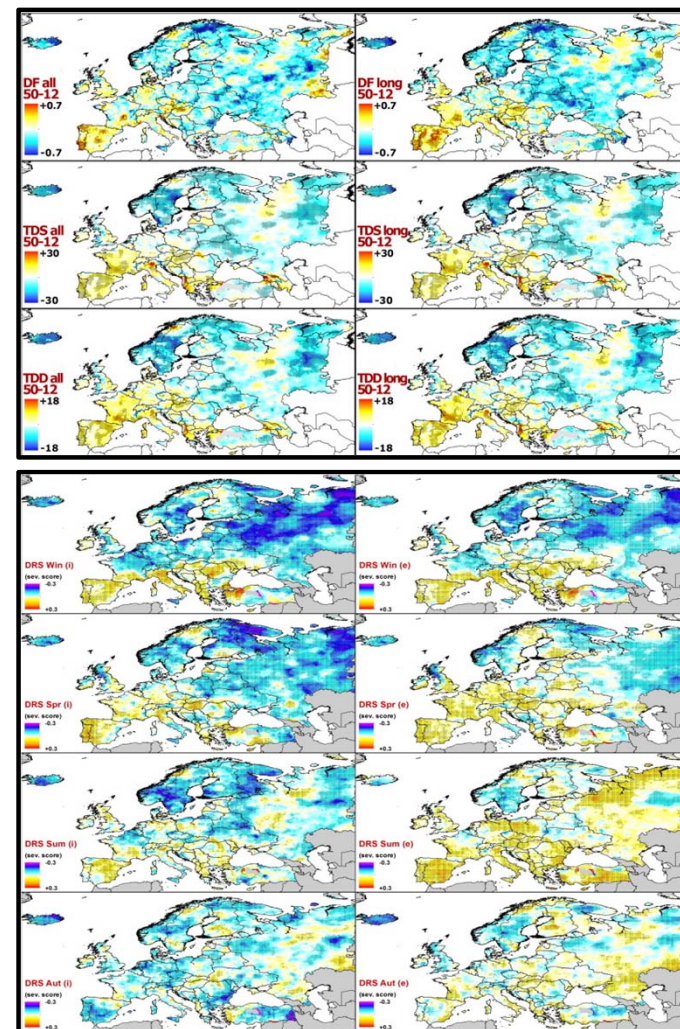
European past trends

- **European drought trends (1951-2012)**

*Composite indicator (Spei, Spi, Rdi), E-OBS as input
(In this case the approach is not event-based)*

- **Seasonal EU drought trends (1951-2014)**

Spei and Spi computed separately, E-OBS as input



DF

TDS

TDD

DS Win

DS Spr

DS Sum

DS Aut



European
Commission

Results (2)

European future projections

- **European drought projections (1981-2100) under moderate emission scenario**

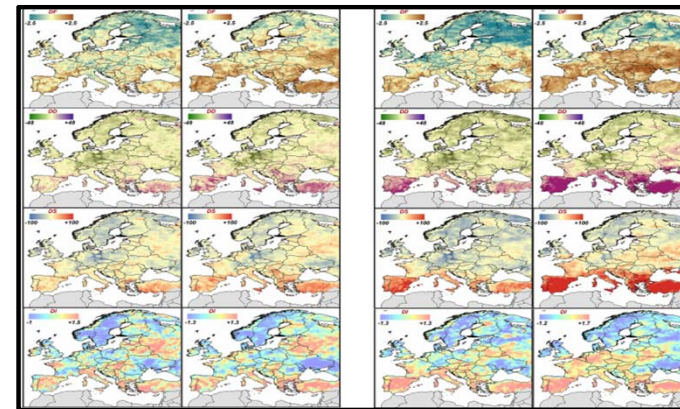
Spi and Spei computed separately

Only one simulation used (A1B scenario)

- **European drought projections (1981-2100)**

Spei & Spi computed separately, EU-CORDEX as input

2 emission scenarios (rcp45 & rcp85) and 11 hi-res bias-adjusted simulations

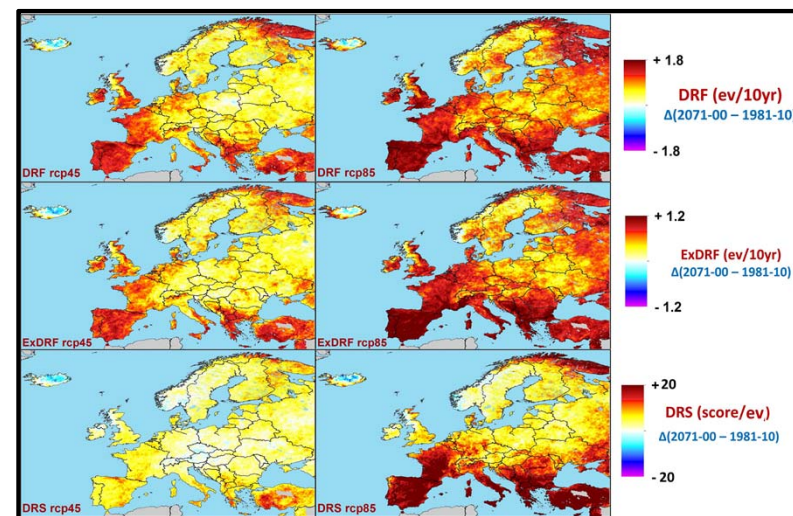


DF

DD

DS

DI



DF

ExDF

DS

Results (3)

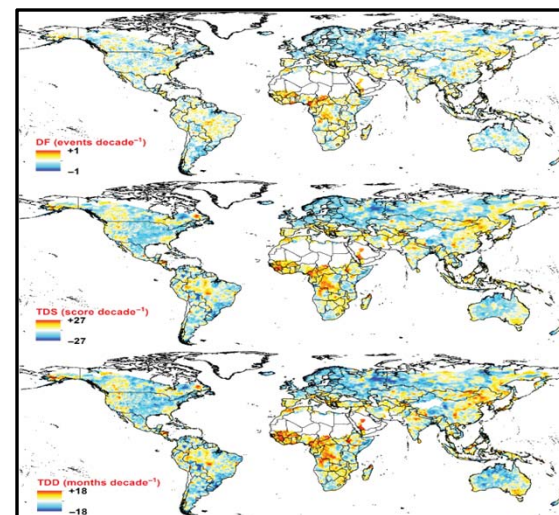
Global past trends

- **World drought frequency, duration, and severity maps (1951-2010)**

*This study is based on Spi-12 only, GPCC as input
(In this case the approach is not event-based)*

- **Results derived from drought events database (1951-2016)**

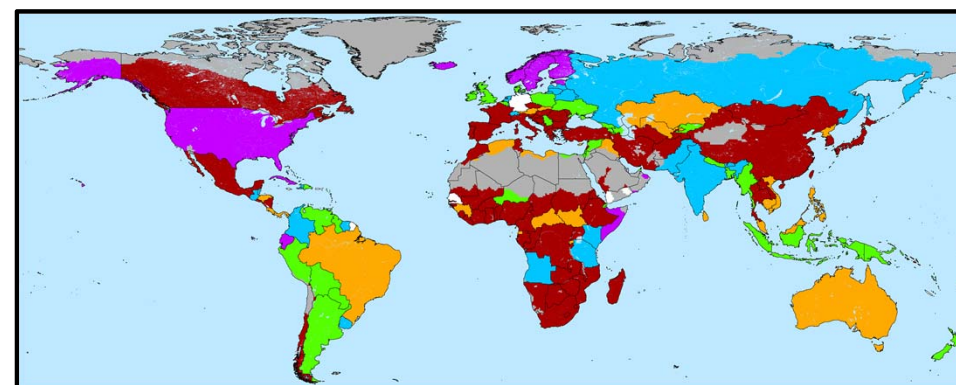
Spei & Spi computed separately, GPCC & CRU as input



DF

TDS

TDD



Global tendency of combined DF and DS

Results (4)

Global future projections

Global drought projections (1981-2100)

Spei & Spi computed separately, CORDEX as input

2 emission scenarios (rcp45 & rcp85) and at least 8 simulations for each of the 11(+3) regions considered

Expected results also include global projections of aridity maps, climate classification, desertification risk, and bio-classification shifts under climate change

Results expected by spring 2018

	CSIRO	CLMcom	CLMcom	CLMcom	CLM	DMI	KNMI	KNMI	KNMI	KNMI	MPICSC	SMHI	CCCma	UQAM	MOHC	CMRM	IPSL-IRIS
	CCAM	CCLM4-8-17	CCLM4-8-17-CLM3-5	CCLM4-8-17-CLM3-5	RegCM4-3	HIRHAM5	RACMO22T	RACMO22E	RACMO22P	REMOT209	RC4	CanRCM4	CanRCM4	CanRCM4	CanRCM4	CanRCM4	CanRCM4
MPICSC-LR	GLD-44 AUS-44	AFR-44 EUR-44	AUS-44	EAS-44							AFR-44 EUR-44 SAM-44 WAS-44 CAN-44	AFR-44 EUR-44 SAM-44 WAS-44 CAN-44					
IPSL											EUR-44						
MPICSC-MR					CAS-44												
CMRM-CMS	GLD-44 AUS-44	AFR-44		EAS-44							AFR-44 EUR-44 SAM-44 WAS-44						EUR-44
ACCESS1-0	GLD-44 AUS-44																
CCSM	GLD-44 AUS-44																
NorthESM1-M	GLD-44 AUS-44				AFR-44						AFR-44 EUR-44 SAM-44 WAS-44 CAN-44						
GFOL-CM3	GLD-44 AUS-44																
GFOL-ESM2M											AFR-44 EUR-44 SAM-44 WAS-44						
CCCma CanESM2											AFR-44 EUR-44 SAM-44 WAS-44 CAN-44	AFR-44 EUR-44 SAM-44 WAS-44 CAN-44	NAO-44				
CSIRO-Mk3											AFR-44 EUR-44 SAM-44 WAS-44 CAN-44						
IPSL-CM5A-MR											AFR-44 EUR-44 SAM-44 WAS-44 CAN-44						EUR-44
HadGEM2-ES		AFR-44		EAS-44	CAS-44		AFR-44	EUR-44	WNT-44		AFR-44 EUR-44 SAM-44 WAS-44 CAN-44						
ICHEC-EC-EARTH		AFR-44	AUS-44	EAS-44		AFR-44 EUR-44 SAM-44 WAS-44	AFR-44	EUR-44	WNT-44	AFR-44	AFR-44 EUR-44 SAM-44 WAS-44 CAN-44				EAS-44		
IPSL											EUR-44 AFR-44 EUR-44 SAM-44 WAS-44						
MIROC5											EUR-44 AFR-44 EUR-44 SAM-44 WAS-44						
HadGEM2-ES		CCLM4-8-17	CCLM4-8-17		RegCM4-3						RC4					ALADINS3	WRF31F
MPICSC-LR		MEQ-44			MEQ-44											MEQ-44	MEQ-44
CMRM-CMS											MEQ-44						
GFOL-ESM2M											MEQ-44						
ICHEC-EC-EARTH											MEQ-44						
CMCC-CM																	

List of simulations used for this study

Next steps

- Implement the results in EDO/GDO
- **Complete the analyses for global drought projections based on CORDEX data**
- Compare the results with other similar studies
- **Derive global projections for aridity, climate classification, and desertification risk**
- Include vegetation-based indicator(s)

Published Papers

- Spinoni J., Naumann G., Vogt J., Barbosa P., Dosio A.: *Will drought events become more frequent and severe in Europe?* *International Journal of Climatology*. Early view online, published on 9 October 2017. DOI: 10.1002/joc.5291
- Spinoni J., Naumann G., Vogt J.: *Pan-European seasonal trends and recent changes of drought frequency and severity*. *Global Planetary Change*, Vol. 148, pages 113-130. 2017.
- Spinoni J., Naumann G., Vogt J.: *Spatial patterns of European droughts under a moderate emission scenario*. *Adv. Sc. Res.* 12, 179-186, 2015.
- Spinoni J., Naumann G., Vogt J., Barbosa P.: *European drought climatologies and trends based on a multi-indicator approach*. *Glo. Pla.Cha.* 127: 50-57, 2015.
- Spinoni J., Barbosa P., Carrao H., Naumann G., Vogt J.: *World drought frequency, severity, and duration for 1951-2010*. *Int. J. Climatol* 34(8): 2792-2804. 2014.



Any questions?

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