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Title: The Cape Town drought: what is happening and will it happen again?

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The Cape Town drought: what is happening and will it happen again?

Cathy Wilson

22 February 2018

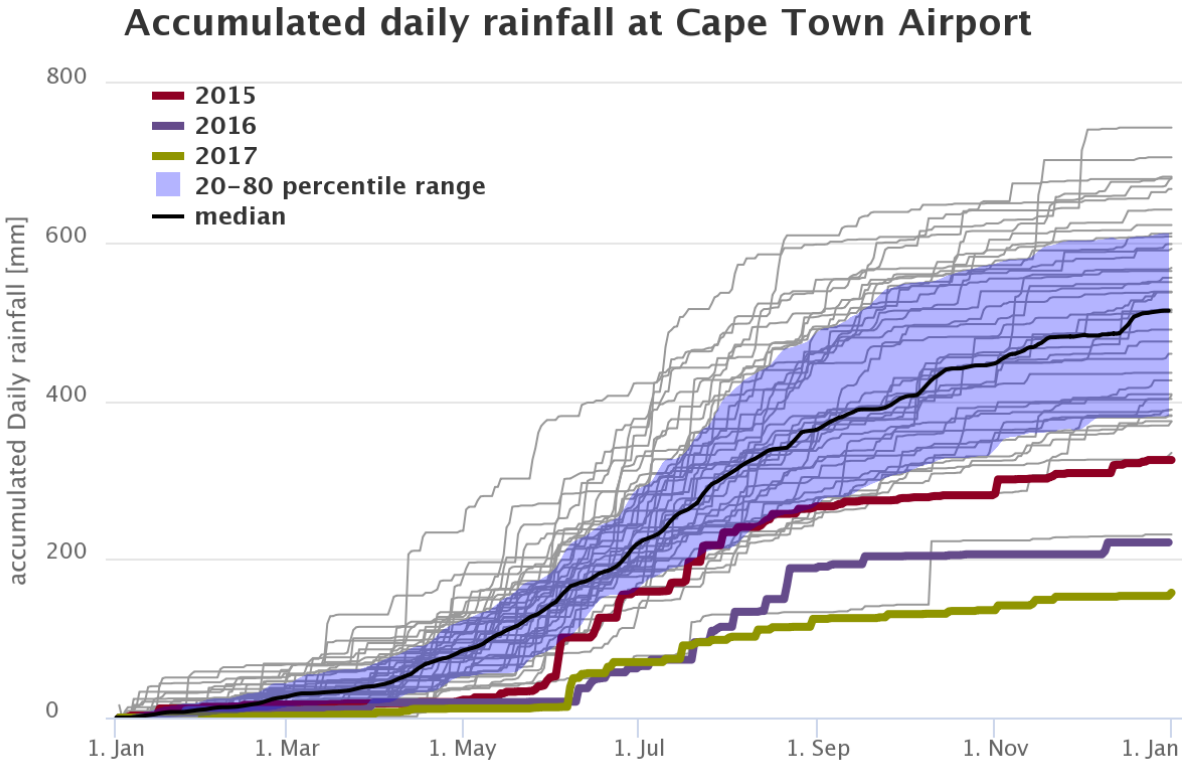
National Nuclear Security Administration
Operated by Los Alamos National Security, LLC for the U.S. Department of Energy's NNSA

What's at stake?

- Water supply in danger of hitting "Day Zero": 6 major reservoir storage falls below 13.5%
- Water supplies shut off for 75% residents
- Current projections push Day Zero from May 11th to June 4th due to extraordinary water saving measures: water use down to 50 L/day (13 gal/day)
- Day Zero triggers deployment of 200 water distribution stations that ration 25 L/day to residents likely under watch of police or National Guard
- Day Zero cost $1 billion to provide 3-months water supply

BBC News, 13 February 2018; NASA, 2018

What Happened?

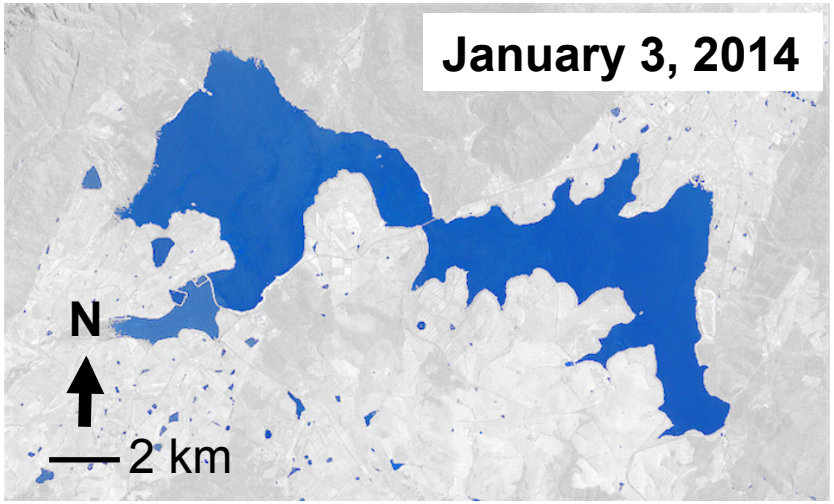


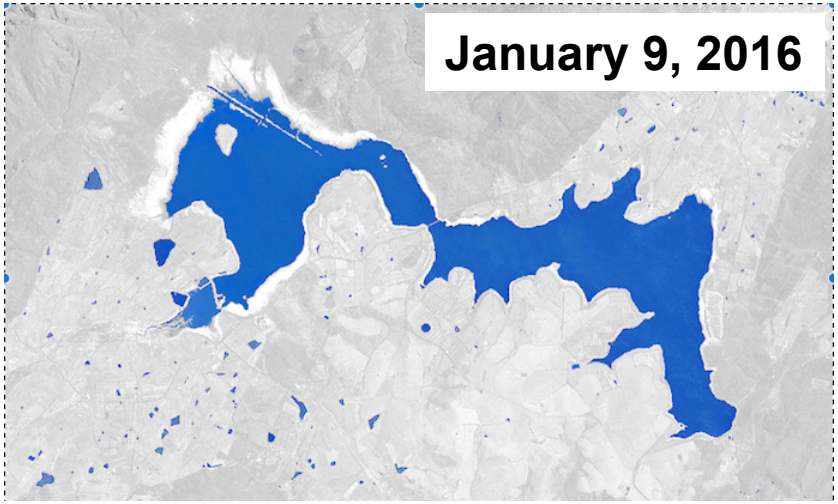
Drought due to below average rainfall & demand/supply pressures

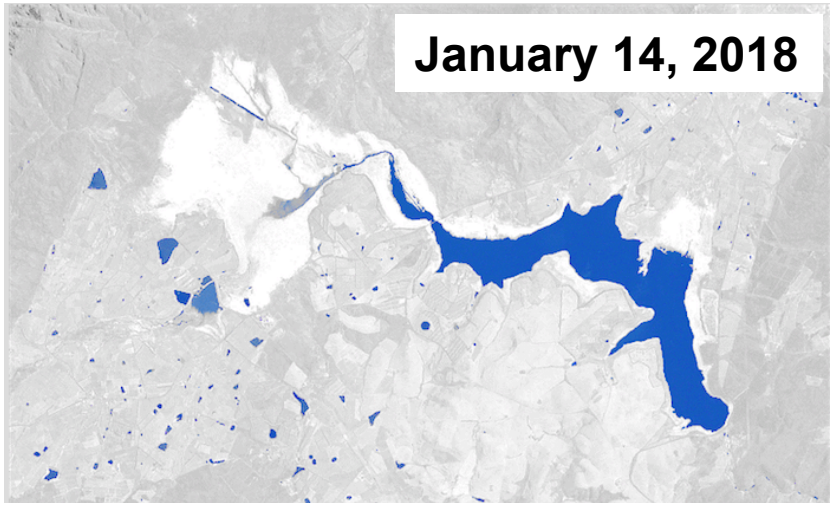
- 2015-2017 = 3 of the top 5 driest years on record since 1977
- Average 46% of 51 cm per year over these 3 years
- Recent changes in water demand high, supplies stagnate
  - ➢ Population grows 80% since 1995; reservoir capacity only increases 15%

CSAG - University of Cape Town, 2018

What Happened?





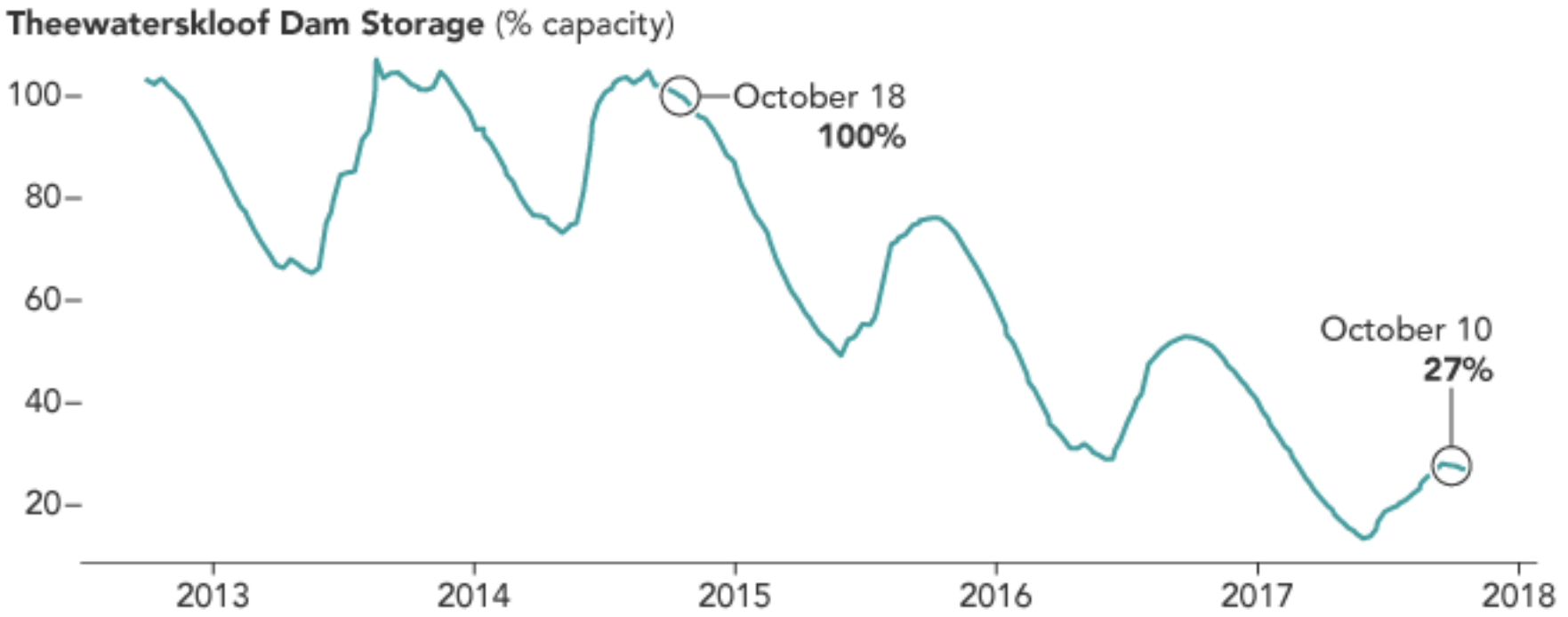


Theewaterskloof Reservoir

- Accounts for >50% water supply
- Currently at 12% capacity

NASA, 2018

What Happened?

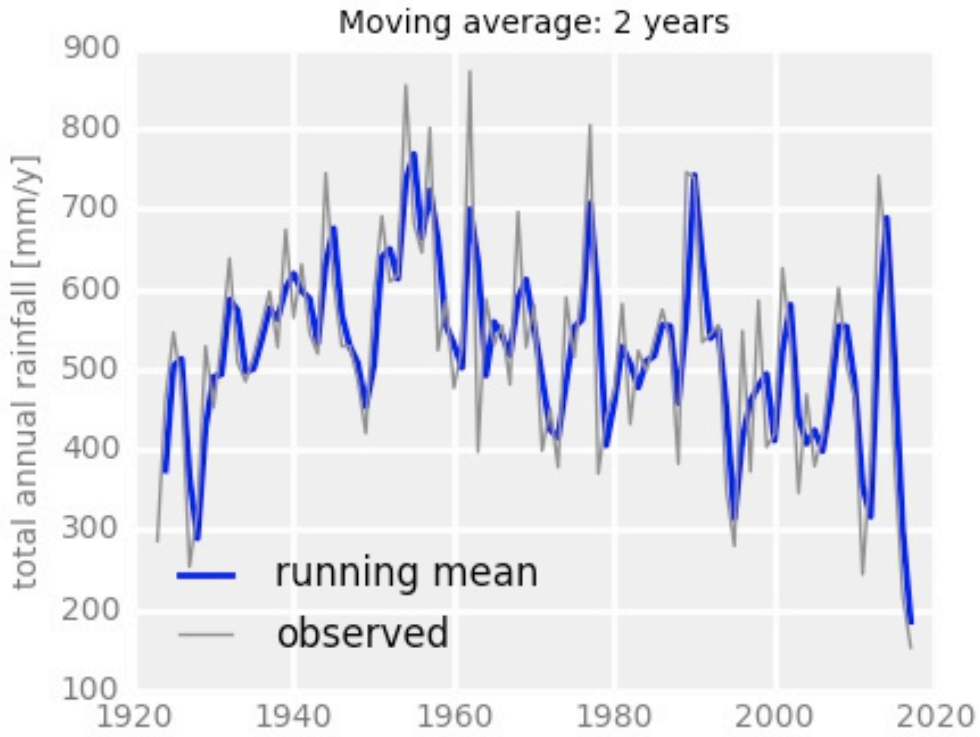


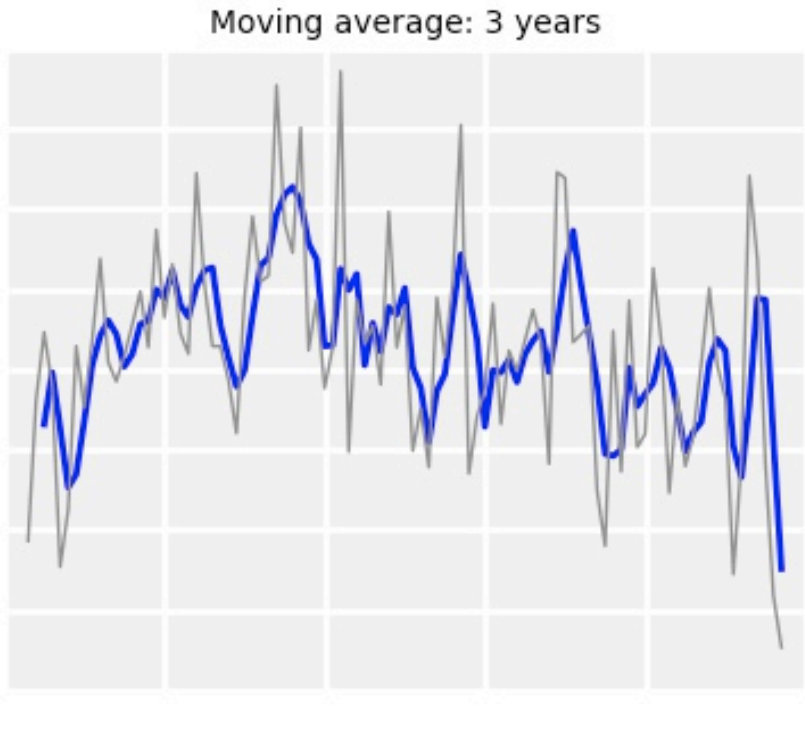
- Theewaterskloof Reservoir storage over last 5-years
- Last full in October 2014

NASA, 2018

Will it happen again (historical perspective)?

Annual Rainfall at Cape Town Airport





Return Intervals

- 2-year (2016-2017) rainfall: 1150 years
- 3-year (2015-2017) rainfall: 628 years

CSAG - University of Cape Town, 2018

Will it happen again (historical perspective)?

Standardized Evapotranspiration Precipitation Index (SPEI)

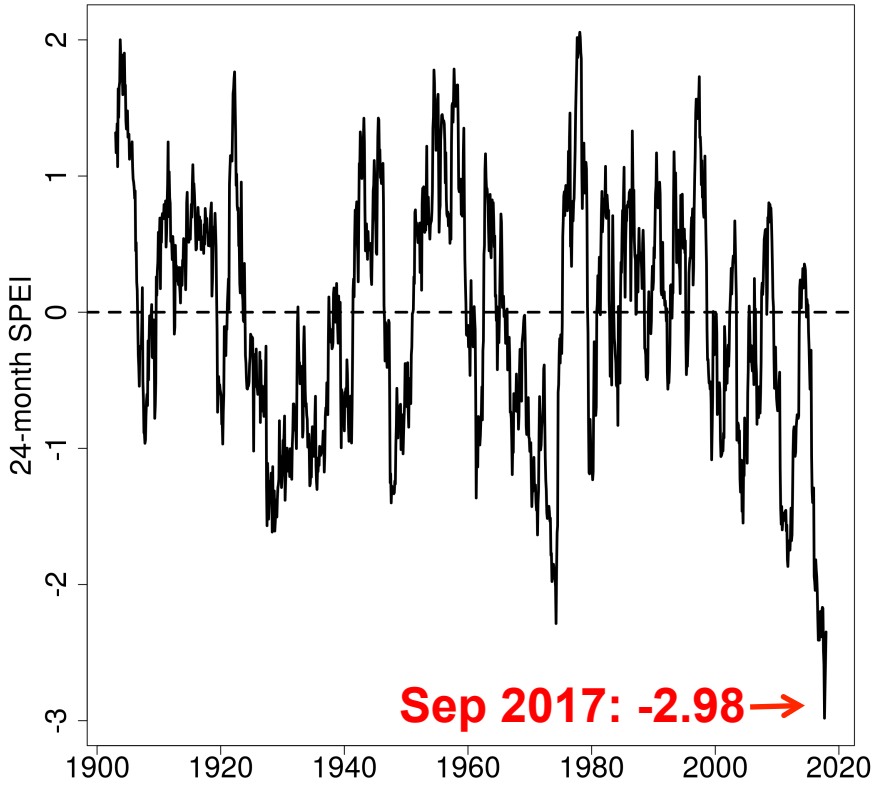
- Based on precipitation and evapotranspiration
- Developed to account for temperature in drought indices
- Data standardized to facilitate comparisons across space & time scales

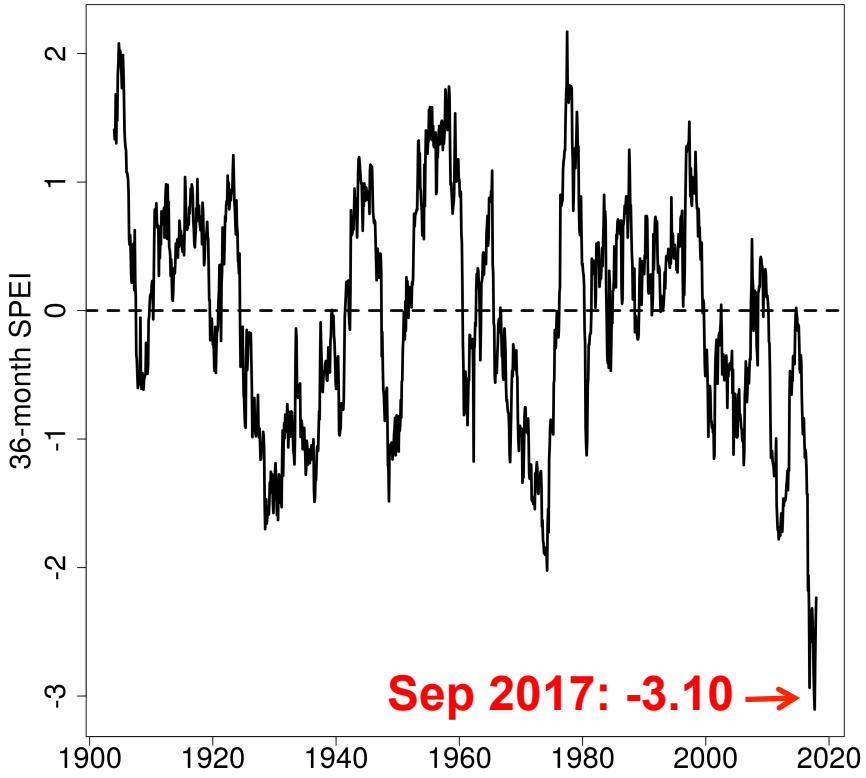
Drought Classification for SPEI	
Classification	**Value**
Extremely wet	≥2.00
Very wet	1.5 to 1.99
Moderately wet	1.00 to 1.49
Near normal	0.99 to -0.99
Moderate drought	-1.00 to -1.49
Severe drought	-1.50 to -1.99
Extreme drought	≤-2.00

Vicente-Serrano et al., 2010

Will it happen again (historical perspective)?

Monthly SPEI Drought Index for Cape Town



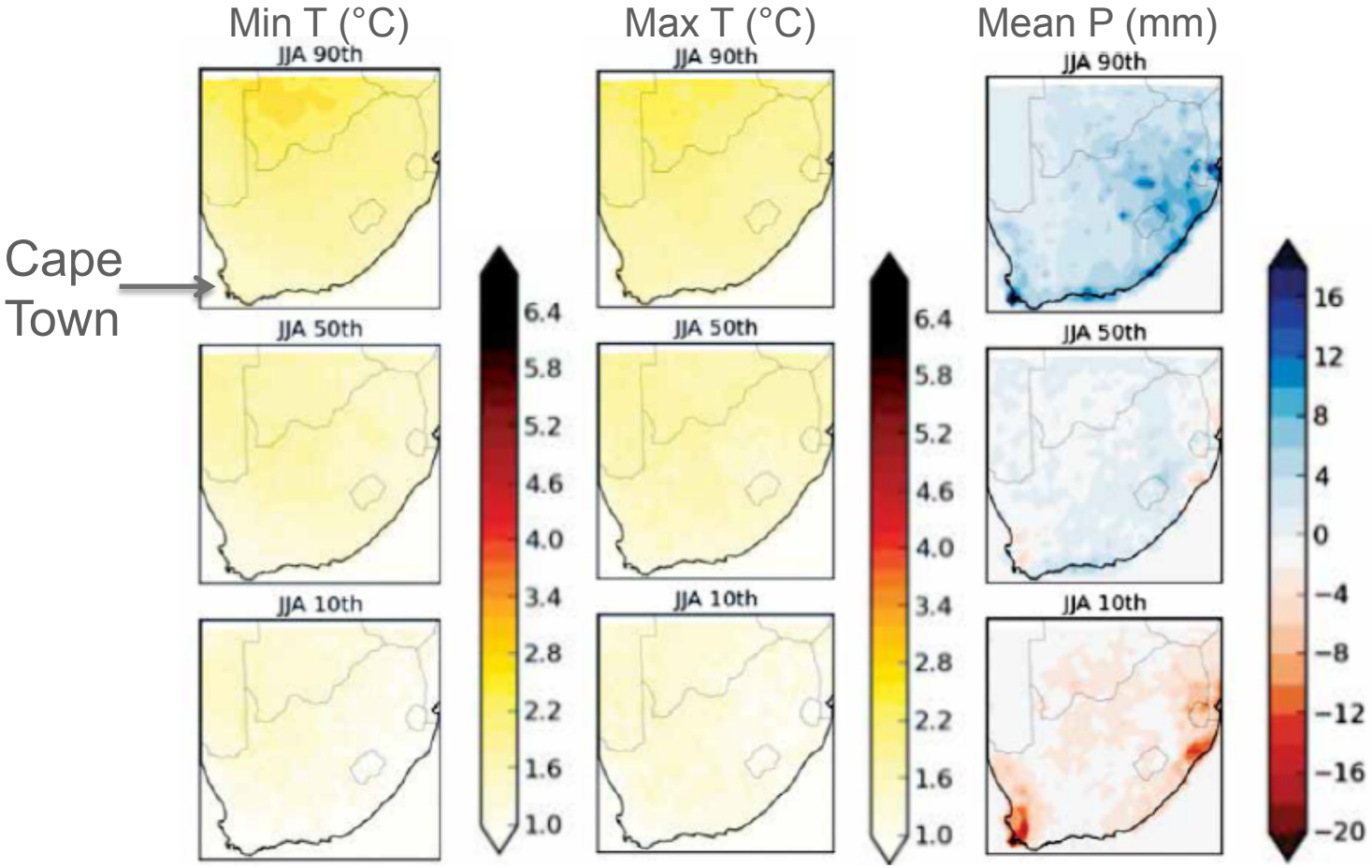


Return Intervals

- 2-year (2016-2017) SPEI: 2050 years (~2x higher than rainfall)
- 3-year (2015-2017) SPEI: 3501 years (~6x higher than rainfall)

Will it happen again (historical perspective)?

10 climate model ensemble (B1 SRES emission scenario) of rainy season June-July-August (JJA) 2046-2065 temperature & precipitation changes

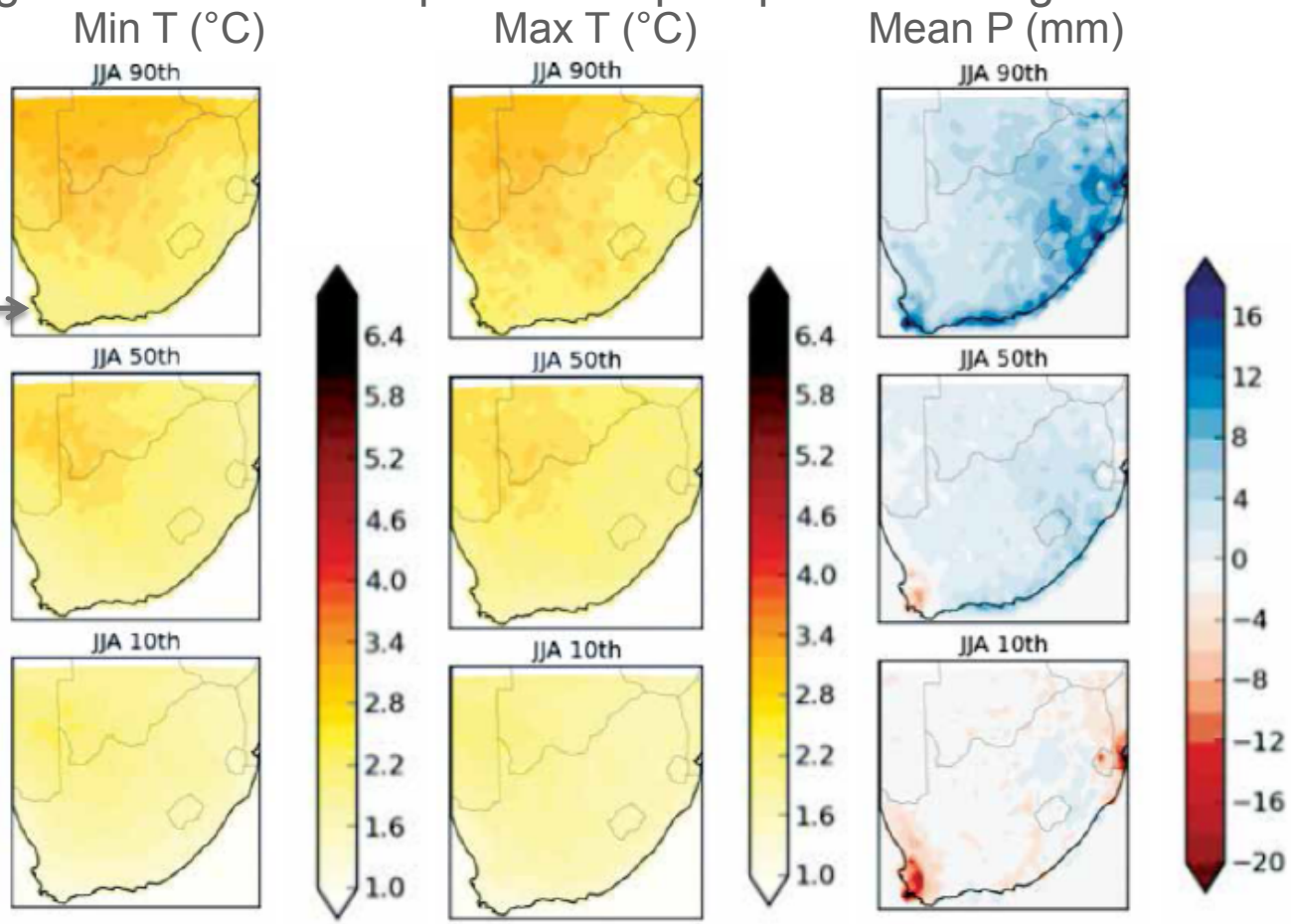


- Min & Max Temperature decrease up to 1°C
- Precipitation decrease up to 20 mm

DEA, 2013

Will it happen again (future perspective)?

10 climate model ensemble (A2 SRES emission scenario) of rainy season June-August 2046-2065 temperature & precipitation changes



- Min & Max Temperature decrease up to 2°C
- Precipitation decrease up to 20 mm

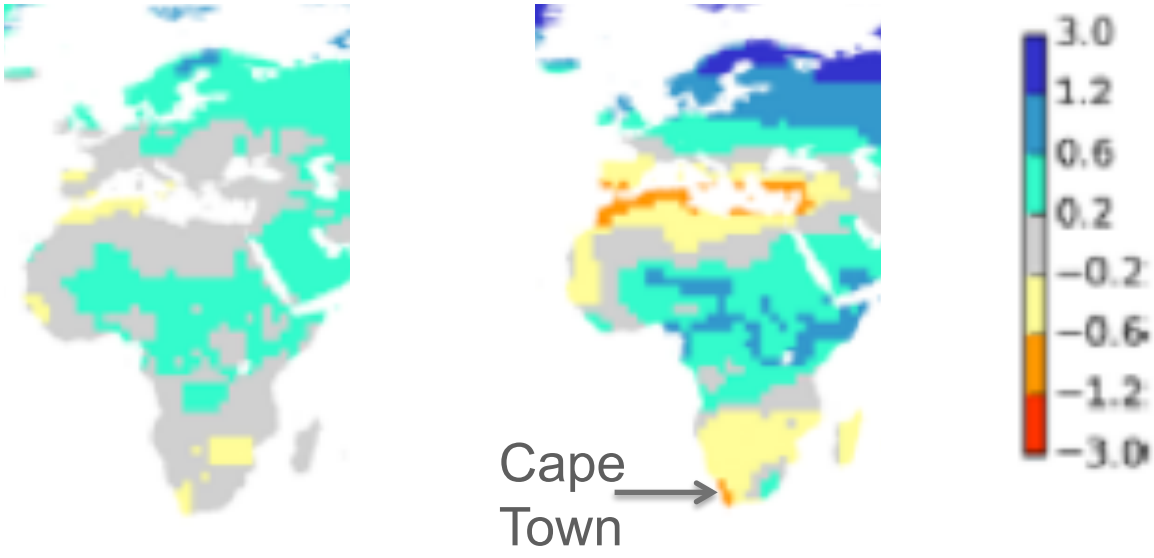
DEA, 2013

Will it happen again (future perspective)?

SPEI based on 16 climate model ensemble under RCP 4.5 (low emissions)

2008-2017

2081-2100



2-Year SPEI Changes for Cape Town

- 2008-2017 monthly mean: -0.6 to -0.2
- 2081-2100 monthly mean: -1.2 to -0.6

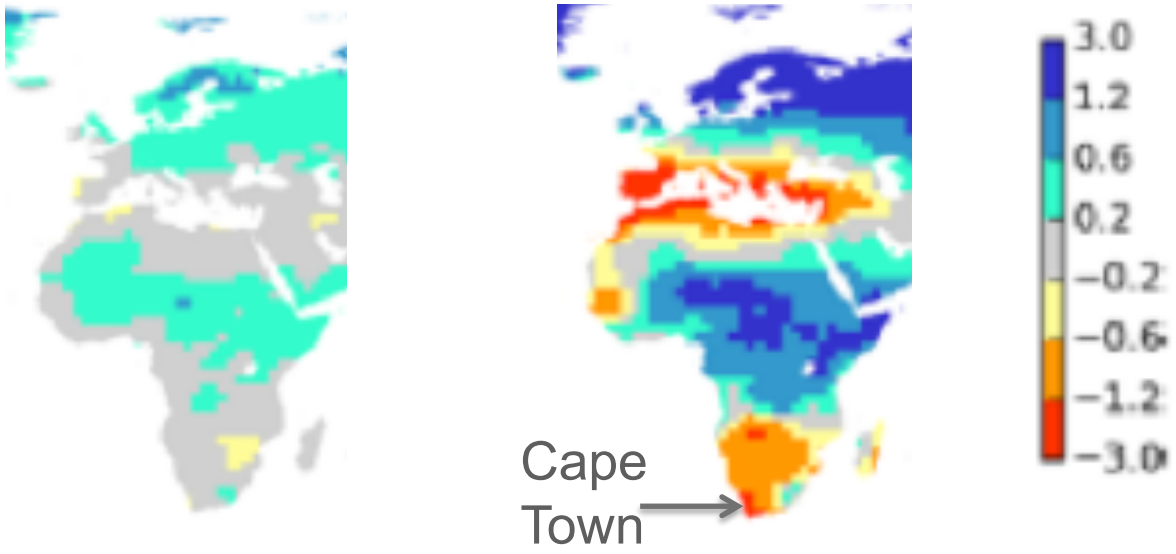
Smirnov et al., 2016

Will it happen again (future perspective)?

SPEI based on 16 climate model ensemble under RCP 8.5 (high emissions)

2008-2017

2081-2100



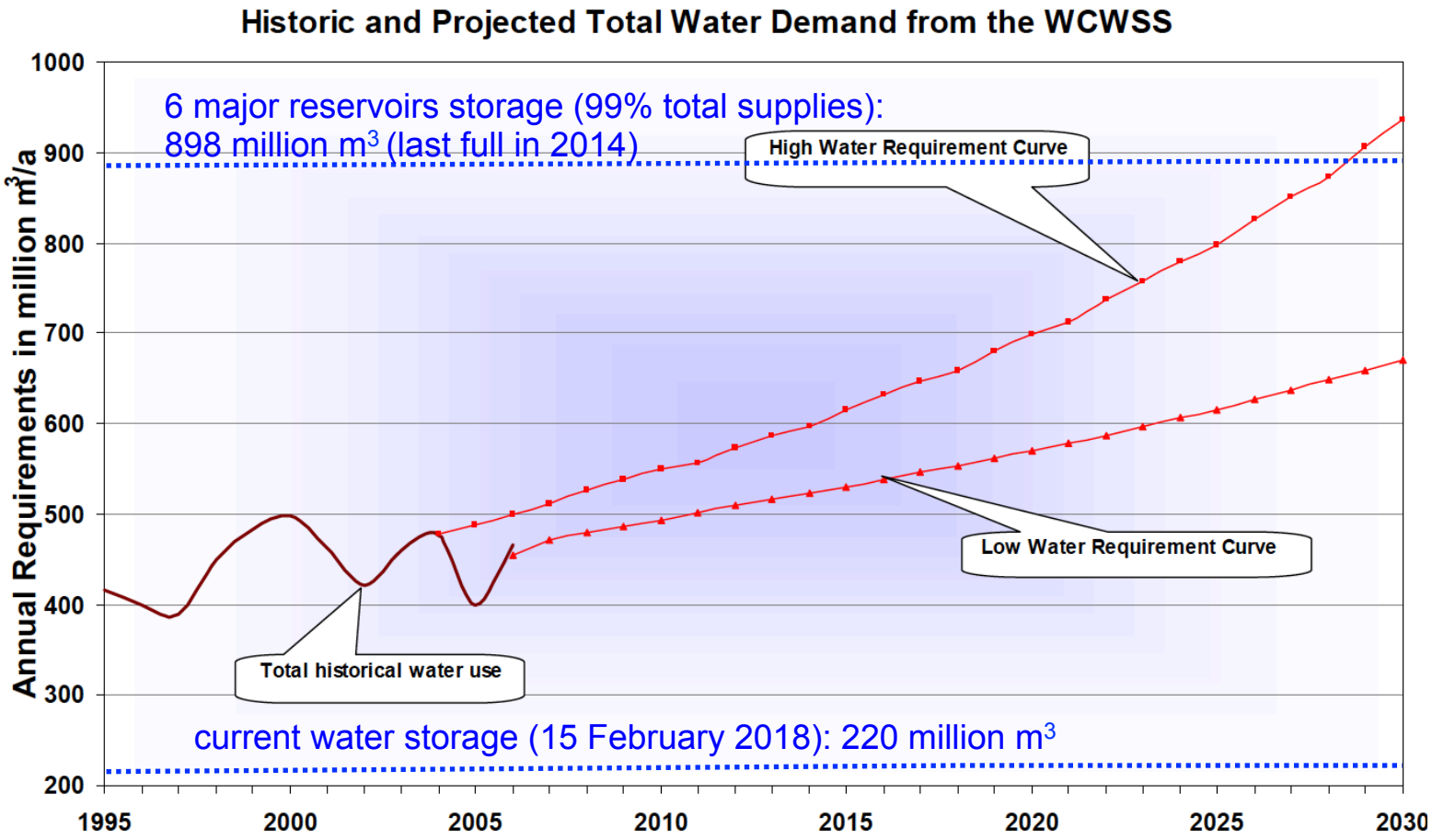
2-Year SPEI Changes for Cape Town

- 2008-2017 monthly mean: -0.2 to 0.2
- 2081-2100 monthly mean: -1.2 to -3.0

***Monthly mean of -3.0 means current drought conditions will become *new normal* by 2100!**

Smirnov et al., 2016

Will it happen again (future perspective)?



- 2-3% annual increase in water use expected from population increase
- Imposes additional pressure on water supply

City of Cape Town, 2007

Conclusions

Is Cape Town the 'Canary in the Coal Mine' for climate change?

- Cape Town drought is rare from historical perspective
  - Return interval = 628 years for 2015-2017 precipitation
  - Return interval = 3050 years for 2015-2017 SPEI drought index
- Could this drought become the new normal?
  - Mid-century: chance of 1-2°C max & min temperature increase during rainy season
  - Mid-century: chance of 20 mm decrease in precipitation during rainy season
  - By 2100: SPEI could equal value of current drought conditions for most years
- Significant internal investment by Los Alamos National Laboratory on topic
  - Recently completed multi-year $3M Critical Watersheds LDRD-DR project to develop model and observation based capability to predict impacts of hot drought (temperature increase combined with precipitation deficits) on natural and engineered water resource systems

    →Williams et al., 2013 (Nature Climate Change); McDowell et al., 2015 (Nature Climate Change); Solander et al., 2017 (J Hydrology); Bennett et al., 2018 (Hydrology and Earth System Sciences)