

## *Identifying Extreme Weather Events through an NSO Climate Data Rescue Project*

Expert Forum for Producers and Users of Climate Change-related Statistics, 2-4 October 2018

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## Overview of Presentation

### 1. Climate daily data rescue project (1830s-1959)

- What is involved in data rescue project
- Data capture process of daily data
- Data quality checking of daily data
- Creating one longitudinal file

### 2. Climate indicators

### 3. Identifying extreme events through internet and data

## 1. Climate Daily Data Rescue Project

- CSO research motivated by UNECE meetings on climate indicators and extreme events
- **Weather is a main cause of many extreme events** and a major factor in the supply of many ecosystem services
- Research on climate change indicators made CSO aware that pre-1960s daily meteorological data for Ireland was generally not computerised (pre-1940s for rainfall)
- The CSO has a role in the development of the Irish Statistical System including ensuring that the **statistical potential of administrative records is realised**
- CSO offered to assist Met Éireann with data rescue and it was agreed that given our experience with capturing and processing large scale datasets that we would take on a data rescue of the full monthly meteorological sheets
- Each monthly sheet contains around **40 data items for each day** as well as summary monthly tables



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## Manuscript Daily Data Page

- |                                      |                          |
|--------------------------------------|--------------------------|
| • Thermometer and barometer readings | • Weather summary**      |
| • Air pressure                       | • Visibility indicators* |
| • Various temperatures               | • Cloud formations**     |
| • Humidity                           | • Rainfall               |
| • Wind force and direction*          | • Sunshine hours         |
|                                      | • Remarks**              |



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Meteorological Observations at Phoenix Park County Dublin				Latitude		53°		21'																					
Month January 1955				Greenwich Time		Railway or Post Office Time																							
Hours of Observations				I: 09:00h		II: 09:00h		Longitude																					
				II: 21:00h		II: 21:00h		6°																					
								21'																					
Day				Attached Thermometer and Barometer as read in inches or millibars				Air Pressure at Mean Sea Level in the Units of Measurement				Temperature (degrees F.)				In C													
				Degrees		In. or mb.		Degrees		In. or mb.				Dry		Wet		Max.		Min.		Grass Min.							
				I		II		I		II		I		II								Evening To Morning							
Numbers of Columns				1		2		3		4		5		6		7		8		9		10		11		12		13	
Day.				I.		II.																							
				(1)		(2)		(3)																					
				in. or mb.																									
1				284		283		283		1028.8		1031.8		39		37		38.7		35.7		47		38		30			
2				283		283		283		1033.4		1032.5		40		36		40		37.3		42		38		35			
3				282		282		282		1027.9		1023		40		36.9		40		35.8		42		37		36			
4				282		282		282		1017		1015.6		37.4		36.4		36.6		34.6		41		33		35			
5				282		282		282		1019.4		1016.1		38		35.7		40		37.8		40		36		32			
6				282		282		282		1015.1		1014.5		42		39		40		38.8		42		39		38			
7				283		283		283		1015.4		1015		41		38.5		40		37.3		42		37		36			
8				282		282		282		1014.2		1011.4		33		33		31.9		31.9		40		31		23			
9				283		283		283		1002.9		995.3		45.6		43.4		48.3		46		49		32		28			
10				284		282		282		984.5		990.3		52		51.3		38		37.8		53		38		45			
11				280		280		280		999.2		1002.5		30.5		29.8		27.5		27.5		39		27		20			
12				278		278		278		999.2		1004.3		29		28.8		25.5		25.3		36		24		9			
13				278		279		279		1002.5		992.5		29		28.8		32.8		30.7		36		20		7			
14				278		278		278		1002.8		1008		28		27.7		25.7		25.6		36		24		11			
15				279		279		279		997.4		987		38		38		39		39		42		24		14			

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## Data Quality Checking of Daily Data

- **Met Éireann will integrate the fully checked daily data from the data rescue project with daily data from 1960 onwards** and publish this as a research file on their website
- Quality of daily data must be very accurate as the file will be used at daily level
- Initial CSO checks are to compare consistency of daily data with monthly summary tables in monthly report e.g. monthly summary table may have maximum temperature in shade as 72.8° F on 15<sup>th</sup> May 1892 which should correspond with the highest daily temperature in shade in that month
- Monthly sheets contain totals and means for numerical variables and these are recalculated by CSO from daily data and compared
- Further checks for outliers e.g. cloud formation codes that only occur a few times
- **Data checking is taking as long as data capture**
- Meteorological offices checking standard is to have two persons key same month and compare but SAS offers an alternative approach



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## What is Involved - Tasks Sequence

- Manuscripts sent by Met Éireann to external company for scanning
- Scanned images named by Met Éireann e.g. MO-1\_54\_095\_c\_-
- Images sent to CSO for keying
- **CSO designed excel template to look like scanned images**
- Monthly daily data excel file read into SAS and checked by CSO
- Further visual checking of keyed month
- Integrated time-series file of all years created by CSO
- Data returned to Met Éireann in one tab-delimited file
- Monthly excel files available to Met Éireann



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## CSO Resource Requirements for Data Rescue

- Day to day management of project at statistician level (recent recruits)
- Excel templates designed to reflect monthly sheets completed by meteorological officer
- SAS used to create a consistent time series file (consistent naming of SAS variables)
- SAS used for checking keyed data
- Data checking is very important but very time-consuming as there have been many changes in the design of the monthly recording sheet => new templates and SAS programs
- **Longitudinal file will be created** for Met Éireann with every data item consistent over time
- Each station month takes around **six hours** on average for all tasks
- -> 2 hours keying; 2 hours checking; and 2 hours excel and SAS programs for longitudinal consistency
- 120 years by 12 months by 6 hours = **8,640 person hours for Phoenix Park**



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## Daily versus Monthly Data

- Monthly maximums, means, minimums currently used for pre 1960s analyses
- Advantages of daily data:
  - more granular analyses including combining months to identify spells of exceptional weather
  - variables can be cross-classified e.g. relationships between air pressure, humidity, rainfall, and temperature
  - analyses of general and extreme weather patterns e.g. days with very high rainfall
  - **more flexible calculation of indicators** e.g. length of frost-free season, drought, and heatwaves
  - **Frequency of unusual weather** e.g. days when snow was on the ground in the Phoenix Park



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Year	Snow lying on the Ground in Phoenix Park 1912-1959					
	Jan	Feb	Mar	Apr	Dec	Days
1947	6	26	8	0	2	42
1937	1	1	14	0	4	20
1941	16	2	0	0	0	18
1955	5	10	0	0	0	15
1950	0	0	0	0	12	12
1952	9	1	0	0	2	12
1958	6	4	1	1	0	12
1945	11	0	0	0	0	11
1956	1	9	0	0	0	10
1917	3	5	0	0	2	10

## 2. Climate Indicators

There are **many weather-related indicators** and 30 year averages are often used as a benchmark period to evaluate short-term data e.g. 1981-2010

Shorter periods such as 10 minute intervals and real-time satellite imagery (Copernicus) are used by meteorologists and emergency alert teams to respond in real-time to storms and floods

### Indicators can be adjusted for specific purposes

Climatological community has defined four types of drought:

- Meteorological drought (dry weather periods)
- Hydrological drought (risk of impact on river ecosystem)
- Agricultural drought (impact on agriculture)
- Socio-economic drought (impact on public water supply)



## Example Climate Indicators

- Maximum, Mean, Median, Minimum, Percentiles
- Frost days (daily minimum temperature  $< 0^{\circ}\text{C}$ )
- Ice days (daily maximum temperature  $< 0^{\circ}\text{C}$ )
- Summer days (daily maximum temperature  $> 25^{\circ}\text{C}$ )
- Tropical nights (daily minimum temperature  $> 20^{\circ}\text{C}$ )
- Heatwave (five consecutive days  $> 25^{\circ}\text{C}$  for Ireland)
- Absolute drought (15 days with all  $< 0.2\text{ mm}$ )
- Partial drought (29 days with total  $< 5.8\text{ mm}$ )



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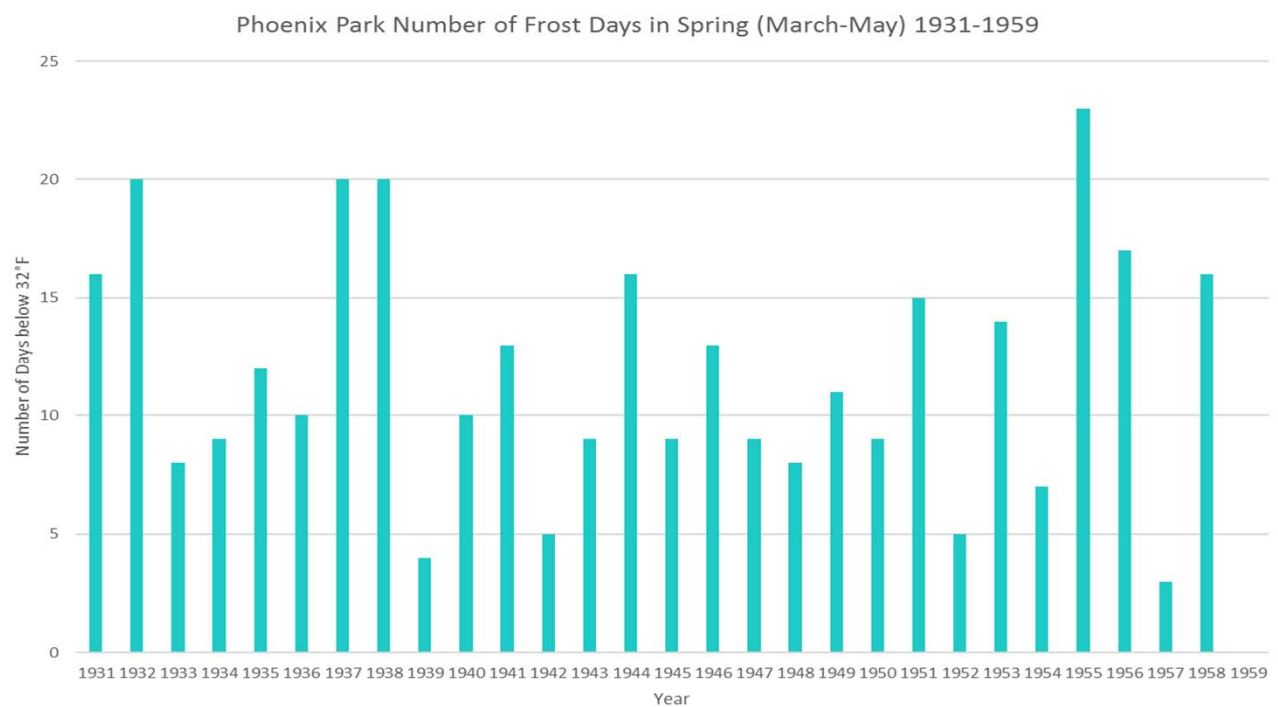
## Rainfall Indicators

- There are many climate indicators that can be derived from rainfall data such as wet days ( $>1\text{ mm}$ ) and very wet days ( $>20\text{ mm}$ ). Rainfall data can also be used to identify historical floods and droughts that may have impacted on human settlements, non-residential premises, agriculture, and water ecosystems.
- An **absolute drought** is defined as a consecutive period of at least 15 days where the daily rainfall was less than 0.2 millimetres on each day.
- There were **10 absolute droughts** recorded at the Phoenix Park during 1931-1959.
- Analysing absolute drought periods in conjunction with other weather data adds important context
- The longest absolute drought in the Phoenix Park during 1931-1959 was in 1947 and lasted for 32 days. It occurred in conjunction with a mean maximum temperature during that period of  $72.8^{\circ}\text{F}$  ( $22.7^{\circ}\text{C}$ ). In contrast the 1932 drought in February/March had a mean maximum temperature of  $45.7^{\circ}\text{F}$  ( $7.6^{\circ}\text{C}$ ).
- Partial drought indicator (29 days  $< 5.8\text{ mm}$ ) would result in only **3 partial droughts** during 1931-1959

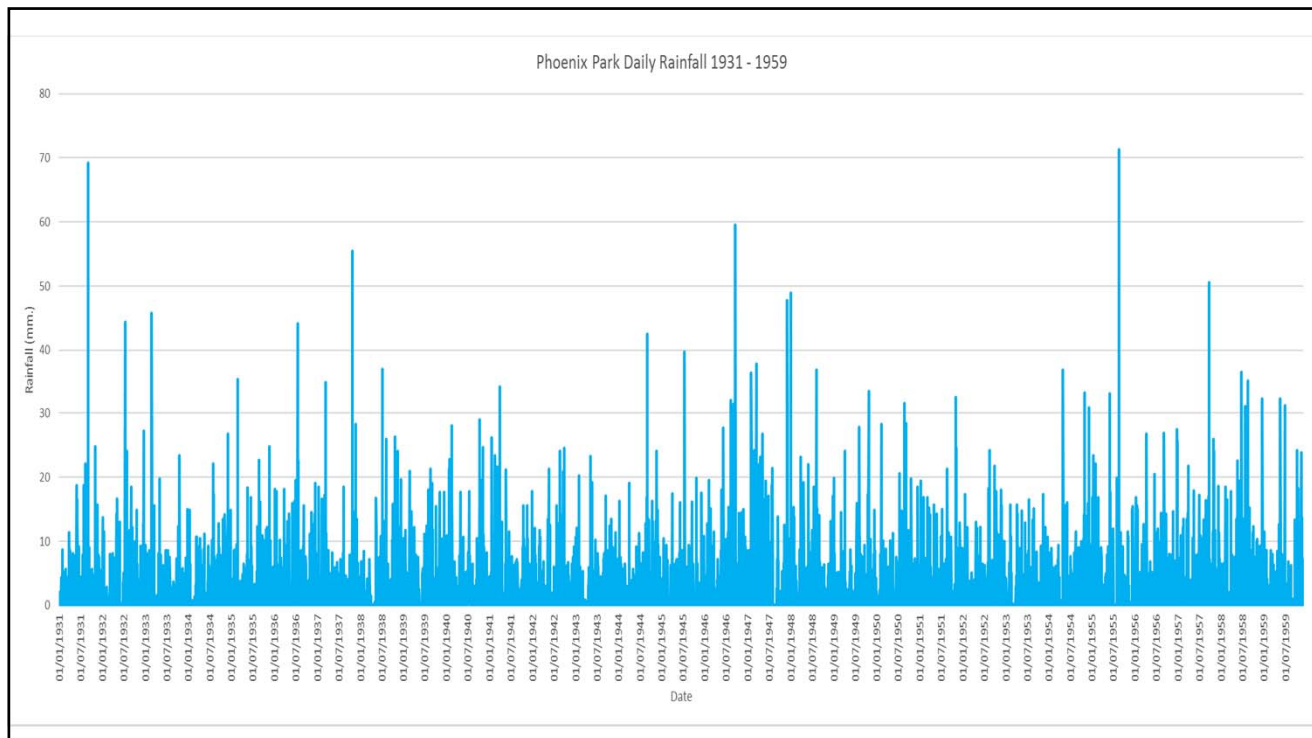


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Absolute drought	Start	End	Duration	Mean maximum temperature	Mean minimum temperature
1	13/02/1932	04/03/1932	21 days	45.7 °F	32.9 °F
2	02/09/1933	16/09/1933	15 days	69.0 °F	48.6 °F
3	03/04/1938	01/05/1938	29 days	55.3 °F	33.6 °F
4	22/05/1939	09/06/1939	19 days	68.7 °F	44.1 °F
5	01/03/1945	17/03/1945	17 days	53.5 °F	38.7 °F
6	01/05/1946	15/05/1946	15 days	56.7 °F	38.5 °F
7	03/08/1947	03/09/1947	32 days	72.8 °F	50.6 °F
8	03/03/1953	24/03/1953	22 days	50.6 °F	32.9 °F
9	12/04/1954	29/04/1954	18 days	55.7 °F	35.7 °F
10	04/07/1955	01/08/1955	29 days	71.7 °F	51.5 °F







### 3. Steps in Measuring Extreme Events

- CSO has recently started compiling an **inventory based on internet searches** of weather-related terms e.g. flooding, wildfires, storms, and **reports**
- CSO will also compile an **inventory based on daily weather data** from 1960 onwards from the Met Éireann website: <https://www.met.ie/climate/available-data/historical-data>
- The characteristics of known exceptional events from the internet inventory will be identified in the daily data e.g. amount of rainfall that resulted in a media reported flood event
- Create a provisional register from daily weather data using thresholds associated with media reported events and meteorological definitions of indicators
- SAS programs will be written flexibly to allow changes to be made easily in the duration and intensity thresholds e.g. 10 days with maximum daily temperature > 25° C rather than five days
- **Duration and intensity inclusion thresholds** can be lowered to include exceptional but not extreme events
- Typology of events will initially be based on UNECE and SENDAI framework etc.



Family	Geophysical	Hydrological	Meteorological	Climatological	Biological	Extra-terrestrial
<b>Main Event</b>	Earthquake Mass Movement Volcanic Activity	Flood Landslide Wave Action	Convective Storm Extratropical Storm Extreme Temperature Fog Tropical Cyclone	Drought Glacial Lake Outburst Wildfire	Animal Incident Disease Insect Infestation	Impact Space Weather
<b>Peril</b>	Ash Fall Fire following EQ Ground Movement Landslide following EQ Lahar Lava Flow Liquefaction Pyroclastic Flow Tsunami	Avalanche : Snow, Debris Coastal Flood Coastal Erosion Debris/Mud Flow/Rockfall Expansive Soil Flash Flood Ice Jam Flood Riverine Flood Rogue Wave Seiche Sinkhole	Cold Wave Derecho Frost/Freeze Hail Heat Wave Lightning Rain Sandstorm/Dust storm Snow/Ice Storm Surge Tornado Wind Winter Storm/Blizzard	Forest Fire Land Fire: Brush, Bush, Pasture Subsidence	Bacterial Disease Fungal Disease Parasitic Disease Prion Disease Viral Disease	Airburst Collision Energetic Particles Geomagnetic Storm Radio Disturbance Shockwave

## Analyses of Currently Computerised Daily Data (1960+)

- <https://www.met.ie/climate/available-data/historical-data>
- Around **17 million days of data for around 1,800 stations from around 1960 forwards** (rainfall data back to 1940s and many manual volunteer stations only record rainfall)
- Around **4 million hourly records** which could be used to identify more intense weather e.g. downpours
- Can be downloaded by public from meteorological agency's website
- Enables identification of exceptional weather and development of thematic reports e.g. Heatwaves in Ireland
- However 1960s was already the start of increased car ownership and foreign holidays so longer time series preferred
- Meteorological **stations are geo-coded** so maps possible and potential to use for SDG reports
- Monthly and seasonal variations and long-term changes in those patterns can be looked for
- **Shortcomings** include missing data and inconsistency in available variables across stations



## Minimum Temperature < -15° C in 1960s-2018

Period (13 days)	Counties
16 <sup>th</sup> and 17 <sup>th</sup> February 1969	Mayo
1 <sup>st</sup> and 2 <sup>nd</sup> January 1979	Carlow, Kildare, Louth, Meath (both days), Offaly
12 <sup>th</sup> January 1982	Offaly
7 <sup>th</sup> January 2010	Kilkenny
3 <sup>rd</sup> December 2010	Kilkenny
<b>20-25 December 2010</b>	Cavan, Dublin, Galway, Mayo (all days), Roscommon, Sligo



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## Heatwaves in Ireland 1960s-2018

Defined as **five** consecutive days > **25° Celsius**

- **354** heatwaves were recorded at meteorological stations across all of the 26 counties in Ireland (**112 in 1995** but 2018 data have only been downloaded up to around June)

Using **five** consecutive days > **28° Celsius**

- **9** heatwaves were recorded across 7 counties

Using **three** consecutive days > **30° Celsius**

- **4** heatwaves were recorded across 4 counties and three years
- Offaly (1976), Kilkenny and Wexford (1983), and Clare (2018)



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Highest Daily Rainfall 1942-2018	Station	County	Date
260.3 mm	Beenreagh mountain	Kerry	03/10/2016
243.5 mm	Cloone lake, Caragh	Kerry	18/09/1993
208.5 mm	Torc mountain no.4	Kerry	05/08/1986
206.5 mm	Glenvicee, Caragh	Kerry	05/08/1986
205.2 mm	Moanbane no.2	Wicklow	09/03/1995
201.2 mm	Waterville oclave no.9	Kerry	03/10/2016
200.2 mm	Kilcoole (treatment plant)	Wicklow	25/08/1986
198.6 mm	Cloone lake, Caragh	Kerry	03/10/2016
194.5 mm	Ballaghbeama gap	Kerry	05/08/1986
192.7 mm	Cummeragh mountain no.2	Kerry	05/08/1986



## Comprehensive Time Series

- One **concern** is to **avoid having greater inclusion of more recent events** because of better media coverage and folk memory. Hence we need to identify criteria based on extreme events, relax the criteria so that more events come into scope of the research (exceptional events) and then do internet and report searches to see if these potential events suggested by the daily data resulted in actual events
- The media searching has resulted in a lot of material including reports such Landslides in Ireland (published 2006), Snowfall in Ireland (2012), and Extreme Wave Events in Ireland (published 2013) however generally no ongoing data collection mechanisms were established so the series in these reports are not being updated on a systematic basis
- Final step will be to try and obtain **costings for the major events** (damage caused and subsequent mitigation and adaptation expenditure). This will create possibility of comparing any reductions in damage costs in repeat events with prevention costs. This work will probably be of most interest to policy-makers and local authorities.



## Conclusions

- Climate change would impact on social and economic aspects of life and of our environment
- Meteorological variables provide important **front-line insight into extreme events**
- Longer time series should result in a much more granular understanding of climate change
- Climate change impact could vary greatly within a country and across seasons
- Ecosystem services would be affected by significant climate change
- **Daily data can lead in the identification of actual extreme events** especially historical ones
- Meteorological offices have in-depth knowledge and WMO is working on climate indicators
- Statistical offices have generally not been involved in climate and meteorological analyses
- Statistical agencies and offices can lead in integrating weather and climate data into official statistics



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