

*Climate
change in
Ireland over
the last two
centuries*



Photo taken from International Space Station 2018

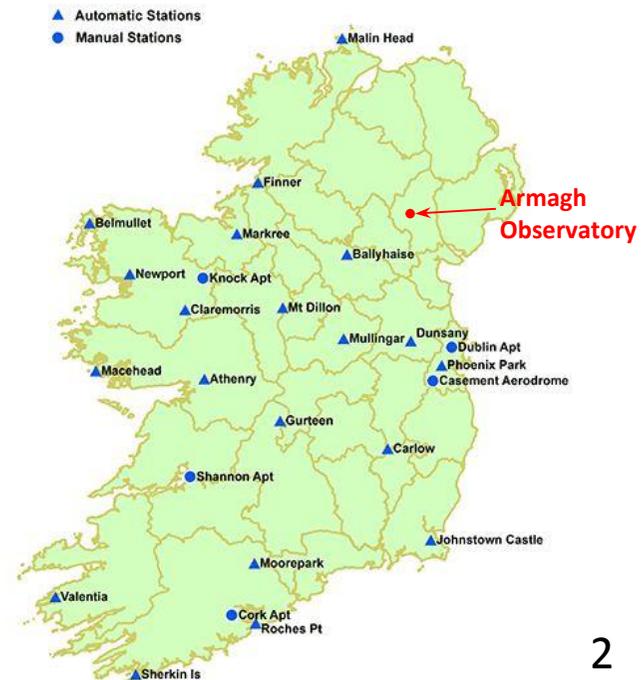
Introduction

- This is a graphical and accessible presentation of Ireland's climate since the early 1800's
- It has a minimum of technical details so all can easily understand it
- Armagh Observatory has one of the longest temperature records in the world for the same site (since 1796)
- Data also from Met Éireann, UK Met Office (NI) and other published academic papers (all sources are detailed)
- Graphs have different start dates due to data availability varying for the different climate aspects such as temperature, rainfall, etc.



Armagh Observatory

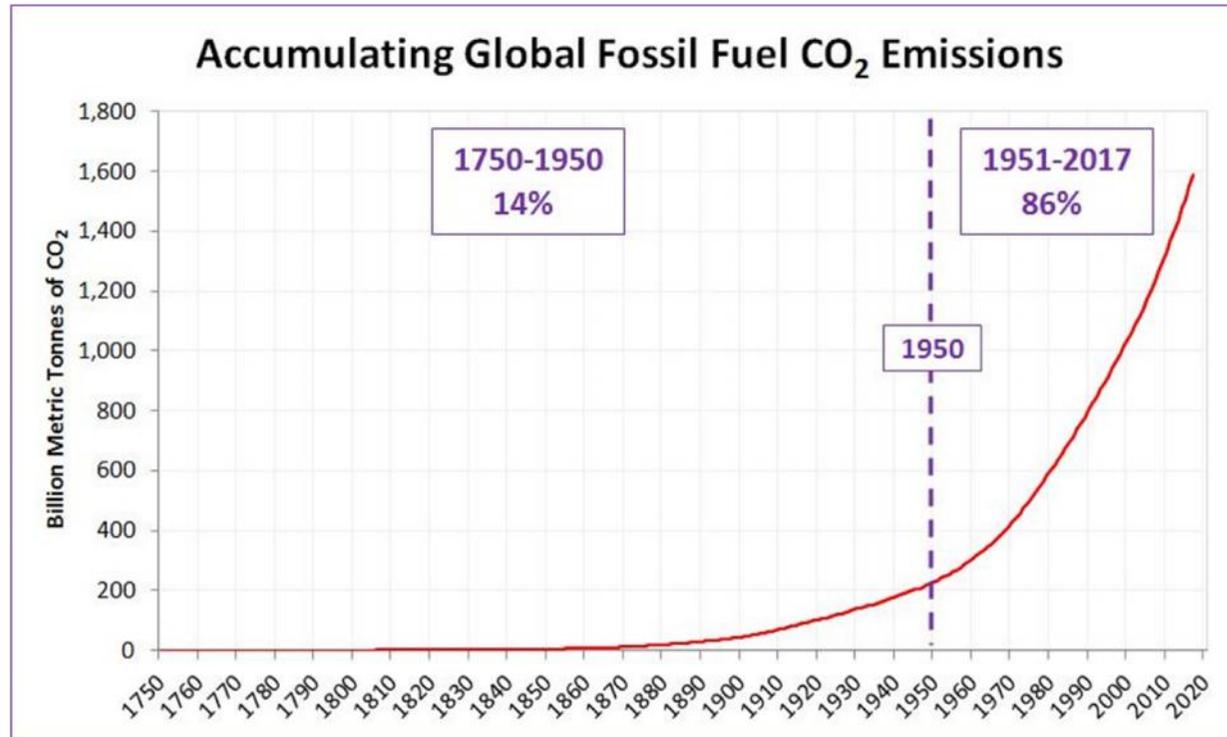
Met Éireann Synoptic Stations Feb 2013



What is climate?

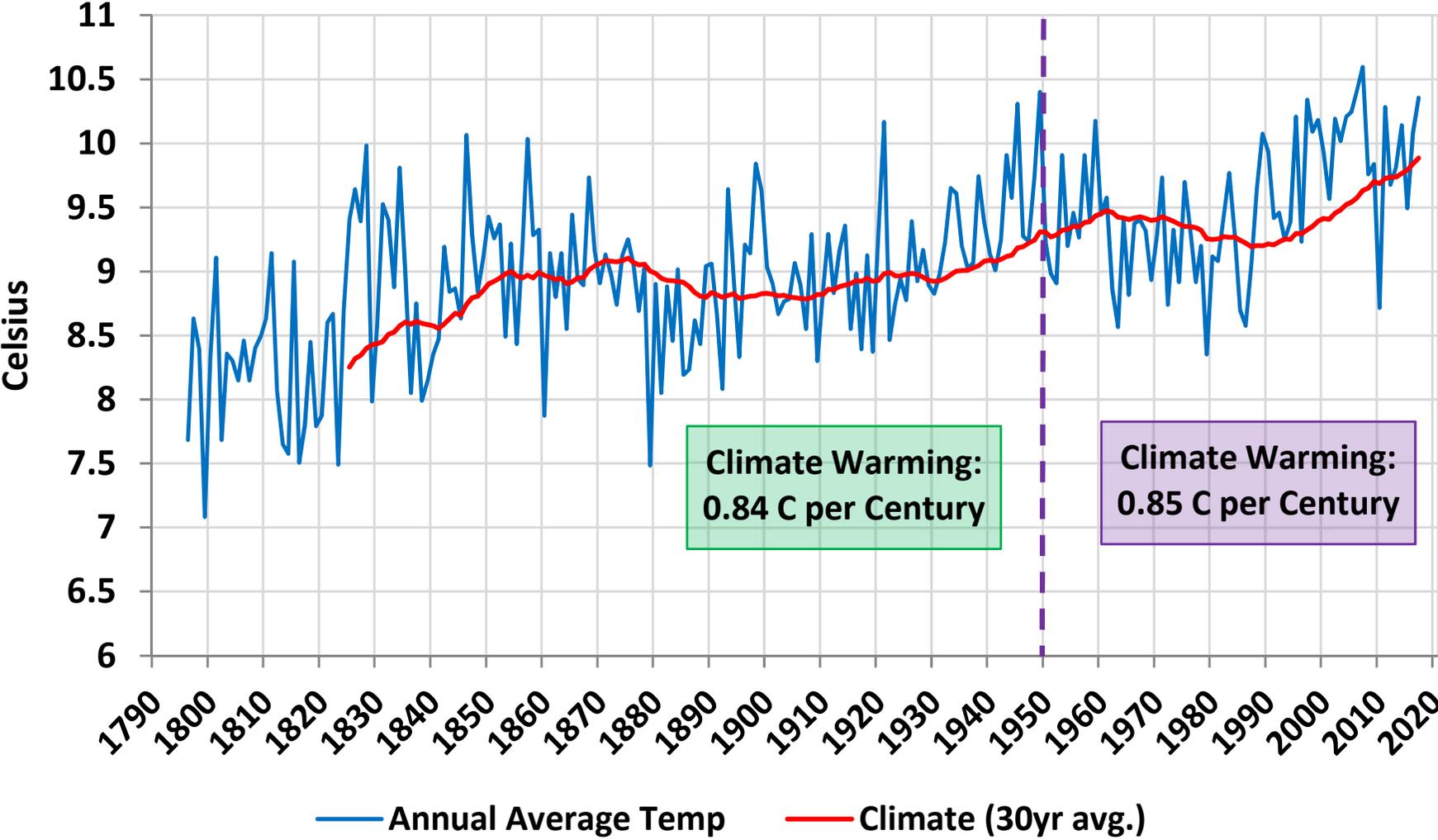
- *Simplest definition is the average of the last 30 years of weather*
- *Met Éireann and other institutions use this definition and compare current weather to defined period averages (e.g. 1980-2010)*
- *Climate includes temperatures (average, max, min), wind speed, wind direction, gale & storm occurrence, rainfall, sunshine, humidity and these are summarised here in graphs*

CO₂ from fossil fuels

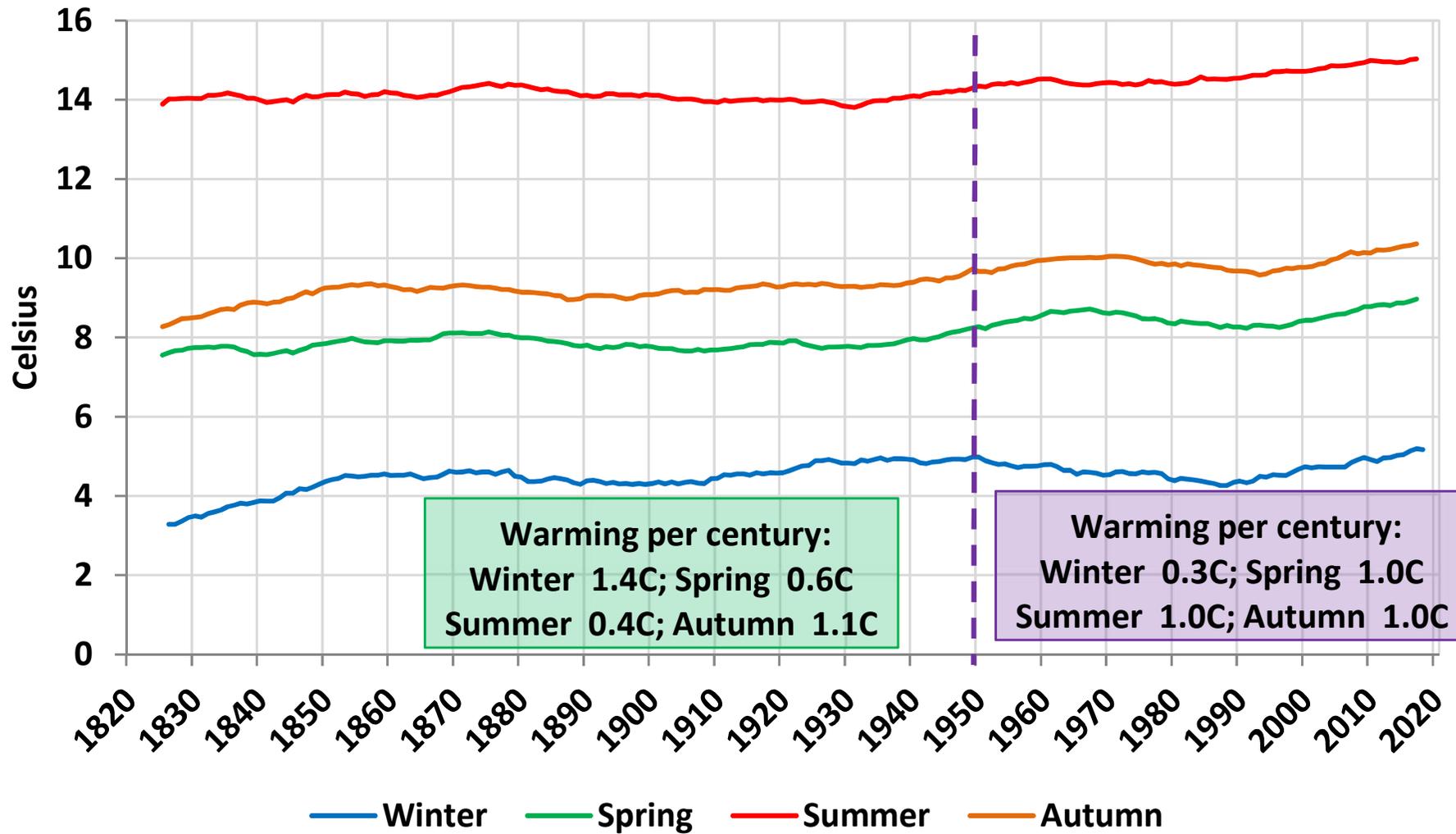


- *Climate scientists generally agree that CO₂ from fossil fuels did not have a measurable impact on climate before around 1950 as there was very little then compared with recent decades*
- *Hence, comparisons of climate change before and after 1950 are important to show the impact of human-caused CO₂*

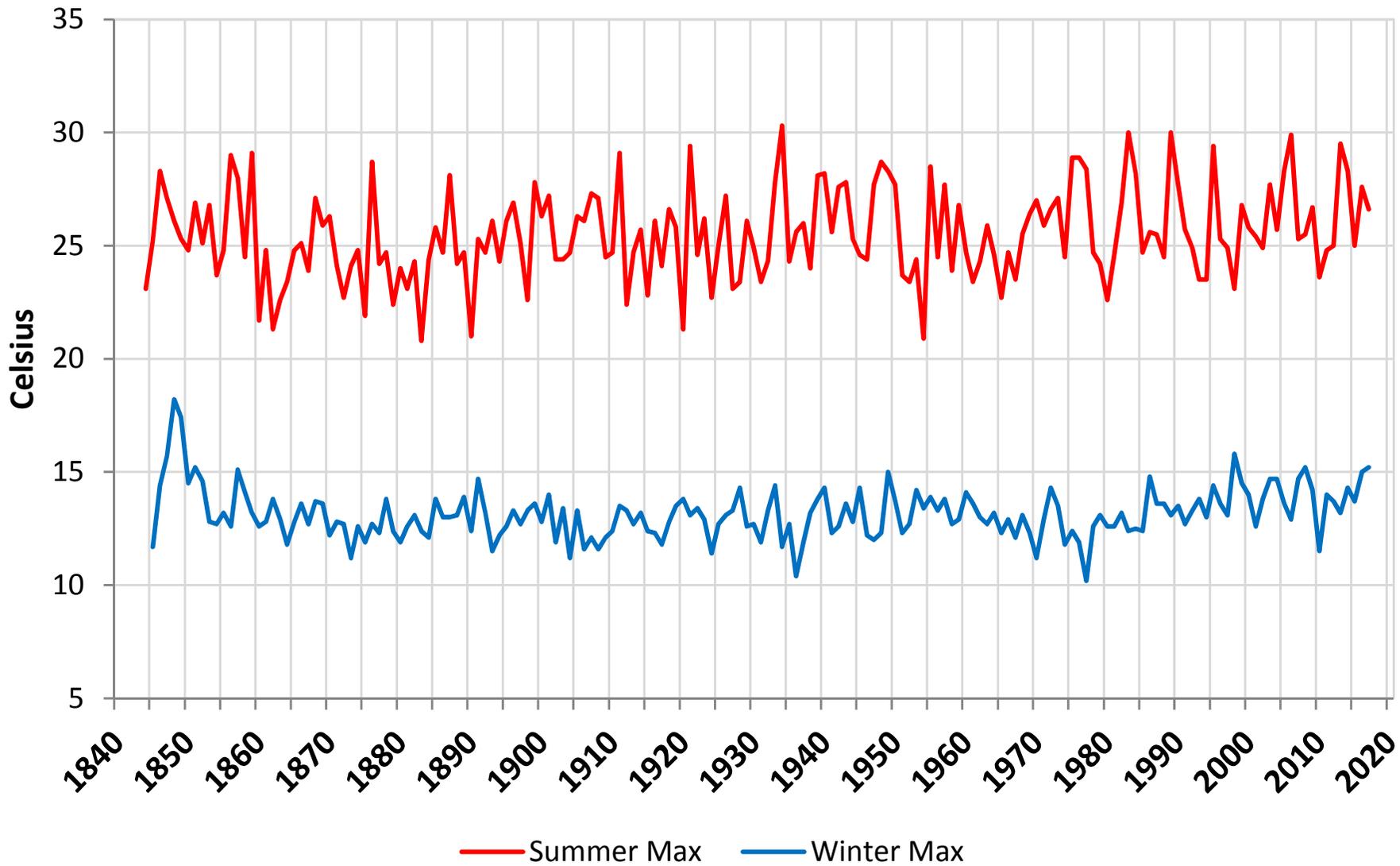
Annual Temperature Armagh Observatory 1796-2017



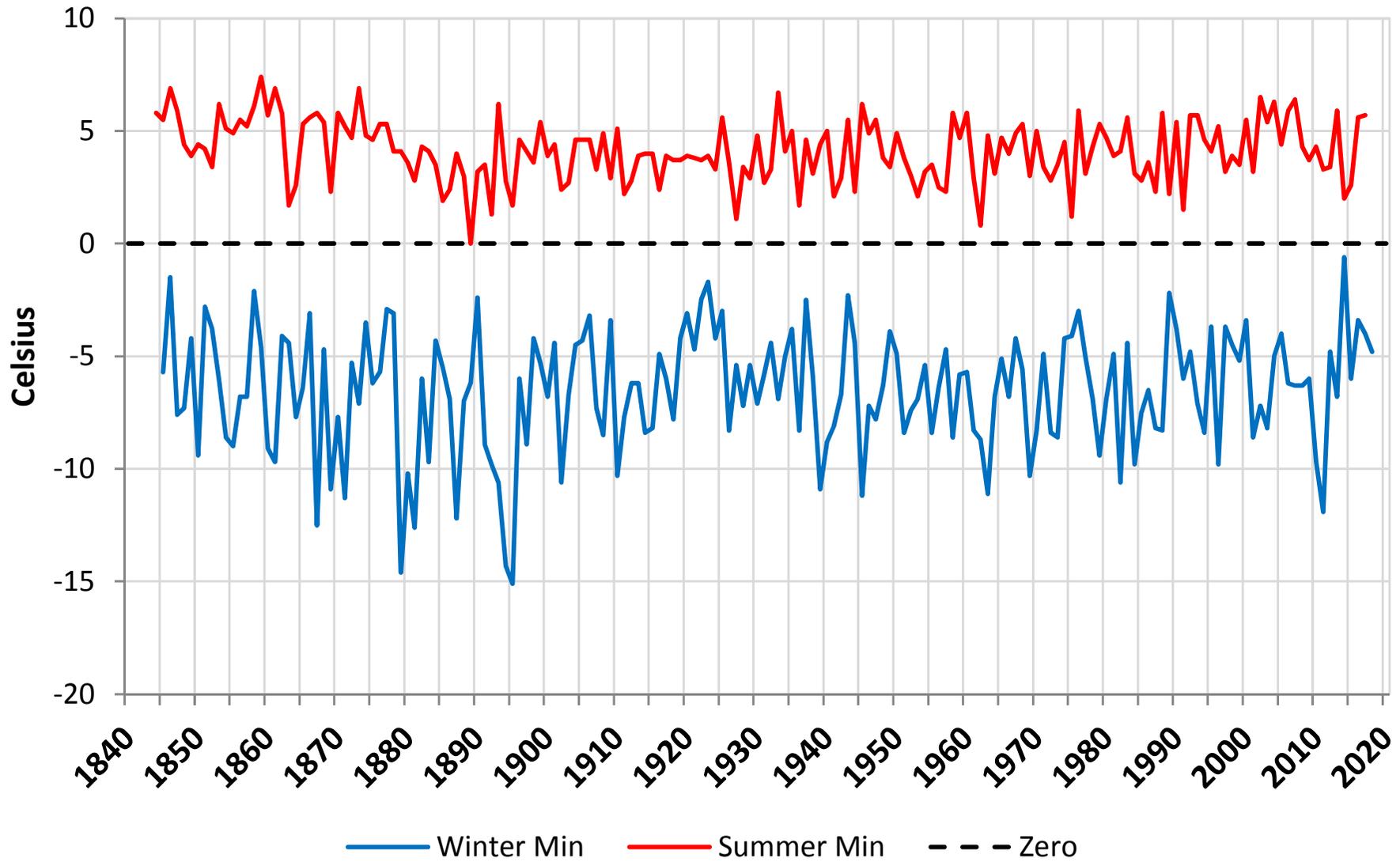
Seasonal Temperature (30yr avg.) Armagh Observatory 1825-2017



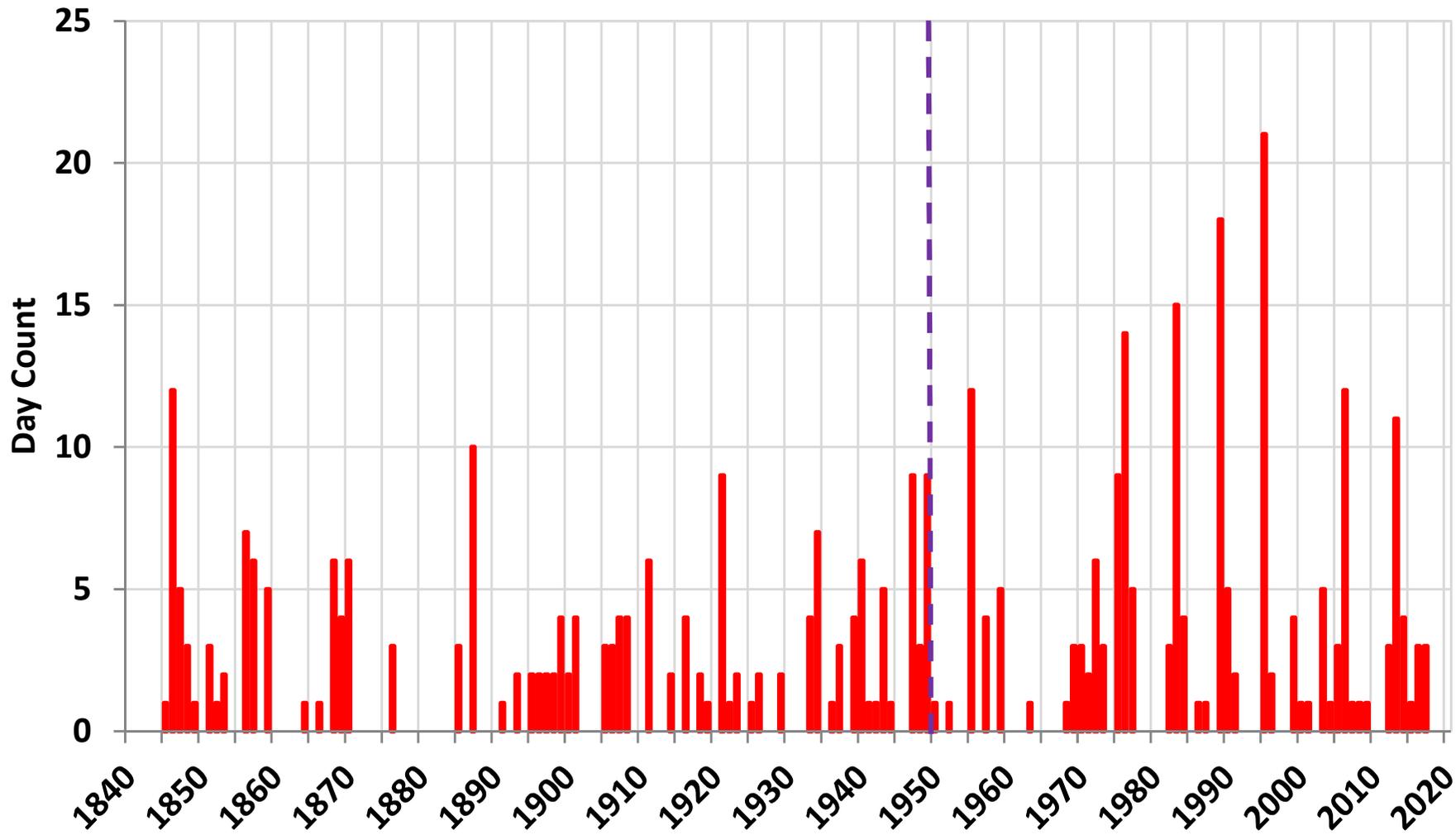
Maximum Temperatures - Armagh Observatory



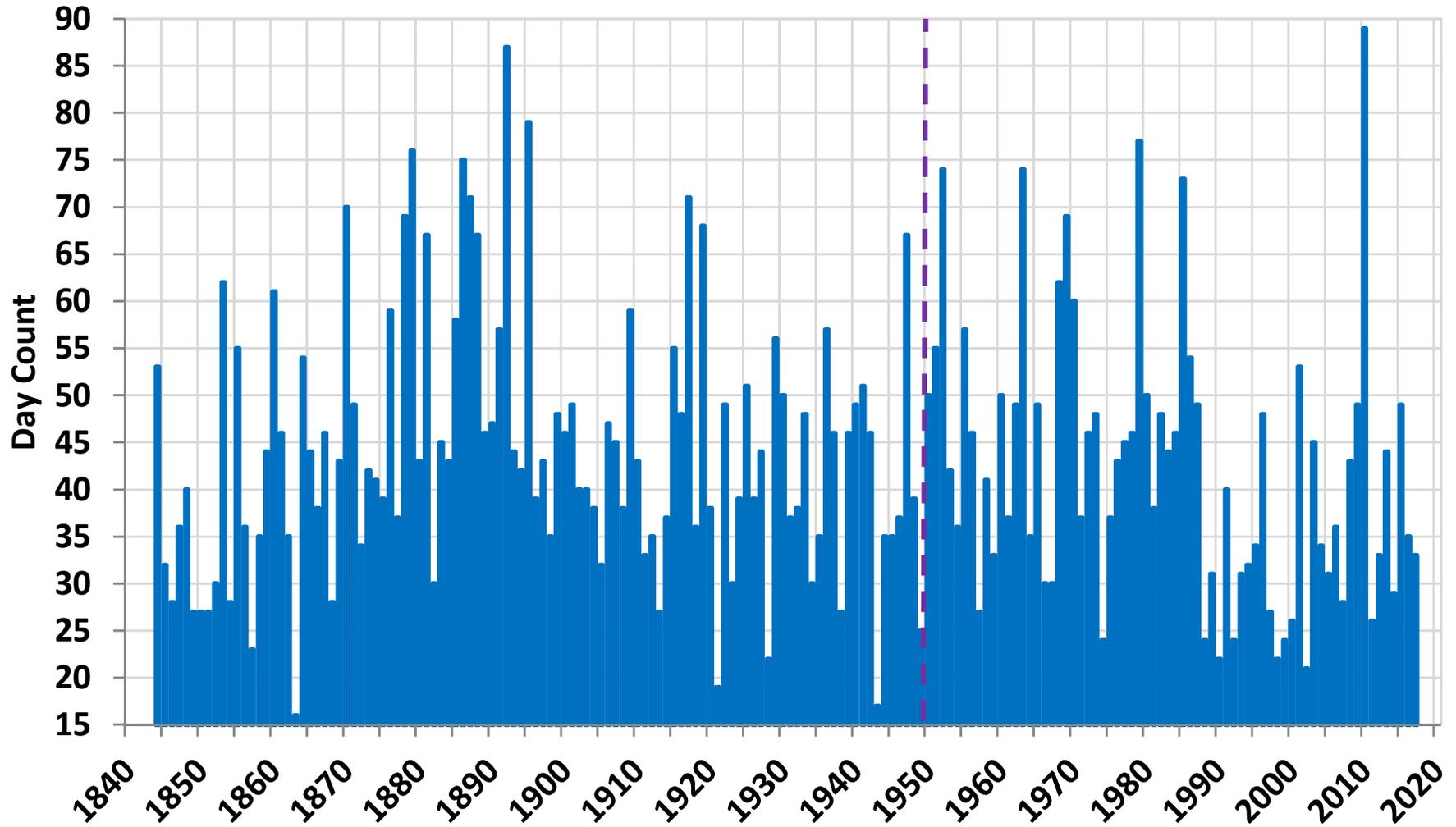
Minimum Temperatures - Armagh Observatory



Number of Days Max Temperature greater than 25C - Armagh Observatory



Number of Days Min Temperature less than 0C - Armagh Observatory



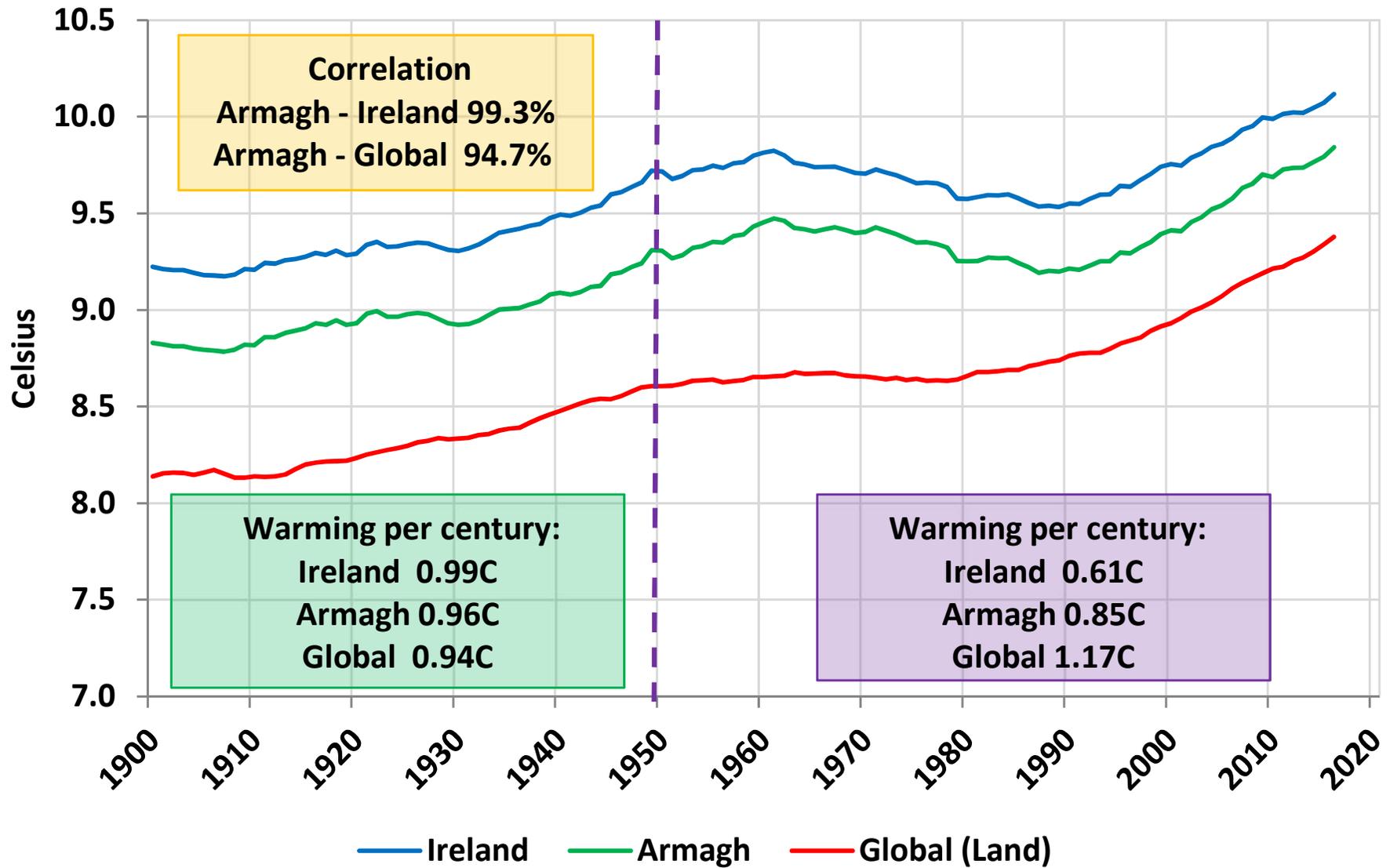
Historical Temperature Record

- Firstly, note the great annual variability: the annual average temperature in some years in the 1940's was greater than has been in recent years despite the upward trend in the climate in the intervening years
- Climate warming (slide 5) is approximately the same rate before and after 1950 (increase in 30 year average in period scaled to a century)
- Max summer temperature (slide 7) has a small but statistically significant rising trend but Max winter temperatures has no trend
- Min summer & winter temperatures (slide 8) have no stat sig trend, however clearly the late 19th century had lower minimums with the winter min frequently below -10C

Historical Temperature Record

- *The number of days that reached above 25C (slide 9) showed an upward trend from 1976 up to around 1995 with 4 years having more than 14 days but since 1995 this has dropped to levels similar to before 1976*
- *The number of days with min below 0C (slide 10) has reduced from longer term trends since around 1986 however 2010 had more than any in the whole period since 1840*
- *Seasonal trends (slide 6) show less warming in winter at Armagh but Island of Ireland trends generally show the greatest warming in winter and spring (not shown here)*

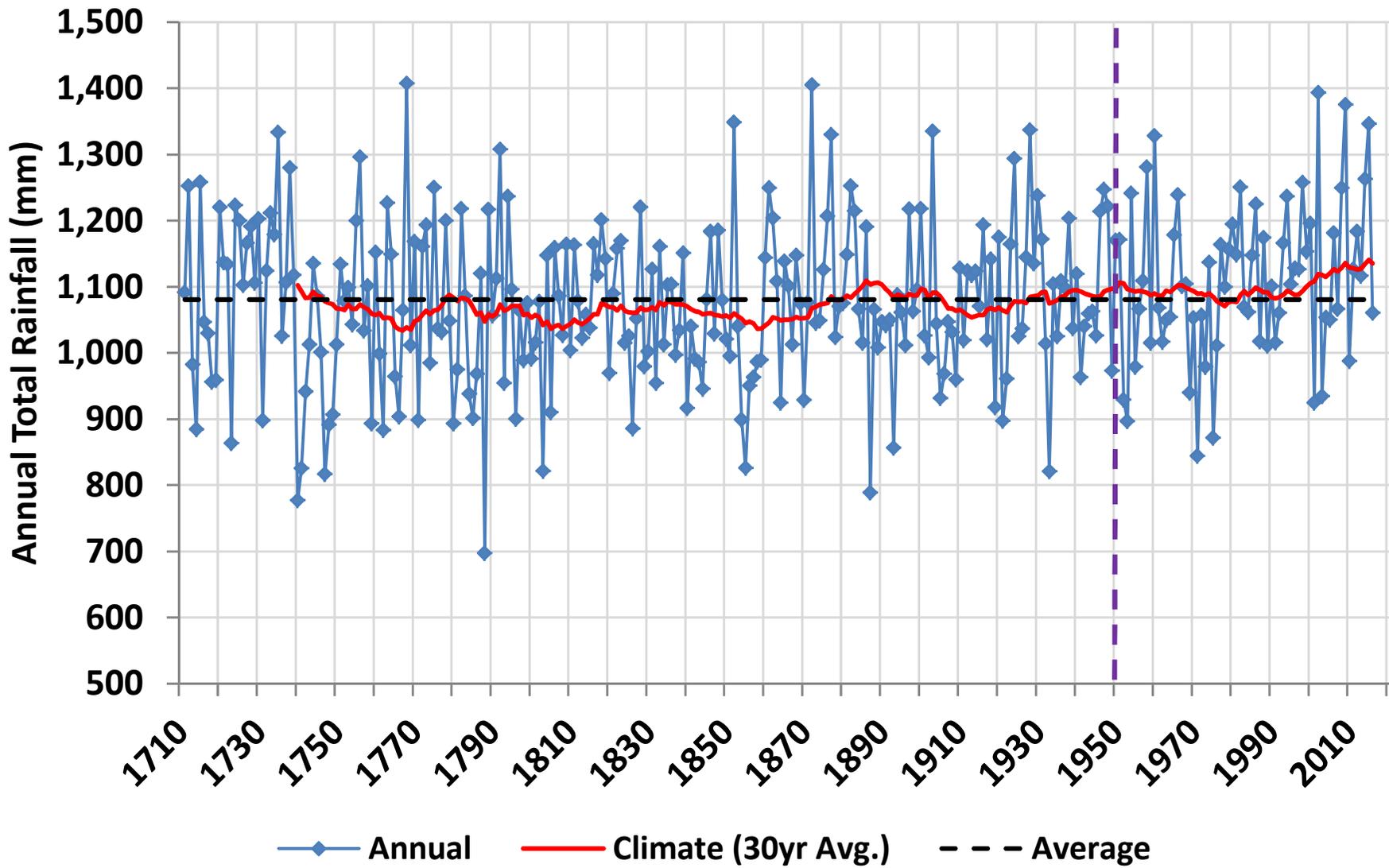
Temperature Trend Comparisons



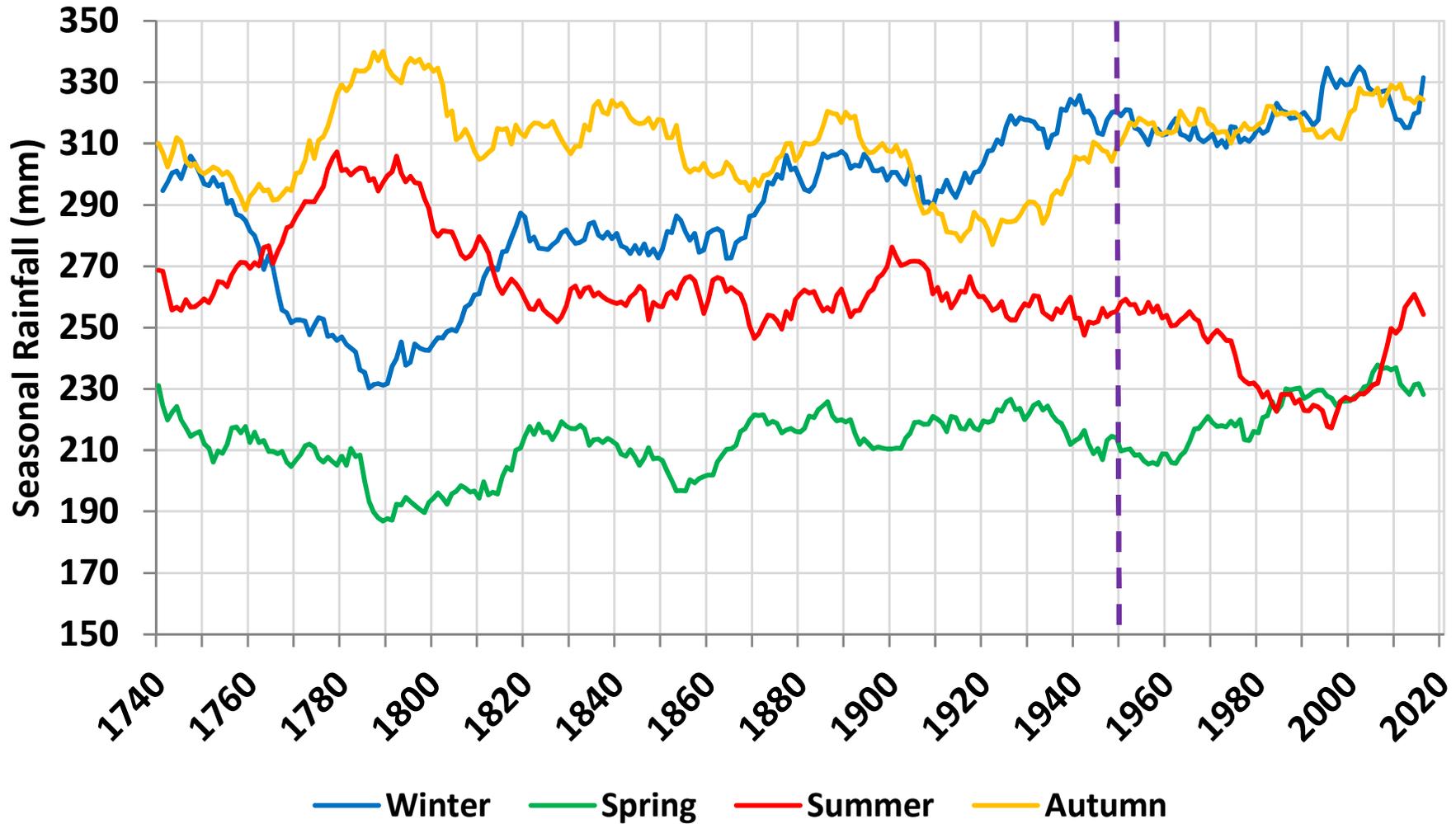
How representative is Armagh of Irish & Global trends?

- *Armagh's climate trend is almost identical to Ireland's (see slide 13) even though it is about 0.35C colder on average there than the average throughout Ireland due to its northerly location on our island*
- *Armagh's climate trend is similar to the global BEST land data - principal difference is the cooling phase in Ireland from 1960-90 which was a plateau to 1980 in the global data (see slide 13)*

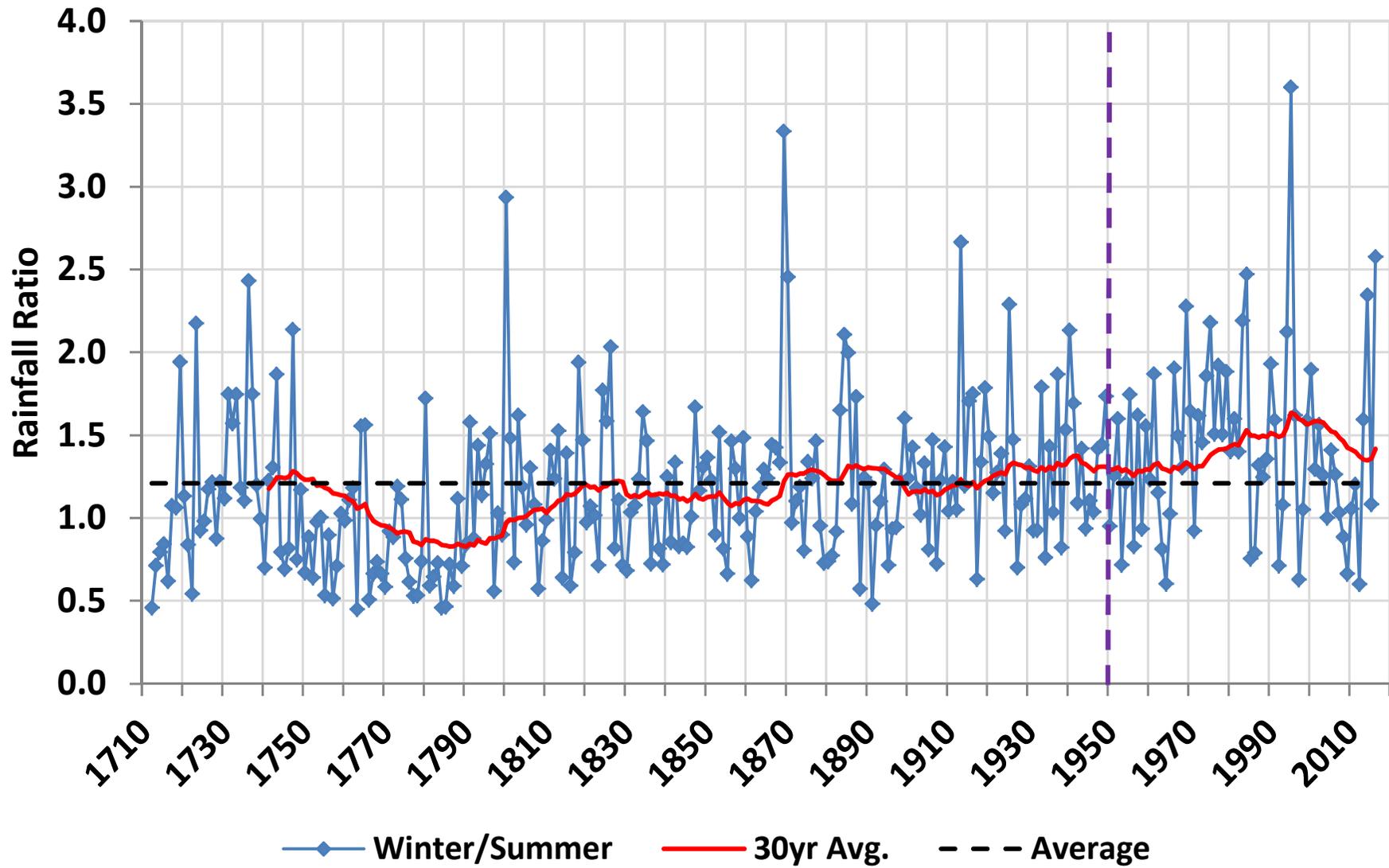
Total Annual Rainfall - Island of Ireland



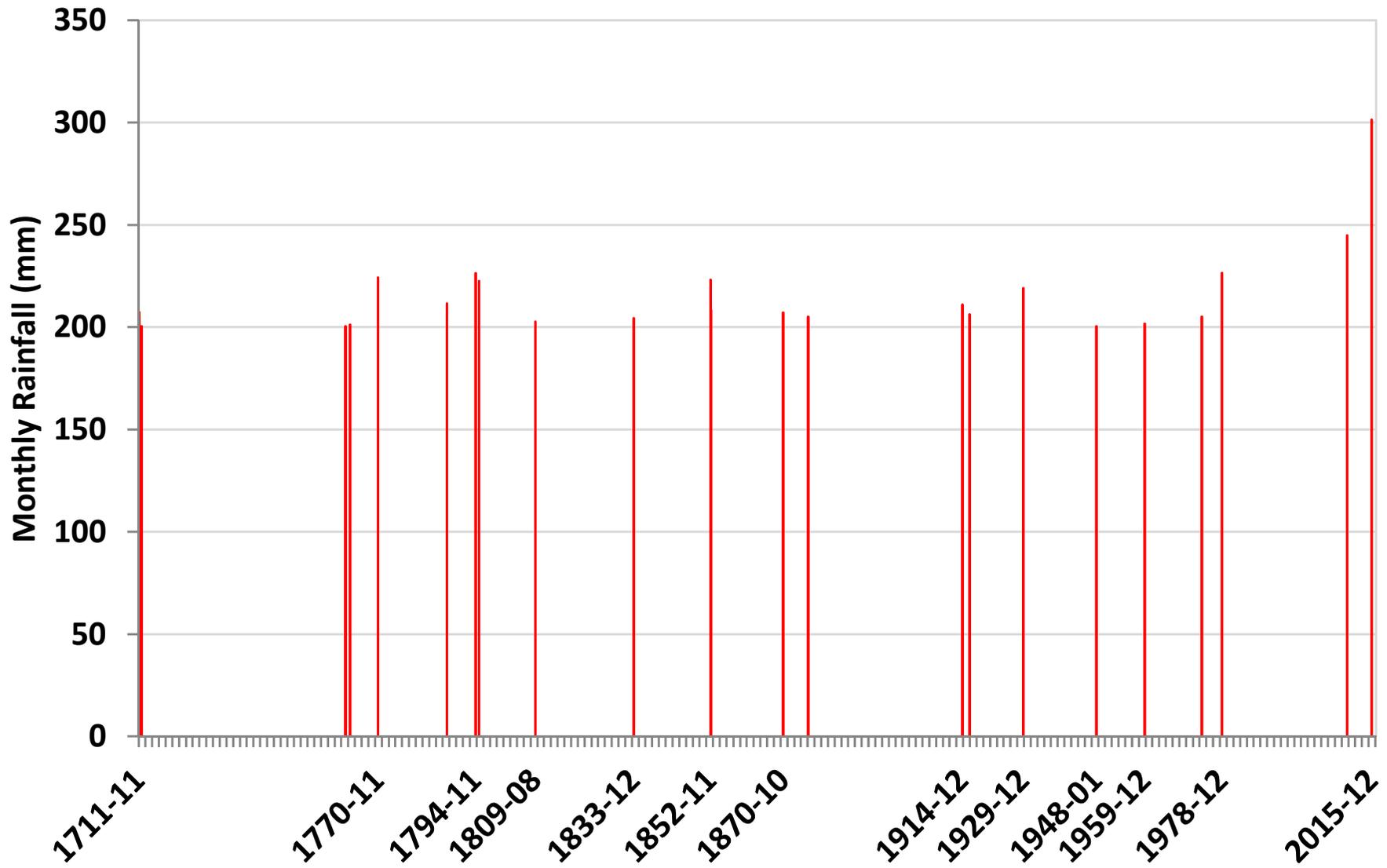
Seasonal Rainfall 30 year average Island of Ireland



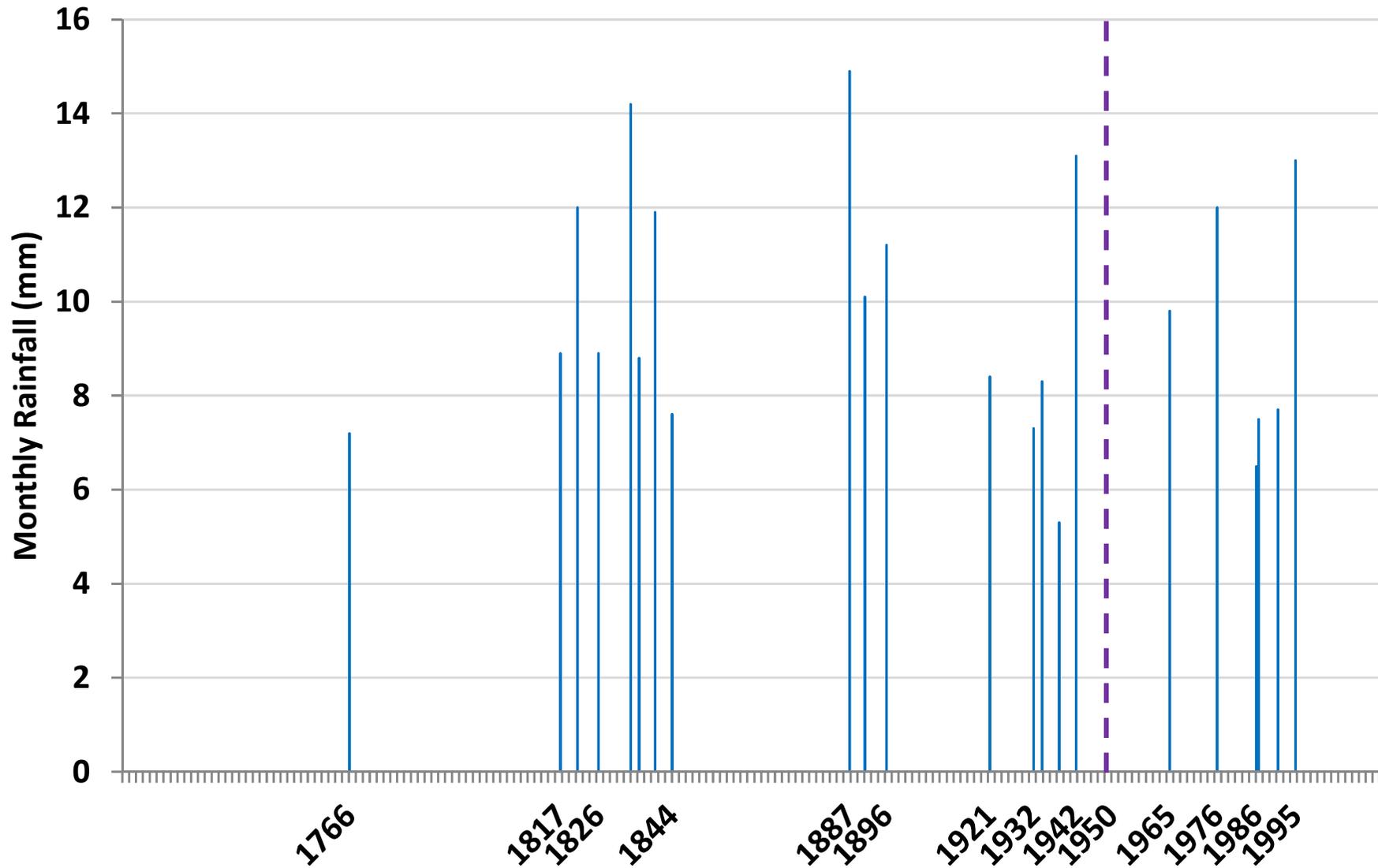
Winter/Summer Rainfall Ratio - Island of Ireland



Occurrence of Monthly Rainfall greater than 200mm



Occurrence of Monthly Rainfall less than 15mm



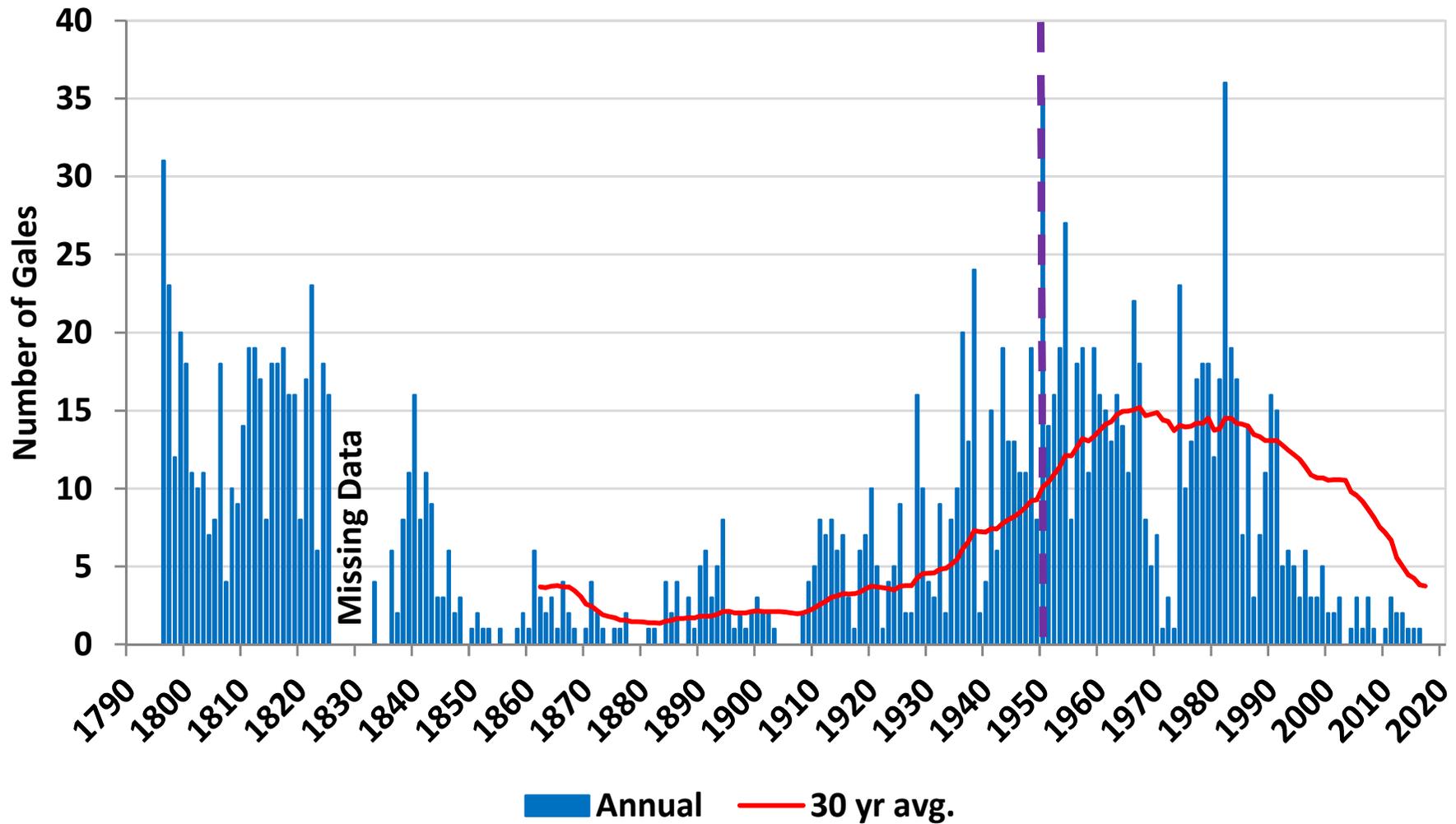
Historical Rainfall Record

- *Total annual rainfall (slide 15) shows a small increase in the 30 year trend above the average since the early 1990's but the extent of the increase is similar to the size of reductions in trends from the average in the past*
- *Seasonal variability of rainfall is quite volatile and slide 16 shows clearly how the ratios vary considerably to even reversing entirely for some*
- *The key summer/winter ratio (slide 17) had a significant increase in 30 year trend since 1970 which has started to reverse recently - extent of the departure from average is similar, but opposite, to another departure from 1750-1800*

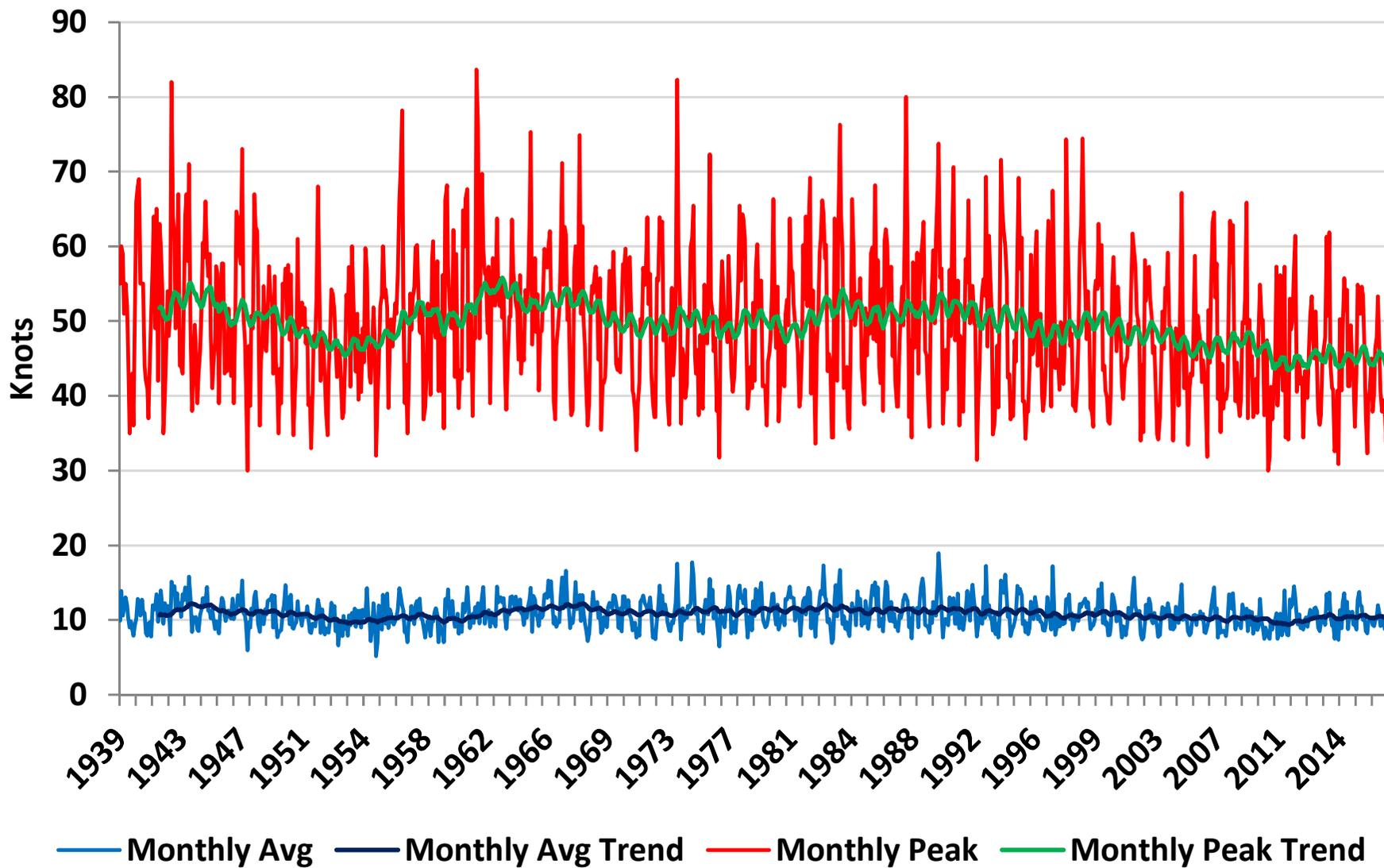
Historical Rainfall Record

- *A noticeable reduction in the trend of summer rainfall (slide 16) from around 1970 onwards had reversed by 2010*
- *The frequency of months in which rainfall is greater than 200mm (slide 18) shows no trend or pattern, however the 2 months with the highest monthly rainfall occurred recently in Dec 2015 and in Nov 2009*
- *The frequency of months in which rainfall less than 15mm (slide 19) shows no significant trend overall or remarkable difference in recent years*

Annual Number of 'Gale' References in Daily Commentary - Armagh Observatory



Ireland Wind Speed 1939-2017

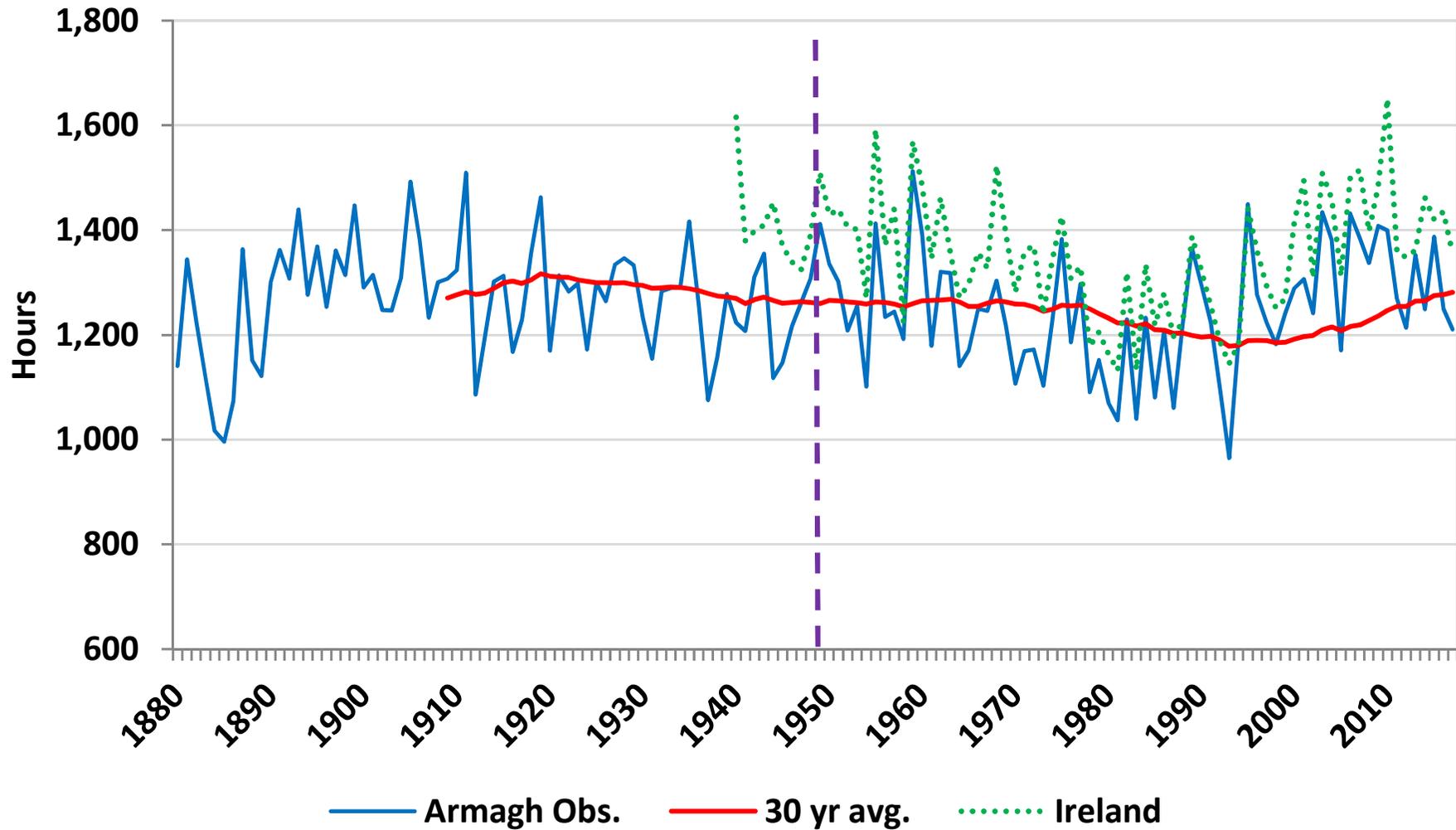


Historical Wind Record

- *The annual occurrence of gales at Armagh displays very large variability in long term trends based on 'gale' references in the daily weather commentary (slide 22)*
- *A 2 to 3 fold increase in the number of gales from around 1920 through to 1970 has largely reversed today and this high level of gales appears to have been present in earlier periods in the record as well (1790's to 1850's)*
- *For Ireland as a whole the average wind speed has not changed (slide 23), however the long term trend in max gust speeds does show a reduction consistent with the Armagh record of gales*

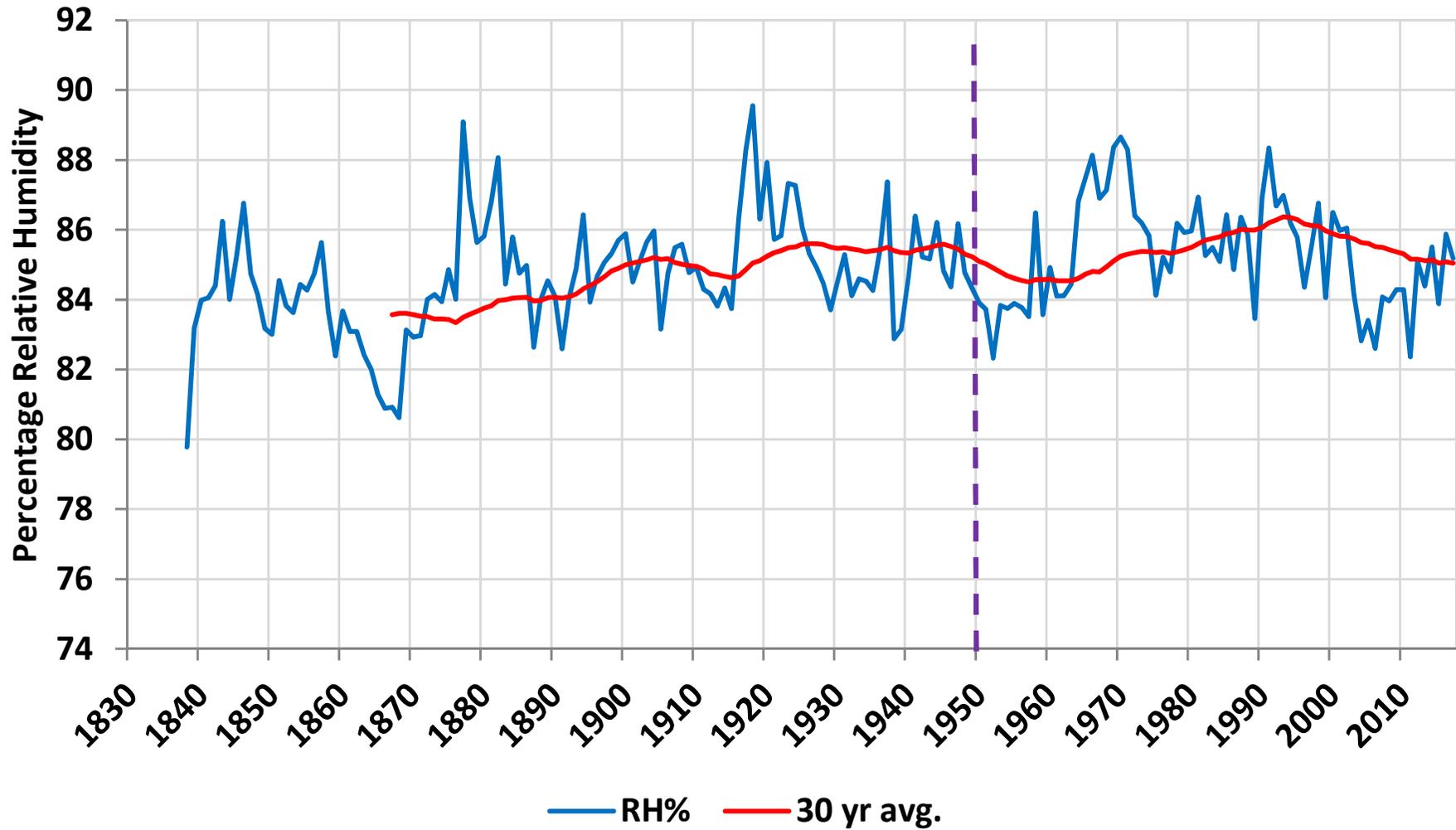
Annual Sunshine 1880-2017

Armagh Observatory & Ireland



Average Annual Humidity 1838-2017

Armagh Observatory



Sunshine & Humidity

- *Sunshine trends (slide 25) do show some variability with variations of the long term trend of up to nearly 10% evident*
- *The reduction in sunshine trend from 1920 to the mid-1990's has been reversing since then to today*
- *The general trend of Ireland's sunshine follows the Armagh trend*
- *Humidity (slide 26) does show some minor variations but no discernible long-term trend*

Overall Conclusions

- *The temperature record shows a clear trend upwards since the late 18th century with the increase largely the same today as it was in the past before CO₂ could have influenced climate*
- *The warming is largely an increase in minimum temperatures as maximum temperatures show no large changes*
- *Rainfall patterns are similar to the past but the two wettest months on record occurred within the last 10 years*
- *A significant increase in the number of gales annually has reversed in recent decades*
- *There are no major trends in Ireland's climate that marks out the period since 1950 as markedly different*

Data Sources

Temperature

- **Republic of Ireland Mean Annual Temperature 1900-2012**
 - Met Eireann (2013) - Ireland's climate: the road ahead (fig. 1 pg. 18)
 - <http://www.met.ie/publications/IrelandsWeather-13092013.pdf>
- **Republic of Ireland Mean Annual Temperature 2013-2017**
 - Met Eireann - Climate Annual 2013 to 2017 (Table - Annual Air Temperature Values)
 - 2013: <https://www.met.ie/climate/MonthlyWeather/clim-2013-ann.pdf>
 - 2014: <https://www.met.ie/climate/MonthlyWeather/clim-2014-ann.pdf>
 - 2015: <https://www.met.ie/climate/MonthlyWeather/clim-2015-ann.pdf>
 - 2016 & 2017: <http://www.met.ie/climate/monthly-weather-reports.asp>
- **Armagh Observatory Temperature Dataset 1796-2002**
 - Butler CJ, García Suárez AM, Coughlin ADS, Morrell C 2005, Air temperatures at Armagh Observatory, Northern Ireland, from 1796 to 2002, *International Journal of Climatology* 25:1055-1079. (Table IV) {note: May-July 1828 & Jan-Jun 1830 linearly interpolated between same months of the previous year and the subsequent year}
 - <http://onlinelibrary.wiley.com/doi/10.1002/joc.1148/pdf>
- **Armagh 2002-2017:**
 - <http://climate.arm.ac.uk/scans/>
- **Global Temperature Dataset (Land)**
 - http://berkeleyearth.lbl.gov/auto/Global/Complete_TAVG_summary.txt

Data Sources

Rainfall

- **Island of Ireland Rainfall 1711-2016**
 - *Murphy, C et al. (2017): A 305-year continuous monthly rainfall series for the Island of Ireland (1711-2016). Climate of the Past Discussions, 14(1), 1-39*
 - Data:- <https://doi.pangaea.de/10.1594/PANGAEA.887593>

CO2

- **CO2 Emissions 1751-2014**
 - Data:- http://cdiac.ess-dive.lbl.gov/trends/emis/glo_2014.html
{note: 2015-2017 linear extrapolation from 2005-14}

Sunshine

- **Sunshine 1880-2003 (Armagh)**
 - Data:- http://climate.arm.ac.uk/calibrated/sun/sun_mver_1880_2003.dat
{updated to 2017 from <http://climate.arm.ac.uk/scans/>}

Wind

- **Monthly Gale Data 1796-2000**
 - Data:- <http://climate.arm.ac.uk/calibrated/storm/monthly-diary>
{updated to 2017 from the daily commentary searching for 'gale' but not 'near gale'}

Humidity

- **Humidity 1838-2008 (Armagh)**
 - Data:- <http://climate.arm.ac.uk/calibrated/humidity/rham-tc-mon-1838-2008-head.dat>
{updated to 2017 from <http://climate.arm.ac.uk/scans/>}