



Comhshaol, Oidhreacht agus Rialtas Áitiúil
Environment, Heritage and Local Government



Weather Extremes in Ireland: Recent examples and influence of climate change

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Met Éireann

RAIN Workshop, TCD, 9 November, 2015

Outline

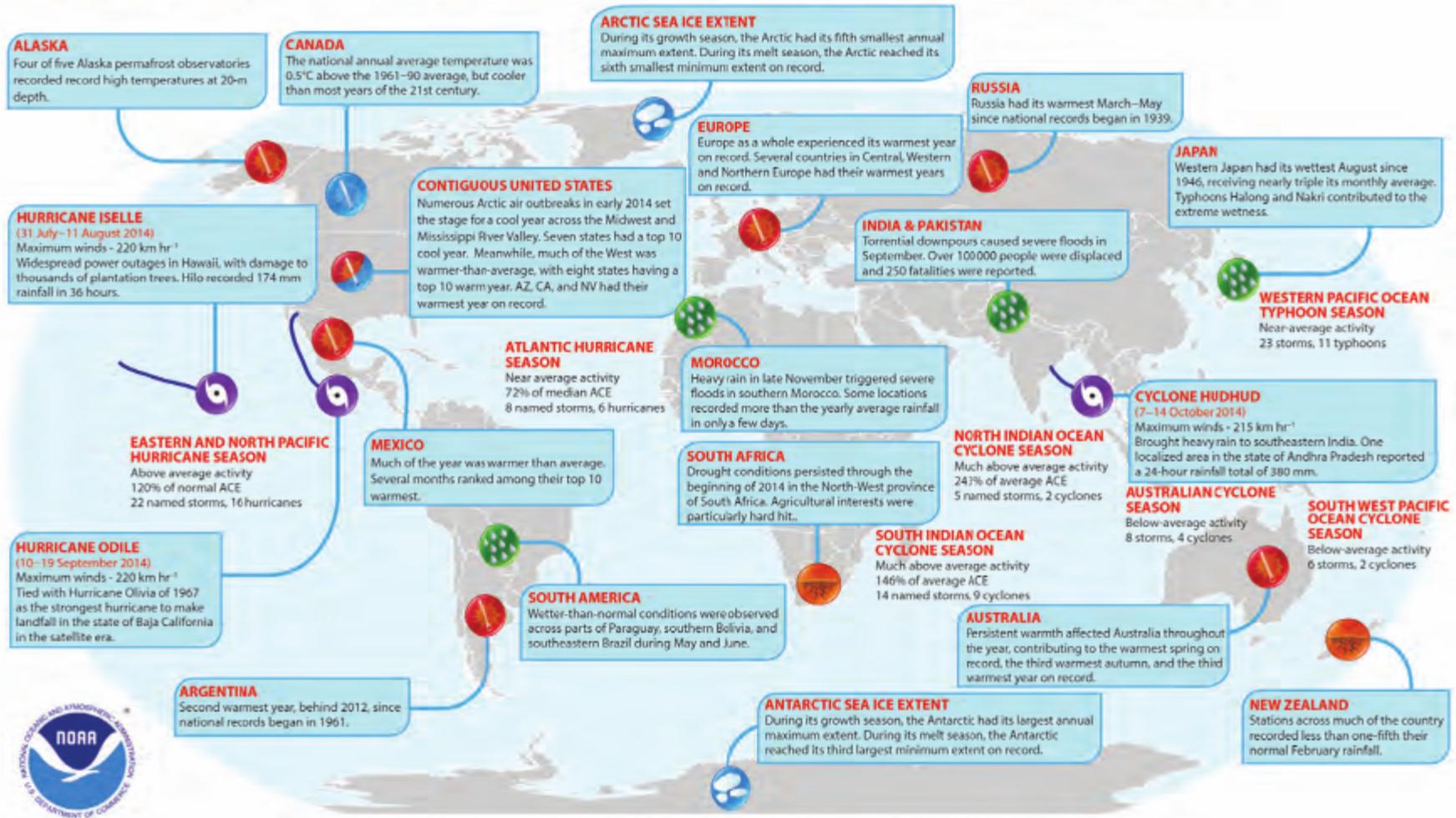
Past climate – what it can tell us

Progress in forecasting weather extremes

Climate change – what to expect in a warming world

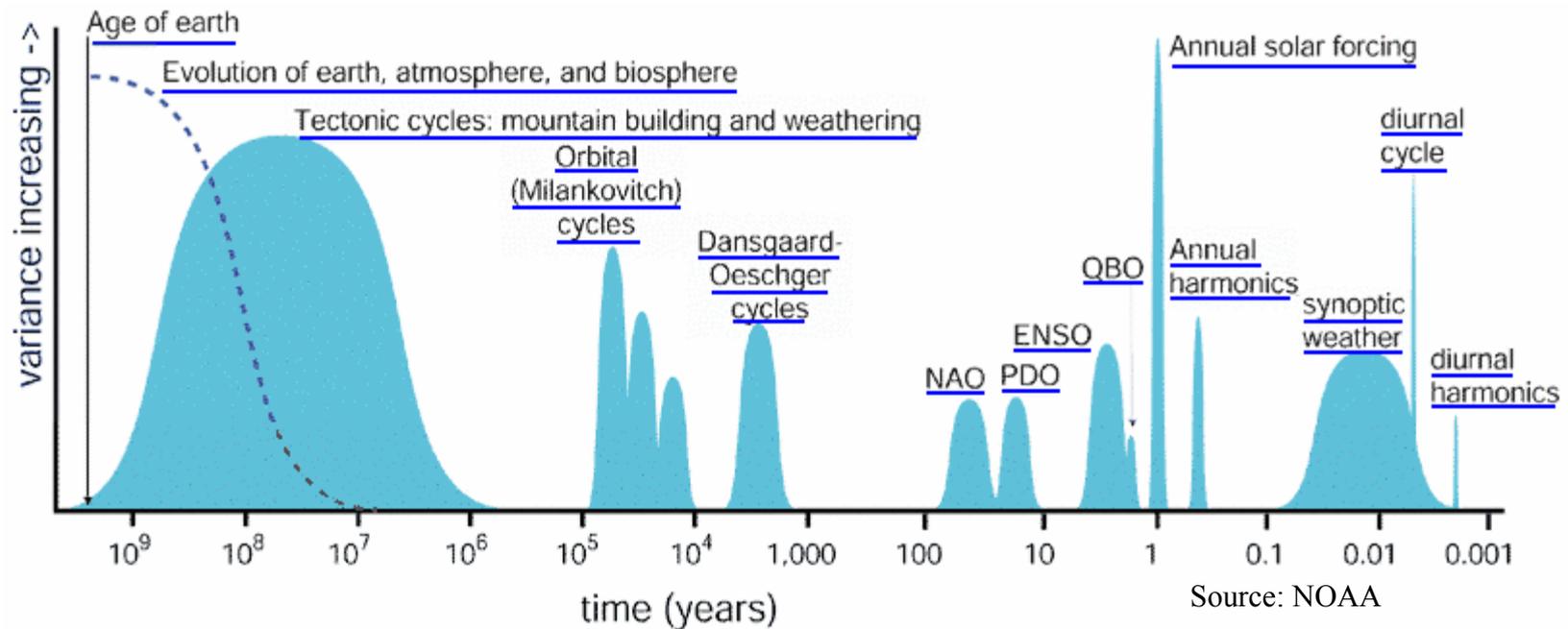
Weather extremes occur somewhere every year!

Selected Significant Climate Anomalies and Events in 2014



Source: Bulletin of the American meteorological Society, 2015)

Climate system: chaotic with quasi-regular cycles at different time scales => “Natural Variability”



Risk assessment for the future? Knowledge of past would be helpful! But '*past performance is no guarantee of future results*'

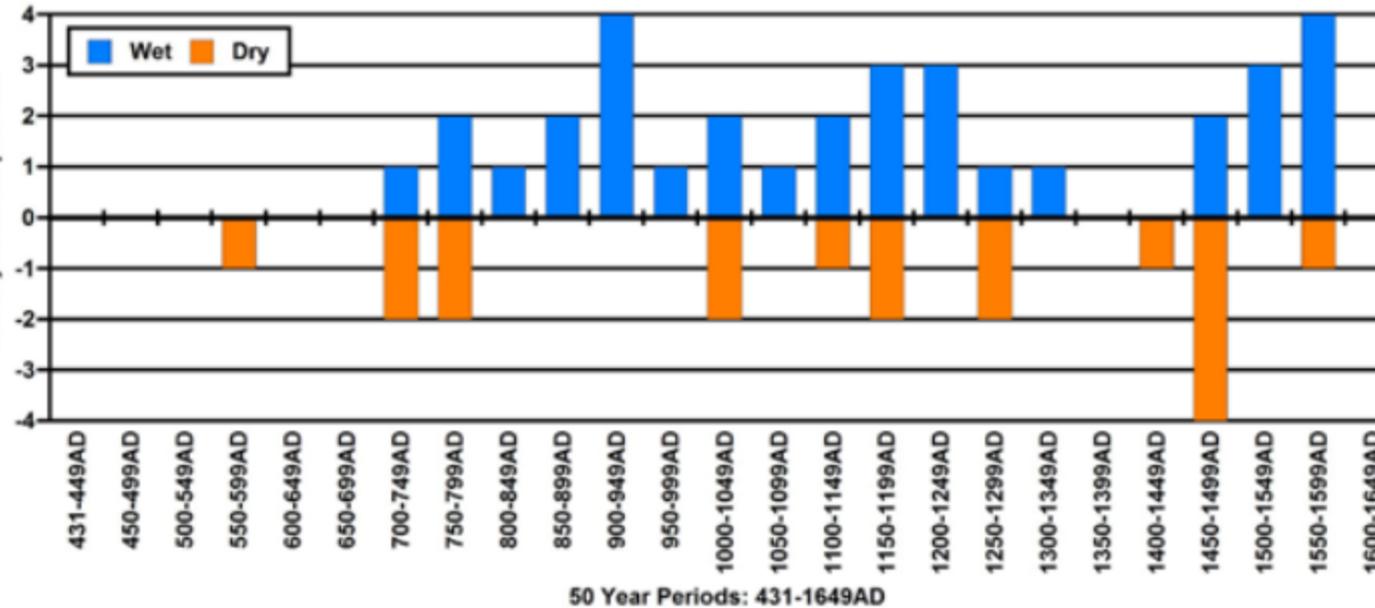
Climate records

Irish instrumental observations go back to 1800s (Armagh records from 1794). Records are not complete:

- Insufficient detail (e.g. lacking wind gust information)
- Spatially incomplete and spatially biased
- Surface based data
- Marine data poorly represented (e.g. for severe waves, surges, coastal flooding, river heights)

Information complimented by historical accounts ...

Climate records

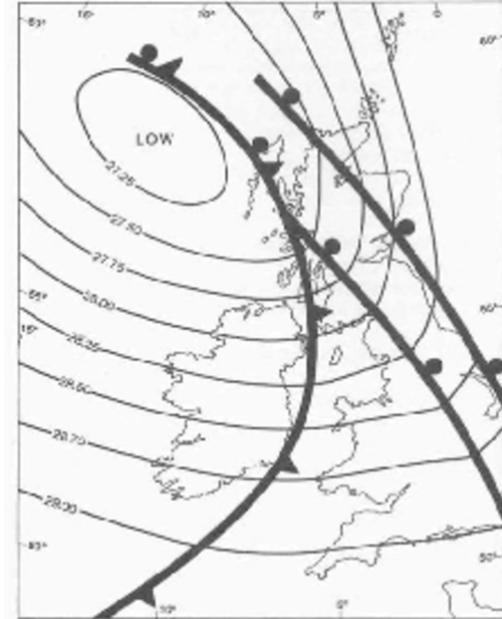


Extremes of precipitation: Frequency of wet/dry events/episodes, 431-1649 AD, based on references in the Gaelic Irish Annals (Kiely, et al., 2007)

Natural climate variability can produce violent weather

'Night of the Big Wind' storm (Jan 1839):

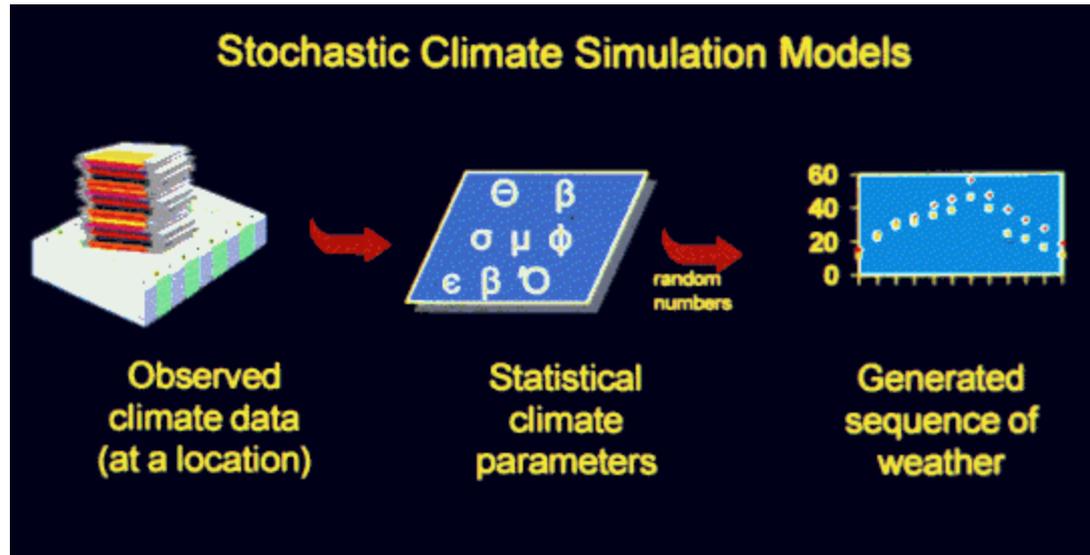
- Hurricane force winds
- 150+ casualties (land and sea)
- Depression centre ~920 hPa.



“Comparing with all similar visitations in these latitudes ... we would say that, for the violence of the hurricane, and deplorable effects which followed ... it remains not only without parallel, but leaves far away in the distance all that ever occurred in Ireland before.” Dublin Evening Post, 1839.

What is the probability of a similar event today?

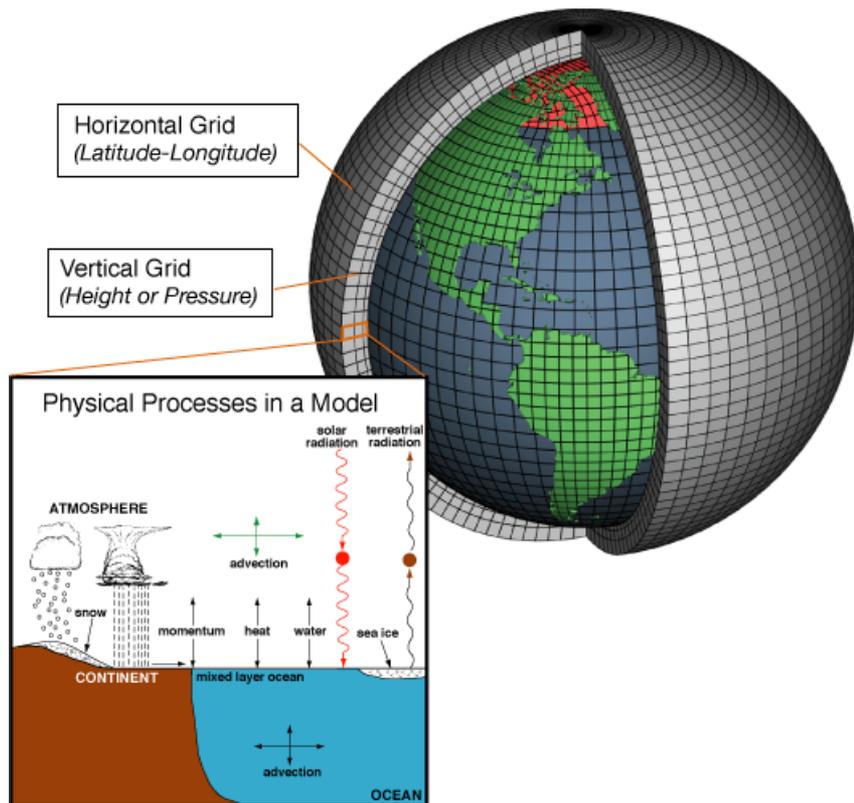
Climate records – filling the gaps



Stochastic weather generators (using existing site observations)

Also: **Numerical Weather Prediction (NWP) models**

Climate records – filling the gaps with NWP models



- Represent the full physical/dynamical complexity of the system

- Moving to full Earth System climate models (e.g. EC-Earth model) to include ocean/sea-ice, atmospheric chemistry, carbon cycle, ...

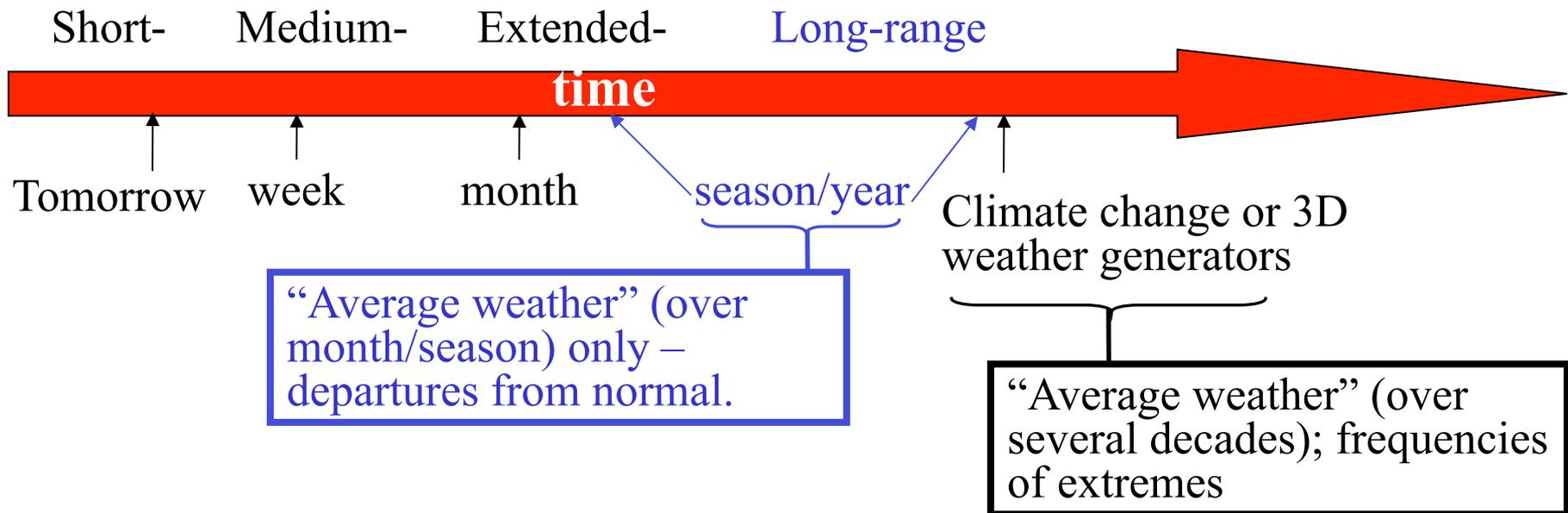
- Can assimilate historical observations to produce 3D datasets of the atmosphere (“re-analysis”)

- Models are run daily to provide weather forecasts

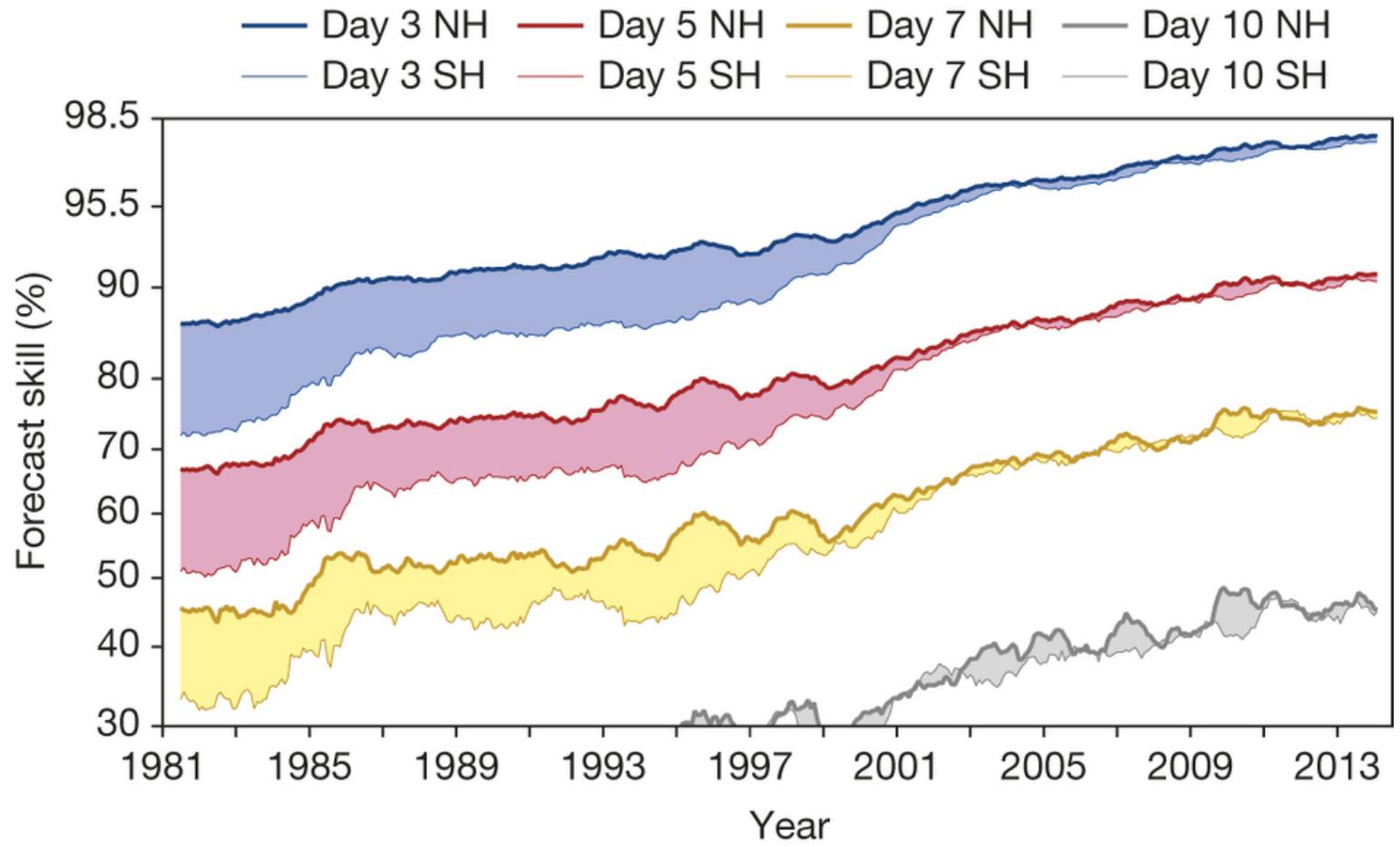
NWP models for analysis and prediction of weather extremes

Detailed Information

Coarse Information



Remarkable progress of NWP in weather forecasting



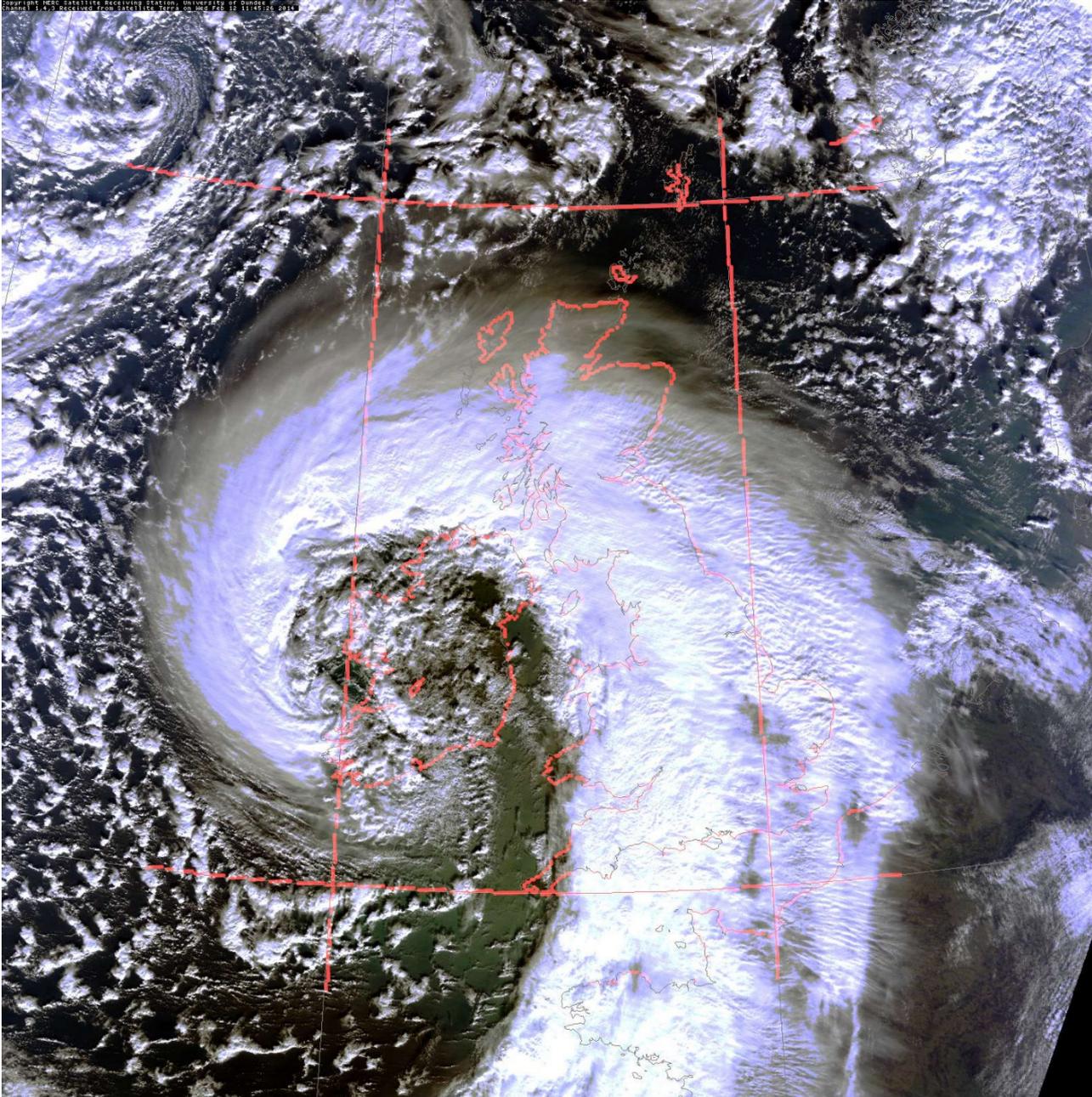
Source: ECMWF

A notable recent Irish storm

Storm Darwin (12 February, 2014):

- Extratropical Atlantic storm
- A “weather bomb”
- **Hurricane force** (120km/h) sustained wind recorded at Mace Head
- Worst 'in living memory' locally
- Major damage by winds but no fatalities

Storm Darwin



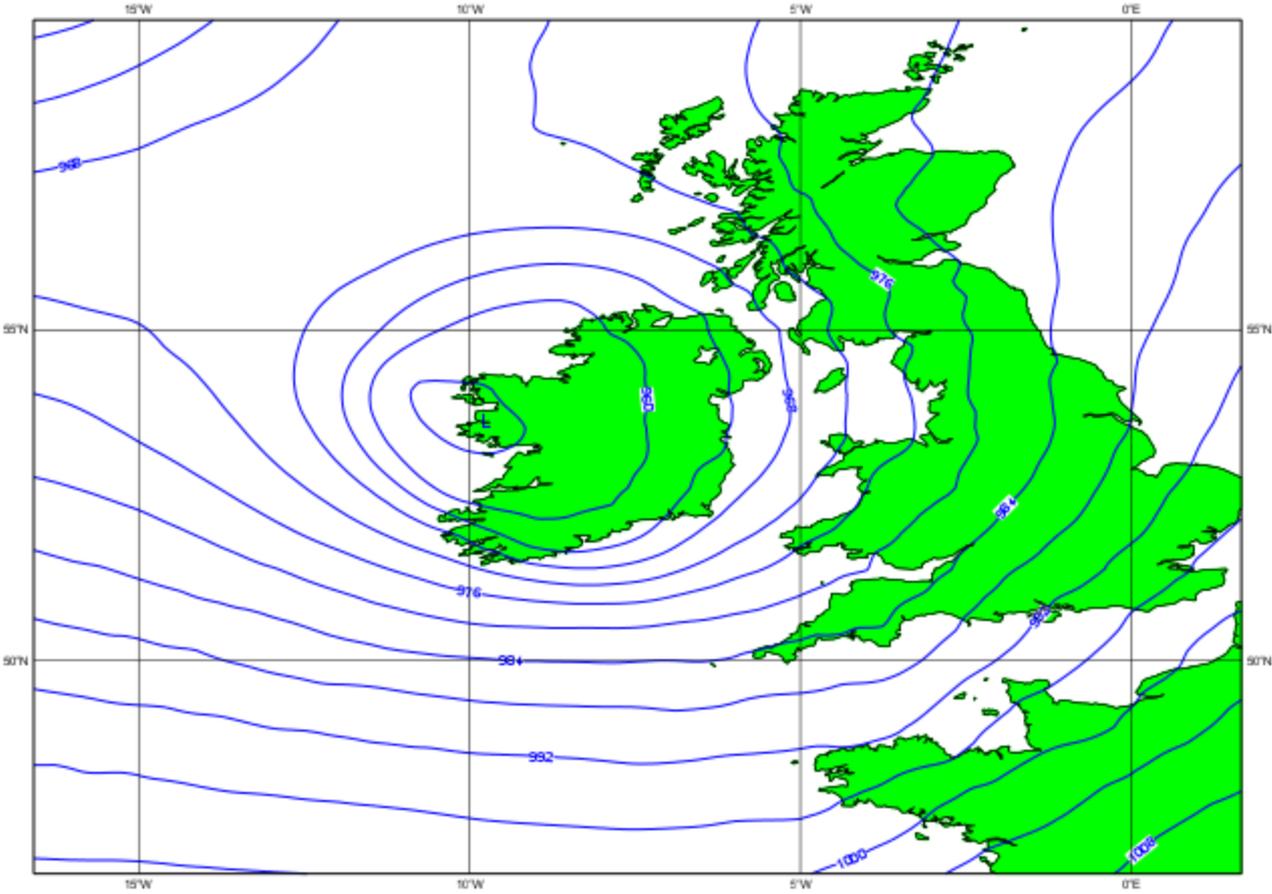
Storm Darwin



“Sting jet”

Most damaging winds near the tip of the occluded front, associated with descending air.

Darwin storm: msl pressure analysis for 12 UTC 12 Feb 2014



7.5 million trees estimated blown down (Dept. of Agriculture,
Food and the Marine)



GLIDE number NA
 Activation ID: E56R-077
 Product N: S2Templogline_17
Templeglantine - IRELAND
 Wind storm - 12/02/2014
 Delineation Map - Detail 01
 Publication date: 2014/03/14

Cartographic information
 1:20000
 Full color (ISO A1, high resolution (300 dpi))
 Map Coordinates System: WGS 1984 UTM Zone 28N
 Graticule: WGS 84 geographical coordinates

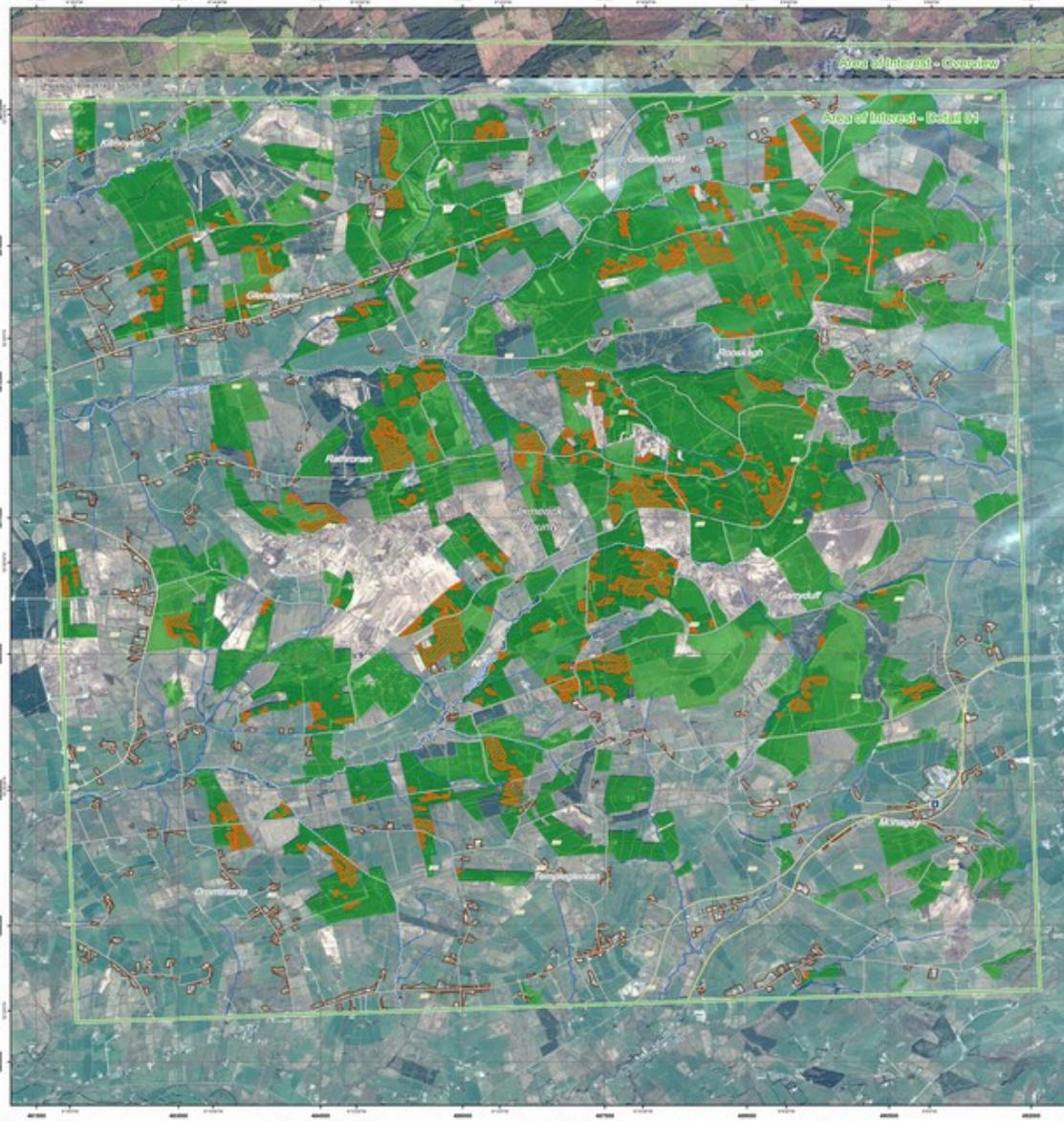
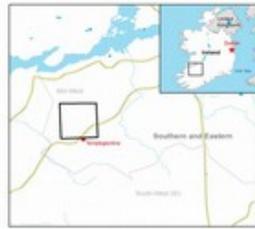
- Legend**
- Crisis Information**
 - Affected Woodland
 - General Information**
 - Sensor Footprint
 - General Information**
 - Area of Interest
 - Administrative boundaries**
 - Electoral Division
 - Settlements**
 - Residential
 - Hydrology**
 - Blue River
 - Stream

Point of Interest

- Transportation
- Contour lines and elevation (m)
- Industry / Utilities
- Quarry
- Transportation
- Primary Road
- Secondary Road
- Local Road
- Land Use / Land Cover
- Woodland

Consequences within the detail AOI on 12/04/2014

Affected area	Affected	Total in AOI
Estimated population	0	262
Settlements	0	41.8
Agriculture	0	11.2
Industrial	0	19.2
Transportation	0	5.7
Utilities	0	18.9
Land use	0	6.9
	0	262

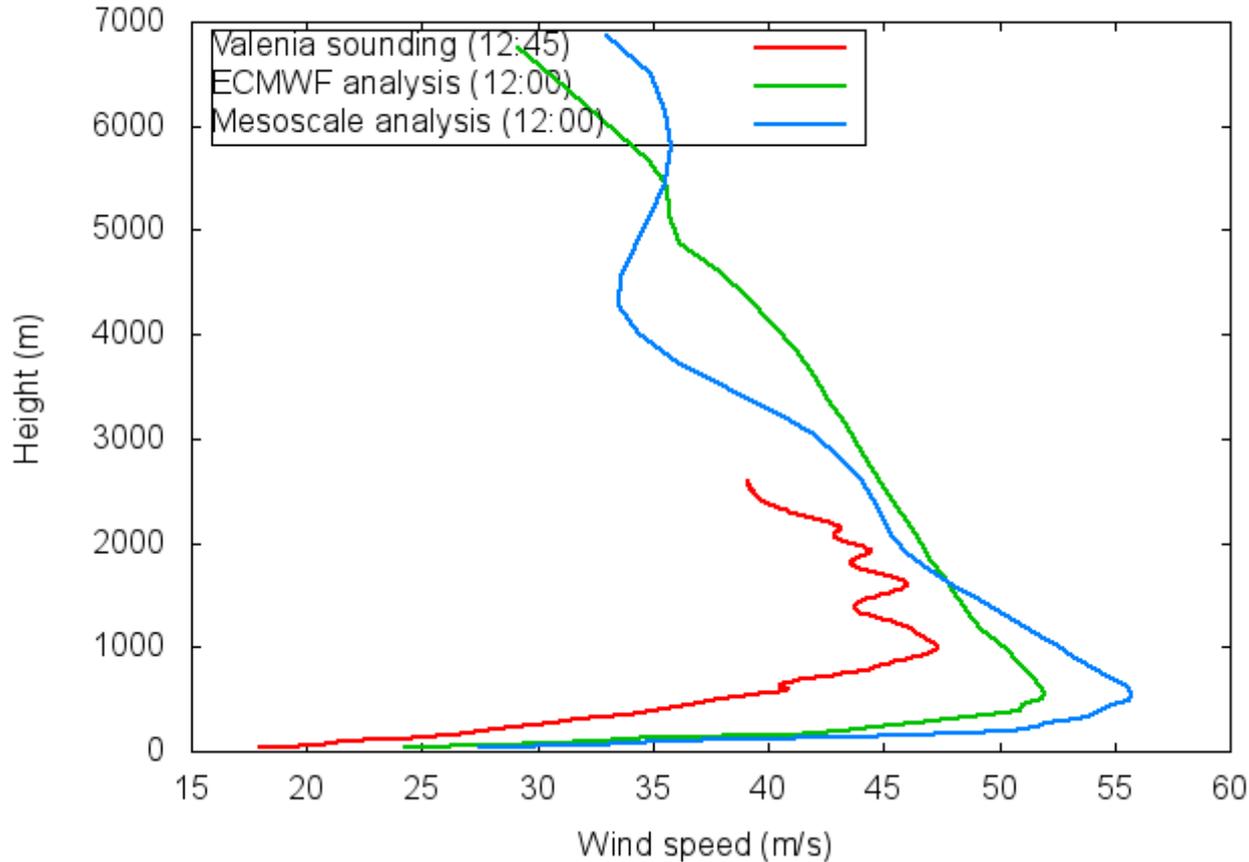


Storm Darwin

Damage to forestry using before/after satellite imagery

Source: Copernicus
 Emergency Management
 Service

Darwin storm: vertical structure



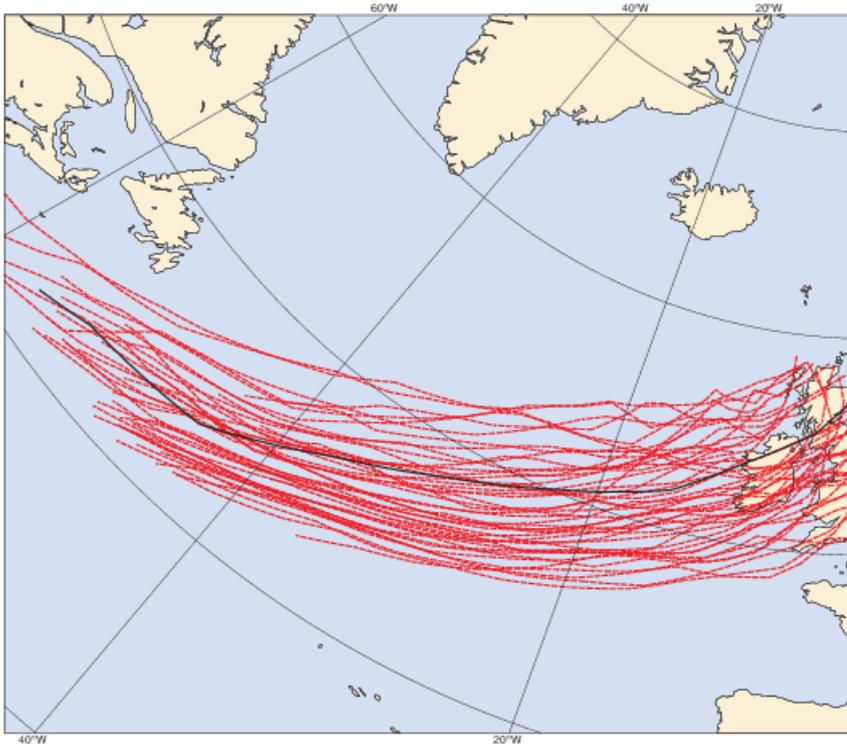
Storm Darwin

Valentia upper-air sounding delayed – missed sampling the core of the low level jet

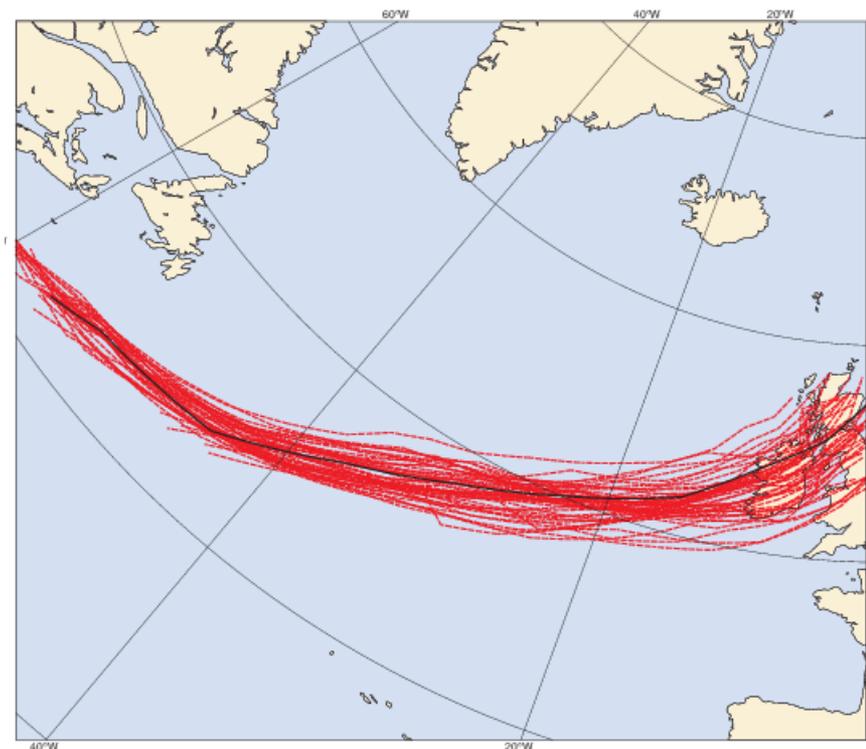
NWP analyses suggest stronger winds than observed

Darwin storm: ECMWF's medium-range forecast performed well

Ensemble forecasts (50 members) showing tracks of possible deep depressions impacting on Ireland (actual storm track in black)



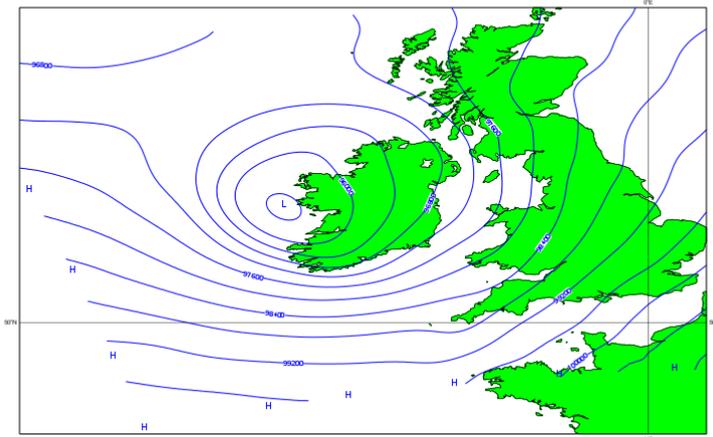
Forecasts from 8th Feb at 12 UTC



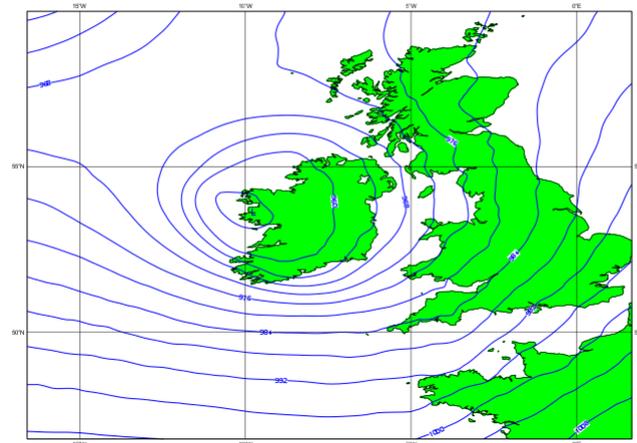
Forecasts from 10th Feb at 00 UTC

Darwin storm: Met Éireann's mesoscale model 24-hour forecast for 12 UTC 12 Feb 2014

Forecast



Observed



Excellent forecast of wind speeds -> 'Red' alert issued at 11am on the 11th

Recent climate: Atlantic Storm Statistics

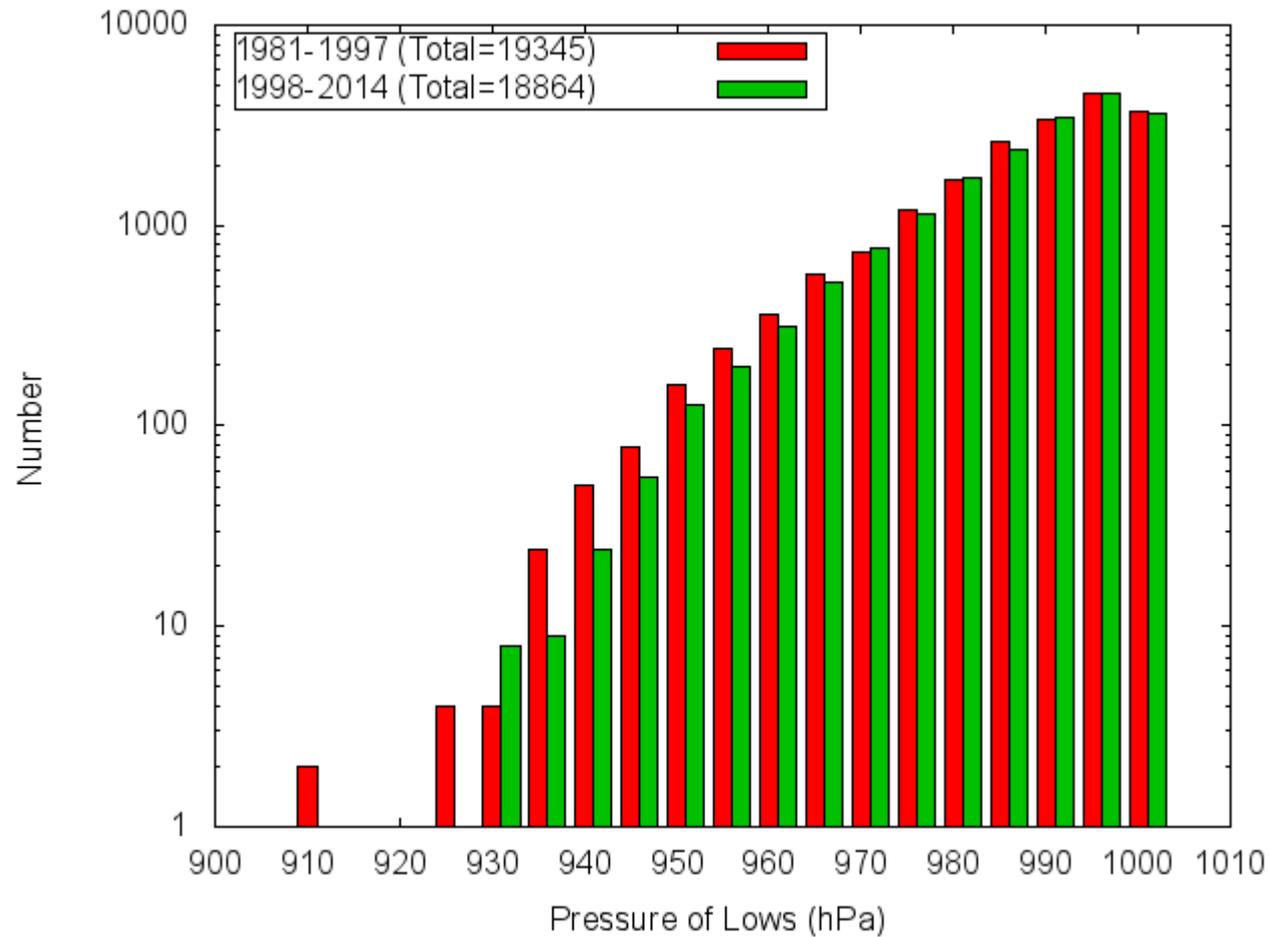
Has the pattern changed in recent times?

- Number of storms?
- Intensity?
- Size?
- Tracks?

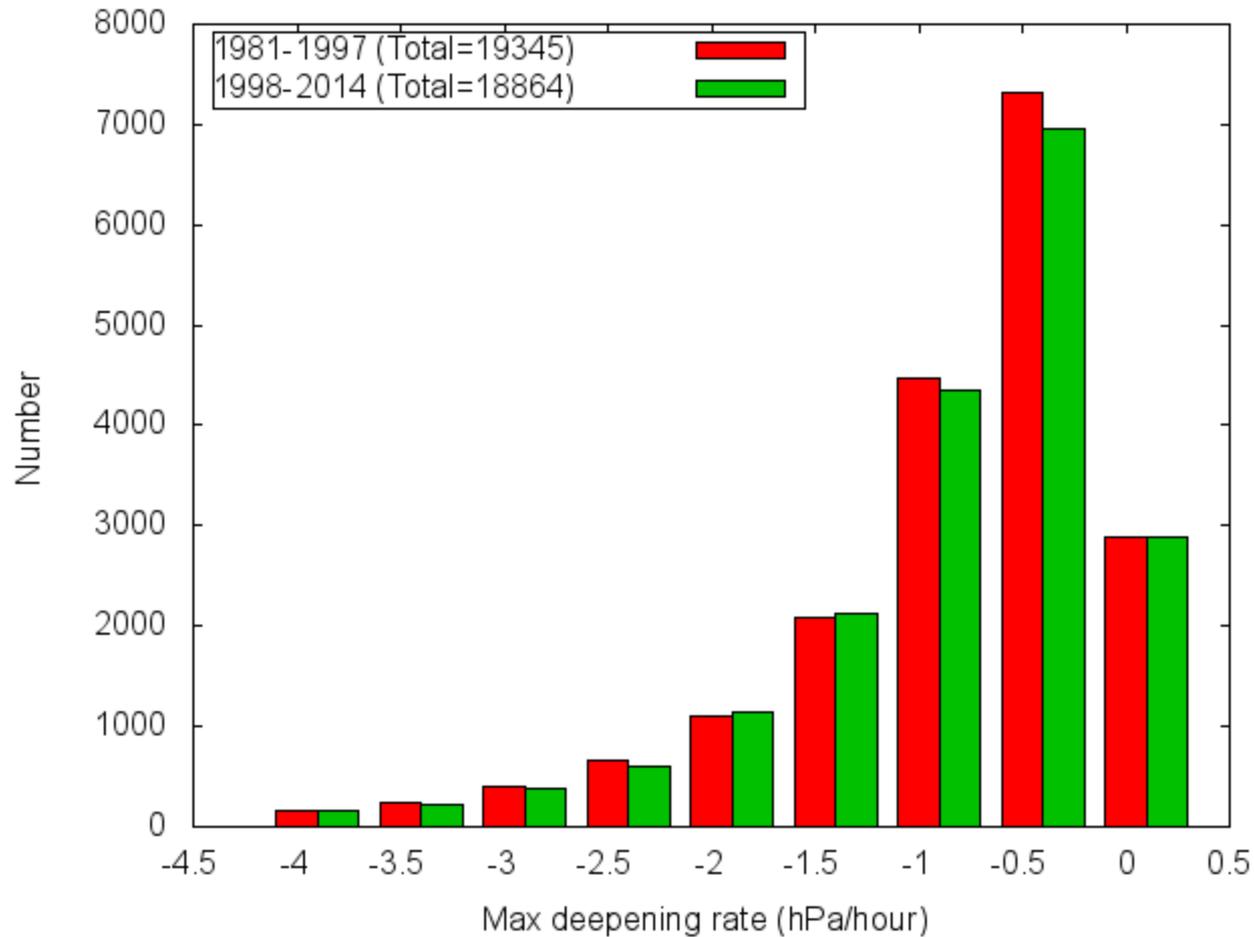
Re-analysis datasets (e.g. ERA-40, ERA-Interim/ERA-5, ERA-20C) are useful resources for evaluating change but ...

- Time spans are short (~100 years or less) – may/will not reflect “true” natural variability.
- Resolution of fields may not identify the intensity of mesoscale features (core pressure, rate of deepening).

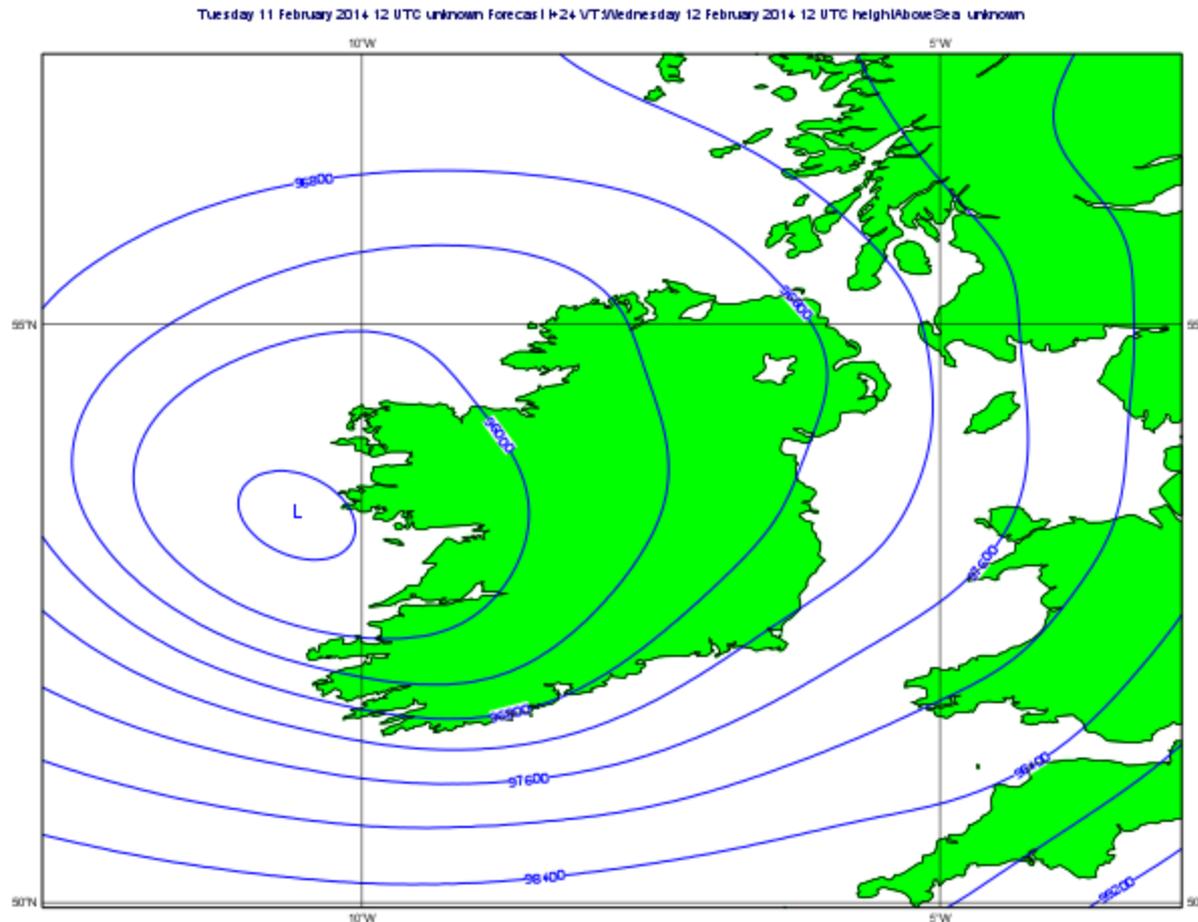
Depressions: distribution as a function of lowest core pressure along track: 1981-1997 v 1998-2014



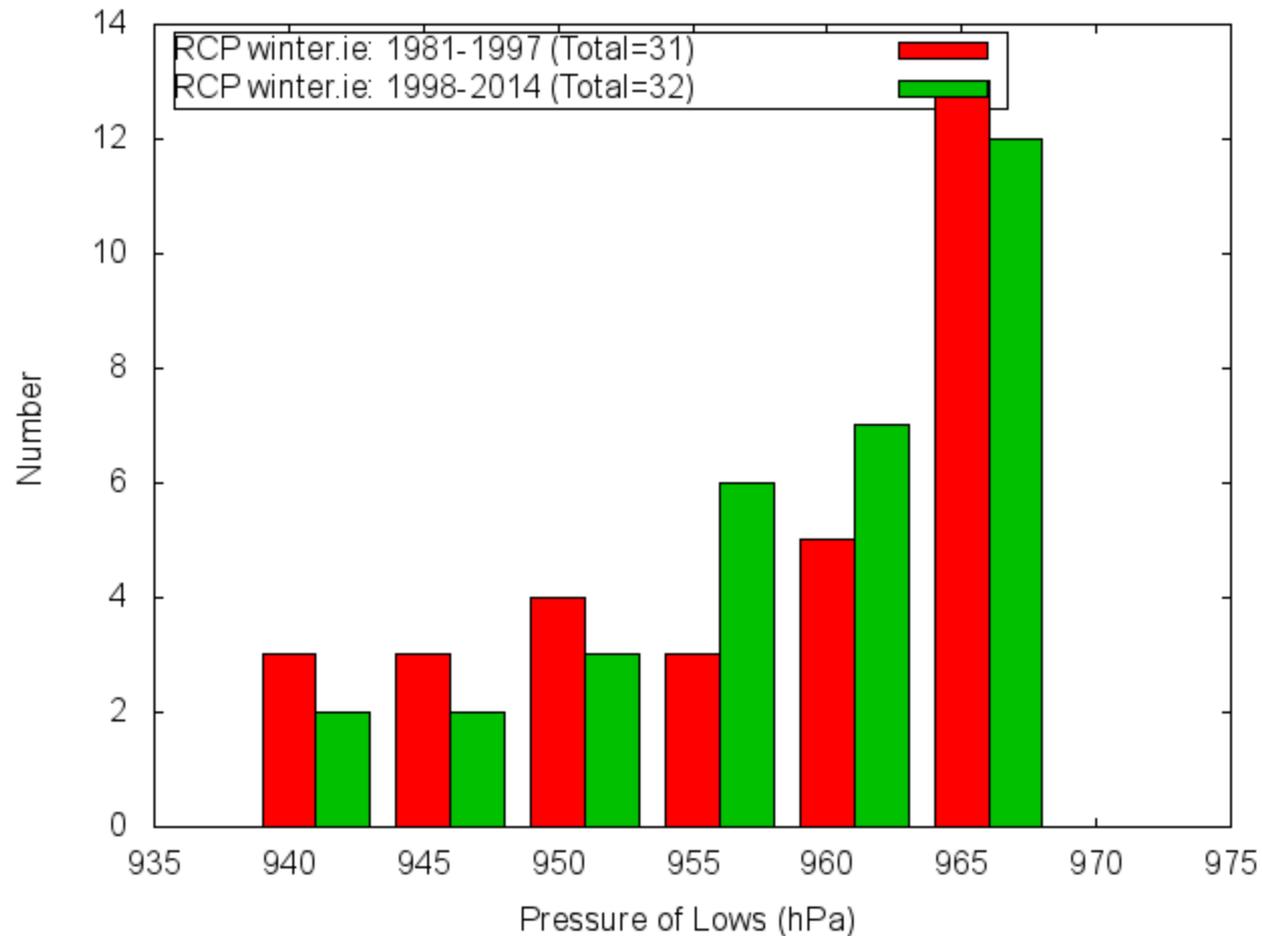
Depressions: distribution as a function of max pressure deepening rate along track: 1981-1997 v 1998-2014



Statistics of depressions tracking across the Irish “box” and core pressure <970hPa: 1981-1997 v 1998-2014

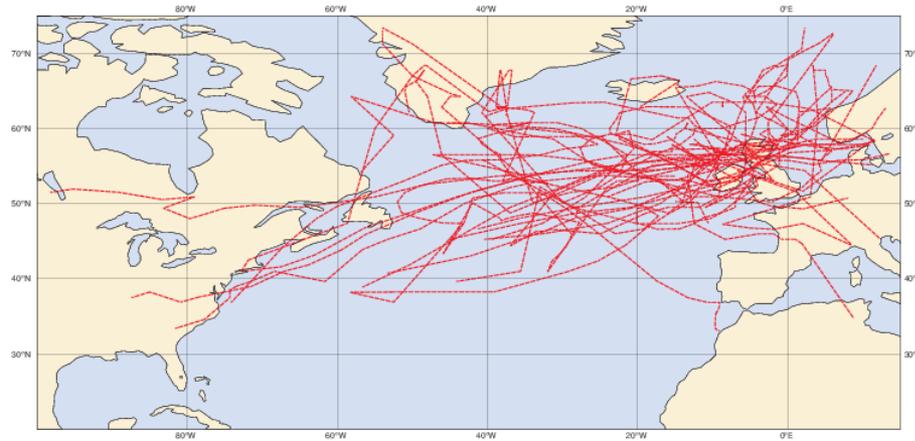


Min core pressure (<970hPa) of depressions tracking across the Irish “box” : 1981-1997 v 1998-2014



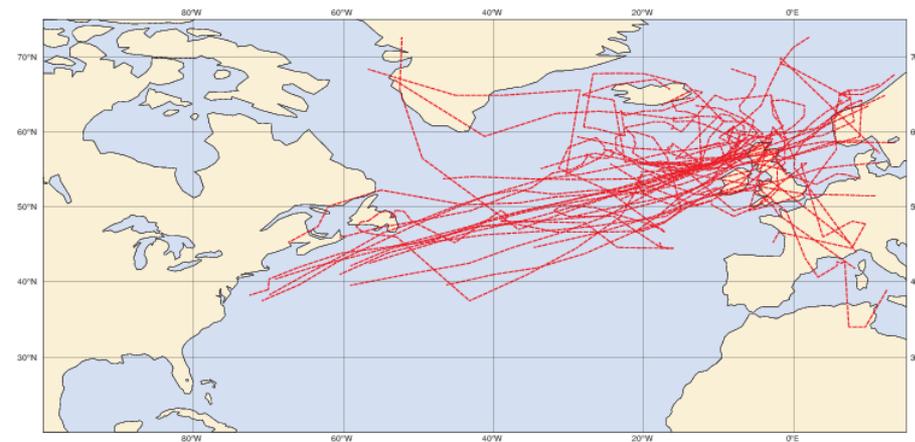
Tracks of depressions tracking across the Irish “box” and core pressure <970hPa: 1981-1997 v 1998-2014

1981-1997



Slight shift
northwards?

1998-2014



Climate change and weather extremes

'Attribution science' using climate models suggests that some recent weather events (wind, precipitation, heat/cold) may be exacerbated by 'climate change'

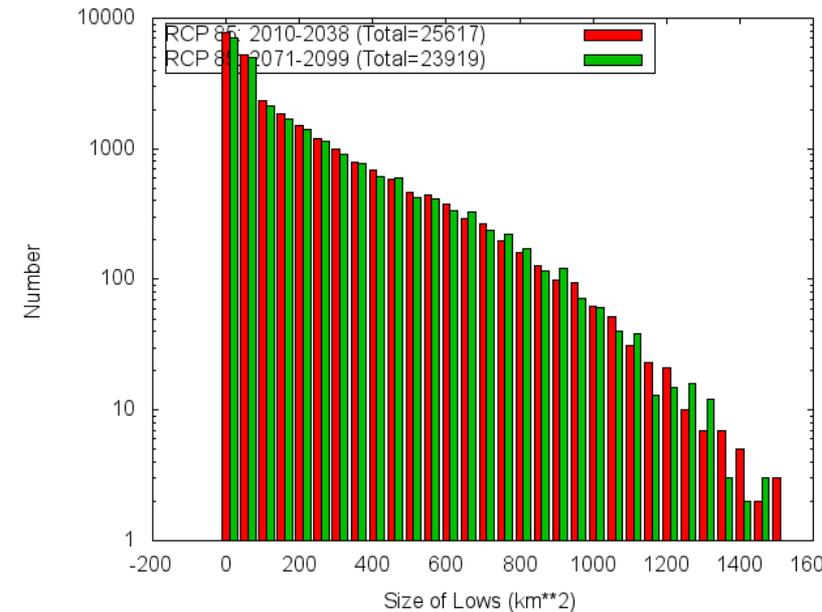
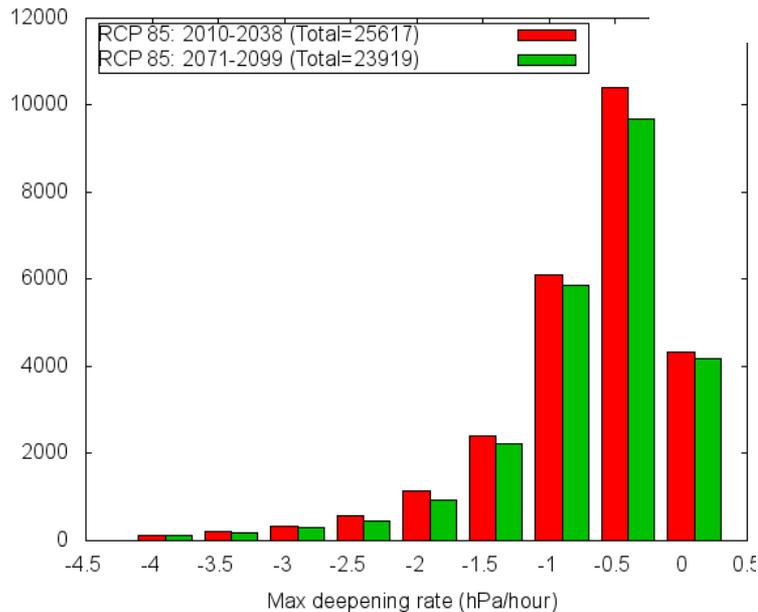
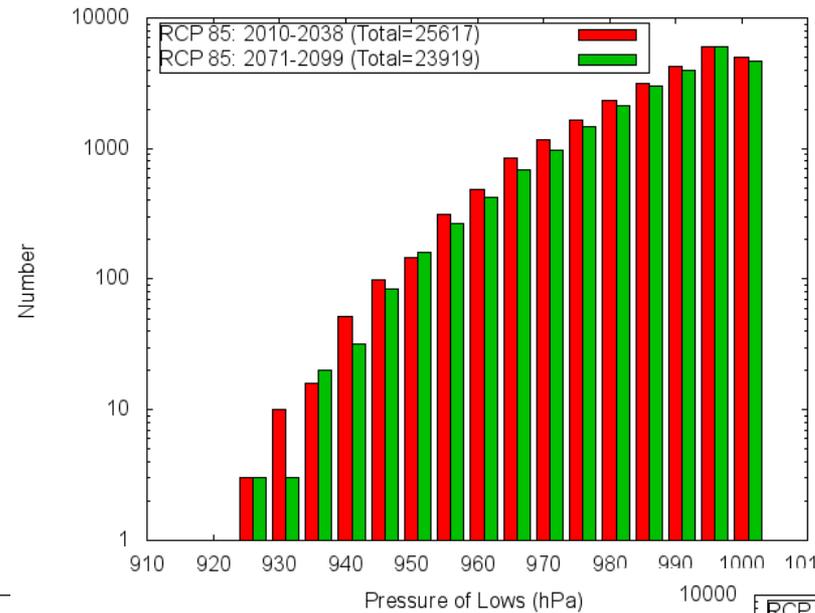
Heat and precipitation events lend themselves more readily to timely attribution assessments.

Signal to noise for heat events is clear:

- For heat events the vast majority find a climate change signal: ~95% found a human influence
- For precipitation events it is more mixed: ~40% found a human influence

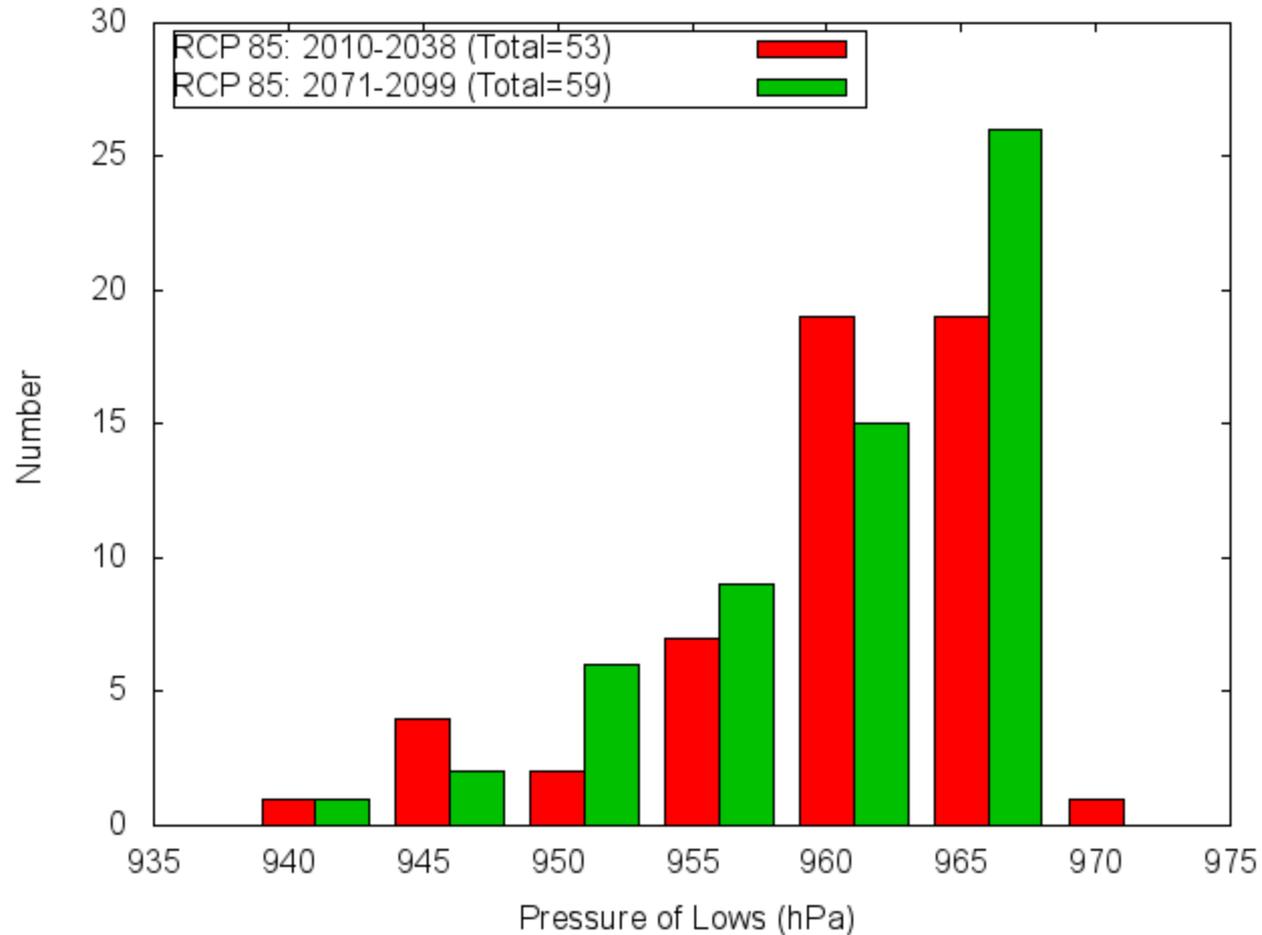
“Explaining Extreme Events of 2014 from a Climate Perspective”,
BAMS, 2015

Climate change: EC-Earth simulation (RCP8.5). Changes in statistics over N. Atlantic area 2010-2038 v 2071-2099



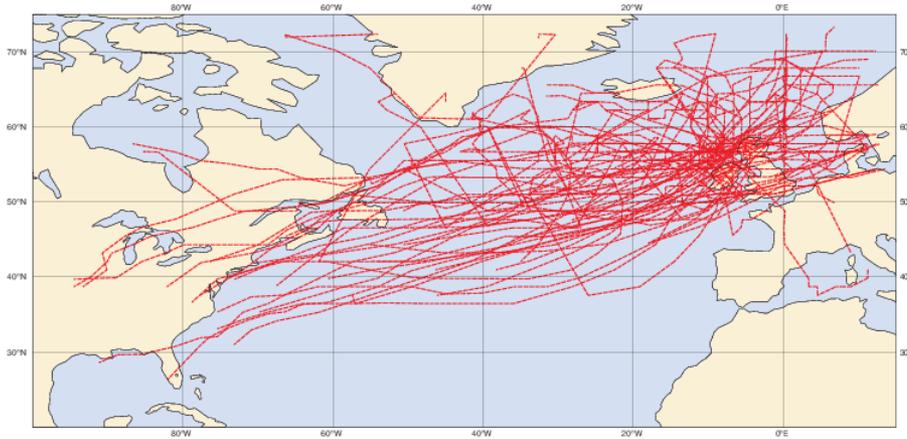
Fewer depression tracks in the future ...

EC-Earth projections (RCP 8.5): Tracks of depressions crossing Irish 'box' with pressure <970hPa 2071-2099 v 2010-2038

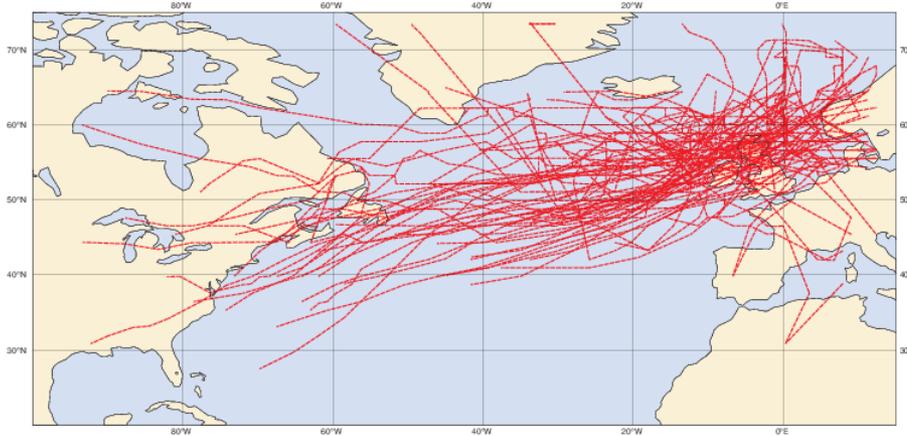


EC-Earth projections (RCP8.5): Tracks of depressions crossing Irish 'box' with pressure <970hPa: 2010-2038 v 2071-2099

2010-2038
(53 tracks)



2071-2099
(59 tracks)



Slight shift
northwards?

Atlantic storms: Impacts of global warming

Meridional temperature gradient decreasing => reduced instability, but increased latent heat release may intensify storms.

Some model evidence of a future increase in the frequency of violent storms over western Europe. (Haarsma, et al (2013), Geophys. Res. Lett.).

Still a lot of uncertainty ...

“The global number of extratropical cyclones is unlikely to decrease by more than a few percent and future changes in storms are likely to be small compared to natural interannual variability and substantial variations between models.”

IPCC, 2013: Climate Change 2013: The Physical Science Basis

Trends in Irish precipitation

Data for 1981-2010 v 1961-1990 show approx. 5% increase in annual totals.

Seasonal trends depend on the length of record:

- Recent decades show an increase in rainfall in all seasons
- Long-term analysis of 25 stations (1850-2010) shows evidence of **decreasing summer and increasing winter rainfall** (Noone et al., 2015)

Extremes: evidence of an **increase in the number of 'wet days'** (>10mm) per annum over the past 50 years in the west and north.

Trends in surface winds

Some evidence of a **slight decrease** in mean surface winds over past decades.

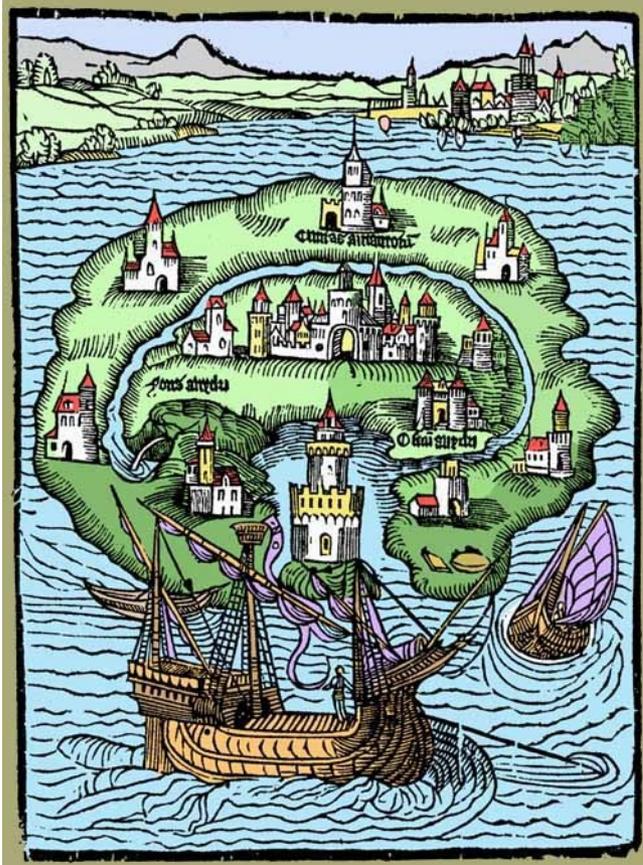
For **extreme winds** the winter storms of 2013/2014 stand out as exceptional in the past 143 years (Matthews et al., 2014) but there is **no obvious trend** ...

Climate Projections for Ireland

Projections are based on simulations of the climate system using physical models. Projections are subject to uncertainty:

- The models are imperfect, although constantly being improved.
- Even with a perfect model there would still be uncertainty as the climate system is fundamentally chaotic.
- Future emissions of GHG are uncertain.
- Uncertainty increases as the focus shifts from global to local climate.

Forecasting the weather (extremes, or otherwise) is not easy



“[Inhabitants] have a particular sagacity, *founded on much observation*, of judging of the weather, by which they know when they may look for rain, wind, or other alterations in the air”.

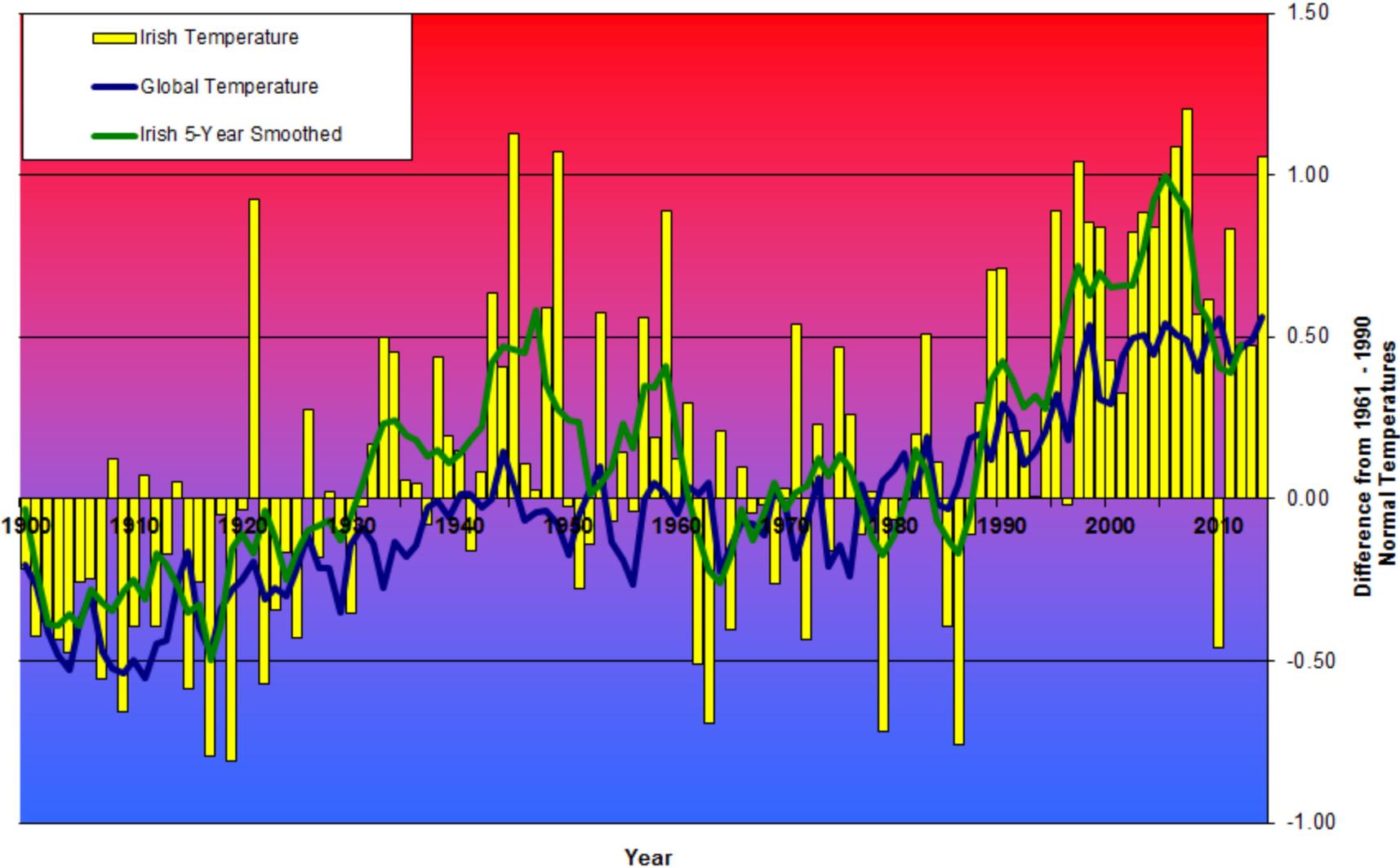
Utopia (1516), Thomas More

Acknowledgements

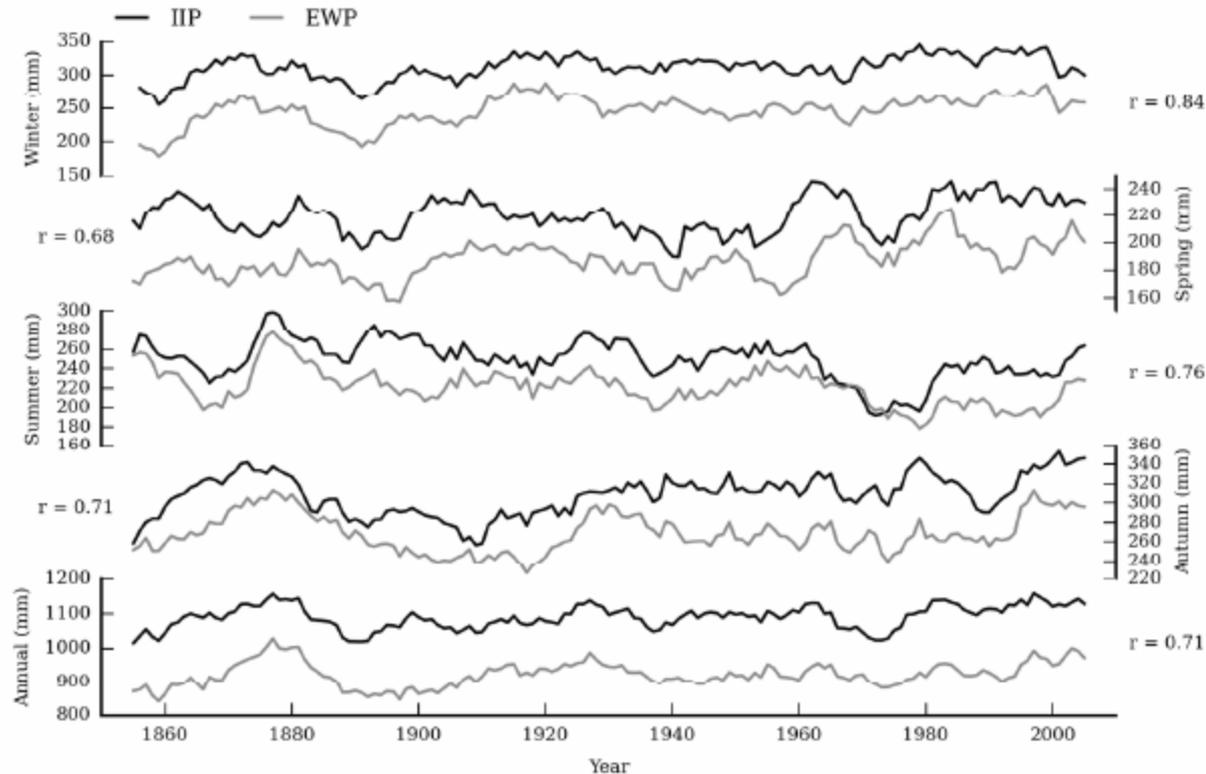
Colleagues in Met Éireann, particularly **Emily Gleeson, Eoin Whelan, Bing Li.**

Questions?

1900-2014 Air Temperature Difference from 1961-1990 Normal Values



Trends in monthly Irish precipitation (25 stations) 1850-2010



Smoothed (11 year) monthly values in mm for the Irish (IIP) and England/Wales (EWP) stations for winter, spring, summer, autumn and annual (top to bottom). Source: Noone et al., 2015

Climate Projections for Ireland: **Temperature**

Depending on the future emission scenarios, the best estimates for Ireland are increases in the range **1-1.5°C** (RCP4.5) to **2.5-3.5°C** (RCP8.5), by the end of the century.

The warming is likely to be more pronounced in the winter and summer seasons, and at night.

Climate Projections for Ireland: **Precipitation**

Increases in winter precipitation of ~10% for RCP4.5 and ~20% for RCP8.5 towards the end of the century.

Decreases in summer ~10%

Increase in the frequency of heavy precipitation events.

But still large uncertainty in the details.

