



Society of Actuaries in Ireland

Modelling Climate Change in Ireland

13 October 2016

Disclaimer

The views expressed in this presentation are those of the presenter(s) and not necessarily of the Society of Actuaries in Ireland

Introduction Slide (1)

Paul Nolan

- Met Éireann
- Irish Centre for High-End Computing (ICHEC)
- Main area of research: Climate Modelling, High-Resolution Weather Forecasting
- Funded by the EPA

Presentation Outline:

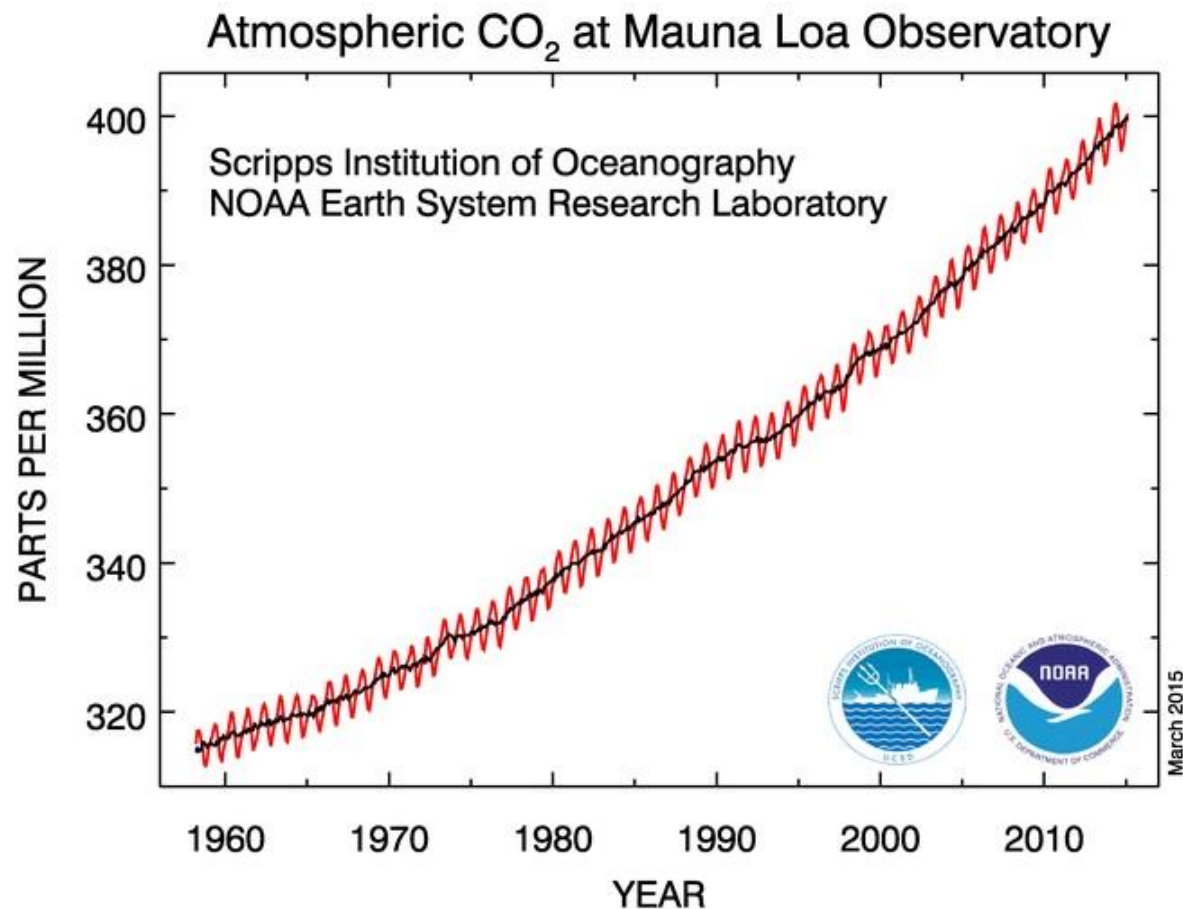
- Global Climate Projections
- Regional Climate Projections for Ireland





Introduction Slide (2)

- How will increasing Greenhouse Gas Emissions (and changing land use) affect the future climate of Ireland?

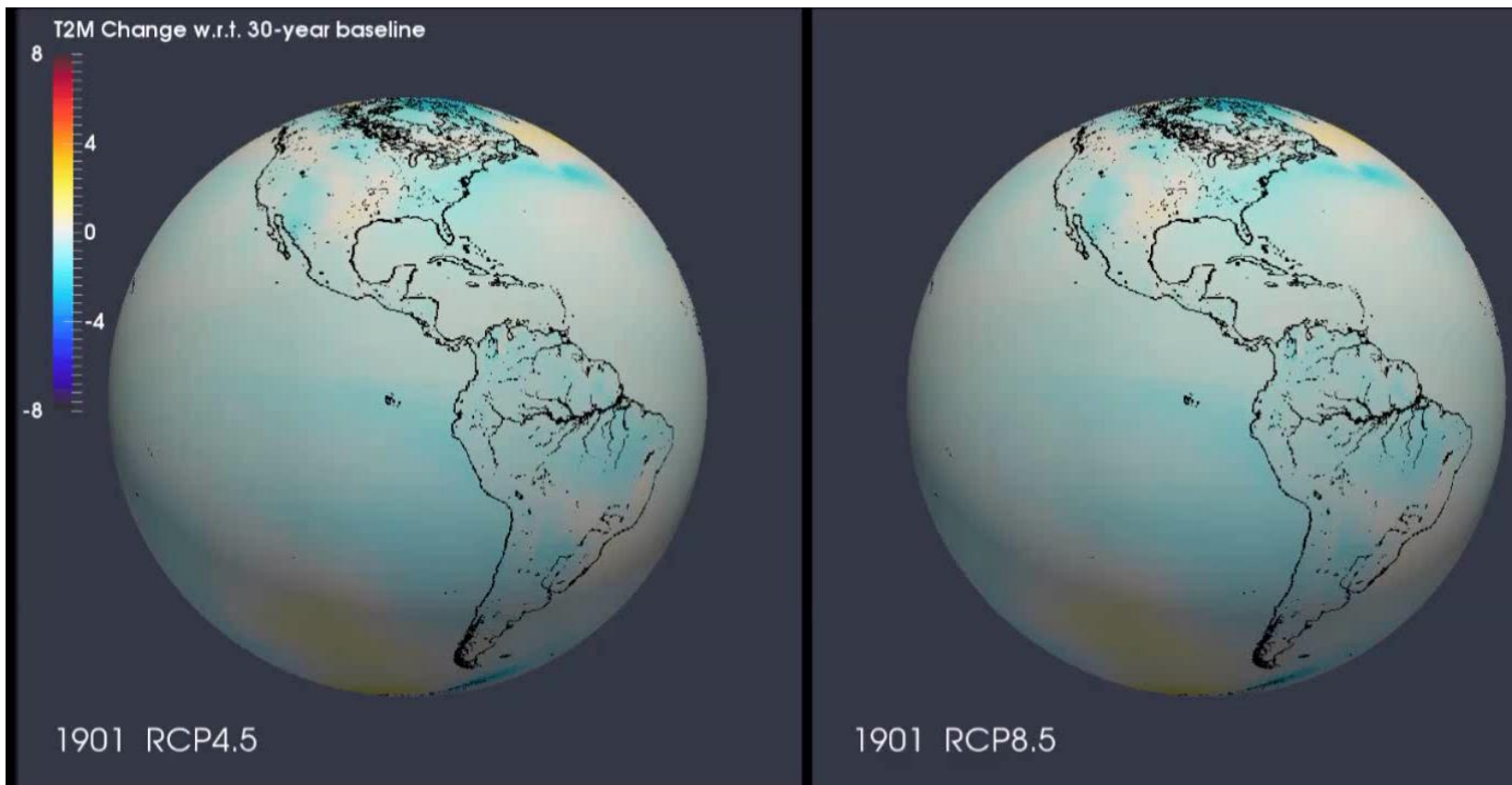




Global Climate Modelling

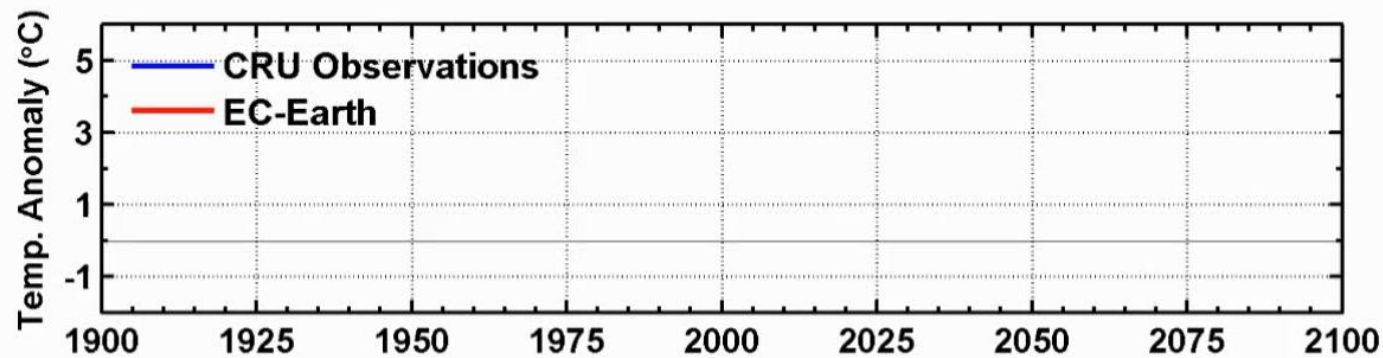
- The impact of increasing greenhouse gases on climate change can be simulated using **Global Climate Models (GCMs)**.
- EC-Earth is one such model (European Consortium, 32 partners). One of ~15 “IPCC-class” climate models.
- Met Éireann & ICHEC partnered in developing and running the model.
- A large number of EC-Earth simulations were run on the ICHEC supercomputing systems.
- Results contributed towards the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report (AR5)





Annual Temperature Change as simulated by the Met Éireann EC-Earth simulations.

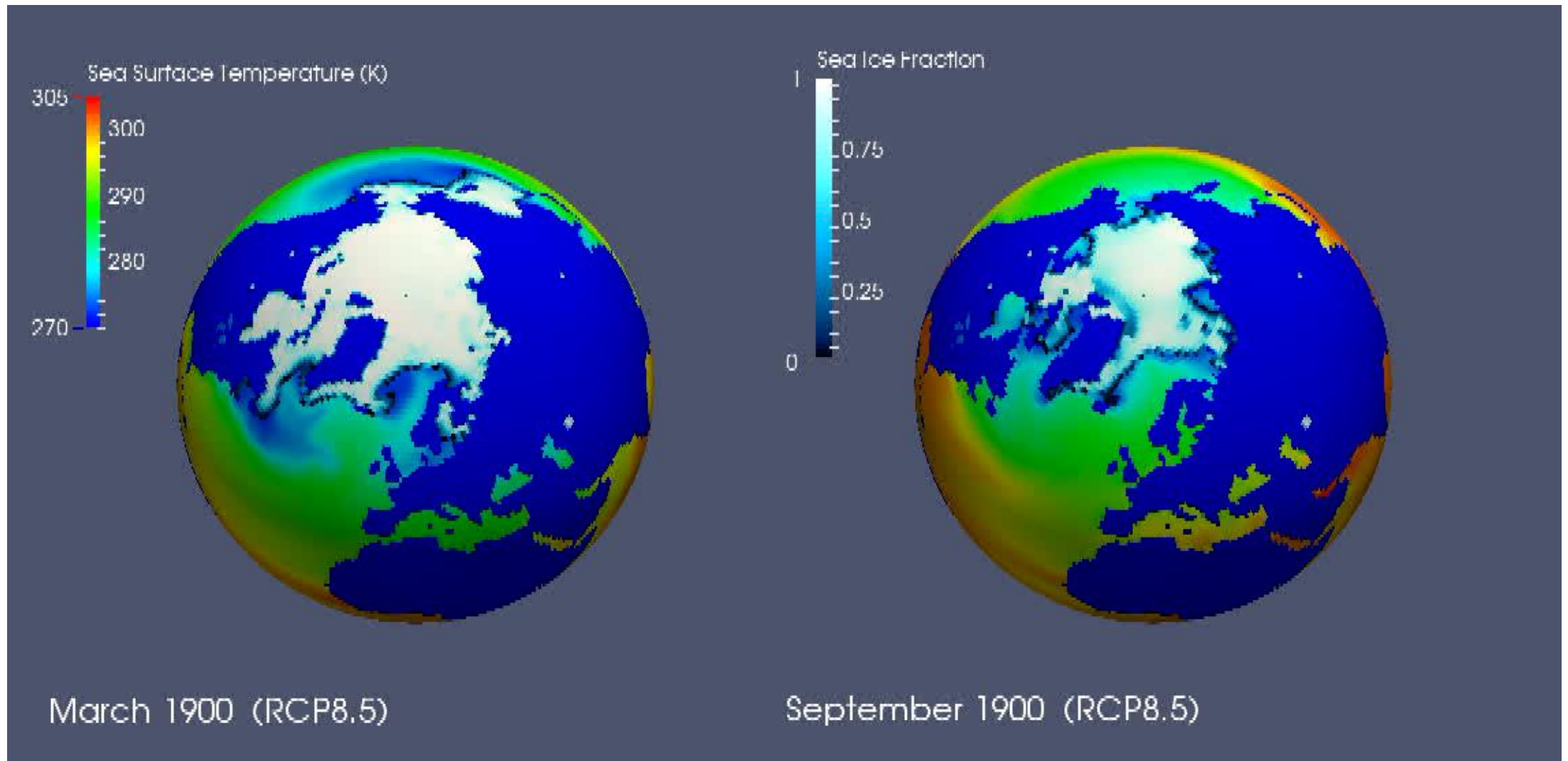
Annual mean temperature minus 1961-1990 mean

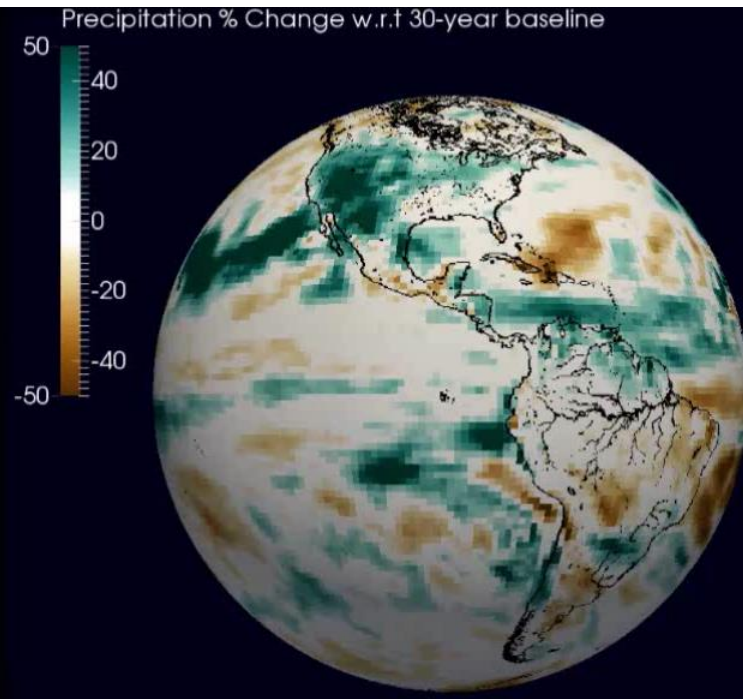
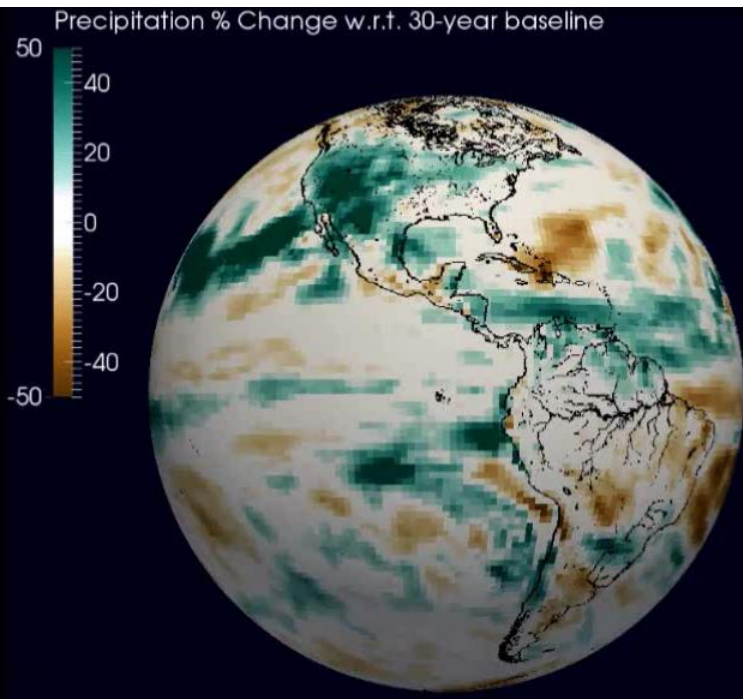


The Albedo “Positive” Feedback



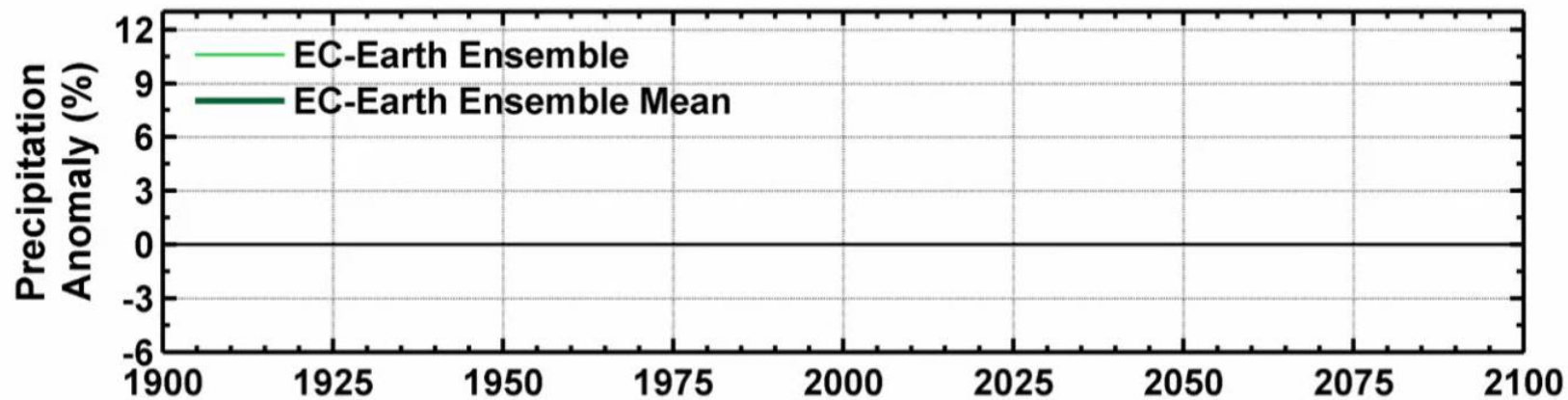
Simulated SST and Arctic Sea Ice Extent 1900-2100





Annual Precipitation change (%) as simulated by the EC-Earth simulations.

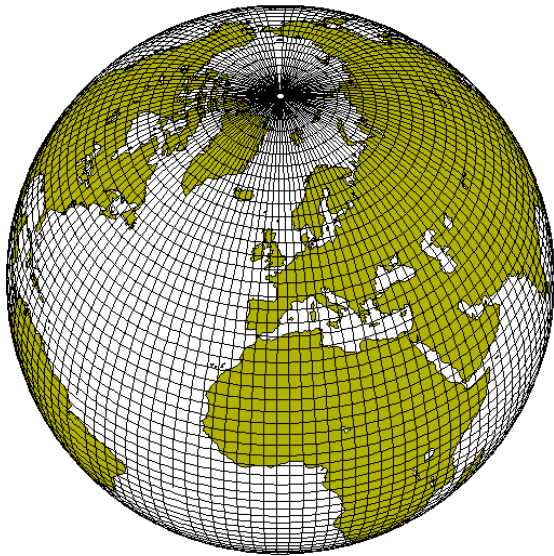
% Change in Annual Precipitation w.r.t. 1961-1990 mean





Downscaling the EC-Earth Data

- The spatial resolution of the global models are constrained by computational resources.



Global Model
to Regional Model



- We used Regional Climate Models (RCMs) to dynamically downscale the coarse information from the global models.



Downscaling the EC-Earth Data

Global
~125 km
resolution



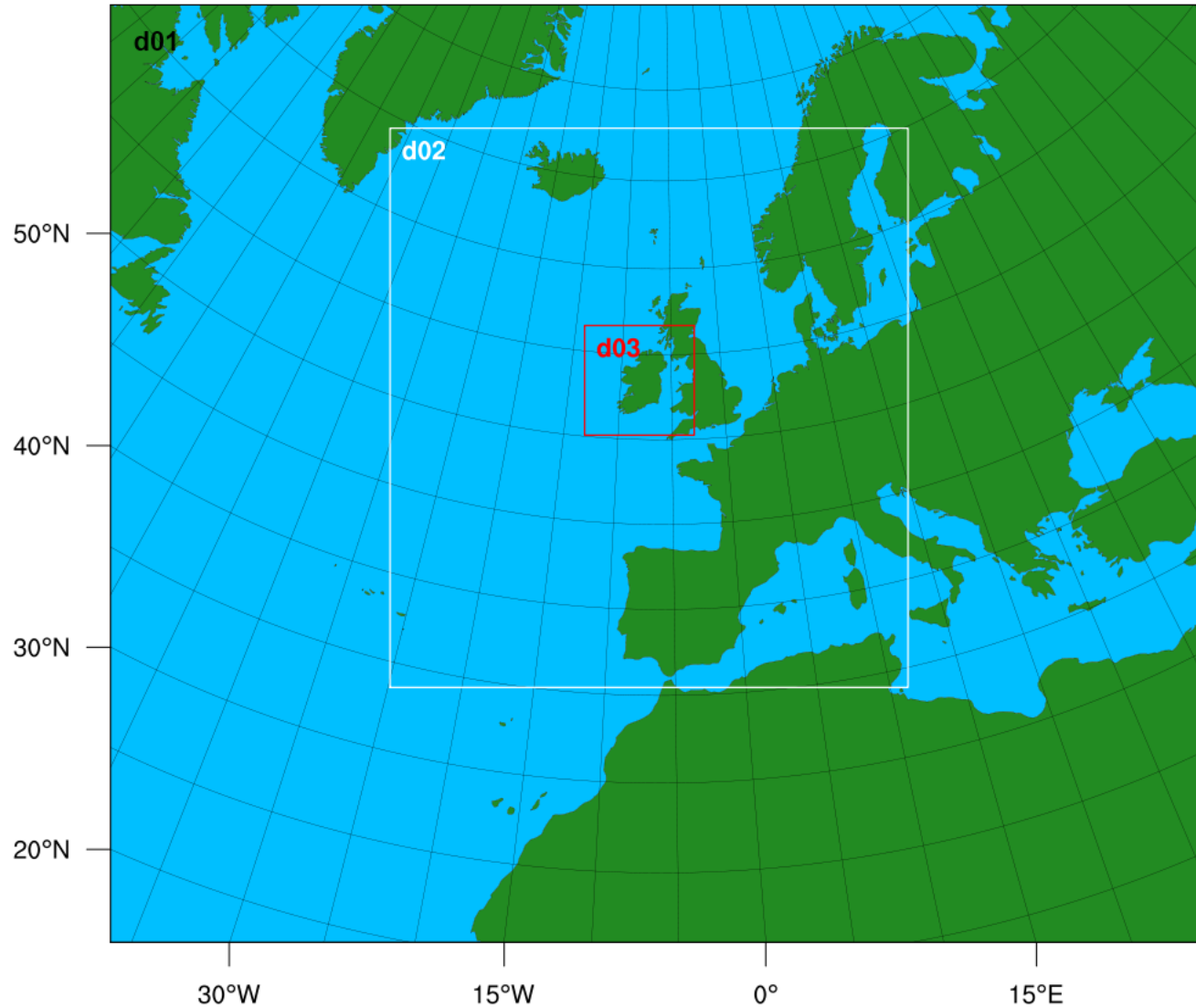
RCM 50 km



RCM 18 km



RCM 4 km

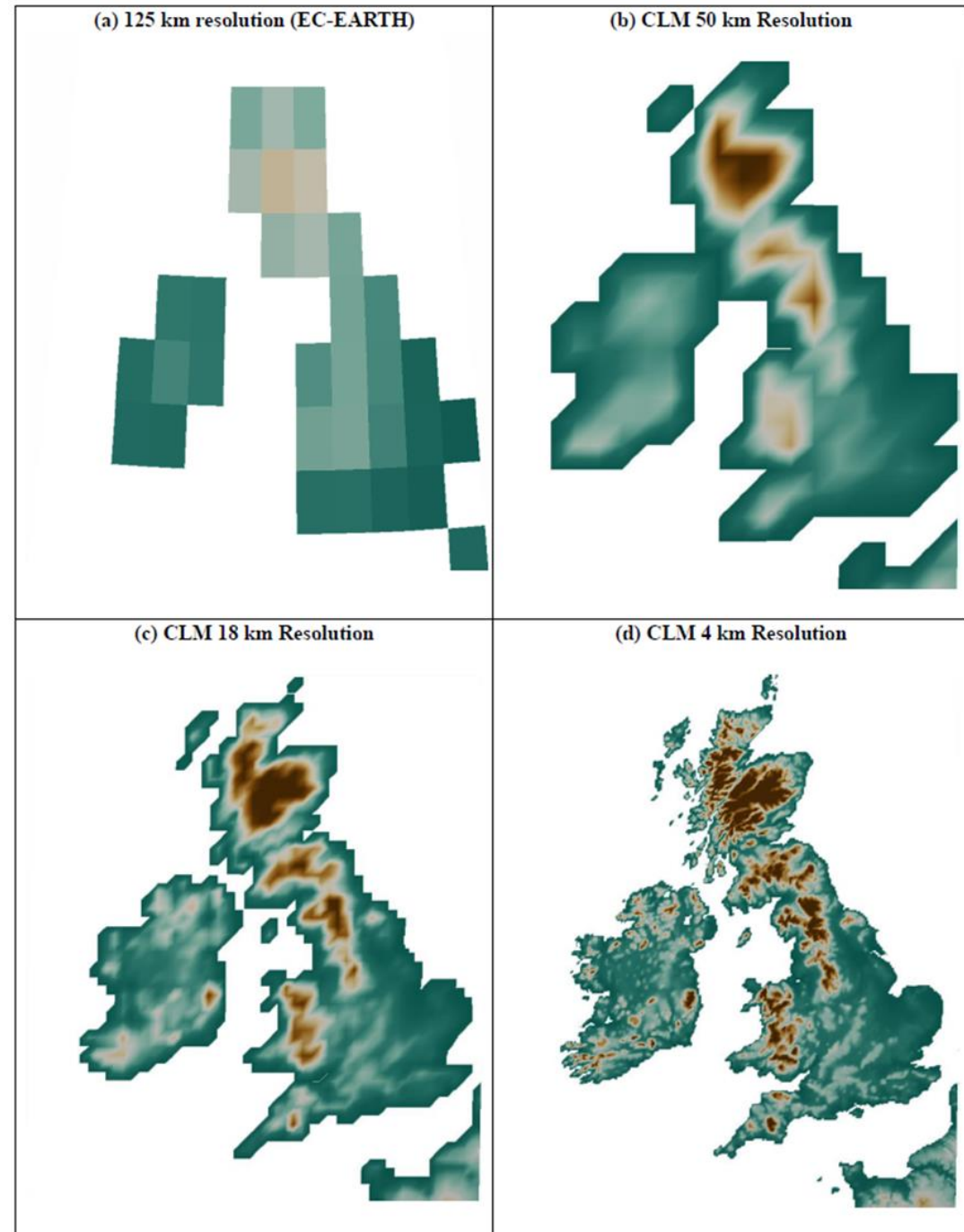


RCM Downscaling Improvements.

Surface Height as resolved by the models.

**GCM
~125km**

**RCM
18km**



**RCM
50km**

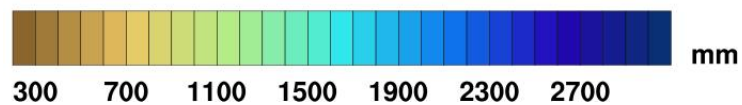
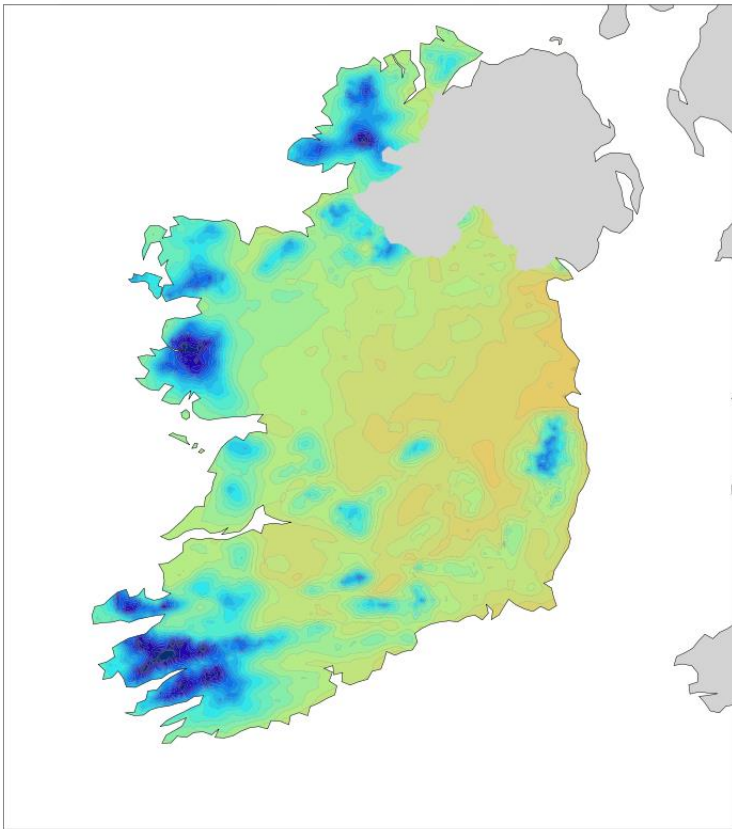
**RCM
4km**



RCM Validations (Precipitation)

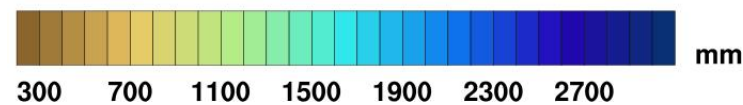
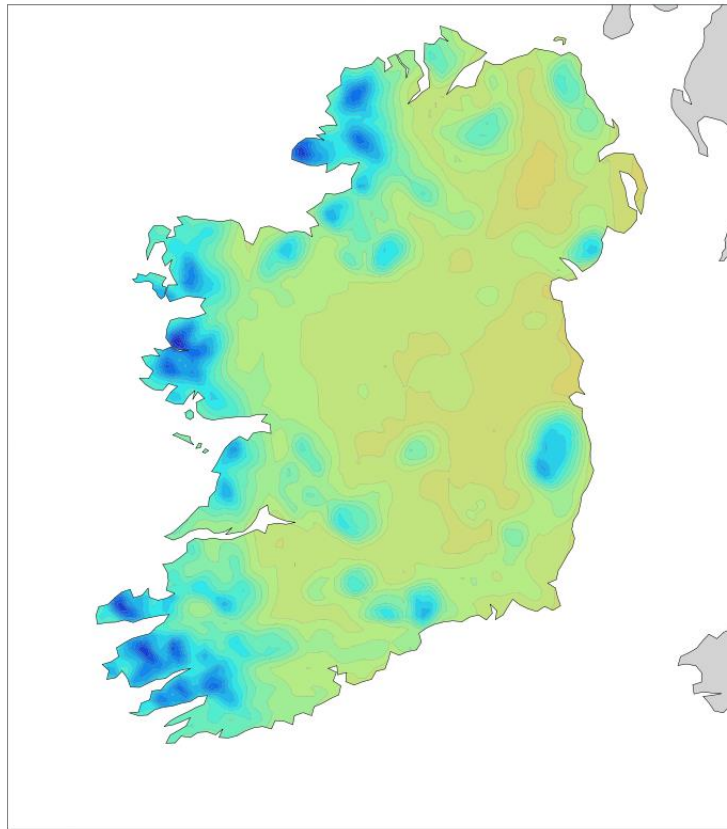
Observations, 1981-2000

Annual Observed Rainfall (1981-2000)



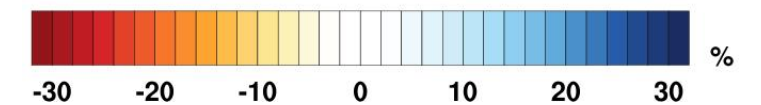
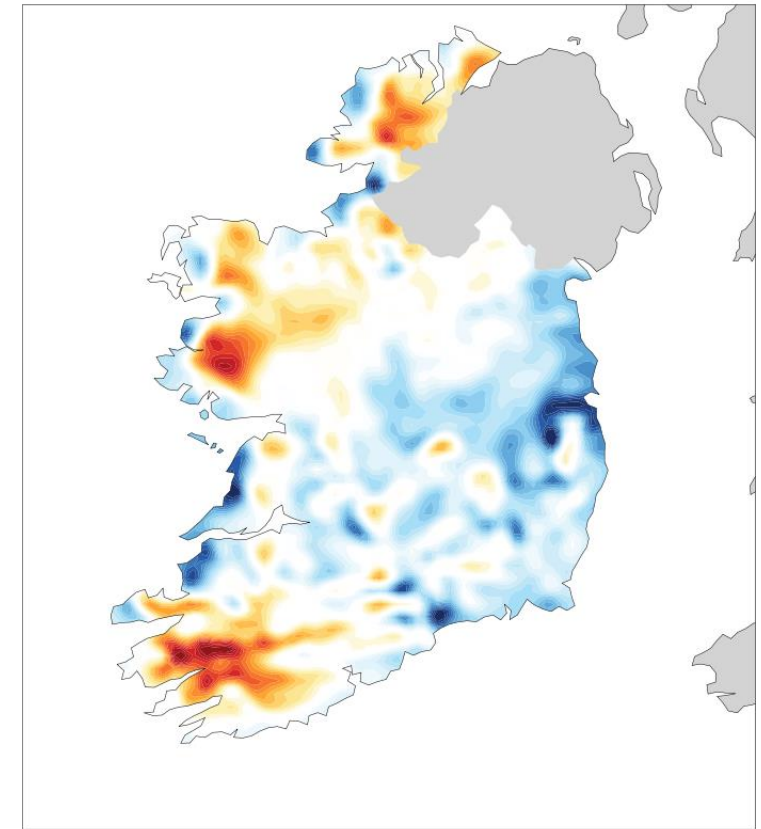
RCM, 4km

Annual CLM-ECEARTH Rainfall (1981-2000)



% Error

Annual Error (1981-2000)





RCM Projections for Ireland

- The future climate of Ireland was simulated at high spatial resolution for the 40-year period 2021-2060
- For reference, the past climate was simulated for the period 1961-2000 (2010)
- Difference between the two periods provide a measure of climate change



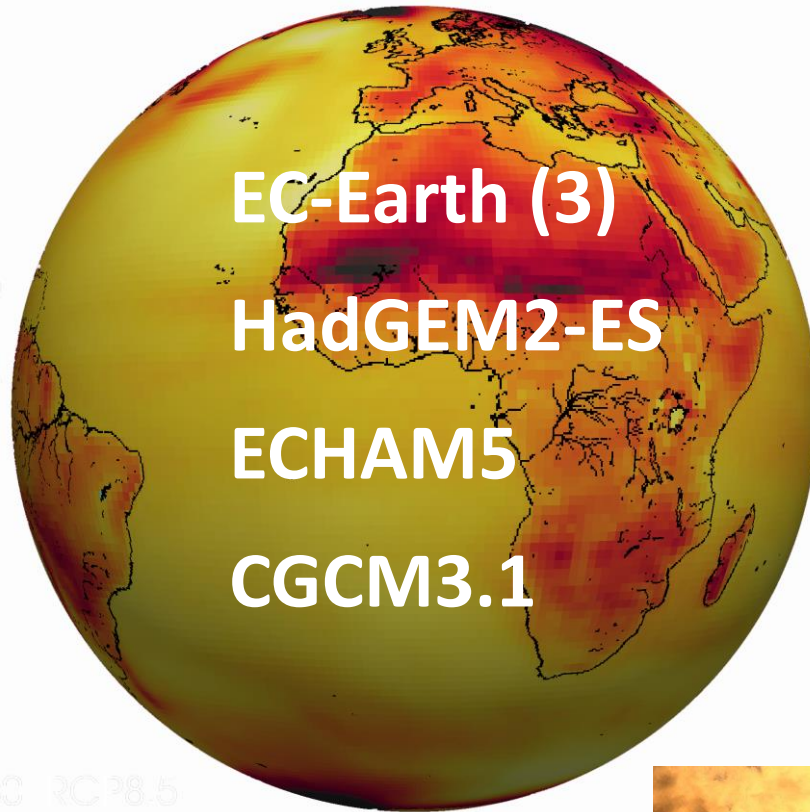
RCM Projections for Ireland - the Ensemble Method (Uncertainty)

- Climate change projections are subject to uncertainty, which limits the value of individual projections.
- To address this issue of uncertainty, an ensemble of Regional Climate Models (RCMs) was run.
- The ensemble approach of the current project uses three different RCMs, driven by several Global Climate Models (GCMs), to simulate climate change.
- To account for the uncertainty in future emissions, a number of SRES (B1, A1B, A2) and RCP (4.5, 8.5) emission scenarios were used to simulate the future climate of Ireland.



RCM Projections for Ireland - the Ensemble Method

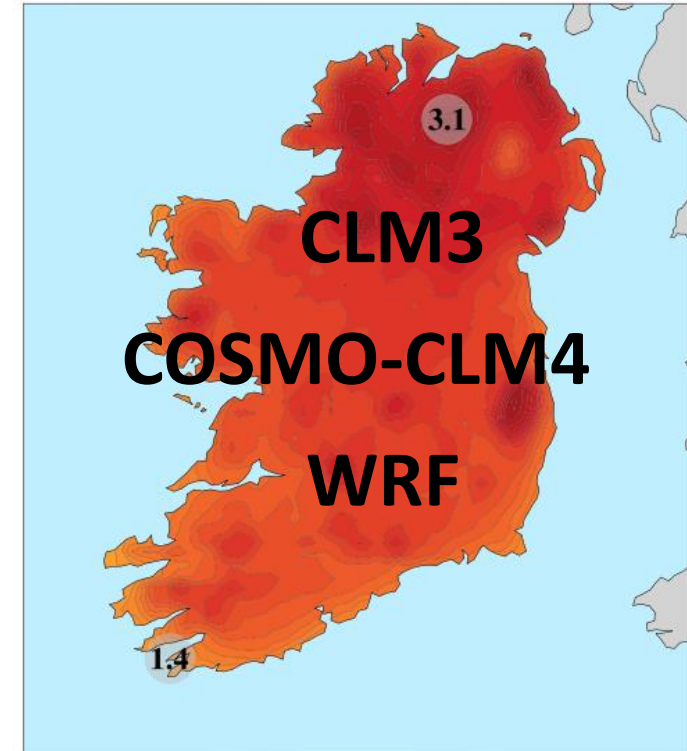
Global Climate Model



Future Climate
Emission Scenarios

**B1, A1B, A2,
RCP4.5, RCP8.5**

Regional Climate Model





RCM Projections for Ireland - the Ensemble Method

Through the ensemble approach, the uncertainty in the projections can be partly quantified, proving a measure of confidence in the predictions.

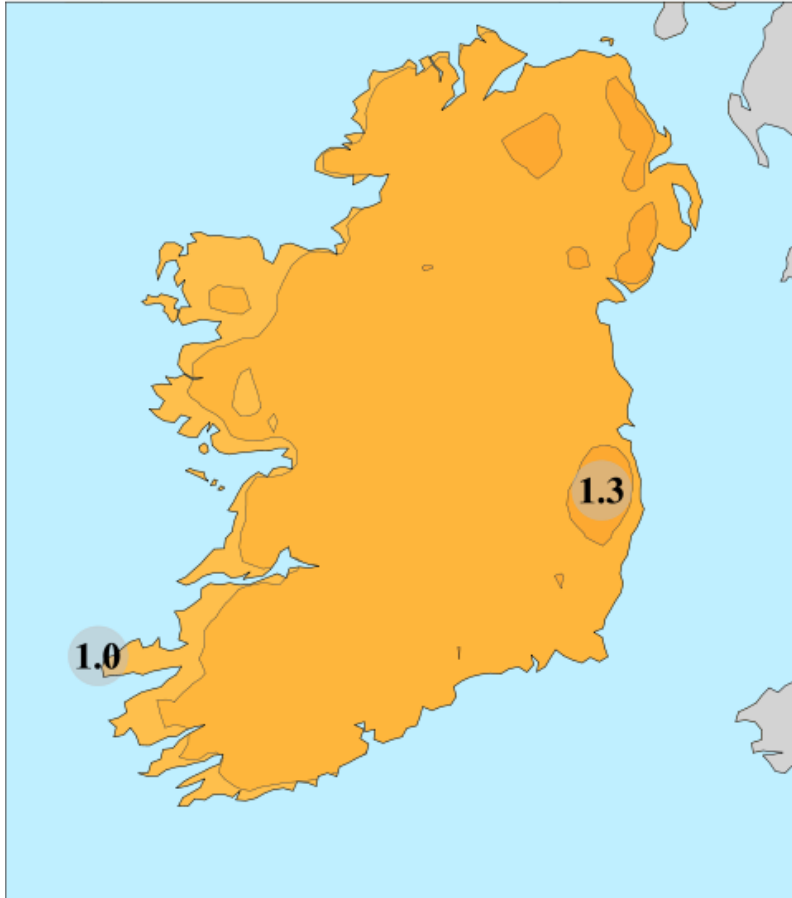
Running such a large ensemble was a substantial computational task and required extensive use of the ICHEC supercomputer systems over 3 to 4 years.

The RCP4.5 and the B1 scenario simulations were used to create a **medium-low emission** ensemble while the RCP8.5, A1B and A2 simulations were used to create a **high emission** ensemble.

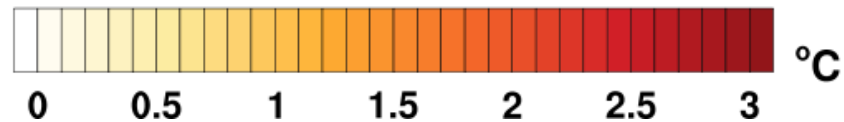
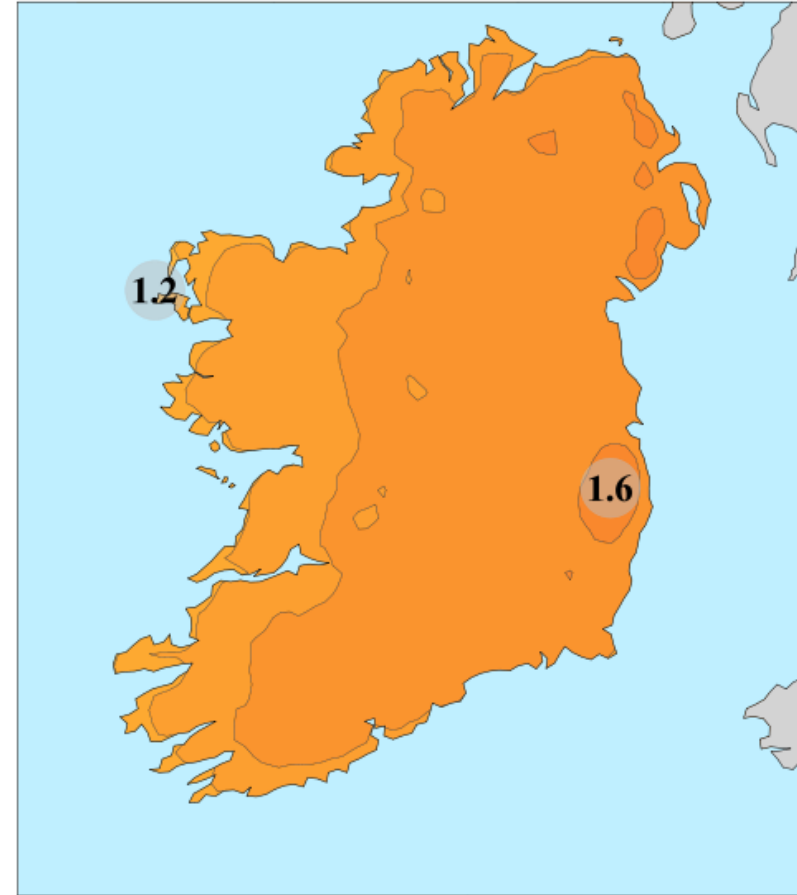


Mid-Century (2041-2060) **Temperature** Projections

Medium-Low Emission



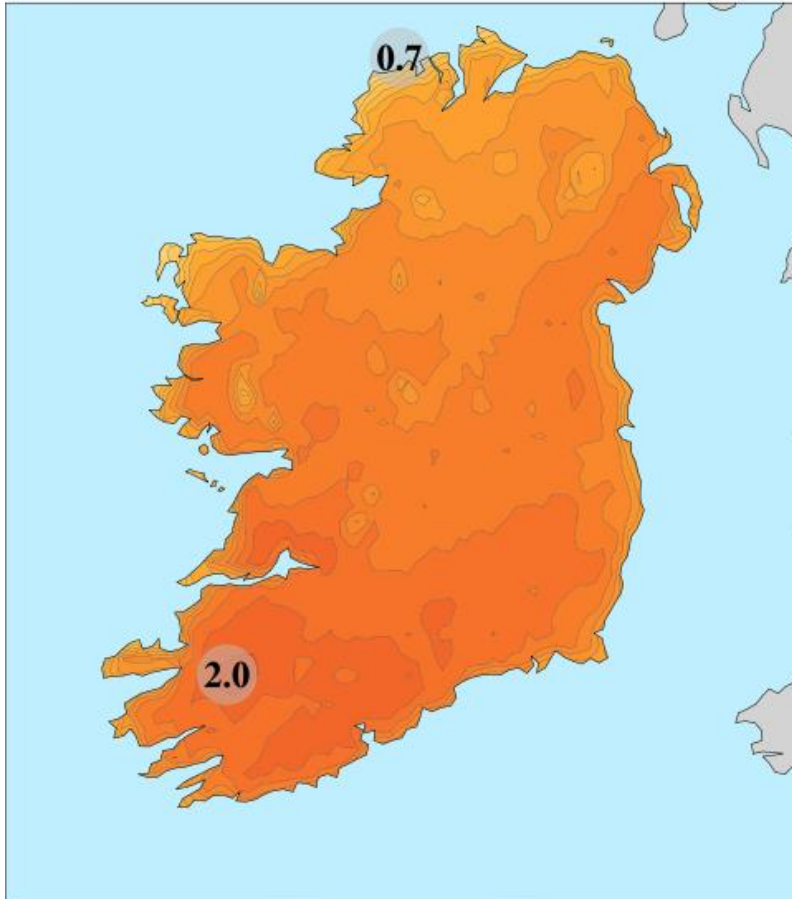
High Emission



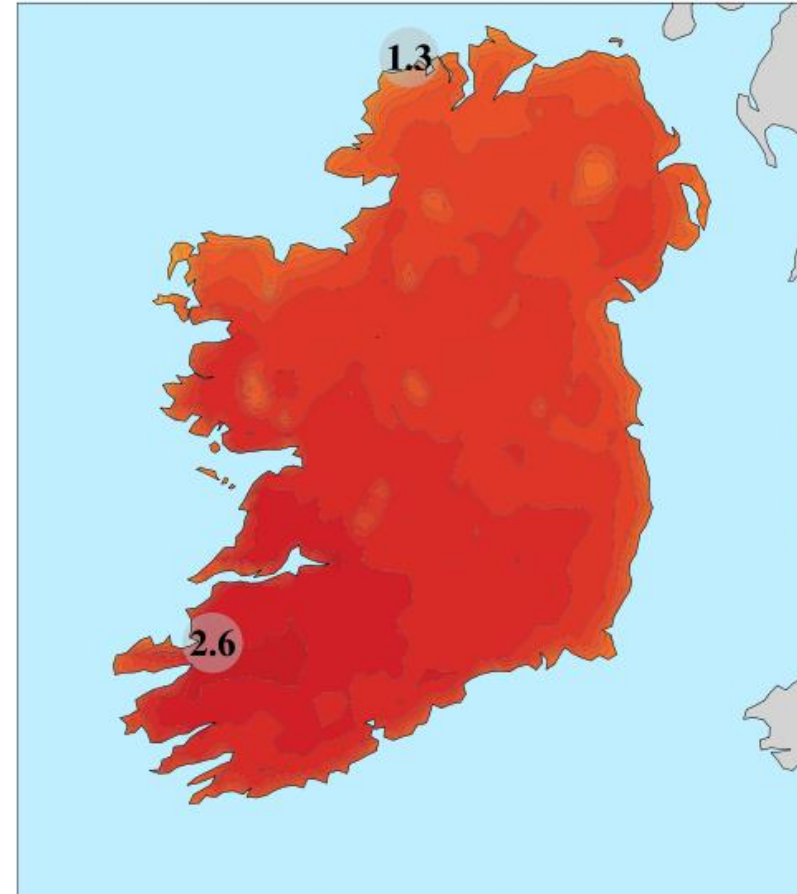


Mid-Century Summer Day-Time Temperature Projections

Medium-Low Emission



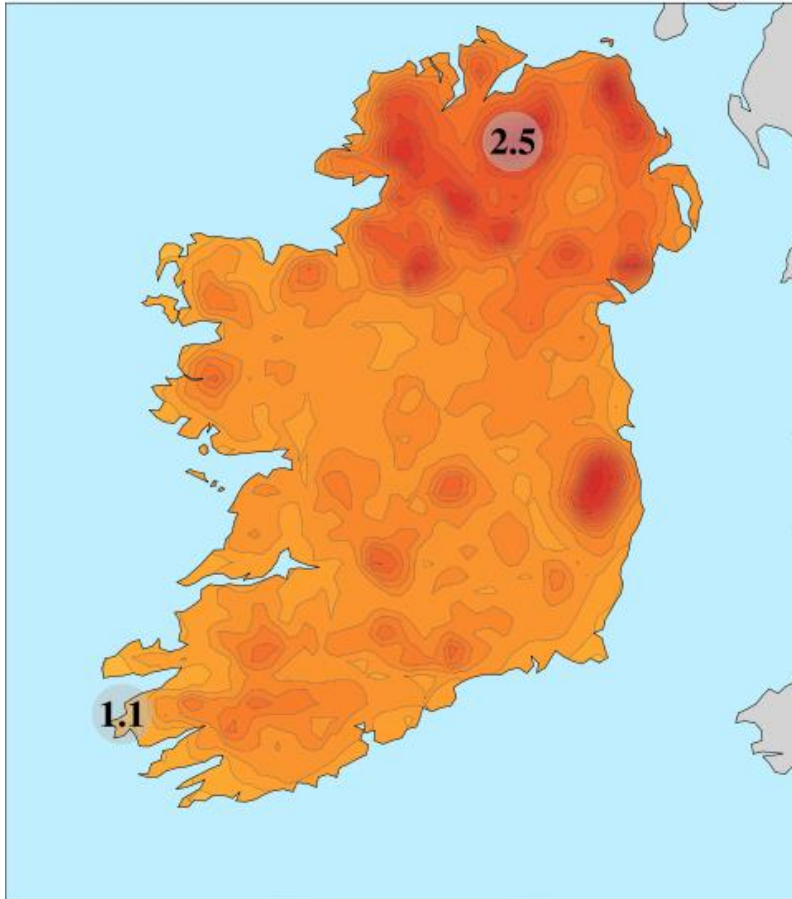
High Emission



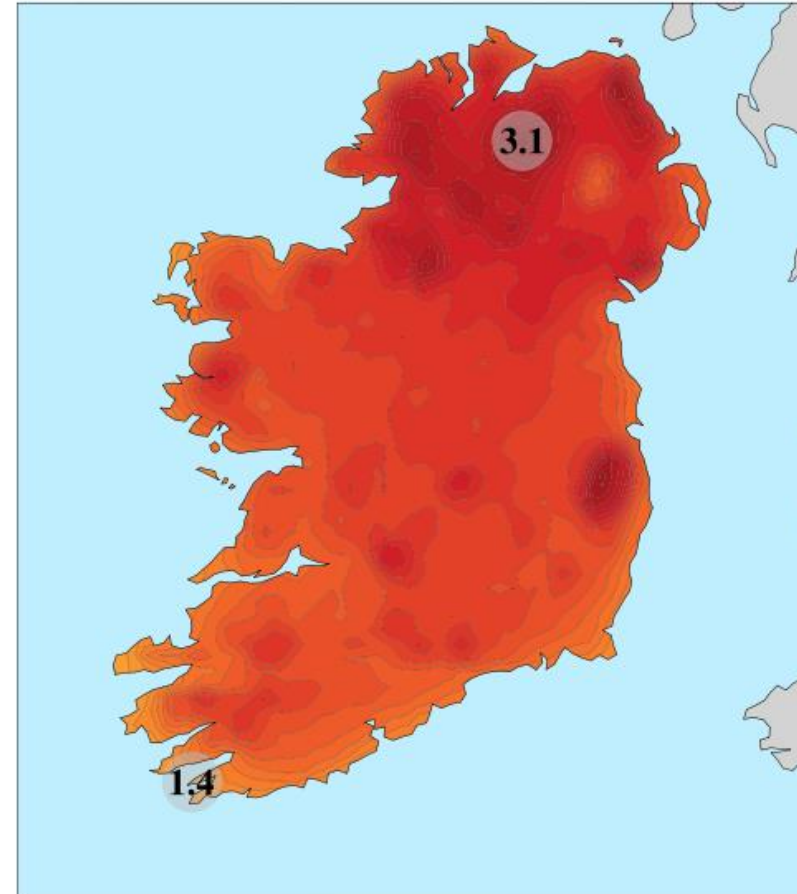


Mid-Century **Winter Night-Time Temperature** Projections

Medium-Low Emission



High Emission



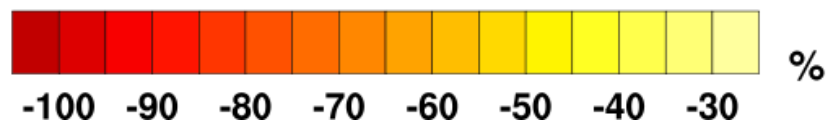
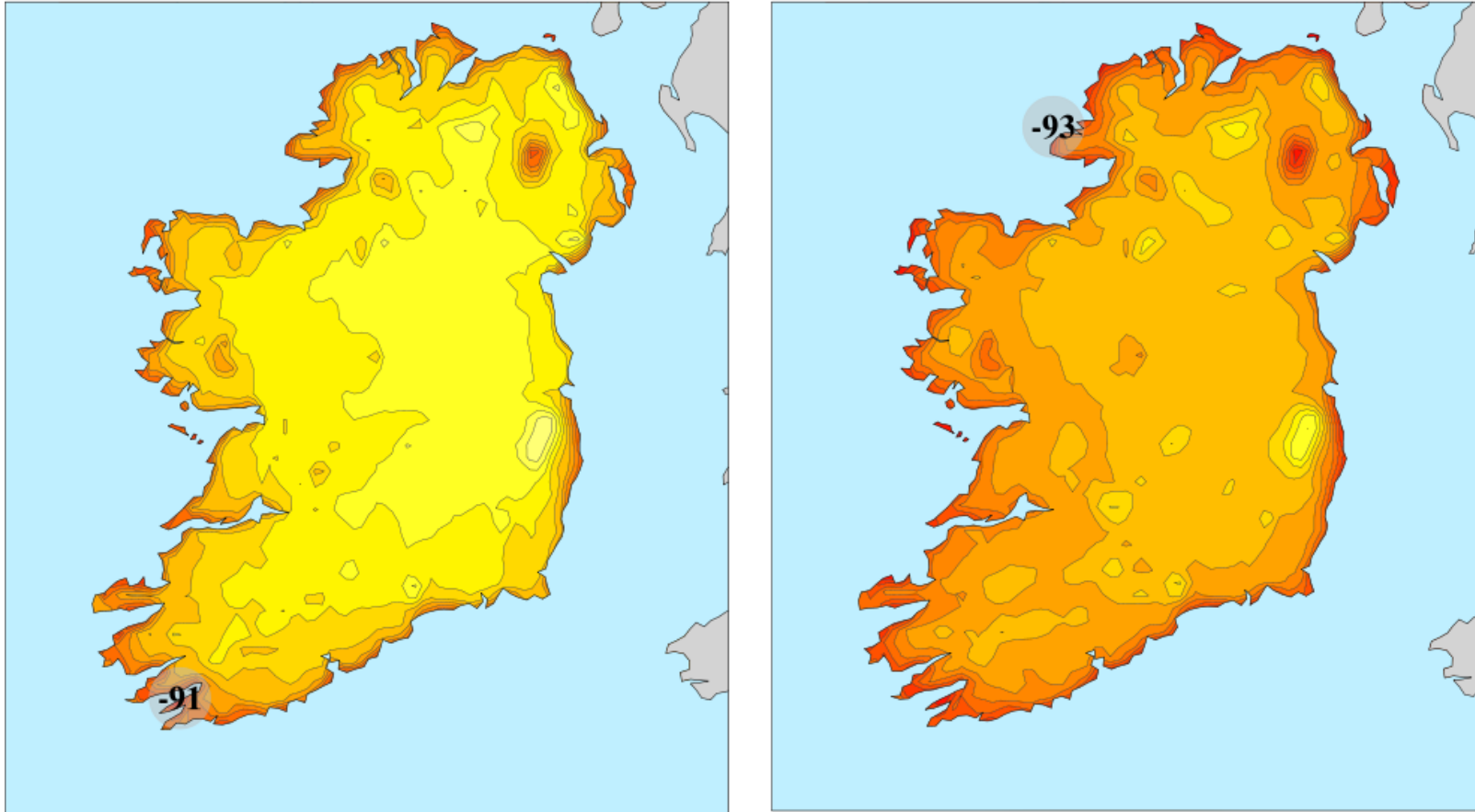


Mid-Century **Number of Frost Days** Projections

Annual Change (%) in Number of Frost Days (TMIN < 0°C)

Medium-Low Emission

High Emission



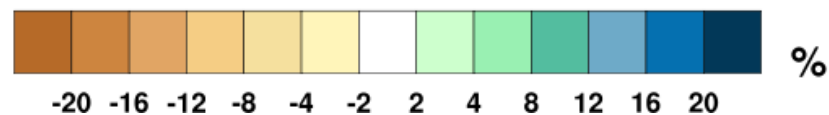
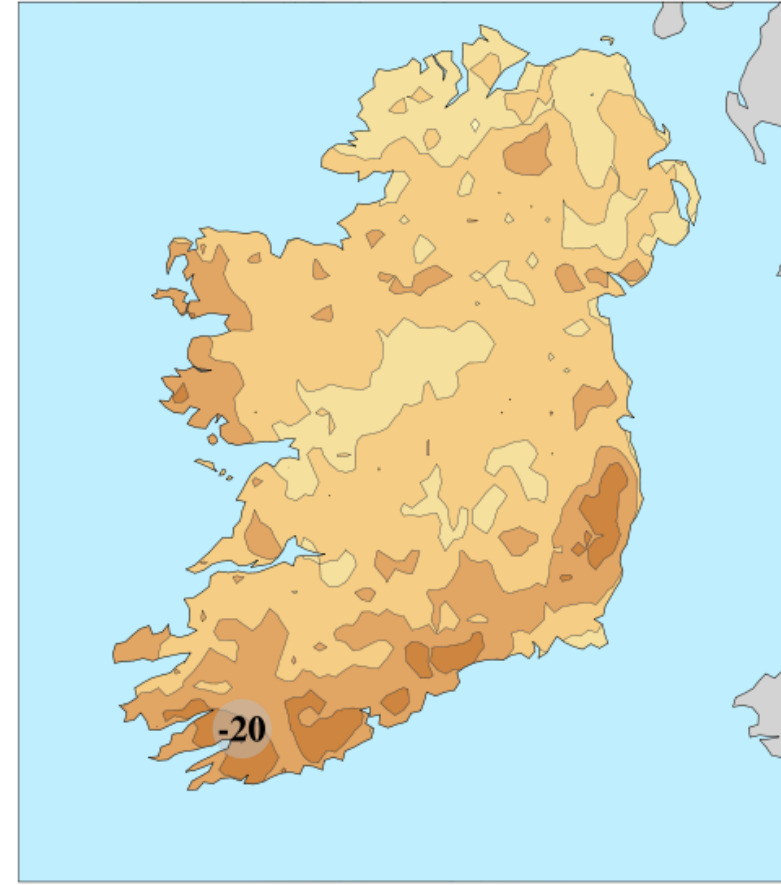
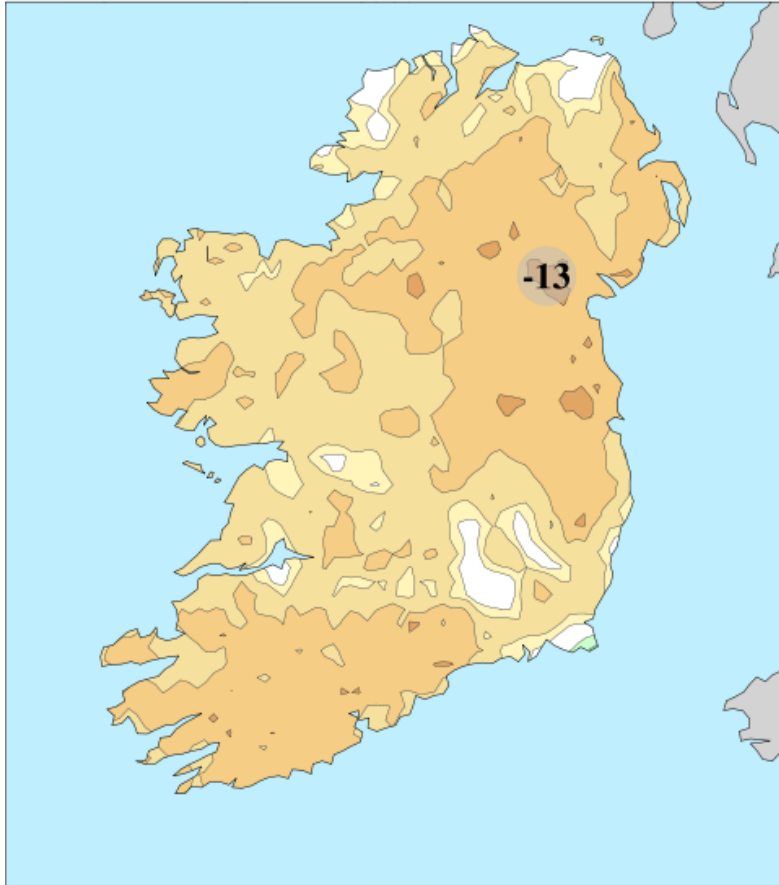


Mid-Century **Rainfall (%)** Projections

"Likely" Summer Precipitation Decrease

Medium-Low Emission

High Emission

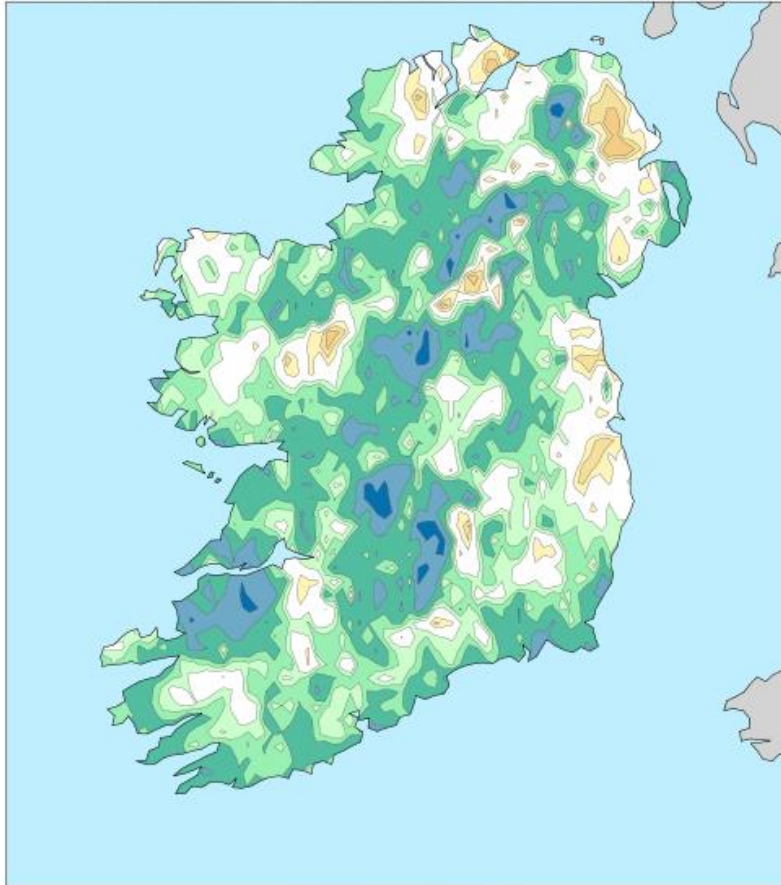




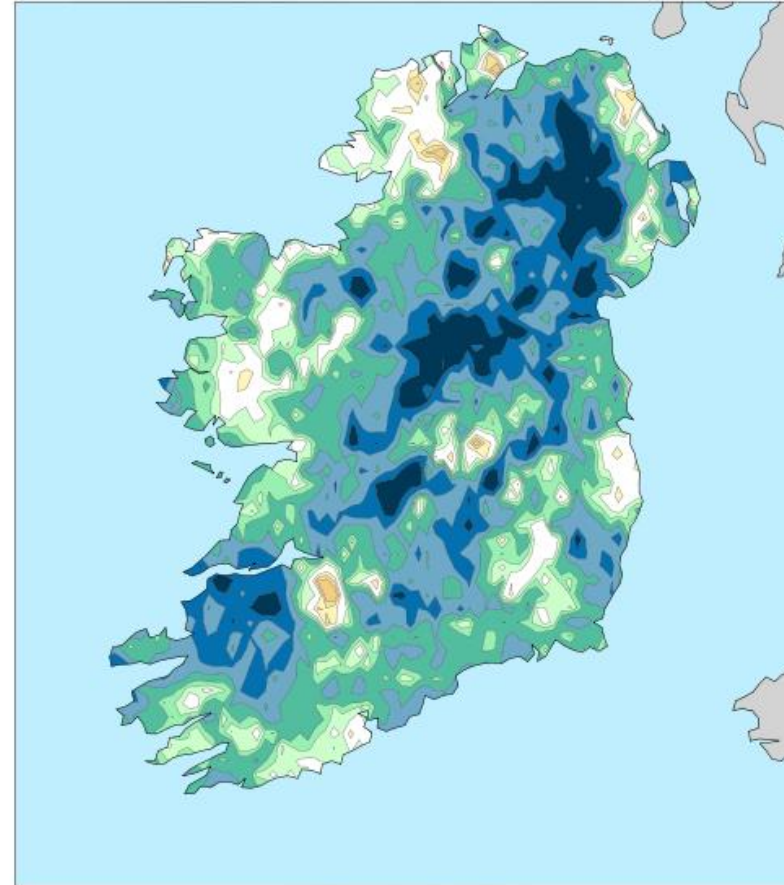
Mid-Century **Heavy Rainfall Days (%)** Projections

"Likely" Increase Very Wet Days ($> 30\text{mm/day}$). High Emission Scenario

Annual



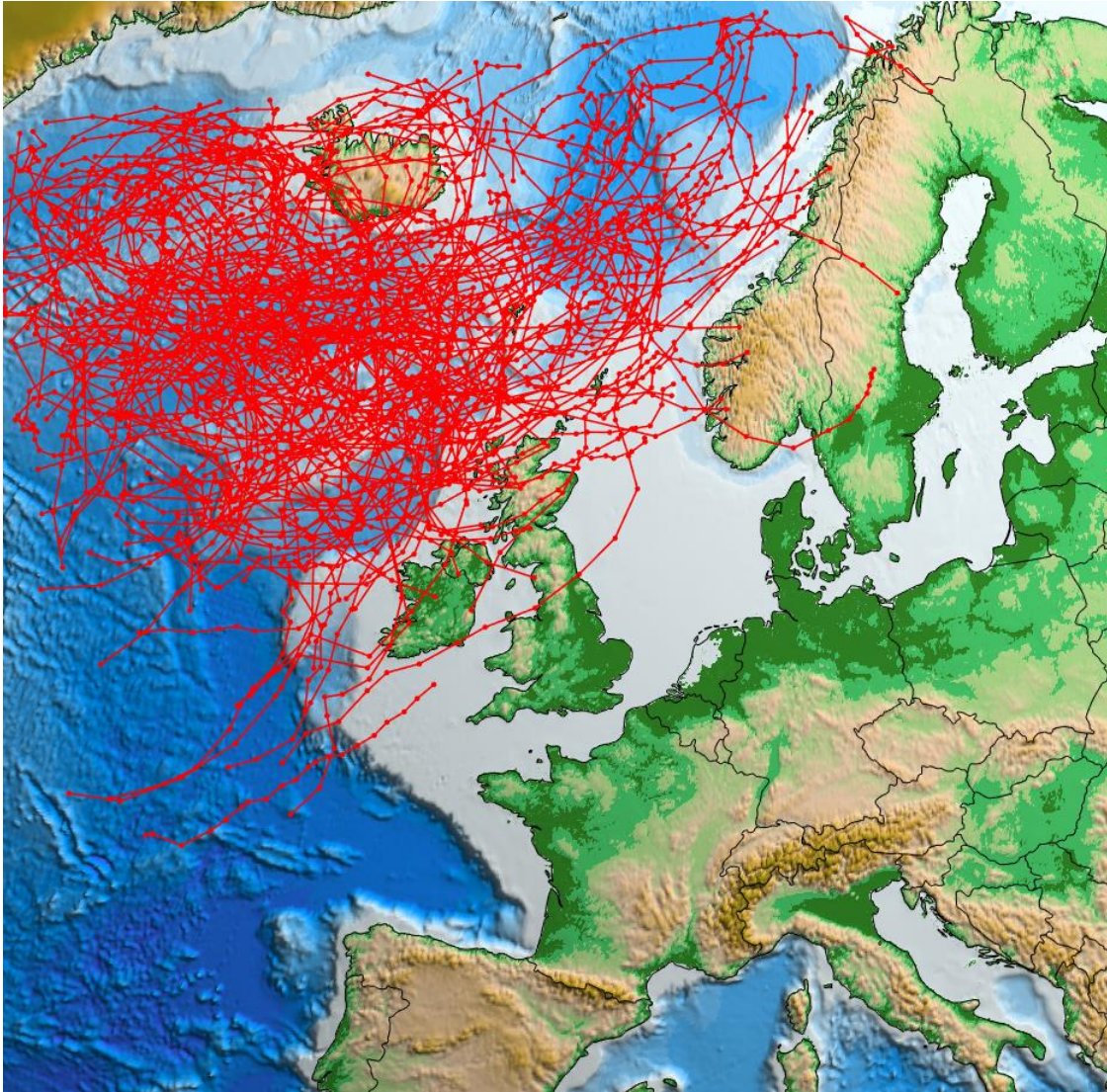
Autumn





Mid-Century **Extreme Storm** Projections

1976-2005



Mid-century RCP8.5





Summary of Future Projections:

Temperature

- Mean temperatures are expected to increase by 1-1.6 °C by mid-century with the strongest signal seen in the east.
- Warming is enhanced for the extremes (i.e. hot or cold days) with summer daytime temperatures projected to rise by up to 2 °C and lowest night-time temperatures to rise by up to 2 to 3 °C in winter.
- Averaged over the whole country, the number of frost days (days when the minimum temperature is less than 0 °C) is projected to decrease by over 50%.



Summary of Future Projections:

Precipitation & Storms

- Large decreases are expected in rainfall (annual, spring & summer).
- The largest drying (~20% reduction in precipitation under the high emission scenarios) is expected during summer.
- The frequency of heavy precipitation events (winter & autumn) shows notable increases of up to 30%.
- The overall number of storms affecting Ireland is projected to decrease. However, the number of extreme storms is projected to increase.



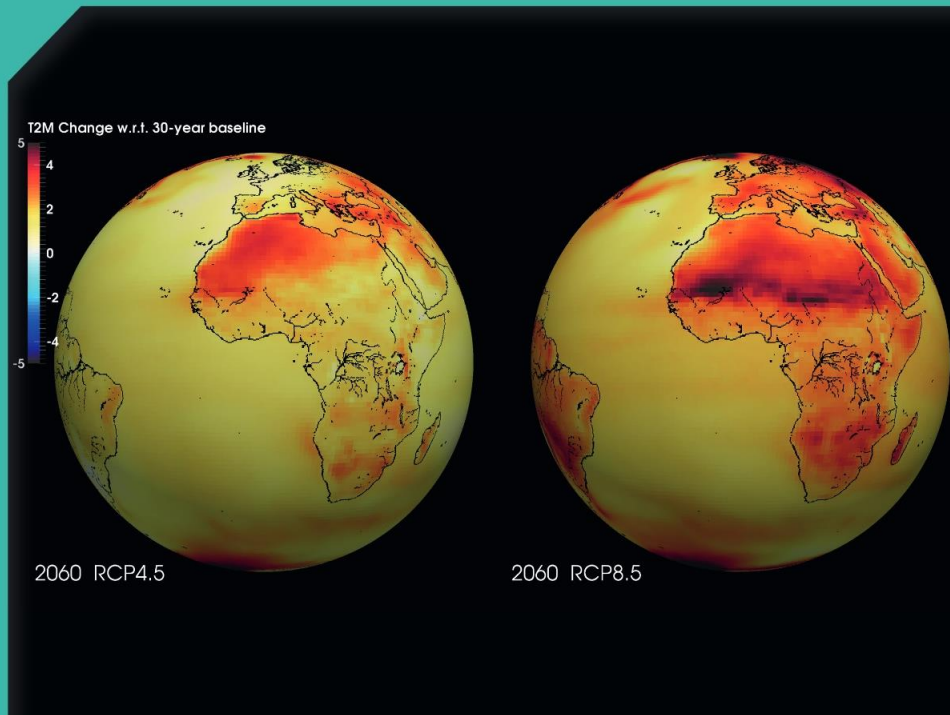
Current / Future Work

- Improve confidence in the RCM projections by increasing the RCM ensemble size and employing more up-to-date RCMs, GCMs and additional emission scenarios.
- Furthermore, the accuracy and usefulness of the predictions will be enhanced by running the RCMs at a higher spatial resolution (~2 km). Better handle on more uncertain projections such as mean winter rainfall and wind speed
- Contribute towards CMIP6 simulations (EC-Earth)



Ensemble of regional climate model projections for Ireland

Author: Paul Nolan, Irish Centre for High-End Computing and Meteorology and Climate Centre, School of Mathematical Sciences, University College Dublin



“Ensemble of regional climate model projections for Ireland”

<http://www.epa.ie/pubs/reports/research/climate/research159ensembleofregionalclimatemodelprojectionsforireland.html>

Datasets archived at ICHEC. We are keen to share the data and/or collaborate.

Contact: Paul.Nolan@ichec.ie

