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An Operational Climate Information Platform for Ireland: Summary Report

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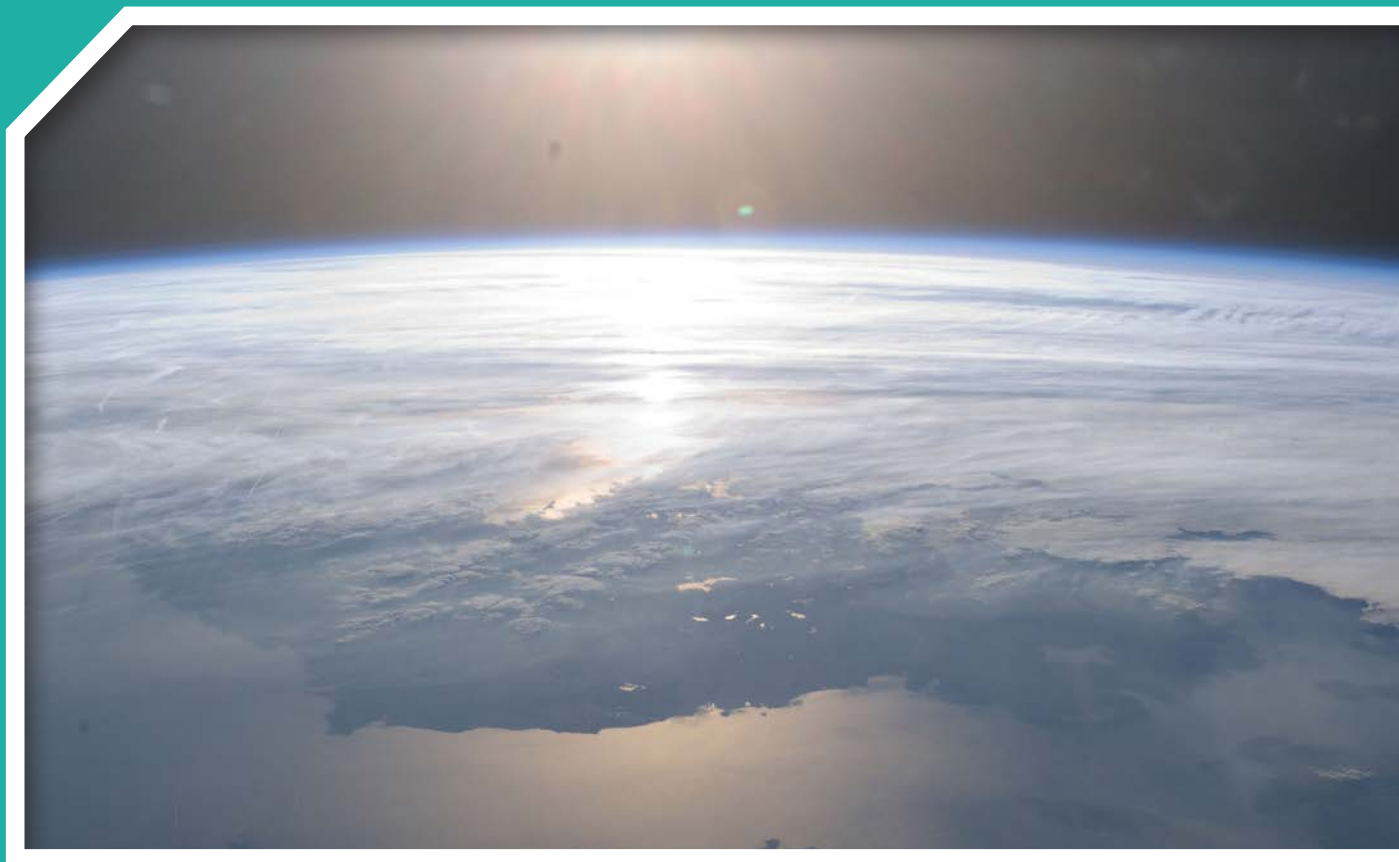

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Rialtas na hÉireann
Government of Ireland

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. We are committed to protecting people and the environment from the harmful effects of radiation and pollution.

The work of the EPA can be divided into three main areas:

Regulation: *We implement effective regulation and environmental compliance systems to deliver good environmental outcomes and target those who don't comply.*

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Advocacy: *We work with others to advocate for a clean, productive and well protected environment and for sustainable environmental behaviour.*

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We regulate the following activities so that they do not endanger human health or harm the environment:

- waste facilities *(e.g. landfills, incinerators, waste transfer stations)*;
- large scale industrial activities (*e.g. pharmaceutical, cement manufacturing, power plants)*;
- intensive agriculture *(e.g. pigs, poultry)*;
- the contained use and controlled release of Genetically Modified Organisms *(GMOs)*;
- sources of ionising radiation *(e.g. x-ray and radiotherapy equipment, industrial sources)*;
- large petrol storage facilities;
- waste water discharges;
- dumping at sea activities.

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- Conducting an annual programme of audits and inspections of EPA licensed facilities.
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- Supervising the supply of drinking water by public water suppliers.
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- Monitoring and reporting on the quality of rivers, lakes, transitional and coastal waters of Ireland and groundwaters; measuring water levels and river flows.
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- Monitoring and reporting on Bathing Water Quality.

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- Funding environmental research to identify pressures, inform policy and provide solutions in the areas of climate, water and sustainability.

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- Providing advice and guidance to industry and the public on environmental and radiological protection topics.
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- Advising Government on matters relating to radiological safety and emergency response.
- Developing a National Hazardous Waste Management Plan to prevent and manage hazardous waste.

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- Generating greater environmental awareness and influencing positive behavioural change by supporting businesses, communities and householders to become more resource efficient.
- Promoting radon testing in homes and workplaces and encouraging remediation where necessary.

Management and structure of the EPA

The EPA is managed by a full time Board, consisting of a Director General and five Directors. The work is carried out across five Offices:

- Office of Environmental Sustainability
- Office of Environmental Enforcement
- Office of Evidence and Assessment
- Office of Radiation Protection and Environmental Monitoring
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet regularly to discuss issues of concern and provide advice to the Board.

EPA RESEARCH PROGRAMME 2014–2020

An Operational Climate Information Platform for Ireland: Summary Report

(2016-CCRP-MS.32)

EPA Research Report

End of project report available for download on http://erc.epa.ie/safer/reports

Prepared for the Environmental Protection Agency

by

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Executive Summary

This report summarises work done to create an operational Climate Ireland platform for the Environmental Protection Agency as part of ICIP3, which is the third phase of the Irish Climate Information Platform. A scalable, maintainable and operational Climate Ireland platform was created and documented.

A workflow was created to process the results of additional analyses and simulations. Additional datasets were added to the platform, including frost days, growing season, precipitation extrema, soil moisture and trafficability, which are expected to be useful in determining the agricultural effects of climate change in Ireland.

1 Aims

The aims of this project were to make an Operational Climate Information Platform (OCIP; www.climateireland.ie), to be:

- scaled to a large number of users;
- maintained operationally, i.e. updated, kept secure and rebuilt in the event of any issues;
- developed continuously, without affecting the operational implementation;
- expanded with new datasets added.

This work was the result of a collaboration between the Irish Centre for High-End Computing (ICHEC) and the Centre for Marine and Renewable Energy (MaREI), and the previous implementation, which operated on a single system, was implemented as a set of services at ICHEC to enable it to be scaled for more users and more data and to be more robust against intrusion and hacking. This meant moving from having the services on a single server to having the services on multiple virtual machines (VMs), which can be replicated quickly to scale with load, recreated quickly if damaged (accidentally or maliciously) and distributed to enable resilience. ICHEC operates multiple VM servers, geographically distributed, to do this for the multiple services it operates.

The primary VM server used was cetus.ichec.ie, which is based at the University College Dublin (UCD) Computer Centre. In addition, ICHEC operates other VM services at Telecommunications Software and Systems Group (TSSG) in Waterford and at Amazon Web Services (AWS) in Dublin, and it can use its main computer, fionn.ichec.ie, as required. The main report documents how this was done, in sufficient detail to enable a third party to re-implement.

These VMs are configured using a service called Salt and are monitored by Nagios. These are services that are used throughout ICHEC and they are also widely used worldwide. The configuration service Salt enables the user to create new machine instances on demand, either to scale (by adding new web server instances in the event of load; this is transparent to the user) or to recover (in the event of accident or malicious damage). Nagios is an industry-standard monitoring framework that informs the administrators of issues, such as load, disk full, hacking attempts and day-to-day maintenance, such as website certificate expiry and link checking.

2 Portals

There are three separate deployments of the portal in operation:

- Production (https://www.climateireland.ie): a public portal available to all public users.
- Development (https://int.climateireland.ie): a secondary portal to allow limited public beta testing of new developments.
- Integration (https://dev.climateireland.ie): an integration portal for testing the new code internally.

3 Virtual Machines

The graphic in Figure 3.1 represents how the VMs (and services) are connected.

The servers are web servers (“web”) and map servers, the latter of which produce maps seen within the mapping tools on the website, but these can be made available elsewhere (e.g. via ArcGIS, Google Earth) if desired. In addition to these, there are database servers that hold the map information and, for development, a subversion repository (holding the code) and “Jenkins” continuous testing and integration server. There are also production, development and integration versions of the web server and database.

The various services are provided by nine VMs, which run on the ICHEC storage and virtualisation infrastructure:

- icip3-dev-db1.ichec.ie [two cores, 2GiB random-access memory (RAM), 50 GiB disk] (Debian Jessie);
- icip3-dev-web1.ichec.ie (four cores, 4GiB RAM, 50 GiB disk) (Debian Jessie);
- icip3-int-db1.ichec.ie (two cores, 2GiB RAM, 50 GiB disk) (Debian Jessie);
- icip3-int-web1.ichec.ie (four cores, 4GiB RAM, 50 GiB disk) (Debian Jessie);

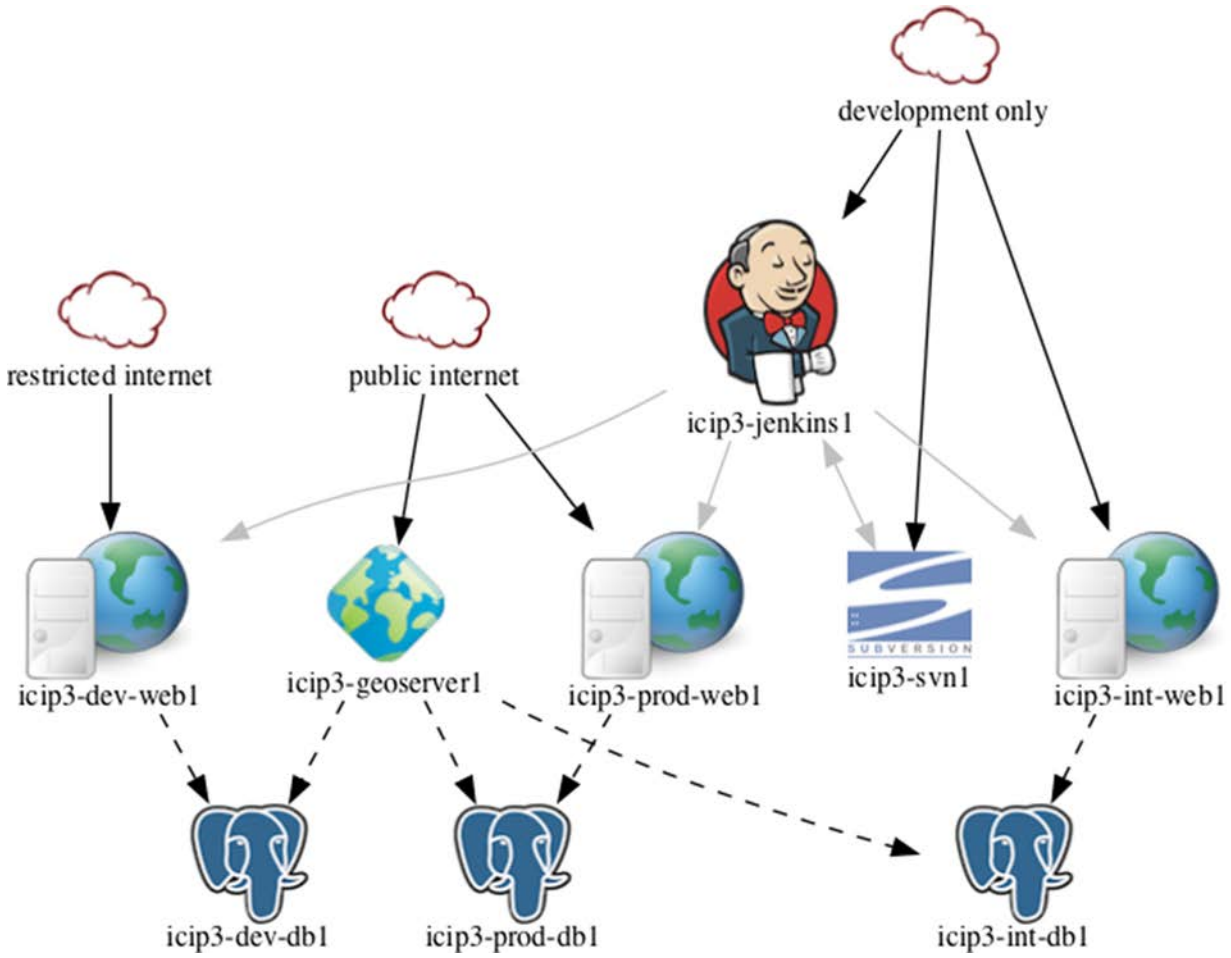

Figure 3.1. Component VMs and connections. The solid black lines represent HTTP(S) access, the dashed black lines represent PostgreSQL connections and the solid grey lines represent workflow automation. For simplicity, not all information flows are described.

- icip3-prod-db1.ichec.ie (two cores, 2GiB RAM, 50 GiB disk) (Debian Jessie);
- icip3-prod-web1.ichec.ie (four cores, 4GiB RAM, 50 GiB disk) (Debian Jessie);
- icip3-geoserver1.ichec.ie (eight cores, 4GiB RAM, 50 GiB disk) (Debian Stretch);
- icip3-jenkins1.ichec.ie (two cores, 4GiB RAM, 50 GiB disk) (Debian Jessie);
- icip3-svn1.ichec.ie (two cores, 2GiB RAM, 50 GiB disk) (Debian Jessie).

Two of these systems are then accessible to the public via aliases (www.climateireland.ie directs to icip3-prod-web1.ichec.ie and geoserver.ichec.ie directs to icip3-geoserver1.ichec.ie). Currently, Geoserver is not advertised and supported by ICHEC outside of this project and some development prototypes. Note that by design, additional instances of the services (e.g. icip3-prod-web2.ichec.ie, icip3-geoserver2.ichec.ie) may be started within minutes by using Salt configuration tools to handle extra load. In this case, Domain Name System (DNS) round-robin is used to load-share the work, e.g. www.climateireland.ie alternately points to icip3-prod-web1 and icip3-prod-web2. This requires an additional load balancer service, which can be added as required.

4 Additional Services at ICHEC

The ICIP3 project also makes use of a number of pre-existing ICHEC services. These services supplement the standard functionality, but their presence is not necessary for successful operation. Their configuration is beyond the scope of this report.

Each ICIP3 VM is backed up to ICHEC's central tape backup facility, using Bacula for disaster recovery purposes. Full backups are carried out monthly, with incremental backups nightly. ICHEC operates an email-based support system called "RT". Problems and requests can be submitted by email (typically addressed to support@ichec.ie) and issues are then tracked, assigned to staff members and handled. This is the primary database for user issues.

Multiple queues are handled within RT. For ICIP3, we use a project-internal queue, ICIP and a public issue queue, "Support".

As bugs are fixed and configurations on systems are changed, they are logged on an ICHEC database called "Mantis". This is an internal tracking system for all changes made to ICHEC systems and all faults.

4.1 RT Web Application for Issue Tracking

Neither RT nor Mantis are documented here, as they are not specific to ICIP3 and can be replaced without changing the ICIP3 implementation (Figure 4.1).

4.2 Monitoring

Each ICIP3 VM is monitored by ICHEC's central Nagios server. We monitor:

- free disk space availability;
- security updates;
- SSH access (should be accessed only by authorised staff, for development);
- web and Geoserver access and usage;
- SSL certificate validity.

Logging messages are also sent from the systems to a standard "syslog" facility at ICHEC for debugging.

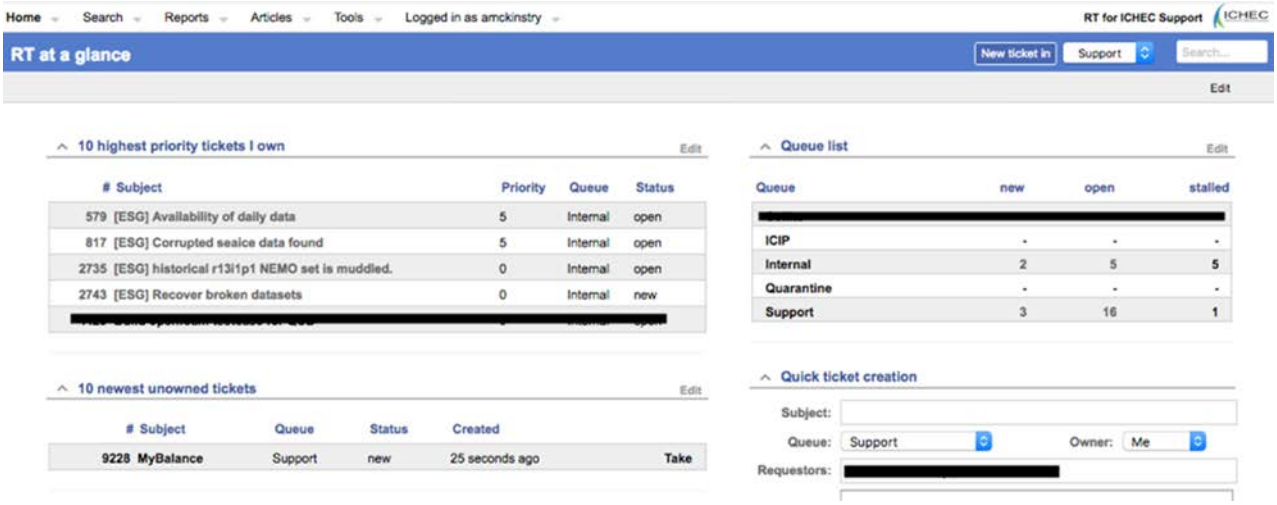

Figure 4.1. Screenshot of the RT Issue Tracking tool.

4.3 Scaling

The web front-end was tested using standard load-testing tools and scripts (wget-based parallel loads) to simulate 50 simultaneous users. Additional users can be supported as necessary by adding additional instances of the website, icip3-prod-web.ichec.ie, using SaltStack. The system was monitored during a training exercise run by MaREI with 35 real users; the load was as expected compared with automated testing.

Currently, the PostgreSQL database has approximately 14 million records, fitting comfortably into 2 GB of RAM. Furthermore, 16 GB of RAM proved to be sufficient to scale the database to 200 million records if required.

4.4 Earth System Grid Federation Portal

The ICHEC operates the Irish node for the Earth System Grid Federation (ESGF) (Williams *et al*., 2009) (https://esgf.llnl.gov/). This service provides a portal on which climate model data can be accessed and downloaded (Figure 4.2). ICHEC currently holds approximately 200 terabytes (TB) of data for the (EPA-funded) Coupled Model Intercomparison Project 5 (CMIP5), CORDEX and Irish Hi-Resolution Downscaling projects.

Files on the ESGF may be “discovered” at any of the portal instances (searching is currently disabled at the Irish node and several others while a fix for a security flaw is finalised). The discovered files can then be either downloaded individually or in bulk or accessed directly from the in-built THREDDs service using the Directory Access Protocol (DAP).

Within ICIP3, the Geoserver can be configured to download files from the ESGF THREDDs server. Currently, this is done when image tiles are generated on the Geoserver.

The ESGF node at ICHEC (http://esgf.ichec.ie) is currently being upgraded to handle additional datasets for CMIP6 (approximately 1 petabyte, PB, of additional files are expected to be generated at ICHEC). As a research tool ESGF comes under heavy load sporadically and, for reliability, the data used by Geoserver will continue to be cached in the database nodes rather than read directly from ESGF.

4.5 Geoserver

One issue of current concern is the heavy load the current portal design places on the Geoserver (map server) and database when querying the mapping tool.

Existing datasets were present at 4–7 km resolution, which is sufficient for the nature of mean temperature, precipitation and wind variables. Additional datasets, such as soil moisture and precipitation extremes, provide useful information at 1 km resolution, and this is the probable resolution for all future presentations. Moving to this higher resolution has put stress on Geoserver architecture.

The current design creates a very complex shape query for Ireland (generated from OpenStreetMap), which queries for primitives at 1 km resolution, to build the map in an active manner. The front-end code in the browser currently presents multiple datasets as a single layer, created from 1 km polygons on the map, simplifying the web front-end code. However, this creates very large queries (several megabytes or MB) and the generated maps bypass the caching capabilities of Geoserver, causing scaling issues on the geoserver.

ICHEC has ameliorated this by adding extra processing as necessary during demonstrations and by using Oracle Java rather than the OS-supplied Java, which speeds up the process fourfold but requires greater maintenance (hand-applied patches, etc.).

Furthermore, we expect some users to avail of the maps beyond the portal, within geographic information system (GIS) tools, such as ArcGIS and GRASS GIS, to overlay the map layers with other datasets, such as roads and power lines. This currently will not be allowed until the Geoserver issues are resolved. ICHEC and MaREI are working on testing caching methods to resolve this. Currently, we can handle “classroom” demonstrations of ~50 users, as long as all users are not viewing high-resolution maps simultaneously; we aim to be able to handle the “9 o’clock news” scenario of thousands of new users when the public explores the site simultaneously.

Figure 4.2. Screenshot of the Earth System Grid Federation portal.

The workflow at MaREI involved ingesting map elements as CSV rows. In addition, it was decided to prepare the datasets as NetCDF files for examination by scientists. The NetCDF files were then presented on the Earth System Grid, allowing additional metadata that were not available in the Geoserver maps to be provided, in particular tracking IDs, comments, history and references. Furthermore, it allows automatic traceability to the originating global model ensemble member and downscaling model to be used.

5 Third-party Libraries

The ICIP portal relies on a number of third-party libraries and packages (i.e. code neither written by MaREI and ICHEC nor supplied by the Operating System, Debian). For operational systems, each piece of software that a hacker may reach needs to have a security maintenance policy, e.g. it is maintained by either the original author (e.g. the code written MaREI) or the OS (which supplies updates as necessary). Third-party code lacks this, which is a potential security issue because it is possible that vulnerabilities are discovered in this code that can be exploited to hack and hijack the portal (a previous example of this is when the “Solr” third-party library used for Search was used to hijack the ESGF-federated websites).

Therefore, as site maintainers, ICHEC undertook to fix this. The THREDDs, Geotools (for NetCDF and other libraries) and Geoserver software packages providing multiple Java Archive (JAR) files needed in the Climate code were packaged for Debian Linux. The Debian Security team get alerted privately whenever vulnerabilities are discovered in Debian packages (see https://www.debian.org/security/). Alastair McKinstry, as a Debian maintainer, then gets alerted and fixed versions of the package are then prepared before the vulnerability is disclosed, hence minimising the risk of the portal being hacked.

The packages are awaiting integration into the main Debian repository; this depends on inclusion of build tools (Gradle) into Debian. In the interim, the packages are available in the Debian source repository.

Along with the move from Google Maps to OpenLayers for the presentation code used by MaREI, this eliminated most of the third-party libraries needed, as Openlayers provides the Javascript layers needed for the front end.

6 Additional Dataset Processing

A “processing pipeline” was created to add additional datasets to the portal. ICHEC publishes climate model and observation datasets.

Additional datasets were added to the Climate Information portal based on work done at ICHEC, Met Éireann and Teagasc. These were based on regional downscaling simulations, driven by two rounds of global climate simulation results (CMIP3 and CMIP5; ICHEC is currently engaged in the CMIP6 round of global simulations with the EC-Earth model).

Observational datasets for the decades 1980s, 1990s and 2000s are also available as a baseline; these are typically “downscaled” using the regional models to calculate variables, such as evapotranspiration, that were not observationally available.

The datasets were stored in post-processing in two forms: a CSV-formatted database input for ingestion into the PostgreSQL server used in ICIP3 and NetCDF files. These NetCDF files were formatted to CMOR/Climate Conventions “CF-1.6” standard (required for publication on the ESGF node) with DRS-formatted names (also required). They were processed onto an Irish Transverse Mercator (ITM) projection, downscaled to 4 km to match the datasets already in use on ICIP3. These NetCDF files are then ingested into the Geoserver map server; the maps produced are then suitable to be published as mapping layers to GIS tools, such as ArcGIS, outside the Climate Information portal as desired, as well as to be used within the portal itself.

It is worth noting that the presentation format used at ICIP is slightly different from CORDEX and other ESGF datasets: the data are formatted as “seasonal averages over a decade”, e.g. “Spring, 2020s” is the mean over the months February, March and April for the years 2010–2019 and is a single data value for the decade. Within CORDEX/CMOR definitions, “seasonal_mean” (abbreviated “sem”) files contain one data point per season over the decade, i.e. 40 data points. Hence, a new time frequency category “season” was created to match ICIP usage.

Within ICHEC and the modelling community generally, NetCDF is the preferred format, with multiple tools available for examining these files. The CSV data processing has proven to be error prone; it could only be examined visually within the ICIP workflow (generated by ICHEC, examined by MaREI), without good checking available for processing errors. Hence, it is recommended to move to the NetCDF-based workflow, allowing better validation at ICHEC (including viewing at the ESGF server and mathematical checks).

Although the new datasets generated within the project have been created using the NetCDF-based workflow, existing datasets have not yet been converted; doing so adds additional metadata (processing history, references, tracking IDs, etc.) needed for CMOR standards but which are not originally present, and this is a work in progress. Links are being added to the portal so that users can track the original datasets that the map images are generated from. In addition, the MERA dataset from Met Éireann (Gleeson *et al*., 2017) will be published to match the observation set used at www.climateireland.ie.

Work on the ESGF server has recently been quiet, as it mostly hosts data from the CMIP5 experiments of 2011–2013. Work is now ramping up as CMIP6 is starting production. The underlying storage will be updated with a move to WOS object-based storage, which is planned to take place as the warranty on existing hardware expires. This will also allow the speedup needed for new volumes.

The long-term funding future for the Earth System Grid and climate model data publishing in Ireland has yet to be secured. ICHEC is submitting a Science Foundation Ireland (SFI) research infrastructure application for a national data infrastructure to enable this and is seeking support for this bid.

6.1 Hydrometeors and Temperature

The following datasets were added to give a more meaningful presentation of climate change effects

than the current annual temperature and precipitation provide:

- number of consecutive dry days (CDDs);
- number of CDD periods of more than 5 days;
- number of consecutive wet days (CWDs);
- number of CWD periods of more than 5 days;
- number of frost days;
- length of thermal growing season (period of > 4°C grass temperature);
- number of days with > 10 mm rainfall;
- number of days with > 5 days consecutive rainfall.

These were derived from the modelling results of Dr Paul Nolan (2015).

6.1.1 Soil moisture deficit

Observational soil moisture deficit was calculated for the observational period (1980–2005) from the regional downscaled models Weather Research and Forecasting Model (WRF) 3.1 and the Consortium for Small-scale Modelling (COSMO). The models were driven by ERA-Interim (Dee *et al*., 2011).

Soil moisture deficit model

The hybrid soil moisture deficit (SMD) model developed at Met Éireann (Schulte *et al*., 2005) was used. This accounts for differences in drainage regimes between different soil types in Ireland. There are three soil drainage classes, namely well drained, moderately drained and poorly drained.

The SMD is calculated as follows:

$$SMD_t = SMD_{t^{-1}} - Rain + ET_a + Drain \quad (6.1)$$

where SMD_t and $SMD_{t^{-1}}$ are the SMDs on day t and day t^{-1}, respectively (mm), *Rain* is the daily precipitation (mm/d), ET_a *is* the daily actual evapotranspiration (mm/d), and *Drain is* the amount of water drained daily by percolation and/or overland flow (mm/d).

Drainage (*Drain*) is the amount of water lost from the topsoil through either percolation or overland flow and is dependent on the soil drainage capacity.

The potential evapotranspiration, ET_0, is calculated according to the Food and Agricultural Organization of the United Nations (FAO) Penman-Monteith equation (Allen *et al*., 1998) for a reference grass crop at an assumed height of 0.12 m:

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad (6.2)$$

where ET_0 is the potential evapotranspiration (mm d^{-1}), R_n is the net radiation at the crop surface (MJ m^{-2} d^{-1}), G is the ground heat flux density (MJ m^{-2} d^{-1}), T is the air temperature at 2 m height (°C), u_2 is the wind speed at a height of 2 m (m s^{-1}), e_s and e_a are the saturation vapour pressure and the actual vapour pressure, respectively (kPa), Δ is the slope of the vapour pressure curve (kPa °C^{-1}) and γ is the psychrometric constant (kPa °C^{-1}).

The SMD is defined for different soil types in Ireland:

- *Well drained:* Soil never saturates, remains at field capacity, even on very wet days in winter. Minimum SMD is 0 mm. When SMD > 0 mm, actual evapotranspiration (*AE*) is less than potential evapotranspiration (*PE*), decreasing linearly to 0 mm when SMD is at a theoretical maximum of 110 mm.
- *Moderately drained:* May saturate on wet winter days, but returns to field capacity on first dry day. Minimum SMD is –10 mm. When SMD > 0, *AE* is less than *PE*, decreasing linearly to 0 mm when SMD is at a theoretical maximum of 110 mm.
- *Poorly drained:* Saturates on wet winter days and water surplus is drained at very slow rates, in the order of 0.5 mm per day. Minimum SMD is –10 mm. When SMD > 10 mm, *AE* is less than *PE*, decreasing linearly to 0 mm when SMD is at a theoretical maximum of 110 mm.

For each soil drainage class, a critical SMD, SMD_c, is defined. When the current SMD is less than this critical value, moisture is not limiting respiration and *AE* equals *PE*:

When SMD ≤ SMD_c:

$$AE = PE \quad (6.3)$$

When the current SMD is greater than this critical value, moisture availability is no longer unlimited; as a result, *AE* is less than *PE*. In this case, it is assumed that *AE* decreases linearly to 0 mm as the SMD approaches a theoretical maximum value, SMD_{max}.

When SMD > SMD_c:

$$AE = PE \cdot \frac{SMD_{\max} - SMD_{t-1}}{SMD_{\max} - SMD_c} \quad (6.4)$$

The value of SMD_c is 0 mm for well and moderately drained soils and 10 mm for poorly drained soils. The value of SMD_{max} is 110 mm for all three soil types. Soil moisture deficits and surpluses are computed from the differences between rainfall and *AE*. Soil moisture surpluses are assumed to be removed by drainage and surface run-off over time.

Daily SMD and calculated *PE* and *AE* were calculated by Chris Werner at ICHEC at 4 km resolution (personal communication, 2017). These were then processed for each soil type and published for each of the decades 1980s, 1990s and 2000s, for both WRF and COSMO regional downscales. They are available on the integration portal and are awaiting scientific assessment before being openly published.

6.1.2 Trafficability

One weakness in the thermal growing season as a measure for potential agricultural productivity is that, although the ground may be warm enough for grass growth, it may also be flooded and unworkable. To answer this, Teagasc came up with a measure called trafficability (Vero *et al*., 2013). This is the period for which the ground is workable by tractor, defined as the period when the SMD exceeds 10 mm.

The standard tool “CDO” (Climate Data Operators) was extended to produce “trafficability”, the number of days where SMD exceeds the threshold, from SMD. These results were then calculated for annual and seasonal averages for the decades 1980s, 1990s and 2000s. Trafficability was calculated for poor, moderately drained and well-drained soils; no significant differences were seen and the moderately drained data will be used as representative.

The results are visible in the integration version of the portal, as they are still being scientifically validated at ICHEC by Dr Paul Nolan and Chris Werner.

6.1.3 Other datasets

- Precipitation variability, e.g. estimated maximum rates for winter storms.
- Frost days.
- Growing days.
- Trafficability (ability to work a field, based on soil moisture and temperature).
- River runoff.
- Soil temperatures (vs 2 m temperatures).

These datasets were available from downscaling and were investigated. The runoff and soil moisture variables had been recorded for the global models (EC-Earth, HadGEM-ES) only and were found not to be useful at ~125 km resolution. They were not saved for the existing downscaling models, but are being saved for current runs at ICHEC, and it is expected that we will publish these in due course when the CMIP5 (RCP2.5) and CMIP6 ensemble runs are completed. Similarly, land use and land change datasets at 125 km were not detailed enough to be worth publishing for Climate Ireland.

Likewise, insolation and cloud changes were not available for the full period, but are being saved in current runs and will be published in the future. Sea level change was not recorded by any model, and wave climatology was not received from Met Éireann in time to be included, but may be processed at a later stage.

As a workflow for the current simulation work at ICHEC (extending previous CMIP5 downscaling to include the RCP2.6 scenario, high-resolution EC-Earth 3.1 global modelling and follow-on downscaling for Ireland; observational analysis of hydrometeors) is now working, it is anticipated that all of the results from these projects will be published on ESGF at ICHEC and then processed for the Climate Information portal and Geoserver as they become available.

7 Conclusions and Further Work

Work is ongoing to process new datasets, adding datasets to the Climate Ireland portal and ESGF as they become available. This includes the upcoming global climate model results for EC-Earth (CMIP6), downscaling multimodel ensembles for Ireland (RCP2.6 scenarios) and additional validated hydrometeors. Updated ESGF files and hydrometeors were completed in May 2018, with RCP2.6 expected to be processed and ready by Q3 2018. CMIP6 runs were started in June 2018, are expected to be validated in Q3 2018 and to be available for publication and downscaling by the end of 2018.

Additional work is needed, and is under way, to scale the Geoserver mapping layer. This includes enabling caching and image pyramids, splitting the work over multiple Geoserver instances and other work under way at MaREI. Sharing work over multiple instances is currently being tested, with testing of cache code changes due before the end of July 2018.

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Abbreviations

AE	Actual evapotranspiration
CDD	Consecutive dry day(s)
CMIP	Coupled Model Intercomparison Project
COSMO	Consortium for Small-scale Modelling
CWD	Consecutive wet day(s)
DNS	Domain Name System
ESGF	Earth System Grid Federation
GiB	Gibibyte
GIS	Geographic information system
ICHEC	Irish Centre for High-End Computing
MaREI	Centre for Marine and Renewable Energy
OCIP	Operational Climate Information Platform
PE	Potential evapotranspiration
RAM	Random-access memory
SMD	Soil moisture deficit
SSH	Secure shell
SSL	Secure sockets layer
VM	Virtual machine
WRF	Weather Research and Forecasting Model

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL
Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaol a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: *Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.*

Eolas: *Soláthraímid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírithe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.*

Tacaíocht: *Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaol atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaol inbhuanaithe.*

Ár bhFreagrachtaí

Ceadúnú
Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaol:
- saoráidí dramhaíola *(m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola)*;
- gníomhaíochtaí tionsclaíocha ar scála mór *(m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta)*;
- an diantalmhaíocht *(m.sh. muca, éanlaith)*;
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe *(OGM)*;
- foinsí radaíochta ianúcháin *(m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha)*;
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil
- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Uisce
- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uiscí idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaol
- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil *(m.sh. tuairisciú tréimhsiúil ar staid Chomhshaol na hÉireann agus Tuarascálacha ar Tháscairí)*.

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn
- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil
- Taighde comhshaoil a chistiú chun brúnna a shainaithint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta
- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaol in Éirinn *(m.sh. mórphleananna forbartha)*.

Cosaint Raideolaíoch
- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas
- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaol ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaol *(m.sh. Timpeall an Tí, léarscáileanna radóin)*.
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosc agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta
- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil
Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:
- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- Oifig um Chosaint Radaíochta agus Monatóireachta Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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An Operational Climate Information Platform for Ireland: Summary Report

Authors: Alastair McKinstry and Eoin McHugh

Identifying Pressures

Information on climate change and options for adaptation can be complex and inaccessible to key stakeholders and decision makers. This project has developed an Operational Climate Information Platform (OCIP) to disseminate the current data and guidance on climate change for Ireland. New datasets have been derived and published; these show that precipitation and temperature extremes in the form of continuous heavy precipitation days, land usability and soil moisture deficits show greater variability and impacts on Ireland than average temperature and precipitation do.

Informing Policy

The online resource can inform planning and policy development across all sectors and regions. The new datasets – on soil moisture deficits, frost days, thermal growing season and land trafficability under projected climate change scenarios for Ireland, in particular – can inform agriculture and land use change policy. Although average temperature changes of 1–2 degrees may not seem immediately significant, this is seen to translate to an extended growing season of up to 35 days in high emission scenarios. This, however, is tempered by water saturation in winter, which makes warmer temperatures irrelevant, as the land is unusable. By plotting the land trafficability measure developed by Teagasc, we can see map-relevant changes that can inform agricultural planning.

Developing Solutions

The project developed an OCIP based on previous work by project partners in MaREI (marine and renewable energy research, development and innovation centre supported by Science Foundation Ireland). The platform is scalable and maintainable, and additional workflows created during the project make it possible to continuously update the platform with the new data that are generated from operational observation systems and research. Improved modelling of climate change for Ireland is under way (with Representative Concentration Pathways (RCP) 2.6 emissions scenarios and model updates for the Coupled Model Intercomparison Project Phase 6, (CMIP6)), and the platform, as implemented, will make it possible to readily upload the updated analysis and has been made accessible to policymakers, decision makers and the general public.

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