Met Office
Public Weather Service
2019/20
Annual Report

Summary

The Met Office has a successful 2019/20 delivering the PWS CSA with all PWS Performance Measures met (7 out of 7) at the end of the year. This included delivering at least 12 of the 14 milestones, with one milestone slightly delayed due to impacts of Covid-19.

There were notable extremes of weather during the year. In particular, the highest UK maximum temperature recorded of 38.7C at Cambridge Botanical Gardens on 25th July 2019 during a summer which saw many other European countries break their national maximum temperatures records. Severe weather impacts were primarily around flooding, especially in the Midlands and northern England during the summer and autumn, and in South Wales and many other parts of the country in February, which was the wettest February for the UK in a series dating back to 1862.

Highlights include:

- High levels of warnings accuracy during the severe flooding episodes associated with Storms Ciara and Dennis during the period 9th-16th February 2020. Nine amber warnings and one red warning were issued during this period with all assessed either Excellent or Good. (The red warning in South Wales was rated Excellent.)
- Action taken by the public in response to severe weather has continued to increase over the past year. Awareness of the warnings associated with Storm Ciara and Dennis was very high (around 90%) whilst the proportions of people taking action in response to these warnings was also very high (70% and 58% respectively) illustrating the continued effectiveness of the warnings service.
- Improvements to temperature forecasts were implemented using a machine learning algorithm in a major model upgrade in November 2019. At the end of the year, the forecast accuracy metric shows improvements or existing high levels of accuracy for all verified parameters, reversing some problems with maximum temperature forecasts seen since the hot summer of 2018.
- A new digital responder panel has been set up to improve user engagement and speed up new product development for civil contingencies.
- The Met Office for Schools was launched in June 2019 providing curriculum materials for teaching weather related topics to 7 to 14 year olds, helping us inform a younger demographic on the impacts of severe weather.
- A new site showing more detailed meteorological output for enthusiasts has been developed and shared as a private Beta, with the public Beta ready to launch imminently.
- Significant progress has been made in both the processes and capability for making large datasets available for re-use, including sub-setting.
- Internationally, we succeeded in agreeing structural changes to the WMO at its quadrennial Congress, and had UK representatives appointed to influential positions, including Penny Endersby onto the WMO Executive Council.
- The Met Office has responded well to the challenge presented by Covid-19 in March 2020 and successfully transitioned to be a remote-working organisation in only a few days. Whilst there has been a small reduction in PWS public content as a result, all the PWS critical for life services have continued with no impacts.

Summary of Performance Measures

PWS Performance Measure	Delivery Status	Comments
PPM1- Warnings 75% of Amber and Red warnings provide "Good" or "Excellent" guidance.	Met	This reporting period included several spells of high profile severe weather, most notably the widespread flooding in February due to Storms Ciara and Dennis. Up until February however, there had been fewer instances of 'warnable' weather than usual, especially in late autumn and early winter. This led to a temporary dip in the PPM1 score due to good/excellent warnings from 2016/17 falling out of the three-year averaging window. But the high number of warnings in February, almost all rated as good or excellent, meant that the target was comfortably met by the end of the FY.
PPM2 – Public Protect and consolidate digital market position and achieve targeted growth of Met Office digital channel reach. Measured by: i)Web market share from digital analytics ii)Mobile app downloads & active users iii)Social media engagement, particularly from new audiences	Met	Average direct reach and indirect reach grew over the period, digital channels (as a source for weather information) overtook traditional TV (64% vs 54%), TV continues to decline along with printed media. Met Office website maintained its digital web market share at 20% largely due to the delivery of a new responsive site. Met Office app downloads increased by an impressive 46%; active users increased by 21% and both Android and iOS achieved a minimum 4.5-star average rating throughout the year. Total social media followers increased by 14% to 1.4m. The launch of the Met Office for Schools programme and a new social media channel TikTok has increased engagement from younger audiences. Covid-19 and the introduction of benign weather in the last quarter saw a drop in reach and engagement of both indirect and direct channels.
PPM3 – Civil Contingencies PWSCG review and assessment	Met	The 2019 Emergency Responder Survey highlighted widespread satisfaction with our services for Civil Contingencies. 78% of responders surveyed were 'very satisfied' with our Advisor team, especially the local knowledge they bring to planning and response around severe weather. The February floods saw the busiest period ever for the team, and its collective performance in delivering hundreds of briefings to regional and national resilience groups was praised by Cabinet Office. In the international arena, the team also contributed significantly to FCO planning and response around Hurricane Dorian and its effects on the Overseas Territories.
PPM4 – Data PWSCG review and assessment	Met	The majority of the Data Performance Indicators (volume of data supplied, number of users, service availability) have shown positive trends across the year and revenue collected from sales is very comparable to last year.

PPM5 – International PWSCG review and assessment	Met	The Met Office has regularly reported to the PWSCG throughout the year on progress within the International Commitments and the recent meeting of the PWS Assurance Group recommended that PPM5 had been met. More detail of the activity within the international organisations is included below.
PPM 6 – National Capability Year on year improvements in forecast accuracy	Met	This PPM requires at least 80% of the public forecast accuracy metrics to be improving or holding steady if already performing at a high level. At the end of the year all 24 of the metrics have reached the criteria, meaning that performance has increased for all variables in the past three years, with the exception of Day 5 maximum temperature which is within 1% of the level in March 2017.
PPM7 – Overall delivery of milestones (11 out of 14 achieved)	Met	The Met Office has delivered 12 of the 14 milestones in line with the CSA. The enthusiast site (Milestone 2.1) was slightly delayed going fully operational due to the need to restrict changes as a result of Covid-19 impacts. Only one milestone was missed – the delivery of the new post-processing system, IMPROVER (Milestone 6.2).

Milestones and Additional Information by Theme

Theme 1: Warnings

Milestones	Delivery Status	Comments
1.1 Implement an operational nowcasting capability for convective events within the Operations Centre **March 2020**	Met	Resources were made available to stand up a 'convective forecasting' position within the Operations Centre Guidance Unit during Summer 2019, trialling a number of new techniques, data sources and potential products to improve short-period thunderstorm forecasting. Advanced training in these new techniques was also successfully rolled out across Guidance. This resource is now available again on an operational footing for the 2020 season, despite the current COVID restrictions. As part of a wider Strategic Action on 0-2 hour forecasting, there is ongoing work to explore applications of this new capability, such as through a prototype Met Office/EA surface water briefing tool.
1.2 Review how storm naming is affecting the response and awareness of warnings. **October 2019**	Met	Based on a literature search of recent studies on the effectiveness of storm naming, a report was submitted to the PWSCG in October 19. The report confirmed that Storm Naming is a powerful tool for enhancing warnings around severe weather, particularly if coordinated with partners through social and conventional media. The report made recommendations to ensure PWSCG maintains a strong stake in naming activities, through annual reports and engagement with the PWSCG Media and Reach Group.

Theme 2: Public

Milestones	Delivery Status	Comments
2.1 Deliver an "enthusiast offer" on the external website target at weather enthusiasts. **March 2020**	Slightly delayed	A private beta version of 'Global Map' the new visualisation service for weather enthusiasts, was developed and delivered to the 600 target users who tested and provided feedback on the site. Due to COVID-19 and the increased risk to the organisation in delivering operational services, we entered a Period of Restricted Change (PoRC) which stopped all non-essential digital updates. This means that the new service can only be accessed via a link and not directly on the Met Office website at the time of writing, but this should be resolved very shortly.
2.2 Deliver a programme of work to analyse and address user feedback produced by the responsive web project. Present outcomes of analysis and make recommendations to address feedback and increase user satisfaction. **August 2019**	Met	Over 100,000 pieces of feedback were received and analysed by the web team. This analysis provided clear evidence and areas for improvement which were compiled in a report and presented to the PWSCG. Improvements implemented so far include: • Giving users more control around parameters • Highlights Card, making language more human • Improved SEO content model for tagging & serving content dynamically • Improving accessibility, speed and understanding • More details section, adding extra information about the weather story • Backend development to improve speed of development

Library & Archive (L&A): The National Archive (TNA) re-affirmed the Library and Archive's on-going status as a TNA Accredited service following a mid-term audit. Reach and engagement has continued to be a major focus with on-going collaborations with other organisations and events - most notably this year with the Royal Society which saw the launch of 'Stormy Weather: From Lore to Science' at the Royal Society in February 2020 following 18 months of preparation. The Digital Library and Archive has seen over 717,000-page views this year which represents an 89% increase year-on-year and is a result of transferring content from the Met Office L&A pages to the archive as well as the addition of new content. This resource is enabling the L&A to continue to provide an operational service despite the closure of our physical resources due to COVID-19 restrictions. 99% of library & archive enquiries were answered within 5 working days. Huge progress made with the transfer of records from MO Edinburgh to National Records for Scotland.

Theme 3: Civil Contingency

Milestones	Delivery Status	Comments
3.1 Report on the effectiveness of hot and cold campaigns during 2017 and 2018 with	Met	Report submitted to PWSCG October 2019, focussing on survey results and feedback from the spells of extreme heat in summer 2019. The core proposal – to develop an extreme

recommendations for future development. **October 2019**		heat warning within NSWWS by summer 2021 in close coordination with PHE and other partners – was accepted by the CG. Work is now ongoing to develop this service.
3.2 Hazard Manager moved to new Cloud-based platform **February 2020**	Met	A new cloud-based Hazard Manager, with a radically redesigned architecture, was successfully launched in Beta form in November 2019. Feedback has been gathered from a selected group of users to inform the programme of ongoing changes. All key PWS services have been migrated onto the new system, and a programme of structured migration for other services is underway (though currently on hold due to current restrictions).

Theme 4: Data

Milestones	Delivery Status	Comments
4.1 a. Upgrade to Service Hub and Met Office Weather DataHub enabling efficient and useful data services using modern technologies. **February 2020** b. Implementation plan approved for delivery of efficient and useful Public Task data services via Met Office Weather DataHub. **February 2020**	Met	This is an enabling project, implementing capabilities that will enable data to be provided to external users using modern, scalable technologies. The first large data set that will benefit is the global model which is expected to become available in Summer 2020. Specifically, within this milestone we have completed: - A review (with the PWSCG Secretariat - 2/7/19) to clarify the scope of the milestone; focus confirmed as the global model, having technical and business designs to implement during 20/21; - Changes to the outputs from the global model were implemented in Nov '19 (PS43) and made available to Service Hub - included ensuring complete gridded fields at pressure levels, transformation of output into more usable format and changes to parameters; - Capability for sub-setting large gridded data sets ('MDDA') was implemented (Beta) in Dec '19 and demonstrated to a key Defence customer; - Technical & Business process designs are being developed (in progress, in line with agreed scope) to enable an external facing data service for global model to be built and implemented during 20/21

Significant medium-term challenges exist as more weather providers adopt open data strategies, coinciding with a time when transition to the cloud is taking longer than expected and the boundary between Public Task and non-Public Task data requires clarification. Noting these specific challenges, the PWSCG may wish to consider whether the PAG should adopt a formal governance role for the Data Services theme in addition to the National Capability.

Theme 5: International Commitments

WMO: UK achieved all but one its objectives at the WMO Congress in June 2019, which included agreement on constituent body reform; budget being kept in line with FCO guidance of zero nominal growth plus 2%; agreement of new "Geneva Declaration" on public-private engagement; and key UK positions secured, including Penny Endersby elected to WMO Executive Council, and Ian Lisk appointed as president of the new services commission. The UK contribution to the WMO Voluntary Cooperation Programme continues to support observations at remote island sites and weather broadcast capability for many African met services, including Tanzania, Uganda, Eswatini, Mali and Mozambique.

EUMETSAT: EUMETSAT operational satellites continued to perform well during 2019-20, although Jason-2 (ocean altimetry satellite) went out of service during the year. Extensions to the current programmes (Meteosat Second Generation (MSG), and European Polar System (EPS)) were approved by all Member States enabling further value to be extracted from these assets. The development of the next generation of satellite missions remains on schedule, although the impact of COVID-19 on potential launch dates remains unknown. EUMETSAT is currently developing a new Strategy and will appoint a new Director-General in Summer 2021.

ECMWF: ECMWF has responded to the UK's departure from the European Union by enquiring whether any of its Member States wish to host its current suite of Copernicus Services. The potential HQ move to Reading University is paused whilst this process continues. Progress on its new data centre in Bologna, Italy, continues although has been interrupted by COVID-19 impacts. ECWMF is also developing a new ten-year strategy and examining a three-year phased move to an open data policy. This will have a significant budgetary impact (circa £8m per annum). Medium-range forecast output from ECMWF remains world-leading and an important input to the PWS; ECMWF data has been included in the "Global Map" product (Milestone 2.1).

EUMETNET: The EUMETNET General Assembly in Exeter in May 2019 agreed the "Exeter Declaration" – a new set of data exchange principles, including private sector engagement, the work on which was led by the Met Office alongside the German and French met services. The Met Office has been leading the Observations Capability Programme since January 2019 and delivered two important pieces of work in this time on data exchange mechanisms and observations R&D to explore gaps in the European network. Met Office leadership has been well received by EUMETNET members.

Theme 6: National Capability

Milestones	Delivery Status	Comments
6.1 Implement PS43 **January 2020**	Met	Parallel Suites (PS) are the means through which major changes to the formulation and operation of forecast models are introduced into the operational environment under a carefully managed process. Parallel Suite 43 included the following changes and was delivered slightly early on the 4th December '19. • Upgrade to Global and UK Ensemble Modelling Systems (MOGREPS) leading to improvements to ensemble probability forecast scores, particularly increased spread and reduced bias which are

		expected to result in improvements to tropical cyclone track forecasts; • Improved atmospheric physical processes within the Global Model • Upgraded physics and new hourly soil moisture assimilation scheme in the UK Model • Inclusion of machine learning within the post-processed forecast step leading to improvements in the accuracy of UK forecast temperatures, especially Summer maxima (to be confirmed during Summer '20) PS43 was also expected to increase the stability of the global ensemble system (MOGREPS-G) but during its implementation an increased number of failures were observed, particularly whilst running in a particular configuration called the 'short time step'. A short-term workaround was subsequently applied, ahead of a further upgrade expected in PS44. We are optimistic that MOGREPS-G will be more stable (when averaged over a year) than the previous version, which routinely failed during the creation of initial perturbations.
6.2 Deliver the next generation post processing system ("IMPROVER") providing consistent gridded and site specific forecasts. System running routinely within operational environment. **March 2020**	Not Met	This milestone was heavily impacted by the decision of the PWSCG to prioritise work to improve the accuracy of public temperature forecasts (delivered through Milestone 6.7). The same science team is involved in both activities. Therefore, much of the work to implement the next generation post-processing system has been postponed to 20/21 (and beyond). A pre-operational system ('alpha') has been developed during the year to enable the science underpinning the new system to progress and for the Digital Team to have a prototype to evaluate, but a lot more work is required before legacy post processing systems can be retired.
6.3 Trial lightning detection system (Leela) implemented and running in parallel with operational capability. **March 2020**	Met	Accurate and timely detection of lightning is critical to many operations (aviation fuel loading, working on infrastructure etc) and this project is set to deliver a major lifecycle update to the operational lightning detection network, to enable replacement of the existing, legacy ATDnet capability. Completion of this milestone forms a critical step towards delivering this goal by implementing new capabilities, which will be evaluated during Summer 2020, by comparing performance with ATDnet and other 3rd party reference lightning location systems. Specifically, within this milestone we have implemented: • New lightning detection hardware and firmware ('LEELA') at six locations across Europe, ready for the evaluation trial; • New software within the cloud which will perform accurate triangulation of detection fixes from sites

		included within the trial - the primary purpose of the trial is for scientific validation and to evaluate the performance of the network across a variety of terrains and distances; • Memorandums of Understanding with owners of the sites included within the trial; • A project plan through until the decommissioning phase of the legacy capability (ATDnet). The plan includes migration of customers to new Lightning Detection APIs, product rationalisation and migration of internal systems to new data feeds
6.4 Service Hub roadmap detailing additional data sets available by API and underpinning capabilities. **December 2019**	Met	The Service Hub is the means through which data created within the National Capability becomes available (in standardised formats and capabilities) to users. A vast amount of data is created and sourced by the Met Office and the diversity of our users and business priorities means that it's important to have strategic prioritisation of activity across the 'data-pipeline', from science-to-services. To ensure that data is provided in ways which are useful, consideration has to be given to how data is created (or sourced) and potentially transformed prior to its provision to users. Within this milestone we have designed and applied a method for assigning a business-led priority to data activity and implemented a form of governance to ensure the prioritisation is applied consistently from science-to-services. Prioritisation of activity covering two periods (April '19 to Nov' 19 and Nov'19 to June '20) has been undertaken and the first tranche have been delivered within science change (Parallel Suite 43) and within the Service Hub. These changes (focussed on the global model) will become available to external users in Summer '20 (via tranche 2).
6.5 Deployment of loggers across the observations network underway (a third expected to be deployed). **March 2020**	Met	Weather observations at ground level are important for monitoring the weather, enabling more accurate warnings and forecasts to be provided through direct use by a meteorologist, assimilation into forecast models and for validation purposes. This is an enabling project implementing new capabilities that will provide more efficient access to surface observations, based on cloud and internet technology. Within milestone activity we have: • Procured new hardware for loggers that will store and transfer surface observations, implementing them at 154 UK locations (total network size 434 installations);

		• Updated hardware operating system to enable compatibility with existing collection system (MMS) and future (SurfaceNet); • Returned legacy loggers to Exeter HQ for disposal or re-use; • Proven the end-to-end collection via the new loggers, reporting observations data via new cloud-based console; • Reduced complexity by replacing legacy loggers with duplicate functionality with a single new component
6.6 a. Strategy and Roadmap agreed with the PWSCG for the visualisation of large data sets from Service Hub. **September 2019** b. Follow-on activity to implement the roadmap will be agreed with the PWSCG.	Met	Visualisation strategy and roadmap presented to the PWSCG (October '19) in a paper and presentation, updated to highlight the implications ("so what statements") to the Public Weather Service. Key principles of the strategy include: • Visualisation is not considered a single problem. It consists of three aspects: 1. Discovering data and understanding what information is being analysed; 2. The rendering of the data into an image; and 3. The user experience and interaction with the data, required by a group of users – the client application. • Metadata is key to discovering and understanding data. • Science pull-through can be accelerated by focusing on ensuring that data and post-processing adheres to common standards within the data ecosystem, rather than building custom, one-off visualisation • Some existing capabilities (Service Hub and de-coupler) provide much need separation between the provider of data and the user, and need to be extended further via well-documented and governed contracts (also known as APIs) The Met Office Strategic Actions (Future of Operational Meteorology, Common Data Platform and Customer Data Services in particular) are already building on these key architectural principles, with governance applied by the (recently implemented) Enterprise Design Authority.
6.7 Improving temperature forecasts. a. Report on relative performance of Met Office temperature forecasts. b. Report on investigations of adjustments to blending	Met	This milestone has provided the Met Office with an improved understanding of the accuracy of Met Office forecasts (particularly maximum and minimum temperatures), relative to other providers, enabling better targeting of research effort. There were three parts to the activity:

weights on Best Data temperature forecasts with recommendations on implementation. c. Draft roadmap of activities to continue to improve surface weather forecasts agreed with the PWS Assurance Group (PAG) **September 2019**		Part a: We provided a report on the relative performance of Met Office temperature forecasts, concluding that there is a difference of 1-2% between Met Office and leading competitors. Met Office minimum temperature and wind speed performance is generally one of the best in class. Part b: We delivered a report covering investigations into adjustments to the blending weights applied to the Best Data temperature forecasts (used on the website and app with recommendations on implementation. Results from using neural network (a form of artificial intelligence) were presented, which showed 2% improvements in max and min temp forecasts. The approach was implemented operationally in PS43 (November '19) Part c: A draft roadmap of activities was provided (and agreed with the PAG) detailing plans on how we will continue to improve surface weather forecasts. This was supplemented by a technical paper detailing the intended science changes.