

ECMWF STRATEGY 2021–2030



The strength of a common goal

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Foreword

Strategy generally involves setting goals and priorities, determining actions to achieve the goals, and mobilizing resources to execute the actions. A strategy describes how an organisation adapts to its environment, and very importantly, how it allocates usually limited resources.

In a strategy, we set out our vision statement focusing on the future and what our organisation wants to ultimately become, but we need a mission statement focusing on today and what our organisation does to achieve it; this is tactics, and both are vital in directing our goals.

So, developing the ECMWF ten-year Strategy is always a key moment for our community of Member States and the Centre. It is the moment when we pause to review what has been achieved and how well suited it all is to our ever-evolving requirements. It is when we set the strategic direction which will allow the Centre to continue to support our National Meteorological and Hydrological Services (NMHSs) as we protect life and property in our nations, in accordance with our mission as reaffirmed by the World Meteorological Organization (WMO) at the 16th World Meteorological Congress in 2011.

Though the process takes place over a limited period of time, it is the fruit of the extremely close relationship and daily exchanges, not just between Member State delegates and ECMWF management, but also and very importantly between our experts and those at the Centre.

Developing a ten-year Strategy is a tall order in its own right but developing it in the midst of what will likely become known as the COVID-era raised the bar further.

We need to re-define our tactics, review our mission, in order to have a successful strategy fully pursuing our goals.

The necessary interaction between the Member States and ECMWF staff started face to face, then we met and discussed remotely, and then we got to where we, as a community united by our common goal wanted and needed to be. So, a tall order, yes, but no taller or more difficult and challenging than the ones we face on a regular basis as National Meteorological Services as we strive to better protect life and property, offer earlier warnings to those affected by severe weather, and support a greener economy we all want to see flourish.

At the core of our vision for the next ten years are ensemble forecasts with increasingly improved resolution and forecasts at increasingly longer ranges. We want to achieve a more powerful magnifying glass to advise decision makers responsible for protecting life and property and we want to approach a “scientific crystal ball” giving advance notice of all necessary actions.

We are not dreamers if over the next ten years we want to make the most of what technology has to offer, from including artificial intelligence across the numerical prediction chain to building an even closer partnership with the computing industry so we can together tailor supercomputing to the needs of meteorology. We want to harness what the Cloud has to offer so we can work as an efficient, smooth and fast community. We want the spirit of collaboration at the heart of ECMWF, which has been the key to its success, to go even further. From supporting the WMO programmes to better share our data with colleagues and partners



Silvio Cau
President, ECMWF Council

in developing countries to getting involved in EU programmes which can enhance our weather predictions and our environmental monitoring capability, we want to continue to be proud of Europe's meteorology. We want the partnerships we value so much with EUMETSAT and space agencies across the globe to help us to assimilate the true Earth system indispensable to our models. And we want to learn to do even more with those observations. Both we as Member States and the Centre will have to learn to work in the new multi-site configuration, with the new data centre opening in Bologna, and some of our activities moving to Bonn. We will not have been dreamers if, in parallel, we keep growing a new generation of talented people open to making the most of these new assets and procedures.

The period will be humbling as we will sometimes fail in our endeavours, it will be enlightening because we will learn from our mistakes, and it will be rewarding because our efforts will deliver results with direct impact on people's lives. Above all, it will be a period when our common goal will continue to lead our actions and our ambition, and when each of us will work and act as one for the benefit of all.

I take pride in presiding over this Council of Member States which has worked so hard with our teams at ECMWF to develop this Strategy, and I wish us all the best as we embark on this ambitious, challenging and so inspiring path. Welcome on board and let's set sail!



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The context

More than ever, society is dependent on accurate weather and climate information. Reliable advance warning of weather events is key to the protection of lives and properties, many sectors of the economy depend on weather conditions, and climate monitoring is crucial for society to find the adequate adaptation and mitigation strategies.

ECMWF is part of the European Meteorological Infrastructure (EMI) and works very closely with the national meteorological services (NMSs) of its Member and Co-operating States and with EUMETSAT to deliver its mission, namely the provision of world-leading global weather predictions that complement the NMSs' capabilities. In recent years, ECMWF has also been a key player in the EU Copernicus programme, delivering monitoring of the Earth system through partnerships across Europe.

The landscape in which ECMWF operates is in constant evolution and offers both challenges and opportunities.

With the opening of the data centre in Bologna, ECMWF has become a multi-site organisation and has transformed the way scientists and analysts interact with the computing infrastructure and work together.

The fear of what Brexit might bring has made its mark, but the Centre's reputation and quick responses have so far mitigated any damaging impact. ECMWF will strive to keep its cohesion while extending its geographical footprint to continue to perform EU-funded activities (Copernicus, Horizon Europe, Digital Europe) and to attract the best staff from across Europe.

The private sector plays an increasing role in the weather enterprise, which creates a more competitive environment in numerical weather prediction, challenges the traditional open and free exchange of observational data by public entities, and accelerates the

move to open data policies. Working in partnership with the private sector also offers opportunities. ECMWF has started and will continue to engage with actors from the private sector at various levels, including through initiatives of the World Meteorological Organization (WMO).

Novel heterogeneous high-performance computing (HPC) architectures, more diverse computing architectures, cloud technologies, machine learning, artificial intelligence and disruptive technologies such as quantum and neuromorphic computing, and the federation of resources are entering the domain of weather and Earth system predictions and they will transform it in the next few years. Indeed, ECMWF is already engaging with these transformations, e.g. by developing together with EUMETSAT the federated European Weather Cloud for the benefit of the whole EMI.

This changing context presents new development opportunities that ECMWF will need to consider with the ambition to remain leader in global medium- and extended-range weather forecasting.

Lastly, the world in 2020 faced an unprecedented situation in contemporary history due to the COVID-19 pandemic, which will no doubt have repercussions on ECMWF and its Member States on many levels. The consequences of the pandemic are not fully understood at the time of writing this Strategy, but they will probably influence its implementation.

The cornerstones of the new Strategy: mission, vision and values

The next Strategy mission can be derived directly from ECMWF's Convention and summarised as:

Mission: *Deliver global medium-range numerical weather predictions and monitoring of the Earth system to our Member States.*

The mission encapsulates the fundamental aspects of ECMWF in terms of its deliverables and the relationship with its Member States, which are not simply customers, but close partners that enable ECMWF's outstanding achievements. The collaboration, extended to the whole EMI, has become an example for the rest of the world and well beyond the realm of meteorology.

In the context of the new Strategy, ECMWF's vision foresees the leveraging of the existing co-operation to maximise mutual benefits and positive outcomes for society:

Vision: *ECMWF produces cutting-edge science and world-leading weather predictions and monitoring of the Earth system in close collaboration with the members of the European Meteorological Infrastructure, for a safe and prosperous society.*

The ambition is to maximise the benefits of initialised seamless predictions exploiting the Earth system approach and the synergies with the EU Copernicus programme, with a focus on medium- and extended-range weather forecasts.

The aspirational values that drive and characterise ECMWF and its people are:

Values:

Collaboration *at the heart of everything we do. We cannot do it alone.*

Integrity *based on honesty and trust. We can be relied upon.*

Passion *about what we do. Our commitment must be unquestionable.*

Framework of the new Strategy: pillars, goals and strategic actions

To achieve the vision stated in the previous section, the new Strategy is organised around three pillars, to address the questions: who is doing what and why?

Pillars

Science and Technology: *Develop and make operational use of cutting-edge science and technology*

Impact: *Provide exceptional value for money to ECMWF's Member States*

Organisation and People: *Be a flexible forward-thinking innovative organisation, inspiring and hiring the best experts*

Each pillar is associated with two high-level goals as shown in **Figure 1**. The goals are in turn associated with a number of strategic actions that will be detailed in subsequent sections and represent the activities that will be carried out to achieve the goals. Finally, for each strategic action, one or more outcomes is listed that can be used to indicate progress.

'Science and Technology' goals

These goals highlight the excellent science and technology that will be delivered to

maximise impact and the opportunities for collaborations with new initiatives at European level and worldwide.

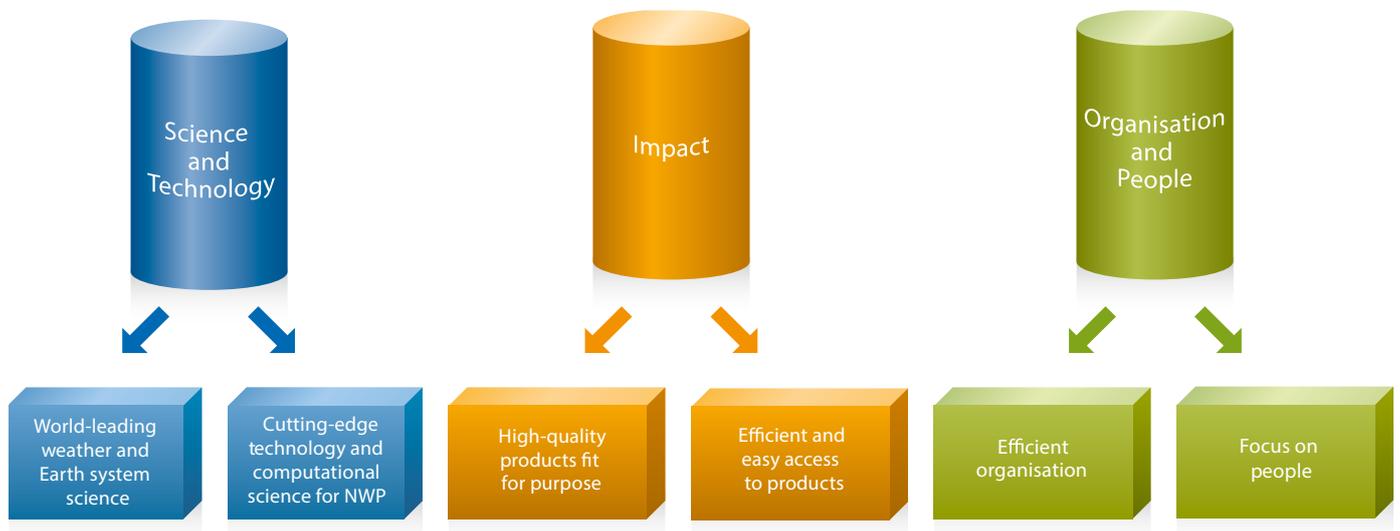
'Impact' goals

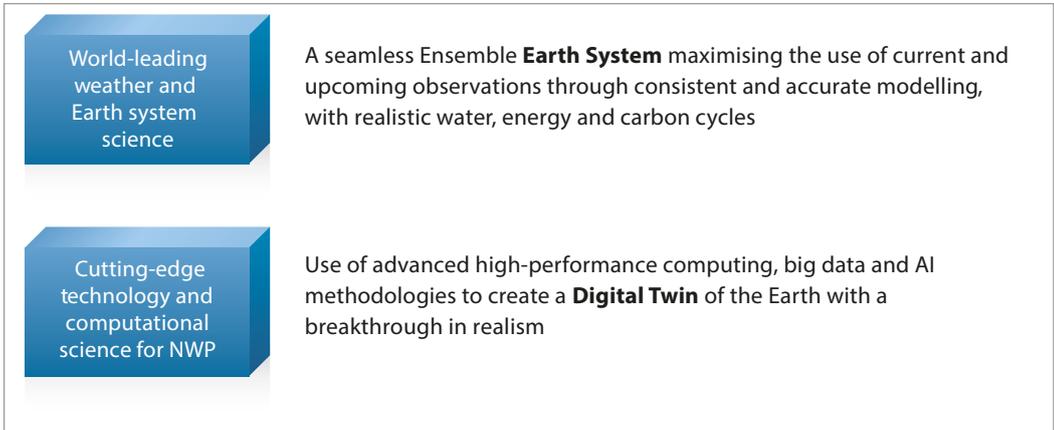
Emphasising the impact of ECMWF's activities is essential to keep the focus on the vision and to communicate ECMWF's added value. What characterises ECMWF is its dual scientific and operational nature, whereby ECMWF develops and delivers products to the Member States. It does not come as a surprise, therefore, that these goals aim to maximise the quality, usefulness and accessibility of ECMWF products.

'Organisation and People' goals

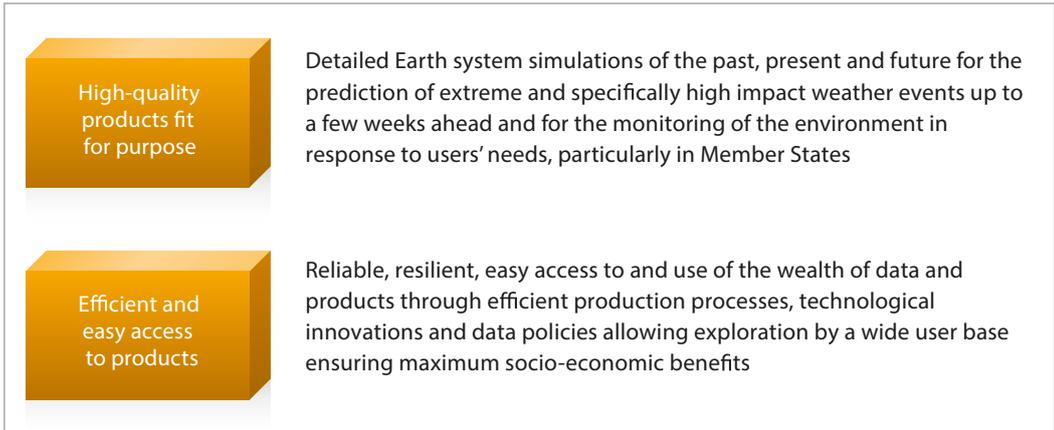
All previous goals must be enabled by an efficient organisation with excellent and motivated people. The "Organisation and People" goals define what ECMWF aspires to be.

▼ **Figure 1:** Pillars and goals of the Strategy 2021–2030.

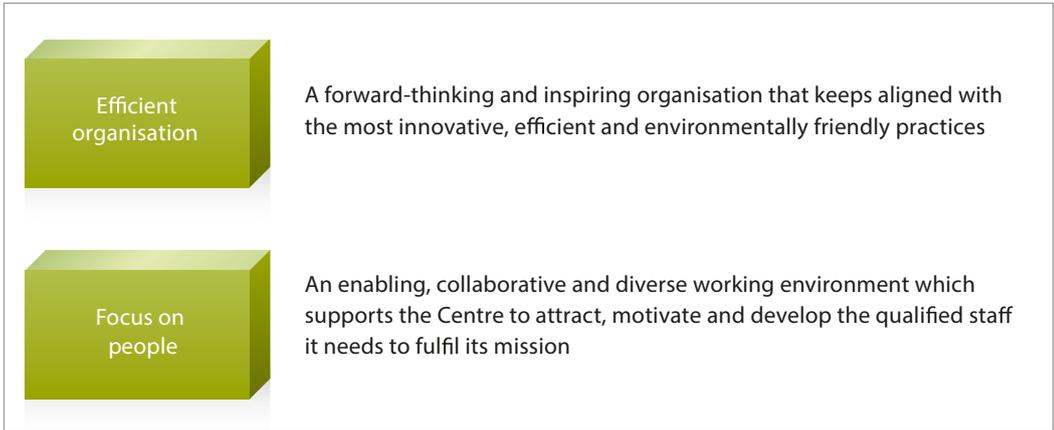




◀ **Figure 2:** ‘Science and Technology’ goals.



◀ **Figure 3:** ‘Impact’ goals.



◀ **Figure 4:** ‘Organisation and People’ goals.

‘Science and Technology’ strategic actions

The ‘Science and Technology’ strategic actions are linked to enhancements in the exploitation of observations, data assimilation, modelling and exploitation of new technologies, computational science and operational processes.

Strengthen leadership in Earth system data assimilation

ECMWF will strengthen its leadership position in data assimilation by progressing in coupled assimilation, algorithmic development and integration of approaches. This will include the incorporation of machine learning, with 4D-Var data assimilation being uniquely positioned to benefit from integrating machine learning technologies because the two fields share a common theoretical foundation and use similar computational tools.

ECMWF will ensure the assimilation system is serving the evolving needs of its Member States. To support this, ECMWF will deliver accurate initialisations of medium-range forecasts using a convection-permitting model, and work towards a seamless integration from the ensemble of data assimilations to the ensemble forecast system.

ECMWF will work towards overcoming challenges in the initialisation of ever more sophisticated Earth system components, e.g. ocean, land, snow and sea ice, as well as atmospheric composition. This will require a concerted effort to develop the assimilation algorithms used in all Earth system components towards a more advanced ensemble-variational framework in line with the atmospheric analysis. To improve the physical consistency of the initial state across multiple Earth system components, the atmospheric 4D-Var will be gradually extended to include interface fields that have a large impact on atmospheric predictability, identifying the optimal level of coupling in the assimilation process and consistent monitoring across all components.

Outcomes indicating progress in Earth system data assimilation

- Accurate initialisation of global forecasts using a convection-permitting model
- Enhanced consistency of assimilation approach and optimal level of coupling between the various components of the Earth system

Improved use of new and existing observations

ECMWF will continue asserting its leadership in the advanced use and representation of observations. In this Strategy period, the Centre will launch a long-term research and development activity, in a step comparable to the hugely successful ‘all-sky’ use of satellite data, to create an ‘all-sky and all-surface’ approach. Not only will satellite data be fully used in clear, cloudy and rainy conditions, but also when they have a marked sensitivity to the surface of the Earth, be it sea, land, snow or sea ice. Incorporating advances in coupled data assimilation, these developments will deliver major advances in forecast quality by allowing a much fuller exploitation of the satellite data.

A fundamental role will be played by the exploitation of the large number and wide variety of newly available observations, from satellites like the new EUMETSAT MTGs, EPS-SG, Copernicus Expansion High Priority Candidate Missions (HPCM) and ESA’s Sentinels. ECMWF will continue to exploit observations from all possible providers in close collaboration with the relevant partners in the EMI, in particular for innovative observation systems, e.g. Internet of Things

(IoT). In order to provide improved initial conditions for convection-permitting models, increased attention will be put on observations linked to physical processes like clouds/rain and lightning from EarthCare and MTG in particular. ECMWF will continue to strengthen its key role, in collaboration with space agencies and the WMO, to define and support long-term visions for global observing system developments.

Outcomes indicating progress in the use of new and existing observations

- Step change in information extracted from satellite data over land, snow and sea ice
- Efficient use of MTG, EPS-SG and Sentinel satellite data
- Enhanced use of observations linked to physical processes (clouds, rain, lightning)

Improve seamless Earth system models

Earth system models will naturally remain at the heart of scientific developments for the next ten-year period. ECMWF will advance science to enable global ensembles at convection-permitting resolutions addressing grey-zone physics, initialisation, and a non-hydrostatic dynamical core. ECMWF will work on driving down model biases that limit the quality of predictions for all timescales. Particular foci will be on interface modelling (e.g. atmosphere–land, atmosphere–wave–ocean–ice) to improve the skill of predictions of near-surface weather parameters especially during the spring and autumn transition seasons, and on the modelling of convection (parametrized and resolved) and its coupling to the large scales.

The Earth system approach will provide more realism in water, energy and carbon cycles. Fuller representation of more processes and associated uncertainties, both natural and anthropogenic (e.g. atmospheric composition and land surface processes such as fire and drought), will improve predictions of those important processes and better represent the feedbacks on the meteorology. Within the seamless modelling approach, improving initialised predictions from week 2 to the extended range will be a major focus, representing a frontier science challenge.

Improved predictions require fundamental predictability research, developments in the use of new observations, advances in (coupled) data assimilation and model improvements, with the reduction of systematic model errors being critical to increasing predictive skill in the extended range. Understanding and improving the representation of teleconnections in order to better exploit potential sources of predictability will also be crucial, and, in research mode, the benefits of step changes in resolution (for atmosphere and ocean) and further enhancements to model complexity will be investigated.

Outcomes indicating progress in seamless Earth system models

- Science developments to deliver operational 3–4 km convection-permitting ensemble forecasts
- Extensions to breadth, consistency and accuracy of Earth system representation with demonstrated benefit for reanalyses and forecasts

Use HPC, technology and computational science for NWP

The role of the HPC and data centre services is of course essential in supporting most of ECMWF's strategic actions and maximising their impact. In collaboration with Member States, ECMWF will investigate the potential of upcoming disruptive HPC technologies for operational deployment, as Member States will also have to go through similar processes for their own facilities. ECMWF will aim to operate resilient, energy-efficient and cost-effective computing resources (HPC, cloud, storage, etc.), data centre services and production processes and will investigate technologies enabling the federation of resources.

To properly exploit future heterogeneous HPC technologies, ECMWF will develop a portable and performant code base for its prediction system and investigate new scientific choices as required to maximise performance, building upon the experience with the Scalability Programme. This will require a wider effort in computational science and will open up further opportunities for collaboration and synergies

with Member States, academia, HPC centres and industry. Besides heterogeneous HPC technologies for operational purposes, novel disruptive HPC technologies and architectures have to be monitored and investigated in collaboration with Member States and the HPC community. Specific artificial intelligence architectures can also be investigated for Earth system modelling.

Outcomes indicating progress in HPC, technology and computational science

- Operational prediction system implemented on heterogeneous GPU/CPU HPC architectures to benefit from boost in time-to-solution and energy-to-solution
- Prototyped next-generation Integrated Forecasting System (IFS) model and programming architecture on future world-leading HPC systems in support of Digital Twins

Harness artificial intelligence and machine learning

In the course of the next Strategy period, use of artificial intelligence and in particular machine learning will continue to spread widely in Earth system modelling. The range of possible applications is vast: from observation processing and data assimilation, to surrogate model components, post-processing, product generation and data management, mining and fusion using both real-time and archived data. ECMWF will harness the opportunities brought by these technologies, seeking to combine the best of what these data-driven approaches can provide with the huge strengths and physical understanding encapsulated in its existing forecasting systems. This is another area where collaboration and exchange of experiences and expertise will bring mutual benefits to the whole of the EMI. The European Weather Cloud will support the development of machine learning applications by providing a platform for users to create tailored environments to facilitate their research.

Outcomes indicating progress in harnessing artificial intelligence and machine learning

- Machine learning support for efficient data processing implemented in production workflow
- Machine learning methodologies integrated in model and data assimilation to support performance enhancement and uncertainty formulation
- Meteorological reference datasets and tools delivered to the community for machine learning applications

Optimise system design and two-way transfer between research and operations

For maximum efficiency, ECMWF will aim to exploit synergies between the development of different systems (e.g. medium range to seasonal; NWP to Copernicus) to converge and consolidate operational suites and processes. ECMWF will increase efficiency in co-development and streamline collaborations by moving towards an open development approach. This approach will not only make some code available as open source but also allow for external code contributions and transparent development processes. ECMWF will modernise the software infrastructure for running, managing and monitoring research experiments, to maximise efficiency and be better prepared for more distributed working. Particular attention will be devoted to ensuring the smooth transfer of research developments to operational implementation and vice versa in order to optimise the generation of products of world-leading quality.

Outcomes indicating progress in system design and transfer of research advances to operations

- Convergence of NWP and Copernicus suites
- Streamlined collaborations through co-development

‘Impact’ strategic actions

To maximise the positive impact of ECMWF activities, the Centre has identified five strategic actions, linked to users’ needs, partnerships, communication and training, the provision of data and computing services, and the exploitation of data.

Meet users’ needs for products of world-leading quality

The constant *raison d’être* for ECMWF is to deliver the best quality medium-range weather predictions to its Member States for their use in providing information and services to society across Europe, especially aiming for better early warning of extremes and high-impact weather. It is clear that to keep ECMWF’s world-leading position, it is necessary to intensify activities in extended-range weather forecasting and Earth system predictions. By exploiting synergies with major European initiatives such as the Copernicus Programme and the European Green Deal, ECMWF and its Member States will be able to provide consistent weather and wider environmental information, including reanalyses and re-forecasts of the Earth system, covering air quality, floods, fire, droughts and climate monitoring.

The continued focus will be on users, hence the necessity to respond dynamically to user requirements and to ensure consistent, timely and high-quality service delivery. The NMSs of ECMWF Member States will play a key role in driving developments based on their operational requirements.

To maximise the value to users, careful cost-benefit analysis will inform system design (e.g. the relative value of investments in resolution, complexity or number of ensemble members).

The quality of products will be monitored through enhanced verification and diagnostics in collaboration with Member States.

Outcomes indicating progress in meeting users’ needs

- Economically and societally valuable forecasts of high-impact weather events well into the second week
- Skilful predictions of extreme temperature anomalies and hydrological impacts such as droughts to three weeks ahead on average
- Integrated global reanalyses and re-forecasts of weather and environmental hazards to monitor changing patterns and predictability of high-impact events from 1950 onwards
- Skilful subseasonal-to-seasonal multi-model outlooks

Optimise provision and sharing of resources

To maximise the impact of ECMWF products and partnerships, ECMWF will provide world-class delivery services, continually monitored using comprehensive service level agreements and key performance indicators. ECMWF will ensure business continuity through geo-redundant data storage and processing as well as disaster recovery capabilities and will identify and develop ways to share resources with Member States, possibly via Optional Programmes. A key role in this sense will be played by federated platforms like the European Weather Cloud. The cloud will also contribute to the improvement of access to the ECMWF data archive, unlocking its great potential for machine learning applications.

Coordinated activities such as the development of the IFS and open software will benefit Member States.

Outcomes indicating progress in provision and sharing of resources

- Operational flexible compute and storage cloud infrastructure to enable value-added exploitation of high-resolution ECMWF ensemble data
- Effective policies, production and support processes to enable efficient and user-friendly exploitation of ensemble data allowing increased socio-economic benefits

Move to open data

Open data has been recognised by the European Union and most of ECMWF's Member States as one of the main tools to maximise the socio-economic benefits of investments in data production. However, to realise the full potential of open policies, data need to be easily accessible. Providing increasingly large and complex datasets for scientists and industry to exploit poses challenges to traditional data centres. Data services need to be able to offer basic processing options to keep retrieved data amounts reasonable (e.g. server-side processing) and offer data in formats and standards popular with different user groups.

Outcomes indicating progress in move to open data

- Relevant datasets provided with an open data policy

Educate and communicate

Enhanced partnerships with the EMI and other entities must be underpinned by excellent education and communication functions. ECMWF will foster scientific engagement through workshops and seminars. Training courses and learning events will continue to be an integral part of ECMWF's activities, blending e-learning and face-to-face content delivery. ECMWF will build effective collaborations with Member and Co-operating States to support and

enrich training initiatives across Europe and in WMO countries.

Strategic communication will remain indispensable for ECMWF to meet its goals of attracting and retaining the talent it needs to fulfil its mission to the Member and Co-operating States, and to seize opportunities for supplementary third-party funding, as and when it can serve its mission.

From an internal perspective, ECMWF must continue to inform its staff to ensure they feel part of the inspiring story which is ECMWF; ECMWF must also illustrate the pride it takes in its staff by showcasing as much as possible their achievements through a range of channels including articles, events, and broadcasts. This will serve the double purpose of highlighting to staff how valued they are and helping to attract others to join the organisation.

From an external perspective, ECMWF must showcase its achievements as this is the best way to ensure it can continue to attract both talent and funding. The focus will be on science, stressing that success is achieved through the vision and ambition of the European Earth science community and collaboration within it. This can be delivered only through appropriate and timely joint activities with the Member States, illustrating the strength of a common goal.

Outcomes indicating progress in education and communication

- Efficient combination of self-service, freely available training resources and dedicated user services to support the effective use of data

Enhance partnerships and collaborations

ECMWF cannot achieve the goals of the Strategy on its own. It can do so only through being an integral part of the EMI, by benefiting from expertise, co-developments, resources, products and services of NMSs of Member and Co-operating States and their consortia, EUMETSAT, EUMETNET and ECOMET and in turn providing its own expertise and products for mutual benefit.

Beyond the EMI, ECMWF will build upon partnerships with the WMO and ESA and

will engage in third-party activities with the European Commission in major initiatives including the Copernicus Programme, the European Green Deal and the European Commission digital Strategy. ECMWF will also engage with the digital economy community, including the ICT industry, for activities relevant to ECMWF's mission.

ECMWF will strengthen its links with the scientific community through targeted collaborations with Member States on specific topics of common interest; through wider collaborations in the framework of WMO activities, following the successes of YOPP, THORPEX, TIGGE, S2S, PPP, WGNE, GEWEX, etc.; and with contributions to the Group on Earth Observations (GEO). Moreover, in collaboration with Member States and the WMO, ECMWF will explore funding opportunities to support developing countries.

Outcomes indicating progress in partnerships and collaborations

- Strategic partnerships reinforced with the EMI
- Contribution to the WMO expert teams and field campaigns
- Support for the strengthening of the Global Observing Network
- Contribution to the European Green Deal



‘Organisation and People’ strategic actions

The ‘Organisation and People’ strategic actions aim to strengthen ECMWF’s structure in a multi-site context, improve its environmental sustainability and promote a flexible working environment fostering diversity and collaboration.

Build multi-site corporate culture

ECMWF is now a multi-site organisation and it is paramount to make every effort to maintain the successful elements of a cohesive ECMWF culture and work methods, benefiting from the specificities of each location. The Centre will develop and implement a dedicated and effective internal communications system and review and redesign organisational structures and business processes required for cross-site operations. A focused staff development programme and the creation of a collaboration platform will be key success factors.

Outcomes indicating progress in multi-site corporate culture

- Fully functioning and integrated multi-site organisation

Improve environmental sustainability

Considering its position, ECMWF should strive to become a model environmentally conscious organisation. Achieving a climate neutral footprint by 2050 is a challenge for society, and ECMWF has an important role to play. Decreasing its carbon footprint, becoming energy efficient and further

exploring the use of renewable energy are key elements in the Centre’s Strategy. This will be achieved by enhancing environmental awareness and embedding it in the organisation’s culture and by implementing processes and technologies aimed at minimising the Centre’s environmental impact.

Outcomes indicating progress in environmental sustainability

- Adherence to the European Commission’s “2030 Climate & Energy Framework”

Promote a diverse, collaborative environment

ECMWF believes in diversity as a key driver towards an inspiring and innovative environment and will proactively promote it. The Centre aims to further enhance its diverse working environment and embrace an inclusive culture of non-discrimination and equal opportunities irrespective of gender, culture or nationality. The Centre will continue fostering a culture of collaboration and team-working across the organisation and its Member States. To succeed, the delivery of a healthy and caring working environment is essential, and the Centre will continue working to provide its staff members with the best available conditions.

Outcomes indicating progress in promotion of diversity and collaborative environment

- Alignment with European diversity and inclusion strategies

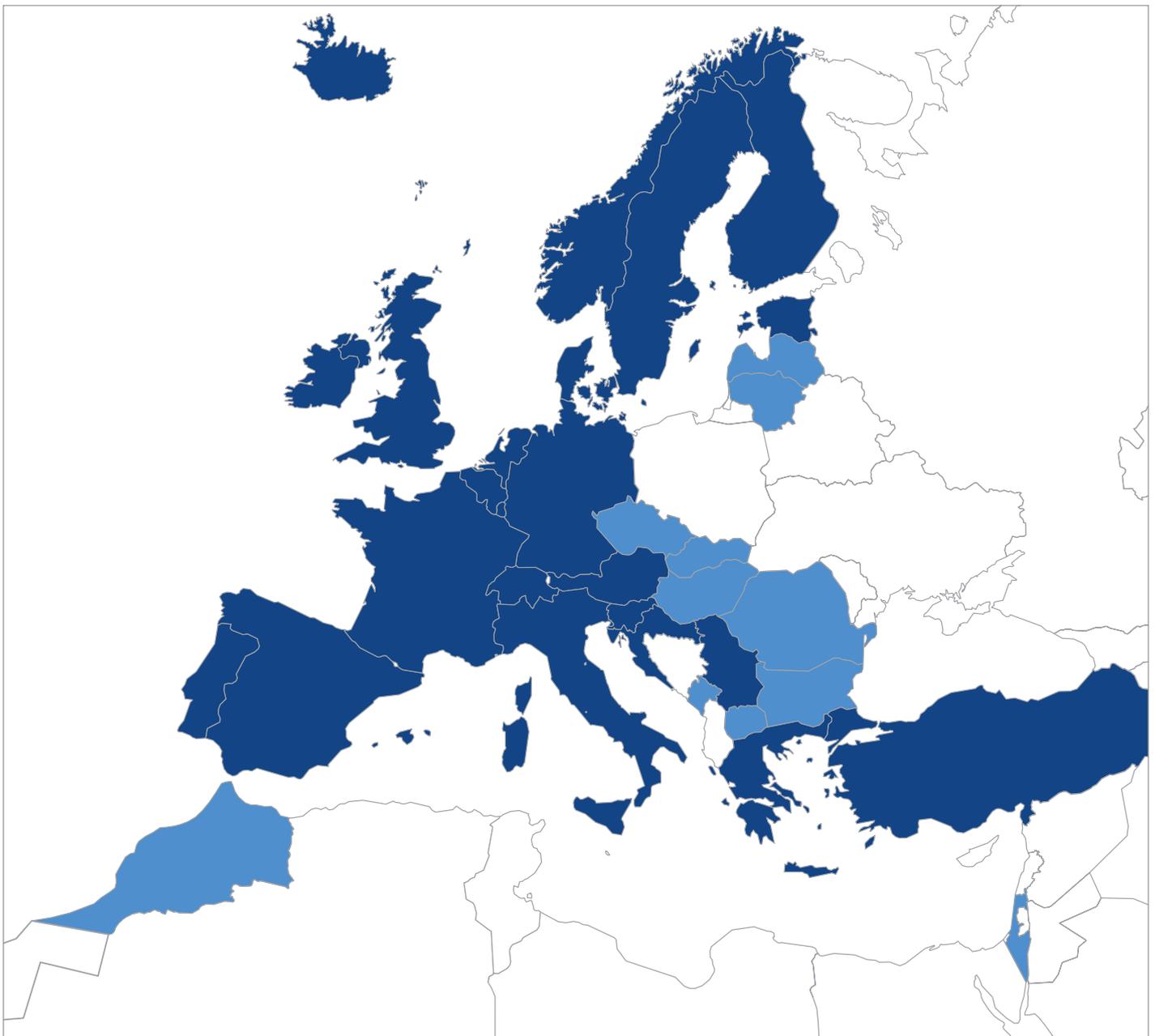
environment by introducing important changes in the contractual relations between the Centre and staff. New contract policies will enable a blend of building, borrowing and buying talent. The Centre will further develop distributed, flexible and resilient work practices, enabled by the use of information technology. These actions will help to attract, retain and motivate staff, as well as improve productivity.

Develop a flexible working environment

Offering a flexible working environment is part of an evolution process required to attract, retain, motivate and inspire the 21st century workforce. To remain competitive in its ability to hire the best professionals, ECMWF will increase flexibility in its working

Outcomes indicating progress in flexibility of working environment

- A flexible working environment required to attract, retain, motivate and inspire the 21st century workforce



Conclusion: the age of maturity

ECMWF's previous Strategy formalised the primacy of ensemble forecasting and further established the Earth system approach as the way to improve forecasts seamlessly across all ranges. The direction taken at that time led to an extremely successful period of ECMWF life. Advances in Earth system modelling allowing coupling between atmosphere/land/ocean and sea ice for all forecasts at all ranges, the delivery of a more continuous data assimilation making 4D-Var even more resilient, the results of the first phase of the Scalability Programme highlighting not just its potential but also its necessity are all advances that the Centre needs to build upon. ECMWF's staff has continued to demonstrate its world-renowned expertise, ingenuity and scientific creativity.

Over the period covered by this Strategy, ECMWF will turn 50, an age of maturity by all accounts. 50 years of learning how to best collaborate with the Member States, understanding users' requirements through active engagement, and serving its community through mutually beneficial schemes.

Throughout the period of this Strategy, ECMWF will seek to optimally combine the most appropriate concepts and technical resources needed to achieve its goals. ECMWF will deliver a working environment mixing those attributes that will allow it to remain attractive to the best in the world; it will look at state-of-the-art heterogeneous HPC technology, cloud and artificial intelligence to fit its specific requirements; ECMWF will continue to investigate a mixture

of larger ensemble and increased vertical and horizontal resolution, and a blend of variational and ensemble methods across the Earth system components. The advent of artificial intelligence and machine learning in the world of meteorology will deliver a well-balanced combination of atmospheric and computational sciences.

These elements will build a canvas on which ECMWF's talented staff can use their expertise to further advance weather science, guided by the ambition to continue to deliver the best numerical weather predictions required by Member States to protect life and property.

The opportunities and challenges presented by the growing role of the commercial sector, the benefits derived from already successful contributions to the programmes of the European Union, support for WMO programmes and the partnership being further developed with space agencies are all key to this Strategy. The European Weather Cloud, developed in collaboration with EUMETSAT, model and software co-development, joint participation in EU programmes, projects and scientific activities such as field campaigns, as well as an increased use of digital channels will deliver even closer collaboration with the Member States, with efficiency at the heart of all interactions.

The ambition of this Strategy is to make ECMWF even more of a collaborative platform where expertise from across the Member States and beyond merges to deliver advances in numerical weather prediction that will best serve society.

