Meteorologisk institutt

Evaluation of MET Norway 2020

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Photo: Ketil Isaksen. Motive from Nordenskiöld Land, Svalbard

Preface

This report provides the findings of an international evaluation of MET Norway done in 2020. The objective of the evaluation is to give an independent assessment of the performance of MET Norway. The assessment will be used in developing the strategy, operational objectives and organisation of MET Norway.

The committee's recommendations are stated in relevant sections of the text, but also summarised at the end of the report.

30 January 2021

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Introduction

Setup of the evaluation

This evaluation of MET Norway was initiated by the Director General (DG) and is owned by the Board. A mandate for the Evaluation Committee was prepared and endorsed by the Board on 13 February 2020. It is provided as the Annex 2 to this report.

The mandate for the evaluation lists a large number of questions (43 to be exact), but it was agreed with the DG and the Board that they were intended for the self evaluations to be performed by MET's departments, and would be seen by the Evaluation Committee as indications of possible issues to address, without expecting answers to all of them individually. In this report, the Committee addresses only the questions that it considered as important elements or issues emerging from the evaluation.

Initially the evaluation was scheduled to take place during the period March to September 2020, with a full week in April booked for meetings in Oslo with MET teams, partners, customers and governing bodies. This plan was disrupted by the COVID-19 pandemic which forbade any travel to Oslo. After two failed attempts to postpone the Oslo week with the hope that travels would become possible, it was agreed with the DG that the evaluation would be carried out through video conferences. This was necessary in order for the Committee to be able to provide its evaluation in time for it to be used in the elaboration process for the next MET strategy, even if this did not allow it to go into the same level of detail. The interviews took place over the period 30 October to 6 November.

The Committee interviewed the Director General, all directors of MET departments, representatives of governmental agencies working with MET, and representatives of research institutions in partnership with MET. Representatives of MET unions, of the Ministry of Climate and Environment, and the Chair of MET board were also interviewed. The detailed list is provided in Annex 4.

Overall impression

It should be noted that the four members of the Committee had previous knowledge of MET Norway: the Norwegian member because she managed organisations in relation with MET, the three non-Norwegian members through the many cooperative entities that exist in the European meteorological community. It can be said that their pre-existing feeling was positive, as MET Norway is highly recognised both within Norway and within the meteorological community.

The Committee's overall impression largely confirms and reinforces this initial feeling of the Committee members that MET is a first class meteorological service. The feedback received by the Committee from governmental agencies and research institutions working with MET was very positive, and all the staff met by the Committee were clearly happy and proud to work for MET. It was clear from the answers provided to our various requests that MET's administrative staff is efficient and swift. Also, MET's capacity to win competitive calls for research funding is very impressive and an important contribution to its successful development.

This judgment is shared by users and has been recognised through various surveys and by several awards including, for example:

- In the Ipsos survey of Norwegian governmental agencies reputation, MET has been ranked first for 15 consecutive years, just ahead of the Public Health Institute;
- Yr is one of the best known brands in Norway, and seen as the best source of weather forecasts by a wide margin;
- In 2018, MET Norway won the "Agency of the year" award. The prize is handed out by the organization responsible for the risk management system widely used by Norwegian public agencies (CIM).

This overall impression must be kept in mind when going through the report as the objective of such an evaluation is to identify areas where further improvements are possible, and warn of possible future threats.

While it was agreed not to address all the questions listed in the mandate for the evaluation, the Committee decided to stick, for this report, to the structure adopted in the mandate, with four main areas:

- Research relevance, quality and impact,
- Forecasting and service delivery,
- Infrastructure and technology, and
- Organisation, strategic leadership and governance structure.

1. Research relevance, quality and impact

The overall impression of MET's research efforts, across both the Research and Development Department (henceforth R&D) and Development Centre for Weather Forecasting (SUV), was very positive, A wide range of impressive research is carried out, influential both nationally and internationally. The publication record per scientist is comparable to that of other strong mission-driven organizations in the environmental field, while interviews confirmed a widespread drive and motivation to do research to ultimately improve services rather than purely for its own sake. The considerable success in attracting external funding is also testimony to the fact that the research is of high quality as well as user-relevant.

NWP modelling

MET has long been a strong player within the HIRLAM consortium. In such a collaborative venture, there is clearly a strategic choice for each member as to the degree to which they spread their efforts over all areas of NWP (Numerical Weather Prediction) science and development as compared to focusing strongly on specific areas where they are or wish to be particularly strong. MET has particular strengths in data assimilation, land surface and ensembles. It noted that in recent years as the consortium has continued to more tightly align and co-ordinate its efforts, it has slightly increased the degree of focus in these areas without neglecting others. This feels to the Committee to be an appropriate evolution.

Looking to the future, there are a number of opportunities and challenges for the future evolution of NWP. One of these is adapting to – and taking advantage of – new computer architectures. Here MET appears to be one of the consortium members most aware of and concerned by these issues. Their ambitions to strengthen efforts both internally and through influencing the wider consortium are warmly welcomed, noting that without action the limitation of current codes may restrict choices for the next rounds of HPC procurements. MET is also appropriately active in research mode in considering new opportunities offered by machine learning and the use of non-traditional observations.

There are also plans to move towards more coupled NWP systems e.g. the introduction of a coupled ocean and more online hydrology were discussed; potentially air quality could also be done in an online framework. These moves are consistent with the general direction of travel internationally, and the Committee is supportive of them. However, the roadmap for these developments was less clear, and the Committee suggests that it would be useful to establish an agreed cross-MET view on the degree to which such a coupled system could be expected to directly meet user needs (thereby replacing separate offline models for some aspects of ocean or hydrological forecasting) c.f. where user requirements would be unlikely to be met by such a system e.g. due to resolution or scheduling constraints. Agreement on this big picture vision and a realistic assessment of the timeline on which it might be achievable could then inform relative investments in the new coupled and existing offline systems.

Recommendation: Develop pan-MET vision for the role of a future coupled NWP system in directly meeting user needs in fields currently served by offline systems (ocean, hydrology, air quality) and high-level roadmap to get there.

Ocean/wave modelling

MET is also active and successful in a wide range of marine research, and a clearly respected partner e.g. links to IMR (Institute of Marine Research), Copernicus, OSI-SAF (Ocean and Sea Ice Satellite Application Facility). The range of activities is broad (waves, ocean drift, 3D ocean, ice…), as is the range of time and space scales covered e.g. from modelling the whole North Atlantic down to sub-km resolution models. One possible consequence of the range of applications and partnerships is that it appears to have led to the use of a large number of separate numerical models. The Committee does not doubt that each choice is individually justifiable, but does wonder about the long-term viability and efficiency of this approach. Furthermore, it is likely that evolving user needs may require new capabilities. For example the Committee heard of one request for still higher resolution products in fjords. Furthermore the ambitions to move to a coupled NWP system may in the medium to long-term remove the requirements for some, but not all, of the offline models - while likely coming with their own constraints in that the ocean model used there will be that chosen by the consortium and not by MET alone. The Committee recognizes that this is a complex landscape with various potentially conflicting drivers, but, precisely for this reason, recommends that MET attempts to develop a long-term roadmap for the evolution of the modelling systems, seeking to streamline the number of systems while taking into account evolving user needs and science opportunities.

Recommendation: MET should develop a 5-10 year roadmap for the evolution of ocean/wave/ice models, looking to streamline the range of models used.

Climate modelling

NorESM (Norwegian Earth System Model) has clearly been a successful initiative in pulling together the Norwegian community, leveraging efforts from both MET and partners to deliver and utilize a Norwegian climate model, built by extending in particular areas (e.g. aerosol modelling) the pre-existing NCAR (National Center for Atmospheric Research) model, although without apparently significantly feeding back to it. This has clearly been a success story which should be built on. The committee did note that the approach of having an exclusively Norwegian model was different to that adopted in NWP, and did have some concerns as to whether it would be long-term viable to maintain it as internationally competitive. It is clearly not for MET alone to decide the future direction, but the Committee recommends that, alongside Norwegian partners, MET looks to consider the 5-10 year direction, specifically including the question as to whether partnerships outside Norway could be strengthened e.g. by forming a tighter relationship between NorESM and the evolution of the NCAR model or, alternatively, by seeking to join forces with other modelling efforts in Europe.

Recommendation: Develop roadmap with research partners with a view towards strengthening climate modelling partnership outside Norway.

Research to Operations (R2O) and Operations to Research (O2R)

The Committee was satisfied that the driver for research in MET, and the motivation of many of those performing it, is ultimately to improve services.

For developments to the main NWP systems, SUV is responsible for delivering operational upgrades, and it is clear that performance is monitored and has improved over time. It was also apparent that significant efforts are made to communicate forthcoming changes so that forecasters in the Weather Forecasting department are aware of changes in the characteristics of the forecasting systems. The Committee was also made aware of a number of projects, often involving part time forecasters, developing new tools and products to allow fuller operational exploitation of the outputs of the NWP systems. In these senses R2O for NWP and associated products may be stated to be working well. In terms of O2R, the Committee was convinced that

the involvement of part-time forecasters in development projects increases the likelihood of the specific projects that they are involved in truly delivering something that meets operational needs. It also seems likely that their presence in SUV brings an operational perspective more generally, thus helping O2R beyond the specific projects that they are involved in. If there were a question as to whether there might be an area for further improvement, it concerned as to whether there was a sufficient mechanism in place to capture operational requirements at a more strategic level e.g. overall priorities from the Weather Forecasting department or external users directly for improvements to underlying NWP and tools for further exploitation. It is suggested that MET may want to review whether there is more that should be done in this area.

Away from NWP (e.g. marine modelling; provision of satellite products to forecasters; air quality modelling) the Research and Development Department directly provides the interface to operational services, covering R2O, O2R and support in the event of operational problems. Again the Committee had the sense of good interactions at a working level.

Recommendation: Consider whether a strong enough mechanism is in place to capture overall priorities for NWP and other operational models improvement (underlying system and tools/products for exploitation) which can be used for prioritization of research and development activities.

Research partnerships

The Committee obtained a very positive impression of METs openness to engaging with outside partners on research projects, and a sense that this happens extensively and effectively. A number of research partners of MET spoke highly of MET as a research partner, variously describing MET scientists as “professional”, “clever”, “well-organized”, and noting that they operated in a “fair and open” manner in terms of sharing resources in joint projects. The impression given was that partnerships worked primarily through scientist to scientist links around individual projects, happening organically without the need for significant senior management action. MET is to be congratulated on having created a culture where this is the case. The Committee were also pleased to see strategic alignment with a number of partners e.g. around joint development of Climate Services. It may already all be in hand, but the Committee wondered whether there were any opportunities to further strengthen links to key partners at the strategic level e.g. further aligning ambitions beyond individual research projects and funding opportunities by agreeing joint visions and roadmaps to give an overall framework for collaboration that individual projects can sit within.

Noting the reliance of both MET and its research partners on external funding, the Committee considered that there might be opportunities to strengthen efforts to influence the research funding agenda by encouraging calls in areas of relevance to MET's science priorities. This could be by lobbying through relevant contacts to influence European (ESA, EU etc) calls, possibly co-ordinated with like-minded international colleagues for more impact. Additional consideration could be given to influencing Norwegian opportunities e.g. Norwegian Research Council. For the latter, of course care needs to be taken not to cause real or perceived conflicts of interest if MET wishes to bid for funds itself. However, lobbying through others (e.g board or partners) may get round this. Also directly working with research funders to encourage funding of upstream research in key strategic partners, which will have impact through MET, is another option that can be considered.[1]

Recommendation: Consider opportunities to strengthen lobbying to influence calls for research funding for MET or for MET's partners in priority science areas.

Internal structures Research and Development

The Committee recognizes that any organizational structure has pros and cons – and that some important activities will cut across management lines for any structure. It also does not regard itself as close enough to the details to make definitive recommendations as to what, if anything, should be changed. Instead it will limit itself to some observations and encourages MET to take these into account in further internal thinking.

- The Committee recognizes that an important initial driver for the setting up of SUV was to bring NWP research and development closer to operations, facilitating R2O and O2R. As detailed above, it believes that this has been largely successful and progress made in these areas (e.g. through individuals working across the boundary between NWP development and operations) must not be lost.
- Nevertheless, the structure does appear rather complex and asymmetrical, with NWP developments coming from SUV to operations, while, in other areas such as marine and air quality it understands that the link is more directly from the Research and Development Department to operations. In other places such as the use of satellite data

[1] In the UK a successful approach was the Met Office and research council agreeing joint programmes where the Met Office put a number of its core funded staff alongside a number of academic staff funded competitively by the research council to work on pre-agreed joint programmes.

in NWP, it assumes that the NWP development in SUV relies on efforts within the Research and Development Department. Even within Research and Development it appears that there are separate areas with closely related or overlapping responsibilities.

- The evolving direction of the NWP models towards more coupled systems may further stress this structure, as more processes (e.g. ocean, wave, ice) for which the expertise lies in the Research and Development department and which are currently modelled with offline systems separate to the NWP start to be introduced through SUV to the NWP system.
- The Committee was assured that there is good cross-department working on individual projects. It was less convinced that directions were completely aligned at a more strategic level. Therefore as a minimum it strongly encourages the development of agreed cross-department long-term vision and roadmaps (see above) for the evolution of the coupled NWP system and for the evolution of the ocean/wave/ice models. Once these are agreed, it is suggested to revisit whether they can be most effectively delivered within the existing structures or whether changes, aligning structures more closely with priority activities, are appropriate.

Recommendation: Revisit question of organizational structure after completion of agreed roadmaps for coupled NWP and for ocean/wave/ice models.

2. Forecasting and Service delivery

Services for governmental agencies

The Committee met representatives of several governmental agencies in charge of security (civil protection, rescue, nuclear safety, and roads). They all receive forecasting services from MET, including tailored automated regular meteorological information from the HALO system developed for this purpose, and warnings when appropriate. All of them signaled the importance of MET services for their activity and expressed their satisfaction regarding the quality of these services. They see MET as a very professional, trusted partner and their de facto most important advisor. They mentioned the low threshold accepted by MET for establishing a direct contact and the good dialogue during crisis management as important characteristics of their relationship with MET. They also mentioned MET's openness to changes, eagerness to participate in common projects and open data policy as very positive features.

During the discussion with the Committee, some of the representatives met by the Committee expressed requirements for new services that could further improve MET's services. They are presented here for MET's consideration in view of next discussions with the agencies.

- Both rescue and roads entities expressed the need for a sort of 'past weather Yr'. The idea here is to be able to quickly assess the meteorological environment of past events (e.g. in the case of missing persons or accidents).
- The second request, from the rescue service, is for a single higher resolution coastal model. In particular the mismatch between various coastal models and between meteorological models and coastal maps is a difficulty.
- A third request, from roads services, was to improve the daily briefings with a provision at a scale smaller than the current county scale.

The case of NVE

NVE (The Norwegian Water Resources and Energy Directorate) is the hydrological service of Norway. As such the relationship is not simply from provider to user, but needs an important cooperation level. The usual distinction is that a met service is responsible for water as long as

it is in the air, and the responsibility shifts to the hydrological service once water reaches the ground (and sometimes it shifts to a third entity for underground water). Of course things cannot be that simple, which has driven some countries to merge the two entities in a single meteorological and hydrological service.

In the case of Norway they are distinct entities, but MET and NVE have developed a high level of cooperation. It is at its highest for avalanche forecasting which is run as a single unit with staff from both sides working together, under NVE's responsibility. This service was developed recently and is already fully recognised by its counterparts in other countries.

There is also a close cooperation between MET and NVE for flood forecasting, warnings for weather induced dangers and hazards, and observing networks with daily exchanges of information. Both entities work together in several projects, in particular as part of the Norwegian Centre for Climate Services. They both recognise that there is room for more cooperation, for example in the area of satellite data utilisation, or coupling of hydrological models into earth system modeling. Such development of the cooperation between MET and NVE should be encouraged. The Committee feels that it would certainly be facilitated by the development of a joint roadmap, indicating whether, at some stage, some new elements of integration could even be envisaged.

Recommendation: MET and NVE should consider elaborating a common roadmap for the development of cooperation between the two entities, including in particular flood forecasting, observing networks, climate services, satellite data utilisation and coupled modeling.

Aviation services

Services for civil aviation were the basis of the development of modern meteorological services just after the second world war: 30 years ago, most meteorological services were part of the ministry of transport or defence[2] as the main source of funding for meteorology came from aviation charges and taxes, organised in particular by the International Civil Aviation Authority (ICAO) created in 1947 by the Chicago Convention. Aviation services are organised by the Annex 3 to the Chicago Convention which states in particular that «Each Contracting State shall designate the authority, hereinafter referred to as the meteorological authority, to provide or to arrange for the provision of meteorological service for international air navigation on its behalf ».

[2] Although this was not the case in Norway

In 2017 MET Norway was reconfirmed as the Norwegian Meteorological Authority. As such, the cost of its services to civil aviation should be covered by the budget allowance, fed by the relevant charges and taxes. However this does not seem to be the case. In 2020 MET Norway received 71 Mill. NOK for aviation forecasting. This corresponds to 12 % of MET budget which is quite low compared to most meteorological services. In addition, in their self-evaluation produced for the Committee, the Forecasting Department evaluates that aviation services represent 60% of their activity.

This was discussed with and recognised by the representatives of the Ministry of Climate and Environment. This problem could become even more crucial with the current COVID-19 crisis which has dramatically reduced the revenues from aeronautical charges and taxes, whilst the aviation services provided by MET are probably only marginally reduced.

The Evaluation Committee also met representatives of Avinor. As other user representatives met by the Committee, they praised the quality of the services received from MET. However they also complained that on some occasions this quality was exaggerated and did not correspond to their requirements. After discussion it appeared that the main point was the provision of services during the closing time of airports. Their view is that, during those periods the only requirement is for pilots to have information to prepare in advance a possible rerouting when getting close to their expected destination, in case they cannot land as and where expected. They consider that, for this purpose, an automatic observation is sufficient, which would allow significant savings. This requirement was presented on various occasions to MET but was not developed further, giving Avinor the impression that MET was reluctant to innovative developments. In fact, this sort of evolution toward automation of automatic observations is an issue that requires modifications of aeronautic regulations regarding necessary meteorological observations. It must be approved between the civil aviation and the meteorological authorities. However, it is possible and has been addressed in several countries. It should be developed and implemented as soon as possible.

Recommendation: Funding allocated to MET should be adjusted to the full cost of the aviation services provided on the one hand, and the services to aviation adjusted to aviation requirements on the other hand.

Monitoring MET forecasts

Monitoring the quality of their forecasts is a crucial activity for all meteorological services. MET has developed a comprehensive set of verification of its operational weather prediction model

output against observations. They are published quarterly, and compared with the same verifications for the ECMWF (European Centre for Medium-Range Weather Forecasts) global model. The comparison with the ECMWF model shows clear improvements obtained with MET's short range high resolution local models. These types of verification are very useful for automated products which are generated from the models, with additional post processing.

Other types of verification concerns warnings. A first type consists of post event verification and usually addresses the accuracy of the corresponding forecast, in relation with its range from the event. Such verification is important as warnings are the most important products for a meteorological service. At MET they are done for red warnings. The Committee feels that MET and the recipients of warnings would benefit from a more systematic evaluation of warnings (at least from the orange level).

In addition systematic surveys concerning how the warnings are perceived and acted on by their recipients, both security agencies and the public, are also very useful in order to identify possible weaknesses or mismatches of warnings on the one hand, but also the most efficient characteristics of warnings on the other hand. Such surveys are not available for MET and would certainly be a valuable tool in order to further improve the MET warnings. In particular we were told by rescue service that the warnings had a very positive impact with less traffic in case of warnings, but realised later that the forecast department was not aware of this impact.

Recommendation: Post event evaluations should be extended to more cases (e.g. orange level), and systematic surveys of recipient's perception of MET's warnings to be implemented.

The forecasting process

The Committee met with the Director of the Weather Forecasting department and with forecasters and got a very good impression of enthusiasm, expertise and pride. MET obviously pays much attention to the regular training of its forecasters. The presence of forecaster-researcher working part-time in the SUV department is an efficient contribution to ensuring that NWP developments meet forecasters requirements (see previous section, R2O and O2R). Other forecasters have a responsibility as a contact point for specific customers. However a majority of the forecasters still spend 90% of their working time in purely operational shifts. The Committee encourages MET to further develop entrusting forecasters with a non-operational shift activity, such as part-time work in other departments (e.g. R&D, ObsKlim) or participation in projects with MET partners. It would also be particularly appropriate to involve

forecasters in the specifications and development of the HALO system, currently discussed directly between SUV and external agencies. This development of forecasters' non-shift activities could be implemented when reductions of the number of forecasters' positions are made possible by further automation of forecasting services.

Recommendation: MET should consider increasing non-shift work by forecasters, such as user engagement, training and participation in R&D projects with other departments or MET partners. This could be done in particular by allocating part of future efficiency gains from forecasting services automation.

The Committee noted that all night shift positions are commercial positions, but was reassured that, in case of dangerous weather developing overnight, the latter would take precedence. This is an oddity and possibly an interesting case of reverse cross subsidisation.

However it should be noted that there is a risk in this situation. It means that human resources necessary to staff night shifts depend upon commercial revenues. An important reduction in the requirements for night support from major commercial customers could result in difficulties for MET to maintain these night shifts which are crucial in case of severe weather events, keeping in mind that such severe situations tend to happen outside normal working hours with about a three to one probability.

Recommendation: MET and the Ministry should ensure that, as long as they remain necessary for supporting governmental agencies in charge of security, the night shift of forecasters could not be endangered by a reduction of commercial funding.

3. Infrastructure and technology

MET Norway shows a good ability to utilize technological developments, and the quality of the infrastructure is high. There is a willingness throughout the organization to use new technologies. Examples of such are container technologies in system development, web technologies in forecaster tool development (GeoWeb), new observations such as citizen's observation (eg. Netatmo). Also, social media is used in user interactions, and there is a joint effort with GeoNorge to serve a wide community with MET's data, following the FAIR (Findable, Accessible, Interoperable and Reusable Data) principles, eg. S-ENDA project.

MET co-operates with companies and agencies, thus gaining access to larger amounts of observation data and better coverage of Norway than their own observation station network would provide.

Based on discussions with Obsklim and IT department management as well as union representatives, the staff of MET is highly motivated and the departments are aligned with the strategy of MET.

Observations, quality control and data

The observation network coverage in Norway is similar to other Nordic countries. A detailed Nordic comparison is from 2013, Benchmarking of Observations within Nordobs (the report is being updated). MET's network of 902 automatic weather stations (AWS) are maintained in cooperation with Avinor, governmental entities, energy companies and municipalities. Co-operation reduces the costs of overall network maintenance. In recent years, the areal coverage of the AWS network has been improved in Northern Norway. This has been done in order to support avalanche forecasting.

Due to the geographic nature of Norway, some of the observation sites are placed in sparsely populated areas that are difficult to access. In these remote location sites, MET could benefit from co-operating with NVE, NILU (Norwegian Institute for Air Research) and DSA (Norwegian Radiation and Nuclear Safety Authority) on maintenance of the observation stations.

There exists good areal coverage with C-band radars maintained by MET in Norway, and this will be further improved with a new weather radar site in Finnmark in the near future. X-band radar has been used for testing and development, for example for Gardermoen airport 2016-2020, and the results from this experiment will be interesting from a busy airport operation optimization and safety perspective.

The AWS network is ISO9001 quality system certified, but the rest of the observation unit is not. The quality system of the observation unit follows MET's own holistic quality management system. A gap analysis could be done between the current quality management system of MET used in the Observation and Climate department and ISO9001 quality management system requirements. The ISO9001 quality management system is oriented towards process and risk analysis, and it is aiming towards continuous improvement by using key performance indicators. Definition of key performance indicators helps streamline activities and enhances discussion of them within the organization. A recommendation for the extension of ISO standards certification throughout MET is formulated further in the report at the end of section 4.

Quality control of network observations is done with internally developed Kvalobs software which will not scale to new demands of higher temporal frequency data. For citizen observations (Netatmo measurements), the quality control is done with newly developed Titan software. Regarding Titan, Nordic or European discussion of development contributions to open source code development by other NMS could be considered.

From the perspective of observations, open data is one way to widen the software community's access to work done by the Observation and Climate Department.

MET has been visionary by giving access to its data in an early phase. In general in the EU, open data is seen as a key building block of the overall EU data economy. It is viewed as stimulating economic growth and innovation: Public data has significant potential to be re-used in new products and services.

In Norway, significant applications could be built on top of other governmental (e.g. transport system) open data jointly with MET's data to produce agile "Mobility as a Service"-applications and for example optimizing housing blocks heating energy consumption. Maybe these applications already exist?

Open data gives opportunities to interact with the private sector, but this opportunity has not been explored for observation data (in contrast to Yr products). The distribution of MET observations for external users is done from the frost.met.no. interface.

It was unclear how the trend in usage was monitored and how the use has evolved. It was also unclear what the impact of distributing observations for external developers has been, and which applications or new enterprises have been generated by external developers on top of MET's generated data.

Recommendation: Consider evaluation or user survey of frost.met.no from an external developer perspective. Consider following up external APIs user trends and evaluating societal impact of MET's data shared via APIs.

The assessment of the societal impact of external open data could be shared with ministries to justify funding for MET's infrastructure sustainment and development.

External partnerships for development

Technology development in different branches of engineering is rapid. There are limited resources within governmental agencies to explore the opportunities this may give. Hence cooperation between NMS in different countries and/or partnerships with technology developers can be very useful.

An illustrative (but certainly non-exhaustive) list of some technology developments which might be of interest is given below:

- In observation and maintenance of the observation stations, usage of high resolution camera and Machine Learning (ML) algorithms for picture analysis could be investigated. Possibilities for development partners eg. Nordic or European co-operation could be considered.
- UAVs (Unmanned Aerial Vehicles) have been used for radar maintenance purposes in MET. UAVs have not been used as a measurement platform. No development partner was mentioned such as Space Center of Norway or international ISARRA (International Society for Atmospheric Research using Remotely piloted Aircraft) society in relation to UAVs. Possibilities within Norway and international networks could be considered.
- Possibilities within IoT and developing telecommunication infrastructure (from LTE to 5G) were not mentioned, for instance in industrial areas such as harbours where there could be possibilities for joint development of services for future automated and

autonomous vehicles. There could be funding opportunities for the development of logistics chain optimization and the reduction of the environmental impact of transport.

Recommendation: Scan new technologies for strategy and identify key partners for selected new technologies.

Information technology

The IT department consists of three groups: services, infrastructure and geo development. In discussions with other departments, basic IT support (extensive use of Google provided services) was considered satisfactory. Within infrastructure, the latest changes from observation legacy systems to IT infrastructure was seen as positive, reducing administrative work in the observation department. Implementation of change management within IT has led to improved uptime of the systems and reduced maintenance work. This has also improved customer satisfaction.

The Nordic co-operation MetCoOp was seen as enhancing operations and strengthening synergies already established, such as joint NWP development. The IT department currently takes part in an open source project (GeoWeb) jointly with other NMS to provide new tooling for forecasters.

The IT department has been in the process of obtaining ISO27001 certification, providing a high level of cybersecurity (which is required for providing services). The certification was a requirement from the Ministry of Climate and Environment.

Within MET, there is wide freedom for employees to express their personal development objectives, and this is the case also in the IT department. In the past, this has led to system development environments with loose guidelines and single point of knowledge systems, where only one person knows how to maintain or update software programs. With more complicated systems to be maintained by groups of people instead of one person, guidelines and standards are essential.

In addition to the IT department, software development is done in other departments, for example in Obsklim and SUV, in discussion with their management they had a positive attitude for setting common MET wide guidelines for software development. The IT department has worked on coordinating and organising the IT infrastructure, and this has been well received by

other departments. The other departments have appreciated the IT department's initiatives for cross-functional processes, such as an architectural team.

Recommendation: MET should continue the process led by the IT department to standardize software development processes/environment across the organization.

Internal IT structures

There was identified lack of communication between system developers at SUV and infrastructure and operation support providers at the IT department side. This led to slower roll out of developed services and additional work on the operation support side.

There were indications of the need for internal discussions between departments and common roadmaps towards strategic goals. As stated earlier in the research section, there are good cross-departmental initiatives on individual projects (such as S-ENDA). On a more strategic level, this did not always seem to be the case. Resource management appeared to be easier in individual projects than when there were issues with "bottlenecks" of staffing to fulfill common goals.

IT resources were in some development cycles seen as a bottleneck, this could be due to the burden of maintaining legacy operational systems reducing the working hours allocated for development. This can be the outcome of insufficient software life cycle management.

Recommendation: Consider setting up life cycle management for developed operational software.

Outsourcing of IT work was only 2-3% of the IT budget. Due to the fact that there is high demand in Norwegian society for certain types of software skills, there is competition between private and governmental sectors for this work force. This could be solved by outsourcing either within Norway or abroad.

External co-operation

IT is well connected within Nordic countries and ECMWF for joint cooperation such as MetCoOp, GeoWeb and ongoing pilot projects in European Weather Cloud (EWC). IT staff view international exchanges as useful, bringing new career opportunities and enhancing skills.

The EuroHPC initiative is a joint effort by the European Commission and 31 countries to establish a world-class ecosystem in supercomputing to Europe. Norway is part of the LUMI (Large Unified Modern Infrastructure) consortium (550 PetaFLOPS, 550K TFLOPS). If access were possible to Norway's LUMI allocation, that could be considered as an asset for MET's research.

An overall policy of MET on how to use cloud in operations should be created. Different cloud implementations are commercial cloud services such as AWS, Google etc, the European Weather Cloud (EWC) and on-premises cloud. A cloud policy could define hybrid usage of these. There are several aspects to take into account when setting up cloud usage policy, such as operational cost, portability cost from cloud provider to cloud provider, governmental legislation, staff capabilities and training needs for new environments and techniques such as AI and ML methods. This transition from on-premises systems to hybrid cloud environments is ongoing in general in IT system operations so experience either from other European NMS or Norwegian organisations could be used to help in this. Once the cloud policy is established this should be taken into account in the system development phase.

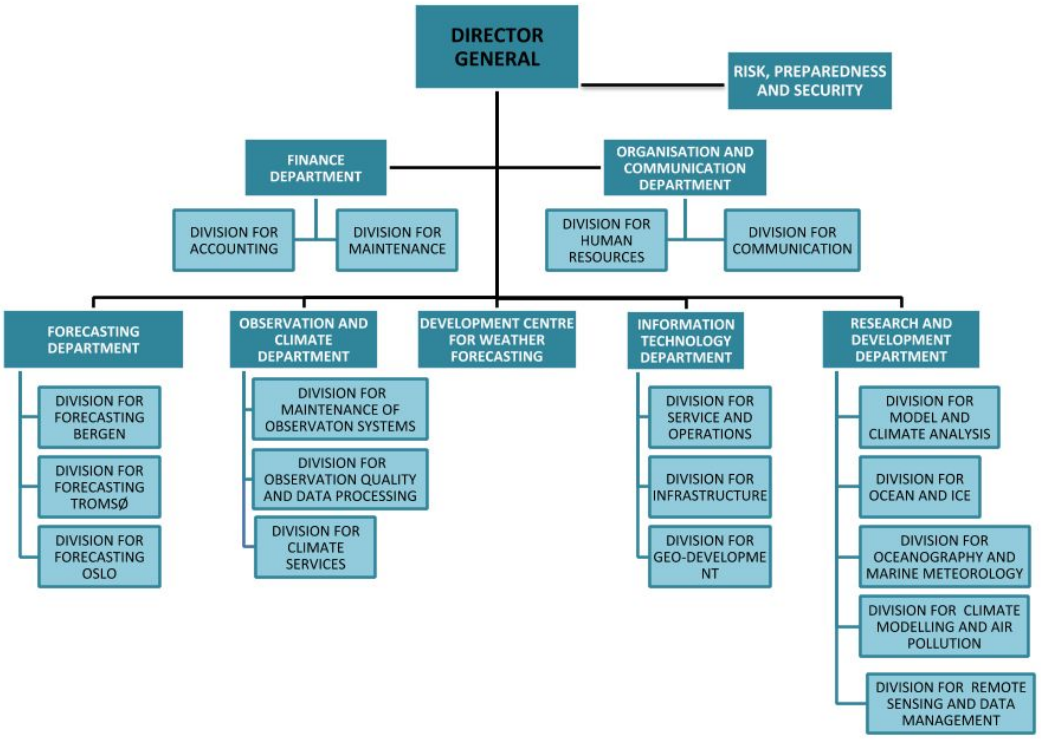
Recommendation: Consider setting up cloud usage policy: public, EWC, on-premises.

4. Organisation, strategic leadership and governance structure

MET is an institute organised under the Ministry of Climate and Environment. The annual allocation letter is the steering document from the Ministry to MET. The document clarifies the overall objective, business objectives, management parameters, performance requirements and administrative directions. The content of the document is elaborated in close collaboration with MET.

MET is led by a Board consisting of 7 members and chaired by Kristin Vinje, chief executive at NOKUT (the Norwegian Agency for Quality Assurance in Education).

The 2020 budget for the running of the institute is NOK 340 mill. 146 mill is earmarked for international collaboration, on a separate budget post. In addition MET's income from research and commercial activity is about NOK 115 mill. In total there are 434 employees situated in Oslo, Bergen and Tromsø.



To follow up the expectations from the Ministry and the Board there is a Strategy document covering the three years from 2019 to 2021. It is due to be renewed during 2021. There is also an annual plan followed by an annual report for every year.

In parallel with this evaluation, there is another similar evaluation being performed on the commercial activities of MET. Based on that report there are a few connections that will apply to this evaluation.

Allocation letter

The content of the letter is the key to the annual performance and is therefore the most important steering document for MET. It describes and levels the objectives and parameters for

the year, although inevitably its content must be influenced to some extent by the longer term direction.

It also describes expectations on both weather and climate forecasting, research and commercial activities. The annual revenue finances the total cost of the core tasks, and a share of the research.

Recommendation: MET should continue to work closely with the Ministry in the input phase of the writing of the annual allocation letter in order to ensure that the important aspects for MET are mentioned with clear goals and are followed by sufficient funding.

Strategy document

The strategy document 2019-21 consists of a vision: “We protect life and property, with world-class services”, which is followed by 5 strategies to meet the different expectations that MET has formulated.

1. MET Norway is always available to society when it is required.
2. We enable society to address climate change
3. Our research transforms science into world-class operational services
4. MET Norway excels in distributing, integrating and sharing data
5. MET Norway has smart value chains

The interviews show that the existing document is well known by most of the employees and is used as a basis for the annual plan. It is difficult to say how important the document is in the planning and performance of the tasks for the coming year and daily tasks. Is there a clear ownership of it by the board and how is that reflected in the discussion between them and the DG? And in the other direction, how well is it working in the governance of the departments and individual employees. From the way it is formulated, the Committee assumes it has most value in the latter aspect.

MET has not prepared a long term plan or vision, but with growing needs for investments in and maintenance of infrastructure and technical equipment this could be necessary further down the road. As a good start we recommend extending the length of the strategy from three years to at least ten years. By doing this change in the strategy, it could be used as a base for large and long term planning, maintenance and investments in knowledge and infrastructure.

Recommendation: MET should start the work on the new strategy and consider changing it into a long term strategy (10-12 years) combined with short term implementation plans (3-5 years) to always have an updated roadmap as a tool for strategic leadership.

Human resources and organisation

Through the interviews with the employees and the unions we have been met by the description of heavy workloads throughout MET. With this as a base we have tried to elaborate whether the resources available are used in the best way. From the interviews there is an understanding of great freedom for the employees to decide on what they spend their working hours on, which in many aspects gives a bottom-up approach to prioritization of a limited amount of capacity. Prioritization of the tasks in and between the different departments is one obvious tool for the board of directors. Having a continuous, thorough and inclusive discussion and coaching of the employees to challenge if the quality and details of some of the deliveries are too high is another tool.

The evaluation has not proposed any organisational changes, but will recommend that this is looked into as a consequence of the recommendations. Questions that should be asked then include:

- Is there enough done to give access to and implement new and easier infrastructure for manual work?
- Is automatisation chosen where it extensively can take down workload?
- Is knowledge gained in projects in R&D and SUV implemented into the core tasks in a sufficient way to strengthen performance and quality of the forecasts?
- Is competence used in the best way and in the best place throughout the institute?
- When recruiting, is that based on an overall and long term plan for competence?
- The future need for different professions will also be an important part of this work. To have the broad and necessary cooperation with the different universities both nationally and internationally will still be the best tool for this.To prepare for student projects at all levels is an easy way to be able to choose among the best candidates
- What will automation and other developments do to the future need for knowledge if you look 10 - 20 years ahead?
- Outsourcing either to the private market or to other public bodies (DFØ -The Norwegian Agency for Public and Finance Management) could be a solution if further efficiency needs to be looked into.
- MET’s work on climate service is scattered in different parts of the organisation. This area is one of the main drivers for new and high level knowledge. Whether there is a

need for changes of the organisation in this matter must be a part of the strategy process.

- The evaluation has not shown any urgent needs for organisational changes, but most of the discussions on this matter has been about SUV and their role and mandate as a “stranger” in the organisation chart. Looking backwards in history this looks natural, but it should be looked into if this is the best way forward to do the necessary development.

With a fairly big organisation in three different cities, there will always be a need for strengthening the work on cross-organisational processes. This is due to geography, but also between the different departments that have very different professions and tasks. It will be possible to gain more and better results from cooperation.

The climate research part of the portfolio is a good case in that aspect. The internal evaluation on organisation is concluding on a cross functional program led by a program manager. This will be a good solution in the short term, but depending on the future importance of climate research in MET, the development should be looked into as part of a long term strategy.

Recommendation: The impact on human resources and organisation must be natural ingredients of the work on the new strategy. The Committee will emphasize the impact from present and planned modernization on the content of the forecaster's job.

Tasks versus economy

As discussed in the earlier chapter, it is necessary to find a balance between the different tasks and the sources of revenues connected to them. We believe that having a clear view of the way forward in a changing future is necessary for avoiding this happening by chance instead of having a plan as a base. The core tasks should be financed solely from the governmental funding, the commercial should be financed by the one ordering the task and the research will mainly be financed from different external sources.

The question that has to be raised must be if today's mix is right for now and for the future. There is a risk that core tasks will lose the competition towards the externally funded, especially if the revenues from the government are reduced. The evaluation on commercial tasks shows there is a similar picture between WF and the commercial activities as we have looked into the relationship between WF and research.There has to be a discussion and decision on a balance between applying for and working with research projects and doing the core and the commercial tasks.

Climate is an area where there is a need for strategy to decide the way forward independent of a complicated revenue situation. The funding of the three divisions differs: climate modelling is almost fully funded from external sources, climate analysis is split more or less equally, which climate services is mainly funded by the core funding from the government. The market for private revenues should be looked into for possibilities for new services.

Recommendation: The strategy should be the natural context to discuss and conclude on the ratio on governmental revenues versus commercial and research incomes.

The board

In the mandate the responsibilities of the board are stated as:

- appointing the Director General
- drawing up MET's main priorities
- deciding the organisation of MET
- ensuring that personnel is hired
- approving the yearly plans
- approving MET's budget proposal to the Ministry of Climate and Environment
- approve the allocation of funds according to guidelines from the Ministry (and the Parliament)
- performance monitoring and budgetary control
- submitting the annual report and financial statement
- ensuring that MET's operations are subject to professional assessments
- analyses identifying the most important risk factors at MET
- decide other issues regarding MET's operations

The board may delegate authority to other parts of the organisation.

The list of tasks can be understood as a short term governance mandate. The evaluation recommendations will clearly advise MET to look and plan further ahead than they are doing at present. The board must be a vital part of that change by supporting MET with views from outside, and broadening the perspectives for the future. The board should also be a driving force for innovation in MET and make sure it has value for the society.

Recommendation: The board should be given an extended mandate with a clear role in developing a long term vision and leadership of MET.

Quality and risk management

ISO 9001 is implemented as the tool for quality standards and risk management in the aviation service and AWS. If the recommendations given on strengthening the internal cross functional and organisational work, there will be a need for common quality standards. There are also plans to develop even more cooperation with other administrations and research institutes. In that aspect, quality of delivery will be vital.

Further implementation of quality standards throughout the organisation can give the necessary assurance of the level of quality. This will apply to the management of IT- and technical infrastructure of MET with emphasis on lifecycle management as a main task as stated in chapter 3.

The allocation letter states that ISO 27001 shall be implemented to cope with the rising risk of cyber attacks. MET's infrastructure and services are a vital part of Norway's tools for preparedness in most of the society and will therefore be an obvious goal for such attacks.

Risk management concerning goals and performance management, finance and administration appears to be very well taken care of as far as the evaluation has looked into the subject.

Recommendation: MET should continue its work on developing the organisation built on the principles of the ISO standards. This is most important for the quality of its own operational performance, but also to easily meet quality and risk management expectations from both national and international cooperation partners.

Conclusion

The overall impression of the Evaluation Committee is that MET Norway is a first class meteorological service, whose technical expertise is highly recognised and appreciated by its users and partners, whose staff are motivated and proud to be members of MET, and whose ability to successfully apply for external funding is particularly impressive.

The Committee has proposed 22 recommendations that it thinks could further improve the performance of MET Norway.

Half of those recommendations can be summarised by the following overarching sentence: MET should develop and update a long term vision that will allow it to anticipate evolutions that might need important changes, be they structural, staffing priorities or funding levels. The way to develop this long term vision should take various formats such as agreeing common roadmaps with partners, anticipating technical changes that will affect working practice, in particular concerning forecasters, or identifying new necessary expertise. The preparation of this long term vision should also be an opportunity to reinforce the role of the Board and the link with the ministry.

Several other recommendations concern developing existing management tools such as quality management and software standardisation, or introducing new ones such as life-cycle management. Another area relates to the implementation of external surveys, in order to give MET a better understanding of how its products and services are used, thus ensuring any required evolution. Finally a few stand-alone recommendations address potential issues or possible improvements identified during the evaluation.

The goal of the Evaluation Committee when drafting these recommendations is to further improve the very good situation of MET Norway. The Committee is confident that MET Norway has the necessary skills and resources to remain a major player within the European meteorological infrastructure.

Recommendations

These recommendations are listed in the same order as they appear in the report, and are not prioritized. They are numbered for easier reference.

1. *NWP modelling*: Develop pan-MET vision for the role of a future coupled NWP system in directly meeting user needs in fields currently served by offline systems (ocean, hydrology, air quality) and high-level roadmap to get there (p. 7).

2. *Ocean/wave modelling*: MET should develop a 5-10 year roadmap for the evolution of ocean/wave/ice models, looking to streamline the range of models used (p. 8).

3. *Climate modelling*: Develop roadmap with research partners with a view towards strengthening climate modelling partnership outside Norway (p. 8).

4. *Research to Operations (R2O) and Operations to Research (O2R)*: Consider whether a strong enough mechanism is in place to capture overall priorities for NWP and other operational models improvement (underlying system and tools/products for exploitation) which can be used for prioritization of research and development activities (p. 9)

5. *Research partnerships*: Consider opportunities to strengthen lobbying to influence calls for research funding for MET or for MET's partners in priority science areas (p. 10).

6. *Internal structures Research and Development*: Revisit question of organizational structure after completion of agreed roadmaps for coupled NWP and for ocean/wave/ice models (p. 11).

7. *The case of NVE*: MET and NVE should consider elaborating a common roadmap for the development of cooperation between the two entities, including in particular flood forecasting, observing networks, climate services, satellite data utilisation and coupled modeling (p. 13).

8. *Aviation services*: Funding allocated to MET should be adjusted to the full cost of the aviation services provided on the one hand, and the services to aviation adjusted to aviation requirements on the other hand (p. 14).

9. *Monitoring MET forecasts*: Post event evaluations should be extended to more cases (e.g. orange level), and systematic surveys of recipient's perception of MET's warnings to be implemented (p. 15).

10. *The forecasting process*: MET should consider increasing non-shift work by forecasters, such as user engagement, training and participation in R&D projects with other departments or MET partners. This could be done in particular by allocating part of future efficiency gains from forecasting services automation (p. 16).

11. MET and the Ministry should ensure that, as long as they remain necessary for supporting governmental agencies in charge of security, the night shift of forecasters could not be endangered by a reduction of commercial funding (p. 16).

12. *Observations, quality control and data*: Consider evaluation or user survey of frost.met.no from an external developer perspective. Consider following up external APIs user trends and evaluating societal impact of MET's data shared via APIs (p. 19).

13. *External partnerships for development:* Scan new technologies for strategy and identify key partners for selected new technologies (p. 20).

14. *Information technology:* MET should continue the process led by the IT department to standardize software development processes/environment across the organization (p. 21).

15. *Internal IT structures:* Consider setting up life cycle management for developed operational software (p. 21).

16. *External co-operation:* Consider setting up cloud usage policy: public, EWC, on-premises (p. 22).

17. *Allocation letter*: MET should continue to work closely with the Ministry in the input phase of the writing of the annual allocation letter in order to ensure that the important aspects for MET are mentioned with clear goals and are followed by sufficient funding (p. 25).

18. *Strategy document:* MET should start the work on the new strategy and consider changing it into a long term strategy (10-12 years) combined with short term implementation plans (3-5 years) to always have an updated roadmap as a tool for strategic leadership (p. 26).

19. *Human resources and organisation:* The impact on human resources and organisation must be natural ingredients of the work on the new strategy. The Committee will emphasize the impact from present and planned modernization on the content of the forecaster's job (p. 27).

20. *Tasks versus economy*: The strategy should be the natural context to discuss and conclude on the ratio on governmental revenues versus commercial and research incomes (p. 28).

21. *The board*: The board should be given an extended mandate with a clear role in developing a long term vision and leadership of MET (p. 28).

22. *Quality and risk management*: MET should continue its work on developing the organisation built on the principles of the ISO standards. This is most important for the quality of its own operational performance, but also to easily meet quality and risk management expectations from both national and international cooperation partners (p. 29).

Annex 1 Composition of the Committee

The committee consists of three members with a background from meteorological services. It is chaired by the former director general of ECMWF and Météo-France, and the committee is gender balanced. An assessment of impartiality and conflicts of interest was performed.

Name	**Profile/expertise according to mandate**	**Position and appointments**	**Country**
Dominique Marbouty	Chair of the Committee Meteorologist Earth observation Computing	- VP European Met Society - VP French Met Society - Interministerial coordinator Copernicus 2012-2018 - DG ECMWF 2004-2011 - DOp ECMWF 1999-2003 - Deputy DG Météo-France 1991-1999	France
Tarja Riihisaari	Infrastructure and technology	- Director, Observation and Information System Centre at Finnish Meteorological Institute (FMI) - Manager, Development of Services Unit at FMI - Project Manager, AC SAF EUMETSAT at FMI - Quality Manager, Nokia Mobile Phones (NMP), Global Sourcing - Senior Research Scientist, Technical Research Centre of Finland (VTT)	Finland
Andy Brown		- Director of Research, ECMWF 2017-present - Director of Science, UK Met Office 2012-2017	United Kingdom
Kirsti Slotsvik	Public sector, organisation and preparedness	-DG Norwegian Railway Directorate 2018- -DG Norwegian Coastal Administration 2007-2018 - Director in region Norwegian Public Roads administration 2003-2007	Norway

Kari Hoel, senior adviser at MET Norway, acted as the secretary of the committee.

Annex 2 Mandate for the Evaluation of MET

v. 1.0, 05.02.2020, ref.2019/1705

1 Background

The Norwegian Meteorological Institute (MET) is a state agency subordinate to the Ministry of Climate and Environment. The institute is headed by a board, while the Director General handles the day-to-day management.

The main offices of MET are in Oslo (head office), Tromsø and Bergen. MET also has offices at three military and one civil airport and manned observing stations at three Arctic island. MET is organized into five departments:

- The weather forecasting department
- The observation and climate department
- The development centre for weather forecasting
- The information technology department
- The research and development department

Two units also support the Director General in his work: The finance department and the organisation and communication department. Furthermore, the Unit for risk analysis, security and preparedness report directly to the Director General.

Figure 1 shows the governing documents of MET and how they are related. The dark boxes show documents set by royal decree or the Ministry of Climate and Environment, the light boxes show documents approved by MET's board. The Articles of association is enacted by royal decree (Dec. 9th. 2005). This document includes the Purpose of MET:

"MET is responsible for the public meteorological services for civil and military purposes. The Institute will work to ensure that authorities, industry, institutions and the general public are best able to protect life and property, plan ahead and protect the environment.

The institute will, among other things:

- Prepare weather forecasts
- Study the climate in Norway and provide climatological reports
- Collect meteorological data in Norway, adjacent sea areas and on Svalbard
- Conduct research and development work
- Deliver aviation services
- Disseminate the results of the work they are doing
- Undertake assignments and provide special services
- Participate in the international meteorological collaboration"

Figure 1: Governing documents of MET Norway

2 Strategy and operational objectives

The Strategic Plan 2019 - 2021 specifies the strategic direction and long term objectives. It also describes how we should develop our culture and ways of working. In short, the plan emphasises the following elements in terms of how the organisation should develop:

- We shall work on the basis of value chains, ranging for observations to user services.
- We will strengthen a culture that facilitates innovation, a good reputation and the ability to adopt enabling technologies.
- We will collaborate and have cooperation (e.g. common production) with other meteorological services, and with private and public actors.
- We share both knowledge and data internally and externally.

The pronounced strategic directions for the period 2019 - 2021 are to

- develop impact-based forecasting and local warnings
- enable society to address climate change
- establish coupled earth system models and effective methods for better use of current and new observations for initialisation and postprocessing
- develop efficient and highly automatised value chains that enables the end user to make smart choices
- increase the societal value of our data

The operational objectives of MET are decided by the Norwegian Parliament annually. The current objectives are:

- to deliver forecasts (weather, ocean, environment) at high international standards
- to ensure that forecasts are useful for all target groups every day all year (24/7)
- to ensure that research is operationalized ("science for service") and that research results are communicated
- to ensure that MET's data have an impact

3 The goal of the evaluation

The primary goal of the evaluation is to obtain an independent assessment of the performance of MET Norway. The assessment will be used in developing the strategy, operational objectives and organisation of MET Norway.

The evaluation will assess to what extent MET Norway is able to fulfil its purpose (as stated above) and the four current operational objectives. However, the objectives should not be considered static, and the committee is encouraged to recommend changes to the objectives. If the main objectives do not match the potential of MET Norway, this should be addressed. Furthermore, the evaluation will assess to what extent we develop in the direction described in the strategy and give indications on elements that should be included in the next strategy.

The main purpose of MET Norway and the funding level are defined by the Government and will not be directly affected by the evaluation. However, the findings of the evaluation may lead to a discussion between MET Norway and the Ministry on these issues.

The criteria and questions listed below will be the basis for the evaluation committee recommendations and assessment. However, the committee is free to provide recommendations that go beyond this framework. The committee may also interview other stakeholders, collaborators and employees than those suggested by MET Norway.

4 Evaluation criteria and questions

a. Research relevance, quality and impact

The evaluation will investigate the relevance, quality and impact of the research, taking into account that the main goal of MET's research is to transform science into world-class operational services. The assessment should address research in earth system modelling for weather, ocean and climate time scales, research in air pollution modelling and the climate adaptation services.

- How is the quality and productivity of the research?
- What is the impact of the research, and is the research-to-operations (R2O) transformation adequate?
- The research is funded partly from governmental grants and partly from external funding. Are there any differences in quality and impact of the research depending on funding source and is MET able to explore the synergies between the two funding sources?
- Is the feedback from operations and user experience adequately incorporated in further research and development (O2R)?

- Is MET contributing to and benefiting adequately from the most relevant and important research networks and research cooperation nationally and internationally?
- How well is MET's research aligned with and positioned for benefiting from and contributing to international research programs and service deliveries (in particular EU research programs and Copernicus)?
- To what extent is MET able to attract, develop and keep excellent national and international research talents?
- How well are the research results communicated to governmental authorities and the general public?
- What are the main research contributions from MET Norway the past five years?

b. Forecasting and Service delivery

The evaluation will investigate the effectiveness and efficiency of MET in (co-)producing and delivering services to public agencies, civil aviation and the general public. Commercial services deliveries will be handled separately and deliveries to the Norwegian armed forces are not a part of the evaluation. Particular focus should be given to collaboration nationally and internationally in operations and delivery and to the user-friendliness of MET's data, products and services. The main collaborating public agencies are the Norwegian Water Resources and Energy Directorate (NVE), the Norwegian Public Roads Administration, the Norwegian Directorate for Civil Protection (DSB), the Norwegian Radiation and Nuclear Safety Authority (DSA), the Joint Rescue Coordination Centres (JRCC) and the Institute of Marine Research (IMR).

- Is MET extracting well the value provided through international collaboration, such as ECMWF, EUMETSAT, Copernicus and MetCoOp, in its operations?
- Are the warnings from MET in accordance with user requirements and are the warnings useful for assessing impact?
- How does MET collaborate with other public agencies in delivering services to the general public? In particular, is the division of responsibility between MET and the main collaborating agencies clear and adequate?
- Is the transparency and seamlessness between MET and these public agencies adequate and sufficient to benefit from the opportunities that emerge in earth system science?
- To what extent are the public agencies able use MET's data, products and services and take action accordingly?
- Is MET able to stimulate the collaborating agencies to supply-induced demand, particularly on specialized services where the expertise to order is presumably low?
- What is the quality and efficiency of MET's services for civil aviation, and to what extent is MET able to take advantage of international collaboration in providing services for civil aviation?
- To what extent are the general public able to access and use MET's data, products and services and take action accordingly?
- How well is MET able to access and understand user needs, and how well does MET respond to user needs and changes in user needs?

c. Infrastructure and technology

The evaluation will investigate the quality and integration of the observation network, the IT-infrastructure and the software supporting research and service delivery. This includes the ability to participate in and take advantage of international collaboration and technological advances.

- Is the coverage and availability of the observation network (in-situ and radar) good enough?
- Does MET take advantage of the established and emerging observations in a forward looking manner?
- Are the systems for collection of observations, quality control and distribution of observations up to modern standards, and are the plans for the future mature and being followed?
- Is the IT-infrastructure for research, operations and delivery of data, products and services up to modern standards, and are the plans for the future mature and being followed?
- Is the quality and relevance of the IT expertise and IT-services supporting research and operations adequate?
- Is there a commitment to the FAIR principles at MET and does the daily practices reflect such a commitment?
- Is MET contributing to and benefiting adequately from the most relevant and important international collaborations in the area of observations, IT-infrastructure and IT-development?
- Is MET responding well enough to technological advances in research, operations and delivery of data, products and services?

d. Organisation, strategic leadership and governance structure

The evaluation will investigate the ability to adapt to changing circumstances and conditions. This includes an assessment of the ability to define and implement relevant strategies and goals. It also includes an assessment of the organisation and governance structure. Furthermore, the evaluation will investigate to what extend the concept of value chains is embraced by the organisation.

- How does the MET leadership work with strategy development and implementation, including the ability to monitor and address societal trends affecting our mission?
- How does the MET leadership address new challenges and emerging research areas?
- How does the MET leadership communicate and follow up decisions internally?
- How does the MET leadership respond to knowledge needs by the government and public agencies?
- How relevant is the MET strategy 2019 - 2021 and what could be important strategic elements in the next strategic plan 2022 - 2024?

- Is there sufficient awareness within the organization of the interlinkages of observations, model development and operations, downstream post-processing

capabilities and service delivery, user interaction and feedback, with research as an essential component of the value chain development and operation?
- Is there a common culture in how observations, IT, research and operations work together on a daily basis and in the planning of future services? To which extent does user interaction and experience influence the value chains at MET?
- Are there any obvious weaknesses or strengths in the way MET is organised? In particular, what limitations exists in the organisational structure with respect to implementing value chains?
- Is MET able to support employees in taking a value chain approach to their work?

- Is the physical organisation of MET, including some units (divisions/departments) having staff at several locations, well-functioning? Do we underestimate the transaction costs of such an organization?
- Is the administrative support adequate to meet the objectives of MET, the requirements of the Ministry and the needs of the five departments, on the background of your experience from similar institutions in other countries?
- How is risk assessment embedded in the decision-making?
- How well does the work with risk analysis, security and preparedness contribute to a common risk understanding and adequate business continuity, and are the units in operations and research able to utilise and benefit from the work?
- How well does MET divide the total available resources and competence among the areas of work? Should the scope of work be changed? Can some tasks or areas be covered better through collaboration, cooperation or outsourcing?
- Is MET interacting in a beneficial way with the academic institutions and relevant research institutions in Norway?

5 Composition of the Evaluation Committee

The evaluation committee will consist of four members, each having expertise in one or more of the areas covered by the evaluation.

1. Dominique Marbouty, Director-General of ECMWF 2004-2011, Chair of the committee
2. Andy Brown, Director of Research, ECMWF
3. Tarja Riihisaari, Director, Observation and Information System Centre, Finnish Meteorological Institute
4. Kirsti L. Slotsvik, Director General, Norwegian Railway Directorate

6 Organization and working procedures

The evaluation will be carried out in three phases:

1. Self evaluation by the departments at MET and preparation of background documents for the panel.
2. The panel meet in Oslo and interview MET personnel and stakeholders. MET Norway will provide suggestions for whom to interview.
3. The panel reviews the material, collect any additional information and write a report.

The evaluation committee reports to the Board of MET Norway. An internal reference group will be available in answering any questions the committee may have. This group consists of

the director general, the directors of the five departments and the directors of the units for finance and the unit for organization and society. MET Norway will provide a secretariat for the committee, headed by our senior advisor for governance.

7 Schedule

The schedule will be agreed with the members of the evaluation committee. In particular, we need to find a time for the committee to meet in Oslo for interview with MET personnel and stakeholders.

8 Background material

1. Description of MET Norway
2. Strategic plan 2019 - 2021
3. Self assessments from the five departments and the three units reporting to the Director General
4. Publication lists 2017 - 2019
5. Evaluation - Research in Earth Sciences in Norway, The Research Council of Norway, 2011
6. Evaluation - Norwegian Climate Research, The Research Council of Norway, 2012

Annex 3 Background material

Most of the background material available for the evaluation committee has been collected and supplied by MET Norway. Parts of these documents (self-evaluations and supplemental information) have been prepared specifically for the evaluation.

Attachments to the mandate:

1. Description of MET Norway
2. Strategic plan 2019 - 2021
3. Self assessments from the five departments and the three units reporting to the Director General
4. Publication lists 2017 - 2019
5. Evaluation - Research in Earth Sciences in Norway, The Research Council of Norway, 2011
6. Evaluation - Norwegian Climate Research, The Research Council of Norway, 2012

Supplemental information:

1. Allocation letter 2020 for MET Norway
2. Activity Plan for MET Norway 2020
3. Årsrapport (yearly report) 2019 (Norwegian)
4. Results from MET Norway's employee survey 2020
5. Articles of Association
6. Mandate for the evaluation of commercial activity (2020)
7. Quarterly reports on Verification of Operational Weather Prediction Models, 2019 and 2020

Annex 4 Interviews

The evaluation committee has had 16 digital meetings with 45 representatives of MET Norway and its collaborative partners. A list of the representatives of the different parties is provided below.

Kristin Vinje	Head of Board MET Norway

MET Norway representatives

Roar Skålin	Director General
Jørn Kristiansen	Development Centre for Weather Forecasting
Tor Ivar Mathisen	Development Centre for Weather Forecasting
Tor Skaslien	Development Centre for Weather Forecasting
Simon Rasmussen	Finance Department
Arnstein Orten	Information Technology Department
Jan Ivar Pladsen	Information Technology Department
Anne-Cecilie Riiser	Information Technology Department
Jo Asplin	Staff representative
Kjell Brandsberg	Staff representative
Siri Spjelkavik	Staff representative
Werner Eriksen	Observation and Climate Department
Hans Olav Hygen	Observation and Climate Department
Vegar Kristiansen	Observation and Climate Department
Kjetil Stiansen	Observation and Climate Department
Kari Hoel	Organisation and Communication Department
Rasmus Benestad	Research and Development Department
Lars Anders Breivik	Research and Development Department
Øyvind Breivik	Research and Development Department
Kai Håkon Christensen	Research and Development Department
Hilde Fagerli	Research and Development Department
Harald Schyberg	Research and Development Department
Yousef Abu Afifi	Unit for Risk, Security and Preparedness
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