19th Met Office Scientific Advisory Committee Meeting (5-7th November 2014)

Chairman's Report with Chief Scientist's Response

Preamble

The 19th meeting of MOSAC took place concurrently with the annual meeting of the Hadley Centre's Scientific Review Group (SRG) and a significant portion of the MOSAC meeting time was dedicated to joint plenary sessions with the SRG.

MOSAC passed on its congratulations to the Met Office's newly appointed Chief Executive, and also congratulated the Chief Scientist on the honour bestowed on her in the Queen's New Year Awards for 2014. The Committee is pleased that the Chief Scientist has agreed to continue in her role at the Met Office. It also welcomed Roy Rasmussen (National Center for Atmospheric Research) and Gabriele Hegerl (University of Edinburgh and Chairperson of the SRG) as new members of MOSAC, and notes that one non-Executive Member of the Met Office Board was present at the meeting as an observer.

At the meeting the Chief Scientist summarized the major advances in the Office's research capabilities and achievements, and the four Deputy Directors overviewed developments and on-going activities in their specific domains. In addition the Chief Meteorologist addressed MOSAC on the evolving role of the Operational Forecaster within a modern National Weather Service, and the Director of Business Development provided a scene-setting overview of the new 'Scientific Consultancy' grouping that is integral to the Applied Science Directorate. A further 15 presentations focused on specific aspects of the Office's research activities, and two of these presentations were somewhat unusually but appropriately given by members of MOSAC.

1. Major Achievements and Challenges.

Here we refer briefly to some major achievements and challenges whilst deferring detailed consideration to subsequent sections. The overall impression is that there has been progress in research on many fronts and that in some areas it is both impressive and strikingly innovative. The quality and strategic vision of the research is highly commendable. In effect the Office has consolidated, and in some respects enhanced, its position as a world-leading institution for weather and climate research and operational weather forecasting.

An indication of the progress is the Office's publication and citation record that continues to improve and places it amongst the foremost institutions in the field. Likewise the active role it plays in multi-national activities has established it as a recognized and acknowledged lead player on the international scene. A further confirmation of its status is that the Office's forecast capabilities were subject to severe and successful testing during the severe weather events of the 2013-14 Winter. It has retained its second place ranking (to ECMWF) in the international league table for global forecast skill, and its suite of deterministic and ensemble regional forecast models for the UK constitutes a regional forecast capability of a high quality. It is to be expected that the introduction of various well tested improvements to the operational suite, and in particular the refined dynamical core (ENDGAME) that became operational in July 2014, will help sustain and improve its performance.

During the year the Office successfully invested a major effort in developing and implementing a rigorous procurement process for the new supercomputer. This achievement,

based upon well-founded technological and scientific criteria and a strong business case, is to be highly commended. Plans to effectively exploit the computer's capabilities are emerging and need to tension carefully the challenges of diverse operational and research opportunities. A priority clearly articulated by the Office is to evolve and undergird the science for improved value-added regional forecast capabilities. It will be an imperative for the Office to demonstrate the value of the new supercomputer.

The plans to exploit the computer also highlight two key issues. First is the scientific challenge to radically improve our fundamental understanding of convection and its representation in models so as to improve predictive capability across a wide span of spatial scales. A welcome development is the establishment of a joint Met Office - NERC project focused specifically on this theme. Second is a generic issue related to the technically advanced and scientifically challenging nature of much of the Office's core research activities. Achieving significant progress for example in the realm of 'Environmental Prediction' will require substantial effort and investment over an extended time period, and this underscores the need to secure a long-term funding base for such activities over and above the potential of engaging in collaborative activities with other Institutions.

An excellent exemplar of collaboration is the GungHo Project in which the Met Office and some academic institutions across the UK (supported by a NERC research programme) have combined to design and develop the next generation dynamical core for the suite of Met Office prediction models. The project has now successfully entered its final phase.

Another welcome and highly innovative development is the component of the new Observational Strategy concerned with identifying, acquiring and utilizing new data sources capable of delivering additional observational information with high space-time resolution and at comparatively low cost. The use of such data to ingest during the rapid cycle of regional NWP predictions has considerable potential, and the pursuit of this strategy merits vigorous and rapid exploration.

We welcome MOSAC's endorsement of our progress this year on several challenging aspects of the programme, in which MOSAC quite rightly expressed some concerns last year with regard to the innovative and bold nature of some of our plans. At the same time we are pleased that MOSAC recognises the major contribution Science has made to improving Met Office operational performance and hence the quality of services that we provide to our customers. This year has been one of consolidation of previous initiatives and preparation for the exploitation of the new supercomputer, due to begin installation in late 2015.

2. Specific Science Issues.

(a) Foundation Science.

Activities and advances in Foundation Science during the last year have been shaped by the further development of ongoing research and by the availability (or imminent availability) of new infrastructure / capabilities.

In the former category a major and noteworthy landmark has been the successful introduction into operations of the global ENDGame dynamical core at 17km resolution accompanied by upgrades to the representation / parameterization of some physical processes. This is to be followed by the ENDGame's introduction to the regional-weather, global-seasonal, global-coupled, and the earth-system model configurations. It is to be expected that the elements

of scalability realized within ENDGame will stand the Office in good stead for a significant part of the next decade.

The progress in the collaborative development of the next generation dynamical core (GungHo) was noted earlier. This is particularly notable because it is an exacting task that is subject to constraints of satisfying desirable horizontal discretization and scalability properties whilst retaining the unified approach. In addition several other major issues including the separation of the dynamical core from other model components, the treatment of tracers, and temporal and vertical discretization are being addressed in a commendable fashion. It is to be expected that the work on designing and preparing the eventual replacement to the UM (- the LFRic project) will soon acquire more momentum and require more staff. A significant feature of LFRic that complements European research on scalability is the new PSyKal structure that delivers scalable kernels that are more universally useful.

The overview that was presented of forecast model performance in the tropics is indicative of the nature of the current challenges in global and regional model development. Progress is evident on a range of topics such as the favourable impact of the ENDGame core and higher resolution upon hurricane representation and tropical winds, and some preliminary encouraging results with a convective stochastic back-scatter scheme. In contrast there are significant deficiencies in the prediction of tropical precipitation, and the representation / parameterization of convection (and possibly other physical processes) in the tropics and elsewhere remains an Achilles heel. Measures that could at least partially address the shortcomings include participation in tropical convection campaigns, and the development and deployment of insightful purpose-designed diagnostic techniques. MOSAC is encouraged that the Met Office has plans to engage in such activities, and welcomes the establishment of a major joint initiative with the UK academic community on the theme of convection.

Since MOSAC, NERC has confirmed matching funding of £5M over 5 years to support a joint strategic research programme on *Understanding and Representing Atmospheric Convection across Scales.* This will exploit the forthcoming advances in HPC capability to develop a suite of process based convective-scale simulations to act as a virtual laboratory to achieve a step change in our fundamental understanding of convective processes and their interactions with atmospheric flows. Ultimately the aim is to develop new approaches to convective parametrisation which reflect our new understanding of convective processes and their spatial and temporal characteristics, and that lead to improvements in our modelling systems. There are also significant opportunities for international engagement with this activity through the WCRP GEWEX[1], and our partnerships with NCAR and JPL. We will report to MOSAC next year on the implementation and progress of this new programme.

The new Observational Strategy is broad in its scope, innovative in its conception, and far-reaching in its implications. MOSAC had noted in its previous report that planning for new observations to support high-resolution regional forecasts would be a fundamentally critical activity over the next decade. The new strategy addresses this point directly and indeed lists possible opportunities to extend the observational capacity that include the seemingly practicable exploitation of Mode S and other opportunistic data sources such as mobile telephones. MOSAC encourages the vigorous pursuit of this strategy. Likewise the Office will need to consider and articulate to what extent the Observational Strategy can or should take into account the

[1] GEWEX - Global Energy and Water Exchanges is a core project of the World Climate Research Programme (WCRP)

(conceivably) very different and more tailored needs of the Applied Science Directorate's stakeholders and customers.

MOSAC further notes that the type, number and frequency of required observations will undergo order(s) of magnitude increase in the transition to 'Environmental Prediction' and will involve interfacing with other scientific disciplines and agencies both nationally and internationally. In this context the Office will need to address a range of issues including the access and timely availability of data, stewardship procedures, ownership and data exchange policies, development of standardized metadata and international repositories.

Now that supercomputing resources are secured for the next few years, it is vital that our observations keep pace with the models and forecasts. Consequently our observations strategy is a key component of our science strategy for the next 5 years. We are pleased with MOSAC's endorsement of our approach and the recognition of the potential contribution from opportunistic data sources. This is likely to become increasingly important in the longer term as we expand our Environmental Prediction activities.

We note also MOSAC's important comments on access to and management of data, spanning science disciplines and user applications, and agree that addressing these issues will be vital not just for Science but wider Met Office operational and business activities. We are currently playing a key role in a Royal Society Report on '*Optimising the benefits of environmental observation for the UK*'[2] which will address many of the issues touched on here. We would be happy to update MOSAC next year on progress with our observations strategy.

A second category of Foundation Science activities related to the new HPC and the arrangements for the 'Facility for Airborne Atmospheric Measurements' (FAAM). For the former the success of the HPC procurement process was noted earlier, and an appropriate staged plan has been developed for its implementation. The accompanying Science Plan met with MOSAC approval, and the percentage of the computing time devoted to operational and to research activities is in line with current usage both at the Met Office and other comparable Institutions.

The FAAM negotiations were completed during the year and it was secured as a UK national asset to be owned and managed by NERC with strong Met Office support. MOSAC was briefed on FAAM's new contractual basis, logistic arrangements, and the (multi-layered!) organizational structure. The new arrangements could in principle enable longer-lead times for ramping-up campaign plans, and opens the possibility for FAAM to lead international campaigns. An outline was given of proposed campaigns involving the FAAM aircraft, and MOSAC noted approvingly that the joint Met Office - NERC campaigns were aligned to key research objectives of the Office.

MOSAC regretted that to the present logistical and other factors have militated against the deployment of the aircraft in the forthcoming T-NAWDEX /Downstream campaign[3]. This campaign is geared to improving our understanding of the processes that trigger waves on the Rossby wave-guide over the Atlantic, determine their subsequent downstream propagation, and their role in the development of high impact weather events over Europe. It would thereby help identify weaknesses in current NWP systems and contribute to refining the observational strategy for 2-3 day forecast for the European area. Even at this late stage, MOSAC encourages the Office to explore the possibility for FAAM to take part in the downstream component of T-NAWDEX.

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[2] https://royalsociety.org/policy/projects/environmental-observation/

[3] T-NAWDEX: THORPEX North Atlantic Waveguide and Downstream Impact Experiment. See *www.wmo.int/pages/prog/arep/wwrp/new/documents/T-NAWDEX.pdf*

Since MOSAC there have been additional internal meetings on the Met Office's participation in T-NAWDEX. There are plans for various modelling and data assimilation activities as part of T-NAWDEX. Further discussions are planned with the UK community on what research measurements could be made, both from the ground and from aircraft to contribute to T-NAWDEX. It may be possible to use FAAM for some UK based flights for a limited part of T-NAWDEX. This option is undergoing further investigation.

(b) Weather Science.

Efforts in Weather Science are currently focused on the eminently appropriate goal of moving to a model constellation comprising global deterministic and ensemble predictions at 10-20km, UK-encompassing regional ensemble predictions at around 1km, and the provision of ensemble-base pdfs for local (hazards) conditions. MOSAC recognizes that basic to this approach is the recognition (a) of the 'grey' zone between the two fore-mentioned horizontal scales separating predominantly hydrostatic and decidedly non-hydrostatic flow features with concomitant implications for the representation / parameterization of physical processes, and (b) the regional prediction models currently provide added-value over the global predictions with the indicative relative benefit for the UK judged to be of the order of 9% (but subject to notable short-term variations).

Illustrative evidence was presented of improvements across the suite comprising the deterministic global and UKV configurations and the MOGREPS-G and -UK ensemble systems, and MOSAC noted approvingly that particular emphasis is to be given to the convection-permitting ensemble system for the UK and risk-based predictions of high impact weather. The attendant progress is in part attributable to the testing and implementation of the ENDGame dynamical core combined with a number of physics and data assimilation upgrades. Other relevant activities have encompassed examining model biases, the assimilation of low-cloud, and the possible introduction of a blended turbulence boundary layer scheme. Further MOSAC endorses the consideration being devoted to the generic 'ensemble prediction' issues of spatial resolution, domain size, cycling frequency, ensemble size and forecast length. Given the commitment to increasing the horizontal resolution of the prediction models, the Committee also emphasized that detailed consideration based upon sound physical grounds needs to be given to the issue of the appropriate vertical resolution for the model suite.

The committee's comments on vertical resolution are well made, especially with respect to our very high resolution regional models. We have experimentation planned this year to investigate higher vertical resolution and its forecast benefits with plans to implement increased vertical resolution in 2016/17 with increased availability of HPC resources. It is worth noting that this may not be a simple change because of the impacts on downstream products that depend on model vertical resolution. We will report on these studies and plans in more detail next year.

MOSAC notes the rationale advanced for introducing a weighted Business Performance Measure (BPM), but believes it would also be helpful for understanding the underlying causes of forecast failure to examine the performance of a sub-set of the ingredients included in the metric. Likewise MOSAC notes that the time-trace of the global model's prediction skill is displayed as a 'comparative' measure. Again in considering synoptic scale flow there is a case for assessing model performance in absolute terms particularly when examining the dependence of prediction skill upon weather regimes. In addition MOSAC again encouraged the use of probabilistic skill measures to assess the skill of ensemble forecasts.

The new BPMs are top level metrics designed to be part of the Met Office Corporate Business Performance Measures which we report to our owner, BIS. They are of course no substitute for the more detailed monitoring and evaluation of our NWP systems which are a core part of Weather Science. The dependence of predictive skill on weather regimes is very important and we welcome MOSAC's recommendation to explore this further. Likewise we are actively developing probabilistic skill measures as part of our future verification suite.

There is no doubt that forecast verification and post-processing is becoming an increasingly demanding area of R&D for us. Consequently we are undertaking a major review of diagnostics, verification and post-processing and we would be happy to report on the outcomes of this next year. We will also plan to provide more detailed evaluation results for the committee to consider.

Data Assimilation (DA) has evolved to become a very valuable component of the Met Office's global and regional prediction suites, and it exerts a significant impact upon forecast performance across a range of scales. Sophisticated refinements have been tested and successfully introduced to accommodate the more rapid cycling frequency and the increased resolution of the global and regional model forecasts. Further upgrades are also under consideration. Interestingly the contribution of DA to regional reanalysis has now been calibrated and demonstrated to be critical to the quality of the derived data sets. The range and depth of these DA activities are commendable and of the highest international standard. In the context of DA, MOSAC noted the timeliness of the emerging Observational Strategy and was supportive of the close collaboration between the two activities. It noted the particular need for water vapour data especially in the boundary layer.

Developing a capability to provide information on the likelihood of hazard events / conditions takes the Office into the evolving realm of Environmental Prediction. This will in turn require ingesting a broader panoply of observations into models, refining the suite of weather prediction models, introducing innovative techniques for data assimilation, and strengthening the Office's capabilities in this broad field. Progress on two themes related to Environmental Prediction that involve collaboration with the Center for Ecology and Hydrology, the National Oceanographic Center and the Plymouth Marine Laboratory were reported in presentations entitled "Coupling Strategy for Weather" and "Land-surface Modelling: strategy and applications".

Here these presentations are commented upon together. The first recorded (a) further development of the prototype regional project outlined last year aimed at linking high resolution UK atmospheric models with models of the coastal ocean, land surface and hydrological processes, and (b) some preliminary experiments using a global atmosphere-ocean coupled models and a weakly coupled atmosphere / land / ocean / sea ice data assimilation system. The second focused on the challenges associated with benchmarking, refining and extending the land surface model (JULES) to accommodate the enlarged range of potential uses and applications that can stem from interfacing the model with high resolution atmospheric models. The research goals of both projects are highly ambitious and require the development of some pioneering elements. Nevertheless the progress achieved to date is significant and highly commendable. Currently both projects are geared to developing an operational capability on a relatively short time-frame (some components to be delivered in 2015 and 2017). MOSAC remains concerned that this time-frame is highly demanding, and believes that both themes would benefit from acquiring a more robustly tested foundation including case studies to demonstrate value. The Committee is encouraged by the Office's considered response to the issue, and invites the Office to further reflect upon this matter in light of the accompanying demand upon resources.

The concerns expressed by MOSAC are well made and we are acutely aware that we are entering some challenging domains with these areas of research. But early results and assessment of the potential customer needs in the future have convinced us that we must pursue these goals albeit with realistic expectations on timescales for delivery. For clarification our current plans are that prior to 2017 only research versions at NWP resolutions will become available to do case studies. Operational coupled global NWP will likely be implemented in 2018 at the earliest.

MOSAC was also presented with an overview of the broad character and the possible forcing factors that contributed to the distinctive and destructive weather events experienced in the UK during the 2013-14 winter. It was stressed that there were a range of forcing factors and that a significant role was played by Rossby waves. MOSAC noted that this particular winter could constitute one of a series of test cases for examining the performance of seasonal prediction systems and that retrospective studies could offer valuable insight.

(c) Climate Science

The comments on Climate studies in this section and elsewhere in the report relate predominantly but not exclusively to the significant portion of fundamental climate research conducted by the Met Office in addition to the MOHCCP activities funded by DECC and Defra.

The Office's activities related to 'Monthly to Decadal Variability and Prediction' has been refined and reconfigured under the new theme "Global Dynamics of Climate Variability and Change". MOSAC was provided with an overview of the general goals and specific objectives of this research area, and notes that addressing the fundamental dynamics of climate variability and change with a view to delivering an improved prediction capability is a major but timely scientific challenge.

One aspect of the challenge is the group's recent study indicating that the predictability signal in seasonal forecast model is probably smaller in amplitude than the corresponding realized atmospheric signal. This result poses queries regarding the fidelity of the underlying model dynamics, and has direct implications for determining the requisite ensemble size of the forecast system and for ascertaining the regions of the globe currently most likely to benefit from seasonal forecasts.

MOSAC appreciated the provision of additional results for the retrospective study of the seasonal predictive skill for the wintertime North Atlantic Oscillation (NAO), and concur that the results lend additional credence to the potential of seasonal forecasting. However MOSAC remains of the opinion that an increase in the sample size is desirable for such a retrospective exercise (there is evidence that the NAO was not as predictable in the 1960 and 1970s compared with the more recent period), and cautions that the NAO itself might not always be the most dynamically meaningful and compelling indicator of extreme seasonal weather over Europe. MOSAC needs to be kept informed of the Seasonal Forecast System's on-going performance. Furthermore it affirms forcibly that strong caveats need to be clearly articulated when propounding the value of, or disseminating the results of, the seasonal forecasts.

These comments on our seasonal forecasting activity are helpful and we will definitely aim to increase the ensemble size when the new HPC resources come available. We also agree with the comments on the NAO; part of the work of the new Climate Dynamics group will be to provide a more scientifically robust framework for considering seasonal predictability and skill.

MOSAC also noted with both interest and caution the preliminary results derived by adopting a typological approach to separating the climate variability from the climate change signal. The impact of climate change upon both the amplitude and the frequency of physical phenomena related to climate variability demands further examination and calibration.

Overall, a deep and broad understanding of climate dynamics, the modes of climate variability and how they influence weather patterns around the world is fundamental to not only seasonal forecasting, but to detecting and attributing climate change and for guiding adaptation at the regional and local level. It is therefore central to the Climate Science programme and we welcome MOSAC's endorsement of our plan to strengthen significantly our expertise in climate dynamics in partnership with academia. This will also provide an important bridge between weather and climate science, enabling us to understand the context of some of our extreme weather, such as last winter's storms and therefore potentially its predictability.

(d) Applied Science and Scientific Consultancy

MOSAC acknowledges that this innovative Directorate faces novel challenges as it seeks to broaden the research culture of the Met Office, builds up its capabilities, and melds together the scientific integrity of its activities with its strong customer-focus. These challenges are exemplified by the ethos, scope and working practices that will be required of the new 'career family' of Scientific Consultants. The Committee is encouraged by the progress achieved during the Directorate's first full year of existence, and notes the appropriateness of the Directorate's administrative and team structure. It recognizes that the response to the pamphlet on the "Human dynamics of climate change" has been diverse and far-reaching. The pamphlet, prepared in close collaboration with Met Office colleagues and other UK Institutions, exemplifies the modus operandi that the Directorate will need to pursue to optimize its effectiveness.

The Committee further notes that the Office and the Directorate will need to carefully consider a range of issues central to the Directorate's mode of operation. First there is a need to ensure that members of the Directorate are fully integrated into the Office's existing scientific career structure, and that they should interact intensely with members of the other Directorates. Second, in the context of research challenges and prioritization, there will be an on-going need to balance the tension between providing purpose-designed commercial services alongside the Office's activities related to the 'public good'. Third it will need to set out the criteria by which it targets and selects stakeholders/customers with whom it will engage with on short and longer-term bases. Fourth the expertise required of the scientific consultants is novel and distinctive, and hence the Office may wish to consider, perhaps in consultation with colleagues from academia, how best in the future to recruit and train such individuals.

The issues raised by MOSAC are important and we will endeavour to ensure that the right process and structures are put in place to mitigate the risks. For clarification it is important to emphasise that this Directorate addresses applied science that is required to service the needs of both public and private sector customers. The key point is that this Directorate focuses on the translational or applied science that is needed to add value to our core operational products and as such encompasses work on, for example, aviation winds, defence applications and animal health to name but a few. Nevertheless MOSAC is right that the Directorate has to develop a clear set of targets and decide which sectors to focus its work on. We will report on progress next year.

MOSAC further notes that as a Committee it is not configured to, nor will it, scrutinize the Met Office's adherence to Trading Fund regulations. However MOSAC should and will concern itself with the degree of mutual benefit incurred from the interaction of the various Directorates and

with the scientific integrity of the Applied Directorate's activities. In respect of the latter it recommends that a suitable topic for next year's meeting would be a paper on scientific integrity that both outlines the framework for cultivating and ensuring integrity within the Directorate, and provides examples of projects drawn from different sectors spanning a range of space-time scales.

When the Applied Science Directorate was established in Science a fundamental aim was to ensure that the applied science we use in our services is of the highest integrity. It was also designed to enrich and guide the core science we do by delivering a deeper understanding of how our science is used by customers in the broadest sense. MOSAC's recommendation that we establish a framework to ensure scientific integrity and endeavour to capture the benefit of Applied Science to both our core science and our services is well made. We will seek to provide the committee with a range of examples that demonstrate tangible benefits to the Science programme and to the Met Office more widely from having this Directorate.

3. Collaborative and Partnership Activities.

Three presentations at the meeting highlighted different aspects of the Met Office's engagement in collaborative activities. *First* an outline was given of the embryonic "Climate Science for Service Partnership (CSSP): China" funded through the BIS Newton Fund. MOSAC recognizes that the CSSP provides an excellent opportunity to collaborate with the China Meteorological Administration, the Institute for Atmospheric Physics of the Chinese Academy, and with other academic institutions in the UK and China. In principle the various Work Packages have the potential to enhance the R&D activities of the participating Institutes and to contribute to the evolution of Climate Services. MOSAC encourages the Met Office to exploit this opportunity to enhance its research activities and to engage and benefit from its collaboration with other Institutions.

Our engagement with the Newton Fund has been an exciting and very important development for us. As with all the science partnerships we engage in, we seek to ensure that they are aligned as well as possible with current research priorities. In the case of the CSSP an important element of the work relates to our initiative on Climate Dynamics and is likely to provide very valuable additional effort not just in the Met Office but with our collaborators in UK academia and in China. We expect to report on a satisfactory start to the CSSP and other opportunities through the Newton Fund next year.

Second MOSAC welcomed the thoughtful overview provided on 'UM Partnership' activities as perceived by participating countries, most notably Australia, Korea and India. The presentation set out the strengths and the weaknesses of the present arrangements, and the desire of partners to engage in mutually beneficial research activities. In particular the Partners emphasized the operational advantages accruing from support in technical and software development, forecast assessment and model improvement, but also highlighted some technical shortcomings such as those associated with the programming format of the UM itself. The Committee appreciated the immediate positive response of the Office, and encourages it to reflect further and respond constructively to the various comments and suggestions. In particular there may be opportunities of pursuing together some specific and fundamental research activity that would be of mutual benefit as well as instigating software management strategies that would be helpful within the Met Office itself.

Third MOSAC appreciated the detailed documentation of the Office's multi-faceted and impressive European collaborative activities, and the plans being assembled related to Horizon 2020. A more immediate concern for MOSAC is the extent of the Office's preparedness for

participation in the Copernicus (European Earth Observation and Monitoring) Programme. Copernicus is well aligned with Met Office goals and the Office has significant expertise and capability in this area. Therefore MOSAC urges the Office to engage actively in the project so as to enhance its own capabilities, to demonstrate its commitment to collaborative activities, and to finesse the benefit to the wider community.

We are following the developments of the Copernicus Services with great interest and expect to have an important role to play in all three – Atmosphere, Marine and Climate Change. It is also worth noting that the Copernicus Services relate primarily to data services and do not support R&D, and so in parallel we will continue to engage actively with the EU Horizon2020 programme. This has some major opportunities for us and we will focus on ensuring that we lead where appropriate, optimise the funding we might receive, while at the same time ensuring that the research is well-aligned with our current priorities.

Again in relation to collaborative activities, MOSAC strongly endorses as noted earlier the establishment of a joint Met Office - NERC research activity on the theme of Convection. The theme amounts to one of the current grand challenges in Atmospheric Science and is of pressing importance for the future development of the Office's weather prediction capability and its climate activity. It also congratulates the Office for playing a leading role in the development of the WWRP HIWeather project and encourages it to work with UK and European partners to frame campaigns that would address directly key contemporary UK forecasting issues (for example to aid the design of convective-scale data assimilation schemes and high resolution NWP modelling). Such activity would concomitantly support satellite agencies in calibration and validation activities. Finally on the international level the Committee recognizes that the Office, as a world leading National Weather Service, can play a very significant role in evolving plans for creating a global legacy of available metadata of observations and model results.

4. Further Remarks

The Office's presentation of its engagement in communicating science was informative and indicated the wealth of such activity. MOSAC would welcome receiving an annual update in the form of a list of such activities, and when appropriate a verbal report on issues or events of special significance.

In line with its responsibility MOSAC reviewed the responses to last year's report. The written responses to the report, the subsequent actions, and the material presented at this year's meeting, addressed directly and appropriately the various points raised by the Committee. Finally MOSAC wishes to thank the administrative staff for ensuring the smooth conduct of the meeting and appreciates the significant effort invested by the scientific staff in preparing the overview papers. In particular it commends the speakers for the quality of their presentations at the meeting and the spirit of openness with which they highlighted the current challenges and problem areas.