OOPC, Ocean Data Requirements and JCOMM

1. INTRODUCTION

Purpose of this document

This document is concerned with ocean data requirements and networks for climate and the role foreseen for JCOMM from the perspective of the GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC). The Action Plan (Document 12) represents the detail of these considerations, as we understand them now. The present document will discuss some of the background and recent developments and suggest how implementation may be carried out through a JCOMM.

The mission of the OOPC

From a phenomenological point of view, the OOPC was established with three principal interests: Seasonal-to-interannual prediction (ENSO), climate change and what we might term "climatologies".

The 1997/98 ENSO received unprecedented attention and provided wonderful opportunities to establish long-term support for the ENSO observing system. Through initiatives of the US (the Tropical Atmosphere-Ocean array, various ship-of-opportunity lines, surface drifters, etc.), Japan (TRITON, JMA XBT lines, etc.), Australia (operational ship-of-opportunity lines in the Indian Ocean and western Pacific) and others, we now have long-term commitment to this system, one of the initial goals of GCOS/GOOS.

The 4th meeting of the Conference of the Parties to the UN Framework Convention on Climate Change (COP IV) provided similar attention and opportunity for climate change. The carbon inventory was one aspect of this interest. If this attention can be turned into commitment, particular with respect to filling global gaps, we will have come a long way toward the observing system recommended by Ocean Observing System development Panel (OOSDP) in 1994.

The Panel is also concerned with the establishment of data sets adequate for determining the mean and annual cycle of the ocean, a fundamental requirement.

Since in part all of the above requirement cooperation and collaboration with the atmospheric community, the OOSDP goals included the determination of fields for and provision of data to the numerical weather prediction community.

Since the OOPC was established in 1995, its remit has broadened to include ocean assimilation and forecasting in general (e.g., the Global Ocean Data Assimilation Experiment, GODAE) and the ice-covered ocean. The former introduces a fourth dimension to OOPC's principal interests, namely short-range ocean prediction and the provision of boundary conditions to other fields in oceanography (e.g., coastal prediction).

The strategy

In terms of strategy, the OOPC has pursued several avenues.

(i) *Formal and Informal Implementation Mechanisms.* The establishment of a body whose dominant mission was implementation of ocean observations for climate was suggested by OOSDP, and pursued by OOPC. Through the energies of IOC/GOOS and the Ocean Affairs Division of WWW/WMO, we now have that body in the form of JCOMM. The JCOMM will herald in a new era in operational ocean observing.

Some elements are not well suited to this mode. For the time being at least, they probably require research facilities and close cooperation with the research community. A partnership of ocean institutions with such capability is emerging (the Partnership for Observations of the Global Ocean, *POGO*) and it is hoped that this partnership may work with JCOMM in areas where conventional mechanisms are not well suited.

(ii) *Demonstrations/Pilot Projects.* Remote sensing was always going to be a critical element of the ocean observing system for climate. But to take advantage of the possibilities, we needed a more integrated approach; vastly improved cooperation and integration of remote and direct data streams; and ocean models and data assimilation to exploit this information. The Global Ocean Data Assimilation Experiment was conceived as a necessary step towards achieving those aims. GODAE has attracted support from many agencies and has enjoyed encouragement and endorsement from all related intergovernmental bodies. Excellent progress has been made with respect to remote sensing, thanks in part to the Committee on Earth Observation Satellites (CEOS), and with the *Argo* initiative, we are about to see a small revolution in direct observation of the ocean.

Such projects are formally referred to as Pilot Projects in the parlance of GOOS and GCOS. Pilot Projects ***must*** have goals and outcomes that conform to GOOS (OOPC) objectives and integrally lead to a non-trivial contribution to the system. Their plans would include

- A set of objectives/goals
- A strategy
- An implementation plan
- A schedule
- Defined outcomes

Successful pilot projects would enable a certain improved/enhanced capacity, in this case for the JCOMM, and one would expect an orderly transition into the operational framework.

(iii) *Work and Renovation.* Specific, focussed projects have always been seen as an important mechanism for advancing implementation. In many cases it is simply a problem of getting the right individuals entrained into an aspect of the observing system, either to make it work as it should or to tune an existing system to work better. The OOPC/CLIVAR Sea Level Workshop provided valuable support to GLOSS in its efforts to implement and maintain the sea level network. The recent SST workshop was envisaged as a way of providing similar focus on problems related to the gathering, analysis and interpretation of SST data. The Time Series Workshop was perhaps less successful but the theme has now been taken up through a proposal for surface reference sites (with the Working Group on Numerical Experimentation) and a revised time-series/ocean observatories effort.

In the era of a JCOMM, this work and renovation should be regarded as actions on behalf of and for the objectives of JCOMM. The SST is a good example since it directly addressed issues identified in the (Interim) Action Plan. The study of the upper ocean thermal (and salinity) network similarly addresses a key aspect of the Action Plan.

2. OOPC AND THE JCOMM

The Action Plan (refer to Document 12) was recently revised to accommodate changes recommended by the OOPC and its companion Panels within GOOS and GCOS. The are are several substantial actions that are underway at present and these will be discussed in later sections. Here we will discuss matters arising related to the “System Analysis” of the Action Plan.

Scientific Oversight

The OOPC remains the prime body for providing scientific oversight to the JCOMM. The GCOS/WCRP Atmospheric Observations Panel for Climate and the GOOS Coastal Panel will also from time to time provide advice directly to the JCOMM. The Action Plan suggests there should be Working Groups aligned with the 3 streams of the system (sea level, surface fields and fluxes, and subsurface measurements). At this time only the Sea Level WG is close to being in place. A WG has been established for SST jointly with the AOPC, and the International GODAE Steering Team and Argo Science Team are in place for the pilot projects GODAE and Argo respectively. The final report of the SCOR/WCRP Air-Sea Flux Working Group is due this year and its immediate future remains uncertain. The TAO Implementation Panel continues to act as a body of scientific advice on matters related to TAO.

The GOOS Steering Committee did discuss the situation and has resolved to clarify the structural arrangements. In principle, each of these sub-groups should report through the OOPC if they are concerned with operational elements and the JCOMM.

Observing Network

Significant effort is being devoted to this area. The 1st International Conference on Ocean Observing Systems for Climate is intended, in part, to draw the different parts together into a system. It will join remote sensing and direct (*in situ*) observationalists together; it will build community consensus and support for the observing system. Its remit has been broadened beyond climate to specifically entrain all the interests of JCOMM, such as surface waves. It is developing a new paradigm for oceanography, with JCOMM as a central element. It is introducing a new era of cooperation between the operational community and research.

The SST Workshop and Working group, the upper ocean study, etc. are all tackling issues identified in the action plan. Some further detail is included in the sections below.

Data and information

Data and information management issues remain a primary concern. There has been some good news with a US initiative to build an ocean data server for GODAE at FNMOC and the SST and thermal studies are constructing more robust frameworks. A more general framework for GOOS remains elusive. JCOMM needs to consider very carefully what role it should play, particularly in the presence of CLIVAR.

Archives and standards

No real progress has been made in this area, at least from the perspective of OOPC.

Quality assurance

The projects/studies being initiated by OOPC and others seem the most effective route to progress in this area. The SST Workshop identified significant problems in this area in relation to products. The upper ocean thermal study is currently addressing this issue for the real-time and climate temperature data streams.

It is essential to build robust working relationships with the scientific community since it is this interaction which best assures climate quality of the highest standard. However these procedures can be costly and we need to better understand what level of quality assurance is appropriate for the rapid-delivery data stream. Satellite data pose particular problems in this regard.

There is also the issue of maintaining standards (calibration) among instruments, a problem that has been extremely painful for meteorology and the radiosonde network. We need to carefully consider the best way to “control” this potential problem. Diversity of manufacturers is generally good for cost but can be potentially damaging for climate.

Resources

The resource side is generally brighter now than it was 5 years ago. We have strong potential support for projects like Argo and we have key parts such as the ENSO observing system with sustained support. We have good prospects in terms of sustained support for key remote sensing instruments.

The COP IV outcome also opens up the prospect of more secure resources for climate observations. Many of the elements that appear in the Action Plan also appear in the Report on the Adequacy of Global Observing Systems that was prepared for COP IV. GCOS is taking the lead in preparations for COP V and beyond, including consideration of national reporting guidelines, intergovernmental mechanisms and funding. This may release new resources, particularly for developing countries.

The Conference will also be a key element in our drive to secure sustained support. It will address the issue of new resource management structures. *POGO* also offers a new opportunity to bring support to the observing system

Regulatory

This is an issue more for JCOMM and GOOS than OOPC. Good scientific oversight, however, is one element of the process required to sustain high quality data streams and products.

Technical support

This is mostly an issue for JCOMM consideration.

Administration

The GOOS Steering Committee did consider the existing arrangements and concluded that a more transparent and responsive structure was needed. There were many groups and regional entities working for, or in association with GOOS, and lines of responsibility and responsiveness were blurred. The creation of the JCOMM would greatly help administration on the implementation side since it would quite clearly define roles and responsibilities, but several anomalies remained and these would need to be examined. The administration of the ocean observing system (scientifically, technically, and in terms of resources and governance) must be efficient and effective and now was an excellent time to ensure that would be so.

GODAE and the OOPC also made specific suggestions with respect to pilot projects (see 1.3iii above). For profilers, for example, the implication is that the project should exercise its own discipline as standards and methods were developed with a view toward transitioning these to GOOS/GCOS (and JCOMM) oversight as the techniques became mature.

Capacity building

The OOPC itself is not directly involved in capacity building activities (a member of the OOPC will work with the GOOS Panel). Through programs such as GODAE and *Argo*, however, a great deal has been done to engage the capable nations in the name of GOOS. Both GODAE and the GOOS SC are considering mechanisms whereby developing nations can more actively participate.

The creation of the IOC Office in Perth has also provided further opportunities. The Report to COP IV identified both the Indian Ocean and the Southern Oceans as weaknesses in the observing system. Negotiations are already underway to engage this Office in the development of an enhanced observing capability for the Indian Ocean.

Affiliates

As outlined in Section 1, the UNFCCC and its Conference of the Parties, now represents are significant factor in the way the observing system is being developed. Operational oceanography is now also a more significant driver than before; the investment by the US Office of Naval Research in the GODAE data server is an excellent example of this maturing partnership. Several operational agencies, including the UKMO, JMA and BoM are now quite prominent.

The maturing partnership with CLIVAR is also quite significant. The Conference will, if things go according to plan, cement a new working relationship and herald in a new era with science as a significant user and, most importantly, a valued partner in the ever-continuing quest to improve and enhance the observing system. Document 13 explores this relationship on more detail.

The affiliation with space agencies through CEOS and its Integrated Global Observing Strategy is also now maturer. The oceans have been adopted as one of the key themes and work is underway to better define and prioritize the remote sensing requirements (see below).

Products

The SST Workshop revealed that one of the key products of the climate observing system, SST analyses, did not meet the high standards we desired. We should not be surprised if, as our user community matures and becomes more demanding, further shortcomings are revealed in our key products. The WG on Air-Sea Fluxes is due to report on surface flux products shortly.

The advent of GODAE and the more active participation of operational agencies is bound to increase the range of products generated under the banner of GOOS. One of the responsibilities that OOPC and JCOMM must share is that of guardian of quality and scientific credibility of products. The SST example cited above, and the work of sea level scientists in better refining changes, are two examples of proper care and diligence being displayed. Similar discipline should be displayed throughout the product range of GOOS, be it a product generated for ENSO prediction, short-range marine and ocean conditions, for commercial users, or for climate change assessments.

GODAE and the GOOS SC are also actively examining the delivery mechanism for products, especially to linked communities (e.g., coastal), and the metrics that need to be in place to evaluate the performance of the system.

Issues

The range of issues has not reduced. As solutions are being sought and implemented for some issues, new issues are arising because of the expanded interest and expanded user exploitation. The studies mentioned above and, in some case detailed below, are targeting some of the high priority scientific and technical issues. The sampling issues for surface variables have, if anything, become more acute as projects like GODAE and the coastal module of GOOS drive demand for high-resolution products.

The Conference is also being used as a way to resolve some issues. The acoustic tomography community, for example, are being invited, and challenged, to provide a persuasive case for it being included within the observing system. Initial indications are that they may well succeed, at least for regional deployments.

3. CURRENT STUDIES AND INITIATIVES

Upper ocean thermal study

The Sydney Implementation Workshop and its Action Plan identified several areas where

further work was needed. One of these concerned the ocean thermal observing networks and the practices used to assemble and process data. TOGA and WOCE were instrumental in implementing a ship-of-opportunity network based on the XBT and in developing (with IGOSS and IODE) complex data exchange and evaluation procedures. OOPC, in collaboration with the CLIVAR Upper Ocean Panel and the SOOP IP, and supported by the US NOAA Office of Global Programs and the Joint (CMR/BMRC) Australian Facility for Ocean Observing Systems (JAFOOS), are conducting a review of the network design (mainly the Ship-of-Opportunity network) and data and information management practices. Following the pattern of the Sea Level Workshop, a consultancy is being used to compile essential background information under the guidance of a scientific advisory committee.

The aims of this study are:

1) To compile a consolidated account of the existing upper ocean thermal database, using WOCE, Levitus and whatever other data bases that are available.
2) Produce consolidated "maps" of information level/content based on the dominant scales of climate signals.
3) Document the existing practices for assembling, quality control and distribution of upper ocean data, working from existing material of GTSPP, WOCE UOT/DPC and IGOSS SOOP.
4) Document to the extent possible the "value adding" of thermal data process chains, be they automated assimilation, quick-look/semi-automated quality control or higher-level scientific quality control and assembly.
5) Provide quantitative assessment of SOOP lines. This should include an assessment of relevance/impact against scientific objectives including seasonal-to-interannual prediction, environmental/ocean prediction, improved climatologies and climate change monitoring, scores against key attributes (continuity, quality, etc.), notes on extenuating circumstances, and the existence of proxies in the event of gaps/discontinuities in the lines. The broad-scale sampling should also be assessed as a precursor to *Argo* with a view to maintaining the temporal and spatial integrity of resolved signals such as the global ENSO wave, the Antarctic Circumpolar Wave, decadal variability, etc.
6) On the basis of 5, provide a renovated SOOP plan including broadcast and high-density strategies.
7) Produce a Report based on the above which will form the background for a Workshop to be convened in the 3rd quarter of 1999.

OOPC/AOPC Workshop on Global Sea Surface Temperature Data Sets

The seeds for this workshop (November 98) came from OOPC III and the 2nd meeting of the AOPC. OOPC was informed that systematic biases appeared near ice-covered regions in some analyses. The goal of the Workshop was to assess global and near-global sea surface temperature (SST) data sets and to recommend to the Panels criteria to be satisfied by SST analyses. To achieve this objective, the Workshop was asked to:

1) Summarize the characteristics of the observations used to produce analyses (gridded fields) of SST.
2) Assess differences among, and strengths and weaknesses of, the various SST analysis products extant.
3) Include both historical time series and current near-real-time analyses.
4) Establish specific criteria to be satisfied by SST analyses that can be certified as adequate for GCOS.

A draft report from that Workshop has been prepared. The conclusions included:

- Climate change is most stringent in terms of precision and accuracy (0.1°C);
- Differences in “global” SST can appear because of:
  - uncorrected satellite biases,
  - use of sea-ice “data”,

- data assembly;
- Still hampered by data gaps;
- Issues related to skin temperature; and
- Demand for high resolution (in space, time) is growing.

As a follow-up to this Workshop a group under the Chairmanship of R. Reynolds (NCEP, USA) is to be formed with the following (draft) terms-of-reference:

1) To record and evaluate the differences among historical and near-real-time analyses SST and SST/SI analyses
   a. Identify a standard data set for the intercomparisons of different products, e.g., COADS;
   b. Select several standard difference products as a minimum set (i.e., define regions and time periods; compute biases, standard deviations, and rms differences, etc.);
2) To identify the sources of difference in the analyses;
3) On the basis of comparison of those differences with the expected climate signals in the SST patterns, to recommend actions needed to ensure the quality and consistency of SST and SST/SI analyses;
4) To establish criteria to be satisfied by SST and SST/SI analyses to ensure the quality and consistency required by GCOS; and
5) To report annually to AOPC and OOPC on progress and recommendations.

Ocean Time-Series Stations/Observatories

The rationale for developing long-term TS stations and/or observatories has been discussed several times and was explored at the recent *POGO* meeting. The reasons include:

a) Surface reference sites for flux validation;
b) Subsurface / Upper ocean data for model development;
c) Deep ocean data for climate change; and
d) Other
   - Coastal
   - Biological
   - Deep Earth Observatories

Several approaches are being explored for implementation:

i) Surface reference sites
   - Build on existing (TAO, Met buoys, coastal buoys, etc.)
   - *Develop a project in cooperation with the CAS/WCRP WG on Numerical Experimentation.* The Working Group on Numerical Experimentation has agreed to collaborate on a project that would see several surface flux reference sites established and used routinely (and continuously) for the validation and development of numerical weather prediction models.

ii) Upper ocean
   - ENSO observing system
   - CLIVAR research
   - develop regional capacity
     - Brazil and PIRATA
     - Another mechanism for Japan, India, Oz, Indonesia, ... for Indian Ocean?

iii) *An OOPC (and CLIVAR UOP) working group*
   POGO devoted considerable time to exploring the possibility of supporting implementation of time-series stations/observatories. They requested OOPC to draft a plan for consideration at the 1st formal meeting of POGO (Dec 1-3 1999) to include:

- The N. Atlantic as an initial demonstration;
- A pilot project for GOOS (OOPC) consideration;
- A contribution to the sustained OS;
- Plan should consider rationale for global and/or selected sites, e.g. KERFIX, ...
- Need for other complementary components;
- Readiness of technology; cost;
- Standards, protocols and communications.

Remote Sensing

The OOPC works with the Global Observing Systems Space Panel (GOSSP) to define remote sensing requirements. The statement of user requirements is an important part of the interface to CEOS, relied upon by the agencies to define what is expected of them. It is thus very important that these statements be clear, accurate, and up to date. The OOPC has reviewed its requirements, in consultation with GODAE and GOSSP, and provided recommendations through the GOOS SC (see attached Table). The GOOS SC II endorsed the requirements as given and requested the keepers of the database to make changes to reflect this decision. All entries in the database should be attributable (sourced back) to GOOS and its Scientific Committee. It is the responsibility of the Panels and Projects to ensure that entries for particular applications are current and accurate.

GOSSP and the OOPC also asked the GOOS SC to support, as an initial draft, a set of priority measurements for GOOS and ocean climate:

(i) Surface topography/altimetry
- T/P-Jason-like precision altimetry
- High-resolution altimeter (e.g., ENVISAT)
- 3rd altimeter desirable

(ii) Sea surface irradiance (SST)
- Need improved methods for assembly, validation
- Trend toward higher resolution products (GODAE) and use of multiple platforms, including geostationary and microwave data

(iii) Surface wind vectors
- at least one scatterometer (or an equivalent) is essential
- Strong multi-application case emerging for a 2nd

(iv) Ocean colour
- Consensus that ocean colour is a priority measurement.

The OOPC has endorsed the suggested priorities but noted that the Conference would provide a more appropriate forum for endorsement. The OOPC has also noted the need for surface short-wave radiation products. An outline for a possible project had been discussed but, as yet, no decision had been made on a project.

4. OTHER IMPORTANT RELATIONSHIPS

The Report on the Adequacy of Global Observing Systems

Through 1998 a report was prepared by GCOS on the adequacy of global observing systems (for climate and climate change). This report was requested as a result of the WCRP Conference and Kyoto with a view to reporting to the 4th meeting of the Conference of the Parties to the UN FCCC in Beunos Aries. The OOPC, working partly from the basis provided by the (then draft) Action Plan, provided significant input to that Report, highlighting among other things the significant gaps in the global ocean observing network and the new opportunities provided for by the possible formation of a JCOMM.

For climate change, the challenge has been to obtain the attention and respect of those bodies

with key roles, such as the Intergovernmental Panel on Climate Change and the Conference of the Parties to the FCCC. The GCOS-led Report on the Adequacy of the Global Observing Systems was regarded by OOPC as a critical step in gaining this respect and the generally positive reaction to that report is we believe an important milestone. The OOPC is committed to doing whatever it can to provide substantial recommendations and input to the continuation of this process.

Under the leadership of GCOS, substantial progress has already been made in response to the recommendations of COP IV. A draft "National Reporting Guidelines" has been prepared to guide nations in the provision of information that would be used to assess the state of the global observing system. For JCOMM, it is important to note that key aspects of the observing system under its remit would be encompassed by such reports. As noted earlier, work is also underway to define possible intergovernmental mechanisms to support implementation of a climate observing system (again, the existence of a JCOMM is an important factor) and to see how funding mechanisms may be exercised in support of the global observing system.

The Partnership for Observations of the Global Ocean

Three of the major oceanographic institutions, Woods Hole Oceanographic Institution, Scripps Institution of Oceanography, and the Southampton Oceanographic Centre convened an exploratory meeting at IOC to examine the options for a more formal, long-term partnership. One of the main motivations was to provide a coherent input to the emerging requirements for sustained, global ocean observations from GOOS and CLIVAR. They were joined by JAMSTEC (Japan), CSIRO Marine Research and IFREMER (France) at this meeting. In all cases, the organisations were represented at the level of Director.

The participants expressed a strong interest in the plans of OOPC (GOOS/GCOS) and GODAE and a desire to assist in the implementation of these plans, if needed. POGO noted the emergence of a strong, focussed intergovernmental mechanism in the form of JCOMM. The meeting agreed there were several areas where a partnership of oceanographic institutions could be effective, working with JCOMM, including surface reference sites, oceanographic observatories (time-series moorings) and hydrographic and trans-ocean sections.

Consensus emerged very quickly at the meeting on the desirability of forming a partnership. It seems likely the partnership will initially focus on institutions with deep-sea going capabilities. This is perhaps too restrictive for the long-term, particularly if they wish to take system integration and modelling seriously, but perhaps it is appropriate for now. The participants gave GODAE and *Argo* high priority.

The participants requested OOPC to draft a Plan for ocean observatories/time-series stations, with the initial focus on the North Atlantic (see 3.3). There was also an excellent discussion on outreach and capacity building, another possible area for collaboration with JCOMM.

The first formal meeting of PGO is scheduled for Scripps, 1-3 December 1999. A Mission statement and Charter have been prepared.

The 1st International Conference on Ocean Observing System for Climate

As a community, we are enjoying respect and support at an unprecedented level after over a decade of working with the ocean observing system for climate. Yet for all the progress that has been made, it is difficult to state with conviction the preferred blend of observations needed for the observing system. The success of *Argo* as a proposal has in fact raised considerable concern within the ocean climate community because there seemed to be a real possibility that this success would be at the expense of other elements. It also highlighted the fact that, despite the best efforts of the OOSDP and OOPC, there still was not an agreed, detailed implementation plan setting out the preferred mix of methods and platforms. The research program CLIVAR faced a similar dilemma [it is worth noting that the CLIVAR Implementation Plan relies to a very large extent on the plans of GCOS/GOOS and the

JCOMM Action Plan].

For these reasons it was decided that a meeting of all the interested parties (scientists, technicians, etc.) was now vital. The 1st International Conference for Ocean Observing System for Climate (Saint Raphael, 18-22 October) is being convened under the joint auspices of the OOPC and CLIVAR's Upper Ocean Panel. The objectives of the Conference are quite bold. A series of papers are being solicited to document different aspects of the observing system (note that the remit has been broadened to include all physical measurements of the ocean). This approach is not unlike that developed by the IPCC for its Assessment Reports. The challenge that will be given to the Convening Authors is to provide a convincing case for their particular view/approach, complete with consideration of needed investment. All papers will be reviewed widely prior to the Conference, by both advocates (to ensure accurate scientific and technical detail) and non-advocates (to ensure a balanced perspective). With this process we hope to draw consensus on the value of the approach, its role within the ocean observing system for climate, and identify key issues that need further debate and/or work.

"Consensus drawing" is the dominant theme of the Conference. It is the hope of the joint convenors that this Conference will agree on the exact blend of methods/techniques that are needed for the (operational) observing system of GOOS/GCOS and the sustained observing system of CLIVAR. The conference organizers also will seek endorsement of a new paradigm for ocean data distribution whereby ALL data are made available without delay or intervention, and that all data are widely available for use. A Conference statement will be produced detailing those aspects for which agreement was reached and detailing those issues for which further study/planning was required.

The aims of the Conference are, not unexpectedly, closely aligned with the needs of JCOMM. Many of the issues raised in the Action Plan are to be addressed in the Conference papers. As a result, JCOMM will have a much clearer picture of what is supported as an initial observing system and of those enhancements that are given initial priority. The Conference will cement linkages for JCOMM into research and, in turn, showcase long-term dependencies from science on the JCOMM.
