Seasons of MISTs and mellow fruitfulness

Article

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Mike Lockwood looks to the future, by reflecting on lessons from the first 50 years of MIST.

By the time I gave my first talk at a scientific meeting, in the second year of my PhD studies in 1979, the Magnetosphere, Ionosphere and Solar–Terrestrial (MIST) forum of the Royal Astronomical Society was thriving. It was the brainchild of Henry Rishbeth and Peter Kendall, who recognized the success of the "gathering of the clans" that took place in July 1968 at the University of Sheffield to celebrate Sydney Chapman's 80th birthday (Cowling 1971). Subsequently the idea was put to, and taken up by, RAS Council; the first full MIST meeting was held on 20 August 1970 (Rishbeth 1997).

MIST rolling in: getting started

That first talk of mine, as for so many UK space scientists and geophysicists over the years, was at a MIST meeting at Burlington House. The meeting was great and the venue was great; my talk was terrible. But, like a teenage footballer scoring an own-goal on a first-team debut, I was allowed to fail. Even better, I received helpful and encouraging advice from the great and the good. And I carried on, learning from watching them at work, making mental notes about what to do and, on a few occasions, what not to do. MIST was the forum in which I learned key aspects of my trade as a scientist: how to make my work competitive nationally and internationally and how to advertise it on the international stage – a stage that would have been much less forgiving of my inauspicious start. But that is not to say that the standards of this benign forum are low; the fact that they are high and that members are keen to maintain that high standard are key parts of the successful formula.

MIST lifting: raising standards

Early in my career, I remember sitting next to a member of my MIST generation, Shaun Quegan (later professor of Earth observation at the University of Sheffield), and being slightly shocked that he was genuinely nervous about giving his talk later in the session. Looking back, I understand that this was because Quegan was somewhat further along the Dunning–Kruger development curve than I was: he had reached the stage where he knew enough to know that there were things that he didn't know (Kruger & Dunning 1999). The specific focus of Quegan's anxiety was that the audience included a senior member of his field, Bob Schunk, who was over from the USA and, at that time, also modelling ionospheric effects of magnetospheric convection. Shaun's talk turned out to be excellent – he even included a few impish remarks about areas where he felt his work was superior to the corresponding American effort (Quegan 1989). Lively and constructive debate followed and we all went off to dinner that night happy and enthused, aware that we had all learned something including, I think, Schunk.

"MIST has managed the balancing act of being both forgiving and cutting-edge"

This was one of a number of incidents that made me realize how important it was that MIST had the ethos of a full international meeting – and the correspondingly high standards. What has been remarkable over the years is just how well MIST has managed the balancing act of being both forgiving and cutting-edge, simultaneously. The responsibility to maintain that balance falls on the more senior members of the field who really need to be there whenever possible – and here I am teetering on the edge of outright hypocrisy. I know and understand, all too well, that the pressures on everyone's time are much greater than they used to be, but if we want PhD students and young postdoctoral research assistants to learn how to deal with a crotchety old guard, then it's the duty of that old guard to turn up and act accordingly! And let's not forget that in discussions after talks, over coffee, in the bar or over dinner, pearls of wisdom, advice and even anecdotes about the past can be of real help to the next generation finding their way. An issue of note here is the tendency for work to be reinvented on decadal timescales (a periodicity that is oddly and uncomfortably close to the average length of the solar cycle). This is a highly undesirable phenomenon for all concerned and one that the older scientist can help prevent.

Incidentally, that first talk of mine was eventually published (Lockwood & Mitchell 1980) and has been cited just the once in 38 years. This overview gives me an opportunity to double that total at a stroke, and one that I am shameless in taking.

MIST gathering: building collaborations

Another key role that MIST has embraced lies in forging collaborations and a community ethos. We are few in number and our research groups have, to a major degree, to specialize and work together. Mechanisms that bring the groups together and give them a chance to discuss their new ideas and new capabilities are vital in fostering collaborations and consortia. The MIST community is extraordinarily diverse, embracing individuals who would describe themselves as geophysicists, planetary scientists, plasma physicists, middle atmosphere scientists, upper atmosphere scientists, ionospheric physicists, magnetospheric physicists, heliospheric scientists, solar scientists (more on them later), spacecraft engineers, space weather experts and space weather forecasters. I will here refer to all in this diverse group as "space scientists", although the term fits some better than others. Emphasis is constantly evolving as centres of MIST science wax and wane and change their focus.

When I first attended MIST meetings, the dominant areas of discussion were transient magnetic reconnection at the magnetopause (driven by the then recent discovery of "flux transfer events" in data from the International Sun–Earth Explorer spacecraft, ISEE), whistler wave propagation (driven by the pre-satellite use of whistlers to remotely sense magnetospheric structure and by the development of theories of energetic particle pitch angle diffusion) and heated debates about solar influences on weather (driven by some strong characters who, we used to joke, had embraced the old retail slogan of "never knowingly undersold"). The


1 Mike Lockwood does not see the Sun going down on MIST after 50 years. (Max Alexander)

contacts between the thermospheric and ionospheric groups fostered by MIST meant that the UK made unique advances in coupled ionosphere–thermosphere numerical modelling. Later notable MIST trends were driven by specific projects such as the AMPTE-UKS spacecraft. Missions to comets and other planets allowed expertise that had been gained in the study of near-Earth space to be applied with great success. The EISCAT and SuperDARN projects allowed the MIST community to lead the world in exploiting the ability of these ground-based radars to remotely sense the ionosphere at high time resolution and so complement the more detailed observations from satellites that suffered from spatial–temporal ambiguity. The SAMNET magnetometer network became an integral part of global studies of the substorm cycle, the dominant response of the magnetosphere to energy input from the solar wind.

MIST obscuring: the Sun and the weather

The relationships between the Sun and weather gave rise to long-running and deeply felt arguments, which taught me a very important lesson. I found that scientists' ways of thinking ("intuition", if you like) are moulded by their field of study to a much greater degree than they tend to realize. I often use Linus Pauling – described in more detail in the box "A cautionary tale" – as an example to suggest that a bit of humility when dealing with a different discipline is a very important thing. My view is that at the heart of the Sun–weather debates was the effect of greater noise, internal variability and chaotic behaviour in the troposphere–ocean–cryosphere system than in the magnetosphere–ionosphere–thermosphere system; these differences matter for the appropriate statistical tools, but also in the ways of thinking about the problems. I mention this partly because I can forsee a similar situation arising over chaotic behaviour in the context of the ultimate source of all space climate, namely the solar dynamo.

Travellers in the MIST: moving forward

This expression was used by the Wazhazhe (also called Osage) Indian nation of the American Midwest and Great Plains to describe the times when the people had to move together onto new pastures. The Sun–weather arguments highlighted a difficult relationship between the MIST community, the Met Office and the UK weather and climate community in general. Thankfully that was put firmly behind us long before the Met Office became responsible for managing the national space weather risk. Now collaborations are flourishing with fruitful studies such as examining the combined effects of solar activity and lower atmosphere–thermosphere coupling on satellite orbital decay and the development of space weather forecasting techniques. The goal of a full national capability of a "cradle-to-grave" numerical space weather prediction (NSWP, see figure 2) is brought closer by the recent adaptation of the GORGON MHD code to the magnetosphere (Mejnertsen *et al.* 2018 and Eggington this issue), although a great deal of research into techniques for "downscaling" will be necessary before one model can be driven by the previous one in a chain (Owens *et al.* 2014).

"Emphasis constantly evolves as centres of MIST science wax and wane and change focus"

In addition, there are now scientists on both sides of the mesopause debating issues with proper respect for each others' respective skills, techniques and knowledge. For example, there are solar and space scientists recognizing the role of internal variability in climate (e.g. Owens *et al.* 2017) and atmospheric, weather and climate scientists are now making use of recent gains in understanding of solar change (e.g. Maycock *et al.* 2015). There is really interesting work being done on a variety of mechanisms that result in troposphere–thermosphere coupling: for example, Scott and Major (2018) have studied the effects of second world war bombing raids on the ionosphere, thereby also bringing historians into the purview of MIST. I am sure this would have fascinated Henry Rishbeth, ionospheric guru, MIST founder, organizer and stalwart, and in whose honour the prize for best student talk at each MIST meeting is named (Weiss 2002).

Perhaps the largest coordination of the community as a whole (ground- and satellite-based, theory and numerical modelling) took place in readiness for ESA's four-craft Cluster mission. Because so many MIST areas had invested so much, the loss of the Cluster 1 craft when the first Arianne 5 launch failed in 1996 was a true hammer blow (Lockwood 1997). Fortunately, Roger Bonnet, ESA's director of scientific programmes, vowed to rebuild the mission and the UK funding agency (at that time PPARC) responded with a programme that allowed us to keep much of the next generation of UK space scientists employed until Bonnet delivered on his promise. Even before the launch of Cluster 2, those young scientists had produced work of remarkable quality and global impact. Our sincere thanks go to both Bonnet and PPARC; it would have been easy to view the funding between the loss of Cluster 1 and the launch of Cluster 2 as maintenance of a "marching army" for its own sake, but UK capability in space science and space weather would have been permanently, probably terminally, damaged without it.

The level of collaboration achieved has resulted in the UK community becoming much more than the sum of its constituent parts; MIST has been a key driver of that. This was made clear to me, time and time again, by foreign scientists invited over for specialist meetings, or who just happened to be in the UK. You could almost see them thinking "we need something like this back home" – although, in the case of German scientists, that happened after they had stopped giggling about our name.

MIST forecasts: thoughts on the future

MIST gave me experience and practice in what I needed to know and do to work successfully on the international stage. Is

MIST today as fit for purpose for helping the bright-eyed young scientist? The world has moved on in so many ways. It is worth reflecting that, as a PhD student, I wrote programs in Fortran on punched cards and got the results 24 hours later. I used a DEC PDP-8 as a datalogger, sent letters not emails, wrote drafts of papers by hand to give to a typist, used Rotring ink pens and stencils to draw schematics and even graphs, and had to go to a place called a library to read or photocopy a paper in a journal. Back then, "social media" consisted of announcements on paper pinned to the noticeboards in the students' union and in the entrance hall of my department. Any younger readers now laughing out loud should remember that during your career the technology and practices of academia, and life in general, will change by at least as much as they have during mine. I believe the twin goals of bringing the parts together into a coherent whole and preparing the community to be competitive on the world stage remain the essence of MIST, but the specifics of what is required have changed and will continue to do so.

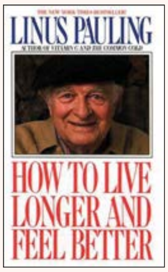
There are many issues where shared knowledge and experience could benefit us all: dealing with trolls, the media, spin doctors, politicians, demand management measures and bibliometrics. And that is a sentence that would have made no sense when I started out on my science career! We also all need to know how to avoid being misrepresented so that we don't find ourselves at the centre of a fake-news storm.

I had thought that, because these issues apply across the board to all science disciplines, they could be taught as "transferrable skills". But watching the really good practitioners of outreach and citizen science in our field – and we do have some truly excellent ones – I have come to think that this isn't so. I now think that there are "tricks of the trade" that are specific to the discipline. As a result, MIST becomes the best forum in which to hone, borrow and lend those skills for our particular science. From this point of view, initiatives such as the MIST meeting in science communication for space science and space weather held in September (and summarized on pages 6.29–6.31 of this issue) are timely and extremely valuable. But these issues cannot be solved forever by one meeting: MIST needs to find ways to keep abreast of the changing outreach and media environment, and the problems it poses, and develop optimum solutions and best practices. Maybe the answer is to ensure such meetings are regular occurrences, or maybe we should reserve a slot at each meeting for an evidence-based talk about good and bad practice and changing trends.

A cautionary tale

Linus Pauling was a Nobel laureate in chemistry who played a key role in founding the fields of quantum chemistry and molecular biology. He is rated by many as one of the 20 most important scientists of all time. Yet in the latter part of his career he became an advocate of vitamin C as a cure for the common cold, cancer, AIDS and even as a treatment for children with brain injuries. This pitched him, and the institute he set up to prove his claims, into arguments with epidemiologists and clinical scientists who used more sophisticated statistics and tests to show the claims to be without foundation. The scientific consensus is now that vitamin C is ineffective in treating or even preventing the common cold.

Pauling was fooled by his own enthusiasm for an idea, by his strong desire that it was right and because his "scientific intuition" was more tuned to the areas that made him great than he realized. When the debates got difficult he formed a habit of saying "if you look at my past career, I think you will find that I have generally been



right" (and that is a direct quote).

Of course, the importance of arguments like this is in the effect they have on the public: research has shown that the scientific debate on vitamin C and colds tended to reinforce individuals' preconceived ideas because they could cherry-pick the evidence. Hence it polarized opinions, making the required compromise or climb-down much harder to achieve when the true scientific consensus became clear (Kobayashi 2018).

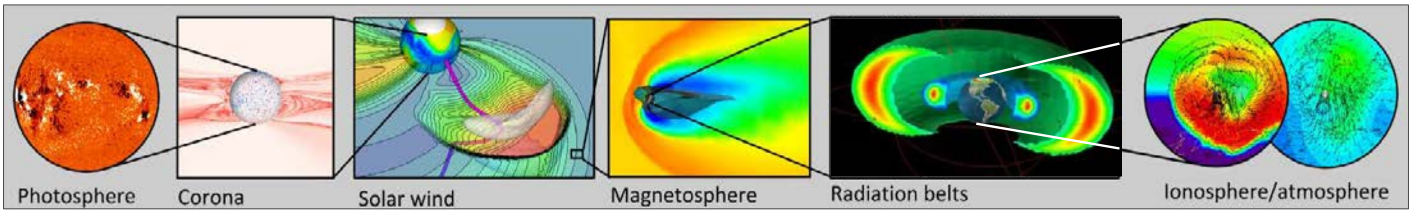
There are other issues that I believe MIST should attend to for the general health of our discipline, such as dealing with unreasonable referees, being a reasonable referee, what we need from journal editors, and how to keep the literature record "clean" and correct for future generations. Peer review can be a flawed and frustrating system (Kassirer & Campion 1994), but the formalization of the procedure by Francis Bacon and then the Royal Societies of Edinburgh and London can be argued to be Britain's greatest single contribution to science (Spier 2002). I can forsee an argument growing that it is outdated and inefficient. Any such case would be a failure to understand the crucial role peer review plays as the means by which scientific consensus is achieved. We should make sure early-career scientists understand its implications and purpose so they can call out abuses, as well as making sure that they themselves use it properly. These issues are both here to stay and constantly evolving; we need to make sure MIST does what it can to ensure we all have the tools to handle them and that we all get them right.

"You could see foreign scientists thinking 'we need something like this back home'"

It seems to me that collaboration within the MIST community also needs some care and attention. Naturally, bringing people together at the same meeting causes collaboration to some degree. But there is now great pressure on time at the MIST meetings; in this sense, MIST may have become a victim of its own success. Having many scientists with important talks to be squeezed in puts pressure on the time allocated to breaks and lunch. Yet these are the times in which those key, direction-changing conversations can take place. Those introductions, meetings and discussions influence consortium building, development of joint proposals and sharing of contacts in the wider world outside our field. Meeting organizers should remember that coffee drives collaboration – tea breaks are not trivial!

I also think we could be smarter and more co-operative as a community in timing grant bids and fellowship applications such that we don't get applications in similar areas competing in the same round.

Another area in which I see potential for development is in rapid opportunistic response to events. For example, at the time of writing, the discovery by the Jansky Very Large Array of the catchily named SIMP J01365663+0933473 is making headlines in the national newspapers. This object was initially thought to be a brown dwarf, but is now thought to be a lone rogue extrasolar planet, 20 million light years away, 20 times bigger than Jupiter and with a magnetic field that is 200 times stronger than Jupiter. The key point is that it has an aurora: therefore one wonders if the UK space science community should be getting involved in developing understanding of what is happening. It may be that the potential is not so great in this particular case, but it begs the question: "Do we have the mechanisms to form a community view and action plan quickly enough if windows of opportunity open up?" For example, how would the UK space science and space weather community best react if a Carrington-scale space weather event occurred tomorrow? This is not so



2 Illustration of the number of different numerical models that would be involved in a full "cradle-to-grave" numerical space weather forecast scheme that starts with observations of the solar photosphere. This poses many problems in terms of spatial and temporal scale-changing when daisy-chaining the models together (adapted from Owens *et al.* 2014). The main area missing from UK capabilities has been a numerical MHD model of the magnetosphere, but this is now being addressed at Imperial College by adapting the GORGON model, originally developed for studies of laboratory plasmas (Mejnertsen *et al.* 2018).

likely right now as we approach sunspot minimum, but you take my point. The new MIST "group leaders" online discussion group is valuable and a step in the right direction, but maybe there is no substitute for sitting round a table and talking through our plans, hopes and procedures.

In the area of potentially fruitful collaborations, it is worth noting that MIST science has two vital interfaces, plus one that is interesting but not quite so crucial in all areas. The latter lies between the heliosphere and interstellar space: it is not critical in that it does not affect the behaviour of the heliosphere as a whole. The solar wind is supersonic and super-Alfvénic and the outer boundary conditions, while not relevant to heliospheric modelling, are still highly relevant to studies of cosmic rays and cosmogenic isotopes. The first of the two critical boundaries for MIST science is the solar wind–surface boundary for unmagnetized solar system bodies, which becomes the lower/middle atmosphere–thermosphere boundary for magnetized bodies. These are generally studied as a natural part of planetary science and have historically fallen into the MIST remit. In the case of the Earth, experts from both sides of this border are now collaborating to good effect, as discussed above.

But the second critical boundary for all space weather studies is the inner heliospheric boundary, which one could think of as being that between the solar atmosphere and the heliosphere. Increasingly, MIST scientists are interested in areas that traditionally have been classed as "solar physics" and solar physicists are looking to solar–terrestrial physics to either help prioritize their work according to space weather and space climate impacts, or to use measurements from the heliosphere to act as boundary conditions. The UK has a very large and very strong solar physics community, which also works under an RAS umbrella as the UK Solar Physics community (UKSP; see box "UKSP: a brief overview"). MIST and UKSP have and do work together on summer schools and on some publications. I was involved in a good example in which understanding of magnetic flux transport and evolution in the photosphere gained by the solar community was successfully combined with reconstructions of the long-term variability of the heliospheric field deduced from historic geomagnetic activity observations and understanding of solar wind–magnetosphere coupling mechanisms (Mackay & Lockwood 2002). What is of interest here is how this came about. I visited St Andrews to give a talk at a summer school and stayed a day or two afterwards to have discussions with Eric Priest and Duncan MacKay. Indeed, even before that, I had visited BGS Edinburgh for a review meeting and again had stayed on to have discussions with Toby Clark about historic geomagnetic data, which started the open solar flux reconstruction work. The message is clear: these collaborations grow out of sufficient time spent discussing each other's work. Because such examples are not as common as they should be, we need to explore more ways to strengthen the links between the MIST and UKSP communities to mutual benefit.

> **"Remember that coffee drives collaboration – tea breaks are not trivial!"**

Voices in the MIST: talking with the public

Public engagement hardly existed when I started out, beyond the odd interview with Patrick Moore on *The Sky at Night*. Nowadays it is central to our task, but I have had a nagging concern about "outreach", ever since it first became part of the scientist's vocabulary and workload. My worry was, and remains, this: if we do a really good job and make a complex science issue simple and understandable, there will be a fraction of the population who, like the hilarious-yet-tragic Yosser Hughes in Alan Bleasdale's polemic *Boys from the Blackstuff*, will think "I could do that!" (Bleasdale 1982, 1990). If you are not familiar with this, I recommend that you watch the whole series. This is the Dunning–Kruger effect at work again, but on a much wider, aggressive and more corrosively worrying scale. My point is that if we provide such a satisfactory explanation that the public think that is all that there is to it, they are likely to be less, rather than more, happy that their taxes are being spent on our research. People's willingness to pay taxes depends entirely on trust that the money is well used (Torgler & Schneider 2007). When I first voiced this concern, I found that I was classed as an elitist dinosaur by some, which I felt was grossly unfair. I was, and still am, fully signed up to the idea that communication with the public is a crucial activity. I just want to be sure that we are doing it the right way – and I still know of no convincing research that either allays or confirms my fears. For sure, we should be working from an evidence base of what effect our outreach is actually having (e.g. Castel *et al.* 2014, McClain & Neeley 2015, Pham 2016) rather than relying on preconceived ideas and beliefs of either its value or its dangers. But much of the sociological research on this is open to doubt (e.g. Smith & Jensen 2014). This kind of consideration means that there is a whole new and evolving skill set required – one of making the core of what we do intelligible to the public while at the same time making it clear that it is actually complex in detail and difficult to achieve. At the same time, of course, we must inspire the young to take up space science, provide the enthusiasts with what they want but, most importantly, ensure that the general public are glad that we do what we do.

In addition to the many positive aspects of explaining what we are doing, there are the negative aspects of failing to explain what we are doing, expressed succinctly by the historian and economist C Northcote Parkinson, originator of Parkinson's Law about work expanding to fill the time available. He is often quoted as saying: "The void created by the failure to communicate is soon filled with poison, drivel and misrepresentation." I don't know if he really did say or write that – but the number of times the quote is used in books and seminars about communication and management is, in itself, interesting. I have no doubt that the public mood about "experts" has been deliberately poisoned by politicians because experts have an annoying habit of pointing out inconvenient truths (Bauer 2017). But some of it may also arise from the fact that we have failed in this balancing act of making our work accessible without giving ammunition to those who are all too ready to believe that what we do is trivial and a waste of taxpayers' money.

All-enveloping MIST: diversity

For many years, the MIST community has been, relatively speaking, ahead of the curve on establishing a proper gender balance – and I am very proud of us for that. But there are some signs that this progress may have stalled a bit in recent years. I am a firm believer that no project, no academic discipline, no nation can afford to ignore half of its talent. Hence it seems to me to be time to press harder on appropriate measures and complete the job. We have in the past made poorer progress in establishing ethnic diversity, but there are genuinely encouraging signs that this is now changing too.

The main conclusion is that we must take every possible step to ensure that MIST remains an open, welcoming and helpful environment for all, and one that encourages talent no matter where it comes from. We must also establish diversity among our ambassadors, which is vital in attracting all possible sources of talent into our field.

An apology, thanks and concluding remarks

Lastly, I apologize for the headline and subtitles used for these comments (Keats 1820), but it has become traditional to name a discussion of MIST with a pun making some kind of reference to small droplets of water suspended in air. I do not feel that I should be the one to break with tradition. But such whimsy should not detract from my central message, namely that MIST is vital to UK space science – absolutely and existentially important. So happy birthday, MIST. I personally am greatly in your debt.

We should all raise a glass to Henry Rishbeth and Peter Kendall, indeed all of the generation before me, who recognized the need for MIST, and also to the RAS for taking us under its wing and making it all possible. But the world has changed and will continue to do so at an accelerating rate: our job now is to make sure that there are young members of our national community who can continue to work on the science that we love and that, at some point in their futures, they will feel the same way as I do now – positively misty-eyed – when they sit back and reflect on the mellow fruitfulness of their own careers. ●

UKSP: a brief overview

Mihalis Mathioudakis, chair of UKSP, explains its origins, achievements and goals.

The UK solar physics community (UKSP) was set up as a specialist scientific group by Robertus Erdèlyi and Helen Mason in the late 1990s. Its precursor was the Solar Physics Study Panel, a subcommittee of the Royal Society, with Alan Gabriel and Helen Mason as convenor and deputy convenor respectively. UKSP is affiliated with the Royal Astronomical Society and its purpose is to promote solar physics both within the scientific community and the public, coordinate science meetings and voice the opinions of the community to funding bodies and policy makers. UKSP maintains a website and distributes information to members through a fortnightly newsletter. We participate in the annual RAS National Astronomy Meeting with dedicated splinter sessions and plenary speakers.

UKSP has strong links with the MIST community. Both communities put a lot of emphasis on postgraduate research training and jointly coordinate the delivery of the Introductory and Advanced STFC Summer Schools on Solar System Plasmas. With the launch of the Solar Orbiter mission in late 2020, the scientific links between the UKSP and MIST communities will become stronger. Solar Orbiter includes a full suite of *in situ* and remote-sensing instruments dedicated to studying the Sun and the heliosphere.

Origins

Solar physics research in the UK is carried out in 21 universities and research institutes across the country. A recent survey revealed that the UK has the highest number of active solar physics researchers in Europe. This strong position is also reflected in the number of research outputs, where we rank fourth worldwide.

The UK has made vital contributions to several space-borne missions and delivered state-of-the-art instrumentation to the Solar Maximum Mission (SMM), Solar and Heliospheric Observatory (SOHO), STEREO, Hinode and more. Some of these missions stimulated the formation of dedicated consortia that helped with the analysis and interpretation of the new datasets. For example, the SMM mission led to the formation of QUACS (Queen's, UCL, Appleton Lab, Cambridge, Strathclyde) consortium in 1979, an effort to get atomic physics researchers involved with SMM data.

In the 1960s, the British Science Research Council provided funding for the Solar Research Station in Malta. The Malta Station obtained spatially resolved observations of the photosphere and chromosphere, but the observations were of limited quality as a result of poor atmospheric seeing and these efforts were soon abandoned. BiSON, the Birmingham Solar Oscillations Network, has been acquiring Sun-as-a-star oscillation data since 1976, but apart from this, the UK has had little involvement with ground-based solar physics until 2008, when the Rapid Oscillations in the Solar Atmosphere (ROSA) imaging system was commissioned at the Dunn Solar Telescope in New Mexico, USA. This field has grown considerably in recent years and we are now a partner in the 4 m Daniel K Inoue Solar Telescope. DKIST is located in Haleakala, Hawaii, and will receive first light in early 2020.

Solar physics research in the UK also has a long heritage in the area of large-scale simulations of solar plasmas. These simulations are now carried out primarily as part of the UK MHD (magnetohydrodynamics) consortium led by St Andrews University. The consortium was formed in 1996 and uses high-performance parallel computing to carry out numerical simulations of MHD processes that take place in the solar atmosphere and interior.

AUTHOR

Mike Lockwood is professor of space environment physics at the University of Reading, UK.

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