A Status Report on US participation in AMMA including a report on the outcomes of a recent AMMA-US workshop (Silver Spring, MD, May 4-5 2006)

1. Rationale and aims of workshop

1.1 Introduction to AMMA

The African Monsoon Multidisciplinary Analysis (AMMA) is an international project to improve knowledge and understanding of the West African monsoon (WAM) and its variability with an emphasis on daily-to-interannual timescales. AMMA is motivated by an interest in fundamental scientific issues and by the societal need for improved prediction of the WAM and its impacts on West African nations. Over the past 50 years the West African change from wet conditions to much drier conditions is among the strongest multidecadal signals of the past century. This drying trend coupled with marked interannual variations has had devastating environmental and socioeconomic consequences. Unfortunately, fundamental gaps in our observation, understanding, and modeling of this complex system have limited prediction skill. To bridge these gaps, AMMA adopts a multidisciplinary approach, involving substantial international collaboration that links observation, data analysis and modeling on a wide range of space and time scales. A short introduction to the AMMA international aims and structure is provided in Appendix A. More details can be found at the AMMA international website (http://www.amma-international.org).

1.2 AMMA-US

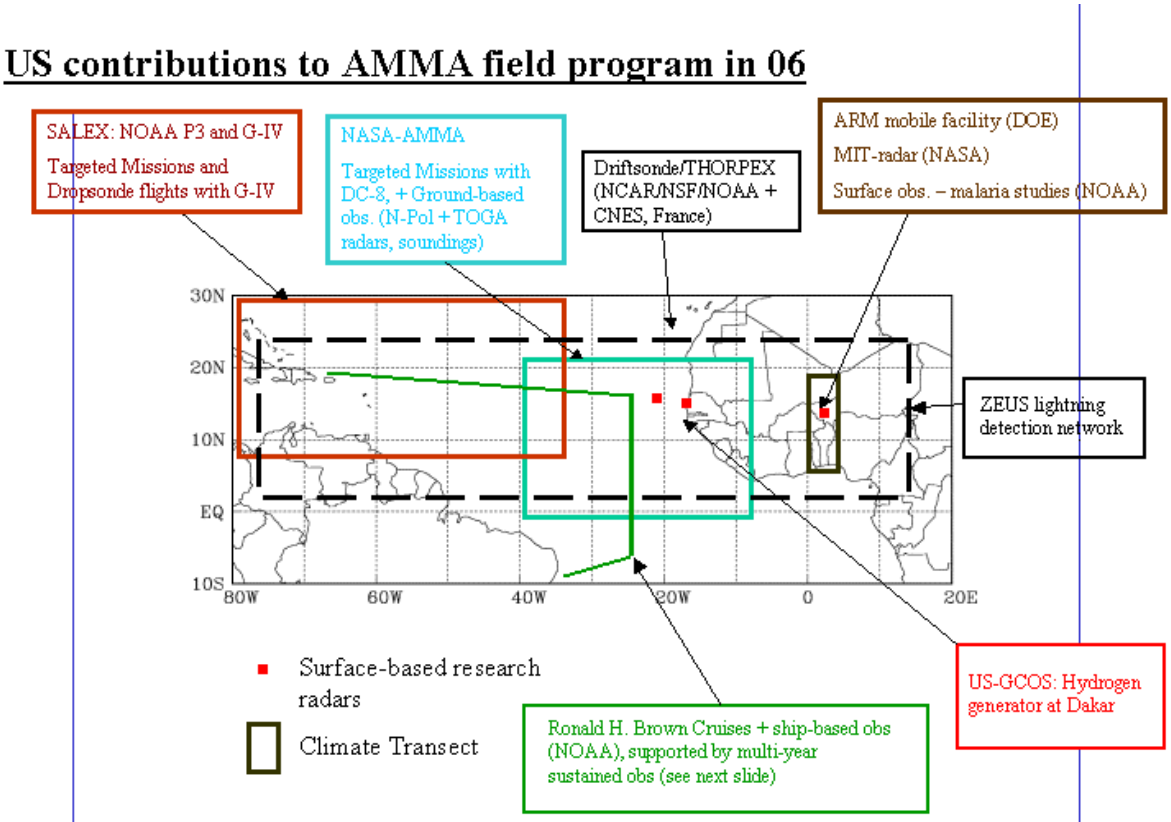
An AMMA-US proposal was prepared in December 2003 (available on the AMMA-US website at http://www.joss.ucar.edu/amma). Due to lack of funding this proposal could not be funded as a unified program. However individual proposals were prepared that addressed various parts of this program. Some of these have been successful, resulting in a significant US contribution to the AMMA field campaign. In addition, NCEP is contributing significantly to the AMMA field activities through provision of forecasts and training (see below).

1.2.1 US-Contributions to the field campaign

The US contributions to the AMMA field campaign in 2006 (see Figure below) include:

- ARM mobile facility in Niamey (DOE)
- MIT Radar in Niamey (NASA)
- Surface observations to support malaria studies in Niamey (NOAA)
- ZEUS lightning detection network (NASA)
- Hydrogen generator in Dakar (US-GCOS)
- NASA-AMMA observations composed of targeted missions with the DC-8, and including ground-based observations (N-Pol radar in Dakar, TOGA-COARE radar in Cape Verde, radiosoundings and surface observations) (NASA).
- SALEX targeted missions with dropsonde flights (G-IV) and P3 reconnaisance (NOAA).
- Ronald H. Brown and ship-based observations, supported by multi-year observations in the tropical Atlantic (e.g. buoys, drifters etc). (NOAA)

- Driftsonde/THORPEX launched east of the climate transect. (NCAR/NSF/NOAA with CNES, France)
- NCEP will provide real-time monitoring and forecast support to AMMA using the NCEP Operational Global Data Assimilation System (GDAS), the Global Forecast System (GFS), and the Coupled Forecast System (CFS). The Africa Desk will host visiting scientists from West African nations prior to, during and after the AMMA field campaign (NOAA). For more details please see Appendix D.



(http://www.joss.ucar.edu/amma).

1.2.2 Aims of the workshop May 4-5

As can be seen from the list of platforms presented above, the US contribution (estimated to be around $14M) is significant. In addition to this there are other significant US contributions to AMMA from NCEP as well as individual PIs funded to work on various aspects of the WAM and its variability. Given this background the aims of the workshop were to:

- provide an overview of the national and international AMMA project including planned research and field observations,

- discuss and identify the key science issues that interest US PIs in the context of AMMA,
- discuss and define coordinated actions regarding funded US contributions to AMMA, and
- discuss the funding opportunities to support unfunded but critical research and its coordination.

The Plenary and Breakout Sessions were organised roughly along the lines of the AMMA-international working groups (c.f. Appendix A): Water Cycle, Radiation-Aerosol issues, AMMA-Downstream (tropical cyclogenesis), Climate Variability and Change, and Land-Surface-Atmosphere Feedbacks. An expected outcome of this workshop was the establishment of an AMMA-US Science Team to help coordinate and carry out US research that contributes to AMMA, and to ensure that this is coordinated, where appropriate, with other national and pan-national projects contributing to AMMA-international.

The presentations made during the plenary sessions can be viewed on the AMMA-US website at http://www.joss.ucar/amma/meetings/200605.

2. AMMA-US Coordination

2.1 Establishment of an AMMA-US Science Team

Based on the breakout sessions and discussions at this workshop we agreed to establish an AMMA-US Science team that would be built around Working Groups that mirror the international structure (c.f. Appendix A). The contributions to the five AMMA-US WGs together with their chair(s), where appripriate, are provided below together with a brief summary of the perspectives for future contributions to AMMA. Complete write-ups from the breakout sessions are included in Appendix B.

WG1: West African Monsoon and Global Climate (Kerry Cook/Pete Lamb/Bob Molinari)

A Working Group 1 breakout session was convened to discuss priorities, funded projects and coordination needed to achieve the goals of U.S. activities directed at the WAM and Global Climate component of AMMA. U.S. objectives are not only directed at the global climate impacts of the WAM but also at the regional climate impacts and the two-way interactions between the WAM and the tropical Atlantic at time scales ranging from seasonal/interannual to decadal. The workshop also decided that the priority aerosol-radiation issues should be included within this WG, consistent with AMMA-international. Both observational and modeling projects are needed to achieve the following priorities:

(i) Monsoon processes,

- The role of SSTs on the evolution of the WAM (including especially the cold tongue);
- The role of the southern hemisphere tropical stratus deck on the evolution of the WAM;
- Scale interactions (e.g., weather/jet interactions and impacts on the WAM) including consideration of clouds, radiation and dynamics and the impacts of aerosol; and
- Evaluation of diabatic heating profiles and their impact on WAM circulations.

(ii) Variability and Predictability of the WAM,

- Mechanisms that force SST variability;
- Variability of mesoscale and synoptic weather systems and their relationship with the large-scale environment;
- Proxies for rainfall to extend the observational record.

(iii) Global impacts of the WAM,

- Impacts of variability of the WAM (e.g., linked to shear, SAL, weather systems) on variability of tropical cyclone activity.

(iv) Aerosol/Radiation issues

- Relative roles of local biomass burning and transport of plumes from other parts of the region on the radiation budget.
- Quantify the extent aerosol experiences wet deposition and the chemical composition of the rainwater.
- Respective roles of dust and biomass burning in modulating the radiation heating profile over West Africa (and how this impacts the WAM).

A key *cross-cutting activity* that falls under the auspices of WG1 is the US-led West African Monsoon Model Evaluation (WAMME) project. This is a CEOP/CIMS modeling initiative led by Yongkang Xue, Kerry Cook and Bill Lau and is concerned with evaluating models in the WAM region. It emphasizes analysis of models at a range of timescales : diurnal, intraseasonal, interannual, intradecadal and includes emphasis on the onset and withdrawal of the monsoon rains. Efforts will be made to coordinate this modeling activity with other modeling projects in AMMA.

To date, considerable financial support is available to collect oceanographic data to address SST issues and aerosol/radiation measurements in Niamey. Additional support has been provided to address research on scale interactions and analytical, modeling studies of tropical cyclogenesis. Areas of scientific and technical coordination that are required include: integration of land-air-sea studies to develop an integrated characterization of the WAM and the systems that propagate downstream into the eastern Atlantic; development of heating profiles through interactions with the international AMMA community; integration of model-observations studies; calibration/validation of satellite products (e.g., SST, surface fluxes, surface winds, aerosol concentrations); estimates of surface fluxes; and generation of time series of aerosol distributions. The WG group recognized that time constraints and the interests of those attending the breakout session limited these lists of priorities, funded projects and required coordination. These constraints led to the group supporting the formation of an AMMA-US Science Team to ensure that the full suite of U.S. AMMA interests were addressed.

Contributors to WG1 include: Anantha Aiyyer, Mike Baringer, Kerry Cook, Sylvia Garzoli, Alesandra Giannini, G. Goni, George Kiladis, Pete Lamb, Bill Lau, Rick Lumpkin, Mark Miller, Bob Molinari, Claudia Schmidt, Chris Thorncroft, Edward Vizy, Yongkang Xue, Chidong Zhang, Dick Johnson, Sylwia Trzaska, Bryan Mapes, Grek Jenkins, Sally McFarlane, Anne Jefferson , Paquita Zuidema, Earle Williams, Bob Houze (this list is incomplete, see AMMA-US website for updates)

WG2: Water Cycle (Paul Houser)

The AMMA-US working group for the water cycle identified several research foci that would be well suited to their community, and would help fill critical gaps in the AMMA research program. The identified AMMA-US water cycle research foci are:

(i)Scale interactions and the water cycle,
Determine and predict the interactions between mesoscale, synoptic and monsoon systems, by identifying scaling structures and process connections (e.g., PV advection, adiabatic ascent, synoptic advection of temperature and humidity, surface processes, etc.).

(ii) Hydrological monitoring and prediction,
Routinely monitor and predict local-scale hydrologic connections and interactions with mesoscale and monsoon processes in order to improve resource allocation and outcomes in climate sensitive sectors.

The AMMA-US working group identified a number of areas that the AMMA research agenda will need to be strengthened to address these research foci. From an observational perspective this includes land surface observations, access to operational radars and raingauge networks, integrated atmospheric profiles from satellites, and combined rain-radar mosaics (including raingauge correction, model and satellite data). From a scientific perspective the group wished to promote the following: a mid-term (weeks to months) forecast skill improvement focus, inclusion of energy & radiation in water cycle studies, coordination of downscaling efforts, improved coastal water cycle observations, use of lightning to bridge between satellite observations and models, enable better atmospheric prediction and local impacts, such as hydrological processes (rainfall spatial/temporal variability), improved estimation of land moisture conditions (soil moisture, streamflow, groundwater) to establish land-atmosphere feedbacks, and to improve general water cycle understanding.

The AMMA-US working group identified a number of resources that it could specifically strengthen and use to address its research foci, including :

- Develop an AMMA Water Cycle data integration activity:
  - Include remote sensing, in-situ observations, and model predictions
  - Leverage on existing programs that integrate data: CEOP
  - Common formats, quality control, easy access interfaces, error assessment and combined data products, “one-stop data shop”, estimate all elements of water budget (HAPEX-SAHEL good example).
  - “Optimal” or “best” data will need to be assessed as each time/space scale and application.
- Tools exist and can be readily applied to study interactions between mesoscale, synoptic and monsoon systems (i.e. cloud resolving models, mesoscale models, and appropriate observations).
- Combined deterministic and stochastic approach could help to address local-scale hydrologic connections & impacts with mesoscale and monsoon systems.
- Establish crosscutting working groups, perhaps based on scale interactions, to enable links between water cycle and other important processes (such as carbon cycle or land-surface hydrology).
- Recommend an international AMMA water cycle workshop.
- Establish an AMMA-US water cycle team coordination on establishing support and funding.

The AMMA-US working group identified some potential funding sources for the ideas above. Generally, since there is no official U.S. program for funding the research above, it is thought that the working group will need to propose compelling AMMA science to existing (non-AMMA) programs. Some working group success has been realized with various NSF proposals, and it is expected that NOAA may be willing to support some AMMA research. NCAR has a small water cycle, university focused effort that may be leveraged. Finally, it was suggested that we contact international programs (USAID, State Dept., etc.).

Finally, it was also recommended that the role of aerosol on the water cycle should be considered by this WG.

Contributors to WG2 include : Paul Houser, Arlene Laing, Karen Mohr, Mitch Moncrieff, Baxter Vieux, Manos Anagnostou (to be completed; see AMMA-US website for updates)

WG3: Surface-atmosphere feedbacks (Fatih Eltahir/Erica Key)

Reflecting the AMMA-international structure AMMA-US considers land-surface atmosphere feedbacks (3a) and ocean-surface atmosphere feedbacks (3b) separately under this WG. The ocean-surface atmosphere feedbacks aspect was not discussed explicitly at the workshop but is briefly mentioned here for completeness.

WG3a: Land-surface-atmosphere feedbacks (Fatih Eltahir)

As background information, we recognize that noone in the working group had any AMMA-specific funding, only one researcher has an active project working in the AMMA region, however a majority of the attendees could apply their current research to the AMMA region.

The following potential contributions by U.S. scientists were identified and discussed:

(i) Remote sensing retrieval algorithms and products for use and for comparison to European products:

Radiation, short wave/longwave.
Surface temperature (MODIS LST)
Precipitation. (CMORPH, TRMM-3B42, etc.)
Atmospheric soundings (NOAA and NASA sounders)
Soil moisture(TRMM/TMI and AMSR-E microwave brightness, Total soil water column from GRACE)
Ground-based RADAR precipitation. A gridded, gauge-Radar precipitation product based on all available radars in the AMMA domain is needed. This requires calibration of the radars and integration of the radars.
Aerosols (products consistent with the above radiation, atmospheric and land surface products)

(ii) Modeling of coupled Land-atmosphere system

Strong US community, is recognized in this area, however they somehow need a funding opportunity to collaborate in AMMA. It was also agreed that European research tends to be hydrologic/BL process-oriented (smaller space-time scales), while US research tends to look at more integrated, large scale factors. Therefore collaboration between the two groups offers broader insights, especially the up-scaling from process scales to synoptic scales. There is a need for in-depth analysis of process-scale observations and modeling studies and the relations from these analyses to similar analyses from large-scale models (Both through inter-comparison

studies and diagnostic studies.) For these activities, the access to AMMA data is critical. The suite of models used should include both research and operational models.

(iii) Dynamic soil moisture and Dynamic vegetation studies
AMMA scientific plans include studies on satellite-based vegetation and land cover classification. There is extensive expertise in the U.S. in this area. An important scientific issue is the accurate simulation of the seasonal cycle of the atmosphere, vegetation and their coupling. AMMA plans for a two-year modeling study, but there is expressed interest to look at a century scale modeling study of dynamic vegetation and its impact on climate variability. Inter-comparison studies of vegetation dynamics (seasonal and inter-annual) are emphasized.

(iv) Data assimilation of remote sensing, and in-situ observations.
Strong US community is recognized in this area and is encouraged to collaborate with AMMA European scientists. Both communities are rather small, so collaboration is critical. AMMA needs a coherent description of the water, energy and vegetation system that can only be provided through remote sensing, and integrated with in-situ observations and models through a data assimilation activity. A U.S. effort is needed to develop this integrated system in collaboration with AMMA.

(v) Value added products for impact studies and societal needs.
An underlying scientific issue is the role of land states (vegetation, soil moisture) on the west African monsoon and its predictability. This would include the predictability of related hydrologic variables like soil moisture, stream-flow, crop production, water pools, and human health impacts.

US Contributors to WG3a include: Fatih Eltahir, Eric Wood, Alan Betts, Randy Koster, Yongkang Xue, Christa Peters-Lidard (to be completed, see AMMA-US website for updates)

WG3b: Ocean-surface-atmosphere feedbacks: Erica Key

No discussion was had on this scientific theme at the workshop but Erica Key has provided a summary of the major observations that contribute to this (see Appendix B.6) and has agreed to coordinate and represent US interests in this area.

Contributors to WG3b include : Erica Key, Chris Fairall, P. Minnet, Bruce Albrecht, K. Voss (to be completed, see AMMA-US website for updates)

WG4: Prediction of Climate Impacts (Sylwia Trzaska)

US contributions to this WG were not explicitly discussed at the workshop but it was clear that the consensus of the workshop was that this WG was a high priority. For AMMA to be successful and leave a significant legacy, it is crucial that better understanding and predicting climate variability translates into more efficient climate risk management in climate-sensitive sectors such as food security, health and water resources management. This WG4 should be seen as **cross-cutting,** benefiting from inputs from other climate-focusing WGs, thus better links should be established between the other WGs and WG4. It should encourage PIs working on all aspects of the WAM and its variability to come together to discuss how their~~is~~ work can be exploited further for the study and prediction of climate impacts. Reinforcement of links and better coordination with the activities within AMMANET and regional institutions involved in operational activities, such as ACMAD and AGRHYMET, is particularly relevant.

The major impediment for the use of climate information in climate-sensitive sectors is the time and space scales mismatch between robust climate information and sectoral scales of interventions/decisions. Important efforts should be put on the assessment of the scales at which robust evidence of climate influence on human activities can be shown, and on the development and assessment of statistical and dynamical methods for downscaling of climate information to appropriate scales. While scale interactions are explicit activities in different WGs, they are not aimed at climate impacts.

IRI wishes to organize an international workshop gathering the key individuals currently involved in downscaling for West Africa and experts from interfacing institutions to better define cross-cutting activities that would demonstrate the feasibility and establish methodologies for new products that could be used in climate risk management activities, thus ~~on different aspects of downscaling for West Africa that could benefit the prediction of climate impacts in order to better map the current activities and coordinate future ones and~~ enable better linking between climate science and its potential applications within AMMA.

Contributors to WG4 include: Sylwia Trzaska (to be completed, see AMMA-US website for updates)

WG5: High impact weather prediction and predictability (US contacts: Dave Parsons, Chris Thorncroft, Zoltan Toth, Jason Dunion, Greg Jenkins)

The US community is making major contributions to this aspect of the AMMA international program. International WG5 is a joint AMMA-THORPEX activity that is concerned with high impact weather over West Africa (e.g. wet/dry spells, onset), the tropical Atlantic (e.g. tropical cyclones) and extratropics (e.g. extratropical transition of tropical cyclones, Rossby wave trains). We expect US PIs to make significant contributions to all three regions. US PIs are also contributing to operational-related activities including, tailoring of forecast products in tropical regions, data impact and predictability studies.

US Contributors to International WG5 include: Dave Parsons, Chris Thorncroft and Zoltan Toth (International co-leaders), and Sim Aberson, Jason Dunion, Pat Harr, Greg Holland, Greg Jenkins, Rolf Langland, Sharan Marumdar, Wasilla Thiaw, Naomi Surgi, Chris Velden, and Peter Webster

It is clear that a major emphasis in the US is given to the issue of tropical cyclogenesis downstream of West Africa, recently highlighted by support provided by NASA for the NASA-AMMA (NAMMA) project that builds on the support in the US already provided by NOAA. This tropical cyclone component is a major contribution to international WG5.

AMMA Downstream (Jason Dunion/Greg Jenkins)

The tropical cyclone component of AMMA will include a number of aircraft, ground-based, and satellite assets from NASA, NOAA, the United Kingdom, and France. Coordination between these various research efforts is considered an important element of the downstream component of AMMA. Key US platforms that will contribute to the overarching goals of AMMA downstream include: (i) Aircraft (North Dakota DC-8, NOAA-GIV, NOAA P3), (ii) Ground-based observations (driftsondes, rawinsondes, pibals, 3 radars), and (iii) Satellite. Coordination of these US platforms with European and African contributions is being done through AMMA

International Task Team 9 chaired by Greg Jenkins and Frank Roux. More details regarding these and the European platforms are included in the appendix together with the funded PIs and their contributions.

Major scientific areas of investigation include:

(i) Life-cycle of African easterly waves and embedded mesoscale systems as they move from the land across the Atlantic including their role in influencing tropical cyclogenesis.
(ii) Comparision of convection and weather systems between continental and maritime regimes including the impact of dust.
(iii) Composition and structure of the Saharan Air Layer and its affect on tropical cyclone intensity change
(iv) Investigation of prevailing hypotheses relating to top-down versus bottom-up development of tropical cyclones.
(v) Impact of moisture information from the GPS dropsondes in operational parallel runs of the NOAA Global Forecast System (GFS) model ; with emphasis on predicted tropical cyclone intensity change and track.

US Contributors to AMMA-Downstream include : Greg Jenkins, Jason Dunion, Bruce Anderson, Edward Browell, Paul Bui, D. Allen Chu, Robert Cifelli, Kerry Cook, Michael Douglas, Leonard Druyan, Michael Goodman, Andrew Heymsfield, Jack Ji, Everette Joseph, Tiruvilam Krishnamurti, Bjorn Lambrigsten, Bill Lau, Paul Lawson, Francis Schmidlin, David Starr, Earle Williams, Liguang Wu, Ed Zipser, Robbie Hood, Jeff Halverson , Sim Aberson, Sharin Majumdar, Rob Rogers, Chidong Zhang, Joe Cione

2.3 AMMA-US Data and Datacenter Proposal

A proposal for establishment of an AMMA-US datacenter was made to coordinate access to the various US datasets and to facilitate access of US PIs to the international datasets. Funding is required for this activity.need to work together to establish the AMMA-US datacenter and discuss key products (satellite, value-added products).

3. Final Comments

3.1 AMMA US Science Team

Recognising the significant US role in the AMMA field campaign and the keen interest of many US PIs in the AMMA Science (79 people attended this workshop), the workshop has lead to the creation of an AMMA Science team built around contributions to the five international WGs and including an emphasis on the cross-cutting themes (Modeling of the coupled WAM system and Climate impacts). Given the lack of earmarked money for AMMA the workshop recognized that the coordination of AMMA-US science must take advantage of funded work and encouraging the submission of future "traditional" proposals lead by one or two PIs.

The AMMA Science Team will be coordinated by an excutive committee that consists of the following people: Kerry Cook, Jason Dunion, Fatih Eltahir, Greg Jenkins, Paul Houser, Arlene Laing, Peter Lamb, Erica Key, Bob Molinari, Chris Thorncroft, Sylwia Trzaska. Scientists wishing to contribute to AMMA-US WGs should contact the US WG leaders directly. For more general information about AMMA please contact Chris Thorncoft. Contact information is available at the AMMA-US website.

3.2 Future Funding Opportunities to support AMMA Science

Along with normal avenues for research such as NSF, current and future funding opportunities to support AMMA-related work include:

- NOAA: Annual Climate Program announcement.
- DOE – An announcement is expected in 2007
- NSF – Normal funding routes are of course available; special calls that relate to AMMA should be watched out for.

3.3 Next Steps

(i) An e-mail list for the AMMA-US Science Team will be established consisting of contributing PIs listed here. Additional contributors wishing to be involved should contact the WG leaders (contact information is available at the AMMA-US website at http://www.joss.ucar.edu/amma).

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(ii) AMMA-US website will be updated to reflect current situation

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(iii) Work to support the AMMA-US datacenter

(iv) Ensure that the US WG contributions are coordinated with AMMA International.

(v) Lobby agencies to support analysis of AMMA observations.

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