

Summary of sessions: Solar and Heliospheric Working Group

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Abstract. The solar and heliospheric working group was very active with 34 contributions in six oral sessions and 15 posters. The topics ranged from the solar interior to the heliosphere's place in the local interstellar medium and covered almost everything in between. There were observations of the photosphere, chromosphere, corona, and heliosphere. We discussed the current understanding of active regions, flares, coronal mass ejections, solar energetic particles, cosmic rays, space weather, and solar influences on climate. Much excellent work is happening already, though some gaps have been identified in the program. ILWS can serve a role in filling those gaps, working to exploit the data that are already available, and encouraging science-driven cross-discipline and cross-agency collaboration.

Index Terms. Heliosphere, Solar Interior and Atmosphere, Solar Physics, Sun-Earth Connection.

1. Introduction

With 34 contributions in six oral sessions and 15 posters, the solar and heliospheric working group was very active. The topics ranged from the Sun's interior to the heliosphere's place in the local interstellar medium and covered almost everything in between. Improved instruments, higher fidelity models, and more comprehensive theories will serve our future needs. Papers described observations of the photosphere, chromosphere, corona, solar wind and heliosphere. Presenters covered the current understanding of active regions, flares, coronal mass ejections, solar energetic particles, cosmic rays, space weather, and solar influences on climate.

This review does not attempt to summarize all of the contributions. The papers and abstracts that follow do a much more thorough job of that. However, it may be useful to identify some of the major themes of the meeting.

2. General Themes

The research opportunities are great and even more impressive when considered in conjunction with the rest of the International Living With a Star activities. The many papers in this volume capture only a fraction of the results presented at the meeting, but perhaps a more important outcome was the new understanding of other fields, and most useful of all were the new contacts that were established among the participants.

Global plans for new ILWS science and observations cover many areas, but the unknowns are even greater. One area of uncertainty is the lower solar atmosphere. The

importance of the chromosphere and the relatively unexplored layers above it became clear in a number of presentations. Opportunities presently exist to obtain new or vastly improved measurements of this mysterious region that is critical to understanding the important questions of energy transport, storage, and release in the Sun's atmosphere.

In addition currently planned missions and these new exploratory observations, continued measurements of the incoming solar wind at L1, of the extended solar atmospheric structure with coronagraphs, and of the interplanetary medium using interplanetary scintillation and radio observations are indispensable to everyone.

Significant progress has been made in the past few years, however, the meeting participants made it clear that two of the most important solar and heliospheric contributors to space weather remain a mystery: the source of coronal mass ejections (CME's) and the origin and acceleration of solar energetic particles (SEP). In truth the basic problem of the propagation of energy still confounds us. Nevertheless, the amazing new measurements and vastly improved models of the last 10 years have opened completely new windows into the understanding of the basic processes and the ways they interact, to be sure. For example, the presence of oscillatory behavior is now observed nearly everywhere – in the solar interior, at the photosphere and in the corona, in the solar wind and at the heliospheric boundary. We are figuring out how to interpret the characteristics of those variations. As we learn more, our questions become increasingly focused and precise. Continued progress requires improved physical

measurements to solve the new puzzles that have come to light.

The ability to forecast the behavior of the system with physical models is the ultimate measure of our understanding. Our discussions at the meeting highlighted some regions of dramatic progress, but it became increasingly clear that every region has a role to play and that predicting the important parameters of space weather must be built on understand each element and how that element fits into the entire system. For example, prediction of geoeffective CME's depends on the vector magnetic field in and above the photosphere as well as prior physical conditions in the corona and heliosphere. The helicity of an associated active region may originate beneath the photosphere and affect the evolution on various spatial and temporal scales far into the heliosphere.

A vast trove of existing data is readily available today. This offers great opportunities right now for researchers in every nation. A key tool needed to take advantage of these observations is data visualization. High-resolution and global-scale observations from multiple sources obtained over long periods together with more complex data analysis and "reduction" products, and more comprehensive results from modeling and simulations demand improved methods for exploring these rich data sets. Without the ability to conveniently access, analyze, and compare parameters from disparate sources, relatively little will be achieved and the data and models will be under utilized.

As modeling becomes more complete and physically consistent, requirements on initial conditions become more demanding. Assimilation of new data places demands on both models and data providers. The requirements may lead to quite different approaches for understanding the quiet or ambient conditions than for modeling and forecasting extreme events.

3. Topics of the Solar & Heliospheric Working Group Sessions

For the purposes of the meeting, the papers can be grouped into broad categories. The chromosphere and above was covered in the papers by Murphy, Hassler, Balasubramaniam, Dame, and Subrmanian. Reports by Simnett, Veselovsky, Berghmans, Jain, Bannerjee, Dwivedi, Krucker, Bothmer, Subramanian, Gopalswamy, Webb, Maia, Desai, Bhatt, Mishra, Ebenezer, Jadav, and Jadeja addressed the understanding of CME's, flares, cosmic rays, and particles. Several authors analyzed the solar wind, described predictive methods, or investigated the large-scale structure and variations of the solar atmosphere: Hayashi, Badruddin, Manoharan, Chanberlain, Lean Srivastava, Janardhan, Sittler, Ji, and Rajaram. Moving outward from the deepest interior, Rajaguru, Hanasoge, Hill, and Hoeksema described the current state of helioseismology. Looking at the

photosphere, specifically active regions, helicity and the solar cycle, were Chatterjee, Zhang, Raman, Bhati, Mathew, Rusin, and Dame. Finally, those addressing the connections, Sun-Earth, Sun-climate, heliosphere-galaxy, and sun-star, included Prabhakaran Nayar, Nandy, Vahia, Hiremath, Selvamurugan, and Tripathy.

4. Recommended Directions for the Future

Solar and heliospheric science addresses important topics for ILWS and a great deal of excellent work has already been completed. This conference demonstrated that achievement and also indicated several areas in which important planning and coordination is already underway.

The conference suggested several clear directions for the future. We have already identified some important gaps in the planned program. Spectroscopy above the photosphere is one clear example of an area where scientists, the ILWS program, and national agencies must now work together to step up their efforts. Several concepts have been defined and now require a commitment of resources to develop further.

An incredible amount of diverse data already exist, and application of new analysis techniques to the data already available, or combining data in novel ways promise immediate progress. The national agencies supporting ILWS can increase support of research using observations already available as an extremely cost-effective way to not only answer important questions, but also to build a strong community that will be able to exploit future advances. The cost is very small compared to the scientific and social pay off.

Finally, the conference brought together scientists and agency leaders from different locations, disciplines, and agencies, many of whom had never interacted before. The excitement and intensity was palpable as people explored new ideas and brought new insights from familiar areas to questions new to them. ILWS, the national agencies, and scientists must renew their efforts to forge new scientific collaborations across disciplines and institutional barriers. This is a strong need in ILWS science and a major challenge.