# International Cooperation Key to Success of Earth Observation System

## — An Interview with Dr. Ghassem R. Asrar

"It is a very wonderful story to tell," in the interview with *BCAS* reporter SONG Jianlan before the opening of the 35th International Symposium on Remote Sensing of Environment (ISRSE), Dr. Ghassem R. Asrar, Director of the World Climate Research Program (WCRP) and former Earth Science Associate Administrator of the National Aeronautics and Space Administration (NASA) could not help expressing his joyfulness and satisfaction at the wonderful job the global community has done in just thirty years: building the Earth observing system (EOS), turning the observations into useful information and making it available to scientists and decision makers around the world. Let's follow him to celebrate the contributions of Earth observations to our understanding of the Earth system and climate, a sub-system of our planet, and recognize China's current and future role in this system. Meanwhile we will have an opportunity to learn about his experiences of EOS and expectation of China's bigger participation in internationally cooperative projects in the field of space-based remote sensing, for future decades.

**Dr. Ghassem R. Asrar**

Director of the World Climate Research Program (WCRP), former Deputy Administrator for the Natural Resources and Agricultural Systems with Agricultural Research Service (ARS) of the U.S. Department of Agriculture, and former Science Deputy Associate Administrator of the U.S. National Aeronautics and Space Administration (NASA). He served as the chief scientist for the Earth Observing System in the Office of Earth Science at NASA Headquarters prior to being named as the Science Deputy Associate Administrator in 1998.

Dr. Asrar is the recipient of numerous awards and honors, including the U.S. Presidential Distinguished Executive Award (2002), and he is an elected Fellow of American Meteorological Society (2001) and IEEE (2000).

***BCAS:*** *I noticed that you introduced some applications of Earth observations in the abstract of your keynote speech for the ISRSE35. Would you give us some general ideas about how this system or this technology can help us understand climate change?*

**Asrar:** Sure. Thank you very much for inviting me to this interview and offering me this option to briefly describe my experience of the contributions of remote sensing or Earth observation to our understanding of the Earth and its environment, and making the knowledge we have gained and resulting information available to the policy makers and the authorities that have to manage natural resources and deal with natural disasters: typhoons, earthquakes, hurricanes, and tsunamis. What is unique about remote sensing of the Earth is that it provides us a holistic view of the whole Earth system, giving us an opportunity to

understand the changes that are taking place in the Earth system. Without observations we cannot develop the necessary understanding of the causes and the consequences of these changes, and without such understanding we could not develop the computer-based models that we use to predict future weather, climate and environmental conditions. So this has been the reason for building the international Earth observing system that we have today: the recognition of the need for monitoring the Earth as a system, using the observations to understand the Earth system and its changes, and ultimately using the knowledge we gain to protect the life and property and improve quality of life on the Earth. That idea has been with us for a long time, and in the past several decades we made great progress to bring most nations from around the world together to join the expertise, to bring in the investments, to bring in together the research institutions, universities, or national laboratories to develop this system. It is a remarkable success that we now have a very comprehensive Earth observing system in space, on the surface of continents and inside oceans around the globe. Of course most of the capabilities are in space, in form of satellites to which countries like China and other countries in Europe and North America have contributed. We have also succeeded in building some of these capabilities on the surface of the Earth, being on the surface of oceans or inside of oceans, or on the land. *So the Earth observing system as we know it today, was truly made possible through international cooperation, because no one nation by itself can do this, even if a nation or the nations were rich enough to build this, they still have to have the permission of other countries to install some of its components on their territories. Therefore international cooperation has been a key to the success of building this wonderful, comprehensive Earth observing system that we have today.*

***BCAS:** Do you mean the data obtained by this Earth observation system is shared for free among the participant countries?*

**Asrar:** Yes. That has also been one of the principles from the early days that we should promote this concept of free and open access to these observations without restriction, because that is intended to serve the global society. Now not every country subscribes to that principle, some countries have openly embraced this principle from the beginning, and some other countries did not embrace it from the beginning but now changing gradually. It is coming along, it is taking shape slowly but surely; and in most cases where there is a need for humanitarian use of the data, most countries do not have any problem with sharing their environmental observations. For example, the United States of America agreed to these open access and availability and data sharing principles from the beginning, other countries in Europe did not quite accept those principles, but now they are embracing them. So this is one of the challenges that have continued to be with us: to make sure that we really fulfill this commitment, to make these observations available to all nations around the world without any restriction, in order to realize the full benefits of this system.

I have more or less given you the background to the evolution, the development of this observing system, and I should like also to share with you what we have been doing with the observation system. Of course it was a


Dr. Ghassem R. Asrar at the panel discussion on the theme “Remote Sensing and Global Environmental Change”, a special session in the scientific program of the ISRSE35. The discussion was arranged to provide an opportunity for representatives from different scientific organizations to jointly deal with global environmental issues in the field of remote sensing. (Photo by SONG J)

major challenge to convince the nations around the world to invest a lot of money to build this observing system, but also to invest in research and development and information technologies to take the observations and turn them into useful information either for scientific research, or for any other application, otherwise we would not have fulfilled or demonstrated full benefits of this comprehensive observing system. *Therefore in my opinion, the value of the observing system, and of the observations, is not fully obtained until we turn the observations into useful information.* The utility or the usefulness varies from one user group to the other: scientists want these observations to be highly accurate, very well documented for their scientific research, while those who deal with humanitarian aid, who want to warn people against typhoons, against tsunamis or floods and droughts, do not need these observations to be so precise — but they need to have them immediately. In one case, the scientists would allow more time to develop these observations into information precise enough for their research, but those who deal with emergencies and natural hazards want these observations to be available immediately. To meet the needs of different users we needed to also have an information management system, having powerful computers that could take very large amount of observations and analyze them, making them useful for scientists and to make them available immediately to the decision makers, to the authorities that have to deal with emergencies. Without advances in computer sciences and technology, without telecommunication, without the Internet and other networks, the value of these observations could not have been fully realized by the full range of users. So we are fortunate that in parallel with the development of remote sensing and observing system, we have seen this tremendous progress in information technology, in computer sciences, and in communication technologies that have helped to process very large amount of observations, interpret them to get their information content, and to make all of these available to interested users globally, without any restriction. *This is a remarkable success story of the international cooperation for using advances in science and technology to serve global society for our generation, and hopefully for our children and their children, a true legacy of international cooperation in environmental sciences and technology.*

What is also remarkable is that all of this has happened in less than three decades. We built the most comprehensive observing system, both in space and also on the surface of this planet; we built a network of information nodes, very powerful computers to process these observations into information; and more importantly, developed the final products, the final information to be useful to scientists for their research on one hand, and to be useful to practitioners on the other hand, making them available in a time-frame that is useful either to the scientists for their research or to the decision makers for the applications that intended.

At the panel discussion, Dr. Asrar proposed that users of remote sensing data should be encouraged to participate in the development of remote sensing.(Photo by SONG J)

I have just described to you a major international accomplishment over the past thirty years. This is a relatively short time if one considers that on average it takes about 7~10 years to develop and launch a satellite that may last for about the same period once it is fully operational. We now have almost one hundred Earth observing satellites from all countries around the world. We have established international coordination and mechanisms to bring together most of these observations from different satellites from different countries, to process and turn them into useful information for scientists and decision makers, and make them available without any restrictions globally ... it is a remarkable story about international cooperation, about the scientific and technical innovation in the past three decades.

***BCAS:*** *So this system is useful for scientists and decision makers in many fields, but specifically how important is it for climate change?*

**Asrar:** Yes, this system is absolutely essential to climate research. As I stated, without the observations, we would not have been able to obtain the understanding about the Earth system, and turn that scientific understanding into some conceptual models of the climate system, because observations, as valuable as they are, can tell us about the past climatic conditions and the present. They cannot tell us anything about future climate conditions, because we cannot take tomorrow's observations today. The only tools that we have available for us to say something about the future climate conditions are computer models that mimic the behavior of the Earth climate system. These

models were built based on scientific understanding that we obtained about the climate of the past and present from these observations. Turning the knowledge from those observations to models, we can predict what the future climate might look like. As you see observations provide the foundation for building these models, and plus we use these observations to validate the models, to see how good they are simulating the past and present climate conditions, to find out if they compare well with what we actually observed, and to build confidence in the accuracy of climate models' ability to mimic the behavior of the climate system, so that we have confidence in their future prediction. Therefore, without observations we would not have been able to develop the scientific understanding that is required to build these models that are used today to predict or project the future Earth climate conditions from seasons, to years, decades and centuries. That is the unique contribution of observations to climate science and climate research.

To be able to develop this understanding or predictive capability of the climate system, we have to understand the changes that are taking place in the Earth's oceans, the Earth's atmosphere, the continents, the forests, the agricultural lands, and lakes, *etc. For that reason we not only need to have this comprehensive observing system, but also we need to bring scientists from many disciplines together — ecologists, hydrologists, geologists, oceanographers, atmospheric scientists, chemists, physicists, biologists, and computer scientists, ... — and that is another major accomplishment of the past few decades.* The Earth system has provided the exciting scientific and technological objectives and motivations for scientists, technologists and engineers from many disciplines from around the world to work together, because they recognize there are linkages and inter-connections among the oceans, the atmosphere, and the forests, and among the water cycle, carbon cycle and the energy cycle of the Earth system that requires their expertise and contributions to study and understand them. So the recognition of the interconnections among different parts of the Earth system and the fact that no one discipline or scientist can really understand this very complicated system have identified the needs for the concepts of the Earth system sciences, bringing all these disciplines to understand the very complex Earth as a planetary system. *Something unique has happened again in the past 30–40 years. These scientific and technical objectives have brought together the international community, have brought together the different scientific disciplines that historically had been working independent of each other, and this enterprise is now serving the global society.* The science-based knowledge and information we obtain from this system are used in managing the natural disasters especially in light of the growing global population, helping to guide the investment in global and regional development, responsible stewardship and management of natural resources for our generation and those who will follow us in the future, while fostering global development to improve our quality of life. *Therefore this is what I prefer to answer how science and technology could serve the society: we are taking innovations in technologies and turning them into the tools that help us understand a very complex system like the Earth, bringing the scientists around the world together to interpret that knowledge, to make that knowledge available to all people around the world without any restriction ... Once again, I cannot think of a better way to illustrate how science and technology can really benefit humanity.*

Dr. Asrar at the ISRSE35.(Photo by courtesy of RADI)

***BCAS:*** *Yes, this answer embodies one of the principles of the Earth observation system: the international cooperation.*

**Asrar:** Precisely!

***BCAS:*** *The founders of the Earth observation system placed a lot of emphasis on the concept of free and open access from its early days. Could you give us a summary of all the principles of this system?*

**Asrar:** Yes. In early days we recognized that the Earth is a complex system and we need to observe it as a whole, and we need to observe all the components of the Earth system, the oceans, the atmosphere, the land, the biosphere, the full Earth system. *We recognized that because of such a complexity we need cooperation among all the disciplines. We recognized that to truly demonstrate the full benefit of this system we need international cooperation in building it as well as in using it from the beginning to the end. If all nations come together to cooperate, they trust the information that is coming from the system; if you exclude*

*any country from the system, they would be suspicious of the outcome — if people participate in the system, they believe in the integrity of the system and the integrity of information resulting from it; they trust the findings and outcomes.*

Although this is a remarkable success, there are still a few challenges that remain with us as we look into the future. Challenge number one, maintaining this wonderful system that we have built is not going to be easy, in light of the current financial difficulties around the world. *It is an expensive system, and it requires maintenance over multiple decades, therefore the challenge of sustaining this comprehensive system is still going to be with us into the future. Therefore conferences like this will help identify this need and encourage governments to continue to cooperate together.* Second, a very important challenge is training and developing the next generation of scientists who continue to be interested in working with other scientists around the world, who are willing to come together from different disciplines, because the complexity of the problems needs such cooperation. It is equally important to build the system and sustain it, but we need to have experts, we need to have knowledgeable scientists and technologists from around the world to maintain and evolve this system into the future, because the technologies will evolve. Once again, investing in education, training and development of the future scientists and engineers is absolutely essential to the success of this system in the future, and because such effort is so expensive that no one nation can do this itself; international cooperation is the key to its continued success. Therefore, we should not forget the principle of open, unrestricted access to this information, which is truly beneficial and useful to all nations and people around the world. These are the key principles or challenges that still remain in front of us.

I believe the benefits of this system will be even greater in the future given the anticipated growth of the Earth's population. There is going to be competition for natural resources, there is going to be a need for science-based decisions about available water, and there are going to be problems or challenges associated with food security, to meet the demand, the need of citizens around the world. All of those needs and challenges point to the fact that we really do need such a comprehensive system, we do need the experts to continue to evolve it with and to make the resulting information available to all people around the world, and we must strive to keep this system open and accessible to all people around the world.


Dr. Asrar gives a keynote speech at the ISRSE35 titled "Observing, Understanding and Predicting the Earth System: Foundation for Global Development". (Photo by SONG J)

***BCAS:*** *Seems that international cooperation is essential to this technology or this whole system. So, has the WCRP run any project in cooperation with China?*

**Asrar:** Yes. Actually WCRP — the World Climate Research Program was created almost 35 years ago with two major objectives: one to determine if we can predict the Earth's climate, and if we are successful in doing that, can we also determine how much of the changes in climate system is due to the natural variability and how much is due to human activities. These were the only two objectives of the program that we had at the beginning.

Those objectives are still valid today in light of the growing concern over the changing Earth's climate conditions and its potential impacts on global development. We have been reasonably successful in building the climate models that can mimic the behavior of the climate system, and using these models to provide some predictive possibilities about the future climate conditions, and this knowledge is being used for assessing the climate variability in change for a wide range of applications, for example to assess the causes of ozone depletion and its consequences for human health, water availability, or other applications. WCRP has been able to do all this due to international cooperation. We have three major sponsors, the World Meteorological Organization, the Intergovernmental Ocean Commission of UNESCO, and the International Council for Science. Each of these key sponsors has a network of 150 to 190 countries, including China. China is involved in all the three organizations. So scientists from these countries work with us on the issue of climate observations, research and prediction, and on the use of resulting information for decision making. China specifically is a major player in many of the WCRP activities since the very beginning. For example, we are envisioning even a greater role for China in major WCRP projects in the future. Internationally, WCRP has four major projects: 1) one focused on research for understanding the Earth's water cycle and energy cycle; 2) one focused on research for understanding the role of frozen water, the cryosphere,

especially the polar regions; 3) the third project is focused on research for understanding the changing chemistry of the atmosphere and how such changes may affect the climate, and how climate change in turn may affect the chemistry of atmosphere; and 4) the fourth is focused on understanding the role of oceans in the climate system, how oceans contribute to climate change and variability, and how climate affects the oceans. Each of these four projects brings together scientists from different disciplines from around the world to identify scientific problems that cannot be solved by individual countries and instead require international cooperation and coordination. For example the project dealing with the oceans brings together oceanographers, atmospheric scientists, meteorologists, and many other scientific disciplines to support its research activities. We are using these four projects to bring together different disciplines to work together to solve the challenging scientific problems and to understand the Earth's complex system. Each of the four projects is normally hosted by a country or a group of countries in order to provide the necessary resources to facilitate the required coordination among the scientific disciplines. China is considering hosting the project that is focused on understanding the role of oceans in climate together with India and Italy in the future. This project is currently hosted by the United Kingdom in co-sponsorship with USA.

***BCAS:*** *Is China a latecomer in the field of Earth observations? Why are you expecting so much of China's leadership?*

**Asrar:** Well For Earth observations from the space, China may be a latecomer, but China has been involved in obtaining the observations by ships, using *in situ* methods on land and also in oceans for a long time. Observations and the network of Chinese scientists have been instrumental in many WCRP-organized scientific expeditions and projects. Clearly, China now has significant space-based observation capabilities, a large number of ships for measurements of the ocean conditions, and a large network of stations on land to monitor the changes that are taking place. China is expected to play a much prominent role, a much more significant one in the future compared with the past. The past contributions are extremely important, but because of China's ability to do more, because of its technology, because of its network of scientists, future expectations for China's contributions will be much greater than the past.

***BCAS:*** *Are you confident of China's ability in coordinating this project?*

**Asrar:** Yes, absolutely, as evidenced in China's hosting a large number of international meetings like this, in being able to attract a large number of scientists from around the world to work closely with Chinese scientists, in investing more in research and research facilities, and helping scientific capacity development in least developed regions of the world. There is a general recognition and great confidence in China's ability and leadership in science and technology, especially in Earth observations and environmental sciences.

***BCAS:*** *Thank you. So how would you evaluate China's latest progress in remote sensing, especially in Earth observations?*

**Asrar:** Very impressive. If you look at the number of satellites that China is building, especially those for weather monitoring that China Meteorological Agency is launching, those in the polar or in the geostationary orbits during past decades, and look at the plans for next decades, it is impressive and, comprehensive. The technologies used are advancing rapidly, the number of satellites is growing, and clearly China is expected to play a major role in sustaining this observing system well into the future. Therefore, China is really expected to play a major role in international Earth observing system.

***BCAS:*** *Would you give us some advice for the development of remote sensing in China?*

**Asrar:** Clearly, as I stated, China's plan is very impressive, very comprehensive, and the investment of your government is fantastic to remote sensing and its use. China is expected to share these observations much more freely than it has. If there is an area where China may consider working with other nations to develop further, is its policy for access to the information, the free and unrestricted sharing of its observations with all nations around the world. Of course through such cooperation, the significant experience by the nations in Europe, North America and elsewhere can also be shared with each other in this process. The benefit China would gain from making its observations available to scientists around the world is that China will get the feedback from those scientists on how to improve these observations. If there is any weakness in them, scientists will provide advice to China for improving them. This is the benefit that most countries have gained by making their observations available to the global community at large, because you have access to the intellectual power of the whole globe. Chinese scientists are among the leaders, but you will benefit from scientists from all over the world by getting their feedback about the utility of these observations, the innovative ways of using them and/or how China can make them even better. They may even suggest

some creative ideas for new systems or new measurements. These are the benefits of having an open system. In addition to demonstrating the benefits of these capabilities not only to Chinese scientists but the global citizens, you get the knowledge and feedback from the powerful global network of experts.

***BCAS:*** *Now may I ask some questions about the EOS system, in which you played a very important role?*

**Asrar:** Yes.

***BCAS:*** *Why do you think it necessary to develop such a huge system, given that we already have so many satellites?*

**Asrar:** Again, most of the changes that are taking place in the Earth system are long-term, especially with the impending population growth, with the rapid development in Africa, and in Asia, we need to have this information maintained over multiple decades. It took us thirty years to build the Earth observing system that I just described to you and put it in place, but we must further maintain it into the future. Some countries may not invest as much as they used to, but some countries like China can invest more. It is important to sustain this complex system. Let countries like China step forward to contribute to it, unless we will lose this capability. The commitment to maintain it over the forward time is also equally important, as it is a combination of investing and using what we have now to build and maintain the system into the future. China's engagement is required in both cases, the use of the current system, as well as the development of the future system.

***BCAS:*** *Actually, however, I did not see any satellite jointly run by NASA and China.*

**Asrar:** Yes, unfortunately you're absolutely right, but if you look at the whole enterprise, you will find that there are different kinds of cooperation. Some countries decided not to invest so much money to launch satellites, but they contribute in other ways, including data sharing, and solving scientific problems together with scientists from other countries.

***BCAS:*** *Is China in any form of cooperation with NASA concerning EOS?*

**Asrar:** In terms of utilization of data, yes. But China can do more than that.

***BCAS:*** *Are you seeing any possibility of launching a satellite to be jointly run by NASA and China?*

**Asrar:** Yes. In the future, we don't know when, but there is such possibility, if we could find some way of cooperation and realize it. You know it is very difficult for Europe to cooperate with Russia, but we made it. The challenge may not be easy to overcome, but the reason is so compelling that we will succeed in finding a solution to cooperate with each other.

And my hope is that, the younger generation, the younger scientists can continue to work together, to achieve these objectives, to maintain the system well beyond the next decade into the following decades, because some of the changes take place so gradually that they require sustained observations over all the decades, for which again we need to have international cooperation to maintain this comprehensive observing system across this multiple decades.

***BCAS:*** *Thank you very much. Now a final question: Did you offset your carbon footprint for your travel here?*

**Asrar:** We usually do that to the WMO, but also we have been receiving some of this carbon footprint offset to invest those dollars in education and training in students for their career development. We do also allocate investment of our funding for this purpose as well. So the answer is yes. We will continue to do that by using this fund for education purpose.

***BCAS:*** *Thank you very much for taking your time to share with us your experiences and insights.*

**Asrar:** My pleasure.