

合作开发“数字地球”，共享全球数据资源*

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在迎接新世纪的历史时刻，来自世界各国的专家、学者，聚会世界文化名城——北京，回眸从长城烽火到网络通讯的历史轨迹，检阅航空、航天遥感、卫星定位、地理信息系统与数字通讯网络等领域的最新成就。我们欣慰地看到，全球化知识经济的浪潮，全球资源、环境问题的困惑与全球可持续发展的共同理念，正在成为促进“数字地球”发展的强大推动力。空间科学技术与信息科学技术的飞速发展，又为“数字地球”的进一步发展提供了充分的技术条件。与此同时，我们也应当清醒地看到：“数字地球”既可能使东西方文明的距离继续缩短；也可能使南北世界的差距继续扩大。但是人类居住的地球只有一个，为了我们共有的家园，我们必须正视未来，协调步伐，共同关心我们赖以生存的地球。

早在70年代，中国科学家就曾提出过地图测绘过程全数字化的创意。目前，中国政府正积极推进国家信息化和国家信息基础设施的建设，积极参与一些全球数据共建共享的国际活动，例如以气象卫星为依托的1×1km格网全球数据库，1:1 000 000地形数字模型(DEM)，科学数据库 Codata-D 等等，同时积极参与许多国际科学合作计划的实施，例如全球测图计划和环太平洋海洋制图计划，国际地圈与生物圈计划，大洋、大陆深钻计划，南北极考察计划，国际地层标准剖面与大陆冰川登录，世界文化遗产登录、生物多样性保护计划等等。并在青藏高原隆起及其环境影响、古季风气候、臭氧低槽、太阳黑子周期、历史地震、板块运动、中、低纬磁层磁爆、深海潜水机器人等许多领域，做出了一些举世瞩目的贡献。这些工作，都得到了政府和人民的大力支持，也包括在座各位专家学者的友好合作，借此机会，我谨代表中国科技界，表示衷心的感谢！

在后工业社会带来的资源短缺、环境恶化、企业

兼并、金融与经济全球化、区域重组、经济动荡与地区发展差距日益扩大等历史背景下，“数字地球”的提出引起了各国科学家、政治家、军事家和社会活动家的共同关注。我国经济的发展和进步的实践证明：对于产业结构调整，区域经济布局，农林牧副渔业的因地制宜发展，交通、通信网络的优化选线等，为“数字地球”提供了战略决策与宏观调控的科学依据，同时“数字地球”本身也因此获得了巨大的发展。

20世纪是科学技术飞速发展的伟大时代。不仅对地观测技术已经实现了全天候、高分辨率、多波段、全球覆盖，同时通过地球物理与地球化学的纵深勘探，获取了地球各个圈层物流、能流与信息流的海量数据，并在计算机网络系统中，把它们同与之密切相关的人文、经济、社会统计数据加以综合集成，实现了真实的地球的数字化，并在电脑中虚拟、仿真、重现出来。这样，“数字地球”就会从很大程度上改变人们的时空观念，提高人们对全球化的意识，从而影响人们生产、生活与相互交往的方式，提高地球系统科学的广度和深度，精确度和综合程度。例如监测全球叶绿素含量的时空变化，可应用于初级生产力的评估或农作物估产；监测地热场的时空迁移规律，可应用于重大自然灾害的突发预警；通过地球化学填图，可应用于矿藏远景区的勘探与环境污染的本底分析，研究厄尔尼诺现象、南极臭氧洞与青藏高原臭氧低槽对全球变化的影响，已经引起了中国和世界地球科学界的密切关注。因此，“数字地球”的应用领域广阔，潜力巨大，大有可为。

“数字地球”本来就是地球科学领域的一项基础性工作。作为描述整个地球上各类信息的时间序列与空间分布的共同框架的“数字地球”，目前主要致力于各种对地观测信息系统的集成，包括数据采集、

* 本文系路甬祥院长在1999年11月29日“'99数字地球”国际会议上的讲话。

存储、分析、处理到传输信息流程的完善,强调以统一坐标系与多维动态模拟、仿真显示的探索。“数字地球”的进一步发展,将会作为一项复杂系统的知识创新工程,即运用多种地球基本数据,建立地球动力学模型,设计反映地球科学时空规律的信息图谱,加强分析与综合能力,提高数据发掘、知识发现与科学预测的能力。为实现更高层次的目标,还需仰赖于地球科学与信息科学、空间科学乃至生命科学的相互交叉与渗透,科学梯队的自我提高与学科领域的自我超越,创立崭新的地球信息科学理论与技术体系。在知识经济和信息社会中,“数字地球”这一新兴领域能够综合研究全球性资源与环境问题,能够为发展地球系统科学,推广远程教育,促进国际合作,维护世界和平,推动全球经济的可持续发展,作出切实的贡献。

面对21世纪信息社会的挑战与机遇,每个国家都在根据各自的国情,审度国际发展趋势,加强本国信息基础设施的建设,独立自主地开发不同尺度的信息系统,并尽可能考虑与全球信息网络接轨。中国的光缆通讯网已达通各个省区,有线电话用户已超过4000余万户,电视与远程教育网正迅速推进到边远山村,海底光缆、欧亚大陆桥已与沿海信息港相连通。中国还陆续发射了气象卫星、资源卫星和宇宙飞船,承担了“铱”系列卫星的发射,组织亚太地区大地基线网的联合测量。我们发起组织这次国际“数字地球”会议,希望通过学习各国的先进技术,取长补短,少走弯路。我们也愿意介绍中国曾经在第三世界国家中开展的防治土地荒漠化、防治洪涝灾害、地震灾害和地方病、合理开发和利用资源、推广良种,提高农业和经济发展水平和可持续发展能力等方面所做工作中的经验。

“数字地球”是一项面向全球的复杂系统工程,其中有许多共性问题,也存在许多区域性和具有本国特征的特定需求和环境,需要大家进一步探讨。求同存异,平等互利,友好合作,是我们合作开发“数字地球”的前提。例如考虑到从全球到地区的不同尺度的需求,应该为“数字地球”提出一个统一的、多层次的科学框架结构;商定自主开发与全球共建共享的数据规范、元数据标准和信息交换协议;建立全球性的网络连接,以保障全球性的对地观测数据的提供与定期更新;创造透明站点访问和导航;协调有系统效率与信息安全的国际协议与管理法规。诸如此类的问题,不仅需要科学家的集体智慧和艰苦努力,还需要全社会的关注和联合国机构与各国政府的参与和合作。

“数字地球”是一柄双刃剑,它为蓬勃发展的全球化知识经济浪潮提供了空前的机遇,使世界各国经济发展的相互依存关系与日俱增。谁占有信息,谁就占有主动。目前,88%的互联网用户生活在工业发达国家,这些国家的人口仅占世界总人口的17%,而这些全世界最富有的国家就占有全球国内生产总值的86%,出口市场的82%,国外直接投资的68%。而最贫穷的1/5的人口在这些方面所占有的份额仅为1%。全球经济这一发展不平衡的现实,发人深省!如何铸剑为犁,让“数字地球”在平等互利、友好合作、共同开发、共享资源的方针下,发展成为全球性、公共性的科学事业,已成为当务之急的新课题。我们大声呼吁:“数字地球”应该为全人类造福,为维护世界和平,摆脱贫穷与落后,扶助区域社会经济可持续发展服务。让我们为实现这一目标进一步加强国际交流合作,合作开发“数字地球”,共享全球数据资源而共同努力。

Building up the Digital Earth Together, Sharing Global Data Resources Each Other*

LU Yong-xiang

President, Chinese Academy of Sciences

At this great milestone as we farewell the 20th century and step into the new era, we are pleased to host the International Symposium on Digital Earth and welcome specialists and scholars from all over the world to Beijing, a city of great history and culture. Here, we can trace the historical tracks of information technology, from the use of fire on the Great Wall as information signals to today's communication satellite networks and now, we can review our latest achievements in the fields of information sciences.

In order to improve the quality of life on this planet, mankind has made unremitting efforts and made tremendous progress. Accompanying the technological and economic progress, however, are increasing concerns over environmental deterioration and natural resource depletion. We have come to realize that we will not be able to sustain the constant improvement of our societies unless we take a global and systematic approach to the development. Global sustainable development is a major issue confronting everyone on this planet and "Digital Earth" is the ideal platform to develop and implement the right solutions.

Those solutions must come from global collaboration. That is why we are here. We are here to ensure we build the spatial information framework, the Digital Earth, for the common interests of mankind. We want to ensure that digital information technology will help narrow the gaps between the rich and the poor, instead of expanding the polarization of peoples. There is only one earth. Its digital representation should encompass all the entities and processes on this planet. We hope to find the strategies through

establishing a forum for international exchange and collaboration. This is the objective of this symposium.

Early in the 1970s, Chinese scientists had put forward the creative proposition for a complete digitization of the surveying process. At present, the Chinese government is actively promoting the *informationlization* of the country by digitizing and networking national information infrastructure. We are also actively contributing to the development of global databases. We have promised to participate in the joint establishment and share of data in the one by one kilometer global grid database, the one to one million scale digital elevation models, and the scientific database Codddata-D. The Chinese government is an enthusiastic member in such international programs as Global Mapping, Pacific Ocean Mapping, Study of the International Geosphere and Biosphere, Deep Sea and Continental Drilling, Continental Glacier Landing, Exploration of the Polar Regions, Standard Cross Section of the Stratum, Categorization of World Cultural Heritages, and Protection of Biological Diversity. Scientists in China have also made well-acknowledged contributions in numerous research fields. Among these are the research on the eminence of the Qingzang Plateau and its environmental effects, the paleomonson climate, the low trough of the ozone layer, the sunspot cycle, historical earthquakes, tectonic movement, magnetosphere and magnetic storms in the central and lower latitudes, and diving robots for deep sea explorations. These achievements are made with the great support from our government and our people as well as cooperative efforts from the

* Towards Digital Earth—Proceedings of the International Symposium on Digital Earth.

scientists and scholars presenting here. On this special occasion, on behalf of the Chinese scientific community, I would like to express our hearty gratitude.

We are facing unprecedented challenges in the post-industrialized society characterized by economic prosperity but also environmental deterioration and resource depletion. Accompanied by the trend of financial and economic globalization, there has emerged economic turbulence, enterprise merger, regional reconstruction and polarization too. We believe that "Digital Earth" will provide the scientific grounds for developing strategies to address these global issues. Spatial information technology has shown its effectiveness in supporting macro adjustment and control of regional economic development as well as management of individual sectors in the economy. We have successfully utilized the technology in industry restructuring, regional economic design, agriculture, forestry, animal husbandry, sideline production, fishery, and various engineering projects. Along with enrichment of spatial information technologies, "Digital Earth" is capable of providing the ideal technical mechanism to meet the needs of regional and global development. The 20th century has been a great era during which significant progress was made in science and technology. Earth Observation Systems make it possible to obtain timely, accurate, and multi-spectral global coverage information through satellite remote sensing. They also facilitate the acquisition of massive amounts of data on the material, energy, and information flows of every strata of the earth through geophysical and geochemical observations. When these data are integrated, analyzed, and visualized, they will have profound impacts on people's consciousness and on the temporal and spatial dimensions of various global and regional problems, which will bring about subsequent changes in their behavior and booster their appreciation and confidence in the accuracy and comprehensiveness of the earth observation systems.

There are numerous promising projects. Monitoring for the temporal and spatial changes of global chlorophyll can be applied to the assessment of primitive productive forces and crop evaluation.

Information on the temporal and spatial shifting regulation of the subterranean heat area can help forecast the occurrence of severe natural disasters. Geochemical charting is useful for fixing promising mineral reserves and for background analysis of environmental pollution. The geoscience communities in China and around the world have already paid much attention to the EI NINO phenomenon as well as impacts on global changes from ozone depletions in the South Pole and the Qingzang Plateau. They believe that the Digital Earth technology will have great potential in these projects.

"Digital Earth" is a fundamental work of the Earth Sciences. As a common framework for describing Earth's information in the temporal and spatial domains, "Digital Earth" is at present mainly used for information integration of Earth Observation Systems and provides functions for data's acquisition, storage, transfer, analysis, and processing. Its emphases are on establishing a unified coordinate system and on developing multi-dimensional dynamic virtual display.

The further development of "Digital Earth" should be taken as a knowledge innovation program with complex systems. In addition to integrating multi-source Earth data, we should develop Earth dynamics models that represent the behaviors and relationships of Earth objects and processes, design information atlases that illustrate temporal and spatial patterns, and enhance the analytical and synthetic capabilities for knowledge discovery and scientific forecasting.

Realization of the grand objectives of "Digital Earth" presents a great challenge. We must rely on the joint efforts across disciplines including the Earth Sciences, Information Science, Space Science, Life Science, and other social and physical sciences. Individual disciplines would need to be improved and reorganized so as to establish the disciplinary echelons and enable better interdisciplinary interactions. We need to establish a unified system that integrates the theories of Earth Information Science and the computer information technology. Such a system presents a new domain of science and technology in which global resource and environmental problems can be researched comprehensively and resolved

systematically. Through this unified system we can promote international cooperation, global sustainable development, and maintenance of world peace.

Facing the challenges and opportunities of the information society in the twenty-first century, countries are adapting various measures to develop their own information infrastructure and to integrate them with the global information frameworks. In China, fiber optics communication networks have connected every province. Television education and other networks for distance learning have reached villages in remote regions. Mobil phone usage is surging and owners have surpassed forty million accounts. Our coastal ports have been connected with submarine cables and with “the Continental Bridge between Europe and Asia”. We have launched meteorological and resource satellites and have undertaken the launching of a series of iridium satellites. In addition, we have organized successive surveys for the Very Long Baseline Interferometry network in the Asian and the Pacific areas.

By initiating this International Symposium, we hope to learn advanced technologies from different countries and to absorb their merits and avoid shortcomings. We are also pleased to present the results and experiences in such areas as the prevention and improvement of desertification, control and prevention of flood, earthquake disaster and local diseases, rational exploration and use of resources, fine seeds popularization and its capability in sustainable development.

“Digital Earth” is an example of global complex systematic engineering with many issues of common interest waiting to be further discussed and with agendas particular to individual regions and countries as well. Let’s seek the common grounds and appreciate the differences between each other. When considering there are different scale requirements from the global level to regional ones, it is necessary first to work out the scientific framework and data structure for handling data of multiple scales. In addition, we need to define the specifications for data sharing, which include

metadata standards and data exchange protocols. Furthermore, we need to establish a network mechanism for global data transfer, which is necessary to ensure a complete coverage and timely updates of information. We will also need to develop the mechanisms for distributing the data and information. User interfaces ought to be improved to facilitate easy search and navigation on the Web. Finally, issues related to information security and management regulations need to be addressed through coordinated international efforts. To tackle all these issues, we need not only the collective wisdom and hard work of scientists but also the whole society’s attention, as well as the involvement of the related units in the United Nations and the participation of every country’s government.

“Digital Earth” offers a great tool that allows us to resolve global problems and overcome difficulties in developing mutual economic relationships between countries. Knowledge is power. We hope everyone in the world is empowered by the Digital Earth. Nowadays, 88 per cent of Internet users live in the developed countries but they account for only 17 per cent of the world population. The one-fifth richest world population occupies 86 per cent of the world’s total value of domestic production, 82 per cent of export market and 68 per cent of direct foreign investment. As a contrast, the one-fifth poorest world population occupies a mere one percent in each of these categories. One must recognize the devastating fact of global polarization and its consequences. We must ask ourselves how to turn “Digital Earth” into a public cause, that reflects the spirits of equality and mutual benefits, promotes friendly cooperation, enables joint explorations and sharing of resources. Let’s make efforts to further international exchange and cooperation for the purpose of making happiness for all the people, for the maintenance of world peace, for the elimination of poverty and backwardness, and for the sustainable development of social economy.