Data Volume Proliferation in the 21st Century
The Challenges Faced by the NOAA National Data Centers (NNDC)

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ABSTRACT

Data Volume Proliferation in the 21st Century
The Challenges Faced by the NOAA National Data Centers (NNDC)

This paper describes the challenges facing the three NOAA National Data Centers (NNDC), as well as the Information Technology Storage Area Network Systems (SANS) and Telecommunications industries in successfully meeting one component of the NOAA mission, Long Term Stewardship (Archiving and Access) of environmental data in the 21st Century.

The collective holdings of digital data for the three data centers are approaching 800TeraBytes (TB), and steadily growing by several hundred terabytes of new data each year. By the year 2001, it is anticipated that the NNDC will be ingesting and processing over two hundred TeraBytes (TB) of new data each year, while managing and providing access to over one PetaByte (PB) of data and information. There is an immediate need to explore what Information Technologies (IT) and Data Handling Techniques will be available to successfully meet the challenges regarding ingest, processing, convenient access, and efficient mass storage of very large volumes of environmental data.

Early in the last decade of the Century/Millennium, it was clear that developments in Information Technologies (IT) would place powerful tools in the hands of most everyone, which could process and display large volumes of data at a relatively small cost. By 1995, NOAA developed a strategic vision and embarked on a program to build a dynamic and responsive IT architecture that would provide worldwide electronic access to the enormous volumes of climatic, geophysical, and oceanographic data under the long term stewardship of the three NOAA National Data Centers (NNDC).

Electronic access and mass storage issues required examination from a total enterprise systems perspective taking into account connectivity between the data collection platforms, the processing and storage facilities, and users anywhere in the world. In 1996, the three centers, under the leadership of the National Environmental Satellite and Information Services (NESDIS) office, embarked on an initial five-year plan to address these issues and meet the challenges of the 21st Century. This plan is referred to as the NOAA Virtual Data System (NVDS) Initiative. At that time, the cumulative digital holdings were about 300TB, and it was projected that by 2000 the total volume of new data would increase to over one hundred terabytes per year. By 1998, the annual volume of new data exceeded the projected Year 2000 figure. The volume of new data per year for 2001 is currently projected to be over two hundred terabytes per year. If history is any indicator, this projection is conservative.

How will NOAA successfully achieve a solution for the end-to-end stewardship of the proliferation of data volume and variety that will be a reality in the very near future?

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Introduction

Climatic, Geophysical, and Oceanographic observations, data, and information are growing at a rate exceeding any projections five years ago. Today, the NOAA National Data Centers (NNDC) provide stewardship (storage and access) to a data volume that increases each year by more than the equivalent all the data managed by the centers over the past 100 years! At the same time, the phenomenal successes of the World Wide Web and Internet have resulted in the worldwide diversification and expansion of the user community by over two orders of magnitude in just the past five years. The data volume curve turns sharply upward in the first decade of the 21st Century. These growth projections are probably conservative. The central issue for the NOAA, in particular the three data centers, is how to respond to the challenges presented by the unprecedented proliferation of environmental observations and data. This paper will describe the NOAA National Data Centers mission, current capabilities, and vision for data management and access. It seeks to educate decision-makers and the Information Technology (IT) industry about the critical and urgent requirement for solutions.

Description of NOAA National Data Centers (NNDC)

The three geographically dispersed NOAA National Data Centers (Figure 1) are designated as official sites for the long-term stewardship of climatic, geophysical, and oceanographic data. The mission of these data centers is to preserve and provide access to these data. The data centers have existed in one form and place or another for many decades. Data are collected by a variety of observing systems and types of instruments, both in-situ earth-based and remote satellite-based. Satellite data represents the overwhelming majority of digital data. These observing systems are operated by different line offices within the National Oceanic and Atmospheric Administration (NOAA), as well as many other agencies, such as the U.S. Geological Survey (USGS), U.S. Department of Agriculture (USDA), Federal Aviation Administration (FAA), the Department of Defense (DoD), and others. Data is also obtained from observing systems operated in foreign countries through bilateral and multi-lateral agreements and other arrangements negotiated through the auspices of United Nations sponsored agencies, such as the World Meteorological Organization (WMO) and the International Council of Scientific Unions (ICSU). Each of the data centers is also a designated World Data Center (WDC) for their respective data types. This further enhances the exchange and availability of worldwide data.

The National Climatic Data Center (NCDC), Asheville, NC, is responsible for the Nation's climate data. Currently, the NCDC manages and provides access to about 220 million paper records (equating to about 38,878 miles – five times around the world), 125,130 rolls of 35 mm and 16mm film (equal to the distance between Washington DC and Los Angles, 2,340 miles), 1.2 million pages of microfilm (equal to the distance between Washington DC and Philadelphia, 114 miles), and about 800 TeraBytes (TB) of digitally stored data on about 600,000 3480, 3590, and 8mm Exabyte magnetic tape cartridges (would fill a million CD ROMs which stacked vertically would be the height of five Empire State Buildings). The 3480 and 8mm tapes are located in Asheville, NC and at the University of Wisconsin (GOES satellite data only). The NCDC has a robotic storage system. In most cases, the observing networks are reasonably well defined and managed, and data collection, formats, and reporting are coordinated. Figure 2 summarizes digital data growth for the period 1989-1999.

The National Geophysical Data Center (NGDC), Boulder, CO, is responsible for a wide variety of specific data categories, such as Solar, Tectonic/Earthquake, Volcanic, Magnetic, Gravitational, and other geophysical specific areas of study. The distinctive division of data into different classes of physical sciences makes the NGDC more unique. NGDC data are stored on paper, microfilm, and digitally on magnetic tapes. Data collection and reporting comes from a much smaller (spatial and temporal) network of data unique observing systems operated by a variety of agencies, both U.S. and foreign. Currently, NGDC manages 400 different data sets and about 15TB of digital data on 3480 and 8mm Exabyte tapes. Satellite data from the Defense Meteorological Satellite Program (DMSP) make up the majority of the digital data holdings. Figure 3 summarizes digital data growth for the period 1988 to 1999.

The National Oceanographic Data Center (NODC), Silver Spring, MD, is responsible for oceanographic data. NODC faces the most difficult challenge relative to the acquisition of oceanographic data and perhaps also the largest variation in how the data is collected and recorded. There are few coordinated and well-defined oceanographic observing networks. In general, oceanographic data are collected by many different individual organizations, such as universities, federal agencies {DoD, NOAA, Mines and Minerals Services (MMS), Environmental Protection Agency (EPA), U.S. Coast Guard (USGS), U.S. Corps of Engineers (COE), etc.}, coastal state agencies, and commercial companies, in particular oil and gas. These data are often not reported for months or years later due to the desire to keep the data secure until research papers and other reports are ready for publication. In other cases the information may be classified and never shared, particularly from oil and gas companies. The data format and methods of recording and reporting the data varies greatly from paper to unique digital recorders. There is a tremendous volume of data that has been collected but gathering the data and formatting it for placement into a digital data base are significant issues for NODC operations. Nearly 75% of the current total volume of digital data, 1.5 TB, managed by the NODC is satellite data. Figure 4 summarizes digital data growth for the period 1990 to 1999.

Current Capabilities

Early in this decade, it was clear that developments in Information Technologies (IT) would place powerful tools in the hands of most everyone, which could process and display large volumes of data at a relatively small cost. By 1995, NOAA embarked on a program to develop a dynamic and responsive IT architecture that would permit worldwide electronic access to the enormous volumes of climatic, geophysical, and oceanographic data.

It was obvious that electronic access and mass storage issues needed to be addressed from an enterprise level perspective for data Ingest, Storage, and Access, to include a complete review of connectivity between the data collection and recording sites, the data centers, and the user anywhere in the world. In 1996, the three Centers, under the leadership of the National Environmental Satellite and Information Services (NESDIS), embarked on a five-year plan referred to as the NOAA Virtual Data System (NVDS) Initiative. Significant capital investment has been made to the three centers' IT infrastructure. Much more needs to be done to sustain the progress made in the first four years of the initiative, if the NOAA is to successfully meet the challenges in the first decade of this new millennium. The NNDC goal is to provide easy, convenient, and timely access to large volumes of the Nation's environmental data and information.

The first two areas addressed were the storage and access components of the enterprise system. A common IT architecture and "look" to the customer are essential elements of the design. Flexibility within the strategic IT architecture plan is paramount in order to capitalize on new IT developments. Acquiring a hierarchical mass storage system that provided direct electronic access to data was a priority. Currently, only the NCDC has a mass storage robotics system, IBM 3494, with HPSS software resident on one of the IBM Scalable PowerParallel (SP2) System nodes. The concept of an On-Line Data Store consisting of a web farm with large storage disk devices has been implemented. The Oracle RDBMS was selected to support the On-Line Store. All three data centers are linked to each other. A single easy to use access and comprehensive ordering system permits browsing, viewing, ordering, and transfer of data while on-line. Populating the On-Line Store System with on-line digital data will continue indefinitely. The ultimate goal is many tens of terabytes placed in an on-line status and the balance of holdings near on-line. Multiple paths to access and browse the on-line data have been integrated into the design to service the sophisticated and the uninitiated users. The NNDC Climate Data On-Line (NNDC CDO) System is now operational and can be accessed by going to: www.nndc.noaa.gov.

Currently, there are several dozens of data sets, products, and other information, about 120 GigaBytes (GB), available through the NNDC CDO System. Direct electronic access to on-line and near on-line data (robotic system) and timely transfer of large volumes of data are now at the fingertips of a worldwide clientele. The net result for the customers will be exceptional service, while the data centers will be able to respond to increasing volumes of new data and greater customer demands in a cost effective manner.

The Data Explosion Challenge

Table 1 and the accompanying graph, Figure 5, provide an overview of the projected volumes of data that are expected to be delivered to the data centers during the first decade of the 21st Century. It is quite apparent that the satellite data will be the largest contributor to unprecedented data growth. The NEXt generation RADar (NEXRAD) network is now in place and this volume should remain relatively constant. However, NEXRAD data does constitute a fair level of total digital volume. The vast majority of the new data volume will be directed to the National Climatic Data Center. All new data must be delivered digitally and immediately placed into the current mass storage system.

In order to efficiently manage and access these large volumes, the centers must be able to create the requisite inventories, place the data immediately into a robotic style mass storage system, and retrieve the data in a relatively straightforward and timely manner.

Another significant challenge is the migration the digital data currently on the 600,000+ off-line 3480 and 8mm tapes into a robotic mass storage system. A multi-year data modernization effort is addressing some of the non-digital data (paper, microfilm, and microfiche). Some of the paper and microfilm records are being optically scanned and the images placed on CD ROM. Eventually these files will need to be place into a robotic system or some other system that permits direct and convenient electronic access and transfer. Some of the data on these records are being manually keyed into digital data bases. In addition to these activities, significant portions of the current and future digital data are periodically "reprocessed" when new mathematical algorithms are developed which can improve the utility and value of earlier data. Therefore, as the volume of data grows, the level of reprocessing efforts will grow in kind.

The centers typically adhere to National Archives and Records Administration (NARA) policies and guidelines. Long term stewardship and access to these data and information must be guaranteed for future generations of customers. If long term stewardship in perpetuity is required, then all these accumulated data and information will have to be migrated to new systems, perhaps as often as every five years, due to rapid changes in the information technology environment.

Meeting the Challenge

Four key areas that must be addressed by the NOAA and the commercial IT marketplace in order to meet the demands of the 21st Century: 1) Network Centric Planning, 2) Highly Automated Mass Storage, 3) Large Volume Storage Media and Data Compression (particularly for satellite data), and 4) Rapid and Convenient Data Access.

Network Centric Planning will contribute to one of the goals of modernization, the digital delivery of data and information from the observing systems to the centers and ultimately to the customers. There have been a number of successes resulting from the practical application of concepts associated with the Network Centric Operations and utilizing available communications and in-place IT systems and capabilities. Over the past few years, the data centers in cooperation with other offices within NESDIS, the National Weather Service (NWS), and the Department of Defense have transitioned from paper forms, diskettes, and magnetic tapes to staging data on a daily basis and using ftp transfer procedures. Examples include digital transfer of DMSP data to NGDC, as well as data transfers from NWS activities to NCDC to include Marine, Surface Hourly (ASOS, AWOS), and global CLIMAT observations. In some cases, these data are posted daily to the web pages for access by a worldwide clientele. The results have been more data received and processed, improved up front quality control, and data available earlier to customers, i.e. hours and days as compared to days, weeks, and months.

There are several areas, which require a focused effort to complete the transition for other established observation networks. These include the 8,000 paper forms and 2,400 punched paper tapes from the COOPerative Observation Network, the 3590 magnetic tapes used to deliver GOES and POES satellite data, and the 8mm and optical disks used to deliver the NEXRAD data. Interactive Voice Recognition (IVR) and Natural Language (NL) can, for a small initial investment, replace the 8,000 COOP paper forms while substantially reducing annual operating costs. Data would be available via the web on a daily basis rather than the current schedule, 45-60 days after the end of a data month. Similarly, a digital recorder can replace the punched paper tapes. Beginning in early CY 2000, all the POES satellite data will be digitally transferred on a daily basis from Suitland, MD directly into the robotic system at Asheville, NC. Daily digital data transfer of GOES satellite data between the University of Wisconsin and the NCDC will begin when the cost-benefit ratio between telecommunications and 3590 tapes becomes more attractive. NESDIS and NWS are currently examining a Network Centric approach to transmitting radar level II data via telecommunications from each radar site to a central data collection facility. This facility will assemble packets of radar data and information, which will then be digitally transmitted to the NCDC on a daily basis. Radar level III data will be transmitted nationwide via the NWS AWIPS/NOAAPort satellite communications system. In the case of the GOES and NEXRAD, the life cycle cost of handling tapes warrants replacing tapes with near real time digital data transfers as soon as practical.

Table 1 reveals that ingest, inventory, storage, and access tasks for the emerging satellite systems (METOP, NPP/NPOES, EOS, and growth in DMSP and GOES) present a far different challenge. Based on past performance, it is reasonable to expect telecommunications bandwidth and associated costs will permit direct data transfer to the robotic mass storage systems. However, the ability to inventory, transfer, and access these data using highly automated mass storage devices and techniques require considerable planning and IT advances. The NCDC procured the IBM 3494 system in 1994-95 and upgraded from UNITREE to HPSS in 1998-99. The NCDC also installed the first nodes of the SP2 system in 1998 and currently use two nodes to manage file transfer activities into and out of the IBM 3494. Many of the performance, staging, inventory, and retrieval issues discussed during the March 1999 Mass Storage Conference in San Diego remain serious concerns for the data centers.

A Highly Automated Mass Storage System provides a solution to another goal of modernization, efficient long-term stewardship of enormous volumes of data and information. These new systems must reduce the cost per Terabyte of storage, provide reasonable write/read throughput, and large data storage with a small physical “foot print.” This presents a bigger challenge than telecommunications capabilities and costs. In the short and near term, next 1-3 years, the NCDC will install additional SP2 nodes and upgrading the current 100Mbps to a higher performance local area network (LAN) will be required by FY 2001. New mass storage systems must provide Large Volume Storage Media and Data Compression features. In FY 00, the NCDC must begin the upgrade to 3590E drives and utilize the new 3590Extended (40GB) tapes. However, even though the IBM 3494 is scalable and will have improved capacity 3590E drives and tapes, the IBM 3494 is not envisioned as the system to manage the high volume satellite data. Therefore, a higher capacity, higher throughput performance mass storage system must be identified and procured about the year 2003-2004. It is envisioned that the existing IBM 3494 and the new higher capacity (less cost per TB and smaller footprint) system will be utilized concurrently to perhaps the year 2010. Use of straightforward data compression techniques must be a consideration in the design of any future mass storage system (magnetic or optical tapes, disk, other). Hardware data compression is now in use on a number of the different types of data, but not satellite data. This will help in the short term to control the growth of the current IBM mass storage system. "No Loss" data compression techniques for satellite data need to be available very soon.

Neither of the other two data centers have a robotic mass storage system to support their current or future needs. The NGDC has the most immediate requirement for a modest automated mass storage system to manage (new and migrate existing) the DMSP and other digital data currently stored off-line on 8mm Exabyte (about 6,800) and 3480 (about 5,200) tapes, respectively. Similarly, the NODC will need a modest mass storage system.

Another goal of modernization to be achieved by 2010 is to have all digital data resident on automated mass storage systems. Only then can these systems and associated software be utilized to migrate in a highly automated fashion the data to the next generation mass storage system beyond 2010. If this goal is not achieved, it may be impossible from a cost and perhaps hardware availability point of view to "rescue" the data (mostly satellite and NEXRAD) stored on off-line tapes from the last half of the 20th Century. Perhaps magnetic tapes will no longer be the preferred, cost effective, media for storage and access in the second decade.

Rapid and Convenient Access to data and information by a worldwide clientele is required if NOAA and the data centers are to succeed in their information services mission. Progress in this area may prove to be the greatest challenge. Electronic commerce developments in the marketplace are providing many of the solutions to customer servicing. The operational implementation of the NNDC Climate Data On-Line (NNDC CDO) System is the first step toward providing rapid and direct access to data and information. The NNDC Home Page and the NOAA Server Home Page provide access, browse, and data transfer capabilities to data under the stewardship of the NOAA. These are interconnected and can pass a customer along to one of the three data centers or other locations based on the type of data being requested. However, placing data into web based systems with real on-line disk access and near on-line mass storage systems only minimally satisfies user requirements. Many of the NOAA clients will require electronic services that allow users to discover, subset, retrieve, overlay, visualize, and analyze data from different data bases and formats. This presents a challenge for the data centers and the NOAA because historically data has been managed primarily on the basis of the characteristics of the observing system. Future success will require the creation and adoption of industry standards and conventions to allow heterogeneous systems and data bases to communicate with one another. Secondly, it will require automated staging of communications and computational resources to execute required applications on the data. Data discovery and retrieval using an information system environment must to be done without the user having to understand the particulars of each individual system. Transaction processing must be implemented that enables an essentially “hands-off” operation requiring little or no human handling or transport of data and where appropriate the system will allow users to pay for data or services through credit and debit cards or automated billing.

Good News

There is an understanding within the NOAA and other agencies that cooperation and collaboration are critical to meeting mission goals and objectives. There are considerable discussions and interest regarding the concept of Network Centric Planning. More than any time in the past, line offices within the NOAA, particularly the NWS and NESDIS, are meeting to discuss the requirements for data transmission over the AWIPS and NOAAPort system, as well as the future directions for NEXRAD data transmission and storage and modernizing the Cooperative Observing Network. These discussions must also take into account communication needs to activities and data bases widely dispersed at many other of the NOAA sites operated by the Fisheries, Ocean Services, and Office of Atmospheric Research line offices, both on land and at sea. The NOAA High Performance Computing and Communications (HPCC) Program Office is leading the way in bringing these different offices together and defining a Network Centric approach to data access and delivery.

Most recently, NOAA and NASA representatives have been meeting to design a Long Term Archiving and Servicing Plan for the Earth Observing System (EOS) to include joint archiving and servicing activities. Similar planning is underway for the METOP and NPP/NPOES programs. The intent is to build on the experiences and lessons learned from the current digital POES transfer project and apply these to the GOES, METOP, and then NPOES which are similar in nature, just a larger daily volume.

The National Environmental Data Archive and Access System (NEDAAS) is being promoted as the successor to the NVDS Initiative. NEDAAS will build on the progress made under NVDS and other information systems modernization efforts within the NOAA, as well as other agencies. NEDAAS is the next step in providing the NOAA the means and capabilities to meet the data management tasks in the first decade of this millennium. A key component will be the ability to access, merge, and visually display multidimensional data and information. The vision is a suite of information services linking observing systems and customers to many locations, such as the NOAA National Data Centers, State and Regional Climate Centers, NOAA Laboratories (i.e. National Hurricane Center, Severe Storms Laboratory, Pacific Marine Environmental Laboratory, Coastal Science Center, etc.), and other university and research facilities. The goal is to provide rapid access to new and historical data and information either on-line or near on-line through the use of the Next Generation telecommunications and other information technologies. NOAA will be a partner in defining and capitalizing on new technologies and capabilities.

Conclusions

The NOAA is at a critical juncture with respect to its information services mission. Preserving the Nation's environmental records now means managing a data volume that increases in one year by the equivalent all the data NOAA has managed over the past 100 years! At the same time, the World Wide Web and the Internet have fuelled the explosion of users by over two orders of magnitude in just the past five years. Today's worldwide clientele demand rapid and convenient access to data and information. The confluence of information management technologies with observation technologies must provide the capabilities to respond effectively to the massive array of new data and satisfy a far larger, more demanding, more sophisticated, and more diverse user community. The NOAA faces a unique and multi-facet task. First, it must be able to process and store very large volumes of new data. It must provide customers rapid access to data and information, which means getting data from observing networks in near real time, rapid processing, and placing large volumes of data on-line. The enormous volume of digital data stored off-line must be migrated to a near on-line mass storage system. Computational systems capable of rapidly reprocessing large data arrays must be available if there is to be any value to aging data and information. Finally, data and information recorded on non-digital media (paper and film) require migration to a digital format, if only optical images for preservation and digital access. Incremental investment in technology designed to integrate new technology advances with the existing IT infrastructure requires strategic planning and an associated supporting budget process.

It is essential that the NOAA clearly articulate to industry and government leaders the magnitude of the challenge. The capacity and complexity of a future integrated mass storage, data processing and reprocessing, and data access system seem overwhelming. However, 30 years ago these same issues appeared to be considerable when the first satellites were being launched.

The question then: How to manage tens or several hundreds of MegaBytes?

The question today and tomorrow: How to manage PetaBytes and then YottaBytes?

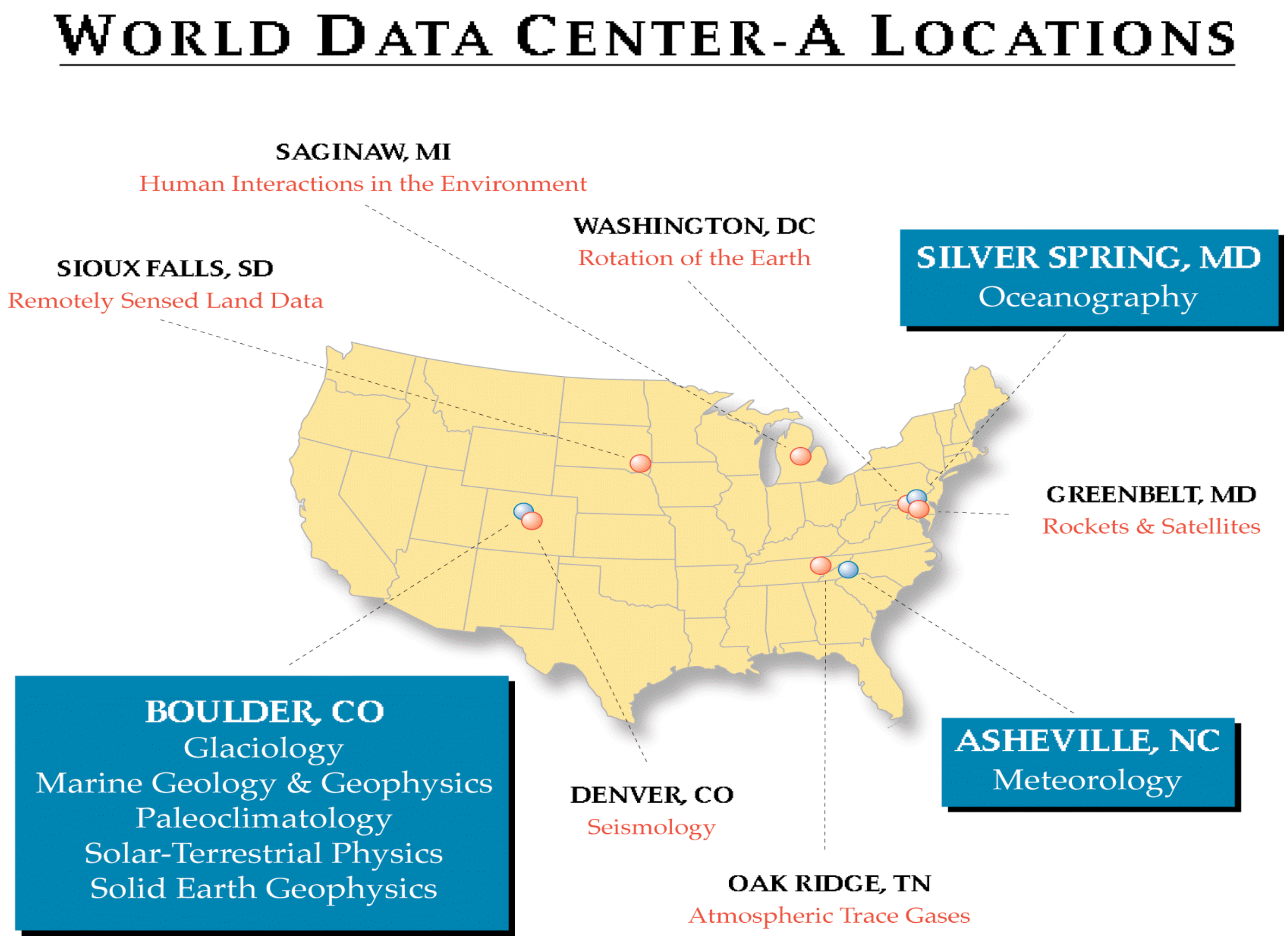
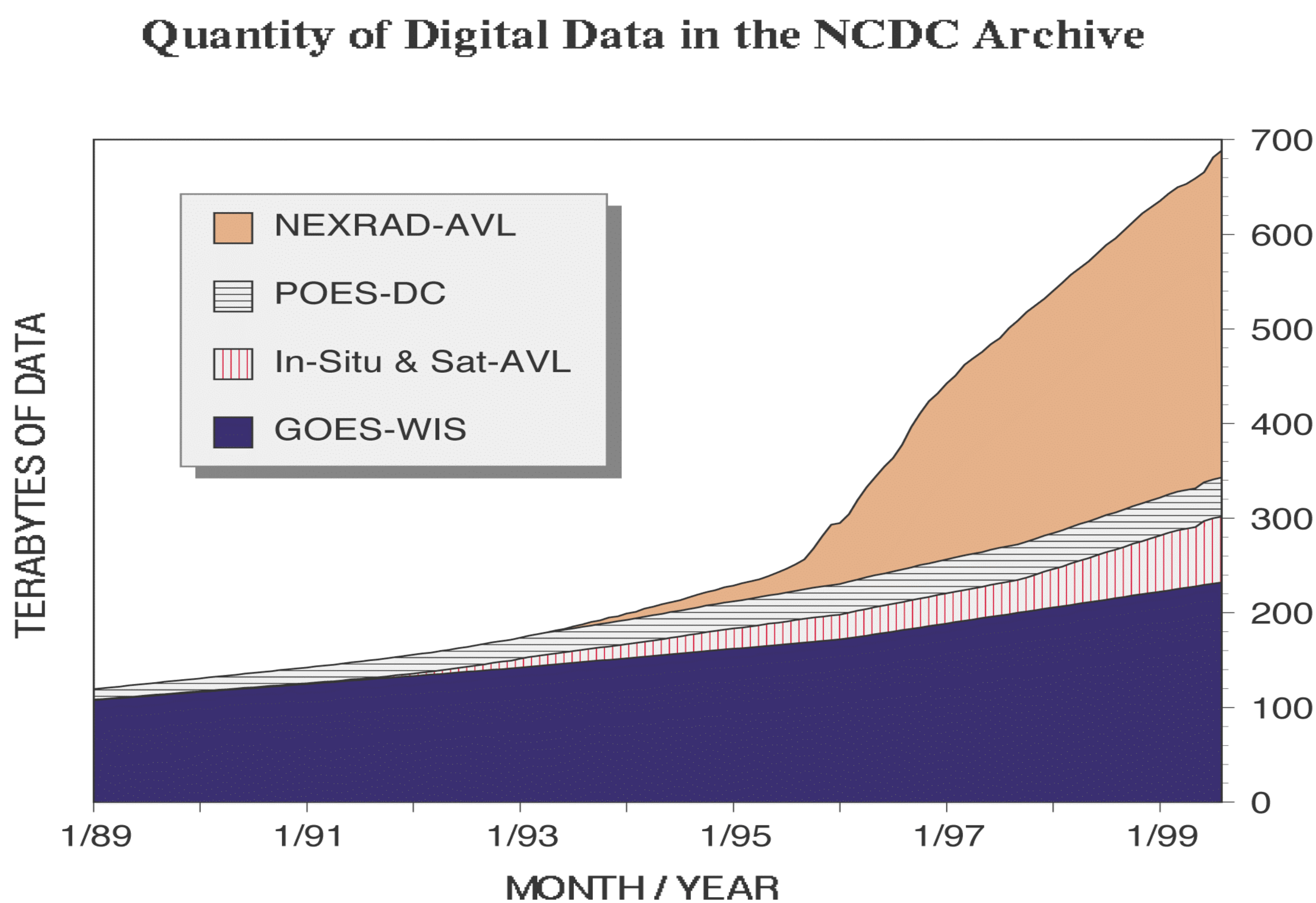

WORLD DATA CENTER-A LOCATIONS
SAGINAW, MI
Human Interactions in the Environment
WASHINGTON, DC
Rotation of the Earth
SILVER SPRING, MD
Oceanography
SIOUX FALLS, SD
Remotely Sensed Land Data
GREENBELT, MD
Rockets & Satellites
BOULDER, CO
Glaciology
Marine Geology & Geophysics
Paleoclimatology
Solar-Terrestrial Physics
Solid Earth Geophysics
DENVER, CO
Seismology
ASHEVILLE, NC
Meteorology
OAK RIDGE, TN
Atmospheric Trace Gases

Figure 1



Quantity of Digital Data in the NCDC Archive
NEXRAD-AVL
POES-DC
In-Situ & Sat-AVL
GOES-WIS
TERABYTES OF DATA
0
100
200
300
400
500
600
700
1/89
1/91
1/93
1/95
1/97
1/99
MONTH / YEAR

Figure 2

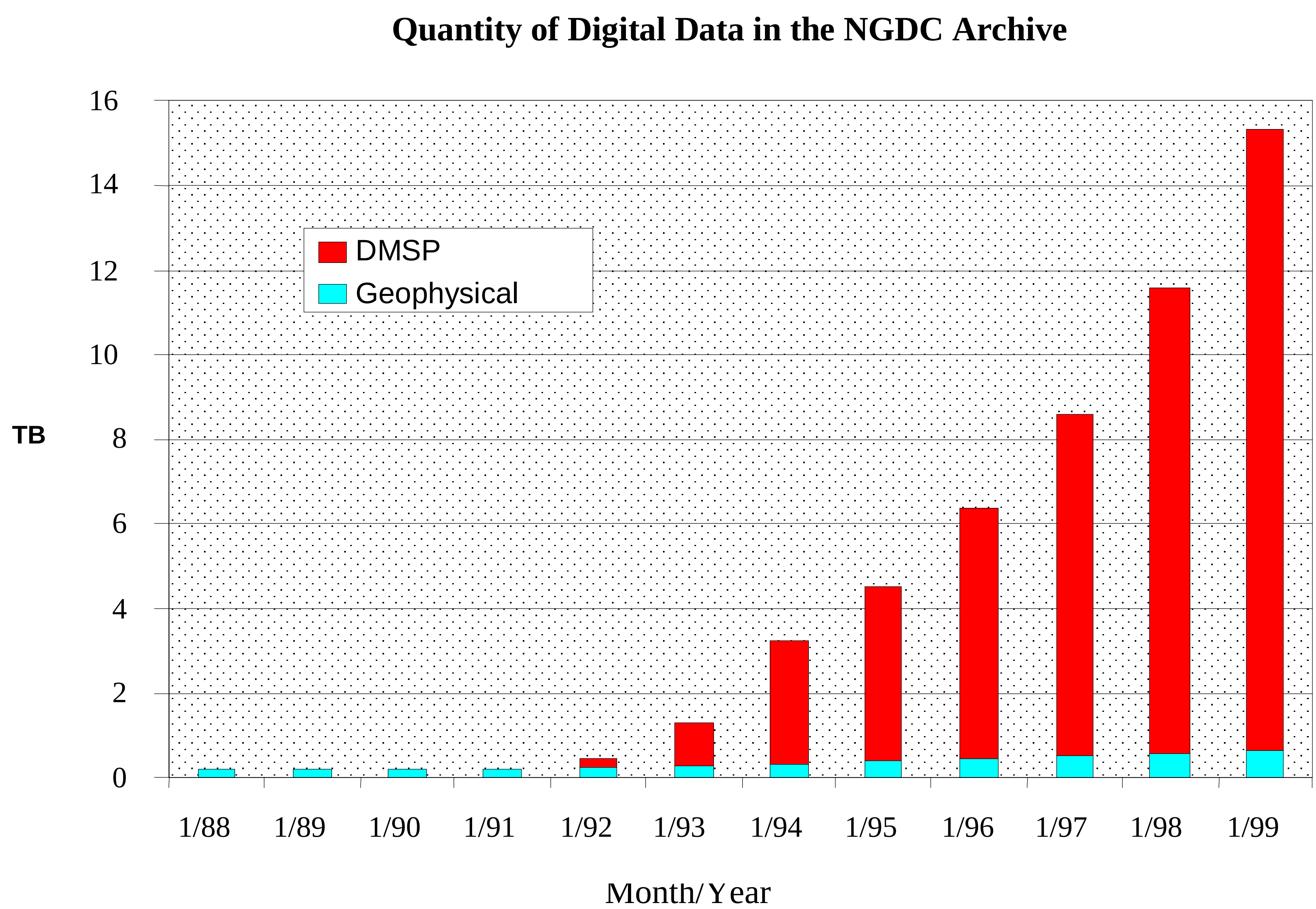

Quantity of Digital Data in the NGDC Archive
TB
16
14
12
10
8
6
4
2
0
DMSP
Geophysical
1/88
1/89
1/90
1/91
1/92
1/93
1/94
1/95
1/96
1/97
1/98
1/99
Month/Year

Figure 3

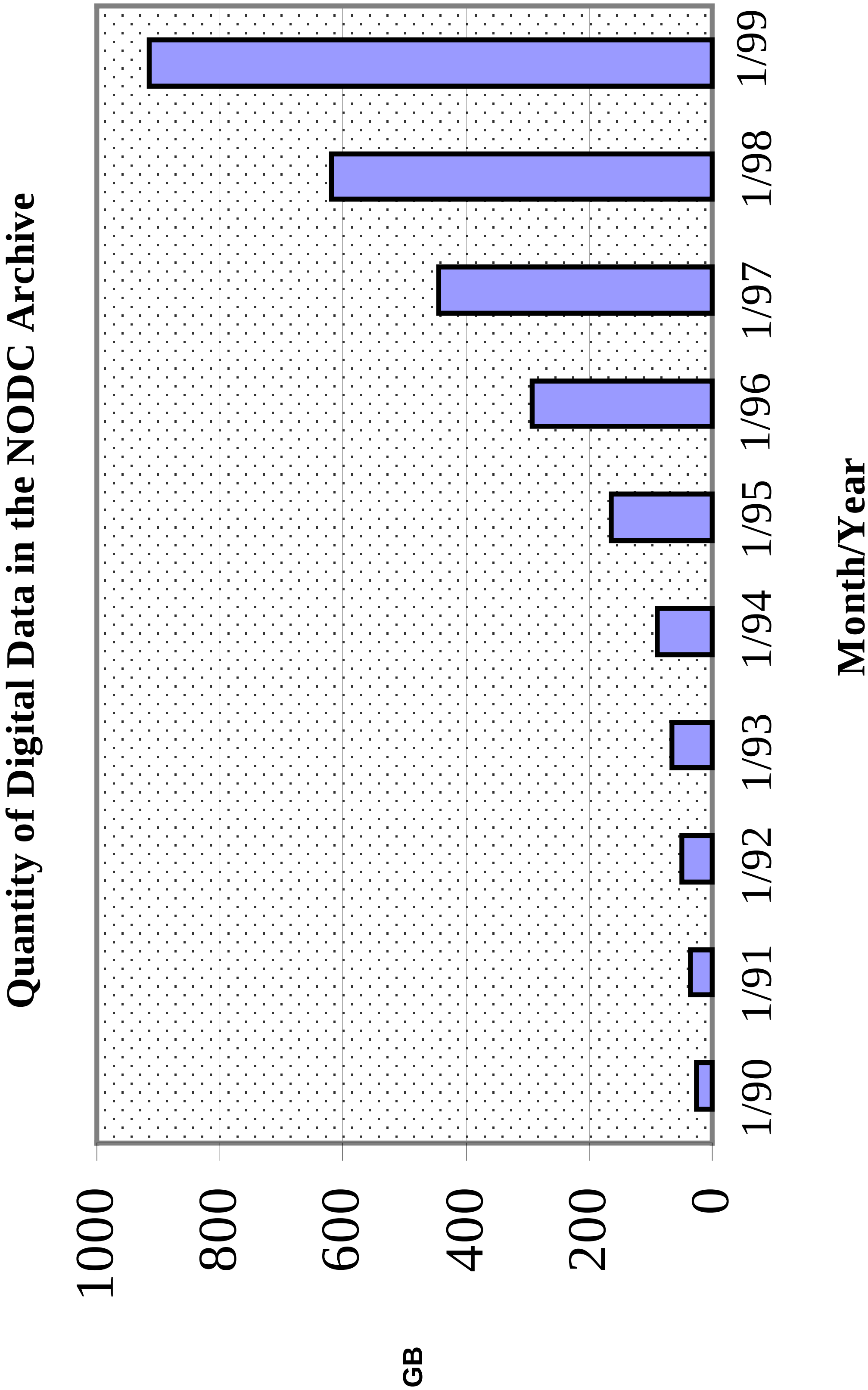

Quantity of Digital Data in the NODC Archive
GB
1000
800
600
400
200
0
1/90
1/91
1/92
1/93
1/94
1/95
1/96
1/97
1/98
1/99
Month/Year

Figure 4

Satellite, Radar (NEXRAD), and In-Situ Observations (ASOS, AWOS, Marine, COOP, Radiosonde, Solar Radiation, Etc.)

(TeraBytes)

	2000	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
EOS	0	1.46	196.52	379.91	636.76	639.75	640.56	640.48	469.48	274.66	23.92	25.2	24.92	24.89	22.73
NPP/TBD	0	0	0	0	0	173	173	173	173	173	173	173	173	173	173
NPOESS	0	0	0	0	0	0	0	0	228	228	456	456	456	456	456
METOP	0	0	0	28	28	28	28	28	28	28	28	28	28	28	28
POES	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0
GOES	36	36	36	36	36	36	36	36	36	36	72	150	300	300	300
NEXRAD	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
In situ	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
NCDC Total Addition	176	178.46	374.52	586.91	844.76	1,021.75	1,023.56	1,024.48	1,080.48	886.66	900.92	981.20	1,131.92	1,132.89	1131.73
NGDC Total Addition	6.88	27	27	90.5	90.5	146	146	146	146	146	146	111	111	55.0	55.5
NODC Total Addition	0.72	0.65	0.65	0.65	0.68	0.68	0.66	0.71	0.70	0.70	0.72	0.74	0.74	0.76	0.76
Cum Total Addition	183.60	206.11	402.17	678.06	935.94	1,168.43	1,170.22	1,171.19	1,227.18	1,033.36	1,047.64	1,092.94	1,243.66	1,189.05	1,187.99
Previous Year Total	763.15	946.75	1,152.86	1,555.03	2,233.09	3,169.03	4,337.46	5,507.68	6,678.87	7,906.05	8,939.41	9,987.05	11,080.0	12,323.7	13,512.7
Cum Total	946.75	1,152.86	1,555.03	2,233.09	3,169.03	4,337.46	5,507.68	6,678.87	7,906.05	8,939.41	9,987.05	11,080.0	12,323.7	13,512.7	14,700.7

Projected Data Volume Delivered to the NOAA National Data Centers (NNDC)

TABLE 1

NNDC Digital Data Archive Projected Growth

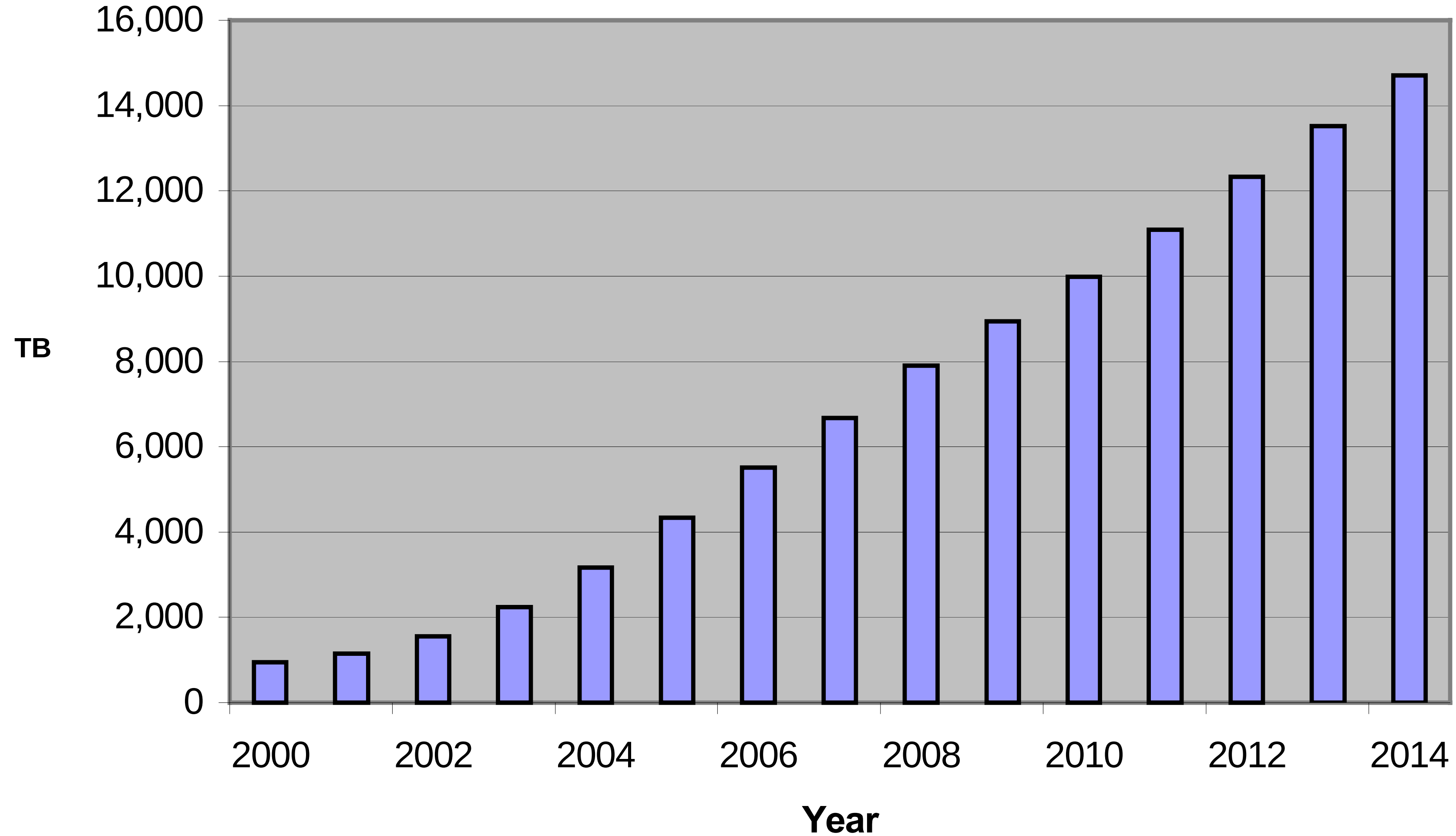


Figure 5