MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Open GIS Software in Brazil: Producing Open Source in Developing Nations

Gilberto Câmara
Director for Earth Observation
National Institute for Space Research
Brazil

CT BRASIL

The issue

- "Developing countries and their donor partners should review policies for procurement of computer software, with a view to ensuring that options for using low-cost and/or open-source software products are properly considered and their costs and benefits carefully evaluated" (UK IPR report, 2002)

- **Yes, but...**
  - We need much more than Linux!
  - Who will develop the open source software we need?
  - Can it be done in developing countries?

The discussion today

- The nature of open source software
  - A realistic model for OS projects
- Spatial information technology
  - The need for open source GIS and Remote Sensing software
- Developing an open source GIS in Brazil
  - 20 years of institutional, nation-wide efforts
  - Technology as social construction
- Some lessons learned
  - How can we do OS software in the South?

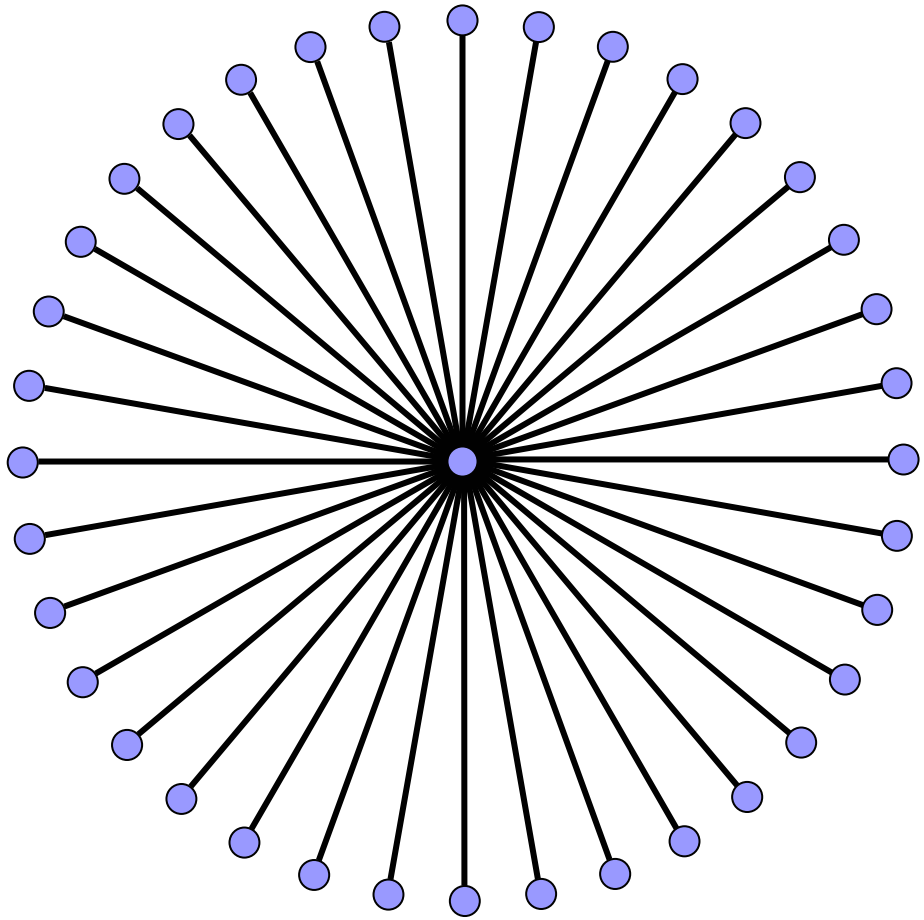
The nature of open source projects

- Idealized view of OS community
  - Network of committed individuals (“peer production”)
  - Based on a limited number of examples
- Reality of software projects
  - Problem granularity
  - Conceptual design
  - Degree of innovation
  - Social context of technology

Naïve view of open source projects

- Software
  - Product of an individual or small group (peer-pressure)
  - Based on a "kernel" with "plausible promise"
- Development network
  - Large number of developers, single repository
- Open source products
  - View as complex, innovative systems (Linux)
- Incentives to participate
  - Operate at an individual level ("self-esteem")
  - Wild-west libertarian ("John Waynes of the modern era")

Idealized model of OS software



Networks of committed individuals

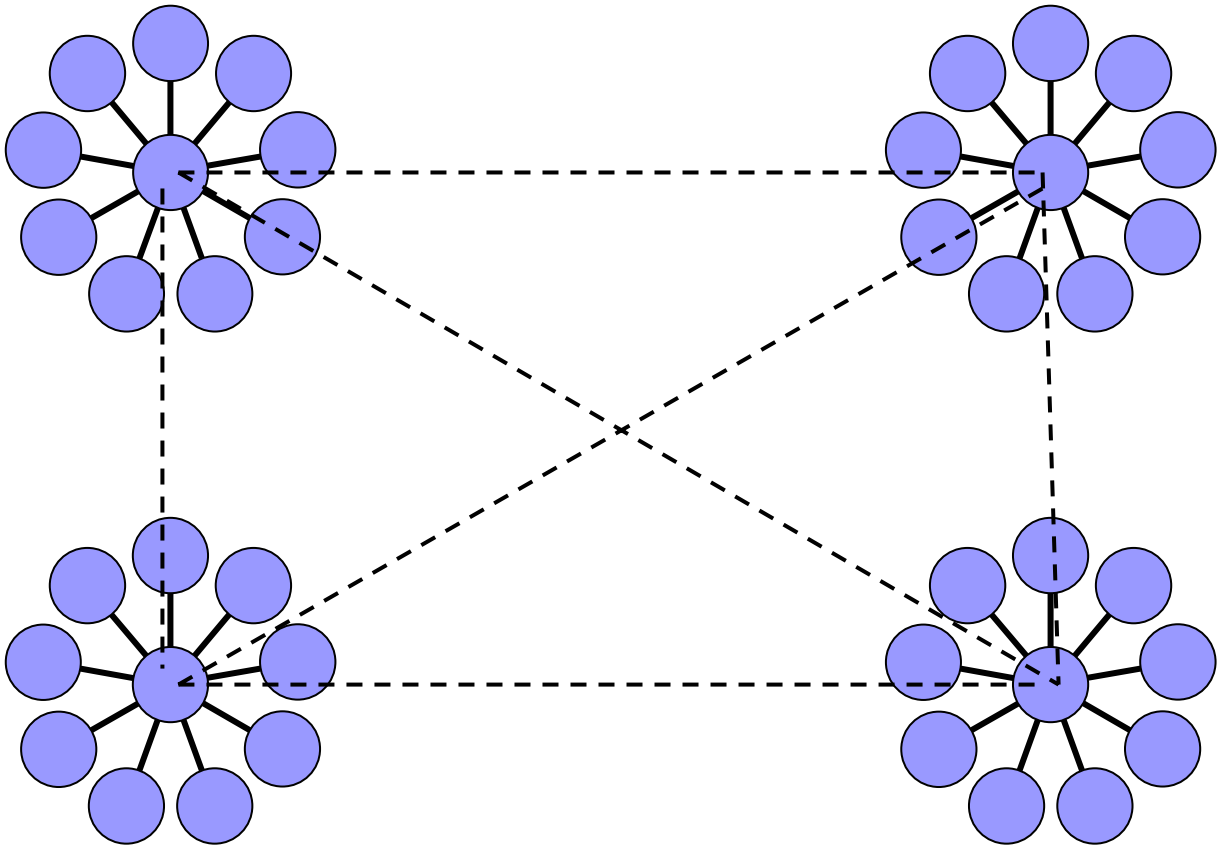
The reality of open source projects

- Problem granularity
  - Effective peer-production requires high granularity (Benkler)
  - Each type of software induces a breakdown strategy
    - What works for an operating system will not work for a database!
- Conceptual design and Innovation
  - Most OS software is based on established paradigms (Linux is a 1970's design)
  - Design is the hardest part of software (Fred Brooks)
- Social context of technology
  - Software development requires closely-knit teams
  - Software will do nothing by itself
    - Complex software requires informed users

The reality of open source projects

- Linux model is not scalable
  - Other types of software are less modular
  - We need more innovation, and less "reverse-engineering"
- Requirements for success
  - Long-term investment
  - Very qualified personnel
  - Accessible mostly to organizations, not to individuals
- Plausible model
  - "Human Genome" x "John Wayne"
  - The "Godzilla" effect (size matters)

Real-life model of OS software

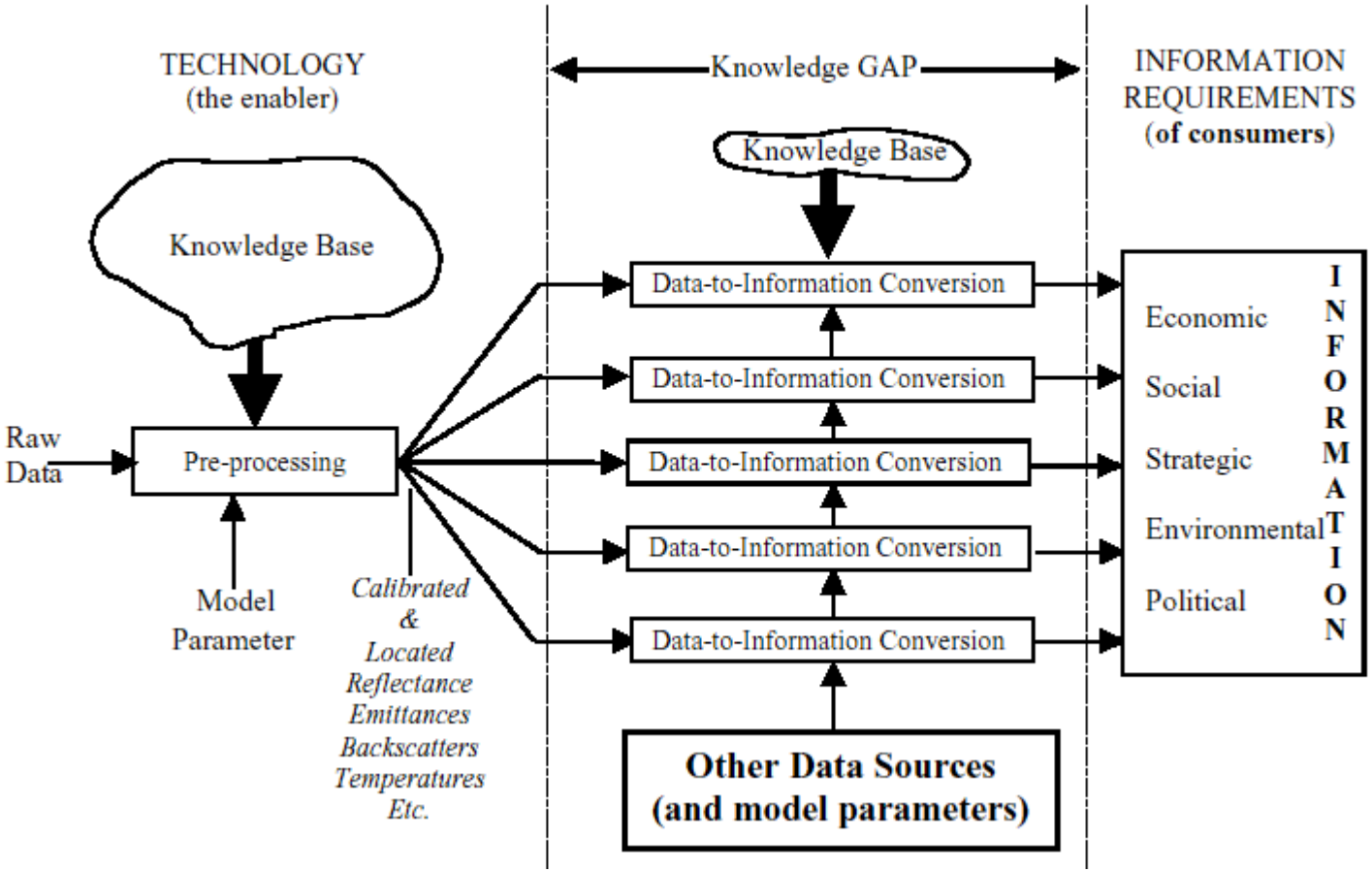


Networks of committed organizations

Spatial information technology

- Basis of the technology
  - Computer representation of spatio-temporal phenomena
    - Discrete objects (e.g., parcels)
    - Continuous fields (e.g., topography)
- Uses of GIS (geographical information systems)
  - Commercial applications
    - Location-based services
    - Business geographics
  - Public good applications
    - Urban cadastral systems
    - Environmental protection and prediction
    - Agriculture crop forecasting
    - Hydrological modeling

Knowledge gap for spatial data



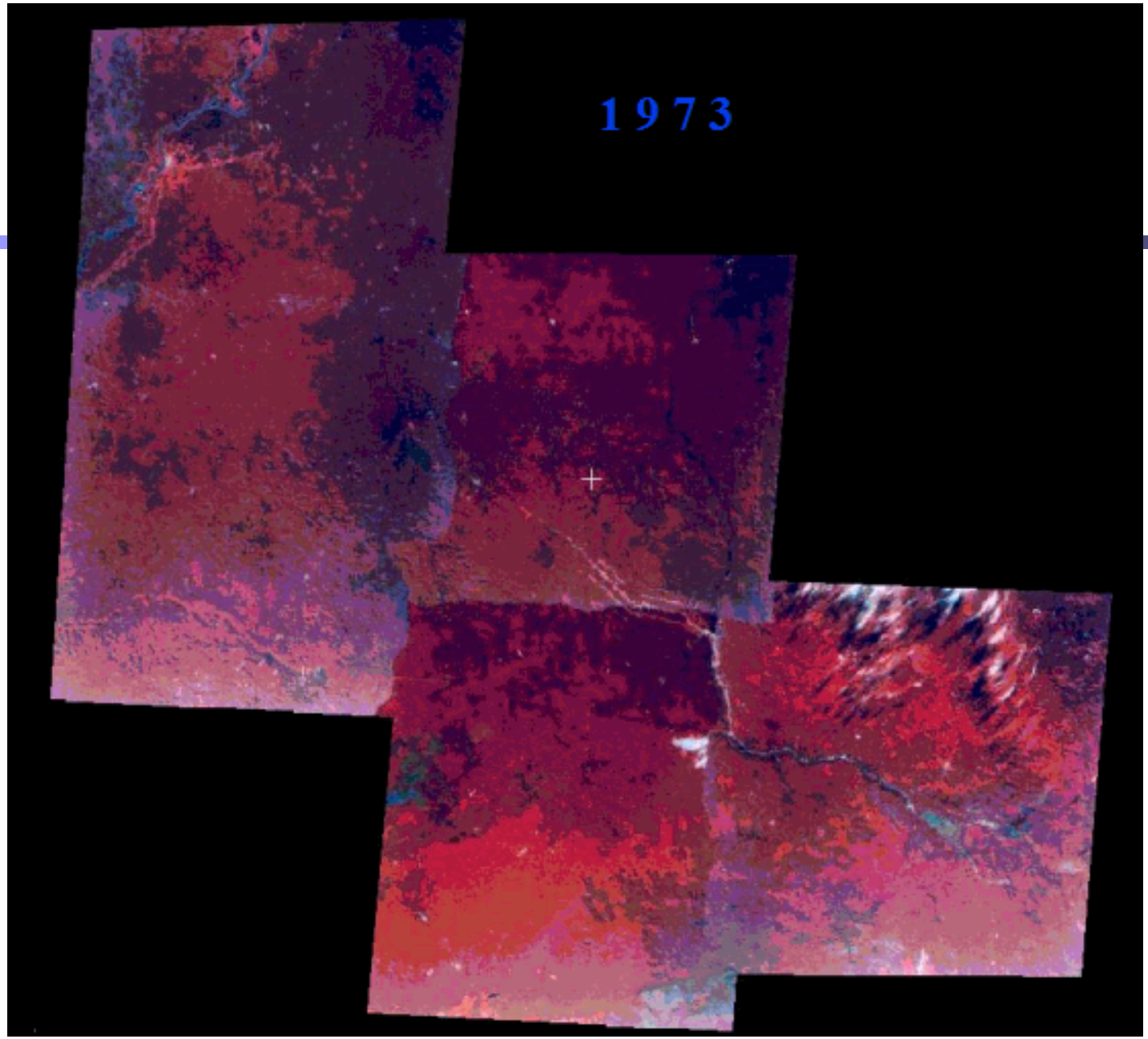
source: John McDonald (MDA)

Knowledge gap for spatial data

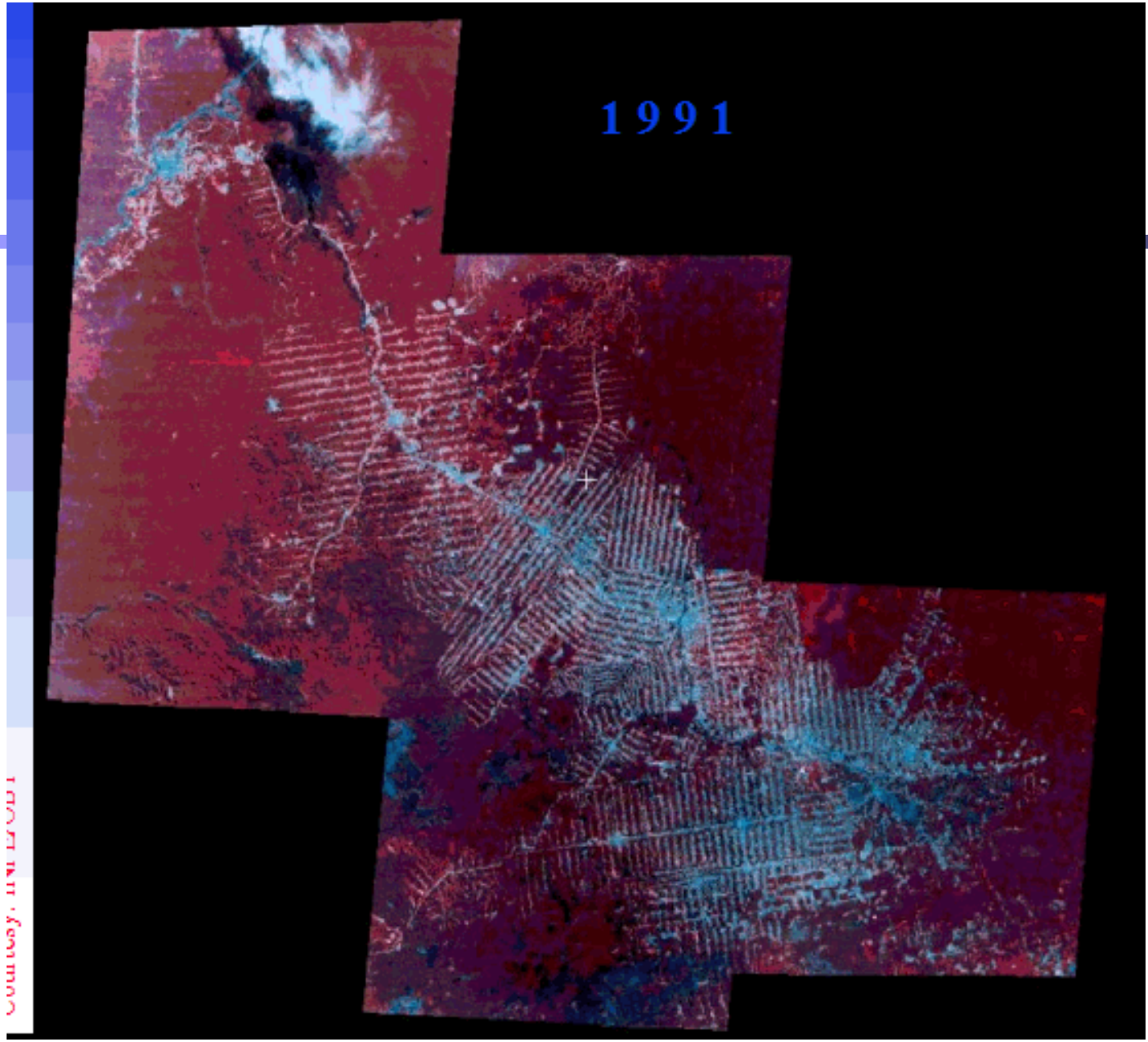
- Imbalance of public expenditure
- Governments build data-gathering satellites…
  - ENVISAT = Us$ 1 billion
  - EOS (Terra/Aqua) = Us$ 1 billion
- ….and they hope the market will do the rest
  - Leading remote sensing software product ≈ US$25 M (gross)
- The model does not add up!
  - There is not enough market to cover large R&D expenses
  - The result is the "knowledge gap"

Knowledge gap for spatial data

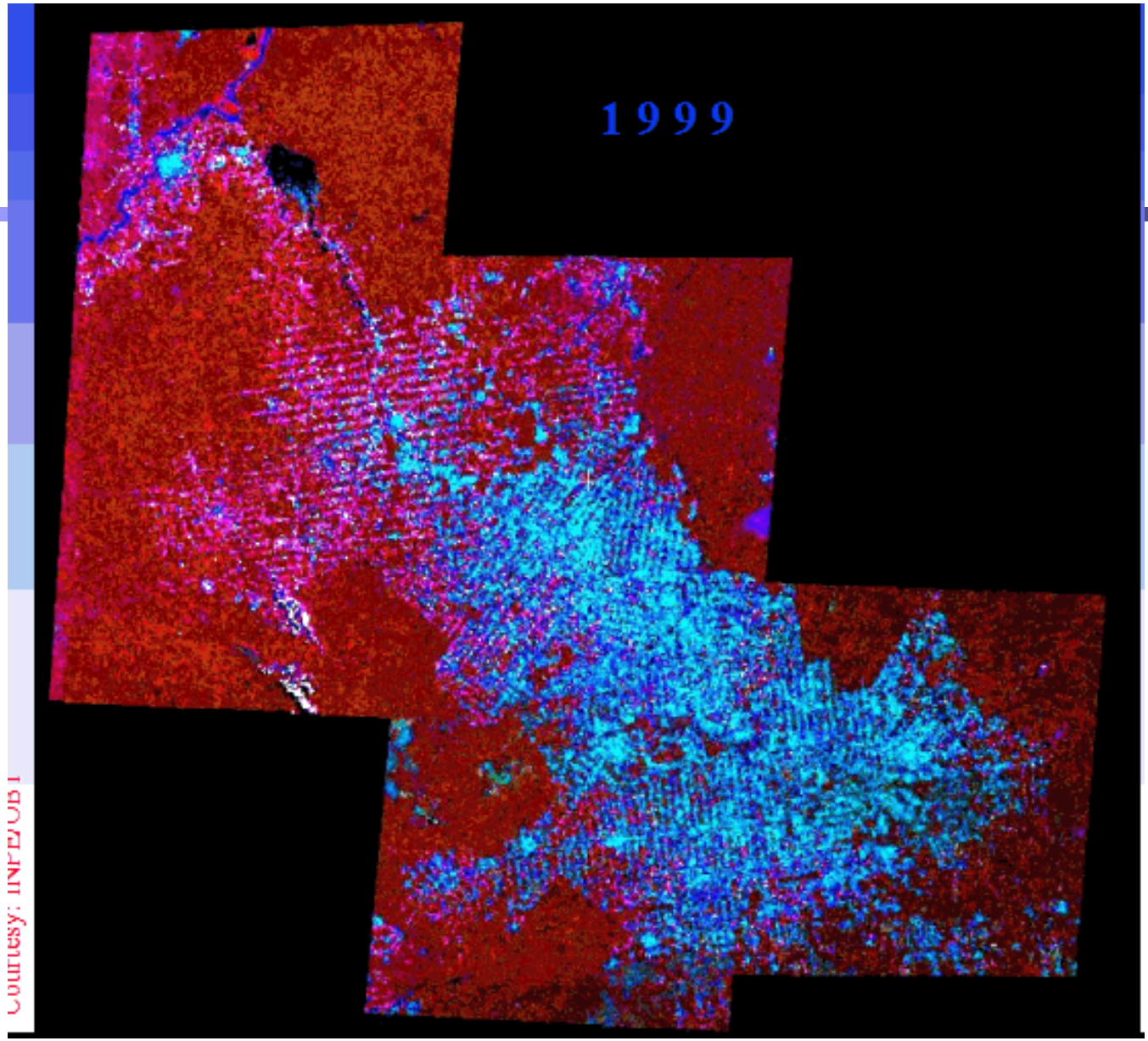
- Most applications of EO data
  - "Snapshot" paradigm
- Recipe analogy
  - Take 1 image ("raw")
  - "Cook" the image (correction + interpretation)
  - All "salt" (i.e., ancillary data)
  - Serve while hot (on a "GIS plate")
- But we have lots of images!
  - Immense data archives (Terabytes of historical images)
  - How many image database mining application we have?



Landsat Image – Rondonia (Brazil)



Landsat Image – Rondonia (Brazil)



Landsat Image – Rondonia (Brazil)

Bridging the Knowledge gap

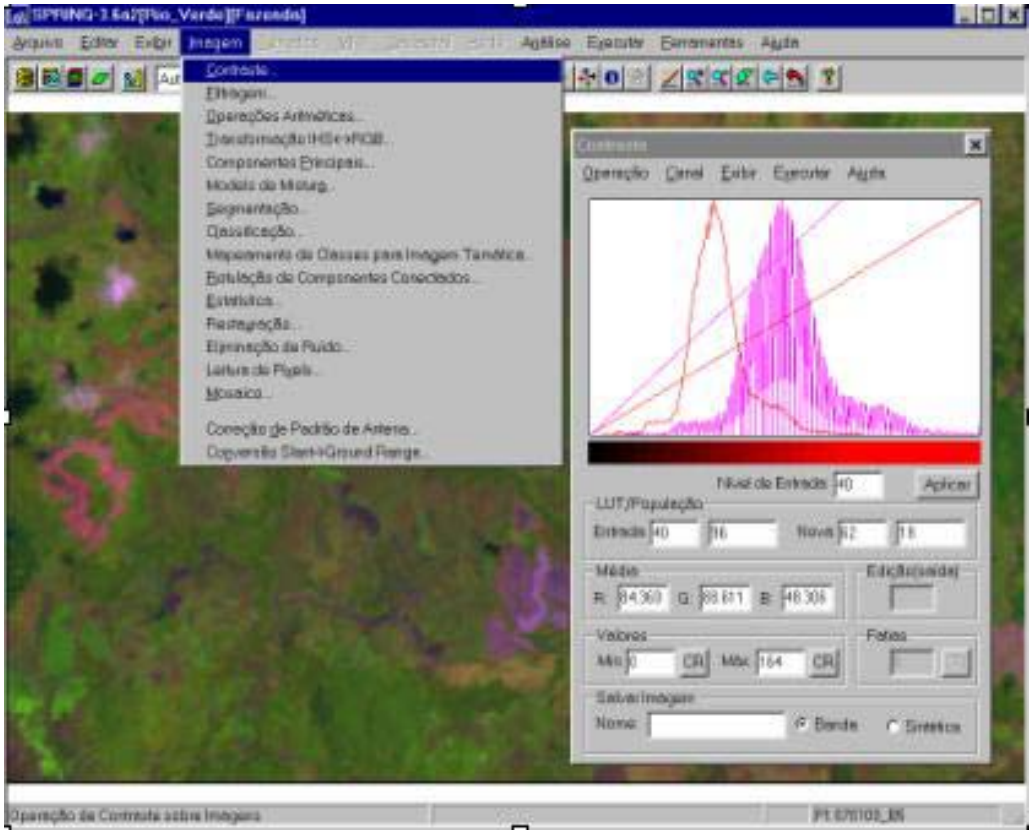
- "Deadlock" situation
  - Small size of commercial IP
    - Not enough income for R&D investment
  - Improvements on information extraction
    - Needed for the market to grow
- Making use of the deluges of data
  - Government-funded software development
  - Strong integration with scientific community
- Open Source GIS projects
  - Provide innovative ways to use spatio-temporal data
  - Effective means of advancing environmental applications

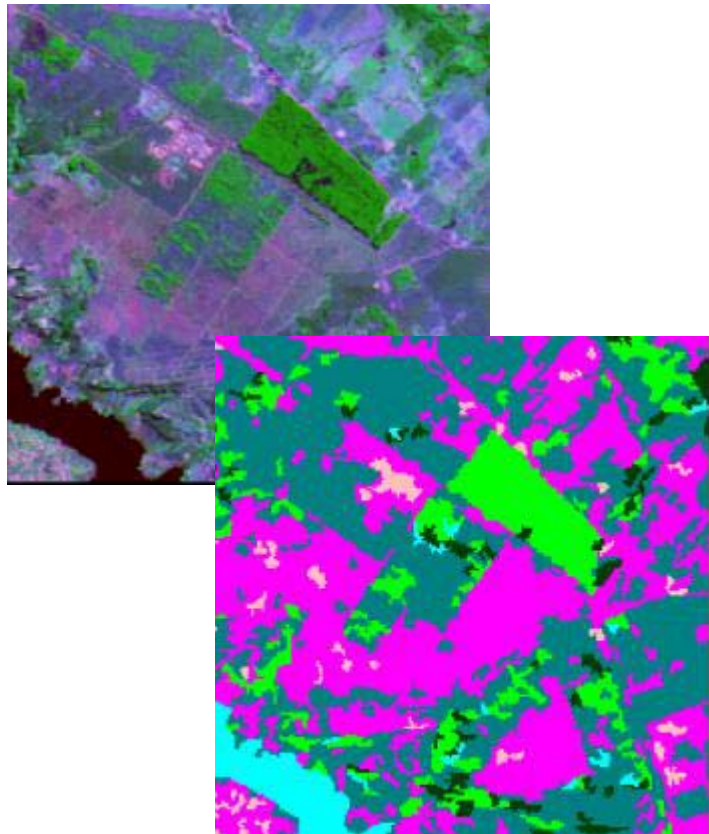
The Brazilian experience

- National Institute for Space Research (INPE)
  - Space Science, Earth Observation, Meteorology and Space Engineering
    - Staff of 1,600 (50% Master and Ph.D. degrees)
- GIS and Remote Sensing software development
  - Institutional program initiated in 1984
  - Aims
    - Make Brazil self-sufficient in GI technology
    - Empower users with public-good applications
  - Strategy
    - Foster qualified human resources
    - Link technology with application

SPRING

- Open access image processing and GIS software.
  - Multi-platform (Windows, Linux, Solaris)
  - Web: http://www.dpi.inpe.br/spring (32.000 downloads)





SPRING

- Significant development effort
  - 140 man-years (1994-present)
  - 500,000+ lines of C++ code
  - Designed from scratch (no reverse engineering)

- Innovative solutions (firsts)
  - Object-oriented spatial data model
  - Integration of remote sensing and GIS
  - Window-based interface in Windows and Linux
  - Geostatistics (kriging) functions in a GIS
  - Region-based segmentation and classification

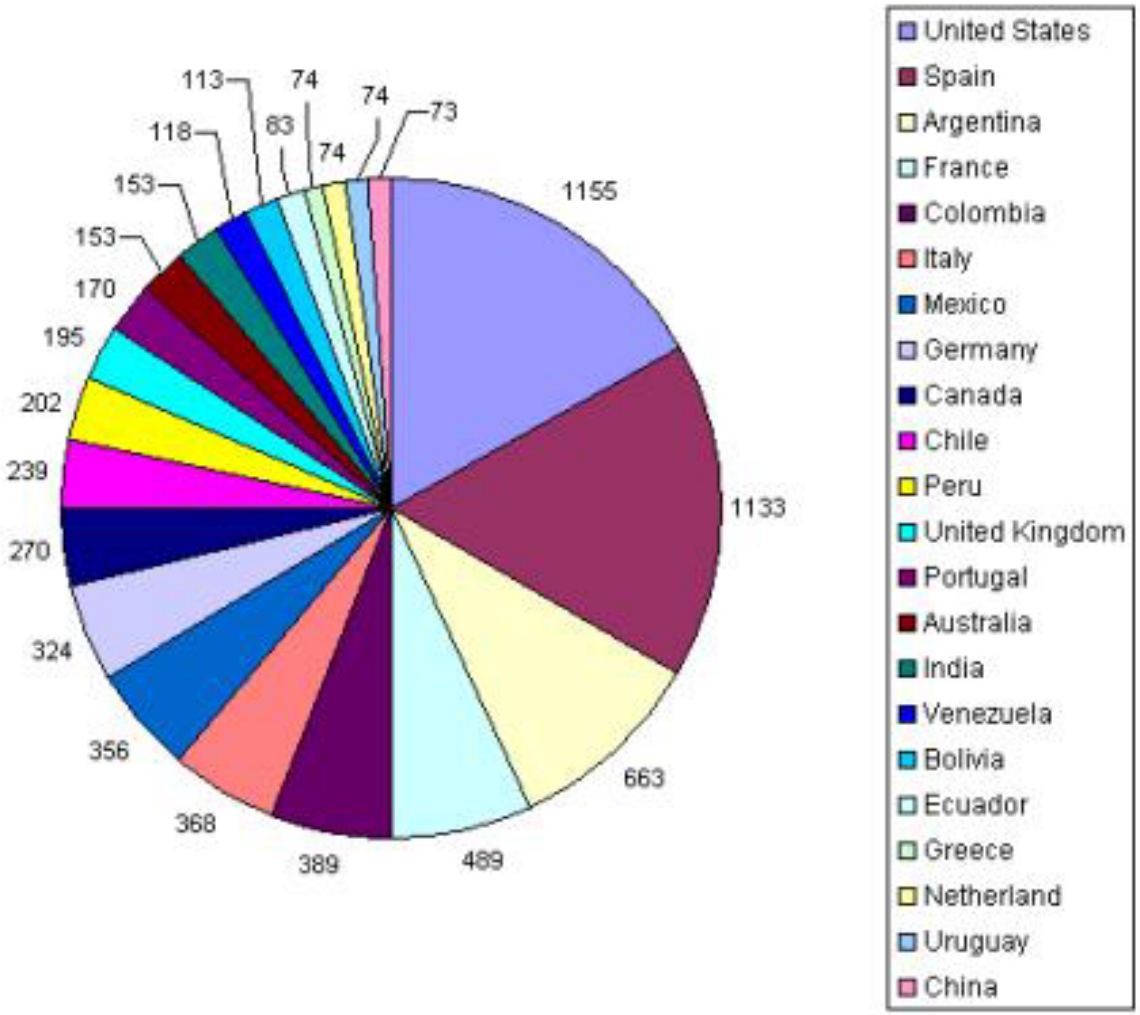
Technology as a social product

- Research system in the developed world
  - discourages the production of training material
  - There are good books on GIS!
    - unfortunately, these books are in English and are expensive
- Need for open access of information
  - Open access literature in local language
- Brazilian experience
  - three-volume set ("Introduction to GIS", "Spatial Analysis", "Spatial Databases")
  - Application examples using SPRING: key factors in software adoption

SPRING: User adoption

- Universities
  - Driving factors: documentation and examples, not price
  - Graduate and undergrads: Geography, Earth Sciences, Social Sciences
- Government institutions
  - Replace existing US-based commercial solutions
    - Agricultural research agency (EMBRAPA)
    - Geological Survey (CPRM)
    - Census bureau (IBGE)
- Private companies
  - Saving of licensing costs
  - Local support and training

SPRING downloads (Top 20 countries)



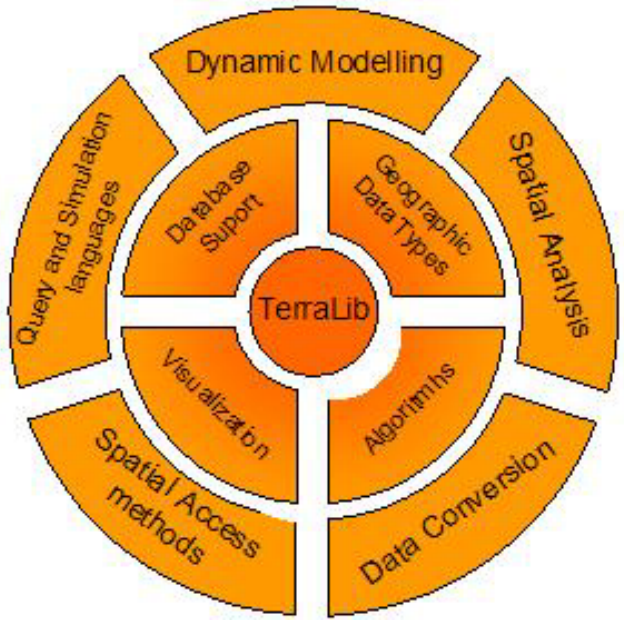
Innovation in GIS

- Current generation of GIS
  - Built on proprietary architectures
  - Interface + functions + database = "monolithic" system
  - Geometric data structures = archived outside of the DBMS

- New generation of spatial information technology
  - All data will be handled by the database (inclusive images and maps)
  - Users can develop customized applications ("small GIS")
  - They need appropriate tools!

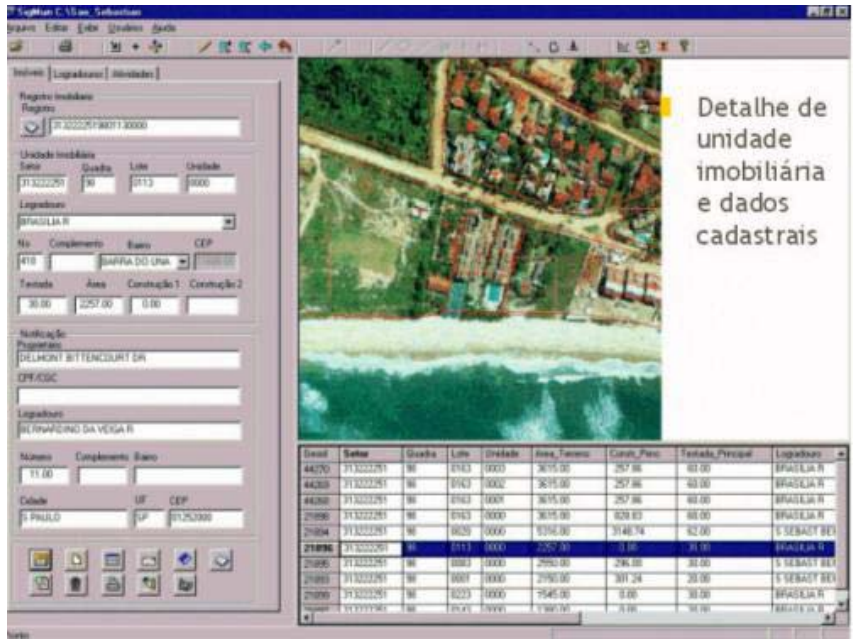
TerraLib: Open source GIS library

- Data management
  - All of data (spatial + attributes) is in database
- Functions
  - Spatial statistics, Image Processing, Map Algebra
- Innovation
  - Based on state-of-the-art techniques
  - Same timing as similar commercial products
- Web-based co-operative development
  - http://www.terralib.org



TerraLib applications

- Cadastral Mapping
  - Improving urban management of large Brazilian cities
- Public Health
  - Spatial statistical tools for epidemiology and health services
- Social Exclusion
  - Indicators of social exclusion in inner-city areas
- Land-use change modelling
  - Spatio-temporal models of deforestation in Amazonia
- Emergency action planning
  - Oil refineries and pipelines (Petrobras)



What does it take to do it?

- SPRING and TerraLib project
  - Major emphasis on "learning-by-doing"
- Development and Application Team
  - Software: 40 senior programmers (10 with PhD)
  - Applications: 30 PhDs in Earth Sciences plus students
- Building a resource base
  - Graduate Programs in Computer Science and Remote Sensing
  - SPRING and Terralib: 20 PhD thesis and 35 MsC dissertations
- Institutional effort
  - Requires long-term planning and vision

Challenges for developing countries

- Need for innovative solutions
  - Software is an enabling product
    - Caters for specific needs of communities
    - There are unfulfilled needs in the South (e.g. educationware)
- The world is getting more complex

  (or at least we are increasing recognizing this)
  - We need talented people to solve difficult problems
  - There is not enough talent in the North of the Equator!

- Why should government money fund open source?
  - Only way to produce results in the South!
  - Open source will not happen by spontaneous growth
    - It is very expensive to conserve qualified resources
    - It is very important to invest in qualified resources

Government and Job Creation

	Low-Tech	*High-Tech*
Fixed	Waiter	Surgeon
Mobile	Assembly-line worker	Software Engineer

Conclusions

- Open Source software model
  - The Linux example is not applicable to all situations
  - Moving from the individual level to the organization level
- Spatial information technology
  - Large R&D is needed to bridge the "knowledge gap"
  - Open source GIS software has a large role
- Open source projects in developing nations
  - Combination of institutional vision, qualified personnel and strong links to user community
  - Government-funded to be viable