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World Data Center for Human Interactions in the Environment

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The Role of Spatial Data Infrastructure in Integrating Climate Change Information with a Focus on Monitoring Observed Climate Impacts

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Introduction

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- Objective: to document the impacts of climate change.
  - How do we do this?

- One way: the methodology of the IPCC's Fourth Assessment (Rosenzweig et al., Chapter 1, Working Group 2)
  - illustration of how integrated spatial data infrastructures are essential for identifying such impacts systematically

The Underlying Question

- Which of the observed changes across systems and geographic regions are actually due to *anthropogenic climate forcing*, and which can be attributed to *natural variability over time*, or other *non-climate drivers of change* such as geological processes, land use change, land-cover modification, invasive species, pollution?

Rosenzweig et al.

- Observed changes and their effects related to the cryosphere, hydrology and water resources, coastal processes and zones, freshwater and marine biological systems, terrestrial biological systems, agriculture and forestry, human health, and disasters and hazards related to regional warming.
  - Describes regional climate and non climate driving forces for the systems,
  - Assesses the evidence regarding observed changes in key processes, and
  - Highlights issues regarding the absence of observed changes and conflicting evidence.

Methods: observed versus predicted

- Where long data series exist, the detection of trends or changes in system properties that are beyond natural variability has most commonly been made with regression, correlation and time-series analyses.
- When data exist from two (or more) discontinuous time periods, two-sample tests have frequently been employed.
- Testing is also done for abrupt changes and discontinuities in a data series.
- Regression and correlation methods are frequently used in the detection of a relationship of the observed trend with climate variables.
- Methods also involve studies of process-level understanding of the observed change in relation to a given regional climate change, and the examination of alternative explanations of the observed change, such as land use change.
- The analysis sometimes involves comparisons of observations to climate-driven model simulations.

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Linking Cause to Effect

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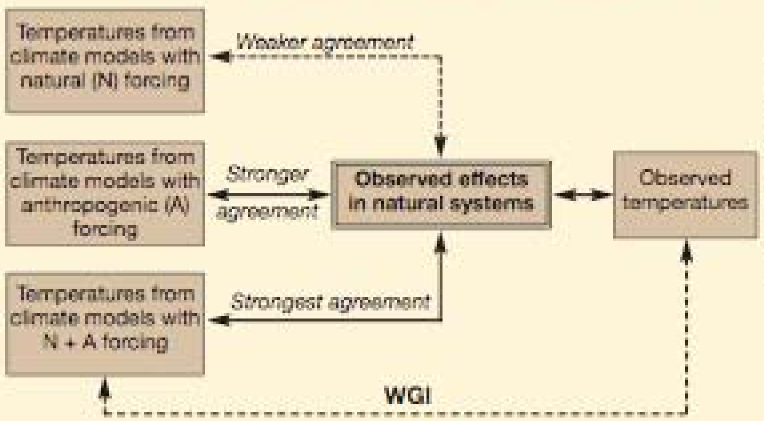
Supplementary Material: Chapter 1 | Assessment of observed changes and responses in natural and managed systems

Box SM.1. Linking the causes of climate change to observed effects on physical and biological systems. In chapter synthesis assessment in Section 1.4



The figure to the left demonstrates the linkages between observed temperatures, observed effects on natural systems, and temperatures from climate model simulations with natural, anthropogenic, and combined natural and anthropogenic forcings. Two ways in which these linkages are utilised in detection and attribution studies of observed effects are described below.

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Climate Models

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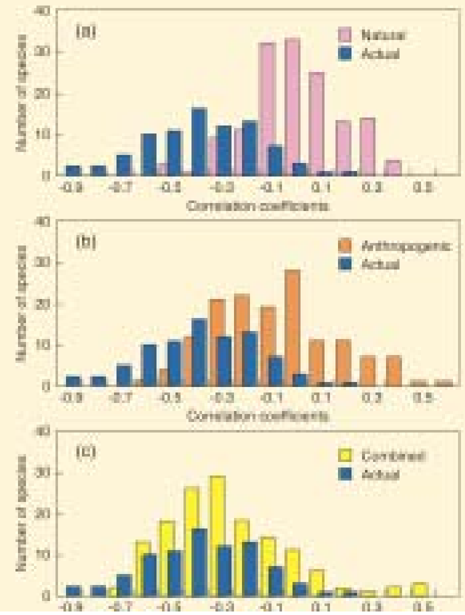
1. Using climate models

The study of causal connection by separation of natural and anthropogenic forcing factors compares observed temporal changes in animals and plants with changes over the same time periods in observed temperatures as well as modelled temperatures using (i) only natural climate forcing; (ii) only anthropogenic climate forcing; and (iii) both forcings combined.

The panel to the right shows the results from a study employing this methodology[1]. The locations for the modelled temperatures were individual grid boxes corresponding to given animal and plant study sites and time periods.

The agreement (in overlap and shape) between the observed (blue bars) and modelled plots is weakest with natural forcings, stronger with anthropogenic forcings, and strongest with combined forcings. Thus, observed changes in animals and plants are likely responding to both natural and anthropogenic climate forcings, providing a direct cause-and-effect linkage [F1.7, 1.4.2.2].



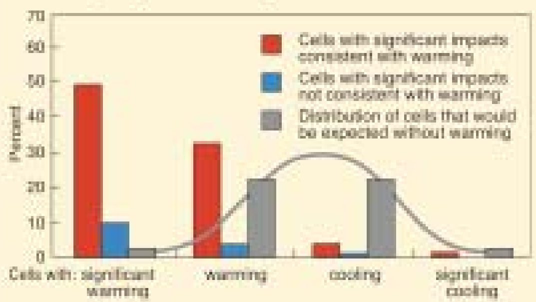
Study of causal connection by separation of natural and anthropogenic forcing factors compares observed temporal changes in animals and plants with changes over the same time periods in observed temperatures as well as modeled temperatures using:

- Only natural climate forcing
- Only anthropogenic climate forcing
- Both combined

Using Spatial Analysis

Correlation coefficients

2. Using spatial analysis



The study of causal connection by spatial analysis follows these stages: (i) it identifies 5° × 5° latitude/longitude cells across the globe which exhibit significant warming, warming, cooling, and significant cooling; (ii) it identifies 5° × 5° cells of significant observed changes in natural systems that are consistent with warming and that are not consistent with warming; and (iii) it statistically determines the degree of spatial agreement between the two sets of cells. In this assessment, the conclusion is that the spatial agreement is significant at the 1% level and is very unlikely to be solely due to natural variability of climate or of the natural systems.

Taken together with evidence of significant anthropogenic warming over the past 50 years averaged over each continent except Antarctica [WGI AR4[2] SPM], this shows a discernible human influence on changes in many natural systems [1.4.2.3].

[1] Plotted are the frequencies of the correlation coefficients (associations) between the timing of changes in traits (e.g., earlier egg-laying) of 145 species and modelled (HadCM3) spring temperatures for the grid-boxes in which each species was examined. (Continues at bottom of previous page).

[2] IPCC, 2007: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, Eds., Cambridge University Press, Cambridge, 996 pp.

SM.1-7

Gridded Surface Temperatures

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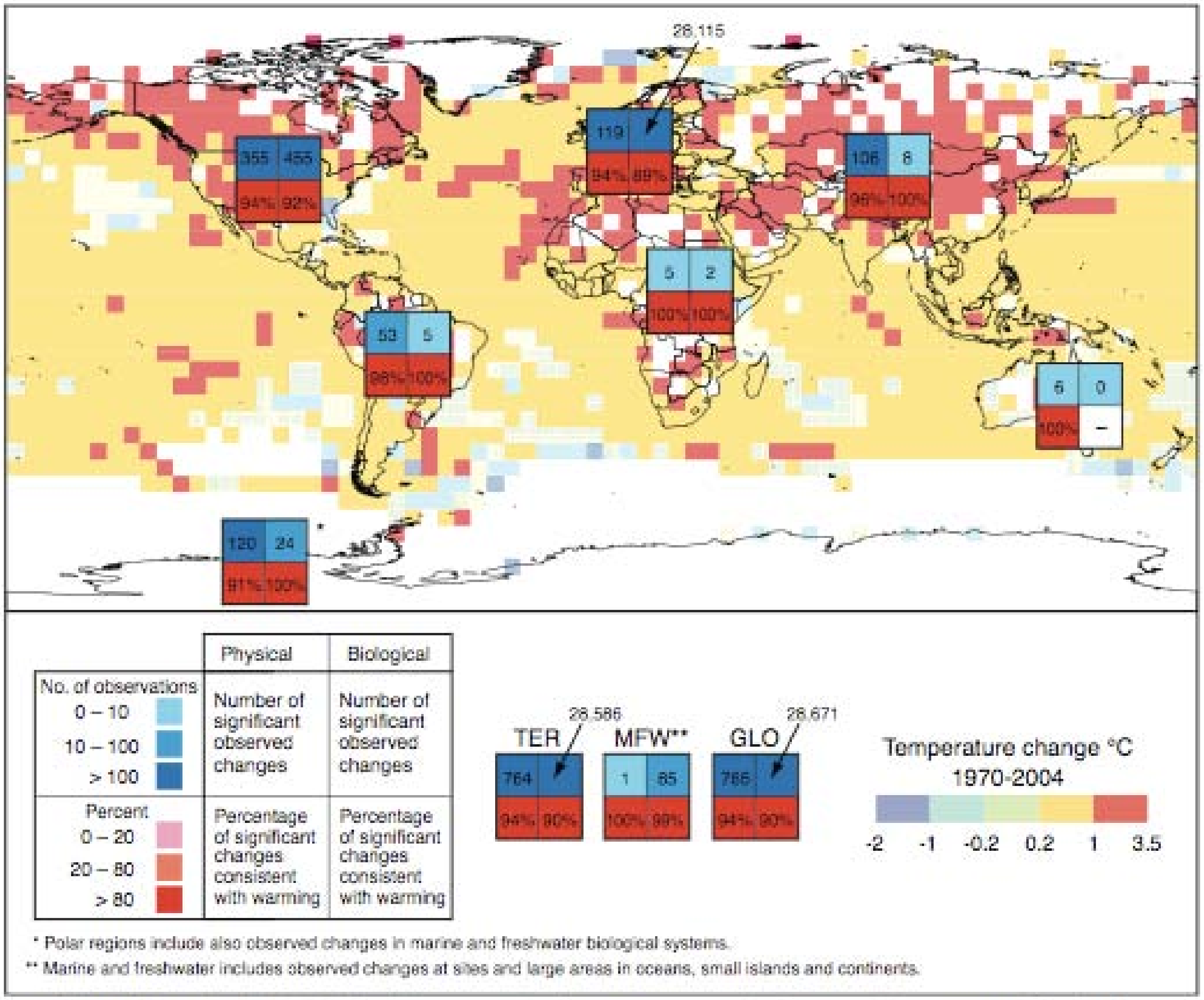

Figure SM-1.4. *Changes in physical and biological systems and surface temperature used in chapter synthesis assessment in Section 1.4. Background shading, and the key to the bottom right, show changes in gridded surface temperatures over the period 1970-2004. The boxes, and the key to bottom left, show the continental-scale changes in physical (left-hand column) and biological (right-hand column) systems calculated from individual series with at least 20 years data in the 1970-2004 period; the top row shows the number of observed series matching the length criterion that show a significant trend and the bottom row shows the percentage of these in which the trend is consistent with warming. At the global scale TER = Terrestrial; MFW = Marine and Freshwater, and GLO = Global.*

Another example: Differences in the mean onset of spring in Europe

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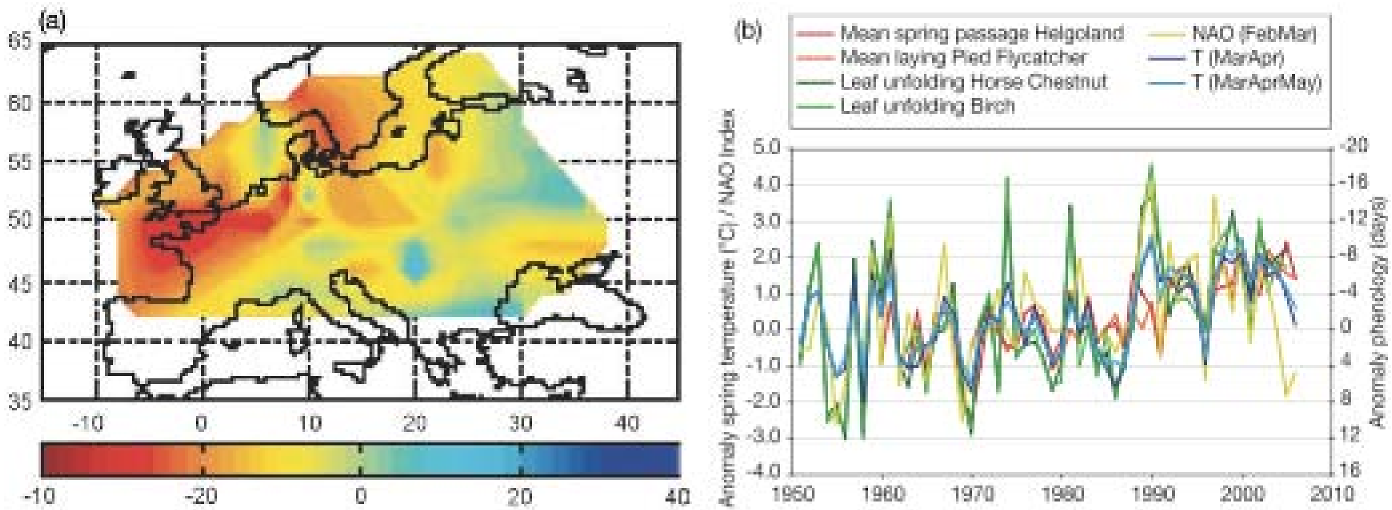

Figure 1.4. *(a) Differences between the mean onset of spring (days) in Europe for the 10 years with the highest (1990, 1882, 1928, 1903, 1993, 1910, 1880, 1997, 1989, 1992) and the lowest (1969, 1936, 1900, 1996, 1960, 1932, 1886, 1924, 1941, 1895) NAO winter and spring index (November to March) drawn from the period 1879 to 1998. After Menzel et al. (2005b). (b) Anomalies of different phenological phases in Germany (mean spring passage of birds at Helgoland, North Sea; mean egg-laying of pied flycatcher in Northern Germany; national mean onset of leaf unfolding of common horse-chestnut (Aesculus hippocastanum) and silver birch (Betula pendula) (negative = earlier)), anomalies of mean spring air temperature T (HadCRUT3v) and North Atlantic Oscillation index (NAO) (http://www.cru.uea.ac.uk/cru/data/). Updated after Walther et al. (2002).*

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Linking Changes in Air Temperature to Physical and Biological Systems

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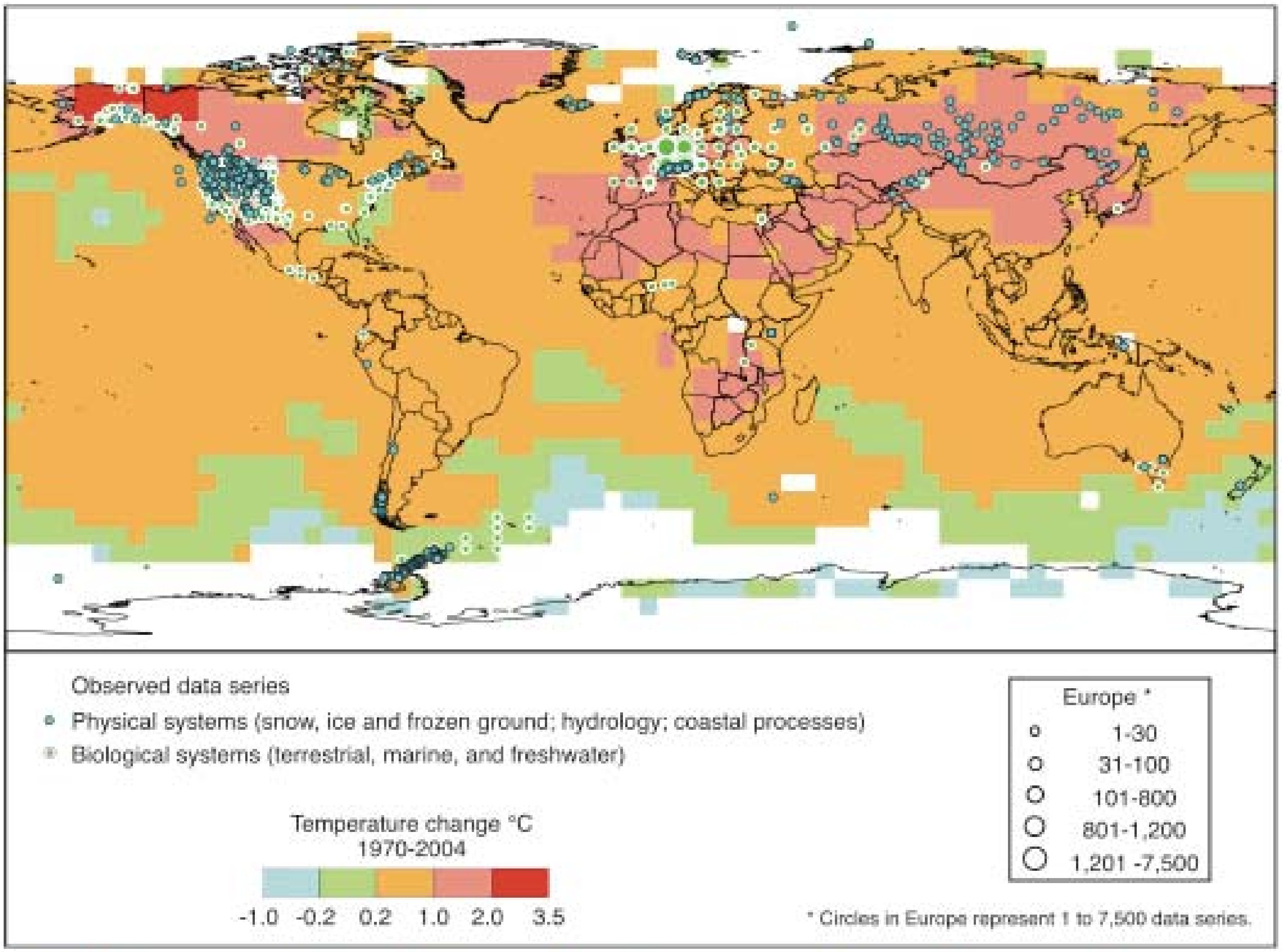

Figure 1.8. *Locations of significant changes in observations of physical systems (snow, ice and frozen ground; hydrology; coastal processes) and biological systems (terrestrial, marine and freshwater biological systems), are shown together with surface air temperature changes over the period 1970 to 2004 (from the GHCN-ERSST datatset). The data series met the following criteria: (1) ending in 1990 or later; (2) spanning a period of at least 20 years; (3) showing a significant change in either direction, as assessed by individual studies. White areas do not contain sufficient observational climate data to estimate a temperature trend.*

Data: Lack of Geographic Balance

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- Dots in the previous slides represent about 75 studies, which have >29,000 data series (of which ~27,800 are from European phenological studies of flora and fauna)

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Chapter conclusions

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- There is a notable lack of geographical balance in the data and literature on observed changes in natural and managed systems, with a marked scarcity from developing countries.

- Possible reasons for this imbalance are:
  - lack of access by IPCC authors,
  - lack of data, research and published studies,
  - lack of knowledge of system sensitivity,
  - differing system responses to climate variables,
  - lag effects in responses,
  - resilience in systems, and
  - the presence of adaptation.

- Needs:
  - to improve the observation networks, and
  - to enhance research capability on changes in physical, biological and socio-economic systems, particularly in regions with sparse data.

Key questions

- How many countries are equipped to document climate change in this way?
- What does it take to get there?

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Building a Spatial Data Infrastructure (SDI)

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"An SDI comprises standards, framework foundation data, framework thematic and other geographic data, metadata, clearinghouses and partnerships."

For example: Linking of weather records, public health data, biological surveillance

Spatial Data Infrastructure Data Layers

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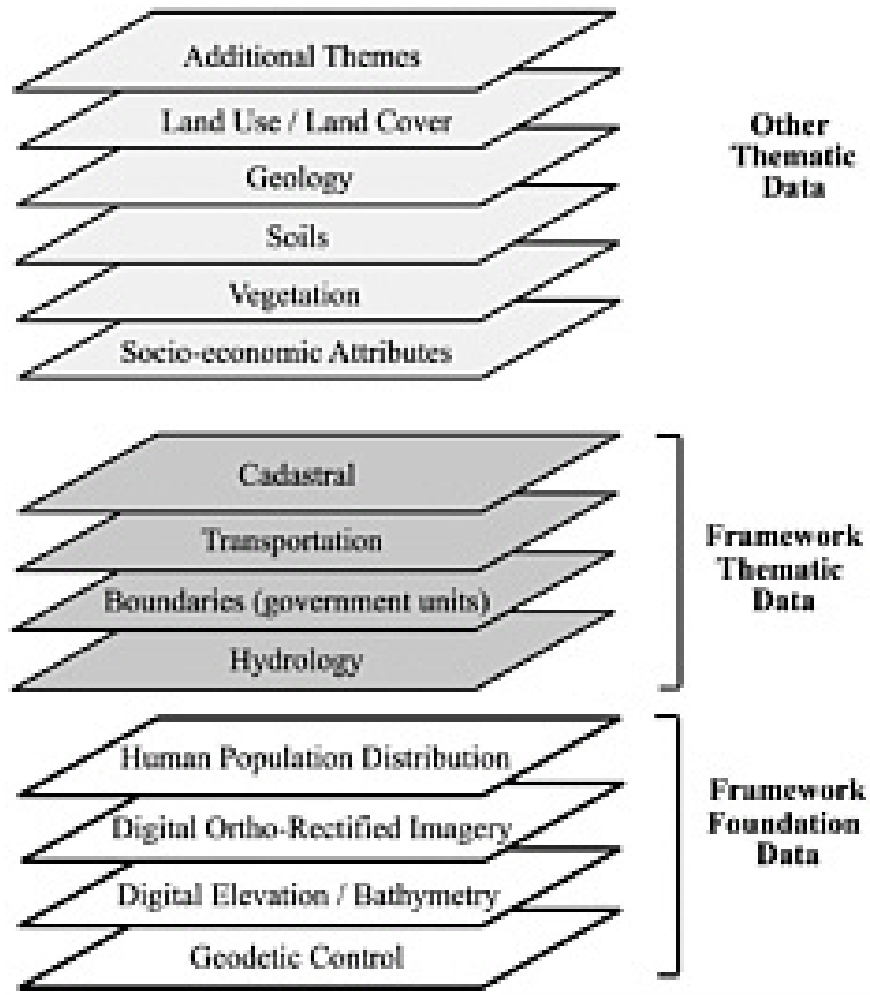
- Earth and social scientists use different units of analysis and have different ways of aggregating data
  - e.g., pixels vs. individuals, physical features vs. households, physiographic vs. administrative regions, grids vs. countries
- Linking such data requires conversion of data between geographies
  - e.g., grids to administrative units or vice versa



US Example

Federal Geographic Data Committee (FGDC) created in 1990 to develop a strategy for an NSDI (national spatial data infrastructure

Goal: "Current and accurate geospatial data that is readily available (locally, nationally and globally)"

US NSDI example

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Intent is to:

1. Reduce duplication of effort by government agencies in data collection
2. Improve quality and reduce costs related to geographic data
3. Make geographic data more accessible to the public
4. Increase the benefits of using available data
5. Establish key partnerships with states, counties, cities, tribal nations, academic, and the private sector.

From US FGDC

SDI Framework Foundation Layers

- **Geodetic Control (GPS) –** common reference system for establishing the coordinate position (lat, long, elevation) of geographic data throughout an SDI
- **Digital Elevation / Bathymetry (GTOPO30, SRTM) –** height above or below a certain point (usually sea level)
- **Digital Ortho-Rectified Imagery (eg Landsat)–** specially processed image prepared from an aerial photograph or remotely sensed image that has the metric qualities of a traditional line map with the detail of an aerial image
- **Human Population Distribution (GPW, Landscan2000)**

Global datasets, national data can be extracted, or alternate national-level sources used

SDI Framework Thematic Layers

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- **Cadastral** – Geographic extent of past, current, and future rights and interests of private and commercial property
- **Transportation** – Roads, railways, waterways, and pipelines
- **Boundaries** (government units)
- **Hydrology** – 3 categories of hydrologic features:
  - 1. Surface water: oceans, lakes, etc
  - 2. Linear features: rivers, canals, shorelines
  - 3. Point features: wells

SDI: Other Thematic Layers

- Socio-economic attributes
- Vegetation
- Soils
- Geology
- Land use/Land cover
- Additional themes

Availability of Remote Sensing Data

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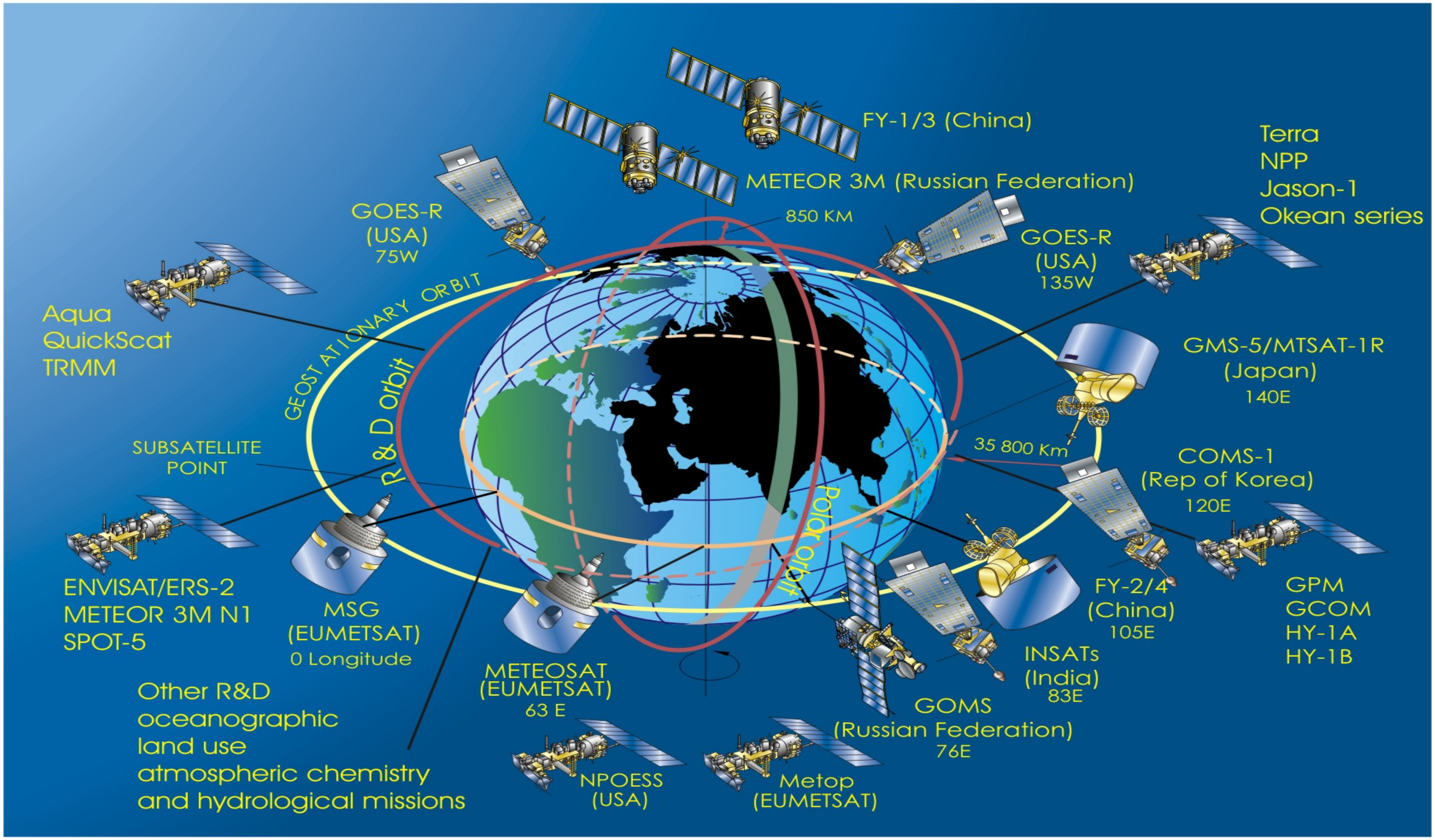

GEO and GEOSS

- Group on Earth Observations (GEO) is coordinating efforts to build GEOSS – Global Earth Observation System of Systems:

"An emerging public infrastructure interconnecting a diverse and growing array of systems for monitoring and forecasting changes in the global environment"

Global Earth Observing System of Systems (GEOSS)

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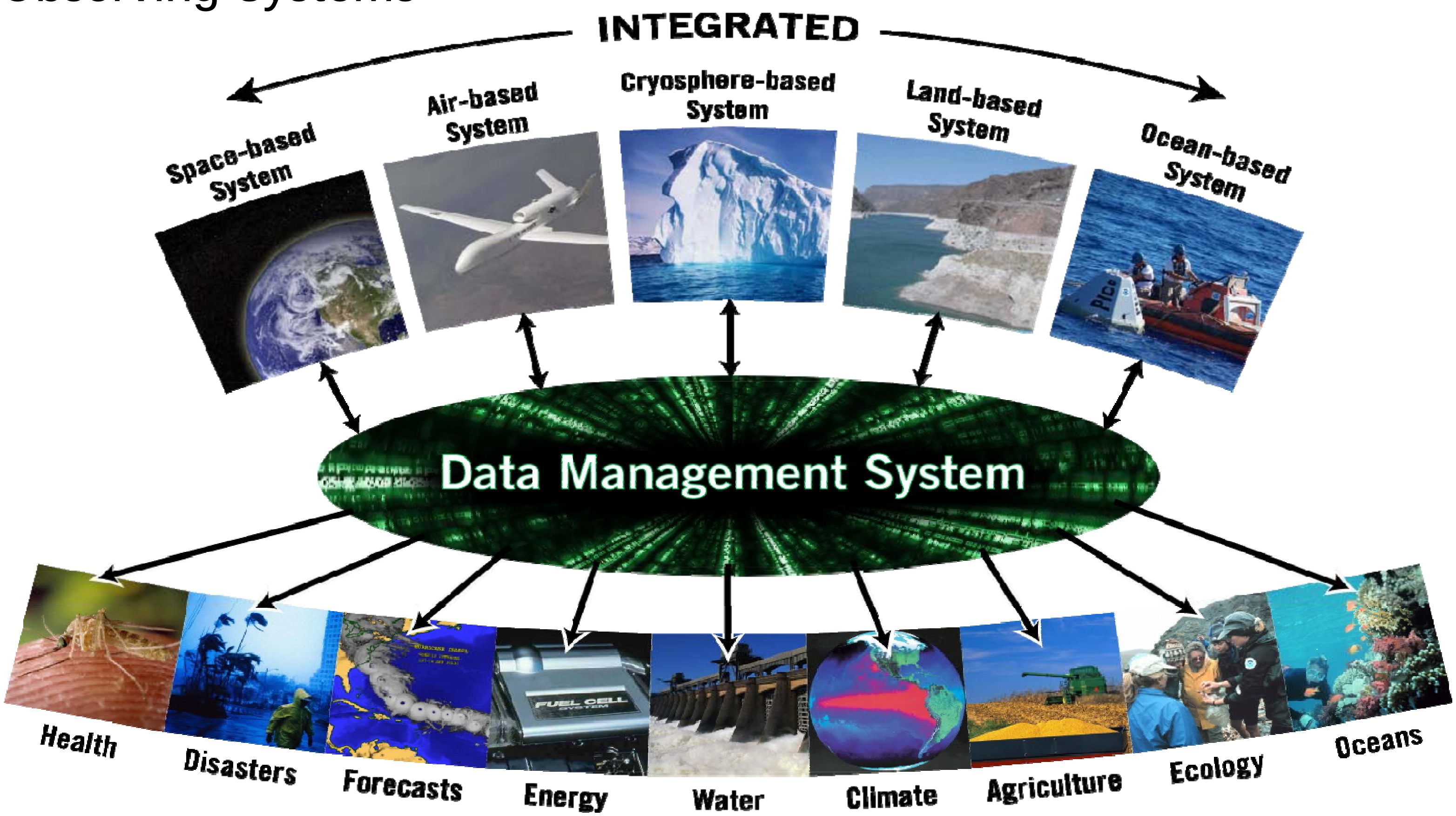
A Global, Coordinated, Comprehensive and Sustained System of Earth Observing Systems



Addresses the need for timely, quality, long-term, global information as a basis for sound decision making.

To detect and assess climate change, one needs to have a stable and reliable reference framework to underpin:

This framework underpins:

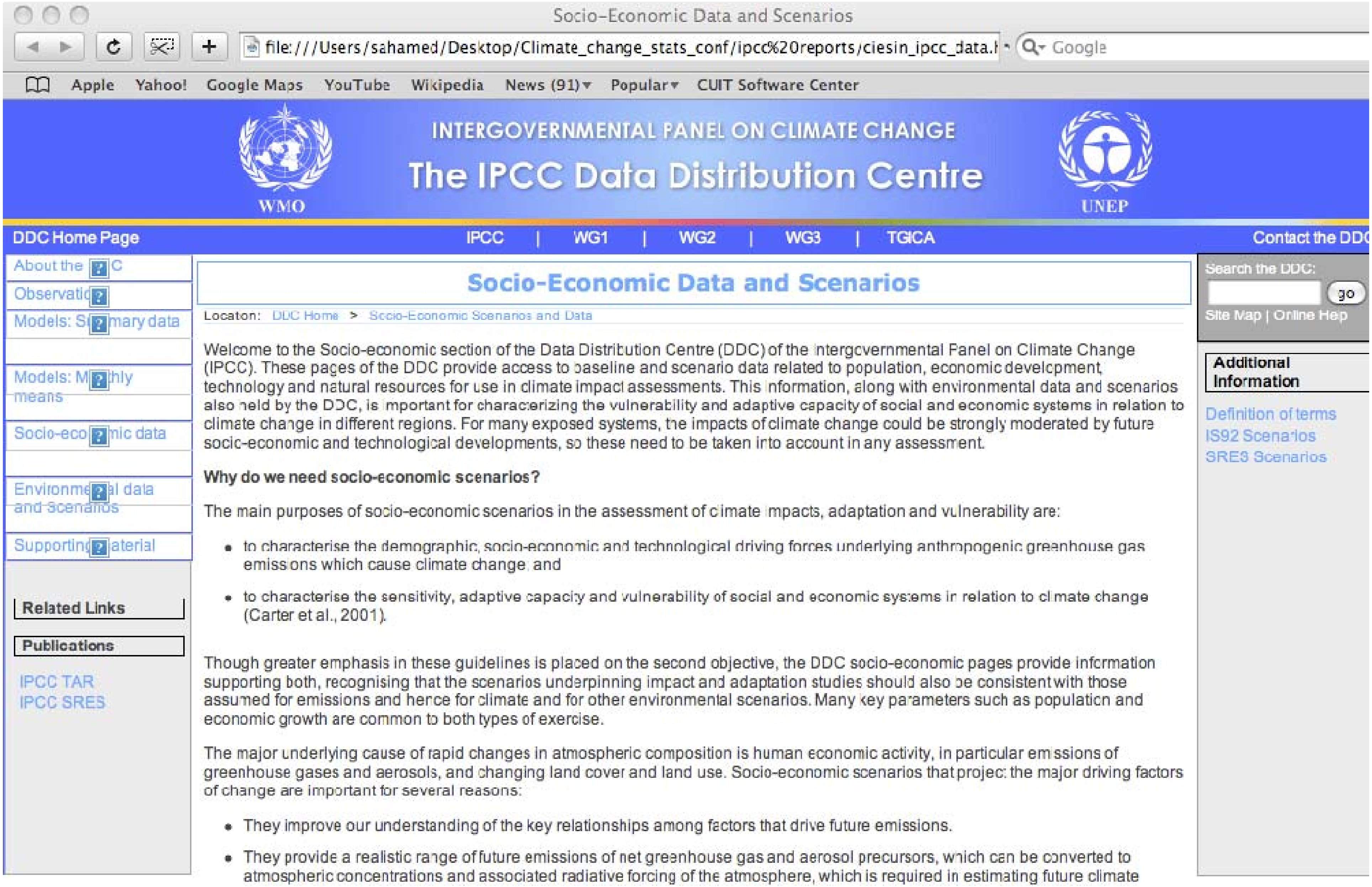
1) preparation of historical or baseline data on climatic, ecological, and socioeconomic conditions

2) development of consistent, long-term records for key parameters in which errors associated with calibration, georeferencing, instrument changes, etc. have been minimized and characterized

3) integration of different types of data to enable understanding of interactions and feedbacks between climatological, ecological, and human systems.

Conclusion

Unfortunately, SDI development even in developed countries is still fairly experimental, and figuring out how to establish an SDI capable of supporting the monitoring, detection, and prediction of climate change on decadal time scales remains a big challenge.


Socio-Economic Data and Scenarios

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IPCC SRES

Socio-Economic Data and Scenarios

Location: DDC Home > Socio-Economic Scenarios and Data

Welcome to the Socio-economic section of the Data Distribution Centre (DDC) of the Intergovernmental Panel on Climate Change (IPCC). These pages of the DDC provide access to baseline and scenario data related to population, economic development, technology and natural resources for use in climate impact assessments. This information, along with environmental data and scenarios also held by the DDC, is important for characterizing the vulnerability and adaptive capacity of social and economic systems in relation to climate change in different regions. For many exposed systems, the impacts of climate change could be strongly moderated by future socio-economic and technological developments, so these need to be taken into account in any assessment.

Why do we need socio-economic scenarios?

The main purposes of socio-economic scenarios in the assessment of climate impacts, adaptation and vulnerability are:

- to characterise the demographic, socio-economic and technological driving forces underlying anthropogenic greenhouse gas emissions which cause climate change, and
- to characterise the sensitivity, adaptive capacity and vulnerability of social and economic systems in relation to climate change (Carter et al., 2001).

Though greater emphasis in these guidelines is placed on the second objective, the DDC socio-economic pages provide information supporting both, recognising that the scenarios underpinning impact and adaptation studies should also be consistent with those assumed for emissions and hence for climate and for other environmental scenarios. Many key parameters such as population and economic growth are common to both types of exercise.

The major underlying cause of rapid changes in atmospheric composition is human economic activity, in particular emissions of greenhouse gases and aerosols, and changing land cover and land use. Socio-economic scenarios that project the major driving factors of change are important for several reasons:

- They improve our understanding of the key relationships among factors that drive future emissions.
- They provide a realistic range of future emissions of net greenhouse gas and aerosol precursors, which can be converted to atmospheric concentrations and associated radiative forcing of the atmosphere, which is required in estimating future climate

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Additional Information

Definition of terms
IS92 Scenarios
SRES Scenarios

For IPCC socio-economic data and scenarios:

http://sedac.ciesin.columbia.edu/ddc/