

Digital Climatic Atlas of Mexico

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Abstract

The Digital Climatic Atlas of Mexico uses current geomatics technologies, such as geographic information systems, satellite teledetection systems, global positioning systems, interactive multimedia digital cartography, Internet map servers, and the Web Map Service to map different climate variables from diverse sources and data bases of Mexico and Central America.

Through the Digital Climatic Atlas of Mexico it is possible to access the climatological monthly mean values of continental variables, derived bioclimatic parameters and scenarios of climate change at a very high spatial resolution (926 m). It also provides variables of oceanic climatology and socioeconomic indicators in different spatial resolutions and links to sea level data. The information is displayed in georeferenced maps in interactive systems in Internet, and can be downloaded in Geotiff and Text formats to be combined with information from other sources.

Keywords: *Digital Atlases, Internet Cartography, Climate Cartography, GIS Technologies, Geomatic Technologies, Geoscientific Cartography, Multimedia Cartography, Marine Cartography, Map Design and Production, Cartographic Visualization, Remote Sensing Technologies.*

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INTRODUCTION

The Digital Climatic Atlas of Mexico (DCAM) is developed in the Informatics Unit for Atmospheric and Environmental Sciences (abbreviated to UNIATMOS in Spanish) of the Atmosphere Sciences Center of the National Autonomous University of Mexico (abbreviated to UNAM in Spanish). The DCAM has been requested to establish a system that makes accessible relevant atmospheric data to the scientific community and users in general. These data should have such characteristics that can be used in combination with other data of different disciplines. Additionally, data should be offered together with those tools that provide free access and use, based on standards and metadata of exchange and classification of information, using the available technological advances that result in an efficient development of this system.

OBJETIVE OF THE ATLAS

The DCAM was created to make available maps of Mexico and Central America containing information of the different climatic variables which are required for a wide diversity of users, to display the distribution of bioclimatic parameters and to reflect regional climate change. In addition, there are many research studies related to biodiversity and to social and earth sciences where climate, bioclimatic, climate change and socioeconomic indicators cartography are basic factors.

The proposal of UNIATMOS is to apply the current geomatic technologies, such as geographic information systems (GIS), satellite teledetection systems, global positioning systems (GPS), interactive multimedia digital cartography, Internet map servers, the Web Map Service (WMS), as well as displays in KML (Keyhole Markup Language) formats,

to map in the web different climate variables from diverse sources and data bases, either national or international.

Educational and decision-making tool

The DCAM offers a new way to know and understand the climatology of the country and adjacent regions in a friendly and easy way. It is a high potential tool in all education levels and for users in general, as well. It is also a useful support to generate, display and manage climate change scenarios for Mexico and Central America at the national, state, regional and municipal levels. The integration and availability of inter-institutional information on climate for continental, oceanic and coastal regions as well as the socioeconomic, bioclimatic and climate change scenarios, allows decision-makers to have quantitative elements to make policy proposals that contribute to reduce vulnerability and to increase the adaptation capability for climate change in different sectors and regions.

CARTOGRAPHIC DISPLAYS, DATA AND METADATA

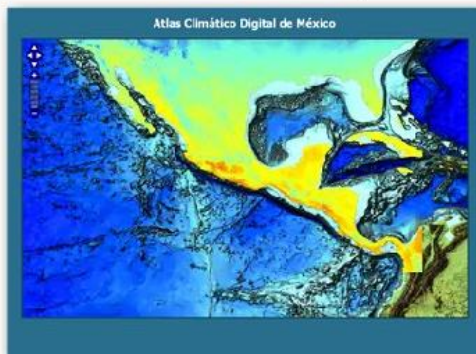
Through the DCAM it is possible to access the climatological monthly mean values of continental variables, derived bioclimatic parameters and scenarios of climate change at a very high spatial resolution (926 m). It also provides variables of oceanic climatology and socioeconomic indicators in different spatial resolutions and links to sea level data. The information is provided in georeferenced maps in interactive systems in Internet, and can be exported in Geotiff and Text formats to be combined with information from other sources. Access to the DCAM may be done through the web site <http://uniatmos.atmosfera.unam.mx> that includes four basic options: “Map server”, “Maps on line”, “Web Map Service” and “KML, Data and Metadata” (Fig. 1).

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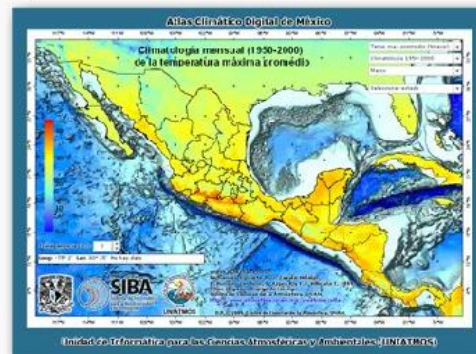
[Descargar calendario UNIATMOS 2010 en pdf](#)

[Resumen de avance del proyecto a enero de 2010](#)

Proyecto: Atlas Climático Digital de México (Presentación, validación y referencias)



Map Server
KML, data and Metadata



Maps on line
Web Map Service

Nueva capa: [Cobertura del suelo en América del Norte](#)



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Figure 1. “Map server”, “Maps on line”, “Web Map Service (WMS)” and “KML, Data and Metadata”.

Map server

The first option of the DCAM, “Map server”, was developed in the Geoserver open source system and allows the

visualization of thematic layers with different approaches in any geographic position. It is also possible to obtain detailed information on displayed layer. Moreover, users may displayed data of any thematic layer and combine it with reference layers such as: countries, Exclusive Economic Zone, states, municipalities, urban and rural locations, hydrological basins, rivers, lagoons and the Digital Elevation Models of Shuttle Radar Topography Mission (SRTM) and General Bathymetric Chart of the Oceans (GEBCO).

Maps on line

The second option, “Maps on line”, was structured in Adobe Flash multimedia platform. This option allows the visualization of integrated maps at a higher speed, to consult climate information in any geographic location and to make transparencies of the thematic layers with the Digital Elevation Models and to compare layers in a clear and easy way.

Both components described above complement each other and are addressed to different users. The first one is for users interested in get detail data values in specific geographic positions of the thematic displays. The second component is aimed at users interested in obtaining general climatic vision of data in an easy and efficient manner.

Web Map Service (WMS)

The layers of the maps in the DCAM may be requested through the Web Map Service (WMS) which is an international standard defined by the Open Geospatial Consortium (OGC). Requests may be done through WMS web map displayers, or by a compatible geographic information system. This way, users may displayed cartographic compositions of the Atlas with any other kind of information of their interest. The thematic and reference layers of the DCAM are available in the following WMS servers of UNIATMOS:

http://uniatmos.atmosfera.unam.mx:8082/geoserver2/wms?	(UNIATMOS Servidor 1)
http://uniatmos.atmosfera.unam.mx:8083/geoserver3/wms?	(UNIATMOS Servidor 2)
http://uniatmos.atmosfera.unam.mx:8084/geoserver4/wms?	(UNIATMOS Servidor 3)
http://uniatmos.atmosfera.unam.mx:8085/geoserver5/wms?	(UNIATMOS Servidor 4)
http://uniatmos.atmosfera.unam.mx:8086/geoserver6/wms?	(UNIATMOS Servidor 5)
http://uniatmos.atmosfera.unam.mx:8087/geoserver7/wms?	(UNIATMOS Servidor 6)
http://uniatmos.atmosfera.unam.mx:8088/geoserver8/wms?	(UNIATMOS Servidor 7)
http://uniatmos.atmosfera.unam.mx:8089/geoserver9/wms?	(UNIATMOS Servidor 8)
http://uniatmos.atmosfera.unam.mx:8090/geoserver10/wms?	(UNIATMOS Servidor 9)
http://uniatmos.atmosfera.unam.mx:8091/geoserver11/wms?	(UNIATMOS Servidor 10)
http://uniatmos.atmosfera.unam.mx:8092/geoserver12/wms?	(UNIATMOS Servidor 11)
http://uniatmos.atmosfera.unam.mx:8093/geoserver13/wms?	(UNIATMOS Servidor 12)
http://uniatmos.atmosfera.unam.mx:8094/geoserver14/wms?	(UNIATMOS Servidor 13)

KML, Data and Metadata

Other mean to visualize the cartographic compositions of the Atlas is available through the option “KML, Data and Metadata”. The KML format is compatible with programs such as Google Earth, Google Maps and Google Mobile, and may be attached with all the components and facilities of these programs.

The map data bases of the DCAM may be downloaded in Geotiff and Text formats with their corresponding metadata which were structured in accordance with the Federal Geographic Data Committee (FGDC) standard. Metadata are available in html and xml formats.

INFORMATION SOURCES

Continental climatology

Continental climatic information of the DCAM and derived bioclimatic parameters (Fig. 2), are based on detailed measurements from different sources, mainly those of the National Meteorological Service of Mexico, as well as information on climate data bases obtained from the National Climatic Data Center (NCDC). These data were interpolated at very high resolution (926 m) with an objective methodology implemented by Hijmans *et al.* (2005) which considers the topographic effects in order to ensure covering quality and proposed resolution. Data for Mexico were validated and processed through geographic information systems.

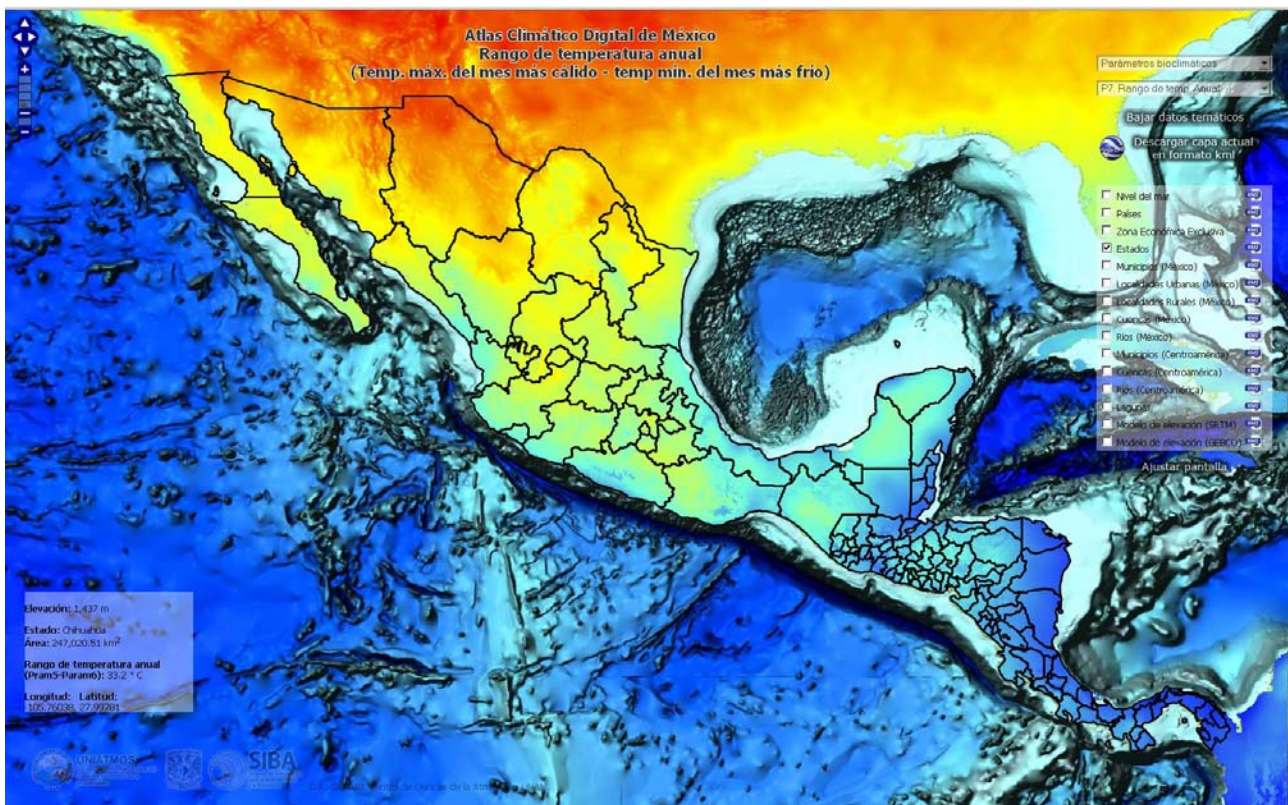


Figure 2. Example of a bioclimatic parameter: Annual Temperature Range

Oceanic climatology

Sea surface temperature and chlorophyll-a concentration were processed from data of night-time images of the NASA satellite sensor AquaMODIS of 4 microns, with spatial resolution of four kilometers. Respective anomalies were calculated from the Aqua MODIS data, with the same spatial resolution of 4 km (Fig. 3).

Climatological surface winds over the ocean were processed based on the QuikSCAT scatterometer data of the NASA, and were processed and interpolated to be displayed in the Atlas with a resolution of 30' (55 km) according to Romero-Centeno *et al.* (2007).

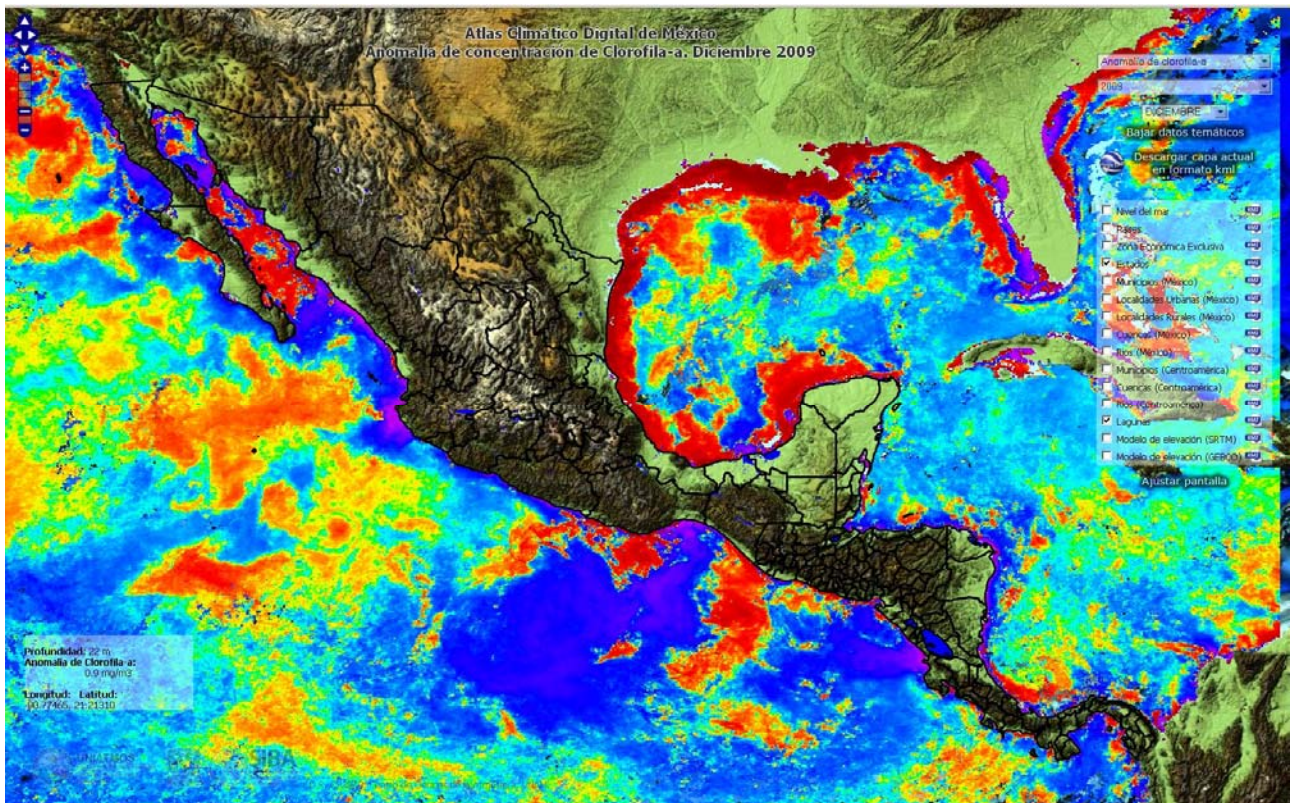


Figure 3. Chlorophyll-a concentration anomaly (mg/m^3) for December 2009

Global Circulation Models and climate change scenarios

Sources for the cartography of climate change models and scenarios (Fig. 4) are the Global Circulation Models and emissions scenarios of the Intergovernmental Panel on Climate Change (IPCC) which were processed and downscaled for Mexico and Central America at very high resolution (926 m) based on the Model for the Assessment of Greenhouse-gas Induced Climate Change. A Regional Climate Scenario Generator. Version 5.3.v2, based on guidelines established by Conde *et al.* (2008).

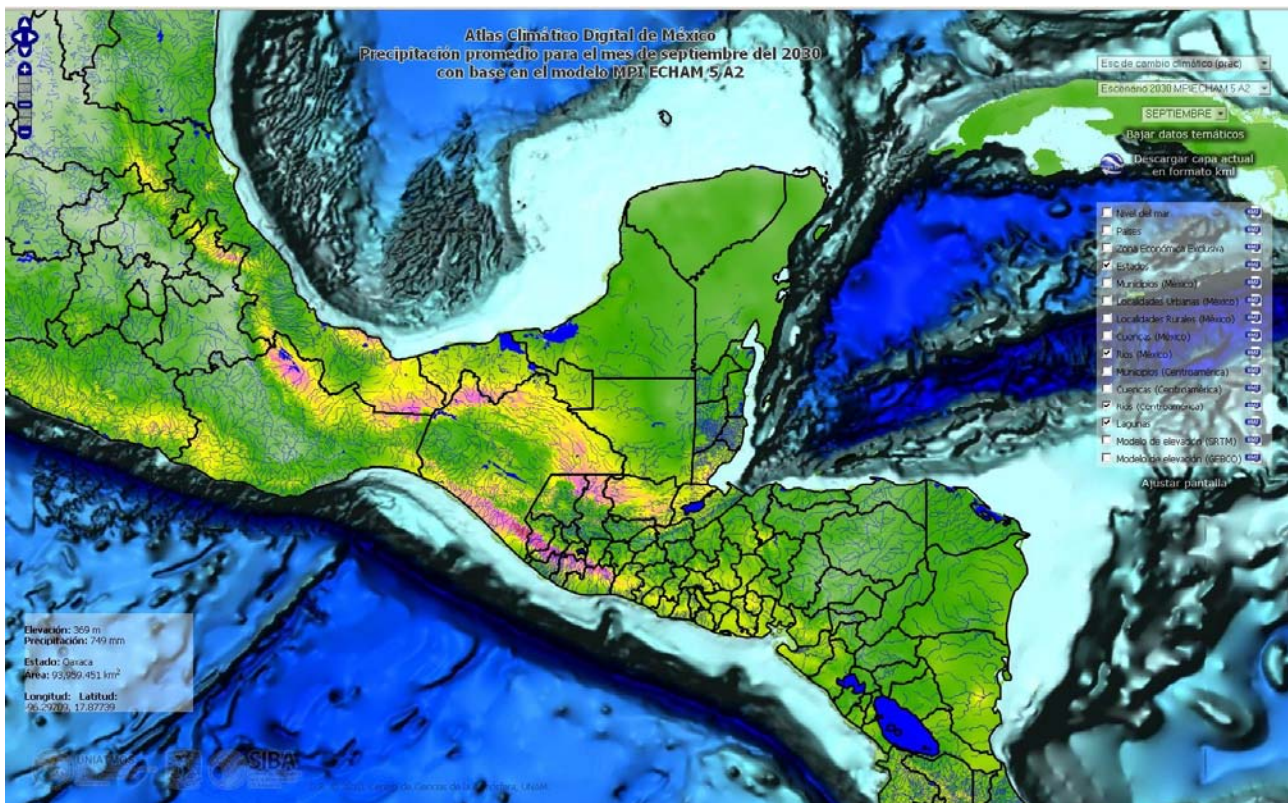


Figure 4. Precipitation for September 2030 based on MPI ECHAM 5 A2 Regional Climate Change Scenario

Sea Level

Information on the sea level comes from the National Sea Level Network of Mexico at the Geophysics Institute of UNAM. The Network holds, records and analyses the information of tide measurements in several locations of Mexico. Sea level measures carried out by UNAM represents an important effort to monitor the coastal environmental variables in Mexico.

Socioeconomic indicators and scenarios

Information on socioeconomic indicators and scenarios is based on the *Greenhouse Gas Initiative (GGI) Program of the International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria*, which has a half degree spatial resolution (55 km).

Land cover

The Land Cover layer in the DCAM reveals the complex mosaic of forest, prairies, deserts, and cities, that will help researchers to analyze issues related to climate change, carbon sequestration, biodiversity loss, and changes in ecosystem structure and function. The information will also support nongovernmental organizations, government decision makers, and other users with an interest in land cover dynamics and conservation.

This map is based on observations from satellite images acquired in 2005 by the Moderate Resolution Imaging Spectroradiometer (MODIS). It is a product with 250 m of spatial resolution of the North American Land Cover Monitoring System (NALCMS), an international collaborative effort facilitated by the Commission for Environmental Cooperation's (CEC) North American Environmental Atlas initiative.

The North American land cover work was initiated at the 2006 Land Cover Summit in Washington, DC. Since then, specialists from government agencies in Canada, Mexico and the United States have worked together to produce the Land Cover 2005 map and develop the North American Land Change Monitoring System.

Participating agencies include Natural Resources Canada/Canada Centre for Remote Sensing (NRCan/CCRS), the

United States Geological Survey (USGS), and three Mexican organizations: Instituto Nacional de Estadística y Geografía (INEGI), Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (Conabio), and the Comisión Nacional Forestal (Conafor).

Digital Elevation Models

The Digital Elevation Models were developed based on data from the General Bathymetric Chart of the Oceans (GEBCO) with a spatial resolution of 1' (1.8 km) and from the Shuttle Radar Topography Mission (SRTM) database produced by the National Aeronautical Space Agency (NASA) with 90 m resolution, according to the adjustment and modification performed by the Consortium for Spatial Information - Consultative Group for International Agriculture Research (CGIAR-CSI).

Reference or base layers

The municipal, state, island, coast and border boundaries, as well as urban and rural locations of Mexico, were taken from the 2009 update of INEGI's municipal geostatistics framework. The vector information on hydrological basins and lagoons comes from INEGI's data bases. Borders of other countries, as well as data on basins, rivers and lagoons were taken from the Mesoamerican Environment Information System (abbreviated to SIAM in Spanish) and processed to make an integrated Central American Data base.

VALIDATION OF THE CONTINENTAL CLIMATIC INFORMATION

Within the context of the DCAM project, the combination of tools of Geographic Information Systems (GIS), statistics methodologies and objective interpolation techniques, it is adequate to create the climatic and climate change scenarios cartography at a regional level for Mexico. Such cartography is highly useful to better understand and manage our environment. Its validation is not only important to prove the objectivity of the cartographic process, but also to calculate the associated error of the resulting maps. It is important to note that the validation is a key element not only to assess the cartographic quality of a map, but also to have a reliability parameter of the resulting product.

Based on the aforementioned, a comparison was carried out –through the different statistic parameters- between the values obtained from the WorldClim climatic data base and the data observed in 1,900 meteorological stations of the country, which have records for more than 30 years (Fig. 5). An example of the results obtained are reflected in Figure 6, which shows the root mean squared error (rmse), the mean differences (media dif) and the geographic distribution of the differences for the mean maximum temperature in January. The validation process was applied to mean maximum temperature, mean minimum temperature and mean precipitation for each one of the 12 months in the 1950-2000 climatic period.

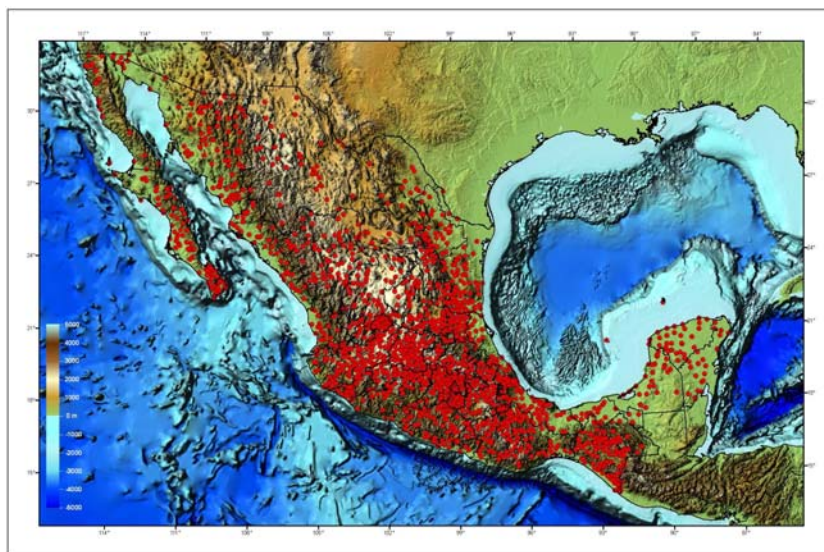


Figure 5. Location of the meteorological stations of the National Meteorological System with more than 30 years of records.

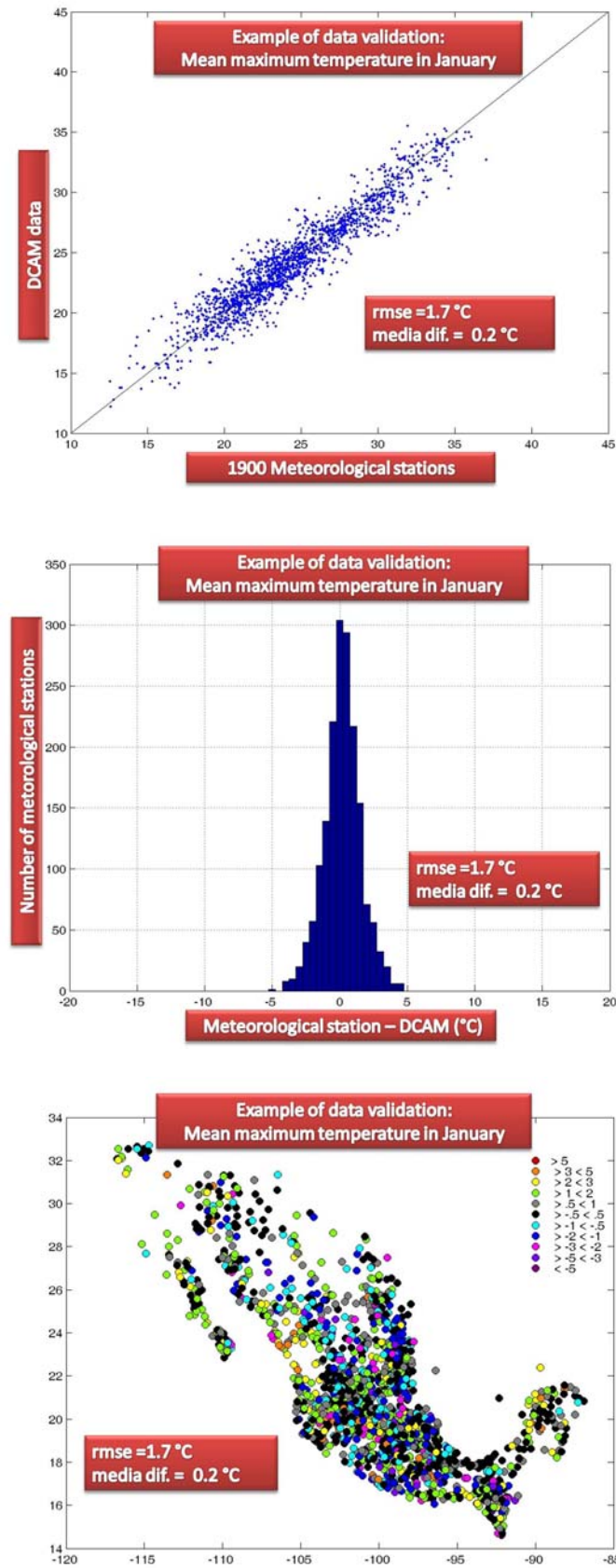


Figure 6. Example of data validation: Mean Maximum Temperature in January

CONTENTS OF THE ATLAS

Thematic cartography

Continental climatology, ocean climatology, climate change projections, bioclimatic parameters, sea level, land cover, socioeconomic indicators and projections.

Reference or basic cartography

Countries, Exclusive Economic Zone, states, municipalities, urban and rural locations, hydrological basins, rivers, lagoons and Digital Elevation Models.

ACCESS TO THE ATLAS

The DCAM may be accessed through the following address: <http://uniatmos.atmosfera.unam.mx>, or through the website of the Atmosphere Sciences Center of the National Autonomous University of Mexico: <http://www.atmosfera.unam.mx>

QUOTING

The authors of the DCAM, request quoting any of the data or the maps thereof contained, as follows:

Fernandez-Eguiarte A., J. Zavala-Hidalgo., R. Romero-Centeno. 2010. Atlas Climático Digital de México. Centro de Ciencias de la Atmósfera. UNAM. <http://uniatmos.atmosfera.unam.mx/>

ACKNOWLEDGMENTS

The ACDM is part of the Information System for Biodiversity and Environment Project of UNAM (abbreviated to SIBA in Spanish). The authors would like to thank the invaluable contributions to: Carlos Gay García, María Amparo Martínez Arroyo, Claudio Mario Amescua García, Enrique Azpra Romero, Francisco Javier Villicaña, Olmo Sebastián Zavala Romero, Oscar Calderón Bustamante, Eduardo E. Estrada Hernández †, Miguel Ángel Flores Espinosa, Erika Mendoza Peña, María Elena Osorio Tai, Carolina Ivonne Castelán Hernández, Artemio Gallegos García, Ana Cecilia Conde Álvarez, Francisco Estrada Porrúa and Benjamín Martínez López.

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<http://www.mareografico.unam.mx/Mareografico/>

Sistema de informática para la biodiversidad y el ambiente (SIBA)
http://www.cic-ctic.unam.mx/cic/mas_cic/megaproyectos/impulsa_5.cfm

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<http://www2.jpl.nasa.gov/srtm/>

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