

Climate analysis and monitoring

Guidance

[Guide to Climatological Practices \(WMO-No. 100\)](#)

All the relevant information regarding the most important practices and procedures in climatology is established in the Guide to Climatological Practices.

[Technical Regulations Volume I: General Meteorological Standards and Recommended Practices \(WMO-No. 49\)](#)

This volume contains the regulations of the World Weather Watch, climatology; meteorological services for marine activities, agriculture and environmental pollution; meteorological bibliography and publications; education and training; units and procedures used in international meteorological research programmes and during special observational periods.

Disaster Risk Reduction

[Associate Programme on Flood Management \(APFM\) Tool Series](#)

The Guidance synthesizes and conceptualizes the approach that can be taken to address the issue of flash floods both on the national and (for flash floods most importantly) on the lower administrative scales of districts and communities. It may serve as a tool to reach out to local communities, mayors, emergency services on various administrative scales and the National Hydrological and Meteorological Services on broader scales to maximize the impact of this initiative towards a significant reduction of the vulnerability of flash flood affected communities and the associated deaths and misery.

[Guidance on Flash Flood Management – Recent experiences from Central and Eastern Europe](#)

The Guidance synthesizes and conceptualizes the approach that can be taken to address the issue of flash floods both on the national and (for flash floods most importantly) on the lower administrative scales of districts and communities. It may serve as a tool to reach out to local communities, mayors, emergency services on various administrative scales and the National Hydrological and Meteorological Services on broader scales to maximize the impact of this initiative towards a significant reduction of the vulnerability of flash flood affected communities and the associated deaths and misery.

[Guidelines on International cross-border collaboration in the warning process \(WMO/TD No. 1560\)](#)

This document provides guidelines on international collaboration in the warning process for severe weather threats and extreme conditions (heat wave, cold wave, drought, storm surge, avalanches, flooding.) It discusses general principles regarding cross-border exchange of warnings and includes the role of the media in raising the public's expectations, focus on public safety, threshold criteria and the scope of cooperation. It also presents examples from different parts of the world to illustrate the factors to be considered in developing international or cross-border collaborations in the warning process for cyclones, earthquakes, tsunamis, and storm surge. It offers a number of observations and suggestions for consideration by countries that may wish to set up bilateral, regional or

international collaboration in the framework of establishing internationally effective systems of warnings.

[National Drought Management Policy Guidelines: A Template for Action](#)

The National Drought Management Policy Guidelines provide a template for action that countries can use in the development of a national drought management policy and drought preparedness/mitigation plans. The process is structured in 10 steps that can be adapted by countries to reflect their institutional, infrastructure, legal, socio-economic and environmental context. It includes case studies from Brazil, Mexico, Morocco and the USA. The Guidelines respond to a need for action-oriented drought policies, which Governments articulated at the High-Level Meeting on National Drought Policies.

[Natural Small Water Retention Measures combining drought mitigation, flood protection, and biodiversity conservation - Guidelines](#)

These Guidelines summarize the outcomes and lessons learnt of the IDMP CEE project on Natural Small Water Retention Measures (NSWRM) implemented by a group of experts from Central and Eastern Europe in the period 2013–2015. The innovative aspect of the approach presented in this publication consists in the active human involvement in the maintenance and the exploitation of the existing water systems. New methods have been suggested to restore the natural water retention capacity of catchments, including drainage systems in river valleys, irrigation techniques, and small hydro-technical investments, such as small damming reservoirs or damming on watercourses. The Guidelines are complemented by a collection of Case Studies from four countries in Central and Eastern Europe (Hungary, Slovakia, Slovenia, and Poland) presenting climatic and topographic conditions representative of the existing situation in the whole region.

[Standardized Precipitation Index User Guide \(WMO-No. 1090\)](#)

The Standardized Precipitation Index (SPI) is a widely used index by all National Meteorological and Hydrological Services (NMHSs) to characterize meteorological drought on a range of timescales in addition to other drought indices currently in use. This guide is a comprehensive SPI user Manual providing a description of the index, the computation methods, specific examples of where it is currently being used, the strengths and limitations, mapping capabilities, and how it can be used.

[WMO Guidelines on Multi-hazards Impact-based Forecast and Warning Services \(WMO-No. 1150\)](#)

These Guidelines establish a road map that identifies the various milestones from weather forecasts and warnings to multi-hazard impact-based forecast and warning services. For completeness, these Guidelines also describe the ultimate step of forecasting actual impacts, although it is recognized that this is a highly sophisticated exercise, requiring strong collaboration with partner agencies and significant research into exposure and vulnerability. For many WMO Members this step will not be the responsibility of the National Meteorological and Hydrological Service (NMHS) but rather that of the relevant Disaster Reduction and Civil Protection Agencies (DRCPA) and other partners.

Agriculture and Food Security

[Guide to Agricultural Meteorological Practices \(GAMP\) \(WMO-No. 134\)](#)

The aim of the guide is to provide, in a convenient form, information regarding the most important practices and procedures in agricultural meteorology.

Water Resources

[Cryosphere Glossary](#)

The Global Cryosphere Watch (GCW) has compiled a database of cryosphere terms from a variety of sources, including WMO, UNESCO, the National Snow and Ice Data Center (NSIDC), Antarctic Sea Ice Processes and Climate (ASPeCt), Environment Canada, the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Geological Survey (USGS).

[Glossary of Glacier Mass Balance and Related Terms \(UNESCO/IHP, 2011\)](#)

This Glossary is a comprehensive update of glacier mass-balance terminology and promotes clarity and reduces ambiguity in the communication of information about glacier mass balance, as well as to provide a range of useful ancillary material. The scope of the Glossary extends beyond the measurement of mass balance. There are articles covering such subjects as glacier zonation; the definition of glacier features and morphological types of glaciers; the administrative structures within which mass-balance data are archived once collected; and the modelling of mass balance.

[Guide to Hydrological Practices \(WMO-No.168\)](#)

The Guide to Hydrological Practices provides practicing hydrologists reliable information on hydrological practices, from simple discharge measurement to modeling complex hydrological systems.

[Guidelines on the role, operation and management of National Hydrological Services \(WMO-No. 1003\)](#)

All aspects of management are reviewed: strategic planning, human resources management, financial management, marketing, asset management, process and quality management, relationships with other institutions. This publication is especially important at a time when NHSs worldwide are typically having their mandate expanded from basic hydrology to hydrology in the broader context of sustainable water resources management.

[Ice Chart Colour Code Standard \(WMO/TD No. 1215\)](#)

While the WMO international standard for ice charts only dealt with black and white charts, in keeping with the paper facsimile technology of the time, colour has long been used to help differentiate the various ice conditions on a paper chart. In the last decade, progress in computer processing and communication, as well as increased demands of users prompted the necessity to develop a new WMO International Ice Colour Code Standard for ice charts.

[International Glossary of Hydrology \(WMO-No. 385\)](#)

This publication is useful to National Hydrological Services as well as educational and research institutions throughout the world to facilitate the translation of technical and scientific publications and the understanding and communicating information about the field of hydrology. More than 1500 equivalent terms in English, French, Russian and Spanish, with definitions in these languages, are included. Also included is the Universal Decimal Classification (UDC) scheme for hydrology in English and Russian as well as tables of recommended symbols and units for hydrological purposes.

[Manual on estimation of Probable Maximum Precipitation \(PMP\) \(WMO-No. 1045\)](#)

The Manual describes procedure for estimating the maximum probable precipitation and the maximum probable flood. This is the third revised version.

The first and second editions of this Manual were published in 1973 and 1986, respectively. The current edition keeps a majority of the content from the second edition. Newly added content in this third edition primarily results from experiences, since 1986, in directly estimating PMP for the requirements of a given project in a design watershed on probable maximum flood (PMF) in China, the United States of America, Australia and India.

[Manual on flood forecasting and warning \(WMO-No. 1072\)](#)

The Manual on Flood Forecasting and Warning provides the basic knowledge and guidance to develop or to set up an appropriate and tailored system for any case in which a flood forecasting and warning system is required. The aim is to provide a succinct but comprehensive overview of the basic knowledge and information that the relevant personnel of the National Meteorological or Hydrometeorological Services or other flood management service should require.

[Manual on Low-flow Estimation and Prediction \(WMO-No. 1029\)](#)

The Manual's objective is to publish state-of-the-art analytical procedures for estimating and predicting low river flows at all sites, regardless of the availability of observational data. The Manual will be useful for many applications, including water resources planning, effluent dilution estimates and water resources management during low-flow conditions.

[Manual on Stream Gauging, Volume I: Fieldwork \(WMO-No. 1044\)](#)

The Manual on Stream Gauging (WMO No. 519) was first released in 1980. Since then, however, there have been significant advances both in the approach and the methodologies employed. Consequently, at its twelfth session (Geneva, October 2004), the WMO Commission for Hydrology (CHy) decided to meet the identified needs of the National Hydrological Services (NHSs) by revising the Manual to include the newer technologies that have been introduced over the period and are currently employed in this crucial field.

[WMO Sea-Ice Nomenclature \(WMO-No. 259\)](#)

The international system of sea-ice symbols is intended for use on synoptic and prognostic ice charts which are issued by national ice centres, either by radio-facsimile or by mail, primarily to serve operational marine activities. Charts transmitted to users by ice-observing units should also follow the international system. Additional symbols determined on the basis of regional or national requirements may be added, provided that they do not overlap or contradict the international system.

[Snow Dataset Inventory](#)

The Snow Dataset Inventory is an inventory of satellite-derived, in situ, and analysis/reanalysis snow datasets, compiled by the Snow Watch Team as of 23 February 2015. It is an up-to-date and comprehensive inventory of snow cover datasets in light of the significant increases in sources of snow cover information over the past decade. The inventory is provided in three categories: (1) Satellite-derived snow products and datasets, (2) Analyses, reanalysis and reanalysis-driven snow products and datasets, and (3) In-situ snow products and datasets. The inventory is meant as a living document with updates and additions incorporated on an ongoing basis.

[Technical Regulations, Volume III: Hydrology \(WMO-No. 49\)](#)

This volume contains definitions of technical terms, a classification of hydrological observing stations, and guidance on the establishment of networks of these stations, their identification, observing programmes, equipment and methods of observation. It also contains a chapter on meteorological services for hydrology.

[The International Classification for Seasonal Snow of the Ground \(UNESCO/IHP, 2009\)](#)

Part 1 of the classification describes the fundamental characteristics of snow on the ground as well as a link to snow microstructure that is examined in Appendix B. Part 2 introduces additional features of snow as well as important measurements of the snow cover. Appendix A presents the grain shape classification, including photographic material. Basic guidelines for snow and snowpack observations are provided in Appendix C. The final three Appendices list the symbols used (D), define principal terms used in the text (E), and present a multilingual list of terms (F). A comprehensive but non-exhaustive bibliography completes the document.

Health

[Heatwaves and Health: Guidance on Warning-System Development \(WMO-No.1142\)](#)

The publication provides meteorological and/or climate-prediction based information on the likelihood of forthcoming hot weather that may have an effect on health. This information is used to alert decision-makers and the general public to impending dangerous hot weather and for the implementation of a range of actions designed to reduce the negative health effects of hot weather extremes.

Energy

[IMPACT2C web-atlas](#)

The IMPACT2C web-atlas depicts the climate change impacts of a +2°C global warming for the key sectors – energy, water, tourism, health, agriculture, ecosystems and forestry, as well as coastal and low-lying areas, – at both the pan-European level, and for some of the most vulnerable regions of the world. By using a multi-model ensemble of both climate and impact projections it is possible to define ranges of impacts and therefore quantify some of the uncertainty around future climate and climate impact projections.

[Best Practice Guidelines for Mesoscale Wind Mapping Projects for the World Bank](#)

The purpose of this paper is to provide a draft set of best practice guidelines for the procurement of mesoscale wind maps in the World Bank Group. The paper explains the basics of the method, its use and its limitations, and provides a set of guidelines to assess the quality and in particular the usability of products supplied by suppliers of mesoscale modeling work.

[Beyond Downscaling – A bottom-up approach for climate change adaptation for Water Resources Management](#)

Climate change adds uncertainty to already complex global water challenges. Because climate change affects poorer countries and vulnerable populations the most, the World Bank strives to mainstream climate change considerations into its operations to inform investment and water resources management decisions. Although no standard method has been adopted yet by the Bank, common practice used downscaled projected precipitation and temperature from Global Climate Models (GCMs), as input to hydrologic models. While this has been useful in some applications, they often give too wide a dispersion of readings to provide useful guidance for site-specific water resources management and infrastructure planning and design. Rather than design for an uncertain situation selected a priori, the so-called “bottom-up” approaches explore the sensitivity of a chosen project to the effects of uncertainties caused by climate change.

[Center for Climate and Energy solutions](#)

The Center for Climate and Energy Solutions (C2ES) maintains a page on their website dedicated to mapping state and regional climate actions in the United States. On this page, users can view maps by different sectors.

[IRENA Global Atlas for Renewable Energy](#)

The Global Atlas for Renewable Energy is an initiative coordinated by IRENA, aimed at closing the gap between nations having access to the necessary datasets, expertise and financial support to evaluate their national renewable energy potential, and those countries lacking such elements. As of January 2015, 67 countries and more than 50 institutes and partners were contributing to the initiative. The Global Atlas facilitates a first screening of areas of opportunity where further assessments can be of particular relevance. It enables the user to overlay information listed in a catalog of more than 1 000 datasets, and to identify areas of interest for further prospection. IRENA is continuously adding information to the system.

[IRENA Project Navigator](#)

Tools and templates to develop a bankable renewable energy project proposals.

[SMHI Energy](#)

SMHI offers products and services for the energy sector designed to facilitate decision-making.

[Energypedia](#)

Energypedia is a wiki-based platform for collaborative knowledge exchange on renewable energy and energy efficiency in developing countries. Securing access to modern and sustainable energy services for developing countries is a significant challenge for development. Access to sustainable energy services can power opportunities for environmental, social and economic development.

[ESMAP Tools](#)

ESMAP has contributed significantly to the development of knowledge tools to guide decision-making about climate change mitigation and low carbon development. Such modeling and planning tools help generate consensus on data and assumptions among a wide range of stakeholders, and the outputs provide a valuable evidence base upon which to define priorities and design policy responses.

[Making the energy sector more resilient to climate change \(IEA\)](#)

The energy sector faces multiple threats from climate change, in particular from extreme weather events and increasing stress on water resources. Greater resilience to climate change impacts will be essential to the technical viability of the energy sector and its ability to cost-effectively meet the rising energy demands driven by global economic and population growth.

Energy sector stakeholders, including governments, regulators, utilities/energy companies and financial institutions (banks, insurers, investors), will need to define climate change resilience and adaptation challenges and identify actions needed to address these challenges.

[World Energy Perspective – The road to resilience - Managing and financing extreme weather risk](#)

This report focuses on identifying and characterizing the nature, frequency and severity of extreme weather risks across the world. By understanding how to technically and financially address these risks, the report provides recommendations for the energy industry to work together with the financial community, investors and policymakers to share and promote measures that must be incorporated into energy infrastructure design and investment decisions.

[Sample Guidelines: Cumulative Environmental Impact Assessment for Hydropower Projects in Turkey](#)

The general objectives of the Guidelines are to improve or strengthen the Environmental Impact Assessment process and implementation, provide support for studies related to Strategic Environmental Assessment (SEA) Regulation and future SEA processes, and promote the sustainable development of natural resources as well as enhance basin management planning.

[Wind Resource Measurement: Guidelines for Islands](#)

The Guidelines offer insights on the goals of measurement campaigns, the basics of wind resource assessment, selection of sites for wind projects and wind monitoring, and the number and placement of measurement systems. Different types of tall towers and sensors, remote sensing systems, installation and operation, and data storage and retrieval are also examined, along with quality control and data validation procedures.

Training

Integrated Water Resources Management and Climate Change

These training materials are intended to increase the understanding about climate change and to explore opportunities of action. There are actions that can be taken to prepare for a more variable climate and we can make a case to our policy makers to prepare for change. The most important immediate action concerns the way water resources are managed. Improving water management today will prepare to adapt tomorrow. Improved understanding of water resources will allow more efficient and flexible allocation systems and better investment in infrastructure, both to improve access to water and reduce risks from climate change.

Derive Products from Climate Data

These training modules aims to derive climate products using climatological records and datasets. Essentially, how do we create visually appealing graphics after the data has been collected? The first section of the competency allows the user to learn about the climatological patterns that are typically analyzed through these products. This gives the user a greater understanding of climate in general and allows them to better understand the derivation of familiar graphics. The second section dives into how the products are actually created, with a plethora of examples containing climate information touched upon in the previous modules. The last module ties all the information together, applying statistical analysis techniques to large scale climatology.

Part One: Background in Key Climate Concepts/Patterns:

1. Introduction to Statistics for Climatology:
https://www.meted.ucar.edu/education_training/lesson/500
2. ENSO and Beyond: https://www.meted.ucar.edu/education_training/lesson/113
3. The Madden-Julian Oscillation Life Cycle: <https://www.meted.ucar.edu/climate/mjo/>
4. Arctic Meteorology and Oceanography:
https://www.meted.ucar.edu/education_training/lessons/758
5. Understanding Drought: https://www.meted.ucar.edu/education_training/lesson/514

Part Two: Creation of Climate Products:

1. NCAR Climate Data Guide:
https://www.meted.ucar.edu/education_training/lesson/1226
2. Satellite-Derived Climatology Products for Monitoring Convection over West and Central Africa: https://www.meted.ucar.edu/education_training/lesson/1205
3. Creating a Local Climate Product Using Composite Analysis:
<https://www.meted.ucar.edu/climate/composite/>

Ensure Quality of Climate Information and Services

These training modules focus on ensuring the quality of climatological products. This competency focuses on explaining the importance and real world purposes of the first three competencies. The above modules are all specific examples on how analysis of climate data and forecasting applies to very specific circumstances. The user will complete these modules and have a deeper understanding of why climate products are important.

1. ASMET: 2009 Drought in East Africa
https://www.meted.ucar.edu/education_training/lesson/923
2. Ocean Acidification: https://www.meted.ucar.edu/education_training/lesson/1195
3. Using the Local Climate Analysis Tool (LCAT) for Water Resilience Decisions:
https://www.meted.ucar.edu/education_training/lesson/1244
4. How Cloud Seeding Works:
https://www.meted.ucar.edu/education_training/lesson/10054
5. Using Climatological Products in Common Operations:
https://www.meted.ucar.edu/education_training/lesson/512

Communicate Climatological Information with Users

These training modules focus on how to properly communicate climate products and forecasts with the general public. This is a key issue, considering how audiences that need this information may have little background in regard to climate. The video modules provide a background into how scientific information, specifically climate, is structured to be easily accessible and readable. The second and third modules dive deeper into communicating specific issues such as drought and climate change.

1. Climate Variability and Lectures:
 - a. Climate Science Communication:
https://www.meted.ucar.edu/climate/cvc_lectures/media/flash/arndt_communication.mp4

- b. Climate Communication Skills for Use with Decision Support Audiences:
https://www.meted.ucar.edu/climate/cvc_lectures/media/flash/buhr_clim_communication.mp4
- 2. Communicating Subseasonal to Seasonal Impacts:
 - a. Climate Weather Interactions:
https://www.meted.ucar.edu/education_training/lessons/10157
 - b. Drought: https://www.meted.ucar.edu/education_training/lesson/10174
 - c. Climate Change:
https://www.meted.ucar.edu/education_training/lesson/10173
- 3. Communicating Climate Change Scenarios with Decision Makers:
https://www.meted.ucar.edu/education_training/lesson/1283

Tools for analyzing and monitoring data

Data analysis

[Climate Data Library](#)

The IRI Data Library is a powerful and freely accessible online data repository and analysis tool that allows a user to view, analyze, and download hundreds of terabytes of climate-related data through a standard web browser.

[ClimateHD](#)

Climate HD is an online tool that provides an integrated visualization of past and future climate evolution on a national and regional scale - available for France.

[ClimPACT2](#)

The ClimPACT software is based on the RClimDEX software developed by the WMO CCI/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (ETCCDI). ClimPACT is the software for calculating indices of climate extremes including SPI and SPEI.

[iTacs \(Interactive Tool for Analysis of the Climate System\)](#)

iTacs stands for Interactive Tool for Analysis of the Climate System. It is a web-based application developed by the Japan Meteorological Agency (JMA) to assist National Meteorological and Hydrological Services (NMHSs) in their production of analysis information on extreme climate events and their climate status monitoring. It can be accessed via web browsers without the need for additional software or plug-ins.

[KNMI Climate Explorer](#)

The KNMI Climate Explorer is a web application to analyze climate data statistically. It contains more than 10 TB of climate data and dozens of analysis tools. It is part of the WMO Regional Climate Centre at KNMI.

[Local Climate Analysis Tool](#)

The Local Climate Analysis Tool (LCAT) helps users identify climate-related impacts on water and weather at a local level. Originally developed to support National Weather Service field offices, LCAT offers data-driven answers to climate-related questions. The tool links local weather and water events to signals in the climate system, providing information about how climate variability and change contribute to local climate trends. This local-to-national perspective on climate can show the effect of climate variability and change on temperature and precipitation in your community in recent decades, and how those trends may continue into the future. LCAT enables users to dive all the way into data from individual weather stations or zoom out to larger regions. Currently available for the US.

[NOAA Weather and Climate Toolkit](#)

The U.S. National Oceanic and Atmospheric Administration's (NOAA) Weather and Climate Toolkit (WCT) is free, platform independent software distributed from NOAA's National Centers for Environmental Information (NCEI). The WCT allows the visualization and data export of weather and climate data, including Radar, Satellite and Model data. The WCT also provides access to weather/climate web services provided from NOAA's National Center for Environmental Information (NCEI) and other organizations.

Monitoring climate

[CAROGEN](#)

The CariCOF Outlook Generator (CAROGEN) is an online portal primarily designed for participating countries to the Caribbean Climate Outlook Forum (CariCOF), allowing their National Meteorological and Hydrological Services to (1) submit and access historical daily and monthly temperature and precipitation data; (2) to generate seasonal climate outlooks and verify past seasonal forecasts. National and region-wide forecasts made in CAROGEN are driven by the Climate Prediction Tool (CPT) which has been integrated into the platform. In addition, CAROGEN contains a public section allowing viewing of climatological norms, summary climate statistics and basic monitoring tools for monthly rainfall and temperature data.

[European Climate Assessment & Dataset \(ECA&D\)](#)

The European Climate Assessment & Dataset (ECA&D) provides a combined collation of daily series of observations at meteorological stations, quality control, analysis of extremes and dissemination of both the daily data and the analysis results. New versions of the daily dataset are being issued at regular intervals. The network of participants has been extended to countries in the Middle East and North Africa.

[National Climate Monitoring Products \(R-NCMPs\)](#)

The National Climate Monitoring Products (R-NCMPs) is a user-friendly software package for the calculation of the 6 products defined in WMO guidelines on "Generating a Defined Set of National Climate Monitoring Products", which can be used for monitoring the temperature and precipitation conditions of a region. The Expert Team on National Climate Monitoring Products (ET-NCMP) has defined the six following products for the production of consistent NCMPs, which can be calculated on a monthly basis: mean temperature anomaly, percentage rainfall anomaly, standardized precipitation index (SPI), percentage of warm days, percentage of cold nights, and counts of temperature and precipitation records.

[NOAA CPC Climate Monitoring Toolkit](#)

The U.S. National Oceanic and Atmospheric Administration's (NOAA) Weather and Climate Toolkit (WCT) is free, platform independent software distributed from NOAA's National Centers for Environmental Information (NCEI). The WCT allows the visualization and data export of weather and climate data, including Radar, Satellite and Model data. The WCT also provides access to weather/climate web services provided from NOAA's National Center for Environmental Information (NCEI) and other organizations.