

Acronyms

Common acronyms used throughout the book are defined here. Additional details on asterisked terms are provided in the Glossary of Terms.

3D-Var	Three-dimensional Variational (Data Assimilation)
4D-Var	Four-dimensional Variational (Data Assimilation)
AGCM*	Atmospheric Global Circulation Model
ACMAD	African Centre of Meteorological Applications for Development
AGRHYMET	Centre Regional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationnelle
AIACC	Assessments of Impacts and Adaptation to Climate Change
AMIP	Atmospheric Model Intercomparison Project
APSIM	Agricultural Production System Simulator
APSRU	Agricultural Production Systems Research Unit
AR	Autoregressive
ARSCO	American Association of State Climatologists Recognized State Climate Office
AU	African Union
BMA	Basin Management Agency
BMRC	Bureau of Meteorology Research Centre
BoM	Bureau of Meteorology
CC*	Climate Change
CCA	Canonical Correlation Analysis
CDF*	Cumulative Distribution Function
CEP	Conditional Exceedance Probability
CGCM*	Coupled Global Circulation Model
CIMMS	Cooperative Institute for Mesoscale Meteorological Studies
CLIMAG	Climate Prediction and Agriculture
CLIPER	CLImatology and PERsistence
CLIPS	Climate Information and Prediction Services
CNRM	Centre National de Recherches Météorologiques
COPES	Coordinated Observation and Prediction of the Earth System

CV*	Climate Variability
DA*	Data Assimilation
DEMETER	Development of a European Multimodel Ensemble system for seasonal to inTERannual prediction
DEWA	Department of Early Warning and Assessment
DJF	December, January, February
DMC	Drought Monitoring Centre
DMN	Direction de la Météorologie Nationale
DNA	Deoxyribonucleic acid
DSP	Dynamical Seasonal Prediction
ECHAM	ECWMF-Max Plank Institute Hamburg
ECMWF	European Centre for Medium-Range Weather Forecasts
EDS	Early Detection System
ENACT	ENhanced ocean data Assimilation and ClimaTe Prediction
EnKF	Ensemble Kalman Filter
ENSO*	El Niño/Southern Oscillation
EOF*	Empirical Orthogonal Function
ERA-15	ECMWF Re-analyses (for the 15-year period 1979-1993)
ERA-40	ECMWF Re-analyses (for the 40-year + period 1958-2001)
ERS	European Remote Sensing
ESSP	Earth System Science Partnership
EUC*	Equatorial Under Current
EUROBRISA	EURO-BRazilian Initiative for improving SOuth American seasonal forecasts
EUROSIP	EUROpean multi-model Seasonal to Inter-annual Prediction
EWS	Early Warning System
FAO	Food and Agriculture Organization
FAWN	Florida Automated Weather Network
FEWS NET	Famine Early Warning Systems Network
FLC	Florida Climate Consortium
FMAM	February, March, April, May
GAEMN	Georgia Environmental Monitoring Network
GCM*	Global Circulation Model
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GERB	Geostationary Earth Radiation Budget
GHR SST	GODAE High Resolution Sea Surface Temperature

GIEWS	Global Information and Early Warning System (FAO)
Gl	Gigalitres (10 ⁹ litres)
GLM	Generalised Linear Model
GMT	Greenwich Mean Time
GODAE	Global Ocean Data Assimilation Experiment
GPC	Global Producing Centre
Ha	Hectare (10,000 square metres)
HEWS	Humanitarian Early Warning System
hPa	hectoPascal (a measure of pressure)
IASC	Inter-Agency Standing Committee
IBM	International Business Machines
ICPAC	IGAD Climate Prediction and Applications Centre
ICSU	International Council for Science
ICTZ*	Inter Tropical Convergence Zone
IGAD	Intergovernmental Authority on Development
IGBP	International Geosphere-Biosphere Programme
IHDP	International Human Dimensions Programme
iid	Identically and Independently Distributed
IMD	Indian Meteorological Department
IOC	Intergovernmental Oceanographic Commission
IPCC	Inter-Governmental Panel on Climate Change
IQQM	Integrated Quantity Quality Model (hydrological)
IRI	International Research Institute for Climate and Society
JAS	July, August, September
JFM	January, February, March
JJA	June, July, August
JMA	Japanese Meteorological Agency
KBDI	Keetch-Byram Drought Index
KF	Kalman Filter
LAD	Least absolute deviation
LEPS	Linear error in probability space
LPM	Linear Programming Model
MAPE	Maximum A Posteriori Estimate
MCA	Maximum Covariance Analysis
MDG*	Millennium Development Goal
MEWS	Malaria Early Warning System

MJJ	May, June, July
MLE	Maximum Likelihood Estimate
MOS	Model Output Statistics
MoU	Memorandum of Understanding
NAO*	North Atlantic Oscillation
NCEP	National Centers for Environmental Prediction
NDJ	November, December, January
NGO	Non-Governmental Organisation
NMHS	National Meteorological and Hydrological Service
NMS	National Meteorological Service
NOAA	National Oceanic and Atmospheric Administration
NCDC	National Climate Data Center
NSWDLWC	New South Wales Department of Land and Water Conservation (Australia)
NWP	Numerical Weather Prediction
OCN	Optimal Climate Normal
ODA	Official Development Assistance
OGCM*	Oceanic (or Ocean) Global Circulation Model
OGP	Office of Global Programs
OI	Optimal (or Optimum) Interpolation
OLS	Ordinary Least Squares
OND	October, November, December
ORMVA	Offices Régionaux de Mise en Valeur Agricole
PCR	Principal Components Regression
PDF (or pdf)*	Probability Density (or Distribution) Function
PNA	Pacific–North America
POP	Principal Oscillation Pattern
PROVOST	PRediction Of climate Variations On Seasonal to interannual Time-scales
QDPI	Queensland Department of Primary Industries
RANET	RADio and InterNET for the Communication of Hydro-Meteorological and Climate Related Information
RCC	Regional Climate Centre
RCOF	Regional Climate Outlook Forum
RISA	Regional Integrated Sciences and Assessment
RMS (rms)	Root-Mean-Square
RMSE (rmse)	Root-Mean-Square Error
SADC	Southern African Development Community

SCOPIC	Seasonal Climate Outlook for the Pacific Island Countries
SECC	Southeast Climate Consortium
SINERGEE	Simulations from a Numerical weather prediction model to Exploit Radiation data from a new Geostationary satellite, Explore radiative processes and Evaluate models.
SIP	Seasonal to Interannual Prediction
SO*	Southern Oscillation
SOI*	Southern Oscillation Index
SSA	Singular Spectrum Analysis
SSH	Sea Surface Height
SST	Sea Surface Temperature
SSTA	Sea Surface Temperature Anomaly
START	SysTem for Analysis, Research and Training
SVD	Singular Value Decomposition
TAO*	Tropical Atmosphere Ocean
TOGA	Tropical Ocean Global Atmosphere
UN	United Nations
UNCED	United Nations Conference on Environmental Development (1992)
UNEP	United Nations Environment Programme
UNFCCC*	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture
USDA-CSREES	USDA Cooperative State Research, Education, and Extension Service
USDA-RMA	USDA Risk Management Agency
UTC	Coordinated Universal Time
WB	World Bank
WCP	World Climate Programme
WCASP	World Climate Applications and Services Programme
WCDMP	World Climate Data and Monitoring Programme
WCIRP	World Climate Impact Assessment and Response Strategies Programme
WCRP	World Climate Research Programme
WFP	World Food Programme
WHO	World Health Organization
WMO*	World Meteorological Organization
XBT	eXpendable BathyThermographs
Z	Zulu: abbreviated form of time equivalent as far as meteorological practice requires to GMT or UTC

Glossary of Terms

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Abstract: No, this is not the definition of abstract! There is still some confusion about meaning of some terms in the climate field. This “glossary of terms” chapter aims at reducing the level of uncertainty of these key terms. Note that when terms in this glossary are used within the definition of other terms we refer to them by italicising the terms.

Accuracy: In the context of forecast *verification*, the magnitude of the error(s) in a single or a set of forecasts: an “accurate” forecast is one with a small error. The accuracy of a set of forecasts is usually calculated by averaging the error metric over the individual forecasts. In the context of data quality, accuracy refers to the difference between the recorded values and the observed values.

Adaptation: Change to accommodate to new circumstances. In the *UNFCCC* this is change of activities to accommodate to *Climate Change*, but can refer more broadly to any changes required to address *Climate Variability*. Can take many forms, e.g. anticipatory/proactive, autonomous, planned, private, public, reactive, future, baseline. Hence also ‘Adaptation Strategy’. ‘Adaptation Capacity’ denotes the level of ability to adapt.

Analogue (US spelling: Analog): In the context of seasonal forecasting, an “analogue year” is a year in which the season in question is considered similar to the *target* season. The similarity is usually defined in terms of the state of the *predictors*, and the outcome is therefore expected to be similar. A commonly used example of applying analogue years is to use the observed climate during past occurrences of *El Niño* conditions to forecast the climate during a subsequent *El Niño*.

Analysis [Field]: The result of the combination of observations with model data for a specific space-time interval, performed with a *data assimilation* method. In the context of forecasts, it provides the initial conditions for coupled *integrations*.

Anomaly: The difference between an observed value of a meteorological variable (e.g. seasonally averaged temperature) for a single period (e.g. JFM 2000) and its long-term average (e.g. JFM 1961–1990). In the case of seasonally averaged

temperature, for example, a positive anomaly occurs when the temperature for the season in question is higher than average, and a negative anomaly occurs when the season is unusually cold.

Anomaly Correlation: The correlation between two sets of data in which distinct mean values are first subtracted from different data points to remove, for example, a seasonal cycle, or a spatially varying *climatology*. These seasonal and spatial effects would otherwise dominate the variances in the data resulting in misleadingly strong correlations.

Application: An activity which makes use of *climate information* such as a seasonal forecast.

Aqua-planet: An idealised configuration used in *Atmospheric Global Circulation Models* (AGCMs) in which the lower boundary is simply represented by a water covered world. This simplified environment is used to investigate atmospheric processes such as the distribution and variability of convection in the tropics and of the storm-tracks in mid-latitudes.

Assimilation Cycle: The sequence of operations necessary to produce an assimilation *analysis*, normally carried out at regular time intervals (typically order of a few hours for the atmosphere and few days for the ocean).

Assistance Strategy: As used for determining aid for developing countries by international aid agencies.

Atmospheric General Circulation Model (AGCM): A *Global Circulation Model* for the atmosphere.

Background (or First Guess) [Field]: A reference model state that is combined with observations to generate an *analysis* [field] using a *data assimilation* method. Background is the best estimate of the system prior to the use of the observations, which might be the direct model output, in which case it is also called *forecast field* or, more generally, the combination of model output with other (pre-interpolated) data (e.g. a *climatology*). The use of the background field ensures that the *analysis* provides a smooth field from regions with good observation coverage to those with no or sparse observations.

Bias: A measure of how far the average statistic lies from the parameter it is estimating; i.e. the expected error that arises when estimating a quantity. In the context of forecast *verification* and model *validation*, the difference is between the average of the forecasts or simulations and the average of the observed values. Forecasts of rainfall, for example, are positively biased if, on average, they indicate conditions that are wetter than observed.

Biodiversity: The spectrum of life forms, and the width of this spectrum.

Bootstrap: A self-help start-off approach, in want of any standard starting procedure, using whatever information is to hand. Originates from “picking oneself up by the bootstraps”, and is used in many basic start-up contexts (including starting computers after a power down).

Bottom Up: A management approach that examines and resolves issues at the lowest, working levels, then ripples solutions upwards to the management and policy levels (cf. *top down*).

Calibration: The correction of model output for *systematic errors*. Model calibration usually involves a correction only for a *bias* in the mean value, and sometimes for the variance, but more sophisticated procedures can be used (Chapter 8, Section 8.3.3). See also *Recalibration*. Calibration can also refer to the training of a statistical model (Chapter 7, Section 7.3.3.5).

Capacity: The resource (human, technological, environmental, management) to complete activities and/or achieve goals. Hence also Capacity Building.

Chaos: A mode of behaviour of certain non-linear dynamical systems in which the most relevant characteristic is its sensitivity to initial conditions (the “butterfly effect”): small variations in the initial conditions of two dynamic systems in otherwise identical states will lead to a dramatic divergence in the behaviour of the systems over time. As a result of this sensitivity, systems that exhibit chaos often appear to be random. The randomness, however, is only apparent as such systems are indeed deterministic: they are in fact described by well defined mathematical expressions that do not contain random parameters.

Chilling Units: See *Degree-Days*.

Climate: The description in totality on all timescales of the atmosphere, the oceans, the land and the cryosphere within which *weather* sits at the short timescale. Relates also to the manner in which atmospheric and/or oceanic and/or cryospheric processes are experienced, personally, environmentally, or through process outcomes.

Climate Affairs: All aspects of policy and management related to processes to which *climate* is pertinent.

Climate (or Climatic) Change: Any real or perceived adjustment in any aspect of the *climate*. Changes can occur over numerous timescales and through a variety of *forcing* mechanisms. However the definition of Climate Change used by the

UNFCCC covers anthropogenically forced change only, on whatever timescales. Change occurring through natural causes on whatever timescale comes under the heading of *Climate Variability* according to the *UNFCCC*.

Climate Extreme: In the statistical sense, a climate event that sits towards the outer limits of observed distribution, such as temperatures in the coldest 5% or rainfall in the wettest 1% of occurrences. However, often used to indicate an undesirable societal and/or environmental consequence in which *climate* is known or is perceived to have played a dominant role. This latter use tends to ignore both any association with the statistical definition and also any other factor(s) that might have been present, however key.

Climate Forcing: Any external or internal mechanism that determines in part the form of the *climate*. Solar radiation and the earth's rotation represent the two major external factors. Internal factors include distributions of sea surface temperatures, of snow, etc.

Climate Forecasting/Prediction: Official terminology of *WMO* for predictions beyond 2 years; includes *Climate Variability* predictions that cover interannual, decadal and multi-decadal climate *anomalies* and Climate Predictions that cover future *climate* resulting both from natural variability and from anthropogenic causes. Elsewhere often used in the sense of predicting any and all changes in *climate* from all causes over the next century (this is the sense used by the IPCC, whereas the *UNFCCC* uses it for anthropogenically forced change only), and thus is broader than the official *WMO* definition. Normally does not imply seasonal or interannual predictions, for which the terms 'Short-Range Climate Prediction' and 'Seasonal to Interannual Prediction' are used.

Climate Information: Any information on *climate* available to be used in informing decisions. Frequently used in the sole context of historical records of observation data, but can include predictions or any other information produced using models.

Climate Risk Management: The process of mitigating the consequences of possible future, perhaps predicted, climate events on timescales of interest in advance of those events, taking into account as many information streams as feasible.

Climate Services: Any service that provides raw and/or interpreted *Climate Information* to users. Normally part of the function of a National Meteorological and Hydrological Service (NMHS), but independent and/or commercial climate services exist.

Climate Shock: The consequences of an unexpected climate event, strictly regardless of timescale but often used in the sense of relatively short timescale events.

Climate Uncertainty: That aspect(s) of future *climate* that cannot be predicted with certainty; often used also to indicate the perception of lack of knowledge of the future.

Climate Variability: Differences in *climate* between any two, or a sequence of, periods; often used in the interannual sense. Variability can occur over any time-scales and through a variety of *forcing* mechanisms. However, the definition of Climate Variability used by the *UNFCCC* covers natural, i.e. not anthropogenically forced, variability on whatever timescales. Variability occurring through anthropogenic causes on whatever timescale comes under the heading of *Climate Change* according to the *UNFCCC*.

Climatology: The description and scientific study of *climate* in all its aspects. Often the term is used to refer to the observed distribution of a meteorological parameter, or set of parameters, over a number of years (typically a 30-year period).

Cognitive Illusions: Perceptual difficulties that enable individuals to draw fully or partially incorrect conclusions while remaining convinced of the certainty of their arguments.

Cold Phase: The *La Niña* stage of *El Niño/Southern Oscillation* (ENSO) during which sea surface temperatures over the eastern equatorial Pacific Ocean are below average.

Coping Range/Strategies: The ability to handle *climate variability*, the process(es) of doing so, and the limits of *climate* beyond which it is not possible to manage.

Cost-Loss Model: A simple economic model covering the costs of protecting against an adverse event and the benefits (losses reduced) gained from that protection.

Coupled Model: Any two or more models which work independently but are linked at set time intervals to provide mutual feedbacks. In the case of seasonal to interannual forecasting this normally refers to the coupling of an atmospheric model to an ocean model and possibly to other important component models such as a land model and a sea-ice model.

Coupled General Circulation Model (CGCM): See *Coupled Model* and *General Circulation Model*.

Cumulative [or Probability] Distribution Function (CDF): A function that describes the probability distribution of a continuous or discrete variable by defining the probability that all possible values of the variable will be exceeded.

Data Assimilation: The combination of observations and model data, with the objective to achieve the ‘best’ description of the system being modelled. The ‘best’ description is normally the one in which the end result (also called *analysis*) is as close as possible to the observations but with the constraints imposed by the system (e.g. its dynamics), as given by the model data as well as by the statistics employed to relate observations and model data (*error covariance*). Many data assimilation methods are available as described in Chapter 5.

Decile: Each part of a distribution that divides the data into ten equal parts.

Decision Maker/Taker: See *User*.

Decision Process: The methodology through which information is assessed and a decision taken. Numerous factors, including cultural and policy factors, determine each process; thus there is no universally standard decision process in any context.

Degree-Days: A method of assessing the overall effect of temperature across a period. Growing degree-days (or units), for example, are calculated from the multiple of the number of hours the temperature is above a value necessary for growth in a particular plant with the excess temperature above that value; heating degree-days (or units) similarly are for those below a value at which heating is required.

Determinism (deterministic): In the context of predictions, to forecast specific values. A deterministic prediction offers a statement of an expected future with no likelihood attached.

Downscaling: The translation of a forecast from one spatial and/or temporal resolution to a finer resolution. In spatial downscaling, the term is frequently applied to the translation of a forecast from a gridded average to a local point.

Drift (also Climate Drift): The tendency for the solution of a *dynamical (or numerical) model* to move away from the observed state of the system being simulated, due to the presence of *systematic model errors*. Normally the drifting solution eventually reaches a new equilibrium, the so-called model climate.

Drought: A shortfall in water supply for an extended period below a threshold that is appropriate within each specific context (e.g. agriculture).

Dynamical Modelling: The process of simulating a system, such as the atmosphere, by solving, usually on a computer, the basic equations of state (the dynamics and the energy) for that system, in a numerical way.

El Niño: The *warm phase* of *ENSO*.

El Niño/Southern Oscillation (ENSO): A complex system of interaction between the atmosphere and the oceans, specifically across the equatorial Pacific Ocean. The strongest known internal *forcing* mechanism of *climate variability* through atmospheric *teleconnections* to many parts of the globe.

Empirical Modelling: See *Statistical Modelling*.

Empirical Orthogonal Function (EOF): See *Principal Component*.

End-to-End: The mono-directional approach frequently used in the delivery and use of meteorological products. At one end sit the raw data, in the middle are data processing, perhaps forecasting, and processing, while at the other end is the *user* and their *application*.

End User: See *User*.

Ensemble: A set of predictions (each referred to as a *member*) for a specific *target period* designed to test the sensitivity of a forecast to various differences, such as in the type of model, the initial state (*chaos*), model physics, etc. Typically uses one or more *dynamical models* but *statistical models* can also be used independently or alongside *dynamical models*. A correctly created ensemble defines an estimated distribution of future states providing a full set of the range of possibilities and their associated probabilities.

Ensemble Member: One of a set of forecasts for the same *target period*. The phrase is usually, but not necessarily, applied to refer to a single prediction from a specific model.

Equity: Used in the development community to indicate fairness in sharing of resources.

Equatorial Under Current (EUC): A jetlike ocean current flowing just below the sea surface toward the east and within a few degrees of the equator, especially in the Pacific and Atlantic oceans. It can reach speeds of more than 1 metre per second at a depth of about 100 m.

Error Covariance [Matrix]: The statistical relationship between a variable and another variable (including itself), in space and time, used to determine the relative weight of these variables when they are combined to produce an *analysis*. Error covariance is central to *data assimilation* as it determines the relative importance of, for example, observations and model, or more generally *background*, data. Hence ‘Observation Error Covariance’ and ‘Background Error Covariance’.

Event: In forecast *verification*, an event is an observation, during the *target period* of a forecast, of a specific outcome of interest. The outcome is explicitly binary: either an event occurs during the *target period*, or it does not occur. For some meteorological variables, occurrence is inherently binary (precipitation occurrence, for example), but for continuous variables, an event can be defined if the observed value lies within the limits defining the category of interest (temperature above 30°C, for example, defines an event for a category with no upper bound).

Extended-Range Weather Forecasting: Official terminology of the *WMO* to indicate predictions from 10 to 30 days (in general provided as averages across periods of several days).

Extension Service: Normally used regarding agriculture, typically a government service that provides expert advice to farmers.

First Guess [Field]: Same as *Background*.

Forcing: The source of the disturbance of a dynamical system, which normally appears on the right-hand-side of the equation of the system. For example, *wind stress* is one of the forcings of the ocean (models). See also *Climate Forcing*.

Forecast [field]: In *data assimilation*, model output used to form the *background* field, so-called because it is usually the result of a model *integration* started from an *analysis* produced in the previous *assimilation cycle*.

Forecasting System: Ranges in meaning from a comprehensive view integrating all the components that go into making a forecast – from the generation of initial conditions of the *dynamical models* used for the forecasts, to the running of the *coupled dynamical models*, to the *calibration* and assessment of the model output, to the application of forecast products to specific *users* – to contiguous parts of this comprehensive definition. The meaning should be clear by its context.

Gambler's Ruin: Risk management under uncertainty leads to a sequence of gains and losses that on average should produce a net gain. Gambler's Ruin occurs when catastrophic losses are taken that prevent further activity.

General Circulation Model (GCM): A set of equations describing the three-dimensional evolution of the system to be modelled (e.g. the atmosphere) in a numerical form. The equations include those of the dynamics and energy of the system, as well as those of any other relevant process (e.g. chemical reactions).

Global Producing Centre: A *WMO* designation conferred from November 2006 on Centres that produce and distribute a minimum suite of global seasonal forecast products, typically using some form of *GCM*.

Group Velocity: The rate at which wave energy propagates. For nondispersive waves, such as a Kelvin wave, the phase and group velocities are the same. For dispersive waves, such as Rossby waves, the group and phase velocities are generally different.

Hindcast: See *Re-forecast*.

Homoscedasticity: The property of homogeneity of variance. A set of data has the property of homoscedasticity if there is equality in the variances of subsets of the data defined a priori (e.g. by time or by value of a second parameter).

Impact: Often used in the sense of the consequence(s) of a climate event, frequently a *climate extreme* or *climate change*, sometimes without due consideration of any other factors that may be present.

Increment: See Observation Increment.

Indigenous Knowledge: That knowledge built over centuries, and passed down through generations, that defines a society's learnt response(s) to events.

Initialisation: All the steps required to prepare a *coupled model* (for an *integration*) normally performed via a *data assimilation* method. Sometimes it refers only to the final step of ensuring dynamical balance intra- and inter-components of a *coupled model*, required to avoid jumps (also called *shocks*) in the solution of the model in the early stages of the *integration*.

Integration [of a Numerical Model]: The advancement in time of the solution of the numerical equations which constitute the model. When the integration refers to future times it is often called a forecast, whereas for past times it can be referred to as *re-forecast* or *hindcast*.

Internal Waves: Waves that can propagate through a fluid because it is stratified. In the tropical ocean, the speed of internal waves is 3 m s^{-1} or less. Internal Kelvin and Rossby waves are important in equatorial processes such as El Niño. They can travel large distances in the ocean (up to 10,000 km). Internal Kelvin waves also exist in the atmosphere where speeds are somewhat higher than in the ocean.

Inter Tropical Convergence Zone (ITCZ): A belt of high rainfall near the equator. It is formed by the vertical ascent of warm, moist air converging from the north and south. It is usually found a few degrees to the north of the equator but moves north and south with the seasons.

La Niña: The *cold phase* of ENSO.

Lead-Time: The time between the earliest moment at which the forecast could be released and the starting-time for which the forecast applies. The lead-time is not the same as the amount of advanced warning that is provided by the forecast: a forecast released at the beginning of the *target period* has a lead-time of zero, but does not imply that there is no advanced warning.

Long-Range Forecasting: Official terminology of the *WMO* to indicate predictions from 30 days to 2 years, usually provided as averages across a sub-period; includes Monthly Outlooks, 3-month or 90-Day Outlooks, and Seasonal Outlooks.

Madden-Julian Oscillation (MJO): A tropical atmospheric phenomenon characterised by an oscillation on the intraseasonal timescale (about 40–60 day). Some aspects of the MJO may have predictability beyond 10 days (the *Medium Range*).

Medium-Range Weather Forecasting: Official terminology of the *WMO* to indicate predictions from 72 hours (3 days) to 240 hours (10 days).

Member: *See Ensemble Member.*

Metadata: Information about the data themselves. In the context of meteorological observations, metadata typically are data about the instruments and their location, and the recording procedures.

Millennium Development Goals (MDGs): A set of eight Goals, originally agreed at the UN Millennium Summit in New York in 2000, that provides a time-bound (2015) international coordination framework for development activities. For all Goals there are certain quantifiable targets, each with sets of indicators.

Millennium Project: A project to assess approaches to achieving the *Millennium Development Goals*.

Mitigation: To reduce the consequences of an adverse event. In the *UNFCCC* mitigation is used in the context of reducing anthropogenically forced *Climate Change* through the reduction of greenhouse gas emissions.

Neutral Phase: That phase of *ENSO* that lies between the *warm phase* and the *cold phase*.

Niño3.4: One commonly used measure (or metric) of the state of *ENSO* based on sea surface temperatures over the tropical Pacific Ocean (similarly Niño3, Niño4, etc.). Specifically, the metric is calculated as the spatially averaged sea surface temperature over the domain 5°N–5°S, 170–120°W.

Normal: Used variously by climatologists and stakeholders, and thus prone to misinterpretation. Statistically it is the average value of a distribution. In seasonal forecasts, it is often used to indicate the central (i.e. inter-*tercile*) category (i.e. the middle third of data); thus also in this context above-normal and below-normal.

North Atlantic Oscillation: An atmospheric see-saw of pressure across the North Atlantic Ocean with two standard ‘centres of action’, one over Iceland and the other on the Azores. Swings from one phase to another produce large changes in the mean wind speed and direction over the Atlantic. Influential on European and North African *climate*.

Nowcasting: Official terminology of the *WMO* to indicate a description of current *weather* conditions and predictions out to 2 hours.

Numerical Modelling: The utilisation of a set of mathematical equations solved by means of computational procedures. In principle it should refer to either *Dynamical Modelling* or *Statistical Modelling*, but in practice it is more often used as synonymous with the former.

Observation Increment [or just Increment]: The difference between an observation and the interpolated model *background* value at the location of that observation. In other words, it determines the strength of the correction due to the *data assimilation* process. Normally, the first step in any *data assimilation* procedure: in the limiting case of an increment being equal to zero (i.e. model datum identical to the observation), no further calculations are required.

Oceanic (or Ocean) General Circulation Model (OGCM): A *Global Circulation Model* for the ocean.

Outlier: A datum that is numerically distant from other data in the same dataset. Outliers may be indicative of observational errors in which case they should be corrected or omitted from analyses, but when they represent *climate extremes* they may have an undue influence on the analysis.

Parameterisation: Normally utilised in dynamical models for simulating physical processes at scales smaller than those resolved by the model: radiative processes, clouds, convection of various kinds, large-scale latent heat release, etc. – the cumulative statistical effects of these processes are represented in terms of the model variables themselves rather than being represented explicitly.

Percentile: Each part of a distribution that divides the data into 100 equal parts.

Poverty: The social condition of having access to insufficient resources to maintain a satisfactory basic state of living. Poverty reduction is the main focus of the World Bank, and is included in the *Millennium Development Goals*.

Prandtl Number: The ratio of kinematic viscosity to thermal diffusivity. Small Prandtl number means heat diffuses more rapidly compared to momentum.

Predictability: The extent to which future states of a system may be predicted based on knowledge of current and past states of the system. Since knowledge of the system's past and current states is generally imperfect, as are the models that utilize this knowledge to produce a prediction, predictability is inherently limited. Even with arbitrarily accurate models and observations, there may still be limits to the predictability of a physical system.

Predictand: Sometimes called a "target" or "response" or "dependent" variable, a predictand is a variable for which a forecast is to be made. Common predictands in seasonal climate forecasting are 3-month rainfall totals and 3-month average air temperature.

Prediction System: Synonymous with *Forecasting System*.

Predictor: Sometimes called an "explanatory" or "independent" variable, a predictor is a variable which is used to make a forecast, and in many cases is some measurement of the forcing mechanism that makes seasonal prediction possible. Common predictors in seasonal climate forecasting are monthly averaged sea surface temperatures, and the *Southern Oscillation Index*.

Principal Component: A new variable, calculated similarly to a weighted average of an original set of variables, with the property that as much of the variance of the original variables as possible is represented, and with the total squared weights adding to one. Additional new variables, or principal components, can be defined that represent as much of the remaining variance as possible. Principal components exploit correlations between the original variables, and thus can act as efficient summaries of large datasets: much of the total variance of the original data may be represented by only a few principal components. Principal components are sometimes called empirical orthogonal functions (EOFs), although, strictly speaking, the EOFs are the weights that define the principal components.

Probability Density Function (PDF or pdf): A function that describes the probability of the value of a continuous variable being within any interval that must be calculated by integration. For discrete variables the probability is described by a probability mass function.

Probability Distribution: A complete mathematical description of the probabilities of all measurable subsets of a variable.

Projection: An estimate of a future state, or a series of envisaged possible future states, obtained from expert interpretation of available information.

Quality: In the context of predictions used as a generic term to indicate the technical level of excellence of the forecasts; e.g. *deterministic* forecasts that are consistently accurate are of relatively high quality. Compare with *Skill*. There is no necessary direct correlation between *skill* and *value*, *value* being dependent on the actual use of a prediction and the manner of that use.

Quintile: Each part of a distribution that divides the data into five equal parts.

Random Error: The imprecision in a given process due to the hard-to-control (sometimes uncontrollable) nature of some elements of the process. For example, repeated measurements of the same quantity are bound to yield different values (if precision of the instrument is sufficiently high) because the conditions of measurement vary, even if ever so slightly, from one measurement to the other. To sample such error, *coupled models* are often started from initial conditions that differ by small amounts.

Reanalysis: Use of the very latest numerical models and all available observations to create new *analyses* of the state of the atmosphere and/or oceans over past years. This approach produces consistent data sets over a number of years of higher quality than previously available, and that are invaluable for meteorological and climatological research.

Recalibration: The statistical adjustment of model output to improve the similarity between the model simulations/forecasts and the observed climate (Chapter 8, Section 8.3.3). See also *Calibration*.

Reference Climatology: A standard *climatology* for a model generated through *integrations* over many years; changes, such as *climate changes*, may be detected against this in late work with the model.

Re-forecast: A model *integration* over past times. Implementation of such *integrations* serves several purposes, two of which are highlighted here: (i) to assess and/or *calibrate* model *integrations* for future times (i.e. forecasts) and (ii) investigate performance of latest models over past events (e.g. the 1997–98 *El Niño*).

Regional Climate Model: A *numerical model* working over a smaller geographical region than a *Global Circulation Model* but at much higher resolution in order

to provide enhanced spatial and temporal detail over that region. It typically employs boundary conditions taken from a *Global Circulation Model*.

Resilience: A measure of the extent to which a society or a system, such as an agricultural system, is capable of withstanding the deleterious consequences of some adverse event. Hence ‘building resilience’.

Richardson Number: The ratio of the static stability squared to the wind shear squared. It gives a measure of the likelihood of a fluid to develop instabilities.

Risk: Uncertainty for which the *probability distribution* of an outcome (e.g. the objective of a *decision making process*) is known.

Risk Assessment: A study to determine the outcomes of decisions along with their probabilities.

Scenario: One vision of the future created through expert interpretation of available information.

Seamless Decision Making System: The implementation of a sequence of related or interlinked decisions across climatic timescales, adjusted as timescales change (cf. *Seamless Forecasting System*). Those decisions may be related only to a specific portion of the timescales, but that portion may readily extend within, beyond or across the artificial timescale boundaries set up by the scientists.

Seamless Forecasting System: The implementation of unified procedures aimed to provide information which appears transparent to the *user*. In weather/climate forecasting it usually refers to the use of a single *dynamical (coupled) model*, which is *integrated* over different time and space scales, e.g. from a few days to many decades, with an essentially fixed setup. Currently, artificial timescale boundaries between *medium-range*, monthly, seasonal, decadal and *climate change* are common in the production of forecasts. Given the absence of such boundaries in nature, Seamless Forecasting seems a natural approach. Note that purely from a *user* perspective, a Seamless Forecasting System is not strictly necessary if model output were provided in a seamless way.

Shock: A jump in the numerical solution of a model *integration* caused by an abrupt change in the initial conditions. Hence ‘Coupling shock’ or, more generally, ‘Forecast shock’.

Short-Range Weather Forecasting: Official terminology of the *WMO* to indicate predictions from 12 to 72 hours (3 days).

Singular Value Decomposition (SVD): The decomposition of a matrix into a diagonal matrix and two orthonormal (orthogonal and with unit length) matrices. Somewhat confusingly, “SVD analysis” is often used to refer to maximum covariance analysis (Chapter 7, Section 7.4.3), which is one of many possible uses of SVD; for example, SVD is often used to calculate *principal components* in multiple regression and canonical correlation analyses.

Skewness: A measure of the asymmetry of the frequency distribution of records of a single variable. If there are more large positive than negative departures from the median then the data are positively skewed. Conversely, if there are fewer large positive than negative departures from the median then the data are negatively skewed. Skewness can affect the results of some statistical tests, and so distributional assumptions always should be considered.

Skill: A relative measure of the *quality* of a series of forecasts taken against an alternate forecast approach, usually a much simpler and cheaper approach such as guessing, or use of *climatology*, or persisting recent observations. Calculated such that a skill of 0% indicates the forecasts and the alternates are of identical *quality*, and positive values are desirable with 100% indicating perfect forecasts.

Solid Body Rotation: When a fluid rotates as if it were a solid.

Southern Oscillation (SO): An atmospheric see-saw of pressure across the Pacific Ocean with two standard ‘centres of action’, Darwin in Northern Australia and Tahiti in the central South Pacific Ocean. At these centres of action long-term sea-level atmospheric pressures are strongly inversely correlated such that when pressure is higher than normal at one it is lower than normal at the other. The atmospheric component of a major atmosphere-ocean interaction across the Pacific, part of which is the *El Niño* – hence *ENSO*.

Southern Oscillation Index (SOI): A measure of the state of the Southern Oscillation (q.v.); various approaches used.

Stakeholders: See *User*.

Statistical Modelling: In the broad sense using statistics to represent linkages within a system, but used within this book to indicate the employment of statistical relationships between *predictors* and *predictands* to create a predictive equation.

Statistical Significance: A standard procedure for interpreting the strength of a test statistic, such as the correlation between a set of forecasts and the corresponding observations. Statistical significance tests estimate how likely it is that a score

that is at least as large as the calculated score on the test statistic could have been achieved purely as a result of a sampling accident. If this probability, known as a *p*-value, is sufficiently low (typically <5%, although other thresholds are used), then the result is said to be “statistically significant”.

Sustainable Development: Probably the most controversial of the terms in this glossary. Here a few alternatives are given: pick your choice.

1. Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Report of the Brundtland Commission, *Our Common Future* (1987).
2. The management and conservation of the natural resources base, and the orientation of technological and institutional change, in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations.
3. Within a country or region, gradual change characterized by economic growth, increased social equity, constructive modification of ecosystems, and maintenance of the natural resource base.

Systematic Error: Any difference between the observed and model climates caused by *non-random sampling errors*. The most commonly considered systematic error is the *bias* in the mean climate of the model.

Target Period: The period for which the forecast applies.

Teleconnection: A simultaneous or successive association between climate *anomalies* in separate parts of the globe. The climate *anomalies* in the disparate regions are related by having a common *forcing* mechanism broadcast over distances through a mechanism generically referred to as a teleconnection. The best known example of a teleconnection is the *Southern Oscillation*, which involves opposite tendencies in sea-level pressure in the western and east-central tropical South Pacific Ocean, and which is then transmitted to distant parts of the globe.

Tercile: Each part of a distribution that divides the data into three equal parts. Note that there are two terciles (the upper and lower), which define three categories. Sometimes, somewhat confusingly, the “tercile” is used to refer to the categories defined by the division (e.g. “above-normal tercile” refers to the category above the upper tercile).

Top Down: A management approach that examines and resolves issues at the highest policy and management levels, then ripples solutions downwards to the working levels (cf. *bottom up*).

Tropical Atmosphere Ocean (TAO) Array: An array of moored buoys across the tropical Pacific Ocean. These relay latest oceanic and atmospheric data via satellite links that are used in many seasonal prediction models.

Type I Error: The rejection of a null hypothesis when the null hypothesis is true. A type I error is made when the result of a statistical test is accepted as *statistically significant* when the strength of the result is only a result of sampling error. In *statistical modelling*, for example, type I errors include accepting spurious predictors, which results in operational forecasts being of lower quality than anticipated.

Type II Error: The acceptance of a null hypothesis when the alternative hypothesis is true. A type II error is made when the result of a statistical test is accepted as statistically insignificant when the weakness of the result is a result of sampling error or insufficient data. In *statistical modelling*, for example, type II errors result in actual forecast quality being less than the potential *predictability*.

Useful: Often used by climatologists in the context of their perceived *value* of their predictions, but frequently unfounded until proven to have *value*.

User: Many terms have been used to name those to whom seasonal predictions are directed – decision makers, decision takers, recipients, stakeholders, end-users, and so on. There is no clear distinction between these terms, and each may be interpreted differently at distinct stages of the delivery chain. Hence ‘user’ is employed here in a generic sense to cover the interpretation intended in this book. A ‘user’ is anyone that makes use of *Climate Information* available at any stage of the (comprehensive) *forecasting system*. As a consequence, there are different levels of users including intermediate or end/final users.

United National Framework Convention on Climate Change (UNFCCC): One of the so-called Rio Conventions that emerged from UNCED in 1992. The UNFCCC provides the framework under which intergovernmental climate change negotiations are held, and from which the Kyoto Protocol emerged.

Validation: The evaluation of the ability of a model to make good forecasts and/or to reproduce observed features of the *climate* system. Sometimes used as synonymous with *Verification*.

Value: Value is provided when information, such as a prediction, is employed actively to adjust an existing decision or to illuminate or confirm a new decision; predictions, of whatever quality, that are not used in, or do not contribute towards, any *decision processes* have no value. It is also used to indicate a measure of the benefit achieved through *climate information* use. Contrast with *quality*.

Verification: The measurement of the *quality* of a forecast or of a sequence of forecasts. The term is sometimes used to refer to the eventual outcome to which the forecast was targeted; thus a forecast is compared to its verification in assessing the *quality* of the former.

Very Short Range Weather Forecasting: Official terminology of the *WMO* to signify predictions from 2 to 12 hours.

Vulnerability: A measure of the extent to which a society or a system might be affected adversely by an event; hence vulnerability reduction.

Warm Phase: The *El Niño* stage of *ENSO* during which sea surface temperatures over the eastern equatorial Pacific Ocean are above average.

Weather: The day-to-day evolution of the atmosphere, as measured by variables such as temperature, wind and precipitation. Given its shorter averaging time, weather undergoes larger fluctuations than *climate*, which therefore acts as a weather smoother or integrator. Thus, at any given location, daily temperature anomalies of many degrees are normal whereas seasonal temperature anomalies are usually only a few degrees.

Wind Stress: Force exerted on surfaces with small irregularities (typically the oceans) by the atmosphere, due to pressure differences and viscosity. It is proportional to the square of the wind speed and it is the main driver of upper ocean circulation.

World Meteorological Organization (WMO): A Specialised Agency of the UN, based in Geneva, responsible for the international management concerning the atmosphere and oceans.

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Suggested Further Reading

A list of references for further reading of interest to both specialists and non-specialists is given here. The number in bold following the reference indicates the chapter(s) to which the reference is most appropriate.

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