Learning Objectives 050 Meteorology

Syllabus reference	Syllabus details and associated Learning Objectives
050 00 00 00	**METEOROLOGY**
050 01 00 00	**THE ATMOSPHERE**
050 01 01 00	**Composition, extent, vertical division**
050 01 01 01	**Structure of the atmosphere**
LO	Describe the vertical division of the atmosphere, based on the temperature variations with height
LO	List the different layers and their main qualitative characteristics
050 01 01 02	**Troposphere**
LO	Describe the troposphere
LO	Describe the main characteristics of the tropopause
LO	Describe the proportions of the most important gases in the air in the troposphere
LO	Describe the variations of the flight level and temperature of the tropopause from the poles to the equator
LO	Indicate the variations of the flight level of the tropopause with the seasons and the variations of atmospheric pressure
050 01 01 03	**Stratosphere**
LO	Describe the stratosphere
LO	Describe the main differences of the composition of the air in the stratosphere compared to the troposphere
LO	Mention the vertical extent of the stratosphere up to the stratopause
050 01 02 00	**Air temperature**
050 01 02 01	**Definition and units**
LO	Define air temperature
LO	List the units of measurement of air temperature used in aviation meteorology (°C, °F, Kelvin) *(Refer to 050 10 01 01)*
050 01 02 02	**Vertical distribution of temperature**
LO	Describe the mean vertical distribution of temperature up to 20 km
LO	Mention general causes of the cooling of the air in the troposphere with increasing altitude
LO	Calculate the temperature and temperature deviations at specified levels
050 01 02 03	**Transfer of heat**
LO	Explain how local cooling or warming processes result in transfer of heat
LO	Describe radiation
LO	Describe solar radiation reaching the earth
LO	Describe the filtering effect of the at mosphere on solar radiation
LO	Describe terrestrial radiation
LO	Explain how terrestrial radiation is absorbed by some components of the atmosphere
LO	Explain the greenhouse effect due to water vapour and some other gases in the atmosphere
LO	Explain the effect of absorption and radiation in connection with clouds
LO	Explain the process of convection

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LO	Name situations in which convection occurs
LO	Explain the process of advection
LO	Name situations in which advection occurs
050 01 02 04	**Lapse rates**
LO	Describe qualitatively and quantitatively the temperature lapse rates of the troposphere (mean value 0.65°C/100 m or 2°C/1000 ft and actual values)
050 01 02 05	**Development of inversions, types of inversions**
LO	Describe development and types of inversions
LO	Explain the characteristics of inversions and of an isothermal layer
LO	Explain the reasons for the formation of the following inversions: - ground inversion (nocturnal radiation / advection), subsidence inversion, frontal inversion, inversion above friction layer, valley inversion - tropopause inversion
050 01 02 06	**Temperature near the earth's surface, surface effects, diurnal and seasonal variation, effect of clouds, effect of wind**
LO	Describe how the temperature near the earth's surface is influenced by seasonal variations
LO	Explain the cooling and warming of the air on the earth or sea surfaces
LO	Describe qualitatively the influence of the clouds on the cooling and warming of the surface and the air near the surface
LO	Distinguish between the influence of low or high clouds, thick or thin clouds
LO	Explain the influence of the wind on the cooling and warming of the air near the surfaces
050 01 03 00	**Atmospheric pressure**
050 01 03 01	**Barometric pressure, isobars**
LO	Define atmospheric pressure
LO	List the units of measurement of the atmospheric pressure used in aviation (hPa, inches) *(Refer to 050 10 01 01)*
LO	Describe isobars on the surface weather charts
LO	Define high, low, trough, ridge, wedge, col
050 01 03 02	**Pressure variation with height, contours (isohypses)**
LO	Explain the pressure variation with height
LO	Describe qualitatively the variation of the barometric lapse rate *Note: The average value for the barometric lapse rate near mean sea level is 27 ft (8 m) per 1 hPa, at about 5500 m/AMSL is 50 ft (15 m) per 1 hPa*
LO	Describe and interpret contour lines (isohypses) on a constant pressure chart *(Refer to 050 10 02 03)*
050 01 03 03	**Reduction of pressure to mean sea level, QFF**
LO	Define QFF
050 01 03 04	**Relationship between surface pressure centres and pressure centres aloft**
LO	Illustrate with a vertical cross section of isobaric surfaces the relationship between surface pressure systems and upper air pressure systems
050 01 04 00	**Air density**
050 01 04 01	**Relationship between pressure, temperature and density**
LO	Describe the relationship between pressure, temperature and density
LO	Describe the vertical variation of the air density in the atmosphere
LO	Describe the effect of humidity changes on the density of air

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050 01 05 00	**ICAO Standard Atmosphere (ISA)**
050 01 05 01	**ICAO Standard Atmosphere**
LO	Explain the use of standardised values for the atmosphere
LO	List the main values of the ISA (mean sea level pressure, mean sea level temperature, the vertical temperature lapse rate up to 20 km, height and temperature of the tropopause)
LO	Calculate the standard temperature in degree Celsius for a given flight level
LO	Determine a standard temperature deviation by the difference between the given outside air temperature and the standard temperature
050 01 06 00	**Altimetry**
050 01 06 01	**Terminology and definitions**
LO	Define the following terms and abbreviations and explain how they are related to each other: height, altitude, pressure altitude, flight level, level, true altitude, true height, elevation, QNH, QFE and standard altimeter setting
LO	Describe the terms transition altitude, transition level, transition layer, terrain clearance, lowest usable flight level
050 01 06 02	**Altimeter settings**
LO	Name the altimeter settings associated to height, altitude, pressure altitude and flight level
LO	Describe the altimeter setting procedures
050 01 06 03	**Calculations**
LO	Derive the reading of the altimeter of an aircraft on the ground when the pilot uses the different settings
LO	Determine the true altitude/height for a given altitude/height and a given ISA temperature deviation
LO	Calculate the terrain clearance and the lowest usable flight level for given atmospheric temperature and pressure conditions
	Note: The following rules shall be considered for altimetry calculations: a) *All calculations are based on rounded pressure values to the nearest lower hPa* b) *The value for the barometric lapse rate near mean sea level is 27 ft (8 m) per 1 hPa* c) *To determine the true altitude/height the following rule of thumb, called the "4% -rule", shall be used: the altitude/height changes by 4% for each 10°C temperature deviation from ISA* d) *If no further information is given, the deviation of outside air temperature from ISA is considered to be constantly the same given value in the whole layer* e) *The elevation of the airport has to be taken into account. The temperature correction has to be considered for the layer between ground and the position of the aircraft*
050 01 06 04	**Effect of accelerated airflow due to topography**
050 02 00 00	**WIND**
050 02 01 00	**Definition and measurement of wind**
050 02 01 01	**Definition and measurement**
LO	Define wind
LO	State the units of wind direction and speed (kt, m/s, km/h)

Syllabus reference	Syllabus details and associated Learning Objectives
	(Refer to 050 10 01 01)
LO	Explain how wind is measured in meteorology
050 02 02 00	**Primary cause of wind**
050 02 02 01	**Primary cause of wind, pressure gradient, coriolis force, gradient wind**
LO	Define the term horizontal pressure gradient
LO	Explain how the pressure gradient force acts in relation to the pressure gradient
LO	Explain how the coriolis force acts in relation to the wind
LO	Explain the development of the geostrophic wind
LO	Indicate how the geostrophic wind flows in relation to the isobars/isohypses in the northern and in the southern hemisphere
LO	Analyse the effect of changing latitude on the geostrophic wind speed
050 02 02 02	**Variation of wind in the friction layer**
LO	Describe why and how the wind changes direction and speed with height in the friction layer in the northern and in the southern hemisphere (rule of thumb)
LO	Explain the relationship between isobars and wind (direction and speed)
	Note: Approximate value for variation of wind in the friction layer (values to be used in examinations): *Type of landscape* — *Wind speed in friction layer* — *The wind in the friction layer blows across the isobars towards the low pressure. Angle between wind direction and isobars* *over water* — *ca. 70%* — *ca. 10°* *over land* — *ca. 50 %* — *ca. 30°* *WMO-NO. 266*
050 02 02 03	**Effects of convergence and divergence**
LO	Describe atmospheric convergence and divergence
LO	Explain the effect of convergence and divergence on the following: pressure systems at the surface and aloft; wind speed; vertical motion and cloud formation (relationship between upper air conditions and surface pressure systems)
050 02 03 00	**General global circulation**
050 02 03 01	**General circulation around the globe**
LO	Describe and explain the general global circulation *(Refer to 050 08 01 01)*
LO	Name and sketch or indicate on a map the global distribution of the surface pressure and the resulting wind pattern for all latitudes at low level in January and July
LO	Sketch or indicate on a map the westerly and easterly tropospheric winds at high level in January and July
050 02 04 00	**Local winds**
050 02 04 01	**Anabatic and katabatic winds, mountain and valley winds, venturi effects, land and sea breezes**
LO	Describe and explain anabatic and katabatic winds
LO	Describe and explain land and sea breezes, sea breeze front

Syllabus reference	Syllabus details and associated Learning Objectives
050 02 05 00	**Mountain waves (standing waves, lee waves)**
050 02 05 01	**Origin and characteristics**
LO	Describe and explain the origin and formation of mountain waves
LO	State the conditions necessary for the formation of mountain waves
LO	Explain how mountain waves may be identified by their associated meteorological phenomena
050 02 06 00	**Turbulence**
050 02 06 01	**Description and types of turbulence**
LO	Describe turbulence and gustiness
LO	List common types of turbulence (convective, mechanical, orographic, frontal, clear air turbulence)
050 02 06 02	**Formation and location of turbulence**
LO	Explain the formation of convective turbulence, mechanical and orographic turbulence, frontal turbulence, clear air turbulence *(Refer to 050 02 06 03)*
LO	State where turbulence will normally be found (rough ground surfaces, relief, inversion layers, CB, TS zones, unstable layers)
050 02 06 03	**Clear Air Turbulence (CAT): Description, cause and location**
LO	Describe the term CAT
LO	Explain the formation of CAT *(Refer to 050 02 06 02)*
LO	State where CAT is found in association with jet streams, in high level troughs and in other disturbed high level air flows *(Refer to 050 09 02 02)*
050 02 07 00	**Jet streams**
050 02 07 01	**Description**
LO	Describe jet streams
LO	State the defined minimum speed of a jet stream
LO	State typical figures for the dimensions of jet streams
050 02 07 02	**Formation and properties of jet streams**
LO	Explain the formation and state the heights, the speeds, the seasonal variations of speeds, the geographical positions, the seasonal occurrence and the seasonal movements of the arctic (front) jet stream, the polar front jet stream, the subtropical jet stream, and the tropical (easterly/equatorial) jet stream
050 02 07 03	**Location of jet streams and associated CAT areas**
LO	Sketch or describe where polar front and arctic jet streams are found in the troposphere in relation to the tropopause and to fronts
LO	Sketch or describe the isotherms, the isotachs, the pressure surfaces and the movements of air in a cross section of a polar front jet stream
LO	Describe and indicate the areas of worst wind shear and CAT
050 02 07 04	**Jet stream recognition**
LO	State how jet streams may be recognized from their associated meteorological phenomena
050 03 00 00	**THERMODYNAMICS**
050 03 01 00	**Humidity**
050 03 01 01	**Water vapour in the atmosphere**
LO	Describe humid air
LO	Describe the significance for meteorology of water vapour in the atmosphere
LO	Indicate the sources of atmospheric humidity

Syllabus reference	Syllabus details and associated Learning Objectives
050 03 01 03	**Temperature/dew point, relative humidity**
LO	Define dew point
LO	Recognise the dew point curve on a simplified diagram (T,P)
LO	Define relative humidity
LO	Explain the factors influencing the relative humidity at constant pressure
LO	Explain the diurnal variation of the relative humidity
LO	Describe the relationship between relative humidity, the amount of water vapour and the temperature
LO	Describe the relationship between temperature and dew point
LO	Estimate the relative humidity of the air from the difference between dew point and temperature
050 03 02 00	**Change of state of aggregation**
050 03 02 01	**Condensation, evaporation, sublimation, freezing and melting, latent heat**
LO	Define condensation, evaporation, sublimation, freezing, melting and latent heat
LO	List the conditions for condensation / evaporation
LO	Explain the condensation process
LO	Explain the nature of and the need for condensation nuclei
LO	Explain the effects of condensation on the weather
LO	List the conditions for freezing / melting
LO	Explain the process of freezing
LO	Explain the nature of and the need for freezing nuclei
LO	Define supercooled water *(Refer to 050 09 01 01)*
LO	List the conditions for sublimation
LO	Explain the sublimation process
LO	Explain the nature of and the need for sublimation nuclei
LO	Describe the absorption or release of latent heat in each change of state of aggregation
LO	Explain the influence of atmospheric pressure, the temperature of the air and of the water or ice on the changes of state of aggregation
LO	Illustrate all the changes of state of aggregation with practical examples
050 03 03 00	**Adiabatic processes**
050 03 03 01	**Adiabatic processes, stability of the atmosphere**
LO	Describe the adiabatic processes
LO	Describe the adiabatic process in an unsaturated rising or descending air particle
LO	Explain the variation of temperature with changing altitude
LO	Explain the changes which take place in relative humidity with changing altitude
LO	Describe the adiabatic process in a saturated rising or descending air particle
LO	Explain the variation of temperature with changing altitude
LO	Find the condensation level, or base of the clouds on a simplified diagram (T,P)
LO	Explain the static stability of the atmosphere with reference to the adiabatic lapse rates

Syllabus reference	Syllabus details and associated Learning Objectives
LO	Explain with a sketch on a simplified diagram (T,P) the different possibilities of atmospheric stability: absolute stability, absolute instability, conditional instability and indifferent
LO	Illustrate with a sketch of the adiabatic lapse rates and the vertical temperature profile of the atmosphere the effect of an inversion on the vertical motion of air
LO	Illustrate with a schematic sketch the formation of Foehn
LO	Explain the effect on the stability of the air caused by advection of air (warm or cold)
	Note: Dry adiabatic lapse rate = 1°C/100 m or 3°C/1000 ft; average value at lower levels for saturated adiabatic lapse rate = 0.6°C/100 m or 1.8°C/1000 ft (values to be used in examinations)
050 04 00 00	**CLOUDS AND FOG**
050 04 01 00	**Cloud formation and description**
050 04 01 01	**Cloud formation**
LO	Explain cloud formation by adiabatic cooling, conduction, advection and radiation
LO	Describe the cloud formation based on the following lifting processes: unorganised lifting in thin layers and turbulent mixing; forced lifting at fronts or over mountains; free convection
LO	Determine the cloud base and top in a simplified diagram (temperature, pressure, humidity)
LO	Explain the influence of relative humidity on the height of the cloud base
LO	Illustrate in a thermodynamic diagram the meaning of convective temperature (temperature at which formation of cumulus starts)
LO	List cloud types typical for stable and unstable air conditions
LO	Summarise the conditions for the dissipation of clouds
050 04 01 02	**Cloud types and cloud classification**
LO	Describe cloud types and cloud classification
LO	Identify by shape cirriform, cumuliform and stratiform clouds and state the respective altitude of each cloud layer
LO	Describe the CB and risk-potential in aviation
LO	Distinguish between ice clouds, mixed clouds and pure water clouds
050 04 01 03	**Influence of inversions on cloud development**
LO	Explain the influence of inversions on vertical movements in the atmosphere
LO	Explain the influence of an inversion on the formation of stratus clouds
LO	Explain the influence of ground inversion on the formation of fog
050 04 02 00	**Fog, mist, haze**
050 04 02 01	**General aspects**
LO	Define fog, mist and haze with reference to WMO standards of visibility range
LO	Explain the formation of fog, mist and haze in general
LO	Name the factors contributing in general to the formation of fog and mist
LO	Name the factors contributing to the formation of haze
LO	Describe freezing fog and ice fog
050 04 02 02	**Radiation fog**
LO	Explain the formation of radiation fog
LO	Explain the conditions for the development of radiation fog
LO	Describe the significant characteristics of radiation fog, and its vertical extent

Syllabus reference	Syllabus details and associated Learning Objectives
LO	Summarise the conditions for the dissipation of radiation fog
050 04 02 03	**Advection fog**
LO	Explain the formation of advection fog
LO	Explain the conditions for the development of advection fog
LO	Describe the different possibilities of advection fog formation (over land, sea and coastal regions)
LO	Describe significant characteristics of advection fog
LO	Summarise the conditions for the dissipation of advection fog
050 04 02 04	**Steam fog**
LO	Explain the formation of steam fog
LO	Explain the conditions for the development of steam fog
LO	Describe significant characteristics of steam fog
LO	Summarise the conditions for the dissipation of steam fog
050 04 02 05	**Frontal fog**
LO	Explain the formation of frontal fog
LO	Explain the conditions for the development of frontal fog
LO	Describe significant characteristics of frontal fog
LO	Summarise the conditions for the dissipation of frontal fog
050 04 02 06	**Orographic fog (hill fog)**
LO	Summarise the features of orographic fog
LO	Explain the conditions for the development of orographic fog
LO	Describe significant characteristics of orographic fog
LO	Summarise the conditions for the dissipation of orographic fog
050 05 00 00	**PRECIPITATION**
050 05 01 00	**Development of precipitation**
050 05 01 01	**Process of development of precipitation**
LO	Distinguish between the two following processes by which precipitation is formed
LO	Describe the atmospheric conditions that favour either process
LO	Explain the development of snow, rain, drizzle and hail
050 05 02 00	**Types of precipitation**
050 05 02 01	**Types of precipitation, relationship with cloud types**
LO	List and describe the types of precipitation given in the TAF and METAR codes (drizzle, rain, snow, snow grains, ice pellets, hail, small hail, snow pellets, ice crystals, freezing drizzle, freezing rain)
LO	State ICAO/WMO approximate diameters for cloud, drizzle and rain drops
LO	State approximate weights and diameters for hailstones
LO	Explain the mechanism for the formation of freezing precipitation
LO	Describe the weather conditions that give rise to freezing precipitation
LO	Distinguish between the types of precipitation generated in convective and stratiform cloud
LO	Assign typical precipitation types and intensities to different clouds
050 06 00 00	**AIR MASSES AND FRONTS**
050 06 01 00	**Air masses**
050 06 01 01	**Description, classification and source regions of air masses**
LO	Define the term air mass

Syllabus reference	Syllabus details and associated Learning Objectives
LO	Describe the properties of the source regions
LO	Summarise the classification of air masses by source regions
LO	State the classifications of air mas ses by temperature and humidity at source
LO	State the characteristic weather in each of the air masses
LO	Name the three main air masses that affect Europe
LO	Classify air masses on a surface weather chart
	Note: Names and abbreviations of air masses used in examinations: *- first letter: humidity — continental (c), maritime (m)* *- second letter: type of air mass — Arctic (A), Polar (P), Tropical (T), Equatorial (E)* *- third letter: temperature — cold (c), warm (w)*
050 06 01 02	**Modifications of air masses**
LO	List the environmental factors that affect the final properties of an air mass
LO	Explain how maritime and continental tracks modify air masses
LO	Explain the effect of passage over cold or warm surfaces
LO	Explain how air mass weather is affected by the season, the air mass track and by orographic and thermal effects over land
LO	Assess the tendencies of the stability for an air mass and describe the typical resulting air mass weather including the hazards for aviation
050 06 02 00	**Fronts**
050 06 02 01	**General aspects**
LO	Describe the boundaries between air masses (fronts)
LO	Define front and frontal surface (frontal zone)
LO	Name the global frontal systems (polar front, arctic front)
LO	State the approximate seasonal latitudes and geographic positions of the polar front and the arctic front
050 06 02 02	**Warm front, associated clouds and weather**
LO	Define a warm front
LO	Describe the cloud, weather, ground visibility and aviation hazards at a warm front depending on the stability of the warm air
LO	Explain the seasonal differences in the weather at warm fronts
LO	Describe the structure, slope and dimensions of a warm front
LO	Sketch a cross-section of a warm front, showing weather, cloud and aviation hazards
050 06 02 03	**Cold front, associated clouds and weather**
LO	Define a cold front
LO	Describe the cloud, weather, ground visibility and aviation hazards at a cold front depending on the stability of the warm air
LO	Explain the seasonal differences in the weather at cold fronts
LO	Describe the structure, slope and dimensions of a cold front
LO	Sketch a cross-section of a cold front, showing weather, cloud and aviation hazards
050 06 02 04	**Warm sector, associated clouds and weather**
LO	Define fronts and air masses associated with the warm sector
LO	Describe the cloud, weather, ground visibility and aviation hazards in a warm sector
LO	Explain the seasonal differences in the weather in the warm sector

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LO	Describe the boundaries between air masses (fronts)
LO	Sketch a cross-section of a warm sector, showing weather, cloud and aviation hazards
050 06 02 05	**Weather behind the cold front**
LO	Describe the cloud, weather, ground visibility and aviation hazards behind the cold front
LO	Explain the seasonal differences in the weather behind the cold front
050 06 02 06	**Occlusions, associated clouds and weather**
LO	Define the term occlusion
LO	Explain the seasonal differences in the weather at occlusions
LO	Sketch a cross-section of occlusions, showing weather, cloud and aviation hazards
050 06 02 07	**Stationary front, associated clouds and weather**
LO	Define a stationary or quasi-stationary front
LO	Describe the cloud, weather, ground visibility and aviation hazards in a stationary or quasi- stationary front
050 06 02 08	**Movement of fronts and pressure systems, life cycle**
LO	Describe the movements of fronts and pressure systems and the life cycle of a mid-latitude depression
LO	State the rules for predicting the direction and the speed of movement of fronts
LO	Explain the difference between the speed of movement of cold and warm fronts
LO	State the rules for predicting the direction and the speed of movement of frontal depressions
LO	Describe, with a sketch if required, the genesis, development and life cycle of a frontal depression with associated cloud and rain belts
050 07 00 00	**PRESSURE SYSTEMS**
050 07 01 00	**The principal pressure areas**
050 07 01 01	**Location of the principal pressure areas**
LO	Identify or indicate on a map the principal global high pressure and low pressure areas in January and July
LO	Explain how these pressure areas are formed
LO	Explain how the pressure areas move with the seasons
050 07 02 00	**Anticyclone**
050 07 02 01	**Anticyclones, types, general properties, cold and warm anticyclones, ridges and wedges, subsidence**
LO	List the different types of anticyclones
LO	Describe the effect of high level convergence in producing areas of high pressure at ground level
LO	Describe air mass subsidence, its effect on the environmental lapse rate, and the associated weather
LO	Describe the formation of warm and cold anticyclones
LO	Describe the formation of ridges and wedges *(Refer to 050 08 03 02)*
LO	Describe the properties of and the weather associated with warm and cold anticyclones
LO	Describe the properties of and the weather associated with ridges and wedges

Syllabus reference	Syllabus details and associated Learning Objectives
LO	Describe the blocking anticyclone and its effects
050 07 03 00	**Non frontal depressions**
050 07 03 01	**Thermal-, orographic-, polar- and secondary depressions, troughs**
LO	Describe the effect of high level divergence in producing areas of low pressure at ground level
LO	Describe the formation and properties of thermal-, orographic- (lee lows), polar- and secondary depressions
LO	Describe the formation, the properties and the associated weather of troughs
050 07 04 00	**Tropical revolving storms**
050 07 04 01	**Characteristics of tropical revolving storms**
LO	State the conditions necessary for the formation of tropical revolving storms
LO	Explain how a tropical revolving storm moves during its life cycle
LO	Name the stages of the development of tropical revolving storms (tropical disturbance, tropical depression, tropical storm, severe tropical storm, tropical revolving storm)
LO	Describe the meteorological conditions in and near a tropical revolving storm
LO	State the approximate dimensions of a tropical revolving storm
050 07 04 02	**Origin and local names, loca tion and period of occurrence**
LO	List the areas of origin and occurrence of tropical revolving storms, and their specified names (hurricane, typhoon, tropical cyclone)
LO	State the expected times of occurrence of tropical revolving storms in each of the source areas, and their approximate frequency
050 08 00 00	**CLIMATOLOGY**
050 08 01 00	**Climatic zones**
050 08 01 01	**General circulation in the troposphere and lower stratosphere**
LO	Describe the general tropospheric and low stratospheric circulation *(Refer to 050 02 03 01)*
050 08 01 02	**Climatic classification**
LO	Name the world climate groups according to Koeppen's classification
LO	Describe the characteristics of the tropical rain climate, the dry climate, the mid-latitude climate (warm temperate rain climate), the subarctic climate (cold snow-forest climate) and the snow climate (polar climate)
LO	Explain how the seasonal movement of the sun generates the transitional climate zones
LO	Describe the typical weather in the tropical transitional climate (Savannah climate) and in the temperate transitional climate (Mediterranean climate)
LO	State the typical locations of each major climatic zone
050 08 02 00	**Tropical climatology**
050 08 02 01	**Cause and development of tropical showers and thunderstorms: humidity, temperature, tropopause**
LO	State the conditions necessary for the formation of tropical rain showers and thunderstorms (mesoscale convective complex, cloud clusters)
LO	Explain the formation of convective cloud structures caused by convergence at the boundary of the NE and SE trade winds (ITCZ)
050 08 02 02	**Seasonal variations of weather and wind, typical synoptic situations**
LO	Describe the seasonal variations of weather and winds
LO	Indicate on a map the trade winds (tropical easterlies) and describe the associated weather

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LO	Indicate on a map the doldrums and describe the associated weather
LO	Indicate on a sketch the latitudes of subtropical high (horse latitudes) and describe the associated weather
LO	Indicate on a map the major monsoon winds *(Refer to 050 08 02 04 for a description of the weather)*
050 08 02 03	**Intertropical Convergence Zone (ITCZ), weather in the ITCZ, general seasonal movement**
LO	Identify or indicate on a map the positions of the ITCZ in January and July
LO	Explain the seasonal movement of the ITCZ
LO	Describe the weather and winds at the ITCZ
LO	Explain the variations in weather that are found at the ITCZ
LO	Explain the flight hazards associated with the ITCZ
050 08 02 04	**Monsoon, sandstorms, cold air outbreaks**
LO	Define in general the term monsoon
LO	Describe the major monsoon conditions *(Refer to 050 08 02 02)*
LO	Explain how the trade winds change character after a long track and become monsoon winds
LO	Explain the formation of the SW/NE monsoon over West Africa and describe the weather, stressing the seasonal differences
LO	Explain the formation of the SW/NE monsoon over India and describe the weather, stressing the seasonal differences
LO	Explain the formation of the monsoon over the Far East and northern Australia and describe the weather, stressing the seasonal differences
050 08 02 05	**Easterly waves**
LO	Describe and explain the formation of easterly waves, the associated weather and the duration of the weather activity
LO	Describe and explain the global distribution of easterly waves
LO	Explain the effect of easterly waves on the tropical weather systems
050 08 03 00	**Typical weather situations in the mid-latitudes**
050 08 03 01	**Westerly situation (weste rlies)**
LO	Identify on a weather chart the typical westerly situation with travelling polar front waves
LO	Describe the typical weather in the region of the travelling polar front waves including the seasonal variations
LO	State the differences between the northern and the southern hemisphere (roaring forties)
050 08 03 02	**High pressure area**
LO	Describe the high pressure zones with the associated weather
LO	Identify on a weather chart high pressure regions
LO	Describe the weather associated with wedges in the polar air *(Refer to 050 07 02 01)*
050 08 03 03	**Flat pressure pattern**
LO	Identify on a surface weather chart the typical flat pressure pattern
LO	Describe the weather associated with a flat pressure pattern
050 08 03 04	**Cold air pool (cold air drop)**
LO	Define cold air pool
LO	Describe the formation of a cold air pool

Syllabus reference	Syllabus details and associated Learning Objectives
LO	Describe the characteristics of a cold air pool with regard to dimensions, duration of life, geographical position, seasons, movements, weather activities and dissipation
LO	Identify cold air pools on weather charts
LO	Explain the problems and dangers for aviation
050 08 04 00	**Local winds and associated weather**
050 08 04 01	**Foehn, Mistral, Bora, Scirocco, Ghibli and Khamsin**
LO	Describe the weather associated with Foehn winds
050 08 04 02	**Harmattan**
LO	Describe the Harmattan wind and associated visibility problems
050 09 00 00	**FLIGHT HAZARDS**
050 09 01 00	**Icing**
050 09 01 01	**Conditions for ice accretion**
LO	Summarise the general conditions under which ice accretion occurs on aircraft (temperatures of outside air; temperature of the airframe; presence of supercooled water in clouds, fog, rain and drizzle; possibility of sublimation)
LO	Indicate the general weather conditions under which ice accretion in venturi carburettor occurs
LO	Explain the general weather conditions under which ice accretion on airframe occurs
LO	Explain the formation of supercooled water in clouds, rain and drizzle *(Refer to 050 03 02 01)*
LO	Explain qualitatively the relationship between the air temperature and the amount of supercooled water
LO	Indicate in which circumstances ice can form on an aircraft on the ground: air temperature, humidity, precipitation
LO	Explain in which circumstances ice can form on an aircraft in flight: inside clouds, in precipitation, outside clouds and precipitation
LO	Describe the different factors influencing the intensity of icing: air temperature, amount of supercooled water in a cloud or in precipitation, amount of ice crystals in the air, speed of the aircraft, shape (thickness) of the airframe parts (wings, antennas, a.s.o.)
050 09 01 02	**Types of ice accretion**
LO	Define clear ice
LO	Describe the conditions for the formation of clear ice
LO	Explain the formation of the structure of clear ice with the release of latent heat during the freezing process
LO	Describe the aspect of clear ice: appearance, weight, solidity
LO	Define rime ice
LO	Describe the conditions for the formation of rime ice
LO	Describe the aspect of rime ice: appearance, weight, solidity
LO	Define mixed ice
LO	Describe the conditions for the formation of mixed ice
LO	Describe the aspect of mixed ice: appearance, weight, solidity
LO	Describe the possible process of ice formation in snow conditions
LO	Define hoar frost
LO	Describe the conditions for the formation of hoar frost
LO	Describe the aspect of hoar frost: appearance, solidity

Syllabus reference	Syllabus details and associated Learning Objectives
050 09 01 03	**Hazards of ice accretion, avoidance**
LO	State the ICAO qualifying terms for the intensity of icing *(See ICAO ATM Doc 4444)*
LO	Describe, in general, the hazards of icing
LO	Assess the dangers of the different types of ice accretion
LO	Describe the position of the dangerous zones of icing in fronts, in stratiform and cumuliform clouds and in the different precipitation types
LO	Indicate the possibilities of avoidance - in the flight planning: weather briefing, choice of track and altitude - during flight: recognition of the dangereous zones, choice of appropriate track and altitude
050 09 02 00	**Turbulence**
050 09 02 01	**Effects on flight, avoidance**
LO	State the ICAO qualifying terms for the intensity of turbulence *(See ICAO ATM Doc 4444)*
LO	Describe the effects of turbulence on an aircraft in flight
LO	Indicate the possibilities of avoidance - in the flight planning: weather briefing, choice of track and altitude - during flight: choice of appropriate track and altitude
050 09 02 02	**CAT: effects on flight, avoidance**
LO	Describe the effects on flight caused by CAT *(Refer to 050 02 06 03)*
LO	Indicate the possibilities of avoidance - in the flight planning: weather briefing, choice of track and altitude - during flight: choice of appropriate track and altitude
050 09 03 00	**Wind shear**
050 09 03 01	**Definition of wind shear**
LO	Define wind shear (vertical and horizontal)
LO	Define low level wind shear
050 09 03 02	**Weather conditions for wind shear**
LO	Describe conditions where and how wind shear can form (e.g. thunderstorms, squall lines, fronts, inversions, land and sea breeze, friction layer, relief)
050 09 03 03	**Effects on flight, avoidance**
LO	Describe the effects on flight caused by wind shear
LO	Indicate the possibilities of avoidance - in the flight planning - during flight
050 09 04 00	**Thunderstorms**
050 09 04 01	**Conditions for and process of development, forecast, location, type specification**
LO	Name the cloud types which indicate the development of thunderstorms
LO	Describe the different types of thunderstorms, their location, the conditions for and the process of development and list their properties (air mass thunderstorms, frontal thunderstorms, squall lines, supercell storms, orographic thunderstorms)
050 09 04 02	**Structure of thunderstorms, life history**
LO	Describe and sketch the stages of the life history of a thunderstorm: initial, mature and dissipating stage

Syllabus reference	Syllabus details and associated Learning Objectives
LO	Assess the average duration of thunderstorms and their different stages
LO	Describe supercell storm: initial, supercell, tornado and dissipating stage
LO	Summarise the flight hazards of a fully developed thunderstorm
050 09 04 03	**Electrical discharges**
LO	Describe the basic outline of the electric field in the atmosphere
LO	Describe the electrical potential differences in and around a thunderstorm
LO	Describe the effect of lightning strike on aircraft and flight execution
050 09 04 04	**Development and effects of downbursts**
LO	Define the term downburst
LO	Distinguish between macroburst and microburst
LO	State the weather situations leading to the formation of downbursts
LO	Give the typical duration of a downburst
LO	Describe the effects of downbursts
050 09 04 05	**Thunderstorm avoidance**
LO	Explain how the pilot can anticipate each type of thunderstorms: pre-flight weather briefing, observation in flight, use of specific meteorological information, use of information given by ground weather radar and by airborne weather radar *(Refer to 050 10 01 04),* use of the stormscope (lightning detector)
LO	Describe practical examples of flight techniques used to avoid the hazards of thunderstorms
050 09 05 00	**Tornadoes**
050 09 05 01	**Properties and occurrence**
LO	Define the tornado
LO	Describe the formation of a tornado
LO	Describe the typical features of a tornado, such as appearance, season, time of day, stage of development, speed of movement and wind speed (including Fujita-scale)
LO	Compare the occurrence of tornadoes in Europe with the occurrence in other locations, especially in the United States of America
LO	Compare dimensions and properties of tornadoes and dust devils
050 09 06 00	**Inversions**
050 09 06 01	**Influence on aircraft performance**
LO	Explain the influence of inversions on the aircraft performance
LO	Compare the flight hazards during take-off and approach associated to a strong inversion alone and to a strong inversion combined with marked wind shear
050 09 07 00	**Stratospheric conditions**
050 09 07 01	**Tropopause influence on aircraft performance**
LO	Describe the tropopause influence on aircraft performance
LO	Summarise the advantage of stratospheric flights
LO	List the influences of the phenomena associated with the tropopause (wind, temperature, air density, turbulence)
050 09 08 00	**Hazards in mountainous areas**
050 09 08 01	**Influence of terrain on clouds and precipitation, frontal passage**
LO	Describe the influence of a mountainous terrain on cloud and precipitation
050 09 08 02	**Vertical movements, mountain waves, wind shear, turbulence, ice accretion**

Syllabus reference	Syllabus details and associated Learning Objectives
LO	Describe the vertical movements, wind shear and turbulence typical of mountain areas
050 09 08 03	**Development and effect of valley inversions**
LO	Describe the valley inversion formed by warm winds aloft
LO	Describe the effects of a valley inversion for an aircraft in flight
050 09 09 00	**Visibility reducing phenomena**
050 09 09 01	**Reduction of visibility caused by precipitation and obscurations**
LO	Describe the reduction of visibility caused by precipitation: drizzle, rain, snow
LO	Describe the reduction of visibility caused by obscurations: - fog, mist, haze, smoke, volcanic ash - sand (SA), dust (DU)
LO	Describe the differences between the ground visibility, flight visibility, slant visibility and vertical visibility when an aircraft is above or within a layer of haze or fog
050 09 09 02	**Reduction of visibility caused by other phenomena**
050 10 00 00	**METEOROLOGICAL INFORMATION**
050 10 01 00	**Observation**
050 10 01 01	**Surface observations**
LO	Define surface wind
LO	Describe the meteorological measurement of surface wind
LO	List the ICAO units for the wind direction and speed used in the METARs (kt, m/s, km/h) *(Refer to 050 02 01 01)*
LO	Define gusts, as given in the METARs
LO	Distinguish wind given in METARs and wind given by the control tower for take-off and landing
LO	Define visibility
LO	Describe the mereorological measurement of visibility
LO	Define prevailing visibility
LO	Define ground visibility
LO	List the units used for visibility (m, km)
LO	Define runway visual range
LO	Describe the meteorological measurement of runway visual range
LO	Indicate where the transmissometers / forward-scatter meters are placed on the airport
LO	List the units used for runway visual range (m)
LO	List the different possibilities to transmit information about runway visual range to pilots
LO	Compare visibility and runway visual range
LO	Indicate the means of observation of present weather
LO	Indicate the means of observing clouds: type, amount, height of base (ceilometers) and top
LO	List the clouds considered in meteorological reports, and how they are indicated in METARs (TCU, CB)
LO	Define oktas
LO	Define cloud base
LO	Define ceiling

Syllabus reference	Syllabus details and associated Learning Objectives
LO	Name the unit and the reference level used for information about cloud base (ft)
LO	Define vertical visibility
LO	Explain briefly how and when the vertical visibility is measured
LO	Name the unit used for vertical visibility (ft)
LO	Indicate the means of observation of air temperature (thermometer)
LO	List the units used for air temperature (°C, °F, Kelvin) *(Refer to 050 01 02 01)*
LO	Indicate the means of observation of relative humidity (hygrometer and psychrometer) and dew point temperature (calculation)
LO	Name the units of relative humidity (%) and dew point temperature (°C, °F)
LO	Indicate the means of observation of atmospheric pressure (mercury and aneroid barometer)
LO	List the units of atmospheric pressure (hPa, inches) *(Refer to 050 01 03 01)*
050 10 01 02	**Radiosonde observations**
LO	Describe the principle of radiosondes
050 10 01 03	**Satellite observations**
LO	Describe the basic outlines of satellite observations
LO	Name the main uses of satellite pictures in aviation meteorology
LO	Describe the different types of satellite imagery
LO	Interpret qualitatively the satellite pictures in order to get useful information for the flights: - location of clouds (distinguish between stratiform and cumuliform clouds) - location of fronts - location of jet streams
050 10 01 04	**Weather radar observations *(Refer to 050 09 04 05)***
LO	Describe the basic principle and the type of information given by ground weather radar
LO	Interpret ground weather radar images
050 10 01 05	**Aircraft observations and reporting**
LO	Describe routine air-report and special air-report
LO	State the obligation of a pilot to make air-reports
LO	Name weather phenomena to be stated in a special air-report
050 10 02 00	**Weather charts**
050 10 02 01	**Significant weather charts**
LO	Decode and interpret significant weather charts (low and high level)
LO	Describe from a significant weather chart the flight conditions at designated locations and/or along a defined flight route at a given flight level
050 10 02 02	**Surface charts**
LO	Recognize the following weather systems on a surface weather chart (analysed and forecast): ridges, cols and troughs; fronts; frontal side, warm sector and rear side of mid-latitude frontal lows; high and low pressure areas
LO	Determine from surface weather charts the wind direction and speed
050 10 02 03	**Upper air charts**
LO	Define constant pressure chart
LO	Define isohypse (contour line) *(Refer to 050 01 03 02)*
LO	Define isotherm
LO	Define isotach

Syllabus reference	Syllabus details and associated Learning Objectives
LO	Describe forecast upper wind and temperature charts
LO	For designated locations and/or routes determine from forecast upper wind and temperature charts, if necessary by interpolation, the spot/average values for outside air temperature, temperature deviation from ISA, wind direction and wind speed
LO	Name the most common flight levels corresponding to the constant pressure charts
050 10 03 00	**Information for flight planning**
050 10 03 01	**Aviation weather messages**
LO	Describe, decode and interpret the following aviation weather messages (given in written and/or graphical format): METAR, SPECI, TREND, TAF, SIGMET, AIRMET, GAMET, special air- report, volcanic ash advisory information
LO	Describe, decode and interpret the tropical cyclone advisory information in written and graphical form
LO	Describe the general meaning of MET REPORT and SPECIAL
LO	List, in general, the cases when a SIGMET and an AIRMET are issued
LO	Describe, decode (by using a code table) and interpret the following messages: Runway State Message (as written in a METAR), GAFOR
	Note: For Runway State Message and GAFOR refer to Air Navigation Plan European Region Doc 7754
050 10 03 02	**Meteorological broadcasts for aviation**
LO	Describe the meteorological content of broadcasts for aviation: - VOLMET, ATIS - HF-VOLMET
050 10 03 03	**Use of meteorological documents**
LO	Describe meteorological briefing and advice
LO	List the information that a flight crew can receive from meteorological services for pre-flight planning and apply the content of these information on a designated flight route
LO	List the meteorological information that a flight crew can receive from services during flight and apply the content of these information for the continuation of the flight
050 10 03 04	**Meteorological warnings**
LO	Describe and interpret aerodrome warnings and wind shear warnings and alerts
050 10 04 00	**Meteorological services**
050 10 04 01	**World area forecast system and meteorological offices**
LO	Name the main objectives of the world area forecast system - World area forecast centres (upper air forecasts) - Meteorological offices (aerodrome forecasts, briefing documents) - Meteorological watch offices (SIGMET, AIRMET) - Aeronautical meteorological stations (METAR, MET reports) - Volcanic ash advisory centres - Tropical cyclone advisory centres
050 10 04 02	**International organisations**

Syllabus reference	Syllabus details and associated Learning Objectives
LO	Describe briefly the following organisations and their chief activities: - International Civil Aviation Organisation (ICAO) *(Refer to subject 010)* - World Meteorological Organisation (WMO)