From WMO BIP-M Guidelines
2.6 Synoptic and mesoscale meteorology

COMET's Tropical Synoptic Meteorology Online Course Package mapped to WMO BIP-M

Emphasis Key: **1 =** Extensively treated, 2 = Well treated, 3 = Basic level only, or just touched upon

Learning Outcomes	Included? Y or N	Emphasis	Comments on how content will be treated, or why excluded
General Topics			
The overall aim of the learning outcomes dealing with synoptic and mesoscale meteorology is to ensure an individual shall be able to:			
• Use physical and dynamical reasoning to describe and explain the formation, evolution and characteristics (including extreme or hazardous weather conditions) of synoptic-scale weather systems in (a) mid-latitude and polar regions and (b) tropical regions, and assess the limitations of theories and conceptual models about these weather systems.	Y	1	See detailed objectives below in other sections.
• Use physical and dynamical reasoning to describe and explain the formation, evolution and characteristics (including extreme or hazardous weather conditions) of convective and mesoscale phenomena and assess the limitations of theories and conceptual models about these phenomena.	Y	1-2	See detailed objectives below in other sections. Mesoscale convective phenomena are emphasized. Other mesoscale phenomena will be emphasized depending on region of course delivery.
• Monitor and observe the weather situation, and use real-time or historic data, including satellite and radar data, to prepare analyses and basic forecasts.	Y	2	Case studies will be presented that offer practical examples to will help synthesize knowledge gained. Real time weather forecast activities will be recommended as regular exercises for courses, but the course package being developed will primarily focus on weather analysis as part of the larger forecast

Learning Outcomes	Included? Y or N	Emphasis	Comments on how content will be treated, or why excluded
			process.
• Describe service delivery in terms of the nature, use and benefits of the key products and services, including warnings and assessment of weather-related risks.	N		Service delivery is beyond the scope of a synoptic course. Should be taught in a separate forecasting course or as part of new forecaster training program.
Mid-latitude and polar weather systems			
• Weather systems. Explain how mid-latitude and polar weather systems differ from those in the tropics.	Y	2	Basics such as baroclinic vs barotropic discussed without need for extensive coverage of midlatitude systems. (More details are covered in the Tropical weather section.)
• Modification of bodies of air. Explain how bodies of air can be modified by the environment, the resulting characteristics of the air, and the ways in which the modifications can affect weather at distant locations through air movement.	Y	2	Discussed in terms of how mid-latitude air masses are modified as they move into the tropics.
• Fronts. Use knowledge of physical processes to describe the characteristics of warm, cold and stationary and occluded fronts, how these fronts are related to synoptic fields, and the three-dimensional nature of frontal boundaries.	Y	2	Useful for extratropical interactions, especially cold fronts during winter. Brief review of cyclone frontal structure.
• Mid-latitude depressions. Apply physical and dynamical reasoning to explain the life cycle of mid-latitude depressions in terms of the Norwegian cyclone model, including the three-dimensional structure of a developing depression and the air flow through the depression.	Y	3	Only briefly touched upon. Distinguish between mid-latitude and tropical cyclones, temperature vs. shear gradients, warm core vs. cold core cyclones, etc.
• Jet streaks and jet streams. Apply physical and dynamical reasoning to explain the development, structure and impact of jet streaks, and the relationship between the jet stream and the development of mid-latitude depressions.	Y	3	Extratropical phenomena briefly covered. Emphasis will be on the subtropical and tropical easterly jet (but this is covered in the Tropical weather section).

Learning Outcomes	Included? Y or N	Emphasis	Comments on how content will be treated, or why excluded
• Synoptic-scale vertical motion. Diagnose synoptic-scale vertical motion in mid-latitude weather systems (e.g., by considering ageostrophic motion, using the Petterssen or Sutcliffe Development Theory or applying the omega equation).	N		These are topics specific to the mid-latitudes, so not covered here.
• Cyclogenesis. Apply knowledge of dynamical processes to explain cyclogenesis and the factors contributing to explosive cyclogenesis.	N		Mid-latitude cyclogenesis is not present in the tropics. This is beyond scope for adequate coverage.
• Frontal structure and frontogenesis. Explain the structure and dynamical characteristics of fronts, the relationship between frontogenesis and vertical motion, and the processes causing upper-level frontogenesis.	N		Mid-latitude frontogenesis is not present in the topics. This is beyond scope for adequate coverage.
• Polar weather systems. Explain the characteristics and formation of polar weather systems, including katabatic winds, barrier winds and polar lows.	N		Polar weather systems are not relevant in the tropics.
• Extreme weather. Describe the weather, with emphasis on any extreme or hazardous weather, that might be associated with mid-latitude and polar weather systems and the likely impact of such conditions.	N		Extreme weather in the tropics is covered in the next section.
• Limitation of conceptual models. Analyse recent and/or historic weather events to assess the extent to which theories and conceptual models of mid-latitude and polar weather systems resemble reality.	Y	3	Include as transition to teaching tropical conceptual models and their relationship to reality.
Tropical weather systems			
• General circulation in the tropics. Describe the general circulation in the tropics and its seasonal variation in terms of the temperature, zonal wind, meridional motions, humidity and sea-level pressure.	Y	1	A fundamental topic, must be sure students demonstrate understanding.
• Main tropical disturbances. Describe the main tropical disturbances and their temporal variability,	Y	1	A fundamental topic, must be sure students demonstrate understanding.

Learning Outcomes	Included? Y or N	Emphasis	Comments on how content will be treated, or why excluded
including the ITCZ, tropical waves, trade inversions, trade winds, tropical/sub-tropical jet streams, cloud clusters, squall lines, tropical depressions, sub-tropical ridges, and upper-level ~~anti~~cyclones. <note potential error in this learning outcome as written>			
• Analysis of tropical flows. Describe the techniques used to analyse tropical flows, including the depiction of streamlines and isotachs, and identification of areas of convergence/divergence.	Y	1	A fundamental topic, must be sure students demonstrate understanding.
• Weather systems. Explain how tropical weather systems differ from those in mid-latitudes and polar regions.	Y	1	Include dynamics discussion: baroclinic vs barotropic, balance of forces, scale analysis of motion, evolution of systems, forcing mechanisms
• Tropical waves. Describe the various types of tropical wave (including Kelvin waves, equatorial Rossby waves and Madden-Julian Oscillation) and their relationship to organized convection and cyclogenesis.	Y	1	Structure, theoretical solutions, observation and prediction, Madden-Julian Oscillation as the dominant intraseasonal circulation
• Tropical cyclones. Apply physical and dynamical reasoning to explain the structure and characteristics tropical cyclones, the main dynamical processes involved in their development, and the techniques used to forecast the development and evolution of tropical storms.	Y	1	Need to decide how to scope this section. It could be extensive without care. Will provide guidelines for instructors.
• Monsoon. Apply physical and dynamical reasoning to explain the structure and characteristics of monsoons and the main dynamical processes involved in their development.	Y	1	Fundamental topic. Most of population of the tropics live in monsoon regions
• Ocean-atmosphere coupling. Describe the role of ocean-atmosphere coupling with emphasis on the theoretical basis and impact of El Niño-Southern Oscillation (ENSO).	Y	2	Covered only as a background and as indicator of seasonal expectations. More detailed content should be covered in a climatology course.
• Extreme weather. Describe the weather, with emphasis on any extreme or hazardous weather, that might	Y	1	Focus is on extreme weather as the product of the preceding systems. Discussion of the local

Learning Outcomes	Included? Y or N	Emphasis	Comments on how content will be treated, or why excluded
be associated with tropical weather systems (including tropical cyclones and monsoons), and the likely impact of such conditions.			scale impacts. This content can be introduced as the topics above are discussed.
• Limitation of conceptual models. Analyse recent and/or historic weather events to assess the extent to which theories and conceptual models of tropical systems resemble reality.	Y	2	This content can be introduced as the topics above are discussed. We recommend the use of case studies throughout the course and/or real time weather discussions.
Mesoscale weather systems			
			Because this is a "Tropical *Synoptic* Meteorology" course, these mesoscale topics will not receive equal emphasis.
• Mesoscale systems. Describe the space and time scales associated with mesoscale phenomena, and the differences in the dynamical processes that drive mesoscale and synoptic scale systems.	Y	2	Concept of scales of weather systems: temporal, spatial, and dynamical scales [Rossby radius of deformation]
• Mesoscale features associated with depressions. Explain the mesoscale features associated with depressions (e.g., rainbands, drylines, gust fronts and squall lines).	N		As applied to tropical depressions, this content is covered elsewhere, e.g. under tropical cyclones
• Gravity waves. Apply physical and dynamical reasoning to explain the structure and formation of mesoscale gravity waves.	Y	3	In relationship to subsequent development of mesoscale weather (also see Orographic section below)
• Convective systems. Apply physical and dynamical reasoning to explain the structure and formation of isolated convective systems such as thunderstorms and convective storms (including single cell, multicell and supercell storms).	Y	1	A fundamental topic, must be sure students demonstrate understanding.
• Mesoscale convective systems. Apply physical and dynamical reasoning to explain the structure and formation of mesoscale convective systems,	Y	1	A fundamental topic, must be sure students demonstrate understanding. Most tropical convection is mesoscale, can evolve into tropical depressions.
• Orographic mesoscale phenomena. Apply physical and dynamical reasoning to explain the structure and	Y	2	Of high importance for some regions, but can't be treated in depth in this Synoptics course.

Learning Outcomes	Included? Y or N	Emphasis	Comments on how content will be treated, or why excluded
formation of orographic mesoscale phenomena (e.g., lee waves, rotors, up-slope and down-slope winds, valley winds, gap flows and lee lows).			Influence on impacts of tropical cyclones, etc.
• Extreme weather. Describe the weather, with emphasis on any extreme or hazardous weather, that might be associated with convective and mesoscale phenomena, and the likely impact of such conditions.	Y	2	Extreme weather as the product of the preceding physical mechanisms. Discussion of the local scale impacts. This content can be introduced as the topics above are discussed.
• Limitation of conceptual models. Analyse recent and/or historic weather events to assess the extent to which theories and conceptual models of convective and mesoscale phenomena resemble reality.	Y	2	This content can be introduced as the topics above are discussed. We recommend the use of case studies and/or real time weather discussions. CMs to be covered include MCSs, sea/land breeze, valley/mountain/gap winds, etc.
Weather observing, analysis and diagnosis			
			Observations, data interpretation, and analysis tools are taught in the context of synoptic and mesoscale weather systems, as described above.
• Monitoring and observing the weather. Monitor the weather, make a basic surface observation using remote and directly-read instruments and visual assessments (including identifying cloud types, cloud amount and weather type), explain the reasons for the visual assessments, and explain the underlying causes of a variety of weather phenomena that are visible from the Earth's surface.	Y	2	Case studies will be presented to offer practical examples that will help synthesize knowledge gained. Real time weather forecast activities will be recommended as regular exercises, but this course package being developed will focus on weather analysis as part of the forecast process. Introduce students to the global observation system and its various components.
• Processing observations. Describe how observations are quality-controlled, coded and distributed.	Y	3	Sources of observation error. WMO standards for GTS, GOS, GDPS
• Synoptic analysis and interpretation. Analyse and interpret synoptic charts and soundings plotted on a	Y	1	Will be covered in practicum activities, in the context of case studies throughout, when

Learning Outcomes	Included? Y or N	Emphasis	Comments on how content will be treated, or why excluded
thermodynamic diagram, and describe the limitations of the observations used in the analyses.			presenting observations and products. Learning can be supported in a capstone activity.
• Interpreting radar data. Interpret common radar displays, including use of enhancements and animated imagery, to identify features associated with convective and mesoscale processes.	Y	2	Taught only in terms of analysis and diagnosis, and depicting conceptual models taught. (Emphasis may depend on current radar capabilities)
• Interpreting satellite imagery. Interpret satellite images, including use of common wavelengths (infrared, visible, water vapour and near infrared) and enhancements and animated imagery, to identify cloud types and patterns, synoptic and mesoscale systems, and special features (e.g., fog, sand, volcanic ash, dust and fires).	Y	1	Taught only in terms of analysis and diagnosis, and in depicting conceptual models taught. Special features (fog, dust, etc.) to be taught based on regional importance.
• Integrating conventional and remote-sensing data. Integrate remote-sensing data and synoptic observations to identify synoptic and mesoscale systems and diagnose the weather situation through relating features found in radar and satellite imagery to features observed from other data sources.	Y	1	Taught in terms of analysis and diagnosis, and depicting conceptual models taught. Infused throughout the course.
• International collaboration. Describe the role of international collaboration in the making and sharing of observations, with emphasis on the World Weather Watch, WMO Global Observing System and WMO Information System (including the Global Telecommunications System).	Y	3	Treated briefly. WMO GTS, GOS, GDPS. Suggest it to be treated more in a forecasting course.
Weather forecasting			
			Most of these outcomes are appropriate for a forecasting course.
• Local weather. Describe factors affecting local weather (e.g., the effect of orography and large bodies of water on cloud and precipitation, or the effect of land surface types).	Y	2	Local weather as the product of multi-scale interactions. This content can be introduced as the topics above are discussed.

Learning Outcomes	Included? Y or N	Emphasis	Comments on how content will be treated, or why excluded
• Forecast process. Describe the main components of the forecast process, including observation, analysis, diagnosis, prognosis, product preparation, product delivery and product verification.	Y	3	Focus is primarily on analysis and diagnosis, but mention is made of the entire process, and it is demonstrated in practice.
• Types of forecasting methods. Explain the advantages and disadvantages of preparing forecasts based on persistence, extrapolation and numerical weather prediction (NWP), and describe the role of the forecaster.	N		Should be taught in a separate forecasting course.
• Conceptual models. Apply conceptual models in making short-range forecasts and interpreting longer-range forecasts.	N		Should be taught in a separate forecasting course.
• Practical forecasting. Combine information from various sources to explain the current weather conditions, and use basic forecasting techniques, including the interpretation of NWP output, to forecast atmospheric variables (e.g., maximum and minimum temperature, wind, and precipitation type and intensity) at a specific location.	N		Should be taught in a separate forecasting course.
Service delivery			
			Service delivery is beyond the scope of a synoptic course. Should be taught in a separate forecasting course or as part of new forecaster training program.
• Function of National Meteorological Services. Describe the function of National Meteorological Services in monitoring and forecasting the weather and the role of other service providers.	N		
• Service provision. Communicate weather information, orally or in written form using deterministic and probabilistic approaches, that meets user requirements.	N		
• Key products and services. Describe the key	N		

Learning Outcomes	Included? Y or N	Emphasis	Comments on how content will be treated, or why excluded
products and services, including warnings of hazardous weather conditions, based on current and forecast weather information that are provided to the public and other users, and describe how the products and services are used (e.g., for decision making and managing risk).			
• Hazardous weather. Describe the extent to which hazardous weather systems affecting the region of responsibility can be forecast, and explain the importance of assessing the risk of hazardous weather, issuing prompt and accurate warnings, and understanding the potential impact of hazardous weather on society.	N		
• Quality of products and services. Explain the basic techniques used to assess the quality of products and services.	N		
• Benefits and costs of meteorological services. Identify the economic and social impacts of meteorological services upon a country and their key user sectors.	N		