

Chapter Ten

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10 Tropical Cyclone Training

Since the original *Global Guide* was written, a tremendous amount of training materials have been developed and made available to the meteorology and hydrology communities. There is absolutely no reason to duplicate these programs and materials in this document. The major sources of training materials come from the WMO, some of the RSMCs and TCWCs, and specific organizations that have their mission as the development of training materials (e. g., UCAR COMET® MetEd). Some of the major sources are listed in this chapter, but this list is in no way exhaustive.

10.1 UCAR, COMET®, MetEd

The University Corporation for Atmospheric Research (UCAR), with its headquarters at Boulder, Colorado, USA, serves as a hub for research, education, and public outreach for the atmospheric and related Earth sciences community. UCAR's mission includes:

- Support, enhance and extend the capabilities of the university community, nationally and internationally
- Understand the behavior of the atmosphere and related systems and the global environment
- Foster the transfer of knowledge and technology for the betterment of life on Earth

A part of UCAR's Community Programs that helps satisfy its advancement of education goals is the COMET® Program (<https://www.meted.ucar.edu/>). This Program is a world-wide leader in support of education and training for the environmental sciences, particularly meteorology, but also oceanography, hydrology, space weather and emergency management. COMET is sponsored by NOAA's National Weather Service (NWS) with additional funding from several national and international organizations. COMET offers the following products and services:

- Media-rich, interactive and multi-lingual distance learning
- Internet-based courses

- The MetEd website with a user tracking and assessment system
- Residence courses, workshops and meetings
- Small grants program (outreach)
- Leadership and consultation in science education and training

The MetEd website hosts hundreds of hours of education and training material for the geosciences. The training materials are composed of modules and courses. A **module** is targeted toward one focused subject. A **course** is a collection of modules that pertain to a broader subject area. You can obtain Certificates of Completion for both modules and courses. Courses are entirely self-paced and are available for open enrollment. This is a free service, and those in the tropical cyclone business are highly encouraged to take advantage of it. Pertinent training topic headings are:

- Tropical/Hurricanes
- Satellite Meteorology
- Radar Meteorology
- Oceanography/Marine Meteorology
- Hydrology/Flooding
- Emergency Management
- Numerical Modeling
- Environment and Society
- Aviation Weather

10.1.1 COMET/MetEd: Tropical/Hurricanes

The following sections list COMET courses sorted by subject matter categories. Courses in **bold** are recommended as the most urgent for tropical cyclone forecaster training.

- **Introduction to Tropical Meteorology**
 - **Chapter 1: Introduction**
 - **Chapter 2: Tropical Remote Sensing Applications**
 - **Chapter 3: Global Circulation**
 - **Chapter 4: Tropical Variability**
 - **Chapter 5: The Distribution of Moisture and Precipitation**
 - **Chapter 8: Tropical Cyclones**
 - **Chapter 9: Observations, Analysis and Predictions**
- **Topics in Tropical Meteorology**
- **Conceptual Models of Tropical Waves**
- **Diagnosing and Forecasting Extratropical Transition: A Case Exercise on Hurricane Michael**
- **Hurricanes Canadian Style: Extratropical Transition**

10.1.2 COMET/MetEd: Satellite Meteorology

- **Remote Sensing Using Satellites**
- **Polar Satellite Products for the Operational Forecaster: Microwave Analysis of Tropical Cyclones**
- **Microwave Remote Sensing: Overview**
- **Microwave Remote Sensing: Resources**
- **Microwave Remote Sensing: Clouds, Precipitation and Water Vapor**
- **Microwave Remote Sensing: Land and Ocean Surface Applications**
- Satellite Feature Identification: Atmospheric Rivers
- Satellite Meteorology: GOES Channel Selection
- Satellite Meteorology: Introduction to Using the GOES Sounder
- Atmospheric Dust
- Multispectral Satellite Applications: RGB Products Explained
- Toward an Advanced Sounder on GOES
- Satellite Feature Identification: Blocking Patterns
- Jason 2: Using Satellite Altimetry to Monitor the Ocean
- WMO Regional Satellite Workshop: Regional Training Course on the Use of Environmental Satellite Data in Meteorological Applications for RAIII and RAIIV.
- GOES-R: Benefits of Next-Generation Environmental Monitoring
- Advanced Satellite Sounding: The Benefits of Hyperspectral Observation
- Environmental Satellite Resource Center (ESRC)
- Creating Meteorological Products from Satellite Data
- **Remote Sensing of Ocean Wind Speed and Direction: An Introduction to Scatterometry**
- **Advances in Microwave Remote Sensing: Ocean Wind Speed and Direction**

10.1.3 COMET/MetEd: Radar Meteorology

- **Caribbean Radar Cases**
- **Weather Radar Fundamentals**
- Radar Signatures for Severe Convective Weather
- Lectures on Radar Applications in Mesoscale Meteorology

10.1.4 COMET/MetEd: Oceanography/Marine Meteorology

- A Forecaster's Overview of the Northwest Pacific
- **Introduction to Ocean Models**
- Mesoscale Ocean Circulation Models
- **Nearshore Wave Modeling**
- **Operational Use of Wave Watch III**
- North Wall Effects on Winds and Waves
- **Analyzing Ocean Swells**
- Wave Ensembles in the Marine Forecast Process
- **Introduction to Ocean Currents**
- **Winds in the Marine Boundary Layer: A Forecaster's Guide**
- Understanding Marine Customers
- Introduction to Ocean Tides
- Rip Currents: Near Shore Fundamentals
- Rip Currents: Forecasting
- Rip Currents: NWS Mission and Partnerships
- **Shallow Water Waves**
- **Marine Wave Model Matrix**
- Wave Life Cycle I: Generation
- Wave Life Cycle II: Propagation & Dispersion
- Low Level Coastal Jets

10.1.5 COMET/MetEd: Hydrology/Flooding

- ASMET: Flooding in West Africa
- Satellite Precipitation Products for Hydrological Management in South Africa
- Flash Flood Early Warning System Reference Guide
- Flood Forecasting Case Study: International Edition
- **Basic Hydrologic Science Course**
- **Flash Flood Processes: International Edition**
- Introduction to Verification of Hydrologic Forecasts
- Techniques in Hydrological Forecast Verification
- Runoff Processes: International Edition
- Streamflow Routing: International Edition
- Flood Frequency Analysis: International Edition
- Unit Hydrograph Theory: International Edition
- Understanding the Hydrologic Cycle: International Edition
- Introduction to Distributed Hydrologic Modeling
- Distributed Hydrologic Models for Flow Forecasts Part 1
- Distributed Hydrologic Models for Flow Forecasts Part 2
- Precipitation Estimates, Part 1: Measurement
- Precipitation Estimates, Part 2: Analysis

- Quantitative Precipitation Forecasting Overview
- QPF Verification: Challenges and Tools
- An Introduction to Ensemble Streamflow Prediction
- NWS Hydrologic Ensemble Forecast System
- Dams & Dam Failure Module 1: Terminology and Open Channel Hydraulics
- Dams and Dam Failure Module 2: St.Venant Equations, Modeling and Case Study
- **Flash Flood Processes**
- **Flash Flood Case Studies**
- **River Forecasting Case Study**
- **Allison Rains in Houston, Texas**

10.1.6 COMET/MetEd: Emergency Management

- Anticipating Hazardous Weather and Community Risk
- Quality Management Systems: Implementation in Meteorological Services
- Role of the Skywarn Spotter
- Skywarn Spotter Convective Basics
- **Hurricane Strike!**
- **Community Hurricane Preparedness**
- **Urban Flooding: It Can Happen in a Flash!**
- **A Social Science Perspective on Flood Events**

10.1.7 COMET/MetEd: Numerical Modeling

- Gridded Forecast Verification and Bias Correction
- Bias Correction of NWP Model Data
- **Optimizing the Use of Model Data Products**
- **Introduction to Ensemble Prediction**
- **Ensemble Forecasting Explained**
- How Mesoscale Models Work
- **Tropical Storm Allison in the Southeastern US**
- Ten Common NWP Misconceptions
- Interpretation of Global Forecast Model "Flip-Flops"
- Preparing to Evaluate NWP Models
- **Effective Use of NWP in the Forecast Process: Introduction**
- **Impact of Model Structure and Dynamics**
- Understanding Assimilation Systems: How Models Create Their Initial Conditions
- **Influence of Model Physics on NWP Forecasts**
- How Models Produce Precipitation and Clouds
- Effective Use of High Resolution Models

- How NWP Fits into the Forecast Process
- Downscaling of NWP Data
- Adding Value to NWP Guidance
- Determining Plausible Forecast Outcomes
- **Understanding the Role of Deterministic Versus Probabilistic NWP Information**

10.2 WMO-sponsored training

The WMO sponsors tropical cyclone, disaster preparedness and hydrological training at various WMO Training Centers such as the one at the University of Nanjing in China.

10.3 Regional training

10.3.1 National meteorological center-sponsored, RSMC-sponsored, and TCWC-sponsored training

Various National Meteorological Centers, Regional Specialized Meteorological Centers and Tropical Cyclone Warning Centers often sponsor and provide regional tropical cyclone training. Some examples are:

- Region Association I: RSMC-La Reunion (Meteo-France), TCWC Perth;
- The Economic and Social Commission for Asia and the Pacific (ESCAP): Japan Meteorological Agency, RSMC-Tokyo, Korean Meteorological Administration, China Meteorological Administration, Chinese Meteorological Society, Hong Kong Observatory, Weather Forecast Office Guam;
- Central Pacific Hurricane Center Pacific Desk/RSMC-Honolulu;
- Regional Association IV: National Hurricane Center/RSMC-Miami;
- Regional Association V: Australian Bureau of Meteorology (BoM), the New Zealand Met Service, RSMC-Nadi, TCWCs at Darwin and Brisbane.

10.3.2 National and regional disaster risk reduction

Training centres include:

- Asian Disaster Preparedness Center (ADPC), based at the Asian Institute of Technology in Bangkok. The ADPC has introduced practical experience for participants through the conduct of field vulnerability assessment studies in towns and villages.
- National Disaster Risk Reduction Institute Japan;
- Asian Disaster Reduction Center (ADRC) sponsored by the Republic of Korea.

10.4 Internal training programs and certifications

10.4.1 NOAA

In the US, NOAA's National Weather Service (NWS) has its own training program through the NOAA Learning Center. This is an online program that not only includes all of the MetEd modules and courses, but also includes modules and courses that pertain specifically to NWS equipment and methodology. In addition, NWS provides a great deal of on-the-job initial and recurrent training with formalized certification.

10.5 The function of training programs in tropical cyclone centers

There are several functions of formal and informal training programs. While education satisfies the basic level of knowledge for tropical cyclone forecasters, training is what qualifies them to actually issue forecasts as a certified forecaster. Training familiarizes a new forecaster with local and regional knowledge, and with other specialized knowledge. Training programs are part of the overall Forecasting Strategy as discussed in Chapter 8. Every TCWC must have some kind of formal training program that includes initial training, preseason readiness training, and training of opportunity as discussed in the earlier sections of Chapter 10.

10.5.1 Certification training

As pointed out in Chapter 8, training needs of staff members are best considered in relation to the roles they will fill in the warning centre. See Section 8.3 for a more complete discussion of training with respect to staffing and the various TCWC roles.

A Tropical Cyclone Warning Center (TCWC) should have some formalized training program that prepares and ultimately certifies a new forecaster. This is generally conducted as local study and on-the-job-training, and may require several months. In general, the new forecaster should be trained, evaluated by a certified forecaster, and ultimately "signed off" as knowledgeable or proficient in that subject or task. Once the new forecaster has satisfactorily completed the training program, he/she can either be designated as certified or can be required to meet and an evaluation board of management and certified forecasters. That board requires the new forecaster to meet with it in order to address and answer a series of pre-selected questions about forecasting, operations and emergency procedures. Following the session, the board either votes for certification or recommends additional training for the new forecaster.

10.5.2 Recurrent training

Recurrent training is discussed in Chapter 8, in the Continuous Improvement Section (8.7) under the topic of "preseason readiness". Even at the Joint Typhoon Warning Center (JTWC), where tropical cyclone warning is a year-round job, some preseason training is required for the switch between northern and southern hemisphere forecasting. And, at the National Hurricane Center at Miami, where hurricane specialists have year-round tasks, hurricane forecasting is

seasonal, and preseason preparation is needed as the season approaches. This may involve something as simple as an annual review of Standing Operating Procedures (SOPs) or something as complicated as attending a formal course at a training center. The TCWC should have a program that addresses recurrent training needs and tracks them.

10.5.3. Advanced or specialized training

The TCWC program should include WMO and national or regional training opportunities as well. These are usually advanced or specialized courses, and the attendee should be prepared to pass his/her newly acquired knowledge to colleagues. Advanced and specialized training is also available through the multitude of online and *MetEd* training programs. These opportunities should be periodically monitored for new, relevant courses.

10.6 WMO Tropical Cyclone Forecaster's Website

The Hong Kong Observatory hosts the WMO Tropical Cyclone Forecaster's Website at

<http://severe.worldweather.wmo.int/TCFW/>

This site has a Training Materials module that includes:

- TC RSMC Training Documentations
- E-material and presentations from RSMC Miami
- Web-based training from MetEd
- Advanced Warning Operations Course from US NWS

The website also includes modules for:

- Observations and Products Data
- Advisory and Warning Centres
- WMO Technical Publications
- Tropical Cyclone Research
- TC Data Archive
- Weather Event Discussion

We highly encourage all forecasters to visit and use this site.