Supported by:

UK International Development

Partnership | Progress | Prosperity

Met Office

Regional Workshop on Framework and Toolkit Development

RIMES : EXPERIENCE IN COMET

Shiromani Jayawardena,

Advisor (Climate and Weather Services), SAHF, RIMES

OVERVIEW

01 **COMET Modules Reviewed**
(Heat, cold, WBGT, HeatRisk, EPS, IBF communication)

02 **Heat & Cold Thresholds** (Heat Index, WBGT, HeatRisk; wind chill and extreme cold)

03 **Case Example: Tropical Cyclone Mandous Wind-Chill Event -**
Importance of Location-Specific Thresholds

04 **COMET Modules for Impact-Based Forecasting & Communication**

05 **Key Observations from RIMES' Review**

06 **Guidance for NMHS Officers and Stakeholders**

Photo by Pawel Janiak on Unsplash

Oak Ridge National Laboratory

Heat and Cold Risk Modules

- **Using Heat Forecast Tools to Provide Decision Support for Extreme Heat Threats** – compares *Heat Index, WBGT,* and *HeatRisk*; builds decision-support messages for vulnerable groups.

- **Interpreting and Communicating EPS Guidance – Iberian Heat Wave Case** – uses ensemble prediction systems (EPS) to assess temperature exceedance probabilities.

- **Communicating Impacts and Mitigation for Wind Chill and Extreme Cold** – highlights cold thresholds, health impacts, and multi-agency communication.

Using Heat Forecast Tools to Provide Decision Support for Extreme Heat Threats

Heat Index | Wet Bulb Globe Temperature | WBGT Regional Threat Level | HeatRisk | HeatRisk Categories

- The lesson trains forecasters to choose the right heat forecast tool—such as Heat Index, Wet Bulb Globe Temperature, or HeatRisk—to assess and communicate local extreme heat threats.
- It helps them practice realistic forecast discussions and understand how to explain limitations and decision-support messages to users.
- This module highlights the “Must Know 4 Ws” for actionable IBF: *What* the hazard is, *When* it will occur, *Where* the risk is highest, and *Who* is affected.
- For example, if an organizer plans a marathon in **X** City on date **Y**, the forecaster must determine which tool—HI, WBGT, or HeatRisk—is most appropriate for that activity, season, and local environment.

Heat stress vs Wet Bulb Globe Temperature (WBGT) vs HeatRisk

- **Heat stress** is commonly measured by the heat index or the “feels like temperature” which is representative of the temperature and moisture in the atmosphere.
- Wet Bulb Globe Temperature (WBGT) index estimates how temperature, humidity, wind, and solar radiation together affect the human body. **WBGT** is best suited for active people such as outdoor workers, athletes, marching band, and others performing strenuous outdoor activities.
- **HeatRisk** is a color-coded, numeric index that shows how unusual and dangerous forecasted heat will be for a specific location. It combines weather forecasts, local climate data, and health-based temperature thresholds to identify the likelihood of heat-related impacts.
  - Uses location-specific daily thresholds, calibrated to local climatology and seasonal norms. HeatRisk identifies unusual heat (defined as the warmest 5% of temperatures) specifically for a particular date and location, resulting in daily thresholds that are unique for each location and date.
  - Health-based index that integrates weather forecasts, local climate data, and CDC heat–mortality relationships.
  - Captures duration and nighttime heat, reflecting cumulative stress—major drivers of illness and mortality.

HeatRisk incorporates multiple factors to determine how dangerous upcoming heat will be **for your specific location and time of year**:

1. How Unusual the Temperatures Are

• Compares forecast temperatures with the top **5% hottest days** for that location and calendar date.

2. Humidity Detection (Forecast-Driven)

• Uses relationships between **minimum temperature, dewpoint, and diurnal temperature range** to approximate humidity when long-term humidity data is limited.

3. Time of Year / Seasonality

• Early-season heat poses higher risk because people are not yet adapted to high temperatures, while mid-summer heat may be more typical.

• **4. Duration of Heat & Nighttime Conditions**

• Considers whether nights are:

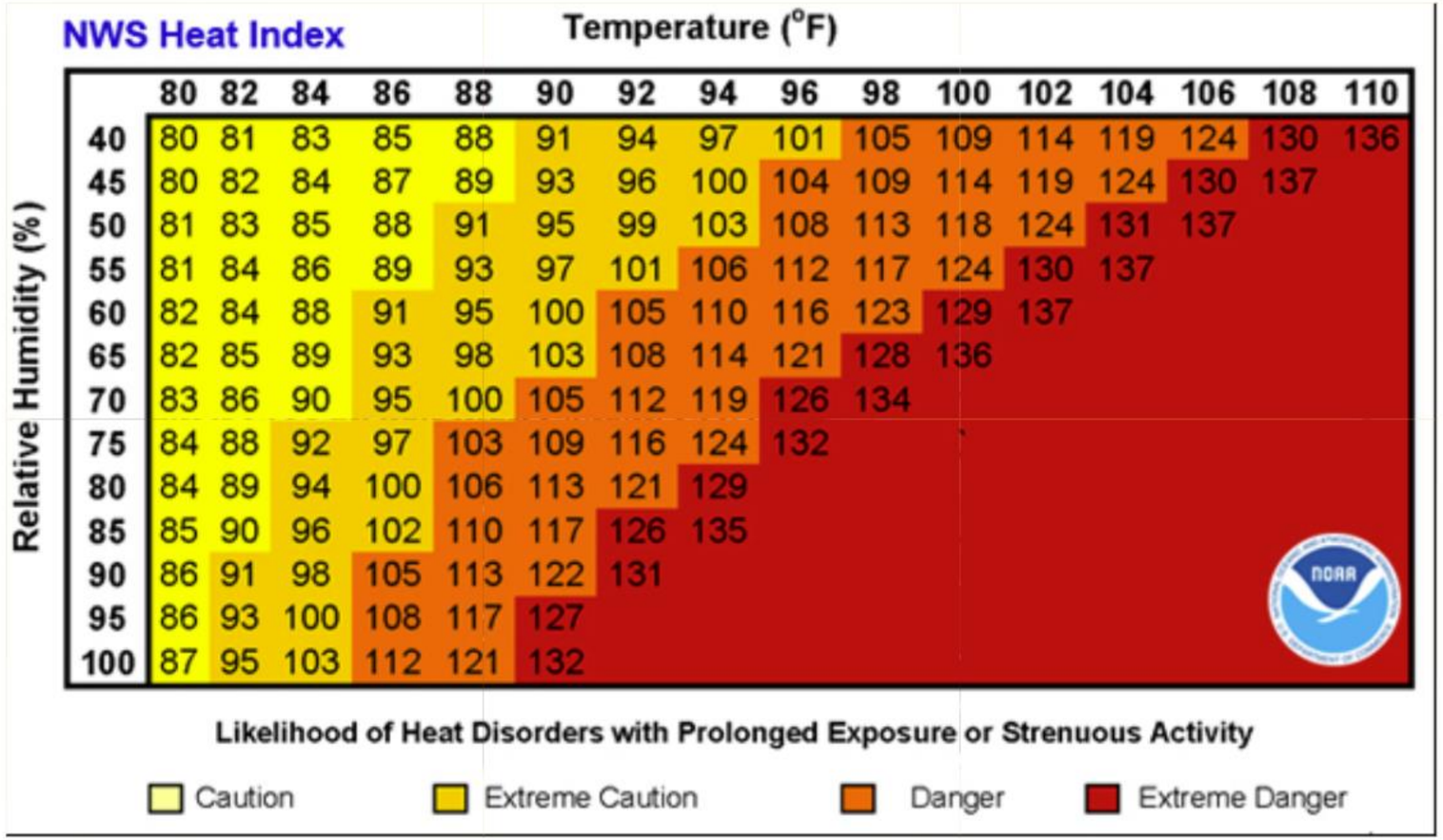
- cooling enough to reduce stress,
- maintaining heat stress, or
- adding to cumulative heat stress.

5. Health Impact Thresholds

• Integrates **CDC-supported heat–health thresholds** and peer-reviewed science to identify when heat becomes dangerous.

Thresholds for Heat Index

- **Heat stress** is commonly measured by the heat index or the “feels like temperature” which is representative of the temperature and moisture in the atmosphere.



RH (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

$$HI = -42.379 + 2.04901523T + 10.14333127R - 0.22475541TR - 6.83783\times10^{-3}T^2 - 5.481717\times10^{-2}R^2 + 1.22874\times10^{-3}T^2R + 8.5282\times10^{-4}TR^2 - 1.99\times10^{-6}T^2R^2$$

where T = ambient dry bulb temperature (°F)

R = relative humidity (integer percentage).

Thresholds for Wet Bulb Globe Temperature (WBGT)

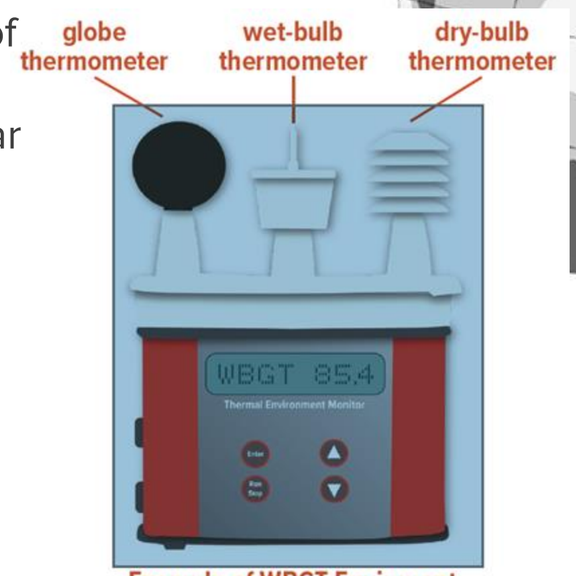
- Wet Bulb Globe Temperature (WBGT) index is widely recognized as an international reference for assessing environmental heat risks in occupational settings.
- Heat risk refers to environmental heat stress assessed by WBGT, indicating potential risks for heat-related illnesses among workers
- The WBGT is derived from a combination of temperatures from three thermometers — wet globe for humidity, black globe for solar factor, and dry bulb for the ambient temperature.
- This index incorporates weather variables such as natural wet-bulb temperature (*Tnwb*), air temperature (*Ta*), and globe temperature (*Tg*), Global Horizontal Irradiance (*GHI*)

General Thresholds for Wet Bulb Globe Temperature

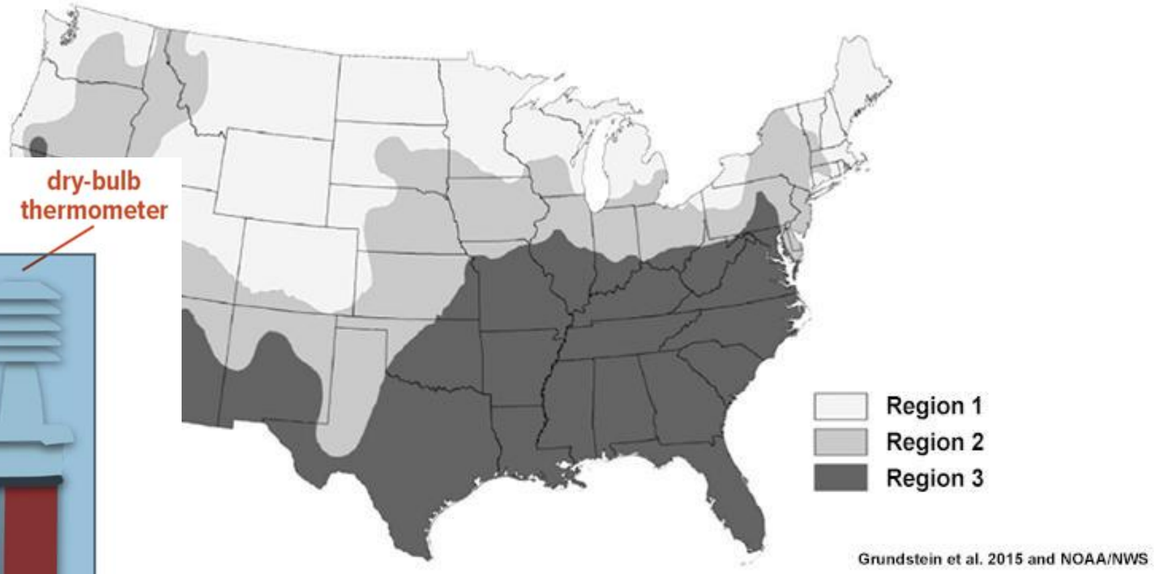
Disclaimer: Always check with local officials for appropriate actions and activity levels. Experienced heat stress will depend upon duration and intensity of activity and personal health and vulnerability.

WBGT by Region (°F)			Threat Level WBGT at these values increasing heat stress.	Risk of heat illness
Region 1	Region 2	Region 3		
< 72.3	< 75.9	< 78.3	Low Threat	Increased risk for heat illness
72.3 - 76.1	75.9 - 78.7	78.3 - 82.0	Elevated Threat	
76.2 - 80.1	78.8 - 83.7	82.1 - 86.0	Moderate Threat	
80.1 - 84.0	83.8 - 87.6	86.1 - 90.0	High Threat	
>84.0	>87.6	>90.0	Extreme Threat	

Regions are from Grundstein, A., Williams, C., Phan, M and Cooper, E., 2015. Regional heat safety thresholds for athletics in the contiguous United States. *Applied Geography*, 56, pp.55-60. 10.1016/j.apgeog.2014.10.014.



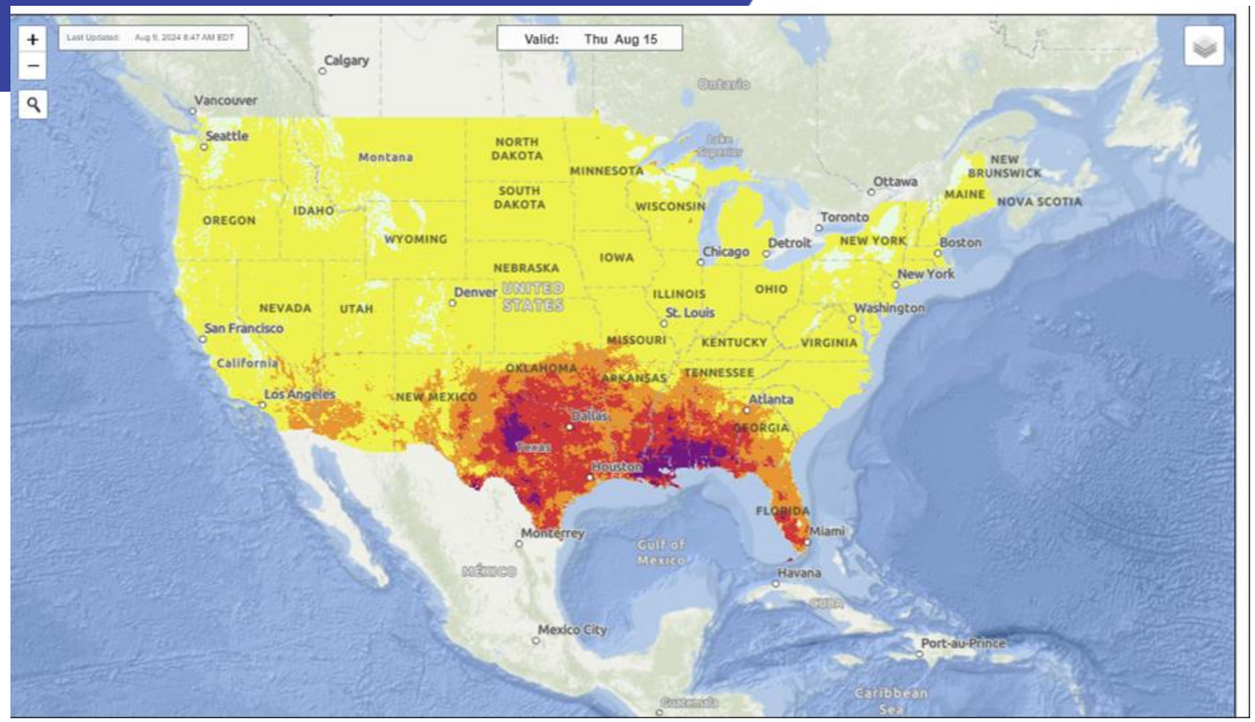
Example of WBGT Equipment



Grundstein et al. 2015 and NOAA/NWS

HeatRisk (Experimental)

Risk of Heat-Related Impacts	
0	Little to no risk from expected heat.
1	**Minor** - This level of heat affects primarily those individuals extremely sensitive to heat, especially when outdoors without effective cooling and/or adequate hydration.
2	**Moderate** - This level of heat affects most individuals sensitive to heat, especially those without effective cooling and/or adequate hydration. Impacts possible in some health systems and in heat-sensitive industries.
3	**Major** = This level of heat affects anyone without effective cooling and/or adequate hydration. Impacts likely in some health systems, heat-sensitive industries and infrastructure.
4	**Extreme** = This level of rare and/or long-duration extreme heat with little to no overnight relief affects anyone without effective cooling and/or adequate hydration. Impacts likely in most health systems, heat-sensitive industries and infrastructure.



Definition of HeatRisk

- **HeatRisk** is a five-level, color-coded forecasting tool jointly developed by **Centers for Disease Control and Prevention (CDC)** and **NOAA's National Weather Service.**
- **It c**ombines weather, climate and CDC data to identify potentially dangerous heat that may lead to increased risk from health impacts.
- It provides a seven-day outlook by combining local temperature forecasts with health-based thresholds derived from CDC data on heat–mortality relationships. The tool adjusts for local climate, geography, and seasonal differences, allowing it to reflect how heat affects health differently in each region. HeatRisk is designed to help state and local health officials understand when heat conditions may become hazardous and require public health action.

Interpreting and Communicating EPS Guidance: Iberian Heat Wave

Temperature Threshold (°C)	Color	Risk
None	Green	No Risk
T > 34° - 38°	Yellow	Risk
T > 37° - 40°	Orange	Important Risk
T > 40° - 44°	Red	Extreme Risk

Note: With respect to extreme temperatures, the exact thresholds for the risk level can vary between provinces based on local climatological characteristics. Accordingly, the risk level shows a range of temperatures to be exceeded, depending on the particular province you are studying.

- Ensemble prediction systems (EPS) provide an opportunity for forecasters to gain local and regional perspectives of a weather event. In this lesson, users selected the most useful EPS forecast products to determine the potential severity, magnitude, and duration of extreme forecast temperatures.
- EPS forecast product to a user:
  - **Extreme Forecast Index/Shift of Tails**: Provides an assessment of a forecast variable that is unusually high or low compared to the model climate.
  - **Probability of Exceedance**: a forecast probability that a specific weather or climate variable, will exceed a certain threshold
  - **Box and Whisker EPSgrams**: Provides an assessment of probabilities and percentiles of a forecast variable at a specific location.

Wind Chill & Extreme Cold

Communicating Impacts and Mitigation for Wind Chill and Extreme Cold

Communicating Impacts and Mitigation for Wind Chill and Extreme Cold

Produced by The COMET® Program

Navigation Menu

Introduction

Wind Chill Chart

Wind (mph) \ Temperature (°F)	Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5		36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10		34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15		32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20		30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25		29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30		28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35		28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40		27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45		26	29	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50		26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55		25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60		25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes | 10 minutes | 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

NWS

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

COMET MetEd

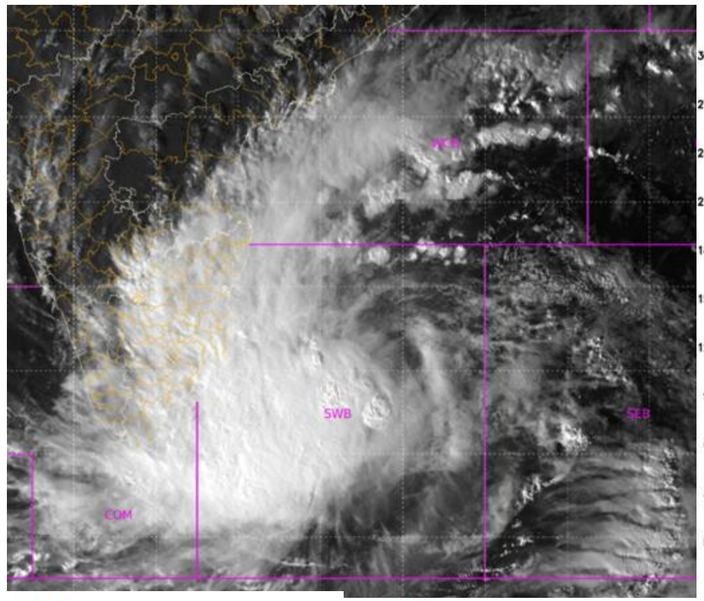
- **A Wind Chill Warning/Advisory (WSW)** should be issued whenever wind chill values are forecast to be at or below the warning/advisory thresholds.
- Forecasters should also take other factors into consideration when making a warning decision.
- Examples of these factors include consistency with surrounding WFOs, time of year, longevity of event, and areal coverage of expected hazardous weather.
- The warning will include wind-chill values and frostbite times so that users clearly understand the level of danger

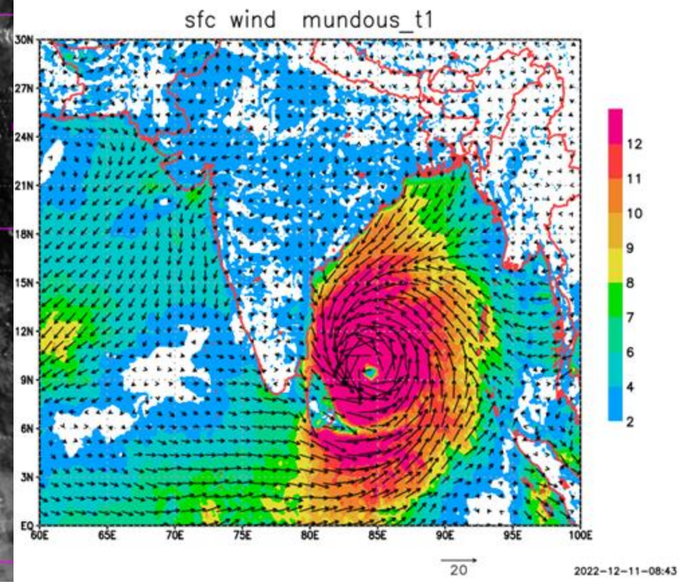
IMPACTS

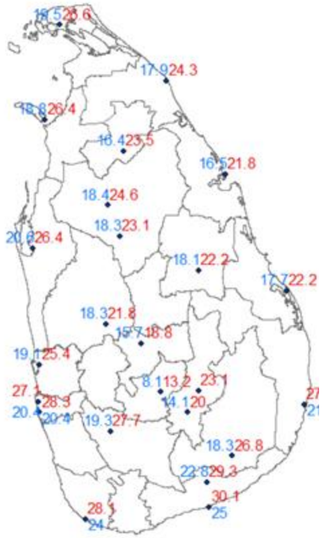
- Cold temperatures and wind chill values have serious adverse health effects:
- Frostbite occurs when tissues freeze. At wind chill advisory temperatures, frostbite can occur in as little as 30 minutes if your skin is unprotected from the cold. The nose, cheeks, ears, fingers, and toes (your extremities) are most commonly affected. Frostbite is very serious and requires immediate medical treatment.
- Hypothermia is a potentially dangerous drop in body temperature. With hypothermia, core temperature drops below 95°F. In severe hypothermia, core body temperature can drop to 82°F or lower. Hypothermia is life-threatening. Symptoms include drowsiness, slurring of speech, confusion, and becoming uncoordinated or unsteady.
- Prolonged exposure to harsh cold is potentially dangerous. Victims of hypothermia are most often:
  - elderly people with inadequate food, clothing, or heating
  - babies sleeping in cold bedrooms
  - children left unattended
  - adults under the influence of alcohol
  - mentally ill individuals
  - people who remain outdoors for long periods, such as the homeless, hikers, or hunters
- Infants lose body heat more easily than adults. Additionally, they can't make enough body heat by shivering. Infants less than one year old should never sleep in a cold room.
- Older adults often make less body heat because of a slower metabolism and less physical activity.

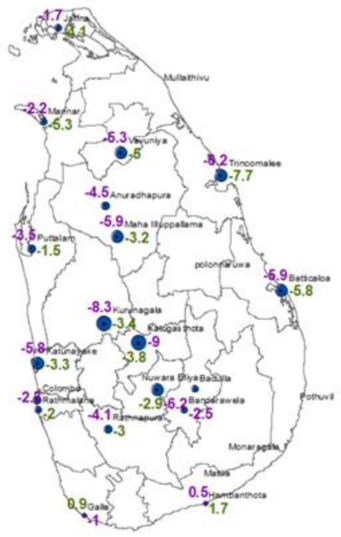
Case Study: Unusual Wind-Chill Conditions Associated with Tropical Cyclone Mandous over Northeast Sri Lanka – Importance of Location-Specific, Sector specific Thresholds

- Thresholds must be location-specific because risk levels depend on local climate, seasonal patterns, and typical temperature ranges.
- During Cyclone Mandous, a thick sheared cloud mass of the system blocked sunlight over Sri Lanka for three days (7–9 Dec, 2022), sharply reducing daytime heating.
- This resulted in a 7–8°C negative temperature anomaly, with both daytime and nighttime temperatures falling far below normal.
- On 9 December 2022, Trincomalee recorded 16.5°C, the lowest night-time temperature ever observed at that station.
- Strong winds, persistent cloud cover, cool temperatures, and continuous rainfall produced a rare wind-chill effect over northeastern Sri Lanka.









- **This prolonged cold stress led to serious livestock losses, including:1800 cattle and Goat due to shock caused by cold also known as hypothermia (DG, Department of Animal Production & Health)**

Cyclone Mandous kills hundreds of livestock in Sri Lanka's northern farms

Death of animals in North & East: safety instructions issued

by Staff Writer
14-12-2022 | 10:39 AM

Colombo (News 1st) - The Department of Animal Production & Health has decided to issue a series of instructions to ensure the safety of cattle and goats in the Northern and Eastern Provinces.

"The cattle and goats had died due to shock caused by the cold (also known as hypothermia," Director General Hemali Kothalawala confirmed.

"About 1,800 cattle and goats have died due to bad weather conditions over the past few days." she added.

Cyclone Mandous kills hundreds of livestock in Sri Lanka's northern farms

By ROSHANI FERNANDO
Saturday December 10, 2022 3:00 pm

ECONOMYNEXT – Unusually cold weather in Sri Lanka's northern province caused by the Mandous cyclonic storm in the Bay of Bengal has led to the death of hundreds of farm animals with hundreds more falling sick.

CEYLON TODAY

Home Local World Sports Business Entertainment Tech Ceylon Today – Daily Ceylon Today – Sunday E-PAPER

FOCUS

A Curious Case of Livestock Deaths in N-E

By: Thameenah Razeek | Date: December 17, 2022 2:00am

The death of scores of cattle, buffaloes, and goats made headlines last week, prompting the President to halt the transportation of beef and mutton at district and provincial levels.

The cause is attributed to the sudden weather change, which experienced a temperature decrease of 20 degrees Celsius. When the temperature dropped, farm animals exposed to it suffered from fatal cold shock.

Popular

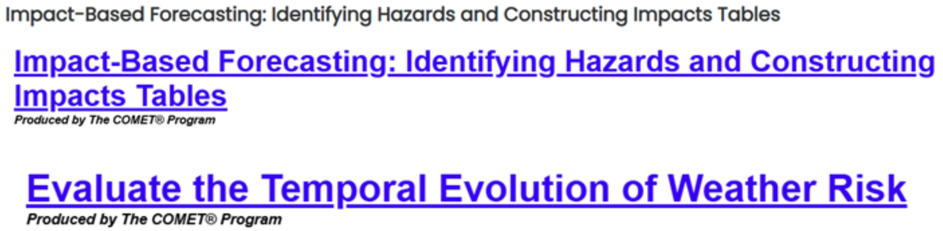
Money Extortion: Chinese Nationals Top List in SL – Police

Impact-Based Forecasting and Risk Communication Modules

- **Impact-Based Forecasting: Identifying Hazards and Constructing Impact Tables**
  → Guides users through identifying *hazards, exposure, and vulnerability*, and populating impact matrices.
- **Analyzing and Evaluating Risk**
  → Demonstrates use of *risk matrices* to determine impact levels, likelihood, and vulnerability conditions.
- **Communicating Risk: The IBF Approach**
  → Interactive simulations for crafting warnings focused on *what the weather will do* instead of *what it will be*.

- **The Process for Implementing IBF and Warning Services**
  → Provides a stepwise roadmap for institutional adoption and partner engagement.

- **Building Partnerships Through Communication**
  → Explores strategies to engage stakeholders and co-develop IBF systems.



Key Observations from RIMES' Review

- COMET and MetEd provide valuable global resources on heat, cold, WBGT, HeatRisk, EPS interpretation, and risk communication, though most examples come from outside South Asia.

- A key lesson is that all hazard thresholds are location-specific—they must reflect local climate, vulnerability, and sectoral needs to be meaningful and actionable.

- Most COMET/MetEd modules use **case studies from Europe, Africa, or North America**, such as *Iberian Heat Wave, Typhoon Matmo (Taiwan), Tropical Storm Kirk (Barbados),* or *South African impact-based rainfall forecasts.*

- Most **Impact-Based Forecasting (IBF)** and **Risk Communication** modules in COMET/MetEd focus on **strong winds, heavy precipitation events, and tropical cyclones**

- Tools such as Heat Index, WBGT, and HeatRisk, together with EPS products like EFI, Probability of Exceedance, and EPSgrams, enhance forecast interpretation and help tailor warnings to local conditions and user requirements.

- **SAHF IBF experience** in developing *impact-based thresholds, co-production processes, and communication pathways* for countries in South Asia presents an opportunity to **localize and enrich** future COMET/MetEd modules.

Guidance for NMHS Officers and Stakeholders

- Use location-specific thresholds for heat, cold, WBGT, and wind-chill, based on local climate, seasons, and sectoral requirements.
- Integrate key tools — Heat Index, WBGT, HeatRisk, EFI, Probability of Exceedance, and EPSgrams — to assess severity, duration, and uncertainty.
- Include nighttime temperatures and multi-day duration, as both strongly influence heat and cold stress.
- Strengthen cross-sector coordination with Health, Disaster Management, Labour, Agriculture, Energy, and Livestock agencies.
- As many countries have significant capacity-building needs, COMET provides valuable training resources that help bridge this gap and support NMHS workforce development.

Conclusion

- COMET and MetEd offer valuable global training resources on heat, cold, WBGT, HeatRisk, EPS interpretation, and risk communication — although most examples are from outside South Asia.
- A key lesson is that all hazard thresholds must be location-specific, reflecting local climate, seasonality, vulnerability, and sectoral needs to ensure forecasts and warnings are meaningful and actionable.
- Tools such as Heat Index, WBGT, and HeatRisk, along with EPS products like EFI, Probability of Exceedance, and EPSgrams, significantly improve forecast interpretation and help tailor warnings to local conditions.
- South Asia has strong capacity-building needs, and COMET resources can help fill this gap by strengthening the skills of forecasters and sectoral users.
- Moving forward, SAHF IBF experience in developing impact-based thresholds, co-production processes, and communication pathways presents an excellent opportunity to collaborate with COMET and partners to develop South Asia–specific case studies and integrate them into the SAHF Knowledge Hub.


THANK YOU
IBF: LINKING THRESHOLDS TO
DECISIONS THAT SAVE LIVES

Additional

$$WBGT = 0.7T_{nwb} + 0.2T_g + 0.1T_a$$

- natural wet-bulb temperature (*Tnwb*)

$$T_{nwb} = T_{wb} + 0.001651GHI - 0.09555V_a + 0.13235(T_a - T_{wb}) + 0.20249$$

wet-bulb temperature (*Twb*)

$$T_{wb} = T_a \tan^{-1}(0.151977(RH + 8.313659)^{0.5}) + \tan^{-1}(T_a + RH) - \tan^{-1}\left(RH - 1.676331\right) + 0.00391838RH^{1.5} \tan^{-1}(0.023101RH) - 4.686035$$

HeatRisk = f(T_anomaly(95th pct), humidity_proxy, season, duration, nighttime_T, CDC_health_thresholds) → Level 0–4

- Experience suggests :
  - EFI values between 0.5 to 0.8 (irrespective of sign) can be generally regarded as signifying that "unusual" weather is likely,
  - EFI values above 0.8 (irrespective of sign) as usually signifying that "very unusual" or extreme weather is likely.

- The SOT index provides information about how extreme an event could potentially be. Positive SOT values indicate that at least 10% of the ensemble is forecasting an extreme event and a high value shows how extreme:
- Solid black isopleths show SOT values associated for:
  - +ve values indicate the highest 10% of ENS results (i.e. at quantile 90) are above the highest 1% of the model climate.
  - –ve values indicate the lowest 10% of ENS results (i.e. at quantile 10) are below the lowest 1% of the model climate.