P1.6 **DEFINING THE IMPACT OF WEATHER**

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1. INTRODUCTION

Weather and weather forecasts affect people's health and lifestyles, the economy, society, and the environment. The degree of impact varies depending upon many factors including weather event type, event timing, event severity, event duration, event location, "unusualness", etc. From a weather forecasting perspective, the appropriate forecast/warning response should be guided by the potential impact of the various weather elements being forecast.

Traditionally, a national weather service will provide basic weather forecasts for the public and specific sectors (e.g. aviation, marine, etc.) as mandated by the government, or through cost-recovered services. When certain defined thresholds are crossed, the weather service will provide advisory/warning products to these groups. Weather events exceeding this threshold have been traditionally called "severe weather, "extreme weather", "significant weather", and more recently, "high-impact weather." But since all forms of weather potentially have some level of impact, is it possible to distinguish whether the impact is high or otherwise? In the "high-impact" category, should all weather events be treated equally or are some more extreme than others?

This document will present a more comprehensive approach to defining the impact of weather events.

2. THE IMPACT OF WEATHER

All weather has impact, whether it is the inconvenience of carrying an umbrella, not getting the suntan you wanted, higher power bills, the dispersion of atmospheric pollutants, to the destruction of a tornado. To someone affected, any of these may seem "significant" at that moment. But in broader terms, some impacts are clearly more significant than others.

Inconvenience, making changes to plans, brief and small economic losses intuitively occur at the lower end of the impact scale. Damage to property, risks to health, a reduction to economic capacity, etc. have a moderate impact depending on a variety of circumstances. Death, injuries, significant destruction, catastrophes, etc. are at the high end of the impact scale. To delineate the magnitude of the various impacts, they could be categorized into four general categories:

Low-impact – minor inconvenience, small and local economic losses, etc.
Moderate-impact – minor damage, some social disruption, etc.
High-impact – damage, risks to health, broad economic impact, etc.
Extreme-impact – Catastrophic losses, deaths, injuries, major social disruption, etc.

Who or what is being impacted can be divided into 4 broad, albeit inter-related, sectors:

1) **People** – individuals, families, workers, personal property, their work, lifestyles, health, etc.
2) **Society** – communities, healthcare, infrastructure, emergency response, etc.
3) **Economy** – transportation, recreation, tourism, agriculture, aviation, etc.
4) **Environment** – atmosphere, water, land, biosphere, etc.

Within each sector there are varying things impacted:

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People:

1) Death/injury/stress/etc.
2) Property damage/destruction
3) increased expenditures, changing plans
4) Inconvenience
5) Hazardous travel

Society:

1) Loss of power, water, sewers, roadways, etc.
2) reduced emergency response
3) Compromising performance/access of hospitals, family services, etc.
4) Reduced access to necessities (food, fuel, pharmacies, etc.)
5) Closures of schools, daycares, transit, churches, etc.

Economy:

1) Reduced quality of product
2) Reduced quality of service
3) Delays
4) Increased costs
5) Loss of customers

Environment:

1) Reduced air quality
2) Contamination of water
3) Disease to animals/plants
4) Erosion
5) Poor usage of pesticides/herbicides
6) Impact to food chain

3. DISCUSSION

Each weather element (rain, wind, etc.) will have different impacts for each broad sector. Within each sector, things will be impacted differently.

To illustrate the varying impacts, let us examine a weather element: dense fog.

In the public sector, dense fog will have no impact on property. For health, the vast majority of the public will be unaffected while those with pulmonary problems may feel adverse affects. Dense fog could impact lifestyle for some people, such as private pilots, people who sail or fish, birdwatchers, etc. People traveling by car could face driving hazards or significant delays.

For society, there would be no impact on infrastructure and the health system. Emergency response could be slowed in rural areas, while air ambulance could be grounded. Most schools would be unaffected except for any bus cancellations for safety reasons. Access to most necessities would remain unaffected though remote areas dependent on fly-in supplies would be affected.

For the economy, the biggest potential impact would be on the transportation sector, including trucking, aviation and marine. To a much lesser degree, recreation, agriculture, and construction could have a small amount of impact. Mining would be an example of a sector unaffected by dense fog.

For the environment, dense fog would have no impact in water quality, land quality or water quality. Air quality may be affected but this would be mostly due to the atmospheric conditions producing inversion-based dense fog episodes.

This information could be summarized into a table:

Fog

Sector	What is impacted	Low	Med	High	Extm
PUBLIC	Convenience	■	■	■	
	lifestyle	■	■		
	property				
	health				
	travel	■	■	■	■
Society	Infrastructure				
	emergency response	■	■		
	health system				
	schools	■			
	access to necessities	■			
Economy	Services				
	transportation	■	■	■	
	recreation	■			
	tourism				
	agriculture	■			
	aviation	■	■	■	
	marine	■	■	■	
	construction	■			
	commerce	■			
	forestry	■			
	mining				
Environment	Air quality	■			
	water quality				
	land quality				
	biosphere				

Here, each sector is divided into subgroups of what is affected. Then based upon the informal assessment above, the potential impact is rated. This example demonstrates that dense fog has varying degrees of impact depending on what is being impacted. For some areas, there is no impact while for other sectors the impact is in the high to extreme categories.

Each weather element can be assessed in this fashion. The author has made preliminary assessment for 42 weather and weather-related (e.g. mud slides, storm surge) elements with a few of these included in this document's Appendix.

An important aspect of this approach is that forecasters should not decide what the varying impacts will be. Weather organizations should approach the various sectors and through their input, agree to the appropriate level of impacts for each element. In many cases, this impact is already being done by the private meteorological sector for their clients. In fact, many of these assessments may be left to the private sector, exclusively. For a national weather service, this approach could still be done for all sectors just to gain a better appreciation of client needs and to better understand what really has impact. An example of this approach was from the World Weather Research Project support of the 2000 Olympic Games in Sydney, Australia (Keenan, 2004).

This approach provides a lot more detail for forecasters and planners. From a national weather service perspective, this information could help define a more appropriate tiered approach to their products since the impact is tiered.

Weather elements that have no or little impact to their end users should be given little attention or they should be automated. Elements that have moderate impact should have human intervention when it can be shown that they improve upon the automated product. However, since the impact is more important, the delivery of that information may need to be more sophisticated.

In Canada, surveys (e.g. Hay and Barkow, 1985, Environment Canada, 1989, Environics Research Group, 1999, Angus Reid Group, 2000, Decima Research Inc. 2002) have shown that the public is interested in not just hearing about an approaching event but also about what the potential impact will be. Forecast products and dissemination systems should be capable of communicating the degree of impact. For moderate impact events, a form of advisory may be required. For high-impact weather elements, a warning type of bulletin may be the most appropriate, whereas extreme events may require "enhanced" warning products (such as a "weather *emergency*"). The distinction between the levels of alerting should be clear to the end user and to the forecasters issuing the products.

By tying this tiered approach consistently with the tiered impact scale, the end user should more readily appreciate what is being communicated. This approach also allows for a more structured approach to education/preparedness activities and emergency planning and response.

4. SUMMARY

The term "high-impact weather" has been in use since at least 1970 (Glahn, 1970). The term was used then to try to differentiate between what was routine and what important to the end user. The motivation was to find the appropriate "machine-man mix", where automation could handle the routine while forecasters could focus on the higher-impact events. This motivation has remained unchanged in the following decades. What also has remained unchanged is what exactly high-impact weather is. The primary problem has been trying to use two categories of impact: "High" and, by default, "not-High". This has stymied forecasters and weather service managers.

Forecasters, researchers, modelers, managers, etc. are being asked to focus their efforts on "High-impact weather." Without a clear understanding of what high-impact weather is, the planning and development of priorities, the allocation of resources, the defining of forecaster roles

(e.g. McCarthy et al, 2005) and the day-to-day production of forecasts and warnings cannot be effectively accomplished.

The approach presented here tries to break this deadlock. The result is a clearer definition of impact, more levels of impact, a better understanding of user needs, a clearer definition to target science and technology development, an opportunity to establish a tiered alerting system that is more directly tied to the tiered impacts, and a more structured approach to education and emergency management.

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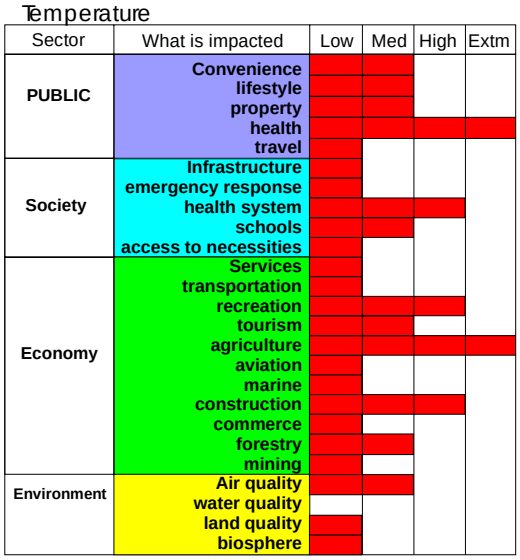
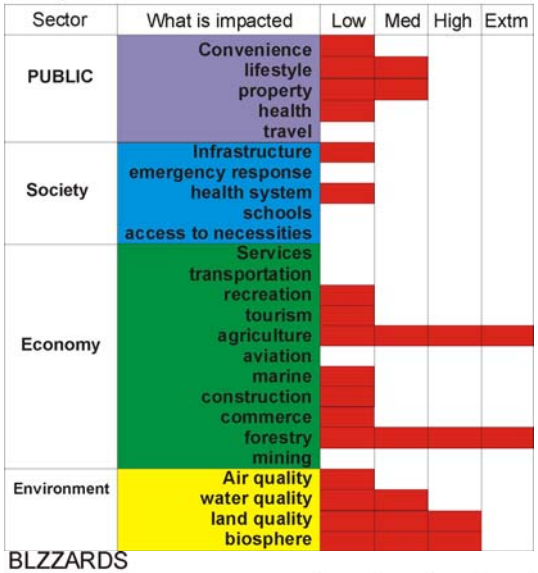
6. APPENDIX

Examples of ranked (preliminary) impact for

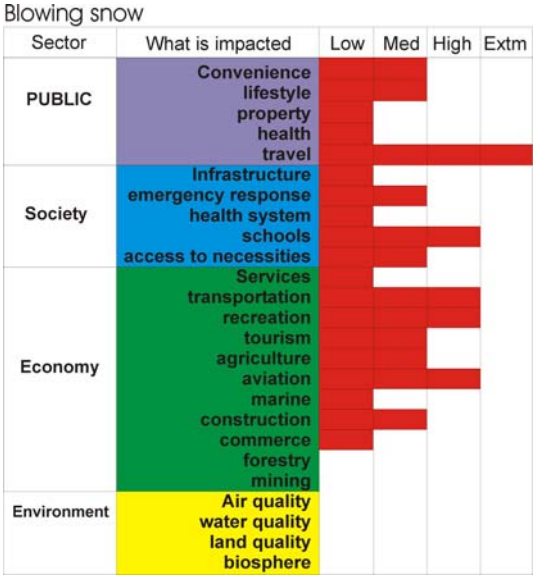


selected weather elements:

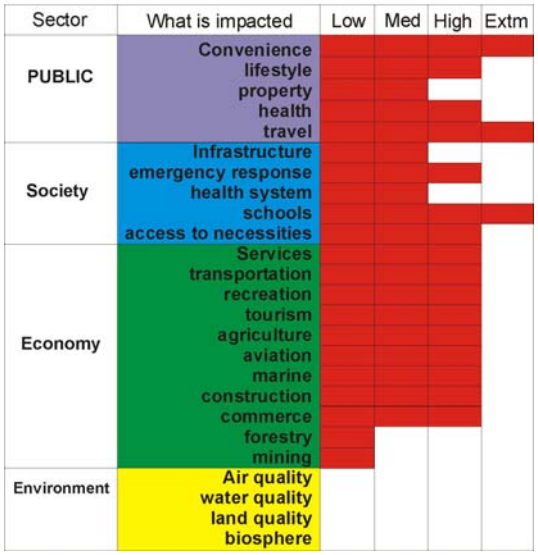
Drought



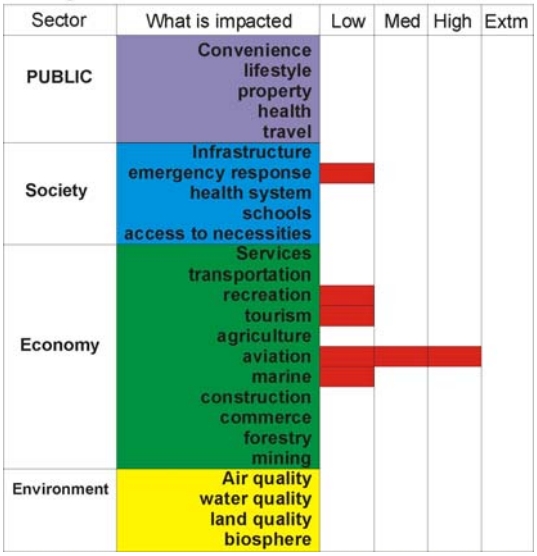
Blowing snow



BLZZARDS



Ceiling



Supercell Tornadoes

Sector	What is impacted	Low	Med	High	Extm
PUBLIC	Convenience	■	■	■	
	lifestyle	■	■	■	
	property	■	■	■	■
	health	■	■	■	■
	travel	■	■		
Society	Infrastructure	■	■	■	■
	emergency response	■	■	■	■
	health system	■	■	■	
	schools	■	■	■	
	access to necessities	■	■		
Economy	Services	■	■		
	transportation	■	■		
	recreation	■	■	■	
	tourism	■	■		
	agriculture	■	■		
	aviation	■	■	■	■
	marine	■	■		
	construction	■	■	■	■
	commerce	■	■	■	
	forestry	■	■		
	mining	■			
Environment	Air quality	■			
	water quality				
	land quality				
	biosphere	■			