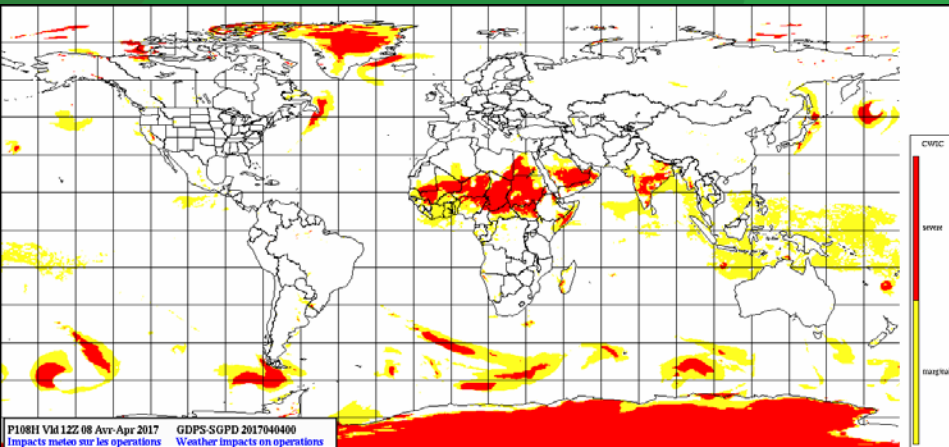


IMPACT BASED FORECAST FOR THE CANADIAN ARMED FORCES

From a deterministic to a probabilistic approach



David Dégardin
Marie-France Turcotte
Joint Meteorological Center
Aviation and Defence Services,
Environment & Climate Change Canada

8th NCEP Ensemble User Workshop
August 27-29, 2019
College Park, MD



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Outline



THE SITUATIONAL AWARENESS PROJECT

1. Project's framework
2. Rationale
3. Consolidated Weather Impact Chart (CWIC)
 - Objectives
 - Principles
4. Current state (deterministic modeling)
 - In house web-site
 - WMS/WCS/WFS capability
5. Looking ahead (probabilistic modeling)
 - CAF Matrix
 - Vigilance-in-Context Matrix



*"Holly cow ...
There's a lot of cows
... !!!..."*



Project's framework



THE SITUATIONAL AWARENESS PROJECT

- **Data centric approach**

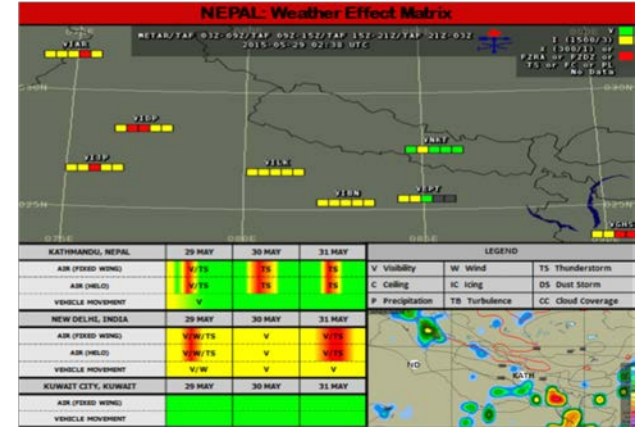
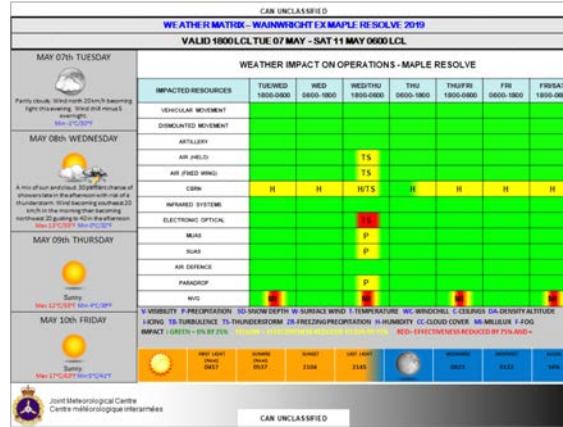
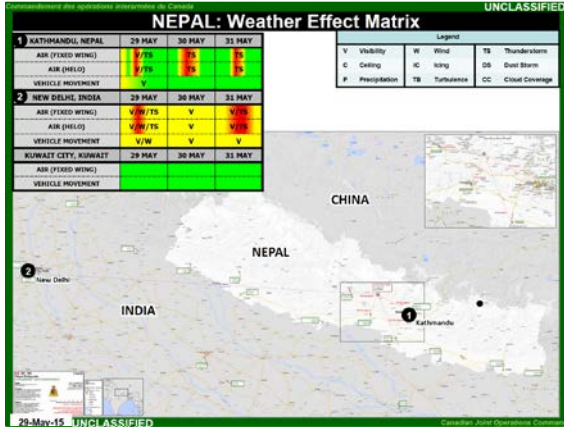
The « *Modernization of MetOc data Services* » Document (SOCD, sept 2015) suggests a significant update of CFWOS website to incorporate OGC-compliant web services **to allow for interoperability** with other applications and services, and **to provide timely and cost efficient transmission** of data to deployed assets.

- **MSC Vision**

*“Prediction system will evolve towards **a greater automation** of forecast production while **allowing the expertise** of the operational meteorologist **to be focused where the risk** of hydrometeorological impacts **is highest**”.*
The evolution will take into account where meteorologist value is added to validate automation of data streams



Rational



- **Currently, these types of products do not benefit from NWP's capabilities:**
 - data set on grid,
 - ensemble forecasts,
 - automation
- **Data centric approach / MSC Vision:**
 - Going away from manual production of weather impact matrix (time consuming),
 - Allowing flexibility in delivery information (data, product, GIS, Web Service etc)
 - Focusing « met » expertise where impacts are highest



Consolidated Weather Impact Chart (CWIC)



Objectives

Relevant
Environmental data
base



Canadian Forces
Intelligence Command



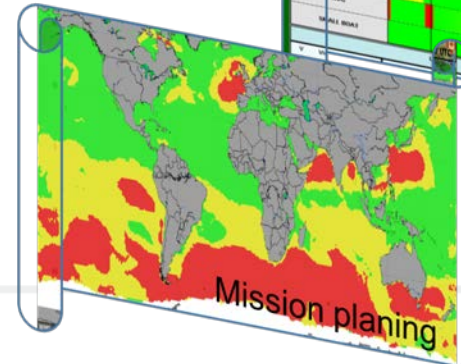
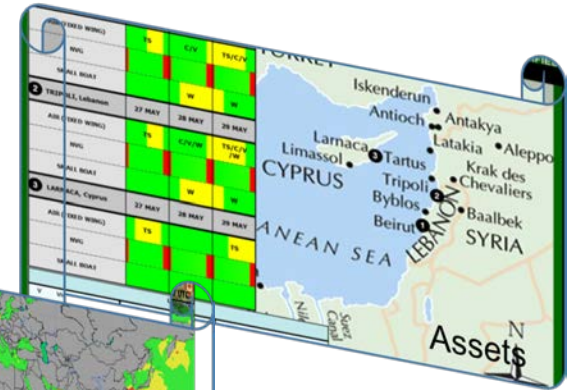
Royal Canadian
Air Force



Royal Canadian
Navy



Canadian
Army



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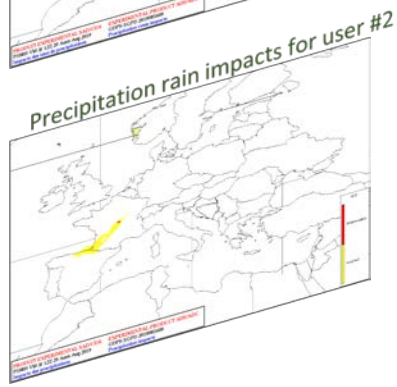
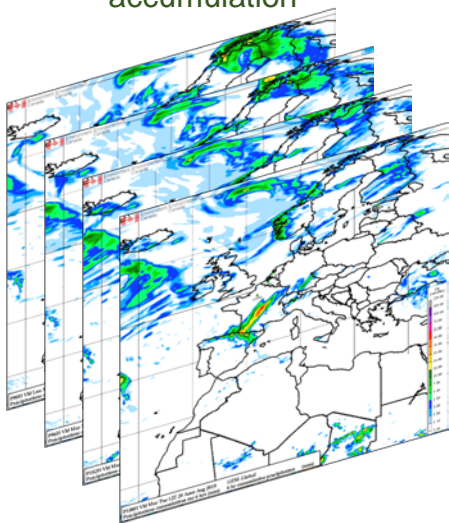
Consolidated Weather Impact Chart (CWIC)



Principles

1. Impacts characterization

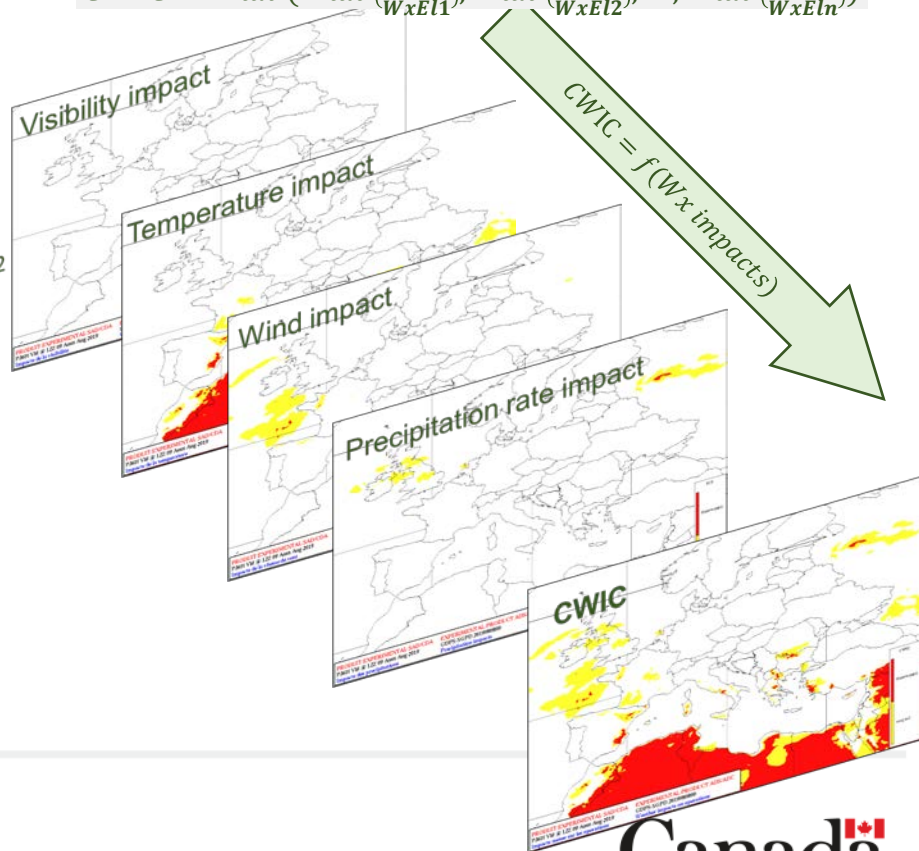
24hrs (4x6hrs) rain accumulation



Adjustable thresholds

2. Consolidation rule

$$CWIC = \text{Max} (\text{Max}_{(WxE11)}, \text{Max}_{(WxE12)}, \dots, \text{Max}_{(WxE1n)})$$



Current state (deterministic modeling)



Canadian Forces Weather and Oceanographic Service

CFWOS

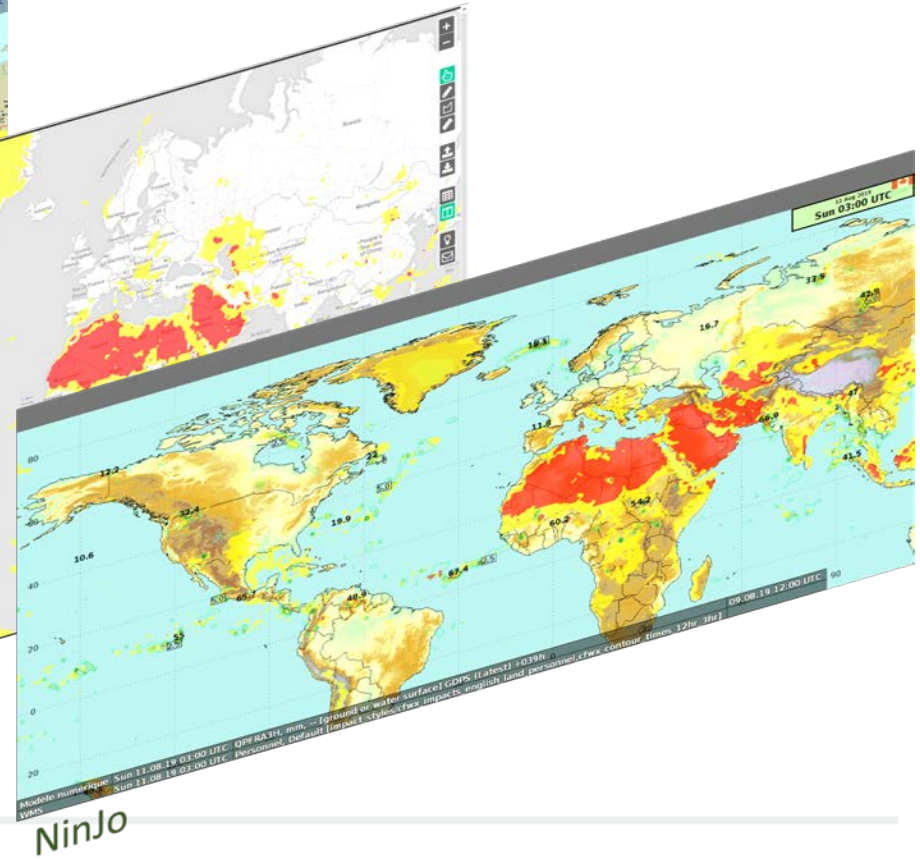
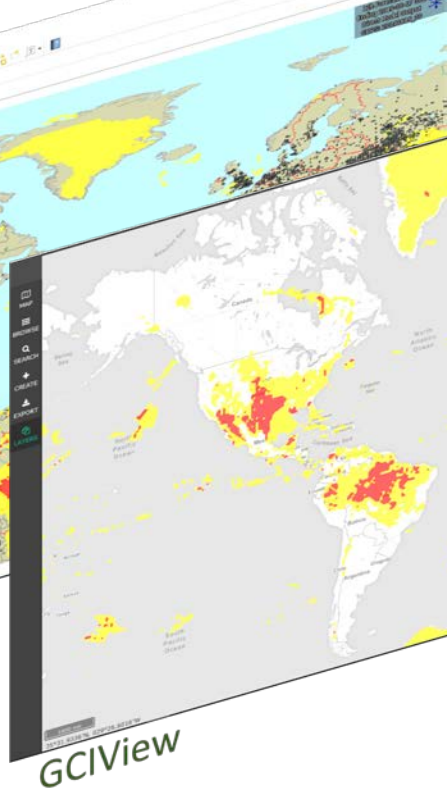
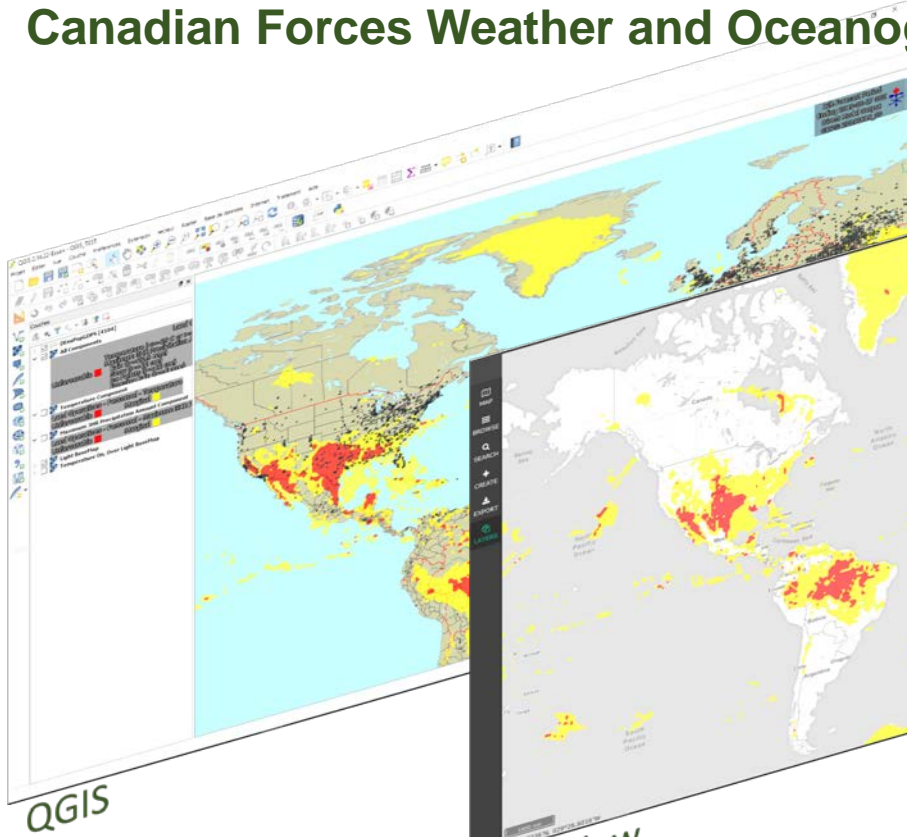


Current state (deterministic modeling)



Canadian Forces Weather and Oceanographic Service

GIS capability



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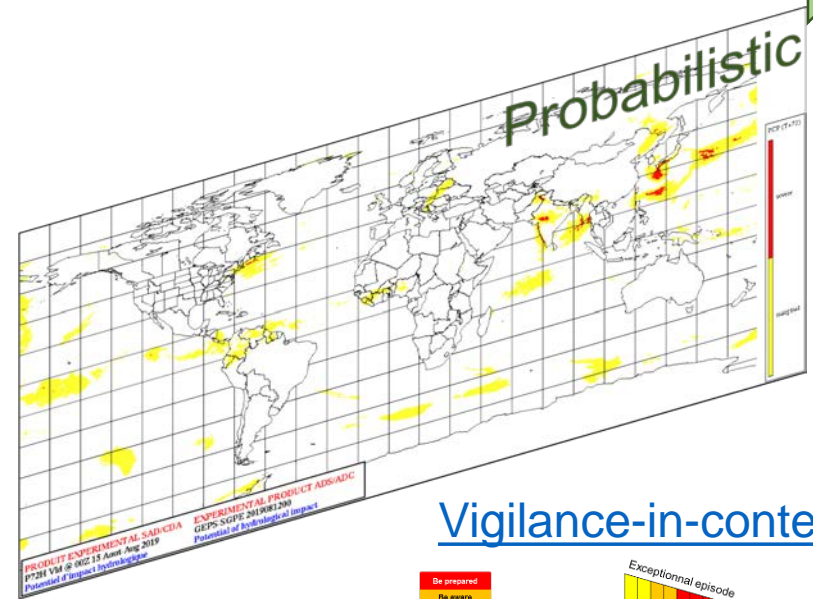
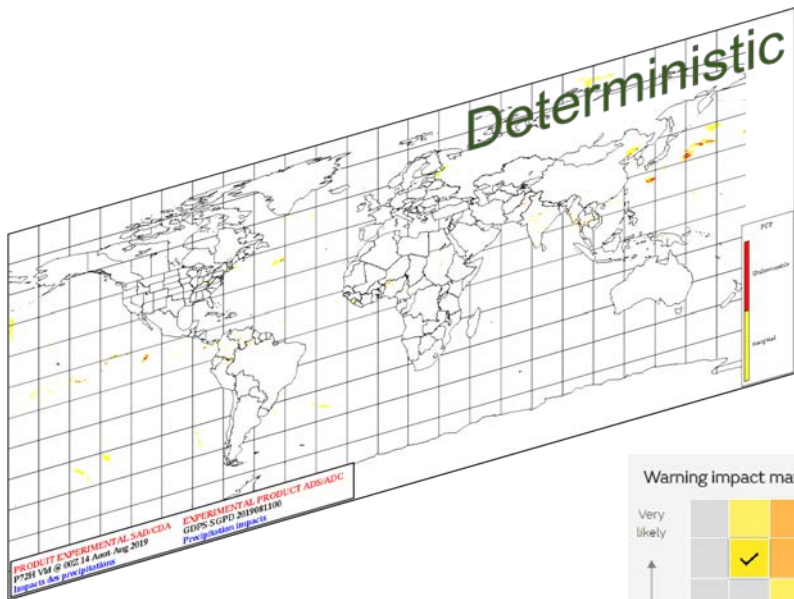
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Looking ahead (probabilistic modeling)

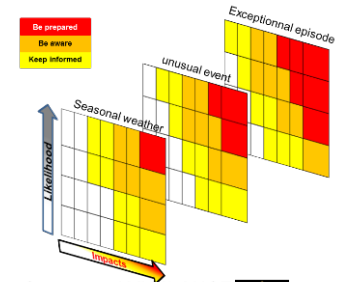
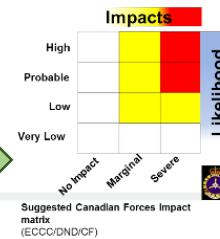


Question: How to keep the info consistency while moving from deterministic to probabilistic NWP?



Vigilance-in-context

CAF Matrix



Answer: The matrix approach

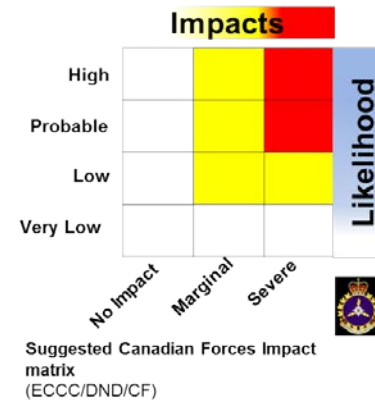
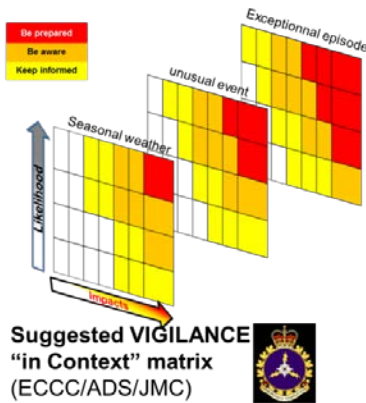
Suggested VIGILANCE "in Context" matrix (ECCC/ADS/JMC)



In a Nutshell



1. The **British Matrix Table Concept** which combines the level of impacts the weather may cause and the likelihood of those impacts occurring.
2. The **European EFI concept**, computed from the GEPS, provides signals of anomalous weather relative to the model climatology.
3. **Percentile's computations** which allow the capability to choose any adapted thresholds for specific needs/issues for all sensitivity types.



are pillars upon which a **MetOc impact database**, relying on forecasted weather elements, will be developed in order to :

- Assist **with the flexibility** of the CAF in their decision making processes and
- Help our forecasters to identify regions where their expertized will be required

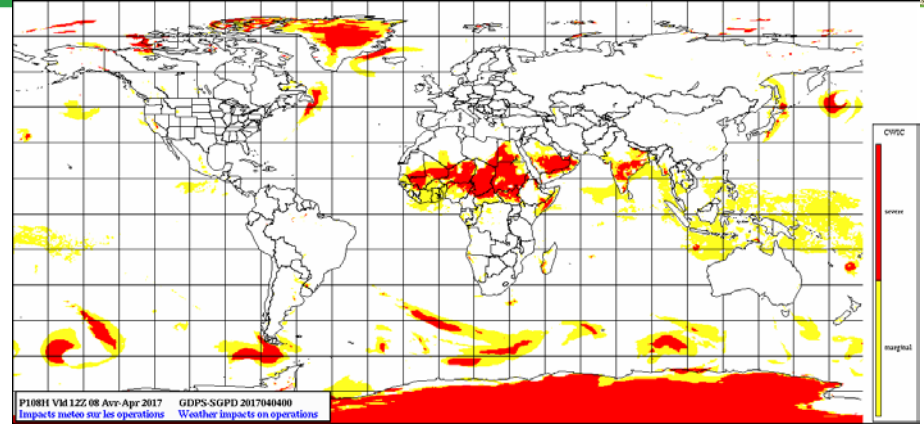


Questions ?



Impact Based Forecast for the Canadian Armed Forces

*From a deterministic to a
probabilistic approach*



Thank you

David.degardin@canada.ca

Joint Meteorological Center

Aviation and Defence Services, Environment Canada



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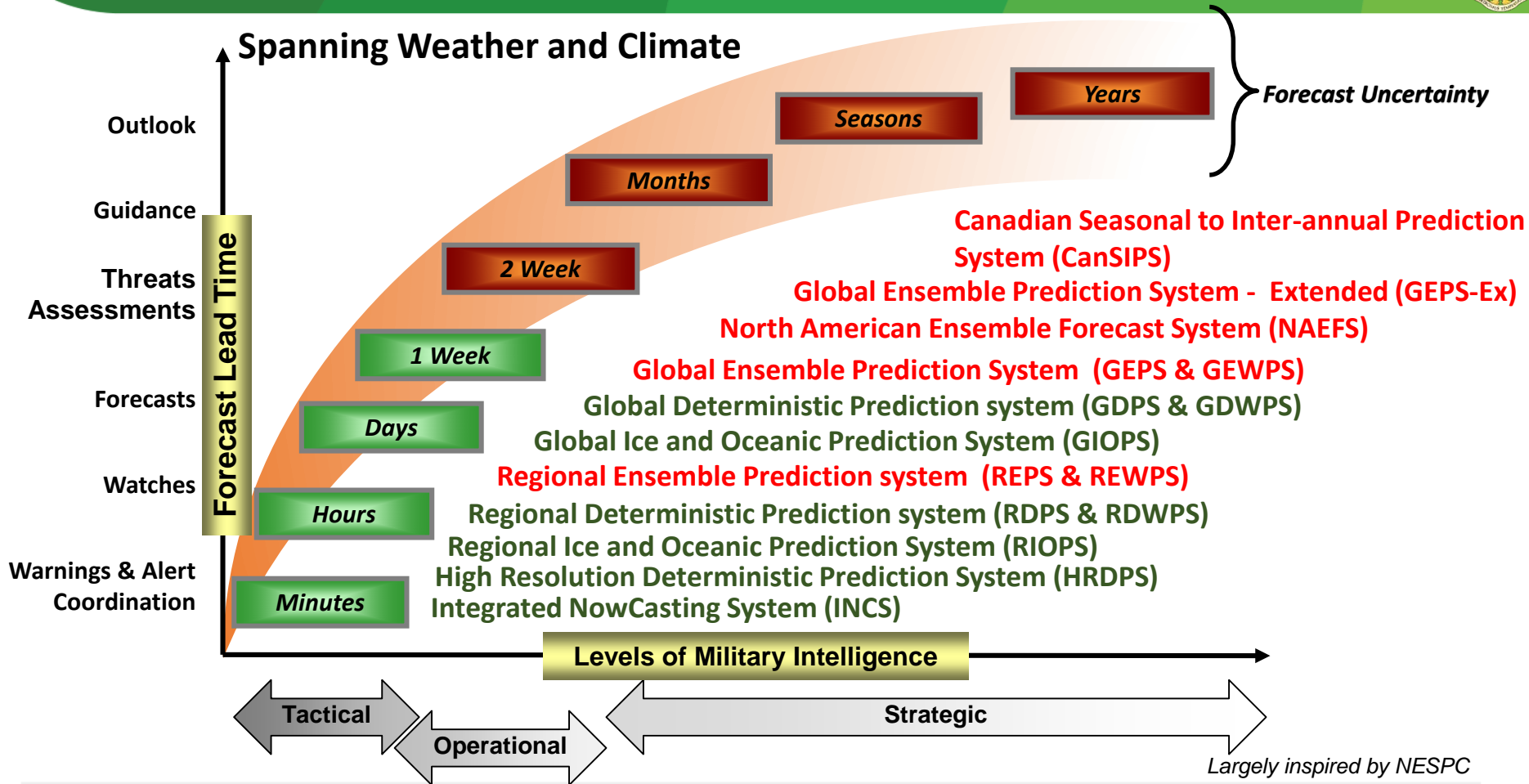


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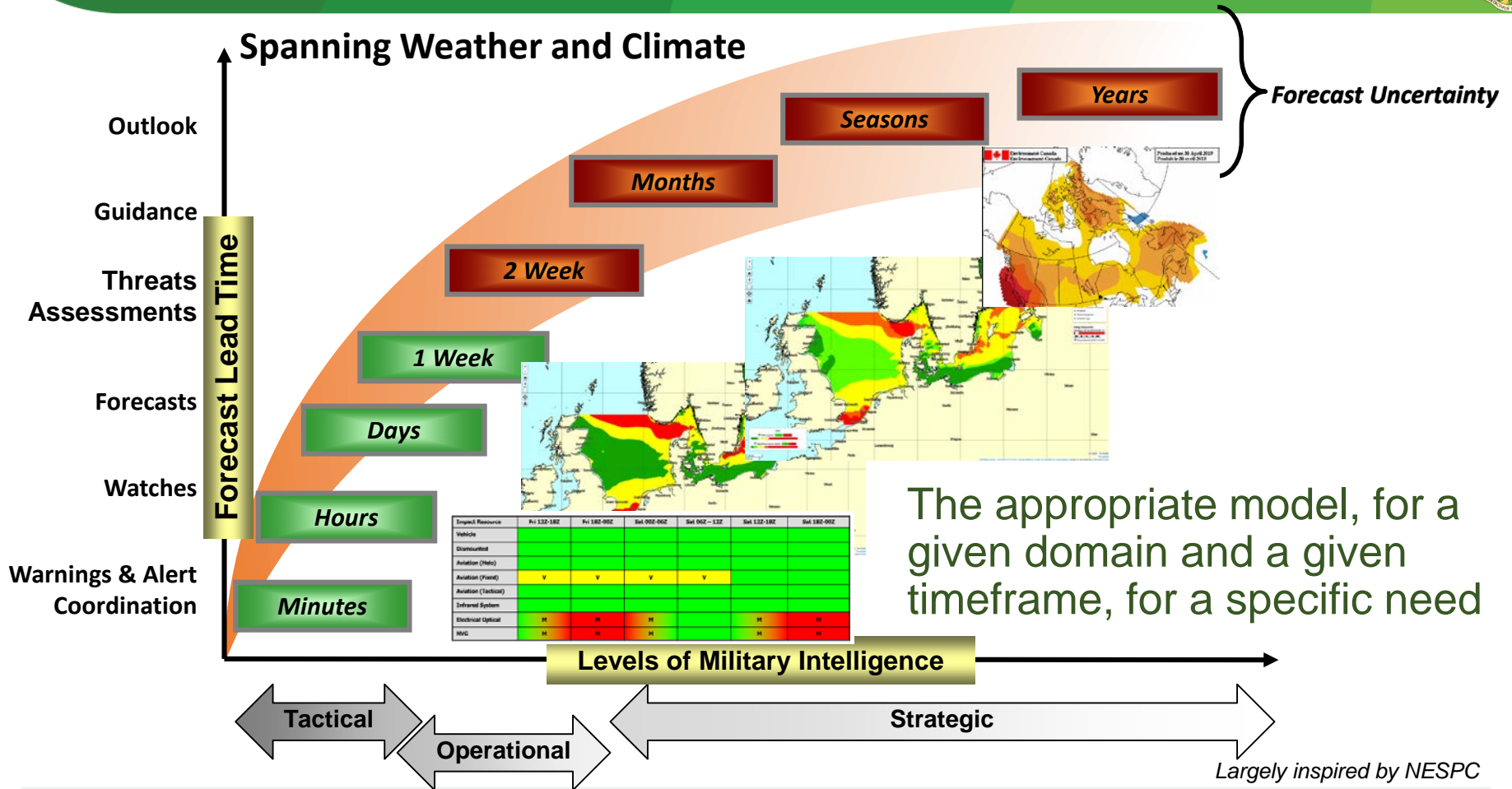
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Consolidated Weather Impact Chart (CWIC) – Seamless suite of systems



Consolidated Weather Impact Chart (CWIC) – Seamless suite of products



Consolidated Weather Impact Chart (CWIC) – A relevant database



A relevant database will be constituted by environmental elements (MetOc) with at least one the following features:

1. Highest temporal and spatial resolutions available.
2. Representativeness of MetOc's impact on considered mission:
 - Highest/lowest intensity,
 - Accumulation over periods
 - Exposition to a potential MetOc's impact,
 - Duration of MetOc's impact.
3. MetOc elements relevant for either Aviation, Navy, Land or Intelligence activities,
4. Known vulnerabilities,
5. ...

Big data and bandwidth issues imply compromises and restrictions on the database elaboration



Consolidated Weather Impact Chart (CWIC) – Impacts characterization



Missions/Assets Definition

The traffic lights code is widely (NATO) used to express the potential risk related to meteorological impacts on troops and materials.

2. METOC impact colour criteria

Color	METOC impact color criteria	
GREEN	Favourable	Little or no impact, no restrictions based on METOC conditions.
YELLOW	Marginal	METOC conditions degrade or limit OPS
RED	Unfavourable	Severe impact with significant degradation to OPS; METOC conditions restrict OPS

METOC_IMPACT_NATO_AMC 13_5b_SHAPE

WEATHER IMPACTS ON MARITIME OPERATIONS			
SMALL BOAT OPS	Sea State < 3 Surface wind < 10 kts	Sea State 3-4 Surface wind 10-20 kts	Sea State > 4 Surface wind > 20 kts
EMBARGO OPS	Sea State < 4	Sea State = 4-5	Sea State > 5
AMPHIBIOUS OPS	Sea State < 4	Sea State = 4-5	Sea State > 5
MCM	Sea State < 4	Sea State 4	Sea State > 4
FLT OPS CARRIER	Sea State < 5	Sea State = 5	Sea State > 5
	Wind < 25 kts	Wind 25-35 kts	Wind > 35 kts
	Visibility > 3.5 km Ceiling > 1500 ft	1 < Visibility < 3.5 km 200 ft < Ceiling < 1500ft	Visibility < 1 km Ceiling < 200 ft
CVS STOVOL	Sea State < 5	Sea State = 5-6	Sea State > 6
	Wind < 25 kts	Wind 25-35 kts	Wind > 35 kts
	Visibility > 5 km	1 km < Visibility < 5 km	Visibility < 1 km
	Temp < 30 ° C Ceiling > 1500 ft	Temp 30°- 35° C 300 ft < Ceiling < 1500 ft	Temp > 35 ° C Ceiling < 300 ft
MPA/ASW (SONOBUOYS)	Wind < 25 kts	Wind 25-35 kts	Wind > 35 kts

For each operation type, operational limits have been defined for every weather element which can interfere with the considered operation.

Due to a wide range of assets, missions or operations, preset formats production is not an efficient solution when only some of them are considered and when further adjustment to impacts are needed.

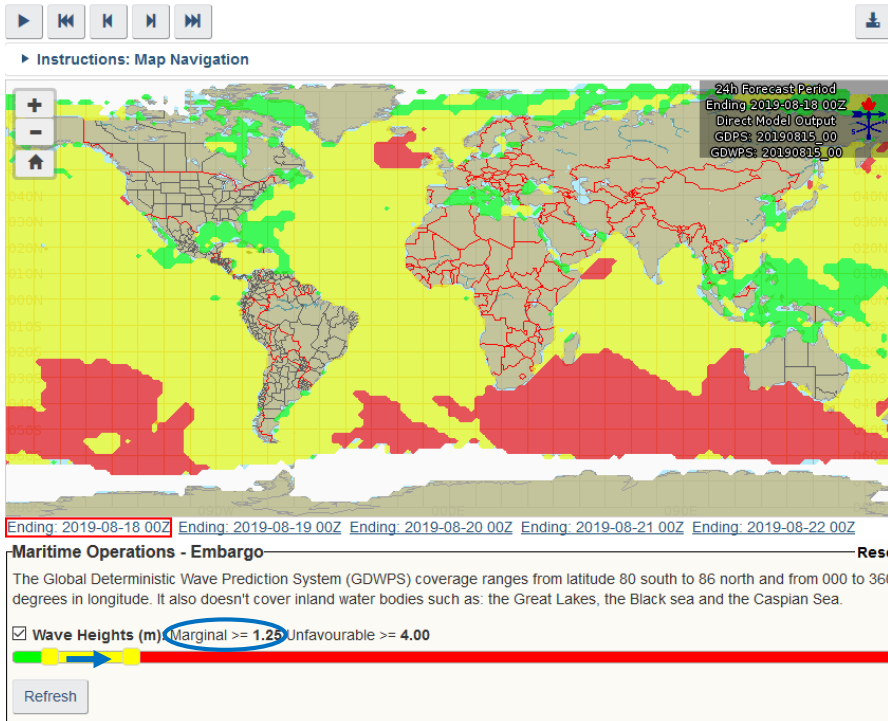


Consolidated Weather Impact Chart (CWIC) – Adjustable thresholds

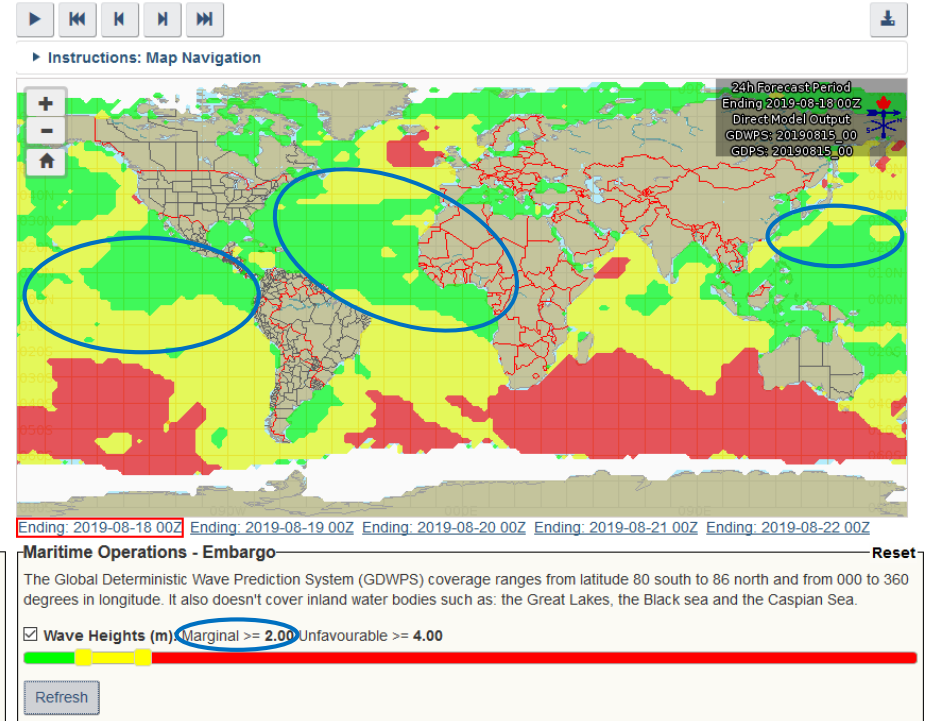


One tool to support the decision process

Maritime Operations - Embargo



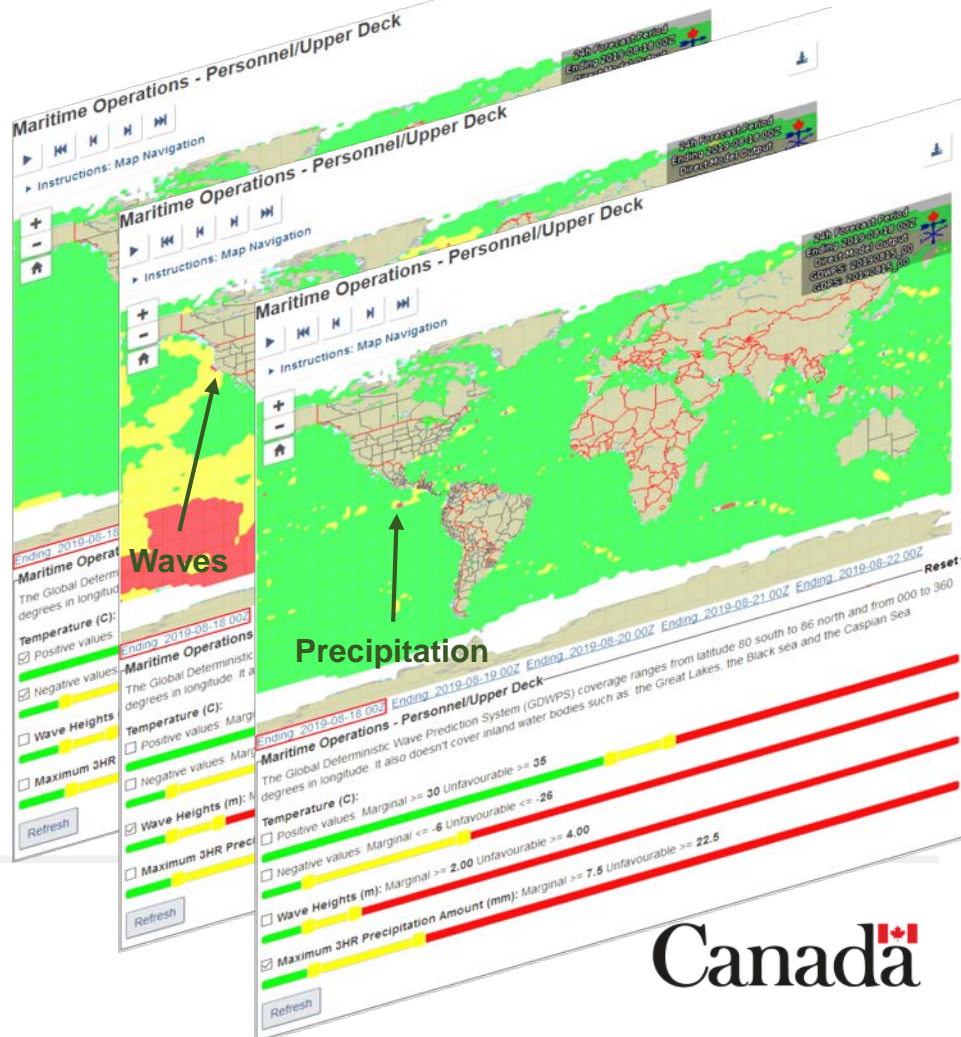
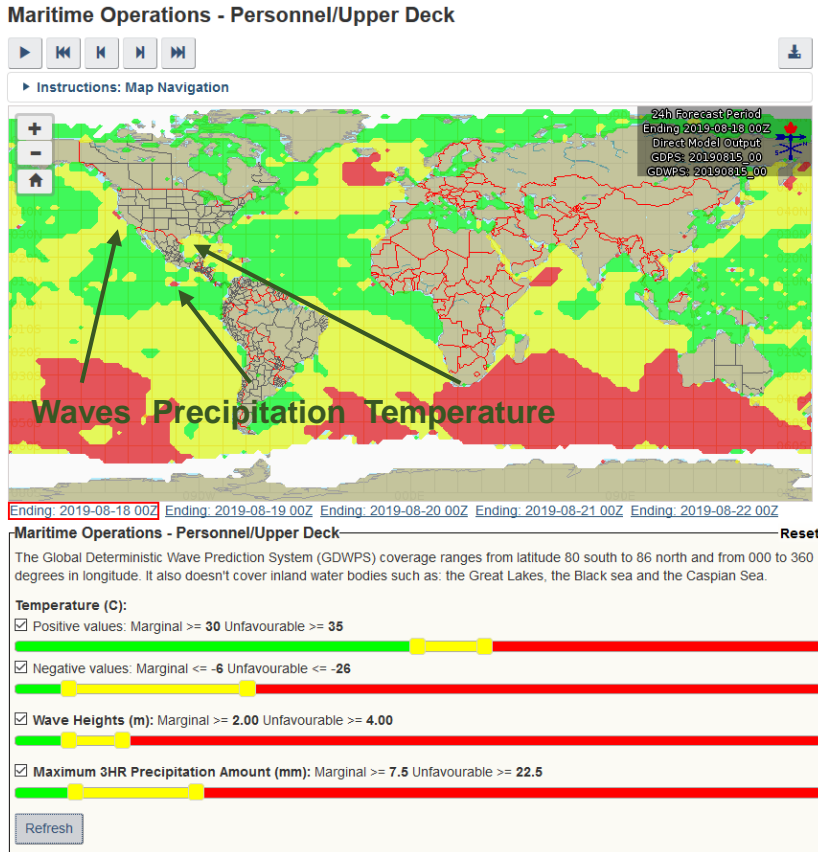
Maritime Operations - Embargo



Consolidated Weather Impact Chart (CWIC) – Consolidation rule



The worst index make the index (worst case scenario)



$$CWIC = \text{Max} (\text{Max}_{(W_{xEI1})}, \text{Max}_{(W_{xEI2})}, \dots, \text{Max}_{(W_{xEIn})})$$

Current state (deterministic modeling) – Configuration page



- NATO's missions Catalog
- Capability of deselection of environmental elements
- Adjustable thresholds
- Temporal windows (12/24hr)
- Area-of-interest's definition capability

Impact Products

Impact Products

Product

Product Types

Personnel

Land Operations - Personnel

Temperature (C):

- Positive values: Marginal ≥ 30 Unfavourable ≥ 35
- Negative values: Marginal ≤ -6 Unfavourable ≤ -26

3HR Precipitation Amounts (mm):

- Rain (mm): Marginal ≥ 7.5 Unfavourable ≥ 22.5
- Snow (cm): Marginal ≥ 6.0 Unfavourable ≥ 12.0
- Ice Pellets (cm): Marginal ≥ 6.0 Unfavourable ≥ 12.0
- Freezing Rain (mm): Marginal ≥ 0.6 Unfavourable ≥ 6.0

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Experimental Site

Search this website

CFWOS Information | CFWOS Transformation | Key Operations | Key Events

Experimental Site | Applied Development | Impact Products

Request weather

Go

General

CF Sites

National

Operational

Navy

Army

Air Force

Joint Ops

Met Tech

Air Crew

Products

Warnings Forecasts

Satellite

RADAR

Lightning

Charts

Climate

MLAK Manuals

Oceanography

NOTAMs

Experimental

CBRN

Settings

Refresh: Enabled

Actions

Login

Presentation

Download ZIP

Download PDF

Impact Products

Product Types

Personnel

Land Operations

Air Operations

HIGH RECCE OPS

Maritime Operations

Small Boats

Embargo

Amphibious

MCM

MPA/ASW (SONOBUOYS)

MW/HUNT

MW/SWEEP

Personnel/Upper Deck

Naval Refuel (RAS)

ASuW

ASW

AAW

FPB

MIO/Boarding

Land Operations - Personnel

Temperature (C):

- Positive values: Marginal ≥ 30 Unfavourable ≥ 35
- Negative values: Marginal ≤ -6 Unfavourable ≤ -26

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- Ice Pellets (cm): Marginal ≥ 6.0 Unfavourable ≥ 12.0
- Freezing Rain (mm): Marginal ≥ 0.6 Unfavourable ≥ 6.0

Location

Map Preview Click to expand/collapse

Instructions: Map Navigation

Scroll-to-zoom

Clear custom map

Submit

Updated: 2019-08-08 13:35 UTC

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Current state (deterministic modeling) – Impacts products page



- Update “on-the-fly”,
- Animation from D3 to D7,
- Capability of deselection of environmental elements,
- Adjustable thresholds,
- Area-of-interests refinement capability,
- Product dissemination: numerical and graphical formats depending on client's bandwidth capabilities.
- Temporal series for 5 locations: **impact-grams**

The screenshot displays the 'Impact Products' web application interface. At the top, there is a navigation bar with the Canadian flag and the text 'National Defence nationale' and 'Canada'. Below this, there are tabs for 'Experimental Site', 'CFW05 Information', 'CFW05 Transformation', 'Key Operations', and 'Key Events'. The main content area is titled 'Impact Products' and features a map of North America with a color-coded overlay. Below the map, there are several data series for 'Land Operations - Personnel' with checkboxes and color-coded bars. The interface includes a search bar, a 'Request weather' button, and a 'Refresh' button. The footer contains contact information and navigation links.



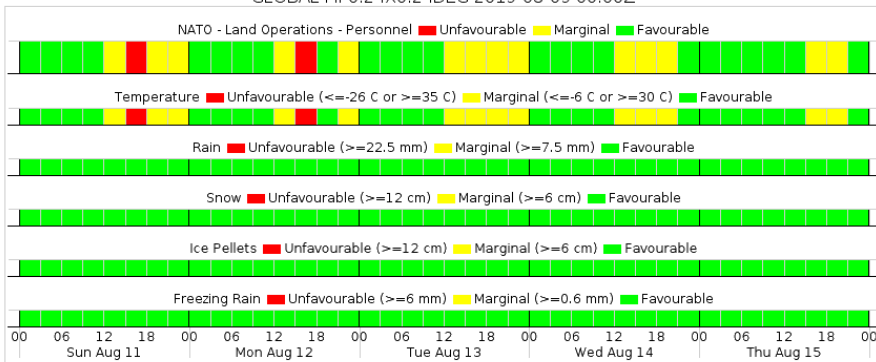
Current state (deterministic modeling) – Impact-grams



- Up-to 5 locations
- Adjustable “on-the-fly”
- Light and full versions

334437N810340W ✕ 670542N421339W ✕ 485239N571306W ✕ 302045N000637W ✕ 555406N090137E ✕

Waypoint At 334437N810340W 334437N810340W 33°44'37N 81°03'40W 118m 387ft
 Generated 2019-08-09 14:43Z
 Valid 2019-08-11 00:00Z to 2019-08-16 00:00Z
 GLOBAL HI 0.24X0.24DEG 2019-08-09 00:00Z



Experimental Site Search the website Search

CFWO & Information | CFWO & Transformation | Key Operations | Key Events

Experimental Site | Journal Development | Impact Products

Request weather Go

General
 CF Sites
 National

Operational
 Navy
 Army
 Air Force
 Joint Ops
 Met Bot
 Air Crew

Products
 Warnings Forecasts
 Satellite
 RADAR
 Lightning
 Charts
 Climate
 ICAO Manuals
 Oceanography
 NDBs
 Experimental
 CBRN

Settings
 Refresh: Enabled

Admin
 Login
 Presentation
 Download ZIP
 Download PDF

Impact Products
 Edit parameters

NATO - Land Operations - Personnel - Personnel

Instructions: Map Navigation

Temperature (C):
 Positive values: Marginal <= -6 Unfavourable <= -26
 Negative values: Marginal <= 6 Unfavourable <= 28

SNR Precipitation Amounts (mm):
 Rain (mm): Marginal <= 7.6 Unfavourable <= 22.6
 Snow (cm): Marginal <= 6.0 Unfavourable <= 12.0
 Ice Pellets (cm): Marginal <= 6.0 Unfavourable <= 12.0
 Freezing Rain (mm): Marginal <= 0.6 Unfavourable <= 6.0

Refresh

334437N810340W ✕ 670542N421339W ✕ 485239N571306W ✕ 302045N000637W ✕ 555406N090137E ✕

Waypoint At 334437N810340W 334437N810340W 33°44'37N 81°03'40W 118m 387ft
 Generated 2019-08-09 14:43Z
 Valid 2019-08-11 00:00Z to 2019-08-16 00:00Z
 GLOBAL HI 0.24X0.24DEG 2019-08-09 00:00Z

NATO - Land Operations - Personnel ■ Unfavourable ■ Marginal ■ Favourable

Temperature ■ Unfavourable (<= -26 C or >= 35 C) ■ Marginal (<= -6 C or >= 30 C) ■ Favourable

Rain ■ Unfavourable (>= 22.5 mm) ■ Marginal (>= 7.5 mm) ■ Favourable

Snow ■ Unfavourable (>= 12 cm) ■ Marginal (>= 6 cm) ■ Favourable

Ice Pellets ■ Unfavourable (>= 12 cm) ■ Marginal (>= 6 cm) ■ Favourable

Freezing Rain ■ Unfavourable (>= 6 mm) ■ Marginal (>= 0.6 mm) ■ Favourable

00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00
 Sun Aug 11 Mon Aug 12 Tue Aug 13 Wed Aug 14 Thu Aug 15

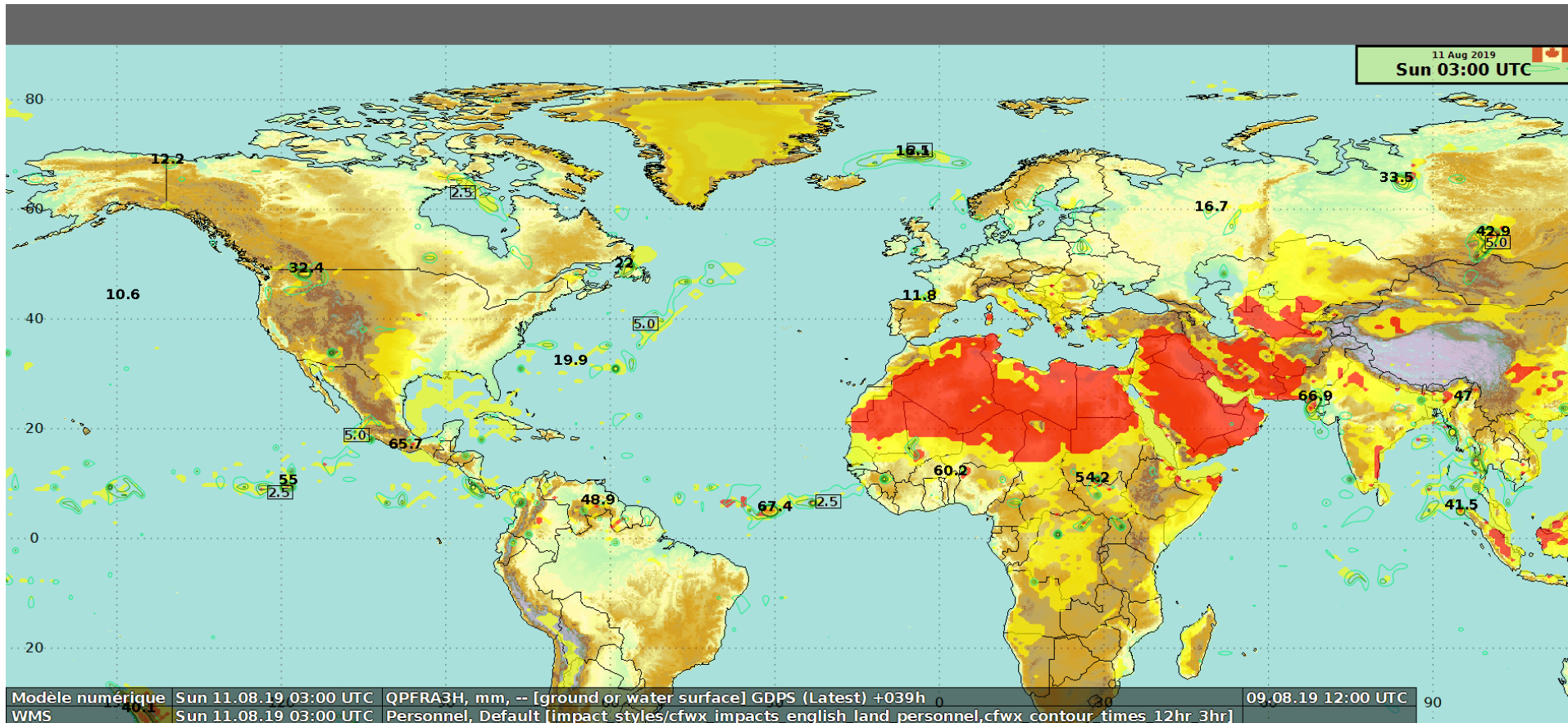
Updated: 2019-08-09 14:37 UTC



Current state (deterministic modeling) – GIS on operational visualisation tool



- NinJo WMS layer

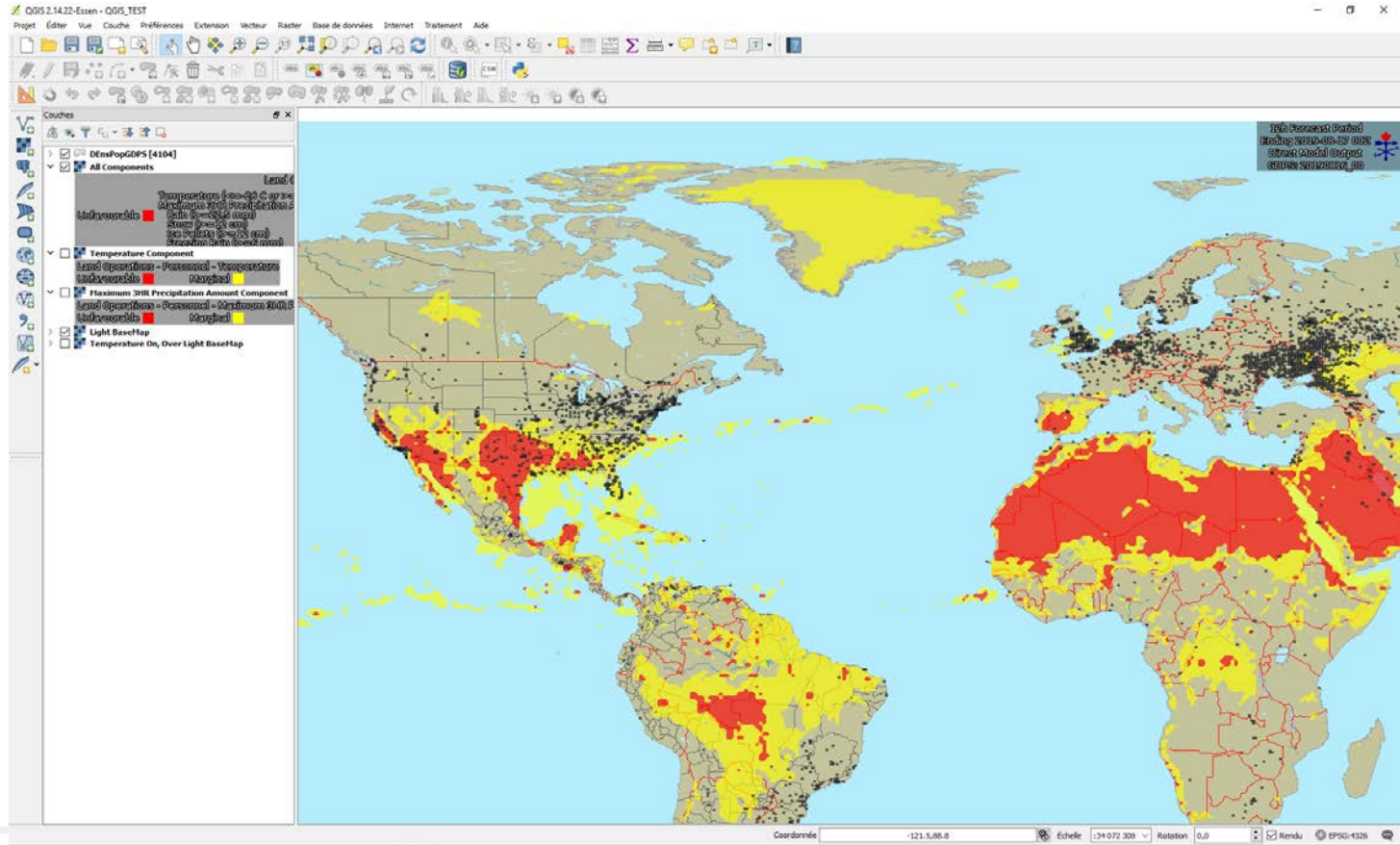


Current state (deterministic modeling) – GIS – ESRI application

Main



- QGIS



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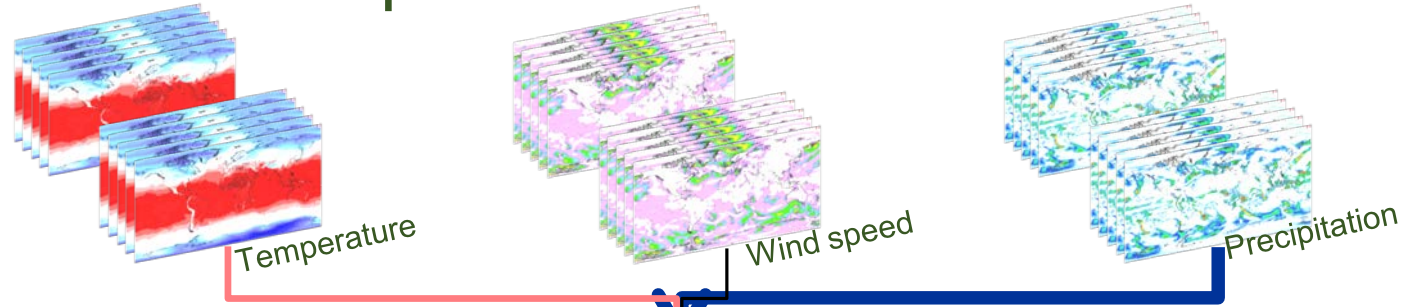
Looking ahead (probabilistic modeling) – Impacts on Operations



How does the concept work?

Forecasted weather parameters
(GEPS)

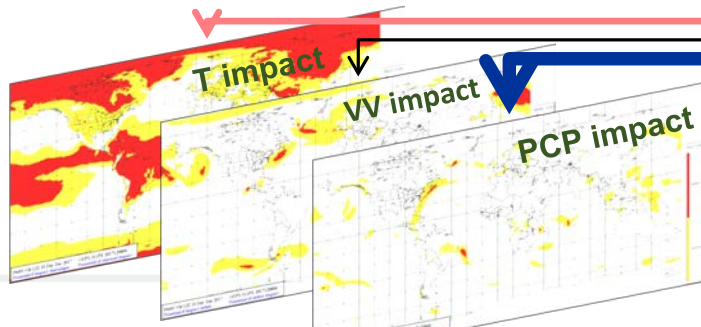
Global Ensemble Prediction System



Potential Impacts due to forecasted weather parameters

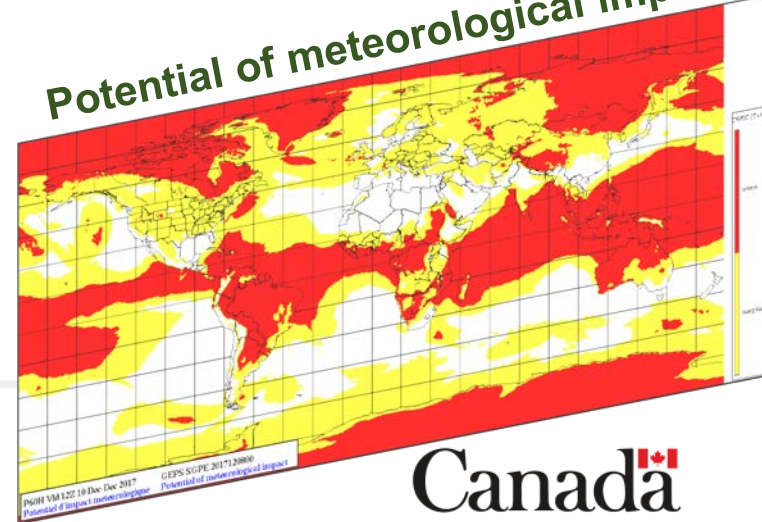
Impacts		Likelihood
High	Severe	
Probable	Marginal	Medium
Low	No Impact	Low
Very Low	No Impact	Very Low

Suggested Canadian Forces Impact matrix (ECCC/DND/CF)



Consolidation

Potential of meteorological impact



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Looking ahead (probabilistic modeling) – Percentiles



How do we use the Ensemble?

Values of

- **90th Perc represents 10%**,
- **75th Perc represents 25%**,
- 50th Perc represents 50%,
- **25th Perc represents 75%**,
- 10th Perc represents 90%

of chance of occurrence to be above a threshold

Usage of percentiles gives more flexibility than the existing calculations on probability of occurrence to be above given thresholds.

More percentiles ranks available would:

1. add more flexibility when dealing with the client's sensitivity;
2. allow to skim the output files since probabilities of being greater than thresholds would become redundant.



	55	100	145
Probability of occurrence	High		
	75%		
	Probable		
	25%		
	Low		
10%			
Very Low			
	No Impact	Marginal	Severe



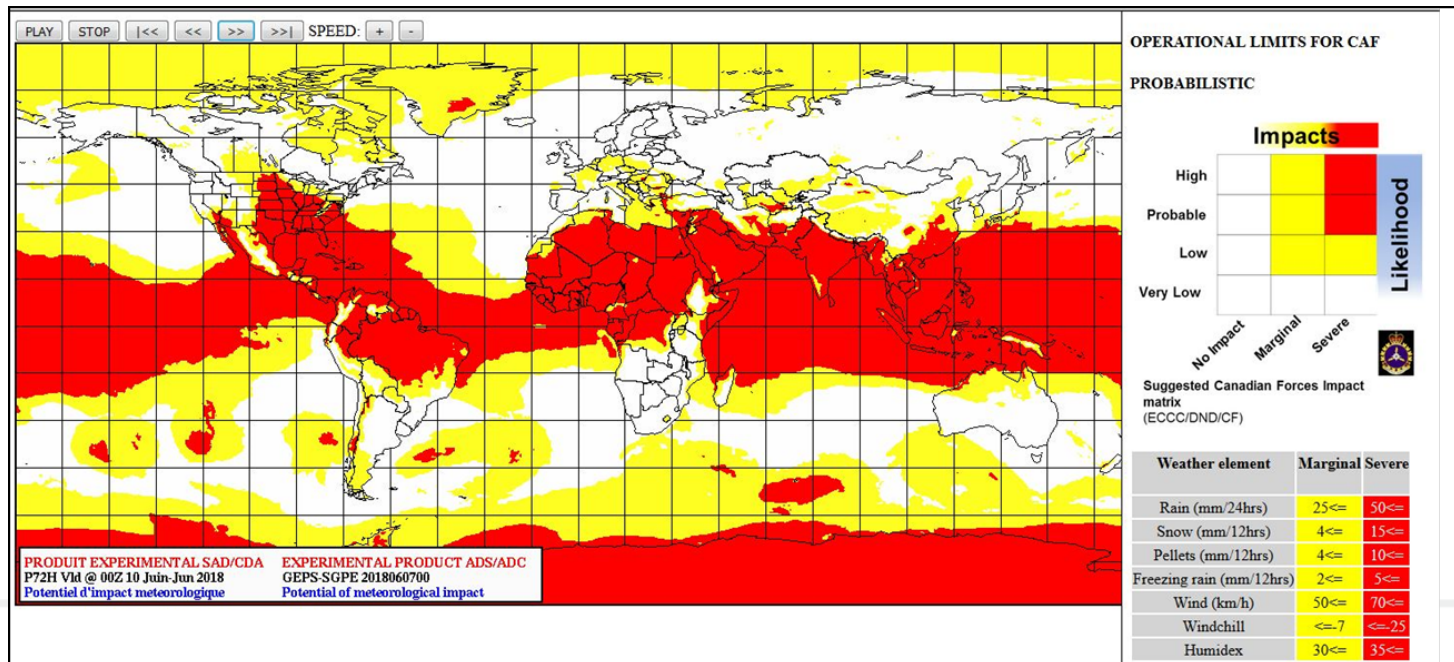
Looking ahead (probabilistic modeling) – CAF Proof of concept

Main



What does the proof of concept look like?

- For a prototype CAF operation purpose.
- Thresholds based on the CAF mission type « Personnel »
- 10%, 25% and 75% probability of occurrence characterize the « sensitivity » of the client.



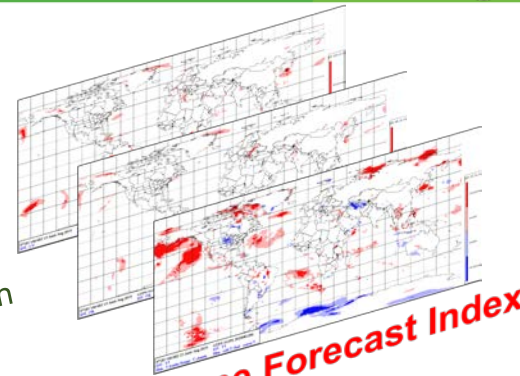
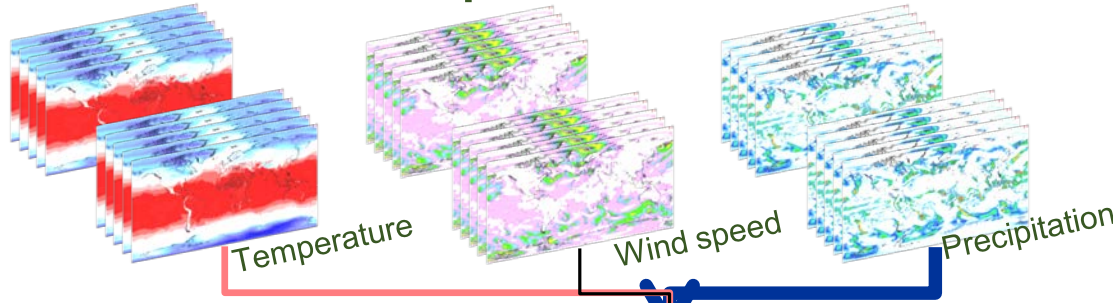
Looking ahead (probabilistic modeling) – Impacts on population/environment



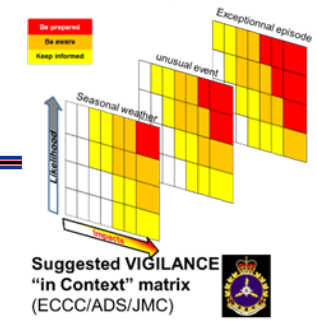
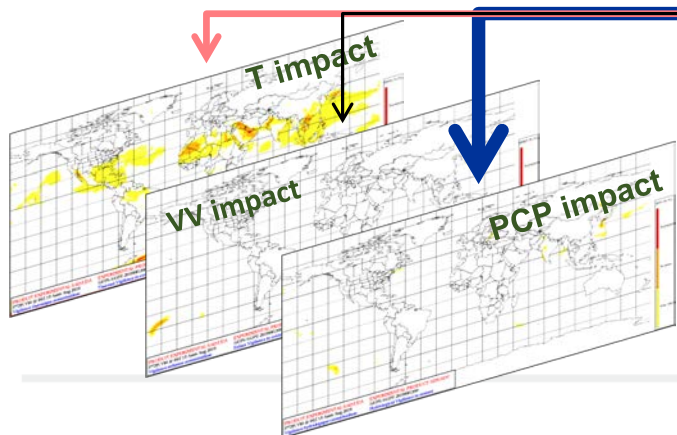
How does the concept work?

Forecasted weather parameters (GEPS)

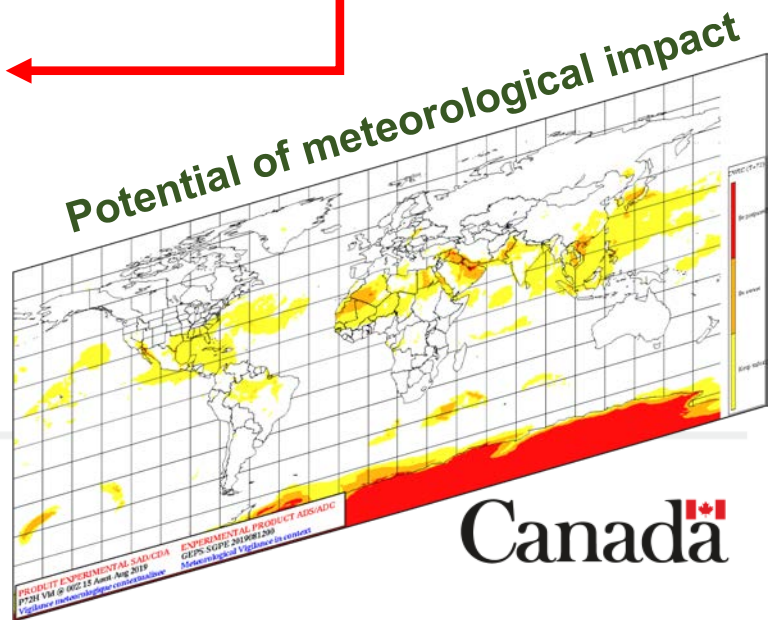
Global Ensemble Prediction System



Potential Impacts due to forecasted weather parameters w.r.t. the M-climate



Consolidation



Environment and Climate Change Canada

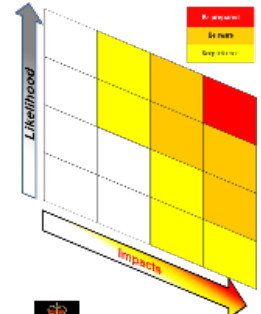
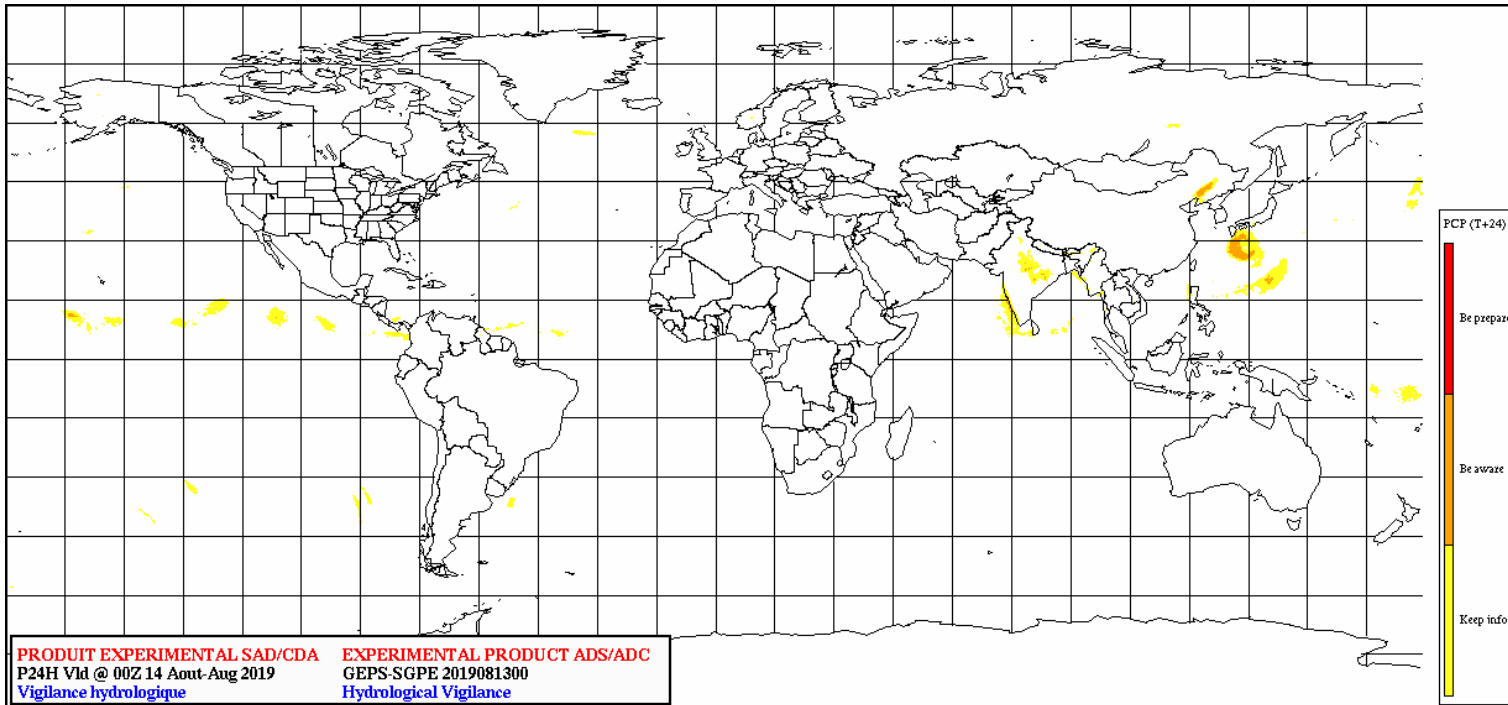
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Looking ahead (probabilistic modeling) – “Vigilance-in-context” matrix



Vigilance inspired by the UK warning impact matrix



VIGILANCE table
(ECCC/ADS/JMC)

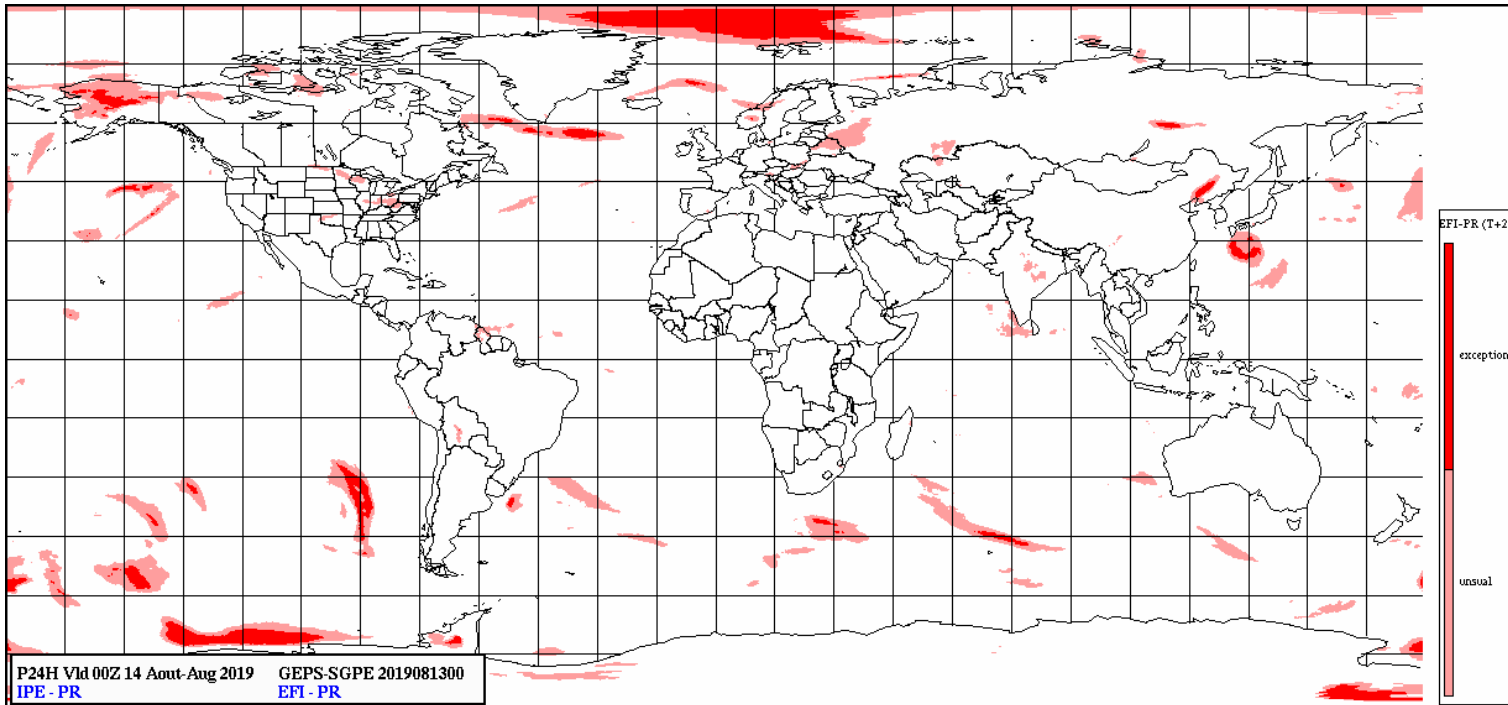
« Maple flavoured »

Snow acc: 15 cm/12hrs
Tmax < [-38°C, -30°C]

Looking ahead (probabilistic modeling) – “Vigilance-in-context” matrix



Contextualization w.r.t. M-Climate



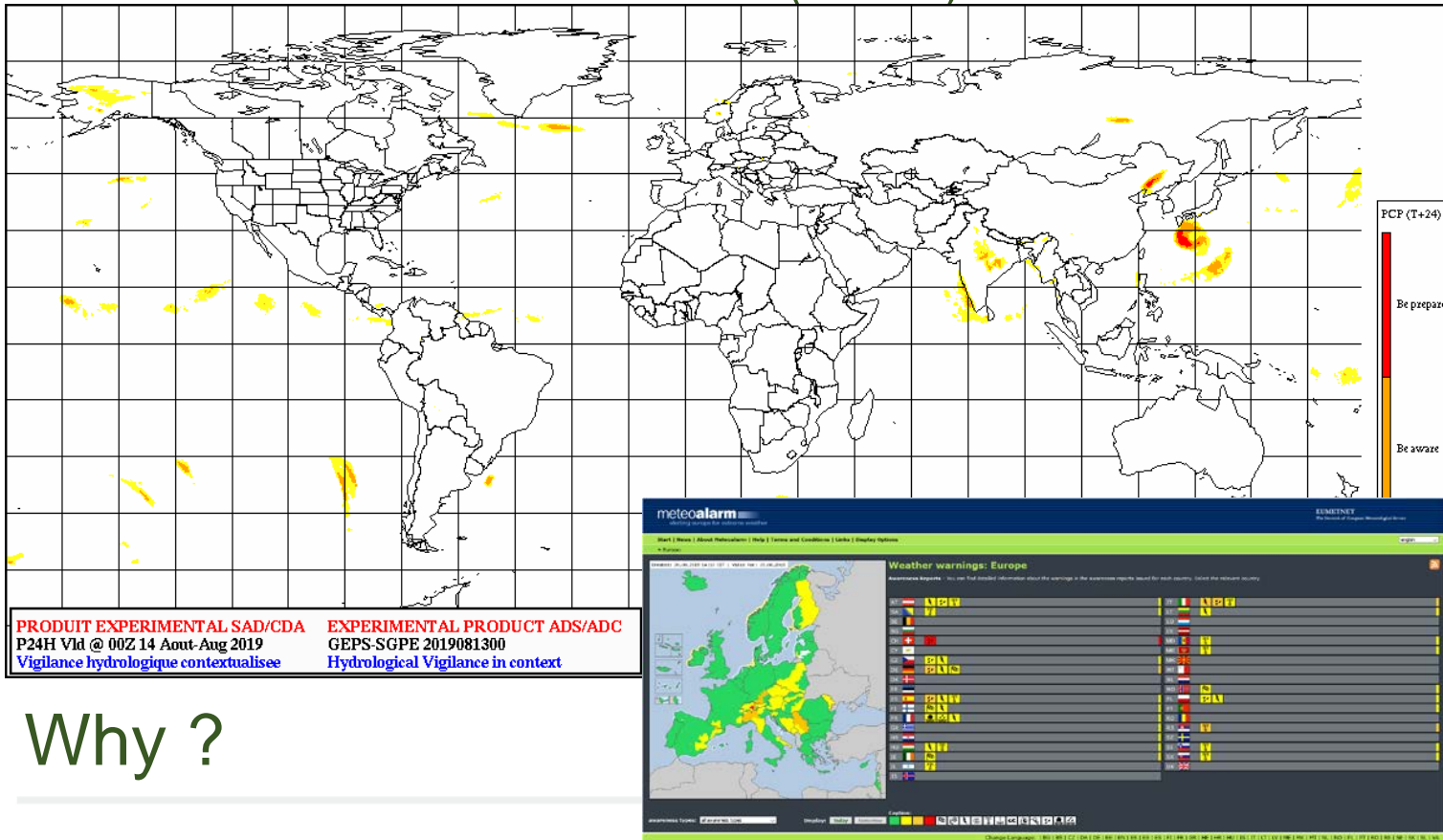
« a pinch of salt »



Looking ahead (probabilistic modeling) – “Vigilance-in-context” matrix



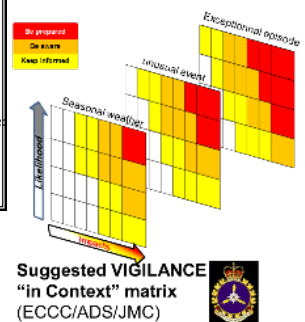
“Vigilance-in-context” matrix for the Canadian Joint operations Command (CJOC)



PRODUIT EXPERIMENTAL SAD/CDA
P24H Vld @ 00Z 14 Aout-Aug 2019
Vigilance hydrologique contextualisee

EXPERIMENTAL PRODUCT ADS/ADC
GEPS-SGPE 2019081300
Hydrological Vigilance in context

Why ?



Environment and
Climate Change Canada

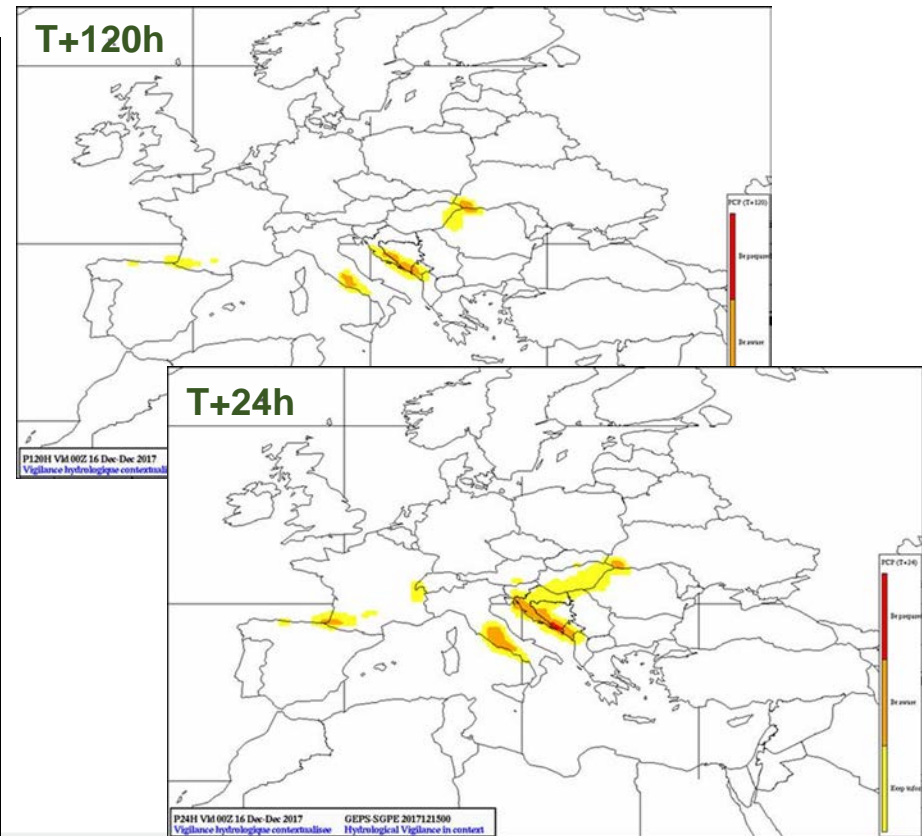
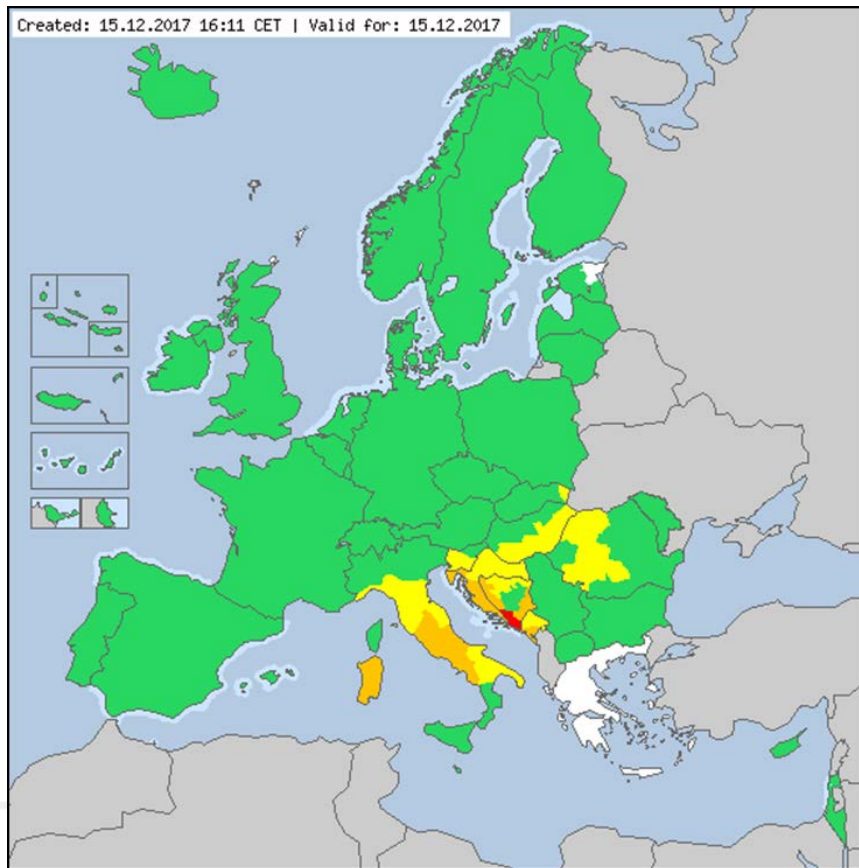
Environnement et
Changement climatique Canada

Canada

Looking ahead (probabilistic modeling) – Example: Rainfall Dec 15th, 2018



- Casualties and significant damages in several regions of Albania



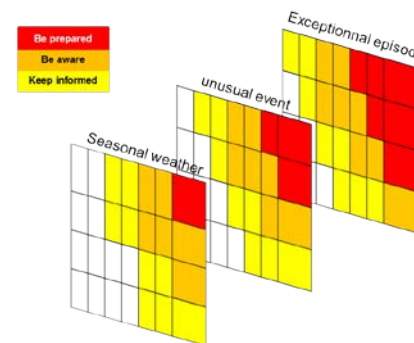
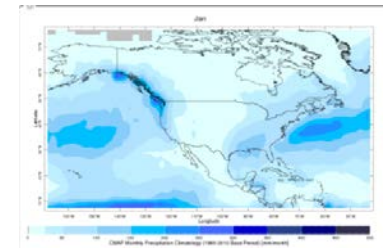
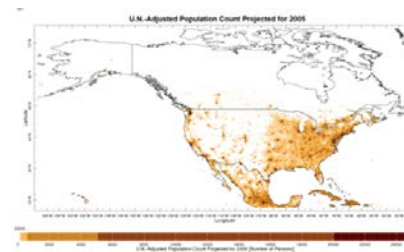
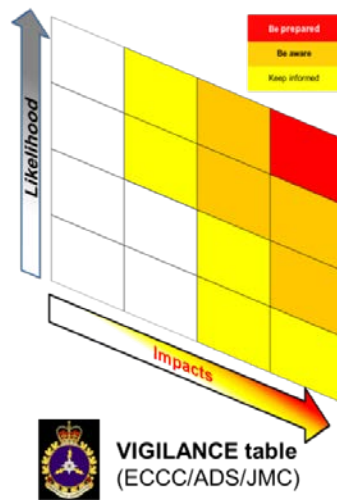
Looking ahead (probabilistic modeling) – Ways of improvements

Main



Additional layer to take into account “vulnerabilities” to METOC hazards:

- Population density
- Urbanization rate
- Land use cover (soil type)
- Climatology
- Latest hazard assessment



Suggested VIGILANCE
“in Context” matrix
(ECCC/ADS/JMC)

