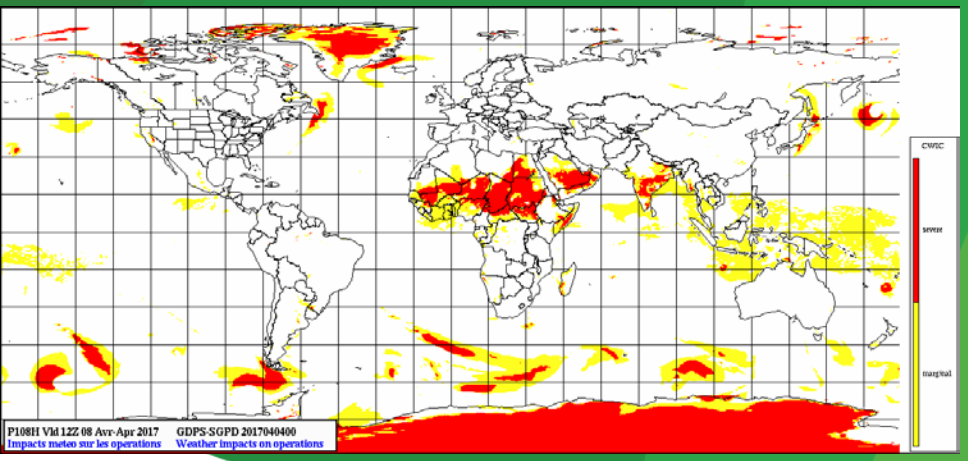
IMPACT BASED FORECAST FOR THE CANADIAN ARMED FORCES

From a deterministic to a probabilistic approach



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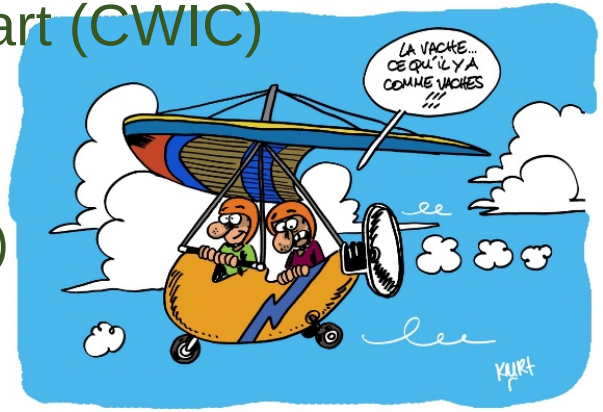
8th NCEP Ensemble User Workshop
August 27-29, 2019
College Park, MD

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

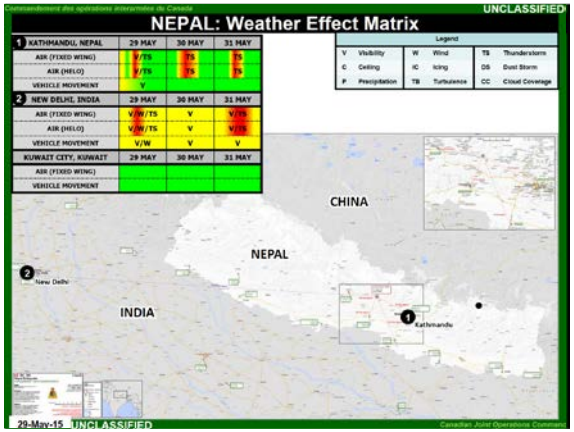
- **Data centric approach**

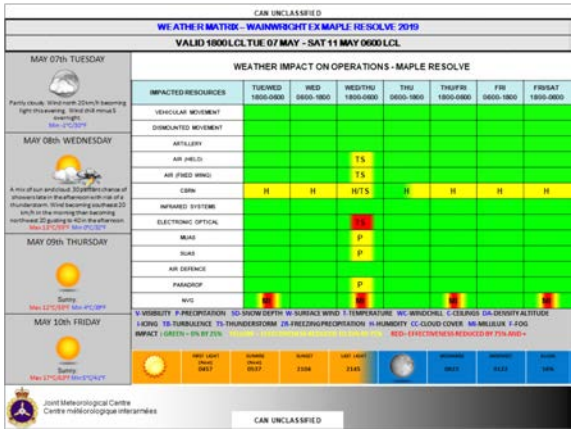
The « *Modernization of MetOc data Services* » Document (SOCD, sept 2015) suggests a significant update of CFWOS website to incorporate OGC-compliant web services **to allow for interoperability** with other applications and services, and **to provide timely and cost efficient transmission** of data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

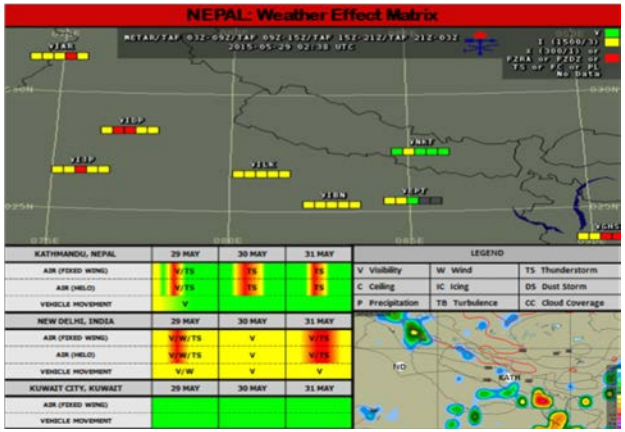
- **MSC Vision**

"*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)

Relevant Environmental data base

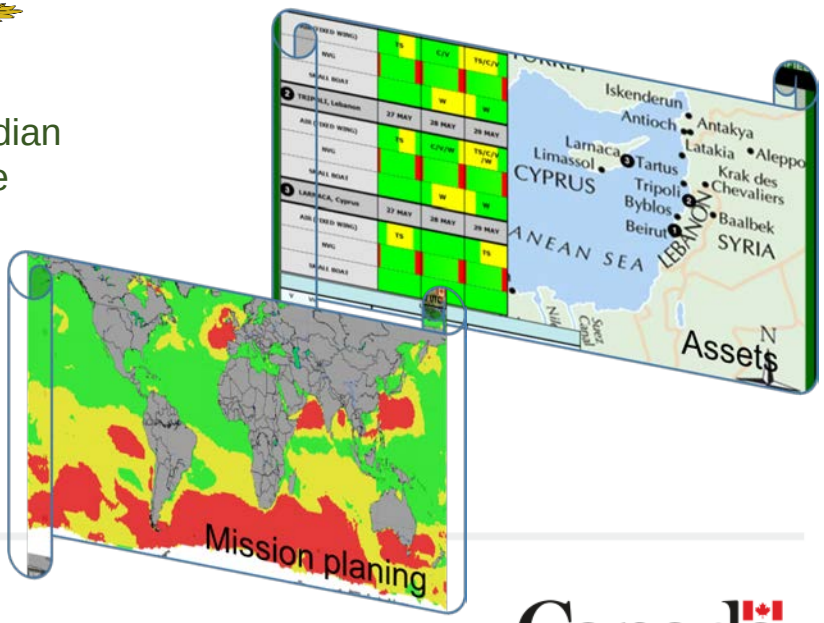
Objectives

Canadian Forces Intelligence Command

Royal Canadian Air Force

Royal Canadian Navy

Canadian Army



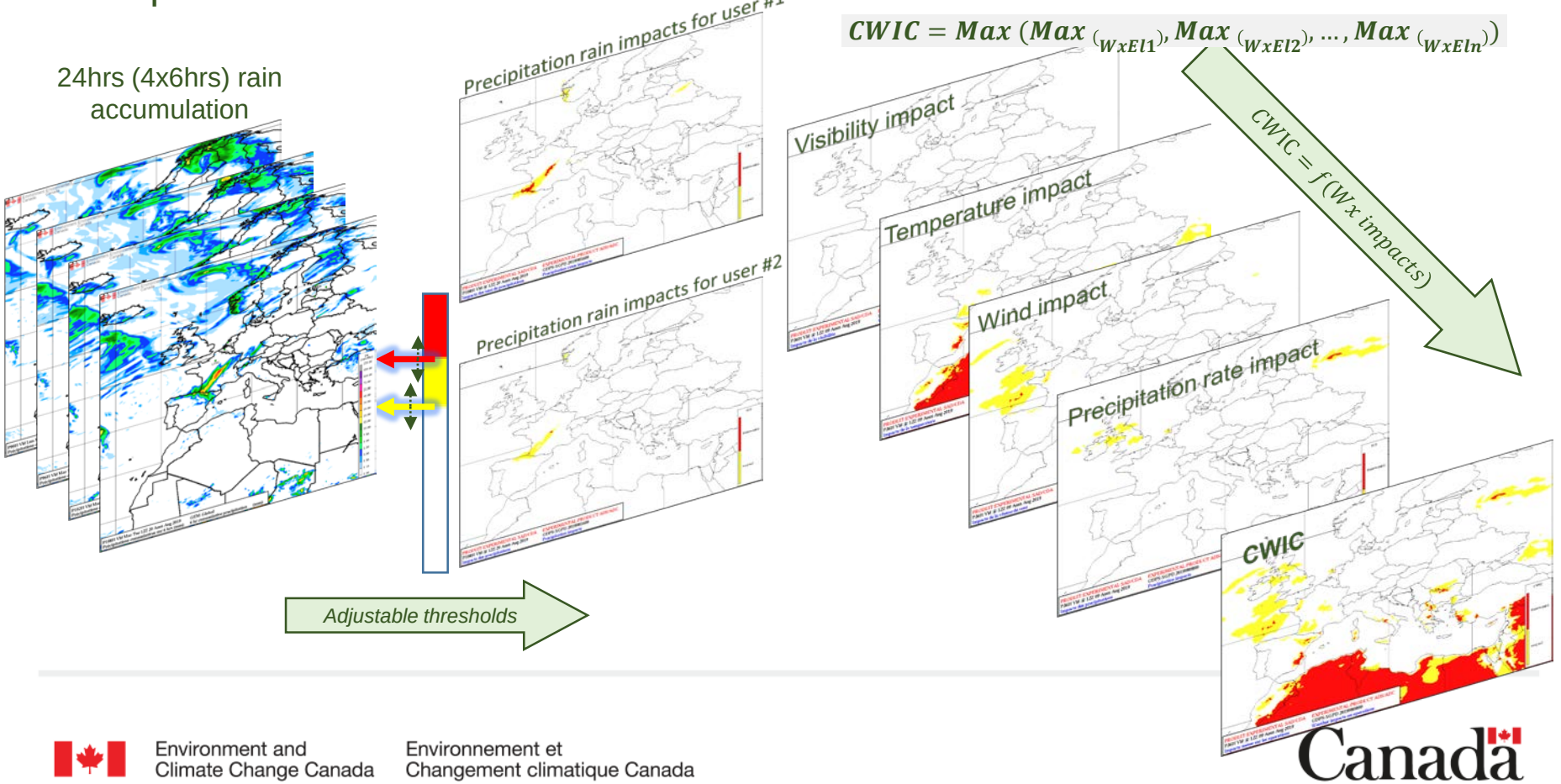
Consolidated Weather Impact Chart (CWIC)

Principles

1. Impacts characterization

2. Consolidation rule

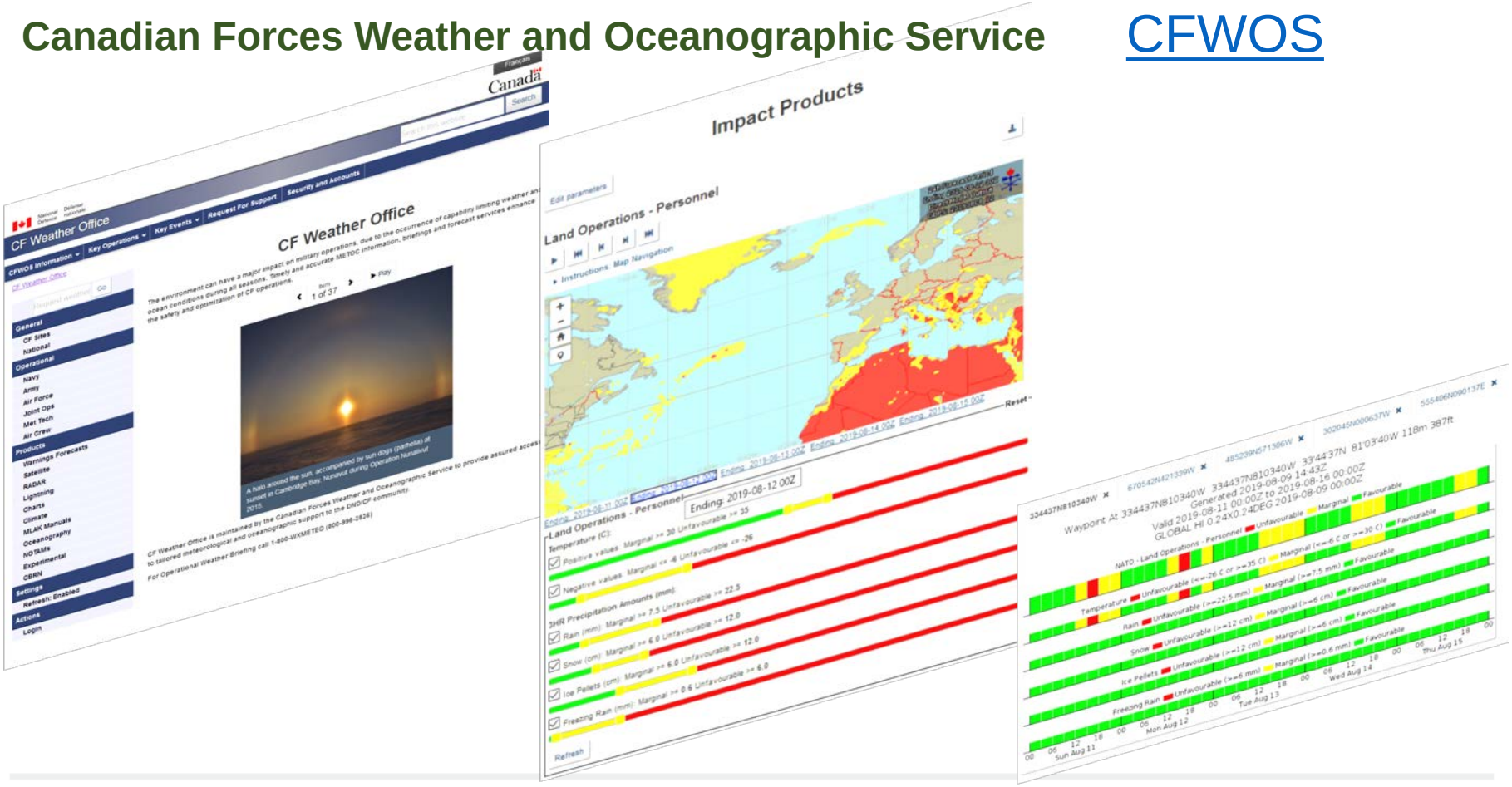
$$CWIC = Max\ (Max_{(WxEl1)}, Max_{(WxEl2)}, \ldots, Max_{(WxEln)})$$



Current state (deterministic modeling)

Canadian Forces Weather and Oceanographic Service

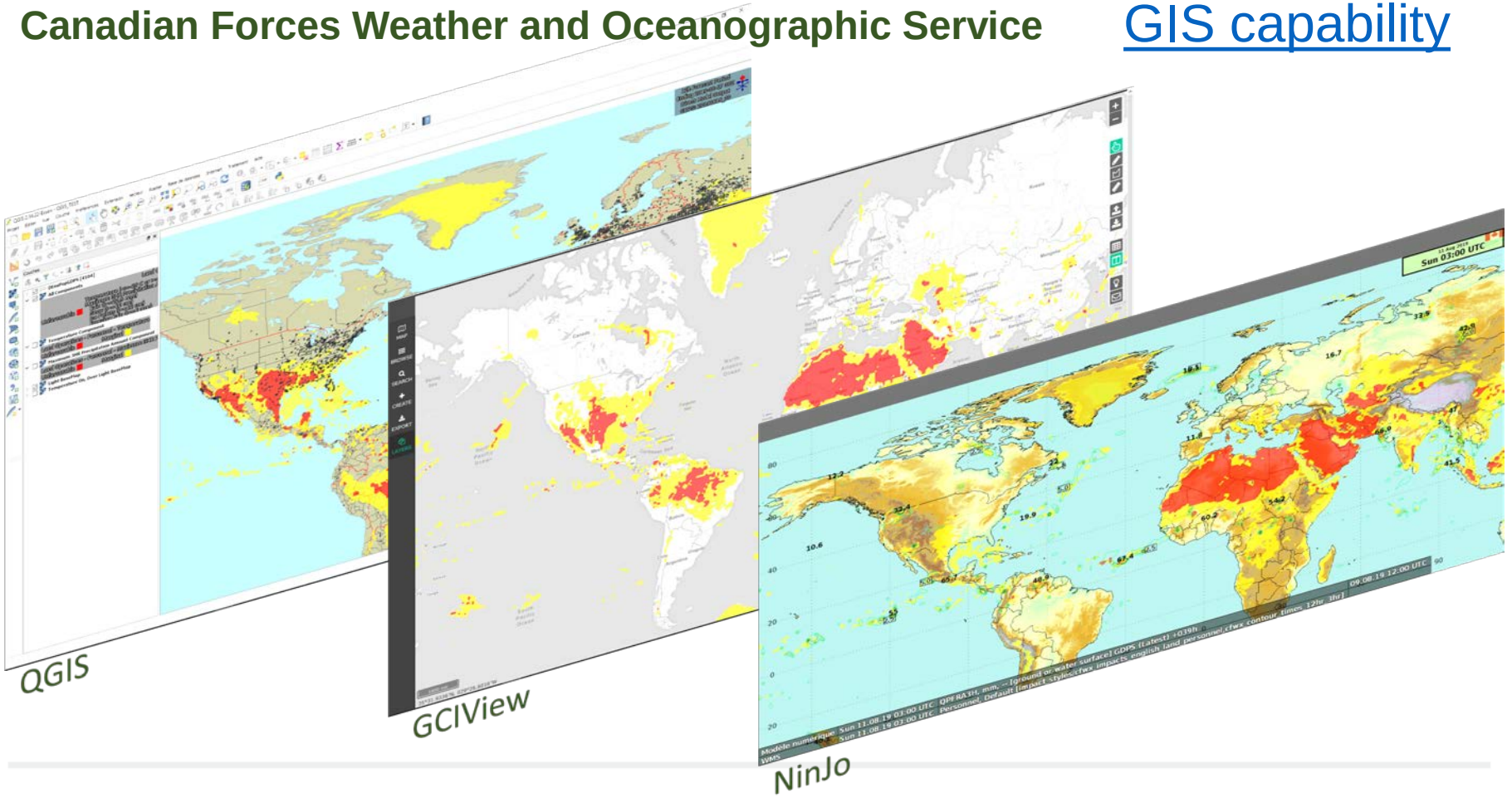
CFWOS



Current state (deterministic modeling)

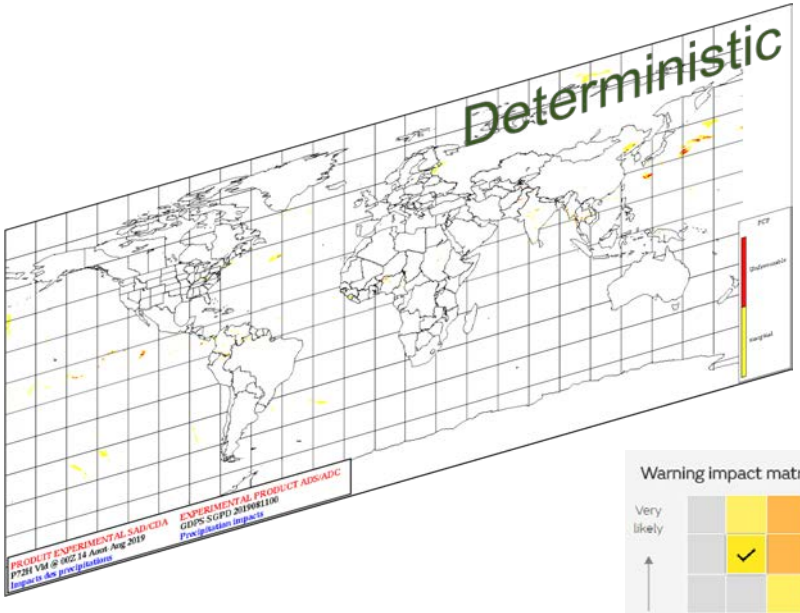
Canadian Forces Weather and Oceanographic Service

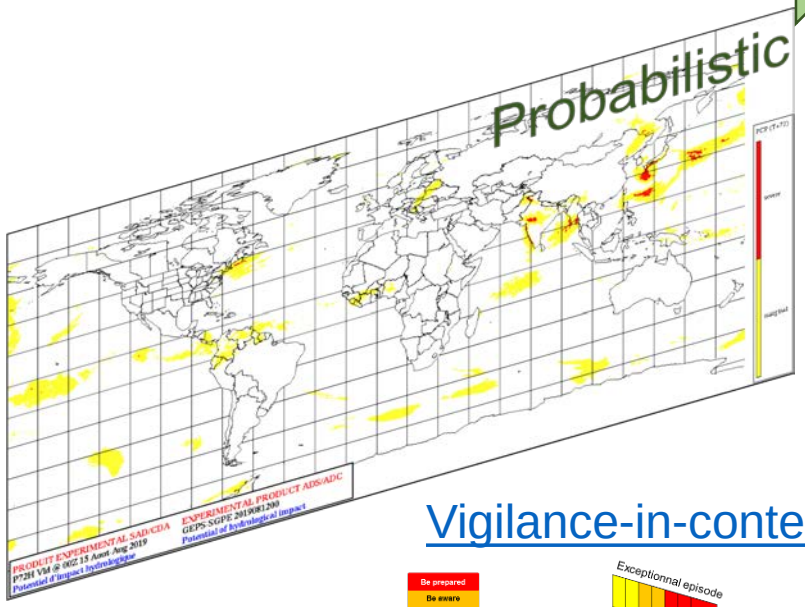
GIS capability



Looking ahead (probabilistic modeling)

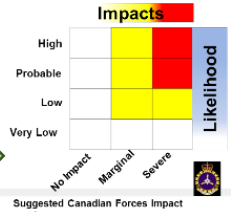
Question: How to keep the info consistency while moving from deterministic to probabilistic NWP?





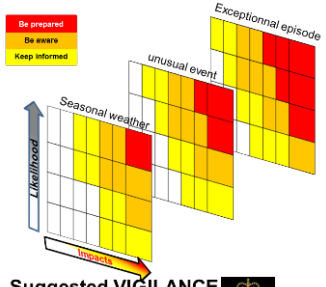
Answer: The matrix approach

CAF Matrix



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

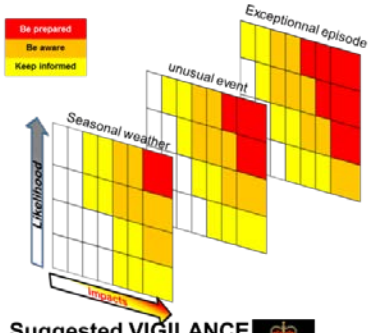
Vigilance-in-context



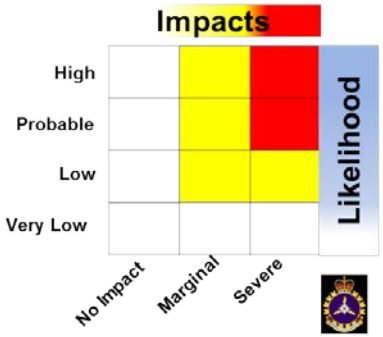
Suggested VIGILANCE "in Context" matrix
(ECCC/ADS/JMC)

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.



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



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

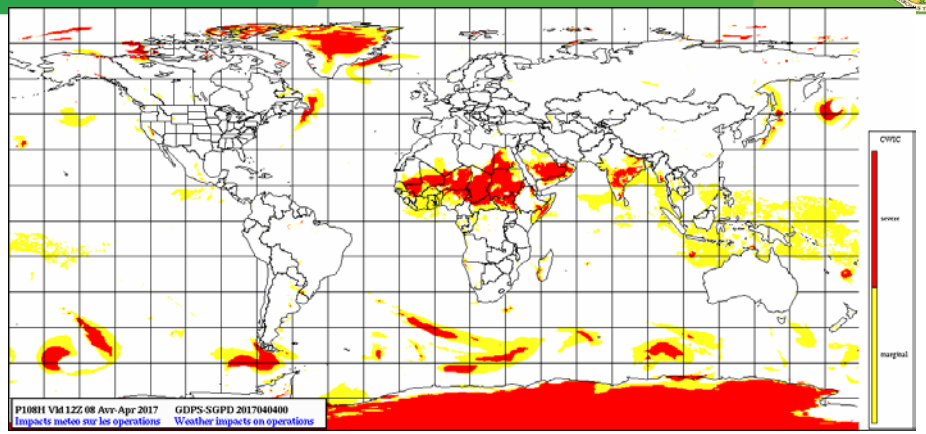
are pillars upon which a **MetOc impact database,** relying on forecasted weather elements, will be developed in order to :

- 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

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Joint Meteorological Center

Aviation and Defence Services, Environment Canada

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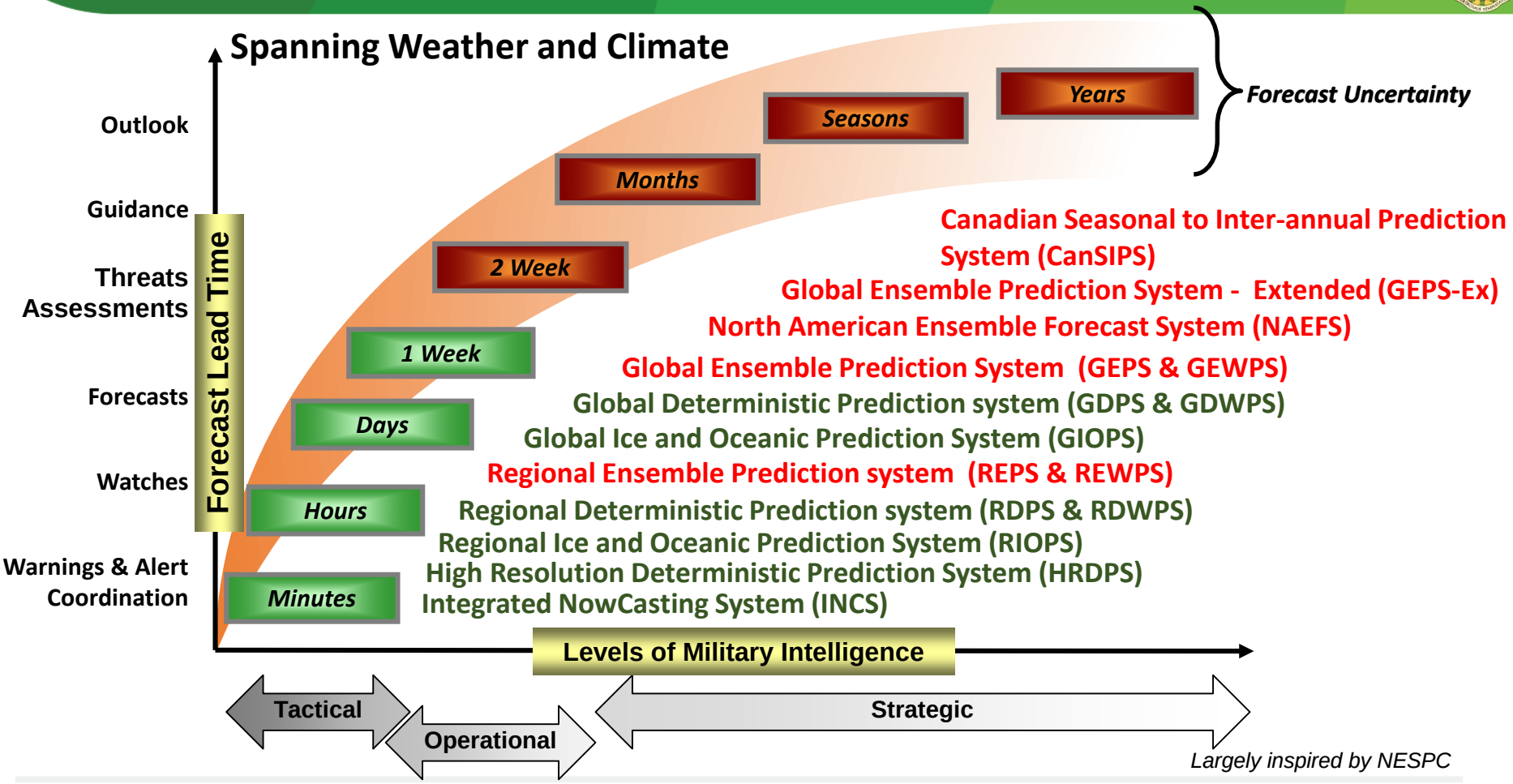
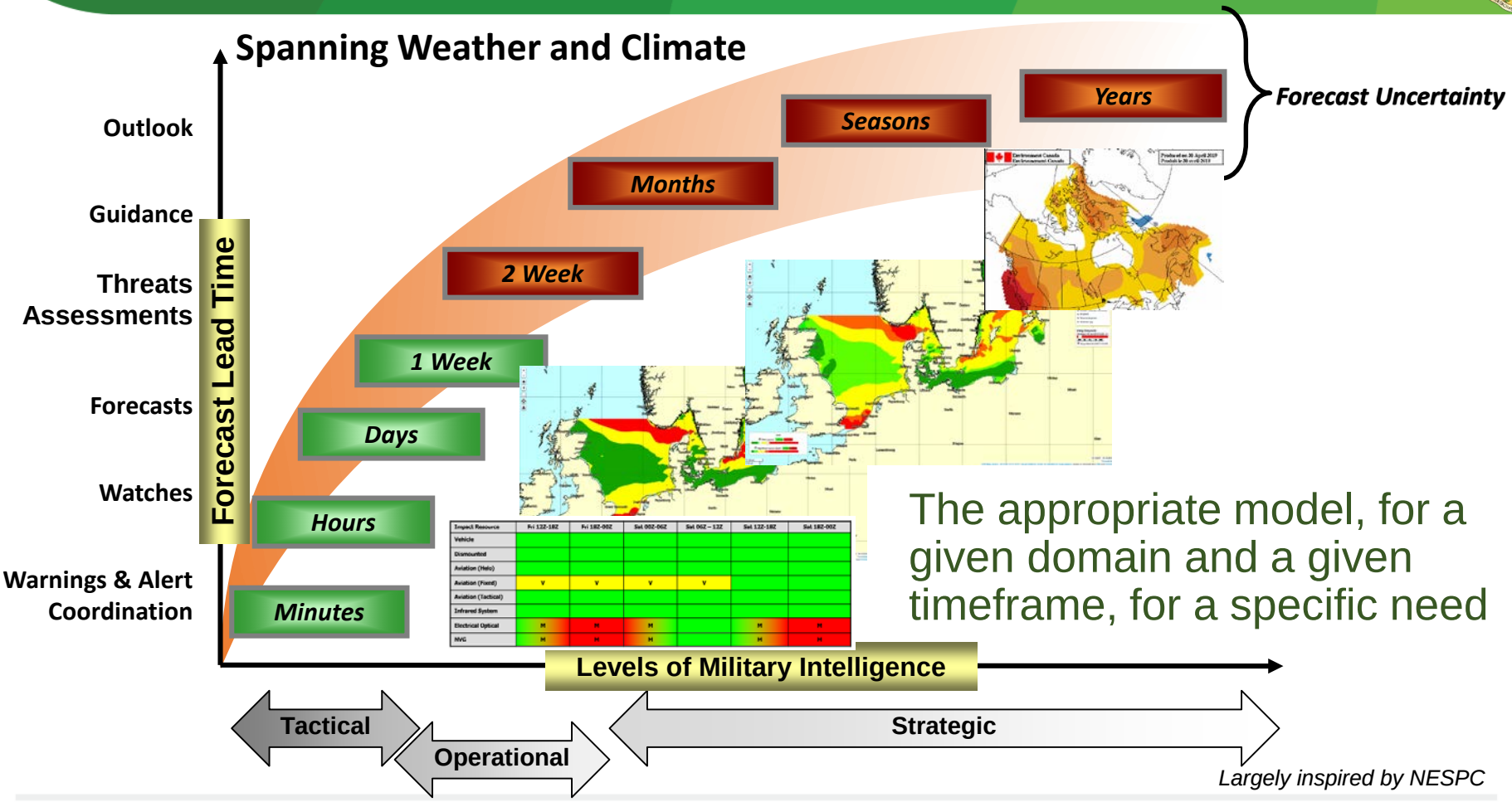
Environment and
Climate Change Canada

Canada

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



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



The appropriate model, for a given domain and a given timeframe, for a specific need

Largely inspired by NESPC

Consolidated Weather Impact Chart (CWIC) – A relevant database

Main

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

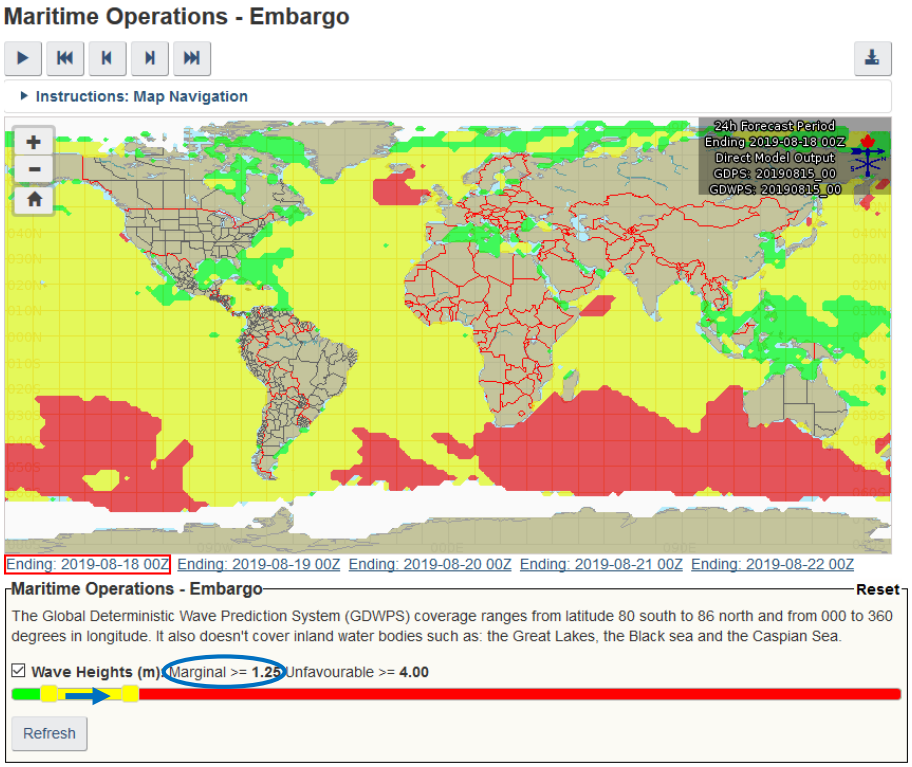
WEATHER IMPACTS ON MARITIME OPERATIONS			
SMALL BOAT OPS	Sea State < 3 Surface wind < 10 kts	Sea State 3-4 Surface wind 10-20 kts	Sea State > 4 Surface wind > 20 kts
EMBARGO OPS	Sea State < 4	Sea State = 4-5	Sea State > 5
AMPHIBIOUS OPS	Sea State < 4	Sea State = 4-5	Sea State > 5
MCM	Sea State < 4	Sea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

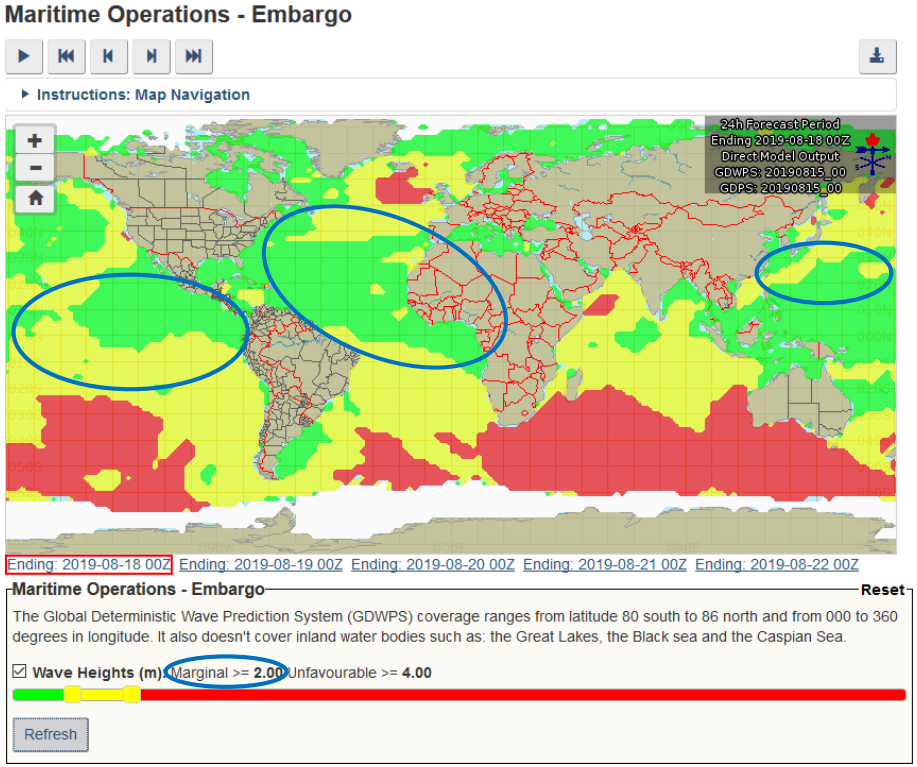
For each operation type, operational limits have been defined for every weather element which can interfere with the considered operation.

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

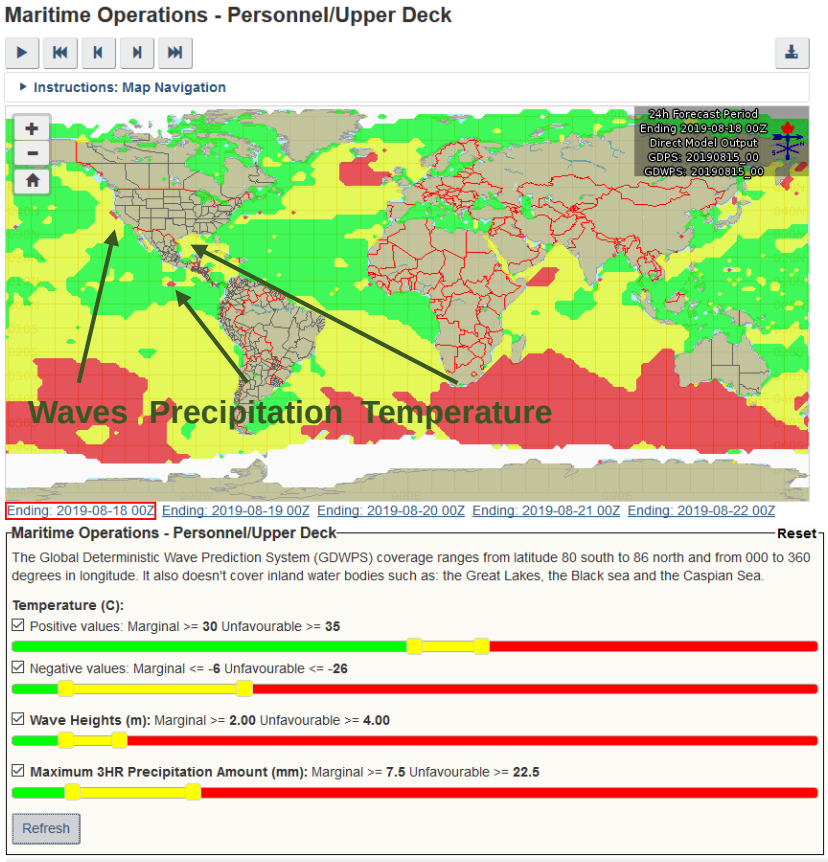


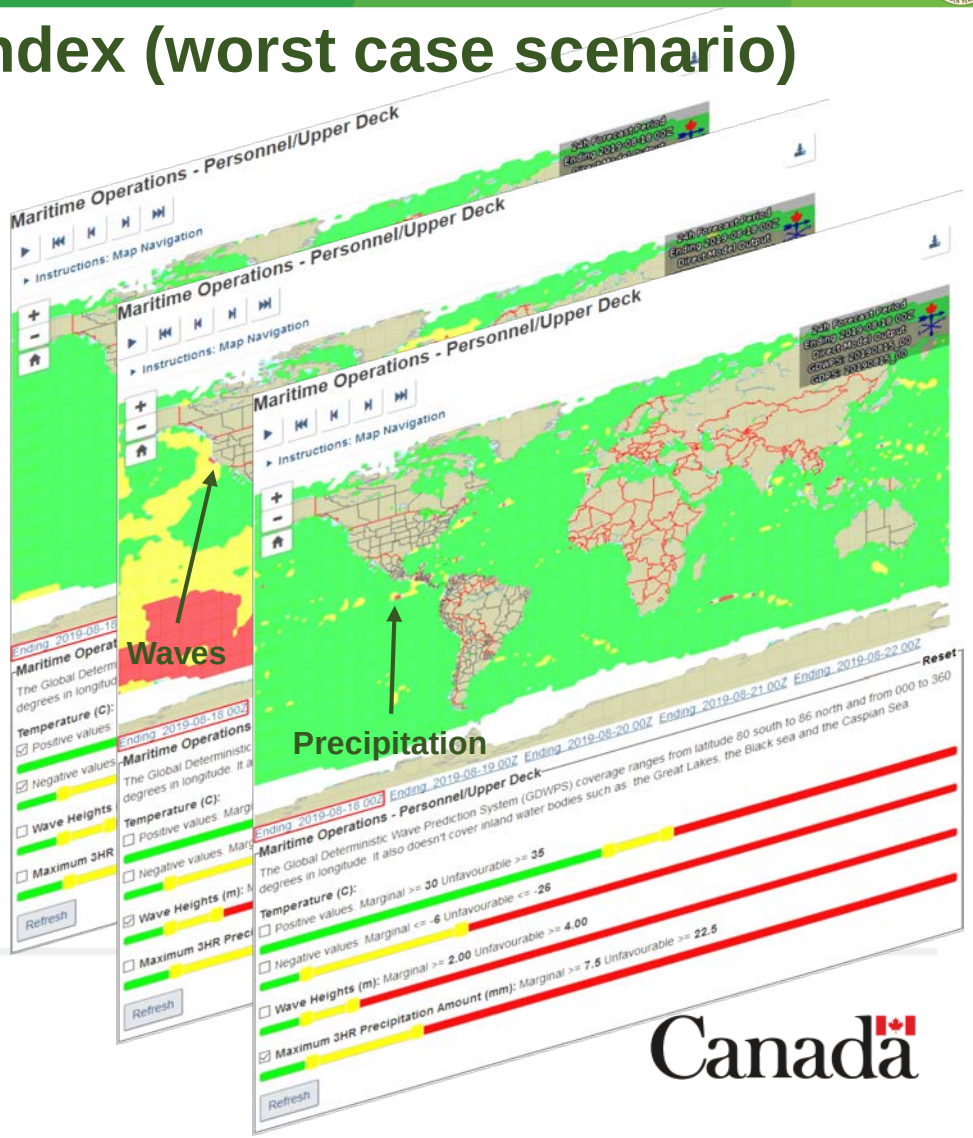


Consolidated Weather Impact Chart (CWIC) – Consolidation rule

Main

The worst index make the index (worst case scenario)





$$CWIC = Max\left(Max_{(WxEl1)}, Max_{(WxEl2)}, \ldots, Max_{(WxEln)}\right)$$

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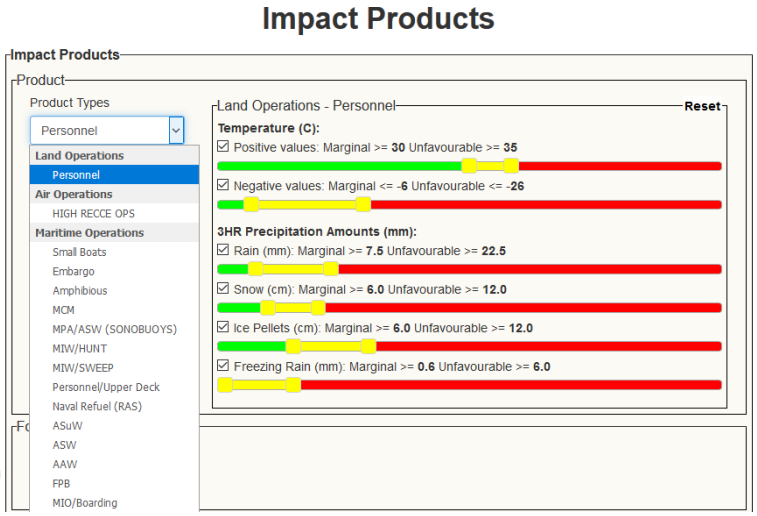
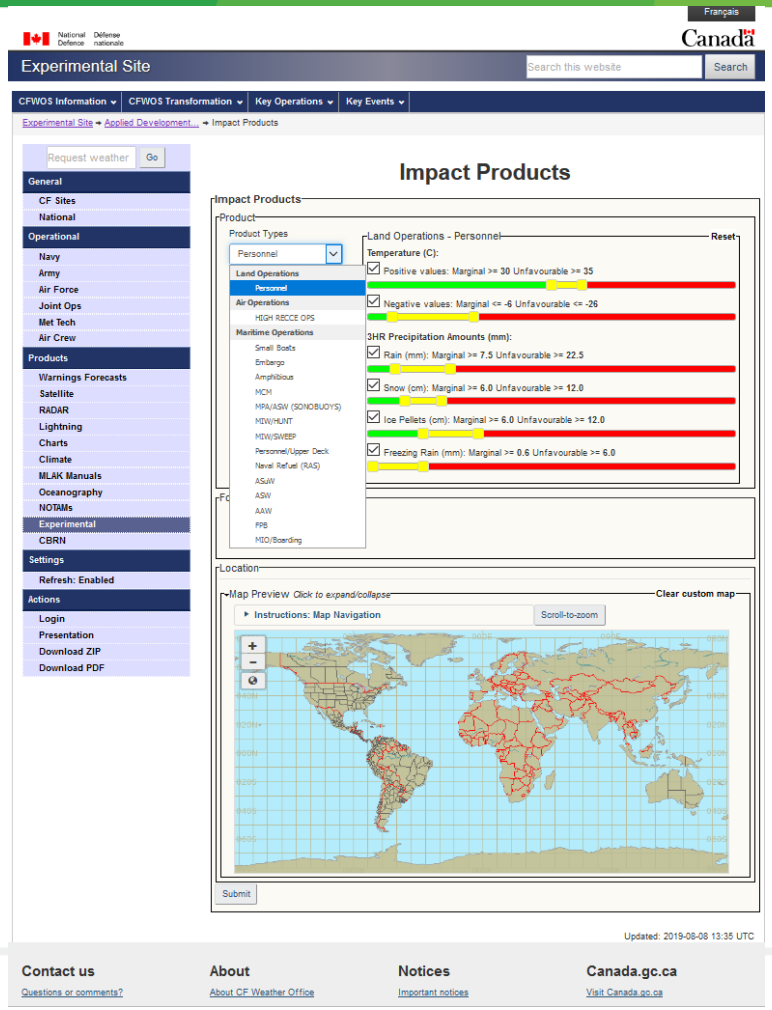
Current state (deterministic modeling) – Configuration page

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



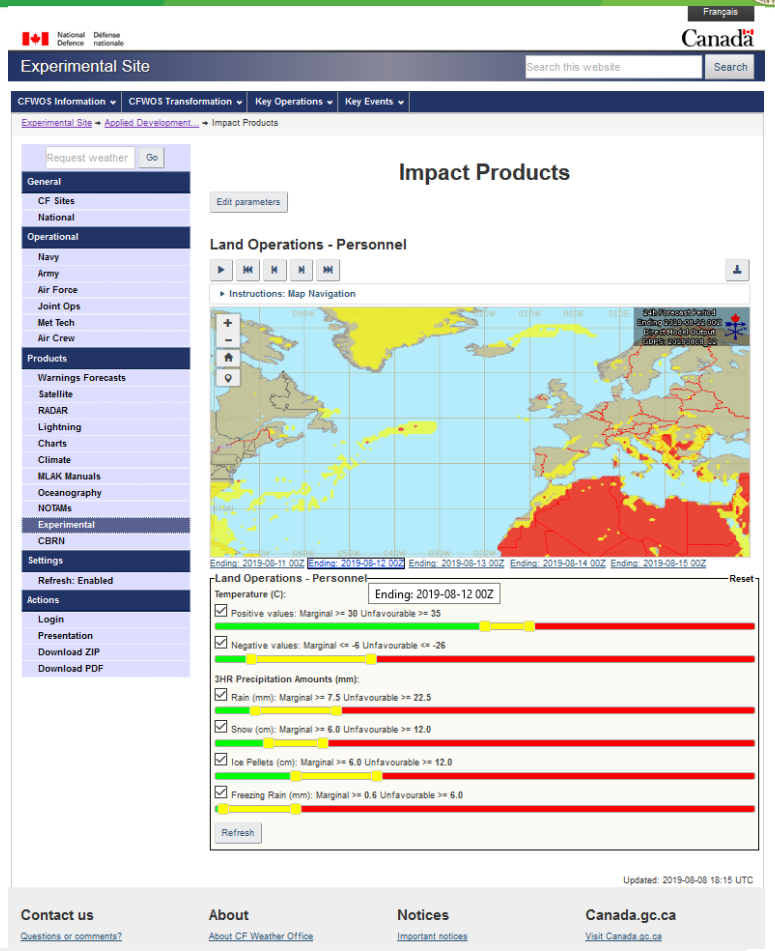


Current state (deterministic modeling) – Impacts products page

- 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.

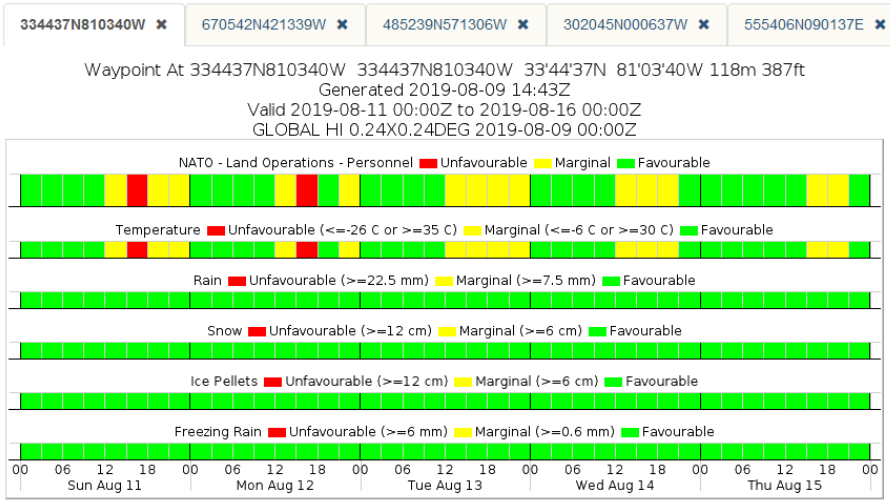
- Temporal series for 5 locations: **impact-grams**

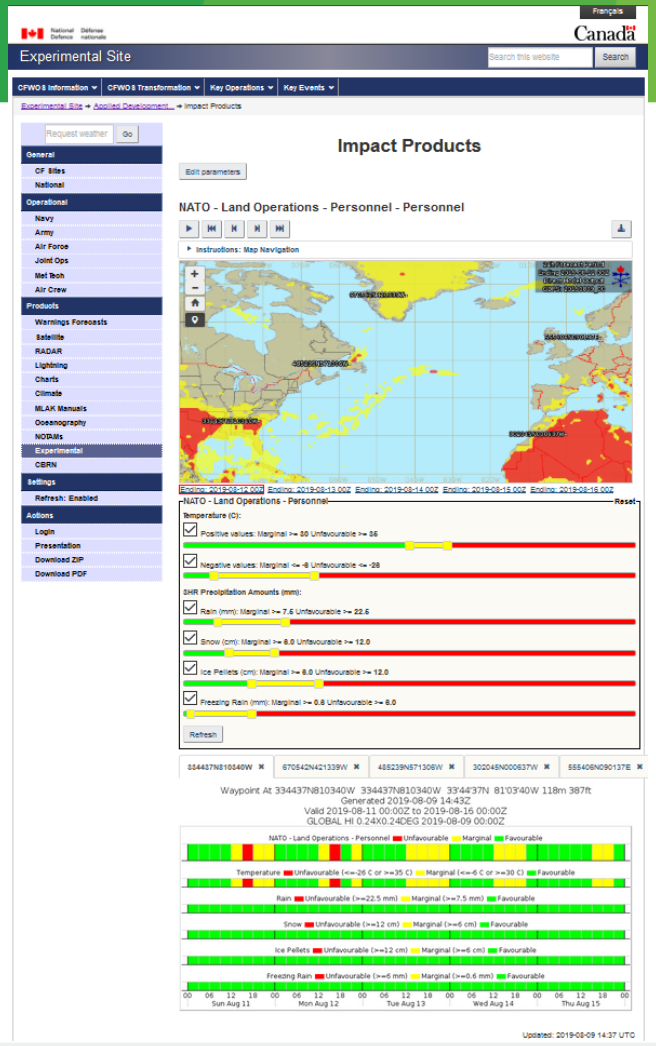


Current state (deterministic modeling) – Impact-grams

Main

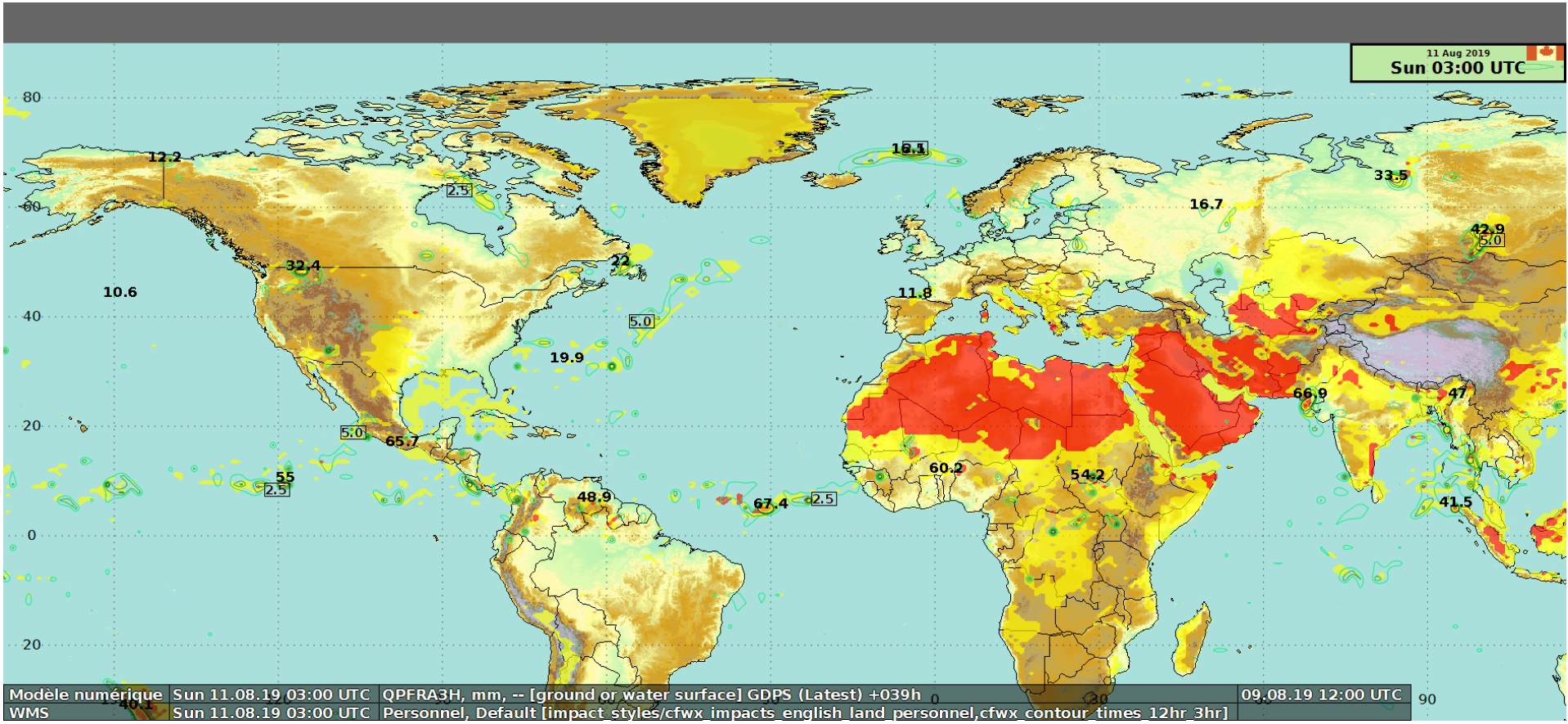
- Up-to 5 locations
- Adustable “on-the-fly”
- Light and full versions





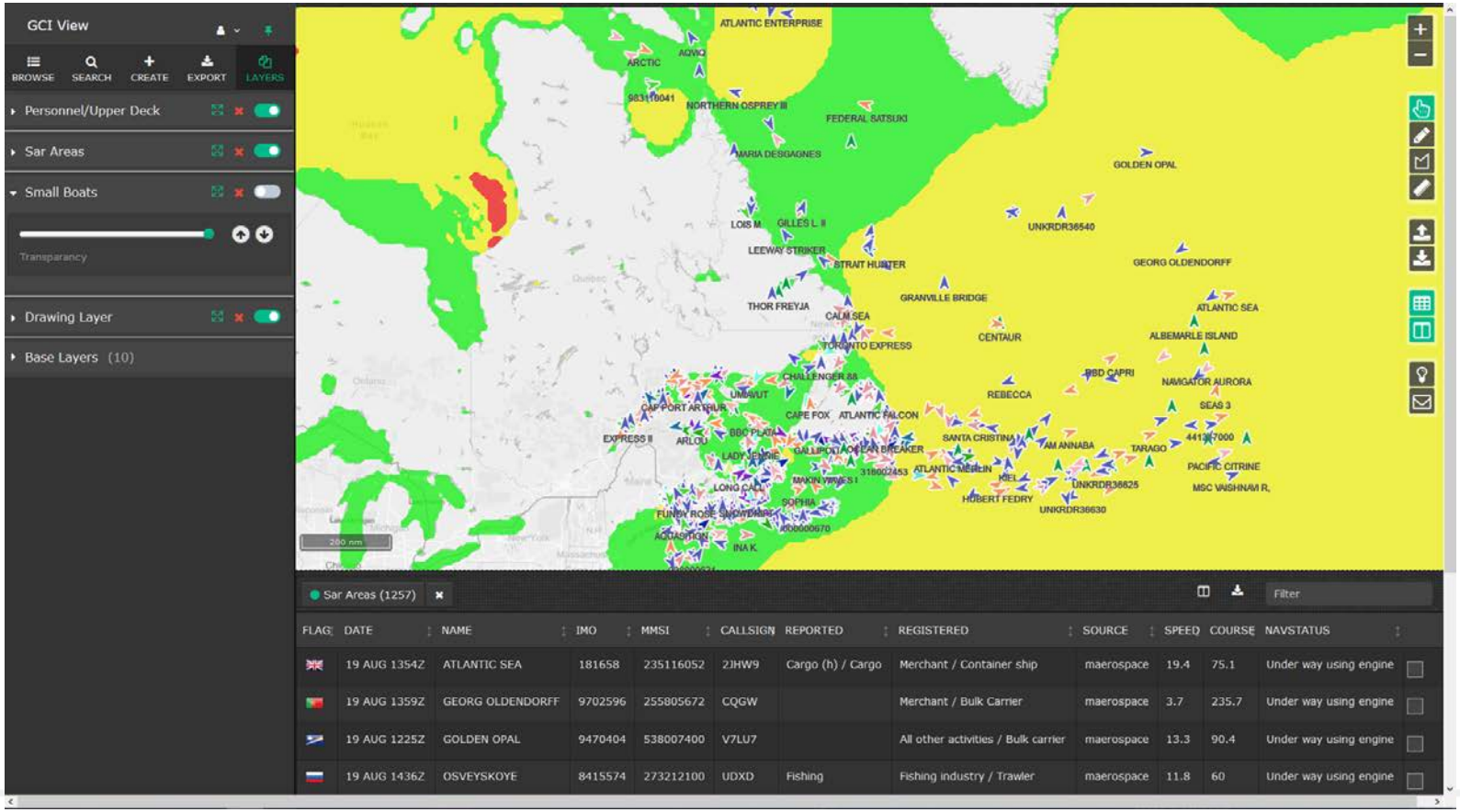
Current state (deterministic modeling) – GIS on operational visualisation tool

- NinJo WMS layer



Current state (deterministic modeling) – GIS – external WMS client interface

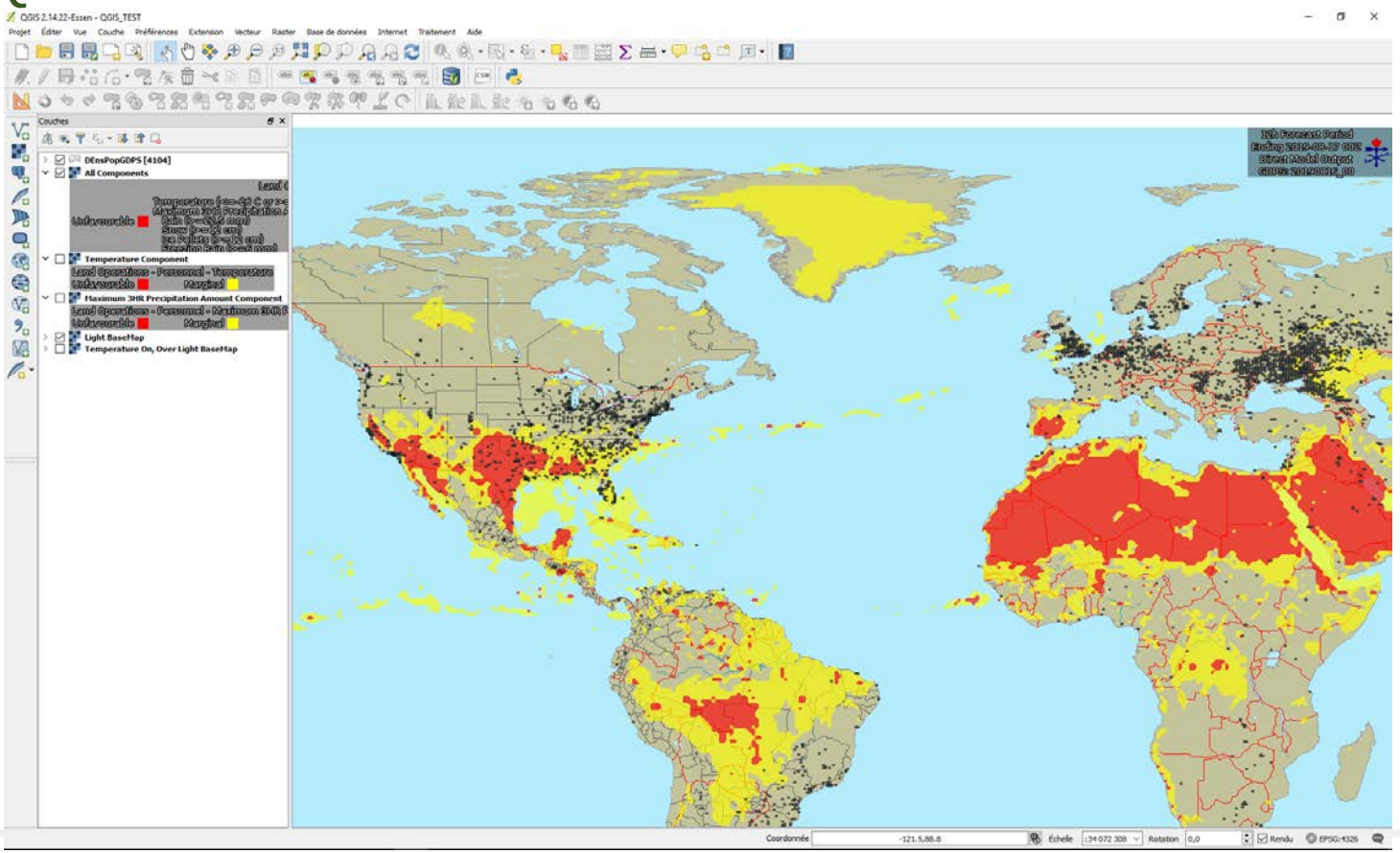
- Partner WFS client interface



Current state (deterministic modeling) – GIS – ESRI application

Main

- QGIS

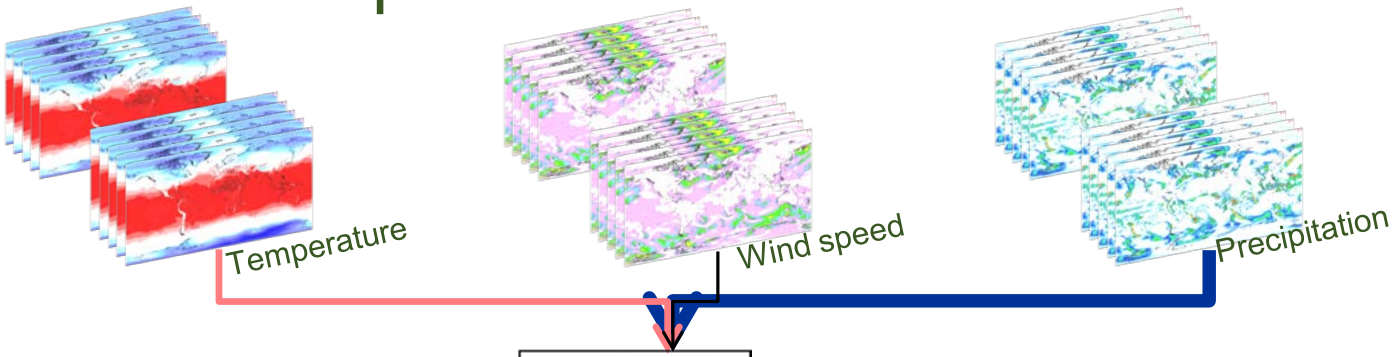


Looking ahead (probabilistic modeling) – Impacts on Operations

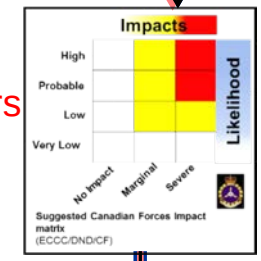
How does the concept work?

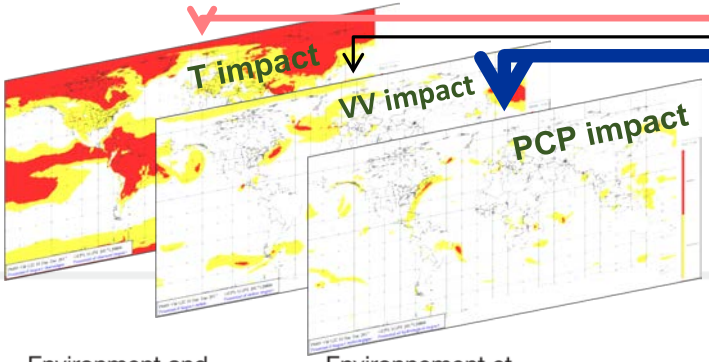
Forecasted weather parameters **(GEPS)**

***G**lobal **E**nsemble **P**rediction **S**ystem*

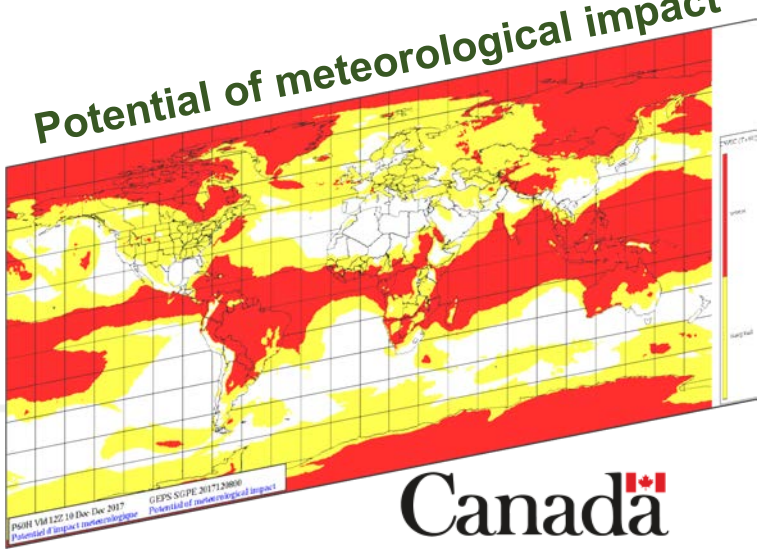


Potential Impacts due to forecasted weather parameters





Consolidation



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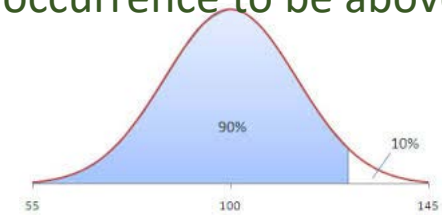
Looking ahead (probabilistic modeling) – Percentiles

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%

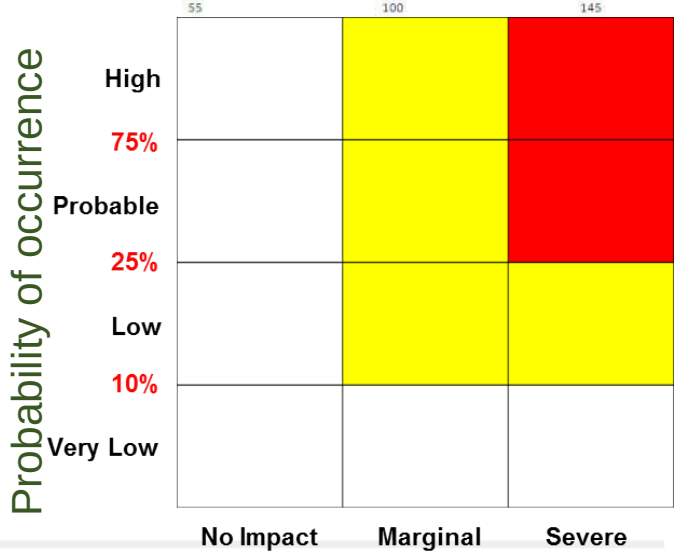
of chance of occurrence to be above a threshold



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.

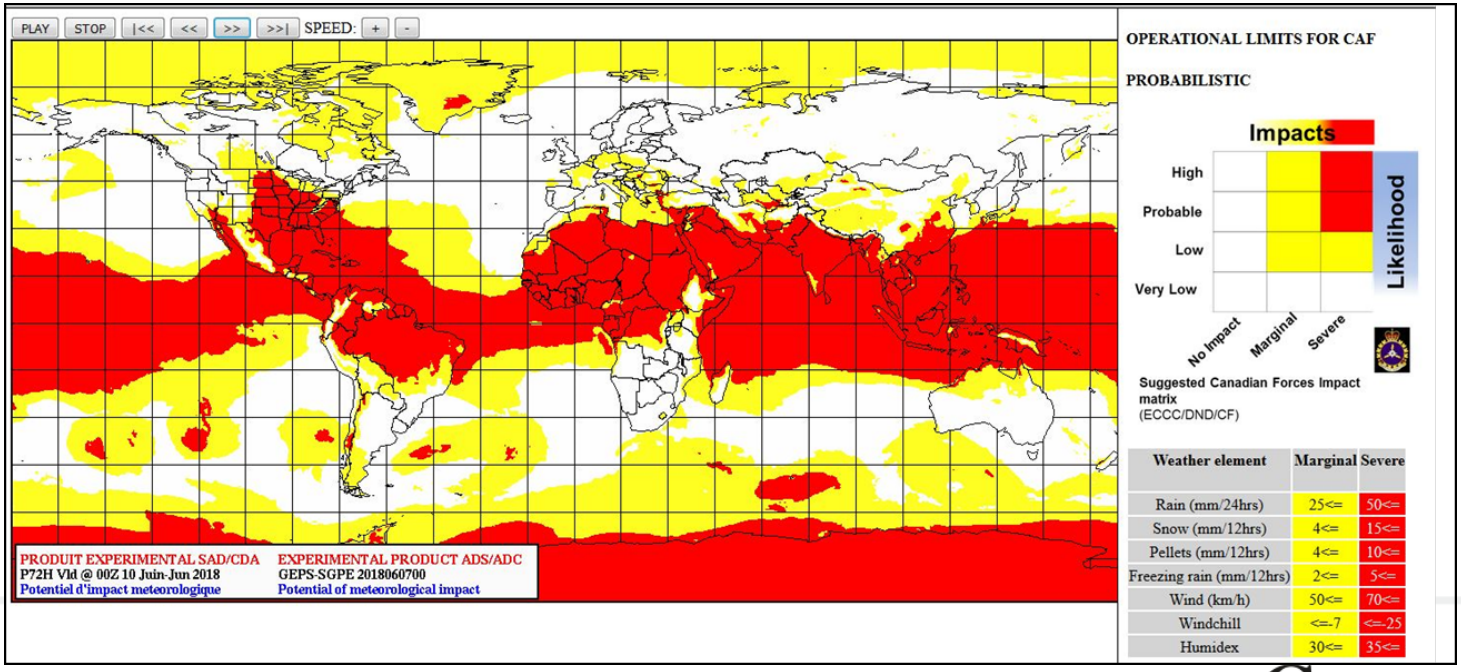


Looking ahead (probabilistic modeling) – CAF Proof of concept

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.

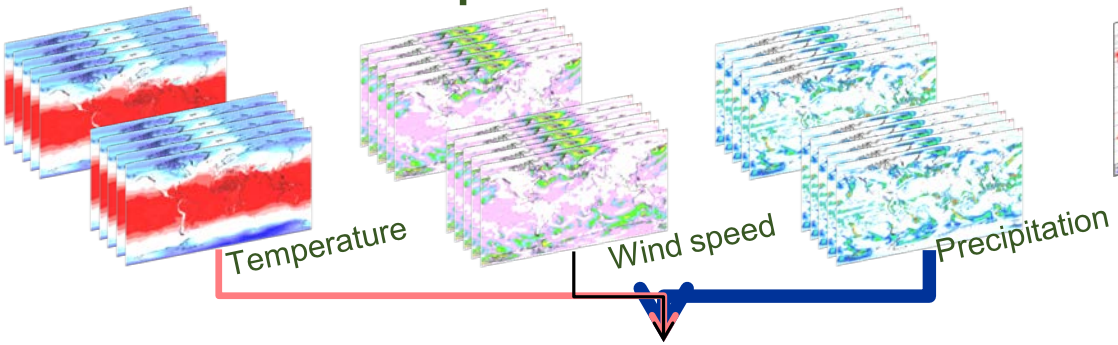


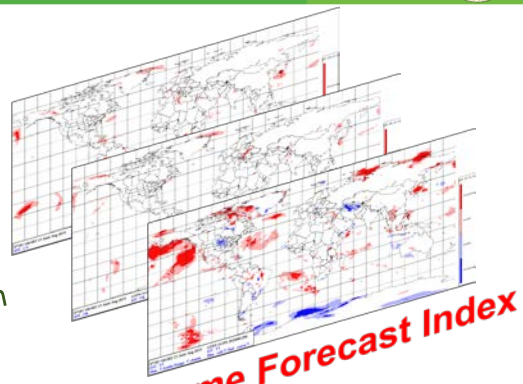
Looking ahead (probabilistic modeling) – Impacts on population/environment

How does the concept work?

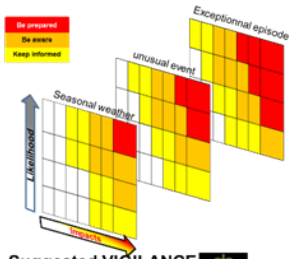
Forecasted weather parameters **(GEPS)**

***G**lobal **E**nsemble **P**rediction **S**ystem*

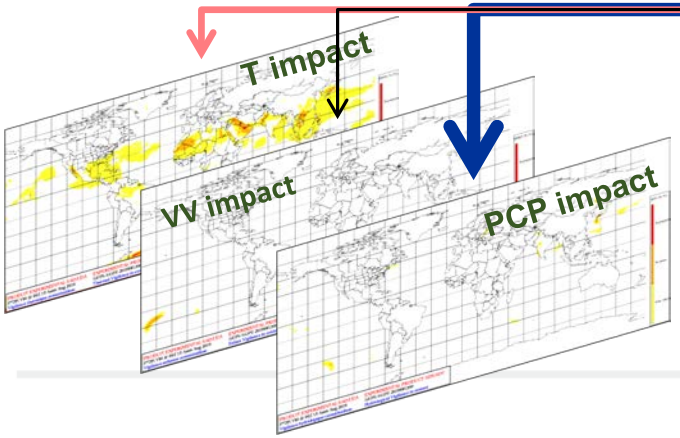




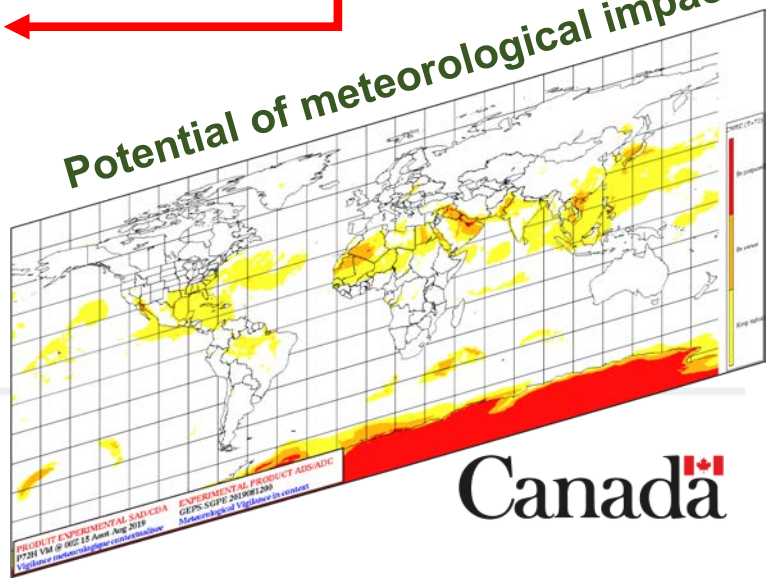
Potential Impacts due to forecasted weather parameters w.r.t. the M-climate



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



Consolidation



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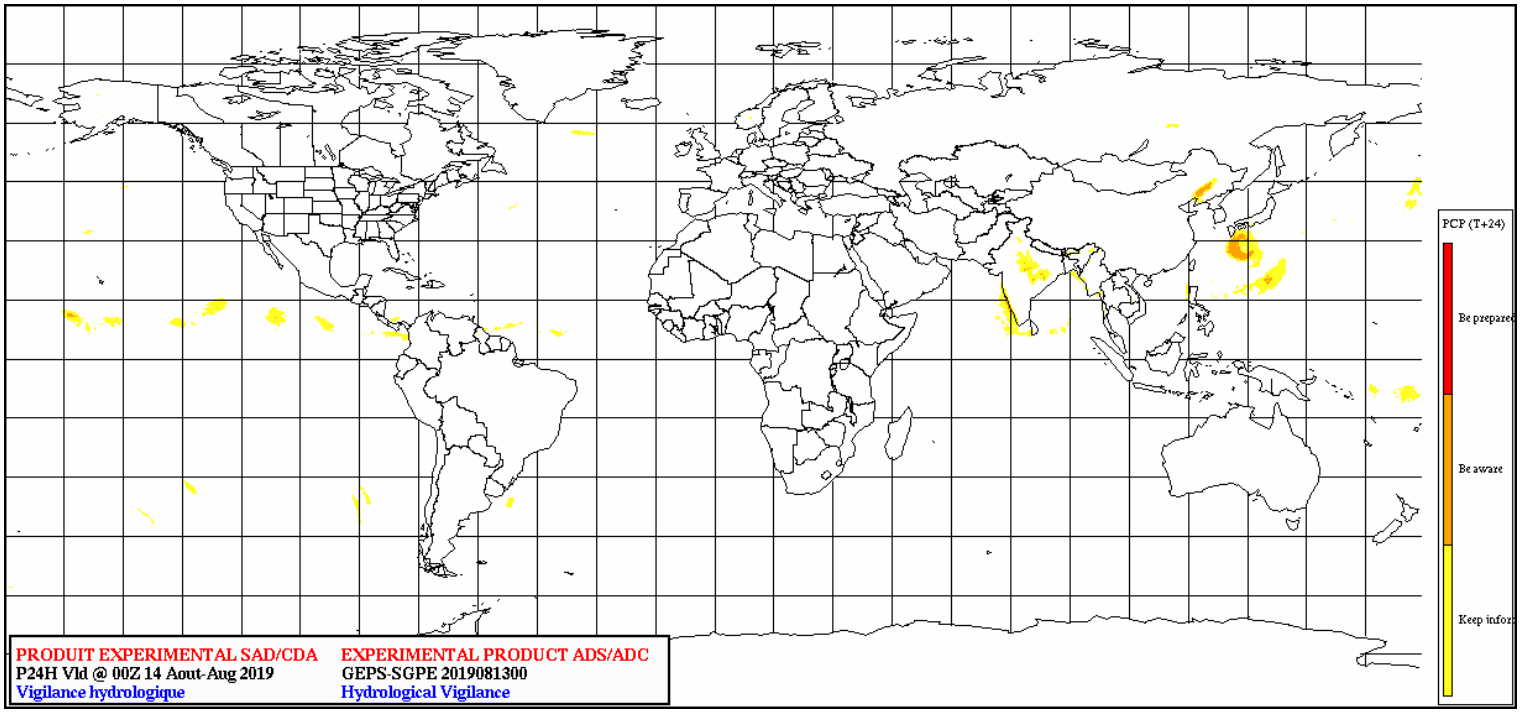
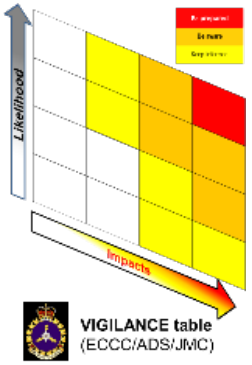
Canada

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

Vigilance inspired by the UK warning impact matrix



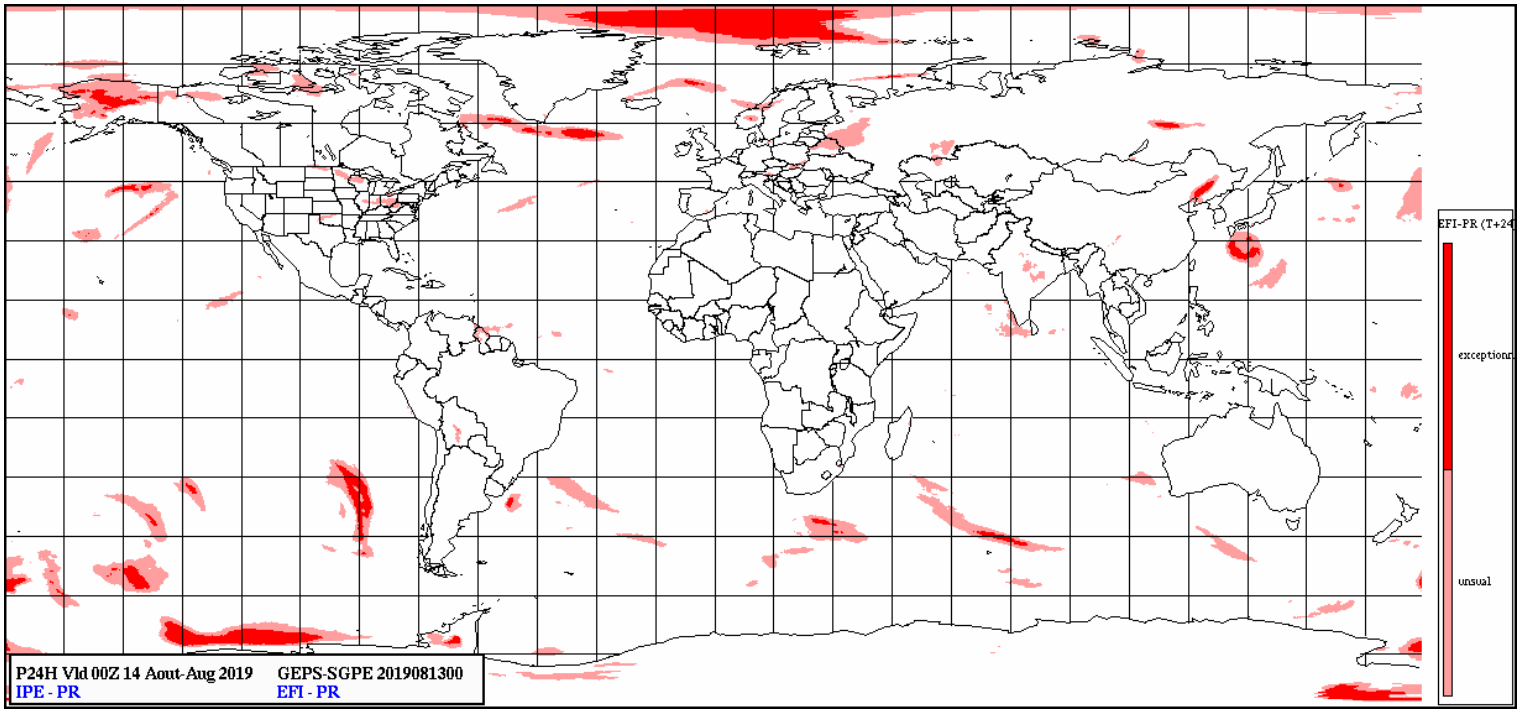


« Maple flavoured »

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

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

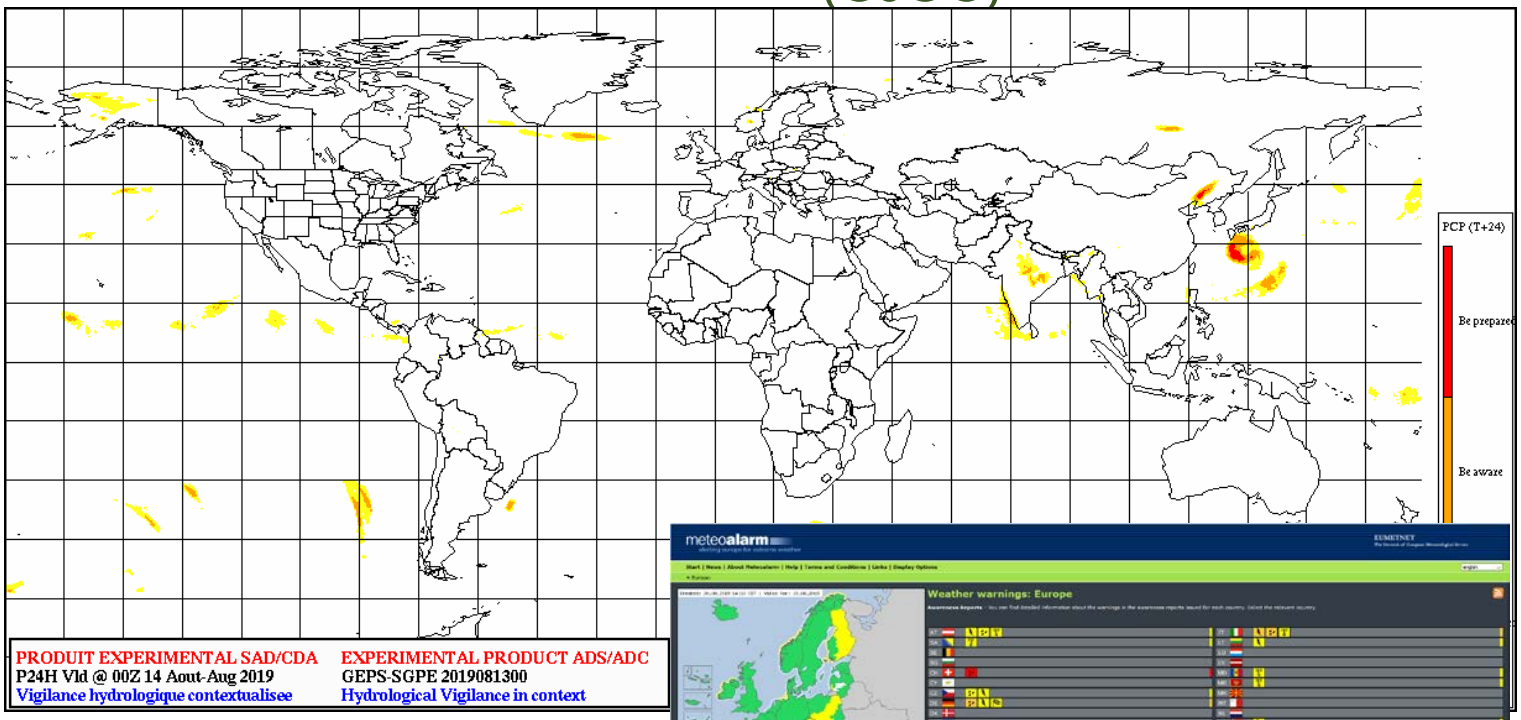
Contextualization w.r.t. M-Climate

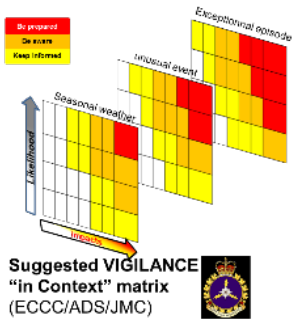


« a pinch of salt »

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

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

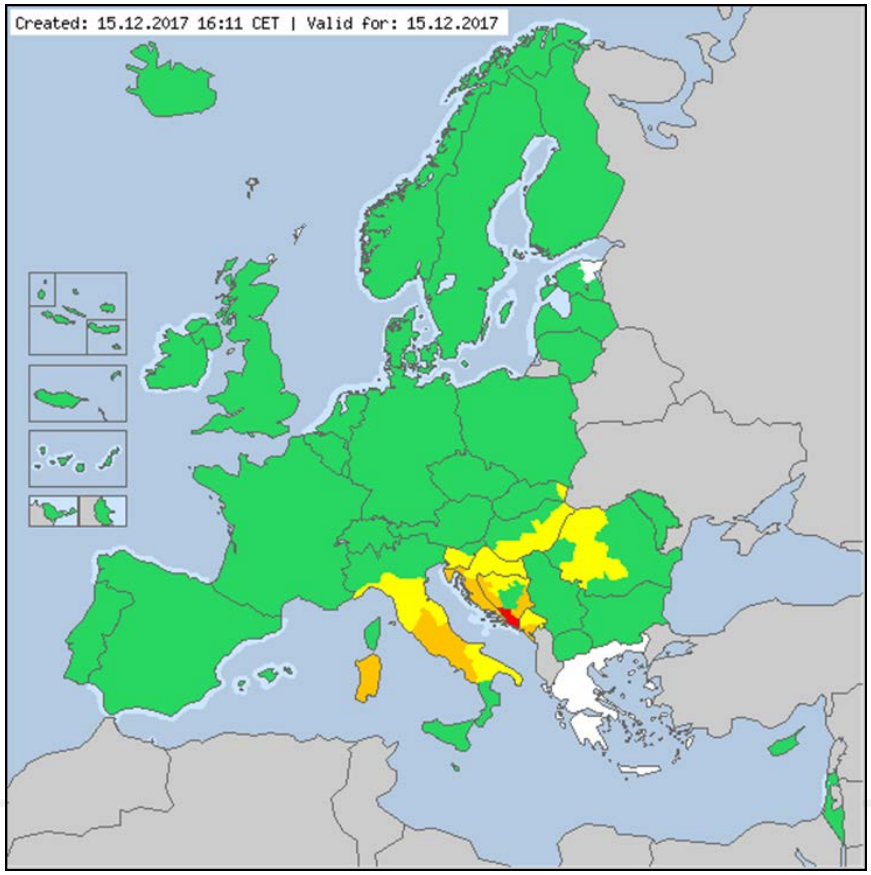


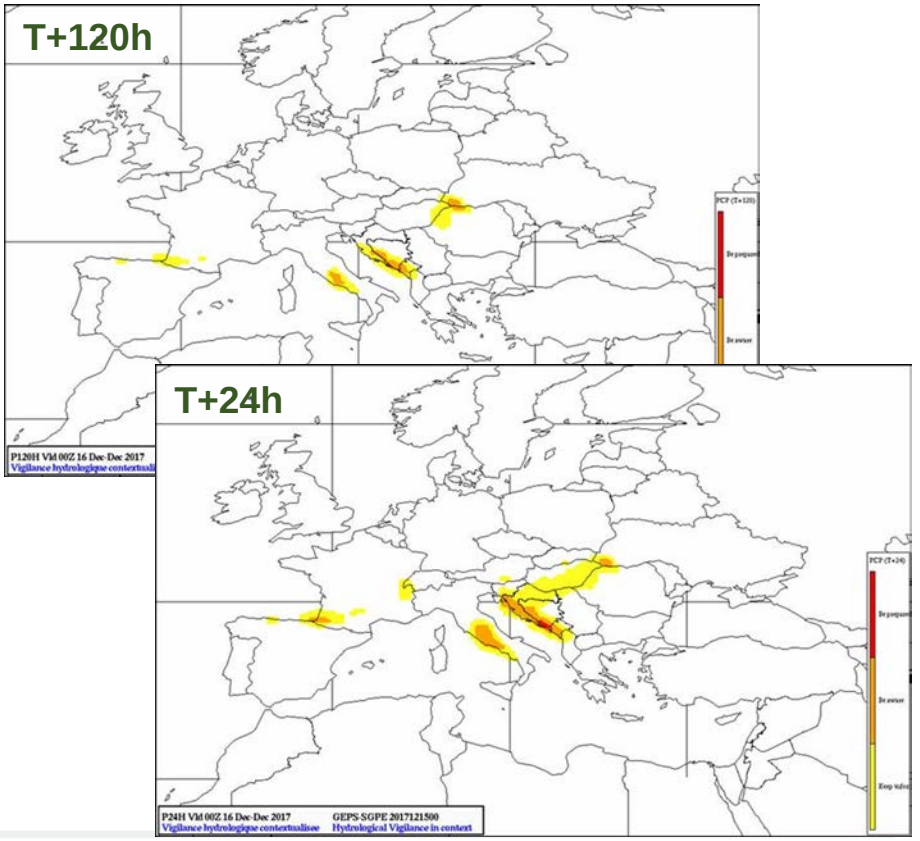


Why ?

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

- Casualties and significant damages in several regions of Albania



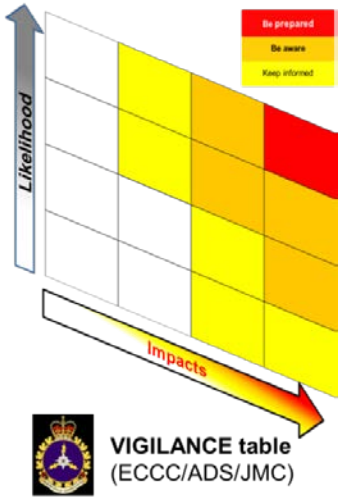


Looking ahead (probabilistic modeling) – Ways of improvements

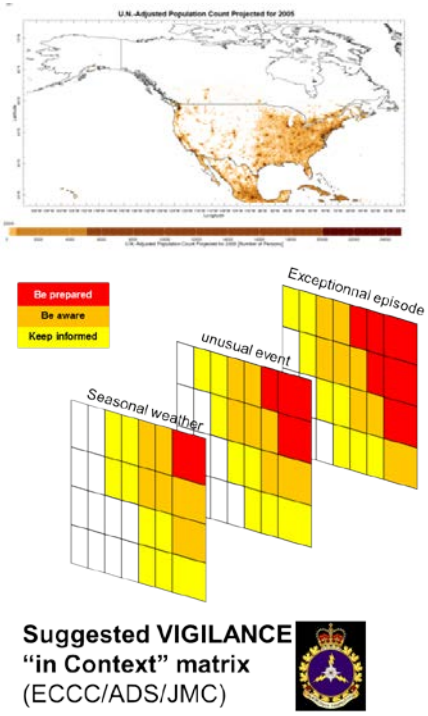
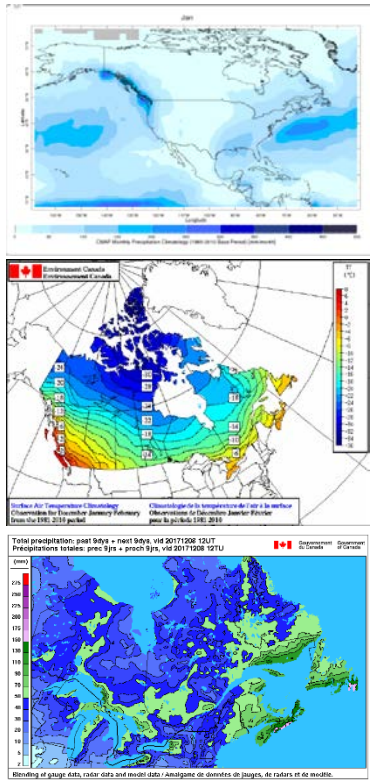
Main

Additional layer to take into account ‘’vulnerabilities’’ to METOC hazards:

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



VIGILANCE table
(ECCC/ADS/JMC)



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