FINNISH METEOROLOGICAL INSTITUTE

RAIN PROJECT

RAIN Workshop: Past Severe Weather Hazards

High Impact Weather Warning Procedures and Assessment

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The Finnish Meteorological Institute (FMI)

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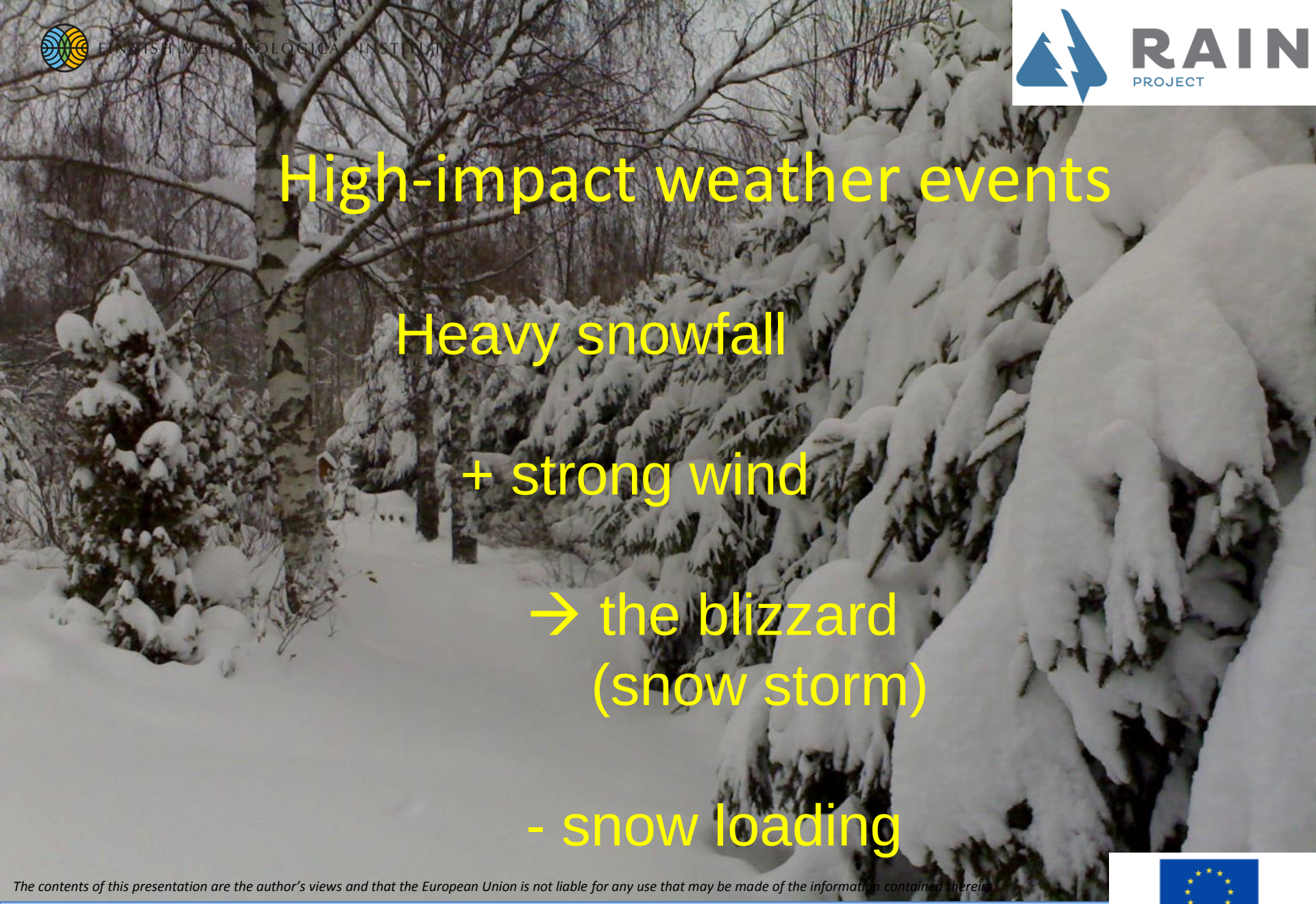

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High-impact weather events

Thunderstorms:

- wind gusts (+tornadoes)

- lightning

- heavy rain & hail

Windstorms (low pressure systems)

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Making weather forecasts and warnings is a multiphase process

1. Analysis of prevailing weather conditions (based on observations)

2. Comparison between the analysis and numerical weather forecasts (initial state or short-range forecast)

3. Comparison between different numerical weather forecasts (and different scenarios)

4. Utilization of professional skill and experience, decision of the “forecast line”

5. Making the forecasts and warnings

6. Active monitoring of the weather situation, updating the forecasts and warnings if needed

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Forecasters' challenges related to high impact weather events

- Large amount of information and limited time

- Increased task load and hectic (group) working

- Compression of the forecast information, structuring into products
  - Highlighting important details as well as uncertainty
  - Describing the temporal and spatial variation

- Decisions have to be made, although the forecasts and warnings will probably include uncertainty

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Uncertainty and forecast errors

- Forecasts (and observations) include uncertainty in timing, spatial coverage and intensity of the weather events (under-/ overestimation) ⇔ Verification difficulties
    - Typically uncertainty grows with forecast length
- Sources of uncertainty and errors:
    - Lack of, or non-homogenous observations
    - Inaccuracy in the initial analysis of the numerical weather prediction (NWP) model
    - The NWP model resolution is too low to predict the event (e.g. thunderstorm cells) properly
    - The duty meteorologists can choose a wrong “forecast line” in the case of diverse predictions by different NWP models

→ deterministic or probabilistic forecasts?

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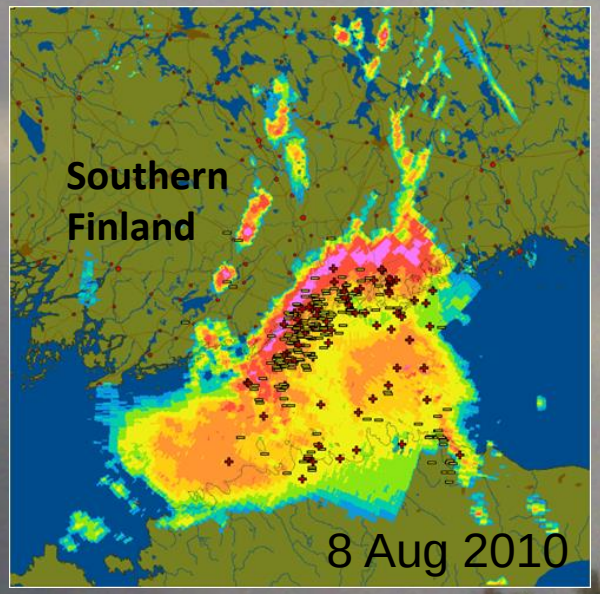
Observation tools

- Surface weather observations
- Atmospheric (vertical) soundings
- Satellite observations
- Weather radar data
- Lightning location network
- Climate statistics
- Novel data sources, e.g. crowd-sourced data; mobile vehicles
- Real-time data of Rescue Service operations
- Media reports
- Forecast verification system output



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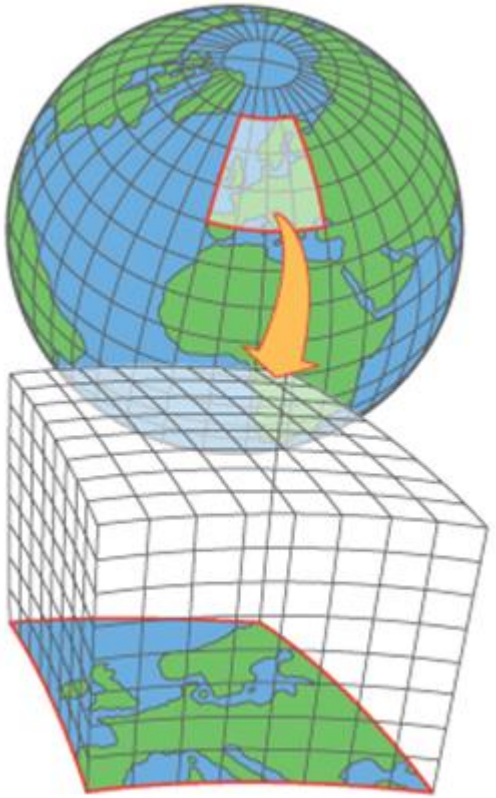
Numerical Weather Prediction (NWP) models

- Making useful weather forecasts several days ahead requires:
  - The most advanced and complicated NWP models, based on physical laws
  - Complete database of weather observations
  - Powerful supercomputers

-There are either global or limited area models (having high resolution)

-The models cover a forecasting period from a couple of days to seasonal, even decadal (climate models)

- The model output can be deterministic or probabilistic (based on ensemble runs)



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Numerical Weather Prediction (NWP) models

-The **ECMWF** (European Centre for Medium-range Weather Forecasts) has developed and run operationally its global models from early 1980's. The present system includes:

- A high resolution deterministic model (two runs daily up to 10 days), horizontal resolution 16 km, in the vertical direction 91 levels from the surface to a height of 80 km
- An Ensemble Prediction System (EPS). In consists of a set of 50 forecasts, each started from a slightly perturbed version of the operational analysis. The horizontal resolution 32 km (up to 10 days) and 65 km (10-15 (32) days)

- Examples of EPS products: Probability "plumes" and Extreme Forecast Index (EFI). These products are good forecasting tools for early warnings
- Monthly forecasts are run twice a week, seasonal forecasts once a month

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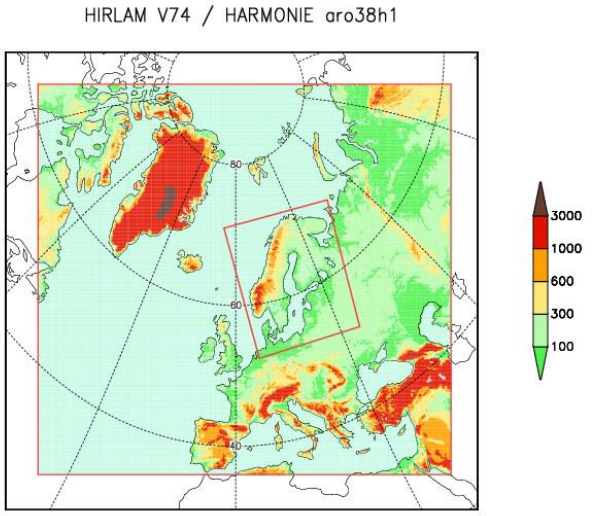
Numerical Weather Prediction (NWP) models

- **FMI** operates two high resolution limited area models:

  - **HARMONIE**: horizontal resolution 2.5 km, in the vertical direction 65 levels, eight runs per day ("Rapid Update Cycle")

  - **HIRLAM** ("Reference model version of the international HIRLAM consortium"): horizontal resolution 7.5 km, in the vertical direction 65 levels; four runs per day

- NWP models are operated also by e.g. UK Met Office, Deutscher Wetterdiest (DWD), Meteo France and NOAA/NCEP (in the USA)



Forecasting areas for HIRLAM (larger area) and HARMONIE (smaller area). Forecast data at boundaries come from the ECMWF model

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Weather warnings

- Weather warnings form an important component in the "toolbox" of the meteorologist:
    - The significant information about high-impact weather phenomena can be disseminated to general public and different authorities, to allow mitigating action to be taken

-Warnings typically cover a 24h time scale and are based either on national thresholds or international agreements (e.g. storm at sea: 10 minute mean wind speed ≥25 m/s)

- Early warnings are issued a few days ahead of potential weather hazards, giving additional time to raise readiness for the event

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The FMI ”warning palette”

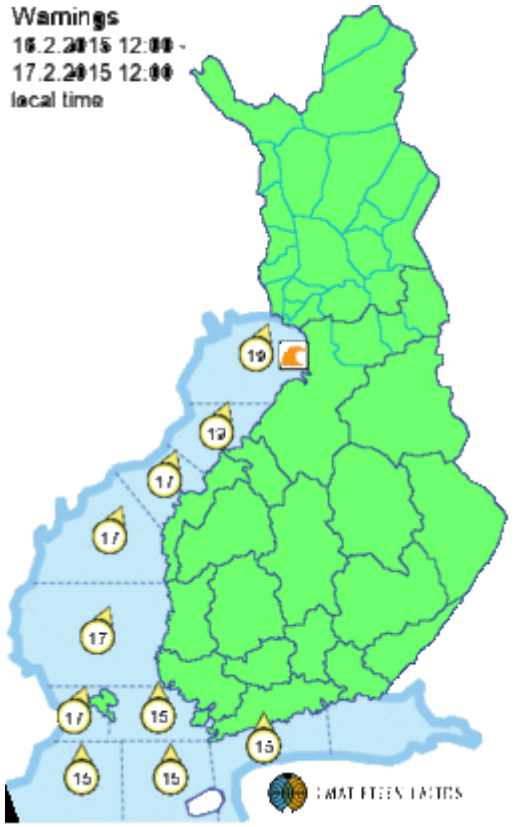
www.fmi.fi

Warnings are valid for the next 24 hours and are updated at least 7 times per day:
5:00, 7:00, 9:30, 12:15, 15:00, 18:30 and 21:15 LT

Transmitted to general public and authorities via radio, TV and internet

Early warnings are issued 2-5 days prior to the event, depending on the weather parameter. They are updated at least twice a day, at 4:00 and 15:00 LT

Storm warning	21 / 25 m/s
Warning for near gale-force/gale-force wind	14 / 17 m/s
Strong wind advisory	11 m/s (May-Oct)
Extremely rough waves	7 m
Very rough waves	4 m
Rough waves	2.5 m
Sea level high / low	
UV radiation is strong	
Strong wind advisory for inland lakes	
Wind warning for land areas	
Severe thunderstorm warning	15 / 25 / 30 m/s (WG)
Heavy rain warning	20 / 30 / 45 mm/h 50 / 70 / 120 mm/24h
Forest fire warning	
Grass fire warning	
Bad road conditions	
Very bad road conditions	
Heat warning	
Cold warning	



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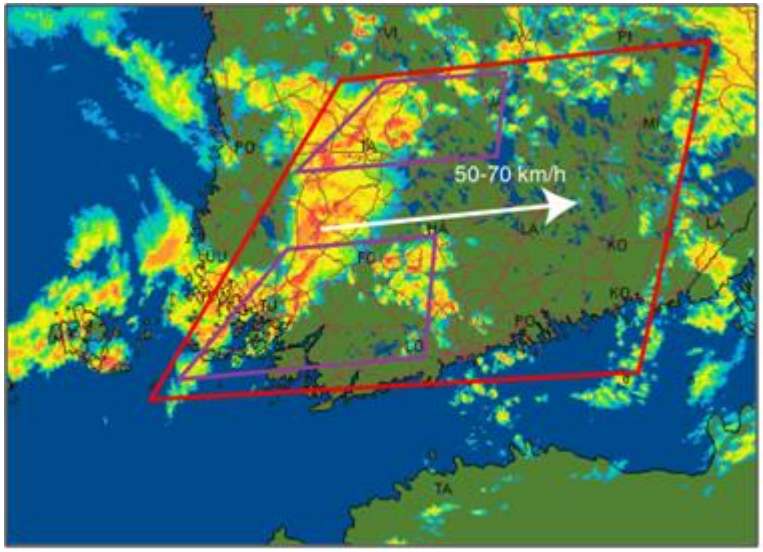
The FMI special warning for weather hazards – The ”Luova Outlook”

-A short ”alert e-mail” is sent via a mailing list. The alert includes a summary of the expected event and a link to the Outlook webpage. The complete outlook includes:

- Reason for the outlook
- The probable hazard area
- Severity and timing of the weather event
- The evolution of the weather situation
- Uncertainty of the forecast
- When updating, changes compared to earlier outlooks
- Attachments (warning map, radar image..)

- First outlooks up to 3 days prior the event
- Hundreds of subscribers in the e-mail list



An example: Thunderstorm wind gust risk area during the next 3 hours (the larger area marked off with the red line) and two areas having highest probability for wind damage during the next hour (marked by violet line)

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Weather warnings on European level: EUMETNET – MeteoAlarm

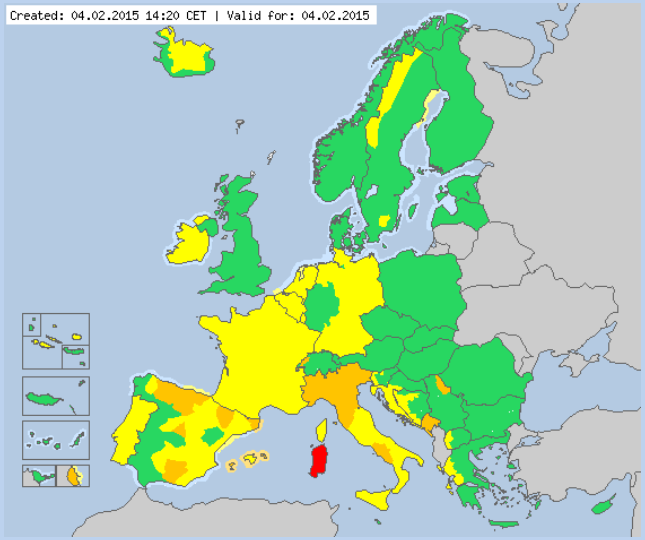
www.meteoalarm.eu

- A co-operative initiative by more than 30 European countries' national weather services

- Colour-coded maps of Europe show where the weather is threatening to become dangerous

- All the countries have agreed on similar colour coding, based on likely damage and danger

- For each weather parameter, meteorological "impact thresholds" define which colour should be assigned. These thresholds are set by the NMS in charge for the region and naturally they differ from country to country



Green: Nothing to worry about
Yellow: Potential danger
Orange: Dangerous situation
Red: Great danger from extremely severe weather

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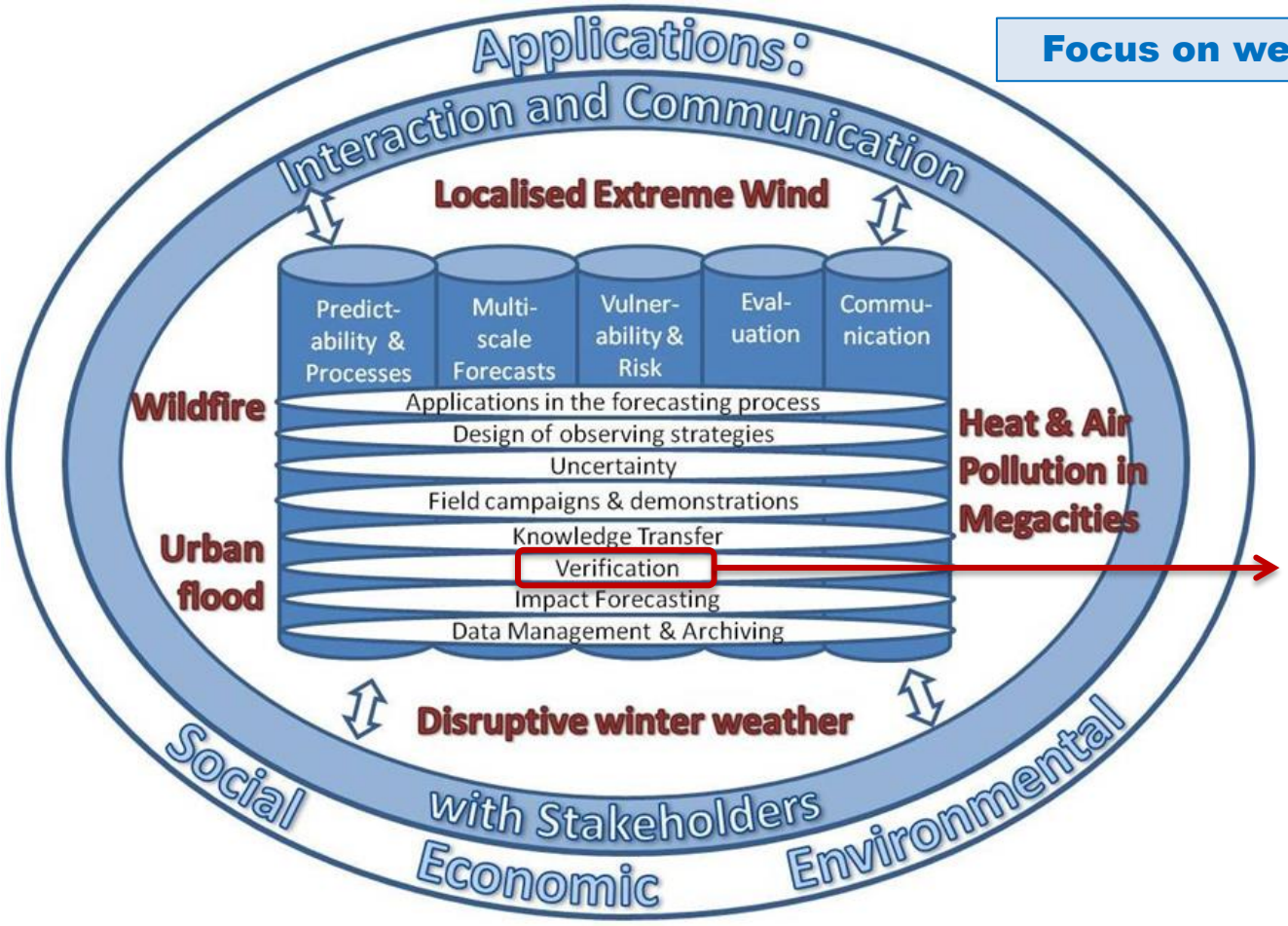
High Impact Weather (HIW) Project within WMO World Weather Research Program (WWRP)



Focus on weather hazards & impacts

1. Hazard Impact Verification

- ✓ Floods
- ✓ Transport delays
- ✓ Accidents, incidents
- ✓ Damage to property
- ✓ Mass events
- ✓ Etc.

2. New Verification methods

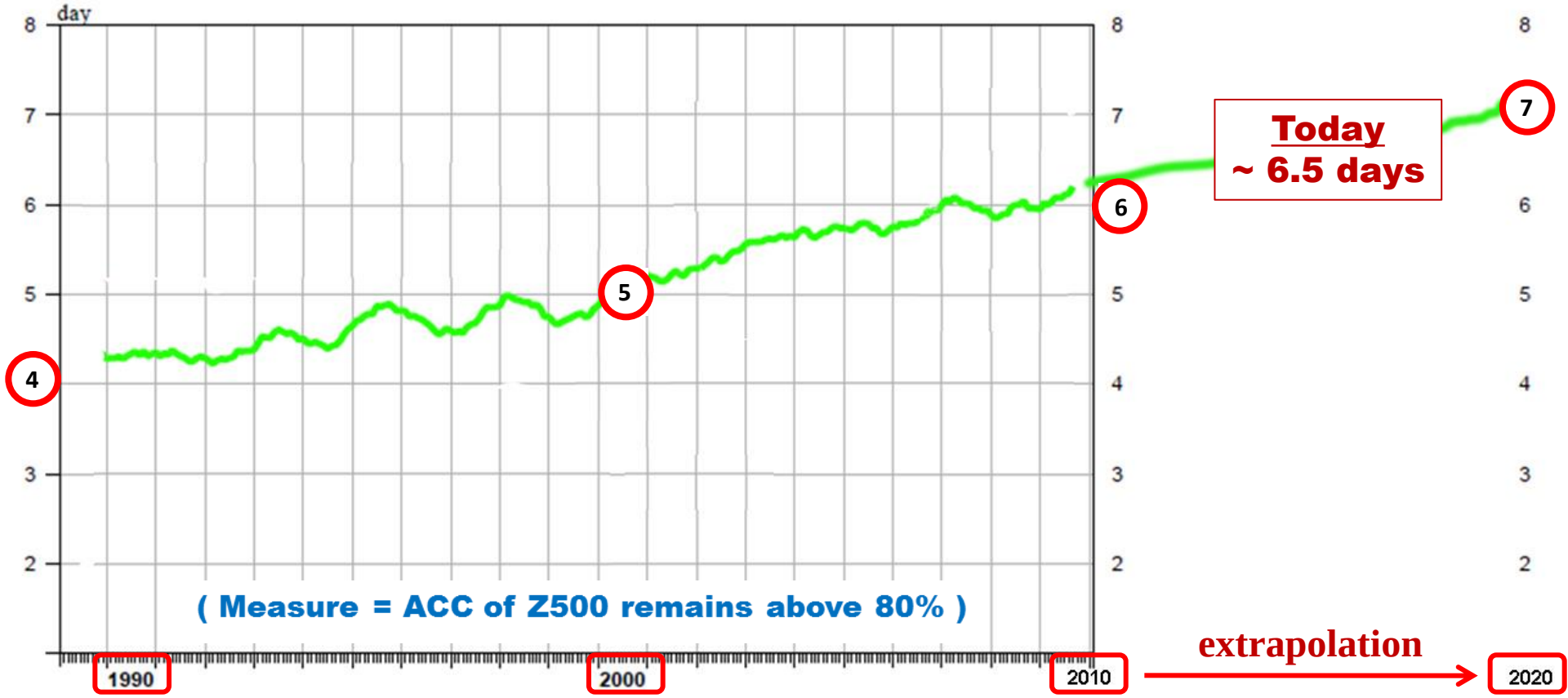
3. New observation types in Verification

- ✓ Crowd-sourced data
- ✓ 3rd party, social media
- ✓ New sensor networks
- ✓ Mobile vehicles
- ✓ Etc.

Assessment of Weather Forecast Quality ⇔ Forecast Verification

Predictability of the free atmosphere circulation

- ✓ 1990 ⇔ 4 days - ECMWF forecast system
- ✓ 2000 ⇔ 5 days
- ✓ 2010 ⇔ 6 days ⇔ **Expected increase ⇔ 1 day / decade**



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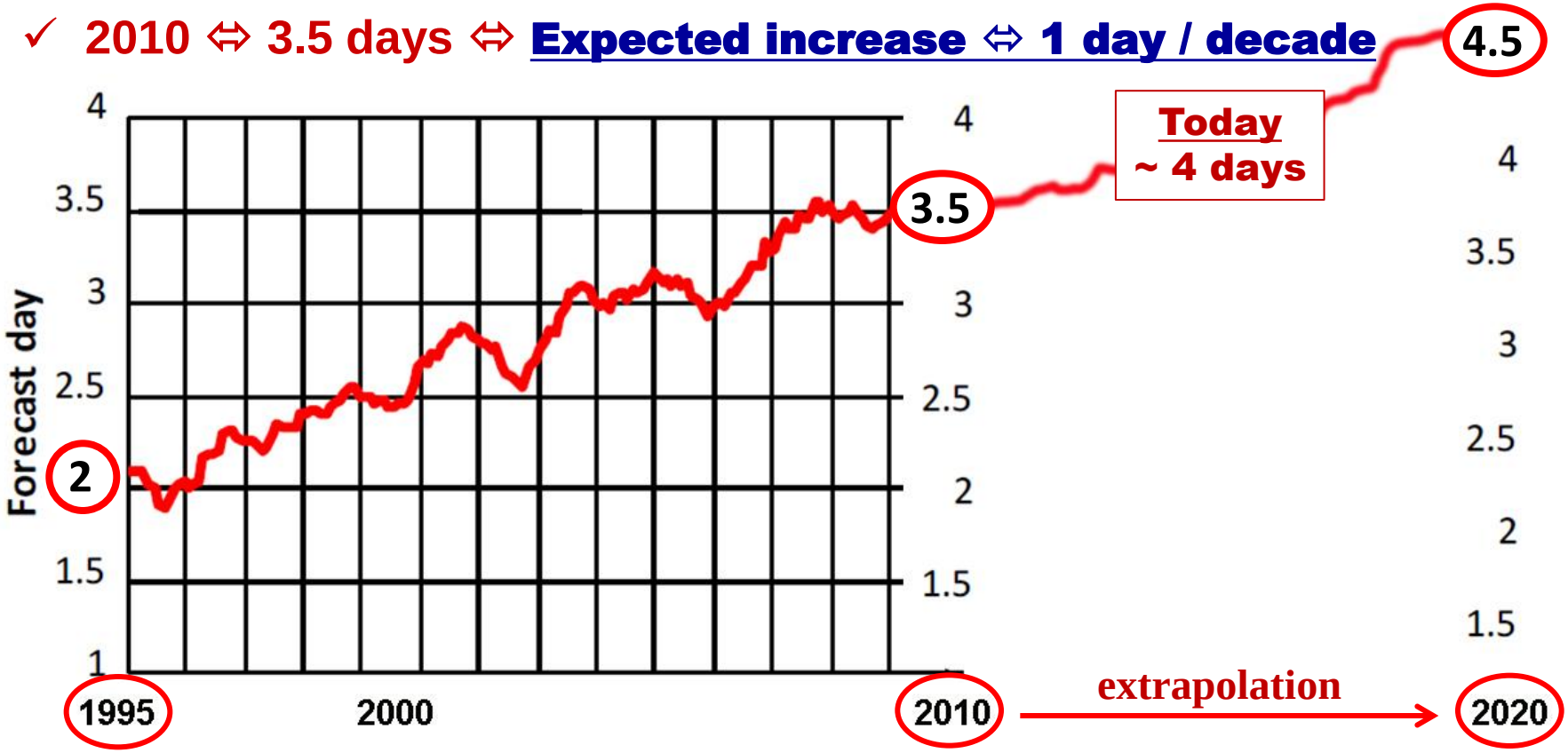
Predictability of surface weather (precipitation)

- ECMWF forecast system

- ✓ 1995 ⇔ 2 days
- ✓ 2010 ⇔ 3.5 days ⇔ **Expected increase ⇔ 1 day / decade**



(Measure = "1-SEEPS" of 24hr QPF remains above 45%)

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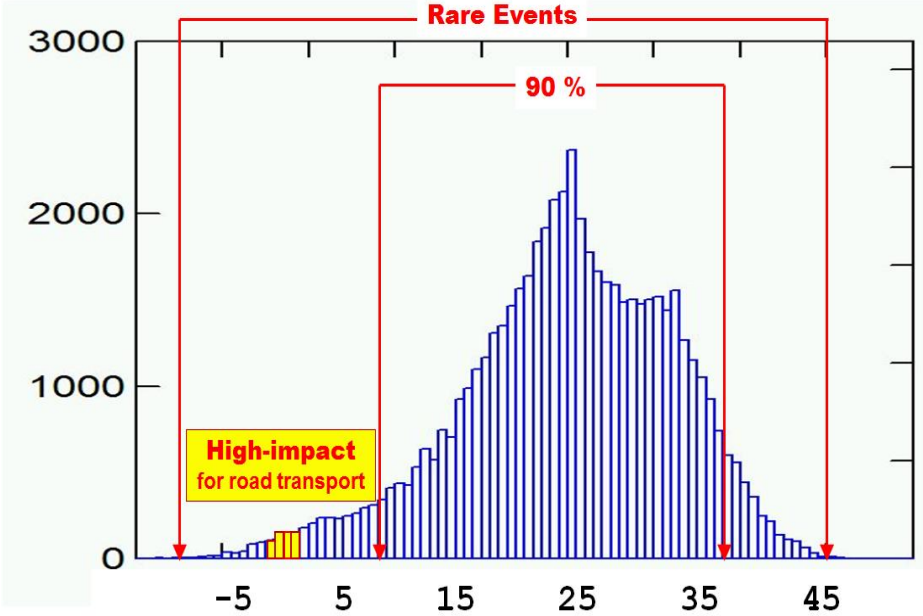
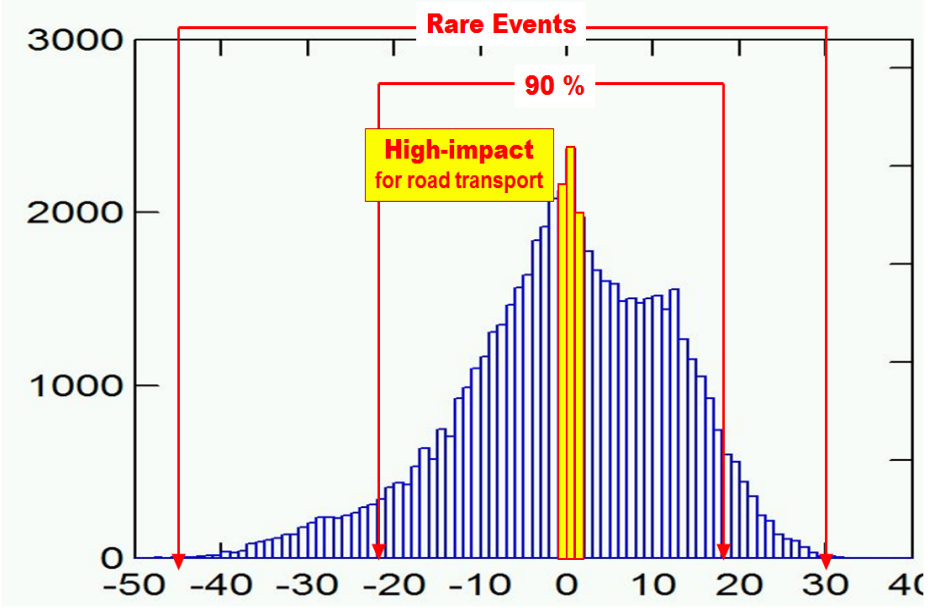
What is RARE for some (left) is VERY COMMON for others (right), but HIGH-IMPACT for all

Temperature distribution at a station somewhere in S. Europe



Temperature distribution at a cold station in Finland (50 years, c. 55000 observations)



… and this addresses a forecast quality assessment issue !

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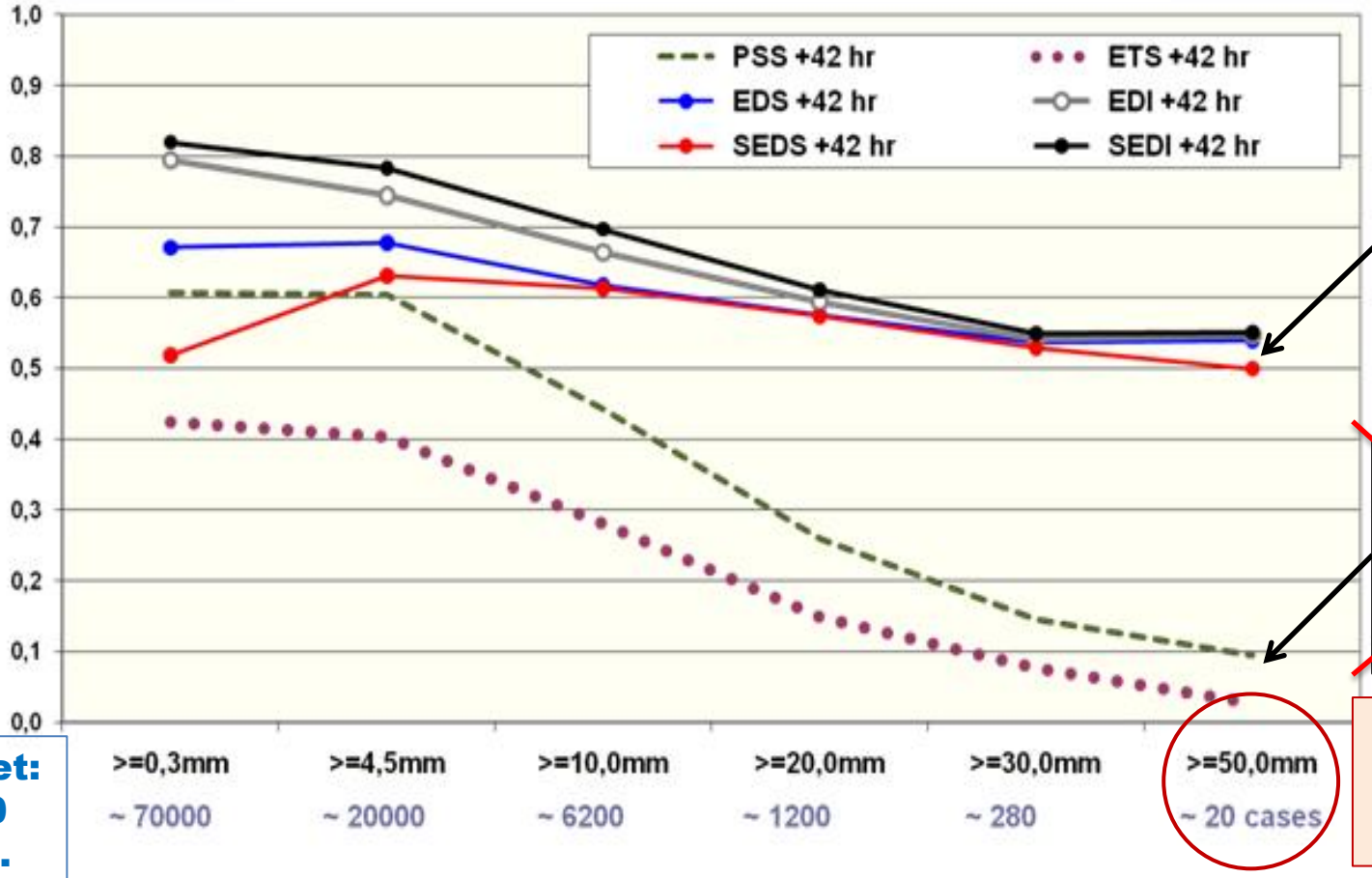
What is RARE for some …



Novelty fc verification measures provide useful information

~~Traditional fc verification measures tend to zero by definition~~

RARE precip. events

Dataset: 97 700 precip. cases

… addresses a forecast quality assessment issue !

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Cross-country skiing

sochi.ru 2014 XXII Olympic Winter Games

WWRP FROST-2014 Project: Weather variables - Thresholds

Temperature (°C)	T < -20	-20 ≤ T < -5	-5 ≤ T < -2	-2 ≤ T < 0	0 ≤ T < 2	2 ≤ T < 5	T ≥ 5
Wind speed (m/s)	WS ≥ 3	WS ≥ 4	WS ≥ 5	WS ≥ 7	WS ≥ 11	WS ≥ 15	WS ≥ 19
Horizontal visibility (m)	V < 100	V < 300	V < 1000	V < 10 000			
Precipitation amount 1-hr and 24-hr (mm)	RR < 0.3	RR ≥ 0.3	RR ≥ 1.0	RR ≥ 5.0	RR ≥ 10.0	RR ≥ 15.0	

What is hi-impact ? ⇔ Warning Thresholds

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Assessment of the predictability of severe weather with current state-of-the art forecasting systems (Task 2.2 / FMI, 6 PM)

- ✓ Examine the Skill of NWP models to forecast heavy snowfall, blizzards and wildfire risk – *also other variables ?*

⇔ Predictability of Hazards !

Advertisement : www.ems2015.eu

Intro Slides for the Panel Discussion (27.2.2015)

(by Pertti Nurmi)

? Definition of Meteorological Extreme Events ?

(terminology)

SEVERE

EXTREME

HIGH-IMPACT

RARE

ADVERSE

⇔

Multi-dimensionality !

Multi-disciplinarity !

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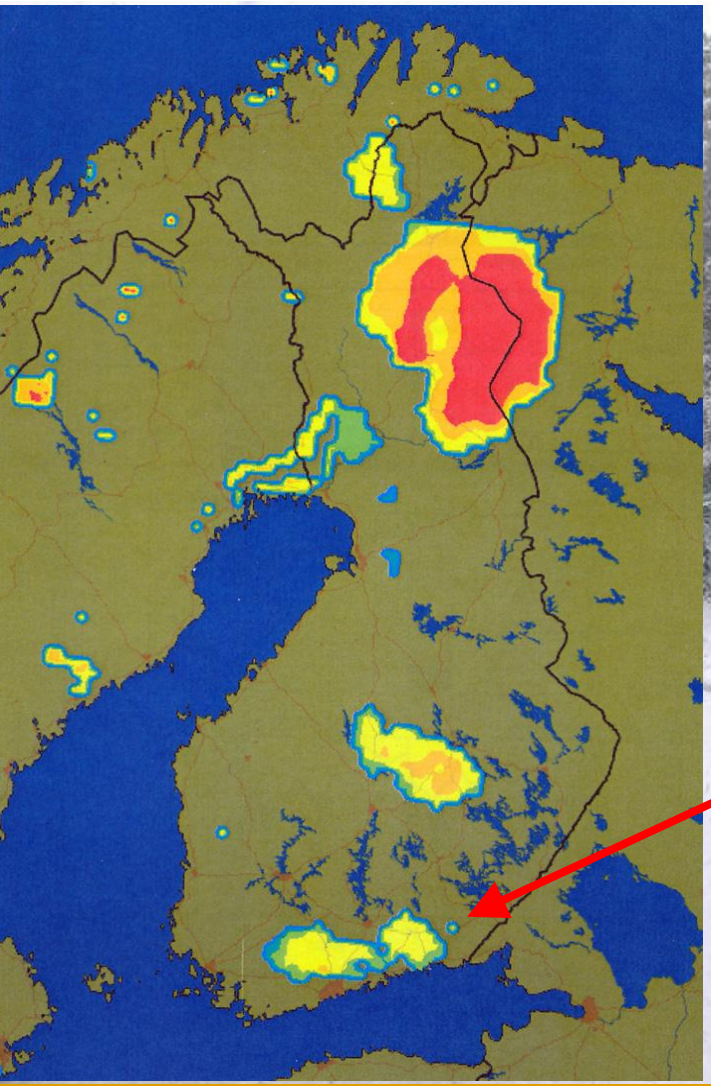
SEVERE ! HIGH-IMPACT ! ADVERSE !



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SEVERE ! EXTREME ! HIGH-IMPACT ! RARE ! ADVERSE !

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