FINNISH METEOROLOGICAL INSTITUTE

FINNISH LOCAL VIEW ON THE FACTORS ACCOUNTING FOR THE COSTS OF WEATHER-RELATED DISASTERS (SPECIFICALLY, FLOODS AND STORMS) IN RECENT DECADES AND IMPLICATIONS OF UNDERSTANDING THESE FOR BOTH RESEARCH AND POLICY

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1. Introduction

As the factors accounting for the costs of weather-related disasters (specifically, floods and storms) in recent decades and the implications of understanding these for both research and policy are considered in the Finnish context. The climatology of the pertinent weather phenomena are discussed also with some outlook to the scenarios. Here some possible future shifts in both flood and storm types causing damages and losses are pointed out. In addition some policy issues are discussed as this seems to be another pertinent point.

2. Factors in weather-related disasters

2.1 Floods

Since 1960 (Puupponen, 2006) in terms of house damage costs the three most severe flood episodes in Finland have occurred as follows.

Spring 1966 – Southern Finland: This spring flood has been since 1969 the highest flood in the rivers of Southern Finland. The water equivalent of the snow at the beginning of April was still widely 200 – 250 mm which was roughly double compared with the normal value and in fact a record value. The melting of the snow was postponed to a late time point around 1 May. Consequently the recurrence value of the observed flood flows exceeded in several drainage basins 100 years in terms of a Gumbel distribution estimate. No exact damage data are available, but in relation to later damage inventories the probable cost level has been of the order of 10 million euros.

Summer 2004 – Southern and Central Finland: The heavy rains end of July 2004 around the line Helsinki – Jyvaskyla – Kajaani were exceptional both in their extent and heaviness. The five-day precipitation at the end of July exceeded 100 mm over a very wide area. As the July precipitation in these areas was of the order of 200 mm, the soil was saturated already prior to the heavy rain episode. Consequently flood damages on houses took place especially in Riihimaki, some 60 km north of Helsinki, and in Voyri and Oravainen close to the central west coast. The damage costs were some 8 million euros excluded any harvest losses or damages to enterprises and public communities.

Spring 2005 – Lapland: At the beginning of May there was a lot of snow in Lapland and its water equivalent increased still slightly during early May. The water equivalent exceeded at places 180 mm in Northwestern Lapland and the head areas of the Kemijoki river and the Ivalonjoki river drainage basins around 10th May. This value was approximately double compared with the normal value. The snow melted very fast after the middle of May, at its fastest by some 20 mm per day. This caused a record flood in the Ounasjoki river and the Ivalonjoki river with highest water levels in 50 years and with an approximate recurrence time of 50 years. The extreme flood caused mainly house damages maily in Ivalo and Kittila (cf. Fig. 1). The damage costs were some 5 million euros excluding any harvest losses or damages to enterprises and public communities.

Extreme spring floods occur when large snow amounts melt under rainy conditions which prevent the more typical conditions of fair weather and consequent large evaporation of snow. In this sense an extreme spring flood can be seen as a combined, accumulative phenomenon which can be foreseen by appropriate early warning systems. Also in case of extreme summer floods their formation is to some extent accumulative in terms of prior saturated soil wetness. Although also extreme summer floods can cover wide areas, in Finland these episodes have been mostly fairly restricted and caused mainly by local heavy showers.

Regarding the potential of extreme spring floods it should be pointed out that the snow water equivalent studies of Hyvarinen (2003) revealed that in the Kemijoki river drainage basin the snow water equivalent on 1 April 1947 – 2001 had an increasing trend (cf. fig. 2). As Hyvarinen (2003) points out the short time series might have exaggerated the slope of this increasing trend. In addition the melting of the snow takes often place under clear sunny weather and a consequent relatively large evaporation. Hence even an increasing snow water equivalent in Lapland does not necessarily imply risk for increasing spring floods there. In more southern parts of Finland the results of Hyvarinen (2003) indicated no or a decreasing trend in snow water equivalent.

Even if two of the floods of large costs in terms of damages have occurred quite recently it should be emphasized that the type of these floods was quite different and that these do not necessarily reflect any climate changes in Finland in terms of an increasing number of extreme floods. Rather they are outcomes of the large natural variability of the Finnish climate and quite possible extreme values even under the latest WMO standard normal period 1961-1990. All in all it should be remembered that even in the future both some spring and some summer floods can be extreme and cause losses in Finland.

Figure 1: Spring 2005 extreme flood in Kittila, Lapland

Beside the floods in inland drainage basins it is possible to have floods due to high water levels on the coasts of the Baltic Sea basin. On the Finnish coast the most severe situation of this type was experienced in the context of storm Gudrun 8-9 Jan, 2005 (cf. fig. 3), when the sea level in the central and eastern parts of the Gulf of Finland reached new record values. In Helsinki the situation was quite critical as the pumping stations could barely survive from the extra load. Fig. 4 shows estimated recurrence values of high sea level at Loviisa (some 100 km east of Helsinki) adjusted by parameterization for the expected climate in 2030 (Johansson et al., 2004).

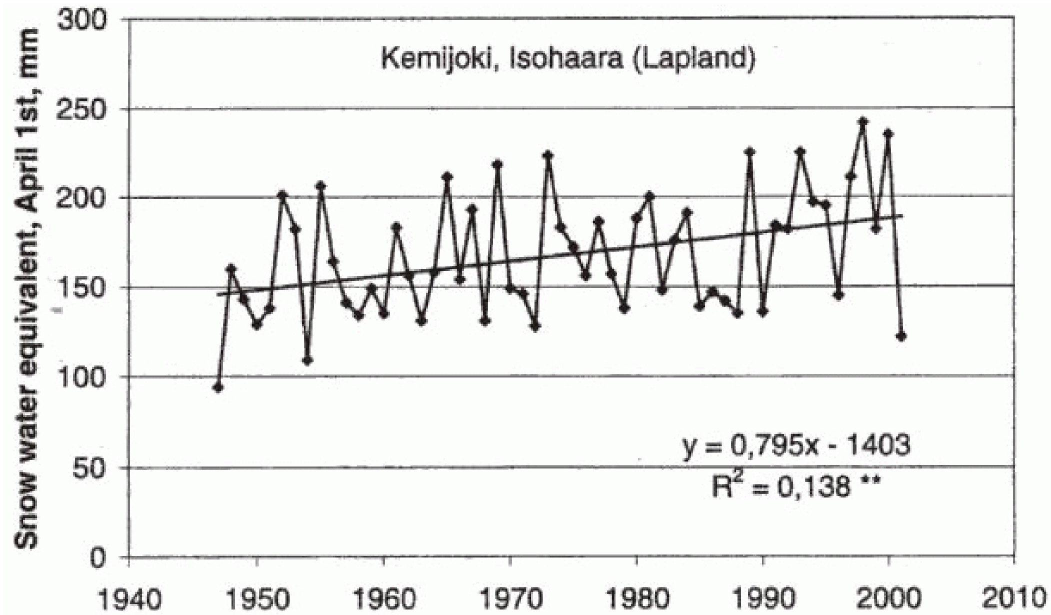

Figure 2: Water equivalent of snow in Kemijoki river drainage basin in Lapland on 1 April 1947 – 2001 (Hyvarinen, 2003)

The exceptionally high sea level can be understood as a coincident combination of several factors. First, we have the natural oscillation or seiche of the water mass in the Baltic Sea basin. Just at the occurrence of the storm Gudrun the phase of the seiche was such that the sea level in the area of the Gulf of Finland was high. Second, the prevailing surface wind direction during Gudrun was such that the strong wind piled water to the Gulf of Finland and kept it there causing record high sea level values in the whole area with the highest values in the easternmost parts of the gulf. This kind of a combination is rare but possible as observed during the passage of the storm Gudrun. The consequent high sea level rise can be foreseen with an appropriate early warning model.

In Helsinki the peak value of the sea level was 1.51 m above the normal sea level and the situation was quite critical with the pumping stations managing just barely the incident.

2.2 Storms

Regarding storms there is a semantic difference between the English word storm and its equivalent in Finnish as the Finnish equivalent is restricted exclusively to wind storms. In addition already the strong gale with a wind speed of at least 21 m/s is classified as wind storm in the Finnish coastal areas. In inland locations the wind is considered dangerously strong as the wind speed is 14 m/s or higher. Both of the adapted definitions are supported by both acceptable climatological risk levels and observed damages and losses in practice.

In addition to the wind storms and severe storms some other phenomena, like freezing rain/slipperiness and heavy snow loads/clinging snow are considered from the point of view of damages.

The annual number of wind storm days for the Finnish maritime areas is given in fig. 5. The corresponding numbers of dangerously strong wind days for the Finnish inland areas are presented in fig. 6. Both of these figures show that there is at least no indication of an increasing trend after 1990.

Gudrun 8 – 9 January 2005

Figure 3: The track and affected regions of the storm Gudrun 8 – 9 January 2005

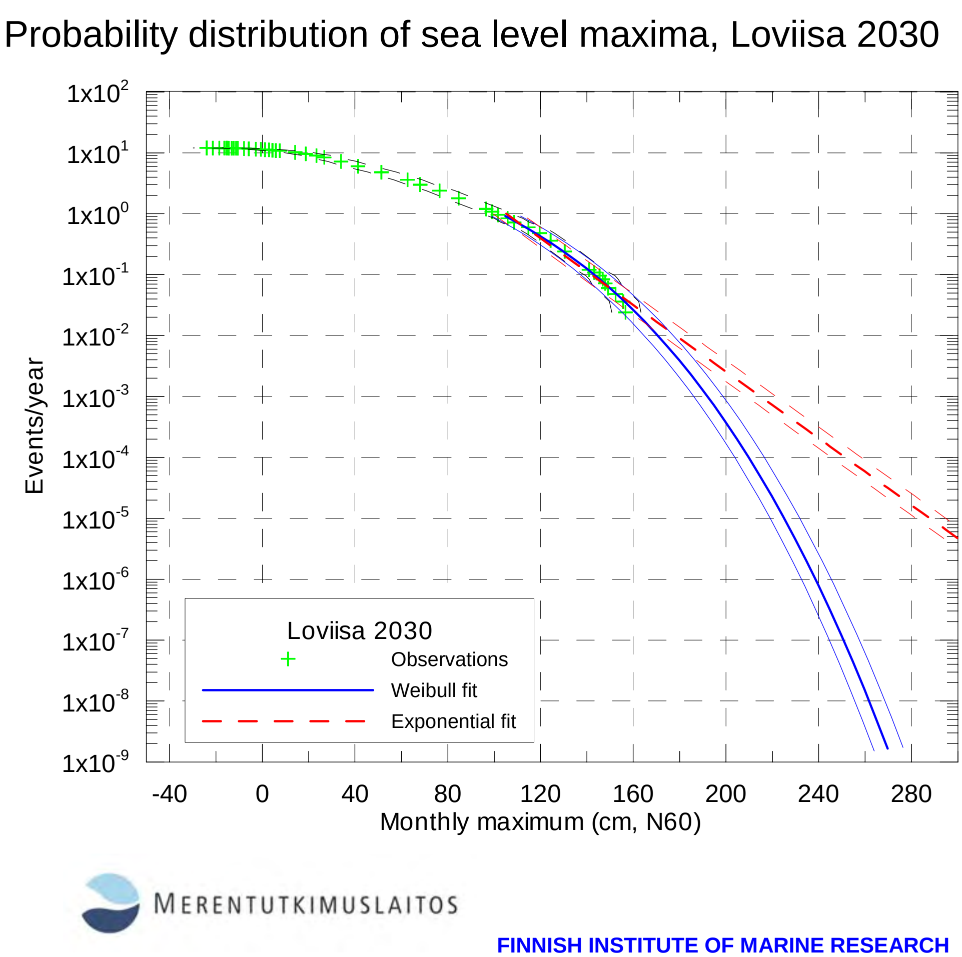

Figure 4: Extreme value distribution fits to observed maximum sea level values at Loviisa with adjustments to the expected climate in 2030 (Johansson et al., 2004). (The figure by courtesy of the Finnish Institute of Marine Research)

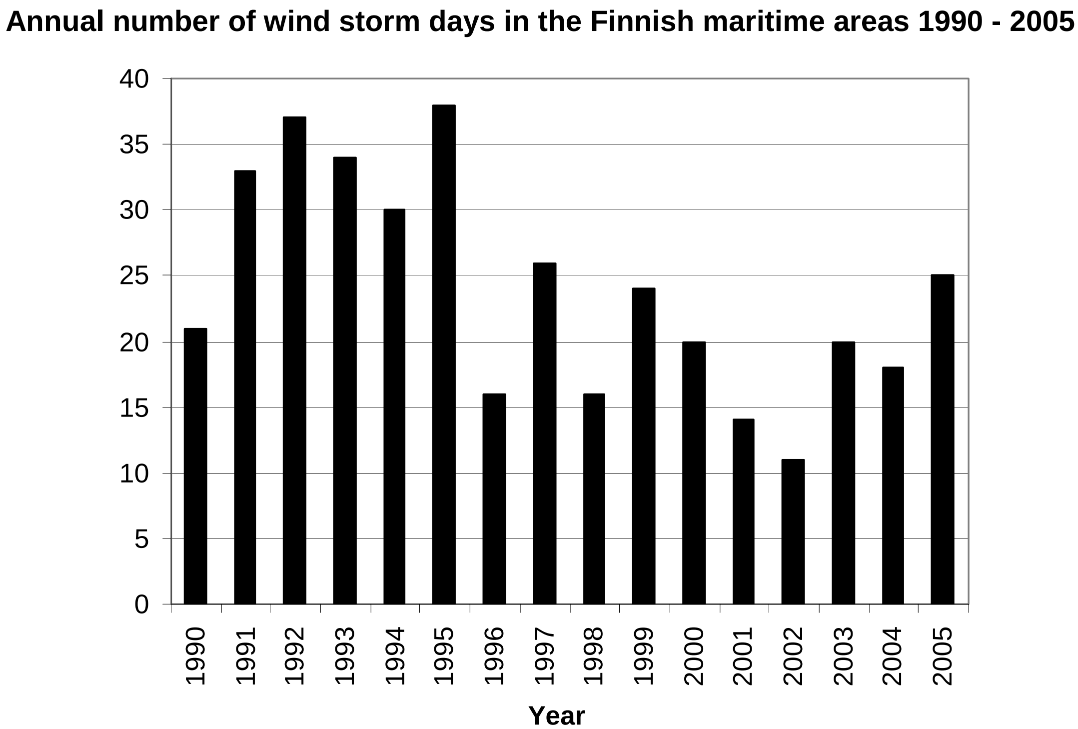

Figure 5: The annual number of wind storm days in the Finnish maritime areas 1990 – 2005

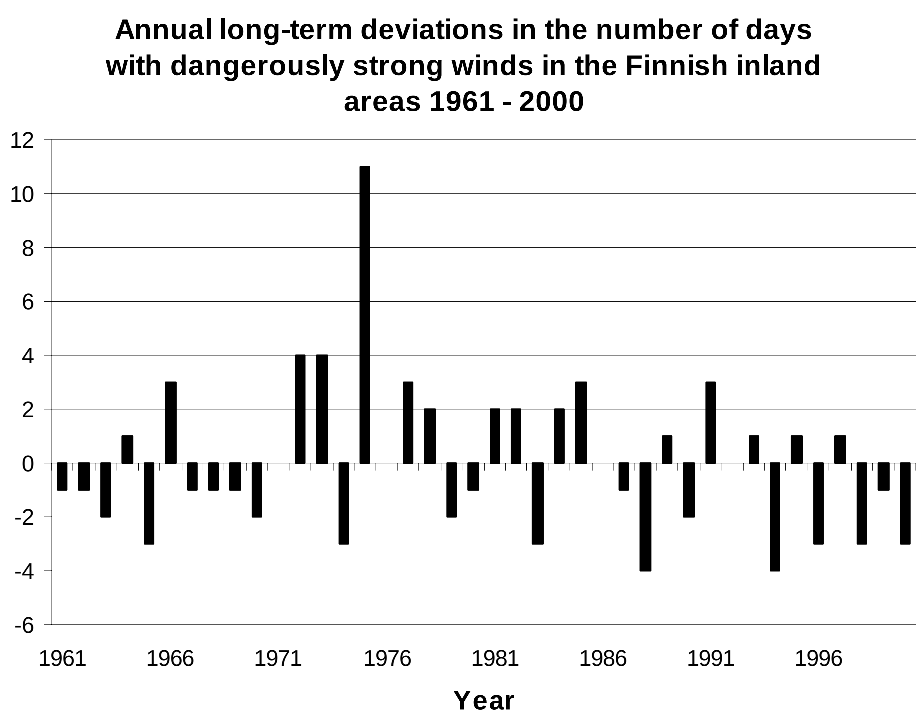

Figure 6: The annual deviations from 1961 – 1990 normal values of the number of days with dangerously strong winds in the Finnish inland areas in 1961 – 2000.

Another study (Myllys, 2006) indicates that the number of deep low pressure systems crossing Finland has remained relatively constant, whereas the number of disturbances moving from southwest to Finland in the context and along the eastern rim of a so-called central low located typically west of Scandinavia is increasing. All this is in line with figs. 5 and 6 as the Finnish wind storms and dangerously strong wind situations are associated with the deep lows which have a different and more northerly path than those causing the largest damages in Southern Sweden and the Baltic countries. Although the storm Gudrun was a close call for some coastal areas of Southern Finland, all the major damages caused by it took place south of Finland.

The annual deviations from 1961 – 1990 normal values of the number of days with dangerously strong winds in the Finnish inland areas in 1961 – 2000.

With the recently installed modern Doppler weather radar network in Finland and encouraged reporting by public on local storms, like trombs and downbursts, the former synoptic manual observations are not comparable in their sparse regional resolution. Despite of the increased public awareness and publicity of these phenomena it is too early to give any estimates of the recent trends in the occurrence of severe local storms in various parts of Finland. With the increasing number of free-time houses in many parts of the country it is possible that there is the statistical chance of getting increases in damages of this kind (cf. fig. 7) (Teittinen, 2006). However, one should be cautious to conclude that this would mean an increase in the number of severe storm events in Finland.

One recently well documented severe storm (storm Unto) event took place in Finland on 5 July 2002 (cf. fig. 8) (Teittinen, 2006). The wind damage area of this storm was 450 km in its length and some 100 km in its breath. In the damage areas the gust speeds exceeded at many places 33 m/s. In some areas of Eastern Finland the gust speeds exceeded 50 m/s so that storm Unto reached at some sites the F2 class. Widely extended thunderstorm related wind damages alike have been documented formerly mainly in North America and only once in Europe. It should be emphasized, however, that there is no reason to believe that severe storms like storm Unto would not have occurred

Figure 7: Damage caused by the F2 class (wind speed 50 – 69 m/s) tromb in Kontiolahti (north of Joensuu), Eastern Finland on 20 August 2004.

earlier in Finland. In fact there is one description in Finnish of an intense tromb family, which swept through Southern and Central Finland on 4 August 1932 and reached at some sites the F4 class (Angervo and Leiviska, 1944).

General probabilistic forecasts of the occurrence of thunderstorms are given 24 hours in advance, but more detailed warnings pose a challenge to the nowcasting and at most some hours ahead.

Freezing rain events, per se, are known to cause problems on power lines and in power supply although such events are rather rare in Finland. The trend in the number of freezing rain events is slightly or modestly increasing both in Helsinki (0.7 events/decade) and Rovaniemi (at the polar circle; 2.4 events/decade). It must be remembered though that Rovaniemi observation station upon a nearby hill is known to encounter freezing rain events more than its surroundings. On the other hand the slight increase in the freezing rain events is in concert with the warming winters and reflects well in general the effect of the mild winters since the 1990's in Finland.

The formation of slipperiness on roads and pavements is a phenomenon connected not only with freezing rain but in fact in many cases with sublimation taking place right at the road or pavement surface. Therefore the prevention of the road and pavement slipperiness is still a challenge both for the weather service and the service providers, as the slipperiness causes annually severe problems both for traffic and pedestrians. Measured in the number of slipperiness prevention tasks per winter season the largest values are encountered in Southwestern Finland with large values in

Storm Unto 5 July 2002

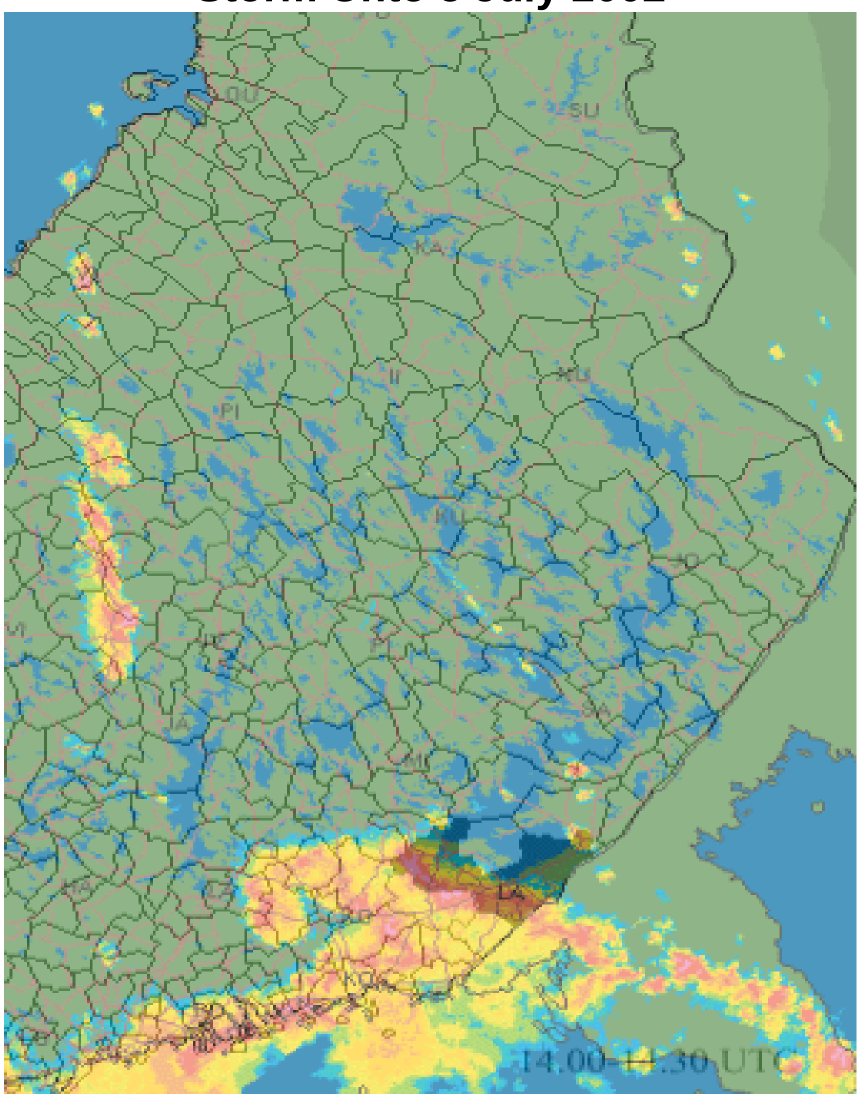

Figure 8: Composited radar observation of storm Unto on 5 July 2002 14:00 – 14:30 UTC

southern, central and western parts of the country. With the relatively short records on traffic accidents and injuries of pedestrians it is still a challenge to relate the slipperiness to its consequences in terms of costs.

According to fig. 2 the snow water equivalent had an increasing trend in Lapland. Even if it per se does not necessarily mean increasing risks for extreme spring floods another risk is more obvious and that is the increasing snow load on the roofs of buildings. Lately incidents of broken roofs have been experienced even in more southern parts of Finland under circumstances where the design loads based on climatological snow water equivalent recurrence values have not been exceeded. Hence the climatic change is not to be blamed on all these damages. In addition the Finnish Environment Institute gives timely regional warnings and recommendations to shovel the snow down from the roofs. This can be considered as an appropriate early warning service.

Clinging snow is another mechanism by which snow can cause excessive loads. In practice this needs specific rain, thawing and snowfall conditions around zero degrees centigrade. As a consequence of such incident trees can get heavy snow load on them which forces them to bend. This can cause local power lines to be broken especially, if a wind storm gets the chance to blow on the preloaded trees. Fig. 9 gives recent 10-year mean numbers on heavy snow load (in excess of 20 kg/m^2) events in various parts of Finland. The map indicates the regional distribution of this risk. Recently two rather consecutive wind storms (storm Pyry, 1 Nov 2001 and storm Janika 15-16 Nov 2001) after a heavy clinging snow incident on 31 Oct 2001 caused large losses of cut trees and broken power lines in Southern and Central Finland.

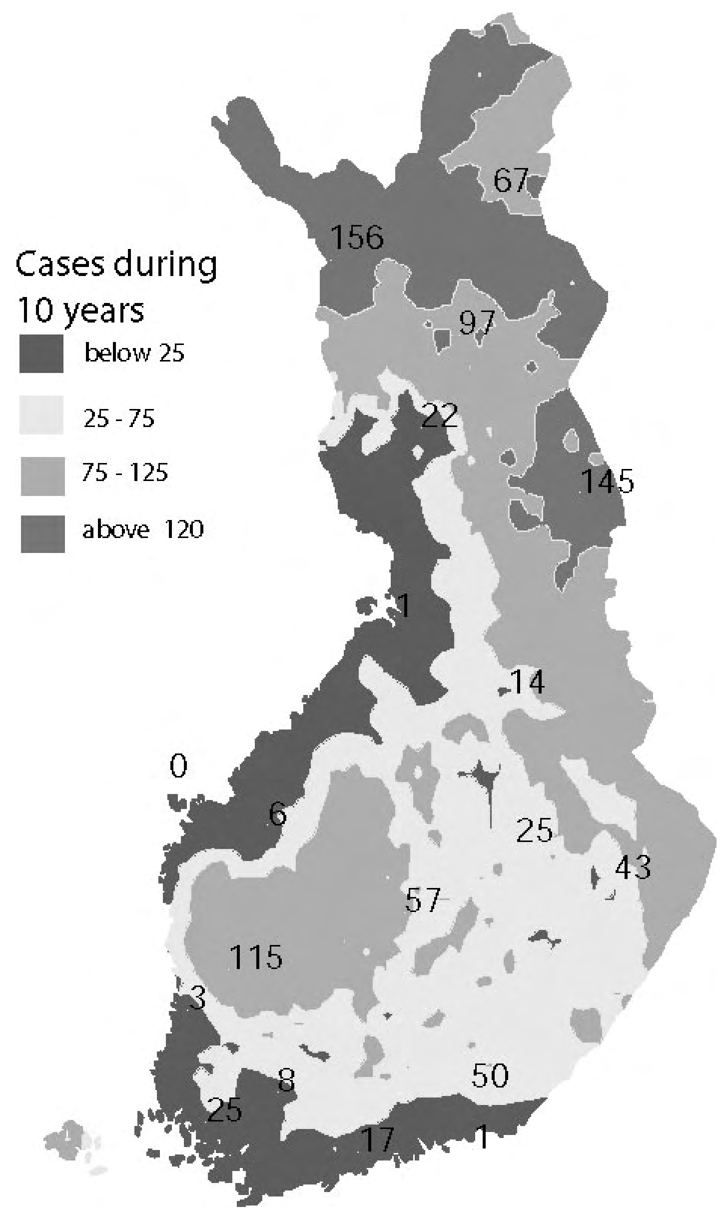

Figure 9: Number of cases in which the snow load on the average during ten years exceeds 20 kg/m2

2.3 Climate scenarios

Climate scenarios for the 21st century in Finland have been published elsewhere by Jylha et al. (2004) in the context of the FINADAPT project and will not be discussed here.

Regarding the floods the shortening snow season is anticipated to decrease the peak values of spring flood flows by 2021 – 2050 (Tammelin et al., 2002).

3. Implications

3.1 Floods

As pointed out by Hyvarinen (2003) the improvement of drainage basin flood forecasts depends primarily on improvements in estimating areal precipitation. This in turn poses challenges to the development of various remote sensing techniques, primarily on weather radar networks, and dense enough rain gauge networks as references. In Finland this challenge is focused both on reliable estimates of snowfall precipitation and on area precipitation estimates in the context of showers. All these improvements would give us a better basis to dimension properly the needed infrastructure, like dams and reservoirs, of various drainage basins in order to avoid excessive floods.

Another important topic is the estimation of recurrence values in the context of short intense showers. With the traditional 24 hour or at its best 12 hour rain gauge measurements it is almost impossible to get any meaningful estimates for the intensities of short showers, although this is important also for the dimensioning of local sewerages and the estimation of local extreme flood risks. Many of the current dimensioning estimates of shower intensities are quite uncertain and need to be improved. This problem is complicated further by the need to consider the simultaneous soil wetness.

In order to hedge against the extreme summer floods caused by intense local showers and thunderstorms under saturated soil wetness we need to improve our knowledge of the mesoscale climatology where we have a joint interest with the development of the nowcasting.

Parallel to the efforts mentioned above we should also develop appropriate early warning models cooperatively with the various users and stakeholders. From the meteorological point of view the use of ensemble forecasts would be a natural choice to bring in the probabilistic view needed.

3.2 Storms

When we widen our view to the hedging against wind storms and the prevention of slipperiness and excessive snow loads as well, we face the fact that with the advanced technology and the post-modern trend to maximize the profit of various services we have exposed us to increased insecurity. This should be kept in mind as we consider the possible trends in weather-related risks and damages. Are we ignoring the impacts of the current natural variability of our climate, when we are trying to blame the damages on the more popular concept of climate change? So far this seems to be the case to a considerable extent in Finland as there seems not to be almost any convincing increasing trends in the weather related phenomena of concern.

The storm category as understood here in the Finnish context consists mainly of short-term phenomena, but also of some accumulative or combined phenomena of longer time span. Most of them relate to typical time scales of the weather service and some even to nowcasting, although the related macro- and mesoscale climatology must not be ignored. Here one important research area is the development of limited area forecasting models and their verification. The use of ensemble forecasts would give a good starting point to develop appropriate early warning models.

3.3 Policies

As far as policies are concerned the view in this paper has been to emphasize the role of the early warning services of the meteorologists, hydrologists and oceanographers where appropriate. In addition it has been pointed out that in Finland its climate of the extremes has so far been relatively stable and indicated predominantly no increasing trends.

On the other hand the Finnish society and business environment have undergone recently quite remarkable changes which should be taken into account in the efforts to build the future on a reasonable balance between the security and the uncertainties and risks to be managed as well as possible with the available resources, the insurance sector included. The example on broken roofs due to more or less regular late winter snow load indicates rather problems in the assembly phases of the roof construction and the liability chain within the construction industry.

4. Summary

Both the weather-related disaster types and the presented implications reflect the related issues of the Finnish climate with respect to insurance. As pointed out, so far it is quite hard to assign any of the weather-related disasters to the recently monitored climate warming of some 1 °C increase in the monthly mean temperature of December – March. In case of increased costs of weather-related disasters in Finland the currently adapted policies should be considered as one important factor as steps to improve the management of risks for the Finnish climate are taken.

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References:

Angervo, J. M. and I. Leiviska, 1944: Maapallon ilmastot (Climates of the World). Werner Soderstrom, Porvoo – Helsinki, Finland.

Hyvarinen, Veli, 2003: Trends and Characteristics of Hydrological Time Series in Finland. Nordic Hydrology, 34 (1/2), pp. 71-90.

Johansson, Milla M., Kimmo K. Kahma, Hanna Boman and Jouko Launiainen, 2004: Scenarios for sea level on the Finnish coast. Boreal Environment Research, 9, pp. 153 -166.

Jylha, K., H. Tuomenvirta and K. Ruosteenoja, 2004: Climate change projections for Finland during the 21st century. Boreal Environment Research, 9, pp. 127 – 152.

Myllys, Hilppa, 2006: Personal communication. Finnish Meteorological Institute.

Puupponen, Markku, 2006: Personal communication. Finnish Environment Institute.

Tammelin, Bengt, John Forsius, Kirsti Jylha, Pekka Jarvinen, Jarkko Koskela, Heikki Tuomenvirta, Merja A. Turunen, Bertel Vehvilainen and Ari Venalainen, 2002: Ilmastonmuutoksen vaikutuksia energiatuotantoon ja lammitysenergian tarpeeseen (In Finnish with English summary) (Effect of climate change on energy production and heating power demand). Reports 2002:2, Finnish Meteorological Institute, Helsinki, Finland.

Teittinen, Jenni, 2006: Personal communication. Finnish Meteorological Institute.