# A DERECHO IN NORTHEASTERN EUROPE ON 8 AUGUST 2010

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## I. INTRODUCTION

On 8 August 2010, a mesoscale convective system moved over northeastern Europe causing 950 km long path of wind damage. The storms started over Belarus and Lithuania and over Latvia formed a large scale bow echo that moved northward over Estonia to Finland. Damage was mainly fallen trees and damaged buildings and mostly of F1 intensity. The strongest measured wind gust was 36.5 m/s observed in Estonia, but also both in Latvia and Finland above 26 m/s wind gusts were reported in several locations.

Johns and Hirt (1987) called a family of downburst clusters produced by a mesoscale convective system a derecho. They also developed a four-part criteria to indentify derecho events:

(a) There must be a concentrated area of reports consisting of convectively induced wind damage or convective gusts of more than 26 m/s (50 kt). This area must have a major axis length of at least 400 km.

(b) The reports within this area must also exhibit a nonrandom pattern of occurrence. That is, the reports must show a pattern of chronological progression, either as a singular swath (progressive) or as a series of swaths (serial).

(c) Within the area there must be at least three reports, separated by 64 km or more, of either F1 damage or convective gusts of 33 m/s (65 kt) or greater.

(d) No more than 3 h can elapse between successive wind damage (gust) events.

The 8 August 2010 event met the criteria of a derecho.

In the United States derecho occurrence is well documented (e.g. Coniglio and Stensrud 2004). An average of 15 derechoes occur yearly. They occur around the year but primarily during the warm season (Coniglio et al. 2004). In Europe, however, there are only few documented derecho events; in Germany in July 2002 (Gatzen 2004), January 2007 and March 2008 (Gatzen et al. 2011), in August 2003 in Spain (López 2007) and in July 2002 in Finland (Punkka et al. 2006).

Besides the derecho event in 2002 (Punkka et al. 2006), to our knowledge other cases have not been documented in Finland or in the Baltic countries. In Finland downburst clusters appear to occur on yearly basis but their climatology and favourable environment is still unknown. Therefore their forecasting is challenging. This study contributes to their better understanding by summarizing both the weather conditions leading to this extreme event and the observed damage path over the affected countries.

## II. DATA

Wind gust measurements and reported wind damage information were gathered from all National Hydro-Meteorological Services in the derecho path; Estonian Meteorological and Hydrological Institute, Finnish Meteorological Institute, Latvian Environmental, Geological and Meteorological Centre, and Lithuanian Hydrometeorological Service. From all affected countries damage data from was also sought from the Internet. Online news articles with pictures of the damage and Youtube videos were used to estimate both the severity of damage with Fujita scale and its geographical extent. In Finland the rescue operations of the Finnish Rescue Services were used in addition to define the damage area.

The path of the convective system was determined with the radar networks in Finland (8 radars) and Latvia (Riga radar).

## III. DAMAGE AND WIND MEASUREMENTS

Although Lithuania suffered extensive severe thunderstorm damage resulting in four fatalities on 8 August 2010, according to Lithuanian Hydrometeorological Service none of them occurred on the path of the derecho producing convective system. The storm started to cause damage in Latvia, which suffered vast forest damage and torn off building roofs. The strongest measured wind gust in Latvia was 33 m/s. Damage and wind gust measurements are gathered in Figure1.

The strongest measured wind gust during the event was measured in Estonia, 36,5 m/s. In Väike-Maarja, where this maximum gust was measured, the storm destroyed church roof and in Elva, in southern Estonia, school roof was destroyed.

The strongest measured wind gust in Finland, 32 m/s, was measured at Gulf of Finland. Wind gusts ≥26 m/s were measured at the coastal stations along the whole width of the northward moving convective system. Most severe damage occurred in south central parts of the country, where alone the Finnish Rescue Services had almost 1000 weather-connected rescue operations (Punkka and Korpela 2010). These were mainly caused by the fallen trees and damaged buildings. The fallen trees cut off the railway connections in southern Finland and caused a train accident. Almost 70 000 homes suffered electricity cuts and in some areas their reparation took several days. The affected area in Finland was estimated approximately 42 000 km² (Punkka and Korpela 2010).

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The mesoscale convective system caused 950 km long path of wind damage extending from southern Latvia to northern Finland. The requirement in derecho criteria (Johns and Hirt 1987) of at least 400 km long damage area was met. Widest part of the damage area was 200 km wide in south central parts of Finland. As seen in Figure 1, the event meets also other derecho criteria; a chronological progression and no caps of more than approximately half an hour between successive damage and severe wind reports.

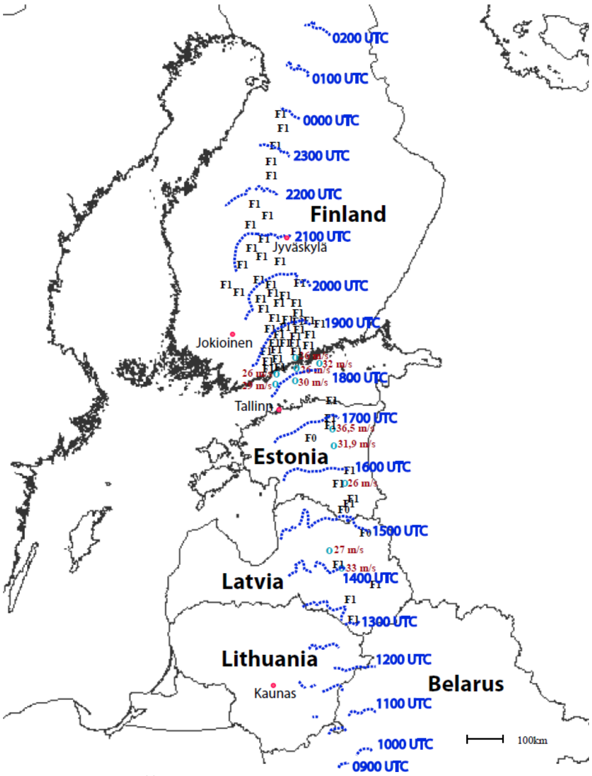

FIG. 1: Area affected by the 8 August 2010 derecho. The wind gusts ≥26 m/s are shown in red and Fujita scale damage estimations in black. Blue dashed line indicates the hourly location of the leading line of the convective system. The red dots indicate the location of sounding stations.

## IV. STORM ENVIRONMENT

Summer 2010 was very hot in northern Europe. There was a blocking high over western Russia which affected on the routes of the low-pressure systems. During the derecho event, a deepening low-pressure center moved over southern Baltic Sea northwards. This allowed warm and very moist continental low-level air flow into Baltic countries and Finland from southeast (Fig. 2). The 850-hPa pattern is very similar to the previously documented derecho case in Finland in 2002 (Fig. 3 in Punkka et al. (2006)).

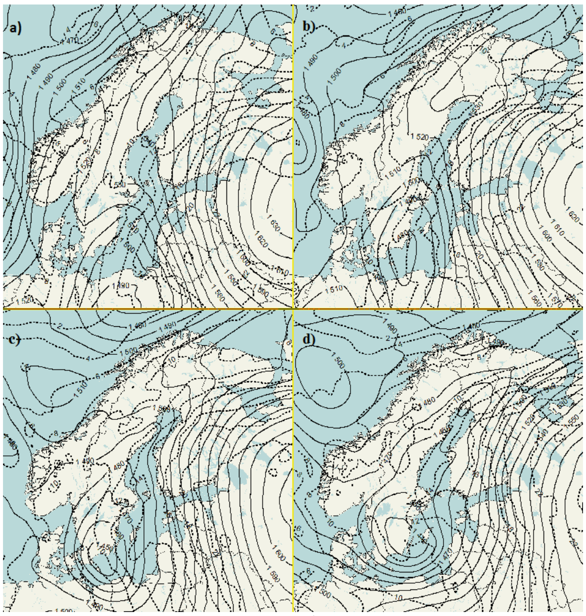

FIG. 2: Hirlam model analysis of 850-hPa temperature (dashed lines) and geopotential height (solid lines) a) 7 August 2010 1200 UTC, b) 8 August 2010 0000 UTC, c) 8 August 2010 1200 UTC, and d) 9 August 2010 0000 UTC.

A weak 500-hPa short-wave trough moved northward southwest of the derecho path area (Fig. 3). It influenced the storm environment by increasing the upper level winds and consequently the deep layer vertical wind shear. Similarly the 2002 derecho event (Punkka et al. 2006) had a northward moving upper-level trough. The upper-level (500-hPa and 300-hPa) positive vorticity advection maximum (not shown), northeast of the through, was co-located with the mesoscale convective system and moved northward along with it.

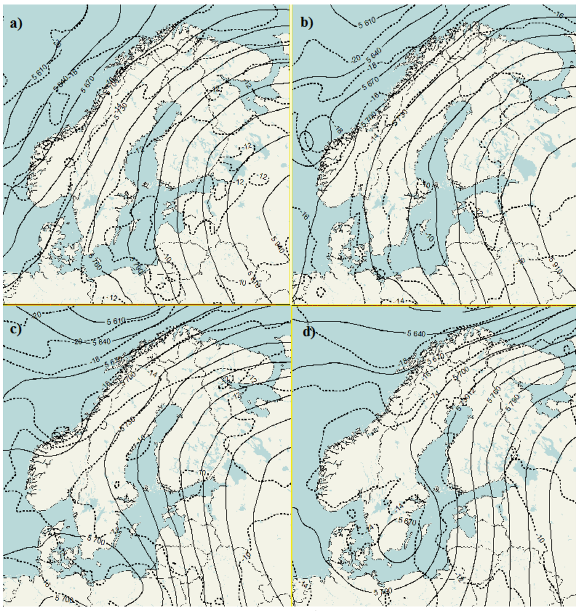

FIG. 3: Hirlam model analysis of 500-hPa temperature (dashed lines) and geopotential height (solid lines) a) 7 August 2010 1200 UTC, b) 8 August 2010 0000 UTC, c) 8 August 2010 1200 UTC, and d) 9 August 2010 0000 UTC.

Pre-convective environment was characterized with steep lapse rates, dry layer above the moister low-level air and elevated inversion at lower level that capped the convective initiation. This can be seen for example in Jokioinen afternoon sounding (Fig. 4, launched more than 7 hours before the squall line passage). The most unstable CAPE (convective available potential energy) was in Jokioinen almost 1800 J/kg, but CIN (convective inhibition) around 80 J/kg. The low-level wind shear was high, as the 1,5 km wind speed was 17 m/s. The mid-level jet was located at 3,2 km height with 20 m/s wind maximum. There was strong veering of the wind from surface to 1,5 km height and close to unidirectional winds above. In warm season derechos it is very common that there is a wind maximum in upper-level, mid-level is relatively dry and there is low-level warm advection (Coniglio and Stensrud 2000). All these features were found in this case also.

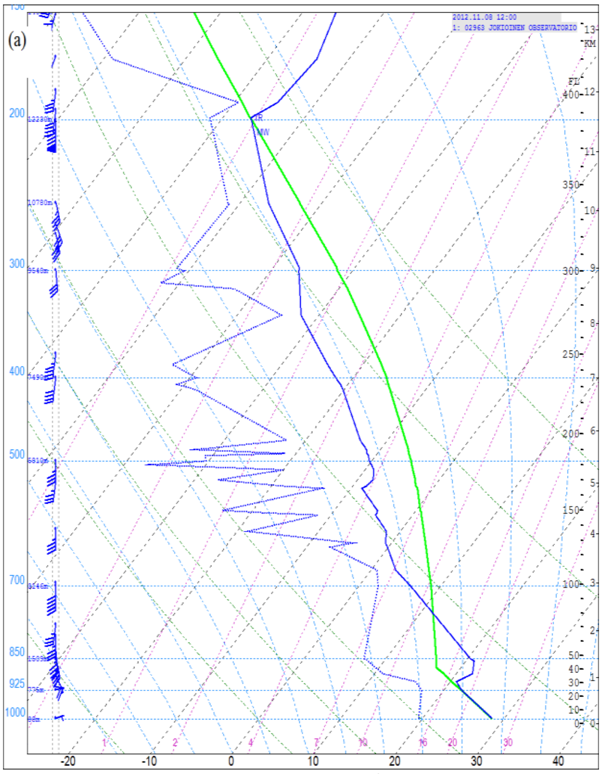

FIG. 4: Sounding on 8 August 1200 UTC from Jokioinen, southern Finland. The most unstable parcel is plotted on the sounding as green line.

As the center of surface low pressure on southern Baltic Sea was moving northward on 8 August 2010, a secondary low developed over Lithuania in the morning. The first reflectivites of the derecho producing storms were observed with Riga radar before noon local time (0900 UTC) in western Belarus. The secondary low moved north during the day. The storms moved north-northwest close to the frontal boundary in eastern Lithuania and started to produce wind damage in southern Latvia (Fig. 1). In Latvia the convective system organized into a squall line. During the passage of the secondary low, the originally almost meridionally oriented frontal boundary in Baltic countries moved towards northeast (Fig 5). The frontal boundary pushed the low-level moisture northeastward in front of it.

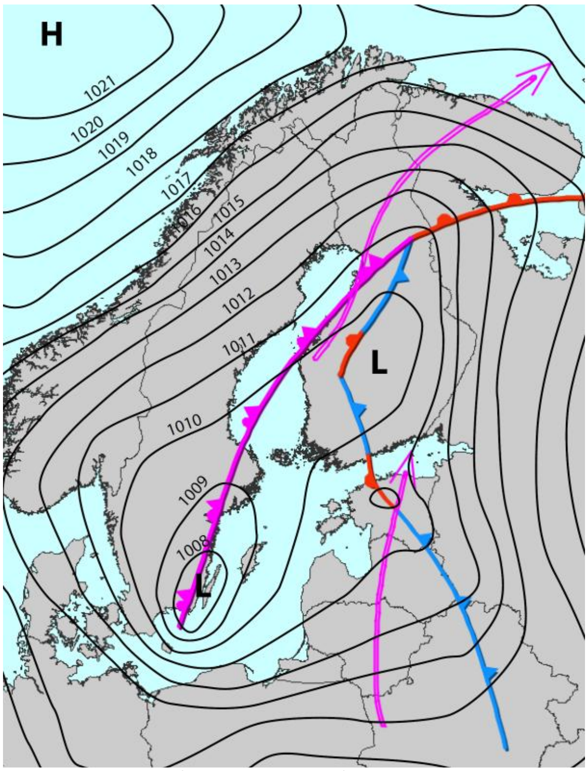

FIG. 5: Manual surface pressure and frontal analysis on 8 August 2010 1800 UTC. 300-hPa jet streams (wind ≥30 m/s) are shown as arrows.

The movement of the squall line from Estonia to Finland is shown in Figure 6. The surface pressure fields were modified by the cold pool (Fig. 7), which is seen as mesohigh behind the leading line of the mesoscale convective system.

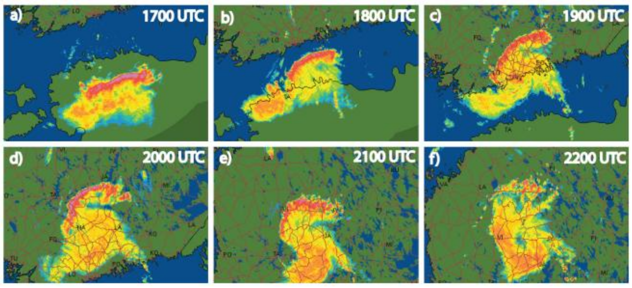

FIG. 6: CAPPI reflectivity (dBZ) imagery on 8 August 2010 a) 1700 UTC, b) 1800 UTC, c) 1900 UTC, d) 2000 UTC, e) 2100 UTC, f) 2200 UTC as the squall line moved from Estonia to over south central Finland.

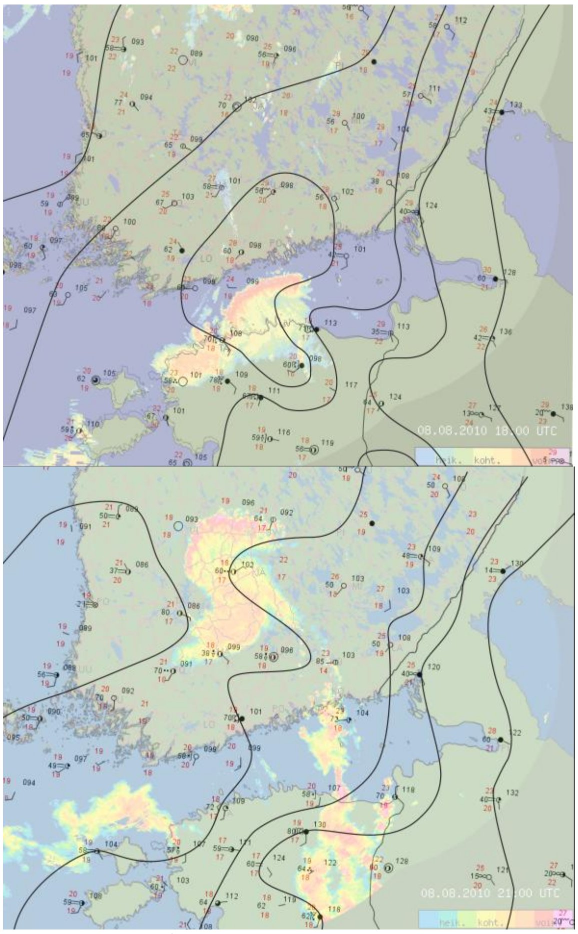

FIG. 7: CAPPI reflectivity (dBZ) imagery on 8 August 2010 a) 1800 UTC, and b) 2100 UTC superimposed along with surface observations and manual pressure (solid lines) analysis.

## V. SUMMARY

The studied mesoscale convective system on 8 August 2010 produced 950 km long path of wind damage in northeastern Europe. During the event northern Europe was in a vast surface low pressure area of which center was over southern Baltic Sea allowing flow of warm and very moist continental low-level air into Baltic countries and Finland from southeast. A weak northward moving 500-hPa short-wave trough influenced the storm environment by both increasing the vertical wind shear and by increasing the instability. The low-level wind shear was increased by the northwestward oriented low-level jet. The mesoscale convective system developed close to a frontal boundary and then moved in a direction nearly parallel to the boundary. It had features commonly described with progressive derechoes.

## VI. ACKNOWLEDGEMENTS

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