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Role of meteorology in logistics planning

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Keywords: meteorology, transport, dangerous weather phenomena, logistics.
Abstract: Meteorology affects every part of life. We need to know the weather conditions for our everyday life, but also for the work activities of the company. Transport is a very sensitive area that is very responsive to changing weather conditions. Each type of transport is sensitive to different weather phenomena. The article provides basic information about weather, its role in transportation, and the fact that hazardous weather phenomena can significantly affect the speed of delivery, safety and quality of transportation.

1 Introduction

Meteorology is a science with a long history [1]. Already in the distant past, our ancestors were aware of the weather's influence on their everyday life. Nations living on see coast also were familiar with wind phenomena, which could adversely influence their sea navigation, so as fishing and the transportation of goods [2].

So let's not be surprised that it was the marine meteorology that pushed meteorology forward. Other modes of transport used the marine meteorology experience gradually [2].

Meteorologists have at their disposal tools for high-quality weather forecasting and individual values of meteorological elements, but they still have to reckon with a high value of uncertainty. In recent years, the use of meteorological satellites and meteorological radars has improved, and numerical prediction models are available with a special focus on various users of meteorological model outputs. However, in addition to high-quality forecasting tools, expert meteorologists who are able to interpret all outputs so that their information is relevant to the user are also needed.

Even though we live in the 21st century, the role of meteorology and its forecasts is still irreplaceable in the planning of activities in transport.

2 The dangerous weather phenomena

Dangerous weather phenomena are meteorological phenomena that significantly affect air traffic safety, jeopardise the flow, or even stop operations. Different dangerous weather conditions can occur in the winter and other during the summer season. The most dangerous weather situations include the frontal interface affecting the airport and its surrounding areas. A warm front is a precipitous activity, but its effects are not as dramatic as on a cold front, especially during the summer season [1]. Cold fronts arise in the wake of a developing extratropical cyclone when cooler air moves into an area of the warmer air mass. The warmer air mass interacts with the cooler air along the frontier and typically produces precipitation. Cold fronts are frequently followed by a warm front or squall line [1,3]. The cold front is typically characterised by heavy clouds, torrential precipitation, storms associated with turbulence, wind shear, hail etc. [1,3].

Information about the occurrence of fog and, as a result, possible lower visibility also has a unique place in traffic. Fog is an aerological aerosol consisting of very small water droplets reducing horizontal visibility in at least one direction below 1 km [4]. While researching the occurrence of fog at Slovakia's international airports in the period 1998-2018, interesting information was found. The urban legend about the low incidence of days with fog at Bratislava Airport was confirmed, and the urban legend about the minimal occurrence of days with fog in summer was not confirmed. According to [5], in the period 1998-2018, fogs occurred during the year with different numbers of days at Slovakia's international airports (Figure 1).

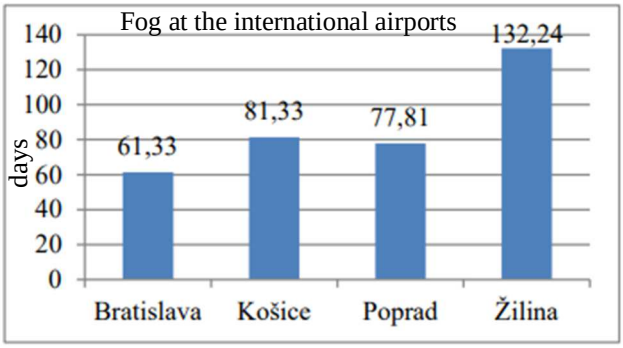

Figure 1 Average number of days with fog at the international airports for the 1998-2018 period [5]

The average number of days varies during the year, with the most days with fog occurring in autumn [Figure 2].

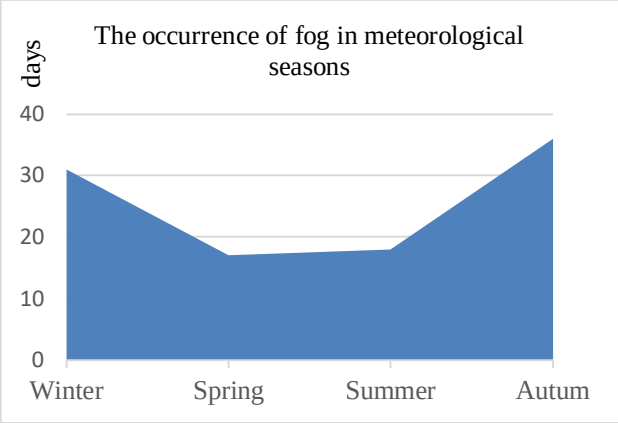

Figure 2 Average number of days with fog during a year at Slovak international airports [5]

More than 1.5 million METAR reports were processed and evaluated in the work [5].

3 What interests us the most?

In meteorology, we are not only interested in the current values of meteorological elements (air temperature, air pressure, wind direction and speed, visibility, phenomena...) but are also interested in the expected development of these phenomena for several days ahead. At present a weather forecast with a relevant warning value can be prepared for a maximum of 3-4 days in advance [1].

Numerous numerical methods are currently used for weather forecasting, which, based on equations and relationships describing events in the atmosphere, can predict the forecast in many places in the globe with a resolution grid of km x km.

We also use information from a wide network of meteorological stations that provide us with information about the course of the weather. This information has different periodicity for different purposes. For example, in aviation meteorology, we use METAR reports - the current state of the weather conditions, or TAF (The Terminal Area Forecast), a forecast for several hours ahead.

In road transport meteorology, it is very important to know not only the state of the atmosphere and possible meteorological phenomena related to it but also the state of the pavement. Here we are served by various sensors built into the pavement, which provide not only up-to-date information about its condition but also serve as an input for pavement condition forecast.

Globally, road transport meteorology is growing importance. There are many papers published on the latest possibilities for dangerous weather phenomena prediction [6-8]. The Standing International Road Weather Commission (SIRWEC) operates as a forum for information exchange on road transport meteorology issues [9]. They include management, road maintenance, road safety, meteorology, environmental protection and other areas of interest considered relevant by the Commission. Historically, SIRWEC holds a conference every two years [9].

SIRWEC's main task is to encourage meteorologists, weather forecasters, highway engineers, road masters and others who are interested in road transport weather problems to exchange ideas to make our road transport safer in all weather conditions [9].

There are also specialised companies focusing on detecting, predicting and evaluating weather conditions on roads in Slovakia. They also expanded their services and experience worldwide. Companies Microstep and/or Spinet could be mentioned as good examples. Both of those offer a wide range of detection options for dangerous phenomena in various modes of transport. This mainly focuses on air and road temperature, fog and wind data. The changes in these elements in space and time may indicate the emergence of intermediate problems in transport [10,11].

An example of how the typical forecasting system works in a simplified form is shown in Figure 3.

To know the weather conditions status is the prime importance for aviation. Even though the weather forecasts have improved considerably in the last two decades, the weather conditions are one of the major causes of air accidents. Weather conditions deterioration can significantly affect air transport and can cause, for example, delays in large areas. However, not every kind of weather creates dangerous conditions for air transport. Nevertheless, 2018 was very specific, and a record number of adverse weather events and industrial actions that severely disrupted network operations was registered [12-14].

The weather can create weather phenomena that could be dangerous for all traffic modes. Just as the weather changes, so do dangerous weather phenomena adversely affect the regularity, efficiency and safety of any transport modes.

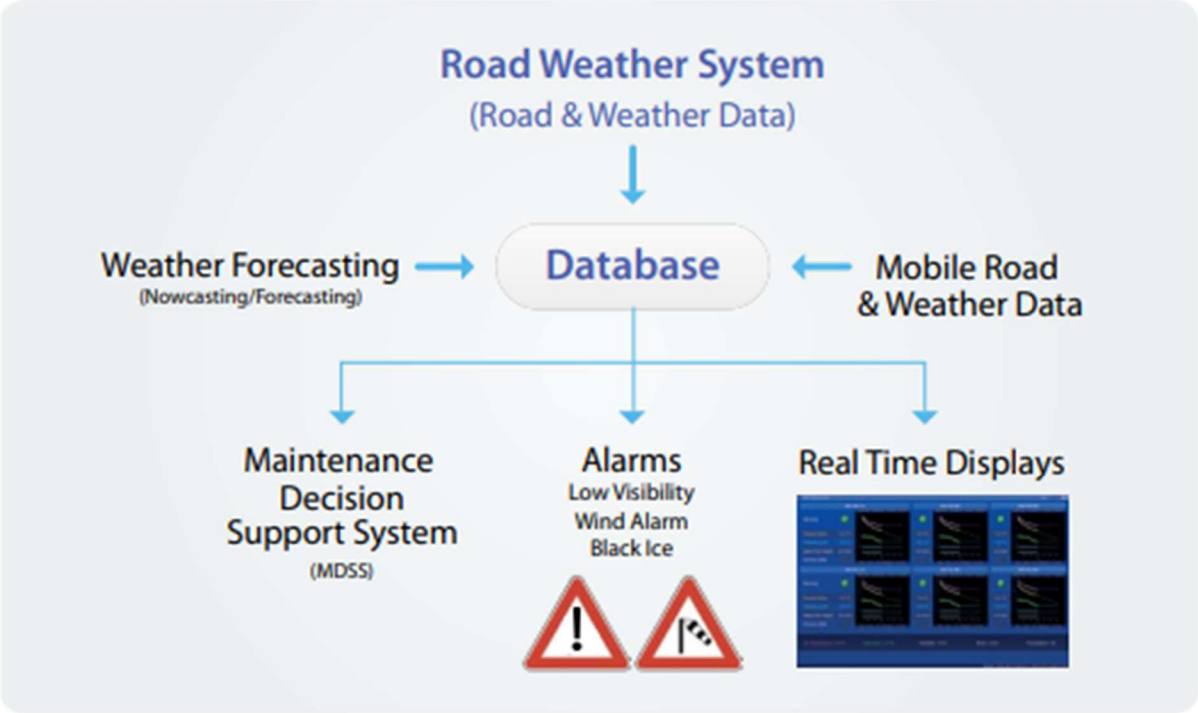

Figure 3 Scheme of road weather registration and prediction system [10]

4 Transport and climate change - new challenges in this industry

As mentioned, the weather and its changes significantly affect our lives and also the transport in small and large areas. In the current period, the problem of climate change is also coming to the fore. Transport is responsible for the amount of greenhouse gases increasing in the atmosphere and intensifying the greenhouse effect.

Global CO2 emissions from energy combustion and industrial processes rebounded in 2021 to reach their highest-ever annual level. A 6% increase from 2020 pushed emissions to 36.3 gigatonnes (Gt), an estimate based on the IEA´s detailed region-by-region and fuel-by-fuel analysis, drawing on the latest official national data and publicly available energy, economic and weather data. The Covid-19 pandemic had far-reaching impacts on energy demand in 2020, reducing global CO2 emissions by 5.2%. However, the world has experienced an extremely rapid economic recovery since then, driven by unprecedented fiscal and monetary stimulus and a fast - although uneven- roll-out of vaccines. The recovery of energy demand in 2021 was compounded by adverse weather and energy market conditions, which led to more coal being burnt despite renewable power generation registering its largest-ever annual growth. Emissions increased by almost 2.1 Gt from 2020 levels. This puts 2021 above 2010 as the largest ever year-on-year increase in energy-related CO2 emissions in absolute terms. The rebound in 2021 more than reversed the pandemic-induced decline in emissions of 1.9 Gt experienced in 2020. CO2 emissions in 2021 rose to around 180 megatonnes (Mt) above the pandemic level of 2019. The 6% increase in CO2 emissions in 2021 was in line with the jump in global economic output of 5.9%. This marks the strongest coupling of CO2 emission with Gross domestic product (GDP) growth since 2010 when global emissions rebounded by 6.1% while economic output grew by 5.1% as the world emerged from the Global Financial Crisis.

Transport was responsible for 30% of global final energy demand and for 23% of global direct CO2 emissions from the energy sector that year [15].

5 Conclusion – meteorology in transport in the future

Meteorology remains an important partner for improving the quality and efficiency of all types of transport. Meteorological information, very detailed and accurate, helps with planning transport around the world. In addition to traditional meteorological tools, which are well known and used (radar, satellites, models...), AI and its help in solving problems in transport are also coming to the fore.

Transport is of prime importance for most of business and is an indispensable part of our life. However, the aim

of greenhouse gas emissions reduction had to be one of the major aims for transport today.

In many modes of transport, ways are being sought to reduce the impact of transport on the amount of greenhouse gases in the atmosphere. Experiments are being done in the use of green types of energy to drive cars, ships and even aeroplanes.

If we assume that a warmer atmosphere can absorb more water vapour, more water vapour can produce more convective clouds, and more dangerous phenomena can occur from it (heavy showers, storms), it is important to pay more attention to observation, prediction and warning. Meteorology and transport must work very closely together in this respect.

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