Success Stories on User Engagement

Global Science & Technology, Inc.

Success Story 7: Logistics and Transport

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This report examines user engagement with NOAA's National Centers for Environmental Information (NCEI) climate and weather data. It demonstrates the value that the free and publicly available provision of NCEI's information provides to the logistics and transportation sector. Interviews conducted with key sector stakeholders and supplemental desk-based research illustrate how the logistics and transportation sector use climate and weather information archived by NCEI. This success story analyzes applications of NCEI's information to express couriers and long-haul carriers and how it helps answer key business questions, manage risk, resolve legal disputes and enhance operational efficiencies. NCEI's information proves an important resource to the logistics and transport sector, a sector which contributes revenues of $1.48 trillion to the U.S. economy and transports goods across the country, and the world.

Acronyms Used

AAR: American Association of Railroads

ASOS: Automated Surface Observation System

BNSF Railway: Burlington Northern Santa Fe Railway

COOP: Cooperative Observer Network

CSV File: Comma-Separated Values File

DHL: Dalsey, Hillblom and Lynn

FAA: Federal Aviation Administration

FRA: Federal Railroad Administration

GDP: Gross Domestic Product

GHCN-D: Global Historical Climatology Network, Daily

ISD: Integrated Surface Database

ISMCS: International Station Meteorological Climate Summary

ITA: International Trade Administration

LCD: Local Climatological Data

NCEI: National Centers for Environmental Information

NESDIS: National Environmental Satellite, Data, and Information Service

NOAA: National Oceanic and Atmospheric Administration

VDRP: Virginia Department of Rail and Public Transportation

UNCTD: United Nations Conference on Trade and Development

Terms and Definitions

Class I Railways: privately owned railways that generate in excess of $457.91 million in annual revenue

Freight: bulk transport of goods

Logistics: the coordination and management of a complex operation that moves goods from origin to consumer

Sun kinks: high temperatures and direct exposure to sunlight can cause thermal expansion of railway tracks that can lead to buckling

Switches: mechanical installations that allow trains to switch from one track to the next

Third-party logistics provider: providers of integrated logistics services that include transportation of goods

1. INTRODUCTION

Logistics and transportation are key economic sectors accounting for $1.48 trillion, or 8%, of U.S. annual gross domestic product (GDP, 2015) (ITA, 2018). These industries are growing rapidly with global market revenue projected to increase from $8.1 trillion in 2015 to $15.5 trillion by 2023 (TMR, 2016). With an estimated $25.3 trillion in global business-to-consumer sales and business-to-business sales (2015), logistics enterprises are highly interconnected and play a pivotal role in global commerce (UNCTAD, 2017).

Logistics industries coordinate and manage complex operations to efficiently route goods from industry to industry and retailer to consumer (Lourenço, 2005). In relation, the transportation industry physically moves goods via a range of transportation modes (Rodrigue et al., 2017). Logistics and transportation operate independently or as an integrated service offered by a third-party logistics provider.[1] Goods are transported via a variety of modes including trains, airplanes, ships, pipelines and trucks. In general, high-value, low-density goods (e.g. medication and priority documents) are transported by airplane, and reach their final destination by ground transport, while low-value, high-density bulk goods (e.g. coal) are transported by ships, rail and semi-trucks, to reach their final destination. Generally, the former operates within a narrow time frame and can be classified as **express**, whereas the latter is less time sensitive and can be classified as **long-haul** (A. McKinnon, personal communication, Dec 12, 2017). While climate data has extensive application within transport and logistics, this study focuses on express services due to the industry's substantial reliance on climate and weather information, and railways due to their unique climate and weather vulnerabilities.

Weather and climate affect both express couriers and long-haul carriers, albeit in different ways, as they operate in different environments and time-scales, and via different transportation modes. Express couriers generally operate within a 72-hour time frame, whereas long-haul operations can span days, weeks or even months. Airplanes and ships have the ability to reroute if they encounter unfavorable weather en route, while trucks and trains are more constrained, relying on fixed assets to reach their final destination. Not only are transportation modes vulnerable to weather and climate extremes, the infrastructure required for operations such as airports, railway tracks, ports, roads, and bridges, are as well.

[1] This study analyzes integrated services offered by third-party logistic providers. In other words, it does not include logistics providers that do not provide transportation services.

While interconnectivity is crucial to the efficient functioning of transportation and logistics systems, the more these systems globalize, the more complex they become. A disruption in a single element of the logistics chain can have cascading impacts in other parts of the world (DHL, N.D.) Furthermore, as logistics and transportation enterprises serve other industrial, commercial and social sectors, weather-related impacts to a logistics company can profoundly affect commerce (Doherty & Misrahi, 2013).

Reducing weather risk and optimizing performance is a top priority for express couriers and long-haul carriers. As the official repository of NOAA weather data, NCEI provides historical records used to optimize performance, inform risk management, and support legal cases. Express couriers and long-haul carriers access information directly from NCEI, or indirectly through the support of a weather service provider. This study uncover the varied applications of NCEI's climate and weather data and demonstrates how the information is used to safeguard the company's bottom line, ensuring worker safety and the timely delivery of goods.

2. EXPRESS COURIERS

Air and express delivery companies offer expedited, time-sensitive, end-to-end services for documents, small parcels, and high-value items that make-up an $82 billion industry (ITA, 2018). FedEx and UPS are two of the largest express couriers, controlling a combined 46% percent of the market share of express shipping (24% and 22% respectively) (Statistica, 2017). Both companies offer one- to three-day delivery services, with a money back guarantee. Depending on the distance, parcels are generally transported by air, and then reach their final destination via ground transportation. Both FedEx and UPS have meteorology teams based out of their aviation departments. Interviews with meteorologists from both companies revealed a considerable reliance on NCEI's data products and services to conduct weather-related analysis and provide strategic decision-making support to the air transport division. The International Station Meteorological Climate Summary, referred to as the *climate disk,* is used extensively by express logistics providers.

Figure 1: Meteorologist at work
Source: NOAA

The International Station Meteorological Climate Summary (ISMCS) or the *climate disk* is a detailed climate summary developed through a tri-agency effort between NCEI, the U.S. Navy, and the U.S. Air Force. It contains climate summaries for 640 primary weather observation sites and over 5,800 secondary sites across the world. The summaries contain detailed information on a daily, hourly and monthly time-step of air temperature, precipitation, wind, clouds, pressure, and various other elements as observed by each station. These data are derived from NCEI's Integrated Surface Database (ISD), a global product that consolidates hourly and synoptic observations from over 35,000 stations worldwide.

The ISMCS is accessible through a CD-ROM, hence the name *climate disk*, and available for the period of record from 1973 to 1996 (W. Brown, personal communication, January 17, 2018).

FEDEX

FedEx is an American courier and third-party logistics provider headquartered in Memphis, Tennessee. The courier's aviation hub and headquarters are located at the Memphis airport, the second busiest cargo airport by volume, in the world. Formerly known as Federal Express, the company moves on average 13 million shipments per day, and operates in 220 countries and territories (FedEx, 2017a). FedEx offers a range of business services including **FedEx Express**, offering same-day to three-day delivery service, **FedEx Ground** offering economical residential and business shipping, and **FedEx Freight** offering truck-load freight shipping (FedEx, 2017b).

Figure 2: FedEx Airbus landing
Source: Pixabay

FedEx has an in-house 15-staff meteorology division located in its Global Operations Control Center in Memphis, Tennessee. Around 80% of the meteorology division supports **FedEx Express**, the air express service, while the rest is divided among trucking units, **FedEx Ground** and **FedEx Freight**. All FedEx employees with a climate or weather inquiry can take advantage of the team's expertise. For example, in the winter months the meteorology team often receives inquiries from the trucking units regarding snowfall forecasts to transit routes in the northeast or through the mountainous areas of the western United States.

UPS

United Parcel Service (UPS) is a package delivery company and third-party logistics provider headquartered in Atlanta, Georgia, with air operations based out of Louisville, Kentucky. UPS's $2.4 billion Worldport air hub is the largest automated packaged handling facility in the world. Worldport, located at Louisville International Airport, is the central hub of UPS's worldwide air network handling over 300 inbound and outbound flights daily (UPS, 2017a). In fact, during peak hours an aircraft lands at the Worldport once every 90 seconds (NPR, 2005). UPS operates in and out of 374 airports in the U.S., and 313 internationally (UPS, 2017b). The facility processes over two million packages per day, which doubles during the December peak holiday shipping season (UPS, 2017a).

UPS has a team of 5 dedicated meteorologists who analyze the weather 24 hours a day. The meteorology unit also primarily supports aviation, with over 95% of the workload focusing on aviation and the remainder on ground transport.

Figure 3: Loading of UPS cargo plane
Source: Spiegel Online

2.1. EXPRESS COURIER APPLICATIONS

Express couriers depend on the *climate disk* for numerous applications including:

- Landing minimums
- Strategic planning of airport locations
- Planning for winter de-icing
- Transporting temperature-sensitive goods
- Weather model verification

2.1.2. LANDING MINIMUMS

The Federal Aviation Administration (FAA) regulates landing visibility minimum requirements for U.S. airport runways. Under FAA regulation, the pilot is required to have certain runway visibility for landing clearance ranging from a quarter mile to half a mile and designated ceiling height, depending on the airport, in order to be permitted a landing. Visibility criteria vary from airport to airport, and runway to runway, depending on airport instrumentation. In general, runways at larger airports tend to be equipped with high-quality instrumentation and the plane can land safely even in poor visibility and low ceilings. If runway visibility is poor due to rain, fog, or snow conditions, the pilot can either maintain a holding pattern until visibility improves or fly to an alternate location. Both options require extra fuel and can lead to delivery delays if the package does not make a delivery deadline at that location or sorting at one of the company's main sort facilities. Further, re-routing aircraft requires additional ground transport arrangements. While express couriers are not liable for weather-related delays, failure to deliver on time can impact brand reputation. As observed by Randy Baker, senior meteorologist for UPS, "Someone awaiting a package in Bangkok doesn't care if it snowed in Louisville, Kentucky. They want their stuff." (Harwell, 2014).

Express couriers rely on NCEI's data to determine the probability of being unable to land, due to FAA visibility landing criteria. This type of analysis is particularly useful when an airport is planning runway construction or repair. If a preferred runway with good visibility or instrumentation is closed due to construction, the aircraft will have to default to another runway at the airport, with higher landing minimums and reduced visibility. In that scenario, the meteorology team conducts an analysis to determine the probability of meeting the FAA landing minimum on an alternate runway. Using the *climate disk,* the meteorology team analyzes historical fog, rain, and snow data to determine how often landing visibility criteria were unmet at a particular runway for a given time of year. Data from the *climate disk* specific to that location is fed into a mathematical algorithm to determine the overall probability of landing based on visibility conditions. If the probability is low (e.g. less than 2% on the average day), the express couriers may accept this as an operational risk. If the probability is relatively high (greater than 10%), a number of contingency plans are developed to ensure alternative means to deliver the freight with minimal impact to service levels. One alternative involves allocating assets to a nearby airport until freight can be moved back to the preferred location (K. Gempler, personal communication, Dec 1, 2017). The courier may present this information to airport authorities to negotiate construction of the runway during a lower traffic period, and / or when negative weather impacts are less prevalent. Couriers retain a designated FAA and local airport authority liaison to facilitate communication of urgent issues that impact daily operations. Concerns are substantiated with the climate analysis results to demonstrate that weather-related conditions may cause the courier to miss a number of days of service and result in extensive economic losses. The courier can then use this information to negotiate more effectively with the airport authorities and FAA to schedule construction during a time when it poses reduced operational risk (J. Sarver & J. Cramer, personal communication, Dec 6, 2017).

2.1.3. STRATEGIC PLANNING OF NEW AIRPORT LOCATIONS

Weather is a prominent factor when considering airport locations to serve as new express courier hubs. The package delivery business is extremely time-sensitive, and couriers are negatively impacted by closures or reduced capacity resulting from low visibility, snow, fog, or strong winds (Cosmas & Martini, 2007).

When strategic planning teams consider expansion into new hubs, the UPS meteorology team receives requests to compare airports that may be more favorable for takeoff and landing due to weather conditions. On one occasion, the UPS meteorology team conducted a feasibility study to determine the reliability of Mobile, AL, or Pensacola, FL, to serve as a new hub based on prevailing weather conditions. While little distance separates the two airports (only 59 miles), both exhibit unique fog frequencies and possess different runway instrumentation, yielding different probabilities of successful airport landings. Using the *climate disk*, the team analyzed nearly 30 years of data in each location to determine how often fog conditions would prevent a successful landing. The outcome of this analysis was a factor in the broader decision to transfer the hub from Mobile to Pensacola (J. Sarver, personal communication, Dec 4, 2017).

2.1.4. PLANNING FOR WINTER DE-ICING

Express couriers need to be prepared for winter de-icing, the removal of winter precipitation; frozen or semi-frozen snow, ice, or slush, from critical aircraft surfaces. De-icing costs several hundred dollars for a single application, depending on the surface area of the aircraft, the type of precipitation, and the fluid used (Lazo, N.D.). De-icing fluid and personnel are not always readily available, or sufficiently resourced at all airport locations, in particular where icing conditions are uncommon. Express courier meteorology teams receive inquiries from airport hubs asking whether, and how much, de-icing fluid may be needed at airport locations, particularly in the southern U.S., during winter. To determine the optimal amount, the meteorology team analyzes *climate disk* data and calculates the number of days on average that an airport experiences icing conditions during the season. The meteorology team incorporates seasonal outlooks to create a forecast of frost and ice days for the upcoming season. The forecast determines how much de-icing fluid the hub should stock based on the probability of winter precipitation and the number of aircraft passing through the airport (K. Gempler, personal communication, Dec 1, 2017).

Figure 4: Airplane de-icing
Source: UPS

2.1.5. TRANSPORTING TEMPERATURE-SENSITIVE GOODS

Express couriers transport a range of products including temperature- and time-sensitive goods like pharmaceuticals. UPS Account Executives tasked with medical supply shipments require temperature projections to determine how often air-conditioning units need to be available at a given transport hub. The meteorology team conducts an analysis to estimate how often temperatures exceed a certain threshold at a given location for a certain time of day. The probability of exceeding that threshold informs the allocation and placement of air conditioning units (J. Sarver, personal communication, Dec 4, 2017).

2.1.6. WEATHER FORECAST VERIFICATION

The *climate disk* is used to verify weather forecasts, particularly if they appear unusual. Prior to releasing a forecast, meteorologists check the climatology to ensure the forecasts fall within the realm of probability. For example, if weather models indicate heavy fog at a gateway, meteorologists look at the climatology to evaluate how often fog has exceeded landing minimums at a given location in the past. If fog has not exceeded landing minimums in the past, this may indicate that the weather models are incorrect and the probability of such an occurrence is very slim. Understanding this probability is important as these types of forecasts can trigger unnecessary and potentially costly action (i.e. choosing to fly into an alternate airport) (J. Cramer, personal communication, Dec 4, 2017, and K. Gempler, personal communication, Dec 1, 2017).

2.2. GROUND TRANSPORT

While express couriers rely heavily on airplanes to transport cargo, they also rely extensively on ground transport to deliver packages to their final destination. However, the probability analysis method used for aviation does not apply well to ground transportation as the spatial resolution of the *climate disk* is too coarse for a highway-specific analysis. Trucking units are interested in understanding the probability of fog or snow frequency along a specific stretch of highway, a question that cannot be answered accurately with airport observations from the *climate disk*. Express trucking units receive forecast information to help plan routes, however this information does not include optimal routing based on climate data. Probability analysis is an area of interest that express couriers seek to integrate. This would involve utilizing interpolation methods to create higher resolution data points along critical routes (K. Gempler, personal communication, Dec 1, 2017).

Figure 5: UPS delivery in snowy conditions in Champaign, Illinois
Source: AP Press

> *“If we didn’t have the climate disk there would be a significant impact to our company in terms of trying to make accurate decisions to avoid weather impacts.*” – Jeff Sarver, Meteorologist, UPS

2.3. ROOM FOR IMPROVEMENT

The *climate disk* is used frequently by express couriers to understand the probability of weather events for a variety of applications. Despite its regular use and importance, the period of record for airport stations extends only through the mid 1990s, meaning that the climatology has not been updated for over 20 years. Express couriers are interested in a more up-to-date version of the *climate disk,* and some expressed the willingness to pay for this product. An extended version would provide a longer period of record and ensure more confidence in the probabilities that are generated (J. Cramer, personal communication, Dec 4, 2017, and K. Gempler, personal communication, Dec 1, 2017).

3. LONG-HAUL CARRIERS

3.1. RAILWAYS

The U.S. freight rail network is considered one of the most advanced freight systems in the world, transporting 5 million tons of cargo on a daily basis (FRA, 2018). The $60 billion industry operates on 140,000 miles of track owned and operated by seven Class I railways[2], 21 regional railways, and 510 local railways. Ninety-five thousand miles, or 70% of these tracks, are owned and operated by Class I railways (Towson, 2016). America's Class I railways: Grand Trunk Corporation, BNSF Railway, CSX Transportation, Canadian Pacific, Norfolk Southern, Union Pacific, and Kansas City Southern, operate in 44 states across the country and employ 90% of railway workers (AAR, 2010) (see Figure 6). Major capital expenditures are required for construction and maintenance of this highly complex network of tracks, and to enhance freight capacity. As railways depend on fixed infrastructure prone to degradation, they are highly susceptible to climatic influences and variable weather conditions (Centrec, 2005).

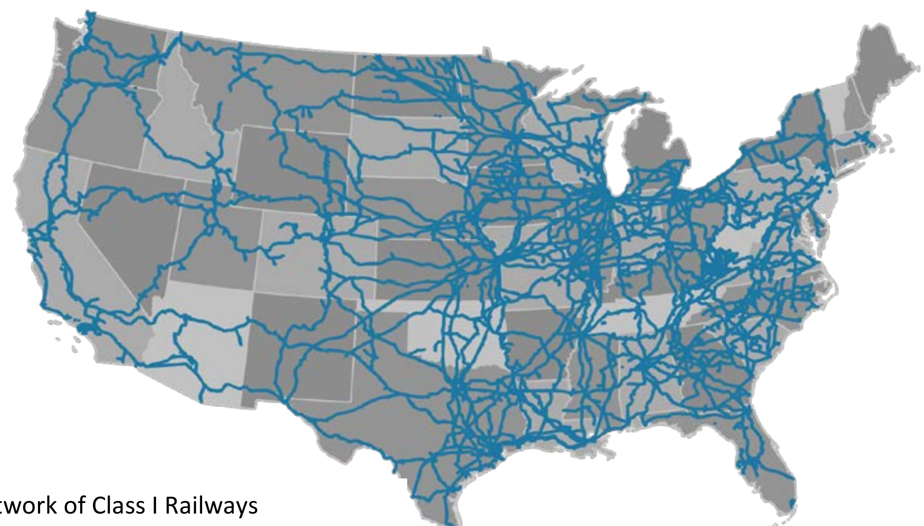

Figure 6: Network of Class I Railways
Source: National Transportation Atlas Database

Railways transport high-density, low-value primary products such as solid fuels, metals and minerals, chemicals, agricultural commodities, and select consumer goods. Freight rail moves 5.2 million carloads of the nation's coal (about 70%), about 58% of the nation's raw metal ores, 1.6 million carloads of wheat, corn, and other agricultural products, and 13.7 million intermodal containers and trailers that transport consumer goods (ITA, 2018). Weather and climate significantly impact railway operations (i.e the ability to deliver freight in the proposed time frame) and engineered infrastructure (i.e. risk to

[2] Private railways that generate in excess of $457.91 million in revenues annually (AAR, 2010).

railway tracks, bridges, etc). Limited connectivity to locations and a lack of alternate routing means that weather-related incidents can have profound service disruptions. Tornados and high winds can topple rail cars, and avalanches in mountainous regions can block tracks with snow and debris. Landslides, mudslides, erosion, and floods, triggered by excessive precipitation, can damage tracks, culverts, and bridges. Cold temperatures can break rails, topple rock slopes, form frost heaves, and cause icing of switches, while high temperatures and direct exposure to sunlight can cause sun kinks. These hazards can cause derailment and in turn, damage private and public infrastructure and endanger railway workers, operators, and bystanders (Centrec, 2005). Indeed, over the past decade, Class I railways have collectively experienced over 10,500 derailments, most of which are attributable to weather-related causes (FRA, 2017).

All seven Class I railways are serviced by Accuweather, a third-party weather service provider. NCEI's information is used broadly as a foundational component, along with other publically available government data, to build the analytics and services that Accuweather provides to Class I railways. Accuweather relies on a series of NCEI products including: Local Climatological Data (LCD), Cooperative Observer Network (COOP), Automated Surface Observation System (ASOS), Integrated Surface Daily Database (ISD) and Global Historical Climatology Network, Daily (GHCN-D), to conduct analysis and develop value-added tools for Class I railway clients. These *in situ*, or station-based, products described in Table 1, are used primarily for three purposes: historical event analysis for risk management, to provide weather-related evidence to support legal claims, and to enhance network optimization (J. Porter, personal communication, Jan 17, 2018). Table 2 illustrates the various ways climate and weather data are used to serve the needs of railways.

Figure 7: Railway Buckling
Source: U.S DOT Volpe Center

Product	Description
LCD	Publications contain summaries from major airport weather stations and record information pertaining to temperature extremes, precipitation, degree days, and winds. Hourly precipitation and abbreviated 3-hour weather observations are also included (NCEIa, 2018).
COOP	Over 10,000 volunteers collect daily weather observations at seashores, mountaintops, National Parks, farms, urban and rural areas, that are collected in the COOP. These data usually consist of daily maximum and minimum temperatures, precipitation totals, and snowfall (NCEIb, 2018).
ASOS	Automated sensor suites collect information regarding temperature, precipitation, sky cover, pressure, and visibility to serve aviation and meteorological observing needs. There are more than 900 ASOS sites in the U.S., most of them located at airports. These systems generally report at hourly intervals although increase in frequency when severe weather conditions arise (NWS, 2012)
ISD	Consolidates hourly and synoptic observations from over 35,000 stations worldwide. ISD records numerous parameters as observed by each station including temperature, wind speed and direction, wind gust, dew point, precipitation, snow depth, and more (NCEIc, 2018).
GHCN-D	The most comprehensive daily global dataset available consolidating records from over 80,000 stations in over 180 countries and territories. Variables commonly include maximum and minimum temperature, total daily precipitation, snowfall, and snow-depth. Data for the U.S. is reported once daily from stations across the country (Menne, et al., 2012).

Table 1: NCEI *in situ*, "station data" used for railway analysis

Railway Applications for which Weather and Climate Data are Needed

Activity	Application	Data Needs: Real-time	Data Needs: Historical
Operations			
Scheduling - train schedules, train and track maintenance, inspections	Short and Long Range Forecasts	✓	✓
Local operations	Short and Long Range Forecasts	✓	✓
Operational inefficiency resulting from severe weather events - derailment recovery; traffic disruption minimization	Weather monitoring and hazard warnings via Decision Support Systems such as weather monitoring systems, precision storm tracking tools, and site specific severe weather warnings	✓	✓
Planning			
Construction	Data summarization; analysis		✓
Weather hazard prediction	Weather monitoring and hazard warnings via Decision Support Systems such as weather monitoring systems, precision storm tracking tools, and site specific severe weather warnings	✓	✓
Historical Event Analysis			
Severe weather conditions related to temperature and precipitation such as landslides, erosion events and flooding	Data summarization; analysis		✓
Legal/Claims/Litigation/Forensic	Data summarization; analysis		✓
Safety (regulatory requirements)	Weather monitoring and hazard warnings via Decision Support Systems such as weather monitoring systems, precision storm tracking tools, and site specific severe weather warnings	✓	✓

sun kinks posing the greatest hazard of derailment (A. Rush, personal communication, Jan 31, 2018). Over the period of 2007-2017 sun kinks caused 366 derailments[3] amounting to a reported $167.2 million in losses (FRA, 2018). While tracks are engineered to withstand certain temperature thresholds, generally warmer in the southern U.S. and cooler in the northern U.S., a 140,000-mile network of tracks

[3] Including all railways, passenger and freight

across the nation, varying ages of infrastructure, and variable rail material composition and metallurgy mean that tracks vary greatly in their heat-tolerance. Further, rail temperature is generally 30°F higher than the ambient temperature due to solar radiation exposure and friction generated from trains, meaning an air temperature of 100°F correlates to a track temperature of roughly 130°F. When rail temperatures become substantially greater than the stress-free rail temperature, it exacerbates the risk of sun kinks (Yujiang et al., 2010). As a general rule, an 1,800-foot track of rail will expand by 1 foot with an 80°F change in temperature, causing the track to curve and misalign (VDRP, 2008). This confluence of weather parameters and engineered elements means that temperature forecasts are a helpful, but not a comprehensive, predictor of sun kinks.

To manage the risk of sun kinks, railways conduct historical analyses to determine the atmospheric conditions that occurred at the time of a kink. Information pertinent to this analysis includes; solar radiation, atmospheric temperature, wind speed, and solar angle. The *in situ* data products described in Table 1, are leveraged to verify the weather that occurred at or near a point location of the kink. *In situ* data may be further interpolated by the service provider to provide data at a finer resolution more relevant for the analysis[4]. An analysis of the weather-related factors that contribute to sun kinks helps identify the confluence of factors that drive this complex phenomena and contribute to greater risk avoidance in the future (A. Kish, personal communication, Jan 31, 2018). The service provider issues notifications to the railway when weather parameters are forecast to breach railway heat tolerance thresholds in pre-defined track parameters. This can generate management actions such as decreasing train speeds, carrying reduced loads during peak heat, or dispatching railway workers to search for visible signs of damage (A. Kish, personal communication, Jan 31, 2018).

3.1.2.2. LEGAL

Railways are prone to extensive liability given their exposure to weather-related risks and the frequency of derailments that can cause damage to freight, injury, or death to workers and bystanders, environmental disasters (i.e. transport of HAZMAT), loss or damage to property, and more (A. Kush, personal communication, Jan 31, 2018). In judicial cases, railways frequently rely on NCEI's information to demonstrate weather conditions that occurred at a specific time and location, and to verify a claim by another party. Personnel in the railway's legal department, or the service provider acting on their behalf, may request a series of certified products from NCEI including: the Severe Weather Data

[4] As many observing stations are located at airports

Inventory, LCD, COOP and GHCN-D. This Department of Commerce certification ensures that these data are obtained from a trusted, reliable source and can be used as evidence in a court of law. If railways are faced with a lawsuit due to an unavoidable weather-related incident such as a tornado or lightning strike that causes a train to derail, NCEI's information can be used as evidence to prove that the incident was an "Act of God" and potentially be absolved of liability. Certified historical weather data is an incredibly valuable resource to resolve legal disputes and potentially protect railways against costly legal liability.

3.1.3. NETWORK OPTIMIZATION

Railways face major challenges in trying to optimize operations while safeguarding against a suite of weather-related risk. For example, the need to reduce operating speed or decrease cargo load as a risk management strategy causes delays and longer travel times resulting in economic losses. In the interest of safety and optimization, historical weather data can answer a series of optimization questions, as nearly every decision related to railway performance has a weather-component (A. Kush, personal communication, Jan 31, 2018). For example, if increased temperatures are projected, and a location-specific analysis shows that this is within the thermal track range, no risk management action may be required. Railways may also need to assess best locations to build new tracks. Analysts evaluate NCEI's historical weather data to calculate the probability of weather-related risk to the region (for example, number of sunny days over 100°F, rainy days, snow days, or days below 30°F) to determine potential routes that would pose the least amount of weather-related risk to the railway. Other inquiries include identifying which switches in the rail network are most prone to freezing (J. Porter, personal communication, Jan 17, 2018). Low temperatures and snow and ice accumulation can lead to the icing of switches, mechanical installations that allow trains to switch from one track to the next. Icing of switches poses an operational challenge that leads to accidents or prolonged delays for trains. Railways currently heat up switches in advance of a deep freeze to avoid icing. Probability analysis using NCEI data determines the percentage of time that temperatures drop below a threshold to identify switches that require heat to avoid icing. If the probability of icing at a given location is low, the railway may choose not to heat the switch to save energy costs (A. Arpachi, personal communication, Dec 14, 2017).

3.1.4. ROOM FOR IMPROVEMENT

Railways suggested several ways that NCEI's information could be improved to better support railway analyses. Station data file formats present a challenge to work with and a more conventional file format, such as CSV or shapefile, is preferred. Conversion from non-conventional to conventional file formats is laborious for service providers and detracts from the use of certain data products. Further, access to reliable gridded data on historical snowfall (minimum, maximum, and liquid equivalent), and wind gusts from NCEI is desired to support further analysis (J. Porter, personal communication, Jan 17, 2018).

4. FUTURE OUTLOOK - DRONES

As global commerce continues to grow, so will the demand for faster and more efficient delivery systems. Amazon presently pilots the use of drones for “last mile delivery,” the last leg of the journey before the parcel arrives at the customer’s doorstep. The drones will transport small packages (under 5 lbs. in weight), from a regional distribution center to their final destination (Amazon, 2018). This concept, still in early stages, will require consideration of many climate and weather variables to ensure effective operations. Drones are sensitive to a range of weather variables, particularly wind gusts and precipitation. Historical information from NCEI can be used to answer key questions pertaining to drone performance relative to weather conditions (J. Porter, personal communication, Jan 17, 2018).

5. CONCLUSIONS

Logistics and transportation companies contend with weather on a daily basis. If unanticipated, or not properly planned for, weather can cause delays, accidents, and liability that translate to economic and reputational losses. As a service offered to other sectors, a disruption to transport and logistics can have ripple effects across the broader supply chain, and even the economy. Managing weather risk and optimizing services are therefore key business interests for logistics and transportation providers. This risk recognition is evidenced by the fact that express couriers maintain in-house meteorological teams to monitor weather impacts on global operations around the clock, and long-haul carriers outsource these operations to a third-party weather service provider. The economic investment in weather services, both in-house and outsourced, is indicative of the impacts weather poses on these enterprises.

While the shared objective of express and long-haul carriers is the delivery of goods, the service they offer and transportation mediums they use, create distinct risk profiles. Express couriers operate within a 24- to 72-hour window; every minute counts, and a weather-related delay can translate to a substantial loss in economic revenue. Delivering on time, regardless of the obstacles that Mother Nature may pose, is essential for business continuity and maintaining a reputation as a leading express service provider. If a plane is delayed due to weather conditions, 50,000 packages may potentially miss sorting at the distribution facility, and the delivery will be delayed. Meaning that roughly 50,000 customers on the receiving end, and 50,000 customers on the sending end will be dissatisfied with the service. While railways are less constrained by time, their dependence on fixed infrastructure that is vulnerable to daily weather hazards poses a severe risk management challenge. Derailments, caused predominantly by sun kinks, not only impact service delivery but also generate extensive liability and reputational losses for railways. While weather vulnerability is inherent to express and long-haul enterprises, the level of risk can be better managed with access to climate and weather information.

As detailed in this report, NCEI offers a variety of data products that the sector relies on. The ISMCS, or the *climate disk*, is an important resource for express couriers as it allows them to conduct probability studies to show the impact that certain actions (i.e. runway closures) may have on operations. The ISMCS is used to conduct analysis to support decision-making pertaining to airport construction, strategic planning of airport locations, planning for winter de-icing, transporting temperature-sensitive goods, and weather model verification. Railway service providers depend on a range of station data products including LCD, COOP, ASOS, ISD, and GHCN-D to conduct analysis and develop value-added tools and products. The information provides the basis for historical analysis that guides risk management, serves as legal evidence in judicial cases, and optimizes operational performance. NCEI's information significantly benefits the industry, offering credible and verifiable information to conduct analyses. With commerce and globalization quickly expanding in a changing climate, demand for climate and weather information is anticipated to grow. Centers like NCEI, and more broadly NOAA, offer logistics and transport companies information needed to maintain a healthy bottom-line in a rapidly changing landscape.

6. REFERENCES

Amazon.com, Inc. (2018). Amazon prime air. Retrieved from, https://www.amazon.com/Amazon-Prime-Air/b?node=8037720011

Association of American Railroads. (2010). National Transportation Atlas Database. U.S. Department of Transportation, Bureau of Transportation Statistics. Retrieved from, http://archive.freightrailworks.org/network/class-i/

Association of American Railroads (AAR). (2017). Class I railroad statistics. AAR Policy and Economic Department. Retrieved from, https://www.aar.org/Documents/Railroad-Statistics.pdf

Centrec, C. B. (2005). Economic value of selected NOAA products within the railroad sector. Retrieved from, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.192.3456&rep=rep1&type=pdf

DHL Resilience 360. (N.D.) Insight on: risk & resilience. Retrieved from, http://www.dhl.com/content/dam/Campaigns/risk-and-resilience/dhl_insighton_final.pdf

Doherty, S., & Misrahi, T. (2013). Outlook on the logistics and supply chain industry. In World Economic Forum (pp. 1-36). Retrieved from, http://www3.weforum.org/docs/WEF_GAC_LogisticsSupplyChainSystems_Outlook_2013.pdf

Federal Railroad Administration Office of Safety Analysis. (2017). 1.12 Ten year accident / incident overview [Data set]. Retrieved from, http://safetydata.fra.dot.gov/OfficeofSafety/publicsite/Query/TenYearAccidentIncidentOverview.aspx

Federal Railroad Administration Office of Safety Analysis. (2018). Office of safety analysis [Database]. Retrieved from, http://safetydata.fra.dot.gov/OfficeofSafety/Default.aspx

FedEx. (2017a). About FedEx. Corporate fact sheet. [Fact sheet]. Retrieved from, http://about.van.fedex.com/our-story/company-structure/corporate-fact-sheet/

FedEx. (2017b). Connecting the world. [Brochure]. Retrieved from, http://about.van.fedex.com/wp-content/uploads/2014/10/FX_Corp_Brochure2017.pdf

Harwell, Drew. (2014, December 8). Meet the secret army of meteorologists who keep your holiday deliveries on time. *The Washington Post.* Retrieved from, https://www.washingtonpost.com/business/economy/meet-the-secret-army-of-meteorologists-who-keep-your-holiday-deliveries-on-time/2014/12/08/2d9d3c82-759d-11e4-9d9b-86d397daad27_story.html?utm_term=.22c93f35cff6

Jarrett, T. (1992). The International Station Meteorological Climate Summary CD-ROM. *Bulletin of the American Meteorological Society*, *73*(10), 1578-1580. Retrieved from, http://journals.ametsoc.org/doi/pdf/10.1175/1520-0477%281992%29073%3C1578%3ATISMCS%3E2.0.CO%3B2

Lourenco, Helena R. (2005). Rego, C., & Alidaee, B. (Eds.), *Logistics Management. An opportunity for metaheuristics.* (pp. 329-356). Retrieved from, http://84.89.132.1/~ramalhin/PDFfiles/2005_ChapterLogistic.pdf

Lazo, J. (N.D.). Assessing the economic impacts of weather and value of weather forecasts. National Centers for Atmospheric Research, Societal Impacts Program. Retrieved from, http://www.7thverificationworkshop.de/Presentation/tutorial_topic2_assessing_value_of_forecasts.pdf

National Centers for Environmental Information. (2018a). Data tools: local climatological data (LCD). Retrieved from, https://www.ncdc.noaa.gov/cdo-web/datatools/lcd

National Centers for Environmental Information. (2018b). Cooperative observer network (COOP). Retrieved from, https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/cooperative-observer-network-coop

National Centers for Environmental Information. (2018c). Integrated surface database (ISD). Retrieved from, https://www.ncdc.noaa.gov/isd

National Public Radio. (2005, November 24). UPS Chases Business Beyond Parcel. (J. Speer, Interviewer) [Audio file]. https://www.npr.org/templates/transcript/transcript.php?storyId=5025262

National Weather Service, National Ocean and Atmospheric Administration. (2012). ASOS & climate observations. What is ASOS? Retrieved from, https://www.weather.gov/media/lmk/pdf/educational_pages/ASOSandClimateObservations__What_Is_ASOS.pdf

Rodrigue, J. P., Comtois, C., & Slack, B. (2017). *The geography of transport systems*. New York, NY: Routledge. Retrieved from, https://transportgeography.org/?page_id=1731

Statistica. (2017, December). Couriers and local delivery service providers' global market share in 2017. Retrieved from, https://www.statista.com/statistics/236309/market-share-of-global-express-industry/

Transparency Market Research. (2016). *Logistics market (type of transport infrastructure - road, waterways, rail, and air; logistics model - first party logistics, second party logistics, and third party logistics; application - industrial and manufacturing, retail, healthcare, media and entertainment, military, automotive, government and public utilities, oil and gas, and fishing) - global industry analysis, size, share, growth, trends, and forecast 2016 – 2024.* Retrieved from, https://www.transparencymarketresearch.com/logistics-market.html

United Nations Conference on Trade and Development (UNCTD). (2017). *Information economy report 2017. Digitalization, trade and development overview.* Retrieved from, http://unctad.org/en/PublicationsLibrary/ier2017_overview_en.pdf

UPS. (2017a). UPS worldport facts. [Fact sheet]. Retrieved from, https://pressroom.ups.com/pressroom/ContentDetailsViewer.page?ConceptType=FactSheets&id=1426321566696-701

UPS. (2017b). UPS air operations facts. [Fact sheet]. Retrieved from, https://www.pressroom.ups.com/pressroom/ContentDetailsViewer.page?ConceptType=FactSheets&id=1426321563773-779

International Trade Administration's Industry & Analysis Unit (ITA). (2018). Logistics and transportation spotlight. The logistics and transportation industry in the United States. Retrieved from, https://www.selectusa.gov/logistics-and-transportation-industry-united-states

Federal Railroad Administration (FRA). (2018). Freight rail overview. The freight rail network. Retrieved from, https://www.fra.dot.gov/Page/P0362

Virginia Department of Rail and Public Transportation (VDRPT). (2008). *Heat order issues technical memorandum.* [Memorandum]. Richmond, VA: Virginia Department of Rail and Public Transportation. Retrieved from, http://drpt.virginia.gov/media/1144/heat-order-issues-tech-memo-full-memo.pdf

Yujiang, Z., & Al-Nazer, L. (2010). Rail temperature prediction for track buckling warning. In *AREMA 2010 Annual Conference*. Retrieved from, http://www.arema.org/files/library/2010_Conference_Proceedings/Rail_Temperature_Prediction_for_Track_Buckling_Warning.pdf

ANNEX A: INTERVIEWS

ACADEMIA
Kuhne Logistics University
Alan McKinnon

GOVERNMENT AGENCIES
NOAA NCEI
William Brown, Customer Service Representative

EXPRESS COURIERS
FedEx
Kory Gempler, Meteorologist

UPS
Jeff Sarver, Meteorologist

UPS
Jim Cramer, Meteorologist

USPS
Carolyn Cole, Manager, Energy Initiatives

WEATHER SERVICE PROVIDERS / CONSULTANTS

Accuweather
Jonathan Porter, Vice President of Business Services and General Manager of Enterprise Solutions

UBIMET
Alexander Arpachi, Research Project Developer

Kandrew Consulting Services
Andrew Kish, Railway Technology Consultant