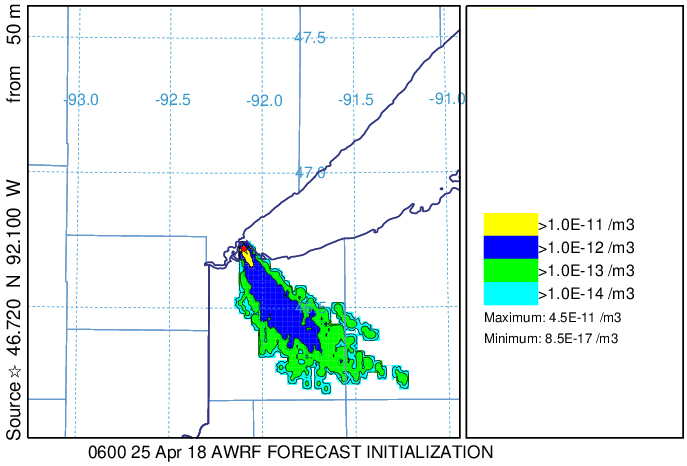
Research on the boundary layer, the portion of the atmosphere where we live and breathe.



Smoke plume following explosion at the Husky Refinery fire, left. Right: HYSPLIT model simulations predicted smoke in the southeast. Husky Energy's evacuation plan baselined a two mile concentric ring of evacuations,

NOAA's Air Resources Laboratory (ARL) conducts research on the lowest part of the atmosphere, the boundary layer, the area where we live and breathe. ARL models generate actionable information and highly localized forecasts to respond to a variety of emergencies efficiently. ARL studies the physical and chemical, short- and long-term processes that occur in the boundary layer, which ranges from one meter below the soil up to 2,000 meters in the atmosphere and impact health and safety, business, and the environment.

ARL's primary modeling tool – Hybrid Single-Particle Lagrangian Integrated Trajectory model (HYSPLIT) – predicts the downwind impacts of hazardous materials released to the atmosphere and is used in a variety of emergency situations. During incidents such as industrial accidents and wildfires, data from HYSPLIT informs local managers whether evacuations or stay- at- home orders may be necessary. These tools offer the most immediate, direct evidence of economic value. Emergency managers use HYSPLIT in a variety of scenarios to prevent bad outcomes or long term health effects. Examples where HYSPLIT models changes a behavior to improve public and environmental health or mitigate bad outcomes are numerous. Some of the likely most beneficial uses of HYSPLIT were difficult to model; however, a study to quantify the value of HYSPLIT offered two case studies.

Industrial Accident: Avoided costs estimated $1.5-10M

A large industrial accident occurred April 26, 2018, at the Husky Energy oil refinery in Superior, Wisconsin, and the contents of an asphalt storage tank caught fire. HYSPLIT models predicted the area southeast of the plant would be impacted (see figure); differing from the concentric ring version used by the plant. HYSPLIT models prevented unnecessary evacuations, but enabled proper ones. Smoke downwind of the fire was extreme and could have led to grievous injury or death of the 6,000 residents in the evacuation area. HYSPLIT-guided evacuation models and shelter-in-place orders prevented such injuries. Estimates of avoided health costs due to the use of HYSPLIT were on the order of $150,000 just for avoidance of eye irritation, with larger values for other endpoints. Avoided health costs in the Husky fire were conservatively estimated at $1,500,000 for the group of health end-points examined.

Public economic studies correlate low air quality and smoke to well-being and life satisfaction, with a disproportionate effect on rural resident life satisfaction. It is estimated that 750 people were spared exposure to levels of fine particulate matter above 250 ug/m^3, a threshold where serious injury, including heart attack and death, can occur. It is unknown how many actual deaths or serious injuries were avoided through the use of HYSPLIT.

At Husky, HYSPLIT models avoided at least $1.5M in health care costs. Hundreds of citizens were spared smoke exposure at levels where serious injury can occur. A single avoided death is estimated at up to $10M.

ECONOMIC BENEFITS FROM HYSPLIT

Nuclear Nonproliferation

ARL is designated as a World Meteorological Organization Regional Specialized Meteorological Center, and works along with the US Depts. of Energy, State, and Defense to characterize the atmosphere and provide backtracking, or source, information for non-proliferation field experiments. ARL is tasked by the Comprehensive Test Ban Treaty Organization to ensure compliance with Nuclear Test Treaties.

Volcanic Ash

HYSPLIT is also used to forecast downwind concentrations of ash after volcanic eruptions; these forecasts alert civil aviation authorities so that aircraft can avoid dangerous ash levels. Aircraft engines can be catastrophically damaged due to volcanic ash, causing crashes; the value of avoiding ash encounters is extraordinarily high. Estimates of the impact of volcanic ash on the commercial air transport industry are $70 million.

Industrial Accidents and Toxic Emissions.

Industrial releases such as the Husky fire described above comprise roughly a quarter of all recorded events in HYSPLIT 2020 simulations. HYSPLIT usage on industrial events nearly doubled between 2018 and 2019. Incident modeling prevented the inhalation of chlorine, ammonia, and a variety of other toxic substances.

Wildfires and Prescribed Burns

HYSPLIT is not only used to plan prescribed burns, but also provides daily forecasts of wildfire smoke throughout the U.S. HYSPLIT is also the basis for a fire emission inverse modeling system that can improve smoke forecasting over North America by combining model estimates with satellite observations.

Special Events

HYSPLIT simulations are used by emergency management agencies in advance planning for many events of national significance, including major parades, the Presidential Inauguration, the Super Bowl and other national sporting events, NASA planetary launches and the Albuquerque Balloon festival, among others.

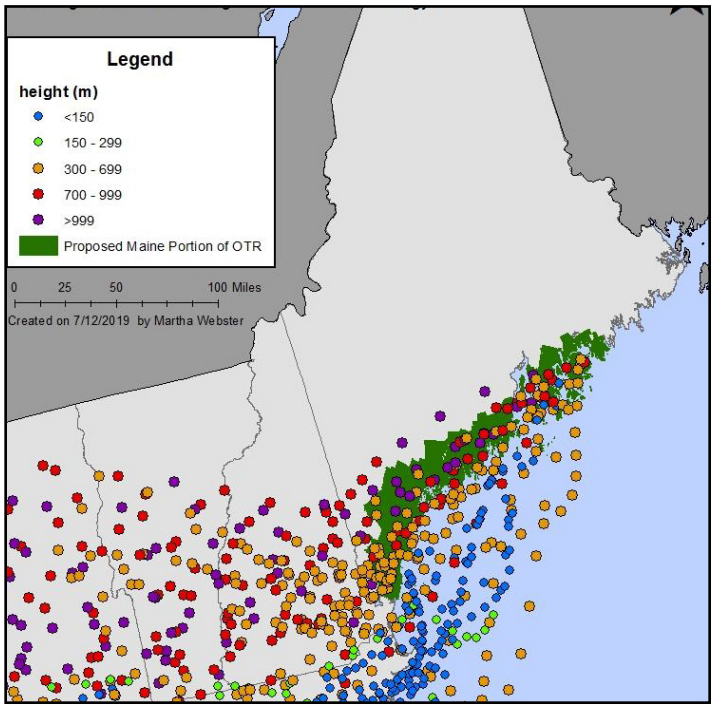
Global Impact and Research

HYSPLIT versatility has been adapted for use by the United Nations to predict devastating Locust swarms in Africa. In its first year of operation, the Locust Forecasting tool saw over 5000 runs. As a research tool, HYSPLIT atmospheric transport models are accepted globally for a policy-relevant analysis by governmental, non-governmental, and academic researchers.

Estimates of net benefits offer ample evidence that the benefits of NOAA's Air Resources Laboratory's HYSPLIT atmospheric dispersion model outweigh the costs.

Environmental Review of Maine 2018-2021.

The State of Maine is part of the Ozone Transport Region pursuant to the Clean Air Act; industrial Maine facilities are subject to more stringent and more costly control and operational requirements than they would otherwise be subject to if excluded from the region. HYSPLIT is one of the EPA's models to determine the classification status for state level compliance. Using HYSPLIT data, shown right, The Governor of Maine requested in 2020 that the EPA remove "the majority of Maine from the Ozone Transport Region." Removal from the region would reduce annual compliance costs and regulatory burden on Maine industry, estimated at $2.3 - $5.5 M per year.



Maine Ozone Trajectory Analyses, at right: HYSPLIT 48-hour Back Trajectories of Maine's Ozone Exceedance Days from 2016-2018. Figure was used to support analysis that Maine industrial activity is not responsible for the ozone exceedances in the southern part of the state, shown in green. Each circle represents flows of particles transported to the southern coast of Maine, differentiated by height in the atmosphere.
Image Credit: State of Maine Clean Air Act Section 176A(a)(2) Petition, February 6, 2020. Figure created by Martha Webster.

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