NATIONAL WEATHER SERVICE

Building a Weather-Ready Nation

How the NWS is Training Artificial Intelligence to Address Language Accessibility Gaps in Weather Information

Monica L. Bozeman
NWS Office of Central Processing

WMO - Workshop on Resilience to Natural Hazards through AI solutions

March 13, 2024

Who is the Most Vulnerable?

American Community Survey (ACS)

01	Does this person speak English at home?	• Yes • No (Skip The Rest of Questions)
02	What is this language?	• Write-In Question ○ E.g., Korean, Italian, Spanish, Vietnamese, etc.
03	How well does this person speak English?	• Very Well • **Well** • **Not Well** • **Not At All**

United States Census Bureau

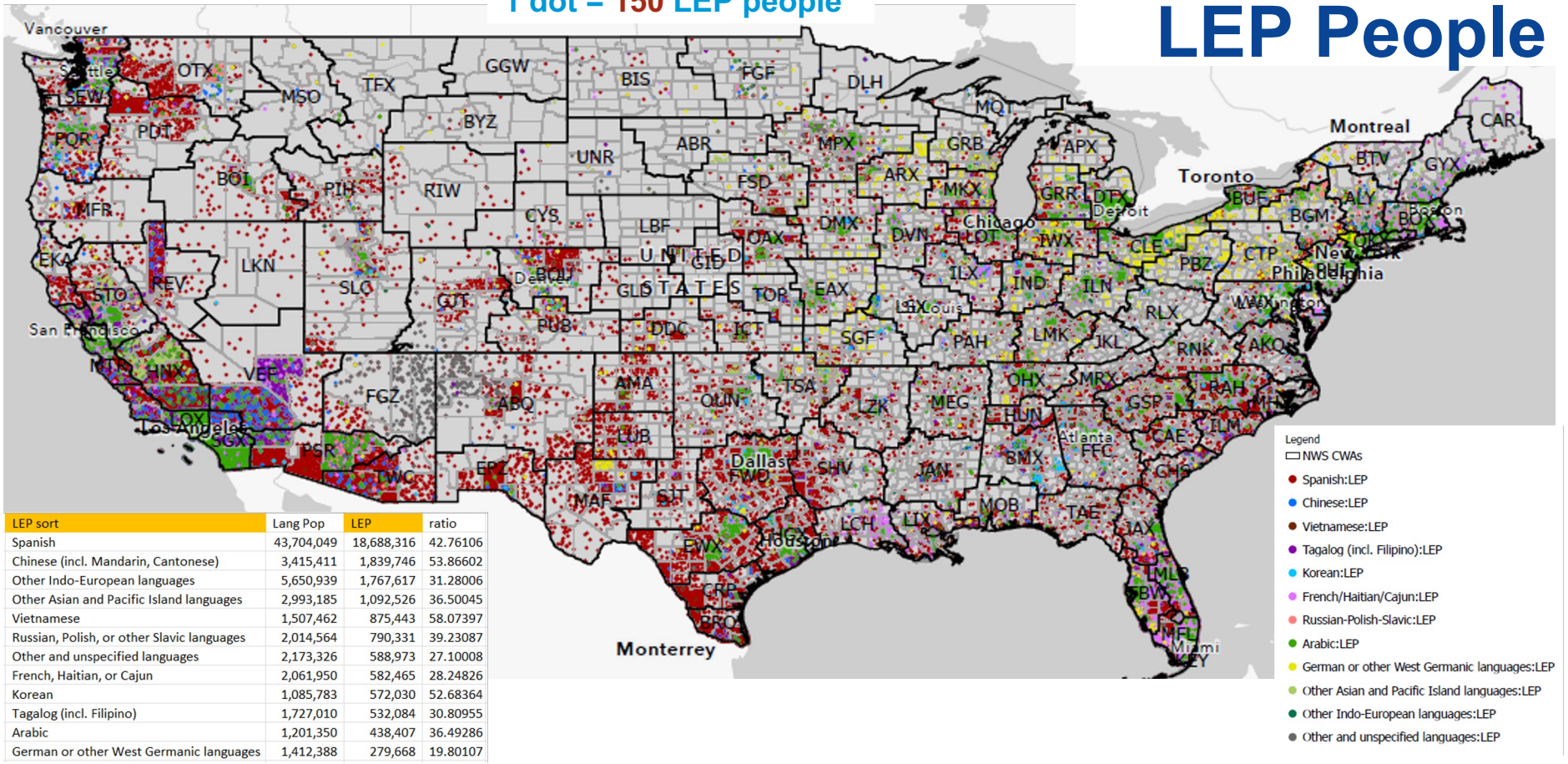
Limited English Proficient (LEP)

Any Person Age 5 or Older Who Reported Speaking English Less Than "Very Well"

LEP Dot Density

1 dot = 150 LEP people

~25 million LEP People



LEP sort	Lang Pop	LEP	ratio
Spanish	43,704,049	18,688,316	42.76106
Chinese (incl. Mandarin, Cantonese)	3,415,411	1,839,746	53.86602
Other Indo-European languages	5,650,939	1,767,617	31.28006
Other Asian and Pacific Island languages	2,993,185	1,092,526	36.50045
Vietnamese	1,507,462	875,443	58.07397
Russian, Polish, or other Slavic languages	2,014,564	790,331	39.23087
Other and unspecified languages	2,173,326	588,973	27.10008
French, Haitian, or Cajun	2,061,950	582,465	28.24826
Korean	1,085,783	572,030	52.68364
Tagalog (incl. Filipino)	1,727,010	532,084	30.80955
Arabic	1,201,350	438,407	36.49286
German or other West Germanic languages	1,412,388	279,668	19.80107

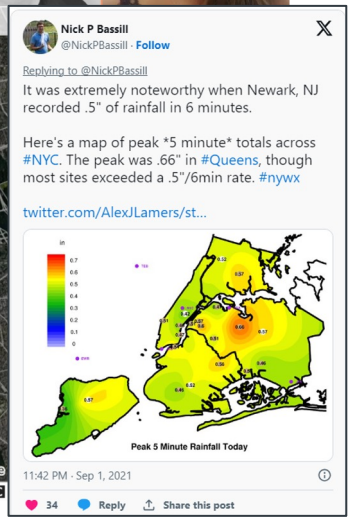
Legend

- NWS CWAs
- Spanish:LEP
- Chinese:LEP
- Vietnamese:LEP
- Tagalog (incl. Filipino):LEP
- Korean:LEP
- French/Haitian/Cajun:LEP
- Russian-Polish-Slavic:LEP
- Arabic:LEP
- German or other West Germanic languages:LEP
- Other Asian and Pacific Island languages:LEP
- Other Indo-European languages:LEP
- Other and unspecified languages:LEP

Possible Weather-Related Human Tragedies due to LEP?

Remnants of Hurricane Ida - September 2021 New York City:

NBC: "Nearly all of the 11 New York City basement-flooding deaths were residents of Asian descent who lived in below-ground dwellings that were particularly susceptible to storms."



Tornadoes & Flooding - May 31st, 2013 - Oklahoma City

Cifuentes/Santos Family

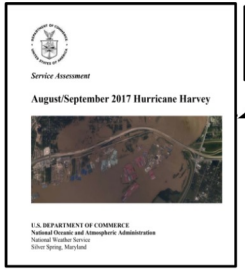
Drivers to Implement Automated Translations

- Executive Order 13166 - Limited English Proficiency (2000)
- NWS CaRDS requirement 16-008: “Products and Services in support of Limited English Proficiency (LEP) and building a Weather-Ready Nation” (2016)
- Executive Order 13985 - Underserved Communities (2021)
- NWS San Juan asks for assistance in translating NHC products. NWS CP investigates translation automation in Spanish (2021)
- Remnants of Hurricane Ida causes Asian deaths in NY (2021)
- NY AG Call for Language Accessibility in Weather Alerts (2022)
- NOAA FY23 Congressional Appropriations bill calling to expand efforts in translation of weather alerts (2022)
- NWS Ida Service Assessment released and is the first time NWS identifies service equity in a service assessment (2023)

Language from the FY23 NOAA Appropriations Bill:

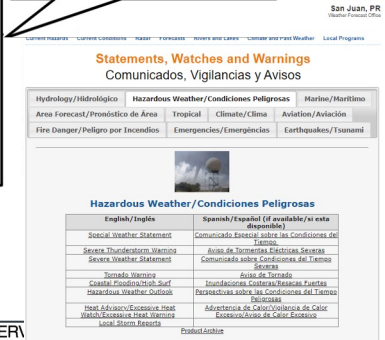
*"**Weather Alerts.**—The Committee appreciates the steps taken by NWS to provide Spanish translation of their weather products. However, more steps must be taken to ensure that all weather forecast and warning products can be understood by limited English proficiency individuals. Therefore, NOAA is directed, within the increases provided for NWS, to expand these efforts. **Further, no later than 90 days after the enactment of this Act, the Committee directs NWS to submit a plan and timeline for how it will provide translation of all its weather products and warnings, not just for Spanish, but for the main dialects of other commonly used languages**, considering both the number of speakers and the density of those speakers in various geographic locations. The Committee expects the fiscal year 2024 budget request to include additional funding for this purpose."*

How did the NWS do translations before AI?

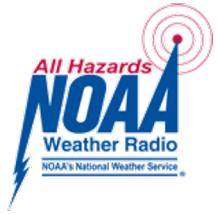


Best Practice: Spanish assistance through the SR Multimedia Assistance in Spanish Team was available during Hurricane Harvey, helping translate flash flood emergencies and messages into Spanish. (Page 56)

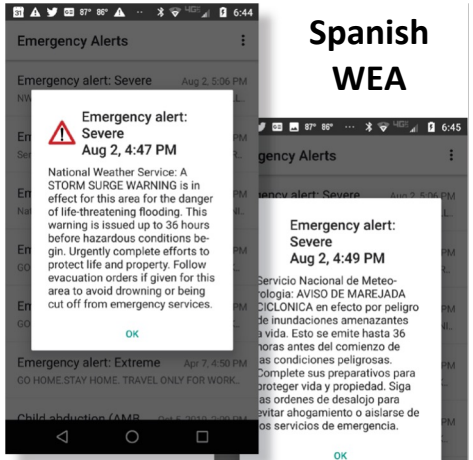
NWS MAS



NWS San Juan Text Products

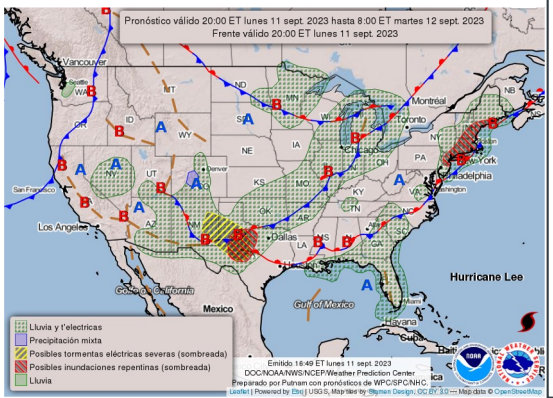


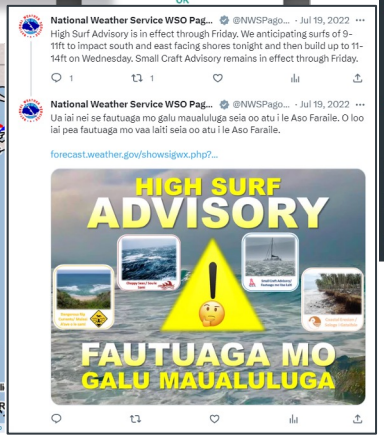
NWS SOT

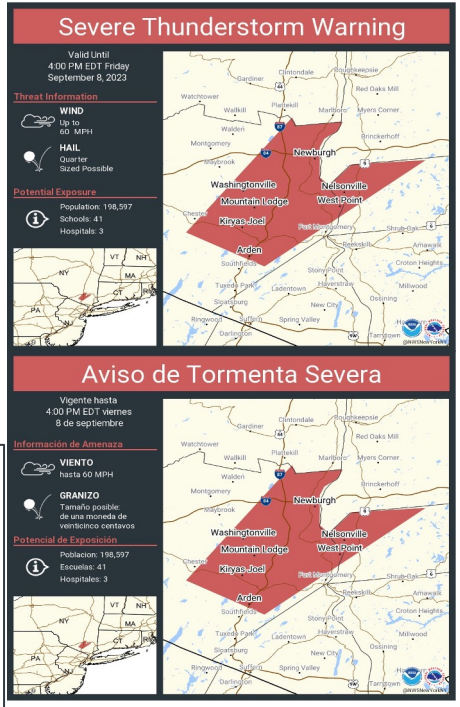


Spanish WEA

WPC Nat'l Fcst Chart

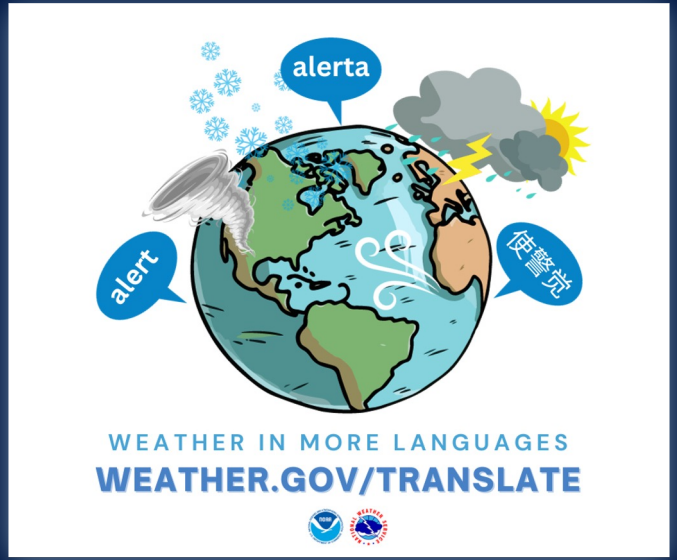






Spanish
Auto Twitter/X

Samoan
Text Products & Twitter



Methodology

National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Search NOAA sites

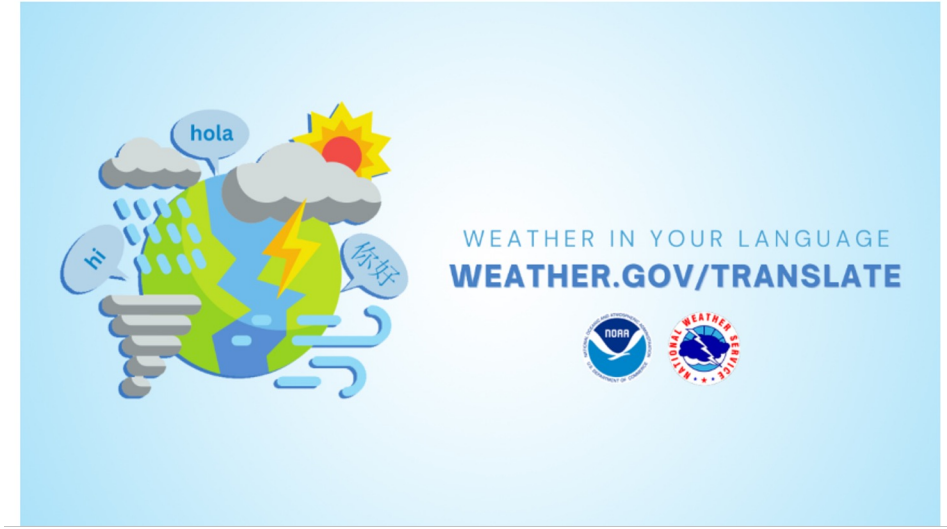
Home / News & Features

NOAA uses artificial intelligence to translate forecasts, warnings into Spanish and Chinese

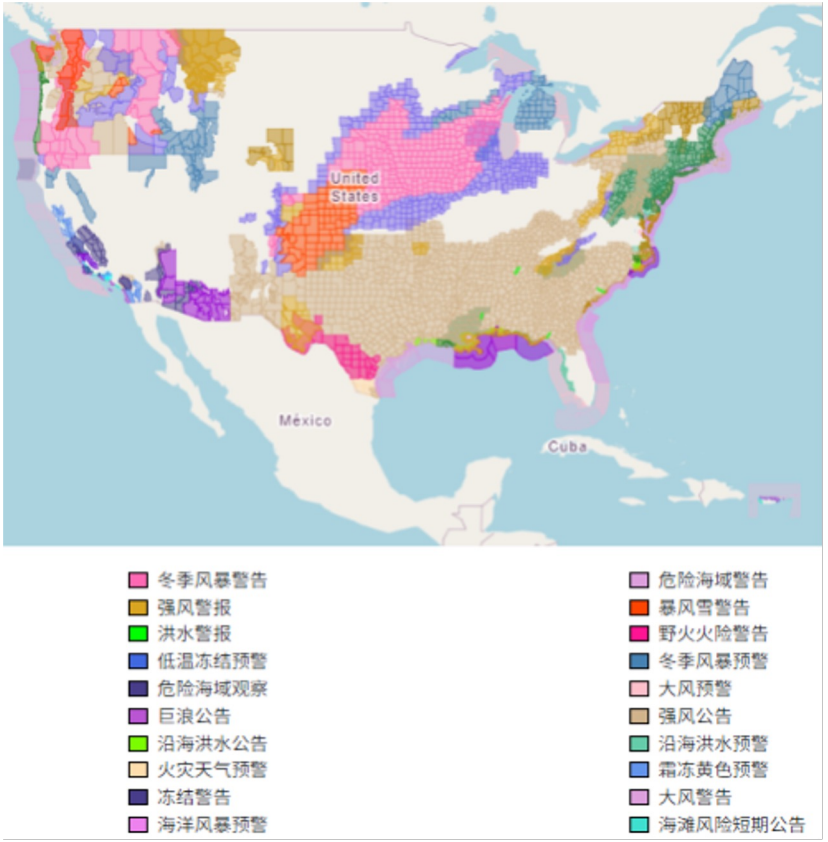
Project scalable to other languages in the future

Focus areas: Weather **Topics:** Science communication piece **Share:**

October 26, 2023



NWS Translate: Chinese hazard map - 1/8/24



AI Translation Objectives & Requirements

Availability:

- Critical weather information in a variety of languages
- Support for NWS offices without bi-lingual forecasters
- Wide access to the products (web, radio, WEA, API, etc)

Efficient:

- **Near real time translation** (A translated TOR does no good if it takes 15 min to translate)
- **Reduce burden of translation** workload on bi-lingual forecasters

Scalable:

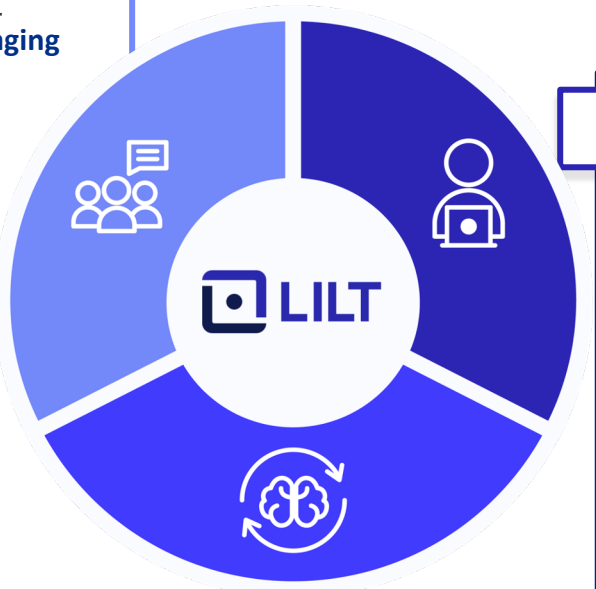
- NWS has many bi-ligual Spanish experts, but what about **unresourced languages** like Chinese, Vietnamese, etc…
- Train models on a variety of weather types across different locales via a “Balanced Diet” of English products
- Account for different dialects and words that do not have one for one translations

SYSTRAN LILT

3 Layers of Language Model Adaptation

LLM Training Strategy
- "Balanced Diet" of Wx messaging
- Multilingual Glossary
- Existing corpus? Cleanup!
  - Spanish:
  - Cleaned Previous Year Training Data
  - +9,000 corrections!

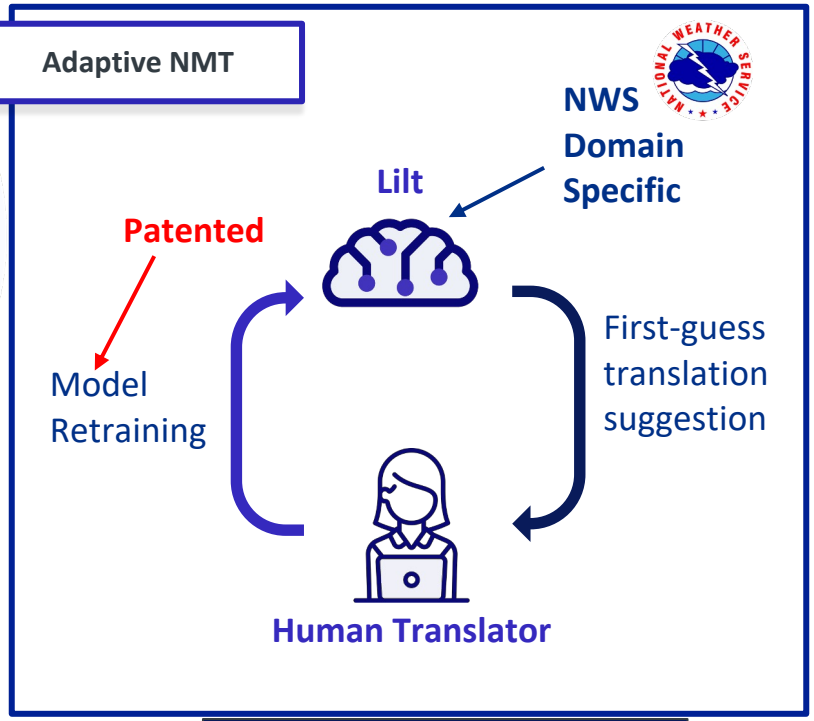
2021: 9,000 instances of "training the model to do something you **don't want**" in 44,000 corpus sentences



Synthetic Data
186 passages with variables (e.g. wind speed, rainfall range)

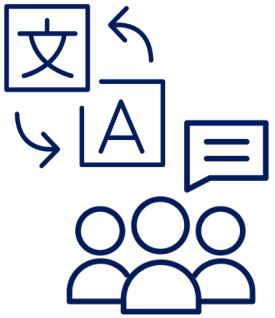
As Lilt learns NWS Terms & Language, the model becomes specialized

Adaptive NMT



Real-time AI Model Training

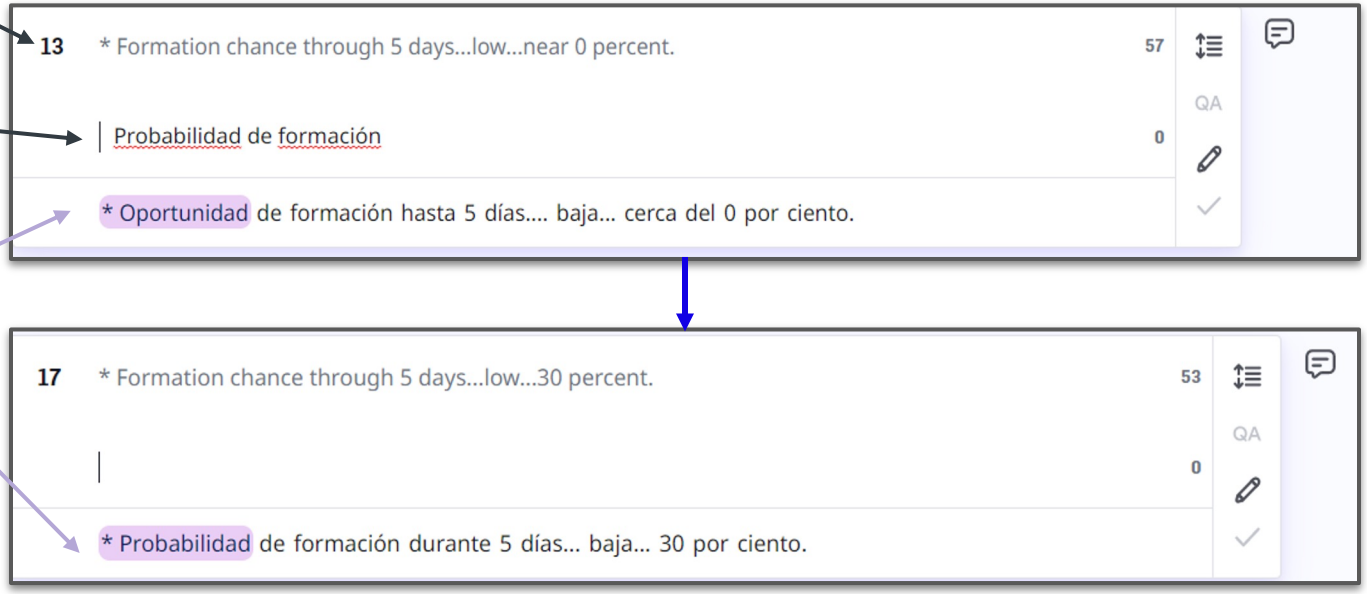
with Lilt's patented *human-in-the-loop* training capability



Product sentence number

Human entered text

NMT suggestion



NWS auto products with LILT

Office disseminates English product

AWIPS text trigger @ WFO kicks off a job/script

Script extracts text to be translated & pre-processing

Remove NWS 69 character wrapping, **converts plain text into .docx with LibreOffice

Script calls LILT translation process

LILT works on translation

Script receives translated text

Add NWS character wrapping back in

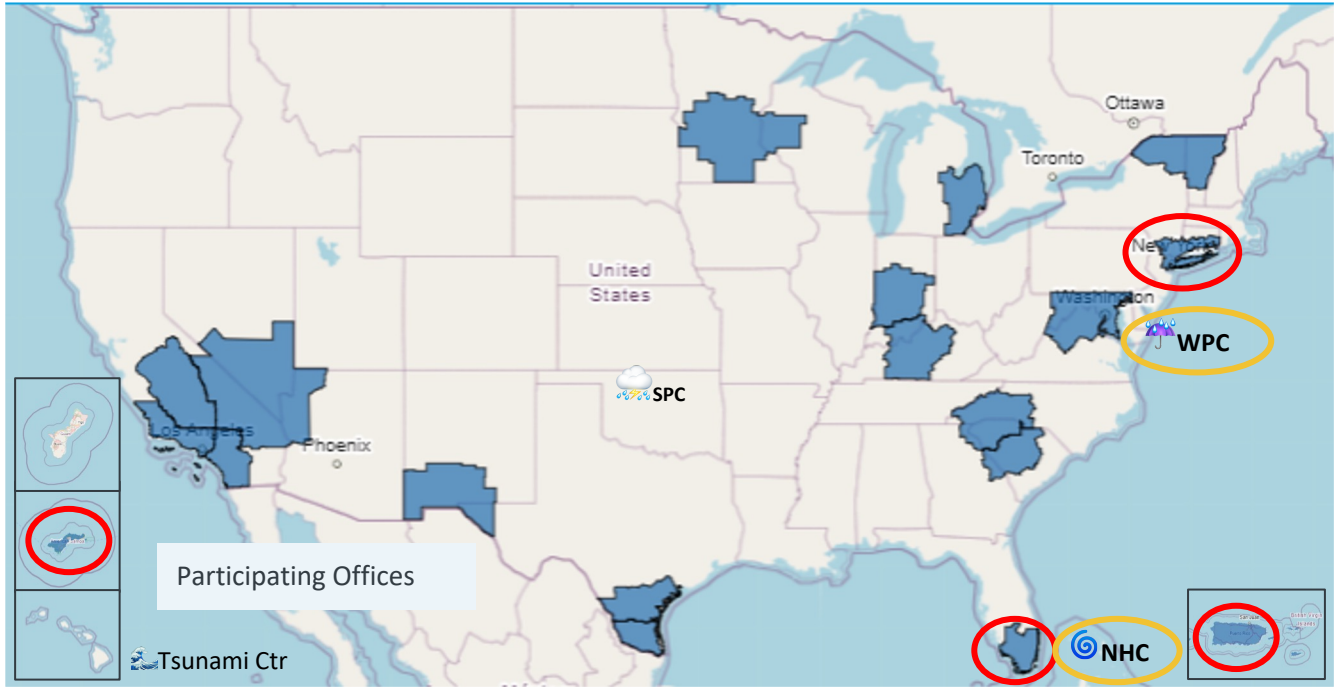
Script applies custom regex & pastes legal disclaimer

Script sends emails to email list (local + Emergency Managers)

Script posts translations to weather.gov/translate website & archives @ AWS S3 bucket

Workflow

Office Pilots & 2024+ Office Expansion



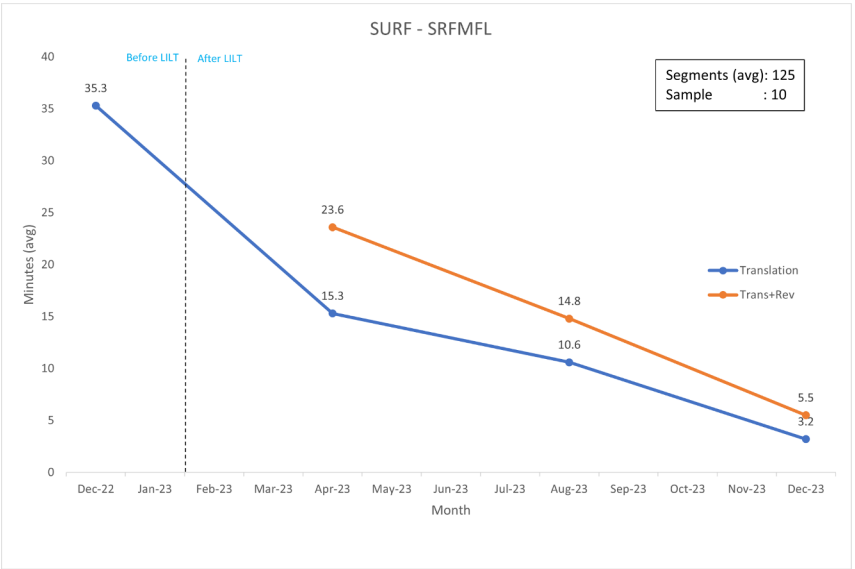
WFO	2019 CENSUS LEP Top 10 Language Count by greatest #'s (12 Total Grps)
Los Angeles ✅	11 languages
New York City ✅	11 languages
Washington/ Baltimore ✅	10 languages
Philadelphia	10 languages
Monterey/San Francisco	8 languages
San Diego ✅	8 languages
Boston	7 languages
Chicago	7 languages
Seattle	7 languages
Dallas/Ft Worth	6 languages

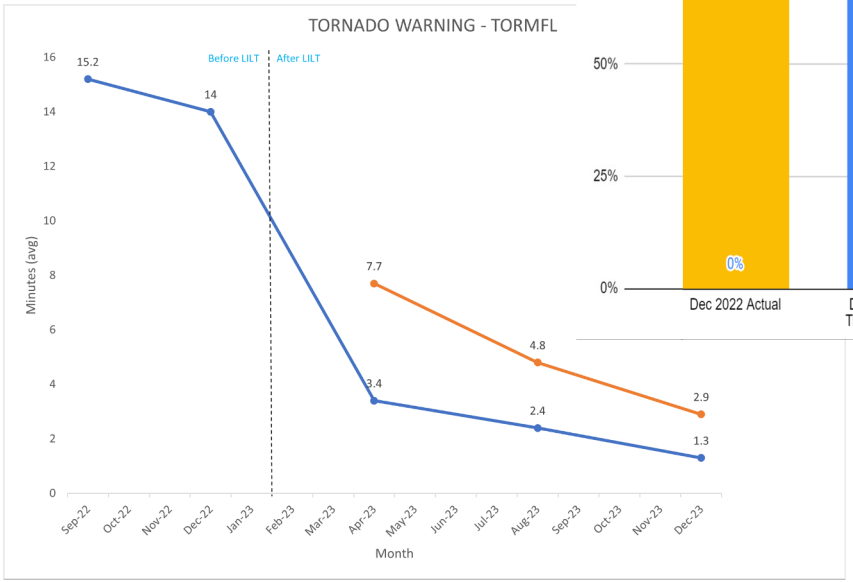
*** Pace of additional languages and Offices is determined by level of funding**

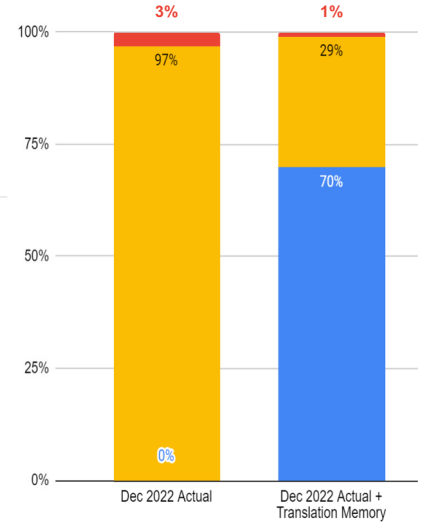
So how much time have we saved? - SJU & MFL

San Juan Forecasters drastically reduced translation time using Lilt!

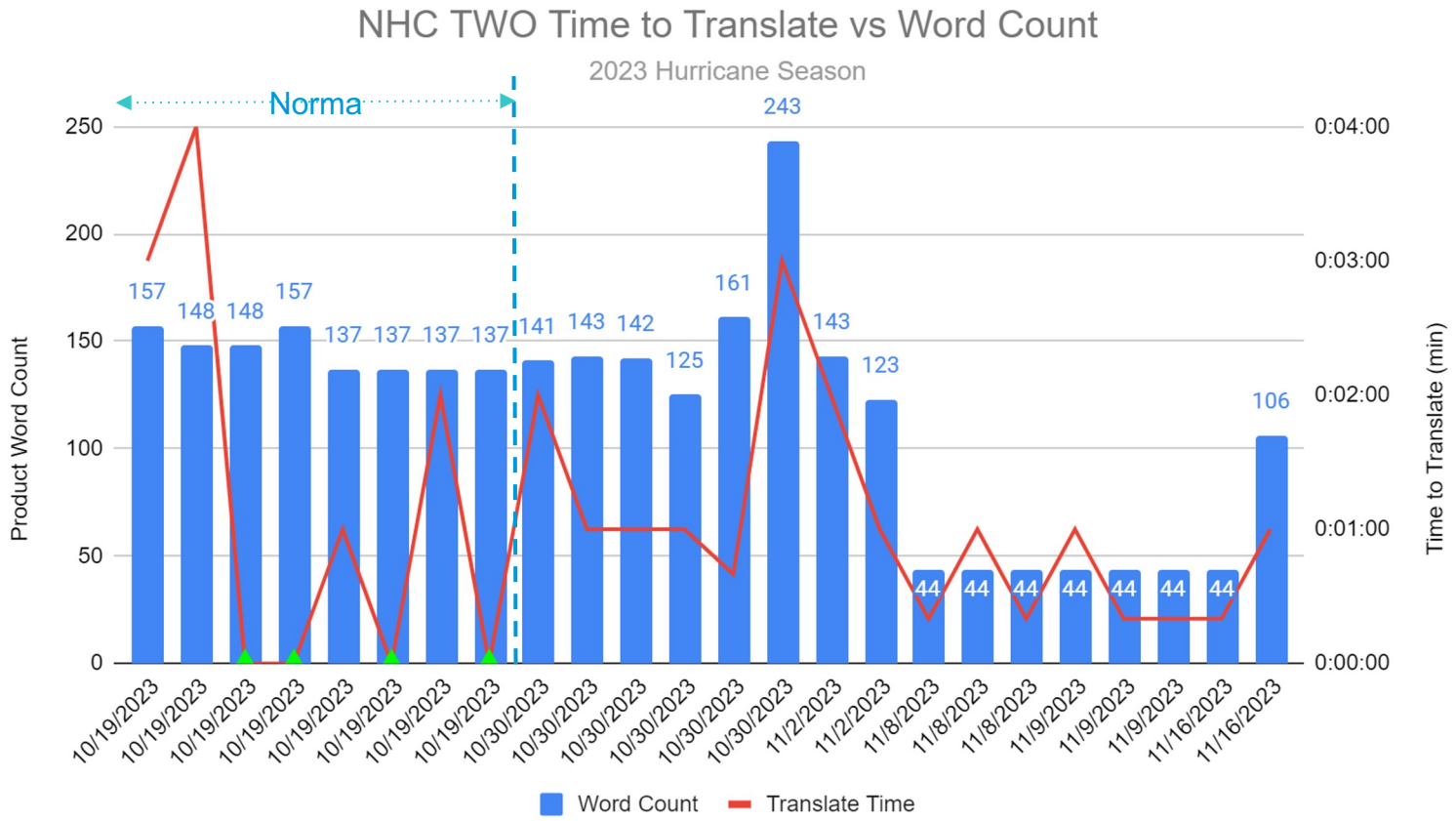
- TCP: ~45 mins -1 hour →10-15 mins(2022) → 5-7 mins(2023)
- TWO: ~10-30 mins → 2-5 mins
- Final result = only changing 1% of the words!



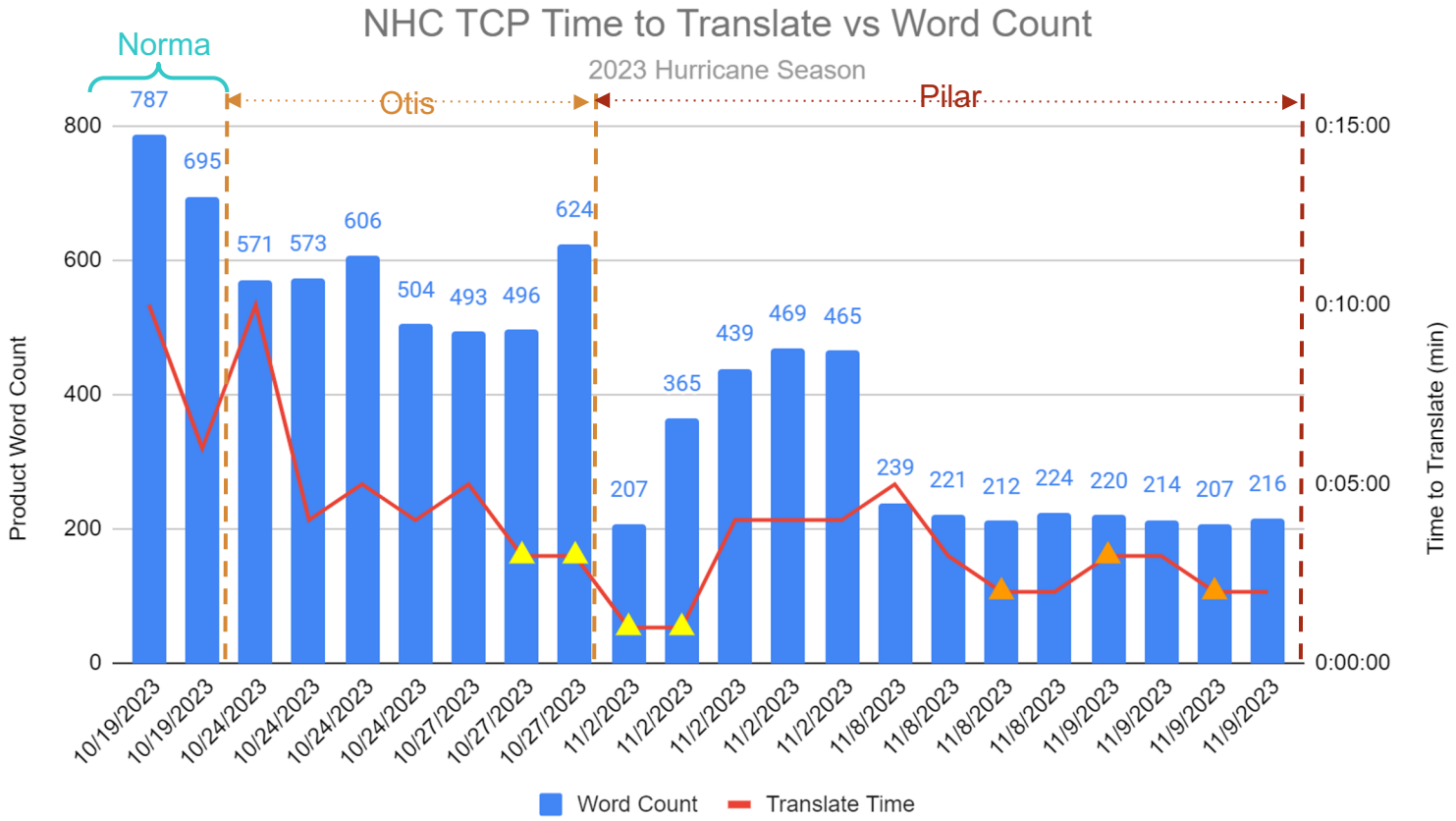




Time to Translate @ NHC - 2023



Time to Translate @ NHC - 2023



AI Success with NHC products - 2023

NHC quickly utilized Spanish AI translations for Key Messages during Hilary!

Mensajes Claves Sobre Hilary

Advertencia 14: 3:00 PM MDT sábado 19 de agosto de 2023

Este producto ha sido procesado automáticamente utilizando un programa de traducción y puede contener omisiones y errores.
El Servicio Nacional de Meteorología no puede garantizar la precisión del texto convertido. De haber alguna duda, el texto en inglés es siempre la versión autorizada.

1. Los preparativos para los impactos de inundaciones deben completarse tan pronto como sea posible, ya que las fuertes lluvias comenzarán con bastante antelación del centro. En el suroeste de los Estados Unidos, se espera que la cantidad potencialmente histórica de lluvia cause inundaciones repentinas, urbanas y de arroyo incluyendo deslizamientos de tierra, deslizamientos de tierra y flujos de escombros. Se esperan impactos de inundaciones peligrosos a localmente catastróficas tarde esta noche hasta temprano el lunes.

2. Se esperan condiciones de huracán a lo largo de la costa oeste y central de la Península de Baja California dentro del área de aviso de huracán esta noche y el domingo por la mañana, y son posibles en el área de Vigilancia de Huracán el domingo.

3. Se espera que las condiciones de tormenta tropical comiencen el domingo en porciones del suroeste de los Estados Unidos dentro del área de Aviso de Tormenta Tropical. Vientos podrían ser particularmente fuertes y con ráfagas en y cerca de áreas de terreno más alto. Se espera que las ráfagas de vientos se extiendan bien tierra dentro de los Estados Unidos

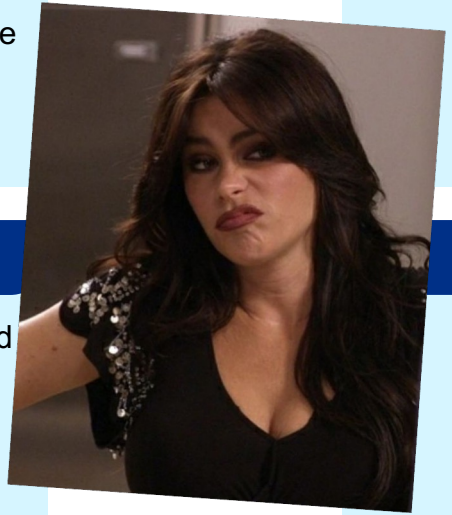
4. Grandes marejadas generadas por Hilary afectarán porciones de la Península de Baja California y el sur de California durante los próximos dos días. Estas marejadas probablemente causarán condiciones de oleaje y corrientes marinas que amenazan a la vida.

Para obtener más información visite la página web hurricanes.gov

Blooper Reel - Spanish

NWS Watches

Occasionally the model translates “**watch**” as “***reloj***” which means “***clock***” or “***wristwatch***” in Spanish as opposed to the correct term of “**vigilancia**” which means “**surveillance or to be watchful**”



Showers

- When untrained on NWS content, the model initially translated rain “**showers**” as “**duchas**” which really means “**showerheads**” or the “**act of showering**”!

Snow Accumulations

- The word "**accumulations**" was translated as "acusaciones" (**which in Spanish means accusations**). It should be "acumulaciones"
  - Additional snow *accumulations* of two to four inches above 10000 feet.

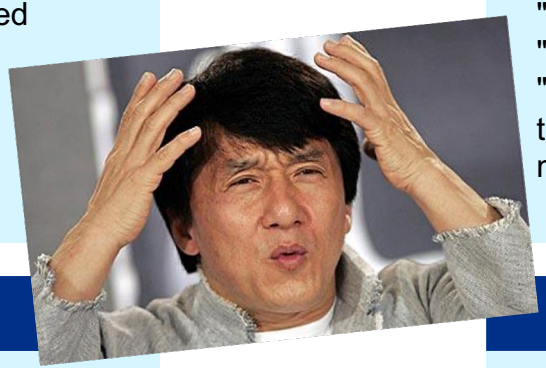
Troughs/Trofs

Sometimes the translation for “**trough**” comes out as “***el comedero***” or “***el abrevadero***” **which is a trough that farm animals eat or drink from** instead of the meteorological term “**vaguada**” for “**pressure troughs**”.

Blooper Reel - Chinese

Small Craft Advisory

For Small Craft Advisories, Lilt interpreted "**Small Craft**" as "***small pieces of art***"



Waterspout

"**Waterspout**" is incorrectly translated to "**tornado**". Elsewhere in the product "waterspout" is translated as either "water tornado" or "sea tornado", both of which are more accurate than just "tornado".

Tornado

Before being trained properly, **Tornado** Warning somehow translated to…

Torpedo Warning!

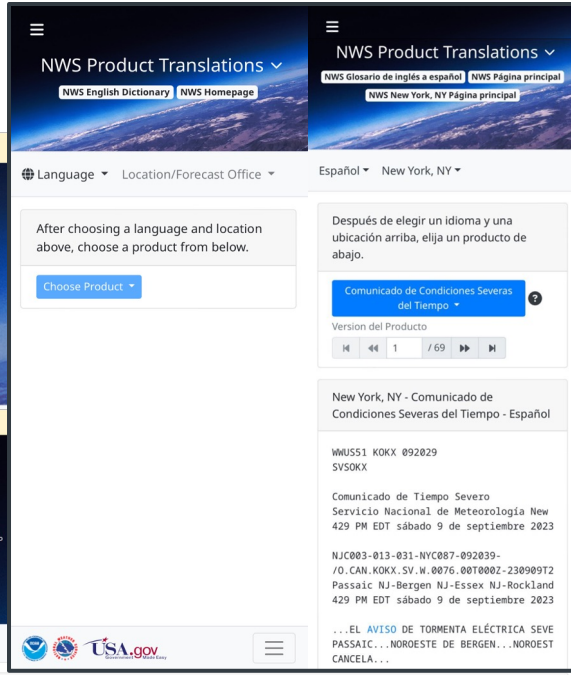
image credit: istockphoto

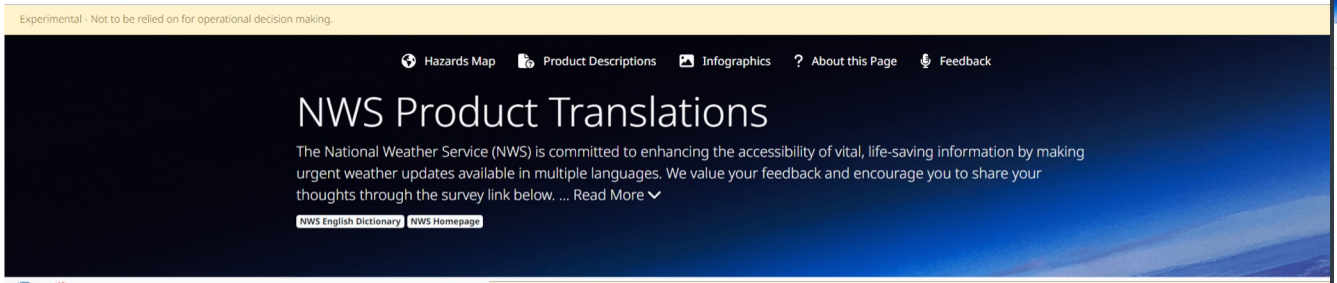
Weather Spotters

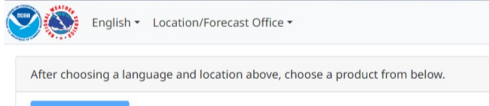
The word "**spotter**" in the Chinese was translated to "**sounder**". We've also seen instances of translations to "***trained detective***". We're probably looking for the equivalent of "*observer*".

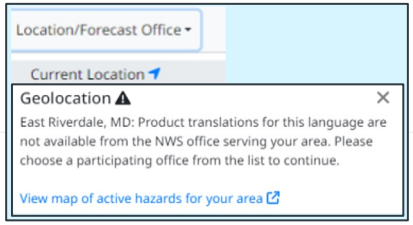
Experimental Website - Products

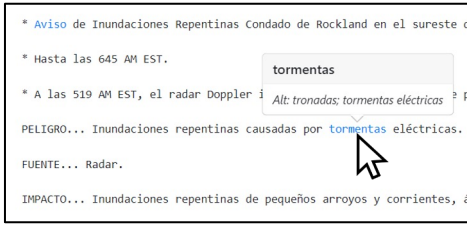
Mobile View:

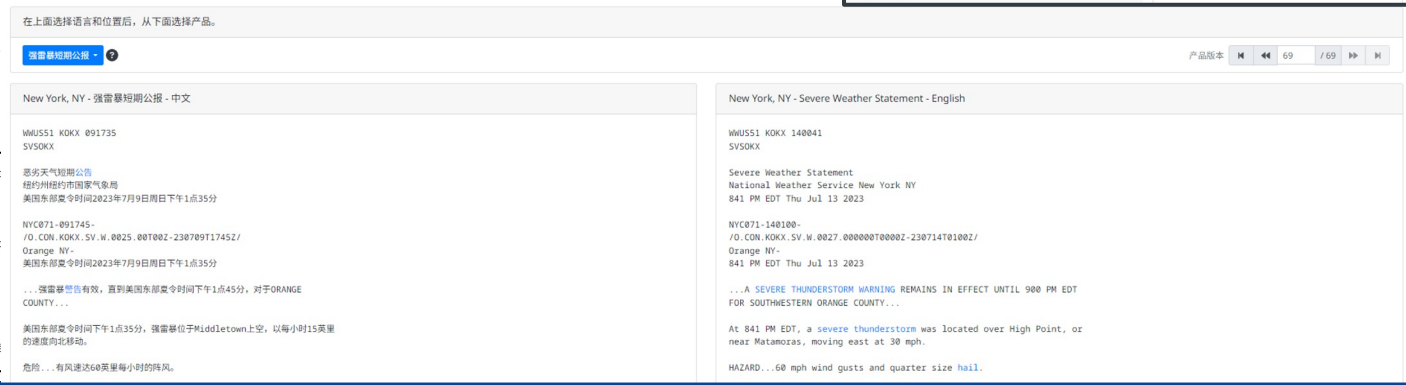










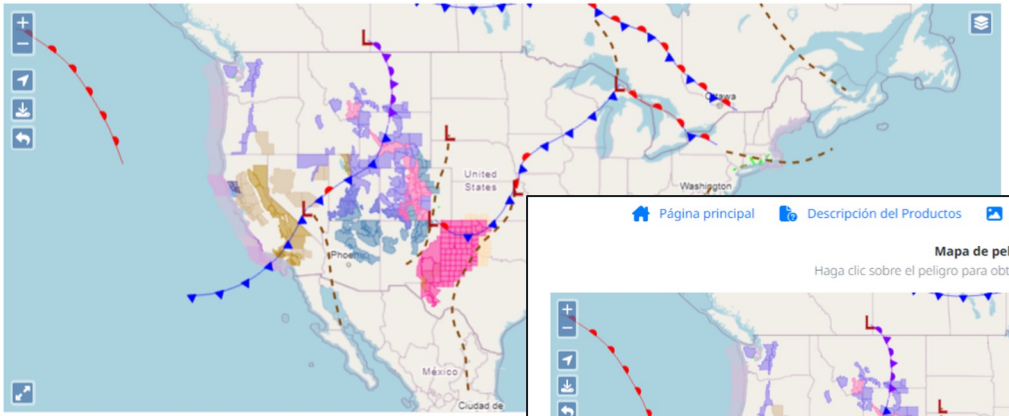


Experimental Website - Hazards Map

Homepage | Product Descriptions | Infographics | About this Page | Feedback

Hazards Map

Click on hazard for additional information



High and Low Pressure

- H High
- L Low

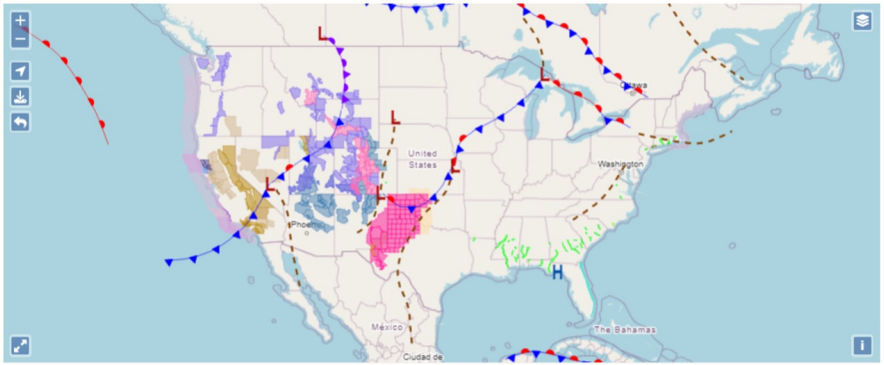
Fronts

- Cold Front
- Warm Front
- Stationary Front
- Occluded Front
- Pressure Trough

Página principal | Descripción del Productos | Infografías | Sobre esta página | Comentario

Mapa de peligros

Haga clic sobre el peligro para obtener información adicional



Alta y Baja Presión

- H Alta
- L Baja

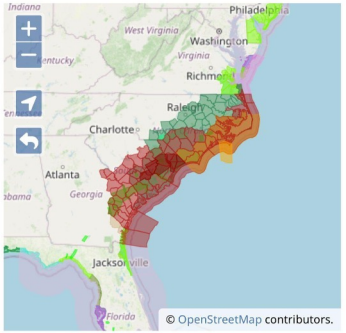
Frentes

- Frente Frio
- Frente Cálido
- Frente Estacionario
- Frente Ocluido
- Vaguada

Mobile View:

Mapa de peligros

Haga clic sobre el peligro para obtener información adicional



- Advertencia de Inundaciones Costeras
- Comunicado de Corrientes Marinas
- Adertencia para Embarcaciones Pequeñas
- Aviso de Tormenta Tropical
- Advertencia de Resacas Fuertes
- Comunicado de Peligros en la Playa
- Aviso de Galerna
- Aviso de Inundaciones Costeras
- Vigilancia de Inundaciones
- Advertencia de Viento
- Vigilancia de Inundaciones Costeras
- Vigilancia de Tornado
- Aviso Marítimo
- Aviso de Inundaciones
- Advertencia de Inundaciones

AI Translation Impacts

LEP People served by

NWS Upton:

Spanish: 1,617,782

Chinese: 387,886

Total CWA Pop: 17,573,514

2019 estimates

NYC Emergency Management

[EXTERNAL] Notify NYC - Advertencia de inundaciones repentinas

Notify NYC
To: Notify NYC

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe. Report suspected phishing emails with the Phish Alert Button or forward them to phish@oti.nyc.gov as an attachment.

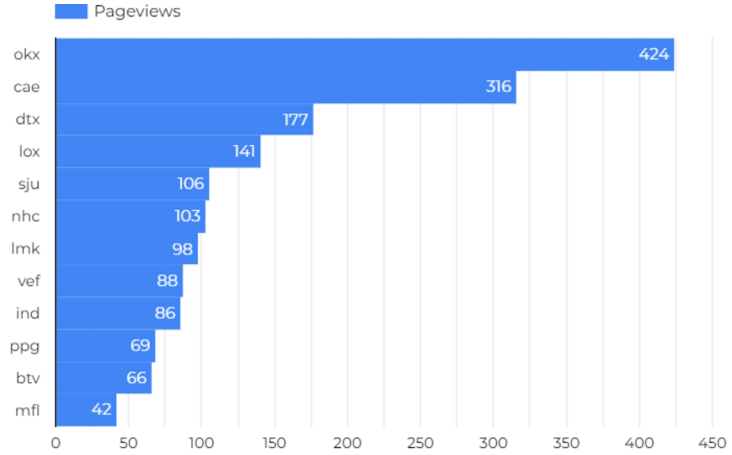
Notify NYC

El Servicio Meteorológico Nacional ha emitido lo siguiente:
Qué: Advertencia de inundaciones repentinas
Dónde: Manhattan, The Bronx
Peligros: Las fuertes lluvias causarán inundaciones en la ciudad, incluso en carreteras, calles y pasos subterráneos, así como en otras áreas bajas y de poco drenaje.

Medidas de preparación:
- Si está en un sótano, trasládese al piso más alto posible.
- No conduzca su vehículo por áreas donde el agua cubre el camino ya que es posible que la profundidad del agua sea mayor que la prevista y no sea seguro cruzar. Trasládese a zonas más altas.
- Si se corta la energía y tiene una discapacidad, necesidades funcionales y de acceso, o usa equipo de soporte vital (life-sustaining equipment, LSE) y necesita asistencia inmediata, llame al 911.
- Los tanques de combustible residenciales en sótanos inundados podrían tener filtraciones o romperse. Para informar un posible derrame de combustible en su casa, llame a la línea de emergencia por derrames del NYSDEC al (800) 457-7362. Para obtener más información sobre los derrames de combustible para calefacción residencial, visite http://www.dec.ny.gov/chemical/8428.html#response o llame al 311.

Para obtener información actualizada sobre el clima, visite https://www.weather.gov/translate/?wfo=OKX&lan=SPA
Este enlace lo llevará a una página web que no pertenece a la Ciudad.
La Ciudad no garantiza la precisión de la información o de las traducciones publicadas en esos destinos. Todas las preguntas relacionadas con el contenido deberán dirigirse a los respectivos propietarios.

Lifetime pageviews Oct 26 2023-Jan 2024



	Page Groupings	Pageviews
1.	Translate Home Page	11,452
2.	Hazards Page	6,429
3.	weather.gov/dtx/nwstranslatewebpage	869
4.	Infographics Page	613
5.	About Page	390
6.	Feedback Page	265
	Grand total	**20,018**

Para obtener información actualizada sobre el clima, visite https://www.weather.gov/translate/?wfo=OKX&lan=SPA
Este enlace lo llevará a una página web que no pertenece a la Ciudad.
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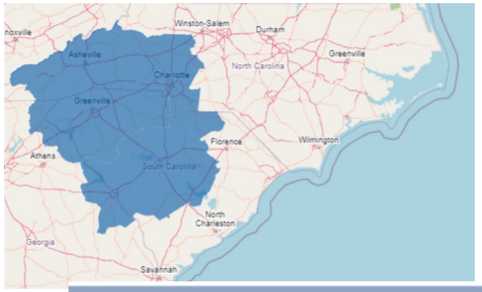
AI Translation Impacts

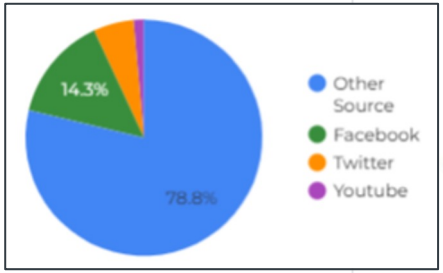


LEP People served by **NWS Columbia:**

Spanish: 28,378

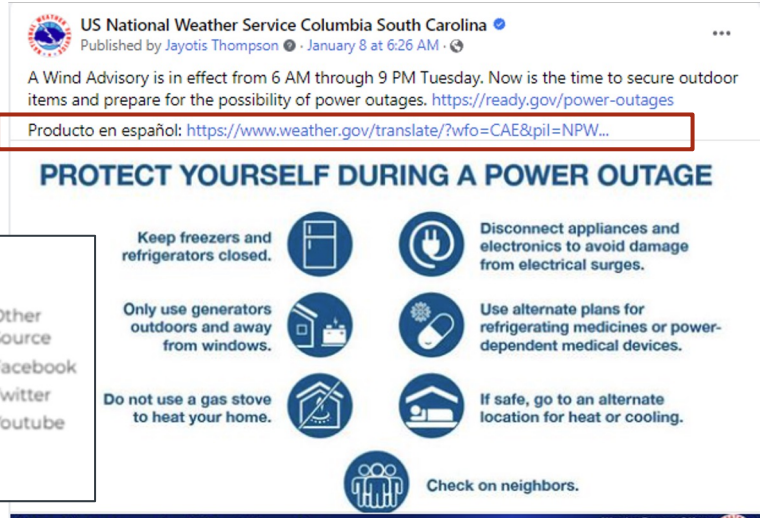
Total CWA Pop: 1,779,180

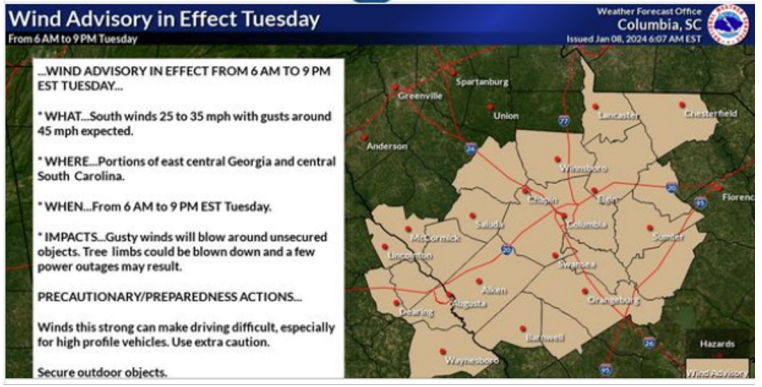
***2019 estimates**



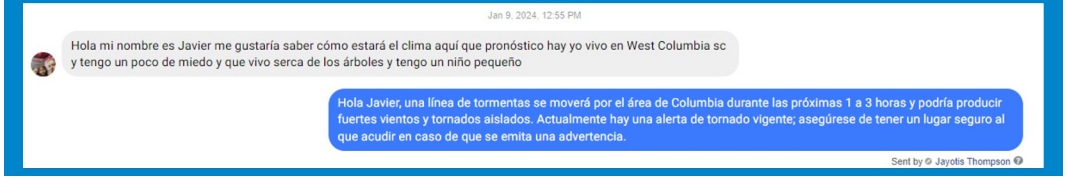
WFO	Pageviews...	Unique P...	New U...
cae	120	59	52
okx	53	23	9

weather.gov/translate/?wfo=cae&lan=spa&pil=npw	85
weather.gov/translate/?wfo=cae&lan=eng&pil=npw	37





"We have already seen an impact on having the translation available. **For the first time since I've been here, we had someone ask a question in Spanish as a direct message on FB. It was during our recent tornado event."**



AI Translation Impacts

LEP People served by
NWS Detroit:
Spanish: 49,131
Total CWA Pop: 5,574,843
2019 estimates

Lifetime pageviews Oct 26 2023-Jan 2024

Page	Pageviews
weather.gov/translate/	8.3K
weather.gov/translate/hazards.html	5.7K
weather.gov/dtx/nwstranslatewebpage	869
weather.gov/translate/infographics.html	370

"[The] team at the radio station are using the NWS Translate web page a lot. ***They are routinely reading the zone forecast and our winter headlines.***"

Radio Centro Multicultural

"Hispanic migration into Southeast Michigan from both Latin America and southern California, … do not understand how truly cold it can get in winter in Michigan. Up until 10 days ago, we were having an extremely mild winter, which gave a lot of the new arrivals a false sense of winter temps in Michigan…Through our webpages and the hazardous weather email notifications that we send to them, Luis said they ***were able to notify their listeners of the impending arctic air outbreak*** and tell them where to go if they needed winter clothing and a place to keep warm…***Centro Multicultural was prepared by having coats, hats, gloves and other cold weather apparel on hand to distribute.***"

Planned Future Capabilities

1. Incorporate translated text, and broadcast over NOAA Weather Radio with existing infrastructure
2. NWS-wide automated Spanish AI translations via Google Drive drop folder
3. AI driven Twitter/X posts in Chinese + more languages to come
4. Spanish CAP format - pave the way for more languages translated in WEA messages
5. AI translation eventual integration into weather.gov 2.0 website re-vamp

WRN
Weather-Ready Nation

Thank you!

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nws.translate@noaa.gov