



Sunshine with a chance of smiles 🌤️

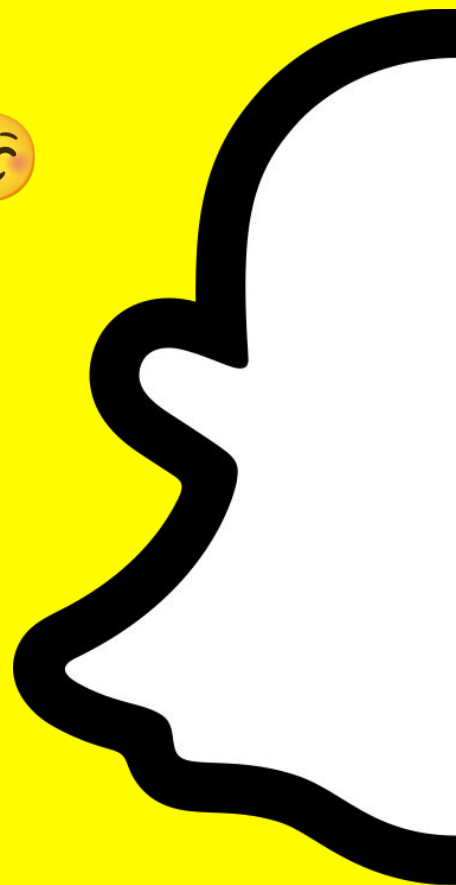
# Weather impacts expressed sentiment on social media

*Julie Jiang,<sup>1,2</sup> Nils Murrugarra-Llerena,<sup>2</sup> Maarten W. Bos,<sup>2</sup>  
Yozen Liu,<sup>2</sup> Neil Shah,<sup>2</sup> Leonardo Neves,<sup>2</sup> Francesco Barbieri<sup>2</sup>*

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@ ISRE 2022



# Motivation

“Beach day”



state-of-the-art  
sentiment classifier:  
?

# Motivation

“Beach day”



state-of-the-art  
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**NEUTRAL**

# Motivation

“Beach day”



state-of-the-art  
sentiment classifier:  
**NEUTRAL**

**Los Angeles**

**SATURDAY**



**Weather is  
AMAZING**



Contextually-aware classifier:  
**POSITIVE**

# Background

Weather impacts our **mood**  
and **behavior**

(e.g., Howard & Hoffman, 1984)

- Sun => happy
- Too hot => aggressive
- Too humid => irritable
- Rain => depression

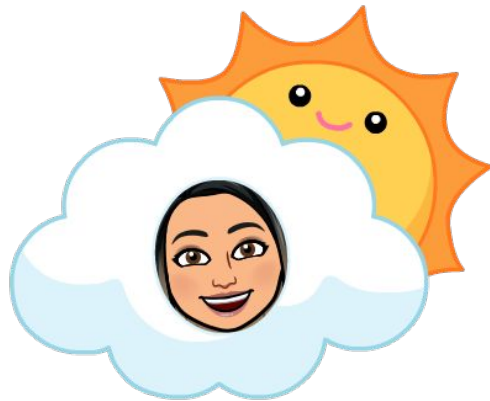
It can predict...

- The stock market (Chang et al., 2008)
- The housing market (Hu & Lee, 2020)
- Crime rate (Chen et al., 2015)
- Dating prospects (Guéguen, 2013)



## Related work & gaps

- Weather predicts sentiment on social media (Hannak et al., 2012)
- Rain-induced emotional contagion on social media (Coviello et al., 2014)

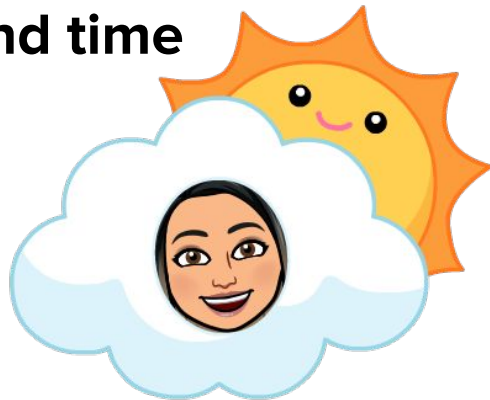


## Related work & gaps

- Weather predicts sentiment on social media (Hannak et al., 2012)
- Rain-induced emotional contagion on social media (Coviello et al., 2014)

But there's little research on ...

- Impact of weather **controlling for location and time**
- Impact of **historical** weather



# Research Questions

**RQ1 MODELING:** Does weather **improve** sentiment detection?

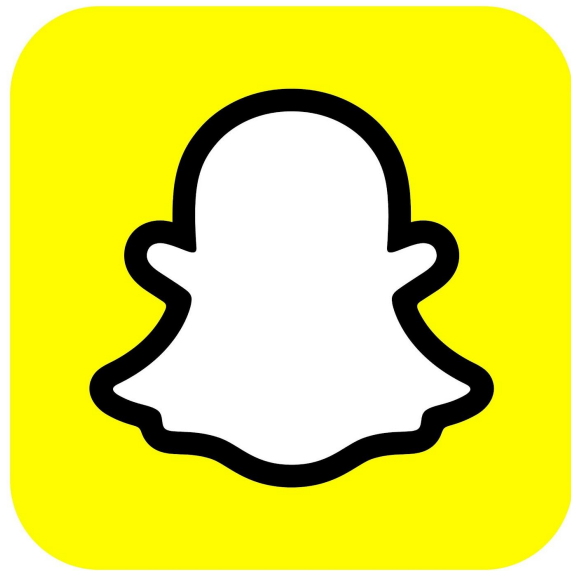
**RQ2 ANALYSIS:** How does weather **impact** sentiment?





# Snapchat data

- 8M **Public Snapchat Stories** from 2020
  - 3K annotated
- **Textual feature:** the caption
- **Contextual features:**  
location, time, and weather
  - Current weather
  - Historical weather



## WEATHER DATA

Hourly  
(exact)

Daily  
avg

3 days

1 wk

2 wks

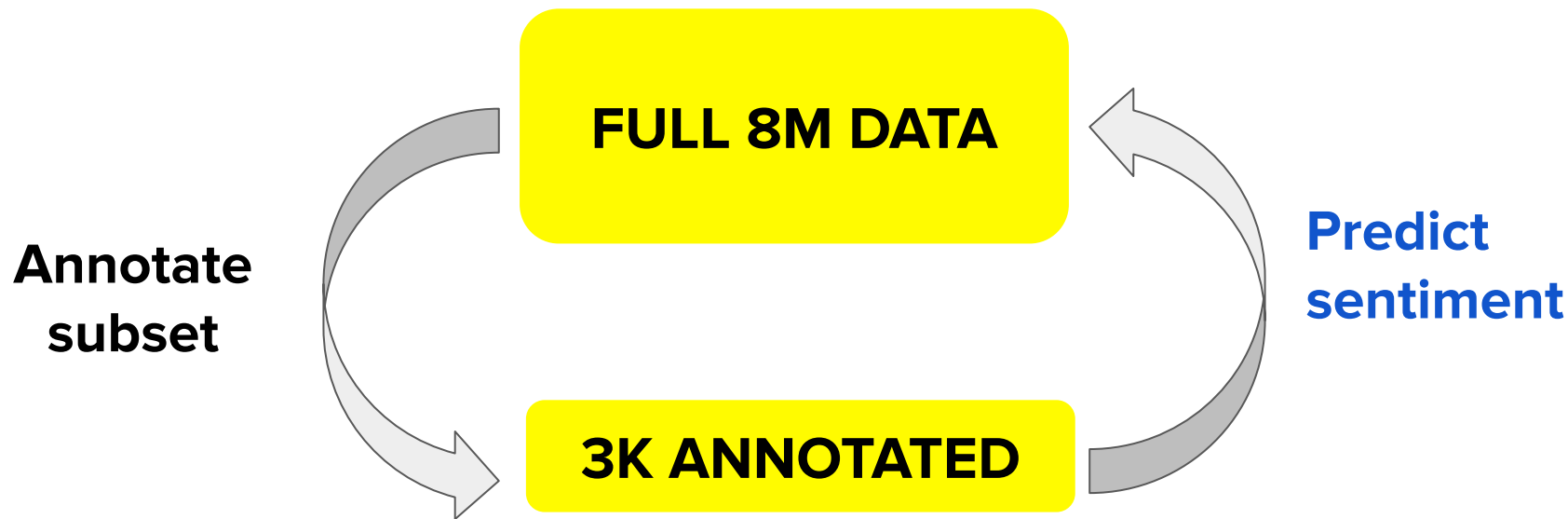
4 wks

8 wks

Historically averaged weather prior to the day of the Snap

# Workflow

**RQ2: examine weather impact**



**RQ1: Train/val models**



## RQ1 MODELING

Does weather **improve** sentiment detection?

## RQ1: Result

	Score	%
<b>LANGUAGE ONLY</b>		
RoBERTa-base	65.07	
Snap-RoBERTa (SR)	74.23	
<b>LANGUAGE+CONTEXT</b>		
		(from SR)
SR+Weather+Location+Time	<b>76.64</b>	3.2%*

$\frac{1}{2}$  F1-Macro +  $\frac{1}{2}$  Pearson  
*Classification*      *Regression*

\* *significant improvement ( $P < 0.05$ )*

**RoBERTa** is the state-of-the-art language model in natural language processing (NLP)

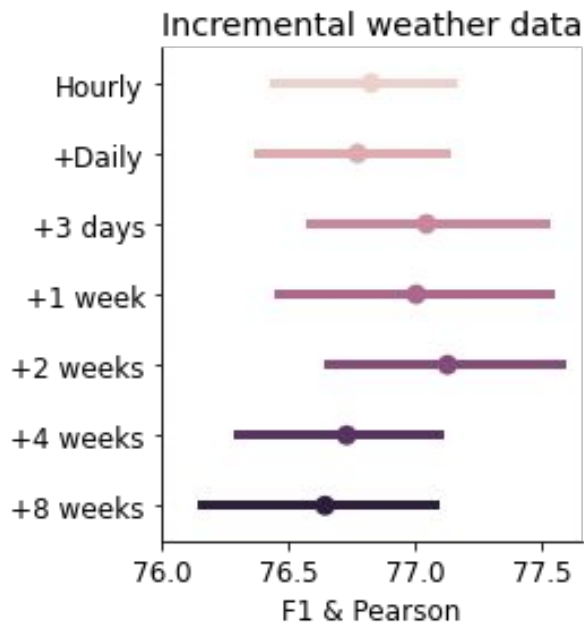
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<b>CONTEXT ABLATION</b> (from SR)		
<b>SR+Weather</b>	<b>76.46</b>	<b>3.0%*</b>
SR+Time	75.85	2.2%*
SR+Location	75.77	2.1%*

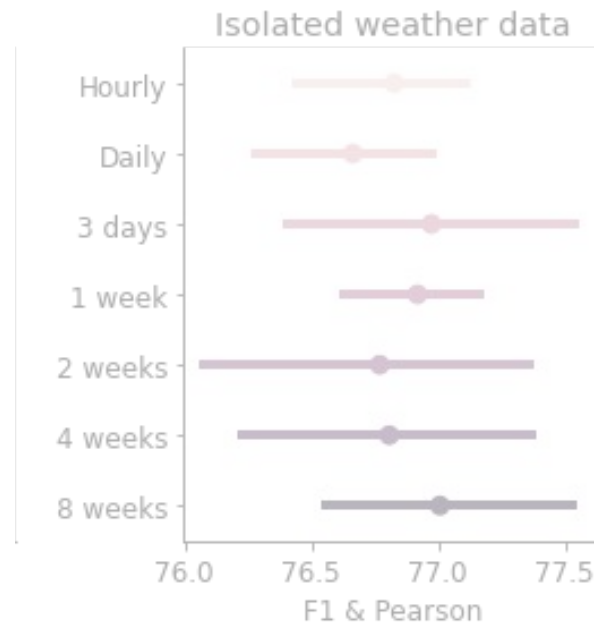
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# Weather ablation

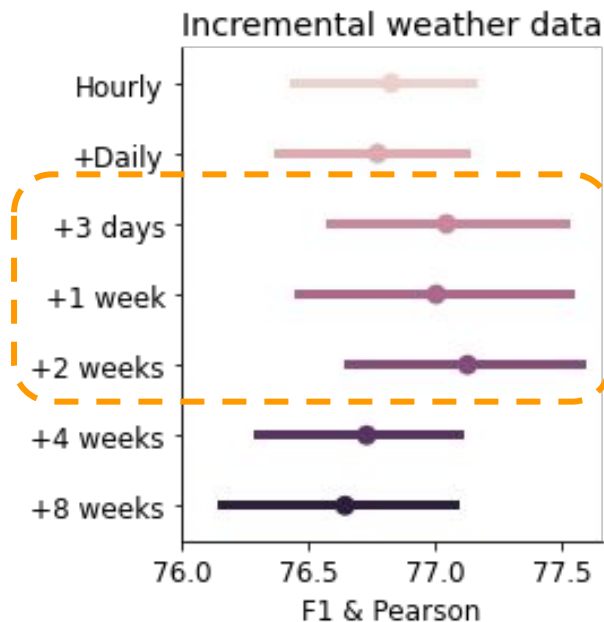


**How much historical weather info is needed for good performance?**

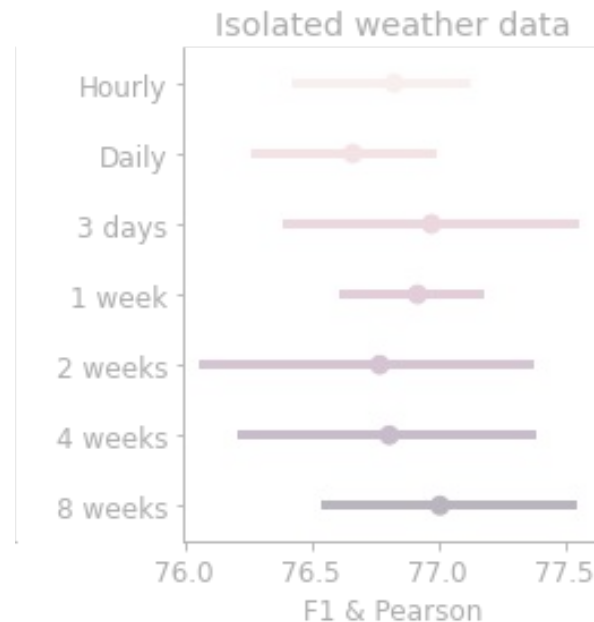


**Weather from which timeframe is the most important?**

# Weather ablation

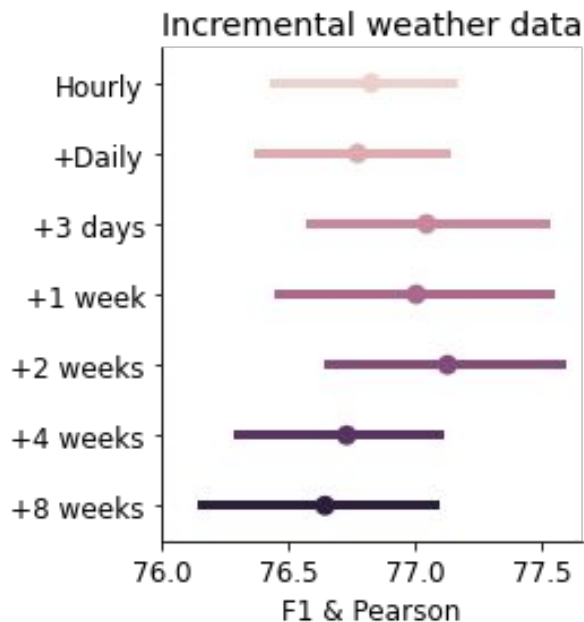


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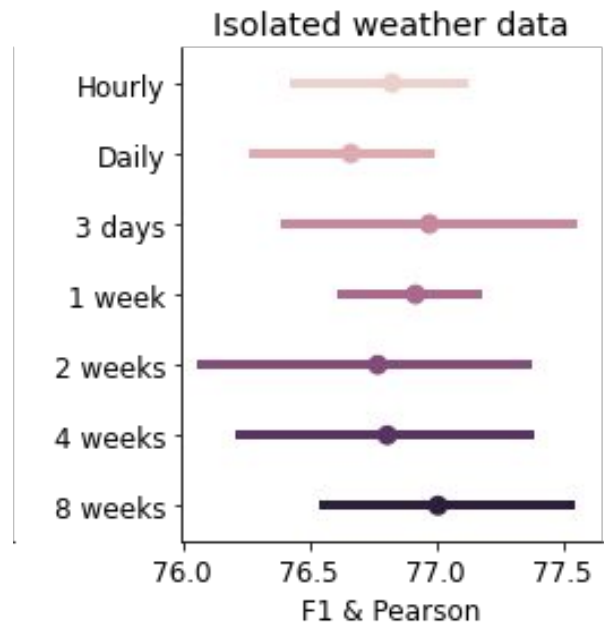


**Weather from which timeframe is the most important?**

# Weather ablation



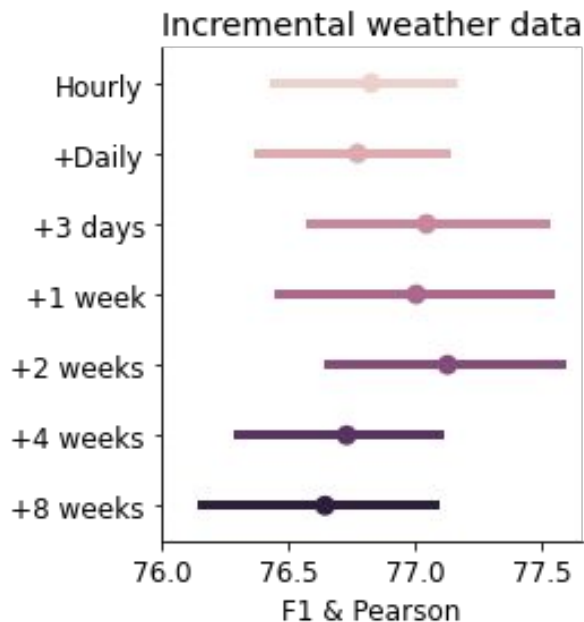
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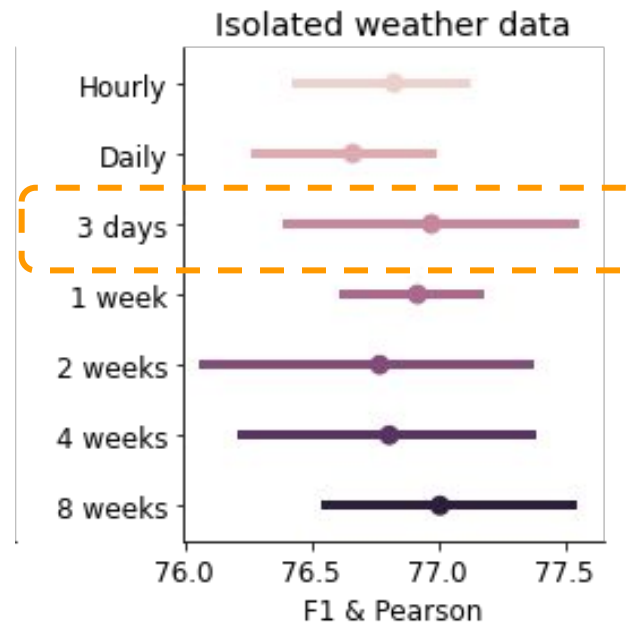
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# Weather ablation



**How much historical weather info is needed for good performance?**



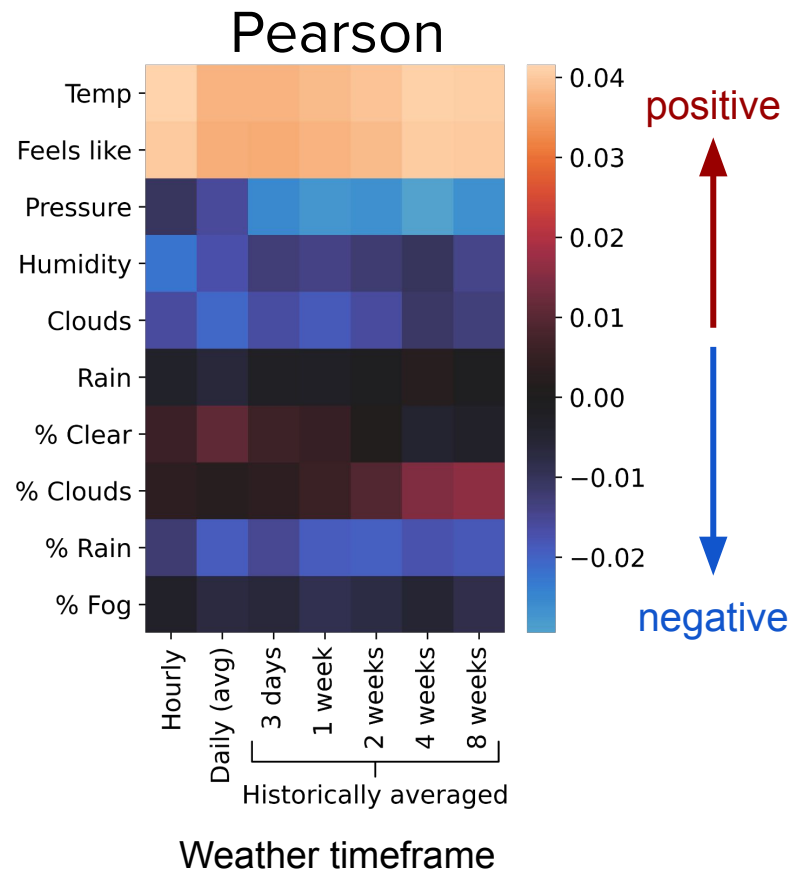
**Weather from which timeframe is the most important?**



## RQ2 Analysis

How does weather **impact** sentiment?

## RQ2: Weather-induced sentiment

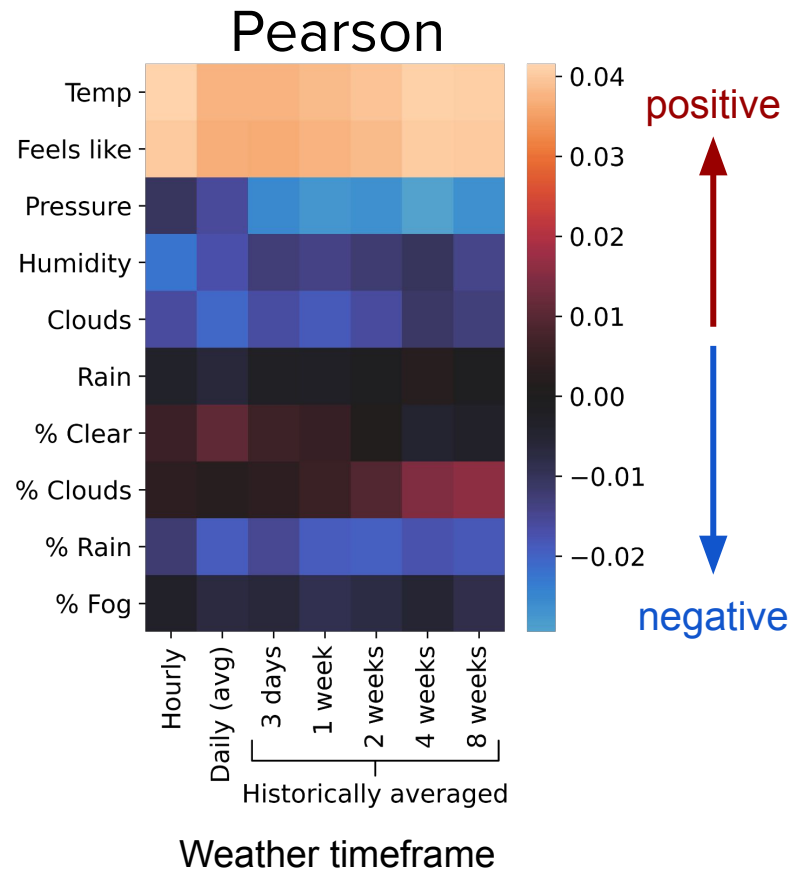


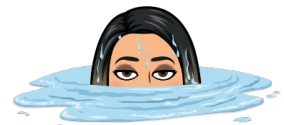
## RQ2: Weather-induced sentiment

High temperature and % clear weather are **positively linked** with sentiment

Pressure, humidity, rain, and clouds are **negatively linked** with sentiment

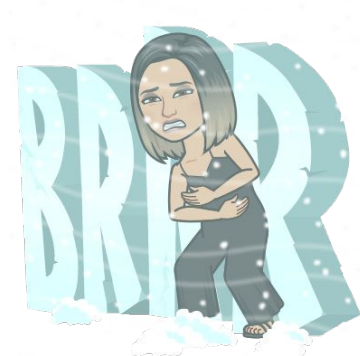
Weather has a **lasting impact** on sentiment



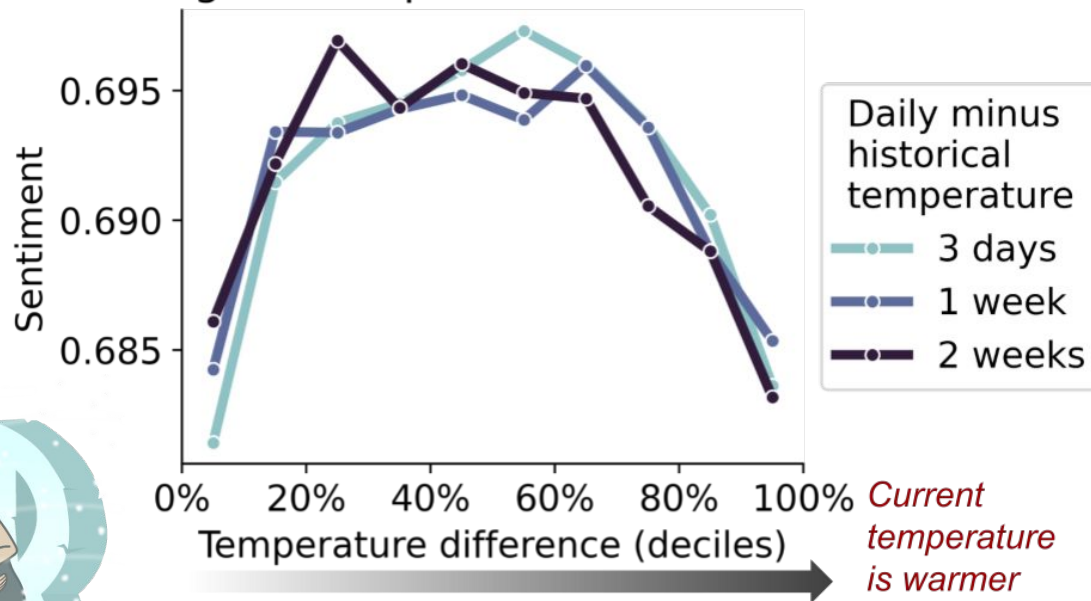


# Weather-induced sentiment

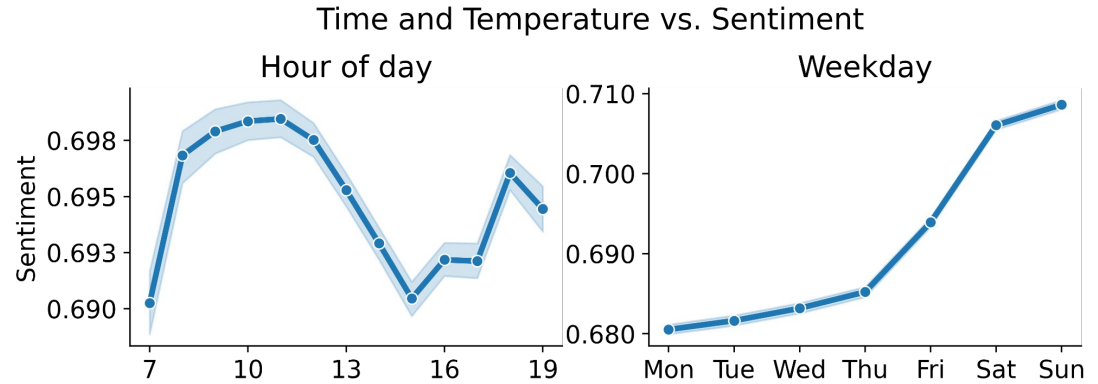
Sentiment declines both when the current temperature is too **hot** and too **cold** compared to previously.



Change in Temperature vs. Sentiment



# Time and sentiment

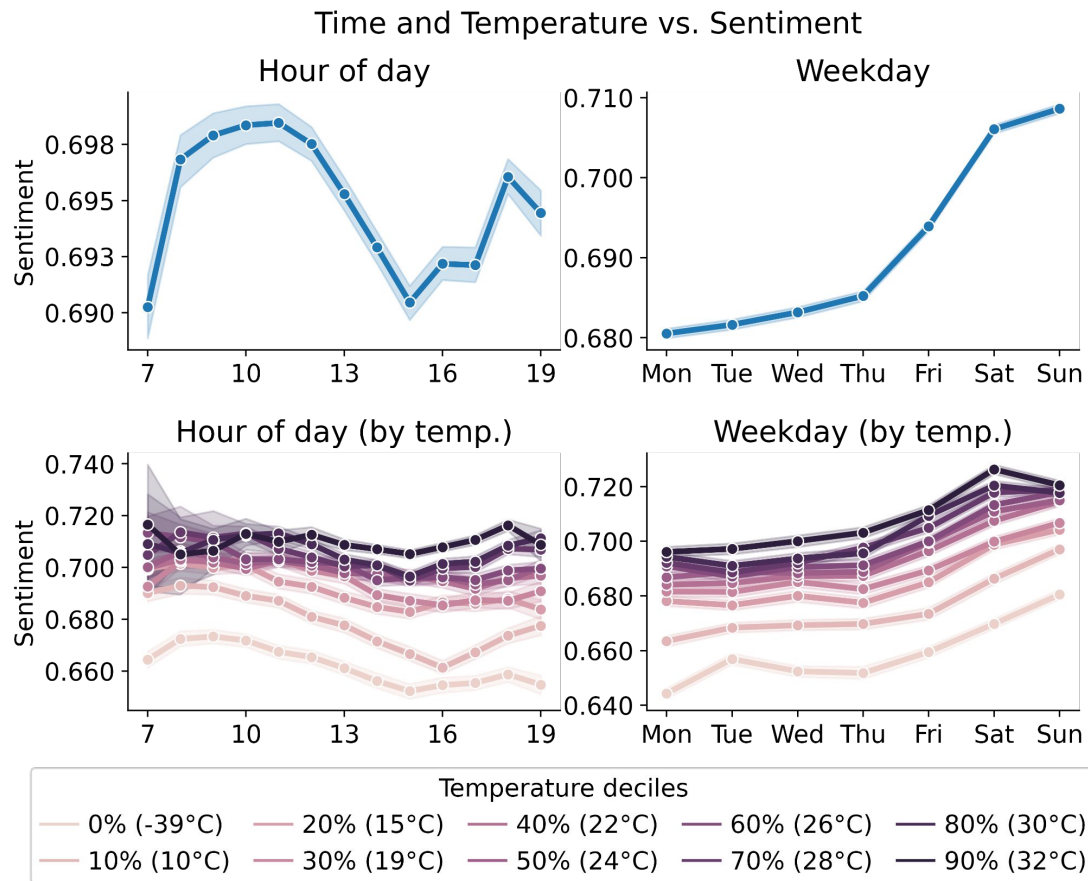


**AFTERNOON  
SLUMP**



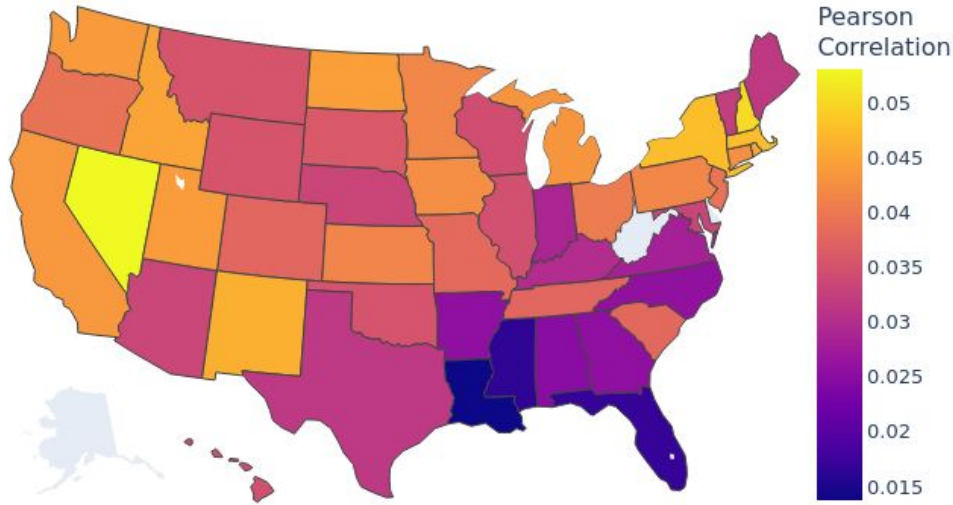
# Time and sentiment

Sentiment is  
**consistently higher**  
when the weather is  
**warmer** controlling for  
time



## RQ2: Location and sentiment

Pearson corr. of temperature  
and sentiment by state



LA has the **biggest**  
decline in expressed  
sentiment due to  
temperature drops  
and rainfall



# Conclusion

## RQ1 MODELING:

- Contextual factors **improve** language modeling
- **Weather** is the most important contextual factor

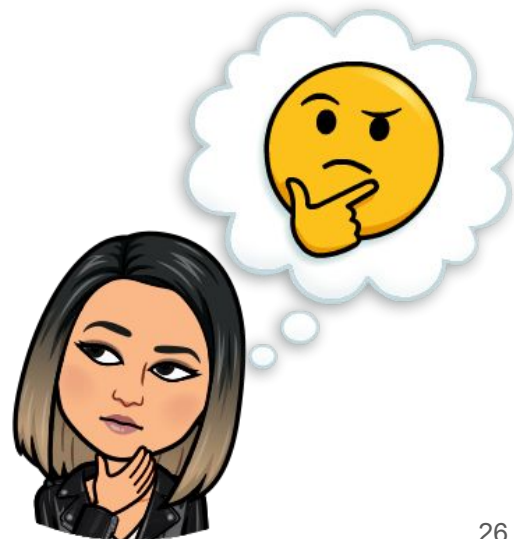


## RQ2 ANALYSIS:

- Weather is significantly **correlated** with expressed sentiment
- Mood sensitivity to changes in weather depends on **location** but does not vary much with **time**

# Implications

- Large-scale empirical proof of weather's impact on expressed sentiment
- Weather's effects on expressed sentiment appears to be **implicit** rather than explicit





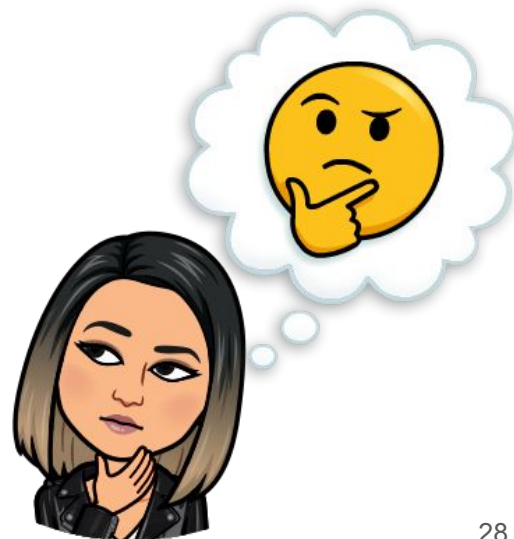
Jiang, Julie, Nils Murrugara-Llerena, Maarten W. Bos, Yozen Liu, Neil Shah, Leonardo Neves, and Francesco Barbieri.

**Sunshine with a Chance of Smiles: How Does Weather Impact Sentiment on Social Media?**

*In Proceedings of the International AAAI Conference on Web and Social Media*, vol. 16, pp. 393-404. 2022.

# Implications

- Large-scale empirical proof of weather's impact on expressed sentiment
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# Ethical considerations

- We can improve user content understanding **without private user information**
- Data used in this research are all public
- Users cannot be identified

## Additional experiment on Twitter

<b>BERT</b>	<b>Context</b>	<b>Score</b>	<b>%</b>
Twitter-roBERTa-base-sentiment		75.85	
Twitter-roBERTa-base-sentiment	+W+L+T	77.19	1.34%*
Snap-roBERTa		63.87	
Snap-roBERTa	+W+L+T	72.69	8.82%*
Twitter-roBERTa-base		61.46	
Twitter-roBERTa-base	+W+L+T	70.44	8.98%*
BERTweet-base		60.35	
BERTweet-base	+W+L+T	68.09	7.74%*

# Annotation

Dataset	IRA	Fleiss' $\kappa$	G&K's $\gamma$
Snapchat	0.69	0.49	0.88
Twitter	0.47	0.25	0.75

Table 1: Both the Snapchat and Twitter datasets have average inter-rater Gammas over 0.70, indicating good reliability of the annotations.

- Sentiment is inherently ambiguous and objective
- **Soft labels:** probability distribution over the individual rater's annotations
  - Regression (metric: pearson)
- **Hard labels:** majority rating
  - Classification (metric: macro-F1)