Determining Wind Speed Discrepancies in Climate Reanalysis Models for Newfoundland and Labrador

Capstone Presentation

David St. George
College of the North Atlantic
GIS Post-Diploma Program
Project Advisor: Dr. Joel Finnis
March 26, 2021

PRESENTATION SUMMARY

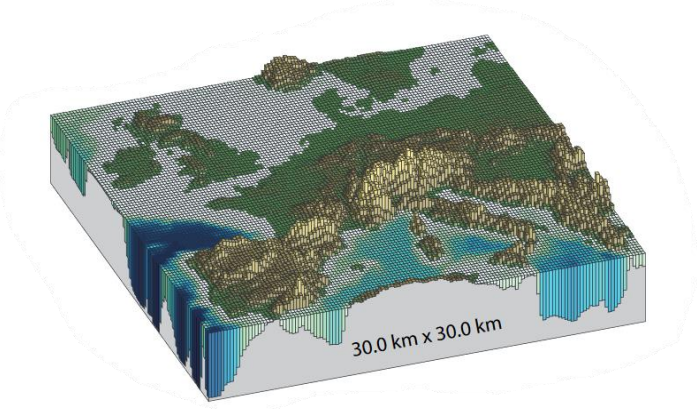
- What is Climate Reanalysis?
- Project Objectives
- Methodology
- Analysis
- Discussion

WHAT IS CLIMATE REANALYSIS?

- Simulation or model intended to reconstruct historical climate
- Produced from modern forecast models massaged with observation records
- Objective to “map” the trajectory of climate through time

PROJECT OBJECTIVE

- Using observational data at 17 weather stations between 1984-2013 to assess the accuracy of **two** climate reanalyses:
    - North American Regional Reanalysis (NARR) – National Oceanic and Atmospheric Administration
    - ERA5 - European Centre for Medium-Weather Forecasts (ECMWF)



PROJECT OBJECTIVE

- Measure accuracy using following metrics:
    - Analysis of Variance (ANOVA)
    - Descriptive Statistics (Mean, Median, Range, Absolute Deviation)
    - Comparative Statistics (Root Mean Square Error, Mean Square Error, Mean Absolute Error, Correlation)
    - Extremes Analysis (Mean/Median/Max # of Days per Month a Threshold Value is Passed)
- Final deliverable provided in CSV files

METHODOLOGY

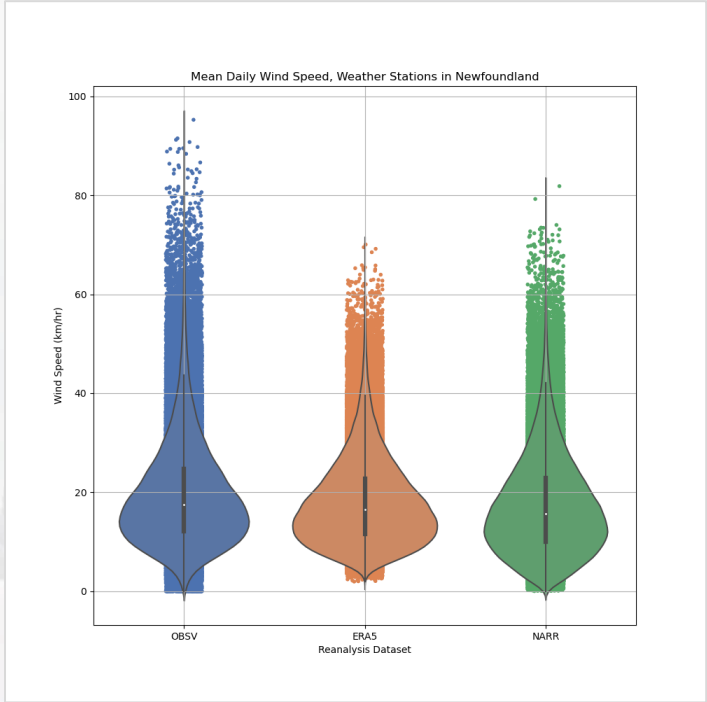
- Used *xarray* module to calculate magnitude wind speed, resample data, and convert to *pandas* dataframe
- *pyproj* package to reproject weather station latitude, longitude coordinates to appropriate cell location in NARR reanalysis
- *pandas* embedded functions and *scikit-learn* package to perform statistical computations
- *seaborn* and *matplotlib* packages used to present and visualize data

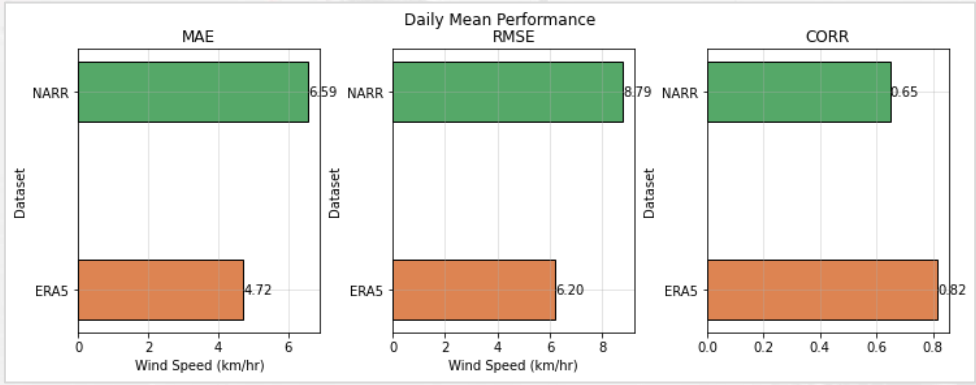
ANALYSIS (OVERVIEW)

- Analysis conducted in three phases:
  - Daily Means
  - Seasonal Means
  - Seasonal Means, Grouped by Location
- Allows for gradually increased granularity, identify trends in data

ANALYSIS

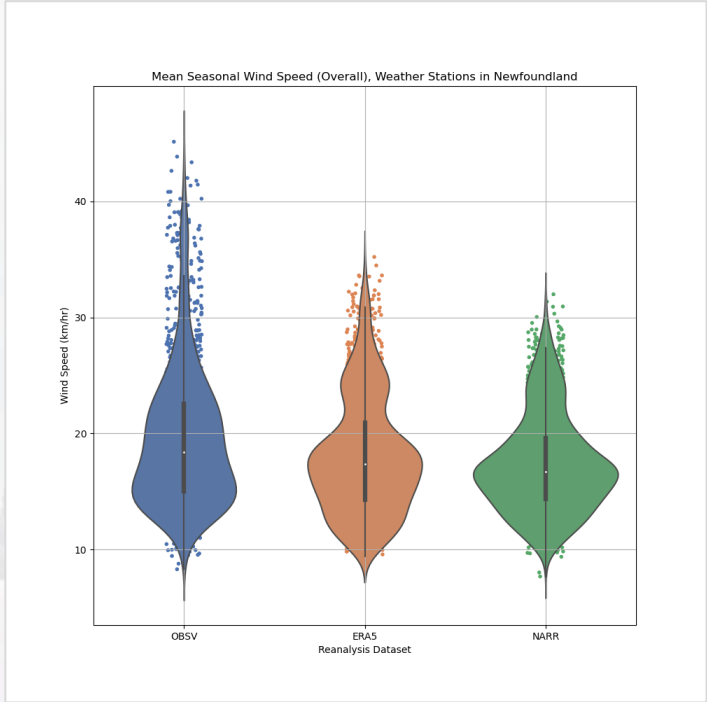
- **DAILY MEANS:**
  - Observations, ERA5, NARR all shown to be statistically significantly different
  - ERA5 outperforms NARR in Mean Adjusted Error (MAE), Root Mean Square Error (RMSE), and Correlation (CORR)

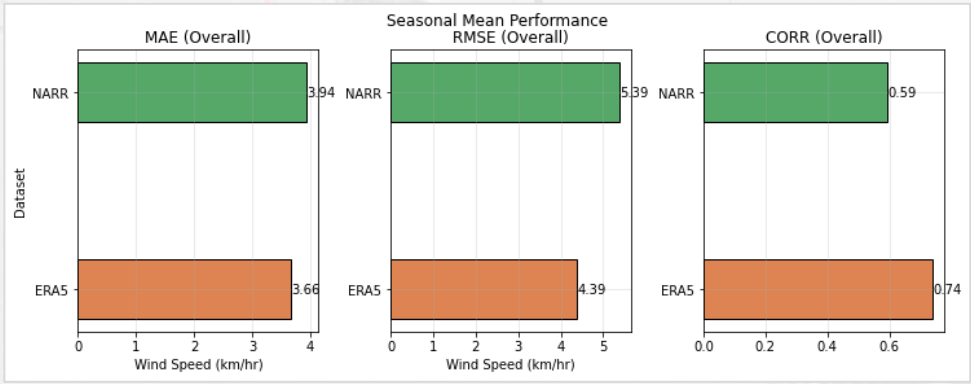




ANALYSIS

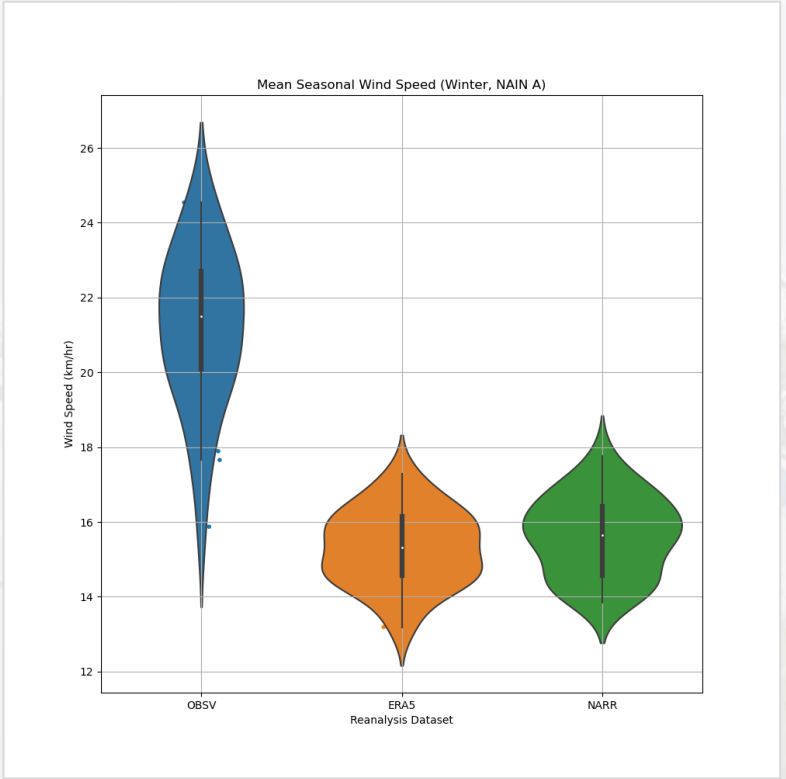
- **SEASONAL MEANS:**
  - No statistically significant difference found when comparing NARR and ERA5 datasets for SUMMER and FALL
  - ERA5 outperforms NARR in WINTER AND SPRING
  - Decrease in Correlation, MAE, RMSE when downscaling from daily to seasonal





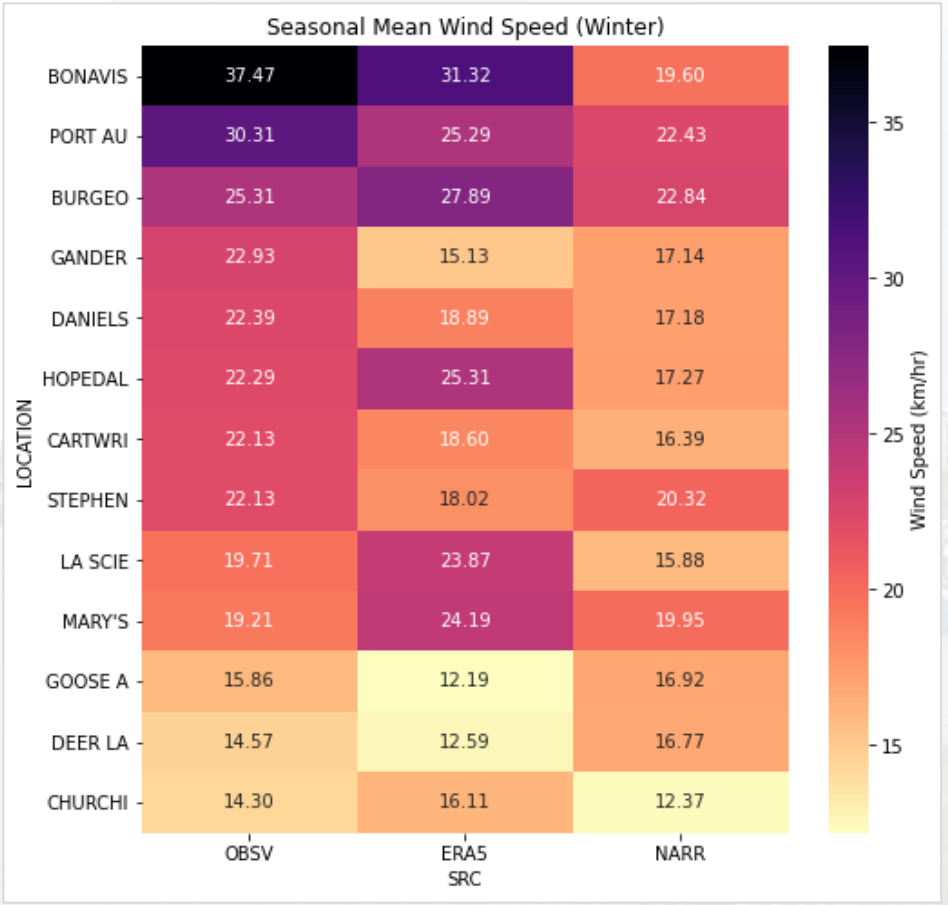
ANALYSIS

- **SEASONAL MEANS, GROUPED BY LOCATION:**
  - At CAPE RACE, NAIN, AND WABUSH no statistically significant differences between NARR and ERA5 means across all seasons
  - Other locations where no statistically significant different means were found between ERA5 and NARR included:
    - DANIEL'S HARBOUR (SPRING)
    - HOPEDALE (FALL)
    - PORT AUX BASQUES (SPRING)
    - ST. JOHN'S (SPRING & WINTER)



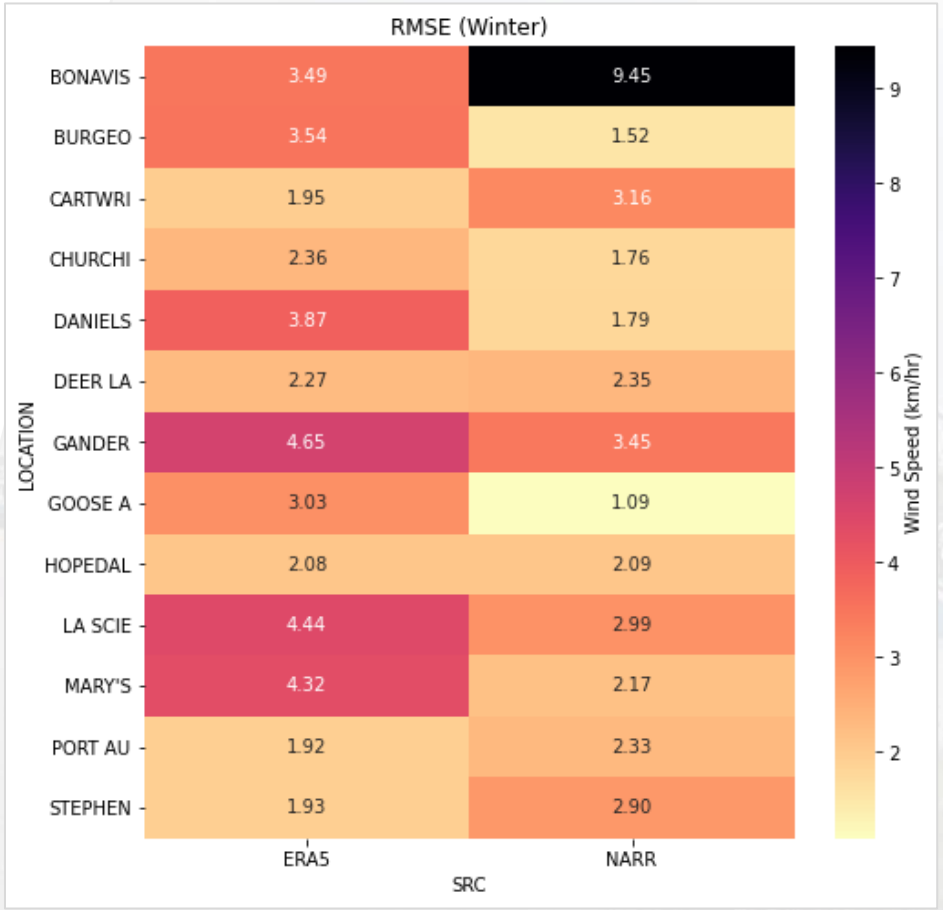
ANALYSIS

- **SEASONAL MEANS, GROUPED BY LOCATION:**
  - Overestimation and underestimation by ERA5 and NARR varying from location to location
  - Hard to establish a specific trend - a more detailed analysis required



ANALYSIS

- **SEASONAL MEANS, GROUPED BY LOCATION:**
  - Potential ‘inland’ stations (Goose Bay, Gander, Churchill Falls) may be more accurately projected by NARR.



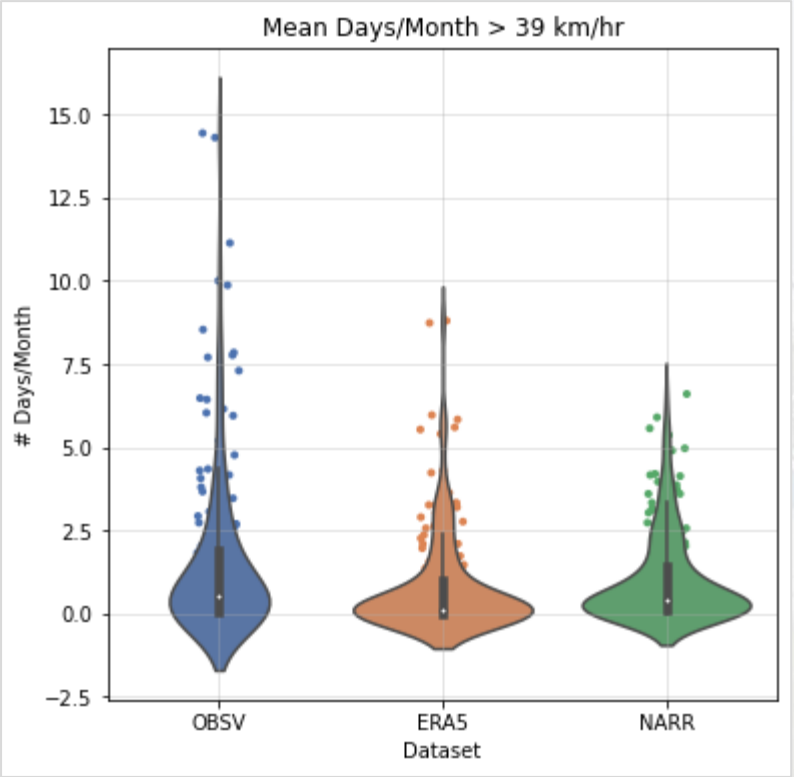
ANALYSIS

- **EXTREMES ANALYSIS:**
  - Using the Beaufort Wind Scale Table (Environment Canada, 2017) – selected three threshold values
  - Calculated the mean, median, and max number of days per month the three threshold values are surpassed in each calendar month for all three datasets

Wind Speed (km/hr)	Name
39	Strong Breeze
50	Near Gale
62	Gale

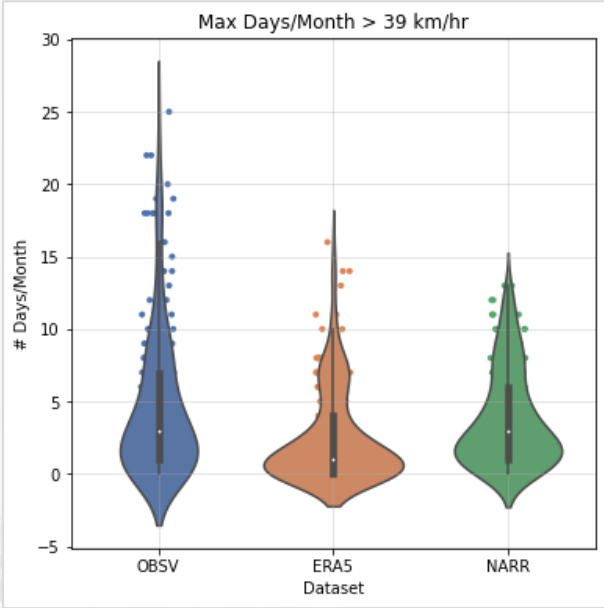
ANALYSIS

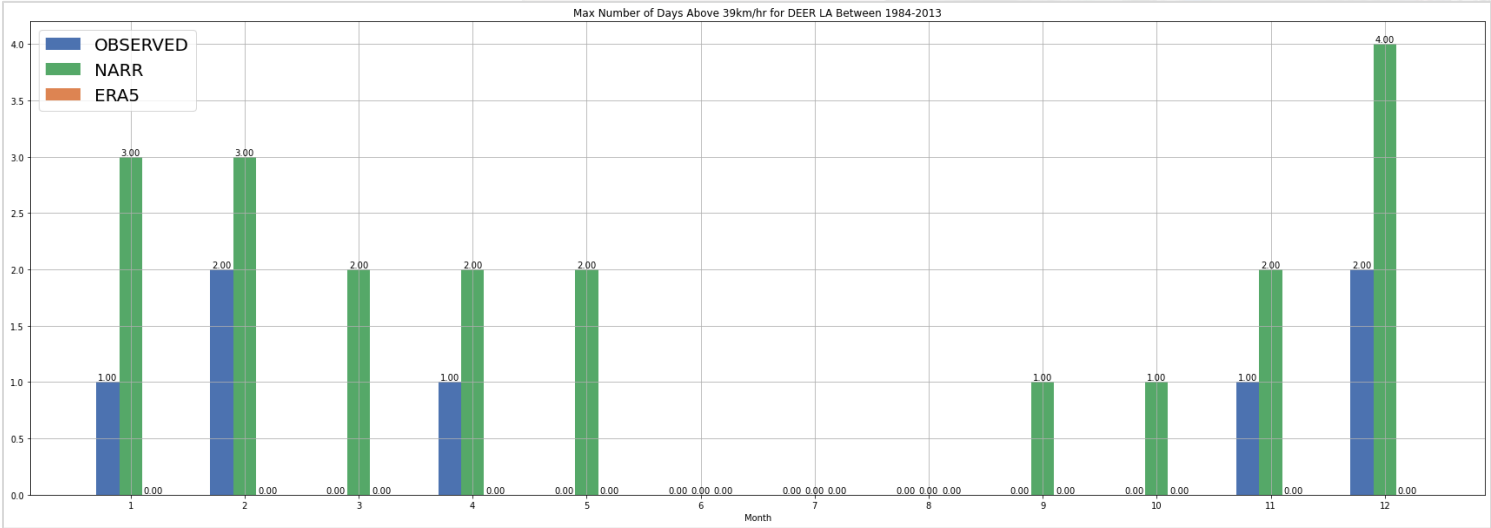
- **EXTREMES ANALYSIS:**
  - When comparing the mean & median number of days per month above both 39 and 50km/hr, there is not a statistically significant difference between the ERA5 and NARR reanalyses.



ANALYSIS

- **EXTREMES ANALYSIS:**
  - The maximum number of days per month may hint to where the NARR dataset proves valuable
  - This may be a case of overestimating extremes by this reanalysis – must be analyzed case-by-case





ANALYSIS SUMMARY

- Both reanalyses tend to underestimate magnitude when analyzing daily or seasonal means over the whole dataset
- ERA5 looks to be the more accurate at the daily and seasonal intervals
- There is clearly value in utilizing NARR in niche roles but identifying these specific scenarios requires further evaluation

DISCUSSION

- **POTENTIAL CAUSES OF ERROR/AREAS FOR IMPROVEMENT:**
  - No minimum quantity required for resampling – presence of outliers
  - Potential measurement errors at weather stations due to physical relocation, sensor outages, etc.

REFERENCES

- Government of Canada, 2017, “Beaufort wind scale table – Canada.ca.” Last modified, March 07, 2017. https://www.canada.ca/en/environment-climate-change/services/general-marine-weather-information/understanding-forecasts/beaufort-wind-scale-table.html

PHOTO CREDITS

- Slide 1: Dungeon Provincial Park, English Wikipedia
- Slide 2-19: Bonavista Harbour, English Wikipedia
- Slide 4: Intergovernmental Panel on Climate Change

THANK YOU FOR YOUR ATTENTION!