

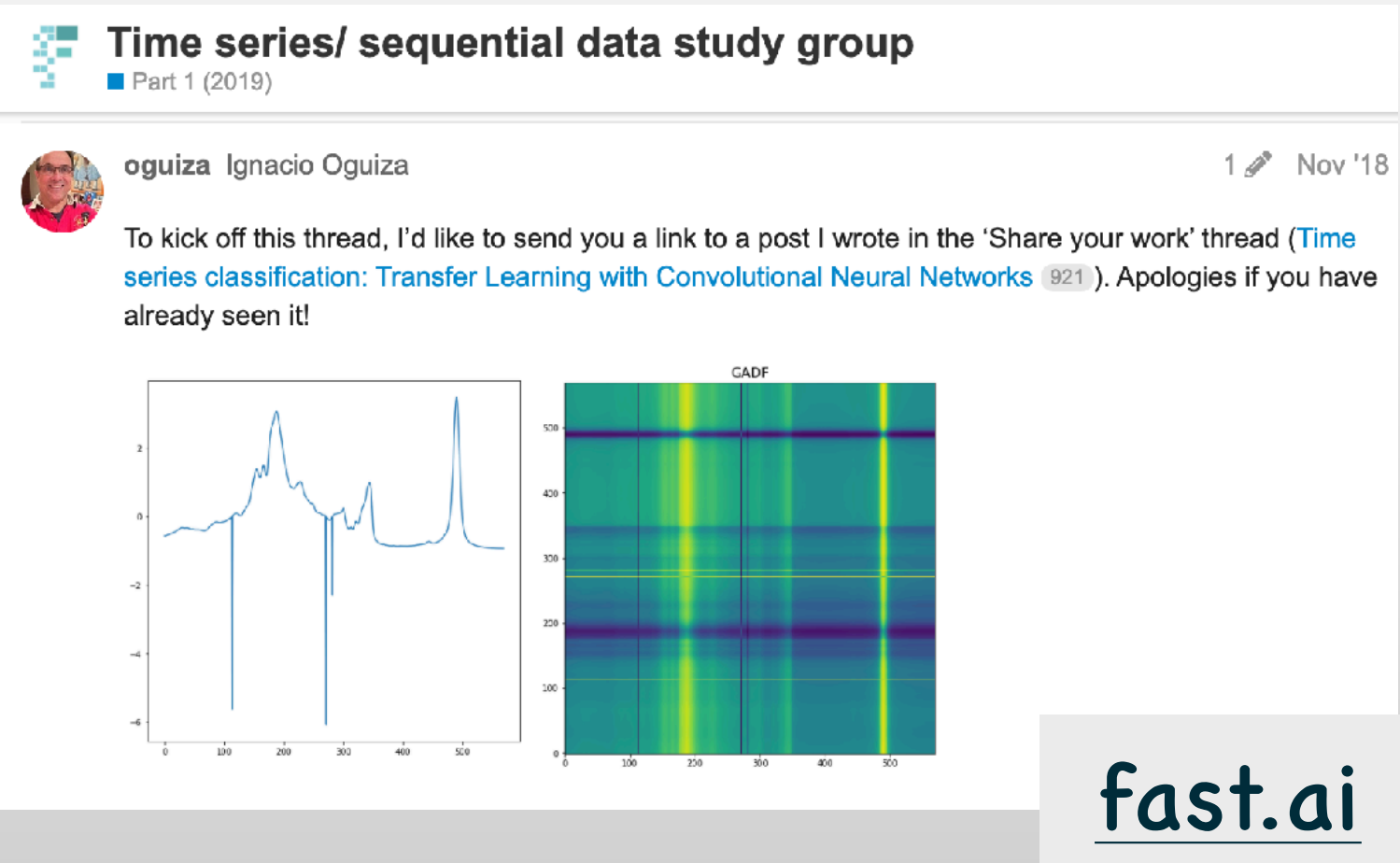
# Unsupervised Time Series Classification for Climate Data

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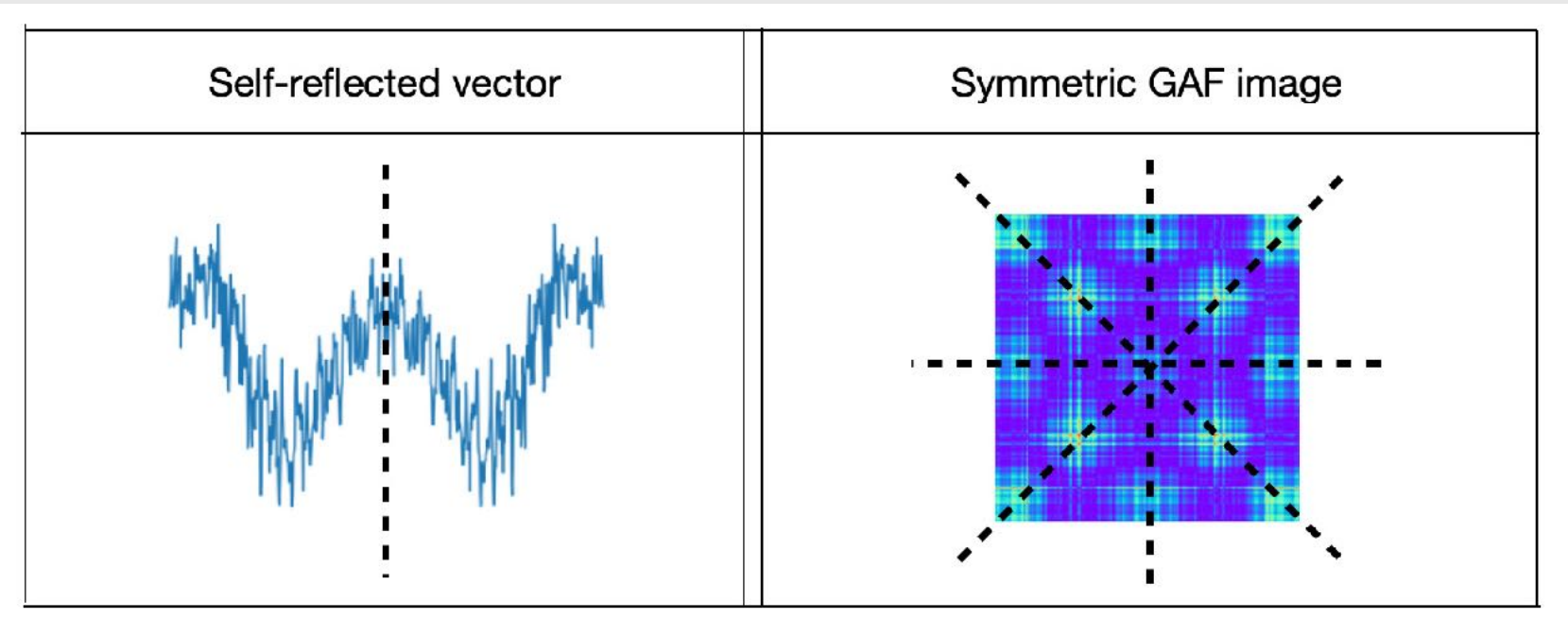
## PAIRWISE VECTORS METHOD

We were inspired by fast.ai student Ignacio Oguiza method: GAF image transfer learning classification

- ◆ Encode time series to GAF images based on polar coordinate transformation
- ◆ Classify GAF images through CNN image classification
- ◆ By fast.ai transfer learning fine tuned ImageNet model using a small dataset.

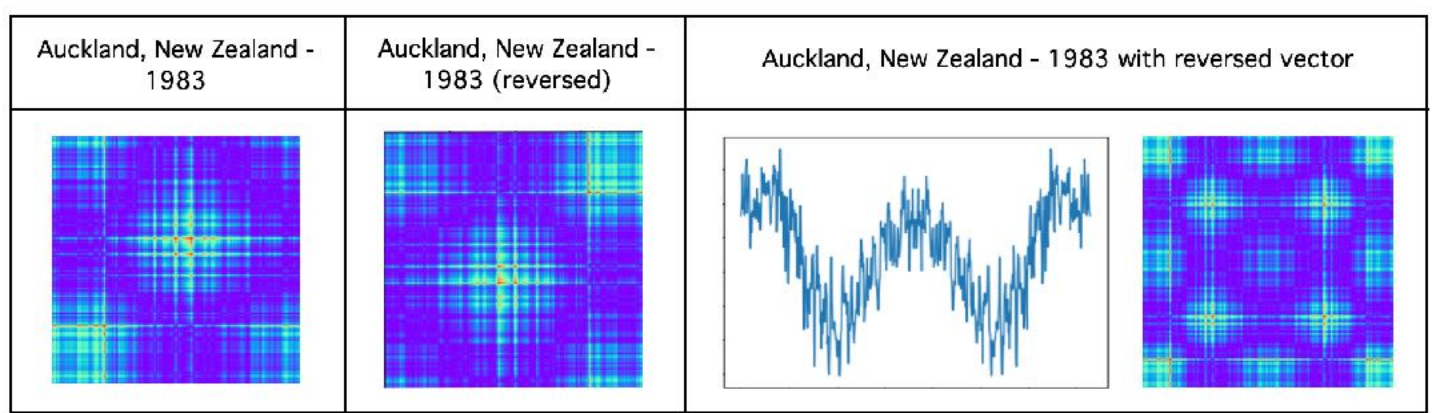


- ◆ Our method applies these techniques to unlabeled data
- ◆ Creates pairwise vectors by concatenating pairs of vectors
- ◆ Transforms vectors to symmetric or asymmetric GAF images.



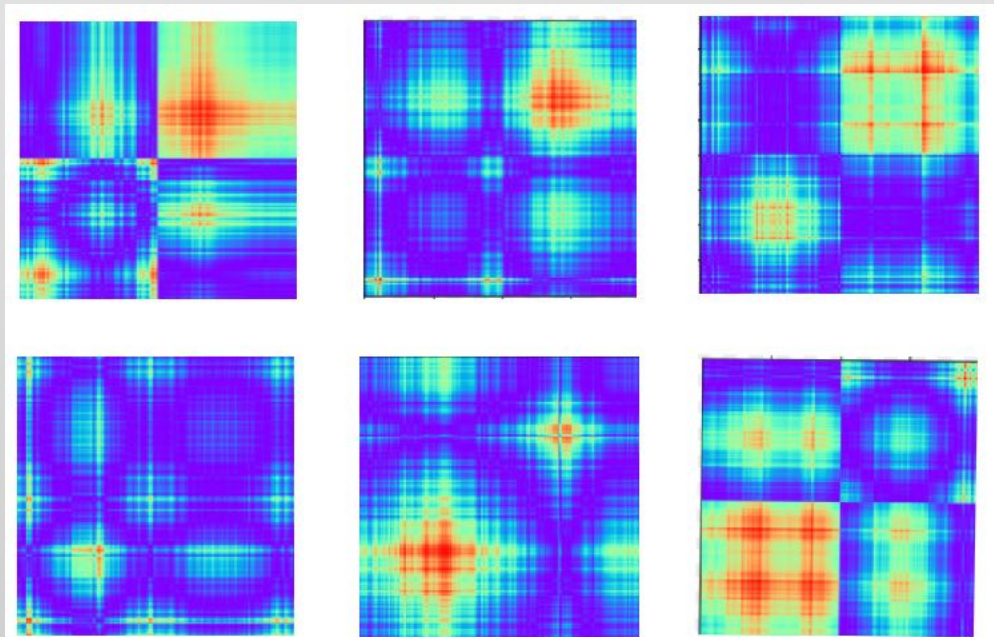
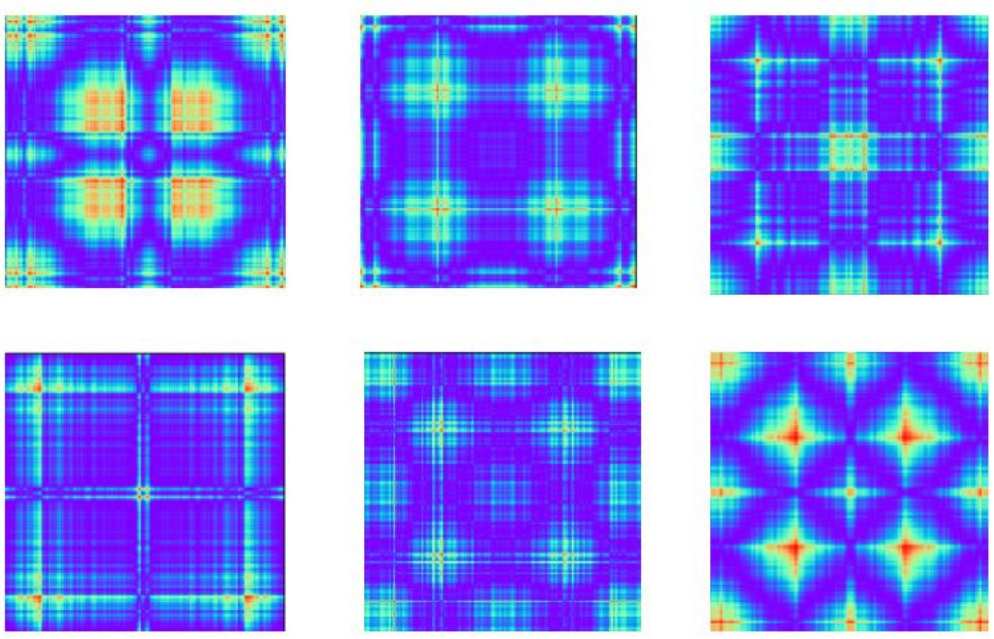
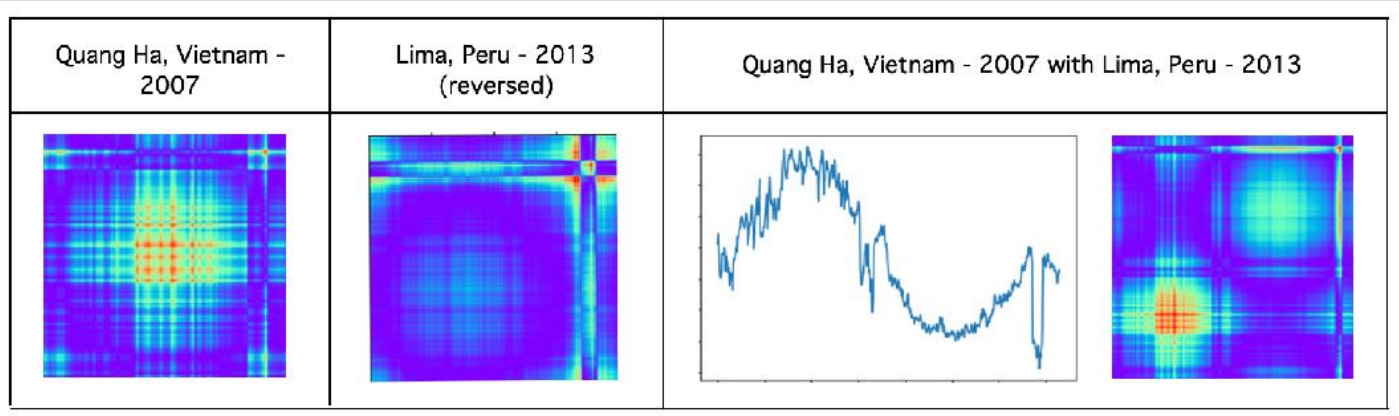
## DATA

- ◆ Average daily temperatures from January 1, 1980 to September 30, 2020 for 1000 most populous cities in the world
- ◆ Embedded vectors of the length 365 for average daily temperatures by city and by year
- ◆ Combined vectors pairs reversing second vectors.



symmetric

asymmetric



## TRAINING

CNN image classification — fast.ai transfer learning

Small data set:

- 2K symmetric
- 2K asymmetric

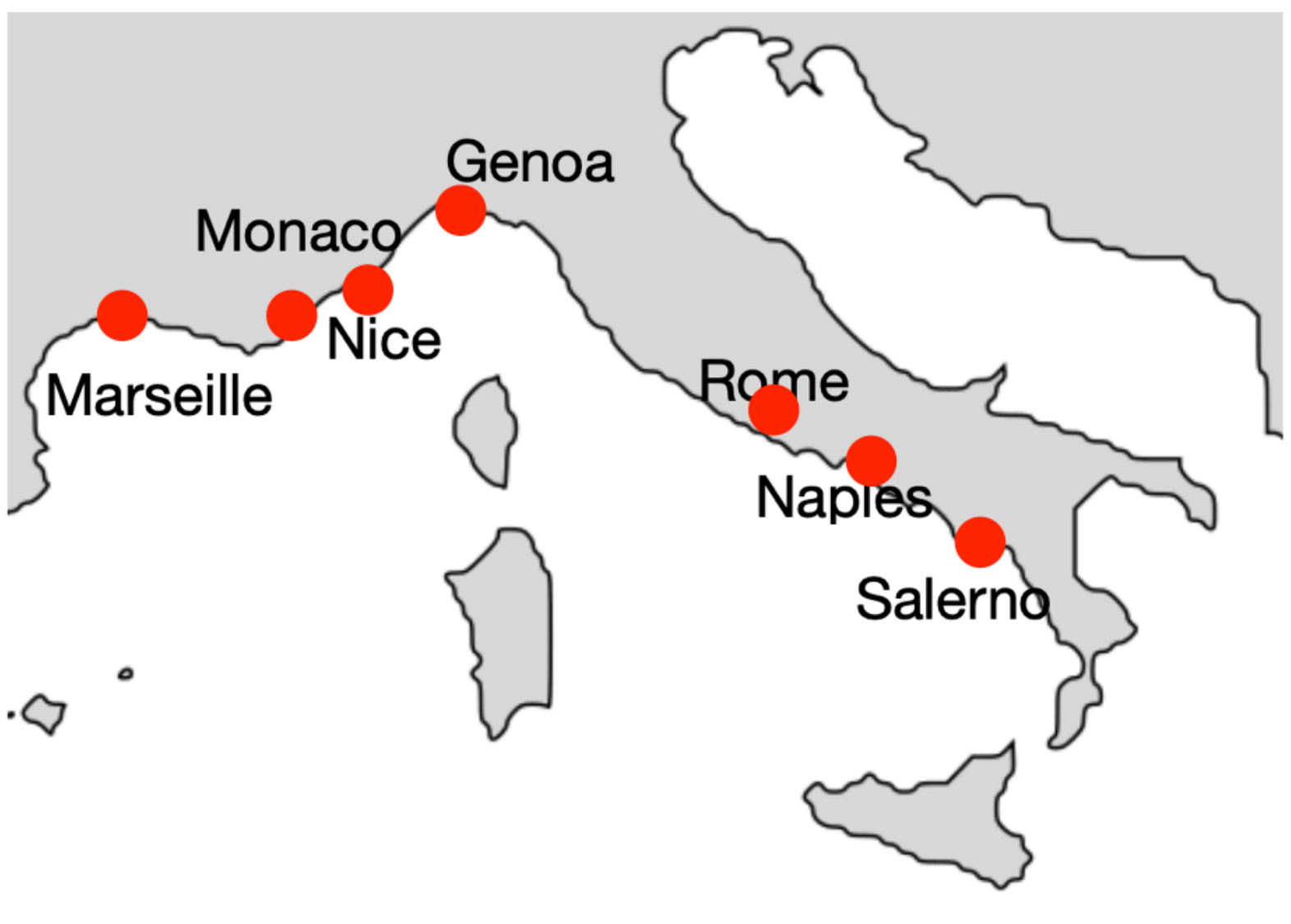
Accuracy metric:

96.5%

## EXPERIMENTS

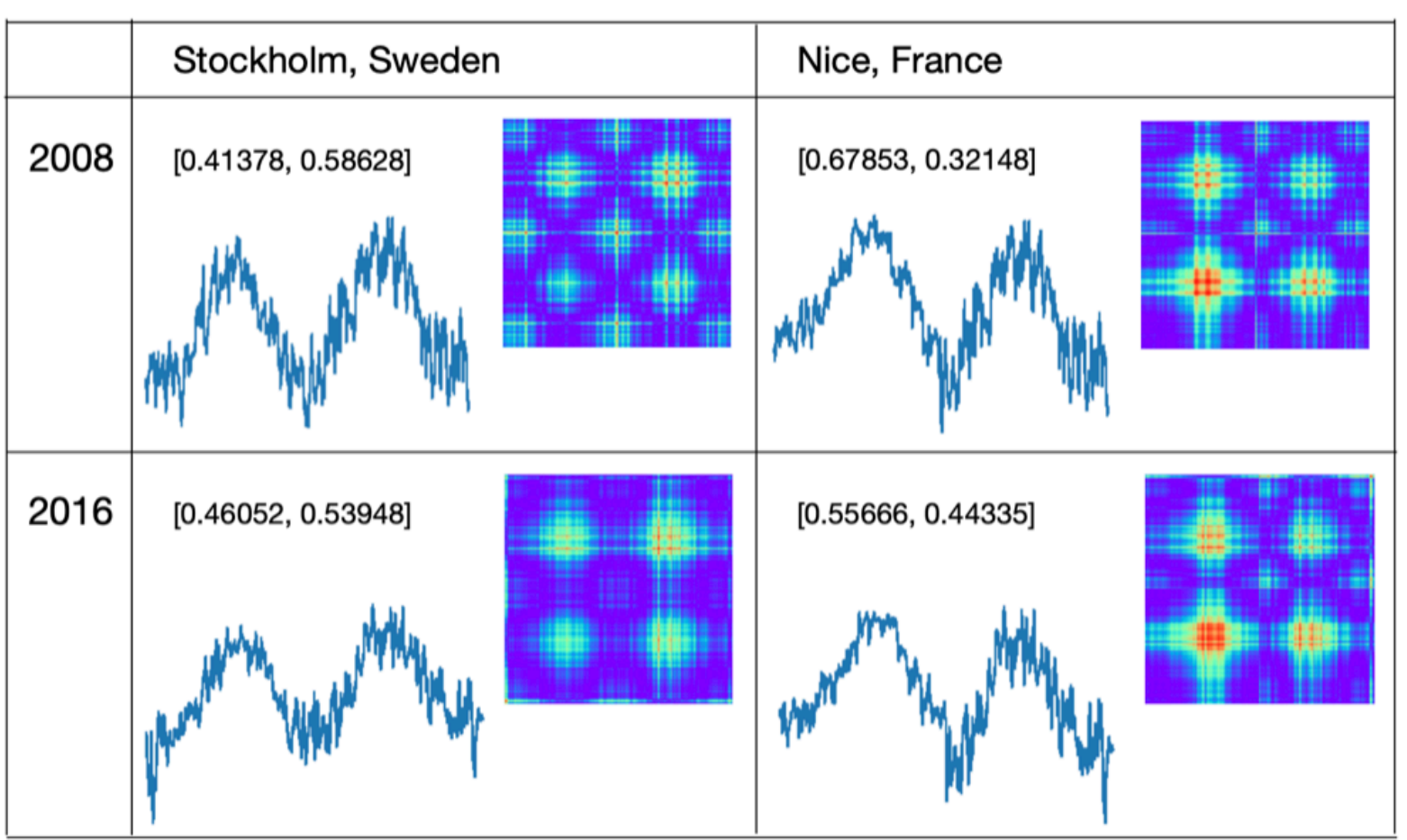
- ◆ 66 cities from West Europe, year 1992
- ◆ Hypothesis: inconsistency of entity pairs with two way relationships
- ◆ Inconsistent city pairs about 15%. Examples:

Pairs of Cities	diff	same
Helsinki (Finland) -- Bern (Switzerland)	0.41	0.59
Bern (Switzerland) -- Helsinki (Finland)	0.74	0.26
Turin (Italy) -- Monaco (Monaco)	0.53	0.47
Monaco (Monaco) -- Turin (Italy)	0.18	0.82
Naples (Italy) -- Lisbon (Portugal)	0.25	0.75
Lisbon (Portugal) -- Naples (Italy)	0.92	0.08



- ◆ Compare city average daily temperatures with average of average for 66 cities
- ◆ Cities on Mediterranean Sea have high probability to be similar to average of average very smooth line

- ◆ Compare with the most centrally located city: Stuttgart (Germany)
- ◆ Nearby cities had similar, faraway city different daily temperature to Stuttgart
- ◆ Example: cities 'on the border'



## CONCLUSION

- ◆ Transforming pairwise vectors to symmetric or asymmetric GAF images
- ◆ Training CNN image classification model on fast.ai transfer learning
- ◆ Proved model insufficiency for entity pairs with two-way relationships
- ◆ For one-way relationships showed that European cities with the most smooth climate are located on Mediterranean Sea.

## BROADER IMPACT

- ◆ Pairwise vectors method can be applied to words, documents, images, videos, and many other embeddable entities
- ◆ Model trained on symmetric / asymmetric GAF images on one data domain can be used for other data domains
- ◆ The 'same' probability metric can also be used to measure differences between vectors like cosine similarity
- ◆ Through this metric direct graphs can be built for graph mining.