El Nino

A Network Tour of Data Science

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ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Goals

- Predicting future temperatures in specific zones of the Pacific ocean.
- Trying to find to best model to make predictions.

Outline

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Data Exploration

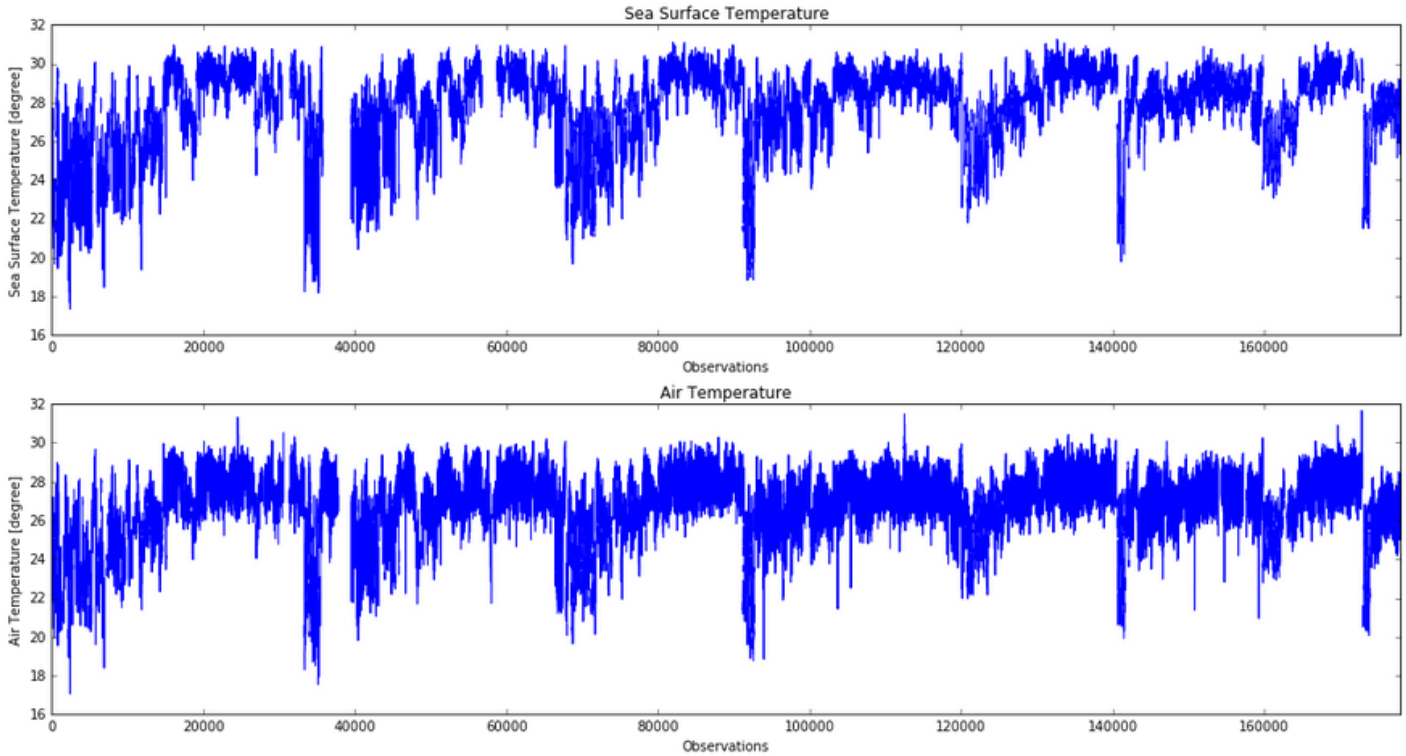

Figure: Exploration of the Air and Sea Surface Temperature

Data Exploration

Base Map

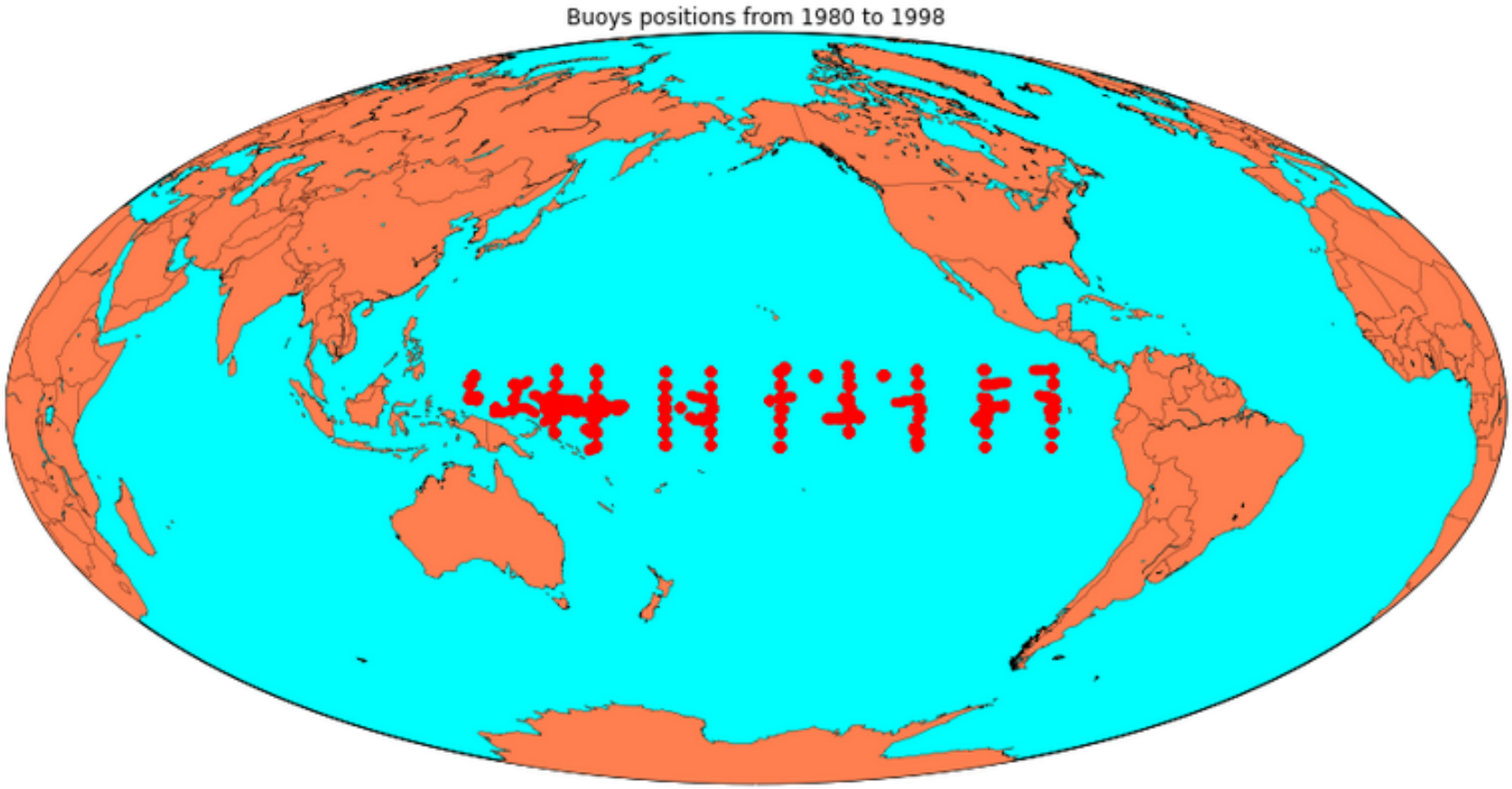

Figure: Positions of Buyos

Data Exploration

Base Map

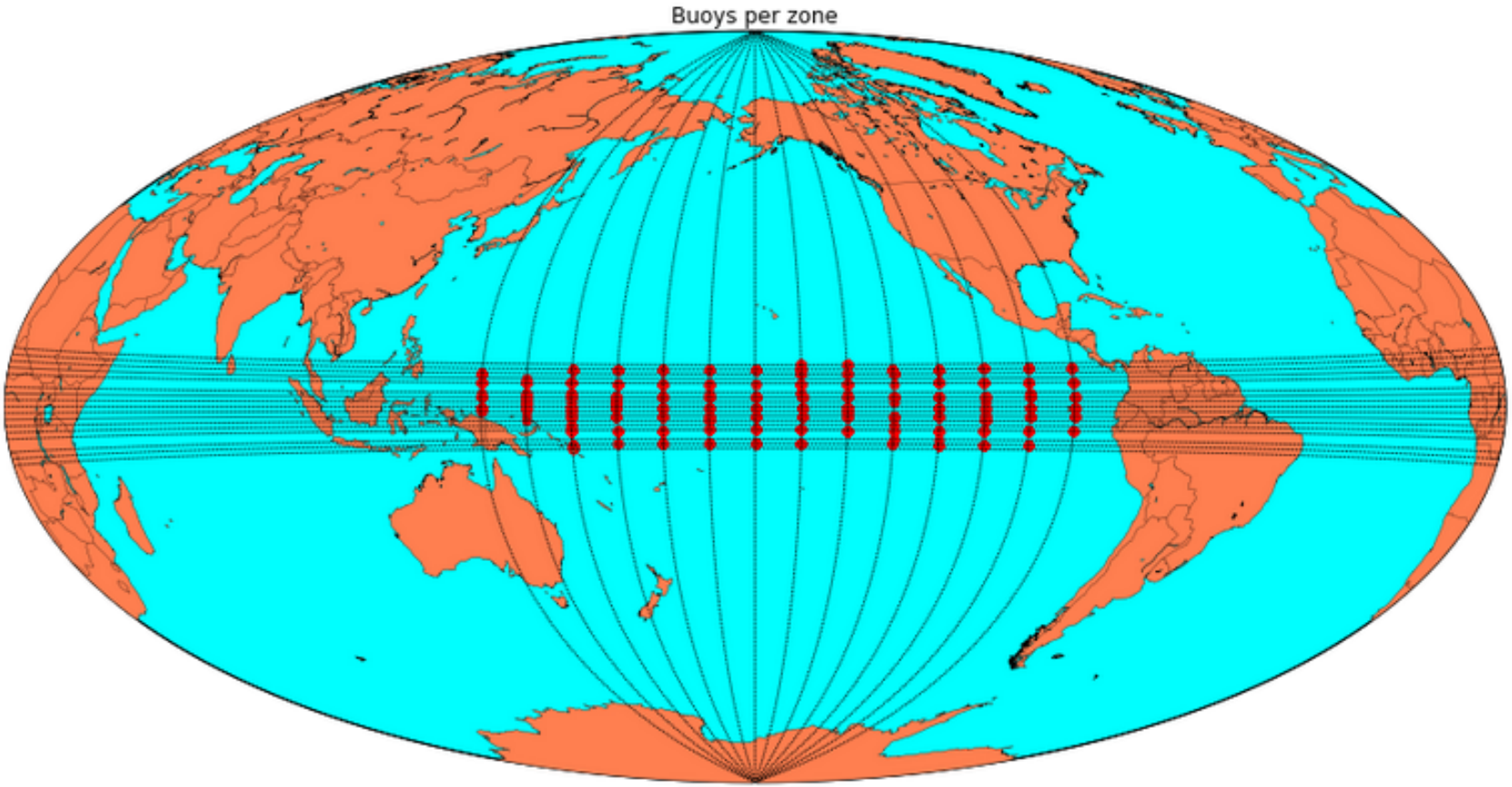

Figure: Positions of Buyos rearranged

Data Exploration

Data evolution

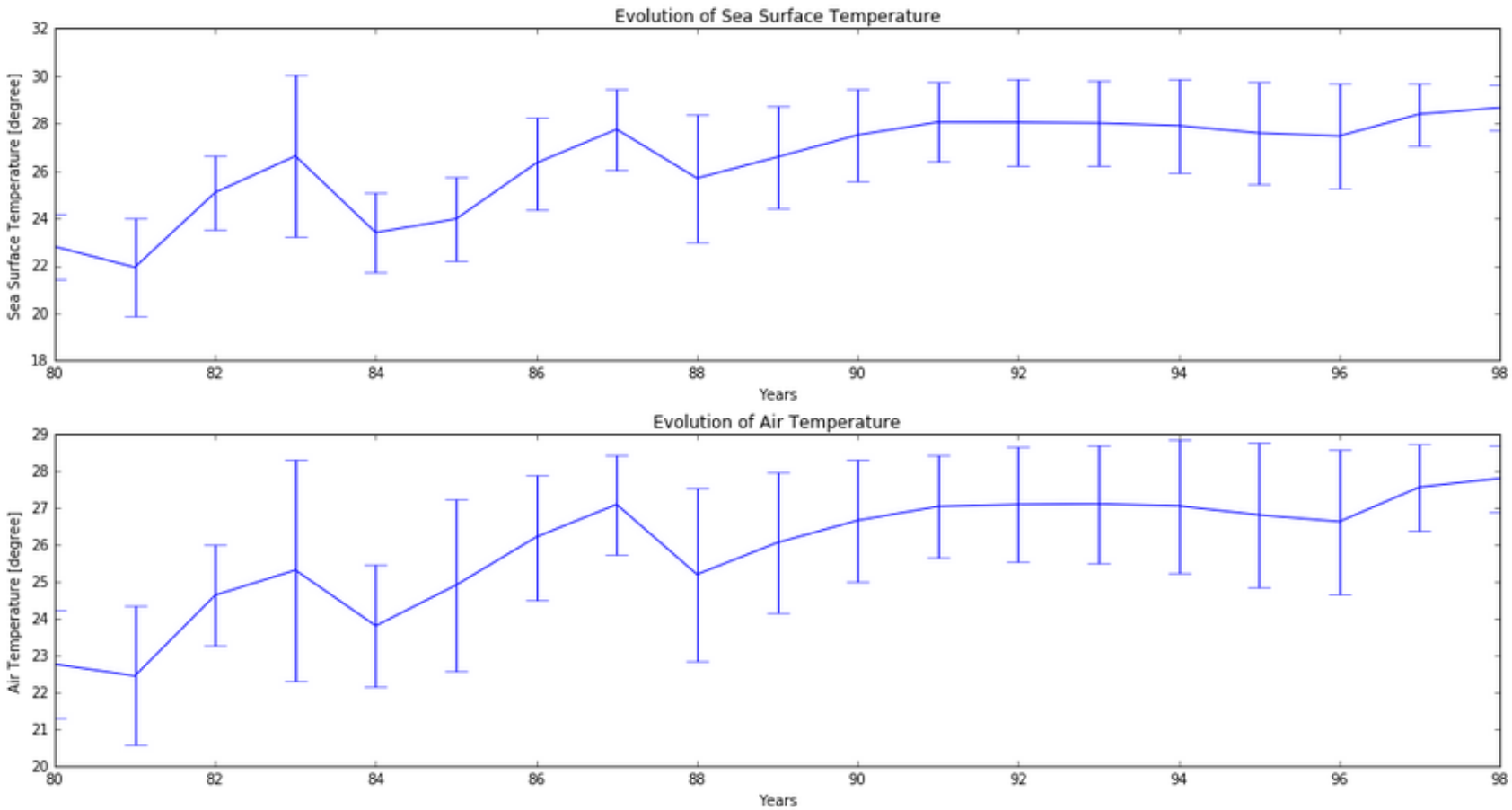

Figure: Evolution of the Air and Sea Surface Temperature

Data Exploration

Data evolution

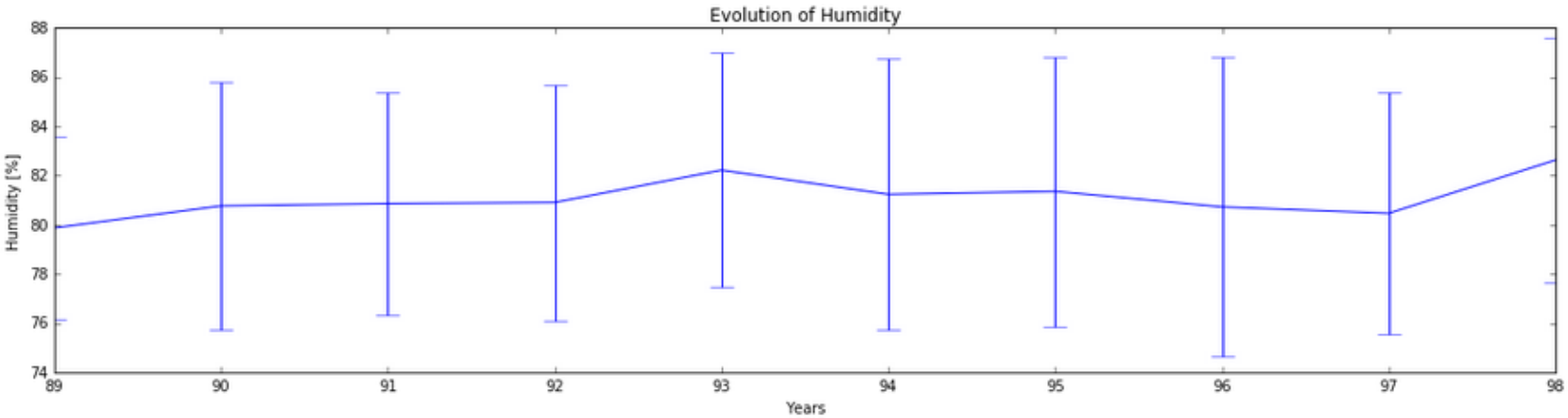

Figure: Evolution of Humidity

Data Exploration

Data evolution

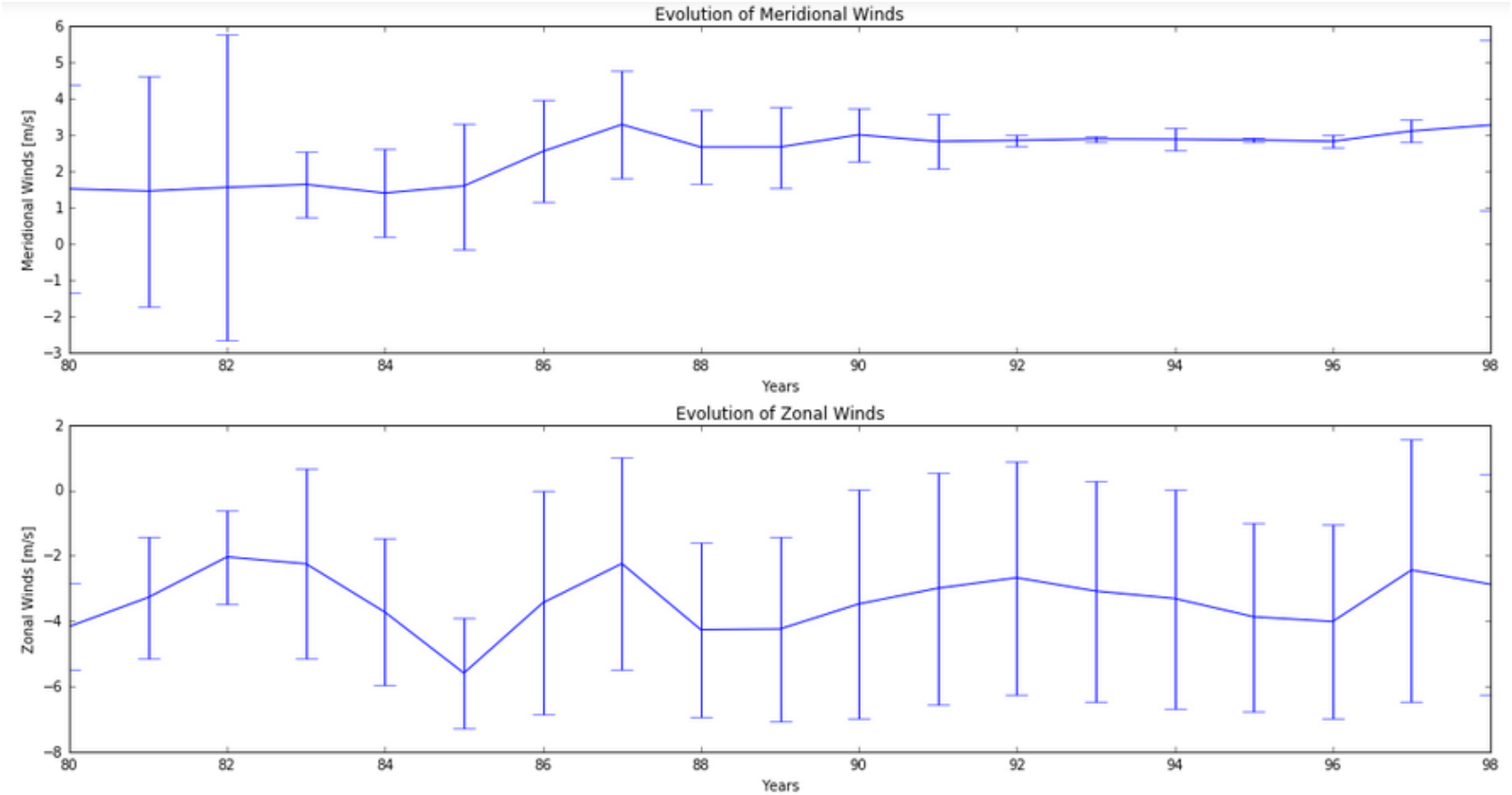

Figure: Evolution of Winds

Outline

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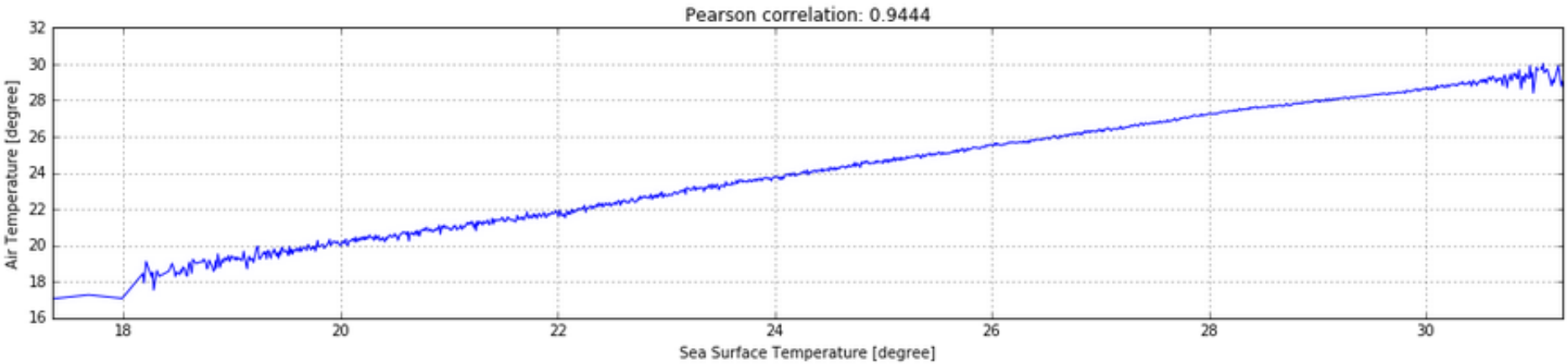
Data Exploration

Correlation between Air and Sea Surface Temperature



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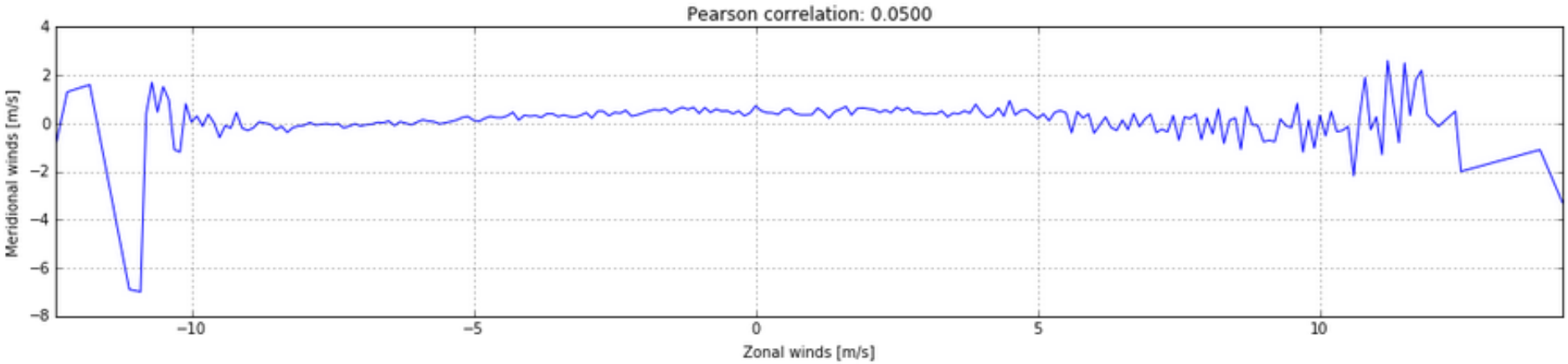
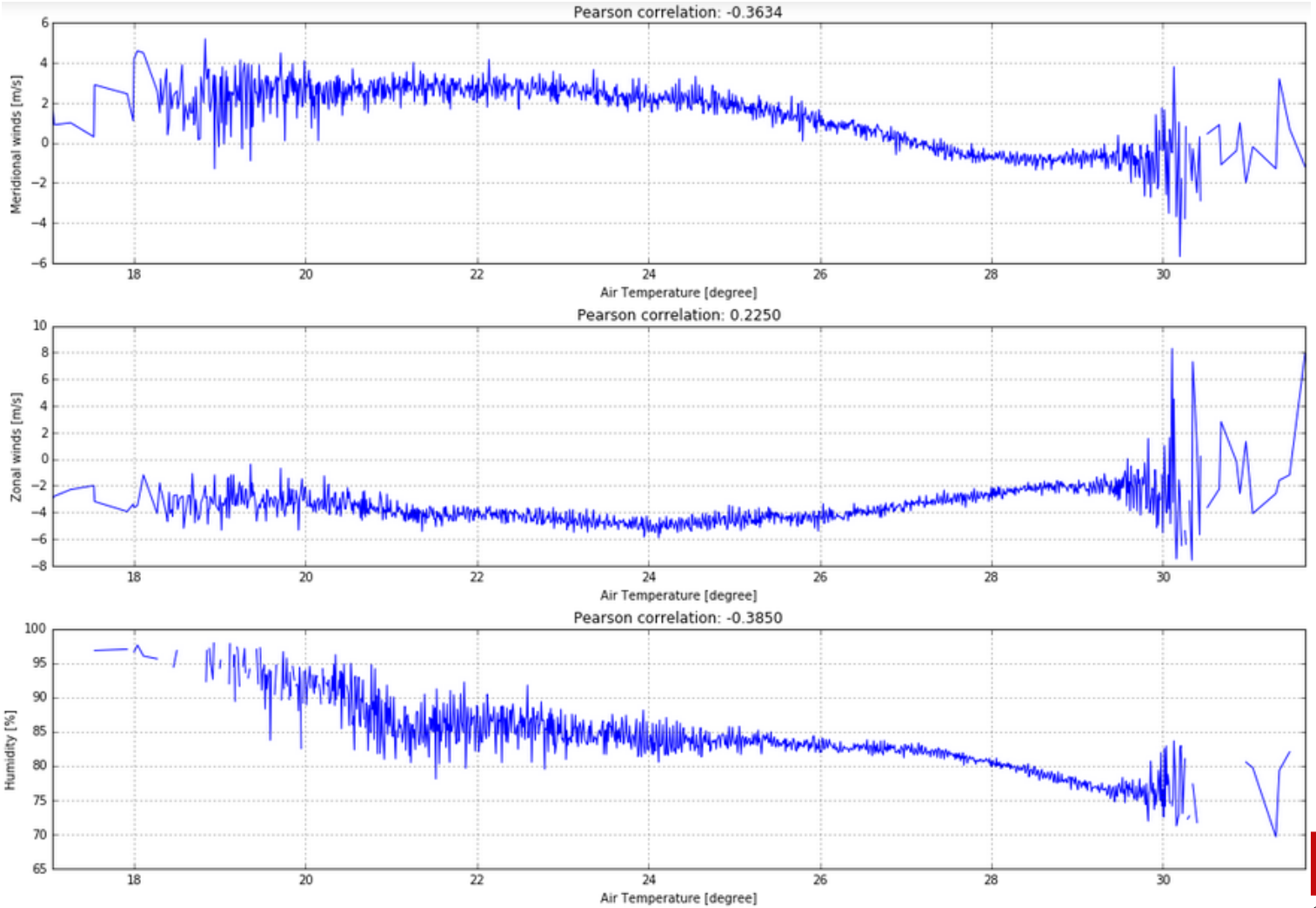
Data Exploration

Correlation between Winds



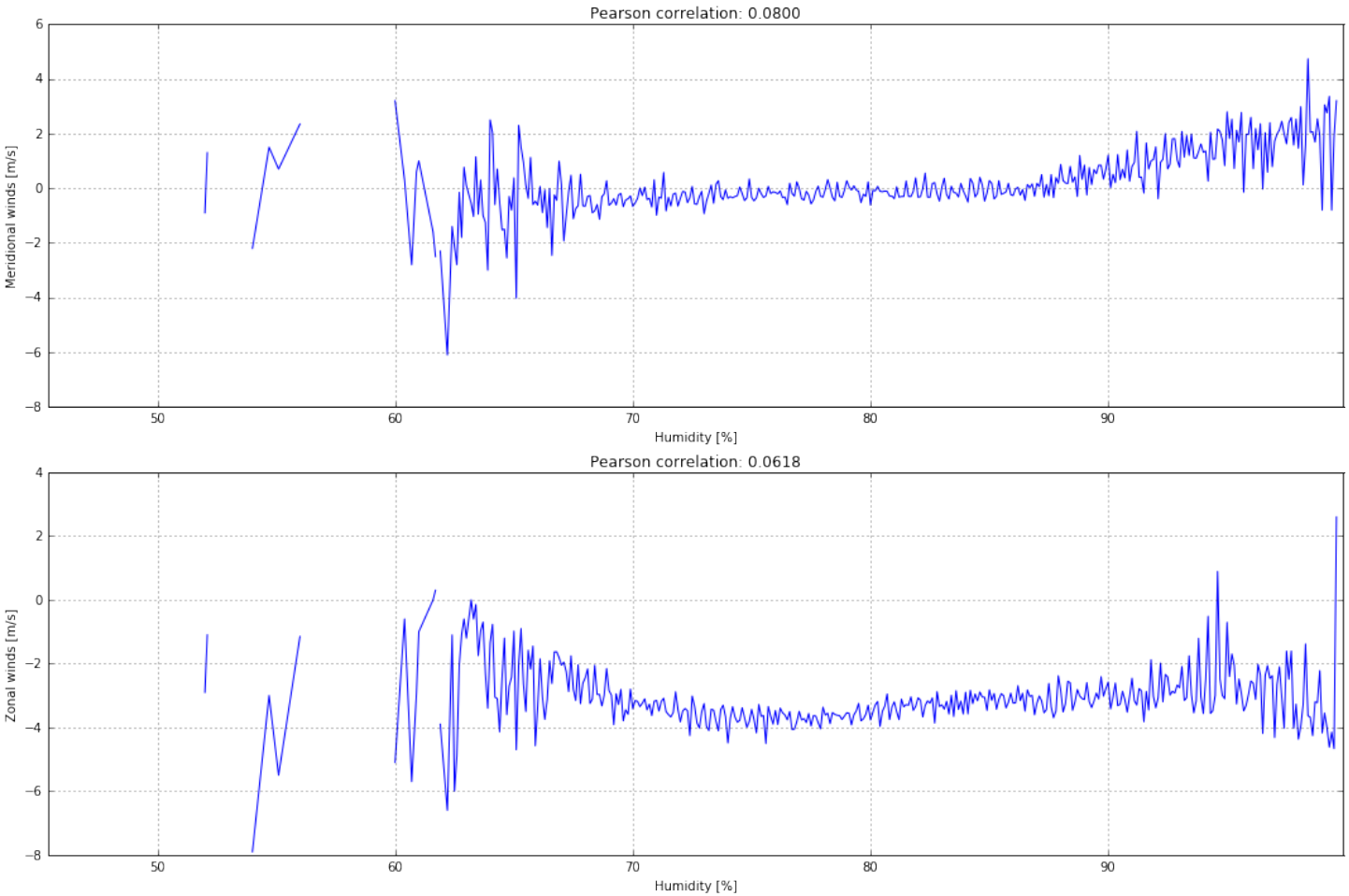
Data Exploration

Correlation between Air Temperature, Winds and Humidity

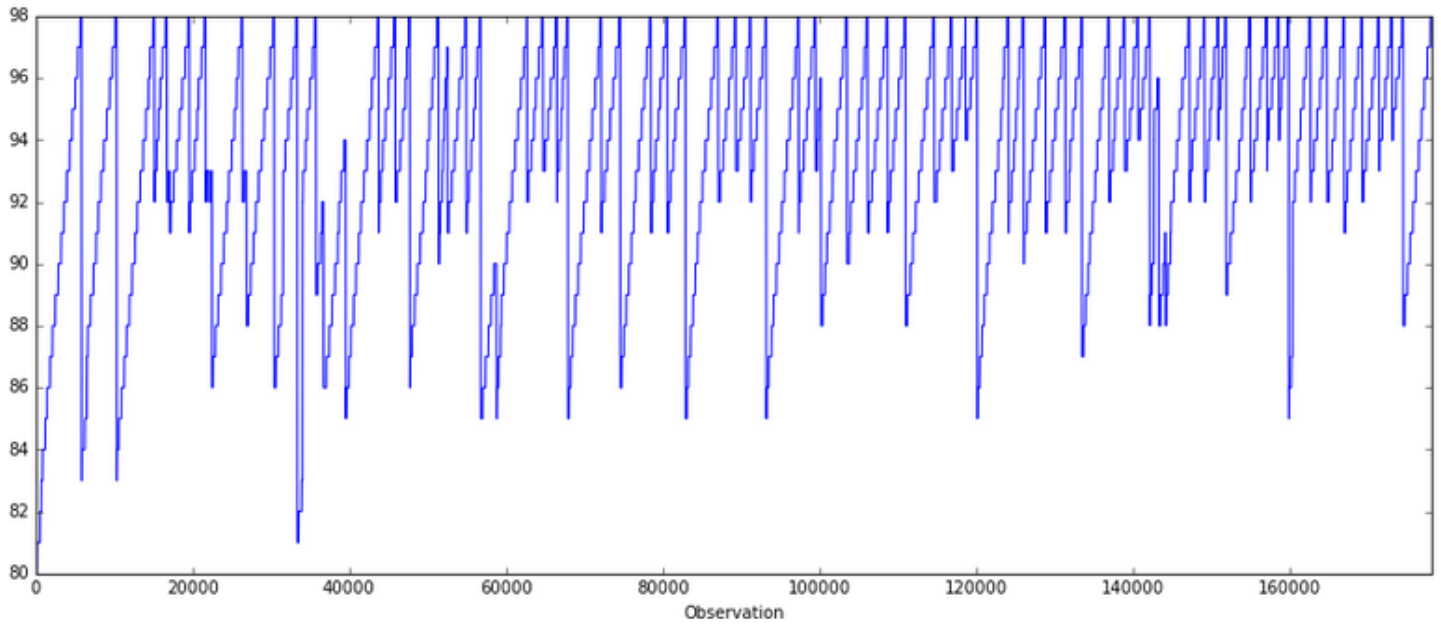


Data Exploration

Correlation between Winds and Humidity



Data Exploration



- Observations are not ordered with time.
- We focus our analysis in one zone in order to be able to make time series predictions.

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Data Exploration

Yearly evolution of meteorological variables for the month of July in a specific zone

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- Monthly air temperature variation from 1980 to 1998
- Selected zone: $(0, -110)$
- Some missing measurements

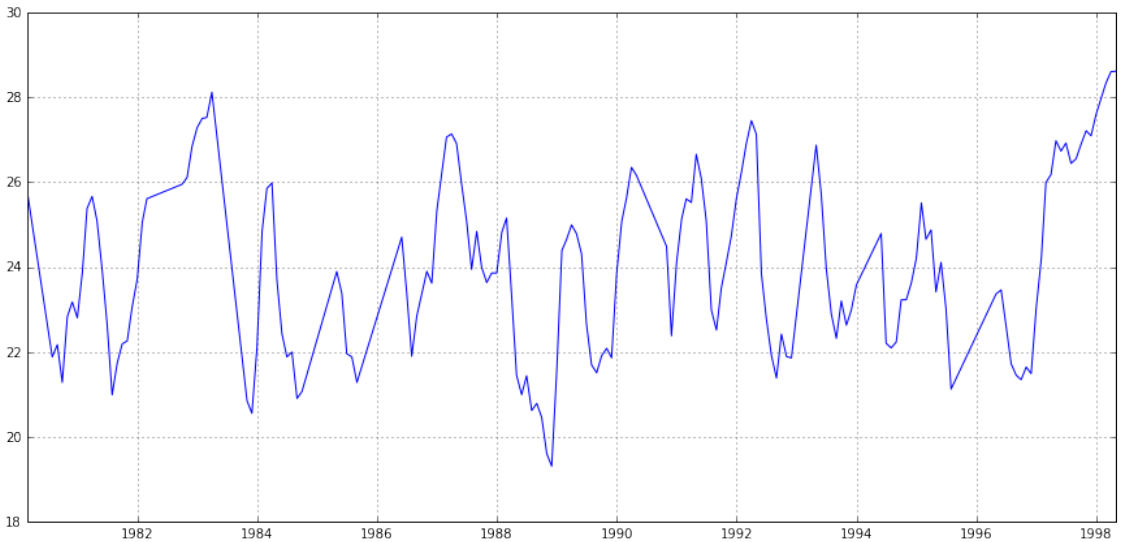

Figure: Air temperature evolution from 1980 to 1998

ARMA

Stationary Check

- Need stationary signal to fit ARMA model
  - Time independent mean
  - Time independent variance
- Perform Dickey-Fuller Test to check stationarity

Results	
Test Statistic	-4.857
p-value	0.000042
Nbre Observations	164
Critical Value (5%)	-2.879
Critical Value (1%)	-3.470
Critical Value (10%)	-2.576

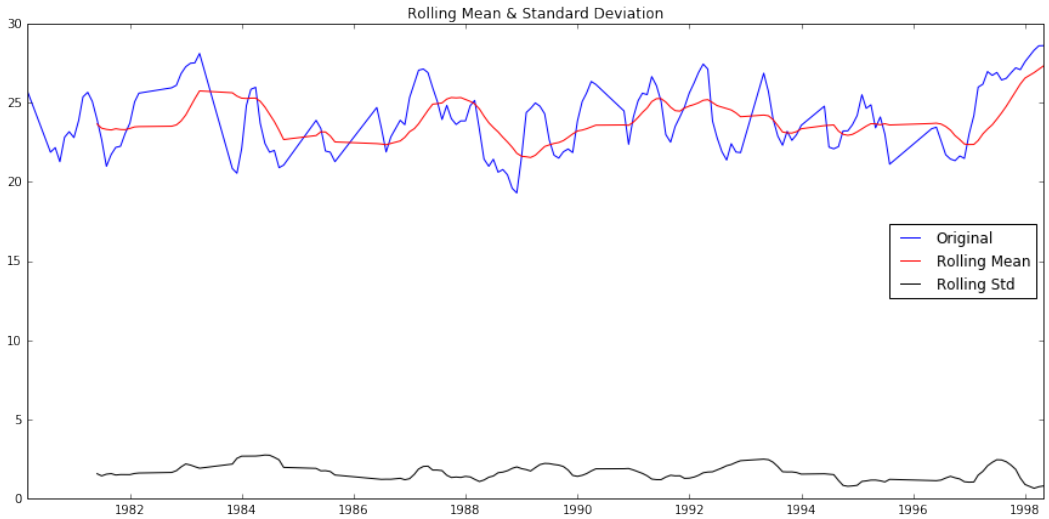

Figure: Rolling mean and standard deviation

- Crital value (1%) $<$ Test statistic
  $\rightarrow$ signal is at 99% stationary

- Compute Autocorrelation (ACF) and Partial Autocorrelation (PACF) function
  $\rightarrow$ determine degree of Auto-Regressive (AR) and Moving Average (MA) model

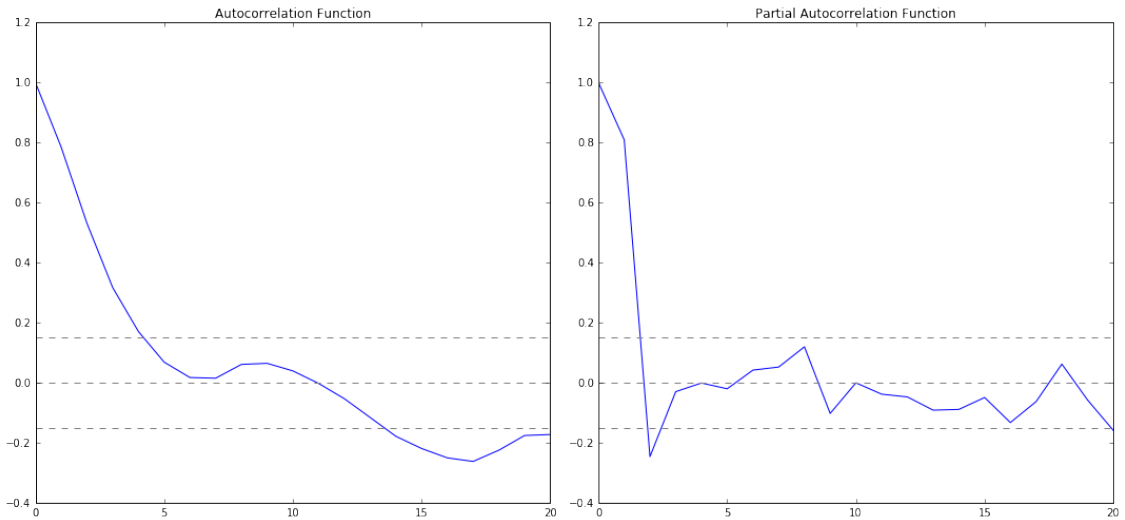

Figure: ACF and PACF

- Min. degrees: AR $\rightarrow$ 3 and MA $\rightarrow$ 4

- Best model ARMA = (5,5)
- MSE = 1.567
- Missing values influence a lot the prediction

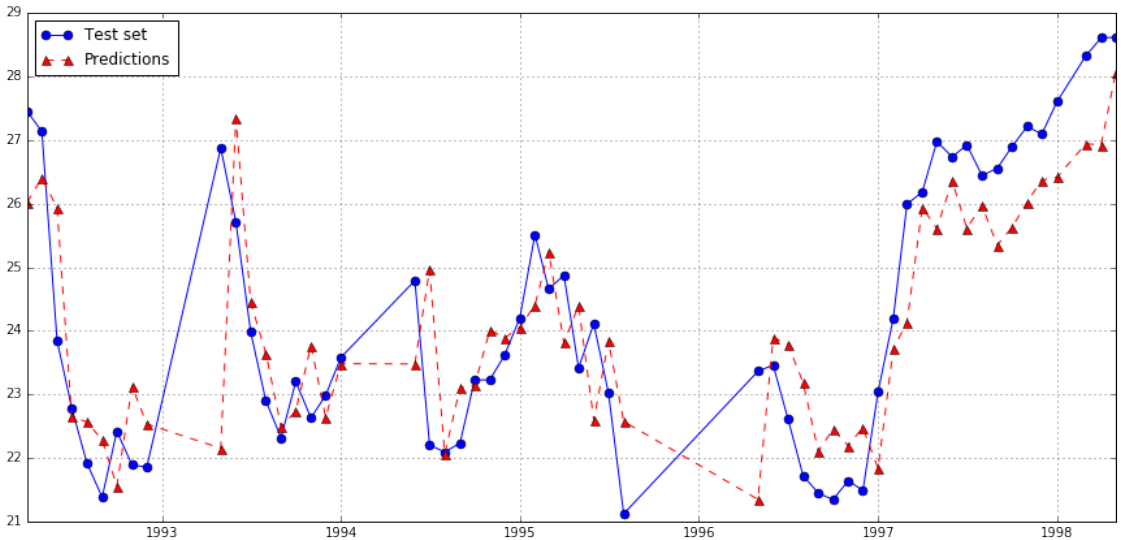

Figure: Predictions

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- Several regression methods have been investigated:
  1. Linear
  2. Ridge
  3. LASSO
  4. ElasticNet
  5. Polynomial up to degree 5
- Used metrics:
  1. $R^2 \equiv 1 - \frac{SS_{\text{res}}}{SS_{\text{tot}}}$

     with $SS_{\text{tot}} = \sum_i (y_i - \bar{y})^2$

     $SS_{\text{res}} = \sum_i (y_i - f_i)^2 = \sum_i e_i^2$
  2. MSE $= \frac{1}{n} \sum_{i=1}^{n} (\hat{Y}_i - Y_i)^2$

- Best results with polynomial regression of degree 2
- Fitting time comparison:

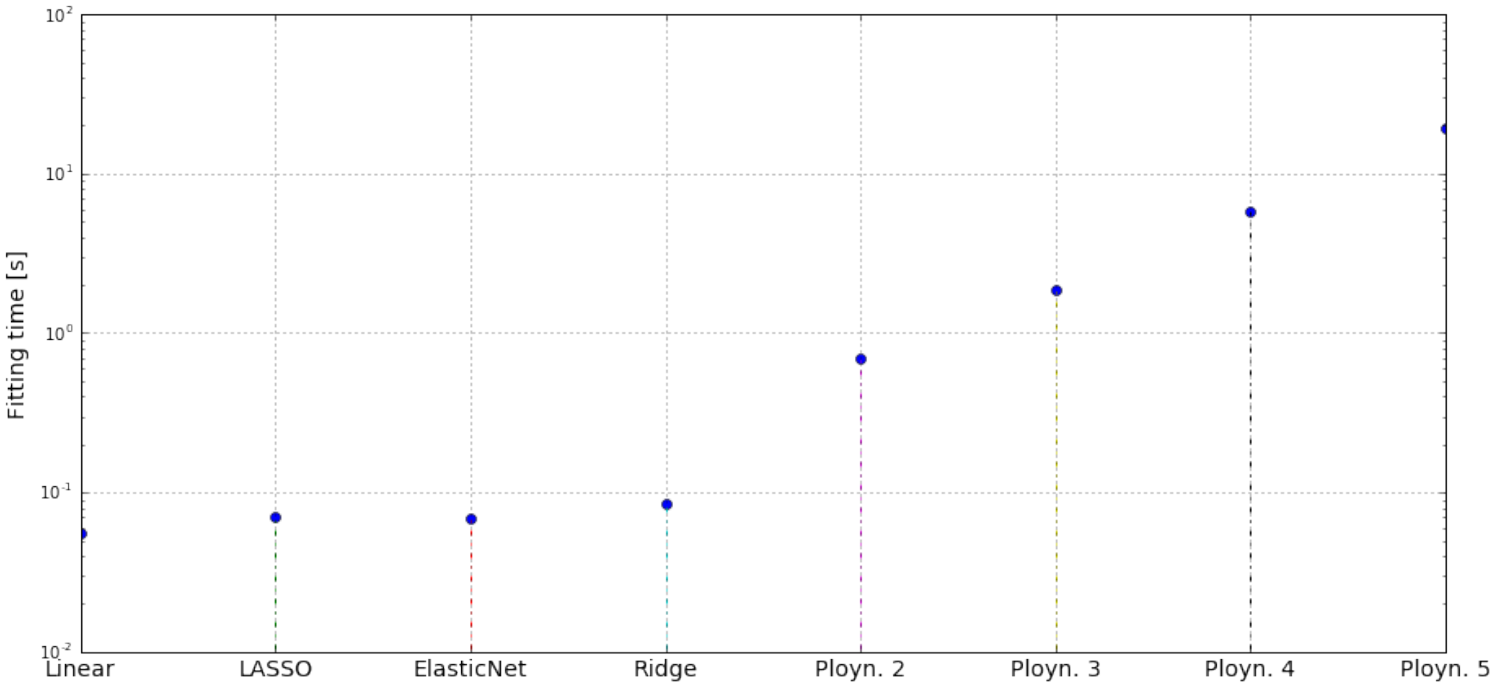

Figure: Fitting time

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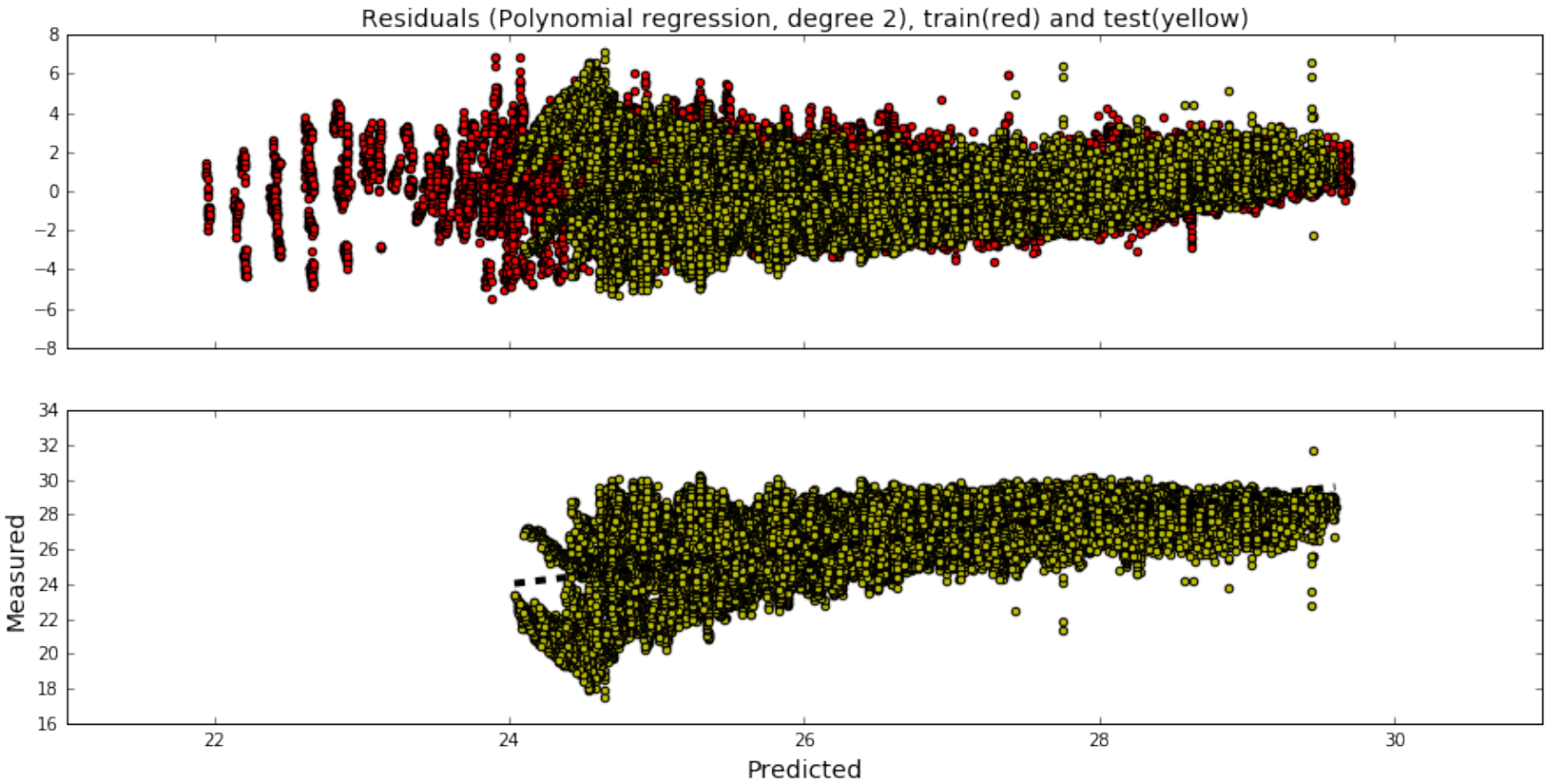
Regression

Polynomial Regression



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- Train on fold 1 $\rightarrow$ Test on fold 2

  Train on fold 1+2 $\rightarrow$ Test on fold 3

  $\ldots$

  Train on fold 1+2+3+4+5+6+7+8+9 $\rightarrow$ Test on fold 10
- Minimization problem for Lasso regression:

$$\min_w \left(\frac{1}{2n_{samples}} ||y - Xw||_2^2 + \alpha ||w||_1 \right)$$

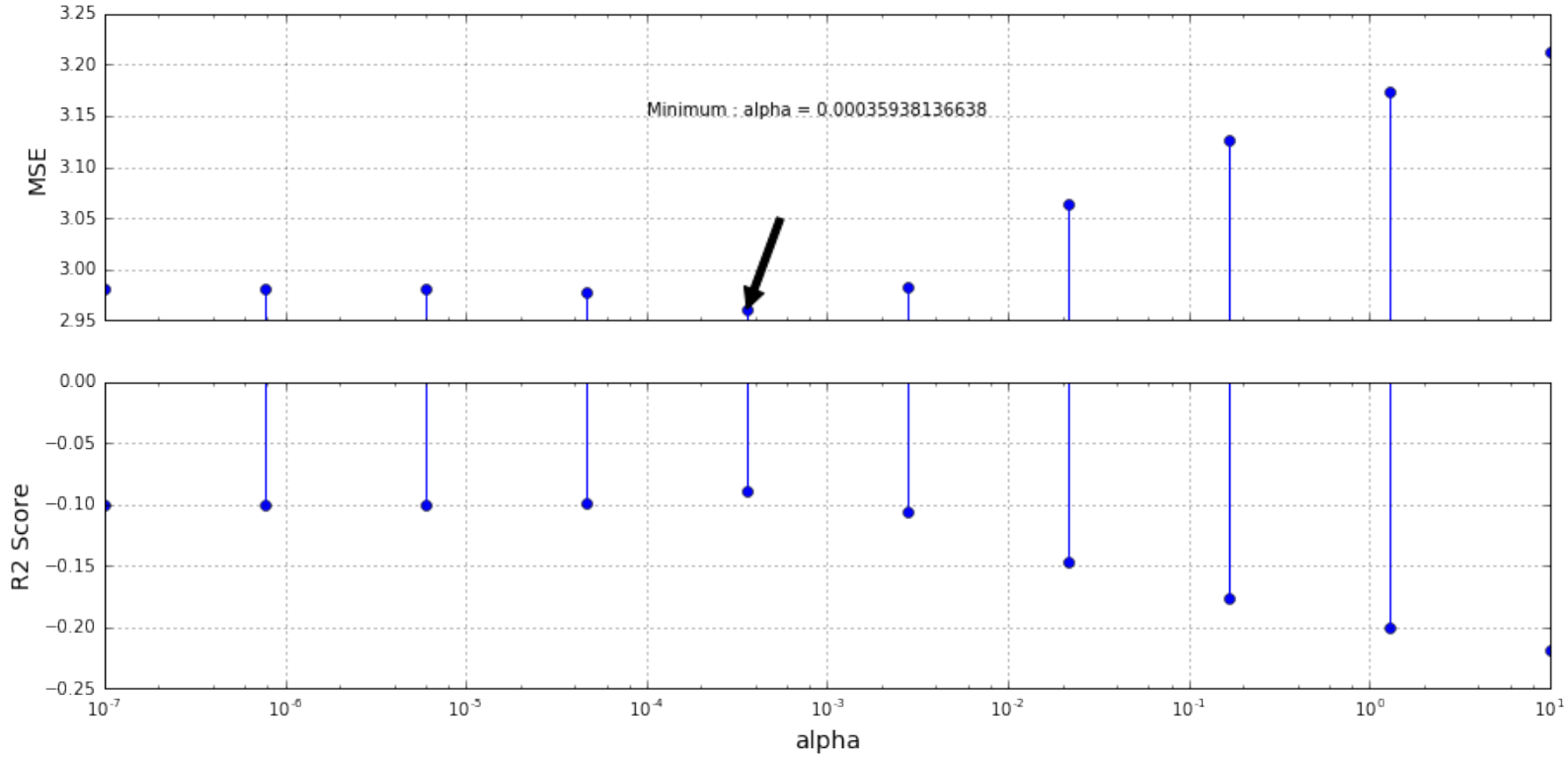

Figure: Optimal α

- Lasso's MSE $>$ polynomial of degree 2's MSE

- ARMA's MSE $<$ polynomial's MSE
  $\rightarrow 1.567 < 6.285$
- Best results: ARMA model

Thank you for your attention !!

"Great things are done by a series of small things brought together."

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