Solar Radiation Prediction

Battery: Solar storage

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Motivation

- Estimate levels of solar radiation
- Why:
  - Solar energy fluctuations
  - Predictability, easier integration to conventional production
- How:
  - Analyze samples from 4 months period (1-9-2016 - 31/12-2016)
  - Machine learning model(s)

The Data

- HI-SEAS weather station, Hawaii
- Collected data/features (32686 rows):
  - Solar radiation [W/m^2]
  - Temperature [F]
  - Atmospheric pressure [Hg]
  - Humidity [%]
  - Wind speed [miles/h]
  - Wind direction [degrees]
  - Time sun rise
  - TIme sun set
- Response variable:
  - Solar radiation [W/m^2]

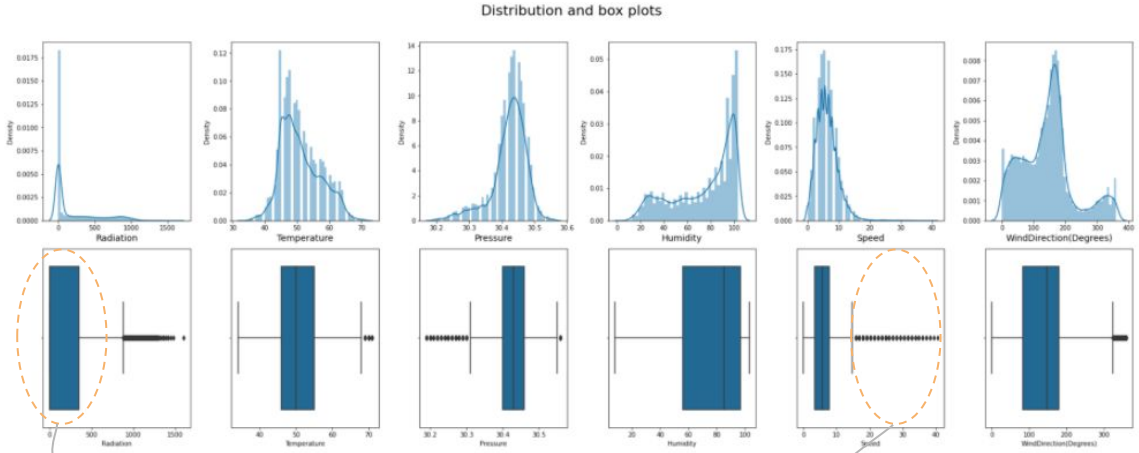
Approach

- Challenge:
  - Time Series
    - Cyclicity
    - Seasonality
- Feature Engineering
  - Deal with Time
- Models
  - Simple Linear Regression
  - Random Forest
  - Gradient Boosting
- Metrics:
  - R-Squared, Mean-Squared Error, CV

Train/Test Split

- Begin Sep. - End Nov.
  - As train set (70%)
- Begin Dec. - End Dec.
  - As test set (30%)
- Training Set, TimeSeriesSplit:
  - 3 Folds to ‘simulate’ seasonality

Explore - Distribution



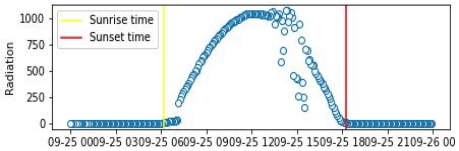
Roughly 50% of values located between 0 and 250 W/m^2

Extreme outliers

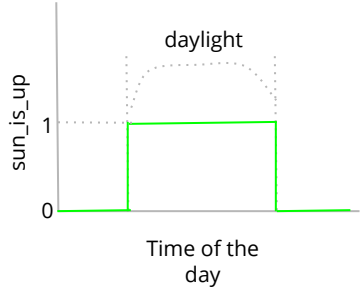
Feature Engineering: Time

2 cases

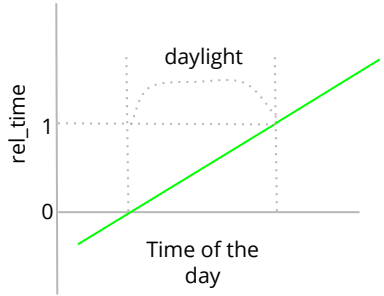
Typical solar radiation dist.



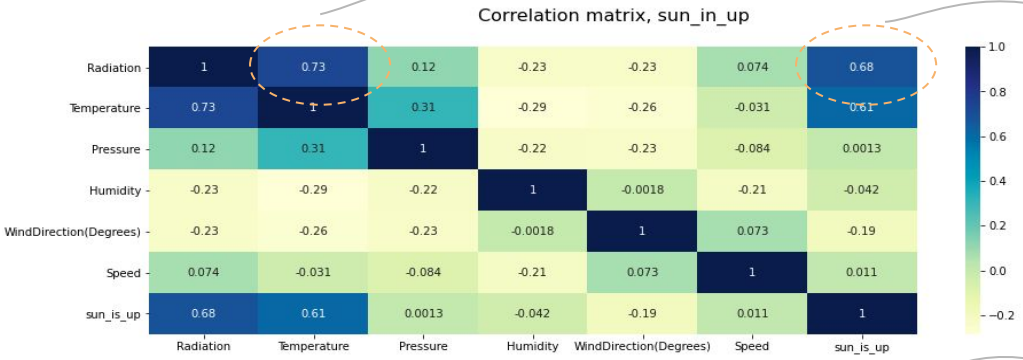
- Sun_is_up feature:
  - 0 - when outside of [SunRise - SunSet]
  - 1 - when during [SunRise - SunSet]
  - Band pass filter, hard cut-off

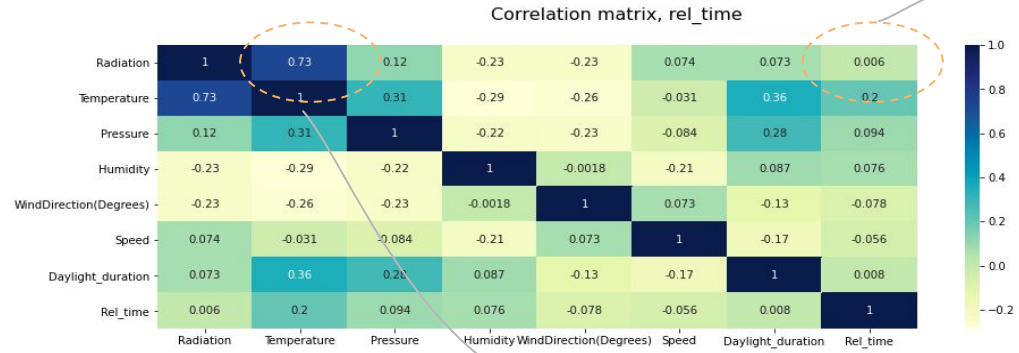


- Rel_time feature:
  - (Current_time - SunRise_time) / Daylight_duration
    - Daylight_duration = SunRise_time - SunSet_time
      - Rel_time < 0, if before sunrise
      - Rel_time = 0 at exact sunrise time
      - Rel_time (0,1) between sunrise and sunset, ***linear***
      - Rel_time = 1 at exact sunset time
      - Rel_time > 1 if after sunset



Explore - Correlation





High positive corr with radiation

Relatively high positive corr with radiation

Practically no corr with radiation, **BUT… see later**

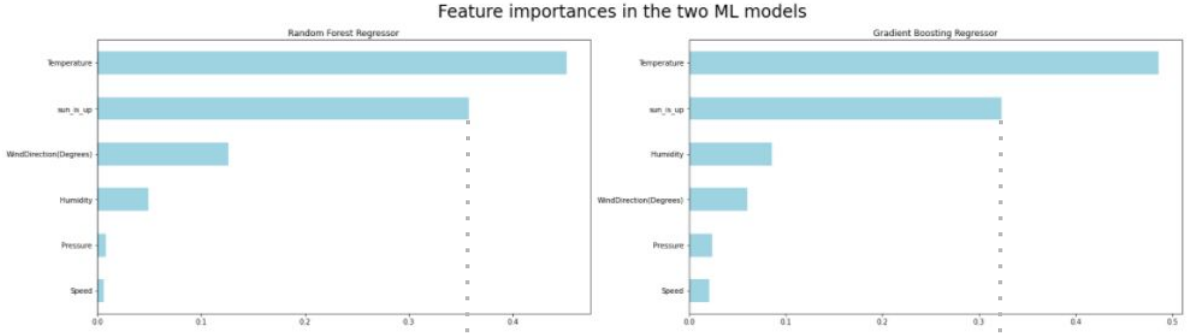
High positive corr with radiation

Models

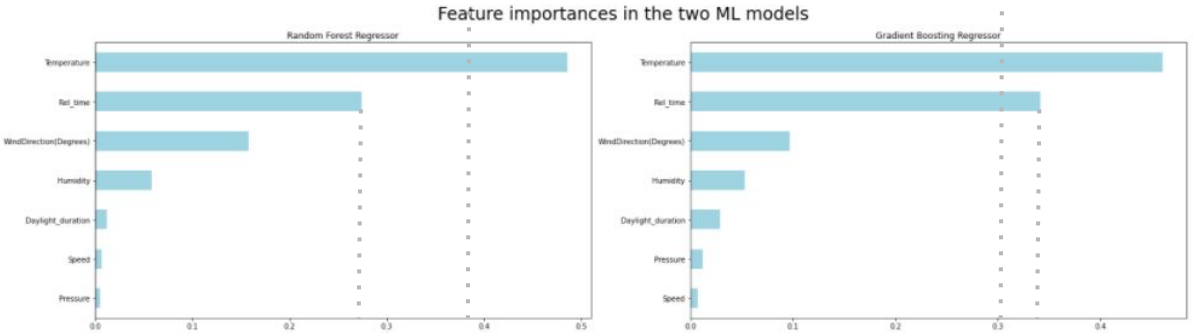
- Multivariate Linear Regression
- Random Forest
  - 3 folds - Cross Validation (sklearn.timeseriessplit)
  - Randomized best hyper-parameters search
- Gradient Boosting
  - 3 folds - Cross Validation (sklearn.timeseriessplit)
  - Randomized best hyper-parameters search

Feature Importance

sun_is_up feature

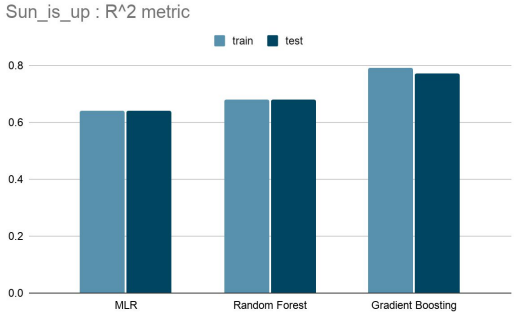


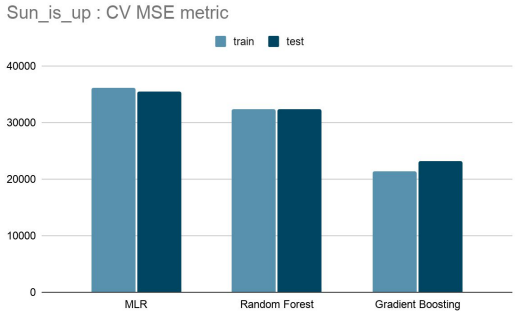
rel_time feature



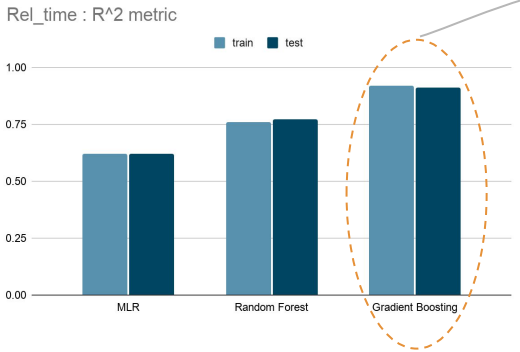
Results - Metrics

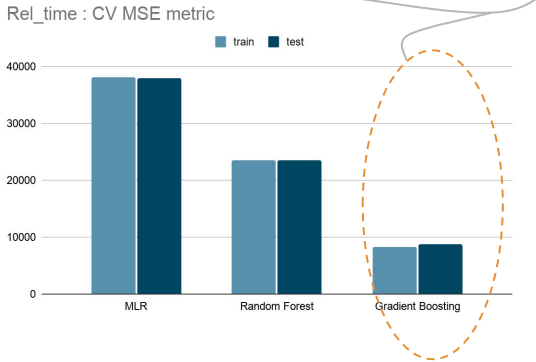
sun_is_up feature





rel_time feature



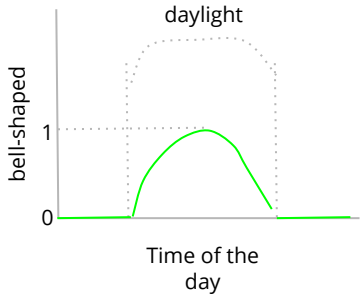


Best combination of model/feature


```
{
  "model": "GradientBoosting",
  "feature_case": "rel_time",
  "cv_mse": "9792.25",
  "train_mse": "8253.57",
  "test_mse": "8690.75",
  "train_r2": "0.92",
  "test_r2": "0.91"
}
```

Future work

- Feature Engineering
  - Model time within daylight period as bell-shaped
  - Exclude samples outside daylight period
    - Since solar radiation in practically zero during night hours
- Models
  - Try more models
    - **XGBoost**...
    - **SVR**



Questions