2018 SDSC Summer Institute
Scalable Machine Learning

SDSC SAN DIEGO SUPERCOMPUTER CENTER

UC San Diego

SparkR Hands-On

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SparkR

- R package that provides frontend to use Spark from R
- Supports distributed machine learning using R API
- Allows R script to connect to Spark cluster
- Can use with R shell or RStudio or other R IDEs.

SparkR

- **Uses MLlib for machine learning functionality**
- **Familiar R syntax:**
  - Read contents of file into a Spark dataframe
    - newdata <- read.df (“data.txt”, source=“csv”)
  - R formula operators for model fitting:
    - model <- spark.randomForest(training, label ~ features, "classification", numTrees = 10)
  - Get summary of fitted model
    - summary(model)
  - Apply model to make predictions
    - predictions <- predict(model, testDF)
  - Save model
    - write.ml (model, “mymodel”)

Server Setup

- **Go to sparkR directory**

  cd <SI2018_dir>/datasci1_scalable_machine_learning/spark/sparkR

- **Request compute node and start jupyter**
  - *sbatch --res=SI2018DAY2 sparkR.slrm*

SparkR Hands-On

- **Data Exploration**
  - Using weather data
  - Similar to PySpark hands-on, except using SparkR
    - Load into Spark DataFrame
    - Describe schema
    - Show summary statistics
    - Calculate correlation between features
- **Classification**
  - Predict wine quality
  - Model: random forest

Dataset for Data Exploration

- **Measurements from weather station on Mt. Woodson, San Diego**
- **Air temperature, humidity, wind speed, wind direction, etc.**
- **Three years of data: Sep. 2011 - Sep. 2014**
- ***minute_weather.csv***
  - measurement every minute
- ***daily_weather.csv***
  - aggregated measurements

Data Exploration

Server Setup (cont.)

- **Check queue**
  - *squeue –u $USER*
  - Note compute node name (e.g., comet-14-43)
    - 18223060 compute bash <user> R 1:19 1 comet-14-43
- **Check that Jupyter Notebook has started**
  - ls –l sparkR*.out

-rw-r--r-- 1 <user> sds148 840 Aug 4 09:32 sparkR.18317995.comet-14-43.out

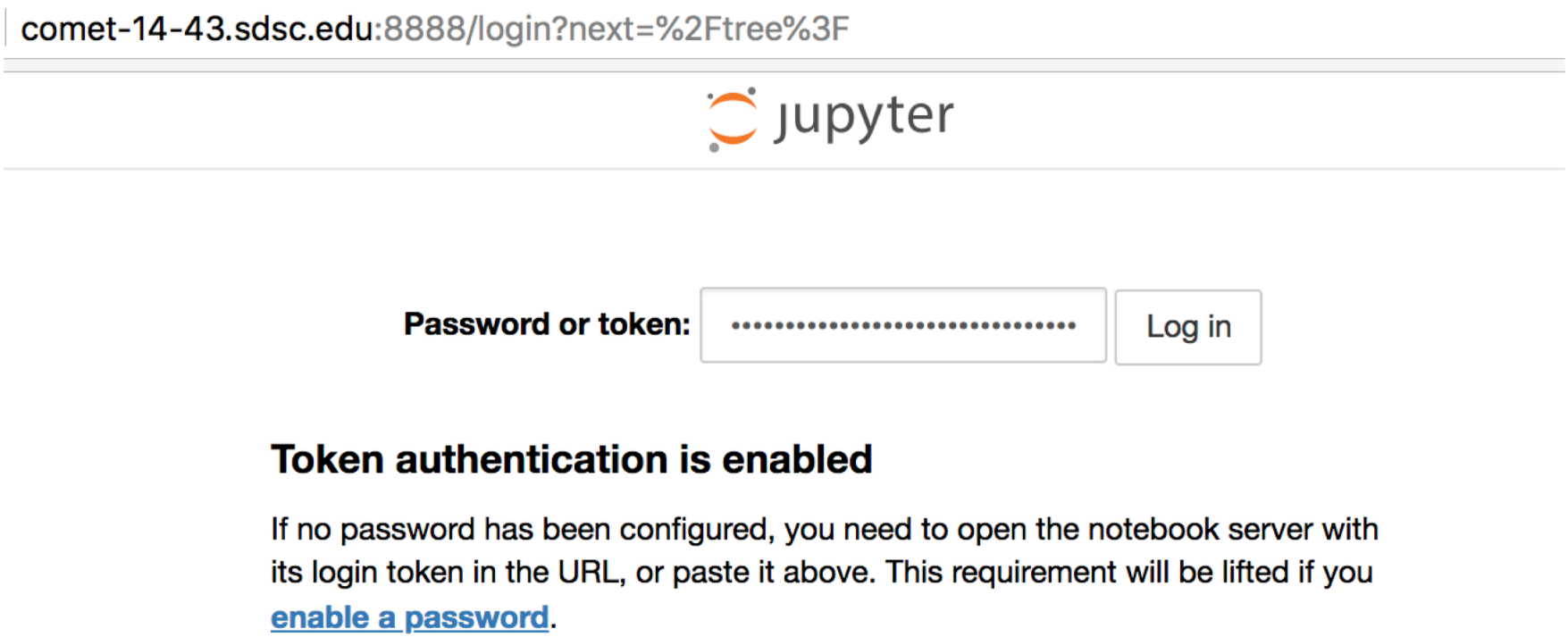
  - tail sparkR*.out
  - Copy token
    - *Copy/paste this URL into your browser when you connect for the first time, to login with a token:*

http://localhost:8888/?token=395fe3d456cb951e34ef125adf27e6a62

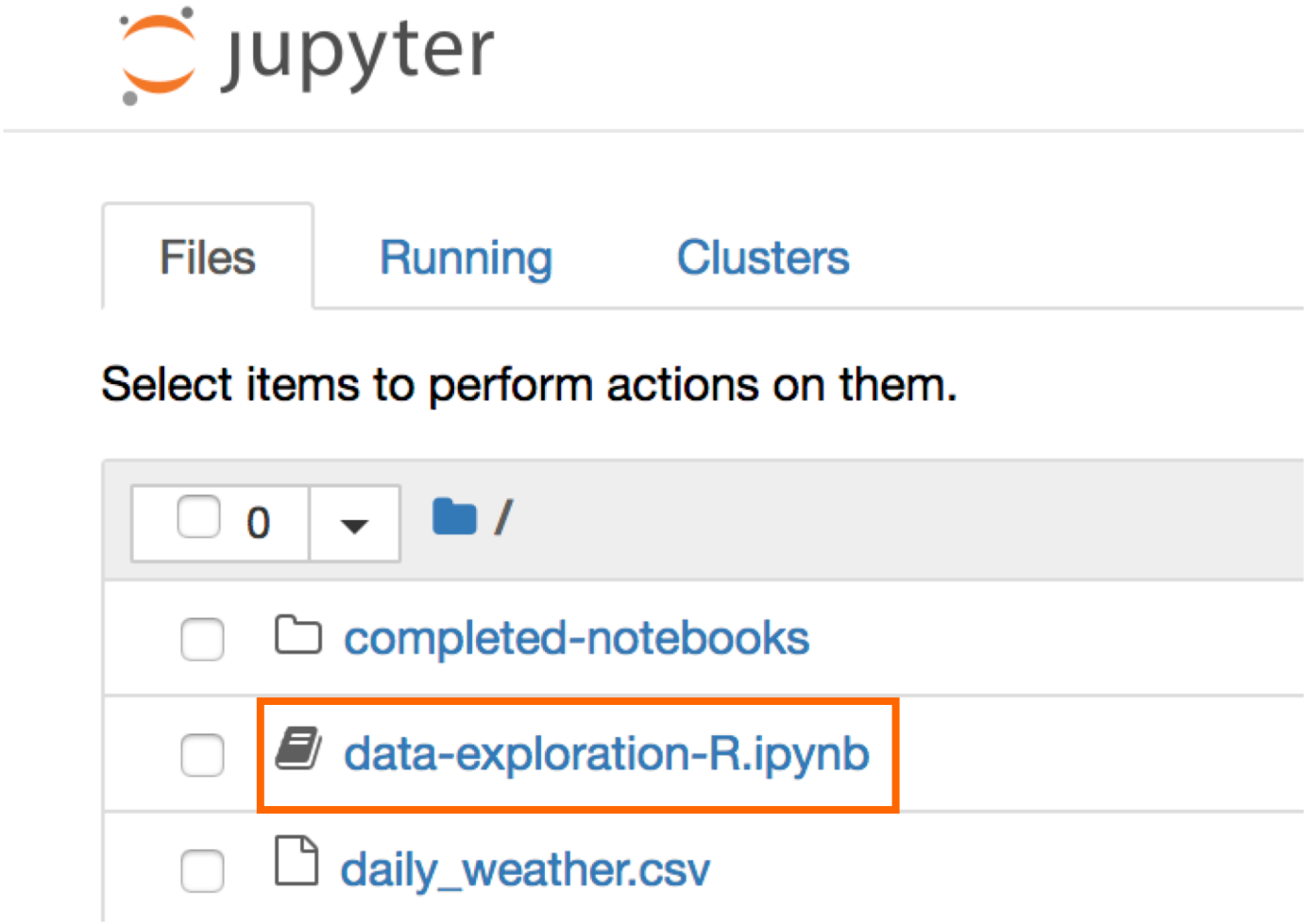
Should be > 0

Browser Setup

- **In browser, type:**
  - comet-xx-xx.sdsc.edu:8888
  - Paste token



Open SparkR Data Exploration Notebook



SparkR Setup

- Load Spark R library

```
library(SparkR, lib.loc = c(file.path(Sys.getenv("SPARK_HOME"), "R", "lib")))
```

- Start up Spark session

```
sparkR.session(master="local[*]", sparkConfig=list(spark.driver.memory="2g"))
```

Read in Data

- Read data into a Spark DataFrame
- Cache Spark DF

```
sdf <- read.df("daily_weather.csv", "csv", header="true", inferSchema="true")
```

```
cache(sdf)
```

Fill in file name

Examine Schema

schema(sdf)

```
StructType
|-name = "number", type = "IntegerType", nullable = TRUE
|-name = "air_pressure_9am", type = "DoubleType", nullable = TRUE
|-name = "air_temp_9am", type = "DoubleType", nullable = TRUE
|-name = "avg_wind_direction_9am", type = "DoubleType", nullable = TRUE
|-name = "avg_wind_speed_9am", type = "DoubleType", nullable = TRUE
|-name = "max_wind_direction_9am", type = "DoubleType", nullable = TRUE
|-name = "max_wind_speed_9am", type = "DoubleType", nullable = TRUE
|-name = "rain_accumulation_9am", type = "DoubleType", nullable = TRUE
|-name = "rain_duration_9am", type = "DoubleType", nullable = TRUE
|-name = "relative_humidity_9am", type = "DoubleType", nullable = TRUE
|-name = "relative_humidity_3pm", type = "DoubleType", nullable = TRUE
```

Show Summary Statistics

head(summary(sdf))

summary	number	air_pressure_9am	air_temp_9am
count	1095	1092	1090
mean	547.0	918.8825513138094	64.93300141287072
stddev	316.24357700987383	3.184161180386833	11.17551400317587 7
min	0	907.9900000000024	36.752000000000685
25%	273	916.550000000009	57.272000000000354
50%	547	918.9020905167166	65.69599999999856

Get Number of Rows

nrow(sdf)

1095

Show First Few Rows

head(sdf)

number	air_pressure_9am	air_temp_9am	avg_wind_direction_9am	avg_wind_speed_9am
0	918.0600	74.82200	271.1000	2.080354
1	917.3477	71.40384	101.9352	2.443009
2	923.0400	60.63800	51.0000	17.067852
3	920.5028	70.13889	198.8321	4.337363
4	921.1600	44.29400	277.8000	1.856660
5	915.3000	78.40400	182.8000	9.932014

Names and Number of Columns

names(sdf)

'number' 'air_pressure_9am' 'air_temp_9am' 'avg_wind_direction_9am' 'avg_wind_speed_9am' 'max_wind_direction_9am' 'max_wind_speed_9am' 'rain_accumulation_9am' 'rain_duration_9am' 'relative_humidity_9am' 'relative_humidity_3pm'

---

ncol(sdf)

11

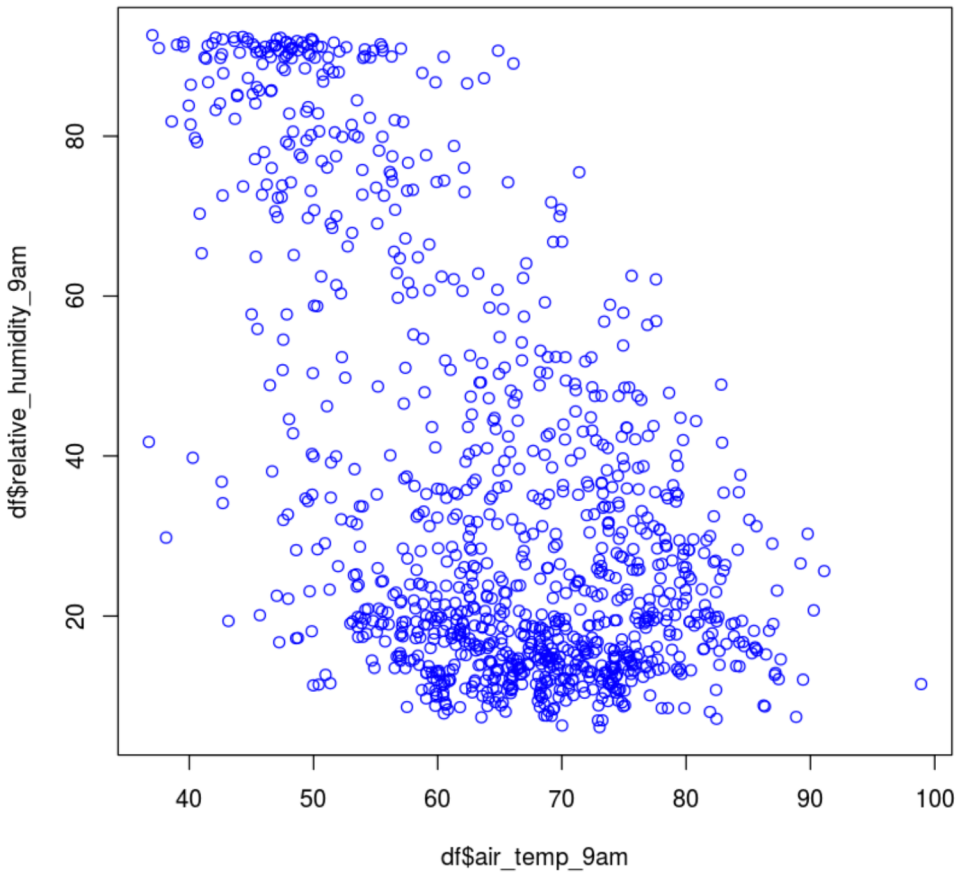
Correlation Between Air Temperature and Relative Humidity

corr(sdf, “air_temp_9am”, “relative_humidity_9am”, method=“pearson”)

-0.536670…

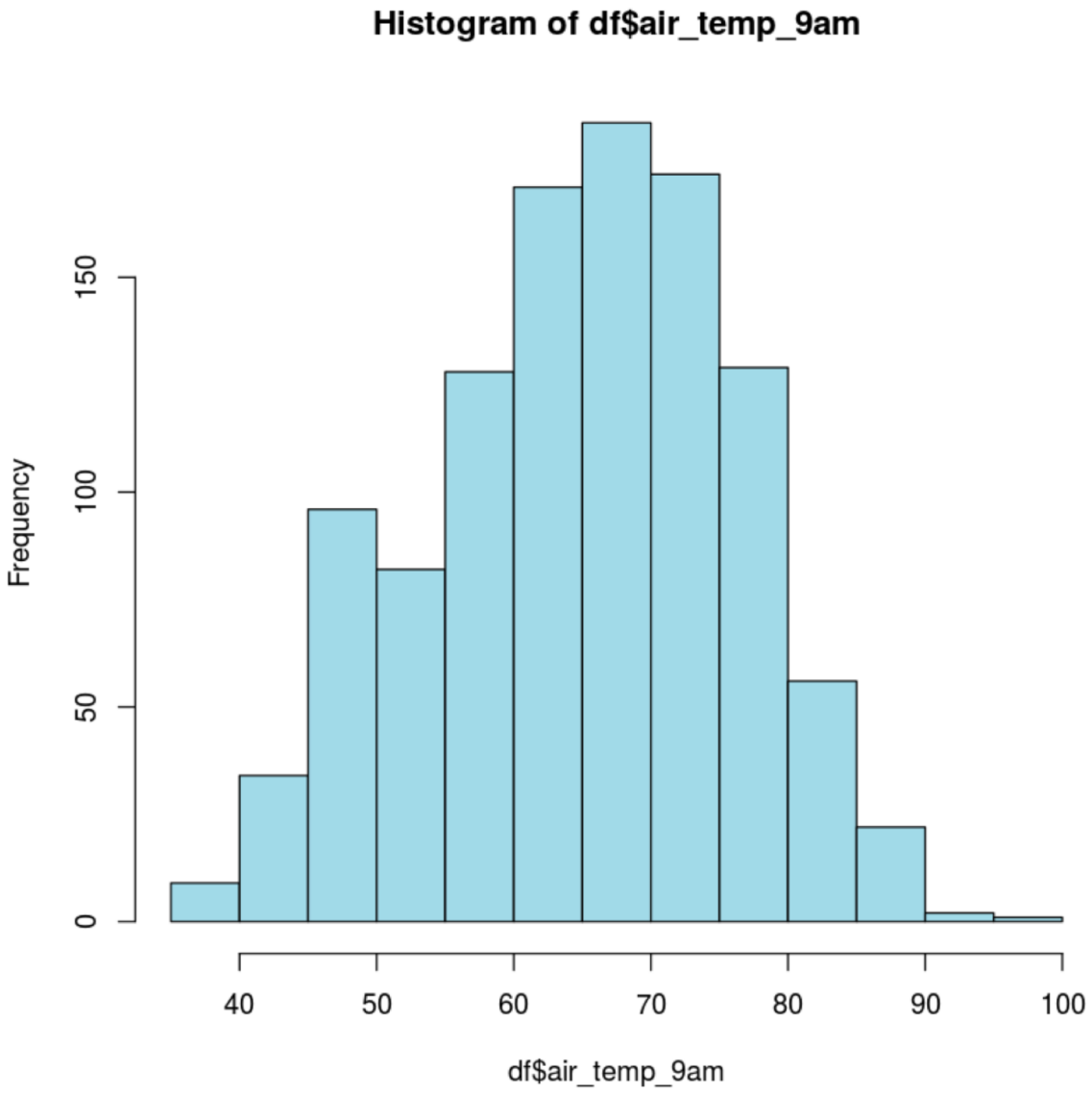
Scatter Plot of Air Temperature vs. Humidity (*)

plot(dfair_temp_9am, dfrelative_humidity_9am, col="blue")

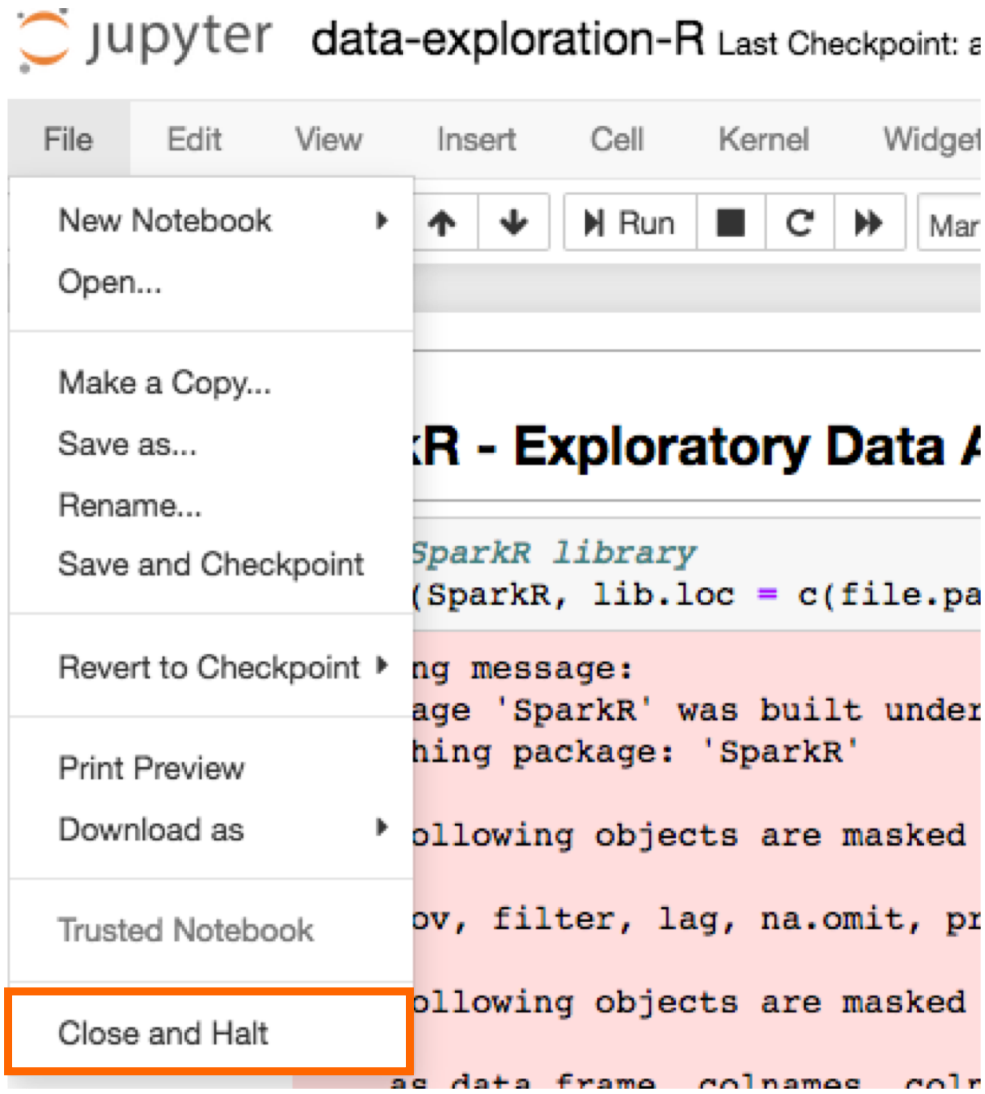


hist(df$air_temp_9am, col="lightblue")

Histogram of Air Temperature



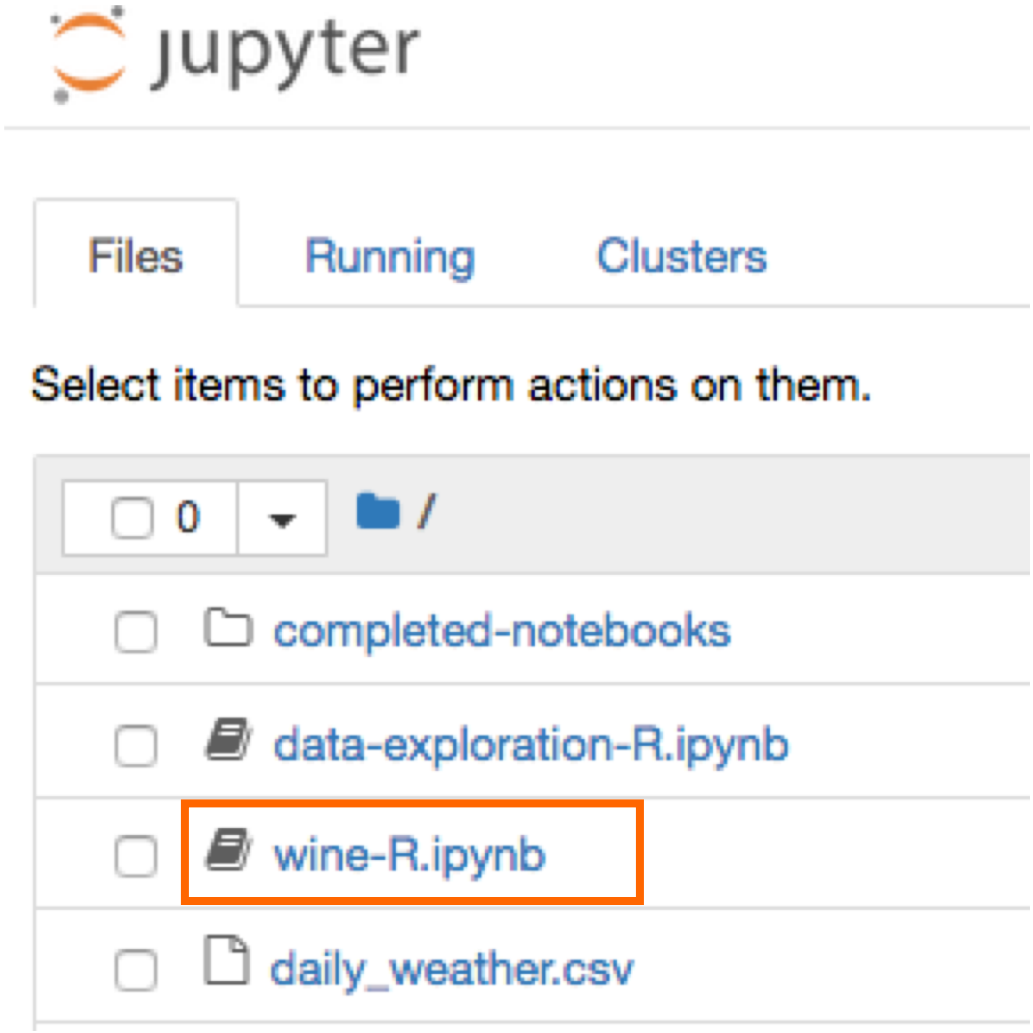
Exit Notebook



SparkR Classification Example

- **Task:**
  - Predict wine quality
- **Data:**
  - Wine dataset from UCI Machine Learning Repository
  - Features: fixed acidity, citric acid, total sulfur dioxide, etc.
  - Target:
    - Good (quality is 7-10)
    - Average (quality is 6)
    - Bad (quality is 0-5)
- **Approach:**
  - Random forest

Open wine-R Notebook



Wine Classification Results

```
mean(actual_vs_predicted$actual == actual_vs_predicted$predicted)
table(actual_vs_predicted$actual, actual_vs_predicted$predicted)
```

```
0.616621983914209
```

	average	bad	good
average	443	165	73
bad	163	342	7
good	153	11	135

Clean Up

- **Exit notebook**
  - File -> Close and Halt
- **Exit Jupyter Notebook**
  - Click on ‘Logout’

Machine Learning Algorithms in SparkR

Machine Learning

Algorithms

SparkR supports the following machine learning algorithms currently:

Classification

- spark.logit: Logistic Regression
- spark.mlp: Multilayer Perceptron (MLP)
- spark.naiveBayes: Naive Bayes
- spark.svmLinear: Linear Support Vector Machine

Regression

- spark.survreg: Accelerated Failure Time (AFT) Survival Model
- spark.glm or glm: Generalized Linear Model (GLM)
- spark.isoreg: Isotonic Regression

Tree

- spark.gbt: Gradient Boosted Trees for Regression and Classification
- spark.randomForest: Random Forest for Regression and Classification

Clustering

- spark.bisectingKmeans: Bisecting k-means
- spark.gaussianMixture: Gaussian Mixture Model (GMM)
- spark.kmeans: K-Means
- spark.lda: Latent Dirichlet Allocation (LDA)

Collaborative Filtering

- spark.als: Alternating Least Squares (ALS)

Frequent Pattern Mining

- spark.fpGrowth : FP-growth

Statistics

- spark.kstest: Kolmogorov-Smirnov Test

SparkR Resources

- **SparkR**
  - https://spark.apache.org/docs/latest/sparkr.html
- **SparkR Tutorial at useR 2016**
  - https://databricks.com/blog/2016/07/07/sparkr-tutorial-at-user-2016.html
- **Spark R API**
  - https://spark.apache.org/docs/latest/api/R/

Questions?

Scalable Machine Learning Topics

- **R in HPC**
  - Scaling R, running R on HPC
  - Scaling R linear models
- **Machine Learning with Spark**
  - Spark stack, RDDs
  - MLlib
- **PySpark Hands-On**
  - Data exploration
  - Clustering
- **SparkR Hands-On**
  - Data exploration
  - Random forest for classification