# Time Series Machine Learning: Weather Forecasting

## Section 1 (90 minutes)

### Topic 1: Introduction to Time Series Data and Weather Forecasting (20 minutes)

* What is time series data and what makes it unique
* Common weather data sources and formats (CSV, JSON, APIs)
* The importance of timestamps and data frequency in weather data
* Key weather variables: temperature, humidity, pressure, wind speed
* Applications of weather forecasting in real life

### Topic 2: Data Preparation for Weather Time Series (25 minutes)

* Loading and examining weather datasets in Python
* Time series preprocessing techniques
* Handling missing values in weather data
* Feature engineering for weather forecasting
  + Creating lag features
  + Adding calendar features (day of week, month, season)
  + Incorporating cyclical features (daily/yearly patterns)
* Data splitting strategies specific to time series

### Topic 3: Visualizing Weather Time Series Data (20 minutes)

* Time series plotting fundamentals
* Visualizing temperature trends over time
* Identifying seasonality and patterns in weather data
* Creating correlation plots between weather variables
* Interactive visualizations for exploratory data analysis

### Breakout Room 1: Weather Data Exploration (25 minutes)

Students will work in small groups to:

1. Load a provided weather dataset with temperature records
2. Clean and preprocess the data (handling missing values, converting timestamps)
3. Create at least three different visualizations that reveal patterns in the data
4. Identify and discuss key patterns found (daily cycles, seasonal trends, anomalies)

## Section 2 (90 minutes)

### Topic 4: Time Series Forecasting Models (35 minutes)

* Classical time series forecasting approaches
  + Moving averages for temperature prediction
  + Exponential smoothing methods
  + ARIMA models for temperature forecasting
* Machine learning approaches
  + Linear regression for simple forecasting
  + Random forests for temperature prediction
  + Introduction to deep learning for time series
* Comparing statistical vs. machine learning approaches

### Topic 5: Model Evaluation for Weather Forecasting (30 minutes)

* Time series specific evaluation metrics
  + Mean Absolute Error (MAE)
  + Root Mean Squared Error (RMSE)
  + Mean Absolute Percentage Error (MAPE)
* Importance of forecast horizon (next hour vs. next week)
* Visualizing forecast results
* Evaluating forecast uncertainty
* Common pitfalls in weather forecasting evaluation

### Breakout Room 2: Building Simple Weather Forecasting Models (25 minutes)

Students will work in groups to:

1. Use the preprocessed dataset from the first breakout session
2. Implement a simple forecasting model to predict temperature
3. Evaluate the model using appropriate time series metrics
4. Compare results between groups and discuss model limitations

## Lesson Summary and Next Steps (10 minutes)

* Review of key concepts covered
* Common challenges in time series forecasting
* Best practices for weather prediction projects
* Introduction to more advanced topics
  + Multivariate forecasting
  + Incorporating external data (like satellite imagery)
  + Ensemble methods for improved accuracy
* Assignment of a mini-project on temperature forecasting

## Additional Resources

* Kaggle weather datasets: <https://www.kaggle.com/datasets?search=weather>
* Time series forecasting documentation with Python: <https://machinelearningmastery.com/time-series-forecasting-methods-in-python-cheat-sheet/>
* Book recommendation: "Practical Time Series Analysis" by Aileen Nielsen
* Tutorial on weather forecasting with Python: <https://towardsdatascience.com/weather-forecasting-with-machine-learning-using-python-55e90c346647>
* NOAA weather data API: <https://www.ncdc.noaa.gov/cdo-web/webservices/v2>

The lesson is designed to provide students with both theoretical knowledge and hands-on experience in time series analysis for weather forecasting, with a specific focus on temperature prediction. The breakout sessions will reinforce concepts and give students practical experience with real weather data.