Training Course on Atmospheric Correction and Radiometric Calibration of Imagery

Professional Development Training Course Outline

Category	GIS	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

In the era of **Big Data** and **Geospatial Analytics**, accurately interpreting satellite and aerial imagery is paramount across diverse sectors like **environmental monitoring**, **urban planning**, and **precision agriculture**. Raw remotely sensed data is often distorted by atmospheric scattering and absorption, as well as sensor-specific characteristics, leading to inaccurate surface reflectance or radiance values. This necessitates robust **Atmospheric Correction** and **Radiometric Calibration** techniques to transform raw imagery into meaningful, quantitative information. Training Course on Atmospheric Correction and Radiometric Calibration of Imagery addresses this critical need by equipping professionals with the expertise to process and analyze large-scale imagery datasets efficiently, leveraging the power of **Apache Spark** and **Hadoop** for distributed computing.

This comprehensive program delves into the theoretical foundations and practical applications of these essential image pre-processing steps, emphasizing **scalable solutions** for **high-resolution imagery**. Participants will gain hands-on experience with cutting-edge tools and methodologies, enabling them to confidently handle the complexities of **remote sensing data processing**. The course will highlight how **distributed computing frameworks** like Spark and Hadoop revolutionize the ability to manage and process massive volumes of geospatial data, ensuring **data quality**, **temporal consistency**, and **inter-sensor comparability** for advanced analytical workflows and impactful decision-making.

Programme Curriculum

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Course Objectives

1. Master the fundamental principles of atmospheric correction algorithms and radiometric calibration techniques.
2. Understand the impact of atmospheric effects (e.g., scattering, absorption) and sensor characteristics on remotely sensed imagery.
3. Proficiently apply pre-processing steps to raw satellite and aerial data for accurate reflectance retrieval.
4. Develop expertise in using Apache Spark for distributed processing of large-scale geospatial datasets.
5. Gain practical experience with Hadoop Distributed File System (HDFS) for efficient storage and management of imagery.
6. Implement various atmospheric correction models (e.g., FLAASH, ATCOR, DOS) using programming languages like Python and Scala.
7. Perform sensor calibration and inter-sensor normalization for multi-temporal and multi-source imagery analysis.
8. Assess the quality and accuracy of corrected imagery through various validation metrics.
9. Optimize Spark and Hadoop configurations for geospatial big data workflows.
10. Explore cloud-based platforms and their integration with Spark for scalable remote sensing applications.
11. Apply machine learning techniques on atmospherically corrected data for advanced image classification and feature extraction.
12. Understand the ethical considerations and data governance best practices in geospatial data processing.
13. Prepare for real-world challenges in remote sensing data analytics and earth observation.

Organizational Benefits

- Enhance the **accuracy** and **reliability** of **geospatial data analysis**, leading to more informed decision-making.
- Significantly improve the **efficiency** of processing **large imagery datasets**, reducing computational time and resources.

- Unlock the full potential of **multi-temporal** and **multi-sensor imagery** for advanced monitoring and change detection.
- Foster internal expertise in **Big Data technologies** (Spark, Hadoop) for **geospatial applications**, minimizing reliance on external consultants.
- Improve **data comparability** across different acquisition dates and sensors, facilitating robust time-series analysis and trend identification.
- Enable the development of **customized image processing workflows** tailored to specific organizational needs.
- Reduce **data inconsistencies** and **artifacts** in remotely sensed products, leading to higher quality outputs for downstream applications.
- Boost overall **productivity** in **remote sensing departments** by automating complex pre-processing tasks.
- Gain a competitive edge by leveraging **advanced analytics capabilities** for environmental, agricultural, and urban planning initiatives.

Target Audience

1. Remote Sensing Specialists and Analysts.
2. GIS Professionals and Geospatial Engineers
3. Data Scientists and Big Data Engineers.
4. Environmental Scientists and Researchers.
5. Agriculturalists and Agronomists.
6. Urban Planners and Civil Engineers.
7. Software Developers.
8. Graduate Students and Academics in remote sensing, GIS, computer science, or related fields.

Course Outline

Module 1: Introduction to Remote Sensing Data and Challenges

- Fundamentals of Remote Sensing: Electromagnetic spectrum, sensors, spatial, spectral, temporal, and radiometric resolutions.
- Types of Imagery: Satellite vs. Aerial vs. Drone data, multispectral, hyperspectral.
- Data Formats and Standards: GeoTIFF, HDF5, Cloud Optimized GeoTIFF (COG).
- Challenges in Imagery Processing: Atmospheric effects, sensor noise, illumination variations, data volume.
- Importance of Pre-processing: Why atmospheric correction and radiometric calibration are critical.
- **Case Study**: Analyzing raw Landsat 8 data to identify visible atmospheric haze and its impact on spectral signatures.

Module 2: Radiometric Principles and Calibration

- Radiance, Reflectance, and Digital Numbers (DNs): Understanding the relationships.
- Sensor Calibration: Absolute vs. relative calibration, gains and offsets.
- Top-of-Atmosphere (TOA) Radiance and Reflectance: Conversion equations and practical applications.
- Inter-Sensor Normalization: Techniques for harmonizing data from different satellite platforms.
- BRDF Correction: Accounting for bi-directional reflectance distribution function effects.
- **Case Study**: Calibrating MODIS data to TOA reflectance and comparing it with Landsat TOA reflectance for a common area.

Module 3: Atmospheric Correction Fundamentals

- Atmospheric Effects: Scattering (Rayleigh, Mie), absorption (water vapor, ozone, CO2).
- Atmospheric Models: Radiative Transfer Models (e.g., 6S, MODTRAN, ATCOR).
- Image-Based Atmospheric Correction: Dark Object Subtraction (DOS), Tasseled Cap, Haze Optimized Transform (HOT).
- Physics-Based Atmospheric Correction: Utilizing atmospheric parameters and radiative transfer theory.
- Aerosol Optical Depth (AOD): Importance in atmospheric correction.
- **Case Study**: Applying Dark Object Subtraction to a cloudy Sentinel-2 image and observing the improvement in land features.

Module 4: Introduction to Big Data for Geospatial

- Overview of Big Data Concepts: Volume, Velocity, Variety, Veracity.
- Distributed Computing Paradigms: MapReduce, In-memory computing.
- Apache Hadoop Ecosystem: HDFS, YARN, MapReduce.
- Introduction to Apache Spark: RDDs, DataFrames, Spark SQL, Spark Streaming, MLlib, GraphX.
- Setting up a Local Spark/Hadoop Environment: Practical installation and configuration.
- **Case Study**: Storing a large collection of drone imagery across an HDFS cluster.

Module 5: Spark for Geospatial Data Processing

- Spark Core API for Imagery: Loading and processing raster data with Spark.
- Geospatial Libraries in Spark: GeoMesa, RasterFrames, GeoSpark (Apache Sedona).
- Parallel Processing of Raster Data: Splitting imagery, partitioning, and aggregation.
- Optimizing Spark Jobs for Geospatial Workloads: Caching, broadcast variables, shuffle operations.
- Fault Tolerance and Resilience in Spark: Handling failures in distributed environments.
- **Case Study**: Implementing a parallel mosaic operation for a large collection of satellite scenes using Spark's DataFrame API.

Module 6: Implementing Atmospheric Correction with Spark

- Parallelizing DOS and HOT Algorithms: Distributing calculations across Spark clusters.
- Integrating Radiative Transfer Models with Spark: Batch processing using pre-computed look-up tables.
- Developing Custom Atmospheric Correction Functions: User-Defined Functions (UDFs) in Spark.
- Handling Metadata for Correction: Extracting and utilizing sensor and atmospheric parameters.
- Performance Comparison: Spark vs. traditional single-machine processing for atmospheric correction.
- **Case Study**: Applying a customized atmospheric correction algorithm (e.g., simplified 6S model) to a regional Landsat dataset using PySpark.

Module 7: Radiometric Calibration in a Distributed Environment

- Distributing Sensor Calibration: Applying gain and offset corrections in parallel.
- Batch Processing TOA Conversions: Efficiently converting raw DNs to radiance/reflectance.
- Automating Inter-Sensor Normalization: Building scalable workflows for cross-platform data harmonization.
- Quality Control of Calibrated Imagery: Statistical analysis and visual inspection.

- Handling Data Gaps and Outliers: Imputation techniques in Spark.
- **Case Study**: Developing a Spark pipeline to radiometrically calibrate an entire archive of Sentinel-1 radar imagery, ensuring consistent backscatter values.

Module 8: Advanced Atmospheric Correction Techniques

- Water Vapor Retrieval: Techniques for estimating atmospheric water content from imagery.
- Cloud and Cloud Shadow Detection: Automated methods for masking contaminated pixels.
- Topographic Correction: Accounting for terrain effects on reflectance.
- Atmospheric Correction over Water Bodies: Specific considerations for aquatic environments.
- Deep Learning for Atmospheric Correction: Emerging AI-based approaches.
- **Case Study**: Implementing a multi-stage correction workflow that includes cloud masking and topographic correction on a mountainous region's imagery.

Module 9: Data Management and Storage with Hadoop

- HDFS Architecture: NameNode, DataNode, blocks, replication.
- Optimizing HDFS for Geospatial Data: Block size, compression, archiving.
- Data Ingestion Strategies: Sqoop, Flume for remote sensing data.
- Data Governance and Security in Hadoop: Access control, encryption.
- Integration with Other Hadoop Ecosystem Tools: Hive, HBase for metadata management.
- **Case Study**: Designing an HDFS schema for storing and indexing a massive collection of high-resolution aerial imagery for a national mapping agency.

Module 10: Geospatial Workflows and Pipelines

- Building End-to-End Processing Pipelines: From raw data to analysis-ready products.
- Workflow Orchestration: Apache Airflow or Oozie for scheduling geospatial tasks.
- Version Control for Geospatial Workflows: Git for code and pipeline management.
- Error Handling and Logging: Robustness in distributed processing.
- Scalable Output Formats: Cloud Optimized GeoTIFF (COG), Zarr for analysis.
- **Case Study**: Designing and implementing an automated pipeline in Spark and Hadoop to continuously process incoming satellite imagery for a deforestation monitoring program.

Module 11: Quality Assessment and Validation

- Quantitative Accuracy Assessment: Root Mean Square Error (RMSE), Mean Absolute Error (MAE).
- Qualitative Assessment: Visual inspection, image histograms, spectral profiles.
- Reference Data and Ground Truthing: In-situ measurements for validation.
- Cross-Validation Techniques: Comparing results from different correction methods.
- Uncertainty Quantification: Assessing the reliability of corrected data.
- **Case Study**: Validating the atmospheric correction results of a time-series dataset against ground-based spectral measurements from an AERONET station.

Module 12: Cloud Computing for Remote Sensing with Spark/Hadoop

- Cloud Platforms for Big Data: AWS, Azure, Google Cloud Platform.
- Deploying Spark and Hadoop on the Cloud: EMR, Dataproc, HDInsight.
- Cloud Storage for Imagery: S3, Azure Blob Storage, GCS.
- Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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