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Research excellence supporting a sustainable ocean

Day 2: Atmospheric Correction of Airborne and Satellite Data

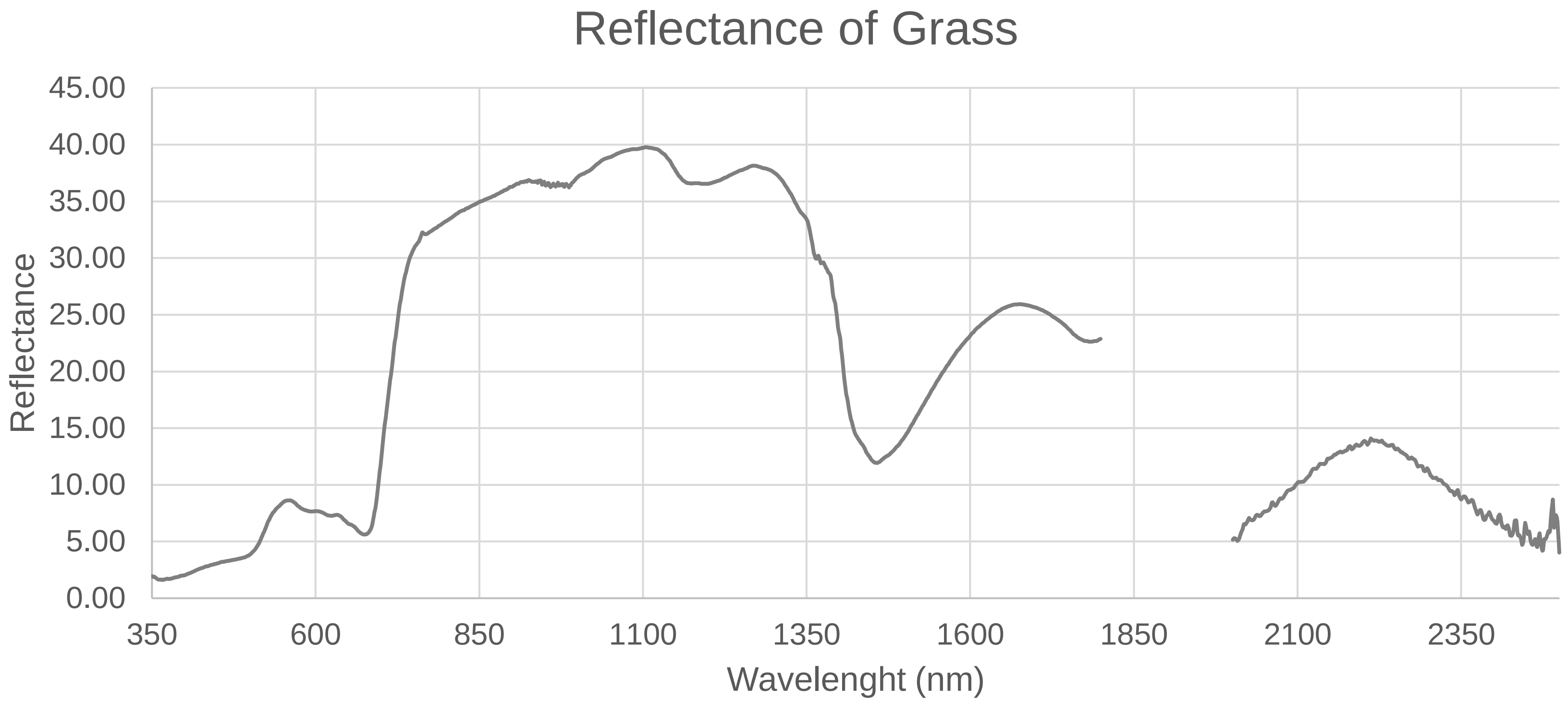
Dan Clewley & Will Jay

Atmospheric Correction

- Why it is needed
- Some methods
  - Empirical Line Correction
  - Radiative Transfer
- Think about how this fits in with your workflows

Reflectance data

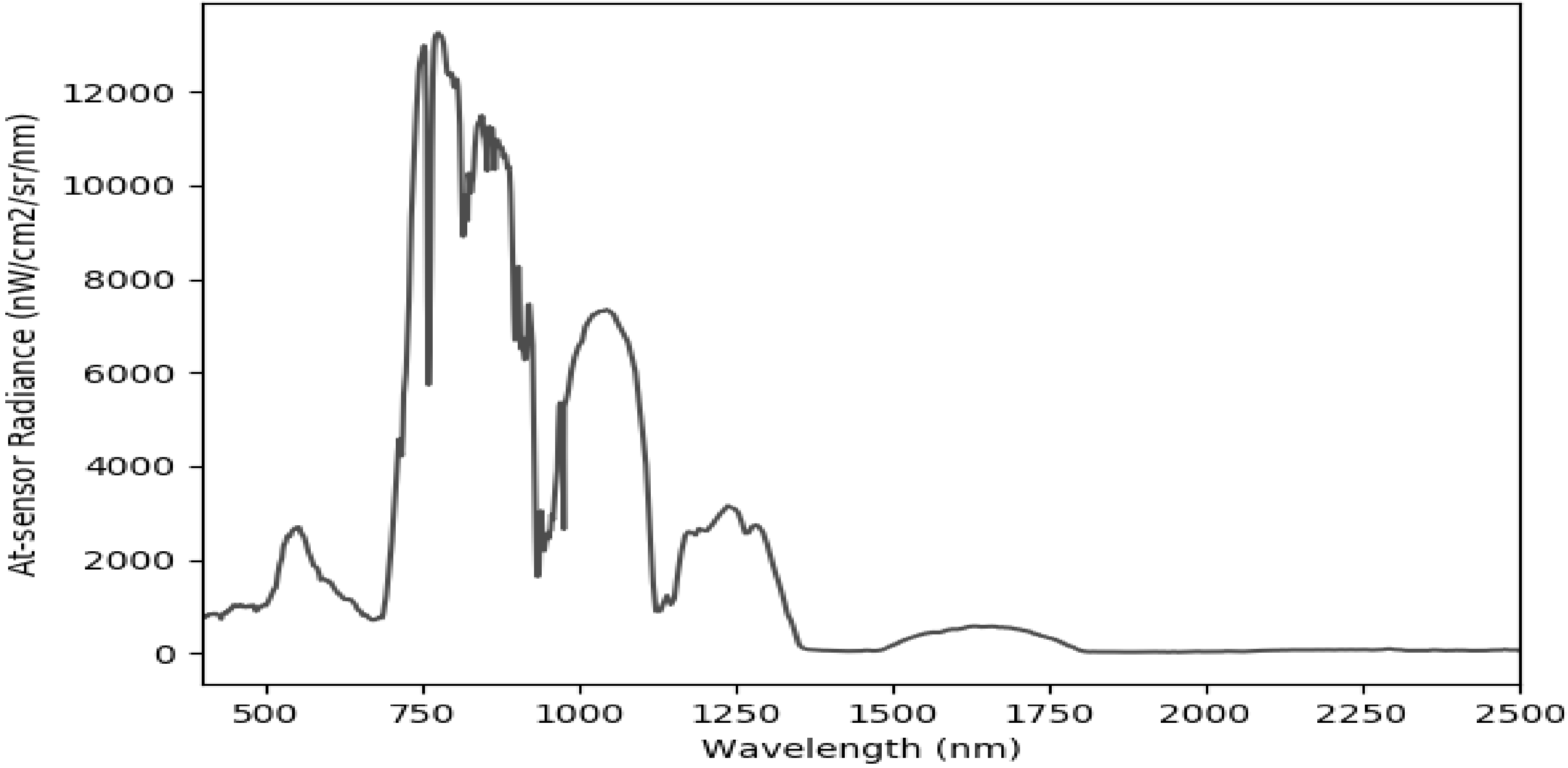
This is what you would measure in the field – more on this tomorrow!



Chris MacLellan, NERC Field Spectroscopy Facility

At-sensor radiance data

This is what level 1b data looks like (hyperspectral example)



Should you do your own atmospheric correction?

- It depends!

Is atmospherically corrected data available for the sensor you want to use?

Yes

Is atmospheric correction suitable for your application?

Yes

You don't need to do your own correction

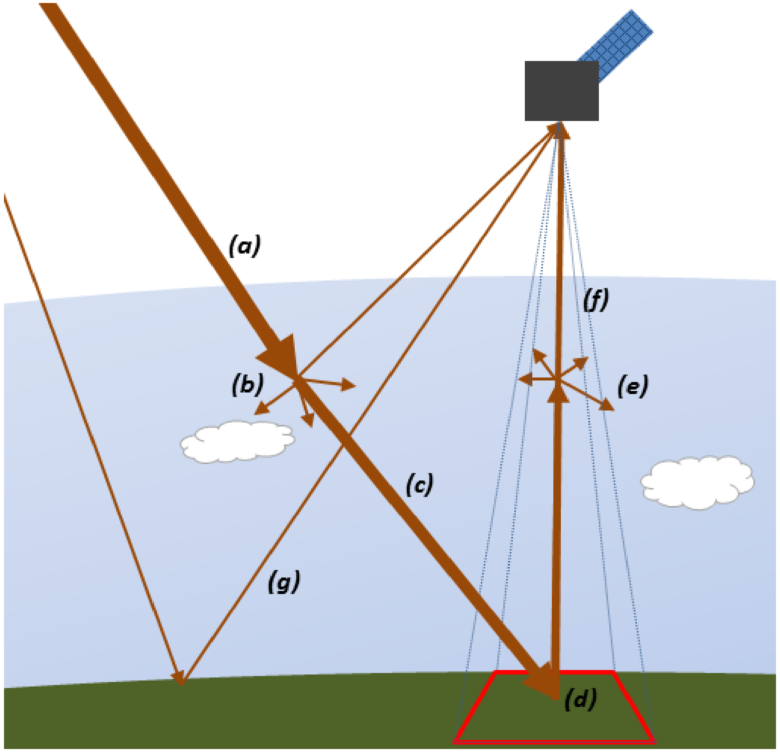
No

No

You need to do your own correction

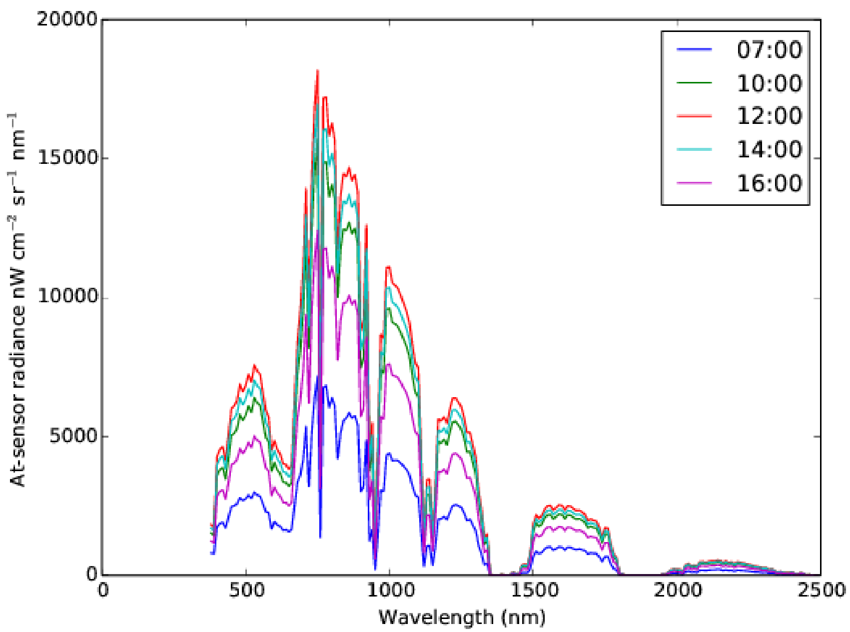
The path of light

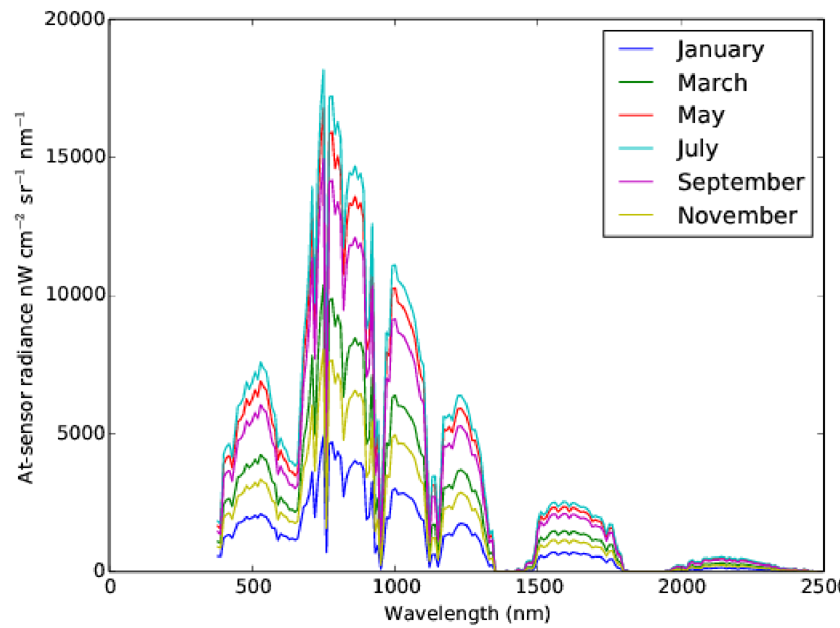
- Difference between surface reflectance and at-sensor radiance
  - Variations in solar irradiance (time and location)
  - Scattering and absorption in atmosphere



a) Down-welling solar irradiance
b) Scattering (down-welling)
c) Absorption (down-welling),
d) Surface reflectance
e) Scattering (up-welling),
f) Absorption (up-welling)
g) Adjacency effect.

Variation in solar irradiance due to time of year and time of day

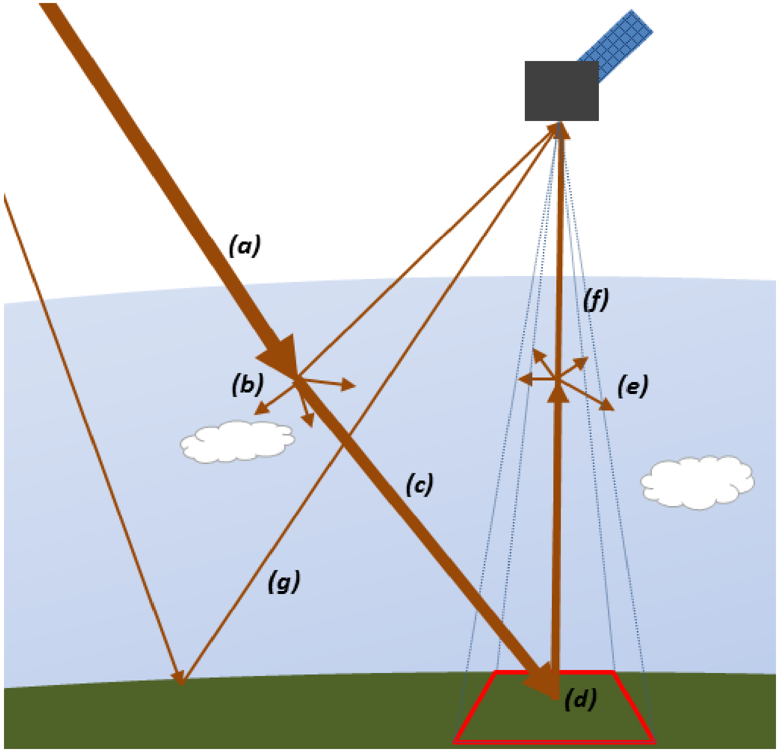




- Assumes atmospheric conditions don’t change
- Simulations produced using Py6S
- Can calculate solar irradiance and convert to Top of Atmosphere Reflectance

The path of light

- Difference between surface reflectance and at-sensor radiance
  - Variations in solar irradiance (time and location)
  - **Scattering and absorption in atmosphere**



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Atmospheric Correction

- Main approaches for airborne
  - Empirical Line Calibration (most suitable for drone)
  - Radiative Transfer models (e.g., FLAASH, ATCOR4)

- For satellite targets normally only used for cal/val – not by most users
  - Radiative Transfer (SEN2COR, ARCSI, ACOLITE, FLAASH, ATCOR3)
  - Water model approaches (e.g., POLYMER)

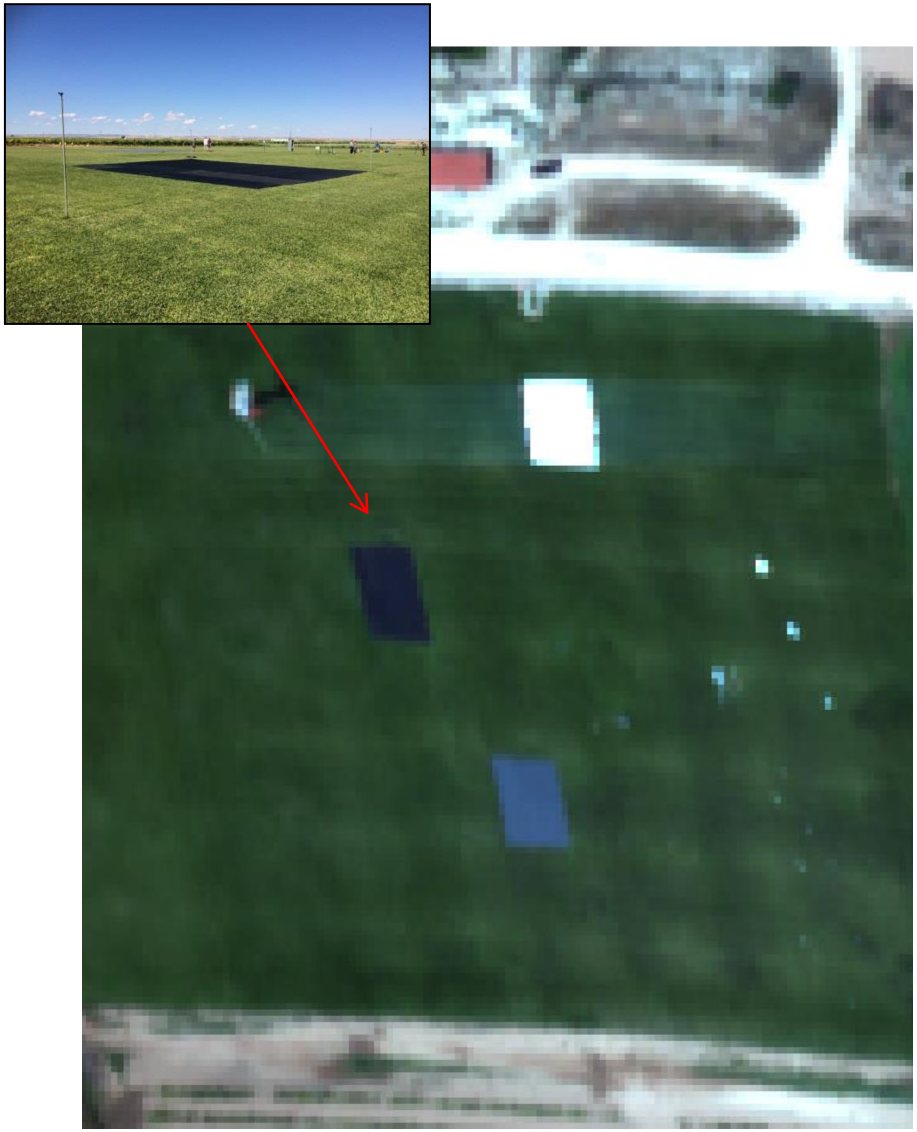
- Different methods better suited for land or water

Warren, M. A., Simis, S. G. H., Martinez-Vicente, V., Poser, K., Bresciani, M., Alikas, K., et al. (2019). Assessment of atmospheric correction algorithms for the Sentinel-2A MultiSpectral Imager over coastal and inland waters. *Remote Sensing of Environment*, *225*, 267–289. http://doi.org/10.1016/j.rse.2019.03.018

Empirical Line Calibration

- Lay out targets or use natural ones
  - FSF and NCEO have targets available
  - Large and heavy (not suitable for all locations)

- Take spectral readings at time of overpass



Empirical Line Calibration

- Form linear relationship for each band

- Apply relationship to all pixels in flight line / flight
  - Function to do this in ENVI
  - We have a Python script which you will use in practical

- Can use corrected orthogonal line to correct other lines in flight
  - Applies to other correction methods (Asmat, Milton & Atkinson, 2011)
  - Flow as standard for NERC-ARF data

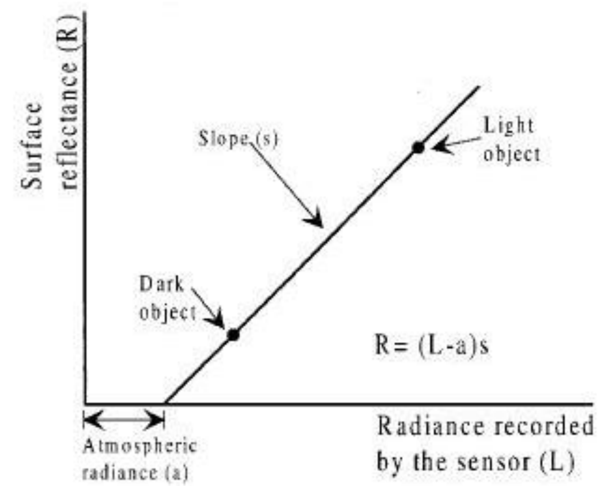


Figure 1. The development of a prediction equation from two calibration targets by the empirical line method.

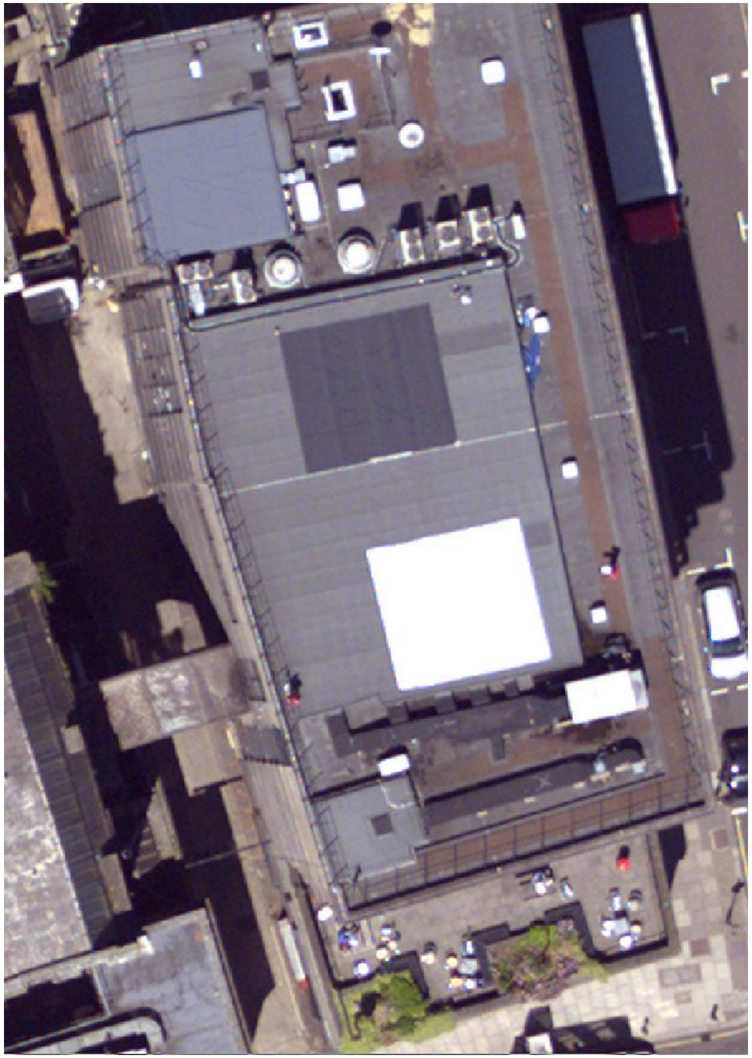
Smith & Milton 1999

Smith, G. M & Milton, E. J (1999). *The use of the empirical line method to calibrate remotely sensed data to reflectance*. **International Journal of Remote Sensing**. Volume 20, Issue 13. pages 2653-2662.

Karpouzli, E & Malthus, T (2003). *The empirical line method for the atmospheric correction of IKONOS imagery*. **International Journal of Remote Sensing**. Volume 24, Issue 5. pages 1143-1150.

Empirical Line Calibration - Assumptions

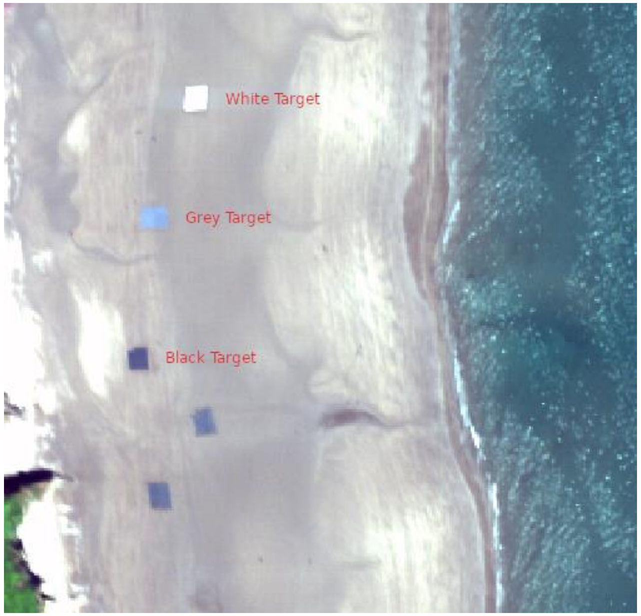
- No differences in illumination across the image
  - changes in radiance due to cloud shadowing or topography would be ignored
- The effects of the atmosphere are uniform across the image.
  - However, atmospheric constituents, especially water vapour, can vary greatly over short distances (Gao *et al.* 1991). NB: flat terrain.
- The Earth's surface consists of Lambertian reflectors
  - But most surfaces have bi-directional reflectance properties (Silva 1978).
- Areas of homogeneous reflectance
  - Of sufficient size to account for the Point Spread Function.

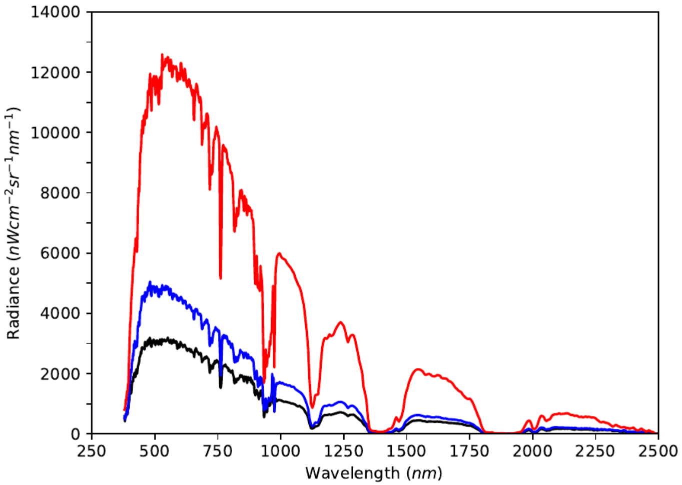


Source Gary Llewellyn, NERC-ARF

Airborne Data (Empirical Line Correction) Practical

- Airborne Processing Library (APL) for working with airborne hyperspectral data
- Empirical Line Correction
  - L1 → L2 → L3
- Introduction to band indices
- macOS users will need to run APL commands in docker
  - Or can use MAGEO (will do a short demo in wonder)





Practical Sessions

- **Now – 10:30: Hyperspectral (Specim AsiaFENIX)**
  - **Atmospherically correct airborne data using the Empirical Line method**

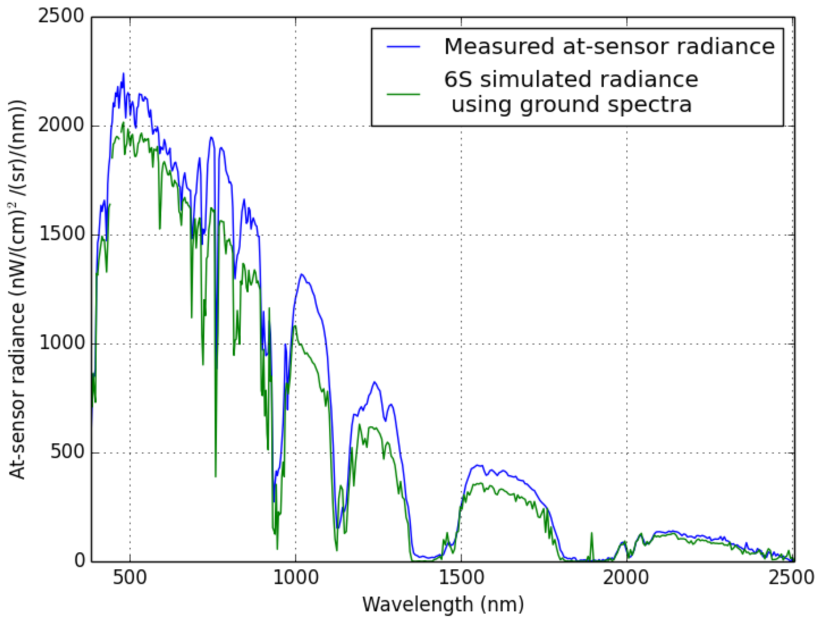
- 11:00 - 13:00: Py6S Practical
  - Learn about the 6S Radiative Transfer Model and how to parameterise

- 14:00 – 16:00: Satellite
  - Learn how to apply atmospheric correction to satellite data using ARCSI and ACOLITE

We'll start each session in Zoom and then move to Wonder for the practical component.

Radiative Transfer (RT) models

- Create a model of the atmosphere and use this to estimate absorption and scattering within the atmosphere
- Examples are MODTRAN and 6S
- Require several input parameters:
  - Aerosol type
  - Aerosol optical thickness
  - Water vapour



Example of ground spectra with atmosphere modelled using Py6S

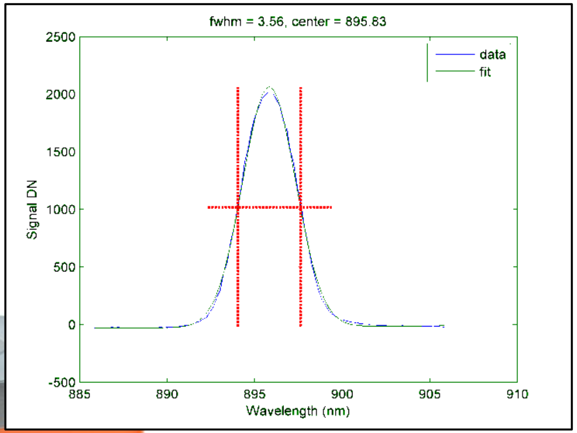
RT modelling - Aerosol optical thickness data

- Derive from image data:
  - ATCOR AOT retrieval based on Dense Dark Vegetation (DDV)
  - ARCSI retrieval based on Dark Object Subtraction
- Measure
  - FSF sun photometer (recommended)
- External data
  - AERONET
- Derive from image and validate

Chris MacLellan, NERC Field Spectroscopy Facility

RT modelling – platform and instrument characteristics

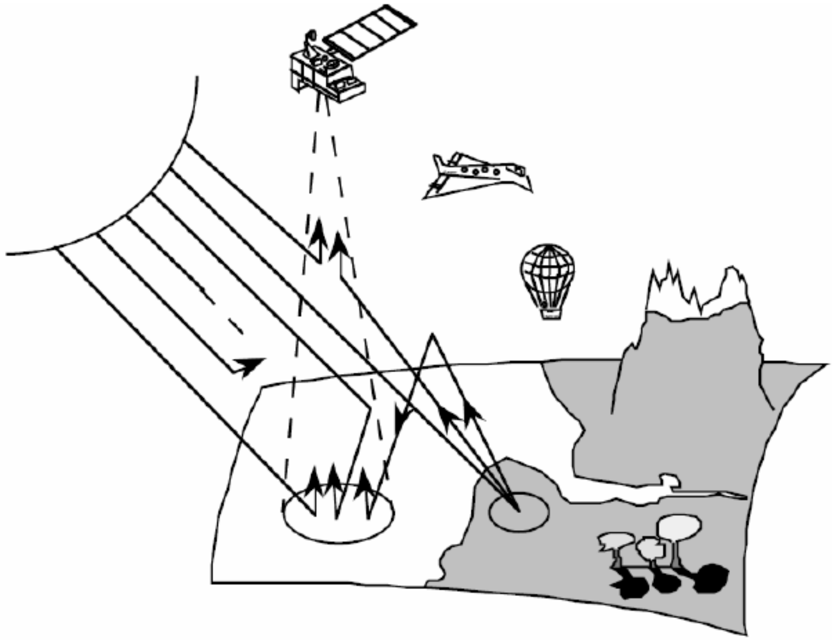
- Instrument
  - Range of wavelengths
  - Centre wavelengths for each band
  - Response function (can approximate with FWHM)
  - Look angle (pixel dependent)



- Platform
  - Height above ground (also depends on surface)
  - Flight heading (for airborne)

Py6S Practical

- Python Interface for the 6S Atmospheric Model
- Used in ARCSI to apply to satellite images (we'll cover this in the afternoon)
- Allows simulation of at-sensor radiance from field spectra



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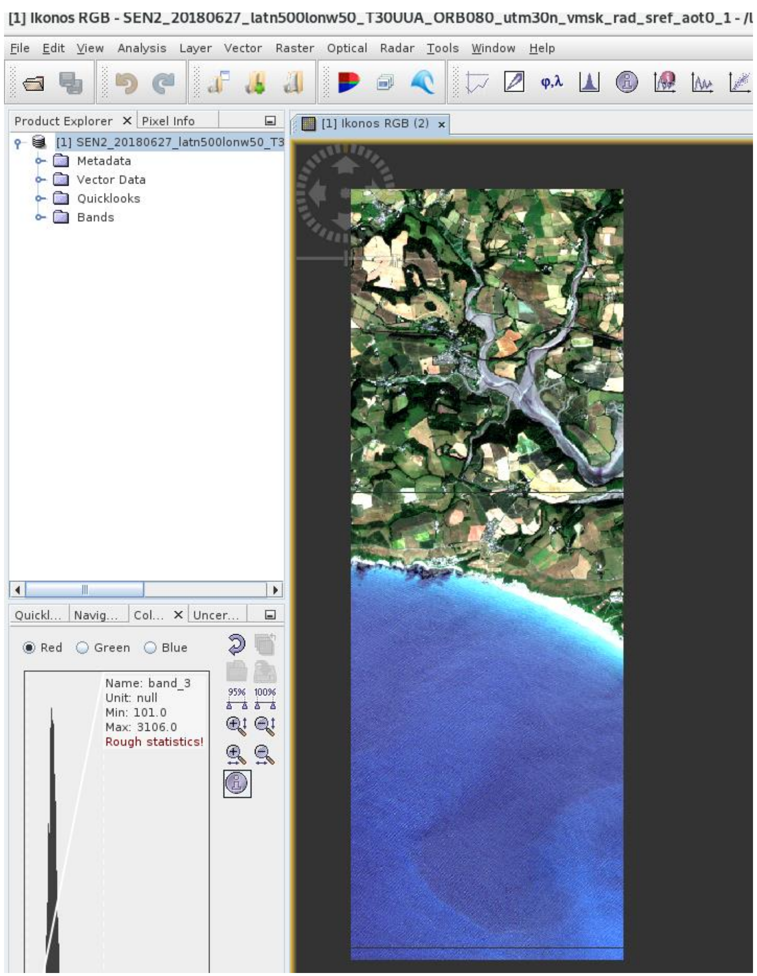
Satellite Atmospheric Correction Practical

- Atmospheric and Radiometric Correction of Satellite Imagery (ARCSI)
  - Written in Python, with Command Line Interface
  - Developed for terrestrial applications
  - Used to process S2 ARD data for England by DEFRA, available from CEDA (https://data.ceda.ac.uk/neodc/sentinel_ard/data/sentinel_2/)



- ACOLITE
  - Written in Python with Command Line Interface / GUI
  - Developed for coastal applications
  - Can perform glint correction for water
  - Can also derive some products (e.g., turbidity)

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Thank you