Reflectance-based method overview

Uncertainty sources
Causes of uncertainties and outliers

There are a variety of effects that lead to larger uncertainties in the predicted, at-sensor radiance:

- Changes in surface conditions
- Atmospheric effects
- Personnel-related issues
User and instrumental errors

The data sets do not rely on the same operators or instrumentation

- Whenever possible, the same spectrometer is used
  - Malfunctions and multiple campaigns prevent this
  - Some users prefer a specific spectrometer
- Examination of the RRV and Ivanpah data sets do not show an obvious user dependence or bias with a specific spectrometer
Absolute versus relative uncertainty

Many of the uncertainties affect absolute accuracy while others affect the precision

- Repeatability is used interchangeably with precision
- Absolute accuracy is affected by
  - Bias in surface reflectance
  - Error in selection of aerosol type
  - Error in aerosol amount
  - Other errors negligible for near-nadir view of ETM+
  - RSS approach gives uncertainty of 2.5% in mid-visible assuming no water vapor and/or ozone absorption

- Precision is affected by
  - Repeatability of surface reflectance data
  - Stability of aerosol type at a given test site
  - Accuracy of solar radiometer
Atmospheric measurements

Primary source of uncertainty in the atmospheric retrieval is the calibration of the solar radiometer

- Details on the calibration are given in discussion on algorithms
- Calibration can change due to
  - Real changes in the sensor
  - Errors in the calibration approach
- Errors in the instrument calibration gives errors in the retrieved optical depth
  - Changes the amount of aerosols
  - Affects the type of aerosols put in the radiative transfer code
- Also assumptions about the aerosol composition
  - Kept constant in many cases
  - Leads to some days being outliers due to larger aerosol absorption
Test sites

Possible bias in results from different test sites such as using Ivanpah Playa and RRV Playa

- Causes could be
  - Different site sizes
  - Assume aerosol type is same at both sites
  - Surface heterogeneity and spectral reflectance effects
- Sensors on orbit are currently not of high enough quality to differentiate issues from the site and from the method
View angle effects

Some sensors will view a test site at large off-nadir angles

- Uncertainties larger due to longer atmospheric path
  - More sensitivity to atmospheric uncertainties
  - Phase functions are different
  - Larger impact from surface/ground interaction
- Surface BRDF plays a bigger role
  - Direct solar term
  - BRDF of the ground interacting with the atmosphere
- Radiative transfer code can be used to evaluate this through a sensitivity study
What causes scatter?
Can compute a theoretical standard deviation based on a single day of data and expected uncertainties

- Repeat predicted radiance calculation based on perturbed input parameters
- Results below are the standard deviation of six radiative transfer calculations with perturbed inputs compared to actual results

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Repeatability

The good news is that there is no clear cause of outlier data sets

- This is also bad news in that there will be no easy fix
- Instruments & personnel could still be an error source
  - Have yet to examine biases in the instrumentation due to temperature effects, instrument malfunction, etc.
  - Stray light, out-of-field response, fiber-optic mounting are some possible uncertainty sources
- Will have to begin to look at correlated errors and not view the errors as an independent effect
  - Know that Junge parameter, aerosol column amount, water vapor, and ozone are all related in the retrievals
  - Surface reflectance may also be correlated with atmospheric conditions (currently no diffuse-light correction)