Error budget
Repeatability versus accuracy
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
  - 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)
Ancillary information

Have discussed the instruments and approaches to data collection but there are several other key points

- Notes related to the collection are critical
  - Descriptions of instrumental issues
  - Weather conditions
  - Logging of key parameters such as pressure
- Help in processing
  - Points to reasons why results may be anomalous
  - Location of data
- Help in planning and undertaking future campaigns
  - Timing
  - Instrument limitations
Note taking

Most important person on the field campaign

▪ Ensures that the reference panel is in the appropriate location and leveled
▪ Helps the spectrometer user to go to the right place
  • Especially important in hot weather
  • Watches health of person
▪ Logs the spectrometer file locations and numbers
  • Keeps track of anomalous data
  • Writes down missing data points
▪ Watches weather conditions for changes in sky irradiance
▪ Helps remind spectrometer operator to check health of instrument
Data conditioning

All data conditioning occurs within the processing algorithms discussed later

- Exception is that surface BRF retrieval can include/exclude data points
- In all cases, no conditioned data are saved
  - Reformating data runs risk of full data loss
  - Cost is that reprocessing of same data set could lead to lost time or inaccurate results
- Notes describing the processing sequence are saved
  - Includes descriptions of excluded/modified data
  - Should help provide reproducible results
- Results from a given processing are saved
  - Included are comments/notes on how processed
  - Important to include solar radiometer calibration information
Outliers

Clear from previous discussions that the results from some dates are not consistent

- Not concerned here with the bias between reflectance-based results and sensor
- Discussion here focuses on the precision of the results
- Possible causes for “outlier” data sets are
  - Real changes in sensor (probably not the case)
  - “Errors” in the ground measurements
- The possible sources of errors in the ground measurements are numerous
  - Surface reflectance errors
  - Atmospheric characterization - aerosol composition and concentration, gaseous absorbers
  - Site dependent effects
  - User and instrumentation driven errors
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
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 UofA processing
  - Leads to some days being outliers due to larger aerosol absorption
Uncertainties

Uncertainties for a typical date are dominated by atmospheric inputs at short wavelengths and reflectance at long wavelengths.
Effect of aerosol concentration

Examining the data sets versus aerosol optical depth also shows little dependency

- Note, significantly cloudy days omitted by not collecting data
- Several moderately cloudy days have also been eliminated

Band 2 results
Effect of size distribution

Results show little correlation with aerosol size

- Rely on a Junge distribution based on the spectral optical depth
- Smaller values imply larger aerosols

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Band 2 results
Calibration versus reflectance

Reflectance also did not show a strong effect.
Other atmospheric effects include gaseous absorption and aerosol absorption

- Ozone shows a correlation in that low ozone amounts lead to an overestimate in the predicted radiance
  - Dominant in band 2
  - Implies that low ozone amounts are not accurate
  - This further implies that the aerosol parameterization could be wrong in these cases
- Column water vapor did not show a correlation with the retrieved calibration coefficient
- Aerosol absorption has not been examined at this point
  - Currently use a single value for aerosol index of refraction
  - Sensitivity studies in the past have shown the aerosol absorption can be a significant error source
Resampling ETM+ results

Show the original average percent difference as well as 10 other cases based on five data point averages

- Five data points were selected randomly
- All averages agree within the original precision of full data set
Selected subset

Evaluate effect of atmospheric conditions by removing “anomalous” dates

- Anomalous refers to a day for which one of the atmospheric parameters is more than 1-σ from average
  - Aerosol optical
  - Ozone
  - Junge parameter
- Left six dates each for RRV Playa and Ivanpah

Band 3

Counts per unit Radiance

Days since launch

Preflight, Average, Reflectance-based
Selected subset

Average and standard deviation of the 12 data sets left after filtering for outlier atmospheric conditions

- No large changes in standard deviation
  - Except for band 1
  - 12 versus 59 data points
- No significant change in average % difference
- Ignores reflectance uncertainty effects

![Bar chart showing comparison of average % difference for different bands between all data and subset.](chart.png)
Results versus season

The final dependency that was examined was that of season (or day of year)

- Higher sun angles in summer causes a change in the site and reference directional reflectance
- Types of campaigns, personnel, and equipment changes with season
- Atmospheric and surface conditions also change
Test sites

Examine the possible bias in results from different test sites 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
- 30 data sets for Ivanpah and 26 for Railroad Valley
Good repeatability allows noticing odd results

Examine the possible bias in results from different test sites using Ivanpah Playa and RRV Playa

- All bands show a significant difference statistically at the 95% confidence level
- Also note that the standard deviations are larger after day 1500
Repeatability

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