SMACAA

SDSU's Modtran Atmospheric Compensation Anywhere Anytime

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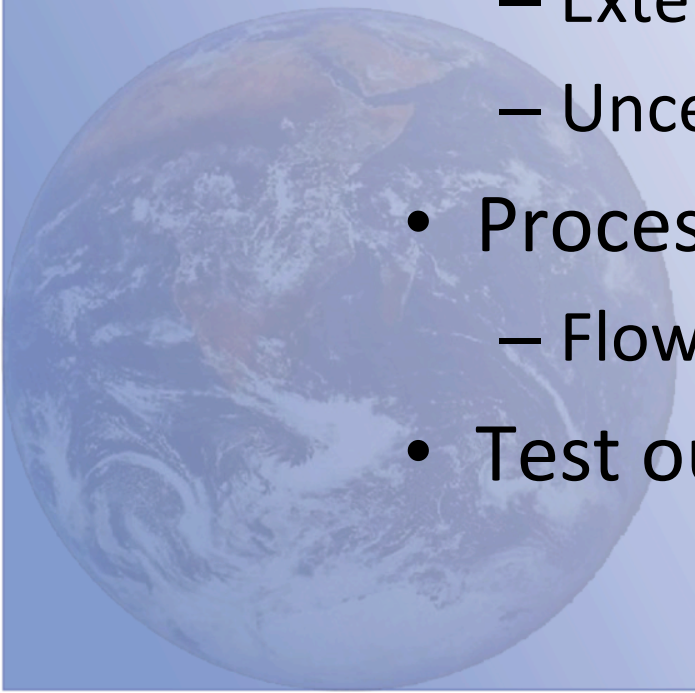
Outline

- Overview
- Inputs
  - In-house
  - External databases
  - Uncertainty
- Process
  - Flowchart
- Test output



Overview: Why

- The objective of this project?
  - To atmospherically correct VNIR/SWIR satellite images
    - No limits on collection time (back through 1972)
    - No acquisition location limits
    - No limits on the sensor being used or the number of bands present
  - Atmospherically correct all Landsat sensors In particular:
    - ETM, TM and MSS
  - Consistent solution through time.
  - Allow for consistent cross calibration work for all platforms through time via the use of atmospherically compensated PICS
  - Capability to perform absolute calibration over PICs

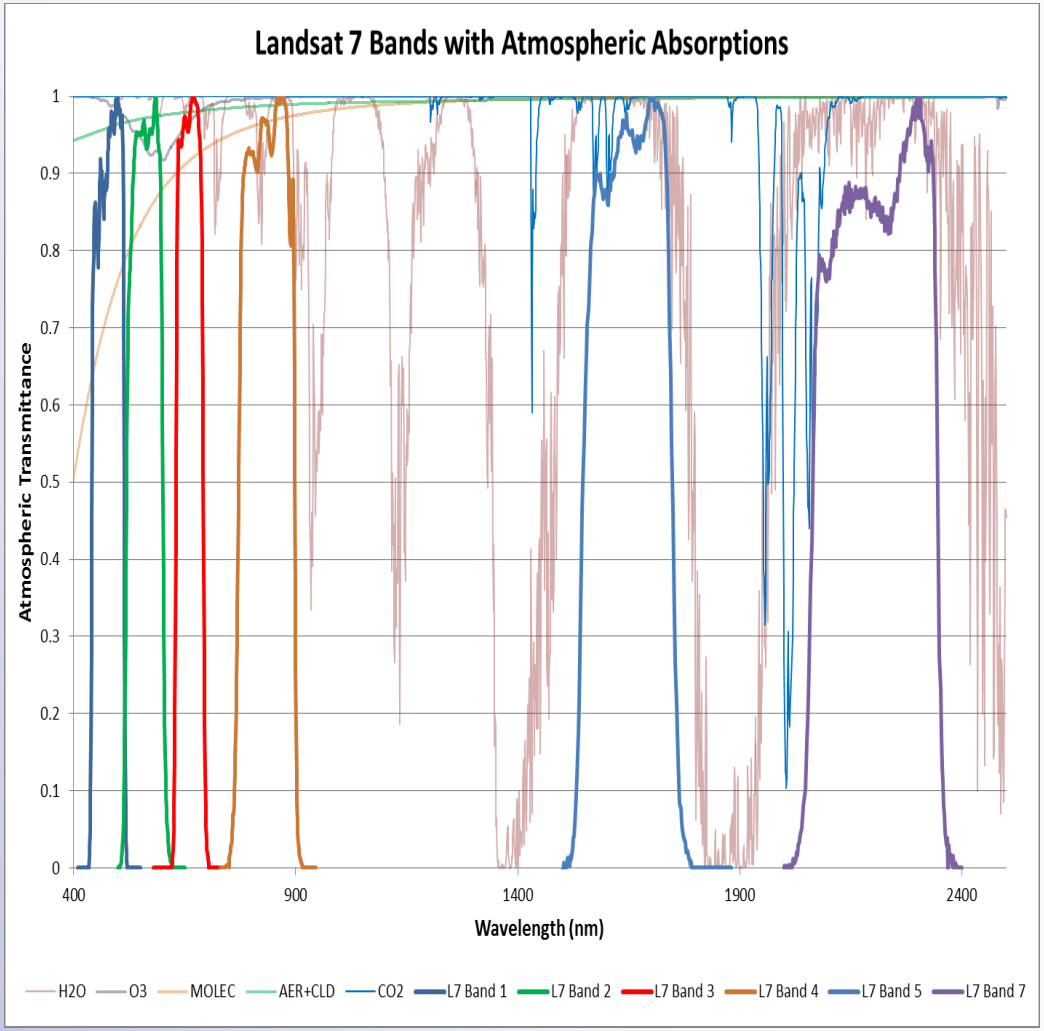
Overview

- In particular, the system needs to work for ETM+, TM, and MSS.
  - With the limited amount of atmospheric information available in the 4 bands of MSS, ancillary data to perform a correction is needed.
  - One-size-fits-all solution to correct imagery requires a atmospheric radiative transfer model: Modtran
- What do we consider to be the most important parameters for the atmospheric compensation?

Inputs

- Three key inputs for doing the atmospheric compensation:
  - Aerosol
    - Affects Bands 1,2 & 3 with decreasing intensity
  - Water vapor
    - Affects Bands 5, 7 & 4 with decreasing intensity
  - Ozone
    - Affects Bands 2 and 3 with decreasing intensity

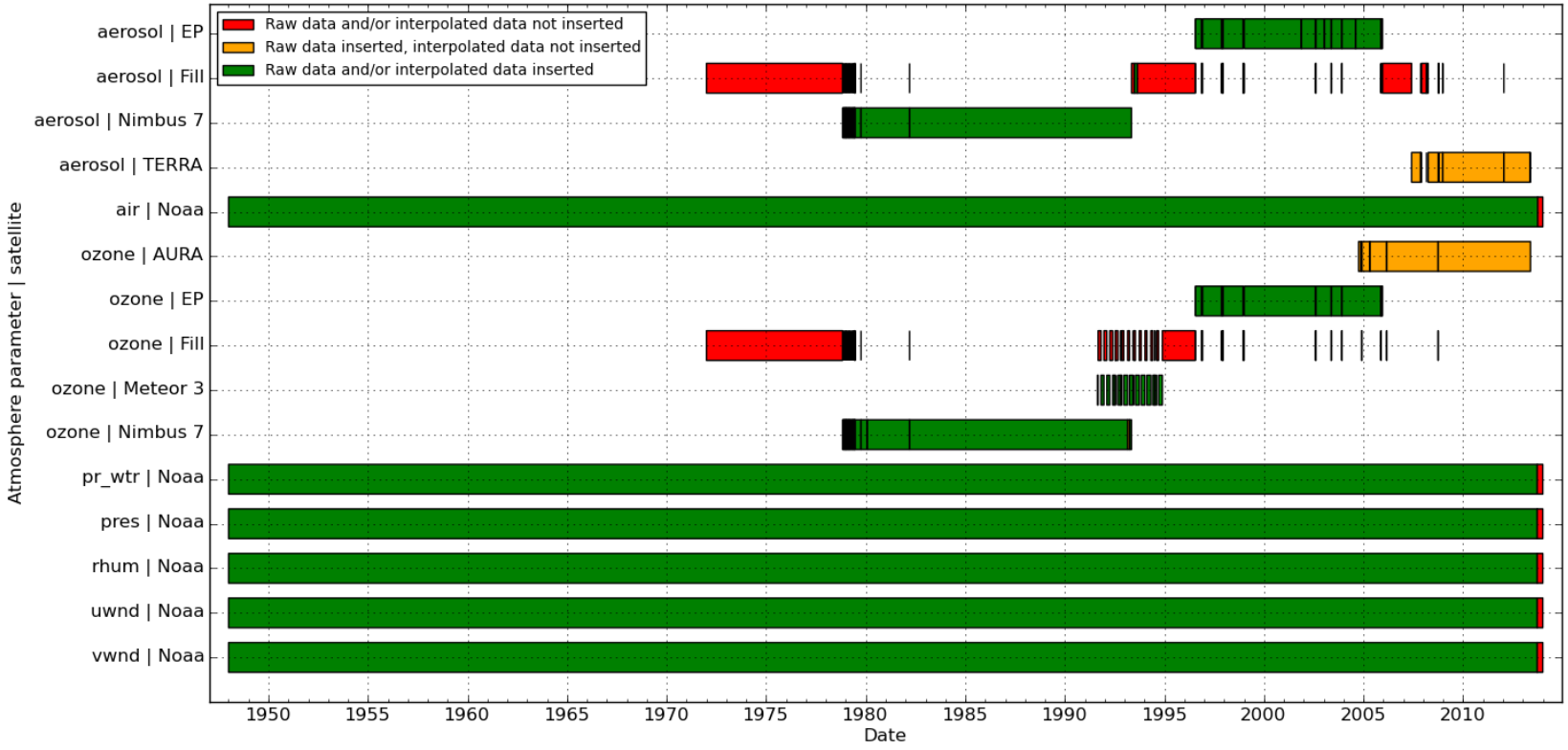
With these 3 atmospheric effects causing most of day-to-day variability and affecting all bands to some level, they become the key components under investigation but a host of other secondary parameters are used as well



Inputs - Ingest Status

Current Status:

- All NOAA NCEP data (water vapor key)
  - **OPERATIONAL**: Automatic processing and ingest
- All OMI / TOMS Ozone ingested
  - **OPERATIONAL**: Automatic processing and ingest
- All MISR/TOMS Aerosol data ingested
  - **OPERATIONAL**: Automatic processing and ingest



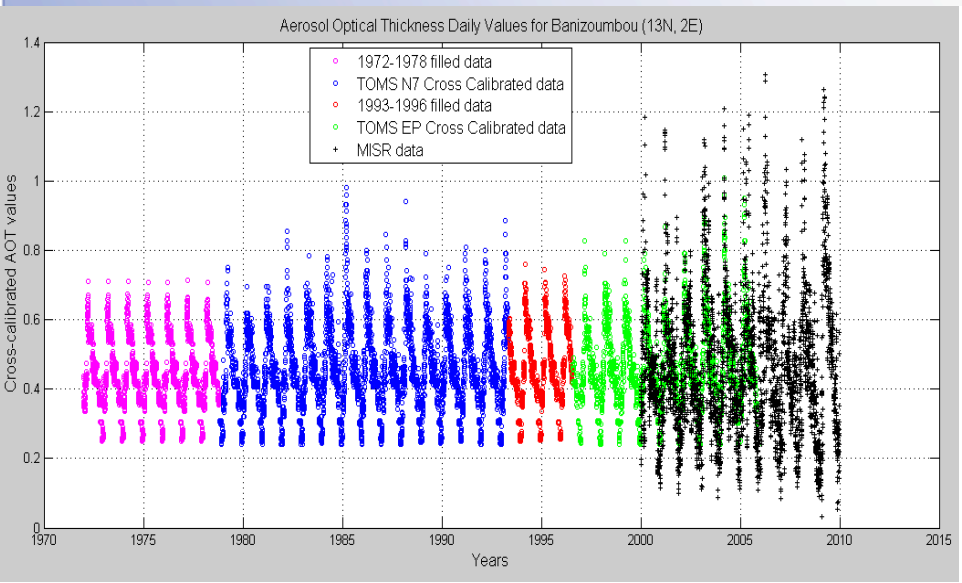
*Kalnay et al.,The NCEP/NCAR 40-year reanalysis project, Bull. Amer. Meteor. Soc., 77, 437-470, 1996

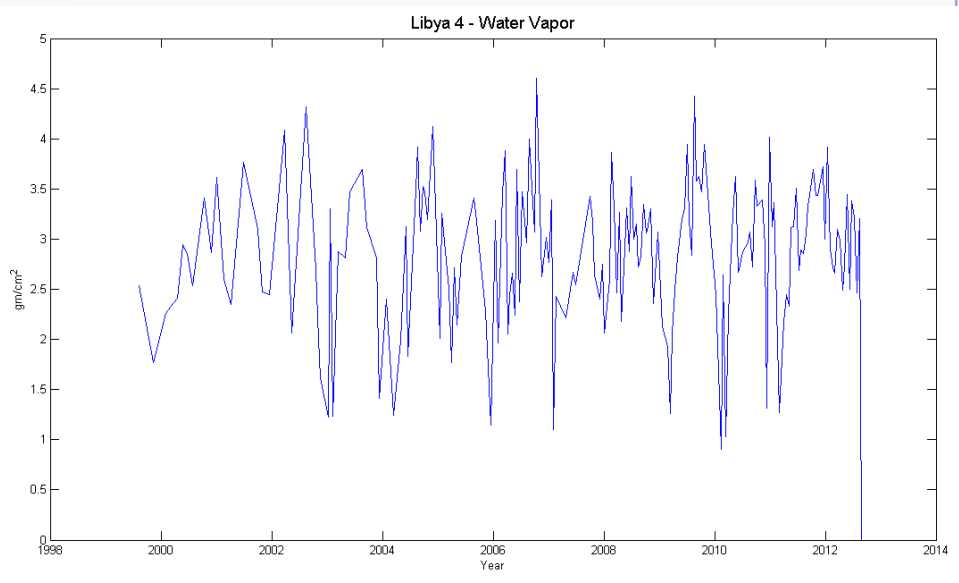
Inputs –MYSQL Database Status

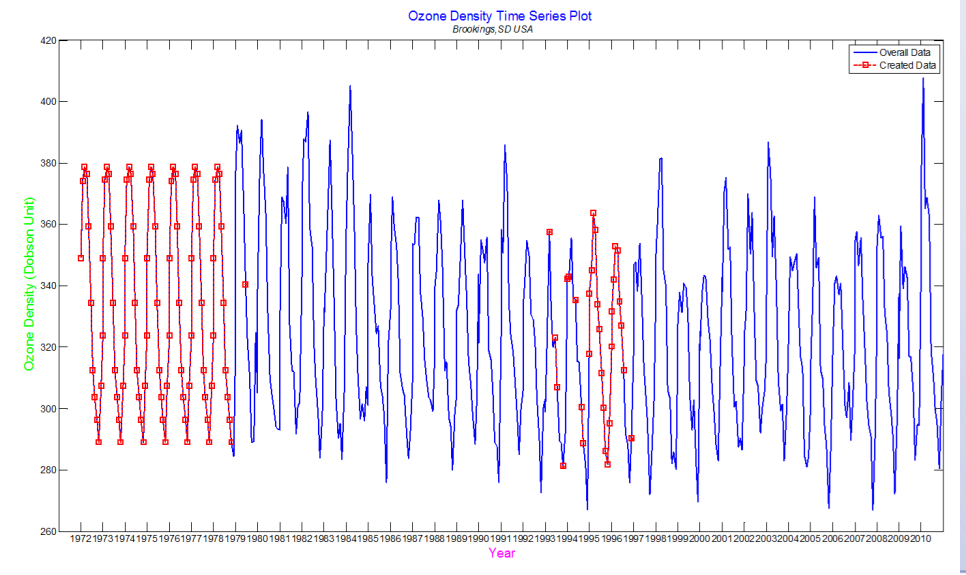
- Currently the database is holding 46 x10^9 entries (~2.5TB) with regular automated weekly updates.
  - Data is automatically screened and cleaned with uncertainty for each value being determined and assigned.
  - Data exists in MSQL database for local and remote access, used to drive SMACAA and other lab research projects

Atmosphere Parameter	Rows	Now	Initial import	Daily	Weekly	Monthly
Aerosol	$6 * 10^9$	$6 * 10^9$	10w	30m	3h30	15h
Air Temperature	$1 * 10^9$	$1 * 10^9$	35h	2m - 12h	2m - 12h	2m - 12h
Easting Wind	$1 * 10^9$	$1 * 10^9$	35h	2m - 12h	2m - 12h	2m - 12h
Ground Level Height	$31 * 10^9$	$0 * 10^9$	31w ?	0s	0s	0s
Northing Wind	$1 * 10^9$	$1 * 10^9$	35h	2m - 12h	2m - 12h	2m - 12h
Ozone	$3 * 10^9$	$(3 - 0.7) * 10^9$	10w	30m	3h30	15h
Relative Humidity	$1 * 10^9$	$1 * 10^9$	35h	2m - 12h	2m - 12h	2m - 12h
Surface Pressure	$1 * 10^9$	$1 * 10^9$	35h	2m - 12h	2m - 12h	2m - 12h
Water Vapor	$1 * 10^9$	$1 * 10^9$	35h	2m - 12h	2m - 12h	2m - 12h
Total	$46 * 10^9$	$14.3 * 10^9$	52w	1h - 3d	7h - 3d	30h - 4d

Inputs – Examples of Meteorological Data





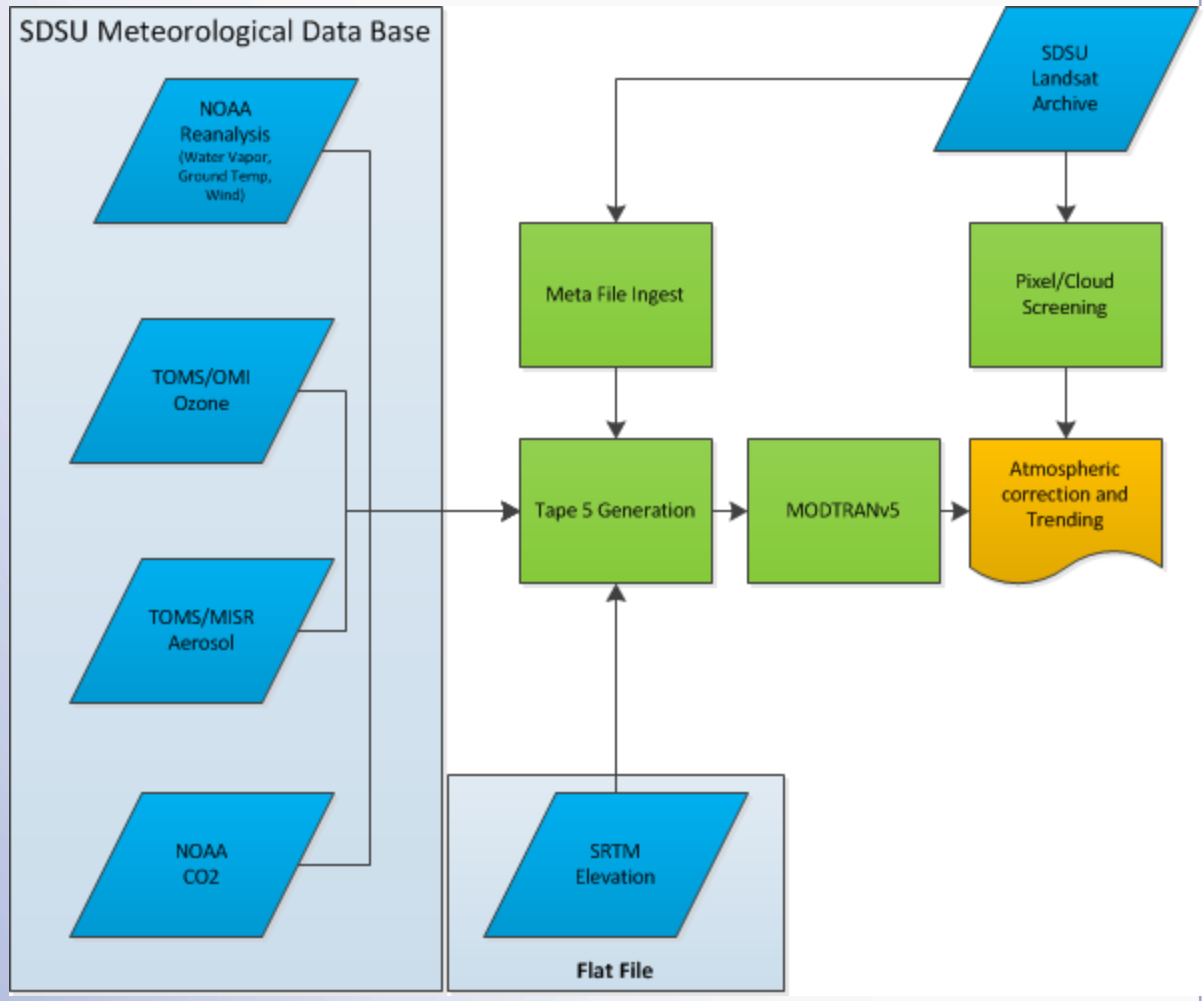


- Top Left: Example of Aerosol* Loading profile for 40 years over Banizoumbou
- Top Right: Water vapor loading for Libya 4
- Bottom Left: Ozone* Over Brookings, SD

*Multi data source and sensors used to develop the entire history and to cover the entire globe

Automated Process - Flow Chart

- Local MYSQL Databases are actively being updated via external links
  - NASA & NOAA
- All data is automatically pulled via Matlab scripts from the database
- Images local to the SDSU Archive are ingested in bulk or individually, screened and processed.
- Finally all inputs are passed through Modtran, with the results being applied to the imagery.



Data Processing:
SDSU Archive Ingest

- Diamondback [Server] Scan
  - Locate all scenes for a specified path/row
    - » (~9000 Images in house)
  - Metafile is ingested for all scenes in the list
    - Acquire: Data, Time, Senor Geometry, Target Lon/Lat etc…
  - Metafile inputs then drive the meteorological database functions

Data Processing: Meteorological Database Ingest

- Database call
  - Determines what level of meteorological data exists in the database.
    - First: Does processed data exist?
    - Second: Does raw data exist?
    - Third: Default to Modtran Standard values
  - Performs a weighted mean to find meteorological data centered to the input longitude/latitude

Data Processing: Modtran Preparation and Ingest

- All inputs come together to create an appropriate Modtran .tp5 card.
- After Modtran run completed all data from card .7sc is ingested.
- This output is broken down and banded for use as a correction for all bands, via the equation

$$\rho = \pi(L\downarrow TOA\ Radiance - L\downarrow Scatter - L\downarrow Skyshine\ ) / ETR * \tau\downarrow\uparrow\ \tau\downarrow\downarrow * \cos(\theta\downarrow z\ )$$

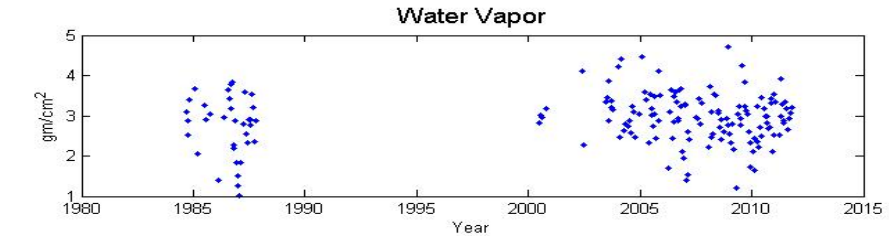
Data Processing: Image ingest and correction

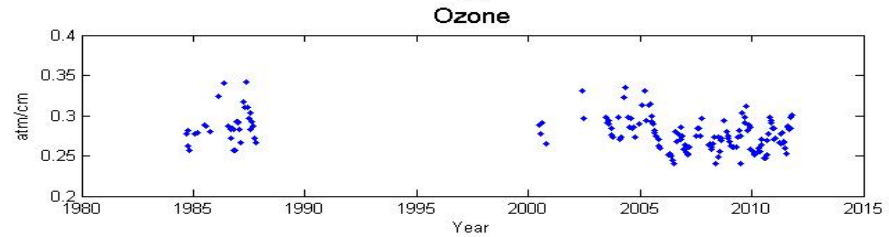
- All scenes are read in, processed through cloud screening*, and filtered for any bad/ saturated pixels and subsetted for appropriate ROI size.
  - Currently using Boston University cloud detection algorithm, updates to in-house solution optimized for PICS site
- Correction applied, results displayed.

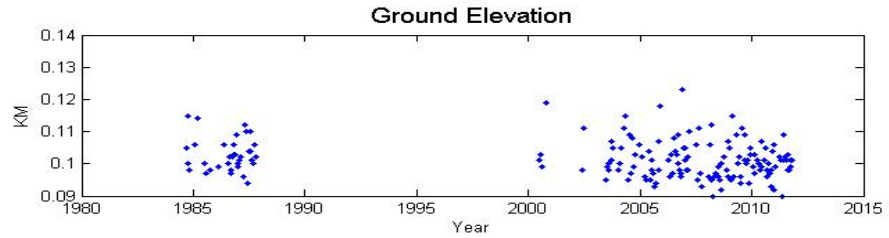
***Curtis Woodcock, Boston University**

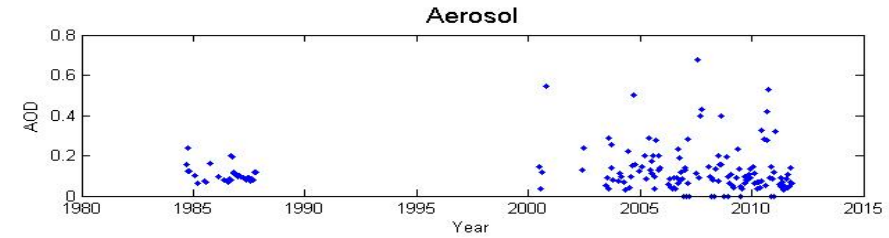
Test Run: Libya 4

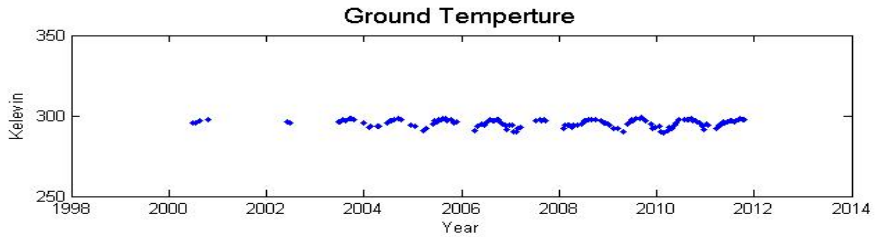
- Data below were extracted from database to correct imagery
  - Each point represents the data used for the date corrected

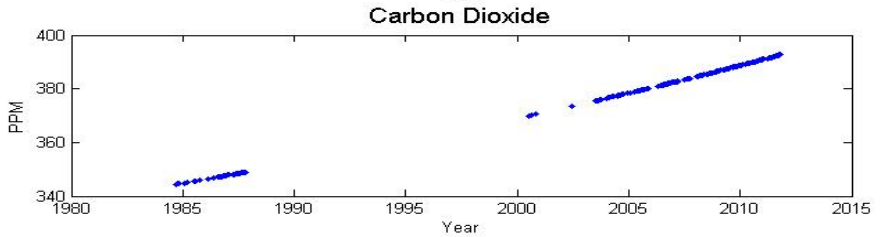


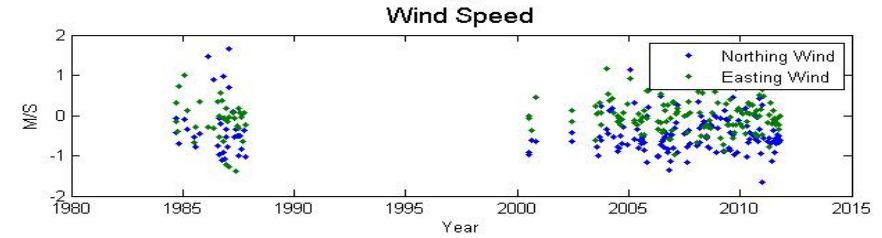




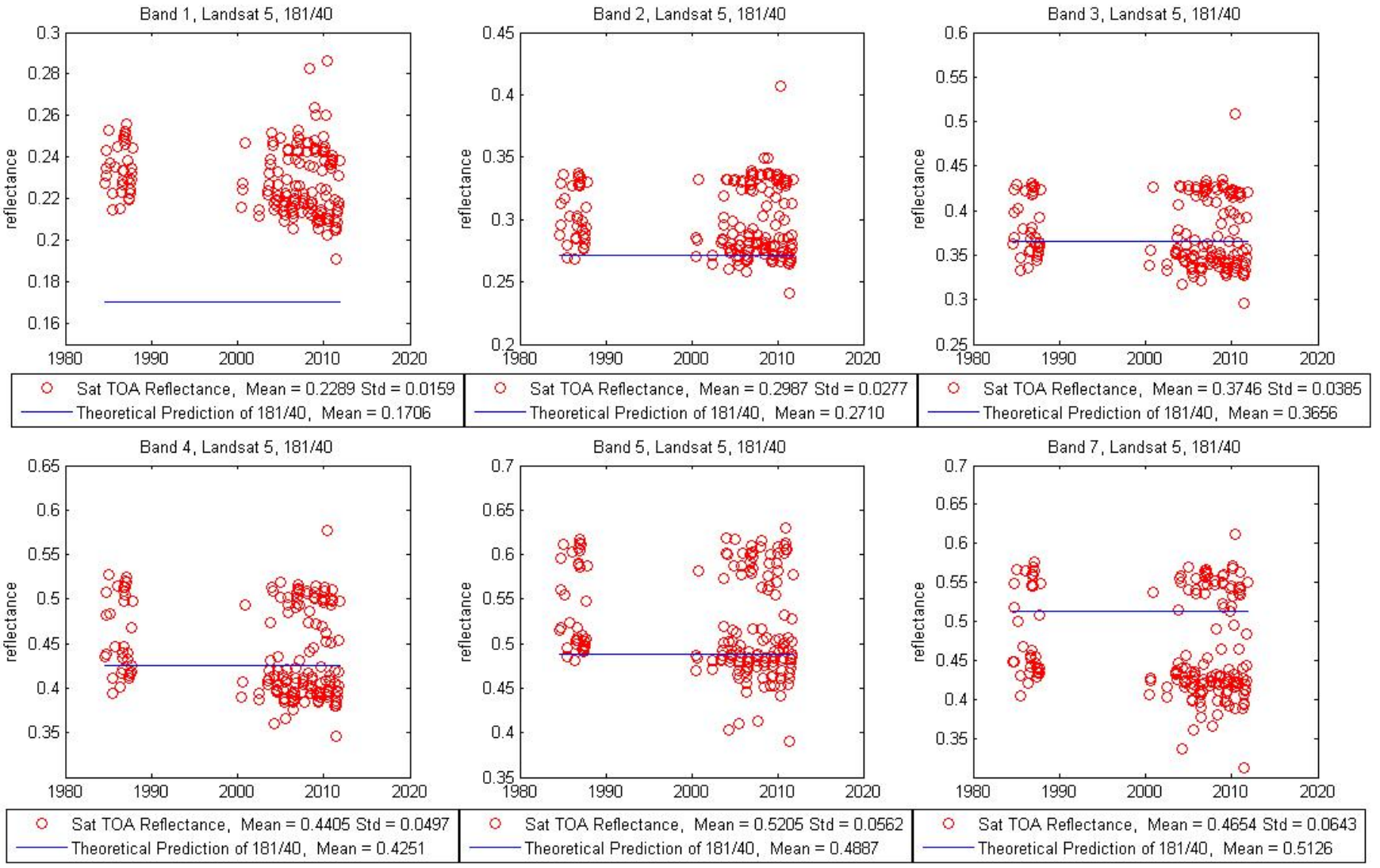






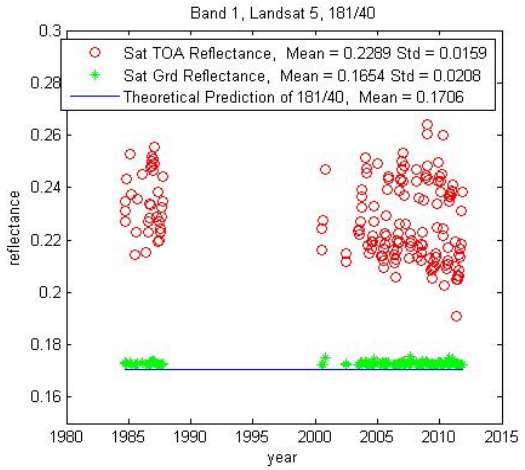


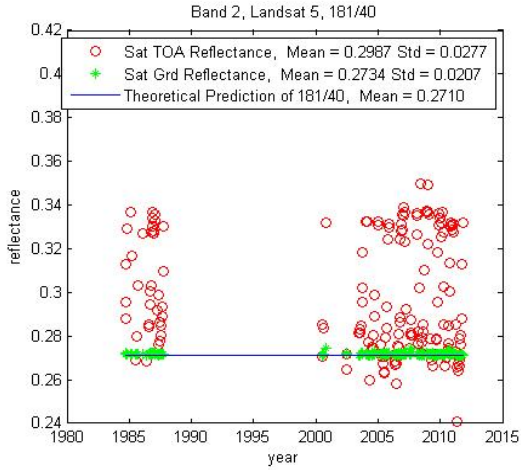
Test Run: Landsat 5 Libya 4

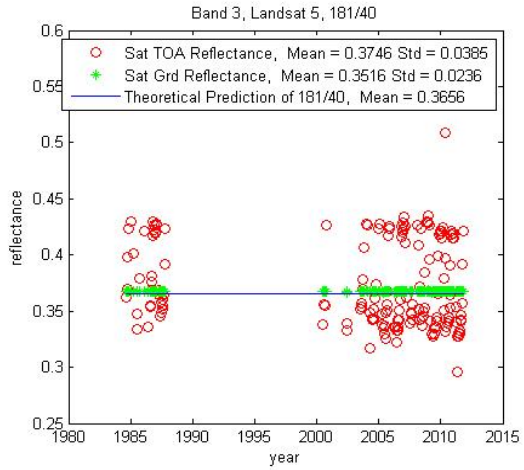


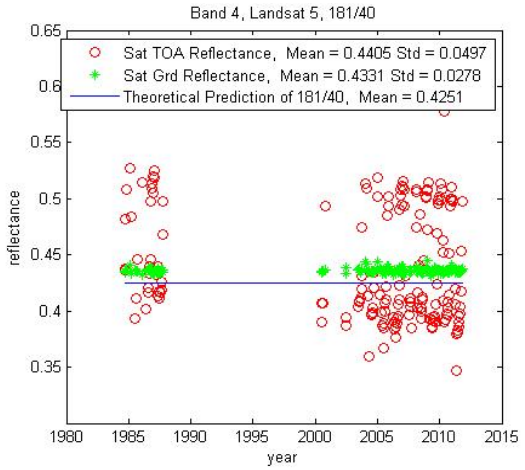
Black line represents our best guess for what the Libyan desert's ground level nadir reflectance is, based on satellite data inversion to ground and comparison to spectral libraries of sand, a more analytical analysis is under way

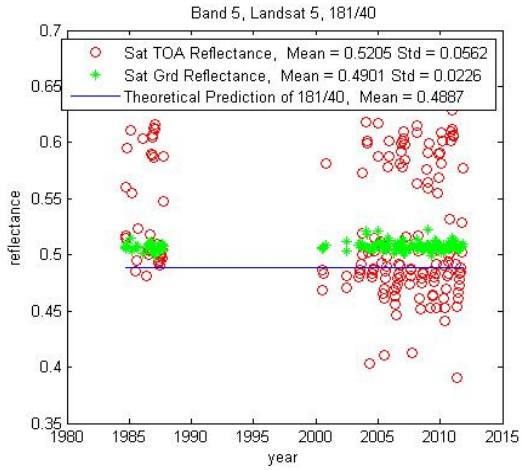
Test Run: Landsat 5 Libya 4

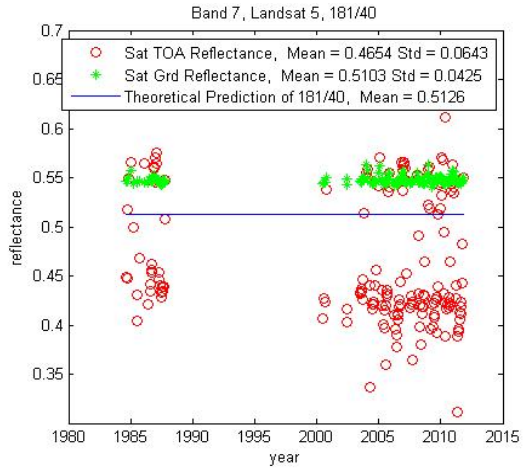












Conclusion

- A completed automated process has been developed to perform atmospheric compensation for all calibration test sites.
- Current status
  - Beta coding done
  - Raw/Processed meteorological data is local
- Next process to evaluate Landsat 5 over Libya 4
- Evaluate over a known reflectance target
- Comparison to other known models.