MODIS Science Team Meeting

SDST Report - Geolocation

Al Fleig
Robert Wolfe

May 4, 1994

Attachment 7

Current MODIS/EOS-AM1 Specification/Estimates

Source	Component	Current Spec.	Likely Built	Likely Built Bias Removed
Spacecraft Position Knowledge	X-Axis	100 m	44 m	44 m
	Y-Axis	100 m	24 m	24 m
	Z-Axis	100 m	7 m	7 m
Spacecraft Attitude Knowledge	Roll Pointing	60 arcsecs	37 arcsecs	7 arcsecs
	Pitch Pointing	60 arcsecs	52 arcsecs	9 arcsecs
	Yaw Pointing	60 arcsecs	32 arcsecs	6 arcsecs
Instrument Pointing Knowledge	Roll Pointing	60 arcsecs	57 arcsecs	30 arcsecs
	Pitch Pointing	60 arcsecs	44 arcsecs	17 arcsecs
	Yaw Pointing	60 arcsecs	47 arcsecs	21 arcsecs
Total RSS Error at Nadir	Along Track	0.30 pixels	0.23 pixels	0.11 pixels
	Cross Track	0.29 pixels	0.23 pixels	0.11 pixels
Total RSS Error at 55 degrees	Along Track	0.30 pixels	0.24 pixels	0.08 pixels
	Cross Track	0.29 pixels	0.21 pixels	0.07 pixels

- 2 sigma Error Estimates for 1 KM Bands (from "An Analysis of MODIS Earth Location Error", V2.0, Sept. 1993)
- ASTER sterling coolers induce high frequency vibrations (around 40 Hz) which exceed error budget (not included above)

MODIS Orbit

- **Orbit Parameters:**
  - Sun Synchronous with 233 Paths (like Landsat-4/-5)
  - 98.2 deg Polar Inclination
  - 705 km Altitude (at Equator)
  - AM - 10:30 AM +/- 15 Min. Descending Node
  - PM - 02:30 PM +/- 15 Min. Ascending Node
  - +/- 20 km Ground Track Accuracy (Cross-Track)
- **TONS Issue** - EOS-AM1 currently uses on-board TONS (TDRSS On-Board Navigation System) to provide real-time definitive orbit.

  EOS-PM1 may use a less frequently updated predicted orbit on-board and use ground based processing of TDRSS tracking data to generate definitive orbit from about +6 to +30 hours after data acquisition.

Our Approach

Develop and Implement MODIS Geolocation Algorithm - Objective is to meet Science Team Accuracy Requirements

- **Perform "Dead Reckoning"** - Use real-time ephemeris and attitude to calculate geolocation information for each spatial element
  - **Geolocation Calculation** - Calculate latitude, longitude and height of intersection of line of sight with "real" Earth surface using digital terrain model
  - **Ancillary Geolocation Data** - Calculate satellite range and solar and satellite azimuth and zenith angles at intersection
  - **Parametric Equations** - To compute sub-spatial element and individual band locations, ellipsoidal geolocation and inverse
- **Ground Control Point QA** - Used to monitor MODIS data product geolocation accuracy post-launch and refine pre-launch knowledge of instrument/spacecraft geometry (static and slowly changing biases)
- **Optional Optical Navigation** - Develop contingency plans for compensating for "out of spec." or degraded spacecraft/instrument pointing knowledge

Terrain Correction Data Sources

- **EDC Generating Global Digital Terrain Model (DTM) -** Derived from Digital Chart of the World (DCW) in areas outside of USA.
- **Estimated Delivery Schedule -** 1 KM grid data set (schedule very tentative)
  - Africa - June '94
  - N. America - Oct. '94
  - S. America - Dec. '94
  - Schedule for the remainder of world has not been set yet. Work will continue on continent by continent basis.
- **DMA DTED -** EDC still hopes that the DMA will allow the release of the DTED for the remainder of the world at "at least" 1 KM resolution.
- **Accuracy -** Currently using DCW 650 meter estimated error. Contours on map imply accuracy of about 150 meters. EDC will Provide a better estimate once DTMs are generated.
- **ETOPO 5 Global Model -** 5 Arc-minute (about 10 KM) data set will be used for some near-term prototyping.

Prototype Testing Status

- **Completed MODIS Viewing Geometry Tools**
  - **MODIS Scan Geometry Simulator** - Resamples an orbit oriented uniform grid into MODIS scan geometry with either nearest neighbor or "fuzzy" (integration over a rectangular pixel) resampling. Uses pixel growth vs. scan angle based on a spherical Earth to generate the MODIS scan pattern, not rigorous projection.
  - **MODIS Viewing Geometry Prediction** - Uses the Landsat WRS-based EOS-AM1 orbit to predict nominal MODIS viewing angles and times for any target point on the Earth.
- **Completed MODIS Simulation Tools** - Uses AVHRR to Simulate the MODIS Viewing Geometry and Engineering Data
  - **AVHRR Preparation** - Reads 1B format, unpacks, and creates image (PCI format) and ancillary data files. Uses the ancillary data to compute the AVHRR orbit/attitude by a least squares solution for the best fit orbit and attitude.
  - **Convert AVHRR Orbit to EOS** - Modifies the orbit to match nominal EOS orbit parameters by adjusting the orbital radius and inclination at the swath center.
  - **MODIS Geometry Routine** - Computes the nominal viewing angles and times for an area based on the EOS-AM1 orbital characteristics. It does not contain a MODIS sensor model other than to limit the allowable scan angle to +/- 55 degrees.
  - **Simulate Engineering Data** - Puts the simulated MODIS orbit/attitude data into the EOS-AM1 spacecraft ancillary data message format.

Prototype Testing Status

- **Scheduled PGS Algorithm Prototypes** - Geolocation Algorithms
  - **Basic Earth Location** - The MODIS instrument model is part of a prototype ellipsoidal Earth location routine. This is a forward (image space to object space) implementation of the look point equation.
  - **Terrain Correction Algorithm** - Performs the basic terrain correction of the ellipsoid locations.
  - **Parametric Geolocation Model** - A set of functions describing the mapping from satellite scan to geodetic latitude and longitude.
  - **Control Point Processing** - A set of routines for control point correlation.
- **Scheduled TLCF Algorithm Prototypes** - Geometric Analysis Tools
  - **Geometric Parameter Estimation** - Routines to estimate the geometric alignment biases for post-launch static bias removal based on the residuals at the control points.
  - **Optical Navigation** - A methodology to update orbit/attitude using residuals at the ground control points.