MODIS Airborne Simulator Level-1B processing summary

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MAS Level-1A data input format

The MAS Level-1A data will be supplied in the format currently used by Ames Research Center for Multispectral Atmospheric Mapping Sensor (MAMS) data. MAMS has been used as the model for MAS software development.

Calibration software assumptions and methodology

(1) Number of channels and spectral bands
The MAS will record 12 image channels, where each image channel may be selected from up to 50 spectral bands. The spectral band assigned to each channel is selected pre-flight and does not change during flight.

(2) Number of bits per channel
MAS image data may be recorded at either 8 bit or 10 bit resolution. This is set pre-flight and does not change during flight.

(3) Visible band calibration
The MAS has no onboard visible calibration capability. MAS visible wavelength image bands are calibrated on the ground either before or after flight missions. A linear calibration (slope and intercept) from digital counts to radiance is generated for each visible band and does not change during flight.

(4) Infrared band calibration.
The MAS has an onboard infrared calibration capability. Two temperature controlled blackbodies are viewed during every scan. The blackbody temperatures and digital counts are used to generate a linear calibration (slope and intercept) from digital counts to radiance for every individual scanline. The valid temperature range for calibration is assumed to be 150K to 373K.

(5) Data quality checking
No quality checking is performed on the MAS image data. Certain items in the MAS engineering data are checked. The time and scan number are checked to ensure continuity. The time is checked against the scan number to ensure scan rate continuity. The blackbody counts for all channels are checked to ensure continuity, and that they lie within the range defined by the number of bits for that channel (e.g. 8 bit implies a range of 0-255). The blackbody temperatures for all channels are checked to ensure continuity, and that they lie within the range 150K to 373K. The blackbody counts and temperatures for the infrared channels are checked to ensure that the values for the hot blackbody are greater than those for the cold black body. If problems are detected with the blackbody data in any channel, then the calibration slope and intercept for that channel are set to zero for that scanline.

(6) Output data
The MAS visible bands have radiance computed in units of milliWatts per square centimeter per steradian per micron. The MAS infrared bands have radiance computed in units of milliWatts per square centimeter per steradian per wavenumber. These values are scaled appropriately and stored as 16 bit integers. The blackbody counts, temperatures, and calibration slope and intercept data are also stored for every MAS channel on every scanline.

Geolocation software assumptions and methodology

(1) Geolocation data format
Geolocation data for the MAS is recorded continuously during flight by the ER-2 Inertial Navigation System (INS). The important parameters are time, aircraft latitude, longitude, heading and altitude. The INS updates these values approximately every 5 seconds. The INS dataset is an ASCII file which is supplied separate to the MAS Level-1A dataset.

(2) Geolocation strategy
Geolocation is only performed for portions of a flight where the aircraft flew a straight and level line. Geolocation data is obtained solely from the INS data, with no reference to the MAS imagery. Straight line flight tracks are identified by manual inspection of the change in aircraft heading with time. The start and end times of the straight line flight tracks are noted. Linear regressions for aircraft latitude, longitude, heading and altitude versus time are computed for the straight line flight tracks.

(3) MAS image geolocation

To geolocate a given MAS straight line flight track, the MAS start time and scanline number at the beginning of the flight track are determined. These are used as a reference for the rest of the flight track, since MAS times are truncated to whole seconds. The scanline number and scan rate are used to determine the time elapsed to subsequent scanlines in the flight track. Once the time for a given scanline is computed, the linear regression relationships are used to compute aircraft latitude, longitude, heading and altitude at that time. Latitudes and longitudes are then computed for every 10th pixel on that scanline (pixels 1, 10, 20, 30, ..., 690, 700, 710, 716). Solar zenith and azimuth angles, and aircraft scan and azimuth angles are also computed for every 10th pixel. Every scanline in a straight line flight track is geolocated in this way. Scanlines which are not included in straight line flight tracks have no geolocation data computed. However it should be noted that the INS data is still available during these sections.

(4) Data quality checking
The whole INS dataset is checked separately before the geolocation computations are done. Plots of aircraft time versus record number, and aircraft latitude, longitude, heading and altitude versus time are inspected for continuity and validity. The INS dataset is then checked for small continuity errors which confirm the selection of straight line flight track times. The method is to check the value of a parameter at a given time versus the previous value of the parameter. In summary,
(a) Time is checked to ensure it is not less than, or more than one minute greater than the previous time,
(b) Latitude is checked to ensure it does not differ from the previous latitude by more than 0.2 degrees,
(c) Longitude is checked to ensure it does not differ from the previous longitude by more than 0.2 degrees,
(d) Heading is checked to ensure it does not differ from the previous heading by more than 1 degree,
(e) Altitude is checked to ensure it does not differ from the previous altitude by more than 100 meters,
(f) Pitch is checked to ensure it does not differ from the previous pitch by more than 2.5 degrees.

(5) Output data
The geolocation parameters are stored for every 10th pixel on every scanline (pixels 1, 10, 20, 30, ..., 690, 700, 710, 716). The geolocation parameters stored are

(a) Pixel latitude (degrees, -90 is South, +90 is North),
(b) Pixel longitude (degrees, -180 is West, 0 is Greenwich, +180 is East),
(c) Pixel scan angle (degrees),
(d) Pixel azimuth angle (degrees),
(e) Solar zenith angle at pixel (degrees),
(f) Solar azimuth angle at pixel (degrees).
These values are scaled appropriately and stored as 32 bit integers. The original INS dataset will also be stored separately as part of the output.

MAS Level-1B data output format

The Level-1B data will be distributed in the Network Common Data Format (netCDF) developed by the Unidata Program Center. The netCDF software is freely available and has been tested successfully on the following platforms:

Sun3, SPARCstation (SunOS)
DEC VAX (VMS, Ultrix)
DECstation (Ultrix)
IBM RISC System 6000 (AIX)
CRAY YMP (UNICOS)
IBM PS/2 (MSDOS, OS/2).

The netCDF software is available by anonymous FTP from unidata.ucar.edu in the file pub/netcdf.tar.Z (both source code and documentation are included in this file).

Distribution of the MAS Level-1B data will be by either magnetic tape (9 track or Exabyte) or Internet.