NASA MODIS Project:
University of Montana SCF QA Scheme

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Synopsis

This white paper further describes the University of Montana SCF proposed Quality Assurance (QA) scheme. This plan will be implemented at the launch of the EOS AM-1 platform for our terrestrial archived data products. The UM SCF AM-1 land data products referenced here include: PGE 34,36,37,38 (8-day FPAR and LAI, 8-day PSN, and the annual NPP) products. This discussion does not yet explicitly cover the Climate Modeling Grid (CMG) variants of these products, the DAO ancillary climatology data, or QA details pertaining to future PM-1 platform products (MOD16, ET and Surface resistance).

Disclaimer

Some aspects of the scheme proposed here will undoubtably change upon further review and experience gained during the period prior to launch of EOS AM-1. In particular, the magnitudes of the various sample efforts could change in either direction, reflecting the compute resource levels actually available at launch and beyond.

Introduction

We consider the assessment of operational data product quality to be an integral aspect of their production. Data products that represent direct, sensor derived measures have the opportunity to assign quality scores based on published hardware error characteristics or specifications. Conversely, derivative model outputs represented by data products such as our Level 3 and 4 biophysical variables are several steps removed from direct sensor hardware outputs. Assessing the quality of these model outputs in a timely manner at native spatial resolutions poses more of a challenge due to this derivative nature. This is particularly true given the clear distinction made between ***validation*** activities occurring some time after data production vs. ***QA*** assignments required operationally in near real-quality of output from algorithms such as our radiative-transfer theory based lookup (FPAR,LAI) method are very directly related to the quality of these aggregated 1KM surface reflectances. A necessary (but not always sufficient) precondition to good quality FPAR and LAI outputs is therefore good quality surface reflectances. It is still possible to produce sub-optimal FPAR and LAI outputs with excellent surface reflectances, if one of the other key independent variables to the algorithm are faulty or missing. Since the 8-day PSN and annual NPP algorithm is driven directly from our 8-day composited FPAR,LAI outputs, the quality of the PSN algorithm too is directly related to the quality of these FPAR and LAI inputs.

The overall philosophy we use in assigning our product QA is therefore to first assign preliminary scores based on the pixel-wise QA of the input product directly upstream, and then to further attenuate this QA by additional factors introduced by the science logic of the given algorithm itself. Lastly, while many aspects of the QA assignment scheme can be predetermined ahead of launch, there will be no substitute for the experience gained with real MODIS data during the out-gassing period. We therefore expect that critical refinements to the initial scheme will undoubtably be made based on this experience.

We anticipate that QA analysis (and problem resolution) of overtly incorrect data products will be somewhat more straightforward. The greater challenge will likely be to consistently distinguish results that are "partially (or weakly) incorrect", whose values lie within "reasonable" and hence difficult to detect ranges. A systematic examination of longer time series of outputs, along with diagnostics aimed at distinguishing spatially driven error patterns should eventually help reveal these more subtle problems. Note that our data products are physically stored in a series of spatially contiguous gridded tile HDFEOS v.2.3 files, projected using the Integerized Sinusoidal (IS) grid, as opposed to the swath/granule HDFEOS file organization used for Level 1 and 2 lower level products.

MODLAND Team Quality Assurance (QA) Definition

The following QA definition is taken from URL:
http://pratmos.gsfc.nasa.gov/~droy/modland/qadefinition.html:

Operationally flag data products which obviously and significantly do not conform to the expected accuracies of that product. In an operational production system information/data will also be stored that is useful for post production quality assurance.

- *summary of per pixel QA over the granule / tile*
- *documentation of the code processing history*

Timing of QA Activities: ("which QA is done where")

QA activities are typically performed at two points in the overall process. First, at the DAAC or TLCF when the product is actually computed, the algorithms themselves generate tile and pixel level QA measures which are stored in the archive product (e.g. for ESDT's MOD15A2, MOD17A2,MOD17A3). Secondly, post-production QA activities are performed at some combination of the SCF (and/or the LDOPE), where additional verification tests can be used to further characterize the quality of the product files. This is represented by the AutomaticQualityFlag metadata fields [confirm]. [Verify: who (DAAC or SCF) actually sets the final value into the ScienceQualityFlag and OperationalQualityFlag]

Relationship of the LDOPE to the SCF

The LDOPE supplies only product metadata and related tile level summaries to the SCF. When the SCF requires more specific data to investigate a problem, the SCF must order this from the DAAC directly. This would include orders for offending input products, as well as copies of erroneous MOD15 or MOD17 outputs. Further, we expect that the LDOPE will QA our immediate upstream input products (MOD09 and MODPRAGG), so that we do not need to operationally perform a (redundant) analysis of these products per se.

Common QA Fields

In each archived land product file, QA information is stored as entries in the ECS Core or ECS Archive metadata blocks. QA entries are further identified here as either general or product specific attributes (PSA). Below, the common tile-level ECS CORE and ARCHIVE metadata fields are listed.

<u>ECS Core Metadata currently include</u>:

ANCILLARYINPUTPOINTER(F)
ANCILLARYINPUTTYPE(F)
AUTOMATICQUALITYFLAG(F)
AUTOMATICQUALITYFLAGEXPLANATION(F)

INPUTPOINTER(T)
LOCALGRANULEID(T)
OPERATIONALQUALITYFLAG(F)
OPERATIONALQUALITYFLAGEXPLANATION(F)
ORBITNUMBER(F)
PARAMETERNAME(T)
PGEVERSION(T)
PRODUCTIONDATETIME(T)
QAPERCENTINTERPOLATEDDATA(F)
QAPERCENTMISSINGDATA(T)
QAPERCENTOUTOFBOUNDSDATA(F)
QAPERCENTCLOUDCOVER(F)
RANGEBEGINNINGDATE(T)
RANGEBEGINNINGTIME(T)
RANGEENDINGDATE(T)
RANGEENDINGTIME(T)
REPROCESSINGACTUAL(T)
REPROCESSINGPLANNED(T)
SCIENCEQUALITYFLAG(F)
SCIENCEQUALITYFLAGEXPLANATION(F)
SHORTNAME(T)
SIZEMBECSDATAGRANULE(T)
VERSIONID(T)

Note: (T) stands for mandatory metadata and (F) stands for optional metadata. (Ref: MODIS Version 2 Science Computing Facility Software Delivery Guide, May 7, 1997).

ECS Archive metadata currently includes:

(Note: this list was taken from URL: pratmos.gsfc.nasa.gov/~droy/modland/modland_v2_metadata/archive_meta.html:

ALGORITHMPACKAGEACCEPTANCEDATE(F)
ALGORITHMPACKAGEMATURITYCODE(F)
ALGORITHMPACKAGENAME(F)
ALGORITHMPACKAGEVERSION(F)
EASTBOUNDINGCOORDINATE(T)

SPSOPARAMETERS(F)
WESTBOUNDINGCOORDINATE(T)

Note: (T) stands for mandatory metadata and (F) stands for optional metdata. (Ref: MODIS Version 2 Science Computing Facility Software Delivery Guide
May 7, 1997)

Product Specific Attributes

A set of Product Specific Attributes (PSA's) are also defined for MOD15A2, MOD17A2, and MOD17A3. The product specific attributes for MOD15A2 are shown below. Note that the majority of these are inherited directly from the upstream products. Where appropriate, these are simply passed through to the our product files unchanged. The PSAs for our other land products are similar.

MOD15A2 (8-day MODIS LAI and FPAR Products): (tile level) Product Specific Attributes:

QAPERCENTGOODQUALITY
QAPERCENTOTHERQUALITY
QAPERCENTNOTPRODUCEDCLOUD
QAPERCENTNOTPRODUCEDOTHER
HORIZONTALTILENUMBER
VERTICALTILENUMBER
N_DAYS_COMPOSITED
QAPERCENTGOODFPAR
QAPERCENTGOODLAI
QAPERCENTMAINMETHOD
QAPERCENTEMPIRICALMODEL
QAPERCENTBIOMEFALLBACK
GEOANYABNORAML
GEOESTMAXRMSERROR
SYSTEMFILENAME
NUMBEROFGRANULES
GRANULEDAYNIGHTFLAG
GRANULEBEGINNINGDATETIME
GRANULEENDINGDATETIME

MAXIMUMOBSERVATIONS
COVERAGECALCULATIONMETHOD

In addition to these tile level QA PSA fields, all producers of land products on the MODLAND team have also adopted a common 2-bit spatial QA encoding scheme, which occupies the 1st two bits of our spatially distributed 8-bit QA data plane (e.g. HDFEOS fields: Fpar_1km_QA and Psn_1km_QA, NPP_1km_QA etc). The MODLAND and other bit fields are described in the table below:

MOD15A2 "Fpar_1km_QC" 8-bit QA bitfield layout				
Sub-field	***Bits***	***Dec. Value***	***Bin. value***	***Bit Definition***
MODLAND QA bits	00-01	0	00	Product pixel produced at ideal quality
		1	01	Product pixel produced, less than ideal quality
		2	10	Product pixel not produced due to cloud effects
		3	11	Product pixel not produced for other reason
Algorithm Path bits	02-03	0	00	Product pixel produced using main RT method (Highest quality)
		1	01	Product pixel produced using 732 Empirical LUT Method
		2	10	Product pixel produced using 6 biome model fallback Method
		3	11	Product pixel could not be produced using any method
Landcover source	04-04	0	01	Pixel classified using valid MOD12 MODIS landcover class
		1	01	Pixel classified using U.Montana landcover 6-biome class
(Not used)	05-05	N/a	N/a	N/a
Pixel quality	06-07	0	00	Highest quality (76-100 percentile quality score)
		1	01	Good quality (49-75 percentile quality score)
		2	10	Questionable/Poor quality (26-50 percentile score)
		3	11	Unacceptable quality, (0-25); we recommend

DAO Ancillary Data QA Issues

One of the primary driving inputs to our daily PGE 37,38 suite (MOD17A1, MOD17A2) is the Data Assimilation Office daily global surface climatology data product. Currently this ancillary daily input does not specifically carry QA fields internally. This makes ascertaining the role of DAO inputs in error propogation resulting in apparently incorrect MOD17 products more complex. This issue is somewhat compounded by the coarse overall resolution of the DAO data products (2 deg by 2.5 deg, or 1 deg by 1 deg sometime after launch). The resolution of this issue is TBD.

Operational QA Methods Proposed

There are two structural layers of QA involved in the production of MODIS land products. The more general layer is represented by "tile-wise" quality indicators -- a set of EOSDIS Core System (ECS) metadata fields attached to each "tile" product file at its creation. The majority of these are set at runtime, but some are adjusted by later, near run-time processes. Note that "tile-wise" QA measures may also be considered "regional" quality assessments, since tiles themselves are organized on a systematic spatial grid. The second structural QA layer is "pixel-wise", spatially distributed quality measures. A good QA approach accommodates an analysis of each of these. Generally, the tile level metadata (CORE, ARCHIVE) are examined first, as in some cases further (pixel-wise) effort may be avoided if the quality of an entire tile falls on either far end of the quality spectrum.

The current spatial tiling scheme based on the IS (GCTP_ISINUS) grid stores a 1200 x1200 km area in each (full) land tile; there are a total of (326) such land tiles required to represent all the land surface on the globe. The MOD15A1 FPAR,LAI daily algorithm is executed daily using 1KM aggregated surface reflectances (MODPRAGG product), producing a series of up to (8) daily "candidate" FPAR and LAI planes per tile per composite period. Once each 8-day period, the MOD15A2 8-day FPAR, LAI compositing algorithm is executed to produce a single "best" output tile from these candidate daily images. This 8-day composite FPAR,LAI product is then passed on to the MOD17 daily PSN algorithm. Since these algorithms fire once daily, a "best case" (e.g. most intense quality assurance) scheme might be to evaluate the QA for all (326) land tiles each day. An exhaustive data sampling scheme like this may be ultimately possible, but is currently considered impractical given the distributed nature of the DAAC, TLCF, LDOPE and SCF topology. The impracticality arises from the limited the centralized LDOPE facility. Refinements in these assumptions are expected to occur during the remainder of this pre-launch time period in 1998-1999.

The QA activities that we intend to perform may be classified along several different gradients:

- Routine (subscription based) vs. problem-triggered
- Batch vs. interactive quality assessments
- Statistical (tabular) vs. image visualization
- Tile level (e.g. LDOPE RDBMS query) vs. spatial (pixel-wise) QA
- Realtime (at production) QA vs. Post-production QA

These are each described in more detail in the next section.

QA Activity Category Definitions

Routine QA activities represent a set of pre-planned evaluations, conducted both at the tile level as well as the pixel (spatial) level. These are performed as a matter of course on a limited sample of tiles for a given 8-day period.

Problem triggered QA activities represent directed, higher-intensity examinations of both QA, archive product output, and input data. If the cause of a given problem cannot be directly traced to a simple problem in the input data as diagnosed via the input data's metadata fields or pixel level QA values, we anticipate the potential need to re-run (at the SCF or at the TLCF) the offending tile model run to identify and rectify the problem.

Statistical QA operations are defined here as typically scripted batch tile or pixel-wise tasks used to determine key diagnostic statistics from QA planes and data product planes (FPAR, LAI, PSN, NPP), from a subset of land tiles retrieved from the DAAC, TLCF, and/or LDOPE. These statistics include various measures of central tendency (median, mode, mean) as well as distribution-related diagnostic measures. The purpose of compiling these statistics is typically to compare them to pre-established equivalent reference ("expected bench-mark") statistics, to quickly identify problem or outlier model results. Also included in the "statistical QA" category are a set of routinely calculated "deltas" -- the residuals (as both arithmatic and absolute value difference) obtained from subtracting the latest modeled result(s) from an appropriate reference data set.

automated scripts run at the LDOPE to function as the first line of defense in checking the presence (and where appropriate, the correctness) of these fields. These scripts should scan key ECS metadata fields each 8-day product sets 326 land tile, and log the identity of any tiles with overt problems.

Spatial level QA operations are defined as critical evaluations on spatially data -- typically one tile (or a contiguous 3x3 group of tiles). The pixel level MODLAND QA bits fall in this category. The evaluation of these elements may be statistical or visual in nature, or both.

Realtime QA operations are defined as any performed by the algorithm in realtime when it executes.

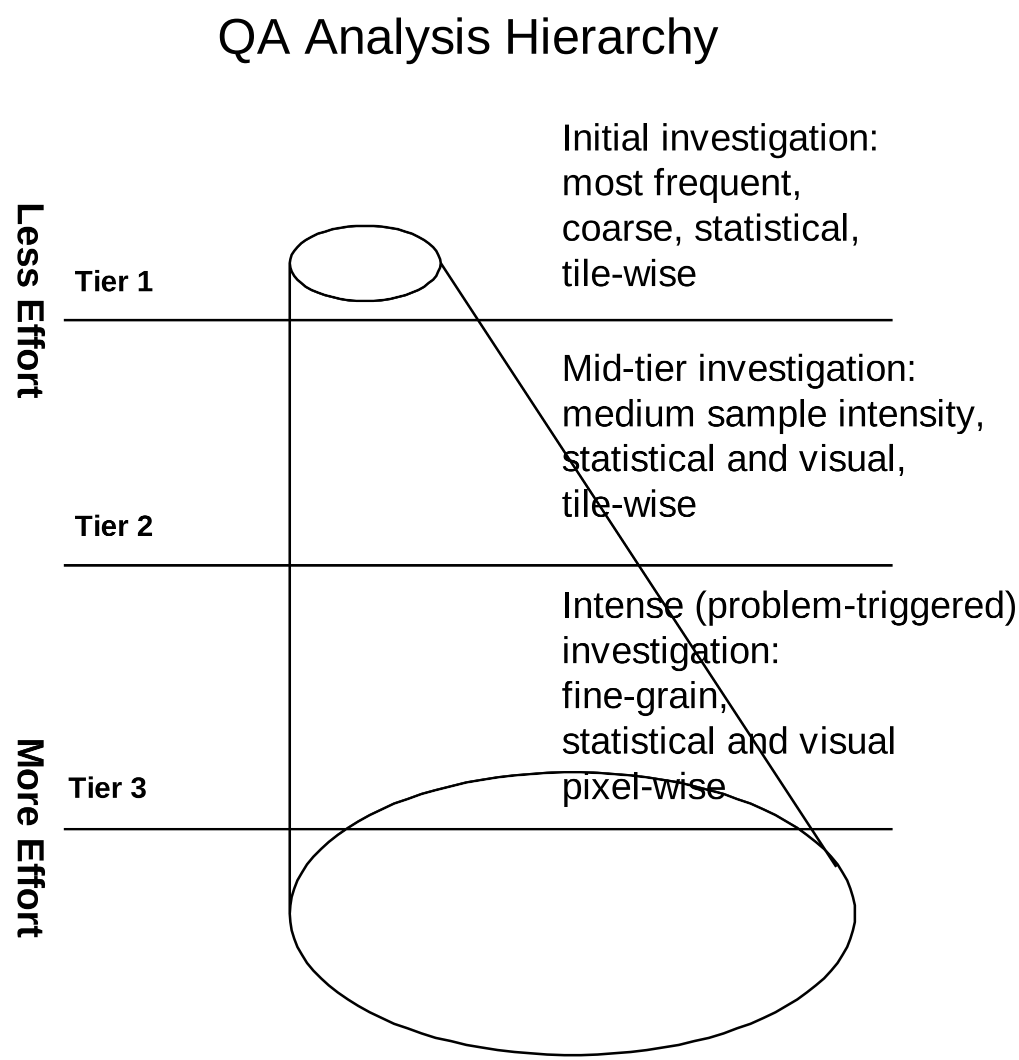
Post-production QA operations are defined as those performed any time after the algorithm is executed, either at the DAAC, the LDOPE, or at the SCF.

QA Activity Hierarchy

Operationally, the goal is to maintain a flow of the "best science" data products as possible, expending as little QA effort over time as is reasonably demanded by this first goal. Thus, the QA operational scheme envisioned here should consist of the following activity layers. Note that while all "routine" aspects of the QA operation are performed over time, we plan to employ the more intense QA activities only as necessary or at infrequent intervals as resources allow. QA is by nature a time consuming task from a staffing standpoint. We will try to periodically re-evaluate our procedures with an eye towards streamlining the process, and increasingly automate tasks that lend themselves to this strategy.

The QA scheme envisioned here consists of several (hierarchical) activity layers, in which more rapid and coarse assessments are conducted first, followed by successively more intense (and potentially time consuming) types of assessments.

QA evaluations are initially divided into two broad categories: statistical, and visual. In addition, our QA evaluations follow a prescribed temporal life-cycle -- with each new 8-day composite period boundary triggering the start of a new QA activity cycle. There are typically (45) such 8-day periods annually. Since our fundamental algorithms fire on a daily basis, we also implicitly recognize a daily QA cycle, but due to resource constraints it is likely that only "problem-triggered" QA activities will be performed on the daily



timestep. The following table describes the types of various QA activities we anticipate conducting, or participating with the LDOPE on.

		sample (1 or 2 per biome, more if practical), and of CMG products, for visual cross-check.
2	Pixel level QA (medium)	a) Routinely retrieve a (globally distributed) systematic sub-sample of land tiles for statistical and visual examination (1 or 2 per biome); results to form a longer term historical time series. b) Routinely retrieve a random sample (without replacement) of land tiles to examine as above.
3	Pixel level QA (fine grain)	a) At less frequent intervals (or as time permits), retrieve and examine a more exhaustive sample of our land product tiles. b) Response to Explicit problems identified at the LDOPE or SCF: this triggers a more intense examination; retrieve 3x3 contiguous tile regions centered on the offending tile (as appropriate) for more in-depth, robust analysis and possible PGE re-execution at the SCF

Spatial Sampling of Land Tiles for QA

For each land product tile from (PGE 34,36,37,38) selected for QA examination, in coordination with the LDOPE we expect to conduct one or more the following types of QA analyses:

- Examination of the tile-level ECS (core,archive) metadata fields for presence and correctness.
- Examination of the tile-level level PSA fields to assure that a sufficient percentage of qualifying pixels were produced (Note: we have not yet set of fixed minimum threshold for the QAPERCENTxxx fields)
- Statistical and/or visual examination of the pixel level QA fields (Fpar_1km_QA, Psn_1km_QA, etc)

When warranted (either by overt problems, or more routinely during out-gassing to verify the product data themselves, the following QA activities may periodically be performed:

- Examination (statistical and/or visual) of the direct and/or ancillary inputs to a given set of PGE execution(s)

Implicit in any quality analysis of biophysical model data is a recognition of the "level of measurement" represented by the model variable, and how the data are likely to be used by practitioners. Technically, our FPAR, LAI, PSN, and NPP measures are all continuously distributed variates, making the application of standard parametric statistical theory relevant. Nonetheless, we must distinguish at the onset the difference between a given measure being "statistically" significant from its biophysical significance. In some cases, a trend or statistic may not be statistically significant at a traditional probability or CI level such as 0.05, yet it may still be very biologically significant. Conversely, differences or similarities objectively judged to be "statistically significant" may be insignificant biologically. Our QA scheme will thus ultimately try to favor a scoring that weights the biophysical importance of a difference or trend over its pure statistical significance.

As indicated earlier, there are 326 IS land tiles. Currently, a Version 2.1 MOD15A2 full tile data product file is 5694 Kb in size, and a V.2.1 MOD17A2 full tile data product file is 4284 Kb in size. Given these per-tile sizes, with our SCF disk store limits and network bandwidth limitations, it is quite likely that we will not be able to network-retrieve all the QA and/or primary data product data generated at a remote site. Indeed, our SCF network bandwidth was specified (at best case) for retrieval of only 10% of our product QA. Therefore, we intend to perform a type of spatial sampling that should help us account for the majority of the anticipated (statistical) variation in the archived data globally.

The foundation for our sampling is a straightforward application of stratified two-stage (or cluster) sampling. Though our land products are produced at a global coverage at each archive time-step, we recognize two spatial sample levels -- a higher resolution more intense sample universe comprised of the US Continent, and a more sparsely sampled (less intensely sampled) universe comprised of the full global scope. Predicating this scheme is our stratification of global terrestrial landscapes into a limited number of biophysically defined biome classes. Further, note that we ignore pixels classified to any of the non-terrestrial classes (water, ice, rock, barren, etc).

The (6) biome classes we use (mapped from the 17 IGBP classes present in the at-launch land product, MOD12A1) tend to form a natural stratification criterion for "primary" sample frames (sub-populations), where the assumption is that within-group variation for a given measured field (FPAR,LAI, PSN or NPP) is significantly less than across-group variation. Even if these variance assumptions are not supported with classic parametric life of the MODIS instrument. There are several implicit goals behind this "fixed" sample frame approach:

- we ultimately desire a longer term history of measured vs. modeled variables for comparison and model refinement.
- we could potentially track larger scale "change detection" patterns in ecosystem variables as they vary in time and space.
- a fixed but sparse set of primary samples centered about LTER, flux tower, or other long term study sites realistically represents what is available for high quality data over longer historical time periods.

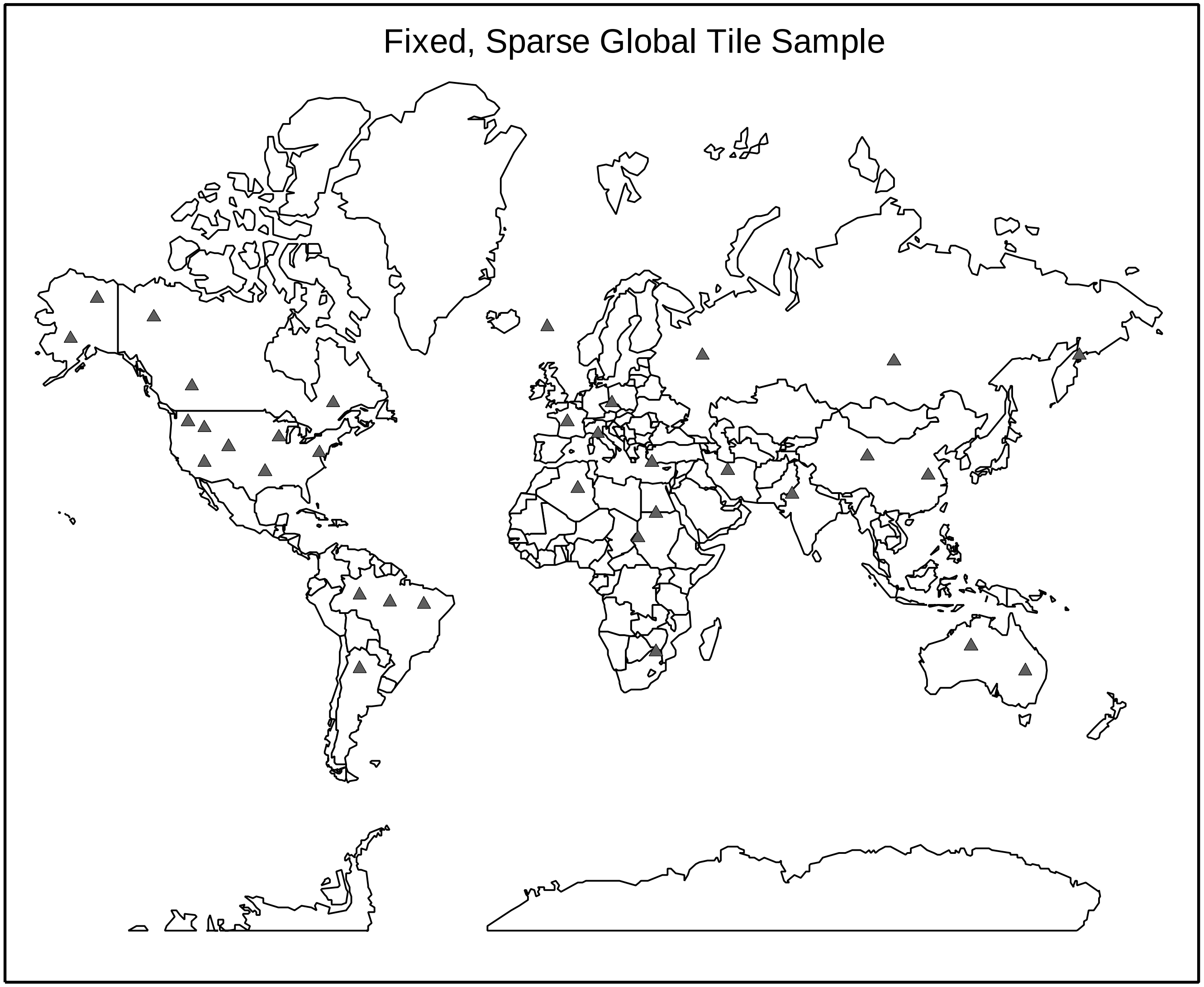
The "fixed,sparse " global sample should generally meet these criteria:

- Each land tile selected should ideally be centered on a "well-characterized site" from a biophysical science viewpoint. This "point" may correspond to an existing LTER site, or any other site for which a temporal record of higher quality validation information for the given variables is available. The site locus could also be one in which a flux-tower or other instrumentation cluster is present.

- As a "smaller" number of tiles (6-18) , the data volume represented for network retrieval at each 8-day composite cycle (for longer term archive at the SCF) should be more practical.

- The globally distributed set of land tiles should, as a whole, represent the range of variation in each variable fairly well over time. Note that the "fixed set" of land tiles chosen for FPAR and LAI should be spatially coincident with the set chosen for PSN and NPP.

Given the establishment of this group of "primary" (sample frame) land tiles, we follow the convention in two-stage sampling of stochastically identifying a sub-population of 1KM pixels within each such "primary frame" land tile. To assure a better spatial distribution and to increase sampling rigor, at each 8-day composite period boundary we would sample an appropriate number of pixels (ca 100 for good Z-score distribution) without-replacement. From this sub-population, we would compute and analyze a limited set of standard diagnostic measures (mode, median, minimum, maximum) and any others identified as helpful to the time series analysis.



Delta Analysis on the Fixed Global Sample

In addition to analyzing simple trend statistics as cited above, we intend to also perform a standard residual or "delta" analysis, where pixel-wise difference values are computed for the fixed sample land tiles described above vs. the spatially coincident pixel in pre-established "reference" images of the same variable (FPAR, LAI, PSN, NPP). The

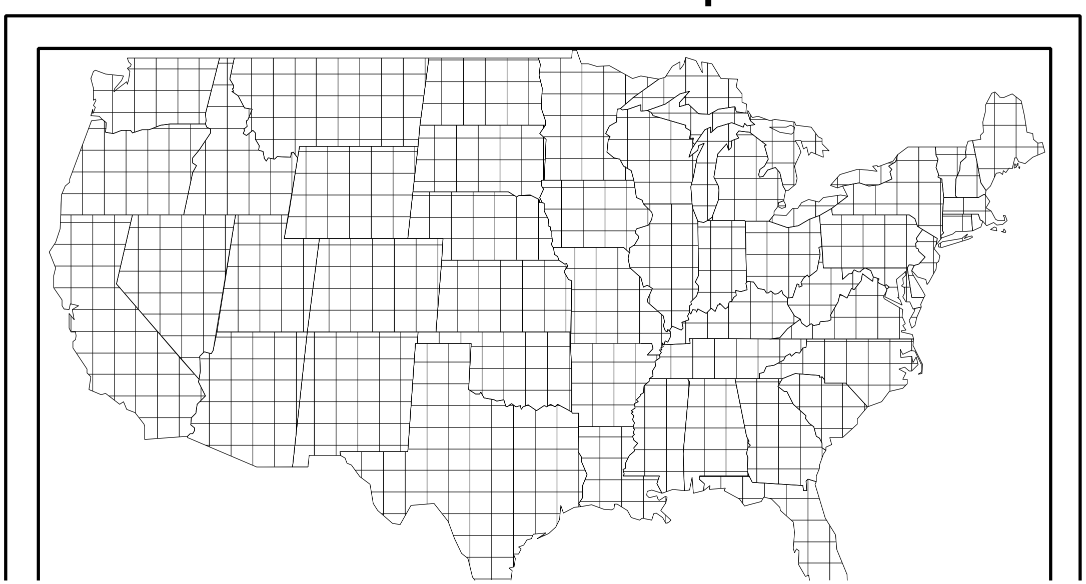
Tier-2 Methods for Stochastic Global Sampling

When a more intensive land tile sampling is justified, a separate sample (uniformly randomly selected) will be chosen. Analyses on these pixels sampled would include those described above -- verification of the QA, the direct variables themselves, or various delta analyses using spatially coincident reference images.

Tier-3: US Continent (Intensive) 1KM Sampling

For more in-depth (and less frequent) spatial QA assessments, pixel wise comparisions between a set of predefined 1KM reference images for FPAR, LAI, PSN and NPP will be compared with the latest model output. The sampling intensity of these comparisons can be readily scaled to the resources (staff time, compute and storage) available. These delta comparisons would probably be conducted once a month. Difference statistics will include pixel-wise simple difference, absolute difference, and a tile-wise mean-absolute difference.

US Continent:
1KM Exhaustive Sample



A number of QA software tools are now in place at our SCF. Interactive tools are listed below, by platform:

QA Software Tools at the Univ. Montana SCF		
Platform	***Mode***	***Tool***
UNIX (SGI, IBM)	Interactive	HDFLook, Sphinx
	Interactive	WebWinds (JPL)
	Interactive, scripted	IDL
	Interactive, scripted	SPSS
	Interactive, scripted	S-Plus
	Batch, scriptable	LDOPE batch command line tools
	Batch, scriptable	Custom SCF tools (delta, freq, etc)
	Interactive	LDOPE ENVY tool
Intel PC (NT OS)	Interactive,scripted	Noesys
	Interactive	WebWinds
	Interactive,scripted	SPSS
	Interactive	SigmaPlot
	Batch, scriptable	Custom SCF tools (delta, freq, etc)

At the LDOPE, we expect only IDL, ENVY and LDOPE command line tools to be implemented for our use. In general, across all the above tools, we believe there is probably currently a sufficient tool set available for all anticipated QA activities. Actual experience may indicate additional needs not yet adequately filled.

Setting the Operational Science Quality Flag

Currently, we plan to set a threshold to indicate the minimum percent of a given tile that was completed correctly (at quality level good or excellent) as the basis for setting this flag. This approach will need refinement [TBD].

Setting Product Level QA (Spatial) Flags

See the QA bitfield layout" table on p. 6 of this document for a list of the specific bit fields present in these spatial QA flags:

- FPAR,LAI: HDFEOS field: Fpar_1km_QC

in lowest quartile. The actual assignment is based on science-specific logic which varies by algorithm.

(TBD: include more specific MOD15 and MOD17 assignment logic for these fields).

Operational QA Scenarios

The following operational hypothetical scenario is offered to help anticipate various real-time coordination issues we expect to encounter. We will coordinate daily with both the LDOPE and the production DAAC (or TLCF, MEBS, etc) in the production of our land products. We are currently envisioning two basic types of communication traffic between the LDOPE and our SCF -- routine and problem-triggered. Routine traffic will include all pre-established, subscription based communication, such as notification email, servicing of standard LDOPE RDBMS queries, as well as any automated (or semi-automated) data transfer. Initially, almost all data transfer traffic should be one directional, from the LDOPE or DAAC to our SCF. Exceptions to this flow will be when our SCF needs to update the production site with a particular (static) ancillary data object, or requested code revision. Details of code updates between our SCF and the TLCF still need to be worked out.

Routine QA

We recognize two basic clocking cycles relevant to the production of our land products; a daily cycle which matches the execution periodicity of our main algorithms (MOD15A1 and MOD17A1), and an 8-day composite period cycle, which matches the production of our archive products. The current phased-production scheme indicates that other upstream products will undergo certification prior to ours, most likely resulting in a "certification lag" of approximately Launch+ 3 months, whereupon the production of our products will elevate to a more public state of maturity. During this initial period, subject to LDOPE resources and availability, we hope to gather as much early information as possible about how our algorithms are faring, if they are running at all. Once the "certification lag" period has passed, we expect to commence all QA subscription communications with the LDOPE. At this point, we plan on implementing a simple in-house SCF database to log routine QA messages and most likely, the body of the ECS Core, Archive, and PSA QA blocks associated with our 8-day products (45 periods annually for each product).

Note that we do not plan on regularly retrieving any QA generated by the intermediate since so much of the quality of our tiled land products stems directly from the continuity and accuracy of upstream products (e.g. aggregated surface reflectance, DAO daily surface global climatology, etc) which are beyond our control. Nonetheless, we hope to put into place a systematic approach for handling as much of the unexpected as possible.

Problem triggered QA events can occur at any time, so we anticipate the development of a "triage" problem classification to allow us (in partnership with the LDOPE) to categorize real-time production problems into those that demand immediate attention, vs. those that can be deferred to the next 8-day composite period boundary, or some other regular time interval. This recognizes that staffing resources at both the SCF and LDOPE may be constrained during periods of high activity.

QA flags retrieved that indicate persistent and severe errors will be attended to first. Indications such as low percentages of tiles being produced correctly (via the QAPERCENTMISSINGDATA or QAPERCENTOUTOFBOUNDSDATA flags, etc). Local retrieval of QA traffic (and possibly product data itself) will be stepped up considerably for problems deemed severe, until the problem is identified and resolved.

Additional Information Sources

A great deal of information pertinent to effective QA methodologies is available. Below I've listed several specific online and published references.

- LDOPE QA home page: (http://pratmos.gsfc.nasa.gov/~droy/modland/qahome.html)
- The NASA software independent verification and validation facility: (http://www.ivv.nasa.gov)
- The NASA Software Assurance Technology Center (http://satc.gsfc.nasa.gov/)
- The Software Engineering Institute home page (http://www.sei.cmu.edu/sei-home.html)

References

MODIS Version 2 Software Delivery Guide

Interface Control Document Between EOSDIS Core System (ECS) and Science

1984. Bezier, Boris. Software System Testing and Quality Assurance. Van Nostrand Reindhold Electrical/Computer Science and Engineering Series, Van Nostrand Reinhold.

1998. McConnell, Steve. Rapid Development. Microsoft Press.

MODIS MOD17 (PSN, NPP)
Data Flow Diagram
(daily firing scenario)