Quality Assurance for Societal Benefit

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QA4EO Workshop on Providing Harmonized
Quality Information in EO data by 2015
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Rutherford Appleton Laboratory, Harwell, UK

Outline

- QA of GEOSS data products for end-users
- Quality Assurance & Indicators for Societal Benefit
- QA Approach for Land & Atmosphere Products
  - Best practice examples
  - TOPS, Rain Water Harvesting
- Error Budgets / Uncertainty Inventories
- Measured Uncertainties
  - Sensor data vs Ground truth
- Sources of Product Uncertainties
- Recommend QI for Societal Benefit “Error Budget” effort
- Summary of Recommendations
- Final thoughts: a GEO dialogue on QA for SB

Quality Assurance (QA) & Quality Indicators (QI) for GEOSS End Users

- QA of GEOSS data products for end-users requires
  - Reference Standards and a set of Best Practices for the Evaluation & Documentation of
    - Sensor Cal/Val processes, uncertainties, and biases
    - Product algorithm uncertainties
    - Product artifacting issues

- A good QA strategy provides for
  - Quality measures or Quality indicators (QIs) that specifically consider the intended performance
    - "It is for the final user of the information to determine if this information, with its associated QI, is suitable for their requirements" QA4EO-GEN-DQK-006
  - Allows end-users to have faith in the data's veracity over an extended period of time

Quality Assurance for Societal Benefit

- QA4EO key objective: Assign a QI to the output of every step in an EO information product processing chain
- GEO concerned with establishing confidence in specific data products that supports all of GEOSS's nine societal benefit areas.
  - Disasters
  - Health
  - Energy
  - Climate
  - Agriculture
  - Ecosystems
  - Biodiversity
  - Water
  - Weather

MODIS Global Burned Area, a Data Product for SB

MODIS Land (MODLand) Products: Nine Years and Counting originally presented at IGARSS09 Cape Town
Chris Justice, David Roy and the rest of the MODIS Land Science Team

Extracting societal benefit from satellite measurements requires the development of a strong linkage between the measurements and the decision makers who will use such measurements.

This linkage must be sustained throughout the life cycle of the mission.

-- Decadal Survey Report (2007)

U.S. National Academy of Sciences

Original analysis Boschetti et al.

Quality Indicators for Societal Benefit
QI4SB implementation proposal

- Goal: Develop a set of Quality Indicators linking initial scientific instrument measurements to the products delivered to societal benefit end-users

- Quality Indicators to be based on the uncertainties of key processing steps; including the errors associated with product modeling
- Combined QIs are to be compared by end-users to their uncertainty requirements
  - **Lower quality data sets may be acceptable for some applications where product uncertainty (or error) tolerances are large**
  - **High quality sensor-calibration data are needed when scientists must estimate small changes in important geo-physical variables**
    - **(e.g. SST time series need to be accurately measured to 0.1 deg over a decade)**

Integrating Earth Observations with Ecosystem Models for Societal Benefit

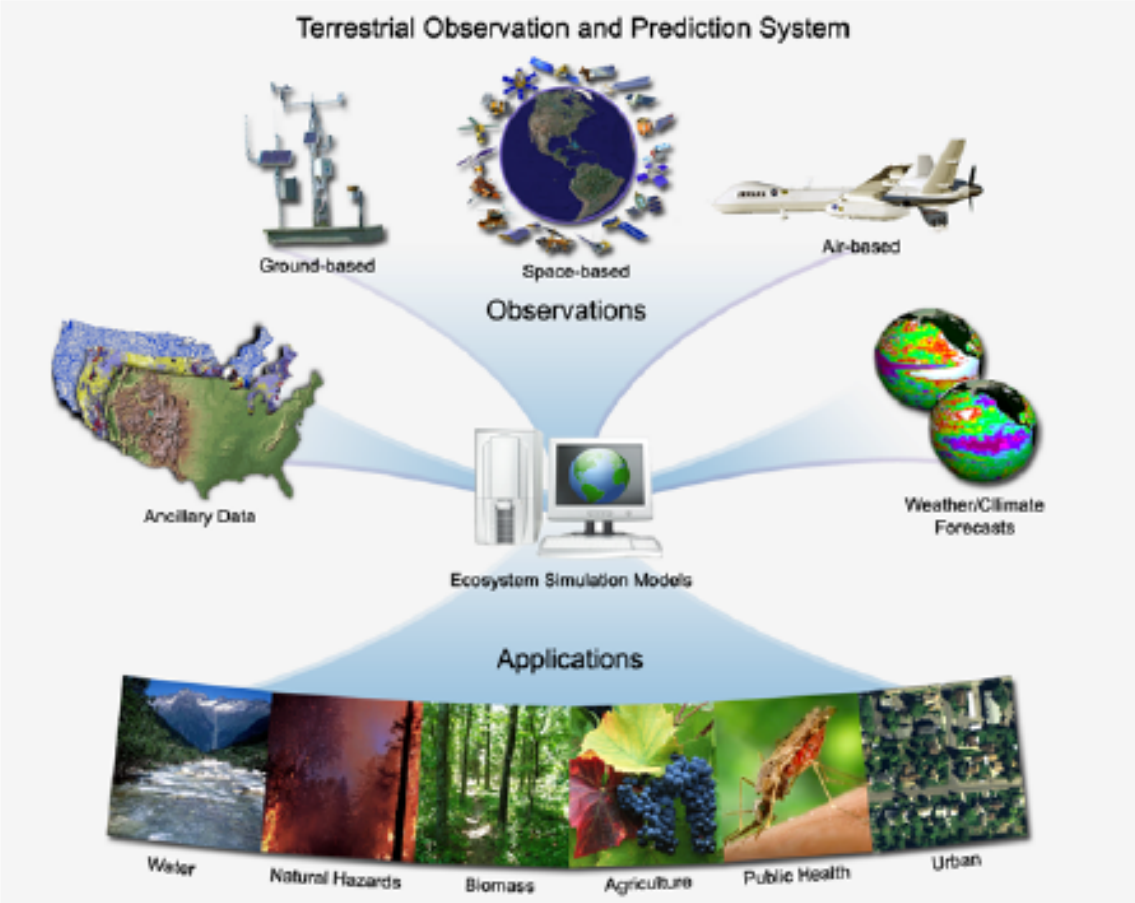
NASA's TOPS Framework (Ref. Forrest Melton, GEOSS Workshop XXXIII, "EO for Water Mgt", 2009)

NASA Modeling and Data Assimilation Frameworks: Terrestrial Observation and Prediction System (TOPS)

Monitoring modeling, & forecasting at multiple scales

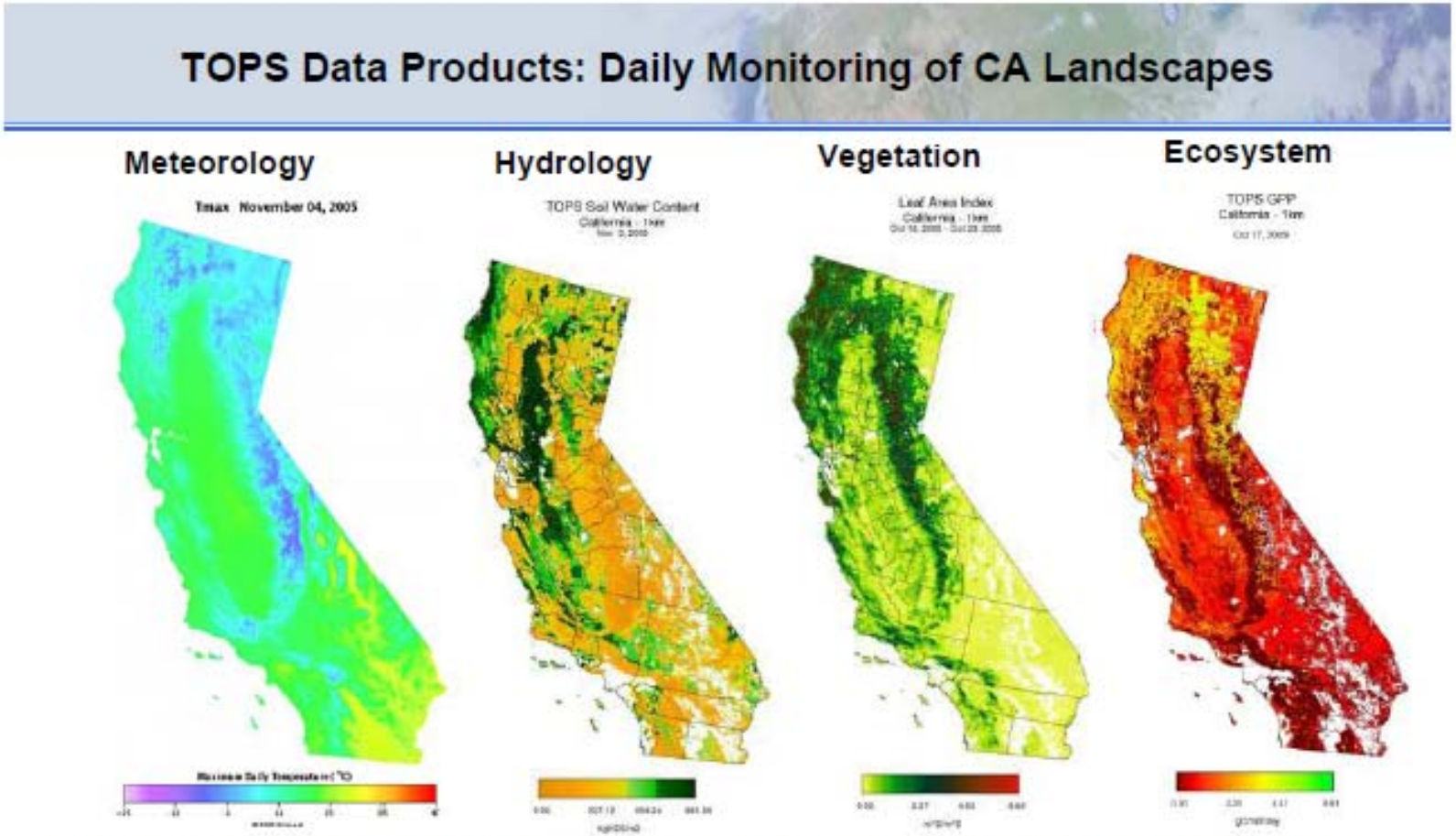
Applications for:

- Monitoring current conditions
- Modeling and forecasting future conditions
- Optimizing resource use



TOPS Data Products for California

(Ref. Forrest Melton, GEOSS Workshop XXXIII, "EO for Water Mgt", 2009)

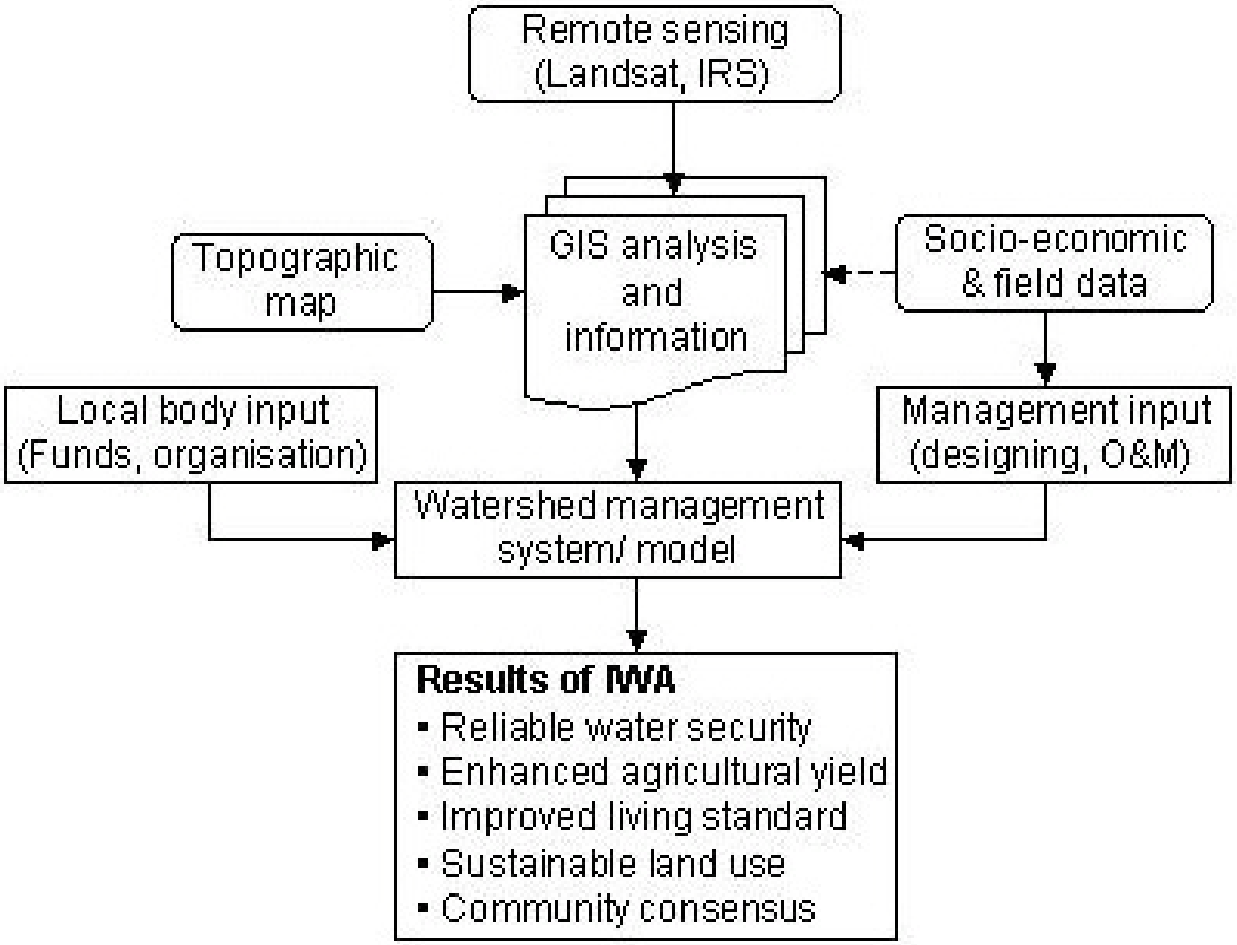


Examples of the TOPS-30 data products, which include daily measures of climate, hydrology, vegetation and ecosystem conditions produced for California at 1km spatial resolution.

Integrated Watershed Mgt Approach in India

Modeling through Advanced Technologies + Rainwater Harvesting,

Ref. Eldho, India Institute of Technology



Cistern built in Melva, India

IEEE sponsored Water for the World Pilot Project
Tom Wiener, GEOSS Workshop XXXIII, "EO for Water Mgt", 2009

- Smart Rain Water Harvesting Capacity Building Project
- J. R. Sharma (ISRO) and J. Pearlman (IEEE/ICEO)
- Goal: Develop & implement Earth Observation based information system methodologies for Smart rain water harvesting projects to assist small-holder farmers in semi-arid environments.

Error Budgets or "Uncertainty Inventories"

A basis for establishing Quality Indicators

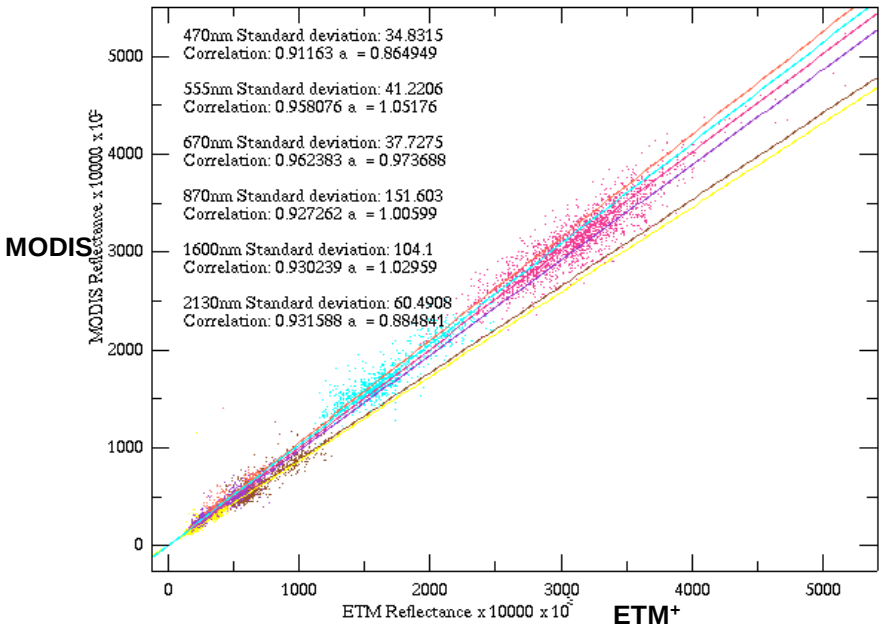
- Error Budgets:
  - Provide a means for tracking source of errors
  - Establishes a quantitative basis for constructing product Quality Indicators and/or QA metadata.
- A comprehensive error budget quantifies the impact of:
  - Calibration Uncertainty, Product Modeling, and Noise Sources
- An example is the Error Budget for the MODIS Land Surface Temperature product

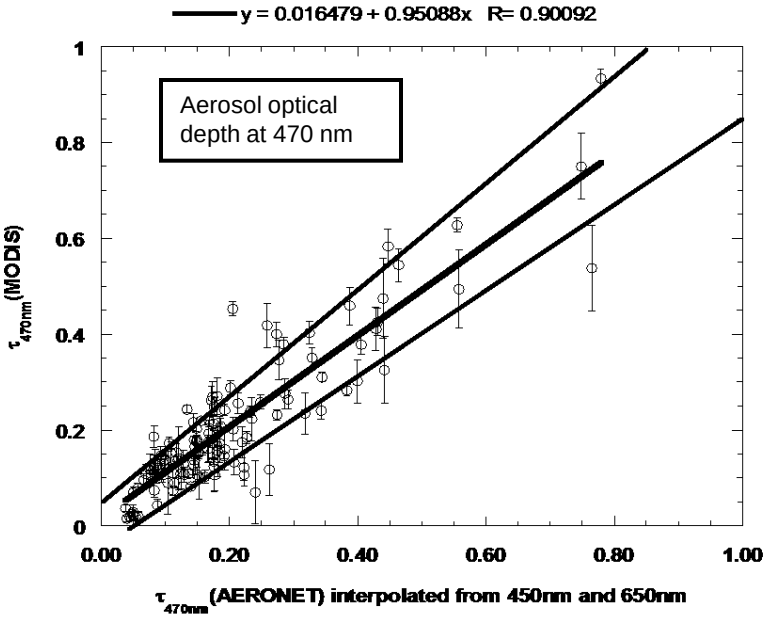
	Instrument and model uncertainties	**Temperature Uncertainty, ^oK**
Algorithm Errors Dominant	Algorithm	0.58 K
	Mean emissivity error estimate, ε	0.31 K
	Delta emissivity error estimate, $\Delta\varepsilon$	0.65 K
Instrument Errors, smaller	Instrument noise, $NE\Delta T = 0.5K$	0.30 K
	Instrument calibration error (deg K)	0.35 K
	Combined Root mean square of all uncertainties	**1.03 K**

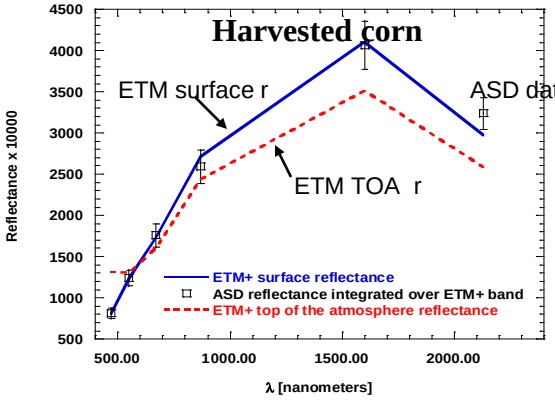
Errors based on split-window LST Algorithm
Ref: Z. Wan, MODIS Land-Surface Temperature Algorithm Theoretical Basis Document, Version 3.3, April 1999

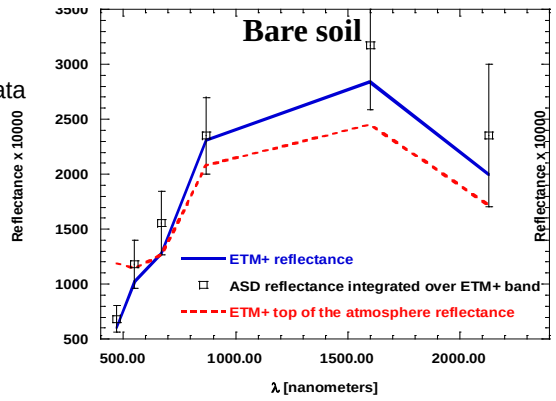
MODIS Surface Reflectance Stage 1 Validation re ETM+ /Landsat 7 data

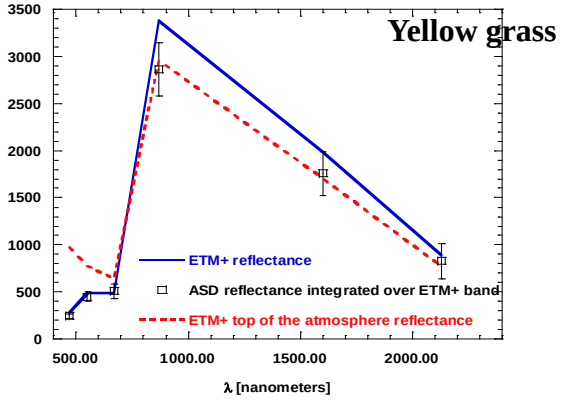
" Evaluation of NPP/VIIRS Land surface Earth data with respect to climate change objectives"
Vermote and Saleous, NPP Science Team meeting, Nov 4-6 2003







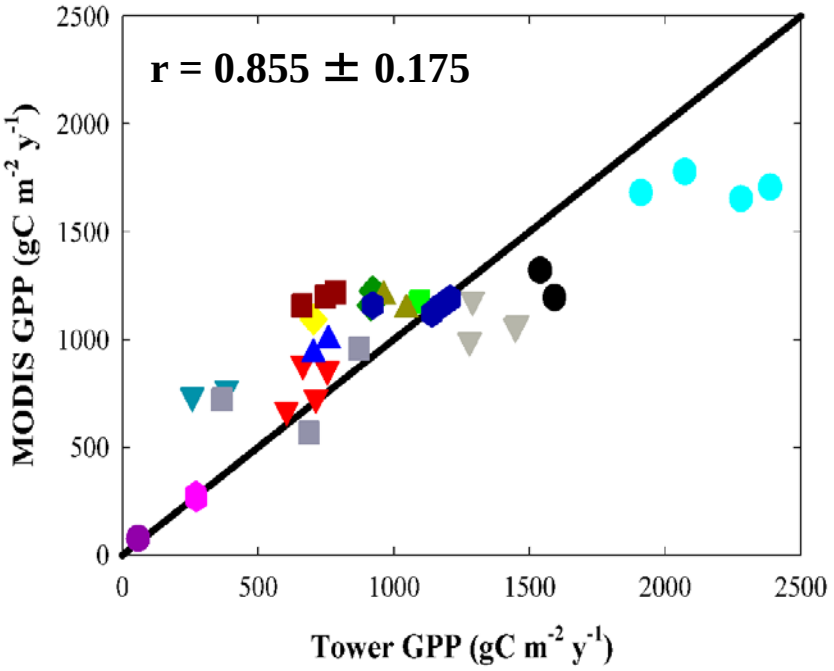




Accuracy of Annual Gross Primary Production (GPP) Data Validation of MODIS vs Tower measured GPP

"Evaluation of Remote Sensing Based Terrestrial Productivity From MODIS Using Regional Tower Eddy Flux Network Observations"

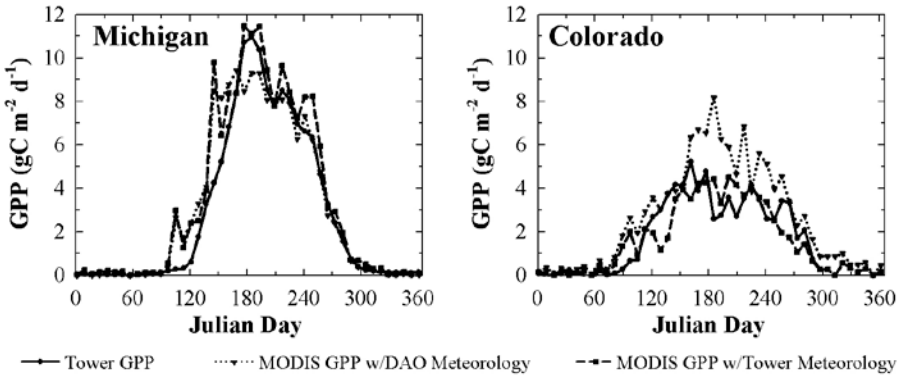
F.A. Heinsch, et al, TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 44, NO. 7, JULY 2006



- Harvard Forest (DBF)
- BOREAS NOBS (ENF)
- Old Metolius (ENF)
- Young Metolius (ENF)
- Niwot Ridge (ENF)
- Lethbridge (G)
- Duke Forest (MF)
- Howland Forest (MF)
- Lost Creek (MF)
- WLEF/Park Falls (MF)
- Old Sylvania (MF)
- Willow Creek (MF)
- Barrow (OS)
- Old Sky Oaks (OS)
- Tonzi Ranch (Sav)

Algorithm Errors Dominate differences between Space and Ground

GPP is a measure of photosynthesis and is estimated from remote sensing data using Visible and NIR spectra

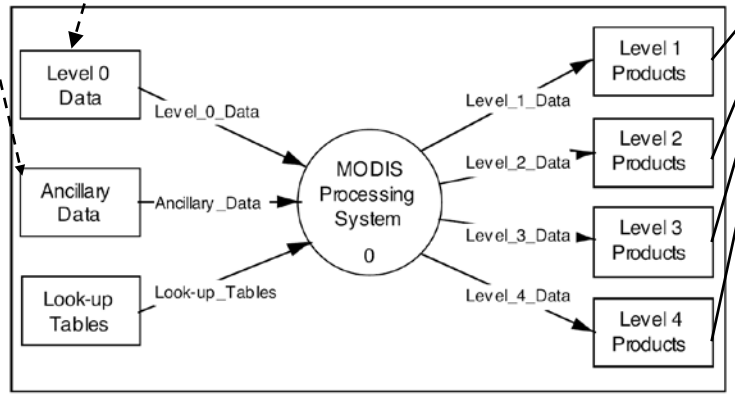


Algorithm Product Uncertainties

Ref: D. Roy, et al Remote Sensing of Environment, Vol. 83, pp. 62-76, 2002

- Product Algorithms often not mature enough
  - Do not adequately model the major physical processes that account for the relationships between instrument measurements and “ground” truth

Recommend GRSS develop "Error Budget" and QIs for a sample set of land and atmospheric products typically requested in the nine societal benefit areas



Quality Indicator

Error Budget

Error Budget shows where in the processing chain the errors are the largest

+ Level 4 QA

Summary of Recommendations

- **Propose a QI for Societal Benefit task be undertaken by the QA4EO community to establish methods for constructing error-budget-based Quality Indicators for GEOSS end users.**
  - **QIs are to be compared with specific uncertainty requirements in each of GEO's nine societal benefit areas**
  - **Goal: Provide quantitative measures or indicators (QIs) to better determine product acceptability by end users**
- **Propose a Pilot Project to create model QIs linked directly to a limited number of important societal benefit problems**

Some final thoughts on QA for Societal Benefit

- **Representatives of the data products communities ought to "sit down" with a wide range of end users to obtain a clearer picture of specific end-user needs**
  - **Identify the QI parameters and their scales that are most important to the end-user**
- These exchanges will directly guide the data world in better defining the level 3 and 4 products, models, and quality measures needed for a range of real-world societal benefit applications.
- An ongoing dialogue between data users and data suppliers is essential if GEOSS is to have a meaningful impact.