Some lessons learned from MODIS: the land product validation approach and applications for time series data.

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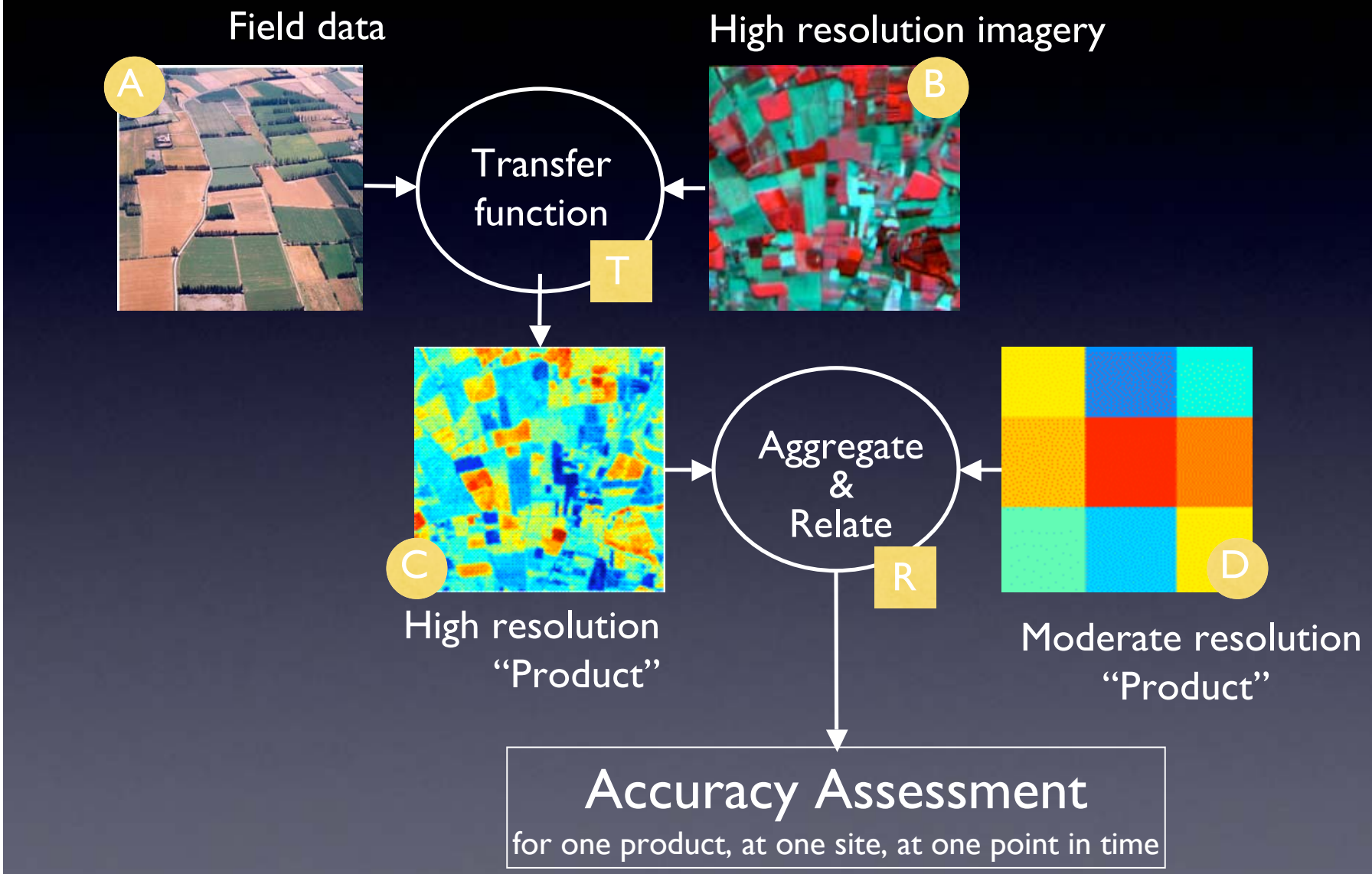
Building on the work of the MODIS land discipline team
(Chris Justice, Jaime Nickeson, and Sebastien Garrigues et al.)

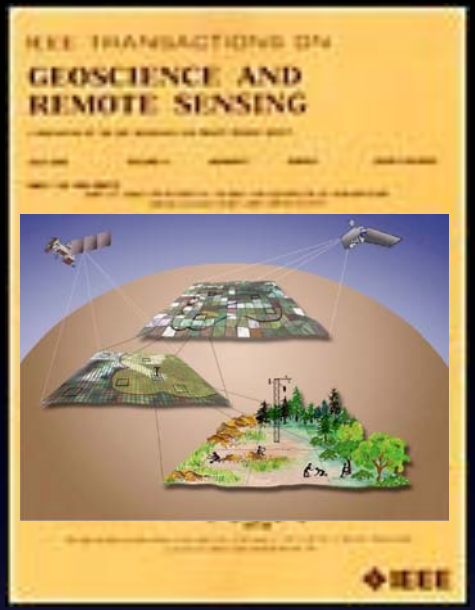
Top Lesson Learned from MODIS Land Product Validation

1. There is a need for scaling from field data to moderate resolution pixels.
2. There is still a need to better define land product accuracy requirements.
3. Validation results must be clearly and concisely communicated to users.
4. There are advantages to focusing on "Core Sites".
5. Validation efforts should utilize the CEOS validation infrastructure and hierarchy.
6. There is a need for global land product Inter-comparisons.
7. Algorithm improvement is the primary use of validation results.

Need for scaling from field to moderate resolution



There is now a significant amount of land product validation literature on "scaling"



Special issue on Global Land Product Validation

- Three "framework" papers
  19 "validation results" and
  four "user response" papers - an attempt to solicit "user feedback".

Morisette, J.T., F. Baret, S. Liang, 2006. Special issue on Global Land Product Validation, *IEEE TGARS* 44(7) 1695-1697.

MODIS Framework

- Fairly thorough overview of the validation approach for each of the MODIS land products

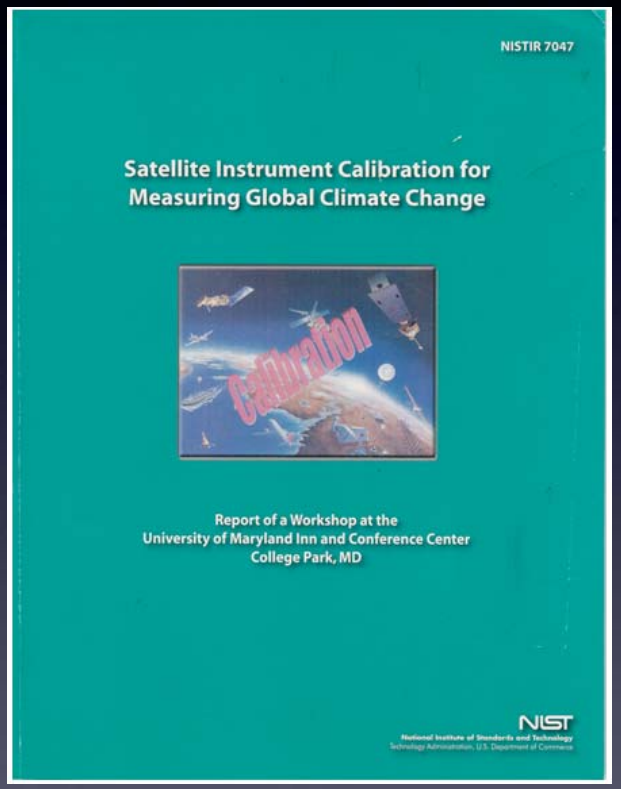
Morisette, J. T., J.L. Privette, and C.O. Justice, 2002. A framework for the validation of MODIS land products, *Remote Sensing of Environment*, *83* (1-2) 77-96.

There is still a need to define land product accuracy requirements

The land validation community could build on the experience of the calibration community.

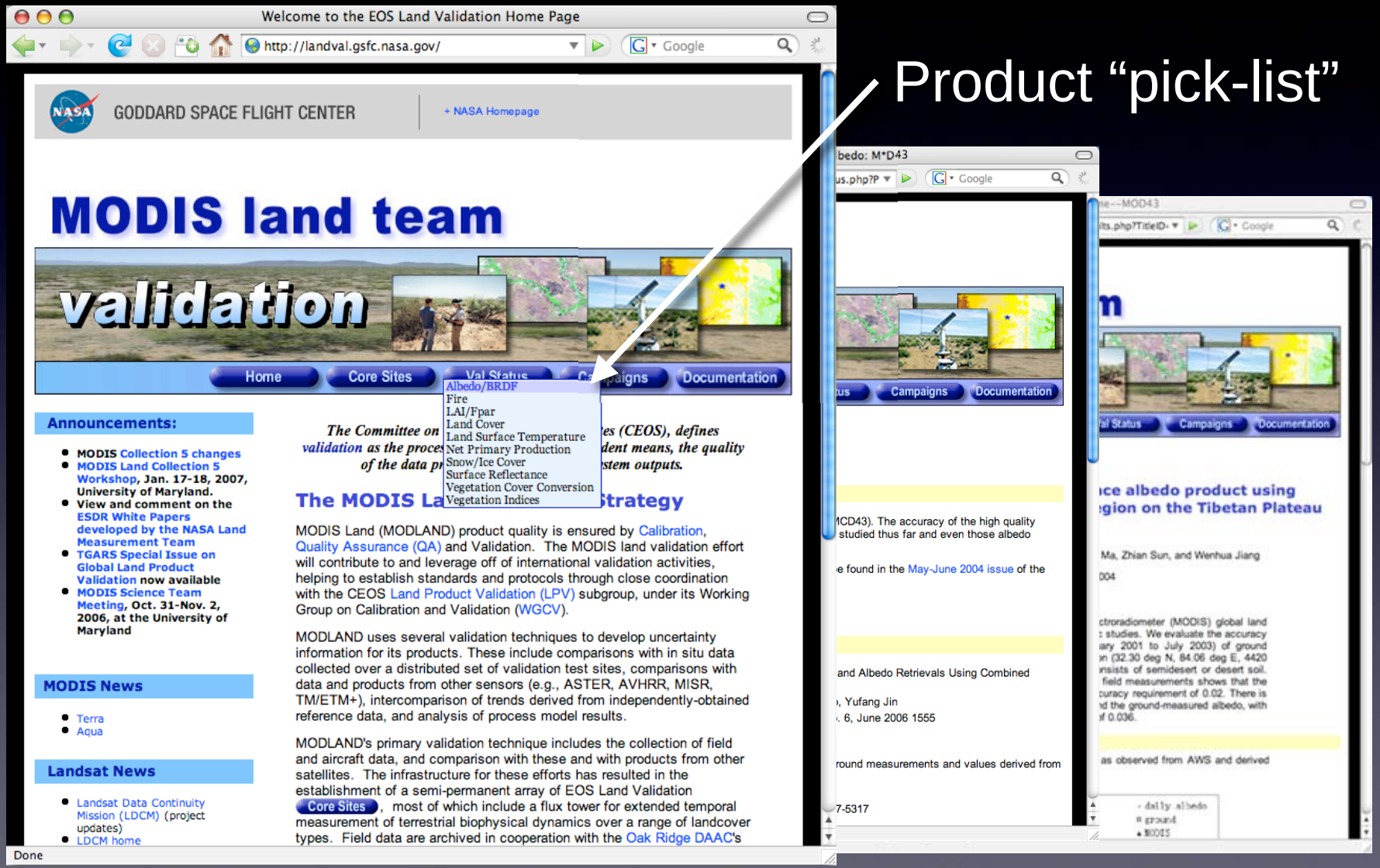
ASIC^3 WORKSHOP

Achieving Satellite Instrument Calibration for climate Change
May 16-18, 2006



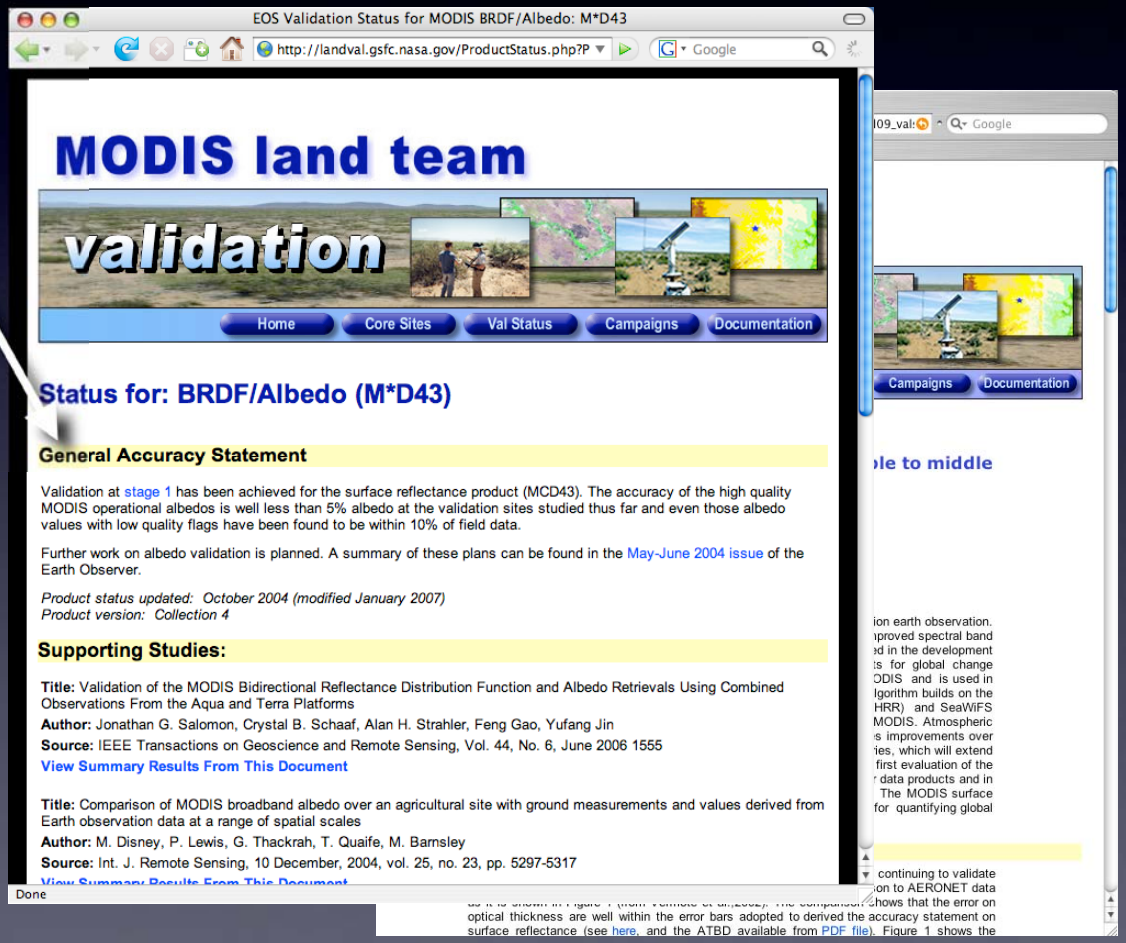
Ohring, G., J. et al. (2007), Achieving Satellite Instrument Calibration for Climate Change, *Eos Trans. AGU, 88*(11), 136

Validation results must be clearly and concisely communicated to users...



Communicating results...

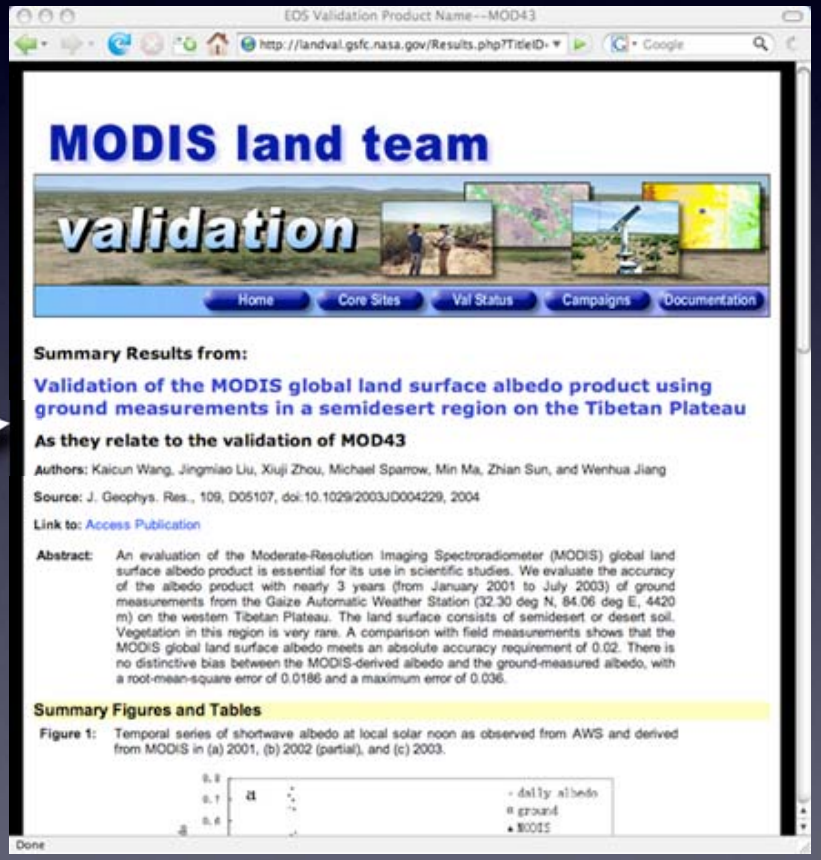
Accuracy statement for each product



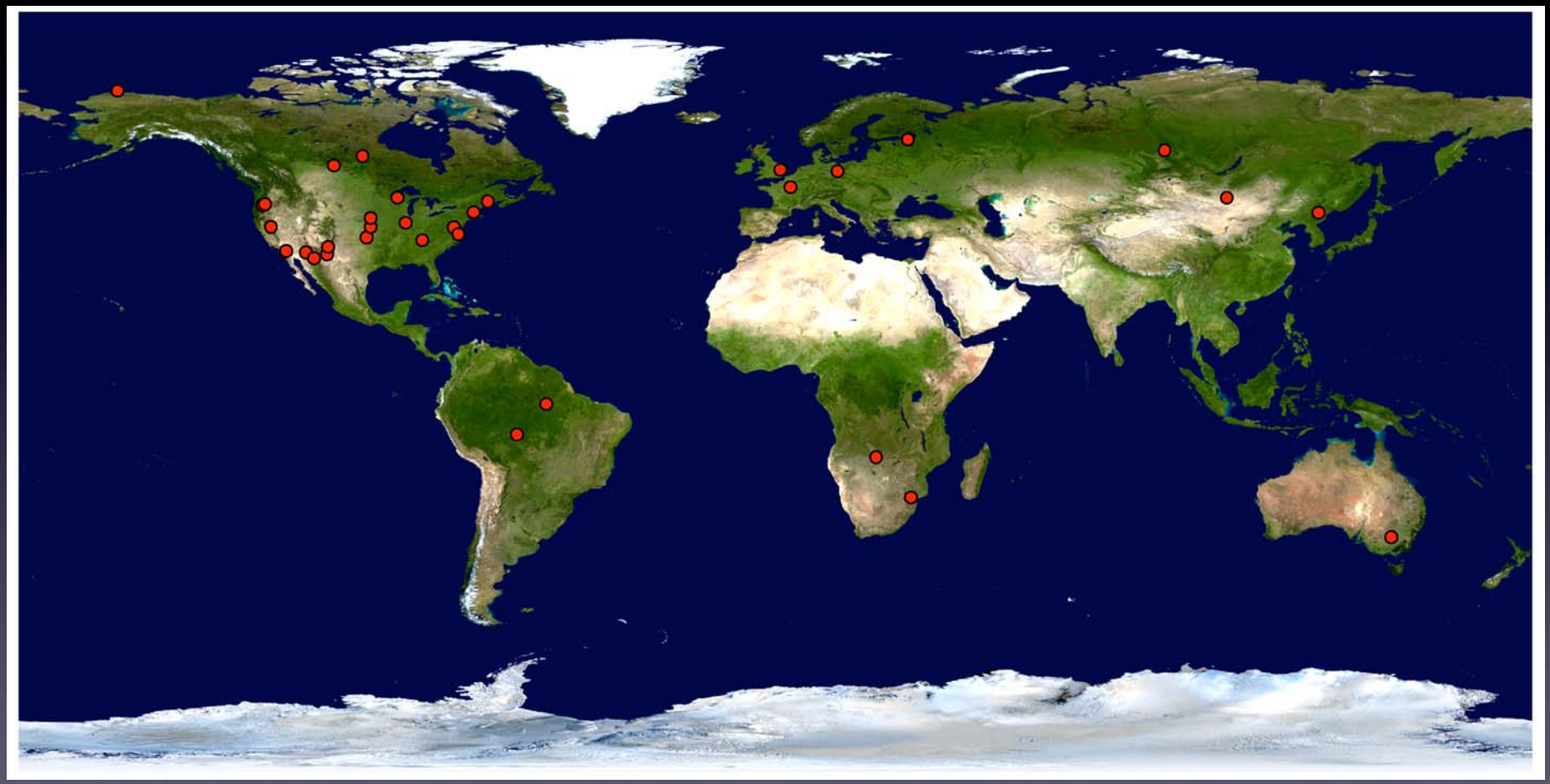
Communicating results...

Support material for each accuracy statement

*- updated by product producer **and** the validation community.*

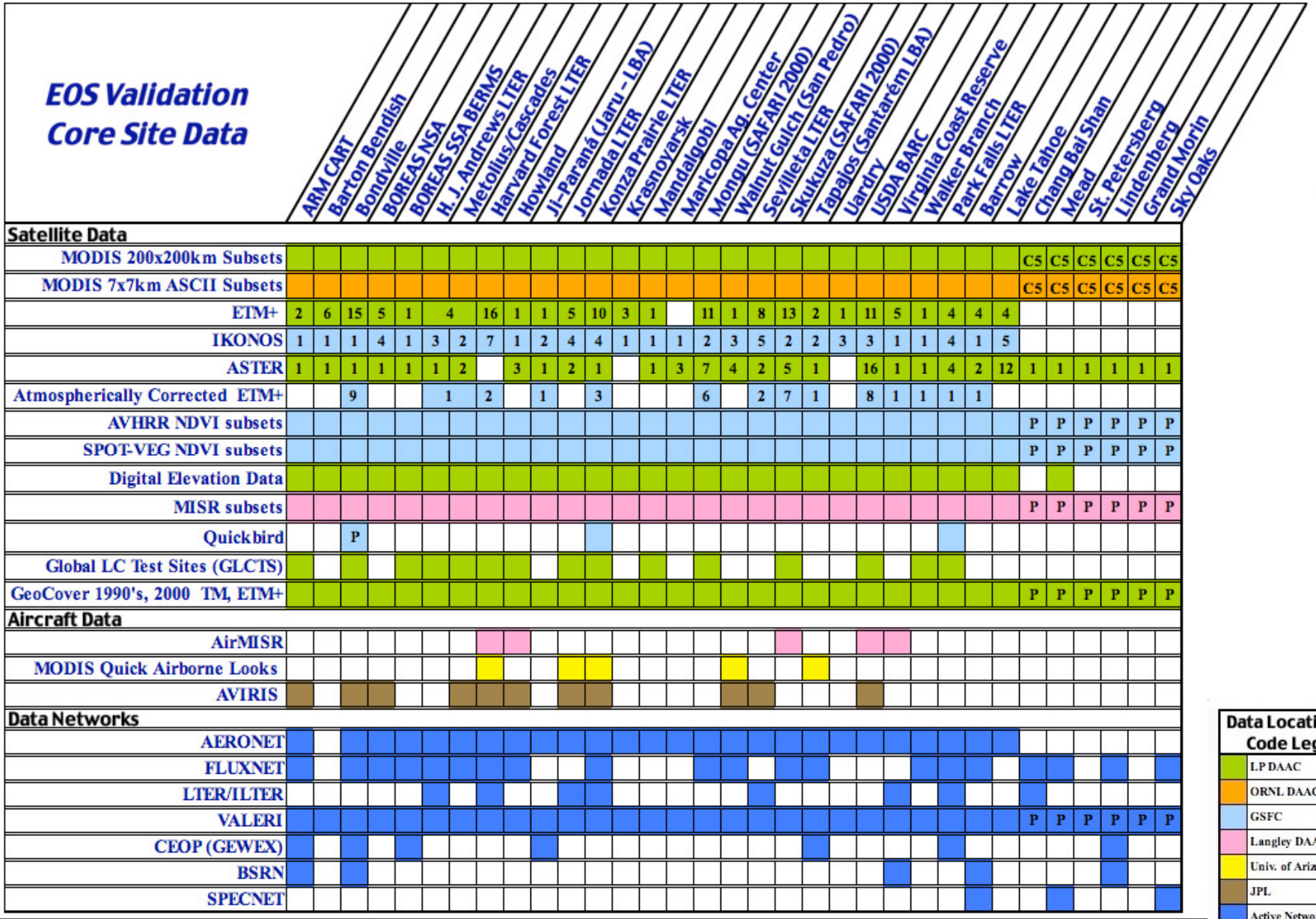


There are advantages to focusing on "Core Sites"



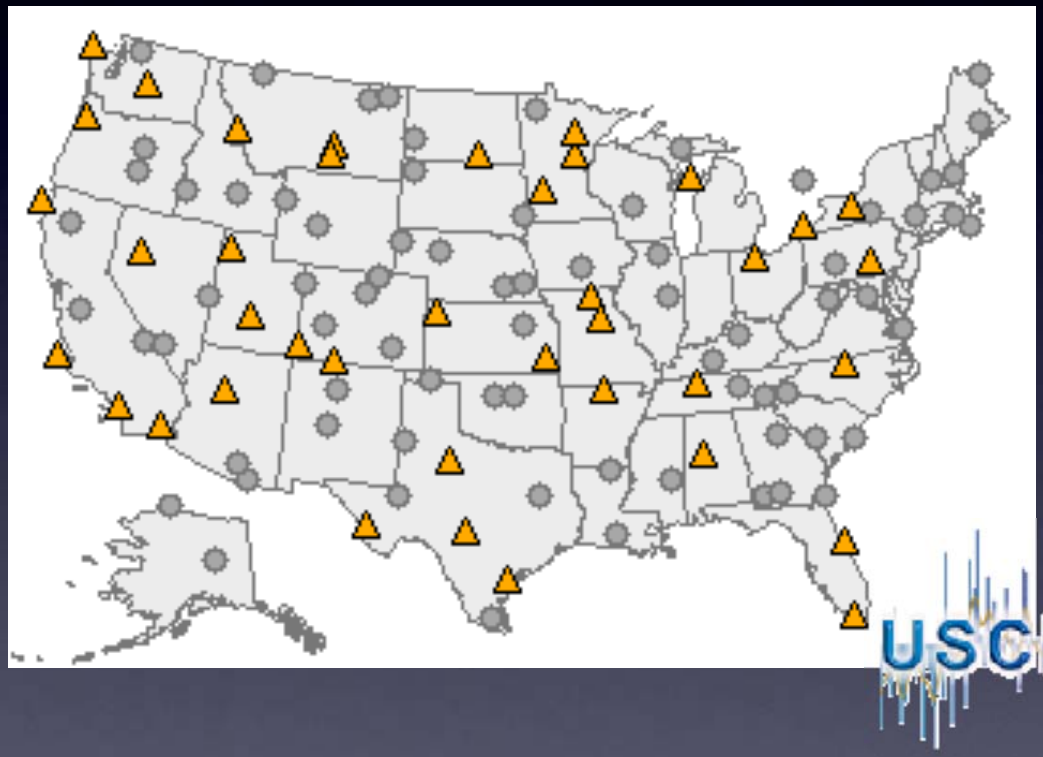
EOS Core Sites

EOS Validation Core Site Data



Nickeson, J., J. Morisette, J. Privette, C. Justice, D. Wickland, 2007. Coordinating Earth Observing System Land Validation, *EOS Transactions*, 88(7)81-82.

Core Sites can be connected to other science networks

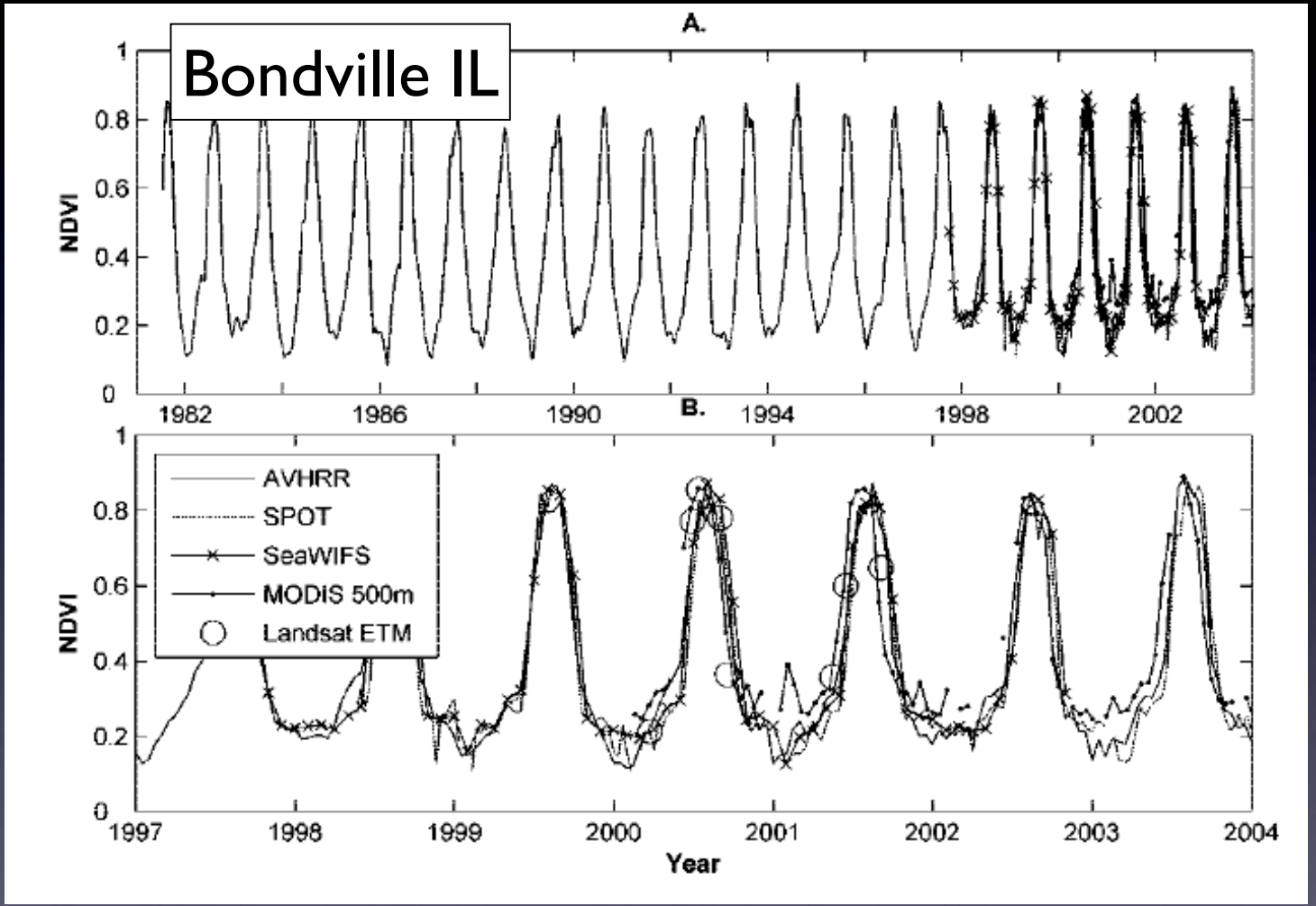


- Air temperature
- Precipitation
- Solar radiation
- Wind speed
- Surface temperature
- Relative humidity (2004/2005)

NOAA's Climate Reference Network

● Existing ▲ Planned

Core Sites can be used for multi-sensor analysis



Brown, M. E. et al., 2006. Inter-Sensor Validation of long-term NDVI time series from AVHRR, SPOT-Vegetation, SeaWIFS, MODIS, and LandSAT ETM+, *IEEE TGARS*, 44(7)1787-1793.

Validation efforts should utilize the CEOS infrastructure

CEOS Land Product Validation subgroup's goals are:

- to foster quantitative validation of ***higher level global land products*** derived from remote sensing data and relay results so they are relevant to users
- to increase the quality and economy of global satellite product validation *via* developing and promoting ***international standards and protocols*** for field sampling, scaling, error budgeting, data exchange for global land product validation
- to ***advocate mission-long validation*** and inter-comparison programs for current and future earth observing satellites.

CEOS Documents

Example from Land Cover...

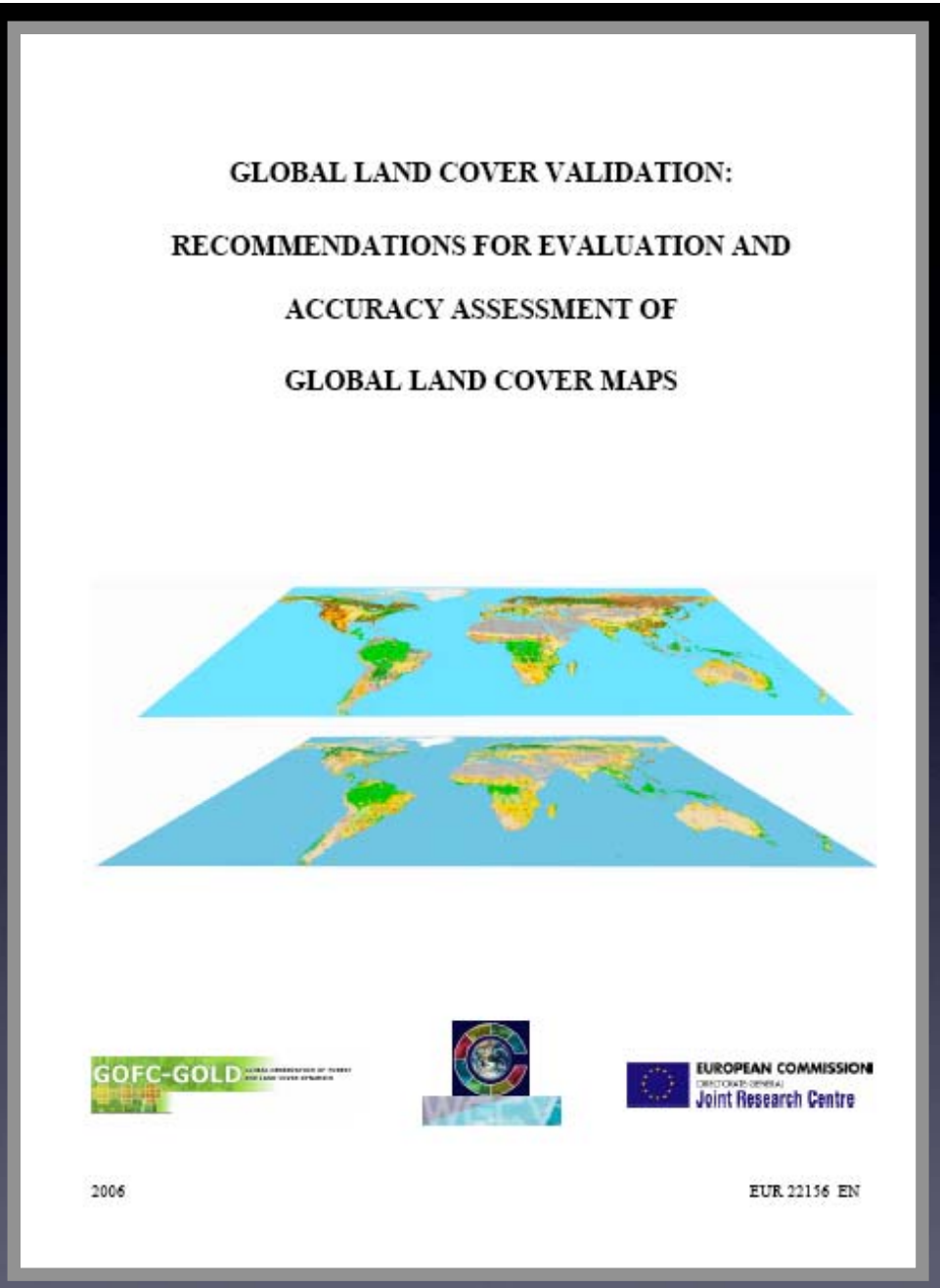
Primary finding:

- Call for global inter-comparisons
- "Hybrid" statistical sampling using fixed sites
- Confidence layers (model-based accuracy)

Edited by: Strahler

Authors: Boschetti, Foody, Friedl, Hansen, Herold, Mayaux, Morisette, Stehman, Strahler, & Woodcock

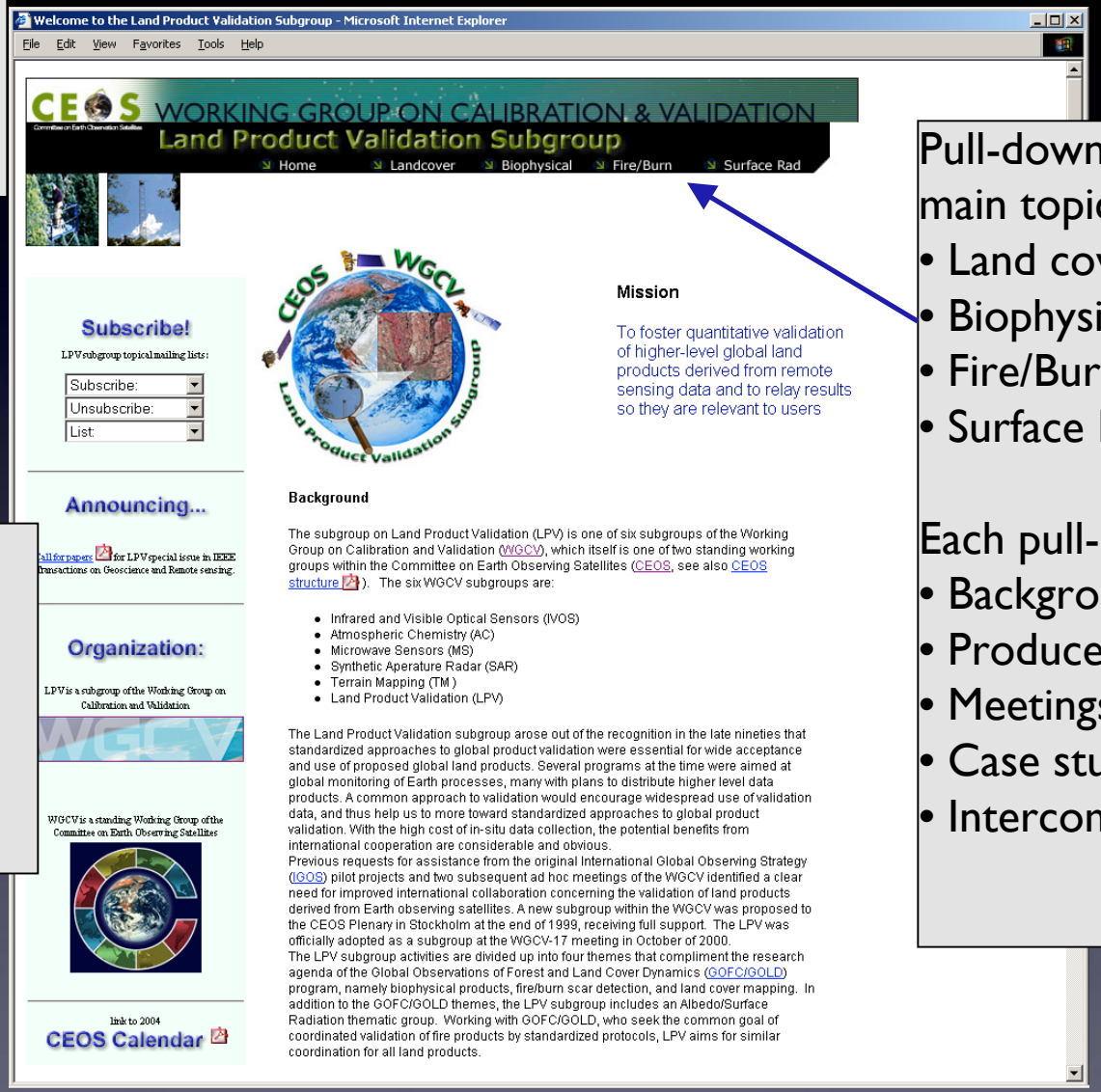
available through the LPV web site.



CEOS Land Product Validation web site

http:lpvs.gsfc.nasa.gov

Matches WGCV page layout and graphic



Pull-down menu for main topical areas:
- Land cover
- Biophysical
- Fire/Burn
- Surface Radiation

Each pull-down lists:
- Background
- Producers *
- Meetings
- Case studies
- Intercomparisons

* input needed

Quick links to:
- List-serves
- Announcements
- WGCV
- CEOS and
- CEOS calendar

web curator: Jaime Nickeson, NASA GSFC

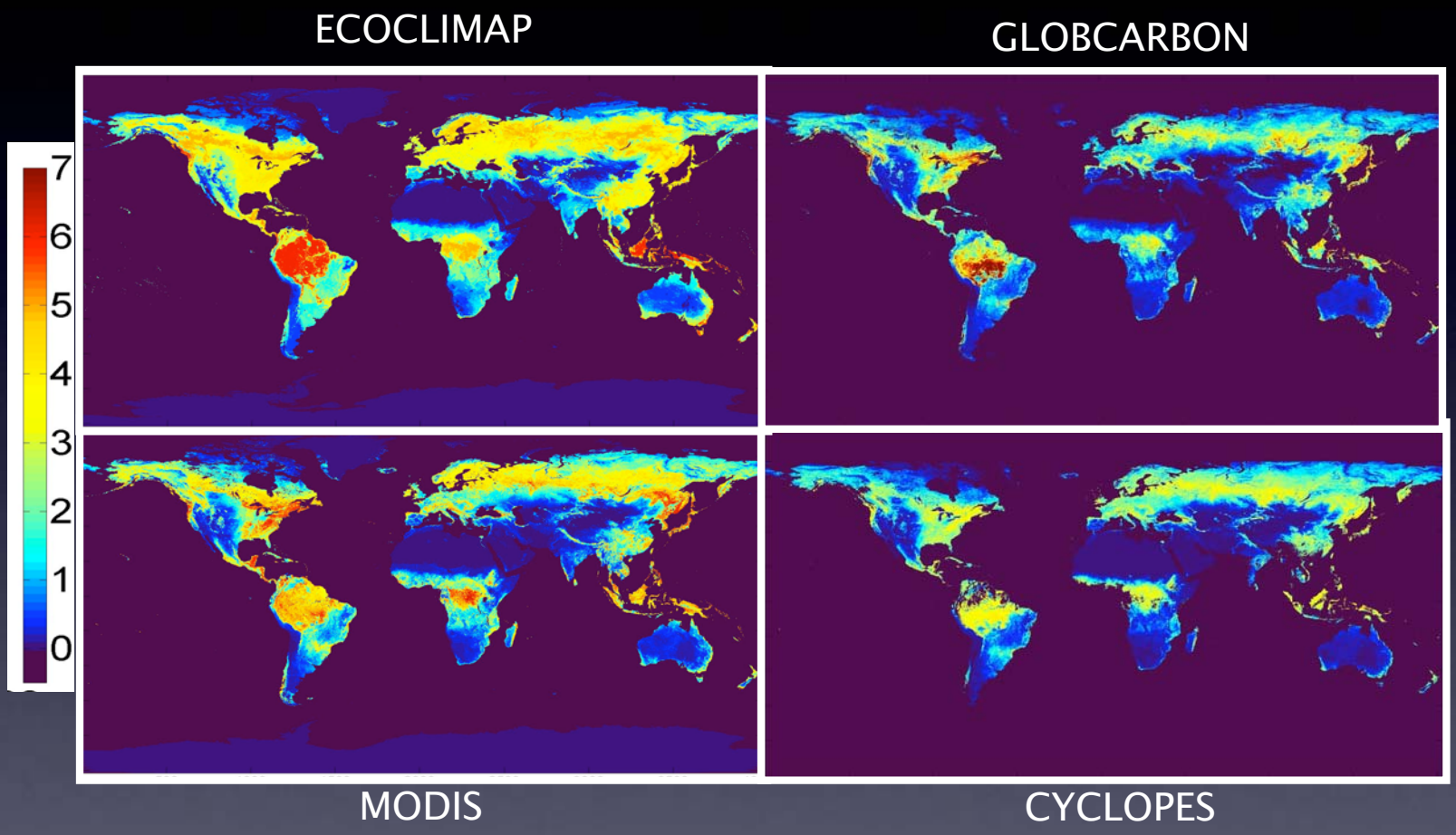
Producers should subscribe to the CEOS Validation Hierarchy

Stage 1 Validation: Product accuracy has been estimated using a small number of independent measurements obtained from **selected locations and time periods** and ground-truth/field program efforts.

Stage 2 Validation: Product accuracy has been assessed over a **widely distributed set of locations and time periods** via several ground-truth and validation efforts.

Stage 3 Validation: Product accuracy has been assessed, and the uncertainties in the product well-established via independent measurements made in a **systematic and statistically robust way that represents global conditions**.

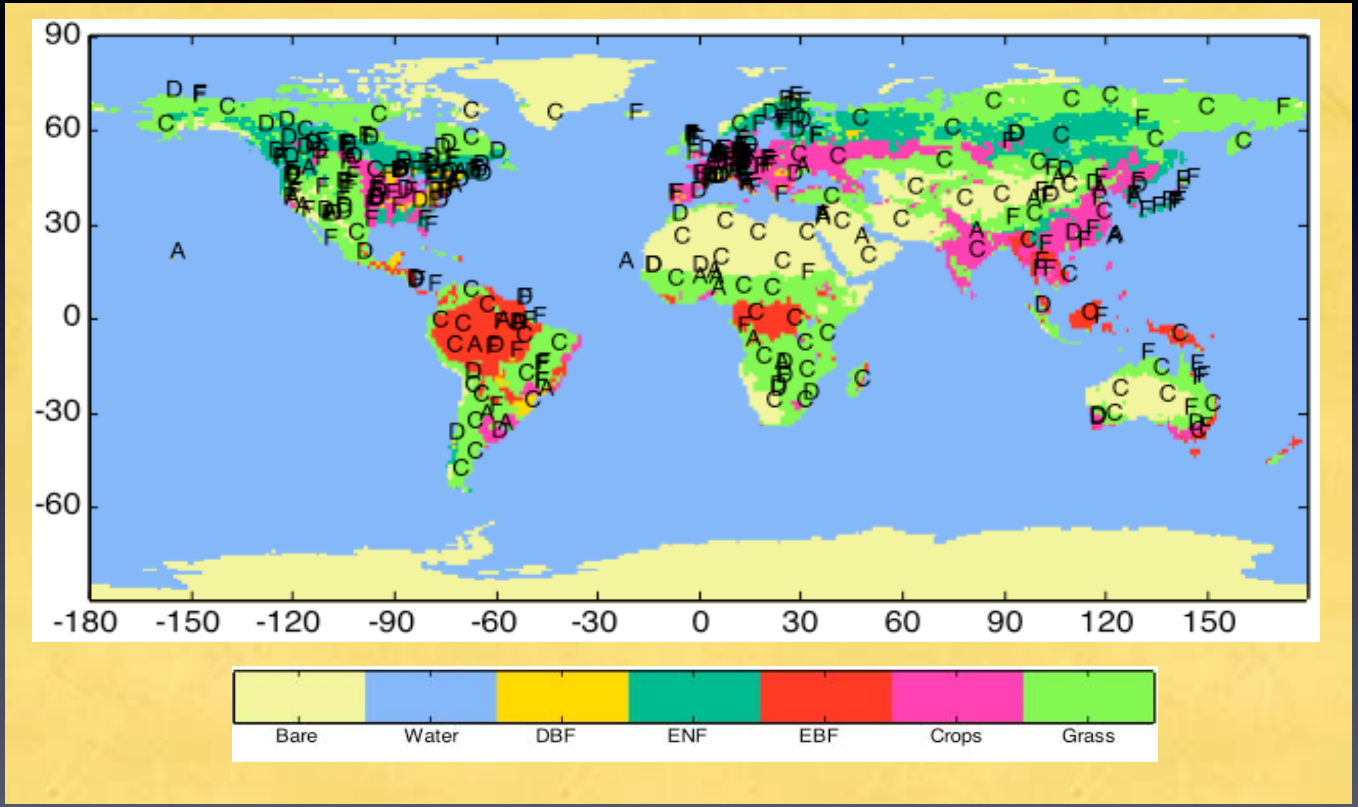
There is a need for global land product Inter-comparisons



Morisette, J., F. Heinsch, S. Running, 2006. Monitoring Global Vegetation, *EOS Transactions,* 87(50)568.

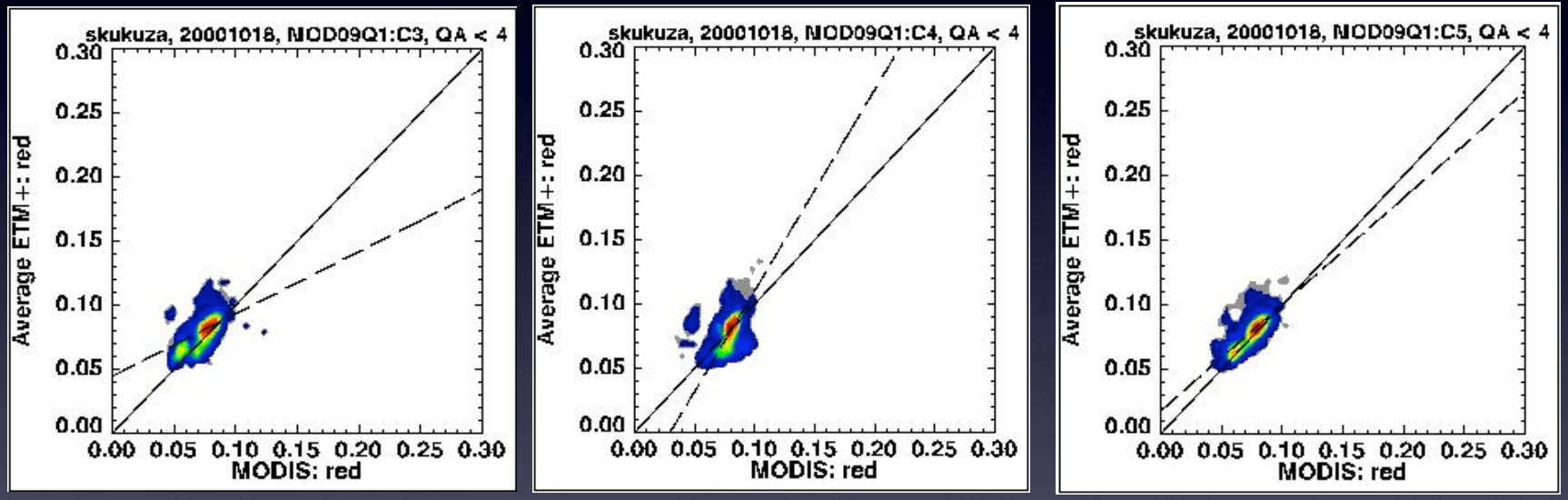
The BELMANIP Global Network of Sites

- representative sampling of global land surface types
- about 400 sites from several networks: direct validation sites (D: BIGFOOT, VALERI…), AERONET (A), FLUXNET (F)…



Baret, F., et al. 2006, Evaluation of the representativeness of networks of sites for the validation and inter-comparison of global land biophysical products. Proposition of the CEOS-BELMANIP, *IEEE TGARS*, 44(7)1794-1803.

Algorithm improvement is the primary use of validation results



collection 3 **collection 4** **collection 5**

Scatterplots showing Aeronet-based atmospherically corrected, aggregated, ETM+ red reflectance compared to MODIS red reflectance.

Top Lesson Learned from MODIS Land Product Validation

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2. There is still a need to better define land product accuracy requirements.
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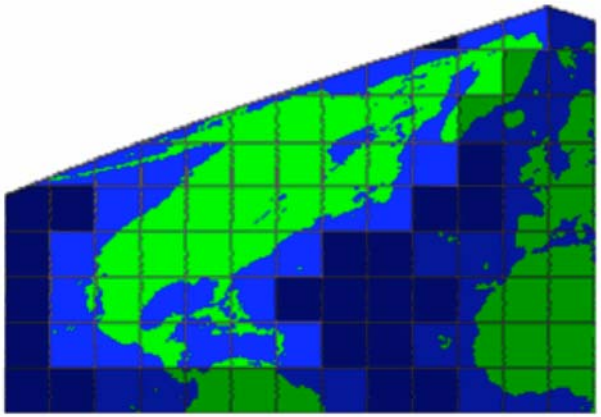
Time-Series and Phenology

GEOSS Data Management Task (DA-07-05):

...encourage the reprocessing of historic data to develop composite time series and temporal phenologic metrics to enable monitoring of vegetation condition and change over time...

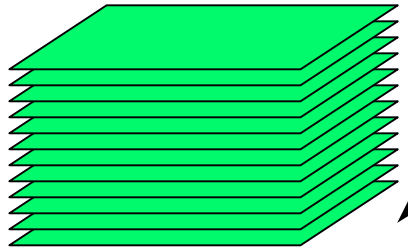
- Carbon modeling
- Invasive species habitat
- Validation of phenology parameters

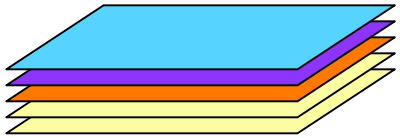
New Approach to Delivering Time Series Data



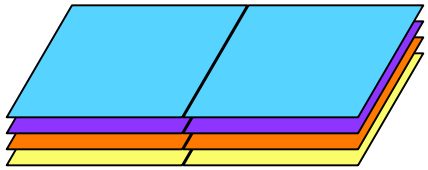
1. Order Data
Six years over North America implies:
7314 files, 1.013GB, ~20 8-hour days to order

Product that meets researcher's needs:
Data through time
User-defined area
One data set, appropriately filtered by the associated QA layer



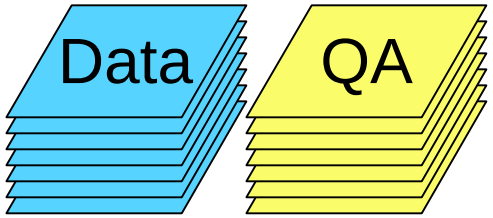


Current MODIS granule:
one time step
Several "bands" or science data sets
One or more associated QA layers
Fixed area (1200km x 1200km)



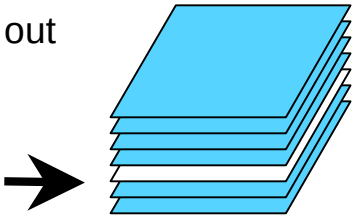
2. Reproject & Mosaic tiles
The "MODIS reprojection tool" is one tool available for this operation

3. Extract data layer of interest & its associated QA and "stack" through time

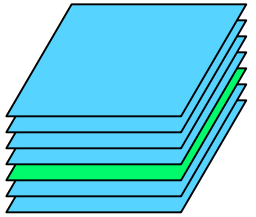


4. Filter data
"LDOPE" tools can be used to interpret QA layers to filter out low quality data

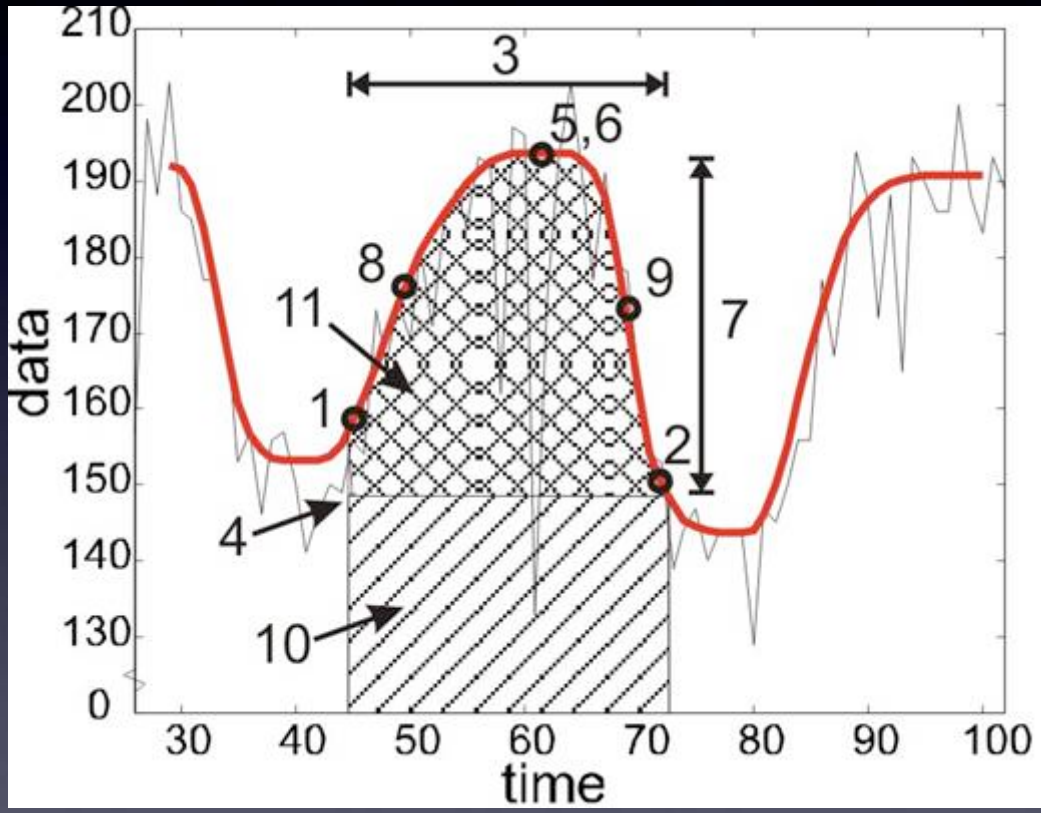
In this diagram, we suppose this layer indicates low quality for this time step



5. Fill gaps
"TIMESAT" or other tools

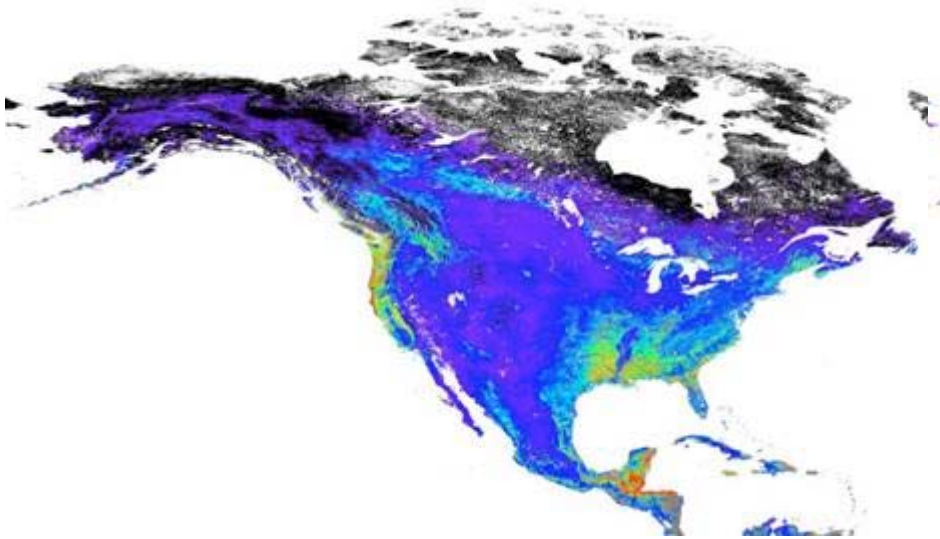


TIMESAT software

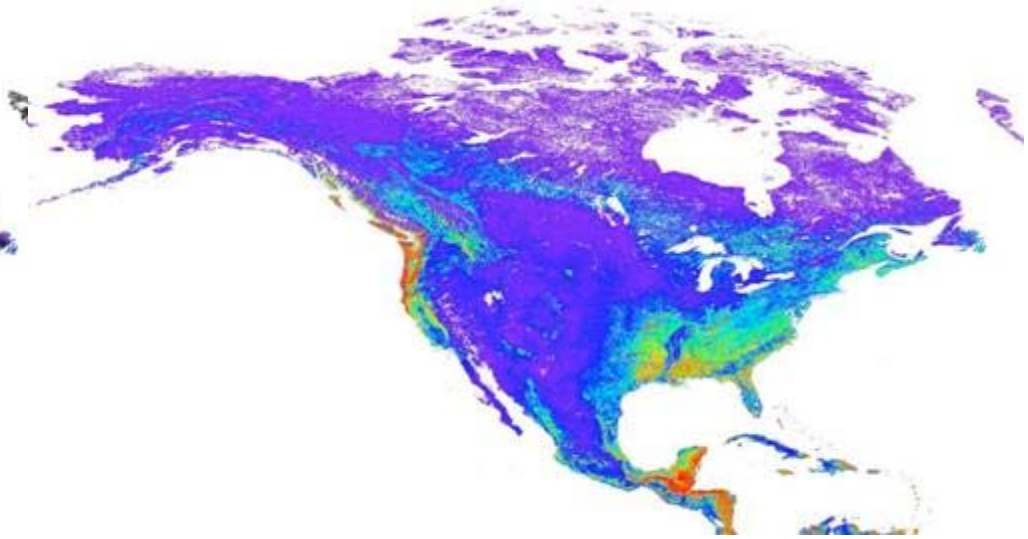


1.time for the start of the season
2.time for the end of the season
3.length of the season
4.base level
5.time for the middle of the season
6.peak value of the fitted function
7.seasonal amplitude
8.left slope
9.right slope
10.large seasonal integral
11.small seasonal integral

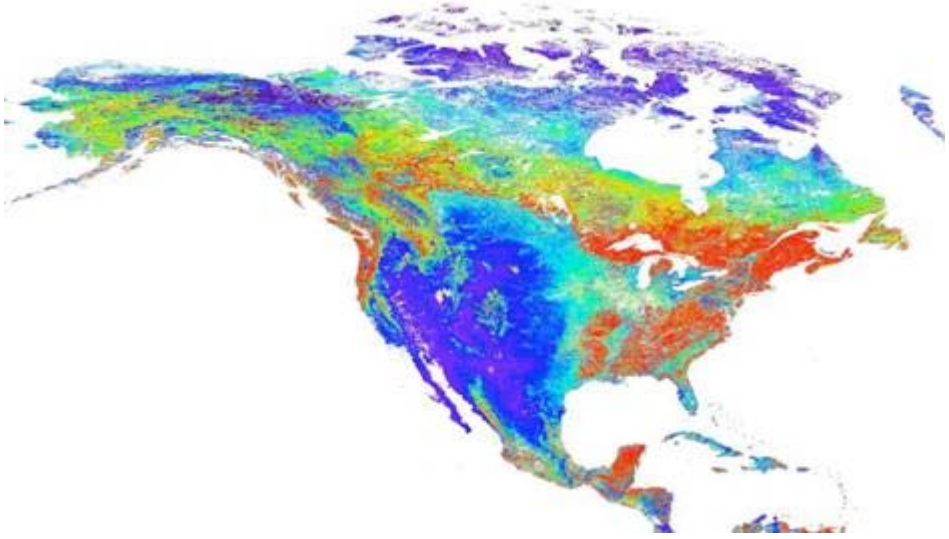
TIMESAT - a program for analyzing time-series of satellite sensor data
Per Jonsson & Lars Eklund, Computers & Geosciences 30:833-845, 2004.



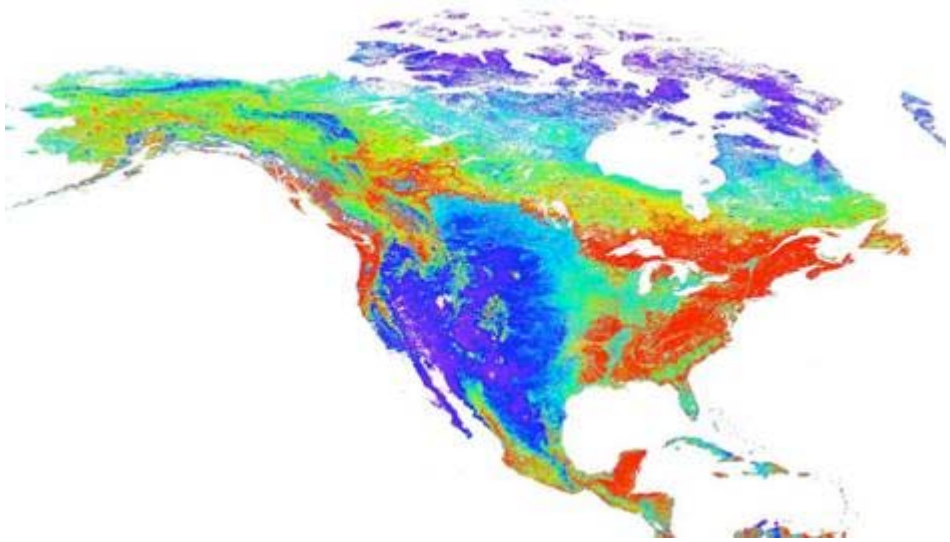
(a) Original LAI, January 1, 2004



(b) Smoothed LAI, January 1, 2004

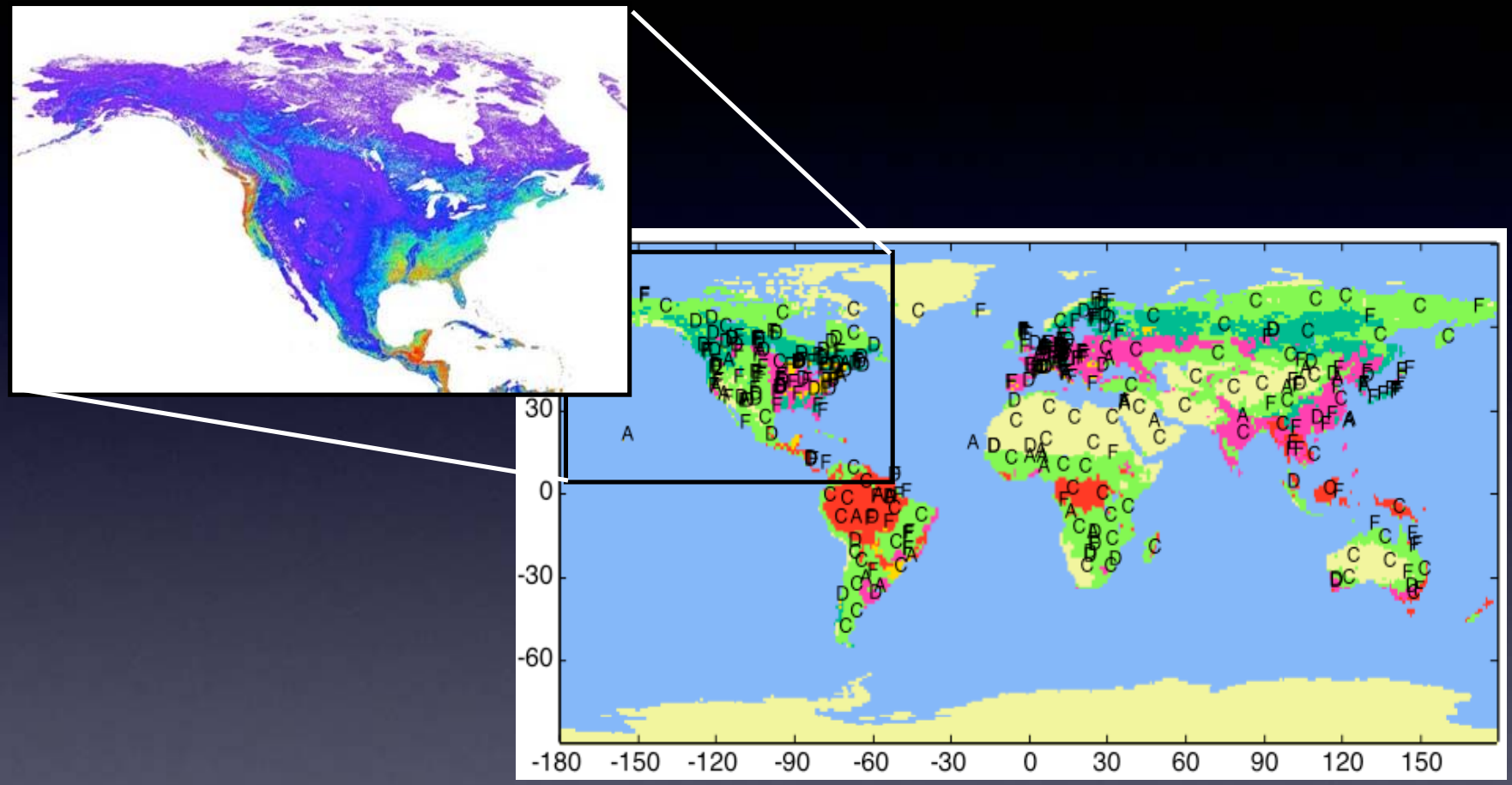


(c) Original LAI, July 11, 2004



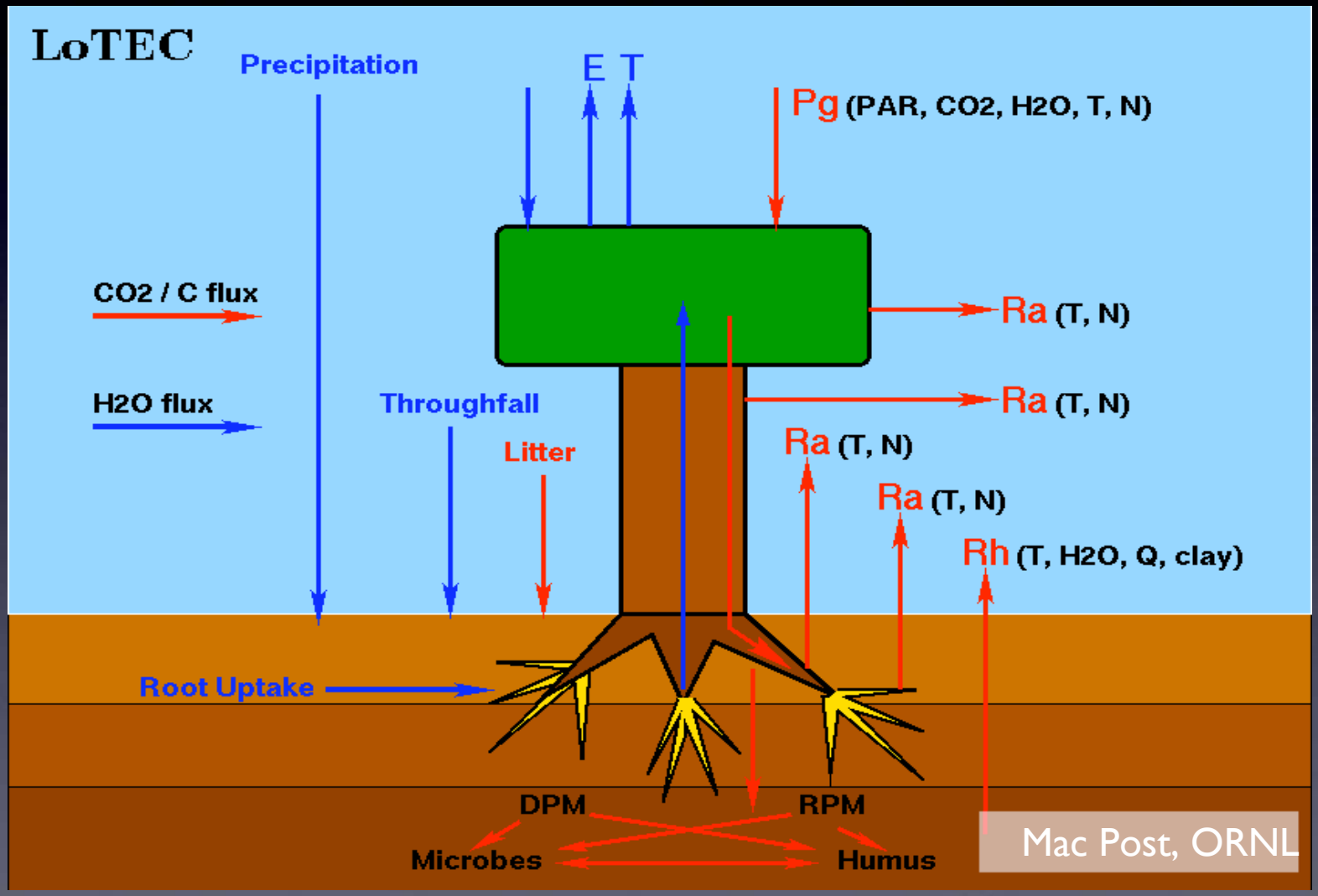
(d) Smoothed LAI, July 11, 2004

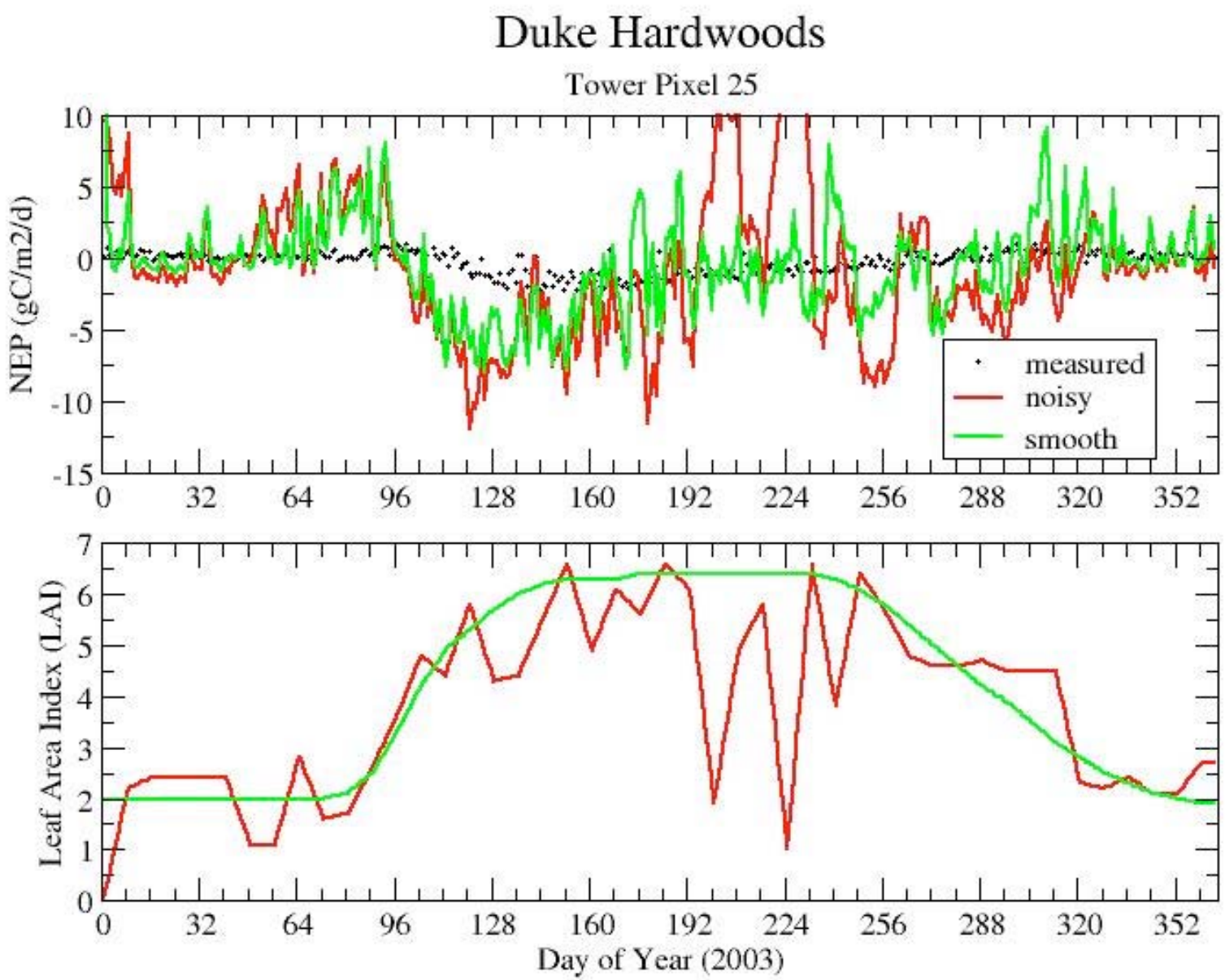
Assessing the smoothed data...

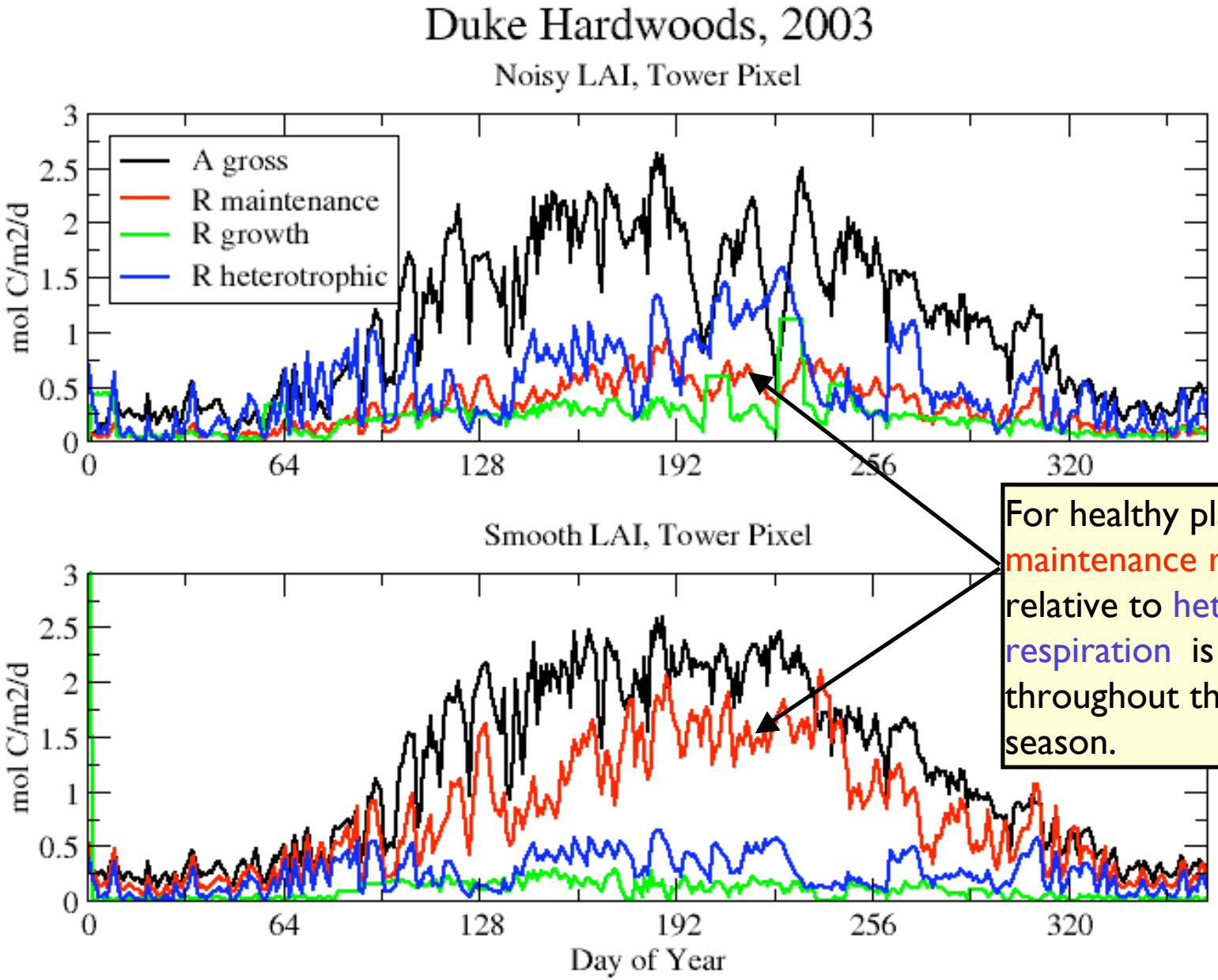


...will leverage off of the LAI inter-comparison by being included in the 1km study being done over North America.

It is also possible to inter-compare by checking differences in model output




Duke Hardwoods
Tower Pixel 25
NEP (gC/m2/d)
10
5
0
-5
-10
-15
0
32
64
96
128
160
192
224
256
288
320
352
measured
noisy
smooth
Leaf Area Index (LAI)
7
6
5
4
3
2
1
0
Day of Year (2003)

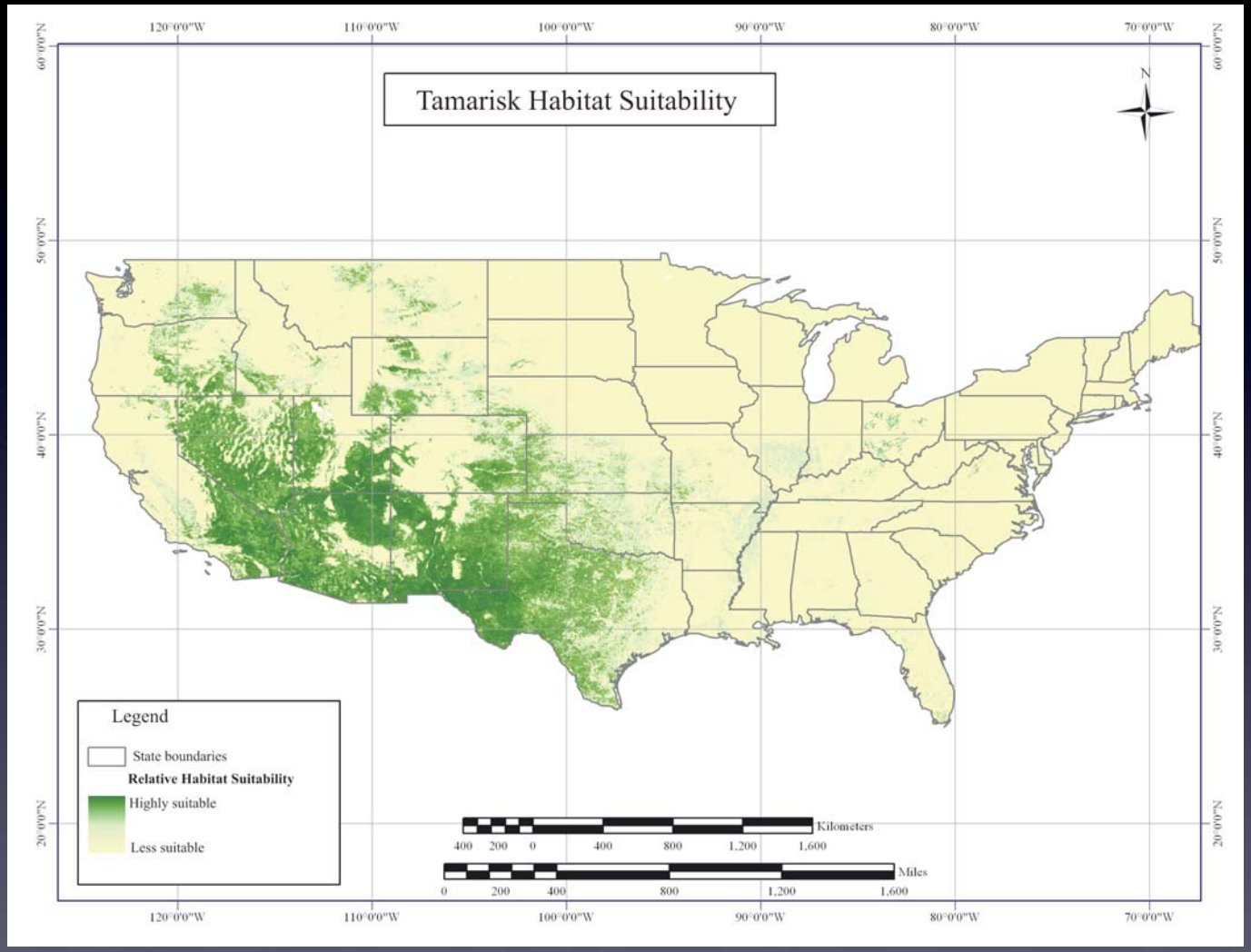


For healthy plants, higher maintenance respiration relative to heterotrophic respiration is expected throughout the growing season.

RNL

Invasive species through the seasons...

National map of habitat suitable for tamarisk

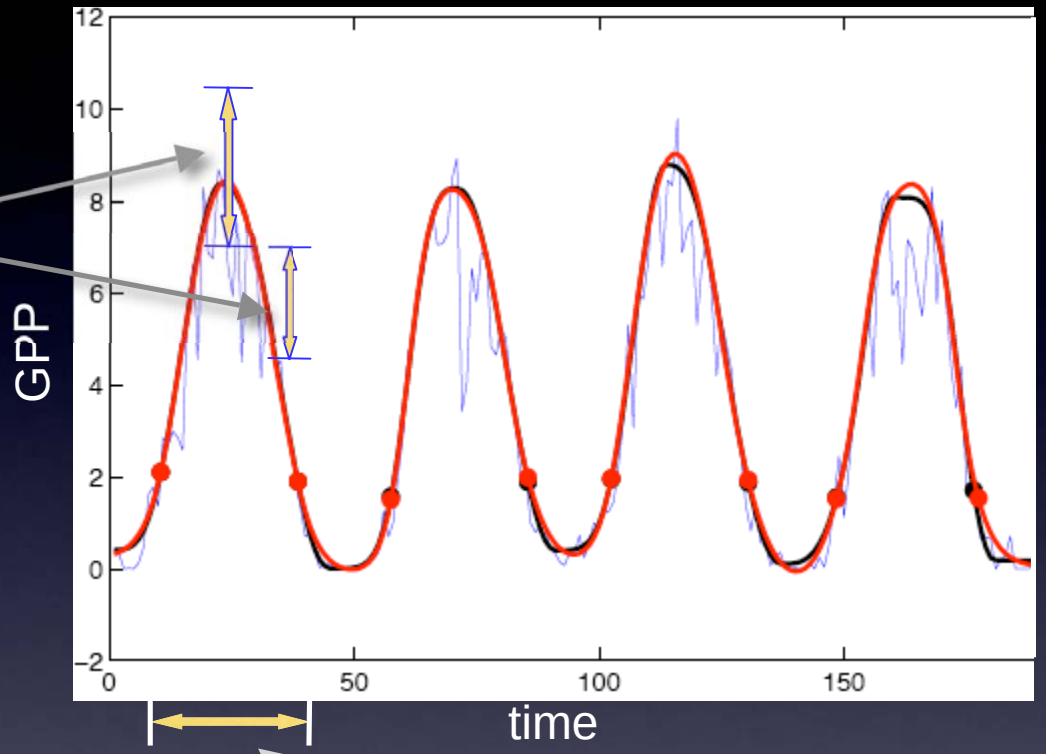


Tamarisk habitat map derived from logistic regression using MODIS land cover and the range in MODIS NDVI and EVI.

Morisette, J.T., C. S. Jernevich, A. Ullah, W. Cai, J.A. Pedelty, J. Gentle, T.J.Stohlgren, J.L. Schnase, A tamarisk habitat suitability map for the continental US., *Frontiers in Ecology*, February 2006.

How do we validate temporal signals?

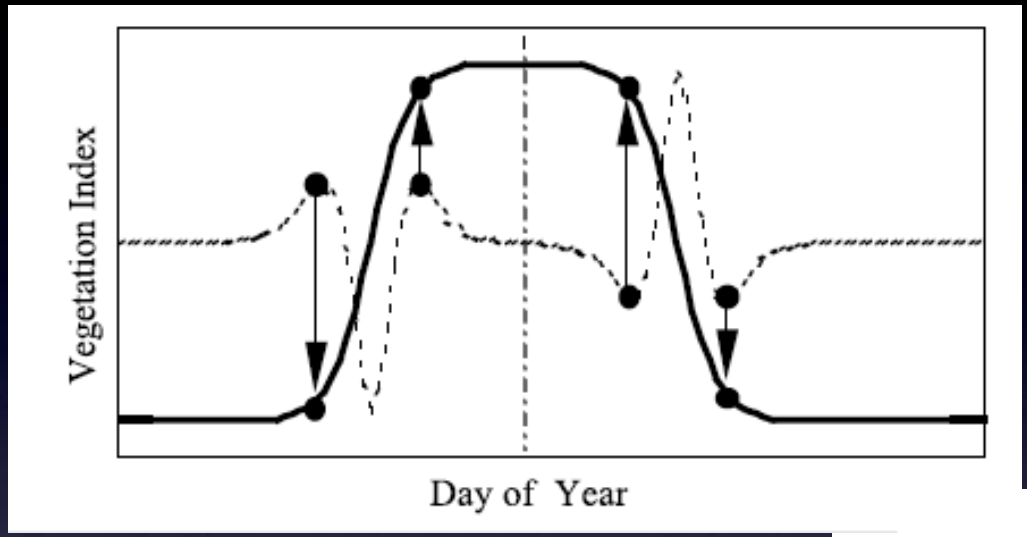
Current validation activities address the accuracy of a specific parameter at one or more points in time.



Validation of phenological parameters requires quantifying the uncertainty in the time domain.

Morisette, J. T., et al. (2006), Report from the CEOS Land Product Validation topical workshop on the Validation of global vegetation indices and their time series, *Earth Obs., 18*(6)34-35,37

MODIS Phenology



Extremes in *K'* define seasonal parameters.

Can we estimate the uncertainty in *K'*?

$$K' = b^3 cz \left\{ \frac{3z(1-z)(1+z)^3\left[2(1+z)^3 + b^2c^2z\right]}{\left[(1+z)^4 + (bcz)^2\right]^{\frac{5}{2}}} - \frac{(1+z)^2\left(1+2z-5z^2\right)}{\left[(1+z)^4 + (bcz)^2\right]^{\frac{3}{2}}} \right\}$$

X. Zhang et al., Remote Sensing of Environment 84 (2003) 471–475

Validation could take advantage of related science networks

- National Phenology Network
- NOAA's Climate Reference Network
- NSF's National Ecological Observation Network (NEON)
- Ameriflux and Fluxnet Flux tower networks
- GEOSS/CEOS could help bring together ground phenology networks (via task DA-07-05)

Conclusion

- The lessons learned from MODIS land product validation present reasonable and feasible opportunities for NPOESS product validation.
- The extended time series of AVHRR/MODIS/NPP/NPOESS presents exciting potential for modeling and monitoring, yet there are outstanding issues related to the validation of time-series data.

Thanks!

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301-614-5498