NOAA/NCDC Surface Reflectance Climate Data Record Initiative

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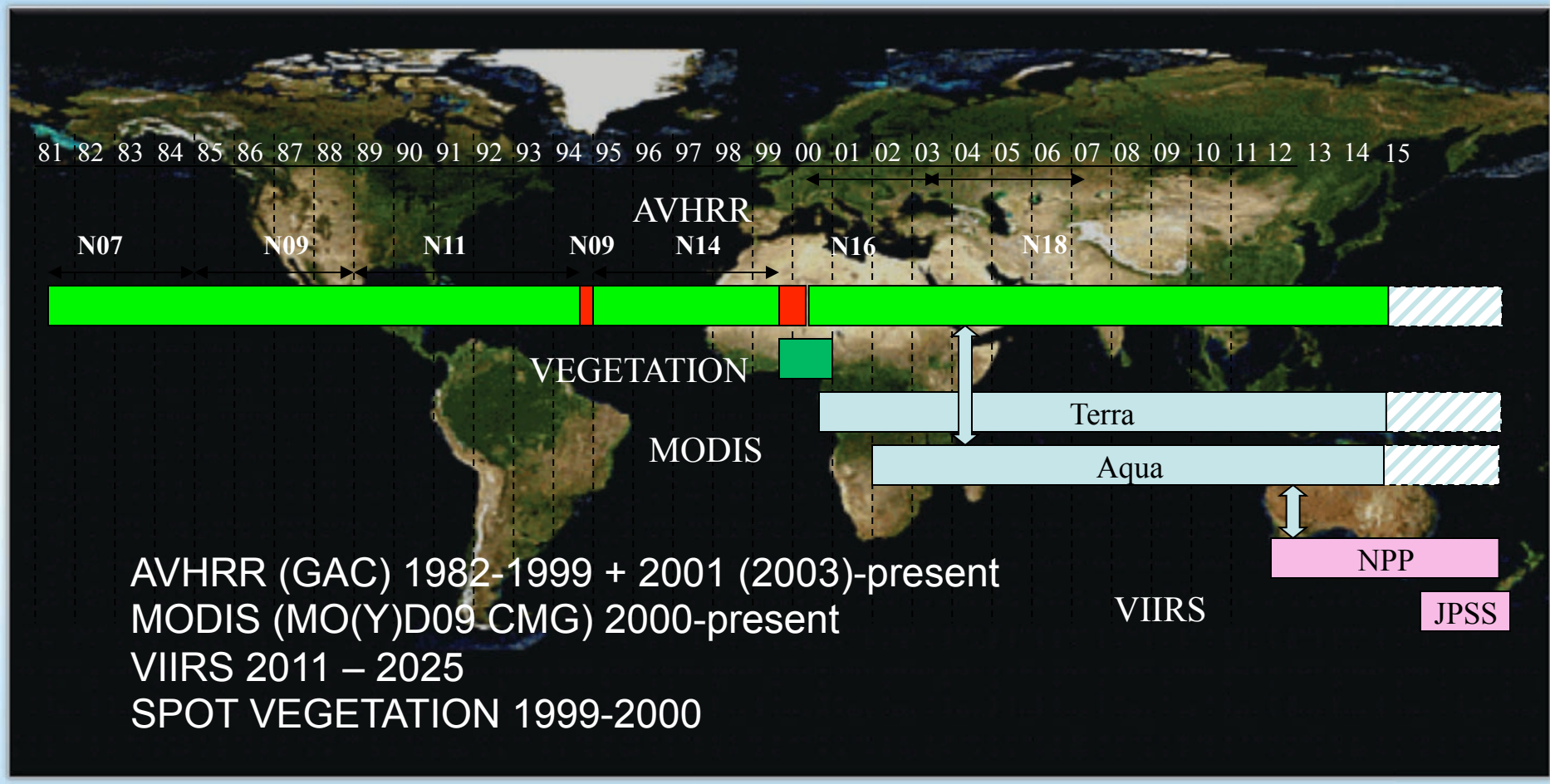
MODIS/VIIRS Science Team Meeting, May 18 – May 22, 2015, Silver Spring, MD

Land Climate Data Record: Multi instrument/Multi sensor Science Quality Data Records used to quantify trends and changes



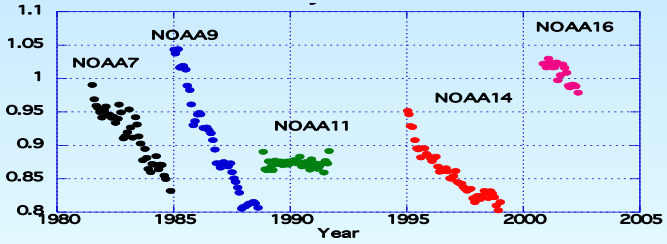
Emphasis on data consistency – characterization rather than degrading/smoothing the data

Land Climate Data Record

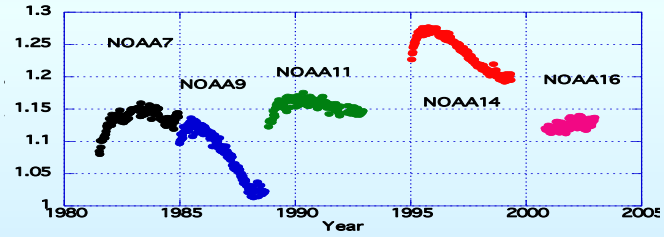
Needs to address calibration, atmospheric/BRDF correction issues

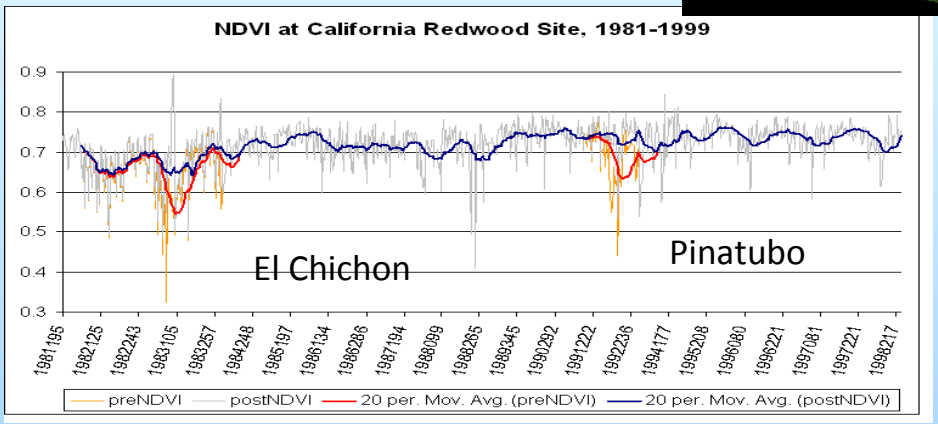
CALIBRATION

Degradation in channel 1
(from Ocean observations)

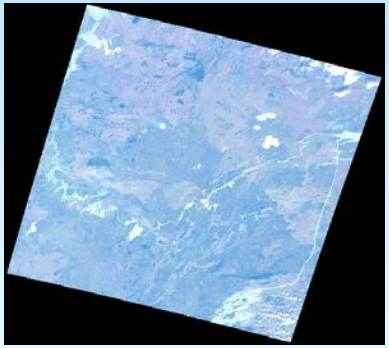


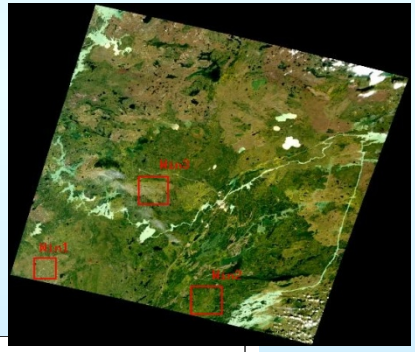
Channel1/Channel2 ratio
(from Clouds observations)



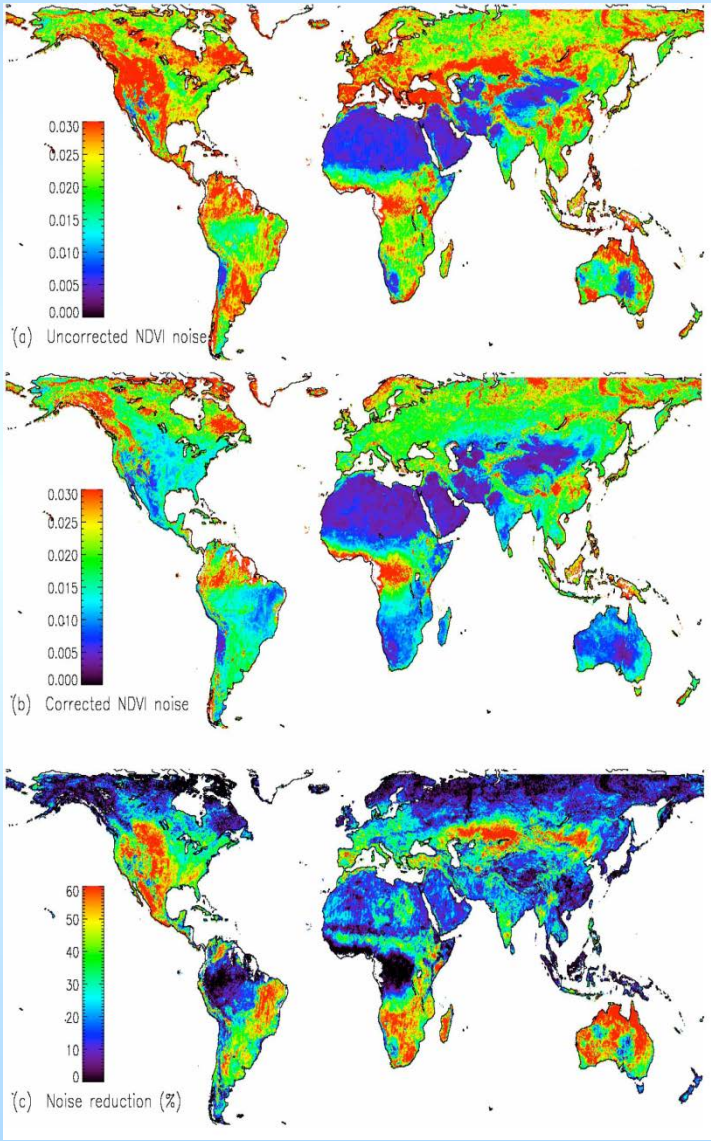


ATMOSPHERIC CORRECTION





BRDF CORRECTION

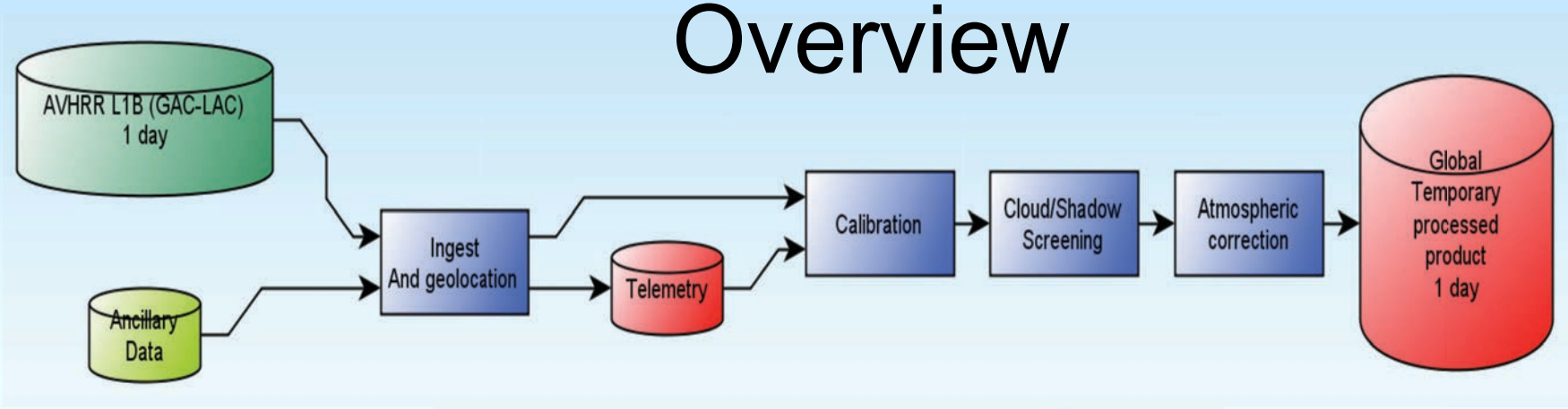


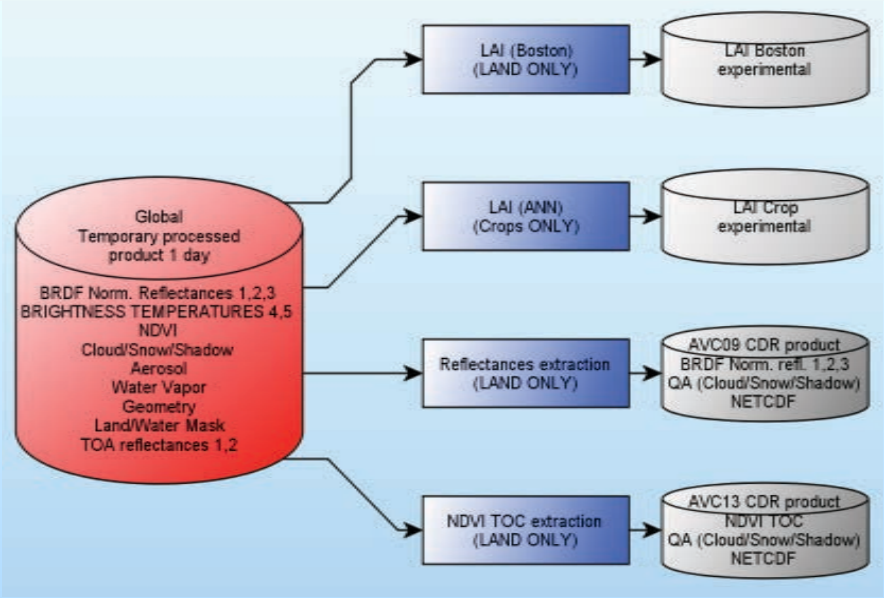
Data products

CDR(s)	Period of Record and Temporal Resolution	Spatial Resolution & Projection Used (if applicable)	Update Frequency	Data file distinction criteria	Inputs	Uncertainty Estimates	Collateral Products
Surface reflectance (Red,NIR) NDVI	1981-present daily	Linear Latitude Longitude (0.05deg)	daily	One file for each day and each CDR: Surface reflectance, NDVI	AVHRR GAC data	Reflectance (Red 0.02; NIR 0.03) NDVI (0.07) 3x3 average Reflectance (Red 0.01; NIR 0.015) NDVI (0.03)	LAI/FPAR

Production Approach

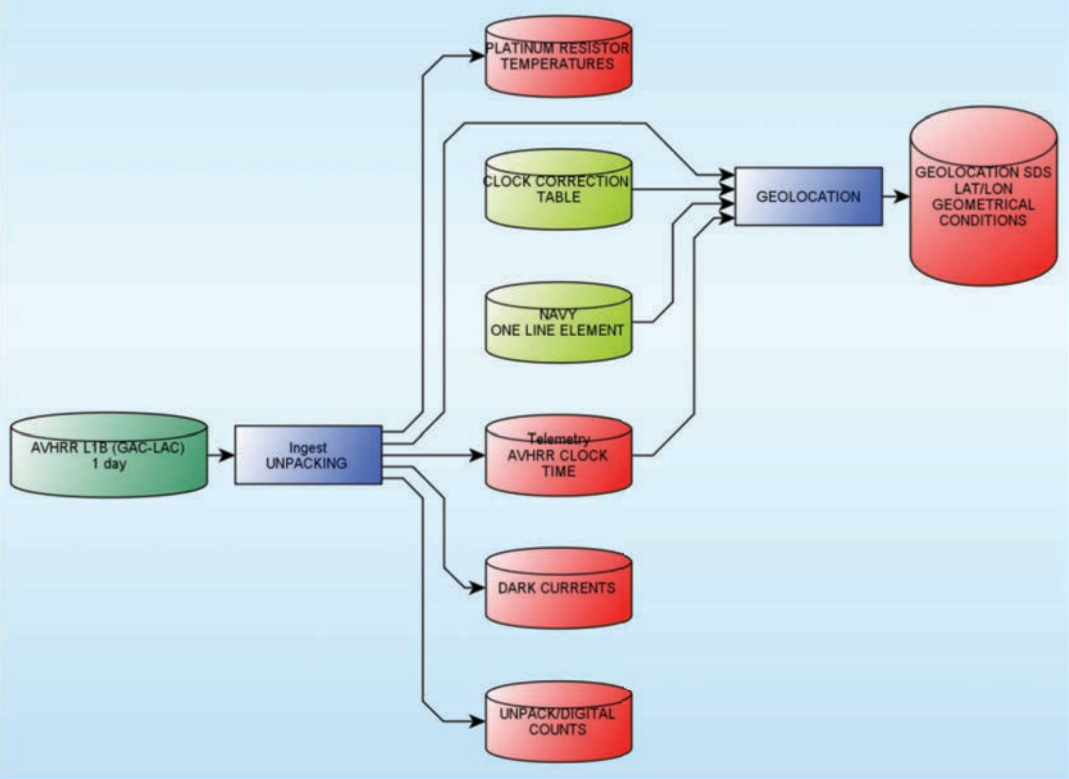
Overview



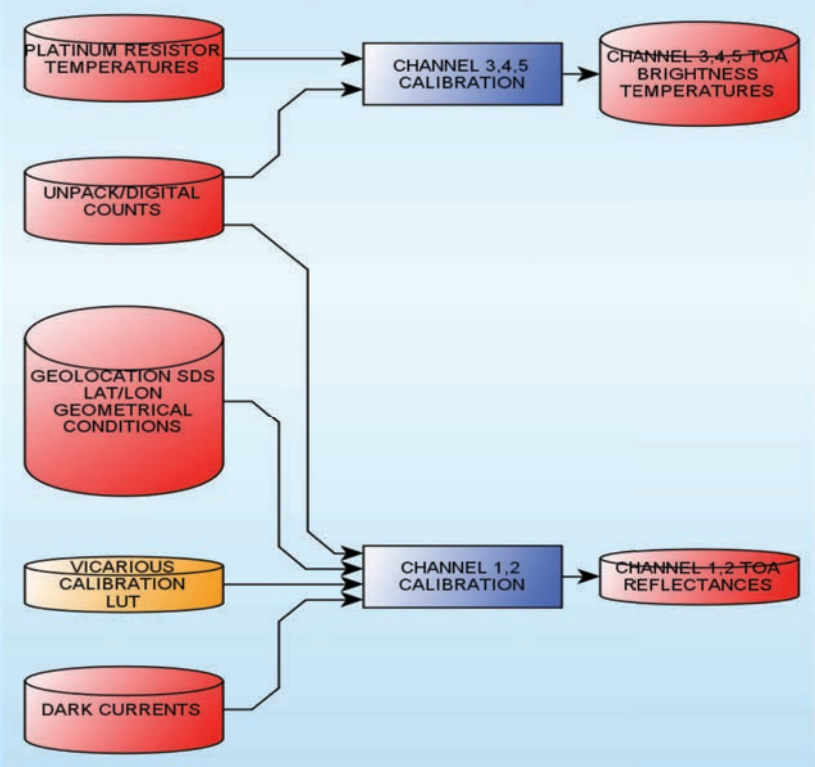


Production details

Geolocation



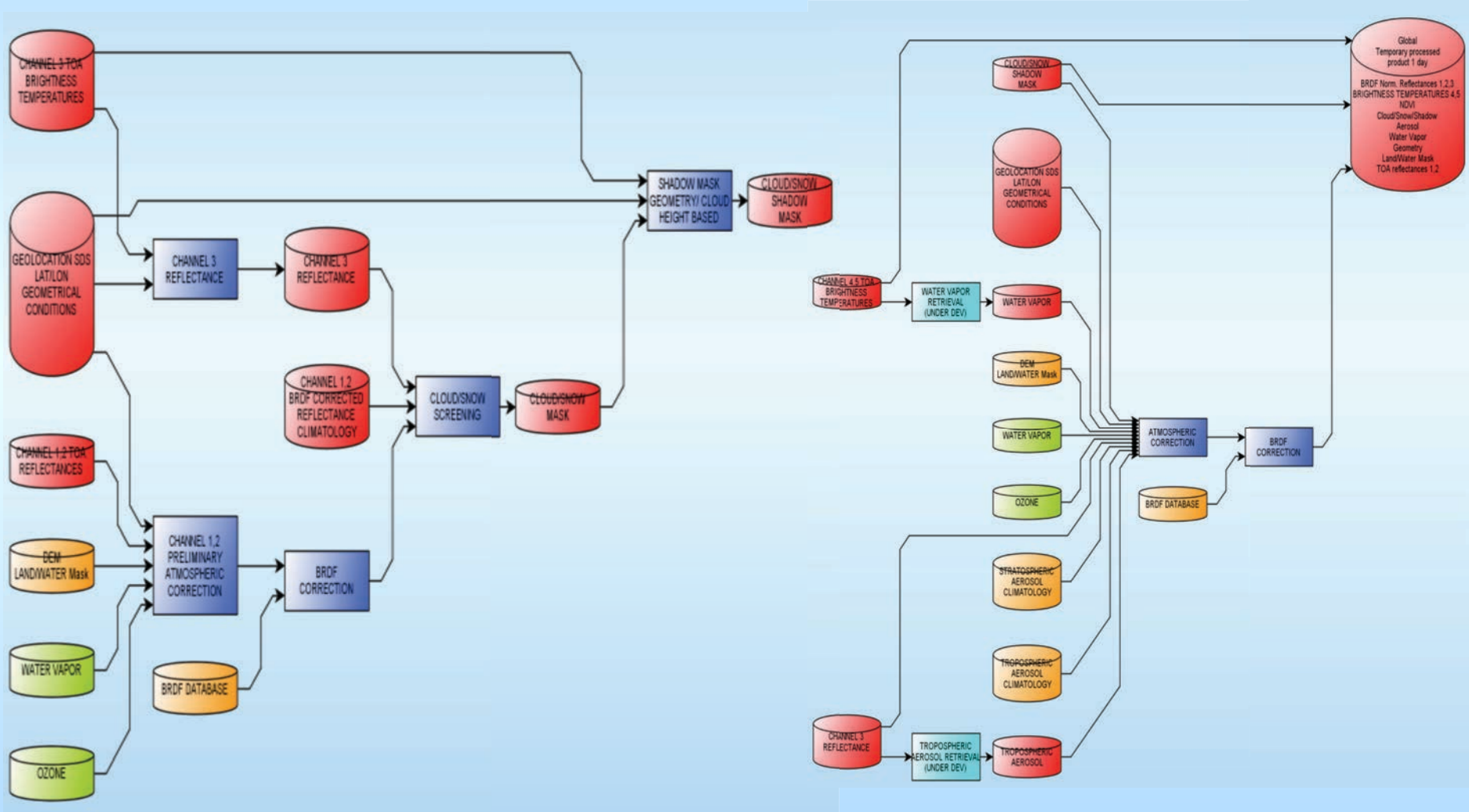
Calibration



Production details (cont.)

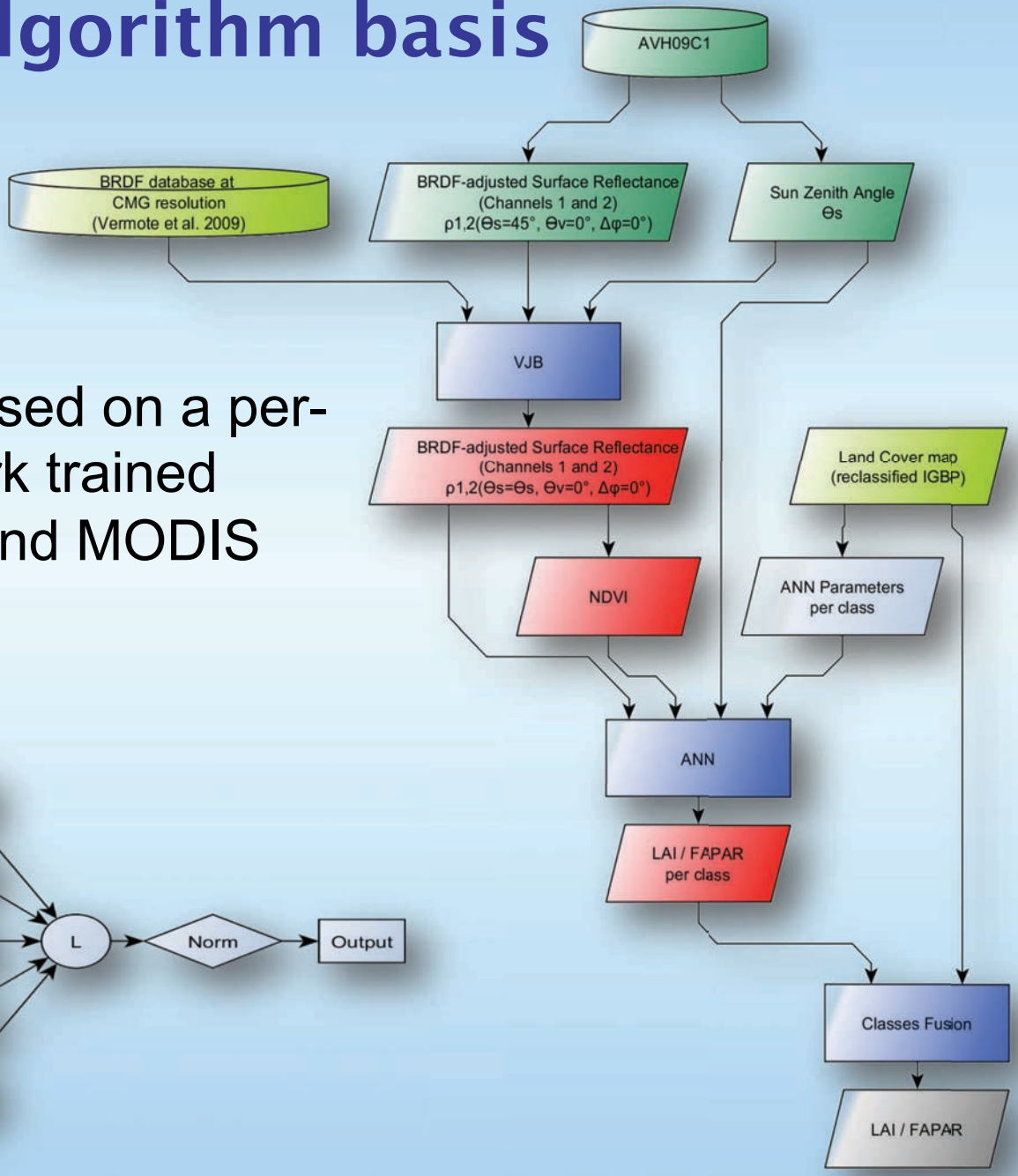
Cloud/Shadow screening

Atmospheric/BRDF correction



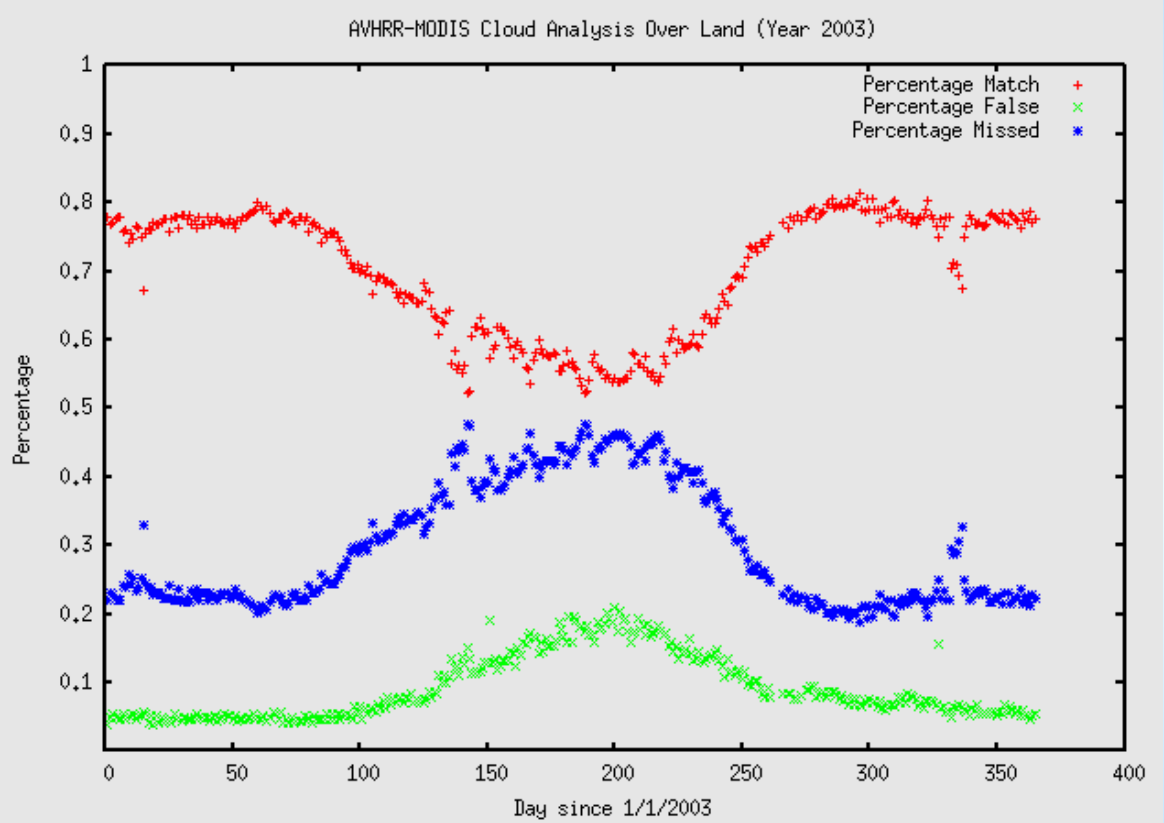
LAI/FAPAR Algorithm basis

The algorithm is based on a per-class neural network trained using AVHRR SR and MODIS LAI/FAPAR.



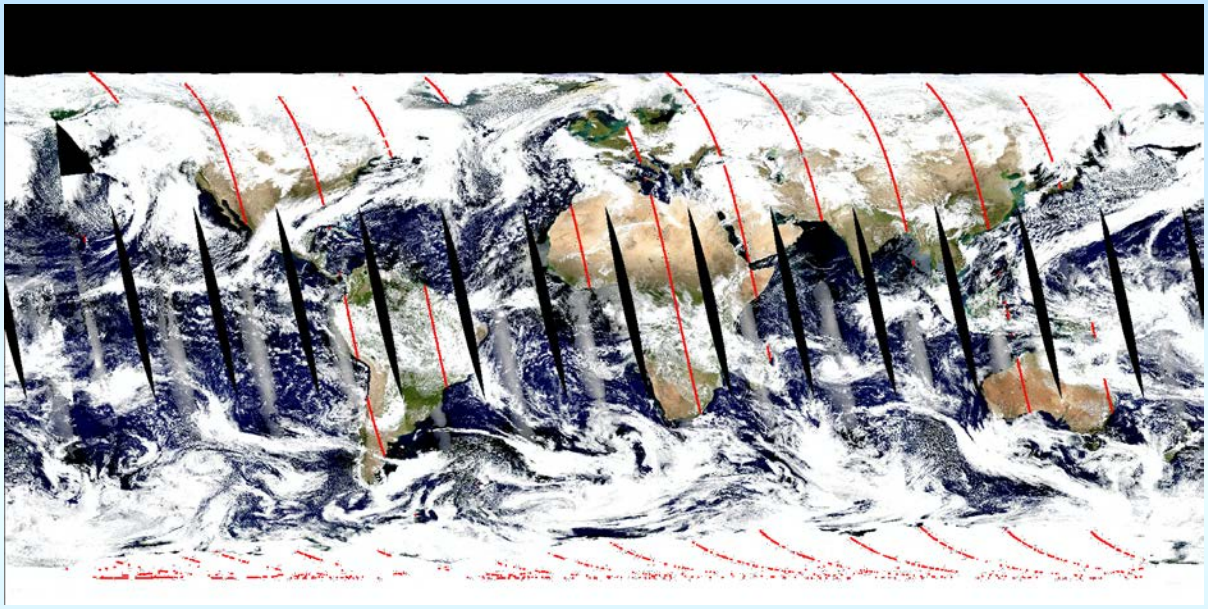
Validation & Quality Assurance

Assessing CLAVR using MODIS shows the need of an improved cloud mask



Evaluation of the global performance of the CLAVR Algorithm reported as percentage. Overall CLAVR identified only 2/3 of the cloud flagged by MODIS (red points), and labeled about 1/3 of the observation flagged as clear by MODIS as cloudy (blue points).

Independent validation of MODIS internal cloud mask

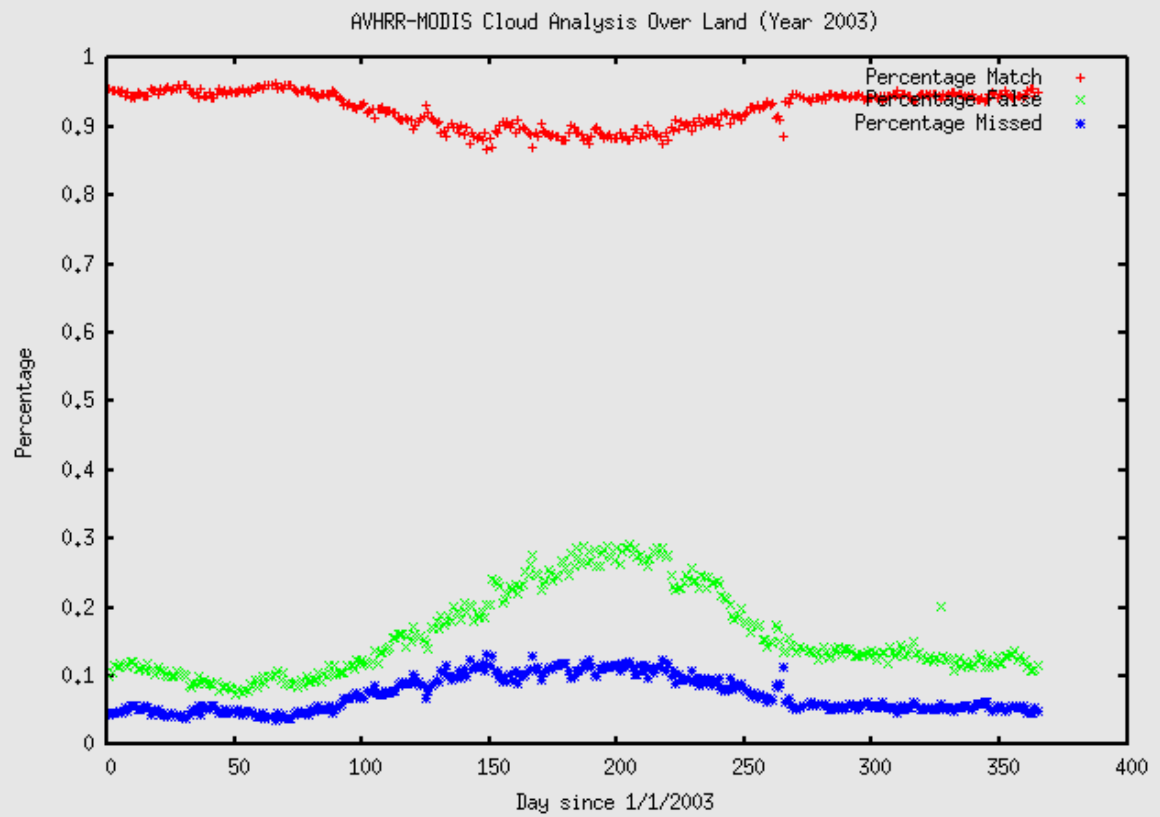


Aqua true color surface reflectance image for March, 2, 2007. The CALIOP track is shown in red, only matchups over Land are selected.

	MOD35 Global	MOD35 60S-60N	ICM Global	ICM 60S-60N	ICM Global Case1	ICM Global Case2
Leakage	6.1%	5.6%	5.8%	**4.0%**	**2.6%**	**2.1%**
False Det.	6.1%	6.4%	6.5%	6.7%	6.5%	6.5%

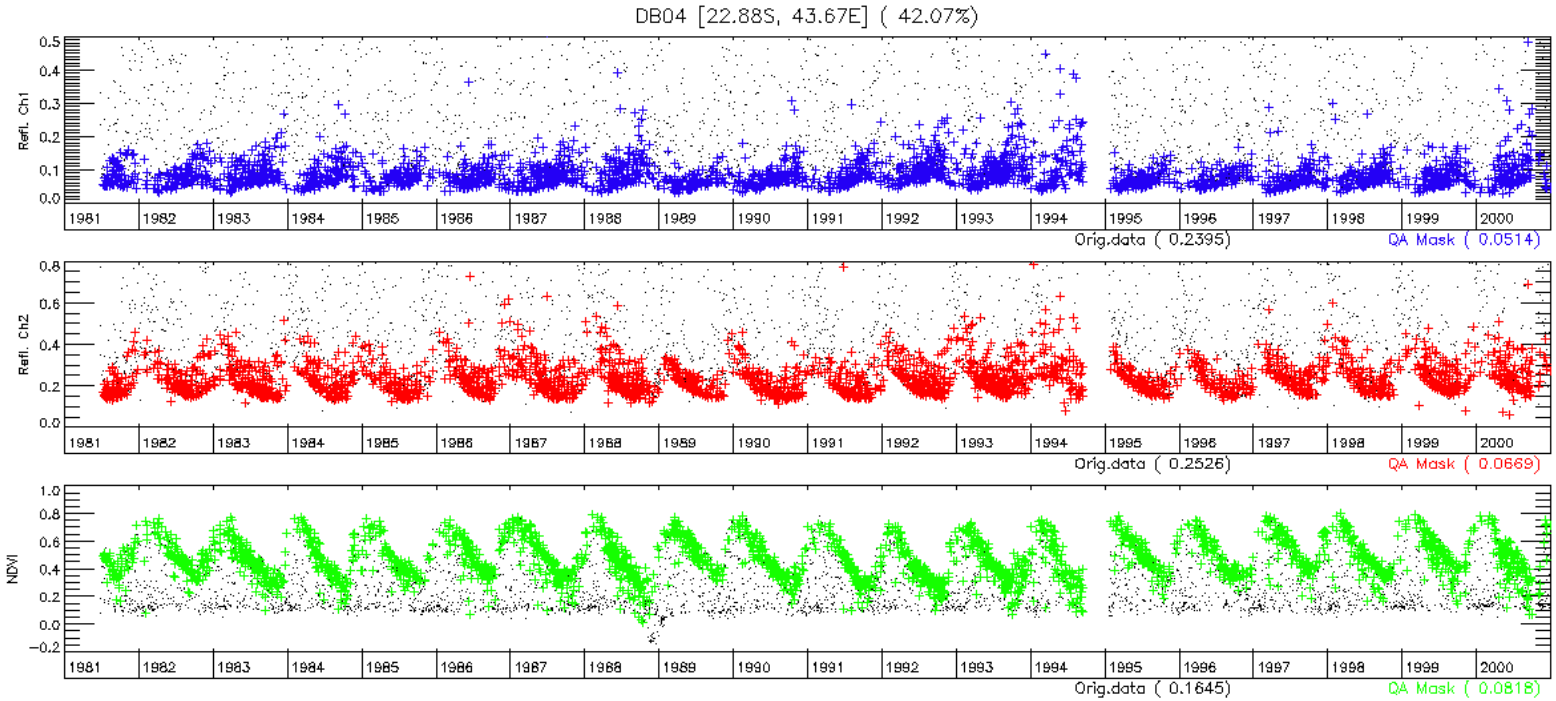
Analysis of the performance of MOD35 and ICM under various scenarios. Global (Global), excluding latitude higher than 60N or lower than 60S (60S-60N), excluding cloud incorrectly detected as snow (ICM Global Case1) using the ICM snow quality flag, and finally further excluding ICM cloud adjacent quality flag (ICM Global Case2).

New improved cloud mask for AVHRR

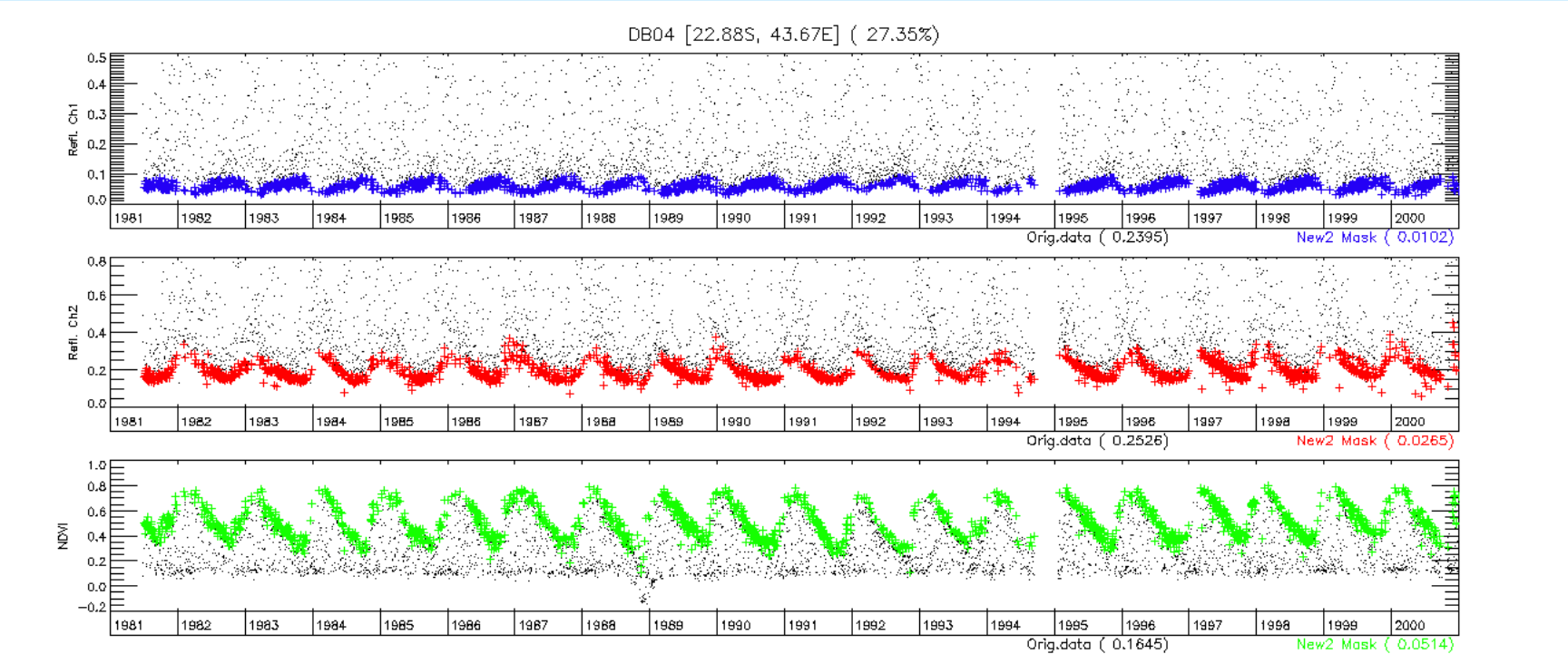


Evaluation of the global performance of the LTDR cloud mask Algorithm reported as percentage.

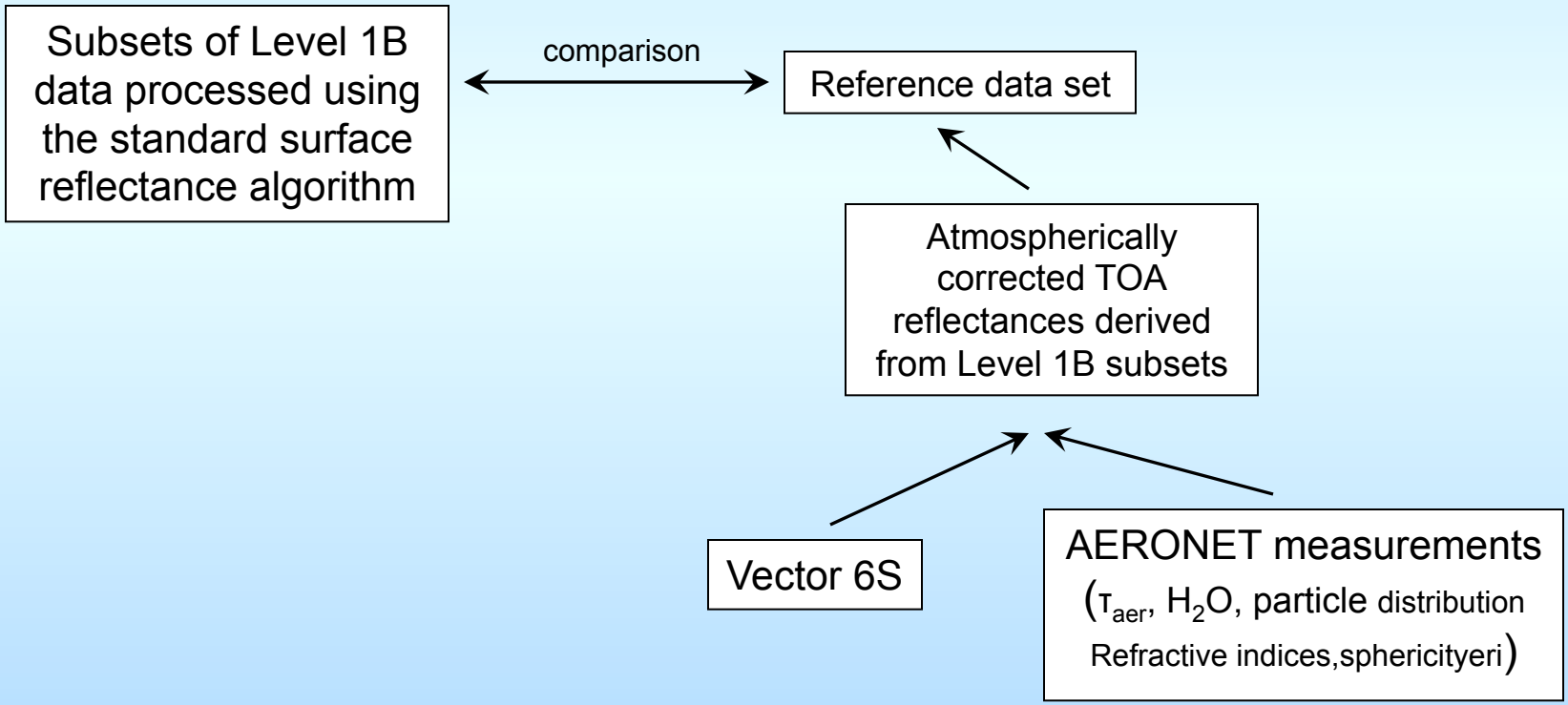
AVHRR Time series CLAVR mask



AVHRR Time series LTDR cloud mask



Methodology for evaluating the performance of surface reflectance product (generic)



Validation Metrics

- Accuracy (A) = the bias

$$A = \frac{1}{N} \times \sum_{i=1}^{N} \varepsilon_i$$

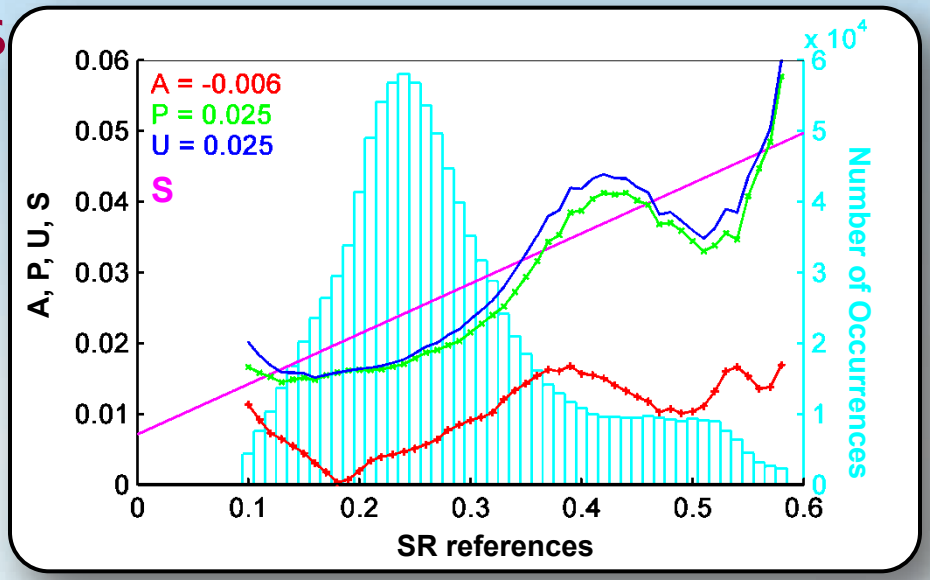
- Precision (P) = the repeatability

$$P = \sqrt{\frac{1}{N-1} \times \sum_{i=1}^{N} (\varepsilon_i - A)^2}$$

- Uncertainty (U) = the actual statistical deviation

$$U = \sqrt{\frac{1}{N} \times \sum_{i=1}^{N} \varepsilon_i^2}$$

$$U^2 = \frac{\sum_{i=1}^{N} (\mu_i^e - \mu_i^t - A + A)^2}{N} = \frac{N-1}{N} P^2 + A^2$$

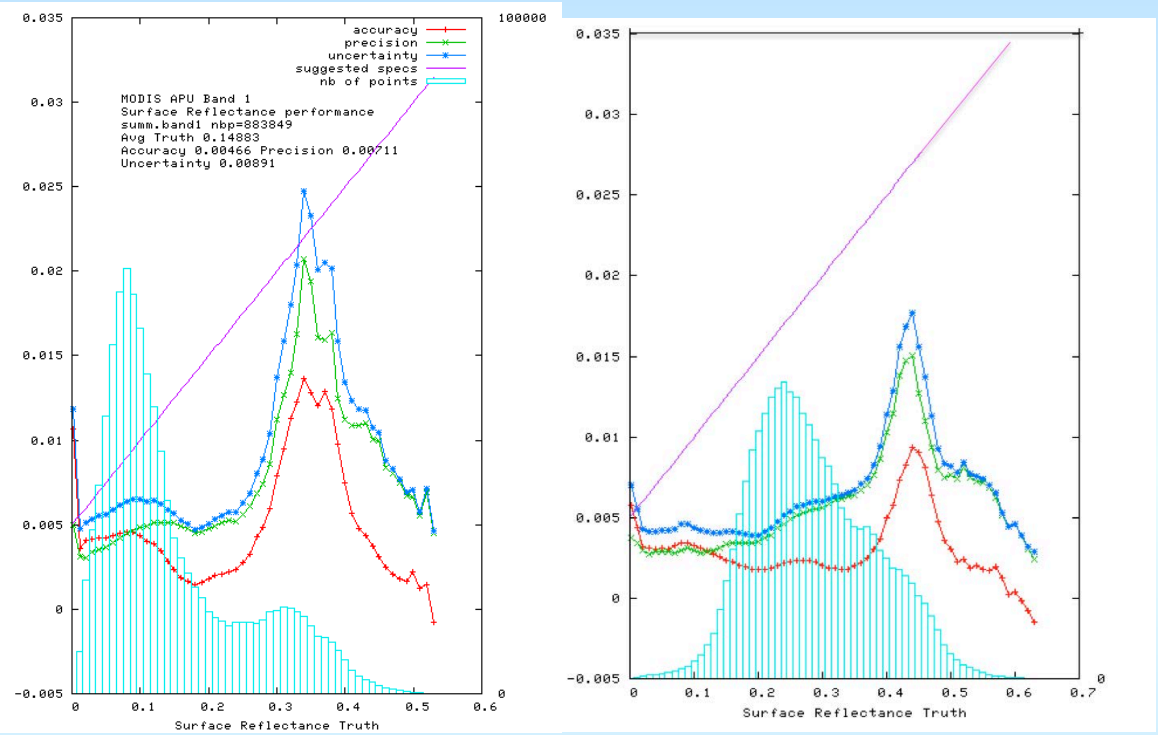


- Specification (S) = Uncertainty requirement

From Vermote and Kotchenova, 2008

$$S = 0.071\rho + 0.0071$$

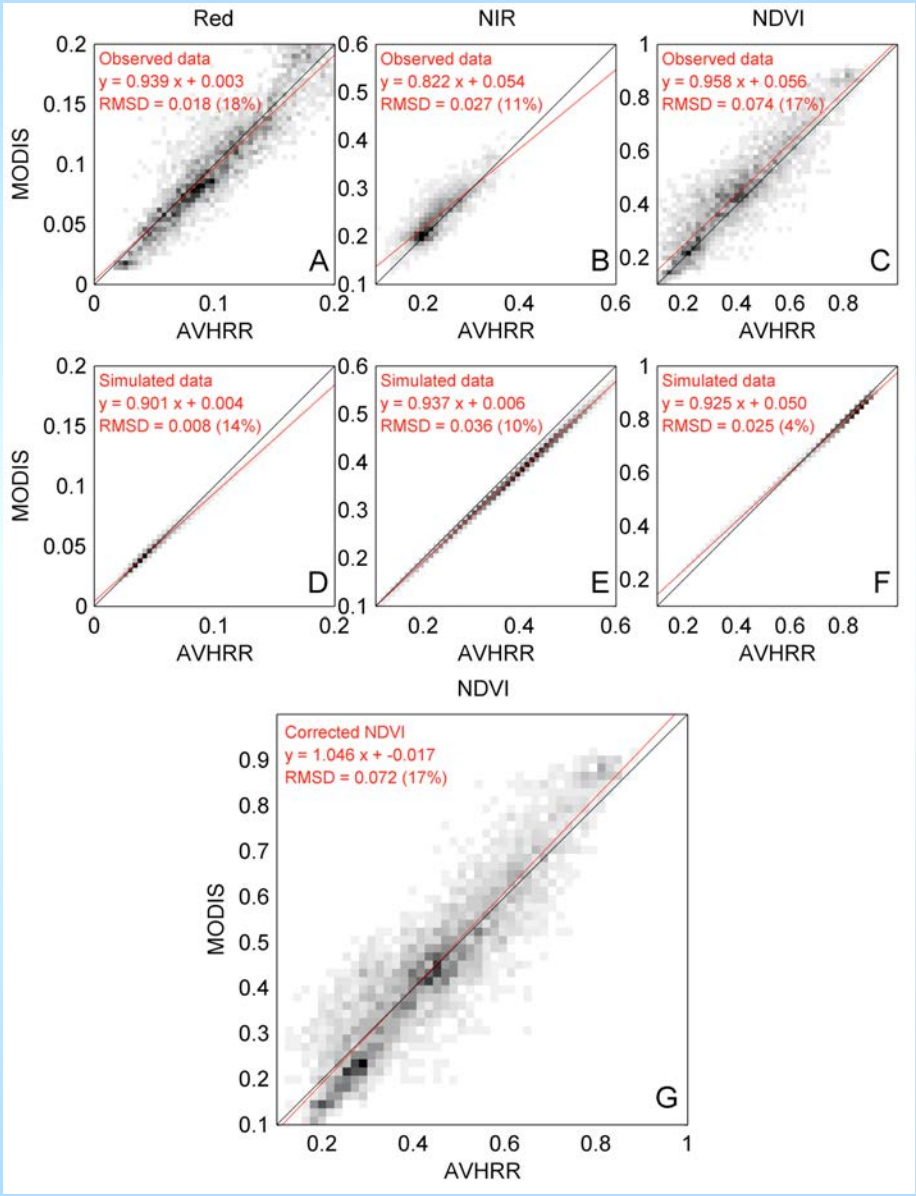
MODIS SR validated over AERONET sites



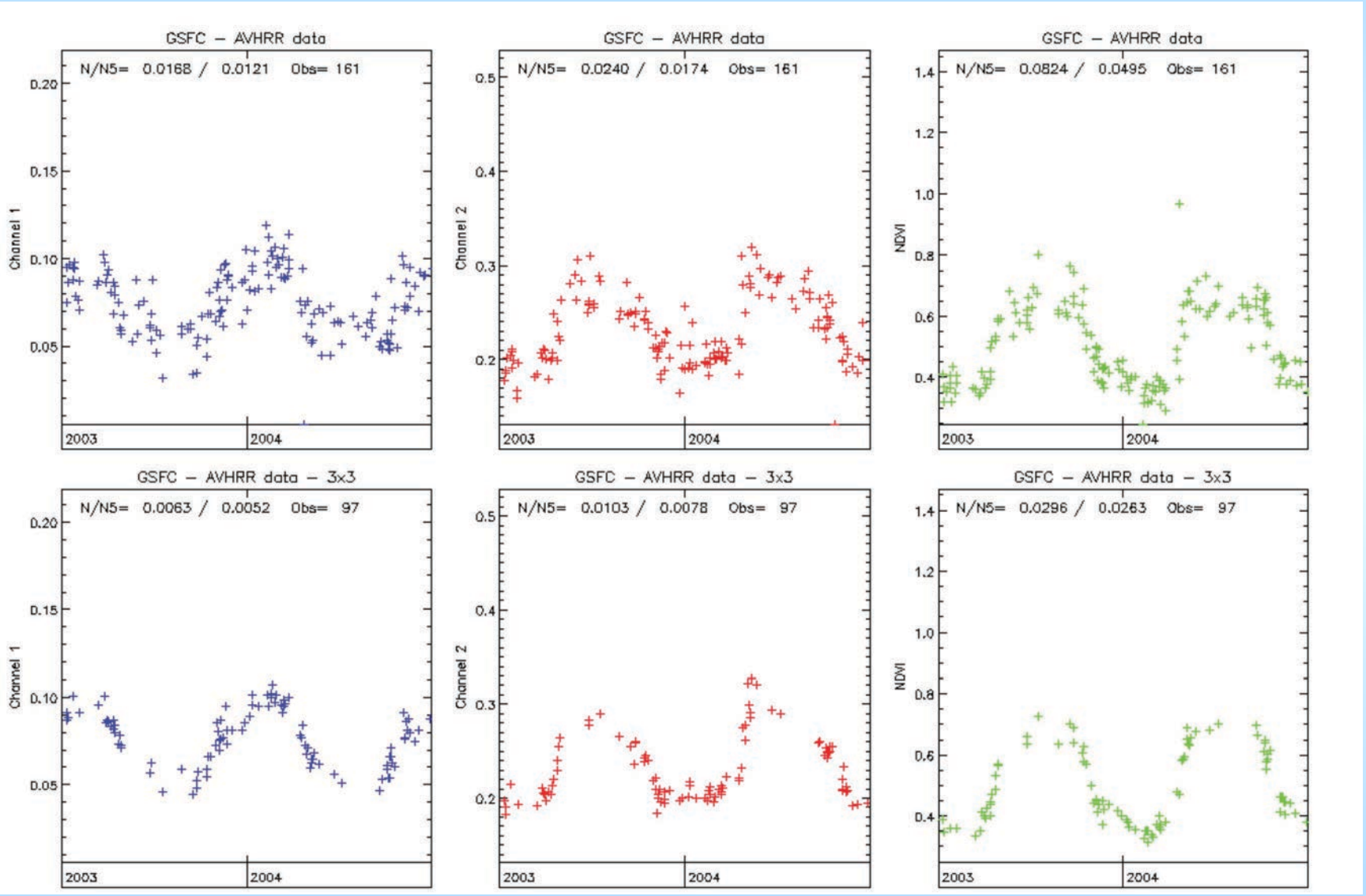
Accuracy or mean bias (red line), Precision or repeatability (green line) and Uncertainty or quadratic sum of Accuracy and Precision (blue line) of the surface reflectance in band 1 in the Red (top left), band 2 in the Near Infrared (top right also shown is the uncertainty specification (the line in magenta), that was derived from the theoretical error budget. Data collected from Terra over 200 AERONET sites from 2000 to 2009.

Using Direct comparison with MODIS Aqua for validation

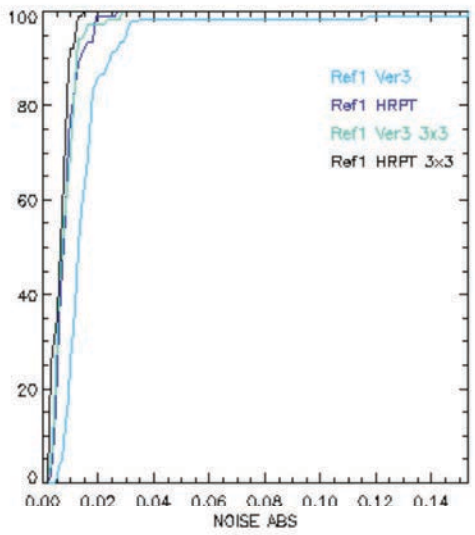
Comparison of MODIS Aqua and NOAA16 AVHRR data, A (Red) ,B (NIR) ,C (NDVI) are observed over AERONET sites for 2003-2004, D (Red), E(NIR), F(NDVI) are simulated using a vegetation model that account for spectral difference between MODIS and AVHRR bands. G shows over the AERONET sites MODIS NDVI versus corrected AVHRR NDVI computed from spectrally adjusted AVHRR surface reflectance.

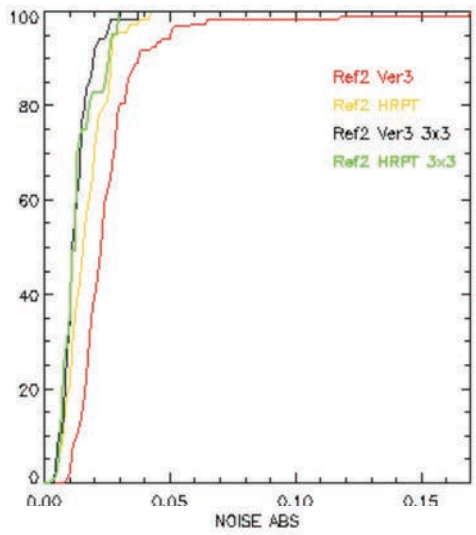


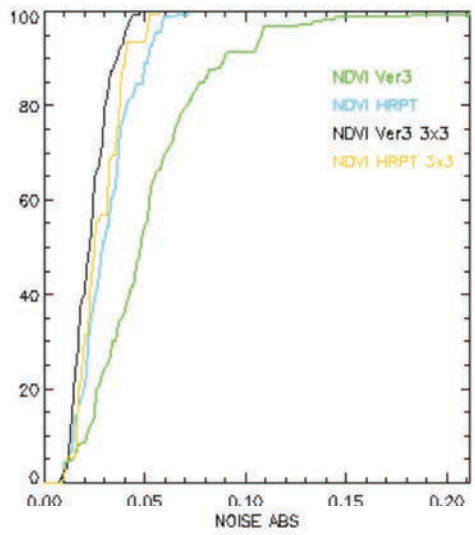
Analysis of the AVHRR reflectance and NDVI time series reveal an issue with GAC sampling

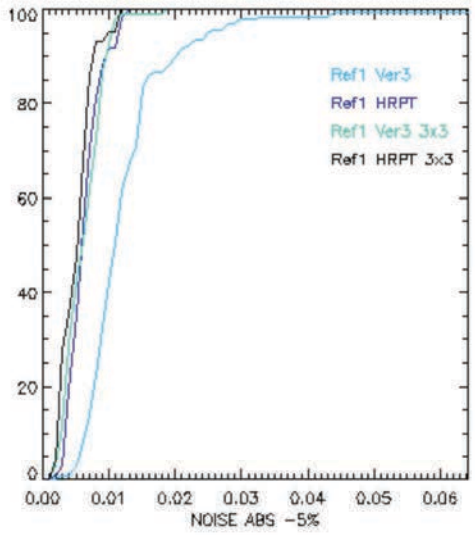


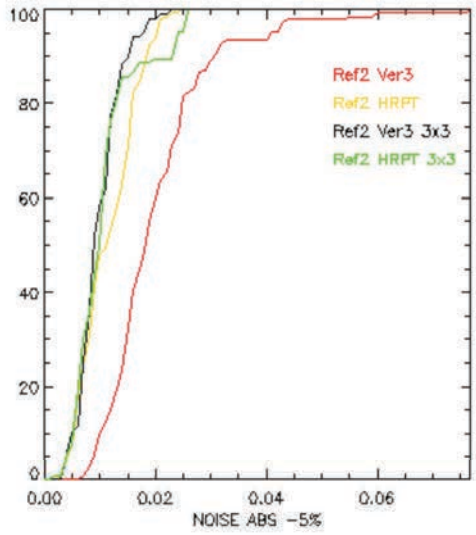
Analysis of the GAC artifact over AERONET SITES

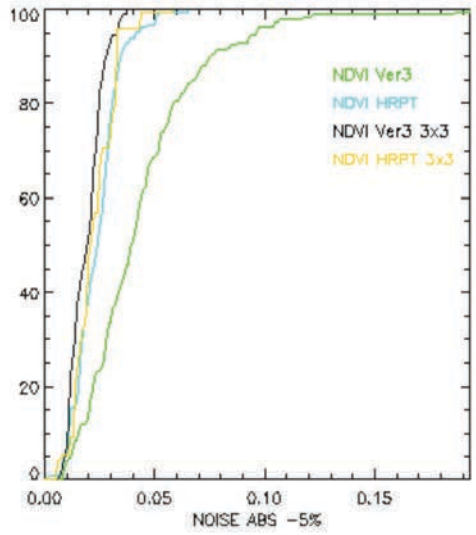




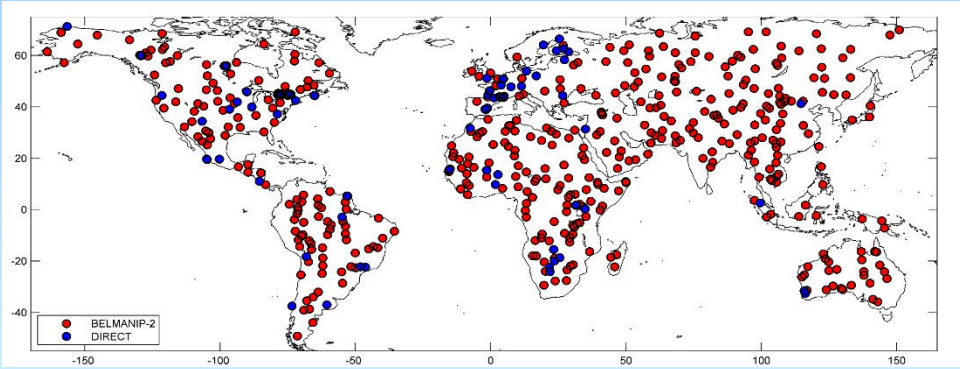




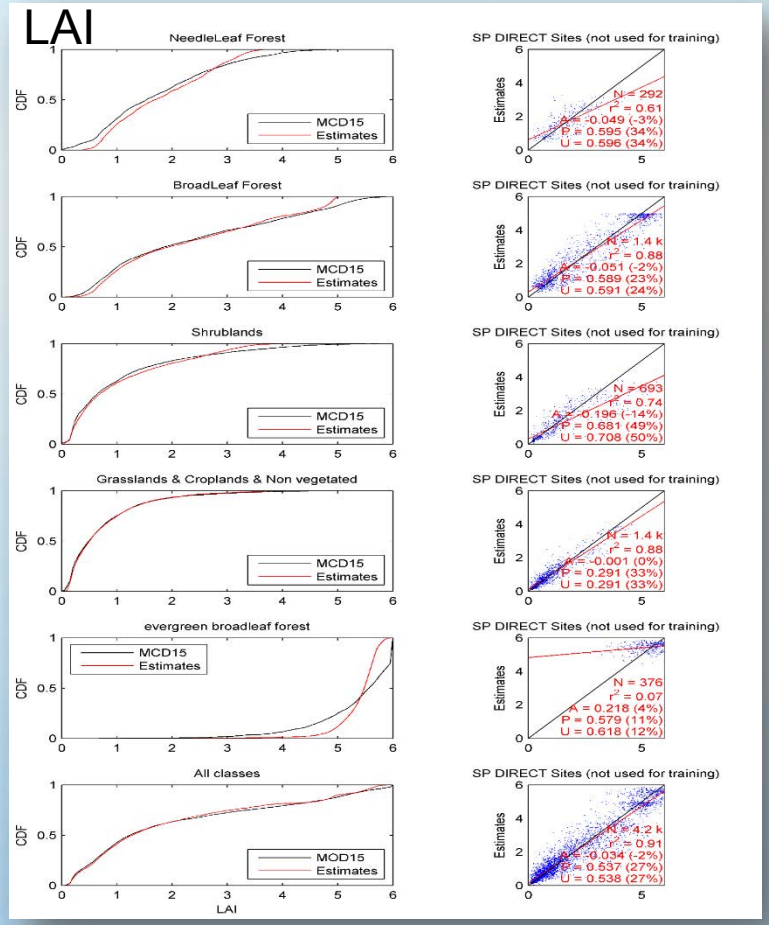


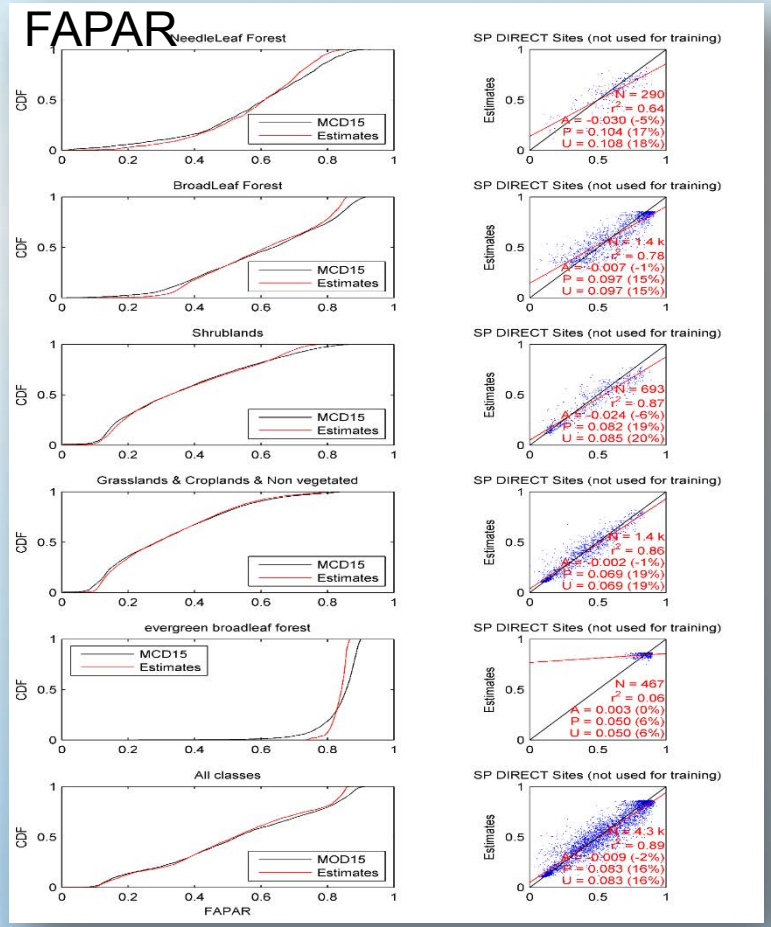


LAI Calibration procedure



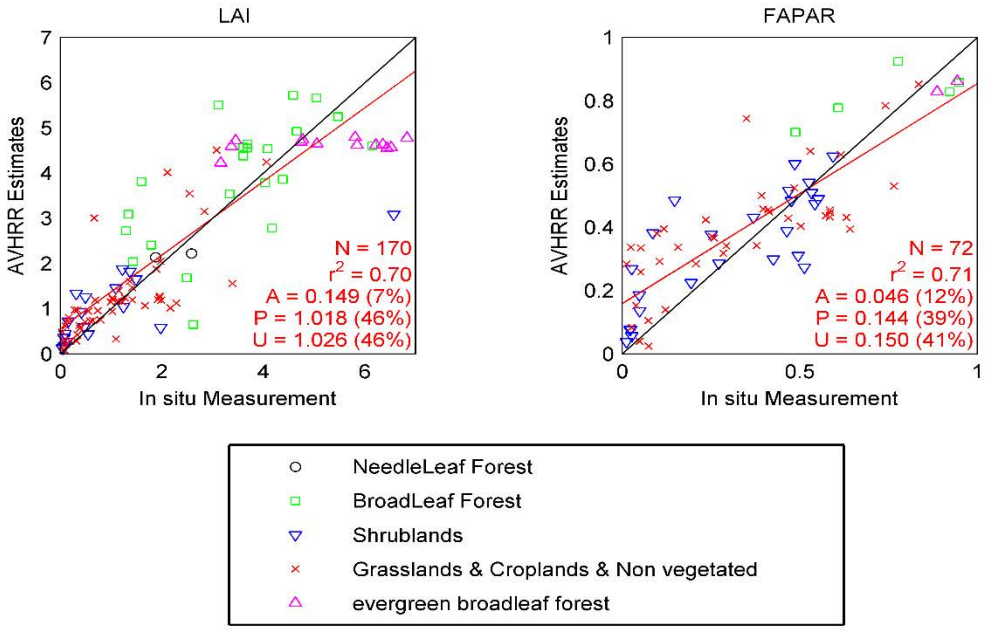
We used the BELMANIP-2 sites network to calibrate the LAI/FAPAR ANN and the DIRECT in situ measurement to assess the uncertainty of the retrievals.





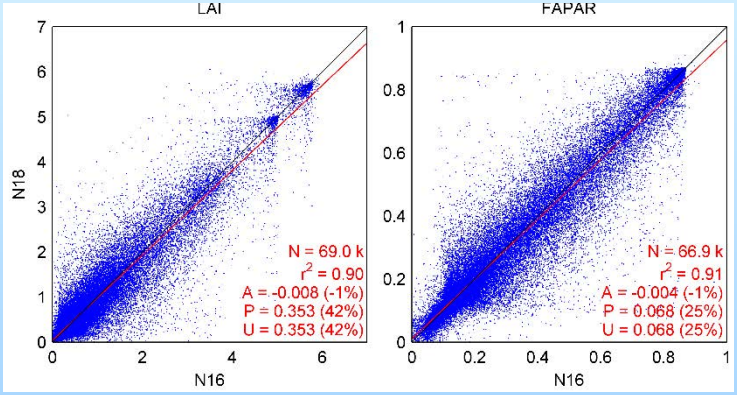
Validation/Evaluation Results

In situ validation: we extrapolated DIRECT measurement (1km footprint) to 0.05degree using MODIS LAI/ products

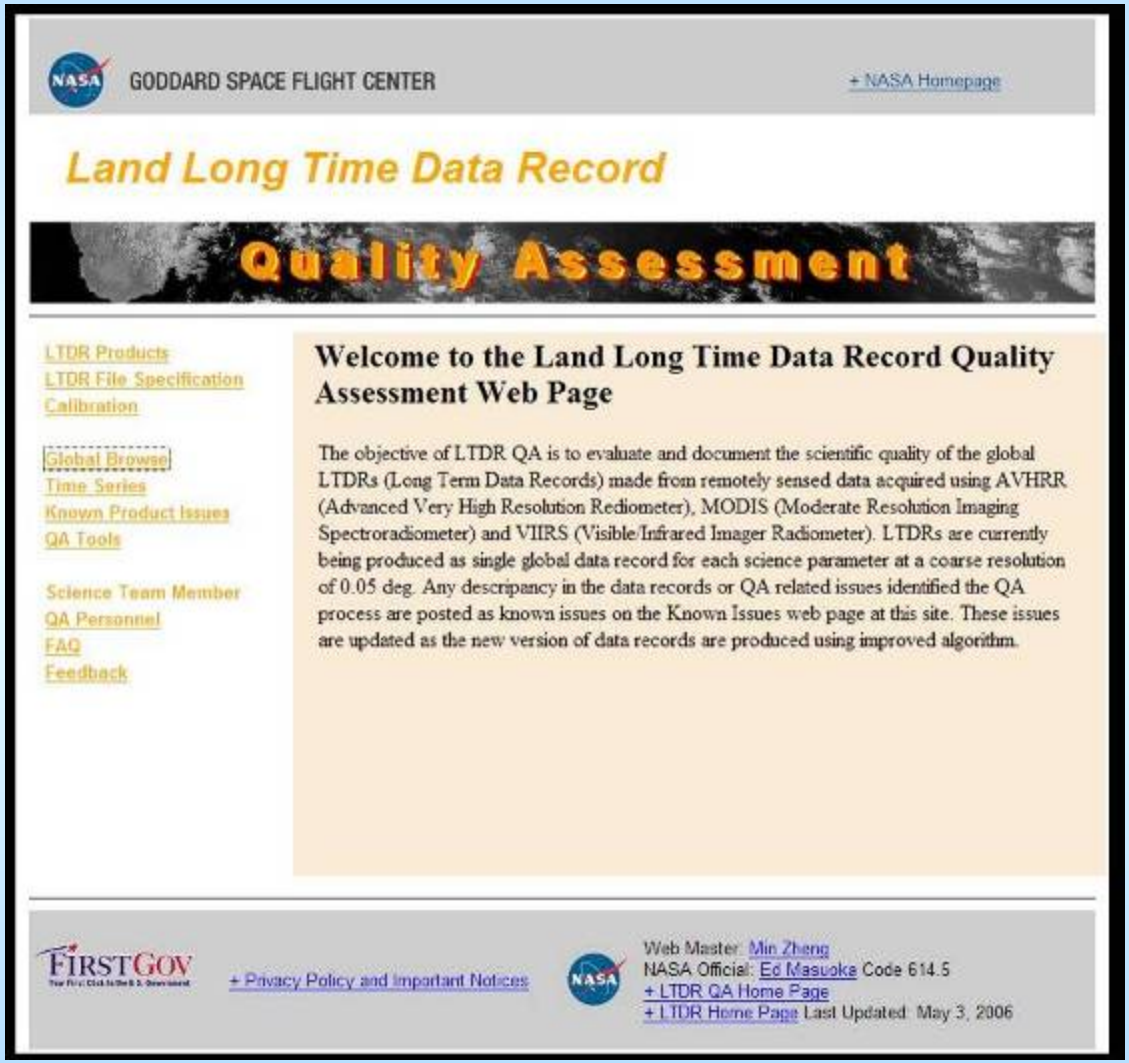


Class	LAI			FAPAR		
	bias	RMSE	N	bias	RMSE	N
NeedleLeaf Forest	-0.04	0.31	2			0
BroadLeaf Forest	0.39	1.18	22	0.07	0.15	5
Shrublands	0.02	0.93	20	0.04	0.13	25
Grasslands & Croplands & Non vegetated	0.11	0.69	51	0.05	0.16	40
evergreen broadleaf forest	-0.81	1.53	14	-0.07	0.07	2
All	0.13	1.05	171	0.05	0.15	72

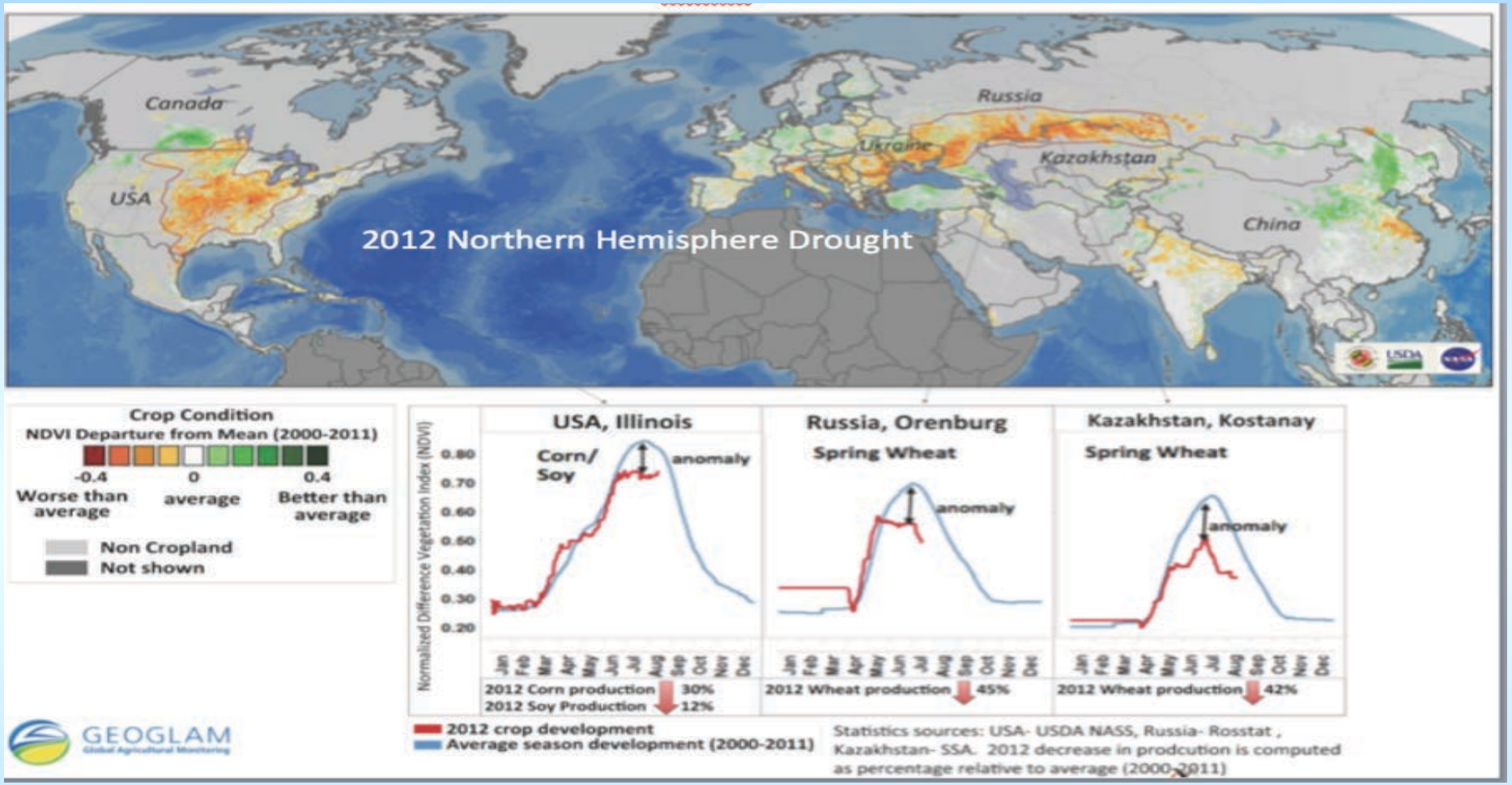
Product evaluation: inter-comparison of NOAA-16 vs NOAA-18 outputs



Operational Quality Assurance

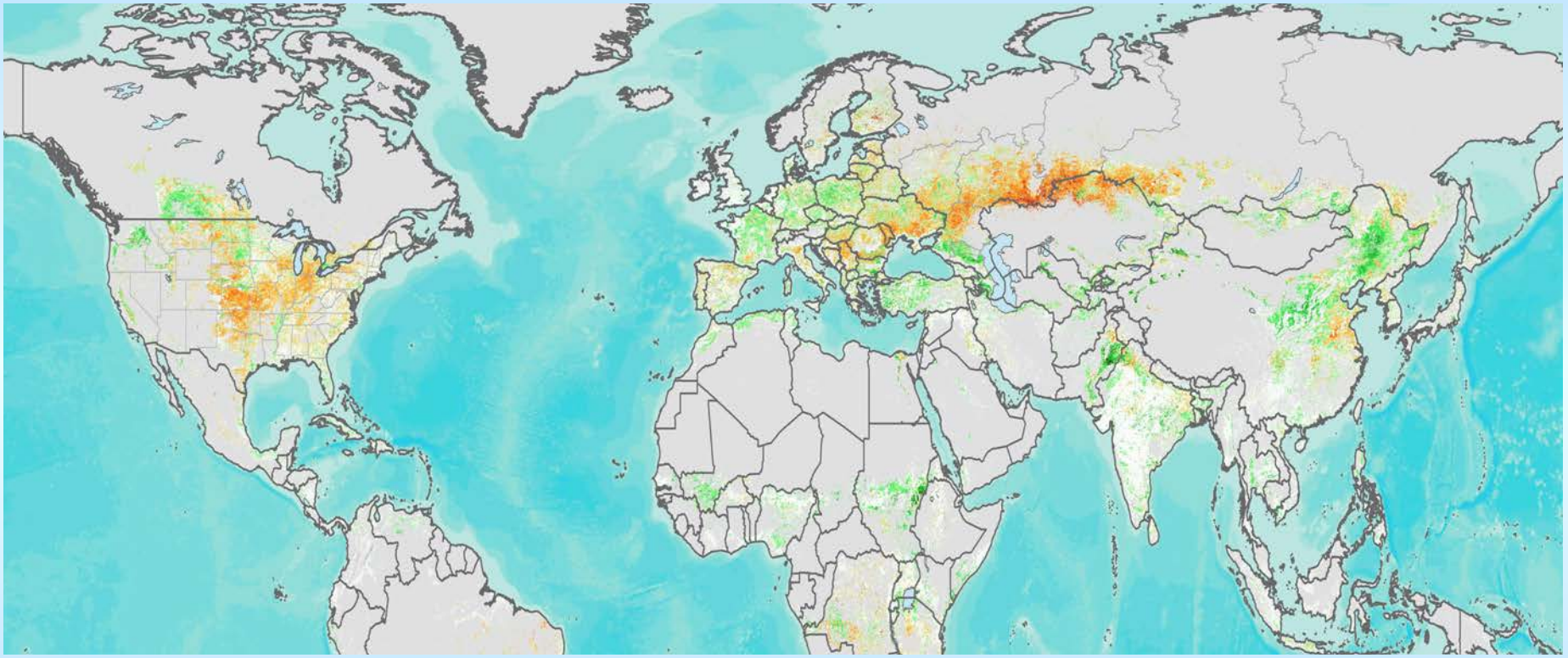


MODIS NDVI Anomaly July 30th 2012



Assessment of the impact of the 2012 Northern Hemisphere Drought from the MODIS Climate Modeling Grid daily NDVI data. The anomaly image shows the cropland NDVI departure from the average (2000-2011) on **July 30th 2012**, highlighting hotspots of crops under stress during the 2012 droughts that affected the United States and the Black Sea region. The time-series curves below compare the daily development of croplands in 2012 (red) to average (2000-2011) in 3 important crop growing regions: Illinois, USA; Orenburg Oblast, Russia; Kostanay Oblast, Kazakhstan. The crop development through the season depicted by NDVI shows consistent negative anomalies with regard to a ten year average, with highest discrepancies during the crops peak development period. In 2012 crops in the US, southern Europe and the Black Sea region suffered from prolonged high temperatures and lack of moisture, which resulted in significantly reduced production. This information was available one month prior to harvest and several months before the release of official statistics.

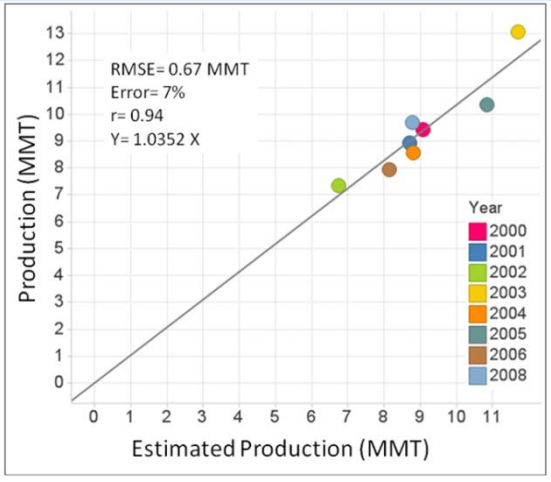
Prototype VIIRS NDVI Anomaly, July 30th 2012



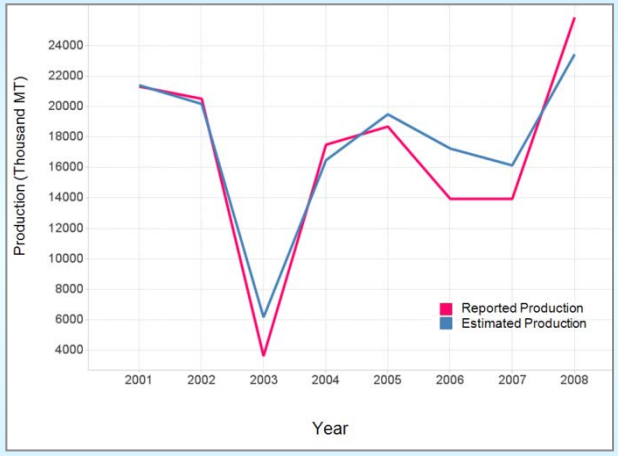
A VIIRS NDVI anomaly (prototype) image computed for the same date (July, 30th 2012) as the MODIS NDVI anomaly shown in the previous slide, generated from data produced at the GSFC Land PEATE.

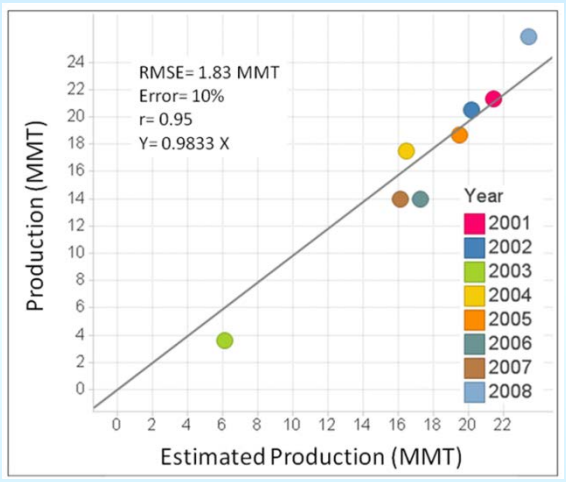
Application to Agriculture: Yield/ Production prediction

Kansas: Wheat



Ukraine: Wheat





Becker-Reshef, I., E. Vermote, M. Lindeman, and C. Justice (2010a), A generalized regression-based model for forecasting winter wheat yields in Kansas and Ukraine using MODIS data, *Remote Sensing of Environment*, *114*(6), 1312-1323.

Improving timeliness of winter wheat production forecast in United States of America, Ukraine and China using MODIS data and NCAR Growing Degree Day

Remote Sensing of the environment, 161,131-148 (2015)

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[3] Global Change Unit, Image Processing Laboratory (UCG-IPL). Parque Cientifico, Universitat de Valencia, Spain

Daily accumulated Growing Degree day (GDD)

Daily BRDF-corrected NDVI adjusted (ANDVI)

Wheat mask

Inputs

ANDVI, GDD climatology

Median ANDVI at the peak and at GDD of the day of forecast

$\left(\overline{ANDVI_{peak}}, \overline{ANDVI_{GDD}}\right)$

(median based on 2000 to 2012 data)

ANDVI, GDD

Adjusted NDVI and accumulated GDD for the day of the forecast

Mpct

% Wheat in each Administrative Unit (AU)

$$\sim ANDVI_{peak} = ANDVI.\frac{\overline{ANDVI_{peak}}}{\overline{ANDVI_{GDD}}}$$

Simulated adjusted peak NDVI ($\sim ANDVI_{peak}$)

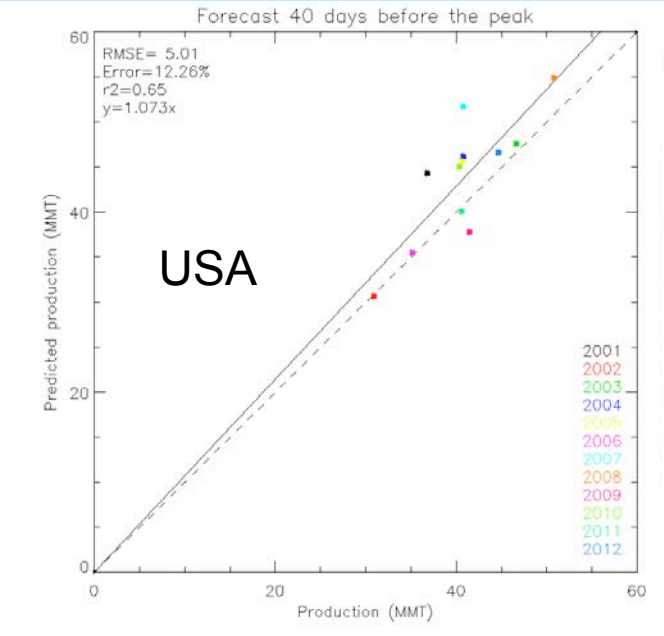
$$S_{Mpct} = 9.61 + \left(-0.05 Mpct\right)$$

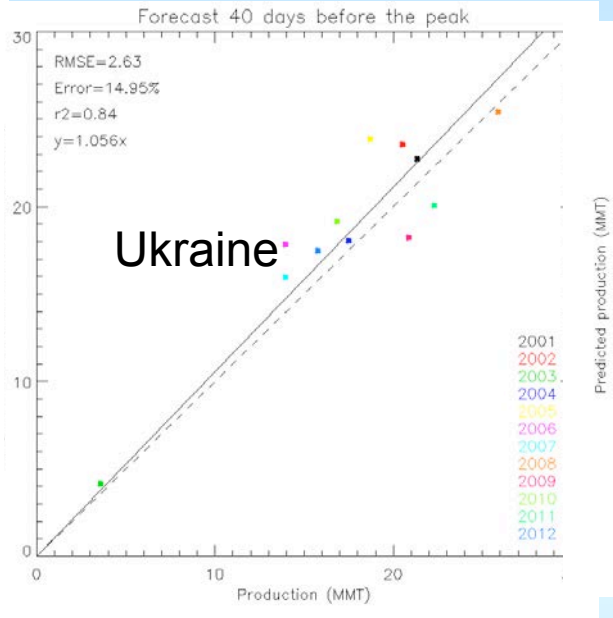
$$Forecast\,Yield = \sim ANDVI_{peak} . S_{Mpct}$$

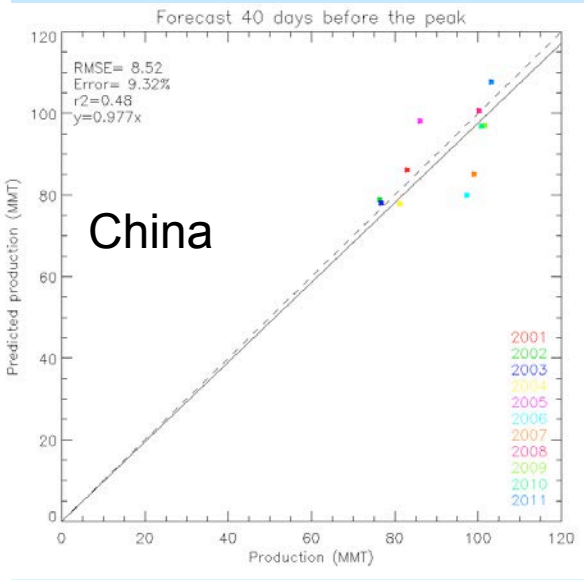
$$\text{Forecast Production} = \sum_{AU} \text{Forecast Yield} \cdot \text{Area Planted}$$

Becker-Reshef et al. (2010) method

Results for major producers

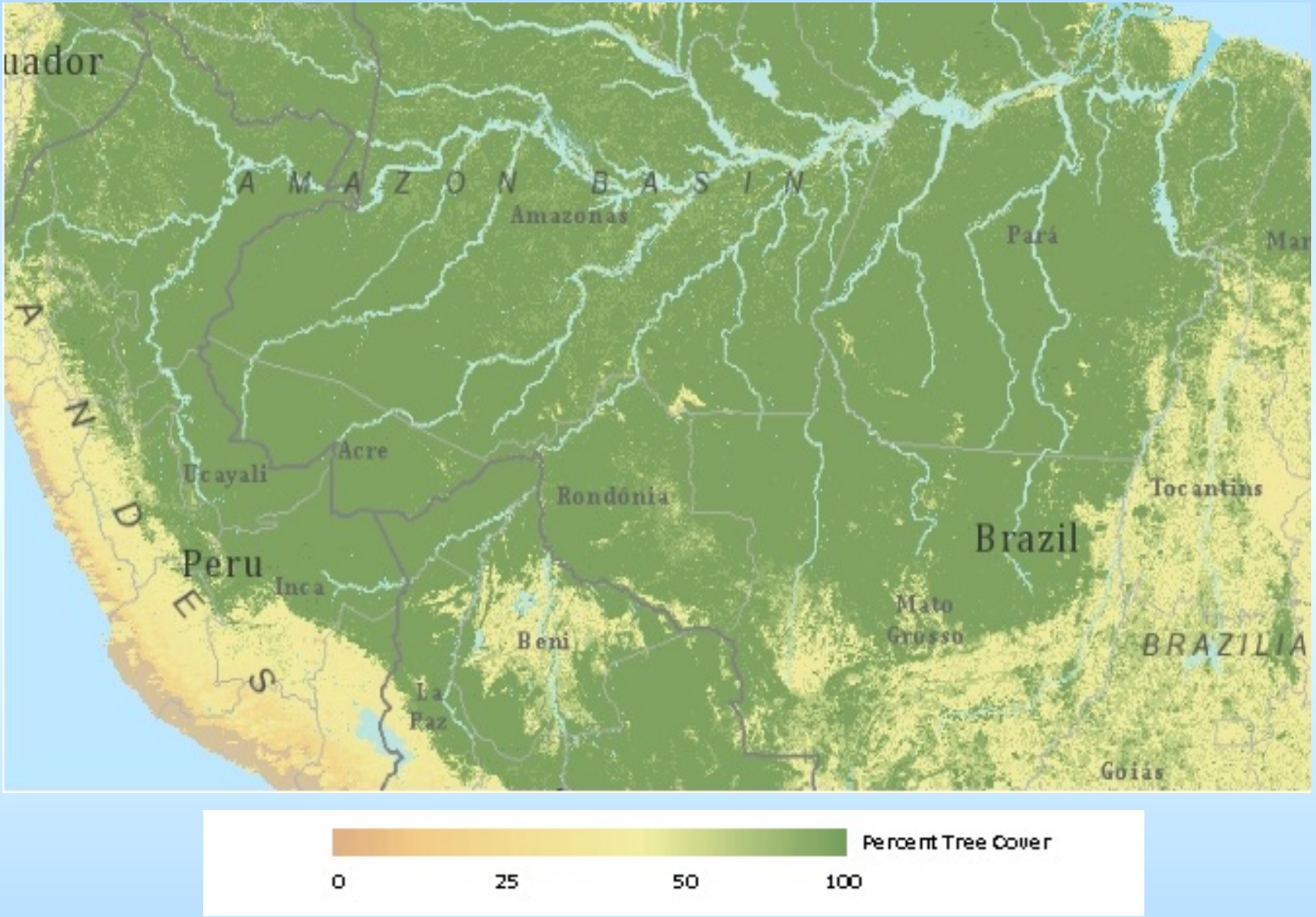




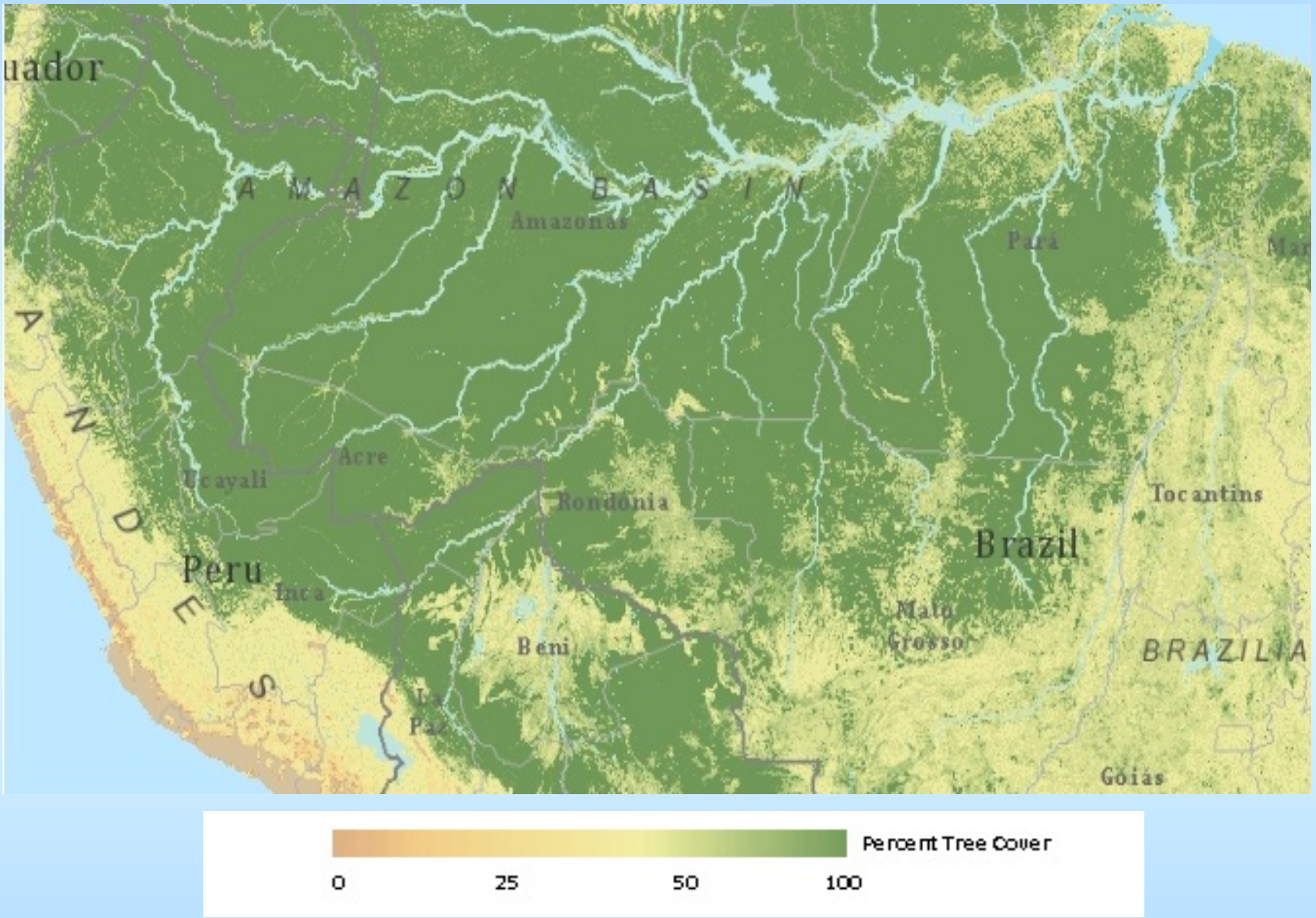


The results show that the earliest time winter wheat production can be forecasted within an error of 10% is roughly one and a half month prior to the average date of the peak, that is two months and a half month prior to the harvest

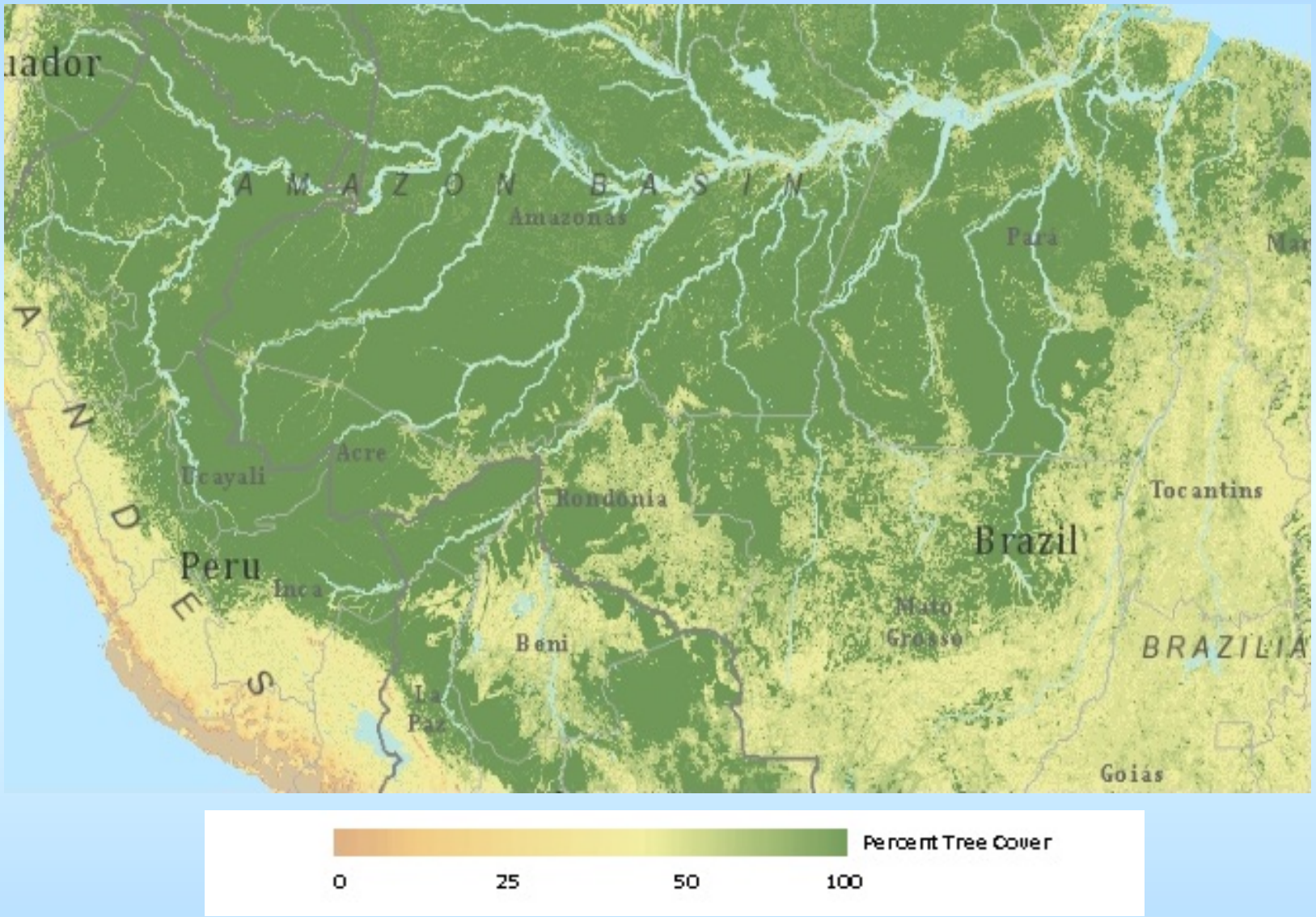
funded MEASURES-2013 proposal entitled "Vegetation Continuous Fields ESDR for the AVHRR and MODIS Records: 1981 - Present", PI: Robert Sohlberg (UMD).



Percent tree cover, Amazon Basin, 1990--Land LTDR AVHRR data



Percent tree cover, Amazon Basin, 2000—MODIS CMG data



Percent tree cover, Amazon Basin, 2010--MODIS CMG data