Amazon Forests During 2005 Drought: MODIS Collection 5 Confirms Green-up Fact

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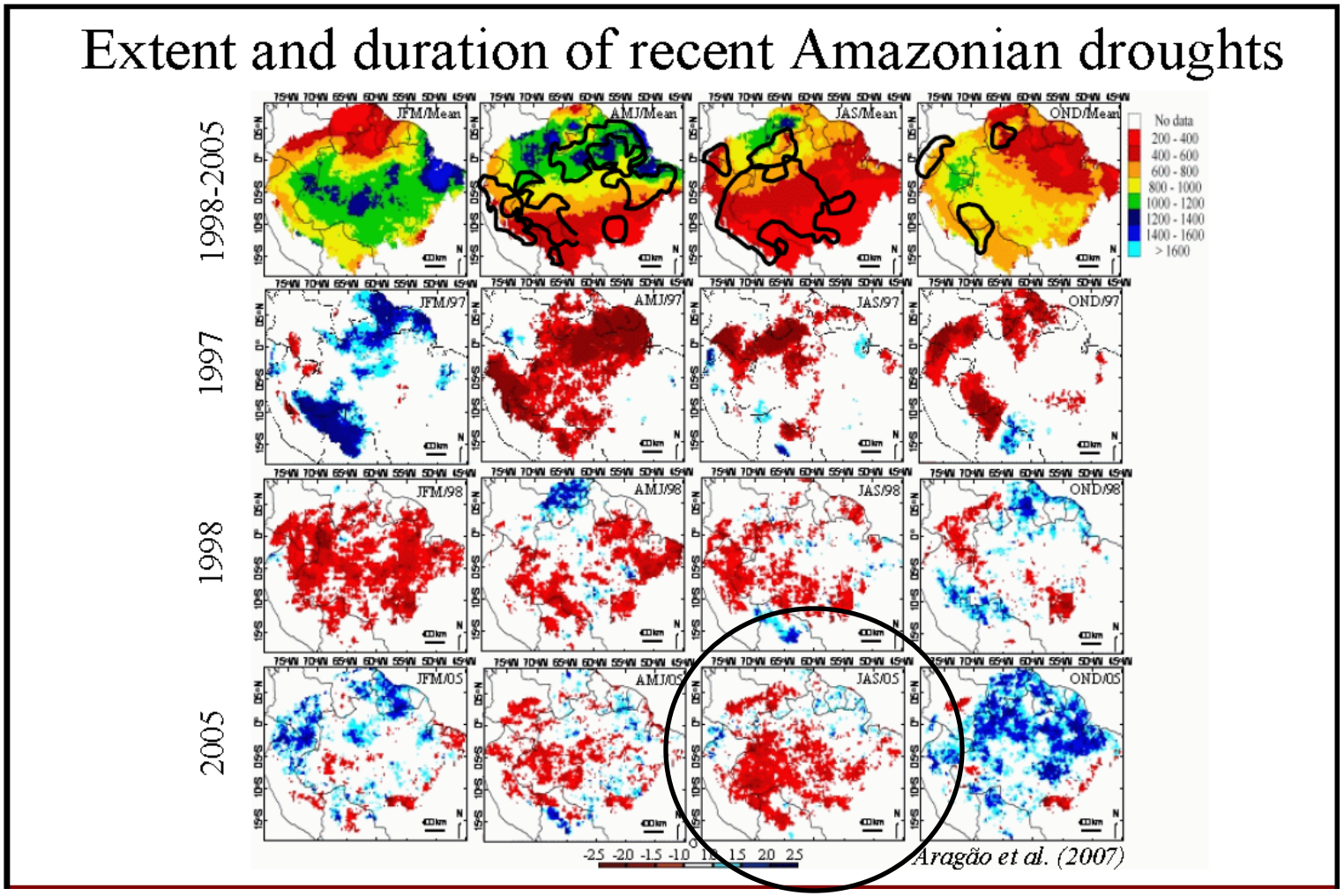
Outline

- 2005 drought
- Hypothesis
- Data & Methods
- Results
- Statistical significance
- Conclusions
- Closing thoughts

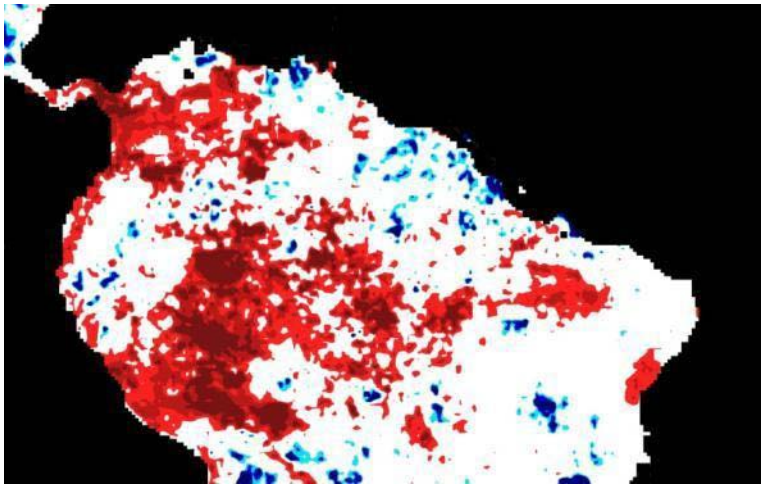
2005 drought

Redistribution of rainfall with an intensification of the drought during the dry season in most of the basin

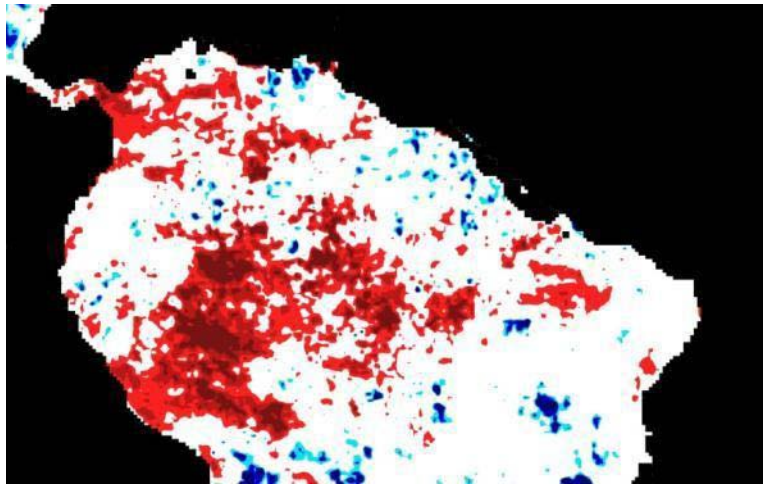


2005 Drought

- One of Amazon's worst droughts in the last century
- Measured by TRMM precipitation data



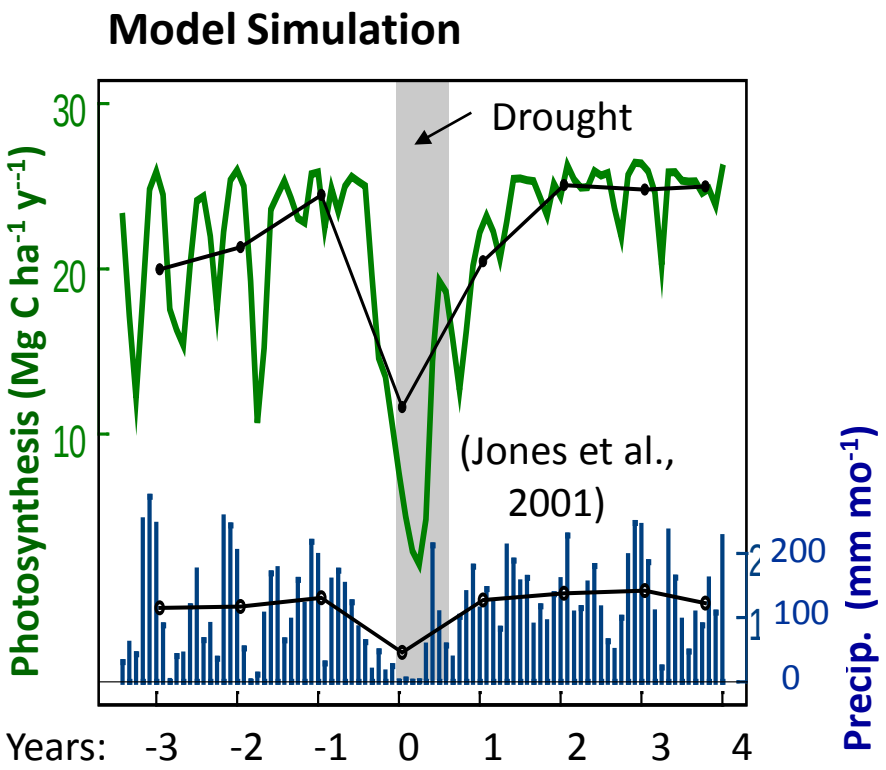
2005 Drought (1998-2006)



2005 Drought (1998-2008)

Basic hypotheses of expected Amazon forest photosynthesis response to drought

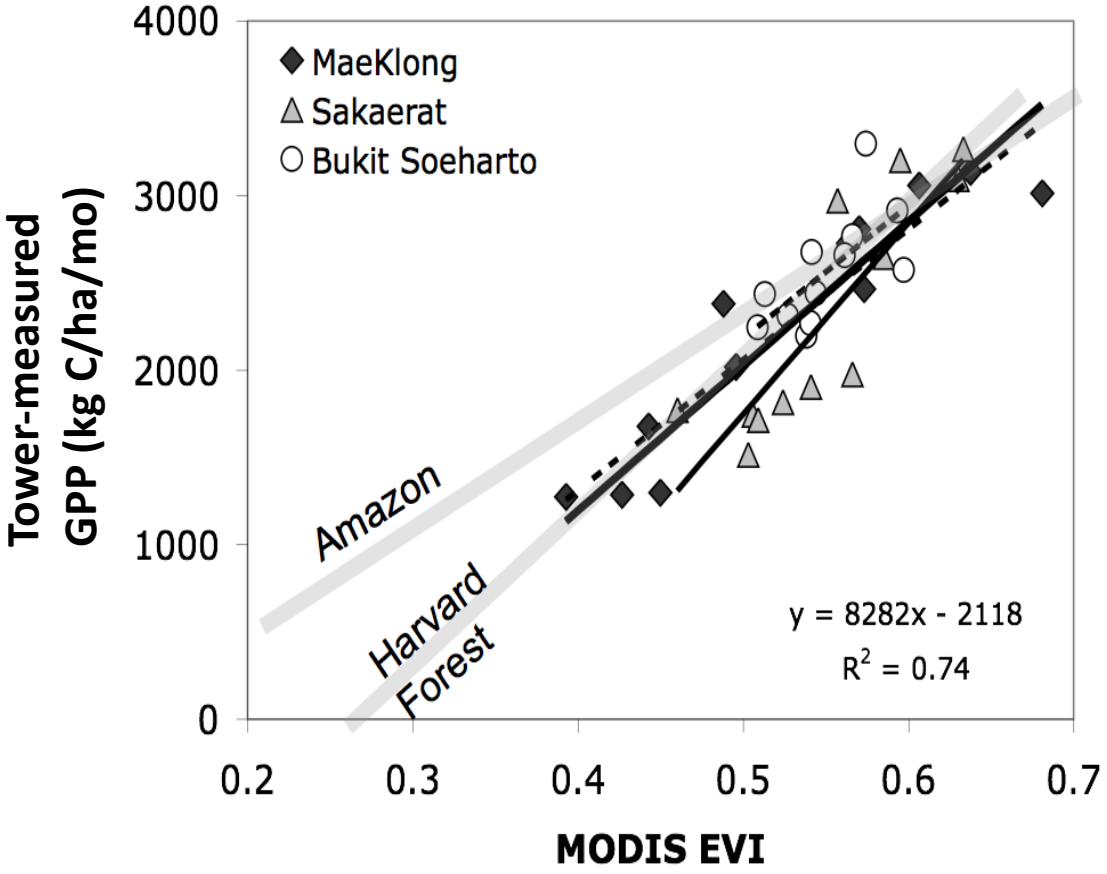
- Hypothesis Provided by models – **prompt negative response**



(the Hadley Center GCM coupled to TRIFFID Veg. model)

Jones, et al., 2001. *J. of Climate*

Basic large scale measure is provide by EVI, which has been tested with towers, and found to be correlated with GPP



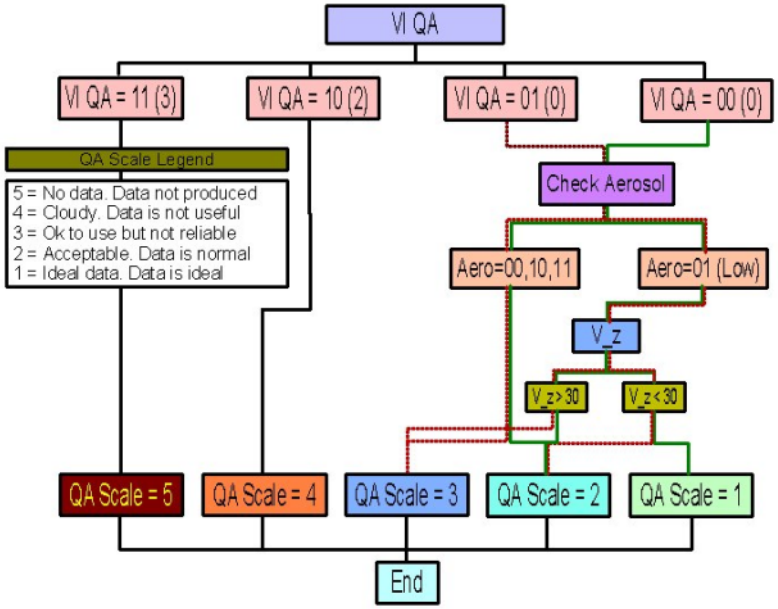
Huete et al., Ag. & For. Meteo 2008

Data and method(s)

- TRMM Precipitation (0.25^{o})
- MODIS* Terra 1km 16-day EVI record
  - EVI (Because NDVI saturates over dense forest)
  - Pixel Reliability
    - Derived from the VI output pixel QA
    - Ordinal number to simply archive and post-processing
  - Standardized anomaly following Aragao et al, GRL 2007
- We also used techniques & results from
  - Ranga et al, (email/manuscript, 2009)
  - Ganguly et al, (manuscript a&b , 2009)
  - Samanta et al, (AGU 2009 poster)

Data filtering & Methodology

- Pixel reliability is based on a decision tree that uses the following information (Didan & Huete, 2005, White paper - MODIS C5 planning)
  - Pixel QA
  - The VI values
  - Viewing geometry
- Generates data reliability classes
  - Ideal (No issues)
  - Good data
  - Marginal data
  - Cloudy
  - Snow/Ice
  - No Data
- Standardized Anomalies, following Aragao et al, 2007, GRL



Original ranking scheme – The actual method is a slight modification of this

QA filtering

- **The purpose is to remove potentially poor quality pixels (identical to S,G,R et al., methods)**

- **QA filtering**
  - RANK = 0 (IDEAL) Data with no cloud, no mixed cloud, no adjacent cloud, no shadow, no climatology aerosol, no high aerosol and view angle < 45 Deg. and Sun angle < 75 Deg.
  - RANK = 1 (GOOD) Data with no cloud, no mixed cloud, no adjacent cloud, no shadow, no climatology aerosol, no high aerosol and view angle > 45 Deg. and/or Sun angle > 75 Deg.

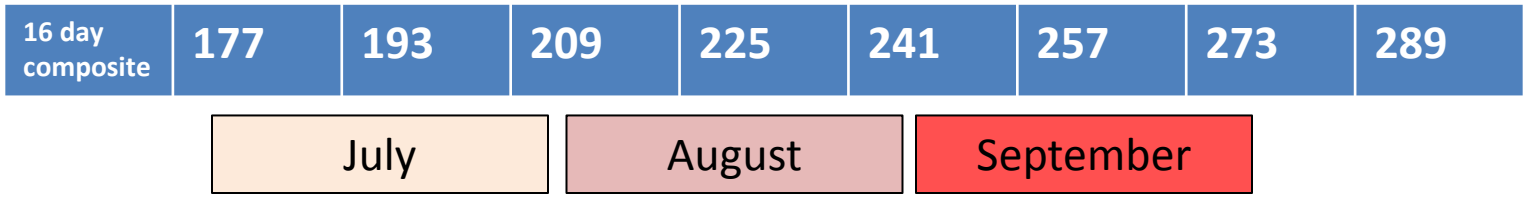
- **We've ALWAYS used the same QA filter as advocated by S,G,R et al., 2009.**

Aggregation method

- **For selecting from and calculating statistics on the valid pixels**
- **Observation filter**
  - Relaxed Filter : As long as there are valid 16-day periods in the JAS quarter the anomaly is computed
  - Restricted Filter : Valid 2005 JAS observations are used to restrict all other obs.

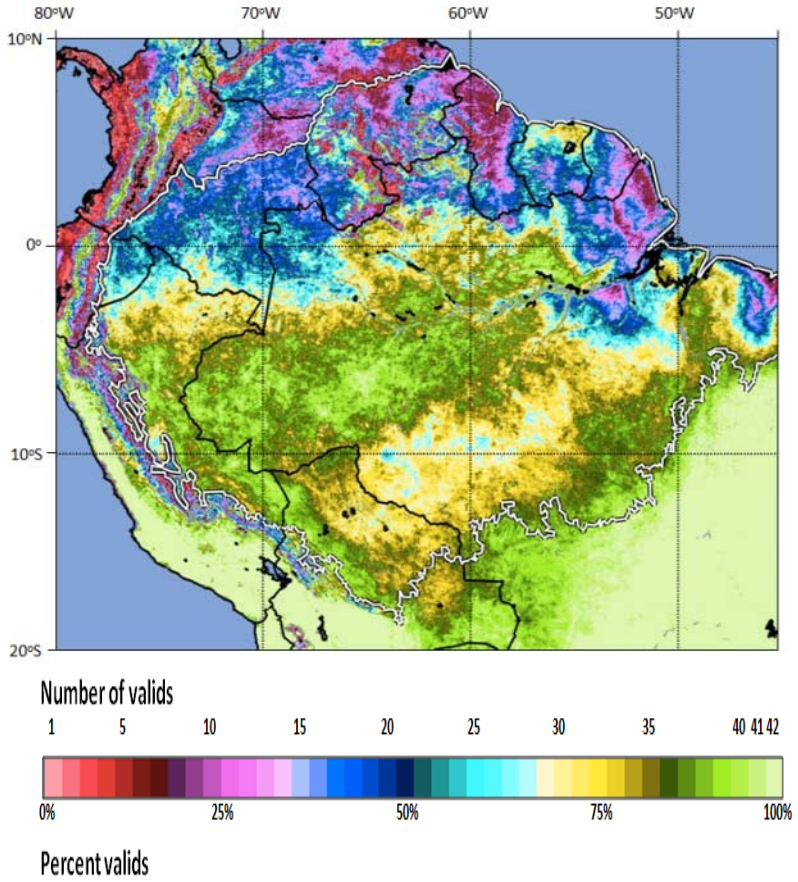
- **Additional notes**
  - Discard observations with Average aerosol loads
  - The JAS quarter is constructed from either 6 periods, 7 periods or lagged with one additional period from early October

- **Possible composites to use (Overlap between 16-day composites and JAS)**

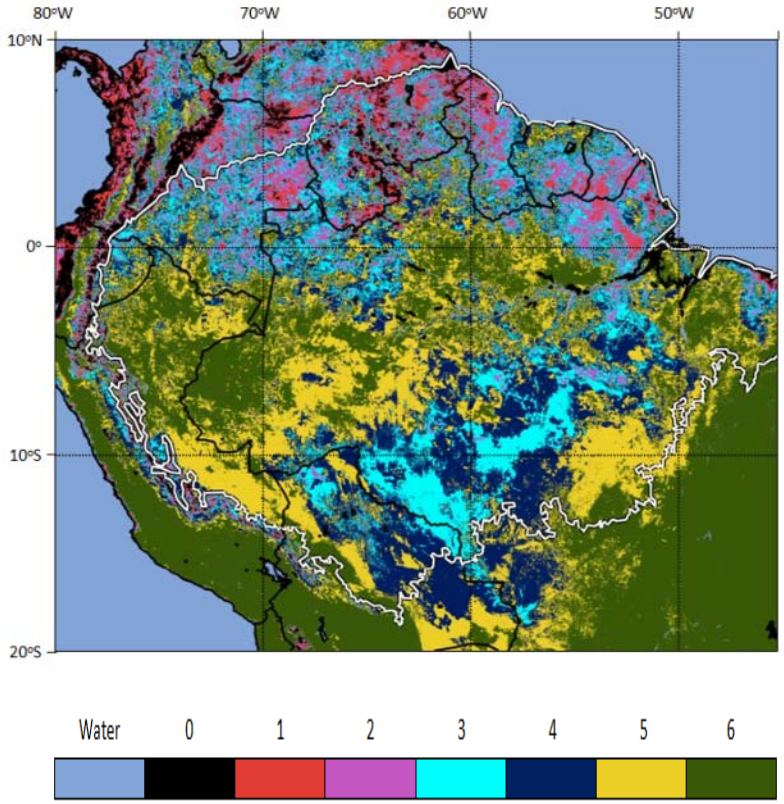


Summary number of JAS valid observations 2000-2006, & 6 composites (Our critics Methods) MAX = 7x6 = 42

All JAS quarters
Area of interest 75% and higher



2005 JAS
AOI : Minimum we have 3 obs.



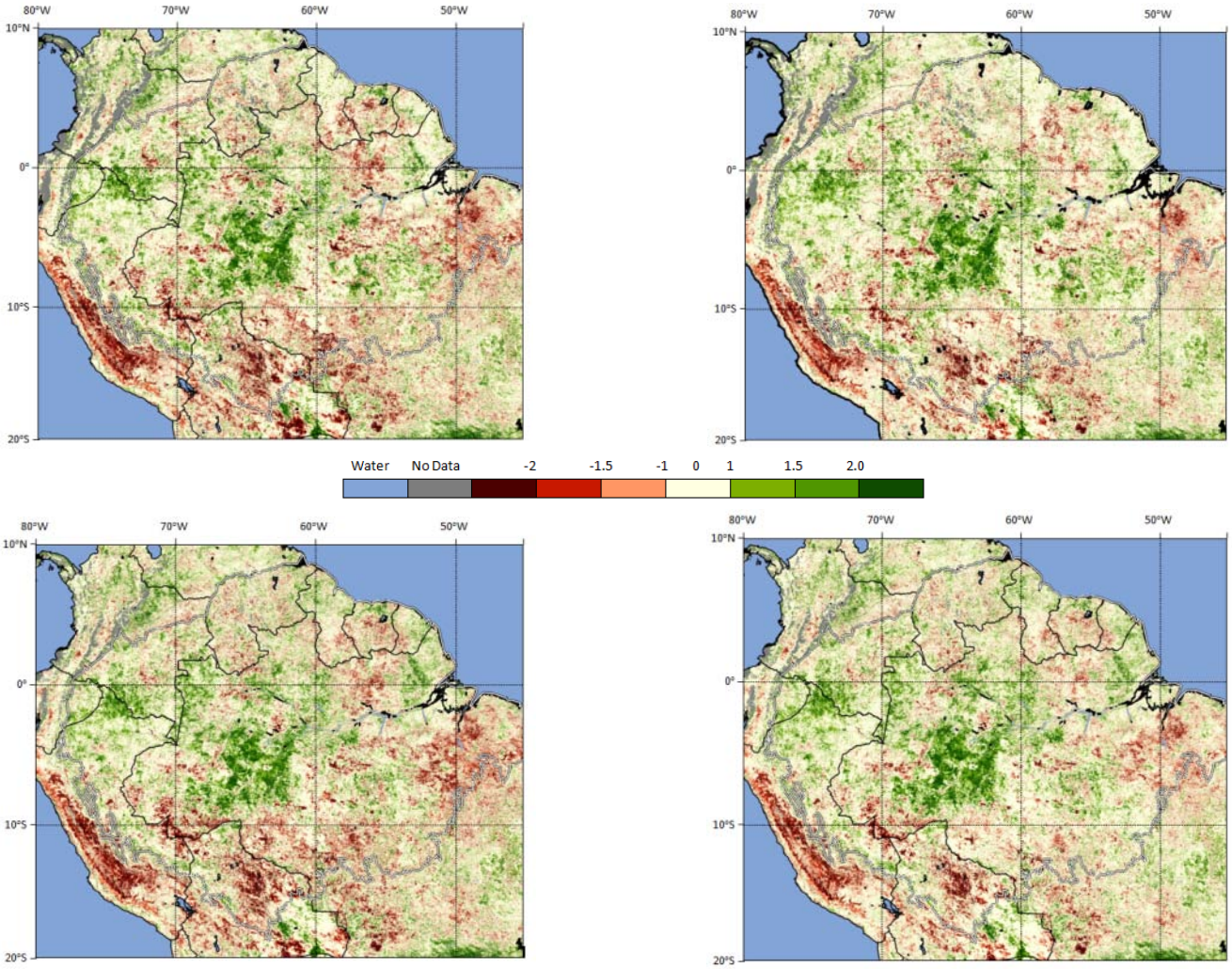
Results – Our method (C5)

2000 to 2006 based

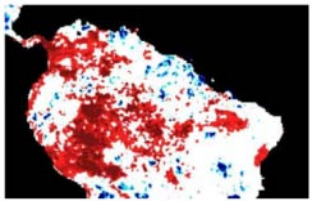
2000 to 2008 based

Strict filter

Relaxed filter

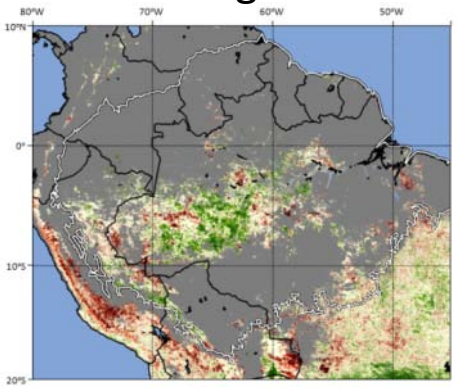


Results (‘00-’06)– Our method vs. Ranga’s
All methods same basic results (notwithstanding the discarded areas)

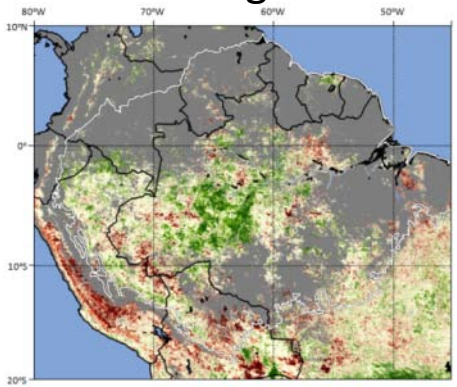


Masked by LC & Drought (>1sd)

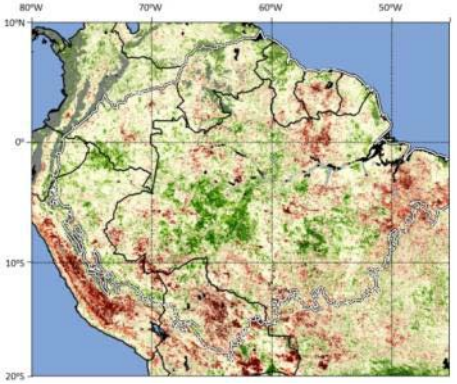
Ranga’s



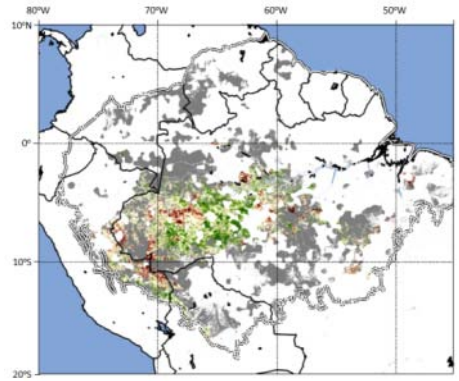
Ranga’s



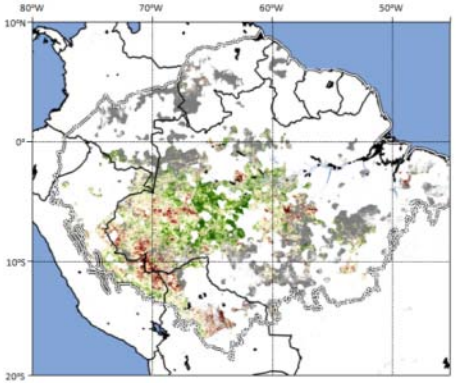
Our method



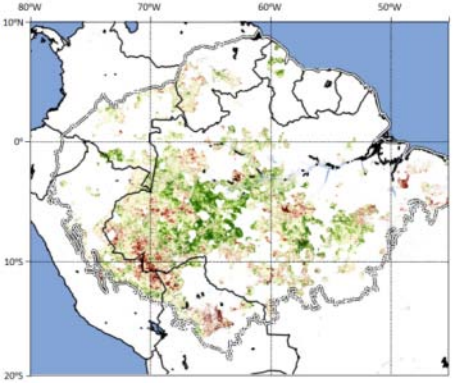
6 composites

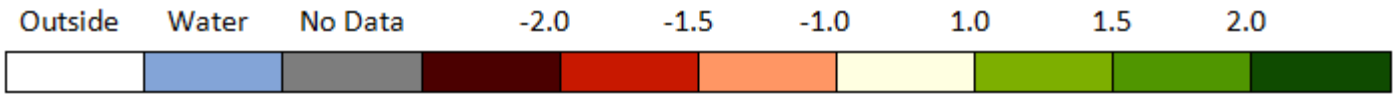


7 composites

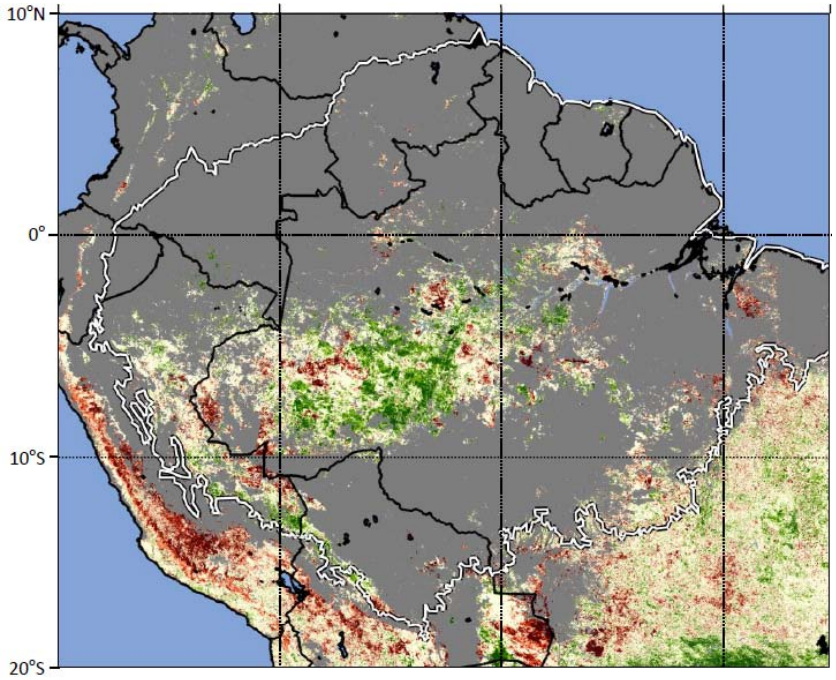


7 composites

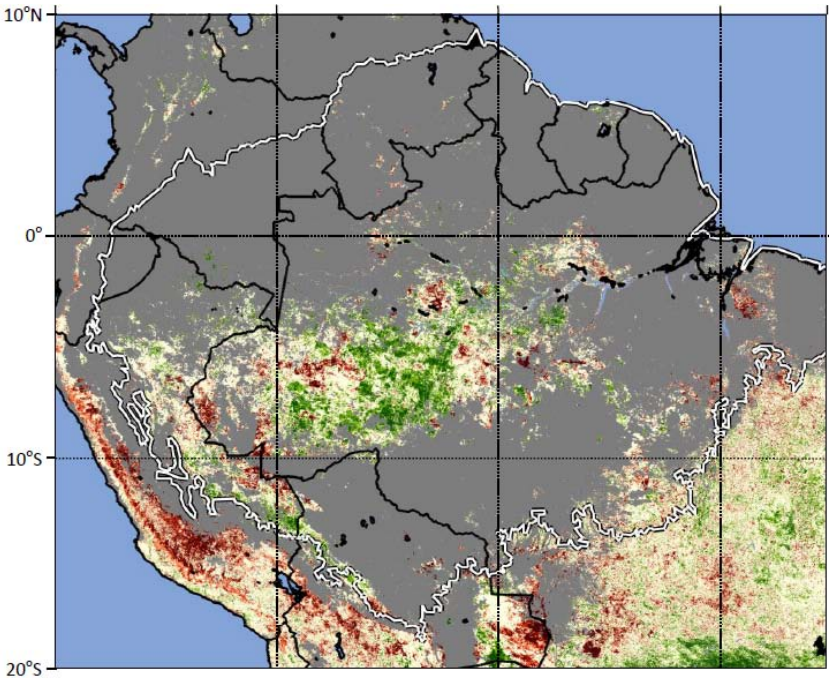




There is no technical disagreement between us and Ranga with regard to C5: We both agree on the basic (conservative) approach to filtering the basic data with QA, and we get the same result if we follow the same subsequent aggregation method (as can be seen here)



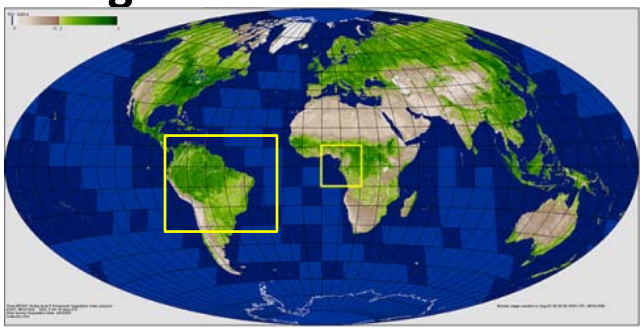
From Ranaga et al, Ganguly et al, Samanta et al, (2009) submitted manuscript



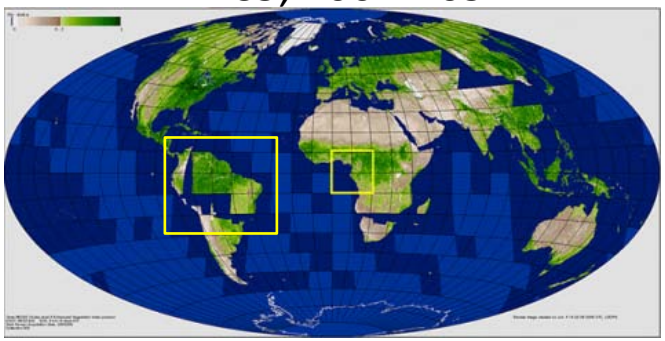
Our reproduction of their method (from Saleska et al 2009) – including the production error.

S, G, R et al., 2009, Aggregation method issues

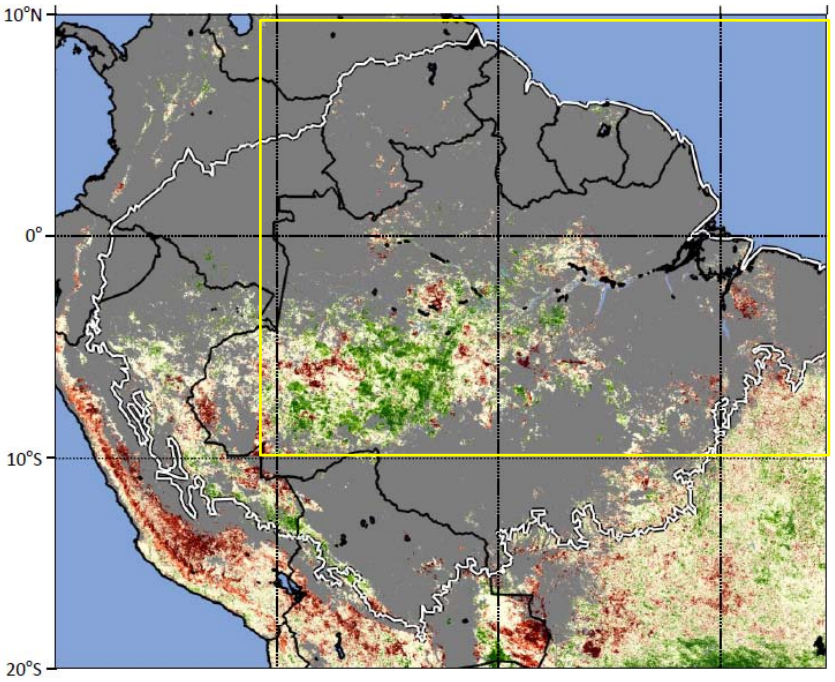
- **If the satellite is to experience problems for few days (which happened), or problems with production (which happened) their method discards all the data (In this case data with up to 95% good temporal coverage)**
- **With time this method will end up rejecting all observations and we can no longer use MODIS data**



C5, 2004-209

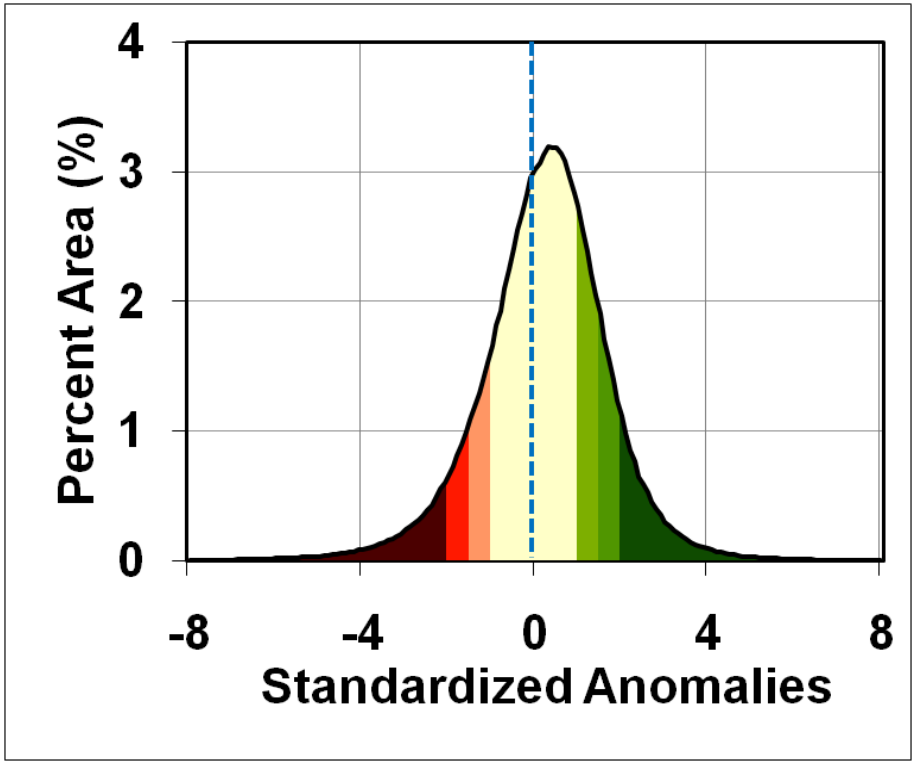


C5 production issues. 2 versions one with problems



Impact on analysis
Ranga et al, Ganguly et al, Samanta et al, 2009

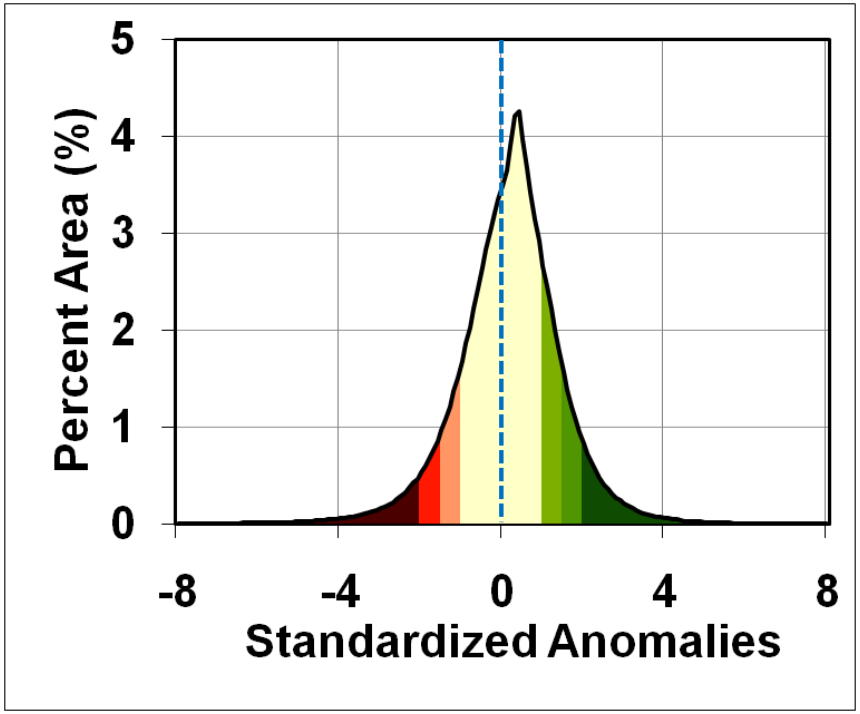
Anomaly histograms – Our method vs. Ranga's



R, G, S et al, 2009, methods

Less overall areas but more green in proportion

Our method



In summary:

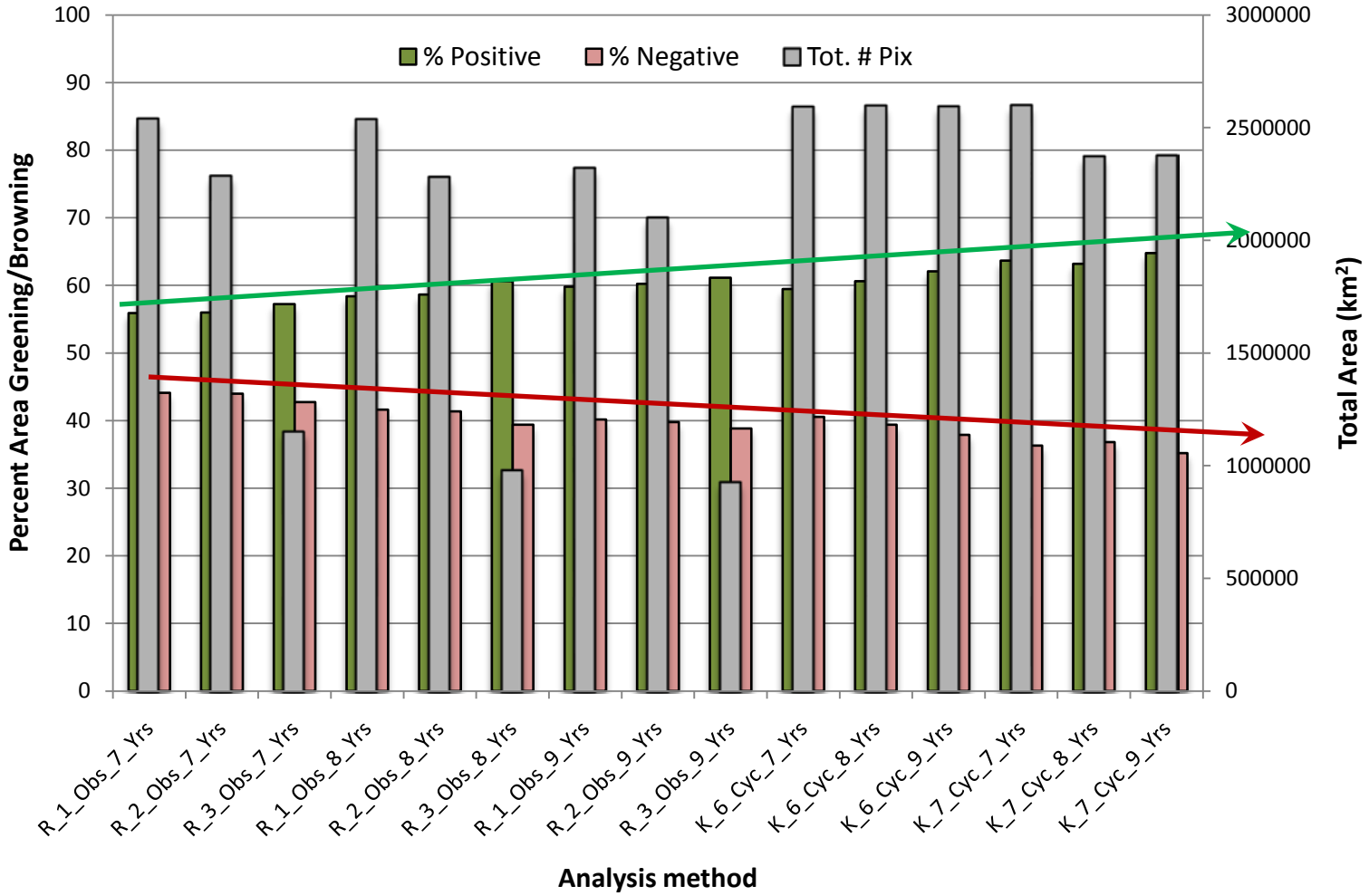
Whatever merits there may be in the arguments for different aggregation methods, it turns out in this application they don't matter: you get basically the same results -- statistically disproportionate greening -- no matter which aggregation method you use.

Statistical method 1:
null: number + = number -

Statistical method 2:
null: tails have equal sizes

	Valid area	Method 1: H_0: % Negative = %Positive			Method 2 H_0: %(An<-1) = %(An>+1)			
Data set	(10^6 km^2)	% Negative	% Postive	Prob	%NoChg	%brown (An < -1)	%green (An > +1)	Prob
Saleska et al. (2007) aggregation method. (note: 'C4 (00-06)' was published in Saleska et al., 2007)								
C4 (00-06)	2.2	36.0	64.0	<0.0001	55.3	10.7	34.0	$<10^{-6}$
C5 (00-06)	2.2	39.6	60.3	< 0.002	62.1	14.3	23.6	<0.009
C5 (00-08)	**2.0**	**35.4**	**64.6**	**< 0.0001**	**62.6**	**11.3**	**26.2**	**<0.0006**
Ganguly et al. aggregation method (requires 3 valid months per quarter to aggregate)								
C5 (00-06)	0.8	40.0	60.0	< 0.02	57.4	15.8	26.8	<0.03
C5 (00-08)	**0.7**	**36.6**	**63.4**	**<0.002**	**55.0**	**14.0**	**31.0**	**<0.004**
Ganguly et al. method, with sensitivity test (x1 requires 1 valid month, and x2, 2 months per quarter)								
C5 (00-08)x2	**1.8**	**39.7**	**60.3**	**<0.003**	**60.1**	**14.7**	**25.2**	**<0.02**
C5 (00-08)x1	**2.0**	**40.3**	**59.6**	**<0.004**	**61.1**	**14.7**	**24.2**	**<0.02**

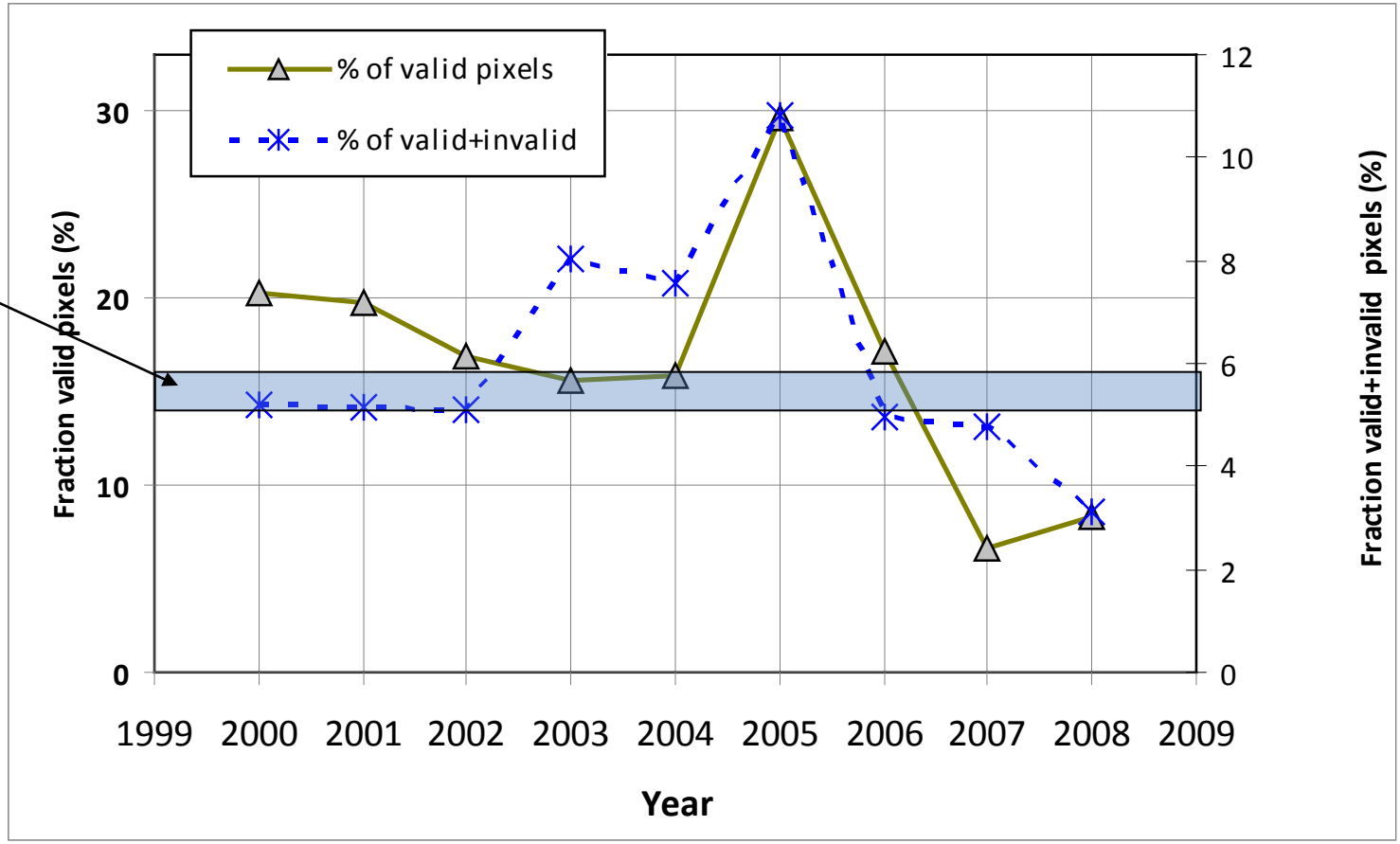
% Greening/Browning area sensitivity to the different methods



C5 EVI Greenness anomaly
(fraction of the 2005 drought area where ΔEVI > 1 SD)

Null hypothesis:

In a normal distribution, +/- 1 SD covers 68% of the data. 34% dEVI of the data is in the tails, 16% in the positive tail. Under the null, 16% of the area will have d(EVI)>1SD



EVI anomalies calculated according to Ganguly et al method
(according to which 64% of drought area is declared invalid)

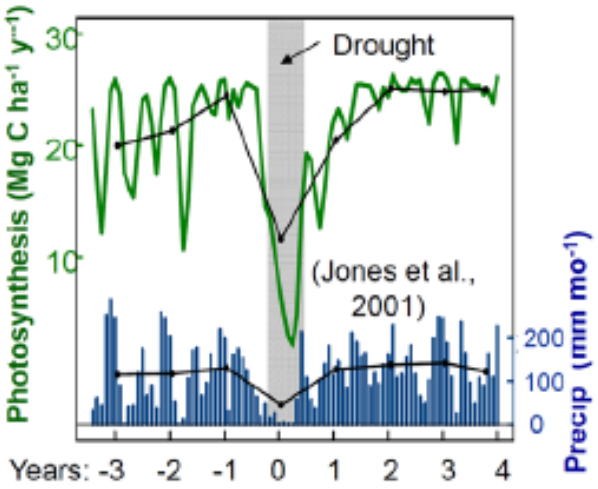
Fraction of valid+invalid pixels taken directly from Samanta et al AGU poster

Samanta et al conclude from this that: "***patterns of EVI changes… in 2005 are not unique compared to non-drought years.***"

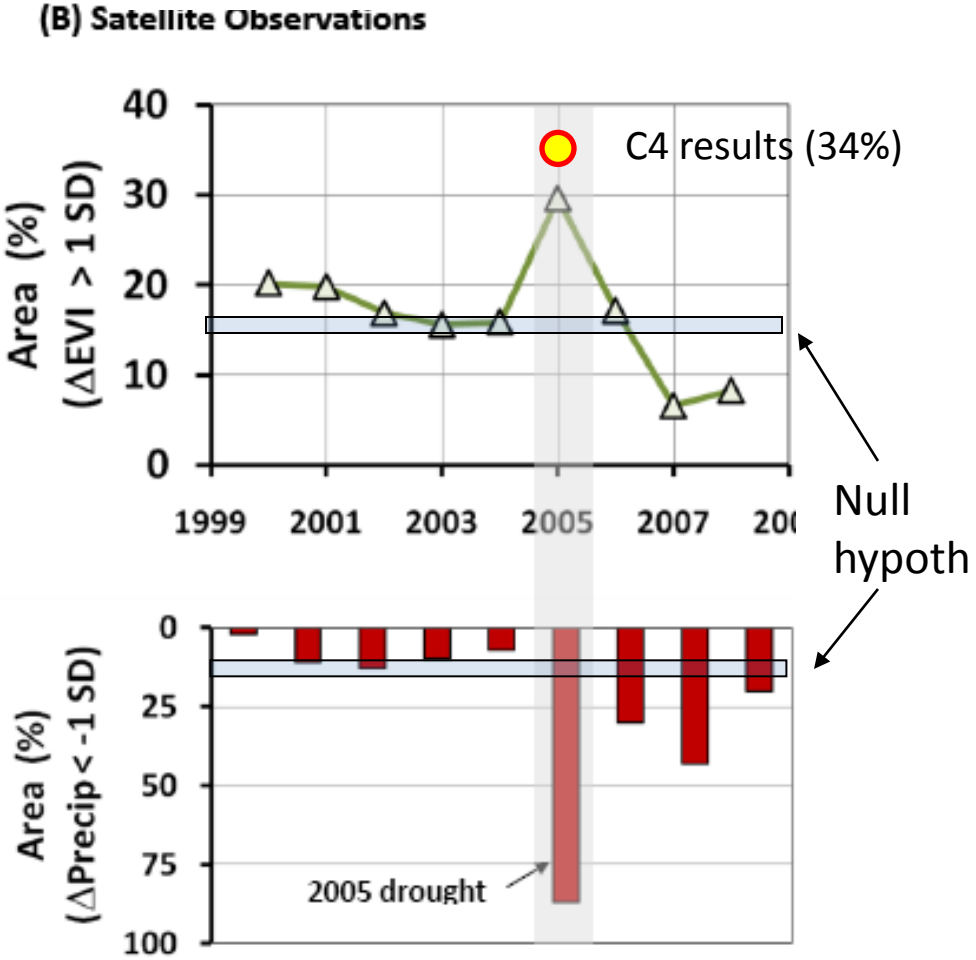
In closing:

The point is (a) expectation is the opposite of (b) observation (calculated according to the method of our critics, Samanta et al, Ganguly et al, and Ranga et al)!

What we expected



What we (including Ranga) observe



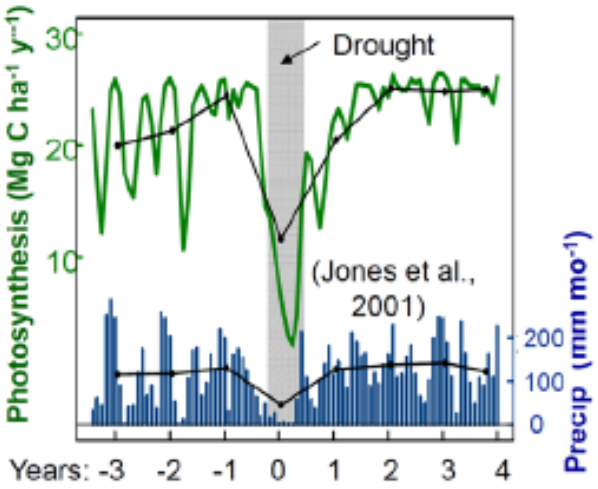
This was already reviewed

- The associate editor at Science declined to publish the technical comment by Ranga's group, because, in her words, "…**the arguments** presented in the comment [by Ranga et al.,], which **were well addressed** in the [Saleska, Didan, et al.] response, **in the end did not pose a sufficiently robust challenge** to the main conclusions of the original [Saleska, Didan, et al.] report…."

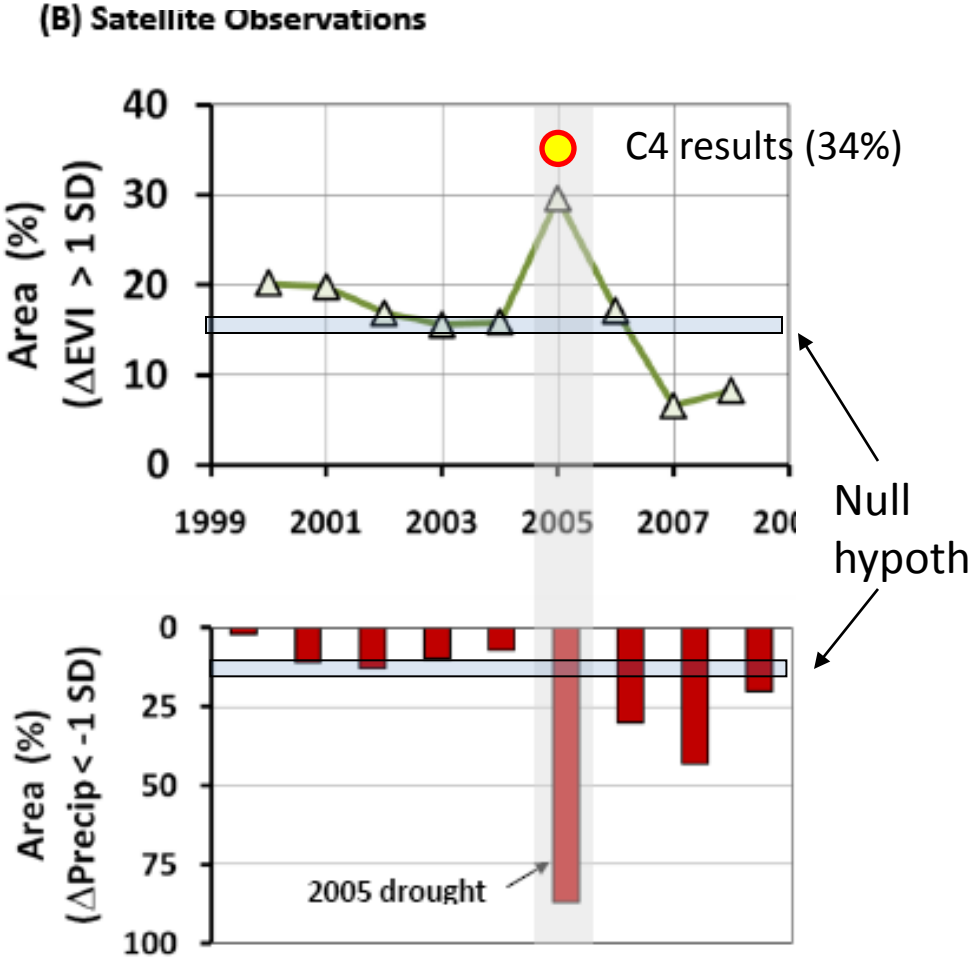
Once again:

The point is (a) expectation is the opposite of (b) observation (calculated according to the method of our critics, Samanta et al, Ganguly et al, and Ranga et al)!

What we expected



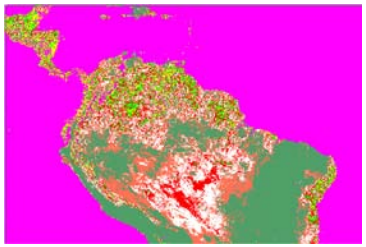
What we (including Ranga) observe



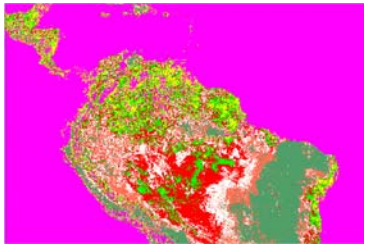
Backup slides

Number of valid observations – Various filtering and temporal coverage methods
JAS - 2005

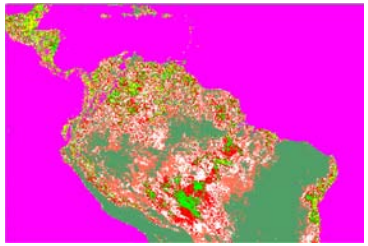
177-257
Kept Avg. Aerosol



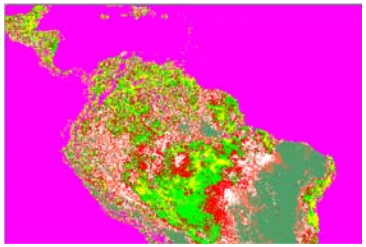
177-257
Filtered Avg. Aerosol



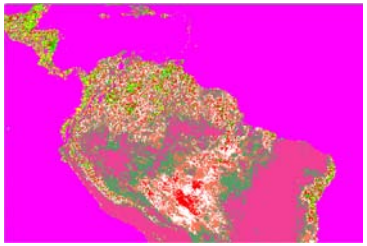
193-273
Kept Avg. Aerosol



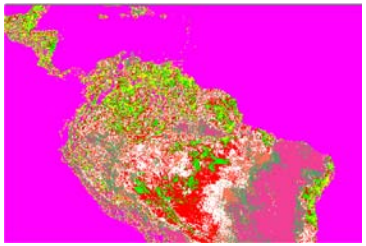
193-273
Filtered Avg. Aerosol



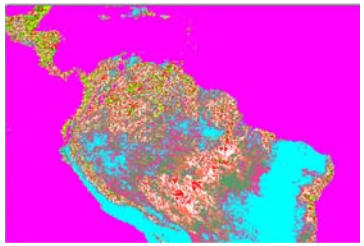
177-273
Kept Avg. Aerosol



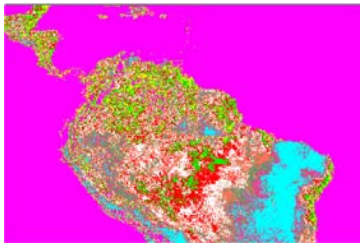
177-273
Filtered Avg. Aerosol



177-289
Kept Avg. Aerosol



177-289
Filtered Avg. Aerosol



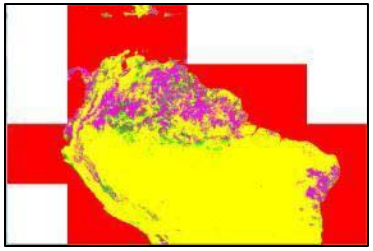
Number of valid observations

1	2	3	4	5	6	7	8

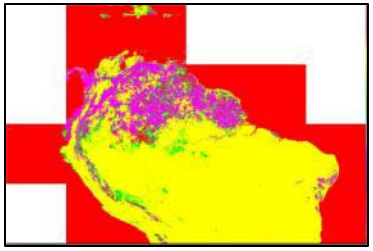
16 32 48 64 80 96 112 128 Days

Aerosol Distribution (JAS-2005)

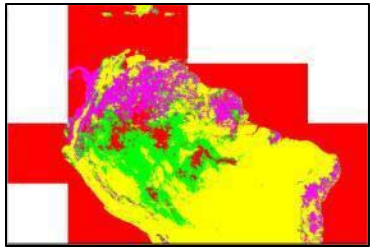
DOY - 177



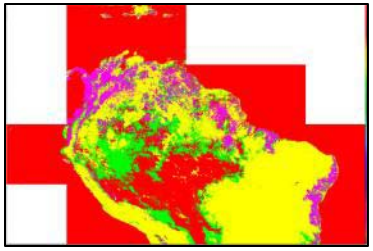
DOY - 193



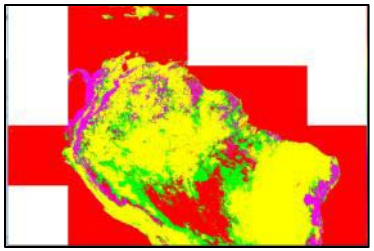
DOY - 209



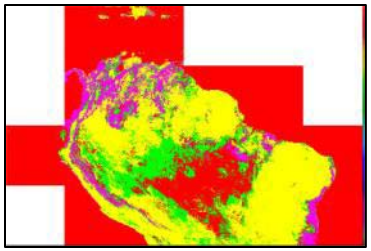
DOY - 225



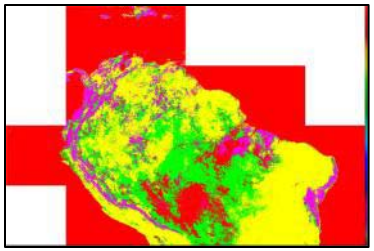
DOY - 241



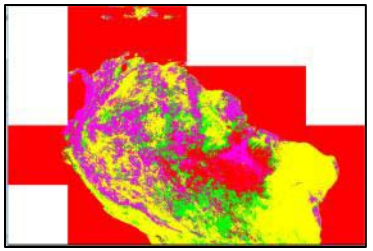
DOY - 257



DOY - 273



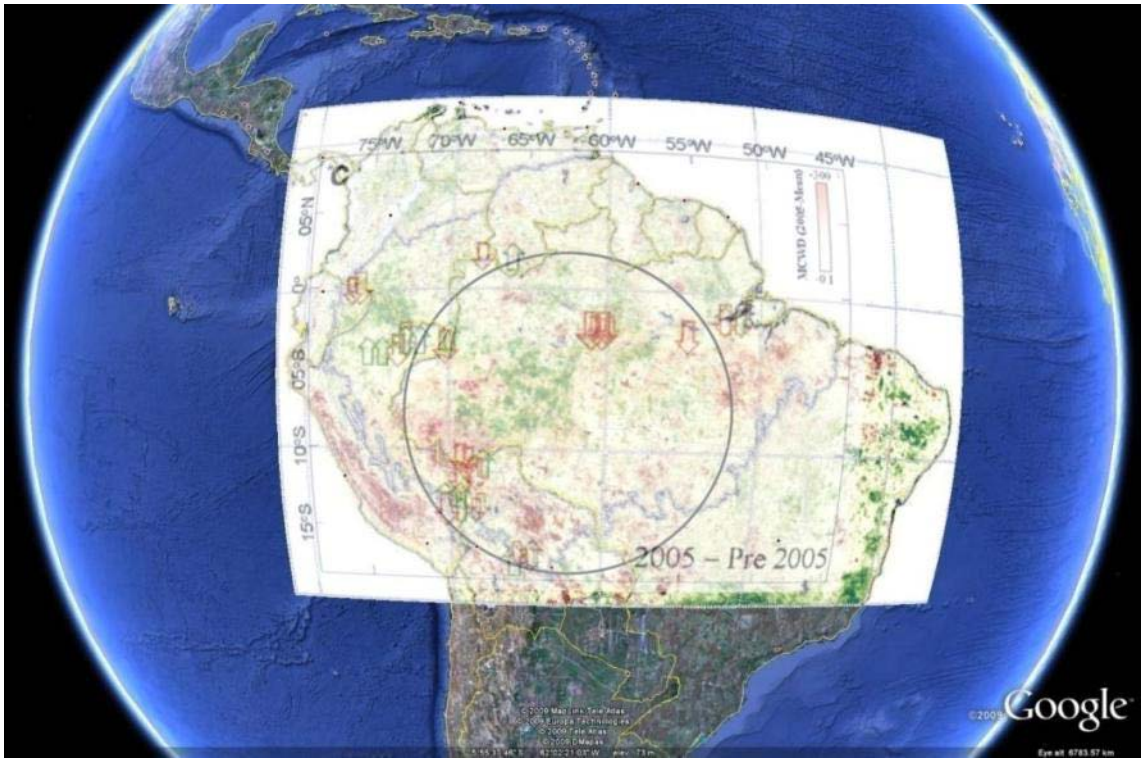
DOY - 289



Clim.	Low	Avg.	High

- Irrespective of the presence of aerosols there are usually at least a few days with clear/good observations to use

Notes on the Phillips et al paper



- One hectare plots versus remote sensing data
- Phillips looked at mortality (results of many things on top of drought, age, competition, hydrologic redistribution, etc…)
- We never said trees will survive all droughts, successive droughts, etc… We said in this case, short and tense drought, the usual did not happen and observation were different than model prediction.
- Most o the plots used/reported in Phillips were outside the bulk of the area of interest
- Eventually a tree will die if water is cutoff