



MODIS/VIIRS Science Team Meeting

Leaf Area Index (LAI) and Fraction of Photosynthetically Active Radiation (FPAR): Updates on MODIS and VIIRS

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Overview of MODIS & VIIRS LAI/FPAR

- ✓ Status of MODIS LAI/FPAR Product
 - Collection 3: November 2000 – December 2002 / **OBSOLETE!**
 - Collection 4: March 2000 – December 2006 / **OBSOLETE!**
 - Collection 5: February 2000 – Present
 - MO(Y)D15A2: Terra (Aqua) 8 day composite LAI/FPAR 1km
 - MCD15A2: Terra-Aqua combined 8 day composite LAI/FPAR 1km
 - MCD15A3: Terra-Aqua combined 4 day composite LAI/FPAR 1km
 - Collection 6: Reprocessing and Ready to be Released
 - MO(Y)D15A2H, MCD15A2H, MCD15A3H: Same with C5 but all for 500m

- ✓ Status of VIIRS LAI/FPAR Product
 - Collection 1.1: January 2012 – Present (Private Archive)
 - D8LFPAR1_L3D: 8 day composite LAI/FPAR 1km (Moderate Band)
 - D8LFPARH_L3D: 8 day composite LAI/FPAR 500m (Image Band)



Update on MODIS LAI/FPAR – C5 vs. C6

- ✓ Changes in Collection 6 LAI/FPAR
 - L2G-lite surface reflectance at 500m resolution as (MOD09GA) input in place of reflectance at 1km resolution (MODAGAGG)
 - New multi-year land cover product at 500m resolution in place of the 1km resolution static land cover product
 - Uses the C5 science algorithm and LUT

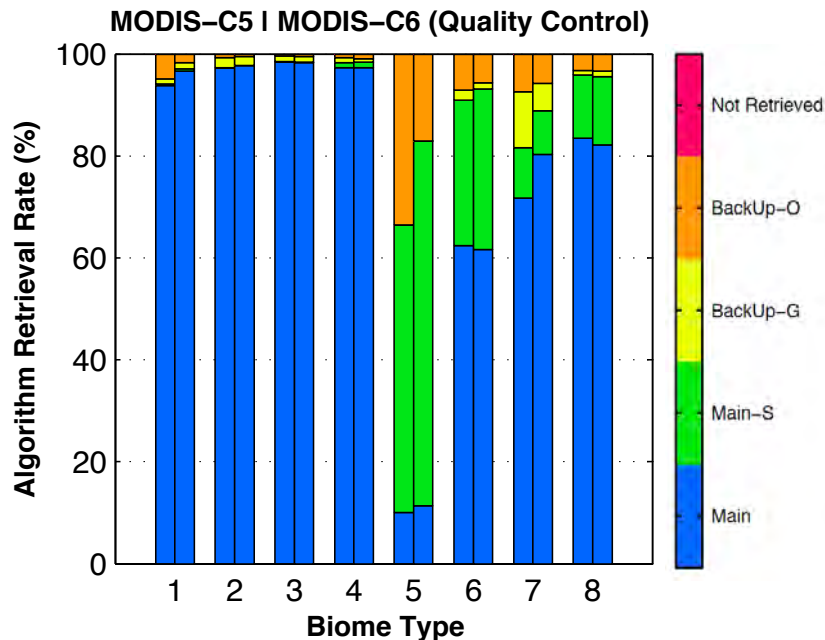
- ✓ C5 vs C6 Comparison Tests
 - MODIS C5: MOD15A2 (1km)
 - MODIS C6: MOD15A2H (500m)
 - Test Period: Jan 1st 2003 (DOY: 001) – Dec 31st 2003(DOY:365)
 - Test Coverage: Global Scale



Update on MODIS LAI/FPAR – C5 vs. C6

✓ Spatial Coverage (Retrieval Index)

- Proportion of Main algorithm execution => Proxy of retrieval quality
- C6 shows slightly improved spatial coverage for most biomes
- Especially, 17% increase in biome 5
- Overall, comparable spatial coverage with C5 product

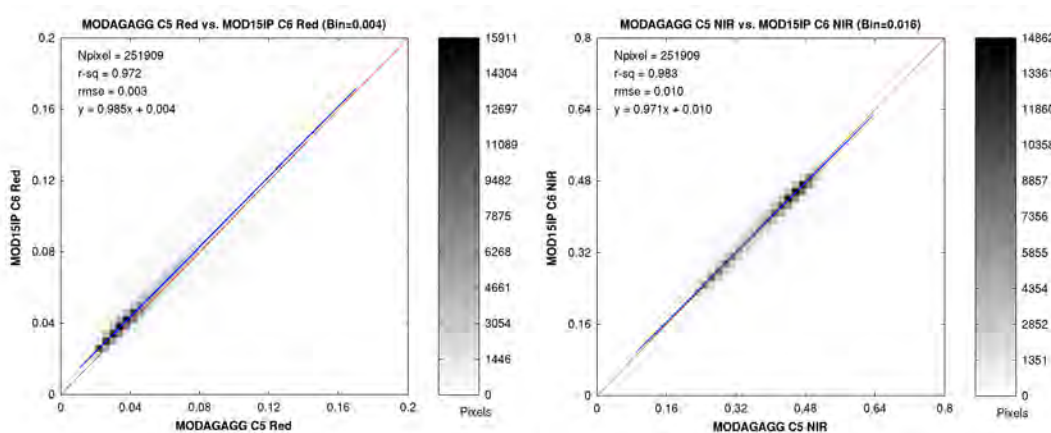


- **Main:** Main algorithm was executed
- **Main-S:** Main algorithm was executed. Saturation
- **BackUp-G:** View/sun zenith angle too low. Backup retrievals
- **BackUp-O:** Main algorithm fails. Backup retrievals
- **Not Retrieved:** not executed because BRF is not available

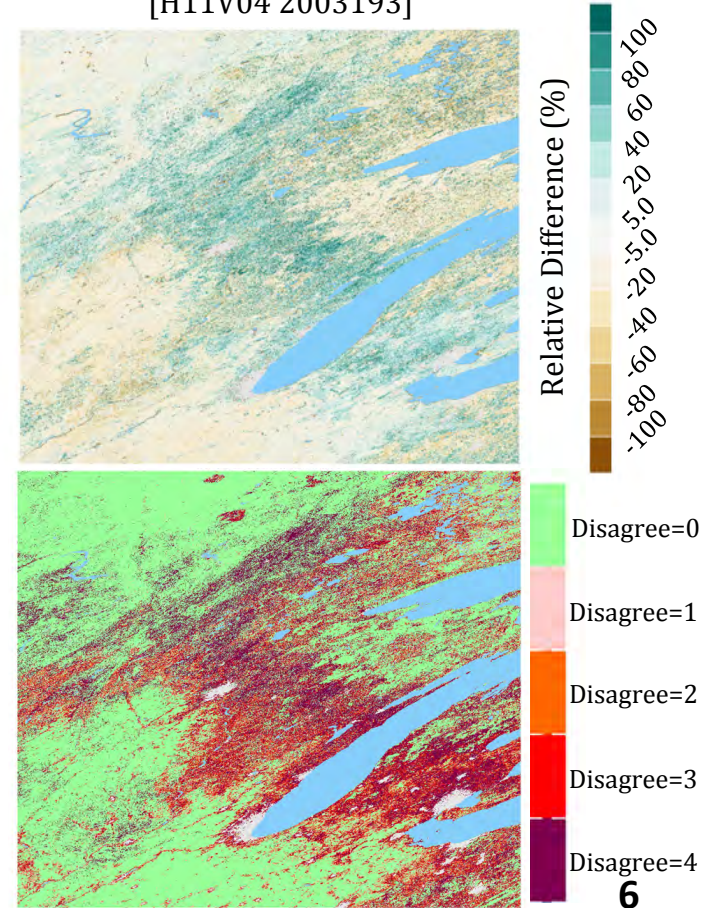


Update on MODIS LAI/FPAR – C5 vs. C6

- ✓ Possible inconsistency due to changes in input
 - Positive bias (0.0035 or 9%) in red band induces negative bias in LAI/FPAR
 - LAI/FPAR C5 and C6 input biome maps disagree by about 30%



[H11V04 2003193]



[Biome Type Input change between C5 and C6 Product]

C6 \ C5	B1	B2	B3	B4	B5	B6	B7	B8	Total (C6)
B1	15.55	4.87	4.14	2.17	0.32	0.30	0.34	0.02	27.70
B2	1.01	16.95	0.04	0.82	0.01	0.04	0.13	0.06	19.08
B3	0.89	0.11	2.22	0.42	0.13	0.04	0.01	0.00	3.82
B4	1.36	1.63	1.46	13.87	1.59	0.64	1.52	0.21	22.29
B5	0.11	0.06	0.10	0.42	12.75	0.16	0.32	0.00	13.92
B6	0.40	0.09	0.23	0.45	0.39	2.36	1.27	0.02	5.22
B7	0.07	0.15	0.03	0.29	0.14	0.20	5.08	0.07	6.02
B8	0.04	0.17	0.00	0.22	0.01	0.09	0.38	1.03	1.95
Total (C5)	19.45	24.03	8.23	18.66	15.34	3.84	9.05	1.41	69.82
Gain&Loss	8.25	-4.95	-4.41	3.63	-1.42	1.38	-3.03	0.54	

(unit: % wrt Global Land Area)

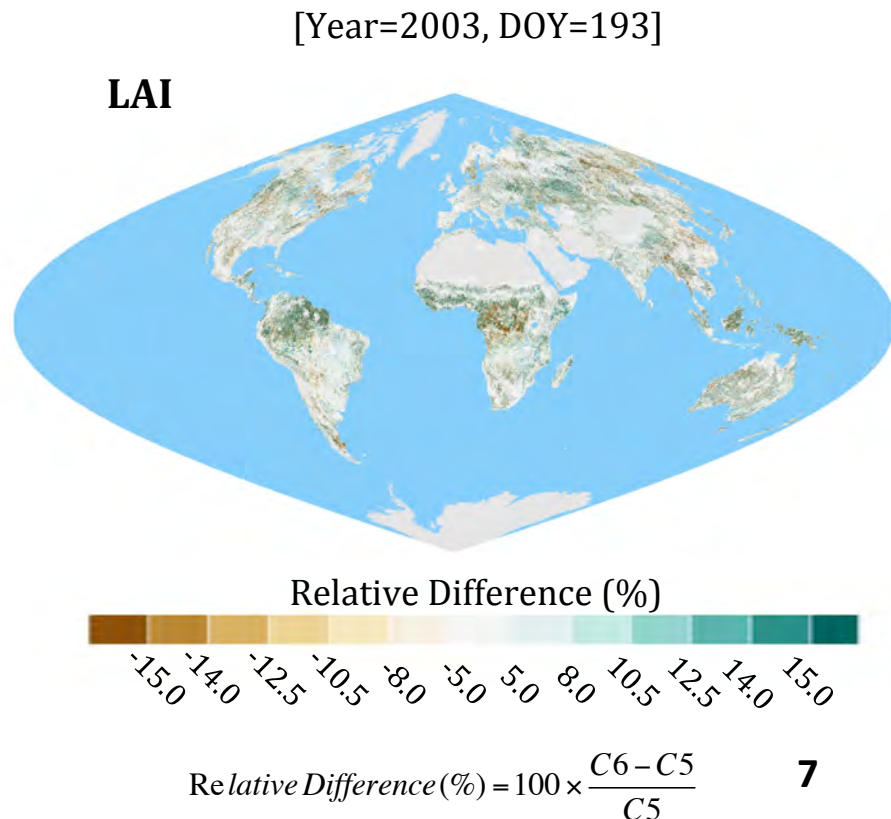


Update on MODIS LAI/FPAR – C5 vs. C6

- ✓ Consistency between C5 and C6 (LAI)
 - C6 underestimates C5 LAI
 - For the same biome input, C6 produces global **LAI within $C5 \pm 0.29$**
 - Biome type disagreement worsens the consistency ($C5 \pm 0.39$)

Relative Difference (%)	Disagree=0	Disagree=1	Disagree=2	Disagree=3	Disagree=4
B1	0.33	-0.75	0.85	1.52	8.21
B2	-1.42	1.67	4.52	7.01	7.19
B3	-1.22	10.26	20.81	31.27	44.63
B4	-0.26	-2.56	-5.04	-7.87	-14.13
B5	-1.61	-12.52	-25.82	-39.17	-49.82
B6	-2.27	-0.34	1.84	4.39	1.81
B7	-6.75	-9.65	-13.48	-17.81	-20.38
B8	-6.35	-10.84	-15.93	-20.18	-24.13
Mean	-1.34	-1.97	-1.92	-1.62	1.82
Overall	-0.85				

Absolute Difference	Disagree=0	Disagree=1	Disagree=2	Disagree=3	Disagree=4
B1	±0.24	±0.30	±0.33	±0.39	±0.43
B2	±0.15	±0.21	±0.24	±0.25	±0.23
B3	±0.22	±0.23	±0.28	±0.35	±0.40
B4	±0.26	±0.30	±0.36	±0.42	±0.40
B5	±0.62	±0.65	±0.71	±0.82	±1.00
B6	±0.48	±0.48	±0.52	±0.58	±0.52
B7	±0.51	±0.50	±0.54	±0.60	±0.73
B8	±0.57	±0.56	±0.61	±0.68	±0.82
Mean	±0.29	±0.33	±0.40	±0.50	±0.60
Overall	±0.39				



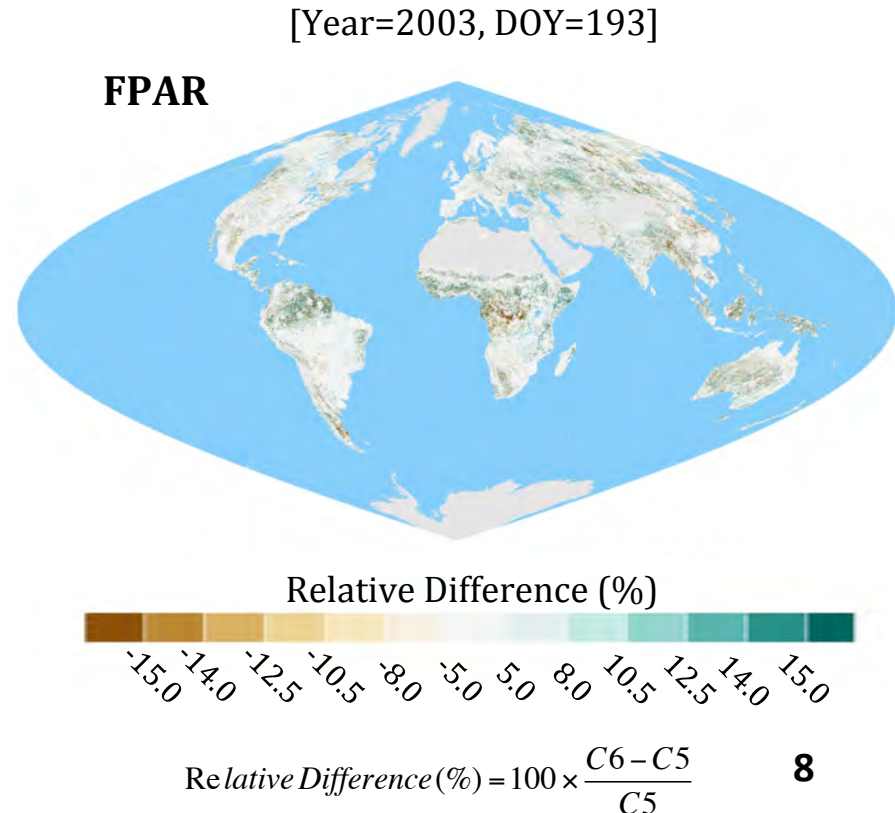


Update on MODIS LAI/FPAR – C5 vs. C6

- ✓ Consistency between C5 and C6 (FPAR)
 - C6 underestimates C5 FPAR
 - For the same biome input, C6 produces global **FPAR within $C5 \pm 0.051$**
 - Biome type disagreement worsens the consistency ($C5 \pm 0.066$)

Relative Difference (%)	Disagree=0	Disagree=1	Disagree=2	Disagree=3	Disagree=4
B1	-0.25	-0.40	0.51	1.03	4.11
B2	-0.91	-1.31	-1.70	-2.16	-3.42
B3	-0.56	1.59	3.75	6.05	10.75
B4	0.00	-0.17	0.02	0.17	-1.29
B5	-0.56	-7.44	-14.96	-22.33	-28.66
B6	-1.35	-1.41	-2.08	-2.83	-7.33
B7	-2.67	-6.33	-10.12	-14.27	-17.64
B8	-2.49	-6.77	-10.81	-14.01	-16.67
Mean	-0.60	-1.49	-1.95	-2.27	-1.46
Overall	-0.97				

Absolute Difference	Disagree=0	Disagree=1	Disagree=2	Disagree=3	Disagree=4
B1	±0.051	±0.060	±0.063	±0.067	±0.071
B2	±0.040	±0.054	±0.056	±0.057	±0.054
B3	±0.048	±0.055	±0.061	±0.068	±0.073
B4	±0.048	±0.055	±0.064	±0.074	±0.073
B5	±0.087	±0.101	±0.109	±0.124	±0.152
B6	±0.037	±0.054	±0.070	±0.084	±0.084
B7	±0.072	±0.075	±0.086	±0.102	±0.124
B8	±0.071	±0.084	±0.096	±0.111	±0.138
Mean	±0.051	±0.061	±0.071	±0.084	±0.095
Overall	±0.066				

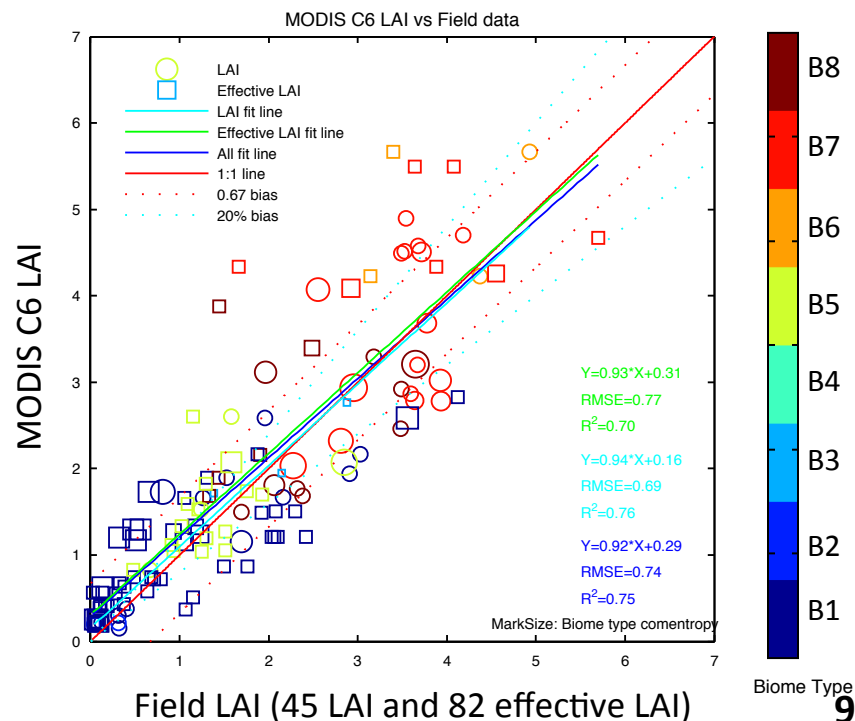
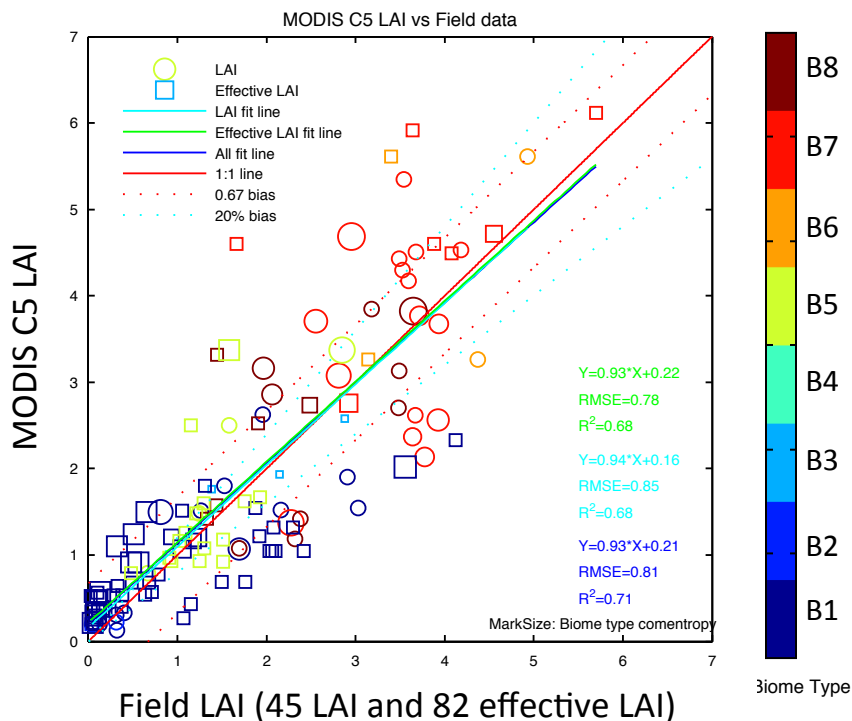




Update on MODIS LAI/FPAR – C5 vs. C6

✓ Validation of MODIS LAI Product

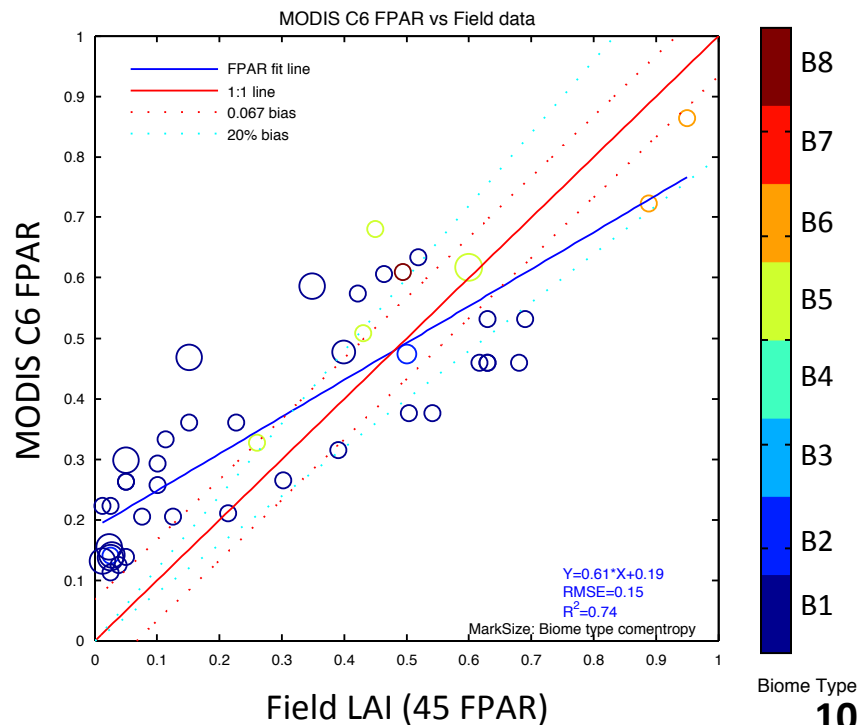
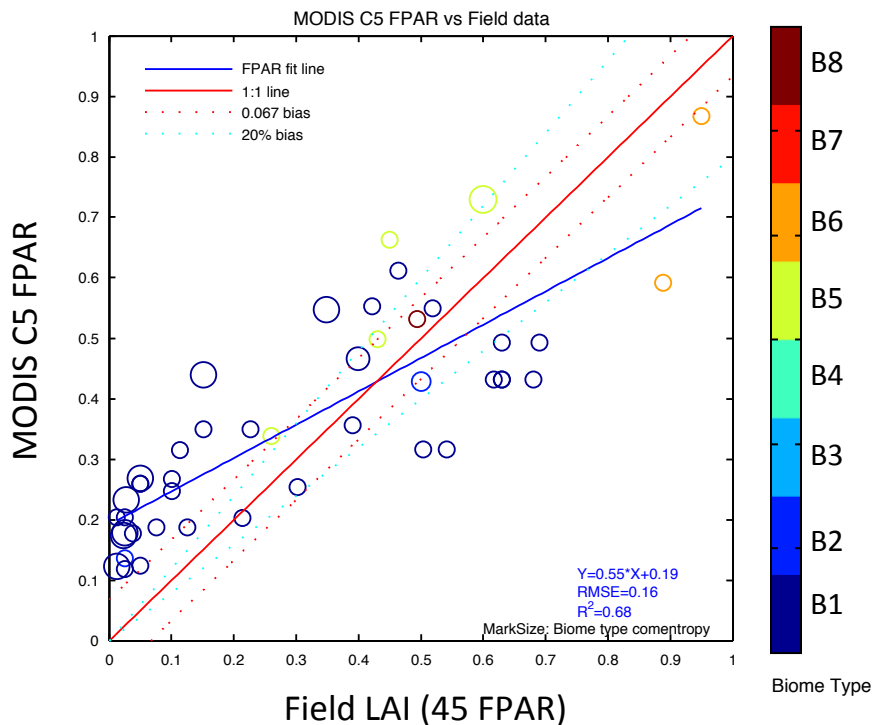
- LAIs & effective LAIs from DIRECT field data set
- C5: $RMSE_{LAI}=0.85$, $RMSE_{effLAI}=0.78$, $RMSE_{LAIall}=0.81$
- C6: $RMSE_{LAI}=0.69$, $RMSE_{effLAI}=0.77$, $RMSE_{LAIall}=0.74$
- C6 shows better agreement with field data compared to C5





Update on MODIS LAI/FPAR – C5 vs. C6

- ✓ Validation of MODIS FPAR product
 - Both C5 and C6 shows overestimation in lower FPAR
 - C6 (RMSE=0.15) shows a better agreement than C5 (RMSE=0.16)
 - Demand for higher FPAR and woody-biome samples
 - Demand for FPAR validation protocol (e.g., understory)

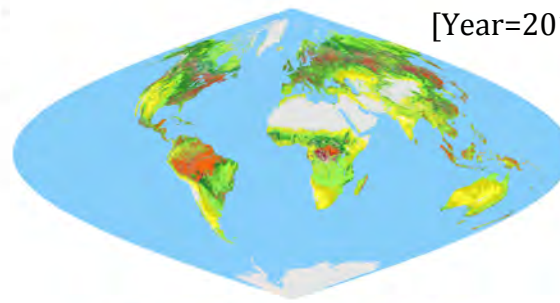
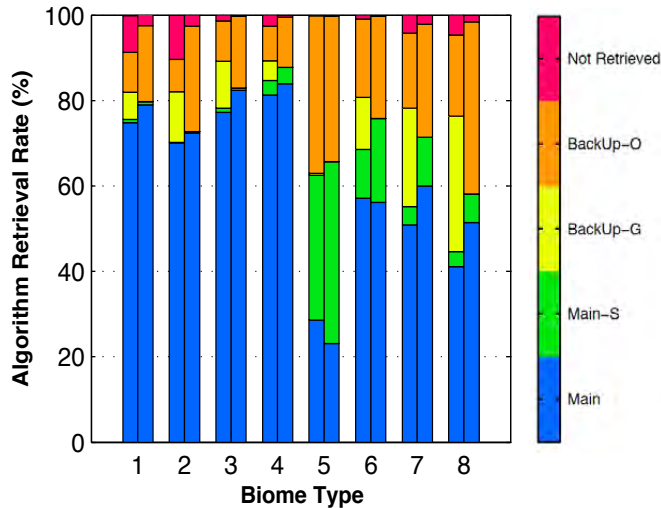




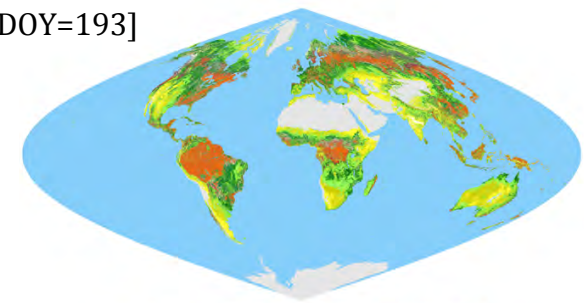
Update on VIIRS LAI/FPAR – MODIS vs. VIIRS

- ✓ Comparison between MODIS C5 and VIIRS C1.1 (MODIS LUT)
 - MODIS C5: MOD15A2 (1km)
 - VIIRS C1.1: D8LFPAR1_L3D (1km)
 - Test Period: Jan 1st 2013 (DOY: 001) – Dec 31st 2013(DOY:365)
 - Test Coverage: Global Scale
 - Spatial coverage and spatiotemporal pattern resemble with MODIS C5

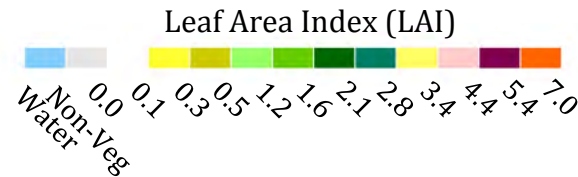
MODIS-C5 | VIIRS-C1.1



MODIS C5 LAI



VIIRS C1.1 LAI

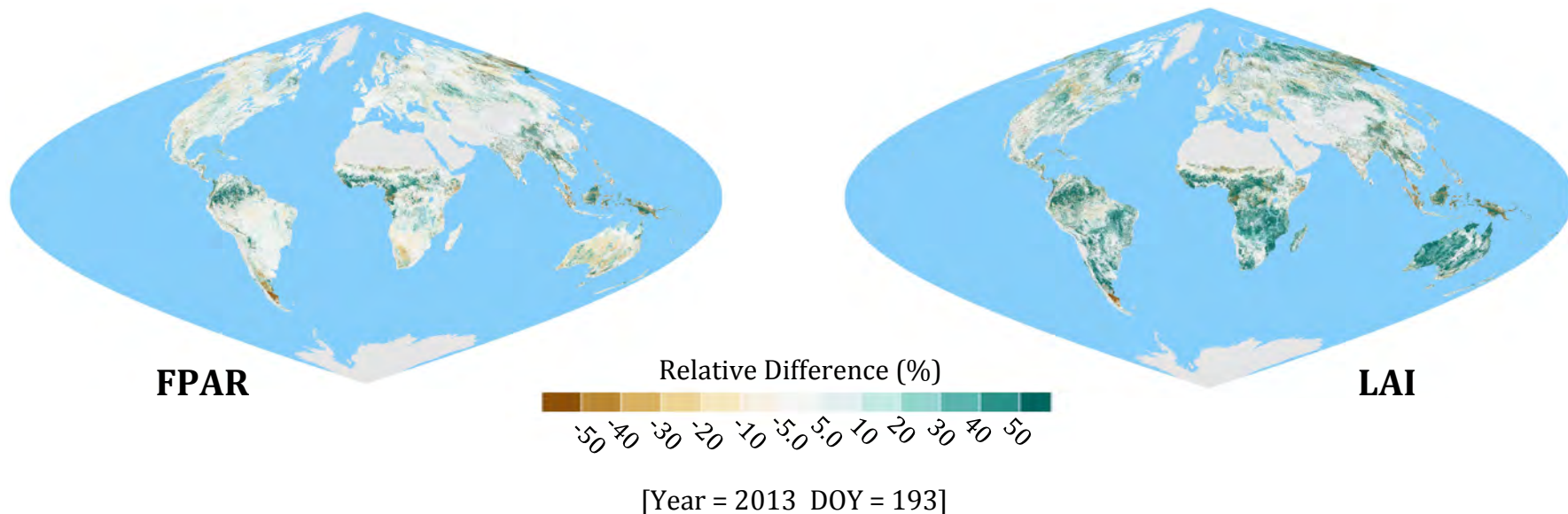


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- **Not Retrieved**: not executed because BRDF is not available



Update on VIIRS LAI/FPAR – MODIS vs. VIIRS

- ✓ Comparison between MODIS C5 and VIIRS C1.1 (MODIS LUT)
 - VIIRS overestimates C5 LAI & FPAR
 - VIIRS produces global **LAI within MODIS C5±1.81**
 - VIIRS produces global **FPAR within MODIS C5±0.207**
 - *Adjustments for VIIRS spectral band composition are needed*

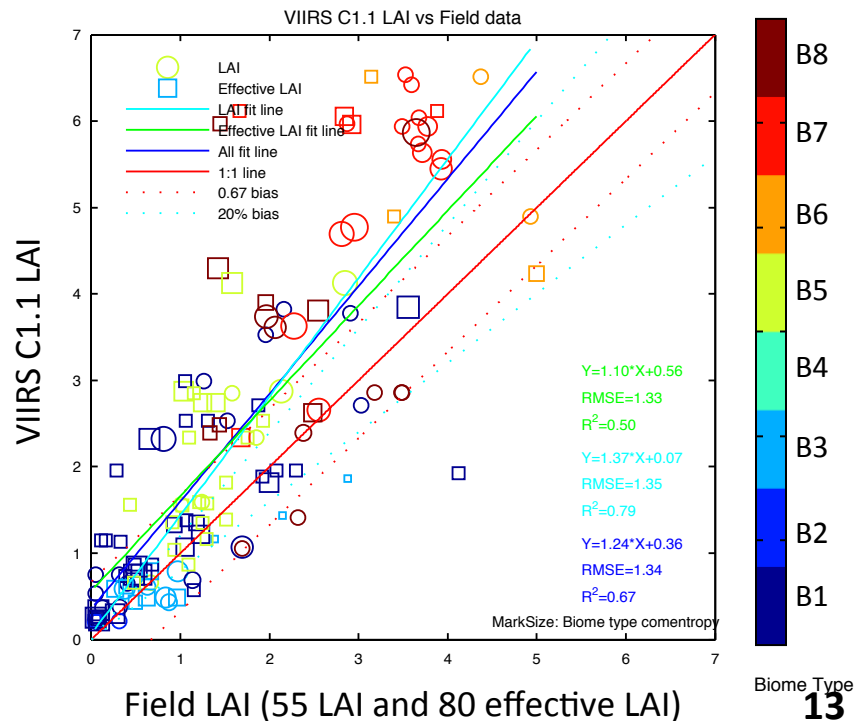
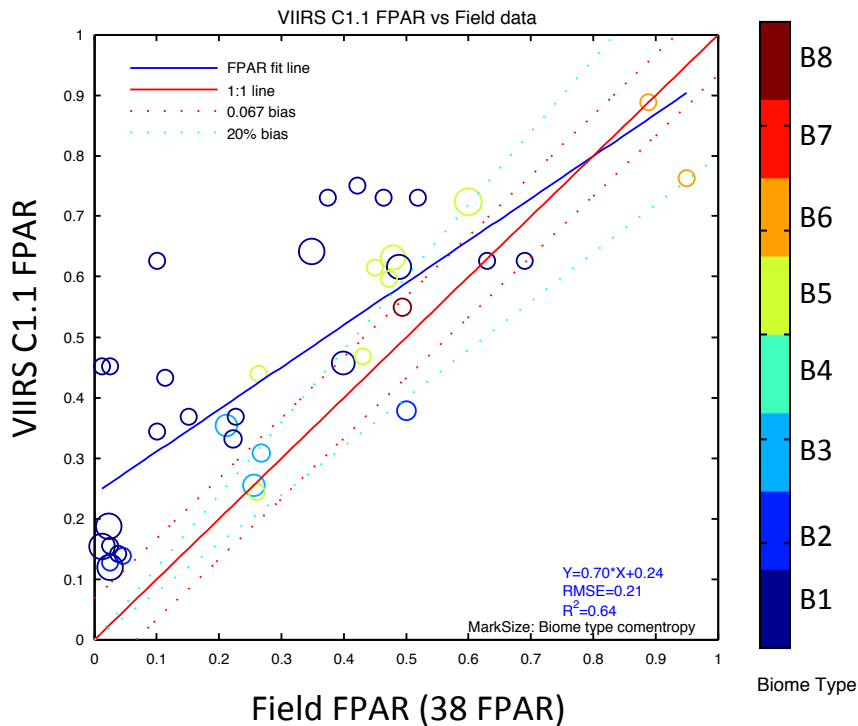


$$\text{Relative Difference}(\%) = 100 \times \frac{\text{VIIRS} - \text{MODIS}}{\text{MODIS}}$$



Update on VIIRS LAI/FPAR – MODIS vs. VIIRS

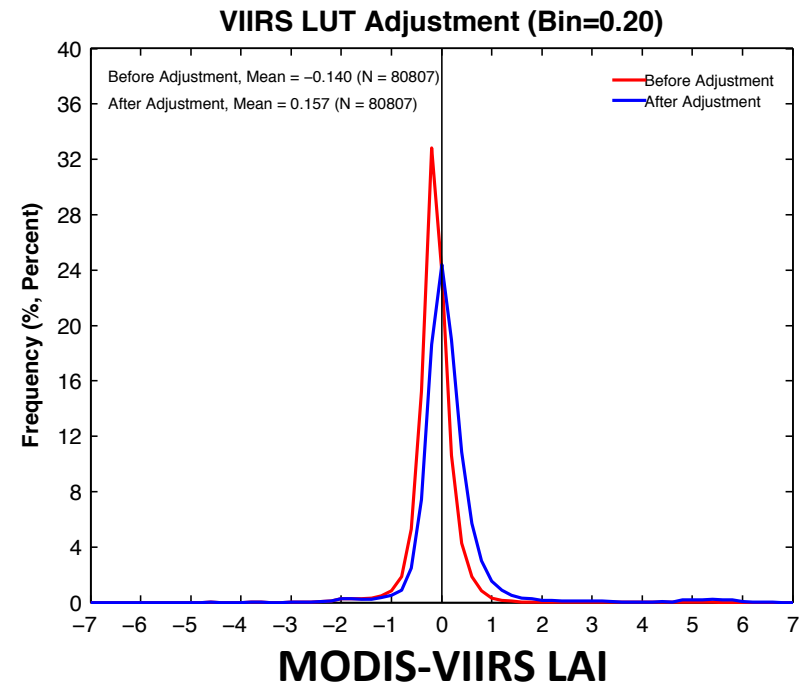
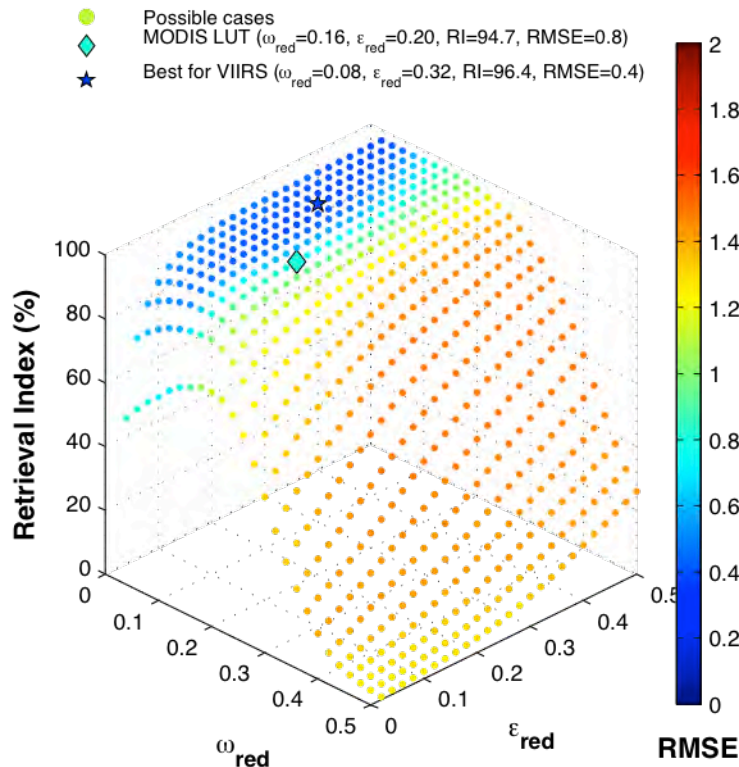
- ✓ Comparison between VIIRS C1.1 (MODIS LUT) and field data
 - Larger overestimations are observed for both FPAR & LAI
 - FPAR: $RMSE=0.21$ (+0.70, C5 $RMSE = 0.14$)
 - LAI: $RMSE_{LAI}=1.35$ (+0.58, C5 $RMSE_{LAI}=0.77$)
 - Caveat: Temporal mismatch between VIIRS and field measurements





Update on VIIRS LAI/FPAR – MODIS vs. VIIRS

- ✓ LUT adjustment for VIIRS spectral band composition
 - Single scattering albedo and uncertainties in Red BRF (<->flatten NIR)
 - Maximizing retrieval index & Minimizing RMSE
 - Biome2: 0.4 RMSE & 1.7% RI improved (overestimation remedied)
 - Potential for MODIS-like LAI/FPAR production from VIIRS

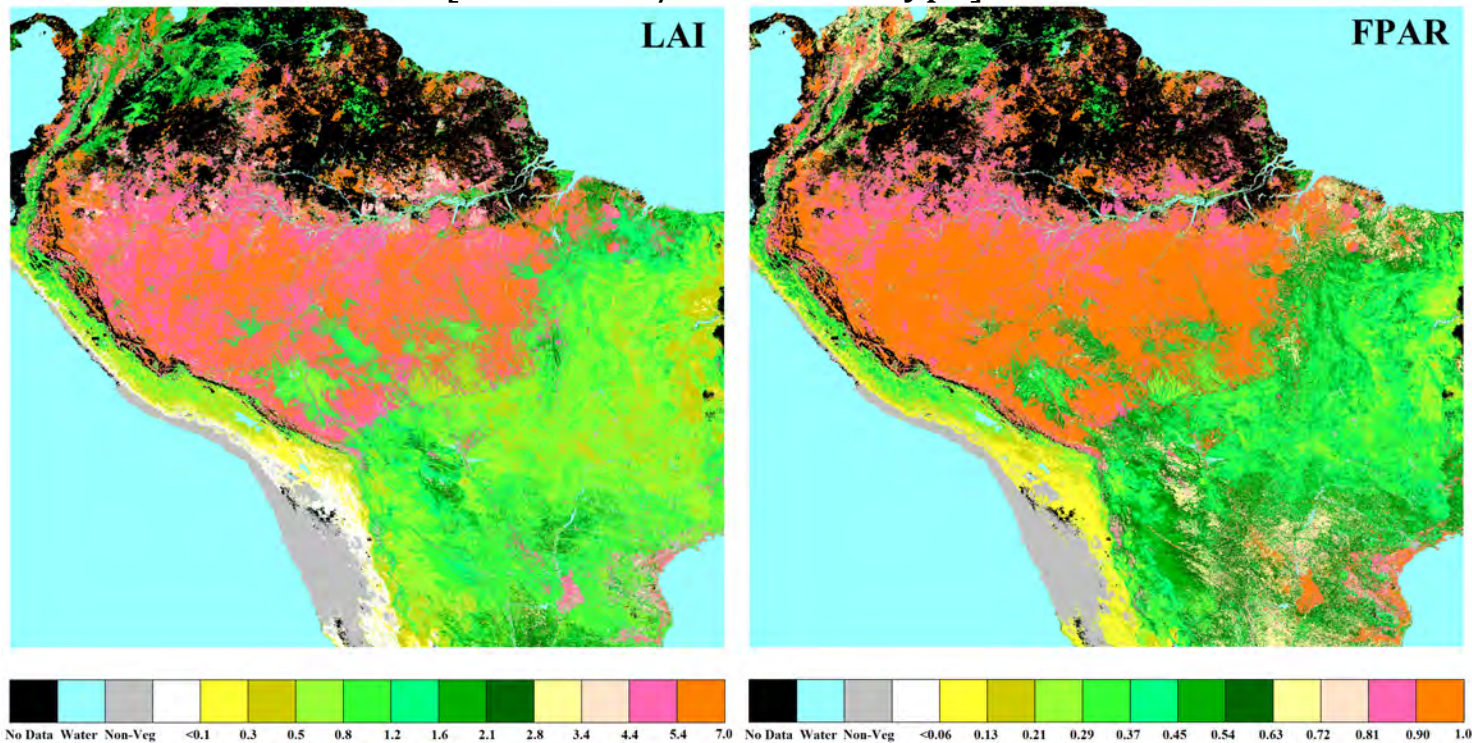




Implementation of Algorithm

- ✓ MAIAC LAI/FPAR Prototype
 - Implement MODIS scientific algorithm into MAIAC BRFs
 - Progressing on MAIAC specific LUT adjustment

[MAIAC LAI/FPAR Prototype]



8-Day Composite MAIAC LAI/FPAR Product Over South America
Compositing period: July 4 to July 11, 2005



Future plan & Summary

✓ Summary

- C6 produces global **LAI within $C5 \pm 0.29$** and **FPAR within $C5 \pm 0.051$**
- C6 agrees better with *in-situ* LAI ($RMSE_{LAI}=0.69$) and FPAR ($RMSE=0.15$)
- VIIRS based on MODIS LUT produces global **LAI within $C5 \pm 1.81$** and **FPAR within $C5 \pm 0.207$**
- VIIRS tends to overestimate both LAI ($RMSE_{LAI}=1.35$) & FPAR ($RMSE=0.21$)
- Potential for MODIS-like global LAI/FPAR product from VIIRS

✓ Further plan

- Input uncertainty and sensitivity assessment
- VIIRS LUT adjustment and Delivery
- Update field observations for both MODIS & VIIRS Missions (e.g., ImagineS)
- VIIRS evaluation and validation



Thank You