MODIS & VIIRS SSES Hypercube

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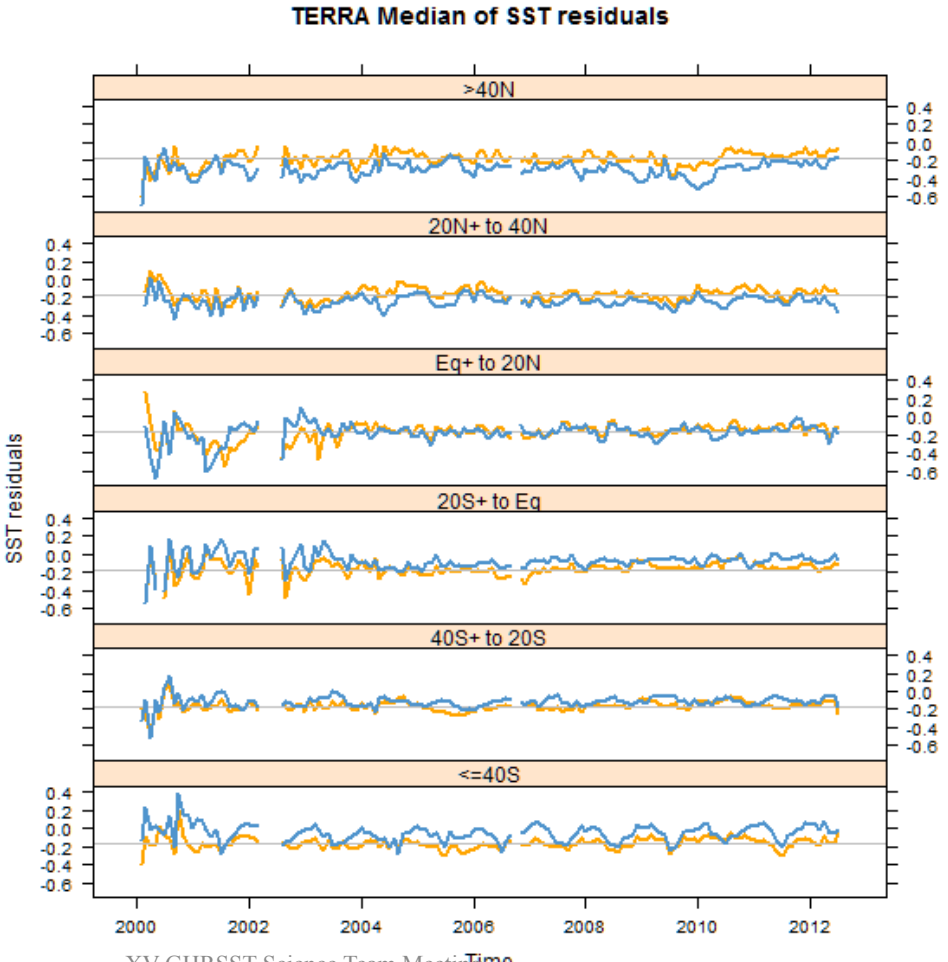
Errors and uncertainties have dependences on a number of parameters, such as latitude and season.



Background

- Objective is to develop a method of assessing accuracies of MODIS SST retrievals that take account of dependences.
- Hypercubes have been generated from MODIS Match-up Data Bases; Terra and Aqua.
- Hypercube cells contain means, st devns and N
- Hypercube cells are used to give estimates of bias and uncertainties for each retrieved SST for the SSES

Hypercubes – Variables and bins

Variable	Number of intervals or levels	Intervals or levels
Day or night	2	(1) Daytime; (2) Nightime (solar zenith angle > 90 degrees)
Quarter	4	(1) Jan-Mar; (2) Apr-Jun; (3) Jul-Sep; (4) Oct- Dec
Latitude Band	6	(1) 90° S to 40° S; (2) 40° S to 20° S; (3) 20° S to Eq; (4) Eq to 20° N; (5) 20° N to 40° N; (6) 40° N to 90° N
In Situ SST	7	(1) -2 to 3° C; (2) 3 to 8° C; (3) 8 to 13° C; (4) 13 to 18° C; (5) 18 to 23° C; (6) 23 to 28° C; (7) > 28° C
Satellite zenith angle		(1) 0° to 30°; (2) 30° to 40°; (3) 40° to 50°; (4) 50°
For SST:		
BT31 – BT32 (1)	4	(1) < 0.0° C; (2) 0.0 to 0.7° C; (3) 0.7 to 2.0° C; (4) > 2.0° C
For SST4		
BT22 – BT23 (2)	4	(1) 0.0 to 2.0° C; (2) 2.0 to 3.0° C; (3) 3.0 to 4.0° C; (4) > 4.0° C
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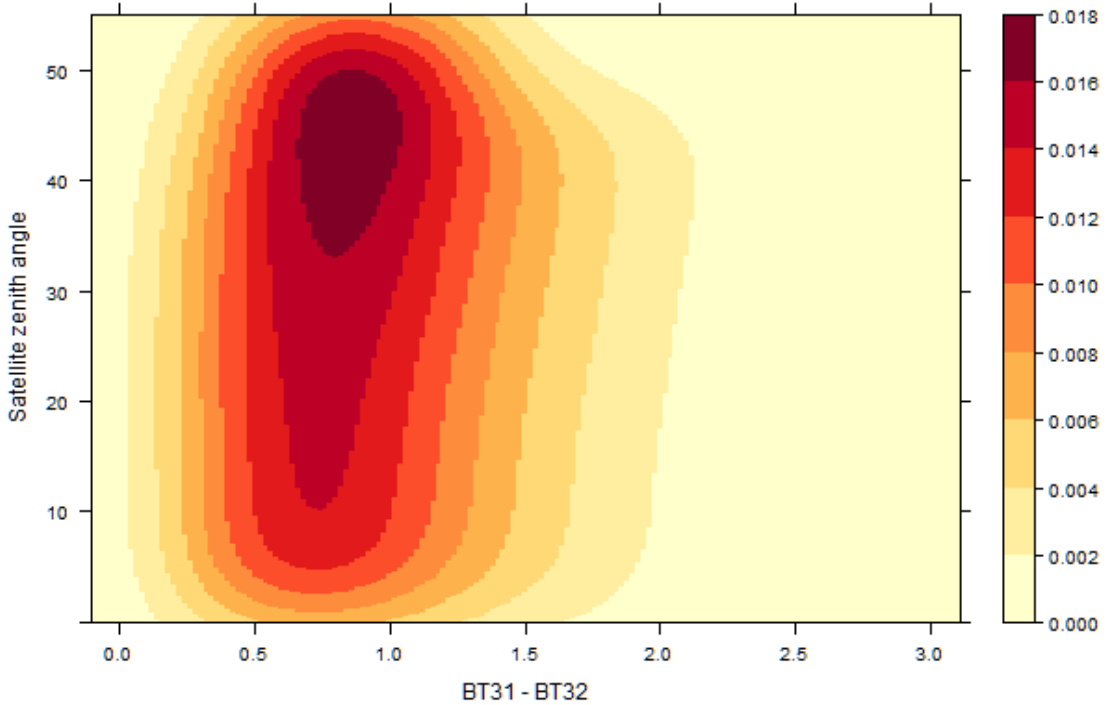
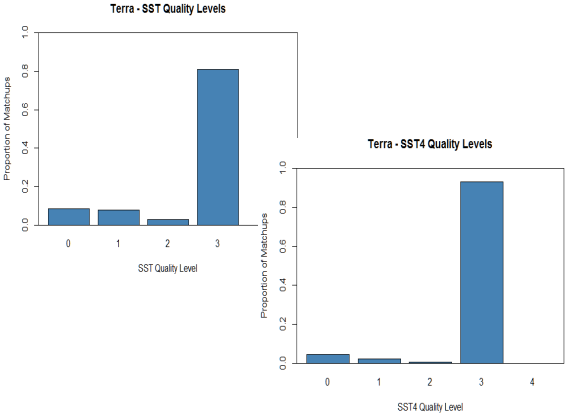
2-D point density

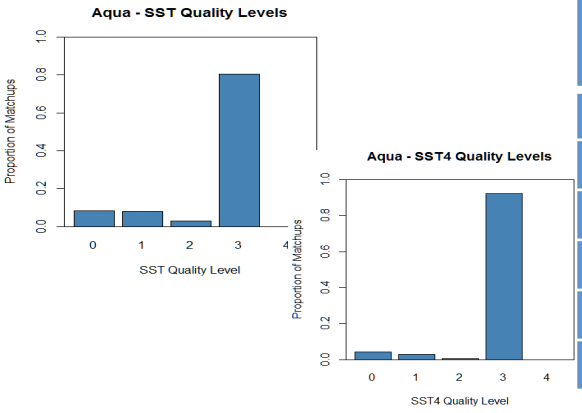


Not all hypercube bins are equally filled.

Matchup Numbers

TERRA Quality	SST		SST4 (night only)	
	No. of Matchups	% of total	No. of Matchups	% of total
0	242,368	8.46	128,504	8.99
1	218,808	7.64	58,835	4.08
2	81,413	2.84	13,395	0.94
3	2,320,740	81.05	1,228,336	85.97
4	188	0.01	241	0.02
TOTALS	2,863,517	100.00	1,429,311	100.00





AQUA Quality	SST (day + night)		SST4 (night only)	
	No. of Matchups	% of total	No. of Matchups	% of total
0	219,658	8.33	112,758	8.50
1	210,274	7.98	77,552	5.85
2	79,434	3.01	14,313	1.08
3	2,126,697	80.67	1,121,383	84.55
4	170	0.01	243	0.02
TOTALS	2,636,233	100.00	1,326,249	100.00

Bin Occupancy - Terra

MODIS TERRA SST(night) and SST4 Hypercubes										
Variable	Quality	Max no of bins	Empty bins	Occupied bins	Q10	Q25	Q50	Q75	Q90	Max
SST	0	2688	1793	895	2	7	40	167	482	3731
SST	1	2688	1968	720	1	3	8	30	124	2001
SST	2	2688	1741	947	1	3	15	58	162	1247
SST	3	2688	960	1728	6	44	262	898	1924	7690
SST	4	2688	2687	1	1	1	1	1	1	1
SST4	0	2688	1308	1380	2	6	22	75	220	2269
SST4	1	2688	1348	1340	2	5	17	55	147	1698
SST4	2	2688	1607	1081	1	2	5	14	33	313
SST4	3	2688	1038	1650	6	42	232	774	1820	11386
SST4	4	2688	2625	63	1	1	1	2	4	9

Bin Occupancy - Aqua

MODIS AQUA SST(night) and SST4 Hypercubes										
Variable	Quality	Max no of bins	Empty bins	Occupied bins	Q10	Q25	Q50	Q75	Q90	Max
SST	0	2688	1856	832	3	10	41	156	431	3618
SST	1	2688	2102	586	1	2	5	32	156	1894
SST	2	2688	1853	835	2	5	21	73	209	1593
SST	3	2688	971	1717	6	43	237	876	1838	7036
SST	4	2688	2680	8	1	1	1	2	2	3
SST4	0	2688	1304	1384	2	6	22	73	218	2284
SST4	1	2688	1348	1340	2	5	17	57	144	1604
SST4	2	2688	1610	1078	1	2	5	13	30	329
SST4	3	2688	1044	1644	7	42	244	782	1807	11297
SST4	4	2688	2626	62	1	1	1	2	4	9

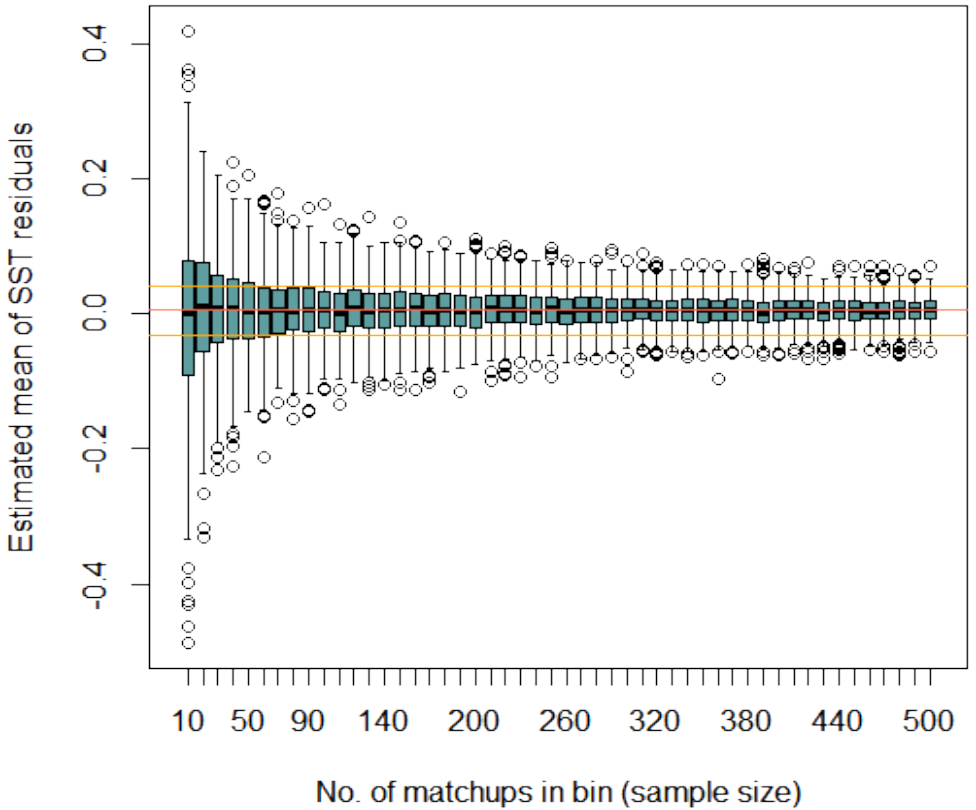
What should be the minimum occupancy of a cell?

- Using hypercube for QL=0
- Select a cell with N>500 (534), and high standard deviation.
  - (a) quarter of year: 2
  - (b) latitude band: 20 to 40°N
  - (c) SST interval: 23 to 28°C
  - (d) abs value of satellite zenith angle: > 50°
  - (e) (BT31 – BT32): 0.7 to 2.0K
- Resample cell in 50 different sizes (10, 20, 30,…, 490, 500), each 500 times.

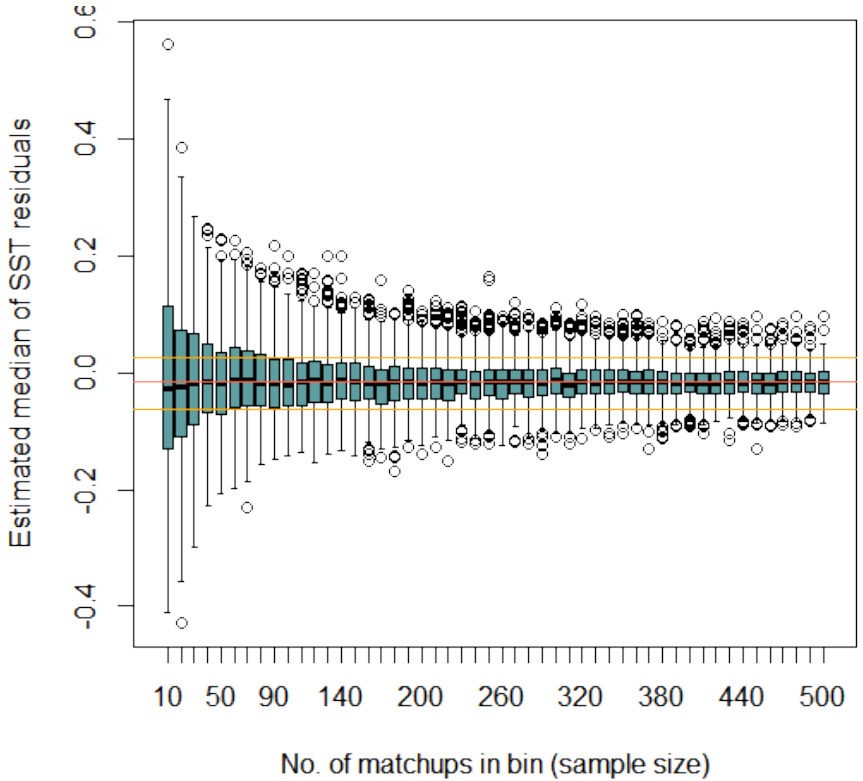
Statistics of the matchups in the test cell

Sample mean	**0.0055°C**
Lower 95% CI for mean	-0.0309°C
Upper 95% CI for mean	0.0414°C
Sample median	-0.0166°C
Lower 95% CI for median	-0.0637°C
Upper 95% CI for median	0.0260°C
Sample standard deviation	0.4322°C
Lower 95% CI for standard deviation	0.4061°C
Upper 95% CI for standard deviation	0.4715°C
Sample MAD	0.4421°C
Lower 95% CI for MAD	0.4022°C
Upper 95% CI for MAD	0.4826°C

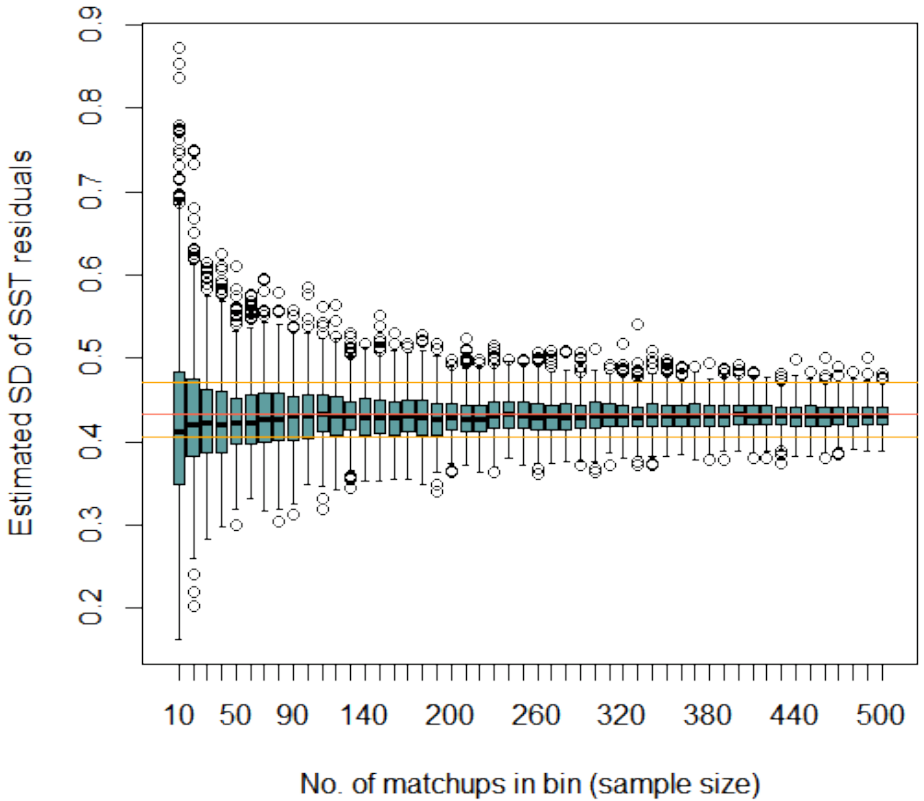
Mean of SST residuals



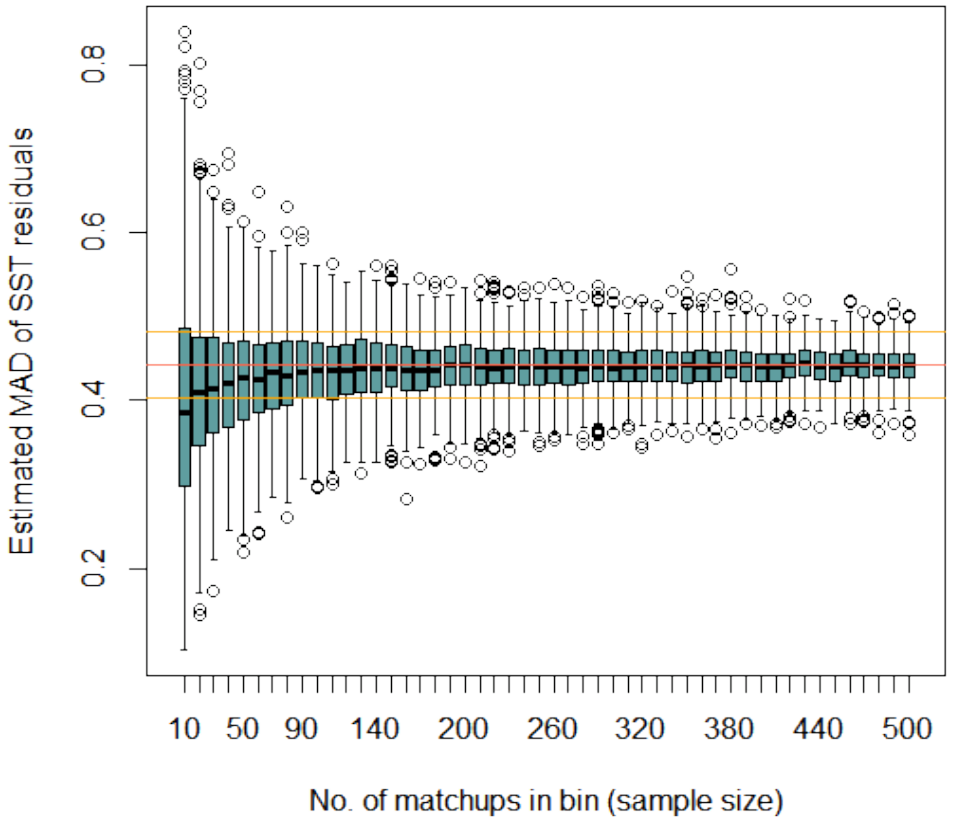
Median of SST residuals



SD of SST residuals



MAD of SST residuals



Conclusions

- Stable stats require >150 samples in each cell.
  - This is a very high target.
- Increase size of cells?
  - This would defeat the objective
- Where parameters vary smoothly, have functional dependences?

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Categorical

Proxies

Continuous

Functional dependences

- Avoid step changes in SSESs at cell boundaries
- Bridge cells with low occupancy
- Provide a mechanism for removing seasonal and latitudinal parameters (these are proxies for other variables; but are easy to implement)

Future plans

- Explore functional dependences for MODIS SSES's
- Apply to VIIRS…….