



Assessing the Impact of Precipitation on ALOS-2 Forest Observation in the Tropics

C.N. Koyama¹, M. Watanabe¹, M. Shimada^{1,2}
and the JJ-FAST Team^{2,3}

¹Tokyo Denki Univ., ²JAXA, ³RESTEC

ALOS Kyoto & Carbon Initiative
Post-KC 1st Science Team meeting (PKC#1)
TKP Shimbashi, Tokyo, Jan. 22, 2020



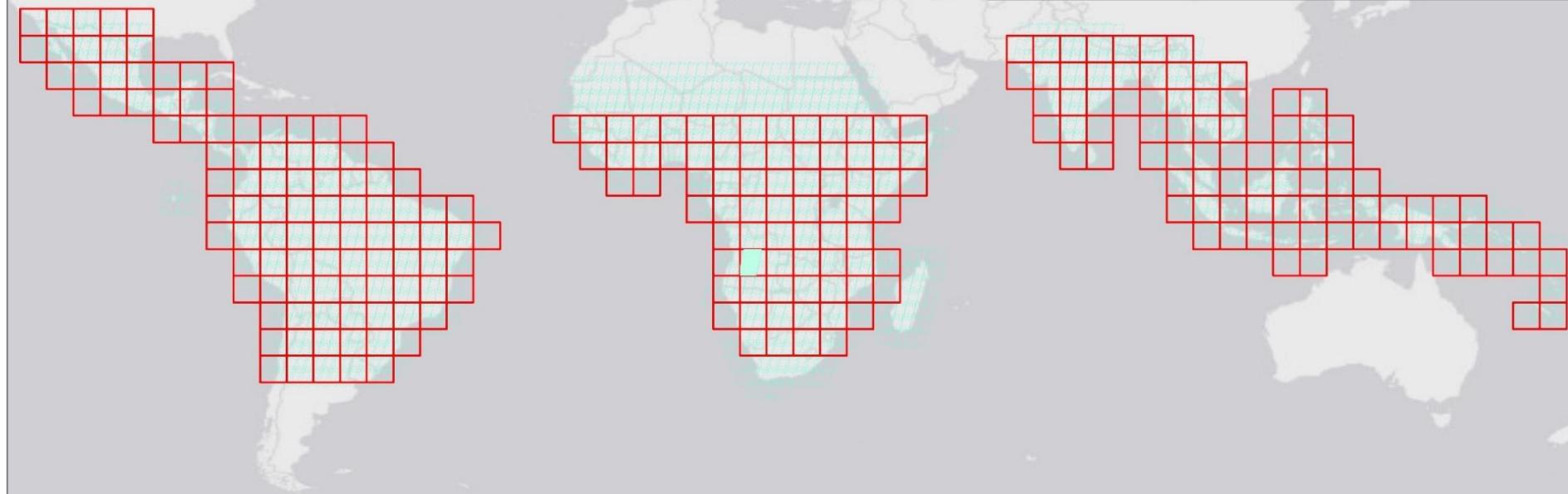
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2. ALOS-2 vs. GSMap Data Analysis
3. Principle Mechanisms for Gamma Naught / Rainfall Correlations
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6. Conclusions



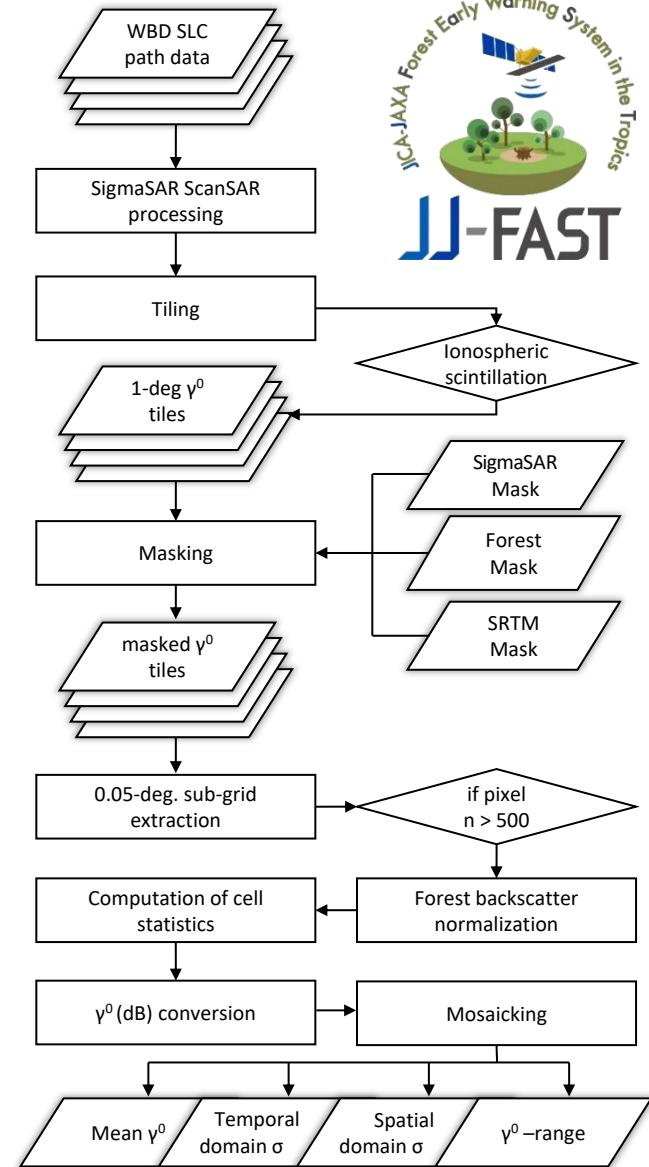
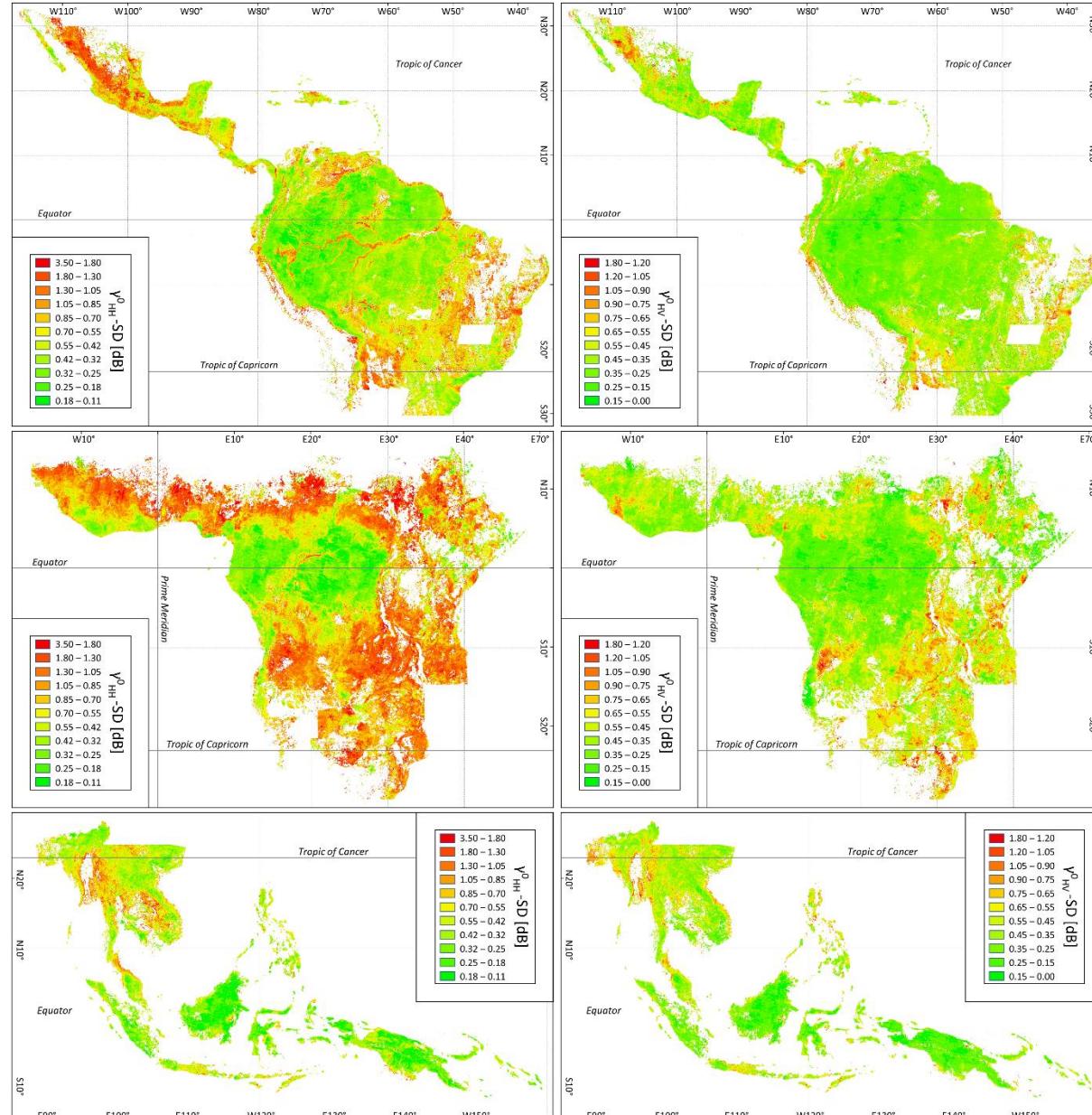
ALOS-2/PALSAR-2 Data

Domain: Entire tropical forest belt
Data type: ScanSAR WBD
Temporal resolution: ~42 days
Dataset size: **~300 TB**

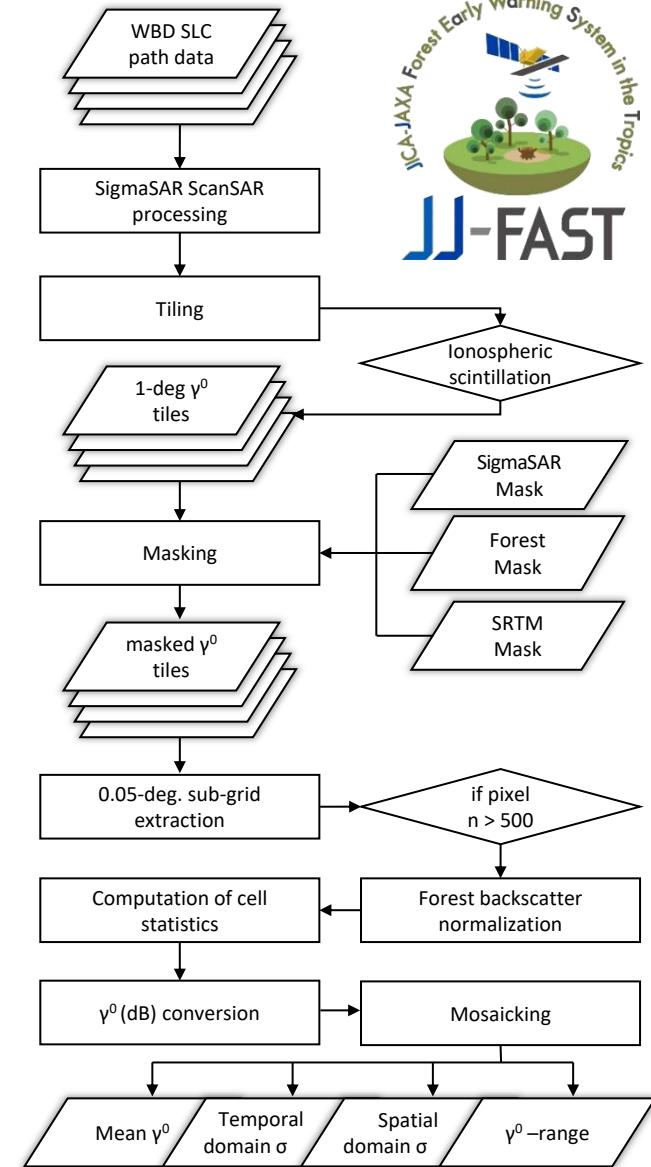
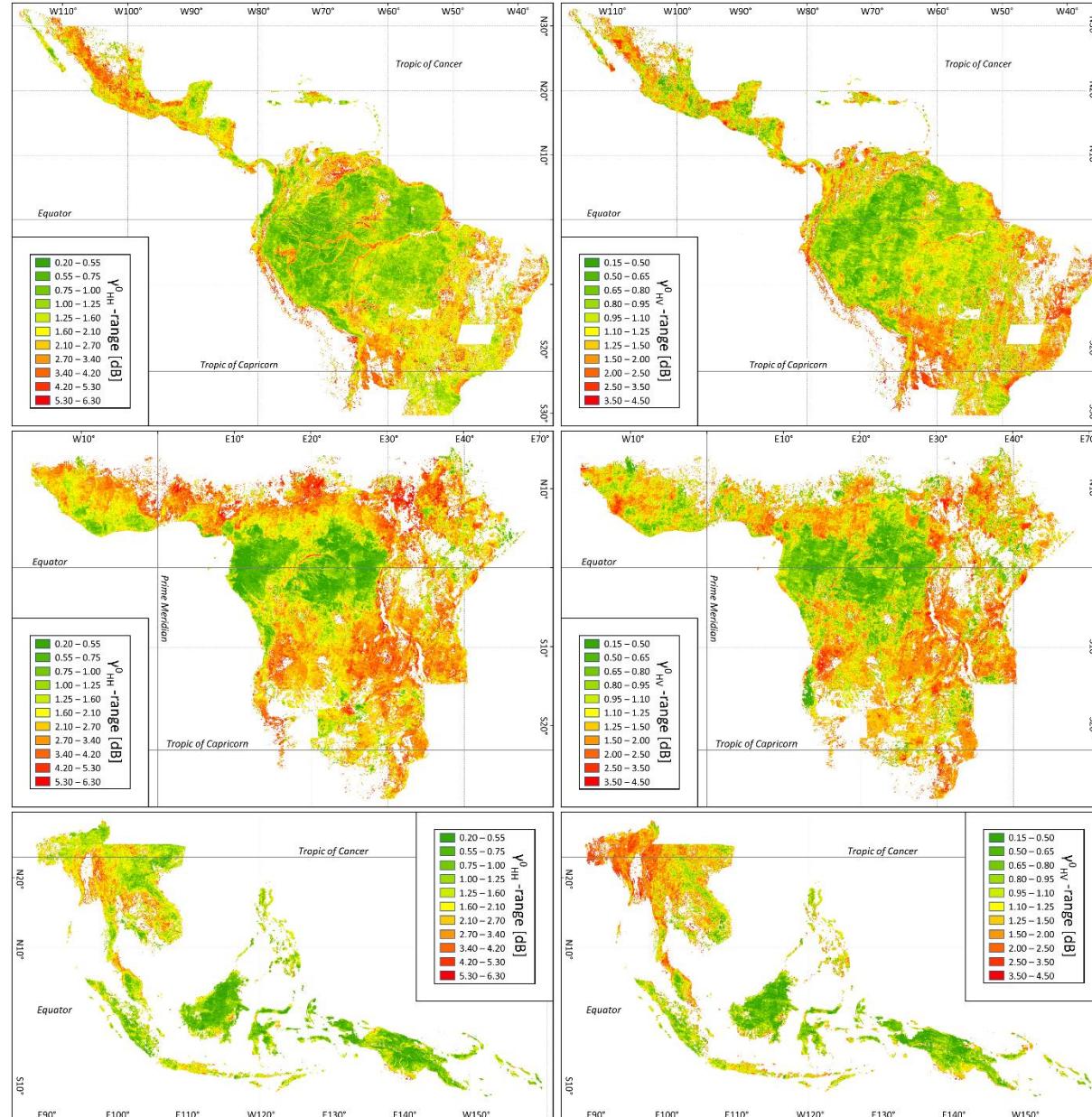


Year	2016												2017												2018											
Month	Jan.	Feb.	Apr.	May	Jun.	Jul.	Aug.	Oct.	Nov.	Jan.	Feb.	Mar.	May	Jun.	Jul.	Sep.	Oct.	Dec.	Jan.	Mar.	May	Jun.	Jul.	Aug.												
Cycle	39	42	45	48	51	53	56	59	62	65	68	71	74	77	79	82	85	88	91	94	97	99	102	105												
Ver.	1.2.3	1.2.3	1.2.3	1.2.3	1.2.3	1.2.3	1.2.3	1.2.3	1.3.0	1.3.0	1.3.0	2.0.0	2.0.0	2.0.0	2.0.0	2.3.1	2.3.2	2.3.2	2.3.3	2.3.3	2.4.0	2.4.0	2.4.0	2.4.0												

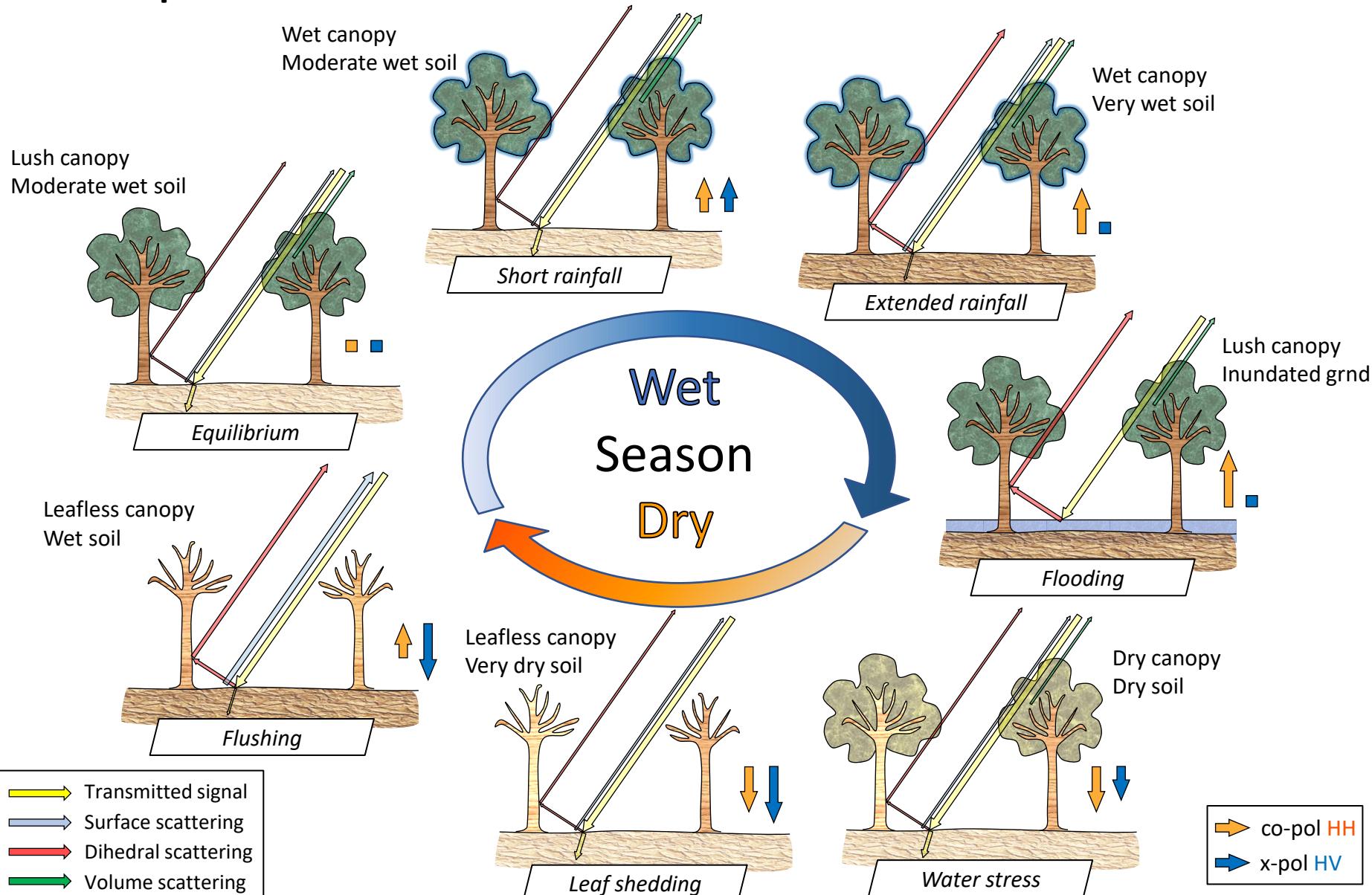
ALOS-2 Forest Variability Maps



ALOS-2 Forest Variability Maps



Principal Factors for Forest Backscatter Fluctuations

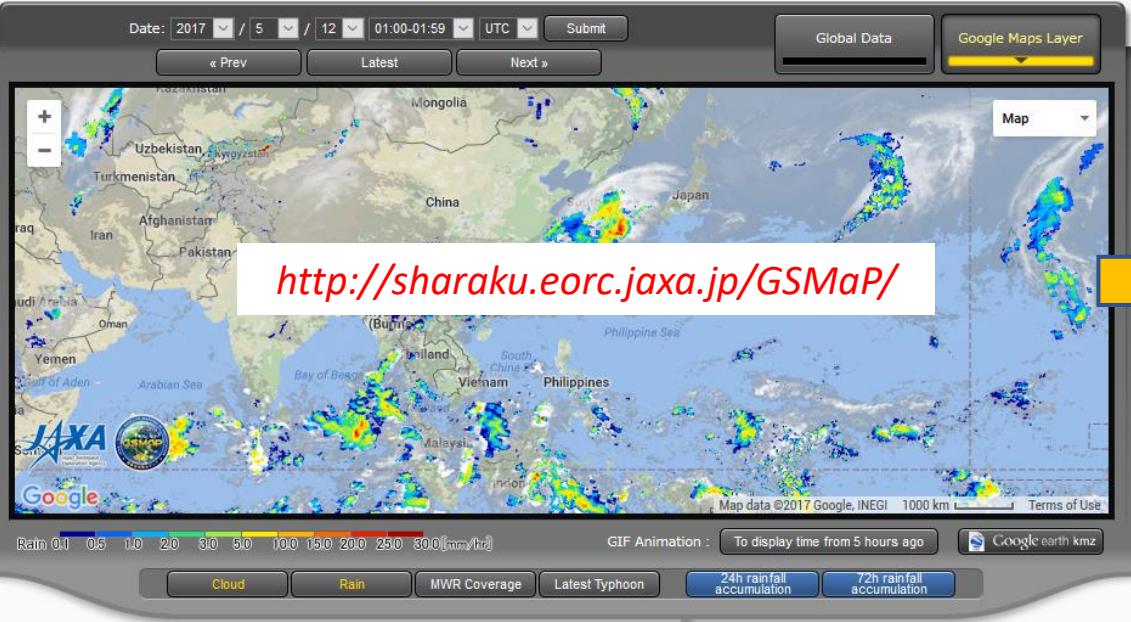


GSMaP Precipitation Data

JAXA GLOBAL RAINFALL WATCH

世界の雨分布速報

日本語 Last Update: 12 May 2017 05:54:06 UTC



Rainfall rate: 0.01 [mm/h]
Temp. resolution: 1 hour -> daily accumulated
Spatial resolution: 0.1-degree lat/lon
Extent: Tropical belt (30N – 30S)
2015/12/01 – 2018/12/31

The figure shows the HeidiSQL interface with the database "jjfast_gsmap" selected. It displays the structure of the "02_southamerican" table, which contains 22 rows of data. The table has columns: ID, Polygon_ID, TheDate, Lat, Lon, and RainRate. A yellow arrow points from the database interface to the table "02_southamerican".

ID	Polygon_ID	TheDate	Lat	Lon	RainRate
1	1	2015-12-01	12.95	-81.95	(
2	2	2015-12-01	12.85	-81.95	(
3	3	2015-12-01	12.75	-81.95	(
4	4	2015-12-01	12.65	-81.95	(
5	5	2015-12-01	12.55	-81.95	(
6	6	2015-12-01	12.45	-81.95	(
7	7	2015-12-01	12.35	-81.95	(
8	8	2015-12-01	12.25	-81.95	(
9	9	2015-12-01	12.15	-81.95	(
10	10	2015-12-01	12.05	-81.95	(
11	11	2015-12-01	11.95	-81.95	(
12	12	2015-12-01	11.85	-81.95	(
13	13	2015-12-01	11.75	-81.95	(
14	14	2015-12-01	11.65	-81.95	(
15	15	2015-12-01	11.55	-81.95	(
16	16	2015-12-01	11.45	-81.95	(
17	17	2015-12-01	11.35	-81.95	(
18	18	2015-12-01	11.25	-81.95	(
19	19	2015-12-01	11.15	-81.95	(
20	20	2015-12-01	11.05	-81.95	(
21	21	2015-12-01	10.95	-81.95	(
22	22	2015-12-01	10.85	-81.95	(

MySQL Database

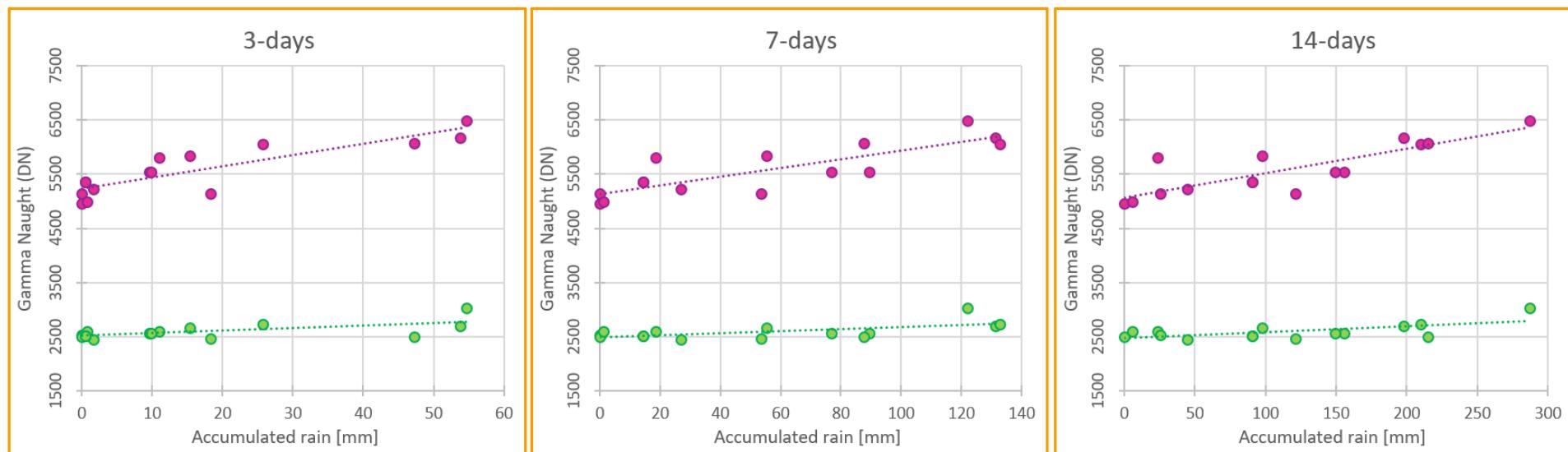
```
1 /* Delimiter changed to ; */
2 /* Connecting to 133.14.136.214 via MariaDB (TCP/IP), username root, using password: Yes ... */
3 SELECT CONNECTION_ID();
4 /* Connected. Thread-ID: 8 */
5 /* Charset: utf8mb4 */
6 SHOW STATUS;
7 SHOW VARIABLES;
8 SHOW DATABASES;
9 USE jjfast_gsmap;
10 ENGINE innodb information "JJFAST_GSMaP_DB" */
11 SELECT `DEFAULT_COLLATION_NAME` FROM `information_schema`.`SCHEMATA` WHERE `SCHEMA_NAME`='jjfast_gsmap';
12 SHOW TABLE STATUS FROM `jjfast_gsmap`;
13 SHOW FUNCTION STATUS WHERE `Db`='jjfast_gsmap';
14 SHOW PROCEDURE STATUS WHERE `Db`='jjfast_gsmap';
15 SHOW TRIGGERS FROM `jjfast_gsmap`;
16 SELECT `DEFAULT_COLLATION_NAME` FROM `information_schema`.`SCHEMATA` WHERE `SCHEMA_NAME`='informa...
17 SHOW TABLE STATUS FROM `information_schema`;
18 SHOW FUNCTION STATUS WHERE `Db`='information_schema';
19 SHOW PROCEDURE STATUS WHERE `Db`='information_schema';
20 SHOW TRIGGERS FROM `information_schema`;
21 SHOW EVENTS FROM `information_schema`;
22 SELECT * , EVENT_SCHEMA AS `Db` , EVENT_NAME AS `Name` FROM `information_schema`.`EVENTS` WHERE `EVEN...
23 SHOW CREATE TABLE `jjfast_gsmap`.`02_southamerican`;
24 SHOW COLLATION;
25 SHOW CHARACTER SET;
26 SELECT * FROM `jjfast_gsmap`.`02_southamerican` LIMIT 1000;
27 SHOW CREATE TABLE `jjfast_gsmap`.`02_southamerican`;
28 SHOW TABLE STATUS LIKE '02_southamerican';
29 MariaDB 10.1.21 Uptime: 1 days, 13:59 h UTC: 2017-05-12 6:16
```

Size: 1,516,705,621 rows

13,862 tiles * 400 polygons * n Cycles => 62,951,200 database queries

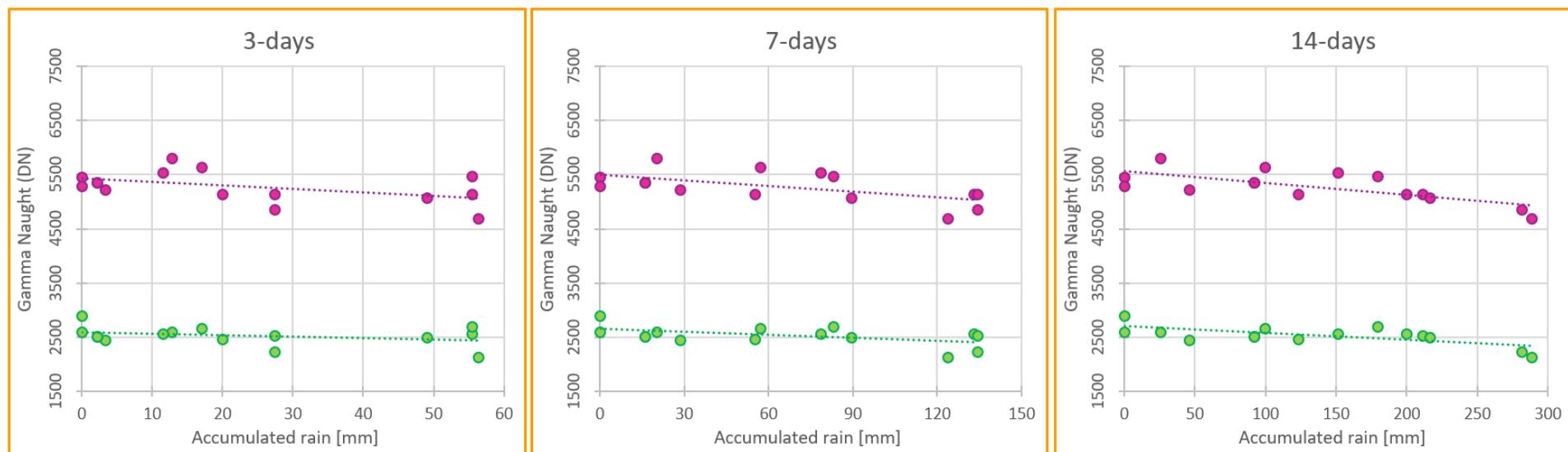
ALOS-2 vs. GSMaP Correlation Analysis

ALOS-2 Cycle	ACCUMULATED RAINFALL														GAMMA NAUGHT		CORRELATION RESULTS		
	1day	2days	3days	4days	5days	6days	7days	8days	9days	10days	11days	12days	13days	14days	HH (DN)	HV (DN)	Integral	r_HH	r_HV
48	1.2	1.2	11.04	11.04	11.28	15.6	18.48	23.52	23.52	23.52	23.76	23.76	23.76	23.76	5801.1	2590.4	1 day	0.564	0.574
51	9.6	9.6	9.6	25.44	25.92	86.4	89.52	90.96	101	101	101	122.9	155.8	155.8	5544.7	2570.2	2 days	0.744	0.663
53	1.68	2.64	15.36	33.84	36	42.48	55.2	56.4	58.56	58.8	72.48	77.52	77.52	97.76	5833.1	2662.1	3 days	0.868	0.747
56	0	0	0	0	0	0	0	0	0	0	15.6	15.6	15.6	25.6	5134.2	2532.5	4 days	0.835	0.771
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4956.3	2501.5	5 days	0.829	0.724
68	0	0.24	0.72	0.72	1.2	1.2	1.2	5.04	5.52	5.52	5.52	5.52	5.52	5.52	4996.3	2601.5	6 days	0.835	0.659
71	0	1.68	1.68	22.8	26.88	26.88	26.88	26.88	44.16	44.4	44.4	44.4	44.4	44.4	5229.6	2453.9	7 days	0.831	0.727
74	7.68	29.52	53.76	54.24	54.24	131.3	131.3	151.4	156.5	157.7	187.2	188.4	188.6	197.8	6171.2	2700.4	8 days	0.823	0.648
79	1.44	25.68	25.68	25.68	42	128.2	132.7	137.8	137.8	146.4	146.6	178.8	209.3	209.8	6050.9	2729.1	9 days	0.833	0.729
82	53.76	54	54.64	108.5	121.2	121.2	121.9	133.9	181.8	192.6	224.5	259.4	260.2	287	6488.6	3036.0	10 days	0.817	0.727
85	0.48	0.48	0.48	4.32	14.4	14.4	14.4	42.96	55.2	55.92	76.08	90.48	90.48	90.48	5356.5	2512.2	11 days	0.827	0.747
91	14.64	14.88	18.24	23.76	37.68	42.72	53.52	81.12	85.92	98.4	104.6	112.6	113.3	121.4	5144.7	2470.2	12 days	0.822	0.759
97	6.72	6.96	47.28	54.24	72.48	78.24	87.6	123.1	124.6	128.2	132	139	179.9	214.7	6071.2	2500.4	13 days	0.822	0.738
102	0	4.32	9.84	21.6	23.76	33.6	76.8	87.12	105.1	116.4	117.6	119	128.9	149.5	5544.7	2570.2	14 days	0.837	0.734
105	0.48	0.48	0.48	4.32	14.4	14.4	14.4	42.96	55.2	55.92	76.08	90.48	90.48	90.48	5356.5	2512.2			



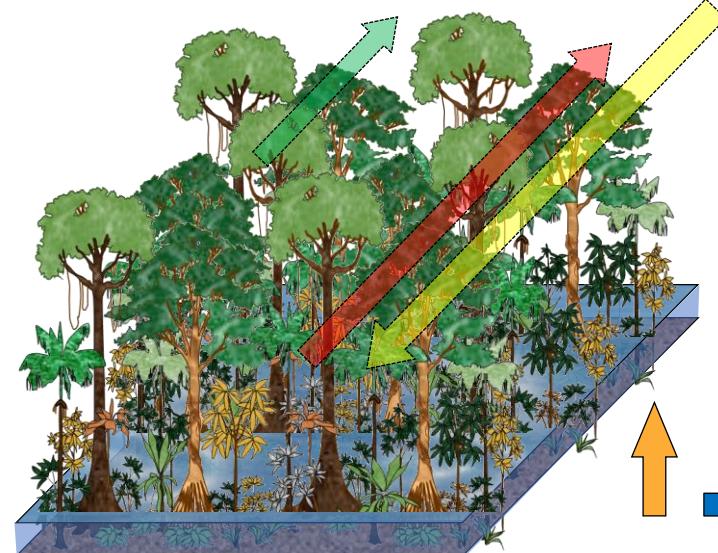
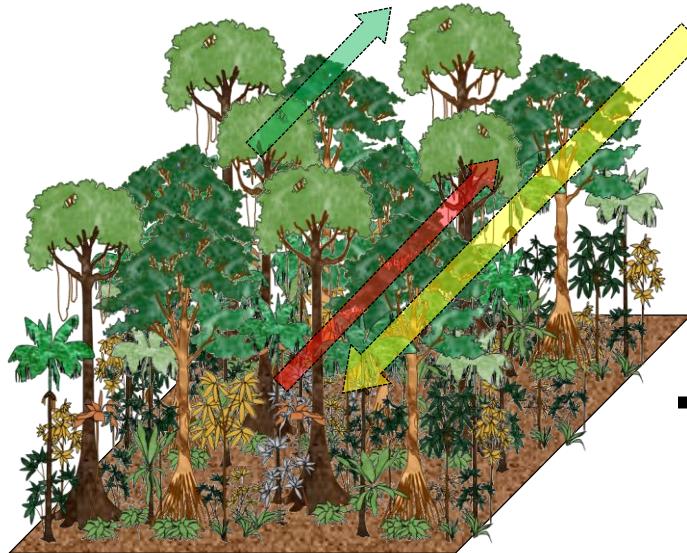
ALOS-2 vs. GSMap Correlation Analysis

ALOS-2 Cycle	ACCUMULATED RAINFALL														GAMMA NAUGHT		CORRELATION RESULTS		
	1day	2days	3days	4days	5days	6days	7days	8days	9days	10days	11days	12days	13days	14days	HH (DN)	HV (DN)	Integral	r_HH	r_HV
48	2.9	2.9	12.74	12.74	12.98	17.3	20.18	25.22	25.22	25.22	25.46	25.46	25.46	25.46	5801.1	2590.4	1 day	-0.354	-0.303
51	9.38	31.22	55.46	55.94	55.94	133	133	153.1	158.2	159.4	188.9	190.1	190.3	199.5	5144.7	2570.2	2 days	-0.379	-0.349
53	3.38	4.34	17.06	35.54	37.7	44.18	56.9	58.1	60.26	60.5	74.18	79.22	79.22	99.46	5633.1	2662.1	3 days	-0.460	-0.338
59	3.14	27.38	27.38	27.38	43.7	129.9	134.4	139.5	139.5	148.1	148.3	180.5	211	211.5	5134.2	2532.5	4 days	-0.523	-0.389
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5456.3	2901.5	5 days	-0.541	-0.452
68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5296.3	2601.5	6 days	-0.559	-0.466
71	1.7	3.38	3.38	24.5	28.58	28.58	28.58	28.58	45.86	46.1	46.1	46.1	46.1	46.1	5229.6	2453.9	7 days	-0.609	-0.518
77	9.38	31.22	55.46	55.94	55.94	82.98	82.98	153.1	158.2	159.4	168.9	170.1	170.3	179.5	5471.2	2700.4	8 days	-0.657	-0.509
79	3.14	27.38	27.38	27.38	43.7	129.9	134.4	139.5	139.5	148.1	148.3	180.5	211	281.5	4850.9	2229.1	9 days	-0.654	-0.530
82	55.46	55.7	56.34	110.2	122.9	122.9	123.6	135.6	183.5	194.3	226.2	261.1	261.9	288.7	4688.6	2136.0	10 days	-0.680	-0.571
85	2.18	2.18	2.18	6.02	16.1	16.1	16.1	44.66	56.9	57.62	77.78	92.18	92.18	92.18	5356.5	2512.2	11 days	-0.696	-0.595
91	16.34	16.58	19.94	25.46	39.38	44.42	55.22	82.82	87.62	100.1	106.3	114.3	115	123.1	5144.7	2470.2	12 days	-0.718	-0.640
97	8.42	8.66	48.98	55.94	74.18	79.94	89.3	124.8	126.3	129.9	133.7	140.7	181.6	216.4	5071.2	2500.4	13 days	-0.723	-0.673
99	1.7	6.02	11.54	23.3	25.46	35.3	78.5	88.82	106.8	118.1	119.3	120.7	130.6	151.2	5544.7	2570.2	14 days	-0.716	-0.664
102	2.18	2.18	2.18	6.02	16.1	16.1	16.1	44.66	56.9	57.62	77.78	92.18	92.18	92.18	5356.5	2512.2			

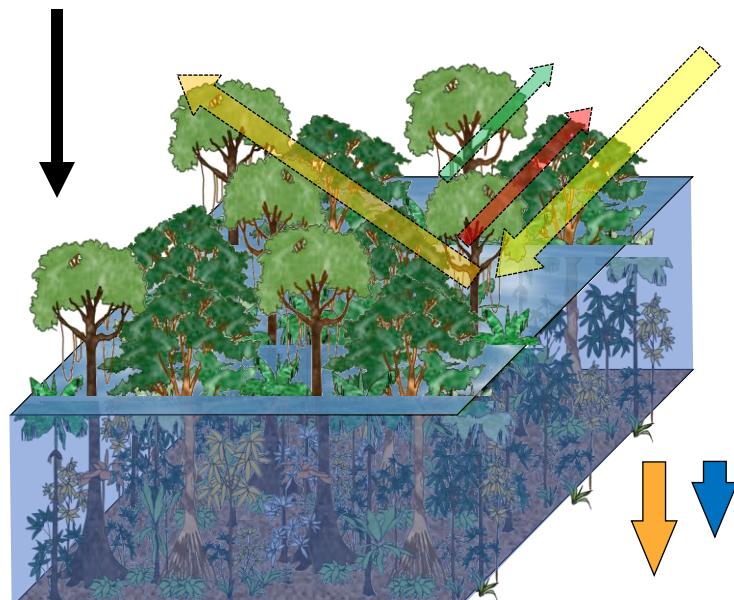


L-band SAR/Rainfall Correlation: Rainforest

Rainforest Equilibrium



Flooding of Forest Floor



Flooding of Forest Canopy

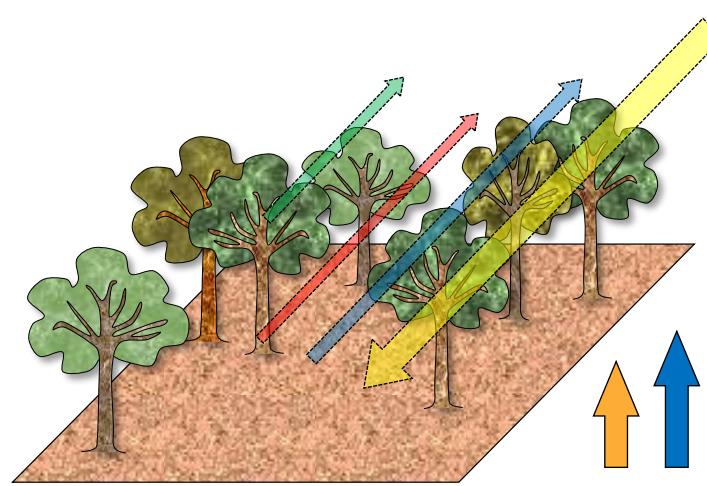
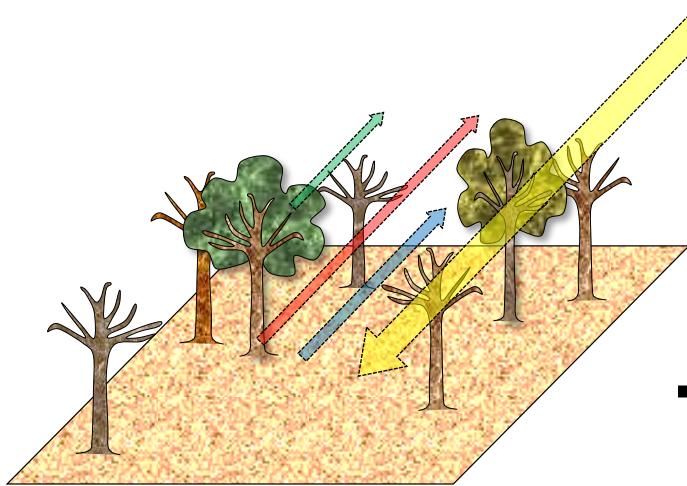
Rainforest L-band γ^0 and accumulated precipitation can be

HH positively correlated when forest floor is flooded

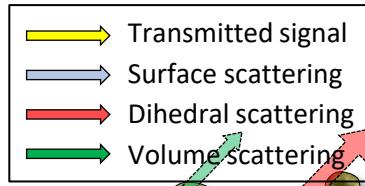
HH+HV negatively correlated when canopy is submerged

L-band SAR/Rainfall Correlation: Dry Forest

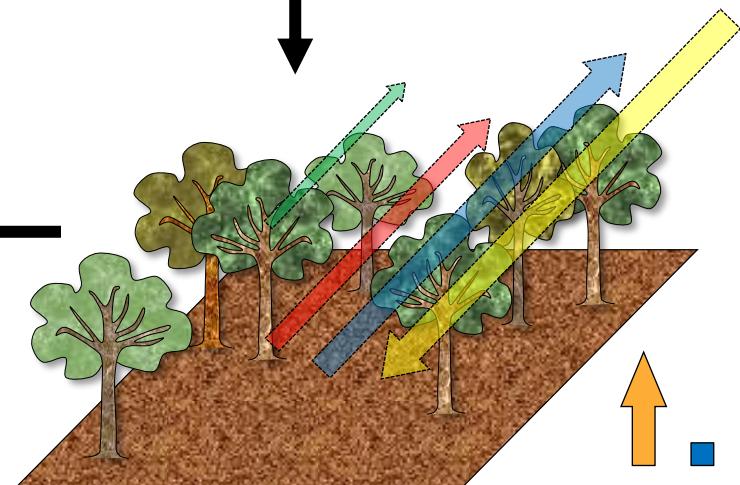
End of dry season



Flooding and Standing Water



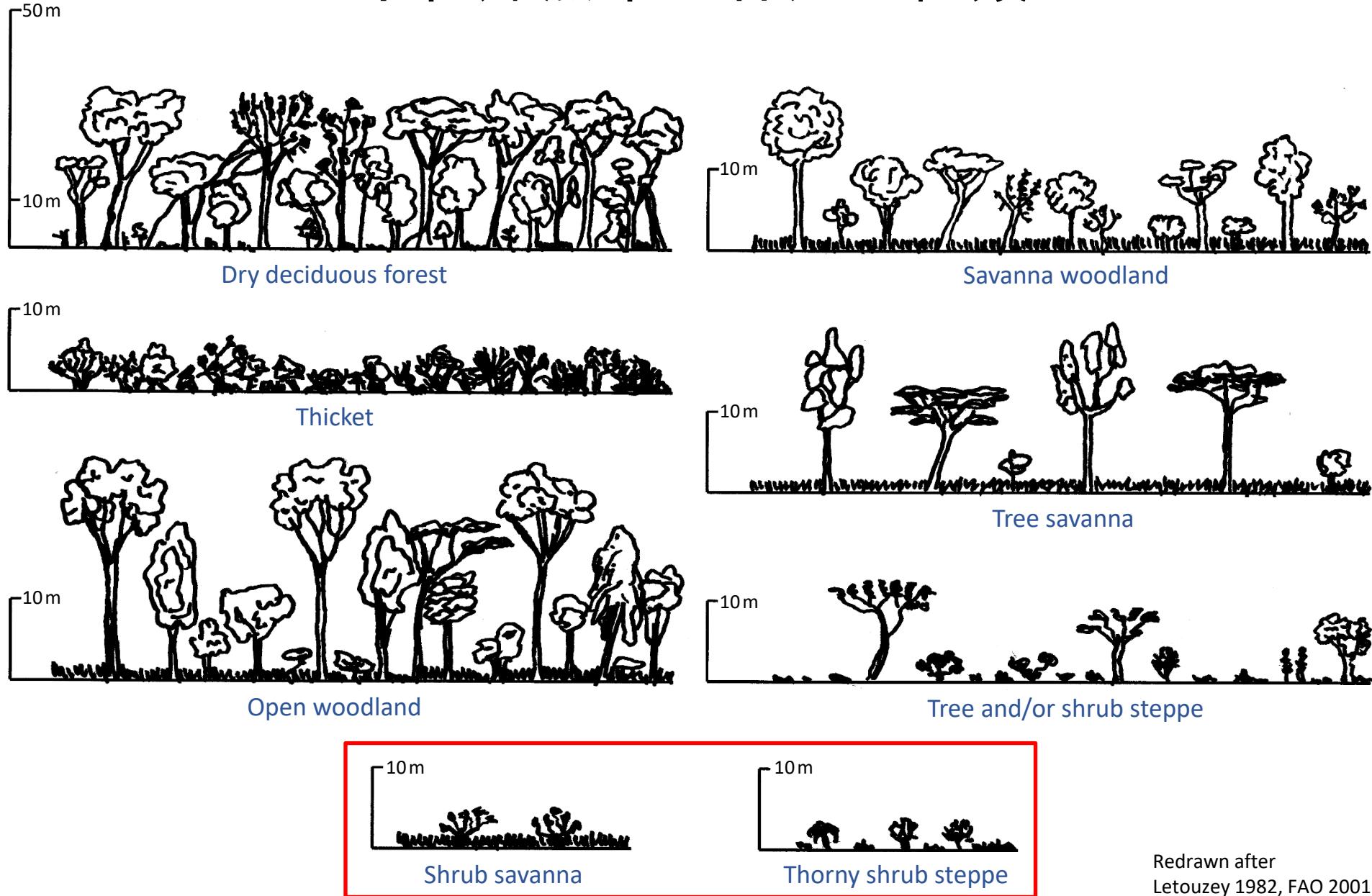
Dry (open) forest L-band γ^0 and accumulated precipitation can be
HH+HV positively correlated when canopy flushes and SM increases
HH+HV negatively correlated when Forest floor has standing water



Soil Moisture and Flushing

Soil Moisture Increase

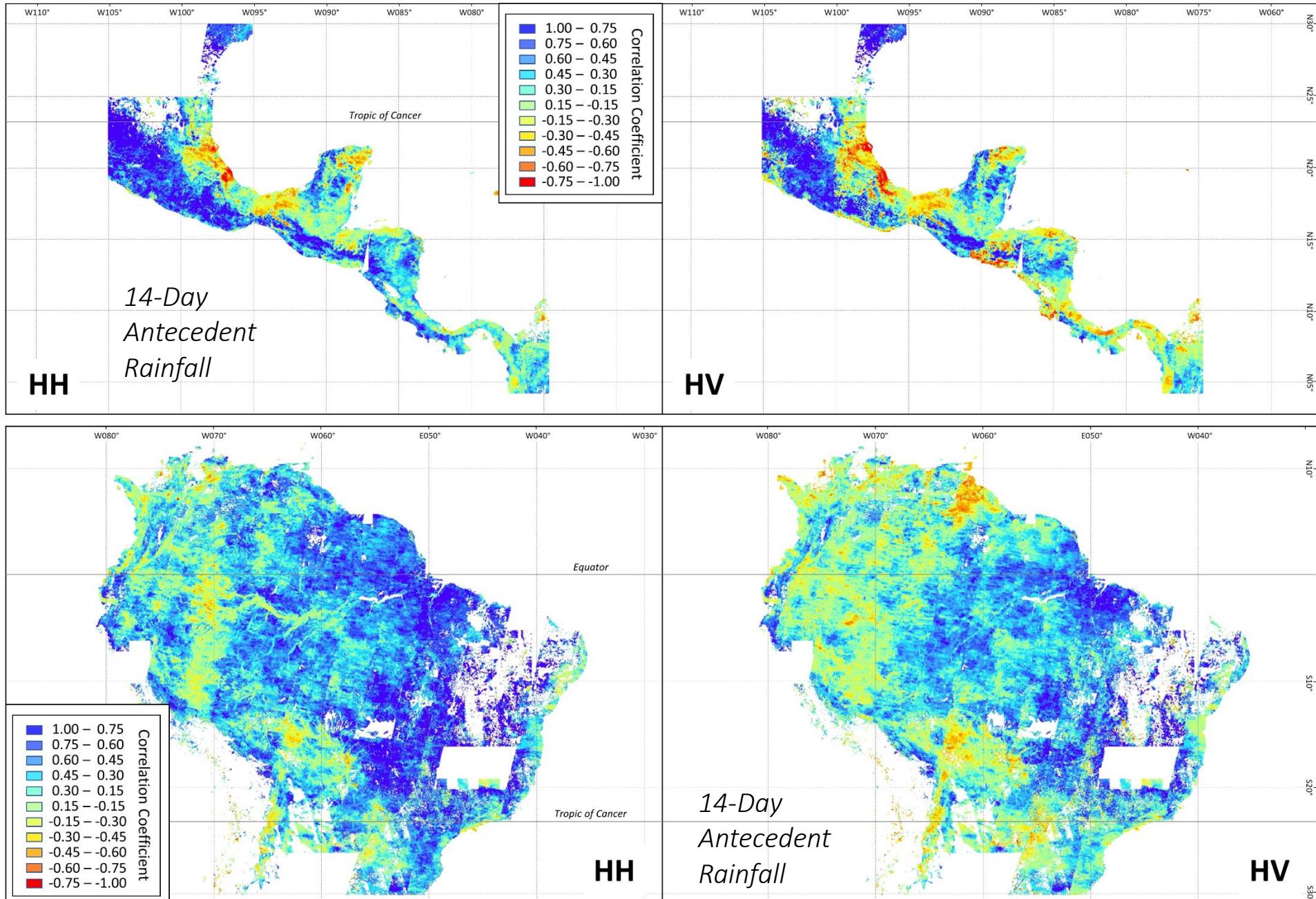
半乾燥熱帯の林分の種類



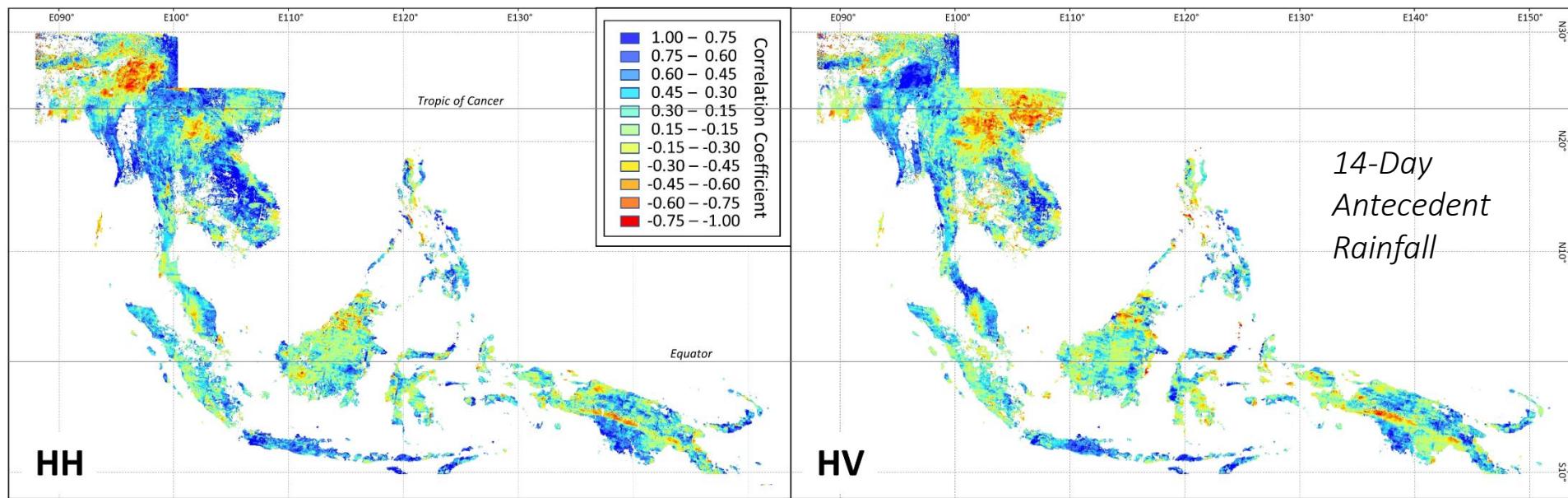
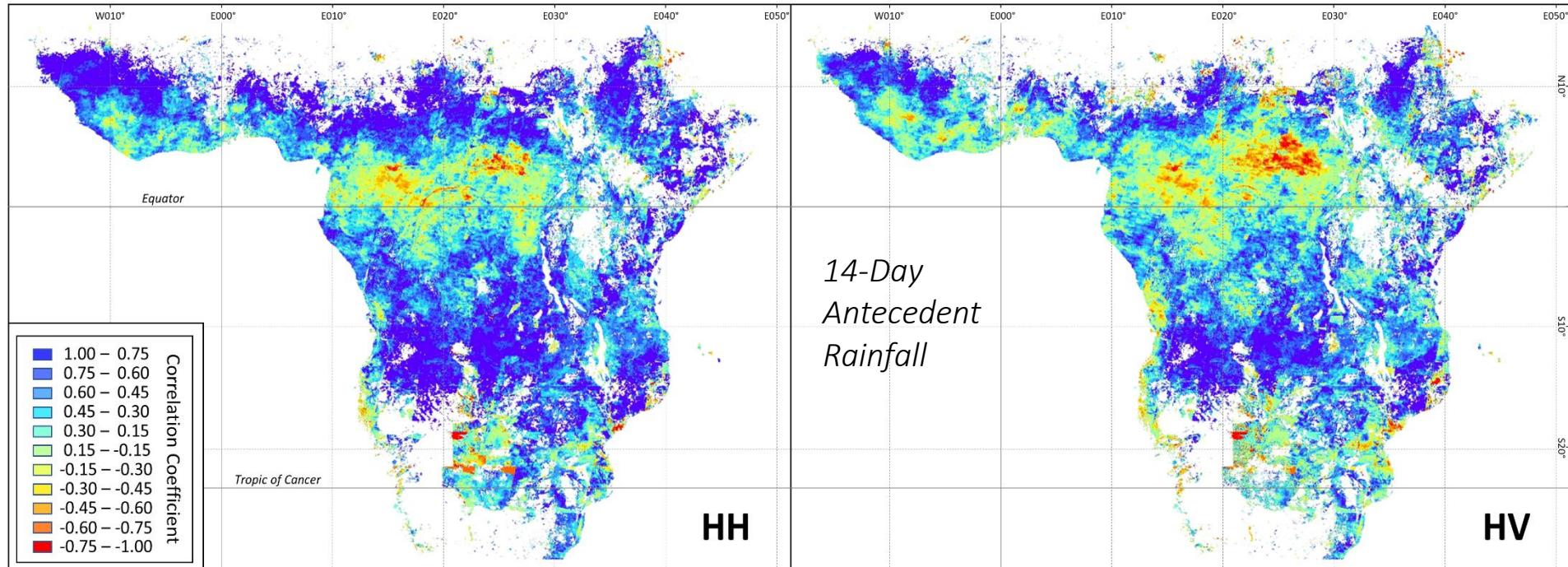
Redrawn after
Letouzey 1982, FAO 2001



L-band SAR/Rainfall Correlation Maps



L-band SAR/Rainfall Correlation Maps



Rain impact on JJ-FAST Accuracy in Africa

3 days antecedent rainfall

	Error	Total	Threshold	Accuracy*
All detections	29368	37344	total	21.4
	7470	10014	>20mm	25.4
	21898	27330	<20mm	19.9
	3415	4578	>50mm	25.2
	25953	32766	<50mm	20.8
	2786	3696	>100mm	24.6
	26582	33648	<100mm	21.0
	427	546	>150mm	21.8
	28941	36798	<150mm	21.4

7 days antecedent rainfall

	Error	Total	Threshold	Accuracy*
All detections	29368	37344	total	21.4
	3086	4440	>100mm	30.5
	26282	32904	<100mm	20.1
	1276	1631	>150mm	21.8
	28092	35713	<150mm	21.3
	729	876	>200mm	16.8
	28639	36468	<200mm	21.5
	166	182	>300mm	8.8
	29202	37162	<300mm	21.4

14 days antecedent rainfall

	Error	Total	Threshold	Accuracy*
All detections	29368	37344	total	21.4
	2026	2859	>200mm	29.1
	27342	34485	<200mm	20.7
	1137	1538	>250mm	26.1
	28213	35786	<250mm	21.2
	657	792	>300mm	17.0
	28711	36552	<300mm	21.5
	255	303	>400mm	15.8
	29113	37041	<400mm	21.4

Dry Forest

	Error	Total	Threshold	Accuracy*
Dry Forest	17634	21701	total	18.7
	14833	17233	>20mm	13.9
	2801	4468	<20mm	37.3
	11098	13024	>50mm	14.8
	6536	8677	<50mm	24.7

14 days antecedent rainfall

	Error	Total	Threshold	Accuracy*
Dry Forest	17634	21701	total	18.7
	8961	11233	>100mm	20.2
	8673	10468	<100mm	17.1
	3824	4211	>150mm	9.2
	13810	17490	<150mm	21.0

14 days antecedent rainfall

	Error	Total	Threshold	Accuracy*
Rainforest	17634	21701	total	18.7
	7781	9503	>200mm	18.1
	9853	12198	<200mm	19.2
	1869	1984	>250mm	5.8
	15765	19717	<250mm	20.0

	Error	Total	Threshold	Accuracy*
Rainforest	11734	16453	total	28.7
	4769	6585	>50mm	27.6
	6965	9868	<50mm	29.4
	2978	3696	>100mm	19.4
	8756	12757	<100mm	31.4

7 days antecedent rainfall

	Error	Total	Threshold	Accuracy*
Rainforest	11734	16453	total	28.7
	7714	10433	>150mm	26.1
	4020	6020	<150mm	33.2
	2432	2609	>250mm	6.8
	9302	13844	<250mm	32.8

**"Accuracy" is defined as overlap ration with GLAD detections

JJ-FASTアルゴリズムのパラメータ調整：ケニアの事例

HV Algorithm

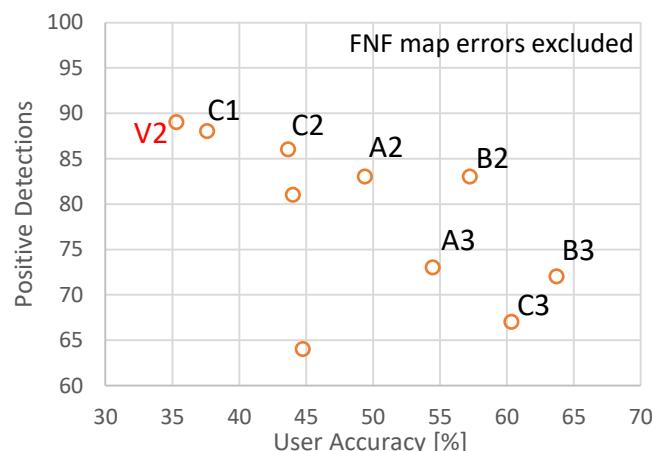
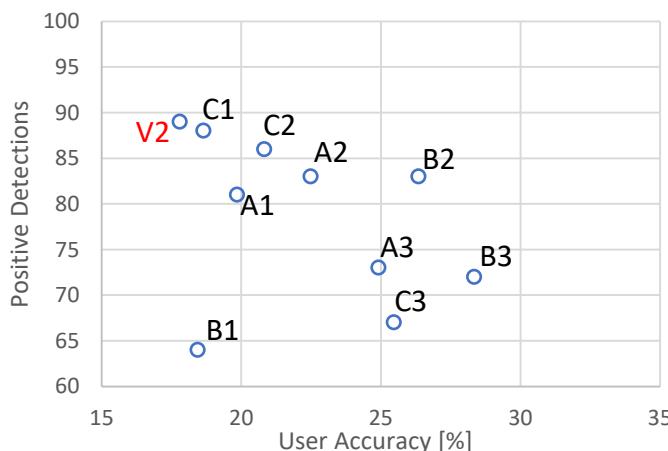
Version (Rain threshold)	Parameter adjustment L-1/L-2	Detections			False Alarms		User Accuracy [%]
		Total	Inspected*	Correct**	FNF error	Other	
Current	V2: -4.2 dB / -3.2 dB	873	500	89	248	163	17.8
A: 20mm/48h	A1: -4.8 dB / -3.8 dB	538	408	81	224	103	19.9
	A2: -5.2 dB / -4.2 dB	442	369	83	201	85	22.5
	A3: -5.4 dB / -4.4 dB	388	293	73	159	61	24.9
B: 40mm/72h	B1: -4.8 dB / -3.8 dB	475	347	64	204	79	18.4
	B2: -5.2 dB / -4.2 dB	337	315	83	170	62	26.3
	B3: -5.4 dB / -4.4 dB	299	254	72	141	41	28.3
C: 70mm/120h	C1: -4.8 dB / -3.8 dB	757	472	88	238	146	18.6
	C2: -5.2 dB / -4.2 dB	674	413	86	216	111	20.8
	C3: -5.4 dB / -4.4 dB	481	263	67	152	44	25.5

FNF map errors excluded

		False Alarms		User Accuracy [%]
Inspected*	Correct**	FNF error	Other	
252	89	248	163	35.3
184	81	224	103	44.0
168	83	201	85	49.4
134	73	159	61	54.5
143	64	204	79	44.8
145	83	170	62	57.2
113	72	141	41	63.7
234	88	238	146	37.6
197	86	216	111	43.7
111	67	152	44	60.4

Deforestation detection results obtained by JJ-FAST v2(shi29)-algorithm

Evaluation based on visual inspection of 500 polygons (Sentinel-2/EarthEngine + GoogleEarth)



Conclusions

- First comprehensive regional- to continental-scale assessment of precipitation effects on L-band SAR imaging
- Patterns of gamma naught and rainfall correlations provide unseen insights in forest structures
- GSMap precipitation data can help to better understand and correct the disturbing backscatter fluctuation in ALOS-2 forest observation
- Using GSMap data can help to improve JJ-FAST reliability:
Deforestation detection accuracy improvement (B2-case)
 - ✓ User accuracy up from **17.8%(v2)** → **26.3%(B2)** ($\uparrow \textcolor{red}{47.8\%}$)
 - ✓ False alarm reduction from **411(v2)** → **232(B2)** ($\downarrow \textcolor{red}{43.6\%}$)



Thank you for your attention!



GSMAP

16hz010@ms.dendai.ac.jp
christian.koyama@outlook.com

Tokyo Denki University
School of Science and Engineering
Ishizaka, Hatoyama, Hiki, Saitama, 350-0394, Japan