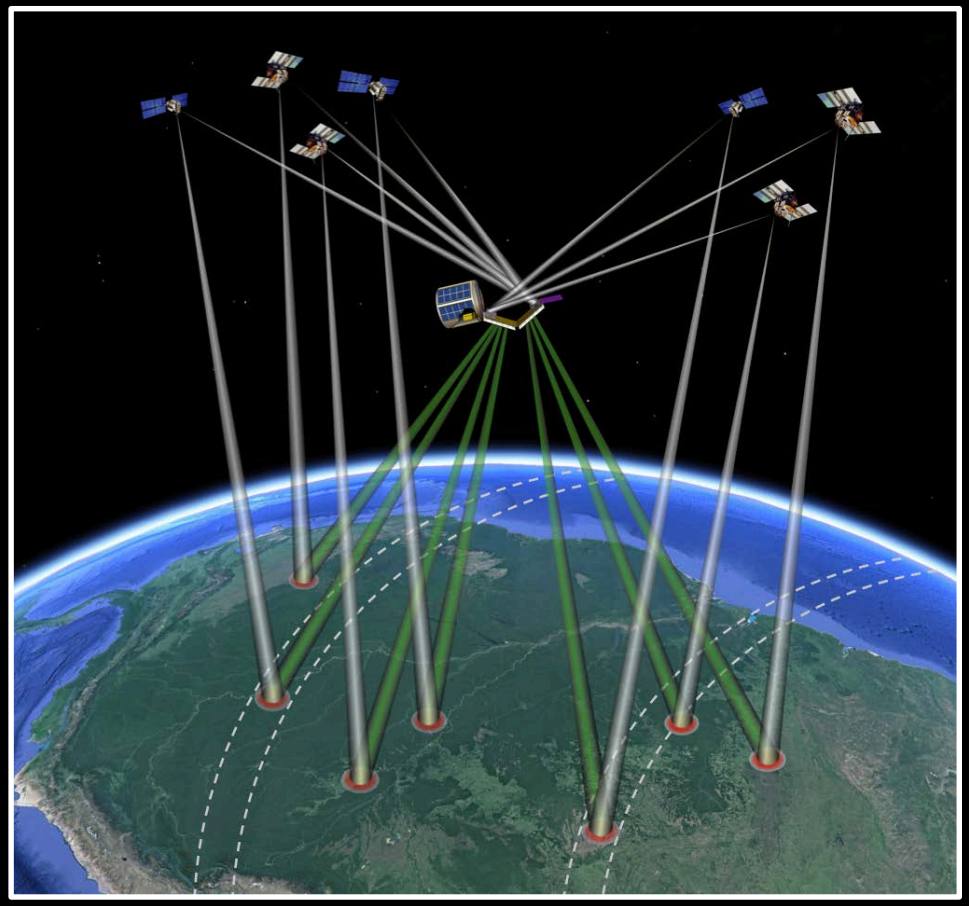
Jet Propulsion Laboratory
California Institute of Technology

Wetland Mapping and Measurement of Flood Inundated Area Using Ground-Reflected GNSS Signals in a Bistatic Radar System



Clara C. Chew, Rashmi Shah, Cinzia Zuffada , and Anthony J. Mannucci

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- Small spatial resolution
- High temporal repeat (daily)

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future

We can use ground-reflected GNSS (GPS) signals to measure wetlands (flood-inundated area).

Disadvantages

- Relatively new technique
- Signals are opportunistic

Outline

Introduce GPS reflections

Example over the Amazon

Inundation classification

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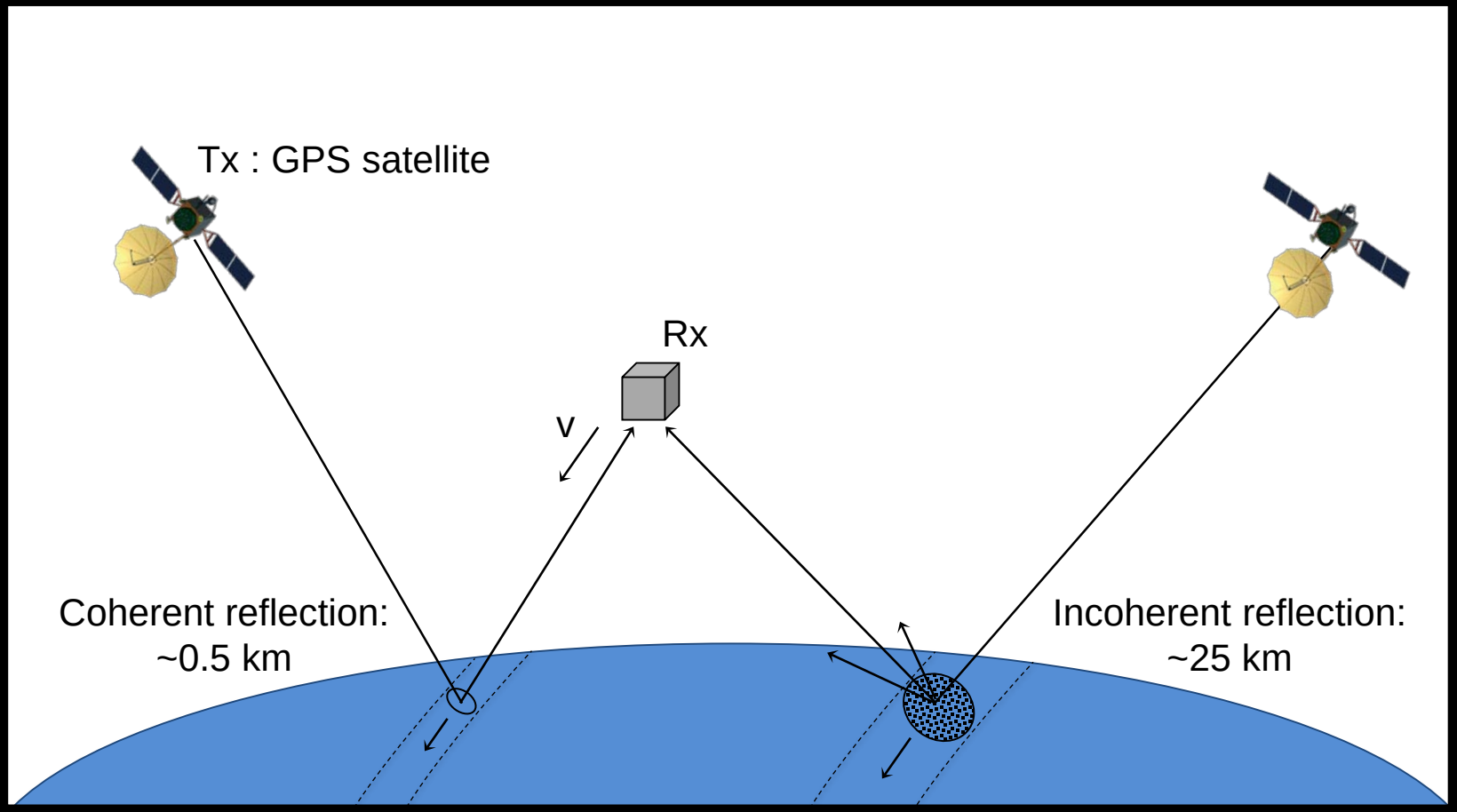
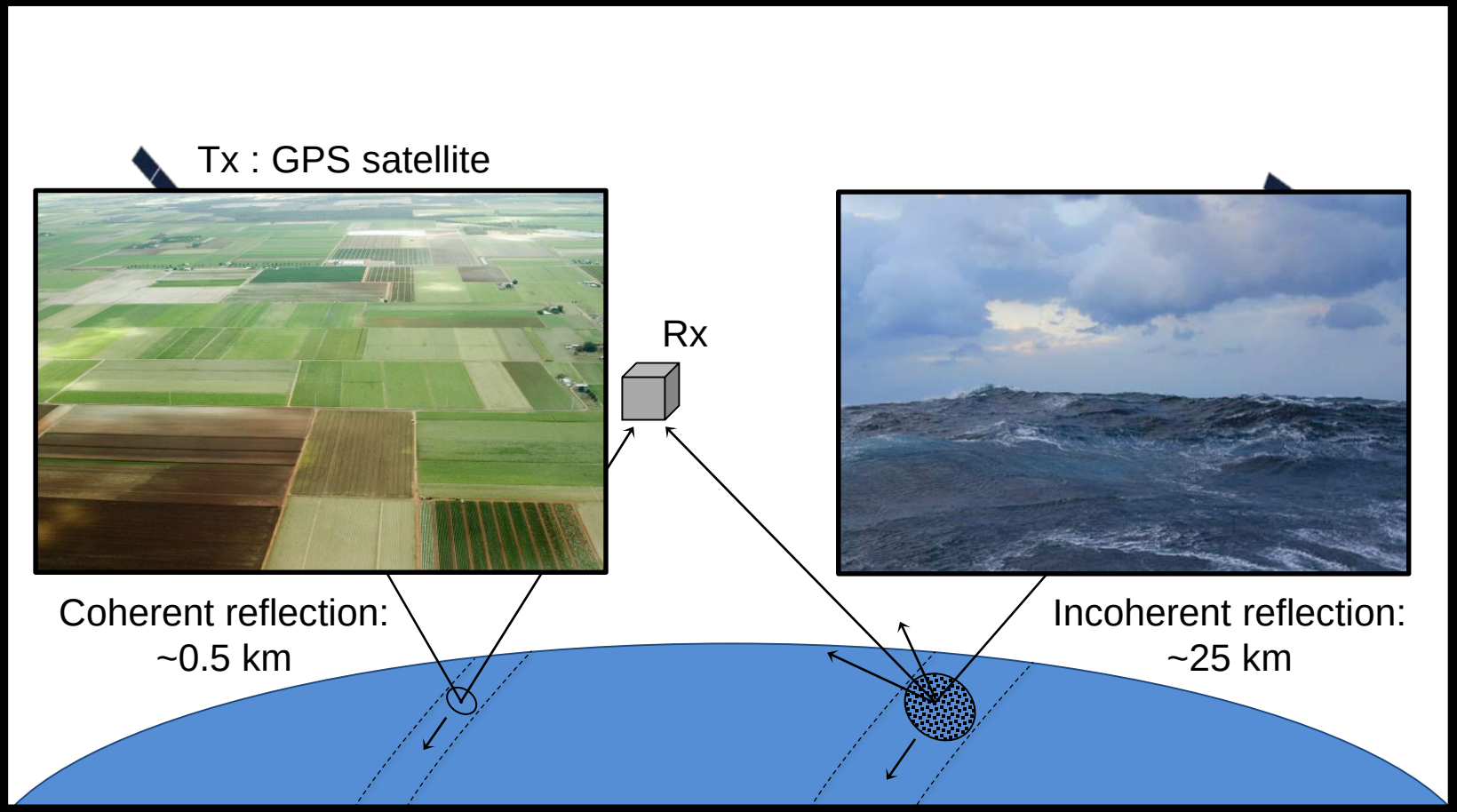


Figure modified from: http://www.ice.csic.es/ca/en/view_research_line.php?RID=13&ap=0



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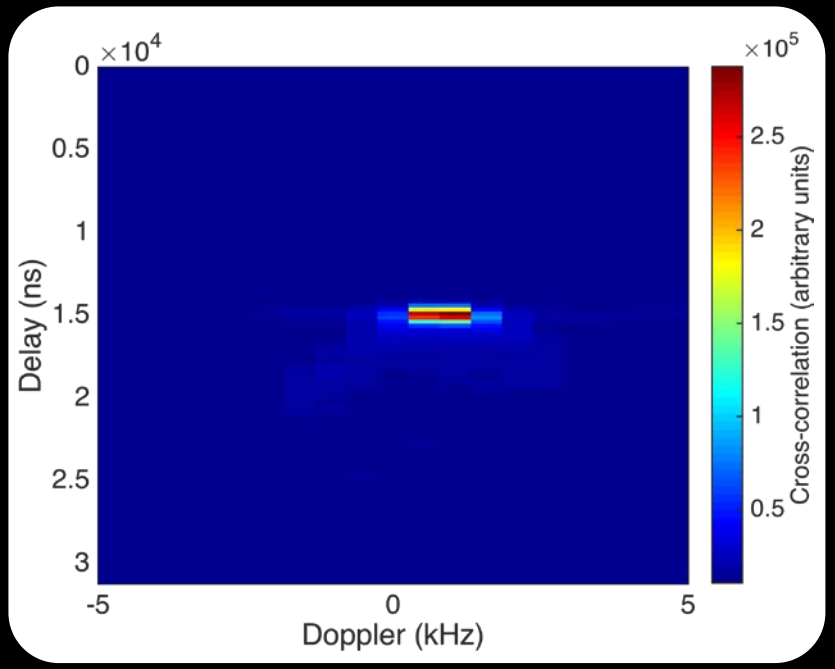
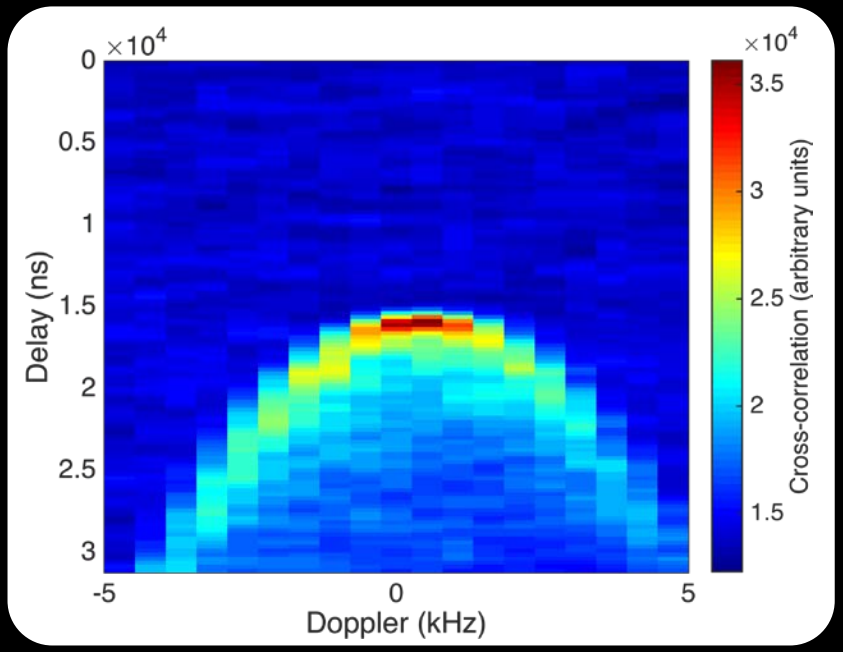
Delay-Doppler Maps (DDMs)



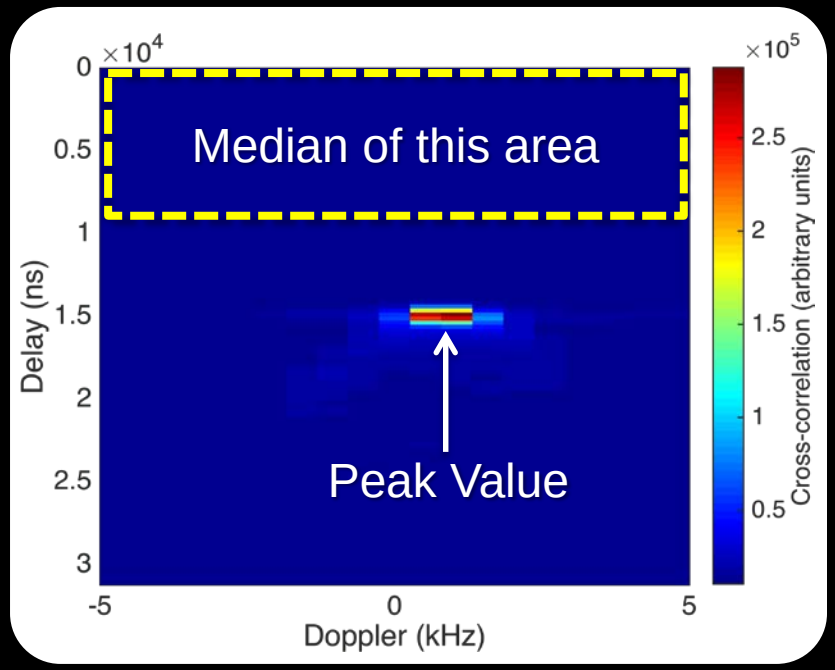


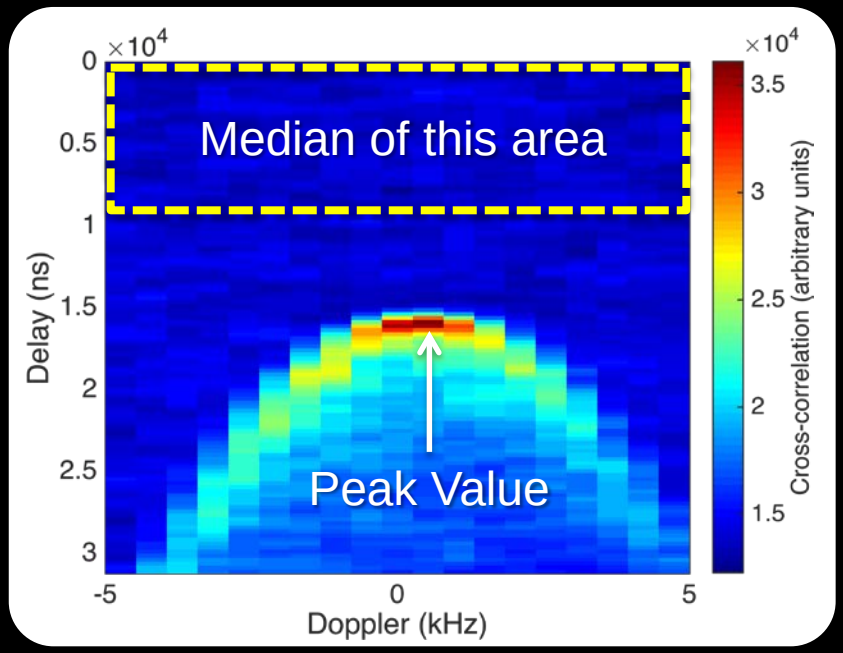
Note: Colorbars differ by an order of magnitude

Delay-Doppler Maps (DDMs)

Reflected power =10log(Peak Value/Median Noise Value)

Also, correct for gain, range, and angle





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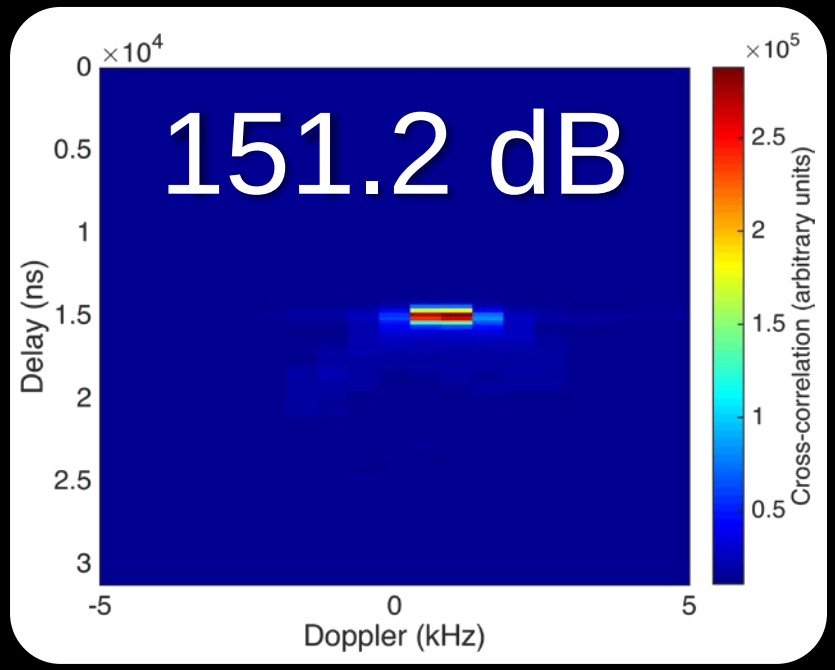

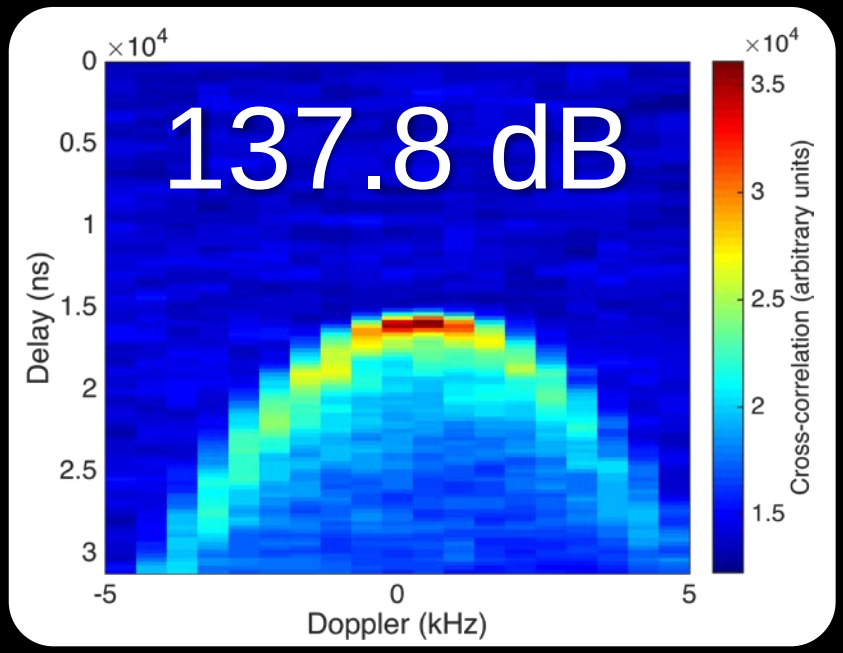

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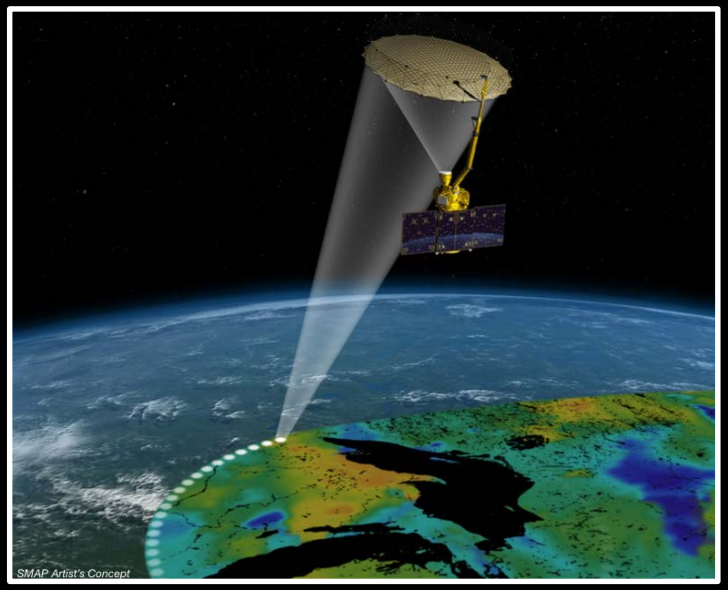
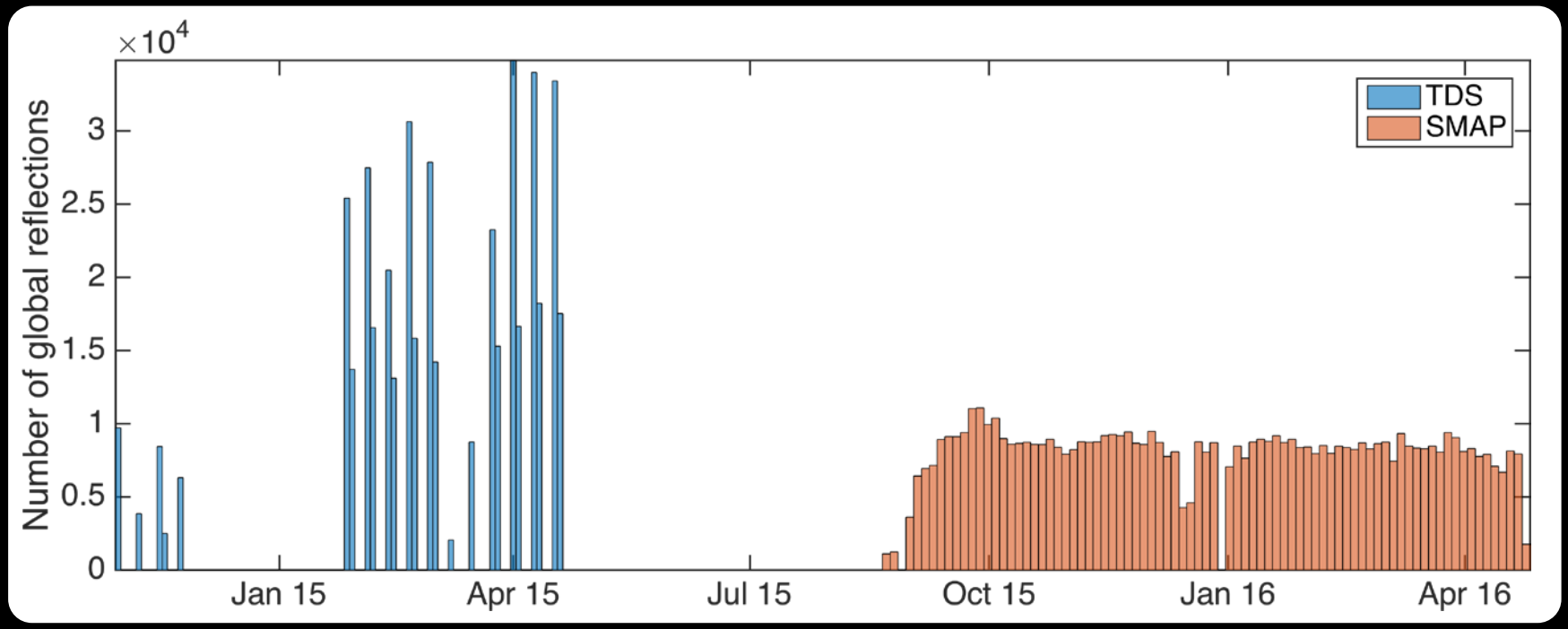
SURREY
SATELLITE TECHNOLOGY LTD


SMAP Artist's Concept


×10^4
Number of global reflections
0
0.5
1
1.5
2
2.5
3
Jan 15
Apr 15
Jul 15
Oct 15
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TDS
SMAP

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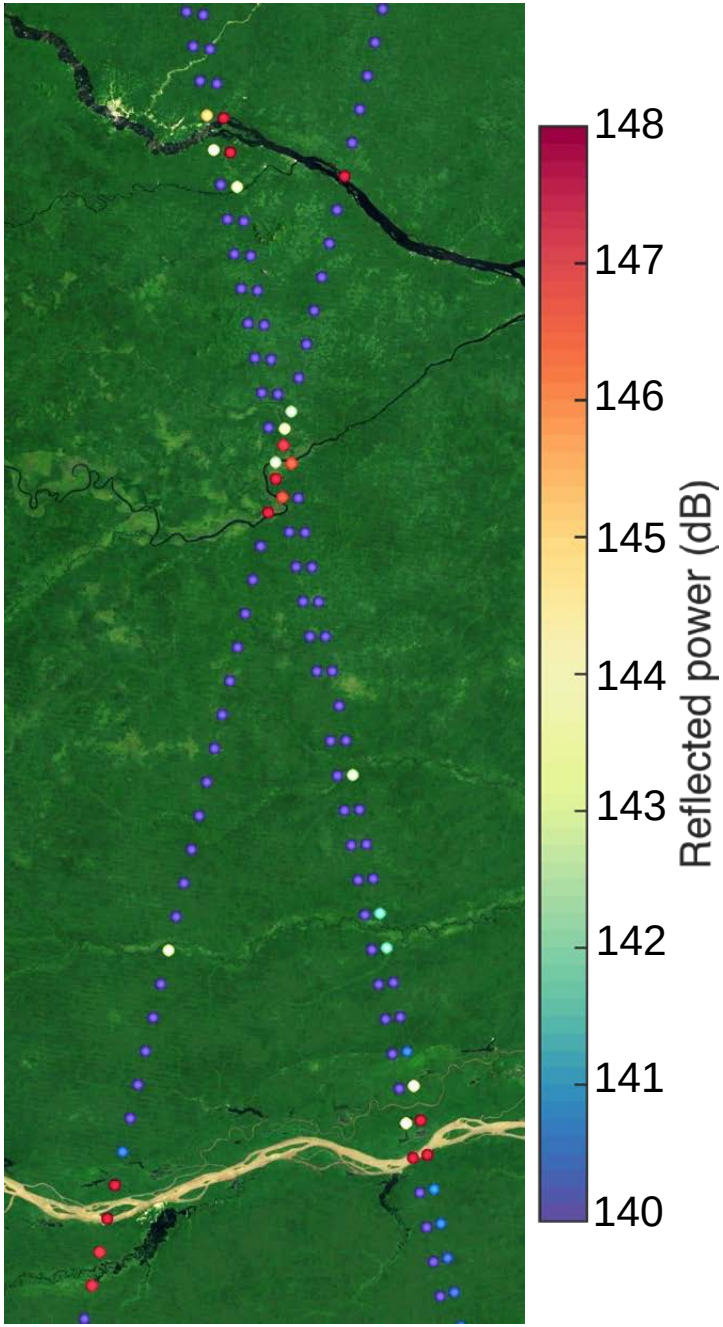
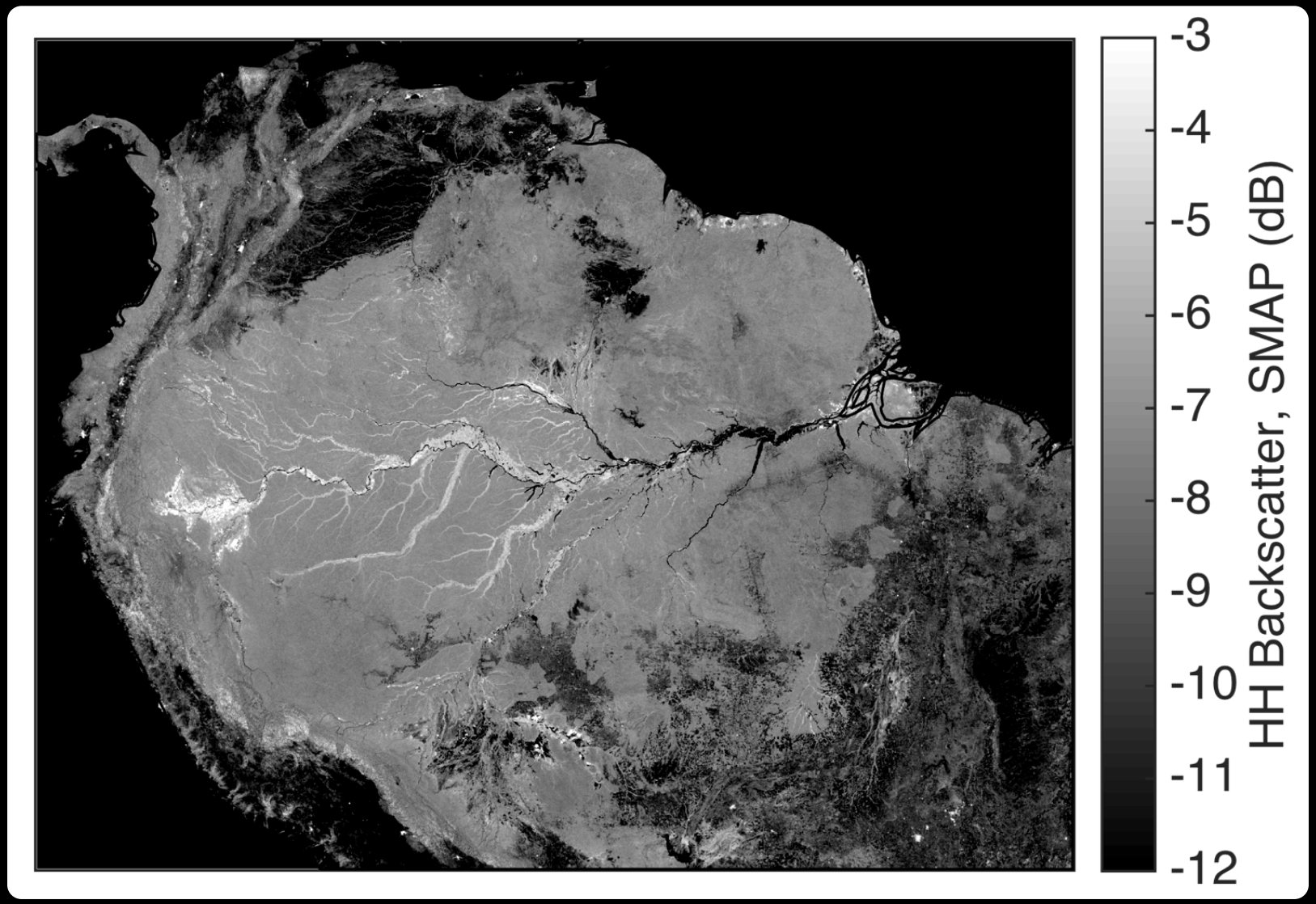
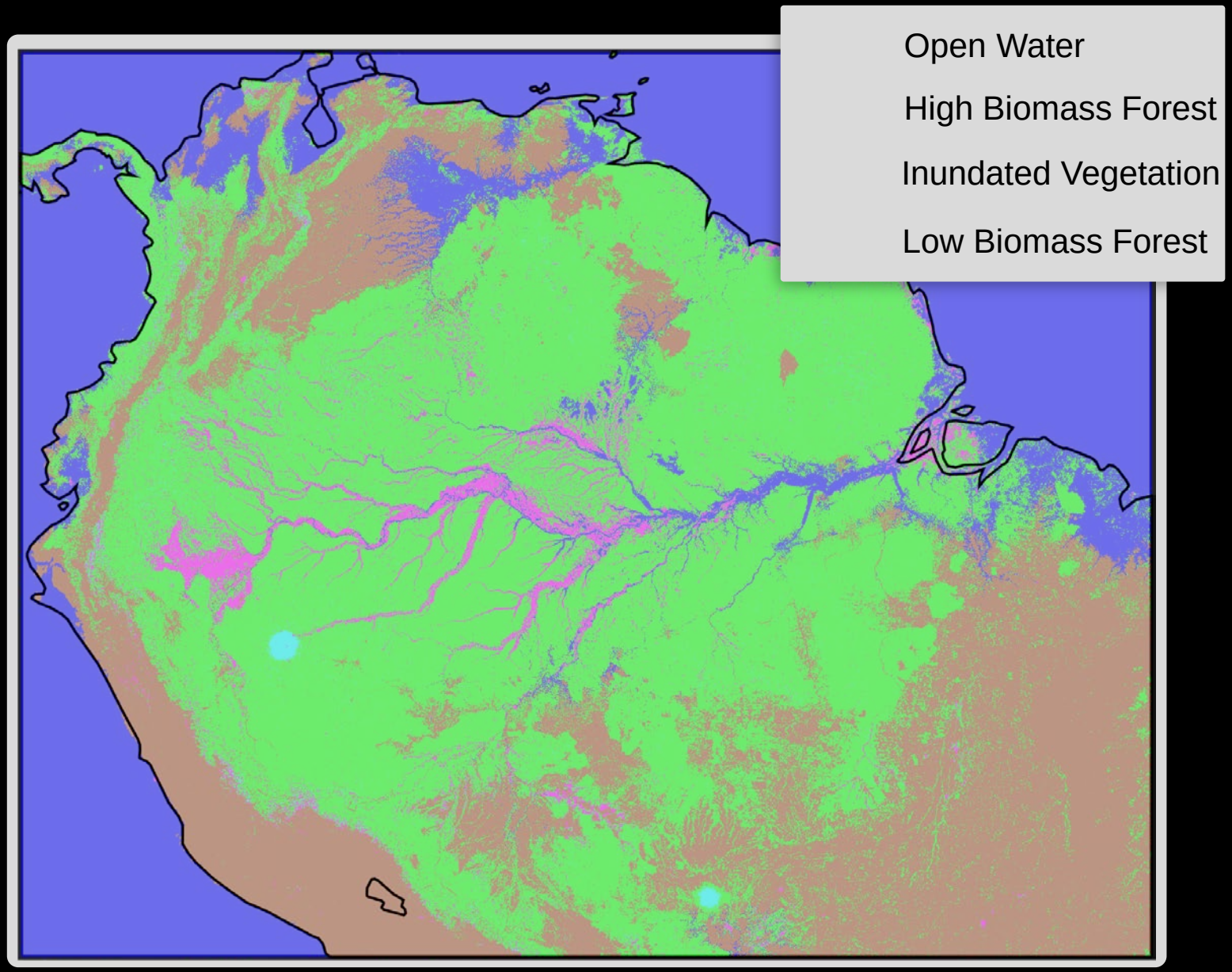
Reflections over rivers in the Amazon

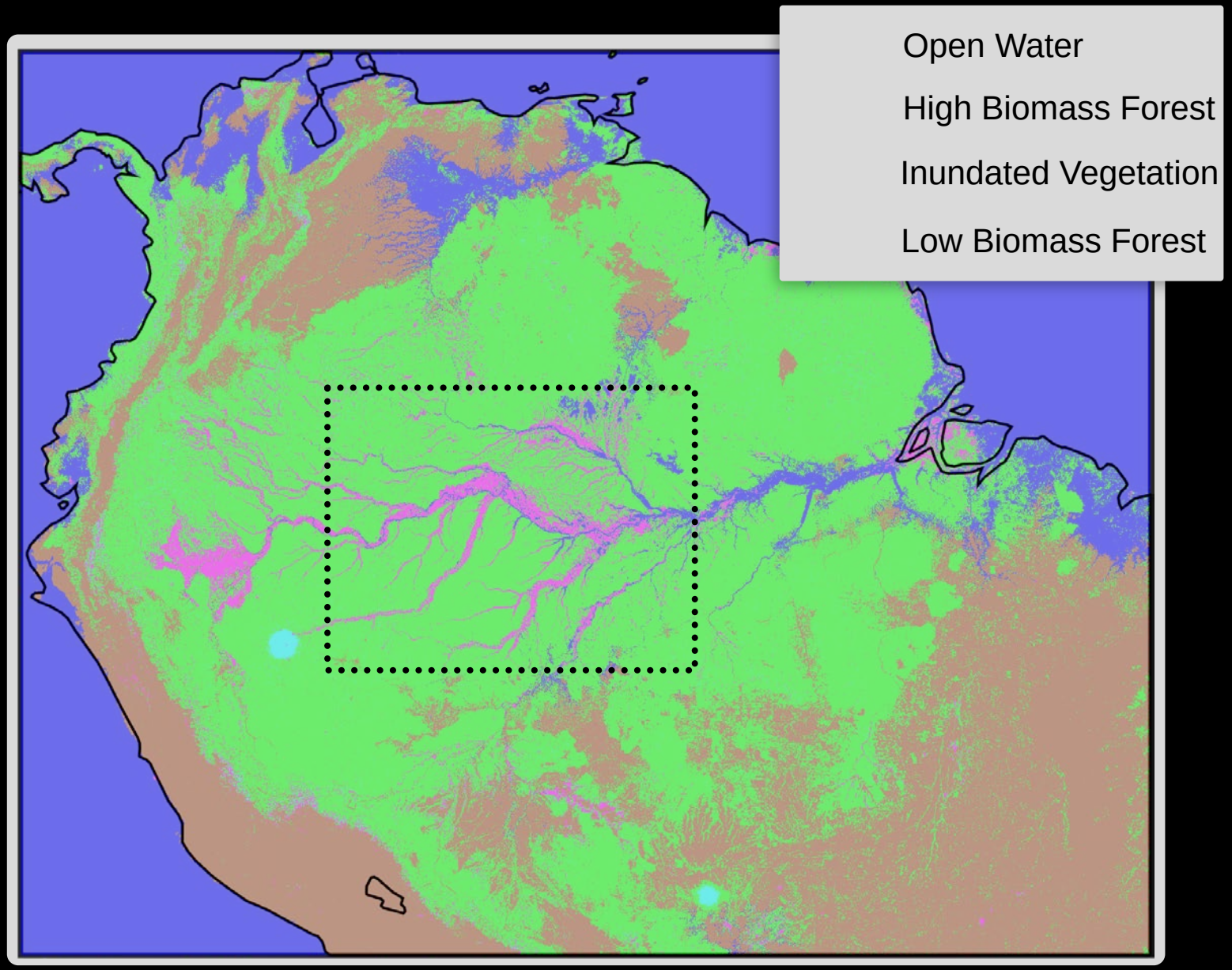


Radar backscatter image from SMAP





Thanks to Erika Podest at JPL for providing land cover information.



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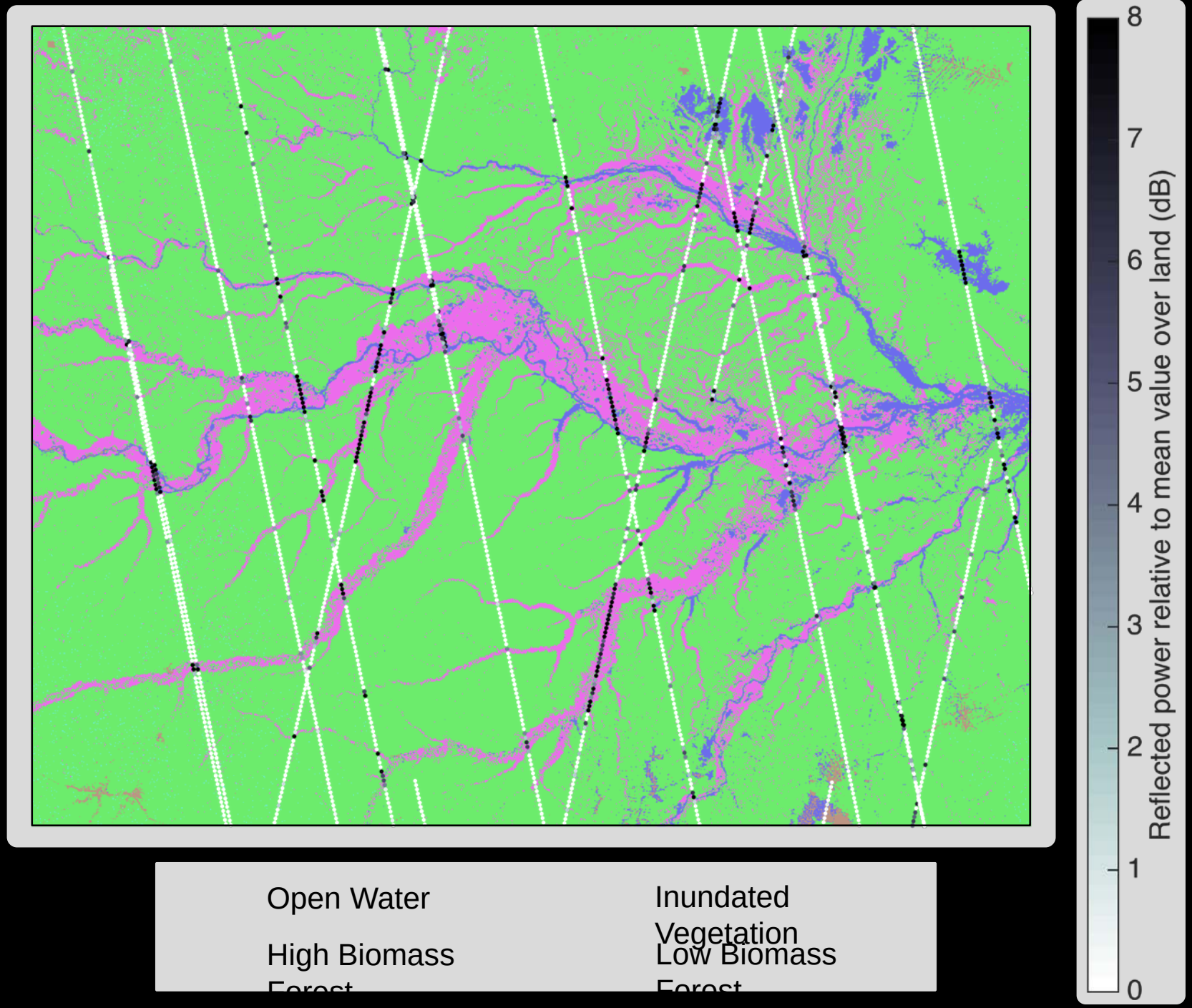
Open Water
Inundated Vegetation
High Biomass Forest
Low Biomass Forest
Reflected power relative to mean value over land (dB)
0
1
2
3
4
5
6
7
8

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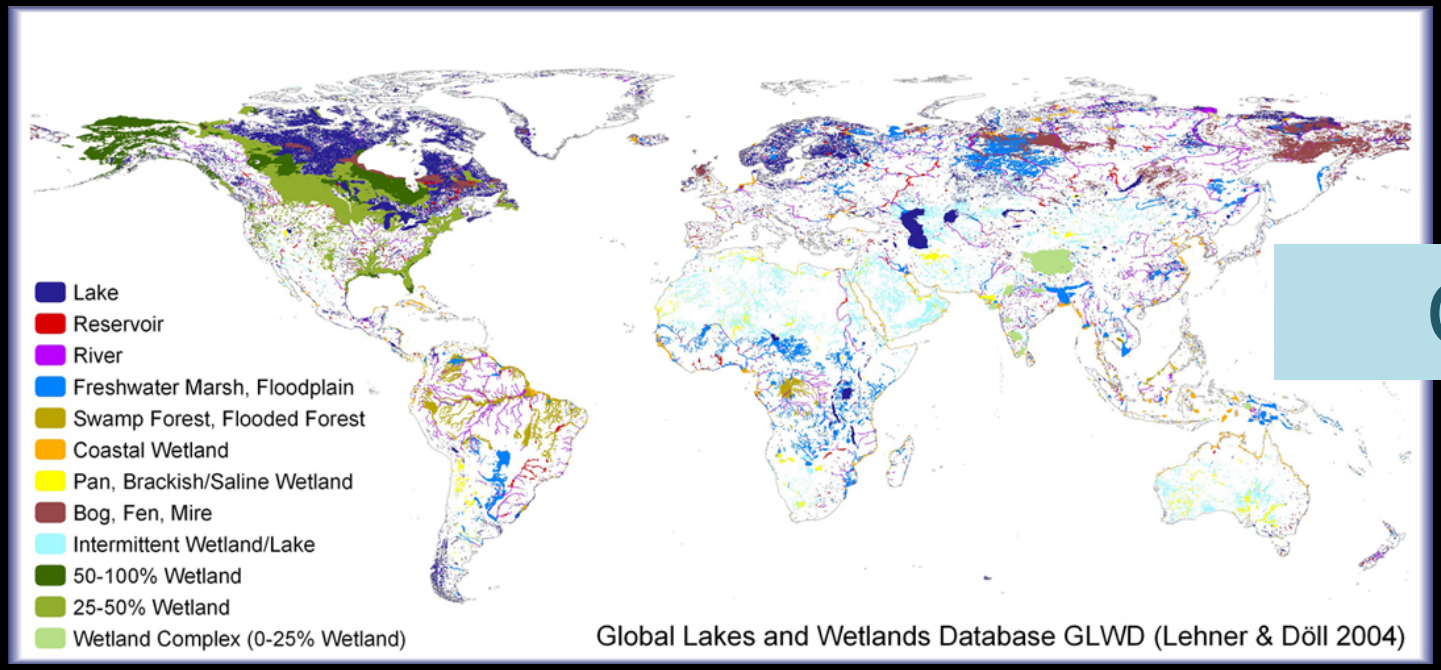
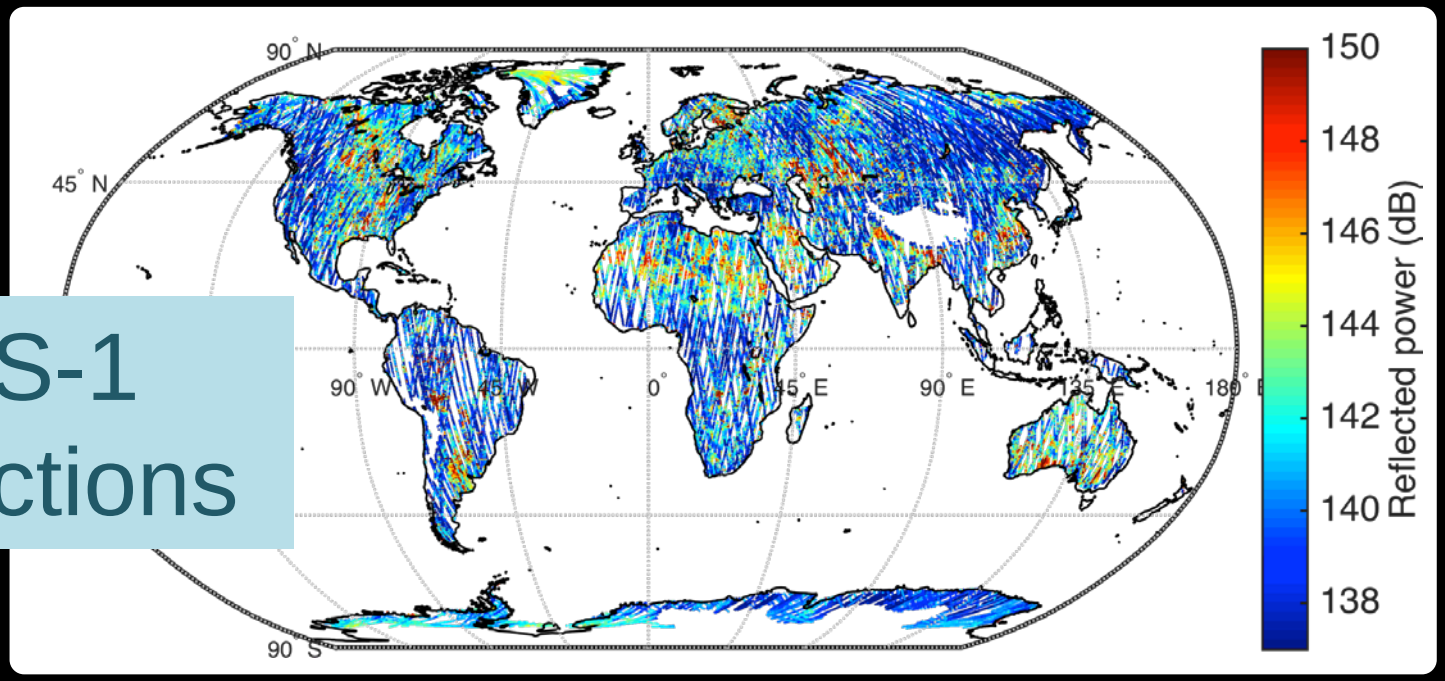
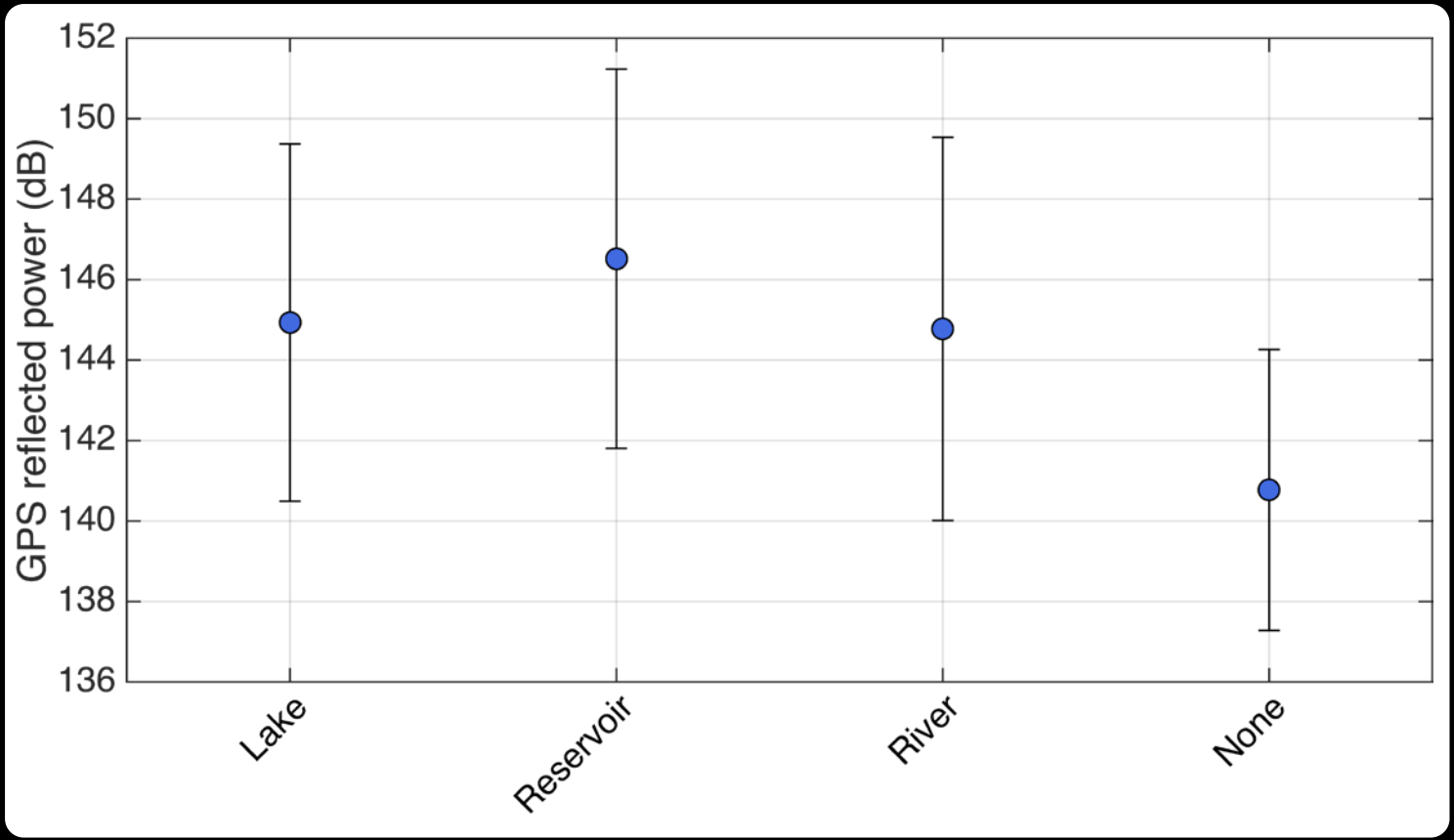


GLWD



TDS-1 Reflections

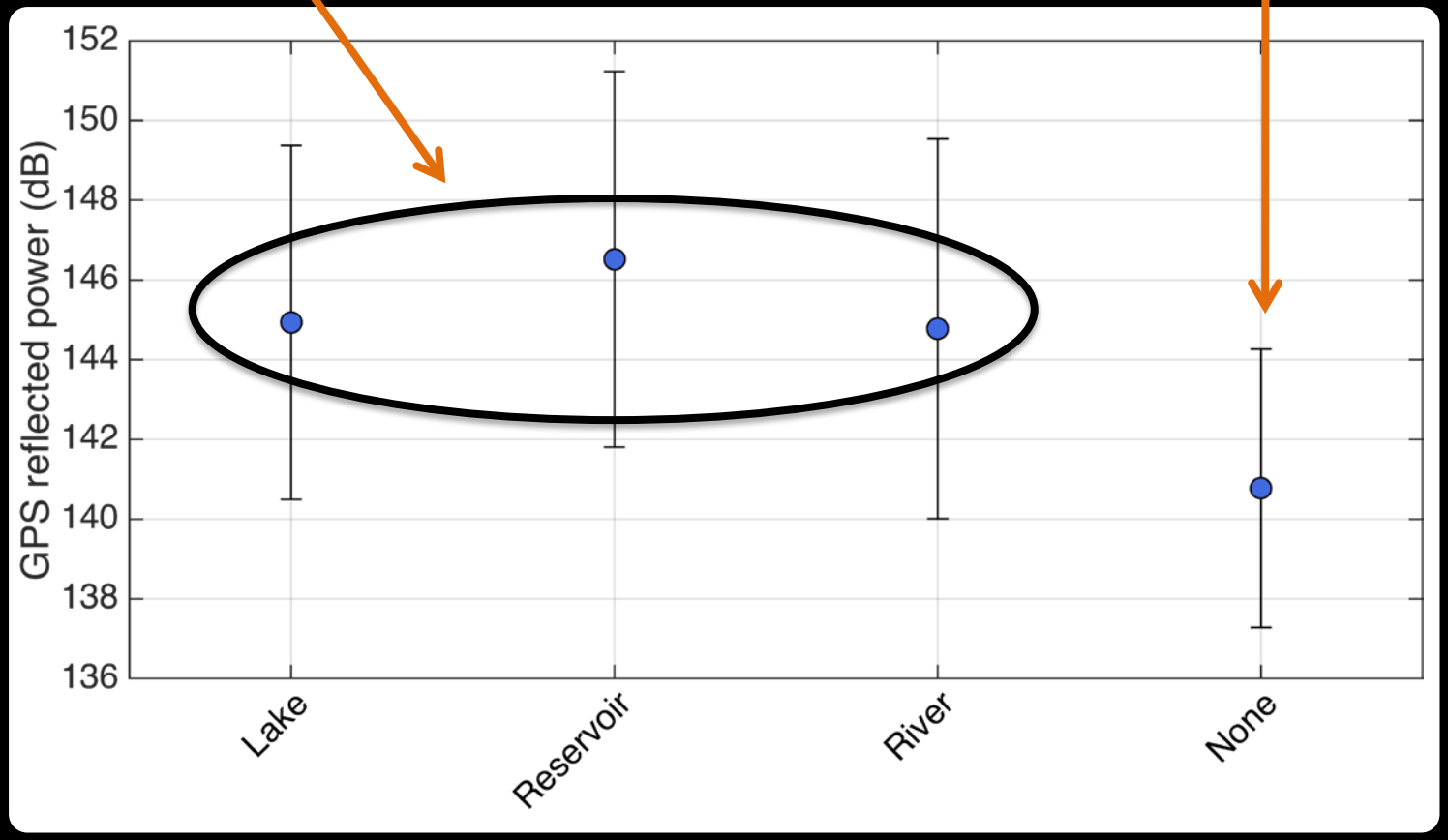

GPS reflected power (dB)
152
150
148
146
144
142
140
138
136
Lake
Reservoir
River
None

‘Inundated’

‘Not inundated’

145.1 dB

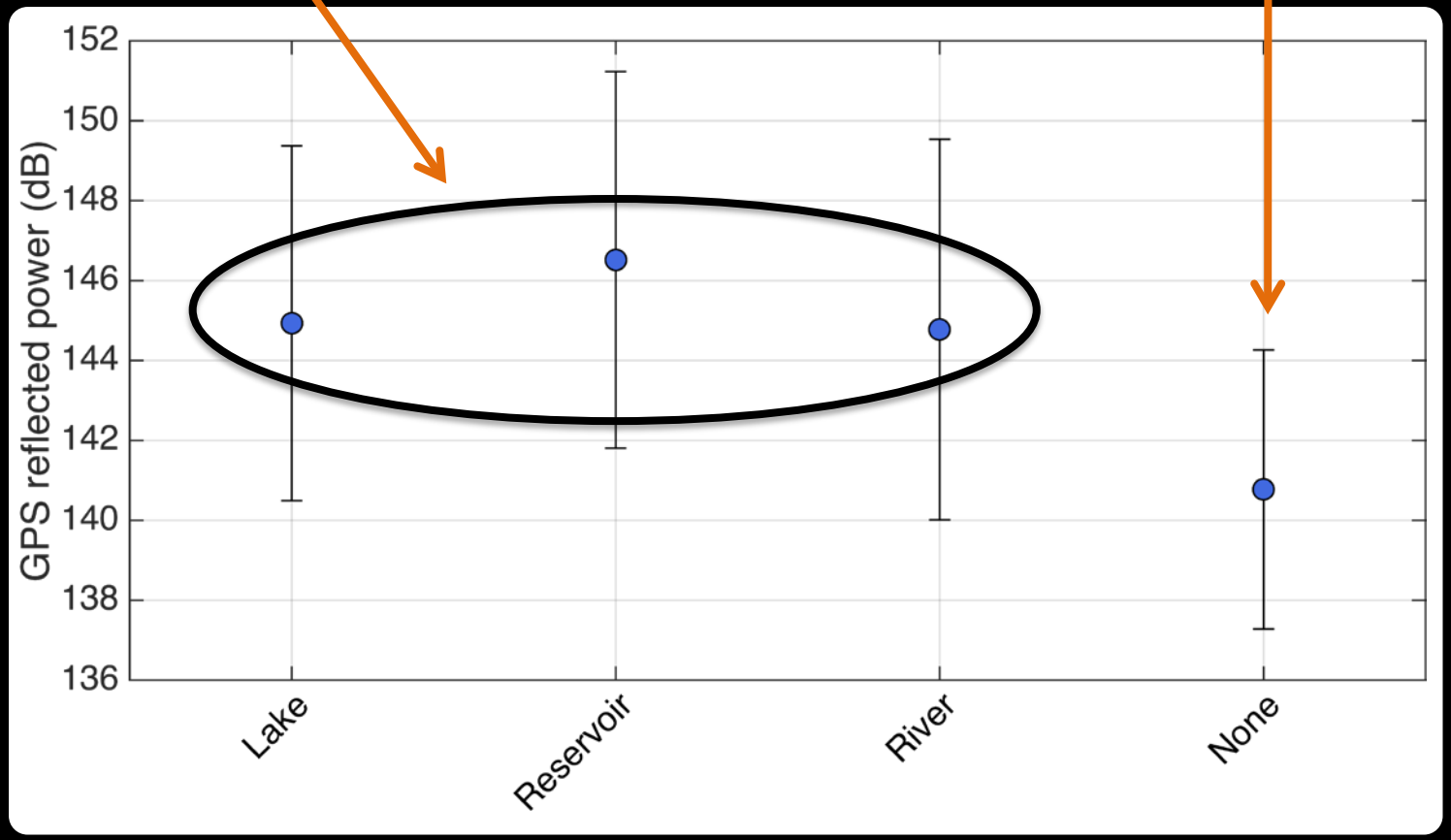
140.4 dB



‘Inundated’ ‘Not inundated’

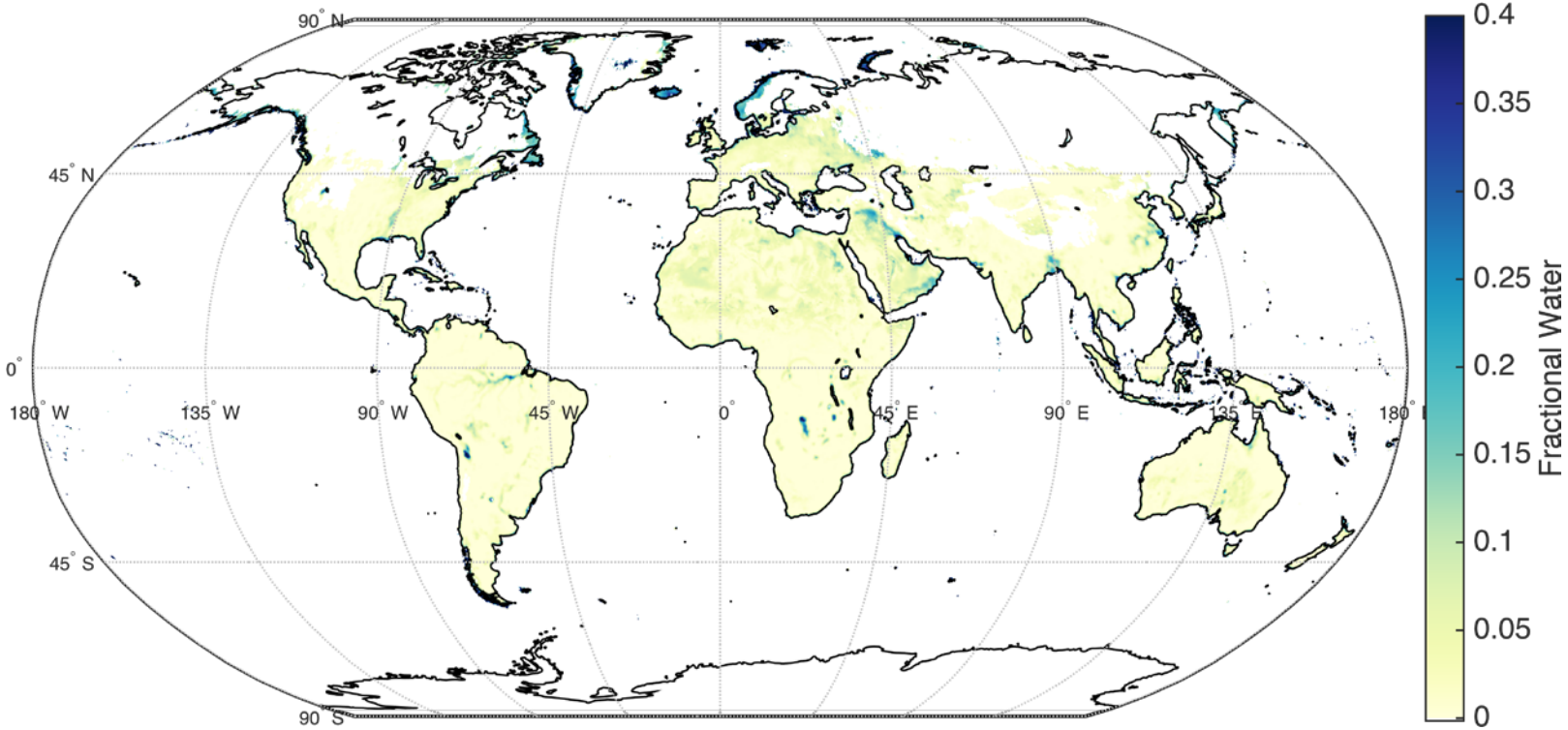
‘Uncertain’

145.1 dB ⟷ 140.4 dB

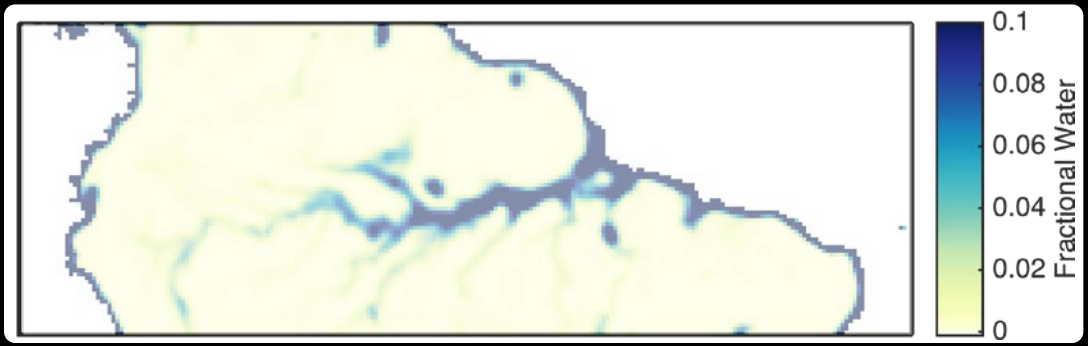


SWAMPS—Surface Water Microwave Product Series

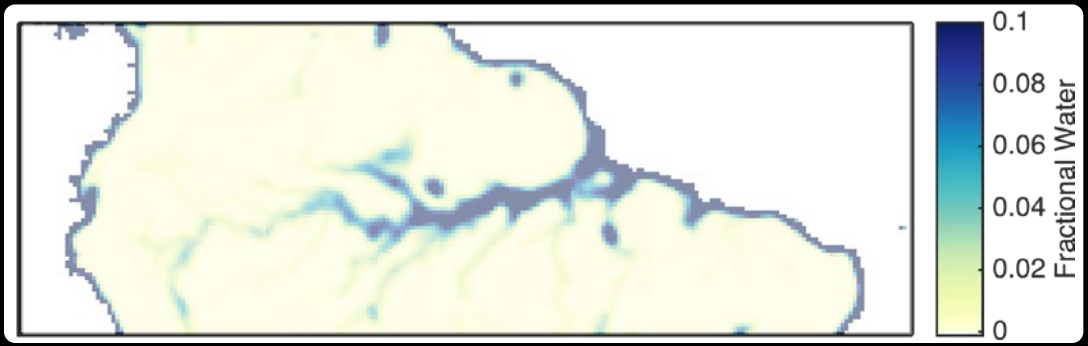
Average surface inundation for February, 2013.

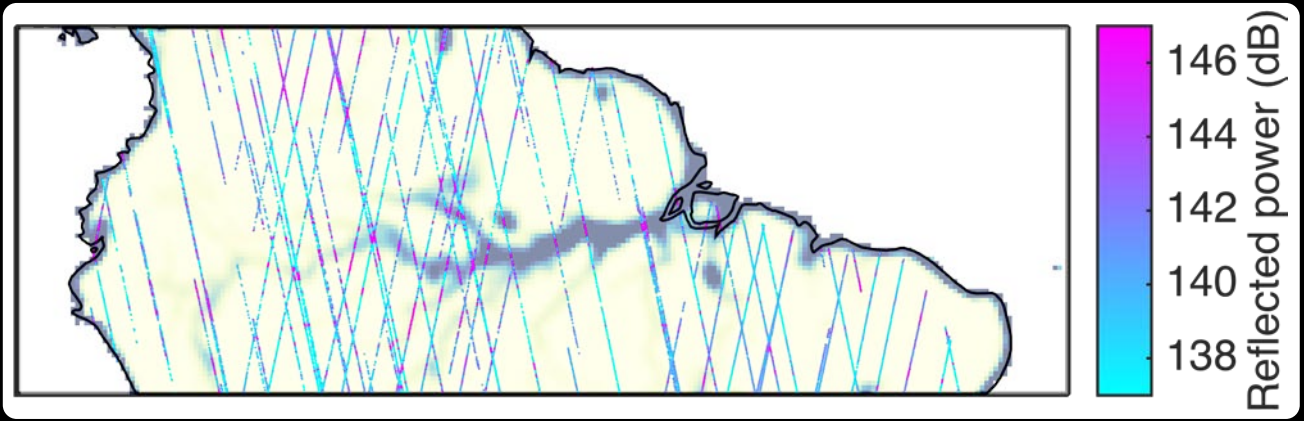


Average inundation for Feb-Apr, 2008-2013

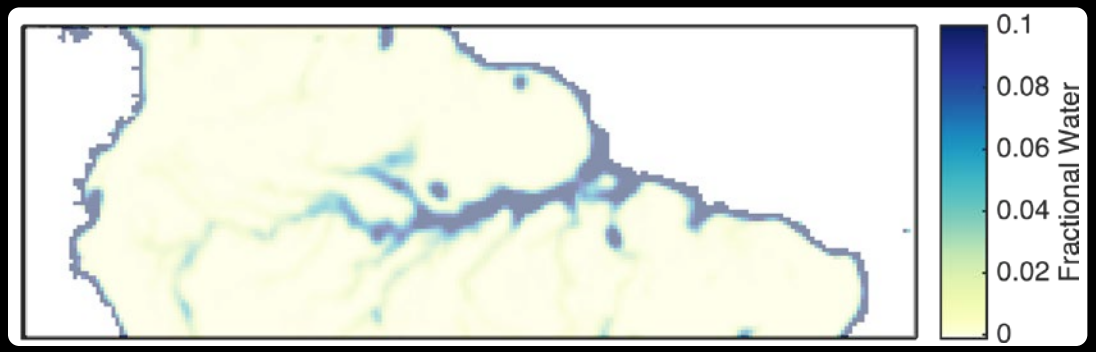


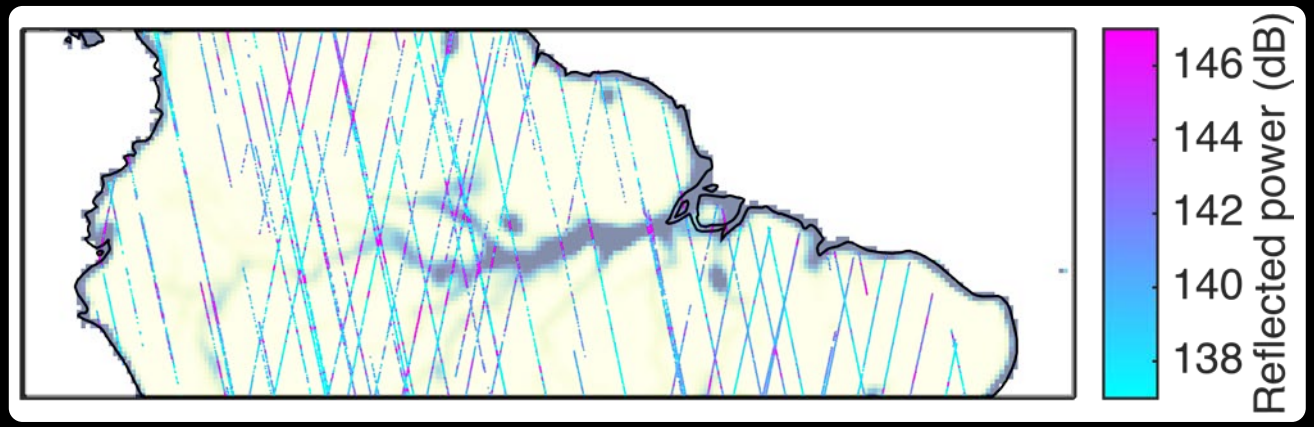
Average inundation for Feb-Apr, 2008-2013

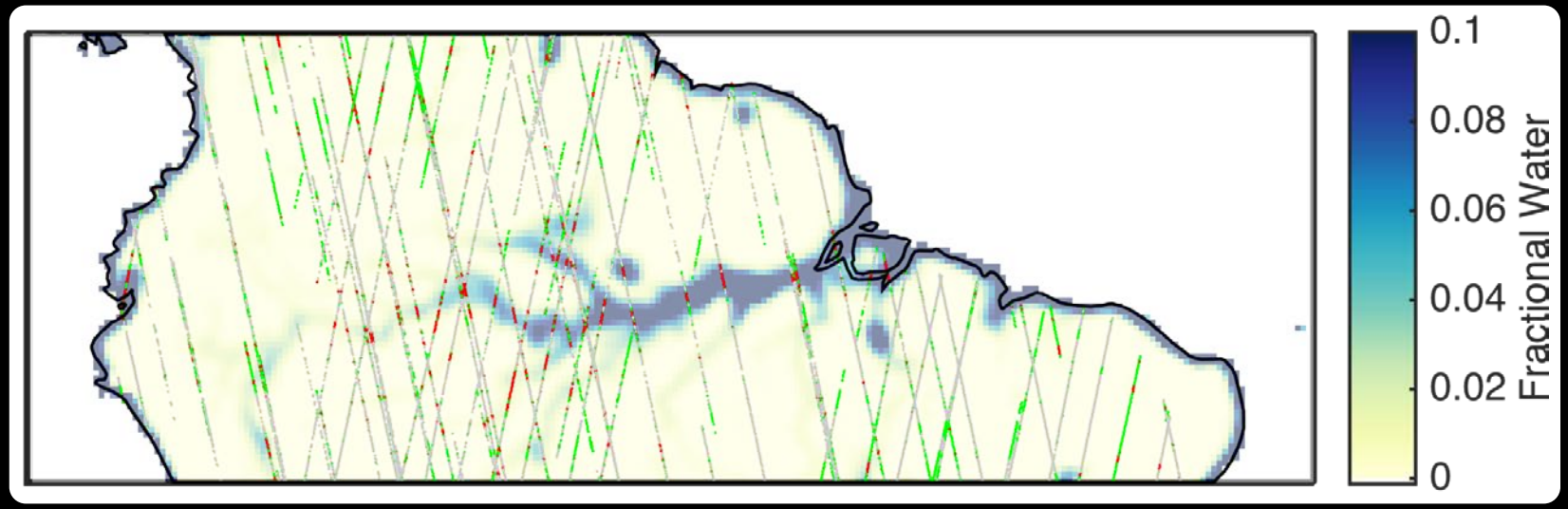




Average inundation for Feb-Apr, 2008-2013







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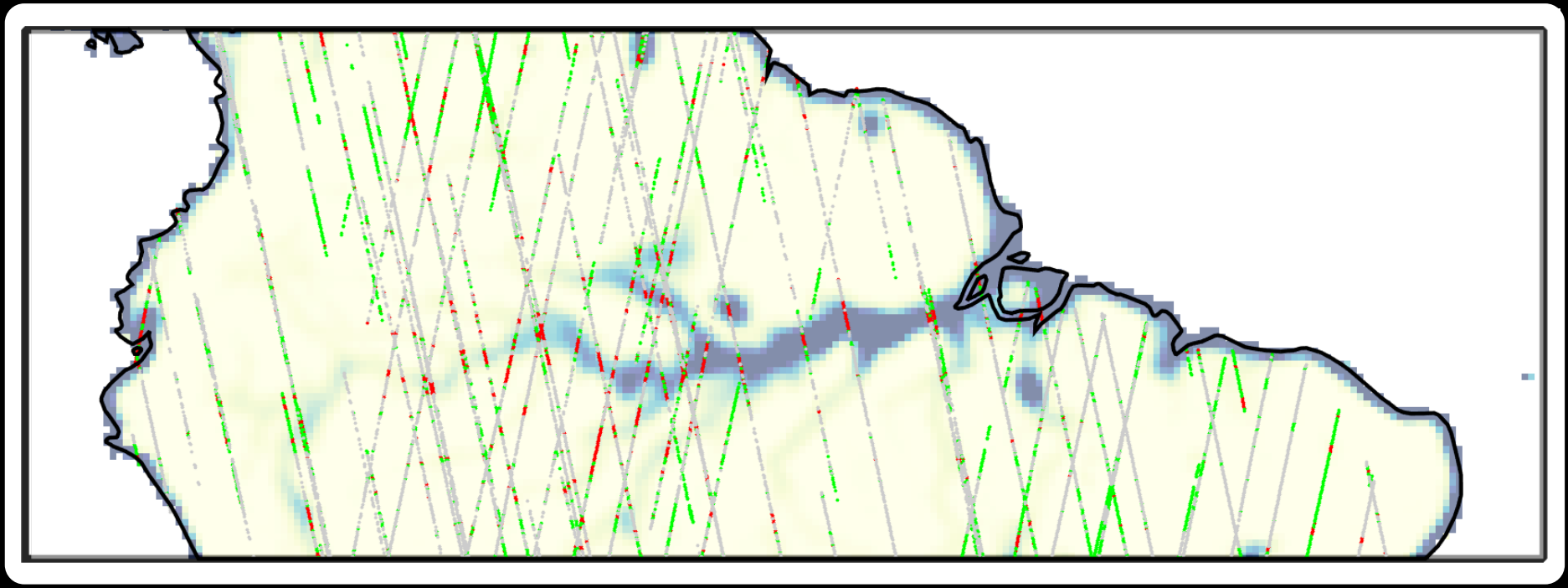
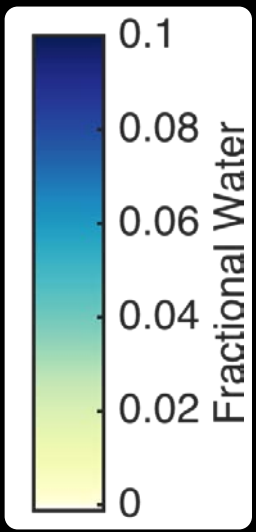
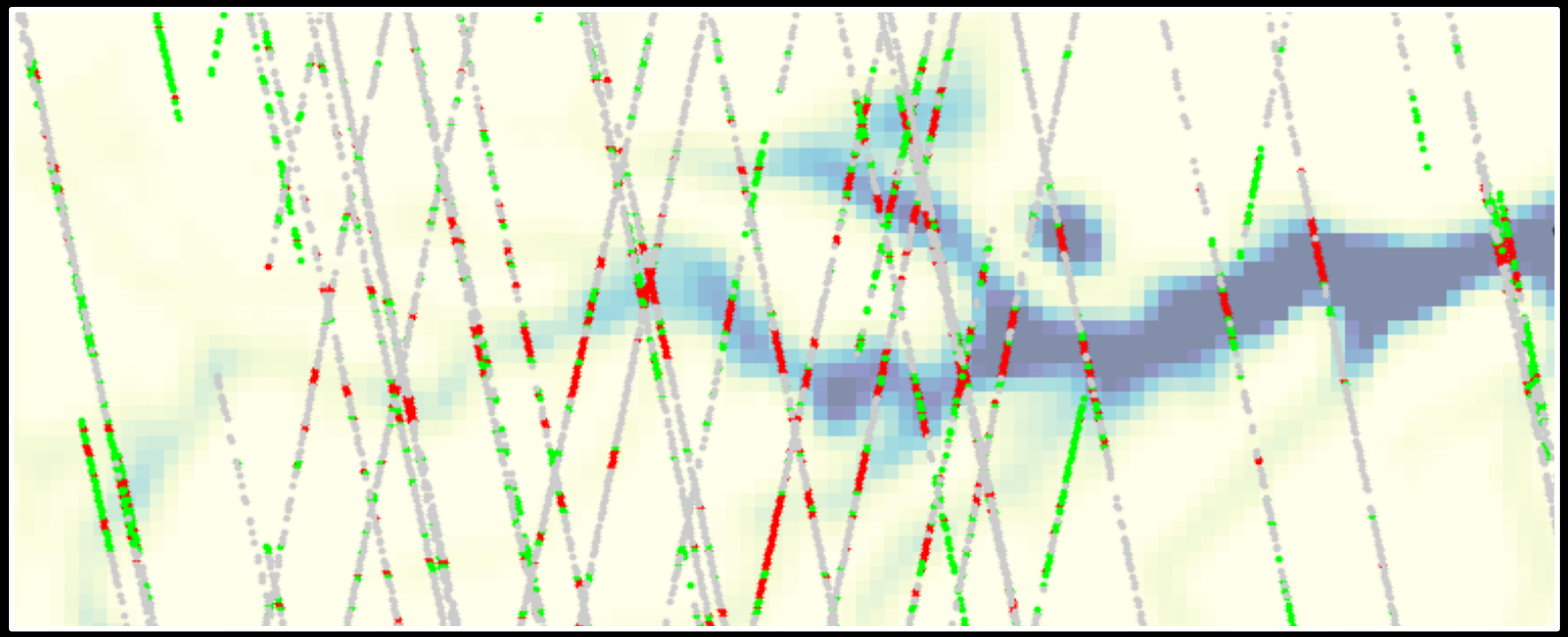
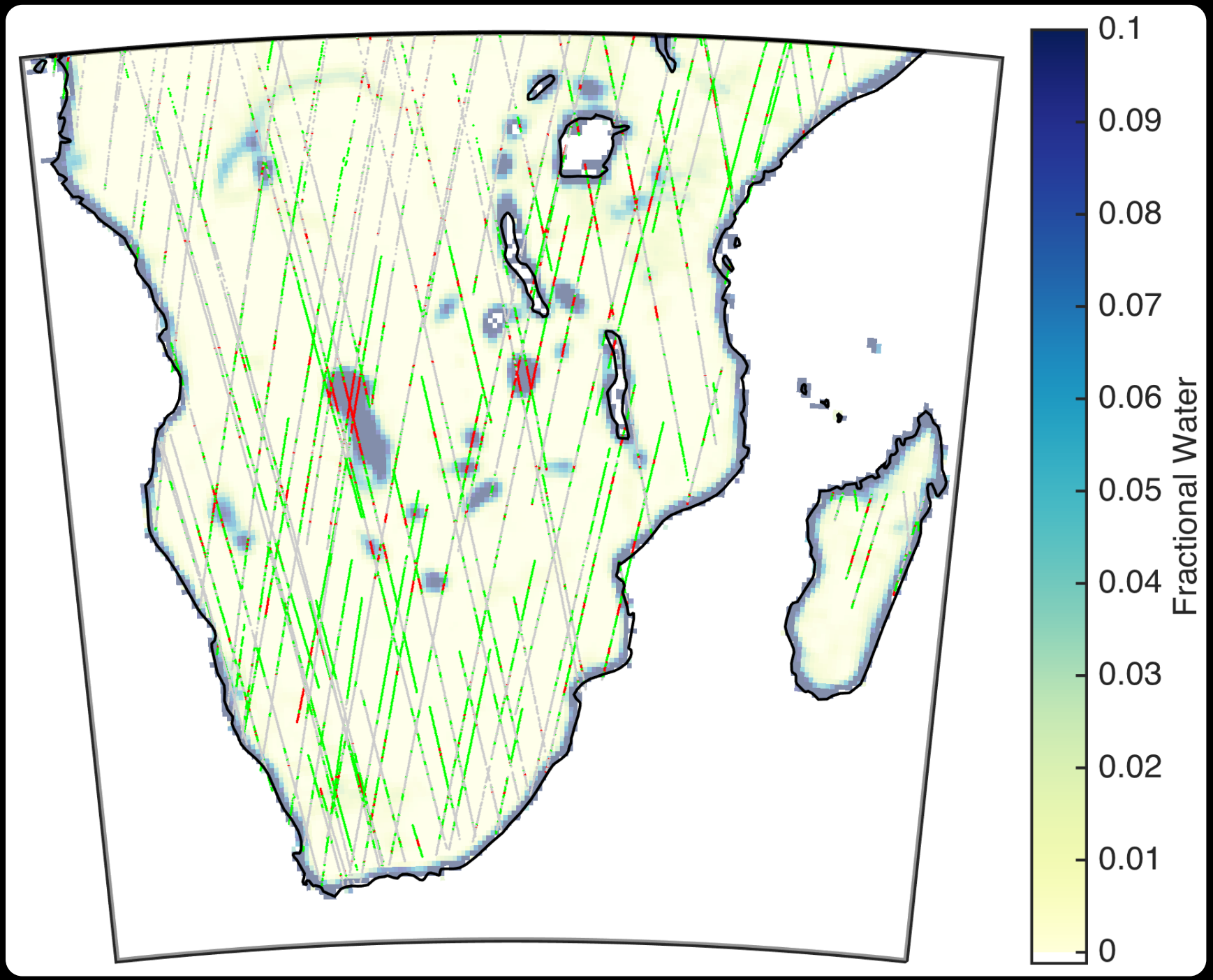
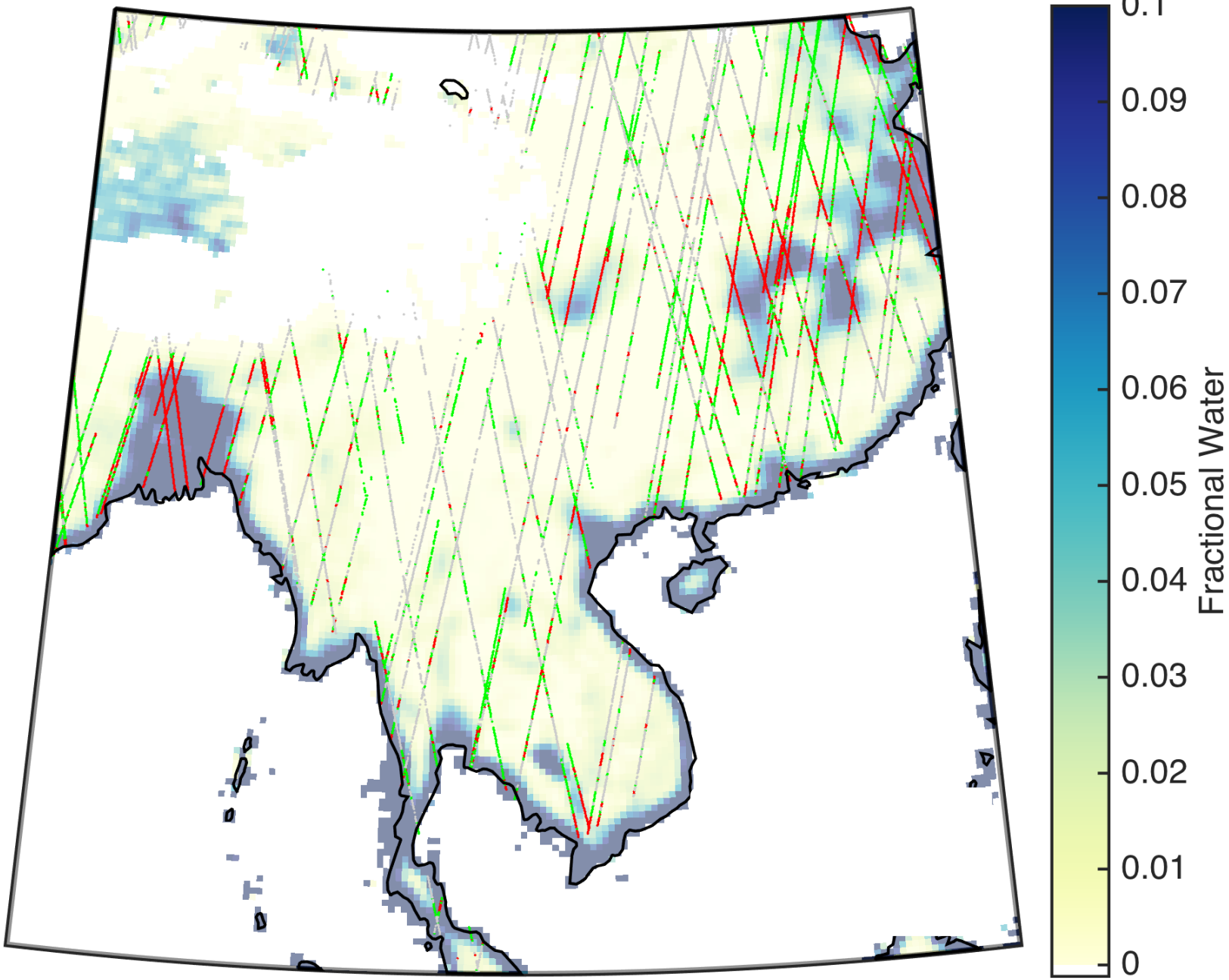



0.1
0.08
0.06
0.04
0.02
0
Fractional Water




0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Fractional Water

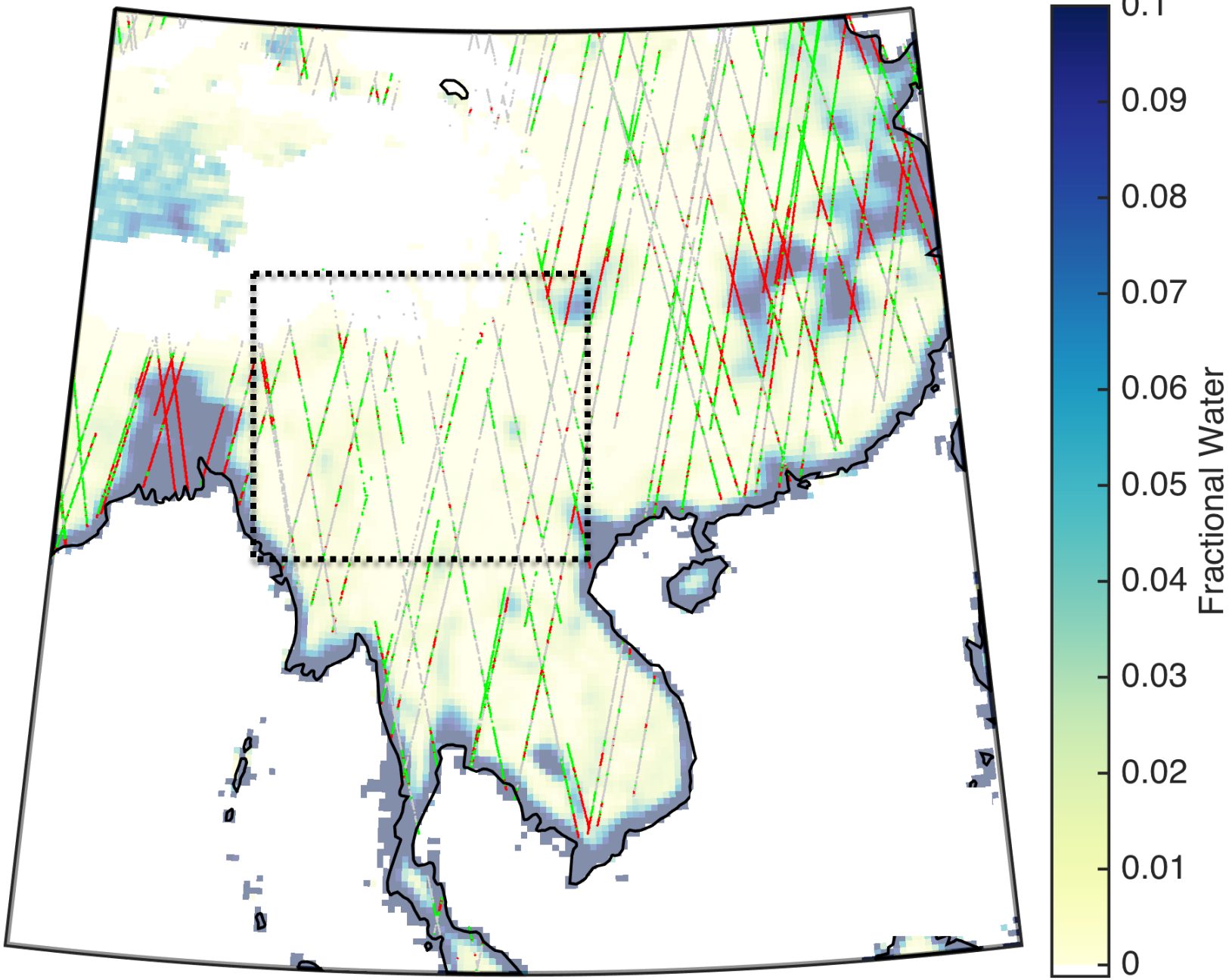

0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Fractional Water

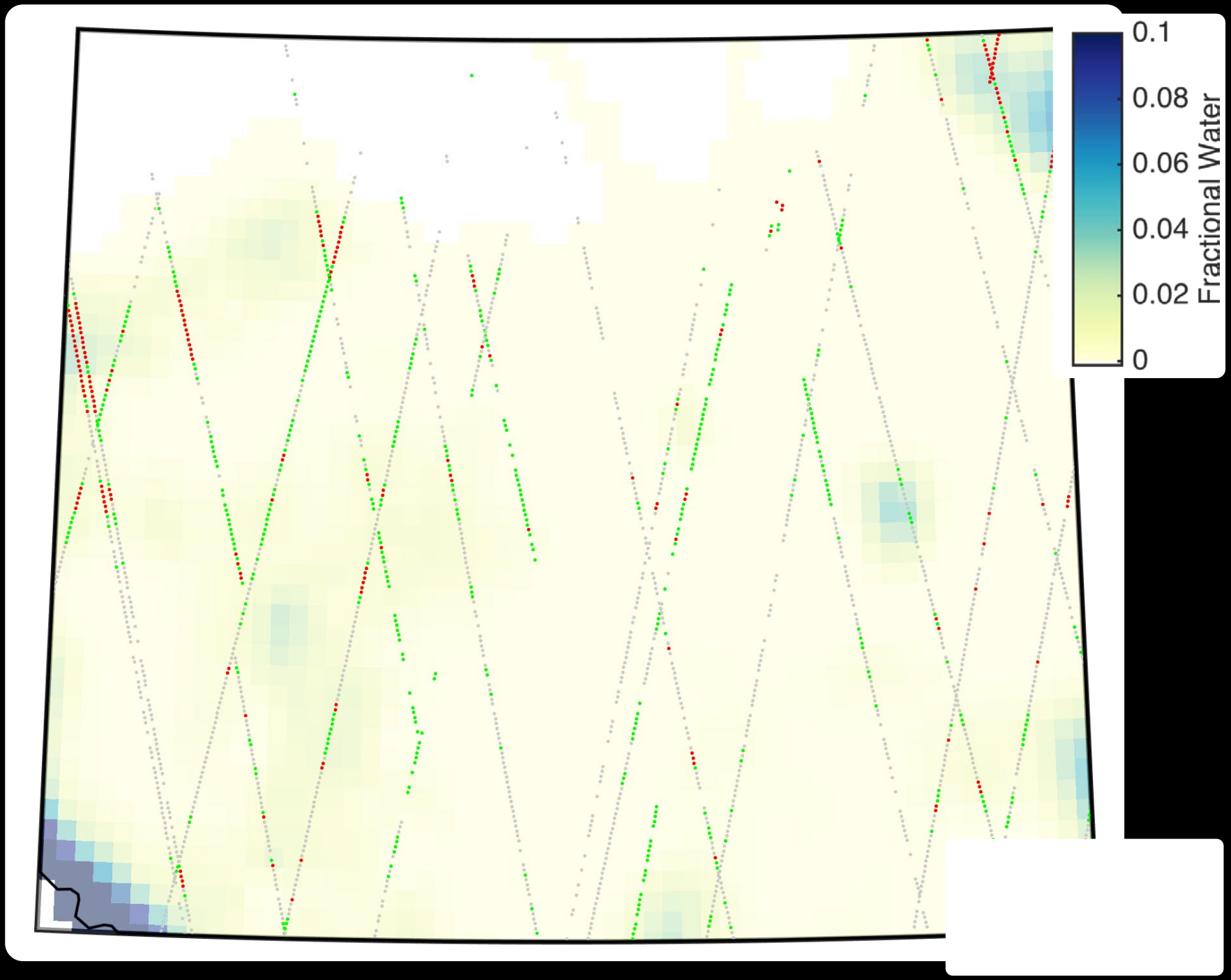
The GNSS-R ‘not inundated’ classification agrees with SWAMPS 84% of the time.

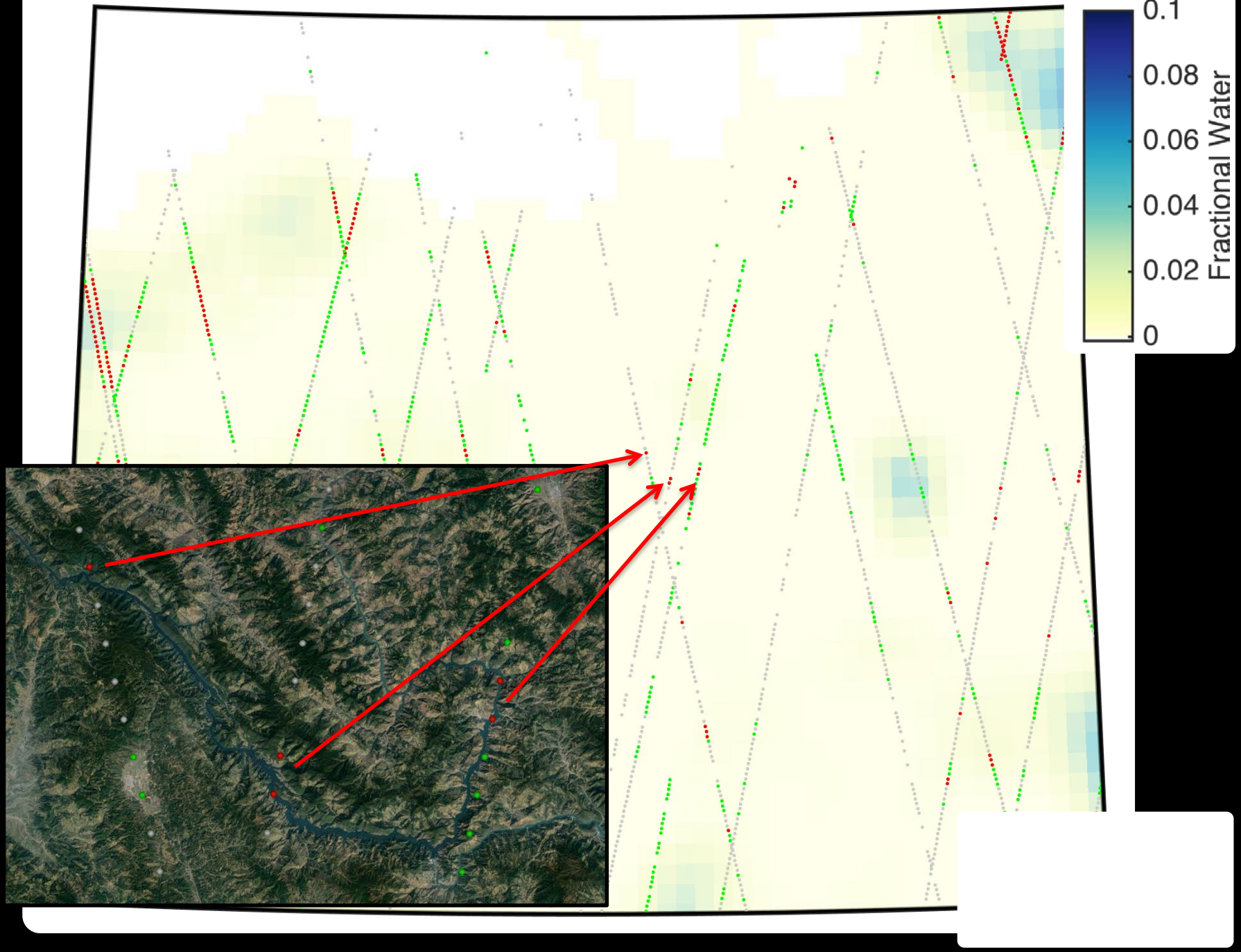
The ‘inundated’ classification agrees with SWAMPS **60%** of the time.

<u>Reasons for disagreement</u>

- SWAMPS shows historical inundation averages.
- Soil moisture influence on our simple classification
- Spatial sensitivity: 25 km (SWAMPS) vs. few km (GNSS-R)


0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Fractional Water


0.1
0.08
0.06
0.04
0.02
0
Fractional Water


0.1
0.08
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0
Fractional Water

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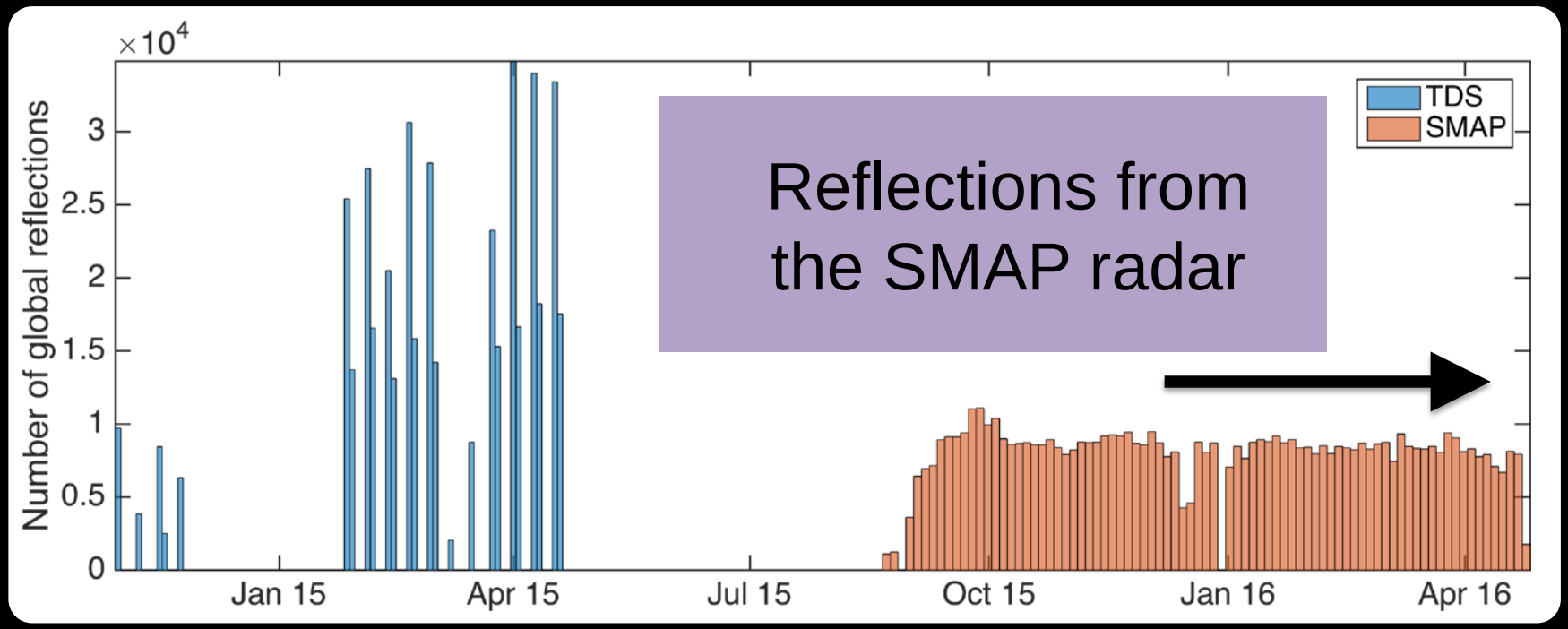
×10^4
Number of global reflections
3
2.5
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1.5
1
0.5
0
Jan 15
Apr 15
Jul 15
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SMAP
Reflections from the SMAP radar

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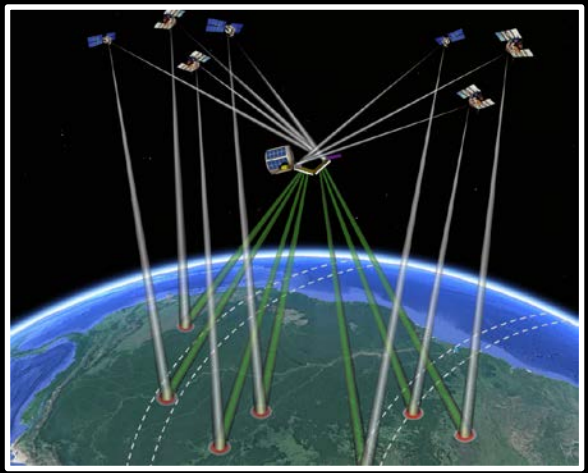
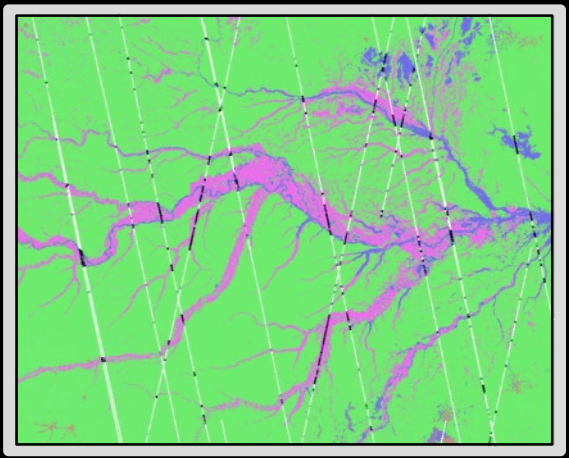
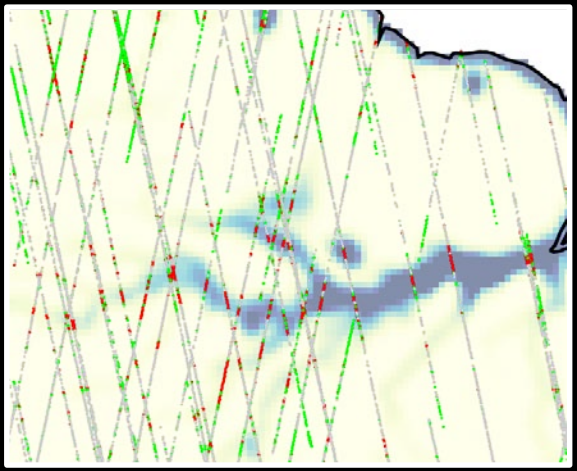


GPS reflections are a form of bistatic radar, which complement traditional monostatic radar or radiometers

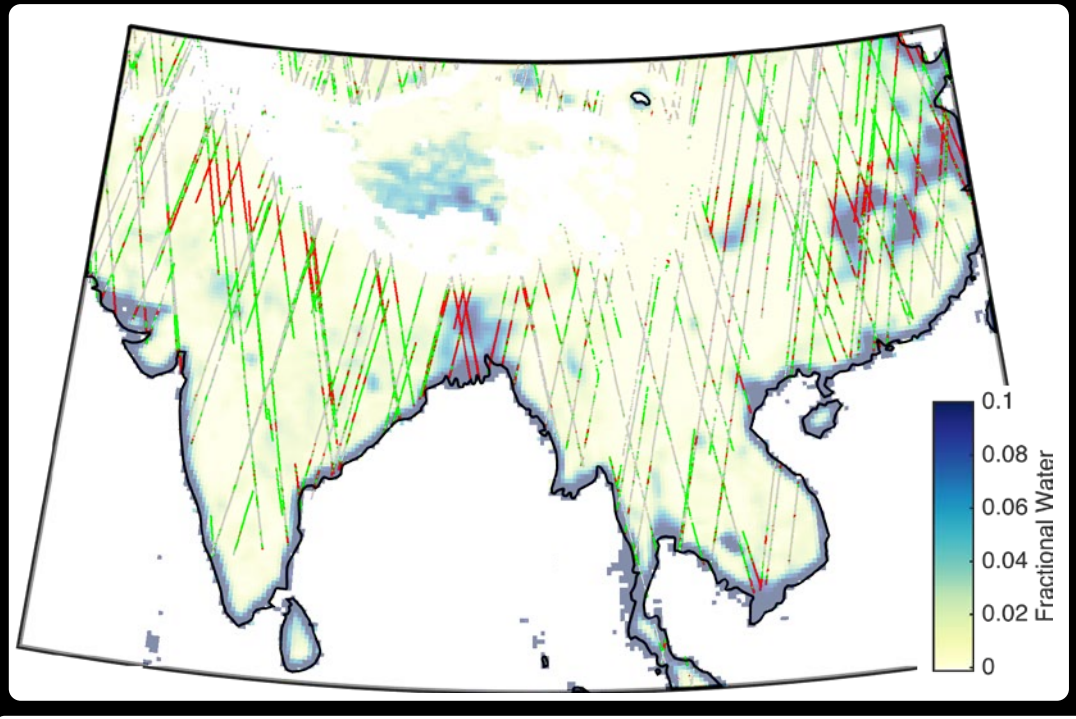
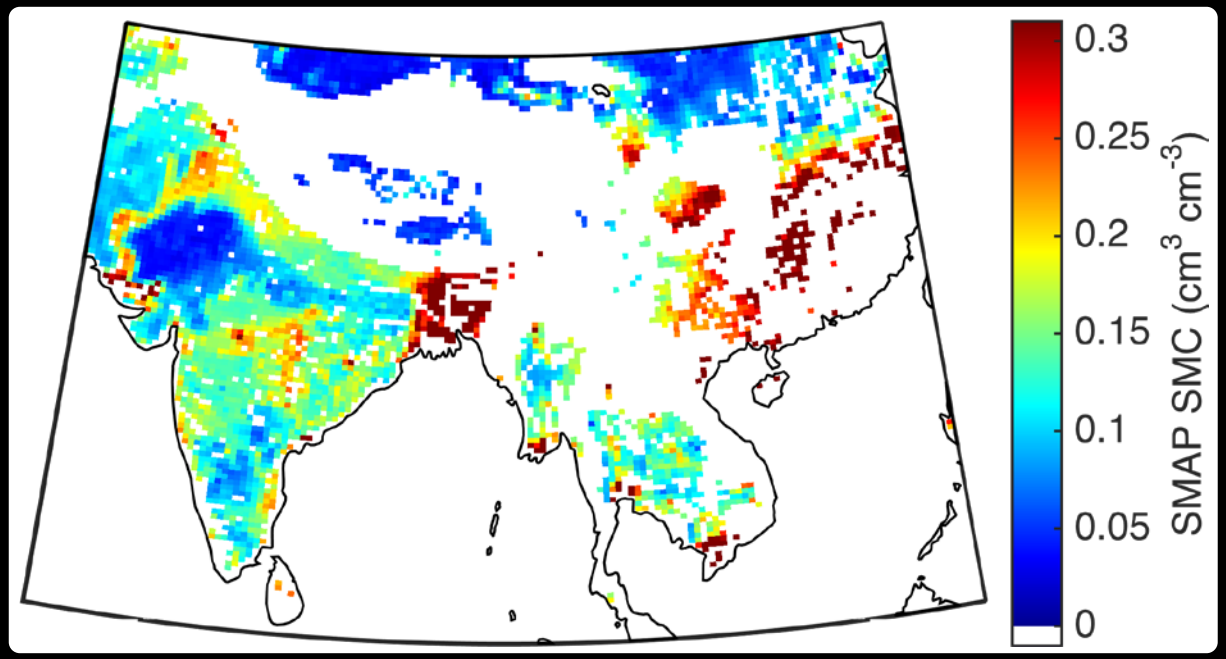


Reflected power is high over inundated vegetation, similar to what was shown by the SMAP radar



A simple inundation classification scheme shows encouraging relationships with existing datasets

Extra slides



Models should be developed to see if ‘inundated’ vs. ‘saturated’ soil signals can be separated