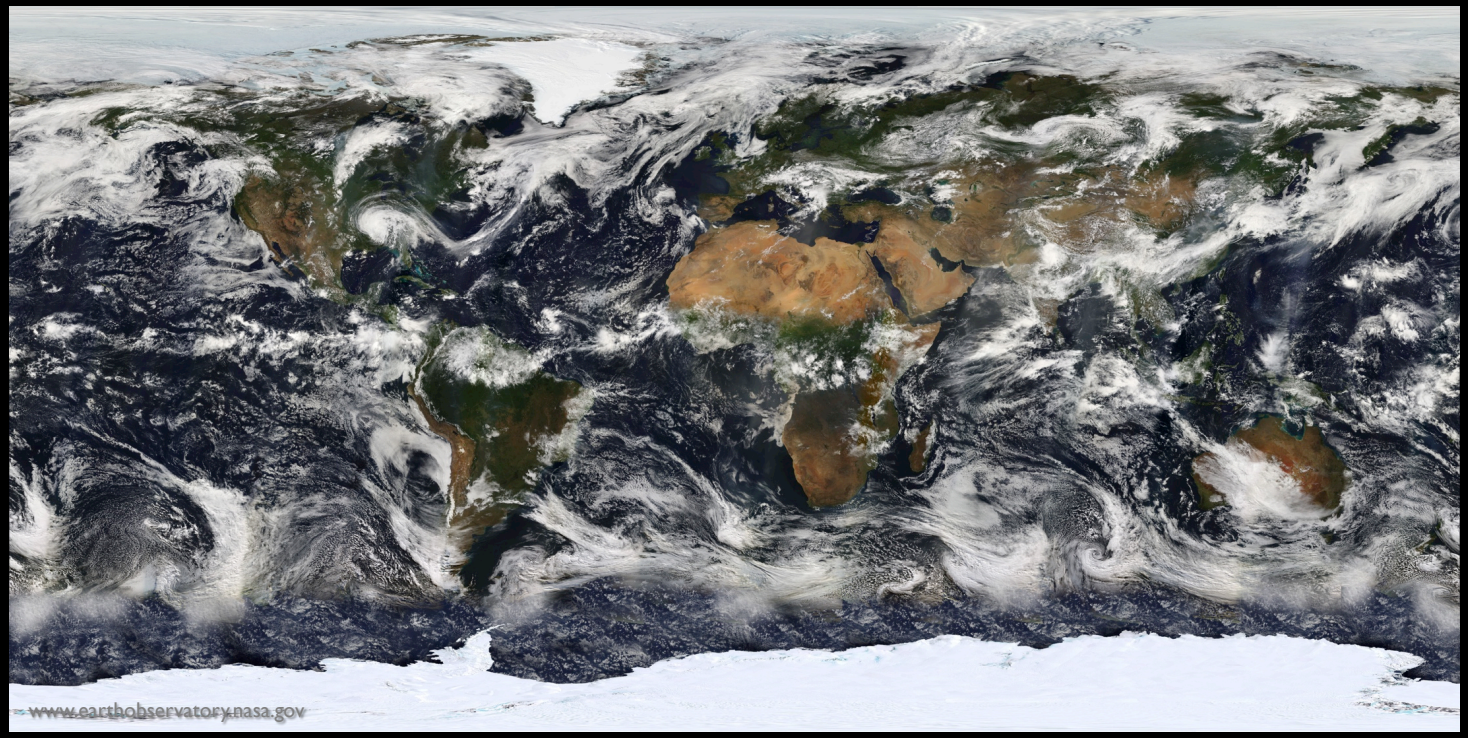
Detecting changes in reflected GNSS signals over land using a spaceborne receiver:

Results from the TechDemoSat Mission



Clara Chew, Anthony Mannucci, Cinzia Zuffada, Rashmi Shah, George Hajj
Jet Propulsion Laboratory, Pasadena, CA

Jet Propulsion Laboratory
California Institute of Technology

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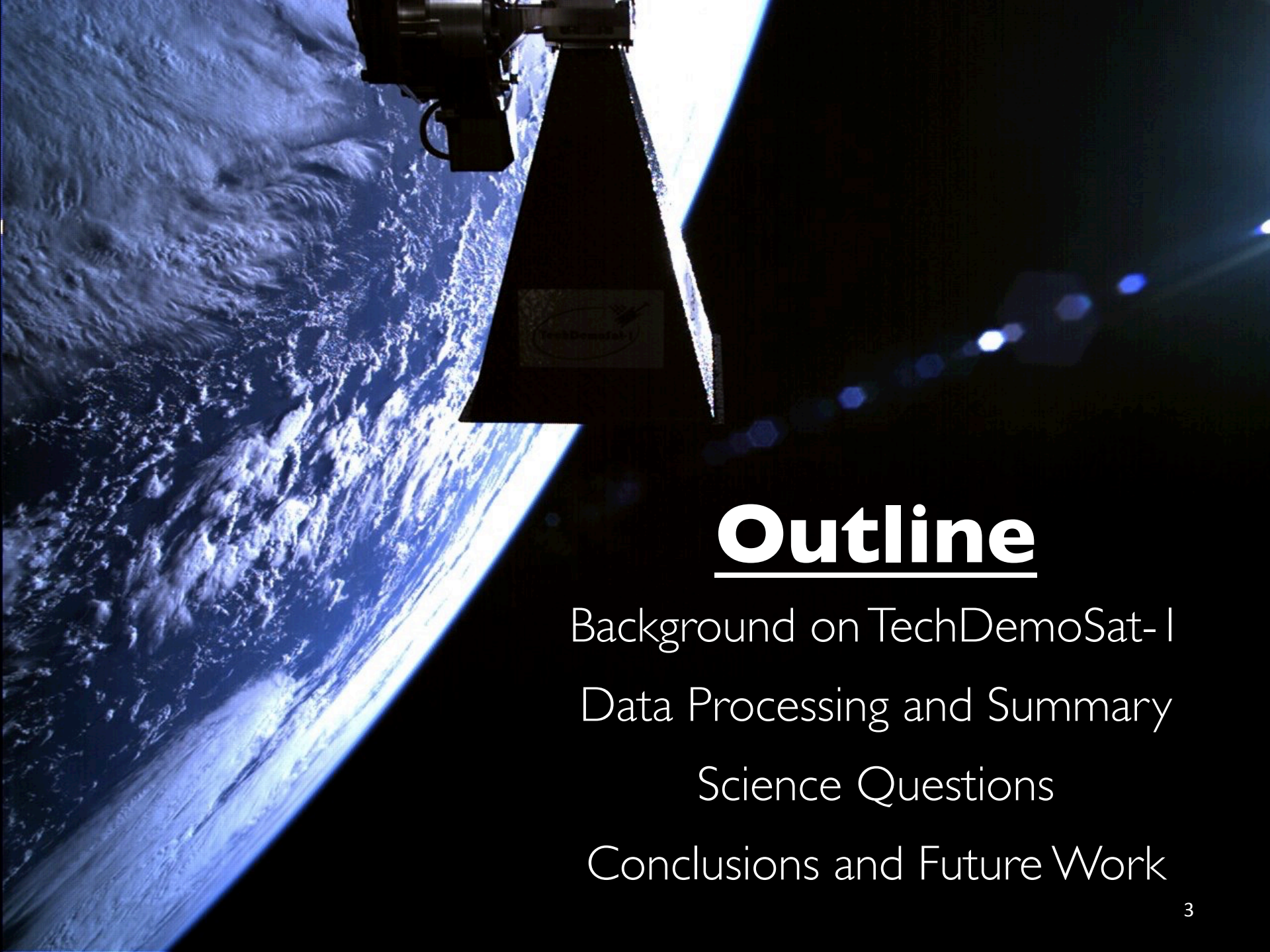
What could ground-reflected GNSS signals*
potentially tell us about the land surface?

*as measured from space



Outline

Background on TechDemoSat-1

Data Processing and Summary

Science Questions

Conclusions and Future Work

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TDS-1

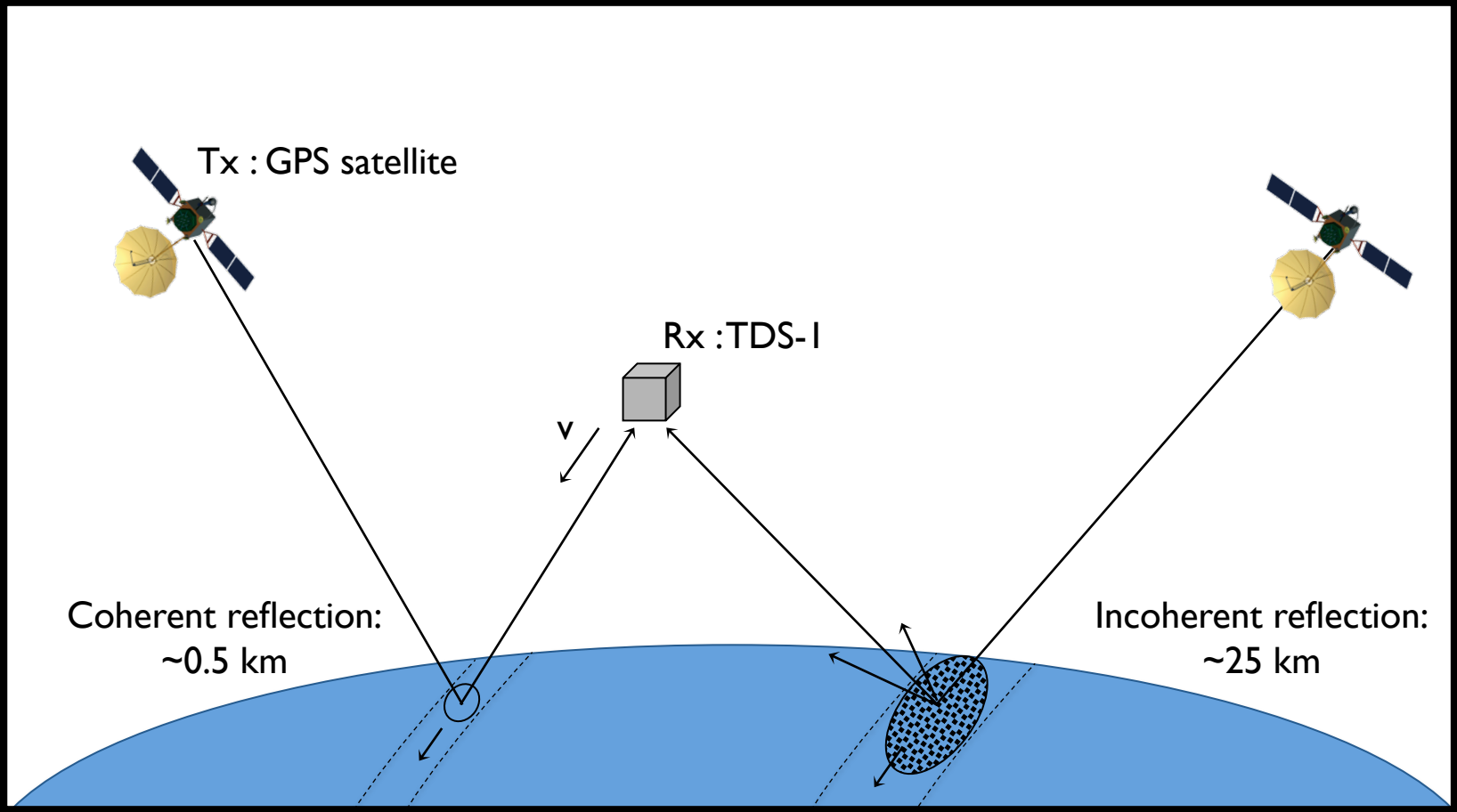


Figure modified from: http://www.ice.csic.es/ca/en/view_research_line.php?RID=13&ap=0

TDS-1

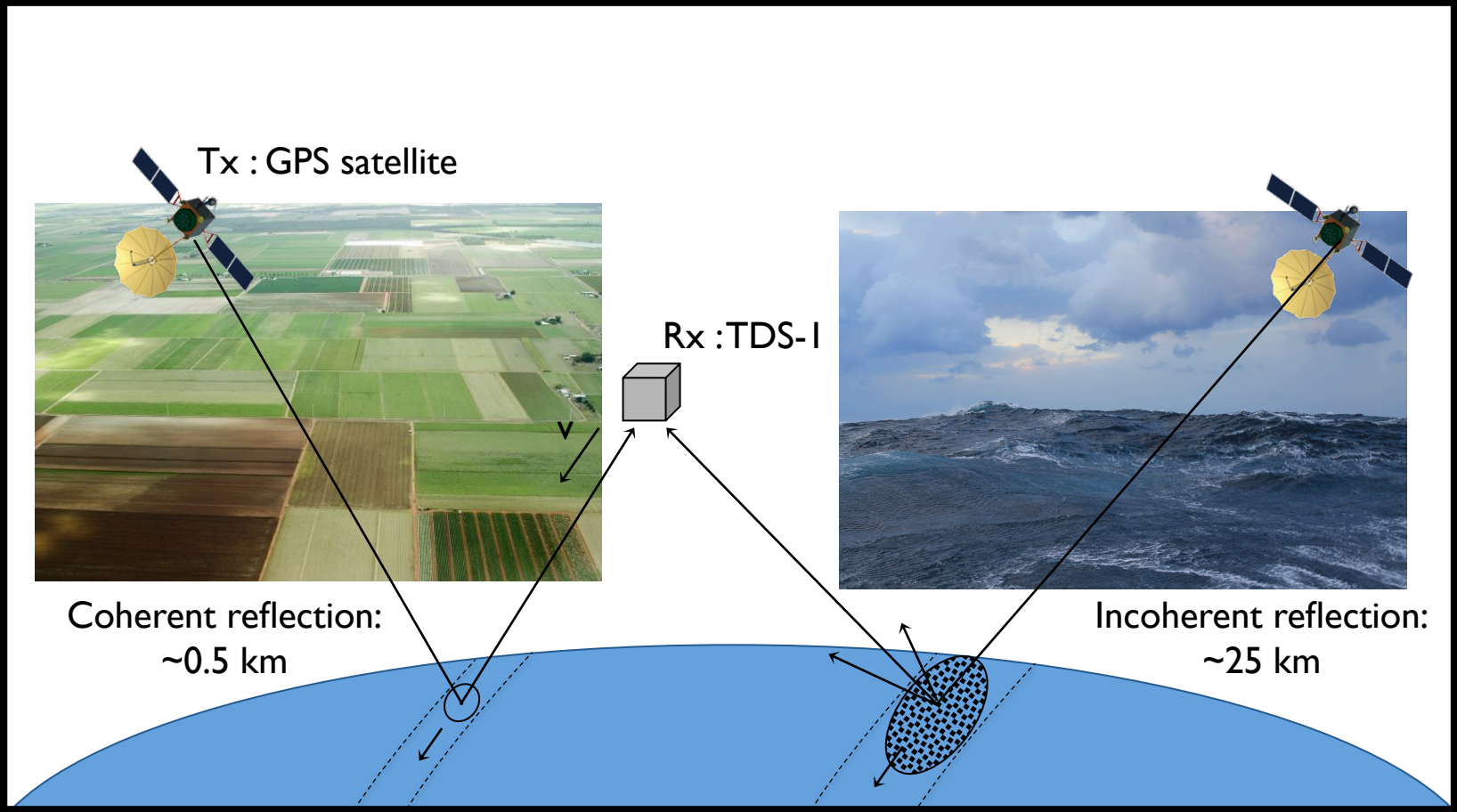
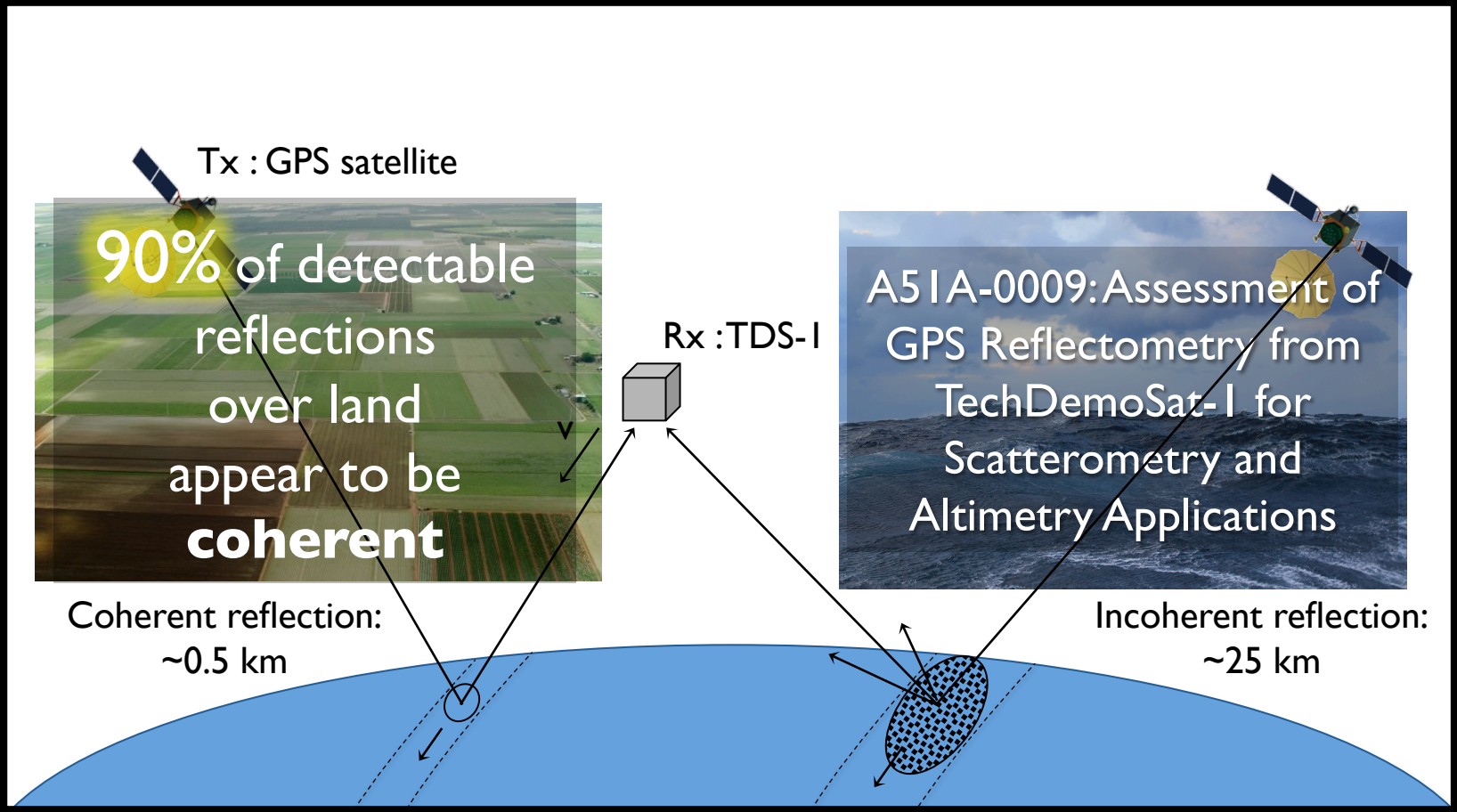
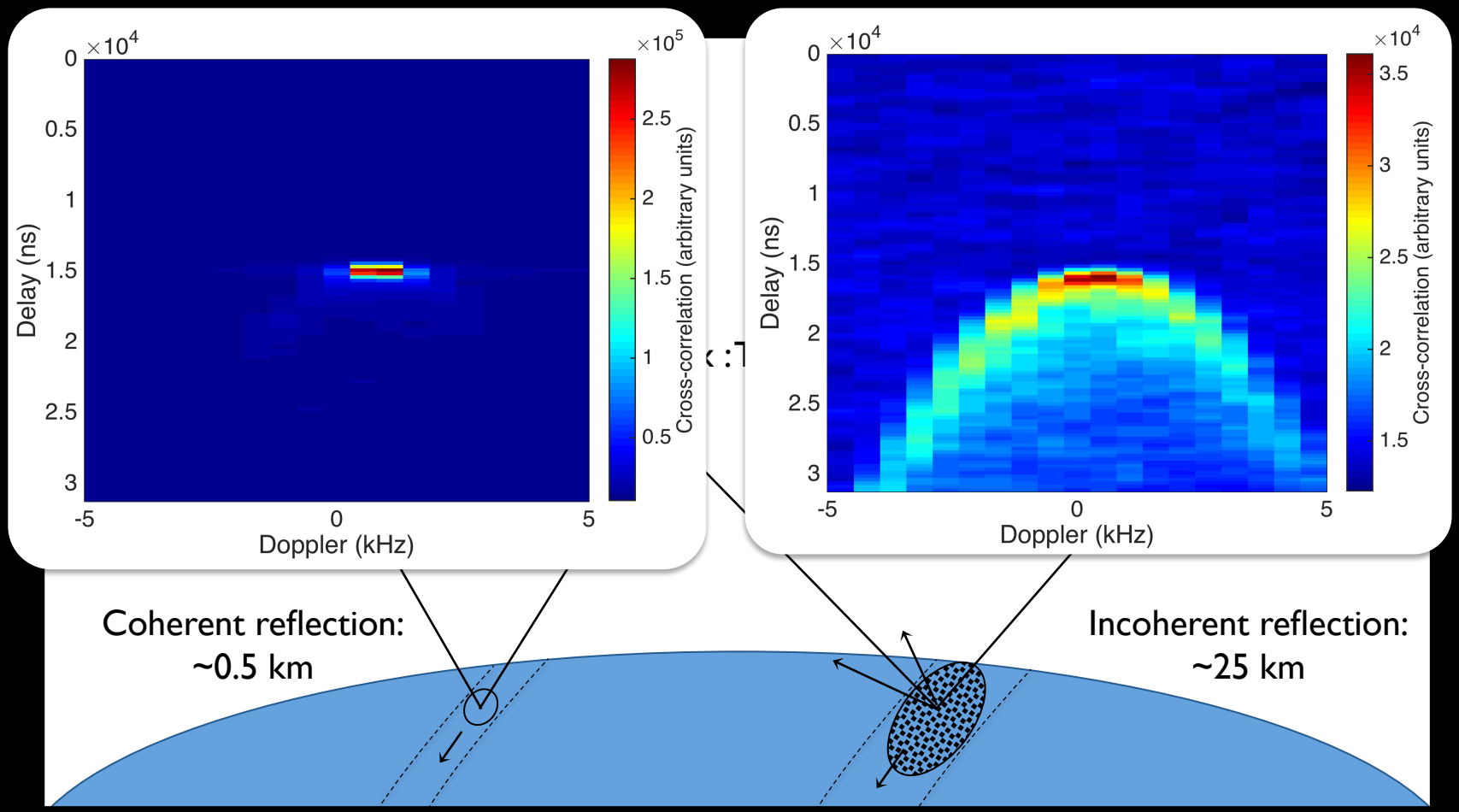


Photo credit: Katlin Bowman
Photo credit: Adrian Jones, Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/imagelibrary/).

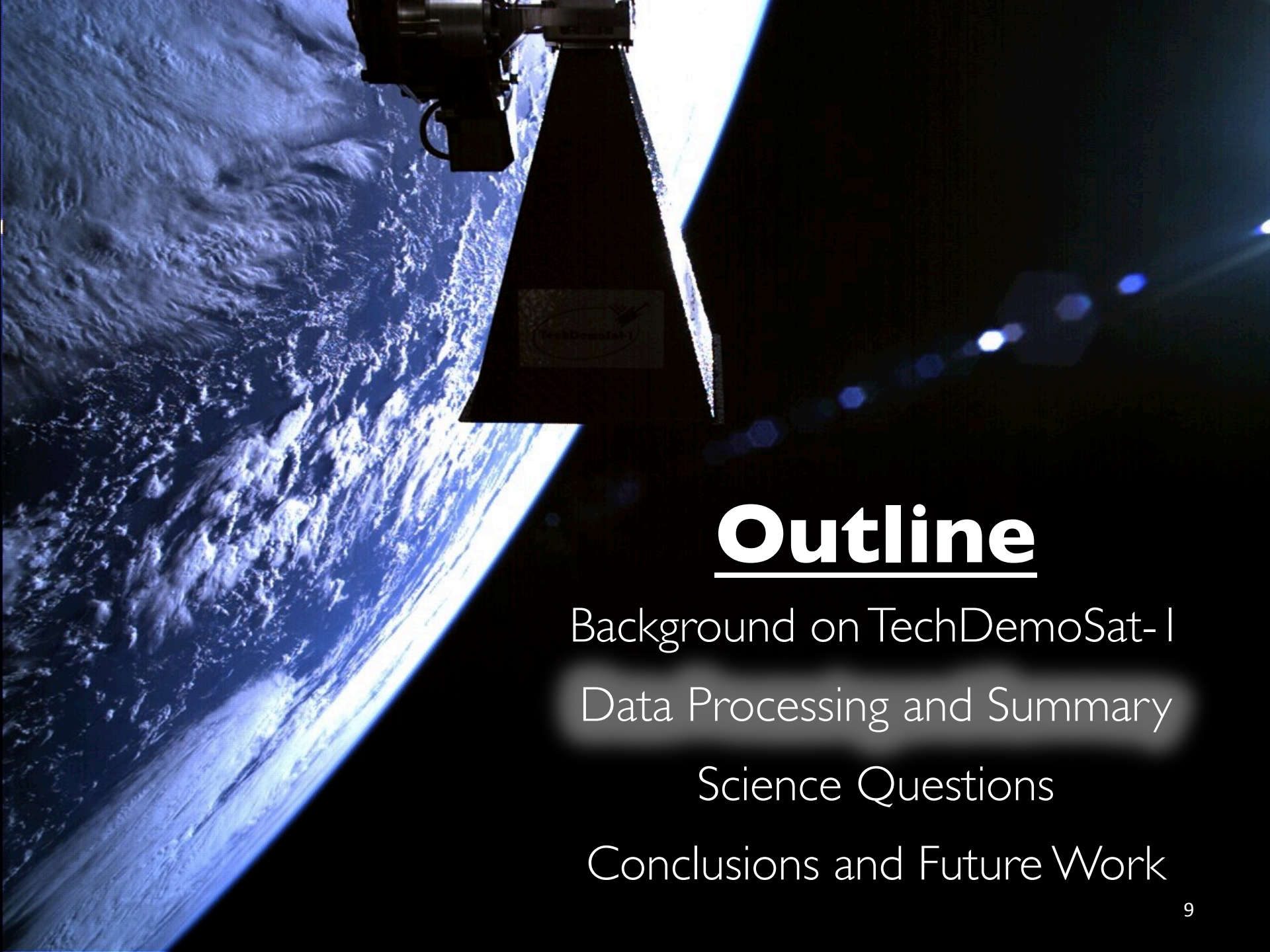
TDS-1


Tx : GPS satellite
90% of detectable reflections over land appear to be **coherent**
Rx : TDS-1
A51A-0009: Assessment of GPS Reflectometry from TechDemoSat-1 for Scatterometry and Altimetry Applications
Coherent reflection: ~0.5 km
Incoherent reflection: ~25 km

Delay Doppler Maps (DDMs)



Note: Colorbars differ by an order of magnitude



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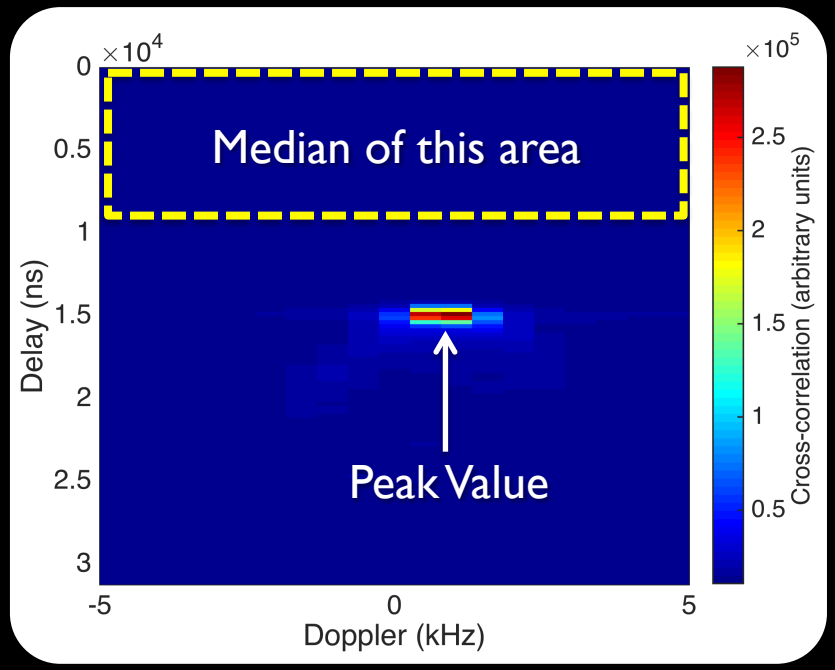
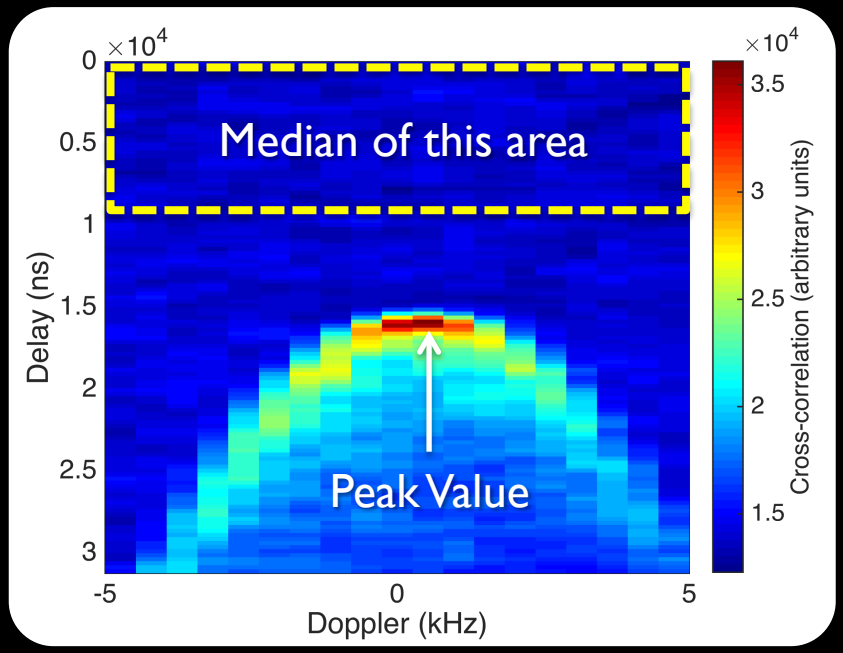
Data Processing

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

Also, correct for gain, range, and angle





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Data Processing

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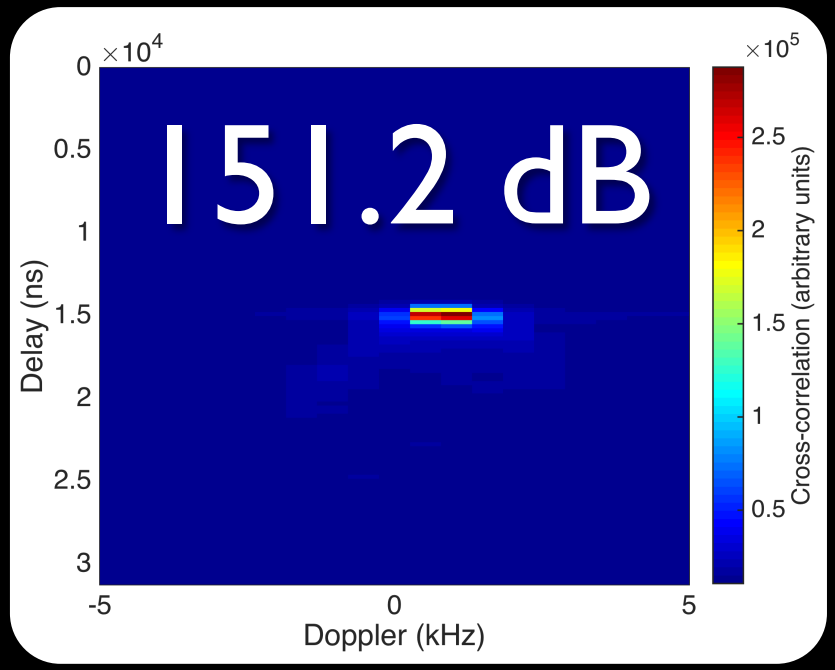
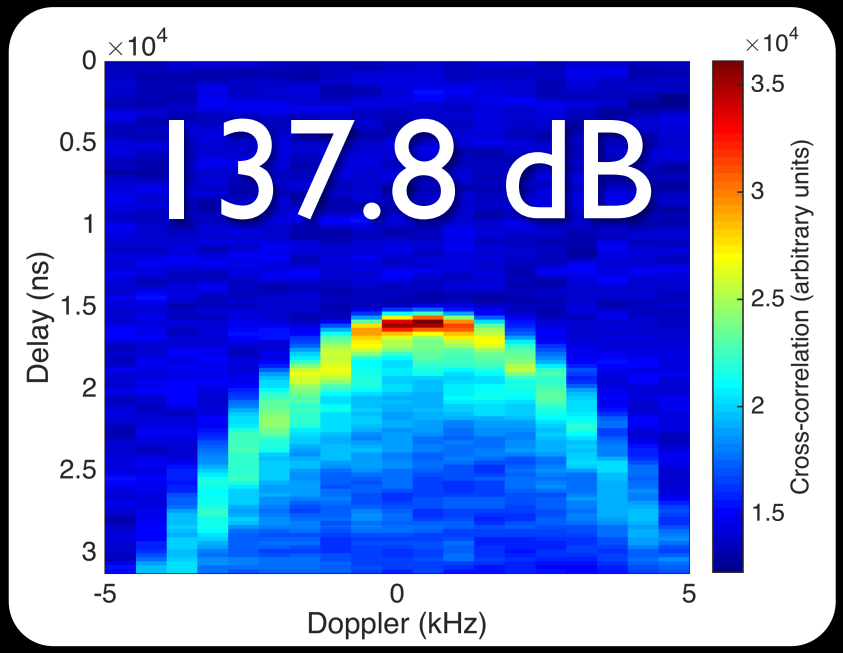
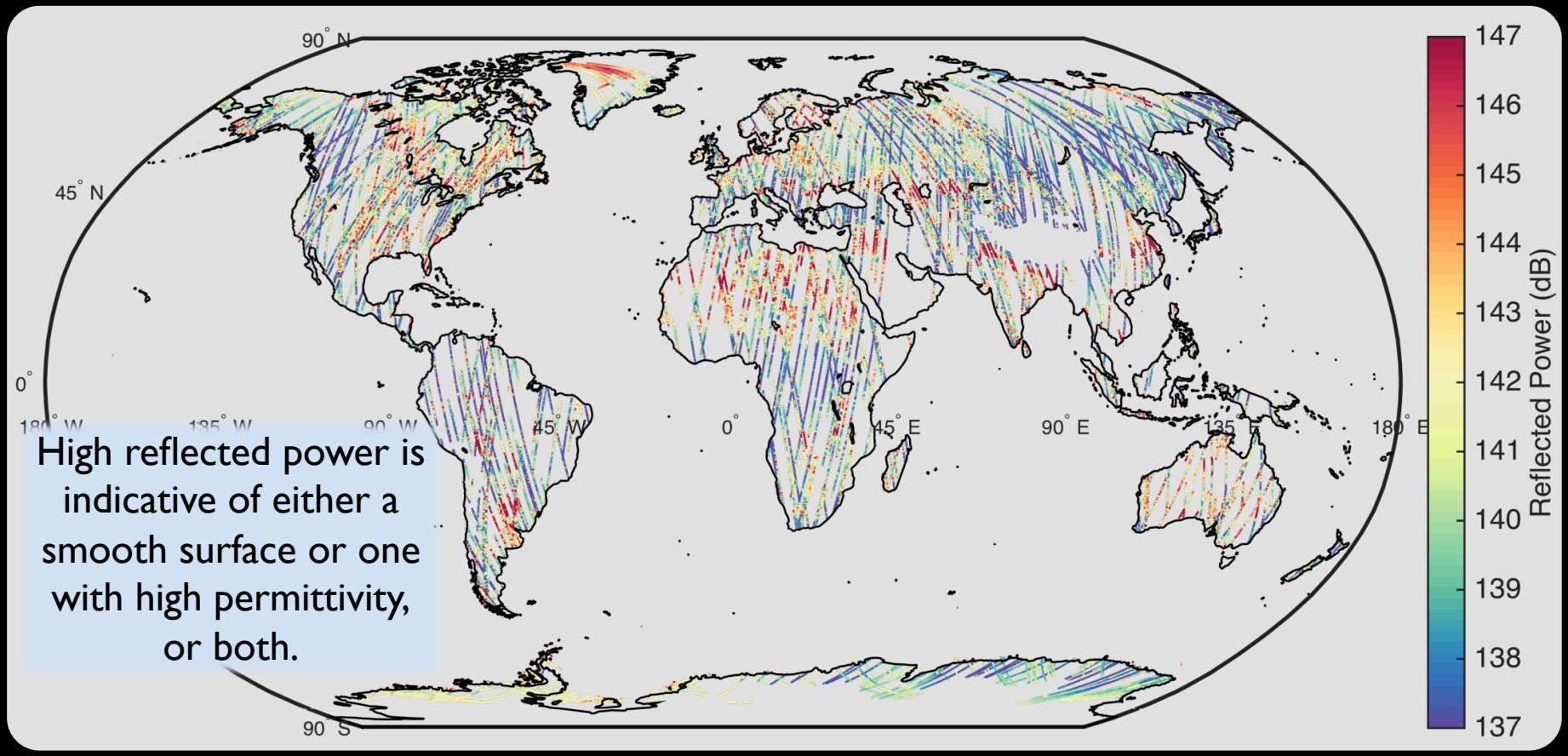


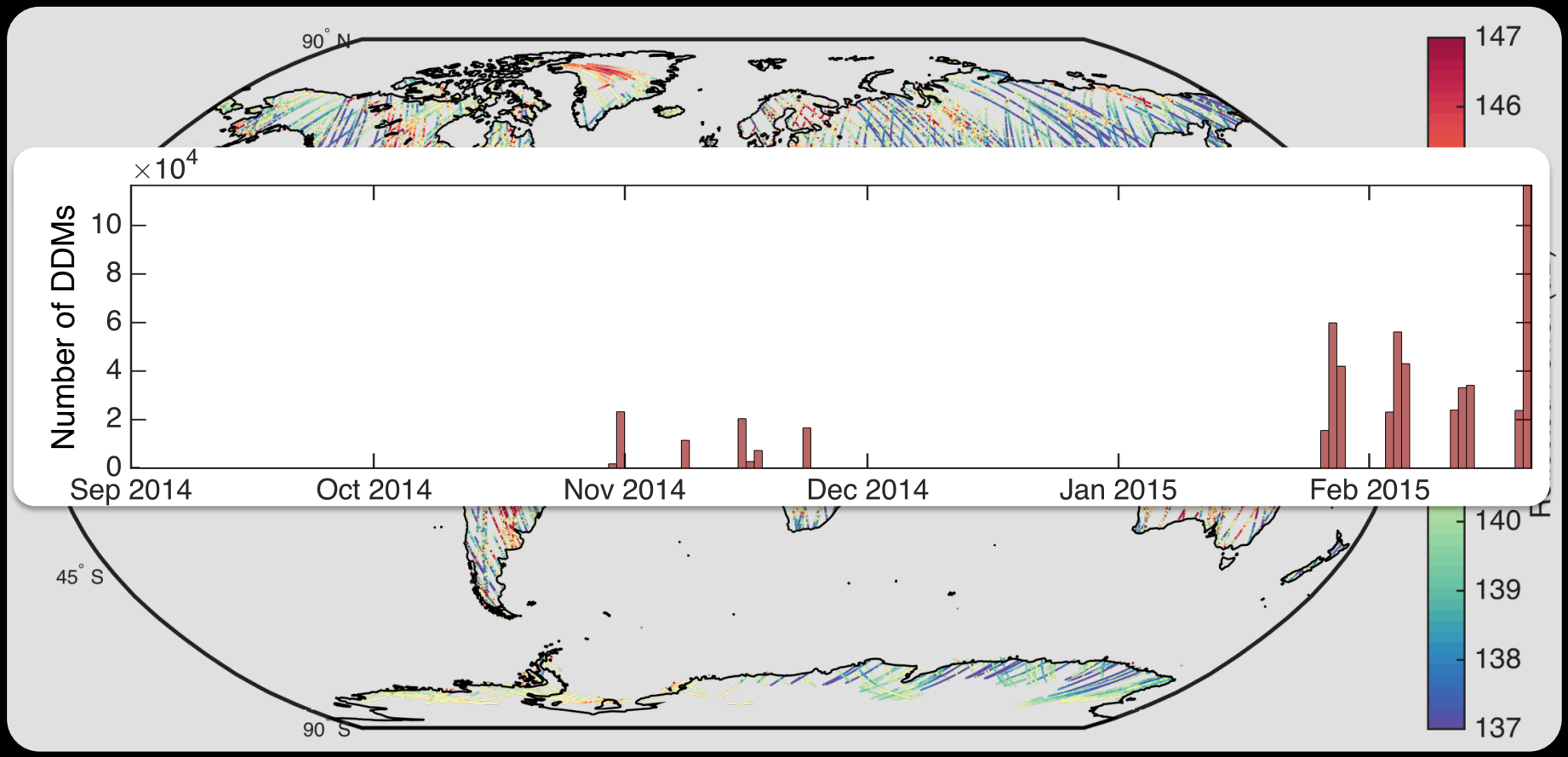


Reflections over land



High reflected power is indicative of either a smooth surface or one with high permittivity, or both.

Reflections over land



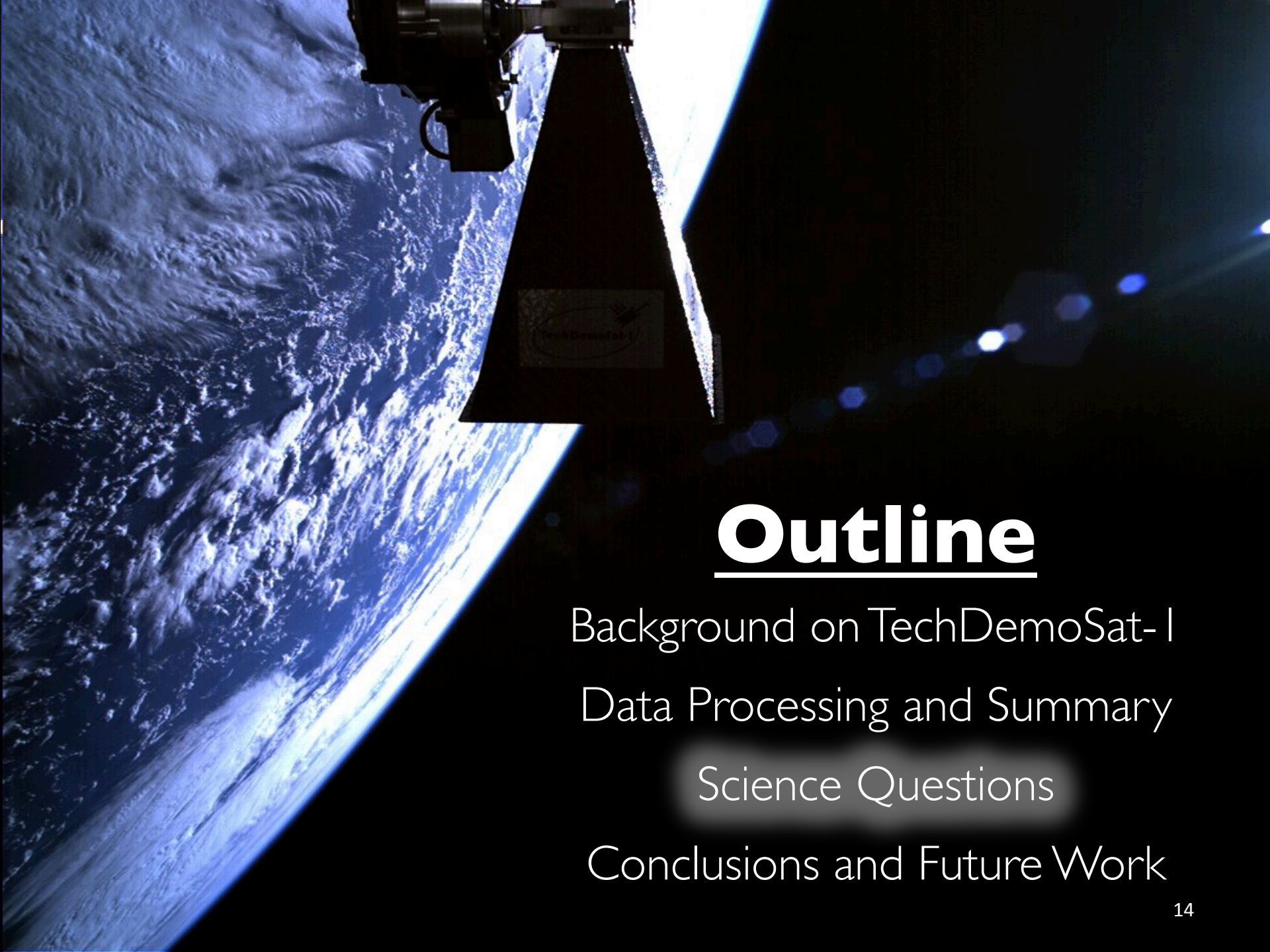


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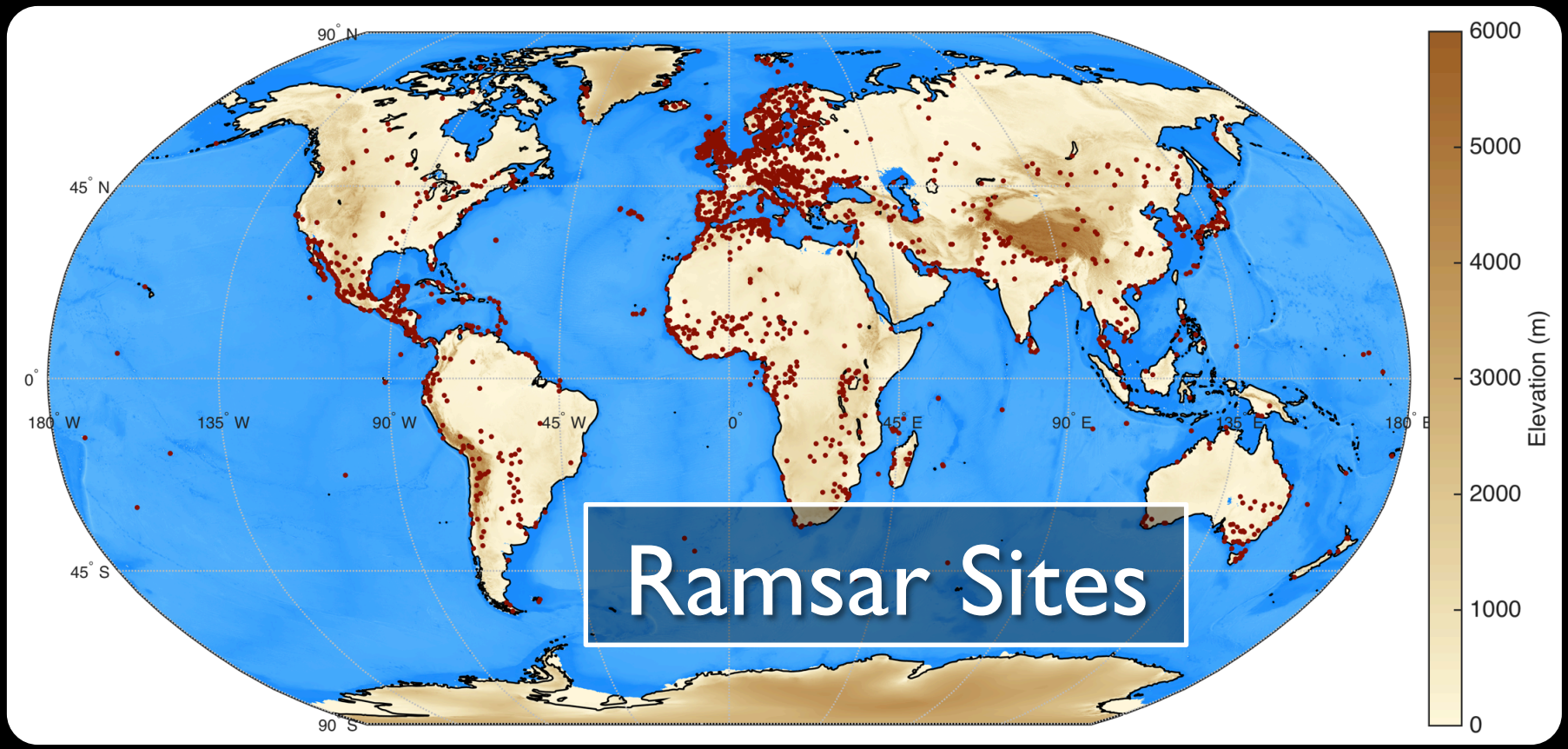
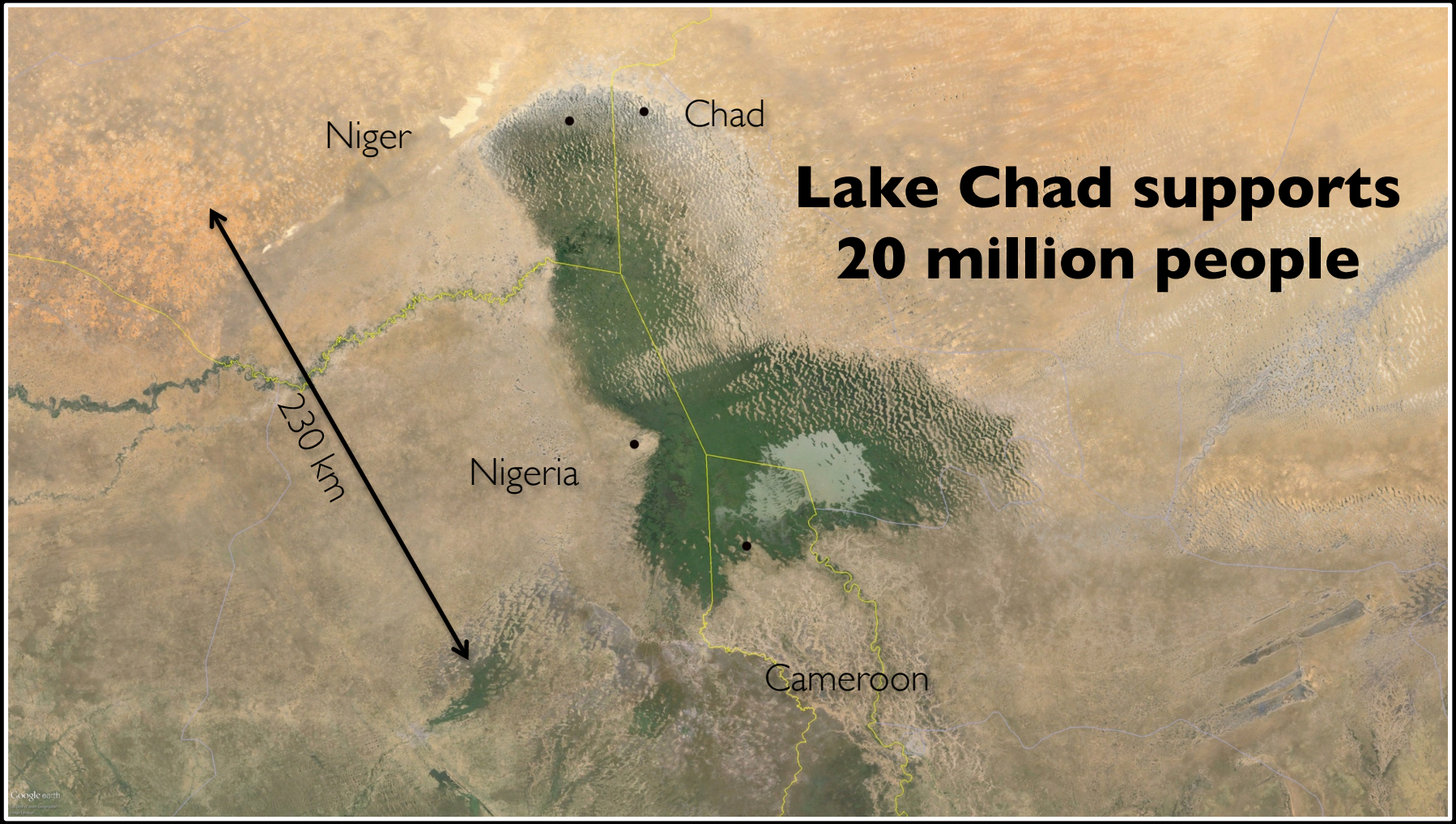
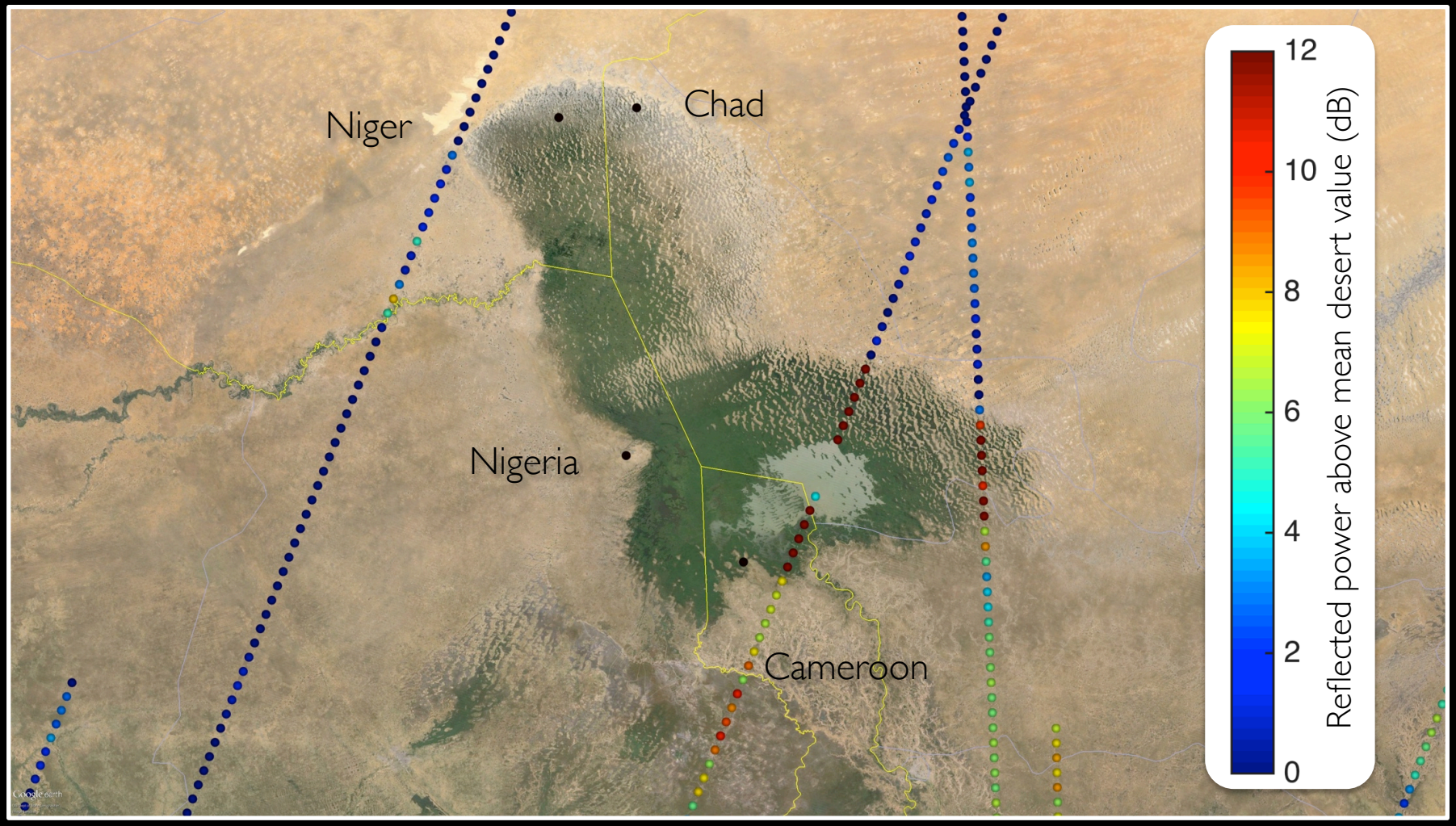
Figure from:
Gallant, A. (2015) "The challenges of remote monitoring of wetlands," *Remote Sens.* 7(8), 10938-10950.



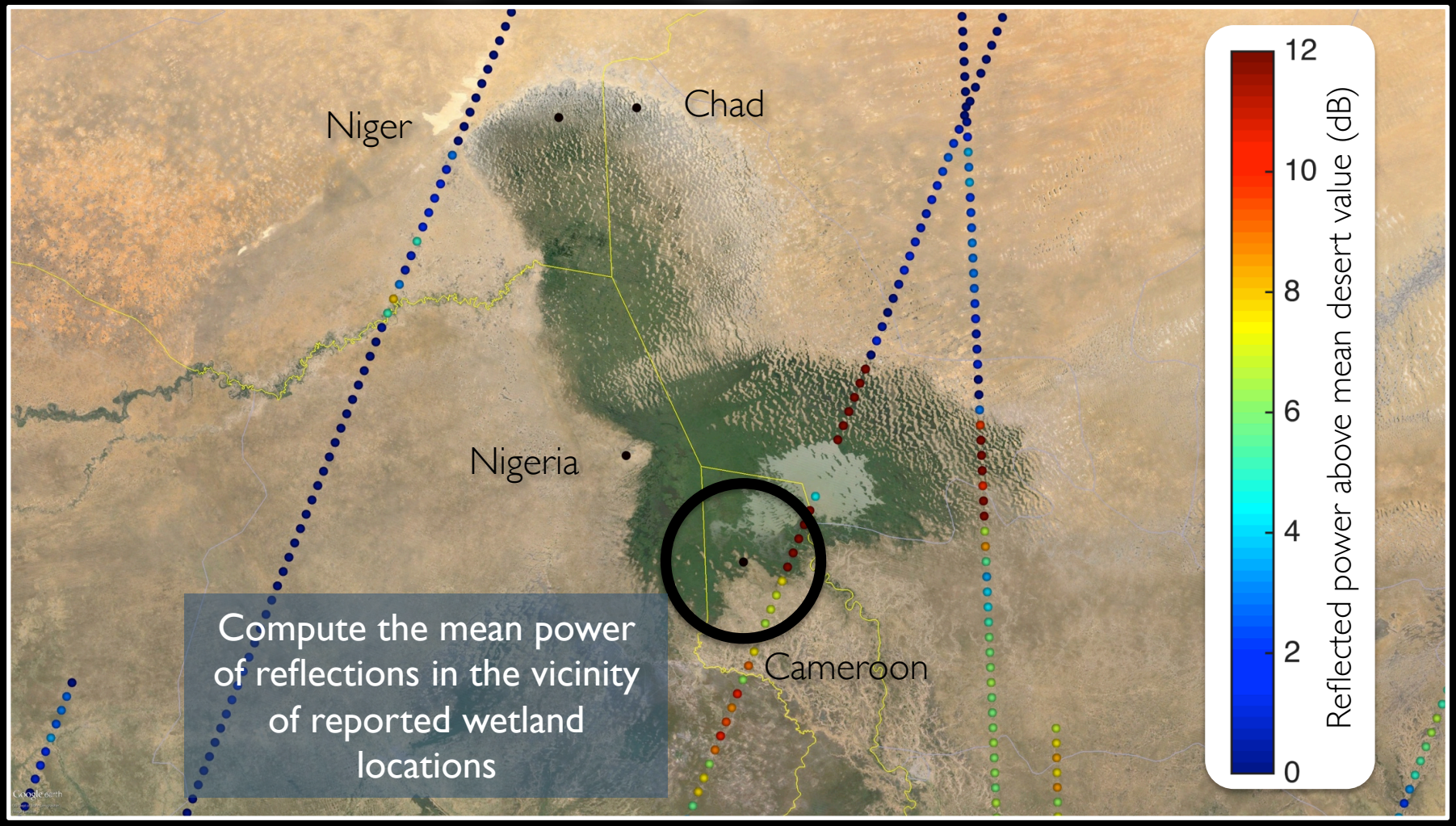
Represent rare or unique wetland types

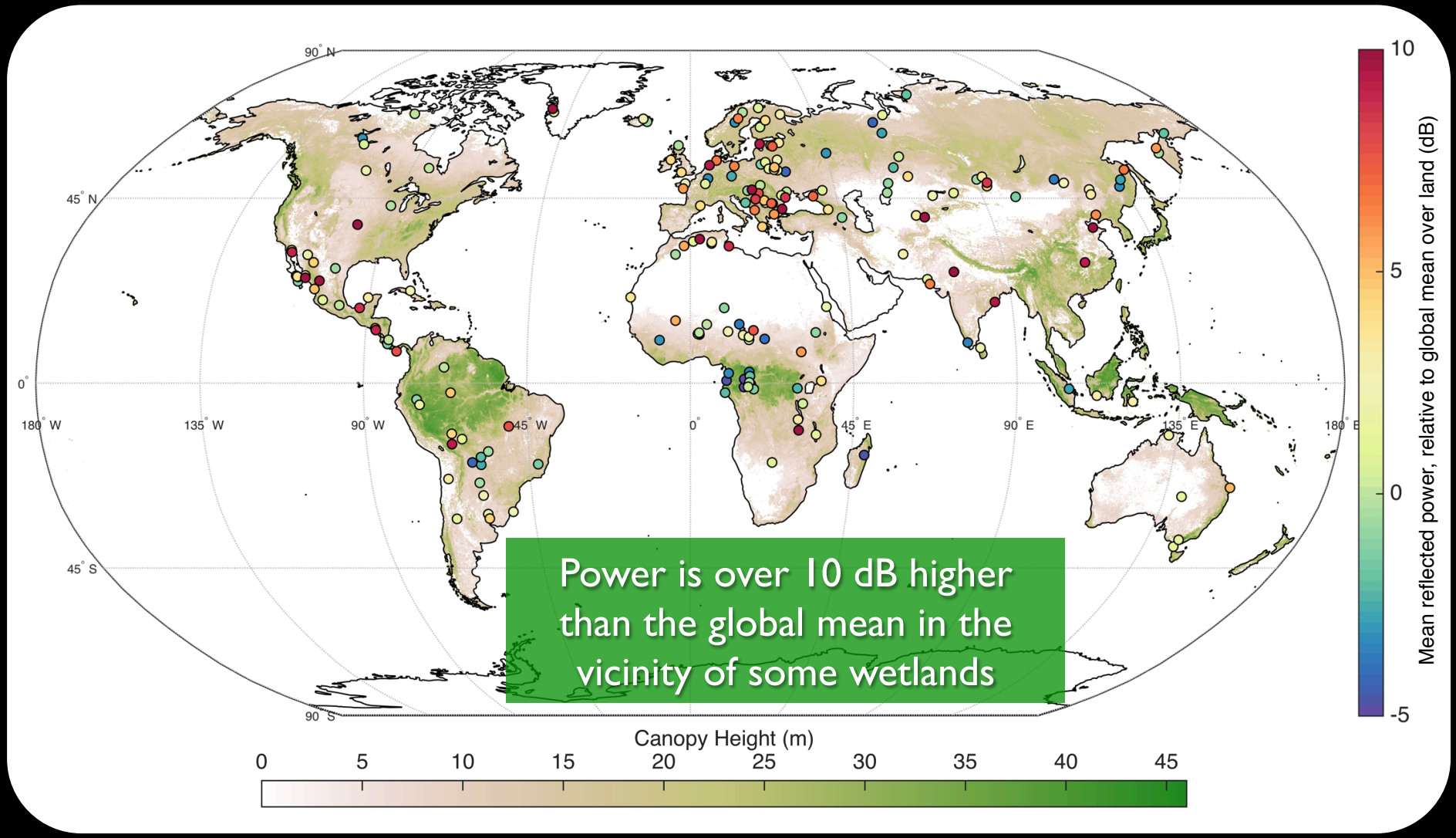
Internationally important for the conservation of biological diversity


Lake Chad supports
20 million people
Niger
Chad
Nigeria
Cameroon
230 km


Niger
Chad
Nigeria
Cameroon
12
10
8
6
4
2
0
Reflected power above mean desert value (dB)

Is reflected power higher around wetlands?





Power is over 10 dB higher than the global mean in the vicinity of some wetlands

B41C-0456: Observation of wetland dynamics with global navigation satellite signals reflectometry

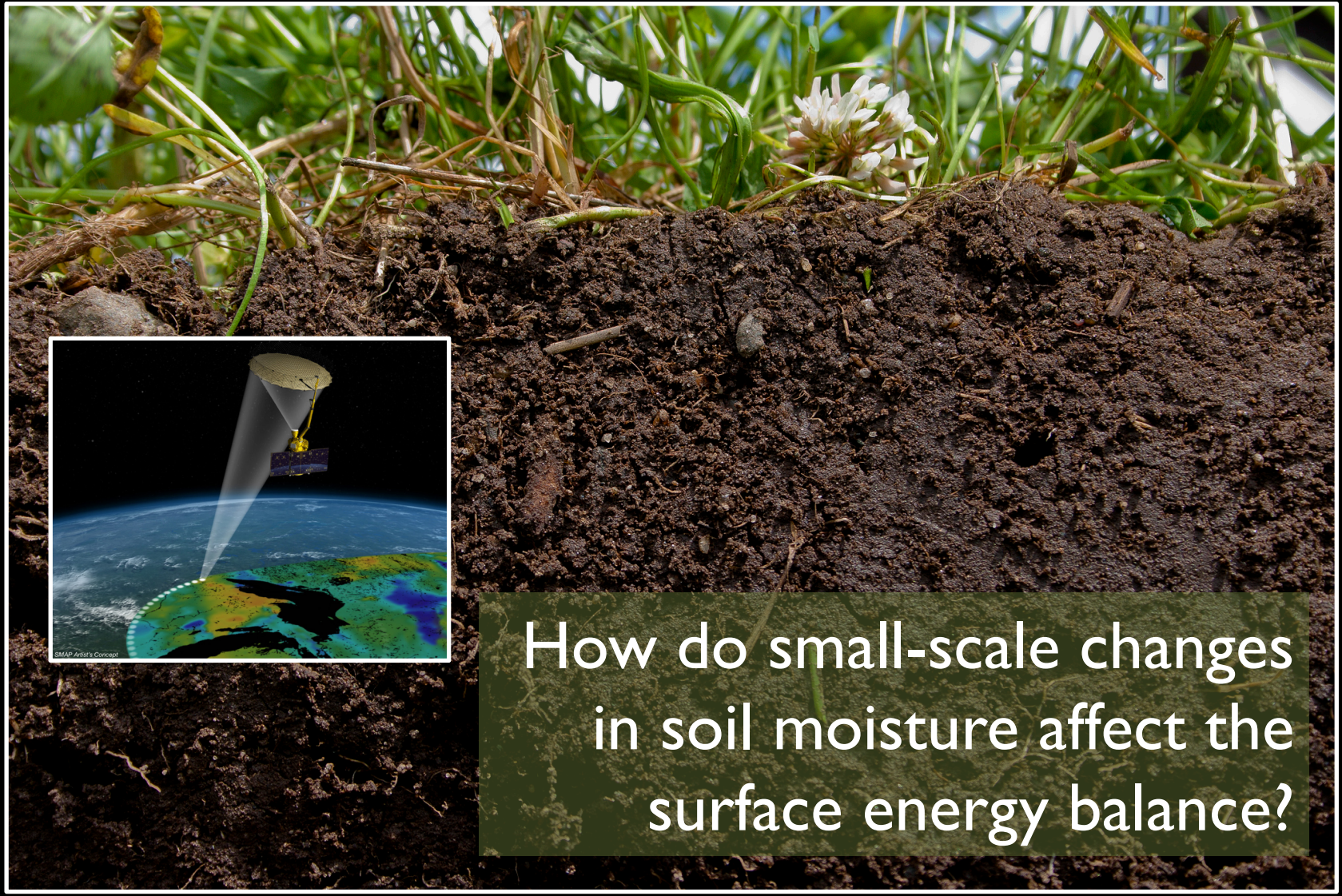
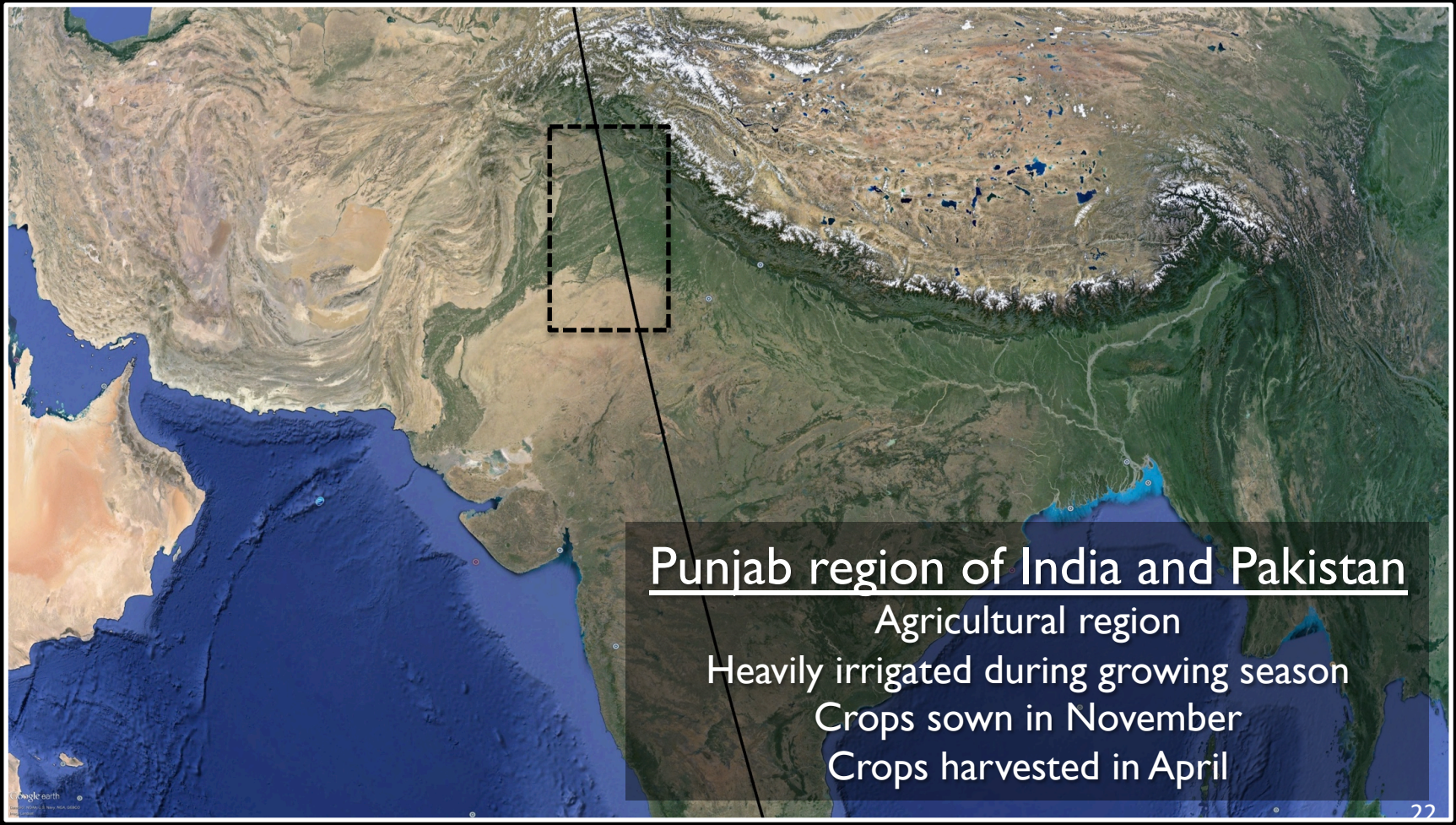
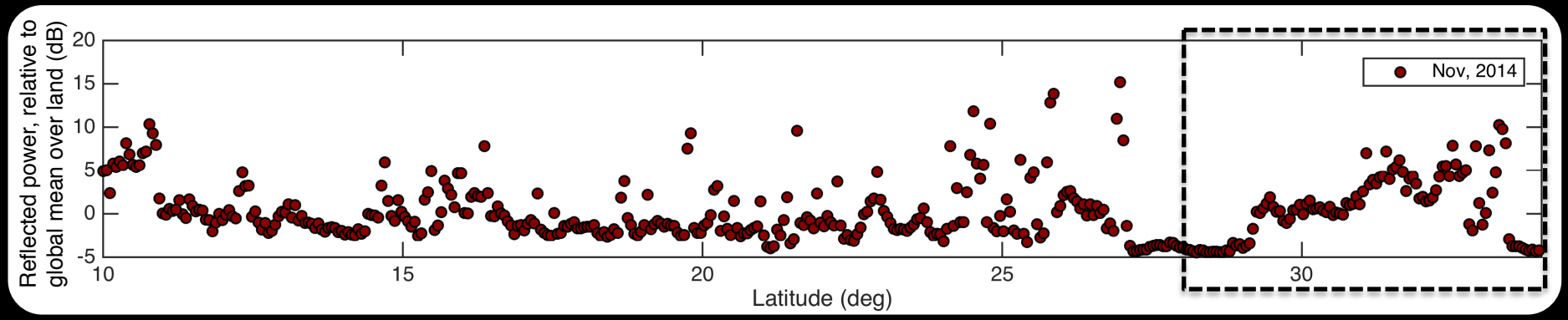
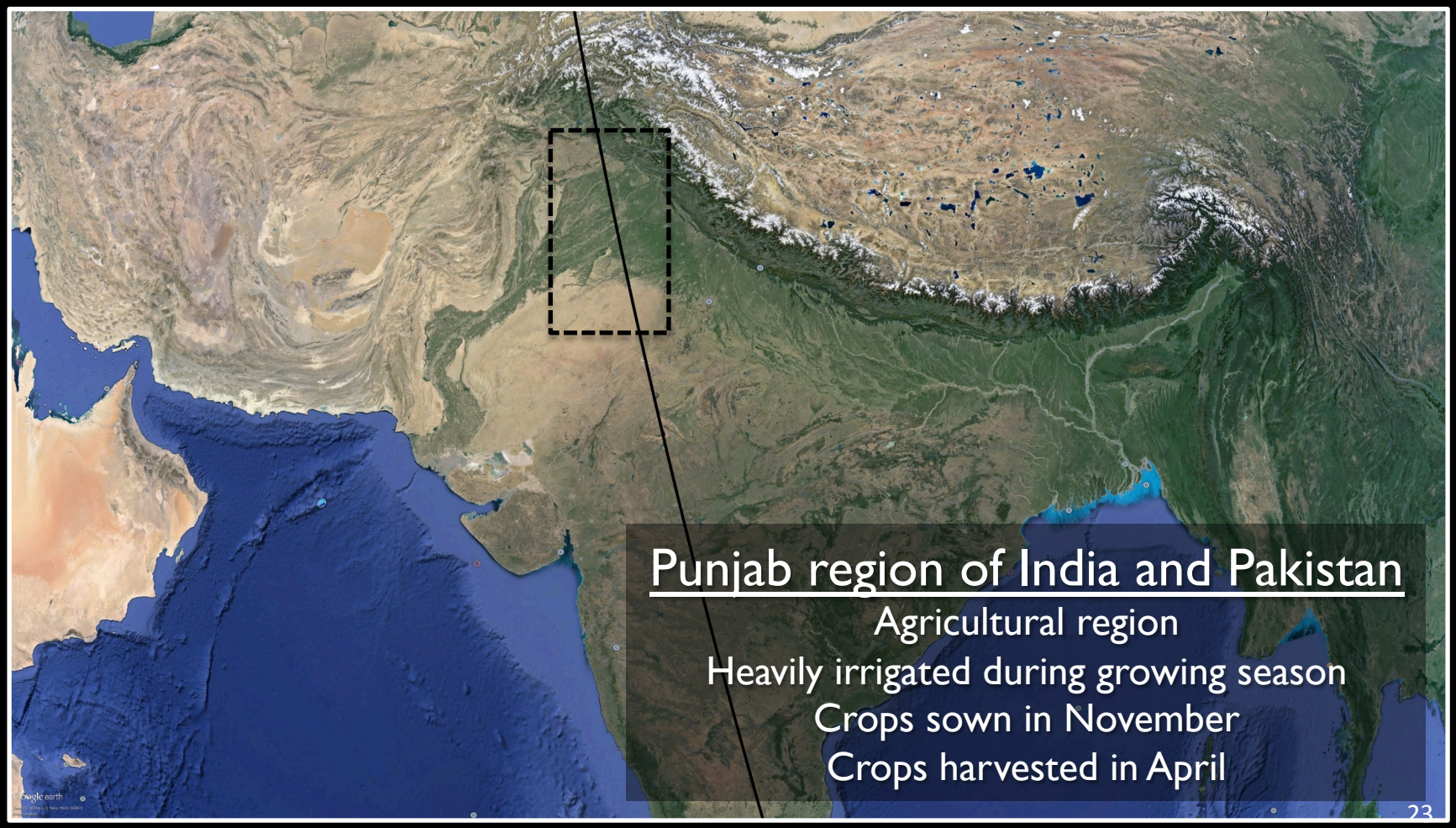


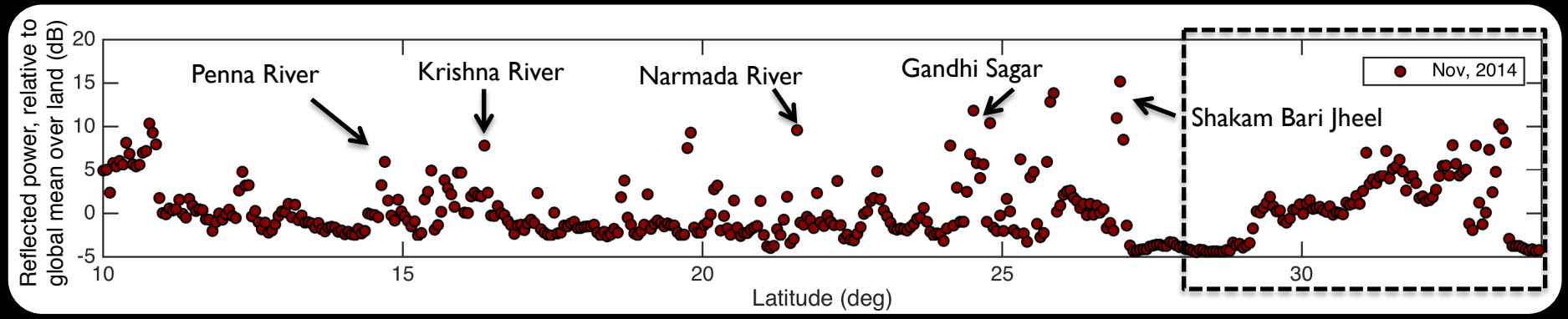
Photo credits:
www.nasa.gov

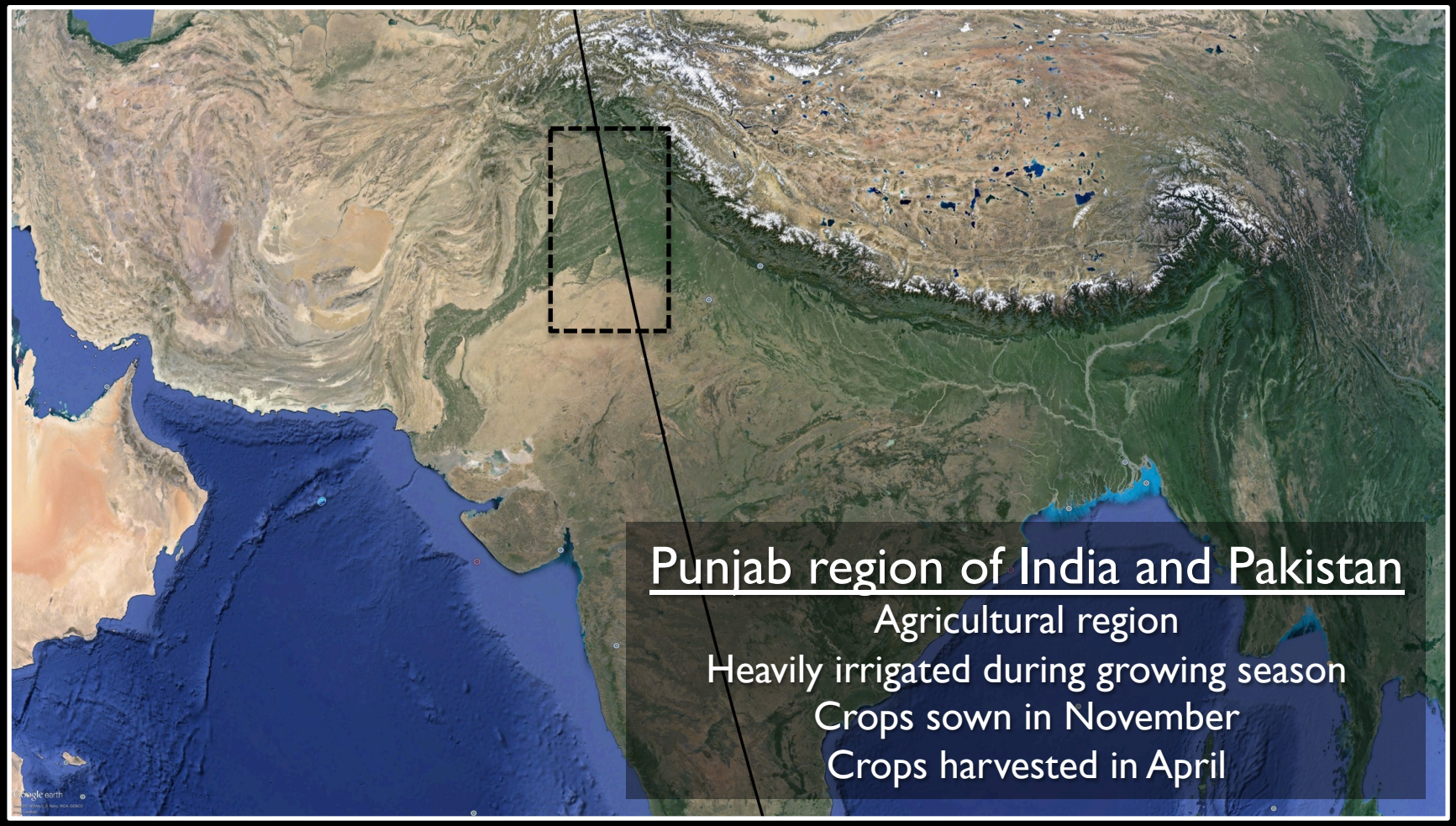


http://www.cotf.edu/earthinfo/sasia/punjab/PJtopic4.html


Reflected power, relative to global mean over land (dB)
20
15
10
5
0
-5
10
15
20
25
30
Latitude (deg)
Nov, 2014


Punjab region of India and Pakistan
Agricultural region
Heavily irrigated during growing season
Crops sown in November
Crops harvested in April


Reflected power, relative to global mean over land (dB)
20
15
10
5
0
-5
10
15
20
25
30
Latitude (deg)
Penna River
Krishna River
Narmada River
Gandhi Sagar
Shakam Bari Jheel
Nov, 2014


Punjab region of India and Pakistan
Agricultural region
Heavily irrigated during growing season
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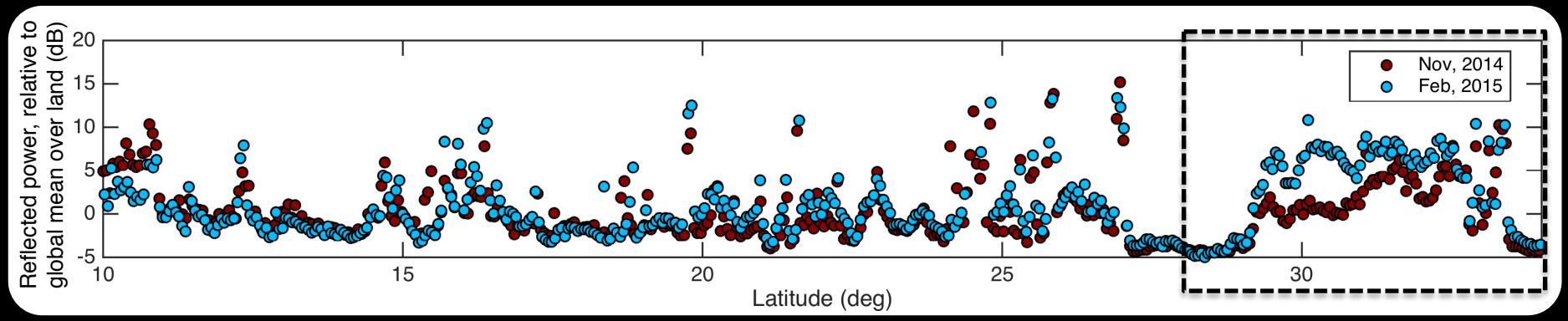
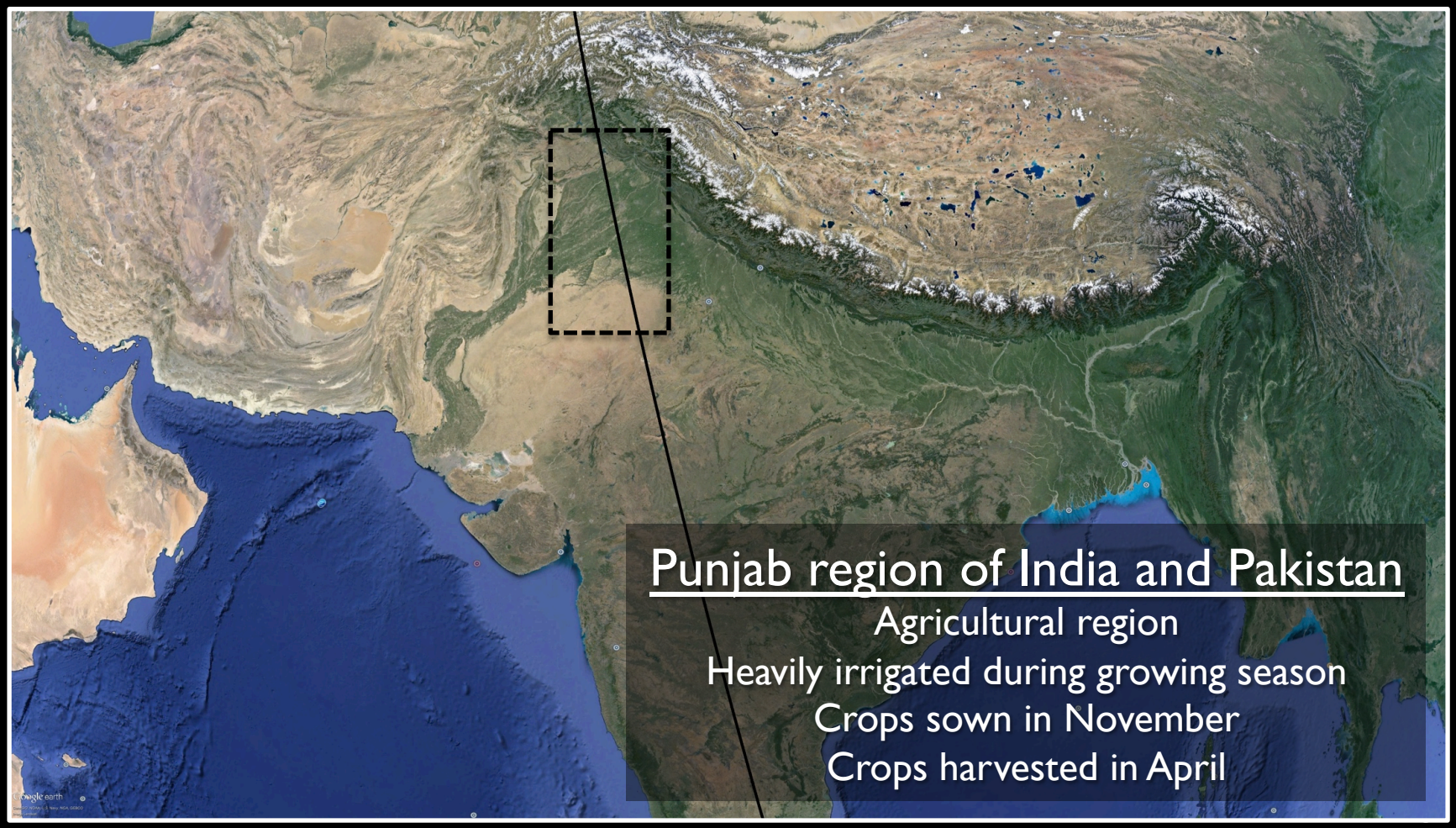
Crops harvested in April


Reflected power, relative to global mean over land (dB)
20
15
10
5
0
-5
10
15
20
25
30
Latitude (deg)
Nov, 2014
Feb, 2015


Punjab region of India and Pakistan
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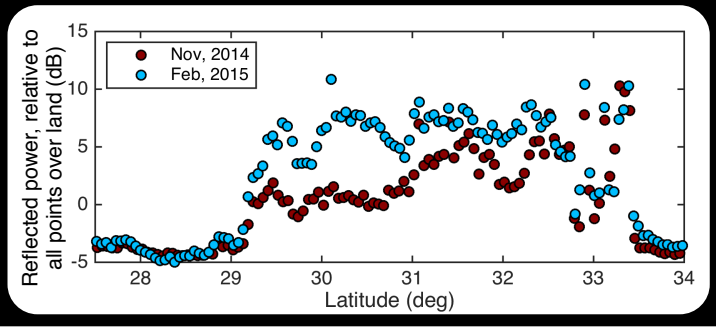
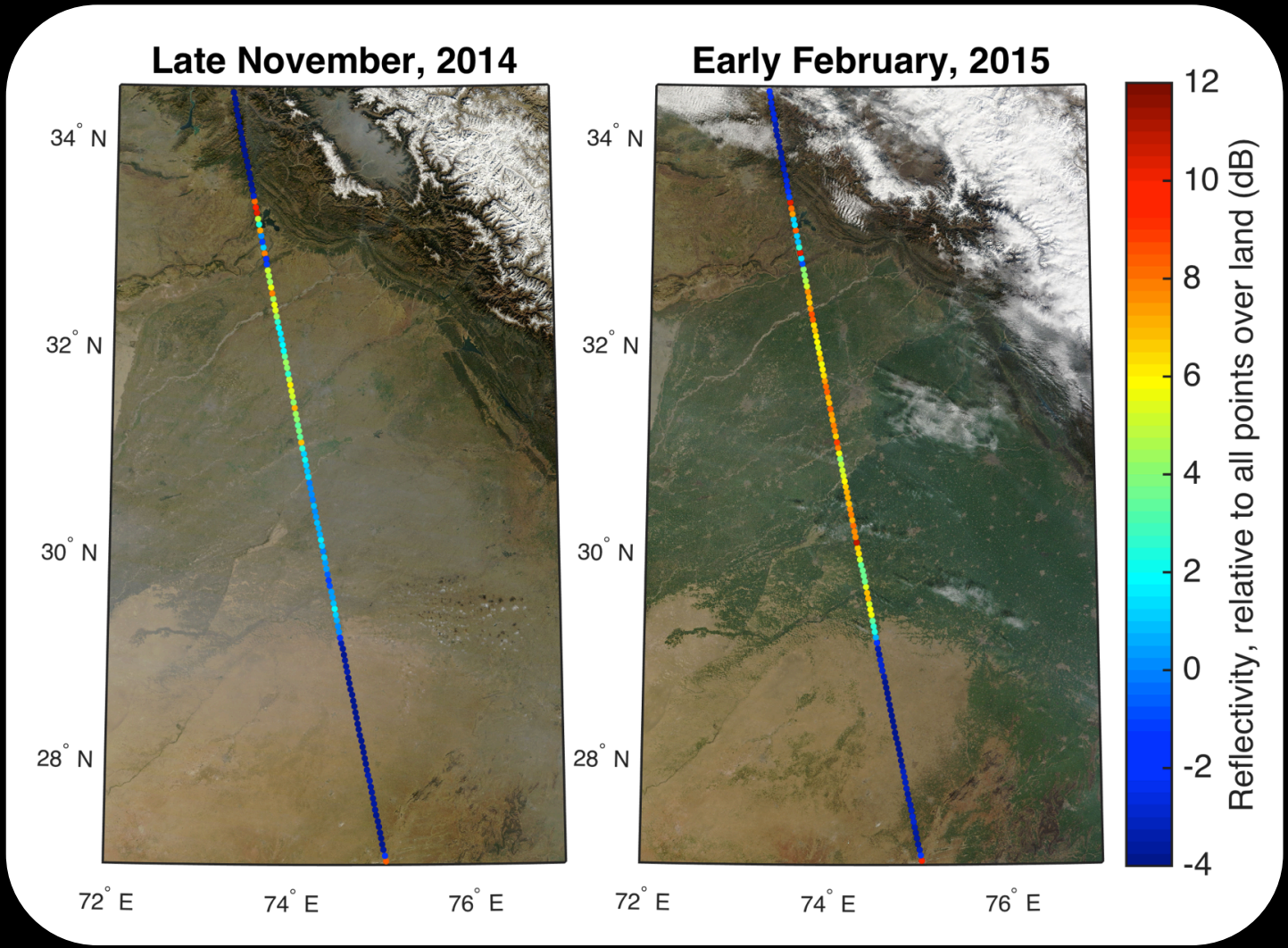
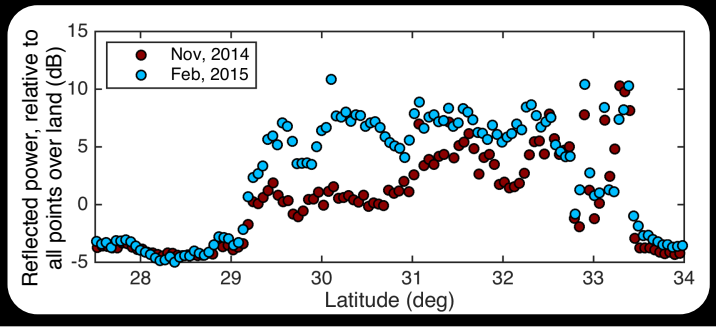
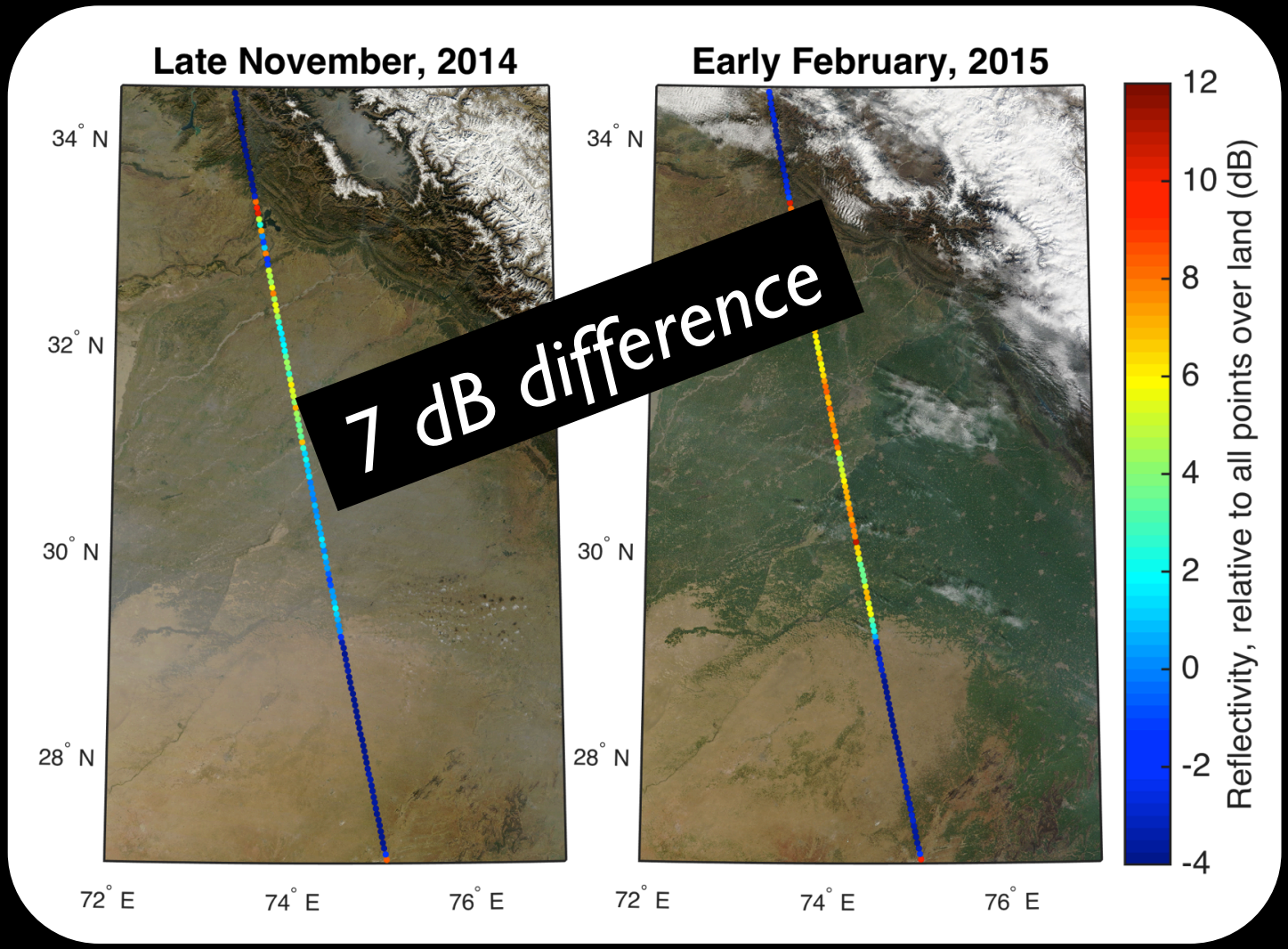


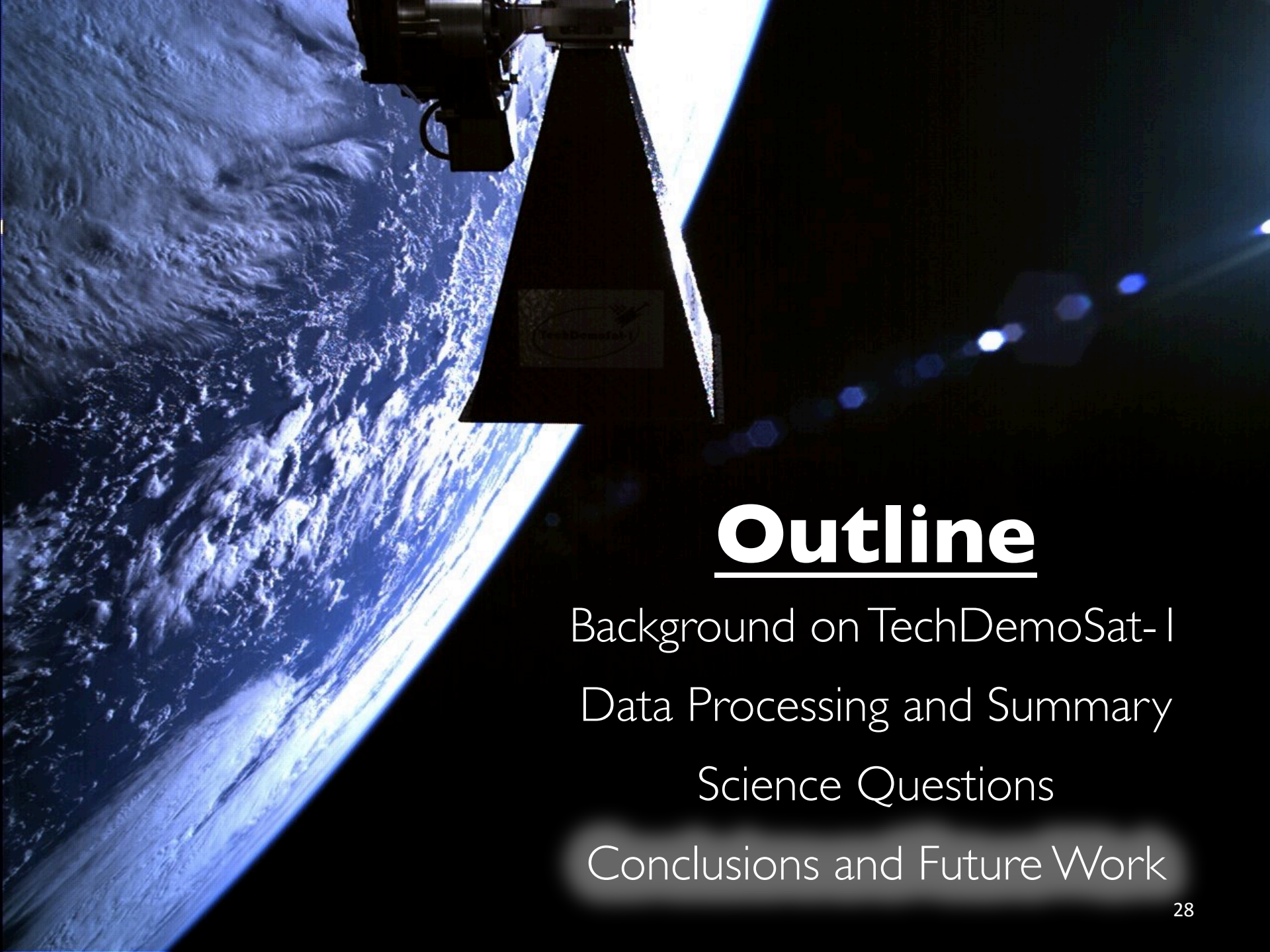


MODIS Aqua data from NASA WorldView





MODIS Aqua data from NASA WorldView



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What could ground-reflected GNSS signals*
potentially tell us about the land surface?

*as measured from space

GNSS reflections could potentially:

measure wetland dynamics,
sense changes in soil moisture,
and provide information about sea ice edge and freeze/thaw state.

Future data products could be:

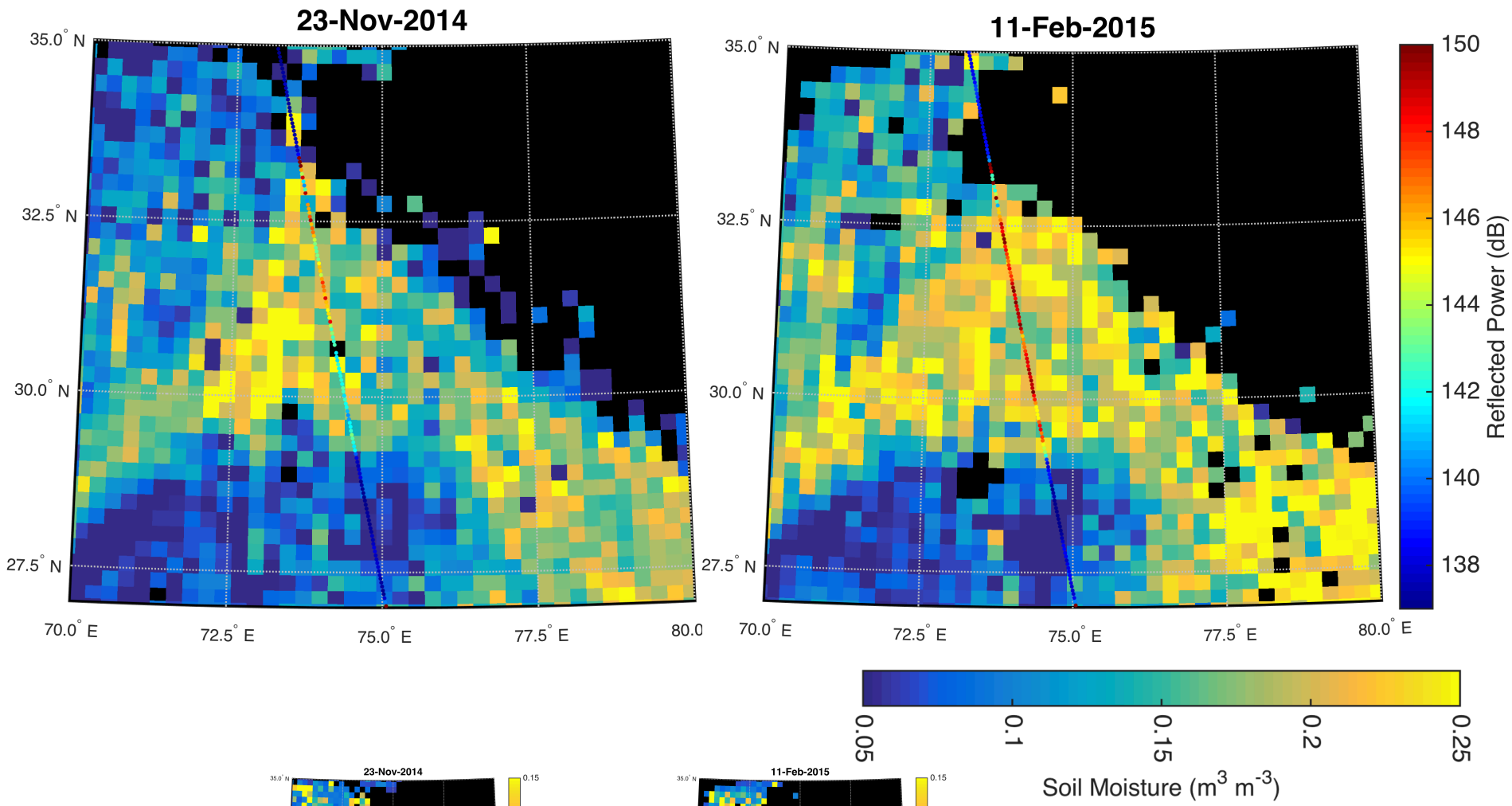
relatively inexpensive,
provide continuity of measurements,
have a temporal revisit time of 12 hours,
and a spatial resolution < 25 km

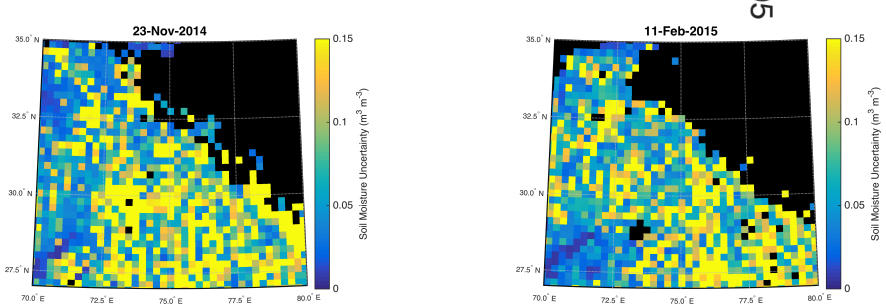
First however, we need:

Better quantification of and correction for roughness
Better understanding of the variable spatial resolution

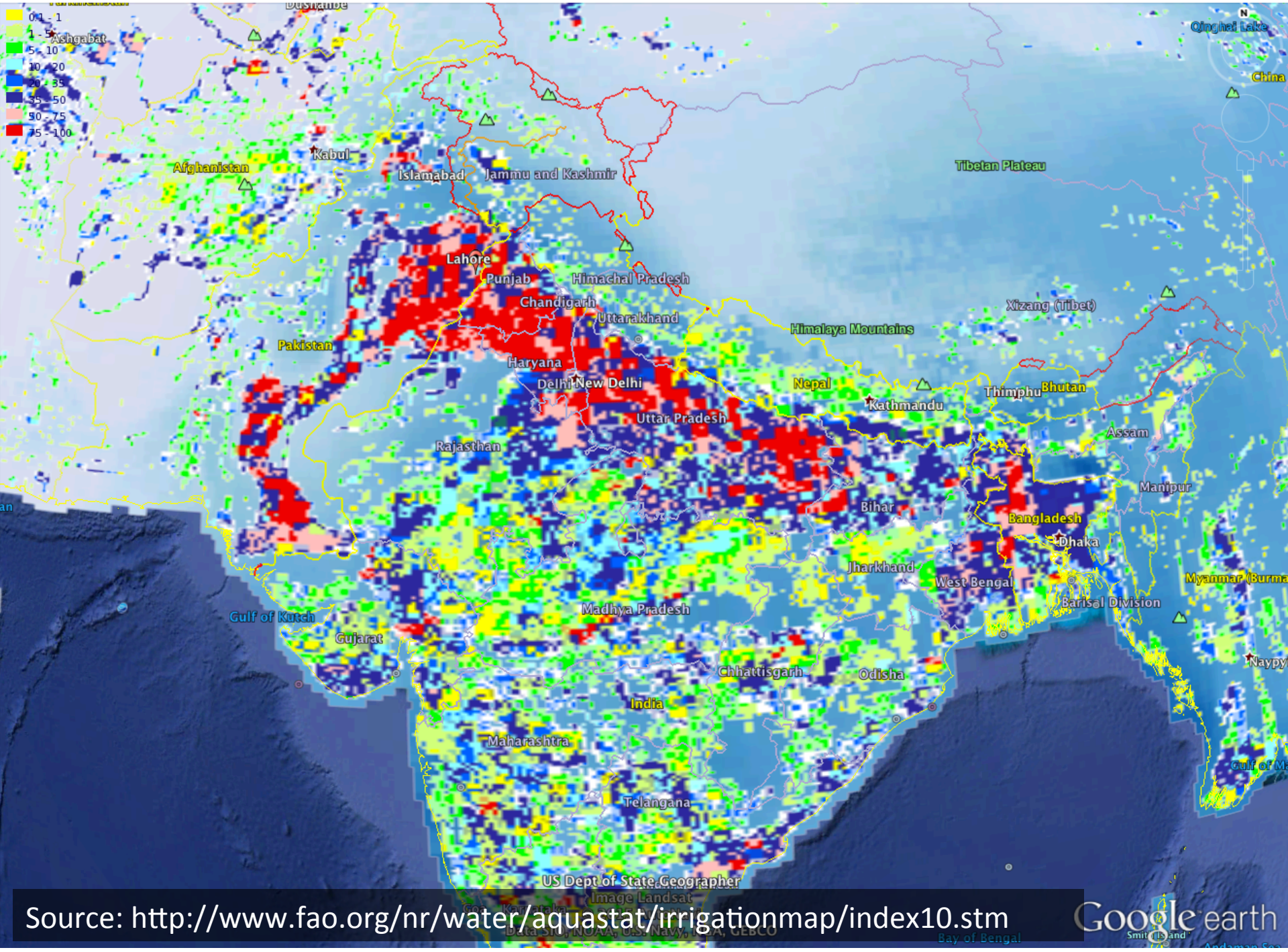
Thank you!

Backup Slides

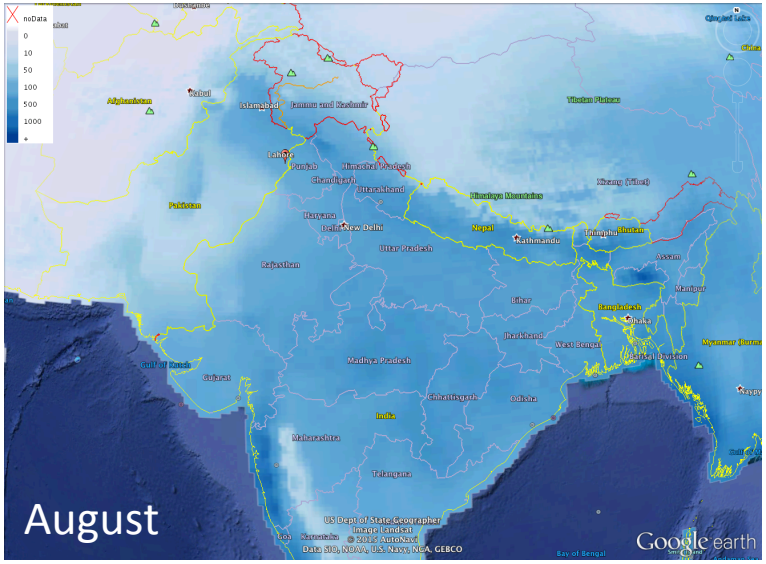




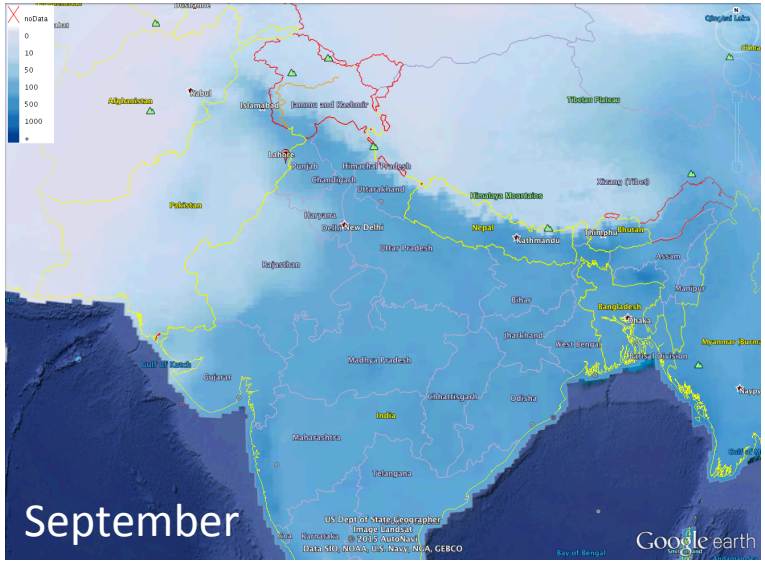
SMOS L3 products downloaded from: http://www.catds.fr/sipad/startPage.do



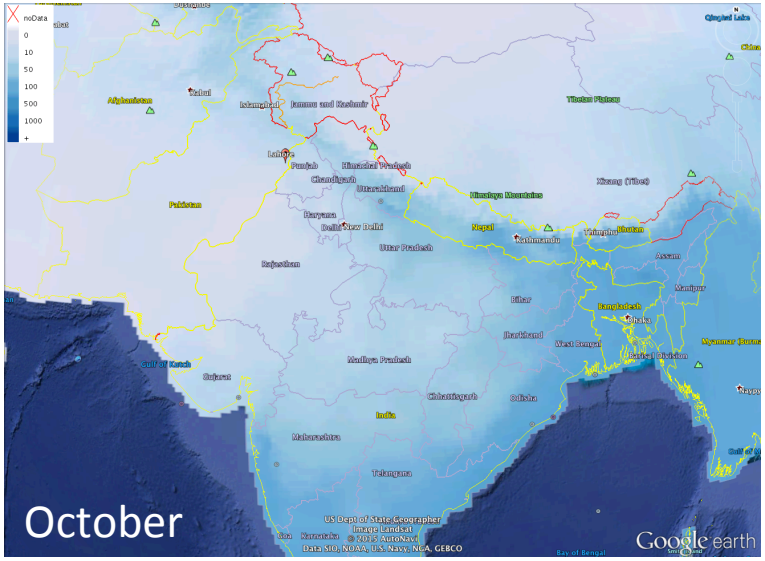
Source: http://www.fao.org/nr/water/aquastat/irrigationmap/index10.stm



August



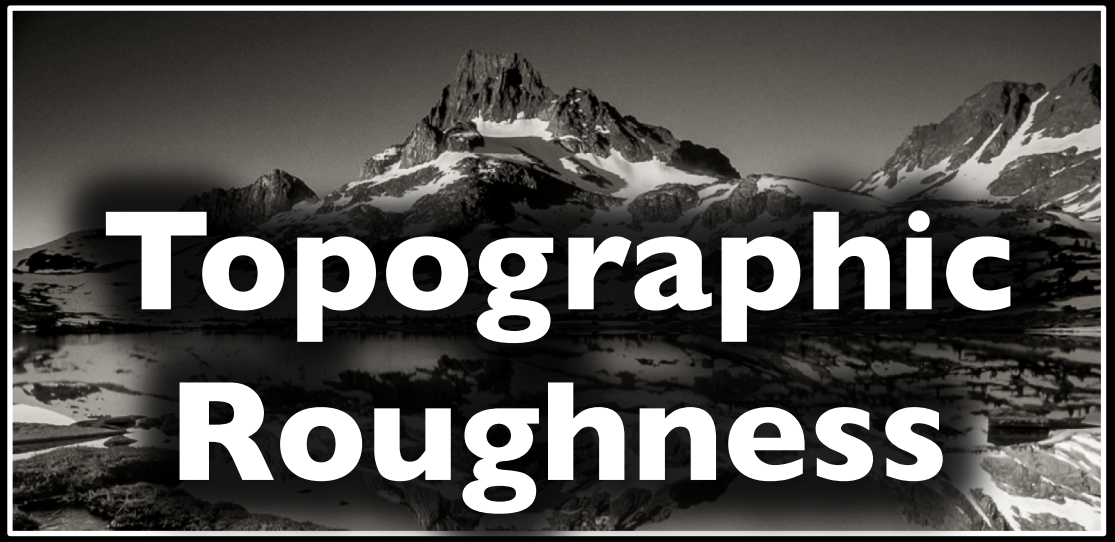
September



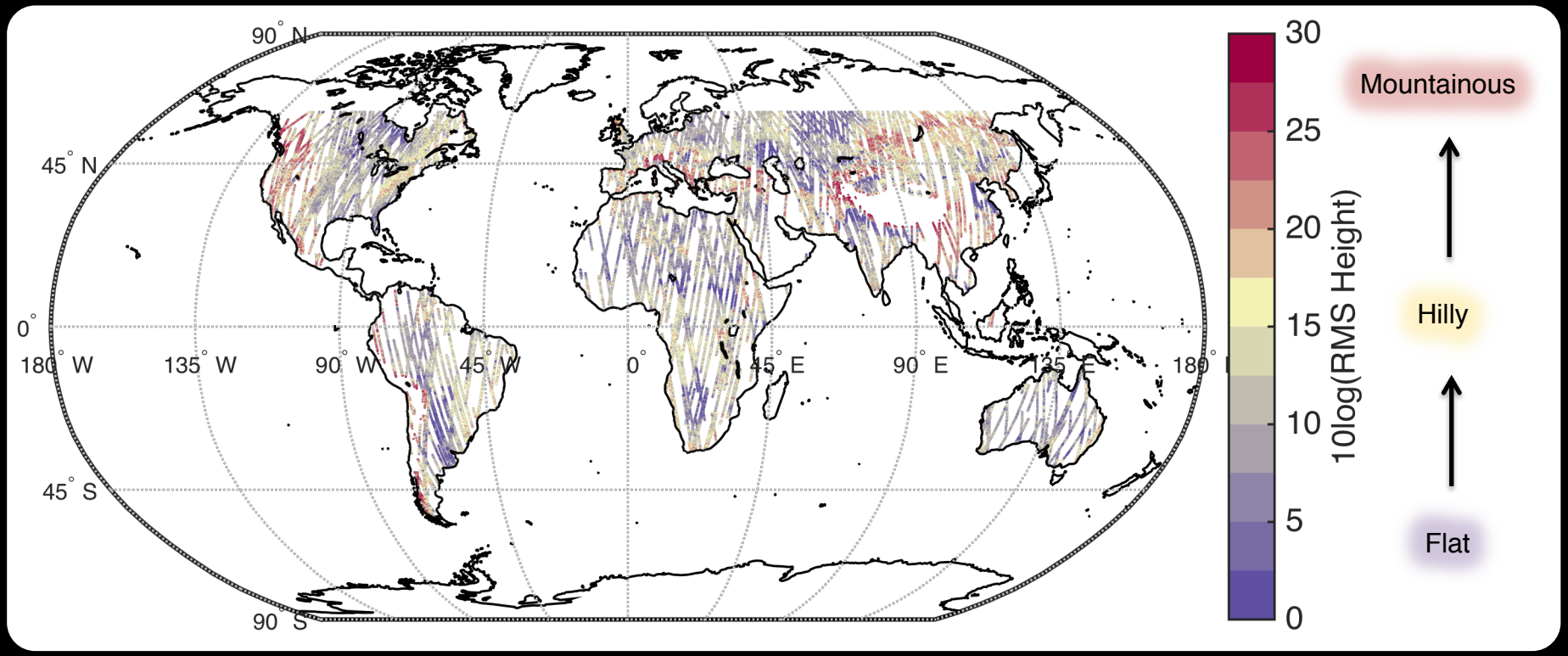
October

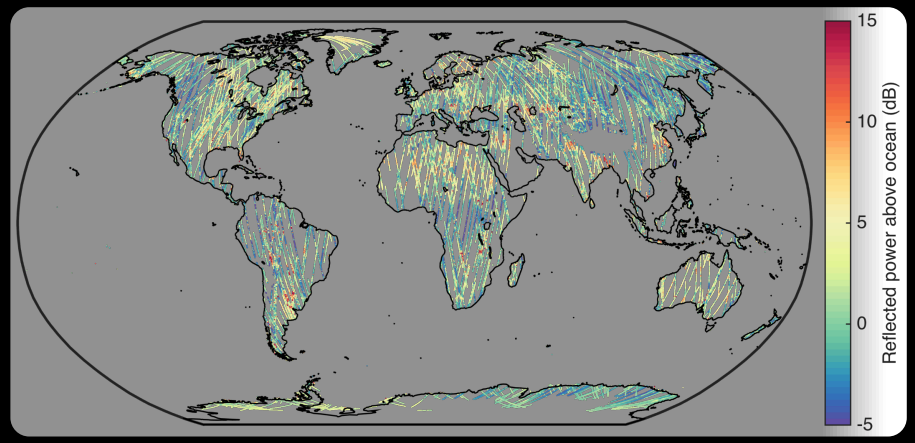
November

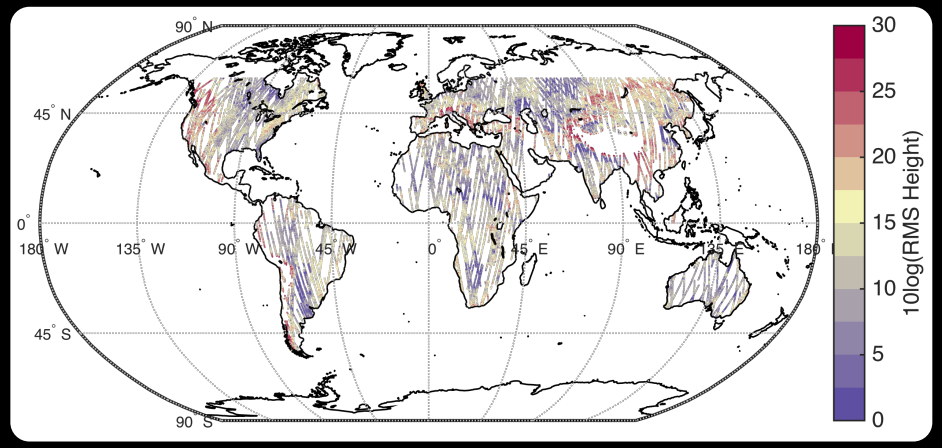
http://www.fao.org/nr/water/aquamaps/

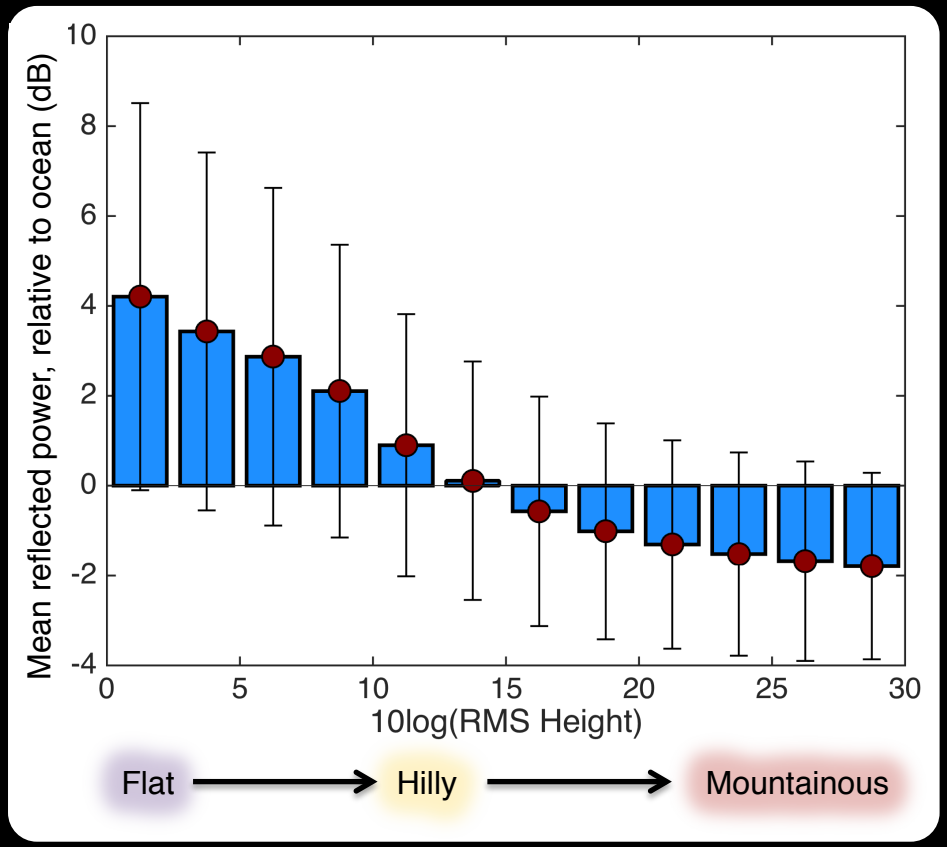


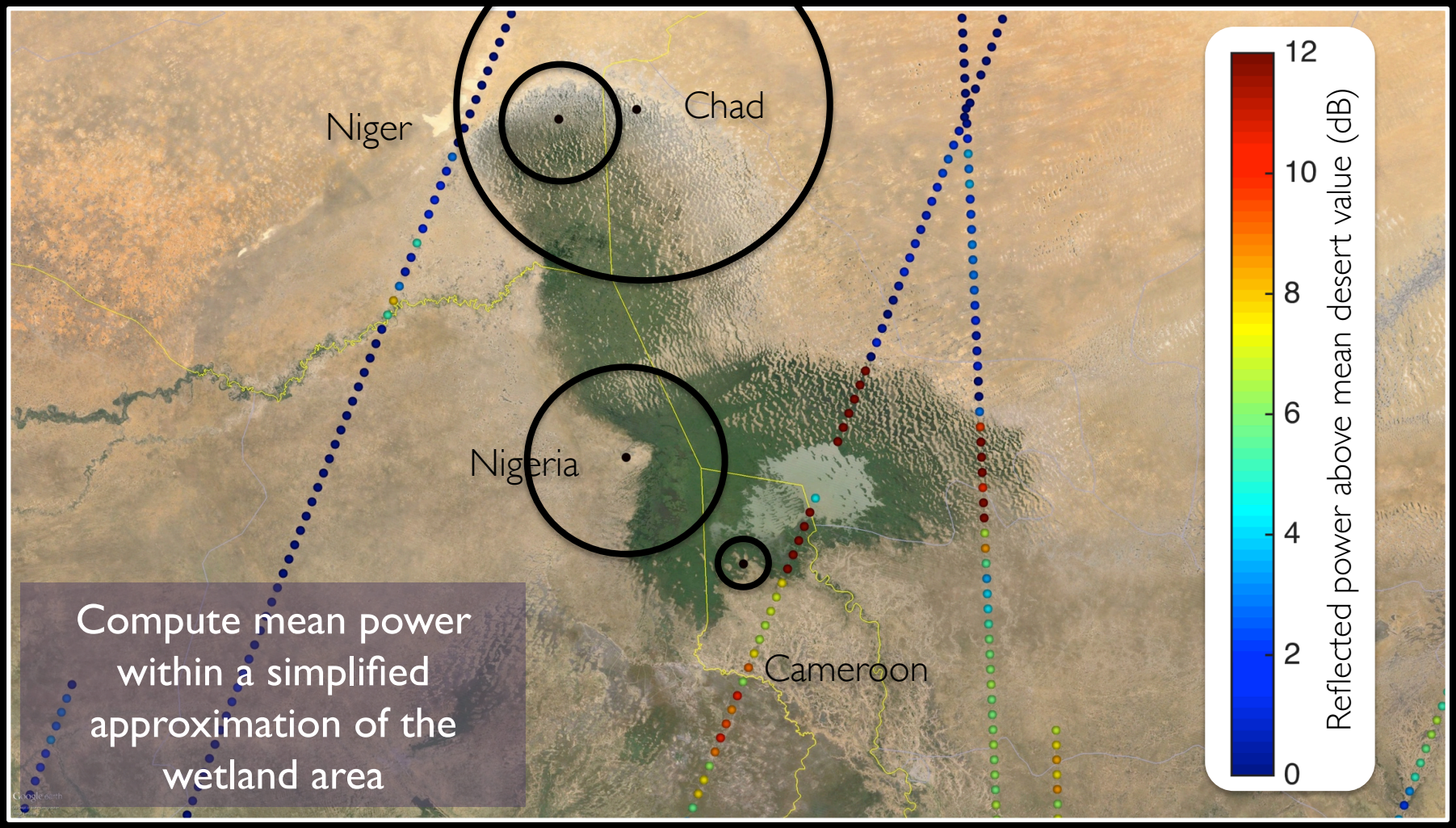
Topographic Roughness

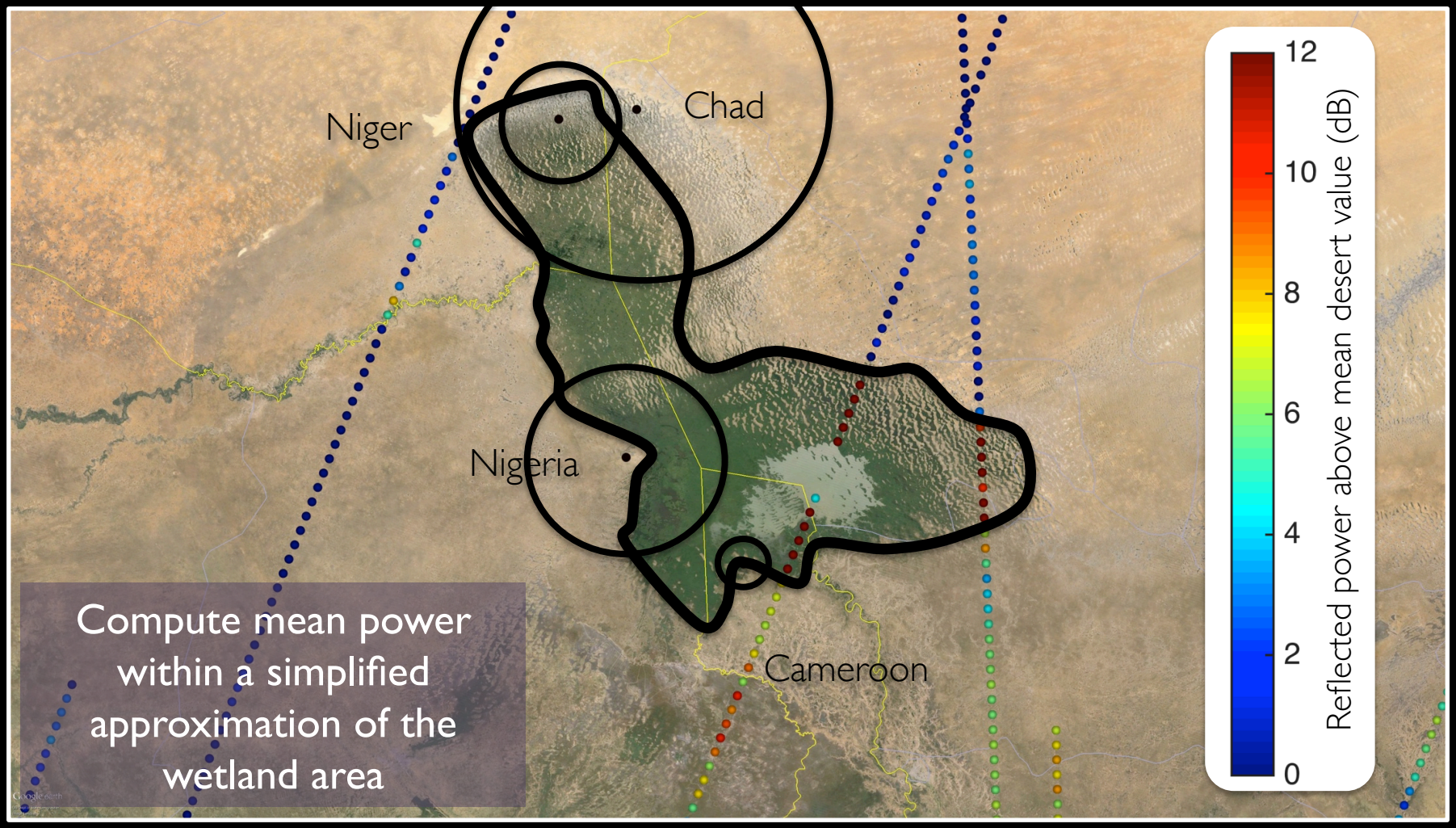



15
10
5
0
-5
Reflected power above ocean (dB)

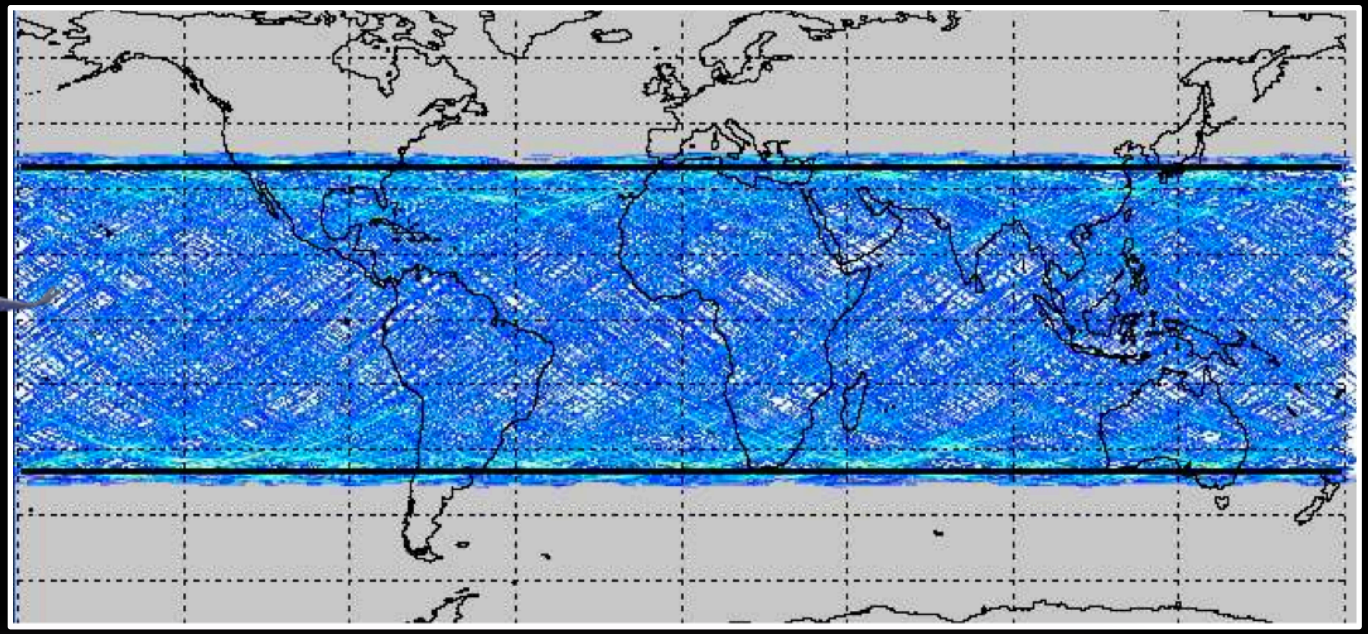

90° N
45° N
0°
180° W
135° W
90° W
45° W
0°
45° E
90° E
45° S
90° S
30
25
20
15
10
5
0
10log(RMS Height)


Mean reflected power, relative to ocean (dB)
10
8
6
4
2
0
-2
-4
0
5
10
15
20
25
30
10log(RMS Height)
Flat
Hilly
Mountainous


Niger
Chad
Nigeria
Cameroon
Compute mean power within a simplified approximation of the wetland area
12
10
8
6
4
2
0
Reflected power above mean desert value (dB)


Niger
Chad
Nigeria
Cameroon
Compute mean power within a simplified approximation of the wetland area
12
10
8
6
4
2
0
Reflected power above mean desert value (dB)

TDS-1



- 8 small satellites
- Same receiver as TDS-1
- Average repeat time: 12 hours

Source: http://clasp-research.engin.umich.edu/missions/cygnss/science.php