Jet Propulsion Laboratory
California Institute of Technology

The FROst Dynamics Observatory (FRODO) Concept

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Jan 4, 2017

Outline

- Why is observing freeze/thaw state important?
- How could FRODO fill existing gaps in observations?
- What evidence do we have that this could work?

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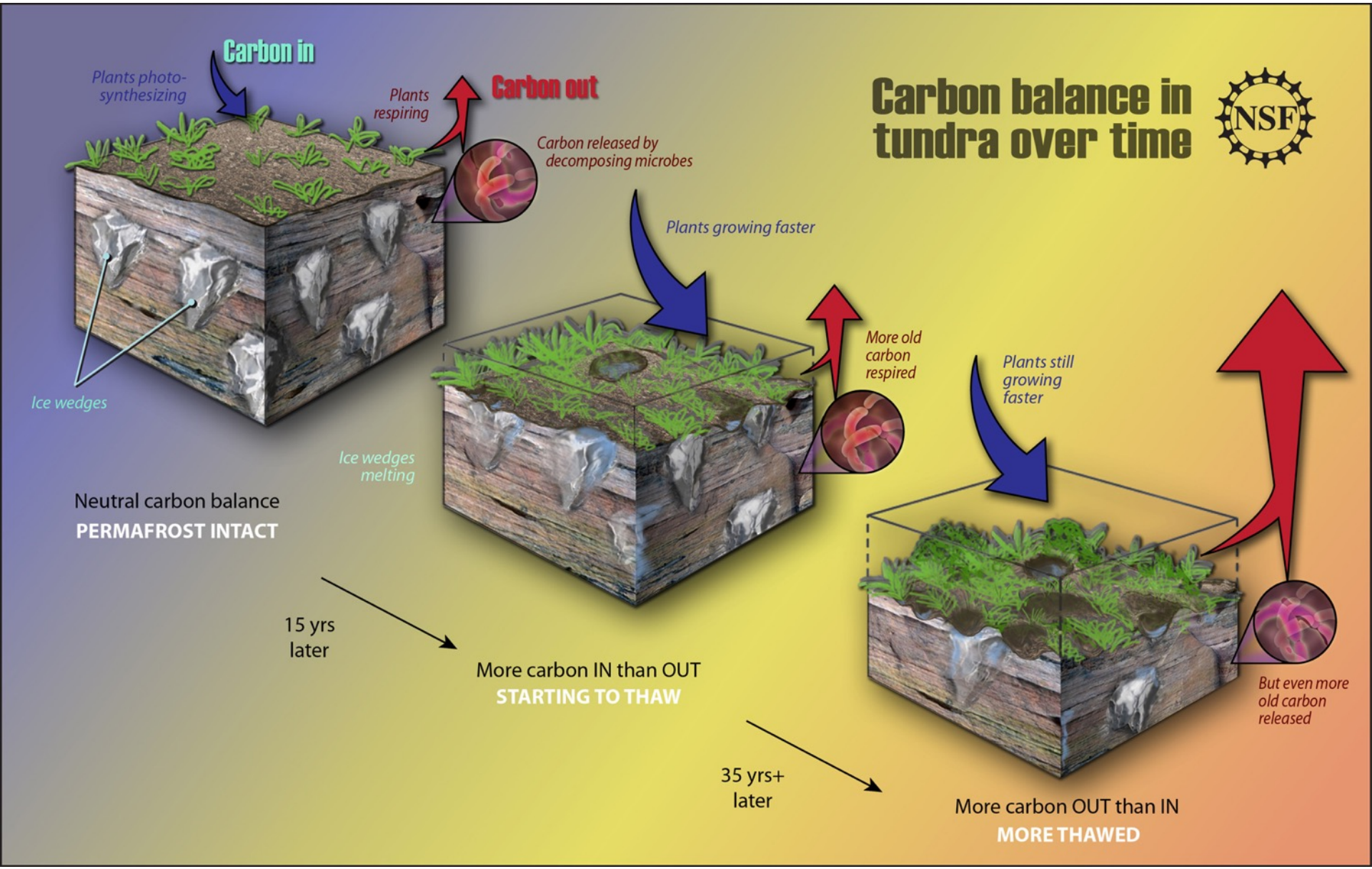
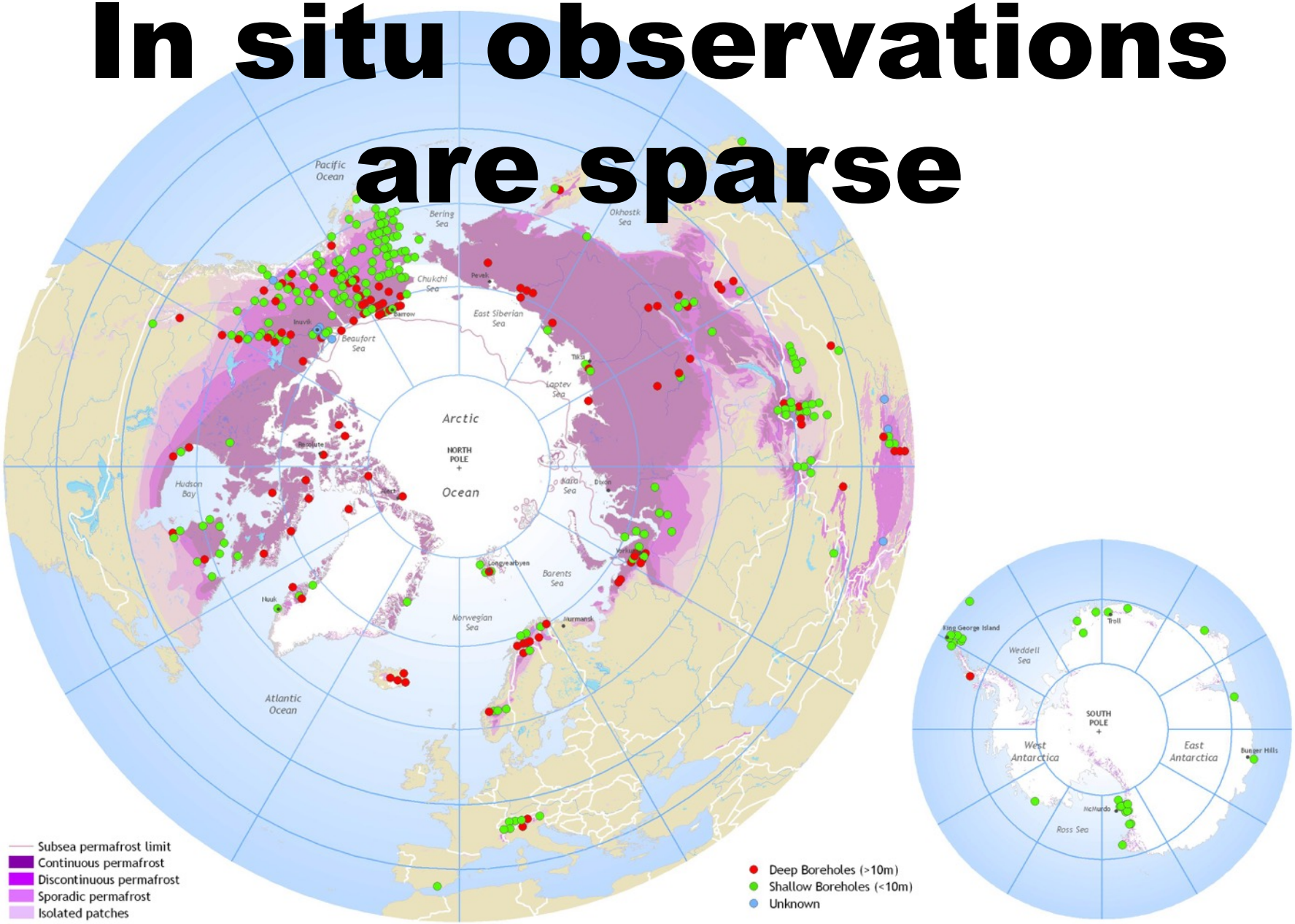
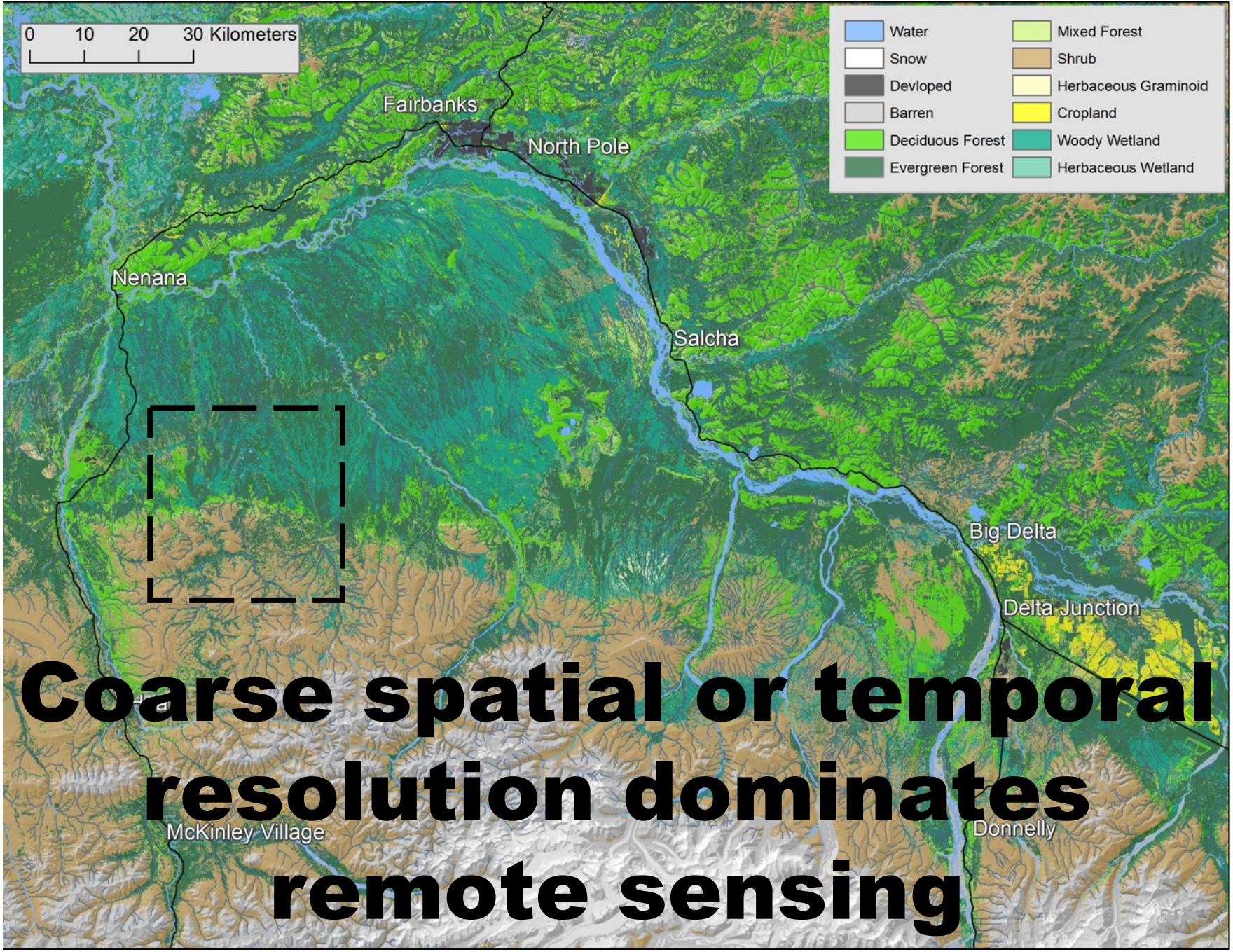

Carbon balance in tundra over time
NSF
Carbon in
Plants photo-synthesizing
Plants respiring
Carbon out
Carbon released by decomposing microbes
Ice wedges
Neutral carbon balance
PERMAFROST INTACT
Plants growing faster
More old carbon respired
Ice wedges melting
15 yrs later
More carbon IN than OUT
STARTING TO THAW
Plants still growing faster
But even more old carbon released
35 yrs+ later
More carbon OUT than IN
MORE THAWED

Freeze/thaw is the on/off switch for these processes

In situ observations are sparse



International Permafrost Association



Coarse spatial or temporal resolution dominates remote sensing

Douglas TA, Jones MC, Hiemstra CA, Arnold JR. 2014. Sources and sinks of carbon in boreal ecosystems of interior Alaska: A review. *Elem. Sci. Anth.* **2**: 000032. doi: 10.12952/journal.elementa.000032

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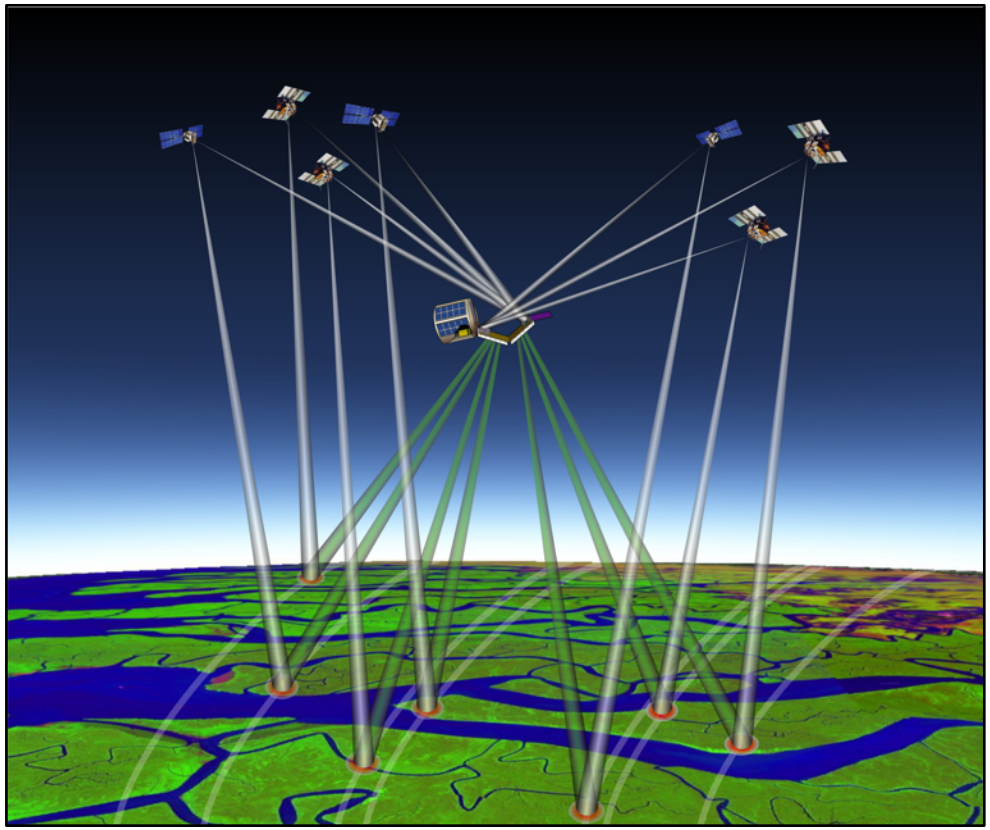
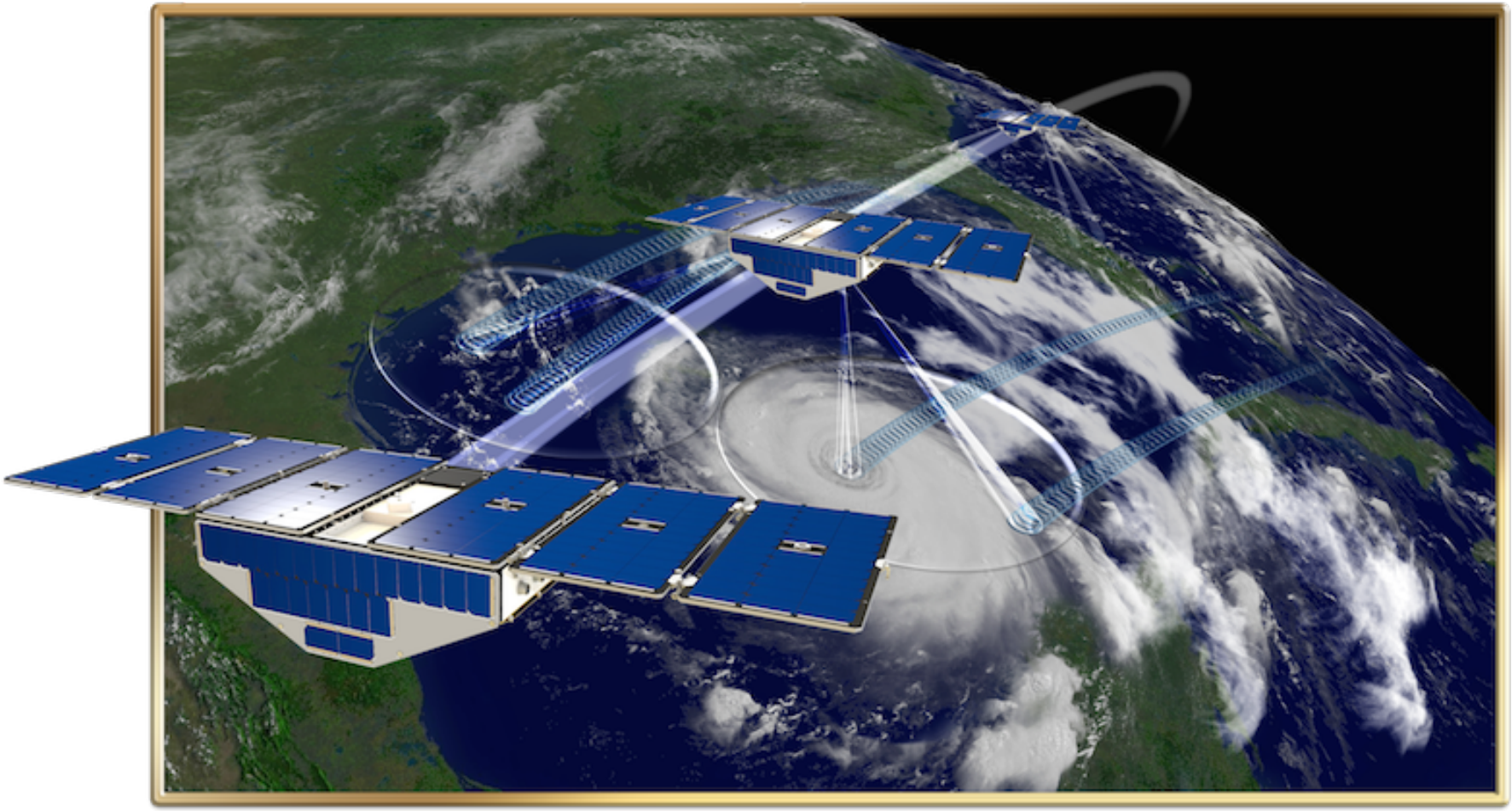
GNSS-Reflectometry



- L-band microwave, sensitive to amount and state of water
    - ‘Smooth’ surface, sub-km spatial resolution

FRODO could be a polar orbiting CyGNSS



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Two sources of data

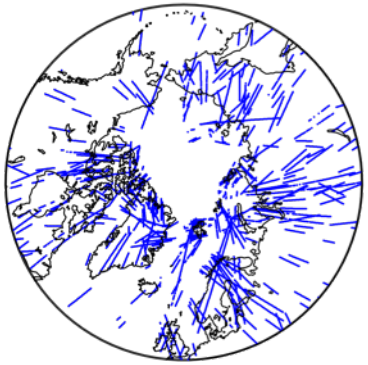
TDS-1

- LHCP antenna ~13 dB
- Data every 8 days since July 2014
- Polar orbiting

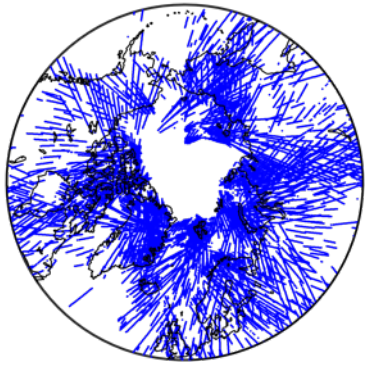
SMAP-R

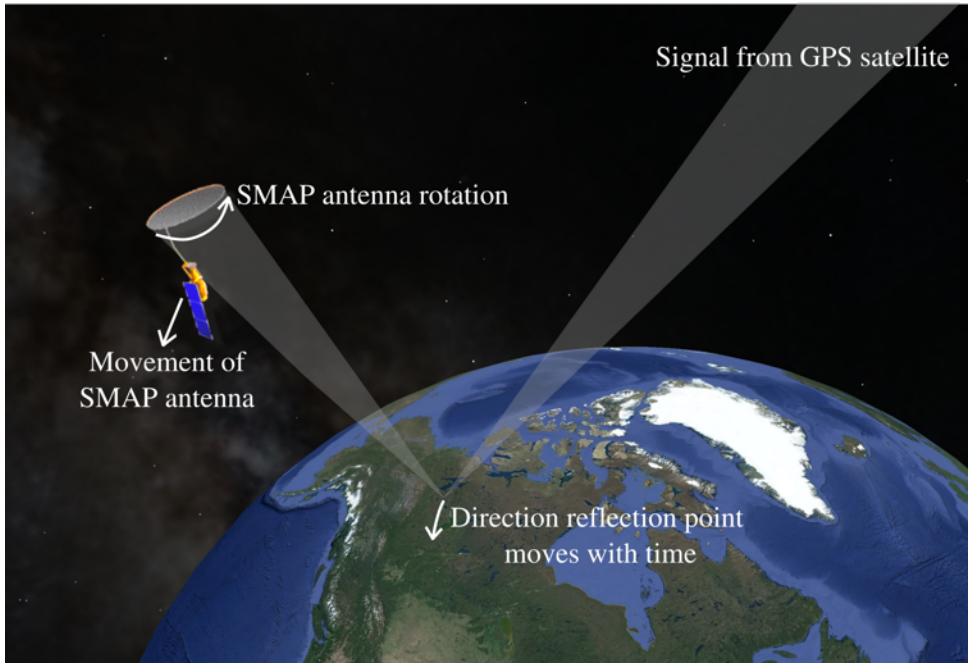
- H and V ~36 dB
- Data since Aug 2015
- Polar orbiting

One week

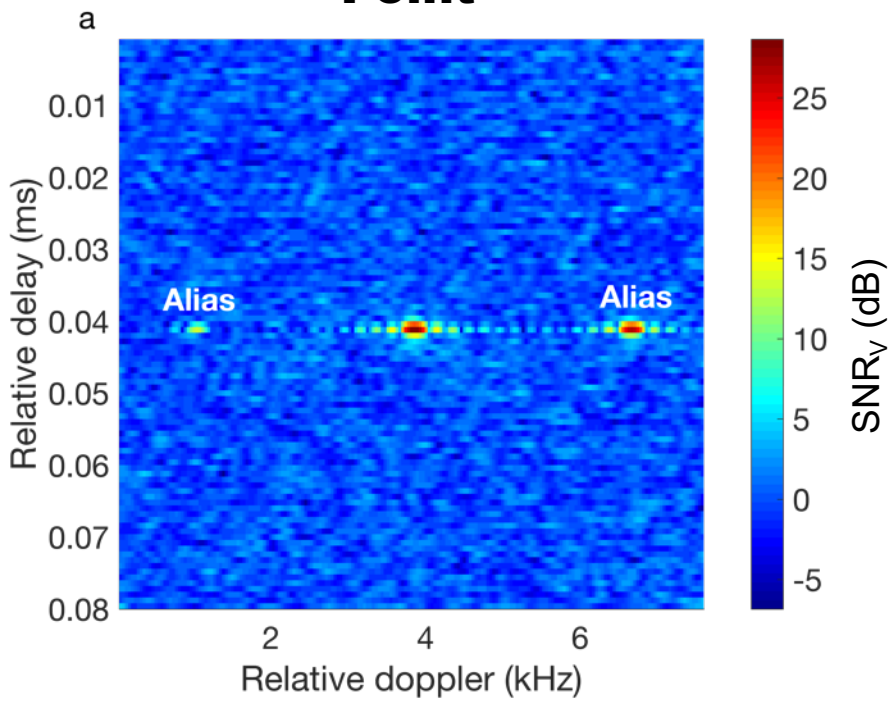


One month





Example of One Data Point



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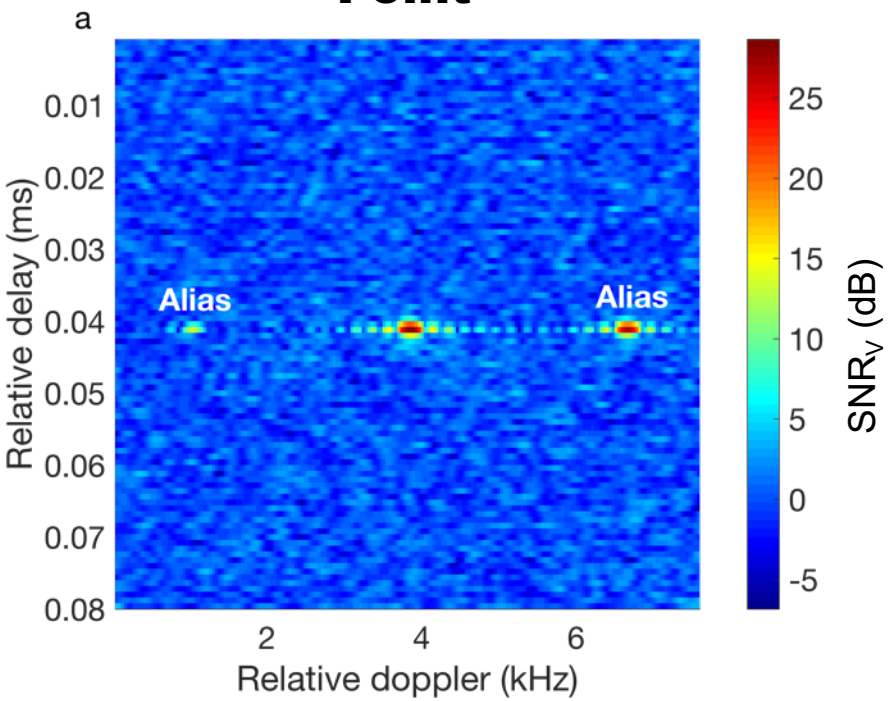
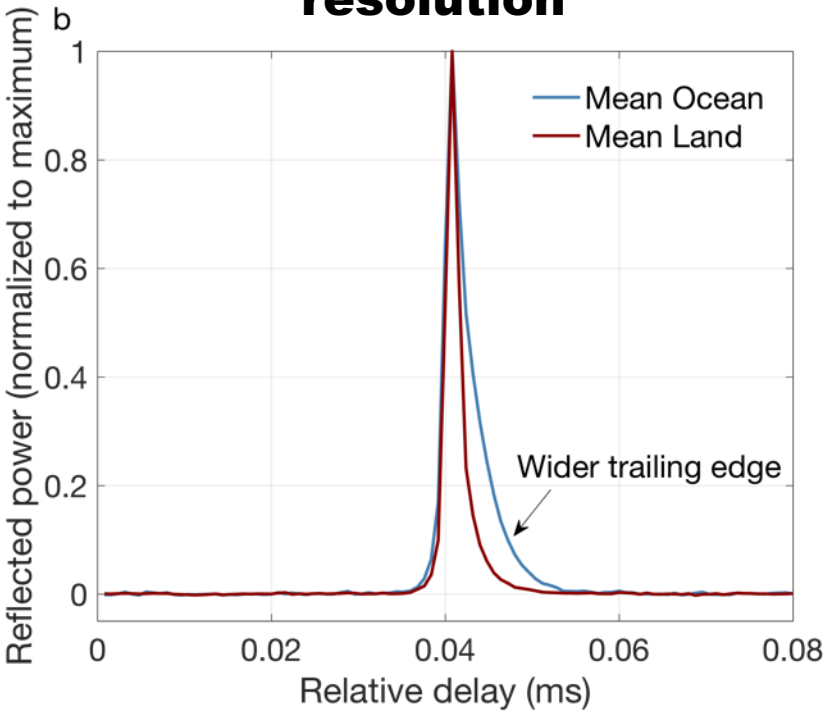


Data have a 'small' spatial resolution



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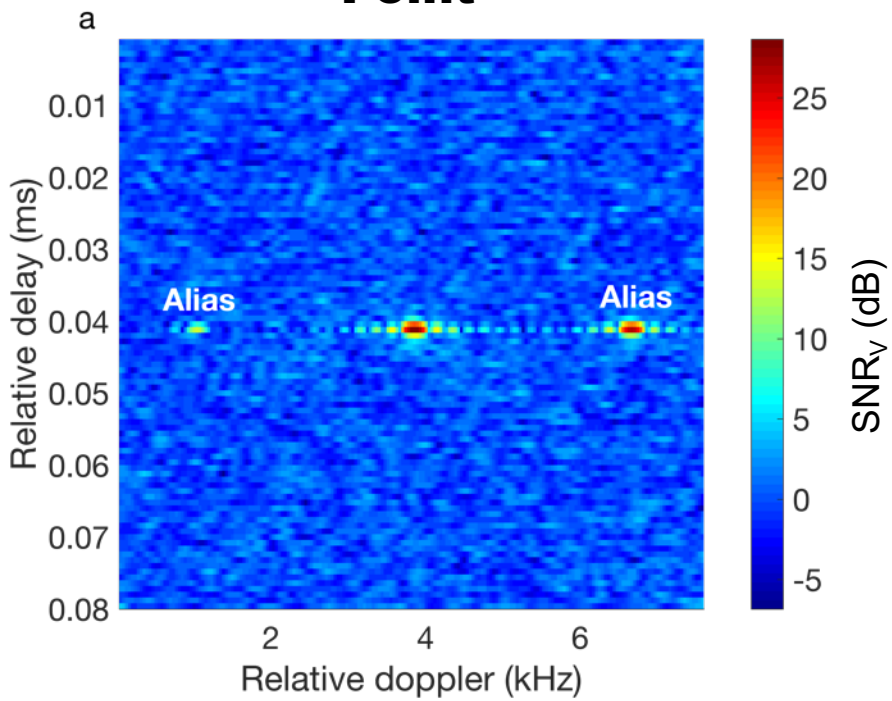

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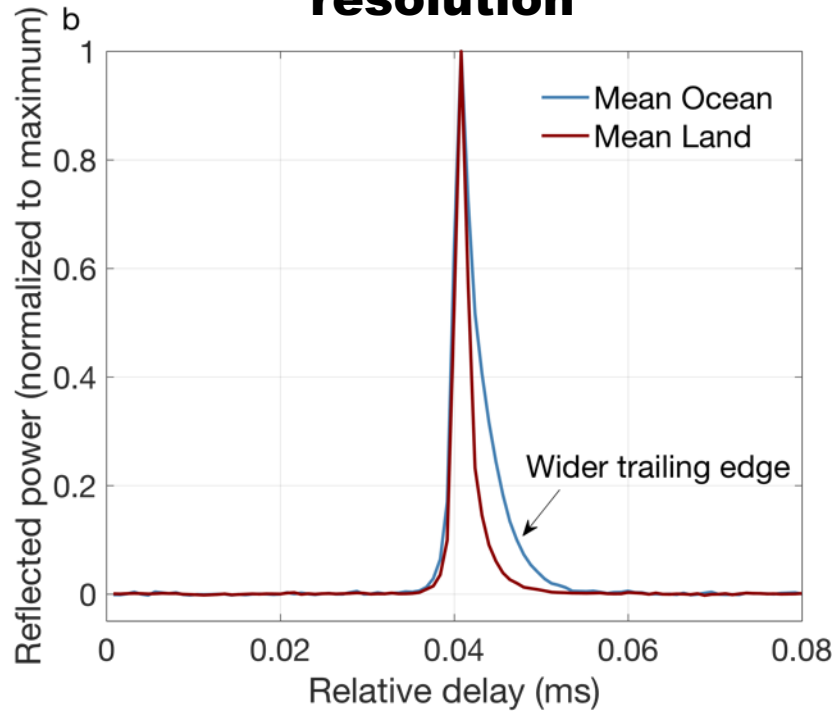
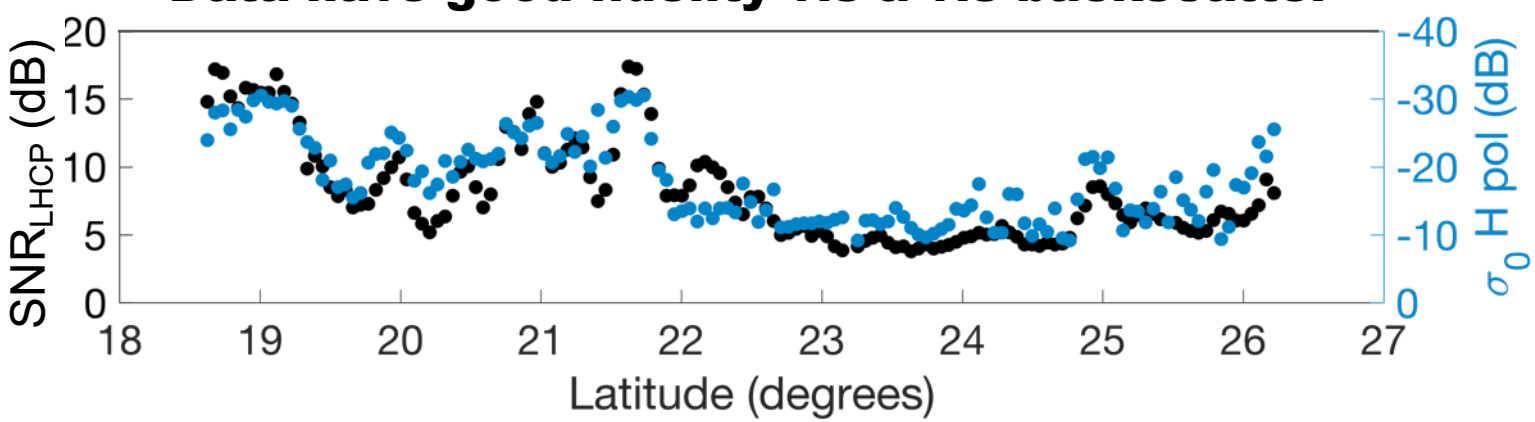
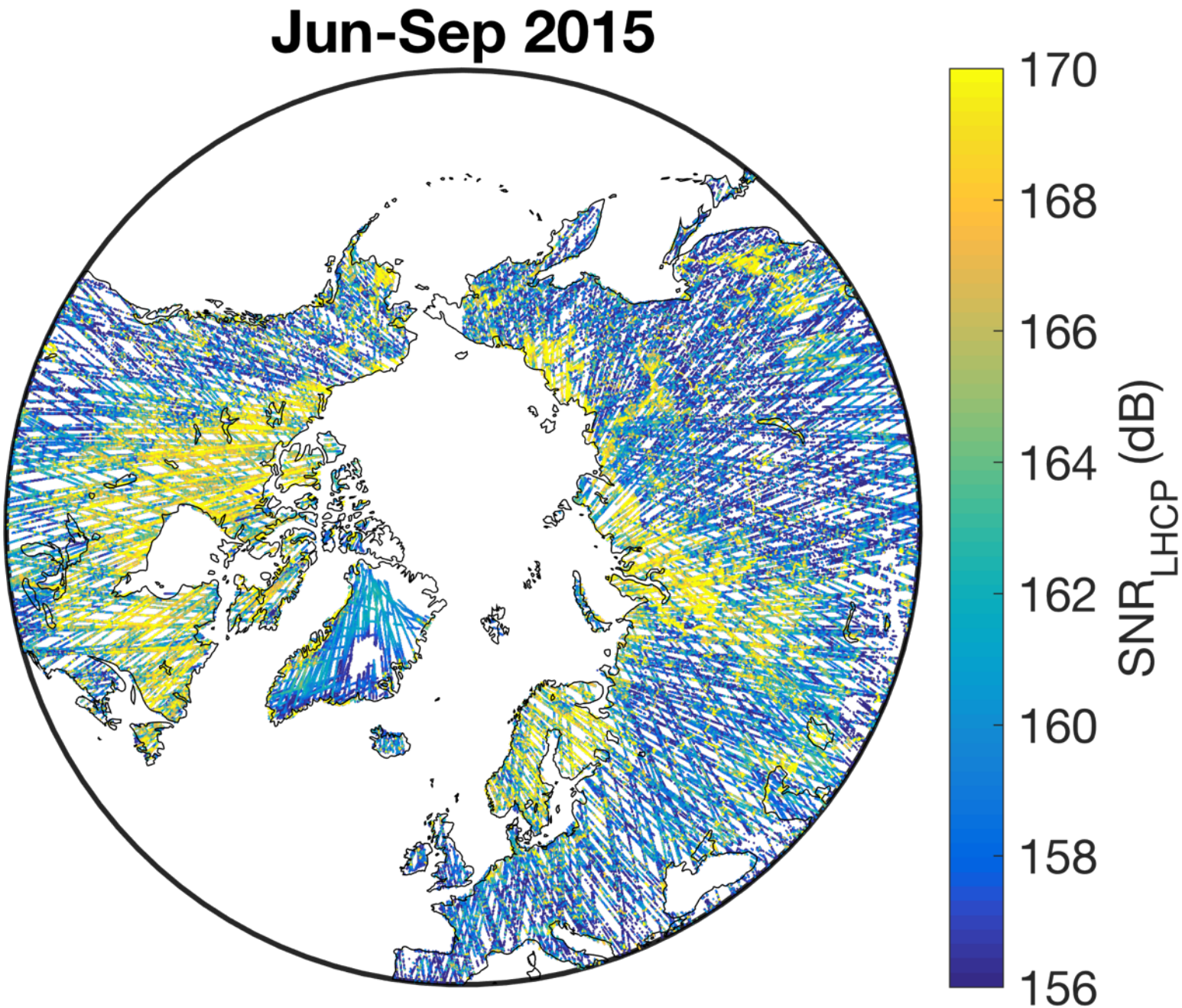
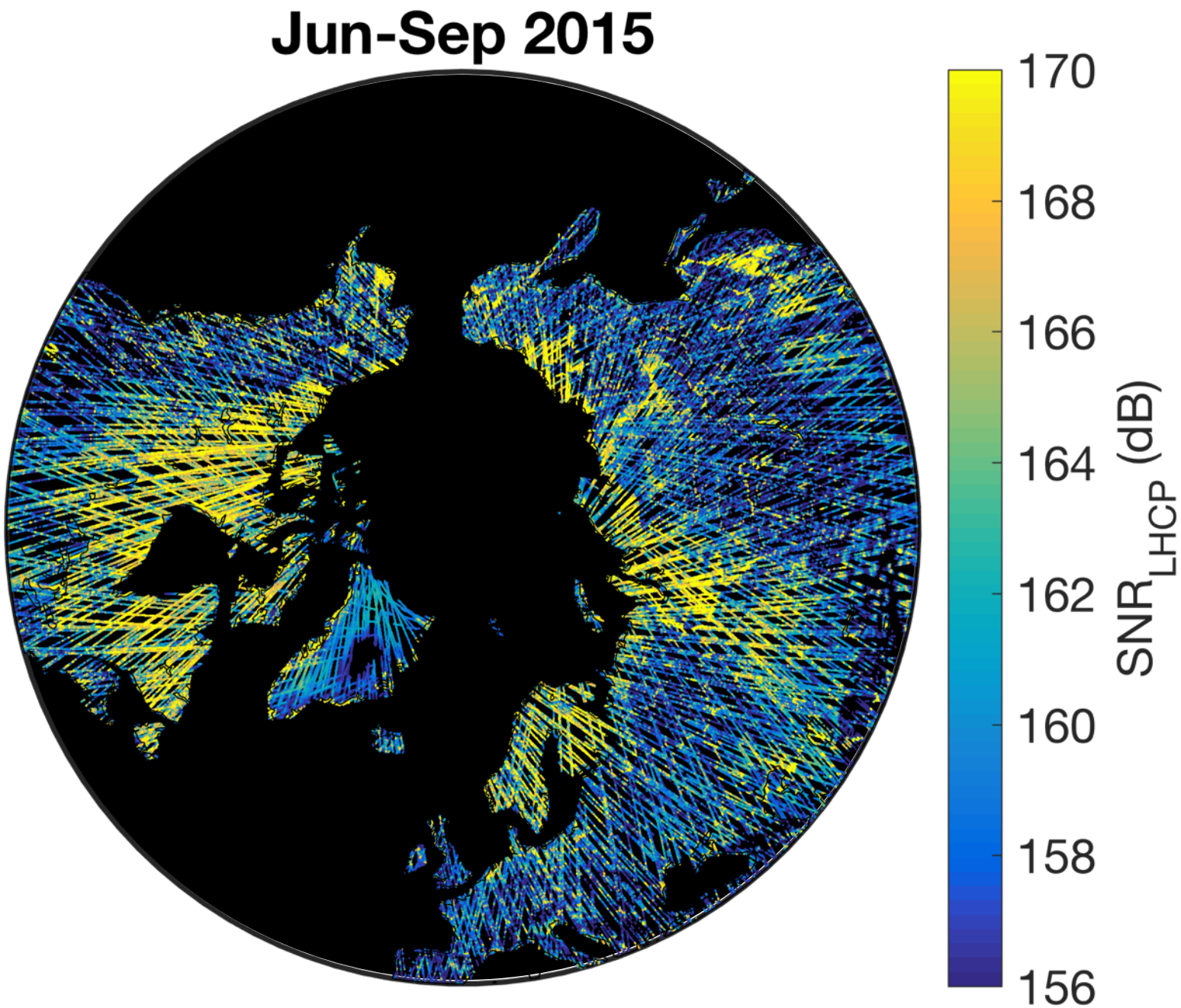


Data have good fidelity vis-à-vis backscatter




Jun-Sep 2015
170
168
166
164
162
160
158
156
SNR$_{LHCP}$ (dB)


Jun-Sep 2015
170
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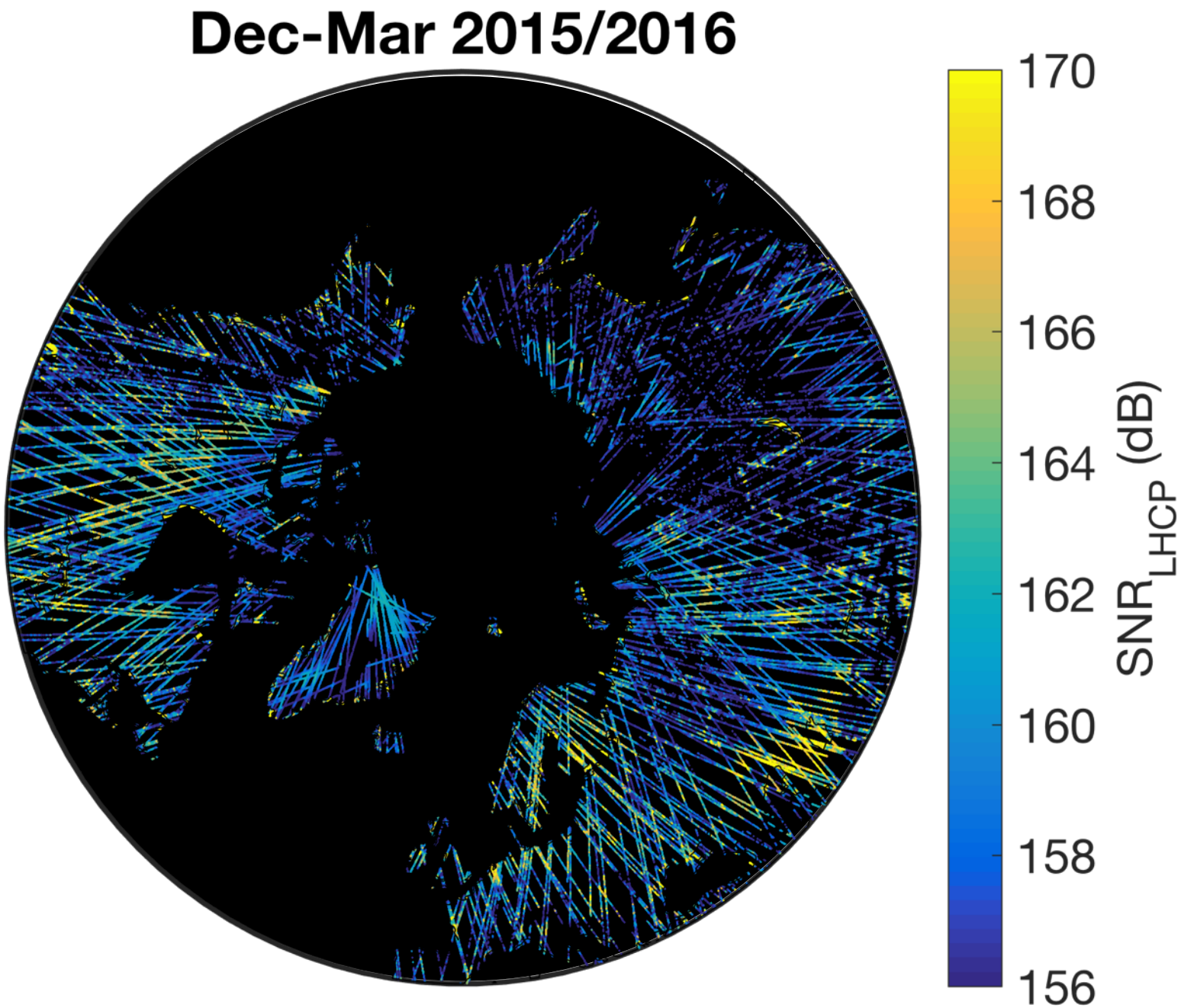
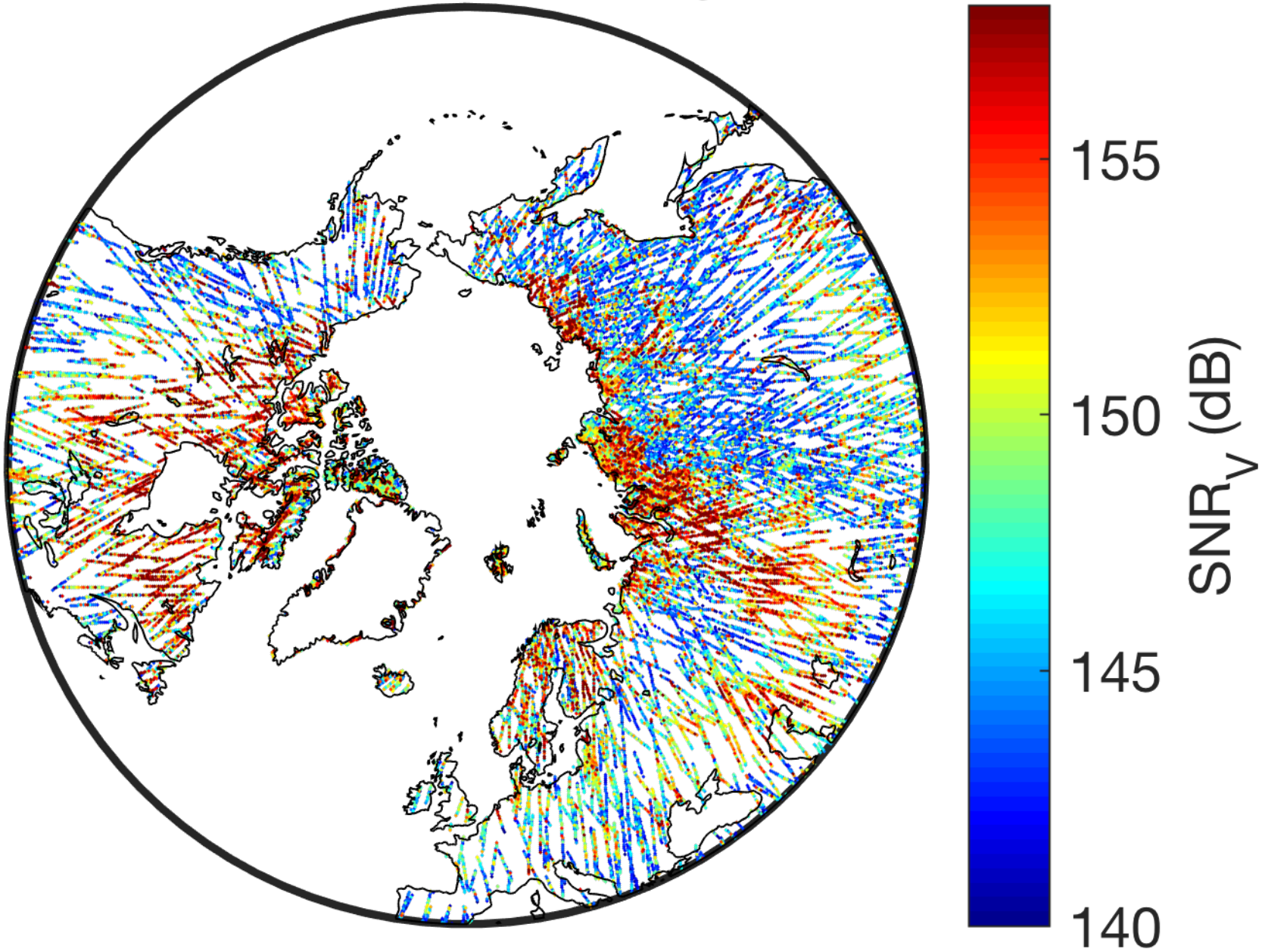
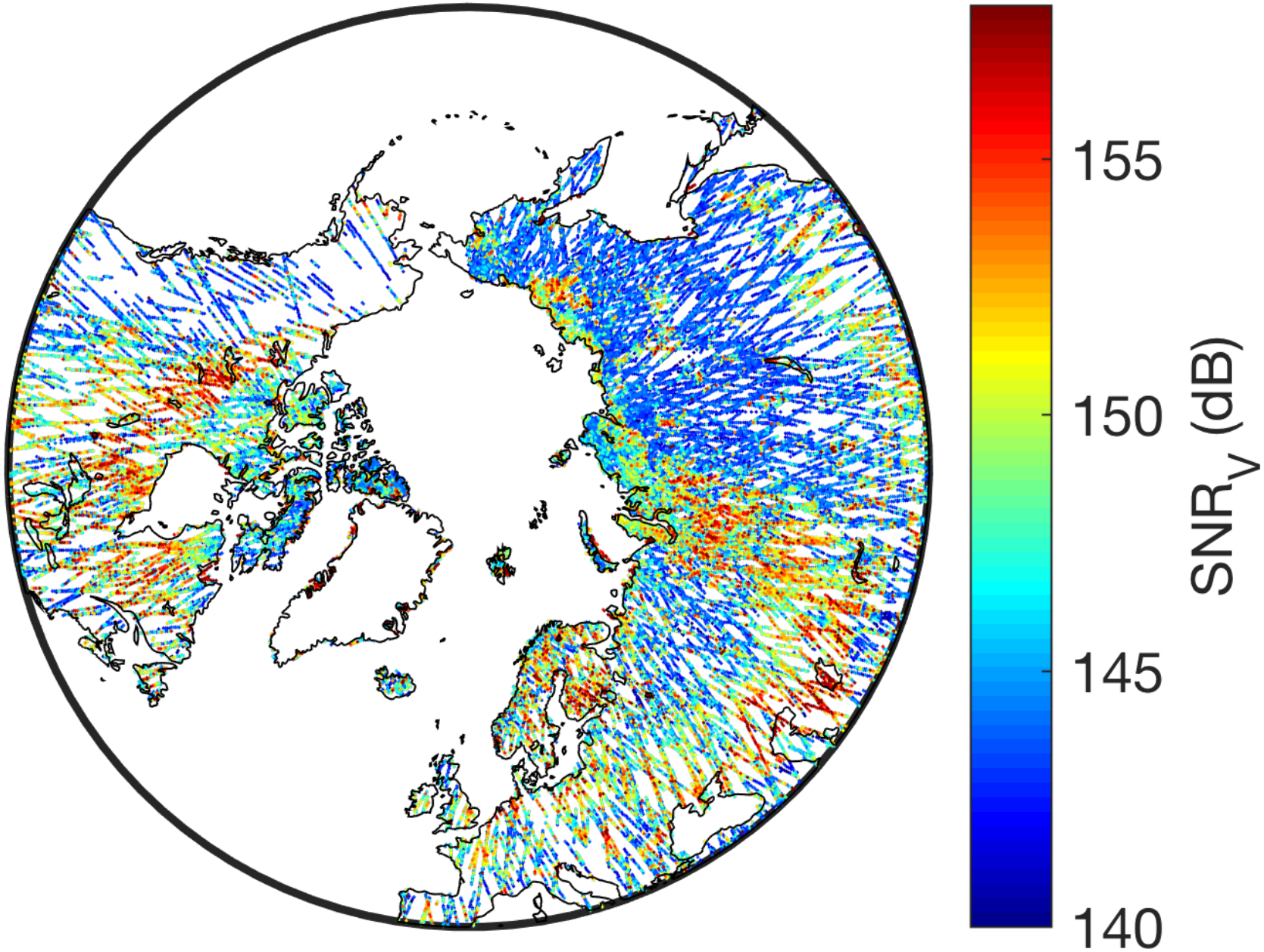
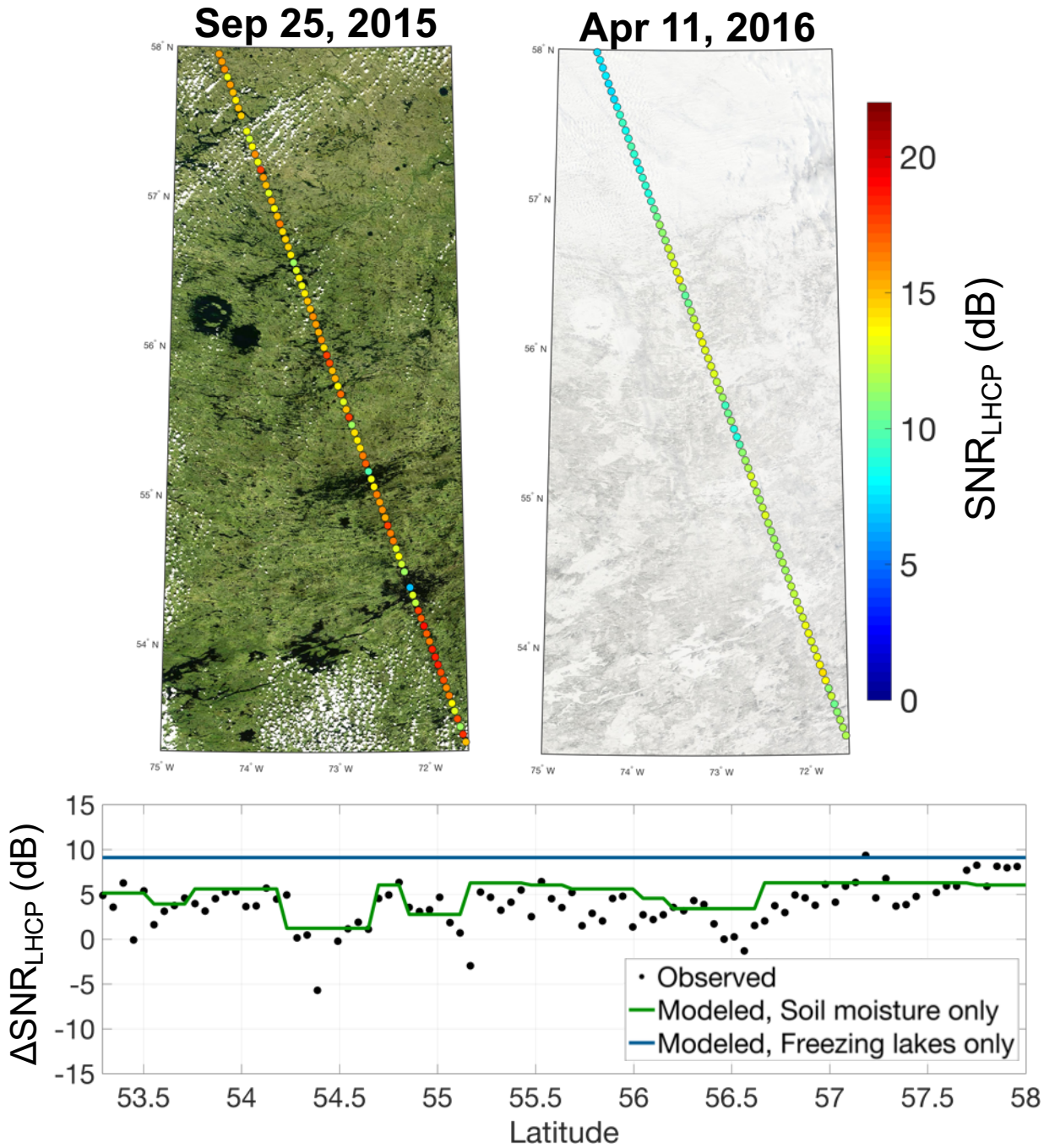

Dec-Mar 2015/2016
170
168
166
164
162
160
158
156
SNR_LHCP (dB)

Summer: Jun, Jul, Aug 2016

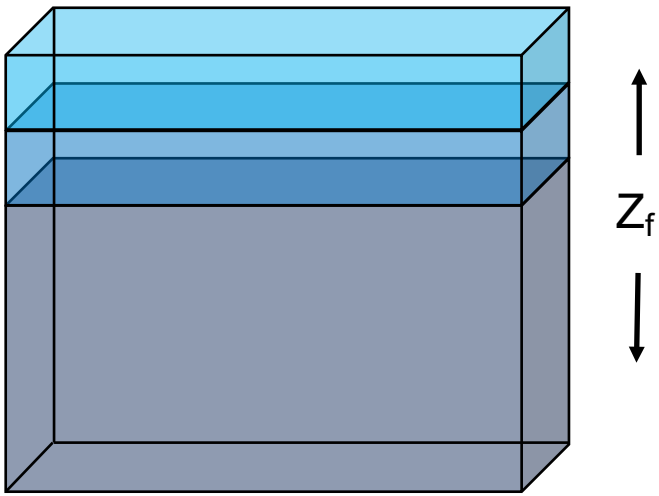


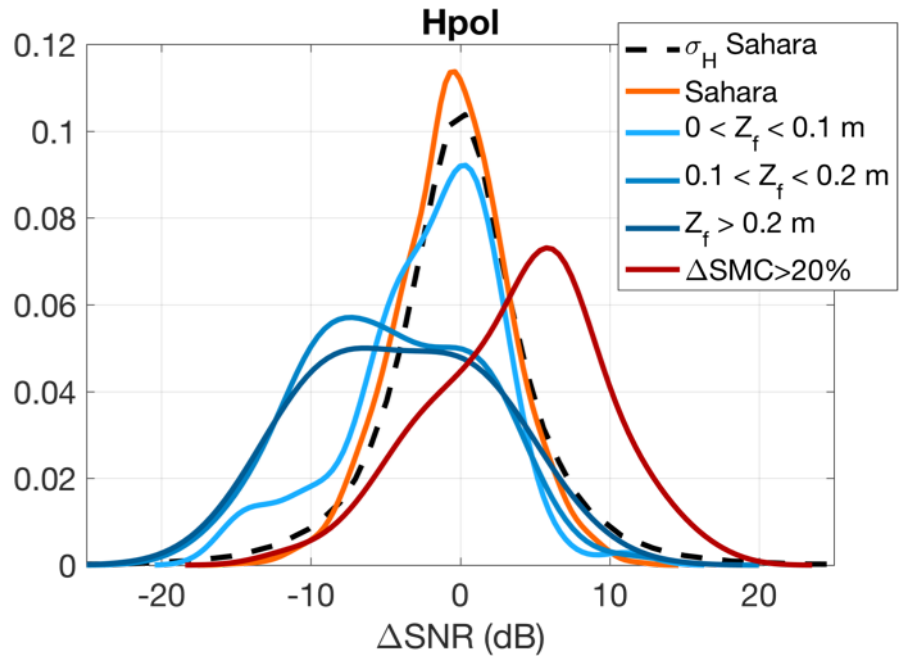
Winter: Dec, Jan, Feb 2015/2016




Sep 25, 2015
Apr 11, 2016
58° N
57° N
56° N
55° N
54° N
75° W
74° W
73° W
72° W
20
15
10
5
0
SNR$_{LHCP}$ (dB)
15
10
5
0
-5
-10
-15
ΔSNR$_{LHCP}$ (dB)
53.5
54
54.5
55
55.5
56
56.5
57
57.5
58
Latitude
Observed
Modeled, Soil moisture only
Modeled, Freezing lakes only

Changes of collocated reflections over time





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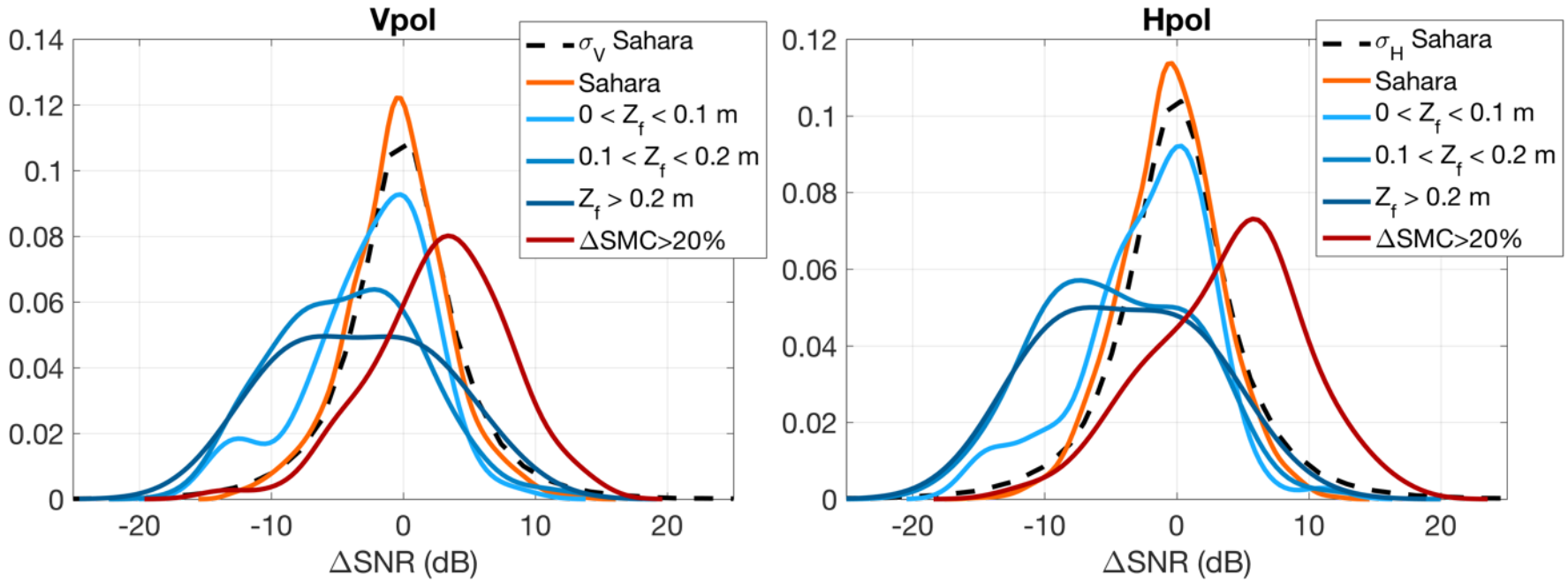
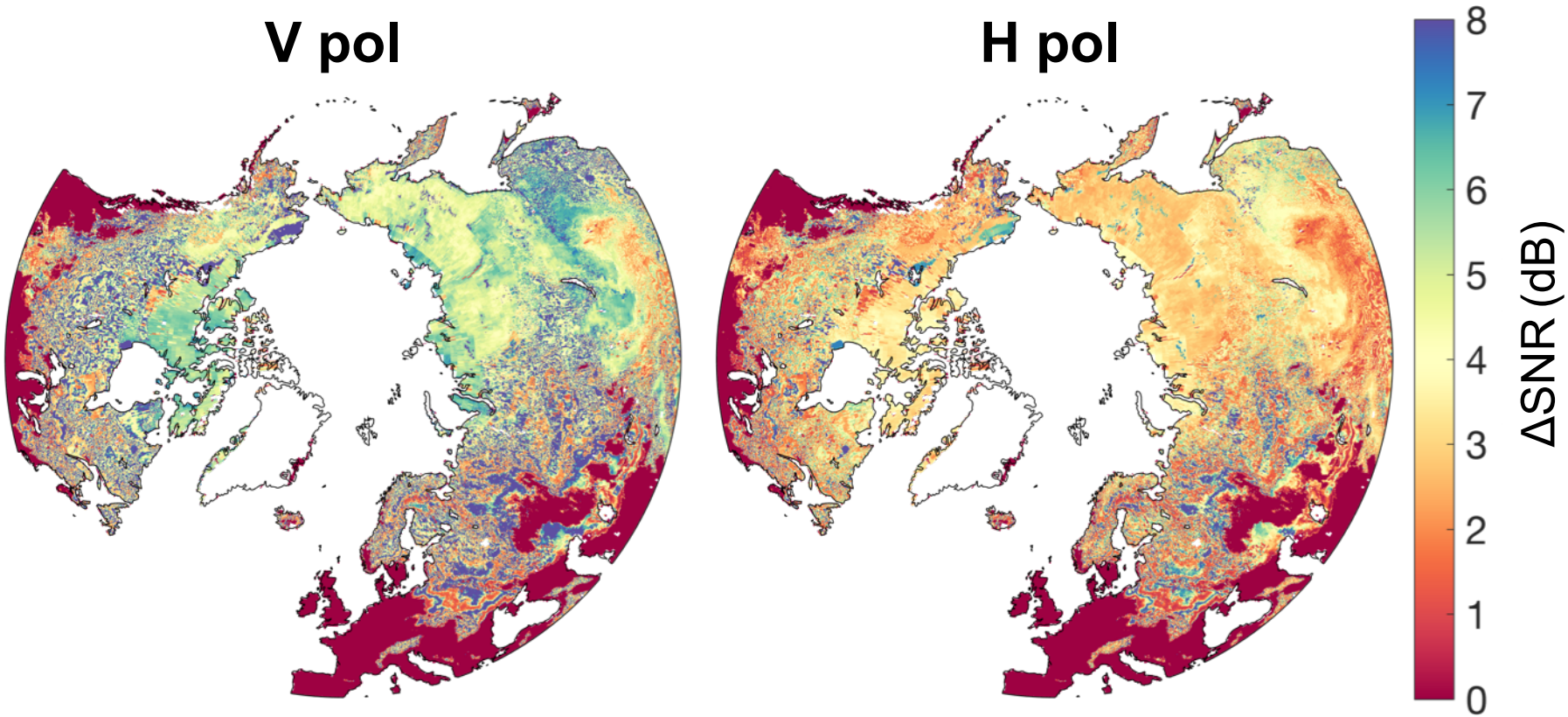
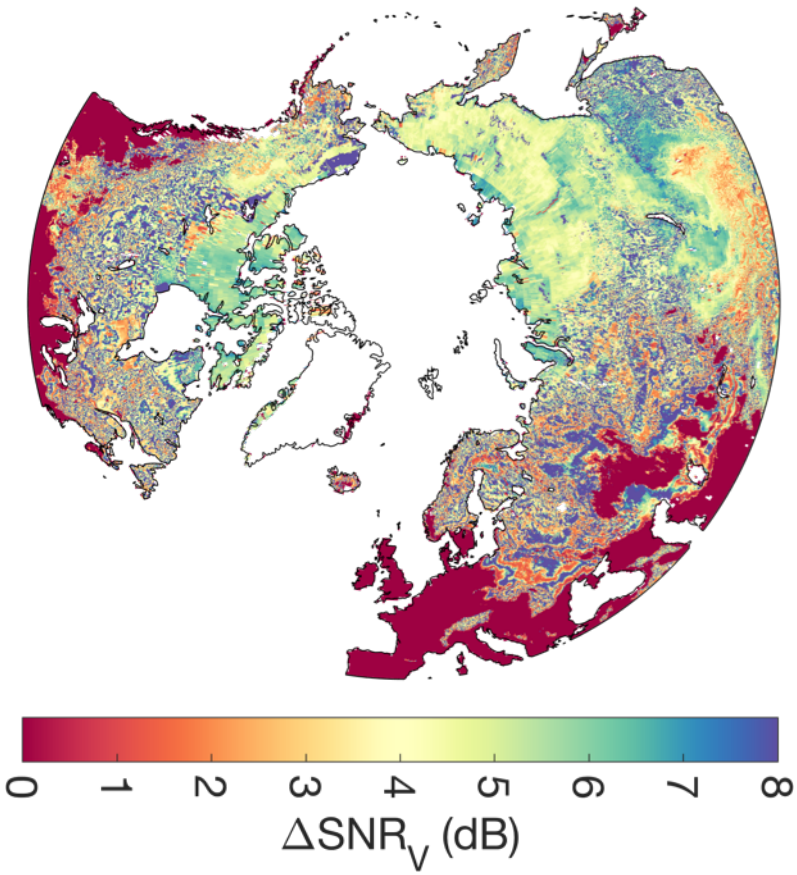
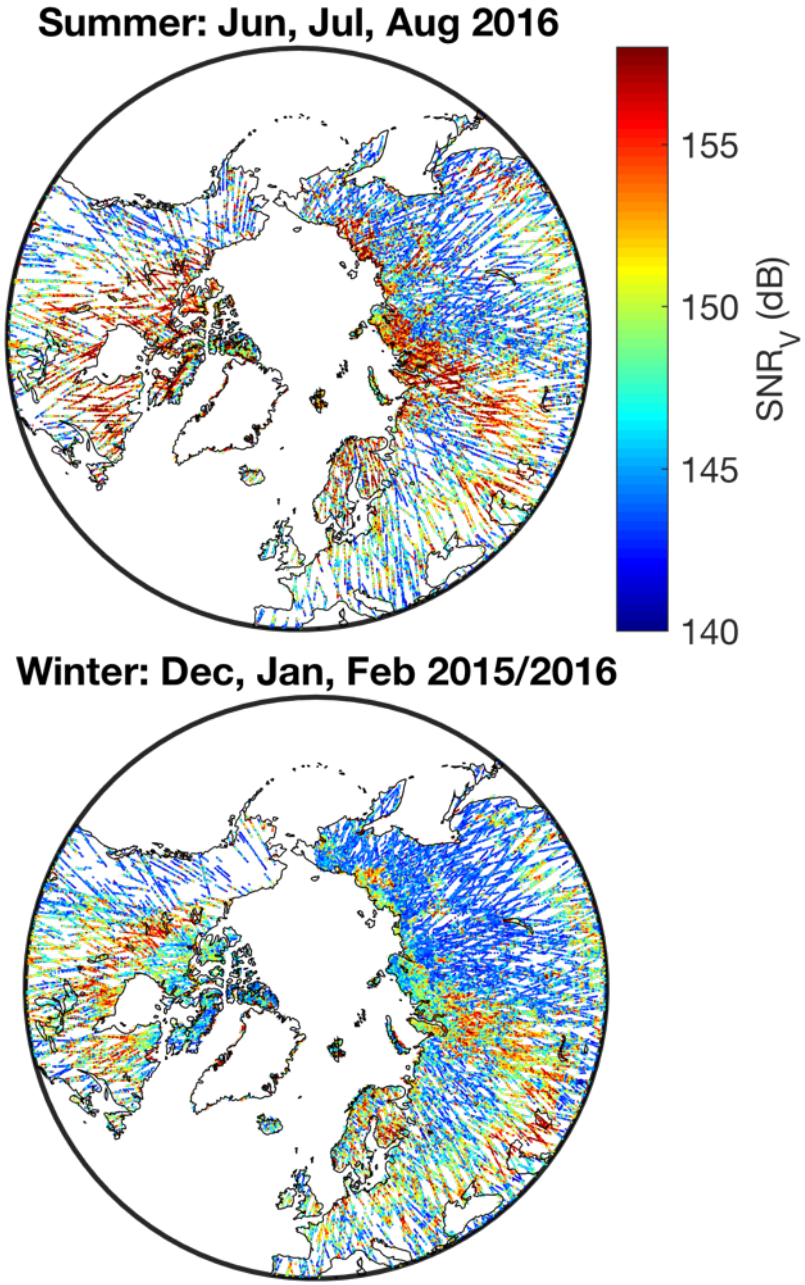


Modeled changes due to F/T




0
1
2
3
4
5
6
7
8
ΔSNR_V (dB)


Summer: Jun, Jul, Aug 2016
155
150
145
140
SNR_V (dB)
Winter: Dec, Jan, Feb 2015/2016

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