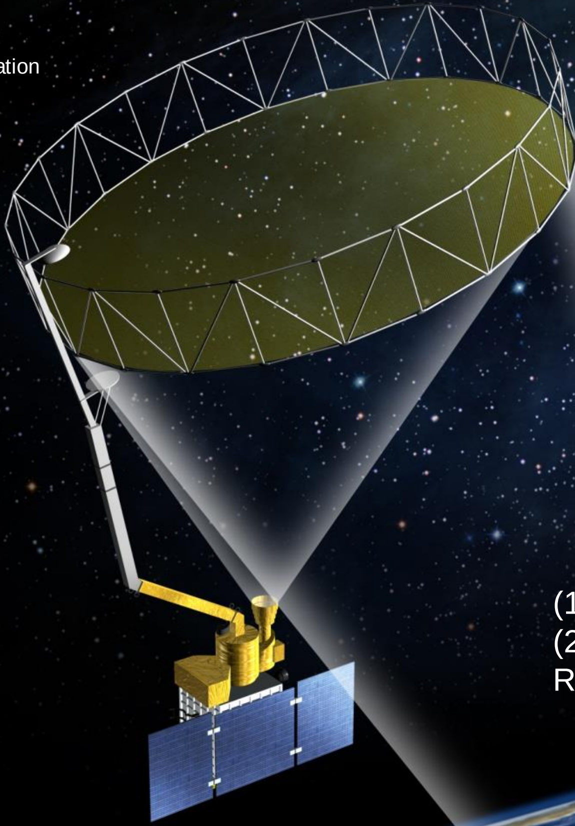
Soil Moisture Active Passive Mission

SMAP



SMAP: Water Contamination Correction

Julian Chaubell[1], S. Yueh[1], S. Chan[1], J. Peng[2]

(1) Jet Propulsion Laboratory, California Institute of Technology.
(2) Goddard Space Flight Center and Universities Space Research Association

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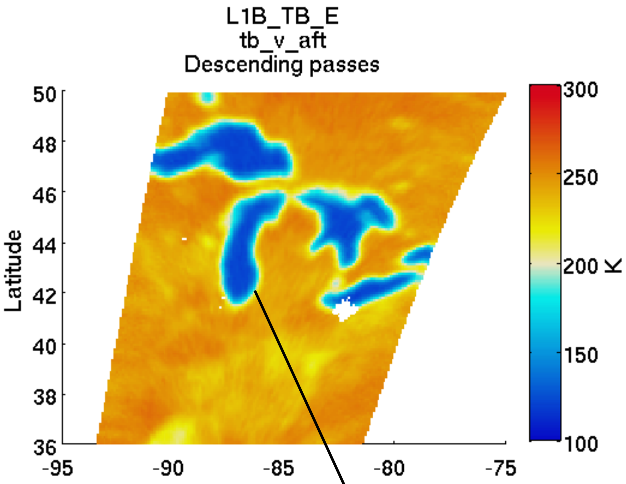
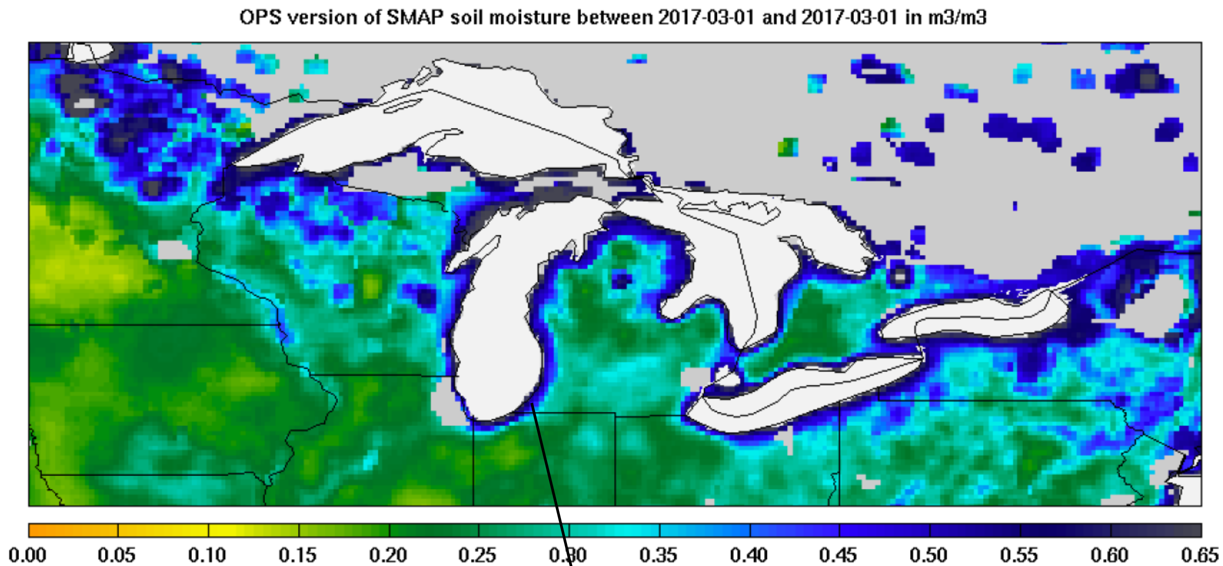
Outline

- Motivation
- Overview of the applied theory for L1B_TB product and L1B_TB_E
- Simulated examples and results
- Application to real data and results
- Preliminary SM examples
- Future work

Motivation

- SMAP radiometer footprints over land can cover water from open water bodies or near coastlines
- Emission by water integrated along with emission by land, leading to underestimated TB
- Underestimated TB leads to wet bias in soil moisture retrieval





Underestimated TB

Overestimated SM

Water Contamination Correction Implementation

– If footprint is on land we apply the formula:

$$TB_p^{land} = \frac{TB_p - f * \overline{TB}_p^{water}}{1-f}$$

$$p = v \ or \ h$$

– If footprint is on water we apply the formula:

$$TB_p^{water} = \frac{TB_p - (1-f) * \overline{TB}_p^{land}}{f}$$

where *f* is the water fraction. *f*=1 in pure water and *f*=0 for pure land.

$$f = \int G.M d\Omega = \int_{\theta=[0,\pi],\psi=[0,2\pi]} G(\theta,\psi)\, M(\theta,\psi) \sin\theta \ \ d\theta d\psi$$

$$\cong \int_{\theta=[0,10*\pi/180],\psi=[0,2\pi]} G(\theta,\psi) M \sin\theta \ \ d\theta d\psi$$

Implementation (continuation)

- M is the land mask defined over 1Km EASE2 grid.

- $\overline{TB}_p^{water}$ is the TB at boresight over water computed from ocean TB model using ancillary files.

- $\overline{TB}_p^{land}$ is the TB at boresight over land computed from land TB model using ancillary files.

L1B_TB_E Implementation

– If grid point is on land we apply the formula:

$$TB_p^{land} = \frac{TB_p - f * \overline{TB}_p^{water}}{1 - f}$$

$$p = v \text{ or } h$$

– If grid point is on water we apply the formula:

$$TB_p^{water} = \frac{TB_p - (1 - f) * \overline{TB}_p^{land}}{f}$$

where *f* is the water fraction. *f*=1 in pure water and *f*=0 for pure land.

$$f = \sum_{i=1}^{6} a_i f_i$$ where a_i are the Backus Gilbert coefficients.

L1B_TB_E Implementation (continuation)

$$f_i = \int G.\,M d\Omega = \int_{\theta=[0,\pi],\psi=[0,2\pi]} G(\theta,\psi)\, M(\theta,\psi) \sin\theta \;\, d\theta d\psi$$

$$\cong \int_{\theta=[0,10*\pi/180],\psi=[0,2\pi]} G(\theta,\psi) M \sin\theta \;\, d\theta d\psi$$

Simulation

TB= $\int G.tbd\Omega = \int_{\theta=[0,\pi],\psi=[0,2\pi]} G(\theta,\psi)\, tb(\theta,\psi) \sin\theta \; d\theta d\psi \;\cong$

$\int_{\theta=[0,10*\pi/180],\psi=[0,2\pi]} G(\theta,\psi) tb(\theta,\psi) \sin\theta \; d\theta d\psi$

- Dielectric constant (ε) over ocean is generated by using Klein and Swift model.
- Dielectric constant (ε) over land is generated by using Mironov model.

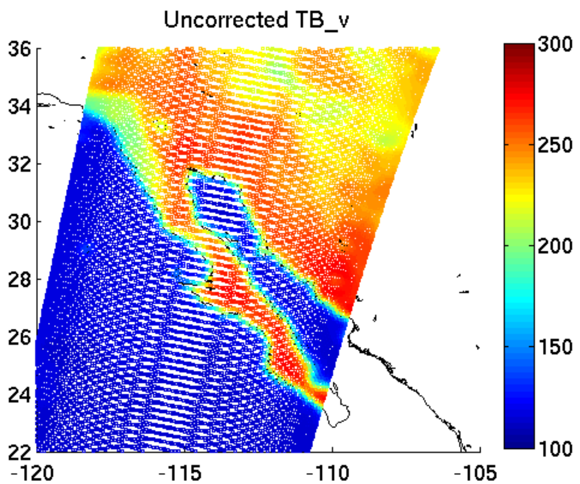
- $R_{vv} = \frac{\varepsilon \;\cos\theta - \sqrt{\varepsilon - \sin\theta^2}}{\varepsilon \;\cos\theta + \sqrt{\varepsilon - \sin\theta^2}}$

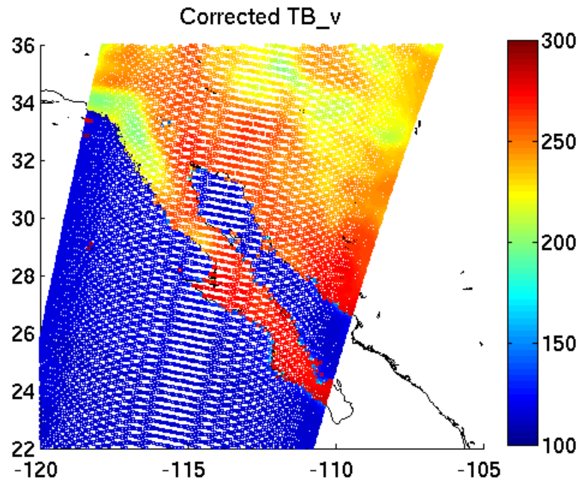
- $R_{hh} = \frac{\cos\theta - \sqrt{\varepsilon - \sin\theta^2}}{\cos\theta + \sqrt{\varepsilon - \sin\theta^2}}$

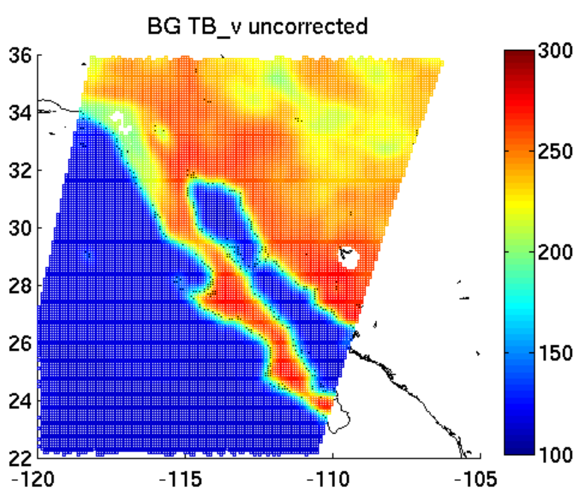
- TB over ocean is computed using model. Takes into account wind, SST, and SSS.
- TB over land is computed using plane surface model.

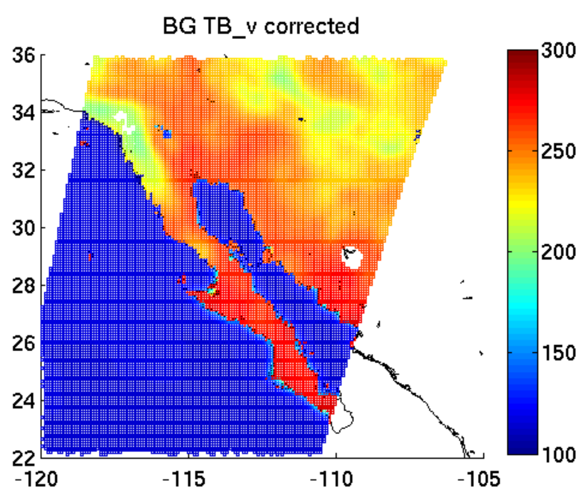
$$tb = (1 - |R|^2)Ts$$

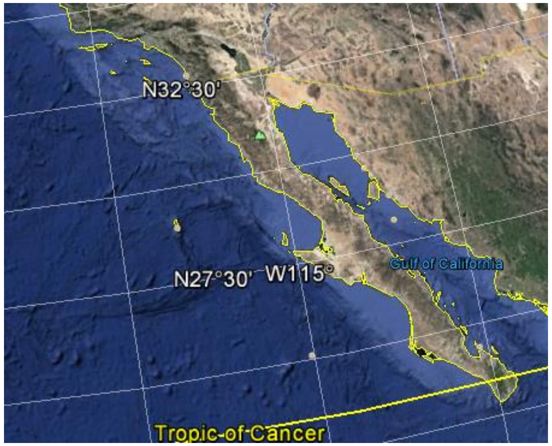
Results over Land



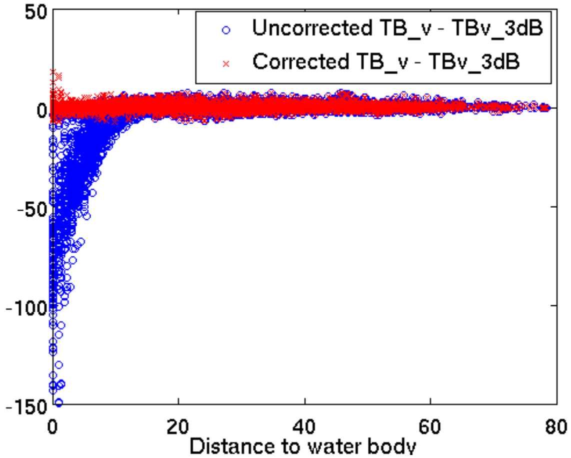




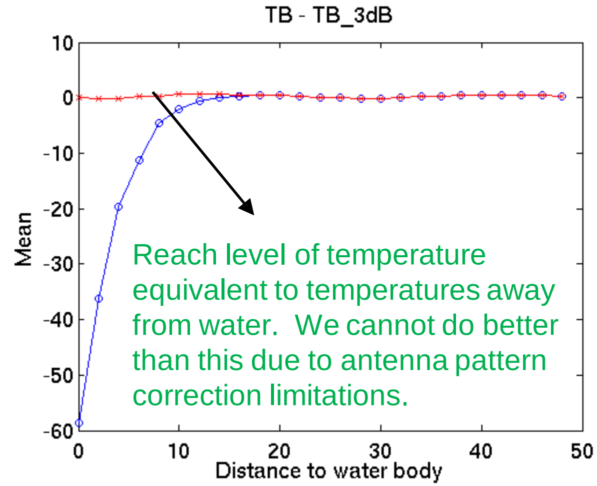




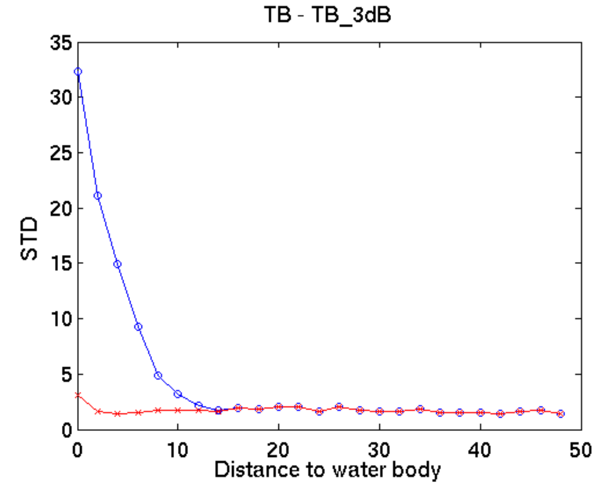
Statistics



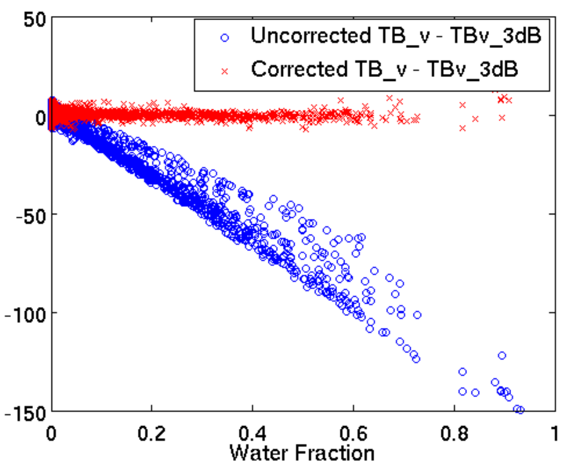
Uncorrected TB_v - TBv_3dB
Corrected TB_v - TBv_3dB
50
0
-50
-100
-150
0
20
40
60
80
Distance to water body



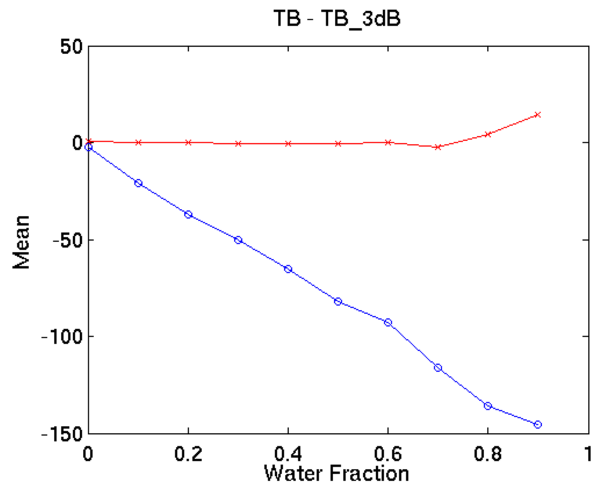
TB - TB_3dB
Mean
10
0
-10
-20
-30
-40
-50
-60
0
10
20
30
40
50
Distance to water body
Reach level of temperature equivalent to temperatures away from water. We cannot do better than this due to antenna pattern correction limitations.



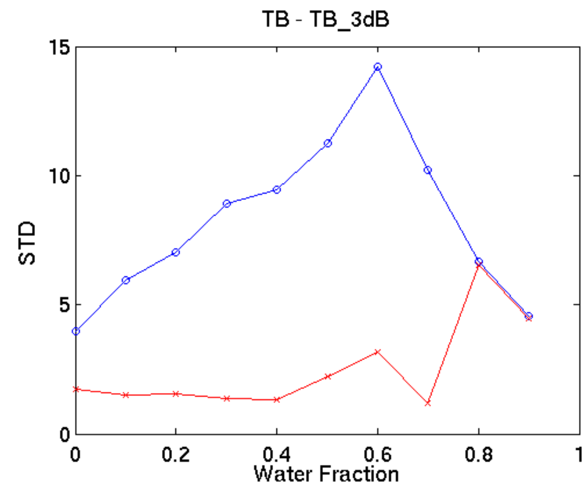
TB - TB_3dB
STD
35
30
25
20
15
10
5
0
0
10
20
30
40
50
Distance to water body



Uncorrected TB_v - TBv_3dB
Corrected TB_v - TBv_3dB
50
0
-50
-100
-150
0
0.2
0.4
0.6
0.8
1
Water Fraction

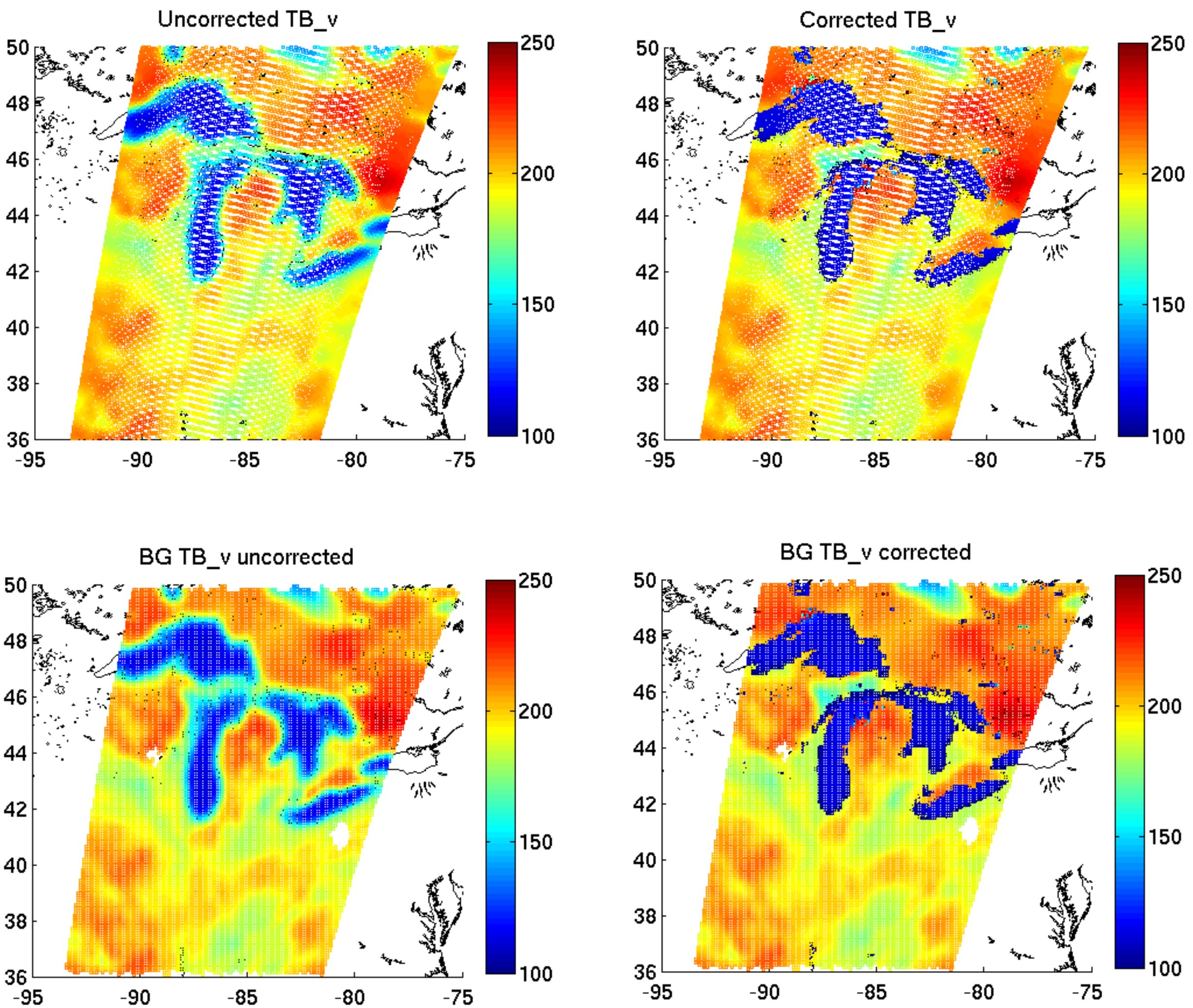


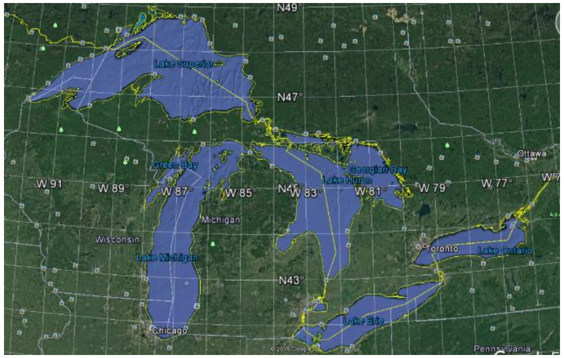
TB - TB_3dB
Mean
50
0
-50
-100
-150
0
0.2
0.4
0.6
0.8
1
Water Fraction



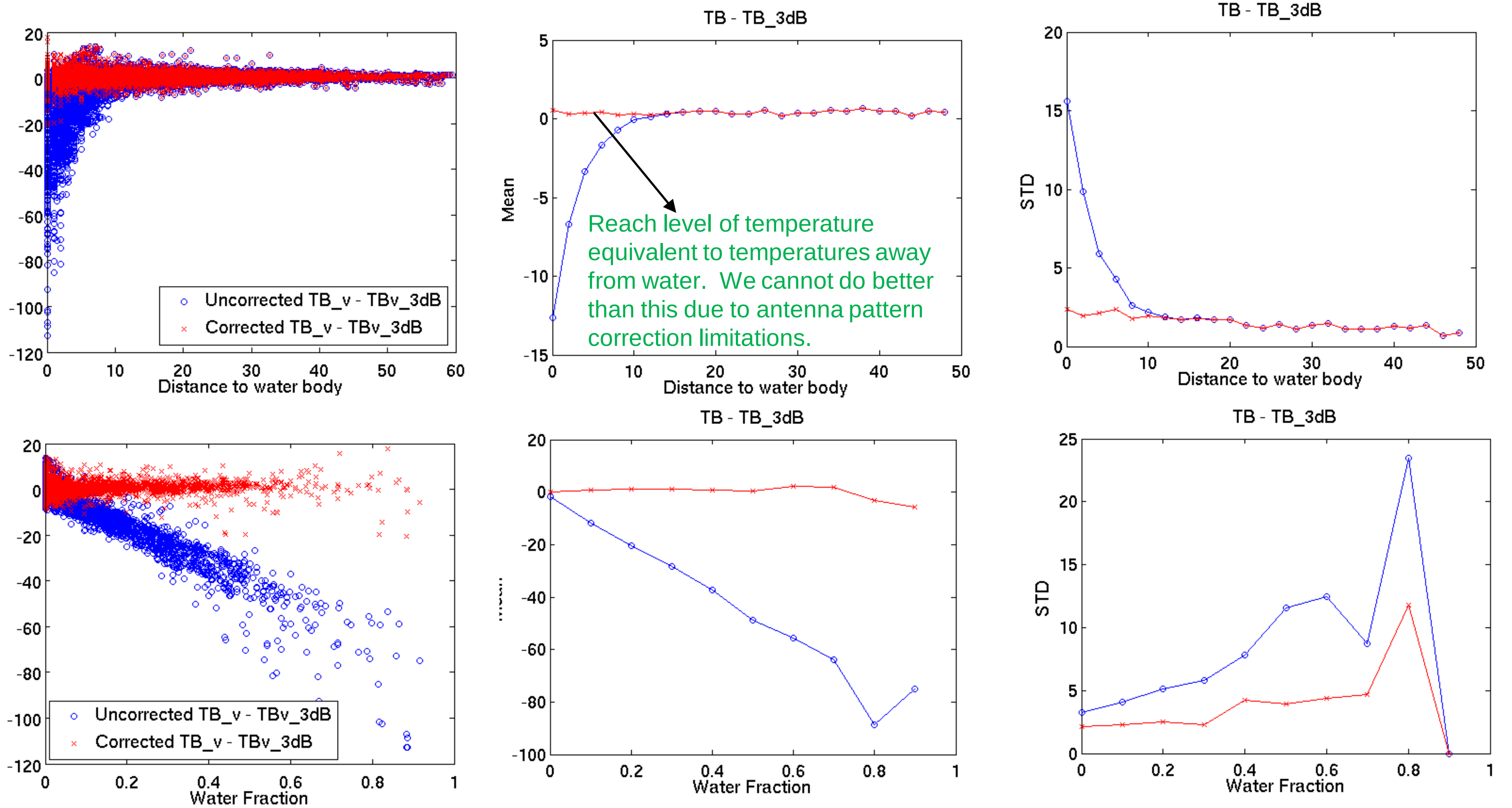
TB - TB_3dB
STD
15
10
5
0
0
0.2
0.4
0.6
0.8
1
Water Fraction

Results over Land



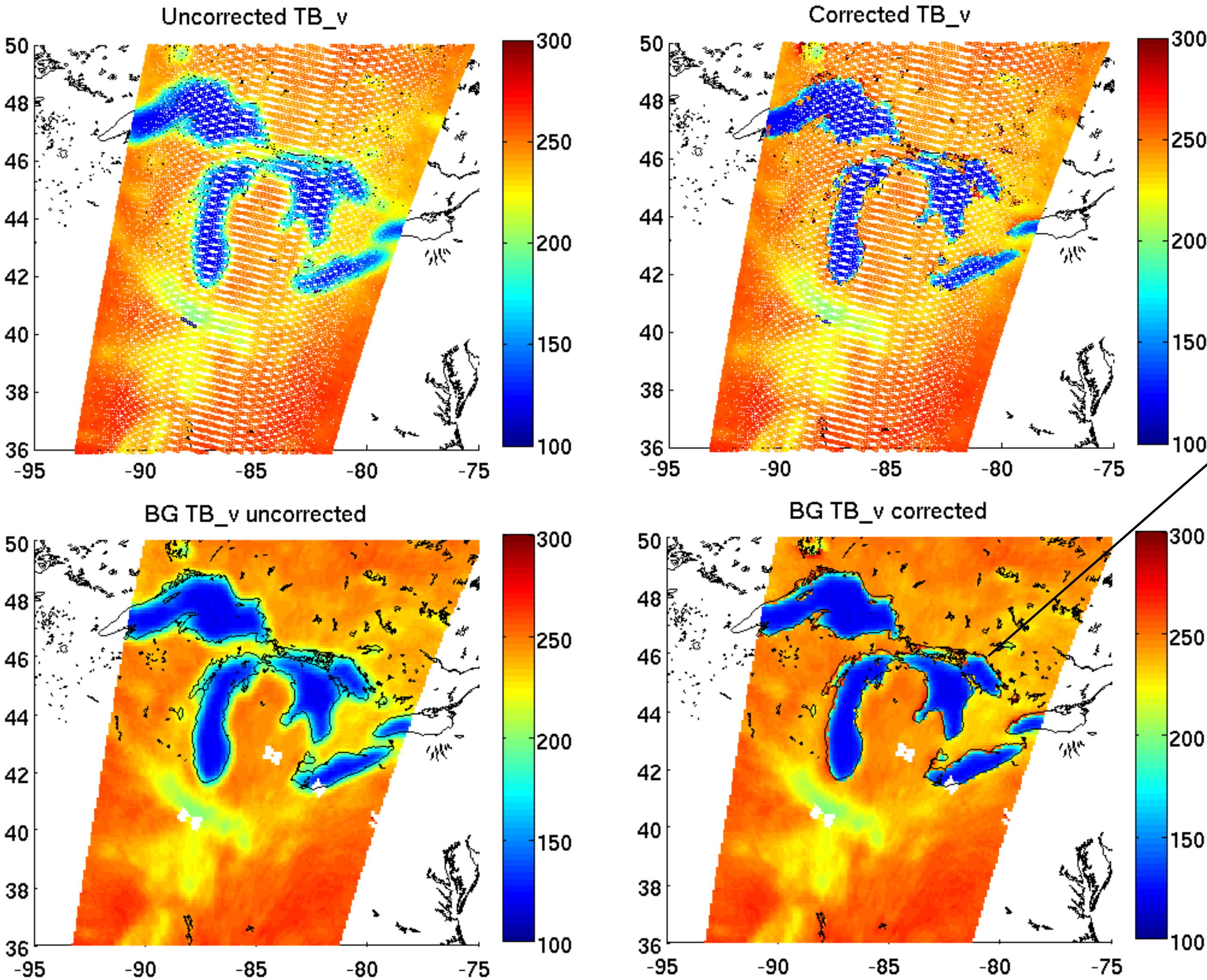


Statistics



Uncorrected TB_v - TBv_3dB
Corrected TB_v - TBv_3dB
Distance to water body
TB - TB_3dB
Mean
Reach level of temperature equivalent to temperatures away from water. We cannot do better than this due to antenna pattern correction limitations.
STD
Water Fraction

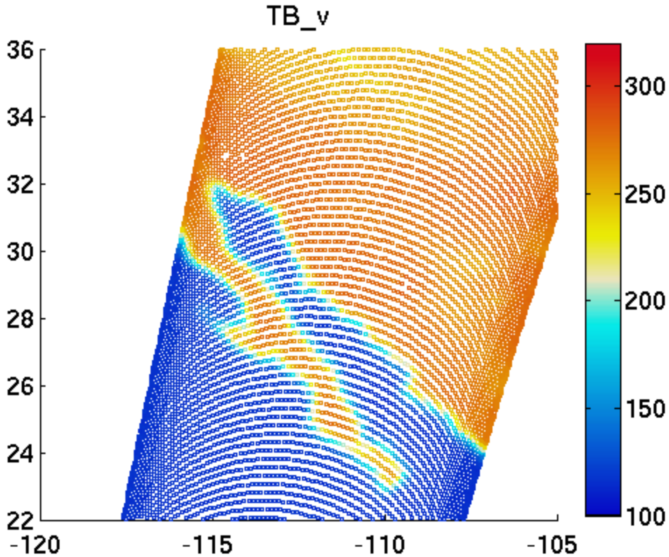
Results from Product

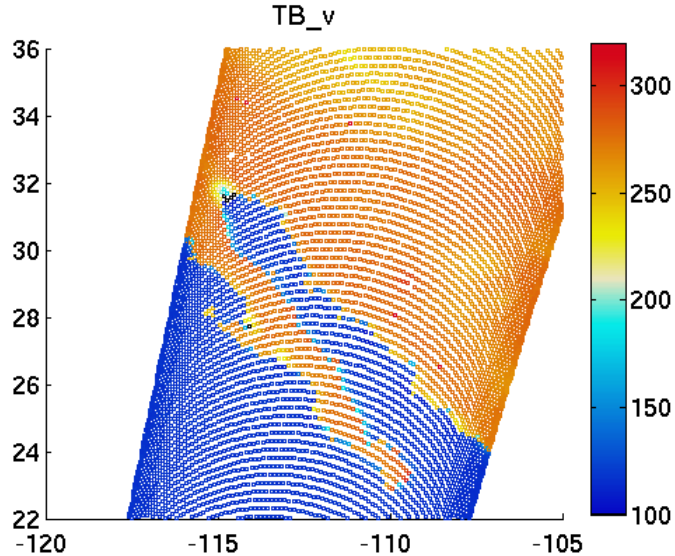


Great Lakes

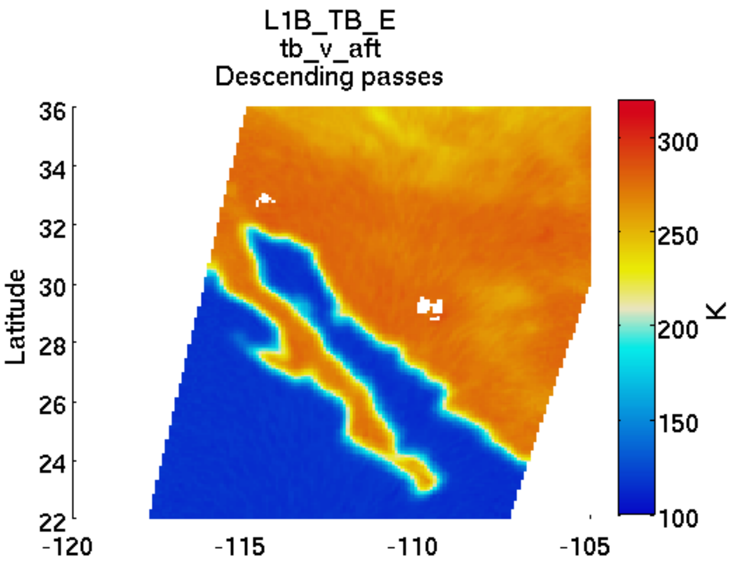
Over estimating water temperature. Bad ancillary data selection.

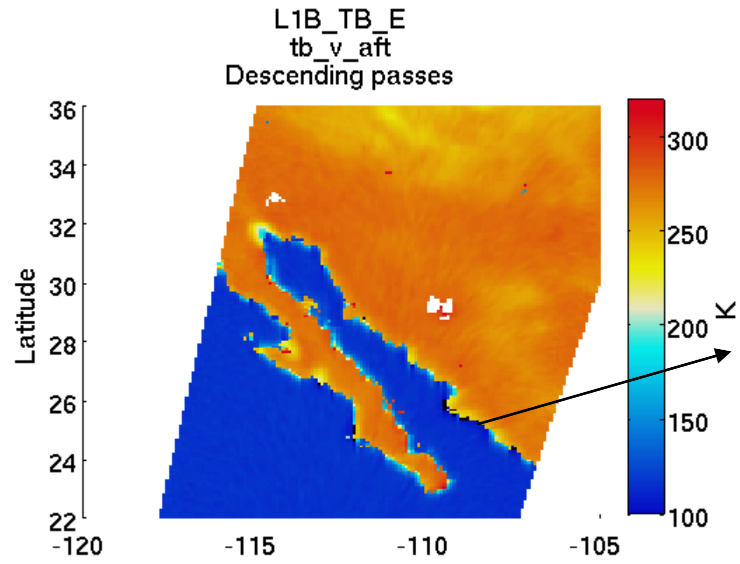
Results from Product





Baja California.





Underestimating ocean TB.
Bad ancillary
Data selection.

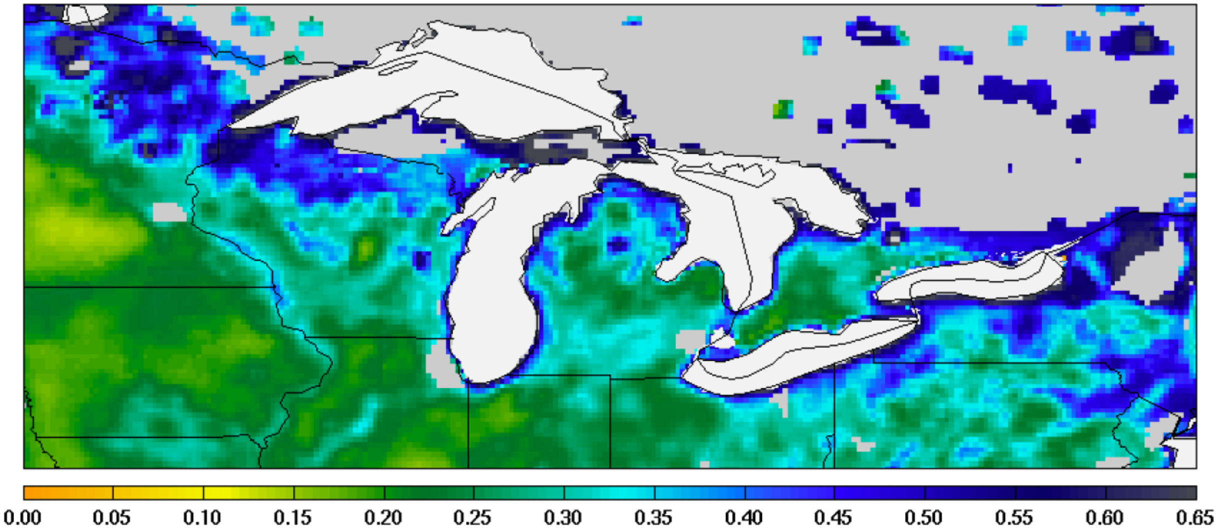
SM Examples

Caveats – Not an exact apple-to-apple comparison:

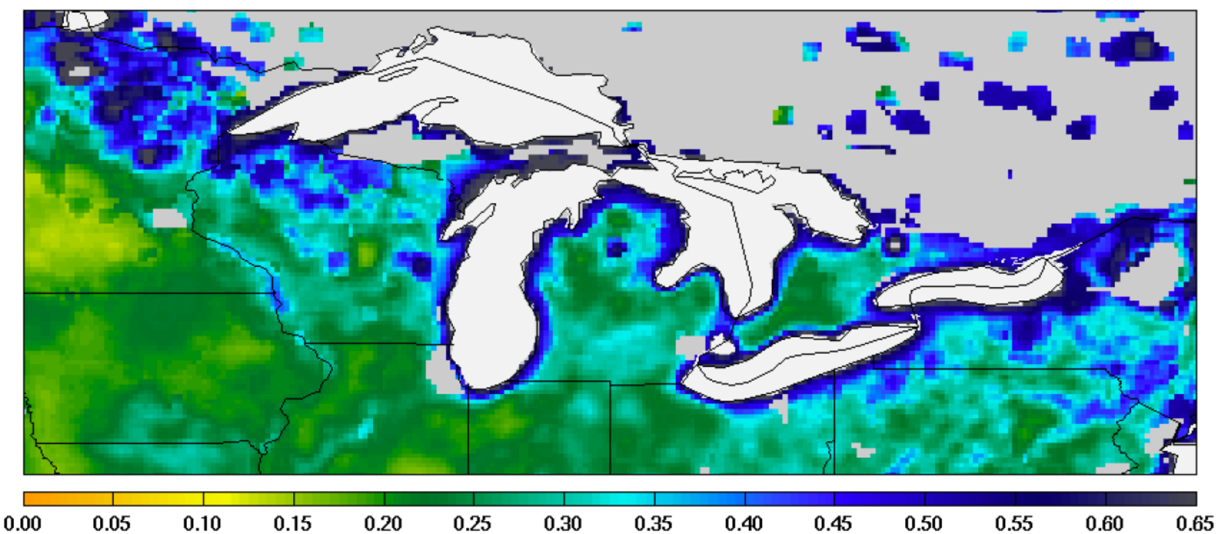
- Baseline passive L2_SM_P_E (**BP**) performs water TB correction only when water fraction is below 0.05. No water TB correction is performed when water fraction is above 0.05.
- Experimental passive L2_SM_P_E (**XP**) does not perform water TB correction. Water TB correction is done in L1B_TB and L1B_TB_E and then followed by L1C_TB_E processing. Water TB correction is performed as long as water fraction is not 1.00, which is an ambitious (and error-prone) scheme.

Example 1: The Great Lakes

OAS version of SMAP soil moisture between 2017-03-01 and 2017-03-01 in m3/m3



OPS version of SMAP soil moisture between 2017-03-01 and 2017-03-01 in m3/m3

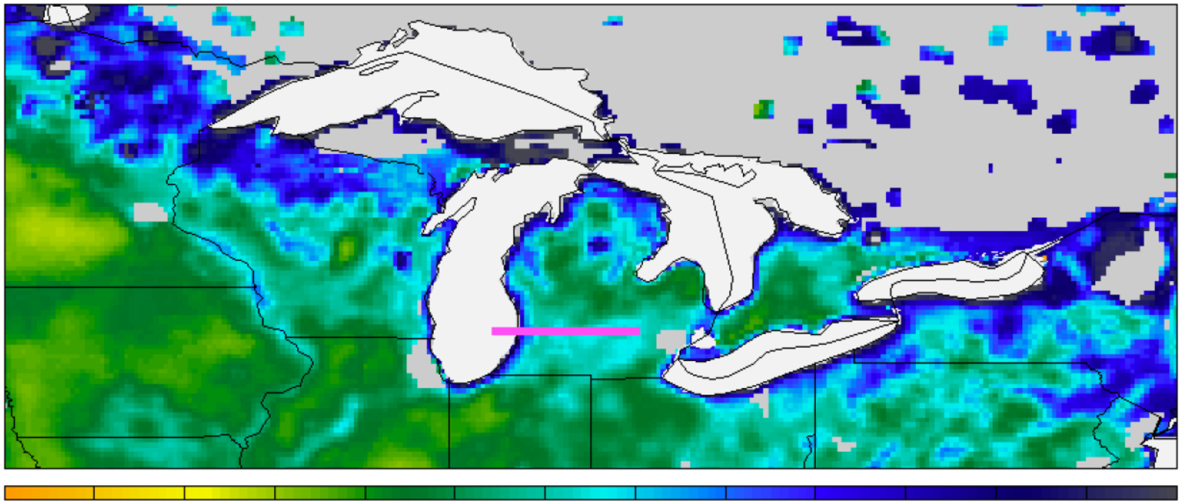


Observations:

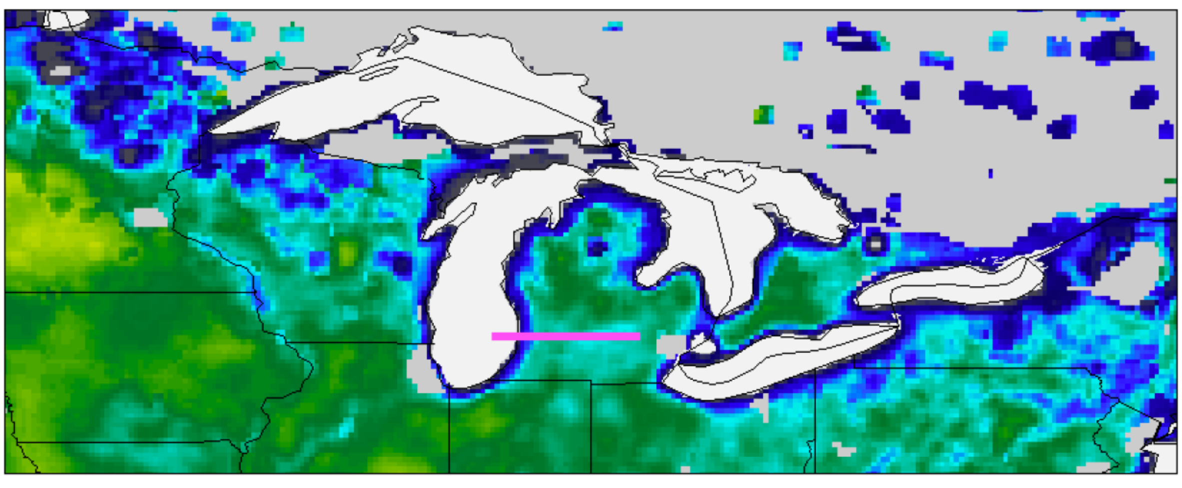
- Narrower near-saturation soil moisture bands around open water bodies (OWB) in XP intuitively more reasonable than BP.
- Harder to interpret their relative merits elsewhere in the absence of ground truth – is XP over-correcting or BP under-correcting?
- BP and XP converge wherever water fraction is zero (i.e., no water TB correction performed).

Example 1: The Great Lakes

OAS version of SMAP soil moisture between 2017-03-01 and 2017-03-01 in m3/m3



OPS version of SMAP soil moisture between 2017-03-01 and 2017-03-01 in m3/m3



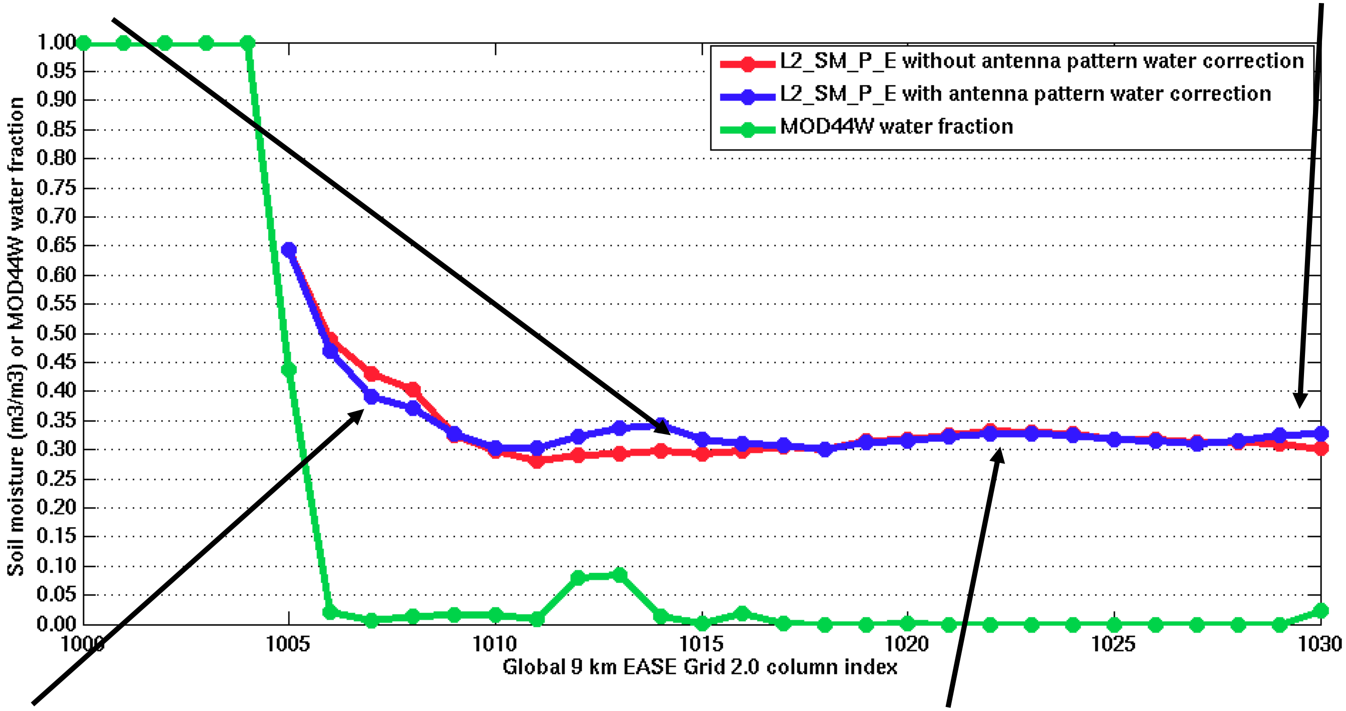
Observations:

- Compare a transect (magenta line) near Lake Michigan between XP and BP.
- Transect covers a wide range of static water fraction.
- BP attempts water TB correction only when water fraction is below 0.05.
- XP attempts water TB correction as long as water fraction is not 1.00, which is an ambitious (and error-prone) correction scheme.
- BP and XP converge wherever water fraction is zero (i.e., no water TB correction performed).

Example 1: The Great Lakes

Inconclusive: At water fraction above 0.05, BP does not attempt water TB correction but XP does. However, XP should result in lower soil moisture than BP but it does not.

Inconclusive: Both XP and BP perform water TB correction when water fraction is below 0.05. Impossible to indicate which one is more accurate without *in situ* data.

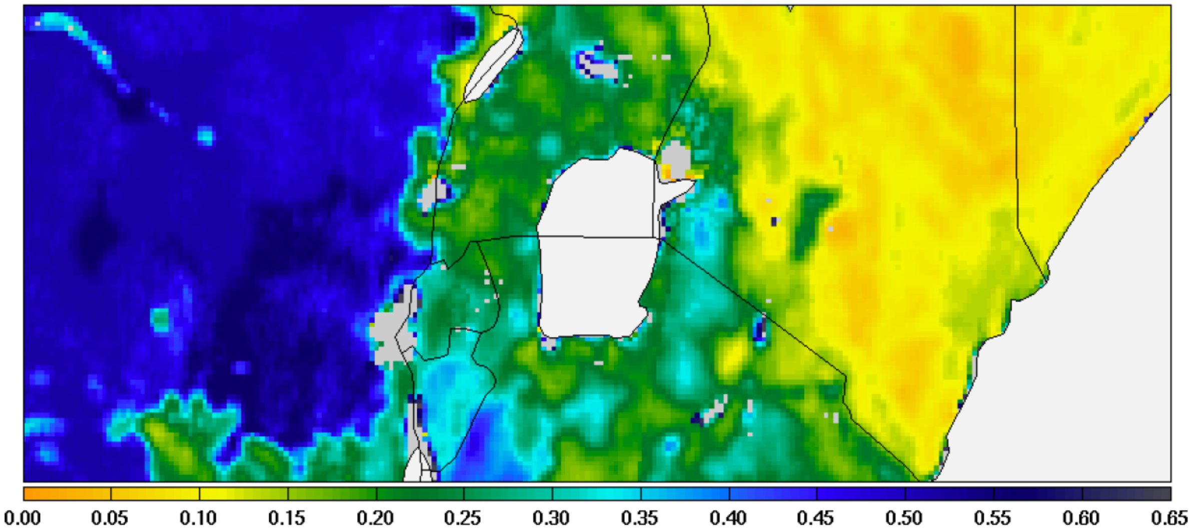


Good: XP seeps less into land from OWB compared with BP.

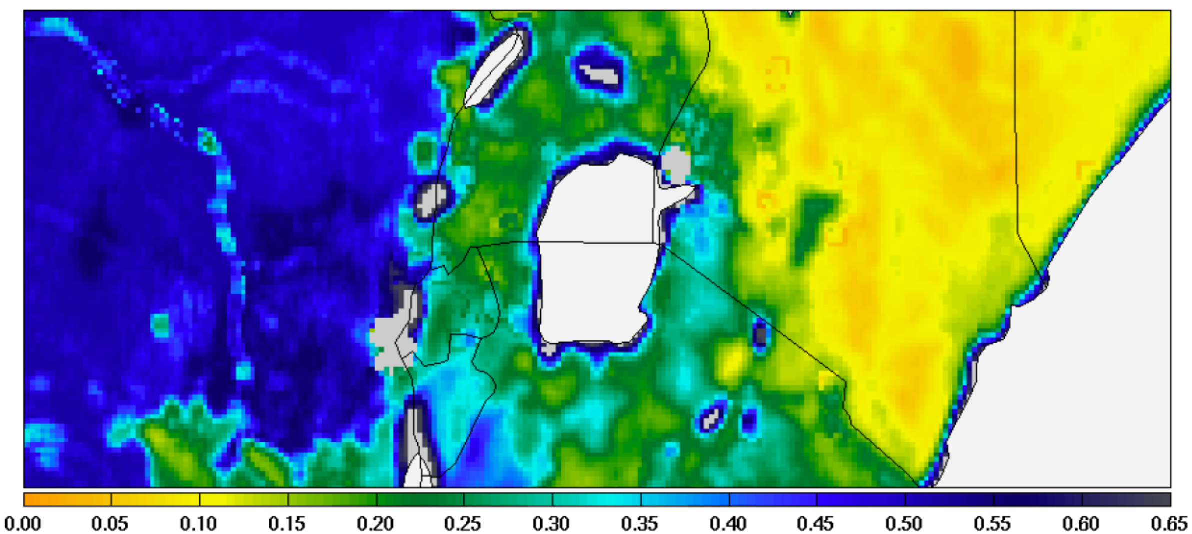
Good: XP and BP converge as expected wherever water fraction is zero

Example 2: Lake Victoria

OAS version of SMAP soil moisture between 2017-03-01 and 2017-03-01 in m3/m3



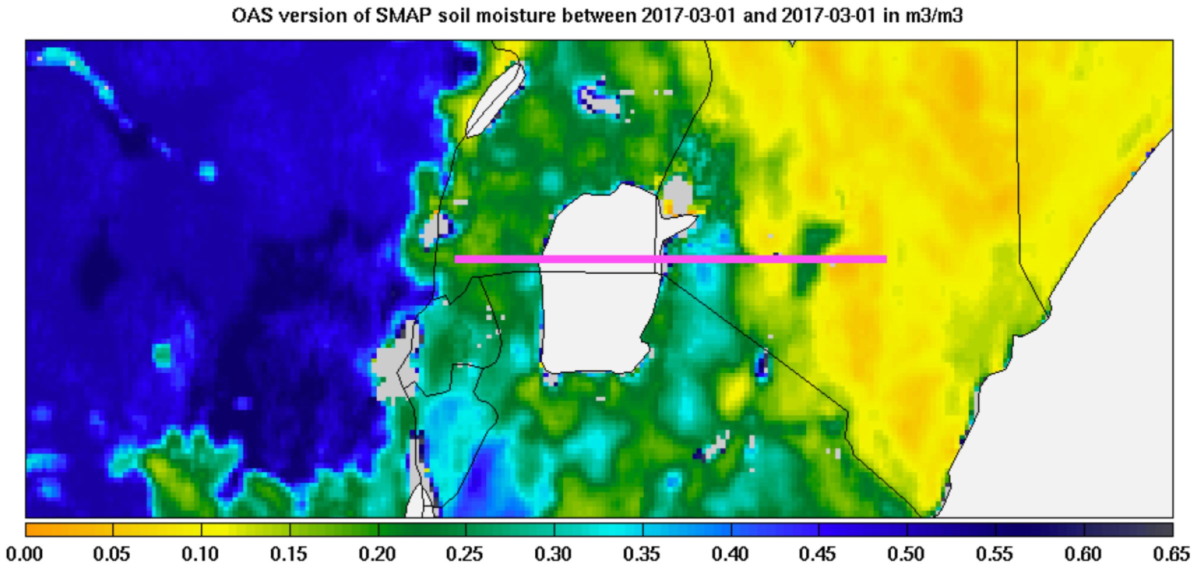
OPS version of SMAP soil moisture between 2017-03-01 and 2017-03-01 in m3/m3

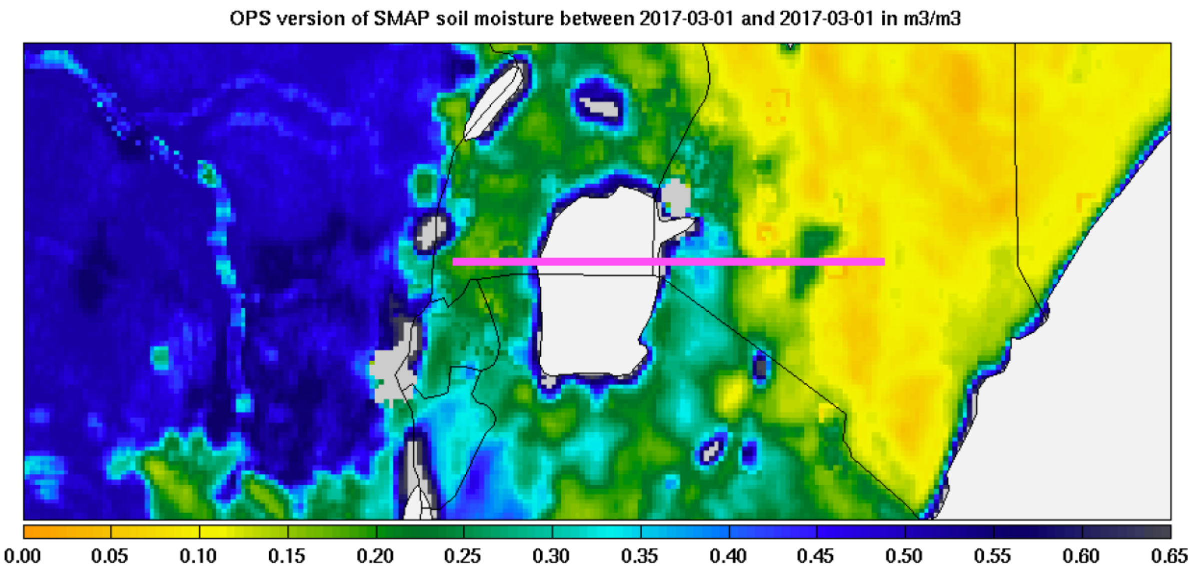


Observations:

- Non-existent near-saturation soil moisture bands around OWB and coastlines in XP visually more pleasing than BP.
- Forest right-hand boundaries better defined in XP than in BP. Real features?
- Forest retrievals in XP and BP hard to interpret. It is likely that BP is over-correcting TB and XP is about right.
- BP's occasional water TB over-correction (dashed circles) addressed quite well in XP.
- BP and XP converge wherever water fraction is zero (i.e., no water TB correction performed).

Example 2: Lake Victoria





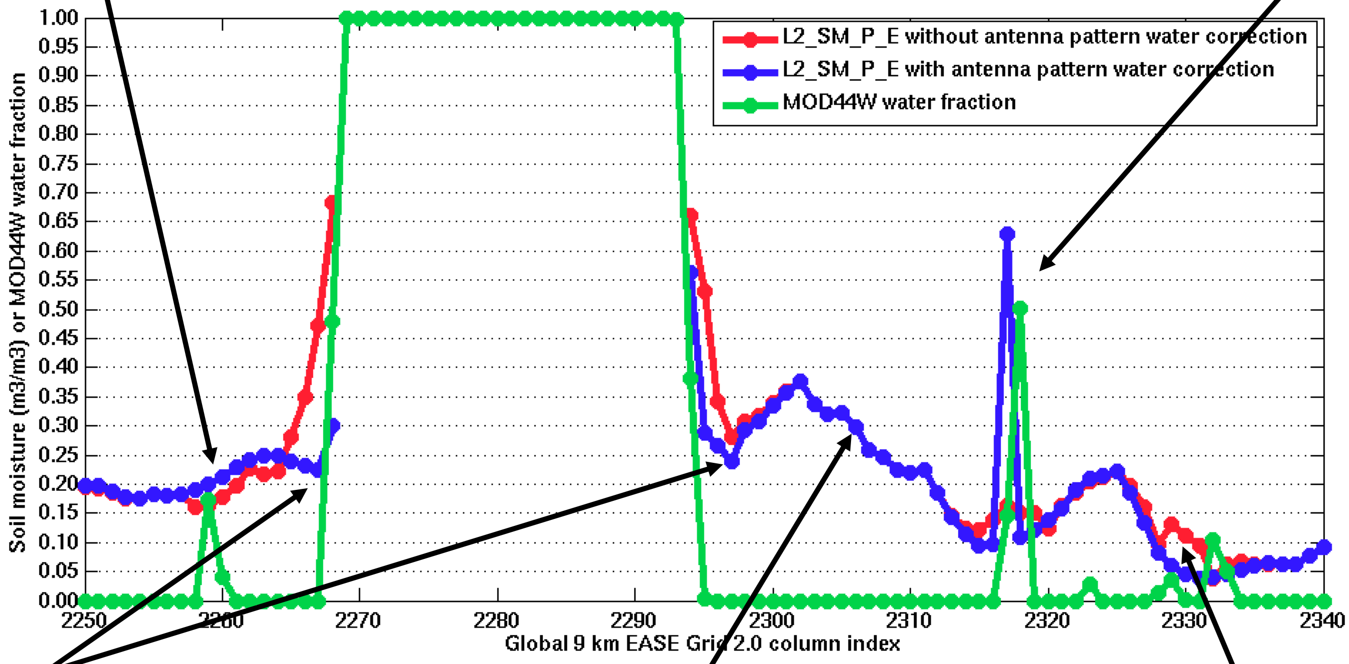
Observations:

- Compare a transect (magenta line) across Lake Victoria between XP and BP.
- Transect covers a wide range of static water fraction.
- BP attempts water TB correction only when water fraction is below 0.05.
- XP attempts water TB correction as long as water fraction is not 1.00, which is an ambitious (and error-prone) correction scheme.
- BP and XP converge wherever water fraction is zero (i.e., no water TB correction performed).

Example 2: Lake Victoria

Inconclusive: At water fraction above 0.05, BP does not attempt water TB correction but XP does. However, XP should result in lower soil moisture than BP but it does not.

Note: Point on water. The code tries to correct for land contamination.



Good: XP seeps less into land from OWB compared with BP.

Good: XP and BP converge as expected wherever water fraction is zero

Good: BP's occasional water TB over-correction (dashed circles) addressed quite well in XP.

Observations:

- XP offers a few noticeable improvements over BP:
  - Seeps less into land from open water bodies (OWB) and coastlines
  - Addresses BP’s occasional water TB over-correction over land (and perhaps dense forests too)
- There are also uncertain behaviors associated with XP:
  - Produces wetter soil moisture than BP even when BP is not doing any water TB correction

Next Steps:

- Improve land fraction calculation efficiency.
- Analyze cause of anomalies.
- Improve ancillary data selection.
- Include ice ancillary data and model.
- Acquire *in situ* data for quantitative assessment.