Modeling of Inhomogeneous Surface Properties for the Advanced Technology Microwave Sounder

Thomas J. Kleespies

NOAA/NESDIS

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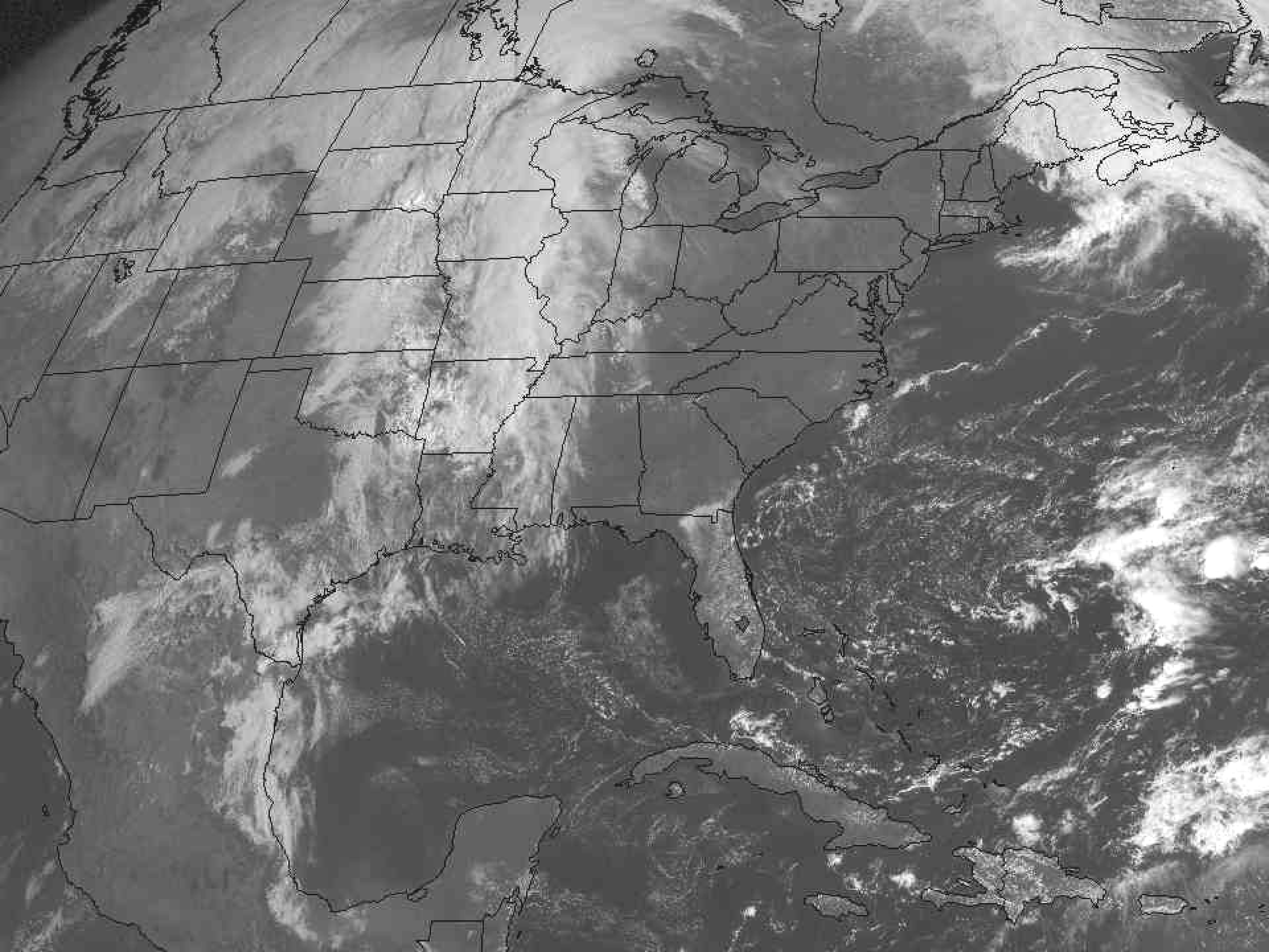
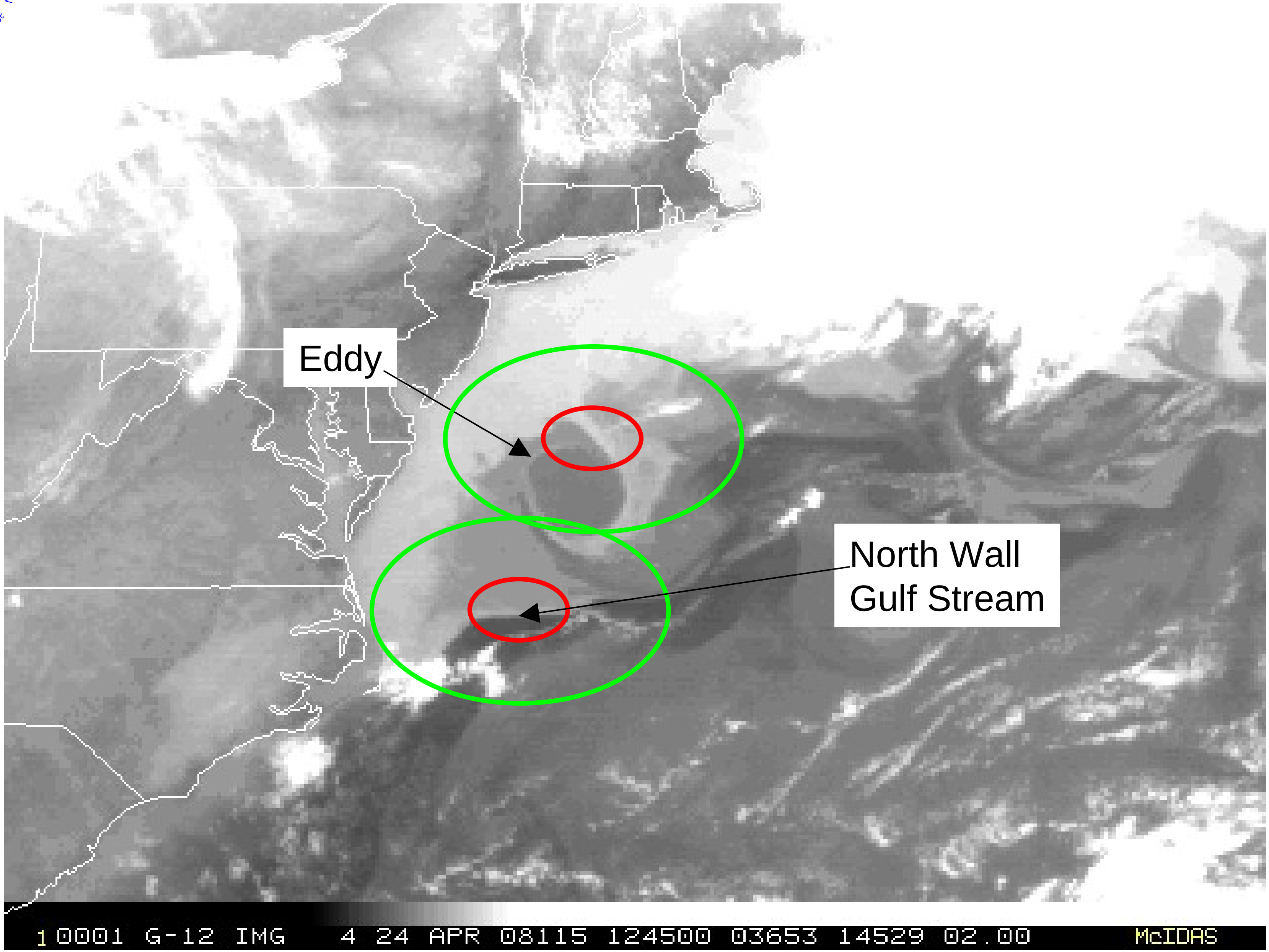
Problem

- Radiative transfer with channels that ‘see’ the surface is problematic because of emissivity and skin temperature uncertainties
- This is especially true of inhomogeneous backgrounds, including coastlines, large rivers, mountainous regions, and even regions of high ocean temperature gradients (e.g. north wall of Gulf Stream).



Inhomogeneous surface over ocean

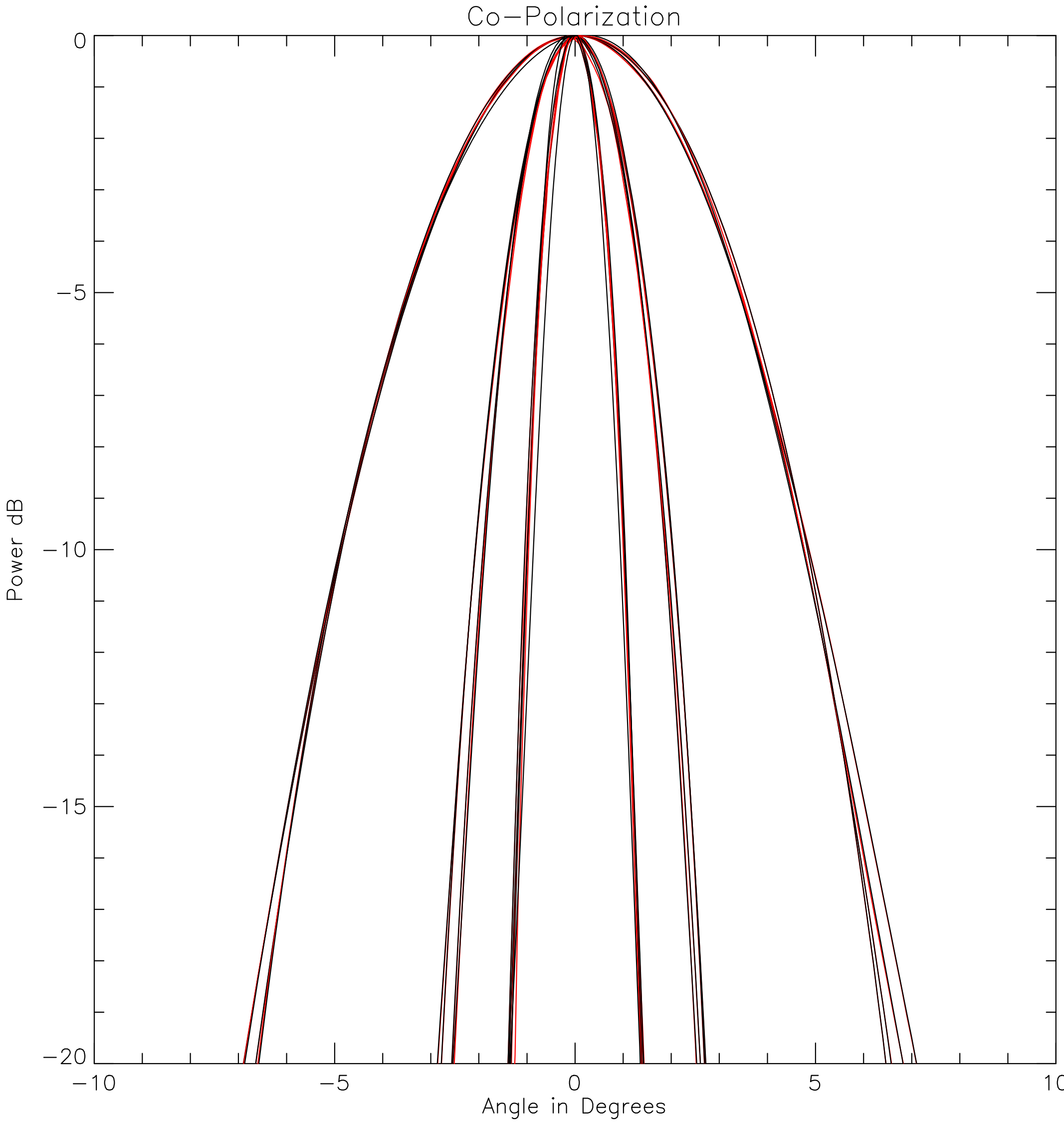


Possible Solution

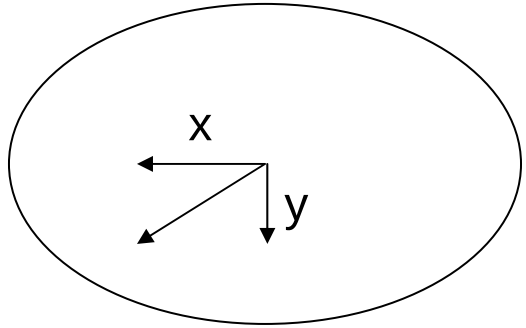
- The ability to integrate high resolution databases within a given field-of-view, and perform multiple radiative transfer within the field of view, weigh that according to the antenna beam power, and integrate.

Normalized antenna patterns by adding (negative) maximum value of each pattern to all values.
(red along track, blue crosstrack)
Got best fit to the eye with a 7th order polynomial
(black solid crosstrack, dashed along track)

50% power is at -3dB
95% power is at -13dB
99% power inside the fov is at -20 dB.



The solid fit line fits almost exactly over the data.
The dashed fit line is almost as good.



50% power has a dB reduction of -10 $\log_{10}$ .50 = -3.01 m=1.0

95% power has a dB reduction of -10 $\log_{10}$ .05 = -13.01 m=2.0

99% power has a dB reduction of -10 $\log_{10}$ .01 = -20.00 m=3.0

$$P_x = C_0 + \sum_{i=1}^{7} C_i x^i$$

Along track power

Right now ignoring the 45º and 135 º slices

$$P_y = D_0 + \sum_{i=1}^{7} D_i y^i$$

Cross track power

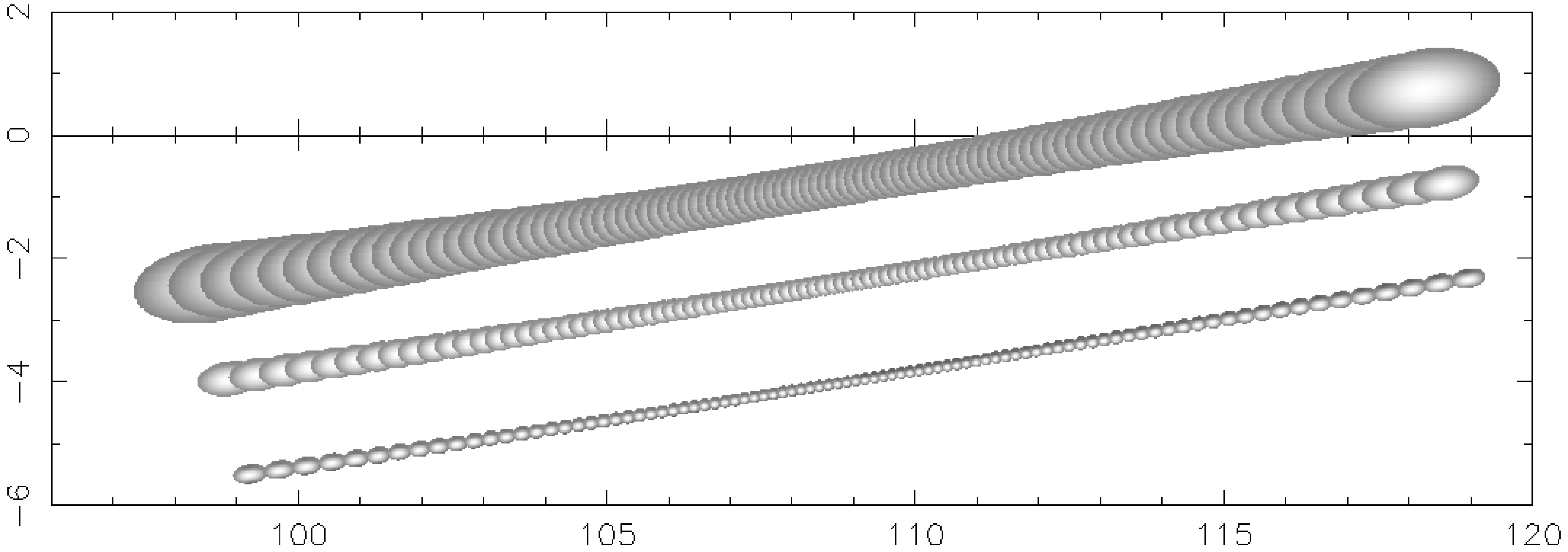
$$P = -\left(P_x + P_y\right)$$

Total power

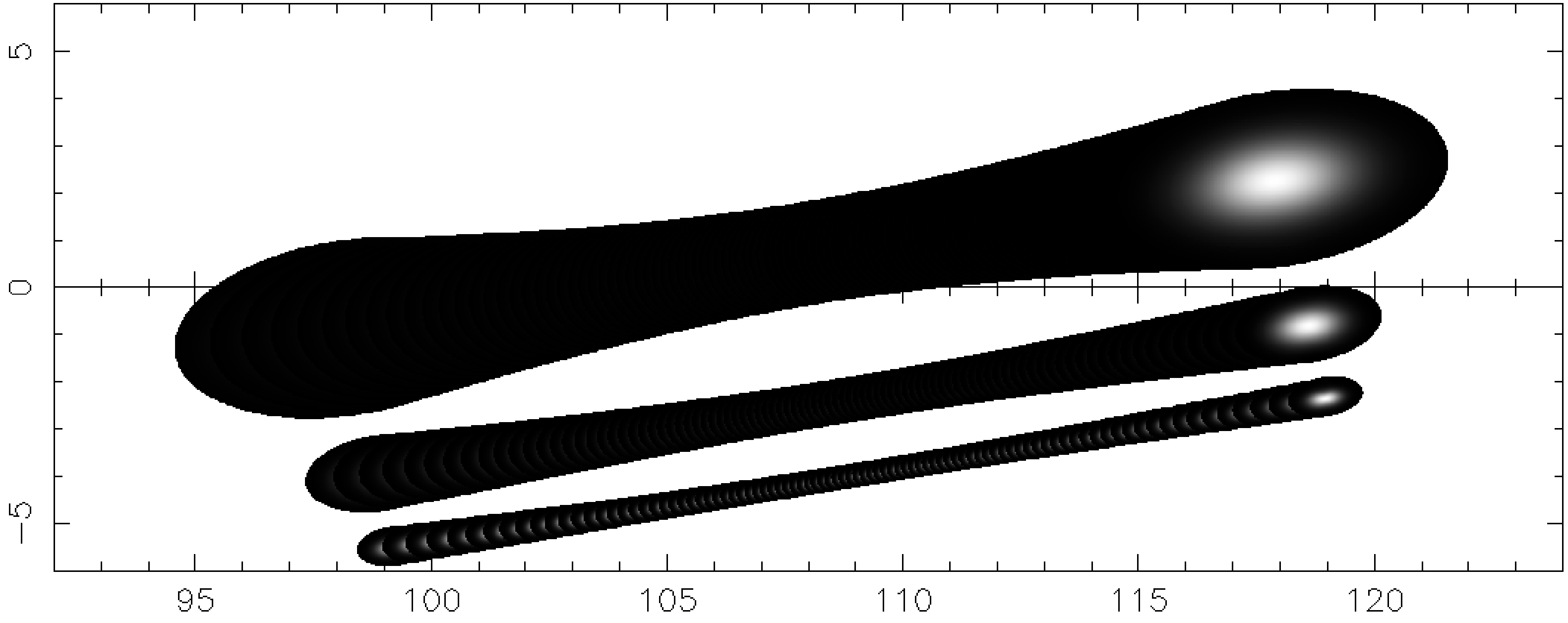
$$P_r = 10^{-P/10}$$

Power expressed as fraction of full power

Sample ATMS scan line with relative antenna power to 50%.



Sample ATMS scan line with relative antenna power to 99%.



Digital Elevation Model for this Study

- GTOPO30 from USGS
- 0.008333º resolution
- translates to .93km at equator

“Radiative Transfer”

- Integrate power/land fraction over fov
- Assume land and sea skin temperature and emissivity homogeneous

"Radiative Transfer" continued

$$T_B = \frac{\int_A \Phi(A) T_R(A) dA}{\int_A \Phi(A) dA} \qquad \hat{\Phi} = \frac{1}{\int_A \Phi(A) dA}$$

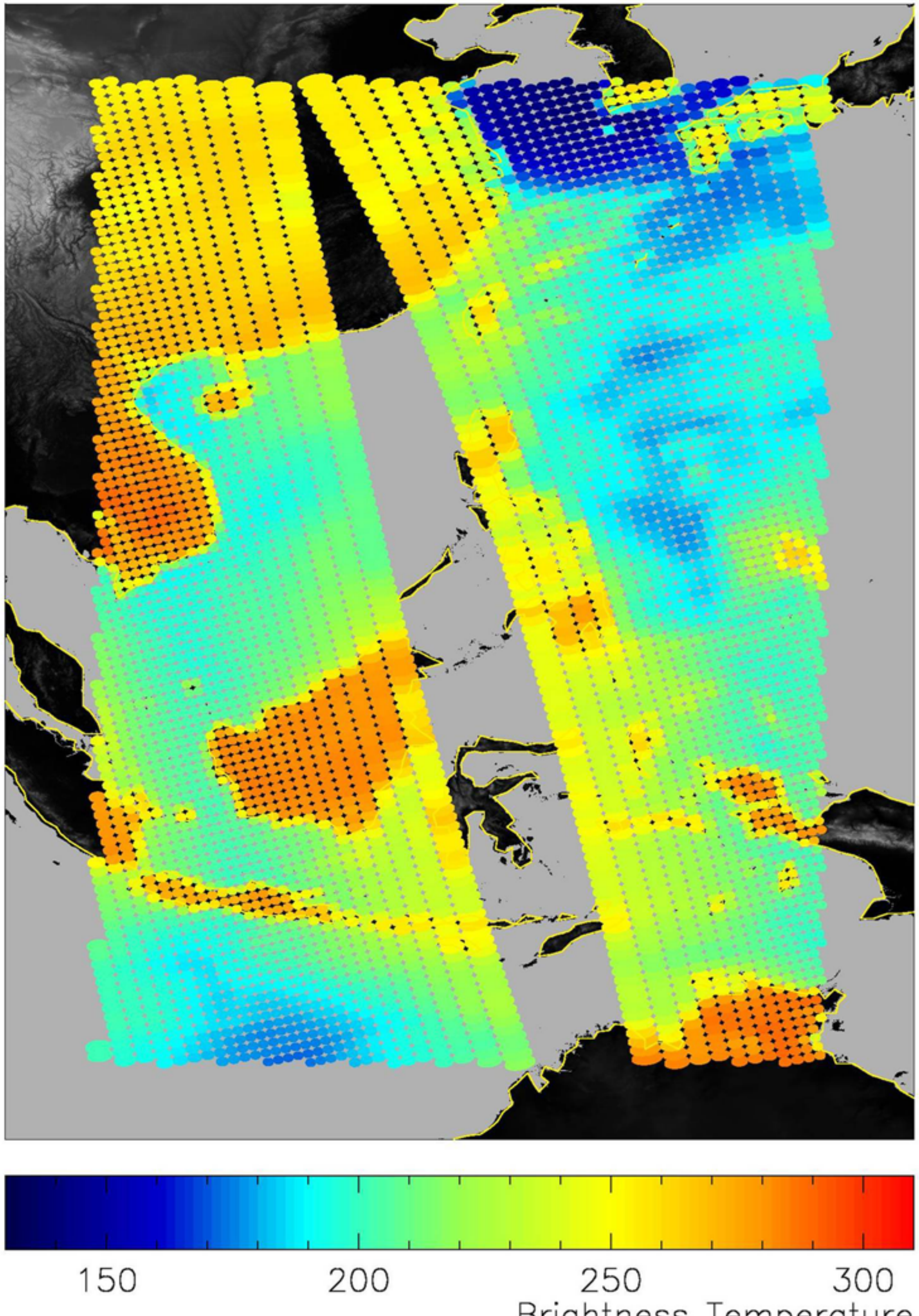
$$= \hat{\Phi} \int_L \Phi(L) T_R(L) dL + \hat{\Phi} \int_S \Phi(S) T_R(S) dS$$

$$= T_{R\,L}\, \hat{\Phi} \int_L \Phi(L) dL + T_{R\,S}\, \hat{\Phi} \int_S \Phi(S) dS$$

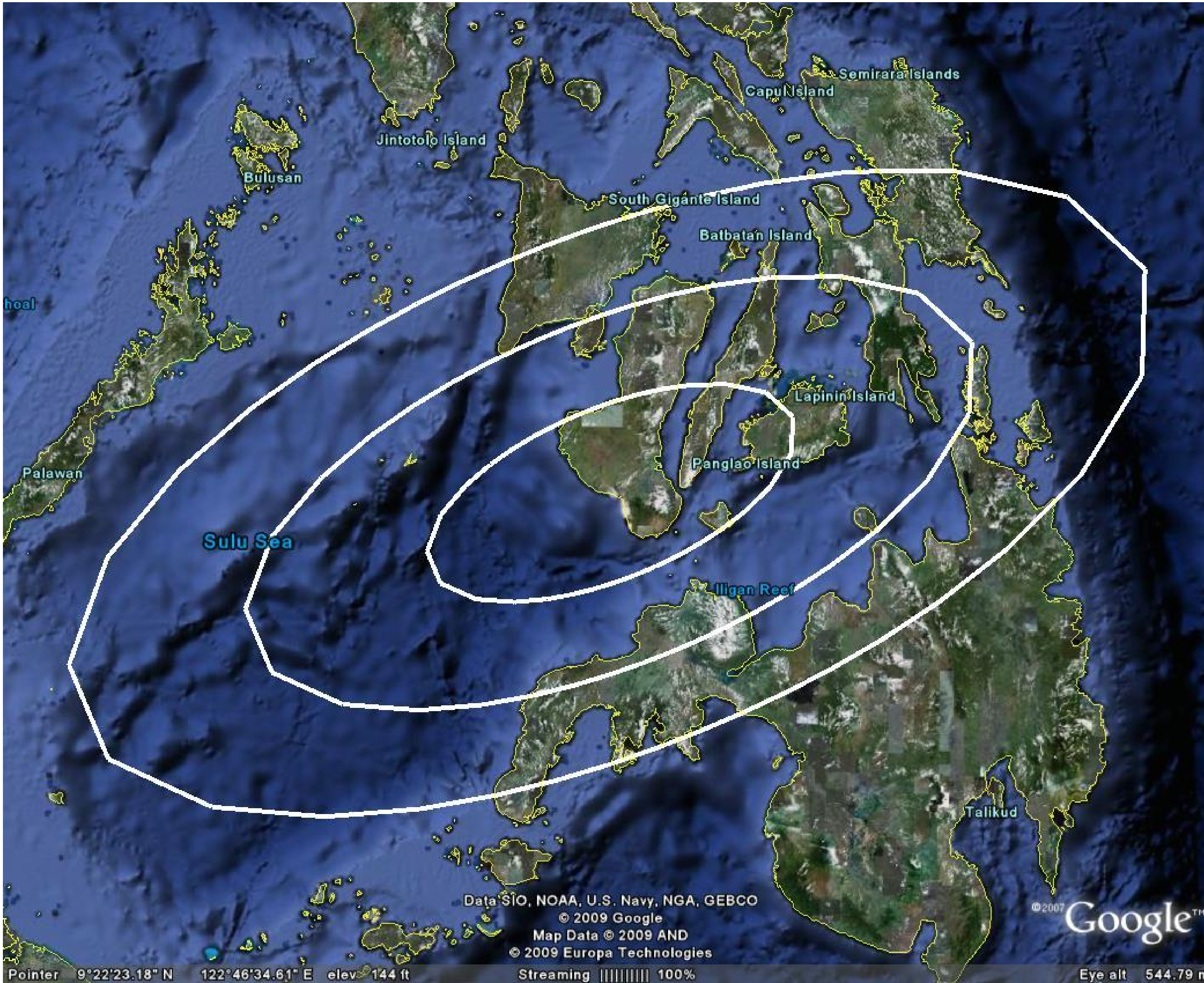
Land Power Fraction Ocean Power Fraction

Power Fraction = Fraction of total antenna power within fov allocated to each surface type

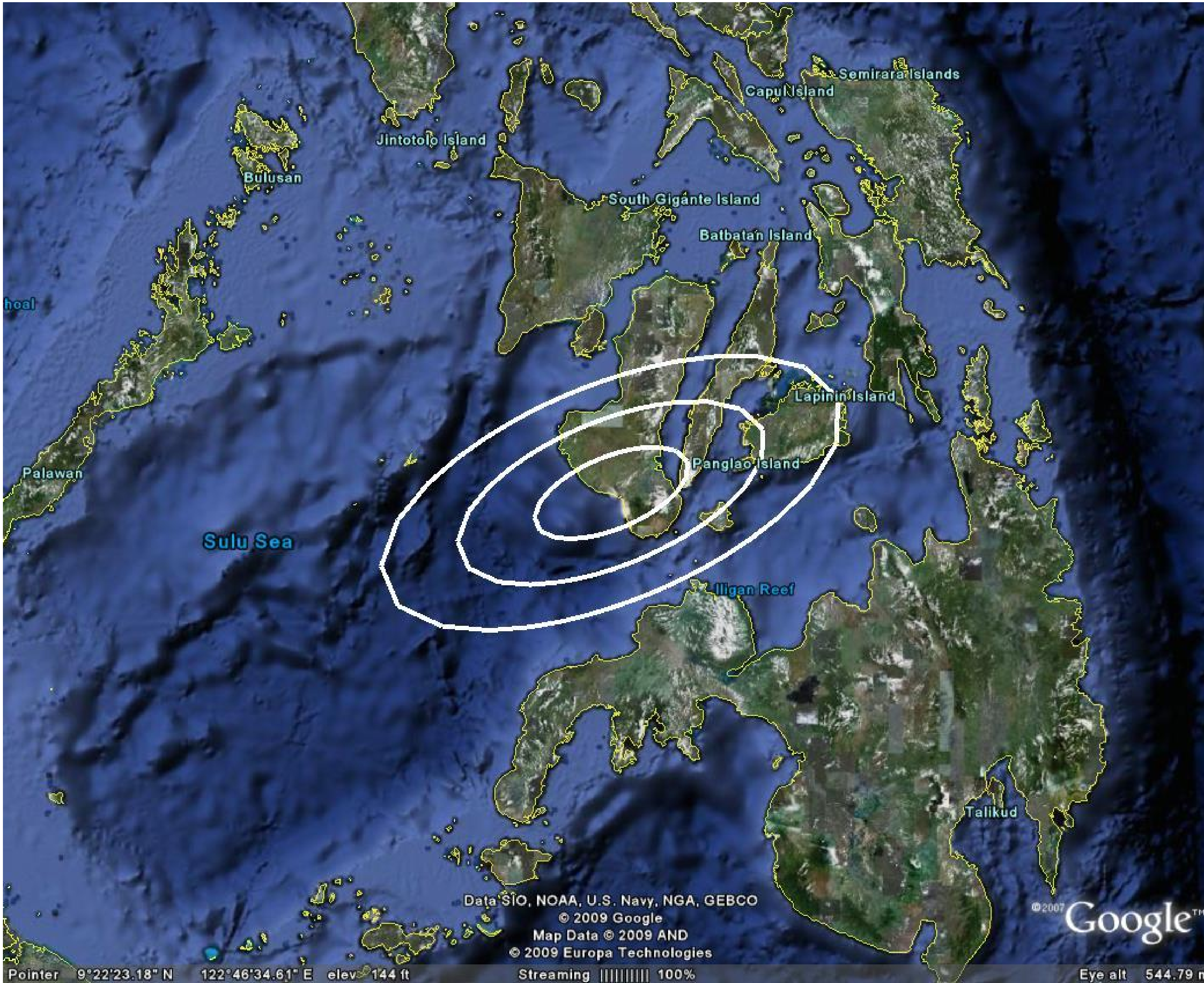
Area of Interest



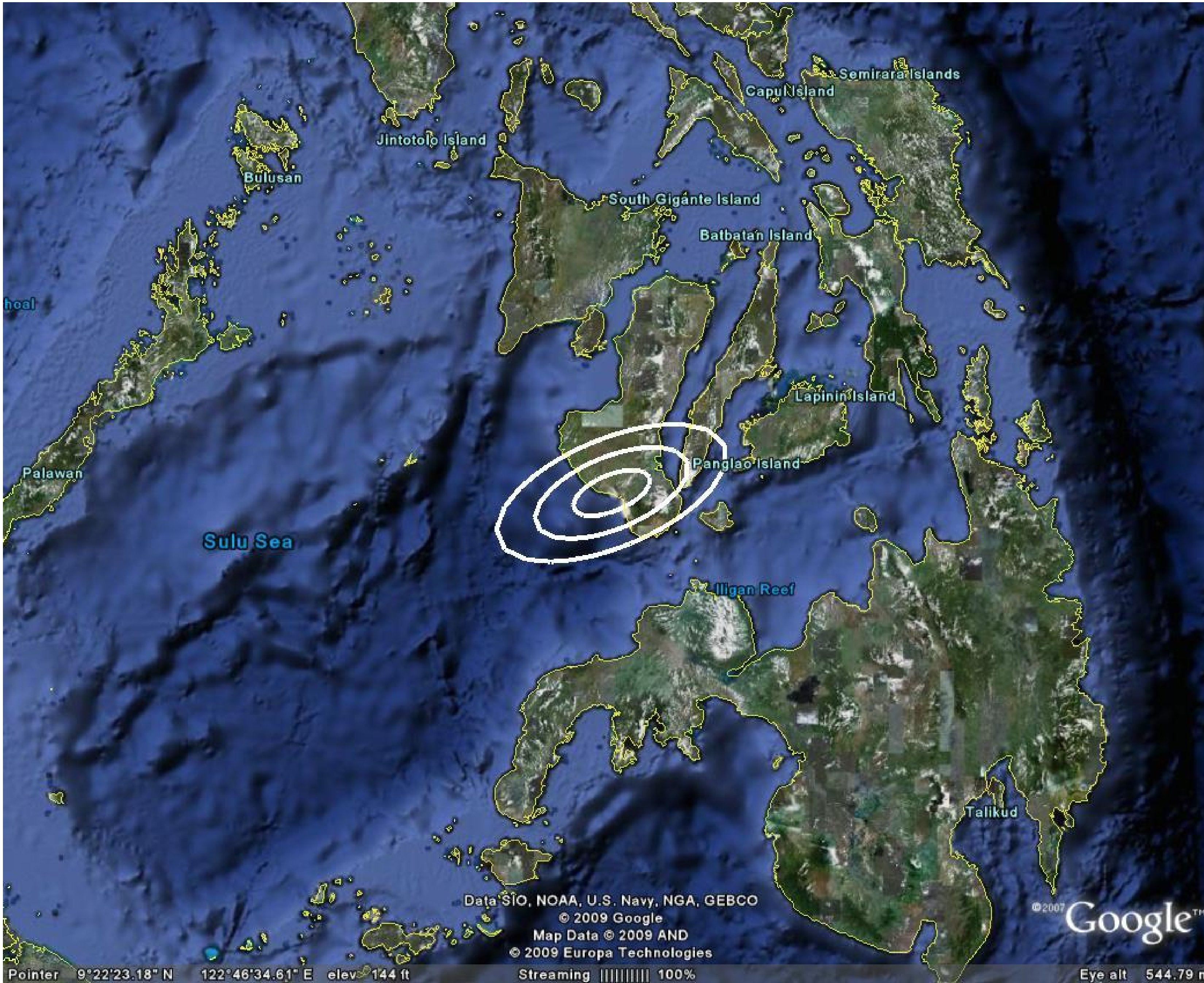
5.2 degree fov

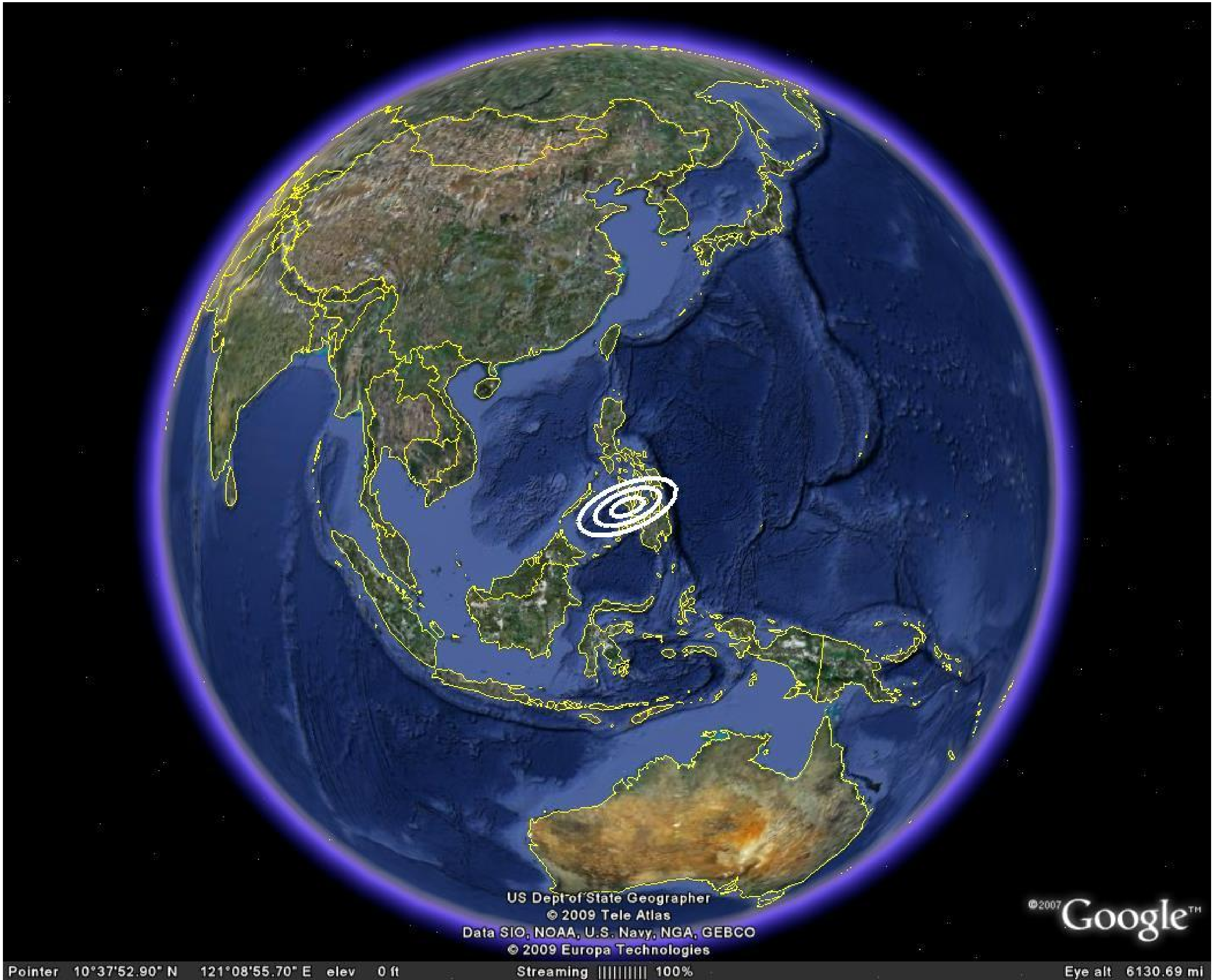


2.2 degree fov



1.1 degree fov




US Dept of State Geographer
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©2007 Google™
Pointer 10°37'52.90" N 121°08'55.70" E elev 0 ft
Streaming |||||||||| 100%
Eye alt 6130.69 mi

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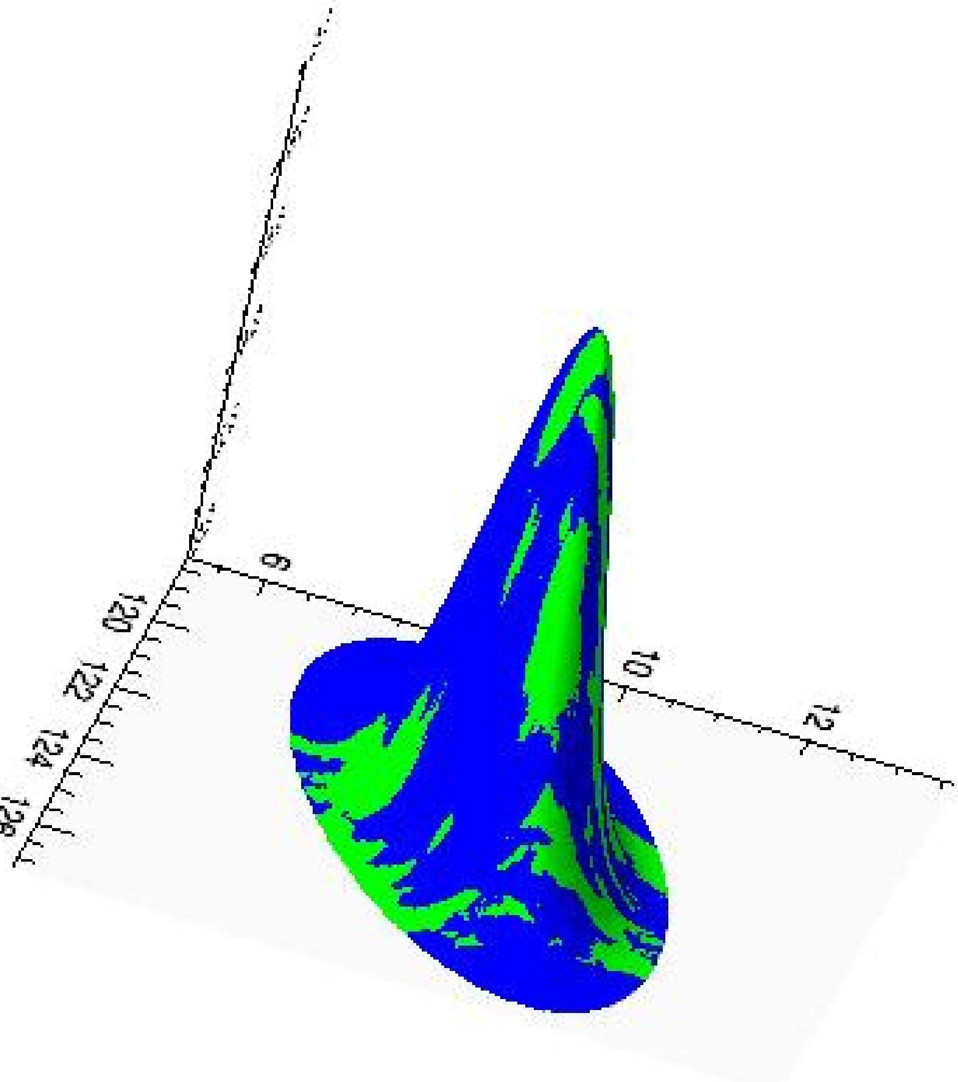

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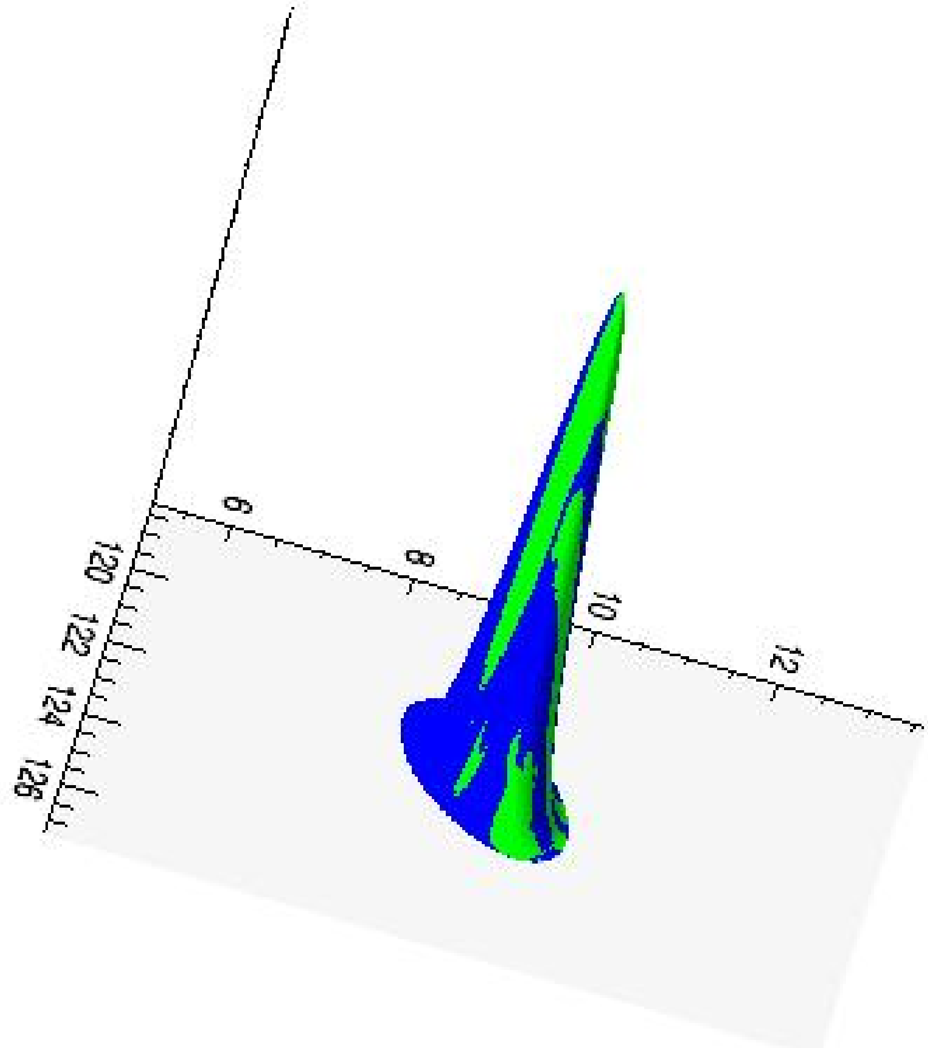
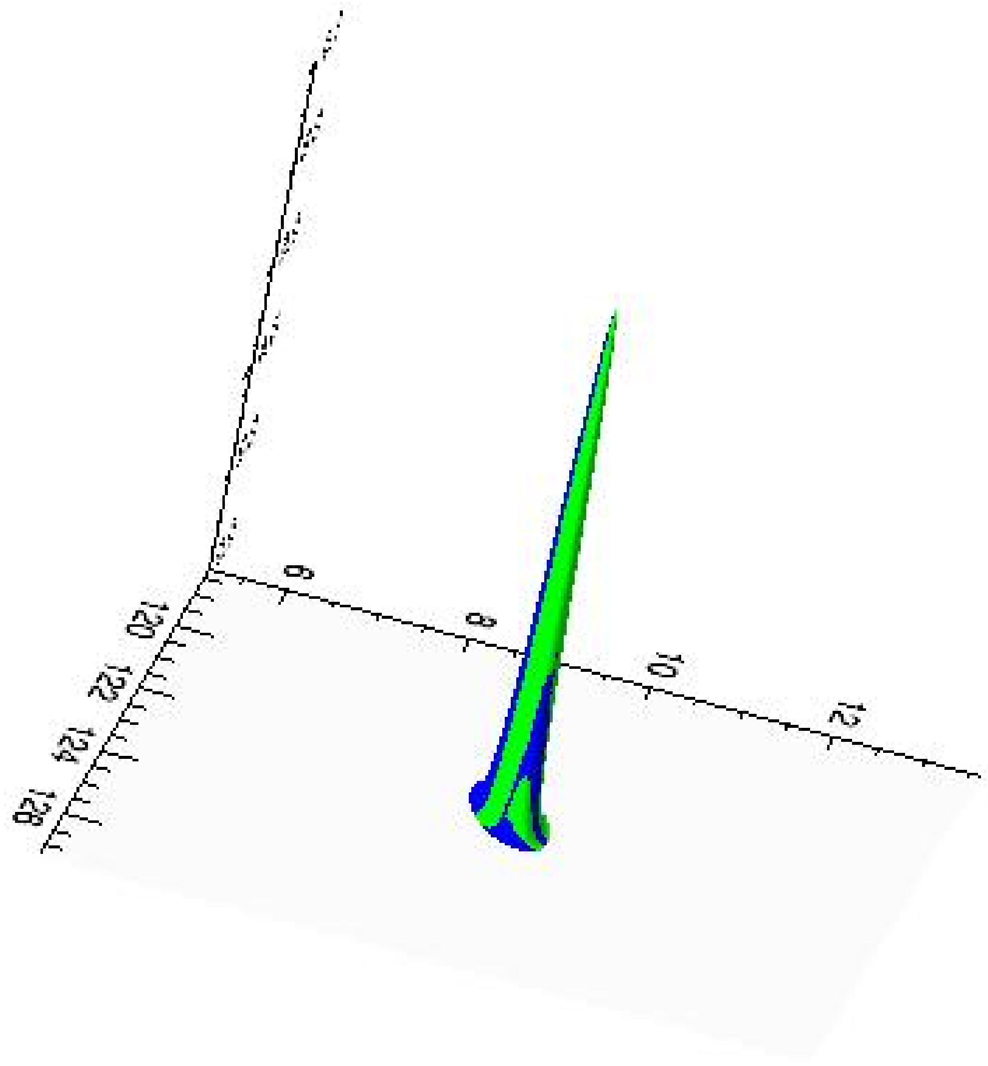



6
8
10
12
120
122
124

Example Tb Differences

TB_land = 280 TB_sea = 210

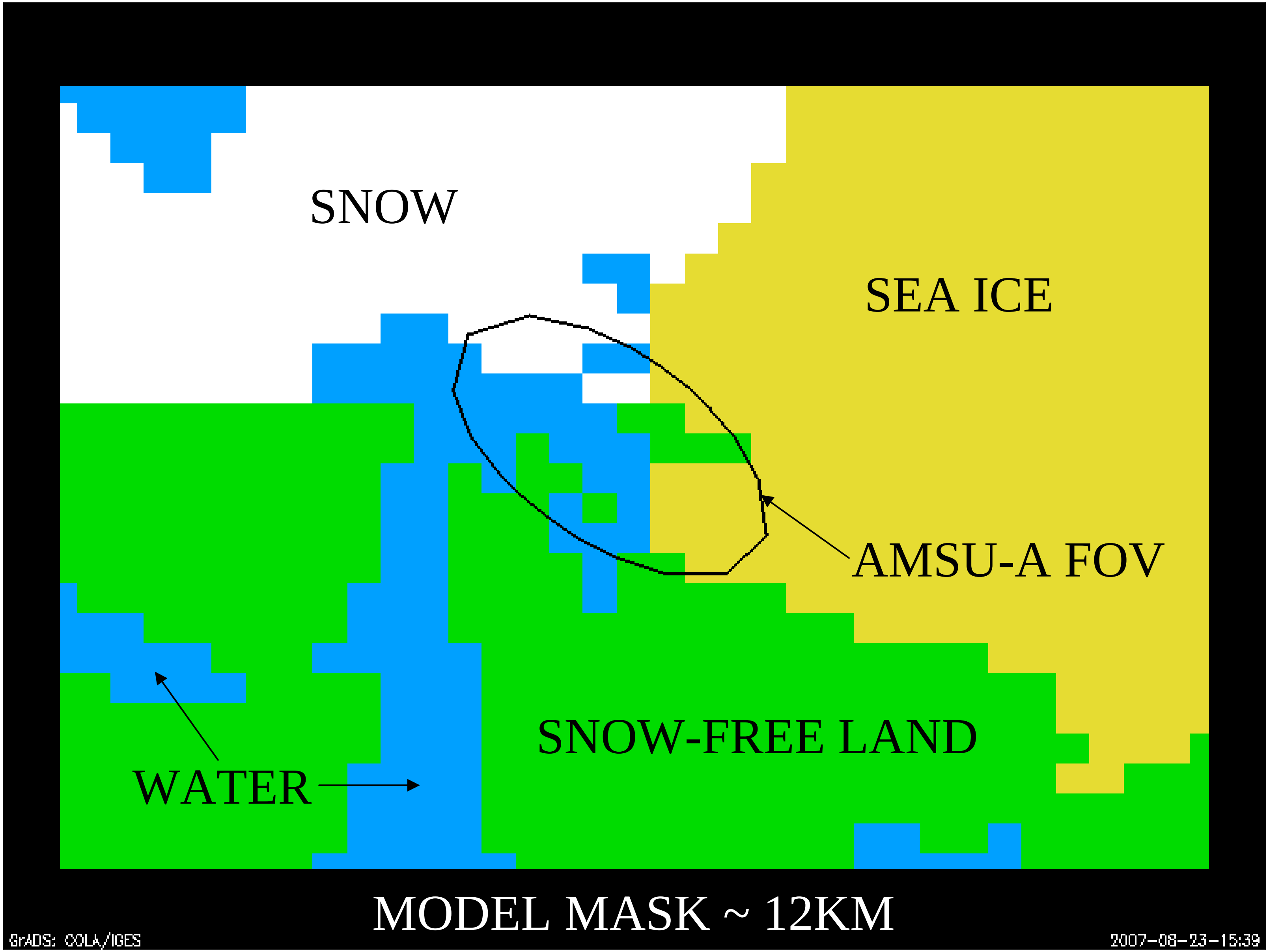
% Power	Land Fraction	Sea Fraction	Land Power Fraction	Sea Power Fraction	Tb
50%	0.476	0.524	0.491	0.509	244.39
95%	0.329	0.671	0.405	0.595	238.36
99%	0.269	0.731	0.397	0.603	237.80

Thanks to Paul vanDelst for suggesting this comparison

What does this look like just using GDAS within the fov?

- Use the above described methods to determine the various land/ water/ snow/ sea ice fractions and pass to CRTM

- Preliminary results in the following slides from George Gayno, NCEP/EMC/JCSDA/SAIC


SNOW
SEA ICE
AMSU-A FOV
SNOW-FREE LAND
WATER
MODEL MASK ~ 12KM
GrADS: COLA/IGES
2007-08-23-15:39

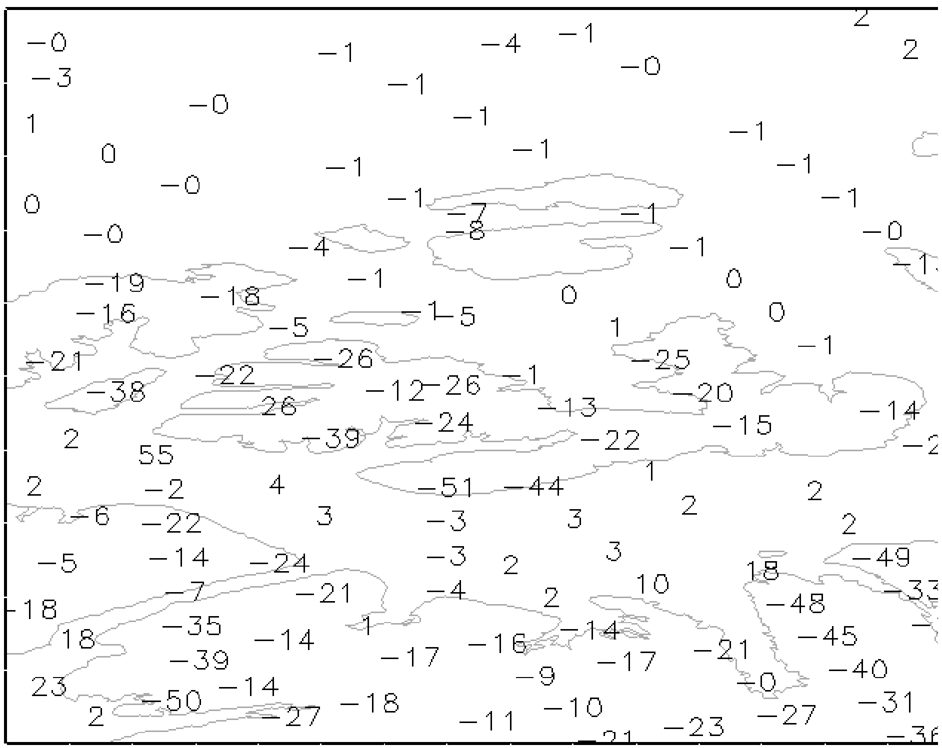
IMPACT: ACCOUNTING FOR FOV

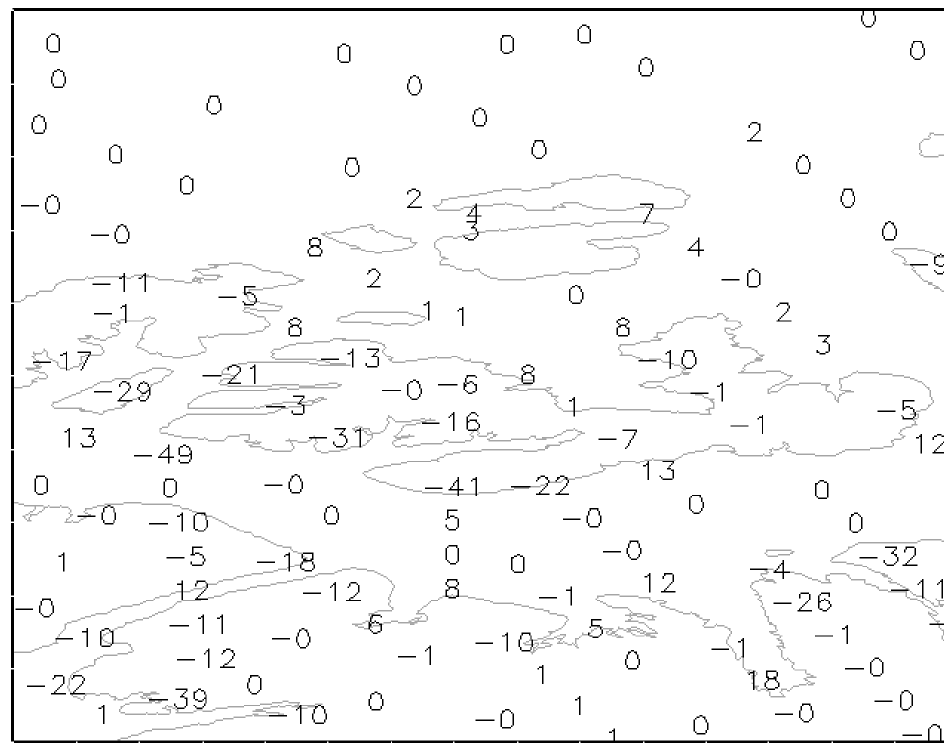
Power not included

EX: NOAA-15 AMSU-A, CHANNEL 2

CONTROL:
OBS. MINUS GUESS T_b

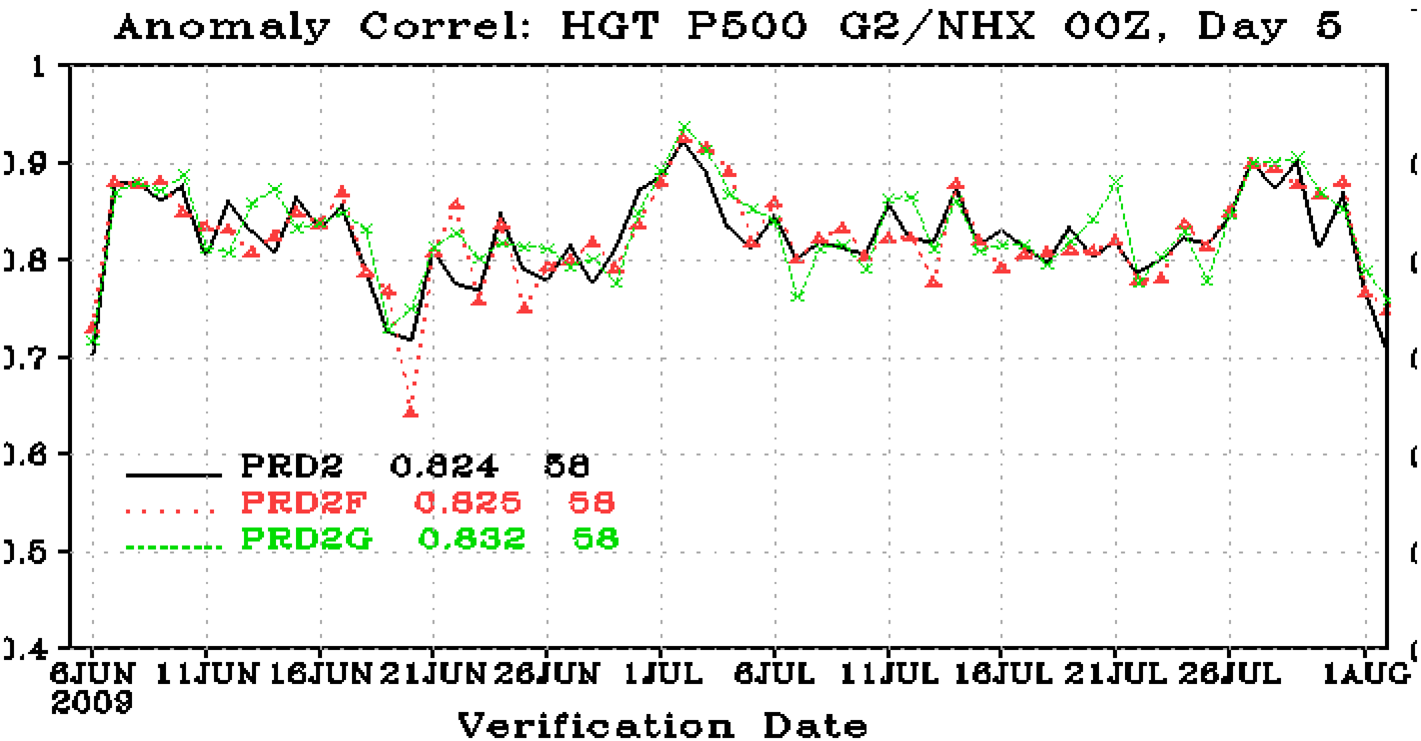
IMPACT: CHANGE IN
OBS. MINUS GUESS T_b





NORTHERN CANADA

NEGATIVE IS IMPROVEMENT



Anomaly Correl: HGT P500 G2/NHX 00Z, Day 5
1
0.9
0.8
0.7
0.6
0.5
0.4
PRD2 0.824 58
PRD2F 0.825 58
PRD2G 0.832 58
6JUN 2009
11JUN
16JUN
21JUN
26JUN
1JUL
6JUL
11JUL
16JUL
21JUL
26JUL
1AUG
Verification Date

Potential Improvements

- Work shown here uses the nominal fov centroid zenith angle. It would be better to use the actual angles within the fov.
- Fit as a function of scan position
- …

This is preliminary work

Summary and Discussion

- A method has been presented to use sub-fov radiative transfer to improve radiances over inhomogeneous surfaces
- Usefulness of this technique is limited by the quality and resolution of available model state/ancillary databases
- Usefulness also limited by the expense of fov integration and multiple RT calculations
- Future application of Moore's law and other hardware development may ease these restrictions

Back up slides

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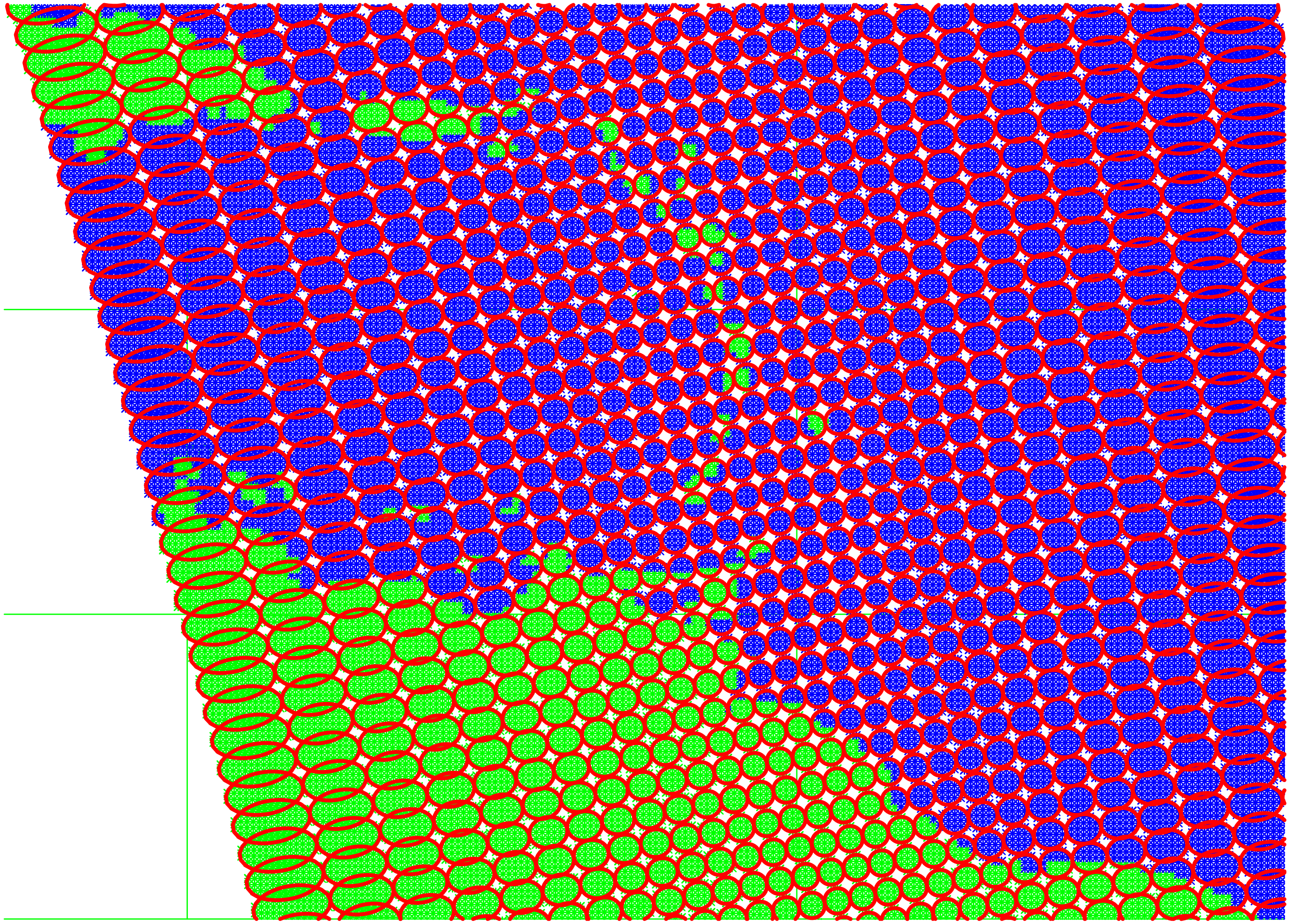

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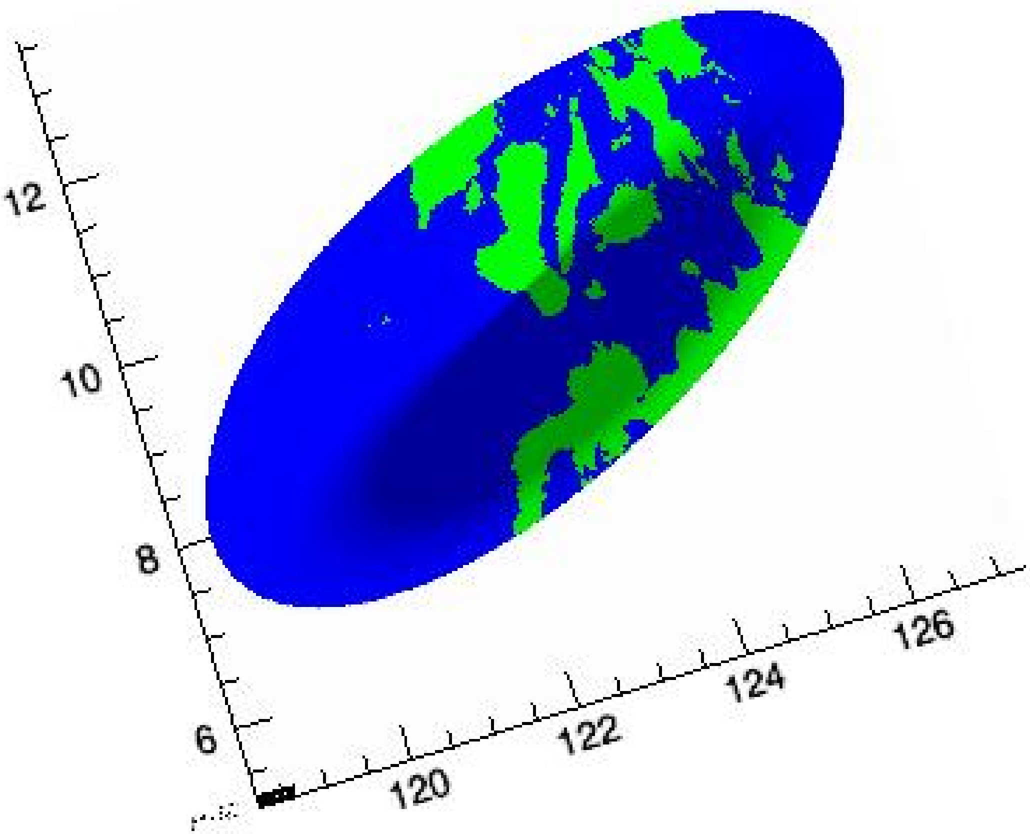

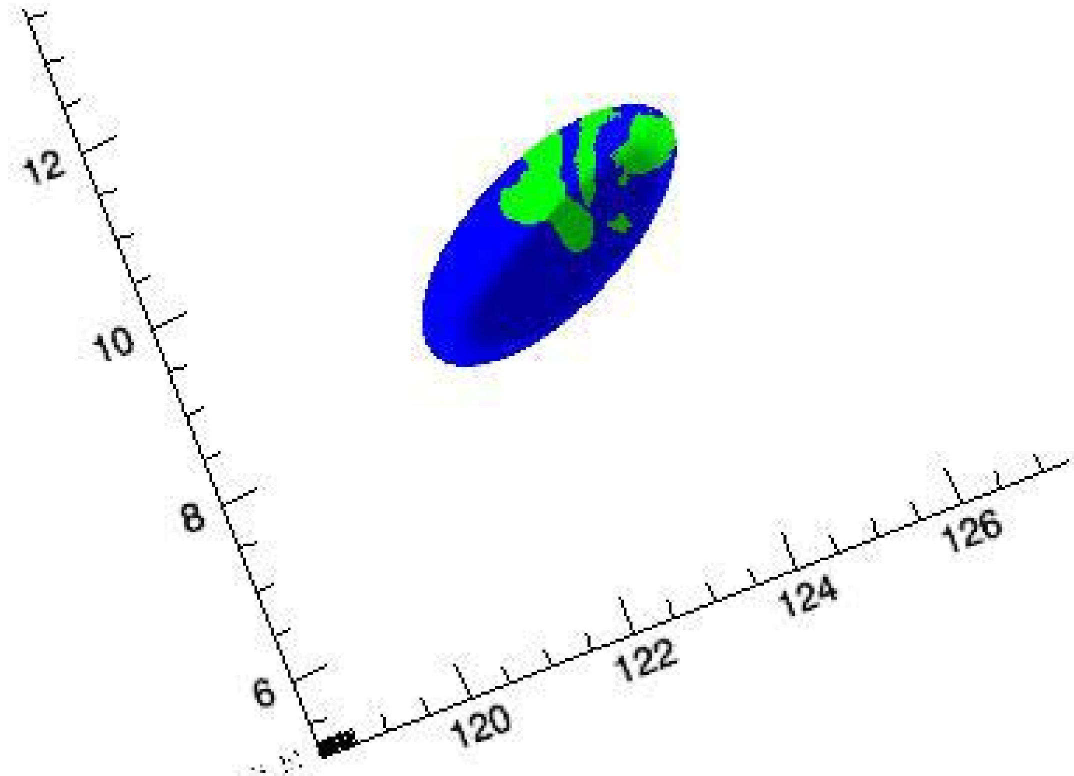
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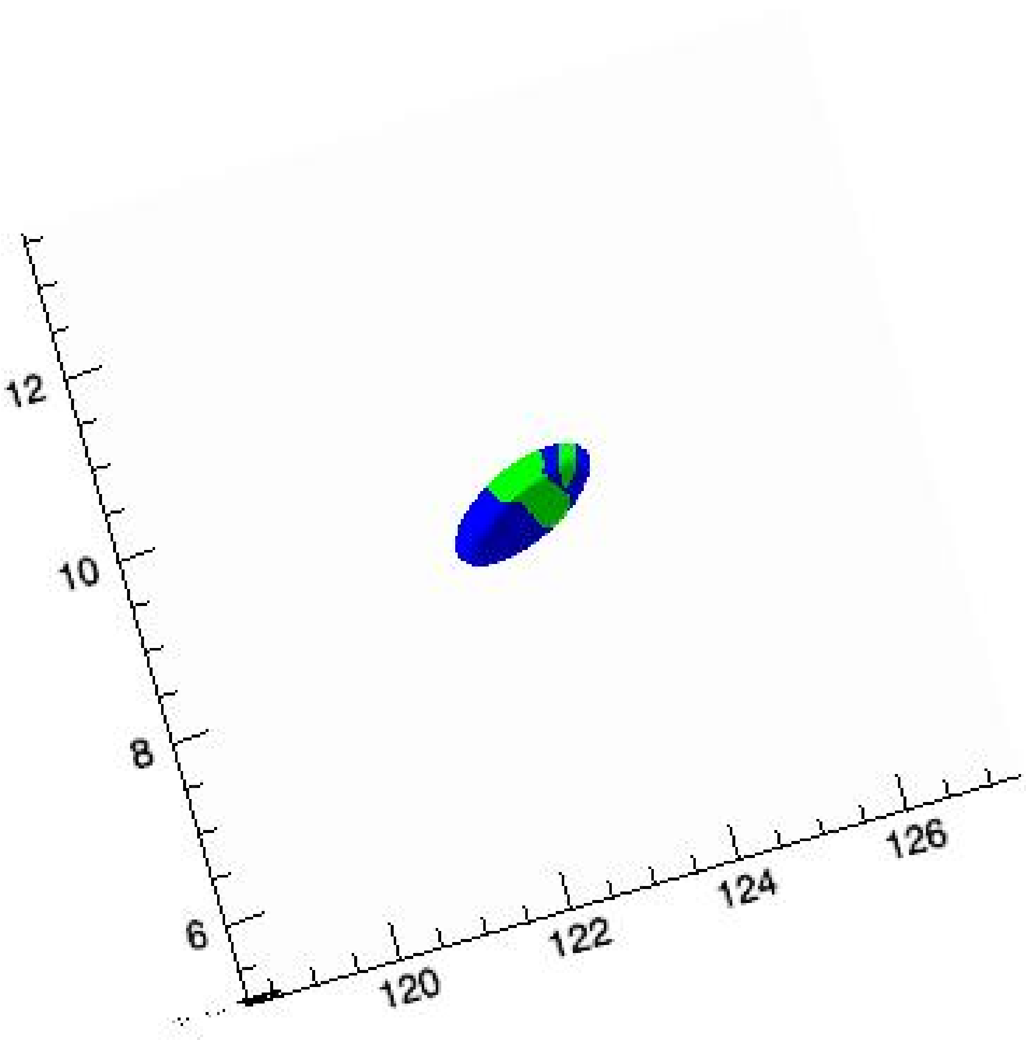

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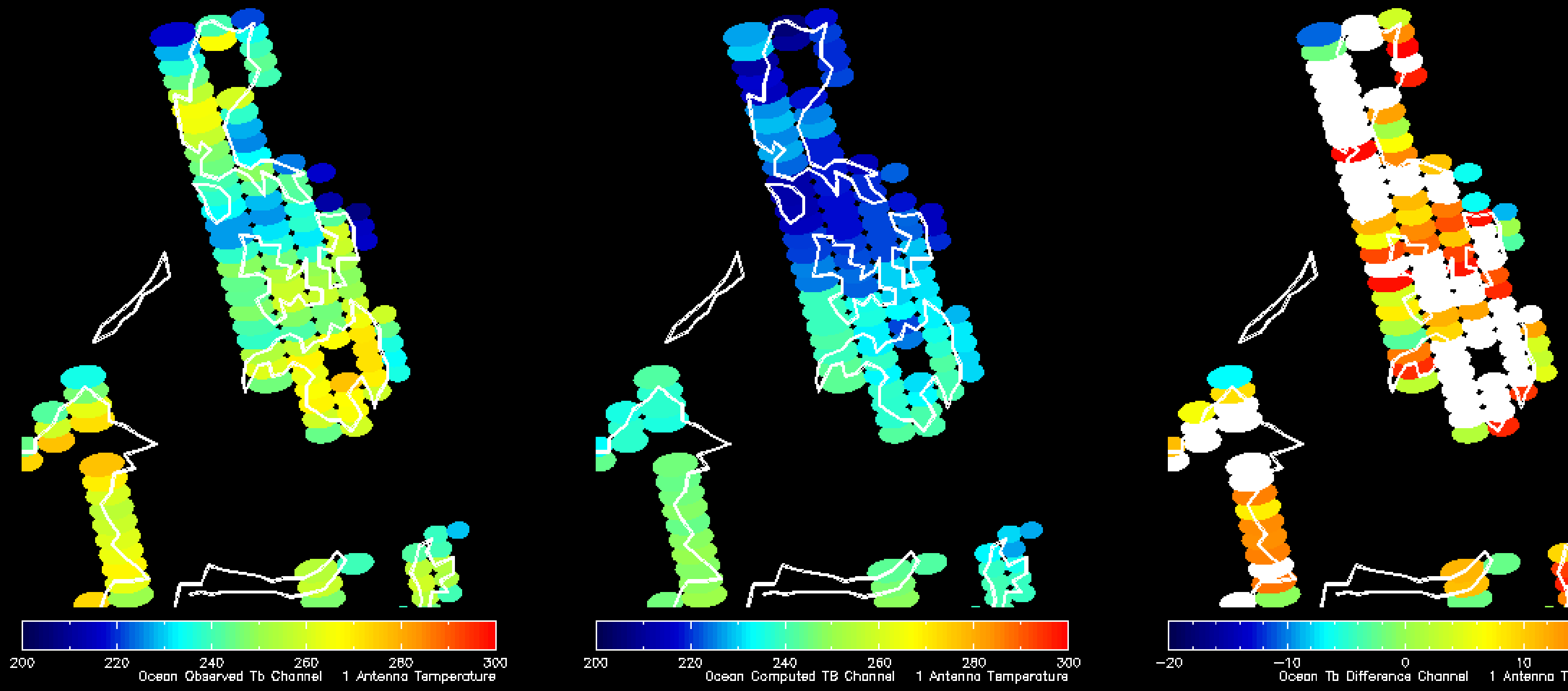
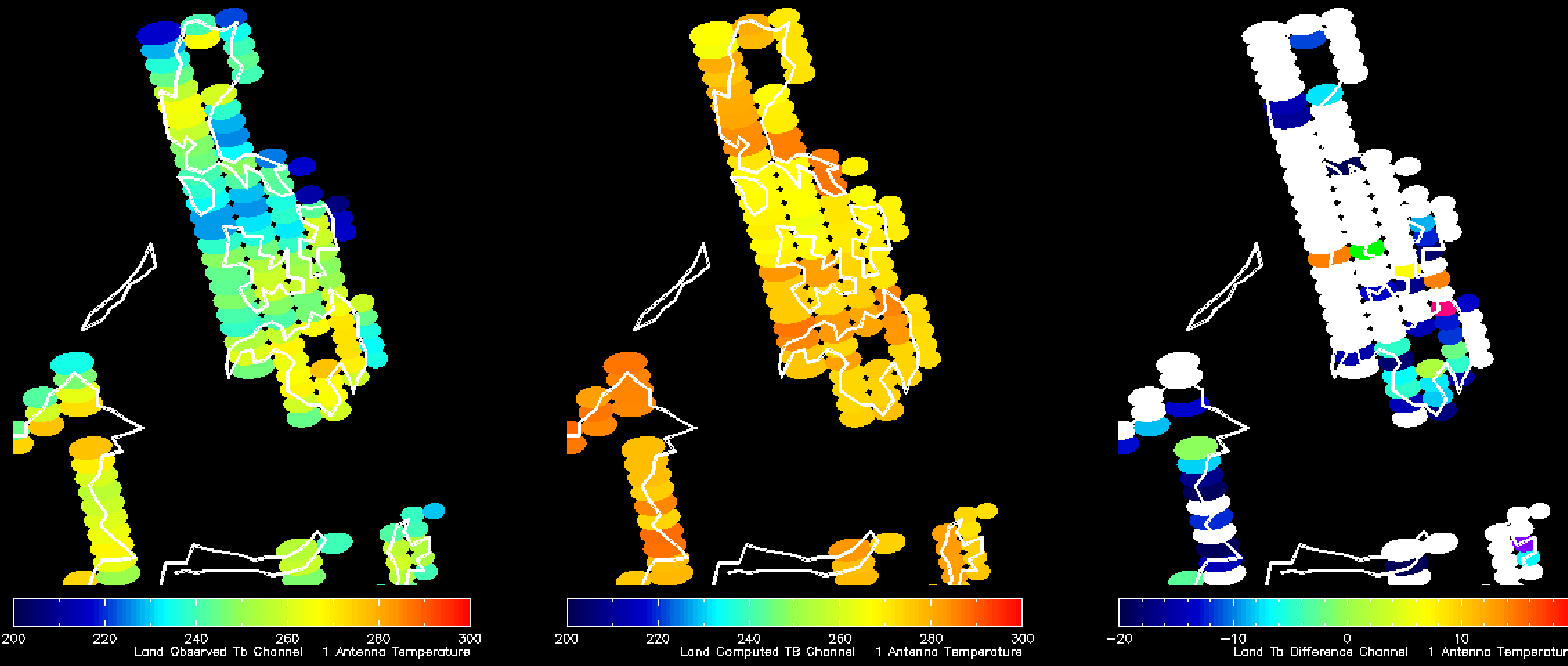
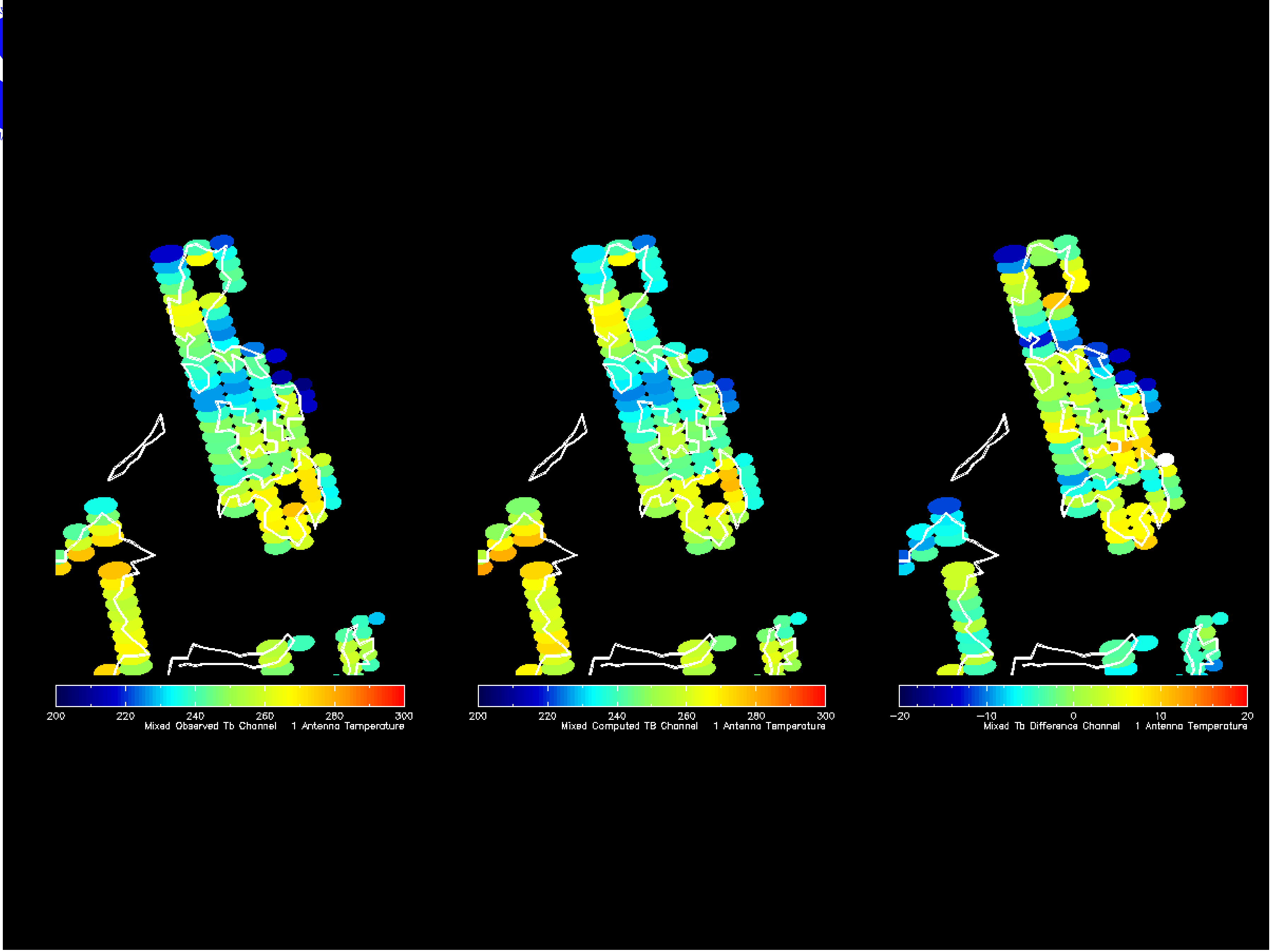


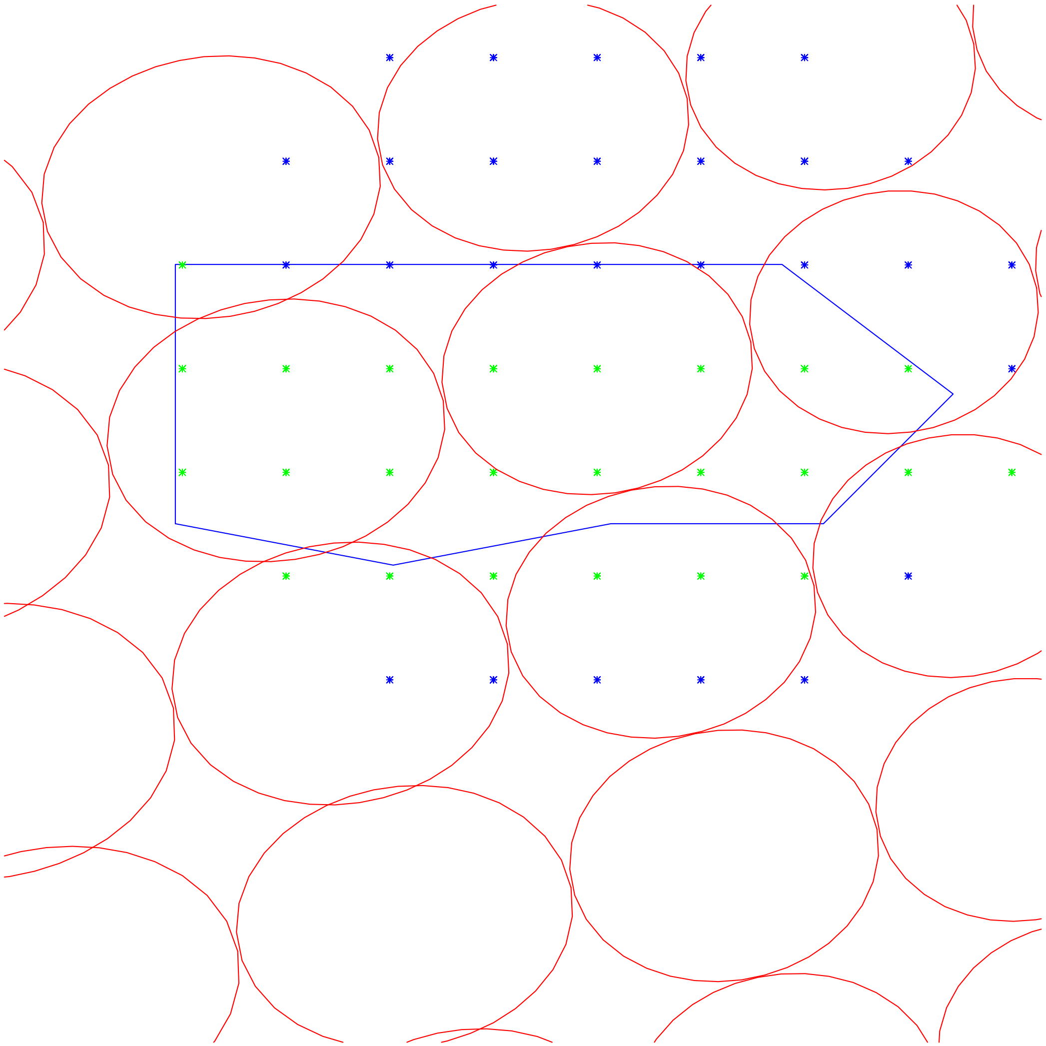
Ocean Temperature



Land temperature

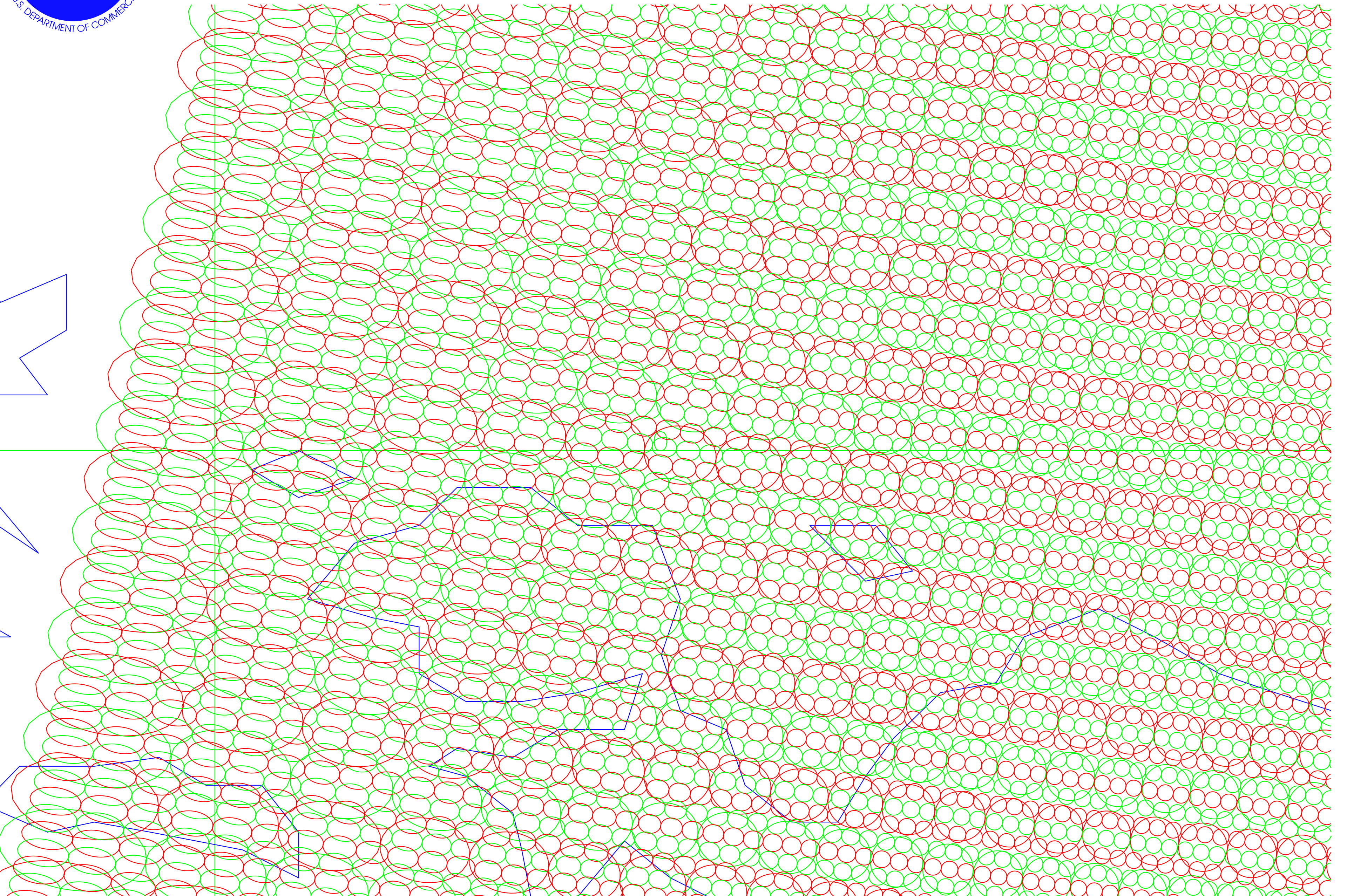


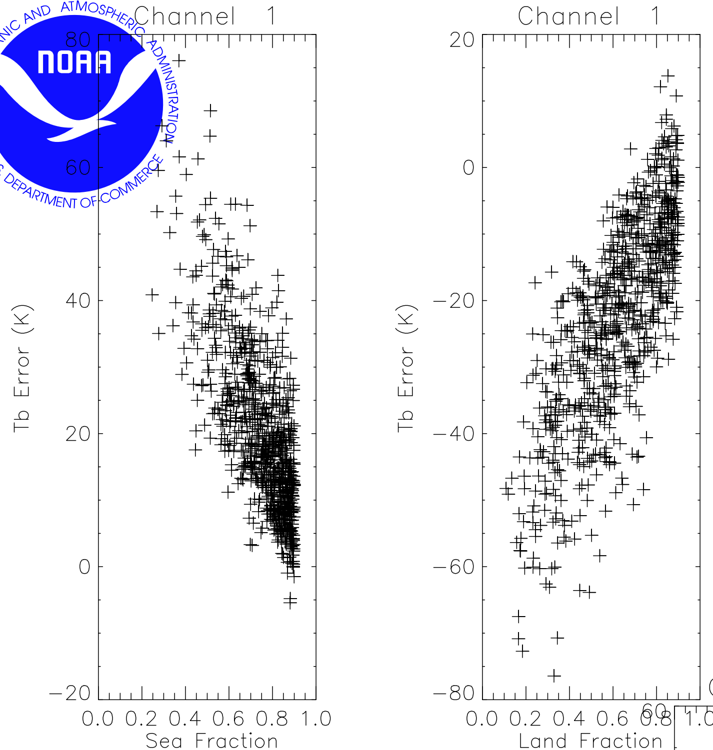
Mixed temperature



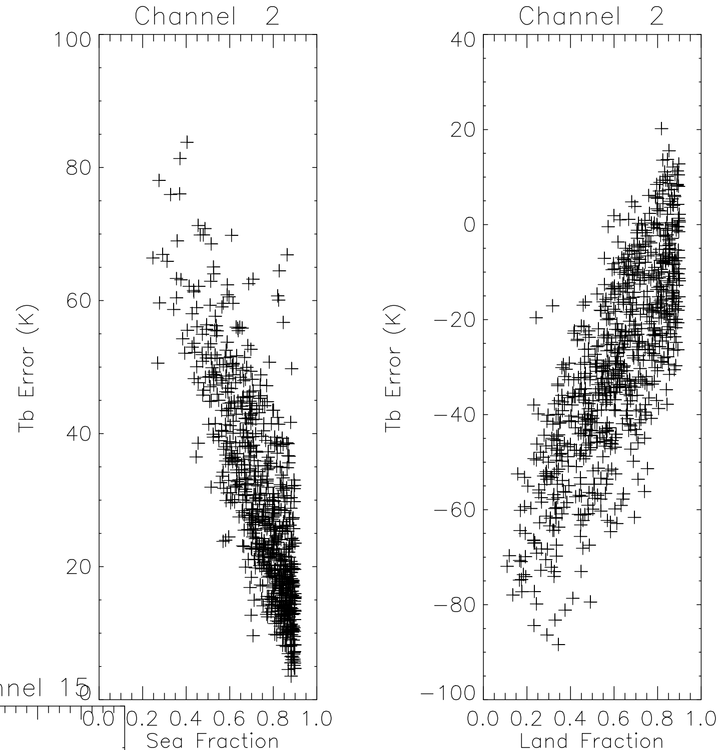
This is a first attempt with idl, using it’s lores coastline (we don’t have the CIA hires coastline, and using the F:\landsea\global.eighth, which is clearly not up to the task.

NOAA-17 AMSU-A and AMSU-B scan pattern in cylindrical coordinates. Coastline is North New Guinea.

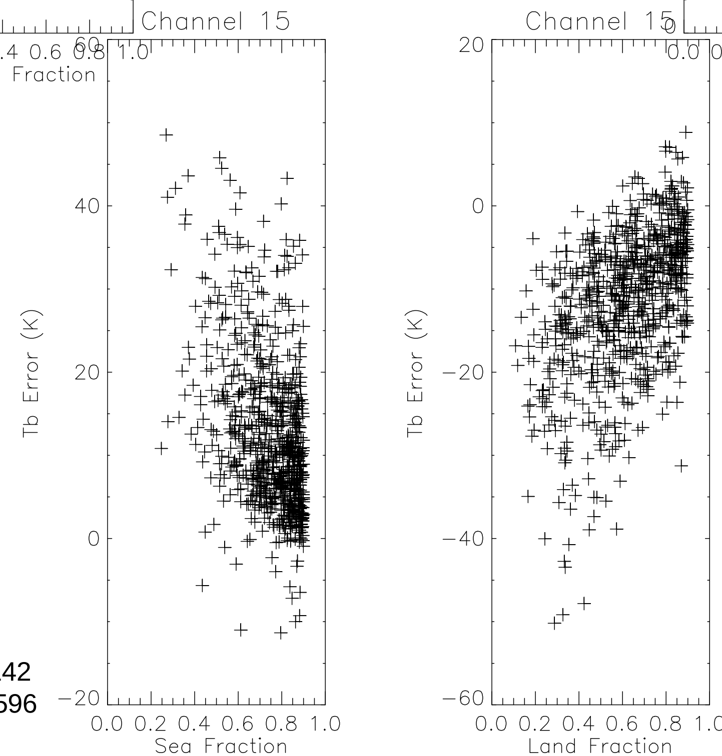




Sea Mean 20.5556 Stdev 12.5523
Land Mean -22.6450 Stdev 15.6544



Sea Mean 29.4404 Stdev 15.1999
Land Mean -28.4093 Stdev 20.9997



Sea Mean 12.3312 Stdev 9.39142
Land Mean -11.5600 Stdev 8.81596