Microwave Radiative Transfer at the Sub-Field-of-View Resolution

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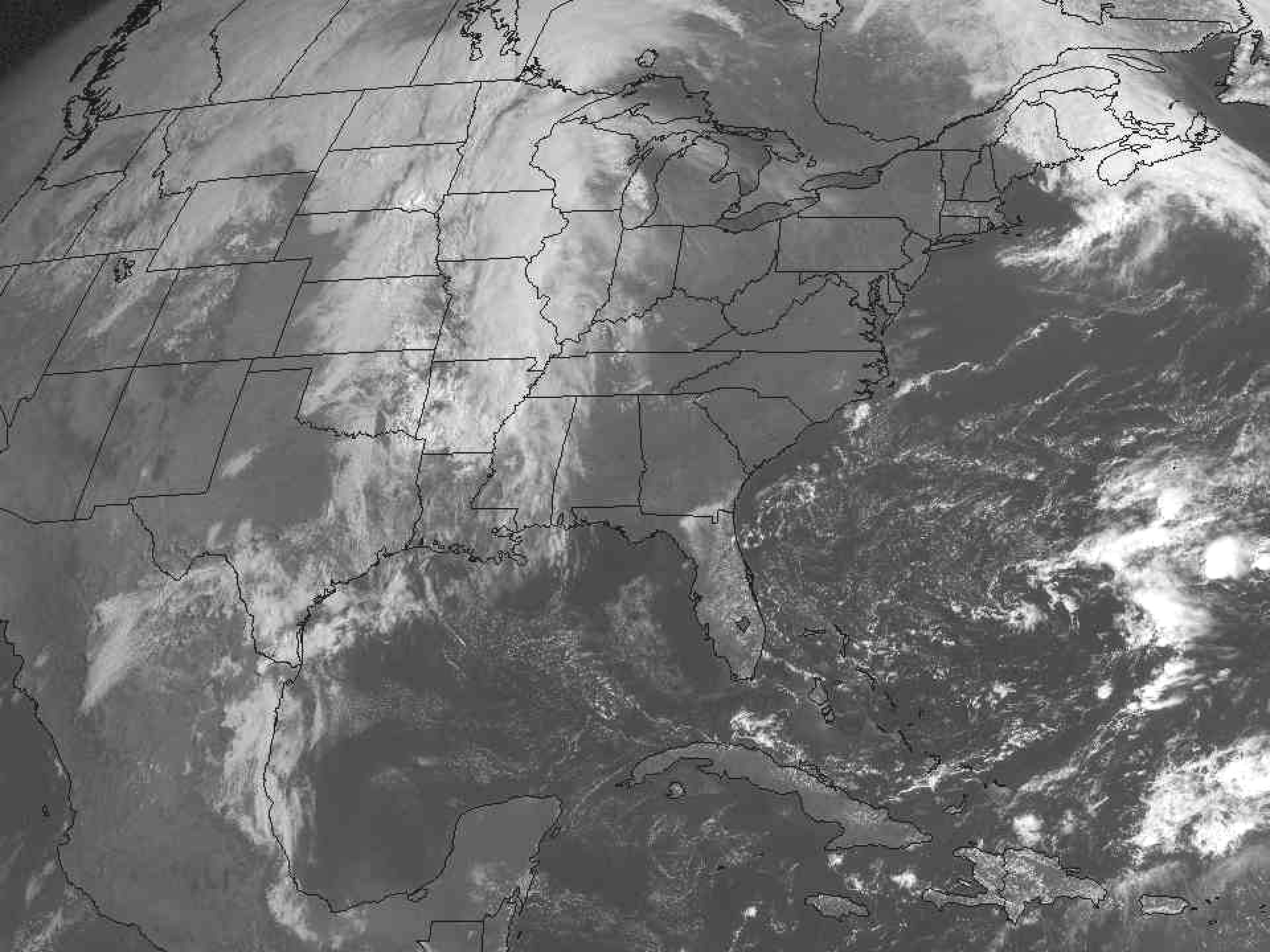
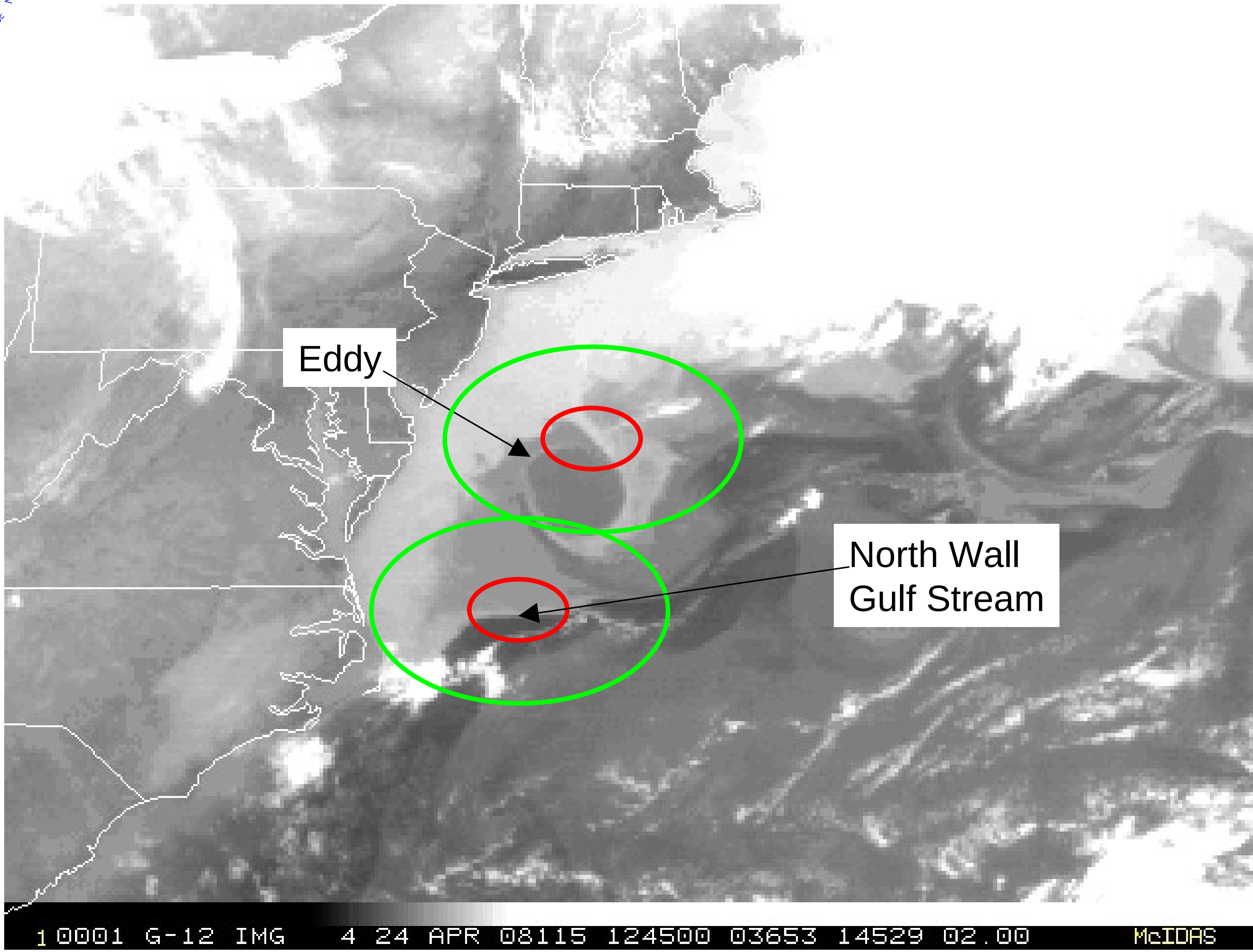
Problem

- 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.

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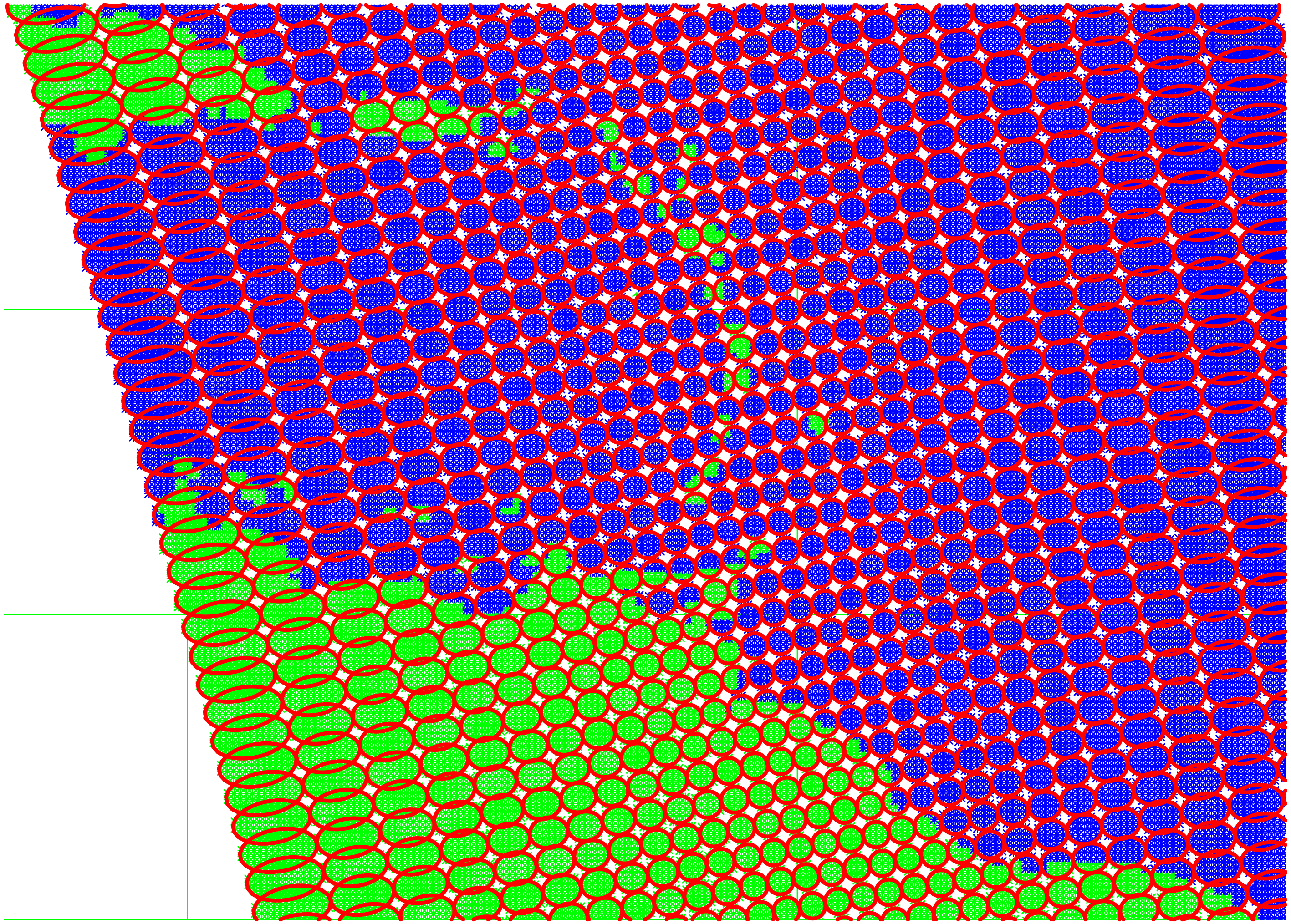
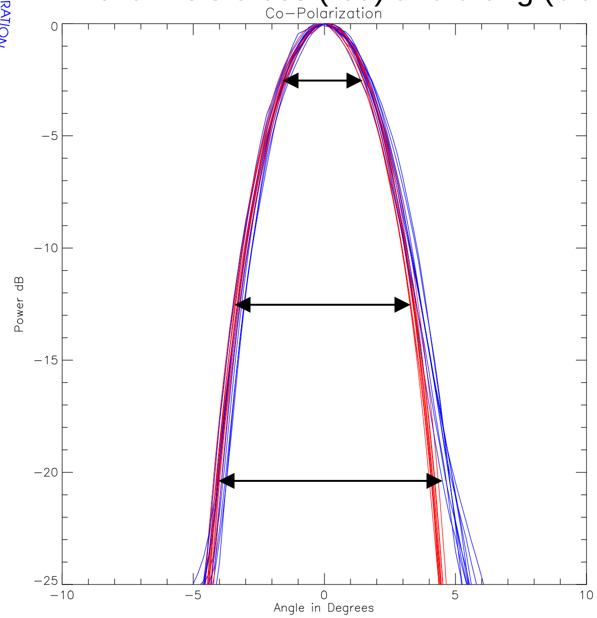


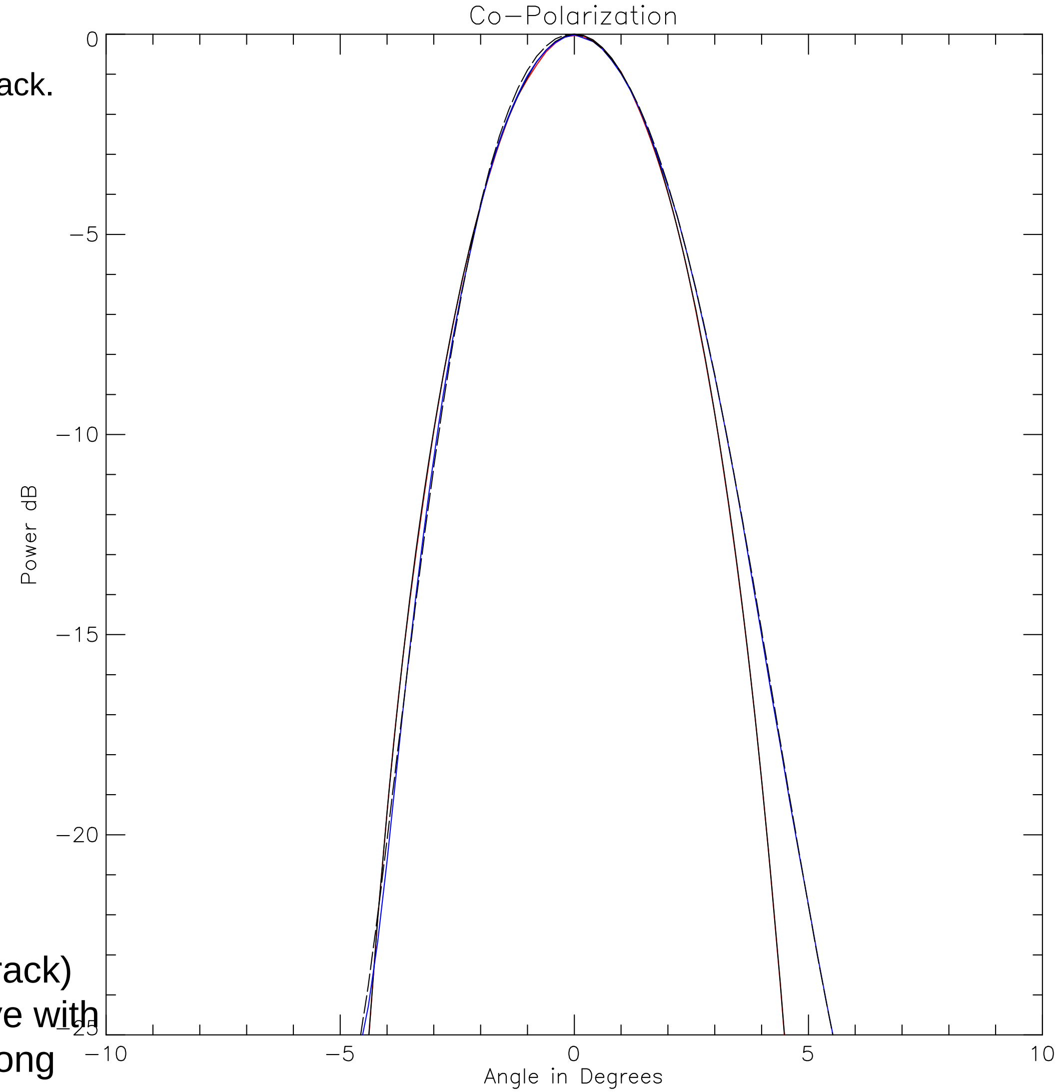
METOP AMSUA

All channels cross (red) and along (blue) track.



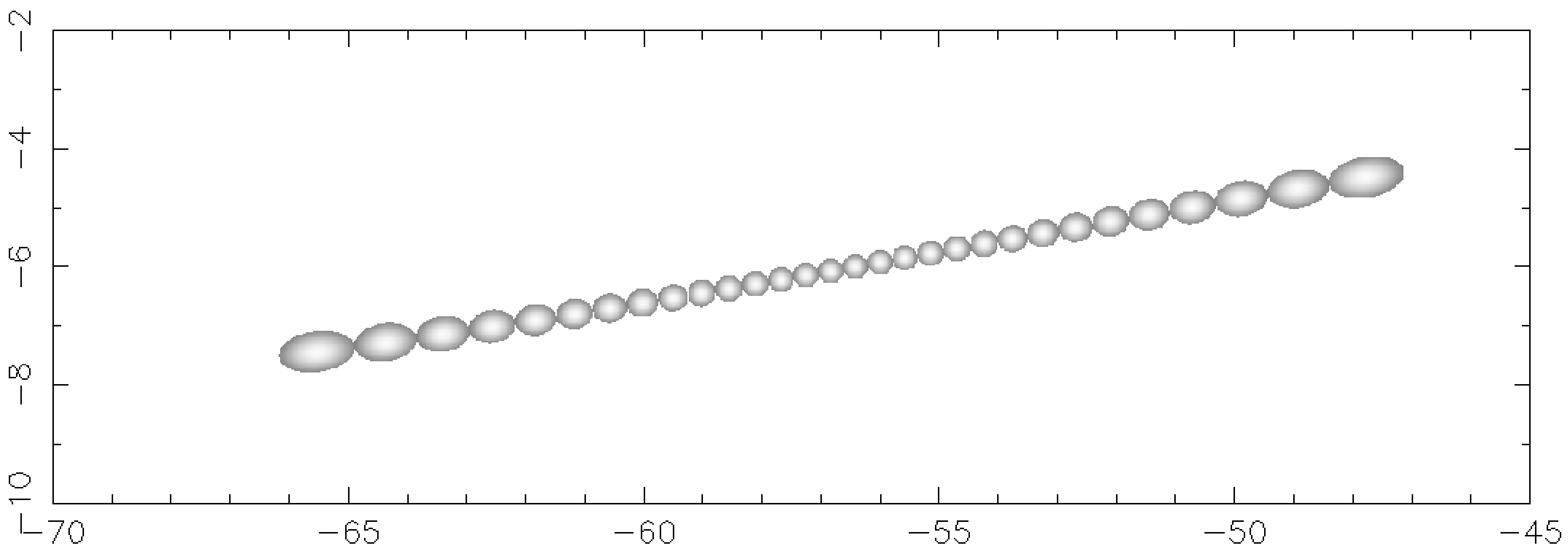
Normalized antenna patterns by adding (negative) maximum value of each pattern to all values. Averaged all 10 channels for the 0 deg (red-crosstrack) and 90 deg (blue alongtrack). Got best fit to the eye with a 7th order polynomial (solid, crosstrack, dashed along track.

99% power inside the fov is at -20 dB. This is approx 10 deg wide. Ran this through the fov_angle_sizes code, compared with 3.3 deg for AMSU and got an expansion factor of 3.0 .

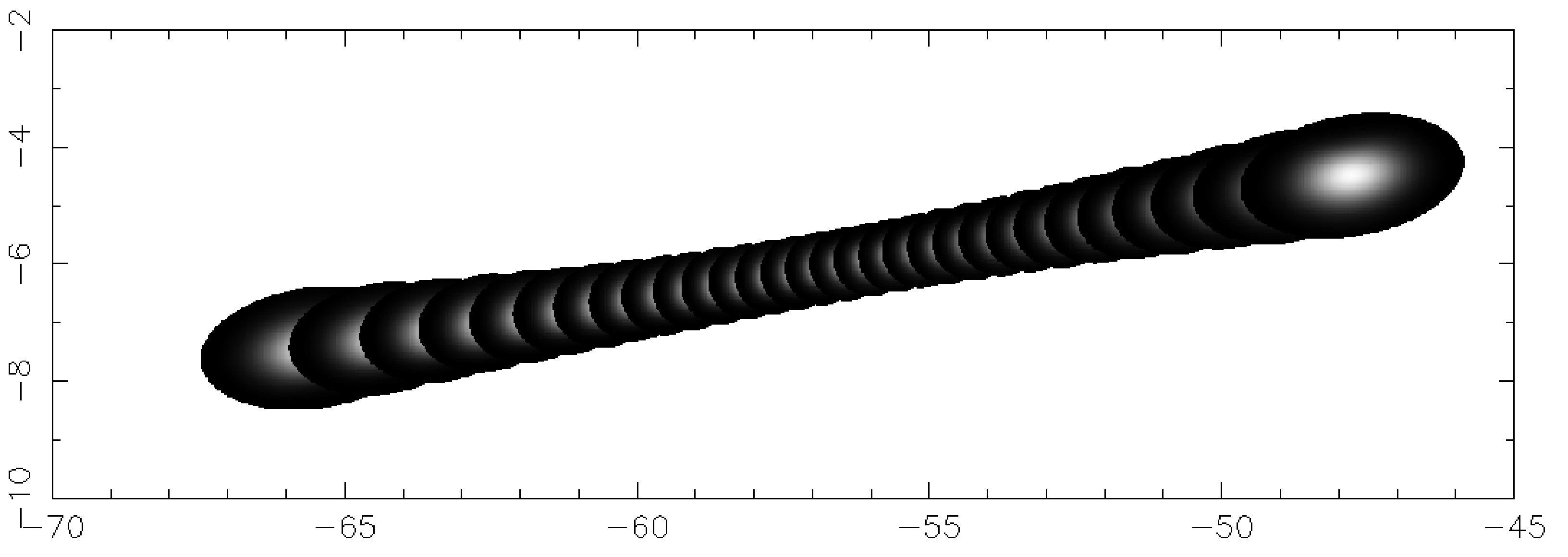


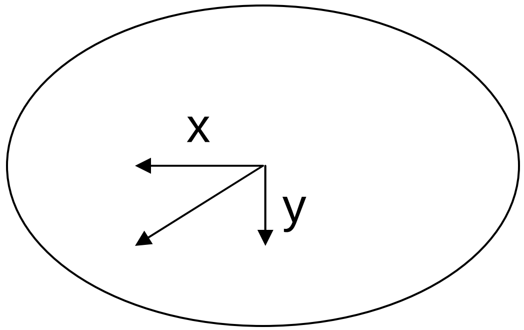
The solid fit line fits almost exactly over the data. The dashed fit line is almost as good.

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



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





50% power has a dB reduction of -10 $\log_{10}$ .50 = -3.01 3.3 deg m=1.0

95% power has a dB reduction of -10 $\log_{10}$ .05 = -13.01 6.6 deg m=2.0

99% power has a dB reduction of -10 $\log_{10}$ .01 = -20.00 10.0 deg 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

Digital Elevation Model for this Study

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

Radiative Transfer

- CRTM
- Fastem-3 ocean, NESDIS emissivity land
- GDAS 0.5 degree resolution output
- Look for GDAS land and sea points nearest to centroid
- Integrate power/land fraction over fov
- Assume land and sea skin temperature homogeneous

Radiative Transfer continued

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

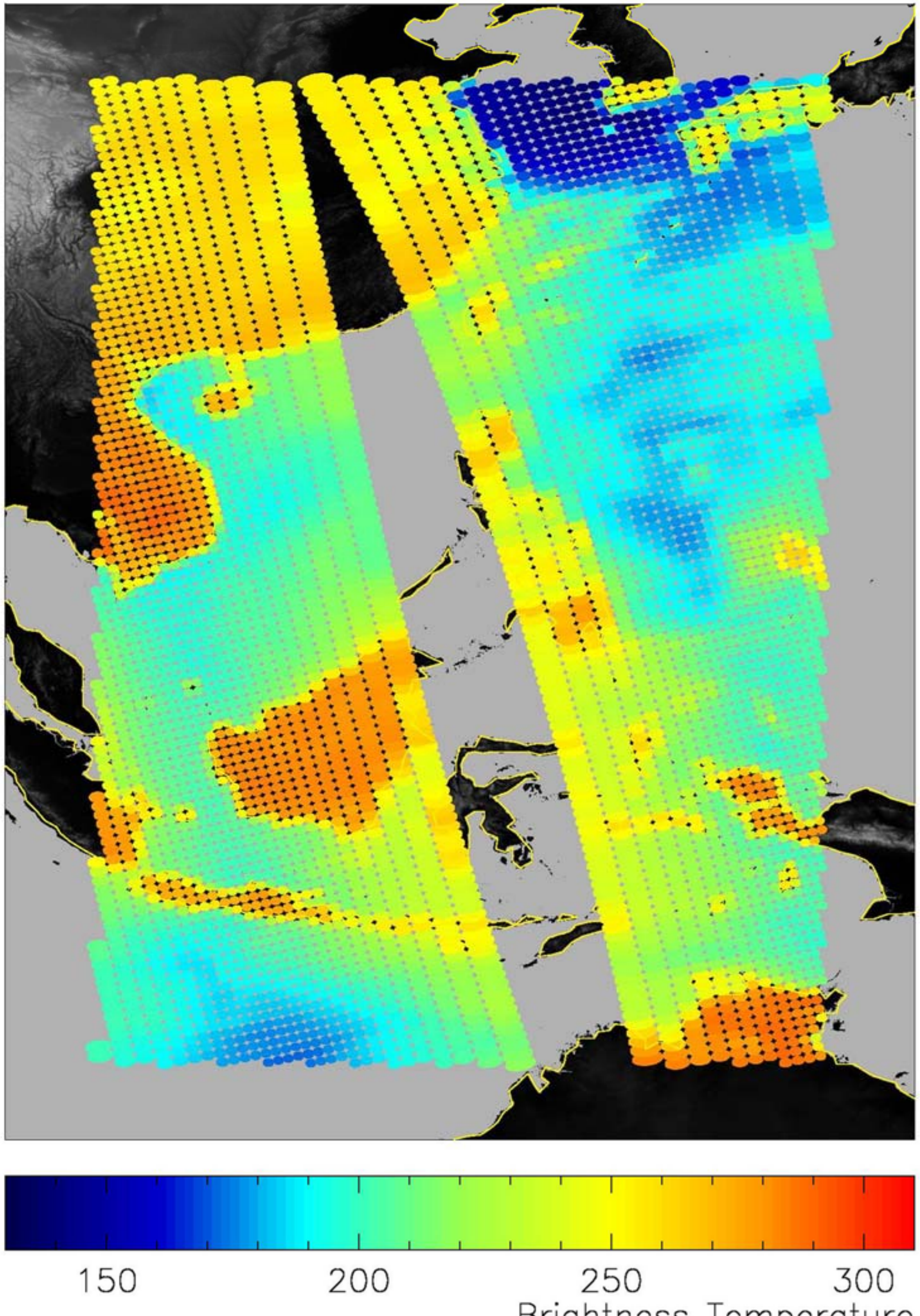
$$= \hat{\Phi} \int_L \Phi(L) T_R(L) dL + \hat{\Phi} \int_S \Phi(S) T_R(S) dS$$

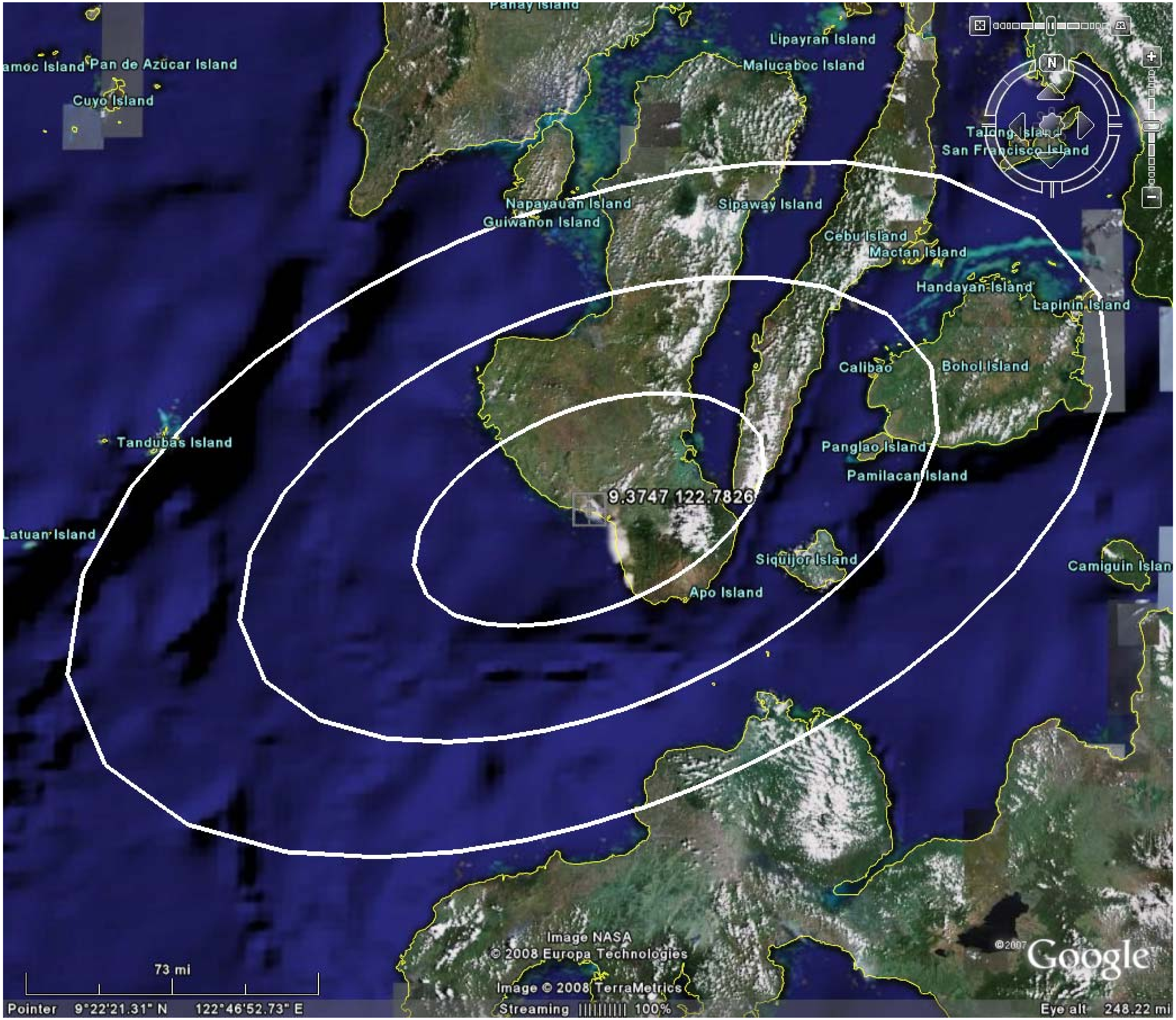
$$= T_{R\,L}\, \hat{\Phi} \int_L \Phi(L) dL + T_{R\,S}\, \hat{\Phi} \int_S \Phi(S) dS$$

Land Power Fraction Ocean Power Fraction

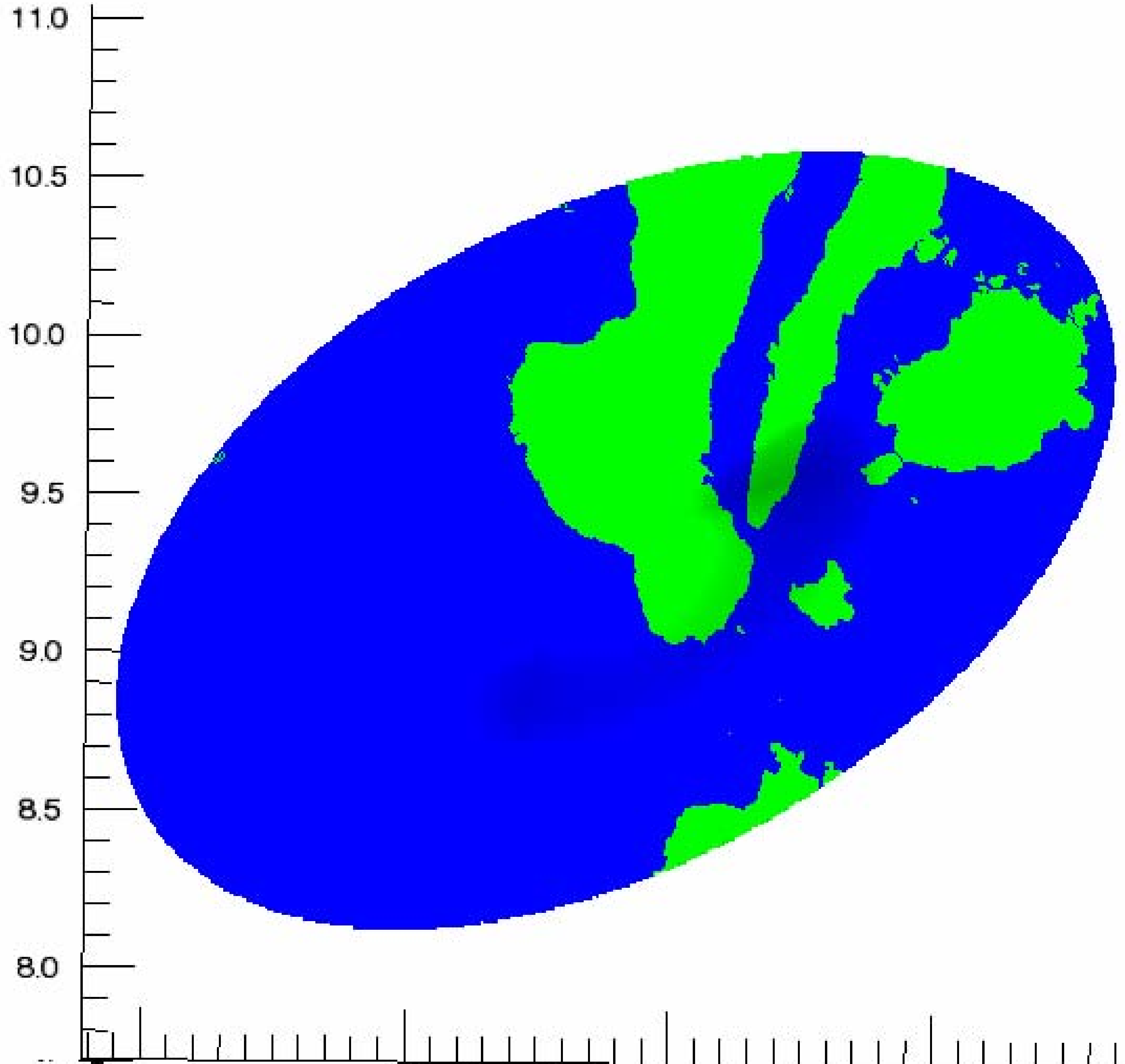
Power Fraction = Fraction of total antenna power within fov allocated to each surface type

Area of Interest

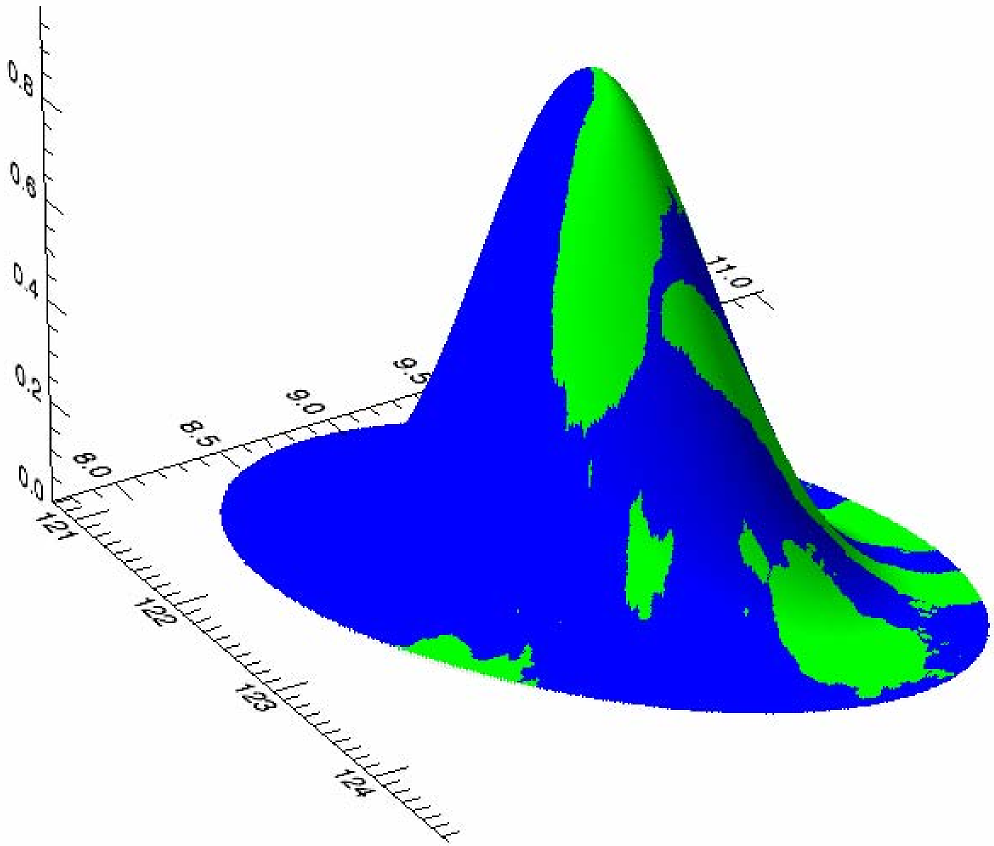




Panay Island
amoc Island
Pan de Azúcar Island
Cuyo Island
Lipayran Island
Malucaboc Island
Talong Island
San Francisco Island
Napayauan Island
Guiwanon Island
Sipaway Island
Cebu Island
Mactan Island
Handayan Island
Lapinin Island
Calibao
Bohol Island
Tandubas Island
Panglao Island
Pamilacan Island
9.3747 122.7826
Latuan Island
Siquijor Island
Camiguin Islan
Apo Island
Image NASA
© 2008 Europa Technologies
Image © 2008 TerraMetrics
©2007 Google
73 mi
Pointer 9°22'21.31" N 122°46'52.73" E
Streaming 100%
Eye alt 248.22 mi



11.0
10.5
10.0
9.5
9.0
8.5
8.0


0.8
0.6
0.4
0.2
0.0
8.0
8.5
9.0
9.5
11.0
121
122
123
124

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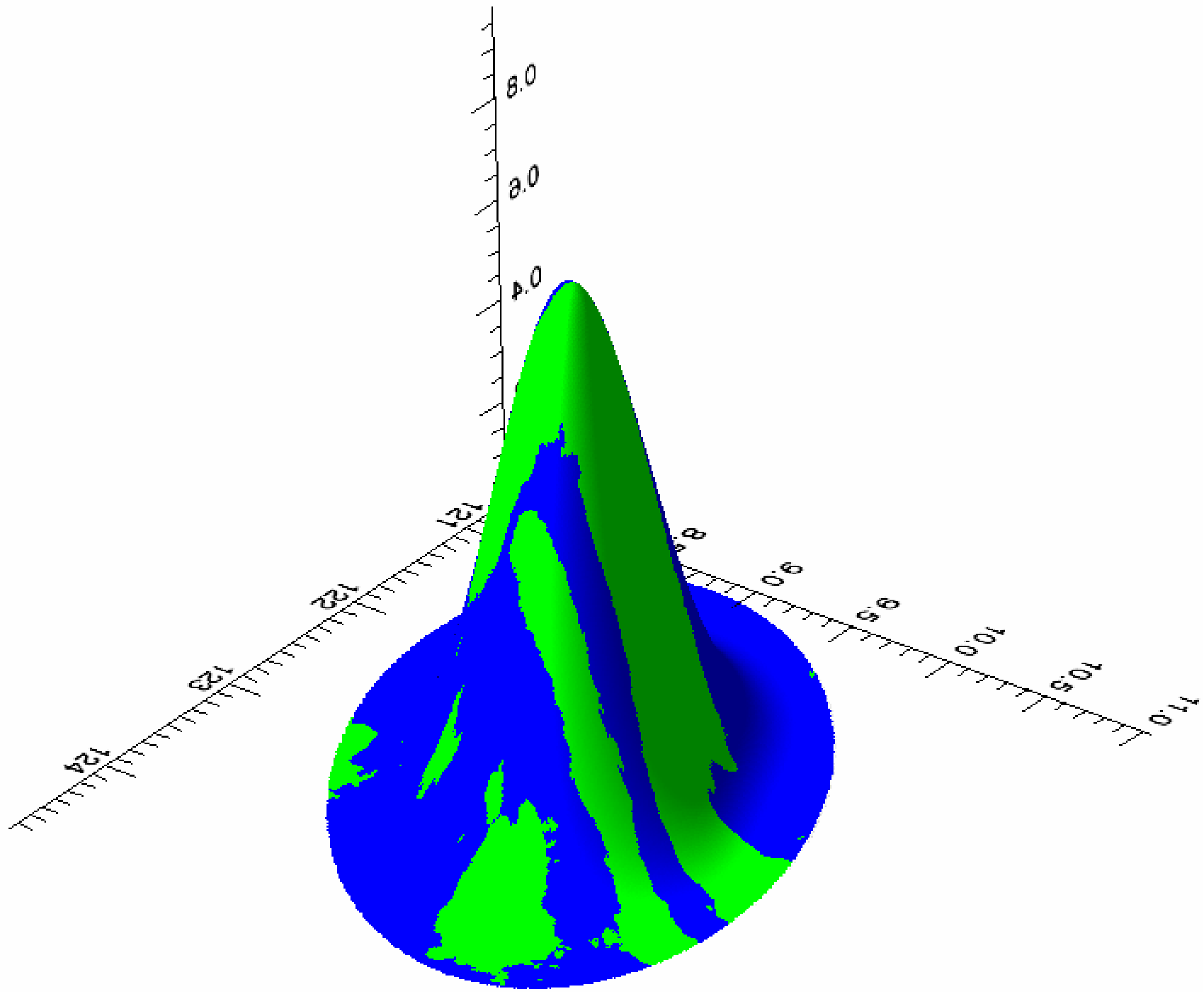
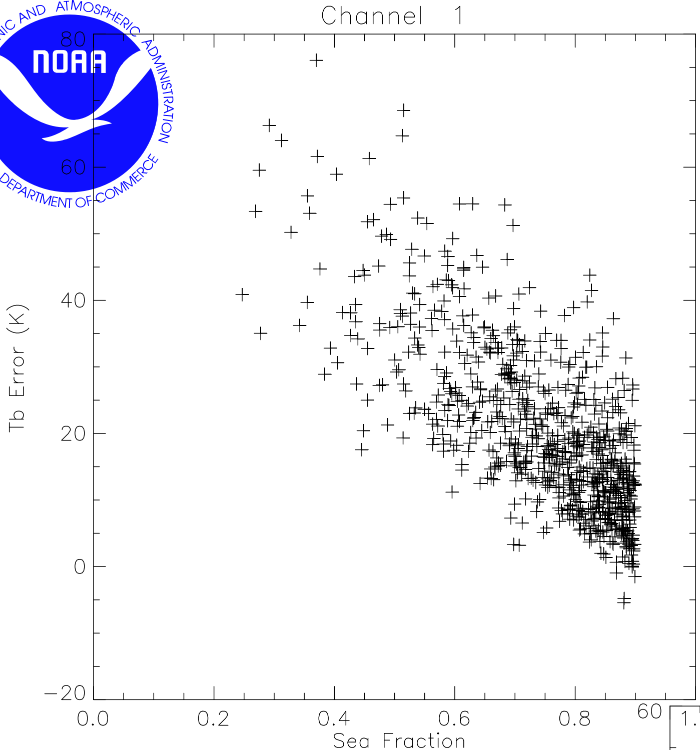


Example Tb Differences

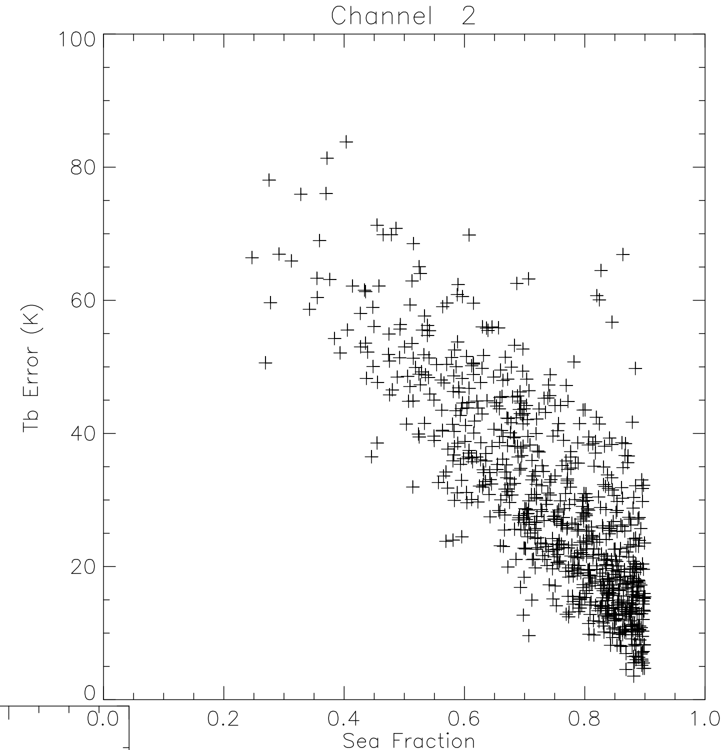
TB_land = 280 TB_sea = 210

	Land Fraction	Sea Fraction	Land Power Fraction	Sea Power Fraction	Tb
99%	0.238	0.761	0.358	0.641	235.13
95%	0.301	0.698	0.371	0.628	236.01
50%	0.480	0.522	0.488	0.512	244.16

Thanks to Paul vanDelst for suggesting this comparison

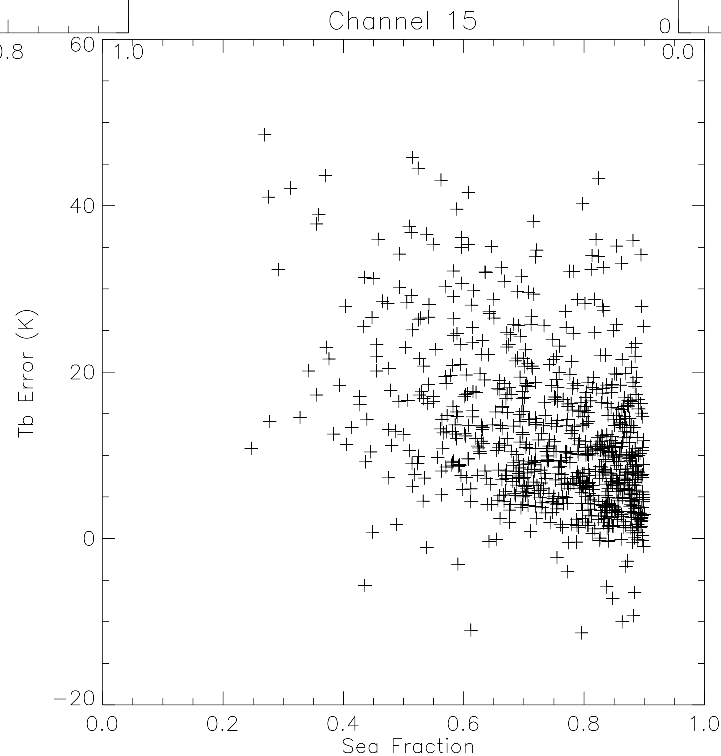


Sea Mean 20.56 Stdev 12.55

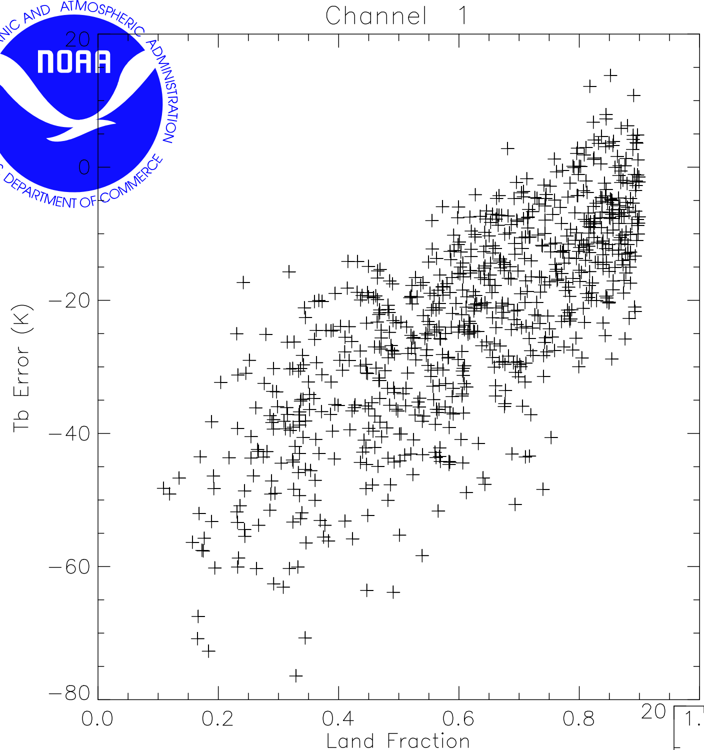


Sea Mean 29.44 Stdev 15.20

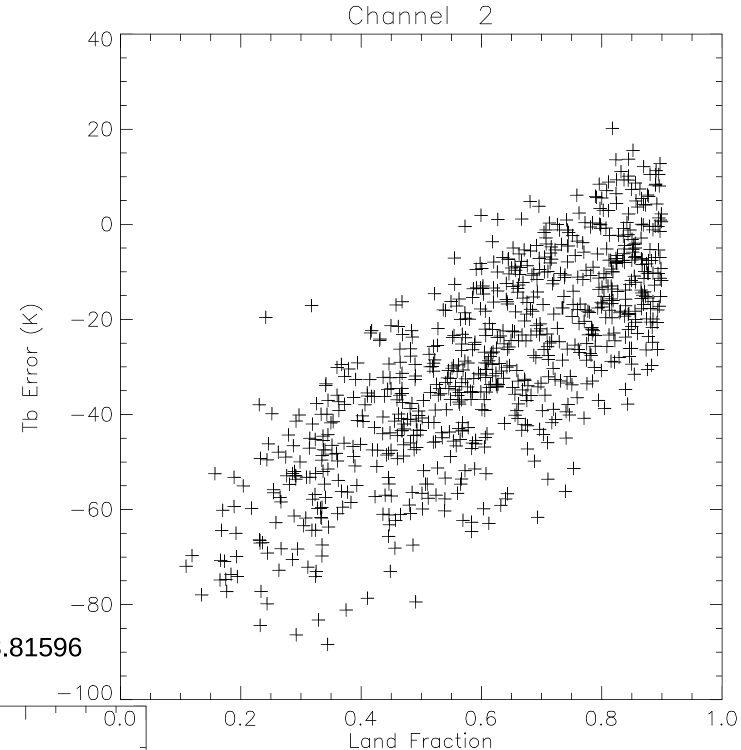
Sea Mean 12.33 Stdev 9.39



Tb Errors in coastlines when assuming Ts is ocean

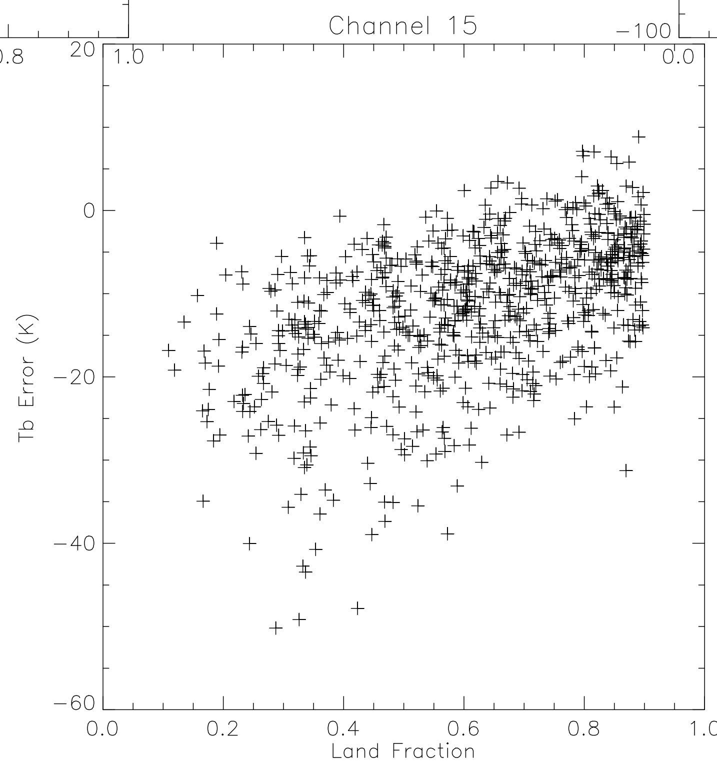


Land Mean -22.64 Stdev 15.65

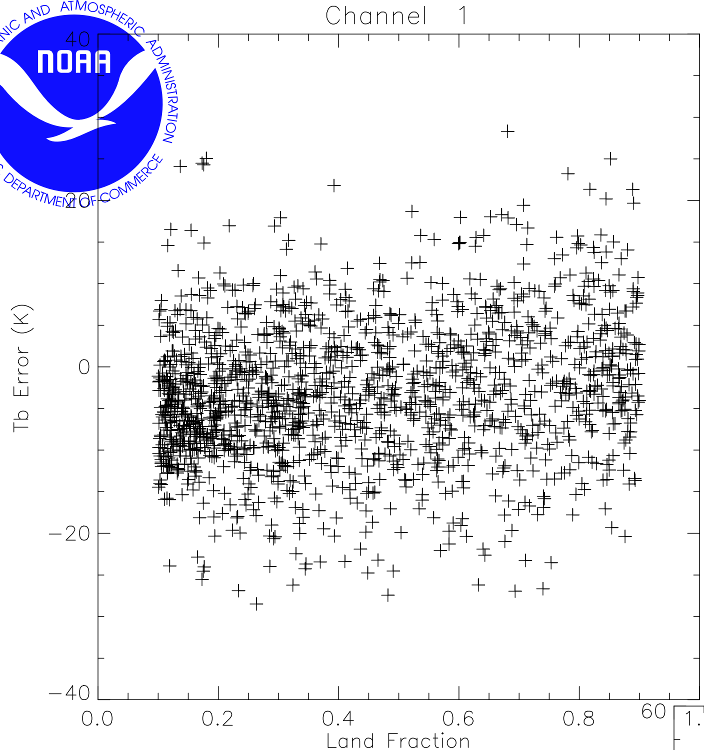


Land Mean -28.41 Stdev 21.00

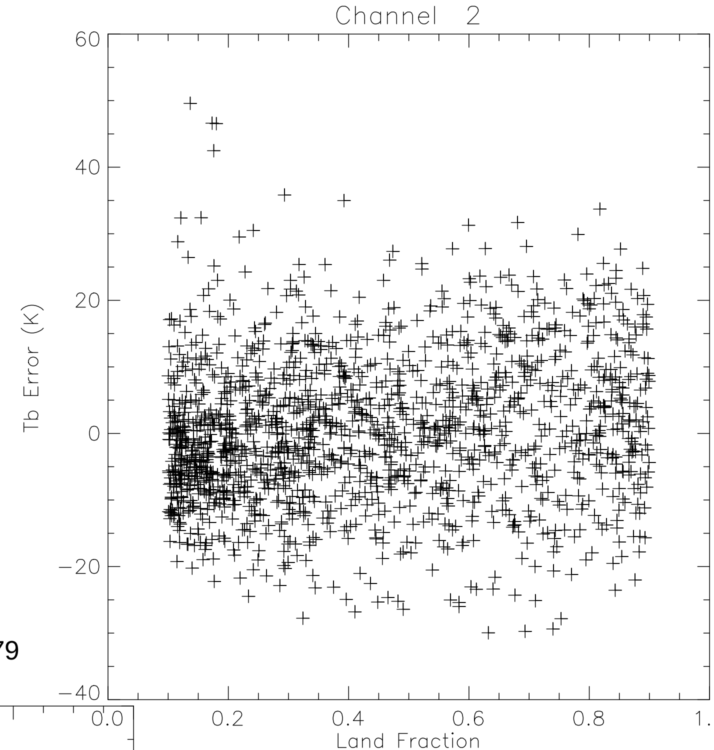
Land Mean -11.5600 Stdev 8.81596



Tb Errors in coastlines when assuming Ts is land

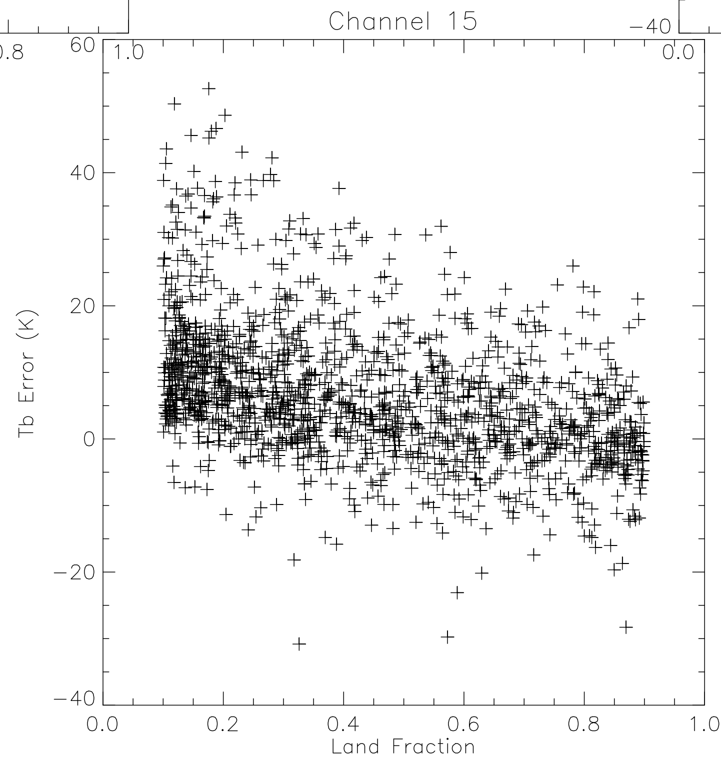


mean,std -3.13347 8.26933



mean,std 0.396287 10.9891

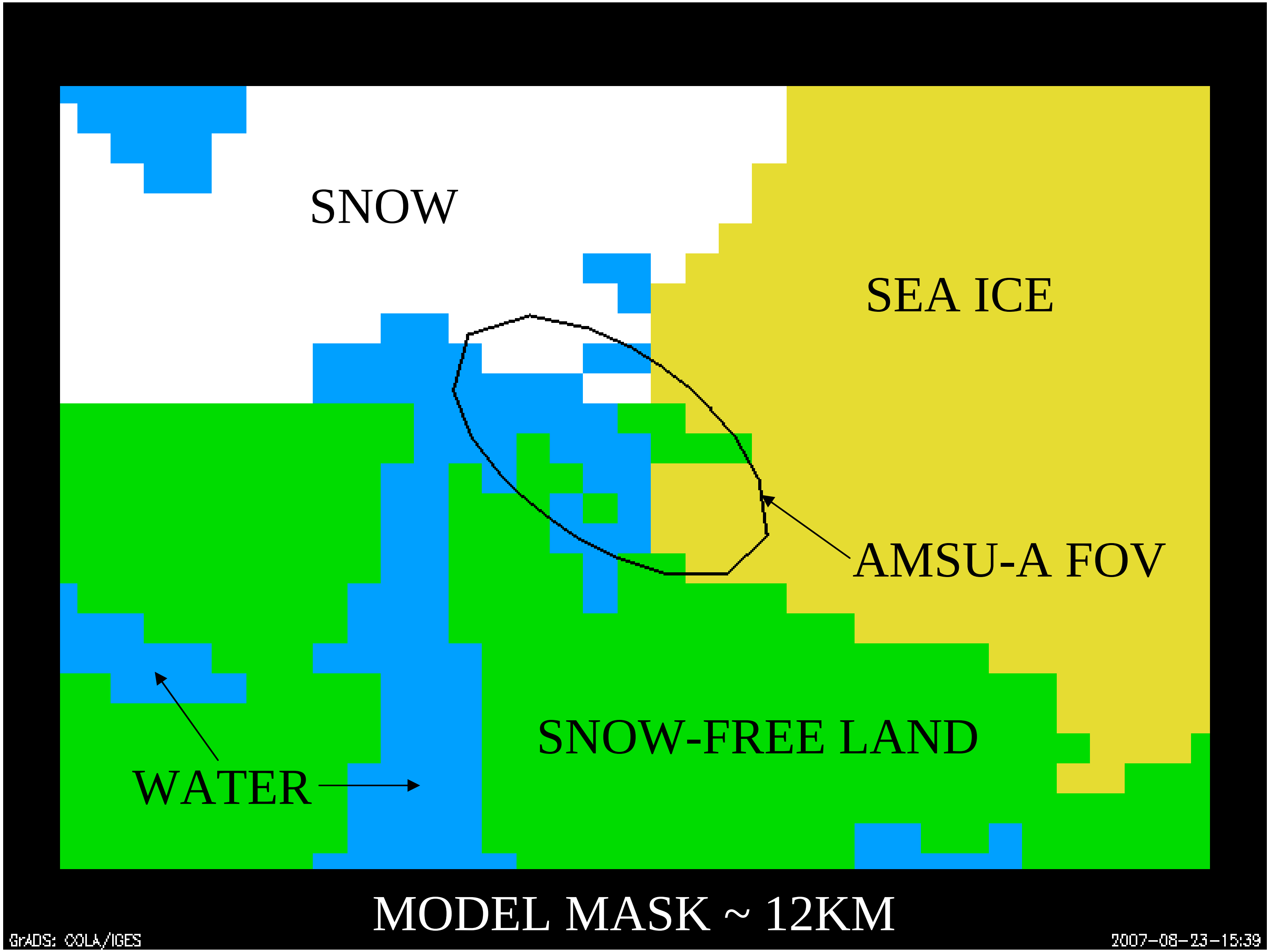
mean,std 6.70169 10.3979



Tb Errors in coastlines with mixed fov

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

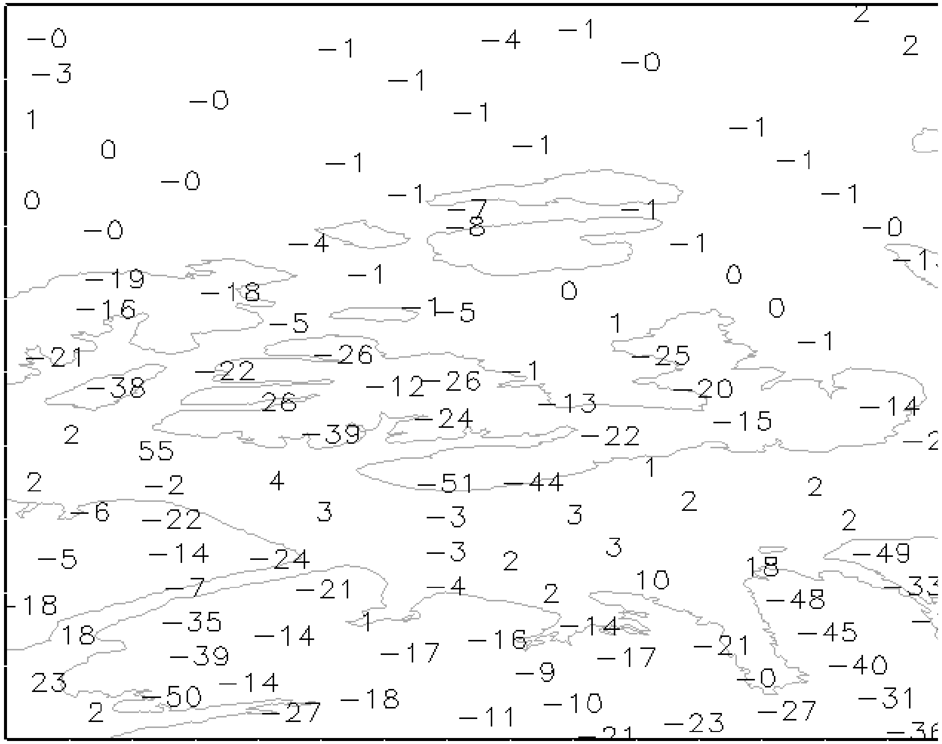
- Use the above described methods to determine the various land/ water/ snow/ sea ice fractions and pass to CRTM
- Preliminary results in the following slides from George Gayno, NCEP/EMC/JCSDA/SAIC


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

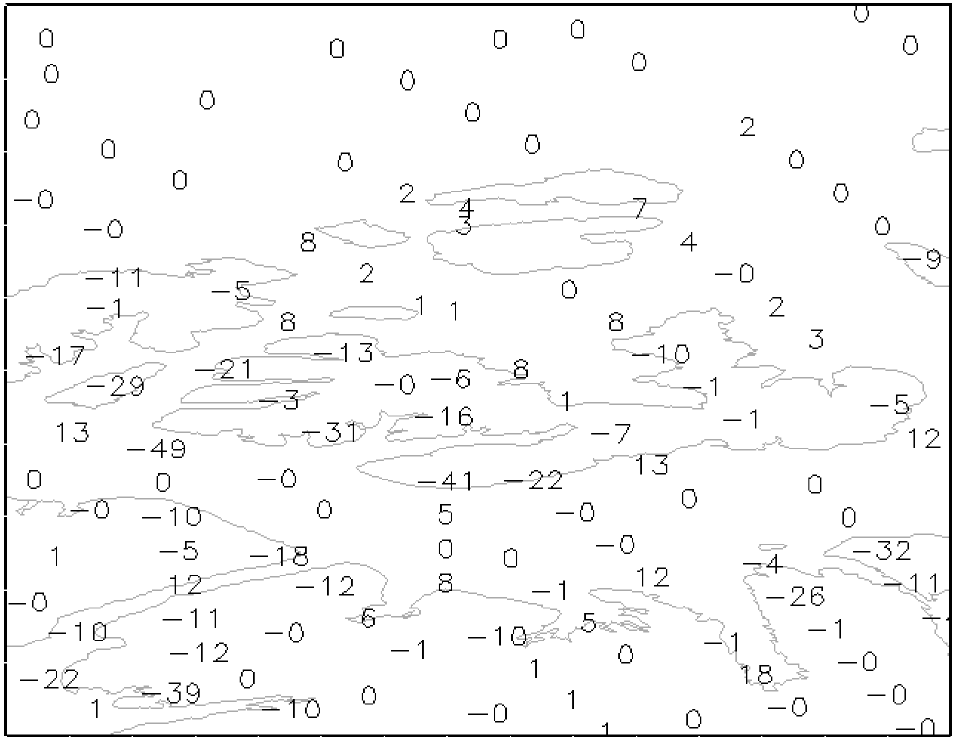
EX: NOAA-15 AMSU-A, CHANNEL 2

CONTROL: OBS. MINUS GUESS T_b



NORTHERN CANADA

IMPACT: CHANGE IN OBS. MINUS GUESS T_b



NEGATIVE IS IMPROVEMENT

Potential Improvements

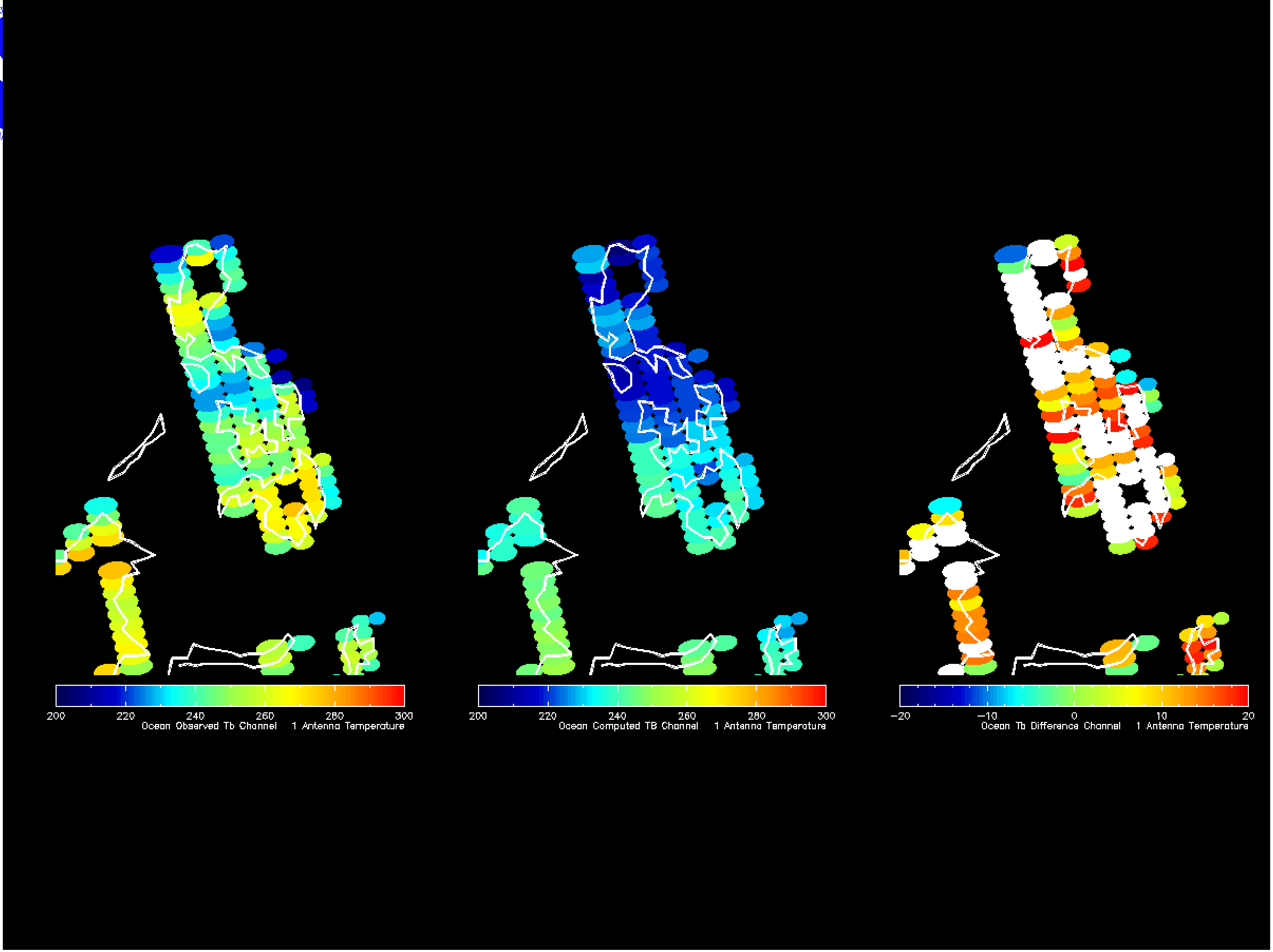
- Work shown here uses the nominal fov centroid zenith angle. It would be better to use the actual angles within the fov.
- Fit each channel independently
- Fit as a function of scan position
- …

This is preliminary work

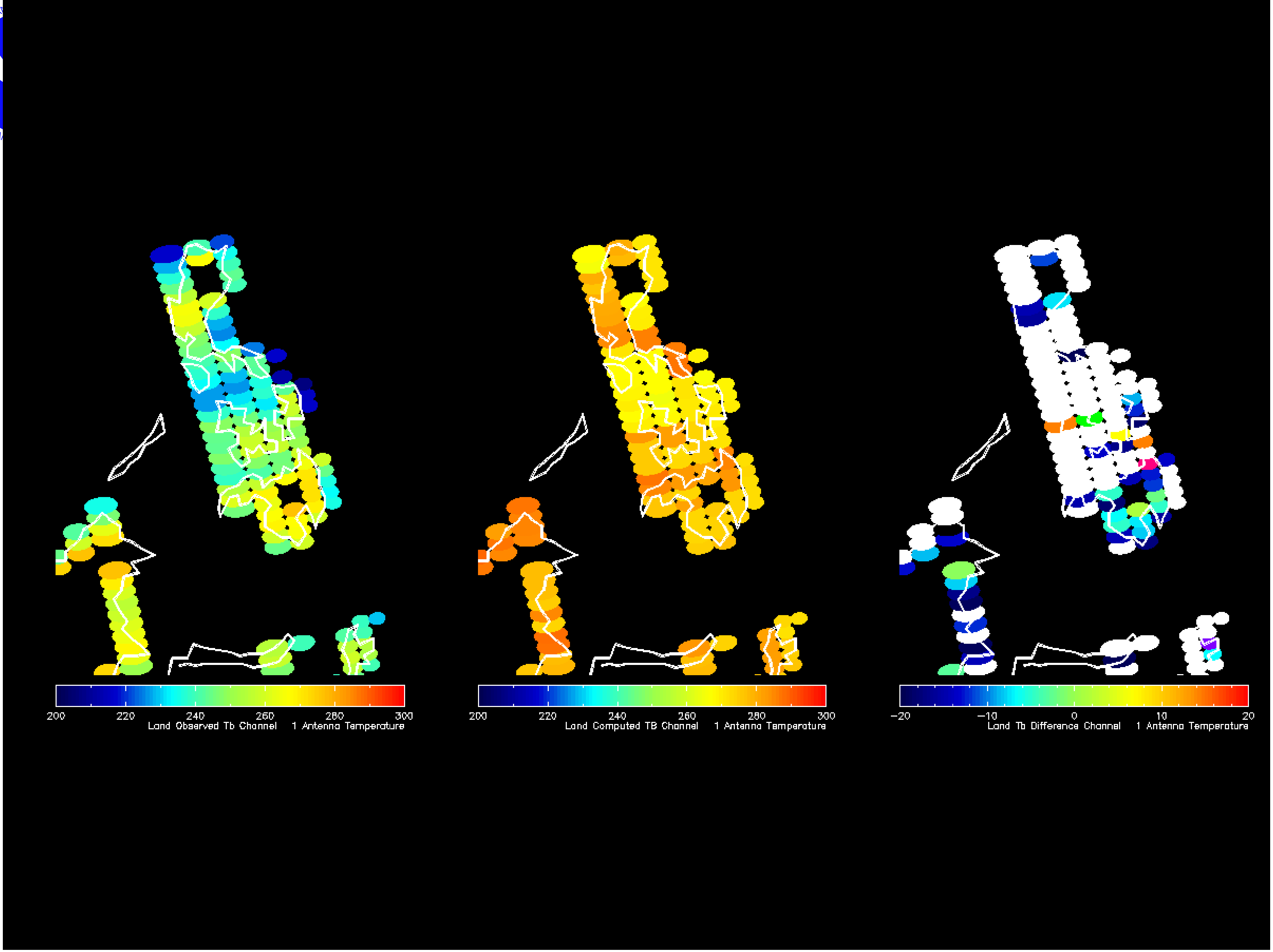
Summary and Discussion

- 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

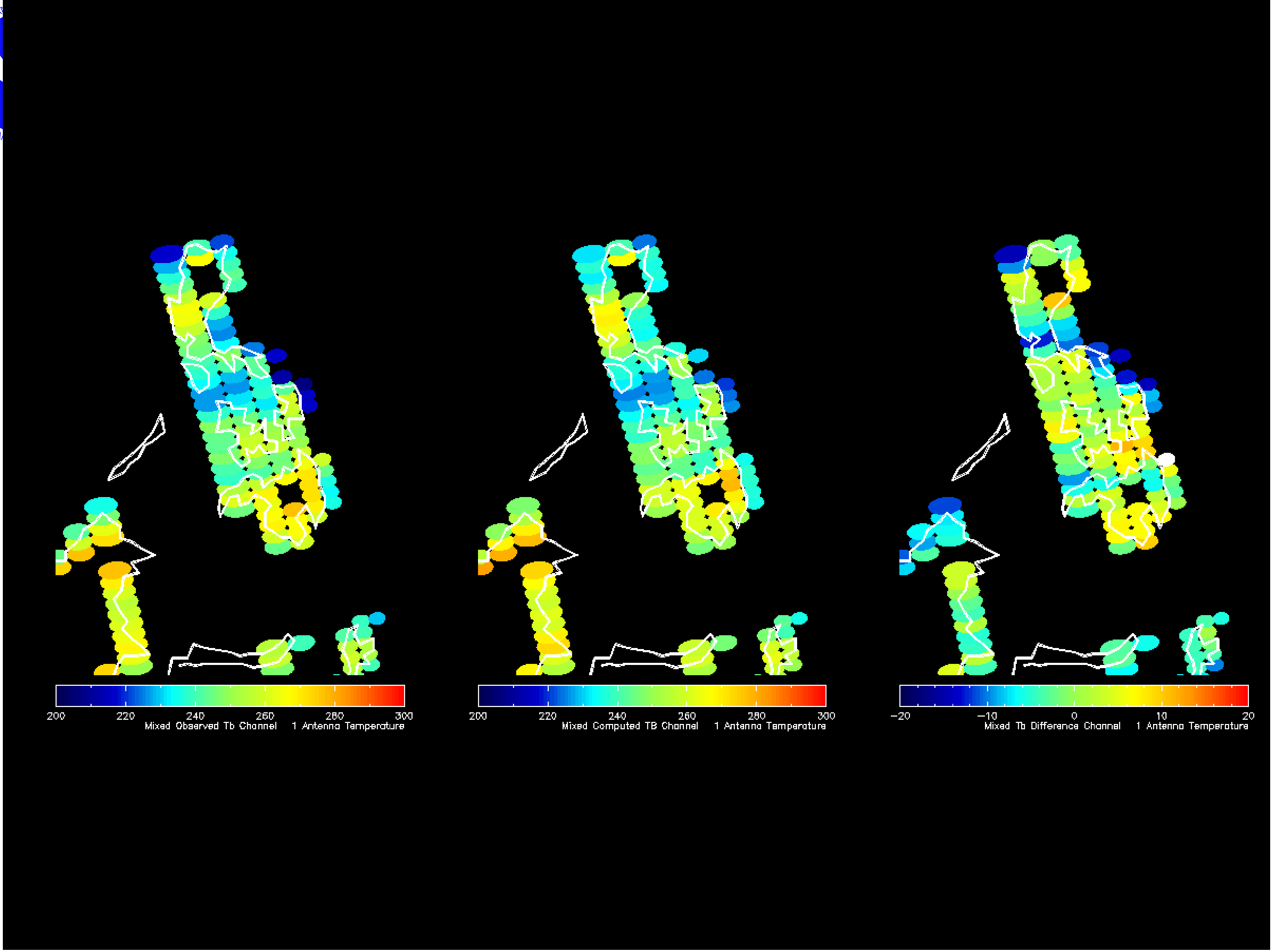
Back up slides



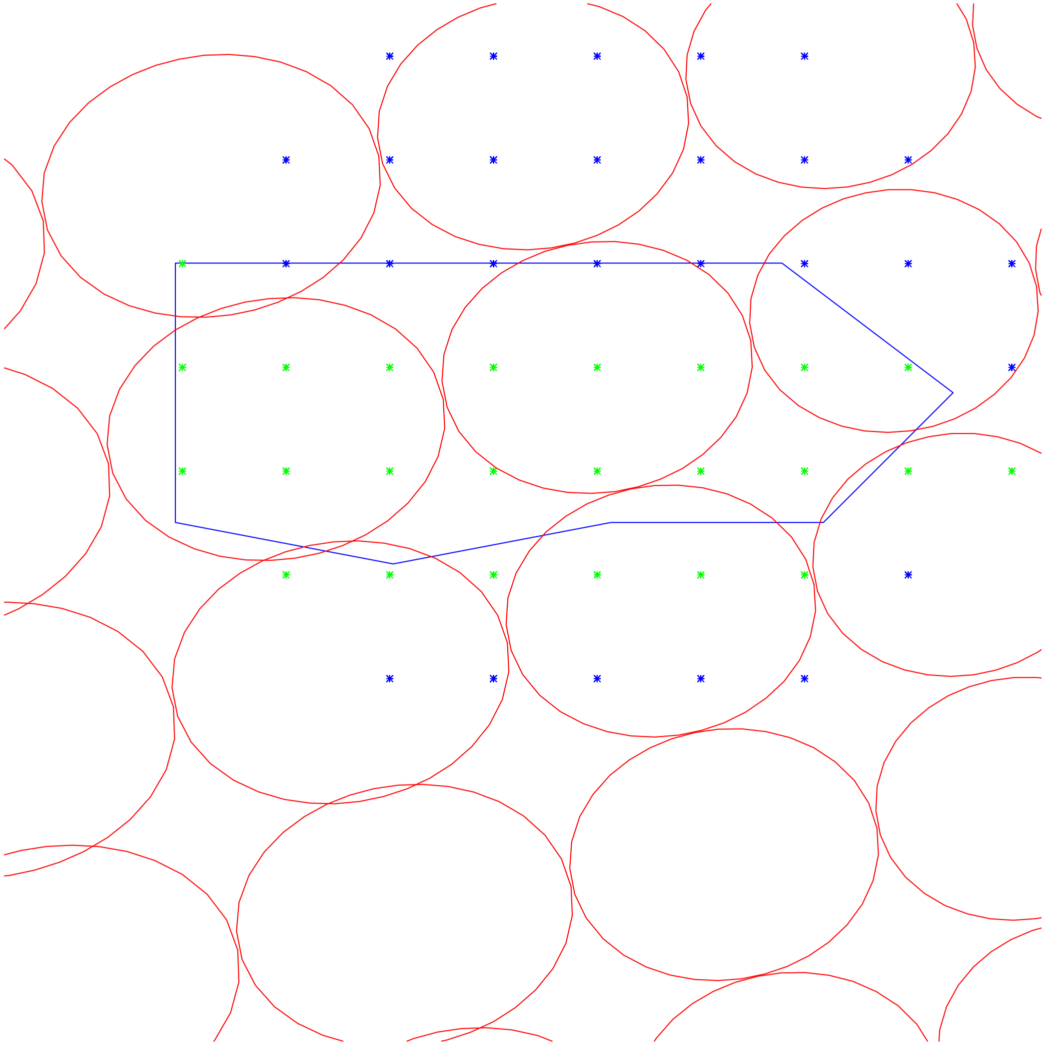
Ocean Temperature



Land temperature

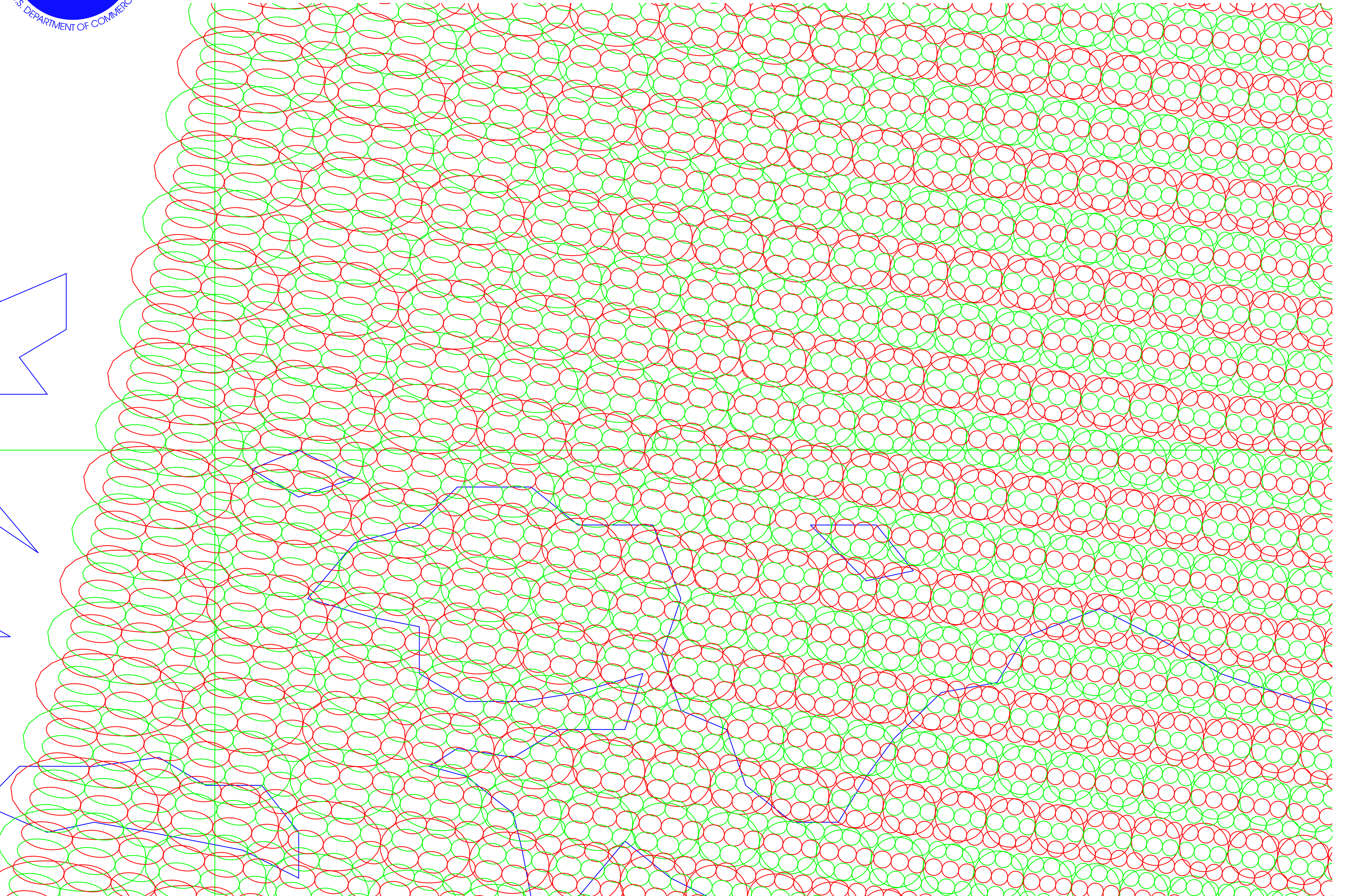


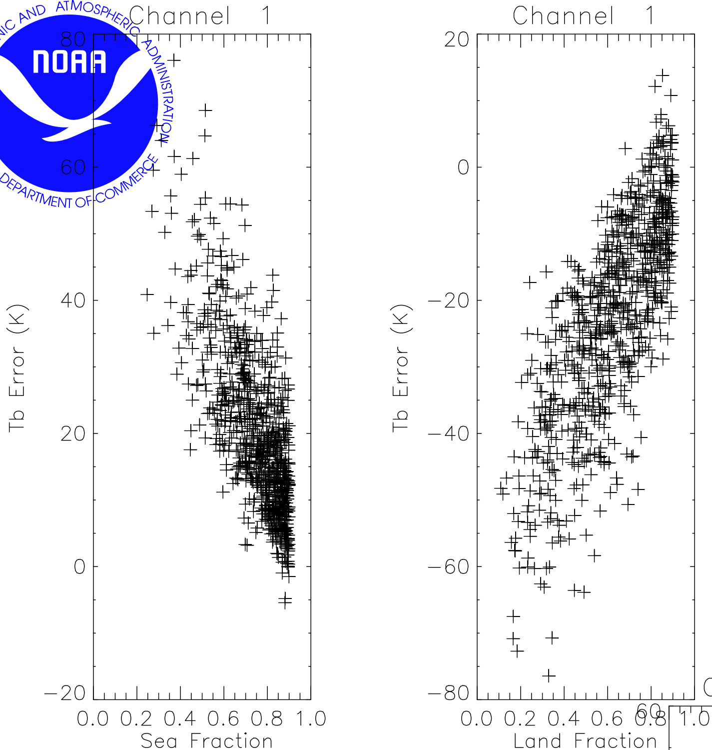
Mixed temperature



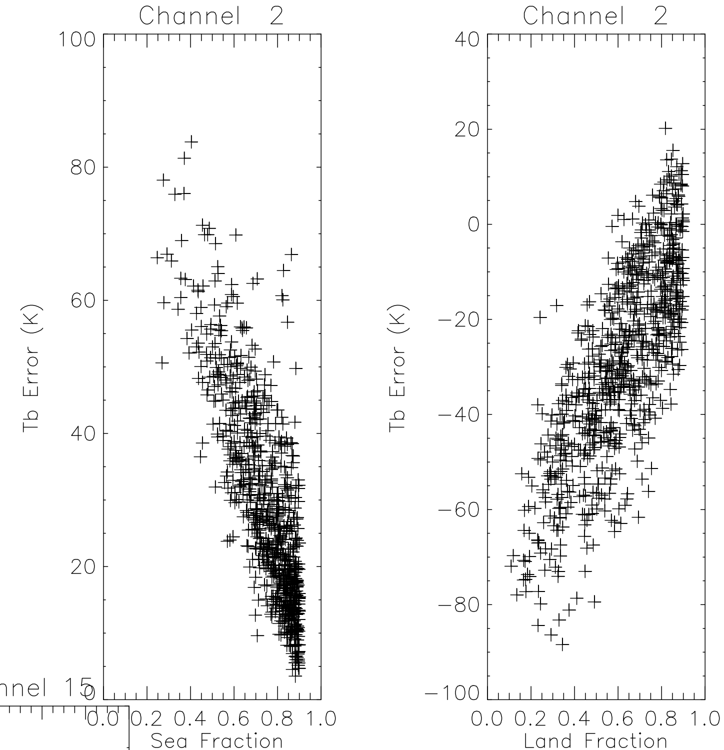
This is a first attempt with idl, using it's lores coastline (we don't have the CIA hires coastline, and using the F:\landsea\global.eighth, which is clearly not up to the task.

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

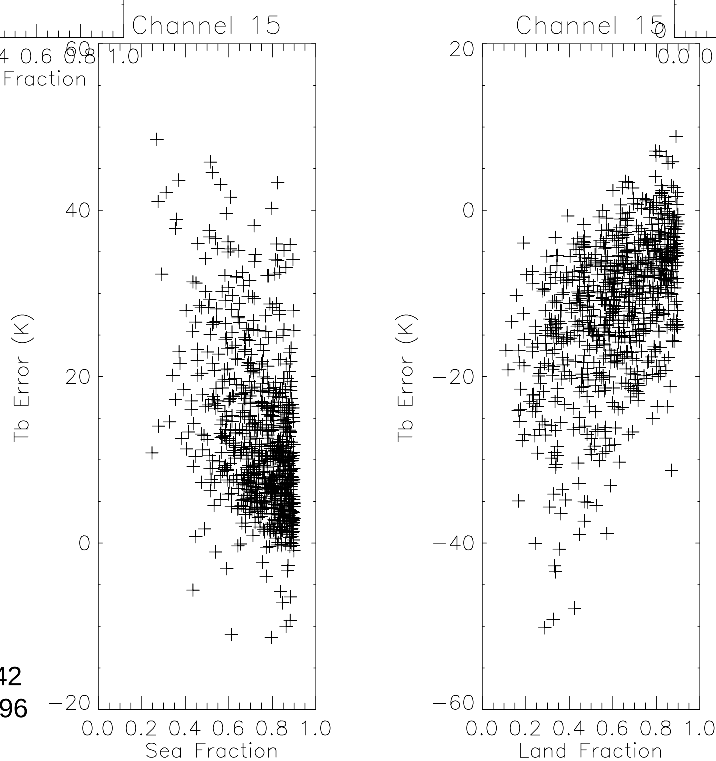




Sea Mean 20.5556 Stdev 12.5523
Land Mean -22.6450 Stdev 15.6544



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