Microwave Radiometer (MWR) Beam-Pointing Validation for the Aquarius/SAC-D Mission

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ABSTRACT

This poster concerns the on-orbit validation of the antenna beam pointing and corresponding instantaneous field of view (IFOV) earth location for the CONAE Microwave Radiometer (MWR). The MWR is a three-channel radiometer, which has two multi-beam parabolic reflector antennas in a pushbroom configuration, with eight beams per frequency (36.5 GHz looking forward and 23.8 GHz looking aft producing 24 simultaneous beams). The scene brightness temperature is dependent upon the earth incidence angle, and MWR retrieval algorithms require good IFOV collocation between channels. Thus, knowledge of the MWR antenna beam footprint geolocation is important to mission success.

As a result, this poster presents results of an on-orbit validation of the MWR antenna beam pointing and comparison with observed and calculated (geometric) MWR IFOV centers. This procedure compares CONAE-calculated IFOV centers at land/water crossings against high-resolution coastline maps. MWR IFOV locations versus time are computed from knowledge of the satellite's ephemeris, attitude (roll, pitch and yaw) and *a priori* measurements of antenna gain pattern boresight directions and mounting geometry.

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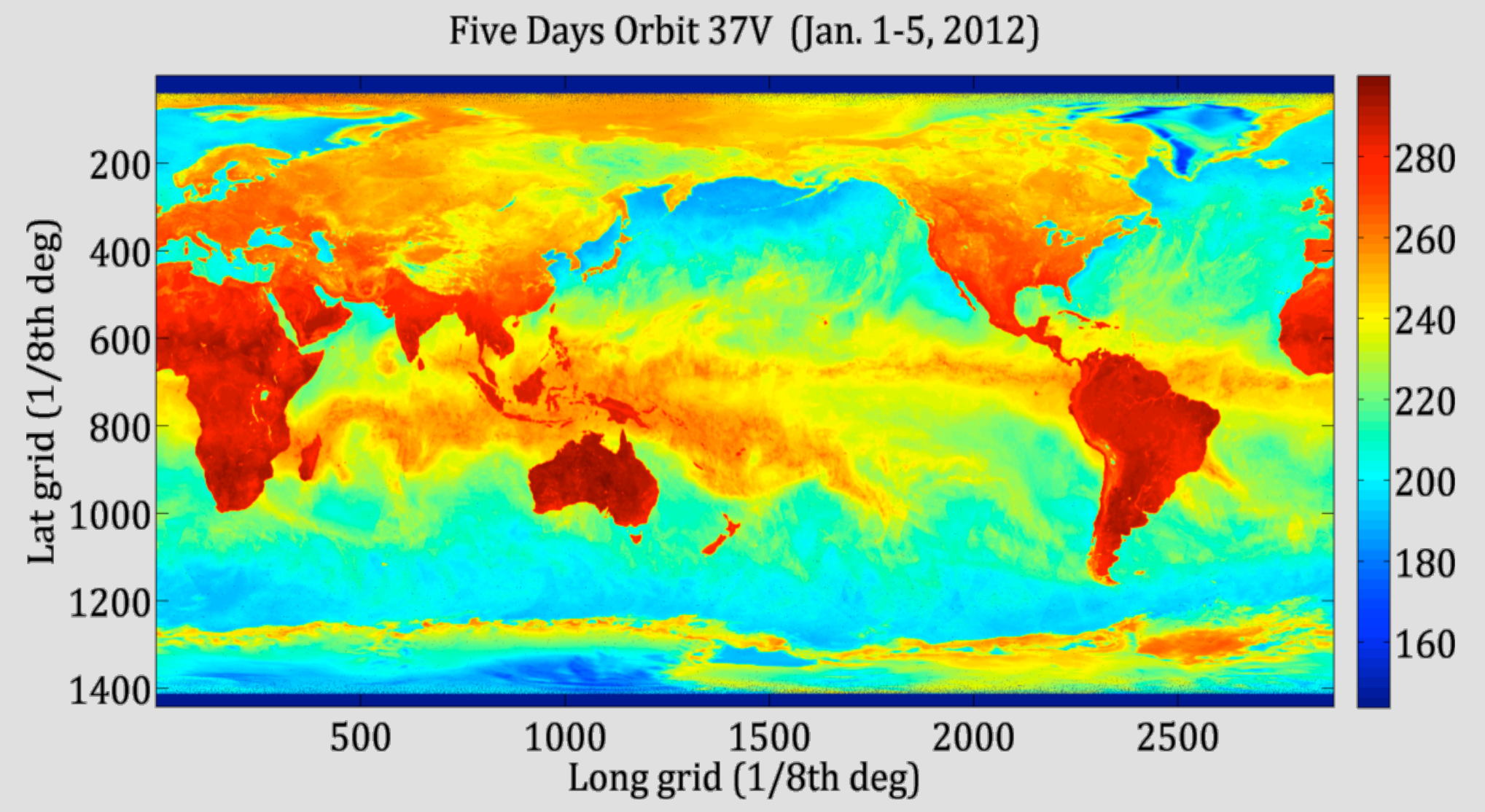
GEOLOCATION POINTING ERROR DETERMINATION

From a single orbit pass, is to:

- **Select a region (site) on the earth that represents an ideal crossing between ocean and land for a given antenna beam/pol**
  - Straight line coast with the absence of water (rivers, lakes, marshes, etc.) on the land side
- **Use MWR data - observed T_B (beam/pol) and calculated instantaneous field of view (IFOV) boresight**
  - Calculate the derivative of the T_B time series and determine the max slope $dTB/dsample$ location
  - Determine the lat/lng of this max-slope IFOV location, where the land/ocean beam-fill is 50%
- **Second technique uses simulated MWR T_B to determine max-slope location**
  - Simulated Gaussian beam pattern convolution with measured hi-resolution T_B image (WindSat)

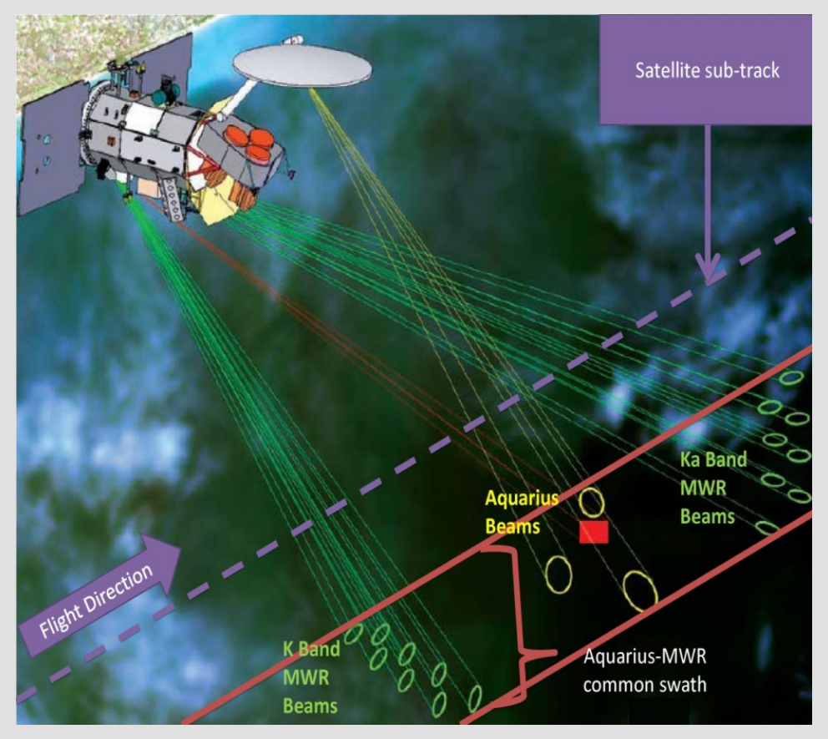
WINDSAT BRIGHTNESS TEMPERATURES

- Map generated from 1/8° lat/long gridding of collocated WindSat data



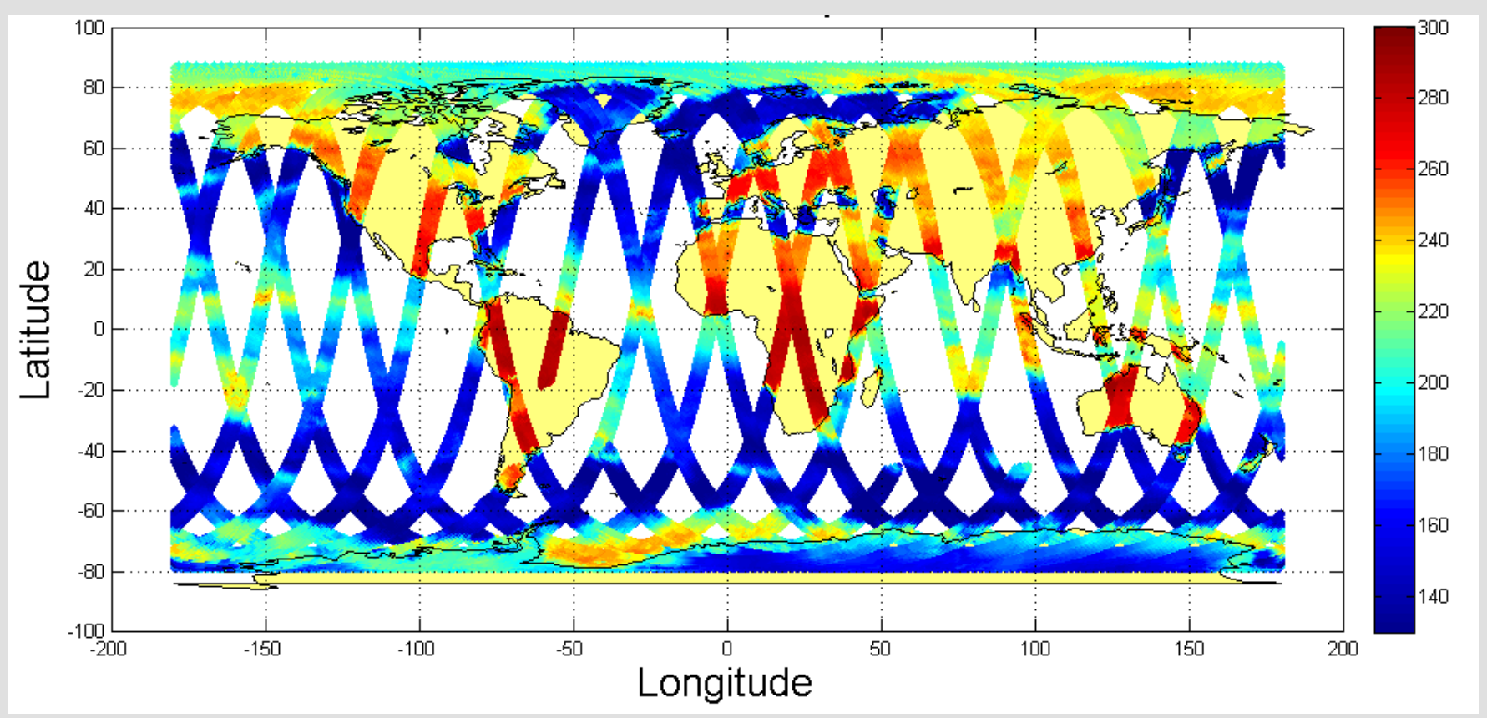
INSTRUMENT GEOMETRY

- 24 channel push-broom Dicke radiometer
  - 36.5 GHz H- & V-Pol (forward-look)
  - 23.8 GHz H-Pol (aft-look)
- Earth Incidence angle
  - 52° for odd beams
  - 58° for even beams
- Matches the AQ swath width of 380 km



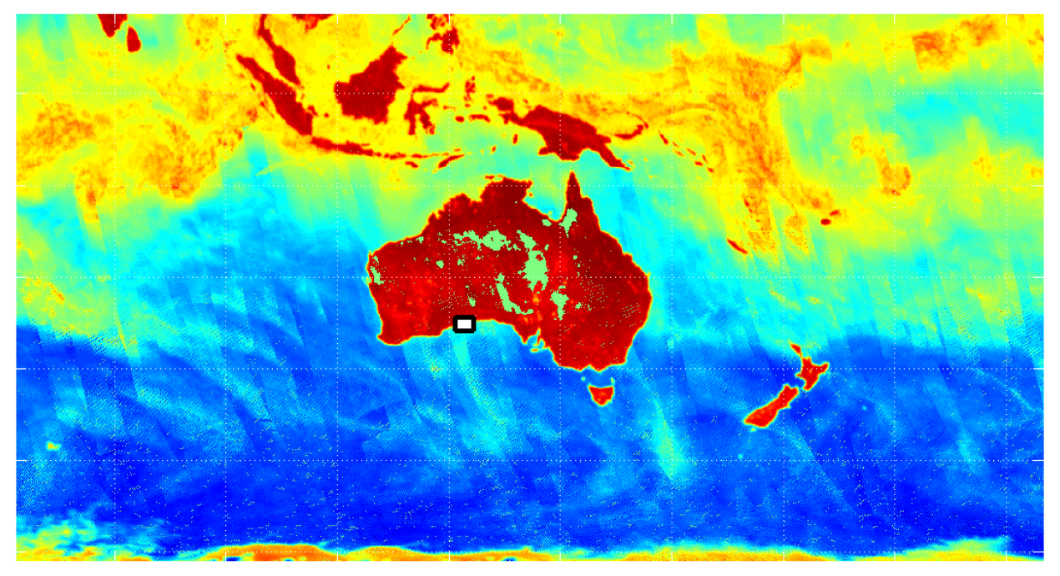
GEOLOCATION APPROACH

- High contrast brightness temperature (Tb) from ocean to land
- Maximum Tb slope occurs at coastline and indicates 'sensor observed' boundary

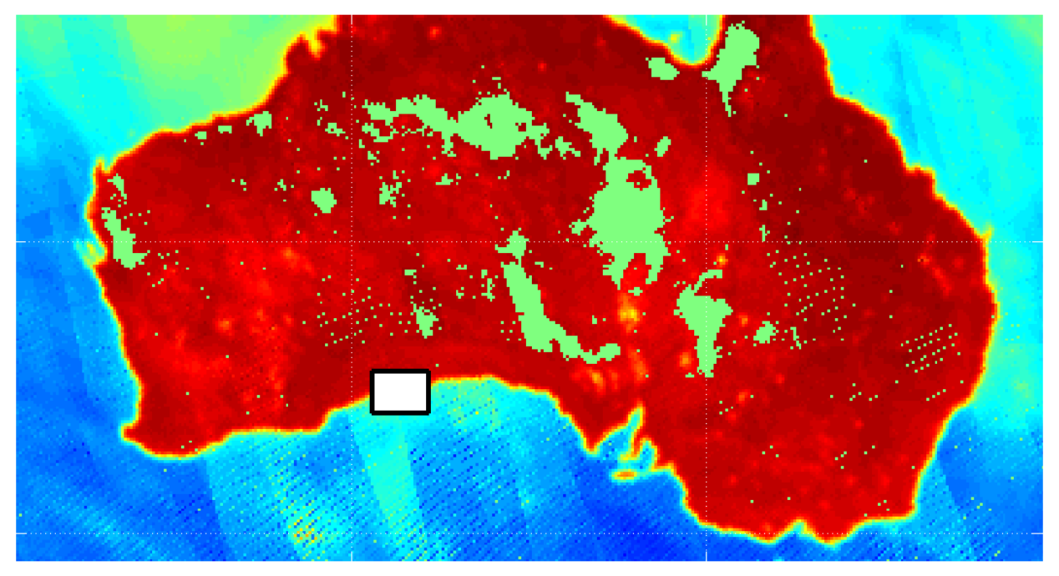


SITE SELECTION

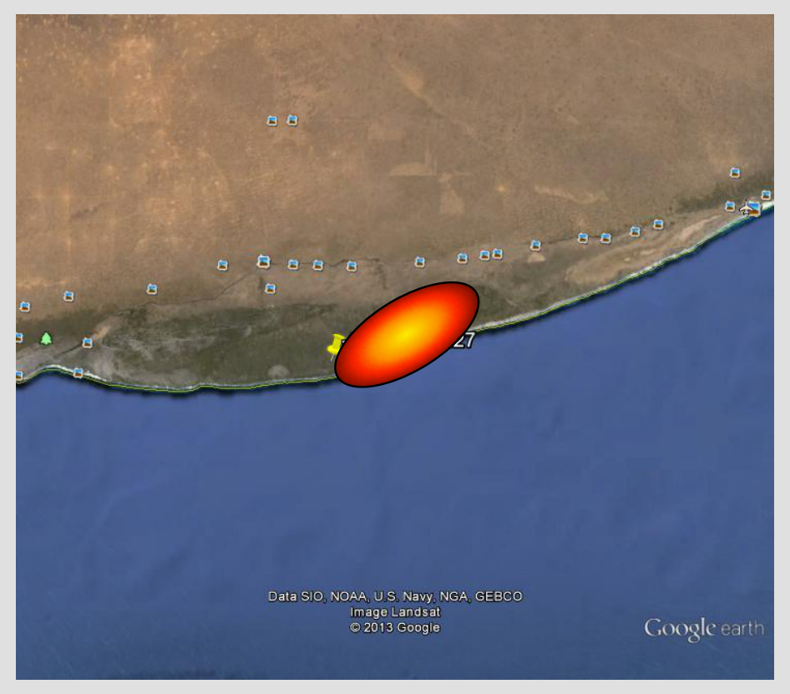
- Desirable sites for evaluation are relatively straight and free of human development
- Site is passed over once per week during the ascending or descending orbit segment



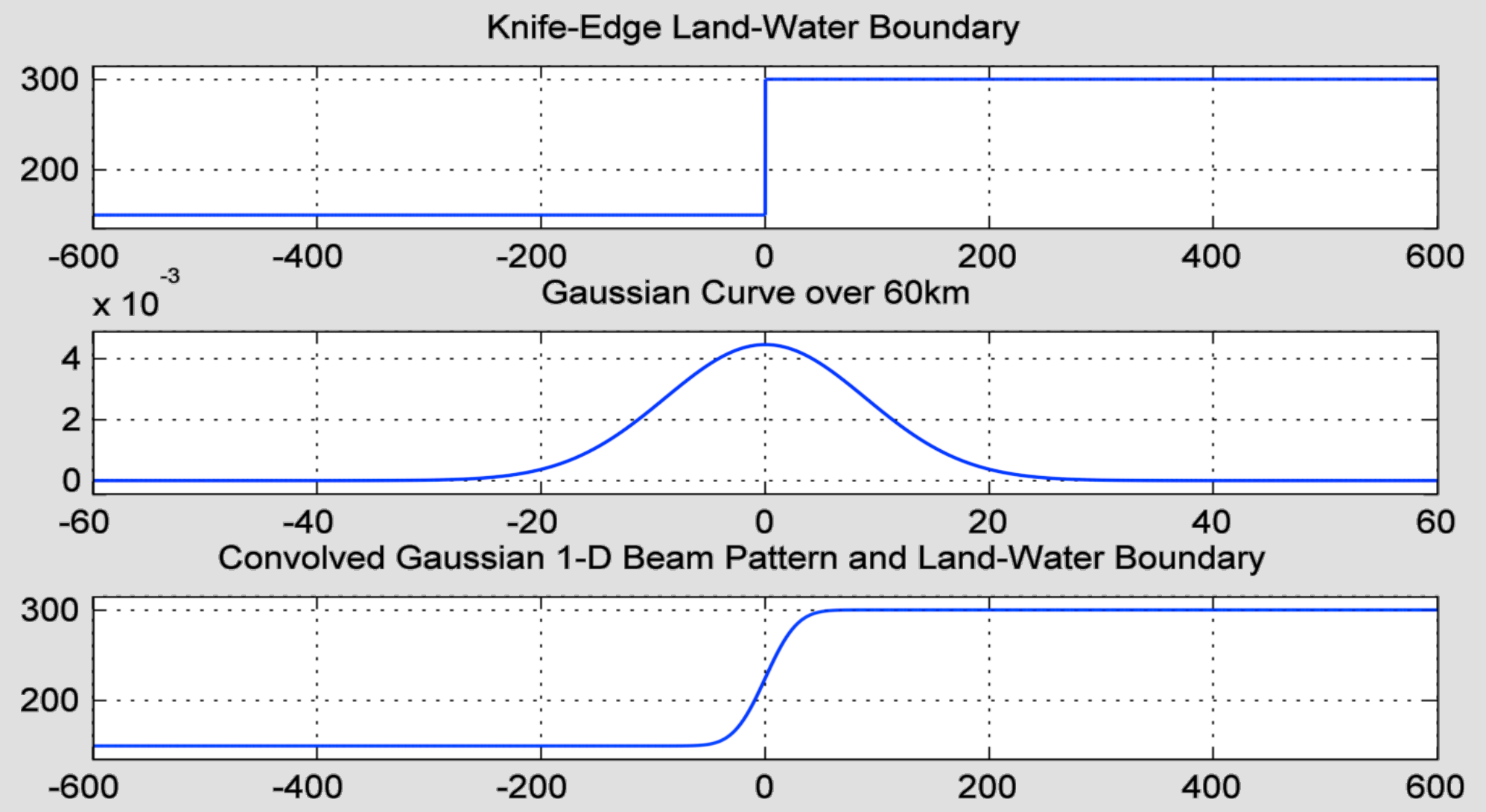
- AQ flies in a repeating ground-track orbit and every 103 orbits (~7 days) a selected site is sampled by MWR
- For this poster, a site on the southern coast of Australia is used



- The site Google Earth image is displayed with MWR IFOV shown (30km x 60km), which corresponds to a single land/water crossing



GAUSSIAN ANTENNA 1-D CONVOLUTION



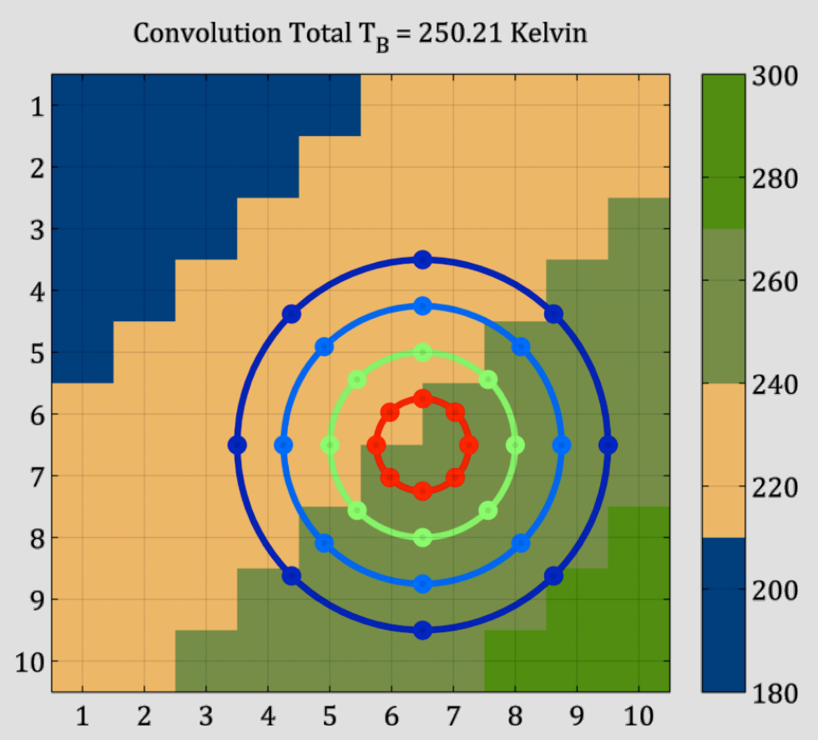
2-D CONVOLUTION

2-D Theoretical Convolution

$$T_A = \iint_{4\pi} T_{ap}(\theta,\phi) * F_n(\theta,\phi) * \sin\theta\, d\theta\, d\phi \;/\; F_n(\theta,\phi) * \sin\theta\, d\theta\, d\phi$$

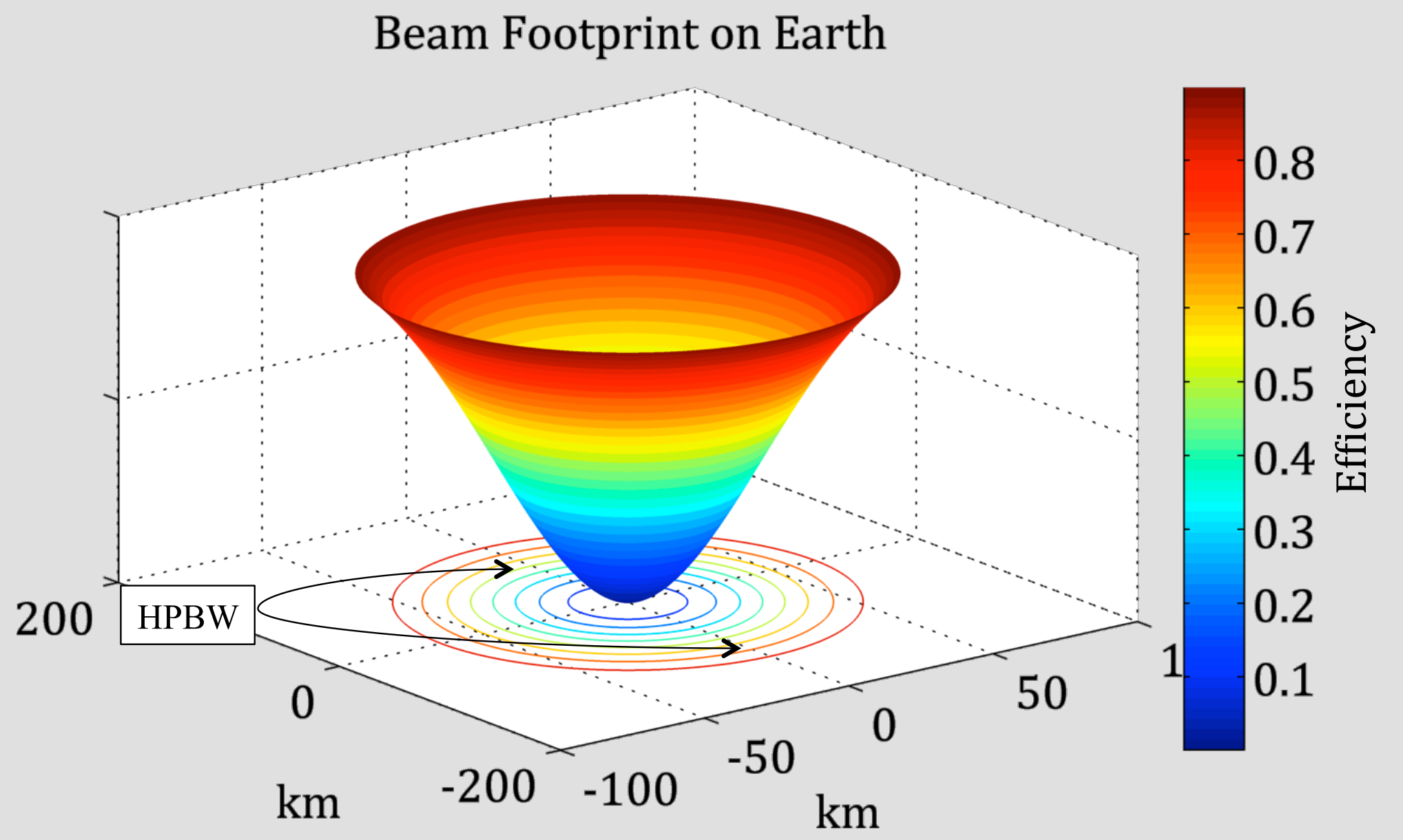
Practical Implementation

$$T_A = \sum_{\theta=0}^{2.5*HPBW} \sum_{\phi=0}^{360} T_{ap}(\theta)\, F_n(\theta) \;/ \sum_{\theta=0}^{2.5*HPBW} \sum_{\phi=0}^{360} F_n(\theta)$$



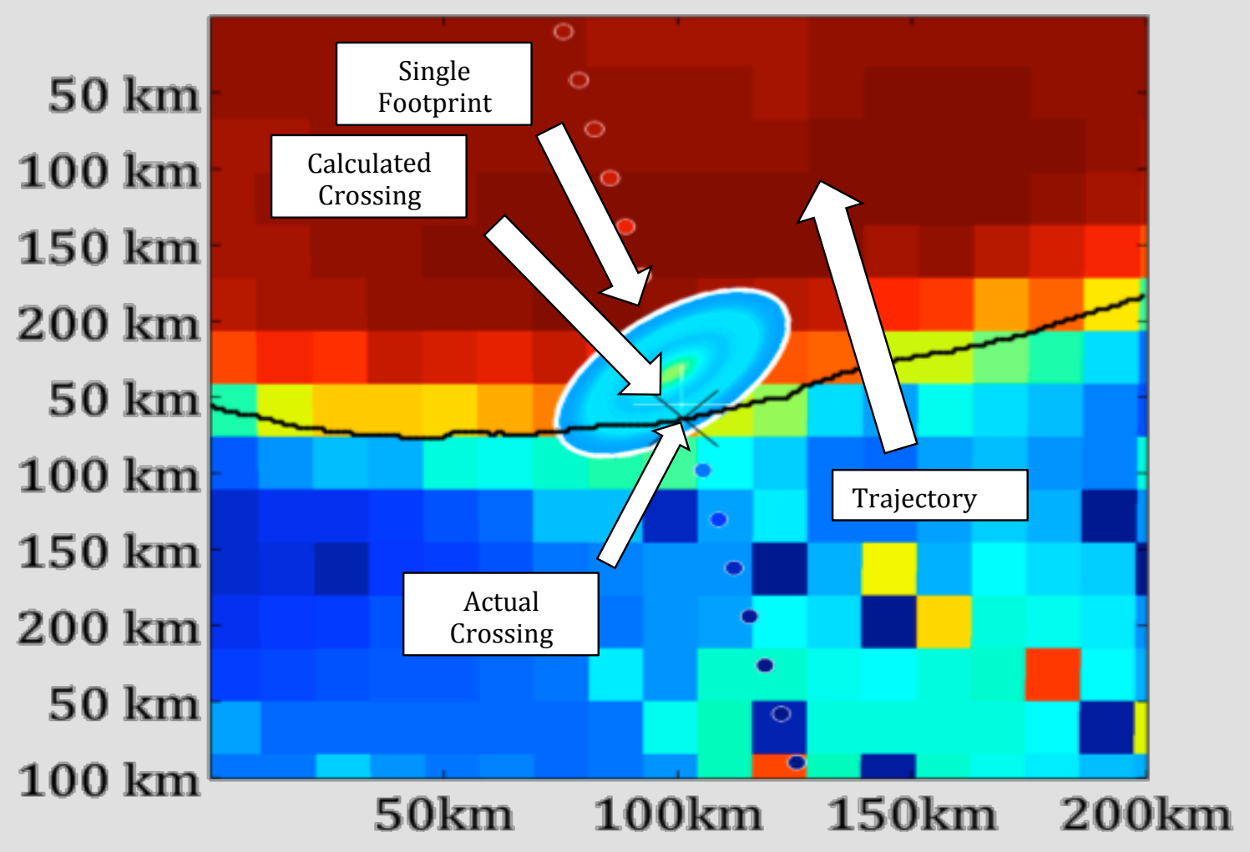
Convolution Example: the weighting of rings is proportional to the differential efficiency in the beam pattern; here a simplified circular Gaussian beam is illustrated.

MODELED GAUSSIAN 2.5*3dB PATTERN

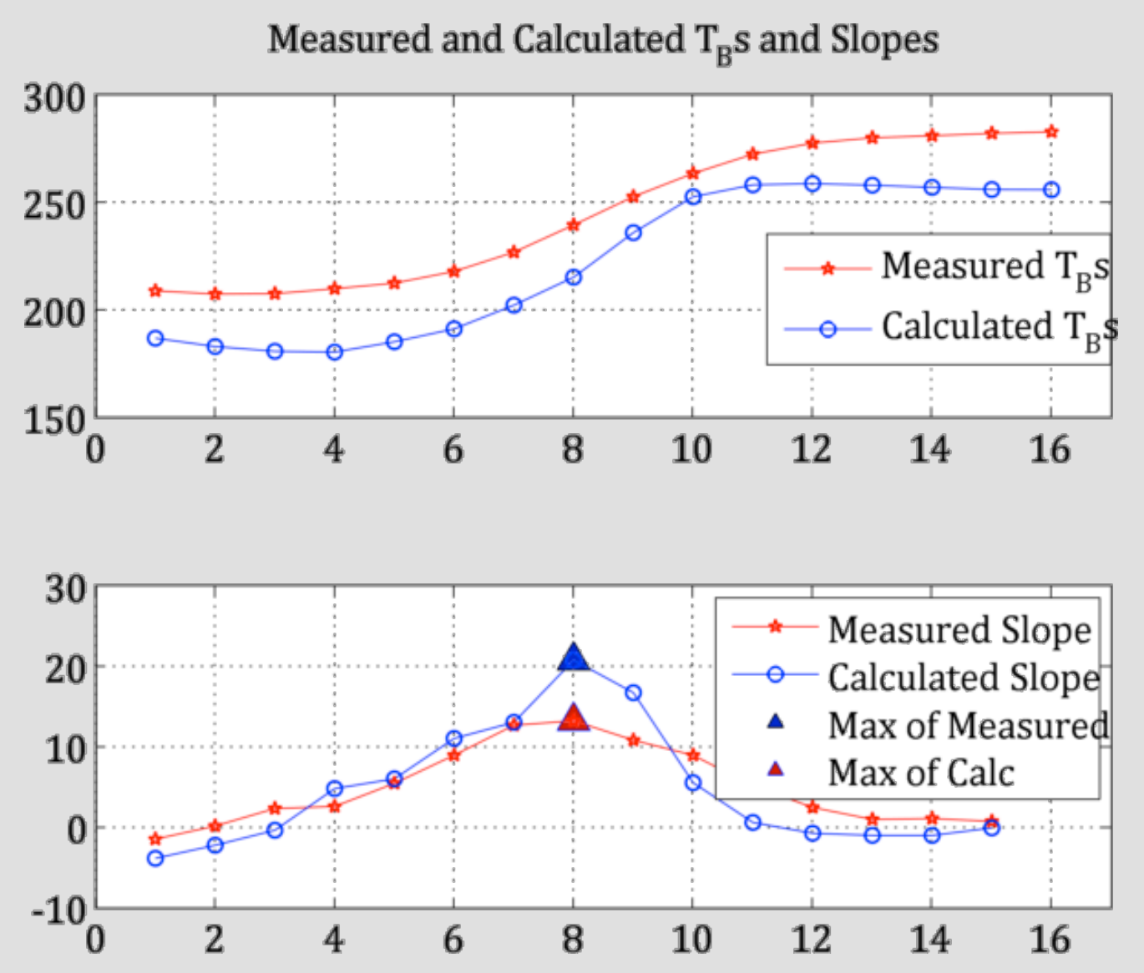


SINGLE IFOV AND ERROR VIEW

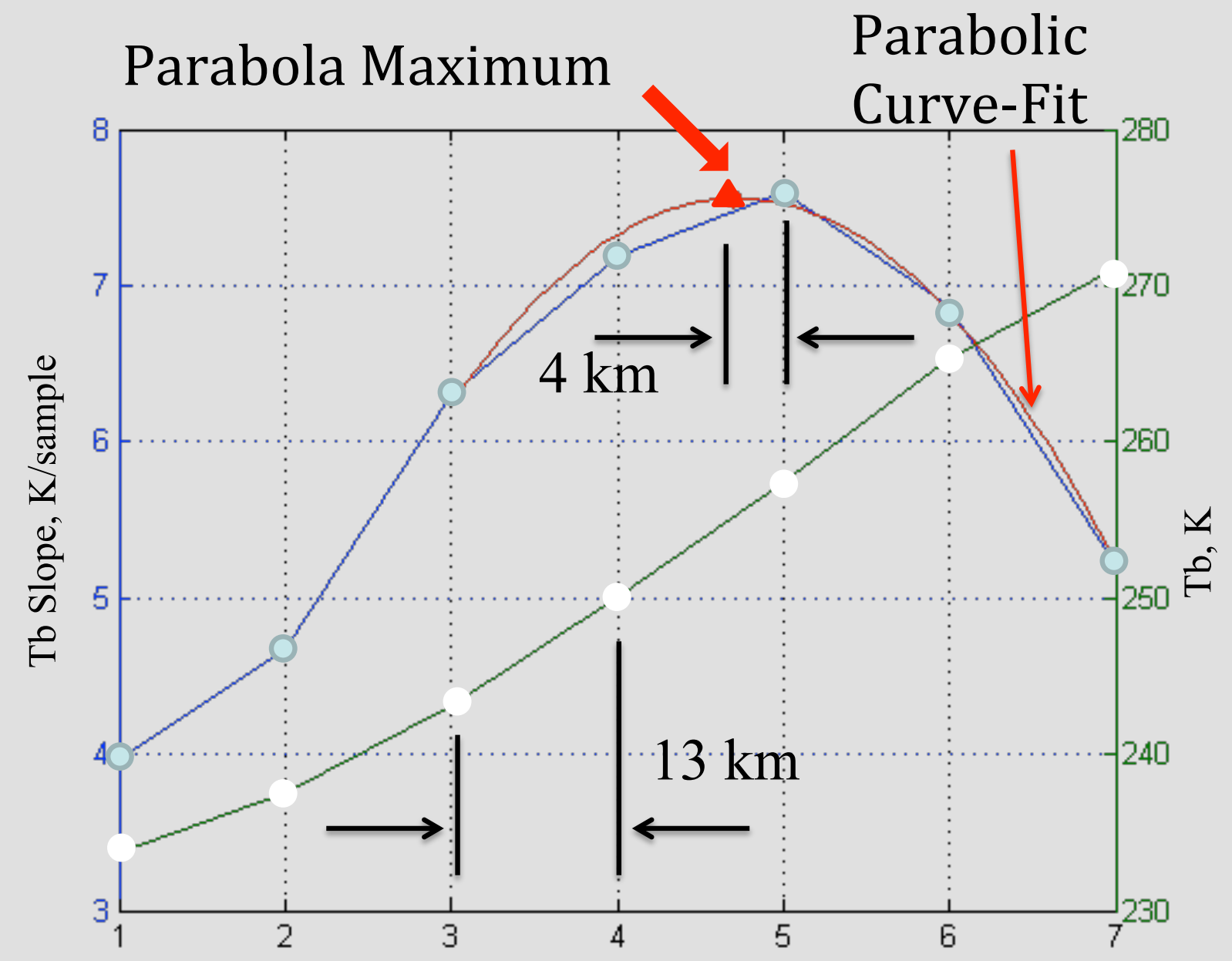
- Instrument Crosses Water to Land
- Highest Slope Indicates Calculated Crossing
- Errors in Beam-Pointing Cause Difference Between Calculated Location and Actual



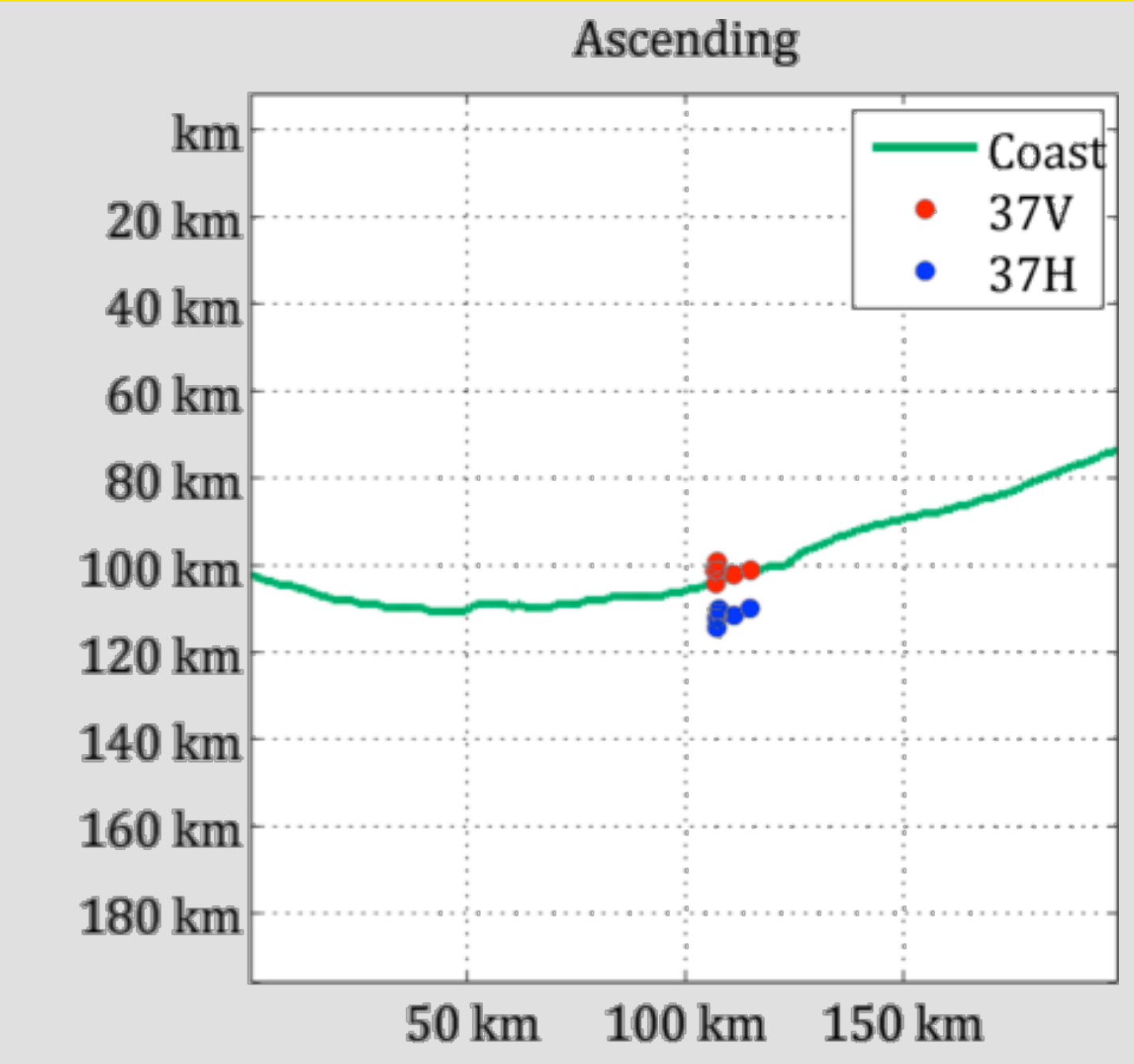
LOCATION ERROR COMPARISON



MAX SLOPE OF PARABOLA



SMALL ERROR SAMPLE



ERROR SUMMARY

For a sample size of N=20 passes each for 37GHz, Vertically and Horizontally polarized, we see the following results

Beam	37V	37H
Mean Error, km	$\mu=2.88$	$\mu=-4.51$
Error Std. Dev, km	$\sigma=1.67$	$\sigma=2.61$

CONCLUSION

- Based upon 1-D and 2-D antenna pattern convolution, the maximum Tb-slope technique appears to accurately identify the IFOV location for 50% land/ocean beam-fill conditions
- Preliminary results indicate that absolute magnitude of geolocation errors < 5 km (meets spec)
  - However, there appears to be a consistent misalignment of corresponding V- and H-pols for the same beam
  - Based upon prelaunch antenna patterns, the V- and H-pol have different boresight directions (measurement error?)