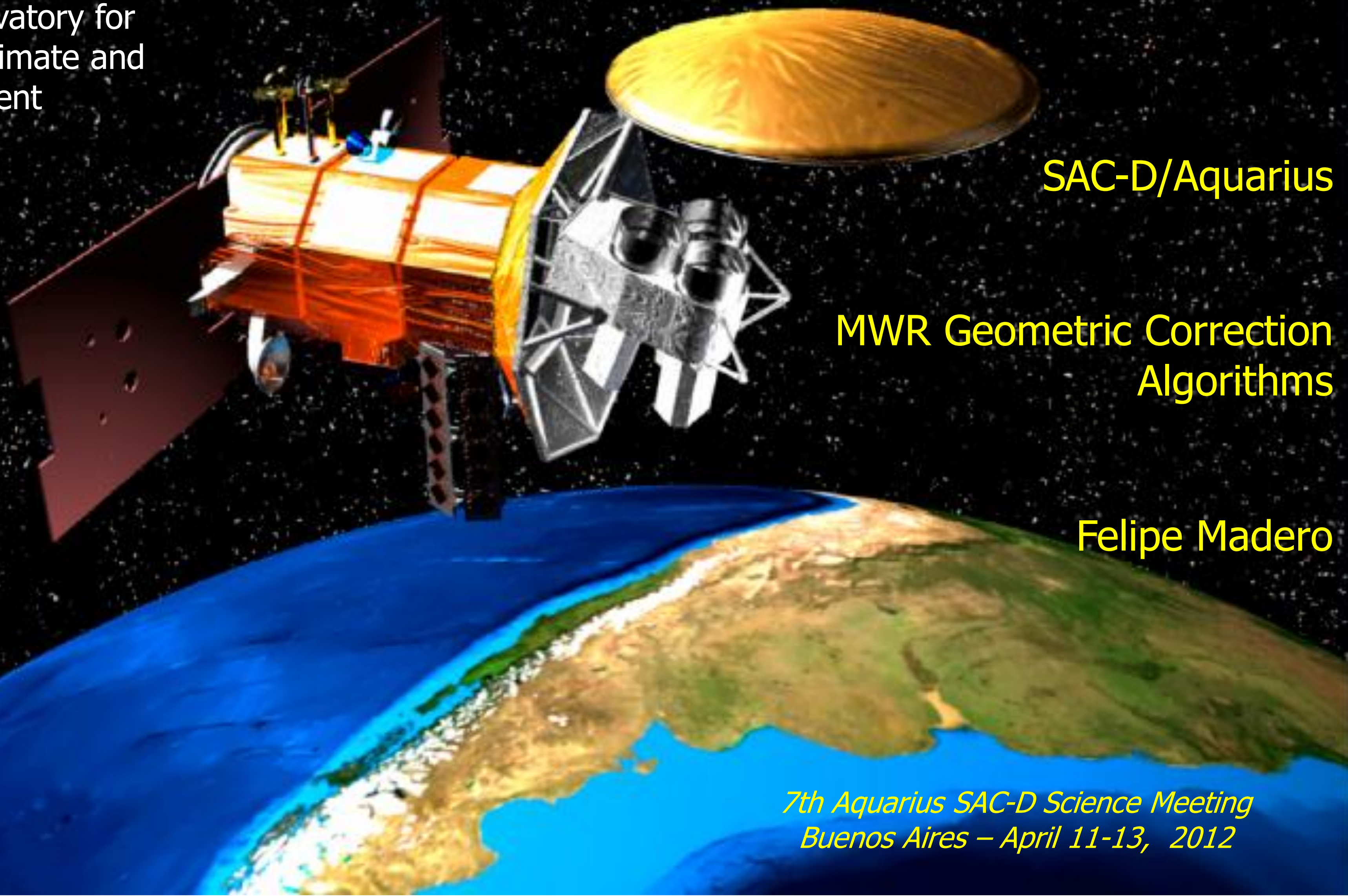
SAC-D/Aquarius

An Observatory for
Ocean, Climate and
Environment



SAC-D/Aquarius

MWR Geometric Correction Algorithms

Felipe Madero

7th Aquarius SAC-D Science Meeting
Buenos Aires – April 11-13, 2012

Geometric Processing Glossary

- Geometric Calibration: Activities done in order to tune the algorithms and models so as to obtain the expected geolocation results

- Geometric corrections: (Systematic) Processes applied to the sensor data, in order to:
  - Obtain knowledge of the geographic location of the measurements.
  - Solve geometric distortions introduced in the acquisition
  - Map the data to useful geographic reference systems

- Geolocation: (Systematic) Process applied to the sensor data in order to obtain knowledge of the geographic coordinates of the measurements

Geolocation Problem

Main reasons for having good geolocation accuracy for this sensor

- Radiometric calibration and retrieval algorithms development is heavily based in inter comparisons with data from other sources.

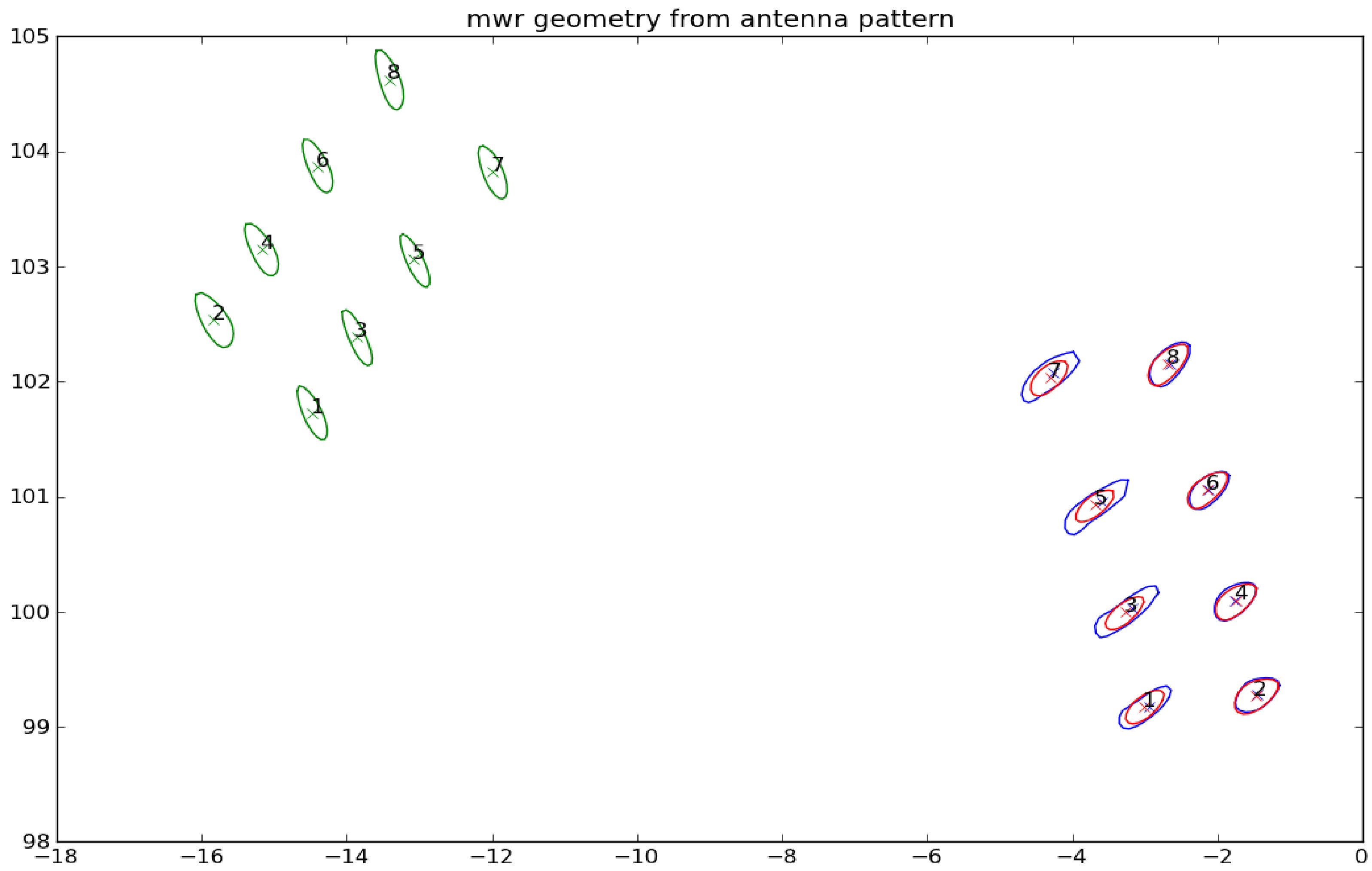
Secondary reason

- Provision of data of good quality to the end users

Geometric requirements for MWR

- Related to the expected location and extension of the swath, and to the geometric resolution of the measurements:
  – Individual footprint across-track < 54 km
  – Swath width of 380 km
  – Look and azimuth angle specifications

- Related to the expected geolocation accuracy:
- Pointing knowledge <= 0.03 degrees


mwr geometry from antenna pattern
105
104
103
102
101
100
99
98
−18
−16
−14
−12
−10
−8
−6
−4
−2
0
1
2
3
4
5
6
7
8

Geolocation outputs

Geographic coordinates (geodetic latitude/longitude) for the center (maximum gain point) of the 8 horn measurements, for K H, Ka V, Ka H, Ka +45, Ka -45 bands.

Auxiliary geographic parameters associated to this positions (range to spacecraft, and zenith/azimuth angle to spacecraft, moon, and sun)

Geographic coordinates for selected points of the of the -3dB contour.

Geographic coordinates for parameters of the approximating ellipse of the -3dB contour.

Pre Launch

Pre launch measurements

- antenna pattern measurements at LaMA/CETT

- mechanical (3d robotic harm) alignment measurement between sensor parts, at INVAP installations

- optical sensor pointing alignment measurement, at LIT/INPE

Pre launch data to processors input data

- Obtain center (maximum gain point) for each beam

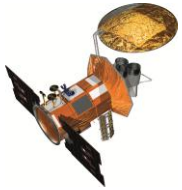
- Interpolation to get -3dB contour

- Sampling of -3dB contour to get selected points

- Fitting ellipse to -3dB contour to get ellipse parameters

- Conversion of alignment measurements to reference system used by processors

Geolocation Algorithms



Geolocation Algorithms development

- ATBD/prototype library developed at the same time

- Geolocation results cross checked with standard geolocation libraries

- Software replacement: library first developed and validated using Python language. Replacement of bottlenecks using c++ code. Last version expected to be mainly c++ code, with python as control code.

Developed Geolocation Libraries

- Time system transformations
- Coordinates systems transformations
- Generic interpolation and smoothing
- Attitude data validation and processing
- State vector data validation and processing
- Intersection of line of sight with earth models
- Generation of auxiliary geolocation parameters

Geolocation Steps: Input data from acquisition

- Validate and filter time data. Fix time measurement errors by fitting the data to a first order polynomial (sample number to time).

- Validate and filter attitude data. No fixing of attitude measurement errors. Quaternions Interpolation.

- Validate and filter state vector data. Fix state vector error measurements by fitting the data to a suitable order polynomial (time to state vector).

Geolocation Steps: Get intersection parameters

- For each sample (measurement of 1 horn per band):
  - Get spacecraft position in ECEF, by using time and state vector polynomial (J2000), and J2000 to ECEF transformation.
  - Get SENSOR2ECEF rotation matrix, by using calibrated SENSOR2PLAT rotation matrix, PLAT2J2000 rotation matrix from interpolated quaternions, and J2000 to ECEF transformation
  - Apply SENSOR2ECEF rotation matrix to the line of sight of the center of each measurement included in the sample

Geolocation Steps: Intersect line of sight with earth

- The spacecraft position in ECEF and the line of sight in ECEF defines a vector pointing to the earth, which is intersected to an earth model (WGS84), by solving a quadratic equation

- The resulting interesection point in ECEF is converted to geodetic latitude/longitude (elevation=0 due to using earth model)

Geolocation Steps: Get auxiliary geolocation parameters

- Obtain moon and sun position in ECEF, by using standard tables, and J2000 to ECEF transformation

- Generate azimuth and elevation angles, between intersection point and spacecraft, sun, and moon, by using acquisition geometry

Optimal Interpolation

Product levels in relation to geometric correction

- L1B: geolocation parameters are included

- L1B3: along track optimal interpolation, with recalculated geolocation parameters

- L1B4: resampling to map projection (grid) by using standard techniques, based in L1B3, with recalculated geolocation parameters.

- L1B5: resampling to map projection (grid) by using optimal interpolation, Based in L1B, with recalculated geolocation parameters.

Optimal interpolation

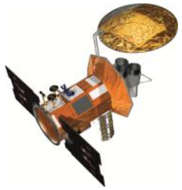
- Along track superposition of 3 to 4 measurements, for -3dB contour, to be reduced to zero superposition, if possible, improving resolution.

- Convolution coefficients to be obtained by Backus/Gilbert, or SVD based reconstruction, in order to improve resolution.

- Simpler scheme of convolution coefficients, to avoid superposition, without improving resolution, to be used in some retrieval algorithms.

- Studying the possibility of gridding by using also optimal interpolation.

Geolocation Errors



Geolocation error from pointing knowledge requirement

- Pointing knowledge error: 0.03 degrees (max 3.1 km)

- Bias plus random

Bias geolocation error

- Error in alignment measurement from ST cube to ref cube: 0.005 degrees (max 180 mts)

- Cyclic (orbital) Thermoelastic deformation errors between ref cube and MWR reference system: 0.015 degrees (max 529 mts)

- Error in alignment between MWR reference system and antenna pattern measurement reference system: 0.0865 degrees (max 3 km)

- Goal to reduce it to 0 by post launch geometric calibration. Cyclic Thermoelastic deformation most difficult to correct.

Random geolocation error

- Error in attitude measurement: 0.011 degrees (max 388 mts)

- Goal is to have it as the final random error, after post launch geometric calibration.

Expected final random geolocation error by beam

Horn	Roll	Pitch	Yaw
1	176	290	136
2	204	388	167
3	199	272	136
4	232	363	165
5	227	249	136
6	267	335	165
7	263	219	138
8	309	302	166

Concluding

Known problems

- Invalid geolocation at high latitudes.

- Geolocation errors due to star tracker error from moon interference

- Current version of the processor uses Ka V antenna patterns to get Ka +45, Ka -45 geolocation info. Further work may be needed in order to estimate and apply suitable antenna patterns for this bands.

- Bugs in generation of sun and moon position in ECEF

- Reported geolocation error of 15 km (CFRSL, Tb Slope, Parabolic fit). To assess, repeat, and correct if needed.

Todo

- Known problems

- Complete post launch calibration

- Assess geolocation accuracy

- Optimal interpolation implementation

- Radiometric calibration and retrieval regressions may be needed to be revised after fine geometric tuning.