Jason2 GPS Antenna Phase Correction Maps

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Introduction

The precise processing of the GPS phase measurements at IGS uses a set of receiver and emitter phase maps (antex files). The ground receiver maps were calibrated using specific tests. The GPS emitter phase maps where then estimated using the residuals of the constellation orbit determination.

For Jason2 precise GPS processing, it is necessary to use a set of antenna maps consistent with the GPS orbits and clocks. For the emitter, it is necessary to extend the reference maps due to larger view angles (a lot of measurements are between 14 and 17 degrees, which are not reachable with ground receivers). This was presented in OSTST 2008.
For the receiver, an analysis can then be performed on the POD residuals, allowing the estimation of the corresponding observed phase map.

The map is estimated with a high model parameterisation for the measurements (ambiguities, receiver clock and map values), using the best Jason2 available orbits and JPL GPS orbits/clocks solution as input for the mesurement modelling. Maps have been constructed independently for each cycle, for Jason2 cycles 1 to 12. The dispersion between these maps is very low, and the dependency w.r.t. the attitude remains small.

These maps are averaged in order to have a unique reference map, which has been used to reprocess the cycles 1-30. The phase residuals rms values are systematically improved from 7 to 5 mm, showing that the map is efficient on cycles which were not used for the construction of the map.

A specific case has been processed using the CODE orbits and clocks as inputs, in order to have a 20 s sampling. A map with 2.5 degrees resolution has been constructed using these data for cycle 6. The result is very close to the maps based on JPL GPS orbit/clocks solutions.

A comparaison has also been performed with the JPL map, showing that these maps are very similar.

Cycle 1-12 phase maps

Maps are constructed for each cycle 1-12, 5x5 deg.

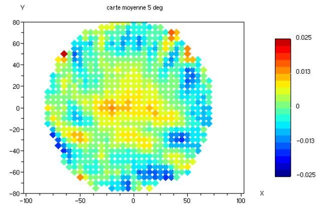
The mean map is constructed by averaging the twelve maps

Comparisons with the mean map :

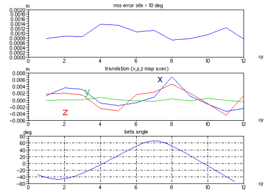
- estimation of the translations x,y,z between each map and the mean map site >=30 deg., strong correlations for x,z axes, no variation along y

- rms error after adjustement (site >=10 deg.) around 1 mm
  the 12 maps are very close

Comparaison with the fine map (2.5 deg.) of cycle 6
similar results



Average map for cycles 1-12

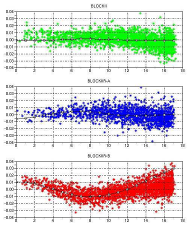


Offset adjustement relative to the average map
(expressed in antenna frame)

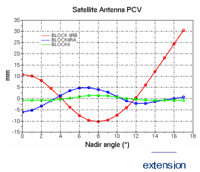
Emitter phase maps extension

GPS satellites maps : an hypothesis is necessary to extend the maps between 14 and 17 degrees angle
(see OSTST 2008 presentation)

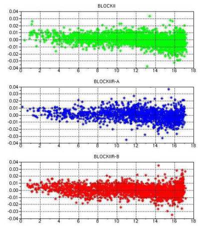
Analysis of jason1 residuals ———— Linear extension of the phase diagram



Jason 1 residuals, no reciever map, no emitter map



Extended GPS emitter maps



Jason 1 residuals, no receiver map extended emitter maps

Receiver phase map estimation

Chosen representation :

- map is described by dx,dy bins in skyplot representation
  $x=\alpha\cos(\theta)$ and $y=\alpha\sin(\theta)$ with α the zenith angle and θ the azimut

- equation for each iono-free phase residual :

$$R_k(t) = N_k + h(t) + C_{i,j}$$

with

$R_k(t)$ phase residual, epoch t, pass k

N_k ambiguity, pass k

$C_{i,j}$ map value fo bin i,j

$h(t)$ receiver clock, epoch t

Solving method :

- least squares adjustment for all measurements, one cycle
  Example : 2.5 degrees bins , 30 s sampling
  5000 ambiguities, 3000 bins, 28000 clock values

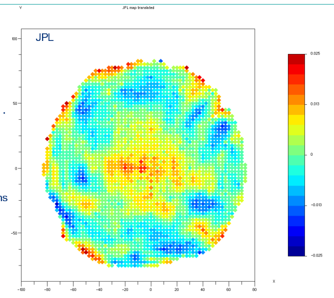
- very sparse partial derivatives matrix, use of a gradient method
  the solution is obtained very rapidly and is not sensitive to bad observability

Comparisons with JPL map

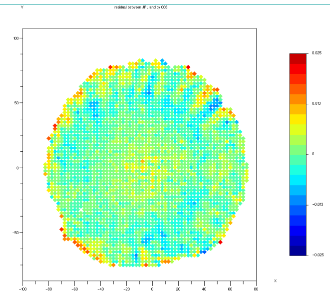
Coordinates (reference point relative to CoM)

	CY006	JPL init.	JPL transl.
X	1.4144	1.4049	1.4089
Y	-0.2170	-0.2170	-0.2180
Z	0.5585	0.5923	0.5590

The observed values are within the dispersions observed on cycles 1-12 maps in x and z
(+- 4 mm)



JPL map after translation



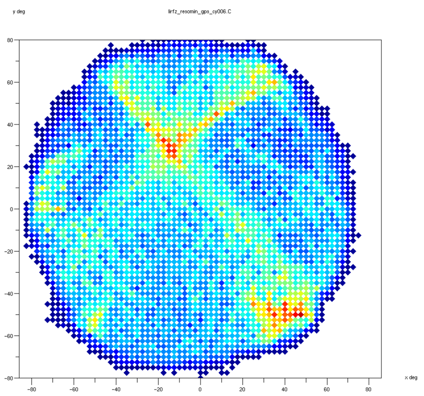
Difference between translated JPL map and CY006 map

After identification of a translation applied on JPL map (x=0.004, Y=-0.001, z=-0.033) using all data above 10 degrees, the two maps are very close

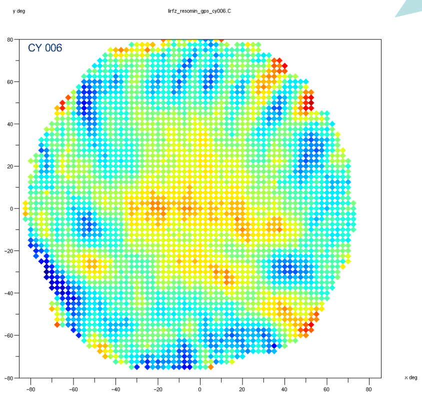
The differences at low elevations are due to different resolution of the maps (jpl map has an azimut sampling of 10 degrees), and maybe also to different extensions of the emitter antenna
JPL map more noisy at high elevation

2.5x2.5 degrees map (cycle 6)

Results for cycle 6, 10 days, 30 s sampling, CODE ephemeris and clocks, standard POD orbit, 2.5 degrees bin



Number of measurements for each bin



Values of the map Cij (2.5 degrees resolution)

Sufficient number of measurements for each bin above 80 degrees, the representation of the bins allows a uniform contribution of the measurements

No constraint applied between the Cij values

Very clear patterns are observed

The results are very close to the JPL ones (see on the right), better definition at low elevation

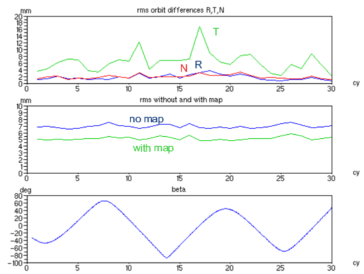
Orbit determination using the 5x5 deg. phase map

Orbit determination results : comparison of POD orbits without map (current configuration)
and with the mean map (5x5 degrees resolution) estimated on cycles 1-12)

No dependency on the beta anlge (attitude effects)

The main effect of the map is to achieve better rms residuals
on all Jason2 processed cycles (1-30)
interesting for further rejection of the remaining outliers
(not applied yet)

Radial effect is around 2mm rms.



Conclusion

An efficient procedure to estimate the phase corrections maps using phase residuals has been developped

- no a priori model for the map values, no constraints applied
- very rapid
- adjusted parameters : map values, ambiguities and receiver clock
- 5x5 degrees maps were estimated on the cycles 1-12 (300 s sampling of the data), using directly the standard POD phase residuals
- a 2.5x2.5 degrees map was estimated on the cycle 6 (30 s sampling), recomputation of the residuals using CODE orbits and clocks

The estimated maps are very stable on the different cycles (no sensitivity to the attitude characteristics)
some correction values can reach 2.5 cm

The estimated maps are very similar to the JPL map, some discrepancies at low elevation
some systematic deviations at a few millimeters level remain, to be further analysed

Application on cycles 1-30 precise orbits (current Doris-GPS-SLR configuration)
phase rms residuals improved form 7 mm to 5 mm, radial effect raound 2 mm rms