GPS PROCESSING FOR JASON 2

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GPS measurements characterisation

Objective : construct passes with continuous ambiguities

- check the results obtained with current approach (Jason1 like)
- possible improvements (for integer ambiguity fixing applications)

Antenna centre of phase characterisation phase maps

Objective : improve the models

- positioning of phase centre, useful for ambiguity blocking
- improvements for the iono-free combination processing

Current results

Results for current procedure (same asJason 1)

Definition of the passes : continuous 10 s measurements

L_1 2 cy

$L_2 - \frac{\lambda_1 L_1}{\lambda_2}$ 10 cy (ionosphere combination) preliminary elimination of wrong L2 measurements

$L_2 - \frac{\gamma \lambda_1 L_1}{\lambda_2}$ 0.1 cy (ionosphere free combination) elimination of wrong L2 measurements, elimination of possible remaining L1

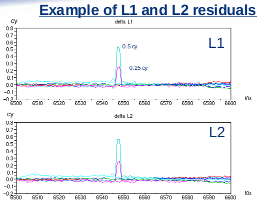
Combinations with small L1 (≤ 3 cy) and smallest effect on iono-free residuals

L1	L2	iono-free cy L2	or cm
3	4	.15	5.7
1	1	.28	10.7
2	3	.43	16.4
1	2	.72	27.1
	1	1.00	37.7
3	5	1.15	43.4

All these combinations are eliminated by the 0.1 cy limit

All integer cycle slips can be detected → Is this valid for Jason 2 ?

Example of L1 and L2 residuals on validated measurements using code igs solution 5 s clocks



Variations on 10 seconds, day 250, 2008

Very few remaining cycle slips (three cases for this day) only fractional cases (0.5, 0.25)

0.25 cycles occur twice : 0.5 cycle in 20 seconds

Same values for L1 and L2 : L2-L1 is correct

Good result, (all this preprocessing was performed without any orbit or clock input)

Is it possible to improve the processing ?
- using 10 s GPS clocks
- without GPS clocks

Widelane is important for ambiguity fixing : study of L2-L1 cycle slips

What about the half cycle slips observed here ?

Analysis of Jason 2 phase measurements

Analysis of the 10 s residuals on all Jason 2 measurements :
day 250, 2008
using 5s igs clocks (codxxxxx.clk_05s solutions)

L_1 possible 0.25 and 0.5 cycls slips on L1

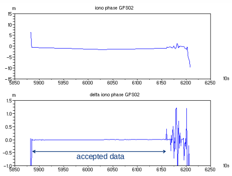
$L_2 - L_1$ integer cycle slips on L2-L1

$\frac{\lambda_2 L_2 - \lambda_1 L_1}{1-\gamma}$ variations (ionosphere correction) for initial eliminations

L1 and L2 processing elimination using ionosphere combination

Use of all L1 and L2 measurements

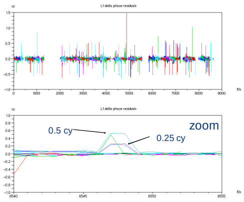
Elimination : variation > 20 cm, pass duration < 100 s
remark : a lot of combined jumps L1 and L2 may still exist



Example : only the central part of the pass is accepted

95.8 % of the measurements remain at this step

Example of L1 residuals using code igs solution 5 s clocks



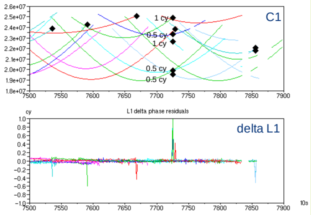
Important number of 0.5 cycles slips

Isolated or on consecutive samples

0.25 cy on two consecutive samples were also observed adjustement to 0.5 cy during 20 s

Cycle slips are mainly located at the beginning or end of the passes

Observed simultaneous occurrences of 0.5 cy on different channels at high elevation



Statistics, (initially 57989 meas. and 451 passes)

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Preprocssing                  std. (jason 1)          new approach
                             % meas.   nb. pass     % meas.  nb. pass
----------------------------------------------------------------------
L1                             96.5 %     427          93.1 %     441
Iono < 0.2 m                                           97.5 %     434
L2-L1 < 0.1 cy                                         91.6 %     413
L1 and L2 (iono-free)          80.7 %     405
L1 and L2 (L1 and L2-L1)                               84.6 %     418
----------------------------------------------------------------------
```

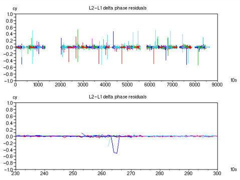
4% more measurements, 3% more passes, not significant but no remaining cycle slip

L1 eliminations have important effects (very low criterion, 0.1 cy)

L1 reconstruction is interesting, but what about half cycles ?

For Jason 2, possible reconstruction of the ambiguities across small durations for complete interruptions

L1 and L2 processing, L2-L1 reconstruction



Use of all L1 and L2 measurements validated using ionosphere criterion (variation < 20 cm)

Reconstruction of integer cycle slips in L2-L1 correction on L2

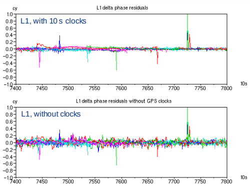
Some successive half cycle slips observed, elimination : > 0.1 cy, pass duration < 100 s occurences at both ends of the passes

Possible preprocessing without 10s clocks

Is it possible to detect (reconstruct) cycle slips without a 10s GPS clock input ?

No limitation for L2-L1 residuals

Not possible for L1 residuals below 0.5 cycle GPS clock noise limits the detection



Conclusion for measurements characteristics

Current processing (Jason 1 like), is performant, but due to half cycles in L1 measurements, some cycle slips may remain in the preprocessed data

Possible improvement using L2-L1 combination, without using GPS high rate clocks, reconstruction of the integer cycle slips, L2-L1 is very important for ambiguity fixing (see the poster on integer zero difference ambiguities)

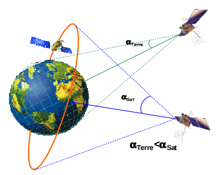
L1 half cycle slips : these values can be detected without using GPS high rate clocks, but if 0.25 cycles cases remain, this is not sufficient. An improvement in the detection/reconstruction algorithms is necessary.

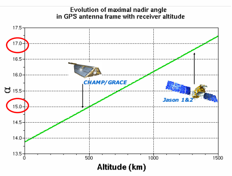
Is there also a possible 0.5 cy bias on each L1 pass ? This is very important, because integer ambiguity fixing is no more possible in this case.
When a pass has in the middle a 0.5 cycle slip, which half of the pass is correct ?

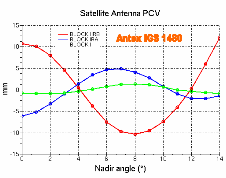
IGS GPS antenna phase correction maps : Extension to low elevation for LEO satellites

Conventions :
Block IIR-B = IIR-M + 4 last IIR
Block IIR-A = others IIR

Maximal nadir angle of a GPS measurement α in GPS antenna frame is depending of the receiver altitude. (Nadir angle are counted from nadir direction)



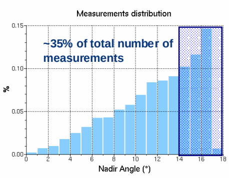




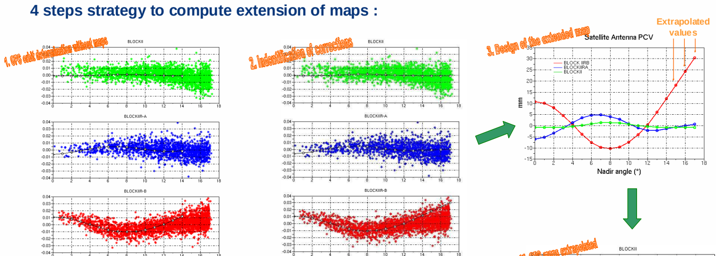
- IGS Antex files give corrections (in mm) only for nadir angle from 0° to 14° which is enough for ground receivers.

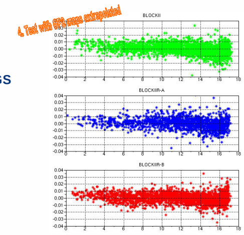
For LEO satellites and Jason like orbits, IGS map must be extrapolated to higher nadir angle.

Indeed :
- The measurements distribution received on Jason1 tends to shows that a lot of measurements are obtained at high nadir angle
- Orbits determination are computed using SP3 files from JPL that are already coherent with IGS maps….



4 steps strategy to compute extension of maps :





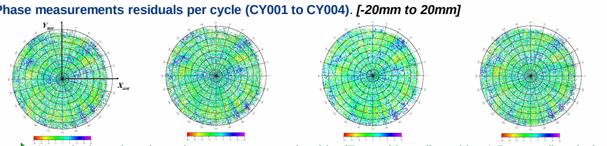
1. **GPS phase residuals are plotted with respect to nadir angle (without the IGS GPS phase maps). Black dots correspond to IGS antenna maps.**
2. **& 3. Model is extended to follow the trend of IGS maps**
4. **Test of the extended map on a real Jason1 cycle. This shows a significant improvement for high nadir angle residuals**
5. **To be used for next GDR standard ?**

Design of a phase correction map for Jason2

Orbits determination have been computed on the four first cycles of Jason2 with this configuration :

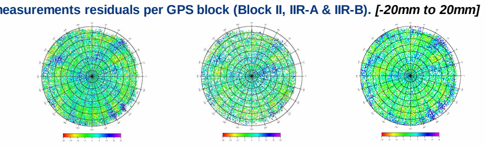
- JPL clk/sp3 constellation solution. Antex IGS_1480 extended maps used for GPS phase corrections
- Receiver antenna reference point : (2.385794 ; -0.217000 ; -0.521790)
- Receiver antenna ionofree phase center along antenna reference axis : (-0.000004 ; 0.000001 ; 0.036919)
- Floatting ambiguities are adjusted
- Jason2 Z-Antenna Bias is also adjusted so that GPS phase residuals represents only phase corrections (high frequencies) *(assuming that X and Y coordinates are good)*

Phase measurements residuals per cycle (CY001 to CY004). *[-20mm to 20mm]*



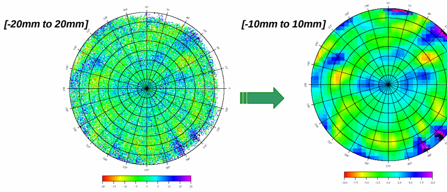
No attitude or time dependant patterns are noticeable. ($Z_{antenna}$ bias adjusted is ~1.5cm on all cycles)

Phase measurements residuals per GPS block (Block II, IIR-A & IIR-B). *[-20mm to 20mm]*



No GPS block dependant patterns are noticeable

Mixing all residuals from 4 cycles, a Jason2 map is computed considering measurement residuals mean by 5° solid angle around each direct ion



Fractional cycles slips (see preprocessing) or satellite environment perturbations possible

Some results when Jason2 and IGS GPS maps are used together with 1.5cm Z antenna bias :

- Differences between orbits computed with and without jason2 phase correction maps are about 1mm rms in radial direction

- Laser residuals are slightly improved on some good stations (e.g Yarragadee L7090, Washington 7105, Herstmonceaux 7840, …)

-SLRF stations coordinates solution used. To be recomputed using LPOD2005

RMS (cm)	YARR_L7090			WASH_L7105			HERS_L7840		
	No corrections	CDP adjusted	J2 Map + CDP	No corrections	CDP adjusted	J2 Map +CDP	No corrections	CDP adjusted	J2 Map +CDP
CY001	1,94	1,82	**1,81**	1,04	0,97	**0,97**	**1,33**	1,44	1,49
CY002	1,51	1,46	**1,42**	1,84	1,77	**1,66**	**1,67**	1,73	1,71
CY003	1,81	1,69	**1,61**	1,23	**0,98**	1,02	1,16	0,89	**0,87**
CY004	**1,82**	1,99	1,93	1,62	**0,85**	**0,85**	1,48	**1,38**	**1,38**