Doris phase mesurements, rinex format

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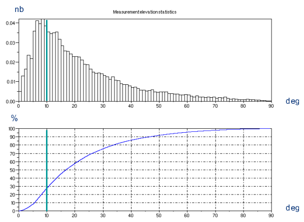
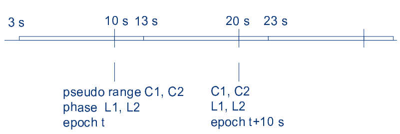
New instrument generation and new measurement file format

- more channels (two for Jason1, six/seven for Jason2)
- new measurement definitions
  - Jason 1 : delta phase, and it3 measurement
  - Jason 2 : synchroneous phase and pseudo-range
- Doris Rinex format, extension of GPS Rinex 3 format

Around 30 % of the measurements are below 10 degrees
- these measurements are eliminated from the POD process
  they are probably very interesting for positioning or troposphere analysis



Phase and pseudo-range measurements general characteristics

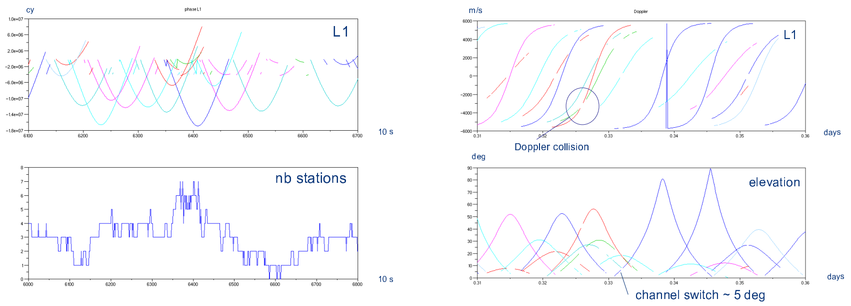


All epochs are present in the rinex file (0 s – 3 s – 10 s – 13 s - 20 s ….)
present study (also POD) : only 0 s - 10 s - 20 s …

Acquisition strategy :
Below 5 degrees, acquisition is performed by channel 7
Above 5 degrees, the emitter is designated by Diode (channels 1 to 6)
and removed from channel 7 —— frequent interruptions around 5 degrees

Low elevations :
New troposphere models are needed to process correctly these low elevations
current POD process > 10 degrees
< 10 degrees useful for positioning, tropospheric studies …
30 % of the measurements are below 10 degrees

Other characteristics : (not specific to Jason 2)
- measurements close to zero Doppler are flagged as invalid, but must be processed in order to achieve the phase continuity over a pass
- 'Doppler collisions ' : when two signals have the same Doppler, measurements are not performed, will interrupt here the phase continuity



The Doris Rinex Format

GPS like phase and pseudo-range measurements
all instrumental delays corrected
Synchroneous acquisition (on board Jason 2).

Example of data record :

(reception epoch; estimated on board clock offset)

```
> 2008 08 31 01 13 16.979948170  0  5        4.873984107 0
D18 -13343786.710 0  -2629434.840 0-135193433.464 1-135193362.999 1      -118.700 7
         -106.800 7      2170.119          997.259 1         19.377 1        80.328 1
D20    -86550.535 1    -17056.397 1-145734619.907 2-145735021.607 2      -133.050 7
         -121.500 7      2170.119         1000.828 1         21.500 0        73.000 0
D19  -2710106.688 0   -534036.209 0-128063516.563 3-128062854.027 3      -128.500 7
         -123.950 7      2170.119         1000.984 1          9.836 1        73.279 1
D16 -11123449.559 0  -2191909.891 0-144169109.475 4-144168971.573 4      -118.350 6
         -108.200 6      2170.119         1010.628 1         25.361 1        72.098 1
D15  -2666097.739 0  -3893168.756 0-145712808.006 7-145711965.597 7      -135.850 7
         -121.500 7      2170.119          995.344 1         25.800 0        86.000 0
```

station number (krvb); L1 phase; C1 pseudo-range; Meteo; W1 S/N ratio

Synchronisation data for master stations, header extract
reference offsets for KRVB,TLSB,YEMB,HBMB

```
D01  JIUB JIUFENG                      21602S005  3   0    STATION REFERENCE
...
D15  KRVB KOUROU                       97301S004  3   0    STATION REFERENCE
D20  TLSB TOULOUSE                     10003S005  3   0    STATION REFERENCE
D39  YEMB YELLOWKNIFE                  40127S009  3   0    STATION REFERENCE
D49  HBMB HARTEBEESTHOEK               30302S008  3   0    STATION REFERENCE
...
D52  HEMB ST HELENA                    30606S004  3   0    STATION REFERENCE
     4                                                     # TIME REF STATIONS
D15          -0.495        -6.944                          TIME REF STATION
D20          29.774         5.787                          TIME REF STATION
D39         -61.692      -158.565                          TIME REF STATION
D49         -11.419       -38.194                          TIME REF STATION
```

bias (10^{-6} s)   drift (10^{-14} s/s)

Pseudo range measurements processing

Objective : estimate the on board clock offset h_{rec}

from the rinex; from the header (a few µs)

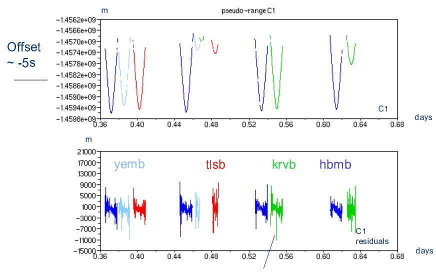
$$C_1 = c\left(t_{rec}^{rec} - t_{emi}^{emi}\right)$$
$$= D\left(t_{rec}^{rec} - h_{rec}\right) + c\left(h_{rec} - h_{emi}\right)$$

model (extrapolated orbit); adjusted (polynomial)

Use of the master station measurements only

h_{rec} : polynomial prepresentation for the on board clock offset (typically degree 2-3 for a 10 days arc)

Other formulation : $t_{emi} = t_{rec}^{rec} - \frac{C_1}{c} - h_{emi} \rightarrow D(t_{emi}) \rightarrow h_{rec} - h_{emi} = \frac{C_1 - D}{c}$

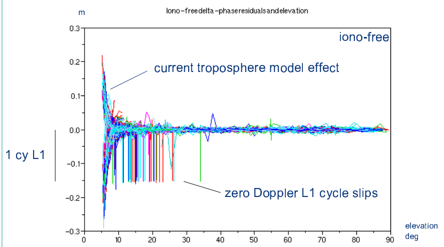


erroneous measurement close to zero Doppler

No specific preprocessing, except few outliers close to zero Doppler (flags in the rinex file)

Phase measurements characteristics

Iono-free delta phase residuals (all measurements)

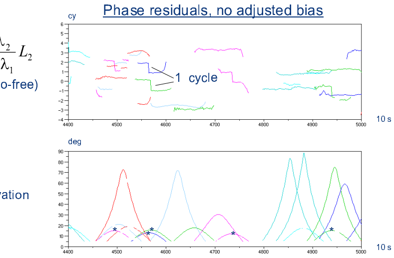


Elevation > 5 degrees only
Most cycle slips occur below 30 degrees, and when Doppler is close to 0
(small Doppler measurements are flagged in the Rinex file)

Phase residuals, no adjusted bias

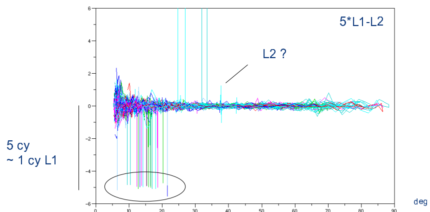
$$L_1 - \frac{\lambda_2}{\gamma \lambda_1} L_2$$

(~ iono-free)



* : 1 cycle L1

Correction of the L1 cycle slips

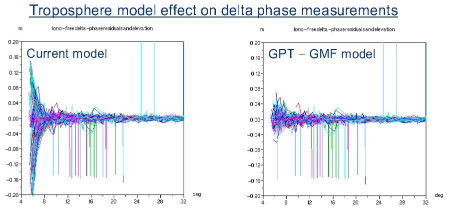


Correction of the L1 cycle slips using 5*L1-L2

Threshold for passes definition on iono-free $L_2 - \frac{\gamma \lambda_1}{\lambda_2} L_1$: 0.5 cy L2

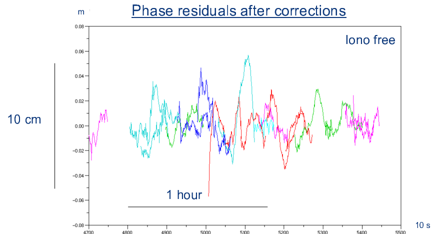
(elimination of the remaining L2 cycle slips, assuming no L1 errors)

Troposphere model effect on delta phase measurements



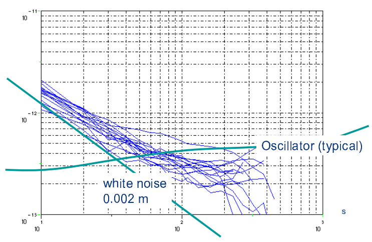
No significative effect on POD, but possible changes in station positioning

Phase residuals after corrections



(bias and drift adjusted for each pass)

Allan variance, station FAIB



Slope between -½ and -1 : effect of the oscillator combined ?
with phase measurement noise
other effects ?
Results similar to 2006 Spot5 processing (see SWT presentation in Venice)

Conclusion

Rinex format : very easy to use
no specific satellite correction to apply
observables very similar to GPS (pseudo-range and phase)
currently used in the POD Jason2 process

Phase measurements :
Investigation of the small cycle slips occurrence
L1 jumps possible at low Doppler, low elevation
- all these jumps can be reconstructed
L2 jumps not so frequent
- not easy to detect and reconstruct

Allan variance analysis
- confirmation of the 2006 Spot5 studies
  similar noise and oscillator effects
- it is necessary to take into account the oscillator behaviour
  the best way (up to now) : Doppler by differentiating the phase

Doris solutions using phase : improve the parametrisation for the oscillators behaviour