Doris Phase Measurements – Rinex Data Format

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New instrument generation

- more channels (two for Jason1, six/seven for Jason2)
- new measurement definitions
  Jason 1 : delta phase, and it3 measurement
  Jason 2 : synchronuous phase and pseudo-range

New file format

- Doris Rinex format, extension of GPS Rinex 3 format
Doris pseudo-range and phase measurements

3 s  
10 s  13 s
20 s  23 s

pseudo range C1, C2
phase L1, L2
epoch t

C1, C2
L1, L2
epoch t+10 s

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 ...

Notation : frequency 1 for 2 GHz, and frequency 2 for 400 MHz
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

Doppler collisions:
When two signals have the same Doppler, interruption in the measurements true for all Doris instruments, but will interrupt here the phase continuity
Acquisition strategy, Doppler collisions

Doppler collision

L1

channel switch ~ 5 deg

deg

days
Phase measurements

L1

nb stations

OSTST Nice 10-15 Nov. 2008
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
GPS like phase and pseudo-range measurements
all instrumental delays corrected
Synchronous acquisition (on board Jason 2).

Example:

```
> 2008 08 31 01 13 16.979948170 0 5 4.873984107 0
D18 -13343786.710 0 -2629434.840 0-135193433.464 1-1351933362.999 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
```

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

estimated on board clock offset
reception epoch
Pseudo Range measurements

Purpose: estimate the on board clock offset

For Jason 2: use of the master beacons only
reference offsets are given in the header

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bias (10⁻⁶ s)  drift (10⁻¹⁴ s/s)
Datation of measurements

from the rinex

\[ C_1 = c \left( t_{rec}^{\text{rec}} - t_{emi}^{\text{emi}} \right) \]

= \[ D \left( t_{rec}^{\text{rec}} - h_{rec}^{\text{rec}} \right) + c \left( h_{rec}^{\text{rec}} - h_{emi}^{\text{emi}} \right) \]

from the header (a few µs)

model

adjusted (polynomial)

Use of the master station measurements only

\[ h_{rec}^{\text{rec}} \]: polynomial prepresentation for the on board clock offset

(typically degree 2-3 for a 10 days arc)

Other formulation:

\[ t_{emi} = t_{rec}^{\text{rec}} - \frac{C_1}{c} - h_{emi} \rightarrow D \left( t_{emi} \right) \rightarrow h_{rec}^{\text{rec}} - h_{emi} = \frac{C_1 - D}{c} \]
On board clock offset adjustment

offset ~ -5s

erroneous measurement close to zero Doppler

OSTST Nice 10-15 Nov. 2008
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)
Improvement of the troposphere models

Delta phase measurements

Current model

GPT – GMF model

No significative troposphere effect on POD, but possible changes in station positioning
\[ L_1 - \frac{\lambda_2}{\gamma \lambda_1} L_2 \]

(\sim \text{iono-free})

no adjusted bias

Phase residuals

Elevation

10 s
Study of the phase residuals

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)

Phase residuals: see Spot5 SWT Venice 2006 (reconstructed measurements)
now we have directly the phase measurements

Analysis of the phase residuals for the remaining full passes
(passes with more than 500 s continuous measurements)

Allan variance

Time history

Results similar to Spot 5
Combination 5*L1-L2

Correction of the small Doppler L1 cycle slips

5 cy ~ 1 cy L1

L2 ?

cy

deg
Slope between $-\frac{3}{2}$ and $-1$: effect of the oscillator combined with phase measurement noise.
Slope between $-\frac{1}{2}$ and -1: effect of the oscillators combined with phase measurement noise?
Allan variance characteristics

See SWT 2006 presentation (Venice)
Phase residuals time history

(bias and drift adjusted for each pass)
rms is important due to the low frequency content does not reflect the true measurement noise
Conclusions

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

**Phase measurements**:
- Investigation of the small cycle slips occurrence
  - \textit{L1 jumps} possible at low Doppler, low elevation
    - all these jumps can be reconstructed
  - \textit{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 parameterisation for
  the oscillators behaviour