



CENTRE NATIONAL D'ÉTUDES SPATIALES

# **DORIS signal integrity monitoring and control**

# DORIS signal integrity monitoring

## What is it ? (1)

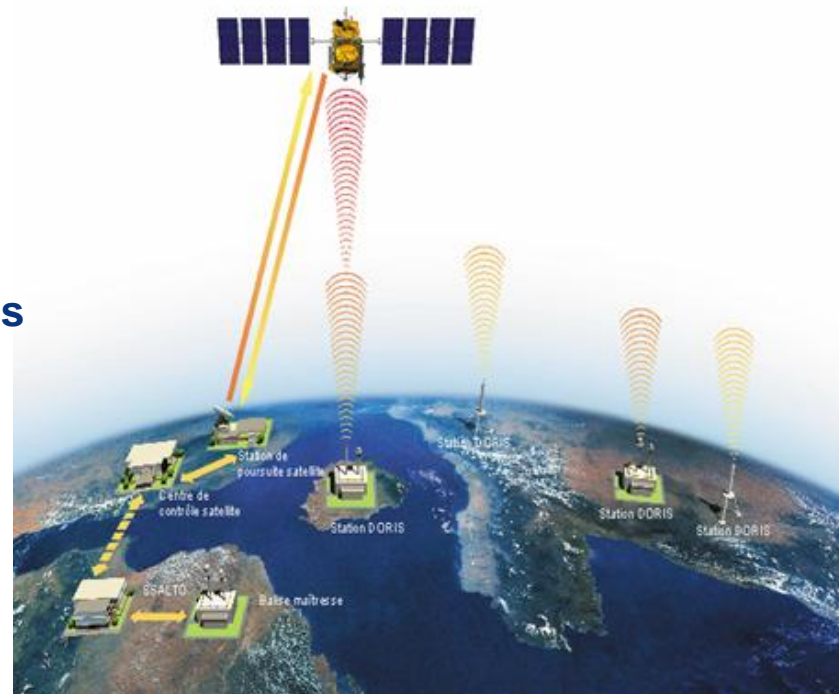
- **Reminder : DORIS system is based on accurate measurements of the Doppler shifts on a radiofrequency signal**

- **The signal :**

- ◆ Dual frequency : 401.25MHz; 2.03625GHz
- ◆ Transmitted by DORIS ground stations
- ◆ Received on-board satellites by DORIS instruments

- **Besides the signal**

- ◆ Beacons transmit system data
- ◆ Especially master beacons (broadcast upload)



⇒ **Without a consistent ground beacon network the DORIS system cannot reach its full performance**

# DORIS signal integrity monitoring

## What is it ? (2)

- **To ensure the capability of the Doris system to carry out its mission, we have to monitor and maintain the network availability and measurements quality**
  - => DORIS signal integrity monitoring**
  
- **Doris involvement in missions and performance required are always increasing**
- ⇒ **This monitoring has become crucial**
  
- **A DORIS integrity team has been in charge since 2005**
  
- **2 main parts of the work described today:**
  - ◆ **Maintain beacon network availability and signal quality**
  - ◆ **Check the consistency of information transmitted to instruments**

# DORIS beacon network monitoring

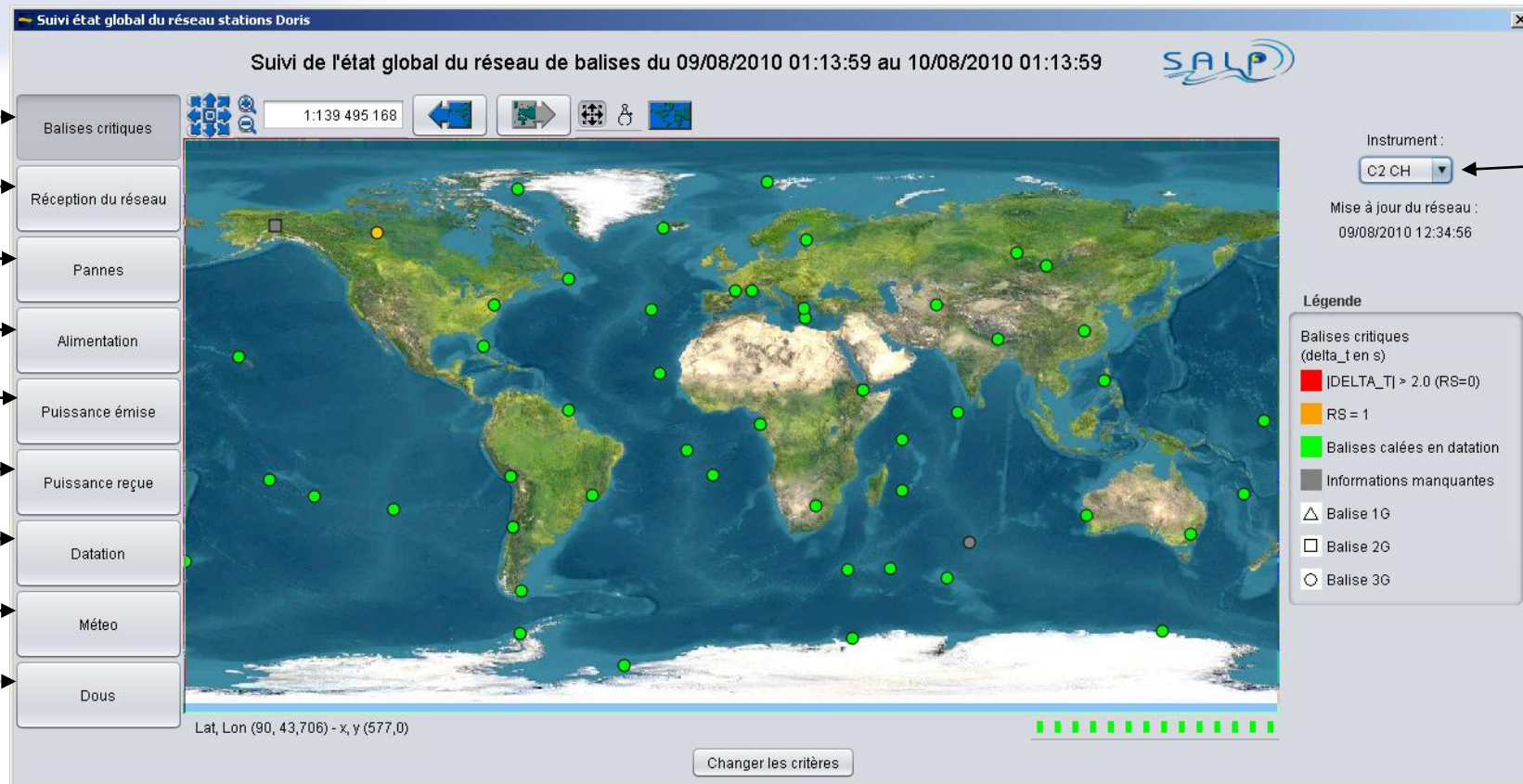
**Daily monitoring**

**Weekly monitoring**

**Long term investigations**

- **Objective:**
  - ◆ **Control the beacons' status**
    - With respect to several parameters
  - ◆ **Detect any major problem on the network**
    - Transmission interruption, signal degradation...
  - ◆ **First investigations and actions**
    - Information request to host agency
    - Corrective action definition and application

## Observation criteria

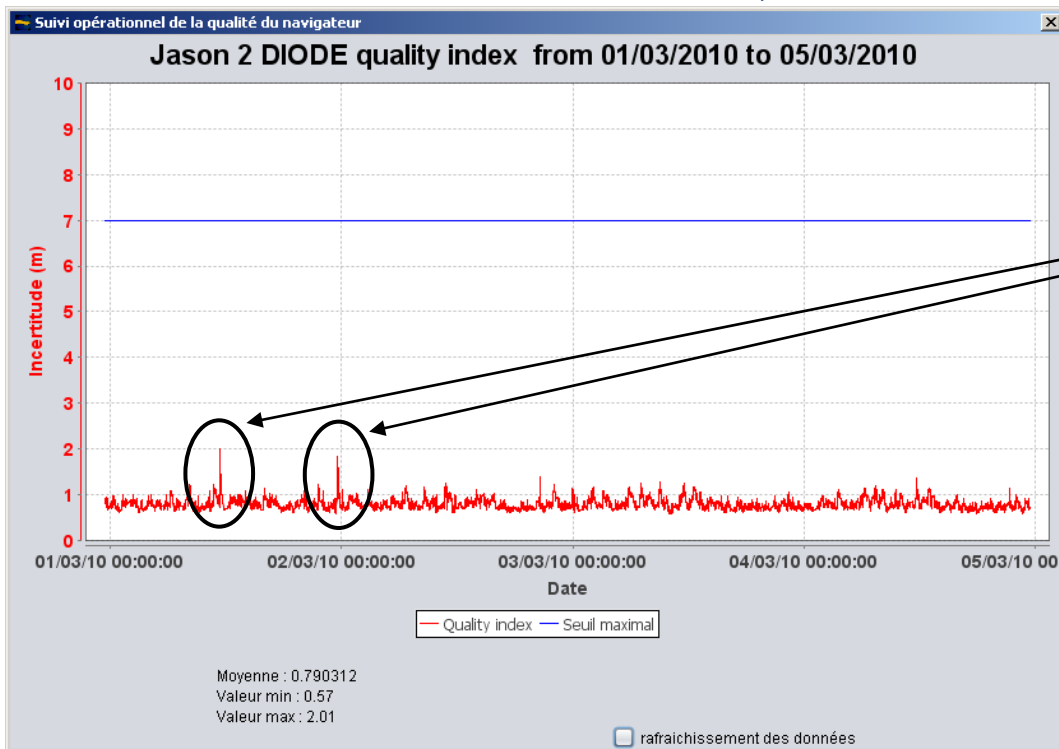


DORIS instrument

## Permits to detect major defaults:

- ◆ Beacon transmitting erroneous data or in a non nominal mode
- ◆ Non received beacons
- ◆ Low power level beacons

- DIODE navigator : first customer of DORIS signal
- Calculates a real time orbit sensitive to almost any perturbation
- => DIODE quality index used to detect noisy measurements
  - ◆ Unexpected peaks are analysed.
  - ◆ Once the default identified, corrective actions are defined and performed



## Cibinong beacon example :

- 2 peaks observed at the beginning of March on Jason 2
- Default identified : USO anomaly (degraded stability)
- Beacon shut down, new beacon sent to replace it

# DORIS beacon network monitoring

**Daily monitoring**

**Weekly monitoring**

**Long term investigations**



## ■ Objective:

- ◆ Identify trends or upcoming degradation
- ◆ Anticipate default in order to fix it before a strong impact

## ■ Crosscheck of several reception statistics calculated over the same 1 week period

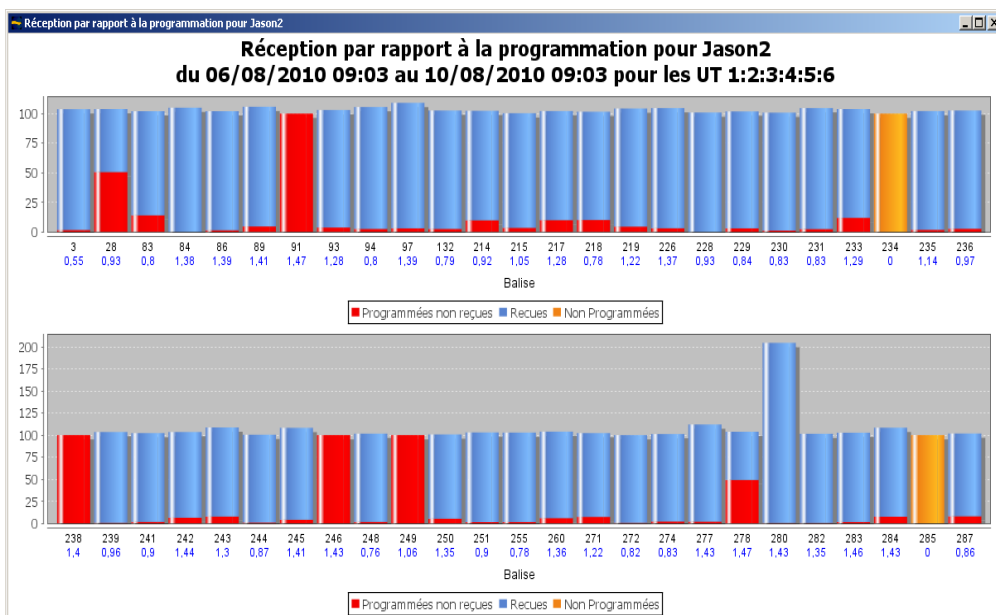
## Statistics giving the network status from the instrument point of view

Based only on instrument telemetry data

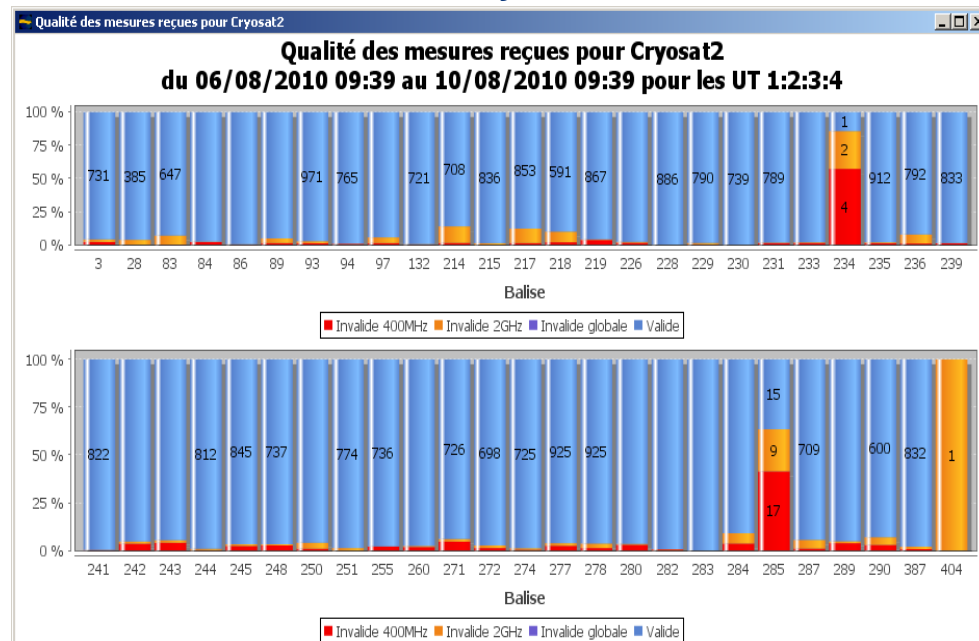
### Allows :

- To check instruments programming and processing
- To detect upcoming transmission default (loss or quality degradation)

### Measurements reception w.r.t. instrument programming



### Quality of received measurements : Measurements validity on the two channels

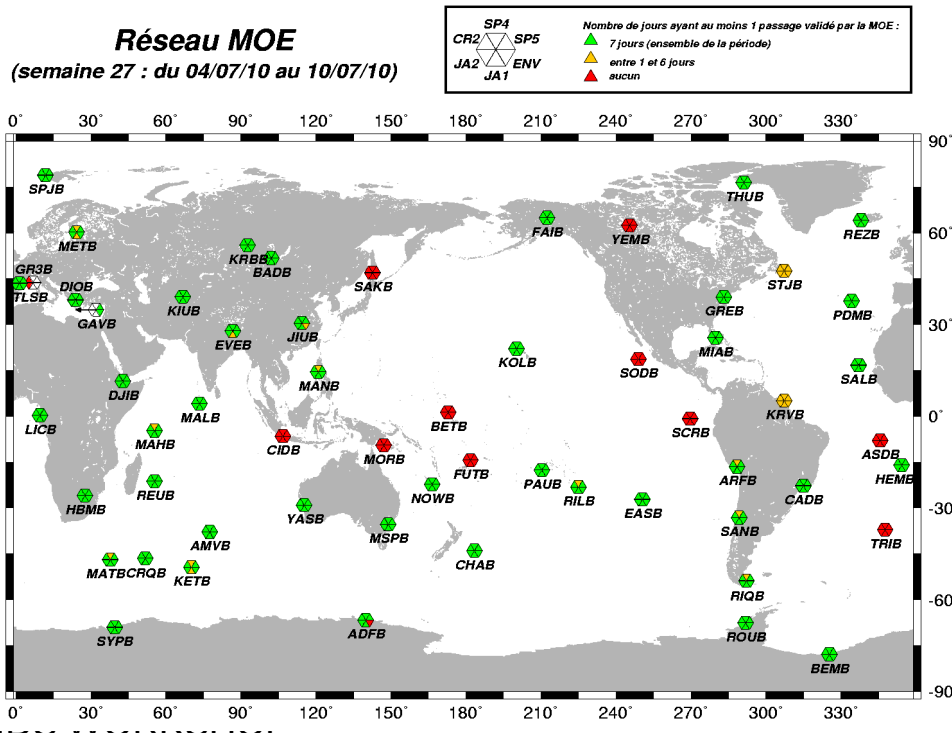


Statistics (maps) giving the network status from ground processing's point of view  
 Provide information about measurements quality

2 maps available :

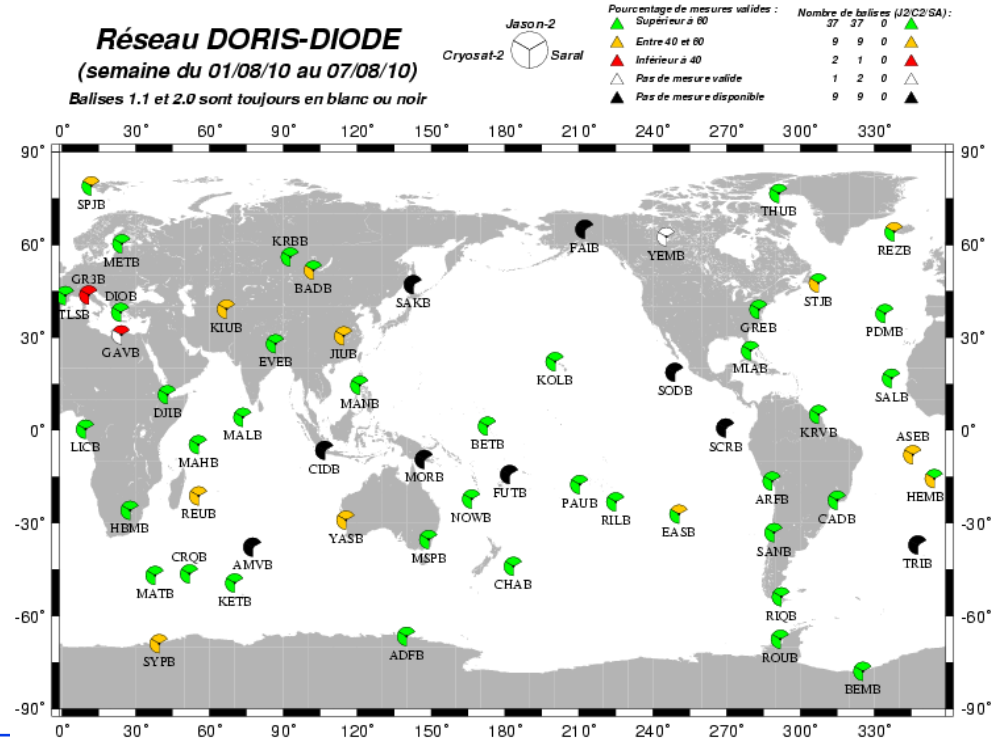
## MOE map

Beacons plotted function of the MOE results on their measurements



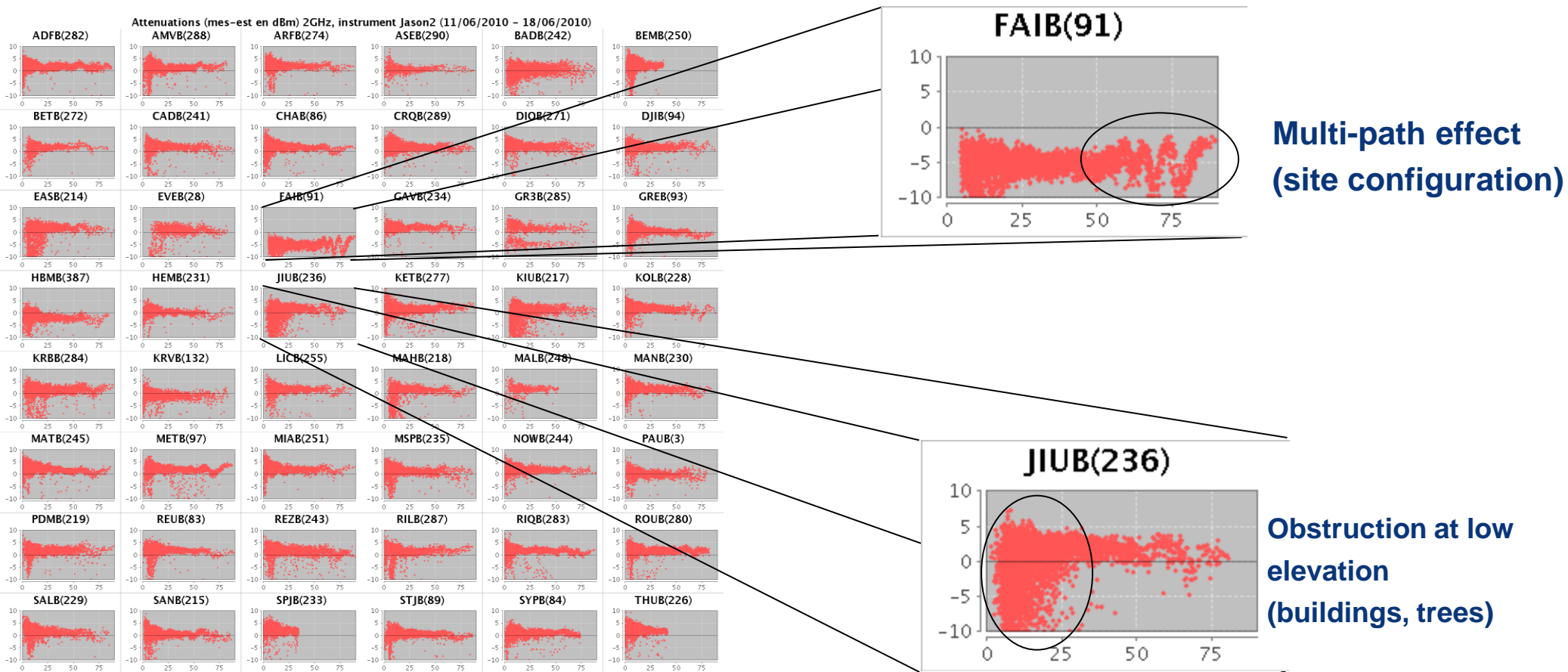
## Technological map

Based on measurements quality w.r.t. technological criteria (consistency between the two channel, power level, transmission mode...)



## ■ Principle

- ◆ Power level measured on-board is compared to a theoretical power level
- ◆ Discrepancies are plotted as a function of elevation for each beacon



# DORIS beacon network monitoring

**Daily monitoring**

**Weekly monitoring**

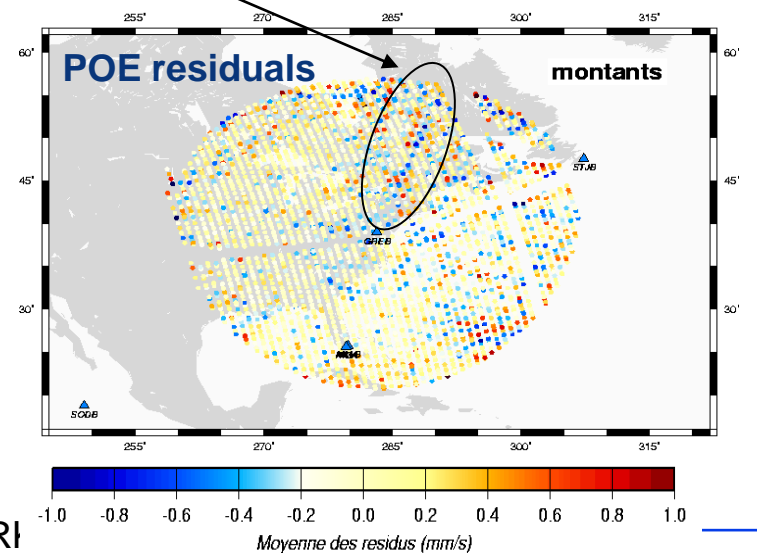
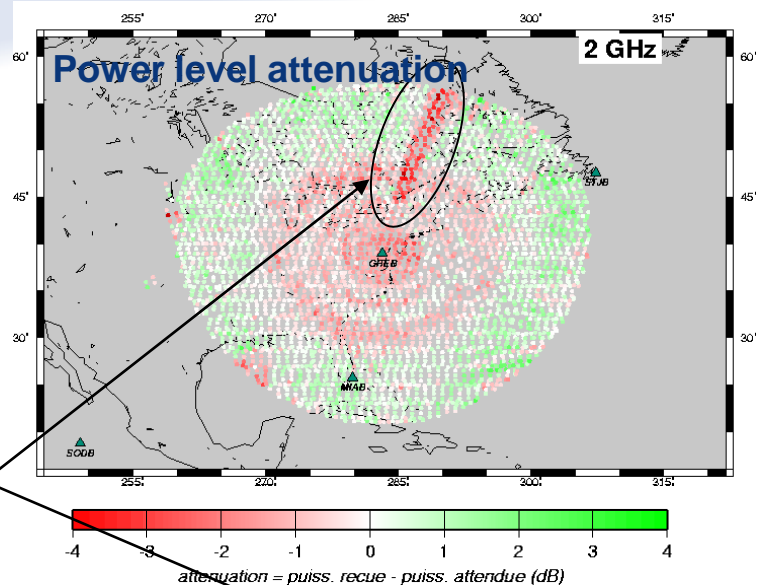
**Long term investigations**

- **Objective :**
  - ◆ Evaluate Doris site quality
  
- **Quality analysed with respect to**
  - ◆ Power level,
  - ◆ POE residuals
  
- **Analysis over a long period (at least 6 months of data)**
  
- **Illustrated via geographic maps**
  
- **Cf. article “Impact of DORIS Ground Antennas Environment on Their Radio Signal Quality”  
P. Yaya and C. Tourain; Advances in Space Research Volume 45, Issue 12, 15 June 2010**

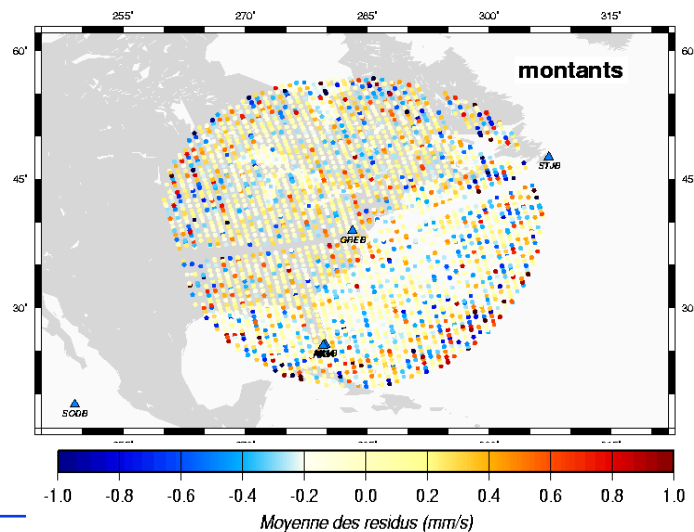
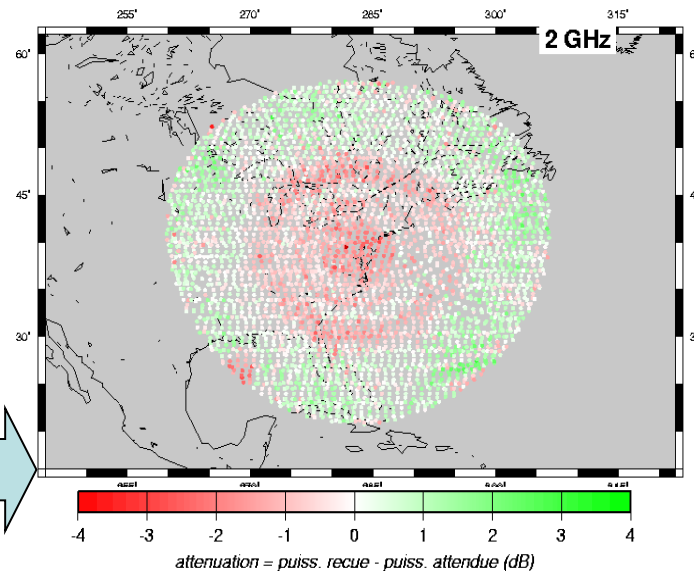
# Long term investigations (2)

## Greenbelt example

Pylon disturbing DORIS signal



Pylon suppressed from DORIS antenna environment

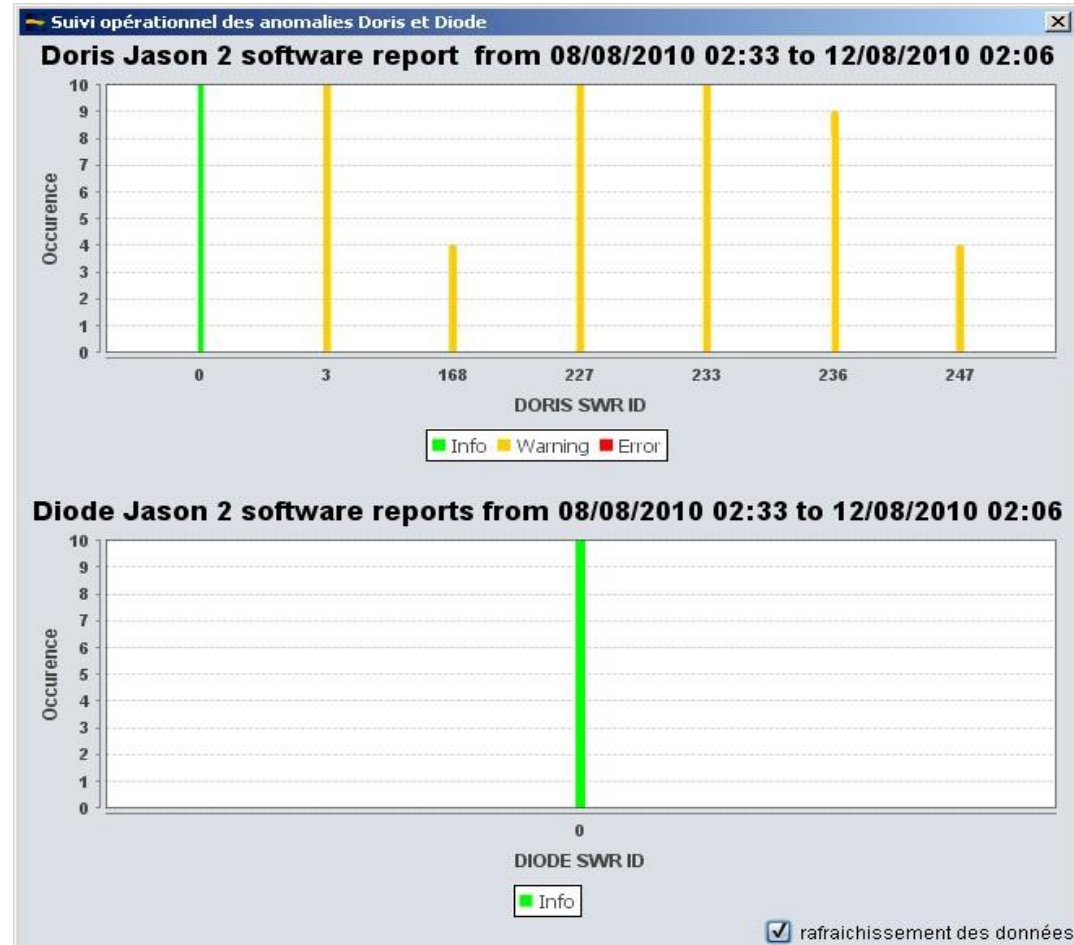


# **DORIS system processing monitoring**



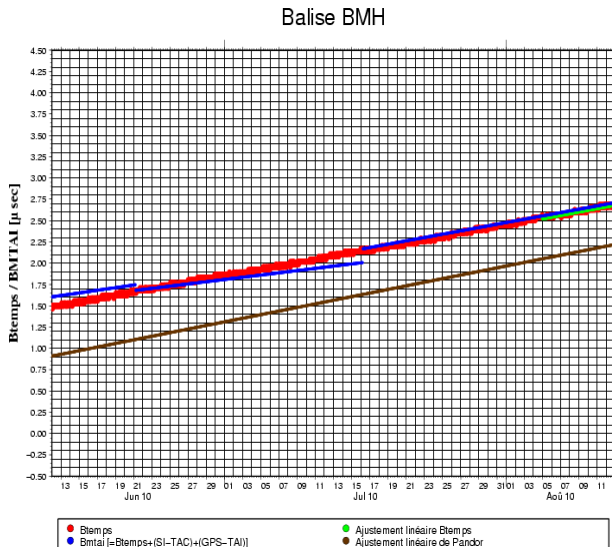
- Besides radiofrequency signal, DORIS beacons transmit information
  - Especially master beacons transmit broadcast uploads:
    - ◆ Station coordinates
    - ◆ Time links data
  - These data are important for DORIS real-time processing and performance.
    - ◆ Error in these data can imply (slight) accuracy degradation of real-time products
- ⇒ **Monitoring of DORIS instrument processing**
- ◆ To detect any impact of erroneous data

- Reports generated by the instrument and transmitted via DORIS telemetry
- “Instrument talking to us”
  
- Gives the status of both :
  - ◆ DORIS on-board software
  - ◆ DIODE software
  
- Operational monitoring allows us :
  - ◆ To follow the behaviour of software.
  - ◆ To detect inconsistency in data transmitted by the beacons

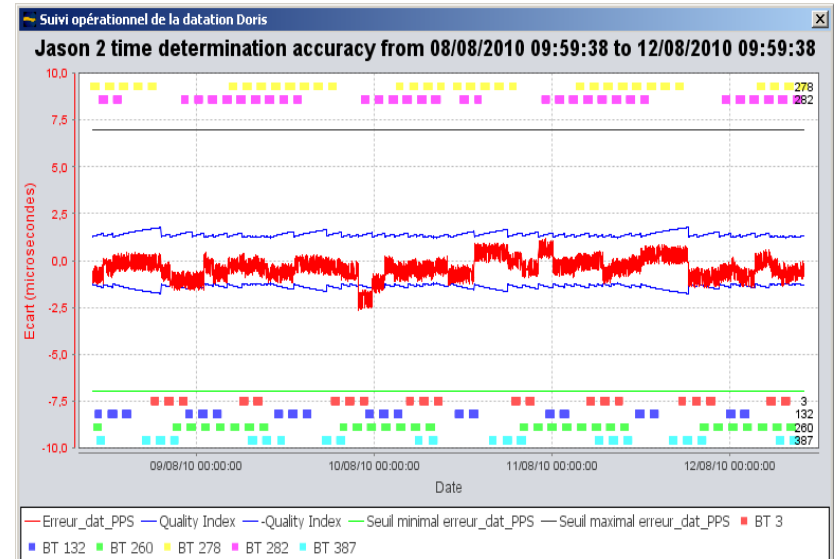


- DIODE navigator performs a time tagging used for platform application and measurements dating
- Process based on time links data transmitted by master beacons
  - ⇒ On board time tagging accuracy directly linked to the accuracy of these data
- Consistency of these data is essential

## Before upload : Time link data accuracy assessment



## After upload : onboard time tagging performance monitored operationally



Drift or jumps are tracked to readjust time links if needed

- **Monitoring and analysis described previously were set :**
  - ◆ To simplify and accelerate detection of defaults,
  - ◆ To identify possible improvements on the network.
  
- **DORIS integrity team have now reached a high level of efficiency**
  - ◆ Network availability : always over 75% since 2005 (mean 85%)
  - ◆ Reactivity : defaults are mostly detected and corrected before they impact users
  - ◆ Quality :
    - ◆ low-quality Doris stations are identified
    - ◆ some of them have already been improved in collaboration with installation and renovation team
  
- **Work still on-going**
  - ◆ Reactivity : remote control (Iridium) of DORIS beacon under deployment
  - ◆ DORIS site quality : continued effort to find quality factors and any source of improvement