

# IMPACT OF GROUND ANTENNAS ENVIRONMENT ON THE ON-BOARD RECEIVED POWER AND DOPPLER RESIDUALS

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# Content

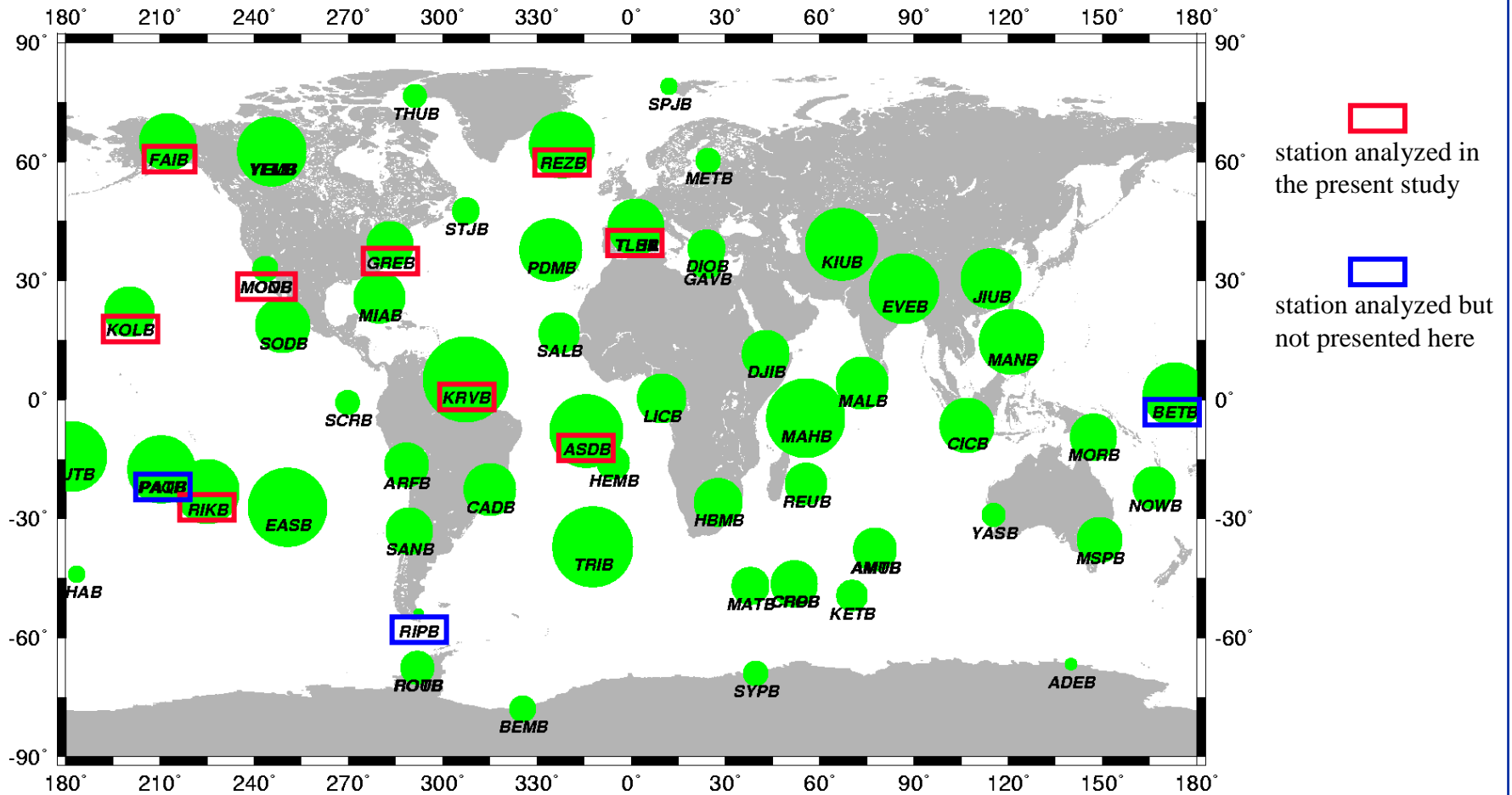
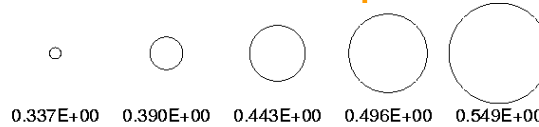
- Motivation of the work
- Methodology
- Analysis of each station
- Synthesis
- Conclusions & prospects

# Motivation

- Large discrepancies in the POE RMS between the DORIS beacons → why ?
- Necessity to evaluate the impact of site renovations
- Two parameters are analyzed : power attenuation & POE résiduels → quality of the measurements
- What's the impact of the environment on these parameters ENVIRONMENT = any physical object that may interact with the signal between the emitter and the receiver
- This presentation is a synthesis of several presentations made for the “Groupe Performances” DORIS at CNES

# POE RMS map (2007)

(all missions except Jason-1)



# Methodology

Power attenuation (ATT) = {measured power – theoretical power\*} on both frequencies (400 MHz & 2GHz)

POE residuals (RES) : DORIS-only 2 GHz residuals from CNES POE

Temporal period and chosen satellite(s) : no rules, in general we took several cycles on SPOT5 (high number of measurements ) & ENVISAT (low elevations)

For a given couple beacon + satellite, we calculated the mean of all values (ATT or RES) located in a  $lat \times lon = 0.5^\circ \times 0.5^\circ$  square. In order to eliminate the biases (cable length, etc.) we subtracted the mean calculated for the entire geometries.

The results are compared with the fisheye views (360° views) from IGN if available, or other pictures of interest

$$* P_{theo} = P_{emi} - l_{gr} + g_{gr}(\theta) - p_{path} + g_{boa}(\theta) - l_{boa}$$

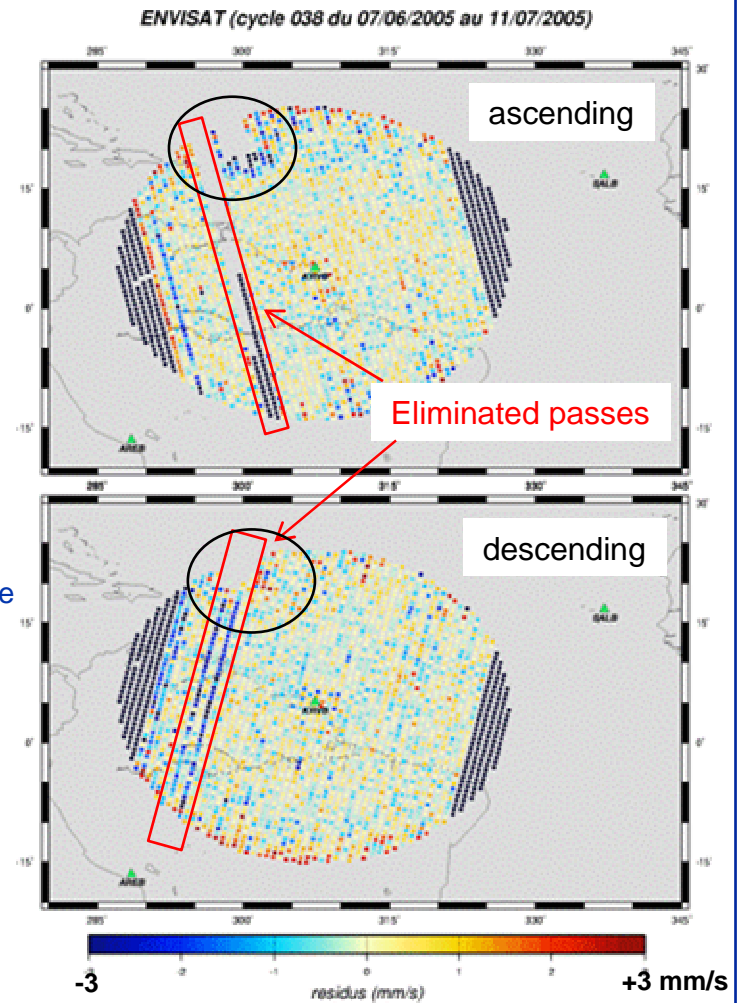
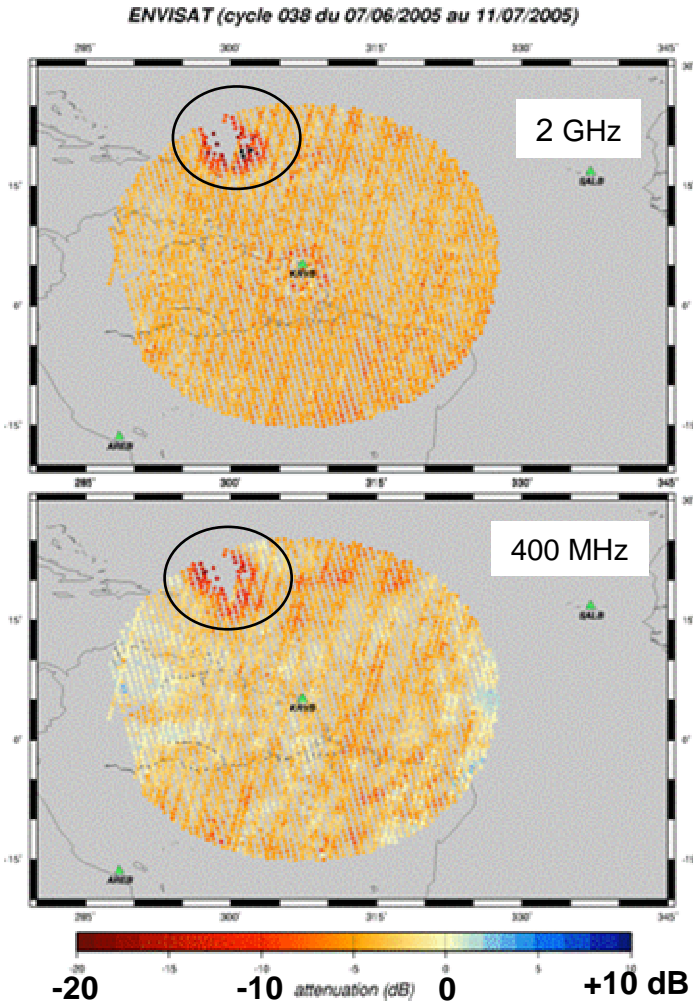
$gr$  = ground,  $boa$  = on-board,  $l$  = cable loss,  $g$  = antenna gain,  $\theta$  = elevation,  $p_{path}$  = path loss

# Kourou antenna

## RECEIVED POWER ATTENUATION (ENVISAT)

DORIS antenna

## POE RESIDUALS (ENVISAT)

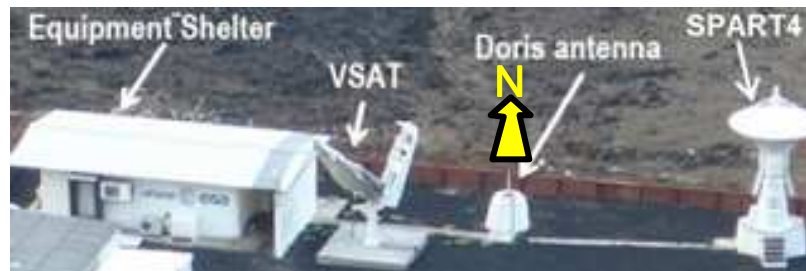


Obstruction in the North-East direction due to a big reception antenna near DORIS antenna.

Impact on the residuals :

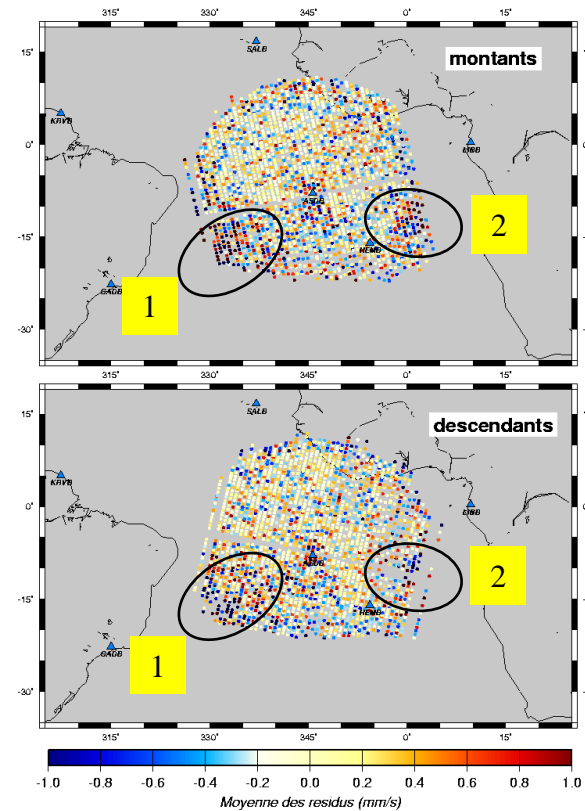
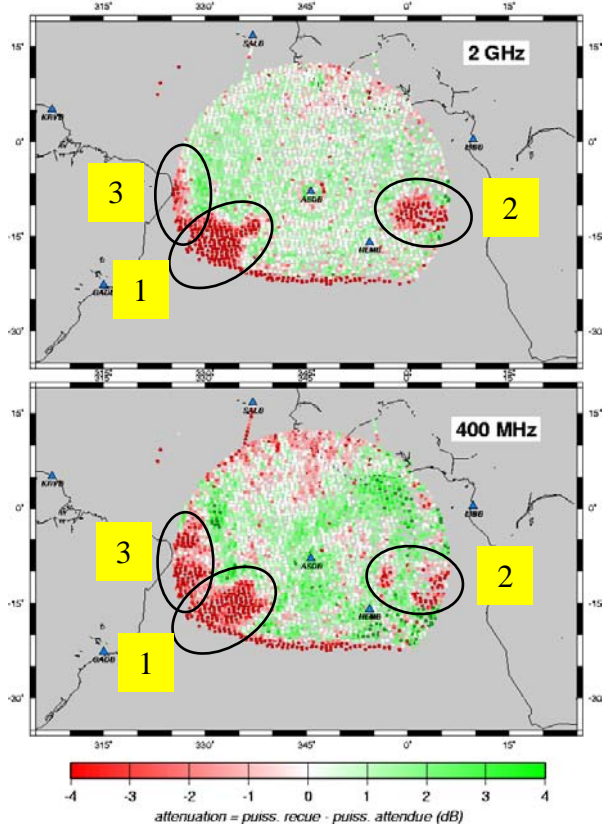
- some measurements impossible to do
- some passes are totally eliminated
- high values near the obstructed zone

# Ascension antenna



Balise DORIS d'Ascension : atténuation de puissance sur ENVISAT  
Moyenne d'avril 2005 à nov. 2005 par cellule de 0.5°x0.5°

Balise DORIS d'Ascension : résidus d'orbite POE ENVISAT  
Moyenne d'avril 2005 à nov. 2005 par cellule de 0.5°x0.5°



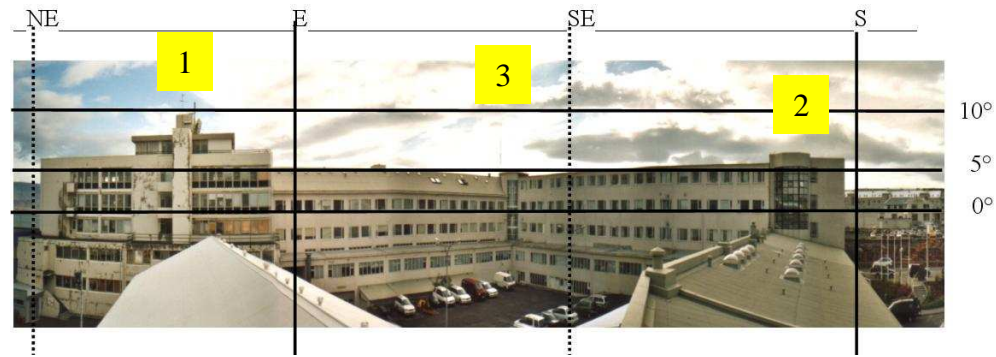
Three sources of obstruction :

1. VSAT Antenna (South-West), since July 2004
2. SPART4 antenna (East)
3. Building roof (West)

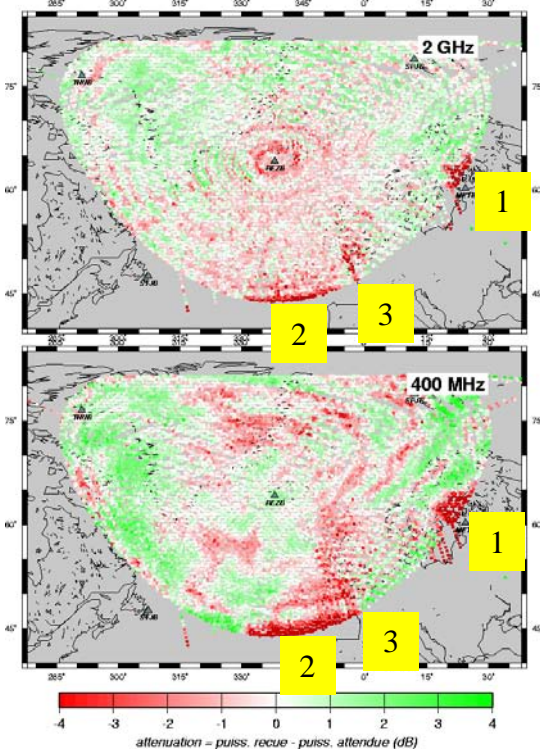
Impact on the residuals : high values due to the antennas (the roof is to low)

Will be done : displacement and raise of the antenna

# Reykjavik antenna



Balise DORIS de Reykjavik : atténuation de puissance sur ENVISAT  
Moyenne du 15/11/2006 au 30/05/2007 par cellule de 0.5°x0.5°



Three sources of disturbances :

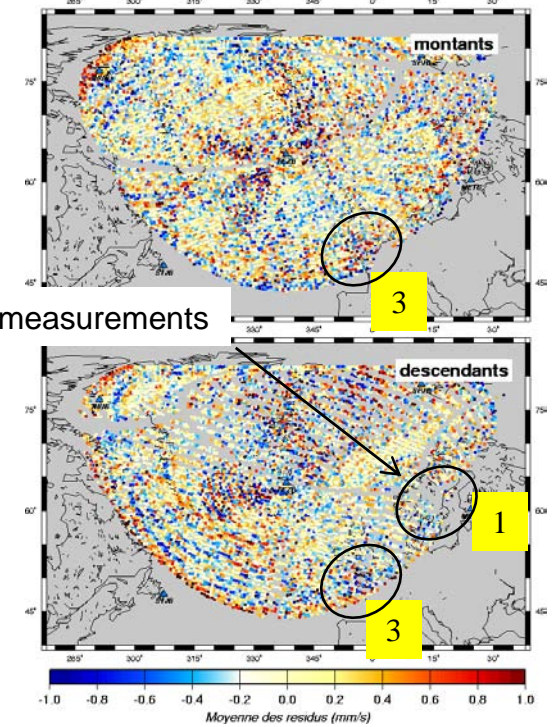
1. Building 10° elev..
2. Building 6° elev..
3. Lightning rod (TBC) 9° elev.

Impact on the residuals :

- less measurements due to building 1
- high value due to the lightning rod

Other observations on the residuals : high values at high elevation, depending on the azimuth → multipaths due to corrugated iron on the roof ?

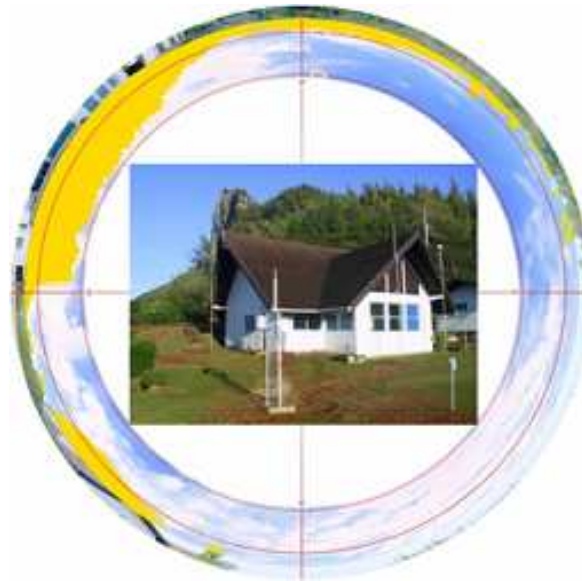
Balise DORIS de Reykjavik : résidus d'orbite POE ENVISAT  
Moyenne du 15/11/2006 au 30/05/2007 par cellule de 0.5°x0.5°



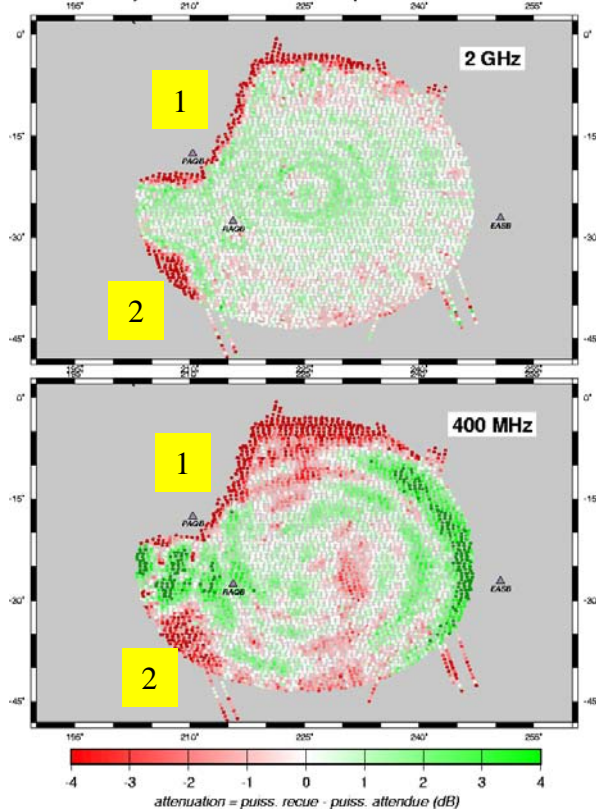
Less measurements



# Rikitea antenna



**Balise DORIS de Rikitea : atténuation de puissance sur ENVISAT**  
Moyenne du 15/11/2006 au 30/05/2007 par cellule de 0.5°x0.5°



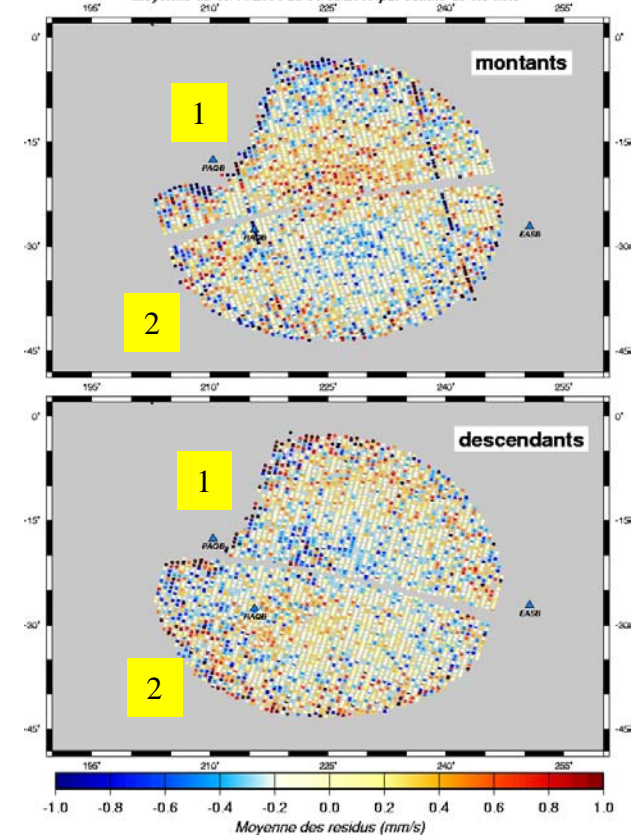
Two sources of disturbances :

1. Cliff and building roof (North-East)
2. Building roof (South-East)

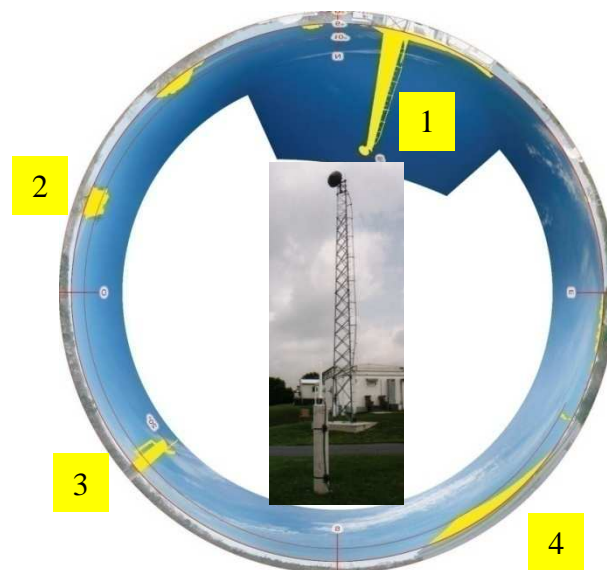
Impact on the residuals :

- no measurements in direction 1 at low elevation  
+ high values at the border
- Minor impact on the South-East direction

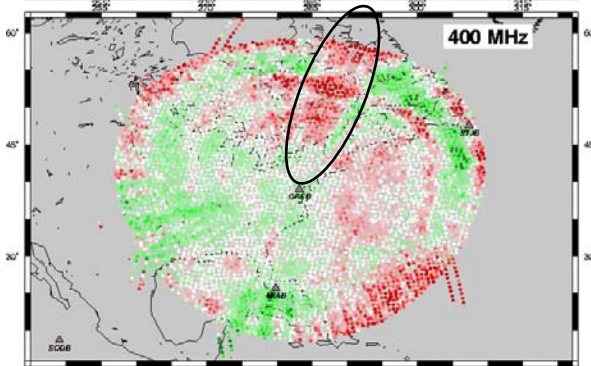
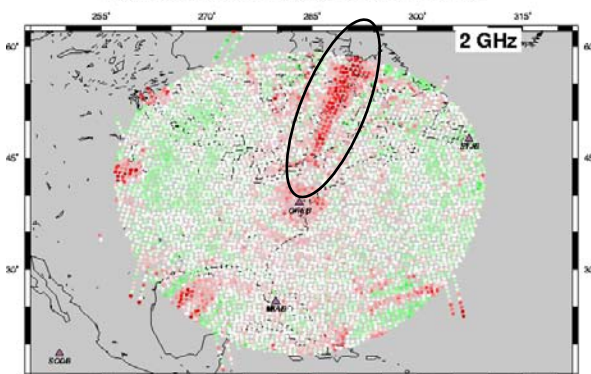
**Balise DORIS de Rikitea : résidus d'orbite POE ENVISAT**  
Moyenne du 15/11/2006 au 30/05/2007 par cellule de 0.5°x0.5°



# Greenbelt antenna

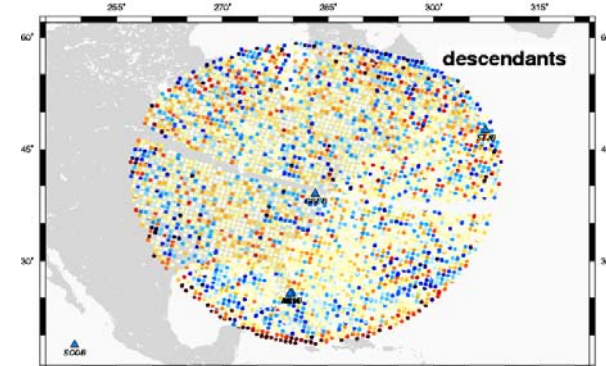
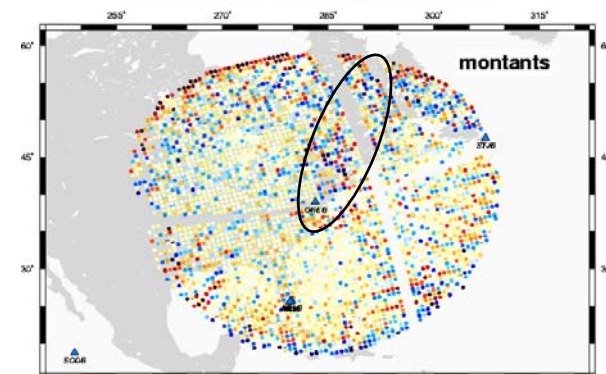


Balise DORIS de Greenbelt : atténuation de puissance sur ENVISAT  
Moyennes du 01/01/08 au 15/09/2008, par cellule de 0.5°x0.5°



attenuation =  $\text{puiss. recue} - \text{puiss. attendue}$  (dB)

Balise DORIS de Greenbelt : résidus d'orbite POE ENVISAT  
Moyenne du 01/01/08 au 15/08/08 par cellule de 0.5°x0.5°



Moyenne des résidus (mm/s)

Main sources of disturbances :

1. Metallic pole
2. Tree
3. Wood pillar
4. Building roof

Impact on the residuals :

- High values in the pole direction (asc. passes)
- Minor impact due to the wood pillar and the building

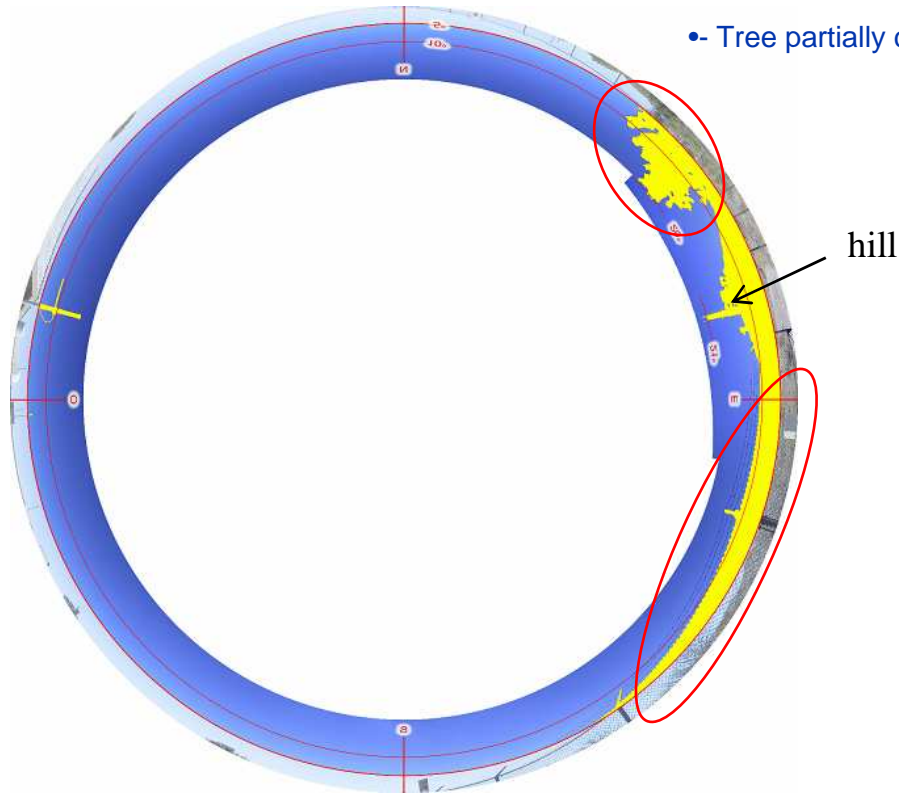
The antenna will be moved

# Monument Peak renovation (1/3)

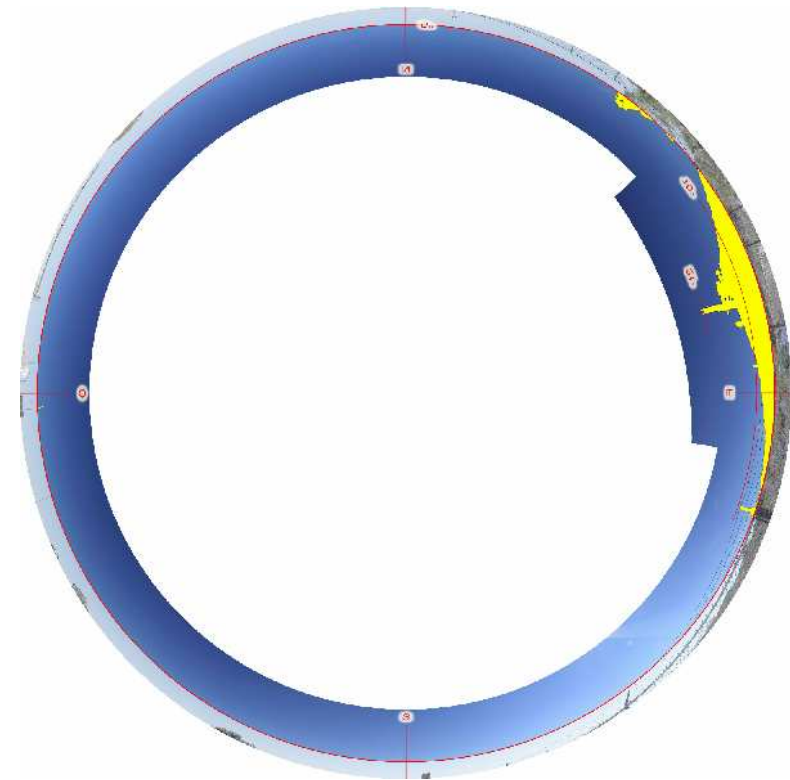
Renovation in December 2007 :

- Raising of the antenna +40 cm  
→ the wire netting is now beneath 5° elev.
- Tree partially cut down

**Before renovation : MONB**



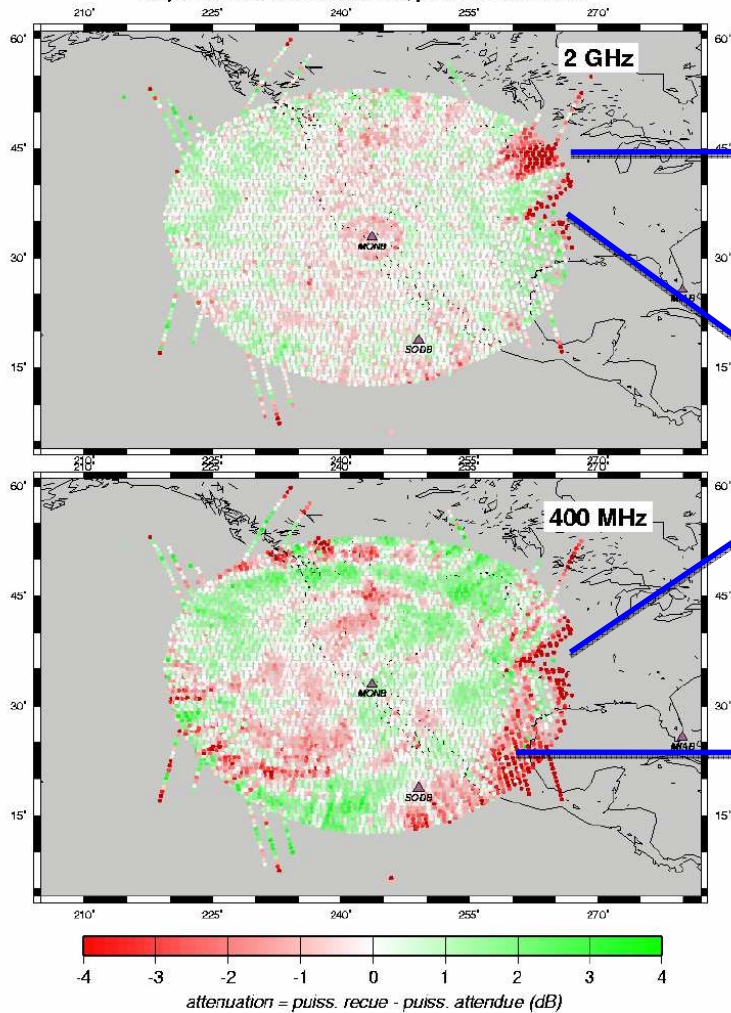
**After renovation : MOOB**



# Monument Peak renovation (2/3)

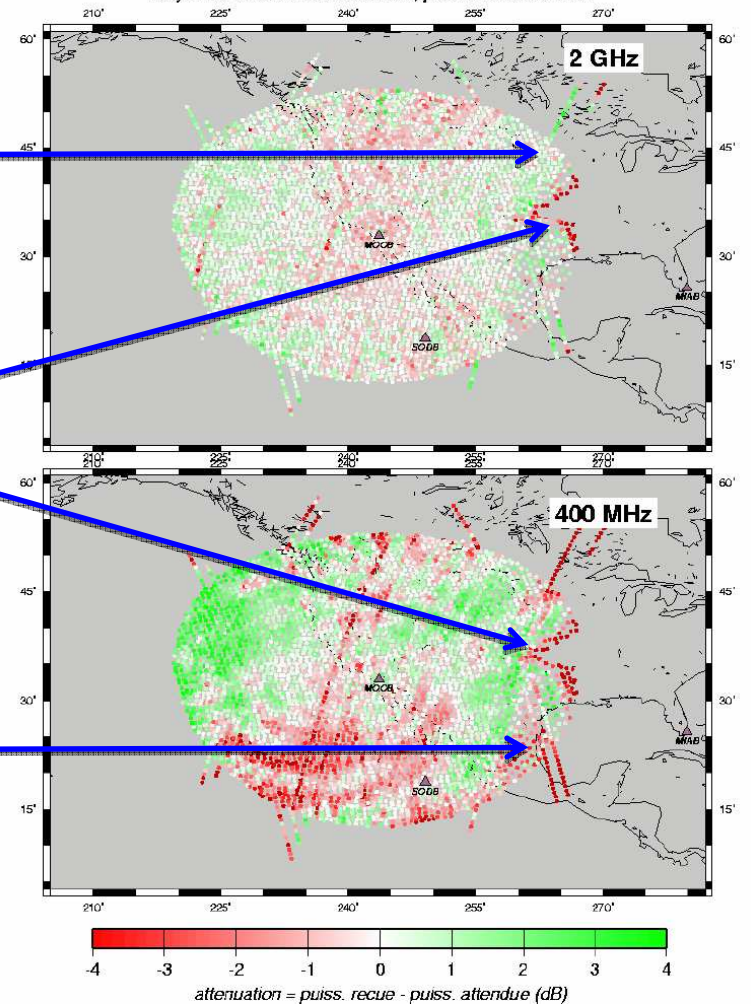
## Before renovation : MONB

Balise DORIS de Monument Peak : atténuation de puissance sur ENVISAT  
Moyennes du 01/01/07 au 04/12/07, par cellule de 0.5°x0.5°



## After renovation : MOOB

Balise DORIS de Monument Peak : atténuation de puissance sur ENVISAT  
Moyennes du 20/12/07 au 23/03/08, par cellule de 0.5°x0.5°



affected region has disappeared (tree)

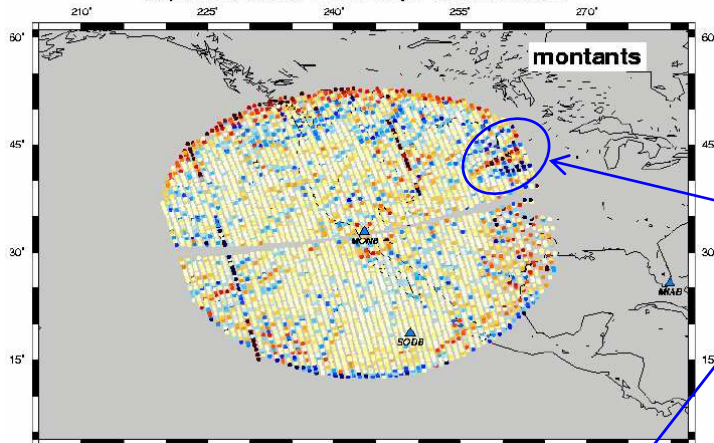
no change (hill)

Improvement  
(wire netting is lower)

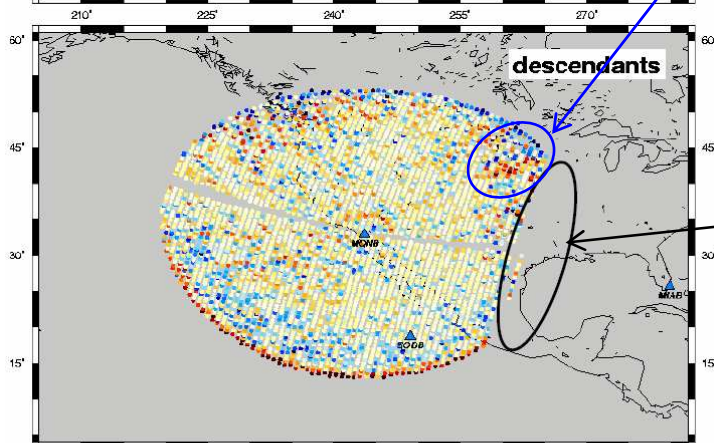
# Monument Peak renovation (3/3)

## Before renovation : MONB

Balise DORIS de Monument Peak : résidus d'orbite POE ENVISAT  
Moyenne du 01/01/07 au 04/12/07 par cellule de 0.5'x0.5'



affected region has disappeared (tree)

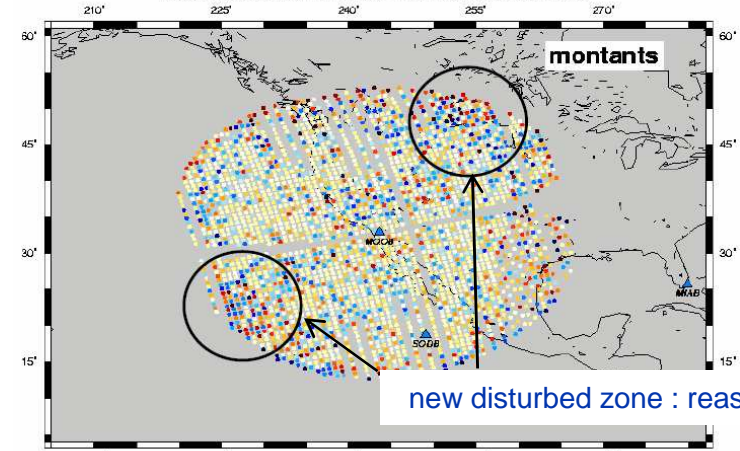


Still a large zone eliminated wire netting ?

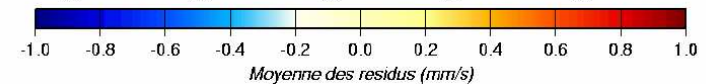
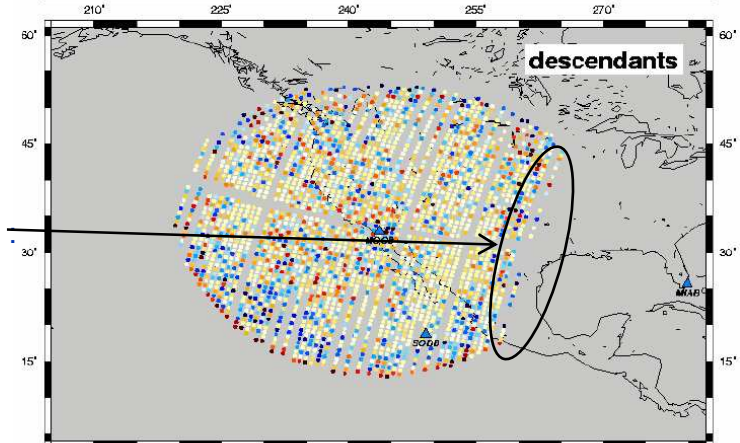


## After renovation : MOOB

Balise DORIS de Monument Peak : résidus d'orbite POE ENVISAT  
Moyenne du 29/12/07 au 11/02/08 par cellule de 0.5'x0.5'

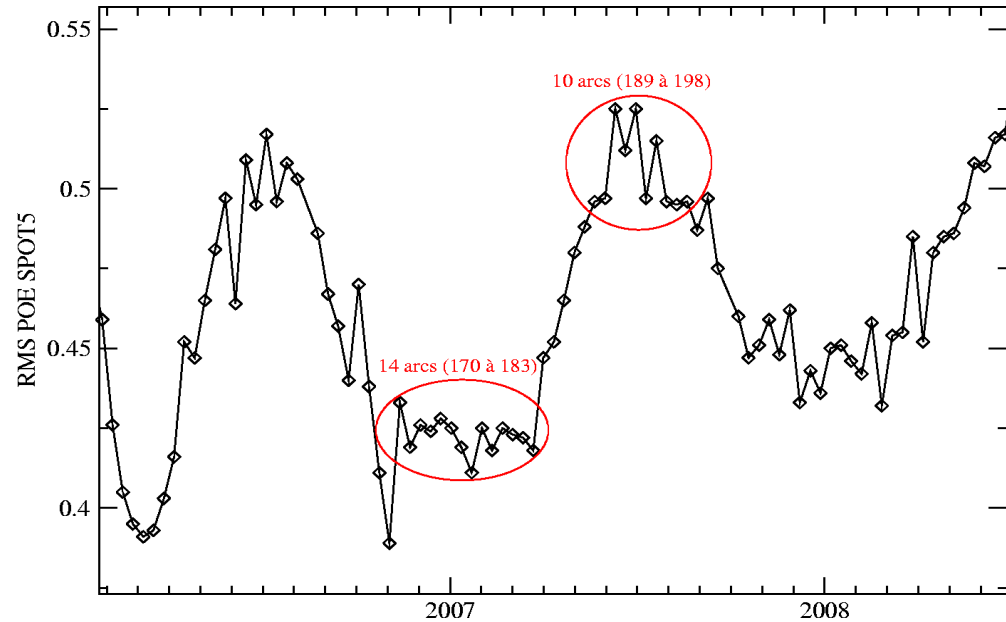
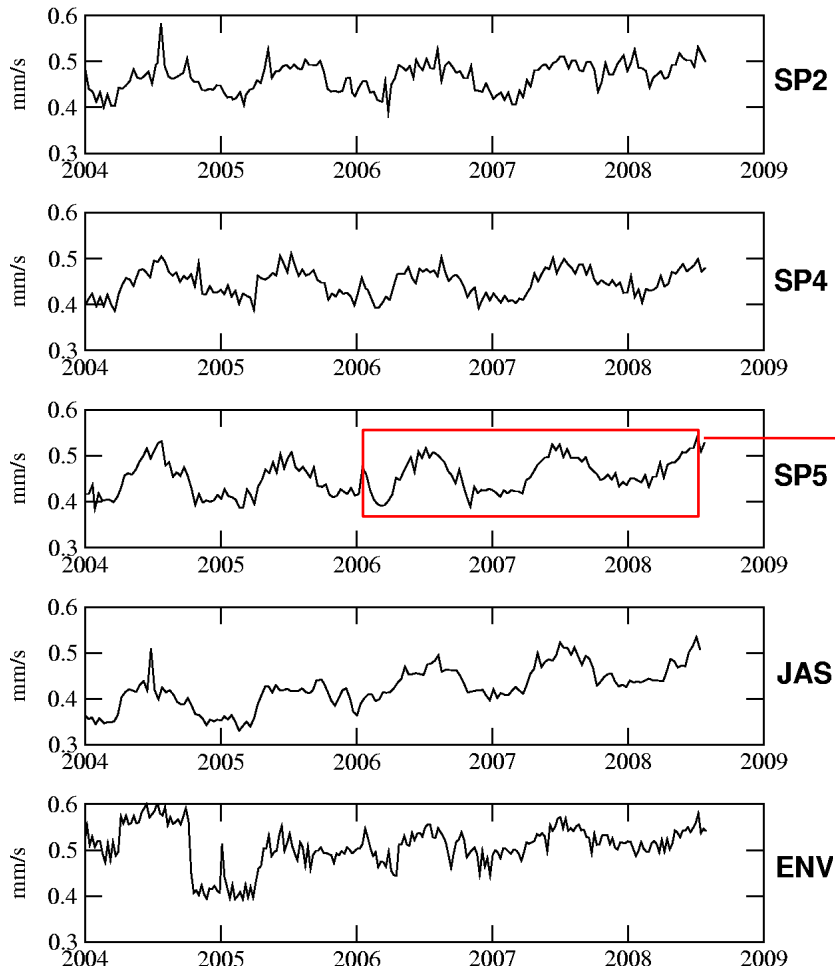


new disturbed zone : reason ?



# Fairbanks antenna (1/5)

RMS POE de la balise de Fairbanks



It is now well known that Fairbanks measurements are affected by multipaths (C. Tourain, C. Jayles in Groupes Performances DORIS).

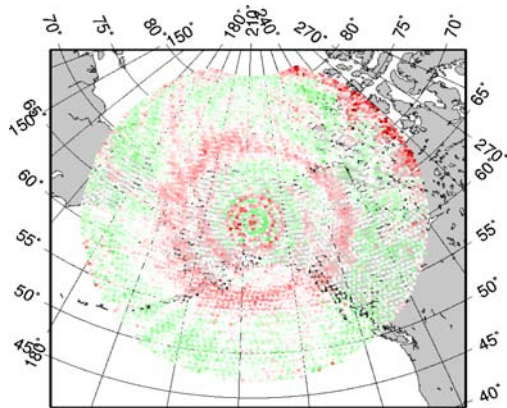
Do they have an annual signature ?

# Fairbanks antenna (2/5)

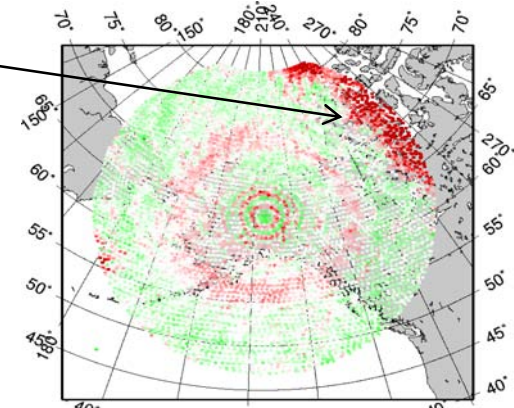
**Winter 2006-2007**  
(15/11/2006 → 31/03/2007)

**Summer 2007**  
(16/05/2007 → 24/08/2007)

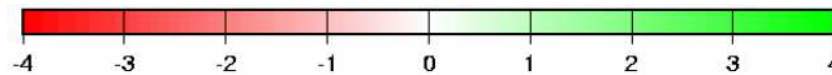
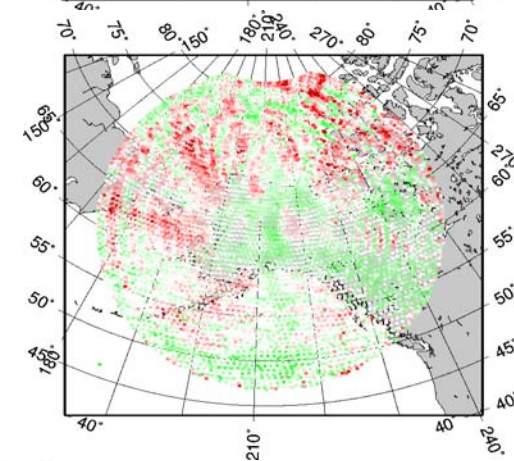
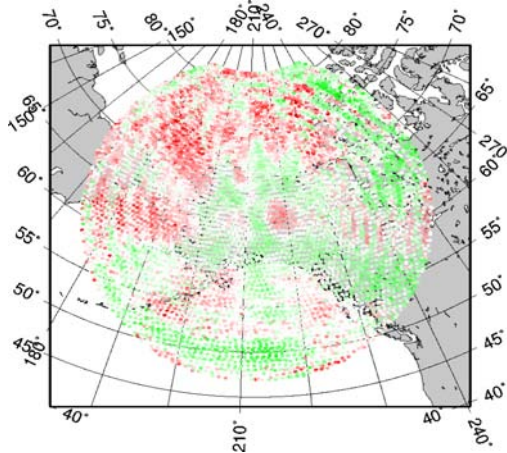
2 GHz



Forest (up to 16 °C)



400 MHz



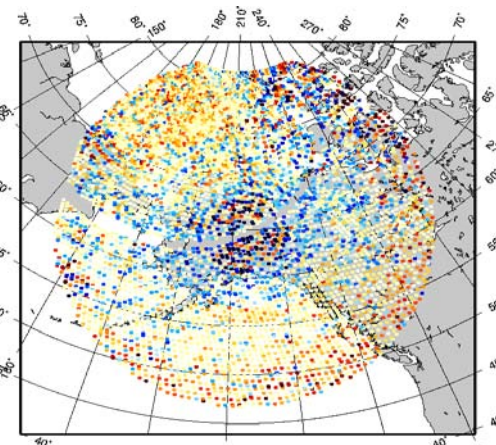
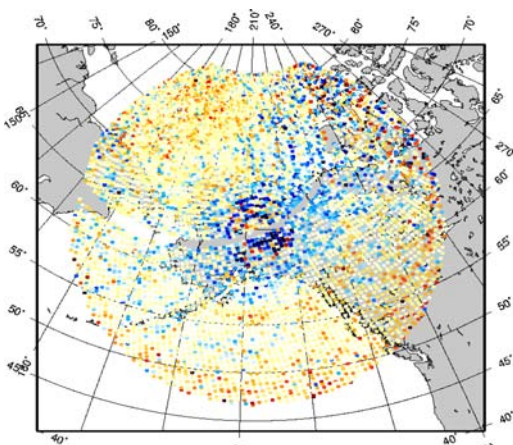
attenuation =  $\text{puiss. recue} - \text{puiss. attendue}$  (dB)

# Fairbanks antenna (3/5)

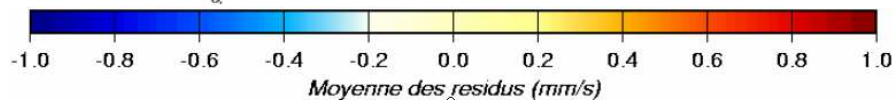
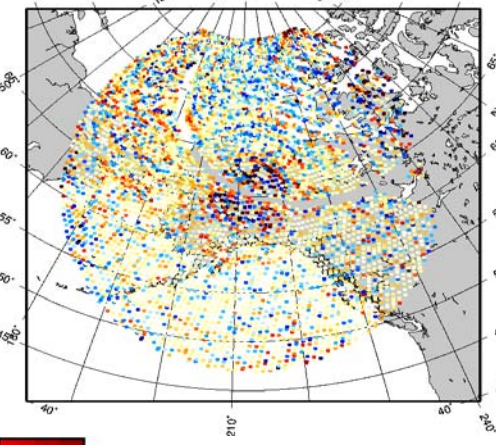
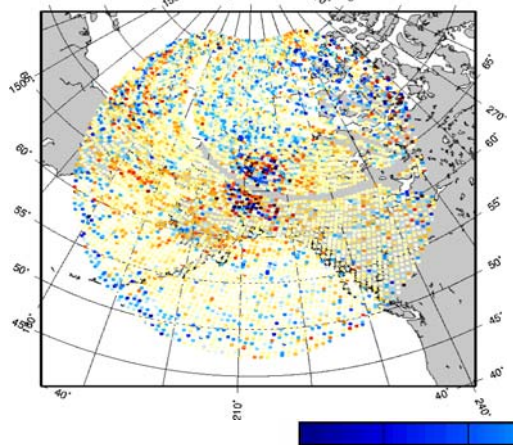
**Winter 2006-2007**  
(15/11/2006 → 31/03/2007)

**Summer 2007**  
(16/05/2007 → 24/08/2007)

ascending



descending



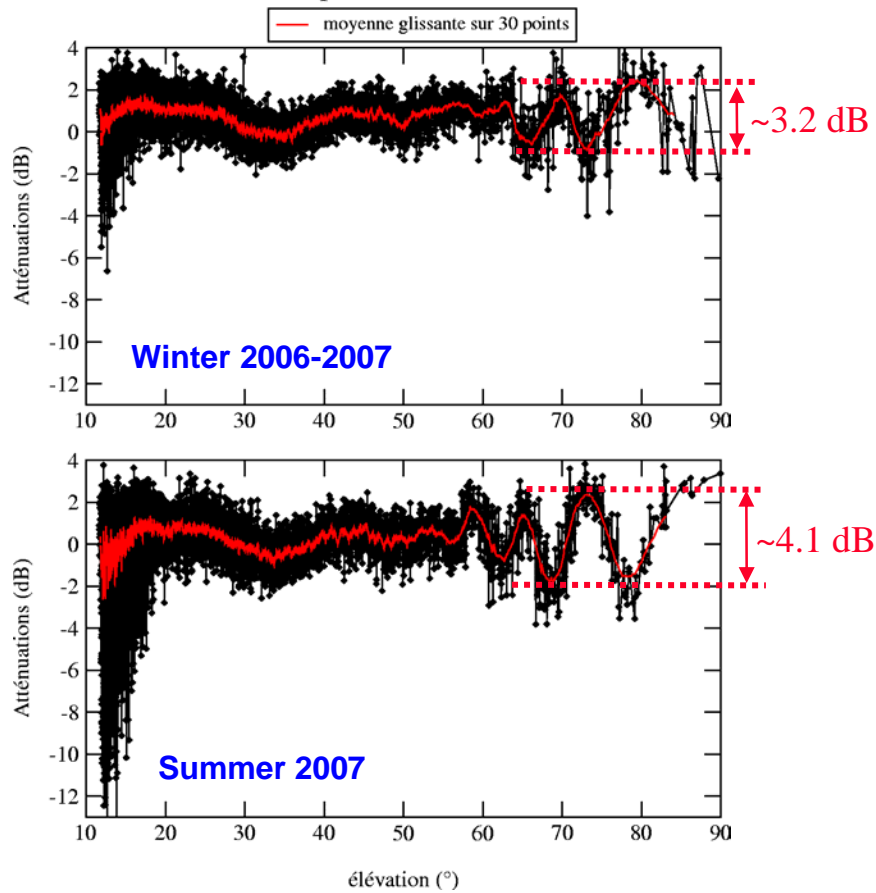


# Fairbanks antenna (4/5)

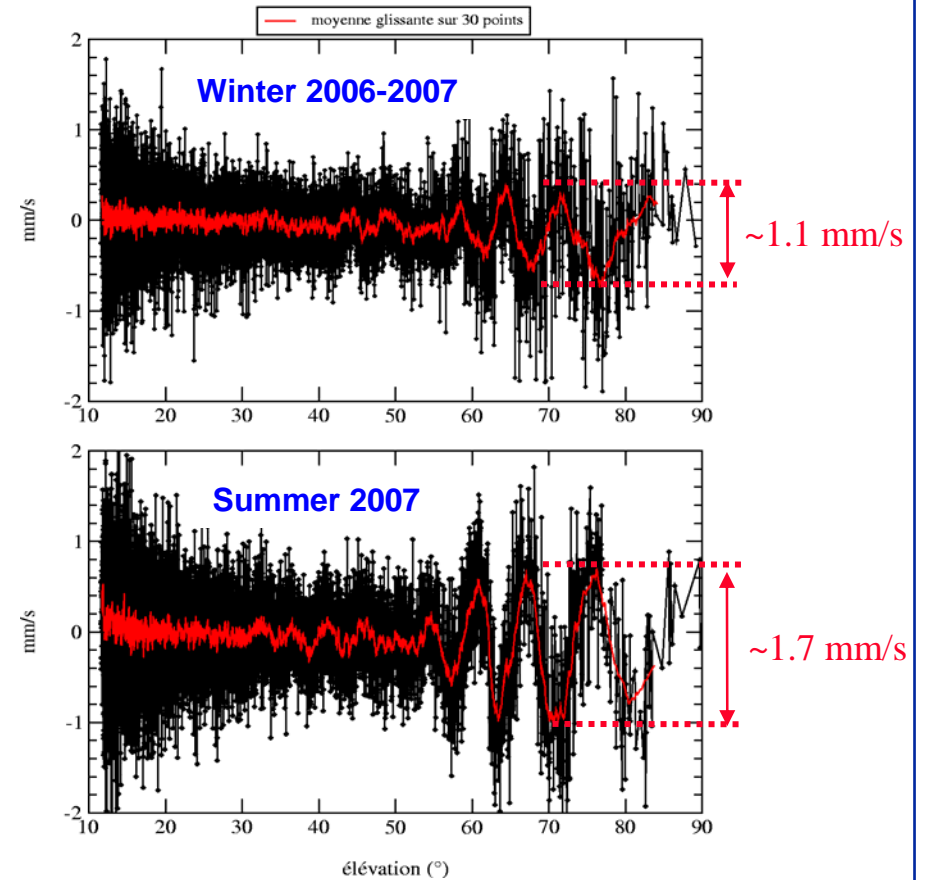
The amplitude of the multipaths is higher in Summer.

Same remarks for the disturbed zone in the North-East, especially regarding the received power

Atténuations de puissance 2GHz vs élévation



Résidus POE vs élévation en fonction de la saison



# Fairbanks antenna (5/5)



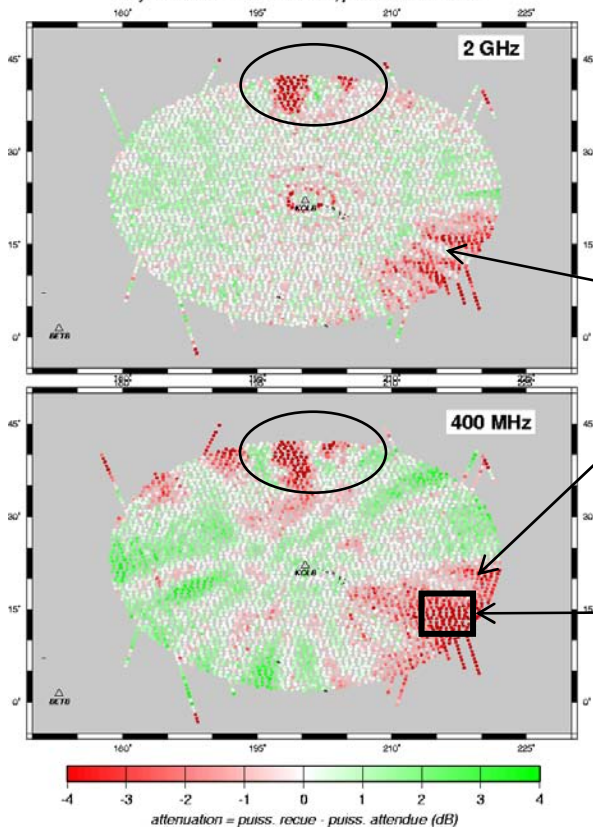
The antenna base might be snow-covered during winter, reducing the effect of the multipaths



# Kokee Park antenna (1/3)



**Balise DORIS de Kauai : atténuation de puissance sur ENVISAT**  
Moyennes du 01/01/08 au 08/06/08, par cellule de 0.5'x0.5'

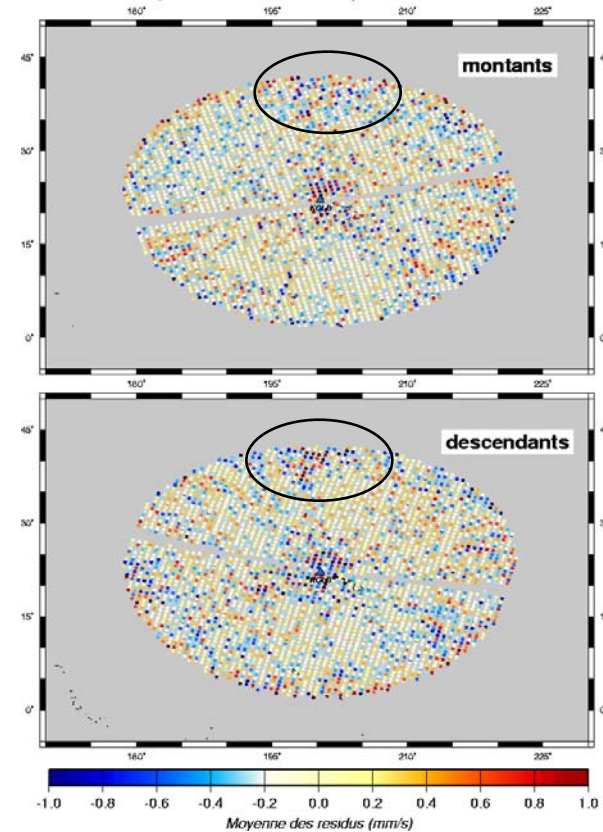


Known obstructions : 2 antennas in the Northern direction, with some minor effect on the POE residuals

??

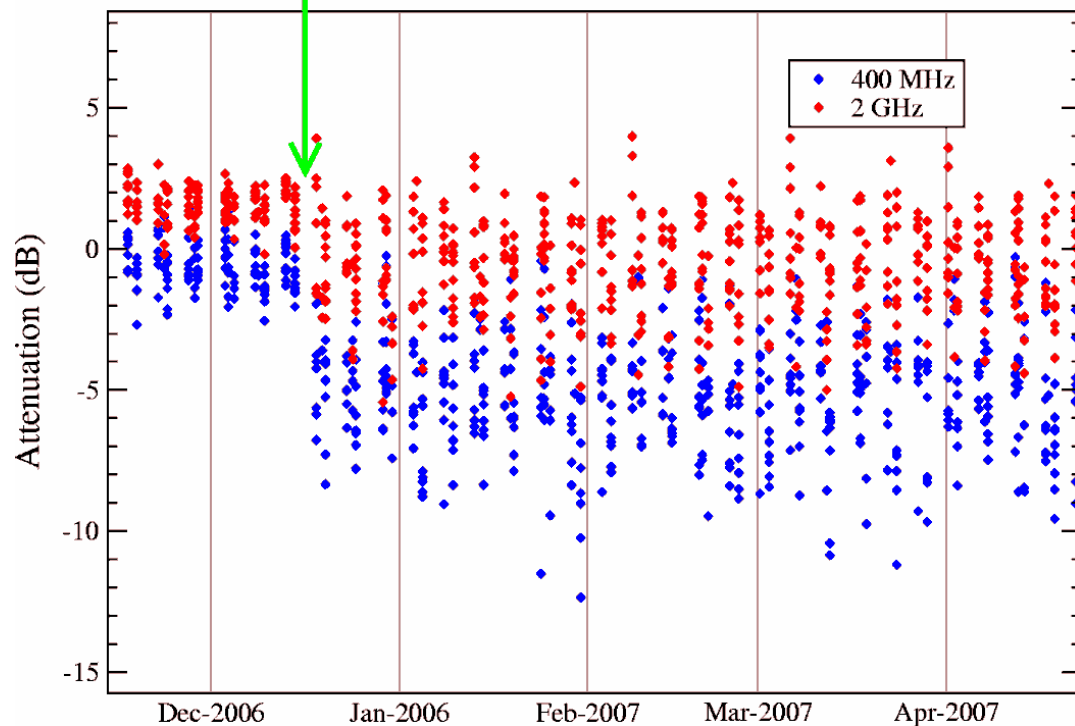
→ We analyzed the time evolution of the power attenuation in this square (next slide)

**Balise DORIS de Kauai : résidus d'orbite POE ENVISAT**  
Moyenne du 01/01/08 au 30/06/08 par cellule de 0.5'x0.5'



# Kokee Park antenna (2/3)

Modification between 15th and 18th of December 2006



The host organization confirmed the installation of a scaffolding at the end of December 2006.

At H. Fagard's request, the upper part was disassembled on Aug. 28th 2008



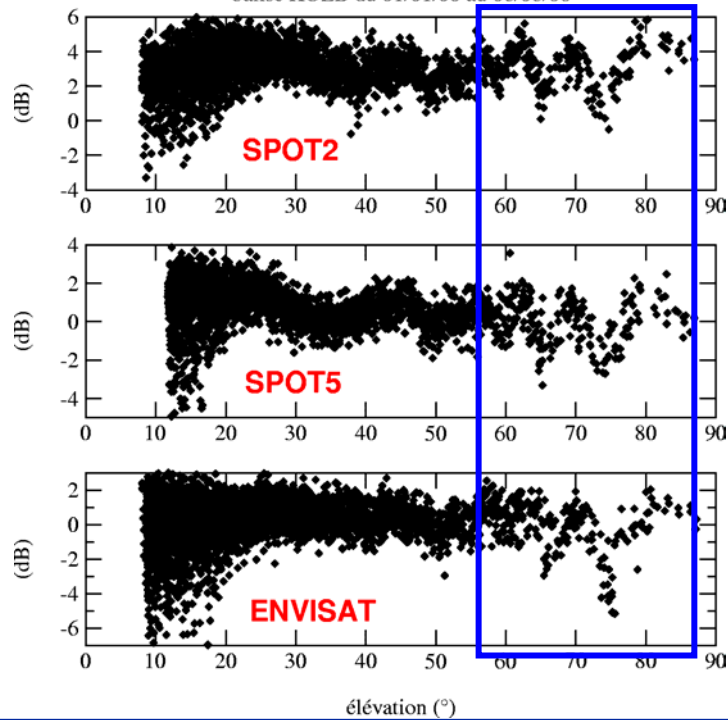
# Kokee Park beacon (3/3)



Similar antenna base  
to Fairbanks one  
→ multipaths ?

Atténuations de puissance 2 GHz

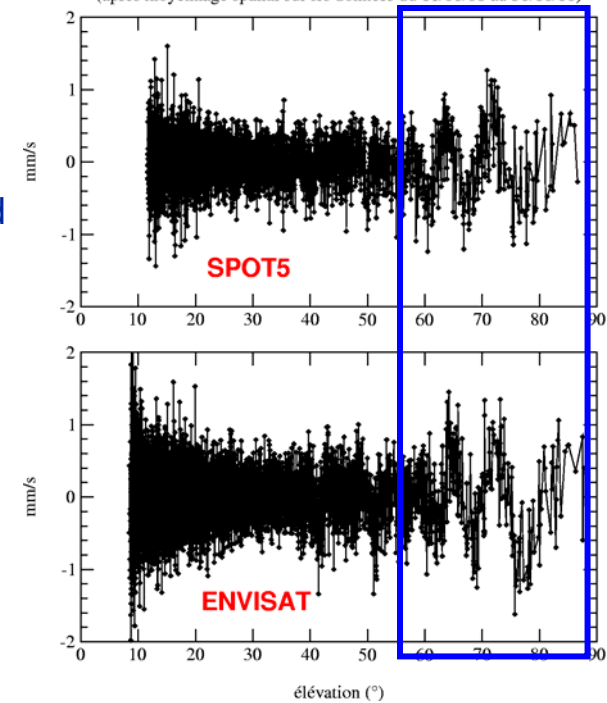
balise KOLB du 01/01/08 au 06/06/08



Wave pattern are observed  
both in power attenuation and  
in POE residuals. The  
multipaths are confirmed but  
with a smaller amplitude than  
for Fairbanks

Résidus d'ajustement d'orbite POE de la balise KOLB

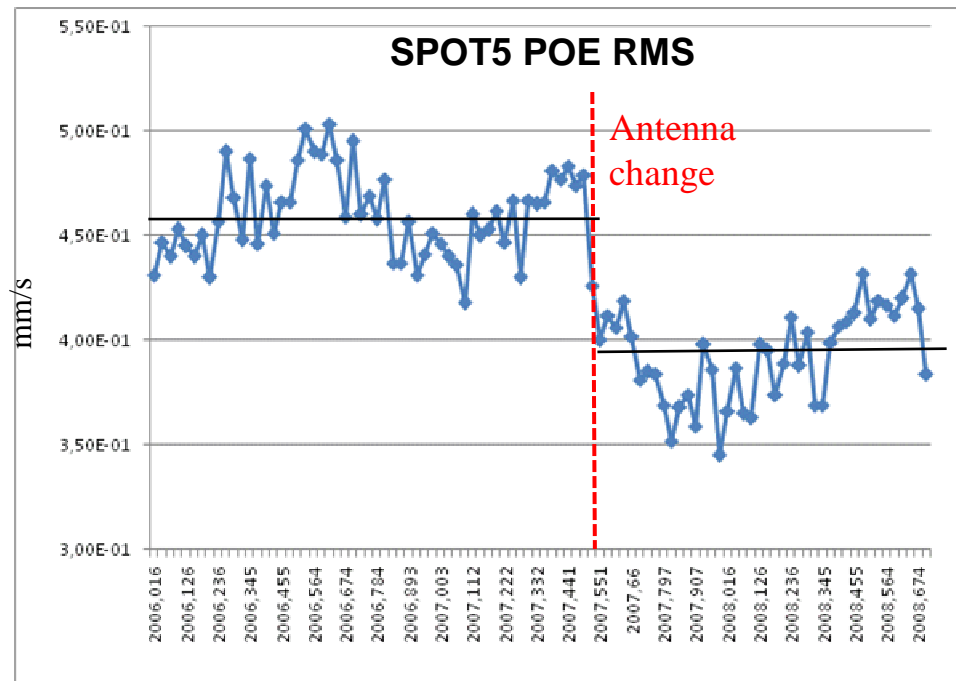
(après moyennage spatial sur les données du 01/01/08 au 30/06/08)



# Toulouse site renovation

Processed in two steps :

- June 1st 2007 : laying of pebbles around the antenna to avoid multipaths → no effect
- July 3rd 2007 : change of antenna type (Alcatel → Starec) and raising of a few cm. Effects :
  - ❑ Power attenuation : less disturbances in the Western and Eastern region
  - ❑ POE residuals : significant improvement



Before : RMS > 0.45 mm/s

After : RMS < 0.40 mm/s

# Synthesis : types of disturbances

Divided into 2 types of disturbances :

- physical obstructions
- multipath

Physical obstructions :

- Solid & large : mountain, roof, large antennas
- Solid & thin : poles, thin antennas
- “Opened” obstructions : wire netting, scaffolding, trees & vegetation

We observed that the regions affected by the obstructions are larger on the 400 MHz frequency than on the 2 GHz frequency. This may be due to the fact that the diffraction effect is in inverse proportion to the frequency.

Multipath : due to the antenna base. Observed on the 2 GHz frequency only.

# Conclusions & prospects

- Depending on the nature of the physical obstructions, and the signal frequency, the power attenuation and POE residuals react differently
- Multipath effects are confirmed in Fairbanks and to a lesser extent in Kokee Park. The snow thickness might reduce this effect
- Interesting example of interactions between actors of the “Groupe Performances DORIS” (scaffolding in Kokee Park)
- Some affected regions are still unexplained
- Use of “standard deviation” instead of “mean” in the  $0.5^\circ \times 0.5^\circ$  process