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Long and Short Term Stability of SMOS Measurement with NIR Front-end Models

SMOS & Aquarius Workshop, Brest, France, April 15-17 2013

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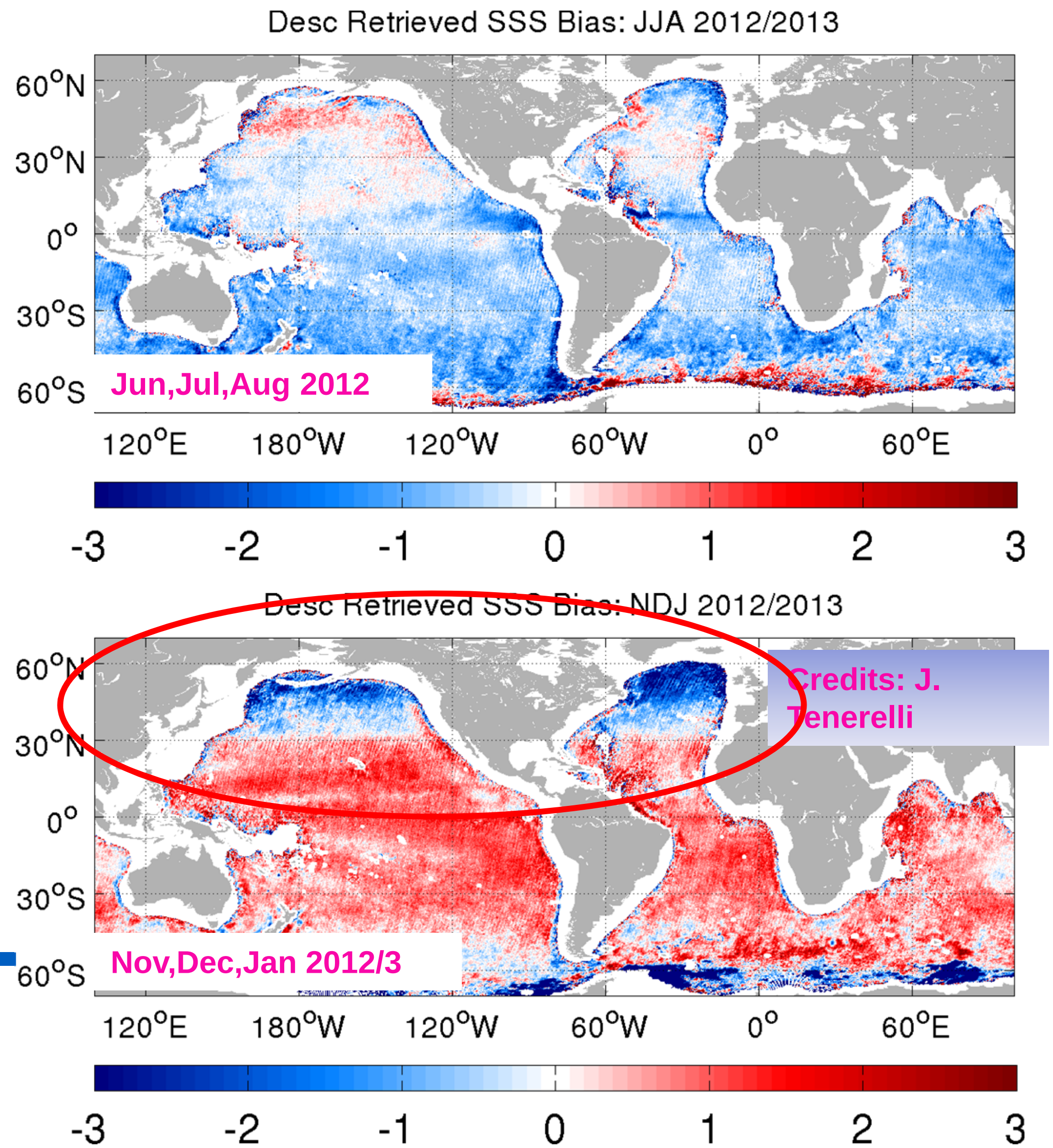
Contents

- Motivation – temporal biases in SMOS measurements
- Noisi Injection Radiometer (NIR) units in SMOS
- Stability of SMOS measurements at Pacific with 4 different front-end models.
- Can the current stability be improved?

Motivation

- **Seasonal (long term) variations? Different bias signature over summer and winter periods.**
- **Latitudinal (short term) variations? Strong SSS-error gradient at the >30°N.**



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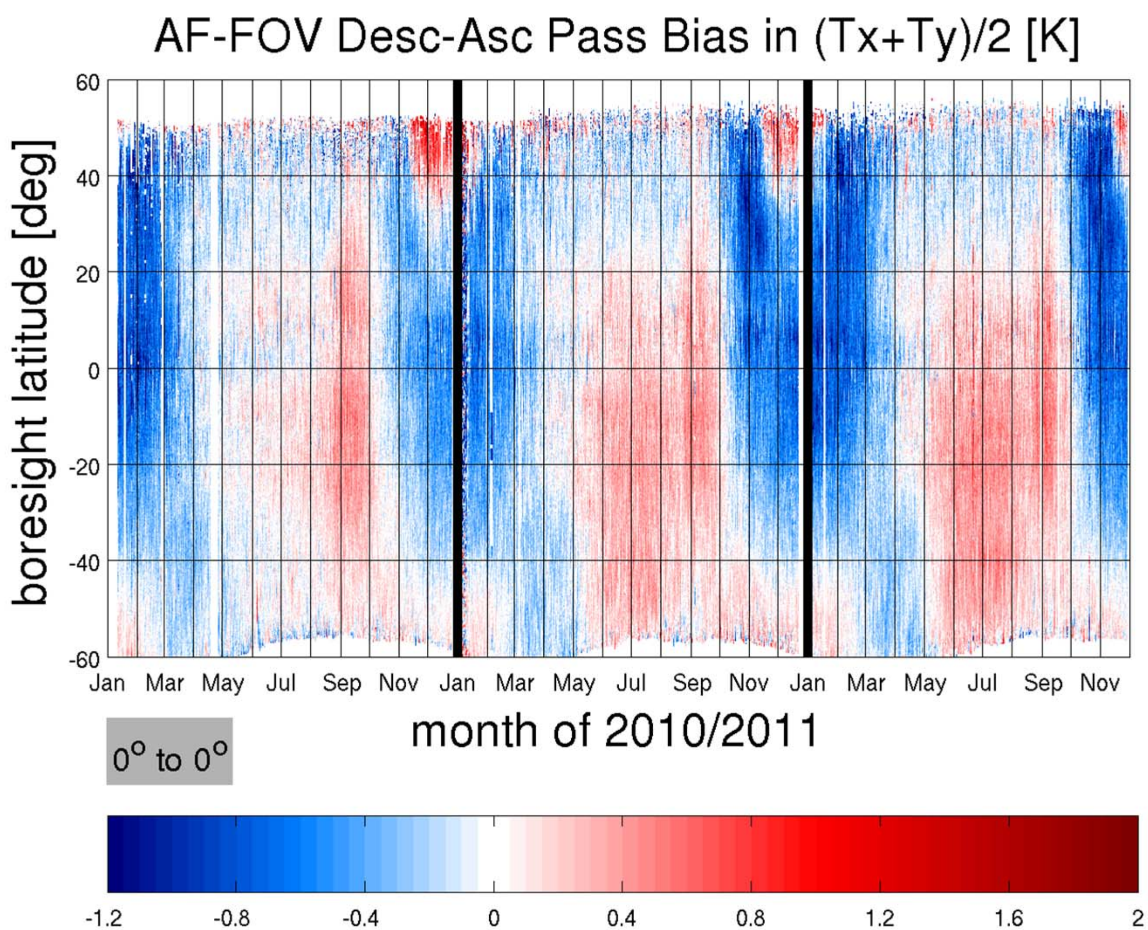
Motivation

- **Orbital (short term) variations? Different bias signature for ascending and descending measurements.**
- **This hovmoller-plot presents Desc-Asc bias in AF-FOV obtained from thousands of half-orbits over different seas.**



Credits: J. Tenerelli

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SMOS reference radiometers – the NIR units Several purposes on SMOS:

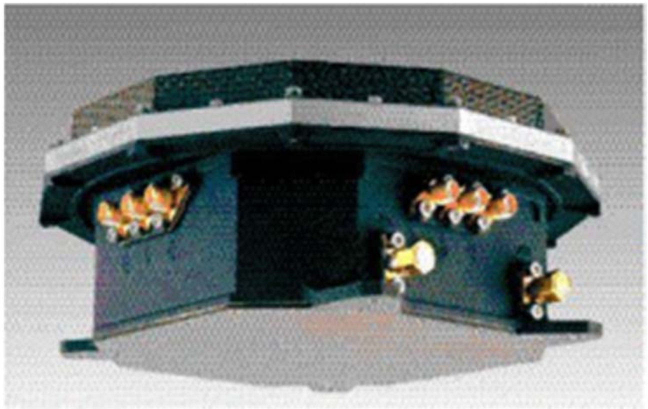
1) to measure the zero baseline visibility (antenna temperature)

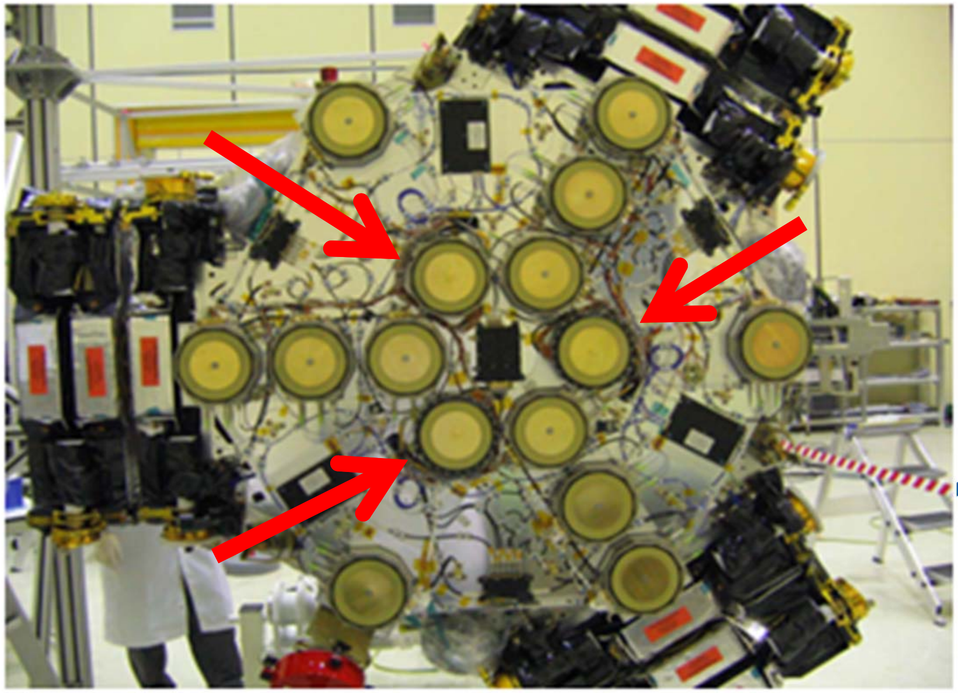
2) to measure the calibration diode power level

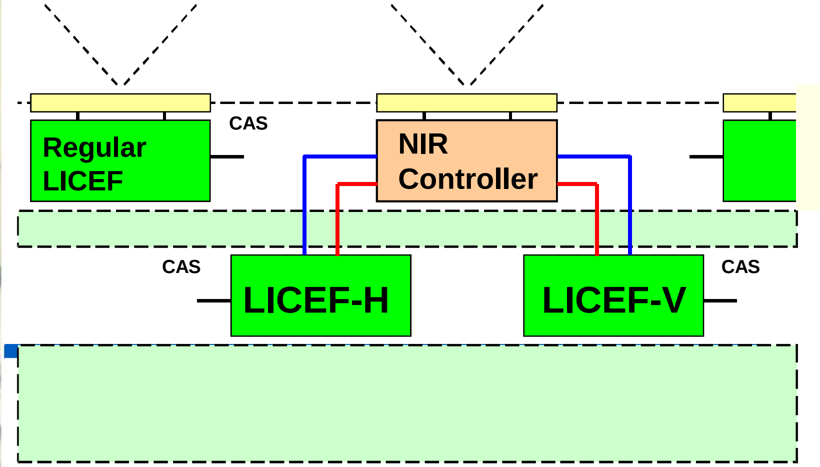
3) to establish baselines with other receivers

4) to calibrate NIR/LICEF antenna losses

5) to detect RFI



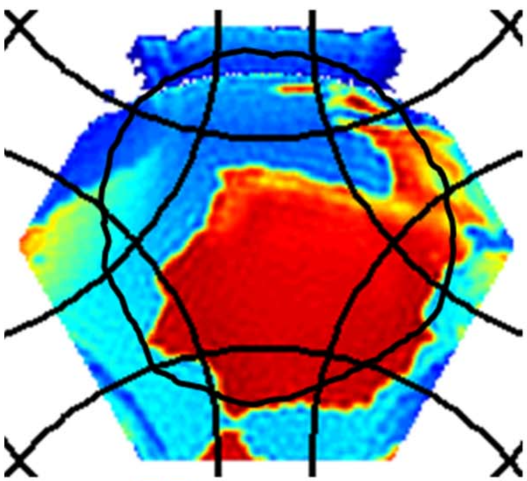




NIR Field-of-View

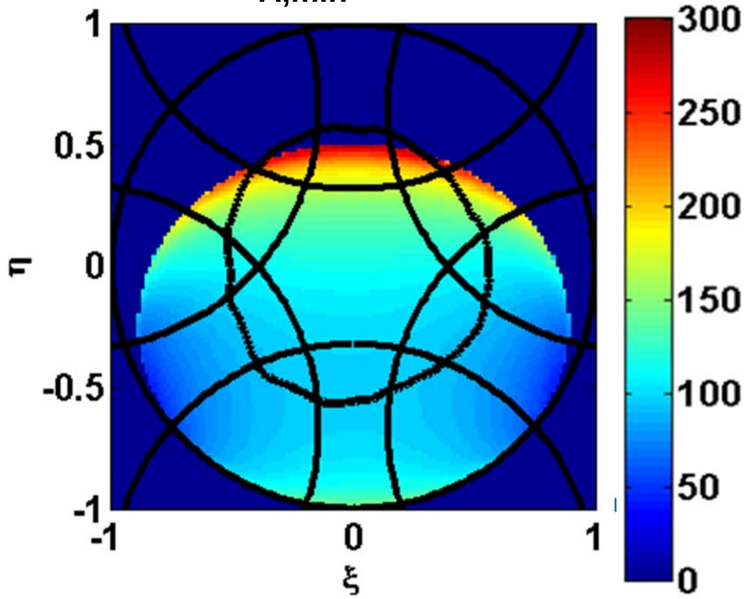
- HPBW of NIR antennas are ± 28-32°. Footprint on ground spans over approximately 1000 km circle.
- Antenna temperature measured by the units is used to determine the overall brightness temperature level of the synthesized image.

Iberian peninsula



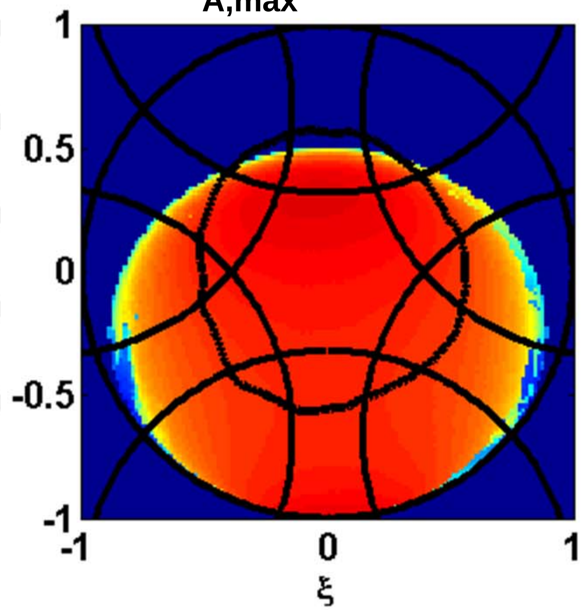
Pure sea view

$T_{A,min} \approx$ 80 K



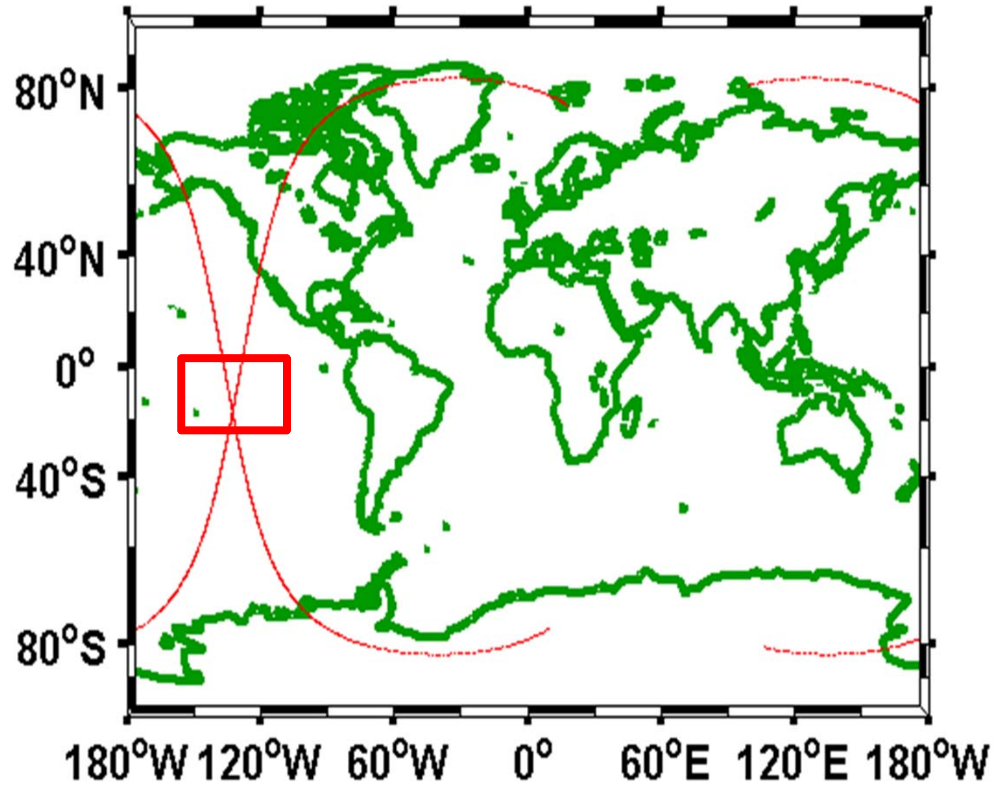
Pure land view

$T_{A,max} \approx$ 220 K



Stability test area Pacific Ocean

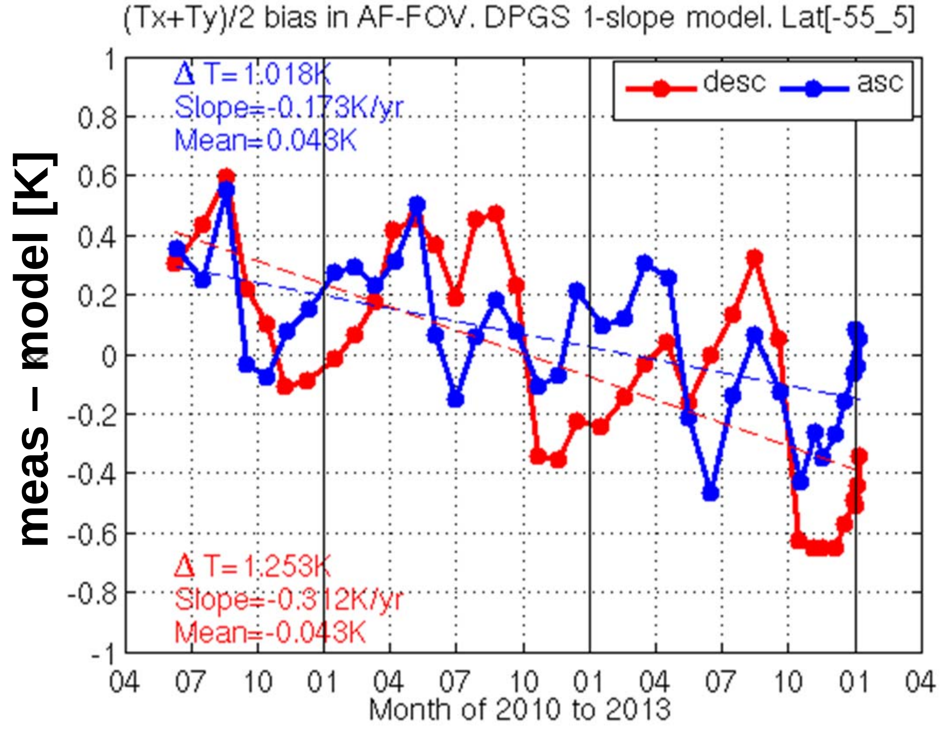
- One of the stability test areas is an area at Pacific Ocean.
- A forward model has been established to simulate both
  1) The brightness temperature of the area
  2) NIR antenna temperatures when measuring the target area
- Stability of SMOS images and NIR measurements are assessed.
- (Bi-weekly measurements of sky.)



Stability test area
Pacific Ocean

- Bias measured from the test area averaging pixels within the AF-FOV area.
- Ascending and descending passes separately.
- Current performance state decreasing trend along the mission (0.2-0.3 K/year) and ~1.2 K peak-to-peak errors over this trend.
- How can we do better?

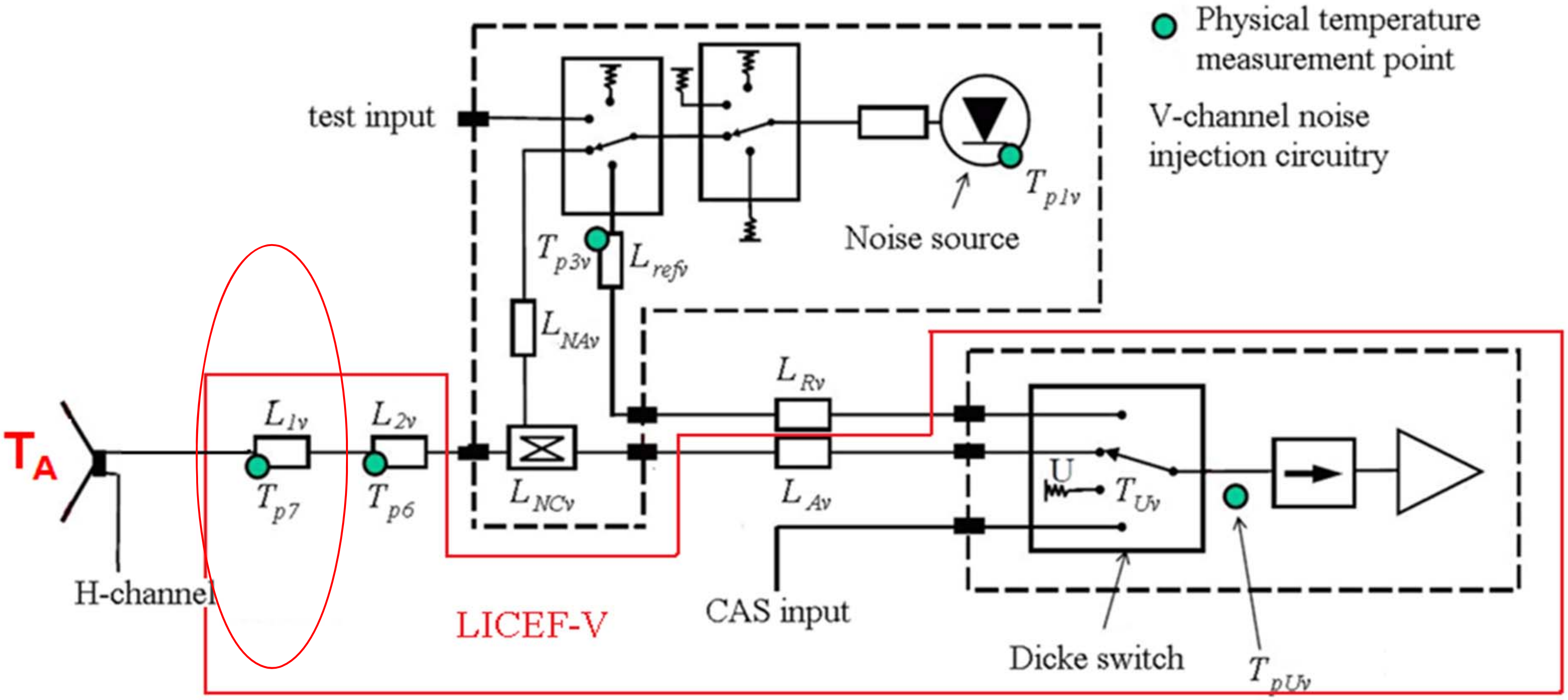
Brightness temperature bias



NIR front-end attenuation L1

- Soon after the commissioning, **difts was observed in sky measurements**. This drift in antenna temperature was resulted when **either NIRs of pure LICEFs** were used in measurements.

→ **The phenomenon causing the drift is common to LICEFs and NIRs → Antenna ?**



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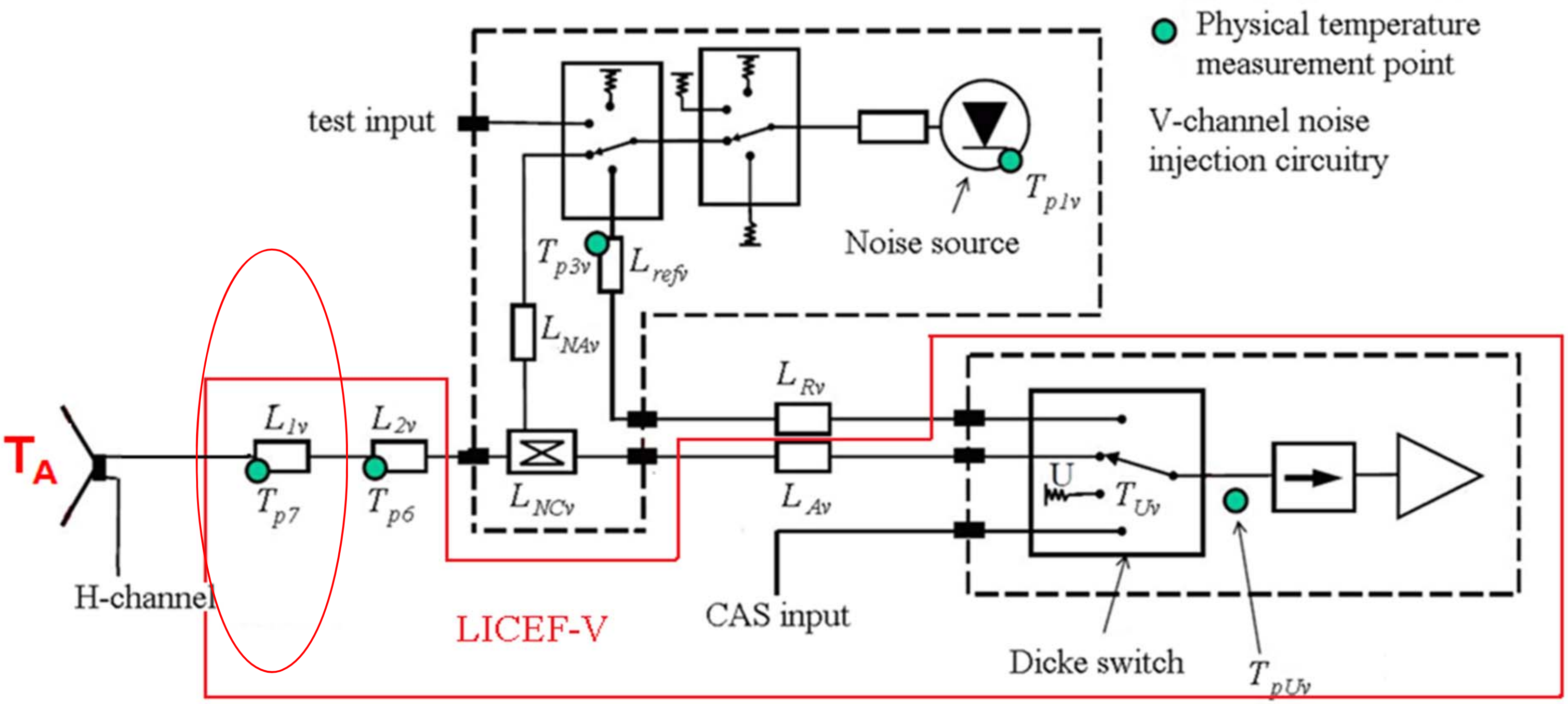
NIR front-end attenuation L1

- On-ground, L1 was determined by the antenna manufacturer **to be 0.05 dB**. L1+L2 attenuation level of ~0.2 dB was anticipated by on-ground characterization of NIR units.



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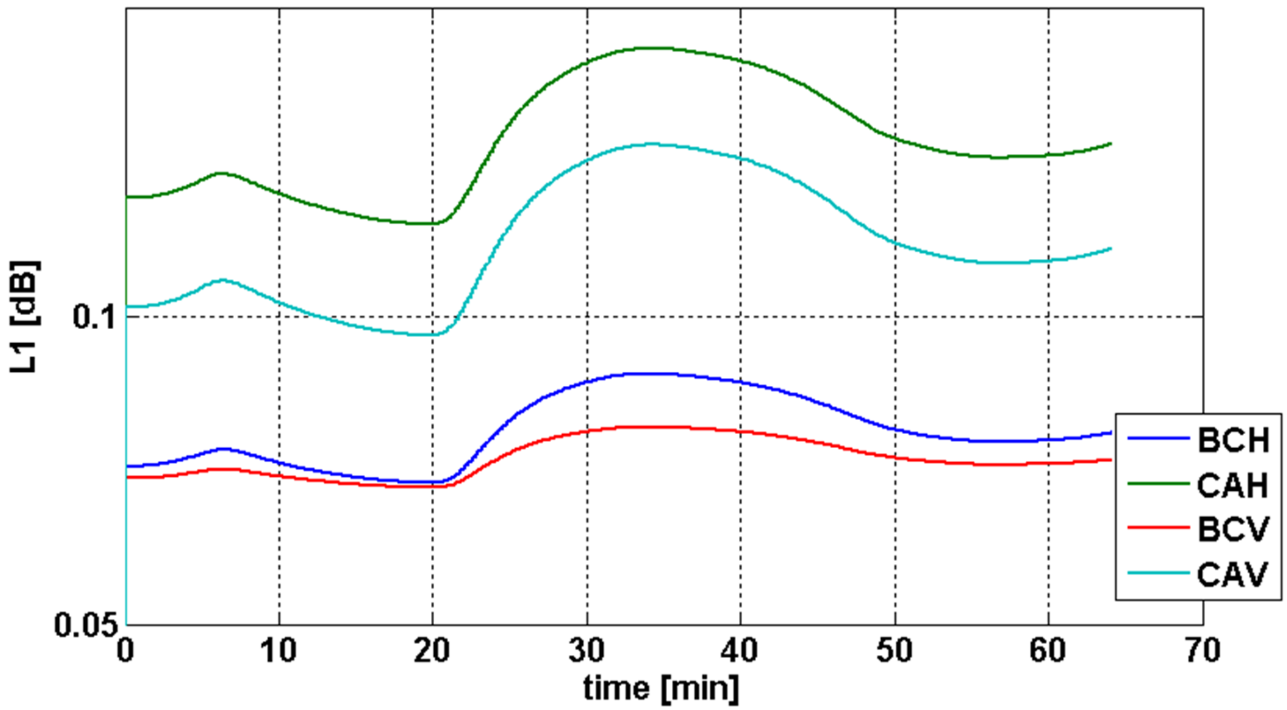
A)1-slope antenna model

- The first attemp to correct biases was developed based on strong correlations between the observed drift and the physical temperature of the antenna patches (T_{p7}). This dynamic model ("1-slope model") related L1 to patch temperatures.
- The method defines L1 attenuation for each epoch. It consists of a part coping with long-term and short term-biases.
- The 1-slope model was implemented for the first mission reprocessing (504), since it was noticed to decrease the discrepancy between ascending and descending passes.

$$L_1(t) = dL_{1,0} + \alpha\underbrace{\left(\overline{T}_{p7} - \overline{T}_{p7,ref}\right)}_{\text{Long-term}} + \beta\underbrace{\left(T_{p7} - \overline{T}_{p7,ref}\right)}_{\text{Short-term}}$$

A)1-slope antenna model

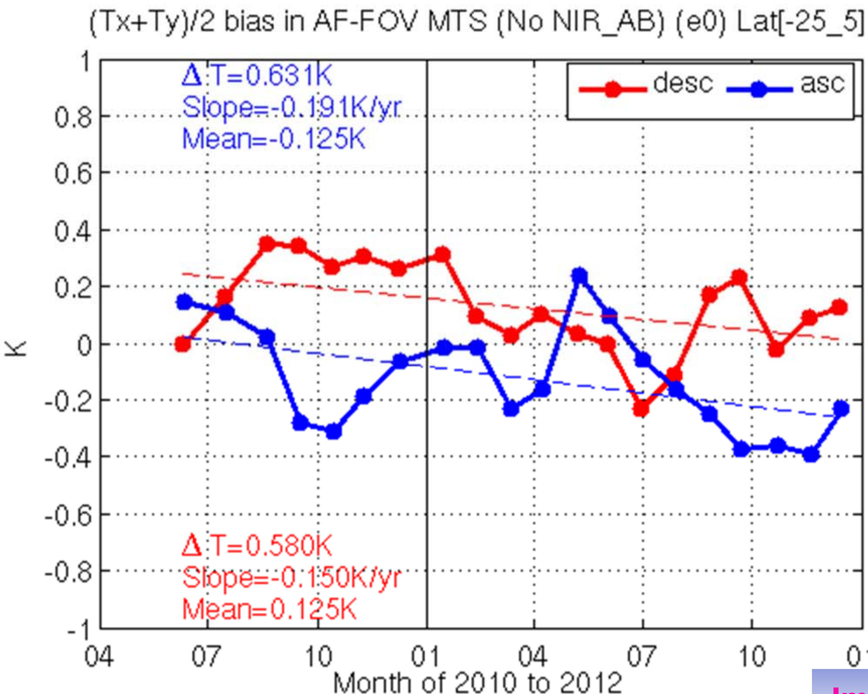
- L1 values from an examplary half-orbit in January 2011.
- L1 values follow the T_{p7} temperature profiles.



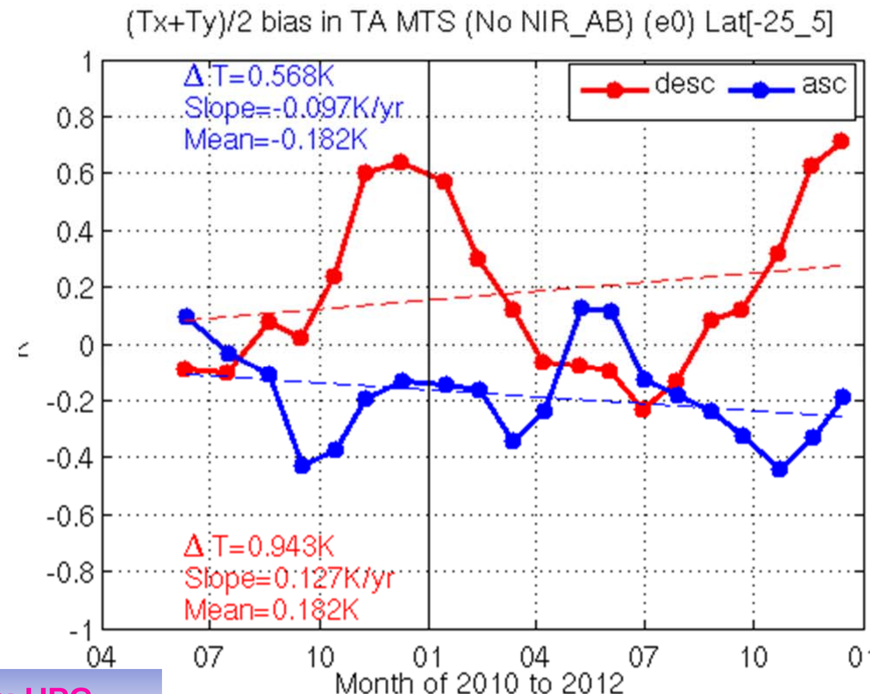
Performance of the front-end models
A)1-slope antenna model

- Nominal NIR processing (v350, with ground characterization)
- Strong asc-desc bias

Brightness temperature bias



Antenna temperature bias

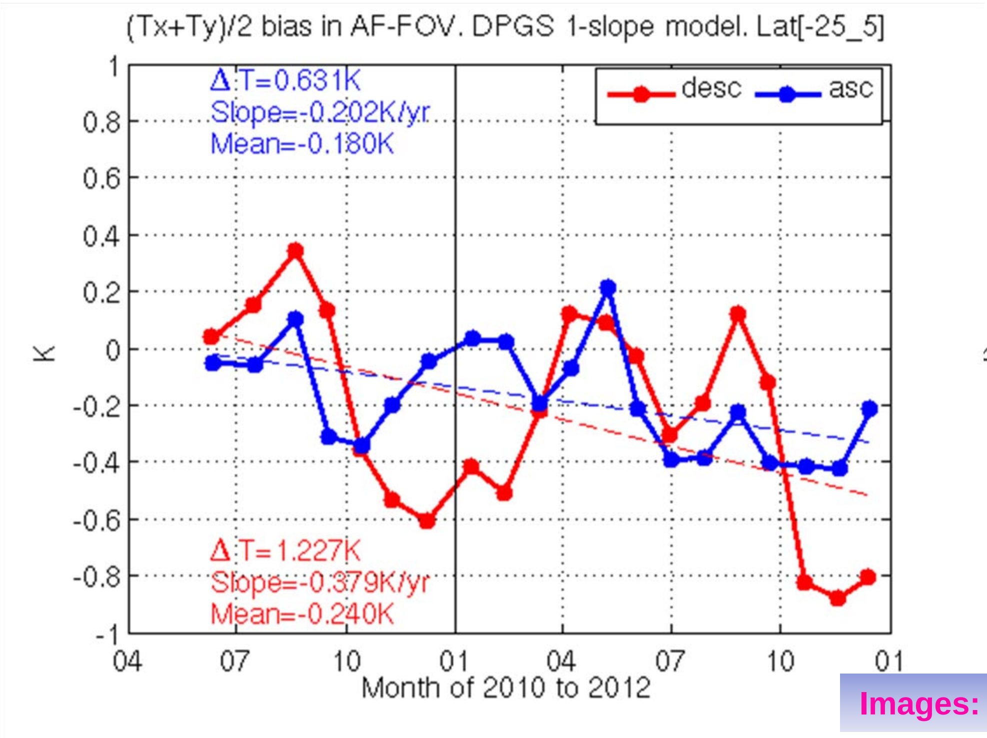


Images: UPC

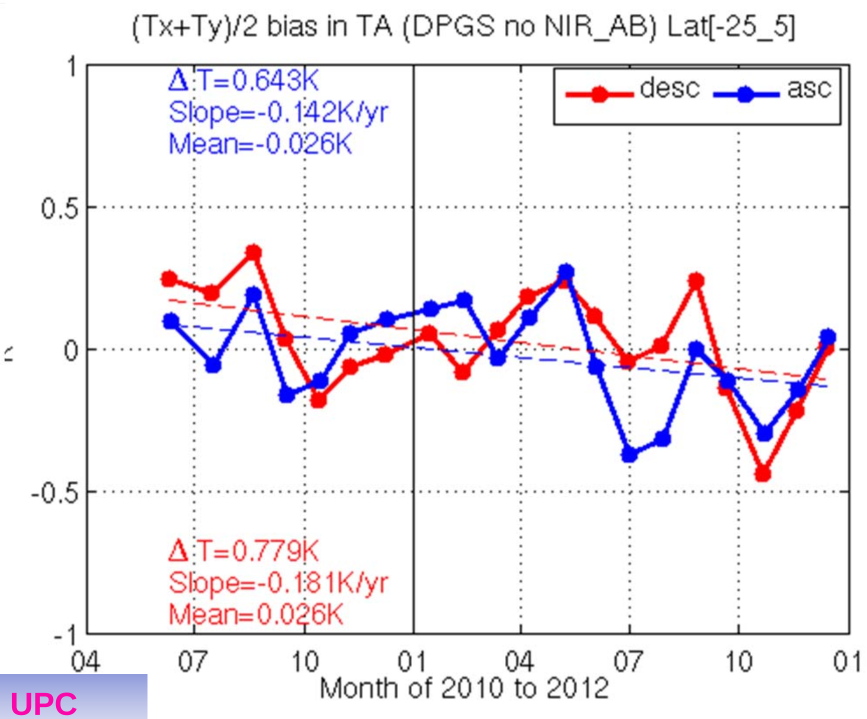
Performance of the front-end models
A)1-slope antenna model

- Previous mission reprocessing data (v504, the 1-slope model)
- Antenna temperature bias stabilises. Brightness temperature bias not. Asc-Desc bias of 2010 decreases, which was one of the reasons to select the model for reprocessing.

Brightness temperature bias



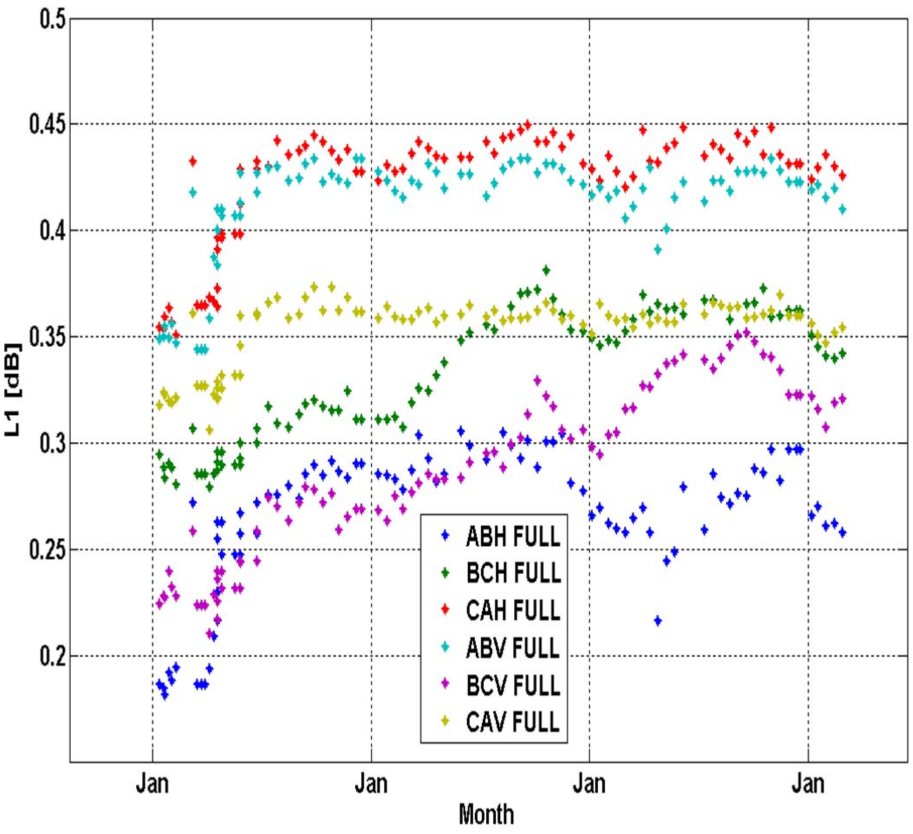
Antenna temperature bias



Images: UPC

B) External L1 calibration

- A method to determine L1 from measurements of sky was introruced by UPC. The method suggested slowly varying L1. In short-term the L1 is constant.
- Based on measurements of sky and internal load.
- L1 values from the method were clearly larger than those determined on-ground those of the 1-slope model.
- Significant differences between units.



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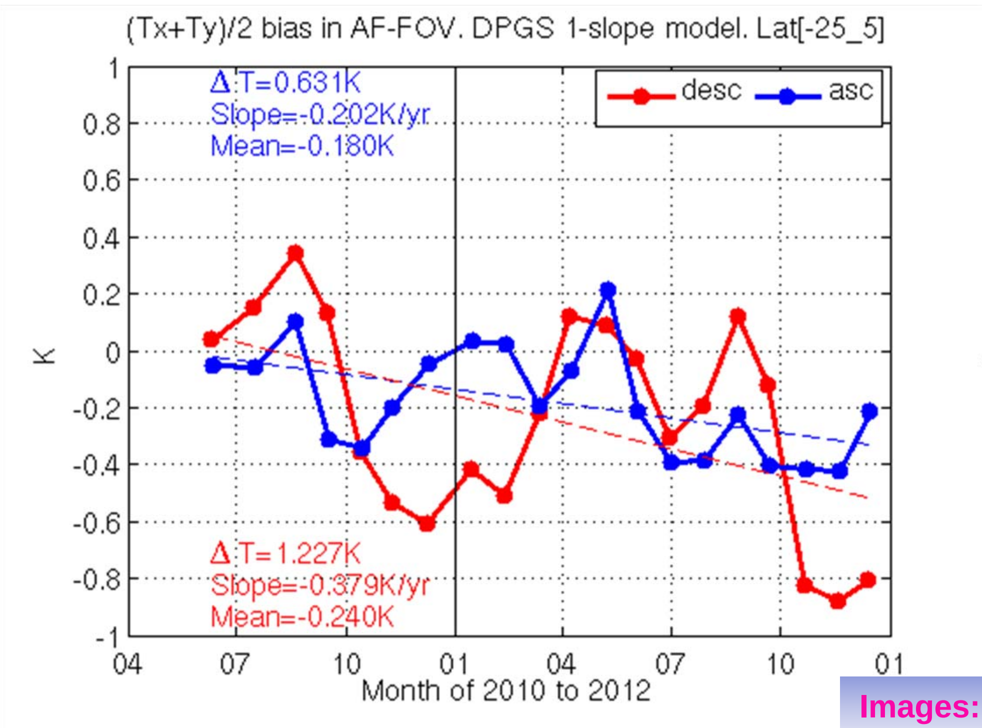
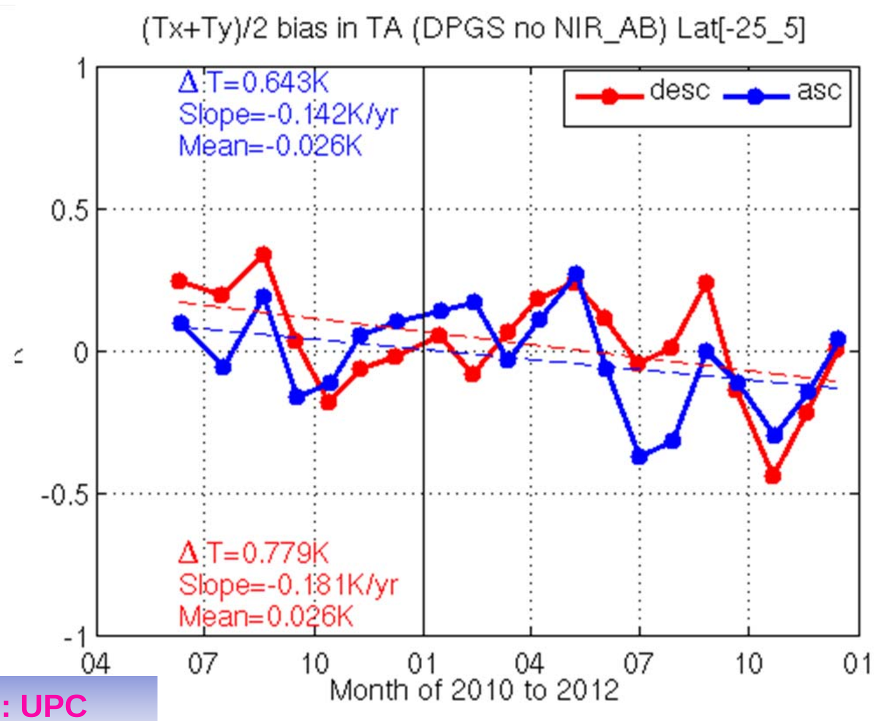
Performance of the front-end models
B) External L1 calibration

- Previous mission reprocessing data (v504, the 1-slope model) here for comparison…

Brightness temperature bias



Antenna temperature bias

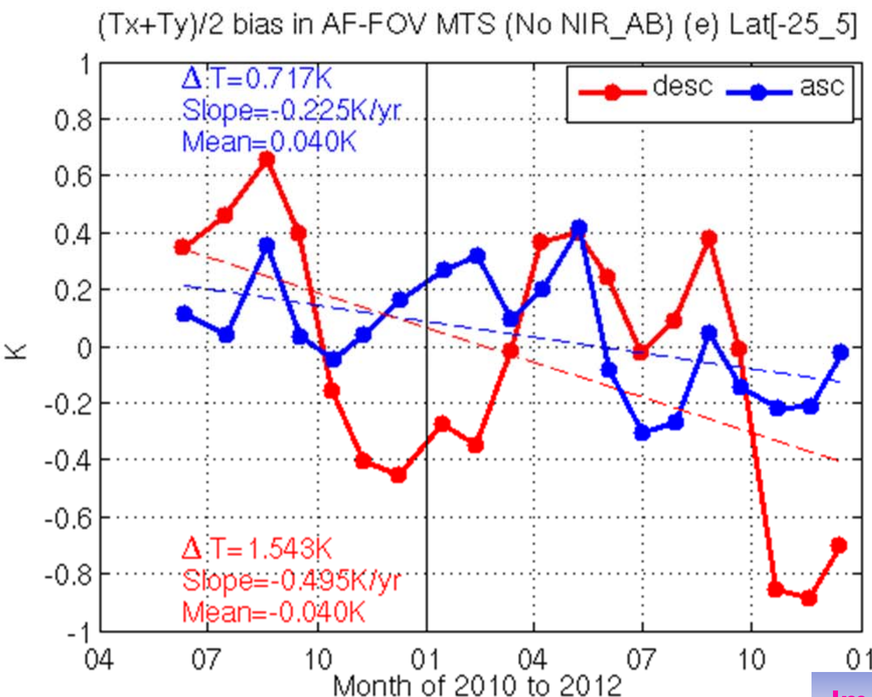


Images: UPC

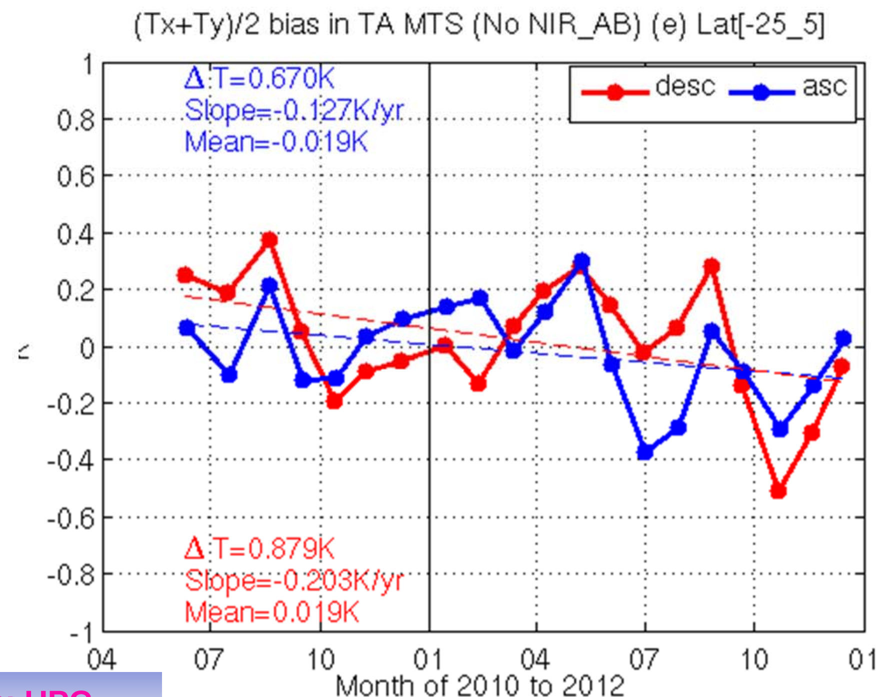
Performance of the front-end models
B) External L1 calibration

- And here with the external L1 calibration… (not yet implemented in L1OP).
- Differences to the 1-slope processed data are small. However, gives more consistent calibration parameters (L1, gain, …)

Brightness temperature bias



Antenna temperature bias



Images: UPC

C) Linear thermal model for the NIR front-end gain and offset (i.e. a/b-correction)

- A correction defined for the units prior to launch, but not defined yet due to demand of large amount of data.
- The method relates the **drifts in sky calibration linearly to gain and offset terms** the NIR channels, i.e. not assigning them to L1.

$$T_A = (-T'_{NA})\eta + T'_U = A\eta + B$$

$$T'_{NA} = L_1 L_2 T_{NA}$$

$$T'_U = L_1 L_2 L_{NC} L_A T_U - \left(T_{p7}(L_1 - 1) + L_1 T_{p6}(L_2 - 1) + L_1 L_2 T_{p3}(L_{NC} - 1) + L_1 L_2 L_{NC} T_{Cab}(L_A - 1)\right)$$

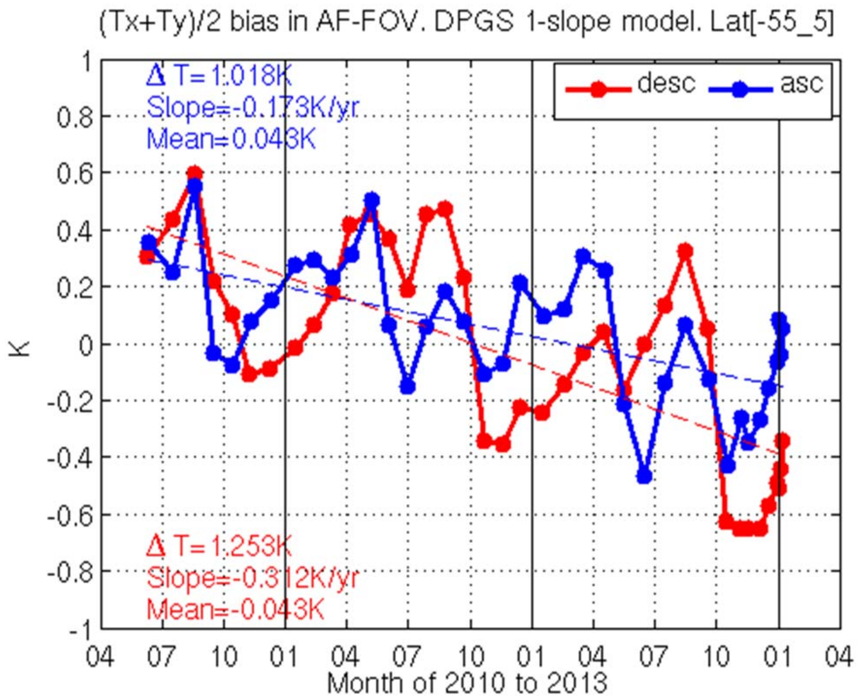
$$T_A = A_{(Tp7)}\eta + B_{(Tp7)}$$

$$T_A = (A + a\Delta T_{p7})\eta + (B_{(Tp7)} + b\Delta T_{p7})$$

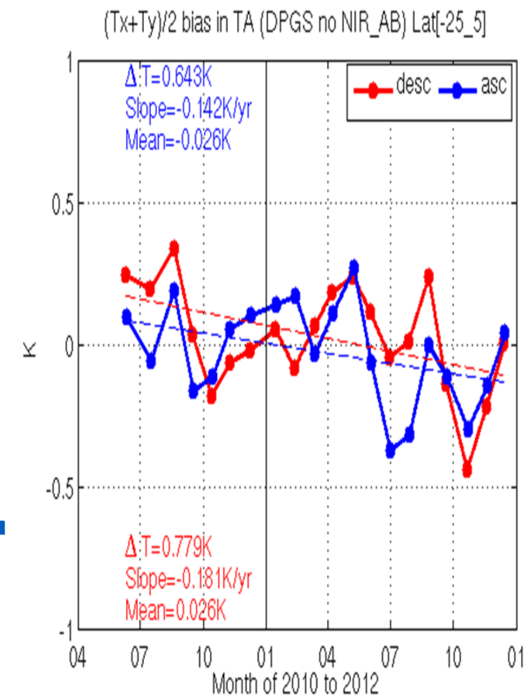
Performance of the front-end models
C) a/b correction

- Previous mission reprocessing data (v504, the 1-slope model) here for comparison…

Brightness temperature bias



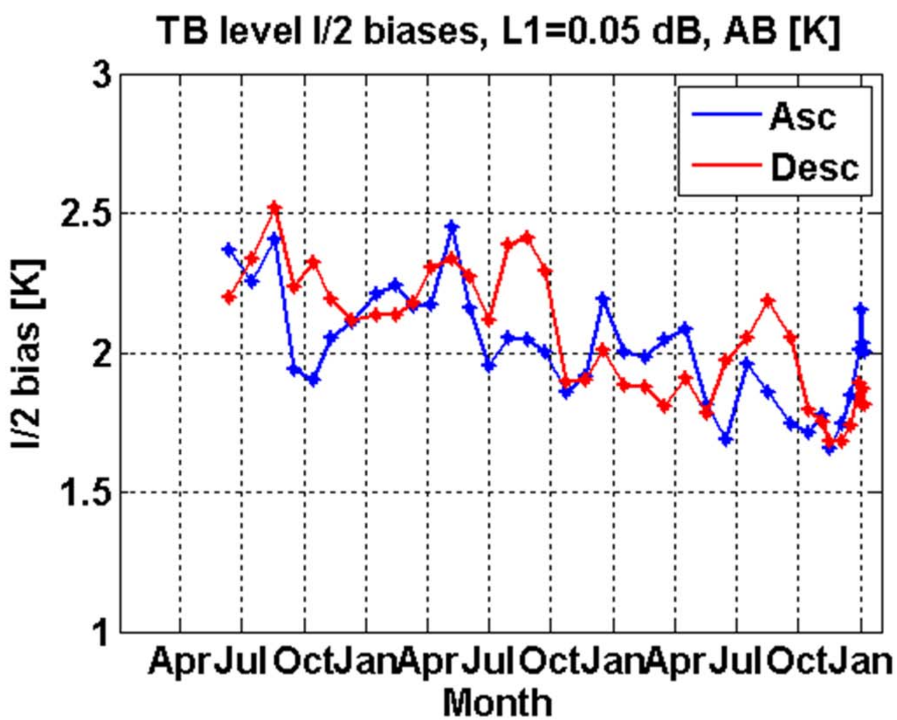
Antenna temperature bias



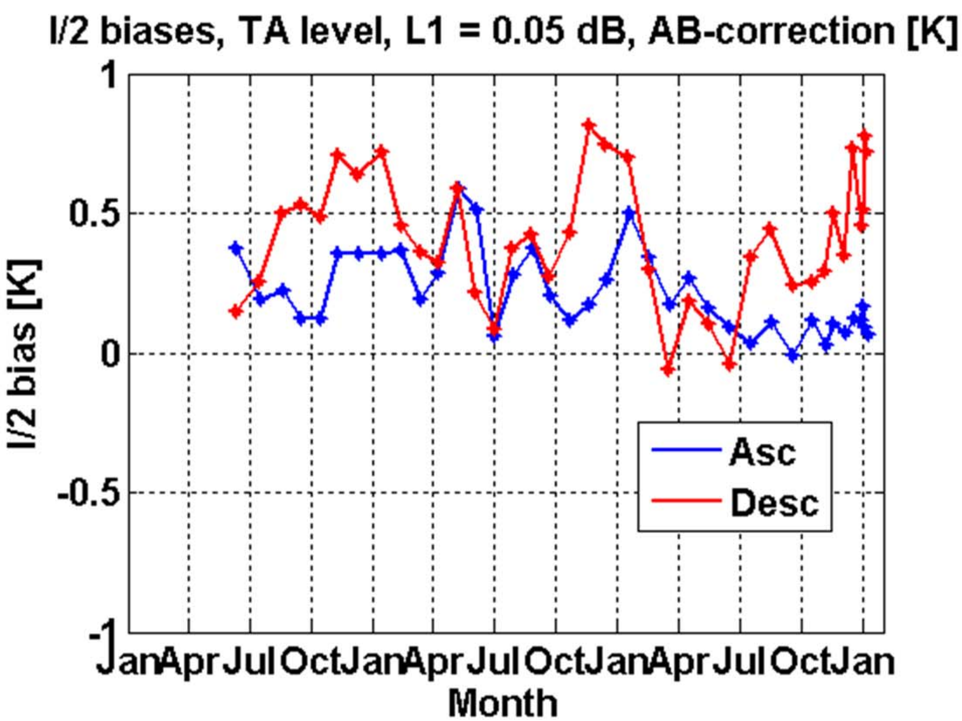
Performance of the front-end models
C) a/b correction

- a/b correction much decreases the seasonal error in brightness temperature level.
- Negative trend 0.2 K/year remains, seasonal peak-to-peak error 0.6 K on top of that.

Brightness temperature bias



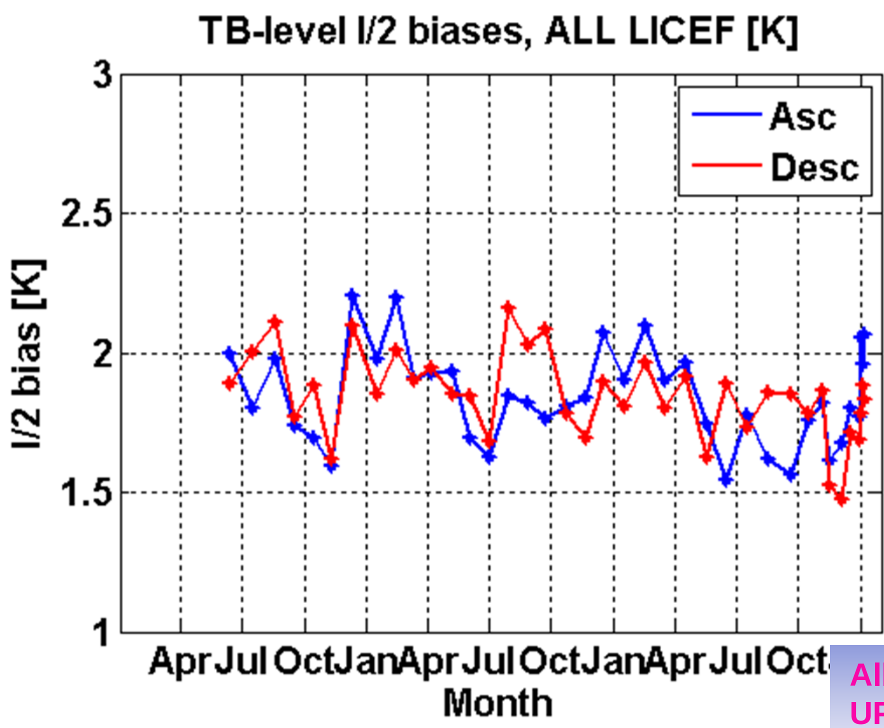
Antenna temperature bias



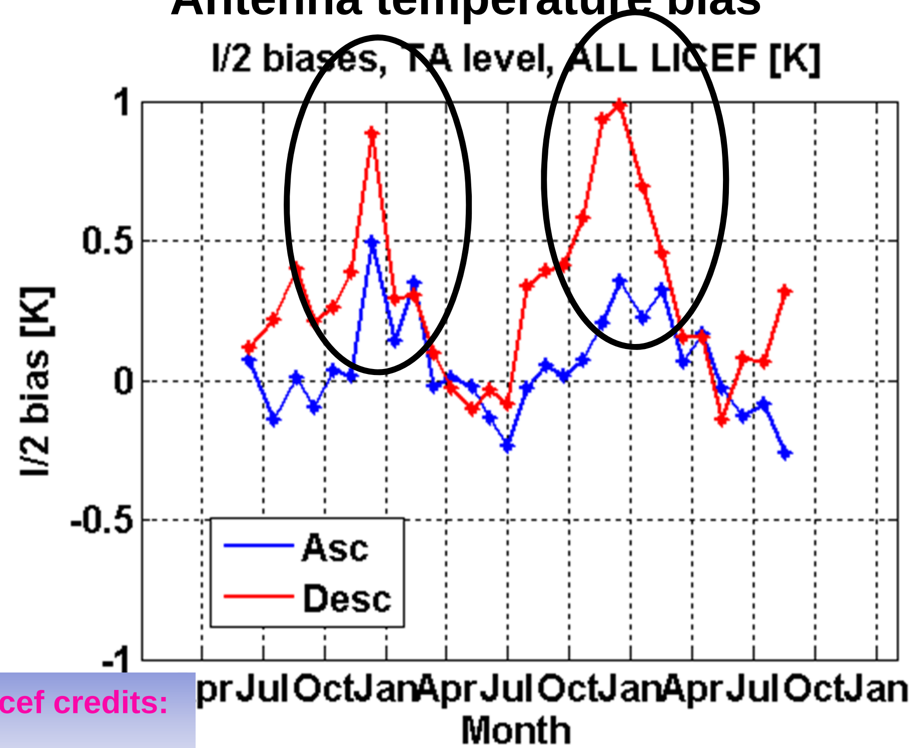
D) ”All-licef” mode

- NIR’s are switched off from the noise inejction mode and used as LICEFs. The antenna temperature is determined averaging measurements of all LICEFs.
- Negative trend < 0.1 K/year, seasonal peak-to-peak error 0.7 K on top of that.

Brightness temperature bias



Antenna temperature bias

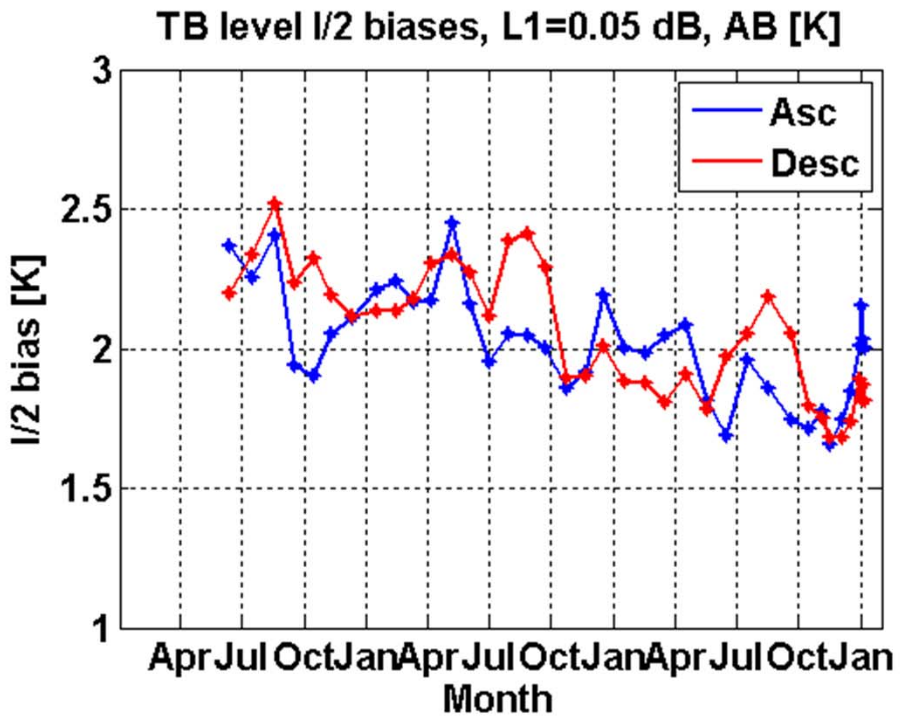


All-licef credits: UPC

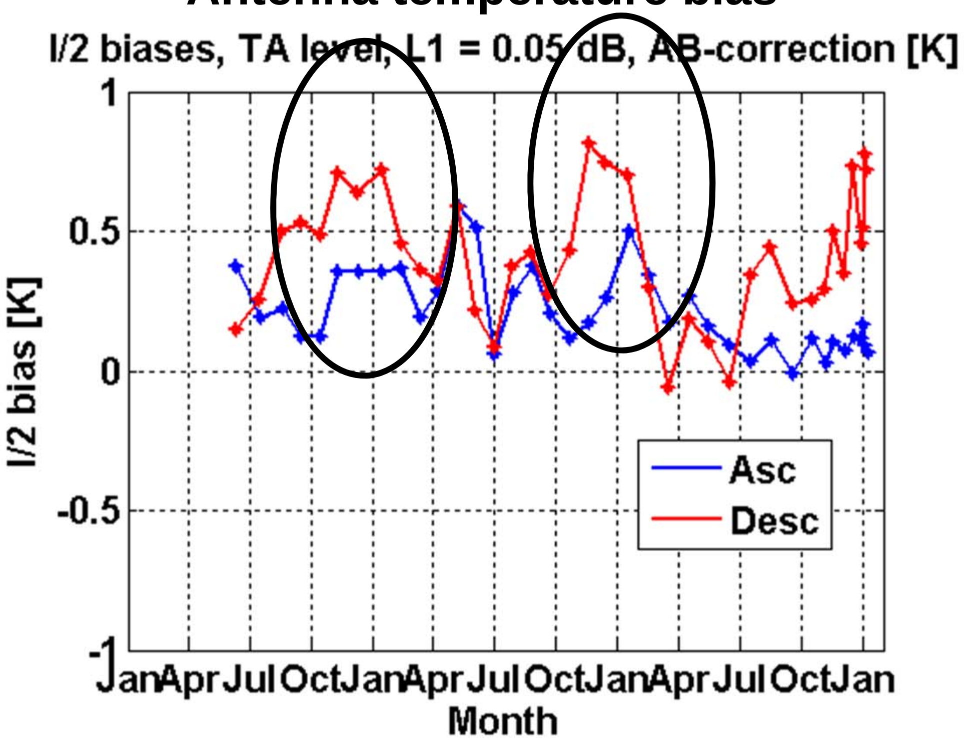
Performance of the front-end models
C) a/b correction

- a/b correction much decreases the seasonal error in brightness temperature level.

Brightness temperature bias



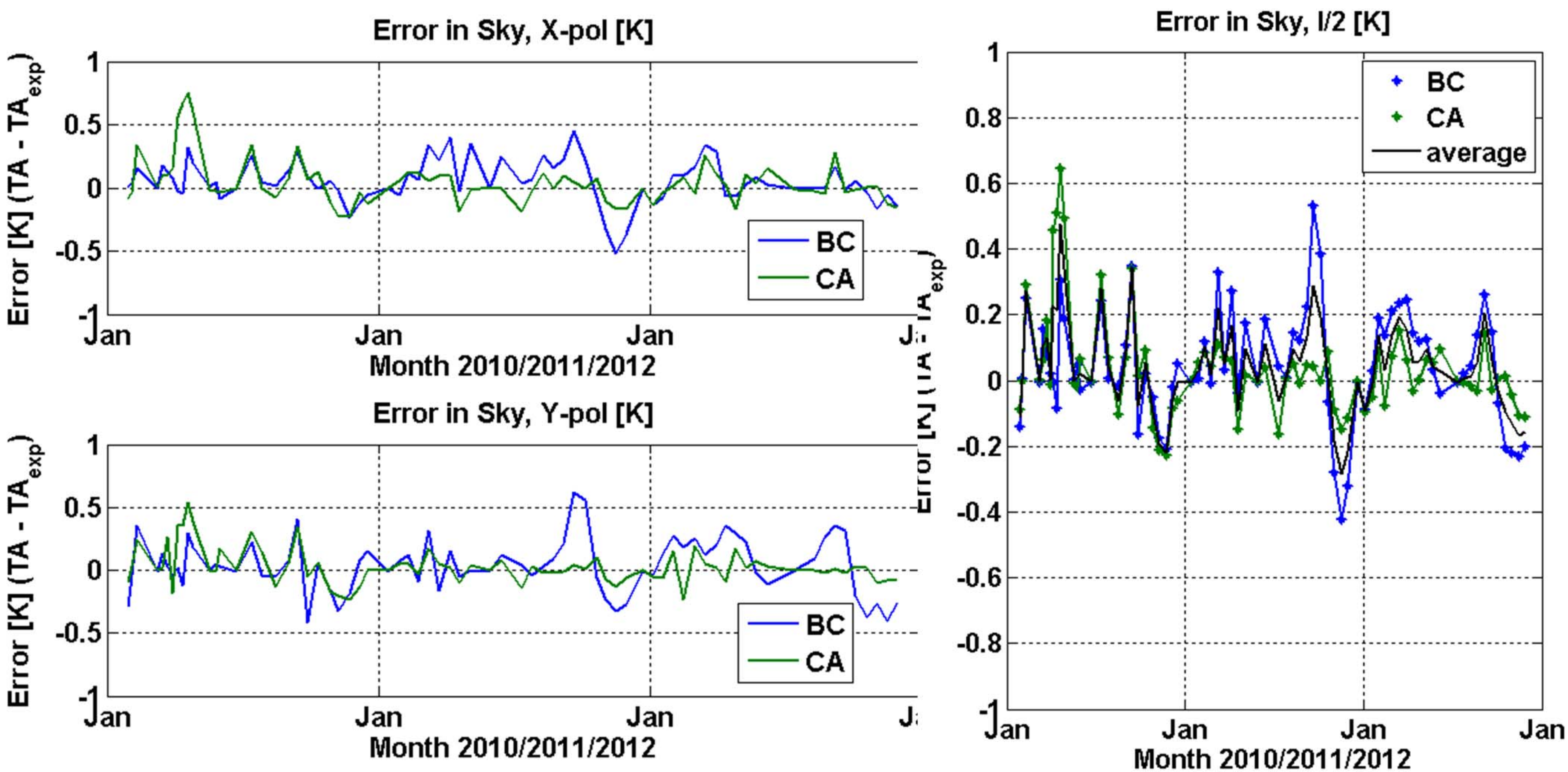
Antenna temperature bias



FURTHER IMPROVEMENTS WITH NIRS?

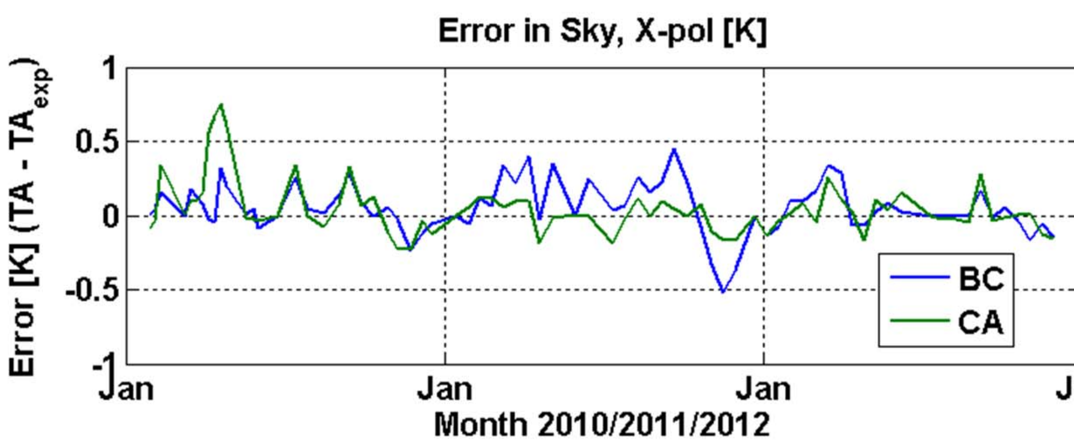
Error in sky measurements

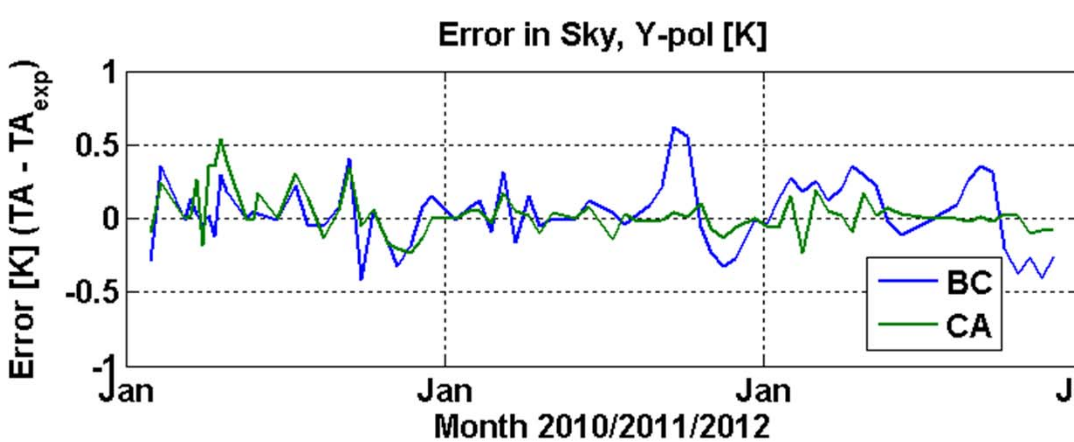
- We use two-week old calibration for each measruement.
- Antenna temperature during sky measurement can be modeled with antenna patterns and L-band sky map.

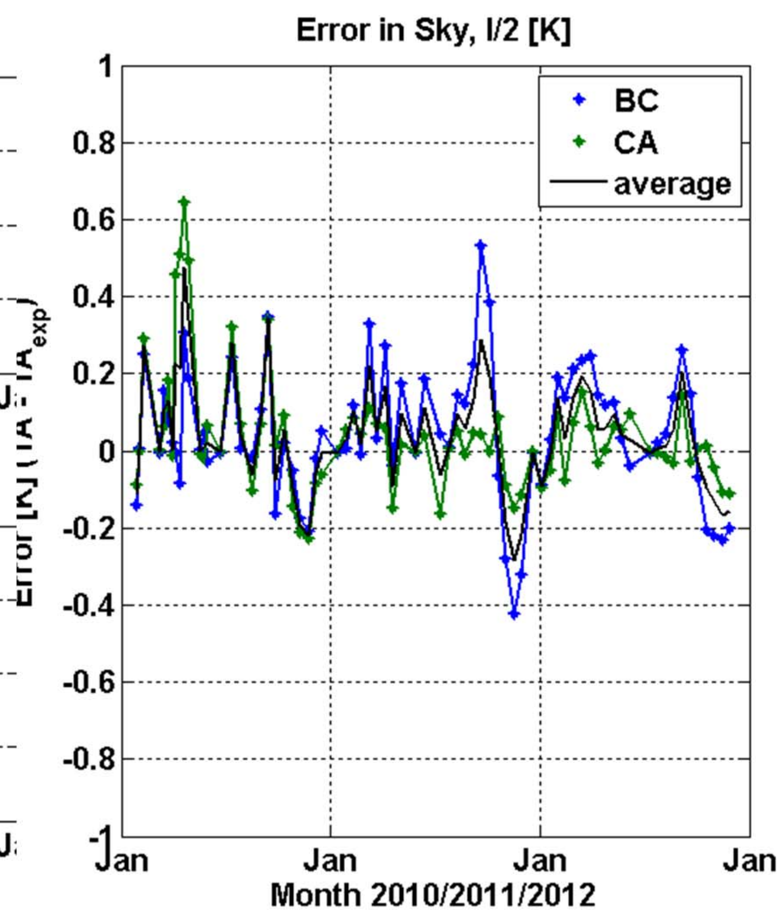


FURTHER IMPROVEMENTS WITH NIRS?
Error in sky measurements

- **Accuracy of NIR CA is significantly better than that of the BC unit.**
- Seasonal behaviour with BC?

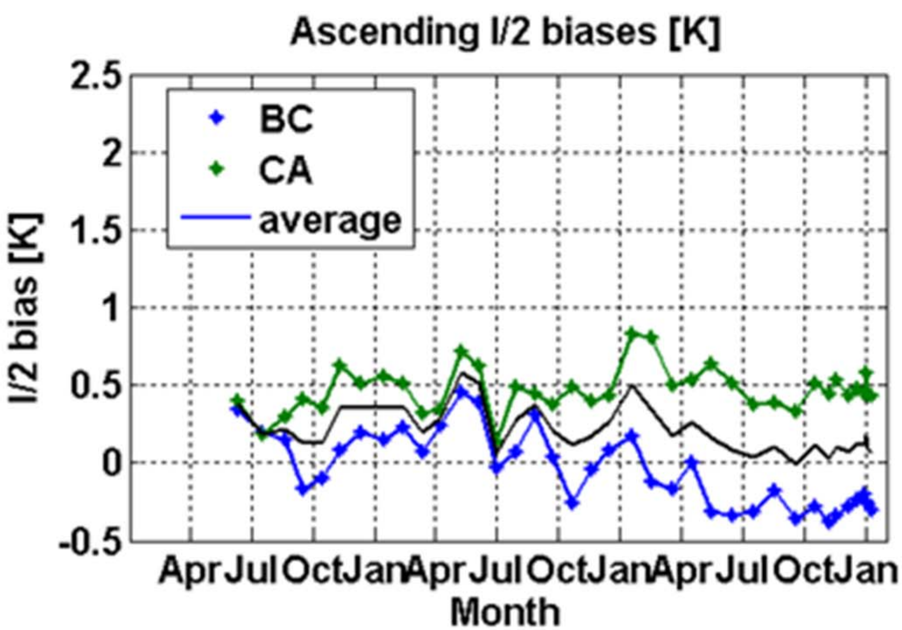


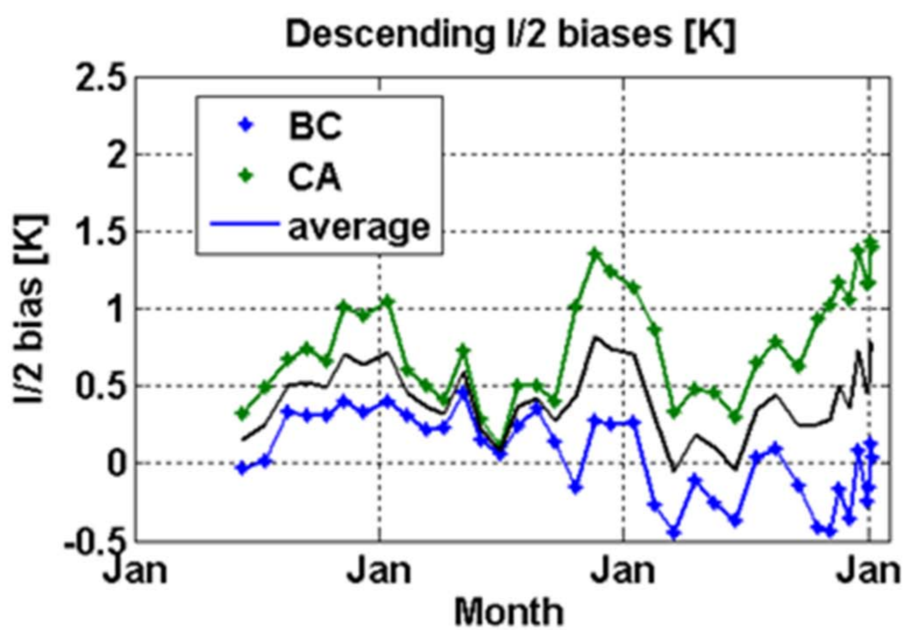




FURTHER IMPROVEMENTS WITH NIRS?
TA error at Pacific (now channel-wise)

- Clearly, BC has a negative trend whereas CA gives more stable response.





Summary and conclusions

- Temporal stability of SMOS measurements is dominated by changes in the antenna layer of the NIR and LICEF units.
- To cope with these effects, several front-end models have been assessed in three years.
- With the currently implemented model, stability of ~0.2-0.3 K/year with 1.0-1.2 K peak-to-peak annual variations on top of this at the Pacific test site are measured.
- **We can still do better**: In the lack of better thermal model for NIR BC, using only NIR CA will do the job.

  → The negative trend is much subjected to NIR BC.

  → Also the seasonal error structure of BC is stronger.
- The Sun L-band signal (direct or reflected) has an influence not yet completely understood.

SMOS-Mission Oceanographic Data Exploitation

SMOS-MODE

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SMOS-MODE supports the network of SMOS ocean-related R&D

Next plenary meeting foreseen in October 2013

Additional institutions and countries are welcome!

Thank you, any questions?

ADVANCE NOTICE

URSI Commission F
Microwave Signatures 2013
Specialist Symposium on Microwave
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Espoo (Helsinki), Finland
28-31 October 2013

Venue: DIPOLI Congress Center, Aalto University Campus
Detailed information at
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