FIDUCEO has received funding from the European Union's Horizon 2020 Programme for Research and Innovation, under Grant Agreement no. 638822

Noise performance of microwave humidity sounders over their life time

Imke Hans
Universität Hamburg

Imke Hans[1], Martin Burgdorf[1], Viju O. John[2,3], Jonathan Mittaz[4,5], and Stefan A. Buehler[1]

1 Meteorologisches Institut, Centrum für Erdsystem- und Nachhaltigkeitsforschung (CEN), Universität Hamburg

2 EUMETSAT, Darmstadt

3 Met Office Hadley Centre, Exeter, United Kingdom

4 Department of Meteorology, University of Reading, Reading, UK

5 National Physical Laboratory, Teddington, UK

Motivation

How does the noise of the MW instruments SSMT2, AMSUB and MHS evolve over their life time?

New aspects in

- Noise: Definition and calculation using Allan Deviation
- MW instruments: individual instruments of SSMT2, AMSUB, MHS on all platforms
- Evolution: assessment over whole life time

→ goals

- overview of usable data
- insight to known issue
- input for uncertainty budget of new FIDUCEO FCDR

Outline

1. Method: Noise definition and calculation

2. Main results
   a. Noise Evolution and usable data
   b. Insight to known issue: AMSU-B N16 bias vs other instruments
   c. Input for uncertainty budget in FCDR

3. Conclusions

1. Method

Noise definition

- "count noise": Fluctuations in instrumental counts:
  - Deep space view (DSV)
  - View of the internal warm calibration target (IWCT)

- Noise Equivalent Differential Temperature (NEdT)
  - From DSV counts: "cold NEdT"
  - From IWCT counts: "warm NEdT"
  - Rescaling to "scene NEdT"

Noise calculation

- Allan Deviation: inter-scanline-wise, on each calibration view

$$\Delta C_{\mathrm{DSV}} = \sqrt{\frac{1}{2(N-1)} \sum_{n=1}^{N-1} \sum_{k=1}^{K} (C_{\mathrm{DSV}_{k,n+1}} - C_{\mathrm{DSV}_{k,n}})^2}$$

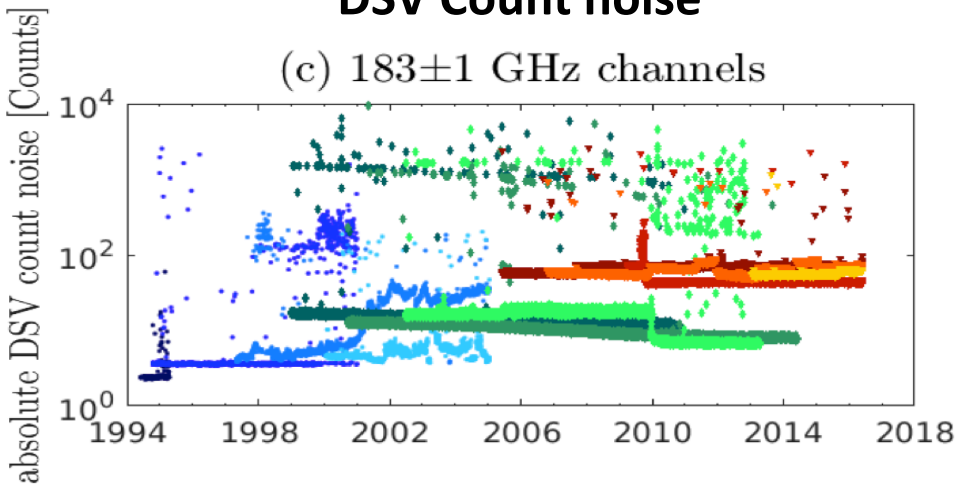
- Advantage: not sensitive to orbital variations

- Scaling of count noise to Temperature NEdT

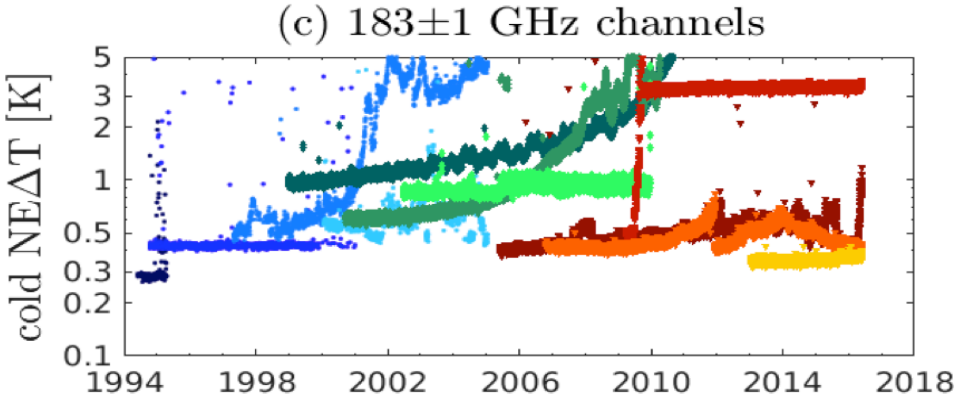
$$\mathrm{NE}\Delta\mathrm{T}_{\mathrm{cold}} = \sqrt{\frac{1}{2(N-1)} \sum_{n=1}^{N-1} \sum_{k=1}^{K} \left(\frac{C_{\mathrm{DSV}_{k,n+1}} - C_{\mathrm{DSV}_{k,n}}}{G_n} \right)^2}$$

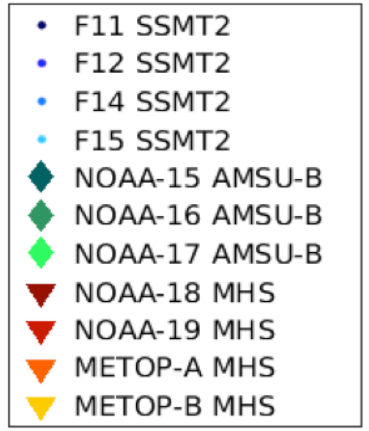
2.a. Noise evolution and usable data

DSV Count noise



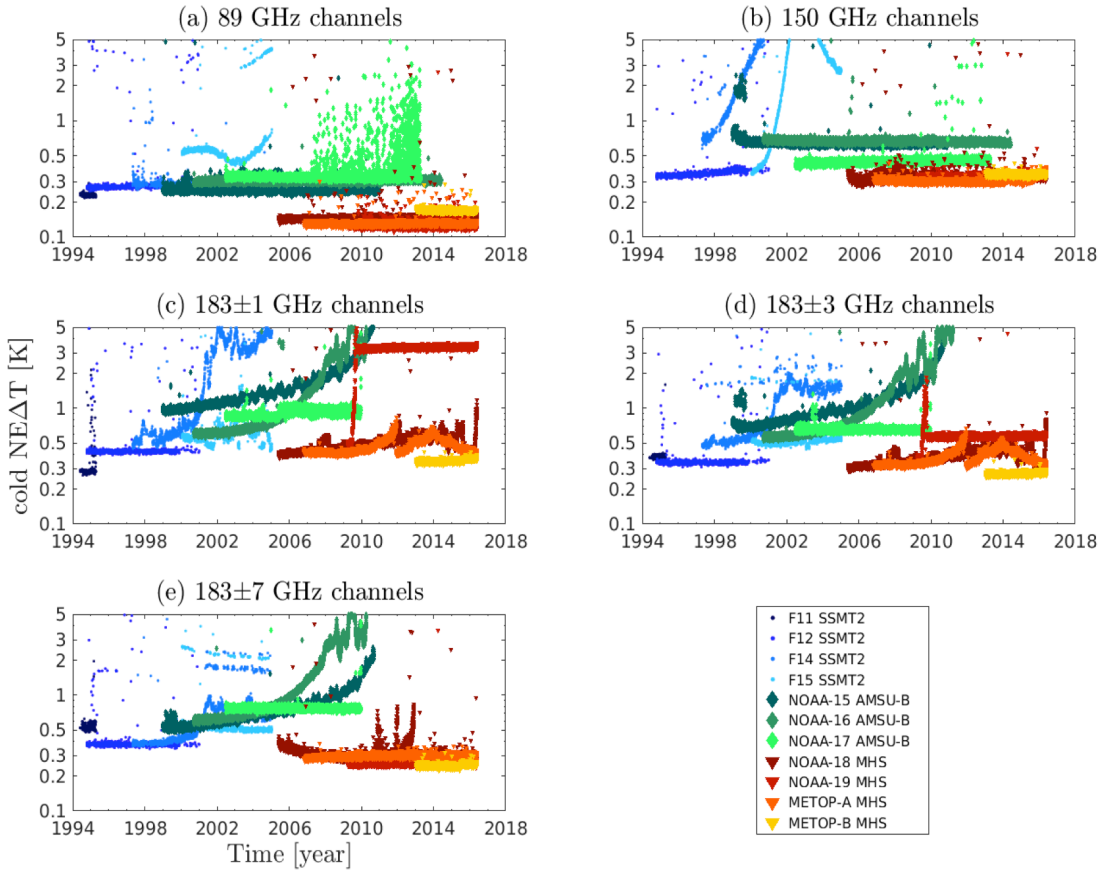
Cold NEdT





- Behaviour of Count noise and NEdT:
  - Changes in count noise → changes in NEdT
  - But: NEdT also reflects changes in gain
- Evolution different for instruments and channels
  - e.g. strong degradation of NOAA15, 16 in Ch3 NEdT
  - on METOP-B: Very stable count noise and NEdT

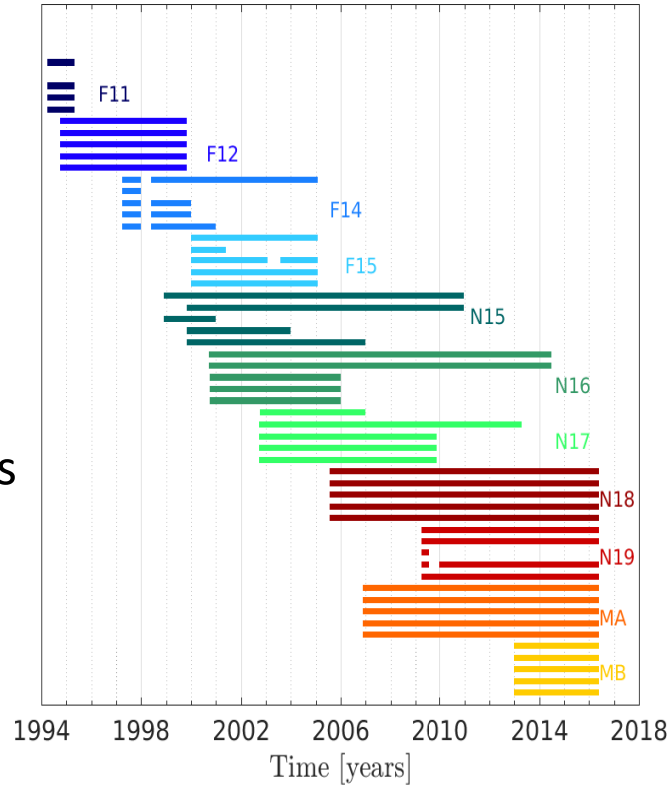
2.a. Noise evolution and usable data



- Usable data:

  e.g. NEdT <1K

- For NEdT <1K: time series for all channels without gaps may be constructed

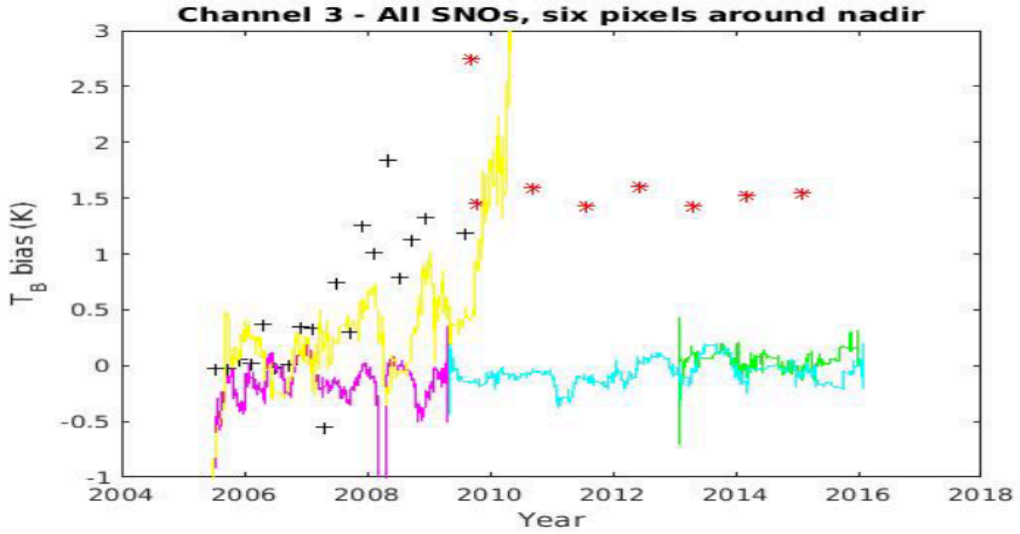


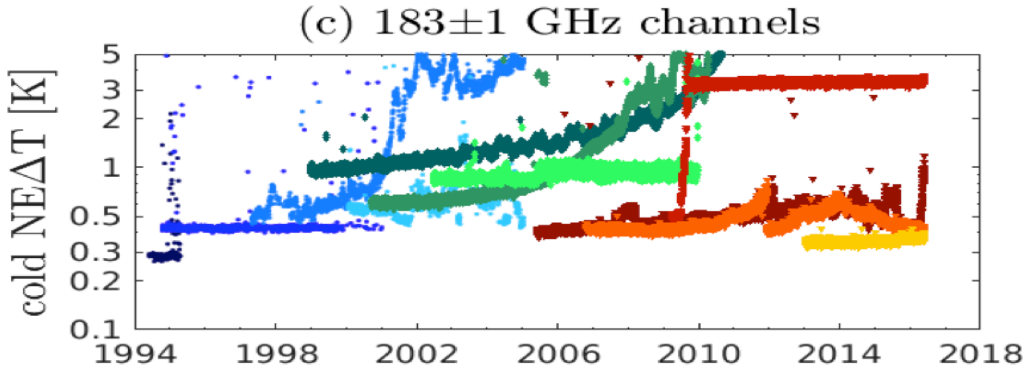
Periods of cold NEdT < 1 K

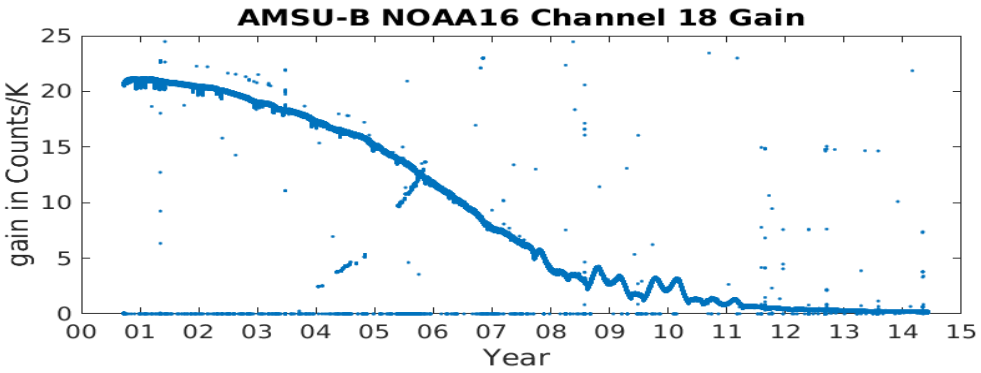
→ "quick look" overview of noise and NEdT for all instruments and channels

2.b. Insight to N16 bias

- Bias N16 vs MHS N18 (yellow) increases dramatically…
- …so does NEdT (green)
- …because of the decreasing gain
- RFI has more impact → likely to cause the bias







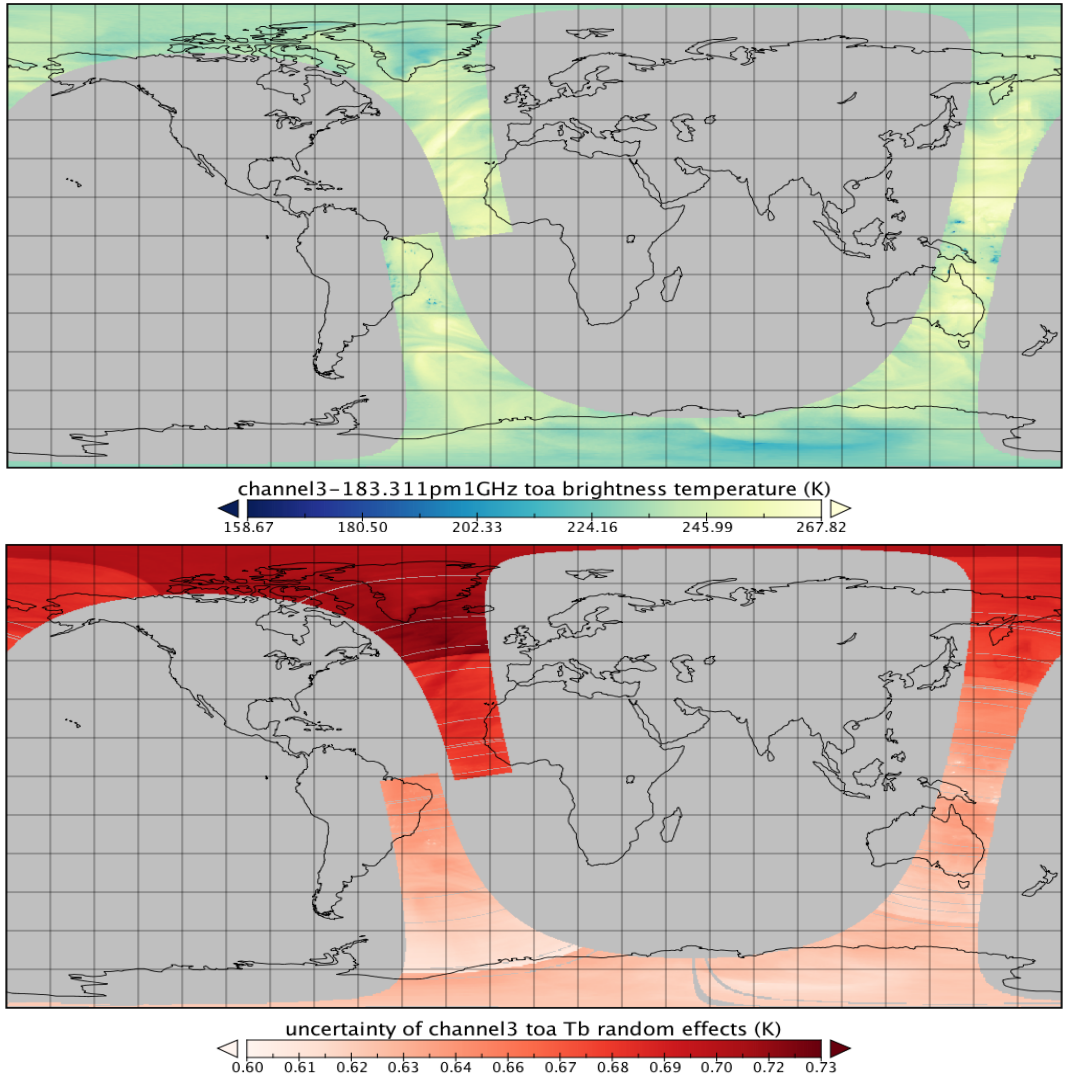
2.c. Input for uncertainty budget in FIDUCEO FCDR

- Count noise estimation (Allan Dev.) applied in FCDR processing

- DSV, IWCT, scene count noise estimated on-the-fly

- Propagated to brightness temperature Tb

→ “uncertainty in Tb due to noise on scene counts” on pixel level



3. Conclusions

- We have used: Allan Deviation (not sensitive to orbital variations) for estimating count noise and NEdT
- We provide: Overview of count noise and NEdT evolution over life time of all individual SSMT2, AMSUB, MHS instruments
- We suggest: RFI as possible explanation for AMSUB N16 bias
- We provide: input for uncertainty budget of FIDUCEO MW FCDR which we work on

Thank you!

FIDUCEO has received funding from the European Union's Horizon 2020 Programme for Research and Innovation, under Grant Agreement no. 638822

Back up slides

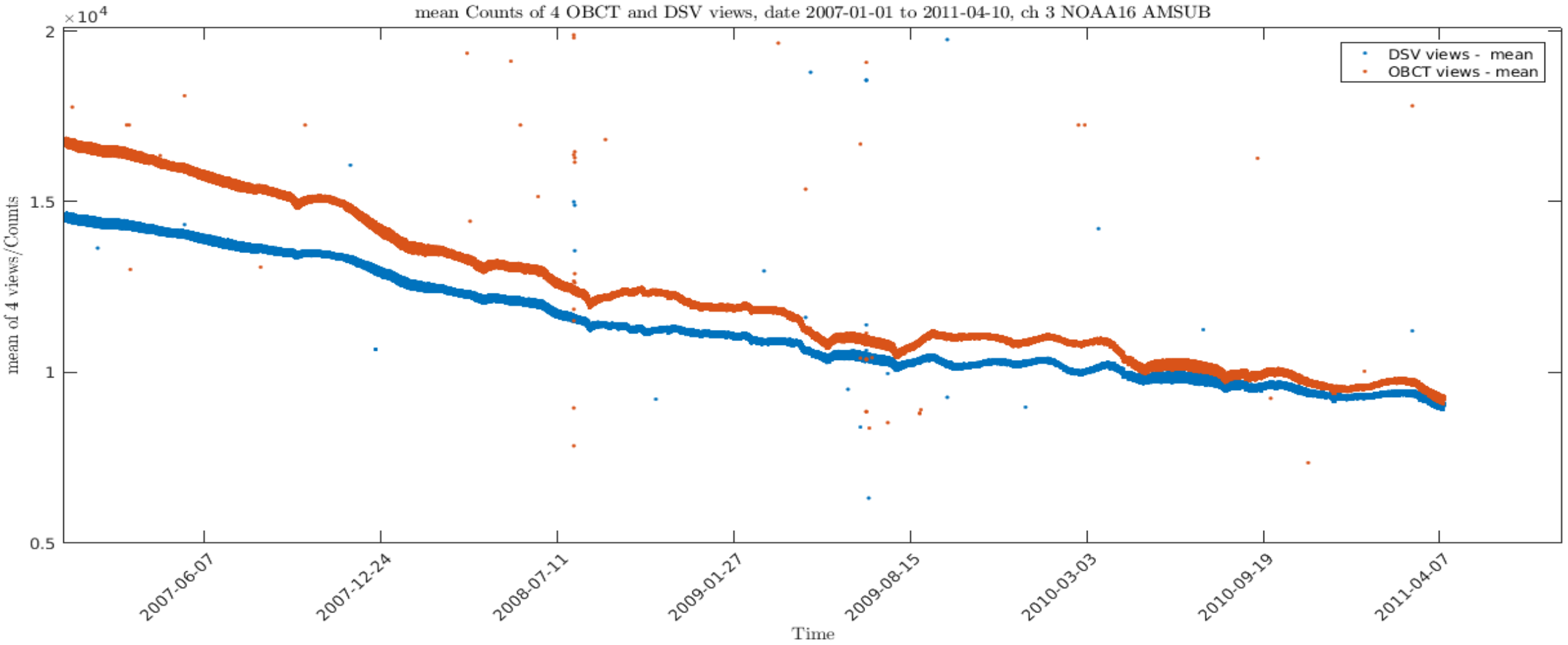
Scene NEdT

- Rescaling for scene NEdT

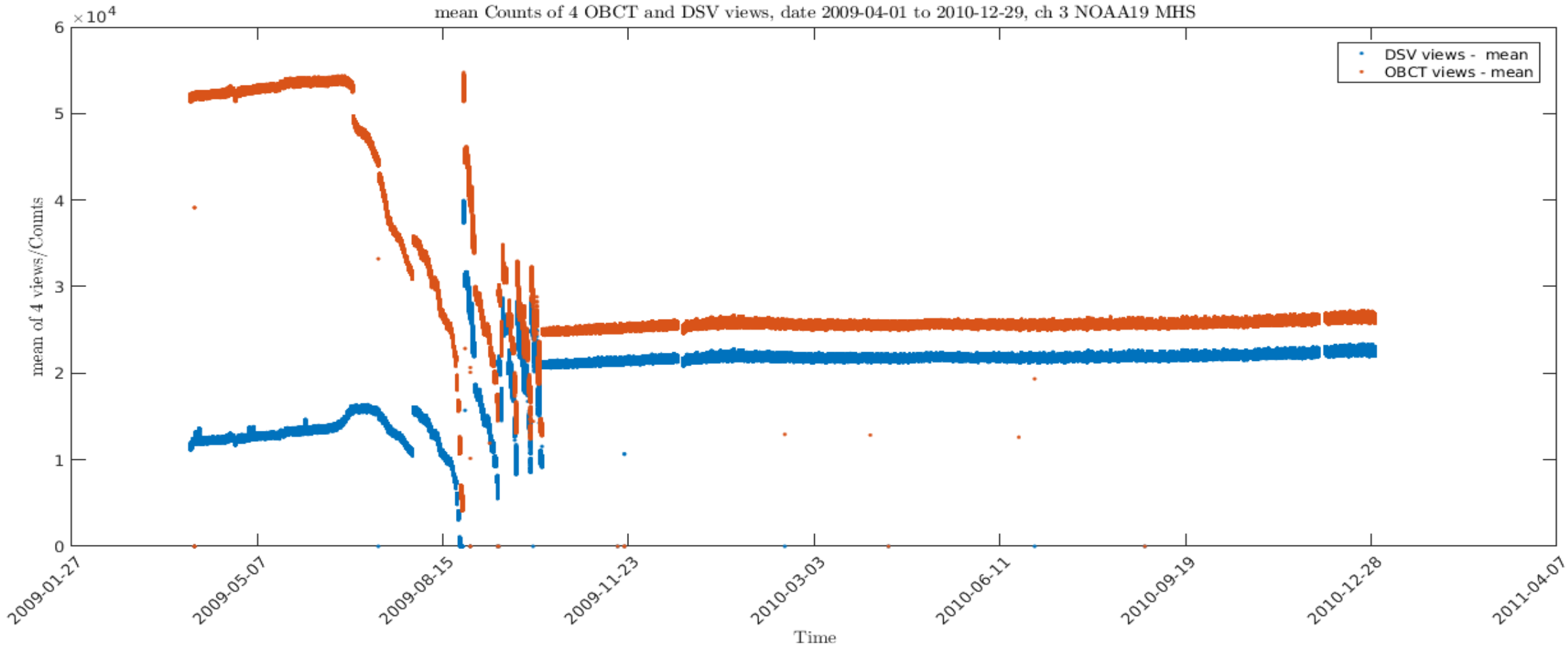
$$\mathrm{NE\Delta T} = \mathrm{NE\Delta T}_{cold} + (T_{\mathrm{a,scene}} - T_{\mathrm{a,DSV}}) \cdot m$$

$$\text{with } m = \frac{\mathrm{NE\Delta T}_{warm} - \mathrm{NE\Delta T}_{cold}}{T_{\mathrm{a,OBCT}} - T_{\mathrm{a,DSV}}}$$

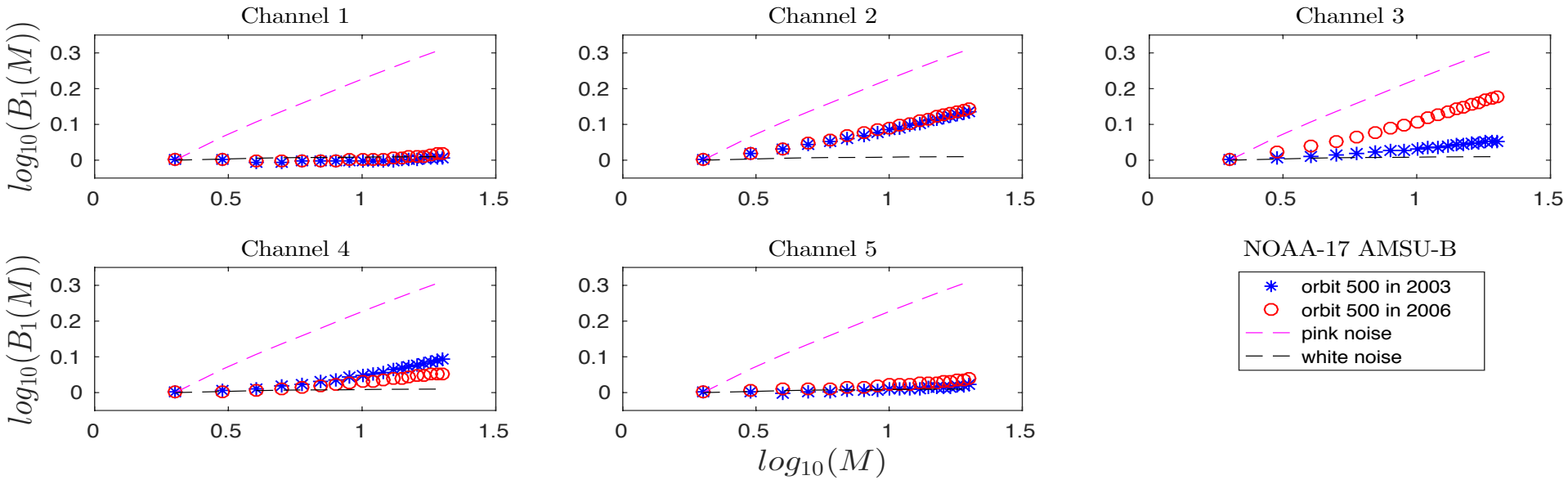
Gain decrease - evolution of counts Channel 3 AMSUB NOAA16



Gain decrease - evolution of counts Channel 3 MHS NOAA19



DSV count noise spectrum



- Noise spectrum calculated with bias function $B_1(M) = \frac{< \sigma_M^2 >_N}{< \sigma_{\text{Allan}}^2 >_N}$
- Ch2 has pink noise component
- Ch3 has stronger pink noise component in 2006 than in 2003

DSV count noise

- Ch2: inter-pixel-method too low
- Ch3: in 2006, when pink noise stronger, inter-pixel-method too low