Quality Control for AMSU-A Observations over Sea Ice

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ABSTRACT

This paper applies the Quality Control theory in Research Note 7/2005 to the AMSU-A radiance observations over sea ice for February and March 2005. Innovation rejection thresholds, the optimal Normal observation bias and innovation variation are identified for the NOAA-15 and NOAA-16 channels used for assimilation in HIRLAM 3D-Var.

No. 12/2005 **Oslo, June 16th 2005**

Introduction

The data assimilation theory implemented in HIRLAM 3D-Var assumes that the observations have Normal (Gaussian) error distributions. Most observations have a slightly non-Normal error distribution component, and Observation Quality Control is usually applied to remove the negative effects of this non-Normal component.

In the IOMASA project, the Norwegian Meteorological Institute is using AMSU-A observations over sea ice that are contaminated by precipitation, and this results in a significant asymmetric and non-Normal error distribution for the AMSU-A observations, especially those channels that are sensitive to radiation from the surface. A Bayesian theory was developed with the purpose of identifying the optimal observation rejection criteria for observations with (asymmetric) non-Normal error distributions. The theory is described in detail in Research Note 7/2005. This Research Note applies this theory to the AMSU-A channels that are assimilated in HIRLAM 3D-Var, based on statistics from February and March 2005.

The Normal approximation that gives maximum positive impact (minimum risk) is identified, and observation rejection thresholds are relative to this approximation. The Normal approximation provides us with the innovation bias and the innovation variance. We have only assumed that the first guess error distribution is Normal. We know from earlier work that we should bias correct the observations so that the innovation becomes unbiased if we do not know the first guess bias nor the true observation bias. We also know from earlier work that we are ensured positive impact if the observation variance is greater than the innovation variance, so the innovation variance gives us a minimum "safe" value for the observation variance, when it is unknown.

The following section shows the innovation distributions, the optimal Normal approximation and the risk for the different AMSU-A channels over sea ice. The rejection thresholds are also listed.

AMSU-A Quality Control

Table 1 shows a summary of the results for all the AMSU-A channels. The innovation bias (μ) and variance (σ^2) for the optimal Normal innovation is given along with the innovation range for which this approximation can be used. Observations with an innovation outside this range should not be used according to the theory.

The appemded figures show in more detail the distributions and risk for each channel as a function of the innovation. The top panels shows the *Innovation probability and optimal Gaussian approximation,* while the lower panels shows the *Risk* (chopped). The optimal Normal approximation is specified by μ and σ.

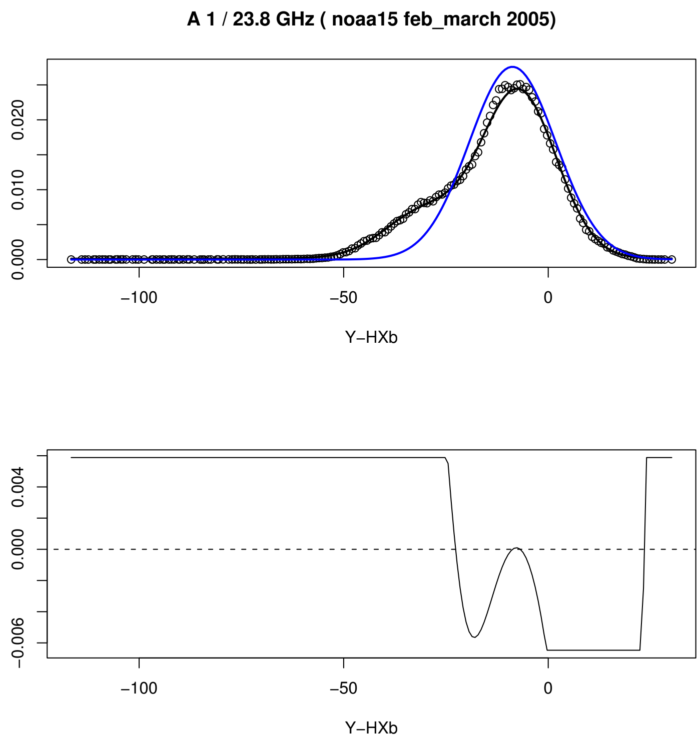
Comments and Conclusions

The quality control theory in Research Note 7/2005 can be applied to AMSU-A observations over sea ice in HIRLAM 3D-Var. This theory only needs to assume that the first guess error distribution is Normal (so that any non-Normal component in the innovation distribution can be attributed to the observation). Preliminary results using AMSU-A thresholds inspired by this theory had a positive effect on the forecasts. Experiments using the latest thresholds are on-going.

The optimal Normal approximation tends to be relatively wide, thereby giving thresholds that pass much observations on to the data assimilation system.

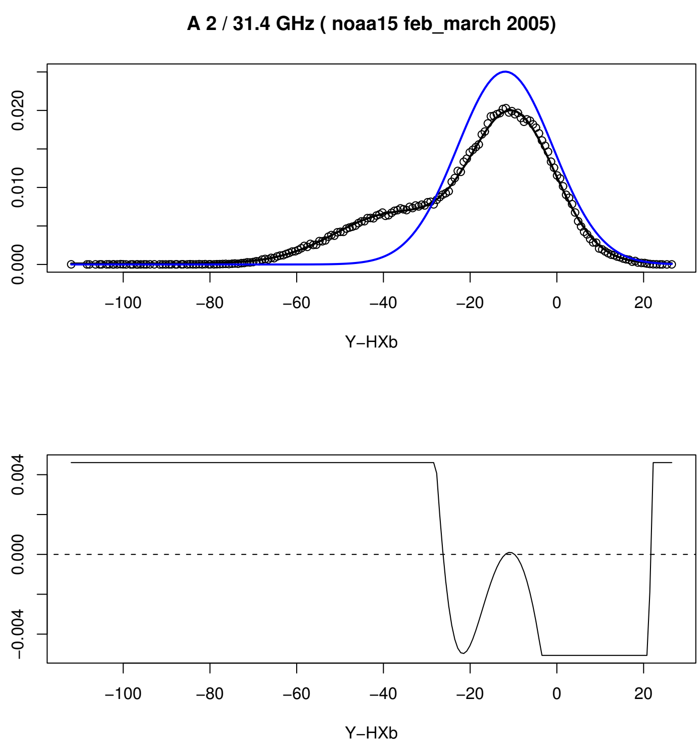
Satellite: Noaa-15 (Channel 1)

$\mu = -8.74059$, $\sigma = 10.61201$, Range$= -22.65159 \rightarrow 23.66040$



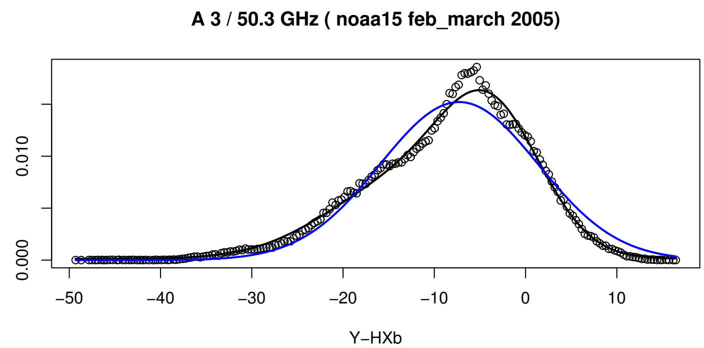
Satellite: Noaa-15 (Channel 2)

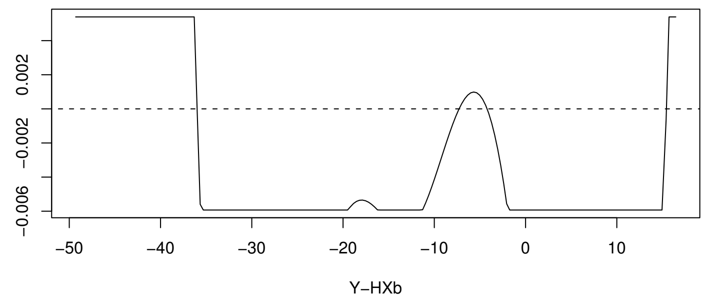
$\mu = -11.91565$, $\sigma = 11.05884$, Range$= -26.67881 \rightarrow 21.83006$



Satellite: Noaa-15 (Channel 3)

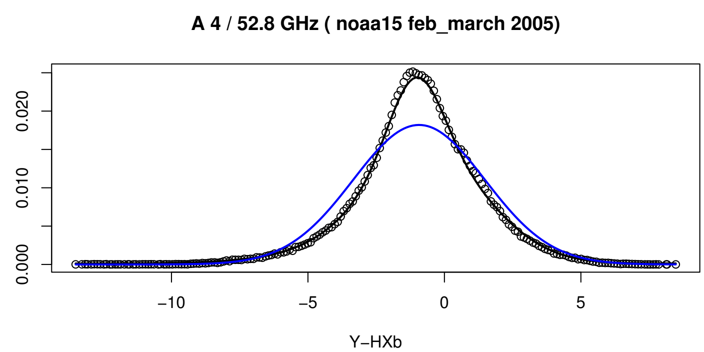
$\mu = -7.28578$, $\sigma = 8.65792$, Range$=-36.14119 \rightarrow 15.56422$

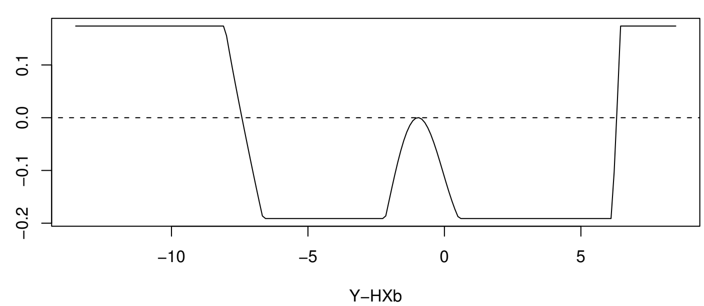




Satellite: Noaa-15 (Channel 4)

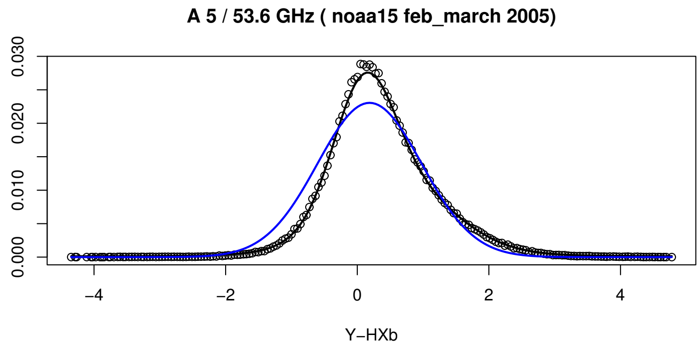
$\mu = -0.92867$, $\sigma = 2.41447$, Range$=-7.38239 \rightarrow 6.27787$

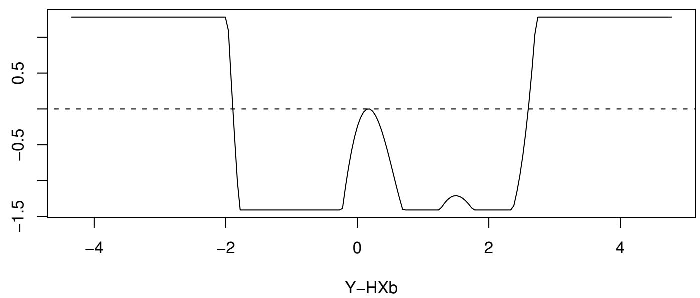




Satellite: Noaa-15 (Channel 5)

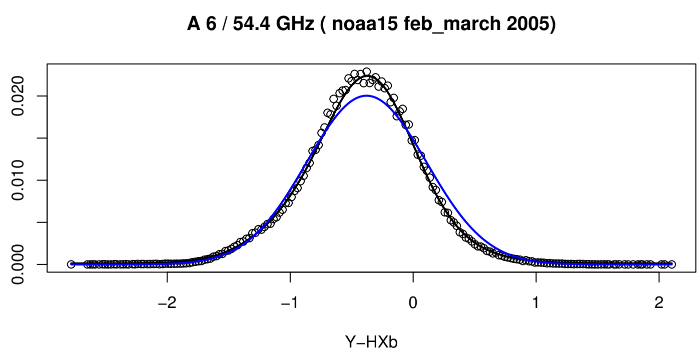
$\mu = 0.18695$, $\sigma = 0.79051$, Range$=-1.89188 \rightarrow 2.58500$

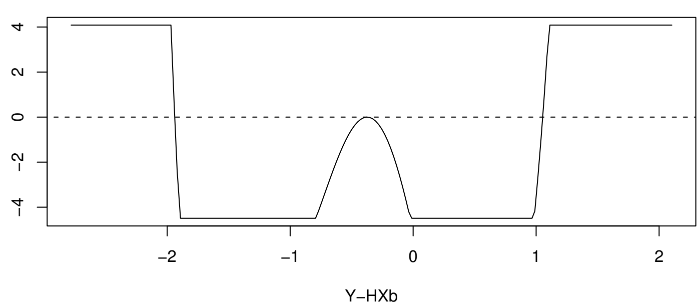




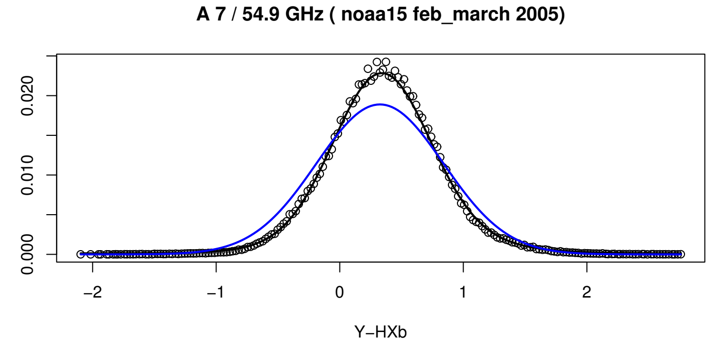
Satellite: Noaa-15 (Channel 6)

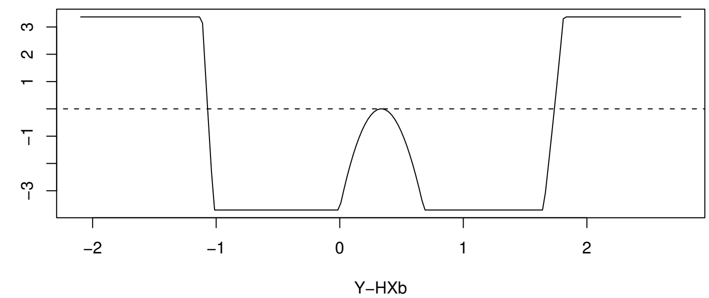
$\mu = -0.37838$, $\sigma = 0.48660$, Range$=-1.93033 \rightarrow 1.05184$



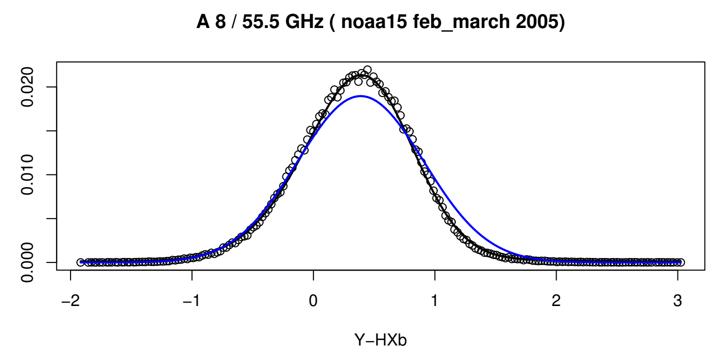


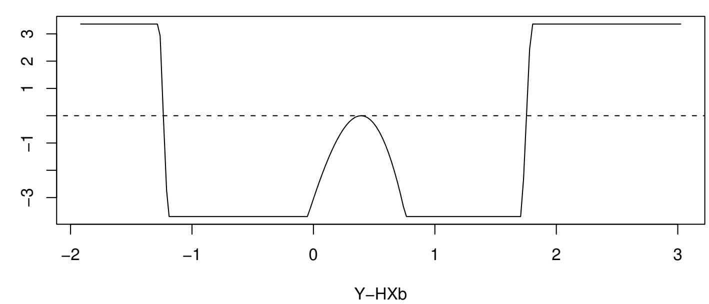
Satellite: Noaa-15 (Channel 7)
$\mu = 0.32533,\ \sigma = 0.51397,\ \text{Range}{=}-1.07438 \to 1.72510$





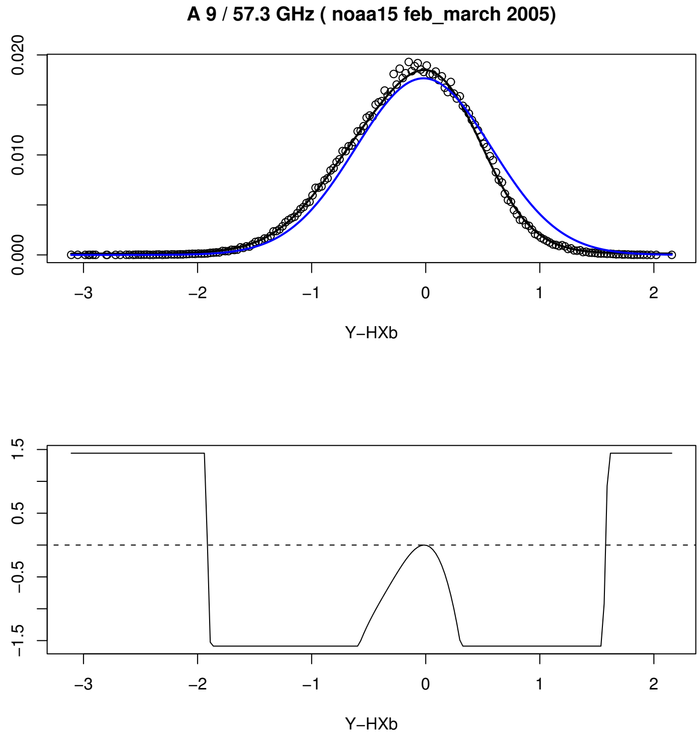
Satellite: Noaa-15 (Channel 8)
$\mu = 0.38913,\ \sigma = 0.52028,\ \text{Range}{=}-1.24914 \to 1.74230$





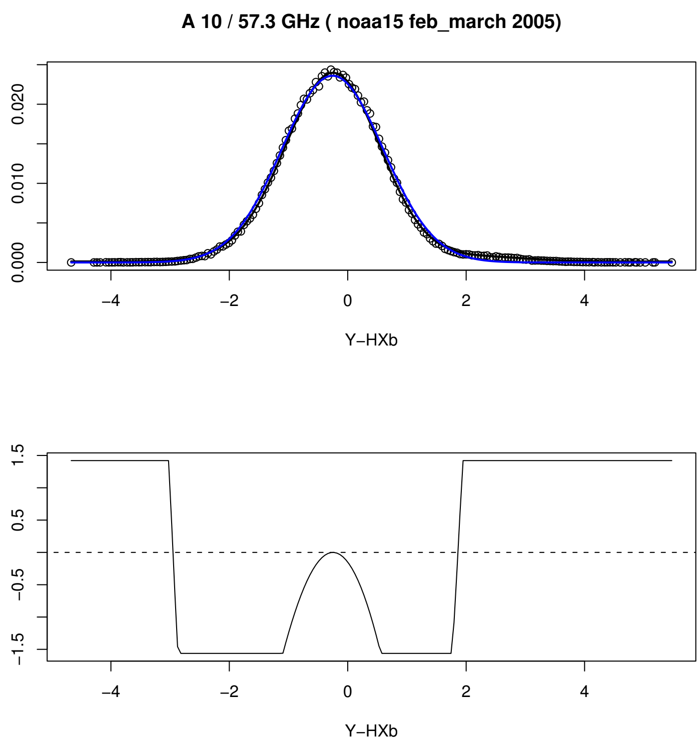
Satellite: Noaa-15 (Channel 9)

$\mu = -0.01864$, $\sigma = 0.59533$, Range$=-1.90122 \rightarrow 1.57715$



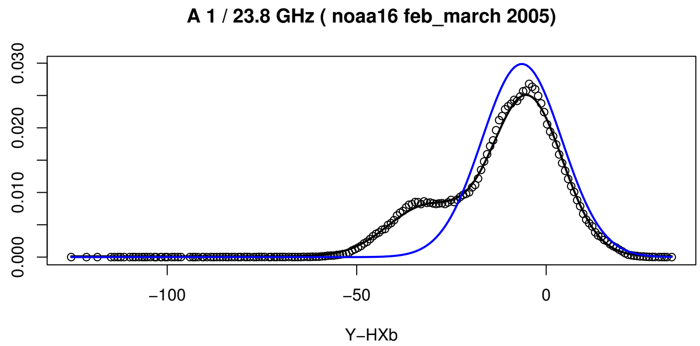
Satellite: Noaa-15 (Channel 10)

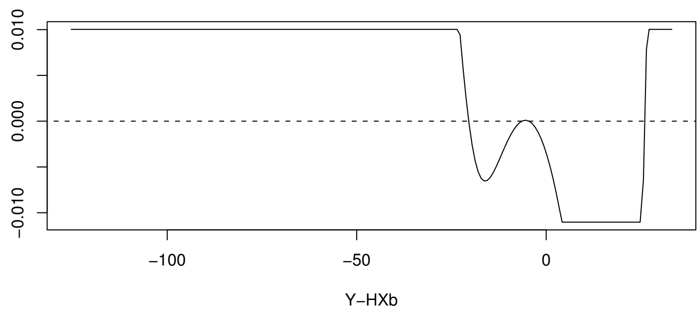
$\mu = -0.25733$, $\sigma = 0.85682$, Range$=-2.94538 \rightarrow 1.87141$



Satellite: Noaa-16 (Channel 1)

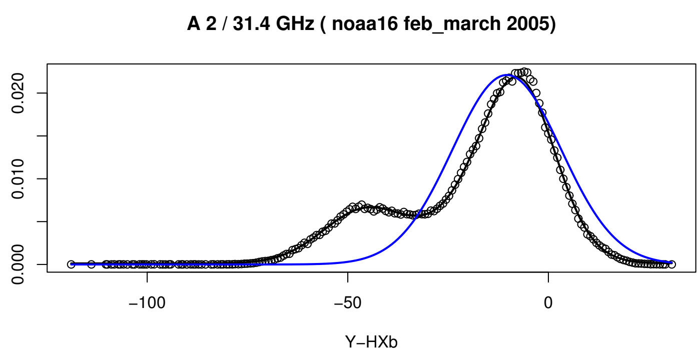
$\mu = -6.41579$, $\sigma = 10.57648$, Range$=-20.73399 \rightarrow 26.05501$

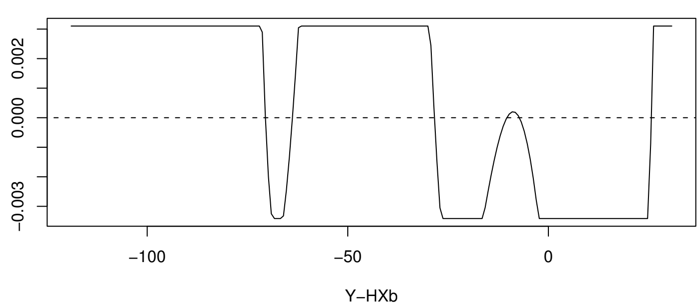




Satellite: Noaa-16 (Channel 2)

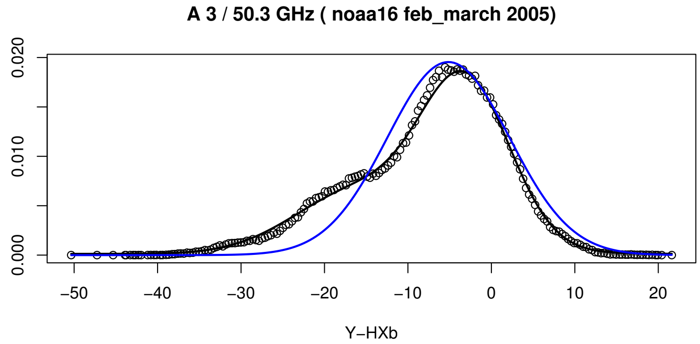
$\mu = -10.35346$, $\sigma = 13.55207$, Range$=-28.89977 \rightarrow 25.86262$

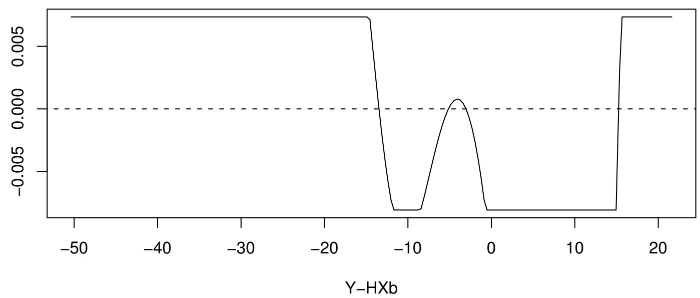




Satellite: Noaa-16 (Channel 3)

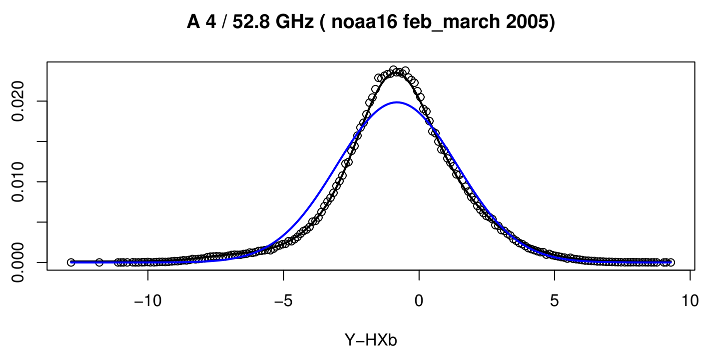
$\mu = -5.14609$, $\sigma = 7.34530$, Range$=-13.64604 \rightarrow 15.15561$

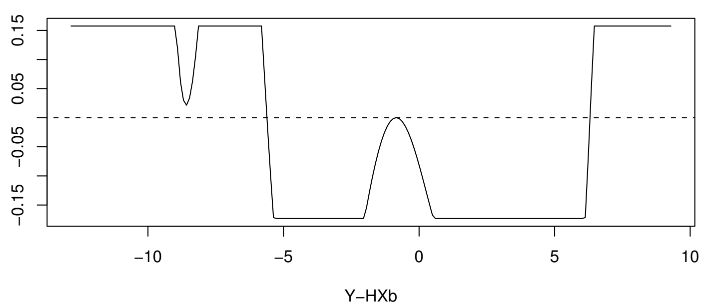




Satellite: Noaa-16 (Channel 4)

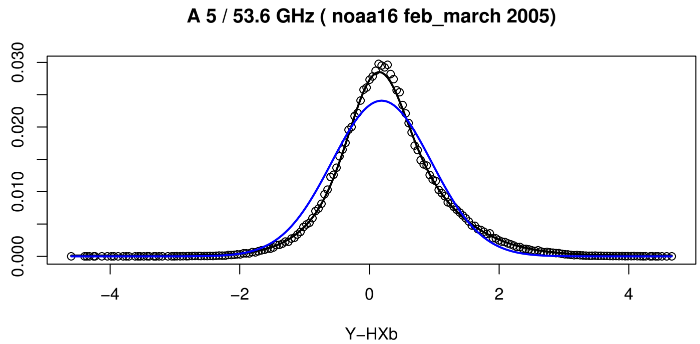
$\mu = -0.81593$, $\sigma = 2.22269$, Range$=-5.64491 \rightarrow 6.29842$

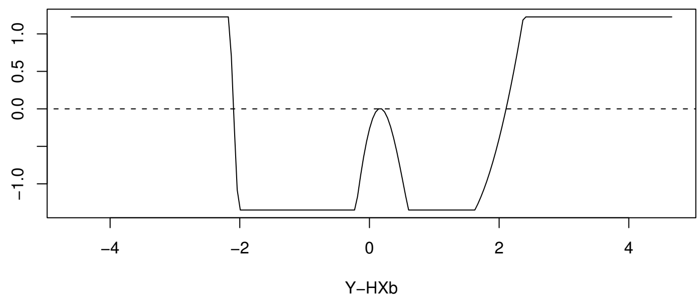




Satellite: Noaa-16 (Channel 5)

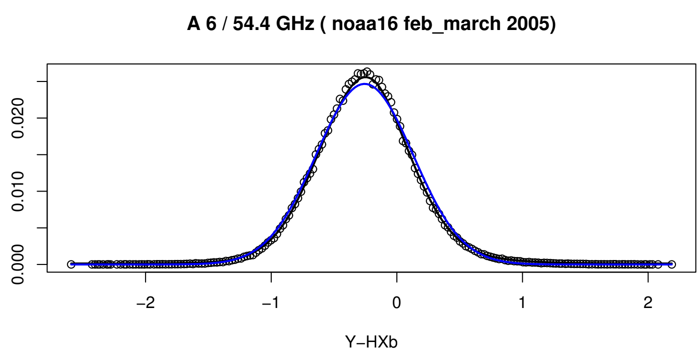
$\mu = 0.18815$, $\sigma = 0.76822$, Range$=-2.10685 \rightarrow 2.11185$

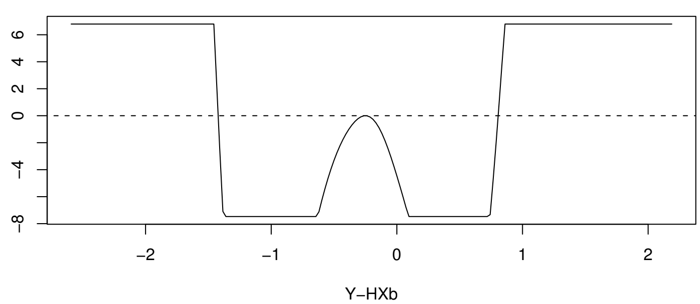




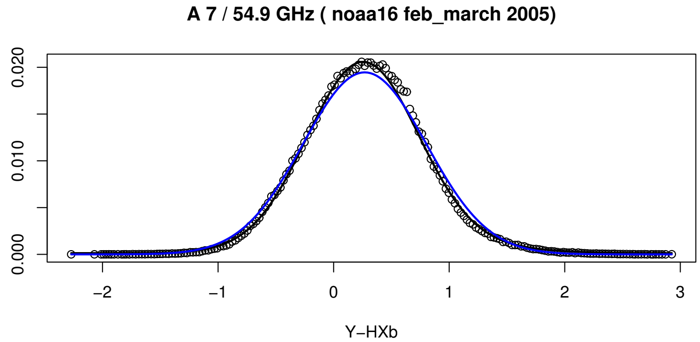
Satellite: Noaa-16 (Channel 6)

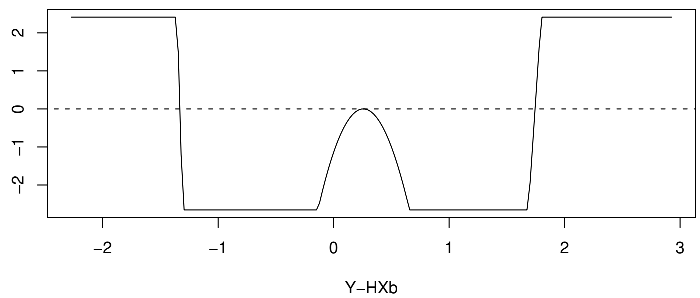
$\mu = -0.25647$, $\sigma = 0.38636$, Range$=-1.42117 \rightarrow 0.80154$



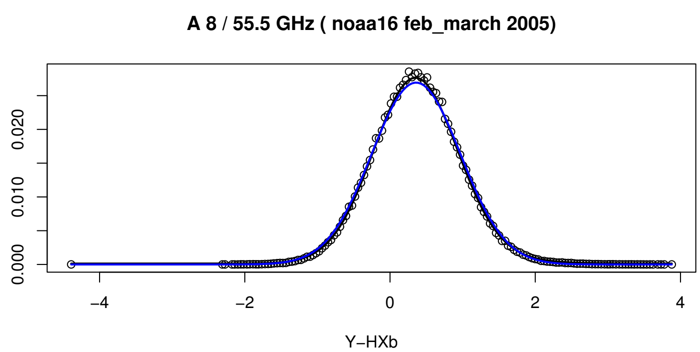


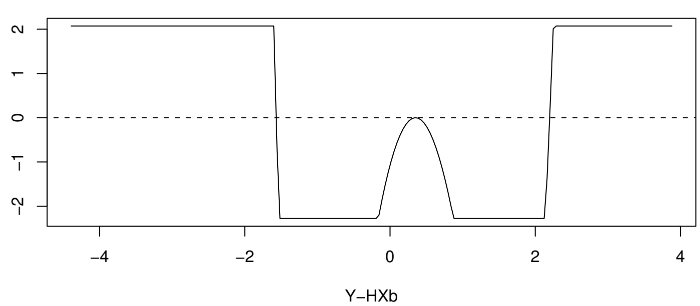
Satellite: Noaa-16 (Channel 7)
$\mu = 0.26869,\ \sigma = 0.53385,$ Range$=-1.33297 \rightarrow 1.73933$





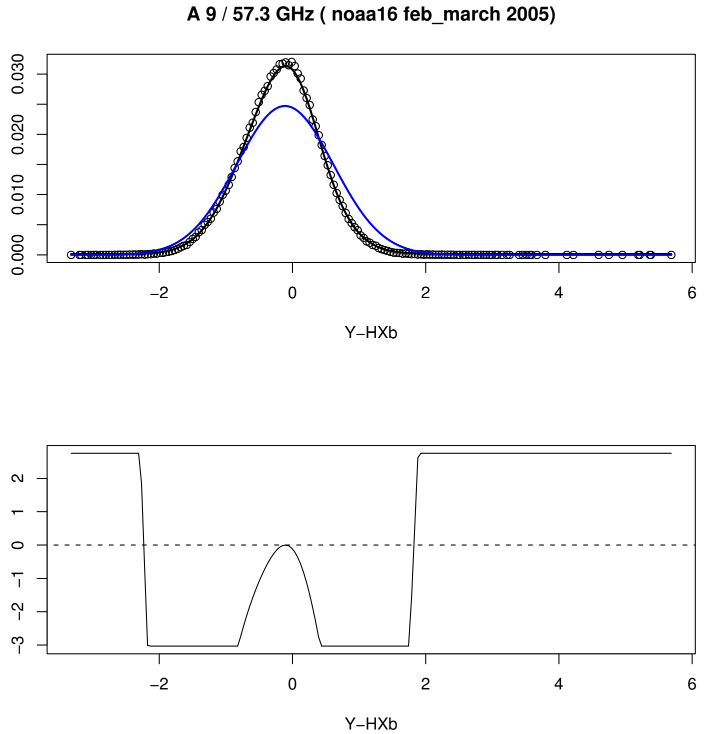
Satellite: Noaa-16 (Channel 8)
$\mu = 0.35887,\ \sigma = 0.61236,$ Range$=-1.57830 \rightarrow 2.18387$





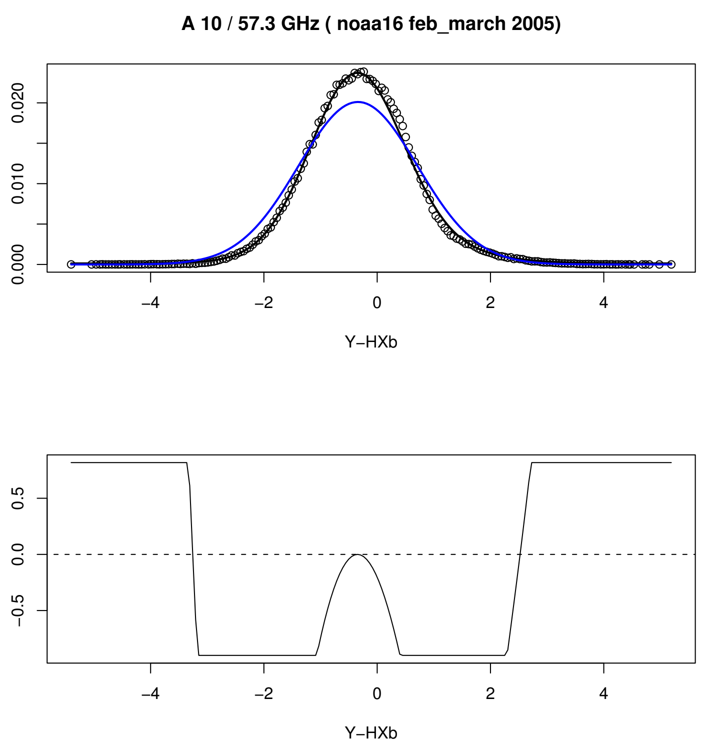
Satellite: Noaa-16 (Channel 9)

$\mu = -0.11220$, $\sigma = 0.72696$, Range$=-2.24278 \rightarrow 1.81148$



Satellite: Noaa-16 (Channel 10)

$\mu = -0.33865$, $\sigma = 1.05059$, Range$=-3.23283 \rightarrow 2.54369$



Satellite	Channel	Approximate μ	Approximate σ	Valid range, $Y - HX_b$
noaa15	ch1	-8.74059	10.61201	$-22.65159 \rightarrow 23.66040$
noaa15	ch2	-11.91565	11.05884	$-26.67881 \rightarrow 21.83006$
noaa15	ch3	-7.28578	8.65792	$-36.14119 \rightarrow 15.56422$
noaa15	ch4	-0.92867	2.41447	$-7.38239 \rightarrow 6.27787$
noaa15	ch5	0.18695	0.79051	$-1.89188 \rightarrow 2.58500$
noaa15	ch6	-0.37838	0.48660	$-1.93033 \rightarrow 1.05184$
noaa15	ch7	0.32533	0.51397	$-1.07438 \rightarrow 1.72510$
noaa15	ch8	0.38913	0.52028	$-1.24914 \rightarrow 1.74230$
noaa15	ch9	-0.01864	0.59533	$-1.90122 \rightarrow 1.57715$
noaa15	ch10	-0.25733	0.85682	$-2.94538 \rightarrow 1.87141$
noaa16	ch1	-6.41579	10.57648	$-20.73399 \rightarrow 26.05501$
noaa16	ch2	-10.35346	13.55207	$-28.89977 \rightarrow 25.86262$
noaa16	ch3	-5.14609	7.34530	$-13.64604 \rightarrow 15.15561$
noaa16	ch4	-0.81593	2.22269	$-5.64491 \rightarrow 6.29842$
noaa16	ch5	0.18815	0.76822	$-2.10685 \rightarrow 2.11185$
noaa16	ch6	-0.25647	0.38636	$-1.42117 \rightarrow 0.80154$
noaa16	ch7	0.26869	0.53385	$-1.33297 \rightarrow 1.73933$
noaa16	ch8	0.35887	0.61236	$-1.57830 \rightarrow 2.18387$
noaa16	ch9	-0.11220	0.72696	$-2.24278 \rightarrow 1.81148$
noaa16	ch10	-0.33865	1.05059	$-3.23283 \rightarrow 2.54369$

Table 1: Table showing the optimal Normal approximate innovation parameters (μ and σ) for the AMSU-A channels, along with the range for which this approximation should be used according to the theory.