

# Evaluation and comparisons of FASTEM versions 2 to 5



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## 1 Introduction

Different versions of the fast ocean surface emissivity model for microwave frequencies are evaluated and intercompared for microwave imagers (AMSR-E, TMI, SSMIS) and sounders (AMSU-A/MHS). The different versions are used with RTTOV-10 in radiative transfer computations, and we present results from comparisons between observations and simulated values.

The following versions of FASTEM are intercompared here:

- FASTEM-2: A fast parametrization of the surface emissivity, based on regressions fitted to a geometric optics model, and with an added correction to the reflectivities, dependent on the surface-to-space transmittance (Deblonde and English, 2001).

- FASTEM-3: Added parametrization for azimuthal effect, otherwise as FASTEM-2.
- FASTEM-4: New permittivity parametrization, different foam cover model (Tang, 1974 rather than Monahan and O’Muircheartaigh, 1986), new parametrization of roughness effects based on a new rigorous two-scale model (see Liu et al., 2011).
- FASTEM-5: Modification to FASTEM-4: Reversal of foam cover change, constrained regressions for large-scale effects, option to use look-up-table for large-scale part instead (Liu et al., 2012).

## 2 Microwave imagers

For microwave imagers, departure statistics have been obtained from ECMWF’s all-sky system in which microwave imager data are used in clear as well as cloudy/rainy conditions. Statistics are based on the data after super-obbing to a T255 Gaussian grid resolution (e.g., approx. 80 km). The azimuthal dependence of emissivity is ignored, and versions FASTEM-2, -4, and -5 are intercompared.

There are significant differences in biases for different sensors, so there is not one version that performs best for all sensors and all channels (Figure 1).

Differences between FASTEM-4 and other versions are most marked for the horizontally polarised channels (Figures 1 and 2).

There are notable differences between the LUT-based and the regression-based versions of FASTEM-5 (Figure 2).

The wind-speed dependence of biases is significantly different for the versions considered, especially at high wind speeds (Figure 3). For high 10m wind-speeds, FASTEM-5 follows the behaviour of FASTEM-2, as expected from sharing the same foam-cover parameterisation. For low 10m wind-speeds, FASTEM-5 follows FASTEM-4 for vertically polarised channels, and FASTEM-2 for horizontally polarised channels. FASTEM-4 shows the smallest standard deviations for high wind speeds among the three versions. It is not clear that the reversal of the foam cover model from FASTEM-4 to -5 leads to a better performance.

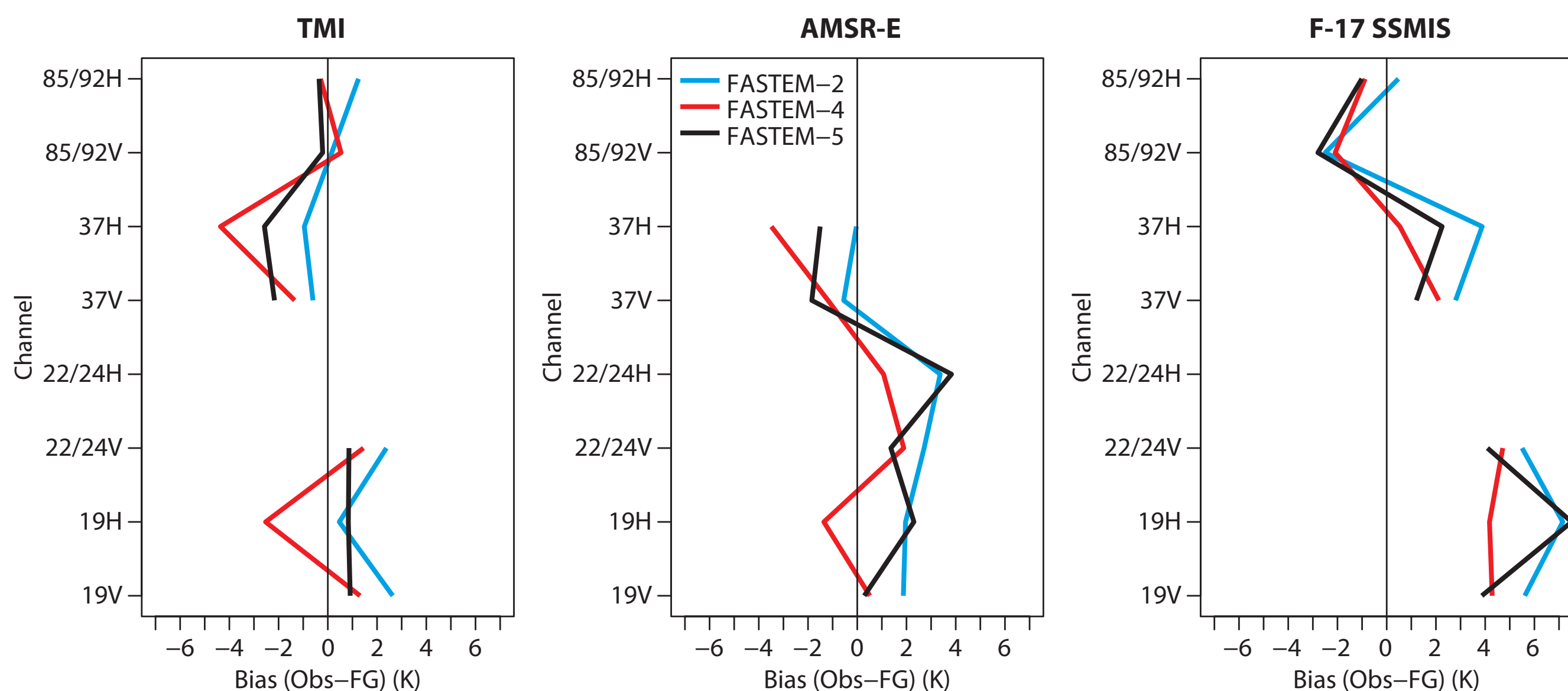


Figure 1 Mean biases (observation minus FG) for different FASTEM versions for the three microwave imagers considered here: TMI (left), AMSR-E (middle), and the F-17 SSMIS (right). Data are for a quality-controlled sub-sample for the period 5–31 January 2011.

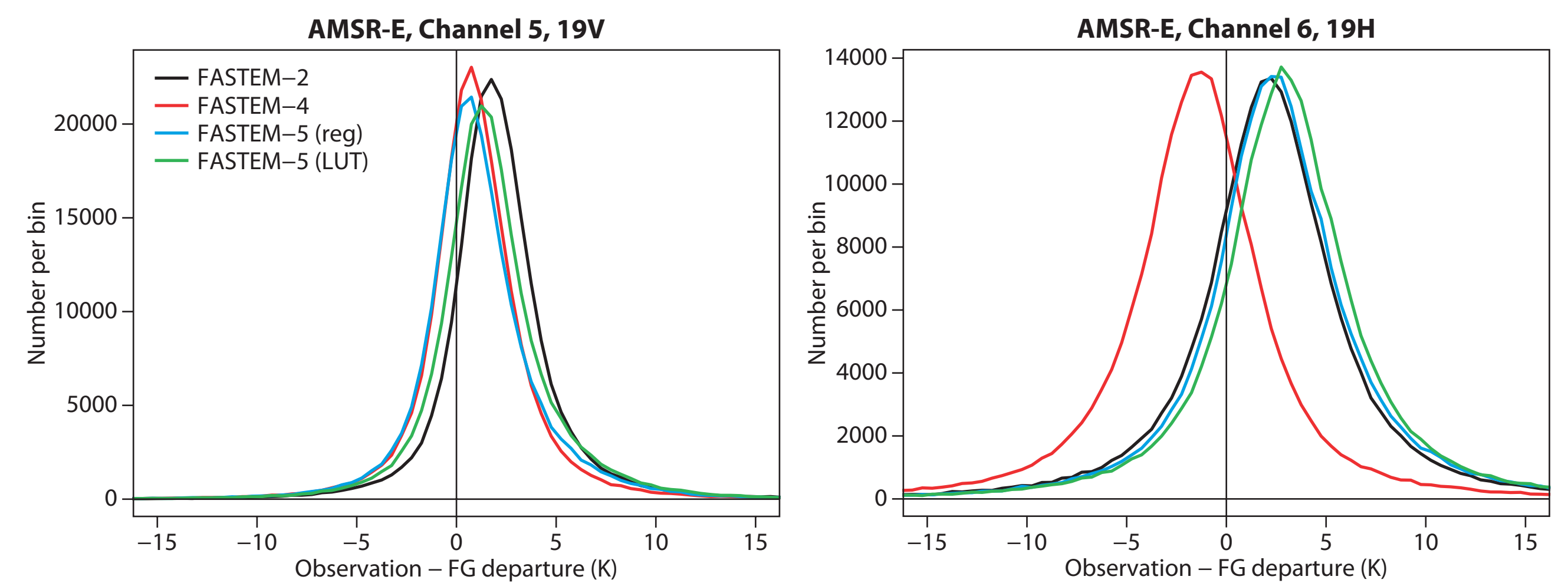


Figure 2 Histograms of FG departures before bias correction for the 19 GHz AMSR-E channels (channels 5 and 6) for different versions of FASTEM for all observations over sea over the period 5-25 July 2010.

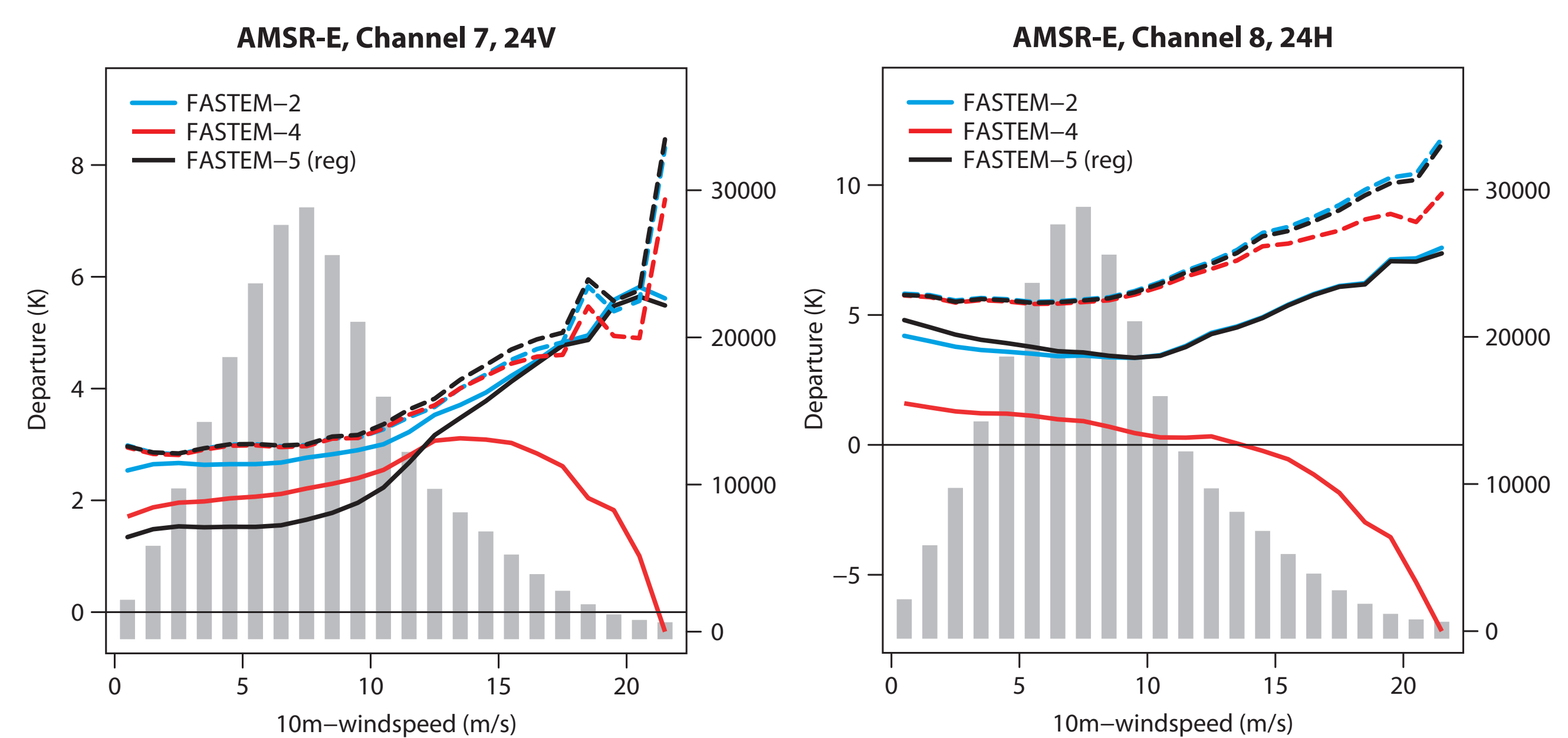


Figure 3 First Guess departure statistics before bias correction for the 24 GHz AMSR-E channels (channels 7 and 8) as a function of the model’s 10m-wind speed, calculated for the period 5-25 July 2010 and based on all observations over sea. Biases (Obs - FG) are displayed in solid lines, standard deviations with dashed lines. Also shown in grey is the population of data considered in the statistics as grey bars (right-hand x-axis).

## 3 Microwave sounders

For microwave sounders, departure statistics have been obtained from assuming clear-sky conditions in the radiative transfer. Changes to biases or standard deviations are confined to the window channels that are not commonly assimilated.

FASTEM-5 shows improvements in biases compared to FASTEM-3 or -4, and in terms of the wind speed dependence of the biases (Figure 4). Note that cloud-affected observations will cause positive departures here, and the mode of the FG departures is hence a better estimate for the true bias.

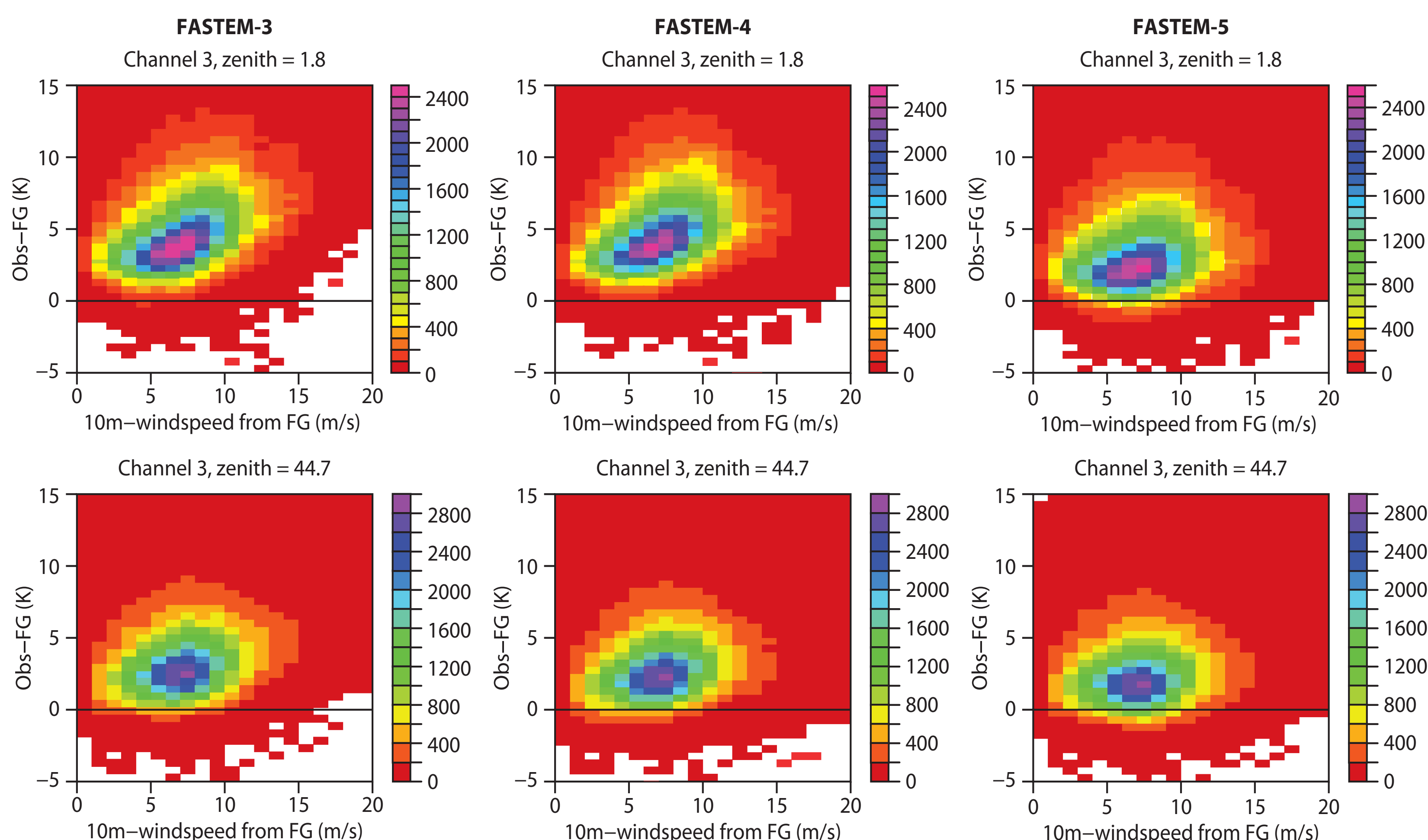


Figure 4 Two-dimensional histograms of the differences between observed and simulated brightness temperatures before bias correction for channel 3 (50.3 GHz) of NOAA-18 AMSU-A as a function of the 10m-wind speed taken from the FG. The data is for the period 5–25 July 2010, over sea within  $\pm 60^\circ$  latitude, showing all data before quality control and thinning. The microwave emissivity model is FASTEM-3 (left), FASTEM-4 (middle), and FASTEM-5 (right). The top row shows data for the central scan positions (zenith angle around  $1.8^\circ$ ), whereas the bottom row shows results for the outermost scan positions considered for assimilation at ECMWF (zenith angle around  $44.7^\circ$ ).

## 4 Conclusions

FASTEM-5 is the latest update of the fast ocean surface emissivity model for microwave frequencies. The main findings from a comparison between observed and simulated brightness temperatures are:

- FASTEM-5 leads to bias characteristics for horizontally polarised lower frequency imager channels that are similar to those for FASTEM-2, whereas FASTEM-4 gives significantly different biases.
- FASTEM-5 leads to a significantly different wind-speed dependence of bias characteristics for microwave imagers and sounders.
- For microwave sounders (AMSU-A), FASTEM-5 produces smaller biases and an improved wind speed dependence compared to earlier FASTEM versions.
- For microwave imagers, FASTEM-4 leads to the smallest standard deviations of the departures at high wind-speeds. This is due to the changes in the foam cover parametrization and suggests that some improvements could be obtained through a more sophisticated treatment of foam cover.
- The evaluation of the FASTEM versions in terms of brightness temperatures is limited by the presence of large inter-sensor biases, so an absolute determination of biases is not possible.

## 5 References

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