Radiance Simulator v1.1 Test Plan

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Change record			
Version	Date	Author / changed by	Remarks
0.1	20/08/2014	A. Smith	Final draft
0.2	23/09/2014	A. Smith	Updated after beta-testing
1.0	17/11/2014	A. Smith	Version updated for release
1.1	25/09/2015	A. Smith	Updated for version 1.1 release

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1 INTRODUCTION

This document defines the Test Plan for the NWP SAF Radiance Simulator in accordance with the guidelines set out in [RD-1]. The aim of the Test Plan is to verify that the requirements of the product specification in [RD-2] are met.

1.1 Reference documents

[RD-1] NWPSAF-MO-SW-002: Development Procedures for Software Deliverables
[RD-2] NWPSAF-MO-DS-027: Radiance Simulator Product Specification
[RD-3] NWPSAF-MO-DS-033: Radiance Simulator User Guide

2 TESTED ITEMS

The following items are covered as defined in [RD-1]:

1. Coding
2. Module and Integration tests
3. Validation tests
4. Portability tests
5. Beta testing
6. User documentation

2.1 Coding

Code is checked for conformance with appropriate coding standards by a reviewer who is independent of the development process. The majority of the code is written in Fortran-90 with the addition of some features from Fortran-2003. These additional features are supported by most modern compilers and have been approved for use in Met Office operational systems.

2.2 Module and Integration tests

The Radiance Simulator consists of a set of Fortran subroutines and modules which are compiled and linked to a single program unit. Independent module testing is not applicable in this case; all testing is performed as an integrated package.

The standard test procedure is to compile and run the code for several instruments in a standard (largely default) configuration. The purpose of this is to ensure that the code compiles successfully without warning messages and runs to completion under test conditions. The procedure is repeated using a variety of compilers/platforms (see section on Portability below). Further tests are performed as part of the validation process.

The distribution file is transferred to a test folder, unpacked and installed. Simulations are then run for all 3 ATOVS instruments in a standard configuration. This procedure is carried out for all supported compilers.

The *standard configuration* is the following

- Input model data: Met Office PP file containing analysis fields for 00 UTC on 01/06/2014. The PP file is obtained by converting an operational suite fieldsfile. The Radiance Simulator can read fieldsfiles but the PP file has been chosen as the reference dataset due to its smaller size.
- Satellite instruments: Metop-2(A), AMSU-A, MHS, Metop-1, (B) HIRS, all channels. The HIRS instrument on Metop-2 is not functional so Metop-1 has been chosen for HIRS in order to allow later validation tests.
- Input observation data: File generated from operational output consistent with the above satellite instrument and model data.
- All other options with default values (see the User Guide [RD-3]) with the exception of `clw_data` which is switched on (`=T` in the namelist file) to match the processing applied in the operational system more closely.

Timing tests are also included.

2.3 Validation tests

The purpose of the validation tests is to check that the main functions of the Radiance Simulator are performing correctly. As described in the Product Specification [RD-2], these are

- Ingest of NWP model fields (several formats)
- Ingest of observation data files
- Interpolation of model fields to observation positions
- Setup and running of the radiative transfer model (RTTOV)
- Writing of results and associated data to an output file

The list of tests to be performed is as follows

1. Scientific validation test

   This uses output from the standard configuration integration test (see item 3 in section 2.2 above). Output results from the Radiance Simulator are compared with those obtained independently from the Met Office operational system. If results agree to within an acceptable tolerance where similar processing has been applied then all processing steps are effectively validated.

2. 64-bit Fieldsfile test

   Configuration identical to the AMSU-A component of test 1 but using the equivalent Fieldsfile. Results are compared with those from test 1.

3. 32-bit Fieldsfile test

As above but with a 32-bit fieldsfile.

4. GRIB file test

   Technical test for simulation from a GRIB file. The test file is one from ECMWF containing 80400 data points. Other configuration options:
   - Satellite instrument: Metop-2(B), AMSU-A, all channels.
   - Uses two observation data points.

5. NWP SAF 60L profiles + IR scattering code

   Technical test for simulation from the NWP-SAF 60L profile set (13495 profiles). Also tested is the use of the IR scattering code with the HIRS instrument.

6. NWP SAF 91L profiles + MW scattering code

   Technical test for simulation from the NWP-SAF 60L profile set (5000 profiles). Also tested is the use of the MW scattering code with the AMSU-A instrument.

7. Miscellaneous options test

   The AMSU-A component of test 1 is rerun with all output control options switched on with the exception of ozone Jacobian production which is not available as there are no ozone profiles in the test file. Output brightness temperatures are checked against the control. The main purpose of this test is to check that the various options are set up correctly and the simulation runs successfully when they are switched on.

8. Heavy load test

   This is a run with IASI simulated on the global model grid, and with emissivity output switched on. This tests how the simulator performs under extreme memory loads.

2.4 Portability tests

All validation tests are repeated for each of the supported compilers and platforms. Specifically, the test environments are the following

- *ifort 12.0.4* on Dell i686 running Red Hat Enterprise Linux version 6
- *pgfortran 11.7.0* on Dell i686 running RHEL6
- *gfortran 4.4.7* on Dell i686 running RHEL6
- *ifort 15.0.0* on Cray XC40 running Cray Linux (SuSE based)

The tests have also been performed on an IBM Power-7 (AIX operating system) with the *xlf* compiler but this can no longer be supported as there is no test platform available.

Results for all tests are cross-checked for consistency.

2.5 Beta testing

As this is a minor release, no beta-testing will be done.

2.6 User Documentation

The Radiance Simulator documentation will be reviewed in-house by one or more people not on the development team.

3 REQUIREMENTS TRACEABILITY MATRIX

This section demonstrates how the requirements listed in the Product Specification relate to the test plan.

Table 1: Requirements traceability

Requirement	**Testing method**	**Test plan reference**	**Comment**
8.1 Functionality	Test run	2.3	
8.2 Release Note	Inspection	2.2	
8.3 Compile test / User instructions	Test run	2.3, 2.6	
8.4 Portability	Test run	2.4	
8.5 Accuracy	Test run	2.3	

4 TEST RESULTS

The following checklist summarises the tests performed and outlined in the document. Timing results (in seconds) are included for all 3 runs (HIRS, AMSU-A, MHS) in each case. These will vary considerably from system to system and with system load and are indicative only.

INTEGRATION/PORTABILITY TESTING			
Compiler, Platform	**Date tested**	**Outcome**	
		Compile	**Run**
ifort, Linux	25/09/2015	OK. No warnings	Control. Time taken = (44, 92, 70).
pgfortran, Linux	25/09/2015	OK. No warnings	Results identical. Time taken = (70, 68, 59).
gfortran, Linux	25/09/2015	OK. No warnings	Results identical. Time taken = (48, 52, 43).
ifort, Cray Linux	25/09/2015	OK. No warnings	Results identical. Time taken = (21, 25, 15).

VALIDATION TESTING			
Test number	**Description**	**Date tested**	**Outcome**
1	Scientific validation	25/09/2015	See section 4.1 below.
2	Fieldsfile, 64-bit	25/09/2015	Results similar to control (see note 1).
3	Fieldsfile, 32-bit	25/09/2015	Results similar to control (see note 2).
4	GRIB file	25/09/2015	Test successful
5	NWP SAF 60L profiles + IR scattering	25/09/2015	Test successful
6	NWP SAF 91L profiles + MW scattering	25/09/2015	Test successful
7	Miscellaneous options	25/09/2015	Test successful.
8	Heavy load	25/09/2015	See section 4.2 below. Time taken=6573s

Notes:

1. Mean brightness temperature difference of -0.0004K, standard deviation 0.011K, and a maximum difference of 0.17K.
2. Results the same as for the 64-bit fieldsfile.

4.1 Scientific validation testing

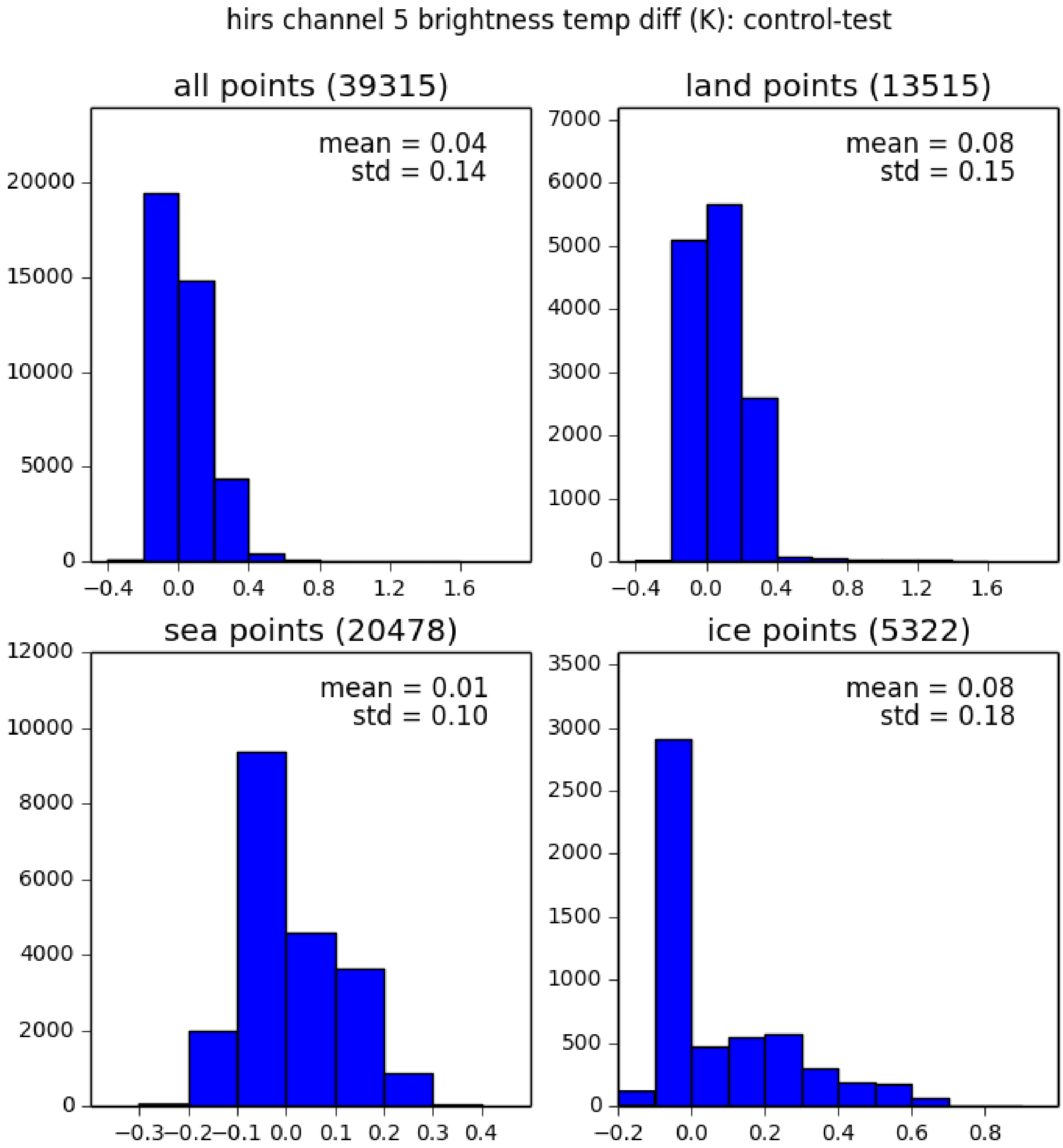
The scientific validation test uses Met Office operational NWP system output as the control dataset, but the operational system includes additional processing that is not replicated in the Radiance Simulator. A true like-for-like comparison is not possible but to help get as close as we can, only points that have the same RTTOV surface type identifier are compared (this may differ in a few cases because the operational system uses observation data to help classify surface type). Other points to note about why values may differ are:

- RTTOV-9 is used operationally and with different coefficients
- Fastem-2 is used operationally for microwave surface emissivity
- Interpolated surface fields may differ significantly near coastlines and the sea-ice edge
- Operational processing is done on fixed levels (the 43 RTTOV coefficient levels). The Radiance Simulator runs on model levels which are interpolated to the new 54 RTTOV levels inside RTTOV.
- Additional processing is applied to correct for surface temperature errors.

Overall, the results are close enough, given the differences in processing outlined above, to show that the Radiance Simulator is working as expected. In particular, results for channels that are sensitive mostly to atmospheric variables are close to within a very small margin. There is much more uncertainty for surface sensing channels, as one would expect. Further details are given below.

HIRS results

Brightness temperature differences are calculated for channel-5 from Metop-1, a tropospheric temperature sounding channel with a small surface contribution. Most values are within 0.25K, with a mean of 0.04K and a standard deviation of 0.14K. Note that HIRS-5 is not assimilated in the operational system when over seaice.

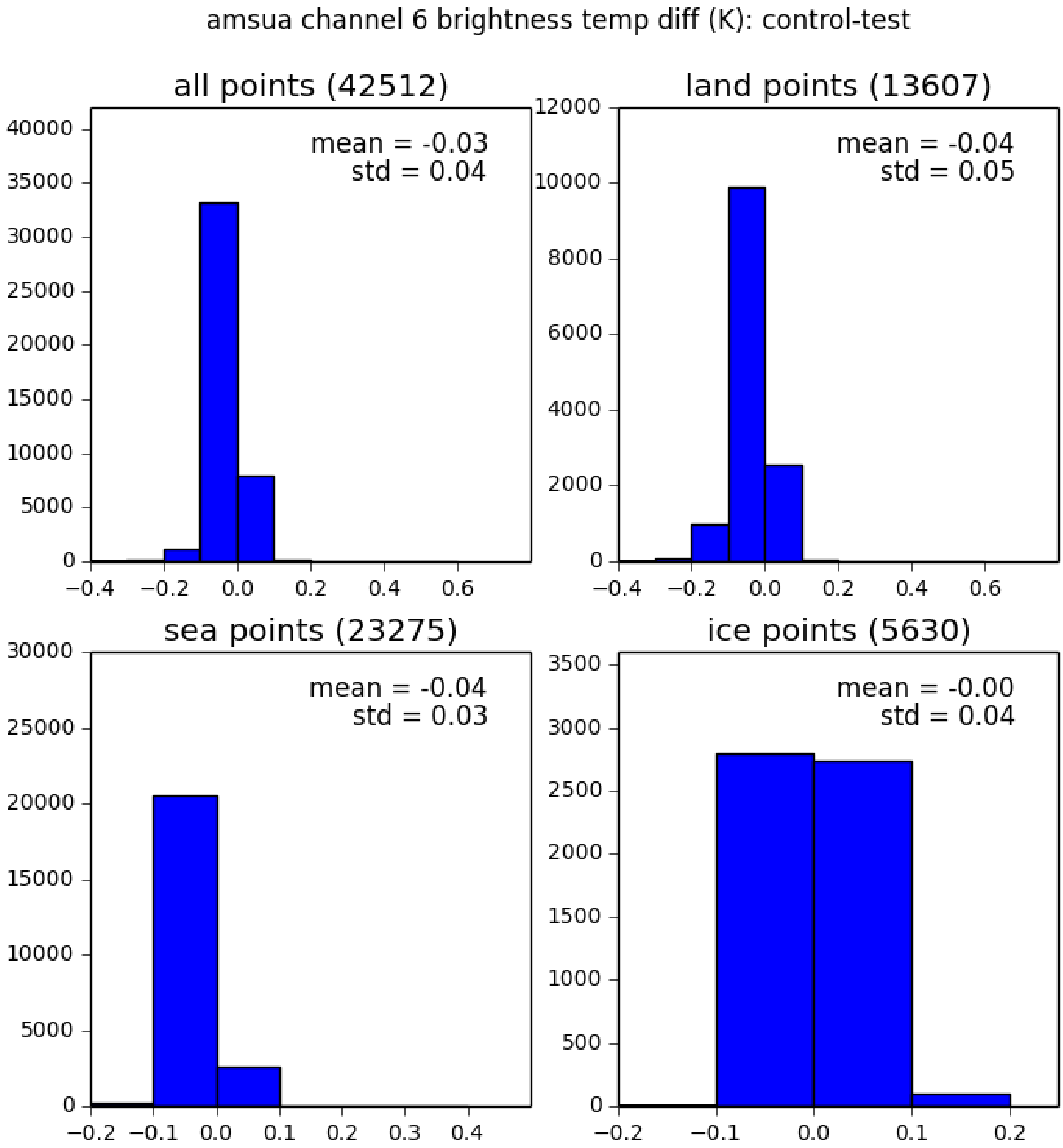


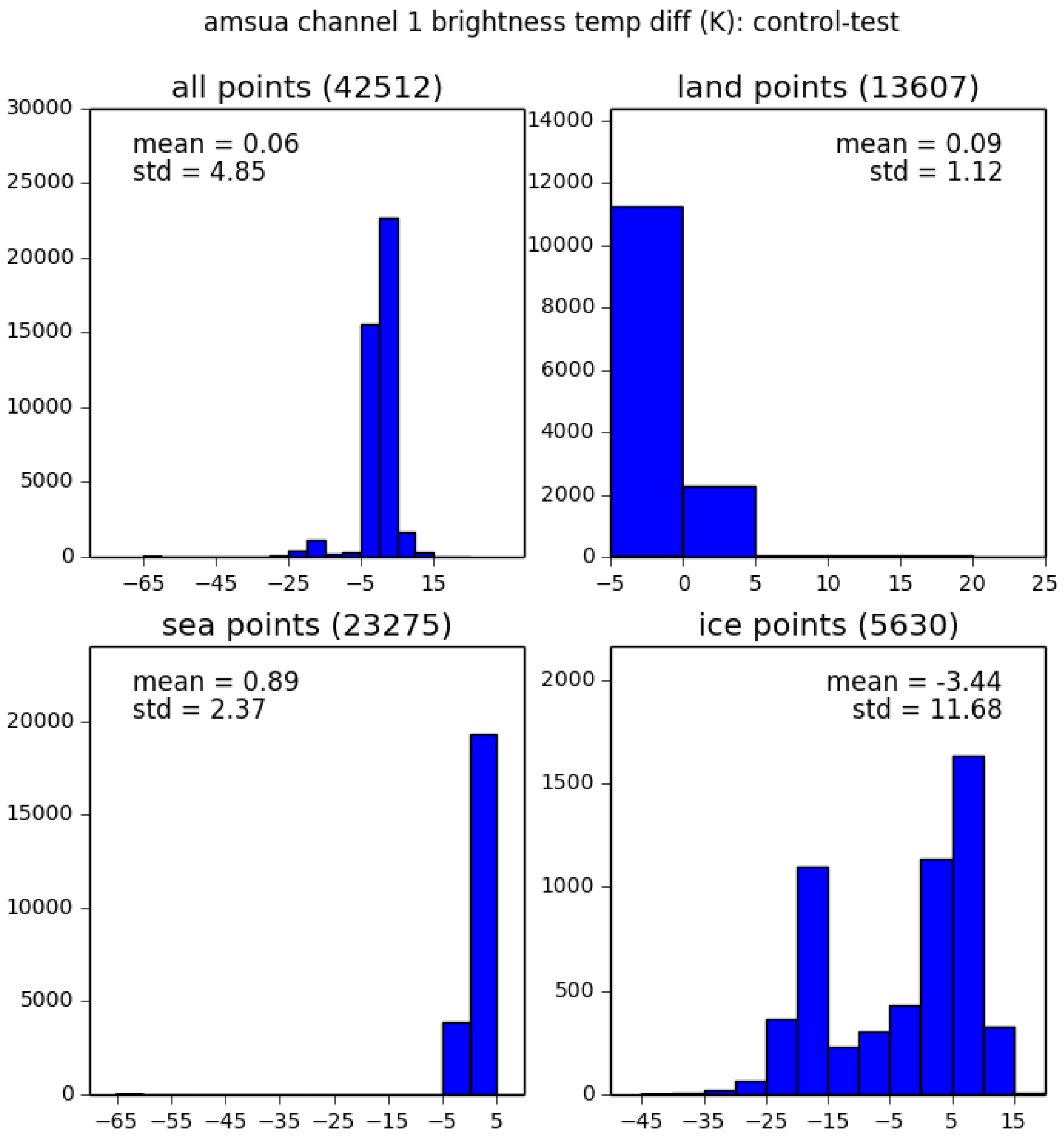
AMSU-A results

Two AMSU-A channels are displayed in the following histogram plots – a tropospheric temperature sounding channel (channel-6 from Metop-2) and a window channel (channel-1 from Metop-2).

AMSU-6 results are all within 0.2K and the majority within 0.1K of the operational system. The results for AMSU-1 show more variation and in a few cases some large differences, most likely due to a combination of the factors outlined in the introduction. Note that

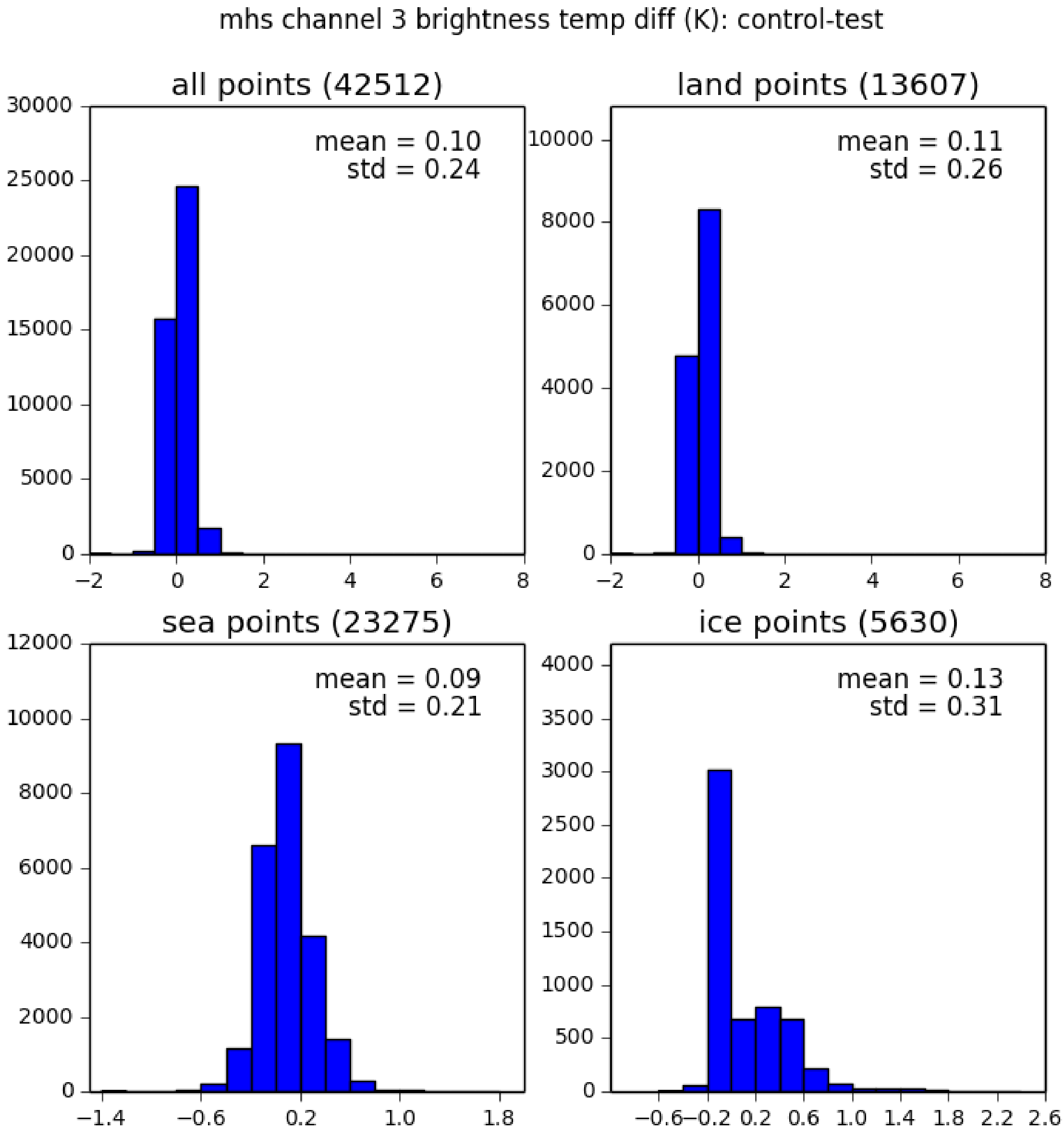
AMSU-1 is never assimilated over seaice in the operational system due to the large uncertainties present.





MHS results

For MHS, the vast majority are within 1K and most within 0.4K



4.2 Heavy load test

Running simulations for IASI (all channels), with emissivity or Jacobian output switched on results in very large output datasets if simulating for a lot of profiles. In some cases, it can result in output files that are too large for most operating systems to handle. It is up to the user to set up the runs in a sensible manner and it is unlikely that most users would encounter such a situation. A test is run here to see how the Radiance Simulator copes with a very large but still manageable output dataset requirement. In processing, a maximum array size is imposed so help avoid exceeding memory limits. If output arrays should be larger than this then the processing is simply done in batches and the data written to the output file a batch at a time.