

## Assessment & Assimilation of FY-3D HIRAS in the Met Office System

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# **Specifications**

#### Hyperspectral Infrared Atmospheric Sounder (HIRAS)

Parameters	Specification
Scan Period (s)	10
View angle (°)	1.1
Scan angle (°)	$\pm 50.4$
Radiative calibration accuracy (K)	0.7
Spectral calibration accuracy (ppm)	7
Direction pointing bias (°)	± 0.25
Pixels per scan	116



	Band	Spectral Range (cm <sup>-1</sup> )	Spectral Resolution (cm <sup>-1</sup> )	No of channels		
	Long-wave	650 - 1136	0.625	777		
FSR	Mid-wave	1210 - 1750	0.625	865		
	Short-wave	2155 - 2550	0.625	633		
	Long-wave	650 - 1136	0.625	777		
NSR	Mid-wave	1210 - 1750	1.25	432		
	Short-wave	2155 - 2550	2.5	158		

# **Pre-processing**

- 2 months (Feb-Mar 2019) of HIRAS FSR (2275 channels) data prepared by CMA in HDF5 format.
- Ingestion in the AAPP version 8.4 [1] and conversion to level 1c binary format using the tool *hiras\_sdr* (incl. Hamming apodization).
- o Degradation to NSR (1367 channels) using the AAPP tool *hiras\_degrade\_fsr.*
- o Channel selection (399 channels) identical to that currently used for CrIS [2, 3].
- Conversion to BUFR format using a locally-defined BUFR sequence (available through AAPP) and stored in the Met Office's observation database.



# **Background Departures**



# **Calibration Anomaly**





Calibration anomaly for detector 3 when the instrument exits the shadow of Earth at solar zenith angle ~ 100-120°. Possible contamination of the cold calibration view by direct of reflected sunlight.

Day

Earth

Night

Clear-Sky / Ocean Only

#### **Met Office**

# **Double Difference Against CrIS**



# **Assimilation Experiments**

○ Low resolution N320L70 UM, N108/N216 4D-Var uncoupled hybrid assimilation full global system.

- Thinning and channel selection are similar to those used for CrIS (but ocean only).
- Observation covariance matrix estimated for 1D-Var (and used in 4D-Var as a day-1 approach) following
  - a similar methodology used by [4].
- Variational bias correction
  coefficients have been spun up offline with a low resolution 4D-Var
   cycling suite for two months.



## **Assimilation Experiments**

#### -0.31% RMSE difference against observations

NH_PMSL	•	÷	1	1			٠		1				1			surf
NH_W250	•	•	٠	•	٠			٠	٠	•	•	•				AMDARS
NH_W500	٠	٠	٠	٠			٠	٠	٠			٠				sondes
NH W850			٠	٠												Satwind
NH_W10m	•		·	•	•											surf
NH_T250	٠	٠	٠	٠	•		٠					•				sondes
NH_T500	•	۳	٠	·	٠		٠			٠	۳	٠				sondes
NH T850	1								٠		٠		٠			sondes
NH_T_2m																surf
NH_Z250	٠	٠	٠	·			٠	٠	٠	۷	٠	٠	٠			sondes
NH_Z500	•	٠	٠	•	•		*		٠	٠	٠	٠	٠			sondes
NH_Z850	•	۳	٠	•			٠	٠	٠		•	٠	٠	٠		sondes
TR_W250	٠	٠			٠											AMDARS
TR_W500	٠	٠	٠						٠		٠					sondes
TR_W850	٠	٠		•				٠	٠	•				۷		Satwind
TR W10m	•	٠	•			•						•				surf
TR T250	v	•	٠												1	sondes
TR T500	•		٠	٠	٠		۳	٠	۷	۷	٠	٠				sondes
TR T850		۳								•				•		sondes
TR T 2m		٠														surf
SH PMSL	•	•	٠					۰	۷	۳	٠					surf
SH W250	٠	٠	٠	٠					•	٠	٠	٠			1	AMDARS
SH_W200		v		٠	•		٠		۷		V	v	٠		1	sondes
SH_W850		٠	٠	•	٠	۷	٠	٠	۷	٠						Satwind
SH W10m	٠	٠	٠	·	·		٠	٠			٠			•		surf
SH T250	v	V	V	۷	۷	۷	٧	۷	۷		۷	V	٠	٠		sondes
SH_T200	⊽	⊽	۷	۷	۷	۷			٠	V	V	v	▼	٠		sondes
SH_T850		+						•	٠	V		v	V		1	sondes
SH T 2m															1	surf
SH Z250									٠	V	v		•		111	sondes
SH Z500	1									v	V	٠	٠			sondes
SH Z850	٠	•	٠						•		•					sondes
	ò	ø	N	4	9	œ	0	N	4	9	8	0	2	4	8	1
	+	+		1	- 0	-47	Q	-	ŝ	S)	0	(N	n,	4	9	

#### -1.06% RMSE difference against MO analyses

NH PMSL		4	۰	·	•	1		1			1	1	1			an
NH W250		▼	•	۷		٧	٠	•								an
NH_W200		▼	▼	V	۷	۷	٠	٠	٠							an
NH_W850		▼	•	٧	۷	٠	٠	٠	٠							an
NH W10m		•	•	٧	٠	٠		٠								an
NH T250	111	▼	•	٧	٠	٠	•	٠								an
NH_1200		▼	▼	V	۷	۳	٠	٠	٠							an
NH_T850		۳	۳	٠	٠	٠	٠	٠	٠							an
NH_T_2m		۳	۳	٠	٠	٠	٠	٠	٠	٠						an
NH_Z250		•	▼	٠	۷	٠	٠	٠	٠							an
NH_Z500		▼	▼	٠	*			٠	٠				٠			an
NH_Z850		•	٠	٠			٠	٠								an
TR W250		▼	v	۷	۷	٠	٠	٠		٠						an
TR_W500		▼	▼	₹	V	۷	۷	٧	٧	۷	٠	٠	٠			an
TR_W850		▼	•	۷	۷	۷	۳	٠	۷	۷	٠	٠	٠	۷		an
TR W10m		•	v	٧	٠	٧	۷	٠	٠	٠	٠	٠	٠	٧		an
TR T250	111	▼	•	٠	٠	٠	٠	٠	•							an
TR T500		▼	▼	▼	⊽		•	7	₹	۷	۷	٧		۷		an
TR T850		•	v	٧	۷	۷		٠	٠	٠	٠	٠	٠	٠		an
TR T 2m		•	۷	۷	۷	۷	•	٠	٠	٠	٠	٠	٠	٠		an
SH PMSL		▼	•	۷	۷	۷	•	۷	7	۷	٠					an
SH W250	111	$\mathbf{\nabla}$	$\mathbf{\nabla}$	▼	V	۷	•	٠	٠	٠	•					an
SH_W200		$\nabla$	$\nabla$	$\nabla$	$\nabla$	▼	⊽	4	۷	۷	۷	۳	٠	٠		an
SH_W850		▼	$\mathbf{\nabla}$	v	•	▼	•		۷	۷	٠					an
SH W10m		▼	V	۷	۷	۷	۷	٧	۷	۷	•					an
SH_T250		$\nabla$	$\nabla$	▼	V	۷	۳	٠								an
SH_T500		$\mathbf{\nabla}$	$\nabla$	$\nabla$	$\nabla$	$\mathbf{\nabla}$	۷	V	V	۷	V	۵	•	۷		an
SH_T850		▼	•	•	•	•	•	۷	۷	•	۷	٠	٠			an
SH_T_2m		•	•	۷	۷	•	•	۷	4	•	V	۷	•			an
SH Z250		▼	▼	V	V	▼	V	v	۷	۷	۷	٠	٠	•		an
SH_Z500		$\mathbf{\nabla}$	▼	•	V	▼	V	۷	V	V	۷	۷	۷	٠		an
SH_Z850		▼	▼	۷	۷	۷	•	۷	7	V	٠					an
	]0+1	T+6	T+12	T+24	T+36	T+48	T+60	T+72	T+84	T+96	T+108	T+120	T+132	T+144	T+168	

#### -0.56% RMSE difference against ECMWF analyses

NH_W250		۷	۷	٧	٣	٠	1	1	1	1	1	1	1		anl
NH_W500		۷	۷	٠	•			÷							anl
NH_W850		۳	٠	٠			٠								anl
NH_W10m		٠	٠	٠											anl
NH_T250		•	•	۷	•	•	٠								anl
NH_T500		۷	۷	۳	٠	•	٠	•			٠				anl
NH_T850			٠												anl
NH_T_2m	1														anl
NH_Z250		V	<b>▼</b>			٠	٠	•	•		٠	•			anl
NH_Z500		۷	۷	٠			٠	•				•			anl
NH_Z850		٠	٠			•	٠								anl
TR_W250		٧	٠	٠											anl
TR_W500			۰	٠		•	٠	•	٠						anl
TR_W850		٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠	٠		anl
TR_W10m		۳	٠	•	•	•	٠	٠	٠		٠	٠	۳		anl
TR_T250															anl
TR_T500		۳	۳	۳		٠	۳	۷	۷	۷	۳	·			anl
TR_T850		٧	٧	٠	•	٠	٠	•	٠	٠	٠	٠	٠		anl
TR_T_2m						•				·		·			anl
SH_W250		•	•	۷		۳	٠	•	•	1					anl
SH_W500		▼	▼	۷	•	۳		۳	•	۳	٠	٠			anl
SH_W850		•	۷	۷	•	۷	٧	۷	۳	•					anl
SH_W10m		۷	۳	۳		۷	٧	۷	۳	÷					anl
SH_T250		▼	▼	▼	▼	•	۷	۷	۳	۷	٠				anl
SH_T500		$\nabla$	V	۷	▼	•	•	۷	•	۷	•	٠	•		anl
SH_T850		٠	٠	•		٠	٠	۲	۳	۷	*	٠	•		anl
SH_T_2m	1.1							٠	٠	۷	•	۷			anl
SH_Z250		V	▼	▼	▼	V		•	•	•		٠	•		anl
SH_Z500		▼	•	۷	•	•	۷	۷	۷	۷	•	۲	•		anl
SH_Z850		۷	۷	۷	•	۷	۷	۷	۷	۷					anl
	99	N	4	9	œ	0	N	4	9	ω	0	N	4	8	
	ㅎ ㅎ	7	7	÷	+	+9	+	4	6	10	12	13	14	19	
		F	F	F	H	F	F	H	F	÷	÷	÷	÷.	÷	

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# **Assimilation Experiments**

# Time series of RMSE difference against MO analyses







# Summary

• HIRAS (det. 4) compares generally well to CrIS at NSR:

- $\circ~$  O-B are on average within ±0.1 K across the 399 channels,
- $_{\odot}\;$  but up to 1 K for high peaking temperature channels in the long-wave band,
- $_{\odot}~$  and up to 0.7 K for humidity channels in the mid-wave band.
- $_{\odot}~$  HIRAS standard deviation is on average 0.2 K larger than CrIS.
- Probable sunlight contamination of detector 3 deep space view affects band 2.
- Preliminary assimilation experiments (det. 4 over ocean) yield negative results when using CrIS channels selection (especially in band 2).
  - $_{\odot}\,$  HIRAS-dedicated channel selection is under investigation.
- o Complete assessment to be submitted to Remote Sensing.

# References

[1] Labrot , T., Atkinson, N. and Roquet, P., "AAPP documentation software description", NWPSAF-MF-UD-002, version 8.1, 2019, <u>https://www.nwpsaf.eu/site/software/aapp/documentation/</u>

- [2] A. Gambacorta and C. D. Barnet, "Methodology and Information Content of the NOAA NESDIS Operational Channel Selection for the Cross-Track Infrared Sounder (CrIS)," in IEEE Transactions on Geoscience and Remote Sensing, vol. 51, no. 6, pp. 3207-3216, June 2013. doi: https://doi.org/10.1109/TGRS.2012.2220369
- [3] Smith, A., Atkinson, N., Bell, W. and Doherty, A. (2015), An initial assessment of observations from the Suomi-NPP satellite: data from the Cross-track Infrared Sounder (CrIS). Atmos. Sci. Lett., 16: 260-266. doi: <u>https://doi.org/10.1002/asl2.551</u>
- [4] Weston, P. P., W. Bell, and J. R. Eyre, 2014: Accounting for correlated error in the assimilation of high-resolution sounder data. Quart. J. Roy. Meteor. Soc., 140, 2420–2429, doi: <u>https://doi.org/10.1002/gi.2306</u>.

# Questions ?

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