Characterisation of NWP Model Biases and Uncertainties in the MW and IR Spectral Domains

Part 1: InfraRed

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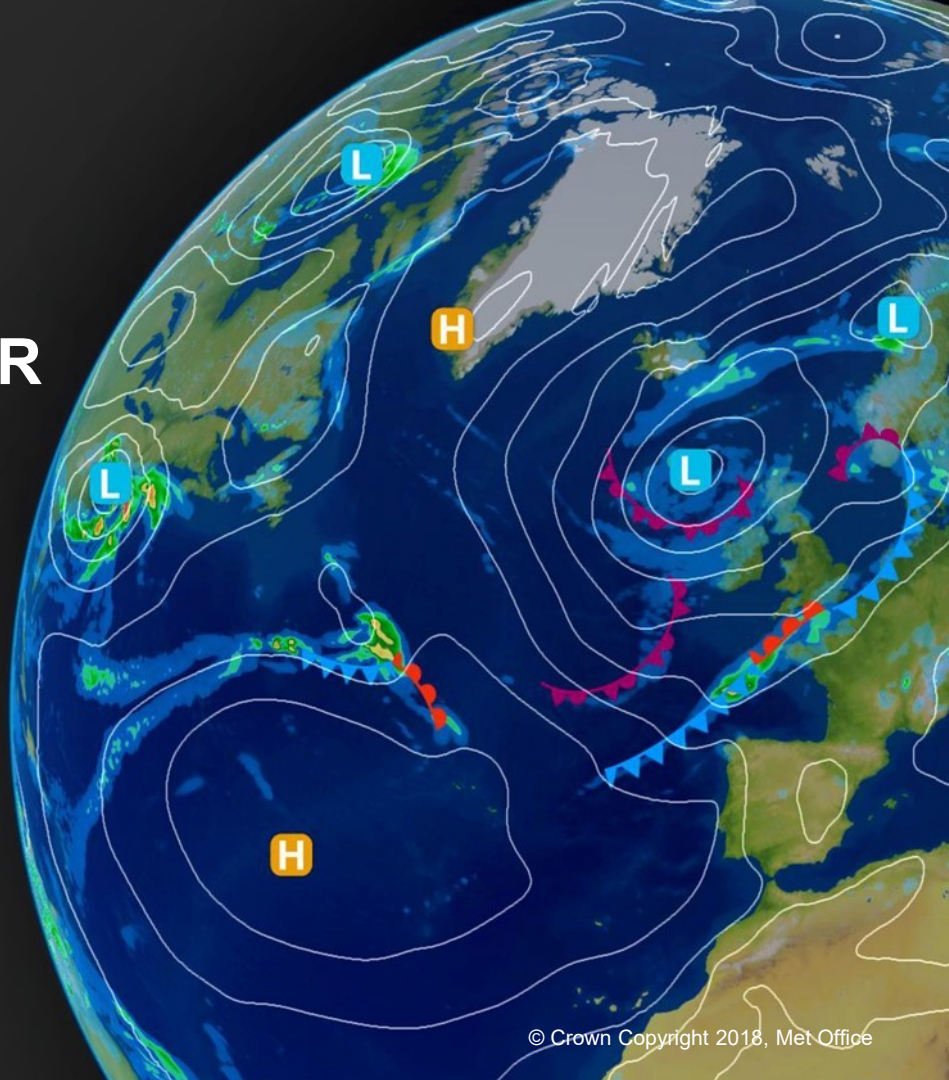
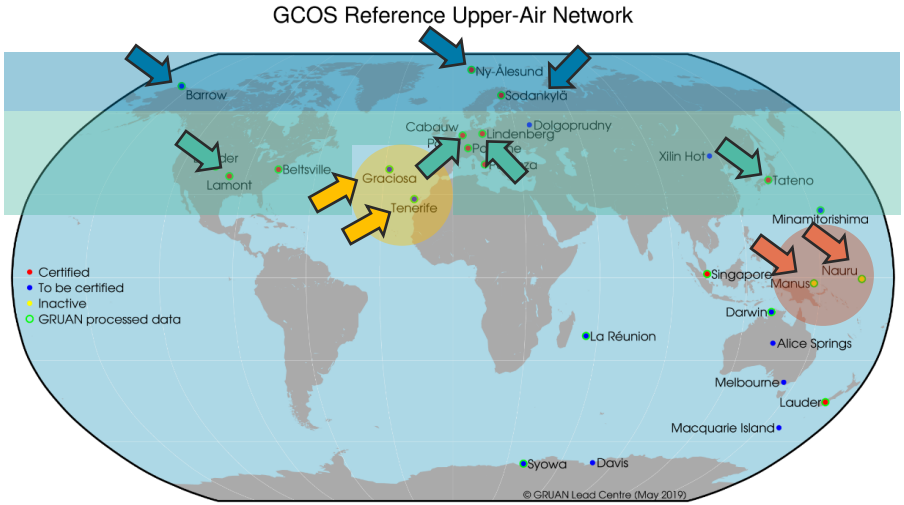


Motivation

What are the biases and uncertainties in NWP temperature and humidity fields when mapped to radiance space?

Sub-Tropics
GRA; TEN
~1200 matchups
2016-2017

Tropics
MAN; NAU
~600 matchups
2011-2014



Northern Latitudes
BAR; NYA; SOD
~7000 matchups
2011-2017

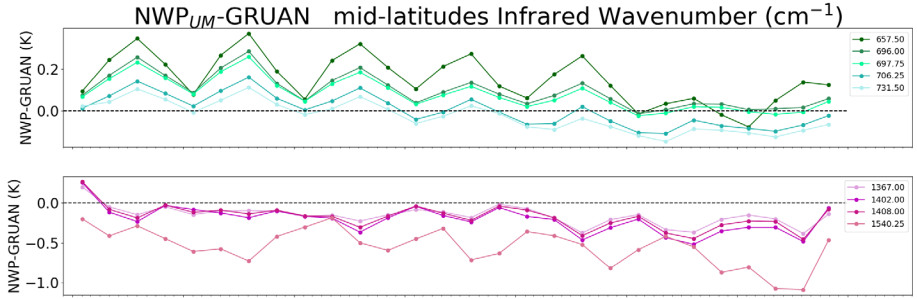
Mid-Latitudes
SGP; CAB; LIN; TAT
~15000 matchups
2011-2017

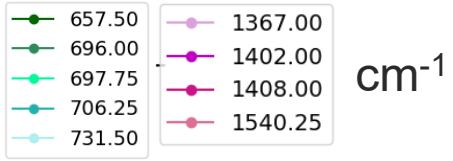
Disclaimer

Simulated radiosonde-based Brightness Temperature
vs
Simulated NWP-based Brightness Temperature

No Satellite Data

Biases Time Series

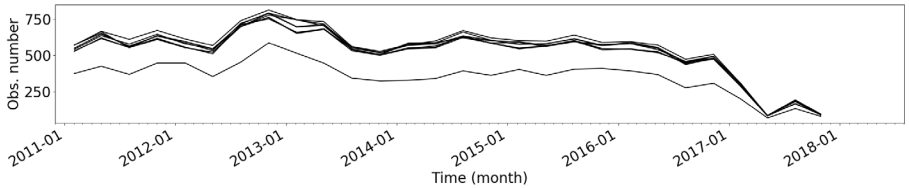




Temperature channels

Humidity channels

Met Office – Mid-Latitudes



$$\delta y = NWP - GRUAN$$

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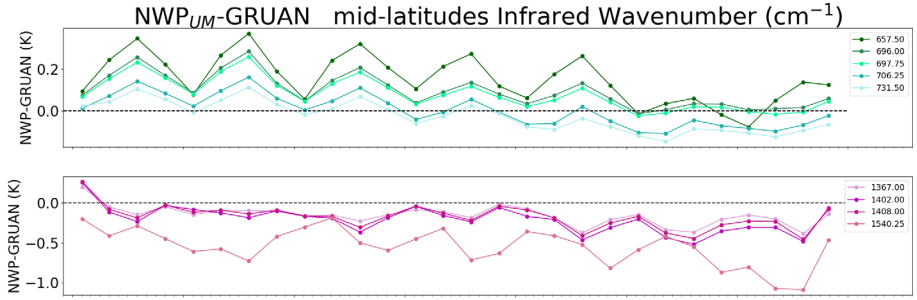
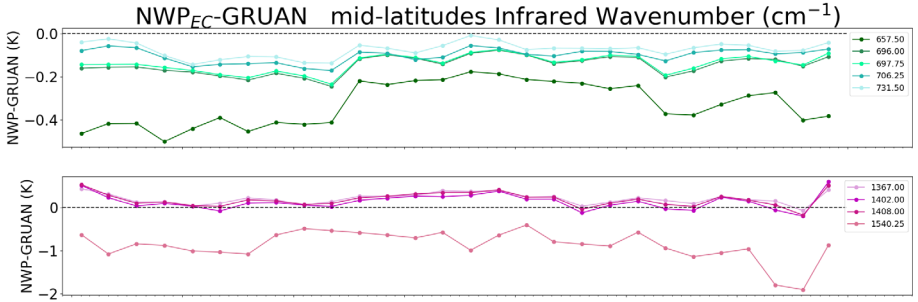
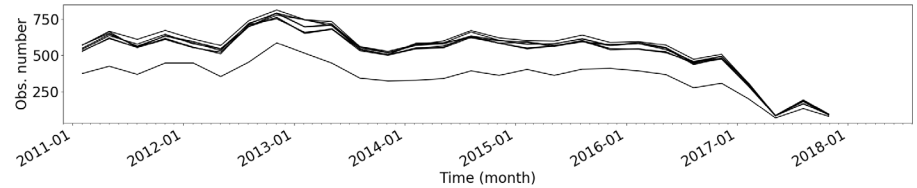
Biases Time Series

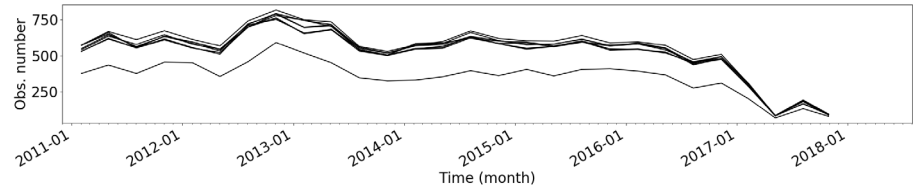




Met Office – Mid-Latitudes



ECMWF – Mid-Latitudes



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Uncertainties

The total uncertainty of the difference δy is expressed as the covariance matrix $S_{\delta y}$:

$$S_{\delta y} \cong HRH^T + HWBW^T H^T + HS_{int}H^T$$

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$$= HR_{temp}H^T + HR_qH^T + HR_PH^T + h\sigma_{surf}^2 h^T$$

Diagonal matrices of GRUAN uncertainties

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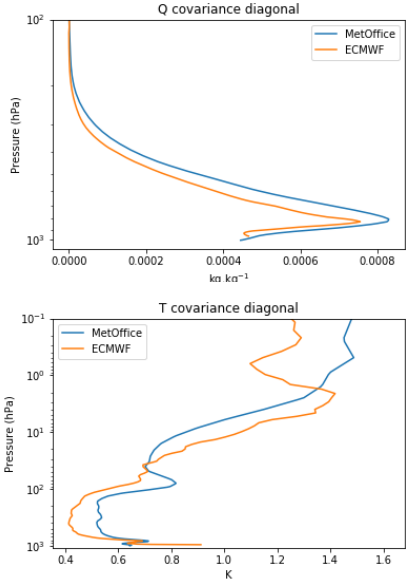
$$S_{\delta y} \cong HRH^T + HWBW^T H^T + HS_{int}H^T$$

$$= HWB_{temp}W^T H^T + HWB_q W^T H^T + h\sigma_{surf}^2 h$$

Full model covariance matrices



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$$S_{\delta y} \cong HRH^T + HWBW^T H^T + HS_{int}H^T$$

function of B and W (interpolation matrix)
see paper in ref.

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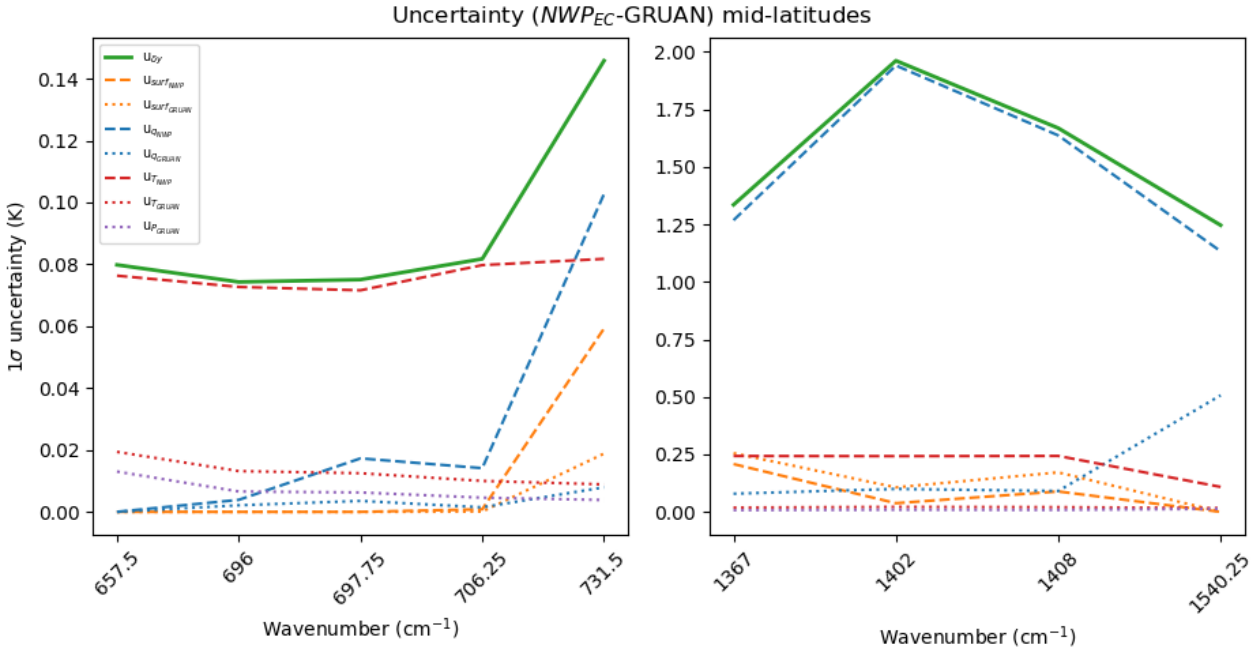
Uncertainties

Total Uncertainty

NWP contribution to total U

GRUAN contribution to total U



ECMWF – Mid-Latitudes

Diagonal of $S_{\delta y}$

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Assessment

The statistical significance of δy is assessed by testing the following:

$$\left| S_{\delta y}^{-1/2} . \delta y \right| < 2$$

NWP and GRUAN brightness temperatures satisfying this test are in agreement with a confidence interval of 95.5%.

$$|m_1 - m_2| < k\sqrt{u_1^2 + u_2^2}$$

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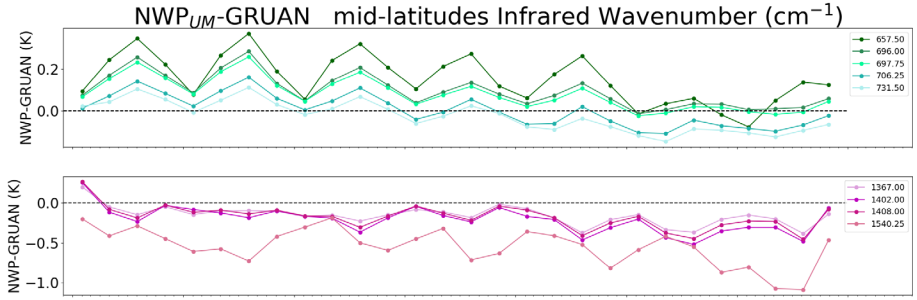
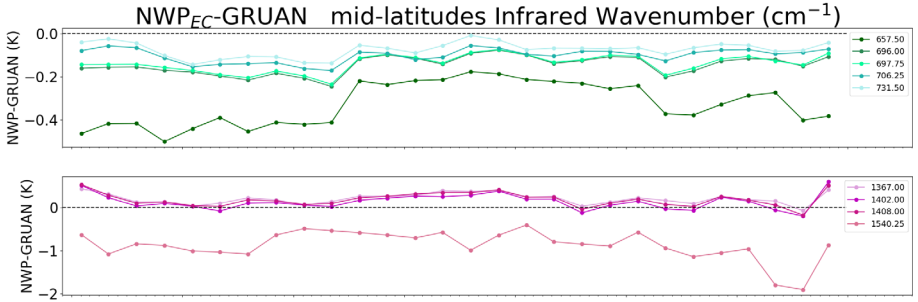
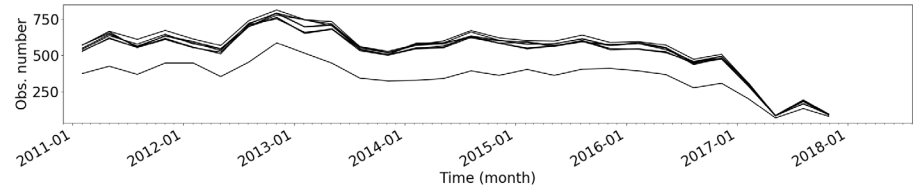
Biases Time Series

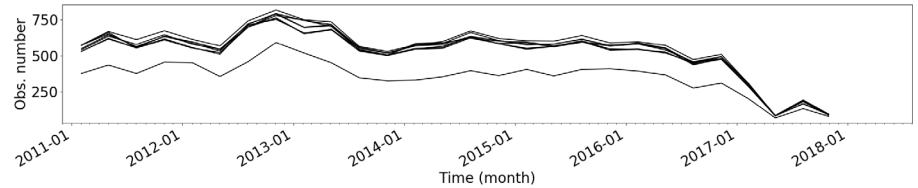




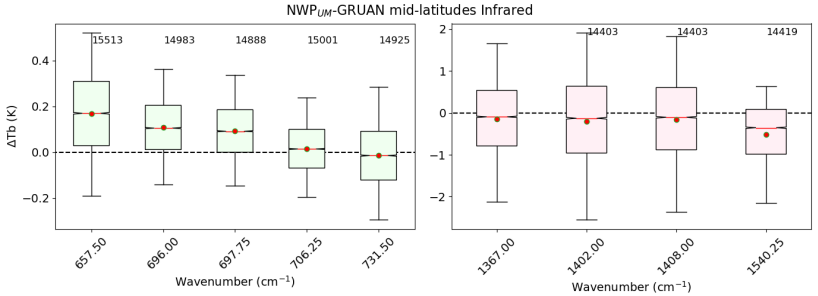
Met Office – Mid-Latitudes



ECMWF – Mid-Latitudes



Summary tables



Met Office – Mid-Latitudes

Wavenumber	Instrument	Matchups	Q1	Median	Q3	Mean	StDv	Kurtosis	Skew	Uncertainty	Success rate (%)
657.50	IASI (51)	15513	0.03	0.17	0.31	0.17	0.22	2.04	-0.18	0.09	49.47
696.00	IASI (205)	14983	0.01	0.11	0.20	0.11	0.16	1.32	-0.04	0.08	53.40
697.75	IASI (212)	14888	-0.00	0.09	0.19	0.09	0.15	1.44	-0.06	0.08	56.71
706.25	IASI (246)	15001	-0.07	0.01	0.10	0.02	0.14	2.00	-0.02	0.08	54.33
731.00	IASI (345)	14363	-0.47	-0.09	0.27	-0.11	0.67	5.42	-0.29	1.27	85.50
731.50	IASI (347)	14925	-0.12	-0.05	0.09	-0.01	0.19	4.27	-0.08	0.20	97.47
1361.9	HIRS (11)	14334	-0.78	-0.15	0.43	-0.20	1.08	4.97	-0.48	2.27	96.35
1367.00	IASI (2889)	14403	-0.79	-0.09	0.54	-0.15	1.24	4.67	-0.27	1.91	81.48
1402.00	IASI (3029)	14403	-0.96	-0.13	0.64	-0.20	1.46	4.63	-0.40	2.97	64.53
1408.00	IASI (3053)	14419	-0.88	-0.11	0.61	-0.17	1.37	4.44	-0.33	2.49	64.67
1540.25	IASI (3582)	9901	-0.99	-0.36	0.09	-0.51	0.91	3.03	-0.95	3.21	73.23
1556.25	CrIS (991)	11973	-1.44	-0.48	0.36	-0.66	1.66	8.00	-1.22	7.21	66.46

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Potential outcomes

- Better understanding of geographical & temporal distribution of model biases.
- More robust NWP-based satellite assessment.
- Refine model covariance uncertainties.
- Improve bias corrections.

Caveat

It ignores the (unknown) uncertainty due to the scale mismatch between coarse model resolution and fine radiosonde measurements. It is expected to be more significant for humidity than temperature as it varies at scales generally smaller than global model resolutions.

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Part 2: Microwave

Poster 11p.01

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References

Carminati, F., Migliorini, S., Ingleby, B., Bell, W., Lawrence, H., Newman, S., Hocking, J., and Smith, A.: Using reference radiosondes to characterise NWP model uncertainty for improved satellite calibration and validation, Atmos. Meas. Tech., 12, 83–106, https://doi.org/10.5194/amt-12-83-2019, 2019.

Dirksen, R. J., Sommer, M., Immler, F. J., Hurst, D. F., Kivi, R., andVömel, H.: Reference quality upper-air measurements: GRUAN data processing for the Vaisala RS92 radiosonde, Atmos. Meas.Tech., 7, 4463–4490, https://doi.org/10.5194/amt-7-4463-2014, 2014.

Immler, F. J., Dykema, J., Gardiner, T., Whiteman, D. N., Thorne, P.W., and Vömel, H.: Reference Quality Upper-Air Measurements: guidance for developing GRUAN data products, Atmos. Meas. Tech., 3, 1217–1231, https://doi.org/10.5194/amt-3-1217-2010, 2010.

Questions ?

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