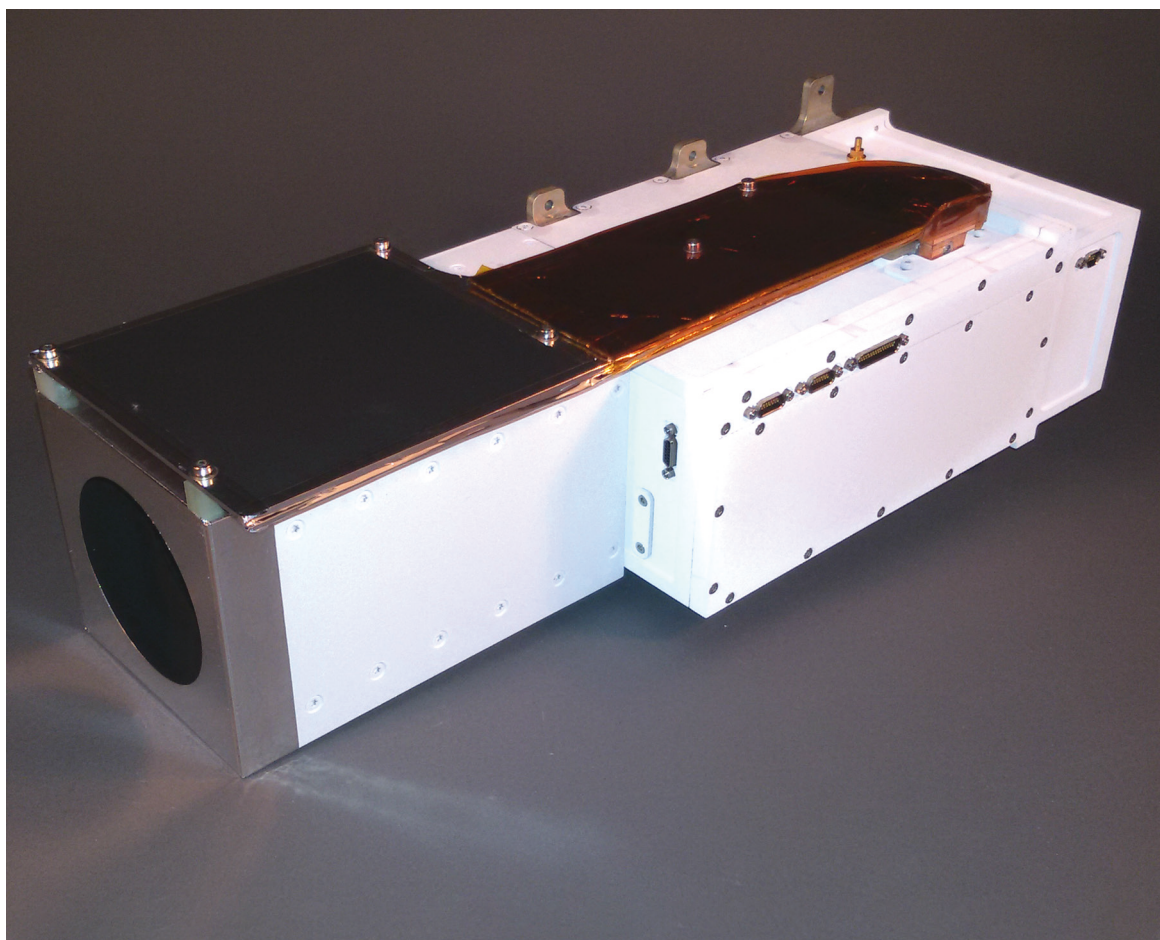




Study on a miniaturized satellite payload for atmospheric temperature measurements

Jilin Liu

Energie & Umwelt / Energy & Environment

Band / Volume 468

ISBN 978-3-95806-415-7

Forschungszentrum Jülich GmbH
Institut für Energie- und Klimaforschung
Stratosphäre (IEK-7)

Study on a miniaturized satellite payload for atmospheric temperature measurements

Jilin Liu

Schriften des Forschungszentrums Jülich
Reihe Energie & Umwelt / Energy & Environment

Band / Volume 468

ISSN 1866-1793

ISBN 978-3-95806-415-7

Contents

1	Introduction	1
1.1	Research background	1
1.1.1	Atmospheric structure	1
1.1.2	Remote sensing of the Earth atmosphere	3
1.2	Instrument introduction	6
1.2.1	AtmoSHINE for mesospheric temperature measurements	6
1.2.2	SHS technology	9
1.2.3	Data processing	14
2	Detector characterization	17
2.1	CMOS and CCD detectors	17
2.2	Electronic and detector configuration	18
2.3	Detector performance tests	20
2.3.1	Detector dark current	20
2.3.2	System gain and readout noise	22
2.3.3	Detector fixed pattern	23
2.4	Radiation test	26
2.4.1	Radiation environment modeling	26
2.4.2	Radiation test	27
3	Distortion correction	33
3.1	Optical distortion	33
3.2	Distortion characterization	35

3.2.1	Model based distortion correction	35
3.2.2	Distortion model comparison	37
3.3	Interferogram distortion correction	39
3.4	Results and analysis	42
3.4.1	Spatial information	42
3.4.2	Phase and spectral information	47
4	Spectrum analysis	53
4.1	Fourier analysis and apodization	53
4.2	Line spectra estimation	58
4.2.1	Multiple signal classification (MUSIC)	60
4.2.2	Estimating signal parameters via rotational invariance techniques (ESPRIT)	61
4.3	Numerical examples	63
4.3.1	Single component scenario	63
4.3.2	Multiple components scenario	66
4.3.3	O ₂ A-band simulation	70
5	Instrument characterization and calibration	75
5.1	Radiometric characterization	76
5.2	Interferogram generation using the calibration unit	78
5.3	Distortion correction	82
5.4	Instrument line shape	86
5.5	Ghost lines correction	90
5.6	Littrow calibration	90
5.7	Visibility calibration	93
5.8	Uncertainty estimation	97
5.8.1	SNR estimation	98
5.8.2	Calibration uncertainty	100
6	In orbit verification	105
6.1	AtmoSHINE onboard the satellite	105
6.1.1	Mission introduction	105
6.1.2	Satellite launch and the first light	107
6.2	Data analysis	109

CONTENTS

6.2.1	Dark current	109
6.2.2	Radiometric calibration	111
6.2.3	Spectral analysis	114
6.2.4	SNR analysis	116
6.2.5	Limb radiance intercomparison	118
6.2.6	Temperature retrieval	119
7	Summary and outlook	125
7.1	Summary	125
7.2	Outlook	127
A	Appendix	128
A.1	Amplitude estimation	128
A.2	O2A-band emission lines inside the filter range	130
A.3	Global coverage	131
A.4	Filter characterization	134
A.5	Composed spectrum with ACU	136
	Acknowledgements	142
	bibliography	153

Energie & Umwelt / Energy & Environment
Band / Volume 468
ISBN 978-3-95806-415-7