HiRDLS

TC-OXF-16

HIGH RESOLUTION DYNAMICS LIMB SOUNDER

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Subject/title:Signal to Noise calculations

This Document describes, in brief, calculations of signal to noise ratio for the HiRDLS radiometer. The channel designations used are those described by JJB 6 March 1990.

Key words:Signal, noise, detectors, radiometer

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Signal to Noise Ratio is defined as the ratio of the output of the radiometer obtained when viewing a target of known emission (usually a black body of known temperature) minus the zero offset, to the root mean square noise output of the radiometer, integrated over the sampling period, when there is no irradiance entering it. This output is therefore generated by the instrument itself.

In the HiRDLS problem we consider the electronics to contribute no noise to the system. The noise sources are detector generated noise and rms of the background thermal emission from the warm optics in the instrument.

The noise equivalent radiance is defined as the amount of irradiance into the instrument from an emitting target that is required to produce an output equal to the noise output of the instrument. It is therfore the signal required to make the SNR equal to unity.

The relevant components of the radiometer are schematically represented in figure 1. Optic elements beyond the chopper are not considered since these have insignificant contribution to the signal. The detector noise sources, including thermal gerneration, are implied in the D-star values, which have been supplied by LORAL EOD.

The input data used in the SNR calculations is shown in figure 2. The transmissions for the Germanium and the Zinc Selenide lenses are calculated using data on absorption coefficients and assuming an optical path of 3mm in each lens. An anti-reflection coating with a constant reflection of 5% over the spectral interval is assumed. The filters are assumed to all have an in-band transmission of 70% . At the time of these calculations the band passes for channels 3 and 20 were TBD. Detectors and filters are at a temperature of 80 K and the remaining optics at 292 K.

The background SNR is evaluated as the ratio of the number of photons falling on the detector from a black body of temperatures 160, 200, 240 K integrated over the 0.25 second sampling period to the square root of the number of photons from the optics.

The detector SNR is evaluated as the ratio of the power in watts falling on the detector from the black body target to the Noise Eqiuvalent Power of the detectors in Watts over the same integration period.

The net SNR is then the reciprocal vector sum of the component SNRs. The Noise Equivalent Radiance is evaluated simply as the Planck function divided by the SNR for the appropriate target temperature.

The typical optical efficiency, for channels 9 to 19, is 0.63. The worst case is channel 1 for which the optical efficiency is 0.35. A chopping factor of root(2)/pi, 0.45, is used.

The calculated SNR for the three target temperatures are shown in figure 3. It is worth noting that all channels are detector limited.

HiRDLS SNR.DAT CLH March 1990 (Provisional Channels, JJB 6-Mar-1990)
3 160 200 240 TARGET TEMPERATURES

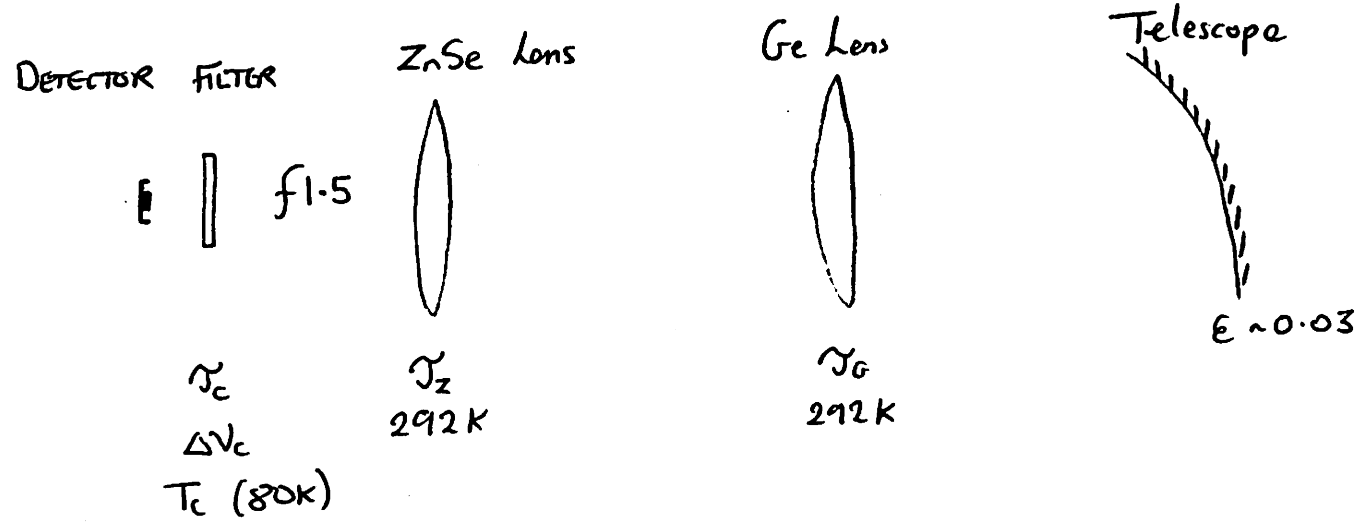
(mm^2)
80 0.07225 0.349 0.25 0.7 DETECTOR TEMP, AREA, SOLID ANGLE, INTEGRATION TIME, QUANTUM EFFICIENCY

'CH1'	80.0	567.0	580.0	573.5	13.0	0.70	292	0.62	0.81	2	3.3e10
'CH2'	80.0	600.0	613.0	606.5	13.0	0.70	292	0.82	0.86	2	3.9e10
'CH3'	80.0	606.1	719.4	662.8	113.4	0.70	292	0.92	0.92	2	3.7e10
'CH4'	80.0	635.0	655.0	645.0	20.0	0.70	292	0.78	0.90	2	5.6e10
'CH5'	80.0	630.0	710.0	670.0	80.0	0.70	292	0.84	0.92	2	5.5e10
'CH6'	80.0	827.0	836.0	831.5	9.0	0.70	292	0.89	0.95	2	13.1e10
'CH7'	80.0	842.0	851.0	846.5	9.0	0.70	292	0.89	0.95	2	17.1e10
'CH8'	80.0	870.0	900.0	885.0	30.0	0.70	292	0.93	0.95	2	23.0e10
'CH9'	80.0	920.0	933.0	926.5	13.0	0.70	292	0.95	0.95	2	23.9e10
'CH10'	80.0	990.0	1010.	1000.	20.0	0.70	292	0.94	0.95	2	25.6e10
'CH11'	80.0	1010.	1070.	1040.	60.0	0.70	292	0.94	0.95	2	25.6e10
'CH12'	80.0	1200.	1210.	1205.	10.0	0.70	292	0.94	0.95	2	26.0e10
'CH13'	80.0	1235.	1255.	1245.	20.0	0.70	292	0.94	0.94	2	26.0e10
'CH14'	80.0	1265.	1285.	1275.	20.0	0.70	292	0.95	0.95	2	25.7e10
'CH15'	80.0	1330.	1348.	1339.	18.0	0.70	292	0.95	0.95	2	24.2e10
'CH16'	80.0	1385.	1400.	1393.	15.0	0.70	292	0.95	0.95	2	23.9e10
'CH17'	80.0	1402.	1416.	1409.	14.0	0.70	292	0.95	0.95	2	23.7e10
'CH18'	80.0	1505.	1580.	1542.	75.0	0.70	292	0.95	0.95	2	22.9e10
'CH19'	80.0	1598.	1615.	1606.	17.0	0.70	292	0.94	0.94	2	21.2e10
	T_c	ν_1	ν_2	$\bar{\nu}$	$\Delta\nu$	τ_c	T_W	τ_Z	τ_G		D^*
	K	$\underbrace{\quad}_{cm^{-1}}$			cm^{-1}		K				$cm\ Hz^{1/2}\ W^{-1}$

FIG 2.

INPUT DATA FOR SNR CALCULATIONS

FIG 1. SCHEMATIC OF OPTICS ARRANGEMENT USED IN SNR MODEL.



RADIATION TERMS:

EMISSION FROM COLD SHIELD + EMISSION FROM ZnSe LENS + EMISSION FROM Ge LENS + EMISSION FROM TELESCOPE + ATMOSPHERIC EMISSION.

τ_c = transmission of filter (0.70)
τ_z : transmission of ZnSe Lens (variable)
τ_G = transmission of Ge Lens (variable)
$\Delta\nu_c$ = filter bandpass.

	ν_1 (cm^{-1})	ν_2 (cm^{-1})	λ_1 (μm)	λ_2 (μm)	$\Delta\nu$ (cm^{-1})	τ_c	τ_2	τ_c		D^* (cmHz$^{1/2}$W^{-1})	NEN (Wcm^{-2} sr^{-1}(cm^{-1})$^{-1}$)		Background SNR	Detector SNR	SNR 160	SNR 200	SNR 240 K
CH1	567.	580.	17.64	17.24	13.	0.70	0.62	0.81	PC	3.3E+10*****	3.13E-5	*******	83611.	2380.	415.	1177.	2379.
CH2	600.	613.	16.67	16.31	13.	0.70	0.82	0.86	PC	3.9E+10*****	1.89E-5	*******	143287.	3810.	605.	1815.	3809.
CH3	606.	719.	16.50	13.90	113.	0.70	0.92	0.92	PC	3.7E+10*****	1.90E-6	*******	629931.	34973.	4712.	15611.	34919.
CH4	635.	655.	15.75	15.27	20.	0.70	0.78	0.90	PC	5.6E+10*****	8.60E-6	*******	163821.	7956.	1129.	3626.	7947.
CH5	630.	710.	15.87	14.08	80.	0.70	0.84	0.92	PC	5.5E+10*****	1.99E-6	*******	392771.	33101.	4358.	14624.	32984.
CH6	827.	836.	12.09	11.96	9.	0.70	0.89	0.95	PC	1.3E+11*****	6.78E-6	*******	123096.	6965.	572.	2555.	6954.
CH7	842.	851.	11.88	11.75	9.	0.70	0.89	0.95	PC	1.7E+11*****	5.20E-6	*******	118875.	8763.	687.	3155.	8739.
CH8	870.	900.	11.49	11.11	30.	0.70	0.93	0.95	PC	2.3E+11*****	1.12E-6	*******	238396.	37198.	2578.	12679.	36753.
CH9	920.	933.	10.87	10.72	13.	0.70	0.95	0.95	PC	2.4E+11*****	2.42E-6	*******	158492.	15291.	944.	4999.	15221.
CH10	990.	1010.	10.10	9.90	20.	0.70	0.94	0.95	PC	2.6E+11*****	1.49E-6	*******	154680.	20151.	995.	6015.	19982.
CH11	1010.	1070.	9.90	9.35	60.	0.70	0.94	0.95	PC	2.6E+11*****	5.04E-7	*******	241975.	53474.	2308.	14986.	52214.
CH12	1200.	1210.	8.33	8.26	10.	0.70	0.94	0.95	PC	2.6E+11*****	2.92E-6	*******	63951.	5230.	141.	1229.	5213.
CH13	1235.	1255.	8.10	7.97	20.	0.70	0.94	0.94	PC	2.6E+11*****	1.48E-6	*******	76977.	8980.	214.	2004.	8919.
CH14	1265.	1285.	7.91	7.78	20.	0.70	0.95	0.95	PC	2.6E+11*****	1.46E-6	*******	79138.	8134.	177.	1754.	8091.
CH15	1330.	1348.	7.52	7.42	18.	0.70	0.95	0.95	PC	2.4E+11*****	1.72E-6	*******	62904.	5439.	98.	1088.	5419.
CH16	1385.	1400.	7.22	7.14	15.	0.70	0.95	0.95	PC	2.4E+11*****	2.09E-6	*******	49372.	3646.	56.	684.	3636.
CH17	1402.	1416.	7.13	7.06	14.	0.70	0.95	0.95	PC	2.4E+11*****	2.26E-6	*******	45596.	3173.	46.	584.	3165.
CH18	1505.	1580.	6.64	6.33	75.	0.70	0.95	0.95	PC	2.3E+11*****	4.39E-7	*******	72221.	9698.	95.	1513.	9612.
CH19	1598.	1615.	6.26	6.19	17.	0.70	0.94	0.94	PC	2.1E+11*****	2.12E-6	*******	25599.	1534.	12.	223.	1531.

FIG 3

SNR output