TC–NCA–33

HIRDLS

HIGH RESOLUTION DYNAMICS LIMB SOUNDER

Originator: John C. Gille Date: 14 July 1994

Subject / Title: IRD Flowdown and SRD Compliance Matrices

Contents / Description / Summary:

This document consists of two cross-reference matrices that show the relationships between the requirements in the Instrument Requirements Document (IRD) and the requirements in the Science Requirements Document (SRD). The first matrix, called the IRD Flowdown, relates each IRD requirement to the SRD requirement(s) from which it is deduced. The column labeled "IRD Requirement Type" indicates whether the IRD requirement flows directly from the SRD and is merely restated, or whether it is derived by some process of analysis and/or judgment. The second matrix, called the SRD Compliance, demonstrates that every SRD requirement flows down to at least one IRD requirement; hence, the second matrix is essentially the inverse of the first matrix.

Key Words: IRD flowdown, SRD compliance, cross-reference matrix

Purpose (20 characters maximum): relate IRD and SRD

Approved / Reviewed By:

Date (yy–mm–dd):

National Center for Atmospheric Research
Atmospheric Chemistry Division
P.O. Box 3000
Boulder, Colorado 80307–3000
United States of America

EOS

SRD Compliance

SRD Section	SRD Requirement Description	IRD Section	IRD Section Heading	IRD Requirement Description	IRD Requirement	Comments
1	—	—	—	—	—	This SRD section contains no requirements.
1.1	—	—	—	—	—	This SRD section contains no requirements.
2	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.
3	—	—	—	—	—	This SRD section is only a heading.
3.1	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.
3.2	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.
3.3	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.
3.4	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.
3.5	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.
4	—	—	—	—	—	This SRD section is only a heading.
4.1	Observe the same region of the atmosphere on successive	2.2.5	Orbital Period Mode	Observe the same atmospheric location from	Direct	
4.1	Horizontal resolution as fine as 100 km	2.2.4	High Resolution Mode	Resolution of 1° in both longitude and latitude, within	Direct	
4.1	Vertical resolution of 1 km	2.5.8 2.5.10.1	Radiometric Noise Radiometric Sampling Rate Spatial Resolution	Radiometric noise for channels 2–5 in Table 3 Radiance measurements five times per FOV	Derived Derived Derived	Retrieval simulations were used to confirm the sufficiency of these noise levels. This enables the 1-km vertical resolution.
4.1	Vertical resolution of 1 km	2.5.10.1 2.5.10.2	and Noise Rejection Digital Filter Filter Characteristic Knowledge	Detailed specification of the spatial signal and noise rejection characteristics (see the IRD) Programmable digital filter for	Derived Derived Derived	This preserves the amplitudes of the required Fourier components. The sensitivity to drifts can be minimized.
4.1	Vertical resolution of 1 km	2.6.1 2.6.1 2.6.1	Field of View Field of View Field of View	Vertical response function FWHM of 1 km Acceptable FWHM range of 0.9–1.05 km	Direct Derived Derived	This SRD requirement is also in SRD § 9.2 and Tables 1 and 2. Based on calculations, this is consistent with a 1-km vertical resolution.

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SRD Section	SRD Requirement Description	IRD Section	IRD Section Heading	IRD Requirement Description	IRD Requirement	Comments
4.1	Vertical resolution of 1 km	2.6.1 2.6.1	Field of View Field of View	FWHM of the horizontal FOV < 72 km At nonzero azimuth angles, the vertical response must not	Derived Derived	The horizon curvature makes a wider FOV inconsistent with a 1-km vertical resolution. The broadening that results from image
4.2	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.
4.3	High vertical resolution	2.2.6	Gravity Wave Mode	Highest vertical resolution, by scanning at the slowest rate	Direct	
4.4	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.
5	Data set that is based on measurements over	2.3.2	Reliability	Operate within specifications during five years in orbit (with	Direct	The probability of proper operation and contamination
6	—	—	—	—	—	This SRD section is only a heading.
6.1	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.
6.2	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.
6.3	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.
7	—	—	—	—	—	This SRD section is only a heading.
7.1	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.
7.2	Combine HIRDLS data with AIRS/AMSU data	2.5.11	Radiometric Intercalibration	Possible to compare the calibration with that of other	Direct	This is also a general EOS requirement.
8	—	—	—	—	—	This SRD section is only a heading.
8.1	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.
8.2	Combine HIRDLS data with MOPITT data	2.5.11	Radiometric Intercalibration	Possible to compare the calibration with that of other	Direct	This is also a general EOS requirement.
9	—	—	—	—	—	This SRD section is only a heading.
9.1	Measurements that extend down to an altitude of 8 km or less	2.7.1	Altitude Scan Range	Lower limit of 8 km for the atmospheric sounding range of all spectral channels	Direct	
9.1	Detect the presence and properties of aerosols	2.4.1	Spectral Response	Response for channels 1, 6, 13, and 19 in Table 1 (regions	Derived	Retrieval simulations and spectral modeling were used
9.2	High vertical resolution	1.2	Necessity of Infrared Limb	High vertical resolution	Direct	This is one of the motivations for the choice

SRD Compliance

SRD Section	SRD Requirement Description	IRD Section	IRD Section Heading	IRD Requirement Description	IRD Requirement	Comments
9.2	Horizontal resolution of 4°	2.8.2.1	Global Mode Azimuth Step Size Flexibility	Perform limb scans on a nominal global grid of 4° longitude by 4° latitude Possible to vary the azimuth step size with latitude	Direct Derived	This SRD requirement is also in SRD Tables 1 and 2.
9.2	Horizontal resolution of 400 km	2.2.2	Alternative Global Mode	Perform limb scans on a nominal global grid	Direct	
9.2	Vertical resolution of 1 km	2.5.8 2.5.10.1	Radiometric Noise Radiometric Sampling Rate Spatial Resolution and Noise Rejection	Radiometric noise for channels 2–5 in Table 3 Radiance measurements five times per FOV	Derived Derived Derived	Retrieval simulations were used to confirm the sufficiency of these noise levels. This enables the 1-km vertical resolution.
9.2	Vertical resolution of 1 km	2.5.10.1 2.5.10.2	Digital Filter Filter Characteristic Knowledge	Detailed specification of the spatial signal and noise rejection characteristics (see the IRD) Programmable digital filter for	Derived Derived Derived	This preserves the amplitudes of the required Fourier components. The sensitivity to drifts can be minimized
9.2	Vertical resolution of 1 km	2.6.1 2.6.1 2.6.1	Field of View Field of View Field of View	Vertical response function FWHM of 1 km Acceptable FWHM range of 0.9–1.05 km	Direct Derived Derived	This SRD requirement is also in SRD § 4.1 and Tables 1 and 2. Based on calculations, this is consistent with a 1-km vertical resolution.
9.2	Vertical resolution of 1 km	2.6.1 2.6.1	Field of View Field of View	FWHM of the horizontal FOV < 72 km At nonzero azimuth angles, the vertical response must not	Derived Derived	The horizon curvature makes a wider FOV inconsistent with a 1-km vertical resolution. The broadening that results from image
9.2	Radiance measurements at 0.2-km intervals	2.5.8	Radiometric Sampling Rate	Radiance measurements five times per FOV	Derived	This enables the 1-km vertical resolution.
9.2	Programmable, for specific process studies	2.2	Scientific Operational Mode	Choice of operational modes for collecting scientific data	Direct	
9.2	Programmable, for specific process studies	2.5.10.2 2.7.2.1 2.7.2.	Digital Filter Altitude Scan Rate Flexibility Altitude Scan Range Flexibility	Programmable digital filter for each channel Altitude angle scan rates of 0.1–1.0°/s Uniform scan rate over ranges	Derived Derived Derived Derived	Each scientific mode can be optimized in orbit. This allows for a flexible
9.2	Programmable, for specific process studies	2.8.2.1 2.8.2.2	Azimuth Step Size Flexibility Azimuth Scan Range Flexibility	Possible to vary the azimuth step size with latitude (especially to allow for coverage of the entire surface of the earth in the global mode)	Derived Derived	

SRD Compliance

SRD Section	SRD Requirement Description	IRD Section	IRD Section Heading	IRD Requirement Description	IRD Requirement	Comments
9.2	Programmable, for specific process studies	2.9.1 2.9.2 2.9.3 2.9.4 2.9.6 2.9.7	Instrument Microprocessor Door/Sunshade Control Altitude Scan Control	IMP that can be programmed from the ground IMP controls the door/sunshade IMP controls the altitude scan parameters	Direct Derived Derived Derived Derived Derived	The scans can be varied as desired.
9.3	Accurate self-calibration in space	2.5.2	In-Flight Radiometric	View space and a known-temperature IFC blackbody	Derived	This is required for accurate temperature and constituent
9.4	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.
10	Measure the temperature and the concentration of O3, H2O, CH4, N2O, NO2, HNO3, N2O5, ClONO2, CFC 11, CFC	1.2	Necessity of Infrared Limb Scanning	Measurements of the temperature and a large number of trace species	Direct	This is one of the motivations for the choice of IR limb-scanning emission observations.
10	Measure the temperature (Tables 1 and 2)	2.4.1	Spectral Response	Response for channels 2–5 in Table 1	Derived	Gille, J. C., and House, F. B. 1971, J. Atmos. Sci., vol. 28,
10	Temperature measurement precision of 0.3 K below 50 km, and 1 K above 50 km (Table 1)	2.5.3 2.5.4 2.5.5	Radiometric Noise Radiometric Digitization Error Radiometric	Radiometric noise for channels 2–5 in Table 3 RMS digitization error ≤ 50% of the specified radiometric noise	Derived Derived Derived	Retrieval simulations were used to confirm the sufficiency of these noise levels. The radiometric digitization error is a small portion of the total measurement error.
10	Temperature measurement precision of 0.3 K below 50 km, and 1 K above 50 km (Table 1)	2.7.1 2.7.5.1 2.10.	Altitude Scan Range Relative Altitude Angle Knowledge within a Scan	View 10 km above the minimum space view tangent heights in Table 2 Random relative altitude angle knowledge error ≤ 1 arcsecond (0.7-	Derived Derived Derived	In the global mode, this yields 50 samples for the determination of the radiometric zero. This is based on retrieval simulations, with
10	Temperature measurement accuracy of 1 K below 50 km, and 2 K above 50 km (Table 1)	2.4.5.2 2.5.9	Spacecraft Attitude Stability Columns of the Focal Plane Array Radiometric	Motion of the S/C around the pitch and roll axes ≤ 1 arcsecond / s Detailed specification of the important coupled groups of channels (see the IRD)	Derived Derived Derived	The horizontal geopotential height gradient cannot be measured without the gyroscope. This increases the accuracy by reducing the error that
10	Temperature measurement accuracy of 1 K below 50 km, and 2 K above 50 km (Table 1)	2.4.4 2.5.1 2.6.2	Out-of-Band Response Knowledge Radiometric	Out-of-band radiance knowledge error ≤ 0.5% of the in-band radiance Radiance knowledge error ≤	Derived Derived Derived	LIMS validation papers, 1984; judgment
10	Temperature measurement accuracy of 1 K below 50 km, and 2 K above 50 km (Table 1)	2.6.3.1 2.6.3.	Vertical Spatial Response Knowledge for a Channel	Relative VSR knowledge error ≤ 1%, between the 1% points Relative VSR knowledge error	Derived Derived	LIMS validation papers, 1984; judgment

SRD Compliance

SRD Section	SRD Requirement Description	IRD Section	IRD Section Heading	IRD Requirement Description	IRD Requirement	Comments
10	Temperature measurement accuracy of 1 K below 50 km, and 2 K above 50 km (Table 1)	2.6.3.2 2.7.1 2.7.5.	Vertical Spatial Response Knowledge for a Channel Pair Altitude Scan Range	Relative altitude angle knowledge error ≤ 4 arcseconds (2-arcsecond goal) View 10 km above the minimum space view tangent	Derived Derived Derived	A 4-arcsecond angle corresponds to a 0.5% change of the radiance in channel 2 at 40 km. In the global mode, this yields 50 samples for the
10	Measure the concentration of O3, H2O, CH4, N2O, NO2, HNO3, N2O5, ClONO2, CFC	2.4.1	Spectral Response	Response for channels 1, 7–9, 11, 14–17, 20, and 21 in Table 1 (one	Derived	Retrieval simulations were used to study the characteristics of these
10	Measure the concentration of O3 and H2O in the upper troposphere (Table 2)	2.4.1	Spectral Response	Response for channels 10, 12, and 18 in Table 1 (additional low opacity	Derived	Retrieval simulations were used to study the characteristics of these
10	Measure the aerosol concentration	2.4.1	Spectral Response	Response for channels 1, 6, 13, and 19 in Table 1 (regions	Derived	Retrieval simulations and spectral modeling were used
10	Constituent concentration measurement precision of 1–5% (Table 1)	2.5.3 2.5.4 2.5.5	Radiometric Noise Radiometric Digitization Error Radiometric	Radiometric noise for channels 1 and 6–21 in Table 3 RMS digitization error ≤ 50% of the specified radiometric noise	Derived Derived Derived	Retrieval simulations were used to confirm the sufficiency of these noise levels. The radiometric digitization error is a small portion of the total measurement error.
10	Constituent concentration measurement precision of 1–5% (Table 1)	2.7.1 2.7.5.1 2.10.	Altitude Scan Range Relative Altitude Angle Knowledge within a Scan	View 10 km above the minimum space view tangent heights in Table 2 Random relative altitude angle knowledge error ≤ 1 arcsecond (0.7-	Derived Derived Derived	In the global mode, this yields 50 samples for the determination of the radiometric zero. This is based on retrieval simulations, with
10	Constituent concentration measurement accuracy of 5–10% (Table 1)	2.4.5.2 2.5.9	Spacecraft Attitude Stability Columns of the Focal Plane Array Radiometric	Motion of the S/C around the pitch and roll axes ≤ 1 arcsecond / s Detailed specification of the important coupled groups of channels (see the IRD)	Derived Derived Derived	The horizontal geopotential height gradient cannot be measured without the gyroscope. This increases the accuracy by reducing the error that
10	Constituent concentration measurement accuracy of 5–10% (Table 1)	2.4.4 2.5.1 2.6.2	Out-of-Band Response Knowledge Radiometric	Out-of-band radiance knowledge error ≤ 0.5% of the in-band radiance Radiance knowledge error ≤	Derived Derived Derived	LIMS validation papers, 1984; judgment
10	Constituent concentration measurement accuracy of 5–10% (Table 1)	2.6.3.1 2.6.3.	Vertical Spatial Response Knowledge for a Channel	Relative VSR knowledge error ≤ 1%, between the 1% points Relative VSR knowledge error	Derived Derived	LIMS validation papers, 1984; judgment
10	Constituent concentration measurement accuracy of 5–10% (Table 1)	2.6.3.2 2.7.1 2.7.5.	Vertical Spatial Response Knowledge for a Channel Pair Altitude Scan Range	Relative altitude angle knowledge error ≤ 4 arcseconds (2-arcsecond goal) View 10 km above the minimum space view tangent	Derived Derived Derived	A 4-arcsecond angle corresponds to a 0.5% change of the radiance in channel 2 at 40 km. In the global mode, this yields 50 samples for the

SRD Compliance

SRD Section	SRD Requirement Description	IRD Section	IRD Section Heading	IRD Requirement Description	IRD Requirement	Comments
10	Horizontal geopotential height gradient measurement precision of 20 m / 500 km (vertical / horizontal) (Table 1)	2.1.3 2.1.3 2.1.3	Orbital Position Knowledge Orbital Position Knowledge	Change-of-orbital-position knowledge error ≤ 4 km, both along and across the orbital track Knowledge error for the relative distance from the	Derived Derived Derived	This is relevant to the along-track geopotential height
10	Horizontal geopotential height gradient measurement precision of 20 m / 500 km (vertical / horizontal) (Table 1)	2.7.5.2 2.8.3.	Relative Altitude Angle Knowledge between Scans Relative Azimuth	For adjacent altitude scans, relative altitude angle knowledge error ≤ 1.4 arcseconds	Derived Derived	1.4 arcseconds ≈ 20 m at the limb (3.5 to 7-m registration error is negligible when RSSd.)
10	Global horizontal coverage, 90° S to 90° N, including the polar night (Tables 1 and 2)	1.2 2.1.1 2.1.2 2.5.6	Necessity of Infrared Limb Scanning Platform Orbit Radiometric	Global coverage, day and night (including the polar night) Flown on an earth-oriented S/C with three-axis stabilization Sun-synchronous near-circular	Direct Derived Derived Derived	This is one of the motivations for the choice of IR limb-scanning emission observations. This is required for IR limb scanning. All locations must be seen by the scans.
10	Global horizontal coverage, 90° S to 90° N, including the polar night (Tables 1 and 2)	2.8.2.1	Azimuth Scan Range Azimuth Step Size Flexibility	Overlap scan tracks from the adjacent orbit Possible to vary the azimuth step size with latitude	Derived Derived	
10	Global horizontal coverage, 90° S to 90° N, including the polar night (Tables 1 and 2)	2.8.2.2	Azimuth Scan Range Flexibility	Possible to vary the azimuth scan range with latitude, along with the number and spacing of the altitude scans	Derived Derived	
10	Vertical coverage from the upper troposphere to the mesopause, 8–80 km (Tables 1 and 2)	2.4.1 2.7.1 2.8.4	Spectral Response Altitude Scan Range Scanner Azimuth	Response for channels 2, 3, 10, 12, and 18 (low altitude) and 1, 6, 13, and 19 (aerosol) Atmospheric sounding ranges in Table 2	Derived Derived Derived	This gives simultaneous channels for sounding low altitudes and correcting for aerosols. Calculation and simulation.
10	Horizontal resolution of 2° (or 200 km) in latitude and	2.2.3	Medium Resolution Mode	Resolution of 2° in both longitude and latitude, within	Direct	
10	Highest possible horizontal resolution, for altitudes below 30 km (Table 2)	2.7.2.1 2.7.2.2	Altitude Scan Rate Flexibility Altitude Scan Range Flexibility	Altitude angle scan rates of 0.1–1.0°/s Uniform scan rate over ranges of 5–140 km	Derived Derived Derived	The scan rate and range determine the scan frequency (ground track velocity ≈ 6.7 km/s).
10	Complete field in 12 h (Table 1)	2.1.2 2.1.2 2.8.1	Orbit Orbit Azimuth Scan	Sun-synchronous near-circular polar orbit Radiance measurements during both the northbound	Derived Derived Derived	Both poles must be seen by the scans.
11	Calculate the basic data products	2.10.1 2.10.4	Spacecraft and Orbital Data Engineering Data	Provide the scientific data to the S/C, for transmission to the ground Incorporate the time and other selected S/C data into the data stream	Derived Derived Derived	This is for convenience and the maintenance of the accuracy of the scientific data.

SRD Compliance

SRD Section	SRD Requirement Description	IRD Section	IRD Section Heading	IRD Requirement Description	IRD Requirement	Comments
12	—	—	—	—	—	The requirements are in SRD Tables 1 and 2.

IRD Flowdown

IRD Section	IRD Section Heading	IRD Requirement Description	IRD Requirement	SRD Section	SRD Requirement Description	Comments
1	Introduction	—	—	—	—	This IRD section is only a heading.
1.1	Purpose of This Document	—	—	—	—	This IRD section contains no requirements.
1.2	Necessity of Infrared Limb Scanning	Measurements of the temperature and a large number of trace species	Direct	10	Measure the temperature and the concentration of O3, H2O, CH4, N2O, NO2, HNO3, N2O5, ClONO2, CFC 11, CFC	This is one of the motivations for the choice of IR limb-scanning emission observations.
1.2	Necessity of Infrared Limb	Global coverage, day and night (including the polar	Direct	10	Global horizontal coverage, 90° S to 90° N, including the	This is one of the motivations for the choice
1.2	Necessity of Infrared Limb	High vertical resolution	Direct	9.2	High vertical resolution	This is one of the motivations for the choice
1.3	Baseline Configuration	—	—	—	—	This IRD section contains no requirements.
1.4	Principles of Infrared Limb	—	—	—	—	This IRD section contains no requirements.
1.5	Definitions	—	—	—	—	This IRD section contains no requirements.
1.6	Referenced Documents	—	—	—	—	This IRD section contains no requirements.
2	Instrument Requirements	—	—	—	—	This IRD section is only a heading.
2.1	Orbital Platform Requirements	—	—	—	—	This IRD section is only a heading.
2.1.1	Platform	Flown on an earth-oriented S/C with three-axis	Derived	10	Global horizontal coverage, 90° S to 90° N, including the	This is required for IR limb scanning.
2.1.2	Orbit	Sun-synchronous near-circular polar orbit	Derived	10 10	Global horizontal coverage, 90° S to 90° N, including the polar night (Tables 1 and 2)	Both poles must be seen by the scans.
2.1.2	Orbit	Daytime equator-crossing time within 4.5 h	—	—	No SRD requirement	This prevents excessive coverage of the terminator, but
2.1.2	Orbit	Radiance measurements during both the northbound	Derived	10	Complete field in 12 h (Table 1)	
2.1.2	Orbit	Acceptable mean orbital height of	—	—	No SRD requirement	Limb scanning is relatively insensitive to the mean orbital
2.1.2	Orbit	Variation of the orbital height above the geoid of at most ±	—	—	No SRD requirement	This reduces the allowable size of the
2.1.3	Orbital Position Knowledge	Change-of-orbital-position knowledge error ≤ 4 km, both along and across	Derived	10	Horizontal geopotential height gradient measurement precision of 20 m / 500 km	
2.1.3	Orbital Position Knowledge	Knowledge error for the relative distance from the center of the earth ≤ 5 m	Derived	10	Horizontal geopotential height gradient measurement precision of 20 m / 500 km	

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IRD Section	IRD Section Heading	IRD Requirement Description	IRD Requirement	SRD Section	SRD Requirement Description	Comments
2.1.3	Orbital Position Knowledge	Knowledge error for the orbital angular velocity of the S/C ≤ 0.25 arcseconds / min	Derived	10	Horizontal geopotential height gradient measurement precision of 20 m / 500 km	This is relevant to the along-track geopotential height gradient.
2.1.4	Spacecraft Attitude Stability	Motion of the S/C around the pitch and roll axes ≤ 1 arcsecond / s	Derived	10 10	Temperature measurement accuracy of 1 K below 50 km, and 2 K above 50 km (Table 1)	The horizontal geopotential height gradient cannot be measured without the gyroscope.
2.2	Scientific Operational Mode	Choice of operational modes for collecting scientific data	Direct	9.2	Programmable, for specific process studies	
2.2.1	Global Mode	Perform limb scans on a nominal global grid	Direct	9.2	Horizontal resolution of 4°	This SRD requirement is also in SRD Tables 1 and 2.
2.2.2	Alternative Global Mode	Perform limb scans on a nominal global grid	Direct	9.2	Horizontal resolution of 400 km	
2.2.3	Medium Resolution Mode	Resolution of 2° in both longitude and latitude, within	Direct	10	Horizontal resolution of 2° (or 200 km) in latitude and	
2.2.4	High Resolution Mode	Resolution of 1° in both longitude and latitude, within	Direct	4.1	Horizontal resolution as fine as 100 km	
2.2.5	Orbital Period Mode	Observe the same atmospheric location from	Direct	4.1	Observe the same region of the atmosphere on successive	
2.2.6	Gravity Wave Mode	Highest vertical resolution, by scanning at the slowest rate	Direct	4.3	High vertical resolution	
2.3	Lifetime Requirements	—	—	—	—	This IRD section is only a heading.
2.3.1	Moved to Section 2.3.2	—	—	—	—	
2.3.2	Reliability	Operate within specifications during five years in orbit (with	Direct	5	Data set that is based on measurements over	The probability of proper operation and contamination
2.4	Spectral Channel Requirements	—	—	—	—	This IRD section is only a heading.
2.4.1	Spectral Response	Response for channels 2–5 in Table 1	Derived	10	Measure the temperature (Tables 1 and 2)	Gille, J. C., and House, F. B. 1971, J. Atmos. Sci., vol. 28,
2.4.1	Spectral Response	Response for channels 1, 7–9, 11, 14–17, 20, and 21 in Table 1 (one	Derived	10	Measure the concentration of O3, H2O, CH4, N2O, NO2, HNO3, N2O5, ClONO2, CFC	Retrieval simulations were used to study the characteristics of these
2.4.1	Spectral Response	Response for channels 10, 12, and 18 in Table 1 (additional low opacity	Derived	10	Measure the concentration of O3 and H2O in the upper troposphere (Table 2)	Retrieval simulations were used to study the characteristics of these
2.4.1	Spectral Response	Response for channels 1, 6, 13, and 19 in Table 1 (regions of lowest gaseous opacity)	Derived	9.1 10	Detect the presence and properties of aerosols Measure the aerosol	Retrieval simulations and spectral modeling were used to study these channels.
2.4.1	Spectral Response	Response for channels 2, 3, 10, 12, and 18 (low altitude)	Derived	10	Vertical coverage from the upper troposphere to the	This gives simultaneous channels for sounding low
2.4.1	Spectral Response	Tolerances for the 50% response in Table 1	—	—	No SRD requirement	These are based on calculated spectra.

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IRD Section	IRD Section Heading	IRD Requirement Description	IRD Requirement	SRD Section	SRD Requirement Description	Comments
2.4.2	Spectral Response Knowledge	Relative spectral response knowledge error ≤ 1%,	—	—	No SRD requirement	LIMS validation papers, 1984; judgment
2.4.2	Spectral Response Knowledge	Relative spectral response knowledge error ≤ 100%,	—	—	No SRD requirement	The total integrated response below 1% is small compared
2.4.3	Out-of-Band Response	Out-of-band radiance ≤ 1% of the in-band radiance	—	—	No SRD requirement	This is consistent with IRD § 2.4.4, which
2.4.3	Out-of-Band Response	Out-of-band radiance ≤ 200% of the radiometric noise in	—	—	No SRD requirement	This is consistent with IRD § 2.4.4, which
2.4.3	Out-of-Band Response	When viewing the IFC blackbody, out-of-band	—	—	No SRD requirement	This is consistent with IRD § 2.4.4, which
2.4.4	Out-of-Band Response Knowledge	Out-of-band radiance knowledge error ≤ 0.5% of the in-band radiance	Derived	10 10	Temperature measurement accuracy of 1 K below 50 km, and 2 K above 50 km (Table 1)	LIMS validation papers, 1984; judgment
2.4.4	Out-of-Band Response	Out-of-band radiance knowledge error ≤ 100% of the	—	—	No SRD requirement	This allows the retrievals to be extended to higher altitudes.
2.4.5	Focal Plane Layout	—	—	—	—	This IRD section is only a heading.
2.4.5.1	Rows of the Focal Plane Array	Place low altitude channels in the lower rows and high	—	—	No SRD requirement	This minimizes the altitude scan range.
2.4.5.2	Columns of the Focal Plane Array	Detailed specification of the important coupled groups of channels (see the IRD)	Derived	10 10	Temperature measurement accuracy of 1 K below 50 km, and 2 K above 50 km (Table 1)	This increases the accuracy by reducing the error that results from interfering species.
2.5	Radiometric Requirements	—	—	—	—	This IRD section is only a heading.
2.5.1	Radiometric Accuracy	Radiance knowledge error ≤ 1% (0.5% goal)	Derived	10 10	Temperature measurement accuracy of 1 K below 50 km, and 2 K above 50 km (Table 1)	LIMS validation papers, 1984; judgment
2.5.1	Radiometric Accuracy	Radiance knowledge error ≤ 100% of the specified	—	—	No SRD requirement	This allows the retrievals to be extended to higher altitudes.
2.5.2	In-Flight Radiometric	View space and a known-temperature IFC blackbody	Derived	9.3	Accurate self-calibration in space	This is required for accurate temperature and constituent
2.5.3	Radiometric Noise	Radiometric noise for channels 2–5 in Table 3	Derived	4.1 9.2 10	Vertical resolution of 1 km Vertical resolution of 1 km Temperature measurement precision of 0.3 K below 50	This SRD requirement is also in SRD Tables 1 and 2. Retrieval simulations were used to confirm the sufficiency
2.5.3	Radiometric Noise	Radiometric noise for channels 1 and 6–21 in Table	Derived	10	Constituent concentration measurement precision of	Retrieval simulations were used to confirm the sufficiency
2.5.4	Radiometric Digitization Error	RMS digitization error ≤ 50% of the specified radiometric noise	Derived	10 10	Temperature measurement precision of 0.3 K below 50 km, and 1 K above 50 km (Table 1)	The radiometric digitization error is a small portion of the total measurement error.

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IRD Section	IRD Section Heading	IRD Requirement Description	IRD Requirement	SRD Section	SRD Requirement Description	Comments
2.5.5	Radiometric Digitization Step Size Uniformity	Radiometric signals that are digitized with a resolution of one part in 2^16	Derived	10 10	Temperature measurement precision of 0.3 K below 50 km, and 1 K above 50 km (Table 1)	This preserves the high S/N measurements.
2.5.5	Radiometric Digitization Step	Step size that is uniform to within one-half of	—	—	No SRD requirement	This allows the noise in the radiometric measurements to
2.5.6	Radiometric Dynamic Range	Measure radiances up to 1.25 times the max. expected	Derived	10	Global horizontal coverage, 90° S to 90° N, including the	This also allows for aging of the instrument components.
2.5.7	Moved to Section 2.6.2	—	—	—	—	
2.5.8	Radiometric Sampling Rate	Radiance measurements five times per FOV	Derived	4.1 9.2 9.2	Vertical resolution of 1 km Vertical resolution of 1 km Radiance measurements at	This SRD requirement is also in SRD Tables 1 and 2. This enables the 1-km vertical
2.5.9	Radiometric Sampling Uniformity	Variation of the spacing between the LOS positions of the radiance samples ≤ 25%	Derived	10 10	Temperature measurement accuracy of 1 K below 50 km, and 2 K above 50 km (Table 1)	Larger variations are difficult to handle in the data reduction.
2.5.10	Radiometric Signal Processing	—	—	—	—	This IRD section is only a heading.
2.5.10.1	Spatial Resolution and Noise Rejection	Signal-processing system must pass signals with spatial	Derived	4.1 9.2	Vertical resolution of 1 km Vertical resolution of 1 km	This passes the required Fourier components.
2.5.10.1	Spatial Resolution and Noise Rejection	Detailed specification of the spatial signal and noise	Derived	4.1 9.2	Vertical resolution of 1 km Vertical resolution of 1 km	This preserves the amplitudes of the required Fourier
2.5.10.2	Digital Filter	Programmable digital filter for each channel	Derived	4.1 9.2 9.2	Vertical resolution of 1 km Vertical resolution of 1 km Programmable, for specific	The sensitivity to drifts can be minimized. "
2.5.10.3	Filter Characteristic Knowledge	Filter characteristic knowledge error ≤ 0.01 dB	Derived	4.1 9.2	Vertical resolution of 1 km Vertical resolution of 1 km	This ensures the knowledge of the amplitudes
2.5.11	Radiometric Intercalibration	Possible to compare the calibration with that of other	Direct	7.2 8.2	Combine HIRDLS data with AIRS/AMSU data	This is also a general EOS requirement.
2.6	Optical Requirements	—	—	—	—	This IRD section is only a heading.
2.6.1	Field of View	Vertical response function FWHM of 1 km	Direct	4.1 9.2	Vertical resolution of 1 km Vertical resolution of 1 km	This SRD requirement is also in SRD Tables 1 and 2.
2.6.1	Field of View	Acceptable FWHM range of 0.9–1.05 km	Derived	4.1 9.2	Vertical resolution of 1 km Vertical resolution of 1 km	Based on calculations, this is consistent with
2.6.1	Field of View	Detailed specification of the integrated vertical response	Derived	4.1 9.2	Vertical resolution of 1 km Vertical resolution of 1 km	This is a testable requirement that meets the vertical
2.6.1	Field of View	FWHM of the horizontal FOV < 72 km	Derived	4.1 9.2	Vertical resolution of 1 km Vertical resolution of 1 km	The horizon curvature makes a wider FOV inconsistent with
2.6.1	Field of View	At nonzero azimuth angles, the vertical response must not broaden more than	Derived	4.1 9.2	Vertical resolution of 1 km Vertical resolution of 1 km	The broadening that results from image rotation is consistent with the

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IRD Section	IRD Section Heading	IRD Requirement Description	IRD Requirement	SRD Section	SRD Requirement Description	Comments
2.6.2	Out-of-Field Response	Out-of-field response ≤ 0.4% of the total	Derived	10 10	Temperature measurement accuracy of 1 K below 50 km, and 2 K above 50 km (Table 1)	LIMS validation papers, 1984; judgment
2.6.2	Out-of-Field Response	Out-of-field response ≤ 100% of the specified radiometric	—	—	No SRD requirement	This allows the retrievals to be extended to higher altitudes.
2.6.3	Vertical Spatial Response	—	—	—	—	This IRD section is only a heading.
2.6.3.1	Vertical Spatial Response Knowledge for a Channel	Relative VSR knowledge error ≤ 1%, between the 1% points	Derived	10 10	Temperature measurement accuracy of 1 K below 50 km, and 2 K above 50 km (Table 1)	LIMS validation papers, 1984; judgment
2.6.3.1	Vertical Spatial Response Knowledge for a Channel	Relative VSR knowledge error ≤ 100%, between the 0.2% and 1% points	Derived	10 10	Temperature measurement accuracy of 1 K below 50 km, and 2 K above 50 km (Table 1)	LIMS validation papers, 1984; judgment
2.6.3.2	Vertical Spatial Response Knowledge for a Channel Pair	Relative altitude angle knowledge error ≤ 4 arcseconds (2-arcsecond goal)	Derived	10 10	Temperature measurement accuracy of 1 K below 50 km, and 2 K above 50 km (Table 1)	A 4-arcsecond angle corresponds to a 0.5% change of the radiance in channel 2 at 40 km.
2.7	Altitude-Pointing and Scanning	—	—	—	—	This IRD section contains no requirements.
2.7.1	Altitude Scan Range	Lower limit of 8 km for the atmospheric sounding range of all spectral channels	Direct	9.1	Measurements that extend down to an altitude of 8 km or less	
2.7.1	Altitude Scan Range	Atmospheric sounding ranges in Table 2	Derived	10	Vertical coverage from the upper troposphere to the	Calculation and simulation, SP–HIR–90A
2.7.1	Altitude Scan Range	View 10 km above the minimum space view tangent heights in Table 2	Derived	10 10	Temperature measurement precision of 0.3 K below 50 km, and 1 K above 50 km (Table 1)	In the global mode, this yields 50 samples for the determination of the radiometric zero.
2.7.1	Altitude Scan Range	View 10 km above the minimum space view tangent heights in Table 2	Derived	10 10	Constituent concentration measurement precision of 1–5% (Table 1) Constituent concentration	In the global mode, this yields 50 samples for the determination of the radiometric zero.
2.7.2	Altitude Scan Flexibility	—	—	—	—	This IRD section is only a heading.
2.7.2.1	Altitude Scan Rate Flexibility	Altitude angle scan rates of 0.1–1.0°/s	Derived	9.2 10	Programmable, for specific process studies Highest possible horizontal	The scan rate and range determine the scan frequency
2.7.2.1	Altitude Scan Rate Flexibility	Altitude angle scan rate that is adjustable in increments ≤	—	—	No SRD requirement	
2.7.2.2	Altitude Scan Range Flexibility	Uniform scan rate over ranges of 5–140 km	Derived	9.2 10	Programmable, for specific process studies Highest possible horizontal	The scan rate and range determine the scan frequency

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IRD Section	IRD Section Heading	IRD Requirement Description	IRD Requirement	SRD Section	SRD Requirement Description	Comments
2.7.2.2	Altitude Scan Range Flexibility	Scan the atmospheric sounding range in four	Derived	9.2	Programmable, for specific process studies	This allows for a flexible response to geophysical
2.7.3	Altitude Scan Rate Uniformity	Altitude angle scan rate variation ≤ 5%	—	—	No SRD requirement	Judgment
2.7.4	Moved to Section 2.7.1	—	—	—	—	
2.7.5	Altitude Angle Knowledge	—	—	—	—	This IRD section contains no requirements.
2.7.5.1	Relative Altitude Angle Knowledge within a Scan	Systematic relative altitude angle knowledge error ≤ 0.25% of the angle, or 0.35 arcsecond	Derived	10 10	Temperature measurement accuracy of 1 K below 50 km, and 2 K above 50 km (Table 1)	This is based on retrieval simulations and hydrostatics.
2.7.5.1	Relative Altitude Angle Knowledge within a Scan	Random relative altitude angle knowledge error ≤ 1 arcsecond (0.7-arcsecond goal)	Derived	10 10	Temperature measurement precision of 0.3 K below 50 km, and 1 K above 50 km (Table 1)	This is based on retrieval simulations, with jitter noise roughly equal to radiometric noise.
2.7.5.2	Relative Altitude Angle Knowledge between Scans	For adjacent altitude scans, relative altitude angle knowledge error ≤ 1.4	Derived	10	Horizontal geopotential height gradient measurement precision of 20 m / 500 km	1.4 arcseconds ≈ 20 m at the limb (3.5 to 7-m registration error is negligible when
2.7.6	Moved to Section 2.7.5.2	—	—	—	—	
2.8	Azimuth-Pointing and Scanning	—	—	—	—	This IRD section contains no requirements.
2.8.1	Azimuth Scan Range	Overlap scan tracks from the adjacent orbit	Derived	10 10	Global horizontal coverage, 90° S to 90° N, including the polar night (Tables 1 and 2)	All locations must be seen by the scans.
2.8.2	Azimuth Scan Flexibility	—	—	—	—	This IRD section is only a heading.
2.8.2.1	Azimuth Step Size Flexibility	Possible to vary the azimuth step size with latitude (especially to allow for coverage of the entire surface	Derived	9.2 9.2 10	Horizontal resolution of 4° Programmable, for specific process studies Global horizontal coverage,	The first SRD requirement is also in SRD Tables 1 and 2.
2.8.2.2	Azimuth Scan Range Flexibility	Possible to vary the azimuth scan range with latitude, along with the number and spacing	Derived	9.2 10	Programmable, for specific process studies Global horizontal coverage,	
2.8.3	Azimuth Angle Knowledge	—	—	—	—	This IRD section is only a heading.
2.8.3.1	Absolute Azimuth Angle Knowledge	Absolute azimuth angle knowledge error ≤ 0.1°	Derived	10	Highest possible horizontal resolution, for altitudes below	Since 0.1° ≈ 5 km, the scan locations are known to within
2.8.3.2	Relative Azimuth Angle Knowledge	For adjacent altitude scans, relative azimuth angle knowledge error ≤ 0.04°	Derived	10	Horizontal geopotential height gradient measurement precision of 20 m / 500 km	A 2-km (i.e., 0.04°) error is acceptable for the largest geopotential height
2.8.4	Scanner Azimuth Angle Knowledge	Absolute scanner azimuth angle knowledge error ≤ 0.02°	Derived	10	Vertical coverage from the upper troposphere to the	This requirement limits the effect of S/C roll when viewing

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IRD Section	IRD Section Heading	IRD Requirement Description	IRD Requirement	SRD Section	SRD Requirement Description	Comments
2.9	Instrument Control Requirements	—	—	—	—	This IRD section is only a heading.
2.9.1	Instrument Microprocessor	IMP that can be programmed from the ground	Direct	9.2	Programmable, for specific process studies	The scans can be varied as desired.
2.9.2	Door/Sunshade Control	IMP controls the door/sunshade	Derived	9.2	Programmable, for specific process studies	
2.9.3	Altitude Scan Control	IMP controls the altitude scan parameters	Derived	9.2	Programmable, for specific process studies	
2.9.4	Azimuth Scan Control	IMP controls the azimuth scan parameters	Derived	9.2	Programmable, for specific process studies	
2.9.5	Scan Synchronization	Synchronize the scans with orbital events	Derived	10	Global horizontal coverage, 90° S to 90° N, including the	
2.9.6	Electronic Filter Control	IMP controls the sampling and digital filtering	Derived	9.2	Programmable, for specific process studies	
2.9.7	Other Subsystem Control	IMP controls other data-related subsystems	Derived	9.2	Programmable, for specific process studies	
2.10	Data Output Requirements	—	—	—	—	This IRD section is only a heading.
2.10.1	Scientific Data	Provide the scientific data to the S/C, for transmission to	Derived	11	Calculate the basic data products	
2.10.2	Moved to Section 2.5.10.1	—	—	—	—	
2.10.3	Moved to Section 2.5.10.3	—	—	—	—	
2.10.4	Spacecraft and Orbital Data	Incorporate the time and other selected S/C data into the	Derived	11	Calculate the basic data products	This is for convenience and the maintenance
2.10.4	Spacecraft and Orbital Data	Temporal sample spacing knowledge error ≤ 0.2 ms, or 2 ppm	Derived	10 10	Temperature measurement precision of 0.3 K below 50 km, and 1 K above 50 km (Table 1)	This ensures that poor timing does not affect the random error requirement in IRD § 2.7.5.1.
2.10.5	Engineering Data	Subcommutate the engineering data within the	Derived	11	Calculate the basic data products	This is for convenience and the maintenance
3	Document Revisions	—	—	—	—	This IRD section contains no requirements.