CIRS
Titan Observations

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Document in work

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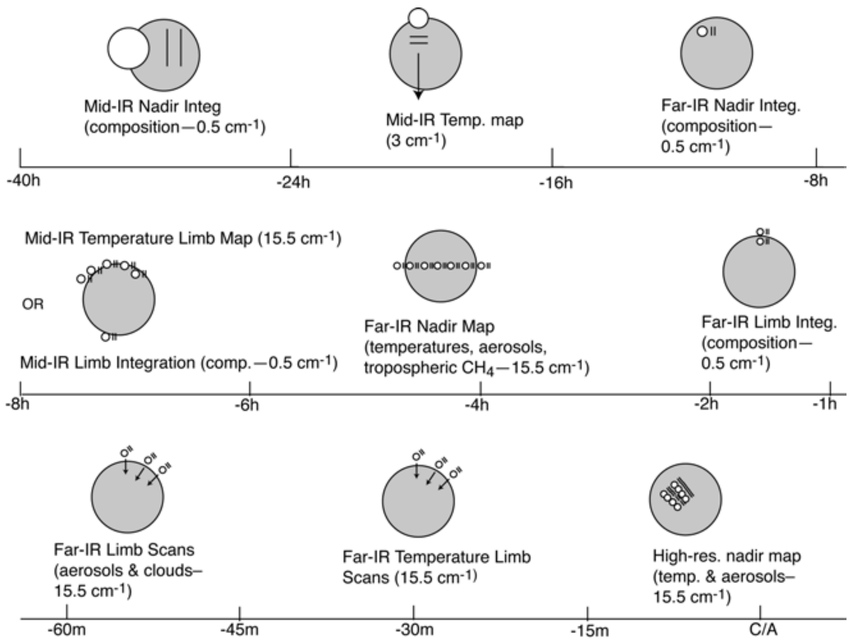
1 Introduction

Although a significant amount of science is done by CIRS (Composite InfraRed Spectrometer) at large distances from Titan, the extended fields-of-view of the instrument mean that the greatest spatial resolution is achieved at the smallest ranges, in flybys of Saturn's largest moon. Within approximately $\pm$1 day of closest approach, the TOST (Titan Orbiter Science Team) working group is responsible for allocating the time-line on all of the targeted flybys of Titan in the Cassini mission (45 in the Prime Mission, forecast to include 101 flybys before the mission terminates in 2017). Due to high competition with other instruments for the time <5 hours from closest approach, most of the CIRS allocations are further out, and consist of a series of planned observation types, each of which occur within a specified range from Titan.

The CIRS instrument consists of two interferometers, sharing a common telescope and scan mechanism. They operate in the far-infrared (10-600 cm^{-1}) and mid-infrared (600-1400 cm^{-1}) with a controllable apodized spectral resolution as high as 0.5 cm^{-1}. The far-IR interferometer (focal plane 1 or FP1) has a circular field-of-view (FOV), which subtends 3.9 milliradians, and the mid-IR interferometer has two focal plane arrays (FP3 and FP4), each consisting of ten detectors with 0.273 milliradian FOV per pixel.

Due to the nature of the focal planes, different pointing designs are required for study in the mid-IR and far-IR, and the varying science requirements of the mission put constraints on the spectral resolution required. This, along with constraints of time and the performance of the Cassini spacecraft has led to the CIRS team using a selection of different observation types within TOST periods, each of which has specific science objectives. This document outlines each observation type, detailing briefly the scientific objectives in each case, and gives a description of how the focal planes are orientated and articulated throughout. Also included are tables which list all of the CIRS-led requests of each type, the times at which they occur and any relevant pointing information. Locations chosen for each request were done so to a vast set of criteria, but in general the limb observations are centred around 'points of least blur' (see **Appendix**), and nadir observations are constrained by the visible hemisphere and emission angle. In all cases every effort has been made to ensure comprehensive spatial coverage of Titan of the duration Cassini's primary tour. Where applicable, an attempt to represent spatial coverage by CIRS diagrammatically has also been made.



CIRS Titan Timeline

Sequence Quick Reference	Time to/from CA (HH:MM)	Distance to/from CA	Duration (HH:MM)	Turn Rate? Scan Rate?	Spec. Res.	Objective	Positioning
FIRLMBINT	±1:15 to ±2:15	25,000 to 40,000 km	01:00 to 01:15		0.5 cm^{-1}	CH_4, HCN, CO, and H_2O	Perpendicular to Limb, 125 and 225 km altitude
FIRLMBAER	±0:45 to ±1:15	15,000 to 25,000 km	00:30 to 00:45		15.5 cm^{-1}	Aerosols in range 250-600 cm^{-1}	FP1 at -120 km scanned towards 480 km
FIRLMBT	±0:15 to ±0:45	< 15,000 km	00:30 to 00:45		15.5 cm^{-1}	Thermal: N_2 20-100 cm^{-1}	Perpendicular to Limb, one or more lat. 10° separation.
FIRNADMAP	~ ±03:00	~ 60,000 km	01:00 to 06:00		15.5 cm^{-1}	Tropospheric temperatures at 40—200 mbar	Skew across disk
FIRNADCMP	±08:00 to ±13:00	160,000 to 270,000 km	00:30 to 00:45		0.5 cm^{-1}	CH_4, HCN and CO	FP1 at fixed position on disk, ideally about 1/3 of the radius from the body center, emission angles of 45-60 degrees
MIRLMBINT	±05:00 to ±09:00	100,000 to 180,000 km	02:00 to 04:00 (2Hr per)		0.5 cm^{-1}		FP3 and FP4 at 125 and 225 km
MIRLMBMAP	±06:00	~ 120,000 km	00:03 to 00:04 per		15.5 cm^{-1}	Vert. temperature in stratosphere and mesosphere.	FP3 and FP4 perpendicular to limb
MIDIRTMAP	±19:00	~ 380,000 km	01:00 to 12:00		3.0 cm^{-1}	Thermal	Full disk/hemisphere coverage, typically 7 scan legs
COMPMAP	±15:00 to ±35:00	300,000 to 700,000 km	02:00 to 06:00				FP3/FP4 are fixed or moved across disk N-S or W-E
TEA	±40:00 to ±100:00	800,000 to 2,000,000 km	12:00 to 36:00				

2 Far-infrared Limb Observations

2.1 Observation Descriptions

2.1.1 Far-infrared Limb Composition Integration (FIRLMBINT)

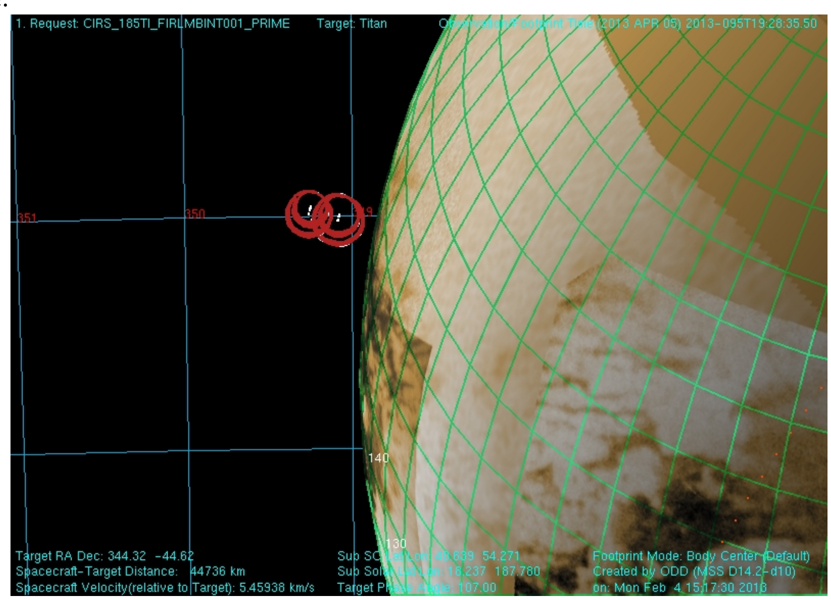
2.1.1.1 Science Description

FIRLMBINT observations are designed to obtain information on the composition of Titan's stratosphere, specifically, to provide coarse vertical profiles of CH_4, HCN, CO, and H_2O. They also allow a search for new molecular species, given long enough integration times.

2.1.1.2 Implementation

FIRLMBINT observations occur at spacecraft positions on the order of 25,000 to 40,000 km, or ±1:15 and ±2:15 from closest approach. The circular far-infrared focal plane (FP1) is positioned for two integrations centred at altitudes of 125 and 225 km (repeated 125-225-125-225) off of Titan's limb for a specified latitude, as with the corresponding mid-infrared limb sequences. The integration times are long, typically at 90 minutes in length with a range of between 75 and 135 minutes. Longer observations are required to resolve CO and H_2O with sufficient confidence. Since only one position on the limb may be sampled in a single sequence, comprehensive latitude mapping is achieved by the compositing of several Titan flybys. If possible, the mid-infrared arrays (FP3 and FP4) are orientated perpendicular to the limb so that they may also obtain useful data as described in later observation types.

2.1.1.3 Example:



This is an example FIRLMBINT observation, CIRS_185TI_FIRLMBINT001_PRIME.
Note the FOV of FP1 in red, at two different elevations above the limb.

2.1.2 Far-infrared Limb Aerosol Scan (FIRLMBAER)

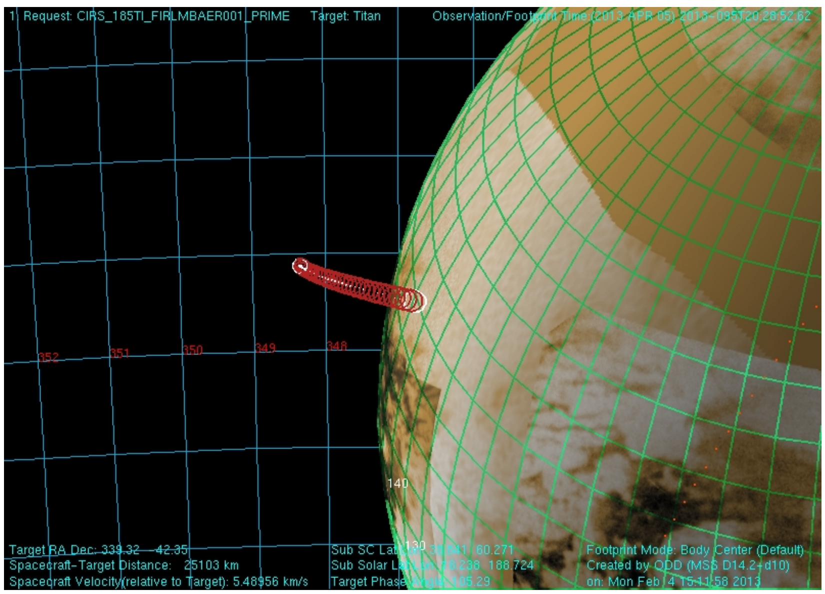
2.1.2.1 Science Description

FIRLMBAER observations are purposed to distinguish aerosols from clouds with spectra in the range 250-600 cm^{-1}, using the CIRS far-infrared focal plane (FP1). This is possible due to the wavenumber-dependence of condensate opacity, which enables distinguishing the abundances of the two as a function of latitude. This is important for determining Titan's weather and climatology, and for determining tropospheric abundances and surface temperatures from nadir-viewing observations.

2.1.2.2 Implementation

FIRLMBAER observations occur at spacecraft positions on the order of 15,000 to 25,000 km, or between ±0:45 and ±1:15 from closest approach. The circular far-infrared focal plane (FP1) is positioned first at -120 km, and then in one scan it is shifted towards +480 km (adjust scan lengths by around 30 mrad). Scan rates should be ideally 17 but up to 21 μrad/sec (slower scan rates are preferred).

2.1.2.3 Example



This is an example FIRLMBAER observation, CIRS_185TI_FIRLMBAER001_PRIME.
Note the FOV of FP1 in red decreasing in size as the altitude is increased; this is due to the changing spacecraft position over the observation duration.

2.1.3 Far-infrared Limb Temperature Sounding (FIRLMBT)

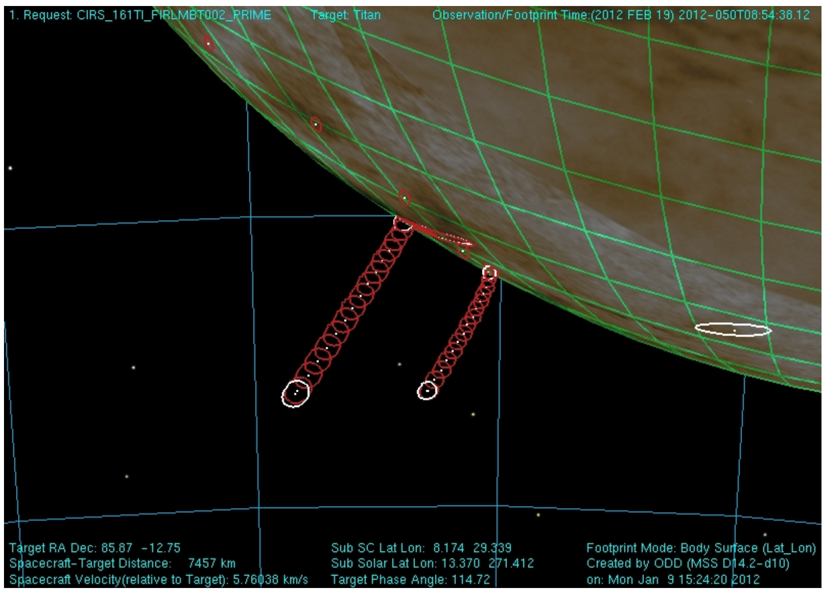
2.1.3.1 Science Description

FIRLMBT observations are intended to obtain information on the thermal structure of Titan's lower stratosphere and tropopause by measurements of the N_2 collision-induced absorption lines at 20-100 cm^{-1}, using the CIRS far-infrared focal plane (FP1).
Radial slews perpendicular to the limb are performed with a spectral resolution of 15.5 cm^{-1}, allowing profiles of temperature between 8 and 100 mbar to be obtained.

2.1.3.2 Implementation

FIRLMBT observations typically occur between ±45 and ±15 minutes of closest approach, at ranges of less than 15,000 km. FIRMBT sequences are the closest to Titan of the FIRLMB triplet and often must absorb turn time to/from the closest approach pointing, with duration of 30 to 45 minutes. Scans can be a pair, separated by 10 degrees of latitude, or a single scan, or a pair of scans at the same latitude. Short durations and rapidly changing geometry prevent slow slew rates and higher resolution, but an effective rate on the limb of 50 μrads^{-1} or less and a length of 28 mrad ensures adequate signal-to-noise for the required objectives. The effects of unresolved rotational lines in the spectra are corrected by the use of far-infrared limb integrations acquired at a spectral resolution of 0.5 cm^{-1}.

2.1.3.3 Example



This is an example FIRLMBAER observation, CIRS_161TI_FIRLMT002_PRIME.

2.2 Time-ordered Table of Observations

Titan rev.	Request Name	Start Time	Duration (HR:MN)	Pointing (Latitudes)
T4	CIRS_005TI_FIRLMBT002_PRIME	2005-090T20:05:16	0:45	80N, 70N
	CIRS_005TI_FIRLMBAER002_PRIME	2005-090T20:50:16	0:30	85N, 75N
	CIRS_005TI_FIRLMBINT002_PRIME	2005-090T21:20:16	0:45	85N
T6	CIRS_013TI_FIRLMBINT002_PRIME	2005-234T06:38:37	1:00	55S
	CIRS_013TI_FIRLMBAER002_PRIME	2005-234T07:38:37	0:30	50S
	CIRS_013TI_FIRLMBT002_PRIME	2005-234T08:08:37	0:35	50S, 55S
	CIRS_013TI_FIRLMBT003_PRIME	2005-234T09:03:37	0:35	45S, 40S
	CIRS_013TI_FIRLMBAER003_PRIME	2005-234T09:38:37	0:30	40S
	CIRS_013TI_FIRLMBINT003_PRIME	2005-234T10:08:37	1:00	45S
T10	CIRS_020TI_FIRLMBINT003_PRIME	2006-015T12:41:27	1:00	55N
T14	CIRS_024TI_FIRLMBINT002_PRIME	2006-140T09:48:11	1:25	50N
	CIRS_024TI_FIRLMBINT003_PRIME	2006-140T13:45:11	0:48	50N
T15	CIRS_025TI_FIRLMBAER003_PRIME	2006-183T09:50:47	1:00	62N
	CIRS_025TI_FIRLMBINT003_PRIME	2006-183T10:50:47	1:00	62N
T16	CIRS_026TI_FIRLMBINT003_PRIME	2006-203T01:40:26	1:00	45N
T17	CIRS_028TI_FIRLMBINT002_PRIME	2006-250T17:52:51	1:00	15S
	CIRS_028TI_FIRLMBAER002_PRIME	2006-250T18:52:51	0:39	15S
	CIRS_028TI_FIRLMBT002_PRIME	2006-250T19:31:51	0:30	15S, 25S
T18	CIRS_029TI_FIRLMBINT003_PRIME	2006-266T16:58:49	1:15	30N
T24	CIRS_038TI_FIRLMBINT001_PRIME	2007-029T05:15:55	0:45	28N
	CIRS_038TI_FIRLMBT001_PRIME	2007-029T06:00:55	0:52	28N
T26	CIRS_040TI_FIRLMBINT001_PRIME	2007-068T23:34:00	0:51	10N
	CIRS_040TI_FIRLMBT002_PRIME	2007-069T02:12:00	0:30	3N, 17N
	CIRS_040TI_FIRLMBAER002_PRIME	2007-069T02:42:00	0:30	15N
	CIRS_040TI_FIRLMBINT002_PRIME	2007-069T03:35:00	0:37	15N
T27	CIRS_041TI_FIRLMBINT002_PRIME	2007-085T01:56:27	0:42	44N
T32	CIRS_046TI_FIRLMBINT903_PRIME	2007-164T18:32:11	0:16	45N
T35	CIRS_049TI_FIRLMBINT001_PRIME	2007-243T04:32:34	1:00	70N
T37	CIRS_052TI_FIRLMBINT001_PRIME	2007-322T22:47:25	0:21	80S
	CIRS_052TI_FIRLMBAER001_PRIME	2007-322T23:08:25	0:54	80S, 70S
	CIRS_052TI_FIRLMBT001_PRIME	2007-323T00:02:25	0:30	65S, 75S
T38	CIRS_053TI_FIRLMBINT001_PRIME	2007-338T21:36:50	1:15	0N
	CIRS_053TI_FIRLMBAER001_PRIME	2007-338T22:51:50	0:25	0N
	CIRS_053TI_FIRLMBT001_PRIME	2007-338T23:16:50	0:35	5S, 5N
T40	CIRS_055TI_FIRLMBINT001_PRIME	2008-005T19:30:20	0:55	30S
T42	CIRS_062TI_FIRLMBINT003_PRIME	2008-085T12:28:48	0:44	55S
	CIRS_062TI_FIRLMBAER001_PRIME	2008-085T13:12:48	0:25	55S
	CIRS_062TI_FIRLMBT001_PRIME	2008-085T13:37:48	0:29	52, 62S
T46	CIRS_091TI_FIRLMBCON001_PRIME	2008-308T14:06:24	1:39	BIU anomaly
	CIRS_091TI_FIRLMBINT001_PRIME	2008-308T15:45:24	0:22	
	CIRS_091TI_FIRLMBINT002_RIDER	2008-308T19:03:24	0:24	
T47	CIRS_093TI_FIRLMBINT002_PRIME	2008-324T16:58:28	1:13	45S
T48	CIRS_095TI_FIRLMBINT001_PRIME	2008-340T11:25:45	1:00	35S

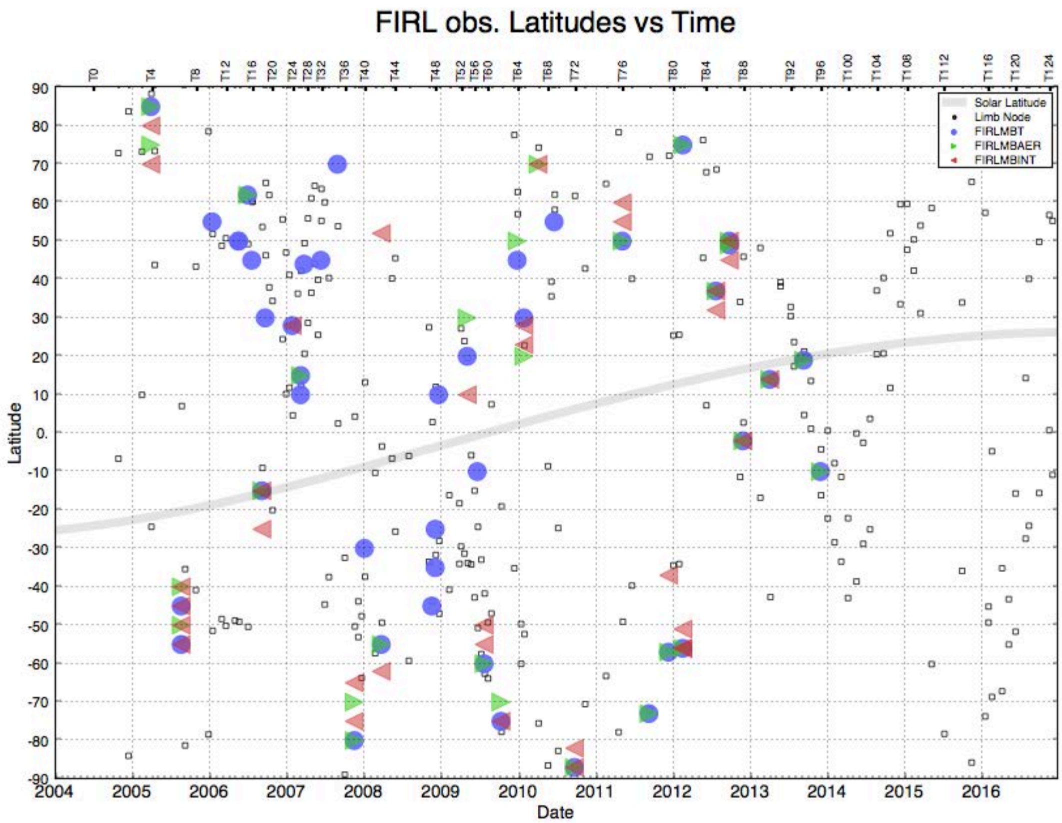
	CIRS_095TI_FIRLMBINT002_PRIME	2008-340T15:20:45	1:20	25S
T49	CIRS_097TI_FIRLMBINT001_PRIME	2008-356T09:59:52	1:00	10N
T53	CIRS_109TI_FIRLMBAER001_PRIME	2009-109T22:45:45	0:37	Downlink
	CIRS_109TI_FIRLMBT001_PRIME	2009-109T23:22:55	0:48	
	CIRS_109TI_FIRLMBAER002_PRIME	2009-110T00:56:46	0:49	
T54	CIRS_110TI_FIRLMBINT001_PRIME	2009-125T20:39:16	1:00	20N
	CIRS_110TI_FIRLMBAER001_PRIME	2009-125T21:39:16	0:30	30N
	CIRS_110TI_FIRLMBT001_PRIME	2009-125T22:09:16	0:35	10N, 5N
T57	CIRS_113TI_FIRLMBINT001_PRIME	2009-173T16:17:35	1:05	10S
T59	CIRS_115TI_FIRLMBT002_PRIME	2009-205T15:49:04	0:35	50S, 55S
	CIRS_115TI_FIRLMBAER002_PRIME	2009-205T16:24:04	0:30	60S
	CIRS_115TI_FIRLMBINT002_PRIME	2009-205T16:54:04	0:55	60S
T62	CIRS_119TI_FIRLMBT001_PRIME	2009-285T07:45:25	0:30	75S
	CIRS_119TI_FIRLMBAER002_PRIME	2009-285T09:01:25	0:50	70S
	CIRS_119TI_FIRLMBINT002_PRIME	2009-285T09:51:25	1:00	75S
T64	CIRS_123TI_FIRLMBINT001_PRIME	2009-361T22:01:59	0:59	45N
	CIRS_123TI_FIRLMBAER001_PRIME	2009-361T23:01:59	0:37	50N
T66	CIRS_125TI_FIRLMBINT001_PRIME	2010-028T19:58:49	1:08	30N
	CIRS_125TI_FIRLMBAER001_PRIME	2010-028T21:06:49	0:34	20N
	CIRS_125TI_FIRLMBT001_PRIME	2010-028T21:40:19	0:34	23N, 28N
T67	CIRS_129TI_FIRLMBCON001_PRIME	2010-095T13:35:39	1:00	70N
	CIRS_129TI_FIRLMBAER001_PRIME	2010-095T14:35:39	0:30	70N
	CIRS_129TI_FIRLMBT001_PRIME	2010-095T15:05:39	0:30	70N
T70	CIRS_133TI_FIRLMBINT001_PRIME	2010-171T23:12:18	1:02	55N
T72	CIRS_138TI_FIRLMBINT001_PRIME	2010-267T16:23:41	1:00	87S
	CIRS_138TI_FIRLMBAER001_PRIME	2010-267T17:23:41	0:30	87S
	CIRS_138TI_FIRLMBT001_PRIME	2010-267T17:53:41	0:30	82S, 87S
T73	CIRS_140TI_FIRLMBT002_PRIME	2010-315T13:12:01	1:10	
	CIRS_140TI_FIRLMBAER002_PRIME	2010-315T14:22:01	0:30	Safing event
	CIRS_140TI_FIRLMBINT002_PRIME	2010-315T14:52:01	1:00	
T76	CIRS_148TI_FIRLMBINT001_PRIME	2011-128T20:38:45	1:00	50N
	CIRS_148TI_FIRLMBAER001_PRIME	2011-128T21:38:45	0:45	50N
	CIRS_148TI_FIRLMBT001_PRIME	2011-128T22:08:45	0:35	55N, 60N
T78	CIRS_153TI_FIRLMBINT001_PRIME	2011-255T00:35:06	1:00	73S
	CIRS_153TI_FIRLMBAER001_PRIME	2011-255T01:35:06	0:32	73S
	CIRS_158TI_FIRLMBINT501_PRIME	2011-347T17:56:24	1:00	57S
T79	CIRS_158TI_FIRLMBAER501_PRIME	2011-347T18:56:24	0:30	57S
	CIRS_158TI_FIRLMBT501_PRIME	2011-347T19:26:24	0:45	37S
T82	CIRS_161TI_FIRLMBINT001_PRIME	2012-050T06:28:17	1:00	75N
	CIRS_161TI_FIRLMBAER001_PRIME	2012-050T07:28:17	0:30	75N
	CIRS_161TI_FIRLMBT001_PRIME	2012-050T07:58:17	0:45	56S
	CIRS_161TI_FIRLMBT002_PRIME	2012-050T08:43:17	0:45	56S, 51S
	CIRS_161TI_FIRLMBAER002_PRIME	2012-050T09:28:17	0:30	56S
	CIRS_161TI_FIRLMBINT002_PRIME	2012-050T09:58:17	1:00	56S
T85	CIRS_169TI_FIRLMBINT001_PRIME	2012-206T17:33:08	1:15	37N
	CIRS_169TI_FIRLMBAER001_PRIME	2012-206T18:48:08	0:30	37N
	CIRS_169TI_FIRLMBT001_PRIME	2012-206T19:19:08	0:34	37N, 32N

T86	CIRS_172TI_FIRLMBINT001_PRIME	2012-270T12:20:39	1:00	50N
	CIRS_172TI_FIRLMBAER001_PRIME	2012-270T13:20:39	0:25	50N
	CIRS_172TI_FIRLMBT001_PRIME	2012-270T13:46:39	0:31	50N, 45N
	CIRS_172TI_FIRLMBAER002_PRIME	2012-270T15:10:39	0:40	49N
	CIRS_172TI_FIRLMBINT002_PRIME	2012-270T16:12:39	0:38	49N
T88	CIRS_175TI_FIRLMBINT001_PRIME	2012-334T06:42:00	1:00	2S
	CIRS_175TI_FIRLMBAER001_PRIME	2012-334T07:42:00	0:30	2S
	CIRS_175TI_FIRLMBT001_PRIME	2012-334T08:13:00	0:29	2S
T90	CIRS_185TI_FIRLMBINT001_PRIME	2013-095T19:28:32	1:00	14N
	CIRS_185TI_FIRLMBAER001_PRIME	2013-095T20:28:32	0:30	14N
	CIRS_185TI_FIRLMBT001_PRIME	2013-095T20:58:32	0:30	14N
T94	CIRS_197TI_FIRLMBAER002_PRIME	2013-255T08:23:56	0:35	19N
	CIRS_197TI_FIRLMBINT002_PRIME	2013-255T08:58:56	1:00	18N
T96	CIRS_199TI_FIRLMBAER002_PRIME	2013-335T01:11:19	0:30	10S
	CIRS_199TI_FIRLMBINT002_PRIME	2013-335T01:56:19	1:15	10S
T97	CIRS_200TI_FIRLMBAER002_PRIME	2014-001T22:29:41	0:45	24S
	CIRS_200TI_FIRLMBINT002_PRIME	2014-001T23:14:41	1:00	24S
T100	CIRS_203TI_FIRLMBWTR001_PRIME	2014-097T11:26:14	0:53	22S
	CIRS_203TI_FIRLMBAER002_PRIME	2014-097T13:50:14	1:06	40S
	CIRS_203TI_FIRLMBINT002_PRIME	2014-097T15:18:14	0:38	40S
T103	CIRS_206TI_FIRLMBINT005_PRIME	2014-201T08:25:58	1:00	3S
	CIRS_206TI_FIRLMBAER001_PRIME	2014-201T09:25:58	0:30	3S
T104	CIRS_208TI_FIRLMBAER001_PRIME	2014-265T05:53:19	0:45	28N
	CIRS_208TI_FIRLMBINT002_PRIME	2014-265T06:38:19	1:00	28N
T109	CIRS_212TI_FIRLMBAER001_PRIME	2015-043T17:38:04	0:45	47N
	CIRS_212TI_FIRLMBINT002_PRIME	2015-043T18:45:04	0:38	47N
T110	CIRS_213TI_FIRLMBAER002_PRIME	2015-075T14:59:49	0:45	49N
	CIRS_213TI_FIRLMBINT002_PRIME	2015-075T15:44:49	1:00	49N
T111	CIRS_215TI_FIRLMBT002_PRIME	2015-127T23:00:24	0:35	60S, 55S
	CIRS_215TI_FIRLMBAER003_PRIME	2015-127T23:35:24	0:30	60S
	CIRS_215TI_FIRLMBINT002_PRIME	2015-128T00:05:24	1:00	60S
T112	CIRS_218TI_FIRLMBINT001_PRIME	2015-188T05:54:51	1:00	80S
	CIRS_218TI_FIRLMBAER001_PRIME	2015-188T06:54:51	0:30	80N
	CIRS_218TI_FIRLMBT001_PRIME	2015-188T07:24:51	0:45	80N, 70N
	CIRS_218TI_FIRLMBT002_PRIME	2015-188T08:09:51	0:45	65S, 75S
	CIRS_218TI_FIRLMBAER002_PRIME	2015-188T08:54:51	0:30	79S
	CIRS_218TI_FIRLMBINT002_PRIME	2015-188T09:24:51	1:00	79S

Table 1. (Continued from previous pages) CIRS-led far-infrared limb observations.

2.3 CIRS Far-infrared Limb Coverage

Fig. 1 This diagram represents the latitudinal coverage of Titan's limb by CIRS in the far-infrared region, along with the Solar Latitude of Titan and boxes representing all limb-node opportunities.



3 Far-infrared Nadir Temperature Maps (FIRNADMAP)

3.1 Observation Description

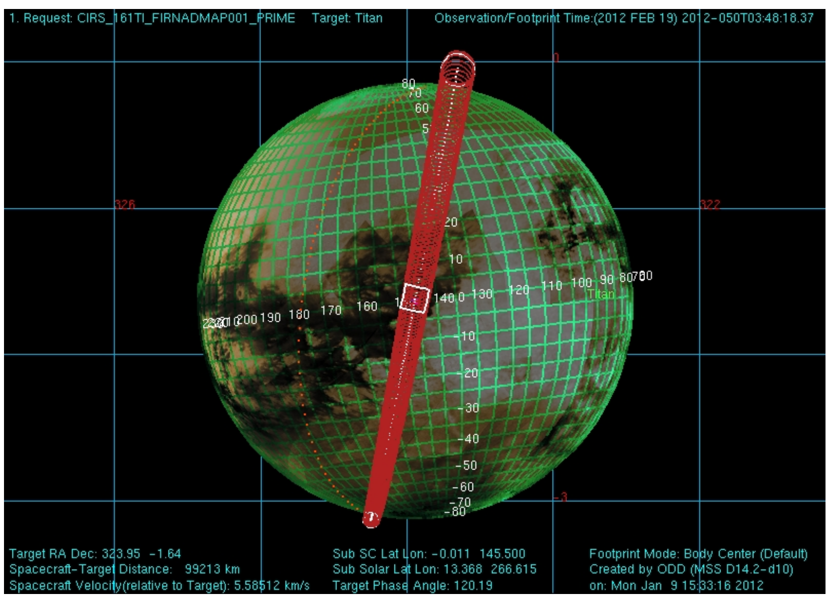
3.1.1 Science Description

The objective of FIRNADMAP sequences is to map the thermal structure of Titan's upper troposphere and tropopause by nadir sounding with the CIRS far-infrared focal plane (FP1). Temperatures are obtained with a precision of 0.2 K via the N_2 absorption lines at 20-100 cm^{-1}, CH_4 super-saturation at 150-400 cm^{-1} and surface temperatures at around 520 cm^{-1}.

3.1.2 Implementation

FIRNADMAP sequences typically occur 60,000 km or ±3 hours from closest approach, at which time FP1 subtends 5 degrees of body-centric arc at the sub-spacecraft point. During these sequences a single slew is executed across the entire visible disk with a spectral resolution of 15.5 cm^{-1}, at a rate of around 7 $\mu rads^{-1}$. Tailored scans over less than a diameter may target areas of particular interest, such as the northern lakes. Also, if time permits, a deep-space calibration is performed at the end of the slew by offsetting the FOV by around 20 milliradians to beyond Titan's exosphere and integrating over a period of at least 10 minutes.

3.1.3 Example



This is an example FIRNADMAP observation, CIRS_161TI_FIRNADMAP001_PRIME.

3.2 Time-ordered Table of Observations

Titan rev.	Request Name	Start Time	Duration (HR:MN)	Pointing (Lat., Lon)
TB	CIRS_00BTI_FIRNADMAP001_UVIS	2004-348T03:38:13	4:00	6S 159W
	CIRS_00BTI_FIRNADMAP002_UVIS	2004-348T14:08:13	2:30	10N 347W
T3	CIRS_003TI_FIRNADMAP003_UVIS	2005-046T08:30:53	3:27	2N 340W
T5	CIRS_006TI_FIRNADMAP003_UVIS	2005-106T11:11:46	5:00	8N 27W
T6	CIRS_013TI_FIRNADMAP002_PRIME	2005-234T03:53:37	2:45	3N 32W
	CIRS_013TI_FIRNADMAP003_PRIME	2005-234T11:08:37	2:45	15S 208W
T9	CIRS_019TI_FIRNADMAP005_UVIS	2005-360T21:29:30	6:24	0N 28W
T11	CIRS_021TI_FIRNADMAP003_UVIS	2006-058T13:25:19	3:30	0N 344W
T13	CIRS_023TI_FIRNADMAP003_UVIS	2006-121T02:18:14	5:10	0N 10W
T14	CIRS_024TI_FIRNADMAP002_UVIS	2006-140T04:48:11	5:00	0N 158W
	CIRS_024TI_FIRNADMAP003_PRIME	2006-140T14:33:11	2:45	0N 155W
T15	CIRS_025TI_FIRNADMAP003_UVIS	2006-183T11:50:47	5:30	0N 200W
T16	CIRS_026TI_FIRNADMAP003_PRIME	2006-203T02:40:26	2:45	6S 339W
T17	CIRS_028TI_FIRNADMAP002_UVIS	2006-250T12:46:51	4:45	10N 149W
T18	CIRS_029TI_FIRNADMAP002_UVIS	2006-266T11:28:49	4:30	14N 141W
T21	CIRS_035TI_EUVFUV001_UVIS	2006-346T04:11:31	5:00	32N 129W
T22	CIRS_036TI_FIRNADMAP002_PRIME	2006-362T04:35:22	3:00	41N 133W
	CIRS_036TI_FIRNADMAP003_PRIME	2006-362T13:35:22	2:00	42S 319W
T24	CIRS_038TI_EUVFUV001_UVIS	2007-028T22:15:55	6:00	59N 116W
	CIRS_038TI_FIRNADMAP002_PRIME	2007-029T11:15:55	1:00	53S 307W
T26	CIRS_040TI_FIRNADMAP001_PRIME	2007-068T20:49:00	2:45	47S 43W
	CIRS_040TI_FIRNADMAP002_PRIME	2007-069T06:04:00	0:45	46N 228W
	CIRS_040TI_EUVFUV002_UVIS	2007-069T06:49:00	3:00	
T27	CIRS_041TI_EUVFUV001_UVIS	2007-084T20:49:27	2:23	36S 35W
	CIRS_041TI_FIRNADMAP002_PRIME	2007-085T02:38:27	0:45	32N 218W
	CIRS_041TI_EUVFUV002_UVIS	2007-085T03:23:27	5:00	39N 223W
T29	CIRS_043TI_FIRNADMAP001_PRIME	2007-116T16:32:58	2:50	27S 28W
T30	CIRS_044TI_EUVFUV001_UVIS	2007-132T11:09:58	3:50	
T31	CIRS_045TI_EUVFUV001_UVIS	2007-148T09:51:55	6:00	11S 24W
	CIRS_045TI_FIRNADMAP004_PRIME	2007-148T22:51:55	1:00	13N 212W
T32	CIRS_046TI_FIRNADMAP002_UVIS	2007-164T12:46:11	2:00	7S 24W
	CIRS_046TI_FIRNADMAP901_UVIS	2007-164T16:12:11	0:51	
	CIRS_046TI_FIRNADMAP902_PRIME	2007-164T20:04:11	2:42	4N 212W
T33	CIRS_047TI_EUVFUV001_UVIS	2007-180T11:59:46	3:00	
	CIRS_047TI_FIRNADMAP002_PRIME	2007-180T20:59:46	1:15	0N 209W
T34	CIRS_048TI_EUVFUV001_UVIS	2007-199T16:11:20	6:00	
	CIRS_048TI_FIRNADMAP002_PRIME	2007-200T05:11:20	1:00	0N 339W
T35	CIRS_049TI_FIRNADMAP001_PRIME	2007-243T01:32:34	3:00	6S 159W
	CIRS_049TI_FIRNADMAP004_PRIME	2007-243T10:32:34	1:00	10N 347W
T36	CIRS_050TI_EUVFUV001_UVIS	2007-274T19:42:43	3:45	
T37	CIRS_052TI_FIRNADMAP001_PRIME	2007-322T19:47:25	3:00	4S 22W
	CIRS_052TI_FIRNADMAP002_PRIME	2007-323T04:47:25	1:00	1N 205W
T38	CIRS_053TI_FIRNADMAP001_PRIME	2007-338T18:36:50	3:00	8N 27W
	CIRS_053TI_FIRNADMAP002_PRIME	2007-339T04:06:50	1:00	10N 215W

T40	CIRS_055TI_EUVFUV001_UVIS	2008-005T12:30:20	4:00	21S 32W
	CIRS_055TI_EUVFUV501_UVIS	2008-005T16:30:20	2:00	
	CIRS_055TI_FIRNADMAP002_PRIME	2008-006T01:30:20	1:00	5S 211W
T41	CIRS_059TI_EUVFUV002_UVIS	2008-053T20:02:07	2:30	25N 227W
T42	CIRS_062TI_FIRNADMAP001_PRIME	2008-085T09:27:48	3:00	0N 28W
	CIRS_062TI_FIRNADMAP002_PRIME	2008-085T18:27:48	1:00	0N 189W
T43	CIRS_067TI_FIRNADMAP002_PRIME	2008-133T12:11:58	2:50	0N 344W
T44	CIRS_069TI_EUVFUV001_UVIS	2008-148T23:24:32	6:00	
T46	CIRS_091TI_FIRNADMAP001_PRIME	2008-308T14:06:23	2:01	BIU anomaly
	CIRS_091TI_EUVFUV002_UVIS	2008-308T19:27:23	7:08	
T47	CIRS_093TI_FIRNADMAP002_PRIME	2008-324T18:11:28	2:45	34N 253W
T48	CIRS_095TI_EUVFUV001_UVIS	2008-340T16:40:45	6:45	
T50	CIRS_102TI_EUVFUV001_UVIS	2009-038T14:50:51	3:00	BIU anomaly
	CIRS_102TI_EUVFUV001_ISS	2009-038T17:50:51	1:00	
	CIRS_102TI_EUVFUV001_UVIS	2009-038T21:50:51	0:13	
T51	CIRS_107TI_FIRNADMAP002_PRIME	2009-086T06:32:45	3:11	54N 266W
T52	CIRS_108TI_FIRNADMAP002_PRIME	2009-094T03:37:47	1:40	58S 257W
T54	CIRS_110TI_FIRNADMAP001_PRIME	2009-125T18:04:16	2:35	55N 82W*
	CIRS_110TI_EUVFUV001_UVIS	2009-126T00:54:16	7:00	
T55	CIRS_111TI_EUVFUV001_UVIS	2009-141T12:26:41	6:30	
	CIRS_111TI_FIRNADMAP002_PRIME	2009-141T23:56:41	2:30	55S 270W*
T56	CIRS_112TI_EUVFUV001_UVIS	2009-157T21:41:01	7:19	
T57	CIRS_113TI_EUVFUV001_UVIS	2009-173T09:32:35	6:45	
	CIRS_113TI_EUVFUV002_UVIS	2009-174T00:02:35	3:00	
T58	CIRS_114TI_EUVFUV001_UVIS	2009-189T08:04:03	6:40	
	CIRS_114TI_FIRNADMAP002_PRIME	2009-189T19:04:03	1:30	24S 294W*
T59	CIRS_115TI_FIRNADMAP002_PRIME	2009-205T18:10:09	2:23	23S 326W
T60	CIRS_116TI_EUVFUV001_UVIS	2009-221T05:03:53	3:50	Downlink
T62	CIRS_119TI_EUVFUV001_UVIS	2009-284T23:36:25	6:51	
	CIRS_119TI_EUVFUV002_UVIS	2009-285T11:12:30	6:21	
T63	CIRS_122TI_FIRNADMAP002_PRIME	2009-346T03:48:14	1:00	0N 200W
T64	CIRS_123TI_FIRNADMAP001_PRIME	2009-361T19:16:59	2:45	4N 121W
T65	CIRS_124TI_FIRNADMAP001_PRIME	2010-012T18:10:37	2:44	Angled track
	CIRS_124TI_FIRNADMAP002_PRIME	2010-013T01:10:37	3:00	Angled track
T66	CIRS_125TI_EUVFUV001_UVIS	2010-028T13:28:49	6:30	
	CIRS_125TI_EUVFUV002_UVIS	2010-029T00:28:49	7:00	
T67	CIRS_129TI_FIRNADMAP001_PRIME	2010-095T10:50:39	2:45	25S 130W*
	CIRS_129TI_FIRNADMAP002_PRIME	2010-095T19:50:39	1:00	10N 310W*
T69	CIRS_132TI_EUVFUV001_UVIS	2010-156T04:26:27	7:00	
T70	CIRS_133TI_FIRNADMAP001_PRIME	2010-171T20:27:43	2:45	0N 9W
T72	CIRS_138TI_FIRNADMAP001_PRIME	2010-267T13:38:41	2:45	5S 50W*
	CIRS_138TI_EUVFUV002_UVIS	2010-267T20:53:41	6:45	
T73	CIRS_140TI_FIRNADMAP001_PRIME	2010-315T08:37:01	2:45	Safing event
T75	CIRS_147TI_EUVFUV001_UVIS	2011-109T07:30:39	6:30	
T76	CIRS_148TI_FIRNADMAP001_PRIME	2011-128T17:53:45	2:45	0N 20W*
	CIRS_148TI_EUVFUV001_UVIS	2011-129T01:53:45	6:00	
T77	CIRS_149TI_EUVFUV001_UVIS	2011-171T06:37:00	9:25	

	CIRS_149TI_FIRNADMAP002_PRIME	2011-171T21:02:01	4:00	0N 217W
T78	CIRS_153TI_FIRNADMAP001_PRIME	2011-254T21:50:06	2:45	0N 118W*
	CIRS_153TI_EUVFUV001_UVIS	2011-255T06:50:06	7:32	
T79	CIRS_158TI_FIRNADMAP501_PRIME	2011-347T15:11:24	2:45	0N 15W
T80	CIRS_159TI_FIRNADMAP001_PRIME	2012-002T10:13:38	2:45	25S 138W
T81	CIRS_160TI_EUVFUV001_UVIS	2012-030T04:39:47	6:45	
	CIRS_160TI_EUVFUV002_UVIS	2012-030T16:39:47	6:00	
T82	CIRS_161TI_FIRNADMAP001_PRIME	2012-050T03:43:17	2:45	0N 148W
	CIRS_161TI_FIRNADMAP002_PRIME	2012-050T10:58:17	2:45	0N 330W*
T83	CIRS_166TI_FIRNADMAP001_PRIME	2012-142T20:10:11	2:33	0N 20W
T84	CIRS_167TI_FIRNADMAP001_PRIME	2012-158T19:07:21	2:45	22N 18W
	CIRS_167TI_EUVFUV002_UVIS	2012-159T02:22:21	6:45	
T85	CIRS_169TI_FIRNADMAP002_PRIME	2012-206T22:18:08	2:45	18S 202W
T86	CIRS_172TI_EUVFUV001_UVIS	2012-270T05:35:38	6:45	
	CIRS_172TI_EUVFUV002_UVIS	2012-270T16:50:38	6:45	
T88	CIRS_175TI_FIRNADMAP001_PRIME	2012-334T03:57:00	2:45	35N 30W
T90	CIRS_185TI_FIRNADMAP001_PRIME	2013-095T16:43:32	2:45	42N 48W
T93	CIRS_195TI_EUVFUV001_UVIS	2013-207T02:56:22	6:45	
T94	CIRS_197TI_EUVFUV001_UVIS	2013-255T09:58:56	6:45	
T96	CIRS_199TI_FIRNADMAP002_PRIME	2013-335T02:56:19	2:45	90S 0W*
T97	CIRS_200TI_EUVFUV001_UVIS	2014-001T12:59:41	6:45	
	CIRS_200TI_EUVFUV002_UVIS	2014-002T00:14:41	6:45	
T100	CIRS_203TI_EUVFUV001_UVIS	2014-097T15:56:14	6:45	
T101	CIRS_204TI_EUVFUV001_UVIS	2014-137T02:12:15	5:15	
T105	CIRS_208TI_EUVFUV001_UVIS	2014-265T02:23:19	0:45	
	CIRS_208TI_EUVFUV002_UVIS	2014-265T11:08:19	1:30	
T101	CIRS_204TI_FIRNADMAP002_PRIME	2014-137T18:57:15	2:15	78N 240W, 72N 313W[1]
T102	CIRS_205TI_FIRNADMAP002_PRIME	2014-169T16:00:25	2:28	65N 195W*
T103	CIRS_206TI_FIRNADMAP002_PRIME	2014-201T13:05:58	2:35	78N 240W[2]
T105	CIRS_208TI_FIRNADMAP002_PRIME	2014-265T07:38:19	3:30	57N 200W*
	CIRS_212TI_EUVFUV001_UVIS	2015-043T08:08:04	6:45	
T109	CIRS_212TI_EUVFUV002_UVIS	2015-043T19:23:04	6:45	
T110	CIRS_213TI_FIRNADMAP002_PRIME	2015-075T16:44:49	2:45	6S 200W
T111	CIRS_215TI_FIRNADMAP002_PRIME	2015-128T01:05:24	2:45	10S 340W
T112	CIRS_218TI_FIRNADMAP002_PRIME	2015-188T10:24:51	2:45	6N 220W
	CIRS_225TI_EUVFUV002_UVIS	2015-317T08:01:31	6:45	

Table 2. (Continued from previous pages) CIRS and UVIS-led far-infrared nadir map observations. Pointing entries indicate the sub-spacecraft point at the mid-point of the duration. Where the observation track is offset from the sub-spacecraft point, the midpoint of the scan is given; these entries are marked with an asterisk.

[1] Two scans on T101, both targeted at northern lakes (Ligeia Mare, Kraken Mare).

[2] Continuous mosaic, seven short scans over Ligeia Mare.

3.3 Graphical Representation of Coverage

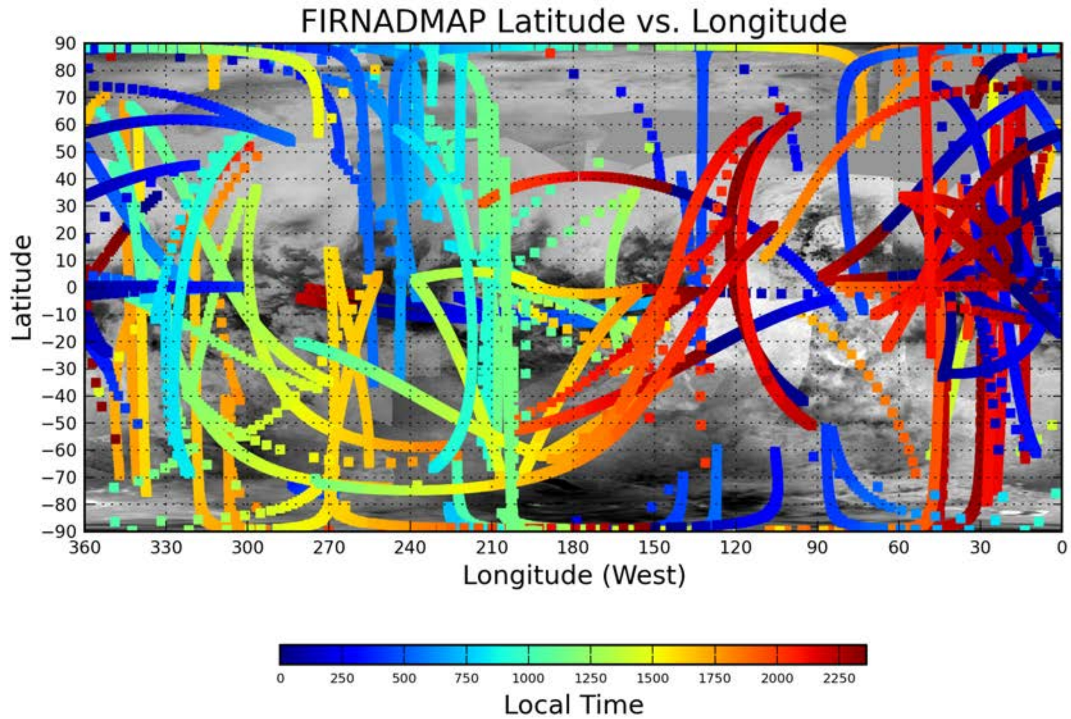


Fig. 4 CIRS FIRNADMAP scans.

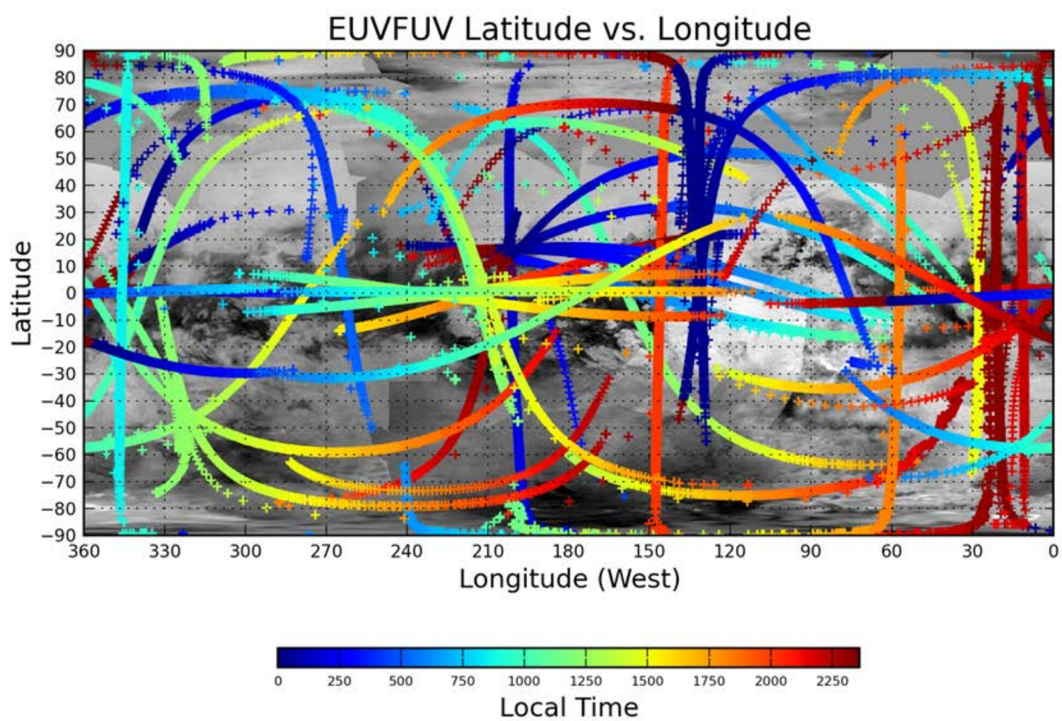


Fig. 5 CIRS UVIS EUVFUV scans.

4 Far-infrared Nadir Composition Integrations (FIRNADCMP)

4.1 Observation Description

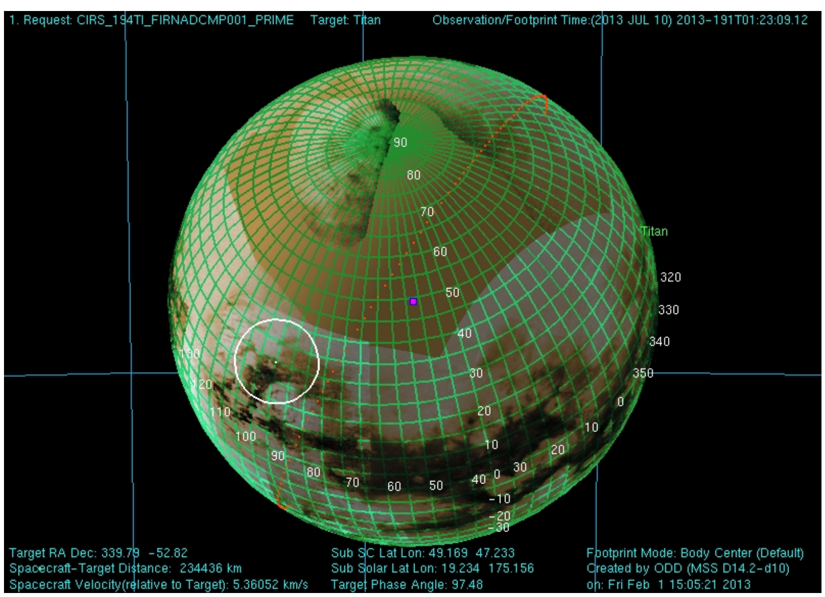
4.1.1 Science Description:

The objective of FIRNADCMP designs is to obtain maps of CH4, HCN and CO abundances in Titan's stratosphere from measurements of their rotational lines, and possibly detect new compounds. Spatial mapping of the disk is composited from multiple flybys during the tour, with only one location being observed in a single sequence, and measurements are repeated over the lifetime of the tour to search for seasonal variations.

4.1.2 Implementation

FIRNADCMP observations are executed at ranges of 160,000 to 270,000 km, or around ± 8-13 hours from closest approach. Long integration times of typically 5 hours are used to improve signal to noise and provide a high spectral resolution of 0.5 cm^{-1} . Locations are chosen on the visible disk at emission angles of 45-60 degrees, to improve spectral contrast of stratospheric emission while ensuring that the focal plane remains on the disk with the included pointing uncertainty, and to provide comprehensive latitude coverage. During a typical sequence the CIRS far-infrared focal plane (FP1) is positioned at a single chosen position on Titan's disk, with the FPB toward Titan center, ideally about 1/3 of the radius from the body center for most of the duration. If time permits, deep-space calibrations of around 10 minutes are performed before and/or after the long integration, during which FP1 is moved beyond Titan's exosphere by executing an offset of around 25 mrad.

4.1.3 Example



This is an example FIRNADCMP observation, CIRS_194TI_ FIRNADCMP001_PRIME.

4.2 Time-ordered Table of Observations

Titan rev.	Request Name	Start Time	Duration (HR:MN)	Pointing (Lat, Lon)
T0	CIRS_000TI_FIRNADCMP017_PRIME	2004-185T01:00:00	2:15	visible center
	CIRS_000TI_FIRNADCMP001_PRIME	2004-185T04:00:00	6:00	visible center
~~TA~~	~~CIRS_00ATI_FIRNADCMP001_PRIME~~	~~2004-300T00:00:09~~	~~4:00~~	~~30S 200W~~
TB	CIRS_00BTI_FIRNADCMP001_PRIME	2004-347T23:38:13	4:00	10N 120W
T3	CIRS_003TI_FIRNADCMP002_PRIME	2005-046T14:57:53	4:00	18S 35W
T4	CIRS_005TI_FIRNADCMP002_PRIME	2005-090T07:35:16	4:00	40S 15W
	CIRS_005TI_FIRNADCMP003_PRIME	2005-091T04:05:16	4:00	47N 210W
T5	CIRS_006TI_FIRNADCMP002_PRIME	2005-106T07:16:46	3:25	55N 15W
T6	CIRS_013TI_FIRNADCMP003_PRIME	2005-233T22:05:37	3:18	30N 330W
	CIRS_013TI_FIRNADCMP004_PRIME	2005-234T16:23:37	4:30	60S 220W
~~T7~~	~~CIRS_014TI_FIRNADCMP002_PRIME~~	~~2005-250T17:11:57~~	~~3:00~~	~~10S 160W~~
T8	CIRS_017TI_FIRNADCMP003_PRIME	2005-301T13:15:25	3:00	20N 35W
T9	CIRS_019TI_FIRNADCMP002_PRIME	2005-360T07:49:30	2:10	0N 62W
T10	CIRS_020TI_FIRNADCMP002_PRIME	2006-014T23:41:27	2:00	20N 190W
T11	CIRS_021TI_FIRNADCMP002_PRIME	2006-058T16:55:19	4:40	30S 170W
T12	CIRS_022TI_FIRNADCMP003_PRIME	2006-077T10:05:57	7:00	0N 190W
	CIRS_022TI_FIRNADCMP008_PRIME	2006-078T12:25:57	1:41	25N 315W
T13	CIRS_023TI_FIRNADCMP003_PRIME	2006-120T05:34:14	6:24	25S 320W
	CIRS_023TI_FIRNADCMP002_PRIME	2006-121T07:28:14	4:07	35S 210W
T14	CIRS_024TI_FIRNADCMP003_PRIME	2006-139T20:48:11	6:30	15S 125W
T15	CIRS_025TI_FIRNADCMP003_PRIME	2006-182T19:50:47	3:30	15N 230W
	CIRS_025TI_FIRNADCMP002_PRIME	2006-183T18:20:47	5:30	40N 20W
T17	CIRS_028TI_FIRNADCMP003_PRIME	2006-250T06:16:51	6:00	30N 145W
T18	CIRS_029TI_FIRNADCMP003_PRIME	2006-266T04:58:49	5:30	10N 95W
T19	CIRS_030TI_FIRNADCMP003_PRIME	2006-282T03:30:07	5:00	60S 300W
	CIRS_030TI_FIRNADCMP002_PRIME	2006-283T03:30:07	5:51	35N 115W
T21	CIRS_035TI_FIRNADCMP003_PRIME	2006-345T21:11:31	5:30	65N 130W
	CIRS_035TI_FIRNADCMP023_PRIME	2006-346T22:09:31	3:00	80S 300W
T22	CIRS_036TI_FIRNADCMP003_PRIME	2006-361T20:05:22	5:30	80N 160W
	CIRS_036TI_FIRNADCMP002_PRIME	2006-362T18:35:22	2:30	90S 320W
T23	CIRS_037TI_FIRNADCMP001_PRIME	2007-012T19:38:31	3:00	75N 210W
	CIRS_037TI_FIRNADCMP002_PRIME	2007-013T17:38:31	2:00	70S 210W
T24	CIRS_038TI_FIRNADCMP001_PRIME	2007-028T16:15:55	5:00	85N 290W
	CIRS_038TI_FIRNADCMP002_PRIME	2007-029T16:15:55	5:00	40S 280W
~~T25~~	~~CIRS_039TI_FIRNADCMP001_PRIME~~	~~2007-052T14:12:24~~	~~3:00~~	~~30S 90W~~
	~~CIRS_039TI_FIRNADCMP002_PRIME~~	~~2007-053T12:12:24~~	~~2:00~~	~~70N 350W~~
T26	CIRS_040TI_FIRNADCMP001_PRIME	2007-068T12:49:00	3:00	50S 80W
	CIRS_040TI_FIRNADCMP002_PRIME	2007-069T10:49:00	2:00	90N 60W
T27	CIRS_041TI_FIRNADCMP001_PRIME	2007-084T11:23:27	3:00	70S 20W
	CIRS_041TI_FIRNADCMP002_PRIME	2007-085T09:23:27	2:00	60N 150W
T28	CIRS_042TI_FIRNADCMP001_PRIME	2007-100T07:58:00	2:00	60S 30W
	CIRS_042TI_FIRNADCMP002_PRIME	2007-101T07:58:00	5:00	70N 180W
T29	CIRS_043TI_FIRNADCMP001_PRIME	2007-116T06:46:58	4:46	50S 30W
	CIRS_043TI_FIRNADCMP002_PRIME	2007-117T06:32:58	2:00	75N 220W
T30	CIRS_044TI_FIRNADCMP002_PRIME	2007-133T05:09:58	2:00	0N 260W
T31	CIRS_045TI_FIRNADCMP001_PRIME	2007-148T04:42:55	4:09	20S 330W

	CIRS_045TI_FIRNADCMP002_PRIME	2007-149T03:51:55	6:14	50N 230W
T32	CIRS_046TI_FIRNADCMP001_PRIME	2007-164T03:39:11	1:07	20N 50W
	CIRS_046TI_FIRNADCMP002_PRIME	2007-165T02:46:11	2:00	20S 257W
T33	CIRS_047TI_FIRNADCMP001_PRIME	2007-180T02:44:46	4:15	10N 330W
	CIRS_047TI_FIRNADCMP002_PRIME	2007-181T02:14:46	4:45	20N 170W
T34	CIRS_048TI_FIRNADCMP001_PRIME	2007-199T10:11:20	2:00	35S 125W
	CIRS_048TI_FIRNADCMP002_PRIME	2007-200T10:11:20	4:49	50N 345W
T35	~~CIRS_049TI_FIRNADCMP001_PRIME~~	~~2007-242T18:17:34~~	~~2:15~~	~~10S 40W~~
	CIRS_049TI_FIRNADCMP002_PRIME	2007-243T15:32:34	6:00	37S 240W
T36	CIRS_050TI_FIRNADCMP001_PRIME	2007-274T13:30:43	5:12	10S 320W
	CIRS_050TI_FIRNADCMP002_PRIME	2007-275T13:42:43	2:00	30N 255W
T37	CIRS_052TI_FIRNADCMP002_PRIME	2007-323T09:47:25	5:00	40N 185W
T38	CIRS_053TI_FIRNADCMP001_PRIME	2007-338T09:59:50	4:07	40S 340W
	CIRS_053TI_FIRNADCMP002_PRIME	2007-339T09:06:50	2:00	60N 215W
T39	CIRS_054TI_FIRNADCMP002_PRIME	2007-355T07:57:55	2:00	60N 270W
T40	CIRS_055TI_FIRNADCMP001_PRIME	2008-005T08:07:20	3:23	20N 355W
	CIRS_055TI_FIRNADCMP002_PRIME	2008-006T06:30:20	5:00	45N 280W
T41	CIRS_059TI_FIRNADCMP001_PRIME	2008-053T04:29:07	3:03	25S 65W
	CIRS_059TI_FIRNADCMP002_PRIME	2008-054T02:32:07	2:00	15N 285W
T42	CIRS_062TI_FIRNADCMP002_PRIME	2008-085T23:27:48	2:00	60N 310W
T43	CIRS_067TI_FIRNADCMP001_PRIME	2008-132T23:07:58	0:54	60S 60W
	CIRS_067TI_FIRNADCMP002_PRIME	2008-133T19:01:58	5:00	30N 300W
T44	CIRS_069TI_FIRNADCMP001_PRIME	2008-148T17:24:32	2:00	45S 50W
	CIRS_069TI_FIRNADCMP002_PRIME	2008-149T17:24:32	2:00	10N 300W
T46	CIRS_091TI_FIRNADCMP001_PRIME	2008-308T04:35:24	6:00	BIU anomay
	CIRS_091TI_FIRNADCMP002_PRIME	2008-309T03:35:24	4:38	
T47	CIRS_093TI_FIRNADCMP002_PRIME	2008-325T01:56:28	3:00	45N 255W
T48	CIRS_095TI_FIRNADCMP001_PRIME	2008-340T01:25:45	4:00	15S 70W
T49	CIRS_097TI_FIRNADCMP001_PRIME	2008-355T23:59:52	4:00	10S 110W
T50	CIRS_102TI_FIRNADCMP001_PRIME	2009-037T19:50:51	3:30	BIU anomaly
T51	CIRS_106TI_FIRNADCMP001_PRIME	2009-085T16:43:36	3:00	60S 150W
	CIRS_107TI_FIRNADCMP002_PRIME	2009-086T14:43:36	3:00	35N 215W
T52	CIRS_108TI_FIRNADCMP002_PRIME	2009-094T10:47:47	3:00	70S 75W
T53	CIRS_109TI_FIRNADCMP001_PRIME	2009-109T11:20:45	5:07	Downlink
T54	CIRS_110I_FIRNADCMP001_PRIME	2009-126T07:54:16	5:00	70S 190W
T55	CIRS_111TI_FIRNADCMP002_PRIME	2009-142T06:26:41	3:00	25S 5W
T56	CIRS_112TI_FIRNADCMP001_PRIME	2009-157T06:07:49	3:52	50N 60W
	CIRS_112TI_FIRNADCMP002_PRIME	2009-158T05:00:01	5:00	60S 255W
T57	CIRS_113TI_FIRNADCMP001_PRIME	2009-173T05:05:48	3:27	15N 75W
T58	CIRS_114TI_FIRNADCMP001_PRIME	2009-190T02:04:03	3:00	70S 340W
T59	CIRS_115TI_FIRNADCMP001_PRIME	2009-205T02:34:04	3:00	50N 100W
T60	CIRS_116TI_FIRNADCMP001_PRIME	2009-221T02:01:49	2:02	Downlink
T62	CIRS_119TI_FIRNADCMP001_PRIME	2009-284T19:36:25	3:00	25S 105W
	CIRS_119TI_FIRNADCMP002_PRIME	2009-285T17:36:25	3:00	0N 20W
T63	CIRS_122TI_FIRNADCMP001_PRIME	2009-345T11:05:56	3:57	40N 0W
T64	CIRS_123TI_FIRNADCMP002_PRIME	2009-362T09:16:59	3:00	45S 190W
T65	CIRS_124TI_FIRNADCMP002_PRIME	2010-013T08:10:37	5:00	0N 170W

T66	CIRS_125TI_FIRNADCMP001_PRIME	2010-028T08:07:18	4:22	40N 40W
	CIRS_125TI_FIRNADCMP002_PRIME	2010-029T07:28:49	5:00	45S 225W
T67	CIRS_129TI_FIRNADCMP001_PRIME	2010-095T03:44:18	2:06	45S 110W
T68	CIRS_131TI_FIRNADCMP001_PRIME	2010-139T14:24:20	3:00	30S 30W
	CIRS_131TI_FIRNADCMP002_PRIME	2010-140T12:24:20	4:00	20S 230W
T69	CIRS_132TI_FIRNADCMP002_PRIME	2010-156T11:26:27	3:00	50N 195W
T70	CIRS_133TI_FIRNADCMP001_PRIME	2010-171T12:06:01	3:21	50S 0W
T71	CIRS_134TI_FIRNADCMP001_PRIME	2010-187T11:07:45	4:15	10S 60W
T72	CIRS_138TI_FIRNADCMP001_PRIME	2010-267T06:12:41	3:26	30S 40W
T73	CIRS_140TI_FIRNADCMP001_PRIME	2010-315T00:37:01	4:00	Safing event
T76	CIRS_148TI_FIRNADCMP001_PRIME	2011-128T09:42:00	4:12	10S 115W
T78	CIRS_153TI_FIRNADCMP001_PRIME	2011-254T13:50:06	4:00	10N 110W
T79	CIRS_158TI_FIRNADCMP501_PRIME	2011-347T04:20:00	6:52	30S 330W
T80	CIRS_159TI_FIRNADCMP001_PRIME	2012-002T01:17:00	4:57	40S 150W
T81	CIRS_160TI_FIRNADCMP001_PRIME	2012-029T23:36:00	5:04	40S 330W
	CIRS_160TI_FIRNADCMP002_PRIME	2012-030T22:39:47	5:36	0N 240W
T82	CIRS_161TI_FIRNADCMP001_PRIME	2012-049T20:43:17	2:00	10N 150W
	CIRS_161TI_FIRNADCMP002_PRIME	2012-050T17:43:17	2:06	15S 290W
T83	CIRS_166TI_FIRNADCMP001_PRIME	2012-143T10:10:11	5:36	15S 170W
T84	CIRS_167TI_FIRNADCMP002_PRIME	2012-159T09:07:21	5:00	45S 255W
T85	CIRS_169TI_FIRNADCMP001_PRIME	2012-206T07:03:08	4:00	10S 345W
T86	CIRS_172TI_FIRNADCMP001_PRIME	2012-270T01:11:00	4:25	45N 315W
	CIRS_172TI_FIRNADCMP002_PRIME	2012-270T23:35:39	5:00	70S 240W
T87	CIRS_174TI_FIRNADCMP002_PRIME	2012-318T19:22:09	5:00	72S 185W
T88	CIRS_175TI_FIRNADCMP001_PRIME	2012-333T21:27:00	2:30	15N 60W
	CIRS_175TI_FIRNADCMP002_PRIME	2012-334T17:57:00	5:00	60S 165W
T90	CIRS_185TI_FIRNADCMP001_PRIME	2013-095T08:43:32	4:00	15N 70W
	CIRS_185TI_FIRNADCMP002_PRIME	2013-096T06:43:32	5:00	89S 245W
T91	CIRS_190TI_FIRNADCMP001_PRIME	2013-143T04:32:56	4:00	0N 50W
	CIRS_190TI_FIRNADCMP002_PRIME	2013-144T02:32:56	5:00	45S 300W
T92	CIRS_194TI_FIRNADCMP001_PRIME	2013-191T01:21:47	3:00	30N 90W
T93	CIRS_195TI_FIRNADCMP001_PRIME	2013-206T23:56:22	3:00	20N 15W
T94	CIRS_197TI_FIRNADCMP001_PRIME	2013-254T17:43:56	5:00	60N 110W
T95	CIRS_198TI_FIRNADCMP001_PRIME	2013-286T16:56:27	3:00	89N 30W
	CIRS_198TI_FIRNADCMP002_PRIME	2013-287T13:56:27	4:53	70S 100W
T96	CIRS_199TI_FIRNADCMP001_PRIME	2013-334T10:41:19	5:00	90N (FPB)
T97	CIRS_200TI_FIRNADCMP001_PRIME	2014-001T09:59:41	3:00	50N 165W
	CIRS_200TI_FIRNADCMP002_PRIME	2014-002T06:59:41	4:00	60S 45W
T98	CIRS_201TI_FIRNADCMP001_PRIME	2014-033T05:12:39	5:00	20N 135W
	CIRS_201TI_FIRNADCMP002_PRIME	2014-034T04:12:39	4:00	40S 20W
T100	CIRS_203TI_FIRNADCMP001_PRIME	2014-097T01:41:14	3:00	75N 90W
	CIRS_203TI_FIRNADCMP002_PRIME	2014-097T22:41:14	4:00	0N 0W
T101	CIRS_204TI_FIRNADCMP002_PRIME	2014-138T01:12:15	4:00	0N 210W
T102	CIRS_205TI_FIRNADCMP001_PRIME	2014-169T01:28:25	3:00	45S 300W
	CIRS_205TI_FIRNADCMP002_PRIME	2014-169T22:28:25	3:00	30N 180W
T103	CIRS_206TI_FIRNADCMP001_PRIME	2014-200T22:40:58	3:00	50S 320W
	CIRS_206TI_FIRNADCMP002_PRIME	2014-201T19:40:58	3:00	30N 240W

T104	CIRS_207TI_FIRNADCMP001_PRIME	2014-232T20:09:09	3:00	70S 110W
	CIRS_207TI_FIRNADCMP002_PRIME	2014-233T17:09:09	3:00	80N 150W
T105	CIRS_208TI_FIRNADCMP001_PRIME	2014-264T15:23:19	5:00	80S 300W
	CIRS_208TI_FIRNADCMP002_PRIME	2014-265T14:38:19	2:45	60N 270W
T106	CIRS_209TI_FIRNADCMP001_PRIME	2014-296T14:40:30	3:00	35S 320W
	CIRS_209TI_FIRNADCMP002_PRIME	2014-297T11:40:30	4:00	50N 255W
T107	CIRS_210TI_FIRNADCMP001_PRIME	2014-344T08:26:35	5:00	70S 0W
	CIRS_210TI_FIRNADCMP002_PRIME	2014-345T07:26:35	4:00	20S 195W
T108	CIRS_211TI_FIRNADCMP001_PRIME	2015-011T07:15:35	3:33	20N 20W
	CIRS_211TI_FIRNADCMP002_PRIME	2015-012T04:48:35	4:00	40N 160W
T109	CIRS_212TI_FIRNADCMP002_PRIME	2015-044T02:08:04	4:00	40S 200W
T110	CIRS_213TI_FIRNADCMP001_PRIME	2015-075T02:29:49	3:00	30S 345W
	CIRS_213TI_FIRNADCMP002_PRIME	2015-075T23:29:49	4:00	25N 205W
T111	CIRS_215TI_FIRNADCMP001_PRIME	2015-127T09:50:24	4:00	50S 140W
	CIRS_215TI_FIRNADCMP002_PRIME	2015-128T07:50:24	4:00	30S 310W
T112	CIRS_218TI_FIRNADCMP001_PRIME	2015-187T19:09:51	4:00	20S 40W
	CIRS_218TI_FIRNADCMP002_PRIME	2015-188T17:09:51	4:00	40S 250W

Table 3. CIRS-led far-infrared nadir composition integrations.

4.3 Graphical Representation of Coverage

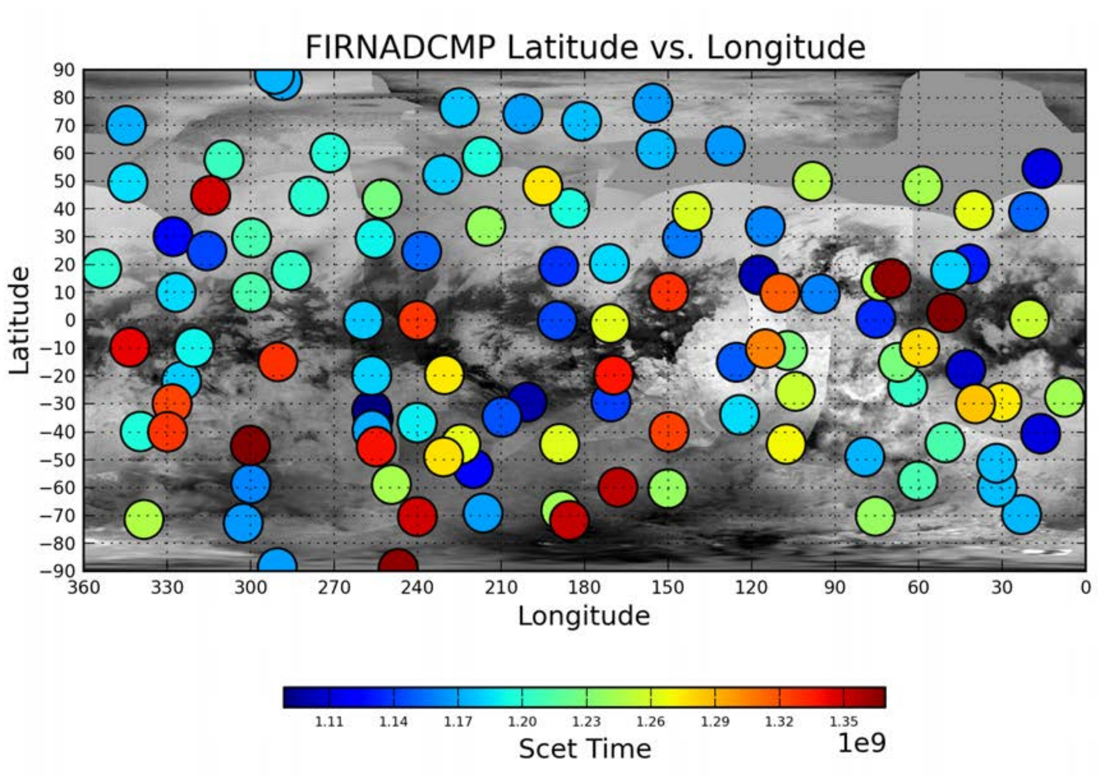


Fig. 3 Spatial coverage by CIRS far-infrared nadir composition integrations. Circular fields-of-view are pictorial only and do not represent the precise size of individual observations, which occur at different ranges and emission angles.

5 Mid-infrared Limb Observations

5.1 Observation Descriptions

5.1.1 Mid-infrared Limb Composition Integration (MIRLMBINT)

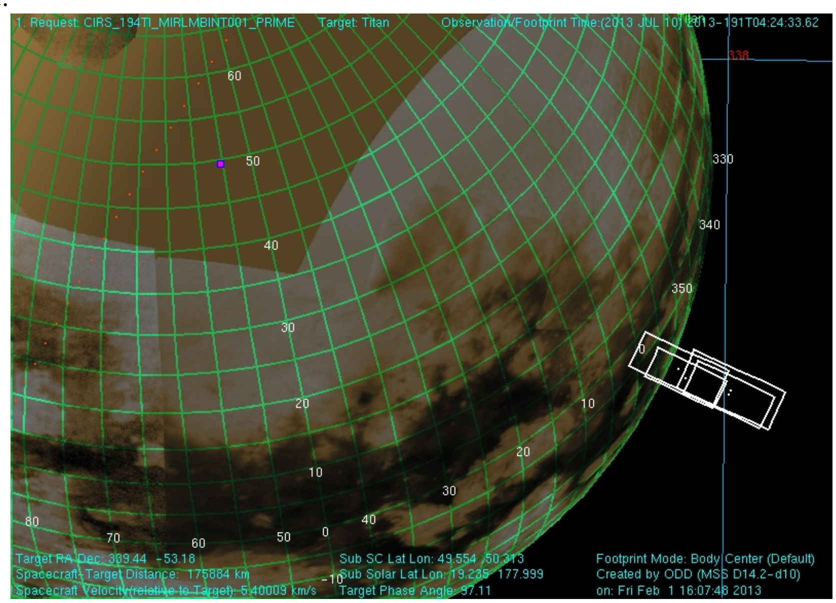
5.1.1.1 Science Description

These sequences are designed to obtain a vertical profile of minor species, as well as to search for new stratospheric species. Similar to a mid-infrared limb map, except that the longer duration of integration allows a spectral resolution of 0.5 cm^{-1} to be obtained at a single location on the limb.

5.1.1.2 Implementation

MIRLMBINT sequences are performed at ranges of 100,000 to 180,000 km, or ±5-9 hours from closest approach. The CIRS mid-infrared arrays (FP3 and FP4) are positioned perpendicular to the limb (stepping towards the limb), with integrations centred at two altitudes (two dwells each), 125 and 225 km, in order to retrieve a full profile while maintaining a 20% overlap to allow for pointing uncertainty. The targeted species would be identical to those for a mid-infrared nadir integration; however, the limb-viewing geometry provides better vertical resolution with the arrays.

5.1.1.3 Example:



This is an example MIRLMBINT sequence, CIRS_193TI_MRLMBINT001_PRIME.

5.1.2 Mid-infrared Limb Map (MIRLMBMAP)

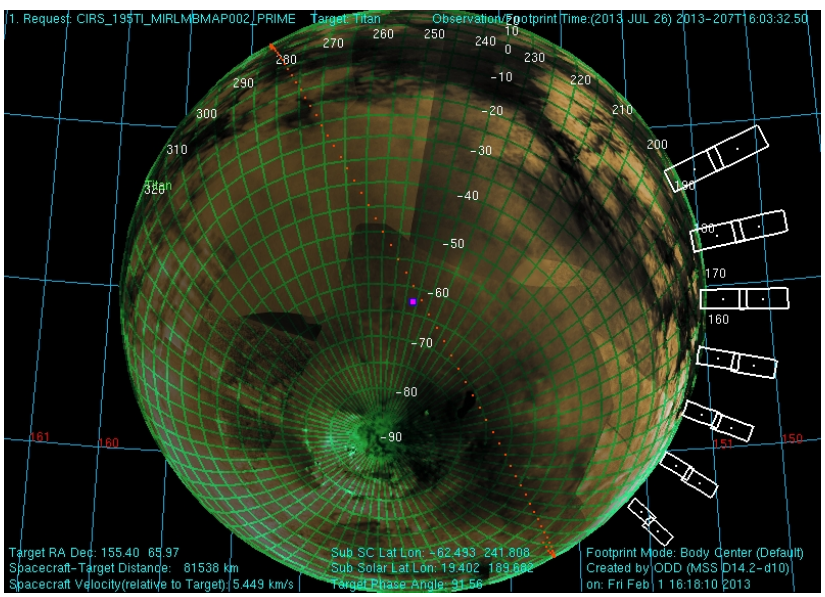
5.1.2.1 Science Description

MIRLMBMAP sequences aim to provide a better vertical temperature resolution in Titan's upper stratosphere and mesosphere. The CIRS mid-infrared focal planes (FP3 and FP4) are used to measure radiances in the υ_4 (1304 cm^{-1}) band of methane. Long durations allow a significant fraction of the limb to be sampled in a single sequence, with a spectral resolution of 15.5 cm^{-1}.

5.1.2.2 Implementation

MIRLMBMAP sequences are performed at a range of 120,000 km, or ±6 hours from closest approach. The focal planes are positioned perpendicular to the limb (away from the limb), and individual mid-infrared pixels provide a vertical resolution of 36 km, which is typical for this type of observation. Two altitudes are observed at each position on the limb in order to provide a full vertical profile, with integrations of 3 to 4 minutes per altitude ensuring a temperature precision of 0.25 K. An overlap of at least 20% between altitudes ensures a complete profile considering pointing uncertainty. Additionally samples should conducted over a quarter of the visible disk, for each latitude the offset should be ±2.493 mrad about X. After one location is observed, the arrays are moved to the next position 5 degrees along the limb, with typically a quarter of the limb being covered in a single sequence. The range of limb chosen is generally centered around a flyby stationary point (see Appendix). Note when the SSCLAT point is near the equator, the sampling should be done every 5 degrees of latitude, up to 18 latitudes. At higher SSCLATs, approximate this geometry by reducing the latitude increments.

5.1.2.3 Example



This is an example MIRLMBMAP sequence, CIRS_195TI_MIRLMBMAP002_PRIME.

5.2 Time-ordered Table of Observations

Titan rev.	Request Name	Start Time	Duration (HR:MN)	Pointing (Lat. range)
TB	CIRS_00BTI_MIRLMBINT002_PRIME	2004-348T16:38:13	2:00	10S
T3	CIRS_003TI_MIRLMBINT002_PRIME	2005-045T19:57:53	4:00	80N
T4	CIRS_005TI_MIRLMBMAP002_PRIME	2005-091T00:35:16	3:30	85N – 0N
T6	CIRS_013TI_MIRLMBMAP002_PRIME	2005-234T01:23:37	2:30	25N - 35S
	CIRS_013TI_MIRLMBMAP003_PRIME	2005-234T13:53:37	2:30	40S – 80S
~~T7~~	~~CIRS_014TI_MIRLMBINT002_PRIME~~	~~2005-250T13:30:26~~	~~3:20~~	~~20N~~
T8	CIRS_017TI_MIRLMBMAP003_PRIME	2005-301T09:38:09	3:20	85M - 10N
T10	CIRS_020TI_MIRLMBINT002_PRIME	2006-015T02:41:27	4:00	55N
T13	CIRS_023TI_MIRLMBMAP004_PRIME	2006-120T11:53:31	2:00	0N – 40S
	CIRS_023TI_MIRLMBMAP006_PRIME	2006-120T14:53:31	2:00	0N – 40N
T14	CIRS_024TI_MIRLMBINT002_PRIME	2006-140T03:18:11	1:30	32S
	CIRS_024TI_MIRLMBINT003_PRIME	2006-140T17:18:11	5:00	50N
T15	CIRS_025TI_MIRLMBINT002_PRIME	2006-183T01:20:47	2:40	55S
T16	CIRS_026TI_MIRLMBINT002_PRIME	2006-202T15:25:26	2:00	45N
	CIRS_026TI_MIRLMBMAP003_PRIME	2006-203T05:25:26	2:15	30N – 75N
T19	CIRS_030TI_MIRLMBINT002_PRIME	2006-282T08:30:07	3:40	60N
	CIRS_030TI_MIRLMBINT003_PRIME	2006-282T22:50:07	2:40	30N
T20	CIRS_031TI_MIRLMBMAP004_PRIME	2006-298T20:28:07	3:00	15S – 50N
T21	CIRS_035TI_MIRLMBINT004_PRIME	2006-346T02:41:31	1:30	15N
	CIRS_035TI_MIRLMBINT003_PRIME	2006-346T18:41:31	2:00	15N
T23	CIRS_037TI_MIRLMBINT001_PRIME	2007-012T23:38:31	4:00	5N
T24	CIRS_038TI_MIRLMBINT002_PRIME	2007-029T12:15:55	4:00	30N
~~T25~~	~~CIRS_039TI_MIRLMBMAP001_PRIME~~	~~2007-052T18:12:24~~	~~3:50~~	~~25N – 30S~~
T26	CIRS_040TI_MIRLMBMAP001_PRIME	2007-068T16:49:00	4:00	30N-30S
T27	CIRS_041TI_MIRLMBINT001_PRIME	2007-084T15:23:27	4:00	20S
T28	CIRS_042TI_MIRLMBINT002_PRIME	2007-101T02:58:00	1:00	30S
T32	CIRS_046TI_MIRLMBMAP001_PRIME	2007-164T08:46:11	4:00	15N – 80S
T35	CIRS_049TI_MIRLMBINT001_PRIME	2007-242T21:32:34	4:00	70N
T37	CIRS_052TI_MIRLMBMAP001_PRIME	2007-322T15:47:25	4:00	60S(R)–20S(L)
T39	CIRS_054TI_MIRLMBMAP001_PRIME	2007-354T13:57:55	3:54	25S – 75N
	CIRS_054TI_MIRLMBINT002_PRIME	2007-355T04:02:55	3:55	45S
T42	CIRS_062TI_MIRLMBINT001_PRIME	2008-085T05:27:48	4:00	55S
	CIRS_062TI_MIRLMBMAP002_PRIME	2008-085T19:27:48	4:00	15S-55S
T43	CIRS_067TI_MIRLMBINT002_PRIME	2008-133T15:01:58	4:00	40N
T45	CIRS_078TI_MIRLMBMAP002_PRIME	2008-213T06:58:11	3:30	0N - 45N
T47	CIRS_093TI_MIRLMBMAP002_PRIME	2008-325T00:56:28	4:00	omitted
T49	CIRS_098TI_MIRLMBINT001_PRIME	2008-356T18:29:52	3:30	15N
T50	CIRS_102TI_MIRLMBINT001_PRIME	2009-037T23:20:51	4:00	BIU anomaly
T51	CIRS_107TI_MIRLMBINT002_PRIME	2009-086T09:43:36	4:00	30S
T54	CIRS_110TI_MIRLMBMAP001_PRIME	2009-125T13:54:16	3:50	30N - 20S
T55	CIRS_111TI_MIRLMPAIR002_PRIME	2009-142T02:26:41	4:00	25S
T59	CIRS_115TI_MIRLMBMAP001_PRIME	2009-205T06:34:04	4:00	0N - 60N
	CIRS_115TI_MIRLMBINT002_PRIME	2009-205T20:34:04	2:00	65N
T63	CIRS_122TI_MIRLMBMAP001_PRIME	2009-345T16:03:14	4:00	85N - 0N
T64	CIRS_123TI_MIRLMPAIR001_PRIME	2009-361T15:16:59	4:00	75N
	CIRS_123TI_MIRLMBINT002_PRIME	2009-362T05:16:59	4:00	75N

T65	CIRS_124TI_MIRLMBINT001_PRIME	2010-012T14:10:37	4:00	75S
	CIRS_124TI_MIRLMBMAP002_PRIME	2010-013T04:10:37	4:00	85S - 0N
T67	CIRS_129TI_MIRLMBINT001_PRIME	2010-095T06:50:39	4:00	88N
T69	CIRS_132TI_MIRLMBMAP001_PRIME	2010-155T17:08:27	4:18	85S - 0N
T70	CIRS_133TI_MIRLMBMAP001_PRIME	2010-171T16:27:33	4:00	5N - 85N
T71	CIRS_134TI_MIRLMBINT001_PRIME	2010-187T15:22:45	3:00	80S
T72	CIRS_138TI_MIRLMPAIR001_PRIME	2010-267T09:38:41	4:00	76N
T73	CIRS_140TI_MILMBMAP001_PRIME	2010-315T04:37:01	4:00	Safing event
T76	CIRS_148TI_MIRLMBMAP001_PRIME	2011-128T13:53:45	4:00	0N - 85N
T77	CIRS_149TI_MIRLMBMAP002_PRIME	2011-171T23:32:01	4:00	0N - 85S
T78	CIRS_153TI_MIRLMBINT001_PRIME	2011-254T17:50:06	4:00	85S
T79	CIRS_158TI_MIRLMBINT501_PRIME	2011-347T11:11:24	4:00	80N
T80	CIRS_159TI_MIRLMBMAP001_PRIME	2012-002T06:13:38	4:00	75N - 10S
T82	CIRS_161TI_MIRLMBINT001_PRIME	2012-049T23:43:17	4:00	45S
	CIRS_161TI_MIRLMBMAP002_PRIME	2012-050T13:43:17	4:00	0N - 80S
T83	CIRS_166TI_MIRLMBINT001_PRIME	2012-142T16:10:11	4:00	0N
T84	CIRS_167TI_MIRLMBINT001_PRIME	2012-158T15:07:21	4:00	45N
T85	CIRS_169TI_MIRLMBMAP002_PRIME	2012-207T01:03:08	4:00	15S - 65N
T88	CIRS_175TI_MIRLMBMAP001_PRIME	2012-333T23:57:00	4:00	50S - 30N
T90	CIRS_185TI_MIRLMBINT001_PRIME	2013-095T12:43:32	4:00	25N
T91	CIRS_190TI_MIRLMBMAP001_PRIME	2013-143T08:32:56	3:00	35N - 15S
T92	CIRS_194TI_MIRLMBINT001_PRIME	2013-191T04:21:47	3:00	20S
T93	CIRS_195TI_MIRLMBMAP002_PRIME	2013-207T15:56:22	5:00	15N - 15S
T95	CIRS_198TI_MIRLMPAIR001_PRIME	2013-286T19:56:27	3:00	16N
	CIRS_198TI_MIRLMBINT001_PRIME	2013-287T10:56:27	3:00	2S
T96	CIRS_199TI_MIRLMBINT002_PRIME	2013-335T05:41:19	4:00	12N
T98	CIRS_201TI_MIRLMBMAP002_PRIME	2014-034T01:12:38	3:00	20N - 25N
T101	CIRS_204TI_MIRLMBINT002_PRIME	2014-137T21:12:15	4:00	35S
T102	CIRS_205TI_MIRLMBINT001_PRIME	2014-169T04:28:25	4:44	10N
	CIRS_205TI_MIRLMBMAP002_PRIME	2014-169T18:28:25	4:00	40N - 13S
T103	CIRS_206TI_MIRLMBINT002_PRIME	2014-201T15:40:58	4:00	30N
T105	CIRS_208TI_MIRLMBINT001_PRIME	2014-264T20:23:19	3:45	See MIDIRTMAP
	CIRS_208TI_MIRLMBMAP002_PRIME	2014-265T12:38:19	2:00	40N - 15N
T106	CIRS_209TI_MIRLMBINT001_PRIME	2014-296T17:40:30	4:00	45S
T108	CIRS_211TI_MIRLMBMAP001_PRIME	2015-011T10:48:35	4:00	30S (R) - 55S (L)
	CIRS_211TI_MIRLMBINT002_PRIME	2015-012T01:48:35	3:00	70N
T110	CIRS_213TI_MIRLMBMAP001_PRIME	2015-075T05:29:49	4:00	80S (L) – 85S – 30S (R)
	CIRS_213TI_MIRLMBINT002_PRIME	2015-128T03:50:24	4:00	80S
T111	CIRS_215TI_MIRLMBMAP002_PRIME	2015-128T03:50:24	4:00	80N (L) – 35N (L)

Table 4. CIRS-led mid-infrared limb observations. For MIRLMBMAP observations, the pointing range given is covered in 5-degree latitude steps.

5.3 Graphical Representation of Coverage

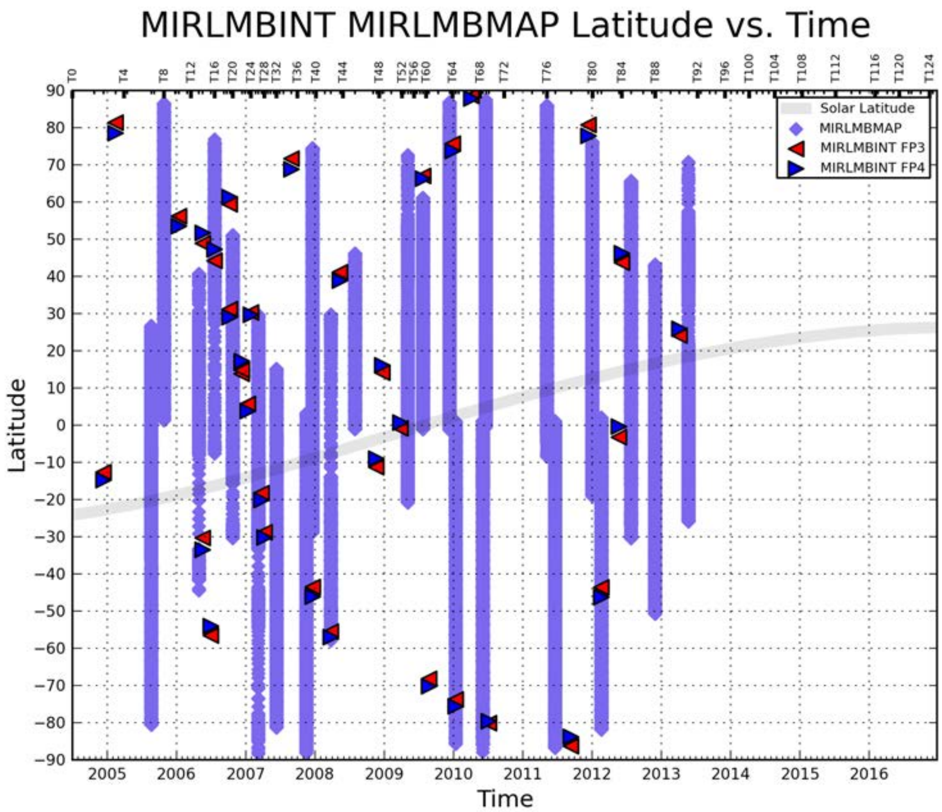


Fig. 4 Latitudinal coverage of Titan's limb by CIRS-led mid-infrared observations

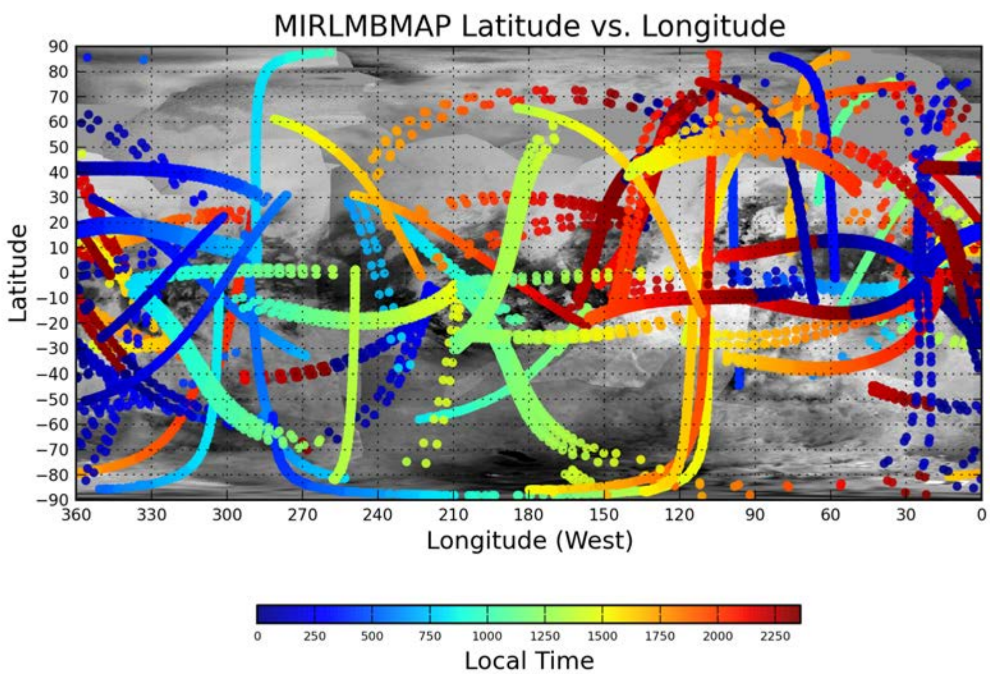


Fig. 5 Latitudinal-longitude tracks of MIRLMBMAP tangent points on Titan, through T32.

6 Mid-infrared Nadir Temperature Maps (MIDIRTMAP)

6.1 Observation Description

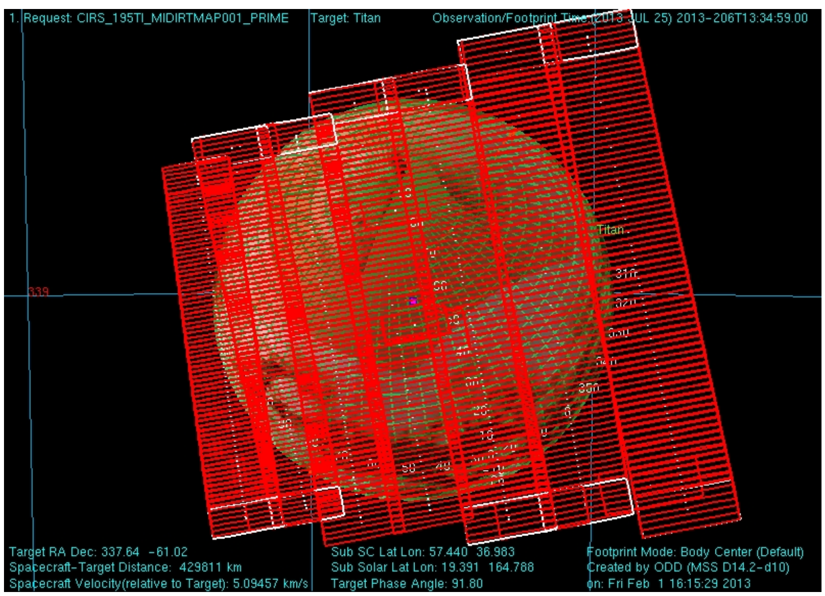
6.1.1 Science Description

MIDIRTMAP sequences map temperatures in the upper stratosphere of Titan by measuring radiances in the υ_4 (1304 cm^{-1}) band of methane, obtained using the CIRS mid-infrared focal planes (FP3 and FP4).

6.1.2 Implementation

MIDIRTMAP sequences are typically executed within a range of 380,000 km, or ±19 hours from closest approach. The map is completed as a series of continuous slews executed in a push-broom fashion, covering the entire visible hemisphere with a spectral resolution of 3cm^{-1}, which ensures a precision of 0.25 K in retrieved temperatures. Typically 6 slews are required to cover the disk, of about 2.6 mrad in X between the scan legs, allowing for pointing uncertainty and around 20% overlap of consecutive slews, at a slew-rate of 4 $\mu rad s^{-1}$. If time permits, deep-space calibrations are performed at the beginning or end of the sequence by positioning the focal planes beyond Titan's exosphere for a period of at least 10 minutes.

6.1.3 Example



This is a example MIDIRTMAP sequence, CIRS_195TI_MIDIRTMAP001_PRIME.

6.2 Time-ordered Table of Observations

Titan rev.	Request Name	Start Time	Duration (HR:MN)
~~TA~~	~~CIRS_00ATI_MIDIRTMAP001_PRIME~~	~~2004-299T17:30:09~~	~~5:15~~
TB	CIRS_00BTI_MIDIRTMAP001_PRIME	2004-347T15:13:13	8:25
T3	CIRS_003TI_MIDIRTMAP002_PRIME	2005-045T09:57:53	9:00
	CIRS_003TI_MIDIRTMAP003_PRIME	2005-046T18:57:53	4:20
T4	CIRS_005TI_MIDIRTMAP003_PRIME	2005-091T08:05:16	6:30
T6	CIRS_013TI_MIDIRTMAP007_PRIME	2005-234T20:53:37	7:03
~~T7~~	~~CIRS_014TI_MIDIRTMAP006_PRIME~~	~~2005-249T06:00:00~~	~~5:00~~
	~~CIRS_014TI_MIDIRTMAP005_PRIME~~	~~2005-250T20:11:57~~	~~6:11~~
T8	CIRS_017TI_MIDIRTMAP008_PRIME	2005-300T01:24:00	7:00
	CIRS_017TI_MIDIRTMAP005_PRIME	2005-301T16:15:25	7:48
T9	CIRS_019TI_MIDIRTMAP009_PRIME	2005-361T14:04:00	13:33
T10	CIRS_020TI_MIDIRTMAP010_PRIME	2006-014T14:23:27	9:18
T14	CIRS_024TI_MIDIRTMAP001_PRIME	2006-141T01:18:11	2:00
	CIRS_024TI_MIDIRTMAP002_PRIME	2006-141T06:18:11	2:58
T15	CIRS_025TI_MIDIRTMAP002_PRIME	2006-183T23:50:47	7:54
T17	CIRS_028TI_MIDIRTMAP006_PRIME	2006-249T21:56:51	7:20
T18	CIRS_029TI_MIDIRTMAP004_PRIME	2006-265T20:58:49	7:00
T19	CIRS_030TI_MIDIRTMAP006_PRIME	2006-281T20:16:07	6:14
T21	CIRS_035TI_MIDIRTMAP006_PRIME	2006-345T16:08:31	4:03
T22	CIRS_036TI_MIDIRTMAP006_PRIME	2006-361T15:04:22	5:01
T23	CIRS_037TI_MIDIRTMAP001_PRIME	2007-012T14:23:31	2:15
	CIRS_037TI_MIDIRTMAP002_PRIME	2007-012T17:38:31	2:00
	CIRS_037TI_MIDIRTMAP003_PRIME	2007-013T22:38:31	3:25
T24	CIRS_038TI_MIDIRTMAP001_PRIME	2007-028T13:00:55	2:15
	CIRS_038TI_MIDIRTMAP002_PRIME	2007-029T21:15:55	5:14
~~T25~~	~~CIRS_039TI_MIDIRTMAP001_PRIME~~	~~2007-052T12:10:59~~	~~2:00~~
	~~CIRS_039TI_MIDIRTMAP002_PRIME~~	~~2007-053T17:10:59~~	~~7:15~~
T26	CIRS_040TI_MIDIRTMAP001_PRIME	2007-068T11:08:00	1:41
T27	CIRS_041TI_MIDIRTMAP001_PRIME	2007-084T09:07:27	2:16
T28	CIRS_042TI_MIDIRTMAP002_PRIME	2007-101T12:58:00	7:14
T30	CIRS_044TI_MIDIRTMAP001_PRIME	2007-132T05:45:58	1:24
	CIRS_044TI_MIDIRTMAP002_PRIME	2007-133T10:09:58	1:19
T32	CIRS_046TI_MIDIRTMAP002_PRIME	2007-165T07:46:11	2:15
T34	CIRS_048TI_MIDIRTMAP001_PRIME	2007-199T01:48:20	7:23
T35	CIRS_049TI_MIDIRTMAP002_PRIME	2007-243T21:32:34	6:00
T36	CIRS_050TI_MIDIRTMAP002_PRIME	2007-275T18:42:43	8:46
T37	CIRS_052TI_MIDIRTMAP002_PRIME	2007-323T14:47:25	7:00
T38	CIRS_053TI_MIDIRTMAP002_PRIME	2007-339T14:06:50	9:37
T40	CIRS_055TI_MIDIRTMAP002_PRIME	2008-006T11:30:20	7:00
T41	CIRS_059TI_MIDIRTMAP002_PRIME	2008-054T12:32:07	2:53
T43	CIRS_067TI_MIDIRTMAP002_PRIME	2008-134T02:46:58	6:30
T44	CIRS_069TI_MIDIRTMAP001_PRIME	2008-148T10:24:32	6:00
T45	CIRS_078TI_MIDIRTMAP001_PRIME	2008-212T08:05:21	4:07
T46	CIRS_091TI_MIDIRTMAP001_PRIME	2008-307T20:17:34	BIU anomaly
	CIRS_091TI_MIDIRTMAP002_PRIME	2008-309T07:35:24	omitted

T47	CIRS_093TI_MIDIRTMAP002_PRIME	2008-325T05:56:28	2:00
T48	CIRS_096TI_MIDIRTMAP001_PRIME	2008-341T04:25:45	3:06
T49	CIRS_097TI_MIDIRTMAP001_PRIME	2008-355T17:24:32	6:35
	CIRS_098TI_MIDIRTMAP002_PRIME	2008-357T02:29:52	3:30
T50	CIRS_102TI_MIDIRTMAP002_PRIME	2009-038T18:50:51	BIU anomaly
	CIRS_102TI_MIDIRTMAP003_PRIME	2009-038T22:20:51	
T51	CIRS_106TI_MIDIRTMAP001_PRIME	2009-085T11:00:31	3:43
	CIRS_107TI_MIDIRTMAP002_PRIME	2009-086T18:13:36	5:12
T52	CIRS_107TI_MIDIRTMAP001_PRIME	2009-093T10:29:34	1:48
	CIRS_108TI_MIDIRTMAP002_PRIME	2009-094T15:47:47	7:37
T53	CIRS_109TI_MIDIRTMAP002_PRIME	2009-110T14:20:45	Downlink
T54	CIRS_110TI_MIDIRTMAP001_PRIME	2009-125T08:11:47	4:42
T55	CIRS_111TI_MIDIRTMAP001_PRIME	2009-141T07:09:49	1:17
	CIRS_111TI_MIDIRTMAP002_PRIME	2009-142T11:26:41	8:00
T57	CIRS_113TI_MIDIRTMAP002_PRIME	2009-174T08:32:35	8:00
T59	CIRS_115TI_MIDIRTMAP001_PRIME	2009-204T23:34:04	3:00
T62	CIRS_119TI_MIDIRTMAP001_PRIME	2009-284T15:15:21	4:21
T63	CIRS_122TI_MIDIRTMAP002_PRIME	2009-346T15:03:14	5:00
T64	CIRS_123TI_MIDIRTMAP001_PRIME	2009-361T10:07:24	4:10
T65	CIRS_124TI_CLOUDMAP001_VIMS	2010-012T09:07:41	2:53
	CIRS_124TI_MIDIRTMAP002_PRIME	2010-013T13:10:37	5:21
T68	CIRS_131TI_MIDIRTMAP001_PRIME	2010-139T08:10:04	5:44
	CIRS_131TI_MIDIRTMAP002_PRIME	2010-140T16:24:20	4:40
T73	CIRS_140TI_MIDIRTMAP001_PRIME	2010-314T21:14:00	Safing event
T74	CIRS_145TI_MIDIRTMAP001_PRIME	2011-048T21:26:11	6:38
	CIRS_145TI_MIDIRTMAP002_PRIME	2011-050T04:04:11	5:01
T76	CIRS_148TI_MIDIRTMAP002_PRIME	2011-129T12:53:45	8:13
T77	CIRS_149TI_MIDIRTMAP002_PRIME	2011-172T08:32:01	9:45
T78	CIRS_153TI_MIDIRTMAP001_PRIME	2011-254T07:42:00	6:08
T79	CIRS_158TI_MIDIRTMAP002_PRIME	2011-348T10:11:24	2:29
T82	CIRS_161TI_MIDIRTMAP001_PRIME	2012-049T15:54:00	4:49
T84	CIRS_167TI_MIDIRTMAP001_PRIME	2012-158T08:24:00	2:43
	CIRS_167TI_MIDIRTMAP002_PRIME	2012-159T14:07:21	7:12
T85	CIRS_169TI_MIDIRTMAP001_PRIME	2012-205T21:33:00	9:30
T86	CIRS_172TI_MIDIRTMAP002_PRIME	2012-271T04:35:39	14:45
T87	CIRS_174TI_MIDIRTMAP001_PRIME	2012-317T14:56:00	6:26
	CIRS_174TI_MIDIRTMAP002_PRIME	2012-319T00:22:09	10:44
T88	CIRS_175TI_MIDIRTMAP002_PRIME	2012-334T22:57:00	11:43
T89	CIRS_181TI_MIDIRTMAP001_PRIME	2013-047T09:21:00	2:30
	CIRS_181TI_MIDIRTMAP002_PRIME	2013-048T13:56:36	8:19
T90	CIRS_185TI_MIDIRTMAP001_PRIME	2013-095T05:56:00	2:48
	CIRS_185TI_MIDIRTMAP002_PRIME	2013-096T11:43:32	5:52
T91	CIRS_190TI_MIDIRTMAP001_PRIME	2013-143T02:41:01	1:52
	CIRS_190TI_MIDIRTMAP002_PRIME	2013-144T07:32:56	8:03
T93	CIRS_195TI_MIDIRTMAP001_PRIME	2013-206T13:33:59	8:22
T94	CIRS_197TI_MIDIRTMAP001_PRIME	2013-254T08:57:59	8:46
T95	CIRS_198TI_MIDIRTMAP001_PRIME	2013-286T07:09:59	7:46

T96	CIRS_199TI_MIDIRTMAP001_PRIME	2013-334T04:40:00	6:01
T97	CIRS_200TI_MIDIRTMAP001_PRIME	2014-001T02:42:59	5:17
	CIRS_200TI_MIDIRTMAP002_PRIME	2014-002T10:59:41	3:23
T98	CIRS_201TI_MIDIRTMAP001_PRIME	2014-033T00:47:00	4:26
	CIRS_201TI_MIDIRTMAP002_PRIME	2014-034T08:12:39	5:59
T99	CIRS_202TI_MIDIRTMAP002_PRIME	2014-066T04:26:48	7:19
T100	CIRS_203TI_MIDIRTMAP001_PRIME	2014-096T20:39:59	3:01
	CIRS_203TI_MIDIRTMAP002_PRIME	2014-098T02:41:14	8:24
T101	CIRS_204TI_MIDIRTMAP001_PRIME	2014-136T17:55:59	3:46
	CIRS_204TI_MIDIRTMAP002_PRIME	2014-138T05:12:15	2:54
T102	CIRS_205TI_MIDIRTMAP001_PRIME	2014-168T15:39:00	7:49
	CIRS_205TI_MIDIRTMAP002_PRIME	2014-170T01:28:25	3:06
T103	CIRS_206TI_MIDIRTMAP001_PRIME	2014-200T13:20:59	7:20
T104	CIRS_207TI_MIDIRTMAP001_PRIME	2014-232T11:15:59	6:53
	CIRS_207TI_MIDIRTMAP002_PRIME	2014-233T22:09:09	2:17
T105	CIRS_208TI_MIDIRTMAP001_PRIME	2014-264T09:11:59	6:11
	CIRS_208TI_MIRLMBINT001_PRIME*	2014-264T20:23:19	3:45
	CIRS_208TI_MIDIRTMAP002_PRIME	2014-265T17:23:19	2:44
T106	CIRS_209TI_MIDIRTMAP001_PRIME	2014-296T07:10:00	5:31
	CIRS_209TI_MIDIRTMAP002_PRIME	2014-297T15:40:30	3:10
T107	CIRS_210TI_MIDIRTMAP001_PRIME	2014-344T04:25:00	4:02
	CIRS_210TI_MIDIRTMAP002_PRIME	2014-345T11:26:35	4:38
T108	CIRS_211TI_MIDIRTMAP001_PRIME	2015-012T08:48:35	6:03
T109	CIRS_212TI_MIDIRTMAP002_PRIME	2015-044T06:08:04	8:17
T110	CIRS_213TI_MIDIRTMAP001_PRIME	2015-074T22:50:00	3:39
	CIRS_213TI_MIDIRTMAP002_PRIME	2015-076T03:29:49	8:31
T111	CIRS_215TI_MIDIRTMAP001_PRIME	2015-127T05:09:59	4:41
	CIRS_215TI_MIDIRTMAP002_PRIME	2015-128T11:50:24	5:29
T112	CIRS_218TI_MIDIRTMAP001_PRIME	2015-187T12:27:00	6:42
	CIRS_218TI_MIDIRTMAP002_PRIME	2015-188T21:09:51	3:54

Table 5. (Continued from previous pages) CIRS-led mid-infrared nadir temperature map requests.

***CIRS_208TI_MIRLMBINT001_PRIME is built as a high-resolution map of the south polar region, covering the region south of 50S with FP1/3/4. The change in target was made when it was no longer possible to change the observation's name.**

6.3 Graphical Representation of Coverage

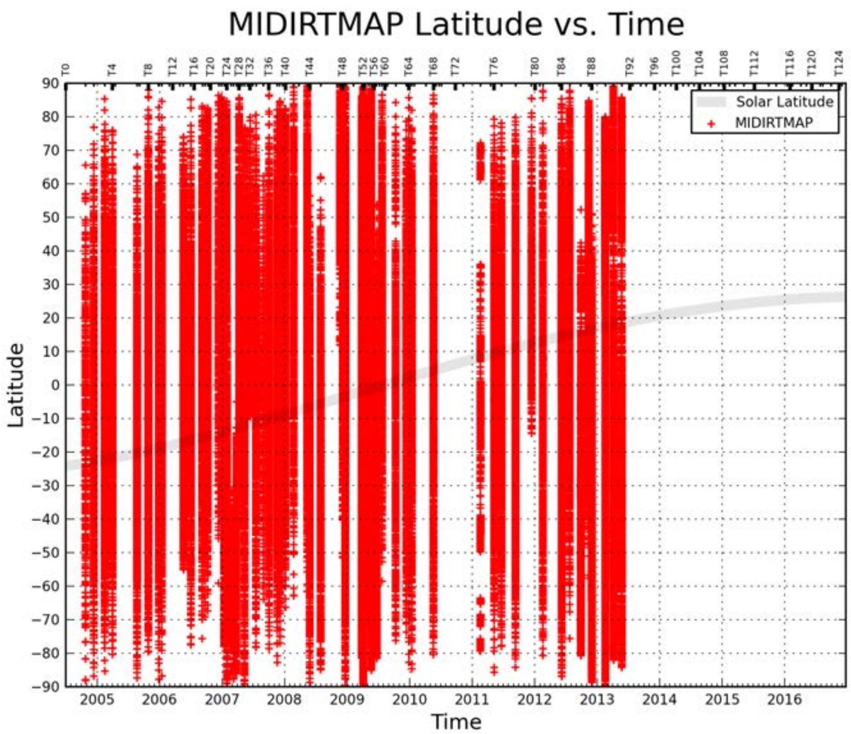


Figure 6. MIDIRTMAP latitudinal coverage.

7 Distant Mid-infrared Observations

7.1 Observation Descriptions

7.1.1 Composition Maps (COMPMAPs)

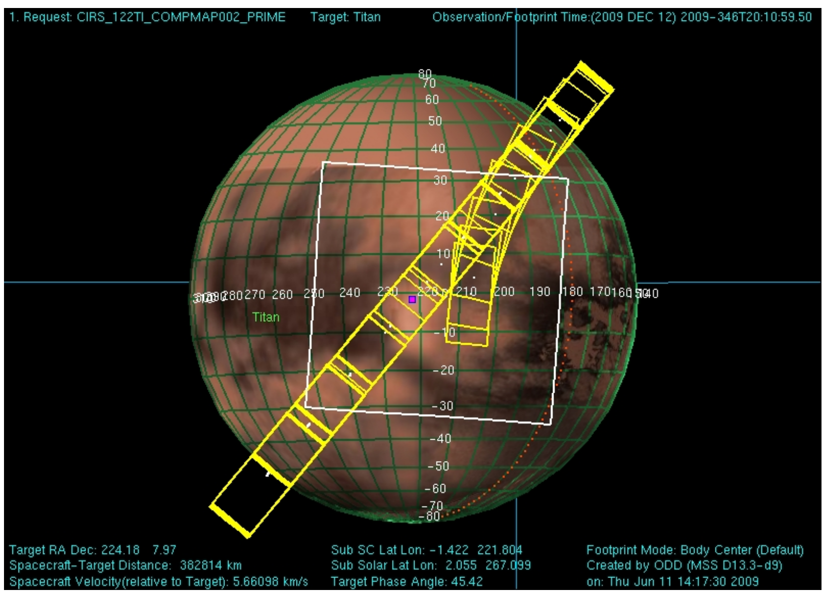
7.1.1.1 Science Description

COMPMAP sequences are designed to search for new species and/or monitor temperatures.

7.1.1.2 Implementation

These observations are generally around 300,000 to 700,000 km distant from Titan, or ±15 to ±35 hours from closest approach. FP3/FP4 are either stepped across the disk in a N-S or E-W transects, or they stare at one or two areas of interest for the duration of the observation. Duration is variable, generally between 2 and 6 hours.

7.1.1.3 Example



This is an example COMPMAP sequence, CIRS_122TI_COMPMAP002_PRIME

7.1.2 Titan Explorations at Apoapse (TEAs)

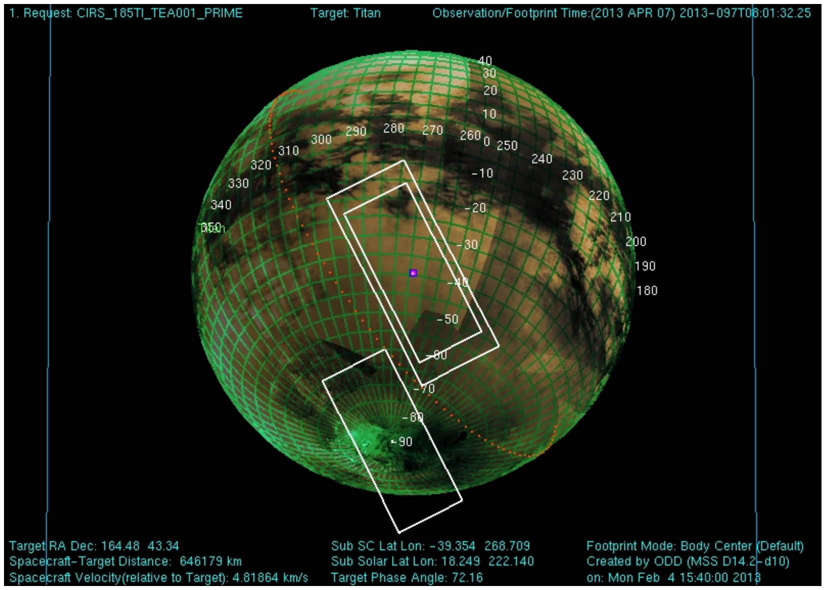
7.1.2.1 Science Description

TEA sequences are similar to COMPMAPs, but at a greater distance from Titan, they are designed to search for new species and/or monitor temperatures.

7.1.2.2 Implementation

TEA sequences occur at 800,000 to 2 million km from Titan and for a longer duration of 12 to 36 hours, or between 40 and 100 hours from closest approach. ISS rides, and when angular diameter is greater than 6 mrad (range less than 860,000 km), an ISS NAC mosaic is performed at intervals until Titan is contained within a NAC field of view.

7.1.2.3 Example



This is a example TEA sequence, CIRS_185TI_TEA001_PRIME.

7.2 Time-ordered Table of Observations

Request Name	Start Time	Duration (HR:MN)	Midpoint (Latitude)
CIRS_009TI_COMPMAP002_PRIME	2005-157T09:30:00	6:30	59S
CIRS_010TI_COMPMAP003_PRIME	2005-173T03:00:00	11:00	35S
CIRS_015TI_COMPMAP005_PRIME	2005-267T19:50:00	8:15	10S
CIRS_016TI_COMPMAP006_PRIME	2005-282T20:27:00	11:00	9S
CIRS_022TI_COMPMAP002_PRIME	2006-076T08:20:00	13:59	7S
CIRS_030TI_COMPMAP007_PRIME	2006-283T19:30:00	3:50	27S
CIRS_031TI_COMPMAP008_PRIME	2006-296T11:26:00	14:00	22N
CIRS_033TI_COMPMAP009_PRIME	2006-328T18:15:00	10:45	63N
CIRS_035TI_COMPMAP010_PRIME	2006-344T19:17:00	10:30	Downlink
CIRS_036TI_COMPMAP024_PRIME	2006-360T19:49:00	9:00	35N
CIRS_037TI_COMPMAP026_PRIME	2007-011T16:13:00	9:51	32N
CIRS_037TI_COMPMAP012_PRIME	2007-014T14:04:00	2:00	41S
CIRS_038TI_COMPMAP013_PRIME	2007-026T17:51:00	9:00	46N
CIRS_040TI_COMPMAP026_PRIME	2007-067T19:51:00	4:00	43S
CIRS_041TI_COMPMAP028_PRIME	2007-083T16:50:00	4:00	RWA interference
CIRS_041TI_COMPMAP029_PRIME	2007-086T07:42:00	15:22	24N
CIRS_041TI_COMPMAP030_PRIME	2007-087T08:45:00	5:30	21N
CIRS_043TI_COMPMAP002_PRIME	2007-117T11:32:58	0:42	75N
CIRS_044TI_COMPMAP015_PRIME	2007-134T02:43:00	8:00	12N
CIRS_048TI_COMPMAP013_PRIME	2007-198T10:40:00	4:00	38N
CIRS_051TI_COMPMAP016_PRIME	2007-292T20:53:00	11:00	1S
CIRS_051TI_COMPMAP017_PRIME	2007-293T20:23:00	3:07	5N

CIRS_051TI_COMPMAP018_PRIME	2007-294T02:00:00	6:23	8N
CIRS_052TI_COMPMAP016_PRIME	2007-323T21:47:25	2:19	57N
CIRS_052TI_COMPMAP015_PRIME	2007-324T10:27:00	7:00	3S
CIRS_055TI_COMPMAP001_PRIME	2008-006T18:30:20	3:14	67N
CIRS_057TI_COMPMAP018_PRIME	2008-022T14:11:00	7:54	51N
CIRS_059TI_COMPMAP001_PRIME	2008-052T12:06:00	6:15	23S
CIRS_062TI_COMPMAP019_PRIME	2008-087T01:50:00	21:30	40N
CIRS_066TI_COMPMAP021_PRIME	2008-118T07:17:00	7:00	58N
CIRS_067TI_COMPMAP001_PRIME	2008-134T09:16:58	3:04	69N
CIRS_069TI_COMPMAP001_PRIME	2008-148T08:19:32	2:05	82S
CIRS_072TI_COMPMAP021_PRIME	2008-165T09:40:00	8:00	59N
CIRS_083TI_COMPMAP001_PRIME	2008-244T17:04:00	7:46	72N
CIRS_103TI_COMPMAP001_PRIME	2009-044T13:13:00	8:17	3S
CIRS_122TI_COMPMAP002_PRIME	2009-346T20:03:14	4:00	5N
CIRS_123TI_COMPMAP001_PRIME	2009-363T15:32:00	8:00	10S
CIRS_124TI_COMPMAP002_PRIME	2010-013T18:31:36	3:39	9N
CIRS_128TI_COMPMAP001_PRIME	2010-078T03:49:00	7:15	7N
CIRS_131TI_COMPMAP001_PRIME	2010-141T09:40:00	8:00	8N
CIRS_134TI_COMPMAP001_PRIME	2010-189T12:49:00	10:10	1S
CIRS_139TI_COMPMAP001_PRIME	2010-287T04:52:00	13:30	75S
CIRS_140TI_COMPMAP001_PRIME	2010-316T22:00:00	8:00	Safing event
CIRS_140TI_COMPMAP002_PRIME	2010-319T09:19:00	8:00	
CIRS_143TI_COMPMAP001_PRIME	2011-014T17:05:00	10:10	5N
CIRS_149TI_TEA001_PRIME	2011-173T09:00:00	7:30	0N
CIRS_149TI_TEA002_PRIME	2011-174T05:42:00	21:00	0N
CIRS_149TI_TEA003_PRIME	2011-175T11:42:00	15:00	0N
CIRS_149TI_TEA004_PRIME	2011-176T11:42:00	37:29	0N
CIRS_154TI_COMPMAP001_PRIME	2011-269T22:50:00	6:00	0N
CIRS_155TI_TEA003_PRIME	2011-297T05:00:00	19:00	0N
CIRS_155TI_TEA004_PRIME	2011-298T14:32:00	13:15	0N
CIRS_155TI_TEA005_PRIME	2011-299T14:17:00	13:30	0N
CIRS_156TI_TEA003_PRIME	2011-303T14:02:00	13:30	0N
CIRS_156TI_TEA004_PRIME	2011-304T14:02:00	13:30	0N
CIRS_156TI_TEA005_PRIME	2011-305T14:02:00	28:45	0N
CIRS_156TI_TEA006_PRIME	2011-307T03:47:00	15:00	0N
CIRS_157TI_COMPMAP001_PRIME	2011-331T18:00:00	15:34	48N, 0N, 48S
CIRS_158TI_TEA001_PRIME	2011-350T11:20:00	15:00	0N
CIRS_160TI_TEA002_PRIME	2012-032T15:57:00	31:30	2S
CIRS_160TI_TEA003_PRIME	2012-034T08:27:00	15:00	1S
CIRS_160TI_TEA004_PRIME	2012-035T08:27:00	20:45	1S
CIRS_160TI_TEA005_PRIME	2012-038T17:22:00	11:10	0N
CIRS_161TI_TEA001_PRIME	2012-042T17:08:00	11:10	0N
CIRS_181TI_TEA001_PRIME	2013-049T08:11:00	28:46	85S, 80S, 75S,

			70S
CIRS_181TI_TEA002_PRIME	2013-050T21:57:00	25:00	60S, 50S
CIRS_182TI_TEA001_PRIME	2013-052T07:57:00	22:30	40S (FP1)
CIRS_182TI_TEA002_PRIME	2013-053T15:27:00	15:00	50S
CIRS_185TI_TEA001_PRIME	2013-097T07:36:00	10:55	40S
CIRS_186TI_TEA001_PRIME	2013-098T05:01:00	14:45	40S
CIRS_186TI_TEA002_PRIME	2013-099T04:46:00	15:00	40S
CIRS_202TI_TEA001_PRIME	2014-061T21:56:00	15:00	50N
CIRS_202TI_TEA002_PRIME	2014-062T21:56:00	15:00	45N
CIRS_202TI_TEA003_PRIME	2014-063T21:56:00	15:00	90N
CIRS_206TI_TEAFP1001_PRIME	2014-191T00:00:00	13:00	48N (FP1)
CIRS_206TI_TEA002_PRIME	2014-191T13:00:00	13:27	49N
CIRS_206TI_TEA003_PRIME	2014-192T12:57:00	37:15	56N
CIRS_219TI_TEA001_PRIME	2015-204T13:06:00	13:20	
CIRS_219TI_TEA002_PRIME	2015-205T12:56:00	13:30	

Table 6. (Continued from previous page) Distant mid-IR Titan surface observations.

Appendix: Limb Stationary Points

Derivation of intersecting coordinates of two circles on the surface of a sphere

Firstly, the formula of a sphere in Cartesian coordinates is given by:

$$x^2 + y^2 + z^2 = R^2$$

Next, imagine a circle projected on the surface of the sphere. In this case, the x-axis runs through the center of the circle. The edge of the circle can be represented as the intersection of a plane with the surface of the sphere, with the distance between the center of the sphere and the closest point on the plane represented by x_0 where $x_0 \leq R$. The distance from the edge of the circle to the center of the circle at x_0 is represented by a, which is simply the radius of the circle.

Hence,

$$R^2 = x_0^2 + a^2$$

$$a^2 = R^2 + x_0^2$$

Therefore the circle is represented by:

$$y^2 + z^2 = a^2 = R^2 - x_0^2$$

The next observation shows the application of deriving such a formula. For example, as the spacecraft rounds Titan, the horizon changes. This is trivial. However, when the spacecraft is within ± 1 hour of closest approach to Titan, the horizon view is rather small relative to distance farther out. As a result of the proximity to Titan, there are always two points on the surface where the horizon changes very little, known as 'positions of least blur'. The formula for finding two intersecting circles on the surface of a sphere is applicable to this example. The first key to finding these points is to find the arc length s traversed across Titan by the probe.

The angle traversed, 2α, is related to the arc length by:

$$2\alpha = \frac{s}{R}$$

The new coordinates based on the traversed angle are obtained by using the rotation matrix:

$$A = \begin{pmatrix} \cos(\alpha) & \sin(\alpha) & 0 \\ -\sin(\alpha) & \cos(\alpha) & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

The angle α is used for symmetry, allowing $y = 0$ at the points of intersection. The matrix equation describing the intersection is:

$$A \cdot u = v$$

where $u = \begin{pmatrix} x \\ y \\ z \end{pmatrix}$ and $v = \begin{pmatrix} x' \\ y' \\ z' \end{pmatrix}$.

This yields the equations:

1. $x' = x \cdot \cos(\alpha) + y \cdot \sin(\alpha)$
2. $y' = -y \cdot \sin(\alpha) + y \cdot \cos(\alpha)$
3. $z' = z$

Substituting these new coordinates into the equation for the circle on the sphere,

$$y^2 + z^2 = a^2 = R^2 - x_0^2$$

yields the equation,

$$(x \cdot \sin(\alpha))^2 - 2 \cdot x \cdot y \cdot \sin(\alpha) \cdot \cos(\alpha) + (y \cdot \cos(\alpha))^2 + z^2 = R^2 - x_0^2$$

Solving this equation with the angle $-\alpha$ yields $y = 0$, after the cancelling of terms. Substituting $y = 0$ into our equation 1 for x' above and letting $x' = x_0$ yields:

$$x = x_0 \cdot \arccos(\alpha)$$

It then follows that:

$$z = \pm\sqrt{R^2 - x_0^2 \cdot \sec^2(\alpha)}$$

Thus we have our two points where the horizons intersect on the surface of Titan, with coordinates given by:

$$x = x_0 \cdot \arccos(\alpha)$$

$$y = 0$$
$$z = \pm\sqrt{R^2 - x_0^2 \cdot \sec^2(\alpha)}$$