IRIS Technical Note 30
30 Day Observing Plan and Beyond

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1. Introduction

This document outline a plan of observations for the first “30+ days” of scientific observations of the Interface Region Imaging Spectrograph (IRIS). The “30+ days” start after many of the IRIS instrumental properties have been characterized during commissioning (which ends about 30 days after launch). We assume that the following properties have been measured/determined to some extent during commissioning:

- optimal focus
- pointing calibration (PZTs and wedge motors)
- typical exposure times for quiet Sun, coronal holes, active region sunspots, and plage, both on disk and at the limb for a range of the brightest spectral lines
- typical cadence that can be obtained on orbit including mechanism movement, readout table generation, readout-time, data processing
- optimal compression parameters, look-up tables and compression of various datasets

If there are significant uncertainties on some of these properties by the end of commissioning, we will focus on calibration of the instrument before embarking on the 30+ day plan.

The main goal of this document is to provide an outline and guide to early operations so that IRIS obtains high quality and novel measurements that address the three science goals from the very start of the scientific mission, when throughput is maximal and the Sun is likely to be the most active. While the plan has a day-by-day “schedule”, this is not meant to be a rigorous schedule that is adhered to at all cost. There will likely be discoveries (both instrumental and solar) and targets of opportunity that will lead to some changes, repeats and deletions.

In the following we briefly outline the top-level and derived science goals of IRIS that this 30+ day observing plan aims to address (section 2), the basic IRIS observing modes that have been designed to address these goals (section 3), and the implementation of the 30+ day observing plan (section 4).

2. Science Goals

IRIS' three main science goals are to determine:

1. Which types of non-thermal energy dominate in the chromosphere and beyond?
2. How does the chromosphere regulate mass and energy supply to the corona and heliosphere?
3. How do magnetic flux and matter with in rise through the atmosphere, and what role does flux emergence play in flares and mass ejections?

These broad science topics cover many different more detailed topics. Below we provide a necessarily incomplete list of subtopics in order to provide a better view of what types of observations and targeting are required to address the science topics. For each of the topics below, we indicate which of the main science goals (G1, G2, G3) they help address.

2.1 Waves

W1: The role of sound waves in heating the quiet chromosphere
    - high frequency, energy budget considerations, ...

W2: The role of magneto-acoustic gravity waves in the solar atmosphere
    - heating of quiet chromosphere, mode-coupling

W3: The role of sound waves in heating the magnetic chromosphere
    - formation of shock waves, dynamic fibrils, type I spicules, …

W4: The role of sound waves vs. upflows in coronal propagating disturbances
    - outflows, spicules, coupling to Alfvenic waves, ...

W5: The generation of transverse magnetic waves (swaying/torsional motions)
    - role of vorticity, mode coupling to magneto-acoustic gravity (MAG) waves, p-mode oscillations, motion of magnetic elements, ...

W6: Energy budget and power spectrum of transverse magnetic waves
    - quiet Sun, active region and coronal holes, chromosphere/corona
    - high frequency waves?

W7: Propagation and dissipation of transverse magnetic waves
    - phase delays, standing waves, spicules, …
    - temporal evolution of Alfven wave energy dissipation in chromosphere/corona

W8: Mode coupling

- MAG waves, sound waves, Alfvenic waves across beta=1

W9: Atmospheric seismology
- fast mode waves, flare-triggered waves, …

2.2 Currents/Braiding

CB1: Role of currents in heating of magnetic chromosphere
- relationship between elevated temperatures and flux tube locations
- ion-neutral effects in dissipation (Pedersen resistivity)

CB2: Role of braiding in heating the corona
- HiC observations of braiding in corona?
- comparison with 3D radiative MHD simulations of the corona
- locations of highest dissipation

CB3: Relationship between chromospheric/coronal heating in footpoint regions

CB4: Relationship between footpoint signals and overlying corona
- time dependence of moss emission

CB5: Are spicules sheets?

2.3 Coronal mass/energy balance

CM1: Role of spicules in providing mass to corona
- thermal evolution of chromospheric spicules to TR/coronal temperatures
- spicule driving mechanism?

CM2: Relationship between chromospheric/TR/coronal velocities in footpoint regions
- coronal contraflow

CM3: Role of torsional motions in coronal energy balance

2.4 Solar wind mass/energy balance

SW1: Role of funnels in providing mass to solar wind
- Doppler shift patterns with temperature in coronal holes

SW2: Role of spicules in providing mass to solar wind
- thermal evolution of chromospheric spicules to TR/coronal temperatures
- driver of spicules (Alfven waves, flux emergence, …)

SW3: Role of “outflows” in solar wind
- open fields, multiple components, …

SW4: Role of Alfvenic waves in solar wind
- energy budget, propagation, dissipation,…

2.5 Flux emergence

FE1: How much of granular-scale flux has energetic impact on chromosphere/corona?

FE2: Does granular-scale flux lead to spicule and/or jet formation?
- blowout jet vs. standard jet

FE3: How does small-scale flux emergence lead to large-scale destabilizations and filament eruptions?

2.6 Flares/CMEs

FC1: Role of flux emergence in triggering flares
- role of currents

FC2: Determining flare effects in chromosphere: thermal conduction, energetic particles and Alfven waves

FC3: Measurement of particle precipitation in chromosphere/transition region

FC4: Measurement of coronal reconnection through footpoint motions

FC5: Role of flux emergence in triggering CMEs

FC6: Chromospheric/TR precursors of eruptions?

2.7 Filaments

F1: Source of filaments: flux rope emergence, shearing arcades?

F2: Coronal condensation as a source of filament mass?

F3: Role of barbs as source of filament plasma

F4: Role of flux emergence in filament eruptions?

F5: Instabilities within filaments?

2.8 Seismology

S1: Flare-triggered transverse waves

S2: Flare/CME-triggered transverse waves

S3: Filament-related oscillations

S4: Spicule-related oscillations

2.9 Spicules/Jets

SP1: Role of spicules in providing mass to the corona and solar wind

SP2: Driving mechanism of spicules
- current sheets
- Alfven waves
- flux emergence

SP3: Role of spicules in TR

SP4: Using spicules to diagnose wave conditions at the interface between chromosphere and corona

SP5: Connection to X-ray jets

2.10 Irradiance

IR1: How do Mg II h/k and other UV diagnostics vary over the solar cycle

3. Basic IRIS observing modes

IRIS contains an imaging spectrograph that allows observations of:
- spectra in two wavelength ranges in the FUV (1331-1358Å, 1390-1407Å)
- spectra in a wavelength range in the NUV (2782-2834Å)
- slit-jaw images in two bandpass in the NUV (Mg II h/k 2796Å and Mg II wing 2832Å) and two bandpasses in the FUV (C II 1330 Å, Si IV 1400Å)

IRIS has a slit that is 1/3” wide. The imaging devices have 1/6” pixels with a spatial resolution of 0.33-0.4” in the FUV and NUV. The slit-jaw images cover a FOV of 175”x175”, while the slit has a length of 175”.

The spectral pixel size is 13mÅ with a spectral resolution of 40mÅ in the FUV, and 26mÅ and 80mÅ respectively in the NUV.

High throughput, and fast readout and mechanism movements allows cadences for the spectra to be as short as 1 second, with rastering options varying from sit-and-stare, dense (at 1/3” or less step sizes), sparse (>1/3”) and various combinations of sparse and dense possible.

The spacecraft can be pointed anywhere within 4 arcmin off the solar limb. IRIS can be rolled at any angle from -90 to 90 degrees with respect to solar north for extended periods of time.

While IRIS is extremely flexible in its operations, we will strive to limit complexity in operations, calibration and data analysis by exploiting a selection of workhorse modes that can address all of the above science goals. We list these basic IRIS observing modes below (Table 1). To allow for easier planning of the IRIS observations, the basic IRIS observing modes will be numbered according to their OBS id number (see ITN 1 for details on OBS lists).

The default line list mentioned below contains spectral windows:
- in the FUV: C II 1335/1336, Fe XII 1349, Cl I 1352, C I 1354, O I 1355, C I 1355, Ci 1357
- in the NUV: Mg II k, Mg II h, several windows in the red wing of Mg II containing photospheric lines

OBS-ID	Spectral WL	Raster step	Raster FOV	Spectral cadence	SJI WL	SJI cad	SJI FOV	Description	Total Datarate (Mbit/s)
10	default	0.33”	3”x30”	10s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	30”x30”	Small dense raster	1.1
11	default	0.33”	6.33”x60”	20s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	60”x60”	Medium dense raster	2.3
12	default	0.33”	21”x120”	64s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	120”x120”	Large dense raster	5.3
13	default	0.33”	132”x175”	400s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	175”x175”	Very large dense raster	8.0
14	default	0.33”	0.3”x30”	1s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	30”x30”	Small sit-and-stare	2.1
15	default	0.33”	0.3”x60”	1s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	60”x60”	Medium sit-and-stare	4.3
16	default	0.33”	0.3”x120”	1s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	120”x120”	Large sit-and-stare	9.1
17	default	0.33”	0.3”x175”	1s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	175”x175”	Very large sit-and-stare	13.8

	18	default	1”	9”x30”	10s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	30”x30”	Small sparse raster	1.1
	19	default	1”	19”x60”	20s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	60”x60”	Medium sparse raster	2.3
	20	default	1”	63”x120”	64s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	120”x120”	Large sparse raster	5.2
	21	default	1”	127”x175”	128s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	175”x175”	Very large sparse raster	7.9
	22	default	2”	18”x30”	10s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	30”x30”	Small coarse raster	1.1
	23	default	2”	38”x60”	20s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	60”x60”	Medium coarse raster	2.3
	24	default	2”	126”x120”	64s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	120”x120”	Large coarse raster	5.2
	25	default	2”	126”x175”	64s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	175”x175”	Very large coarse raster	8.0
	26	default	1” 0.33” 1”	2”x30” 1.67”x30” 2”x30” t: 5.67”x30”	12s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	30”x30”	Small sparse/ dense/sparse raster	1.1

	27	default	1” 0.33” 1”	4”x60” 3”x60” 4”x60” t: 11”x60”	20s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	60”x60”	Medium sparse/dense/sparse raster	2.4
	28	default	1” 0.33” 1”	11”x120” 11.67”x120” 11”x120” t: 33.67”x120”	60s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	120”x120”	Large sparse/dense/sparse raster	5.1
	29	default	1” 0.33” 1”	39”x175” 39.33”x175” 39”x175” t: 117.66”x175”	200s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	175”x175”	Very large sparse/dense/sparse raster	13.1
	30	default	0.33”	31.66”x175”	96s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	175”x175”	Synoptic dense raster	8.5
	31	default	1”	35”x175”	36s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	175”x175”	Synoptic sparse raster	7.4
	32	default	0.33”	0.33”x50”	2s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	50”x50”	Two-step dense raster	2.8
	33	default	1”	1”x50”	2s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	50”x50”	Two-step sparse raster	1.9
	34	default	2”	2”x50”	2s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	50”x50”	Two-step coarse raster	1.9
	35	default	0.33”	1”x50”	4s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	50”x50”	Four-step dense raster	1.9

	36	default	1”	3”x50”	4s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	50”x50”	Four-step sparse raster	1.9
	37	default	2”	6”x50”	4s	C II Si IV Mg II h/k Mg II wing	10s 10s 10s 10s	50”x50”	Four-step coarse raster	1.9

Table 1: Basic Observing modes of IRIS

The IRIS instrument has significant flexibility in terms of choices of SJI wavelengths and their respective cadence, exposure times, spectral wavelength coverage, onboard summing to increase S/N, lossy or lossless compression, AEC operations, etc…

To facilitate easier operations and planning, pre-defined sequences with the same basic properties as the basic observing modes (Table 1) but with variations in SJI cadence and wavelength selection, exposure times, wavelength coverage, etc… have been created. These are listed in Table 2 below. The numbering scheme is such that the same basic observing mode properties are maintained in the last two digits of the OBS-ID, whereas leading digits indicate various choices for exposure times, SJI cadence, etc… The numbering scheme thus acts similarly to a binary mask (see Table 2) with the digits listed in Table 2 acting as “bits” switching options on and off.

The logic of the ID numbering system is outlined in tables 1 and 2.

OBS ID	Size + description	Impact on cadence (>1 = slower)	Impact on SG datarate	Impact on SJI datarate
0	C II Si IV Mg II h/k Mg II w	1	1	1
100	C II Si IV Mg II h/k Mg II w s	1	1	0.791666667
200	C II Si IV Mg II w s	1	1	0.541666667
300	C II Mg II h/k Mg II w s	1	1	0.541666667
400	Si IV Mg II h/k Mg II w s	1	1	0.541666667
500	C II Mg II w s	1	1	0.291666667
600	Si IV Mg II w s	1	1	0.291666667
700	Mg II h/k Mg II w s	1	1	0.291666667
800	Si IV Mg II h/k Mg II w	1	1	0.75
900	C II Mg II h/k Mg II w	1	1	0.75
1000	Si IV Mg II h/k Mg II w	1	1	0.75
1100	C II Si IV Mg II h/k	1	1	0.75
1200	C II Si IV	1	1	0.5
1300	C II Mg II h/k	1	1	0.5
1400	Si IV Mg II h/k	1	1	0.5
1500	C II	1	1	0.25
1600	Si IV	1	1	0.25
1700	Mg II h/k	1	1	0.25
1800	Mg II w	1	1	0.25
1900	C II Si IV s Mg II h/k Mg II w s	1	1	0.583333333
0		1	1	1
2000	Deep x 0.5	0.5	2	1
4000	Deep x 2	2	0.5	1
6000	Deep x 4	4	0.25	1
8000	Deep x 8	8	0.125	1
10000	Deep x 15	15	0.06666666667	1
12000	Deep x 30	30	0.03333333333	1
0		1	1	1

20000	Spatial x 1, Spectral x 2	1	0.5	1
40000	Spatial x 1, Spectral x 4	1	0.25	1
60000	Spatial x 1, Spectral x 8	1	0.125	1
80000	Spatial x 2, Spectral x 1	1	0.5	1
100000	Spatial x 2, Spectral x 2	1	0.25	1
120000	Spatial x 2, Spectral x 4	1	0.125	1
140000	Spatial x 2, Spectral x 8	1	0.0625	1
160000	Spatial x 4, Spectral x 1	1	0.25	1
180000	Spatial x 4, Spectral x 2	1	0.125	1
200000	Spatial x 4, Spectral x 4	1	0.0625	1
220000	Spatial x 4, Spectral x 8	1	0.03125	1
0		1	1	1
250000	FUV spectrally rebinned x 2	1	0.5	1
500000	FUV spectrally rebinned x 4	1	0.25	1
750000	FUV spectrally rebinned x 8	1	0.125	1
0		1	1	1
1000000	SJI cadence 0.25x faster	1	1	0.25
2000000	SJI cadence 0.5x faster	1	1	0.5
3000000	SJI cadence 3x faster	1	1	2
4000000	SJI cadence 10x faster	1	1	10
0	Default compression	1	1	1
10000000	Lossless compression	1	1.5	1.5
0	Linelist 1	1	1	1
20000000	Linelist 2	1	1	1
40000000	Linelist 3	1	1	1
60000000	Linelist 4	1	1	1
80000000	Linelist 5	1	1	1
100000000	Full readout	3	1.49761904762	1

OBS-ID 0 to 1999: variations in cadence and wavelength choice of the four SJI filter images (C II 1335Å, Si IV 1400Å, Mg II h/k 2796Å, Mg II h/k wing 2830Å). Nominally cadence is ~10 seconds. If a "s" is following the wavelength, it means the cadence is slower (~60 seconds).

OBS-ID 2000 to 13999: variations in exposure time. Deep x 2 means exposure times are doubled, which lowers the cadence by roughly a factor of 2. Etc.

OBS-ID 20,000 to 239,999: variations in onboard summing for the whole spectrograph.

OBS-ID 250,000 to 999,999: variations in onboard summing but applied only to the FUV spectra.

OBS-ID 1 million to 4 million: variations in SJI cadence.

OBS-ID 10 million to 20 million: variations in compression.

OBS-ID 20 million to 200 million: variations in linelist (and thus cadence, see ITN 1), including full readout.

Initial (version 0) OBS-IDs will be assigned prefixes of "4.0 billion", with subsequent improvements lower prefixes, e.g., version 1 will keep the numbering system in the tables, but with a prefix of 3.8 billion.

Some examples:

OBS ID 100,610: Small dense raster at 10 s cadence with default spectral wavelength coverage, Si IV SJI images at 10 s cadence, Mg II wing images at 60 s cadence, with the spectra rebinned spatially by 4 and spectrally by 8.

OBS ID: 100,009,837: Coarse four-step raster at 4x8=32 s cadence with full spectral wavelength coverage and deep exposures (8s), Mg II wing images at ~10 s cadence.

OBS ID: 10,314,321: Very large, sparse raster at 540 s cadence with lossless compression, FUV spectra rebinned by a factor of 2 spectrally, NUV spectra rebinned by 8 spectrally, both exposed deeply by a factor of 2, with C II, Si IV, Mg II h/k at 10 s cadence and Mg II wing at 60 s cadence.

4. 30+ day observing plan

The 30 day plan is described in detail in a Mac OSX iWorks "Numbers" file. The current version is not yet compatible with the tables described in this document, but rather based on a previous version of the driving tables. It will be updated by mid June 2013.

The overall activities consist of observations of:

4.1 Active Regions

The goal is to track an active region on a roughly semi-daily basis as it crosses from one limb to the other to sample a wide variety of viewing angles and activity stages. For each "day" of observing the active region, IRIS will spend a large fraction of a day pointed at roughly the same target while obtaining a variety of types of rasters:

a. small dense (and thus fast) rasters to study dynamics,
b. large dense or coarse rasters that cover a large fraction of the active region,
c. sit-and-stare "rasters" (to focus on the fastest dynamics),
d. deep rasters (to obtain the weakest lines), etc…
e. propagation studies (two or four step fast rasters)

The smaller rasters will be focused alternately on sunspots, plage or fans (whereas the larger rasters will cover the whole region). We will also perform some of these observations while rolled. Most of these observations will be done with solar rotation tracking.

4.2 Quiet Sun

The goal is to obtain quiet Sun observations for a variety of viewing angles from the limb to disk center. This will be done every few days so as not to interfere with the active region tracking too much (see 4.1). For each day of "observing" the quiet Sun, IRIS will spend about 12 hours pointed at roughly the same target and obtain a variety of types of rasters:

a. small dense (and thus fast) rasters to study dynamics,
b. large dense or coarse rasters that cover a large fraction of the active region,
c. sit-and-stare "rasters" (to focus on the fastest dynamics),
d. deep rasters (to obtain the weakest lines), etc…
e. propagation studies (two or four step fast rasters)

Note that the quiet Sun count rates are significantly lower so the cadence of these observations will be reduced compared to active region. We will also perform some of these observations while rolled. Most of these observations will be done with solar rotation tracking.

4.3 Coronal Hole

The goal is to obtain coronal hole observations for a variety of viewing angles from the limb to disk center, starting with the limb. The exposure times will be longer than in quiet Sun, but the overall approach is similar to that described in 4.2: every few days we will focus on a coronal hole for about 6-12 hours.

4.4 Prominences

The goal is to obtain prominence observations for a variety of viewing angles from the limb to disk center, starting with the limb. The exposure times will be longer than in quiet

Sun, but the overall approach is similar to that described in 4.2: every few days we will focus on a prominence for about 6-12 hours.

4.5 Flares/CMEs

Towards the second half of the 30+ day plan we will start focusing more attention on flare/CME watch programs, i.e., after some of our basic science targets have been satisfactorily observed. The flare/CME watch programs will focus on moderate cadence, moderate field of view programs with AEC enabled.

4.6 Synoptic Observations

The synoptic program is still being defined, but a preliminary list of observations includes:
a. full disk coarse rasters in several bright lines,
b. limb-to-limb relatively narrow rasters from pole to pole, along the equator, and a variety of angles from solar north.

These programs will be run every few days to a week and will take up a significant fraction of the day.

4.7 Calibration

Every few days we will obtain flat-field, dark current and “orbital wobble” calibration studies. In addition, depending on targets of opportunity, we will do occasional stellar calibrations.

A detailed timeline for the 30+day plan including data rate estimates and duty cycle is provided in the accompanying Numbers file.

Headers:
- Description: brief descriptor of observing program, color coded for clarity
- Obs ID: follows “binary” mask described above, can be changed manually to study impact of different observation programs
- cadence: automatically populated once Obs ID is entered
- target
- Obs time (hr): can be changed manually to study impact of observing program duration
- dl time (hr): download time in excess of observing time that is required to download data based on very rough estimates pre-launch -- will be refined closer to launch
- roll: SPEL and SPAL stand for slit perpendicular to limb and slit parallel to limb
- rot track: solar rotation track on or not?
- repeat
- science topics: attempt at tracing program back to science goals described in section 2
- Science description
- coordination: to be completed

- raster description: automatically populated once Obs ID is entered

By changing the Obs ID and Obs Time in columns E and H in the “numbers” file (on a Mac OSX with iWork’09), it is possible to study the impact of changing observing programs and observing times. Download times, cadence and raster description are automatically populated based on input in Obs ID and Obs Time. The calculation of downlink time are not precise at this point and meant to guide only. Will be refined in coming months.