

# **SOFIA Observing and Flight Planning**

## **Useful Information for Proposing and Planning SOFIA Observations**

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## Airborne Observing

What is special about airborne observing?

- The observatory is moving while observing. Local sidereal time loses its meaning. Sources rise and set faster or slower. The elevation where a certain target culminates can vary.
- The targets dictate the aircraft heading. The observing plan translates into a flight plan and the observing plan has to be prepared so that the flight plan can be flown and starts and ends at the (same) airport.
- *You can help us flight planners to your own benefit.*

## SOFIA's Telescope

*Before you can propose observations, you need to know what the telescope can do:*

- The telescope door is on the **port side** of SOFIA. Thus, the azimuth dictates aircraft heading ( $\sim AZ+90^\circ$ ).
- Telescope door elevation range:  $24.15^\circ - 57^\circ$
- The telescope can exceed the door elevation range by  $\sim 5^\circ$  without getting vignetted (depends on instrument).
- Due to variability of aircraft pitch and roll angle and their effect on available elevation, observations should not exceed the door elevation range more than  $\sim 3^\circ$ .

For planning purposes:

**→  $20^\circ < \text{useful elevation range} < 60^\circ$**



## Flight Planning

*Flight Planning starts with you, the observer!*

*You need to provide targets that are observable.*

- Target observability can be evaluated via the Visibility Tool <https://dcs.sofia.usra.edu/> → Visibility Tool (publically available)
  - It calculates **elevation** and **aircraft heading** ( $\sim AZ+90^\circ$ ) for a given target, location, and date and plots it over 24 hours.
  - Default location is Palmdale Airport (N34° 38', W118° 05'). You can select from a few airports or enter coordinates freely.
  - The proposal call allows sources with  $DEC > -36^\circ$  for flights from Palmdale, i.e. SOFIA will routinely fly from there to latitudes south of N30°.

## Flight Planning

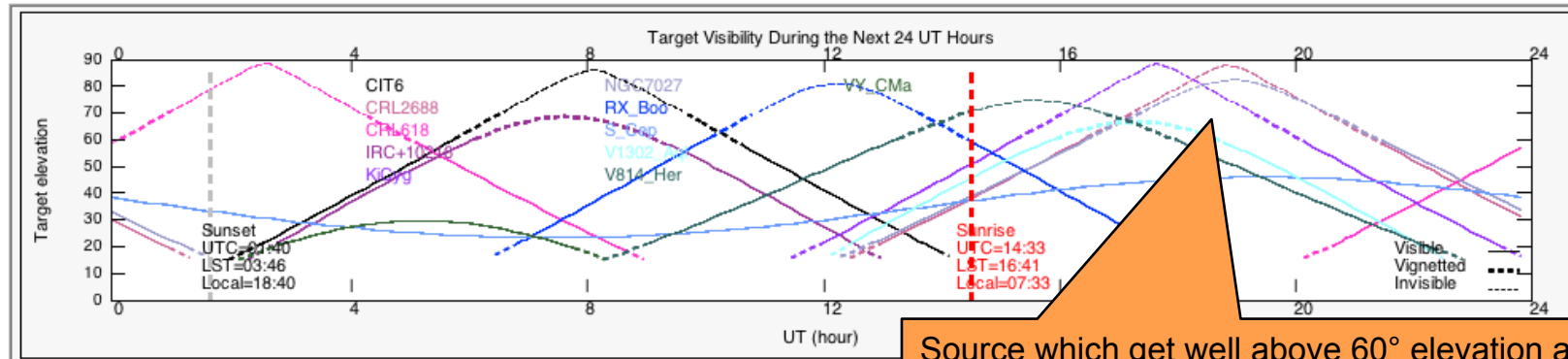
Since SOFIA has to fly back to Palmdale usually, **targets need to be well distributed over the sky**. Flight Planners will be in need of targets **opposite in azimuth of popular regions** like the Galactic Center in summer or Orion in winter. Give us good choices.

*A good source distribution on the sky does not help your proposal to get approved. But once approved, sources culminating in the north tend to have higher completion rates.*

- For top rated proposals that can mean completion rates of >100%, while 80% is considered completed in oversubscribed regions.
- Second tier proposals only got observed if they were outside of oversubscribed regions.
- Surveys should not expect a uniform sky coverage but to be biased towards the north.

# Visibility Tool

File Help ?



Close Window

Source which get well above 60° elevation are out of range for a long time and thus harder to schedule.

Plot True Plane Heading Plot Target Elevation Edit Targets Clear Plot

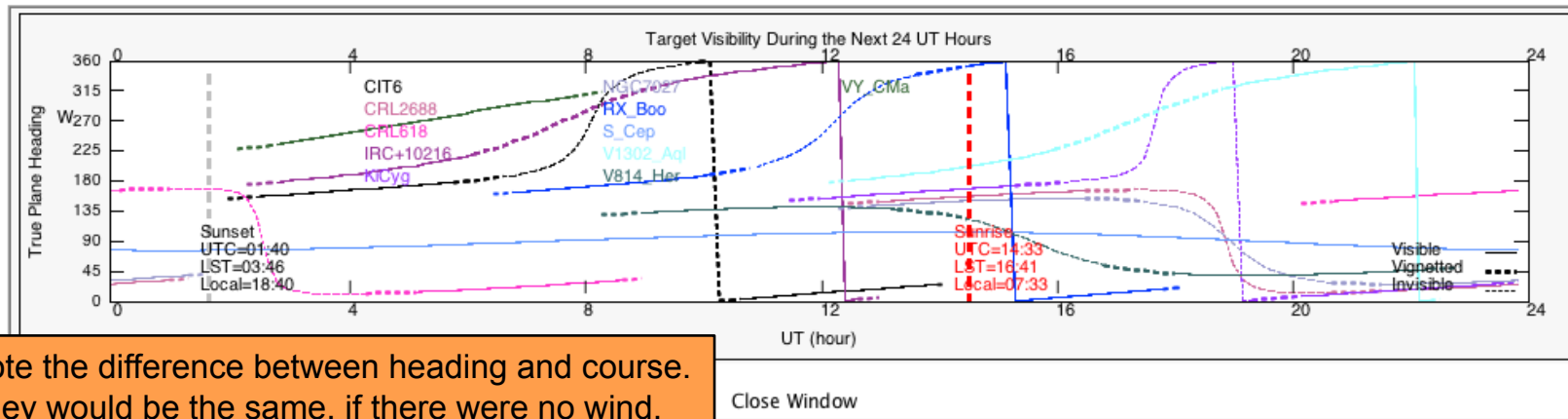
<p><b>Target</b></p> <p>Name: <input type="text" value="Name"/></p> <p>SIMBAD*/Sol Sys target: <input type="text"/></p> <p>RA : <input type="text"/> h <input type="text"/> m <input type="text"/> s</p> <p>Dec : <input type="text"/> ° <input type="text"/> ' <input type="text"/> "</p>	<p><b>Take-off Location</b></p> <p>Location: <input type="text" value="Palmdale, CA"/></p> <p>^Longitude: <input type="text" value="-118"/> ° <input type="text" value="5"/> ' <input type="text" value="0"/> "</p> <p>Latitude: <input type="text" value="34"/> ° <input type="text" value="38"/> ' <input type="text" value="0"/> "</p>	<p><b>Date</b></p> <p>Year: <input type="text" value="2011"/></p> <p>Month: <input type="text" value="February"/></p> <p>Day: <input type="text" value="20"/></p> <p>Start Time (UT or Local hr): <input type="text" value="0"/></p> <p>Duration (hr): <input type="text" value="24"/></p> <p><input type="checkbox"/> Start Time is Local <input type="button" value="Set Starttime to Now"/></p>
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\* Centre de Données astronomiques de Strasbourg, France ^ West Longitude is negative

Dashed lines means vignettted or invisible.

# Visibility Tool

File Help ?



Note the difference between heading and course. They would be the same, if there were no wind.

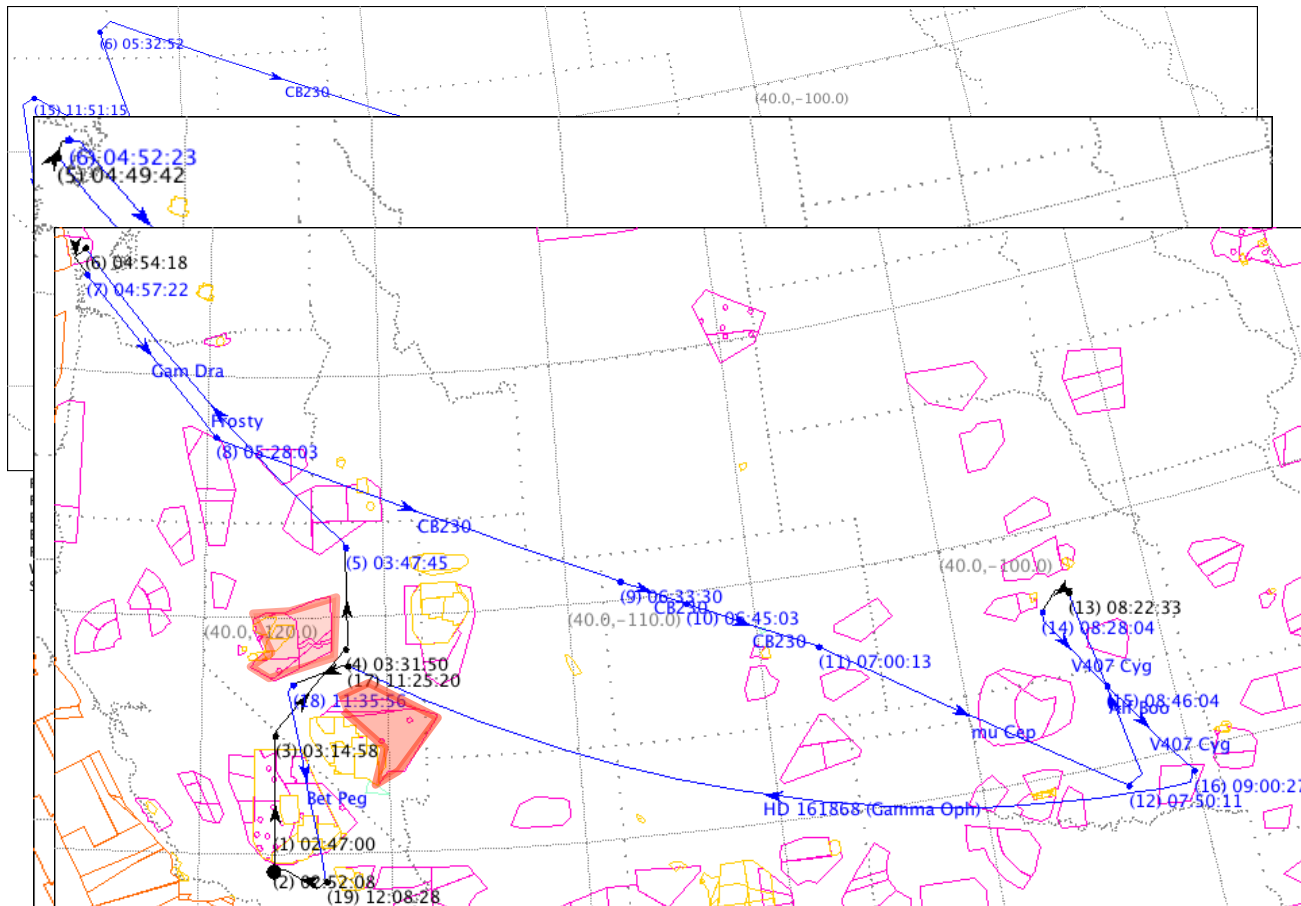
Plot True Plane Heading Plot Target Elevation Edit Targets Clear Plot

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Dashed lines means vignetted or invisible..

# Flight Planning – A jig saw puzzle with changing tiles



Flight Plan Name: File: BS1\_postMOPs.fp  
 Flight ID: 2011/05/06  
 Est. Takeoff Time: 2011-May-06 02:47 UTC  
 Est. Landing Time: 2011-May-06 12:18 UTC  
 Flight Duration: 09:31  
 Weather Forecast : 1200 Mon Apr 25 2011 – 0000 Thu Apr 28 2011 UTC  
 Saved: 2011-Apr-27 19:28 UTC User: kbowser

Flight Plan: Basic Science 1  
 flight #1  
 Planned for 2011-05-06 (UT)

1. The top panel shows a draft version of the plan, which was too long.
2. The plan shortened.
3. When the pilots reviewed the plans, they indicated additional problematic airspaces.

A set-up leg needs to be added.

The orange and yellow areas (SUAs) are off-limits except Edwards.

Mexican air space is off-limits for now. Canadian will become available.

On the next slides, see how tracks and source positions relate.



# 5:00 UT – Frosty Leo/Gamma Draconis

**XEphem 3.7.4**

File View Tools Data Preferences Help

Make changes then press Update to run.

Local		UTC-8 Calendar	
<No site defined>			
Latitude:	42:25:24	Mo	Tu
Longitude:	119:42:09	We	Th
Elevation:	810.0 m	Fr	Sa
Temp:	10.0 C	Su	1
Atm Pres:	1010 hPa	25	26
Equinox:	2000.0	27	28
Mag decl:	0:00:00	29	30
		31	

Time		Night	
Julian:	2455687.70833	Sun Dip:	0.25°
UTC Date:	5/06/2011	Dawn:	4:49
UTC Time:	5:00:00	Dusk:	19:03
Sidereal:	11:56:03	Length:	9:46
TZ Name:	UTC-8	LST@0:	14:56:32
TZ Offset:	8:00:00		
Local Date:	5/05/2011	-1 +1	Looping [RT]
Local Time:	21:00:00	Step:	1:00:00
Delta T:	(Auto) 67.45	N Steps:	1
		Pause:	0

Update

LMT: 21:22:20      LST: 12:17:10

**xephem Sky View**

Control Images Favorites Telescope History Help

What

Gamma Draconis

Frosty Leo

IRAS 22272+5435, IRAS 22272+5435, NGC7027, NGC7027, Gulf Field/Targets B, Gulf Field/Target A, Mu\_Cep, CE230, IRAS 20000+3239, IRAS 20000+3239, NGC6543, NGC6543, Gamma\_Dra, Alf\_Aur, Alf\_Aur, Moon, Alf\_Orl, Bet\_Gem, Mu\_UMa, Alf\_Her, Alf\_Boo, M2-9, M2-, Alf\_CMl, Frosty, Alf\_Hya, Sig\_Lib, Saturn

How

Where

FOV: 180:49W x 180:00H      Az: 180:00      Alt: 90:00

90H 1:1 2:1      5/05/2011 21:00:00 UTC-8      -45:00 0:00 45:00

# 8:00 UT – Alpha Bootis

**XEphem 3.7.4**

File View Tools Data Preferences Help

Make changes then press Update to run.

Local		UTC-6 Calendar	
<No site defined>		May 2011	
Latitude:	34:58:45	Mo	Tu
Longitude:	94:50:48	25	26
Elevation:	810.0 m	27	28
Temp:	10.0 C	29	30
Atm Pres:	1010 hPa	31	1
Equinox:	2000.0	2	3
Mag decl:	0:00:00	4	5

Time		Night	
Julian:	2455687.83333	Sun Dip:	0.25°
UTC Date:	5/06/2011	Dawn:	5:24
UTC Time:	8:00:00	Dusk:	19:09
Sidereal:	16:35:58	Length:	10:15
TZ Name:	UTC-6	LST@0:	14:39:35
TZ Offset:	6:00:00	-1 +1	Looping RT
Local Date:	5/06/2011	Step:	1:00:00
Local Time:	2:00:00	N Steps:	1
Delta T:	(Auto) 67.45	Pause:	0

Update

**xephem Sky View**

Control Images Favorites Telescope History Help

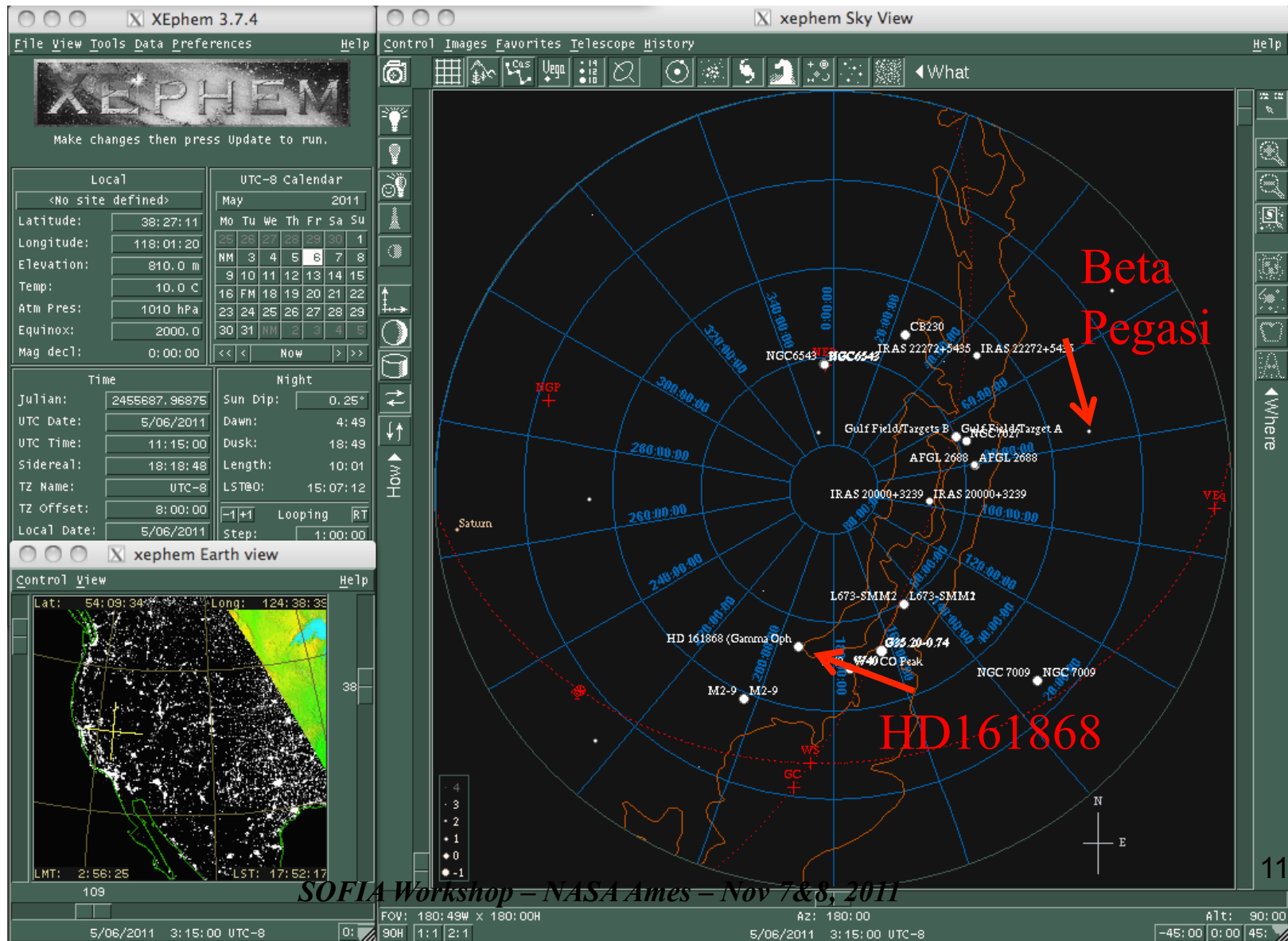
What

Where

Alt: 90:00  
Az: 90H 1:1 2:1  
5/06/2011 2:00:00 UTC-6

**SOFIA Workshop – NASA Ames – Nov 7&8, 2011**

# 11:15 UT – HD 161868 & Beta Pegasi



SOPIA Workshop – NASA Ames – Nov 7&8, 2011

## Input to Flight Planning

### Per Flight Rules

- Total maximum flight time is **10 hours** per flight take-off till landing. Shorter in the summer. Initially we plan for **9.5hrs** to have room for adjustments.
- Approximate altitude profile:
  - 4 hours before landing at 43,000ft
  - 6 hours before landing at or above 41,000ft
  - 9 hours before landing at or above 38,000ft
- Telescope cavity door remains closed below 15,000ft.
- Telescope door remains closed when the sun is above the horizon as seen from the aircraft.
- First observation ~60 minutes after take-off
- Last observing leg should end within 150nm of Palmdale
- Observations should end when sun comes above  $-10^{\circ}$
- Aircraft descent and approach takes 30min, and SOFIA must land before 30min before sunrise.

## Flight Planning Timeline

*A flight series is an uninterrupted sequence of flights with one instrument.  
"T" is the start date of a flight series.*

- T - 2months: Series requirements defined:  
[T – 2months to T - 6wk: Flight planners work on flight series.]
- T - 6wk: **“Initial Series Plan”** released to Science and Mission Operations and to pilots and navigators.
  - The Series Plan contains detailed flight plans for all flights in a series.
  - The Series Plan gets reviewed for observing efficiency, target ranking, calibrator requirements, calibration times get adjusted  
[T-6wk to T-4wk: Science Operations and Flight planners iterate series plan until signed of by Director]
  - Observers get notified of possible chances to fly with SOFIA
- T - 4wk: **“Post-Science Series Plan”** released
  - This package gets reviewed by Mission Operations for flight constraints, schedule, etc.  
[T-4wk to T-2wk: Mission Ops and Flight Planners finalize Series Plan]
- T - 2wk: **“Post-MOPS Series Plan”** released. Final Series Plan

## Flight Planning Timeline

*"t" is the take-off time of an individual flight in the series.*

- t - 7d: **"Initial Flight Plan"** is submitted to the pilots.  
[t - 7d to t-3d: Pilots and Science Flight Planners iterate individual flight plan]
- t - 1d: **"t-36hWX Flight Plan"** Flight Planners submit the flight plan updated to the weather forecast from 12:00 UT (04:00 PST) the day before the flight.
- t-8to12h: **"t-12hWX Flight Plan"** submitted to pilots.  
Forecast from 12:00 UT (04:00 PST) the day of the flight.



## Summary

- Flight Planning starts with you!
  - Check source visibility with the visibility tool on the DCS web page or your favorite tool
  - Elevation range  $\sim 20^\circ$ - $60^\circ$  plus moving observatory
  - ***If possible***, choose your sources “opposite” of popular regions, ie. northern sources. Avoid sources that transit near the zenith.
- The flight plans go through many checks by Science and Mission Operations and pilots. No big changes after T-2m.
  - ➔ Flight planning has a two month lead time.
- Once the flight plan is filed with Air Traffic Control on the day of flight, SOFIA has to stay on it.
  - ➔ In general no adjustment of the observing sequence or even durations in flight.
- Questions: [sofia\\_help@sofia.usra.edu](mailto:sofia_help@sofia.usra.edu)

*Thank you!*