# AIRS-RTA/AIRS-Ref-RTA

## Status/Plans/Validation

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## Overview

1. AIRS-RTA (fast forward model) delivery schedules
2. AIRS-Ref-RTA; needed for validation and NWP centers
3. AIRS-Ref-RTA: proposed interface, capabilities, and delivery schedules
4. Validation and AIRS-Ref-RTA Requirements
   - Data system requirements
   - Database search requirements
   - Early validation time-lines, activities
5. Implications for delivery of new AIRS-RTAs, and tuning coefficient generation.

Concrete requirements and deliveries are discussed, coupled with an informal “listing” of validation activities. AIRS validation will be demanding, and we need to ensure we have an organized validation system in place that meets our needs.

# Delivery Schedule for AIRS-RTA

| Date | Version | Comments |
|---|---|---|
| August 2000 | V 5.0a | At launch frequencies, no fringes |
| October 2000 | V 5.0 interp data set | Regression profile radiances at 6x finer grid than channels for L. McMillin |
| January 2001 | V 5.0 b,c | 2 more V 5.0 models for 3x finer grid |
| Launch + 4 | V 6.0 | Correct frequencies, fringes? I suggest we do this. |
| Launch + 8m | V 6.0, V 7.0 | "Final" frequencies, fringes, improved parameterization and spectroscopy for $CO_2$ and $H_2O$ |
| Launch + 8m + 1yr | V 7.0, V 8.0 | Con't improvements from V 6.0, plus any req'd variable gases |

– Red means not required by JPL

– Will (new) interpolation software be required after V 5.0?

– Delivery times assume special validation period starts by Launch + 2 months, which is unlikely.

# Potential Problems with Interpolated Radiances

- Status: UMBC will soon be delivering data to L. McMillin needed to develop radiance interpolation software.
- Allows Level 2 work to start earlier after launch (by ~2 months??).
- Important for risk reduction for radiance assimilation at NWP centers.
- We will be validating L1B radiances, not the interpolated radiances! Max difference in grids 1/12 $\Delta\nu$, our spec is 1% of $\Delta\nu$ and probably should be 1/2 %.
- How will we reconcile radiance biases and variances generated for L1b validation (using special and routine sondes, model profiles) versus those generated for tuning in Level 2?
- Cloud-cleared radiances will be at interpolated scale, we need cloud-cleared radiances on L1b scale for radiance and forward model validation.
- If the Level 2 system uses interpolated radiances until Launch + 240 (really more like + 270), a lot of detailed analysis will have to be re-done.
- Absence of fringing in at-launch AIRS-RTA (V 5.0) will affect accuracy of interpolation. Max bias error due to fringing is 0.5K, but interpolation could enhance errors.
- Proposal: Implement radiance interpolation as a stop-gap, but plan to integrate new AIRS-RTA at Launch + 90 days. **We can easily produce this model.**
- Could end up with 5 different "radiances", (1) Obs L1b, (2) L1b interpolated to L1c, a pseudo-observation, (3) Computed L1c (fast model), (4) Computed L1b (AIRS-Ref-RTA), (5) Computed L1c (AIRS-Ref-RTA). Confusing...

## AIRS Forward Models at NWP Centers

- NCEP, DAO?, UKMO?, ECMWF, CMS? plan to assimilate AIRS radiances.
- It is important that their forward models be faithful to the instrument.
- I will assume that UMBC's spectroscopy is the best for them to use, or, at least then the NWP centers will be consistent with the AIRS Science Team retrievals.
- NCEP, ECMWF, others? appear willing to use UMBC spectroscopy (kCARTA).
- Most centers are requesting that UMBC provide them with the time consuming convolved layer-to-space transmittances which they will use to build their own forward models and adjoint. This means:
  - They are using UMBC spectroscopy (kCARTA)
  - They will be using the AIRS Cal Team instrument model (SRFs, $\nu_o$'s).
  - They will *not* be using the AIRS-RTA parameterization.
- So far, it appears that the NWP centers plan on using more simple parameterizations, based on the layer-to-space transmittances they have requested. These simpler parameterizations *might not* be accurate enough. However, new ideas/techniques could alleviate this concern.
- Unclear when/how NWP centers will obtain spectroscopy, instrument model updates as they occur.

## Validation Issues (AIRS-Ref-RTA Background)

- Forward model is at front end of schedules, needs early validation
- We need *at least* 4 months after special radiosonde. launches end to produce an updated forward model.
- Implies special validation period should start at Launch + 60, going to Launch + 120. We need 4 months minimum to fix, validate, and produce new AIRS-RTA, allowing delivery at Launch + 240.
- Important to intercompare various NWP models for a subset of data, minimum 1 day, **using clear FOVs**.
- NWP model comparisons should be initiated at JPL/STM facilities to ensure we all compare same clear FOVs for each model.
- Golden day may not contain enough FOVS (especially over good sonde sites) for understanding radiance residuals.
- Should we develop a “clear” golden day, maybe using 7 days of observations. Will contain gaps, but will get 7x more clear FOVS.
- Can JPL reformat NCEP, DAO, and ECMWF model output into standard HDF format? We will grid to AIRS FOVs.

## Radiance Residuals

- Will need to monitor Level 2 radiance residuals.
- How? Initially this must be done “on-line” if Level 2 is failing, so use QA files. Should practice this.
- We need to monitor radiance residuals *for all channels*, and the correlations between them compared to theory. Golden days may be enough, so we can do the calculations.
- Does our forward model regression profile set contain a proper sub-set of profiles for training? Large comparison set (golden day with NWP models) important since forward model has a statistical component via regression profiles.
- Someone will need to fit residuals to a simple physically-based model in order to understand trends. Something simpler than tuning model.
- Our minor gas abundances may be incorrect, interfering with retrievals. Suggest using AIRS observations directly to correct for these abundance errors in an ad-hoc fashion.

## Several Types of AIRS-RTA's Exist for Validation

1. Fast transmittance model with radiative transfer (stand-alone AIRS-RTA)
2. Convolved monochromatic radiances generated by kCARTA from compressed absorption coefficient look-up tables. This will be the AIRS-Ref-RTA.
3. Convolved monochromatic radiances generated by our true LBL code, UMBC-LBL, which is written in Matlab and is very similar to GENLN2.
4. Combination of the last two, using kCARTA for speed for gases which do not require changes to the spectroscopy.

We plan to only deliver items (1) and (2) above to JPL.

We hope that upgrades to the stand-alone AIRS-RTA and to the AIRS-Ref-RTA will only involve changes to their associated data files.

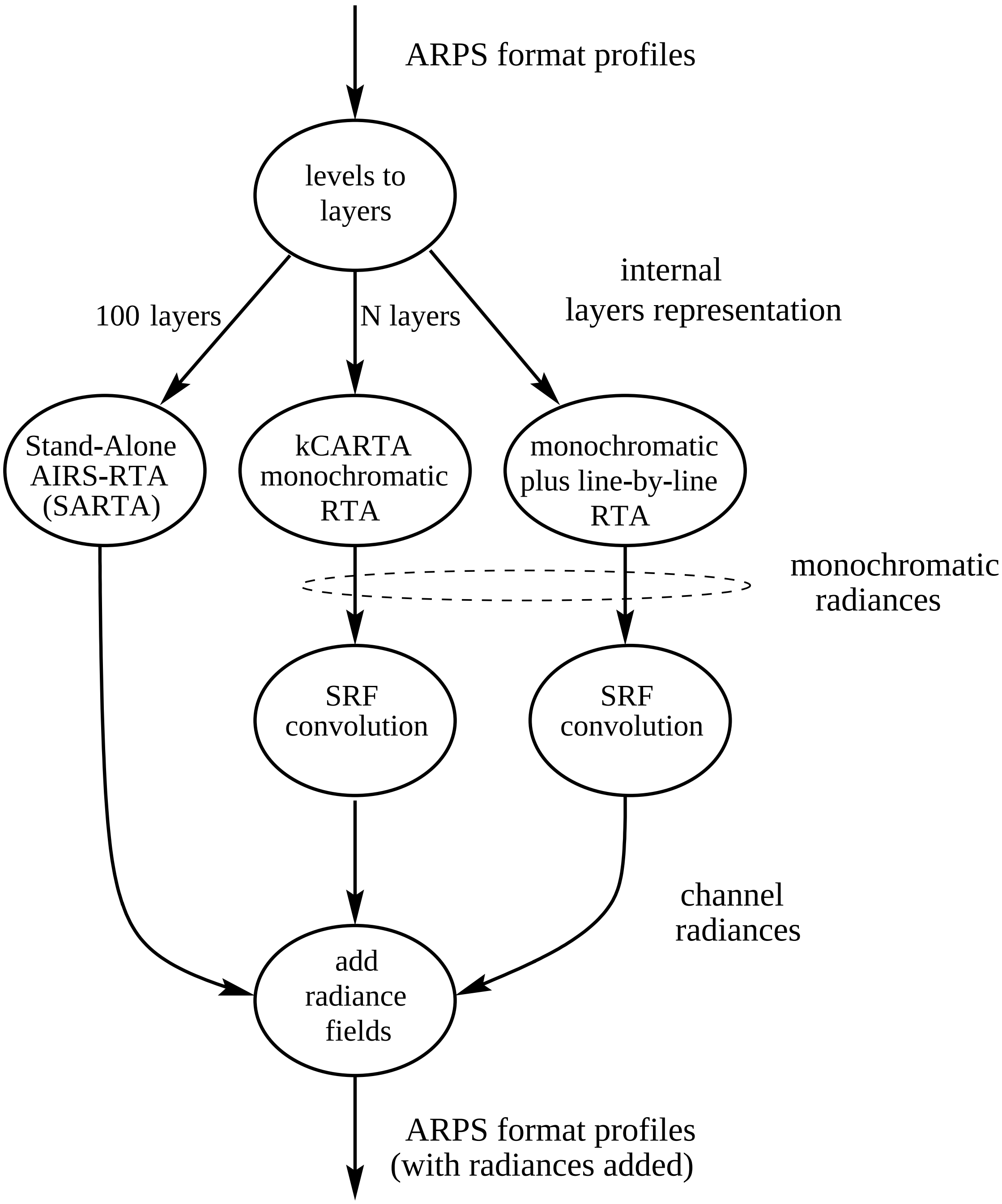
Potential new versions of the AIRS-RTA can be delivered to JPL via updates to the stand-alone AIRS-RTA (SARTA), allowing pre-integration testing.

Can we consider the stand-alone AIRS-RTA to be our delivery of a new RTA to JPL?

Should the stand-alone AIRS-RTA be used to generate tuning coefficients?

Answers to the two above questions should wait until we discuss how data (profiles) will be interfaced to the AIRS*RTA's.

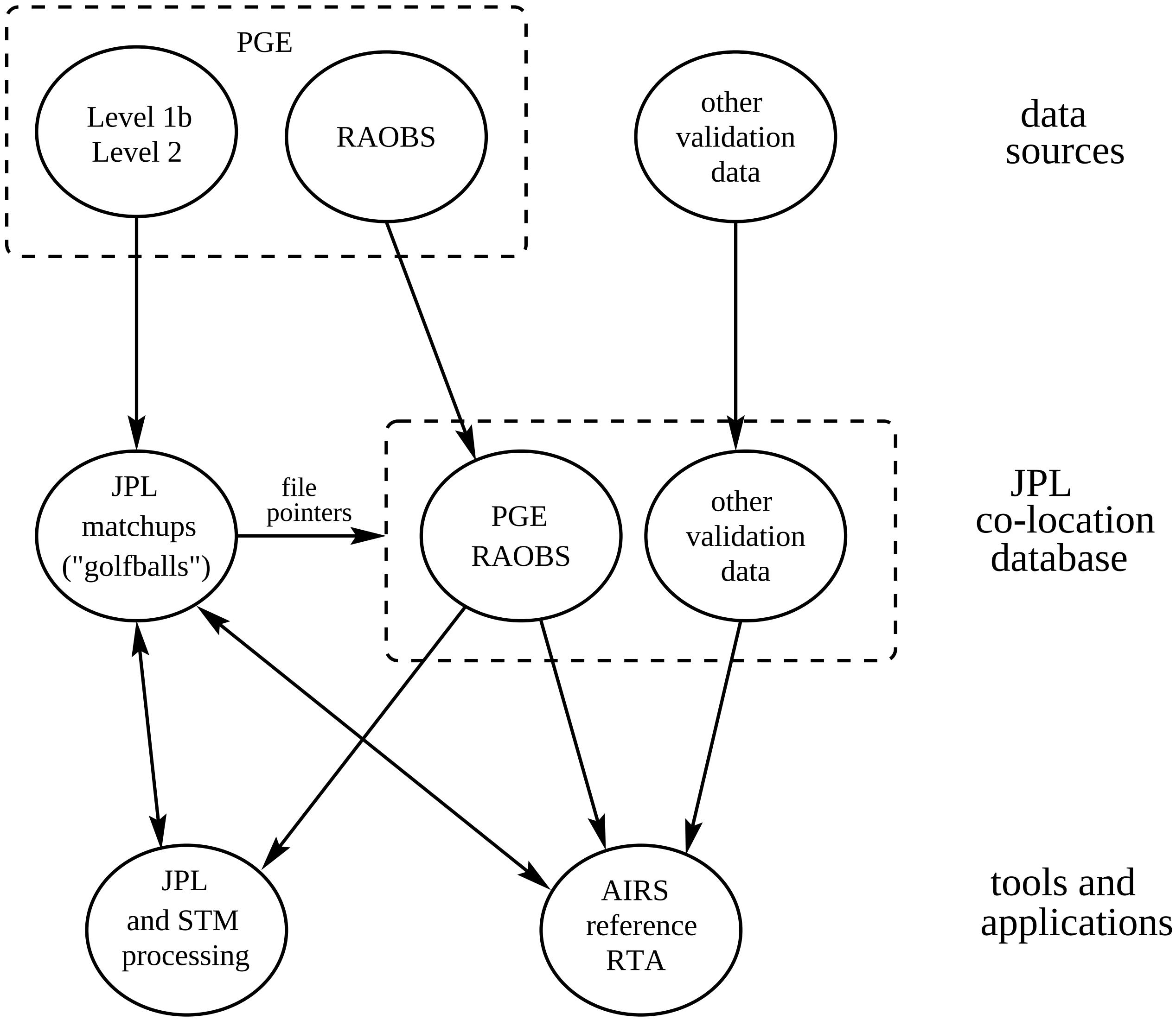
# AIRS-*-RTA Structure



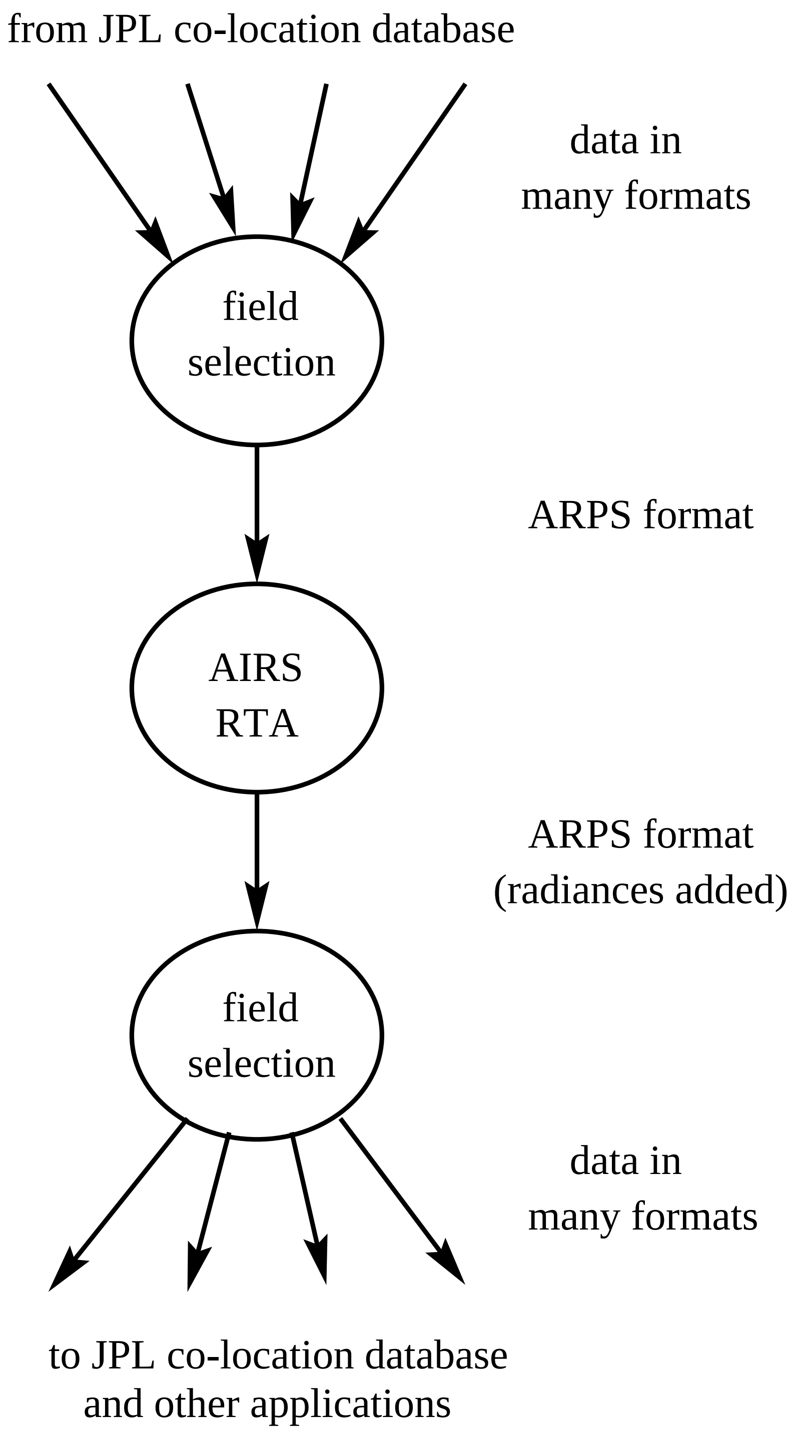
# AIRS-Ref-RTA

- AIRS-Ref-RTA has line-by-line algorithm accuracies, based on kCARTA.
- Has new spectroscopy (P/R branch mixing in $CO_2$) that is not in other LBLs.
- Generates layer-to-space transmittances needed for developing AIRS-RTA (fast forward model). Not proposing to deliver this capability to JPL.
- Only way to compute observed AIRS radiances before instrument stabilizes and a new fast AIRS-RTA is constructed. Allows for (1) arbitrary channel center frequencies, and (2) variable SRF properties (fringing).
- Much more general purpose than AIRS-RTA
  - Allows all constituent profiles to be varied, we supply missing ones.
  - Arbitrary layering
  - Any viewing angle, accurate reflected thermal/solar radiation
  - Hidden capability to include cirrus scattering via code from Frank Evans (U. Colorado) or via DISORT (real slow).
- Slow compared to AIRS-RTA. kCARTA takes roughly 30-60 minutes to compute all AIRS channels (not including convolution time), basically 0.5 -1 min per 25 $cm^{-1}$.

# Validation Data Overview



# AIRS-Ref-RTA Inputs/Outputs



# AIRS-Ref-RTA Data Format Considerations

We (H. Motteler) have developed a simple prototype HDF data format for sets of profiles paired with corresponding channel radiances. Reasons for doing this include the need for;

- An interface to simplify integration of the AIRS RTA into the JPL validation system
- A relatively simple subset of the most commonly used fields from the JPL co-location data, for many related applications
- An easily describable and portable set of co-locations for general use by STMs and the sounding community.

# Profile Sources for AIRS-Ref-RTA

- AIRS level 2 data
- RAOBS, possibly in several formats
- ARM CART sites
- NWP center data
- Profile archives (e.g., TIGR profiles)
- Fitting profiles (for fast trans model)
- Reference profiles

## RTA Input Considerations

- All the RTE calculations require a levels to layers translation.
- Possible translation of units.
- Filling in missing info with reference or supplied default values. This will most likely be the source of many changes to the AIRS-Ref-RTA.
- Consistency with Level 2 RTA within reason.

## Proposed Format for ARPS Files

- ARPS = Airs Radiance (and) Profile Sets
- General HDF representation of profiles, allowing
  - variable pressure (or altitude) levels
  - as many constituent fields as desired
  - optional fields for radiances
  - location and time information
- With the proposed representation, translation from (or to) most other profile formats involves
  - deciding what the relevant info is, in the source format
  - translation of units, if necessary
  - copying selected fields
- These steps are a necessary part of any integration process; defining a specific target format helps to break the system up into manageable components

# Minimal Co-location Data Sets

- Validation and related applications typically work with sets of profiles and radiances, for example for
  - statistical tests
  - sets of residuals
  - statistical retrievals
  - comparison of software versions
  - fast model fitting and testing
- A relatively compact and portable representation of profile and radiance sets thus has many applications
- In database design, it is common for different users to have different views of the database; the proposed format is just a simplified user's view of the necessarily more complex JPL co-location database
- The co-location data sets must be portable to AIRS STM computing facilities. This includes match-up files (golfball files) and ARPS files. For example, match-up file pointers should probably have a relative address.

# Format Details

- Profiles may have variable levels and constituents and a preferred set of units, although some variability in units is acceptable
- Fields have associated unit labels, allowing for the possibility of accepting other units.
- Proper format design guarantees that space required for radiances is not taken up unless they are actually needed

| Profile Fields | Radiance fields |
|---|---|
| lat, lon, time | time |
| constituent gas list | FOV lat, lon |
| pressure levels | subpoint lat, lon |
| temperature profile | view angle |
| constituent profiles | channel center freq's |
| | observed radiance values |
| | (msc. other L1b fields) |
| | calculated radiance values |

# Particular HDF Format

- The proposed formats can be implemented in either EOS point, or in a more general fashion in ”regular” HDF with the HDF SD and Vgroup data types.
- The EOS point representation has some disadvantages; it
  - requires fixed field sizes, at least within a file, and
  - the representation of radiances is somewhat clunky
- A more flexible representation is as a set of sets of arrays, implemented with the HDF SD and vgroup data formats
- Because there are a relatively small number of fields, the programming interface for either representation can be made quite simple
- HDF 4 has some restrictions on number of records representable and total file size, restricting a single set to on the order of 1000 profiles, with radiances
- These restrictions are greatly relaxed in HDF 5; there are significant benefits to upgrading from HDF 4 to 5. HDF 5 was released in 1998.

# Delivery of AIRS-Ref-RTA

- Propose initial delivery in Feb/March 2001.
- Need concensus on ARPA format and preliminary examples.
- Matlab version will be available (prototype), but final version probably in FORTRAN
- Will AIRS-Ref-RTA be given to NWP centers?
- We do not want to necessarily deliver operational capability to do production of layer-to-space transmittances, will help others do that in a more informal manner.

# General Data Selection Issues

- We would like to form queries of the JPL level 1b/2 data archive based on values of any of the following fields:
  - time
  - lat, lon; both as points and a bounding box
  - view angle
  - clear/cloudy flag(s)
  - day/night flag
  - ocean/land flag
- These should be specifiable in any combination, so that, e.g., we could ask for all clear nadir views within a given time interval and lat/lon box, or all granules on a pole-to-pole swath. There will be sensible restrictions.
- We will want to select level 1b/2 records both with and without co-locations.
- The data returned by a one-point selection could be either a single or small group of 3x3 FOVs (match-up file?), while for some queries, such as lat/lon boxes, it might be an entire granule.