Characterizing GLM Data Quality

And shipping backgrounds, too!

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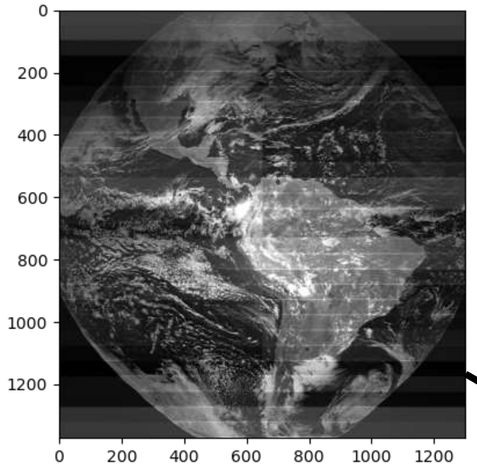
Toward a DQP

- Known to work
  - 8-bit slot saved in GLM L3 products (glmtools/ISatSS) for a DQP in AWIPS
  - FDE can be calculated from minimum detectable energy
  - L0 background images can be navigated outside the ground system
- To be implemented
  - Combination of L0 backgrounds, FDE and (if available) additional data quality flags into final product.

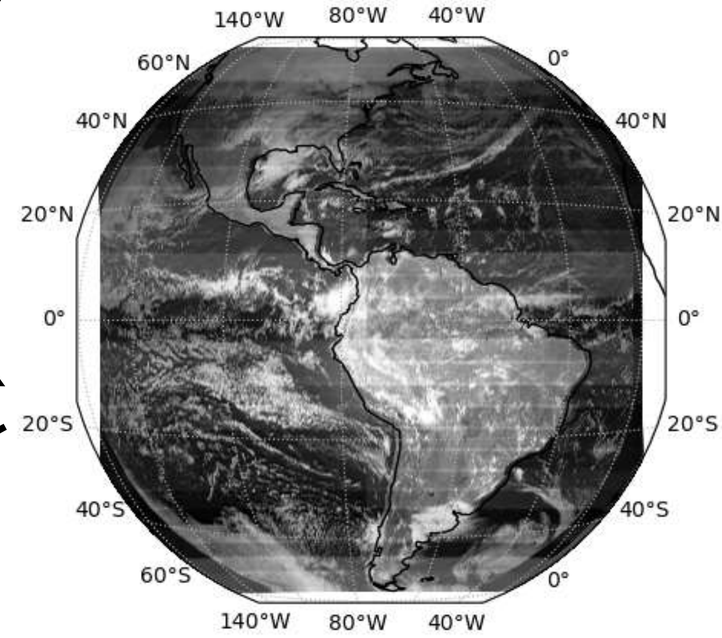
L0 background navigation

Bitzer (2022, AGU)

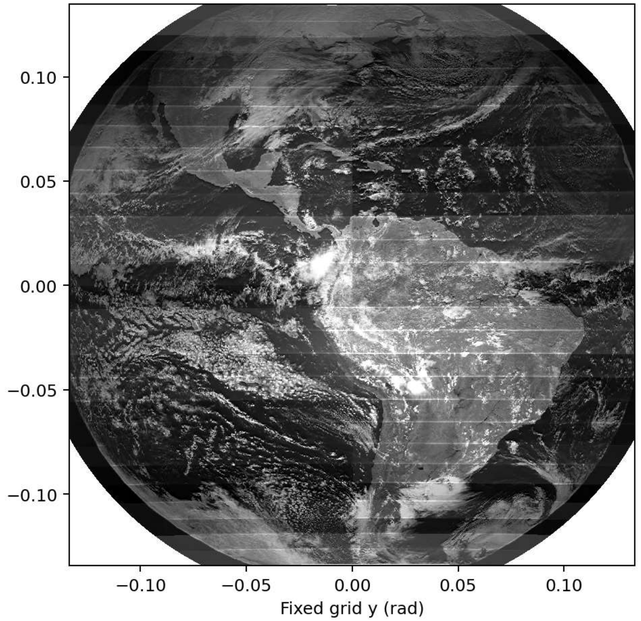
- To navigate GLM data operationally, the angles to determine the orientation of the satellite relative to Earth is done with coastlines. But, this is not available through typical operational data.
- To get this information back, we can:
  - Identify “groups” of L0 data
  - Match these to L2 data using the shape of the group.
  - Do a regression based on known pixel locations (from L0) and known navigation (from L2) to then navigate any pixel.
- One example is to navigate GLM backgrounds!
- But now, we can use backgrounds (and other data) to find the current background value in a pixel, the thresholds, and other parameters for a data quality product!



CCD



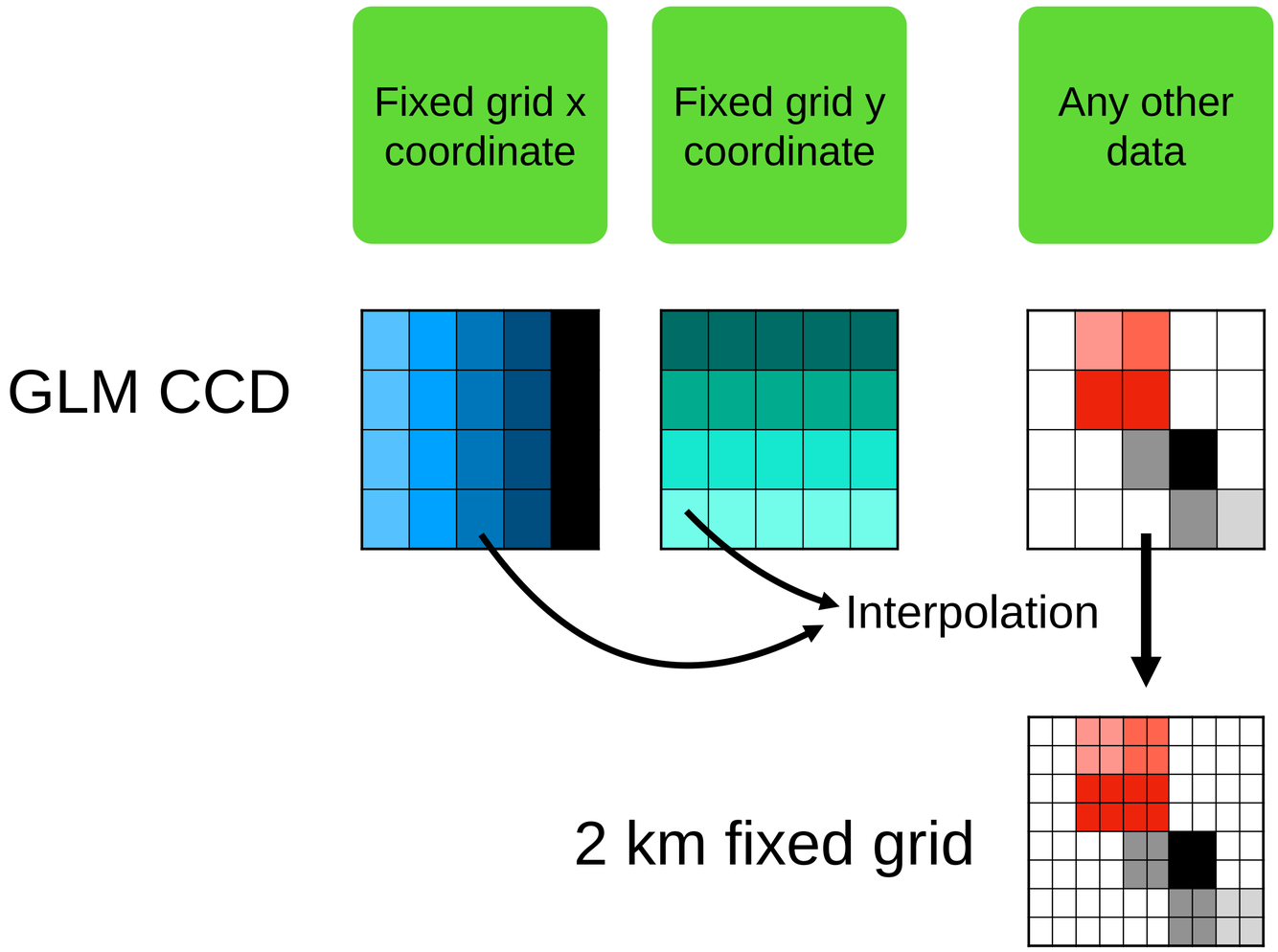
lat-lon

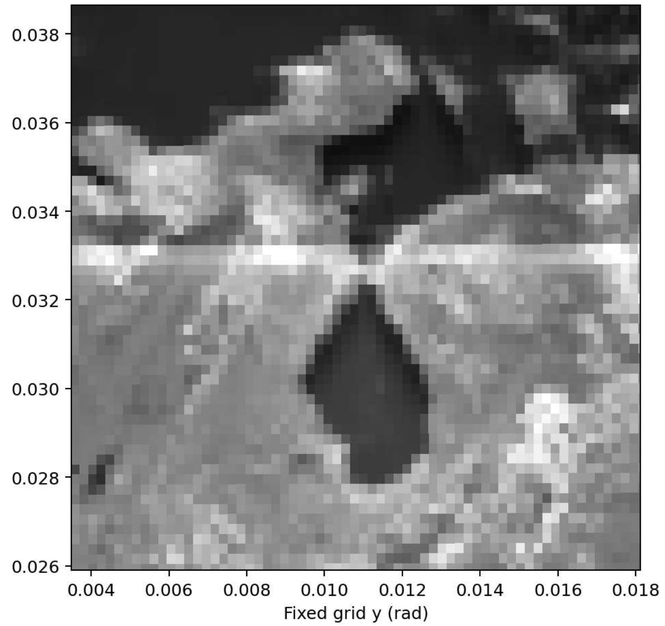


Fixed grid

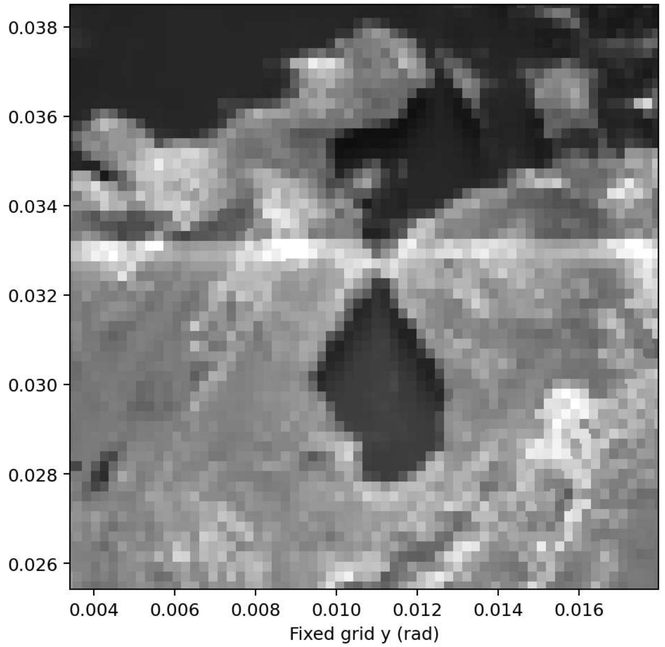
All images here are 1300x1372, but plotted in different coordinates.

The next step is to interpolate the CCD data and fixed grid coordinates to the 2 km GOES fixed grid. This can be done with standard interpolation routines.





1300x1372 Native, nonuniform CCD spacing



5424x5424 upsampled to 2 km (28 μrad) grid

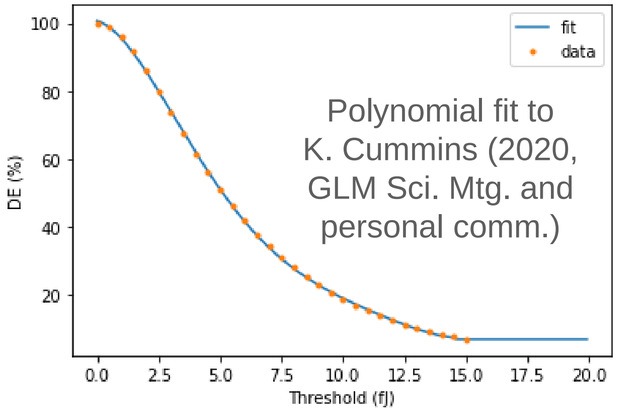
FDE calibration from optical energy sensitivity

Cummins, Bruning (2020-2022, GLM Sci)

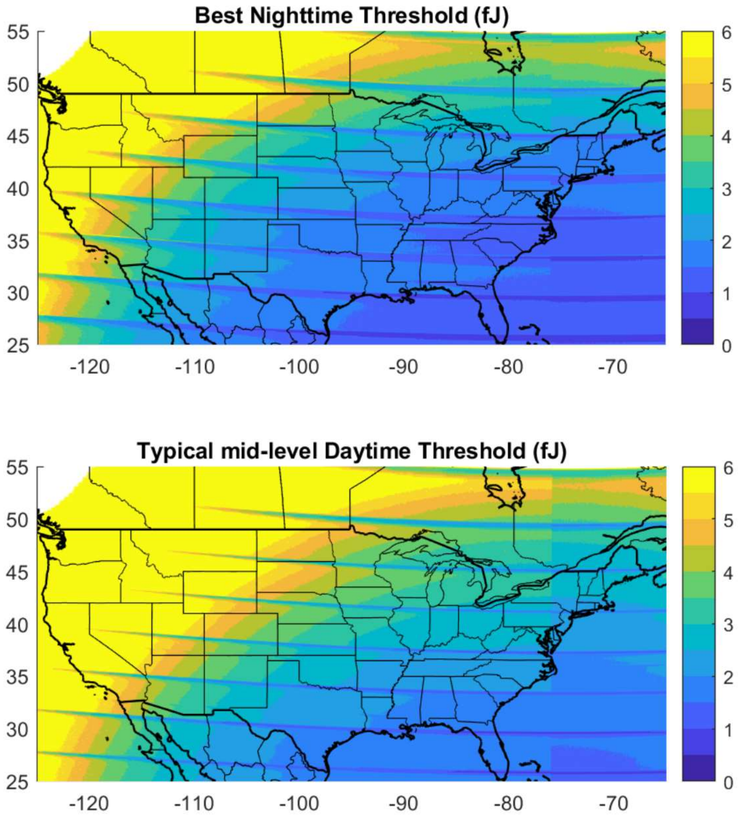
Key insight from Ken Cummins (2020, GLM Sci. Mtg.): **Flash DE** can be inferred **from the local minimum detectable energy.** Uses a transfer function built from LIS group energy statistics.

Bruning (2022 GLM Sci) showed it was possible to infer FDE from the minimum observed GLM energy.

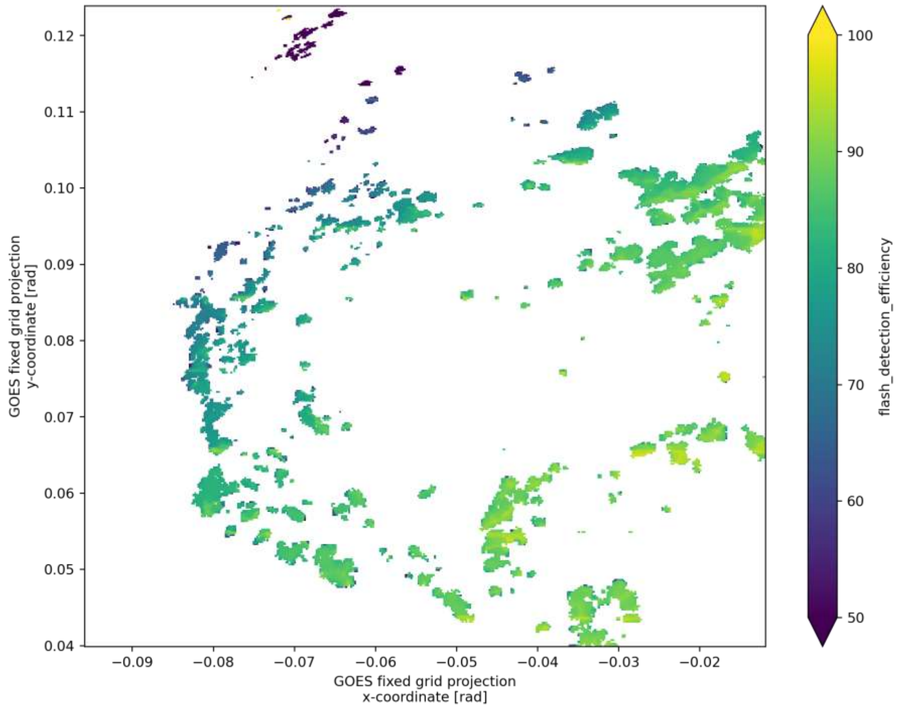
Estimated GLM Flash DE Relative to Long-term TRMM LIS Group Energy Observations



Climatological characterization of performance



FDE from observed minimum event energy

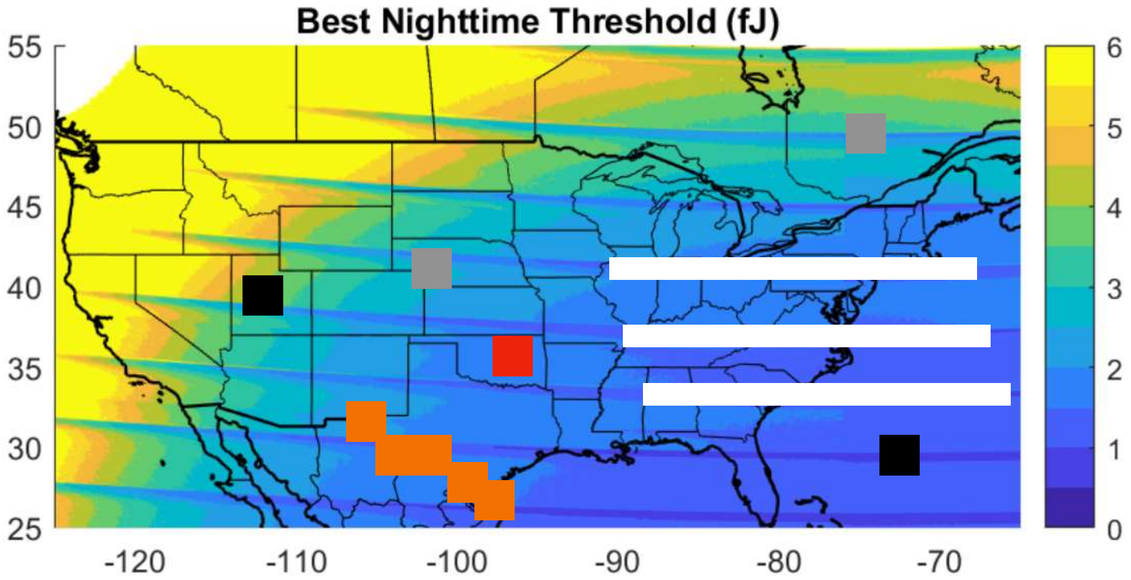


New idea: use background images and static lookup tables to directly calculate minimum detectable energy and FDE

Additional DQ flags

Design based on LM memo from 2017, CDRL038, GLM06090

- 8 unique flags, overriding FDE where they occur
  - 2 solar (glint, intrusion)
  - 2 kinds of dropped events (hardware, algorithm)
  - 2 at or near saturation
  - 2 dead or obscured
- Reported by CCD pixel location
  - Make fixed grid images using same process as backgrounds

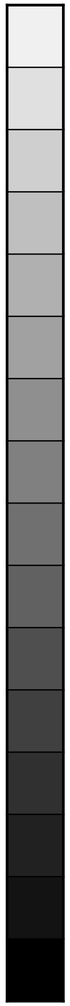


Integration of backgrounds, FDE, and flags

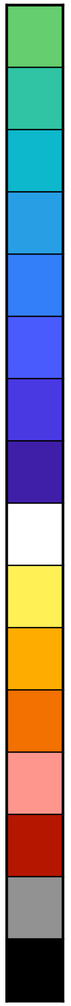
Packing two images into one byte

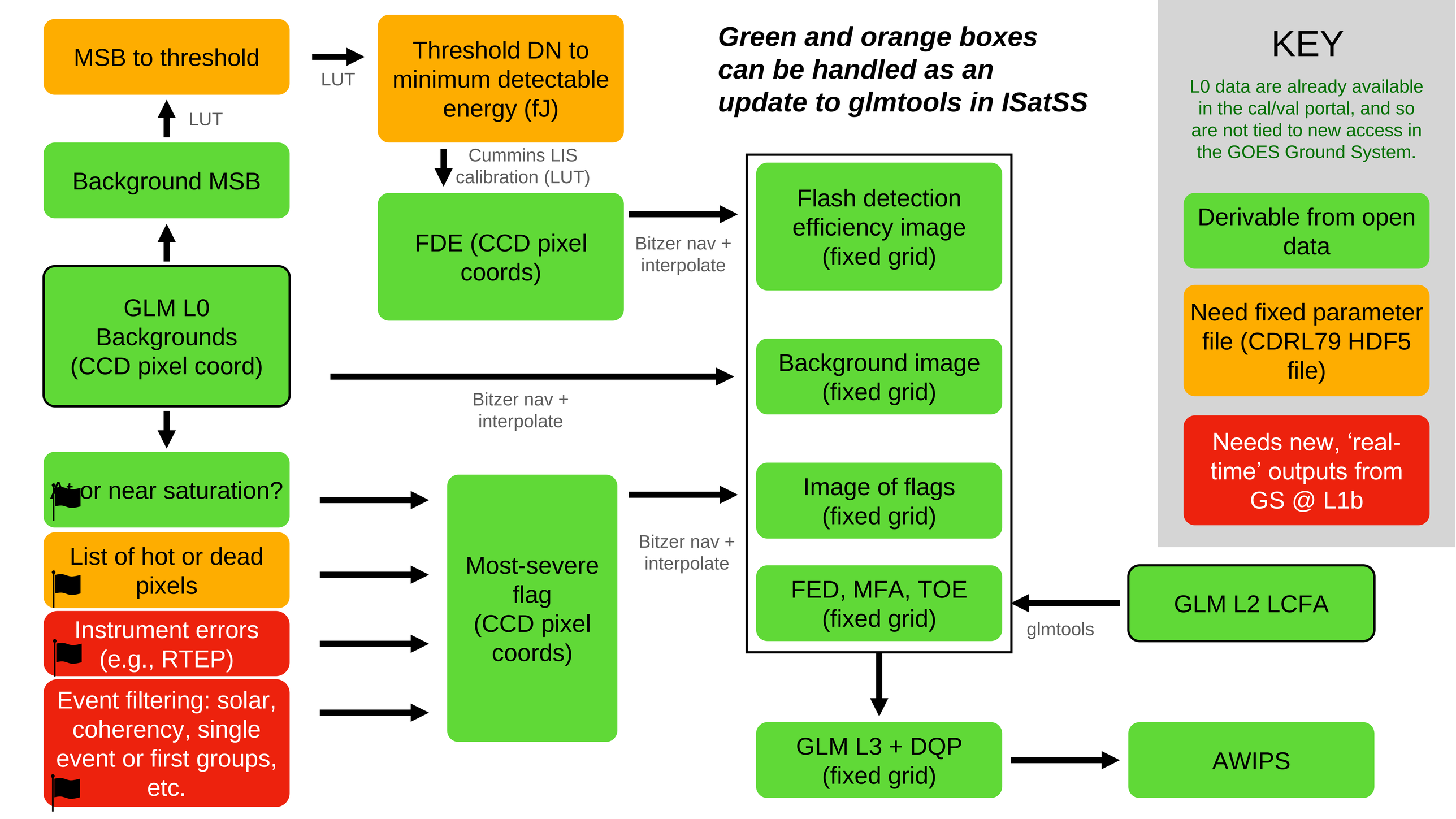
- In the data flow to AWIPS, one byte (8 bits) is reserved for a DQP on a (5424 x 5424), 2 km fixed grid.
- Send **two images** with 4 bits allocated to each
- **16 gray shades for background** (4 bits)

Alternative: Four, 4 km images with 256 bits/pixel into the same number of reserved bytes



- Color shade for **FDE and artifacts** (4 bits)
  - 8 FDE shades: >90, >80, >70, >60, >50, >40, >20, >0 %
  - 8 unique flags, overriding FDE where they occur
    - 2 at or near saturation
    - 2 solar (glint, intrusion)
    - 2 kinds of dropped events (hardware, algorithm)
    - 2 dead or obscured




MSB to threshold
LUT
Threshold DN to minimum detectable energy (fJ)
LUT
Background MSB
Cummins LIS calibration (LUT)
FDE (CCD pixel coords)
Bitzer nav + interpolate
Flash detection efficiency image (fixed grid)
GLM L0 Backgrounds (CCD pixel coord)
Bitzer nav + interpolate
Background image (fixed grid)
At or near saturation?
List of hot or dead pixels
Instrument errors (e.g., RTEP)
Event filtering: solar, coherency, single event or first groups, etc.
Most-severe flag (CCD pixel coords)
Bitzer nav + interpolate
Image of flags (fixed grid)
FED, MFA, TOE (fixed grid)
glmtools
GLM L2 LCFA
GLM L3 + DQP (fixed grid)
AWIPS
Green and orange boxes can be handled as an update to glmtools in ISatSS
KEY
L0 data are already available in the cal/val portal, and so are not tied to new access in the GOES Ground System.
Derivable from open data
Need fixed parameter file (CDRL79 HDF5 file)
Needs new, ‘real-time’ outputs from GS @ L1b

Summary of DQP options

We can deliver backgrounds, a DQP and some flags with only a change to glmtools/ISatSS

- **Backgrounds**
  - Only need L0 (as on cal/val portal) + reader
  - Bitzer's Python can can be packaged in ISatSS
- **FDE**: from conversion of background MSB to minimum detectable energy in fJ.
  - Need tables (CDRL79 HDF5 file)
    - Backup plan: use minimum lightning event energy
  - Can be packaged in ISatSS
- **Dead pixel flags**
  - Needs a static file (CDRL79 HDF5)
  - Can be packaged in ISatSS
- **Saturated pixel flags**
  - Needs L0 background only (probably)
  - Can be packaged in ISatSS
- **Solar intrusion, glint, dropped event flags, instrument errors**
  - Requires new info from the ground segment
  - Given availability of new files, can be packaged in ISatSS

Next: integrate proof of concept code into glmtools/ISatSS, confirm timeliness, HWT/field test.

Notes

- The tables for FDE are part of the CDRL79 HDF5 file (one per instrument) that is loaded into the ground system. That contains a copy of the on-board threshold table (unit DN, size 56 channel x 32 MSB), the ground-based second level threshold (unit DN, size 1372 x 1300 pixels x 32 MSB) as well as the calibration factor from DN to energy (unit J, size 1372 x 1300 pixels x 32 MSB)