# Maximizing the Value of the Landsat Archive for Forest Change Applications

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Tree 1

Tree 2

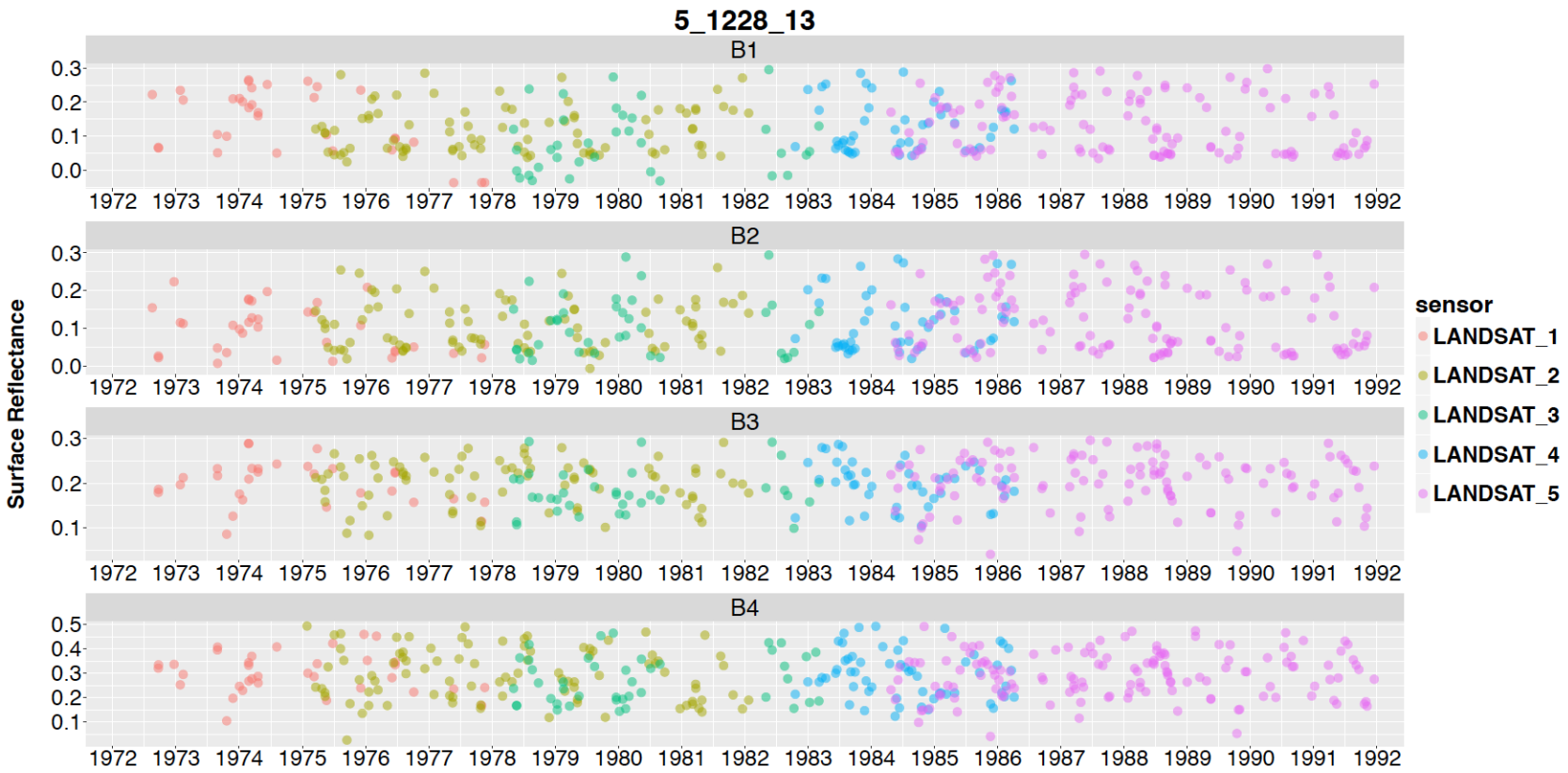
# <u>Alternate Title</u>
# Salvaging Neglected Landsat Data & Putting It To Work For The Greater Good

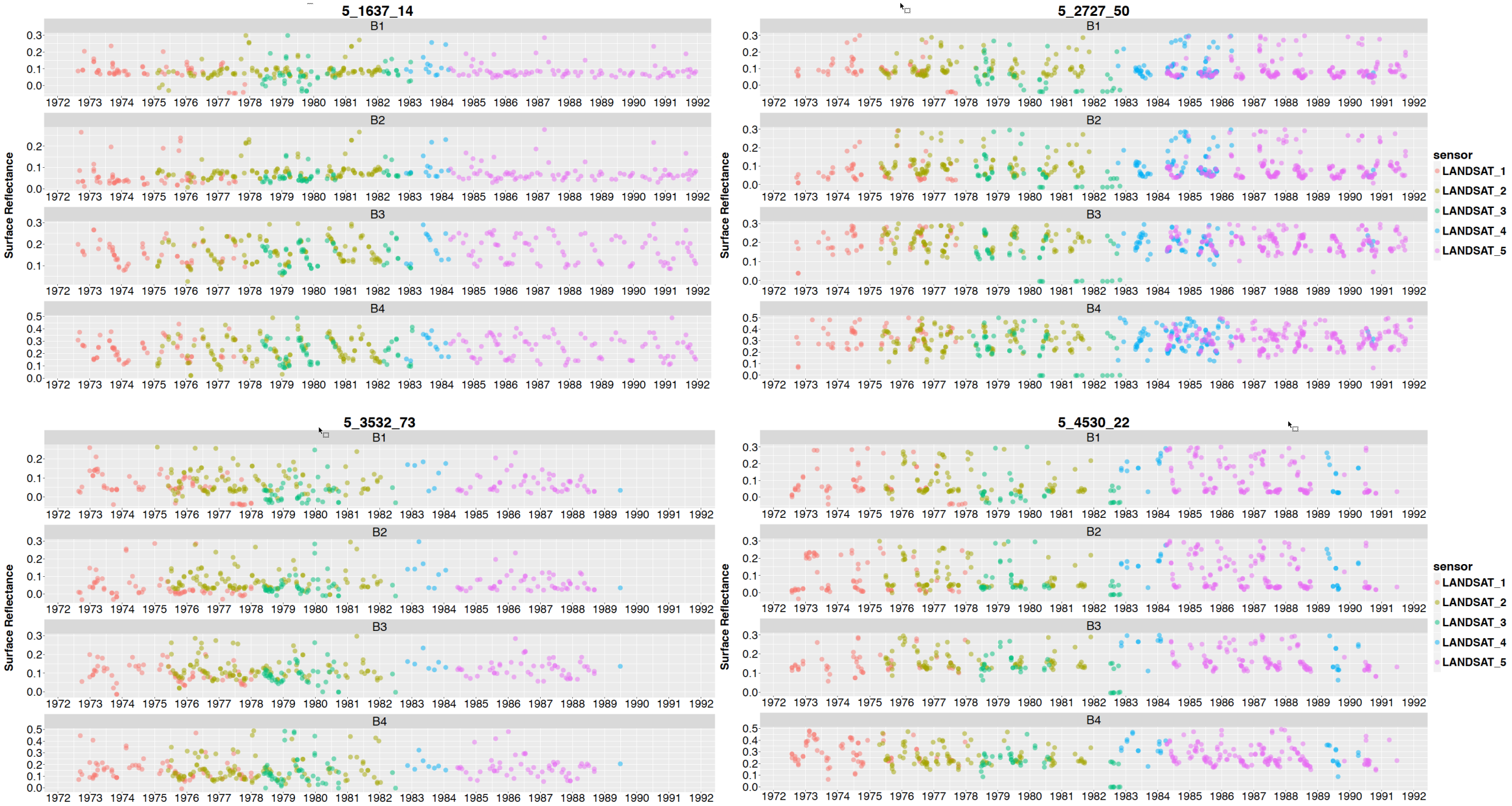
- MSS (Embracing the Landsat family's black sheep)
- ESA no PCD data (Recovering lost Landsat children)

# Embracing the Landsat family's black sheep (MSS)

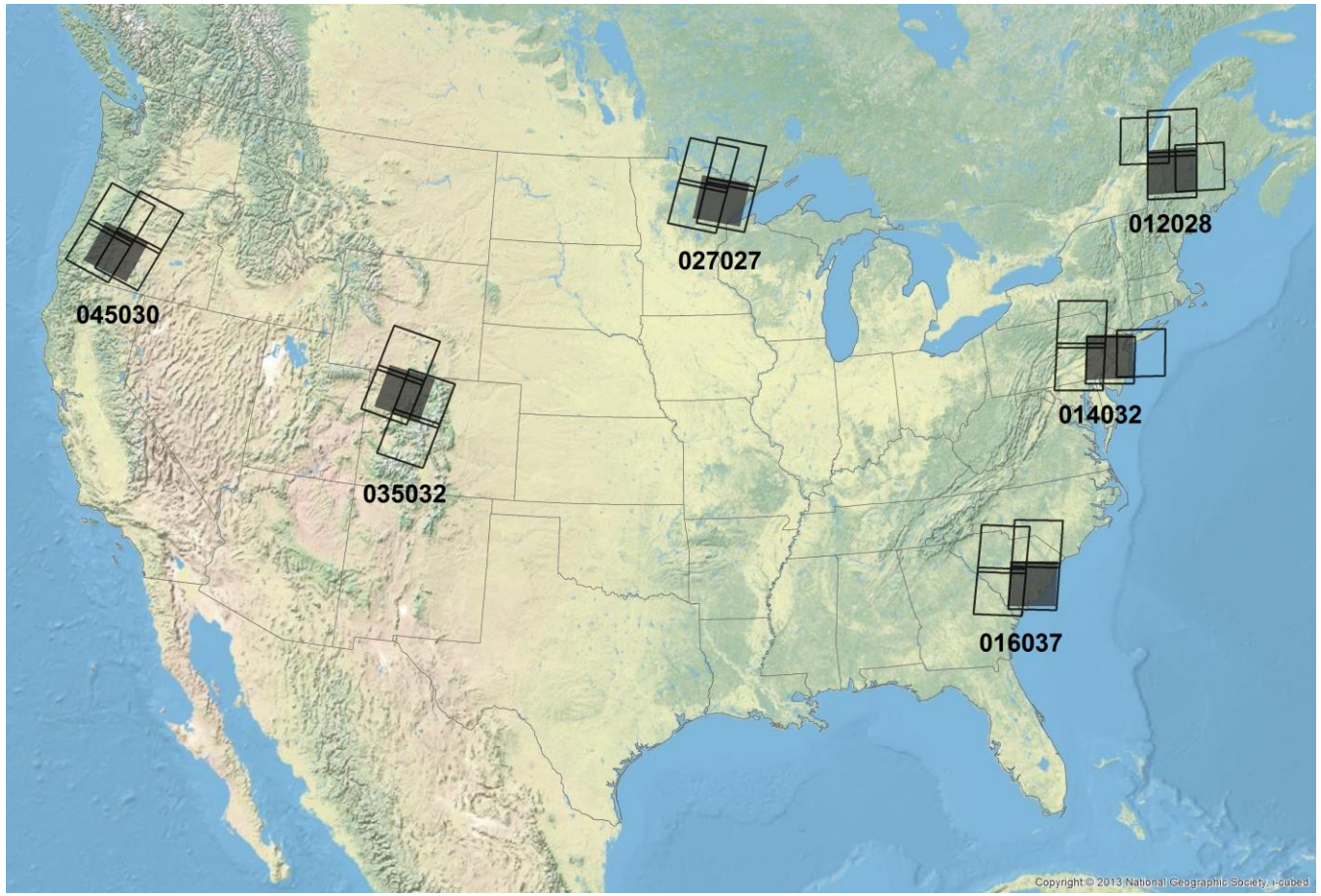
- A long strange trip….but thanks to Dennis, Larry, and Sandeep, Yang, Justin, Erik I think we've made good progress (for our six scenes of interest)

- <u>First 3 steps</u>
  1. Cloud masking (Braaten et al. 2015, RSE)
  2. Radiometric calibration fix where L1-L3 ≠ L4-L5 (Sandeep, Dennis)
  3. SR via SMACAA (Larry, Dennis); 1800 pixels over 6 scenes – no observed problems



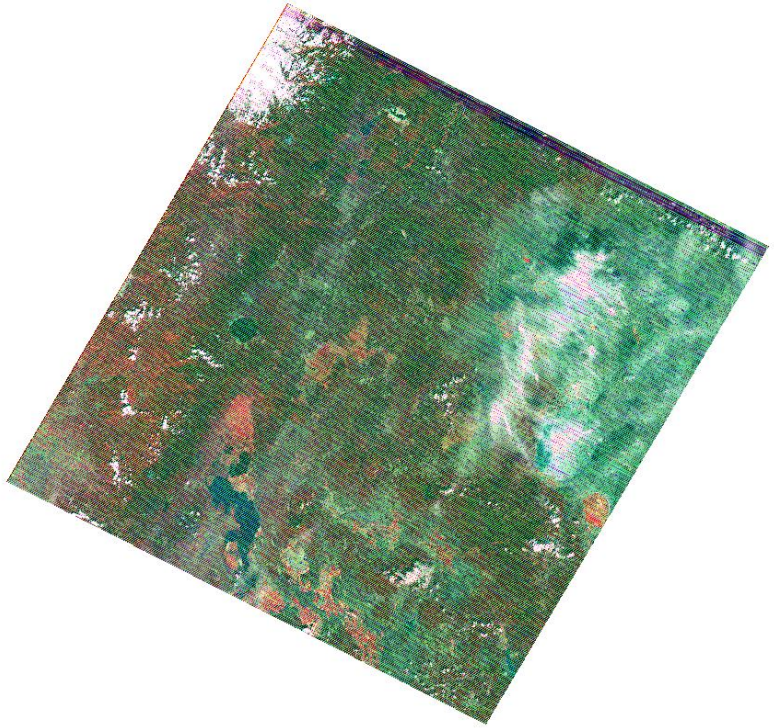

5_1637_14
5_2727_50
5_3532_73
5_4530_22
B1
B2
B3
B4
Surface Reflectance
1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992
sensor
LANDSAT_1
LANDSAT_2
LANDSAT_3
LANDSAT_4
LANDSAT_5

# Step 4: Salvaging L1Gs (Quasi-L1Ts)

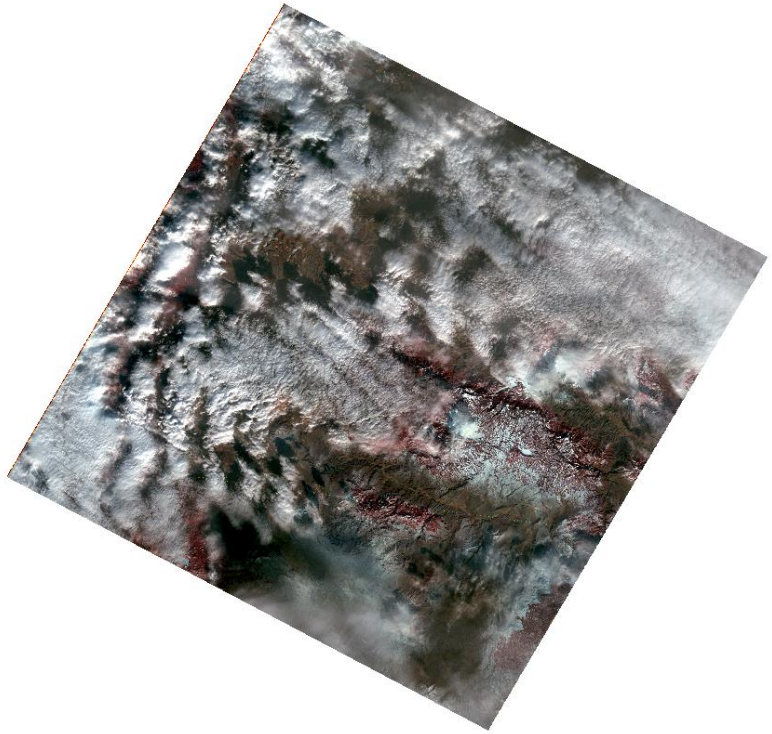



- 6 WRS2 sample scenes covered by 24 WRS1 scene pieces
- Visual screening of 2930 WRS1 & WRS2 L1G MSS images, identifying those with reasonable portion of cloud-free pixels and minimal number of bad lines

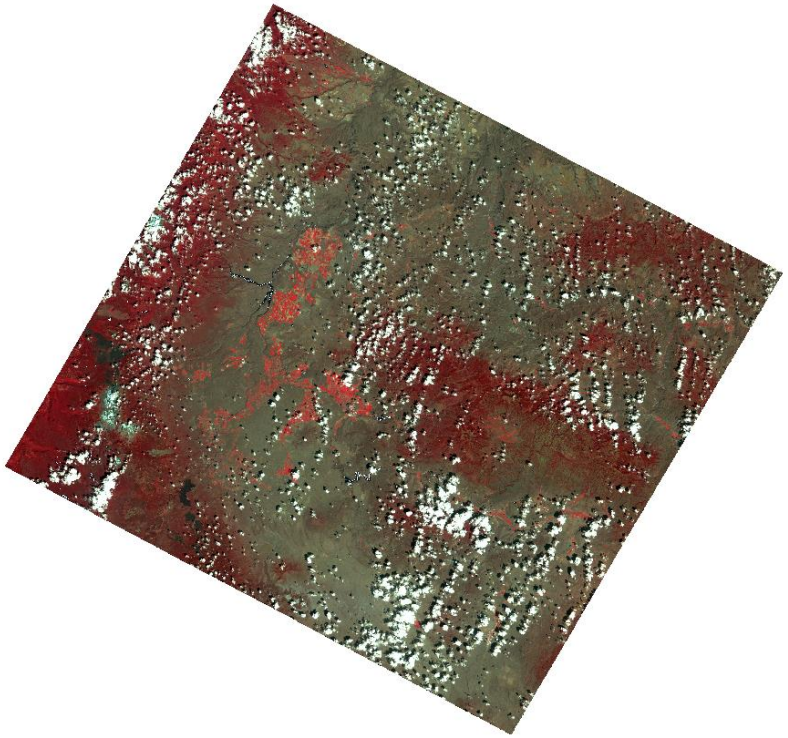
# Unusable and Usable L1G Examples



Unusable – Bad Data



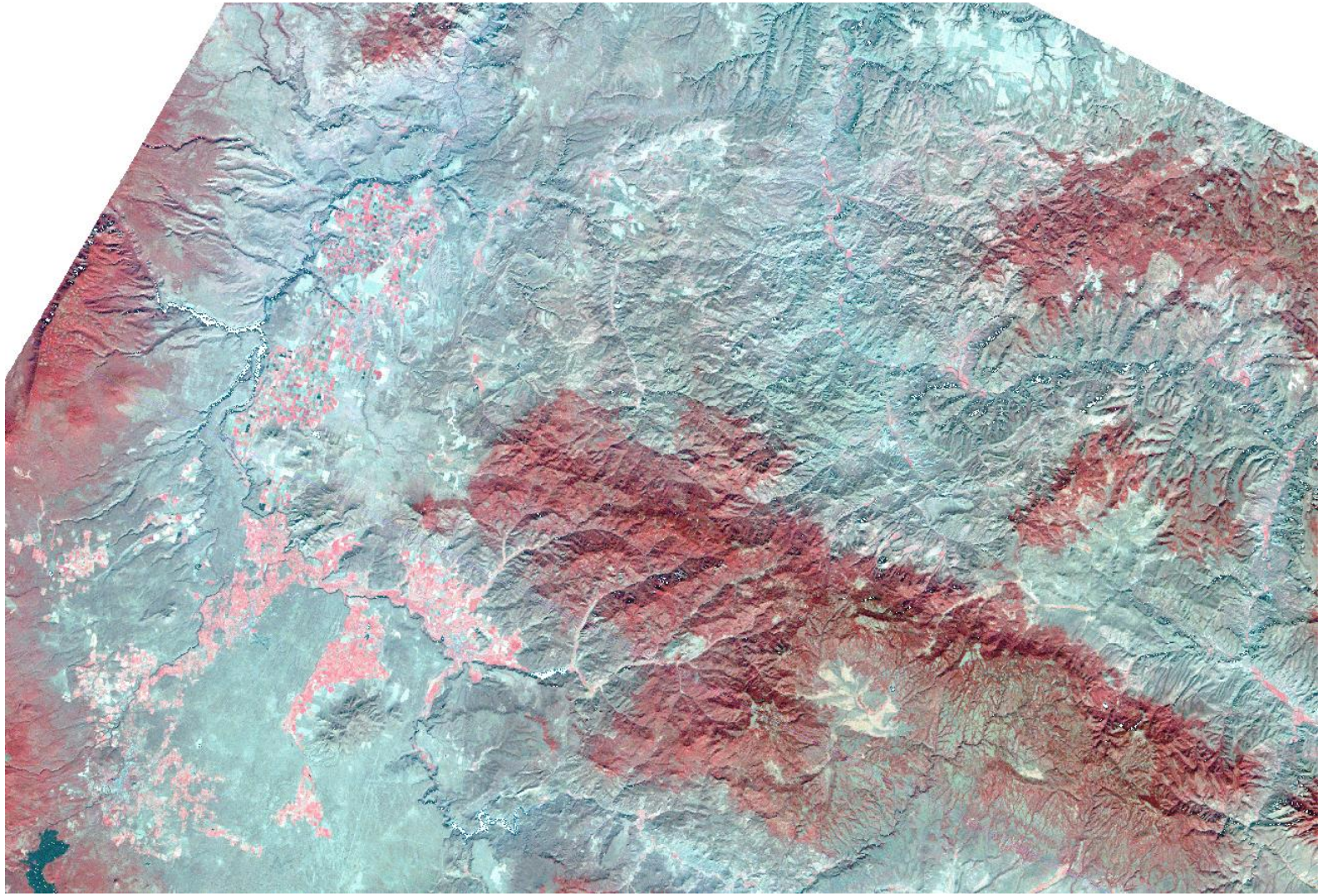
Unusable – Clouds



Usable

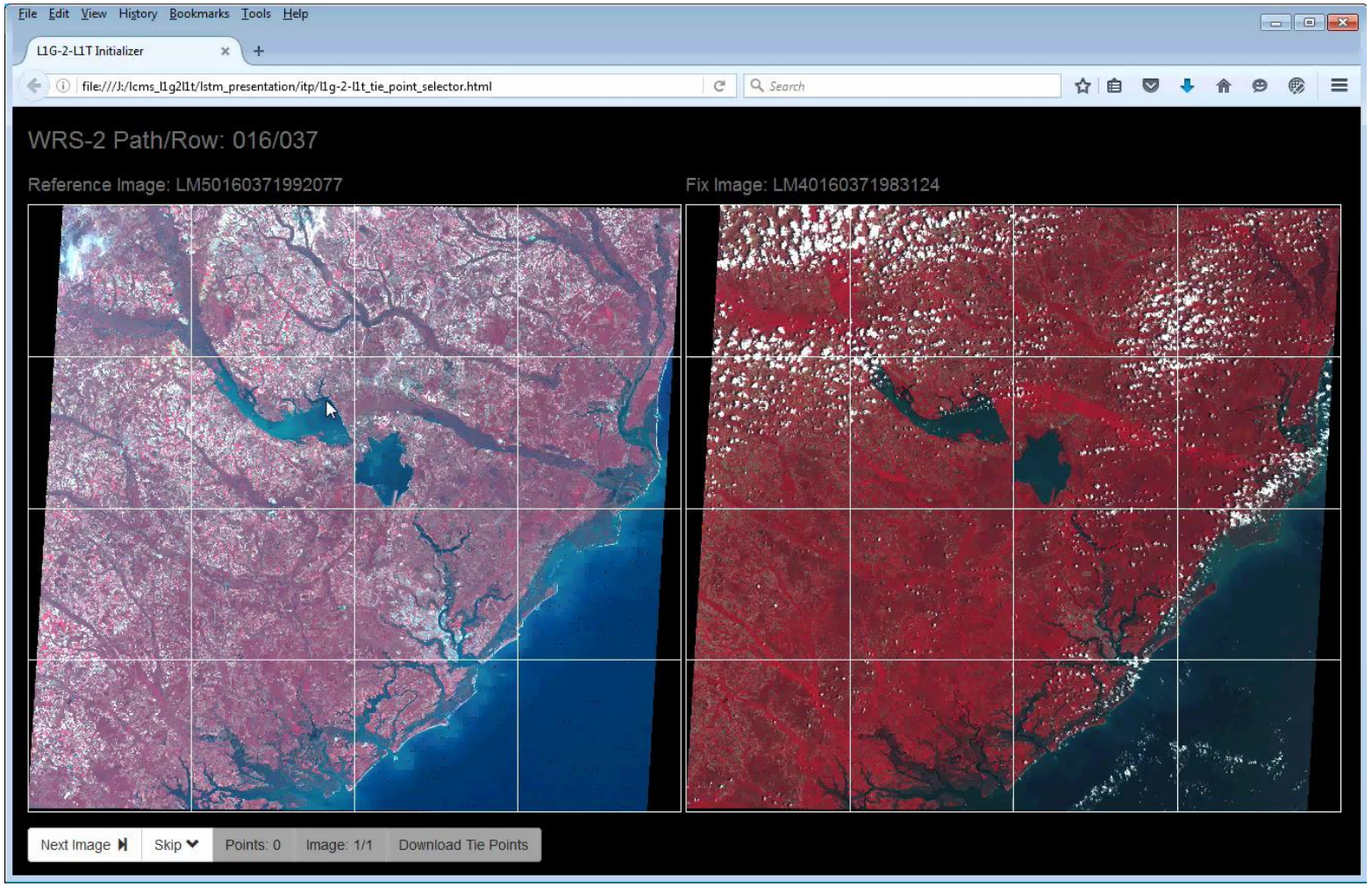
# Original Offset of Usable L1G

- Reference L1T 421 (RGB) v. L1G 124 (RGB)
- L1G image offset many kilometers south and west



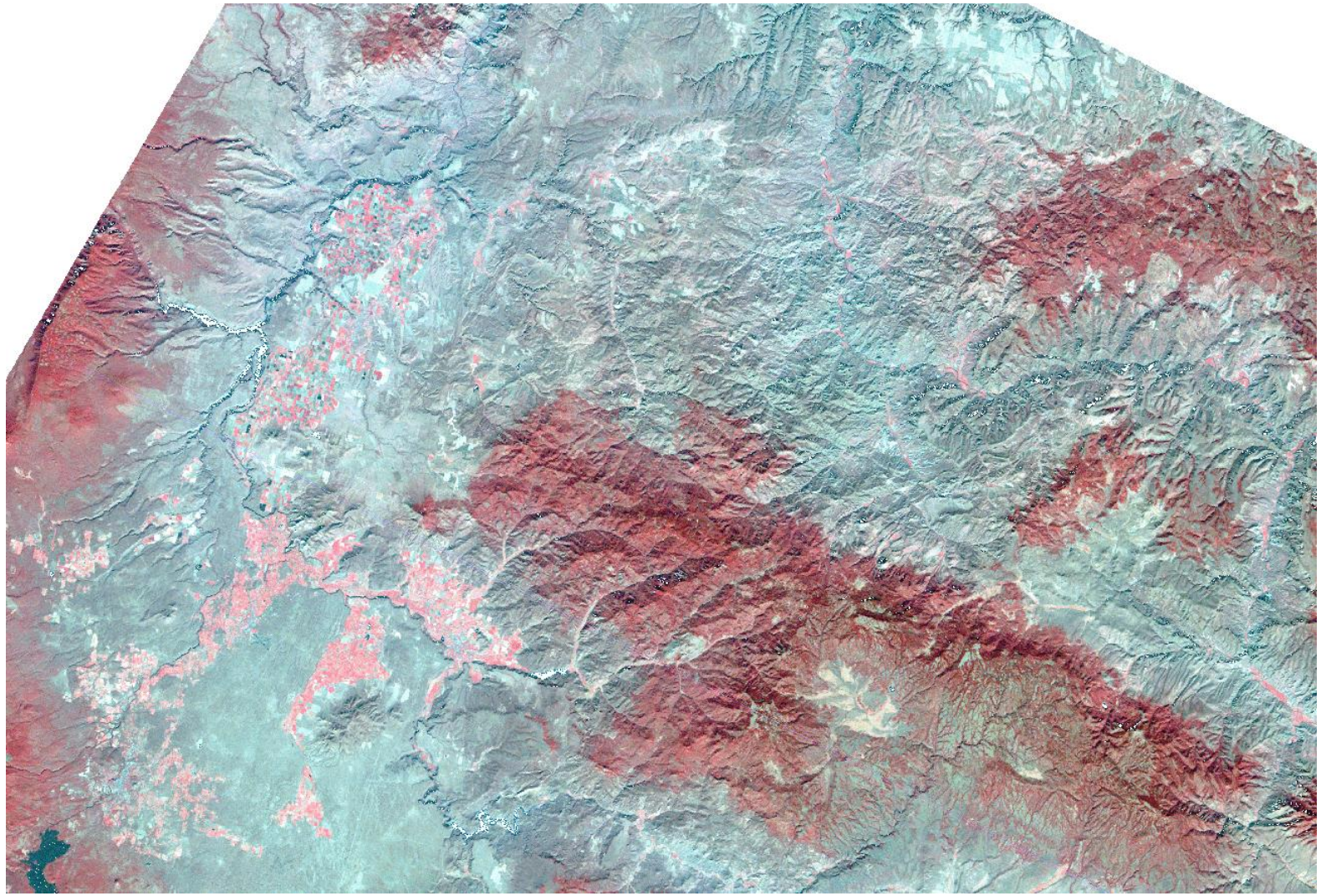
# Initial 3 Tie-points Per Usable L1G

- Justin created nifty user interface
- One reference L1T per path/row
- All usable L1G images per path/row per session
- Download points
- Very quick
  - Students?
  - McTurk?



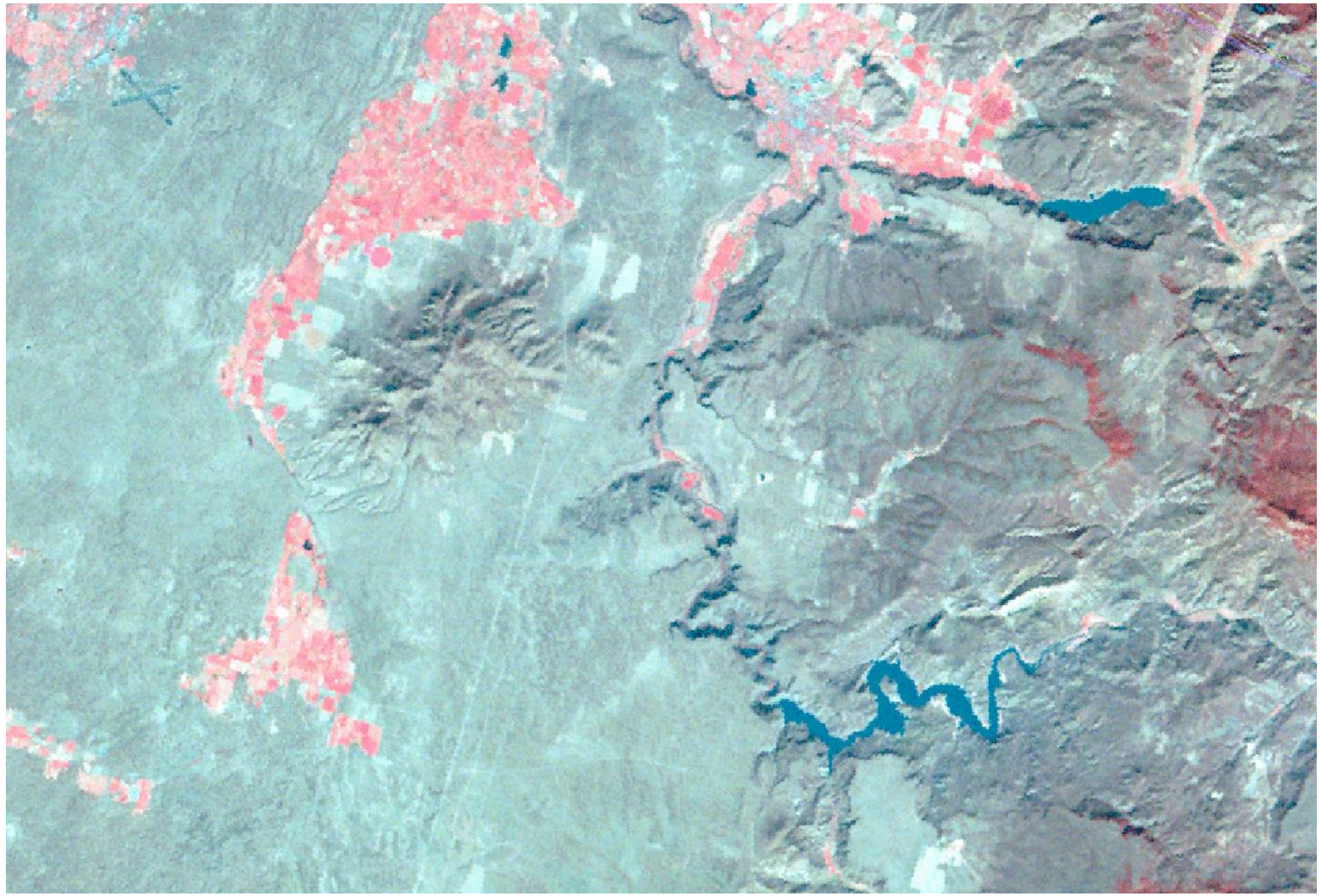
# Image Matching with itpfind (Kennedy & Cohen 2003)

- Reference L1T 421 (RGB) v. L1G 124 (RGB)
- 100s of automated tie-points
- Ready for use as quasi-L1T

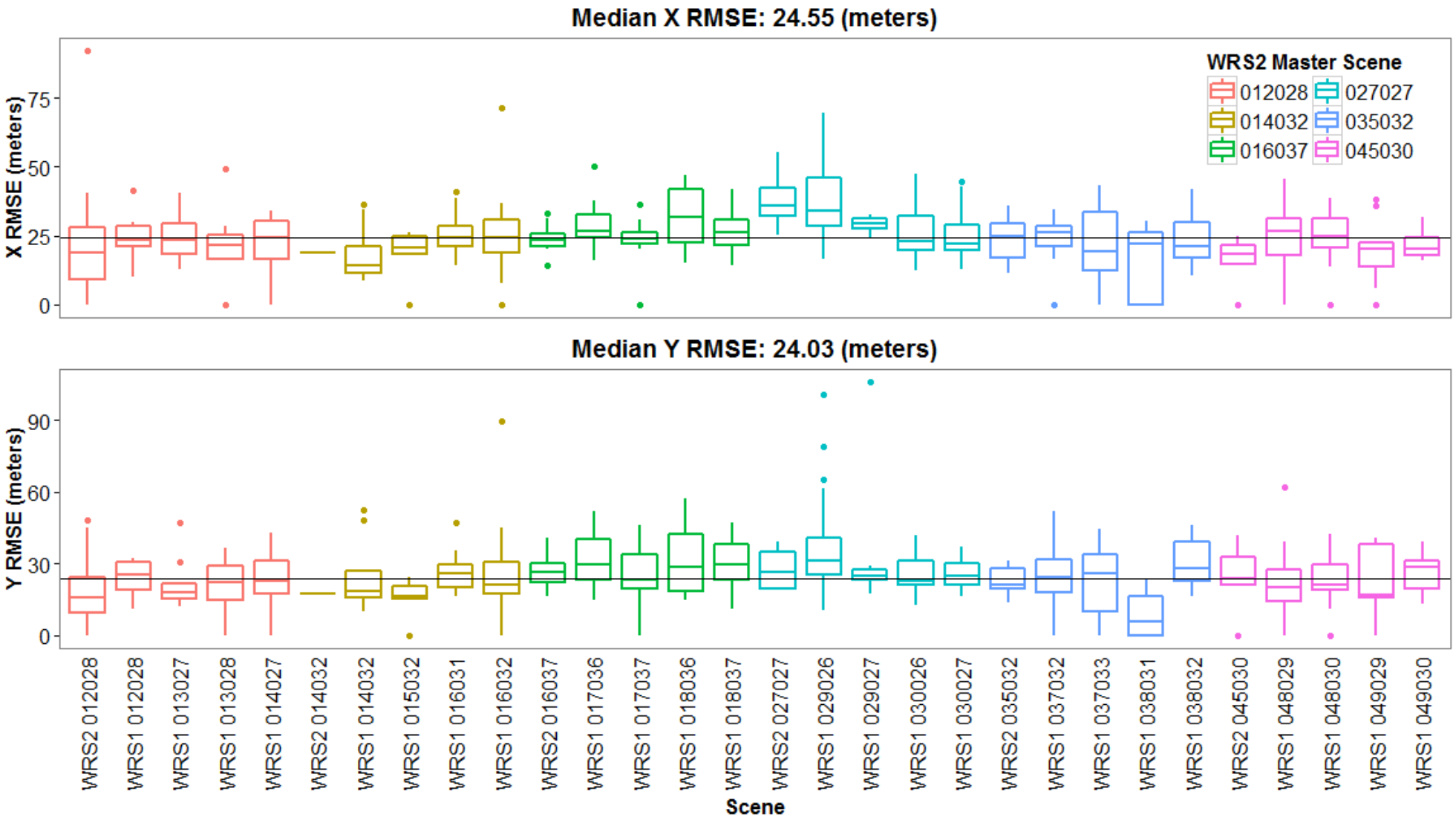


# Quasi-L1T Zoom

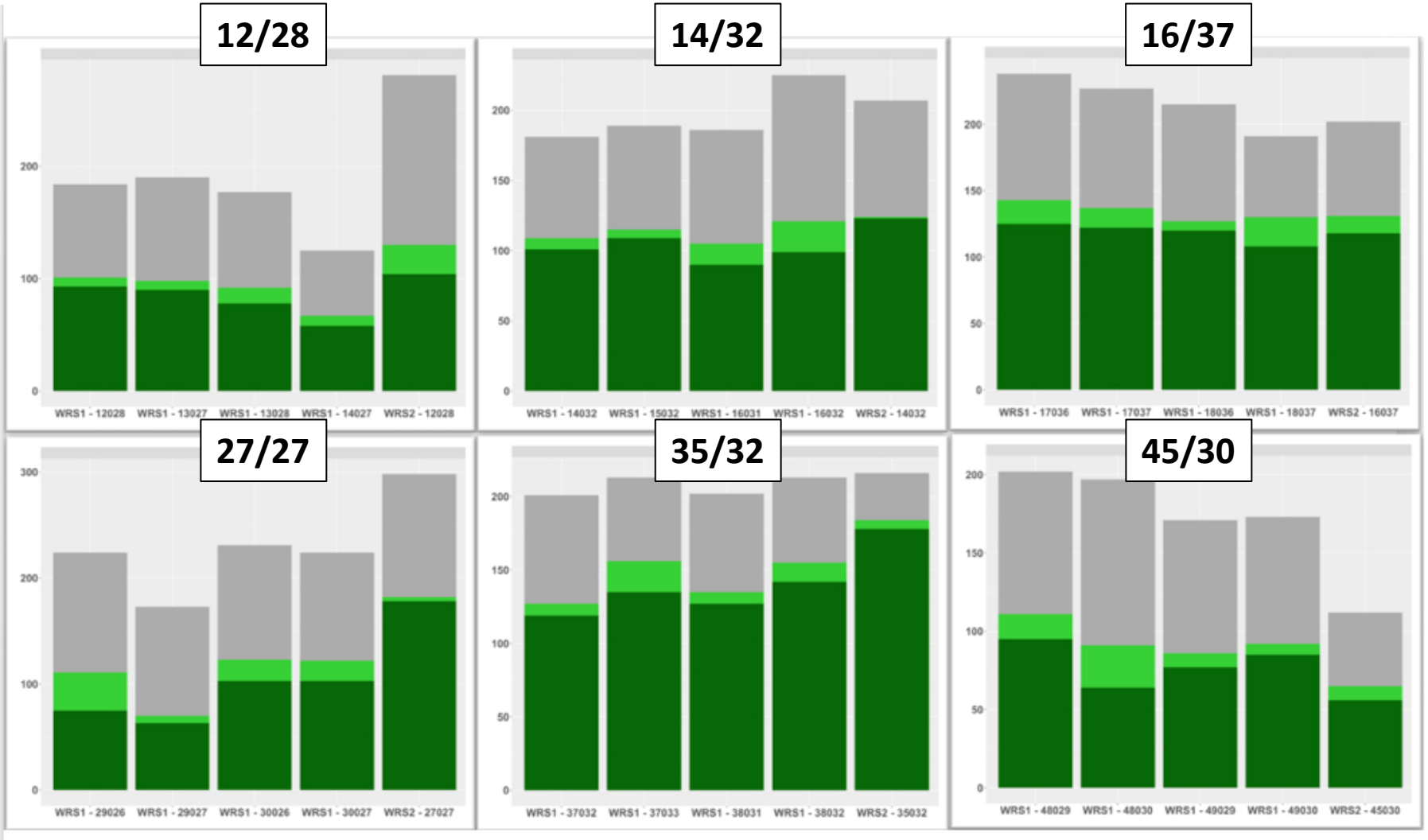
- Reference L1T 421 (RGB) v. L1G 124 (RGB)
- Replacement for “no data” to densify time series



# “Verified” RMSE – X, Y

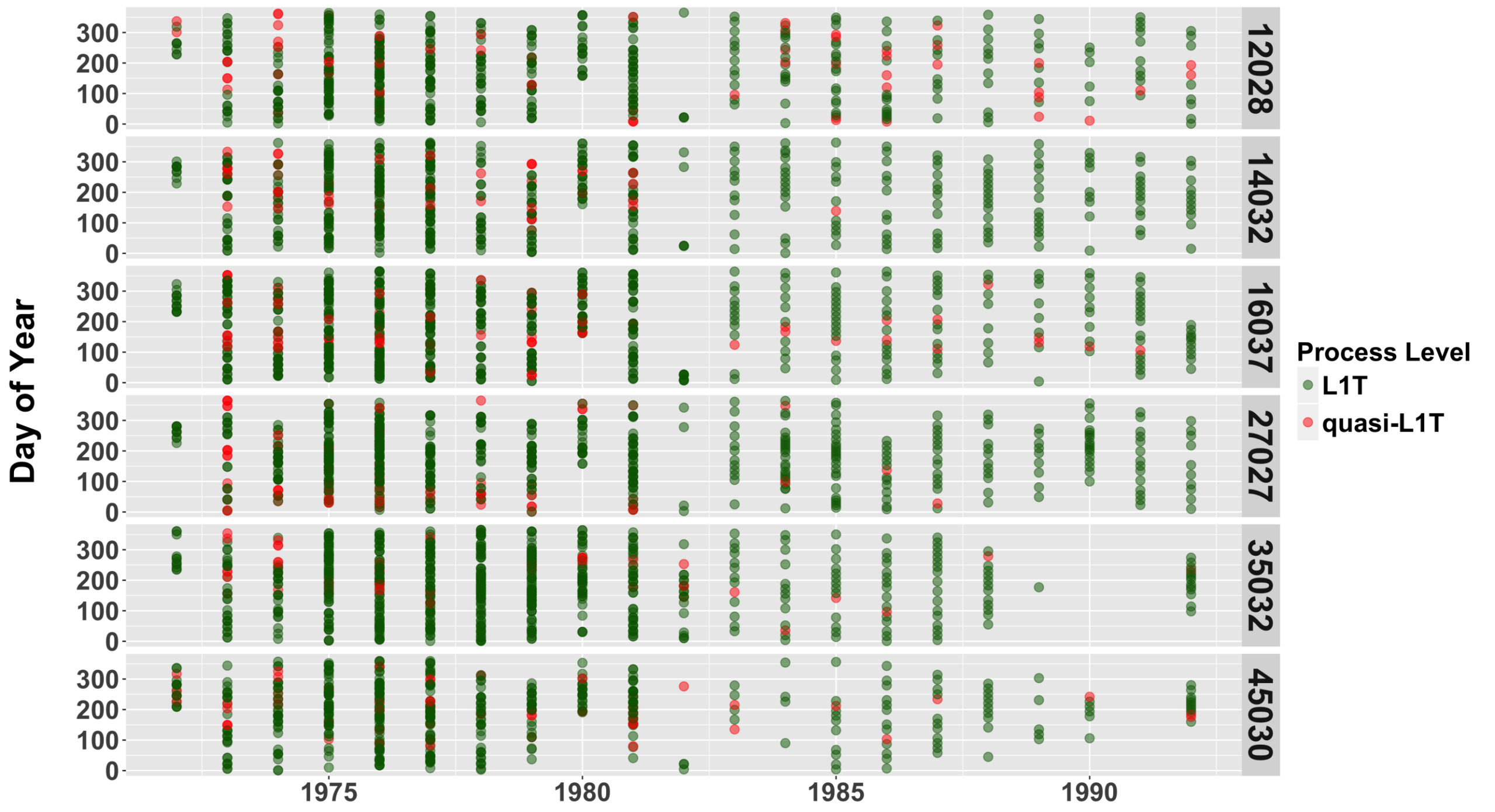


# Summary Stats – 6 Scenes



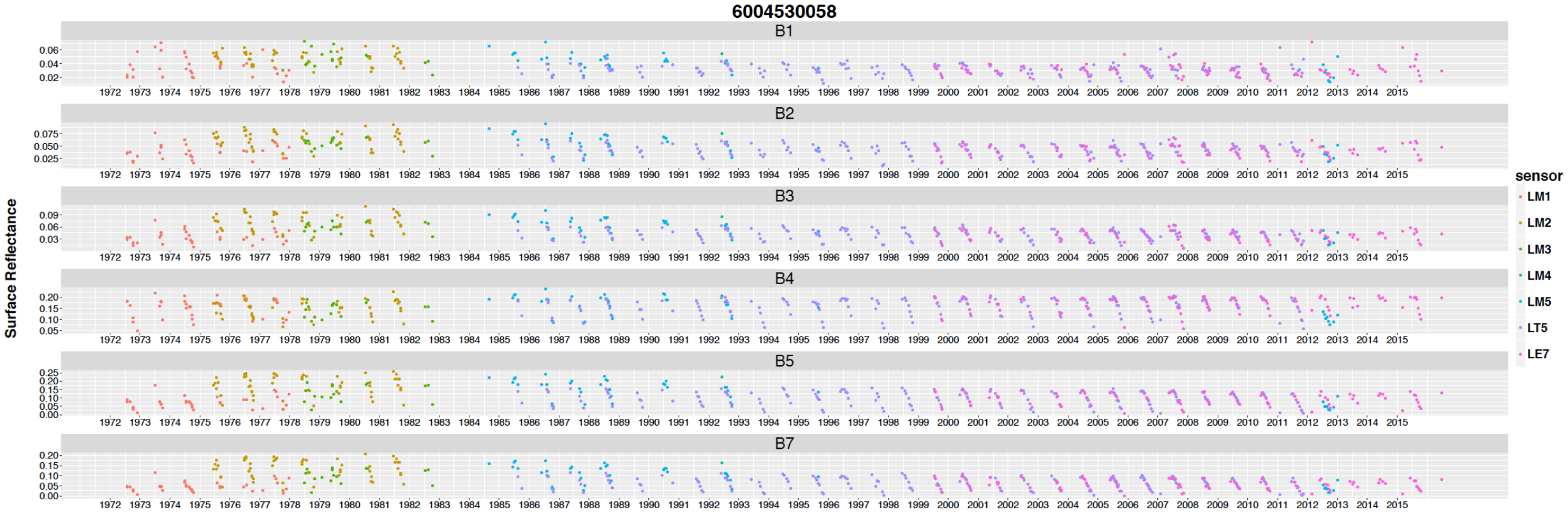

- 3138 total L1T, 2930 L1G – 402 salvageable as quasi-L1T (14%)
- Quasi-L1T added between 2% and 48% new mostly cloud-free per pixel observations, more with overlap

L1T
L1T.Quasi
L1G.Unusable

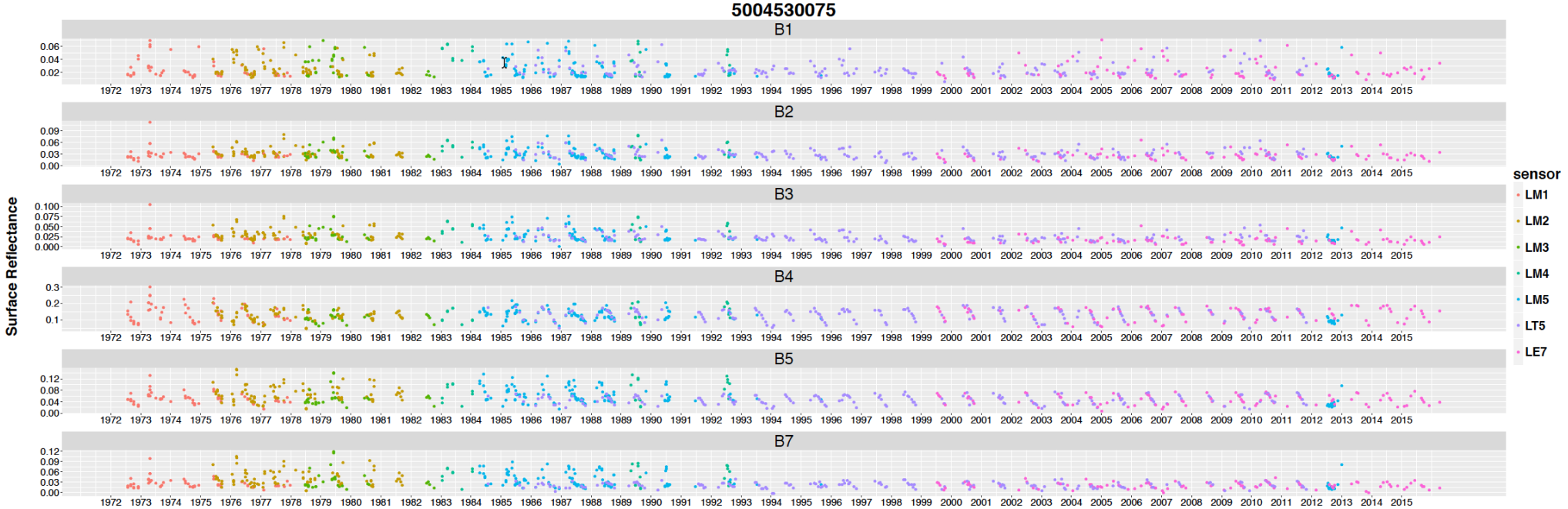

Day of Year
300
200
100
0
12028
14032
16037
27027
35032
45030
1975
1980
1985
1990
Process Level
L1T
quasi-L1T

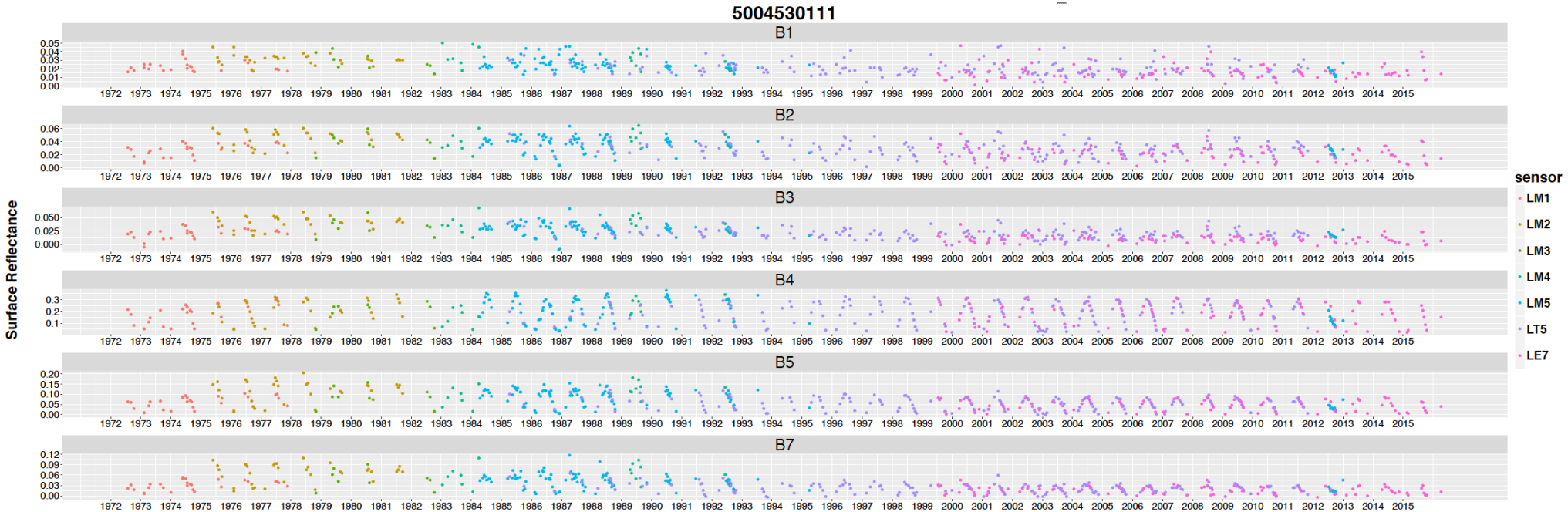
# Step 5: Harmonization (MSS – TM; 4530 example)

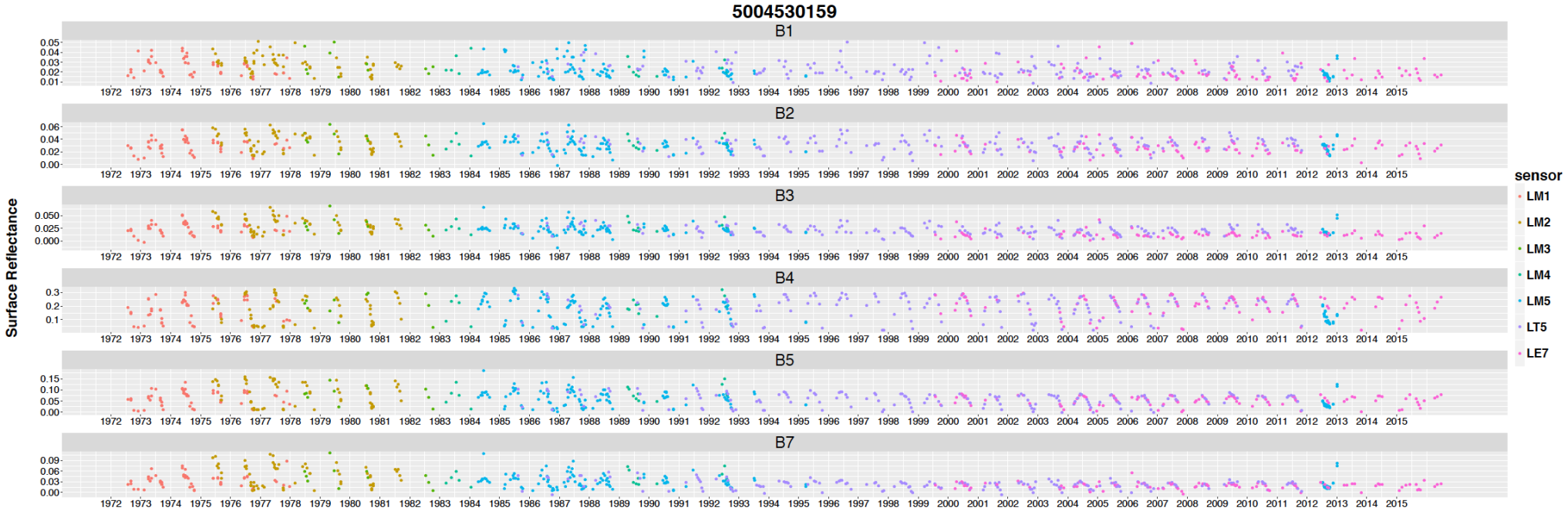
- Random Forests modeling approach presented last meeting (Blacksburg) – TM bands

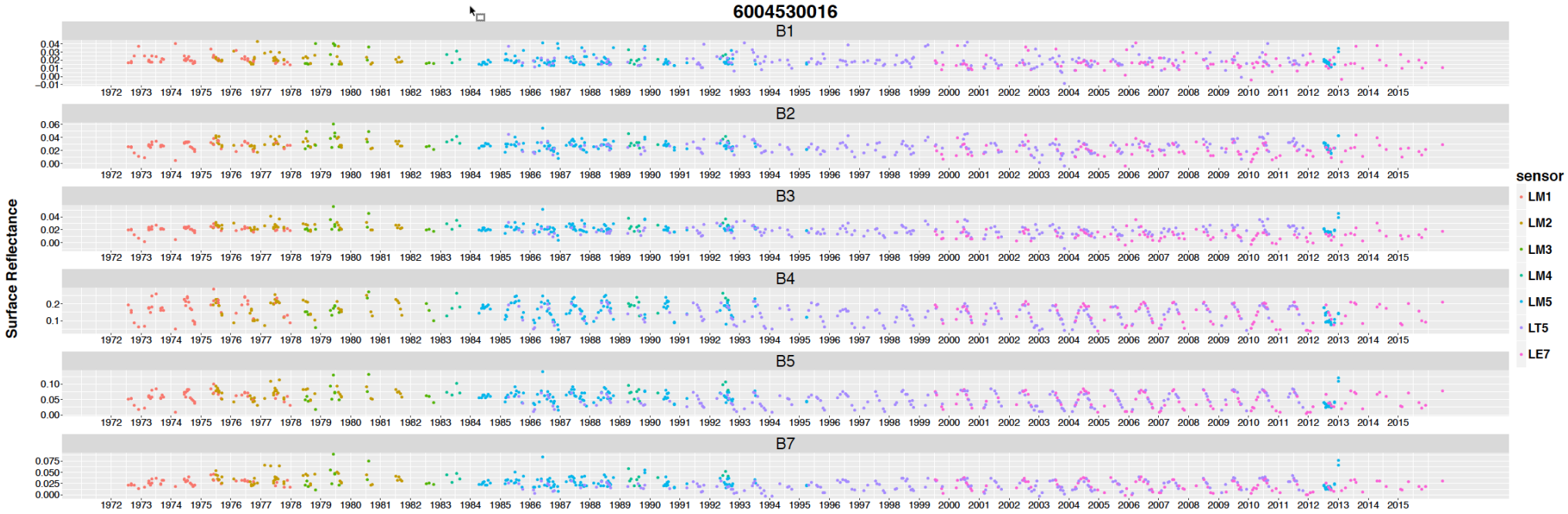


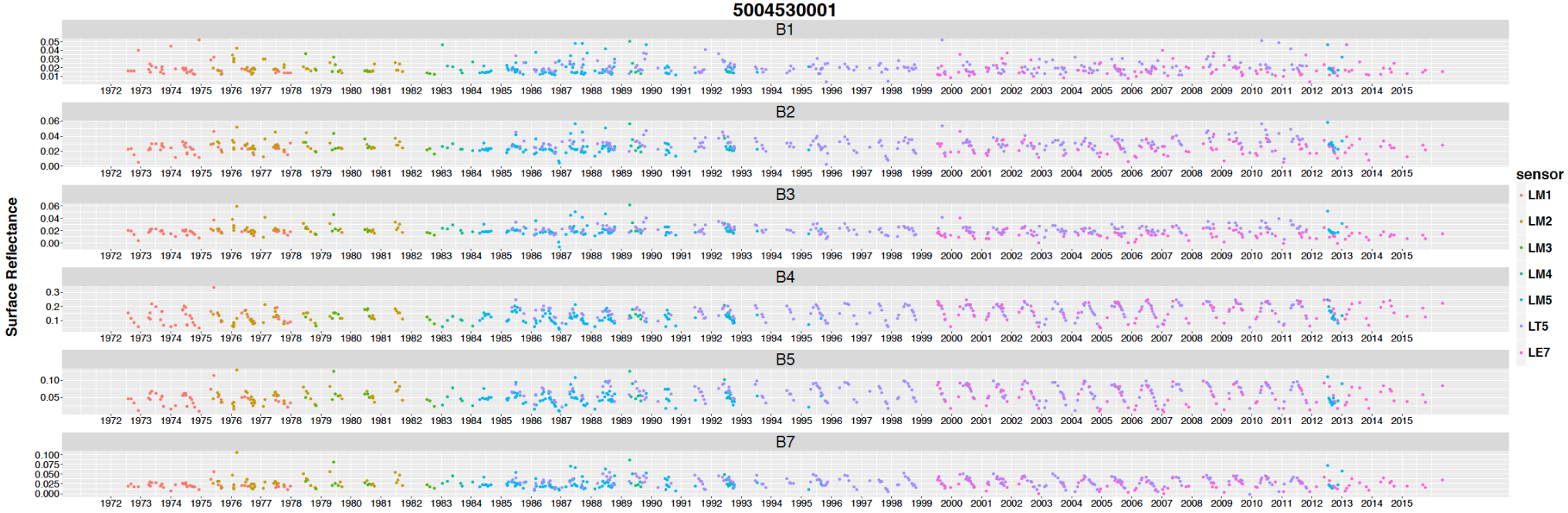
5004530055
B1
B2
B3
B4
B5
B7
Surface Reflectance
sensor
LM1
LM2
LM3
LM4
LM5
LT5
LE7


5004530075
B1
B2
B3
B4
B5
B7
Surface Reflectance
sensor
LM1
LM2
LM3
LM4
LM5
LT5
LE7


5004530111
B1
B2
B3
B4
B5
B7
Surface Reflectance
sensor
LM1
LM2
LM3
LM4
LM5
LT5
LE7

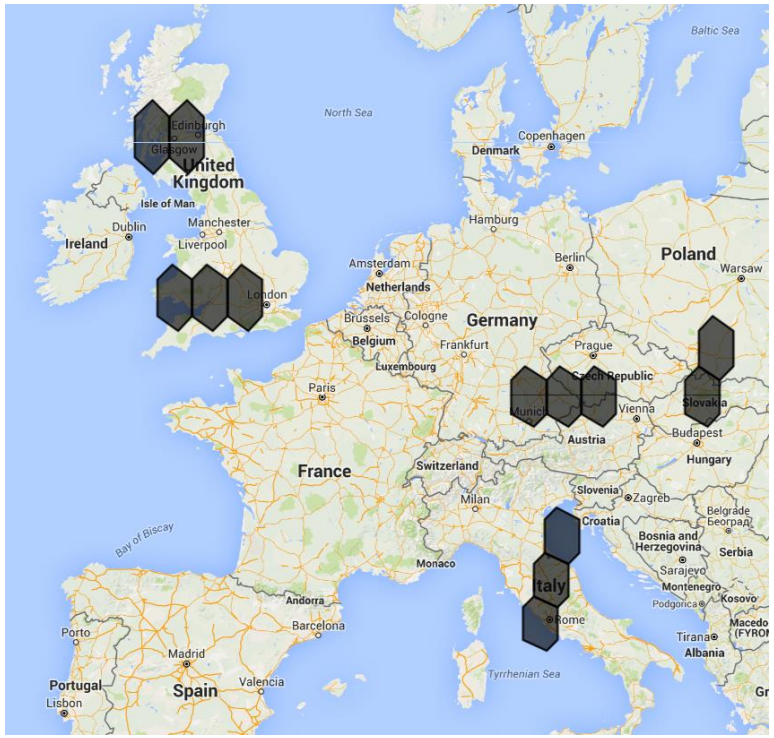

5004530159
B1
B2
B3
B4
B5
B7
Surface Reflectance
sensor
LM1
LM2
LM3
LM4
LM5
LT5
LE7

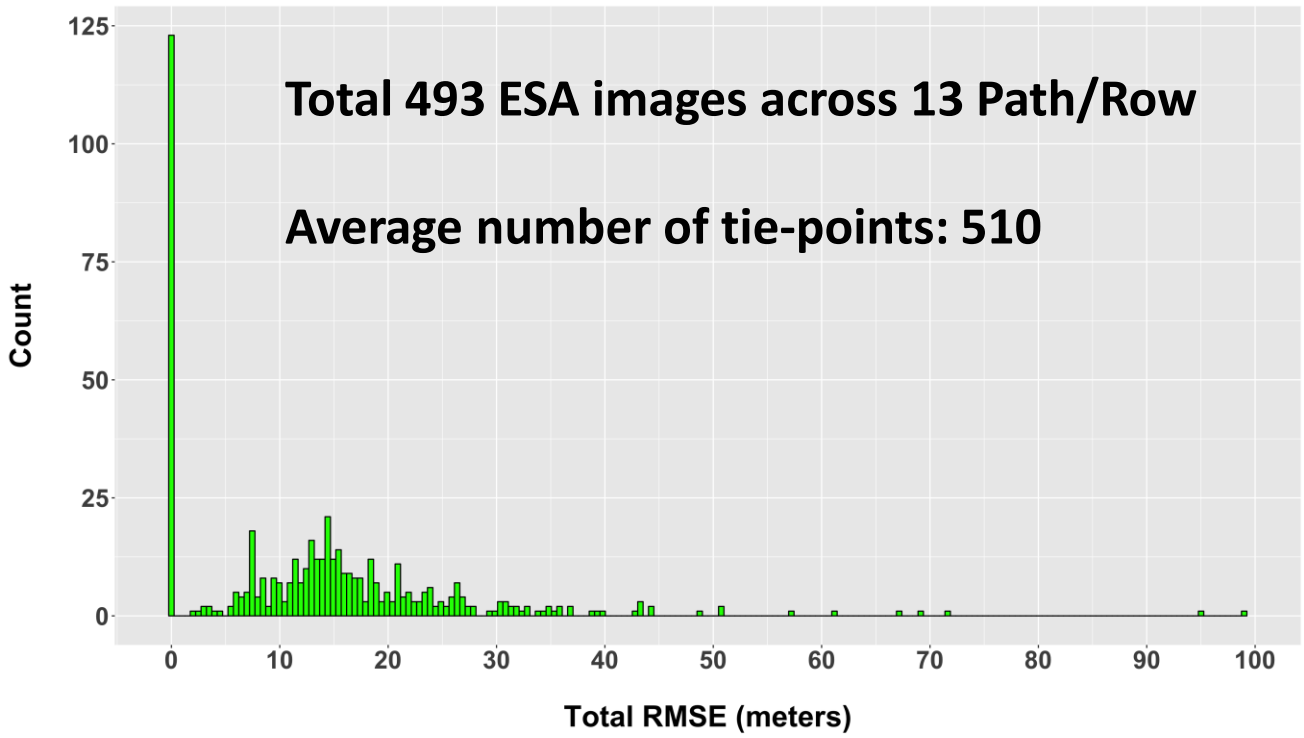

6004530016
B1
B2
B3
B4
B5
B7
Surface Reflectance
sensor
LM1
LM2
LM3
LM4
LM5
LT5
LE7

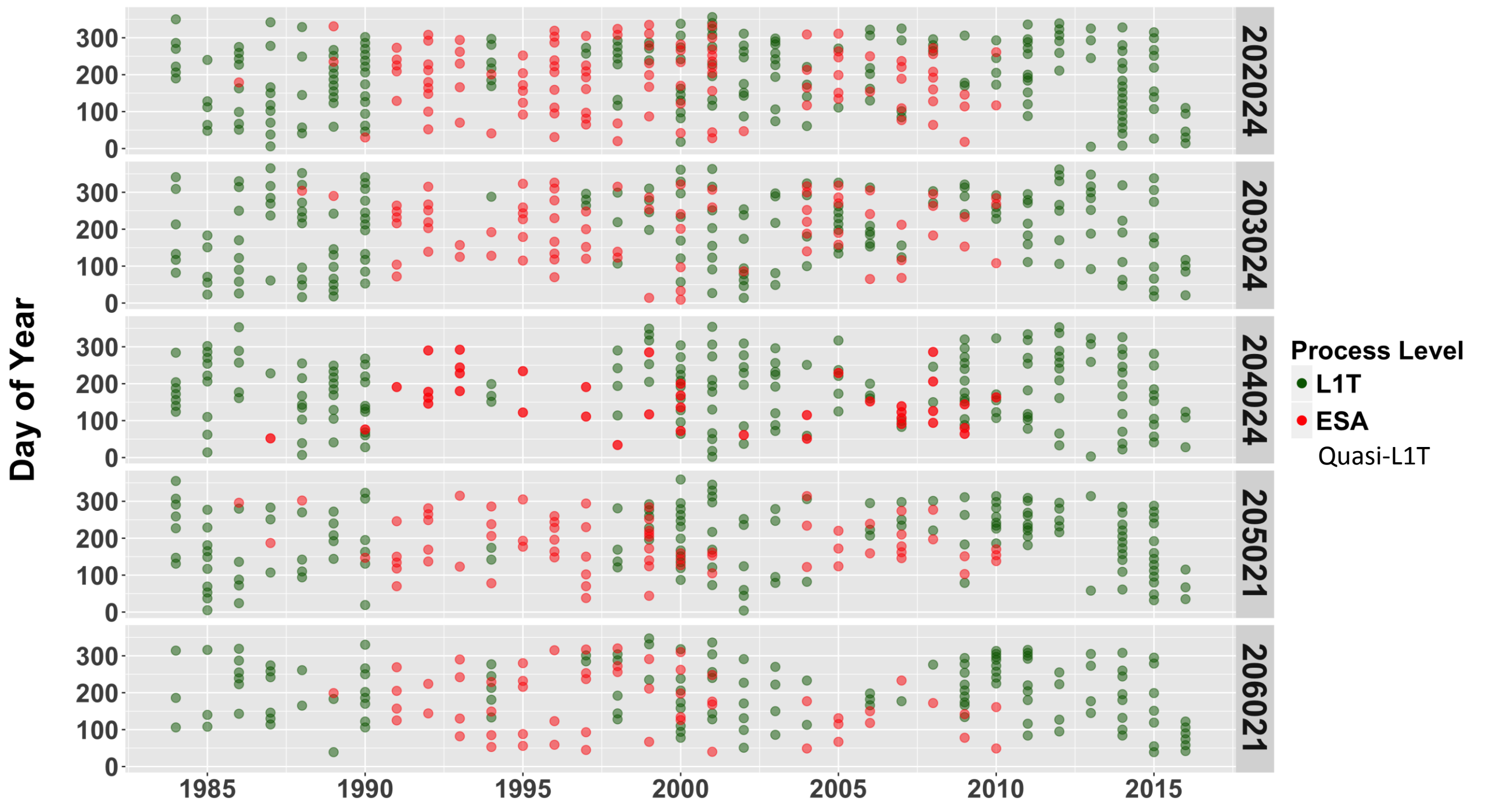

5004530001
B1
B2
B3
B4
B5
B7
Surface Reflectance
sensor
LM1
LM2
LM3
LM4
LM5
LT5
LE7

# Recovering lost Landsat children (ESA no PCD)

- Dirk Pflugmacher downloaded ESA GTC (L1T) TM/ETM+ data
- Feng's AROP with USGS L1T reference images
- We "verified" with itpfind




Day of Year
300
200
100
0
202024
203024
204024
205021
206021
1985
1990
1995
2000
2005
2010
2015
Process Level
L1T
ESA
Quasi-L1T

# Final Words

- Derived MSS SR with new calibration and SMACAA
  - Didn't see single bad example from 1800 examined pixels trajectories across 6 different forest-dominated scenes from the conterminous US
  - These data are useful for those wanting to maximize the temporal extent of their analyses
  - Assume new calibrations will be implemented at EROS
  - But what about SMACAA or equivalent? Cloud mask?
- Deriving quasi-L1T images that fill important temporal gaps in the archive could enhance the value of the archive for a large segment of users…

# Final Words

- Quasi-L1T MSS images have acceptable “verified’ RMSEs and are a useful replacement for no data
  - Quick to scan for usable v. unusable
  - Easy and inexpensive to find 3 initial tie-points enabling use of an automated tie-point algorithm to find 100s more for any given image
  - Only needs to be done once (ever), and could use inexpensive high-school geography students or crowd sourcing to get it done
  - As of July 21, 2016 1.1 million MSS images in archive – 49% L1G, assume 14% salvageable quasi-L1T (~76,000): **Should those be salvaged**?
  - Tier 2.1 dataset, or is L1T enabled by the first 3 tie-points?
  - 138887 PR (process ready) MSS images – Weren’t these already taken care of or was that just TM/ETM+, or are these new from LGAC?

# More Final Words

- ESA no PCD data can also be morphed into quasi-L1T which dramatically improves our capabilities of doing time series analyses over Europe
  - Enhances impact of LGAC
  - European science, several institutions; UK Forestry Commission
- Harmonization is an active area of Landsat-related research (ETM+ to OLI, Landsat to Sentinel, etc.)
  - Similar efforts can be applied to MSS (with admittedly more challenges due to bandpass differences)
  - If not comfortable with MSS to TM harmonization, could still do time series analyses with MSS in original bands or NDVI and splice results to TM, ETM+, OLI time series analysis results