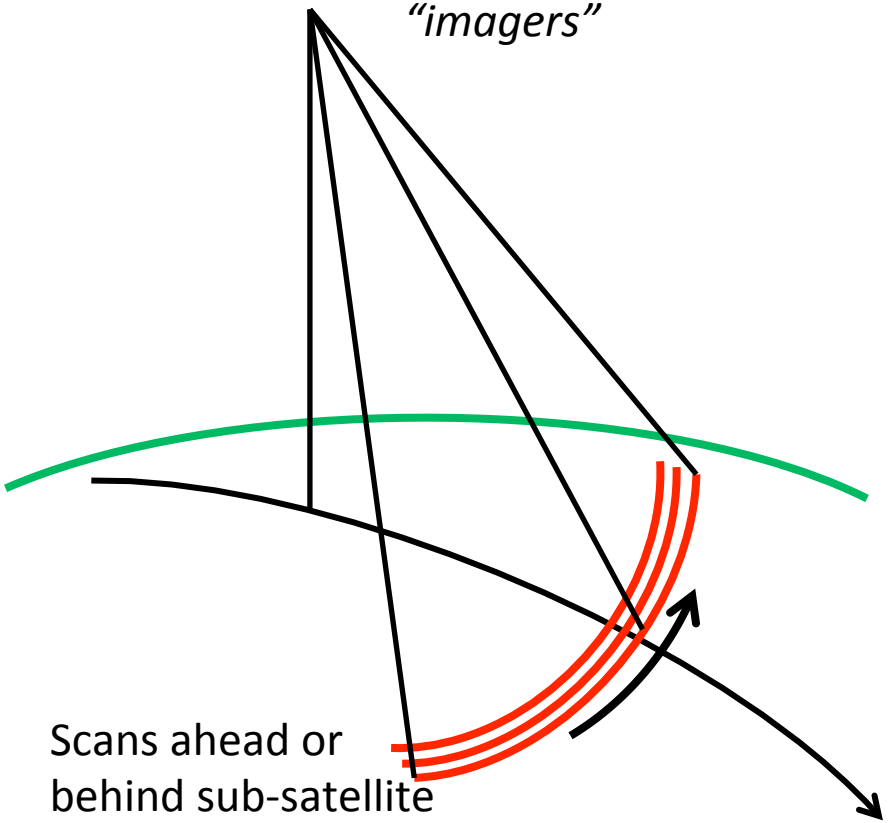
LSWG:
Cross-track retrievals

Chris Kidd
University of Maryland, Earth System Science Interdisciplinary Center
& NASA/Goddard Space Flight Center

Gail Skofronick Jackson, Erich Stocker, Dave Randel, Chris Kummerow
Joe Turk, Pierre Kirstetter, Joe Munchak, Ben Johnson, George Huffman

Conical

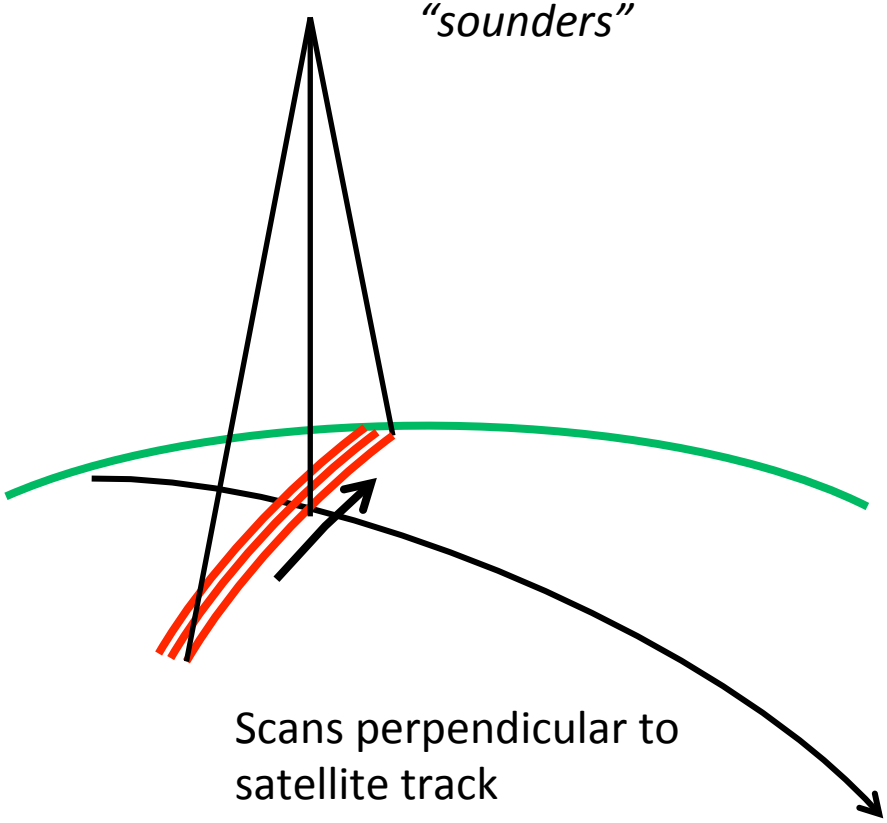
"imagers"



Scans ahead or
behind sub-satellite

Cross-track

"sounders"



Scans perpendicular to
satellite track

consistent:

variable:

polarization, resolution, Earth-incidence angle, atmospheric path

GPROF cross-track sensor retrievals

- Consistency necessitates retrievals from partner sensors to be within the framework of GPROF-scheme
- Observations from cross-track sensors pose new challenges, due to the variable scan angle, affecting:
  - Resolution
  - Polarization
  - Earth incidence angle
  - Atmospheric path
- Main instruments (*AMSU-B*, MHS, SAPHIR, ATMS) are similar, but have subtle differences

Cross-track sounder characteristics

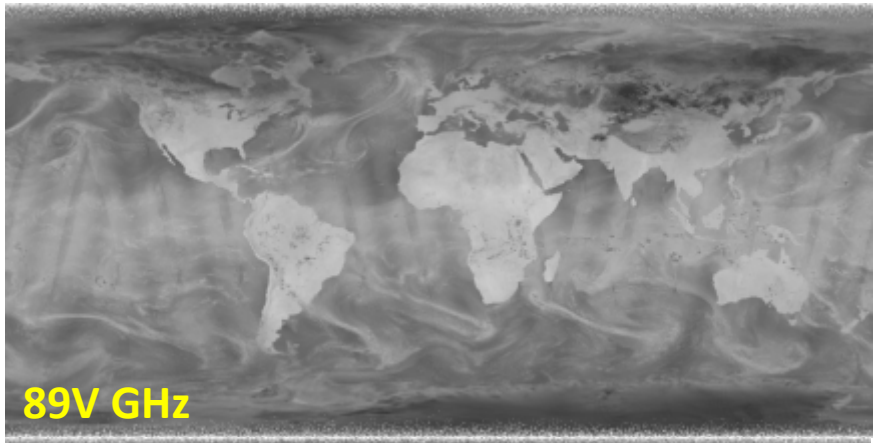
AMSU-B: 16 km at nadir, 90 pos., ±48.95°
89V, 150V, 183.3±1H, 183.3±3H, 183.3±7H

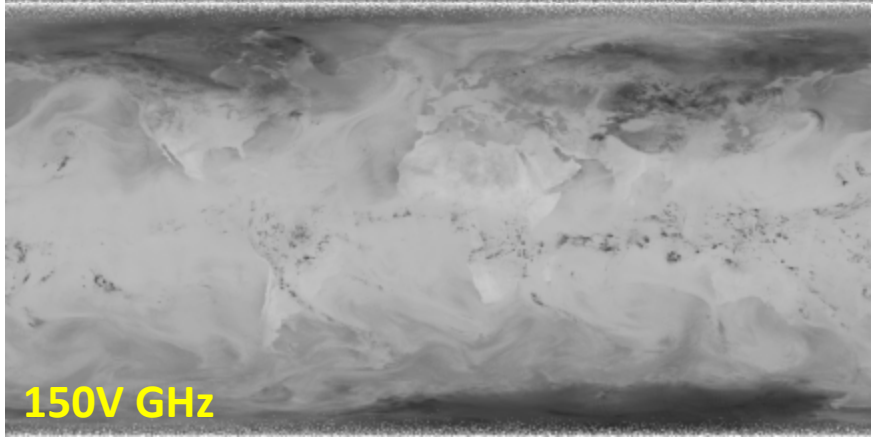
MHS: 17 km at nadir, 90 pos., ±48.94°
89V, 157V, 183.3±1H, 183.3±3H, 190.3V

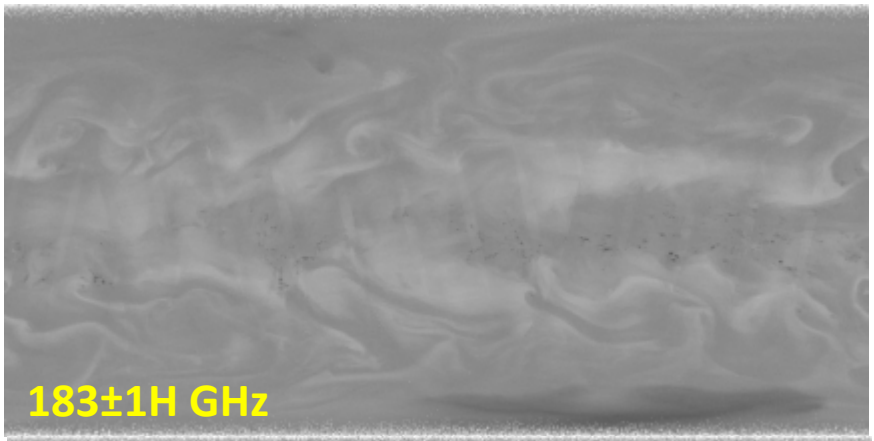
ATMS: 32/16 km at nadir, 96 pos.,
88.2V, 165.5H, 183.3±7H, 183.3±4.5H, 183.3±3H,
183.3±1.8H, 183.3±1H

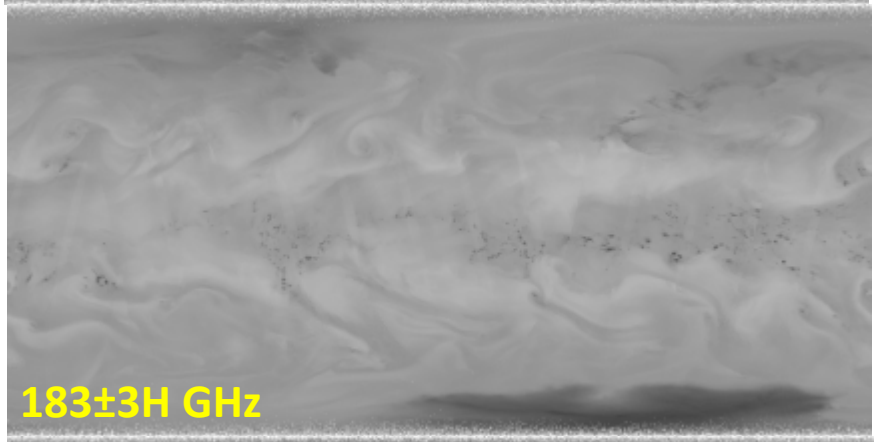
SAPHIR: 10 km at nadir (22.8x14.7 km) , 182 pos., ±50°
183.3±0.2H 183.3±1.1H, 183.3±2.8H, 183.3±4.2H,
183.3±6.8H, 183.3±11.0H

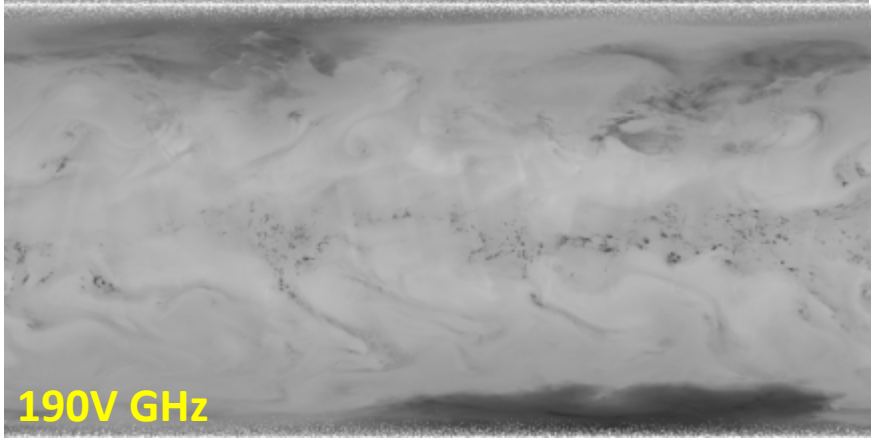
NOTE: polarization is at nadir and varies with scan position







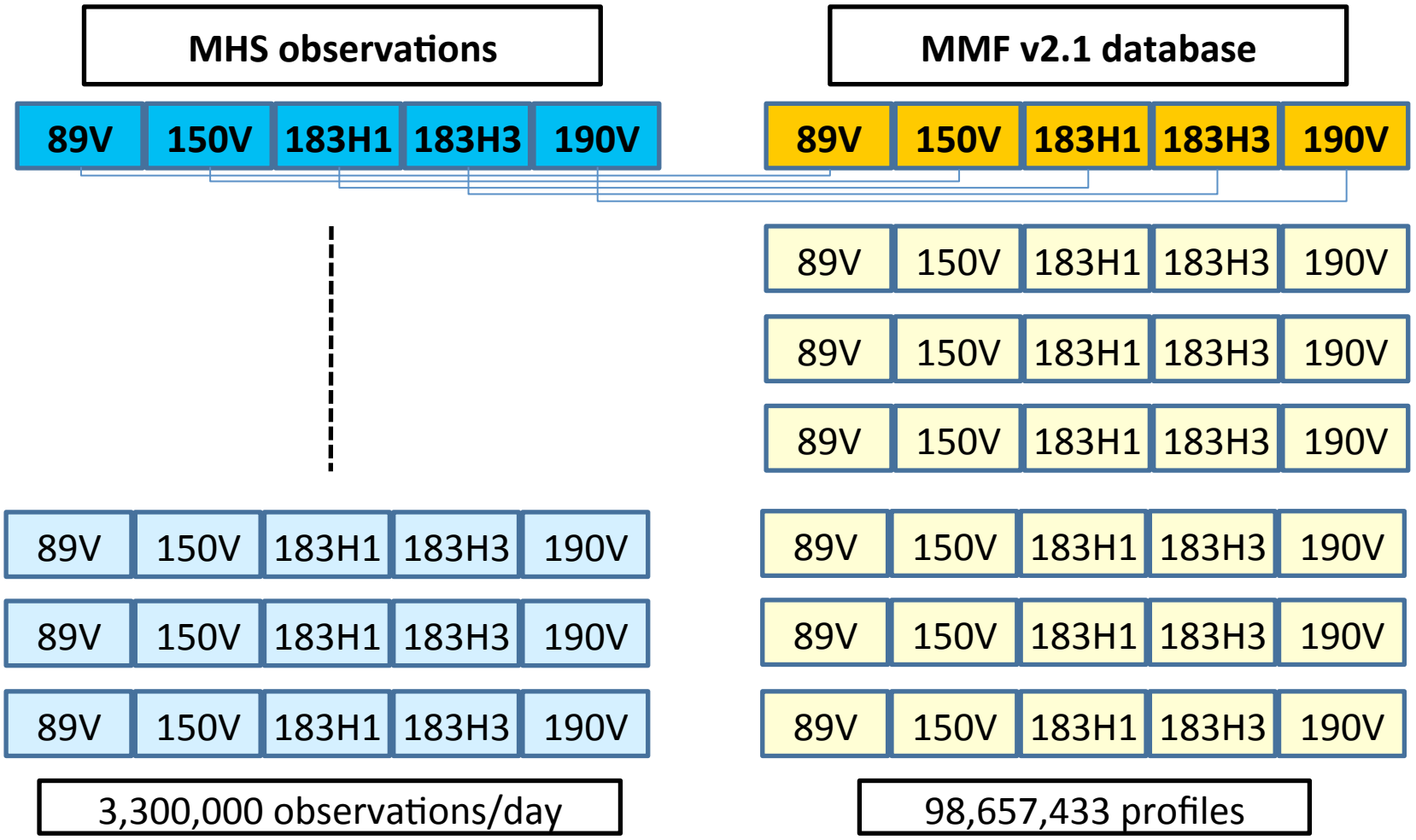




Chan	Central Freq (GHz)	Beam width	Polarization
1	89.0	1.1111°	V
2	157.0	1.1111°	V
3	183.311 ± 1.0	1.1111°	H
4	183.311 ± 3.0	1.1111°	H
5	190.311	1.1111°	V

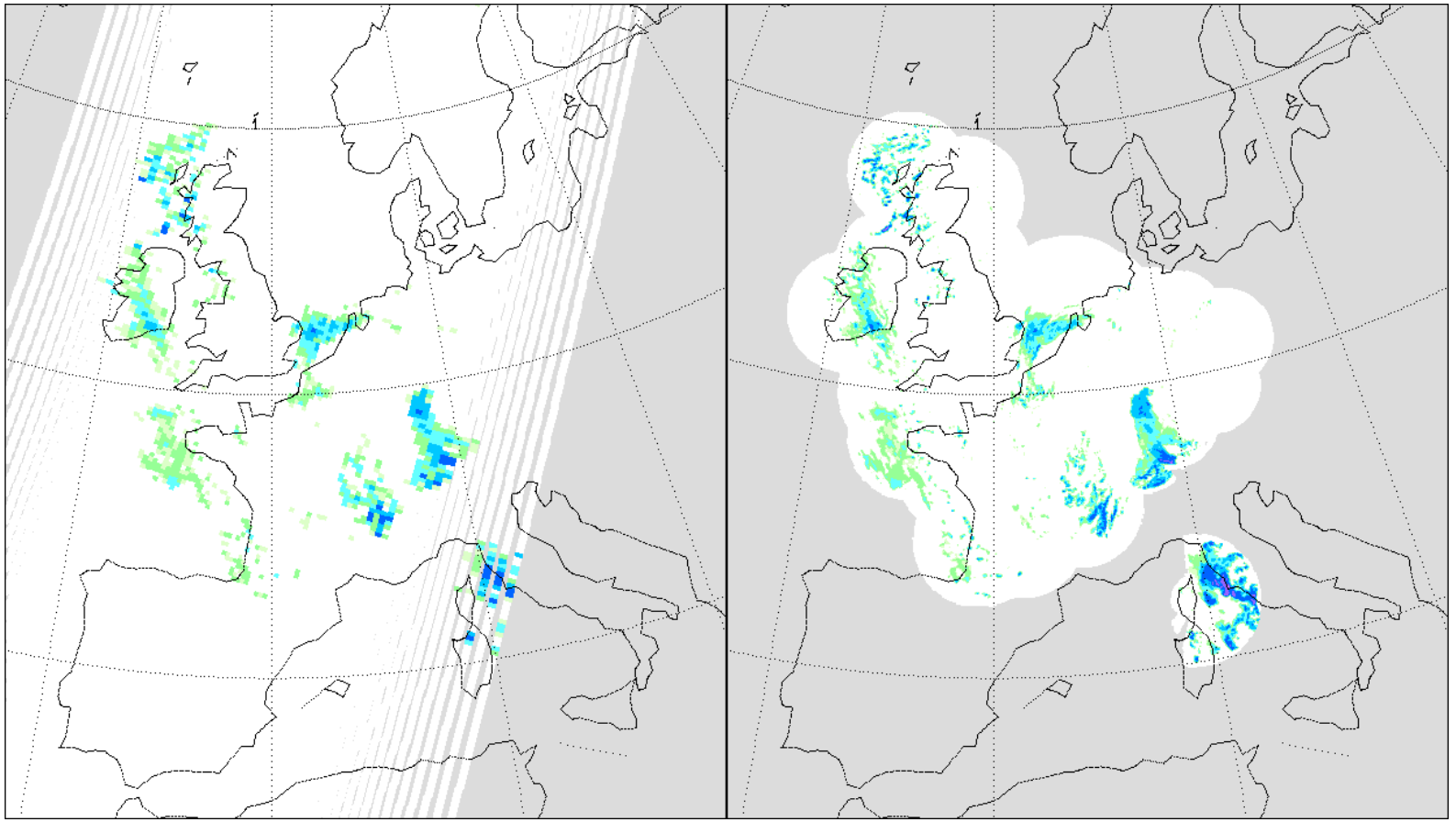
MHS channels

Tb matching



c.70 minutes/orbit CPU time

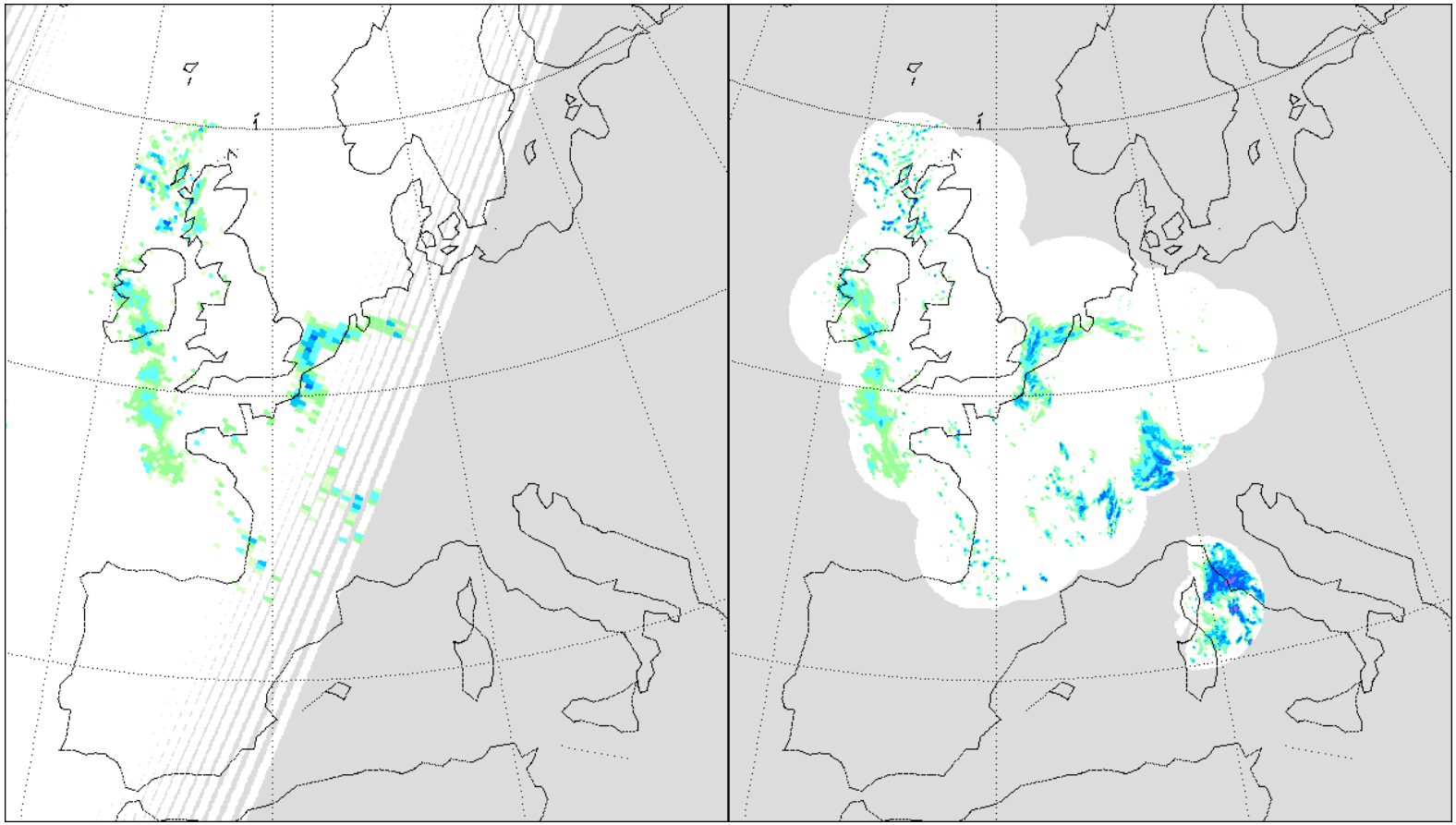
Ideal retrieval: 5921 profiles



MHS NOAA-18 20140301 0445Z

Using good calibration a simple nearest-profile scheme works perfectly (!)

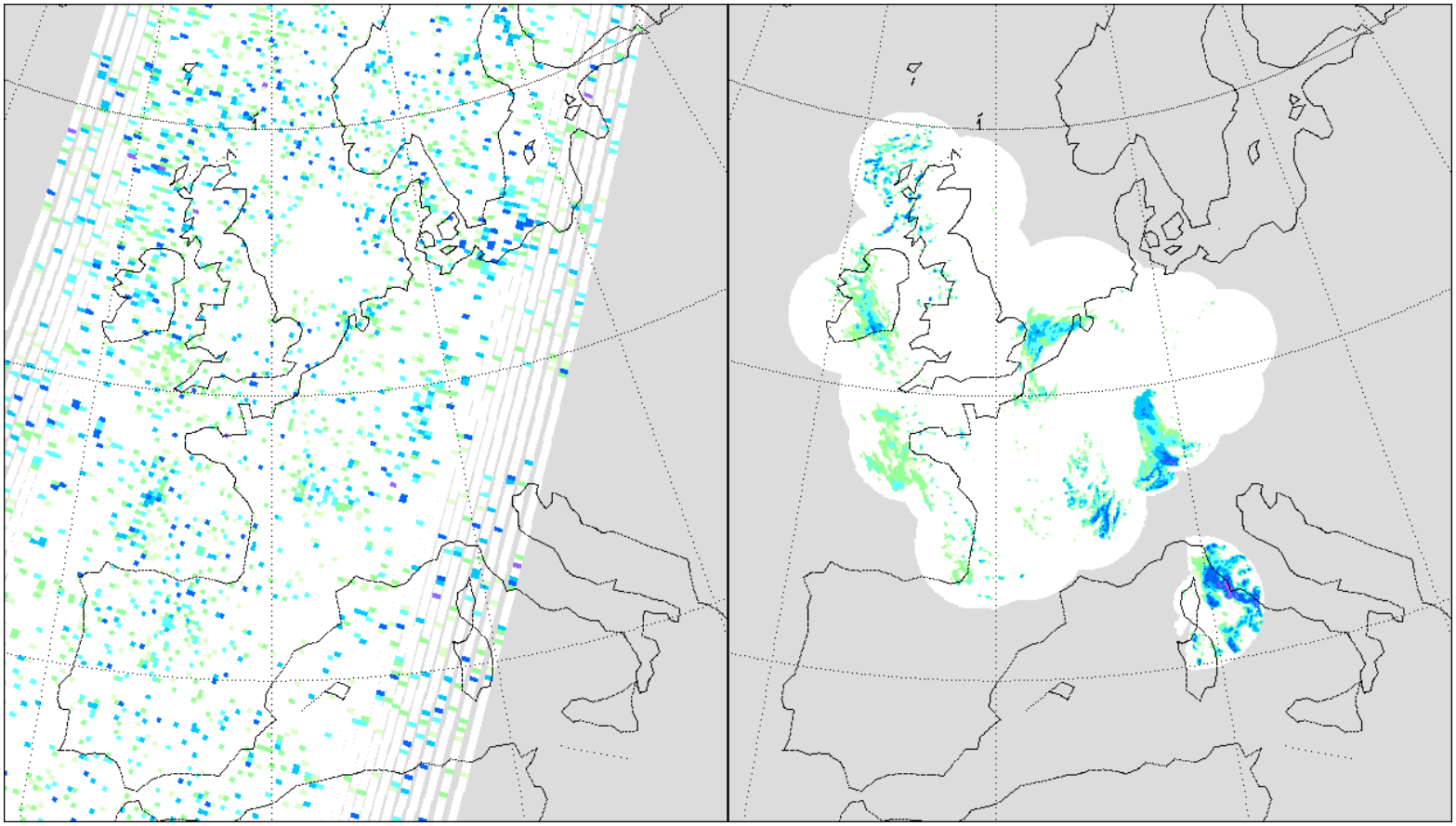
Ideal retrieval: 3678 profiles



MHS NOAA-19 20140301 0315Z

Using good calibration a simple nearest-profile scheme works perfectly (!)

0315Z database, 0445Z retrieval



But 'outside' calibration location/date retrievals are very sensitive to database entries and retrieval scheme – or "representativeness"

Constraining retrievals

By:

a) Total columnar water vapour *(tcwv)*

b) Surface temperature *(Tskin)*

c) Surface type (incl. snow/ice, coast, sea, land)

d) Scan angle (for x-track sensors)

a & *b* can be obtained from numerical models (for realtime products, forecasts)

c can be obtained from *a priori* datasets

d can be obtained from sensor information

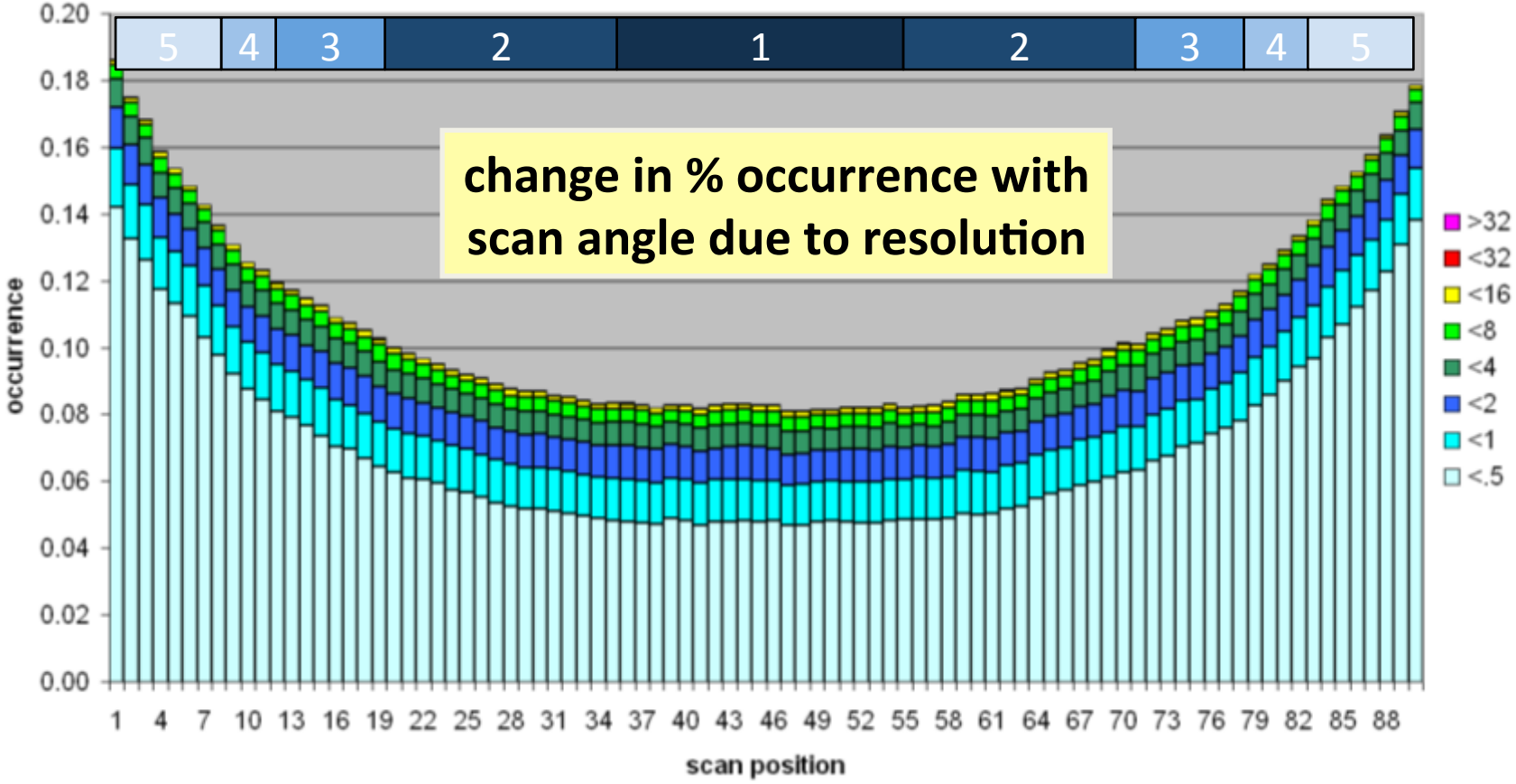
Incorporating cross-track into GPROF

Cross track *(sounders)* **vv conical scanning** *(imagers)*

- Incidence angle varies with scan position (0-45°)
- Resolution changes with scan position (10-70 km)
- Polarization changes with scan position (V-H/H-V)

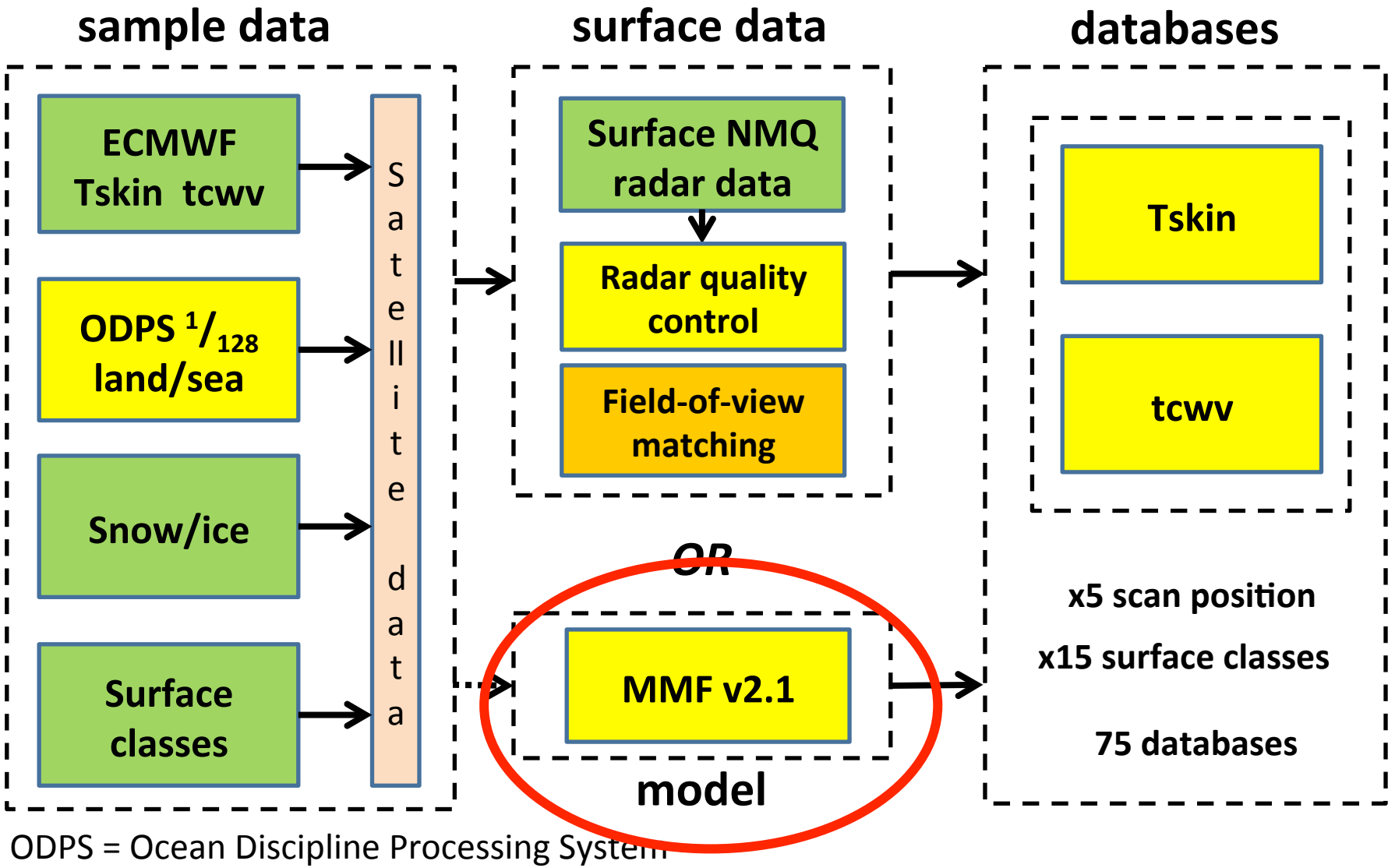
- But, due to WV, surface background and polarization less of an issue (particularly over the Tropics)
- Impractical (as yet) to calculate databases for each scan position – interpolation may be required.
- Beam-filling problematic vv concial scanning

Rain occurrence by scan position



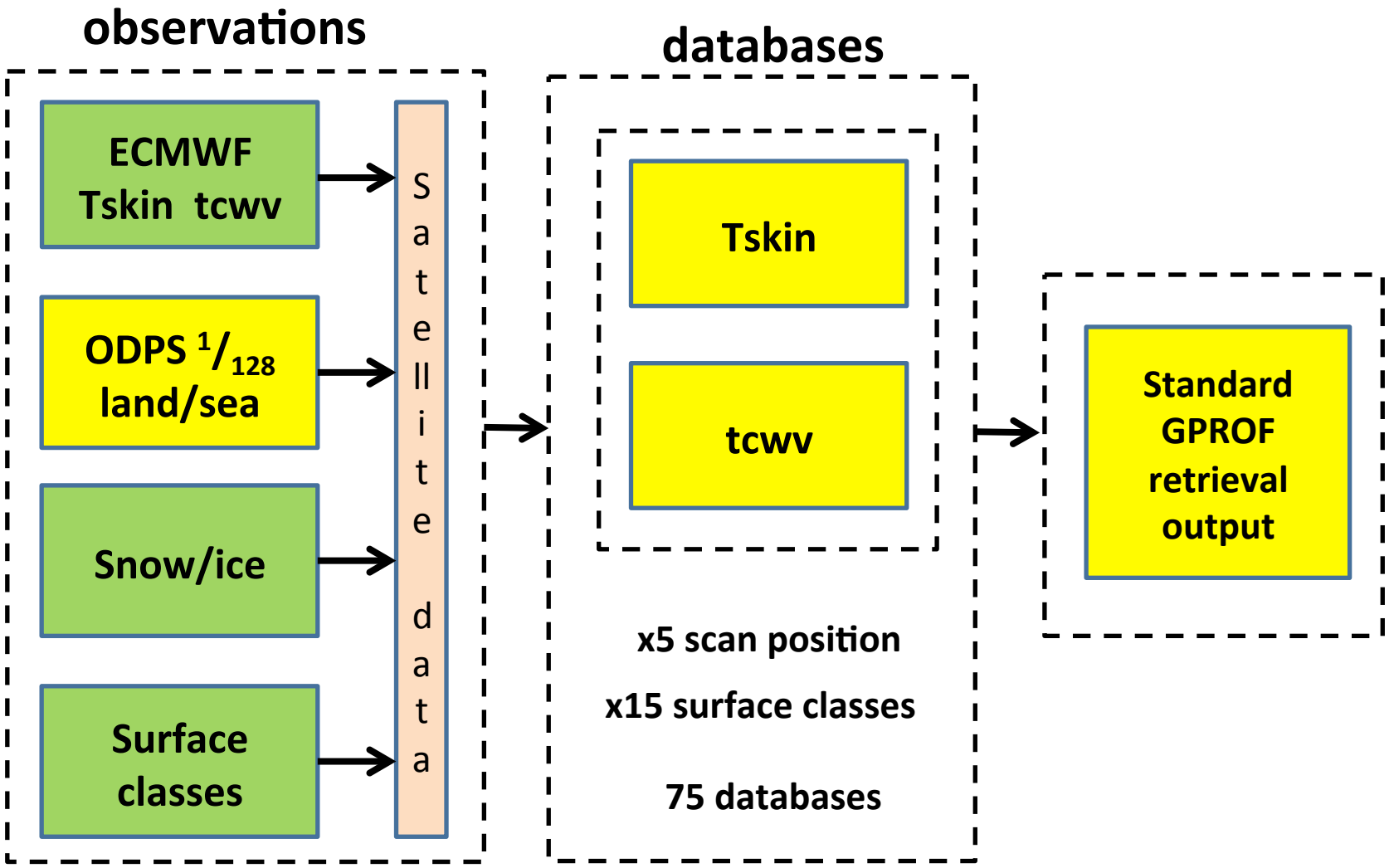
5 scan positions selected based upon change in rain occurrence

GPROF cross-track databases



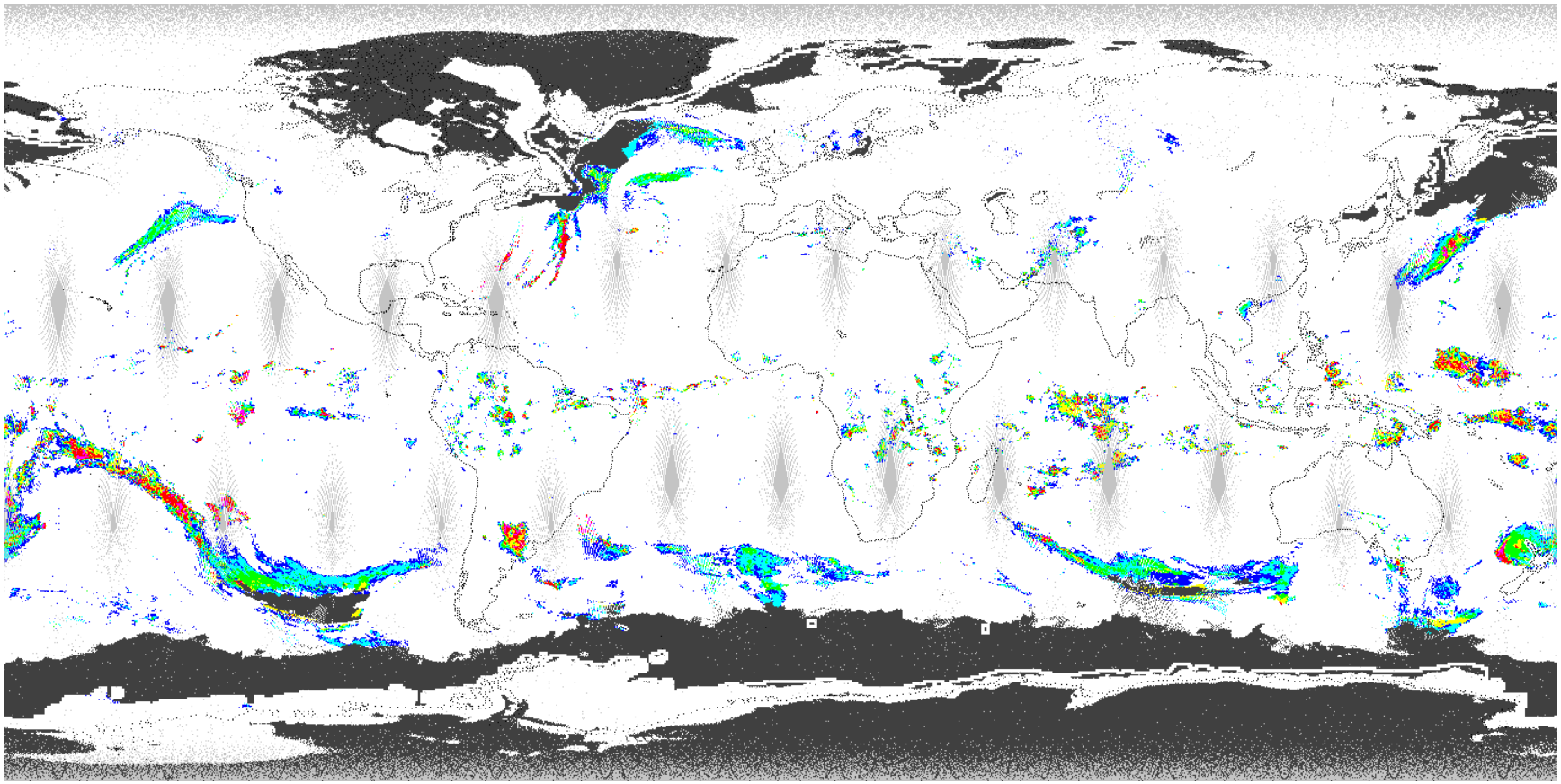
ODPS = Ocean Discipline Processing System

GPROF cross-track retrievals



GPROF cross-track, observation database

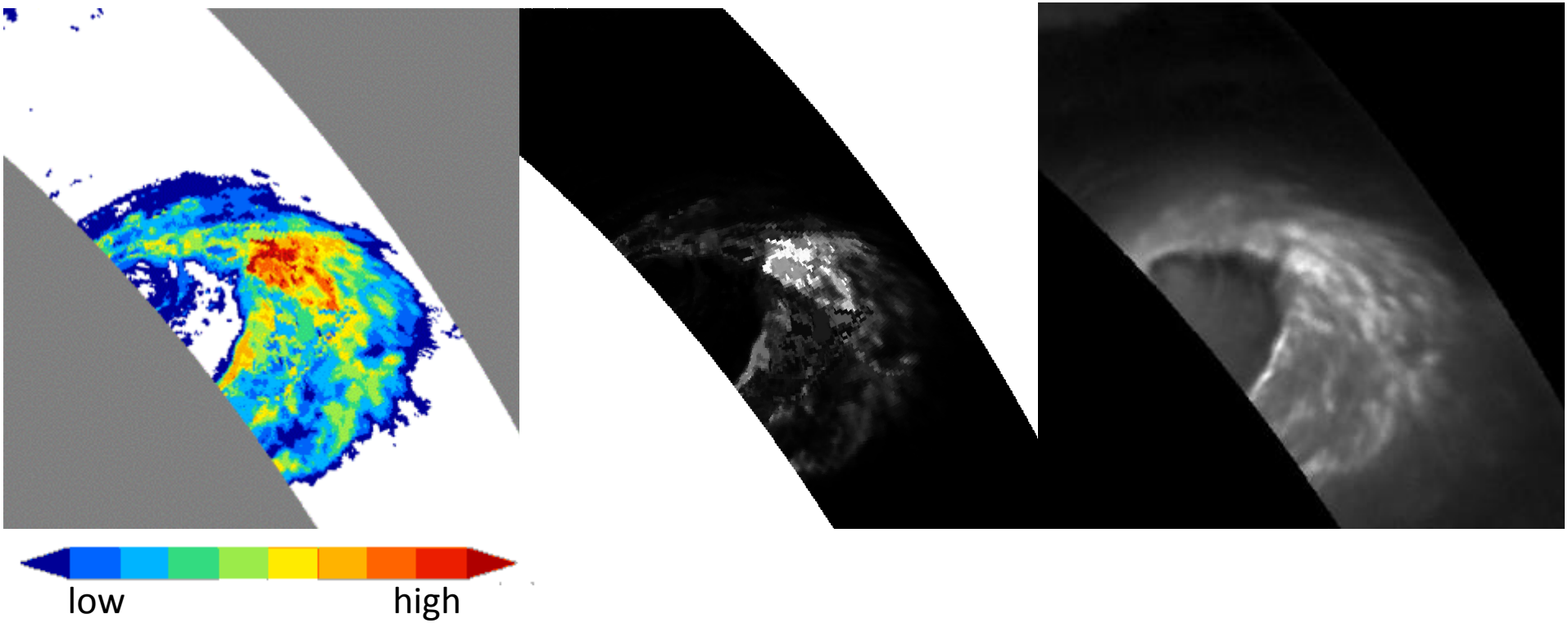
V1.0



Database sampling

GPROF GMI retrieval

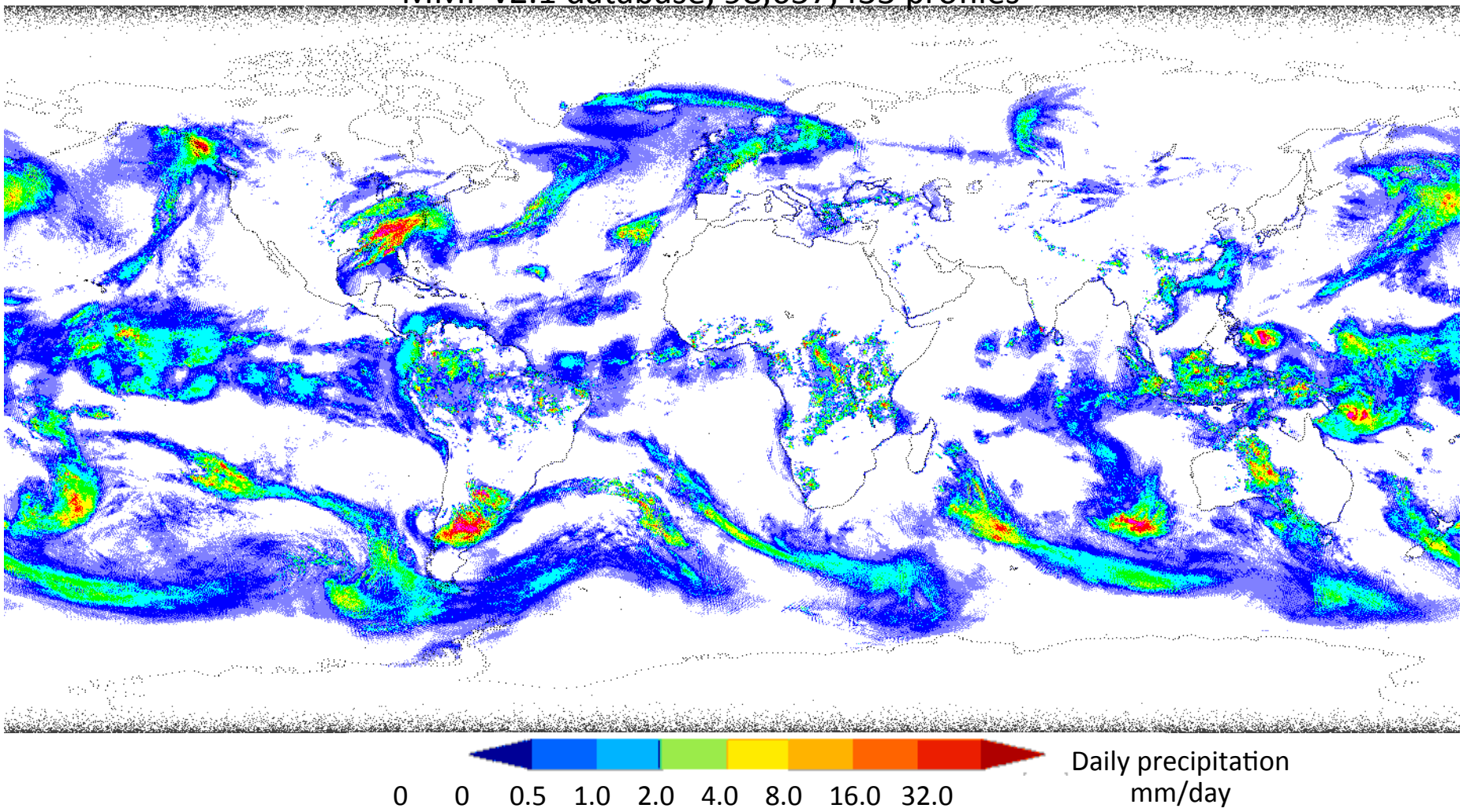
GMI horizontal 10 GHz



Care needed to ensure that sufficient observational/constrained samples are present in each Ts/tcwv bin for a consistent retrievals

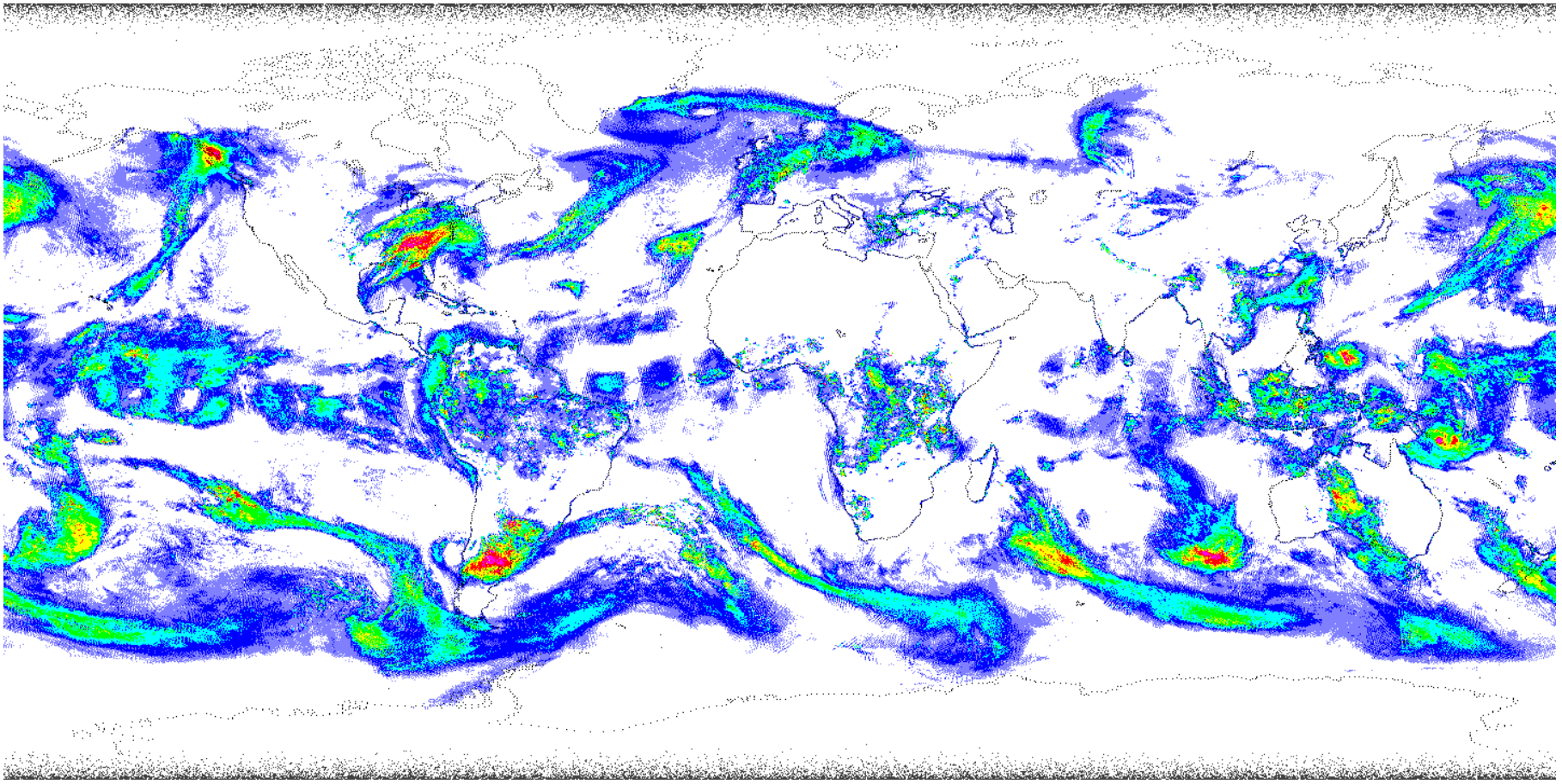
Global Precipitation: XPROF 20140407

MMF v2.1 database, 98,657,433 profiles



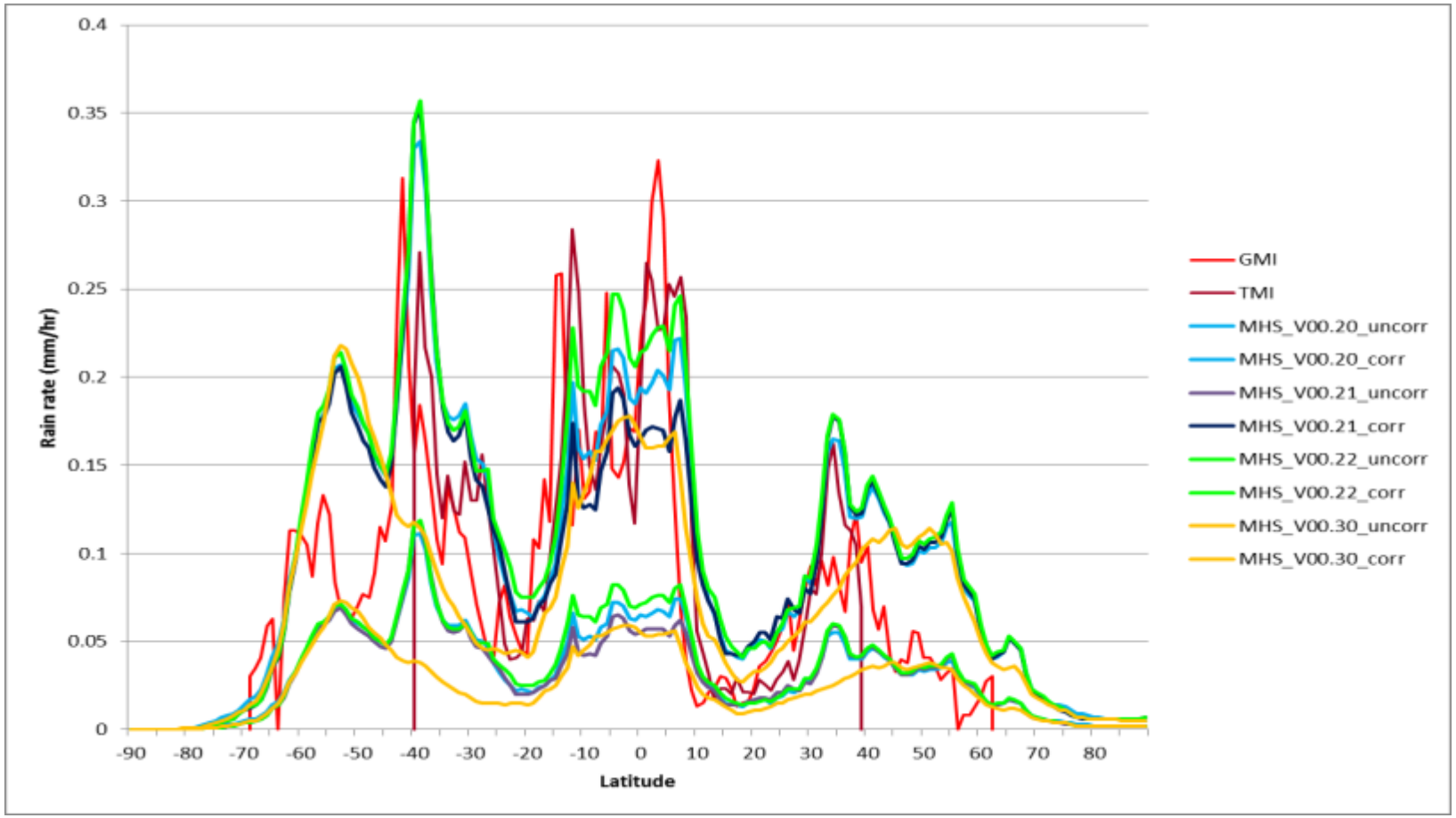
Global Precipitation: XPROF 20140407

MMF v2.1 database, 98,657,433 profiles - uncorrected

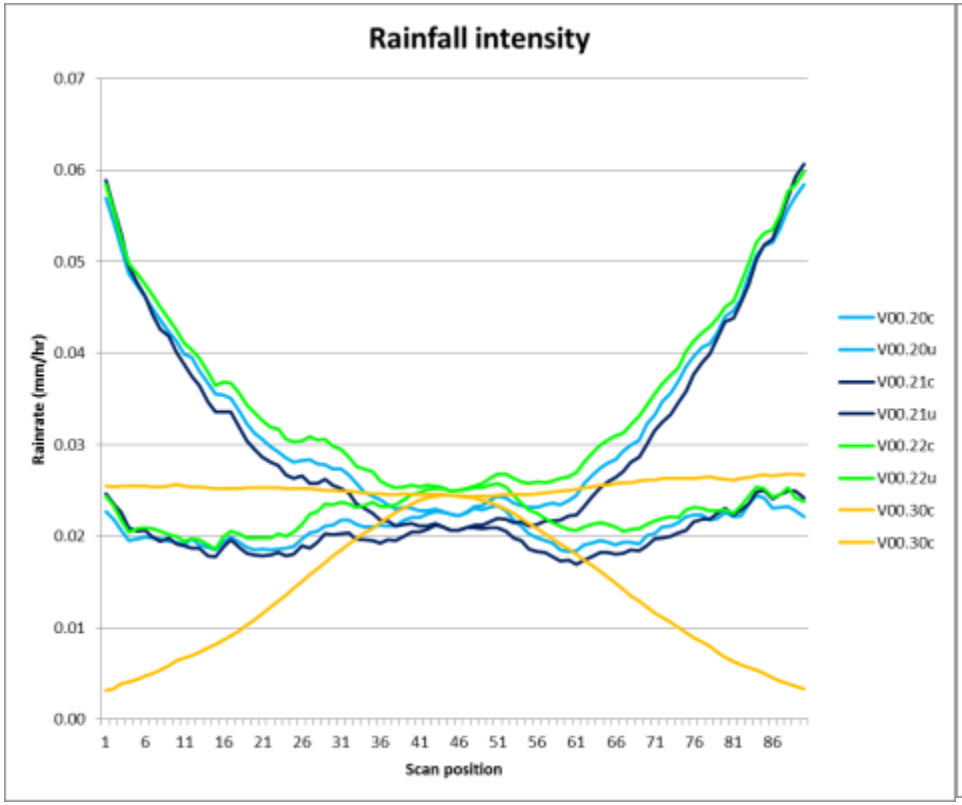


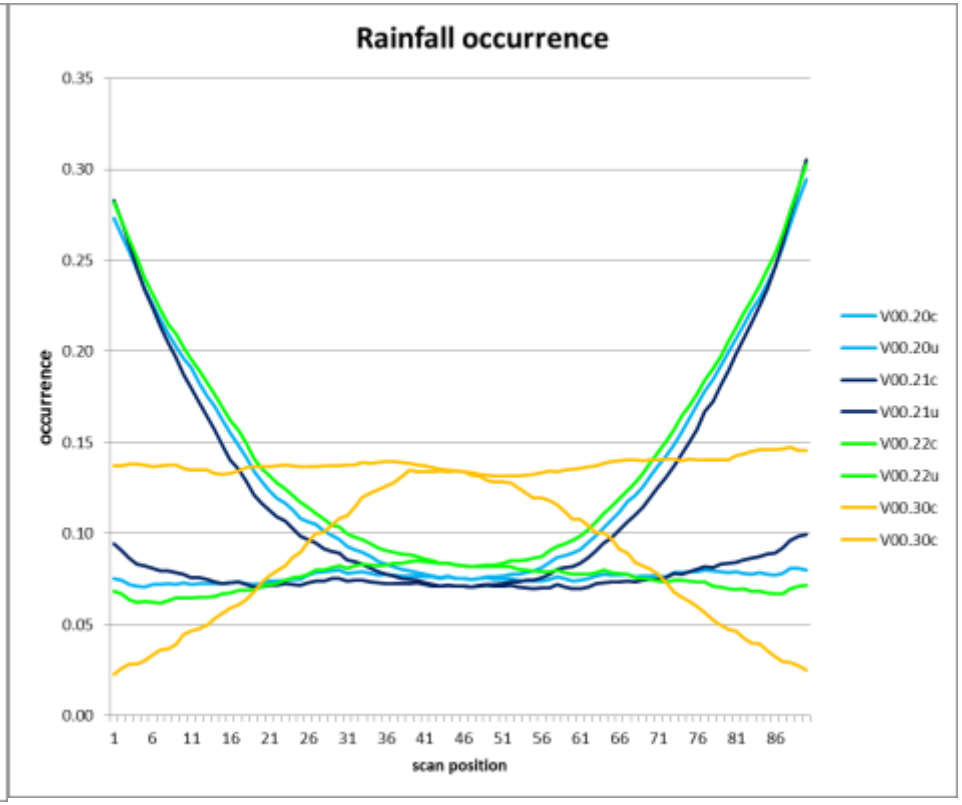
Daily precipitation
mm/day

Correction scheme - magnitude



Correction scheme – cross-track correciton

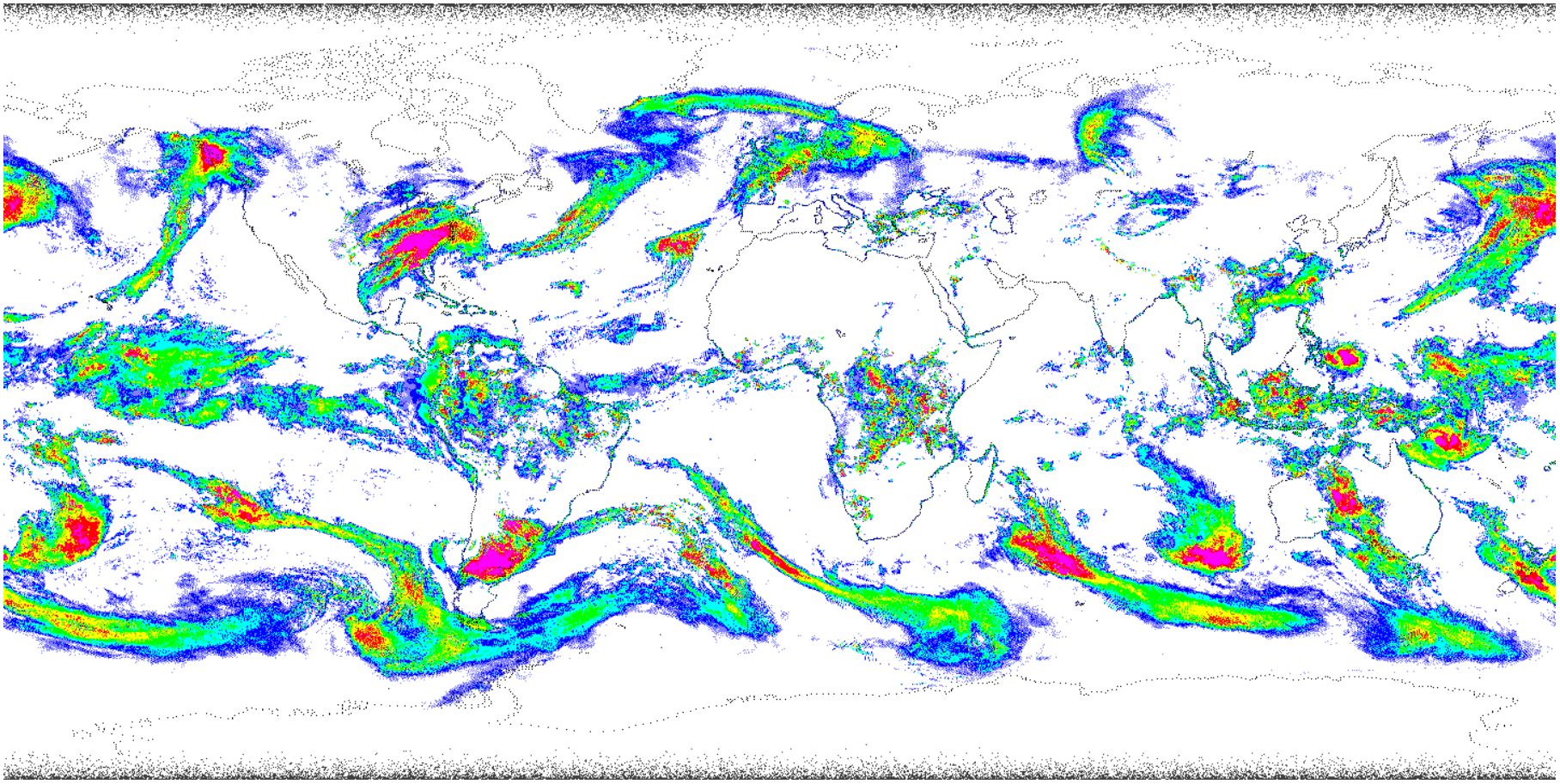


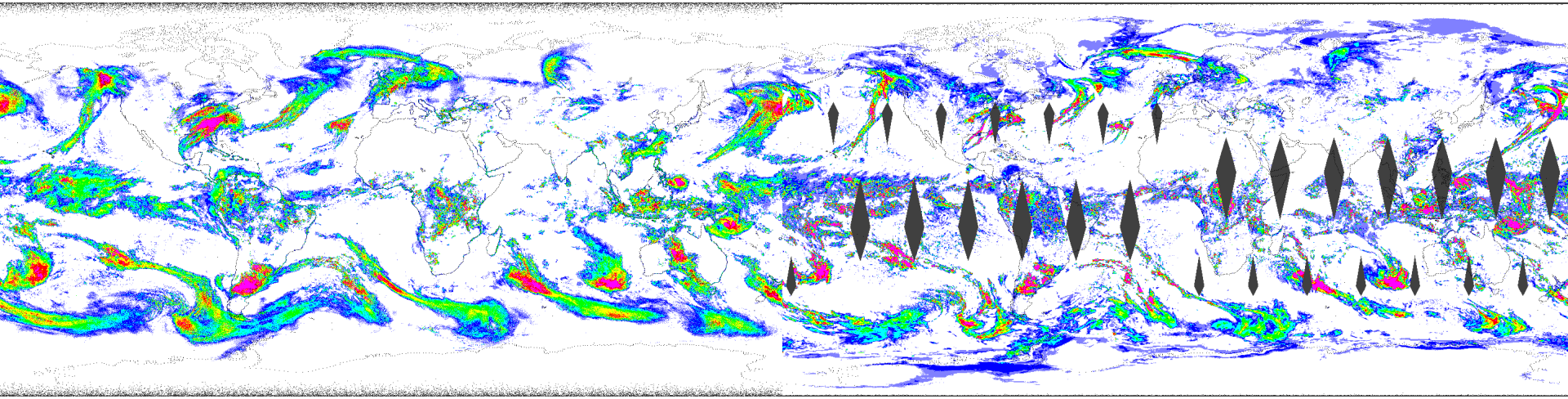


Versions:
V00.20 = full year of MMFv2.1 data
V00.21 = one month of MMFv2.1 data using 0.5xFOV
V00.22 = one month of MMFv2.1 data using 2xFOV
V00.30 = no satellite observations used in retrieval

Global Precipitation: XPROF 20140407

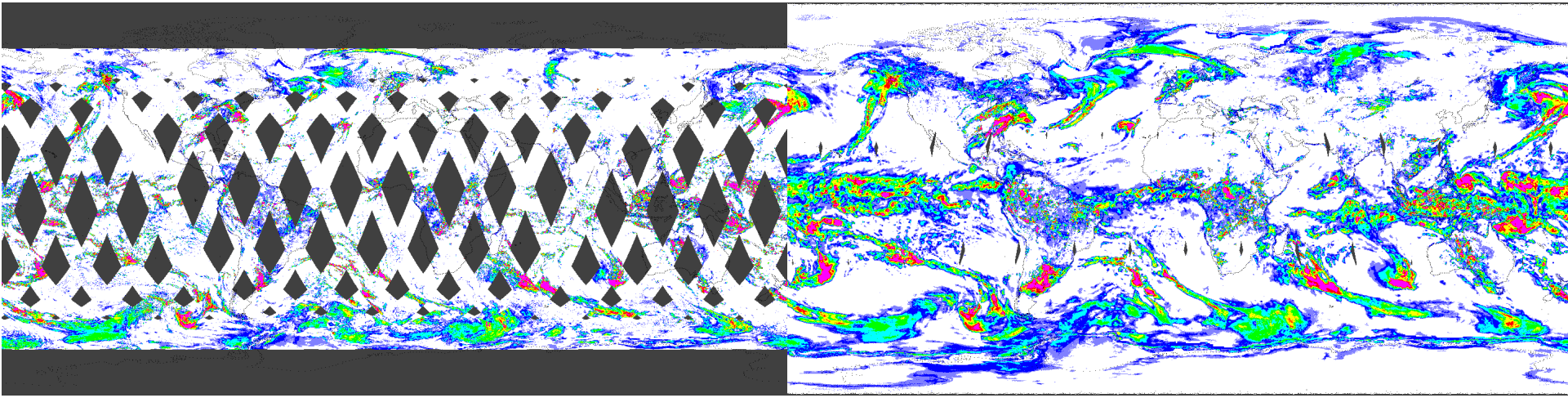
MMF v2.1 database, 98,657,433 profiles - corrected





MHS

AMSR



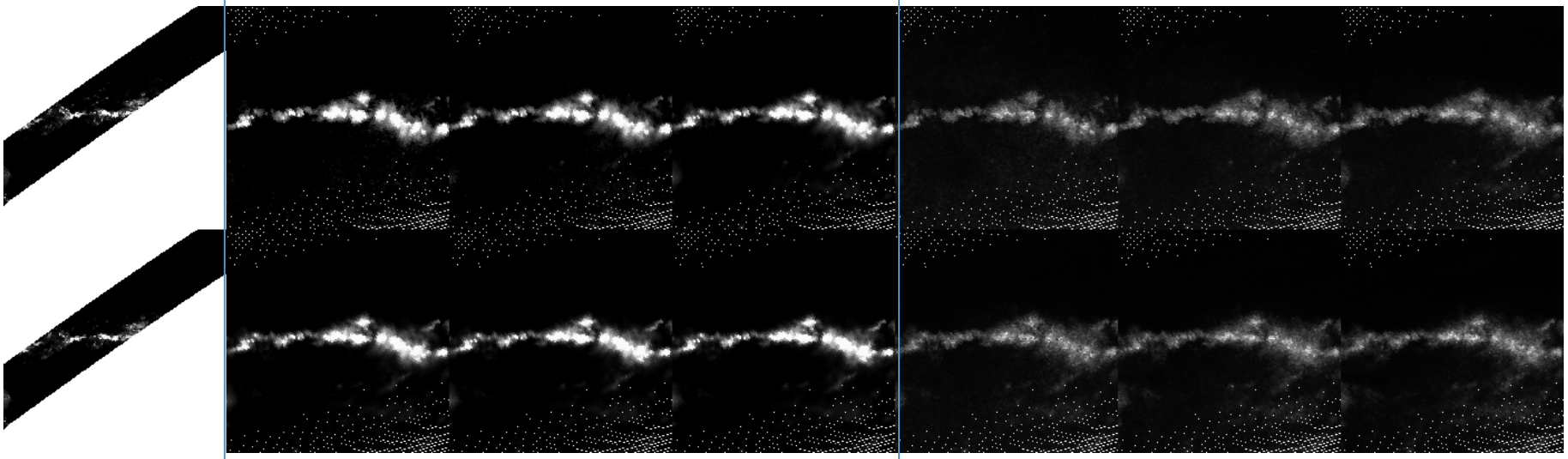
GMI

SSMIS

Summary of current scheme

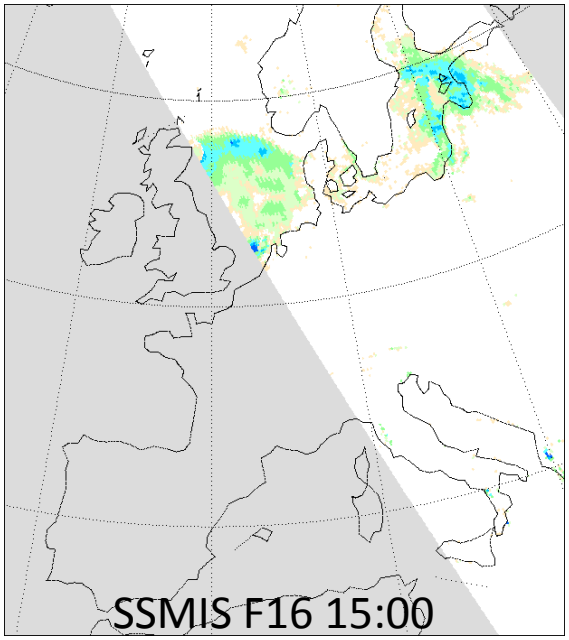
- scan position and surface –blind
- The same database is used for all surfaces
- Post-processing correction applied (magnitude & scan position)
- Run time is about 70 minutes/orbit (1.87GHz single processor)
- Some indication that moderate rain rates are under-represented – need to investigate MMF performance
- Rain occurrence may be slightly low

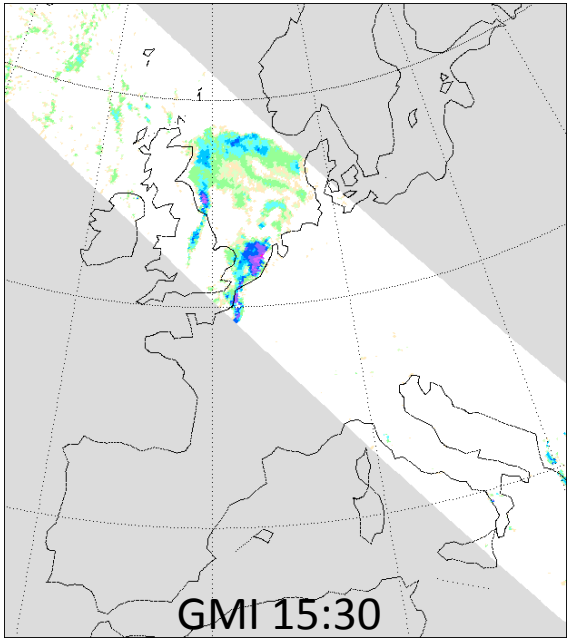
Initial SAPHIR retrievals

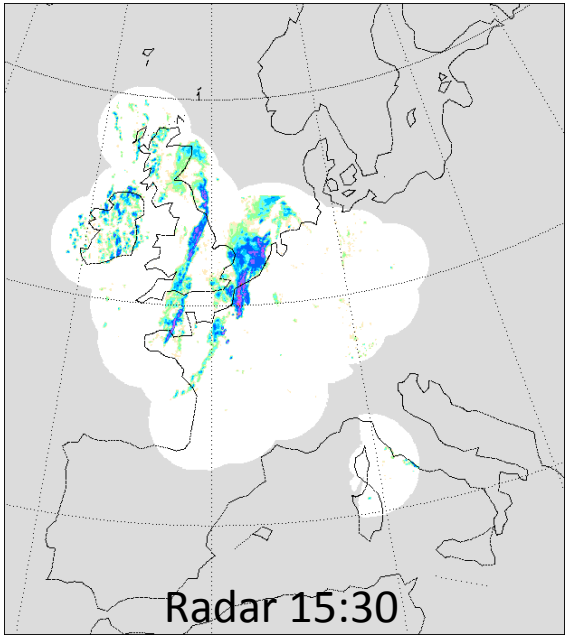


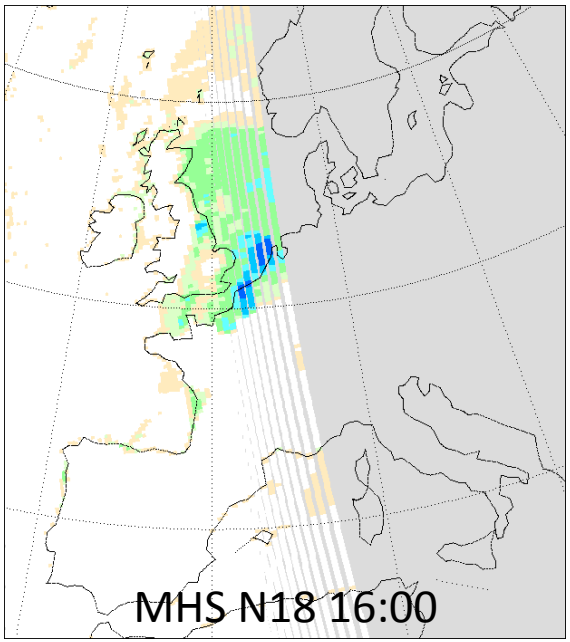
'Simple' Tb:PR histogram-matched retrieval Error = 1 std.deviation

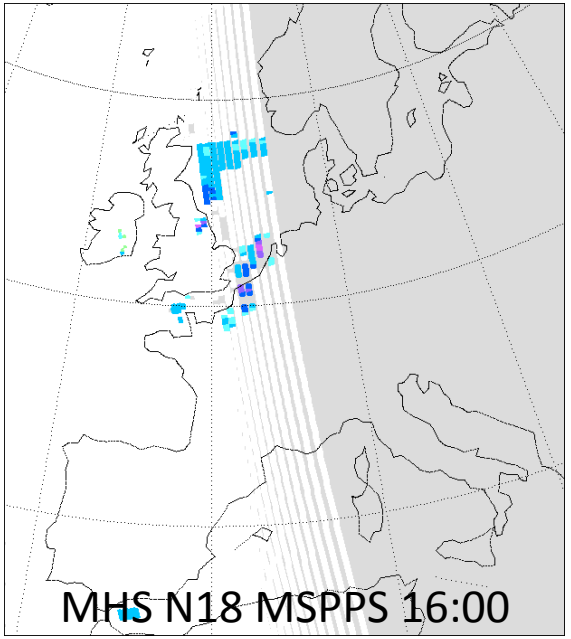
183 Ghz channels exhibit strong auto-correlation

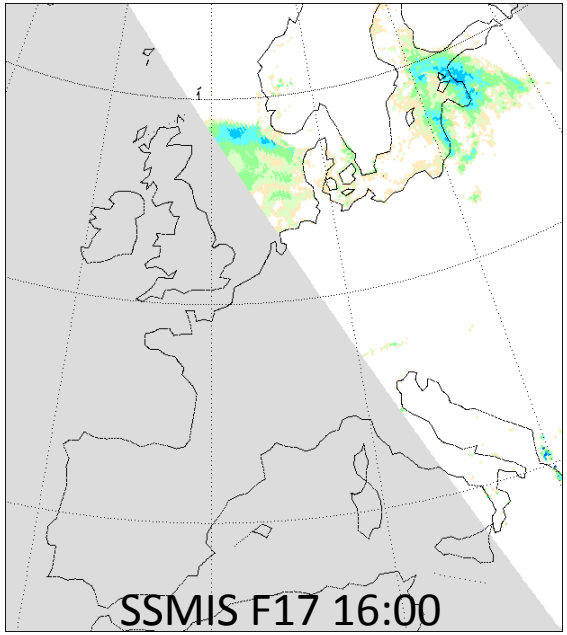








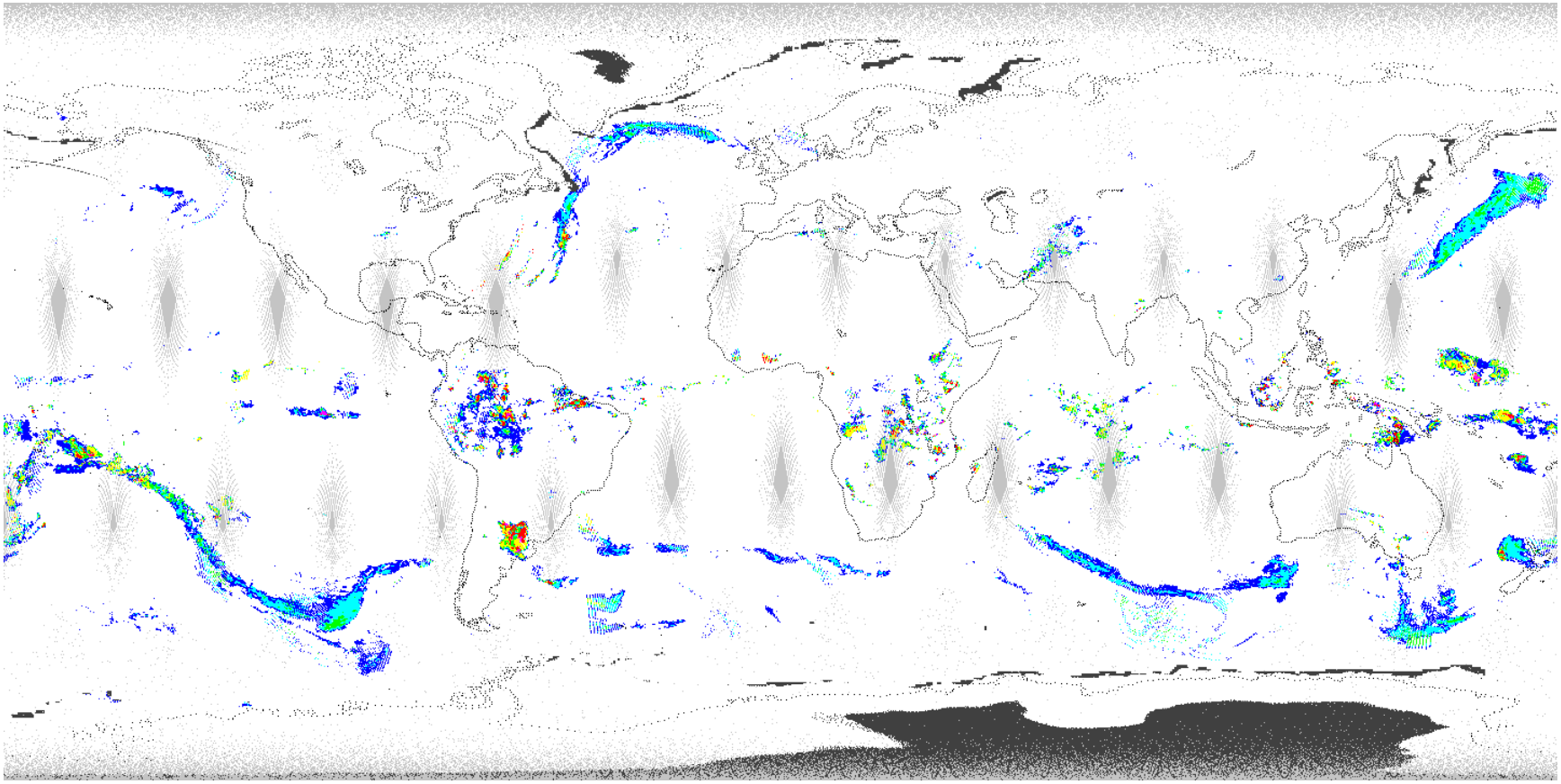




Precip retrievals 7 April 2014

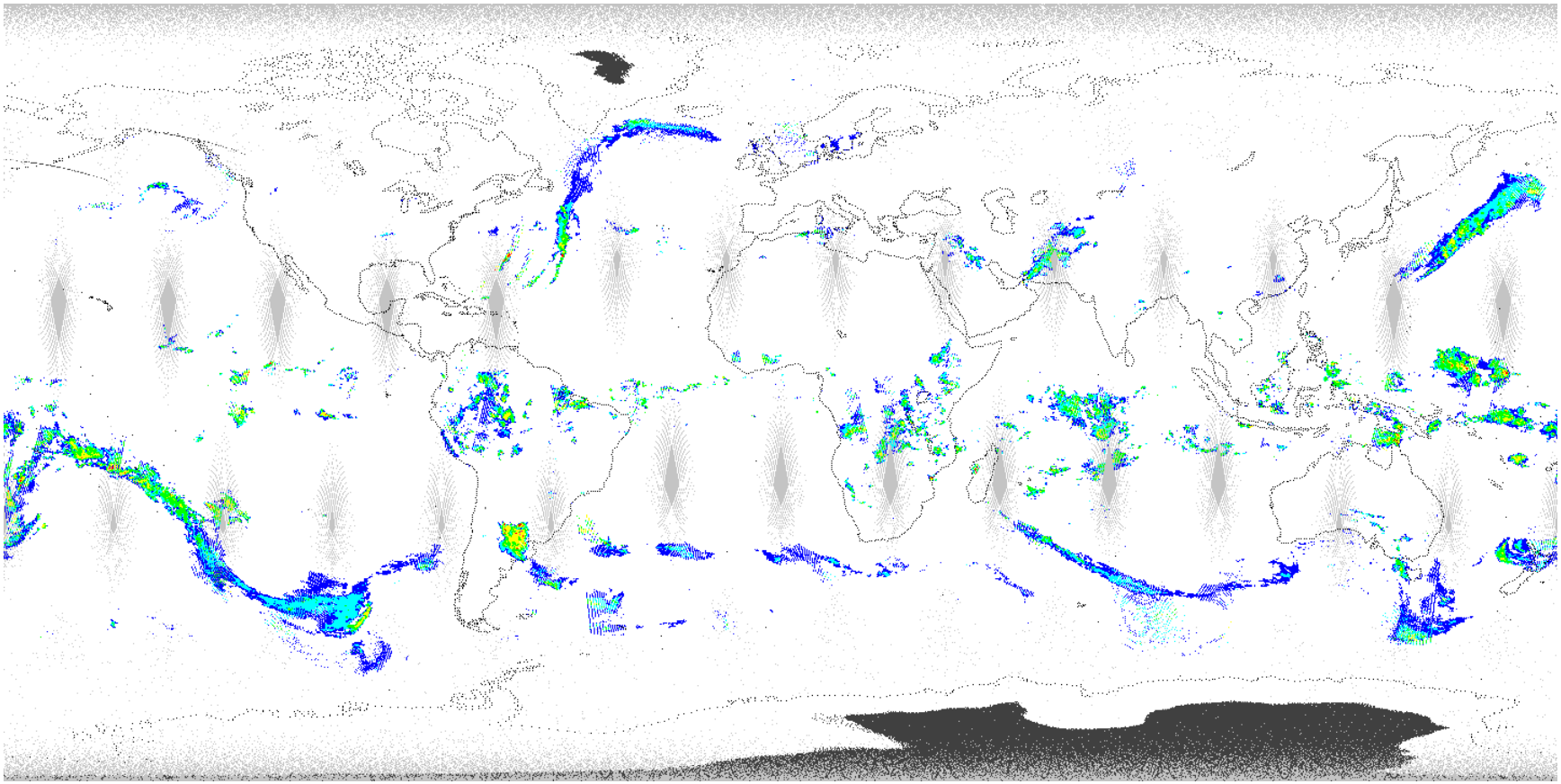
GPROF cross-track, MMF v1.0 database

B4

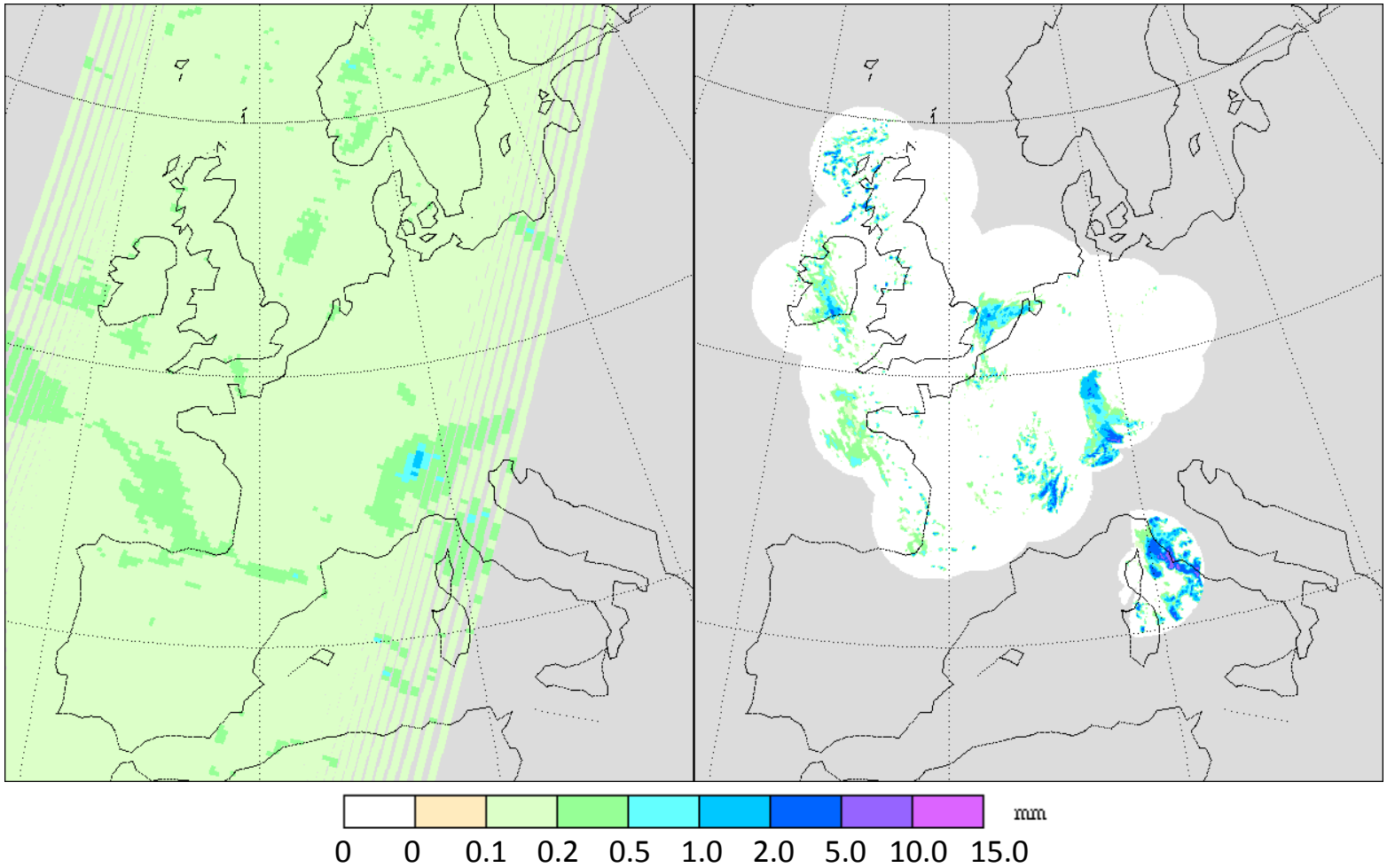


GPROF cross-track, MMF v2.0 database

V00.10

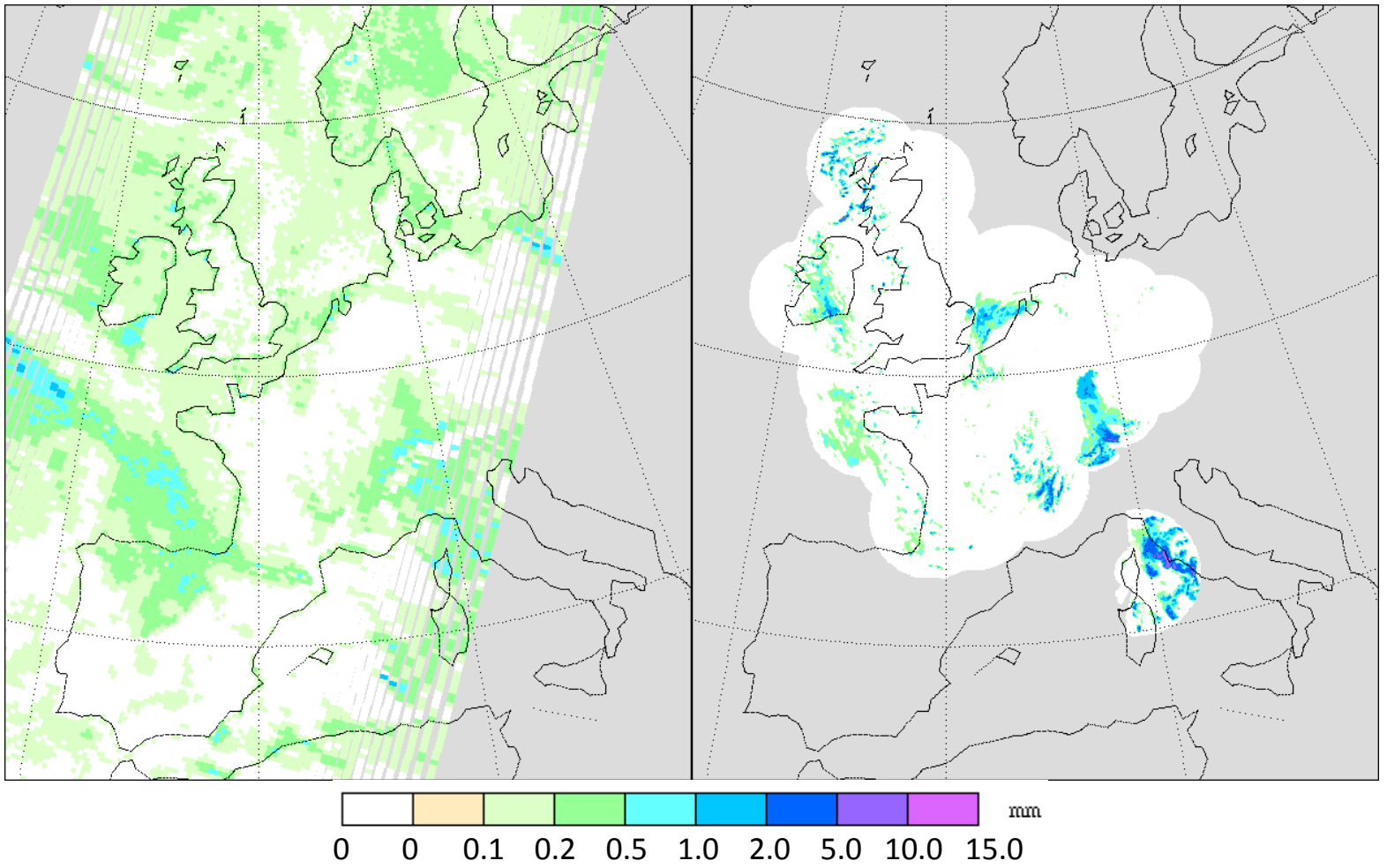


Many too many choices… (Σdis^2=all)



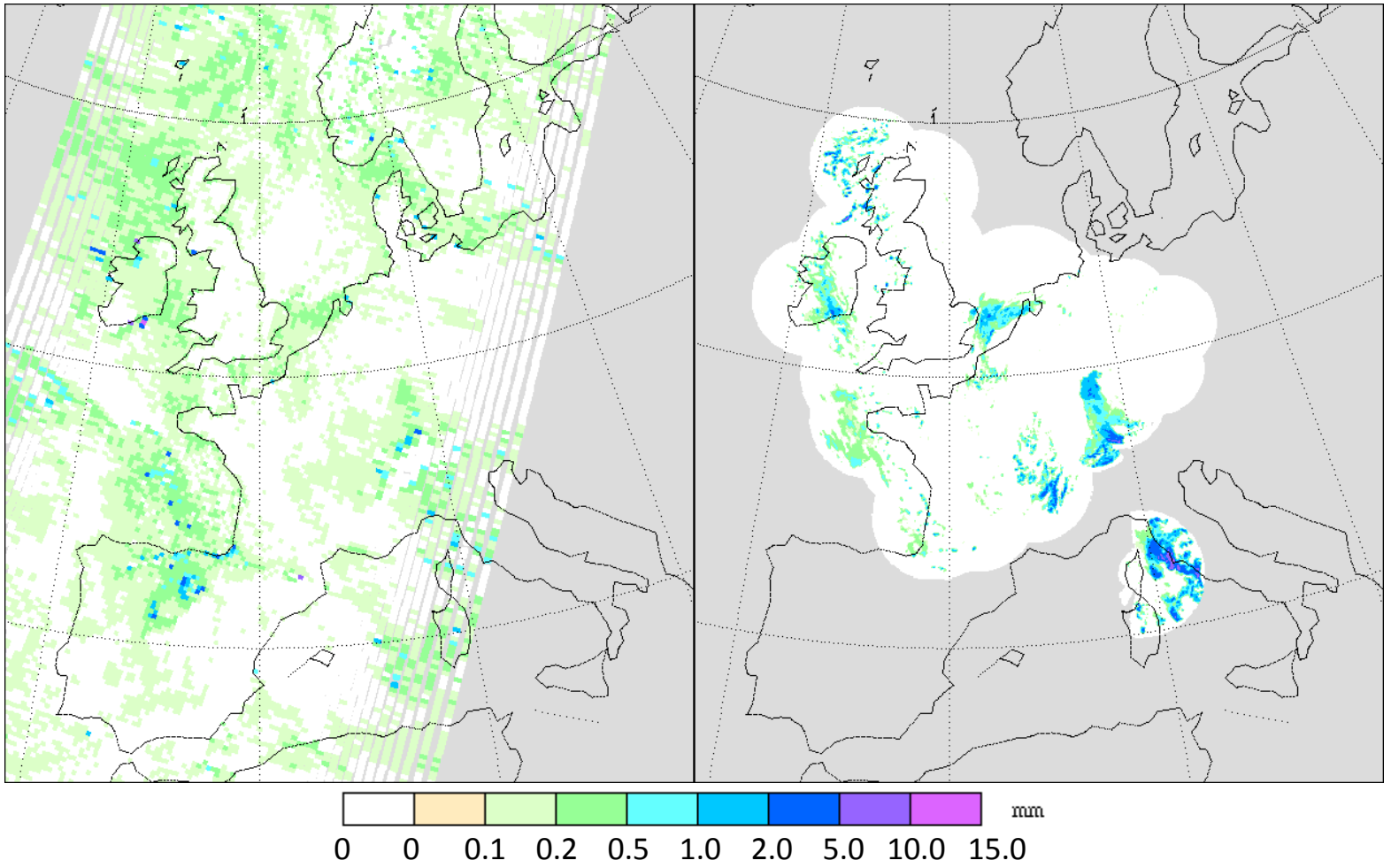
Bayesian scheme is good – but too many database entries tends towards a mean rainfall field (2280894)

Too lax… ($\Sigma dis^2=100$)



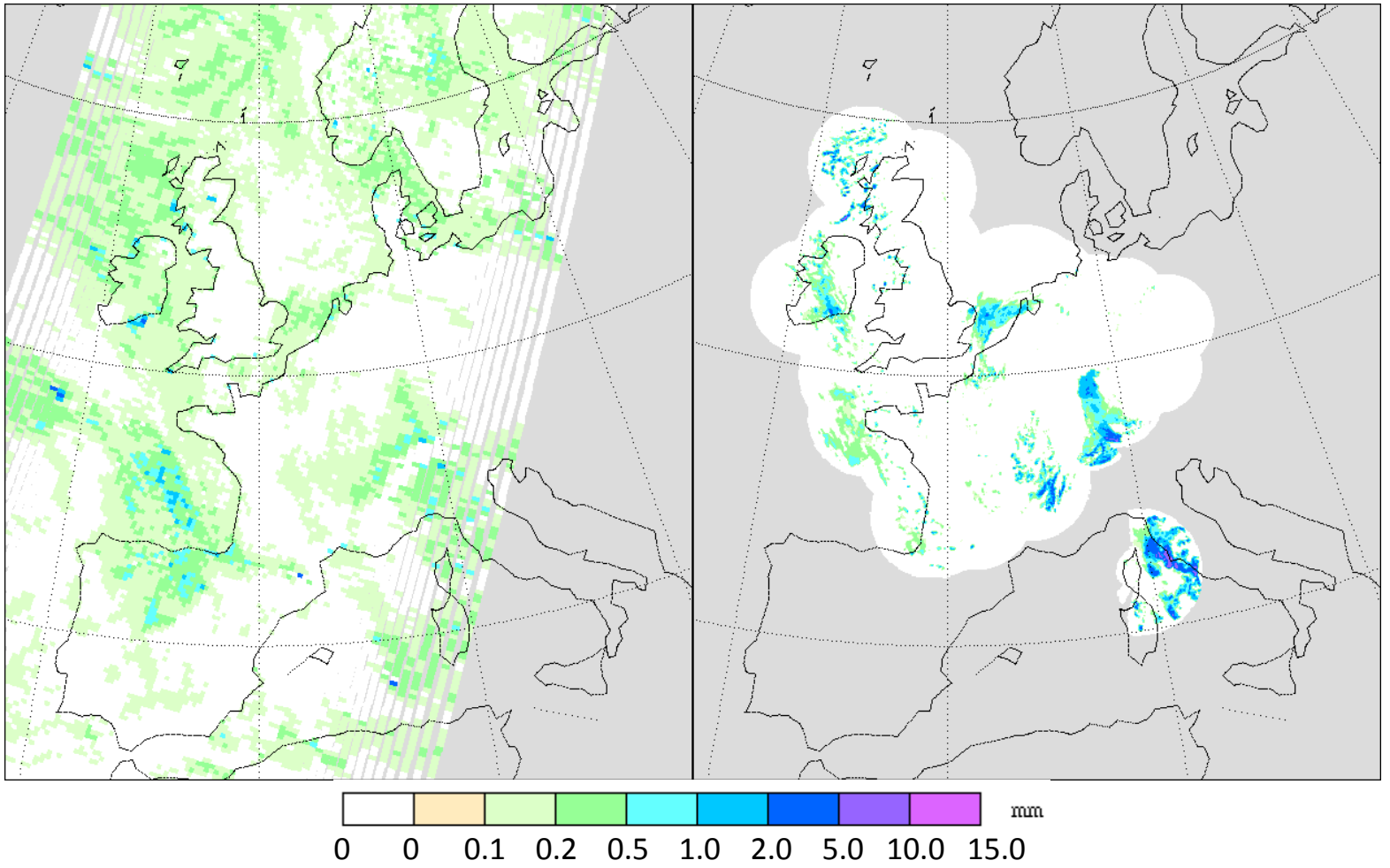
Still too many database – too great rain occurrence

Too restricted… ($\Sigma dis^2=10$)



Too restricted leads to noise in the retrievals

Just right? ($\Sigma dis^2=25$)



What is 'just right'?

Constraining problems

Reliance on outside (model +) information:

- Reliable data flow required
- Interoperability issues (portability)
- Accuracy/quality control
- Potential cross-talk in resulting products
- Error tracing

What is driving the retrieval – observations, models or climatology?

- If all observations are removed, GPROF still retrieves precipitation.