XGOHI
(eXtended GOes High Inclination operations)

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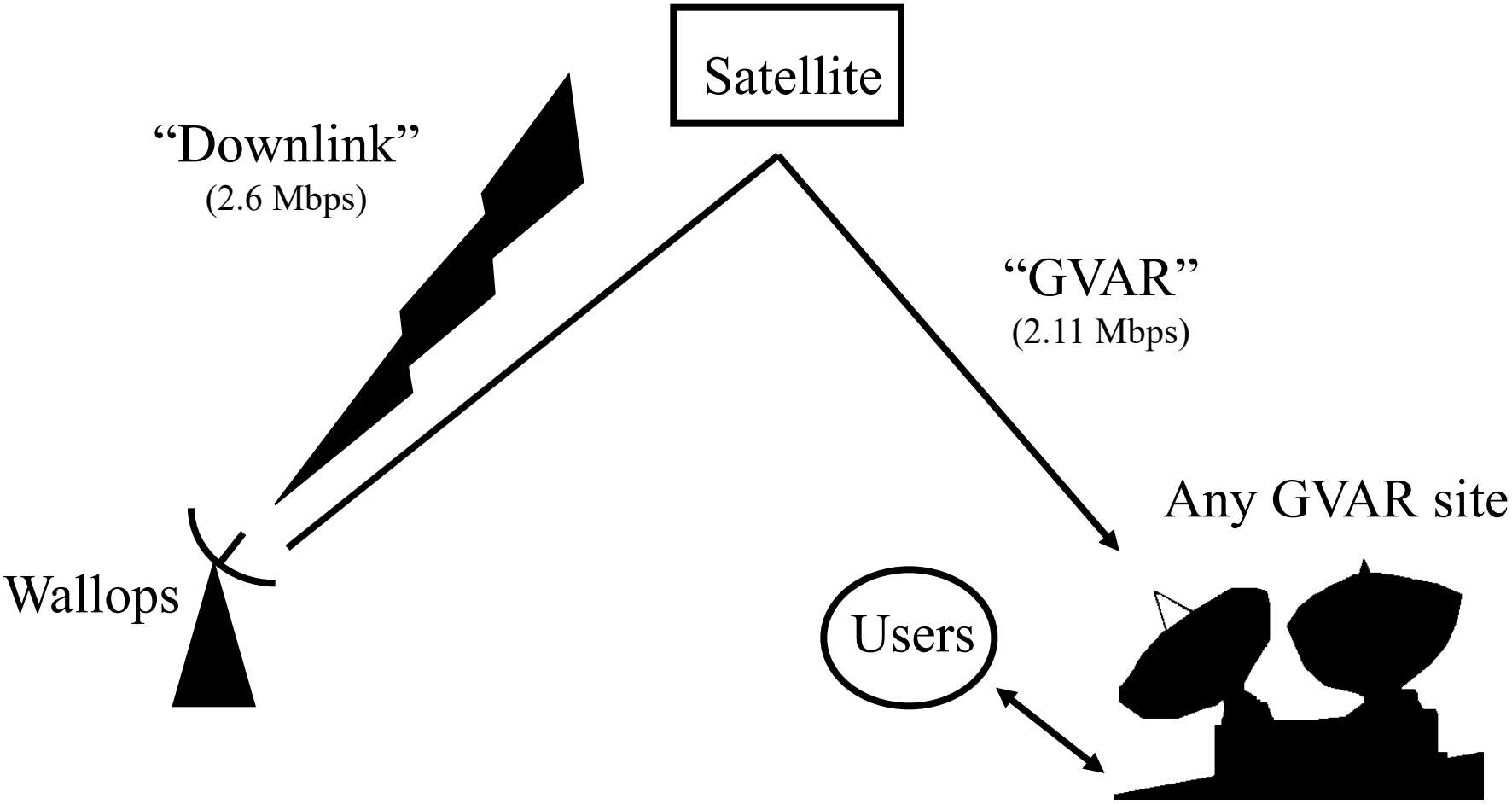
Cachoeira Paulista - São Paulo, Brazil
November, 2007

UW-Madison

GVAR SYSTEM



Note that the data is calibrated and navigated on the ground and then bounced off the GOES.

XGOHI

- XGOHI = eXtended GOes High Inclination operations (only Imager)
- Due to a large satellite inclination, a remap (before) GVAR distribution for GOES-10 Imager data only.
- Remapped GOES-10 GVAR data from 25-June-2007 and via the satellite re-broadcast (12-July-2007, 23-July-2007) were investigated.
- Without XGOHI, the growing satellite inclination would continue to cause loops with an ever increasing ‘wobble’.
- There’s no meteorological reason the NOAA/NESDIS should not remap the GOES-10 Imager data.
- Care must be taken to monitor the fire products.
- Given the current remapping parameters, the pro’s of XGOHI (steady image loops) outweigh the con’s (slightly changed hot spot detection).
- GOES-10 Imager XGOHI operations started at 19:13UTC on October 2, 2007

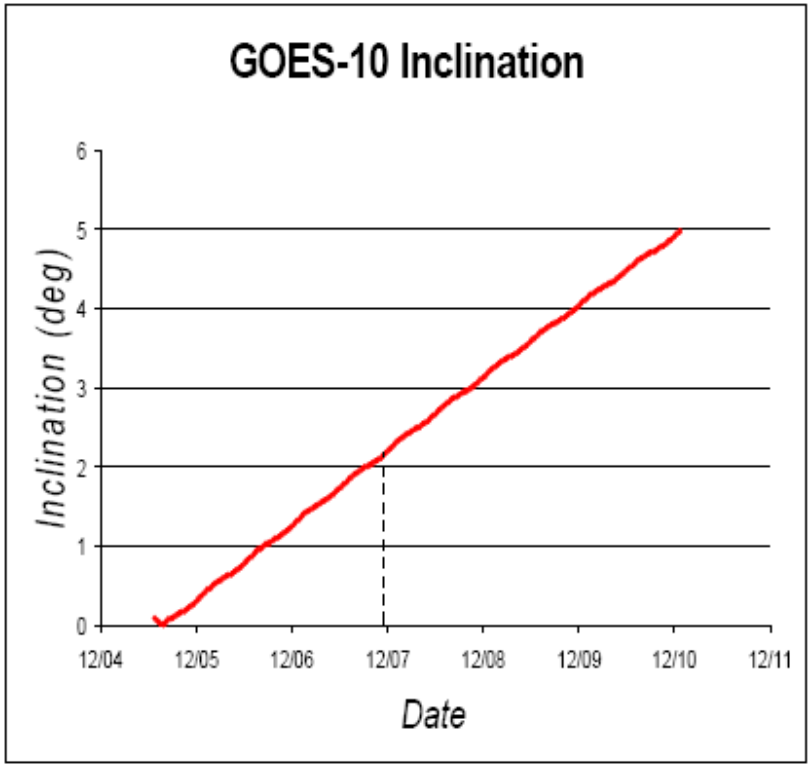
XGOHI/ESPS Overview

- ✓ Currently-operational GOES spacecraft, both east and west, each operate within a 0.5º inclination "box"
- ✓ NOAA desires to support operations outside of the 0.5º limit in order to extend the operational life of older spacecraft
- ✓ GOES Imager is operated in fixed-grid mode, meaning that the **Image Motion Compensation** (**IMC**) creates small adjustment motions of the scan mirror to maintain image stability and co-registration
  - The inclination > 2 degrees saturates the dynamic range which is reached by late 2007
  - Since the projected drift will exceed 2 degrees, the on-board capability for IMC will be turned off and subsequent processing for image navigation will be done on the ground
- ✓ The scope of this task was to design and implement an operational ground system for XGOHI mission
  - **E**nhanced **S**ensor **P**rocessing **S**ystem (ESPS) extends the capabilities of the **M**odernized SPS (MSPS) by implementing resampling to apply Image Motion Compensation (IMC) to Imager products on the ground
  - Allows extending the GOES-10, GOES-11, and GOES-12 Imager INR Ops when orbital inclination exceeds 2 degrees
  - No change in Sounder operations
  - The first GOES I-M S/C to Operate in XGOHI mode will be GOES-10

GOES-10 Operational Status

- ✓ GOES-10 Status
  - Was launched on April 25th, 1997
    - Has already outlived its 5-year life expectancy
  - Healthy spacecraft
  - Arrived on station at 60° W longitude on Dec 4th 2006
- ✓ GOES-10 will operate normally until IMC dynamic range saturates at ~2° inclination late 2007
- ✓ High-Inclination operations begin October 2007
  - Normal spacecraft commanding and orbit and attitude determination (OAD) operations
  - ESPS resampling with latency managed according to inclination to implement "IMC"
  - Fixed coverage of South America is all NOAA/NESDIS Satellite Operations and Control Center (SOCC) will be able to support
    - No support for rapid scan Imager coverage over South America when GOES-10 is in operation
  - Sounder operated normally

GOES-10 Operational Status (2)

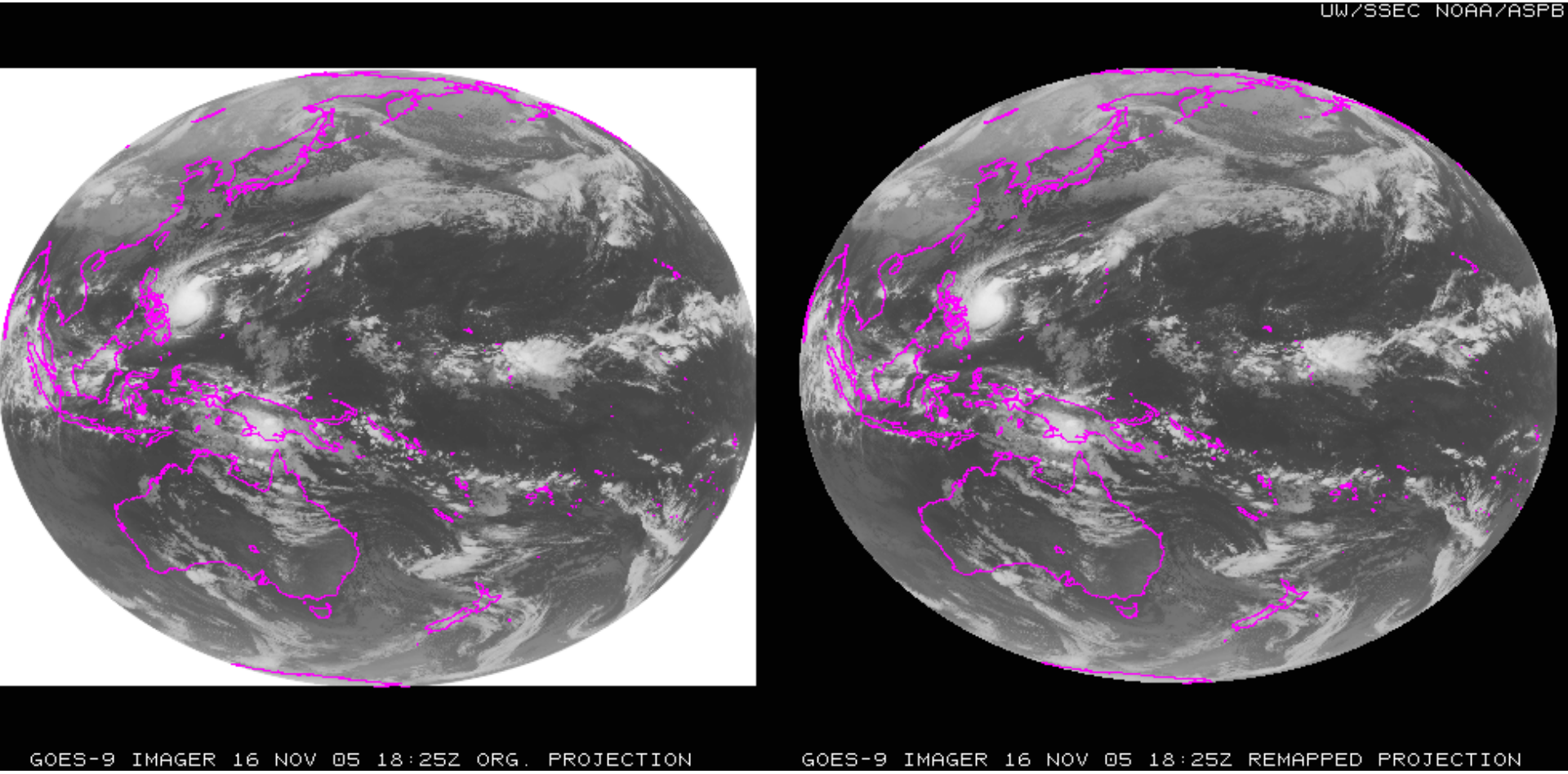


- The orbital inclination of GOES-10 positioned at 60° W longitude has currently passed 2 degrees.
- There is no more fuel available to control the orbital inclination, so it will continue to increase at the rate of approximately 0.95 degrees per year
- **GOES-10 Saturated its IMC Dynamic Range September 2007**

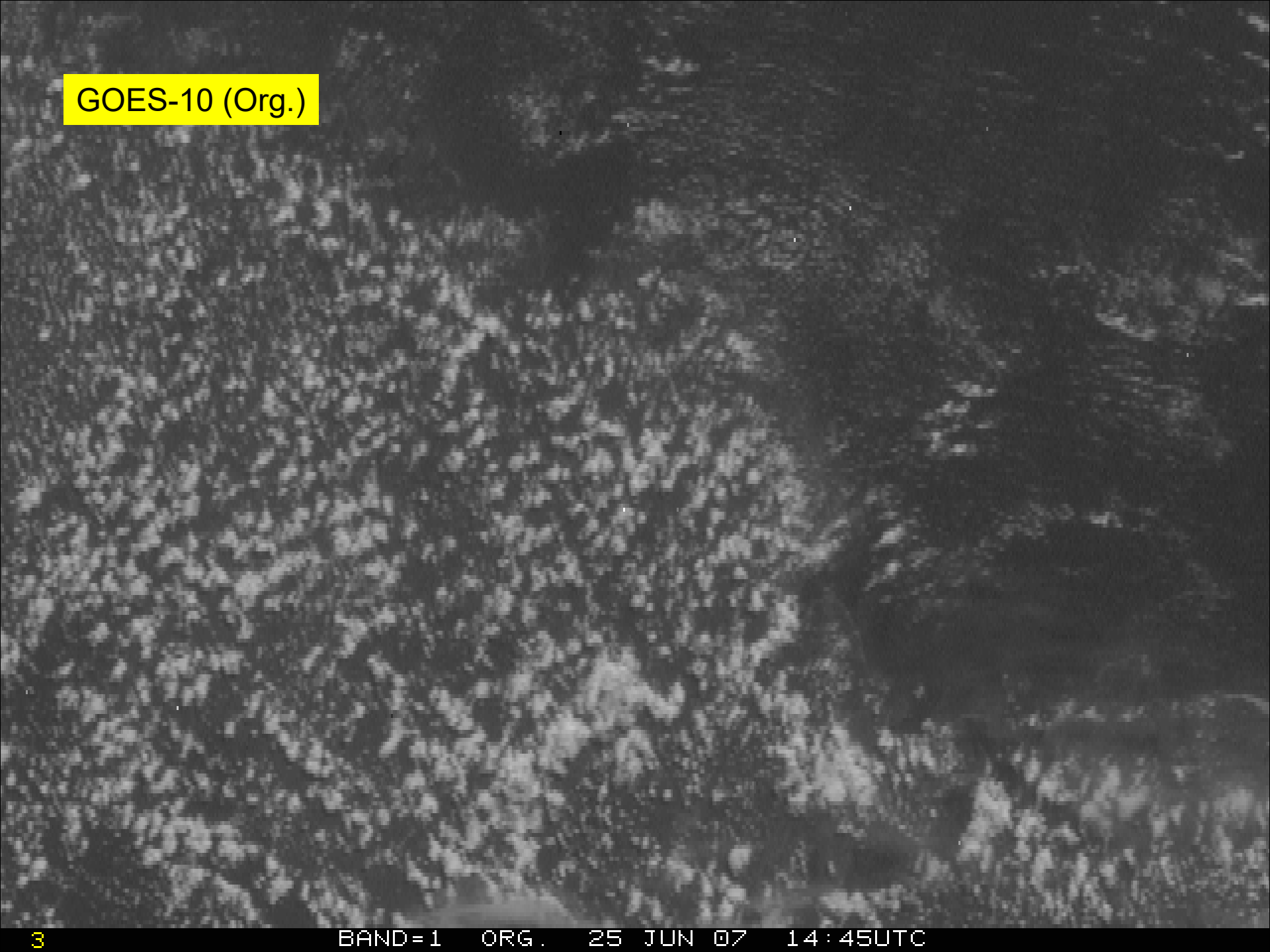
Why Resample for IMC?

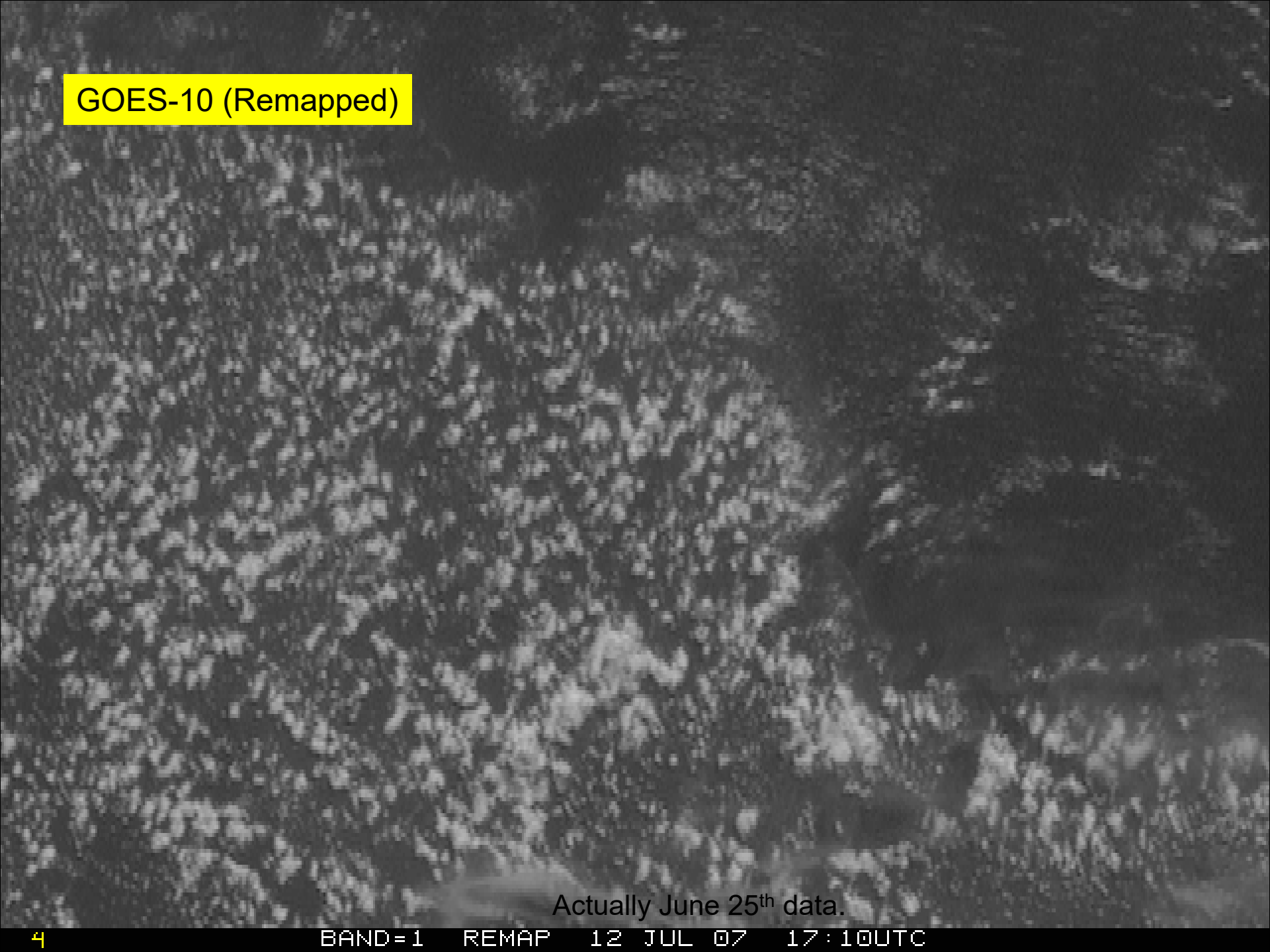
- ✓ Resampling implies that onboard IMC function will be performed on the ground
- ✓ Resampling On is equivalent to onboard IMC On and allows to generate GVAR with "fixed grid"
  - Both functions CANNOT be active at the same time
- ✓ Fixed grid GVAR is "user-friendly" – no need to implement time-variant ELUG routines on user's ingest systems
- ✓ Images in the loop are stable – land & grids are stationary – only clouds are moving

GOES-9 High Inclination Movie

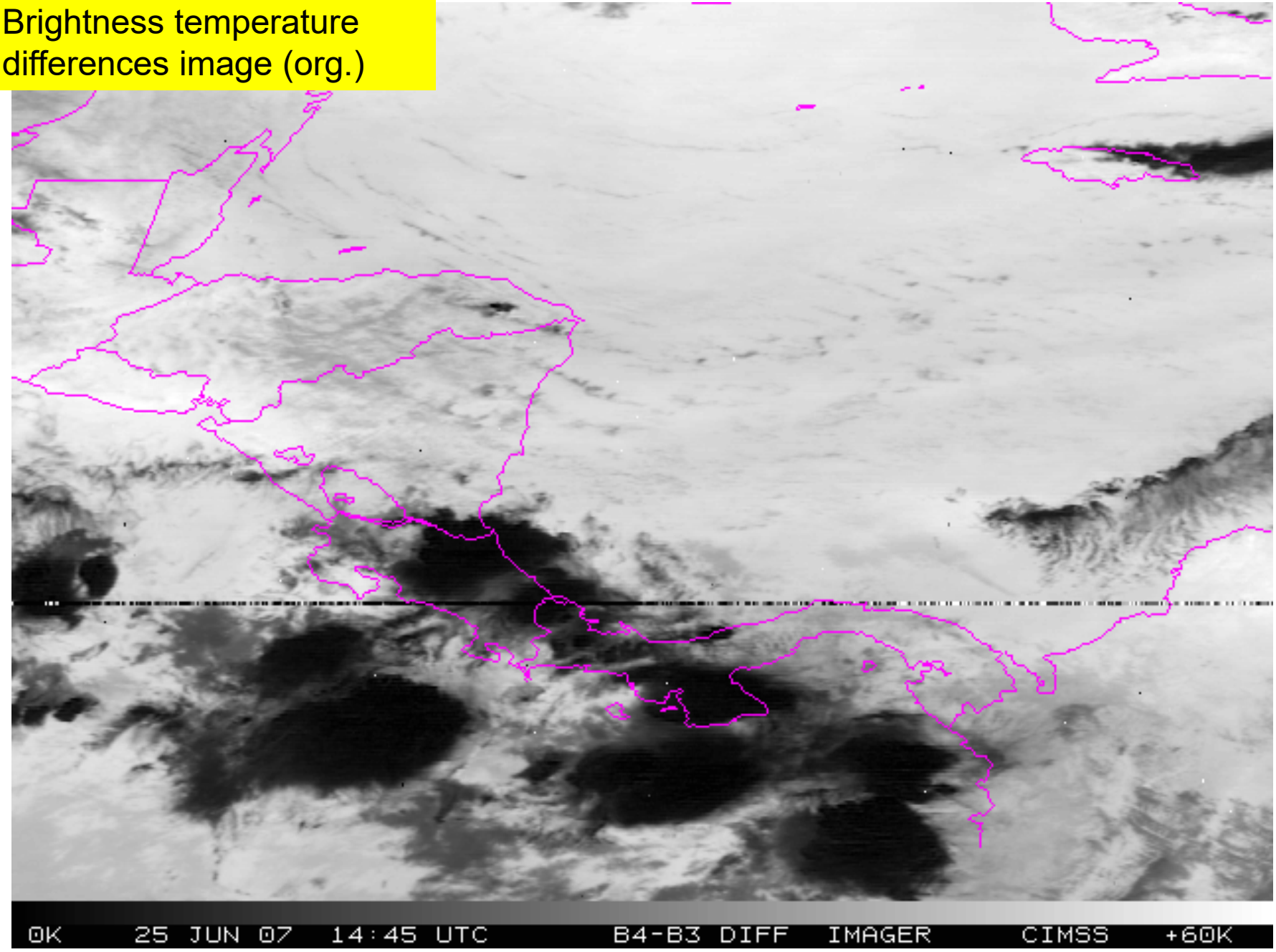


Inclination of approximately 1.8 degrees

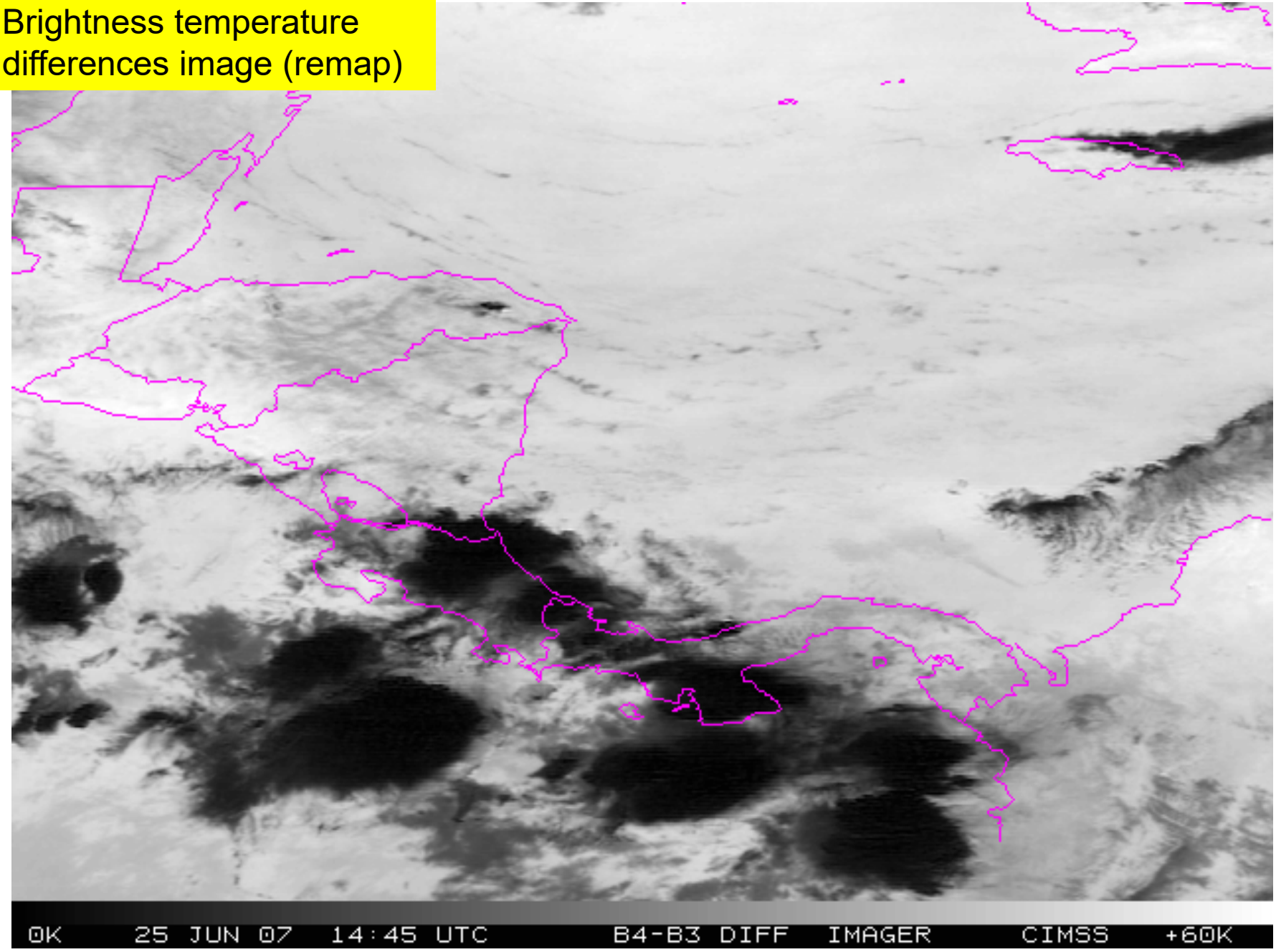

GOES-10 (Org.)
3
BAND=1 ORG. 25 JUN 07 14:45UTC


GOES-10 (Remapped)
Actually June 25th data.
4
BAND=1 REMAP 12 JUL 07 17:10UTC

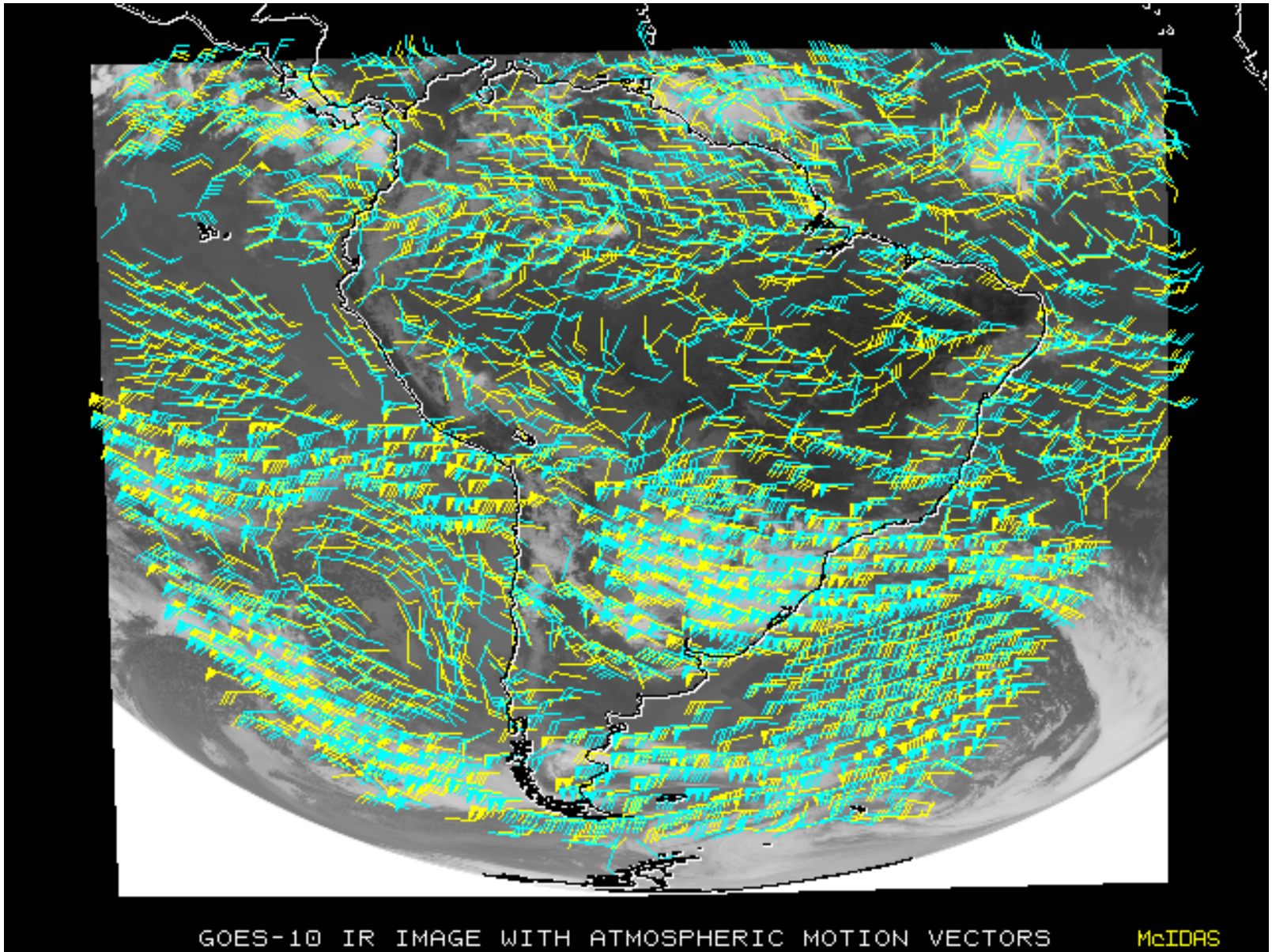
Brightness temperature differences image (org.)

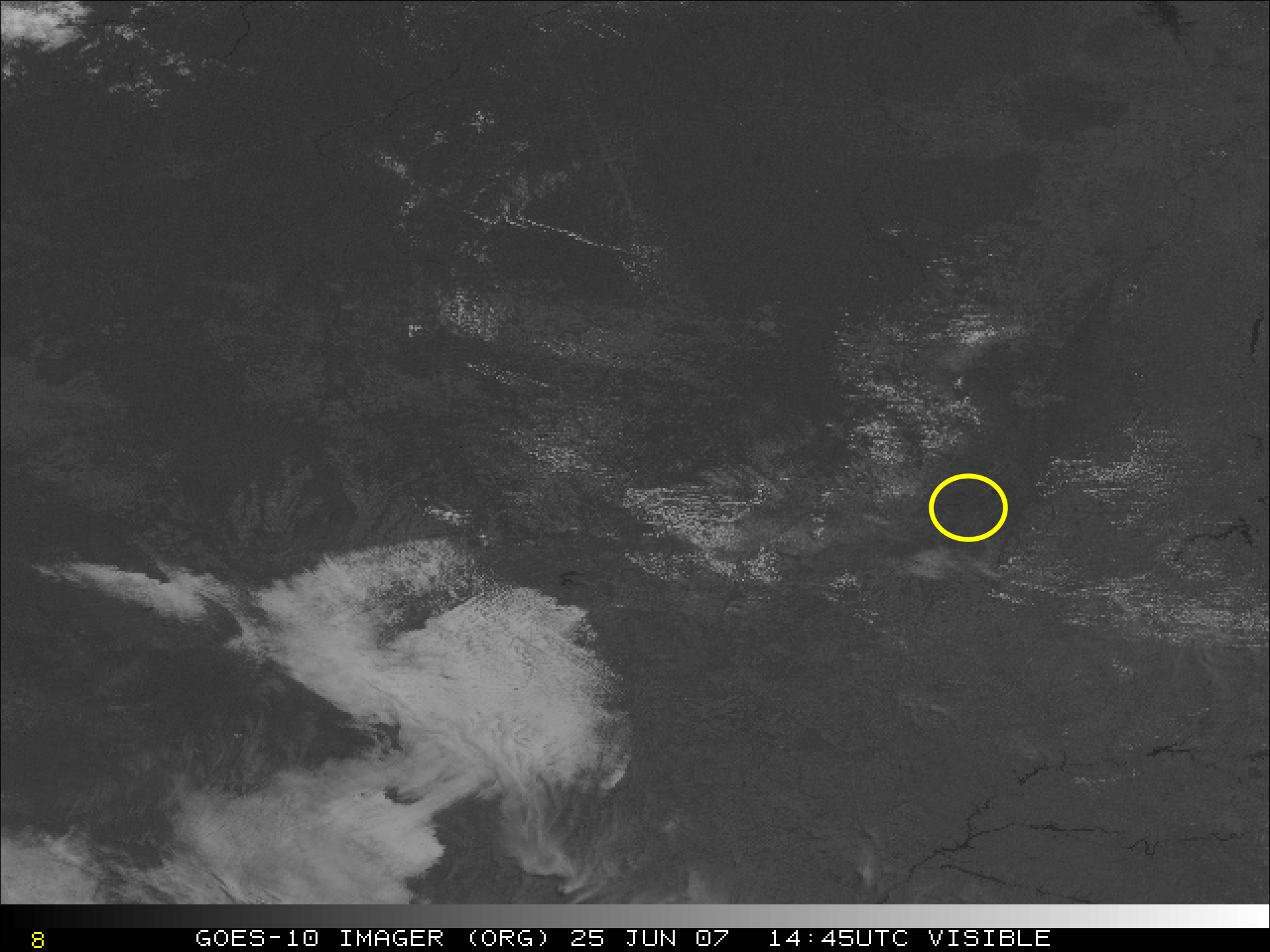


Brightness temperature differences image (remap)

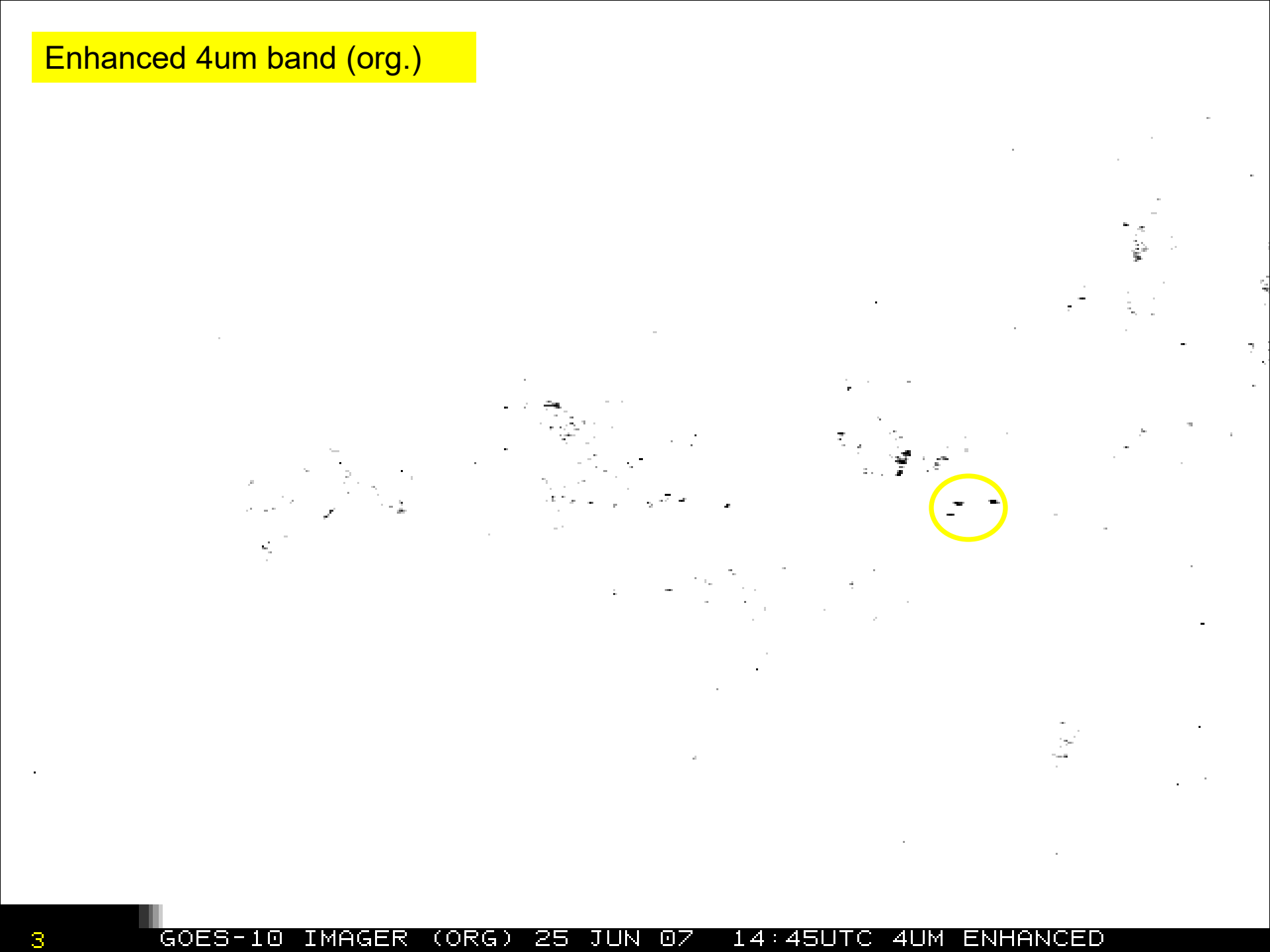


AMV (both sets, thinned)

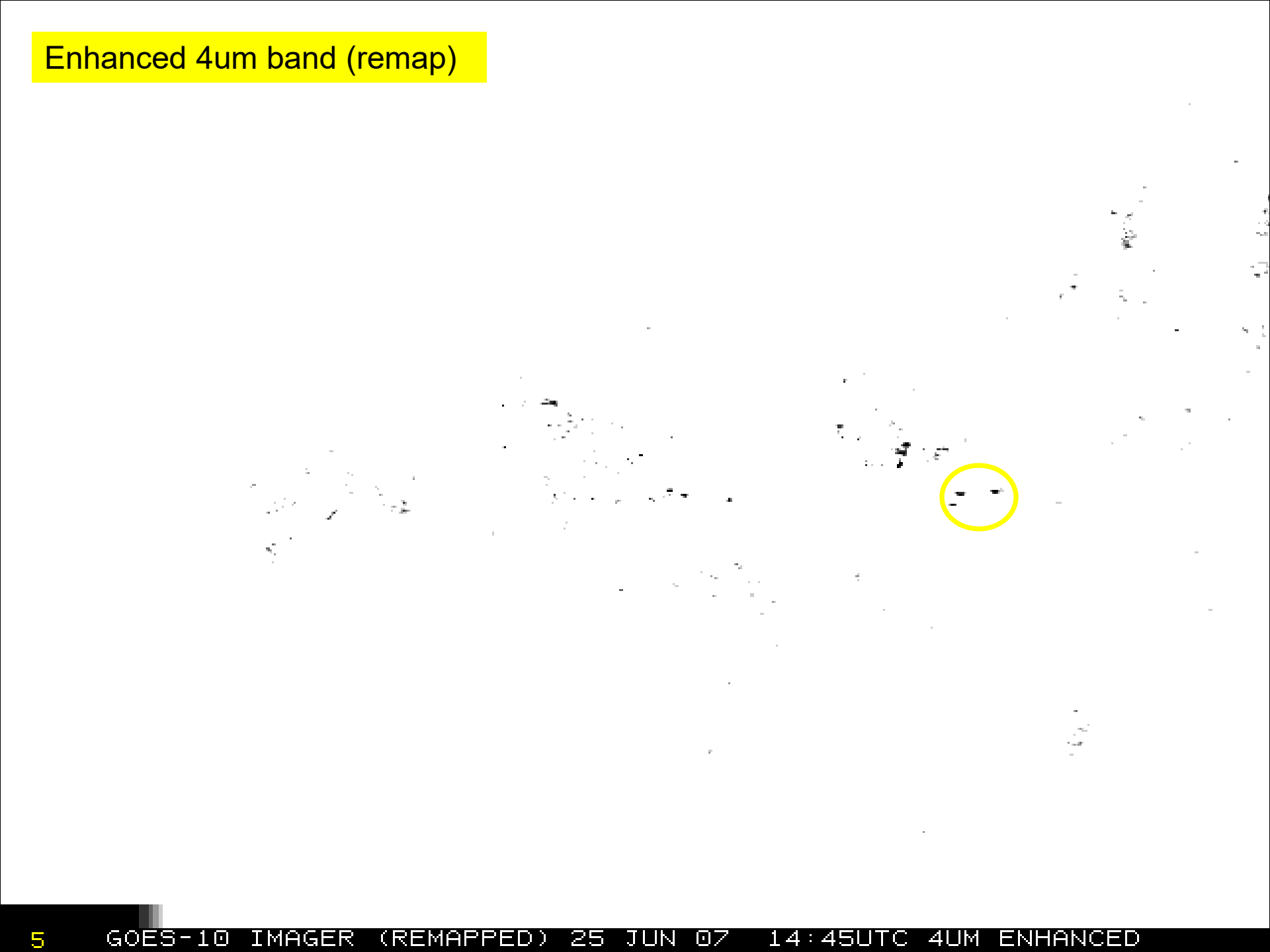



8
GOES-10 IMAGER (ORG) 25 JUN 07 14:45UTC VISIBLE

Enhanced 4um band (org.)

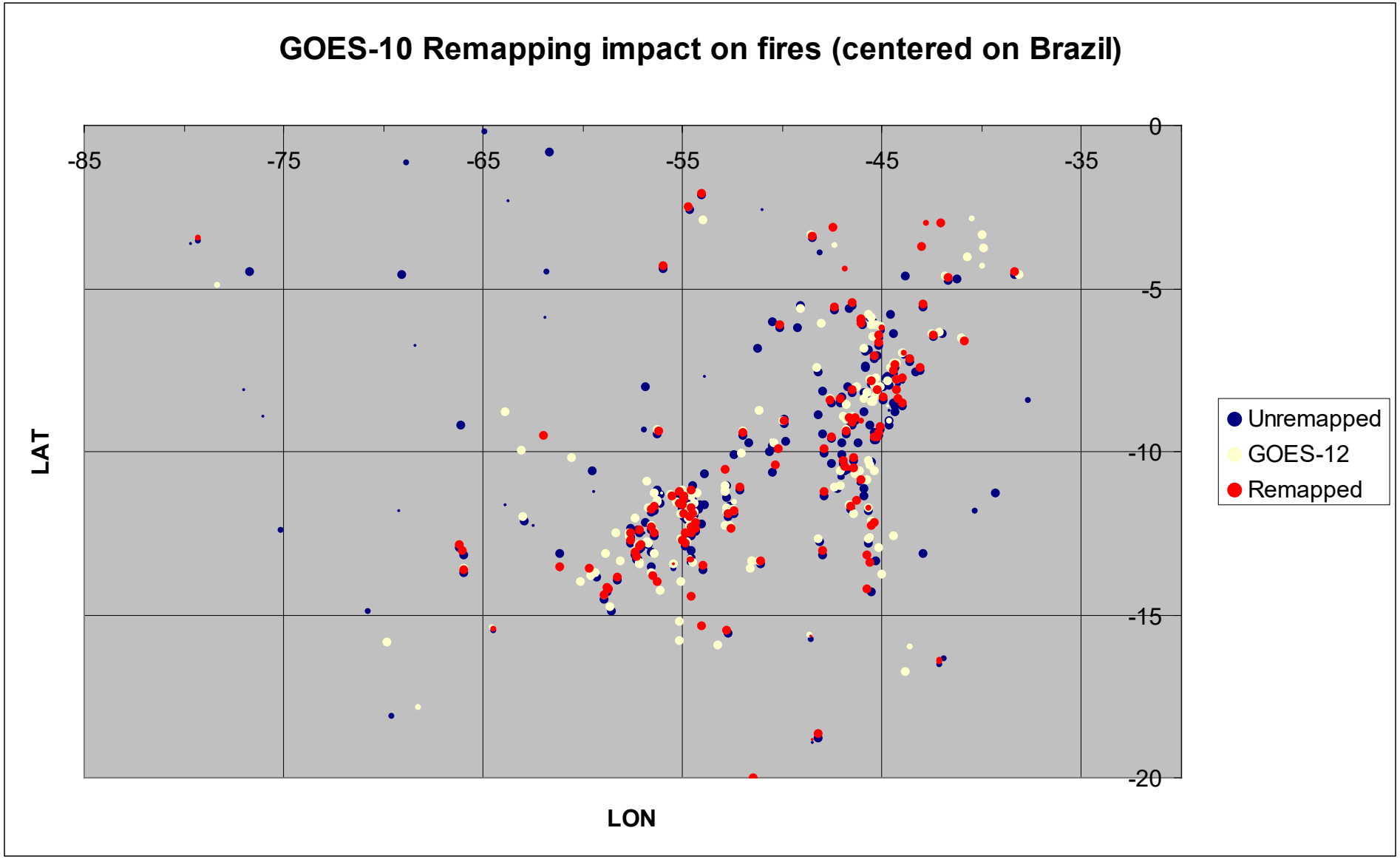


Enhanced 4um band (remap)

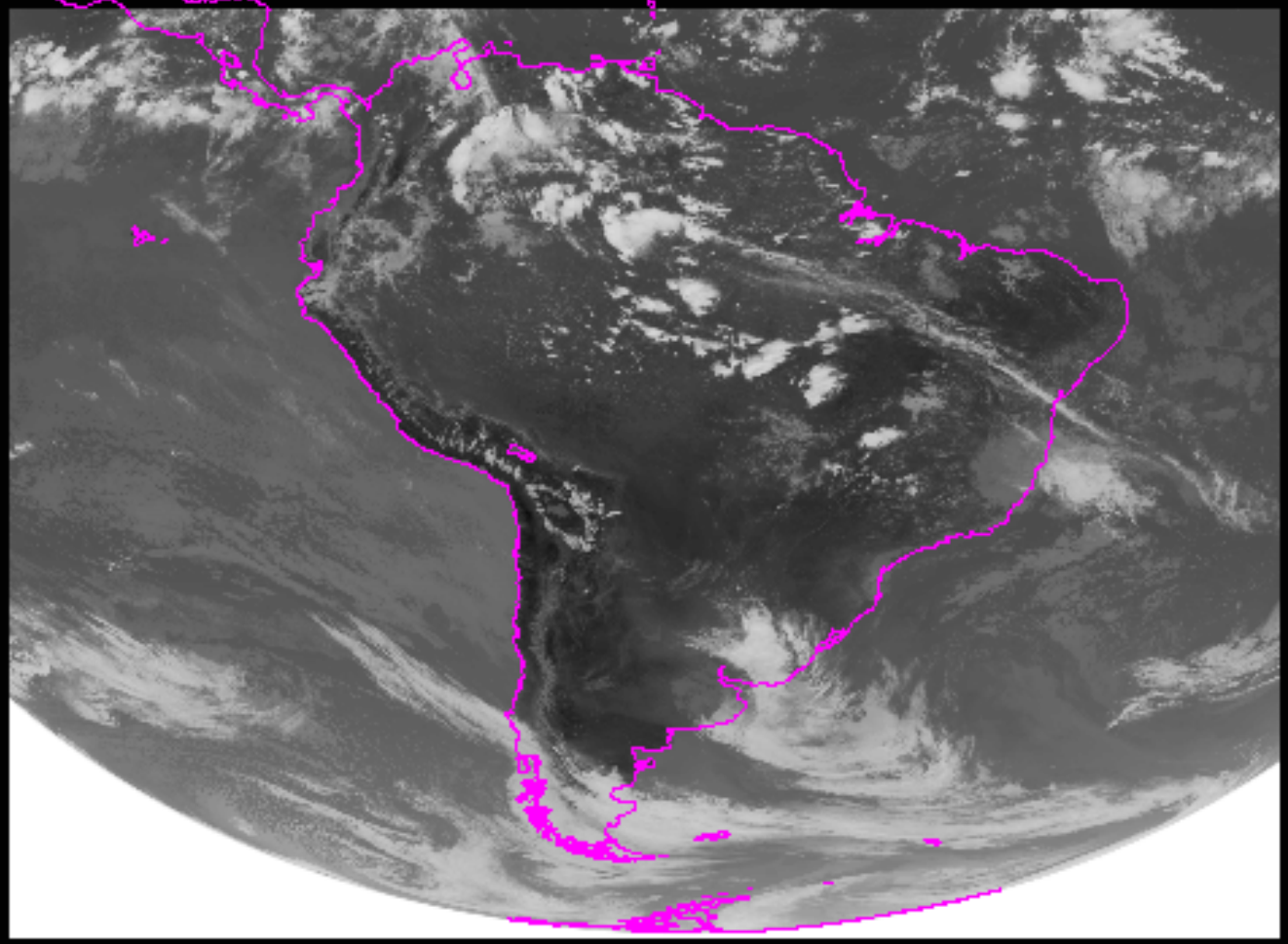


5 GOES-10 IMAGER (REMAPPED) 25 JUN 07 14:45UTC 4UM ENHANCED

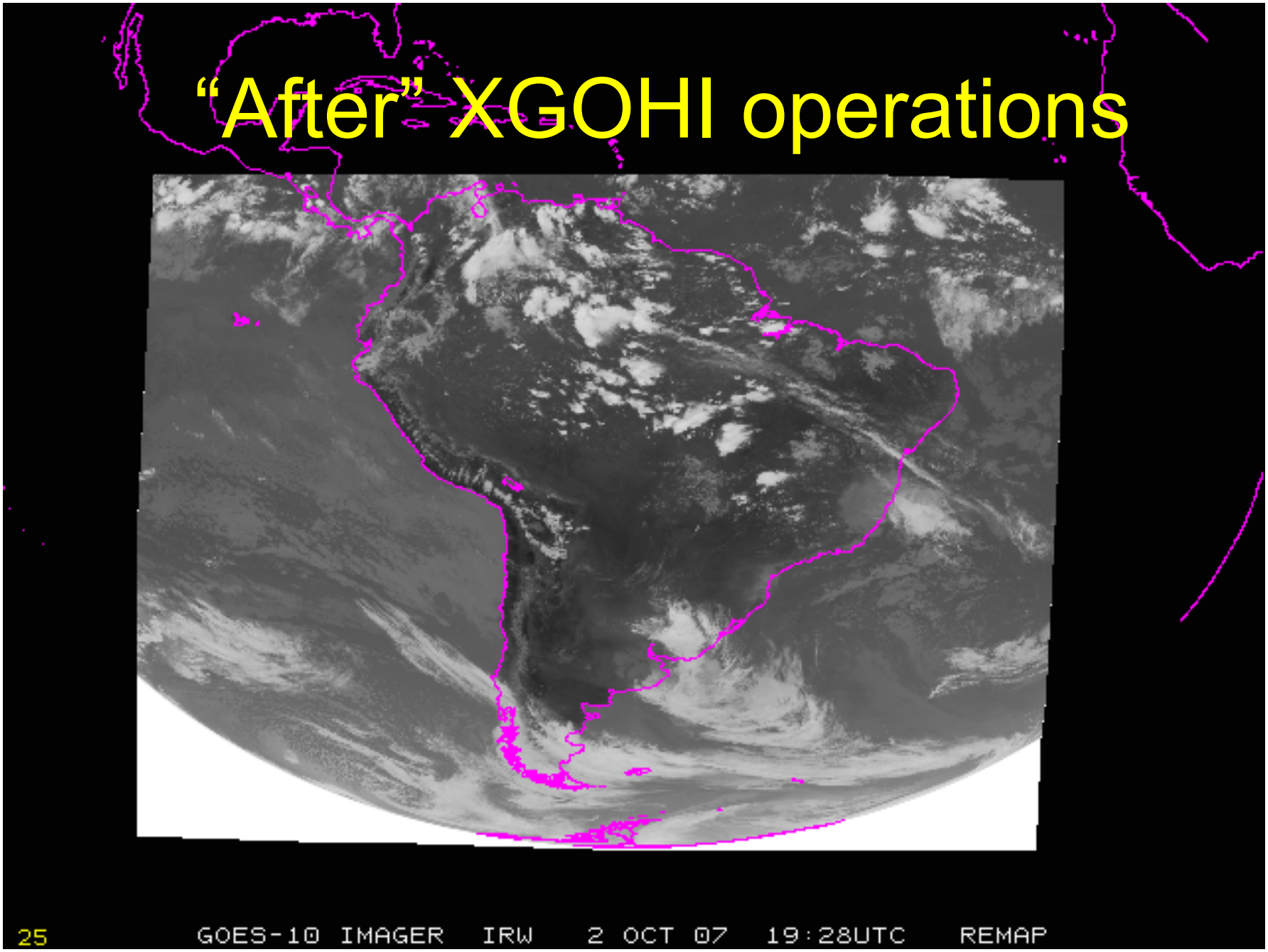
GOES-10 Unremapped vs GOES-10 Remapped vs GOES-12



Before" XGOHI operations



“After” XGOHI operations

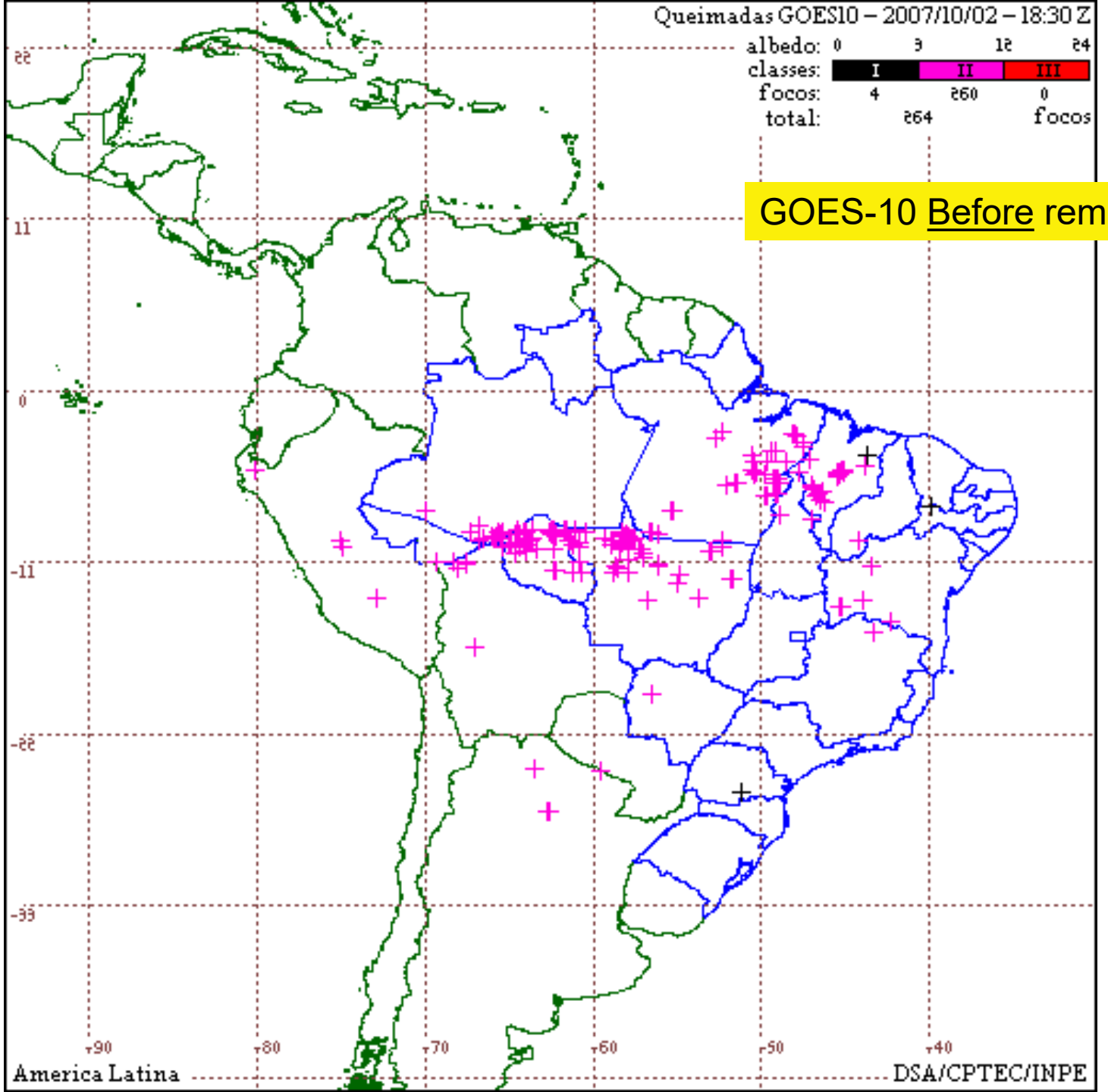


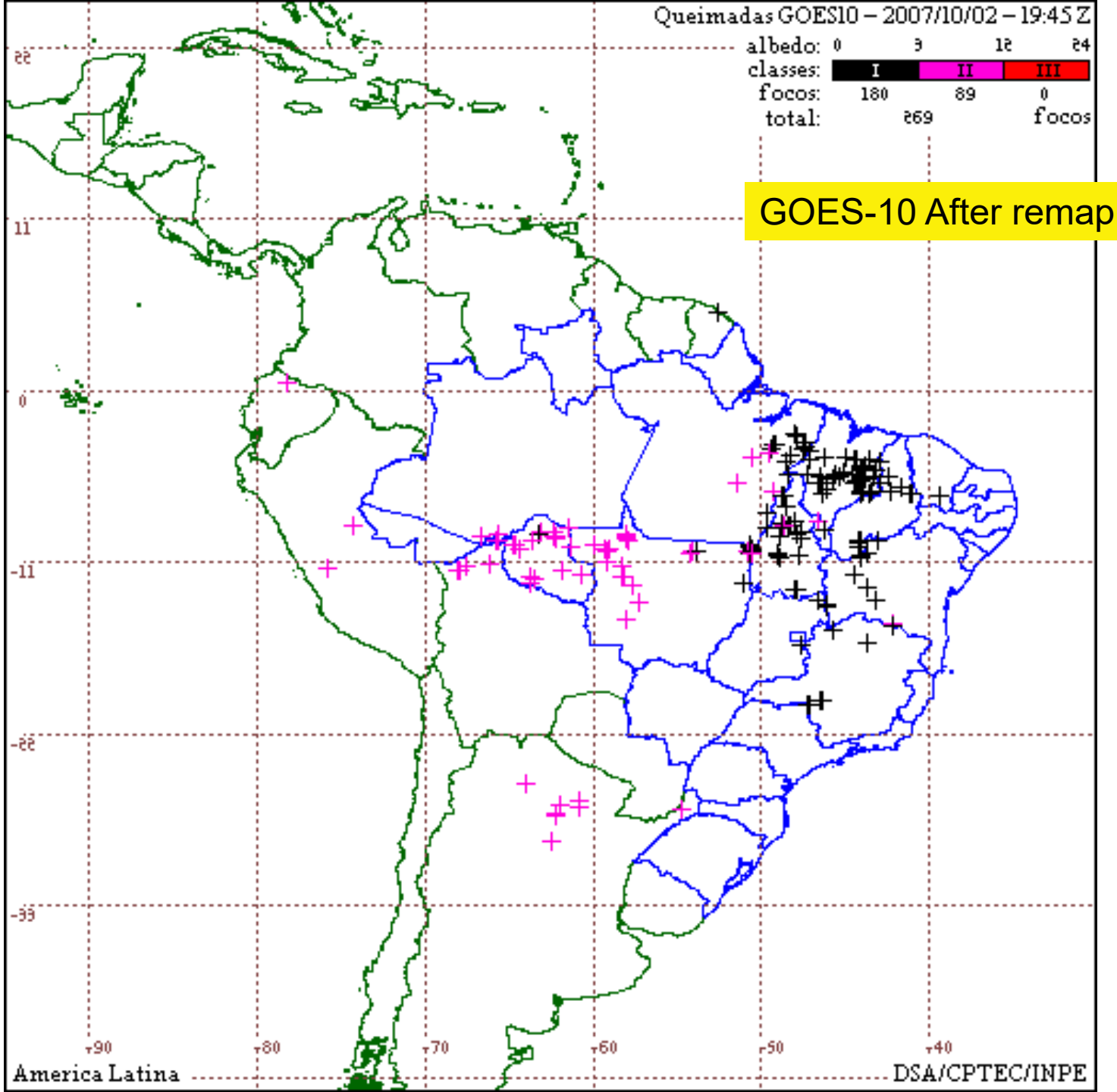
GOES-10 Fires

CPTEC, Brazil

Courtesy of web page of Dr. Alberto Setzer

http://www.cptec.inpe.br/satelite/metsat/queimada/GeoSat/Old/Qda/Goes10/2007/10/


Queimadas GOES10 – 2007/10/02 – 18:30 Z
albedo:
classes: I II III
focos:
total:
focos
GOES-10 Before remap
America Latina
DSA/CPTEC/INPE


Queimadas GOES10 – 2007/10/02 – 19:45 Z
albedo: 0 3 18 24
classes: I II III
focos: 180 89 0
total: 269 focos
GOES-10 After remap
11
0
-11
-35
-55
-90
-80
-70
-60
-50
-40
America Latina
DSA/CPTEC/INPE

Pro's and Con's of XGOHI

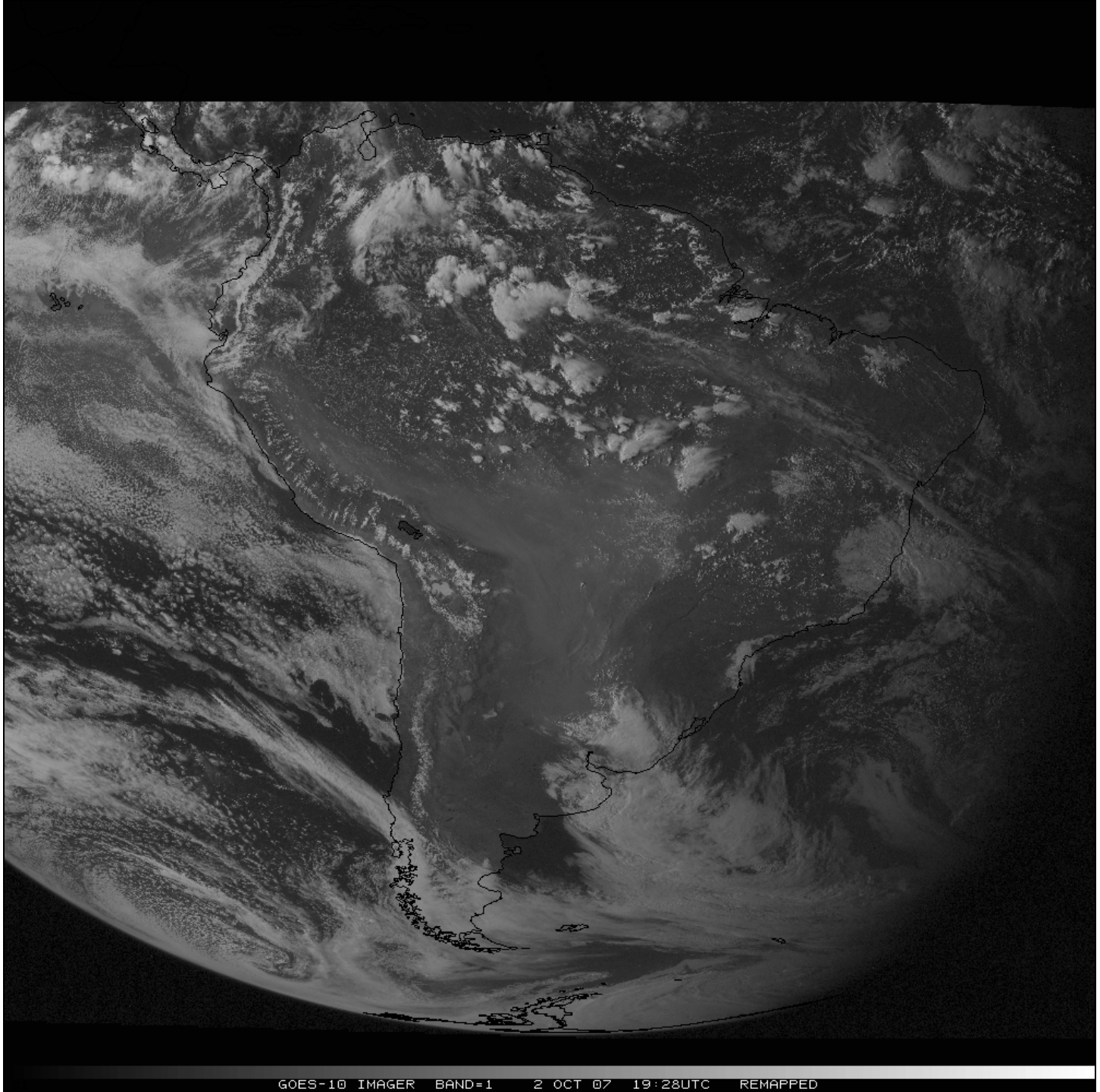
- Apparent earth 'wobble' is removed prior to distribution.
- Good navigation with XGOHI data.
- Each user does not need to remap GOES-10 Imager data. Done once, with the same method.
- Remap data latency increase is not huge (~3 minutes).
- In general, the fire signature is retained.
- Meteorological product information retained.
- Helps prepare uses for future remapped imager data (eg, the ABI)

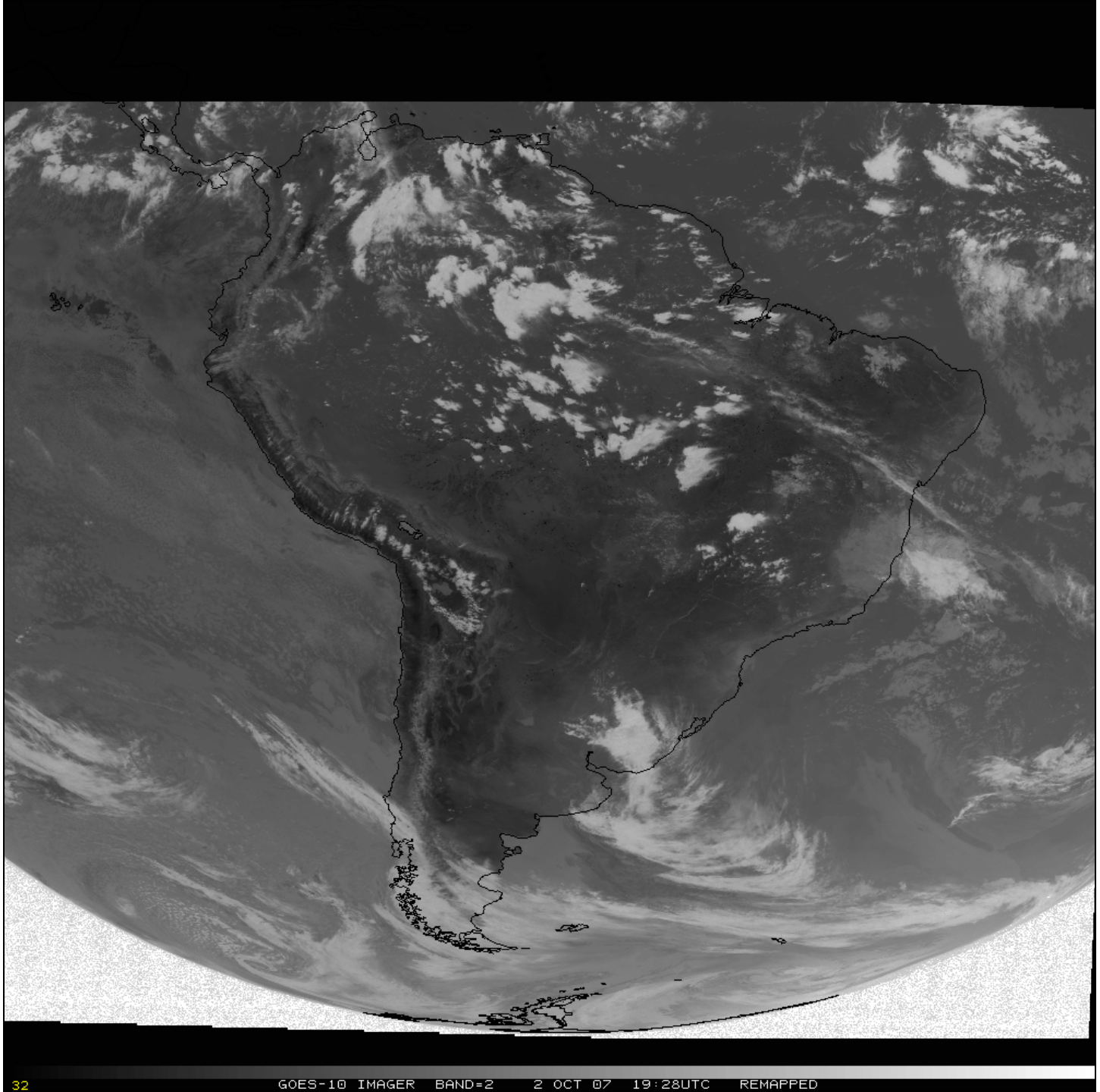
- Detector number/line information is lost. (Most users/applications do not use this information.)
- Process is not reversible
- Users still need to remap GOES-10 Sounder data. (Fewer users of direct GOES Sounder radiances)
- Increased data latency (~ 3 minutes).
- Fire detection is changed (slightly degraded) from original data. (No 'truth' for comparisons.)

More information

- http://www.ssd.noaa.gov/PS/SATS/GOES/TEN/
- ftp://gp16.ssd.nesdis.noaa.gov/pub/volcano/GOES10/XGOHI_Resampling_Suite_00.doc
- ftp://gp16.ssd.nesdis.noaa.gov/pub/volcano/GOES10/XGOHI_summary_09Oct07.ppt

- Conference
  - AMS 2007 Conference
    - *XGOHI, Extended GOES High-Inclination Mission for South-American Coverage*
  - AMS 2008 Conference
    - *Remapping GOES Imager Instrument Data for South American Operations, Implementing the XGOHI System*


GOES-10 IMAGER BAND=1 2 OCT 07 19:28UTC REMAPPED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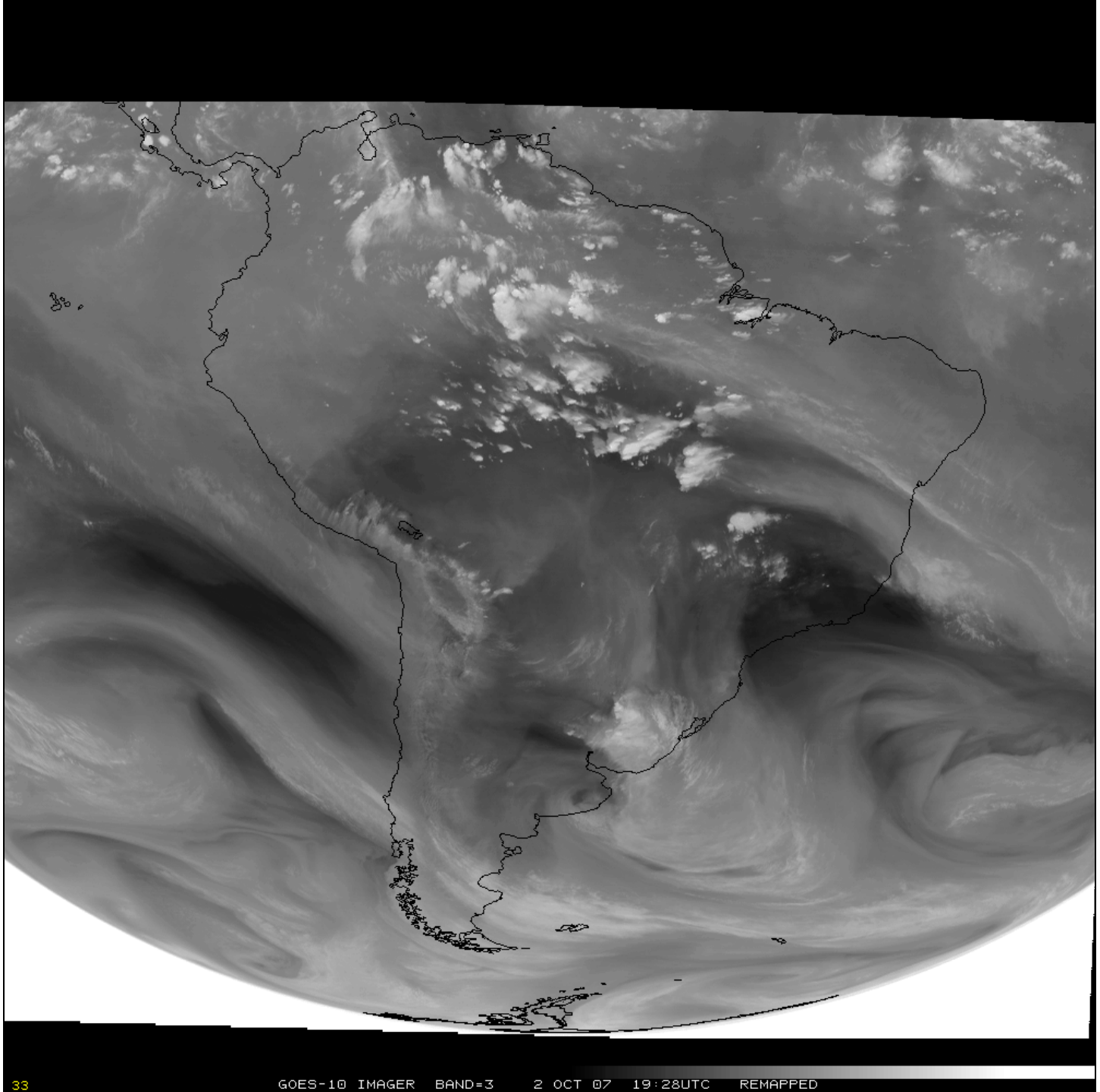
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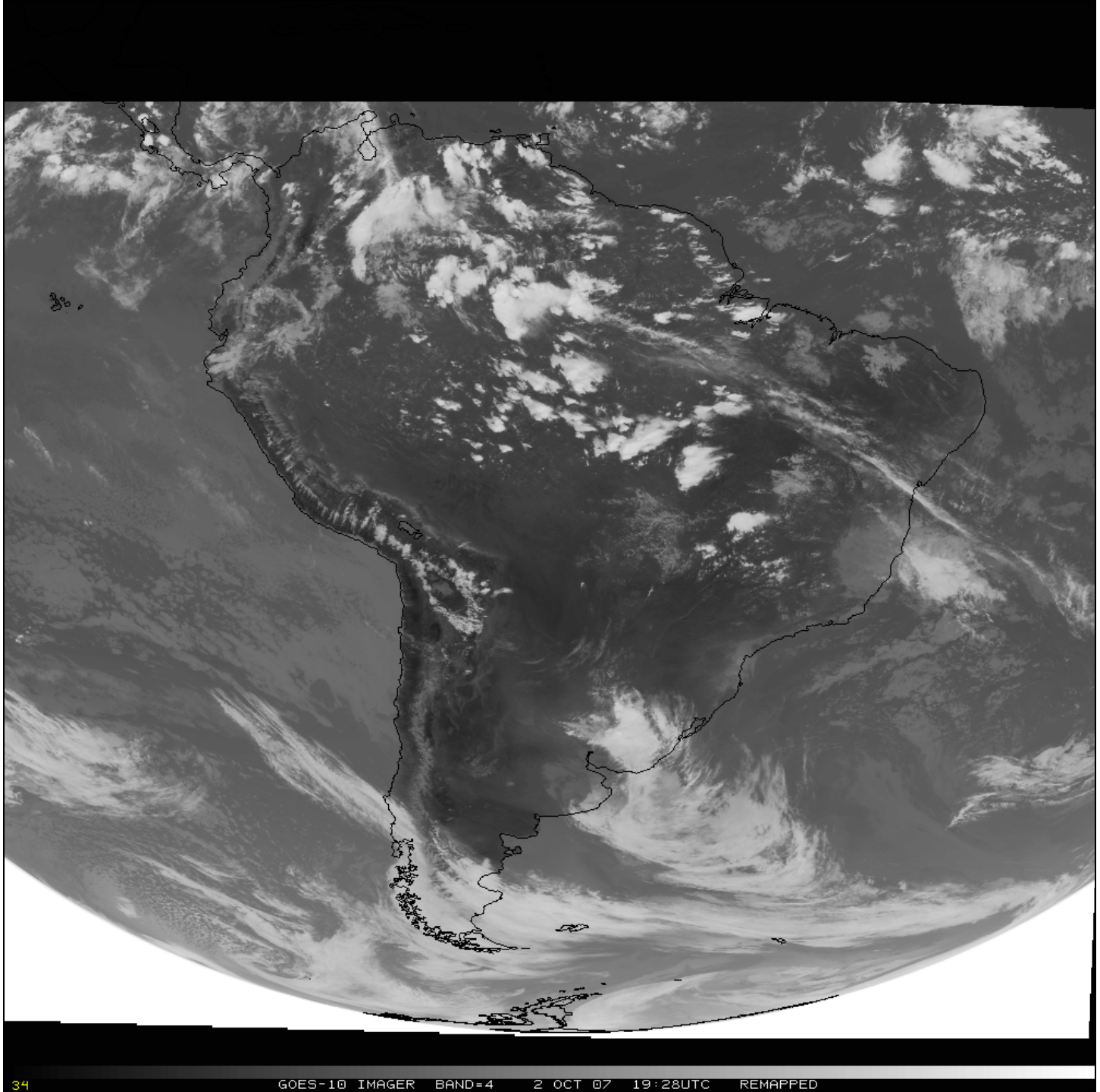
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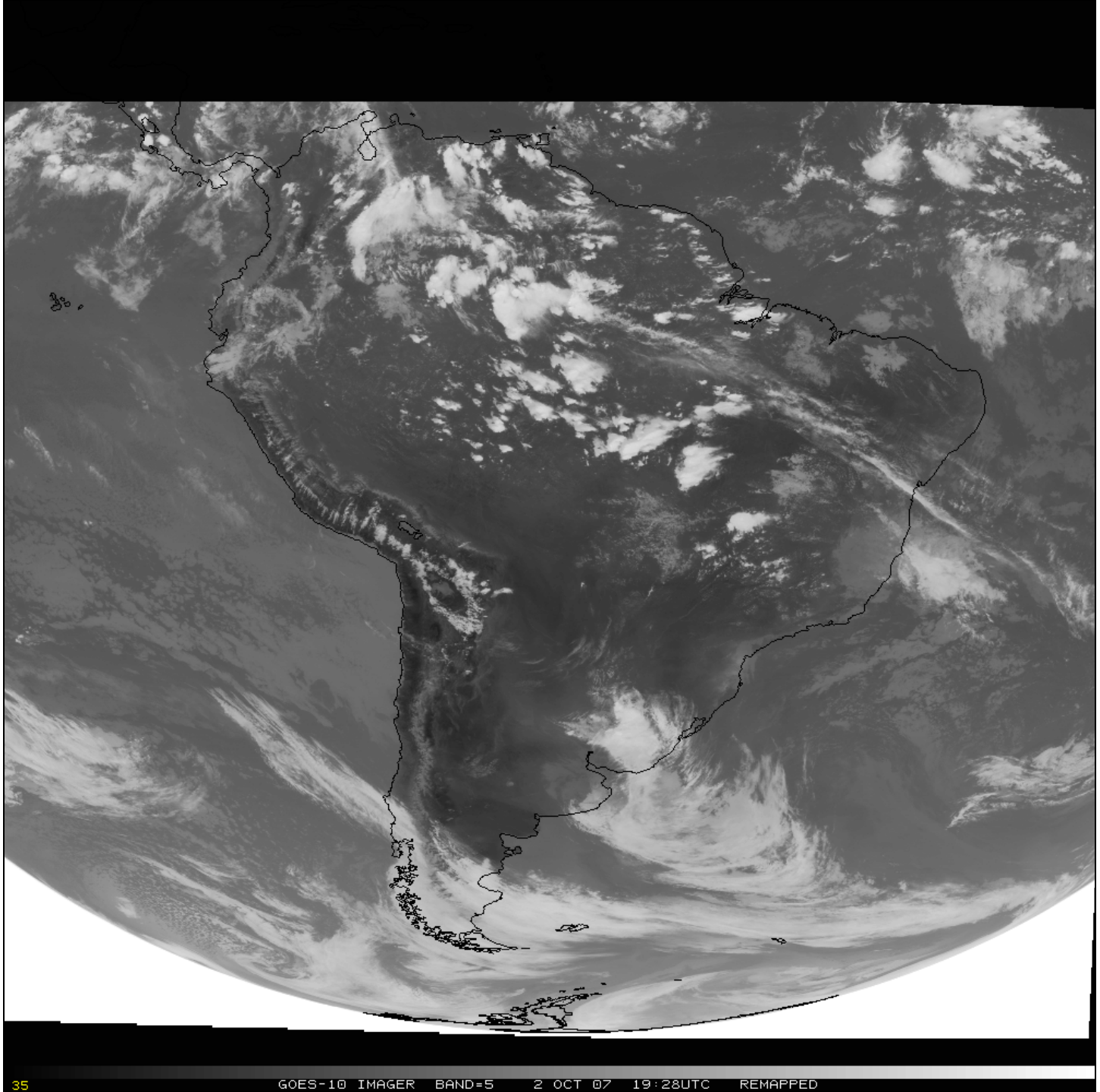
GOES-10 IMAGER BAND=4 2 OCT 07 19:28UTC REMAPPED


35
GOES-10 IMAGER BAND=5 2 OCT 07 19:28UTC REMAPPED

Back-up

GVAR

- GVAR Receiving Station Requirements
- User data (GVAR) is downloaded from the spacecraft on 1685.7 MHz
  - To register as a GVAR user: **http://www.osd.noaa.gov/gvar/gvar.asp**
  - NOAA developed a document that describes antenna requirements which located on GOES-10 web site http://www.ssd.noaa.gov/PS/SATS/GOES/TEN
  - Solution was found for less than $20,000
  - Antenna range of 3.8 - 4.0 m

Antenna Look Angles

Table 1- Ground Location Parameters

Ground Location	Longitude (Deg W)	Latitude (Deg)	Altitude (Meters)	Azimuth Angle (Degrees)	Elevation Angle (Degrees)
Yucatan	90	20	10	111-128	44-53
Ecuador	80	-5	10	61-93	63-67
Rio de Janeiro	45	-23.5	10	318-332	52-64
Buenos Aires	60	-35	10	-0.4-0.3	43-56
Santiago	72	-35	200	18-24	41-54
Cape Horn	70	-55	0	11-13	20-33
Recife, Brazil	35	-8	10	273-298	56-61
Manaus, Brazil	60	-3	10	-215-10	80-90
Boa Vista, Brazil	60.7	2.8	10	10-175	80-89
Paramaribo, Suriname	55.3	5.5	10	202-277	75-85

GOES-10 Upgrade - XGOHI

- NOAA has developed a ground system to provide image navigation for inclination higher than 2º
  - New system uses a re-sampling method to provide a fixed grid image
- User's antennas will have to track the spacecraft above 2º inclination. The spacecraft reached this limit ~ September 2007

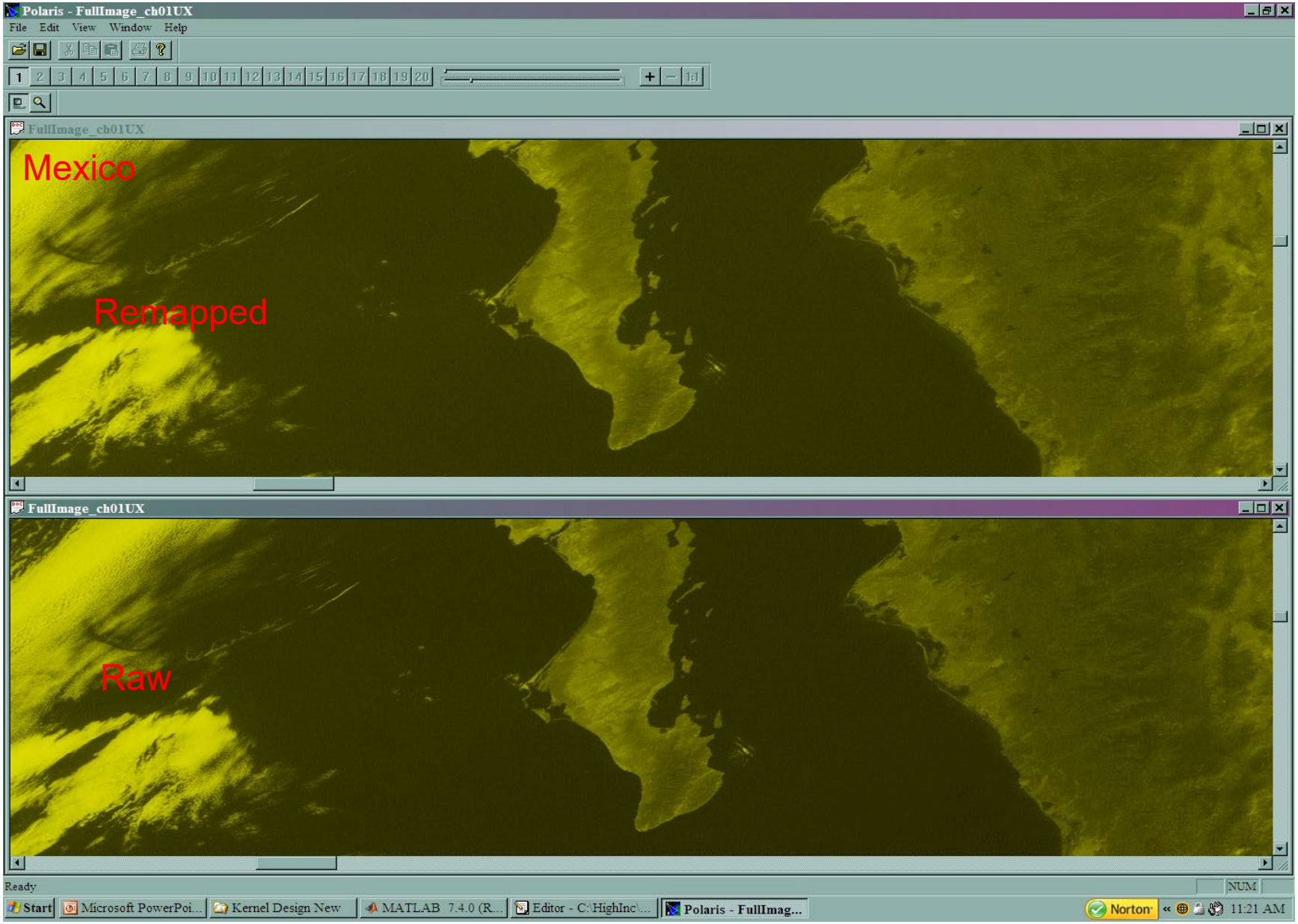
Remapped GVAR

- XGOHI Remapping/Resampling is similar to that on other programs
  - MSG and MTSAT
  - ABI for GOES-R
- XGOHI GVAR is Interchangeable with regular GVAR
  - Spare GVAR words are used to document
    - Processing (resampling on/off, resampling method)
    - Fine adjustments for pixel time tags
  - All other fields are unchanged

Remapped GVAR

- Flexible Resampling design provides a Menu of options that are Adaptable to user needs
  - Nearest Neighbor
  - Bilinear, Bicubic
  - Wiener Filter kernels

- Initial delivery kernel design
  - Minimizes fire signature impacts for IR2, IR4, IR5
  - Slightly sharpens VIS, IR3
  - University of Wisconsin has assessed impact on select products


Polaris - FullImage_ch01UX
File Edit View Window Help
FullImage_ch01UX
Mexico
Remapped
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MATLAB 7.4.0 (R...
Editor - C:\HighInc\...
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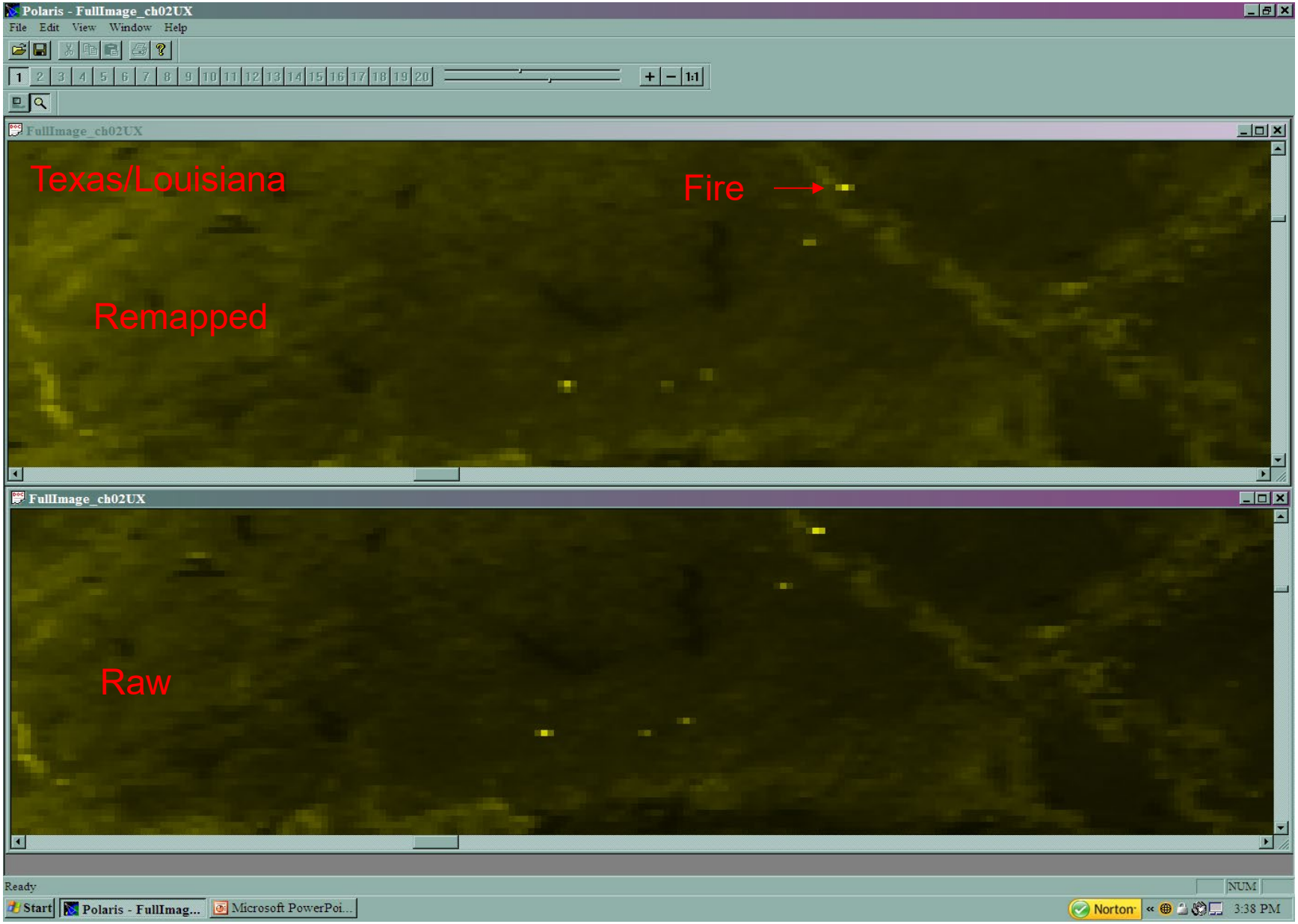
Norton
11:21 AM

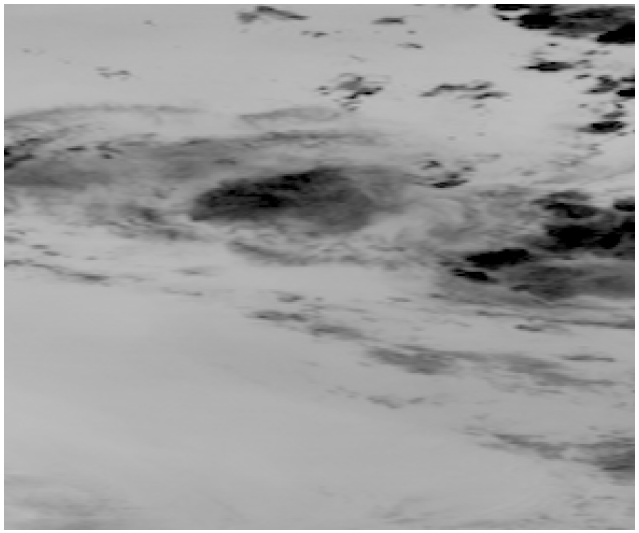
VIS Channel



IR2 Channel – Hot is Bright and Cold is Dark

IR3 Channel with Sharpening

Remapped (sharpened)



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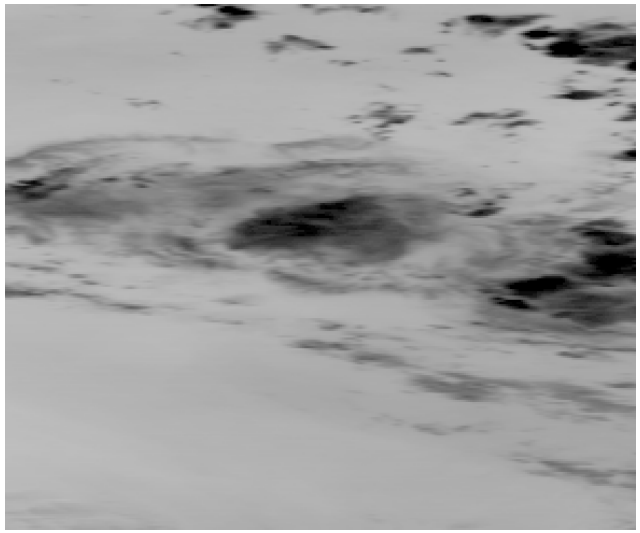

IR3 Channel – Hot is Bright and Cold is Dark