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Interim evaluation of the New IR Sensor Technology (NIRST) as a wildfire monitoring tool

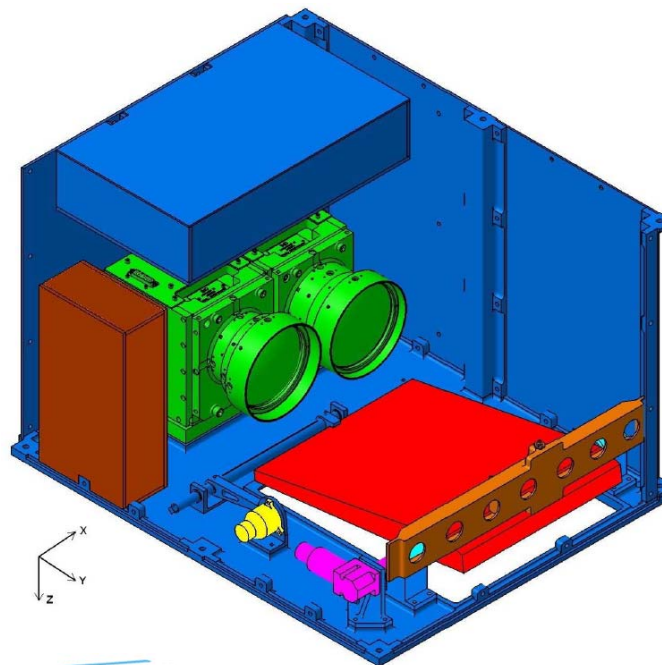
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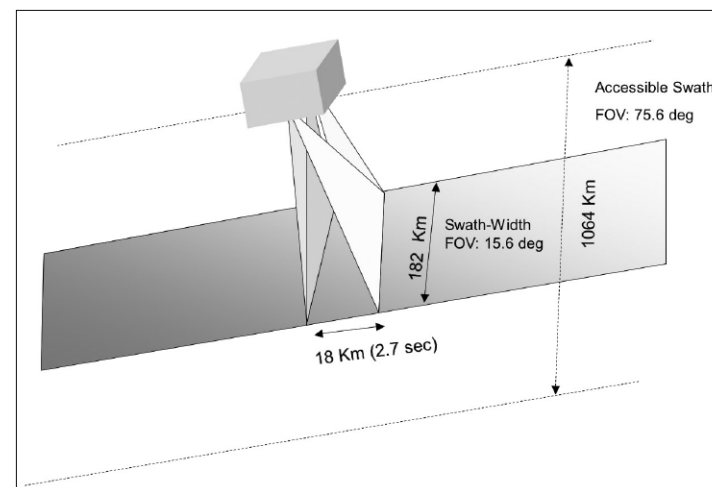


New IR Sensor Technology (NIRST)

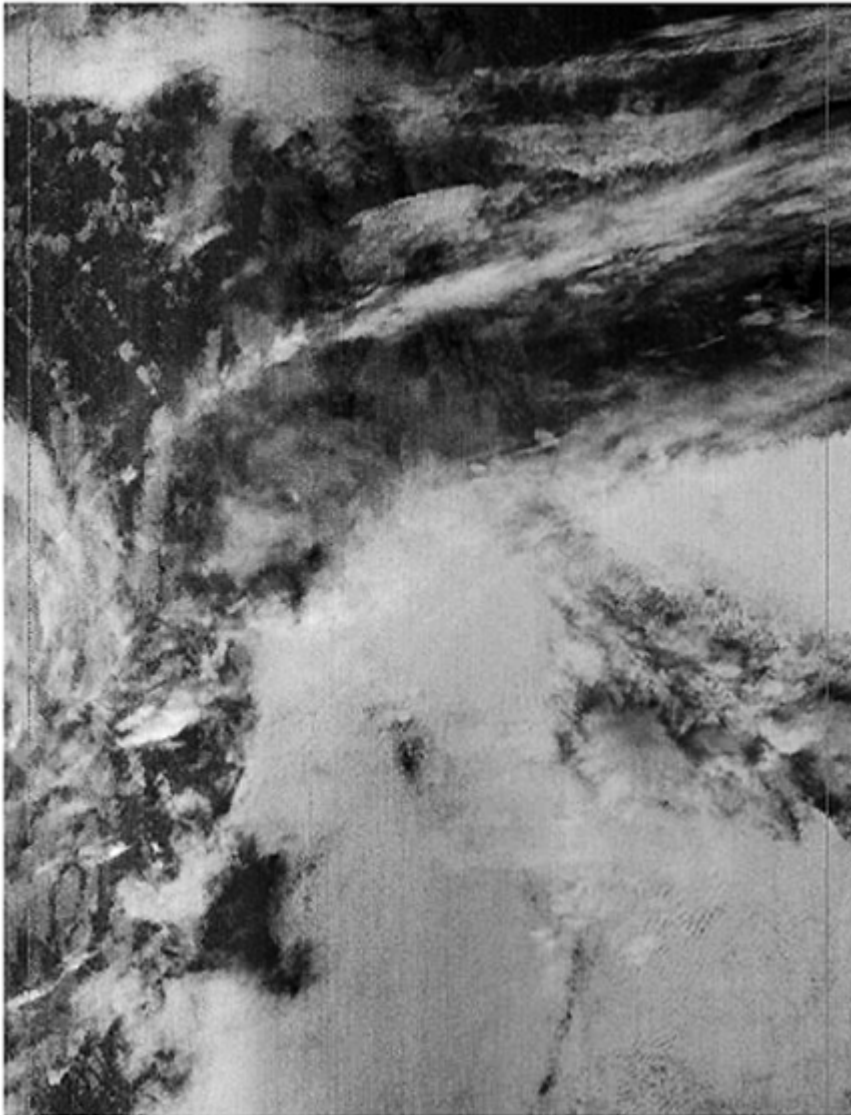
- Uses uncooled microbolometer IR detectors in a **SCANNING** 512 x 3 pixel array configuration

Parameter	Value
Space craft	SAC-D
Payload mass	7.3 kg (Phong et al. 2013)
Power consumption	~ 16 W/orbit
Scan method	Push-broom
Overpass time	Ascending node 18:00 LCL
Spatial resolution	351 m
Swath width	182 km
Across track maximum observable	1060 km
Temporal resolution	< 1 day (with pointing)

Band	MWIR	LWIR 1	LWIR 2
Central wavelength	3.8 μm	10.85 μm	11.85 μm
Band limits	3.4 – 4.2 μm	10.4 – 11.3 μm	11.4 – 12.3 μm



(Figure from: Marraco and Phong 2006)



September 2011

- First transmission from NIRST
- Acquired over Bolivia
- LWIR 2 pictured here (uncalibrated image)
- MWIR band reported only noise at this point

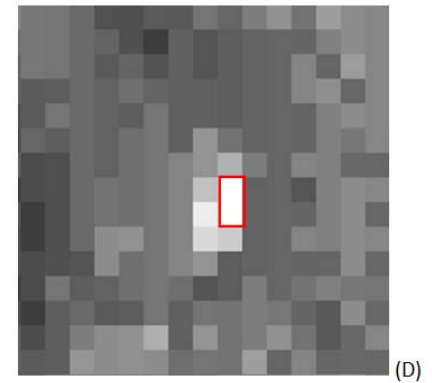
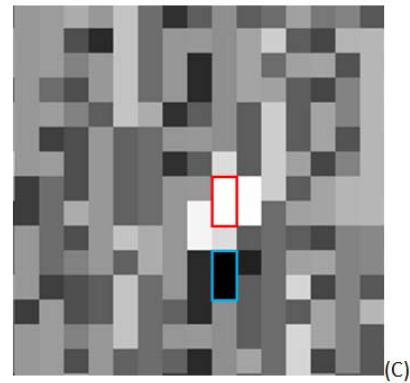
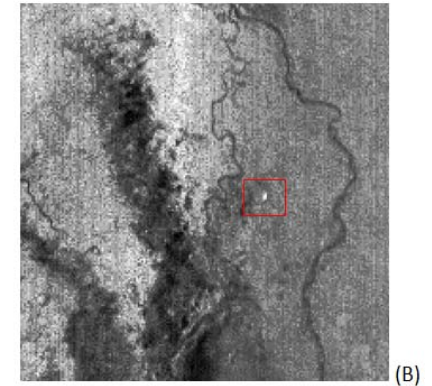
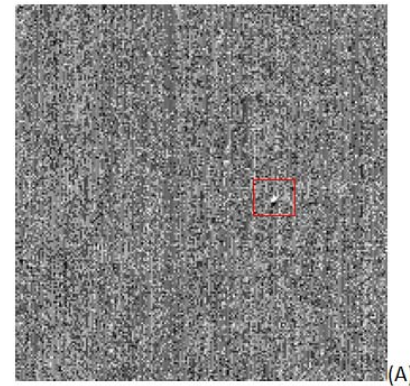
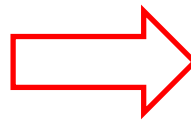
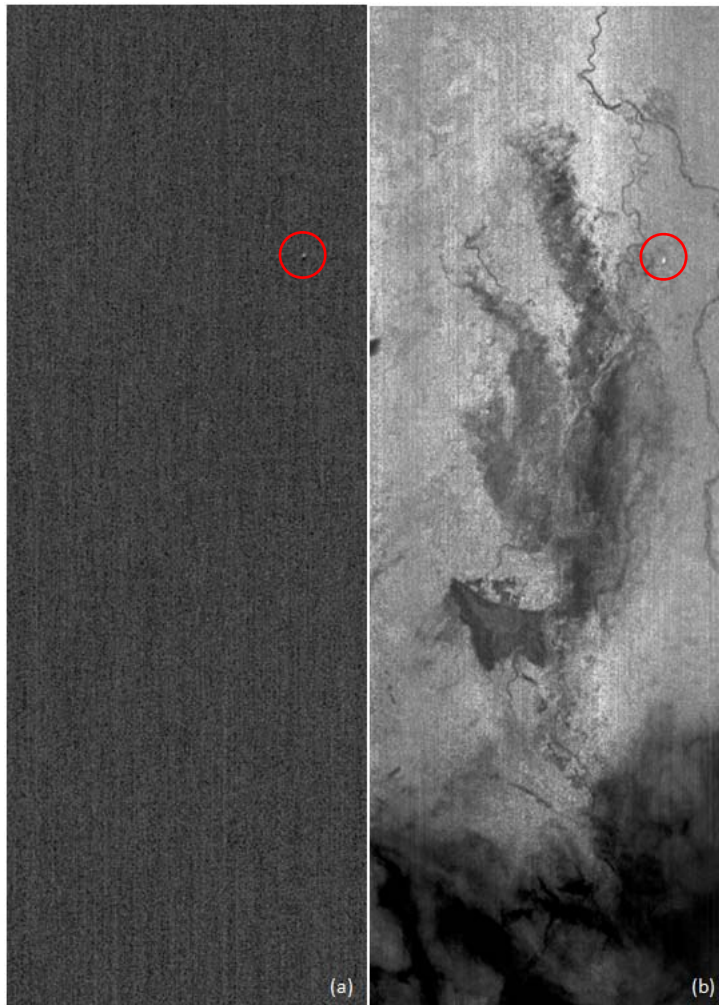


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First wildfire detection



Uncalibrated imagery collected in bands 1 (a) and 2 (b) by NIRST of a wooded area just south of Lake Chad in the Central African Republic (March 19th, 2012).

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Calibration

Pre-launch

- Universidad Nacional de la Plata, Argentina
- Blackbody in laboratory conditions
- Counts measured for each band to determine gain and offset values
- BB scenes incremented in 10 K intervals:
 - 390.15 – 600.15 K (MWIR)
 - 273.15 – 520.15 K (LWIR)
- *Time constraints allowed for this calibration to be performed under only a few ambient conditions*

Inflight

- In-orbit conditions were sufficiently different from the laboratory conditions to prevent direct use of the ground calibration
- Absolute calibration was accomplished using ground truthing targets and coincident overpasses of other sensors (MODIS and GOES-13)
 - Clearly successful with LWIR bands
 - Additional considerations wrt MWIR



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Deconvolution using Wiener filtering

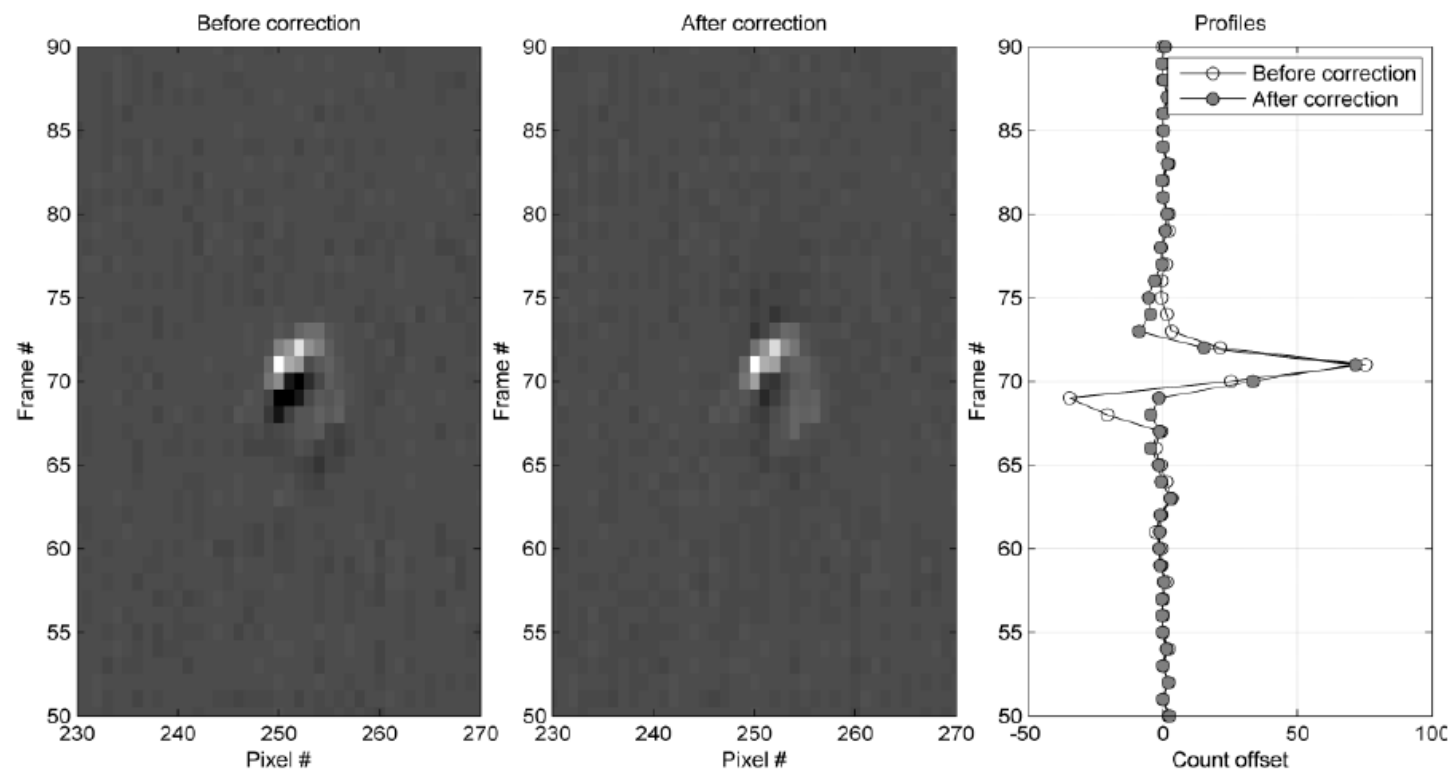


Figure 8 - *Left*: MWIR image section of a forest fire in Alberta, Canada. *Center*: Same image section after crosstalk correction. *Right*: Plots of center column of both images illustrating signal recovery from crosstalk correction.

~ 70% signal recovery

(Figure from: Phong et al. 2013)

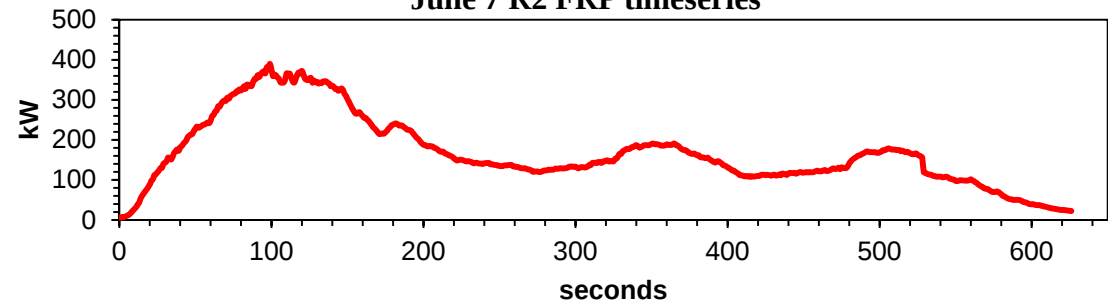
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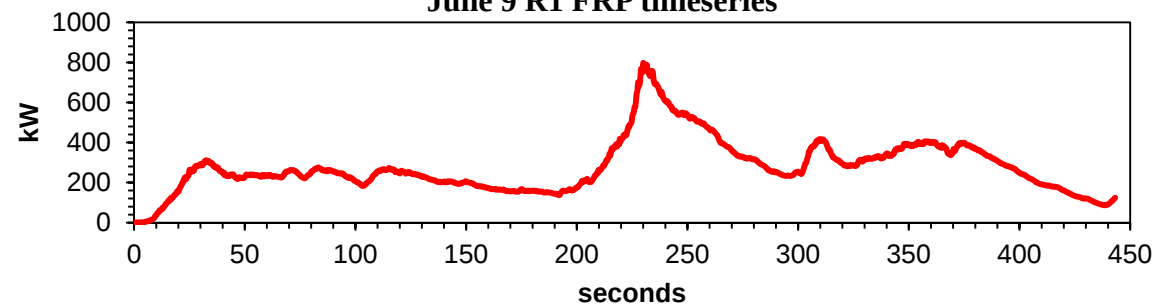
MWIR calibration concerns

- MWIR only detects signal from HTEs
- *Thermal output from many HTEs are temporally unstable*
- It is difficult to estimate the accuracy of the MWIR calibration

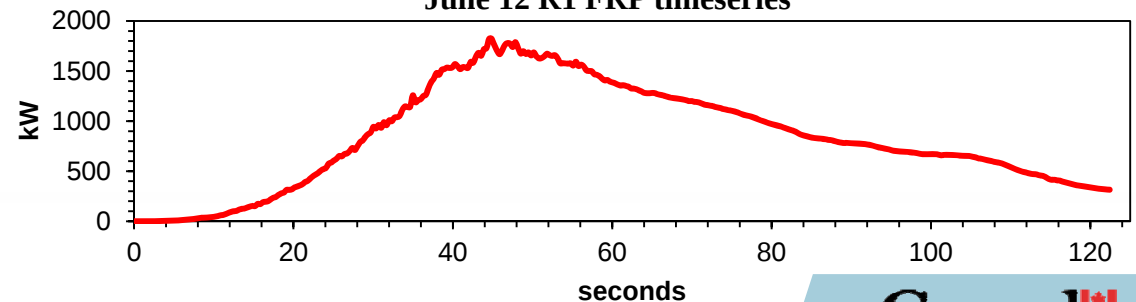
June 7 R2 FRP timeseries



June 9 R1 FRP timeseries



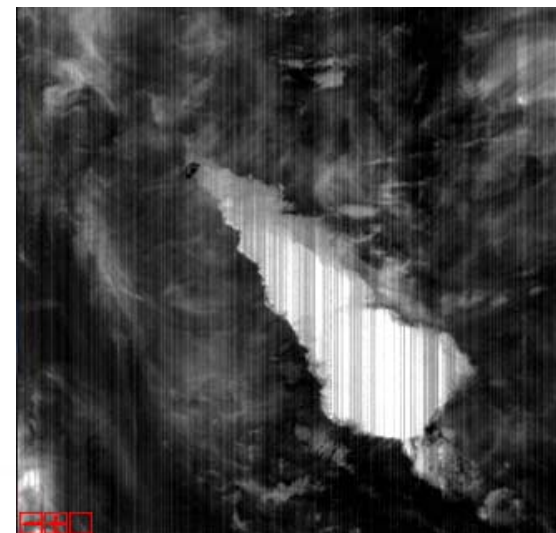
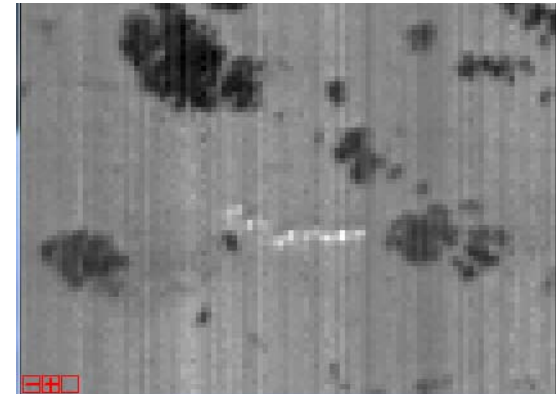
June 12 R1 FRP timeseries





NIRST Advantages

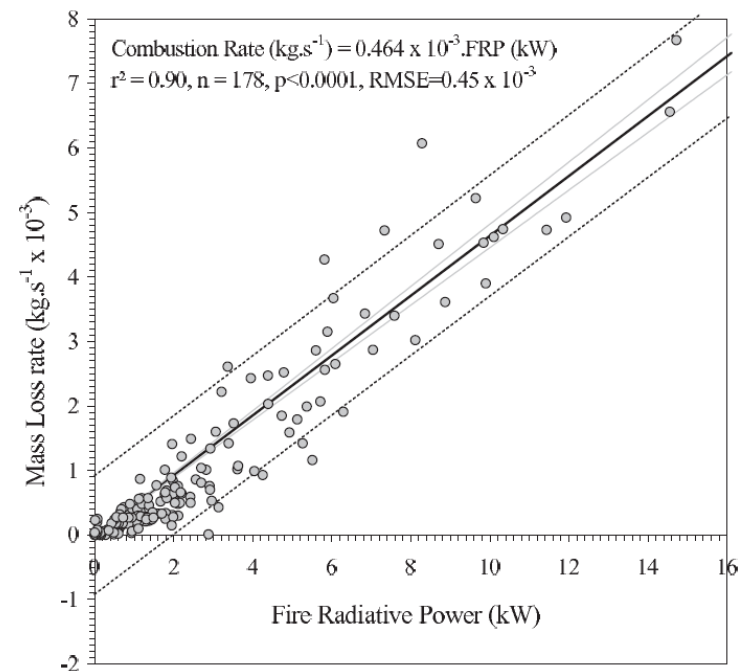
- **No need for cloud masking for fire detection**
 - MWIR appears to only respond to true HTEs (uncertain about sunglint)
- **Fire detection algorithm is very simple due to the nature of the MWIR**
- **350 m spatial resolution allows for excellent fire front definition**
- **Low cost, low energy, small payload**





NIRST Limitations

- **MWIR calibration accuracy is a concern**
 - Precise instantaneous MWIR fire radiances are necessary for measuring Fire Radiative Power (FRP)
- **Inability to measure background radiance in MWIR prevent the application of sub-pixel analysis**
 - Dozier Method requires HTE radiance and background radiance from both LWIR and MWIR bands



(Wooster *et al.* 2005)



Improvements for Fire Monitoring

Suggestions:

- **On board calibration capacity**
 - Ensures highest quality in FRP measurement
- **A second MWIR band which is calibrated for surface temperatures**
 - This, when combined with the current MWIR, will provide a complete MWIR scene for sub-pixel analysis
- **OR increase spatial resolution (i.e. ~500 m) to allow for surface and HTE observation in a single MWIR band**



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References

Marraco, H., & Phong, L. N. (2006). *NIRST, a satellite based IR instrument for fire and sea surface temperature measurement*. Paper presented at the Non-intrusive Inspection Technologies.

Phong, L. N., Pancrati, O., Marchese, L., & Châteauneuf, F. (2013). Spaceborne linear arrays of 512x3 microbolometers. *Proc. of SPIE*, 8614(86140N-1).

Wooster, M. J., Roberts, G., Perry, G. L. W., & Kaufman, Y. J. (2005). Retrieval of biomass combustion rates and totals from fire radiative power observations: FRP derivation and calibration relationships between biomass consumption and fire radiative energy release. *Journal of Geophysical Research*, 110. doi: 10.1029/2005JD006318



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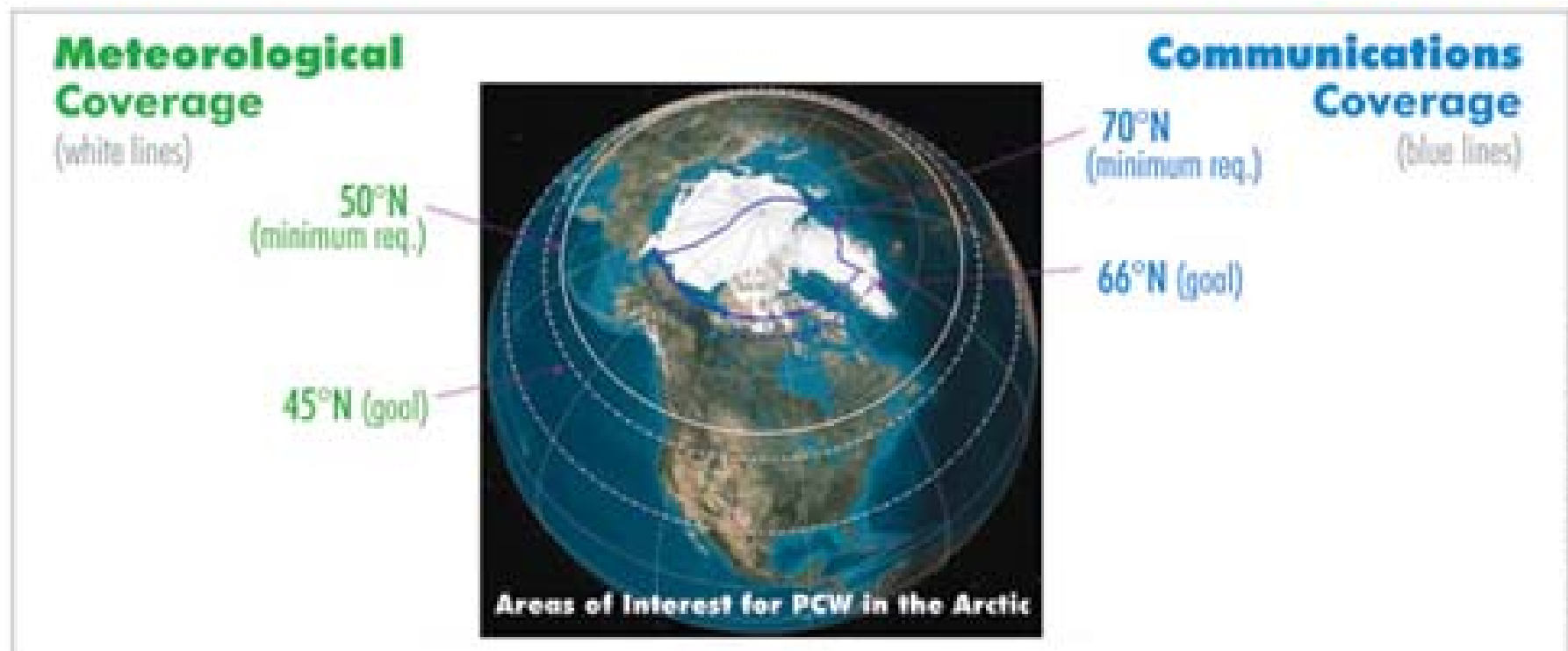
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Polar Communications and Weather (PCW) Mission Molniya Orbit





Proposed Satellite Mission Canadian Wildland Fire Monitoring System (CWFMS)



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Canadian Forest Service
Natural Resources Canada

User/Science Team
NRCan, EC, CSA



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CWFMS Mission Objectives

- To provide near real-time information in support of fire management.
- To provide emissions measurements in support of international requirements for carbon reporting and air quality forecasting.



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CWFMS Mission Rationale

To Provide:

- Improved accounting of increasing fire frequency and intensity.
- Assessment of socio-economic impacts.
- Aid for decision-making between aggressive fire suppression vs. monitoring.
- Current and accurate data to decide on active fire mgt. strategies.
- Improved burned area mapping to deliver better fire statistics and carbon emissions estimates.
- Inputs for better smoke transport and air quality estimates.
- Improved air quality advisories.



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Existing and Planned Space-Based Systems

- GOES, MSG, MTSAT – 4 km res. with good coverage between 40°N/S but res. deteriorates at northern latitudes. Resolution moving to 2 km.
- NASA MODIS (on Terra & Aqua) – 1 km res. Not an operational system despite operating since 1999 (Terra) and 2002 (Aqua). High & low gain MWIR bands avoids saturation with fires.
- NASA VIIRS – operational replacement for MODIS. 350 m res. in MWIR.
- ESA Sentinel-3 – 1 km res. and the F1 fire channel (500°K) will not saturate in the MWIR (3.74 μm); CSA is a partner.
- CONAE/CSA NIRST – experimental fire monitoring instrument on AQUARIUS/SAD-D; no onboard calibration; pointing failed; MWIR not optimized for fire detection but LWIR is very sensitive. Provides background for Canadian Wildland Fire Monitoring System (CWFMS) mission concept.
- TET-1 and BIROS – experimental satellites from DLR that use the basic principles learned from BIRD.
- PCW – CSA, 2 satellites in molniya orbit. 50°N to the N. pole at 2 km res. every 15 min. Includes MWIR & LWIR detectors. Uses ABI like GOES-R.



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Priority Applications and Services

- Assists Provinces, Territories & Parks Canada with fire mgt. by offering continuous monitoring of the whole of Canada, every day.
- Adds active fire detection and monitoring tool for remote regions of Canada that do not have organized detection.
- Covers the complete range of VIS-NIR-SWIR (150 m) and TIR (300 m) wavelengths.
- Supports the Fire Monitoring, Accounting and Reporting System (FireMARS) by supplying data for hotspots and VIS/SWIR for the National Burned Area Composite (NBAC).



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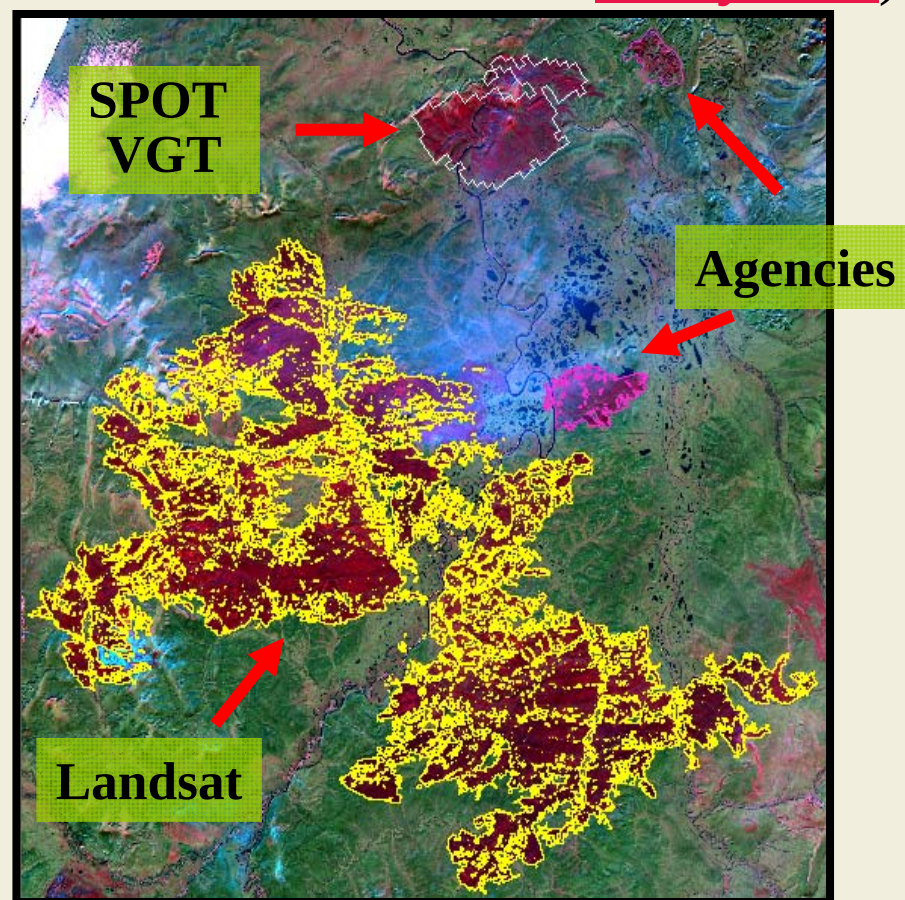
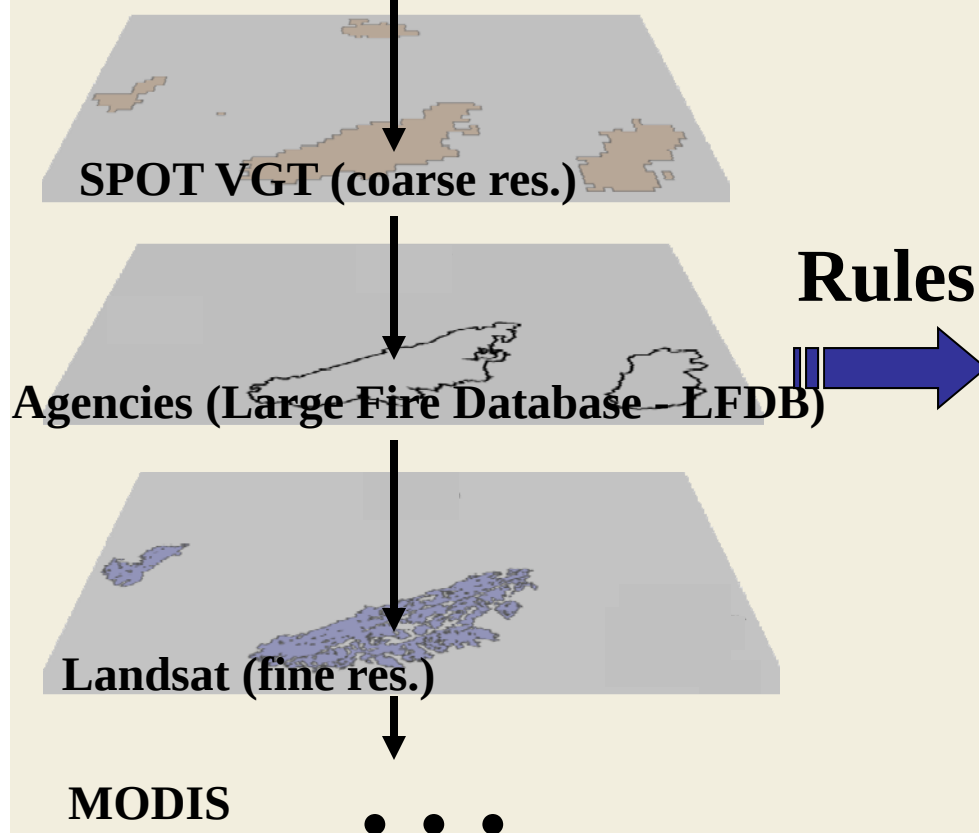
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National Burn Area Composite (NABC)

(Ensure the best available burn area products across-Canada at any time)

Access to burn area products from
multi-sources, **BUT at different times...**



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Priority Applications and Services (Cont'd)

- Enable the use of hotspots for Rate of Spread estimates, especially for emerging fuel types (MPB & SBW mortality, peatlands) and for Fire Intensity estimates.
- Support the Canadian Wildland Fire Information System - CWFIS that tracks fire danger, fire behaviour and hotspots.
- Measurement of FRP to estimate trace gas and particulate emissions.
- Provide model inputs for improved Air Quality (Env. Canada) and smoke transport models (BlueSky).



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CWFMS Coverage

- Coverage – Canadian territory (grasslands, forest and tundra zones).



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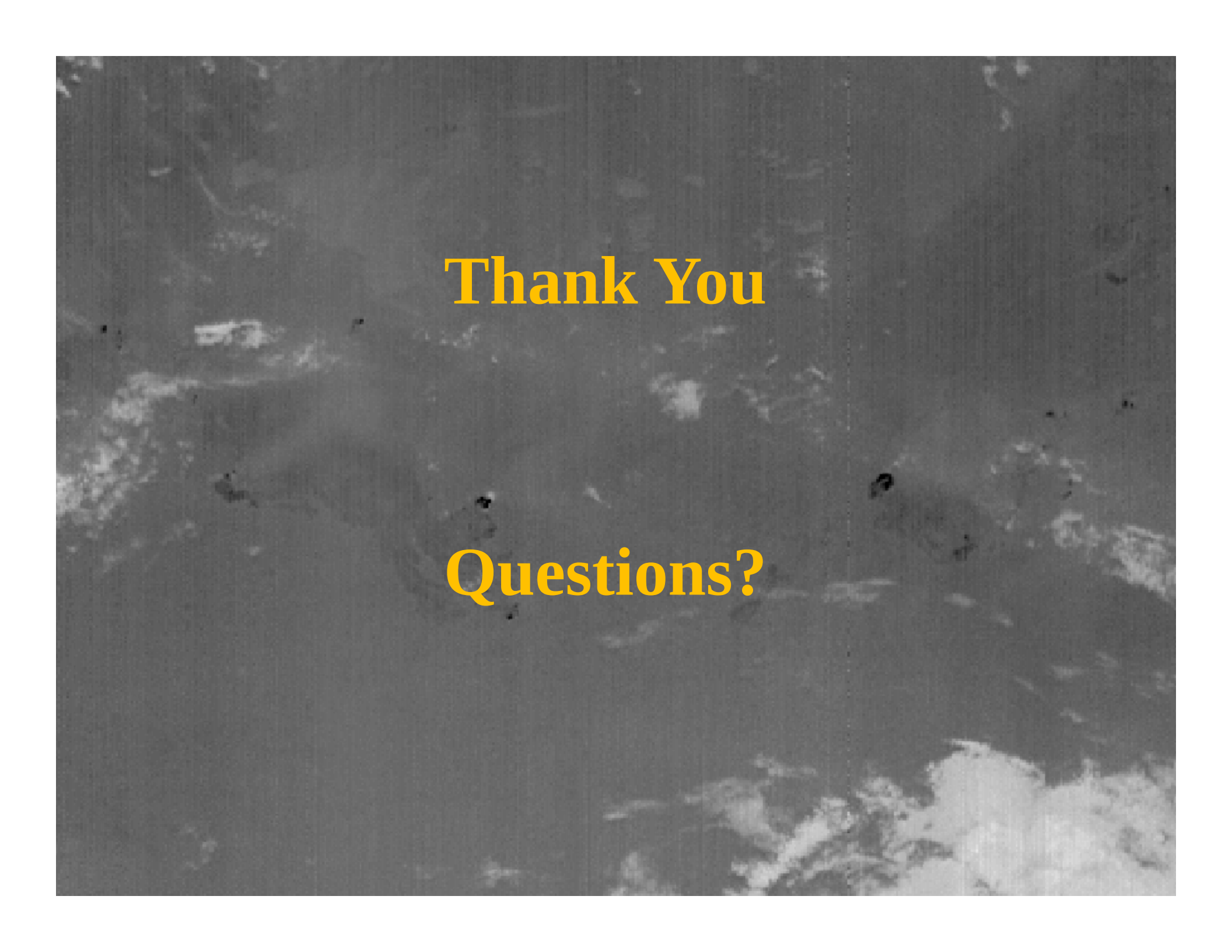
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Thank You

Questions?