DLR FireBIRD Mission - Technology Mission and Precursor Mission for Detection an Quantification of Wildfires

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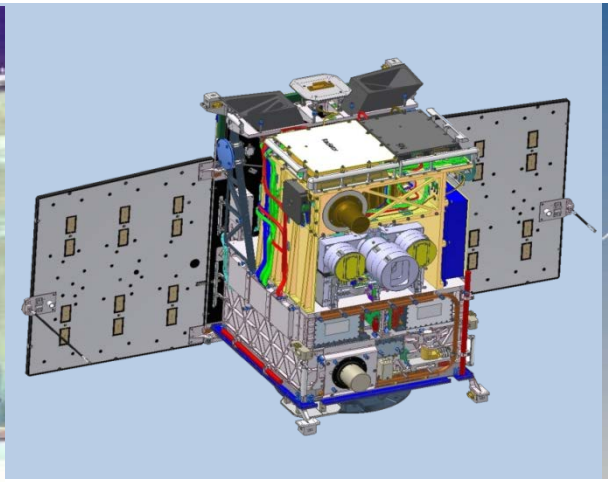
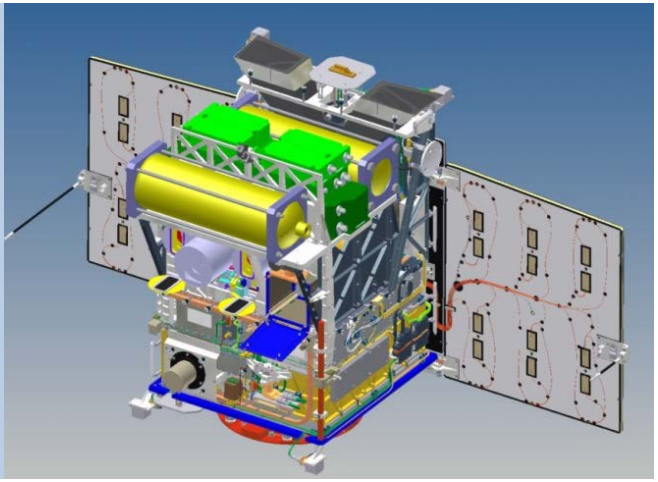
KAYSER-THREDE

FireBird Motivation and Heritage:
from BIRD via TET-1 to BIROS satellite





BIRD (2001-2004 [2014]) TET-1 (2012- ?) BIROS (2016- ?)

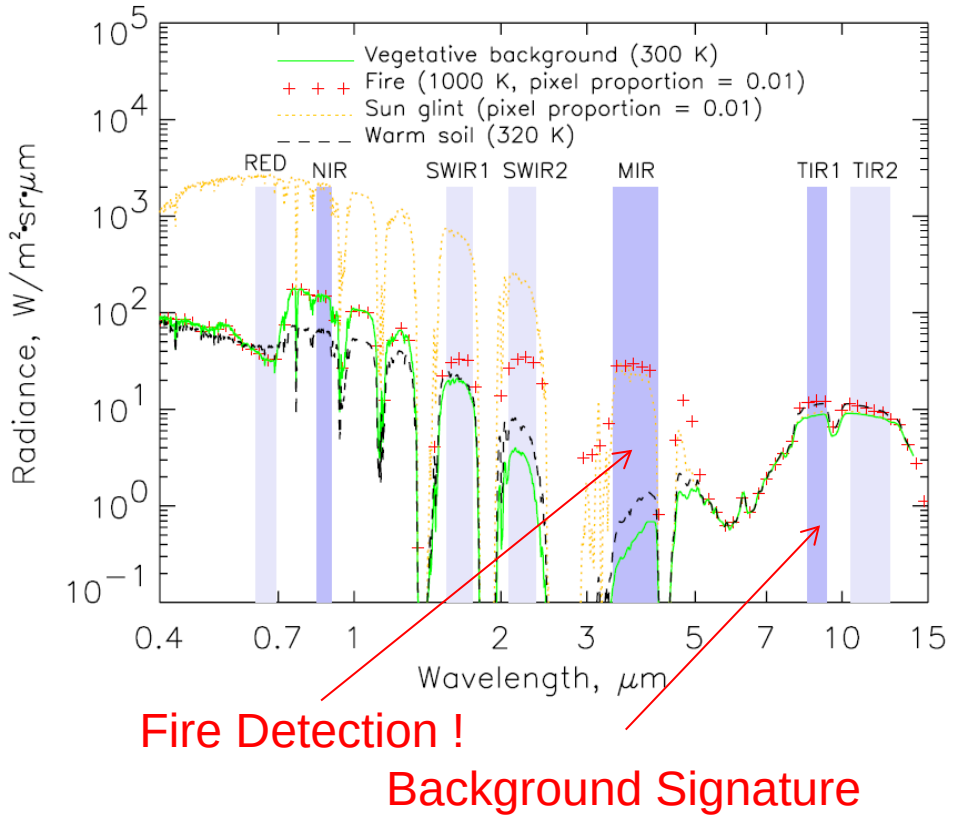
Design Philosophy: see

- „ **Cost Effective Earth Observation Missions"** (R. Sandau et al, 2006)
- "**Affordable-Space -Missions"**(L.Fröbel et al, DLR 2004)
- **"BIRDTECH"** (ESA Contract Ref No: 3471983 , 2005)

{…Uses similar: bus-concepts, teams, ground facilities, test strategies…}

DLR

Fire Detection and Estimation - Theoretical Background



Planck's law

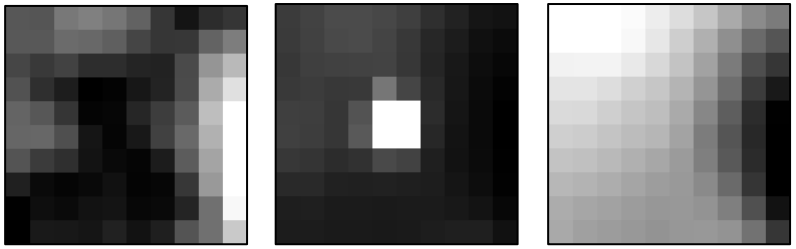
$$L_{BB}(\lambda,T) = \frac{2hc^2}{\lambda^5}\left(\frac{1}{e^{\frac{hc}{\lambda kT}}-1}\right)$$

Perfect Emitter:	L_{BB} [Wm^{-2}m^{-1}]
Planck's constant:	h [Js]
Boltzmann's constant:	k [Wm^{-2}K^{-4}]
Speed of the light in vacuum:	c [ms^{-1}]
Temperature	T [K]

Wien's displacement law

$$\lambda_{\max} = \frac{b}{T} \quad [\mu m]$$

Wien's displacement constant: $b \approx 2900$ μm K

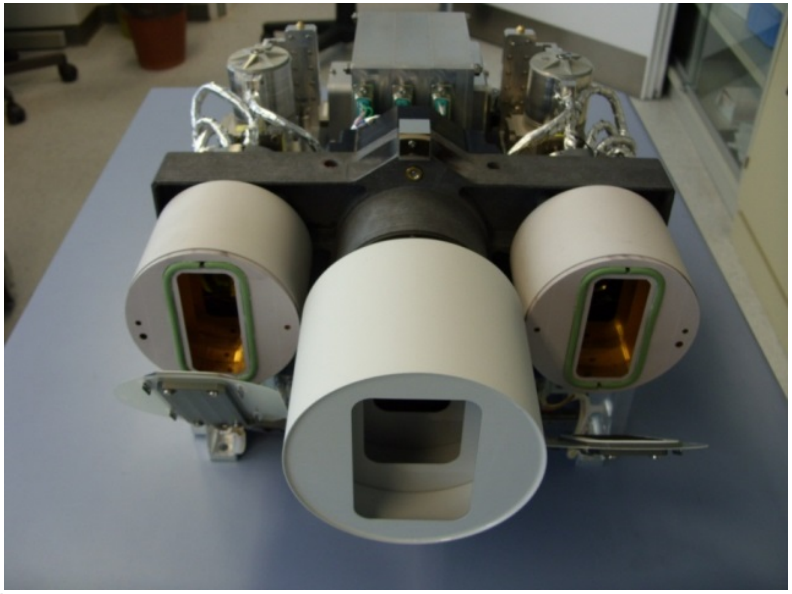


VIS Red 0.645 μm | MWIR 3.825 μm | LWIR 8.90 μm

Zhukov, B., Lorenz, E., Oertel, D., Wooster, M., Roberts, G.: Experience of detection and quantitative characterization of fires during the experimental small satellite mission BIRD. DLR-Forschungsbericht 2005-04 (2005).- p. 96.

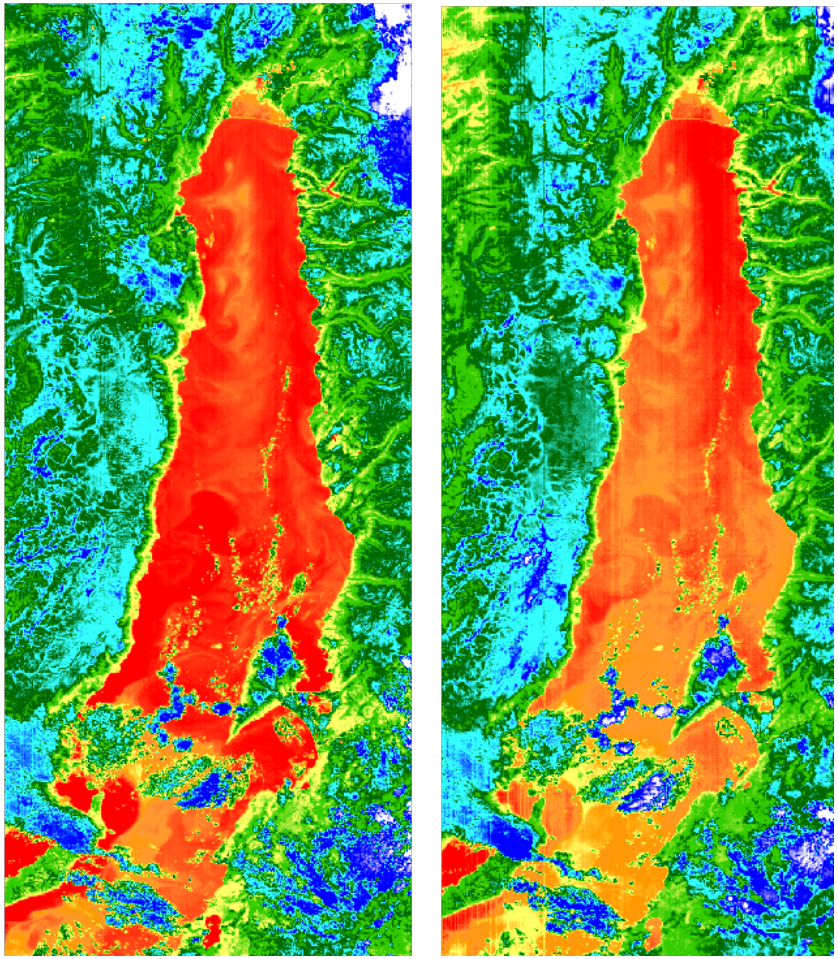
FireBIRD Multispectral Camera Payload

- IR-Camera:
  - Staggered lines
  - Black-Body for In-Flight Calibration
  - Dwell time 20 ms,
  - Integration time 4 ms and 2.7 ms for hot areas on demand
- VIS Camera synchronized with IR camera



	3 line-VIS Camera (3 line FPA, 6 ° separated)	2 Infrared-Cameras (staggered lines)
Wave length	1 460 - 560 nm 2 565 - 725 nm 3 790 - 930 nm	MWIR: 3,4 - 4,2 µm LWIR: 8,5-9,3 µm
Detector	CCD- Zeile	CdHgTe Arrays
Detector cooling	Passive, 20 ° C	Stirling, 80 - 100 K
Pixel size	7 µm x 7 µm	30 µm x 30 µm
Number of Pixel	3 x 5164 (1250)	2 x 512 staggered
Quantization	14 bit	14 bit
Ground resolution	42,4 m 2)	356 m 2)
Ground sampling distance	42,4 m 2)	178 m 2)
Swath width	211 km 2)	178 km 2)
Accuracy	100m on ground	100m on ground
Main FireBird camera parameters 2) Altitude 510km		

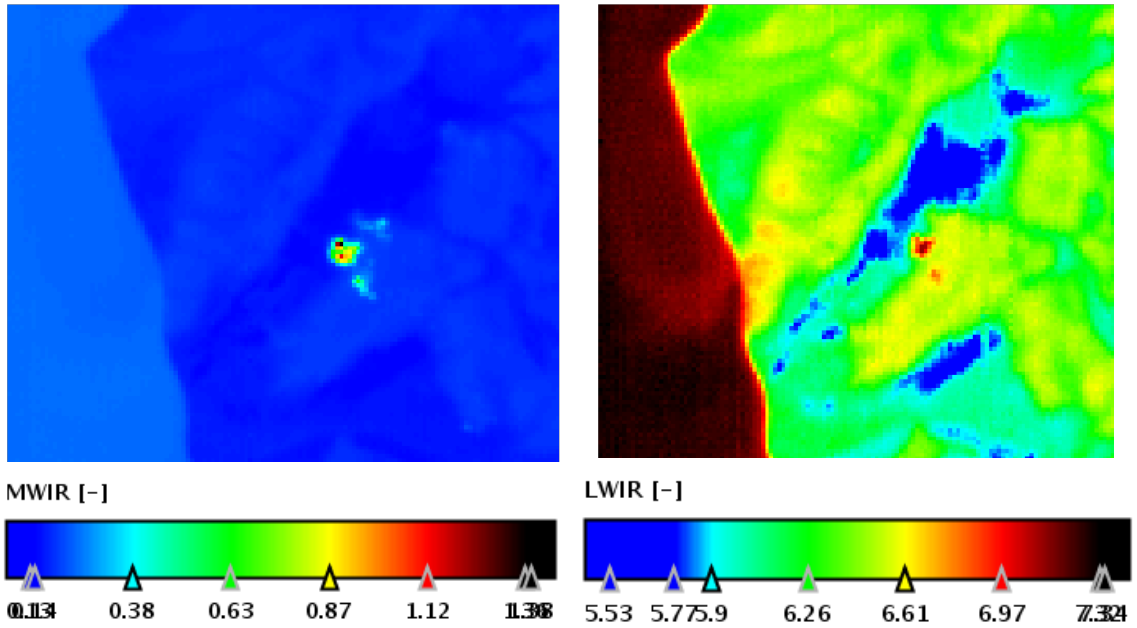
Fire Detection & Lake Surface Temperature



Lake Baikal 13.09.2017 13:00 UTC

- Atmospheric temperature from night scene
  - MWIR 3.85 µm (left)
  - LWIR 8.9µm (right)
- fixed atmospheric correction has errors of ≈ 3K
- Improvement possible by use of Optimal Estimation Algorithm in combination with meteorological data is needed

Forest Fire – a small example



Fire parameter

Cluster Size	FRP (MW)	*T_min (K)*	T (K)	*T_max (K)*	*A_min (m^2)*	A (m^2)	*A_max (m^2)*
40	**33**	*460*	502	*586*	*3098*	9190	*18230*
8	**3**	*500*	531	*577*	*340*	603	*936*

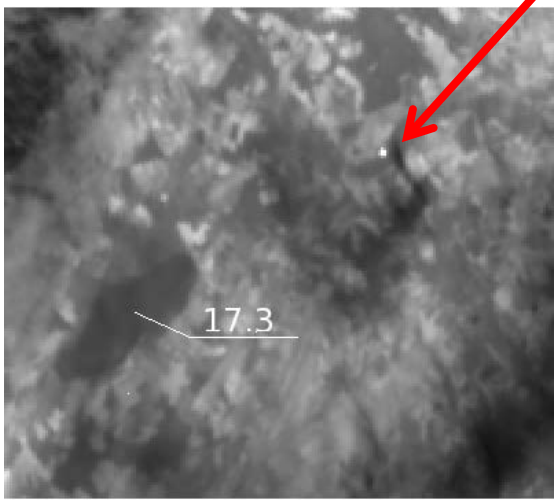
Fire detection algorithm

(B. Zhukov)

1. Detection of Anomalies
2. Screening of background
   - Clouds
   - Sun Glint
   - Warm surfaces
3. Determination of background temperature
4. Hot pixel detection
5. Cluster consolidation
6. Parameter estimation
   - Coordinates
   - Temperature
   - Effective Fire Area
   - Fire Release Power

Validation of fire parameter estimation

- Error in FRP within 35 % relative to ground data
- T_F and A_F within estimated margins
- Inhomogeneus background accounts for largest error
- Lake temperature
  - estimated: 17.3 °C
  - measured: 21.4 °C

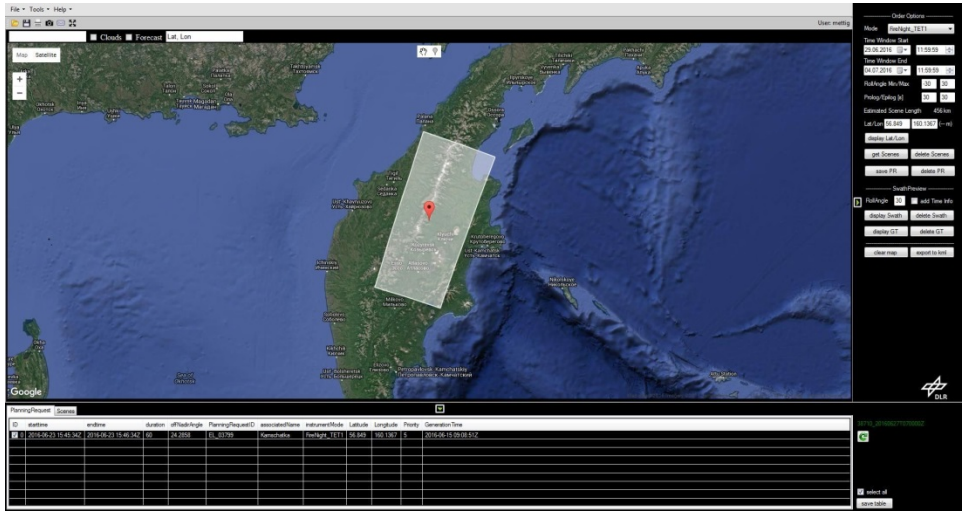


	Savannah Shabeni			Savannah Skukuza 6 Plot			Experimental Fire DEMMIN / Germany		
	TET-1	Helicopter	Ratio	TET-1	Helicopter	Ratio	TET-1	Ground	Ratio
T_{min}/ K	661	550		559	550		490		
T_{mean}/ K	685	668	1,02	580	595	0,97	727	940	0,77
T_{max}/ K	713	907		606	803		1500	1150	
AF_{min} / ha	0,15			0,36			0,001		
AF / ha	0,19	0,24	0,80	0,47	0,60	0,79	0,0141	0,0143	0,99
AF_{max} / ha	0,23			0,60			0,173		
FRP / MW	23,6	35,1	0,67	30,3	25,5	1,19	2,24	1,36	1,65
FRP / kW / m²	12,48	14,80		6,43	4,27		15,85	9,51	

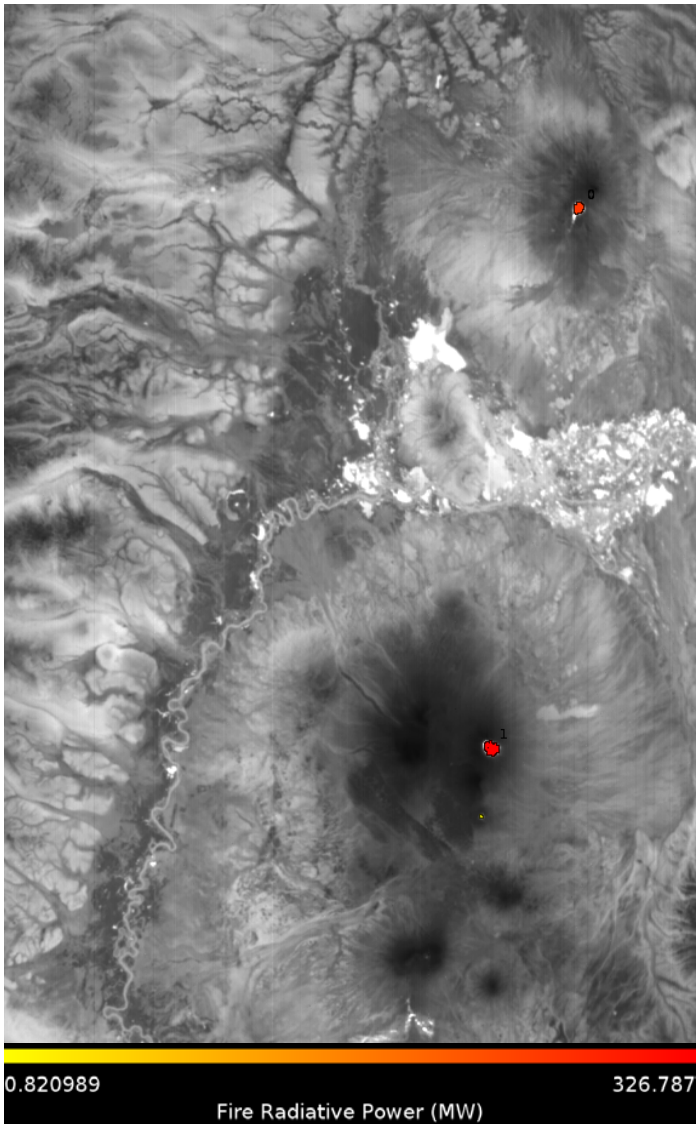
T - Effective fire temperature; AF - Effective Fire Area; FRP – Fire Radiative Power (Helicopter based data still pre-liminary. Source: Paugam, R., Wooster, M., KCL)

Volcanoes

Kamchatka 23.06.2016

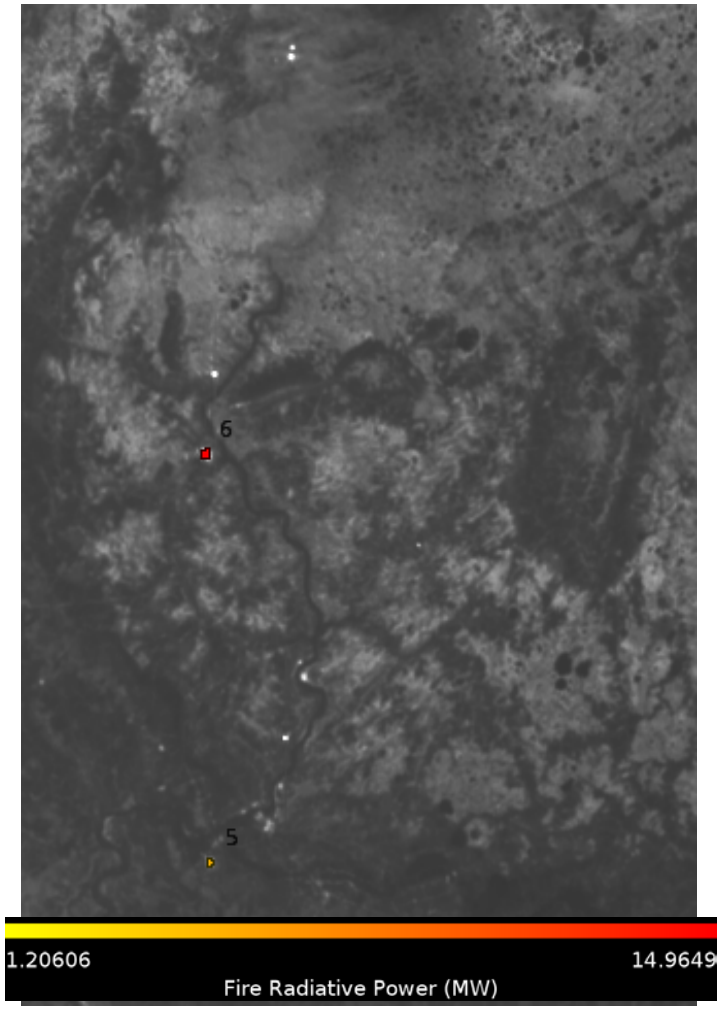


Cluster Size	FRP (MW)	*T_min (K)*	T (K)	*T_max (K)*	*A_min (m^2)*	A (m^2)	*A_max (m^2)*
46	**83**	*474*	486	*500*	*39820*	49660	*60363*
85	**84**	*755*	766	*778*	*15467*	16710	*17995*



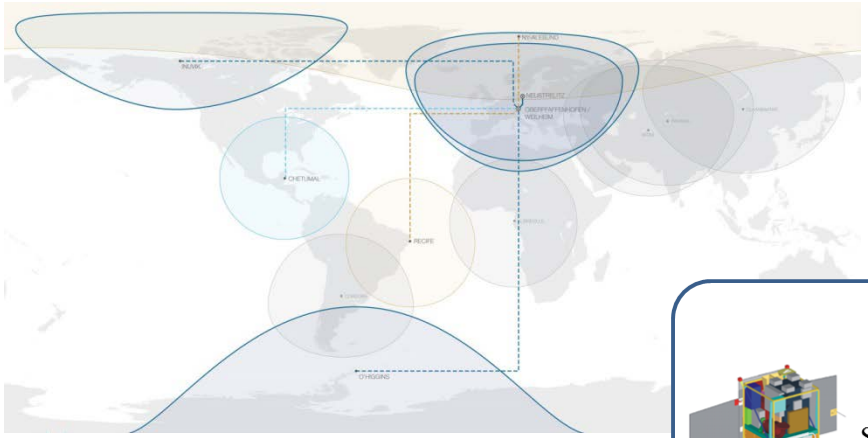
Gas Flaring Estimation

- So far based on visible light
- No quantities in terms of power and therefore CO_2
- Results show that fire algorithm (with lowered thresholds) provides quantities
- Possibly longer integration time needed

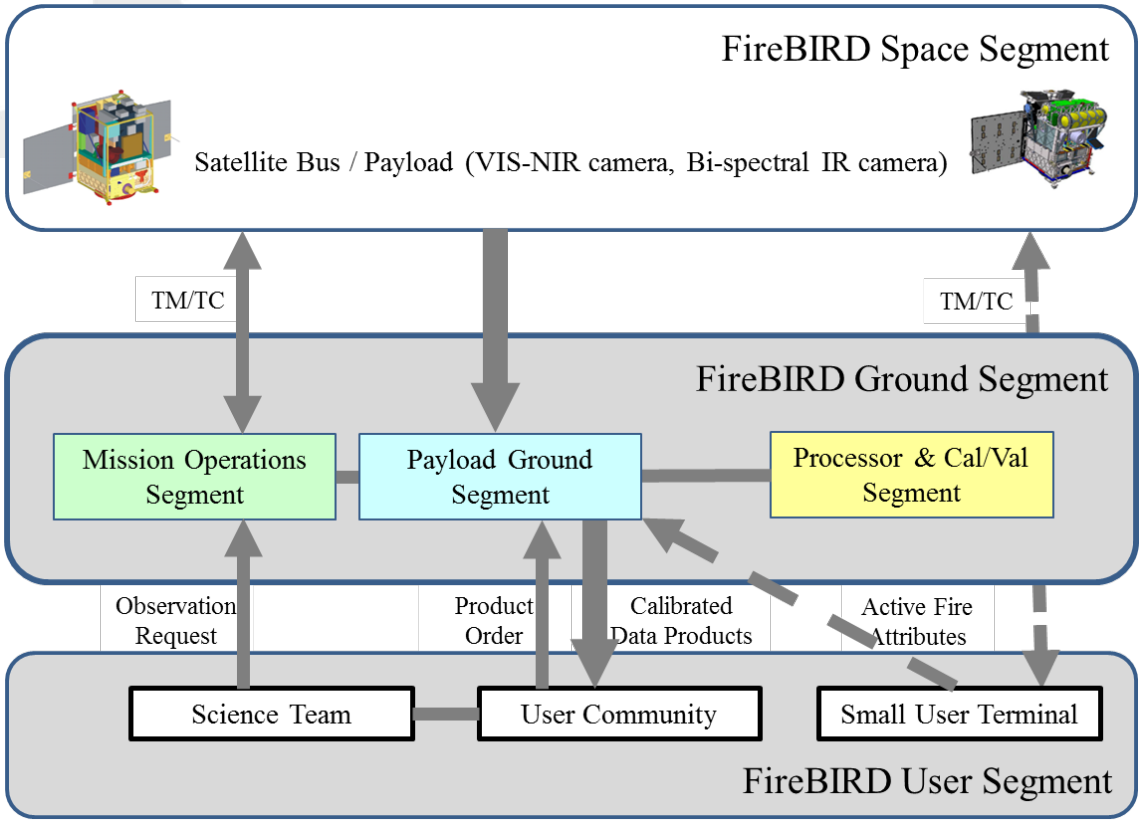


- Energy released by gas flare in Novy Urengoy in a night time image of the MWIR band on 23. July 2016
- Up to 15 MW

Up- and Downlink and Data Processing



- Data reception at DLR Ground Station Network and collection in Neustrelitz
- Operational Near-Real Time Processing (25 min) to L1B and L2 Fire Products
- Delivery via FTP



Data Archiving and Distribution

Ordering

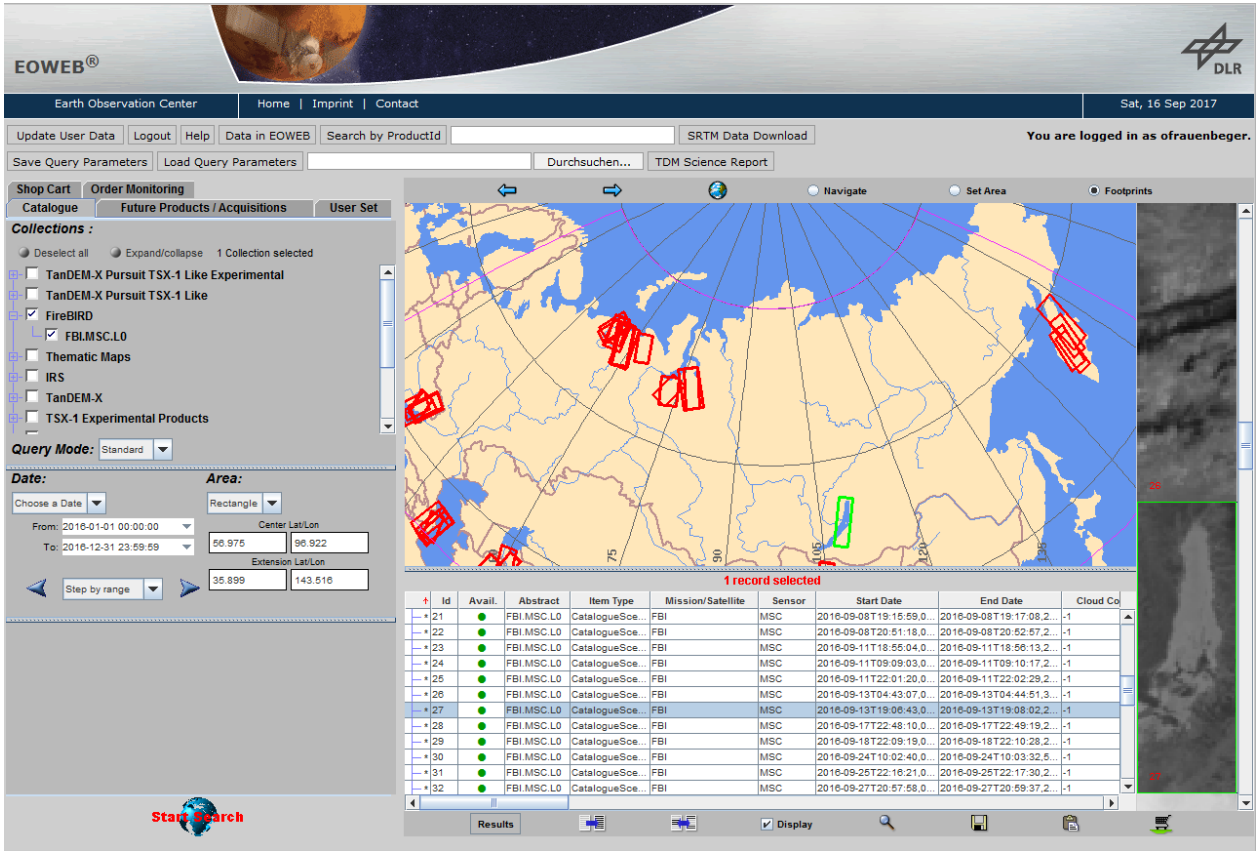
- Products are free available
- Registering as science user

Product Content

- Geoannotated Spectral Radiances L1b
- Coregistered Spectral Radiances L2a
- Thematic Fire Products

Product formats

- HDF5
- ENVI + ASCII



Special Products for Crisis Information (DLR-ZKI)

www.eoweb.de: Product search Russia summer 2016

Conclusions

- Fire detection is successful
- Valuable for fire monitoring in remote areas, e. g. Russia
- Coverage is limited to 7 Scenes per day due to downlink capacity
- Future: On-board data processing is needed for
  - fast alerts
  - data reduction, e. g. cloud screening
- More users are welcome!

Spacibo