DLR Micro-Satellite BIRD Mission - Hot Spot Detection Results
Rationale

- Every year burn
  - Ca. $10^9$ ha savannah area
  - Ca. $10^7$ ha tropical rain forest
  - Ca. $10^6$ ha Mediterranean vegetation
  - Ca. $10^8$ ha boreal forests

- The impacts on
  - atmosphere (green house effect, ozone, aerosol, relation CO/CO$_2$),
  - climate
  - global carbon cycle
    are poorly investigated

- Up to now - there exists no system in orbit dedicated to fire observation
Mission Objectives
(BIRD = Bi-spectral Infra-Red Detection)

- Test of a new generation of infrared sensors dedicated for fire investigation from space
- Remote sensing of fires and of the land surface
- Space demonstration of new micro-satellite technologies
The BIRD Payload

<table>
<thead>
<tr>
<th>WAOSS-B</th>
<th>MWIR</th>
<th>TIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength</td>
<td>600-670nm</td>
<td>3.4-4.2μm</td>
</tr>
<tr>
<td></td>
<td>840-900nm</td>
<td></td>
</tr>
<tr>
<td>Focal length</td>
<td>21.65mm</td>
<td>46.39mm</td>
</tr>
<tr>
<td>Detector</td>
<td>CCD</td>
<td>CdHgTe</td>
</tr>
<tr>
<td>Ground pixel size</td>
<td>185m</td>
<td>370m</td>
</tr>
<tr>
<td>Ground sampling distance</td>
<td>185m</td>
<td>185m</td>
</tr>
<tr>
<td>Swath width</td>
<td>533km</td>
<td>190km</td>
</tr>
</tbody>
</table>

1 at 572km Orbit altitude

Payload platform of the flight model with assembling tools
Total mass: 30.2 kg
The BIRD Scientific Instruments

The 2-channel-Infra-Red Sensor System (15kg, 90W)
2x 512pixel HgHgTe detectors
Ground sampling Distance (GSD): 185m

The CCD-matrix camera
HORUS

The 3-line-CCD-stereo camera
WAOSS-B (10kg, 18W)
3 lines x 2480 pixels, GSD: 185m
BIRD Launch: 22 October 2001 (piggy back)

Launcher: PSLV-C3 (India)
Launcher payloads: TES (ISRO), PROBA (ESA), BIRD (DLR)
BIRD Orbit: 568km circ., i = 97.8 (sun-synchronous)
First Image: 05/11/2001, 9:42 UTC
Investigation of Pixel Co-registration

WAOSS- nadir channel (840-900nm)

Mid-wave Infra-Red channel (3.4-4.2µm)
(semi-transparency overlay)
BIRD-Highlight:
Hot-Spot-Detection Within the Sub-Pixel Range

(Dozier, 1981: Bi-spectral Technique for retrieving temperature and area of sub-pixel hot spots)

\[ q \] - relative area of the hot spot
\[ T_F \] - absolute temperature of the hot spot
\[ 1-q \] - relative area of the background
\[ T_{bg} \] - absolute temperature of the background

\[ L_{MIR} (T_F, q) = q B_{MIR} (T_F) + (1-q) L_{MIR-bg} \]
\[ L_{TIR} (T_F, q) = q B_{TIR} (T_F) + (1-q) L_{TIR-bg} \]

\[ B_{MIR/TIR} \] - integral Planck-Function within each channel
\[ L_{MIR/TIR-bg} \] - estimated radiance of background from the surroundings
Quantitative Fire Evaluation from Space

BIRD data allow to retrieve characteristics of Australian bush fires

10:08 local time
BIRD-image, MIR-channel
Fire colour coded

5. Jan. 2002
10:08 local time
BIRD-image, MIR-channel
Fire colour coded
Simultaneous Fire detection by MODIS and BIRD (Australia, January 5, 2002)
**Typical characteristics of fire fronts (BIRD, Australia, January 5, 2002)**

<table>
<thead>
<tr>
<th>No</th>
<th>Eff. fire temp., K</th>
<th>Eff. fire area, Ha</th>
<th>Front length, km</th>
<th>Energy release, MW</th>
<th>Front strength, kW/m</th>
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<tbody>
<tr>
<td>1</td>
<td>815</td>
<td>0.48</td>
<td>4</td>
<td>130</td>
<td>30</td>
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<td>2</td>
<td>715</td>
<td>2.3</td>
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<td>3</td>
<td>893</td>
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<td>3</td>
<td>210</td>
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<tr>
<td>4</td>
<td>&gt;670</td>
<td>&lt;0.78</td>
<td>5</td>
<td>79</td>
<td>15</td>
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<tr>
<td>5</td>
<td>852</td>
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<td>300</td>
<td>30</td>
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<tr>
<td>6</td>
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<td>1.0</td>
<td>9</td>
<td>530</td>
<td>60</td>
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<tr>
<td>7</td>
<td>&gt;690</td>
<td>&lt;0.51</td>
<td>4</td>
<td>62</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>796</td>
<td>0.39</td>
<td>3</td>
<td>96</td>
<td>30</td>
</tr>
</tbody>
</table>
BIRD Detects Hot Spots in and around Munich (29 January 2002)

Infrared Image of region Munich at 29 January 2002, local time: 10:10

Hot spot Nr. 1 – In-situ verification: at this time at this place wooden waste has burned for several hours (4m diameter, hot temperature) by Farmer J. Kranz (written in his working diary)
BIRD Detects Coal Seam Fires in Ningxia Area, China (6 February 2002)

(BIRD is the first space borne system providing data for daytime coal seam fire energy and emission analysis)
BIRD Detects Easter Fires in the Steiermark -Kaernten, Austria, 30 March 2002

MIR

Energy release
Etna Summit Hot Event Characteristics Recognised by BIRD (3.8 µm channel shown)

18 July 2002
T > 595 K
A < 0.45 ha
E = 12 MW

19 July 2002
T > 406 K
A < 1.4 ha
E = 8.5 MW

20 July 2002
BIRD Recognised Fires in Tannu Mountains, Russia, 24 July 2002)

MIR-channel at 3.8 µm

Radiative energy release retrieval
BIRD Observed Gas Prospecting Area of Urengoy, Russia, 27 July 2002

MIR channel

Radiative energy release
BIRD Detects Industrial Hotspots in the Rhein-Ruhr area, Germany, 1 August 2002

MIR channel

Radiative energy release

Thyssen AG

Mannesmann AG
Bush fires in the area of Sydney (BIRD, 20 October 2002)

MIR channel with detected hotspots (coded with radiative energy release)
Etna eruption (BIRD, 2 November 2002)

Red: MIR, Green: TIR, Blue: NIR

Effective lava temperature
Etna eruption (BIRD, 3 November 2002)

Red: MIR, Green: TIR, Blue: NIR

Effective lava temperature
BIRD images of bush fires in Australia

8 November 2002

9 November 2002
BIRD images of bush fires in Australia

8 November 2002

9 November 2002