



# New Space Missions for Understanding Climate Change

- from data to decisions -

J.-D. Wörner

German Aerospace Center, DLR



## Summer School Alpbach 2010

### "New Space Missions for Understanding Climate Change"

July 27 - August 5, Alpbach/Tyrol - Austria





## Global challenges

- mobility
- communication
- energy
- **climatic change**
- shortage of resources
- demographic development
- conflicts
- health
- ....



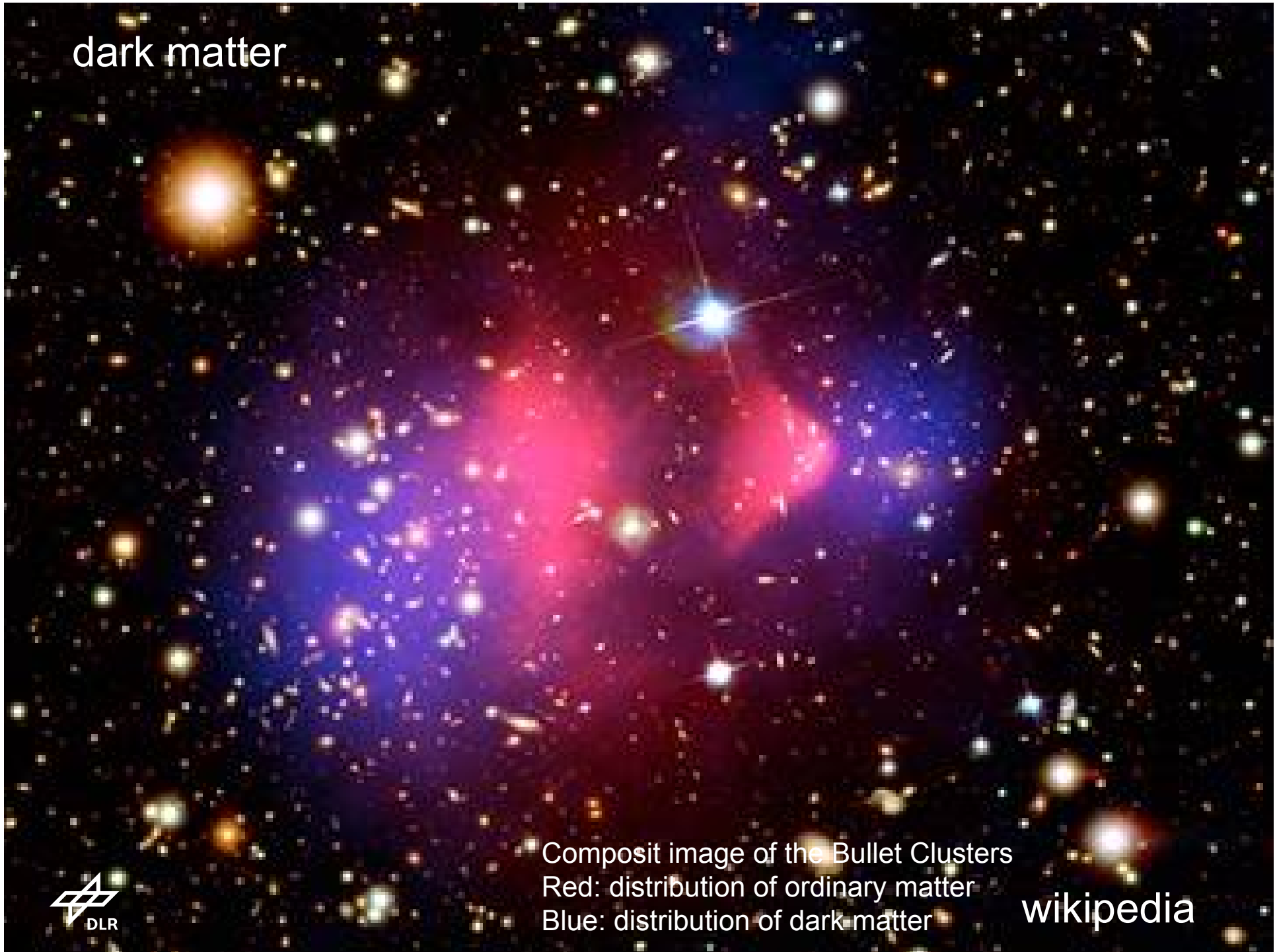


# global air traffic



earthly problem:  
transportation

dark matter

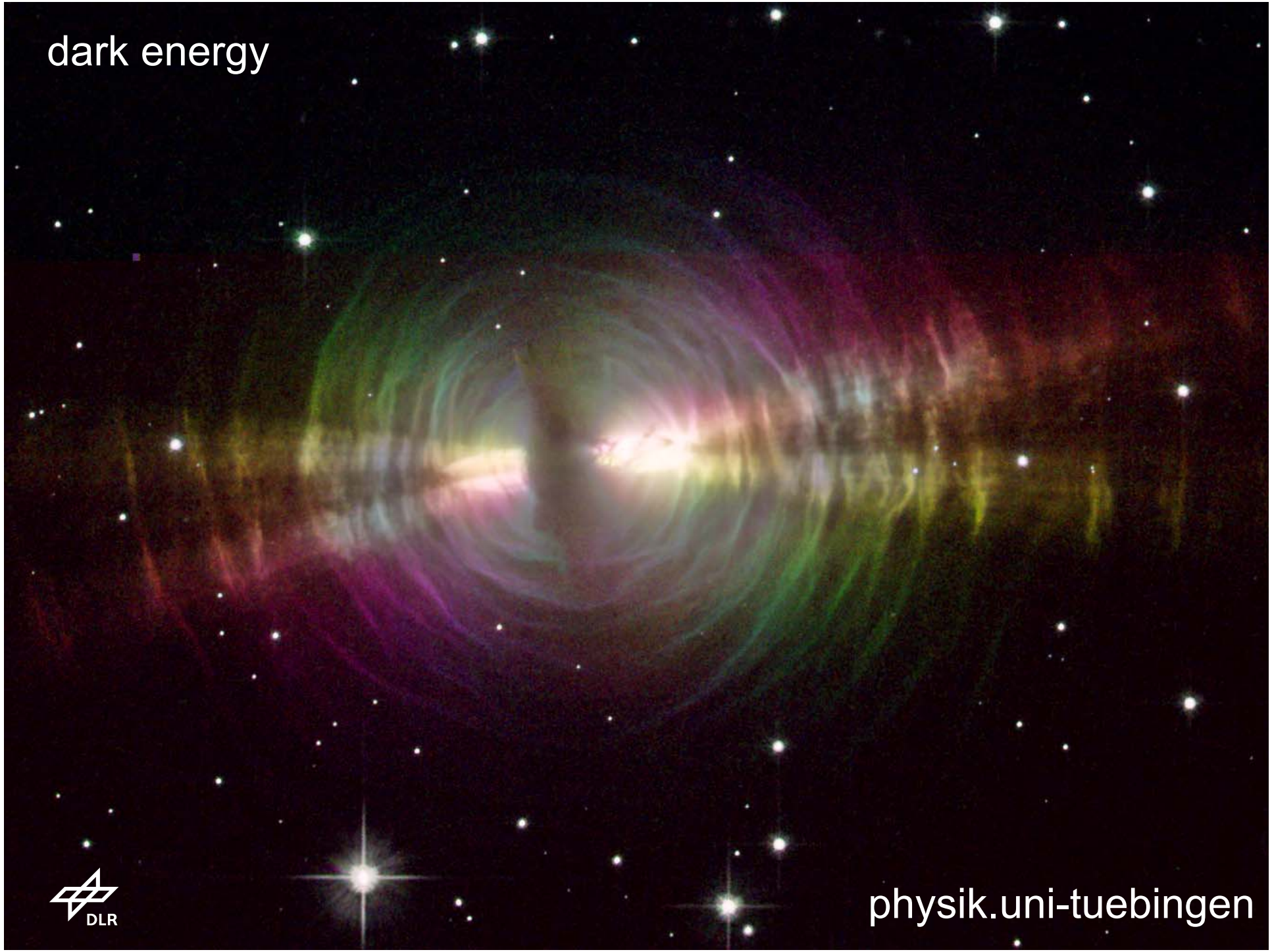


Composit image of the Bullet Clusters  
Red: distribution of ordinary matter  
Blue: distribution of dark matter

wikipedia



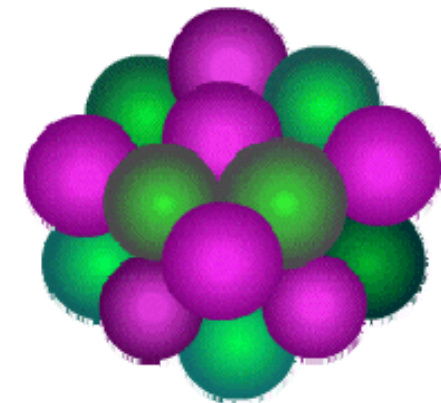
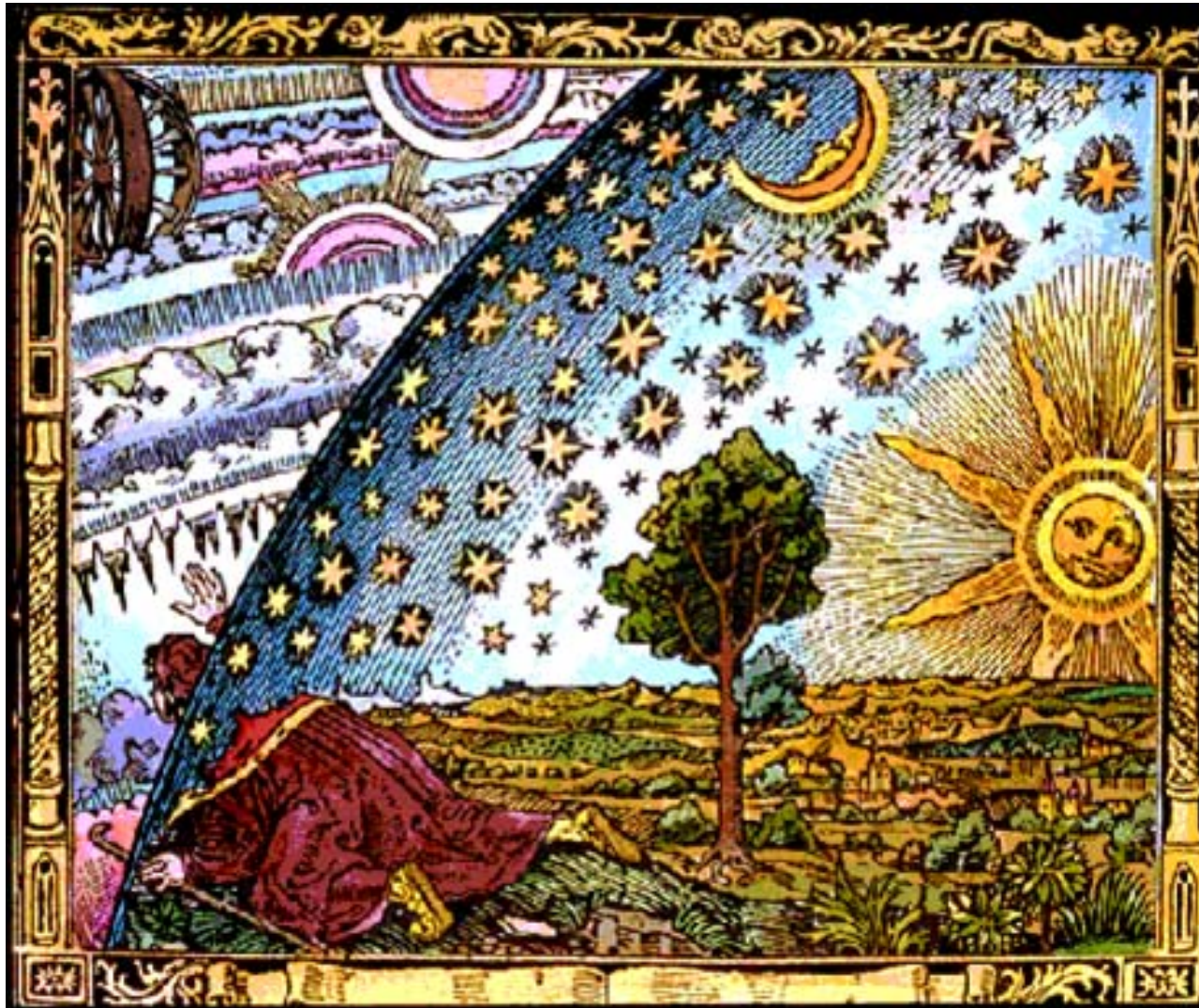
dark energy



physik.uni-tuebingen



# ...curiosity of mankind



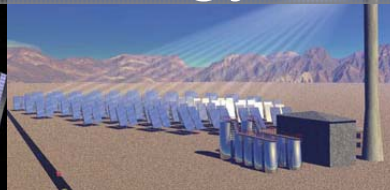
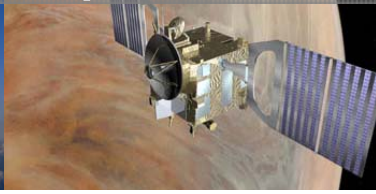
Aeronautics

Space

Energy

Transport

Security

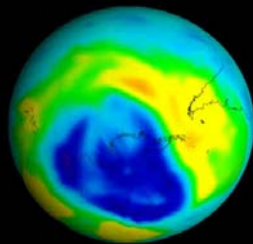


**Research Center  
&  
German Space Agency  
&  
Project Management Office**



# SPACE ACTIVITIES

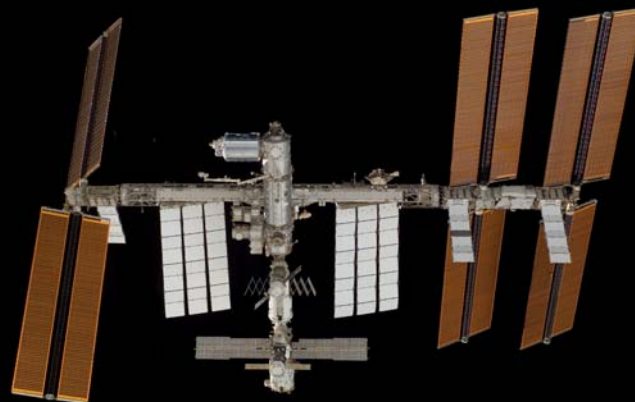
earth observation



Aug. 01, 2007

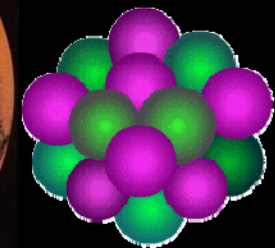


technology,  
communication,  
navigation,  
 $\mu$ g-research,  
international forum

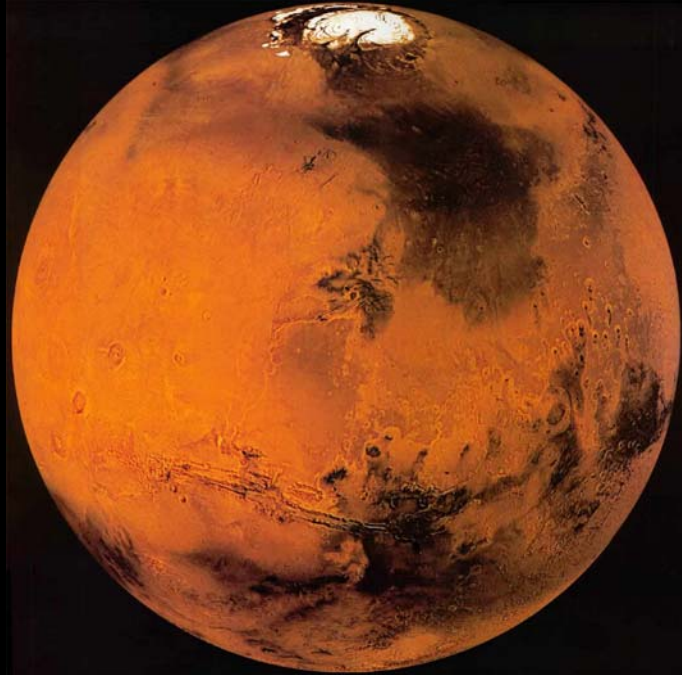


public outreach

exploration,  
science



# MARS



# VENUS

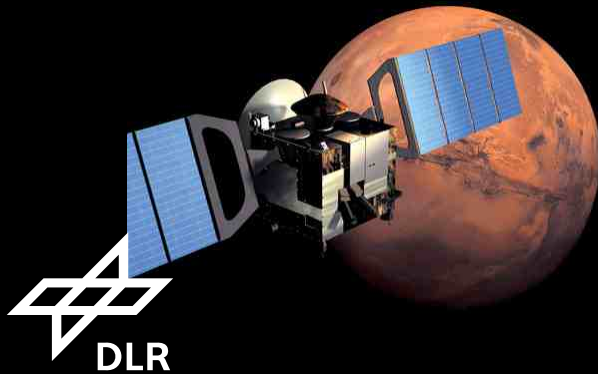


 **esa** mars express

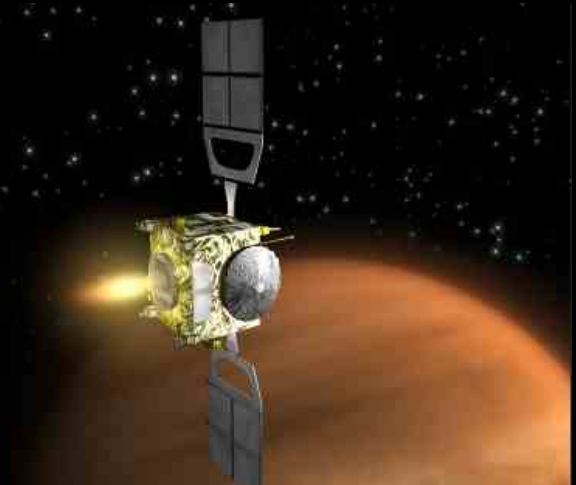
European Space Agency

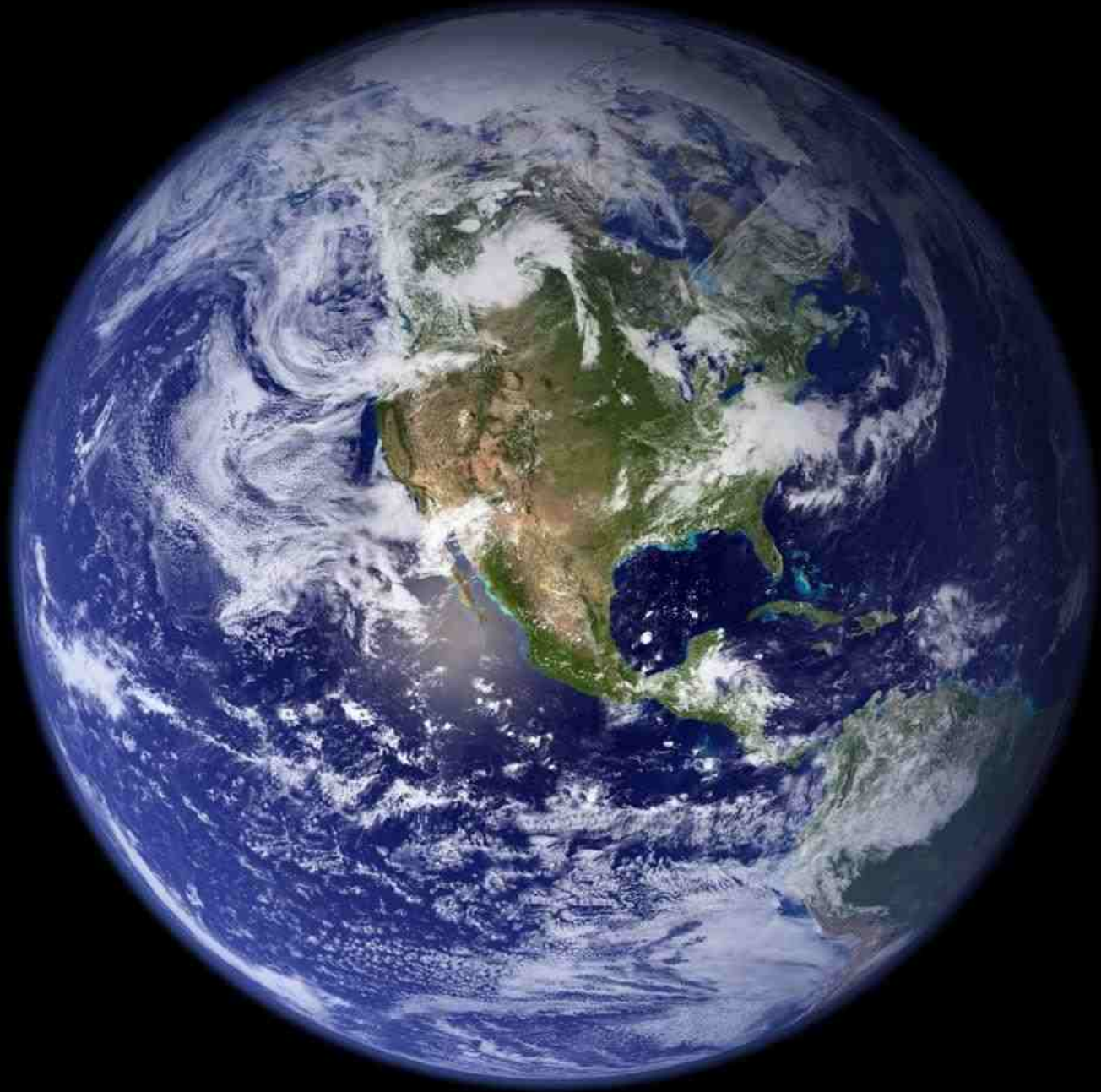
 **esa** venus express

European Space Agency



DLR







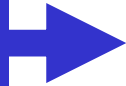
*scientific*

*societal*

*political*

*commercial*

**demands**



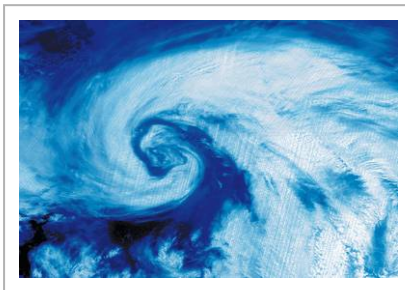
## Earth Observation

- German national space program
  - TanDEM-X, TerraSAR-X
  - EnMAP
  - ...
  
- European programs
  - ESA Earth Observation Programme
  - GMES (ESA & EC)
  - EUMETSAT programs EPS, MSG, MTG
  - ...

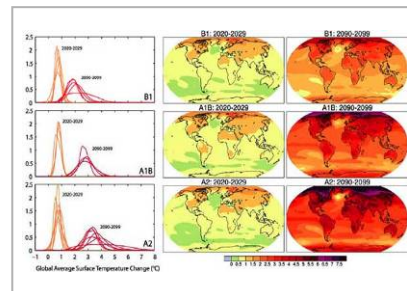




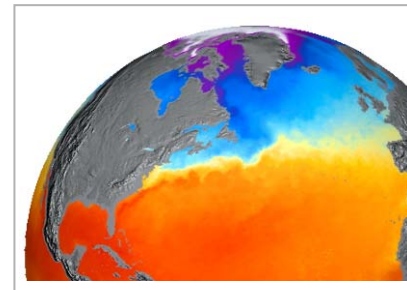
# Earth Observation



Meteorology



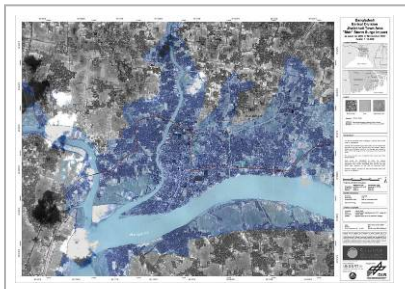
Climate change research



Earth system and environmental sciences



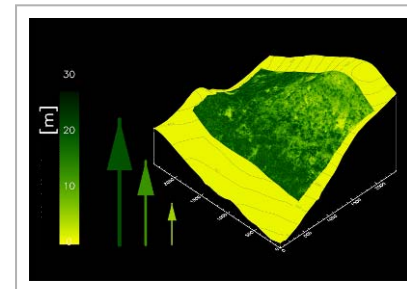
Sustainable development



Safety and security



Disaster management



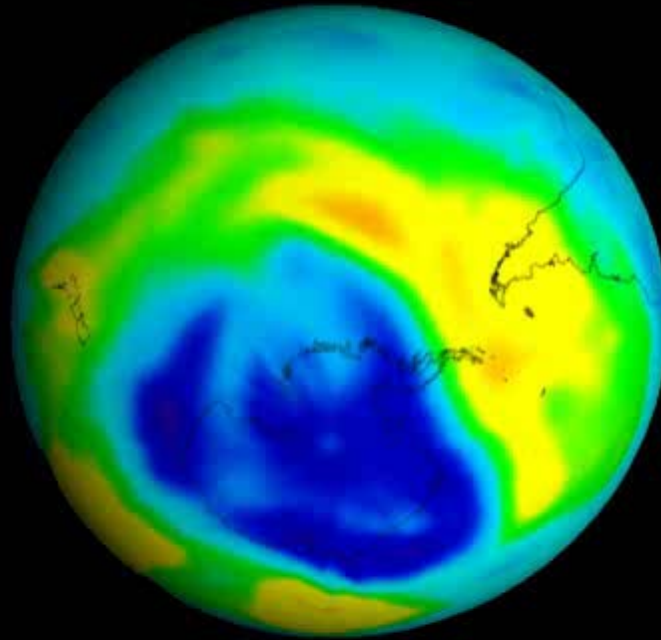
Resource management



Civil engineering and urban planning



# Monitoring of the antarctic ozone hole



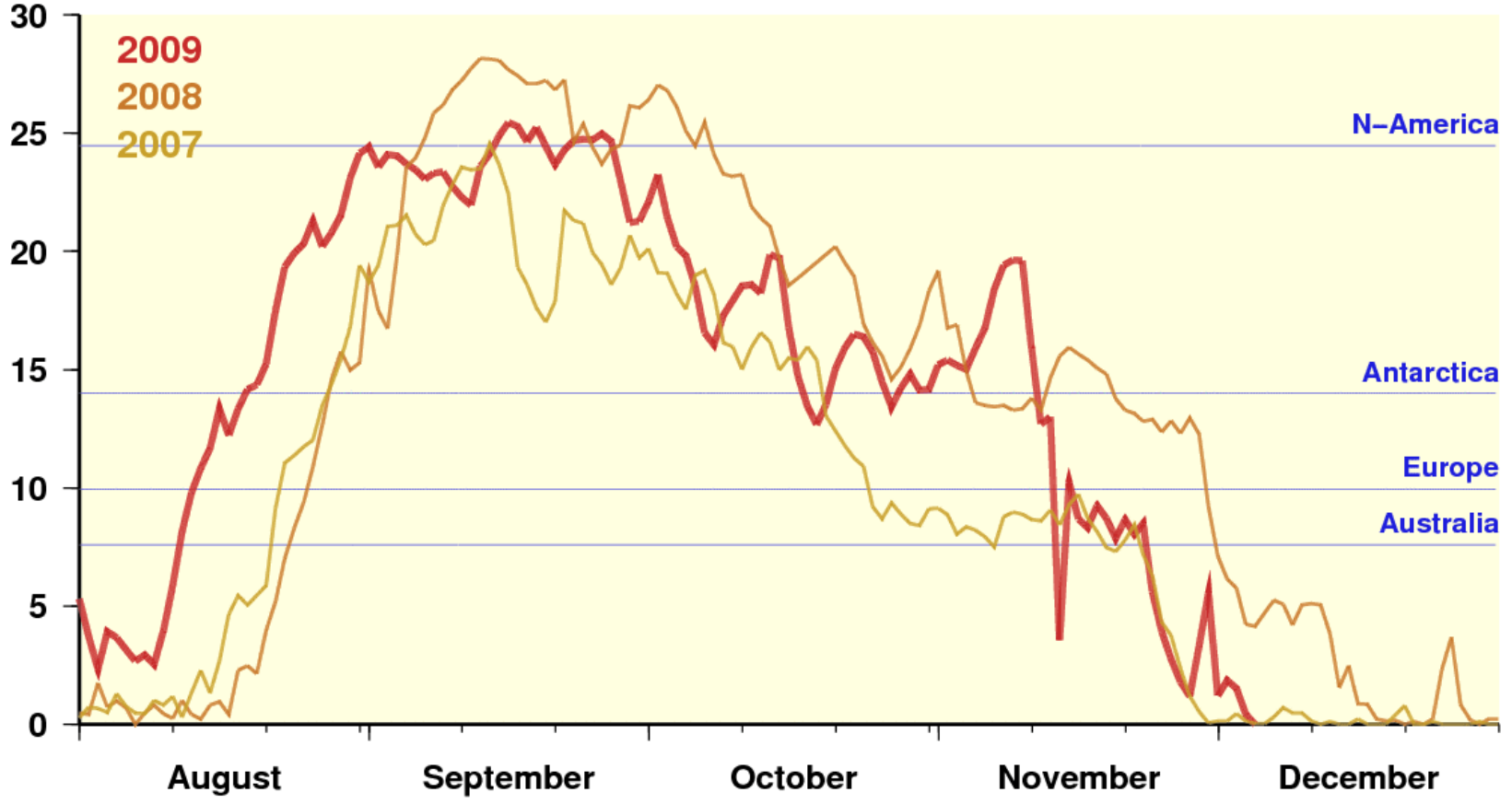
Aug, 01, 2007





# Monitoring of the antarctic ozone hole

Ozone Hole: Area [ $10^6 \text{ km}^2$ ]



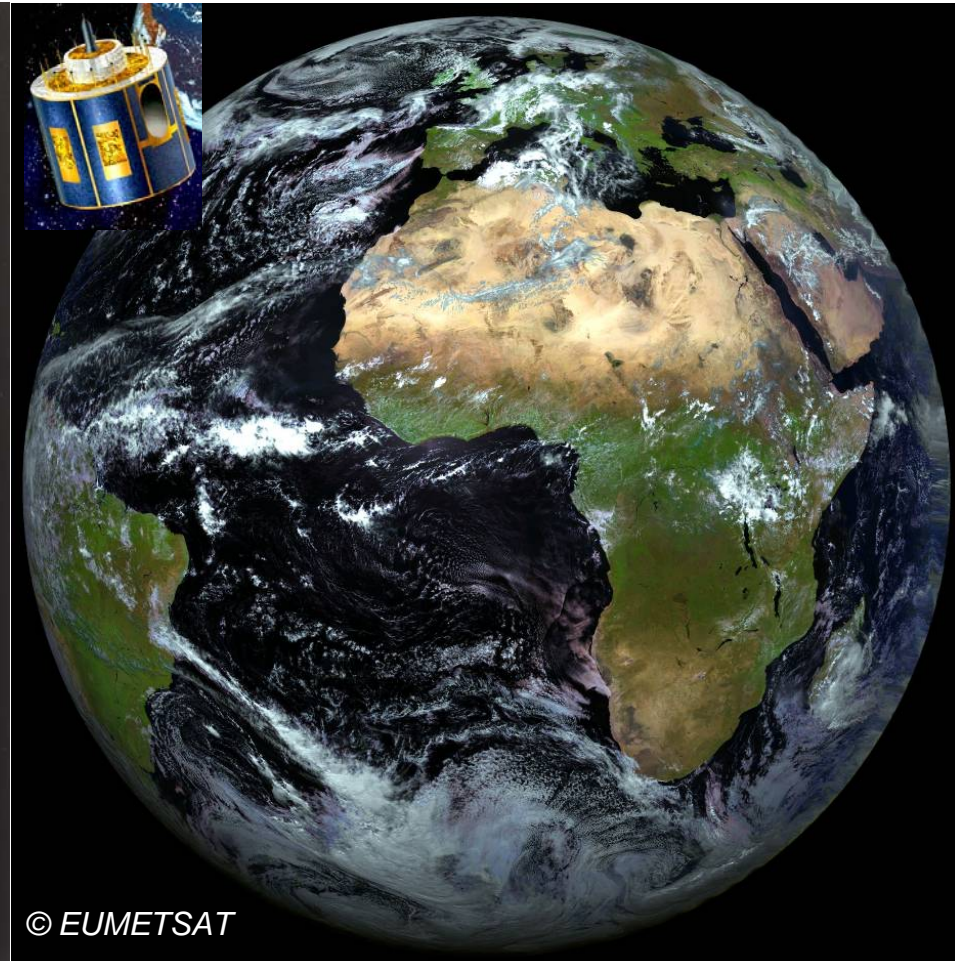


# Observing the Earth from geostationary orbit: A story of success for over 30 years



© ESA

1977: METEOSAT-1



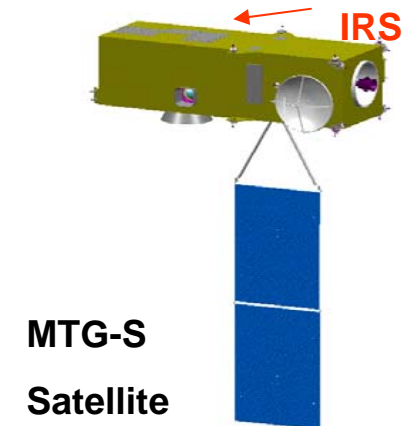
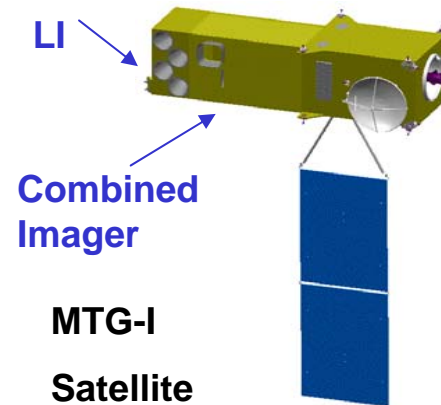
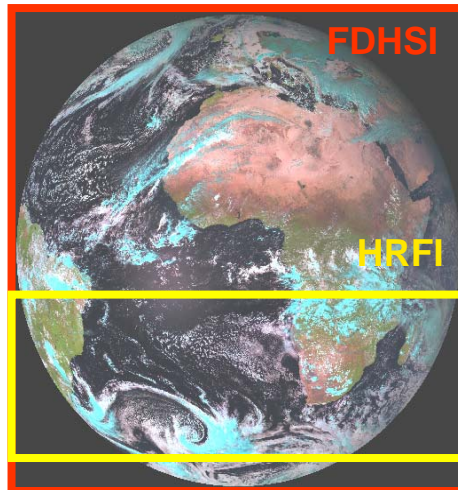
© EUMETSAT

2002: METEOSAT-8



# MTG General Features

## Meteosat Third Generation 2015-2025



- Imagery satellite MTG-I carrying both, the
  - Flexible Combined (FC) imager, providing
    - High Resolution Fast Imagery (HRFI), and
    - Full Disk High Spectral resolution Imagery (FDHSI)
  - Optical Lightning Imager (LI)
- Sounding satellite MTG-S carrying the Hyperspectral InfraRed Sounding (IRS) instrument





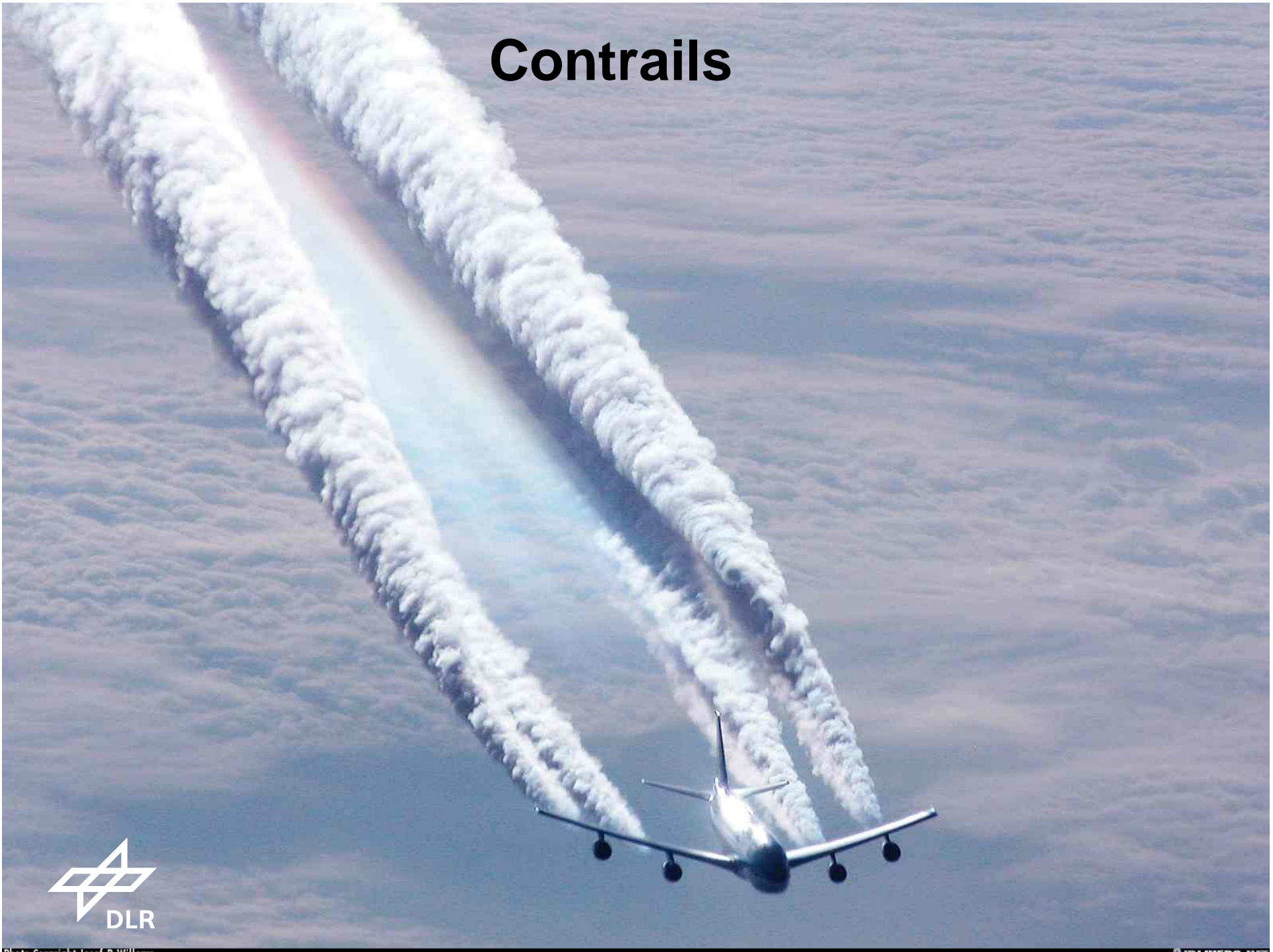
# MTG – Meteosat Third Generation 2015-2025

## The Lightning Mission

- Observing the climatology of thunderstorms and lightning
- Improving weather and climate models
- Enabling severe weather warnings

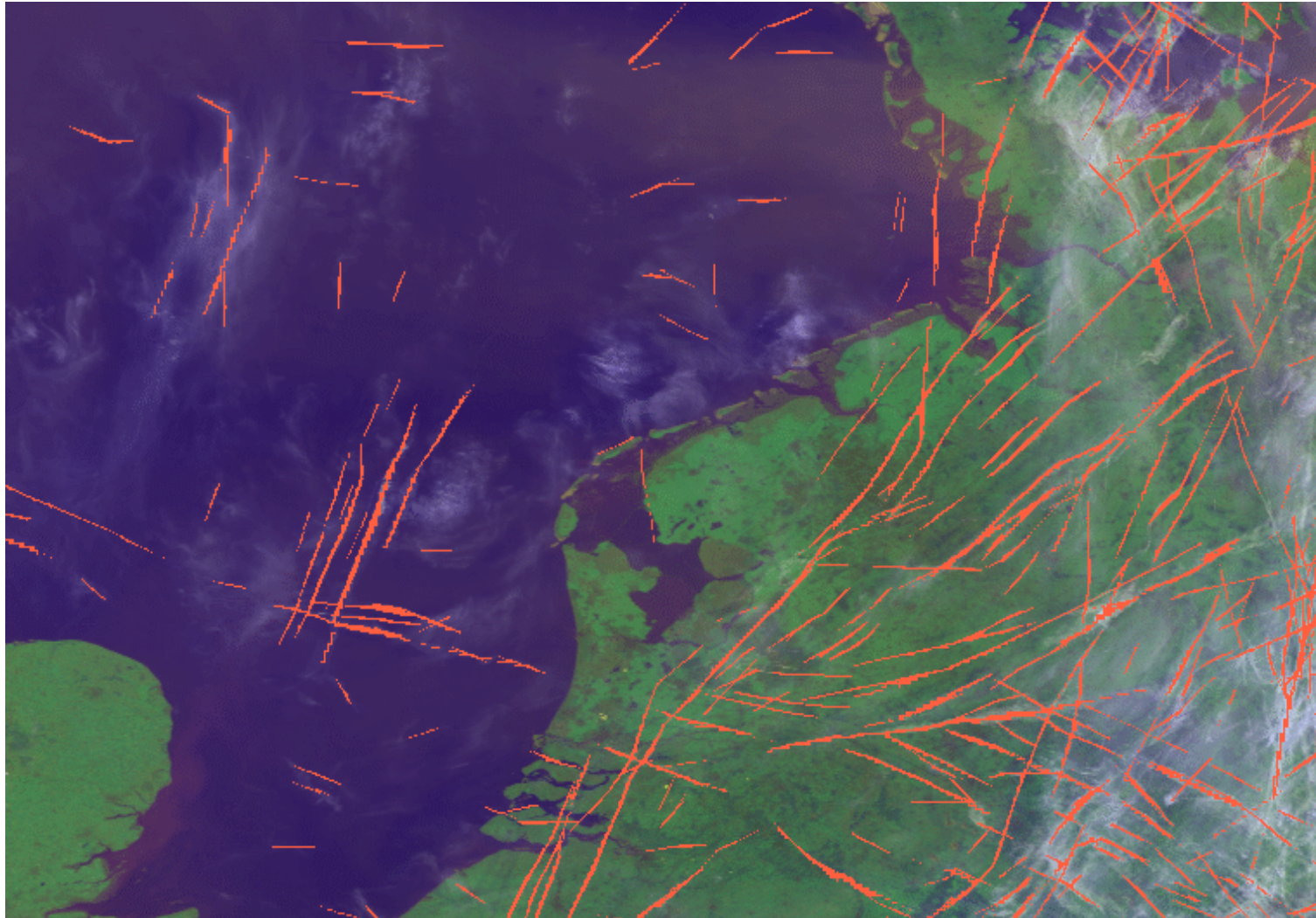


# Contrails



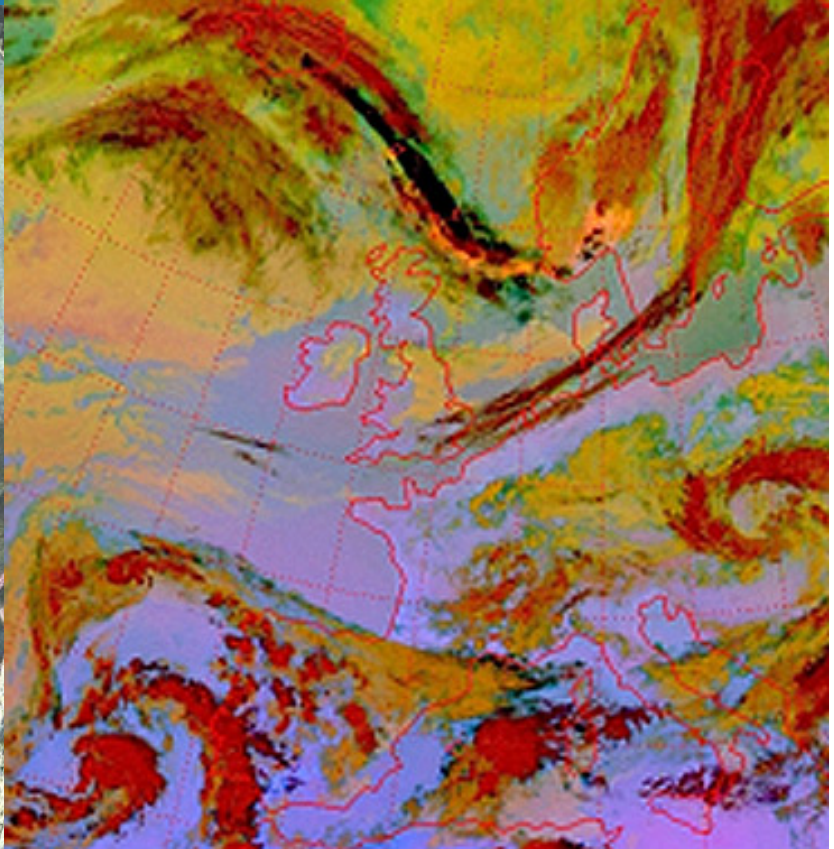
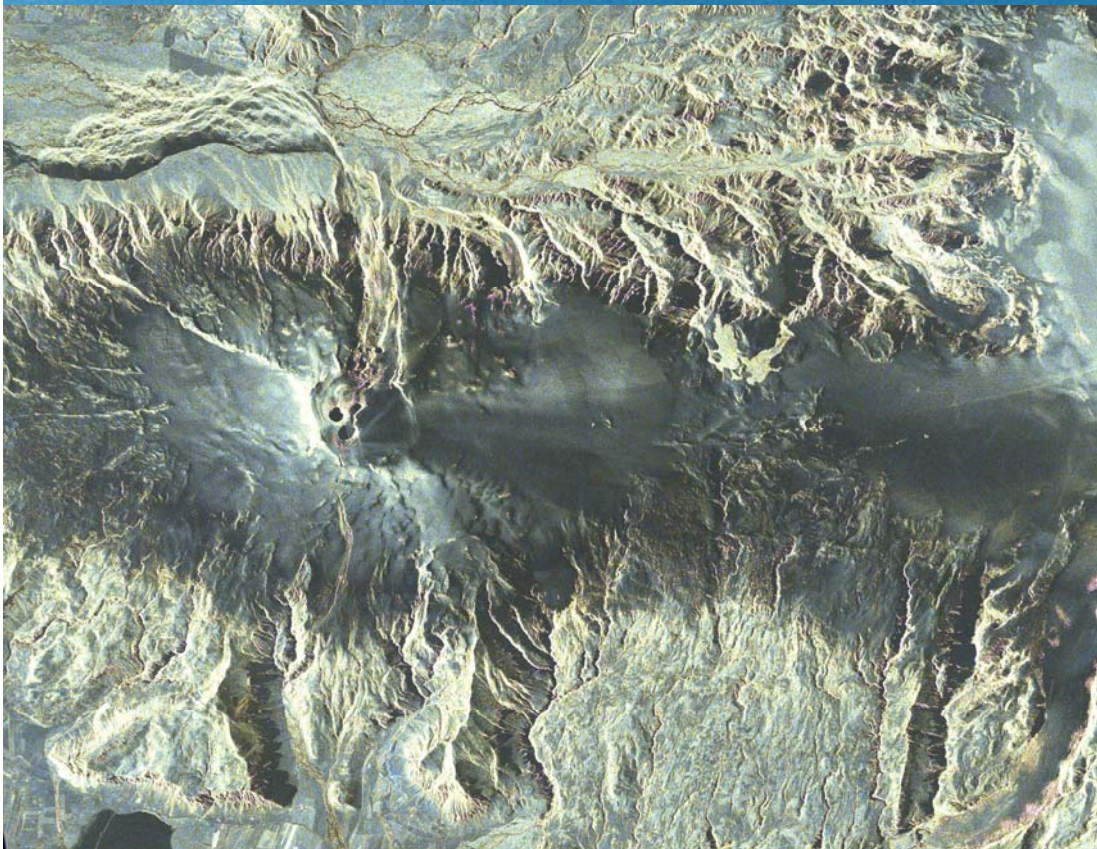


# Algorithms for the detection of contrails



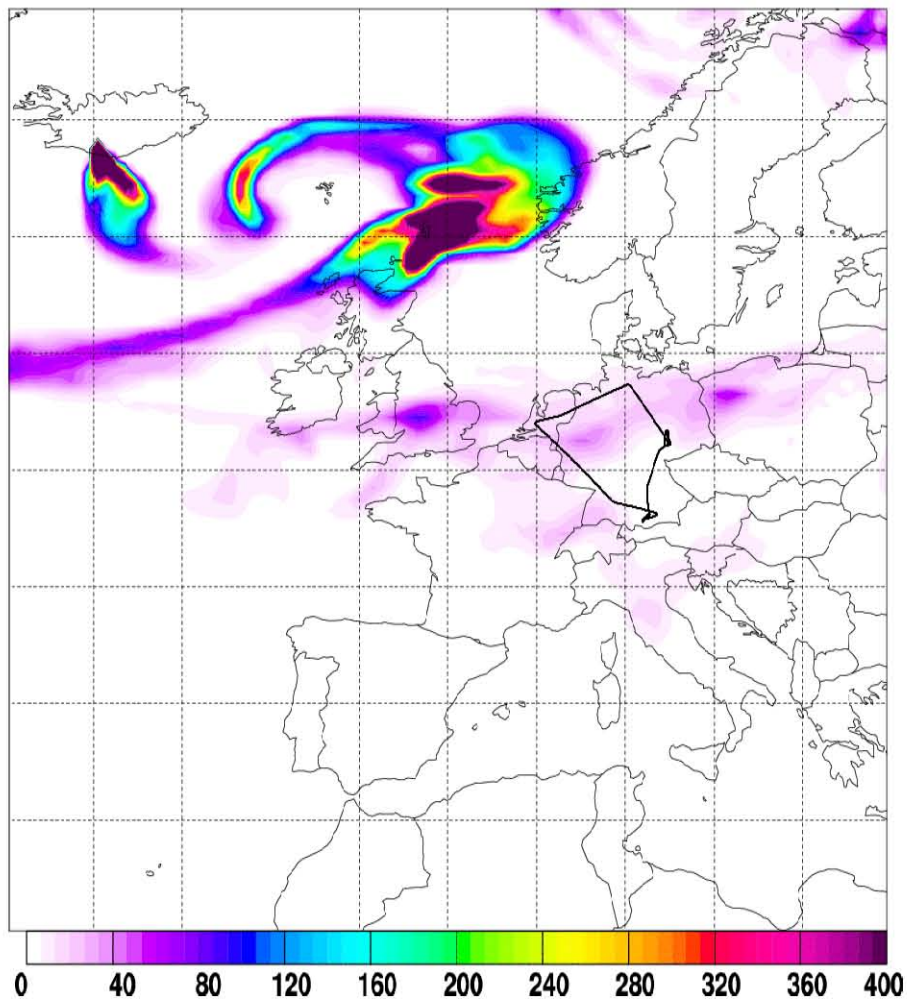
Data: NOAA ENVISAT



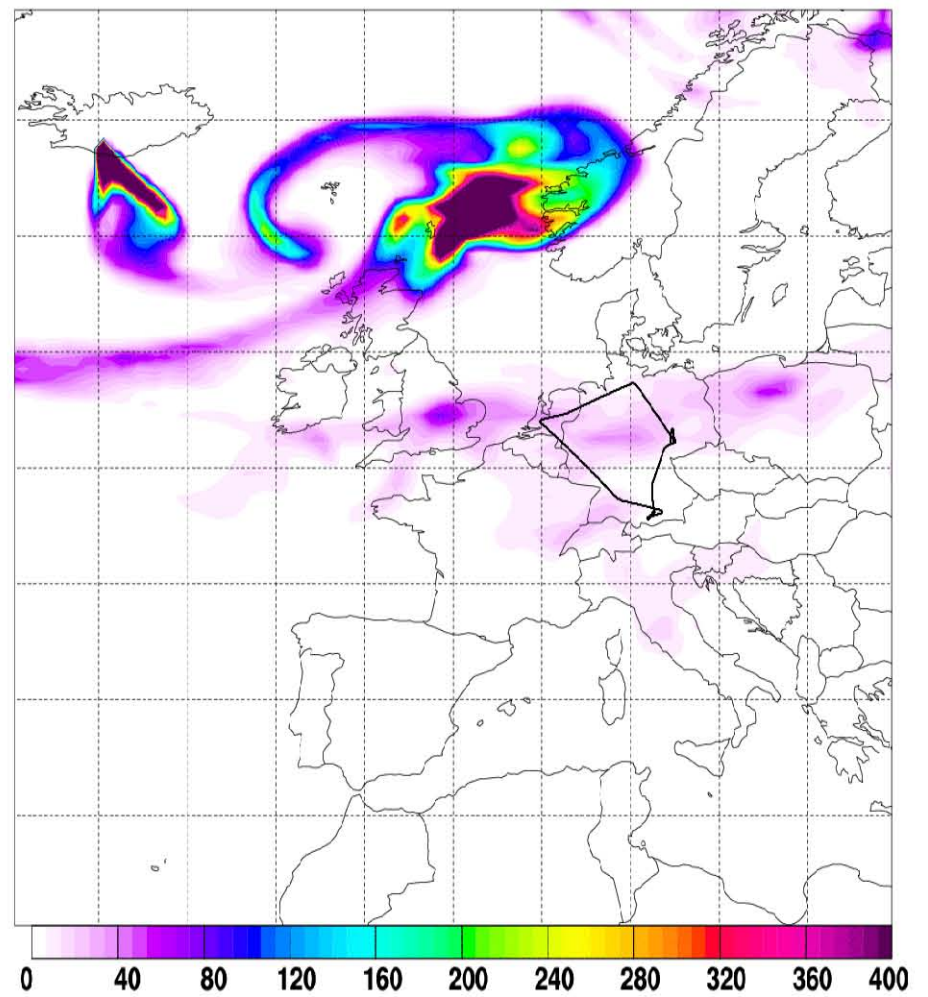


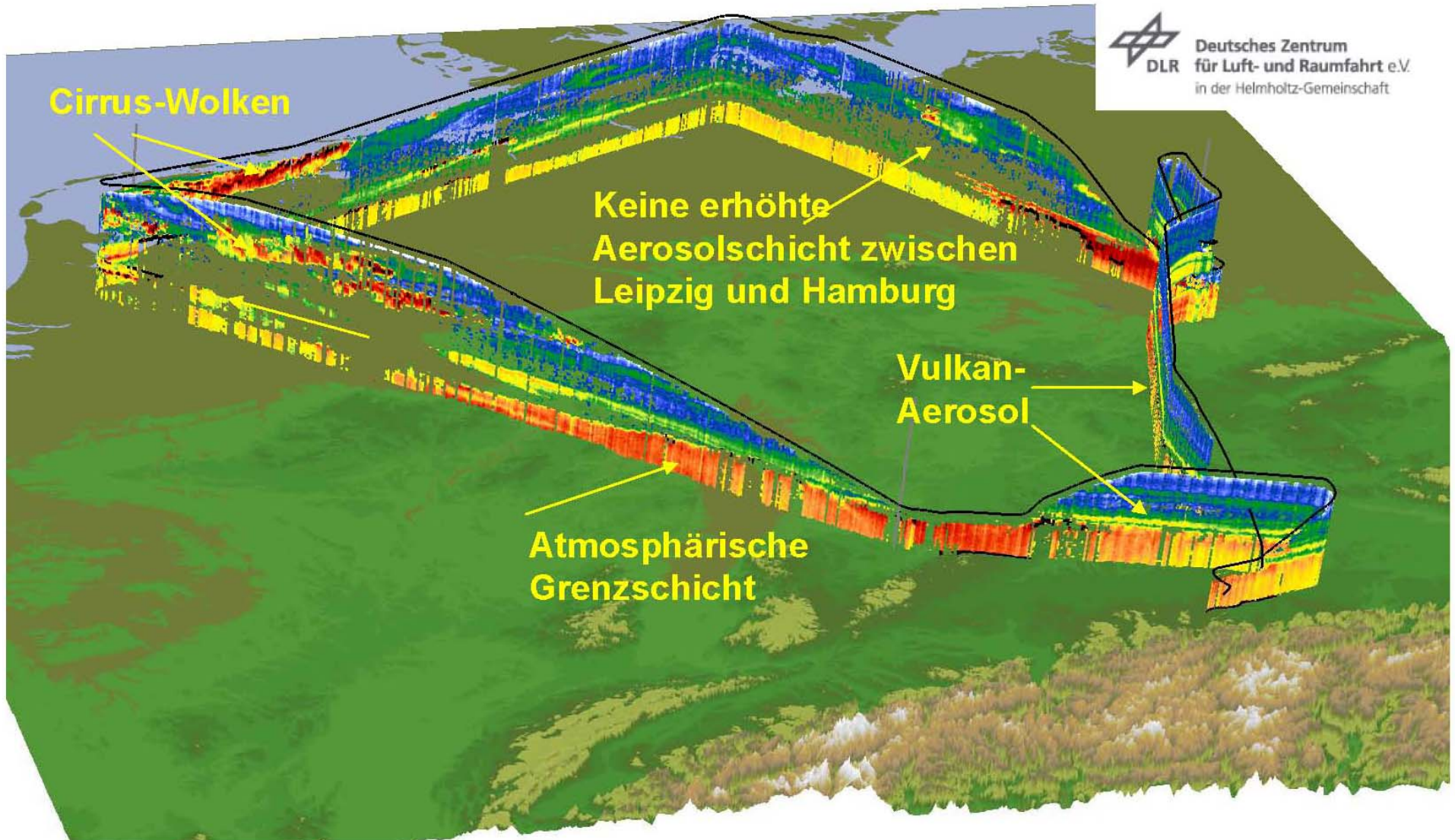
# FLEXPART simulations using non-continuous emissions for Falcon flight on 19/4/2010

Total column of species SO<sub>2</sub>  
Simulation start 20100414.150000 Actual time 20100419.150000



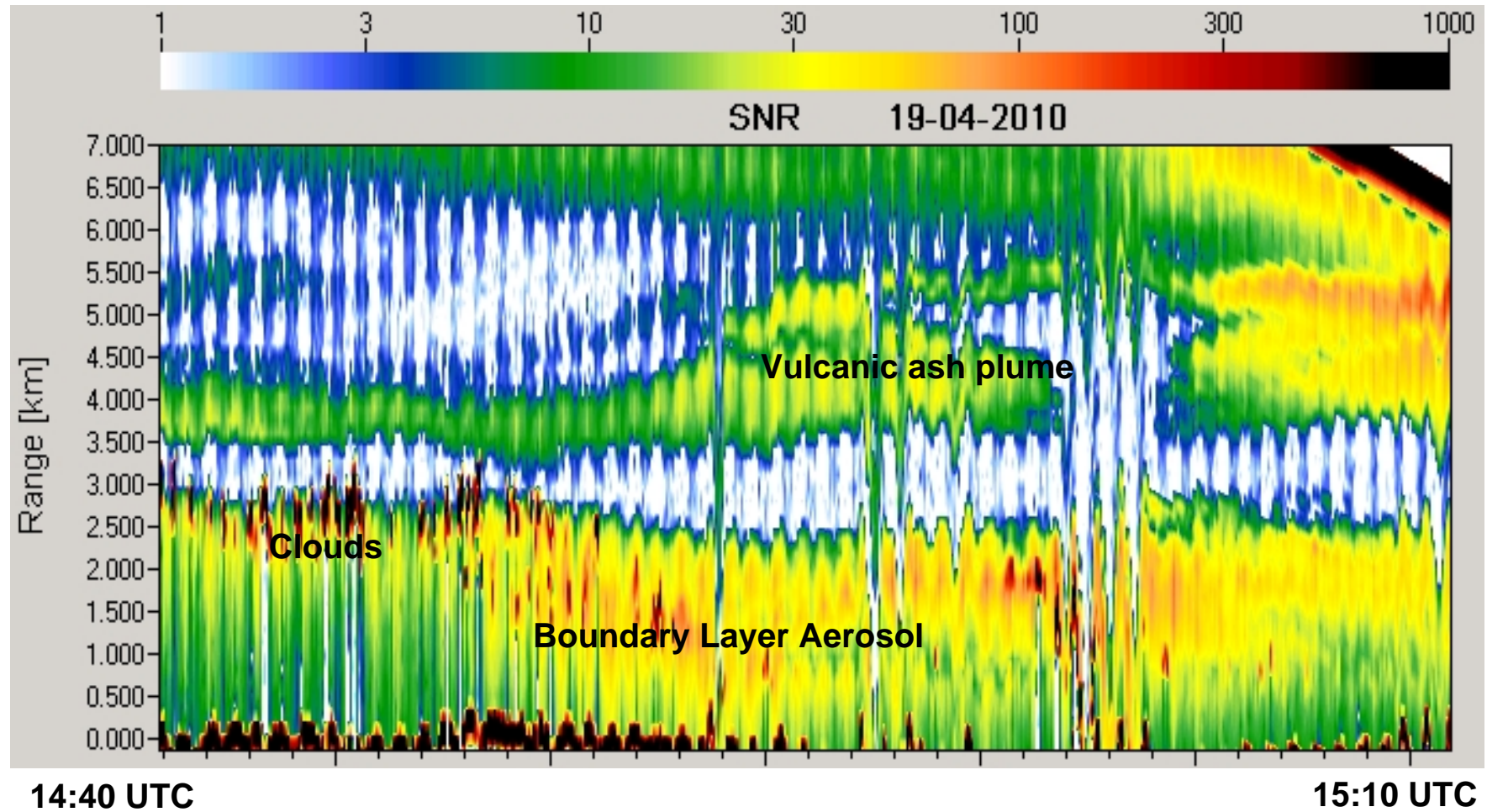
Total column of species SO<sub>2</sub>  
Simulation start 20100414.150000 Actual time 20100419.180000





## LIDAR Light detection and ranging





Area of Leipzig





# The Mission MERLIN

(MEthane Remote Sensing LIDAR MissioN)

## Prime objective

- Measurement of **atmospheric methane** from space using the **Differential-Absorption Lidar** technique
- Calculation of the **strength of methane sources** on ground with the help of inverse modelling

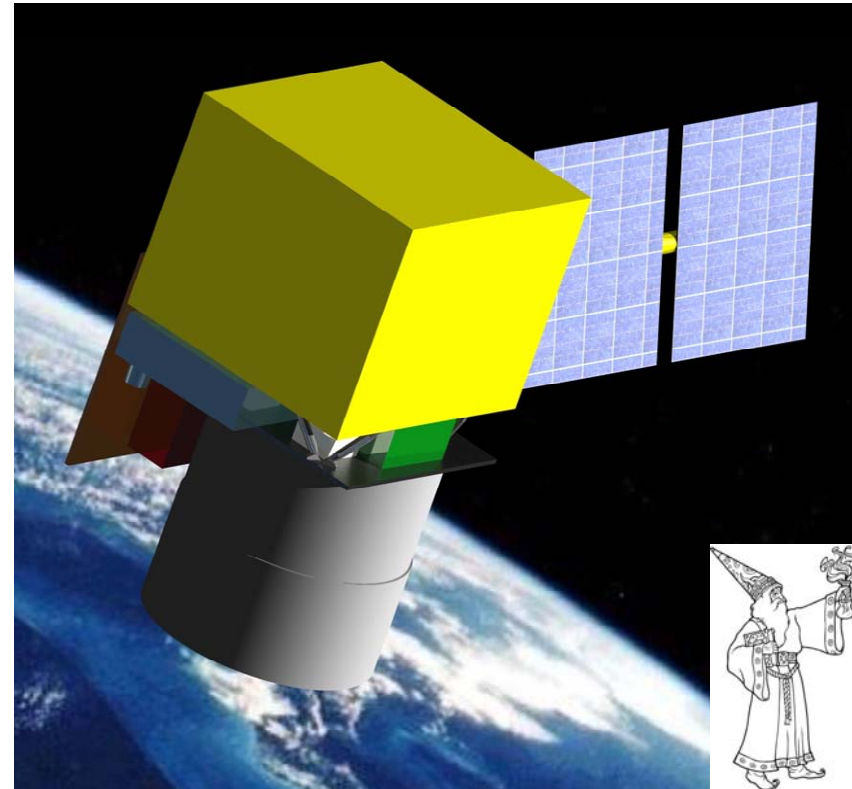
## Spin-off

- Mapping of **vegetation height** and structure
- Measurement of **cloud boundaries** and elevated aerosol layers

## Status

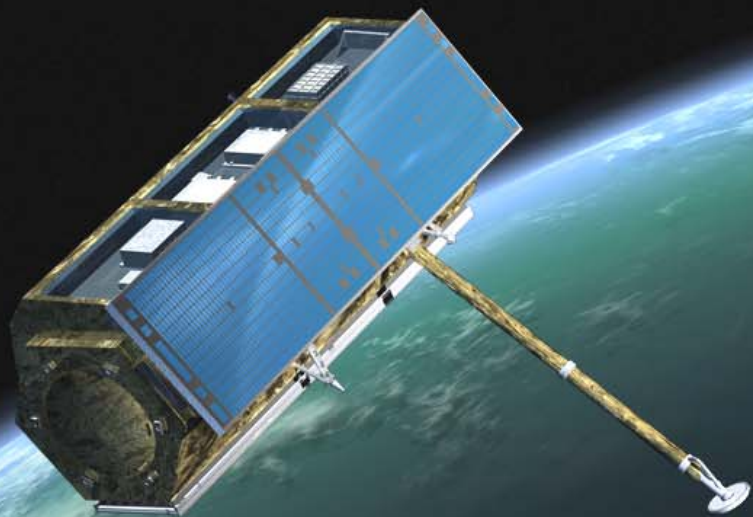
**Joint Phase 0/A since May 2010**

**Envisaged early launch date: 2014/15**



*Artist view of the spacecraft MYRIADE from CNES carrying the CH<sub>4</sub> IPDA lidar instrument from DLR*

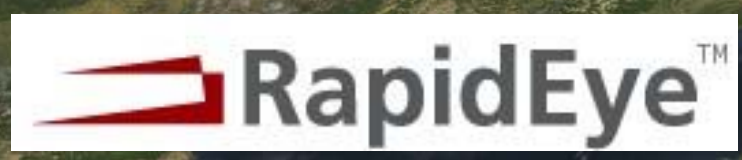




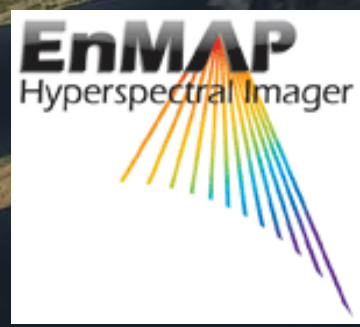
2007



2010

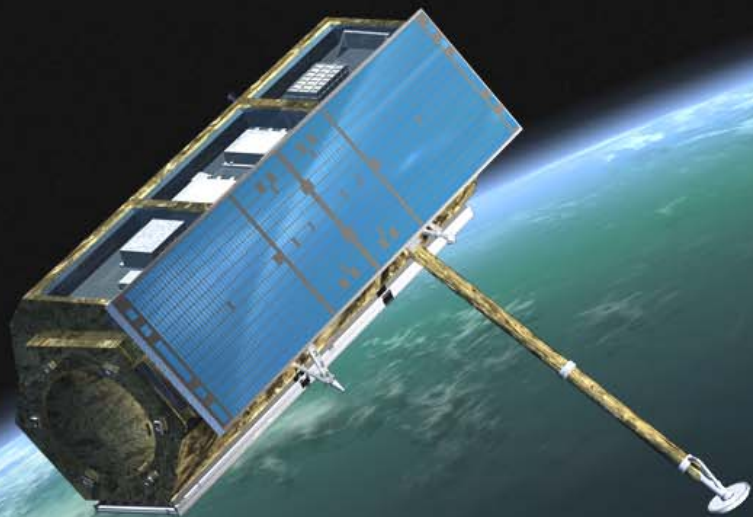


2008



2012





**2007**

**Radarsatellite TerraSAR X  
ppp  
Launch June 15 2007  
First Images June 19 2007  
Operational Service Jan. 7 2008**

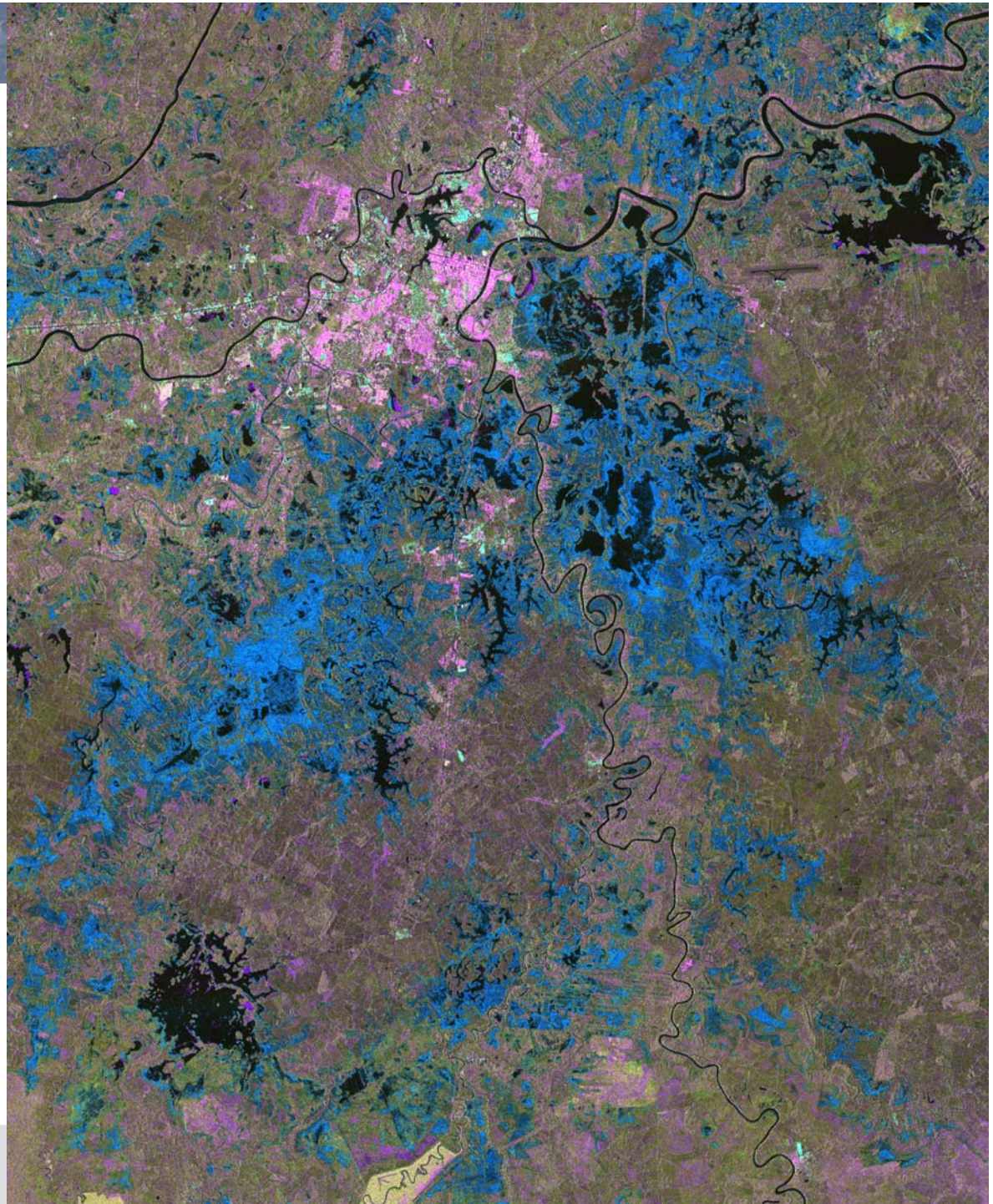




Mexico

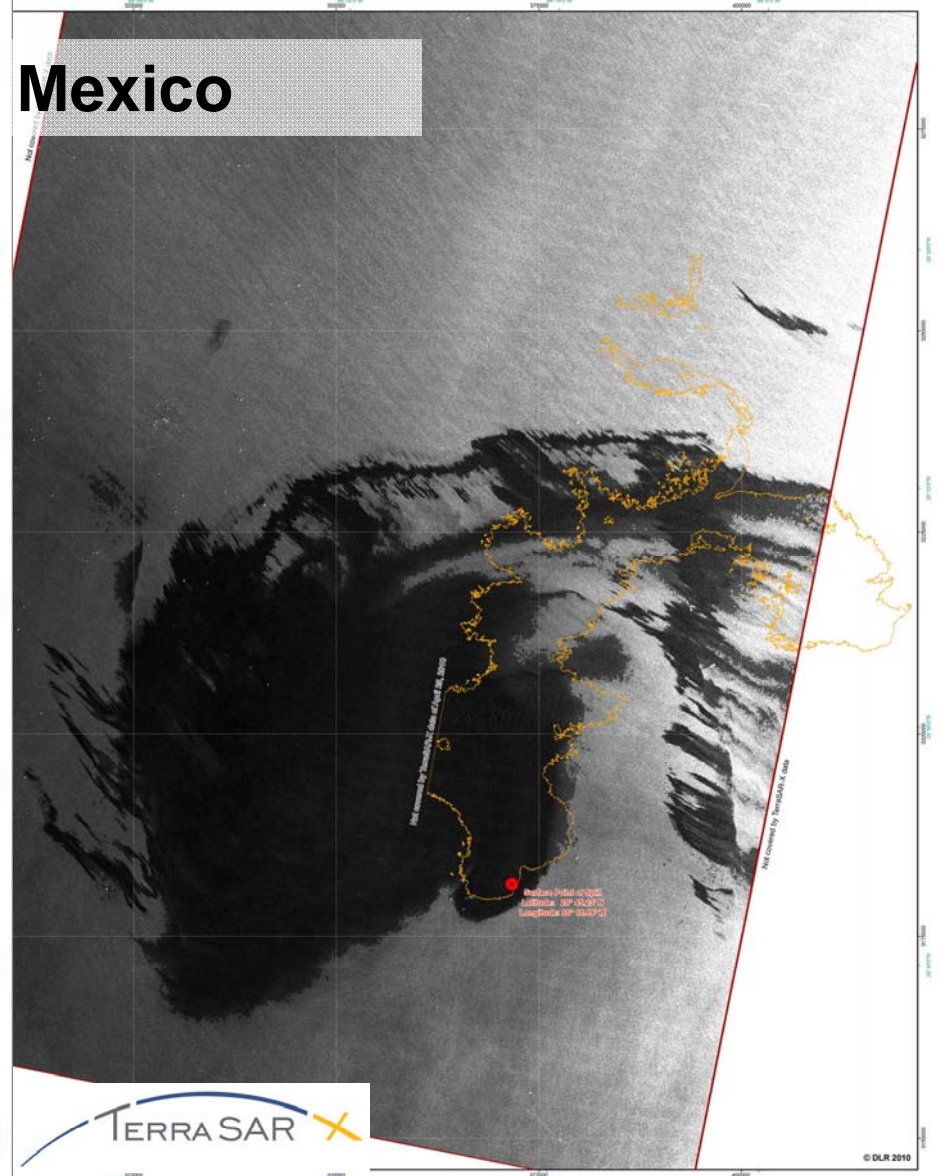
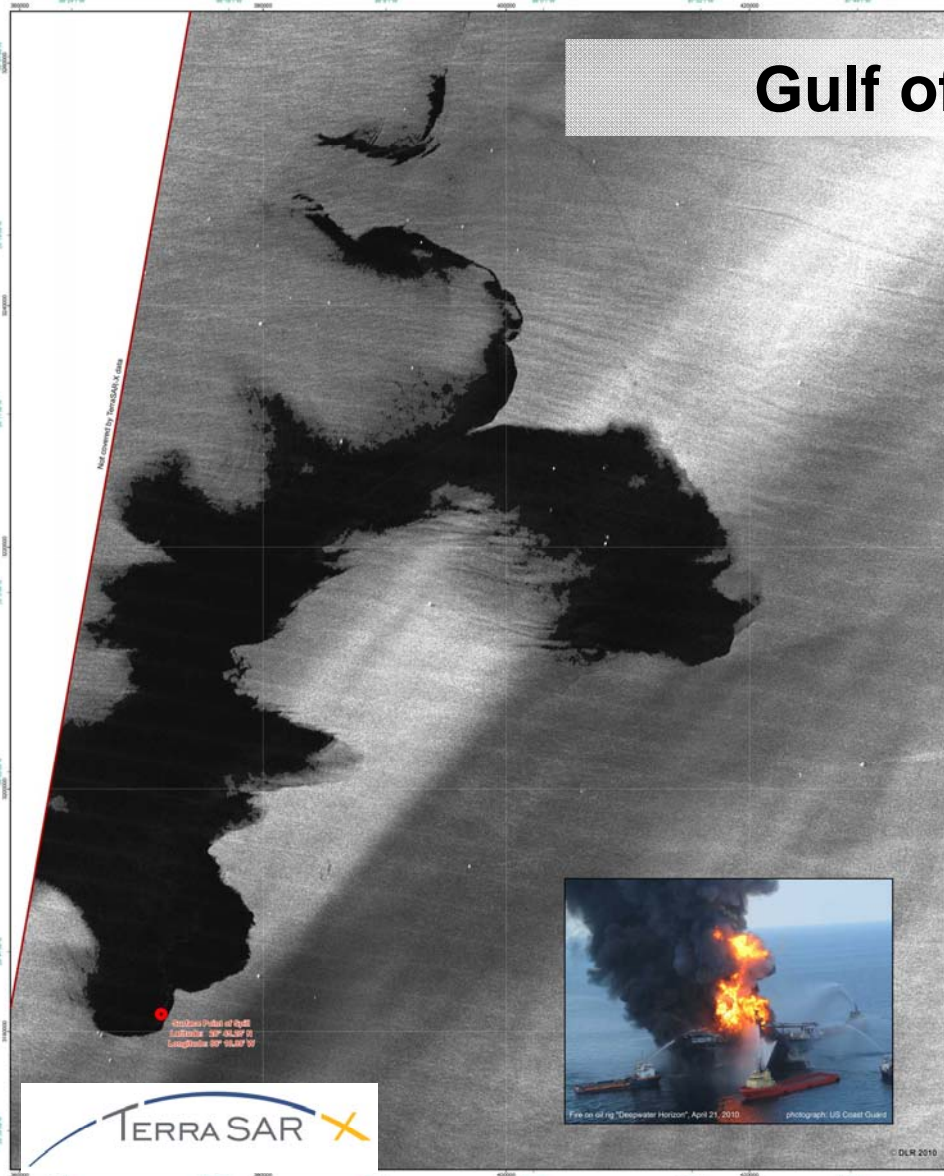
Villahermosa

8. November 2007 and  
2. December 2007



Deutsches Zentrum  
für Luft- und Raumfahrt e.V.  
in der Helmholtz-Gemeinschaft

# Gulf of Mexico



**Center for Satellite Based Crisis Information**  
Emergency Mapping & Disaster Monitoring

German Remote Sensing Data Center  
German Aerospace Center  
DLR

**Framework:**  
The products elaborated for this Rapid Mapping Activity are limited to the best of our ability, within a very short time frame, during a crisis, optimizing the material available. All geographic information has limitations due to the scale, resolution, date and interpretation of the original source materials. No liability concerning the content or the use thereof is entailed by the producer.

Map produced April 28, 2010 by DLR  
© DLR 2010

**Legend**

- Oil
- Ship
- Water

**Data Sources**

TerraSAR-X  
© DLR 2010  
Commercial exploitation rights:  
inoterra

**Interpretation**

On April 21, 2010 an explosion occurred on the oil rig "Deepwater Horizon" and it caught fire. 11 workers were missing after the incident and are believed to be dead. On the following day the rig sank to the seabed about 1500 m below the surface and approximately 400 m northwest of the well. Every day an estimation of 500.000 tons of oil are leaking from two places of the well and threaten the marine ecosystem of the Gulf of Mexico and the coast of Louisiana, USA. Efforts to stop the leakage have not been successful to date.

During its pass over the Gulf of Mexico on April 25, 2010, the German TerraSAR-X Satellite acquired a radar image showing an extensive oil spill, caused by the oil rig disaster. The extent of the oil spill shown on the map is about 80 km in north-south direction and 50 km in west-east direction. Ships are visible as very bright objects.

**Scale**  
Scale: 1:150.000 for DIN A1 printing

Reference coord. system: **Geographic (DMS)**  
WGS 84  
WGS 84

Projection: UTM Zone 18 N  
Signed: WGS 84  
Datum: WGS 84

**TERRA SAR X**

For more information visit: <http://www.zki.dlr.de>

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Emergency Mapping & Disaster Monitoring

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Map produced April 28, 2010 by DLR  
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**Legend**

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During its pass over the Gulf of Mexico on April 30, 2010, the German TerraSAR-X Satellite acquired a radar image showing an extensive oil spill, caused by the oil rig disaster. The map also shows the extent of the oil spill on April 25, 2010. It was derived by semi-automatic analysis of TerraSAR-X data. Ships are visible as very bright objects.

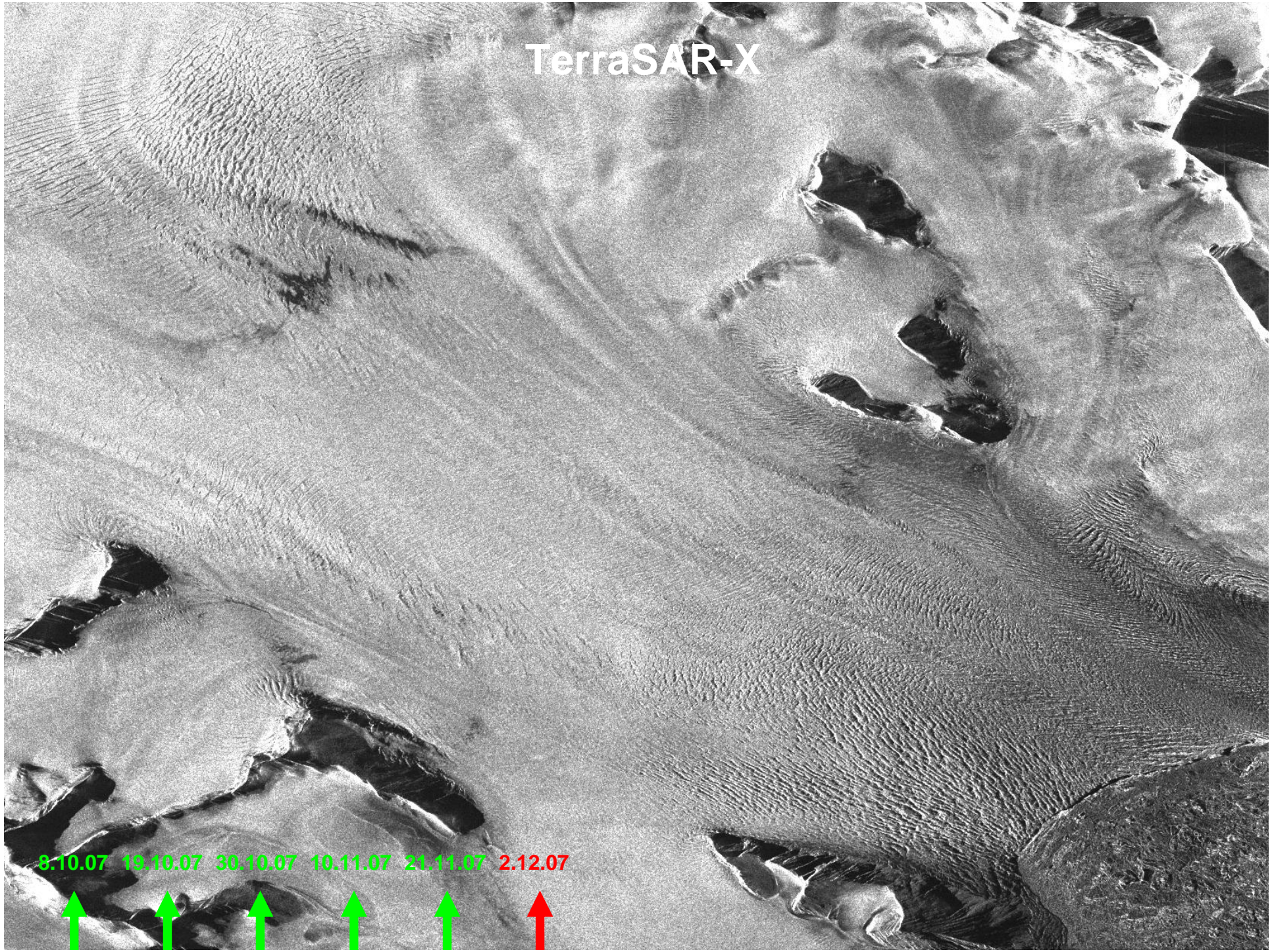
**Scale**  
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Reference coord. system: **Geographic (DMS)**  
WGS 84  
WGS 84

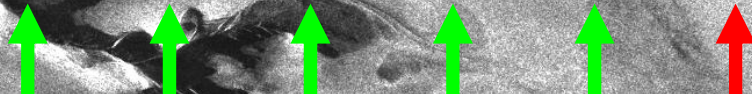
**TERRA SAR X**

For more information visit: <http://www.zki.dlr.de>

TerraSAR-X

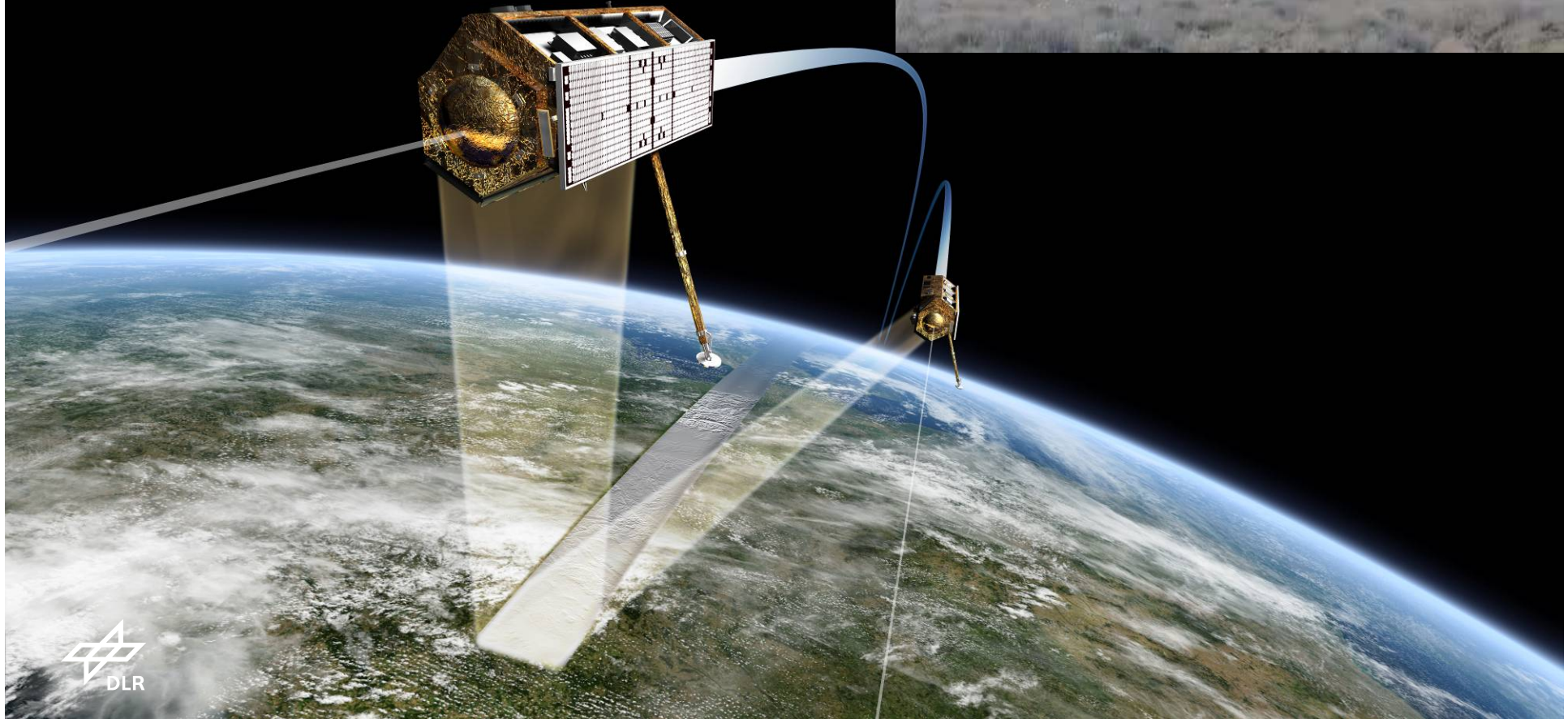


8.10.07 19.10.07 30.10.07 10.11.07 21.11.07 2.12.07



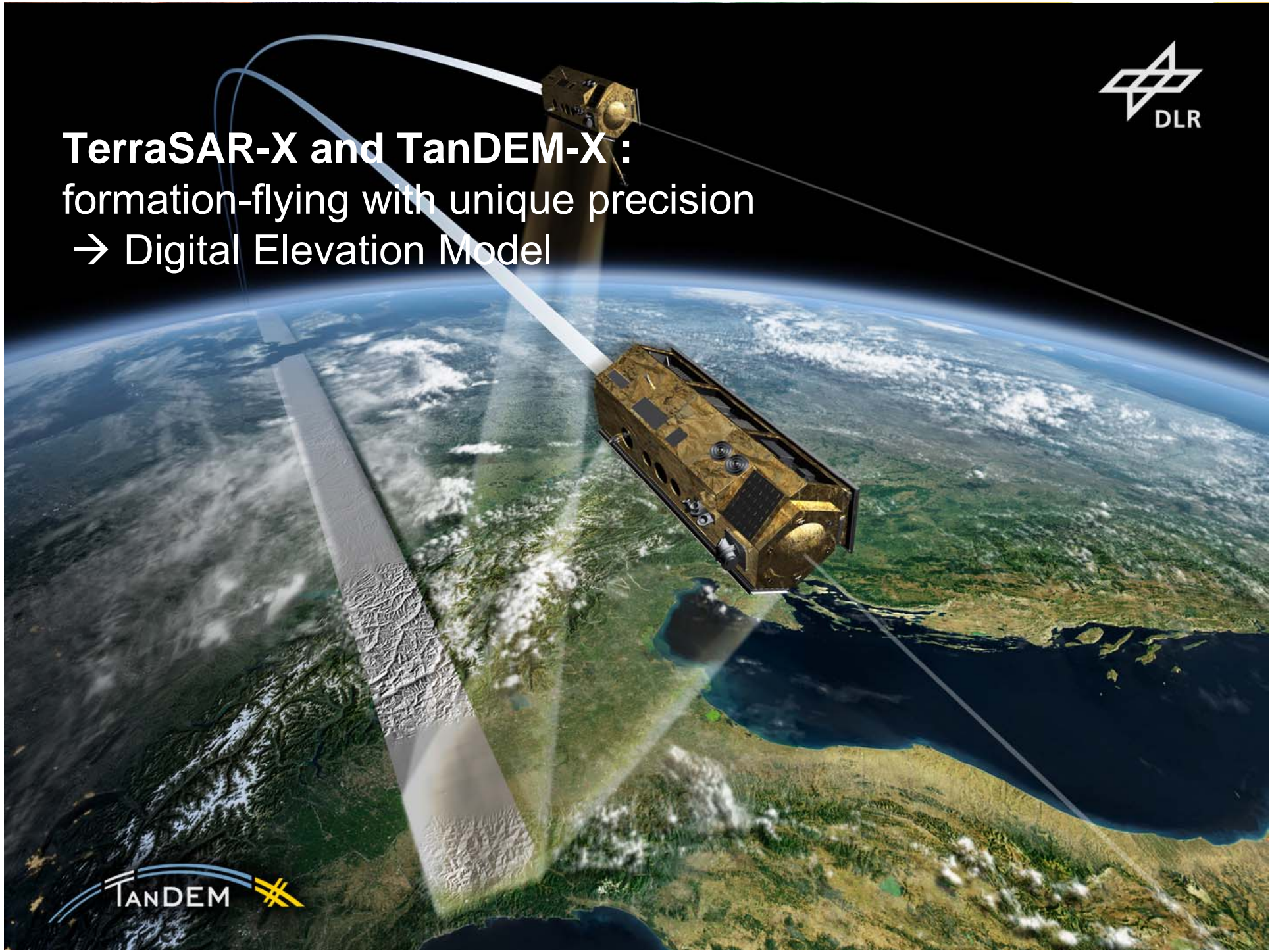
# TANDEM

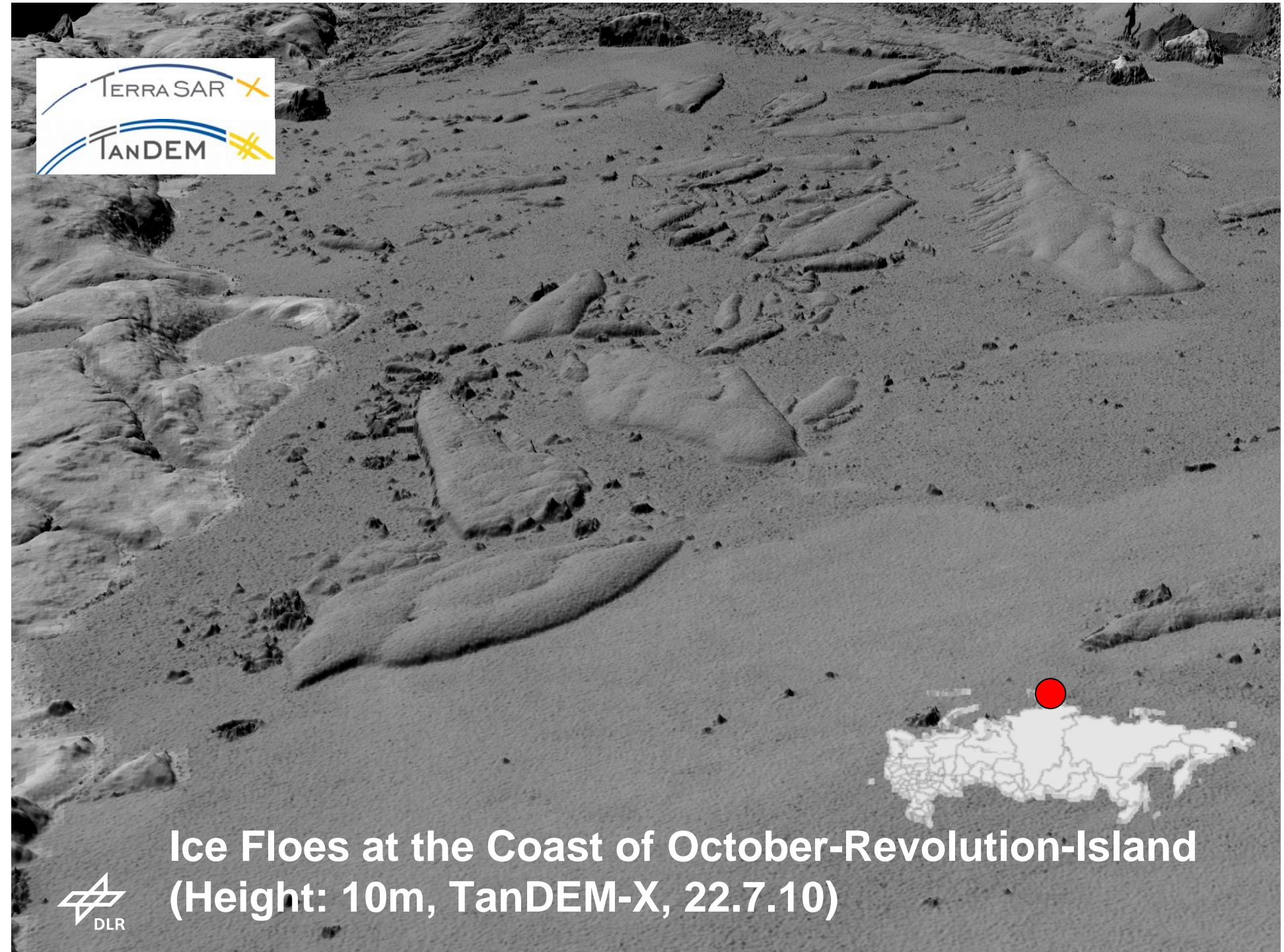
Launch June 21 2010





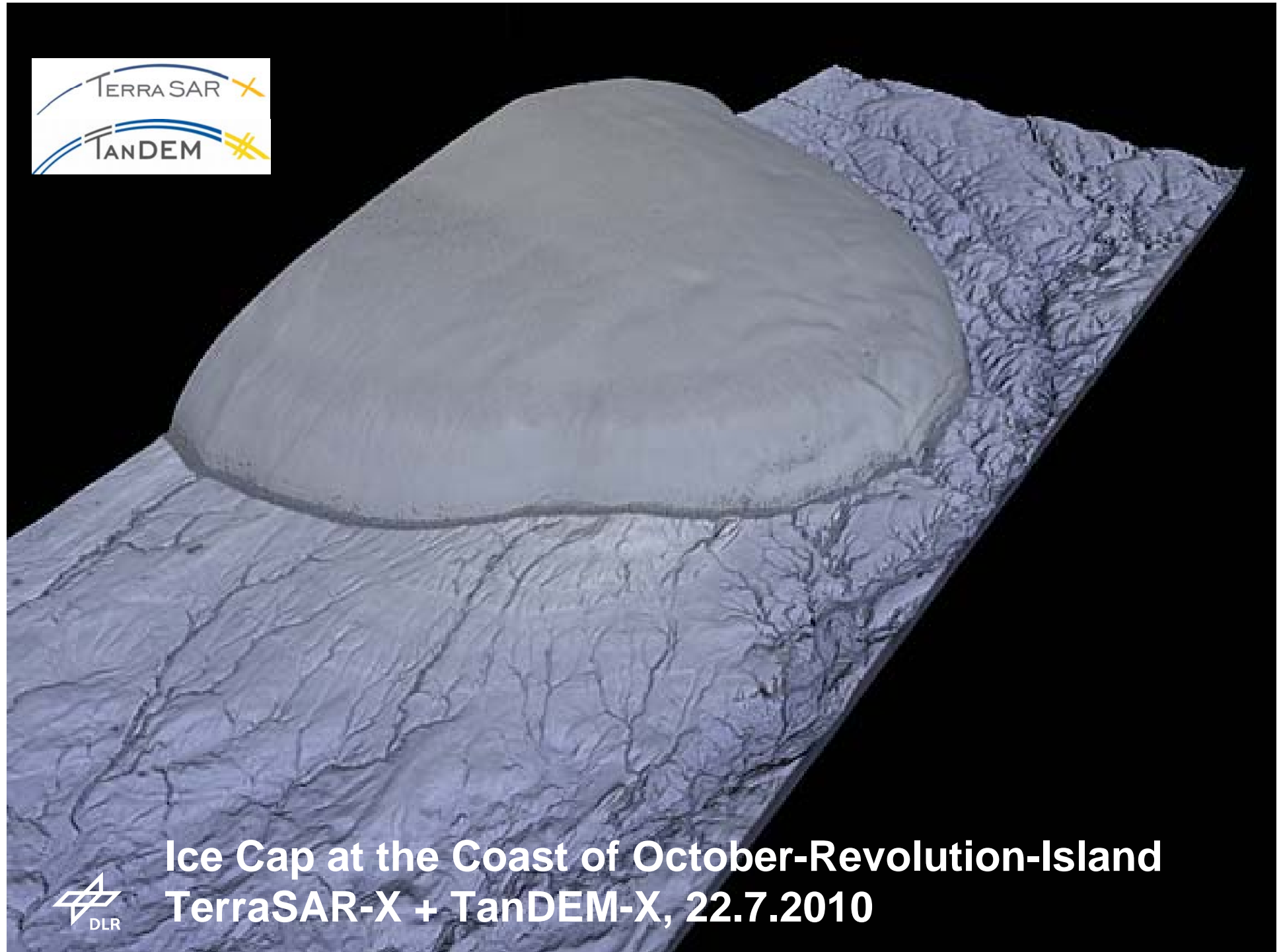
**TerraSAR-X and TanDEM-X:**  
formation-flying with unique precision  
→ Digital Elevation Model





**Ice Floes at the Coast of October-Revolution-Island  
(Height: 10m, TanDEM-X, 22.7.10)**

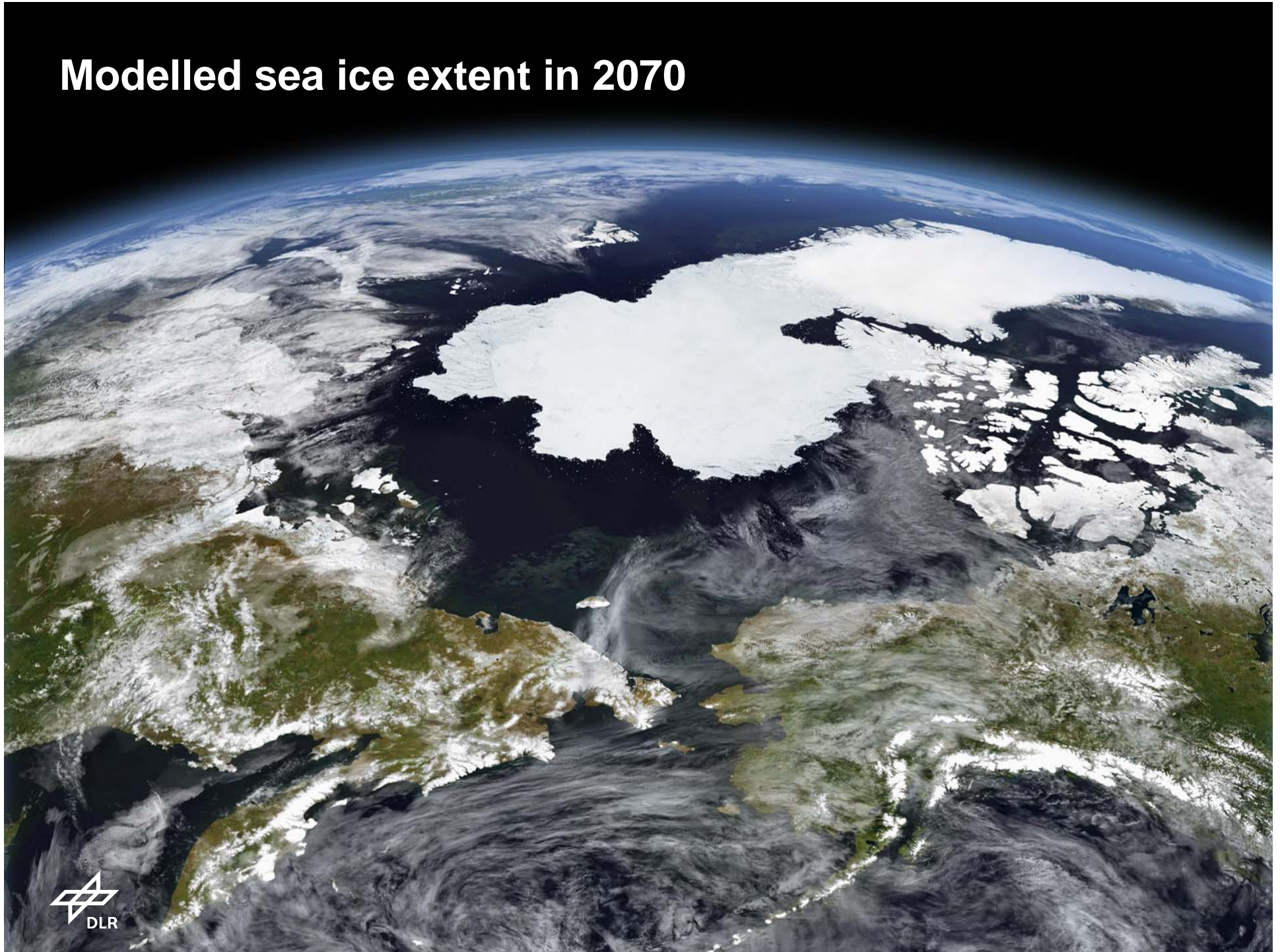




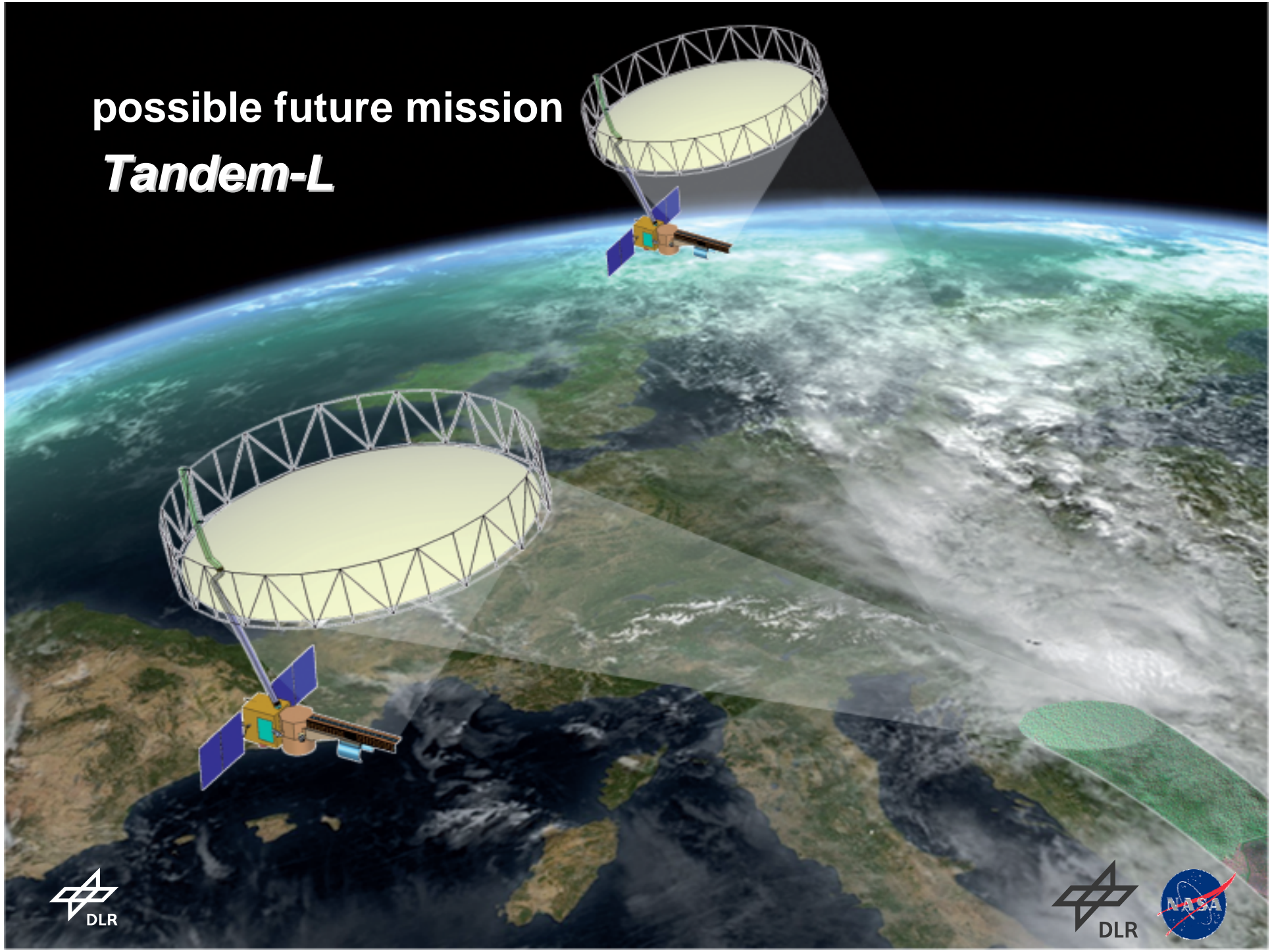
**Ice Cap at the Coast of October-Revolution-Island  
TerraSAR-X + TanDEM-X, 22.7.2010**



# Modelled sea ice extent in 2070



possible future mission  
*Tandem-L*



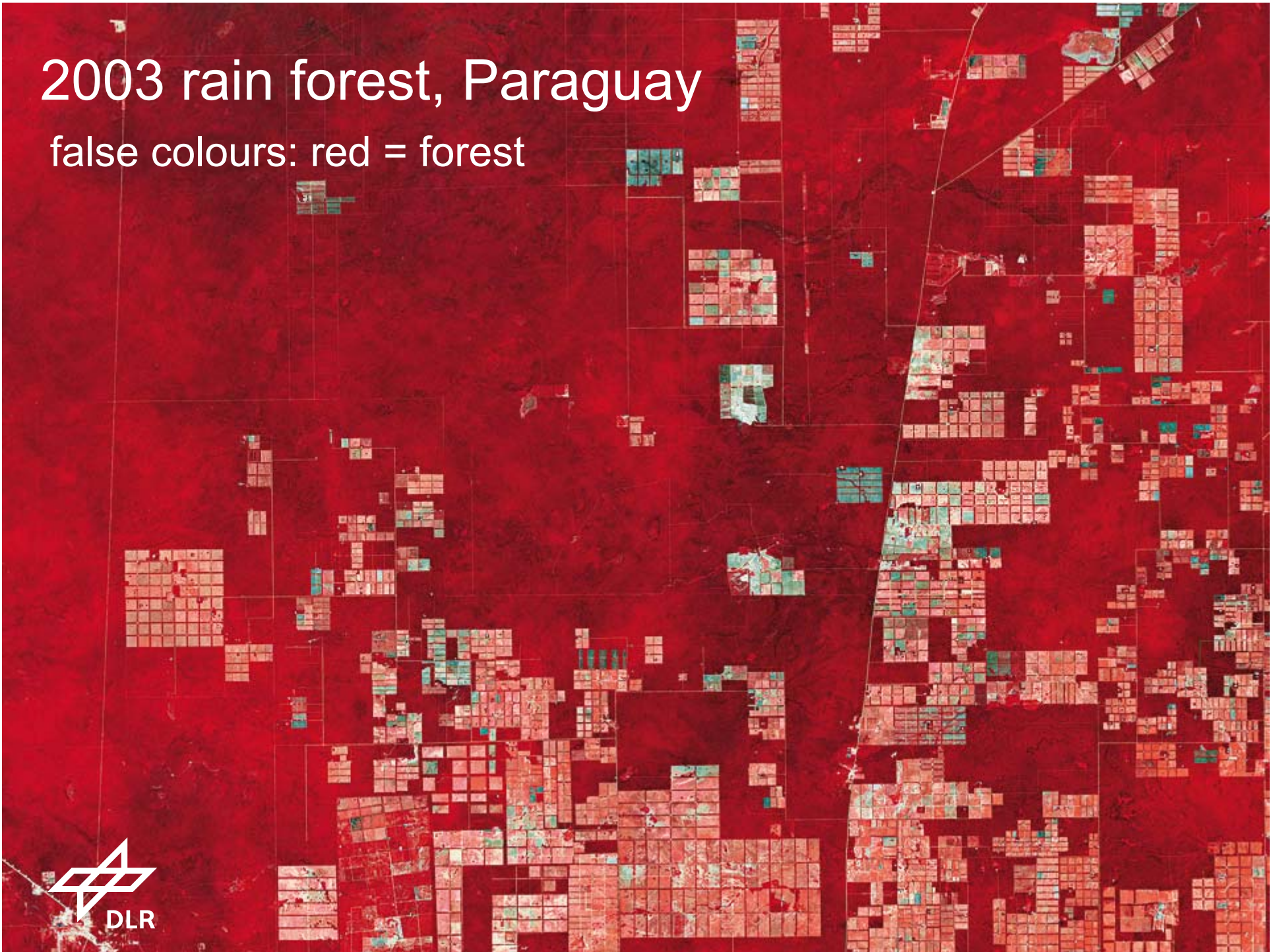
# 1985 rain forest, Paraguay

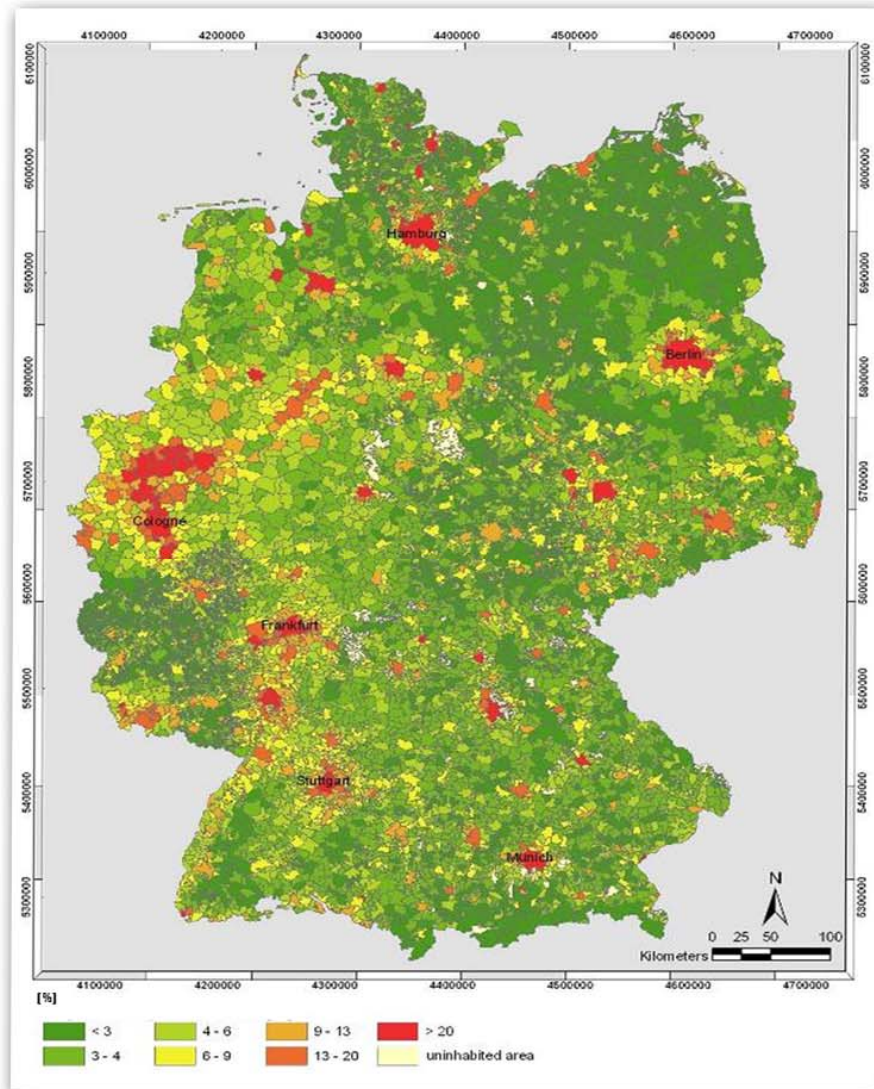
false colours: red = forest



# 2003 rain forest, Paraguay

false colours: red = forest



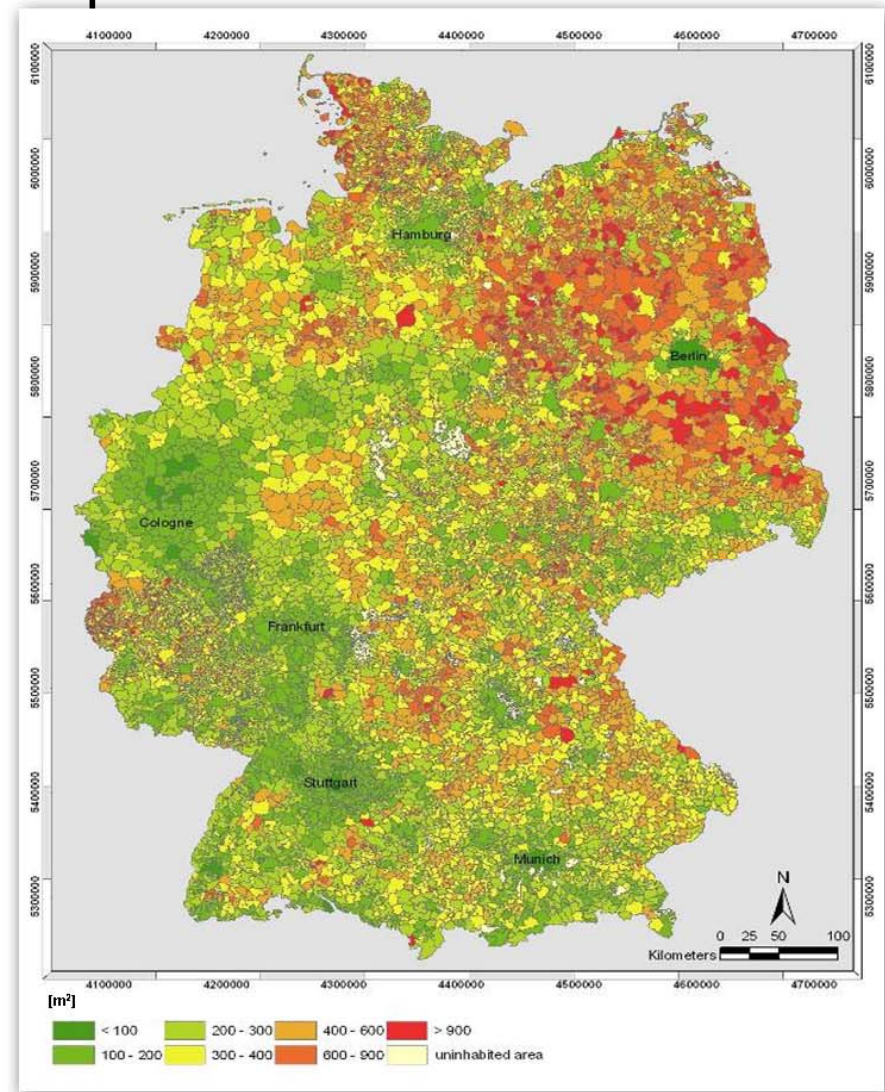
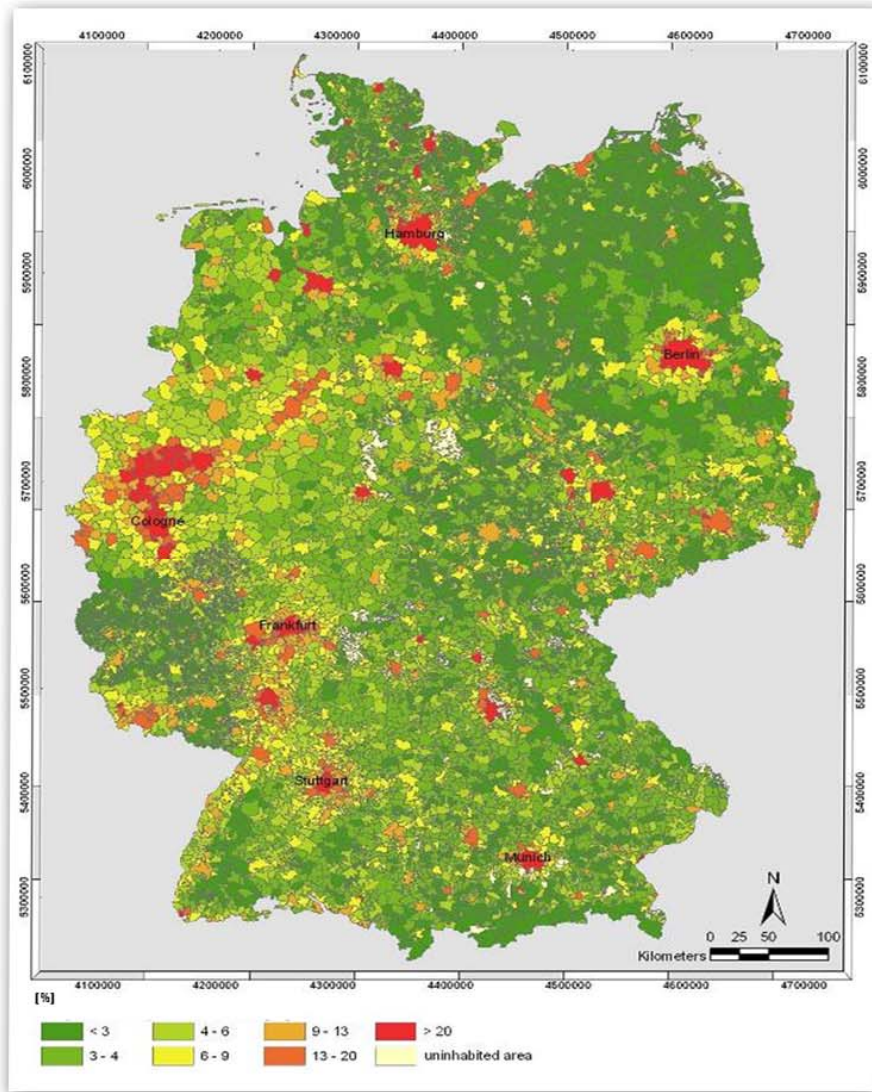


Land-planning: „sealing“ of ground





per citizen

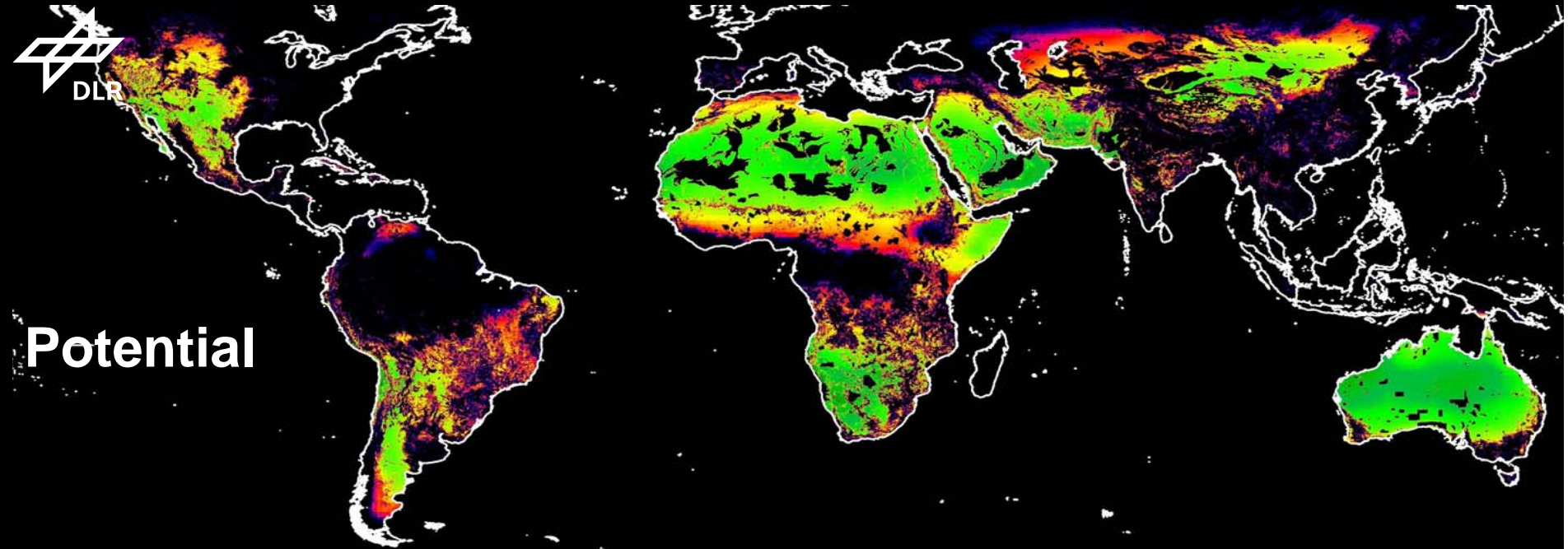


Land-planning: „sealing“ of ground

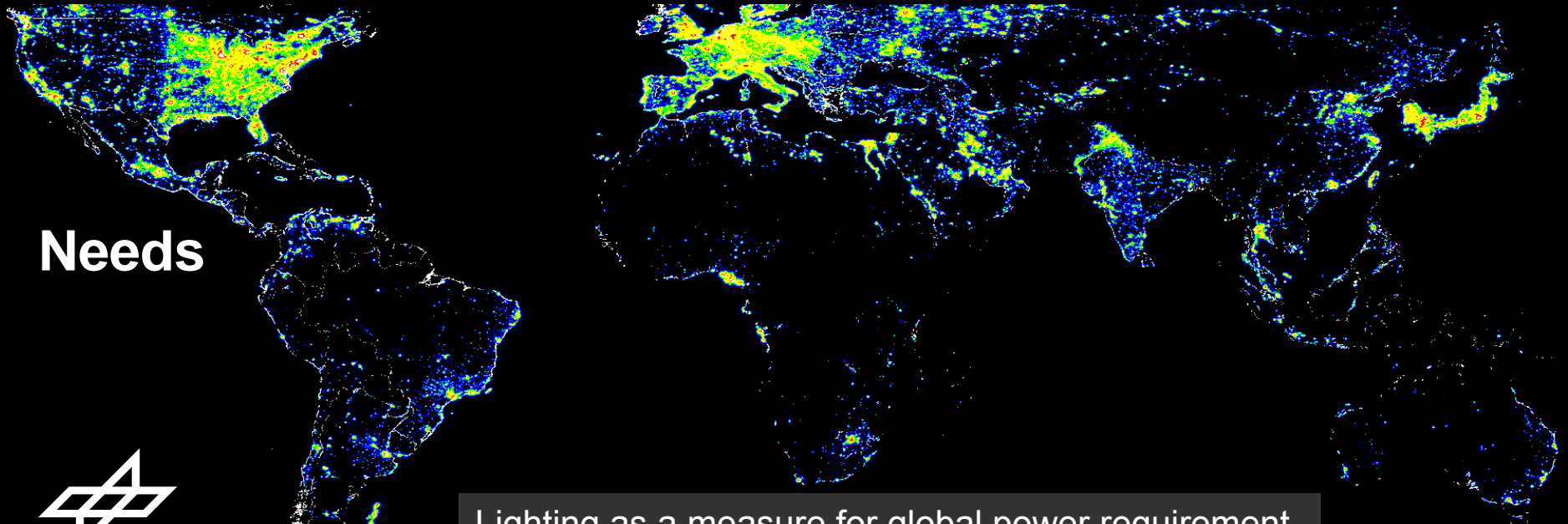




Potential



Needs



Lighting as a measure for global power requirement



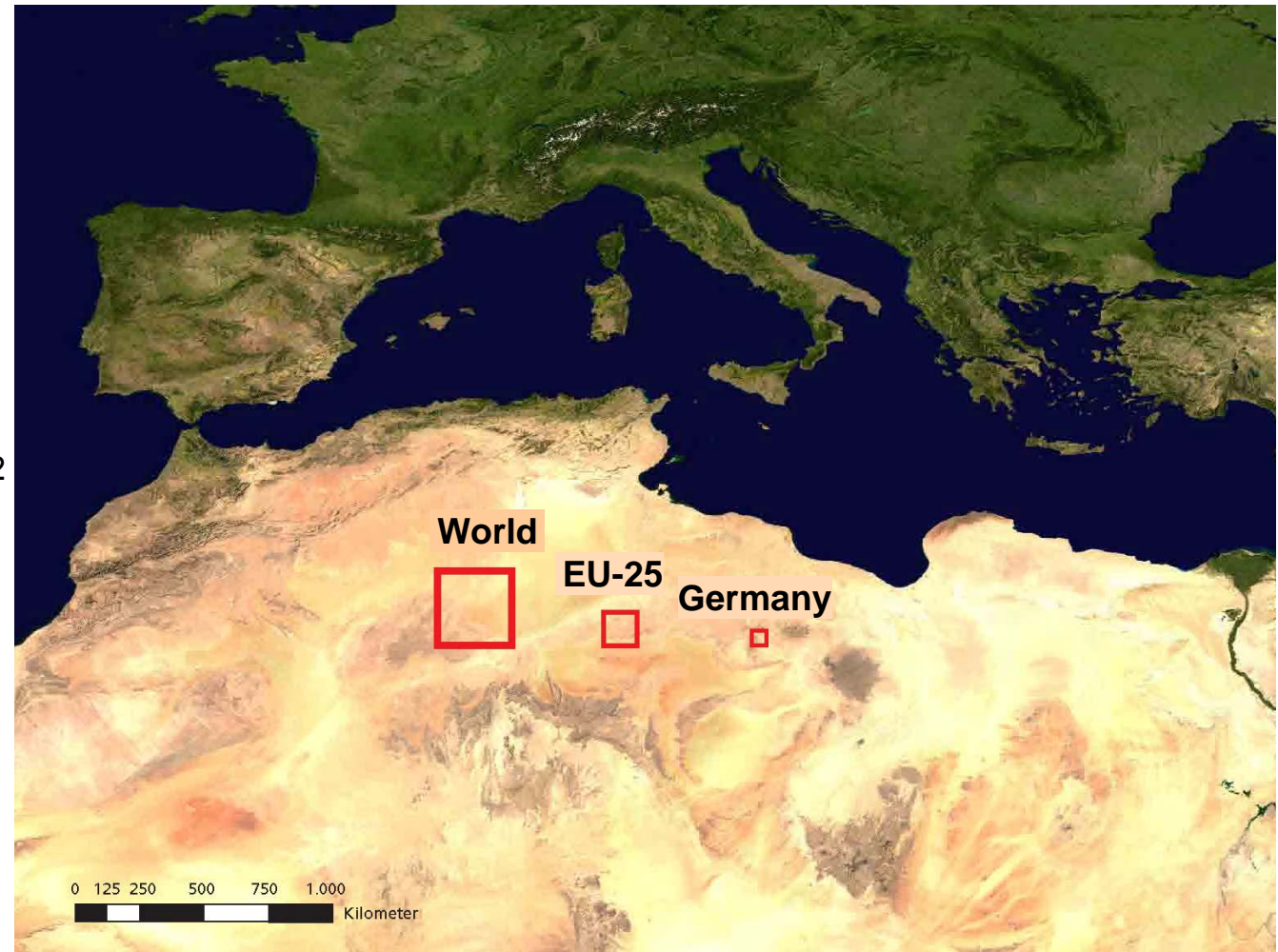
Artificial Night Sky Brightness  
Cinzano DLR DMSP Satellites  
Copyright 2004 International Dark Sky Association

More information available at: <http://antwrp.gsfc.nasa.gov/>



# Required desert area for the sustainable supply of electricity

World 300 x 300 km<sup>2</sup>  
EU-25 150 x 150 km<sup>2</sup>  
Germany 50 x 50 km<sup>2</sup>



# Earth observation:

Weather, climate and more → data fusion!



Weather Satellite + Opt. Satellite + Computer Model



# Global Monitoring for Environment and Security



stakeholder

central elements





Pres. Ronald Reagan  
Remarks at the Johnson Space  
Center in Houston, Texas  
September 22, 1988

...The truth is, our space program doesn't invest in machines; it invests in people. And you don't only launch rockets, you launch dreams. This is the age of technology, but technology is only a tool....



**Technology → Earth Observation Data → Basis for Decisions**



**Knowledge for  
Tomorrow**



**DLR**

