SOIL MOISTURE
Measured by Microwave Radiometers: Airborne and from Space (SMOS)

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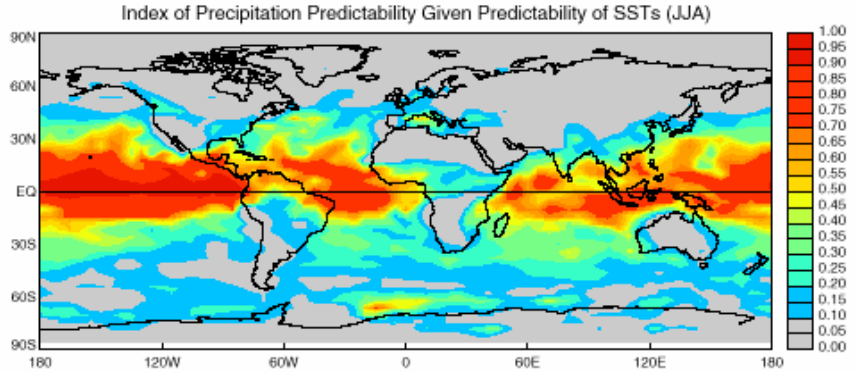
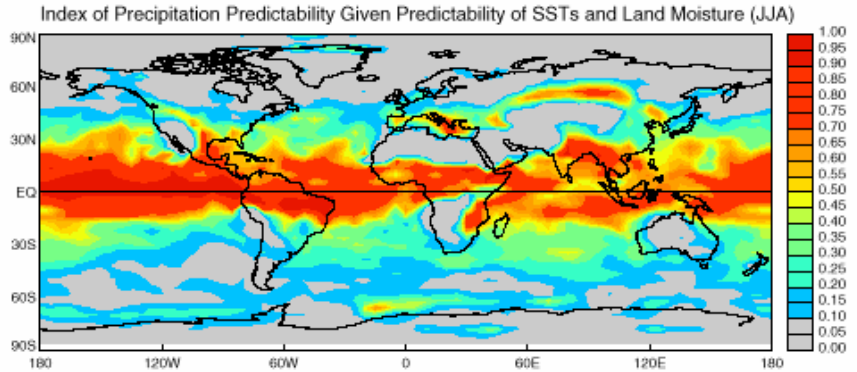
Why measure soil moisture from space?

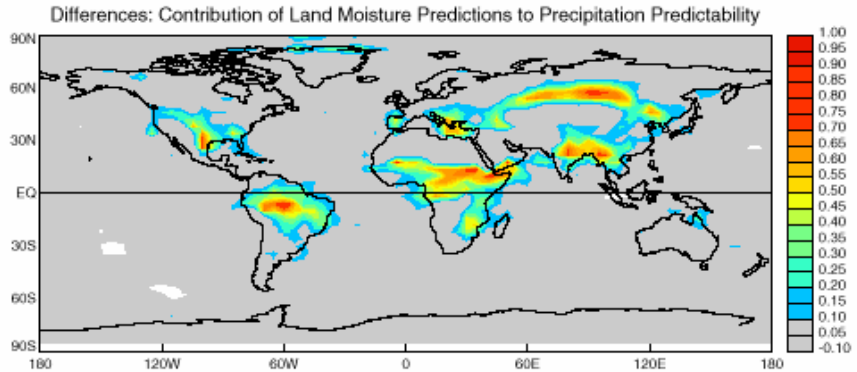
Soil moisture important for global climate and weather models.

Presently, soil moisture is guessed.

Unsatisfactory knowledge of soil moisture is presently considered to be the most important uncertainty in the models!







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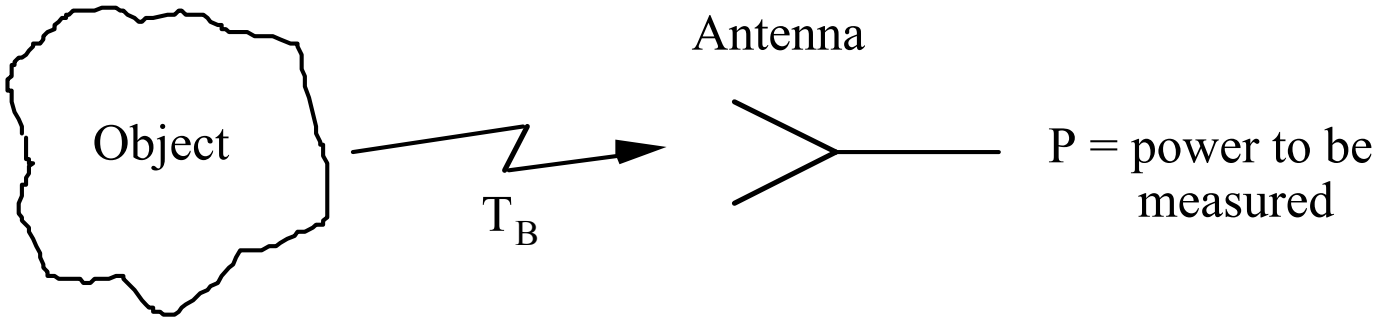
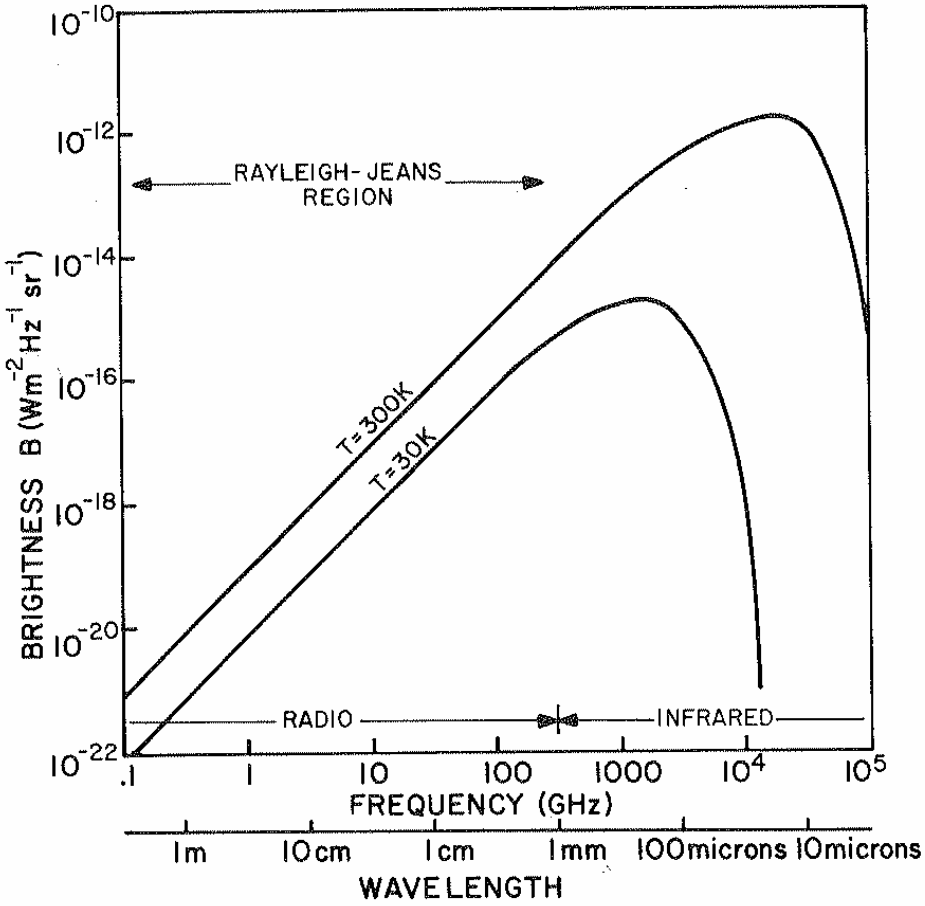
What is a Radiometer?



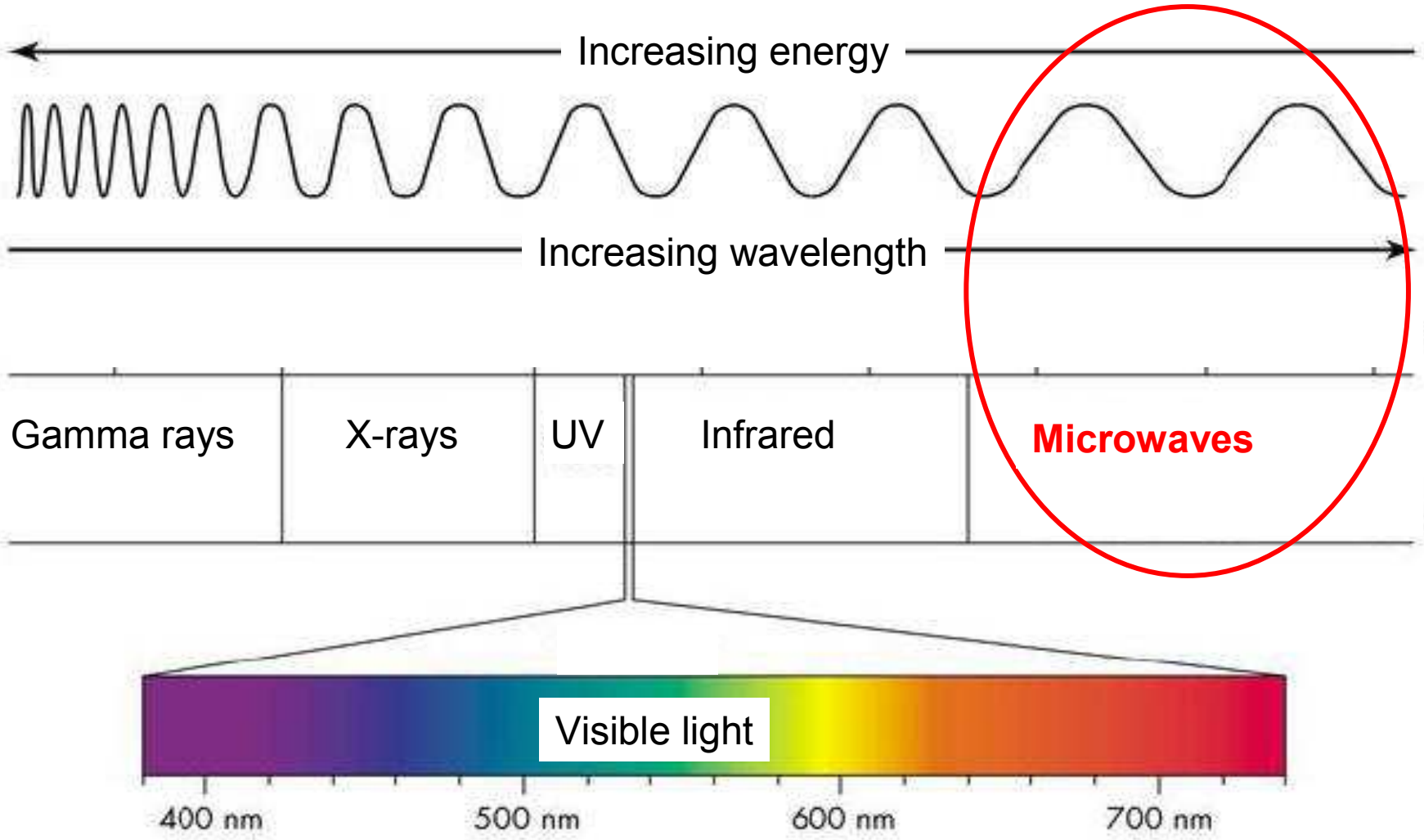
The radiometer is simply a calibrated receiver!

What kind of signals?

- radiated power follow Planck radiation law
- noise-like signal
  - we measure mean value as the so-called brightness temperature T_B
  - with a standard deviation known as the radiomtric resolution ΔT

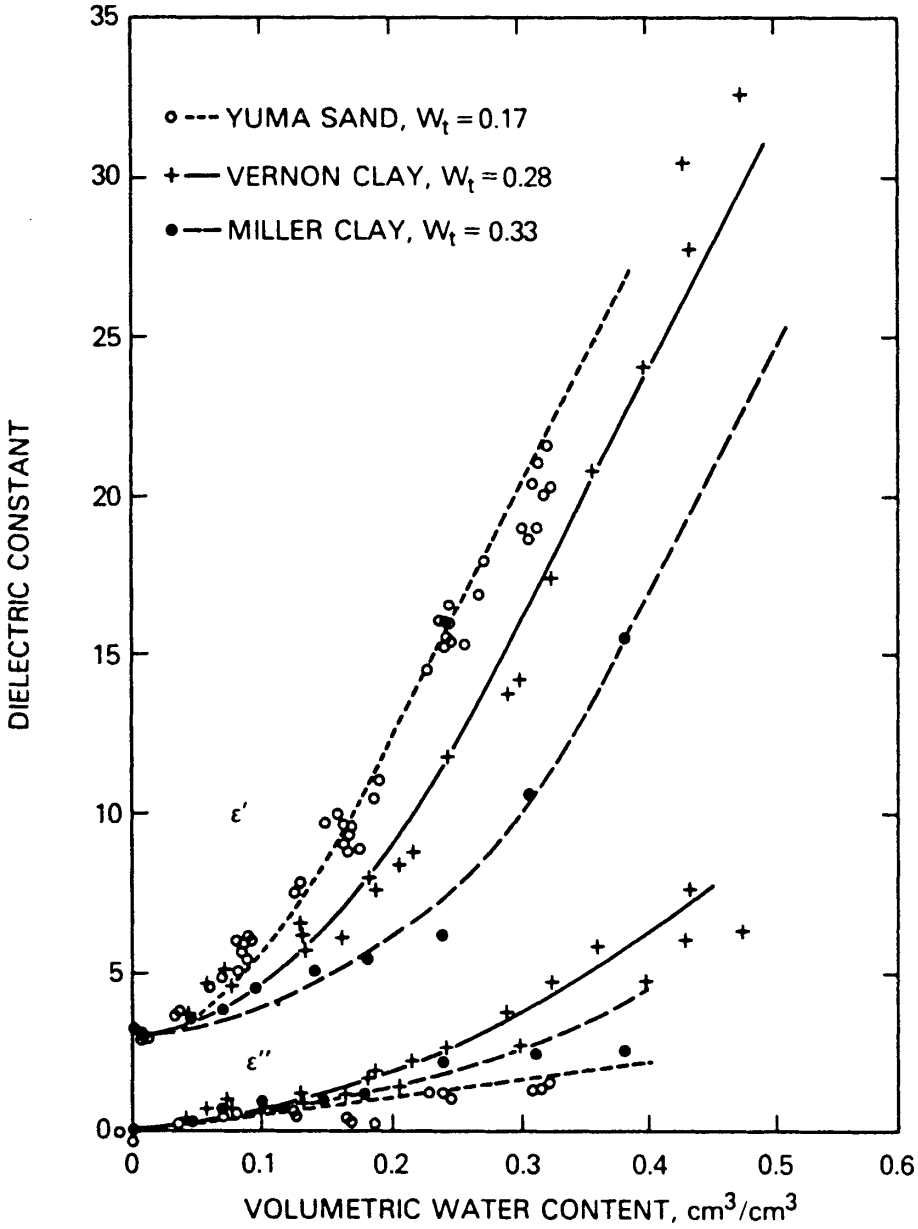


Radiation spectrum



- Good distinction between signal coming from water & signal coming from soil
- Good penetration through clouds and vegetation

L-band Measurements of Moist Soil



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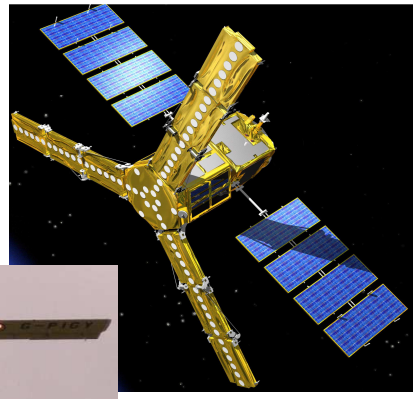
Measurement Situation

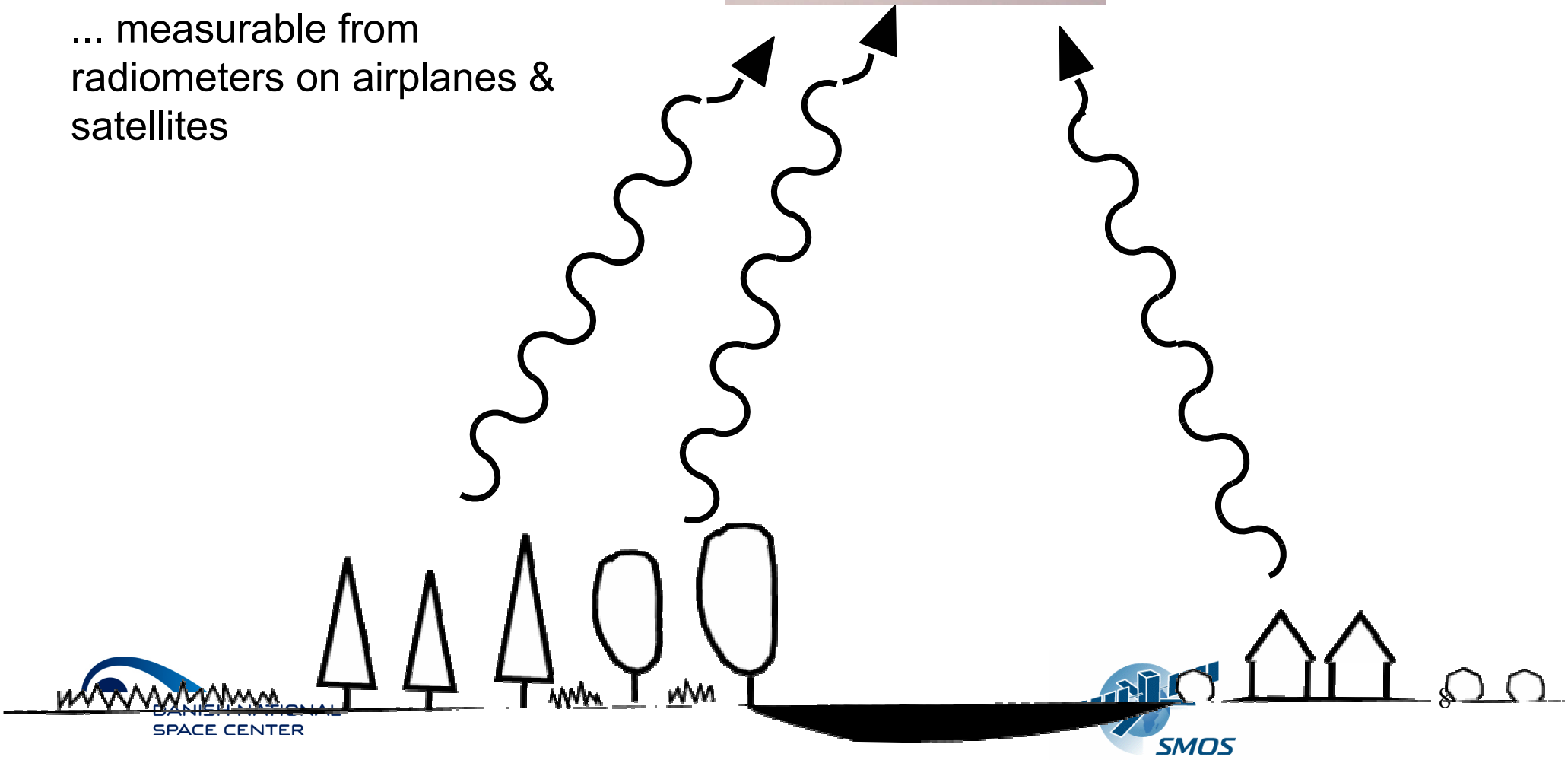
- In principle no problem: we can measure soil moisture remotely by L-band radiometers.
- What we measure is the top 5 cm soil layer.
- Antenna size / ground resolution is a problem
- From a typical orbit, a 10 m antenna will give around 50 km ground resolution
- This has been a technology challenge, hence no space mission - until now: SMOS is launched 2 November!
- About 50 km ground resolution fits well GCMs.
- Aircraft instruments have much better ground resolution.
- Aircraft measurements can help close gap between ground “truth” point measurements and coarse space measurements - Cal / Val activities.

Remote sensing measuring principle



Every body emits radiation...

... measurable from radiometers on airplanes & satellites



Skyvan Aircraft

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Antenna Horns on Skyvan

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Radiometer and Antennas in Skyvan

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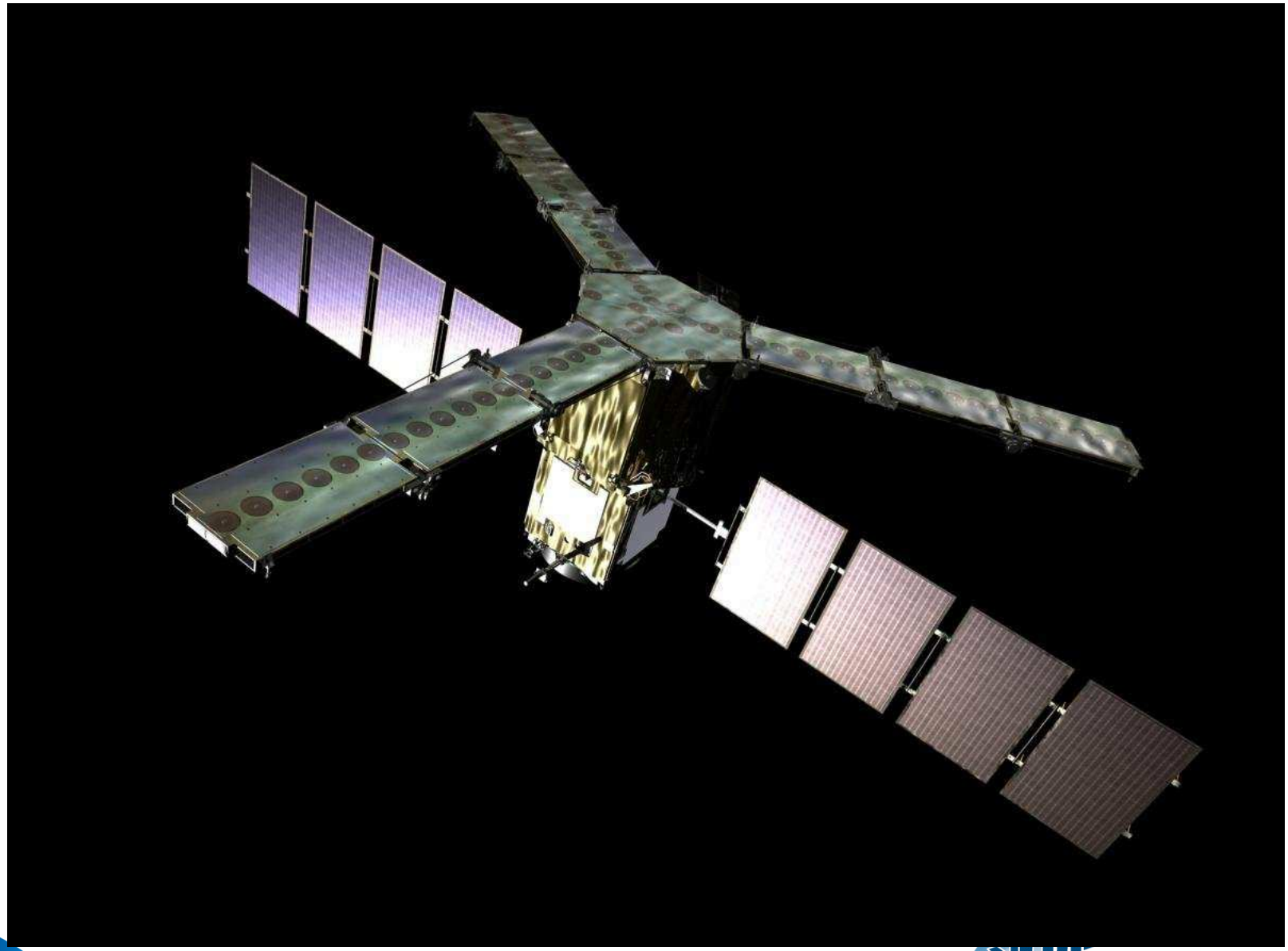
SMOS Layout



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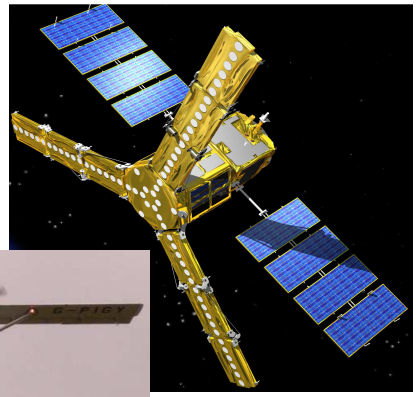
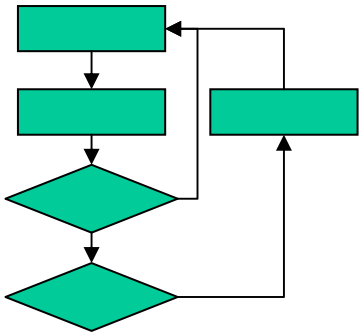
Remote sensing measuring principle (2)



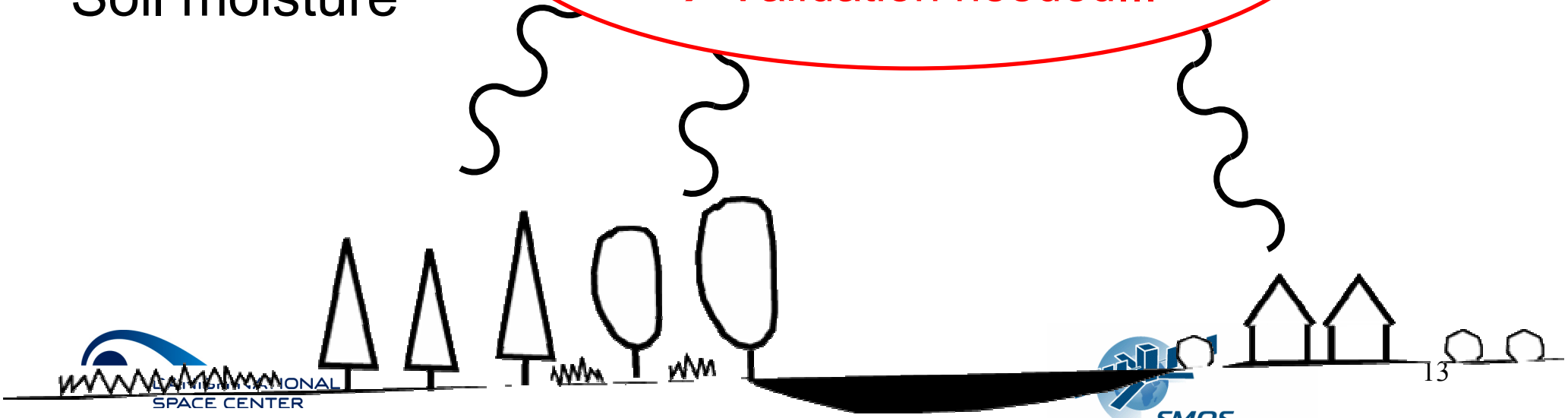


Retrieval algorithm

Soil moisture

Large spatial coverage, BUT indirect measurement

→ Validation needed...



From point scale to large scale...

Point soil moisture measurements
→ very important to study and understand hydrologic processes

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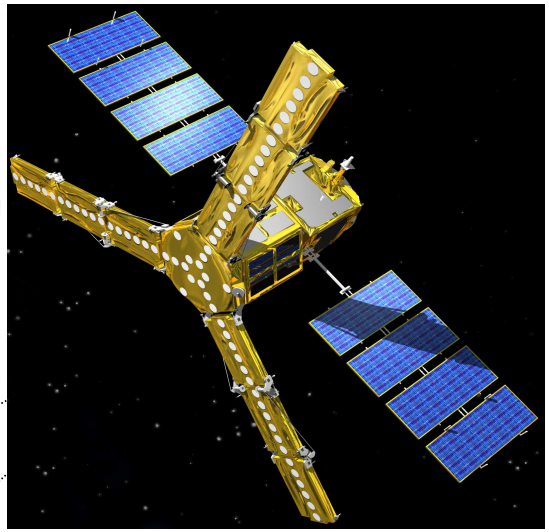
EMIRAD (DTU Space)



SMOS (ESA):
Launch Nov. 2009

few km

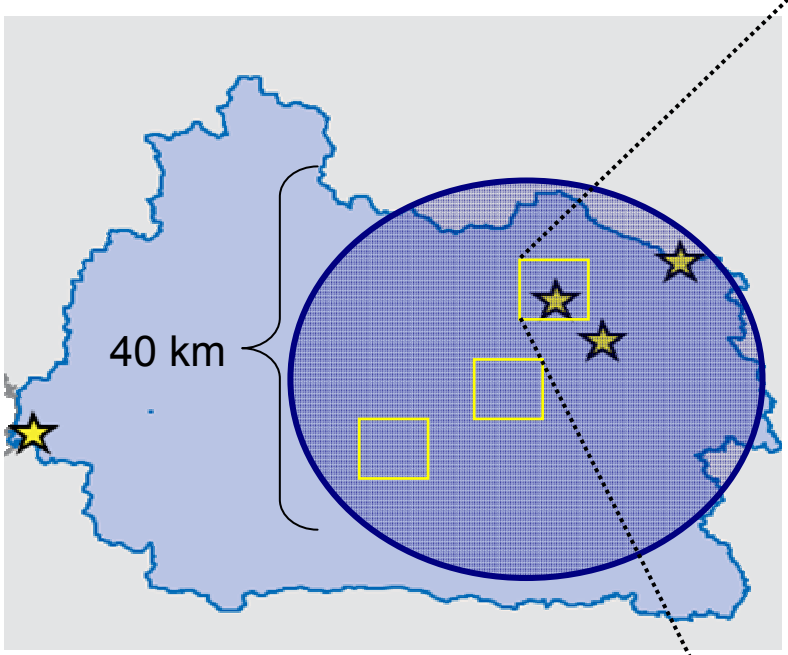
~ 40 km

0 25 50 100 km

Large scale soil moisture information
→ very important to assess water resources

Validation (1)

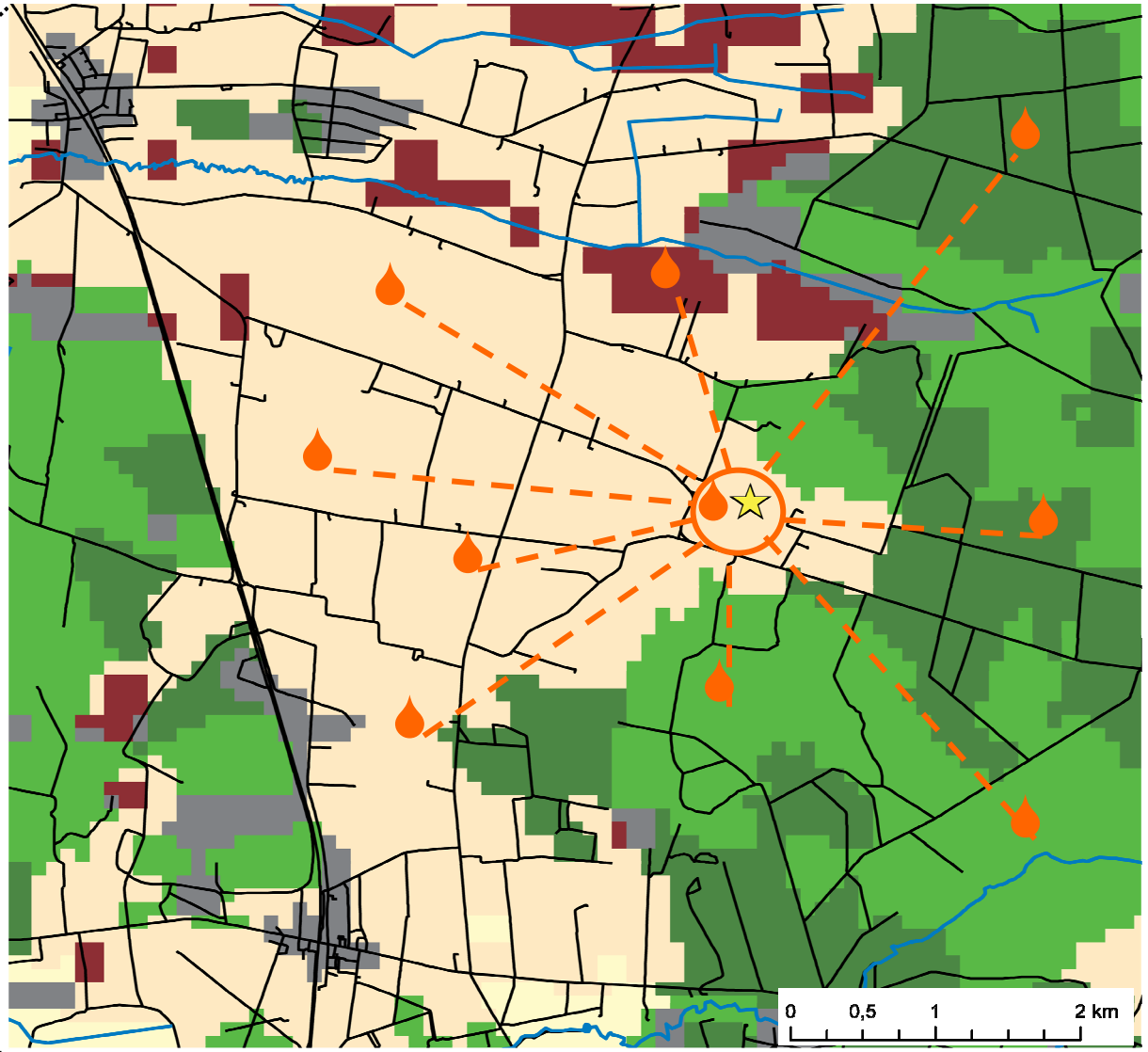
3 wireless soil moisture networks



Wireless connection

Logger

Receiver

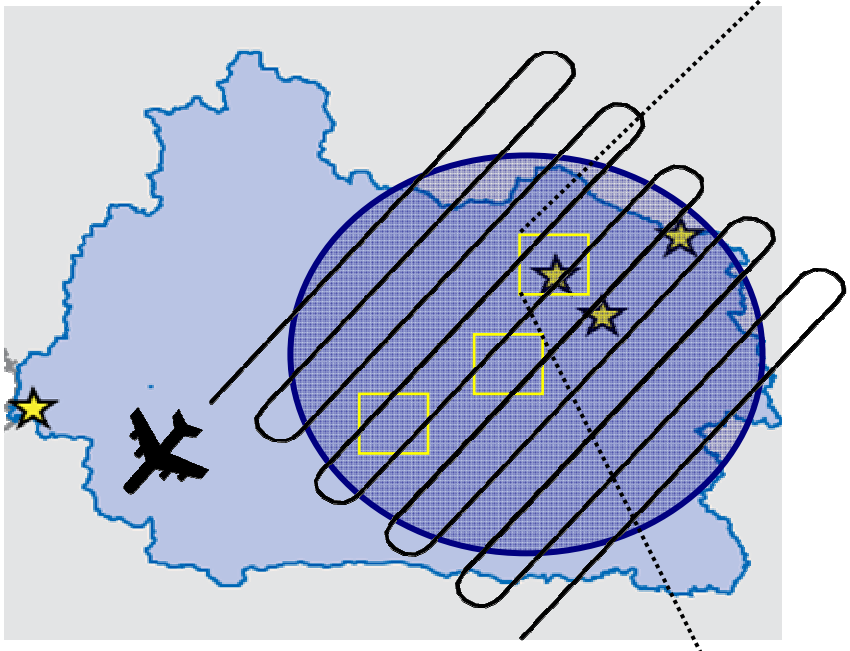


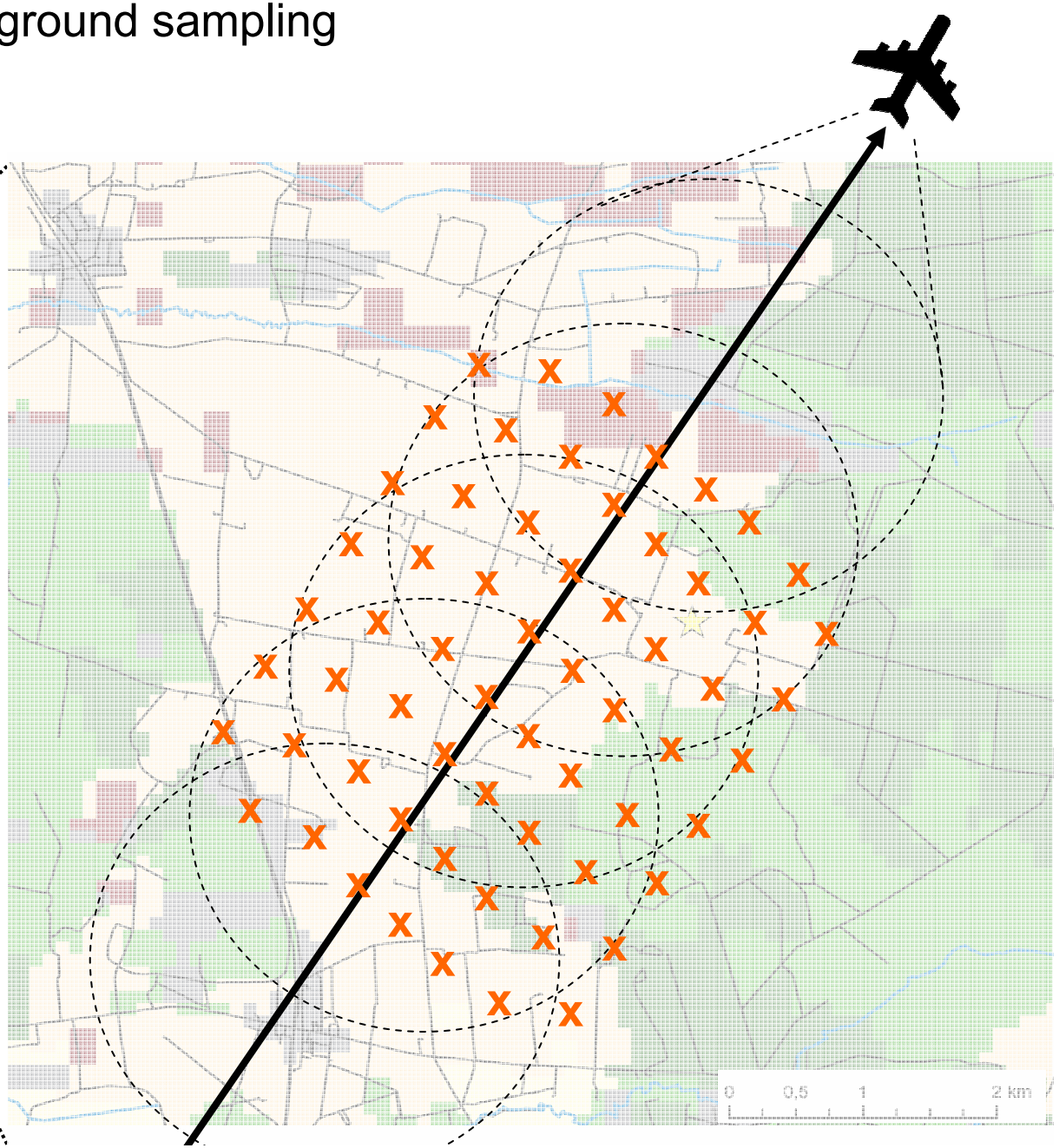
- Agriculture with sandy soil
- Nat. grass/heath with sandy soil
- Forest with sandy soil
- Not sampled classes
- Agriculture with organic soil

Validation (2)

Flight campaign with simultaneous ground sampling

Radiometer EMIRAD, DTU Space
~ 5 flights within 14 days
→ spring 2010





X dense ground sampling

Summary: Soil moisture measurements at 3 different scales

SMOS satellite data
(~40 km)

EMIRAD airborne data (few km)

Validation

Validation

Point measurements:

Dense sampling during flight campaign

&

Wireless soil moisture network

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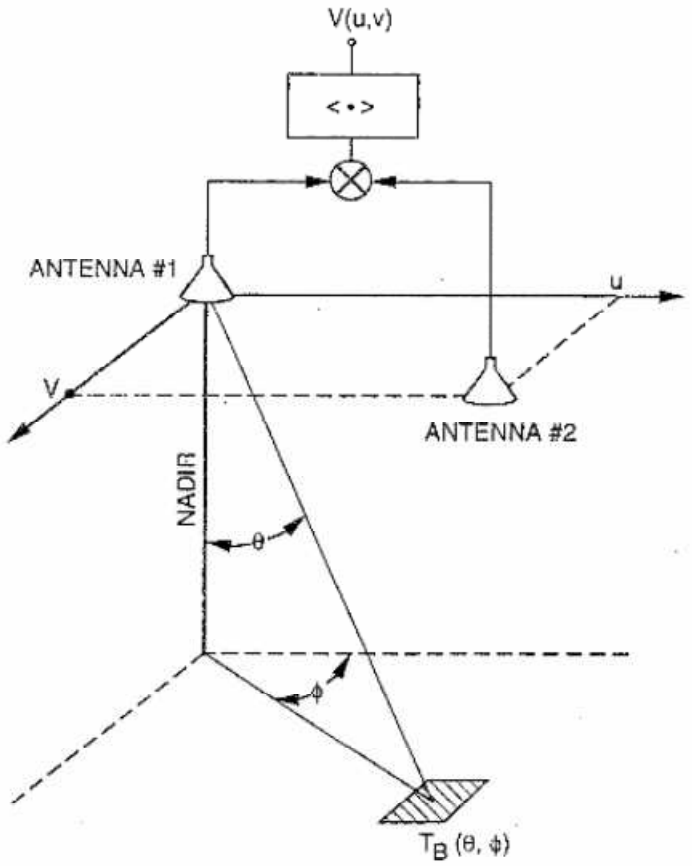
About SMOS

- SMOS is a synthetic aperture radiometer
- 69 antenna elements i Y shape
- All possible pairs of antennas correlated to give samples of the visibility function from which T_B map is calculated by an inverse Fourier transformation (ideal case)

Synthetic Aperture Radiometer Principle



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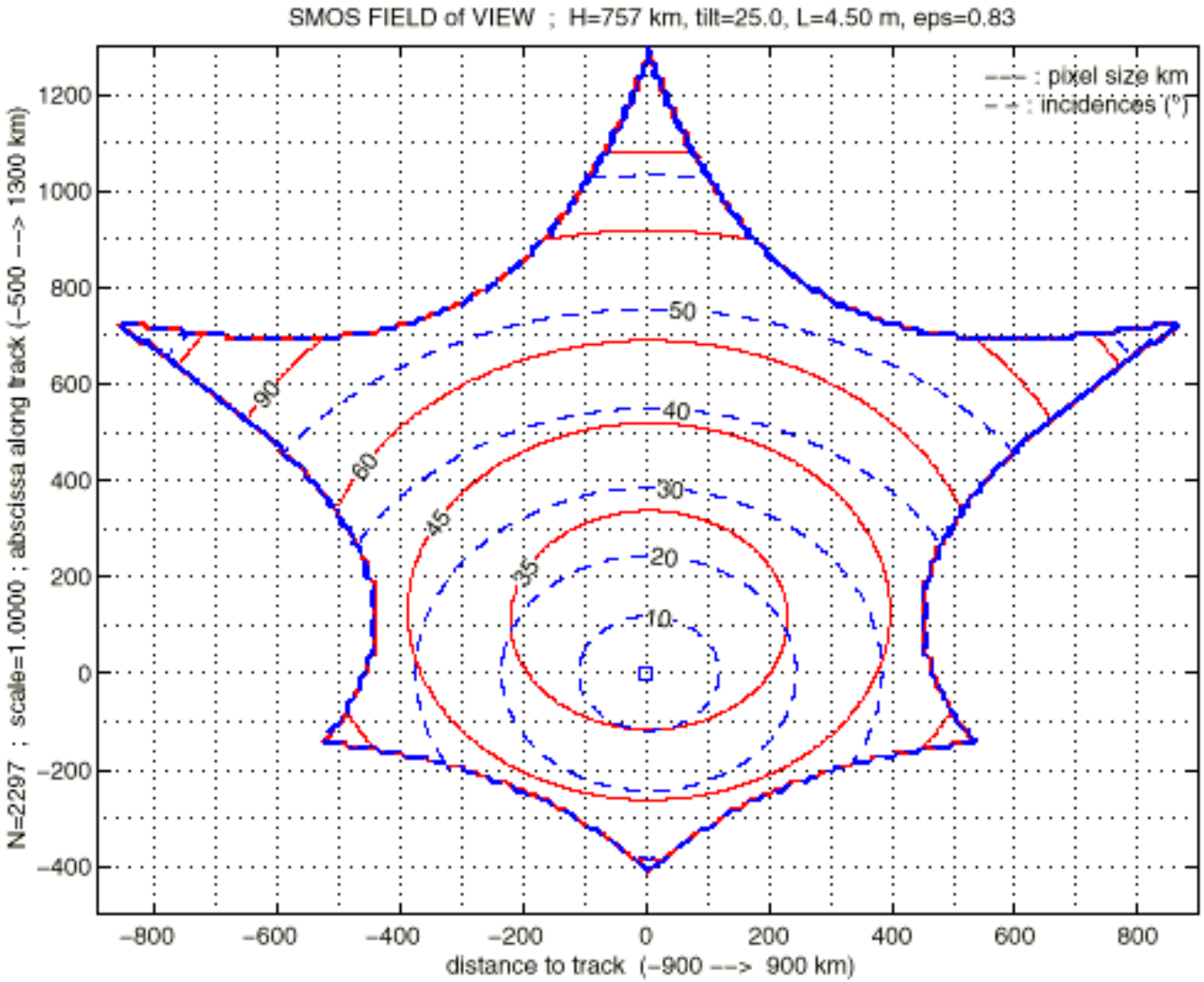
About SMOS

- SMOS is a synthetic aperture radiometer
- 69 antenna elements i Y shape
- All possible pairs of antennas correlated to give samples of the visibility function from which T_B map is calculated by an inverse Fourier transformation (ideal case)
- **Inspired by radio astronomer's interferometers**
- **Works as a "radio camera" - makes a full picture in one snapshot**
- **Arms are about 4.3 m long**
- **Same ground resolution as 9 m diameter traditional antenna dish**
- **Arms are "easy" to fold**

Illustration of SMOS Field-of-view



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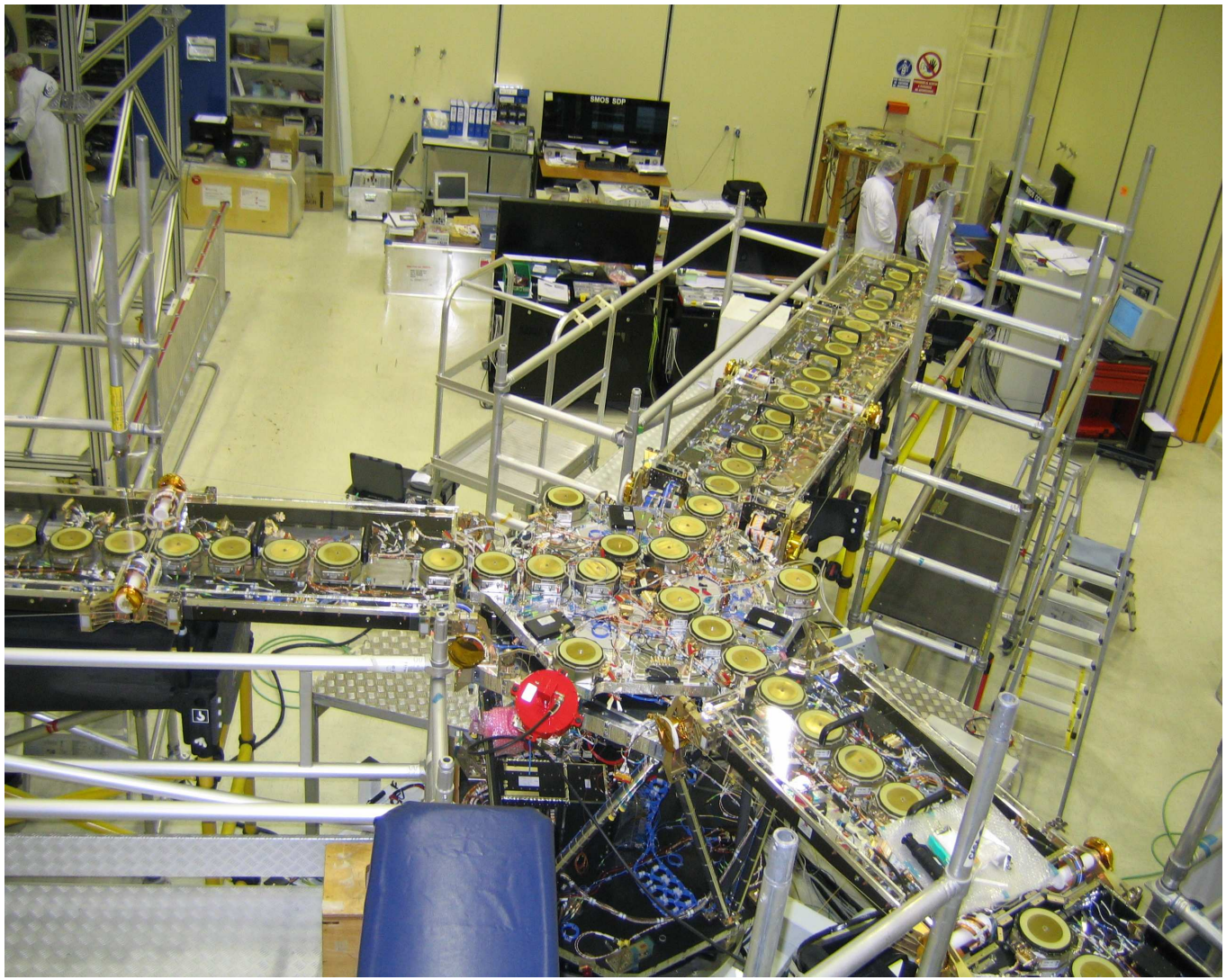
- Variable footprint (average is around 43 km)
- Variable incidence angle
- Narrow swath (around 800 km) with many incidence angles
- Wide swath (around 1200 km) with fewer incidence angles
- Altitude 757 km
- Snapshot integration time 1.2 sec
- Global coverage in 3 days
- Snapshot radiometric resolution 2 - 4 K

SMOS Being Built



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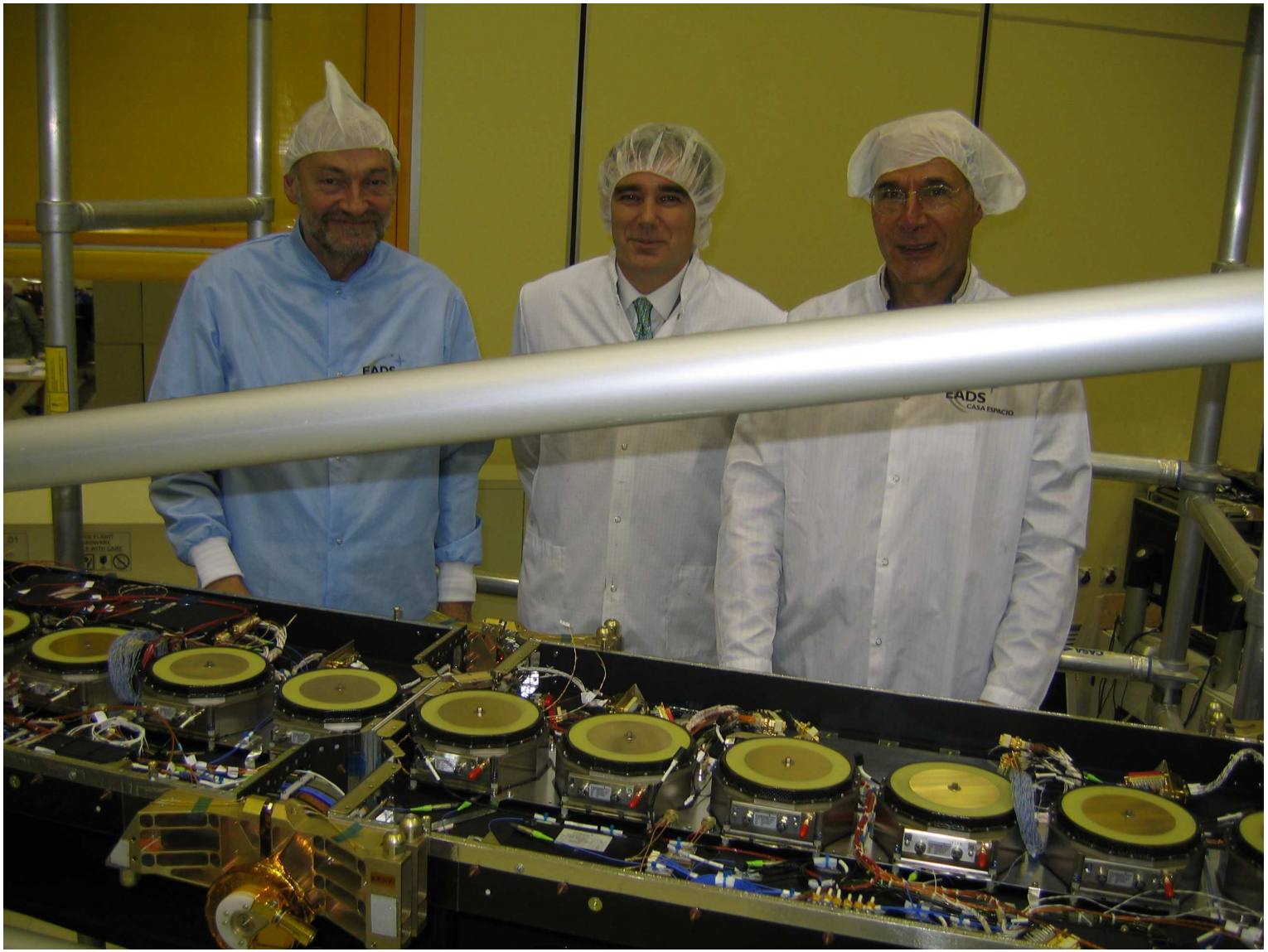
- and Being Checked!



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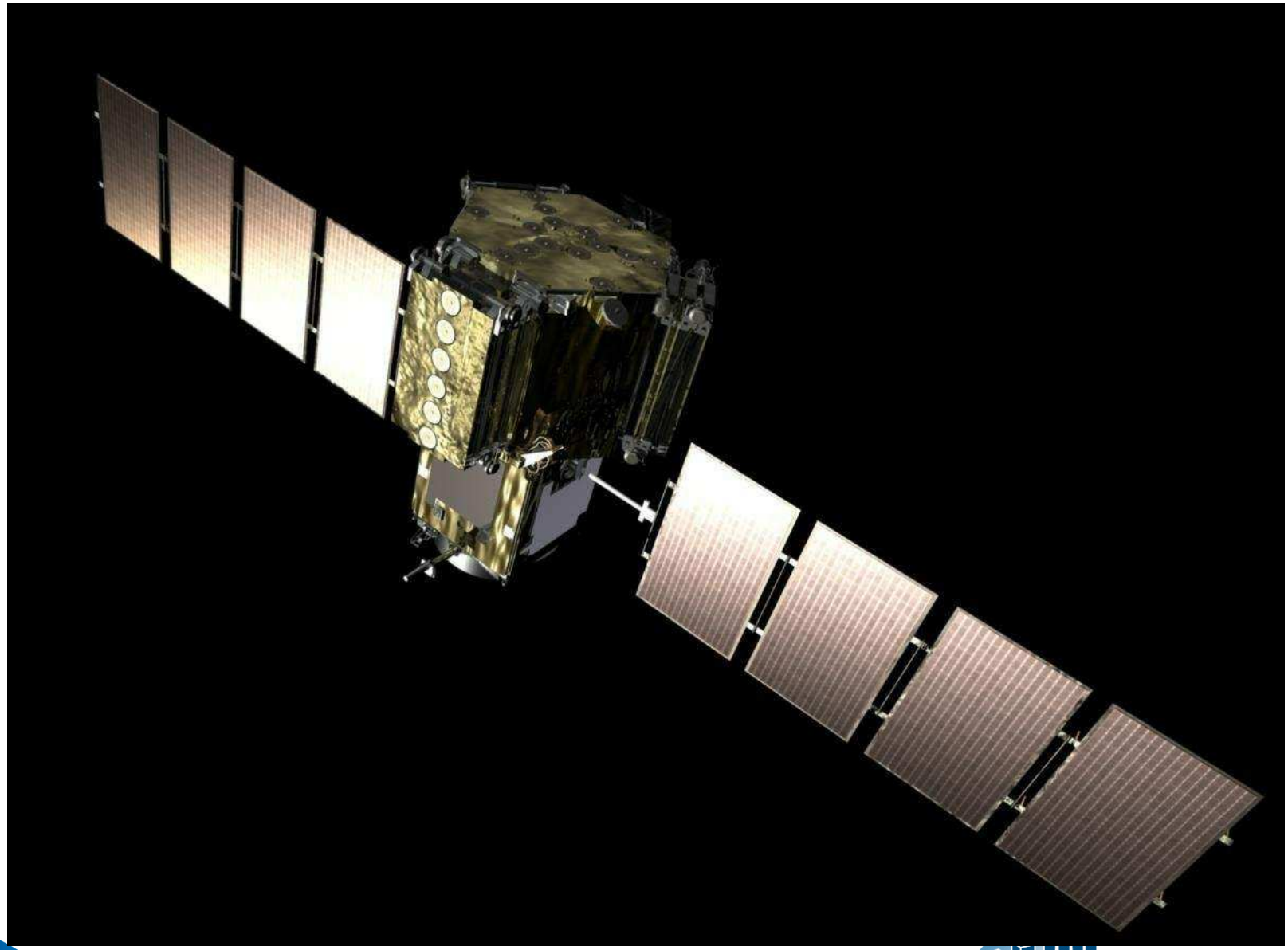
Deployment-1



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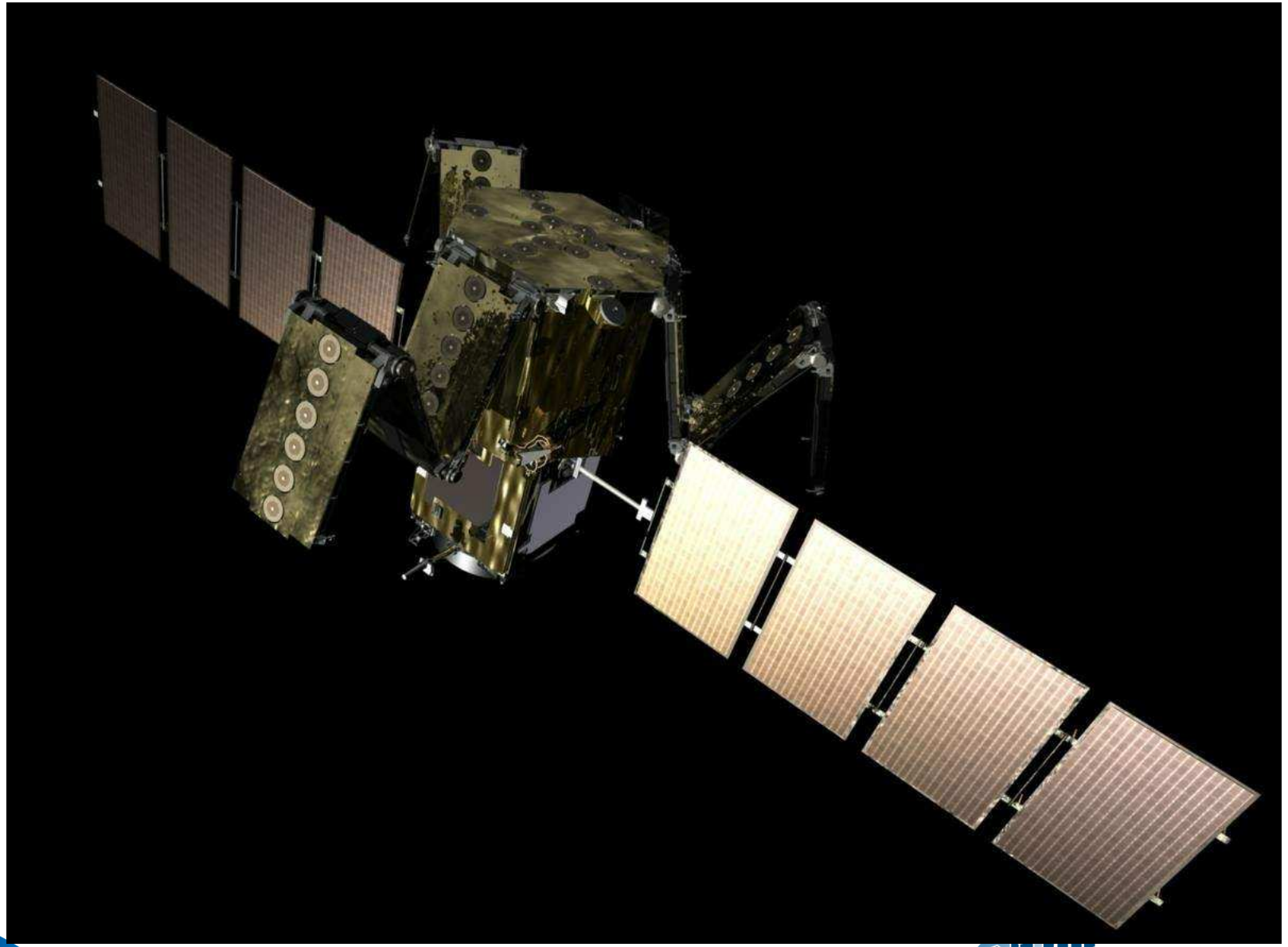
Deployment-2



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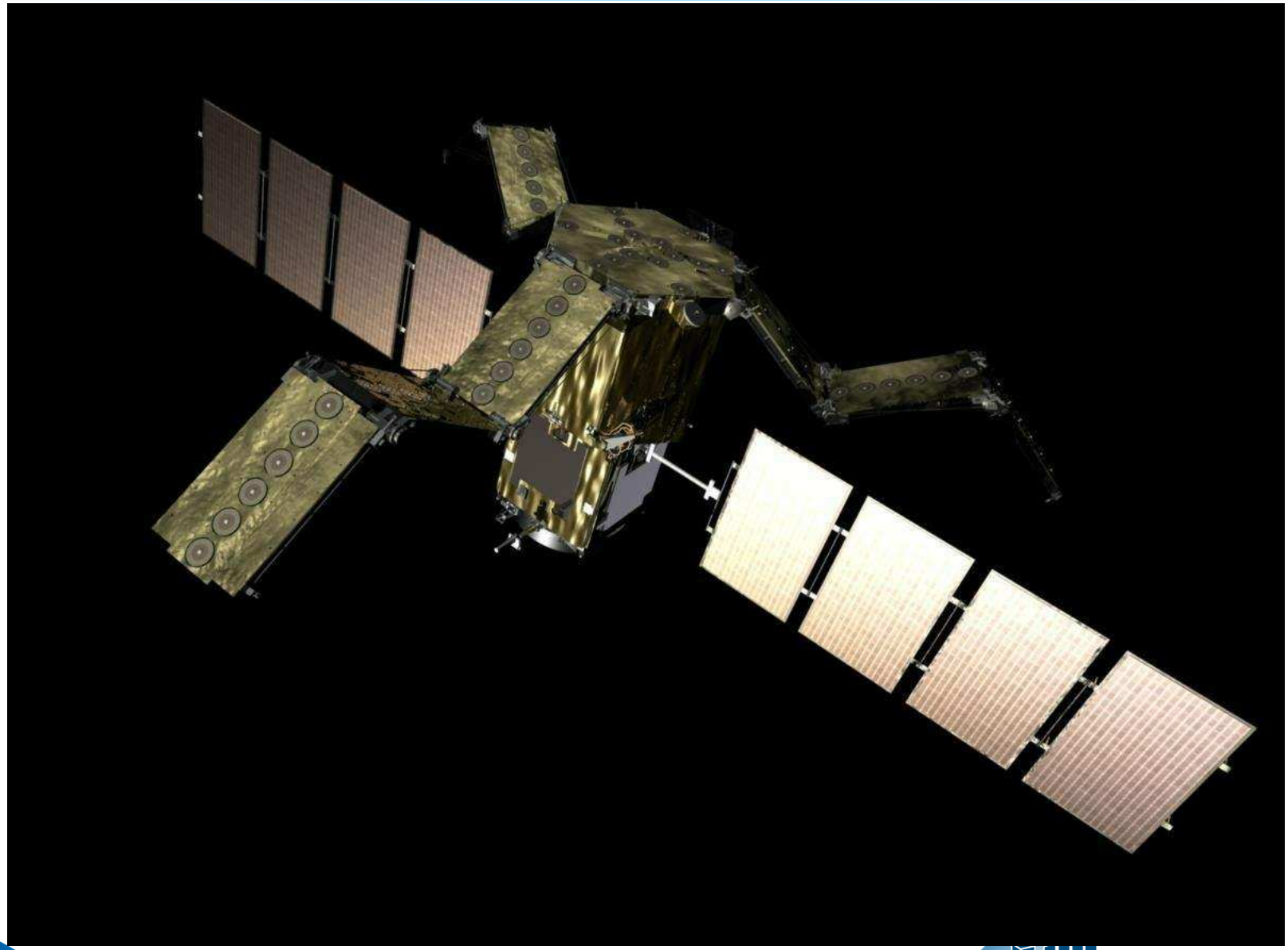
Deployment-3



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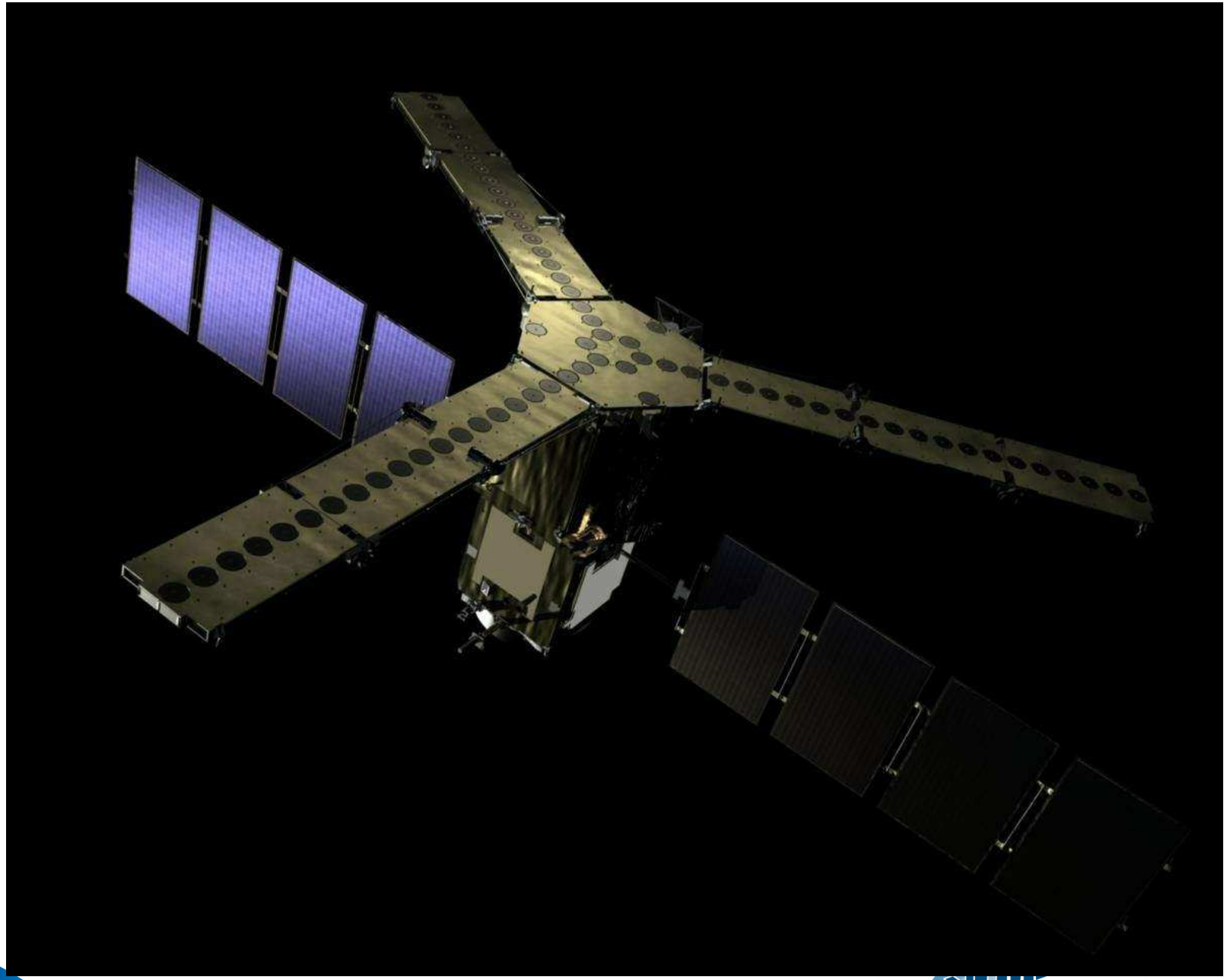

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