

# Keskkonna kaugseire I

Matti Mõttus (matti.mottus@aai.ee)

1. Sissejuhatus: kaugseire olemus ja meetodid 17.02
2. Kaugseire aparatuur, tooted, arengusuunad 3.03
3. Taimkatte kaugseire: indeksid ja algoritmid 10. 03
4. Vee kaugseire 17.03
5. Muud kaugseirerakendused 24.03
6. Seminar 31.03
7. Info leidmine ja kasutamine; kaugseire tulevik 07.04
8. **EKSAM**



Euroopa Liit  
Euroopa Sotsiaalfond



Eesti tuleviku heaks

# Keskkonna kaugseire

## Seitsmes loeng: mitmesugust

Matti Mõttus (matti.mottus@aai.ee)

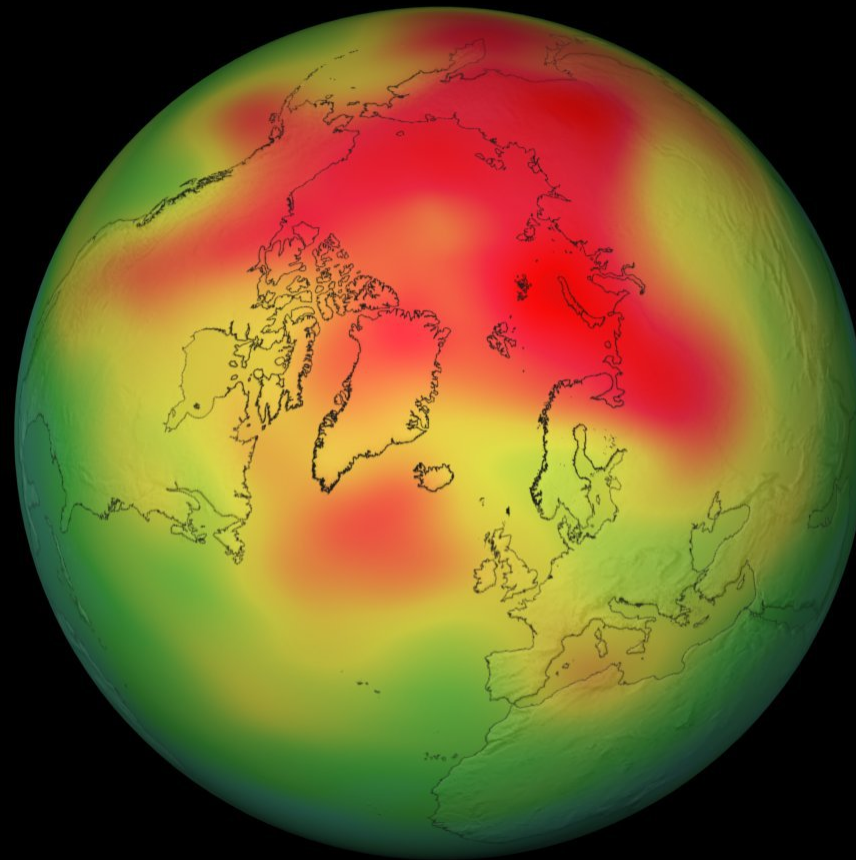
- Atmosfääri kaugseire
- Uuemad arengud
- Kaugseire Eestis
- **Eksam nädala pärast!**



# Atmosfäär kui uuritav objekt

- Atmosfääri olek
  - ilm (tuul, temperatuur, pilved,...)
- Atmosfääri keemiline koosseis
  - Veeaur
  - Osoon
  - Aerosool
  - Süsinikdioksiid ja -monooksiid
  - Muud gaasilised komponendid, sealhulgas ka teised kasvuhoonegaasid

GOME-2 / MetOp  
ANALYSED TOTAL  
OZONE COLUMN



Dobson Units  
[DU]

500

400

300

200

100



DLR



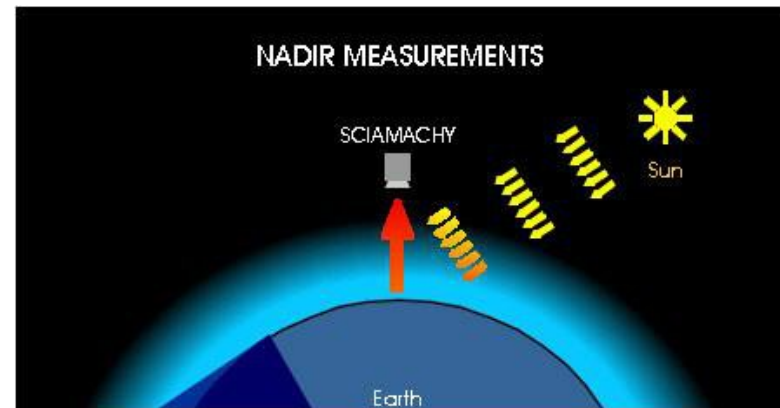
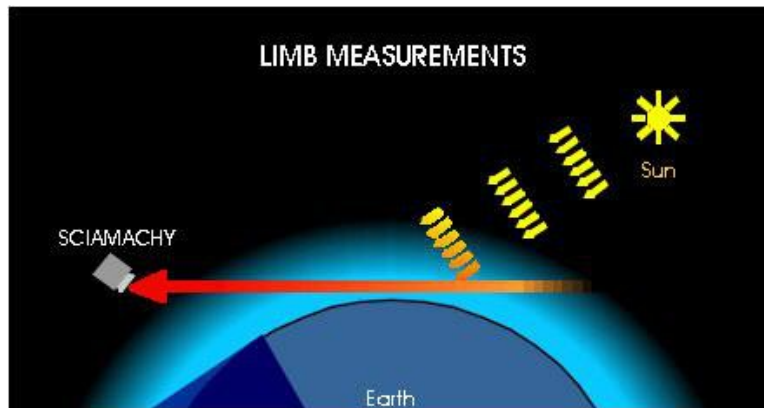
EUMETSAT

APR-04 -2009

<http://wdc.dlr.de>

- GOME (Global Ozone Monitoring Experiment)

# SCIAMACHY



- SCIAMACHY -SCanning Imaging Absorption spectroMeter for Atmospheric CartograpHY
- platvorm: ENVISAT
- Mõõdab troposfääri O<sub>3</sub>, CO, CH<sub>4</sub>, N<sub>2</sub>O, NO<sub>2</sub>, SO<sub>2</sub>, HCHO, H<sub>2</sub>O
- kaks vaatenurka: alla ja horisontaalselt (limb)

# SCHIAMACHY

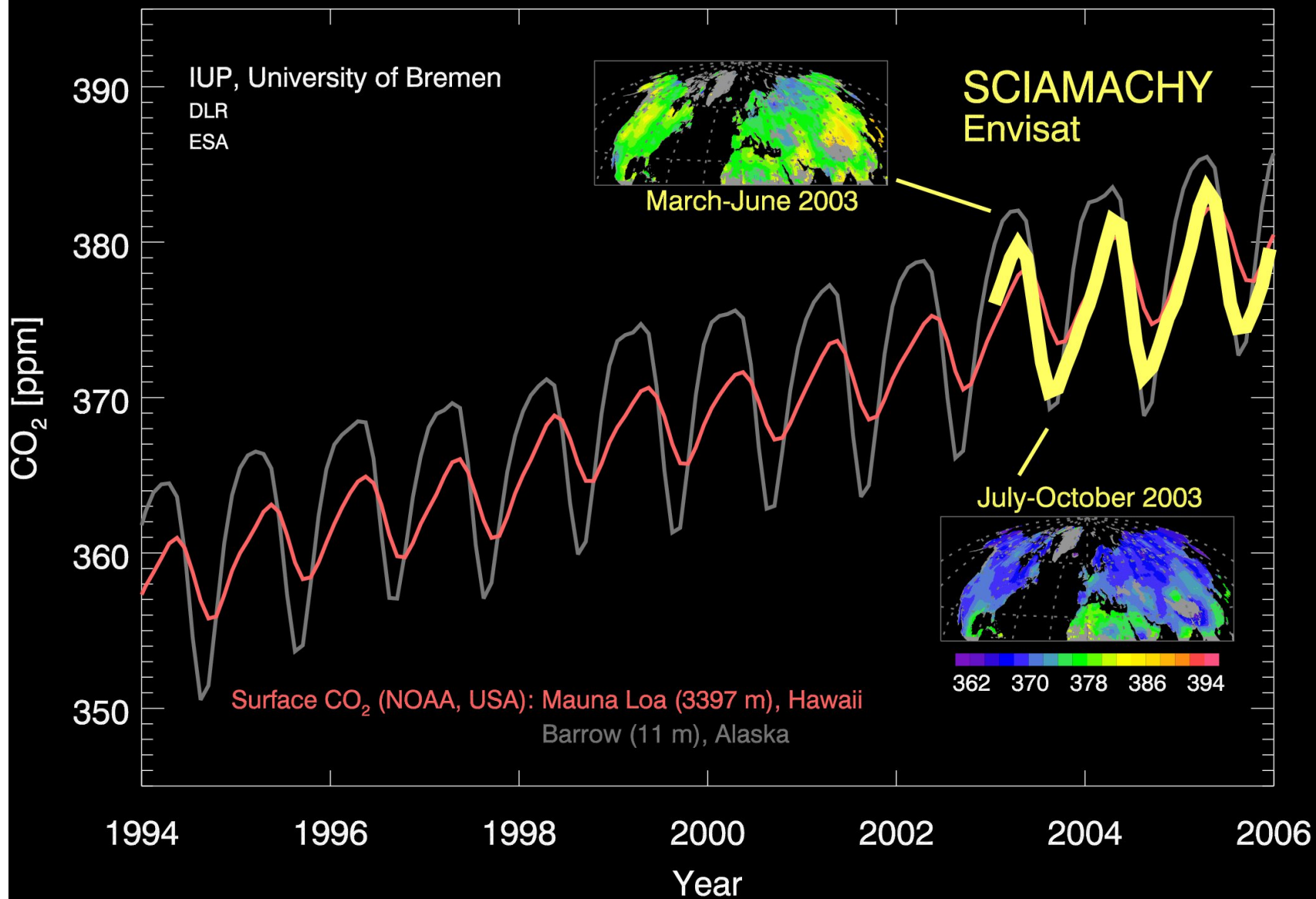
- Max. ruumiline horisontaalne lahutus 26 x 50 km, vertikaalne lahutus 2,6 km
- Tavaline lahutus 32 x 215 km
- Spektromeeter: 8 piirkonda UV-SWIR:
  - 240–314 nm (lahutus 0,24 nm)
  - 309–405 nm (0,26 nm)
  - 394–620 nm (0,44 nm)
  - 604–805 nm (0,48 nm)
  - 785–1050 nm (0,54 nm)
  - 1000–1750 nm (1,48 nm)
  - 1940–2040 nm (0,22 nm)
  - 2265–2380 nm (0,26 nm)
- polarisatsiooni mõõtmine
- radiomeetriline kalibratsioon < 4%



Kuu SCIAMACHY poolt läbi atmosfääri nähtuna. Valguse murdumine muudab kuuketta lapikuks



# Atmospheric Carbon Dioxide (CO<sub>2</sub>)

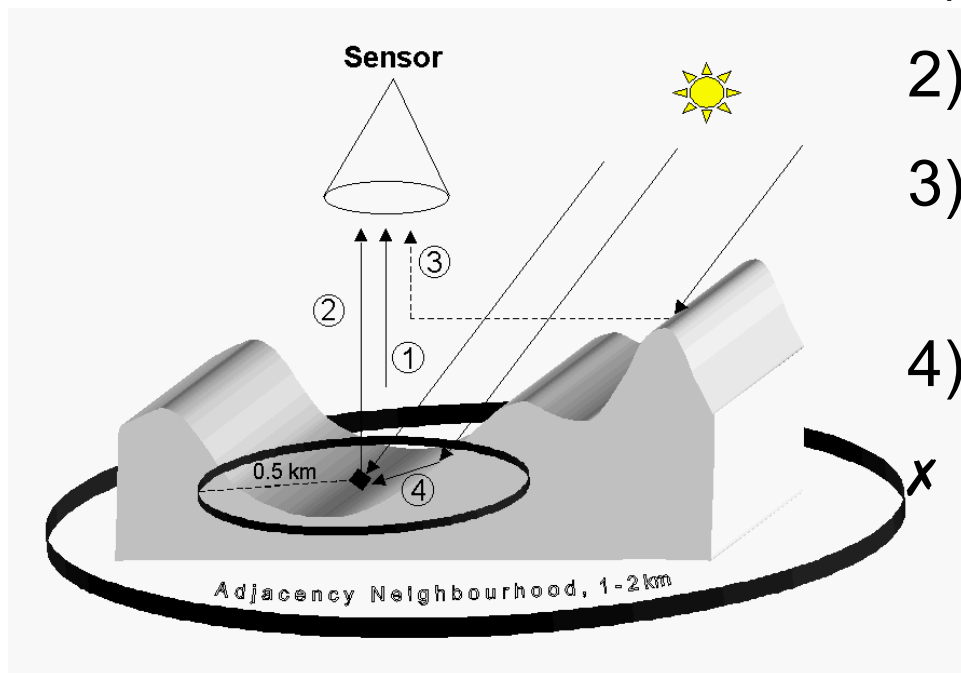




# Atmosfäär kui segav objekt

- Tumedate objektide (vesi, taimkate) kohal on suurem osa signaalist pärit atmosfäärist
  - Otsene atmosfäärimõju (atmosfäär neelab ja hajutab päikesevalgust, neelab objektilt peegeldunud valgust)
  - Naabrusefekt (objekti heledus oleneb ümbritsevate objektide heledusest)
- Empiirilised ja **füüsikalised** meetodid
  - 6S (Second Simulation of the Satellite Signal in the Solar Spectrum)
  - Modtran (ja atcor jpt)
- Lisaks probleemiks pilved, pilvede varjud jne

# Atmosfääri signaal



1) ☀️ → atmosfäär → 😊

2) ☀️ → objekt → 😊

3) ☀️ → muu objekt → atmosfäär  
→ 😊 :naabrusefekt

4) ☀️ → muu objekt → objekt → 😊

☀️ → objekt → atmosfäär

5) ☀️ → atmosfäär → objekt → 😊 :hajuskiirgus

😊 : vastuvõtja (sensor)

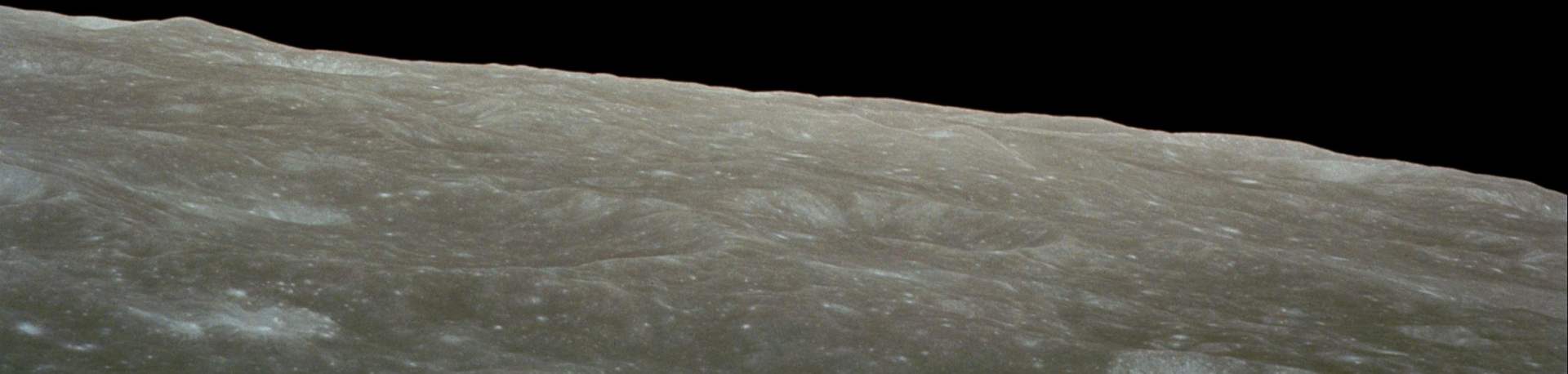
# AERONET

- AErosol RObotic NETwork
- Päikese-fotomeetrid, tüüpiliselt CIMEL CE-318
- 440, 670, 870, 1020 nm kanalid aerosooli hindamiseks
- 940 nm veeauru hindamiseks (veeauru neeldumisriba)
  - päikese otsene kiirgus absoluutsetes ühikutes
  - taeva heledust päikese almukantaraadil ja vertikaalil
- Enam kui 300 jaama üle maakera, ka Tõraveres
- Andmed internetis <http://aeronet.gsfc.nasa.gov/>
- Väljundid
  - Aerosooli osakeste optilised parameetrid
  - Veeauru hulk

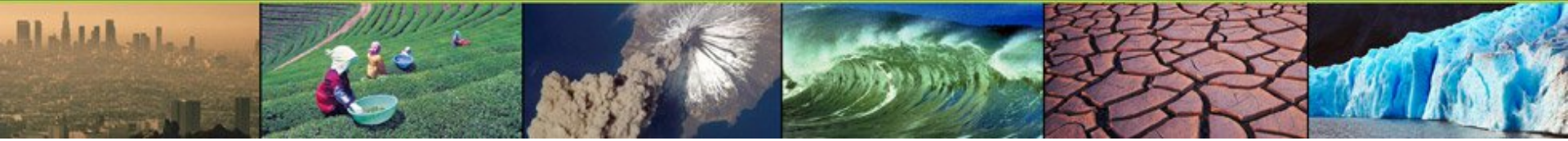


# Suurem pilt

- organisatsioonid
- tulevikuplaanid
- tegevusest Eestis



# CEOS Committee on Earth Observation Satellites



- CEOS was established in 1984, in response to a recommendation from a Panel of Experts on Remote Sensing from Space, under the aegis of the G7 Economic Summit of Industrialised Nations Working Group on Growth, Technology and Employment.  
<http://www.ceos.org>
- Liikmed: kosmoseuringutega tegelevad asutused (NASA, WMO jt)



# GEO ja GEOSS

- The Group on Earth Observations is coordinating efforts to build a Global Earth Observation System of Systems, or GEOSS.
- GEO was launched in response to calls for action by the 2002 World Summit on Sustainable Development and by the G8 (Group of Eight) leading industrialized countries.
- <http://www.earthobservations.org/>



GEO, March 2009

- 77 Governments and the European Commission
- 56 intergovernmental, international, and regional organizations



# GMES

- Global Monitoring for the Environment and Security
- GMES will be the European programme implementing an Earth observation service system with satellites, sensors on the ground, floating in the water or flying through the air to monitor our planet's environment and to support the security of every citizen.
- GMES represents a concerted effort to bring data and information providers together with users, so they can better understand each other and make environmental and security-related information available to the people who need it through new enhanced services.

[http://ec.europa.eu/gmes/index\\_en.htm](http://ec.europa.eu/gmes/index_en.htm)





# Tulevikusuunad: ESA Sentinels

- Sentinel-1 is a polar-orbiting radar imaging mission for GMES land and ocean services. The first Sentinel-1 satellite is planned for launch at the end of 2011.
- Sentinel-2 is a polar-orbiting, multispectral high-resolution imaging mission for GMES land monitoring to provide, for example, imagery of vegetation, soil and water cover, inland waterways and coastal areas. The first Sentinel-2 satellite is planned for launch at the end of 2012.
- Sentinel-3 is a multi-instrument mission to determine parameters such as sea-surface topography, sea- and land-surface temperature, ocean colour and land colour with high-end accuracy and reliability. The first Sentinel-3 satellite is planned for launch at the end of 2012.

# Tulevikusuunad: ESA Sentinels

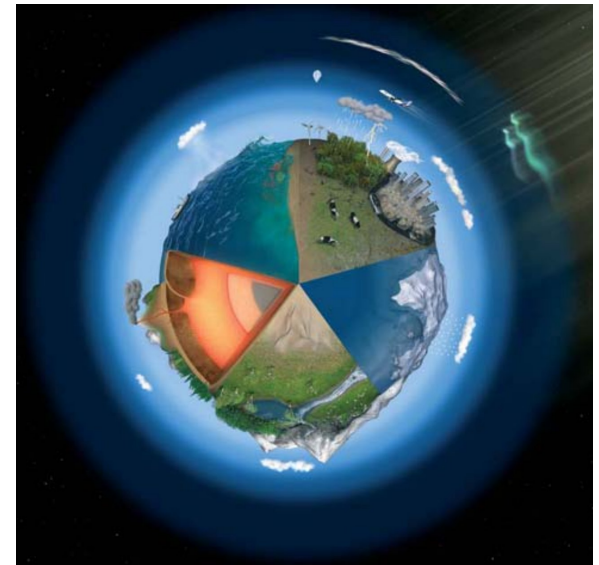
- Sentinel-4 is a payload that will be embarked upon a Meteosat Third Generation (MTG) satellite in geostationary orbit and launched in 2017. Sentinel-4 is devoted to atmospheric monitoring.
- Sentinel-5 is a payload will be embarked on a post-EUMETSAT Polar System (EPS) spacecraft and launched in 2019. A Sentinel-5 precursor mission is planned to launch in 2014, to avoid data gaps between Envisat (Sciamachy data in particular) and Sentinel-5. This mission will be devoted to atmospheric monitoring.

<http://earth.esa.int/missions/>

# ESA Earth Explorers

- Core missions:
  - GOCE (Gravity field and steady-state Ocean Circulation Explorer) was placed in orbit on 17 March 2009.
  - ADM-Aeolus (Atmospheric Dynamics Mission) measures vertical wind profiles from space, using a high performance Doppler Wind Lidar. Due for launch in 2011.
  - EarthCARE (Earth Clouds Aerosols and Radiation Explorer): Earth's radiative balance in climate and numerical forecast models. Due for launch in 2013.

The Changing Earth. July  
2006, ESA SP-1304.



# ESA Earth Explorers

- Opportunity missions:
  - SMOS (Soil Moisture and Ocean Salinity): two-dimensional interferometer for acquiring brightness temperature observations at L-band (1.4 GHz) for the estimation of soil moisture and ocean salinity (2009)
  - CryoSat-2: SAR altimeter (SIRAL), 2009
  - Swarm: geomagnetic field and its temporal evolution (2010)
- Future: 3 candidate missions undergoing Feasibility Study.
  - BIOMASS –P-band SAR to take global measurements of forest biomass.
  - CoReH2O (Cold Regions Hydrology High-resolution Observatory – to make detailed observations of key snow, ice and water cycle characteristics.
  - PREMIER (PRocess Exploration through Measurements of Infrared and millimetre-wave Emitted Radiation) – to understand processes that link trace gases, radiation, chemistry and climate in the atmosphere.

# Tulevikusuunad: NASA

EARTH SCIENCE AND  
APPLICATIONS FROM SPACE

**Decadal Survey 2007**

NATIONAL IMPERATIVES FOR  
THE NEXT DECADE AND  
BEYOND

Committee on Earth Science and Applications  
from Space: A Community Assessment and  
Strategy for the Future  
Space Studies Board  
Division on Engineering and Physical Sciences  
NATIONAL RESEARCH COUNCIL OF THE  
NATIONAL ACADEMIES



TABLE II.2 Launch, Orbit, and Instrument Specifications for Missions Recommended to NASA

Decadal Survey Mission	Mission Description	Orbit <sup>a</sup>	Instruments	Rough Cost Estimate (FY 06 \$million)
<b>2010-2013</b>				
CLARREO (NASA portion)	Solar and Earth radiation; spectrally resolved forcing and response of the climate system	LEO, Precessing	Absolute, spectrally resolved interferometer	200
SMAP	Soil moisture and freeze-thaw for weather and water cycle processes	LEO, SSO	L-band radar L-band radiometer	300
ICESat-II	Ice sheet height changes for climate change diagnosis	LEO, Non-SSO	Laser altimeter	300
DESDynI	Surface and ice sheet deformation for understanding natural hazards and climate; vegetation structure for ecosystem health	LEO, SSO	L-band InSAR Laser altimeter	700
<b>2013-2016</b>				
HyspIRI	Land surface composition for agriculture and mineral characterization; vegetation types for ecosystem health	LEO, SSO	Hyperspectral spectrometer	300
ASCENDS	Day/night, all-latitude, all-season CO <sub>2</sub> column integrals for climate emissions	LEO, SSO	Multifrequency laser	400
SWOT	Ocean, lake, and river water levels for ocean and inland water dynamics	LEO, SSO	Ka- or Ku-band radar Ku-band altimeter Microwave radiometer	450
GEO-CAPE	Atmospheric gas columns for air quality forecasts; ocean color for coastal ecosystem health and climate emissions	GEO	High-spatial-resolution hyperspectral spectrometer Low-spatial-resolution imaging spectrometer IR correlation radiometer	550
ACE	Aerosol and cloud profiles for climate and water cycle; ocean color for open ocean biogeochemistry	LEO, SSO	Backscatter lidar Multiangle polarimeter Doppler radar	800

2016-2020

# Tulevikusuunad: muud

- EnMAP: German Hyperspectral Satellite Mission
  - 2012 alguses?
  - [www.enmap.org](http://www.enmap.org)
- Prisma: itaallaste pildispektromeeter
  - 2011???
- FLEX (FLuorescence EXplorer)
  - ESA tehnoloogiademonstraator, 2011?
- Pléiades: SPOTi järeltulija (Prantuse-Itaalia), 2010
- SEOSAT-INGENIO: Hispaania SPOTi-sarnane multispektraalne (2012)



# Tulevikusuunad: Eesti

- EstCube <http://www.estcube.eu/>
- EstSpace <http://www.estspace.ee/>
- Enterprise Estonia – Carrying the Role of Estonian Space Office
  - <http://www.eas.ee/space>
  - 20. juunil 2007 allkirjastatud leping ESAga
- LOFY.01.044 Kosmosetehnoloogia kursus on sügissemestril, teisipäeviti kell 14-16. Kõik huvilised on teretulnud. Muuhulgas räägib ilmselt Jaan Praks radarkaugseirest, Anu GMES programmist, Ene Ergma Eesti kosmosepoliitikast

# Eksam!

- Suuline eksam, vajalik praktikumi arvestuse sooritamine
- Kuupäev: 14., 17. ja 21. aprill
- Registreerumine internetis (kuupäev, kellaaeg)
- Eksamiküsimused homsest ÕISis