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FinCOSPAR 2013 – Abstracts
29–30th August, Vantaa, Finland

Erkki Tomppo, Sini Merikallio and Irene Murtovaara (eds.)

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Abstract

The Committee on Space Research (COSPAR) was established by the International Council for Science (ICSU) in 1958 "as an interdisciplinary scientific body concerned with the progress on an international scale of all kinds of scientific investigations carried out with space vehicles, rockets and balloons". Finland became a member of COSPAR a few years later, on June 2, 1964. The first Finnish space science conference was organized in 1987 at Hotel Rantasipi Hyvinkää. Since then, multiple FinCOSPAR meetings have brought together space scientists in Finland to venues from the southern seas to North Finland. The XIV meeting, FinCOSPAR 2013 takes place at the premises of the Finnish Forest Research Institute, METLA, in Tikkurila, Vantaa. The link to space sciences of this new venue is the operational use of space-borne remote sensing in monitoring forests.

The presentations of FinCOSPAR 2013 include various corners of the space sciences, varying from space-borne remote sensing of the Earth to the planetary sciences and deep sky observations. The program consists of four invited presentations and 48 contributed talks or posters. Furthermore, the strategy by Tekes – the Finnish Funding Agency for Technology and Innovation for space activities for years 2013–2020 will be introduced. The participants range from university students to the professors and on the other hand also from secretary to the chief editor of the most popular astronomy magazine of the Nordic countries. The program and the abstracts of the meeting are collected into this Working Paper volume by Metla.

Keywords

space, remote sensing, space research, COSPAR

Available at

http://www.metla.fi/julkaisut/workingpapers/2013/mwp276.htm

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Foreword

The Committee on Space Research (COSPAR) was established by the International Council for SCIENCE (ICSU) in 1958 "as an interdisciplinary scientific body concerned with the progress on an international scale of all kinds of scientific investigations carried out with space vehicles, rockets and balloons". Finland became a member of COSPAR a few years later, on June 2, 1964, that is, almost 50 years ago. The first Finnish space science conference was organized in 1987 at Hotel Rantasipi Hyvinkää. Since then, multiple FinCOSPAR meetings have brought together space scientists in Finland to venues from the southern seas to North Finland. The XIV meeting, FinCOSPAR 2013 takes place at the premises of the Finnish Forest Research Institute, METLA, in Tikkurila, Vantaa. The link to space sciences of this new venue is the operational use of space-borne remote sensing in monitoring forests.

FinCOSPAR 2013 brings together more than 60 space scientists from the Finnish Universities and Research Institutes, as well as from other European countries and USA. The meeting has attracted interesting scientific talks and posters for full two days giving a good look of the current scientific focus of Finnish space research. The organizers and participants are particularly delighted by the keynote speakers from the top of their scientific disciplines, with two of them from the Jet Propulsion Laboratory, NASA, Pasadena, California.

The support and participation of scientific community is of vital importance for the success of conferences like this and the organizers have happily noted how plentifully the abstracts have flown in from all areas of space research, from the solar physics, planetary sciences, atmosphere, ionosphere and super-massive black holes to space-borne remote sensing of the Earth.

We hope that many ideas of new science endeavours will be sowed, old contacts strengthened and new ones introduced. We also wish good and enjoyable time around the space science topics had so that afterwards we can all return to carry out our research with new invigorated and inspired spirits.

The FinCOSPAR 2013 and its participation are financially supported by the Federation for Finnish Learned Societies, the The Finnish National Committee of COSPAR and the Finnish Forest Research Institute, Metla. Metla and the Finnish Meteorological Institute have provided their staff for the meeting preparations. Professor Taneli Kolström, Research Director at Metla, accepted this abstract book to the publications of Metla Working Papers. The support and encouragement of the professor Hannu Raito, Director General at Metla is acknowledged with a pleasure.

The organizers wish to express their sincere gratitude to all the individuals and organizations that have contributed and made this meeting possible.

Erkki Tomppo, Sini Merikallio, Tuija Pulkkinen and Mirja Vuopio

Committees

Organizing Committee

Erkki Tomppo, Metla

Sini Merikallio, Finnish Meteorological Institute

Tuija Pulkkinen, Aalto University

Mirja Vuopio, Metla

Scientific Committee

Sini Merikallio, Finnish Meteorological Institute

Tuija Pulkkinen, Aalto University

Erkki Tomppo, Metla

FinCospar 2013 Programme

The XIV meeting of Finnish space researchers 29-30.8.2013 at The Finnish Forest Research Institute (METLA).
More information can be found online: **http://www.cospar.fi/fincospar2013**

Thursday 29.8.2013	Friday 30.8.2013
8:15 Registration and coffee, setting up posters 9:00 Erkki Tomppo and Tuija Pulkkinen; Wellcome 9:05 CHAIR: Hannu Koskinen **Mars Marsiin!** **Way to Mars!** **1. Joy Crisp, The Curiosity Rover Mission (40)** 2. Ari-Matti Harri: Mars Science Laboratory (MSL) - First Results of Pressure and Humidity Observations (15) 3. Henrik Kahanpää, Mars Science Laboratory (MSL) – First results of pressure observations (15) 4. Mark Paton, Atmosphere-surface interactions on Mars (15) 5. Sini Merikallio, Modelling scattering by Palagonite (Mars analog dust) dust. (15) 10:45 Coffee	8:30 coffee 9:00 CHAIR: Johanna Tamminen **Kaukonäköistä kaukokartoitusta** **Far reaching remote sensing** **1. David Crisp, The OCO-2 Mission - The Next Step in Space-Based CO2 Measurements (30)** 2. Gerrit de Leeuw: Aerosol retrieval using AATSR data (15) 3. Larisa Sogacheva: Retrieval of cloud properties using AATSR data (15) 4. Heikki Saari: New compact spectral imaging technology offers unforeseen opportunities for atmospheric remote sensing (15) 5. Seppo Hassinen, Observing atmospheric composition: Usability of the Direct Broadcast transmission (15) 6. Poster Talk, 2 min/1 slide (2): a. Virtanen 10:30 Coffee
11: 15 CHAIR: Tuija Pulkkinen **Katse tulevaisuuteen** **Eyes for the future** 1. Stigell Pauli: Finnish space activities for years 2013-2020 (15) 2. Tuija Pulkkinen, Cospar study reports; towards global space exploration program (15) 3. Osku Kemppinen, Retrieval of Martian dust properties by surface observations and radiative transfer models (15) 4. Mark Paton, Trajectory simulations of Martian and Uranus atmospheric entry vehicles (15) 5. Heidi Kuusniemi, Tracking the First Satellites of the European Galileo and the Chinese BeiDou Systems (15) 6. Poster talks, 2 min/1 slide: a. Merikallio b. Tomppo 12:30 Lunch (at Metla cafeteria, 3 min walk)	11:00 CHAIR: Jaan Praks **Ilmakehästä ylöspäin** **From atmosphere to ionosphere** 1. Pekka Kolmonen, Determining the aerosol radiative effect using satellite retrievals (15) 2. Johanna Tamminen, Highlights of GOMOS measurements of atmospheric composition and dynamics during 2002 – 2012 (15) 3. Anu-Maija Sundström, Estimating the direct aerosol radiative effect over China using multi-sensor satellite remote sensing measurements (15) 4. Gabor Facsko: A climate simulation comparison study: regions and footprints (15) 5. Yann Kempf, Ion distributions up- and downstream of the Earth's collisionless bowshock obtained using Vlasiator (15) 6. Eija Tanskanen, Magnetospheric response to Alfvenic and non-Alfvenic interplanetary fluctuations (15) 12:30 Lunch (at Metla cafeteria, 3 min walk)

http://www.cospar.fi/fincospar2013/

Thursday 29.8.2013 afternoon

13:30
CHAIR: Ari-Matti Harri
Kiviä avaruudesta
Space debris

1. Karri Muinonen, Photometric and Polarimetric Modeling of Small Solar System Bodies (15)
2. Walter Schmidt: SOHO/SWAN: 17 Years Monitoring of Solar Wind, Comets and Space Weather (15)
3. Jenni Virtanen, StreakDet data processing and analysis pipeline for space debris (15)
4. Lauri J. Pesonen, Two striking meteorite events: the “roof meteorite” Oslo 2012 and the “catastrophic” Chelyabinsk 2013 meteorite (15)
5. Maria Gritsevich, A comprehensive study of Chelyabinsk meteorite: physical, mineralogical, spectral properties and Solar System orbit (15)
6. M.S. Väisälä, High resolution ammonia mapping of the candidate First Hydrostatic Core object Cha-MMS1 (15)
7. Four poster talks, a 2 min/1 slide (10)
   a. Harri
   b. Ahmadzai
   c. Henriksson

15:10
Coffee

15:30
CHAIR: Riku Järvinen
Tähtien kutsu
Stars are calling

1. **Marko Pekkola: Scientist Navigating Media Space (20)**
2. Markku Alho, Esa Kallio, Riku Järvinen: Hybrid Modeling Insights Into the Interaction Between the Solar Wind and Lunar Magnetic Anomalies (15)
3. V. F. Sofieva, Studying gravity waves and turbulence in the stratosphere using satellite observations of stellar scintillation (15)
4. Mika Juvela: Initial phases of Galactic star formation (15)
5. Peter H. Johansson: Modelling the impact of supermassive black holes on massive galaxies (15)
6. Four postertalks, á 2 min/1 slide (10)
   a. Hoilijoki
   b. Gritsevich
   c. Silén
   d. Malinen

17:10 Poster session

17:50 → Walk to Heureka (takes 10 min)
18:15 Heureka Info
19:30 Dinner in Heureka - Cafe Einstein,
After dinner speech by Martti Tiuri
Dinner music by pianist Jesse Rouvinen

Friday 30.8.2013 afternoon

13:30
CHAIR: Eija Tanskanen
Auringosta tuulee
Winds of Sun

1. Cole, Elizabeth: Nonaxisymmetric large-scale dynamos in rapidly rotating spherical shell convection (15)
2. Urs Ganse: Heliospheric Particle-Shock Interactions with nontrivial Shock Profiles (15)
3. Petri J. Käpylä: Solar-like magnetic activity and differential rotation from simulations of spherical shell convection (15)
4. Maarit J. Mantere: Solar dynamo: time for a paradigm change? (15)
5. Minna Myllys, Geomagnetically induced currents in the Norwegian power grid (15)

14:45
Coffee

15:00
CHAIR: Erkki Tomppo
Tutkimusta ja tutkailua
Research with radar

1. **Jaan Praks, Modern spaceborne radar in forest applications (20)**
2. Tuija Pulkkinen, Space Research at Aalto University: Recent Highlights (15)
3. McKay-Bukowski D. KAIRA — the Kilpisjärvi Atmospheric Imaging Receiver Array (15)
4. Markku Poutanen, Renewal of Metsähovi Geodetic Observatory (15)
5. Turunen E., National research infrastructure roadmap proposal 2013: EISCAT and EISCAT_3D (15)

16:20 Risto Pellinen, Some highlights of the national Finnish COSPAR activities during the past 50 years

16:30 **Erkki Tomppo - loppusanat**

Free poster discussion and farewells → 17:00.

Poster programme

1. Ari-Matti Harri. METNET lander Network for Martian Atmospheric Research
2. Sini Merikallio. Uranus and Neptune to be scouted by Esail
3. Timo H. Virtanen. Retrieval of volcanic ash plumes and their height using AATSR data
4. Shabana Ahmadzai. Spotting auroras with the help of geomagnetic field recordings
5. Sanni Hoilijoki. Reconnection and energy conversion at the magnetopause as influenced by Earth's dipole tilt angle and interplanetary magnetic field
6. Svante V. Henriksson. A concept of an electromagnetic highway to Mars and beyond
7. Maria Gritsevich. Physical properties of meteoroids according to Middle and Upper atmosphere radar measurements
8. Johan Silén. Time of flight spectra of dust impacts in the solar system and at comets Wild 2 and Tempel 1 as measured by CIDA
9. Johanna Malinen. Profiling filaments: comparing nearinfrared extinction and submillimetre data in TMC1
10. Heid Kuusniemi. Tracking the First Satellites of the European Galileo and the Chinese BeiDou Systems
11. Erkki Tomppo. Spaceborne remote sensing at Metla – selected examples

Posters from outside the abstract programme

12. Jaan Praks. Aalto1


Mars as seen by NASA Curiosity

Content

Keynote presentations

The Curiosity Rover Mission

Joy Crisp and the MSL Science Team

Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA.
joy.a.crisp@jpl.nasa.gov

The goal of the Curiosity rover mission is to assess whether past and present environments on Mars were favorable for life. The rover is equipped with an alpha-particle X-ray spectrometer (APXS) to determine rock and soil chemistry; X-ray diffractometer (CheMin) to determine mineralogy of rocks and regolith fines; laser-induced breakdown spectrometer and remote micro-imager (ChemCam) to measure the chemical composition of rocks and regolith from a distance of up to 7 m; neutron spectrometer (DAN) to measure hydrogen in the ground; color cameras (Mastcam, MAHLI, MARDI) to image landscapes, rock/regolith textures, and sky; sensors (RAD) to monitor solar energetic particle and cosmic radiation; weather station (REMS); quadrupole mass spectrometer, gas chromatograph, and tunable laser spectrometer (SAM) to characterize organic carbon in rocks, regolith fines, and atmosphere; and tools for drilling, scooping, sieving, and brushing. Since the August 2012 landing in Gale crater, the rover has spent the first 11 months of its surface mission exploring the area around the landing site and 450 m to the east in the Glenelg region. Although the rover did not travel very far during this part of the mission, a variety of geologic materials was examined and clues were revealed about past environments suitable for microbial life. The rover is now on a several-kilometer trek to Aeolis Mons (unofficially known as Mount Sharp), which rises 5.5 km above the base of Gale crater and exposes an extensive layered rock record that is expected to reveal information about changes in the ancient environmental history of Mars. This talk will describe the challenges of operations and highlight the major science results of this discovery-driven mission.

The OCO-2 Mission – the Next Step in Space- Based CO_2 Measurements

David Crisp and the OCO-2 science team

Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA.
david.crisp@jpl.nasa.gov

Space based remote sensing observations of the column-averaged CO_2 dry air mole fraction, X_{CO2}, hold substantial promise for future long-term monitoring of CO_2 and other greenhouse gases on regional scales over the globe. However, such measurements must have adequate precision and accuracy to resolve the small (< 1%) variations associated with typical CO_2 emission sources and natural sinks. X_{CO2} estimates can be derived from coincident, spectra of the absorption of reflected sunlight by CO_2 and molecular oxygen (O_2). The European Space Agency's (ESA) EnviSAT SCIAMACHY and Japanese Greenhouse gases Observing SATellite (GOSAT) TANSO-FTS were the first two satellite instruments designed to exploit this approach. SCIAMACHY returned global maps of X_{CO2} and X_{CH4} from 2002–2012. The precision of its measurements over land eventually approached 1–2%. However, the instrument's low sensitivity precluded useful observations over the ocean and its large sounding footprints (30 km by 60 km) were often contaminated by clouds. GOSAT has been returning X_{CO2} and X_{CH4} soundings since April 2009. Recent GOSAT X_{CO2} products show little or no bias and random errors that are typically less than 0.5% (2 ppm) on regional scales over much of the globe. While GOSAT measurements have fostered dramatic improvements in X_{CO2} retrieval algorithms, the restricted coverage over the ocean (±20° of the sub-solar latitude) and low yield over high latitudes has limited its impact on flux inversion studies.

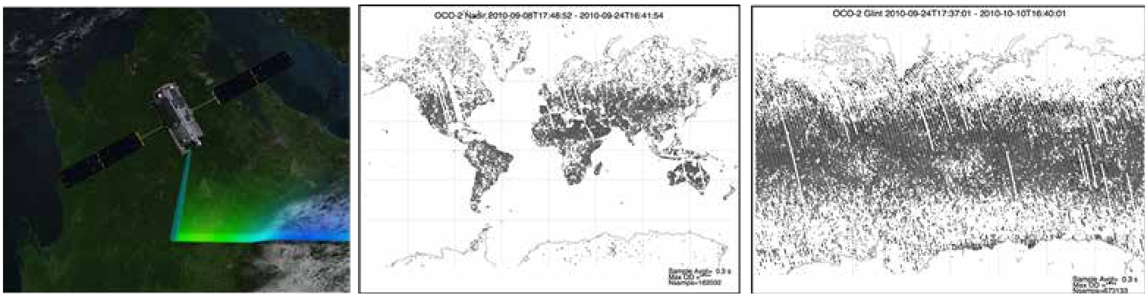


Figure 1: OCO-2 will collect continuous measurements along a narrow track (left). The spatial sampling for nadir (center) and glint (right) observations collected on alternate 16-day repeat cycles are shown.

The NASA Orbiting Carbon Observatory-2 (OCO-2) is the next space-based CO_2 satellite. OCO-2 carries and points a single instrument that incorporates 3, co-bore-sighted high-resolution, imaging, grating spectrometers. This instrument records the absorption of reflected sunlight by O_2 and CO_2 within spectral ranges that overlap those used by the GOSAT. To maximize spatial resolution and coverage, it was optimized to yield a high signal to noise ratio over a large dynamic range. It has a small sounding footprint (< 3 km^2) and will collect 24 X_{CO2} soundings per second, yielding up to one million soundings over the sunlit hemisphere each day. To further increase its sensitivity to CO_2 variations over dark, ocean or ice-covered surfaces, OCO-2 can point the instrument's field of view toward the bright ocean glint spot at solar zenith angles > 75°. OCO-2 is expected to yield the data needed to retrieve X_{CO2} with single-sounding random errors < 0.25% over > 80% of the range of latitudes on the sunlit hemisphere each month. The OCO-2 instrument and spacecraft bus are now being integrated and pre-launch characterization and calibration tests are ongoing. OCO-2 is currently scheduled to launch on Delta-II 7320 launch vehicle from Vandenberg Air Force Base on July 1, 2014. This presentation will summarize the final preparations for launch, and describe the mission plans for OCO-2.

Modern Spaceborne Radar in Forest Applications

Jaan Praks

Department of Radio Science and Engineering, School of Electrical Engineering, Aalto University, Finland. jaan.praks@aalto.fi

The first spaceborne Synthetic Aperture Radar (SAR) was launched 35 years ago on board of Seasat satellite. Despite its short lifetime, the satellite become an important landmark for spaceborne Earth Observation largely due to its SAR instrument and the mission opened an entire new era of spaceborne microwave imaging. Seasat demonstrated for the first time the SAR ability to map environment in a large sacle and revealed many features which were never seen before. Since then, usage of microwave SAR in Earth Observation has been steadily increased and both imaging techniques and instruments have significantly developed. Current spaceborne SAR systems provide all-seasonal, all-day, and nearly all-weather high resolution imaging capability which is utilized in both research and operational monitoring. Current trend in modern spaceborne SAR systems is towards to increased amount of independent observables through multi-polarization, multi-frequency, multi-antenna measurement configurations, by utilizing imaging techniques such as SAR polarimetry, interferometry, polarimetric SAR interferometry, tomography, and advanced modeling of radar scattering.

These new techniques have brought along new possibilities also for remote sensing of global vegetation, especially remote sensing of forests, which has been gaining more and more attention as general understanding of global ecosystem global climate is improving. Traditionally forest has been mapped mostly with optical sensors, but lately potential of new microwave SAR system has been realized. Compared to optical sensors, SAR reveals different features of vegetation due to its much longer wavelength. Microwaves interact directly with vegetation structure and the coherent nature of the SAR measurement allows one to study structural parameters. Many contemporary SAR studies focus on retrieving forest parameters related to the 3D structure such as tree height, biomass, vertical and horizontal heterogeneity by utilizing new techniques such as interferometry and polarimetry.

Significant progress has been made in forest height estimation by developing technique called polarimetric interferometry. The technique is developed by using airborne SAR systems and now for the first time it is demonstrated also that tree height can be retrieved by using spaceborne Xband measurement of TerraSAR-X and TanDEM-X mission. However, X-band is not the most optimal wavelength for tree height measurement and cannot be used globally for all types of forest. Therefore European Space Agency has selected a SAR mission called Biomass to become the seventh Earth Explorer mission. The Biomass mission should give a significant improvement in global forest biomass estimation accuracy.

The presentation gives an overview of latest developments and trends in spaceborne SAR based forest remote sensing and presents the latest results achieved in this topic in Finland.

Scientist Navigating in Media Space

Marko Pekkola

Tähdet ja avaruus, Stars and Space -magazine. jmpekkol@ursa.fi

Scientific articles in average are read by few people and the impact of individual paper in the society may remain small. A typical press release might not help much. Simultaneously media is seeking for interesting science news–particularly in the internet, but the two needs rarely meet successfully. The biggest problem is the wide gap between the aims and means of journalist and scientist. Yet a scientist who knows how and what to popularize, may obtain a large audience and sometimes even help the chosen media to win the news competition.

Conributed and Poster Presentations

Finnish Space Activities for Years 2013–2020

Pauli Stigell

Tekes – the Finnish Funding Agency for Technology and Innovation. pauli.stigell@tekes.fi

Ministry of the economy published on 28 February 2013 the tenth Finnish space strategy since year 1985. This strategy is the first to cover a longer timeline: from 2013 to 2020.

The main fields of Finnish space activity are the scientific exploration of space and Earth, Earth observation, satellite positioning and the spacecraft equipment manufacturing industry. The core of Finnish space activity, especially related to satellite industry, is formed by the European Space Agency's (ESA) programmes. Some 30 Finnish companies and 20 research institutes are presently participating in space activities mainly in Europe, either in the programmes of ESA or the European Commission.

Finnish space activities are focusing base on the strategy on applications: Arctic solutions and the usage of open-source data material.

The four main fields of Finnish space activity are, and have been,

1 scientific exploration of space and Earth,
2 Earth observation applications,
3 satellite positioning applications and equipment
4 spacecraft equipment manufacturing industry

Finland has not participated in human space flight apart from one space debris instrument on board ISS and some astronaut heath test experiments. Finland has not participated in making any parts of launch vehicles.

Finnish space activities are focusing on:

5 Supporting activities in the Arctic region by means of space technology. The Sodankylä based satellite data centre fortifies research on the Arctic, its natural resources, climate change and environmental safety, while also creating services in the public and private sector.
6 Open positioning data enhances the competitive edge of the services. The new Earth observation satellites produce a wealth of information never before available. Combined with the four global positioning satellite networks (GPS, GLONASS, Beidou/Compass, Galileo), it facilitates countless positioning applications.
7 The level of scientific research is enhanced through participation in ESA and EU programmes. The international integration of Finnish space research and Earth observation know-how will be further intensified, particularly through ESA and EU programmes.
8 Our space industry's answers to increasing international competition are specialisation and applications. The competitiveness of Finnish space technology enterprises on the international satellite market is being further improved.

A small group of Finnish enterprises designs and manufactures satellite components, structures and software. The number of these companies corresponds to the space industries in other European countries of comparable size. The combined turnover of these enterprises was approximately EUR 13 million in 2011. The estimated annual turnover of domestic enterprises applying space technologies is EUR 240 million.

Science – space science and scientific earth observation – are large part of Finnish space activities, several hundred scientist work in these areas in universities and research institutes. The amount of science publications in these fields has increased steadily ever since Finland decided to join e.g. ESA. In remote sensing research has turned into operational EO activities in e.g. forestry and sea ice. In space science the participation in designing and building science instruments for spacecraft has been perceived as highly beneficial to science.

The strategy has been prepared by the Finnish Space Committee in cooperation with the Ministry of Employment and the Economy. The strategy steers the space activities funded by the Finnish public sector, as well as the development and utilisation of related knowledge and technology.

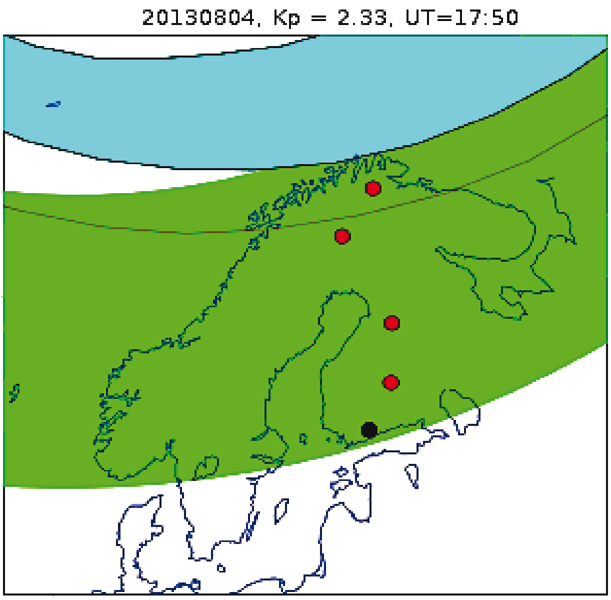
All past strategies have had similar pro-applications focus. Not satellite applications companies, about 50 in Finland ranging from nanosize companies to a very large GPS-navigation and maps (in celluler phones) company, are in satellite navigations. Commercial remote sensing is to large based on aerial images but Sentinels etc. may change the picture during this strategy period. Opening of all public sector geospatial and environmental data (all over in Europe) may speed up changes.

Spotting Auroras with the Help of Geomagnetic Field Recordings

Shabana Ahmadzai, Ari Viljanen, Noora Partamies, Liisa Juusola and Kirsti Kauristie

Finnish Meteorological Institute. sahmad@utu.fi

The Finnish Meteorological Institute (FMI) maintains the AurorasNow! -service (aurora.fmi.fi) for nowcasting auroral activity with the help of all-sky cameras and geomagnetic recordings. Geomagnetic recordings provide important supporting information for optical measurements especially during cloudy conditions. In addition, magnetic data are more convenient to handle in statistical surveys on auroral occurrence rates than auroral camera data. When estimating the prevailing auroral occurrence probability one can use regional magnetic recordings (like AurorasNow does) or some statistical models which link global geomagnetic indices with the position of the auroral oval. In the presentation we will compare results from these two approaches during some recent auroral storm periods.



The auroral oval location (the cyan zone) as estimated with the statistical model presented in Sigernes et al. (2011) and as estimated by the regional magnetic field recordings (the green zone) on August 4, 2013.

Reference

Sigernes, F., et al. (2011). Two methods to forecast auroral displays.

Hybrid Modeling Insights Into the Interaction Between the Solar Wind and Lunar Magnetic Anomalies

Markku Alho, Esa Kallio and Riku Järvinen

Finnish Meteorological Institute. markku.alho@fmi.fi

The localized, crustal magnetic fields on the Moon show complex interactions with the impinging solar wind. Understanding these interactions will aid in characterizing the lunar dust environment possibly finding suitable sites for lunar bases, in developing advanced remote imaging techniques for airless bodies with energetic neutral atoms (ENAs) for example, for the the Hermean magnetic and plasma environment, and in comprehending the basic plasma processes of plasma environments and phenomena on the Hall current scale. In this work we model a lunar magnetic anomaly in the mesoscale of hundreds of kilometers with an 100nT surface field anomaly. We employ the HYB hybrid plasma model (HYB-Anomaly), in which ions are treated as fully kinetic macroparticles, with electrons providing a massless, charge-neutralizing fluid.

We discuss the effects of Hall currents in these environments and present results on the effect of the interplanetary magnetic field (IMF) conditions on the mini-magnetosphere in three cases: Open, closed, nominal, in which the IMF and the dipole are aligned parallel with the lunar surface, and a cusp case, where the dipole is perpendicular to the surface. We also discuss the effects of the electric fields resulting from the interaction with respect to deceleration and reflection of the impinging proton flux and the corresponding ENA emissions. Particle observations of the Chandrayaan-1 lunar mission are used as a comparison.

Nonaxisymmetric Large-Scale Dynamos in Rapidly Rotating Spherical Shell Convection

Elizabeth Cole[1], Petri J. Käpylä[2], Maarit J. Mantere[3], Jörn Warnecke[4] and Axel Brandenburg[4]

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[2] University of Helsinki, Nordita, Finland
[3] Aalto University, Finland
[4] Stockholm University, Nordita, Sweden

We report the results from turbulent convection simulations in spherical wedges, keeping the density stratification fixed and varying the rotation rate. An upper limit to the Coriolis number that resulted in solar-like differential rotation is reported, above which the simulations exhibit almost-rigid rotation profiles. Adding a magnetic field into these rapid rotators within this interesting regime, we examine the resulting dynamo, searching for equator-ward migration and changes in the dominant dynamo mode. The wedges covering a quarter of the longitudinal extent were extended to full 2pi to search for large-scale non-axisymmetric modes. These results are put into context with observations of rapidly-rotating late-type stars.

A Climate Simulation Comparison Study: Regions and Footprints

Gabor Facsko[1,2], Karin Agren[3], Ilja Honkonnen[1,4], Chandrasekhar Anekallu[1,4], Pekka Janhunen[1], Minna Palmroth[1], Hermann Opgenoorth[3] and Steve Milan[5]

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[3] Swedish Institute of Space Physics, Uppsala, Sweden
[4] University of Helsinki, Finland
[5] Department of Physics and Astronomy, University of Leicester, Leicester, UK

One full year (155 Cluster orbits) is simulated using the Grand Unified Magnetosphere Ionosphere Coupling simulation (GUMICS) in the European Cluster Assimilation Technology project (ECLAT). Real solar wind measurements downloaded from the OMNIWeb are given to the code as input. The data along the orbit of the Cluster reference spacecraft orbit is dumped from the simulation, and the Cluster SC3 footprints are also determined. These products give an opportunity to compare and verify the GUMICS to the real measurements.

The dayside magnetosphere, magnetosheath, solar wind, tail and lobe are studied separately. Intervals are selected in each of them, in which the Cluster orbit is in the same region in the simulation and in reality. The time shift is calculated by correlation calculation using five minutes smoothed real data and compared to the calculated shift based on OMNIWeb data. The correlation coefficients describe how the shape of the functions is related; the ratio of the parameters provides additional information about the accuracy of the simulation. The location and time of the boundary layers in the simulation and the measurements are also compared.

The footprints are located by ray tracing from the simulation results and the Tsyganenko model. The footprint determination could result in two footprints on each hemisphere or only one footprint of an open but connected field line. The closed field lines are in the magnetosphere, the open-close field lines are in the cups, the lobe and the tail. Only the deviance of the appropriate footprints (close-close and open-close) are compared as the function of different parameters, like solar wind velocity and temperature; furthermore IMF magnitude and orientation. The location and time of the non-appropriate pairs are determined.

Heliospheric Particle-Shock Interactions with nontrivial Shock Profiles

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Charged particle acceleration at coronal and heliospheric shocks forms a longstanding problem in understanding solar energetic events.

Analytic treatment typically assumes adiabatic invariants to be conserved during particle-shock interaction. In-situ observations of shocks indicate however that strong kinetic-scale structures on the shock are present, potentially invalidating the assumption of adiabatic invariance and contributing significantly to the accelerations characteristics, with potentially important effects on the superthermal particles' distributions.

Since self-consistent kinetic-scale simulations of shocks, spanning scales from the kinetic to the global, are not yet computationally feasible, we have devised a test particle simulation system to study the effects of different types of kinetic-scale structures on the resulting particle distributions, such as shock ripples, over-oscillations and turbulence.

Preliminary results indicate that large-amplitude magnetic structures at kinetic scales may qualitatively change the particle-shock interaction, while incoherent small-amplitude field fluctuations have a more limited effect on the interaction.

A Comprehensive Study of Chelyabinsk Meteorite: Physical, Mineralogical, Spectral Properties and Solar System Orbit

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On February 15, 2013, at 9:22 am, an exceptionally bright and long duration fireball was observed by many eyewitnesses in South Ural, Russia. A strong shock wave associated with the fireball caused significant damage such as destroyed windows and parts of buildings in the city of Chelyabinsk and the surrounding territories. A number of video records of the event are available and have been used to reconstruct atmospheric trajectory, velocity, deceleration rate, and parent asteroid Apollo-type orbit in the Solar System (see the Figure below). Two types of meteorite material are present among recovered fragments of the Chelyabinsk meteorite. These are described as the light-colored and dark-colored lithology. Both types are of LL5 composition with the dark-colored one being an impact-melt shocked to a higher level. Based on the magnetic susceptibility measurements, the Chelyabinsk meteorite is richer in metallic iron as compared to other LL chondrites. The measured bulk and grain densities and the porosity closely resemble other LL chondrites. Shock darkening does not have a significant effect on the material physical properties, but causes a decrease of reflectance and decrease in silicate absorption bands in the reflectance spectra. This is similar to the space weathering effects observed on asteroids. However, no spectral slope change similar to space weathering is observed as a result of shock-darkening. Thus, it is possible that some dark asteroids with invisible silicate absorption bands may be composed of relatively fresh shock darkened chondritic material.

Physical Properties of Meteoroids According to Middle and Upper Atmosphere Radar Measurements

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We introduce a novel approach to reliably interpret the meteor head echo scattering measurements detected by the 46.5 MHz Middle and Upper atmosphere (MU) radar system near Shigaraki, Japan. The data reduction steps include determining the exact trajectory of the meteoroids entering the observation volume of the antenna beam and calculating meteoroid mass and velocity as a function of time. The model is built using physically based parameterization. The considered observation volume is narrow, elongated in the vertical direction, and its area of greatest sensitivity covers a circular area of about 10 km diameter at an altitude of 100 km above the radar. Over 100,000 meteor head echoes have been detected over past years of observations. Most of the events are faint with no alternative to be detected visually or with intensified video (ICCD) cameras. In this pioneer study we are focusing on objects which have entered the atmosphere with almost vertical trajectories, to ensure the observed luminous segment of the trajectory is as complete as possible, without loss of its beginning or end part due to beam-pattern related loss of signal power.

METNET Lander Network for Martian Atmospheric Research

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A new kind of planetary exploration mission for Mars is being developed in collaboration between the Finnish Meteorological Institute (FMI), Lavochkin Association (LA), Space Research Institute (IKI) and Institutio Nacional de Tecnica Aerospacial (INTA). The Mars MetNet mission is based on a new semi-hard landing vehicle called MetNet Lander (MNL), using an inflatable entry and descent system instead of rigid heat shields and parachutes as the earlier developed semi-hard landing devices have used. This way the ratio of the payload mass to the overall mass is optimized. The landing impact will make the payload container penetrate into the Martian soil providing a more favorable thermal environment for the electronics and a suitable orientation of the telescopic boom with external sensors and the radio link antenna. Eventually, the MetNet Mission is to deploy several tens of MNLs covering all the sections of the Martian surface. The MNLs will be operating simultaneously that is a major prerequisite for the understandong of the Martian atmospheric dynamics and to generate profound meteorological network science.

Currently we are developing the MetNet Precursor Mission (MMPM) deploying one MetNet vehicle to Mars to demonstrate the technical robustness and scientific capabilities of the MetNet type of landing vehicle. Full Qualification Model (QM) of the MetNet landing unit with the Precursor Mission payload is currently under functional tests. During the next few months the QM unit will be exposed to environmental tests with qualification levels including vibrations, thermal balance, thermal cycling and mechanical impact shock. One complete flight unit of the entry, descent and landing systems (EDLS) has been manufactured and tested with acceptance levels.

Definition of the Precursor Mission and discussions on launch opportunities are under way. The baseline program development funding exists for the next few years. Flight unit manufacture of the payload bay is estimated to take about 18 months, and it will be commenced after the Precursor Mission has been defined. The current MMPM system and payload configuration and their performance parameters will be discussed.

Mars Science Laboratory (MSL) – First Results of Pressure and Humidity Observations

Ari-Matti Harri[1], Henrik Kahanpää[1], Osku Kemppinen[1], Maria Genzer[1], Javier Gómez-Elvira[2], Robert M. Haberle[3], Walter Schmidt[1], Hannu Savijärvi[4], Jose Antonio Rodríquez-Manfredi[2], Scott Rafkin[6], Jouni Polkko[1], Mark Richardson[7], Claire Newman[7], Manuel de la Torre Juárez[5], Javier Martín-Torres[2], Maria Paz Zorzano-Mier[2], Evgeny Atlaskin[1], Janne Kauhanen[1], Mark Paton[1], Harri Haukka[1] and the MSL Science Team

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The Mars Science laboratory (MSL) called Curiosity made a successful landing at Gale crater early August 2012. MSL has an environmental instrument package called the Rover Environmental Monitoring Station (REMS) as a part of its scientific payload. REMS comprises instrumentation for the observation of atmospheric pressure, temperature of the air, ground temperature, wind speed and direction, relative humidity, and UV measurements. The REMS instrument suite is described at length in (Gómez-Elvira et al. 2012). We concentrate on describing the first 100 sol results from the REMS pressure and humidity observations and comparison of the measurements with modeling results.

The REMS pressure (REMS-P) and humidity (REMS-H) devices are provided by the Finnish Meteorological Institute. REMS-P is based on silicon micromachined capacitive pressure sensors developed by Vaisala Inc., and makes use of two transducer electronics sections placed on a single multi-layer PCB inside the REMS Instrument Control Unit (ICU) with a filter-protected ventilation inlet to the ambient atmosphere. The absolute accuracy of the pressure device (< 3 Pa) and zero-drift (< 1 Pa/year) enables the investigations of long term and seasonal cycles of the Martian atmosphere. The relative accuracy, or repeatability, in the diurnal time scale is < 1.5 Pa, less than 2% of the observed diurnal pressure variation at the landing site. The pressure device has special sensors with very high precision (less than 0.2 Pa) that makes it a good tool to study short-term atmospheric phenomena, e.g., dust devils and other convective vortices.

The observed MSL pressure data enable us to study both the long term and short-term phenomena of the Martian atmosphere. This would add knowledge of these phenomena to that gathered by earlier Mars missions and modeling experiments (Haberle et al. 2013, Smith et al. 2006). Pressure observations are revealing new information on the local atmosphere and climate at Gale crater, and will shed light on the mesoscale and micrometeorological phenomena. Pressure observations show also planet-wide phenomena and are a key observation for enhancing our understanding of the global atmospheric flows and CO2 cycle of the Martian atmosphere.

REMS-H is based on polymeric capacitive humidity sensors developed by Vaisala Inc. The humidity device makes use of one transducer electronics section placed in the vicinity of the three (Smith et al. 2006) humidity sensor heads. The humidity device is mounted on the REMS boom 2 providing ventilation with the ambient atmosphere through a filter protecting the device from airborne dust. The absolute accuracy of the humidity device is temperature dependent, and is of the order of 2% at the temperature range of -30 to -10 °C, and of the order of 10% at the temperature range of -80 to -60 °C. This enables the investigations of atmospheric humidity variations of both diurnal and seasonal scale. The relative humidity results appear to be aligned with earlier observations of the total atmospheric precipitable water contents as well as with the modeling results. (Smith et al. 2006, Savijarvi et al. 2010).

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Observing Atmospheric Composition: Usability of the Direct Broadcast Transmission

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The modern society is more and more dependent on real-time information about the atmospheric composition affecting the air quality and air traffic. The need and usefulness of real-time satellite data products of volcanic ash was clearly recognized during the last major Icelandic volcanic eruptions, which disturbed the European air traffic. While geostationary satellites provide information continuously at lower latitudes the high latitudes are best covered with polar- orbiting satellites whose data is downlinked typically only once per orbit.

Most of the satellites have so called Direct Broadcast (DB) capability, i.e. the ability to broadcast data at the same time as it is measured. This enables new kind of services with a very short time lag between the measurement and available products. Such services may be targeted to monitoring of volcanic plumes and timing of atmospheric soundings and research flights, for example. Existing example is the OMI Very Fast Delivery (VFD) Service (http://omivfd.fmi.fi) for monitoring atmospheric composition and UV-radiation in almost real time, within 20 minutes after the overpass.

In this presentation we demonstrate the DB approach by focusing on existing OMI service. Furthermore, we will show more extensive possibilities enabled by usage of two or more ground stations and/or instruments, particularly Sodankylä/Alaska and OMI/OMPS combinations.

A Concept of an Electromagnetic Highway to Mars and Beyond

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An idea of road-like infrastructure in space is presented. Most existing concepts for spacecraft propulsion in interplanetary space are based upon launching exhaust material in the direction opposite to the traveling direction or on collecting momentum from the sun's radiation or particle wind. On the electromagnetic highway, momentum would be provided by pieces of the road, consisting of stone and an electric engine utilizing magnetic suspension. The pieces would be placed in orbits around the sun between starting point and destination. Sources for the electric energy needed could be solar, fusion, fission or another form as well as kinetic energy retrieved from braking spacecraft. The individual spacecraft would be free from needing any energy source of their own while great speed could be achieved and large volumes of spacecraft served. The highway needs to be coupled with an initial launch system, that could be electromagnetic or consisting of rockets.

A major issue for the highway is its dynamic nature, leading at large scale to a spiral-like form as the Earth orbits the Sun at a faster rate than Mars. How to retrieve the original form of the highway in a fast and feasible way is discussed. Orbital mechanics, initial construction and smaller-scale stabilization issues are also very important and discussed.

On the proposed highway, a trip to Mars would last for about 2 days when using a comfortable acceleration and deceleration for humans of 1 g when the distance between the two planets is at its shortest. For freight traffic, significantly higher accelerations could be used. The scale of the project can be compared for example to the current world road network, approximately double in length to the shortest distance between Earth and Mars. Possibilities brought by such an infrastructure to for example the mining industry are enormous and in theory hugely exceed the needed material input.

The idea is presented here for criticism and initial evaluation of technological feasibility using current or foreseeable technology. Additionally, technological issues, initial investment costs and convincing people are large challenges to be won before considering to implement the idea in reality.

Dynamics of the Magnetopause Reconnection as Influenced by Earth's Dipole Tilt Angle and Interplanetary Magnetic Field

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We study the effect of Earth's dipole tilt angle and interplanetary magnetic field (IMF) Bx and By components on the location of reconnection and the energy conversion at the magnetopause. We carry out three sets of runs with different dipole tilt angles using a global MHD model GUMICS-4. Each set consists of IMF parameters satisfying both inward- and outward-type Parker spiral conditions during southward IMF.

We find that different combinations of IMF Bx and By components and the dipole tilt angle modify the location, morphology and magnitude of the reconnection and energy conversion at the magnetopause. We discuss the relative role of the non-zero Bx and the dipole tilt angle in dayside reconnection first separately and then by changing the parameters simultaneously. We find evidence that processes induced by reconnection modify the shape of the magnetopause, which in turn has and effect on the reconnection location.

Modelling the Impact of Supermassive Black Holes on Massive Galaxies

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Observations in the last decade have shown that supermassive black holes (SMBHs) reside in the centers of most if not all massive galaxies. The properties of the SMBHs and their host galaxies are correlated in the sense that the more massive black holes are found in general in more massive galaxies. Supermassive black holes are also the prime suspect for terminating star formation in the most massive galaxies and thus setting an upper limit for their masses.

Here using numerical simulations of binary galaxy mergers of both gas-rich disk galaxies and gas-poor elliptical galaxies including radiative cooling, star formation and supermassive black holes we demonstrate that energetic feedback from black holes is an efficient method for terminating star formation. We also study the impact of feedback from SMBHs on the detailed properties of galaxies. In particular we attempt to constrain the energy input mechanism of the black holes and compare models with thermal heating of the gas to more realistic models which involve a mixture of thermal heating and kinetic feedback, resulting in mass outflows on galactic scales, as observed in active galaxies

Initial Phases of Galactic Star Formation

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The project "Galactic cold cores" is studying star formation in the Milky Way using data from Planck and Herschel satellites. Planck has detected a large number of cold sources that are interpreted as dense, prestellar clumps within Galactic molecular clouds. Thus, the Planck all-sky survey provides an exciting opportunity for a global study of prestellar sources. The full catalogue of over 10,000 Planck detections will be published shortly.

We have completed Herschel observations of 115 fields where Planck detected a strong signature of cold dust emission. The fields were mapped with Herschel PACS and SPIRE instruments, confirming the sources as dense clouds within the Milky Way. Observations have revealed numerous prestellar cloud cores but most fields are already actively forming stars.

With Herschel data, we have built a catalogue of ~500 reliable core detections. Infrared surveys were used to separate starless and protostellar objects. The latter were found to be warmer and more compact. The temperatures, column densities, and masses were correlated against Galactic position and the characteristics of the host clouds. No significant trends were found, indicating that the core properties depend weakly on environmental factors. Because of low level of background emission, high galactic latitude clouds are ideal targets for studies of low mass star formation. As an example, I will discuss our observations of the cloud LDN1642.

Mars Science Laboratory (MSL) – First Results of Pressure Observations

Henrik Kahanpää[1], Ari-Matti Harri[1], Jouni Polkko[1], Maria Genzer[1], Javier Gomez-Elvira[2], Robert Haberle[3], Manuel de la Torre Juarez[4], María Paz Zorzano[2], Javier Martin-Torres[2], Sara Navarro[2], José Antonio Rodriquez-Manfredi[2], Veronica Peinado[2], Nilton Rennó[5], Hannu Savijävi[6], Janne Kauhanen[1] and the entire REMS/MSL science team

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NASA's Mars Science Laboratory (MSL) rover named Curiosity landed in Gale crater, Mars, on 6 August 2012. MSL has an environmental instrument package called the Rover Environmental Monitoring Station (REMS) as a part of its scientific payload. REMS is comprised of instrumentation for the observation of atmospheric pressure, air and ground temperature, wind speed and direction, relative humidity, and UV radiation. We concentrate here on describing the REMS pressure sensor and its first results.

The REMS pressure sensor is provided by the Finnish Meteorological Institute and is based on Barocap® technology developed by Vaisala, Inc. The pressure sensor is located inside the rover body with a filter-protected ventilation inlet to the ambient atmosphere. The absolute accuracy of the pressure sensor (< 3 Pa) and zero-drift (< 1 Pa/year) enable investigations of long term and seasonal cycles of the Martian atmosphere. The relative accuracy, or repeatability, in the diurnal time scale is < 1.5 Pa, less than 2% of the observed diurnal pressure variation at the landing site. The pressure sensor has special sensors for very high precision of less than 0.2 Pa that makes it also a useful tool for the study of short-term atmospheric phenomena, e.g., dust devils and other convective vortexes.

The REMS pressure sensor has observed atmospheric phenomena with time scales from seconds to months and spatial scales from meters to global. Some of the observed phenomena have not been detected by earlier Mars landers and are probably caused by local flows associated to the complex topography of the landing site.

Ion Distributions in the Earth's Foreshock and Magnetosheath Obtained Using Vlasiator

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We present ion distribution functions from 2D-3V simulations of the Earth's magnetosphere with Vlasiator, the world's first global magnetospheric hybrid-Vlasov simulation code. The unprecedented uniform discretisation of the ion distribution functions in the velocity space at resolutions comparable to in-situ measurements allows detailed studies of a variety of phenomena. We show that Vlasiator reproduces well-known observational features of ion distributions in the foreshock and the magnetosheath.

Retrieval of Martian Dust Properties by Surface Observations and Radiative Transfer Models

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We present a line of work to investigate the properties of Martian dust based on observed changes in atmospheric opacity and surface temperature by using fast and accurate radiative transfer models.

We utilize large amounts of atmospheric data, such as the recent data from Viking Landers reprocessed by Finnish Meteorological Institute, and select periods of time when there are sudden changes in the observed atmospheric opacity. Then, we will automatically fine-tune the dust and other optical parameters in a radiative transfer model and other models to reproduce the observed effect in the atmospheric temperature. This will result in a large number of required computations, which dictates that the models need to be computationally fast, while also being accurate and flexible. Due to these restrictions, we will be using the SMART model developed by Dr. David Crisp.

As is usual for inverse problems with several free parameters, there will likely be an infinite number of possible solutions. We hope to limit the valid solution space by using a large amount of separate instances of opacity changes. We will also utilize a priori information based on the current knowledge of Martian dust to achieve additional accuracy on top of the purely computational approach.

Determining the Aerosol Radiative Effect Using Satellite Retrievals

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In climate studies the reliable estimate of radiative effect (or forcing) by atmospheric aerosols is a very important parameter that is related to Earth's energy budget. Usually the estimate is obtained from model simulations. This study discusses an alternative method to determine the effect. Satellite retrieval of the needed parameters to compute the effect is described. These parameters include e.g. aerosol loading, aerosol optical properties, aerosol size distribution, and surface reflectance. The described method is able to give good estimates of the instantaneous effect as the use of aggregated model or climatological data is avoided as much as possible.

The method is being developed for data from the AATSR satellite instrument.

Tracking the First Satellites of the European Galileo and the Chinese BeiDou Systems

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Satellite-based positioning is undergoing a rapid change. There is a need to reform the U.S. GPS and Russian GLONASS systems due to the increasing number of applications that utilize positioning, more demanding requirements from users and the need to mitigate interferences and disturbances to the radio signals used by these systems. Both the GPS and the GLONASS systems are being modernized to serve better the current challenging applications in harsh signal conditions. These modernizations include increasing the number of transmission frequencies and changes to the signal components. In addition, the European Galileo and the Chinese BeiDou systems are currently under development for global operation. There is a strong intention to design the forthcoming: to make the modernized systems to be resistant to interference as well as make them more accurate and available over a wider range of conditions. Also, the use of multiple systems for positioning increases the accuracy and reliability even further.

Europe's own satellite navigation system Galileo is designed for civilian use and has been under development for almost a decade. Two test satellites (GIOVE-A, GIOVE-B) have already been in orbital operation since 2005 and 2008, respectively, and in October 2012 the latest Galileo launch secured 4 actual in-orbit validation (IOV) satellites to be successfully transmitting signals from their planned orbits. The amount of 4 IOV satellites is already sufficient to determine the position, time and speed of a Galileo receiver in real-time. The fully deployed Galileo system will consists of 30 satellites positioned in three circular Medium Earth Orbit (MEO) planes at around 23,000 km altitude above the Earth's mean sea level with an inclination angle of 56 degrees with respect to the equator. The system is expected to be operational by the year 2020. Galileo will provide EU countries an independent navigation system that has better positioning accuracy and reliability compared to the current satellite systems of the US (GPS) and Russia (GLONASS). Galileo satellites will transmit signals on the same frequencies as GPS, but modulated with different code techniques.

The Chinese satellite navigation system BeiDou has a mixed space constellation that has, when fully deployed, five Geostationary Earth Orbit (GEO) satellites, twenty-seven MEO satellites and three Inclined Geosynchronous Satellite Orbit (IGSO) satellites. The GEO satellites are operating in orbit at an altitude of 35786 kilometers and positioned at 58.75°E, 80°E, 110.5°E, 140°E and 160°E respectively. The MEO satellites are operating in orbit at an altitude of 21,528 kilometers and an inclination of 55° to the equatorial plane. The IGSO satellites are operating in orbit at an altitude of 35,786 kilometers and an inclination of 55° to the equatorial plane. These satellites broadcast navigation signals and messages within 3 frequency bands. The BeiDou system has been in development for more than a decade, and it is estimated to be operational with global coverage at the latest in 2020. The BeiDou satellites transmit ranging signals based on the CDMA (code division multiple access) principle, like GPS and Galileo. The mixed constellation structure of BeiDou results in better observation geometry for positioning and orbit determination compared to current GPS and GLONASS, and future Galileo, especially in China and neighboring regions. The BeiDou system contributes to the multi-GNSS benefits where increased accuracy, availability and integrity are possible when utilizing interoperable GNSS (Global Navigation Satellite Systems).

Researchers at the Finnish Geodetic Institute are following signals from all four IOV-satellites of the Galileo-system as well as the visible BeiDou satellites with their software-defined satellite navigation receiver FGI-GSRx which has been developed for research purposes. So far the platform has been used to verify that the Galileo satellites are sending accurate signals as defined in the Galileo system specifications and also to acquire and track BeiDou satellites. The software receiver is a unique platform in Finland for analyzing Galileo and BeiDou signals. Better positioning methods utilizing Galileo and BeiDou signals can be developed, especially for challenging environments such as urban spaces or high-dynamics space applications. We will present initial results on Galileo and BeiDou signal acquisition and tracking with the developed FGI-GSRx software receiver platform.

Solar-like Magnetic Activity and Differential Rotation From Simulations of Spherical Shell Convection

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Explaining the solar magnetic cycle remains one of the main challenges in solar physics. Whilst simplified models relying on averaged equations of magnetohydrodynamics can reproduce many observed features, the included physics are poorly constrained due to which the desired result is achieved only after finetuning. On the other hand, more realistic models solving the equations of magnetohydrodynamics in three dimensions from first principles, have a hard time reproducing many observed features such as the internal rotation profile of the Sun and the equatorward migration of the activity belts.

Here we summarize the numerical challenges, shortcomings of direct simulations, and the connection of current simulations to real stars. We present recent results from moderate resolution 3D magnetohydrodynamic simulations which for the first time show equatorward migration and solar-like differential rotation.

Aerosol Retrieval Using AATSR Data

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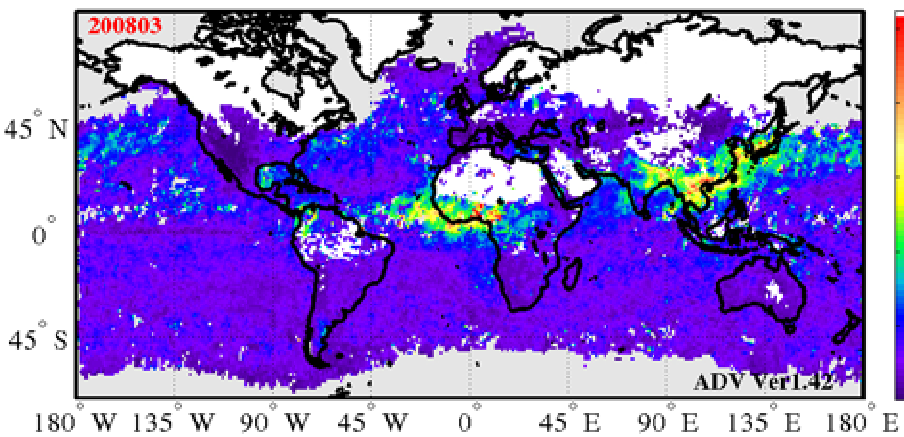
The Advanced Along Track Scanning Radiometer (AATSR) aboard ESA's Environmental satellite ENVISAT measures the radiance at the top of the atmosphere (TOA) at seven wavebands from the visible to the thermal infrared in each of the two viewing directions (nadir and 55° forward). The radiances are converted to reflectances which in turn are used to retrieve properties of aerosols in the atmospheric column. To this end, clouds are detected using a combination of tests using almost all wavebands; cloud-contaminated pixels are discarded from further aerosol retrieval because of their high reflectance which overwhelms the atmospheric signal. Next, over land the contributions of the surface reflectance to the TOA reflectance are eliminated by using the ratio of the reflectances in the nadir and forward viewing directions. Thus, the atmospheric reflectance, or path radiance, for cloud-free pixels is retained. Aerosol properties are subsequently retrieved in an iterative comparison by application of forward and inverse radiative transfer models. Aerosol properties are described in these models by a combination of four aerosol components which allow for the variation of the optical and physical properties. An *a priori* combination, based on a combination of global climate models, can be used in the first retrieval step, but the eventual aerosol component combination is determined as the best fit to the measurements. The AATSR dual view algorithm (ADV) is applied over land where surfaces may be bright. Over ocean the surface is darker and only one of the views is used together with a surface reflectance model, to account for effects of wind speed which creates waves and whitecaps, and reflecting substances in the water column. The over-ocean algorithm is called AATSR Single View (ASV).



Aerosol Optical Depth (March 2008, mean) retrieved with AATSR ADV algorithm.

ADV and ASV were introduced in Helsinki in 2007 and further developed and improved for application in a variety of studies. A large improvement was made as part of the ESA Climate Change Initiative (cci)) project Aerosol-cci where the most prominent European aerosol retrieval groups cooperate and retrieval experts from NASA participate in workshops. The cooperation resulted in statistical performance of AATSR algorithms including ADV and ASV, as determined by an independent validation team, which is similar to that of NASA instruments. The fundamental aerosol property retrieved is the Aerosol Optical Depth (column-integrated extinction) at 3 (land) or 4 (ocean) wavelengths, including per-pixel uncertainty, and the AOD wavelength dependence described by the Ångström exponent. Other, research, products are information on aerosol composition and single scattering albedo.

Further improvements are (1) the introduction of a cloud retrieval scheme which allows for the determination of cloud properties (see presentation Sogacheva), while eventually a common aerosol-cloud retrieval is foreseen; (2) since the surface properties are not used in the aerosol retrieval, the aerosol properties can be used as independent information to retrieve surface reflectance (Sogacheva).

Applications are in the field of, e.g., radiative effects of aerosol and climate (see presentation Kolmonen; and Sundström who used MODIS and CERES data), detection of volcanic ash plumes and their height, air quality studies, forest fires, etc. The combined ATSR-2 and AATSR data provide a 17-years global time series of aerosol properties, which is available for trend analysis. Uncertainty characterization allows for assimilation of the data in air quality and climate models.

An overview of current activities in Helsinki will be presented.

Profiling Filaments: Comparing Near-Infrared Extinction and Submillimetre Data in TMC-1

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Interstellar filaments are an important part of the star formation process. To understand the structure and formation of filaments, the filament cross-section profiles are often fitted with the Plummer profile function. Currently this profiling is often approached with submm studies, especially with Herschel. If these data are not available, it would be convenient if filament properties could be studied using groundbased near-infrared (NIR) observations. We compare the filament profiles obtained by NIR extinction and submm observations to find out if reliable profiles can be derived using NIR data. We use J-, H-, and K-band data of a filament north of TMC-1, which we call TMC-1N, to derive an extinction map from colour excesses of background stars. We compare the Plummer profiles obtained from these extinction maps with Herschel dust emission maps. We present two new methods to estimate profiles from NIR data.

Plummer profile fits to median Av of stars within certain offset or directly to the Av of individual stars. We compare these methods by simulations. In simulations the extinction maps and the new methods give correct results to within 10–20% for modest densities. The direct fit to data on individual stars usually gives more accurate results than the extinction map, and can work in higher density. In the profile fits to real observations, the values of Plummer parameters are generally similar to within a factor of ~2. The parameter values can vary significantly, but the estimates of filament mass usually remain accurate to within some tens of per cent. NIR extinction maps can be used as an alternative to submm data to profile filaments. However, Plummer profile parameters are not always well constrained, and caution should be taken when making the fits.

In the evaluation of the Plummer parameters, one can make use of the independence of dust emission and NIR data and the difference in the shapes of the confidence regions. We also present studies of filaments using NIR scattered light and 3D MHD simulations.

Solar Dynamo: Time for a Paradigm Change?

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The solar magnetic field is commonly believed to arise due to the action of a hydromagnetic dynamo, in which fluid motions at different scales generate and sustain the magnetic field against diffusive effects. Two competing theories of how the dynamo process works in detail exists, namely the so called flux-transport dynamo, which is based on two separate layers of field generation (shear layer beneath the convection zone and near-surface sunspot formation and decay region) connected by a conveyor-belt due to a single-cell meridional circulation pattern with a poleward flow near the surface and a return flow in the bottom of the convection zone. The distributed dynamo theory, on the other hand, assumes that meridional circulation plays a less important role, while convective turbulence, present throughout the convection zone, is the major player in the game together with the large-scale shear.

The flux-transport scenario has been, during the past two decades, the leading theory of the solar dynamo. It has been evolved to a stage, in which the dynamo models have been used as predictive tools of the forth-coming solar activity. The predicting power of the models arises from the fact that turbulent mixing in the convection zone is considered unimportant–therefore magnetic fields can have a ‘memory’ over a few consequtive solar cycles. Distributed dynamo models naturally do not, by definition, possess significant predicting power as turbulent diffusion destroys the generated structures in a time scale comparable to the solar cycle length. So far the usefulness of the flux-transport models as long-term prediction tools has shown to be poor. There is also gathering theoretical and observational evidence of the single-cell meridional conveyor-belt picture being too idealized. Direct numerical simulations of the solar convection zone, such as the ones extensively investigated in our reserach group, tend to show more complicated flow patterns with two- or multi-cellular meridional circulation. Recently, analysis of solar helioseismic observations have also given evidence for similar meridional circulation patterns. These new results seriously challenge the flux-transport dynamo picture. Moreover, the most realistic direct numerical simulations of the magnetic solar cycle being consistent with the distributed dynamo picture, it might be a time for a paradigm change in solar dynamo theory.

KAIRA – the Kilpisjärvi Atmospheric Imaging Receiver Array

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The Kilpisjärvi Atmospheric Imaging Receiver Array (KAIRA) is a new facility of the Sodankylä Geophysical Observatory at Kilpisjärvi, near the Nowegian-Finnish border. This new Finland's largest radio telescope was officially opened on 6th June 2013, although the first successful measurements were done already in August 2012. KAIRA comprises a dual array of omni-directional VHF radio antennas, principally funded by the University of Oulu, Finland. KAIRA offers all-sky multi-beam and imaging capability. It has wide frequency coverage between 10 and 88 MHz (LBA) and 110 and 275 MHz (HBA) and high time resolution. It makes extensive use of the proven LOFAR antenna and digital signal-processing hardware, and can act as either a stand-alone passive receiver, as a receiver for the EISCAT VHF incoherent scatter radar near Tromsø, Norway, or for use in conjunction with other Fenno-Scandinavian VHF experiments. The facility is modular with a very flexible software-controlled experiment system and DSP, so that KAIRA conduct a large range of astronomical, geophysical and atmospheric experiments, and operate even simultanously for different science targets with different instrumental setups. KAIRA will act as a pathfinder for technologies to be used in the proposed EISCAT_3D radar system, for which it was originally built. However, since the first successful experiments, KAIRA has proved to be a powerful and versatile instrument in its own right.

Here we present an overview of KAIRA, its principle hardware and software components, and its main science objectives. We also introduce the facility from a new-user perspective, outlining its capabilities and possibilities both as a receiver site complementary to EISCAT facilities, and as an independent multi-role instrument. A showcase of the recent results will be presented, illustrating our recent scientific accomplishments and the future opportunities emerging after the commissioning phase of this new radio observatory.

Modelling Scattering by Palagonite (Mars Analog dust)

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Due to future MetNet (Harri et al. 2007) Mars lander mission, which has optical instruments onboard, we are interested in modeling accurately the radiative effect of dust present in the Martian atmosphere, to allow reliable and accurate retrieval of information from their measurements. This radiative effect depends on size, shape and composition of the dust particles. Shape information on Martian dust is not available, but it is reasonable to assume their shapes to resemble that of terrestrial dust. Recently, Bi et al. 2009, showed that scattering properties of terrestrial dust can be closely mimicked using ellipsoidal model particles. We therefore apply ellipsoids to model Martian dust. Precomputed scattering properties for ellipsoids are readily available from the database by Meng et al. 2010.

In contrast, there are many in-situ measurements of the Martian dust composition. Interestingly, there are terrestrial soils with similar composition, such as Palagonite. Scattering properties of Palagonite particles have been measured in a laboratory (Laan et al. 2009), so we use these measurements to validate our modeling approach.

The ellipsoids can closely reproduce the laboratory-measured scattering properties of Palagonite. When comparing the uncertainties related to size and composition to those related to particle shape, these are found to have comparable effects on the scattering properties. Properly accounting for the particle shape is therefore important in interpretation of remotely sensed data (Merikallio et al. 2013).

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Uranus and Neptune to be Scouted by E-sail

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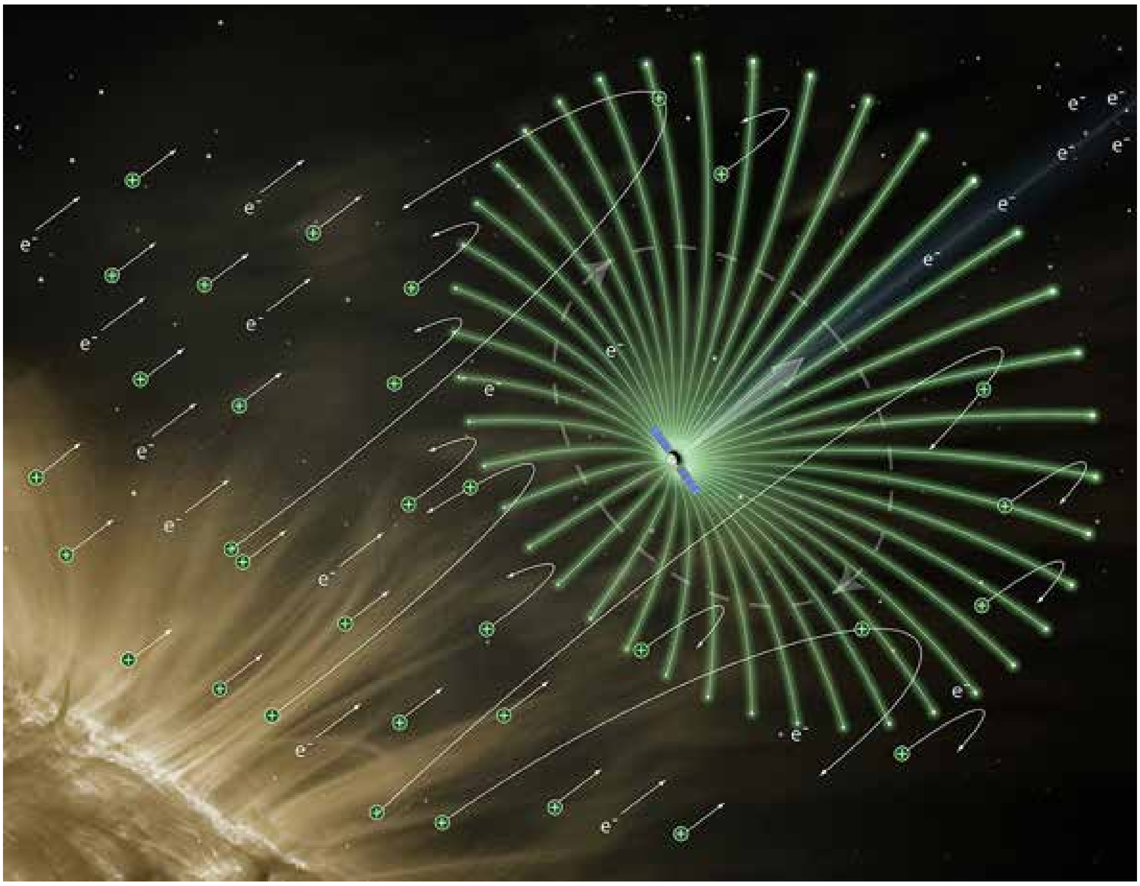
The Electric Solar Wind Sail technology provides the means to reach outer planets in a reasonable time, with a flexible launch window and low cost. This new propulsion method uses long (20 km) and thin tethers charged to high voltages (~20 kV) to convert the momentum of the solar wind particles into spacecraft thrust (Janhunen et al. 2010). Contrary to traditional photonic solar sails and solar power, which both scale as 1/r2, the E-sail thrust scales as 1/r, r being the distance to the Sun, which further increases E-sails appeal for outer solar system exploration. The technology is being developed in an FP7 project ESAIL, http://www.electric-sailing.fi/fp7 and currently tested onboard ESTCube1, which was successfully launched on May 2013. Here we take a look at the possibilities and feasibility of an ice giant mission realised with the E-sail propulsion.

E-sail, once in the Solar Wind, can be steered continuously after launch, making it possible to send probes to several different destinations on a same launch. In essence, the continuous, steerable acceleration does not require planetary fly-bys and is relatively free of launch window constraints. Moreover, low spacecraft mass due to the absence of fuel tanks leads to low costs, and as a similar design can be implemented on both Uranus and Neptune probes, also the manufacture and assembly costs are greatly reduced.

As an example, with a standard E-sail (1 N thrust at the 1 AU distance from the Sun), Neptune could be reached in five years with 500 kg of payload. Payload here stands for the whole spacecraft mass from which the mass of an E-sail has been subtracted. Delivering 1000 kg would take 8 years and could be launched anytime, without needing to wait for a suitable launch window. Entry probes have been proven to be possible with entry speeds as high as 47 km/s (Galileo in Jupiter, 1995), which makes them very good combination with E-sail probes with entry speeds less than 30 km/s for both Uranus and Neptune.

If an orbiter mission would be considered, orbital insertion would be somewhat challenging due to the relative low masses of the ice giants and the fast approach velocity of the E-sail propelled spacecraft. Traditional chemical engines will be unable to provide the required impulse for orbit insertion and aerocapture technologies are needed. Presently available solutions, without E-sail, would require a large spacecraft due to massive amounts of the fuel needed. Moreover, they would require dedicated launches, most likely one separate for both of the planets within a very time-constrained launch window.



Electric Solar Wind Sail deflects solar wind particles with highly charged hair-thin tethers to produce spacecraft thrust. Among other things, this new technology enables ambitious missions towards the outer solar system. Graphics by: Alexander Szames/Antigravite.

Relatively light-weight and high payload ratio vehicles enabled by the E-sail could, on the contrary, piggyback on any launch taking them to the escape orbit so that they could unwind their tethers and start sailing on the solar wind. The E-sail thus has the potential to change the trend of dedicated launches and to enable low-cost small and moderate mass planetary probes to the outer planets that can be launched in arbitrary mixed combinations with any Earth-escape-capable launcher to any outer solar system targets, Uranus or Neptune, but also Jupiter and Saturn.

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Photometric and Polarimetric Modeling of Small Solar System Bodies

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Polarimetric observations of atmosphereless Solar System objects are interpreted using a radiative-transfer coherent-backscattering model (RT-CB) that makes use of a so-called phenomenological fundamental single scatterer (Muinonen & Videen, JQSRT 113, 2385, 2012). Extensive computations with the discrete-dipole approximation (DDA) are then utilized to extract, from the phenomenological single-scattering solutions, physical solutions in terms of the size, shape, and complex refractive index of the scatterers (Zubko, Light Scattering Rev. 6, 39, 2012). For the validity of RT-CB, see Muinonen et al. (Astrophys. J. 760, 118, 2012). The new RT-CB-DDA modeling allows us to constrain the single-scattering albedo, phase function, and polarization characteristics as well as the mean free path length between successive scatterings. It further allows us to put constraints on the size, shape, and refractive index of the fundamental scatterers. We illustrate the application of RT-CB-DDA by interpreting the polarimetric observations of the C, M, S, and E-class asteroids.

Geomagnetically induced Currents in the Norwegian Power Grid

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Geomagnetically induced currents (GIC) belong to space weather phenomena affecting ground infrastructure. These currents flow in electric power transmission systems, oil and gas pipelines, telecommunication cables and railway equipments (Pirjola, 2005). In power systems GIC can cause saturation of transformers which may possibly result in an increase of exciting current, harmonics in the electricity, unwanted relay trippings, excessive reactive power demands, a blackout of the whole system and permanent damage of transformers.

We have derived comprehensive statistics of geomagnetic activity for assessing the occurrence of geomagnetically induced currents in the Norwegian high-voltage power grid. We have considered two scenarios: the present grid in 2012 and extended grid expected in 2030. The statistical study is based on a long-term time series of geomagnetic recordings from which the geoelectric field can be modelled and applied to a DC description of the Norwegian high-voltage power grid to estimate GIC. The purpuse of this study is to offer information about the risks of GIC to Statnett company.

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Atmosphere-surface Interactions on Mars

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The thermal properties of the Martian regolith play a key role in controlling its temperature and the rate at which volatiles are transferred between the atmosphere and surface. The thermal properties themselves will in turn vary depending on the quantity of volatiles contained in the regolith which may vary over daily and seasonal time scales. A way to track regolith-atmosphere volatile exchanges is then to measure the thermal properties of the regolith. This can be done using in-situ temperature measurements and an atmospheric model with a realistic numerical scheme for the thermal modelling of the subsurface (Paton et al., 2013a).

Landers have taken in situ surface and subsurface temperature measurements at three points in the Martian northern hemisphere. Viking lander 1 (VL-1), Viking lander 2 (VL-2) and the Phoenix lander measured the surface temperature, using a sensor located on their surface-samplers (Moore, 1987; Zent et al., 2010), at the latitudes of 22°N, 48°N, 68°N respectively. Additionally VL-1 made subsurface temperature measurements using a sensor located on its footpad that was buried under the Martian regolith during landing (Moore, 1987). The VL-2 footpad temperature sensor remained above the surface and made measurements at an altitude of a few centimetres.

We used a 1-D atmospheric column model (Savijärvi, 1999) with an updated realistic subsurface numerical thermal conductivity scheme (Paton et al., 2013b) for our analysis. Apparent seasonal variations of thermal properties, that we observed at the VL-1 landing site, are reported together with the surface thermal properties we determined for the VL-2 landing site and for the Phoenix lander landing site. Our results are discussed in terms of the coupling of the Martian atmosphere with the surface.

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Trajectory Simulations of Martian and Uranus Atmospheric Entry Vehicles

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In situ measurements of planetary atmospheres are a valuable source of information for helping to understand planetary atmospheres, planetary formation and evolution, and helping divulge the story of the Solar System. Entry probes (Fig. 1) are spacecraft that have been designed to survive the intense aerothermal regimes encountered during high speed entry into a planetary atmosphere from space. They can deliver specialised instrumentation for the investigation of planetary atmospheres and deliver payloads to the surface. Entry probes have been used successfully on Venus, Earth, Mars, Jupiter and Titan. The most important design considerations for an entry probe are the peak heating, heating load, peak deceleration and peak dynamic pressure.

A model for generating trajectory simulations are presented here that can be used to help determine the forces and heating that may be experienced by a probe entering a planetary atmosphere. The simulations numerically solve the equations of motion in three dimensions. The model has primarily been developed to investigate the problems of landing on Mars building on previous work (Paton and Schmidt, 2007). The model has been expanded from a two degree of freedom model to a three degree of freedom model. Also included is a mathematical representation of the Martian climate in terms of wind speed and density. This allows the deflection of a spacecraft's trajectory from seasonal and latitudinal variations in wind and density to be examined. Guidance algorithms are also included for flying vehicles through the atmosphere to a precise landing points on the Martian surface. The model has been compared to flight data from past lander missions to Mars. The model has also been compared to an established 6-DoF flight simulator directly and indirectly via a virtual prototyping technique.

The model has now been slightly modified to simulate the trajectory of an entry probe released from an E-sail (Janhunen et al., 2010) and entering the atmosphere of Uranus as proposed by Merikallio et al. (2011). It is not immediately clear if an entry probe will survive the entry into the atmosphere of Uranus when delivered by an E-sail due to the high entry speeds. In addition the rotation around the equator of a giant planet like Uranus is very fast relative to the rotation at higher latitudes. Choosing a prograde over a retrograde entry into the atmosphere may have a significant benefit in terms of managing the aerothermal regime that the probe will experience.

Multiple trajectories into the Uranus atmosphere were generated by first varying the initial conditions, i.e. the entry velocity and entry angle. Then the trajectories were repeated at different latitudes to examine the effect of the planet's rotation on the heat loading and other entry probe design considerations. The trajectory simulations were repeated for both retrograde and prograde directions to examine the significance of the direction of entry on the heat loading. We repeat the simulations to determine trajectory dispersions due to the wind speeds of the entry probe and of the probe after it has deployed its parachute.

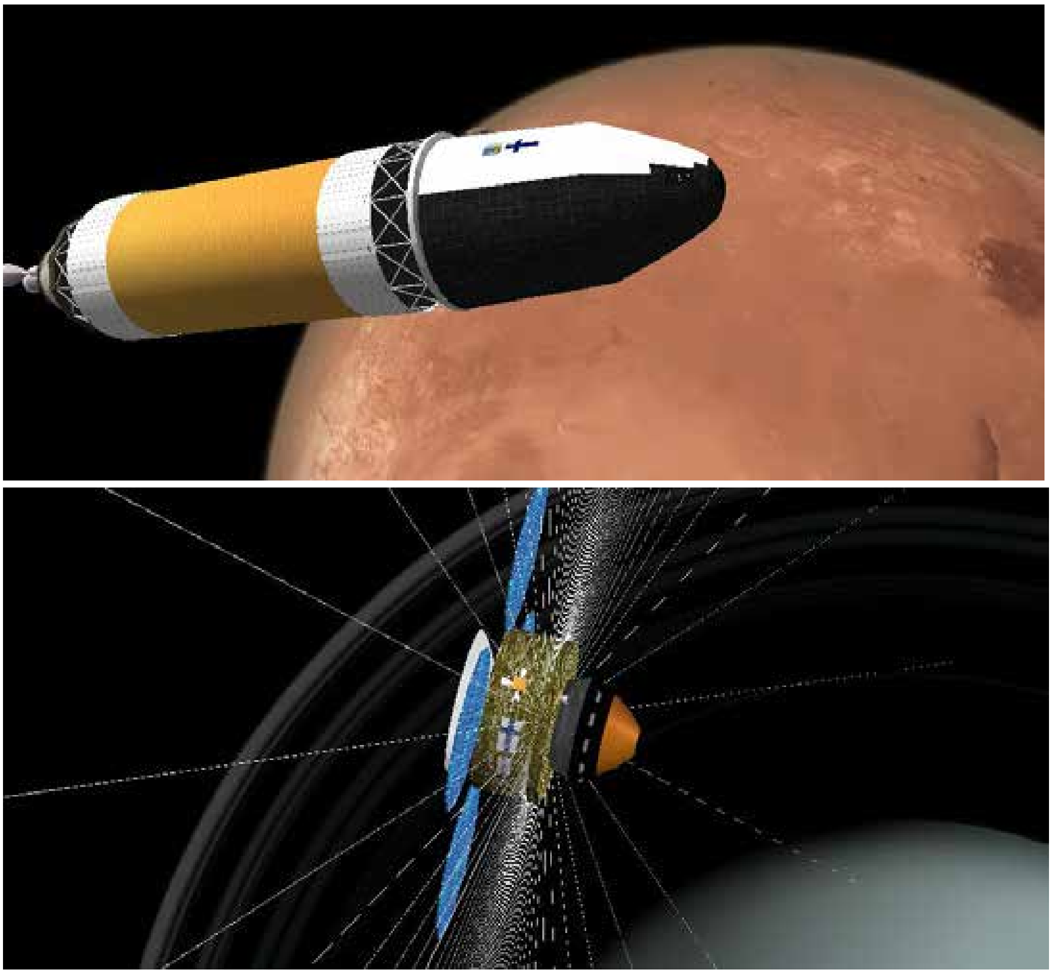

Figure 1. Artist's renderings of a Martian biconic entry vehicle (top) and the E-sail with a Galileo-type entry probe for use in the Uranus atmosphere (bottom). The Orbiter Space Flight Simulator (Schweiger, 2006) was used for these renderings.

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Two Striking Meteorite Events: The "Roof Meteorite" Oslo 2012 and the "Catastrophic" Chelyabinsk 2013 Meteorite

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Recently, two striking meteorite events occurred in Europe. On March 9/10, 2012, a meteorite fell through the roof of a cottage in Rodeløkka, Oslo, Norway. The University of Helsinki geophysics group received fragments of this meteorite from Rune Selbekk (Natural History Museum, Oslo). On February 15, 2013 a small asteroid exploded in a remarkable fireball-event above Chelyabinsk city, Russia. We obtained pieces of this asteroid as meteorite fragments by Dmitri Badjukov from the Verdansky Insitute, Moscow. Here we report preliminary physical properties of these meteorites in order to estimate their class and petrographic type.

Methods. The Oslo fragments had a fusion crust, which were scraped off using a diamond saw, in order to obtain more representative results of the "fresh" inner part of the meteorite. The Chelyabinsk meteorite had less fusion crust but had clearly two different populations: dark and light fragments. We used standard non-destructive petrophysical and rock magnetic methods to study their physical properties. The measurements were performed at the Solid Earth Geophysics Laboratory of the U of H. Bulk density was determined using the glass bead method and grain volume (volume of material without pores) was measured with an automatic pycnometer Quantachrome Ultrapyc 1300e using Nitrogen gas. Porosity was scalculated from bulk and grain densities. Magnetic susceptibility was measured with RISTO-5 kappabridge (Oslo) and with ZH Instruments SM-100 (Chelyabinsk). Hysteresis properties were measured using a MicroMagTM3900 Vibrating Sample Magnetometer by Princeton Measurement Corporation. Some hysteresis data of Chelyabinsk meteorite pieces were provided by Natalie Bezaeva from Verdansky Institute.

Results. Petrophysical bivariate relationship plots, porosity and hystresis data reveal that the Oslo meteorite is an H3 or H4 chondrite. This is consistent with a recent petrogaphic classification which suggest that it is an H3–6 chondrite supported by existence of chondrules in microscope images. The somewhat high porosity suggest that it is not highly shocked. The petrophysical and rock magnetic data of the Chelyabinks meteorite are consistent with its petrographic class/type of LL5 chondrite. In next, we aim to measure the paleomagnetic and rock magnetic properties of these meteorites in more detail including IRM- and ARM-spectra, röntgen microtomographic studies and paleointensity experiments.

Acknowledgements

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Renewal of Metsähovi Geodetic Observatory

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Metsähovi Geodetic Observatory was founded in 1975 and it has through the years become an essential part of the space geodetic activities of the Finnish Geodetic Institute. Satellite Laser Ranging (SLR) observations started in 1978, and since that the station has been developed towards a core station in the global geodetic network. Metsähovi has a versatile set of space geodeic instruments, including SLR, several GNSS receivers, geodetic VLBI together with Aalto University and a DORIS beacon of CNES and IGN. There are also ground based superconducting and absolute gravimeters.

Today, scientific challenges are changing rapidly with new emerging techniques and demands. To keep Metsähovi as a modern and globally relevant fundamental station, a remarkable amount of investments is expected. Ministry of Agriculture and Forestry allocated special funds for 2012–2016 for renewal of Metsähovi instrumentation and infrastructure. This includes a new VLBI2010 compatible radio telescope, a modern telescope for the SLR, and a new superconducting gravimeter. In addition, FGI maintains the national permanent GNSS network which will be upgraded as well.

In this presentation we describe the renewal of Metsähovi station, its current status and the role of geodetic fundamental stations in satellite positioning and research of the global change.

Space Research at Aalto University: Recent Highlights

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Space activities at the Aalto University School of Electrical Engineering (Aalto-ELEC) comprise space technology, space science, and radio astronomy. The space technology activities focus on application of microwave remote sensing techniques especially in questions of Earth observation and climate change monitoring, such as monitoring the arctic sea and snow cover or soil moisture. The research group also operates its own aircraft, which provides high-resolution local radiometer observations to validate satellite measurements as well as to provide independent local information. The Aalto-1 and Aalto-2 student satellite projects focus on developing complete satellite system technologies in a cubesat format. The space science activities focus on examination of the solar wind influence of the near-Earth space environment, and its consequences on space-borne and ground-based technological systems. The recently launched NASA van Allen probes provide observations in the inner parts of the magnetosphere where the navigation and geostationary communication satellites reside, while the ESA Cluster and NASA Themis missions provide multi-point observations from the outer parts of the magnetosphere and the upstream solar wind. The Metsähovi Radio Observatory operates a 14-m diameter radio telescope focused especially on study of quasars and other active galactic nuclei. Very long baseline interferometry research is carried out in collaboration with several VLBI networks, the Metsähovi speciality is in shorter wavelengths including mm-VLBI. The Metsähovi team has been part of the ESA Planck mission core science program from the beginning, focusing on mapping the extragalactic point sources in the Planck data foreground. In this poster we present recent research highlights from each of the three main areas.

New Compact Spectral Imaging Technology Offers Unforeseen Opportunities for Atmospheric Remote Sensing

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Push broom imaging spectrometers has been used in instruments like GOMOS, SCIAMACHY, OMI and GOME. In these instruments the light is dispersed by means of a prism or by a diffraction grating. These push broom instruments form a 2D image on detector in which one axis is spectral and the other spatial dimension making it impossible to get an image of the atmospheric limb instantaneously. In ALTIUS[1] (Fussen et.al.) the concept is to use the entire detector as an imager of the atmospheric limb to solve the tangent altitude registration problem (ref. http://altius.oma.be). In ALTIUS acousto-optical tunable filters (AOTF) are used. A similar type of mission titled “Spectral Imaging of Middle Atmosphere for Climate Change[2] (SIMACC, Antila et.al.)” has been proposed by Erkki Kyrölä, et.al. in response to ESA Call. In SIMACC instrument Fabry-Perot Interferometer (FPI) tunable filters are planned to be used. The advantages of the novel FPI technology over AOTF technology are higher optical throughput and flexibility in the wavelength range. Canadian Space agency has studied use of a miniature high-resolution Fabry–Perot guided-wave spectrometer for planetary atmospheric remote sensing in connection of the MEOS Microsatellite concept study[3]. The MEOS spectrometer concept enables lighter and smaller instruments than conventional push-broom designs but its size is still larger than what can be achieved with VTT compact FPI technology.

This paper describes the technology and properties of MEMS and Piezo-actuated FPI modules and spectral imagers based on them. Novel instrument concepts to utilize this technology in atmospheric studies will also be discussed. VTT has developed MEMS and Piezo-actuated Fabry-Perot Interferometer (FPI) modules for miniaturized spectrometers covering spectral regions from UV to thermal IR since 1990[4] (Saari et.al.). This technology enables to build extremely compact imaging spectrometers. VTT has built spectral imagers for UAV that can be used in forest and agriculture applications which are based on Piezo-actuated FPIs accompanied with 4…5 Mpixel RGB CMOS image sensors. The mass of the spectral imager is 400...650 grams. The MEMS FPI is a monolithic device, i.e. it is made entirely on one substrate in a batch process, without assembling separate pieces together like in Piezo-actuated device. The gap is adjusted by moving the upper mirror with electrostatic force, so there are no actual moving parts. Benefit of the MEMS FPI is a low mass.

The Aalto-1 Spectral Imager[5] (AaSI, Kestilä et.al.) is a Piezo FPI based miniaturized spectral imager capable of recording images at any 20+ selectable wavelength bands between 500 and 900 nanometers and it will fly on the Finnish Aalto-1 student satellite. AaSI will have an RGB CMOS sensor consisting of 1,024 x 1,024 pixels which will be used in 2 x 2 binning mode. This allows the minimum ground pixel size of ca. 200 m from a 600 km orbit. In addition to this, AaSI will also include a normal colour camera with a resolution of 1,910 x 1,270 pixels. The images taken by this camera will be used as a georeference for the spectral images. The spectral, radiometric and spatial performance of the instrument will be tested on the Aalto-1 nanosatellite mission. As Aalto-1 will have limited downlink capacity, the amount of measured spectral bands has been reduced. However, the instrument itself can measure 60+ spectral bands, and this feature may still be tested during the mission. In-orbit spectral calibration is planned to be done by using known bright spectral features (e.g. the Sahara desert) and measuring the spectrum around strong absorption peaks (e.g. O2 absorption at 750–760 nm). Also on-board calibration using the 500 and 900 nanometer filter edges will be applied. The piezo-actuated FPI used in AaSI has already passed space qualification testing and the instrument has passed the critical design review. In the current design the instrument envelope is 97 x 97 x 48 mm^3 with a mass of ~600 g. The construction of the complete qualification model is currently under way and the flight model is expected to be completed during the autumn of 2013. The main advantages of the AaSI concept are the small size and the spectral programmability, which provides flexibility and reduced data rate when the application is well defined. A successful space qualification and orbit demonstration will enable development of more advanced instruments based on piezo and MEMS Fabry-Pérot interferometer technologies.

VTT is also involved in the development of the spectral imager for the Visible Spectral Imager for Occultation and Nightglow (VISION) instrument for the Belgian Picasso CubeSat mission[1]. VISION is a tunable spectral imager based on a Fabry-Perot in the visible and near-infrared wavelength. Its spectral range is 400 nm…800 nm and resolution ~10 nm @ FWHM. The pixel FoV is around 0.002 degrees (~35 µrad). The dimensions and mass of VISION instrument are similar to the AaSI spectrometer.

VTT, together with Finnish Meteorological Institute, have developed new space, UAV and ground based instrument concepts for atmospheric remote sensing based on the compact Fabry-Perot Interferometers. Instrument concepts for the UV hyperspectral imager for the wavelength range 250–400 nm and SWIR (Short Wave Infrared) instrument for 1,000–2,500 nm will be presented.

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Time of Flight Spectra of Dust Impacts in the Solar System and at Comets Wild 2 and Tempel 1 as Measured by CIDA

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Cometary and Interstellar Dust Analyzer, CIDA, has been operated in space from launch on Stardust in February 1999 until its second comet flyby on StardustNExT in February 2011, yet not cotinuously. During its mission, it has made observations of dust at comet Wild 2 in 2004 and at comet Tempel 1 in 2011, as well as during the cruise phases to the comets. The instrument operates as a transient recoder of signlas from ions produced by impacts of dust grains onto its silver target. Data sets are stored whenever an ion signal reaches the trigger level.

The method has been used successfully earlier during missions to Halleys comet in 1986, where both, mineral and organic material was found. By nature the ion formation processes depend on the speed and the size of incident dust grain_. While at Halley impact speeds were 70 km/s and higher. The CIDA observations have been made under a wide range of conditions from a minimum speed of 6.2 km/s at Wild 2 to 10.9 km/s at Tempel 1 and possibly much higher speeds of assumed ~ 30 km/s in interplanetary space. Observations of both, positive and negative ions have been made.

To understand the measurements, we have applied modern mathematical methods, which showed the existence of several groups of data with similar properties. Comparisons between each group of events and a large set of calibration data obtained at the Heidelberg Dust accelerator Laboratory have been made. Due to the complexity of the mechanisms for ion production from complex organic mixtures, it is difficult to identify individual chemicals. The use of advanced methods to determine the classes of chemistry from the observations shows encouraging first results.

Some120 spectra have been recorded at the comets and some 50 during the interplanetary cruising phases of the mission. The results show the presence of complex organic molecules. At the comets, in negative ion mode spectra we find CN ions. Only a few spectra point to the presence of minerals. This might be another hint that mineral grains are coated by organic materials. We present the observational data acquired and demonstrate the methods for their interpretation.

SOHO/SWAN: 17 Years Monitoring of Solar Wind, Comets and Space Weather

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Since the launch of the Solar & Heliospheric Observatory SOHO on December 2, 1995, the Solar Wind Anisotropy instrument SWAN has been mapping nearly continuously the solar Lyman alpha radiation intensity distribution in the Solar system from SOHO's vantage point at the Lagrange point L1. The data collected as routine daily full sky maps with an angular resolution down to 0.04 steradian were used to monitor the solar wind intensity and velocity distribution, to detect comets and derive their water production rates, and to predict the space weather development up to 15 days into the future. By combining data collected with a time difference of half a year, 3D information could be derived for the heliopause and the details of the interaction between the heliosphere and the surrounding space. Following the intensity distributions through more than a complete Solar cycle, the solar wind distribution variability with the Solar cycle could be shown.

As SWAN is monitoring once in 24 hours the complete solar system, solar wind intensities and velocities at the locations of the different planets can be calculated and are routinely published by an automatic analysis system at the SWAN website together with calibrated intensity maps and space weather predictions. During late winter 2013 SWAN was monitoring the rare event of two larger comets chasing one another through the sky of the southern hemisphere, C2011 L4 PanSTARRS and C/2012 F6 Lemmon.

For details see the web sites http://space.fmi.fi/index.php?id=swan and http://swan.projet.latmos.ipsl.fr/images

Acknowledgements
SOHO is a project of international cooperation between ESA and NASA. SWAN is a cooperation project between LATMOS, former Service d'Aeronomie, in Paris, France and the Finnish Meteorological Institute in Helsinki, Finland. The instrument development was supported by CNRS in France and TEKES in Finland.

Studying Gravity Waves and Turbulence in the Stratosphere Using Satellite Observations of Stellar Scintillation

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Stellar scintillation observed through the Earth atmosphere is the result of interaction of light wave and turbulent atmosphere. This presentation is dedicated to using satellite stellar scintillation measurements for studies of gravity waves and turbulence in the Earth atmosphere.

A methodology for retrieving the information about the small-scale air density irregularities from scintillation measurements is discussed. The overview of the main geophysical results that are obtained from EFO-2/MIR and GOMOS/Envisat fast photometer measurements is presented.

The benefits of the scintillation method in studies of the structure of air density irregularities and its limitations will be also discussed.

Retrieval of Cloud Properties Using AATSR Data

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The Advanced Along Track Scanning Radiometer (AATSR) aboard ESA's Environmental satellite ENVISAT measures the radiance at the top of the atmosphere (TOA) at seven wavebands from the visible to the thermal infrared in each of the two viewing directions (nadir and 55º forward). The AATSR aerosol retrieval algorithms are briefly described in the presentation by de Leeuw. For aerosol retrieval clouds are discarded because of their high reflectance. However, information on clouds is valuable for, e.g., climate studies and for studies on the effects of aerosols on cloud properties, such as cloud droplet size affecting albedo and precipitation. For that reason a cloud retrieval scheme, SACURA (Kokhanovsky et al., 2003), has been implemented. This complements the AATSR aerosol products with the following cloud properties: cloud optical thickness, effective radius, liquid water path and cloud albedo. These properties are retrieved using nadir observations in the wavebands at 865 and 1600 nm, for solar zenith angles smaller than 30º. The retrieval of both aerosol and cloud properties in the same scheme will allow for studies on aerosol-cloud interactions. In the future common aerosol-cloud retrieval will be attempted.

One of the areas of interest is the atmospheric composition in the Arctic. Aerosols are of interest because of their effect on the albedo of snow and ice, and snow melt, which in turn affects the Arctic climate. Likewise, clouds are of interest because of their effects on climate. However, because both snow/ice and clouds are highly reflecting, cloud detection over snow/ice covered surfaces is very challenging.

First results of SACURA will be presented and the detection of clouds over snow/ice covered surfaces is addressed.

Estimating the Direct Aerosol Radiative Effect Over China Using Multi-Sensor Satellite Remote Sensing Measurements

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The quantification of aerosol radiative effects is complex and large uncertainties still exist, mainly due to the high spatial and temporal variation of the aerosol concentration and mass as well as their relatively short lifetime in the atmosphere. In this work a multi-sensor satellite based approach is studied for defining the direct short wave aerosol radiative effect (ADRE) over China. ADRE at the top of the atmosphere (TOA) is defined as the difference between the net solar flux with (F) and without (F^0) aerosols. The negative values of ADRE correspond to increased outgoing radiation and planetary cooling, whereas positive values correspond to decreased outgoing radiation at TOA and increased atmospheric warming.

To derive instantaneous ADRE from the satellite observations, the challenge is to estimate the value for F^0. In this work F^0 is derived using the colocated observations of CERES (Clouds and the Earth's Radian Energy System) short wave broad band TOA-flux and MODIS (Moderate Imaging Spectroradiometer) aerosol optical depth (AOD). Assuming that aerosol type does not change systematically within a 0.5 deg. grid cell over a month, a linear relationship is established between the TOA-flux and AOD when AOD < 2.0. Using the linear fit an estimate for F^0 can be obtained while F is the monthly mean of CERES observations. However, there are several other parameters affecting the observed TOA flux than the aerosol loading and aerosol type, such as solar zenith angle, water vapour, land surface albedo and Earth-Sun distance. Changes in these parameters within a grid cell over a month inflect the correlation. To minimize the effect of zenith angle, water vapour, and Earth-Sun distance the CERES fluxes are normalized before the linear fitting using reference fluxes calculated with a radiative transfer code (Libradtran). The normalization, especially to a fixed zenith angle increases the correlation between TOA flux and AOD significantly. For a comparison the F^0 is also modeled using Libradtran. Comparison shows that the modeled aerosol-free fluxes are mainly 5–10 Wm^2 lower than the estimate from the linear fitting, but on the other hand over bright surfaces the satellite based estimate is lower than the modeled F^0. Nevertheless, the fitting method in most of the cases produces qualitatively similar results for instantaneous ADRE than what is obtained with modeled F^0 over the region of interest. In some cases, the satellite based method gives positive ADRE over areas where it is expected to be negative. This is most probably a method failure, related to either subvisible cirrus contamination, systematic change of aerosol type or both.

Highlights of GOMOS Measurements of Atmospheric Composition and Dynamics During 2002–2012

Johanna Tamminen, Erkki Kyrölä, Viktoria Sofieva, Pekka Verronen, Janne Hakkarainen, Simo Tukiainen and the international GOMOS team

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During the ten years of its operations, from 2002 to 2012, Envisat/GOMOS (Global Ozone Monitoring by Occultation of Stars) instrument demonstrated the capabilities of stellar occultation technique for atmospheric profiling. In this presentation we show highlights of GOMOS measurements of climatologies and process studies in the stratosphere and mesosphere. The UV-VIS wavelengths of GOMOS were used for measuring O_3, NO_2, NO_3 and aerosols, including polar mesospheric clouds and polar stratospheric clouds while O_2 and H_2O were measured using two near-IR channels. High vertical resolution temperature profiles were obtained using the time delay of the red and the blue photometers of GOMOS. The two photometers were also used for studying turbulence and gravity waves. Constituents with weak spectral signatures, such as OClO and Na, were retrieved using temporal averaging. Vertically the measurements extend from 10 km to 100 km with varying valid altitude range depending on constituent. Stellar occultation technique ensures high vertical resolution of 2–4 km, very accurate altitude registration and relatively simple data retrieval. The self-calibrating feature of the occultation technique is particularly suitable for long term trend analysis and thus crucial for studying the climate-chemistry interactions. The ten years of global GOMOS ozone measurements are presently included in ESA's Climate Change Initiative on ozone. Here we present also several process studies of atmospheric composition and dynamics where GOMOS data is used.

Magnetospheric Response to Alfvenic and Non-Alfvenic Interplanetary Fluctuations

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Solar originated structures such as interplanetary coronal mass ejections and high-speed streams are known to modulate geomagnetic activity. Most dramatic magnetospheric effects are caused by interplanetary coronal mass ejections (CMEs), but auroral region geomagnetic activity is best modulated by interplanetary high-speed streams (HSS). How does the effects of Alfvenic and non-Alfvenic solar wind fluctuations differ from each other is an open and interesting question we aim answering in this presentation. We will show examples of HSS and ICME embedded fluctuations and furthermore geomagnetic conditions during those intervals. Seasonal, annual and solar cycle-to-cycle variation of geomagnetic activity will be presented during different driving conditions. Driving conditions are separated to the Alfvenic intervals, ULF intervals, other fluctuations and no fluctuations. We will cover time scales from seconds to solar cycles and include data from both hemispheres.

Space-borne remote sensing at Metla – selected examples

Space-borne remote sensing at Metla – selected examples

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The Finnish Forest Research Institute (Metla) developed a method called multi-source national forest inventory (MS-NFI). The first operative results were calculated in 1990. Small area forest resource estimates, in here municipality level estimates, and estimates of variables in map form are calculated using field data from the Finnish national forest inventory, satellite images and other digital georeferenced data, such as topographic database of the National Land Survey of Finland. Six sets of estimates have been produced for the most part of the country until now and five sets for Lapland. The number of the map form themes in the most recent version, corresponding year 2011, is 45. The biomass by tree species groups and by tree compartments have been estimated in addition to the volumes by tree species and timber assortments (Fig. 1.). The first country level estimates correspond to years 1990–1994. The most recent versions are from years 2005, 2007, 2009 and 2011. The maps from year 2011 compose the second set of products freely available, at http://kartta.metla.fi/index-en.html and for viewing at http://www.paikkatietoikkuna.fi/web/en.

The new set of the products will be produced annually or biannually in the future. The maps are in a raster format with a pixel size of 20m x 20m and in the ETRS-TM-35FIN coordinate system. The products cover the combined land categories forest land, poorly productive forest land and unproductive land. The other land categories as well as water bodies have been delineated out using the elements of topographic database of the Land Survey of Finland.

The forest resource statistics and map form estimates and have been made using the improved k-Nearest Neighbour method (ik-NN method) (Tomppo et al. 2013 and 2008). The weights of the features in the ik-NN method are sought using an optimization method based on genetic algorithm. Coarse scale estimates of forest variables were used as the supplementary data. The volumes by tree species groups were se-

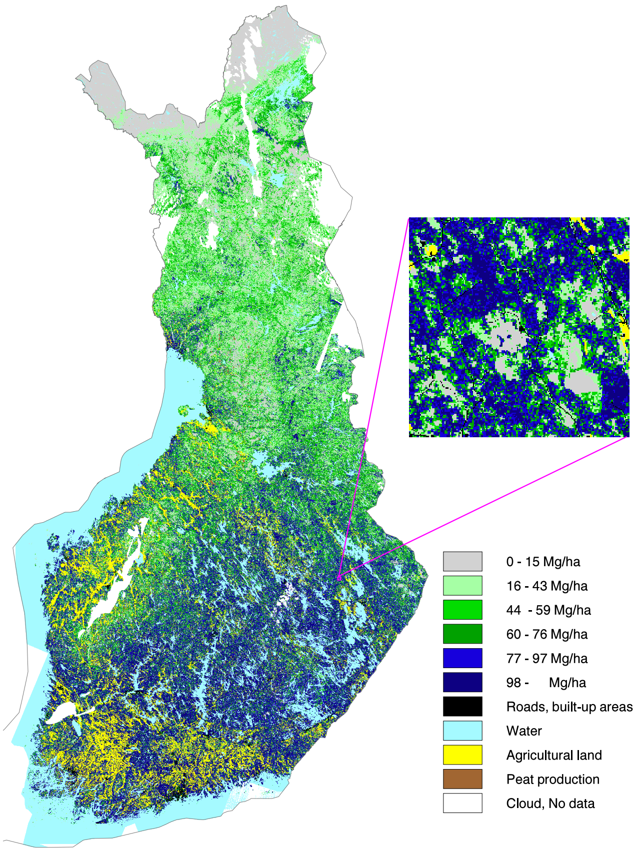

Figure 1. The total biomass of trees, above and below ground per hectare (mg/ha), produced using multi-source national forest inventory of Finland. The estimates correspond year 2009. Some areas against East and West border in North Finland are indicated by the cloud colour (white), in addition to some areas inside the borders, due to lack of satellite images caused by clouds. © Finnish Forest Research Institute, MS-NFI 2009 National Land Survey of Finland MML/VIR/MYY/328/0.

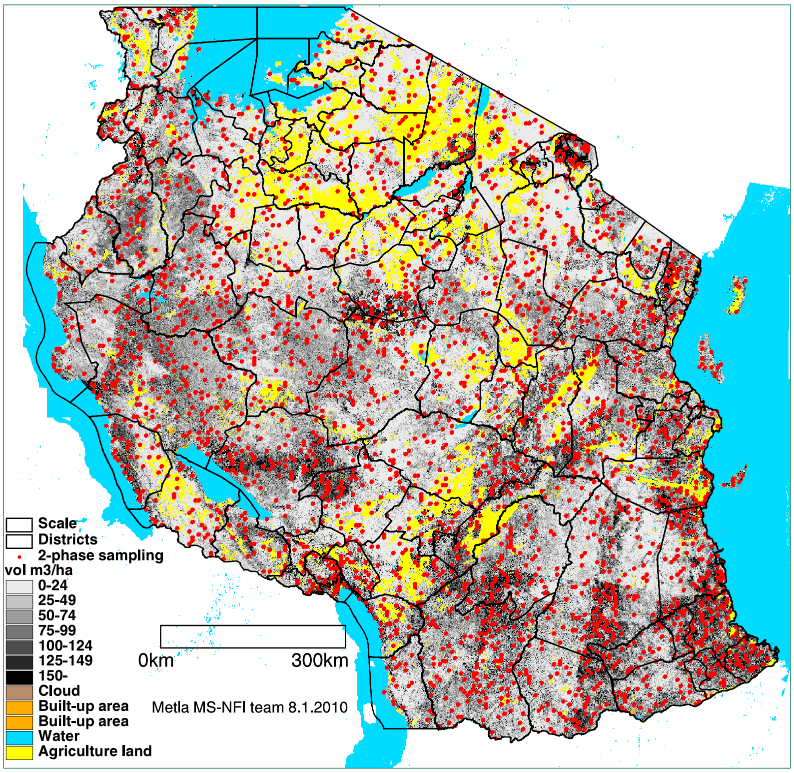

Figure 2. The result of the sampling study for Tanzania, the location of the field plot clusters using double sampling for stratification and a volume map based on Landsat 5 TM space-borne images.

lected as the variables. The purpose is to direct the selection of the neighbours, on the average, to forests similar to the target pixel (see the references below). The stratification of both the satellite image and the field plots were made using the topographic map data of Land Survey Finland.

MS-NFI team at Metla assists nations to establish forest inventories in countries world-wide, e.g., in Africa, South-America, and Asia. The first national forest inventory was developed for Tanzania in 2009–2010 in collaboration with the local experts and the Government of the United Republic of Tanzania. The role of Landsat images were crucial in constructing the ground sampling design (Tomppo et al. 2010) (Fig. 2.). It is crucial also making the results for the local management units.

Method development is an essential component in improving the quality of the estimates.

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National research Infrastructure Roadmap Proposal 2013: EISCAT and EISCAT_3D

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Incoherent scatter (IS) the most advanced radio method to remotely sense the upper atmosphere and the near-Earth space. Since 1981 the EISCAT IS radars in Northern Fennoscandia have provided the EISCAT associates a long-standing experience in developing the radar measurement techniques and their scientific applications. The EISCAT radars provide unique measurements from the upper atmosphere in the polar regions, where forcing both by solar activity and lower atmospheric phenomena are present. The facilities are maintained by the EISCAT Scientific Association (http://www.eiscat.se), an international research organisation registered in Kiruna, Sweden. The mainland EISCAT system consists of high-power VHF (224 MHz) and UHF (930 MHz) radars and the ionospheric modification facility (3.85–8 MHz) in Tromsø (Norway), as well as radar receiving sites in Kiruna (Sweden) and in Sodankylä (Finland). In addition, the EISCAT Svalbard Radar (ESR) operates at 500 MHz in the polar region.

The proposed EISCAT_3D phased-array facility will be a 3-dimensionally imaging radar, distributed in Norway, Sweden, and Finland. It will surpass all the current IS radars of the world in technology and act as a pathfinder for other types of radar facilities worldwide. When realized, EISCAT_3D will make continuous measurements of the geospace environment and its coupling to the Earth's atmosphere in the polar region and at the southern edge of the polar vortex for the next 30 years. Planning of the new IS radar facility (http://www.eiscat3d.se) started with the EU-funded Design Study (2005–2009). In December 2008, the European Strategy Forum on Research Infrastructures (ESFRI) selected EISCAT_3D to the Roadmap for Large-Scale European Research Infrastructures. The preparation continues in the EU FP7 Preparatory Phase project (2010–2014). The total project funding 4.5 MEUR is divided between nine partners, where University of Oulu has a share of about 1.1 MEUR. The EISCAT_3D will be realised as a multi-sited infrastructure using phased-array antennas and a key aspect is the use of advanced software and data processing techniques. This type of "software radar" will act as a pathfinder for other facilities worldwide. The current estimate of the total international investement required for EISCAT_3D amounts to 132 MEUR. Current proposal for the Finnish share of investing into construction of EISCAT_3D is 25 MEUR. Here we give a summary of the planned characteristics and science goals of the proposed international research infrastructure and review the current status of preparations towards realizing EISCAT_3D.

StreakDet Data Processing and Analysis Pipeline for Space Debris

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We describe a novel data processing and analysis pipeline for optical observations of space debris. During the past decades, the near-Earth space has become densely populated by man-made objects. It has been estimated that our space activities have left behind a population (active satellites as well as debris) of over 300,000 objects larger than 1 cm. Only some 15,000 have been tracked and catalogued, leaving the vast majority of the objects unknown.

The monitoring of space object populations requires the reliable acquisition of observations of objects, in particular to support the development and validation of space debris environment models, the build-up and maintenance of a catalogue of orbital elements, the assessment of conjunction events, or the support during contingency situations or launches.

Currently available, mature, image processing algorithms for detection and astrometric reduction cover objects that cross the sensor field-of-view comparably slow, and within a rather narrow, pre-defined, range of angular velocities. Typically, certain tracking techniques can be applied and the objects appear point-shaped or as short object trails in the exposures. The typical survey scenario is, however, always a “track before detect” problem.

For longer object trails (streaks) precise position information related registered epochs need to be extracted with sufficient precision. Algorithms for this task in the low signal-to-noise ratio (SNR) domain are not available yet. Some considerations are available in the current image processing and computer vision literature. There is a need to discuss and compare these approaches, to consider possible alternatives or modifications, and, finally, to develop and evaluate prototype implementations.

In the ESA-funded StreakDet project, we investigate all-around detection and reduction algorithms applicable to any observing scenario and to both low- and high-altitude objects. Processing involves several steps, including the segmentation and classification of moving objects, reference stars, artefacts and background, the identification of the objects of interest, the determination of the epoch-related positions of the objects in a reference frame (centroiding), and the estimation of the apparent brightness.

Retrieval of Volcanic Ash Plumes and Their Height Using AATSR Data

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The Advanced Along Track Scanning Radiometer (AATSR) aboard ESA's Environmental satellite ENVISAT measures the radiance at the top of the atmosphere (TOA) at seven wavebands from the visible to the thermal infrared in each of the two viewing directions (nadir and 55° forward). In contrast to the aerosol retrieval algorithms described in the presentation by de Leeuw, where the thermal infrared bands are only used for cloud detection, here they are also used for the detection of volcanic ash which is primarily based on the brightness temperature difference (BTD). In addition, information from VIS/NIR channels is used. The aerosol optical depth (AOD) within the ash plume is retrieved using the AATSR Dual View (ADV) and AATSR Single View (ASV) algorithms. Using the AOD, information on the volcanic aerosol mass load can be derived, based on the aerosol models used in the retrieval.

In addition to the plume position, information on the plume height can be obtained using the AATSR stereo view. The AATSR Correlation Method (ACM) height estimate algorithm uses an area-based cross correlation method. It estimates the parallax between the AATSR nadir and forward views, and converts the resulting plume-top pixel shifts to a height estimate using the known satellite-Earth geometry. The algorithm is based on existing cloud-top height estimate methods, but is implemented independently with focus on volcanic ash plumes. The ACM algorithm can be run simultaneously with the ADV/ASV aerosol optical depth retrieval algorithm, using the same ash mask.

First results of volcanic ash plume and plume height detection will be presented.

High Resolution Ammonia Mapping of the Candidate First Hydrostatic Core Object Cha-MMS1

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Cha-MMS1 was mapped in the NH3(1,1) line and the 1.2 cm continuum using the Australia Telescope Compact Array, ATCA. In addition, the core was mapped with the 64-m Parkes telescope in the NH3(1,1) and (2.2) lines. Observations from Herschel Space Observatory and Spitzer Space telescope were also used to help interpretation. The ammonia spectra were analyzed using Gaussian fits to the hyperfine structure, and a two-layer model was applied in the central parts of the core where the ATCA spectra show signs of self-absorption. An elongated rotating core with a steep velocity gradient (~ 20 km s-1 pc-1) is seen in ammonia. The rotation axis goes through the position of a compact far-infrared source detected by Spitzer and Herschel. The spectral energy distribution (SED) of the far-IR source is consistent with a class 0 protostar. A string of 1.2 cm continuum sources is tentatively detected near the rotation ax! is. An hourglass-shaped structure is seen in ammonia at the cloud's average LSR velocity, also aligned with the rotation axis. The observed ammonia structure mainly delineates the inner envelope around the central source. The velocity gradient is likely to originate in the angular momentum of the contracting core, although influence of the outflow from the neighboring young star IRS4 is possibly visible on one side of the core. Although this structure resembles a pair of outflow lobes, the ammonia spectra show no indications of shocked gas. However, the two-layer model suggests the presence of a warm gas in this region, possibly owing to an embedded outflow. We conclude that the object has passed the first hydrostatic core phase.

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Invited speakers:

Thursday 9:00
Joy Crisp
NASA Jet Propulsion Laboratory
The Curiosity Rover Mission

Thursday 15:30
Marko Pekkola
Tähdet ja Avaruus, URSA
Scientists Navigating Media Space

Friday 9:00
David Crisp
NASA Jet Propulsion Laboratory
The OCO-2 Mission
– the Next Step in Space-Based CO_2 Measurements

Friday 15:00
Jaan Praks
Aalto University
Modern spaceborne radar in forest applications

Programme Committee: Erkki Tomppo, Metla, Tuija Pulkkinen, Aalto University, Sini Merikallio, Finnish Meteorological Institute

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Mars picture by NASA
Design and Finnish forest by Sini Merikallio