List of Abstracts
3rd Swiss SCOSTEP Meeting

6-7 March, 2019
PMOD/WRC, Dorfstrasse 33, Davos Dorf
Conference room, 3rd floor
http://projects.pmodwrc.ch/scostep/

Abstract 1:
Title: The magnetic sensitivity of the scattering polarization signal in the wings of the Ca I resonance line at 422.7 nm
First Author: Ernest **Alsina Ballester**
Co-authors:
Abstract: The radiation emerging from the solar atmosphere is the main observable through which its thermal, dynamical, and magnetic structure can be inferred and studied. In particular, the polarization properties of the emergent spectral line radiation encode valuable information on the strength and orientation of the magnetic field at different atmospheric regions, depending on the line under consideration.
Near-limb observations of the Ca I resonance line at 4227 Å reveal a large-amplitude linear polarization profile with a peculiar triple-peak structure, produced by the scattering of anisotropic radiation. It presents a sharp central peak, whose radiation originates mainly from the middle chromosphere, and two broader peaks in the wings, which carry information regarding the photosphere. The latter peaks are a consequence of frequency coherence in line scattering processes and thus cannot be reproduced with a theoretical modeling that assumes complete frequency redistribution (CRD) in scattering. Relatively weak magnetic fields (on the order of 10 G) are capable of appreciably modifying the central peak via the so-called Hanle effect. On the other hand, it is well-known that this effect only operates in the Doppler core of the line. Therefore, it had been previously thought that the amplitude of the wing polarization peaks was insensitive to magnetic fields present in quiet regions of the solar atmosphere. Recently, it was theoretically shown that the so-called magneto-optical effects are capable of introducing a magnetic sensitivity also in the line wings, in the presence of magnetic fields of strengths comparable to those required for the Hanle effect to operate.
In this talk we discuss the expected signatures of this new physical mechanism on the wing linear polarization signals of the Ca I resonance line. The diagnostic implications, both for quiet and more strongly magnetized regions of the solar atmosphere, are also explored.

Abstract 2:
Title: The upper stratospheric solar cycle ozone response
First author: W. T. **Ball**
Co-authors: E. V. Rozanov, J. Alsing, D. R. Marsh, F. Tummon, D. J. Mortlock, D. Kinnison, J. D. Haigh
Abstract: Changes in the output of the Sun are thought to influence surface weather and climate through a set of processes initiated by the enhancement of upper stratosphere (32-48 km) ozone. In order to understand and assess the solar impact on the climate system, it is important that models reproduce the observed solar signal. However, the recommended dataset for comparison with climate models remains disputed. We use newly improved observed ozone composites to determine both why there is disagreement between composites, and which is most likely to be correct. We find that artefact-corrected composites represent the response better than those based on SBUV data alone. Further, we identify a U-shaped spatial structure with lobes emanating from the tropics to high altitudes at mid-latitudes. An idealised chemistry climate model experiment, and simulations considering historical meteorological conditions, both support this conclusion. The results are of benefit to satellite-instrument scientists, and to those engaged in atmospheric and climate research using both observations and climate models. The results will be important for assessing the solar signal in currently active and future assessments of chemistry climate models (e.g. CCMI). We recommend recommend the BASICv2 ozone composite to best represent historical upper stratospheric variability.

Abstract 3:
Title: The European Solar Telescope, Swiss participation
First Author: Michele **Bianda**
Co-authors: Renzo Ramelli, Daniel Gisler, Luca Belluzzi, Oskar Steiner
Abstract: The 4 m aperture European Solar Telescope (EST) is foreseen to be constructed in the Canary Islands and should be operational at the end of next decade. The project is promoted by the European Association for Solar Telescopes; Switzerland is member of this association and is represented by IRSOL. The H2020 research and innovation programme SOLARNET-2, connected with EST, was recently approved; the Swiss project within this project will be described.

Abstract 4:
Title: High-precision spectropolarimetric investigations to study the magnetic field in the granulation
First Author:Emilia **Capozzi**
Co-authors:Michele Bianda, Sajal Kumar Dhara
Abstract: Most of our knowledge of the photospheric magnetic field arises from the analysis of the polarization signals that the “Zeeman effect” induces in the spectral lines. However the main disadvantage of Zeeman effect diagnostics is that signals produced by magnetic fields with opposite polarities within the resolution element cancel out. So that vanishing Zeeman polarization does not necessarily imply the absence of magnetic

fields.
Nevertheless, the “Hanle effect” does not suffer from cancellation effects.
One of the most used and theoretically best understood lines in the second solar spectrum, which can be considered as a diagnostic tool for study magnetic field via Hanle Effect is the SrI 4607 Å line.
This absorption line was historically exploited for the determinations of spatially unresolved and turbulent magnetic field and numerical simulations foresee a particular behavior at subgranular scale.

Abstract 5:
Title: Feasibility study of a filter polarimeter dedicated to the measurement of the scattering polarization at the Sr I 4607 Å for DKIST
First Author: Sajal Kumar **Dhara**
Co-authors: Emilia Capozzi, Michele Bianda, Renzo Ramelli, Daniel Gisler
Abstract: We are planning to investigate the unresolved turbulent magnetic fields of the quiet solar photosphere with a spatial resolution sufficiently high (order of 0.1 arcsec) so to resolve granular and intergranular regions. To this aim, we are doing a feasibility study of a dedicated filter polarimeter system in collaboration with NSO to measure the scattering polarization and the Hanle effect in the SrI line at 4607 Å as a second generation instrument foresee to be installed at the new 4m aperture Daniel K. Inouye Solar Telescope (DKIST), under construction in Maui (Hawaii, USA). In this talk I will present an overview of the work related to the foresee instrument, 1) the estimation of photon budget at DKIST, compared with other existing solar telescopes required for this measurements, 2) draft of the construction of the prototype instrument using a Fabry-Perot interferometer (FWHM 35mÅ with finesse 1.7Å) and a broad band Sr filter (centered at 4607.3Å, FWHM 1.5 Å) with the Zurich Imaging Polarimeter (ZIMPOL) and 3) the observed results obtained during recent GREGOR campaign related to this project. We had also made test imaging polarimetric observation using broad Sr filter with fast camera and ZIMPOL at GREGOR and obtained some furious unexpected polarimentric structures.

Abstract 6:
Title: Contributions of natural and anthropogenic forcing agents to the early 20th century warming
First Author: T. **Egorova**
Co-authors: E. Rozanov, and P. Arsenovic, T. Peter, W. Schmutz
Abstract: The observed early 20th century warming (1910 – 1940) is one of the most intriguing and less understood climate anomalies in the twentieth century. To investigate the contributions of natural and anthropogenic factors to the surface temperature changes, we performed seven model experiments using the chemistry-climate model with interactive ocean SOCOL3-MPIOM. Contributions of energetic particle precipitation, heavily (shortwave UV) and weakly (longwave UV, visible and infrared) absorbed solar irradiances, well-mixed greenhouse gases, tropospheric ozone precursors and volcanic eruptions were considered separately. Model results suggest only about 0.3 K of global

and annual mean warming during the considered 1910-1940 period which is by about 25% smaller than the trend obtained from observations. We found that the half of the simulated global warming is caused by the well-mixed greenhouse gases (WMGHG: CO2, CH4 and N2O) increase, while the increase of the weakly absorbed solar irradiance is responsible for approximately one third of the total warming. Because the WMGHG behavior is well constrained only higher solar forcing or including new forcing mechanisms can help to reach better agreement with observations. The other considered forcing agents (heavily absorbed UV, energetic particles, volcanic eruptions and tropospheric ozone precursors) contribute less than 20% to the annual and global mean warming, however they can be important on regional/seasonal scales.

Abstract 7:

Title: The solar radio flux observed by dual-polarization weather radars in Europe: examples of monthly and daily observations at C-band

First Author: Marco **Gabella**

Co-authors: Asko Huuskonen, Maurizio Sartori, Michael Frech, Urs Germann , Marco Boscacci, Hidde Leijnse, Iwan Holleman

Abstract: The radio noise that comes from the Sun has been proven to be an effective reference for checking the calibration accuracy of dual-polarization radar receivers and monitoring their stability with time. The operational monitoring is based on the analysis of solar signals in the polar volume reflectivity data produced during the weather scan program. Several operational weather radars located in Europe have been used to monitor the solar emission at C-band, specifically at 5.3 cm (Finland, Germany, The Netherlands) and 5.5 cm (Switzerland). At the workshop we are presenting the results obtained from the inter-comparison between such radar observations in Europe and the Sun's reference signal at S-band (10.7 cm to be precise), which is accurately measured by the Dominion Radio Astrophysical Observatory (DRAO) in Canada. From a physics viewpoint, the measured flux densities are spectral irradiances; consequently, they are given in power per unit bandwidth and per unit equivalent collecting area of the antenna. The observation period covers more than 4 years: from the remarkable activity of January 2014 and the following months until the current quiet period. The Sun's reference values acquired by DRAO three times per days are converted to C-band using both the standard DRAO formula and the modified (a bit larger) transposition coefficient presented at the previous workshop in Locarno. Various temporal scales have been investigated: in addition to daily observations (as in the previous workshops), also more representative and accurate estimates solar flux values have been considered. We have used, in fact, much longer integration periods: monthly averages or even 9-month averages, which corresponds to ten solar rotations above its axis. Using as a score the standard deviation of the log-transformed ratio between radar and DRAO values, it is confirmed that by using a larger coefficient the agreement improves during the active months, for instance from January 2014 to June 2015, which corresponds to 20 solar rotations. This is the case not only at daily scale, where the larger amplitude of the oscillation was originally observed, but also at monthly scale (with only one solar flux value per month). Then an "intermediate" 20-rotation period takes place where both formulas provides more or less the same performance. Finally, as expected, the formula

found in literature gives better results during the current quiet period, which is exactly the situation for which it has been designed. Finally, all radar receivers, at both horizontal and vertical polarizations, are able to capture and reproduce the oscillation of the solar signal emitted at microwave frequencies.

Abstract 8:
Title: The Spectrometer/Telescope for Imaging X-ray (STIX) on Solar Orbiter: flight design, status of spacecraft integration, and operation perspectives
First Author: Oliver **Grimm**
Co-authors: STIX Team
Abstract: Solar Orbiter is a Sun-observing mission of the European Space Agency, addressing the interaction between the Sun and the heliosphere, with launch planned for 2020. The Spectrometer/Telescope for Imaging X-rays (STIX), one of ten instruments on-board the spacecraft, will observe thermal and accelerated electrons near the Sun through their Bremsstrahlung X-ray emission, addressing in particular the emission from flaring regions on the Sun.
STIX uses indirect Fourier imaging. The Sun is observed through pairs of tungsten grids, casting a Moire transmission pattern on pixelized CdTe detectors. The source location and morphology will be reconstructed on the ground using the transmitted pixel count rates.
STIX has been integrated last year to the spacecraft, which is nearly completed and has recently undergone thermal-vacuum testing.
This contribution will briefly review the final instrument design, report results from pre-integration performance testing and from the spacecraft thermal-vacuum test, and outline the mission operation concept. Due to the nature of the orbit, Solar Orbiter is essentially an offline mission, substantially affecting the operation planning.

Abstract 9:
Title: Upcoming TSI mission with DARA
First Author: Wolfgang **Finsterle**
Co-authors: Alberto Remesal Oliva, Benjamin Walter, Margit Haberreiter, Dany Pfiffner, Werner Schmutz
Abstract: The Digital Absolute Radiometer (DARA) has been selected to fly on two upcoming space missions featuring very different mission profiles. The DARA for the Joint TSI Monitor (JTSIM) will be part of China Meteorological Adminstration's FY-3E mission, to be launched in Q1 2020. The DARA for PROBA-3 will fly on the occultor spacecraft of ESA's PROBA-3 mission, which is a techonology demonstrator for formation flying. The characterization and calibration of the flight model of DARA for JTSIM has just been finished at PMOD/WRC and the FM will be delivered to China within the next couple of weeks for integration with the JTSIM solar tracker and the satellite. A pre-flight cross-calibration campaign of both TSI radiometers on board JTSIM (DARA and the Chinese-built SIM) will take place at a high-altitude site in China during Summer 2019. The flight model of DARA for PROBA-3 is currently being built at PMOD/WRC. The first components have already been characterized. DARA has been

developed based the Compact and Light-Weight Absolute Radiometer CLARA which is currently flying on the Norwegian NORSAT-1 mission. CLARA for NORSAT-1 was PMOD/WRC's first newly designed TSI radiometer since the PMO6 type, which first flew on EURECA (1992). We will present the measurements from CLARA as well as the results of the characterization and calibration experiments for DARA, and outline the future prospects of DARA-type radiometers in space.

Abstract 10:
Title: The Micro Solar-Flare Apparatus: MiSolFA - a Progress Report
First Author: Erica **Lastufka**
Co-authors: Säm Krucker
Abstract: The micro-satellite MiSolFA (Micro Solar-Flare Apparatus) is designed both as a stand-alone X-ray imaging spectrometer and a complement to the Spectrometer/Telescope for Imaging X-rays (STIX) mission to provide stereoscopic X-ray imaging. These instruments will be the first such pair of cross-calibrated instruments to observe solar flares from very different points of view, providing a 3-dimensional view of X-ray emitting regions during the next solar maximum period. MiSolFA will be the most compact X-ray imaging spectrometer in space. Thanks to absorbing grids produced using a novel approach, MiSolFA will perform indirect imaging between 10 and 100 keV and with 10 arcsec angular resolution, sufficient to separate most hard X-ray footpoint sources from each other. The instrument is small enough to equip a 6-units cubesat such as the GSFC-developed Dellingr platform.

We present a progress report of the instrument development. The Engineering Model was produced in 2017 and successfully endured the necessary space qualification tests. A Qualification Model was designed and manufactured in 2018. While some aspects of the new design caused undesired side effects, inspection with a synchrotron X-ray beam revealed remarkably uniform fine gratings with acceptable transmission properties. As we finalize requirements for the Flight Model, we highlight some key lessons learned.

Abstract 11:
Title: Solar signatures in the tropics
First Author: Stergios **Misios**
Co-authors: Lesley J. Gray , Mads Knudsen , Christoffer Karoff , Hauke Schmidt , Joanna Haigh
Abstract: Influences of the solar variability on climate have been speculated, but here we provide robust evidence that the SC affects decadal variability in the tropics. By analyzing independent observations, we demonstrate a slow-down of the Pacific Walker Circulation (PWC) at solar cycle maximum. We find a muted hydrological cycle at solar maximum that weakens the PWC and this is amplified by a Bjerknes feedback. Given that a similar muted hydrological cycle has been simulated under increased greenhouse gas forcing, our results strengthen confidence in model predictions of a weakened PWC in a warmer climate.

Abstract 12:

Kalevi **Mursula** (invited)

Title: High-speed solar wind streams: Connection to solar magnetic field evolution and effects to the Earth's atmosphere and climate

Abstract: High-speed solar wind streams (HSS) emanate from the cores of large solar coronal holes. Large coronal holes with unipolar, oppositely directed magnetic fields typically form around the two poles in the declining phase of the solar cycle. While developing, the polar coronal holes form extensions to low solar latitudes, from which HSS streams can flow toward the Earth. Since these structures are longitudinally asymmetric and last for several rotations, they cause repetitive disturbances, typically weak to intermediate storms and substorms in the Earth's magnetic field. Direct observations of coronal holes exist only from 1970s but the occurrence of HSSs can be estimated from the observed geomagnetic activity for more than 100 years. This allows to obtain information on the long-term evolution of the solar large-scale magnetic field, in particular on persistent coronal holes. The centennial evolution of solar wind speed at 1 AU is different when the Earth is at solar equator or at higher latitudes, which reflects differences in the evolution of polar coronal hole extensions and isolated low-latitude coronal holes. Polar coronal holes had exceptionally persistent extensions in the declining phase of cycle 18, just before the peak of the Grand Modern Maximum of solar activity, validating the solar dynamo model during the most active period of solar activity. On the other hand, low-latitude coronal holes dramatically increased during the declining phase of solar cycle 23, reflecting a change in solar magnetic field due to the demise of the Grand Modern Maximum.

High-speed solar wind streams are the most effective driver of magnetospheric energetic particles. The flux of energetic particles maximizes during long HSS events of the declining phase of the solar cycle. The amount of kinetic and thermal energy of HSS is very small compared to the dense atmosphere, but the atmospheric effects of HSS can be greatly amplified by electromagnetic and chemical reactions. HSS-caused energetic particle precipitation (EPP) is known to cause dramatic changes in chemistry, energetics and dynamics of the upper atmosphere. EPP created HOx and NOx molecules destroy ozone directly in the upper atmosphere and, via dynamical effects, even in the stratosphere during polar winter. There is increasing evidence that HSS-related effects have important consequences even to the tropospheric climate, especially in winter at high latitudes. HSS have been found to modulate regional/hemispheric climate patterns in winter, in particular the NAO/NAM oscillation, the dominant climate pattern in the northern hemisphere. The positive phase of the NAO/NAM oscillation is systematically favored in winters of the declining phase of the solar cycle. HSS-effects are strongly dependent on the phase of the Quasi Biannual Oscillation (QBO) of equatorial winds. Positive relation between HSS and NAO/NAM is found to be valid in the easterly QBO(30 hPa) phase during the whole 20th century. EPP related ozone loss and consequent enhancement of polar vortex is significantly stronger in the easterly QBO phase than in the westerly phase. These results indicate an intimate, global connection between low and high latitudes, and underline the importance of considering the preconditioning of the atmosphere when studying the solar (wind)-related effects upon climate.

Abstract 13:
Title: Machine learning and solar flares
First Author: Brandon **Panos**
Co-authors: Lucia Kleint, Cedric Huwyler, Säm Krucker, Martin Melchior, Denis Ullmann, Sviatoslav Voloshynovskiy
Abstract: Solar physics has a wealth of image and spectral data sets. These large data sets have not been extensively explored using machine learning techniques. We apply a simple clustering algorithm to a spectral data set of several M and X-class flares collected by the IRIS satellite. By analyzing the once ionized magnesium k line (Mg II k), we can begin to answer whether the chromospheric physics of all these flares are similar or weather some flares show unique spectral signatures. Using an adapted version of the k-means clustering algorithm, we found single peaked Mg II profiles (in contrast to their double peaked quite sun counterparts) appearing prevalent in every flare. This indicates similar atmospheric heating, densities and velocity flows in the upper chromosphere. We also found extremely broad unique profiles at the front of fast moving flare ribbons. X-ray data both from RHESSI and GOES seem to indicate a strong spatial and temporal correlation with these profiles, suggesting that flare accelerated electrons play a vital role in their formation. We also explore new techniques for analyzing larger multi-line spectral data. This includes the use of an additional machine learning algorithm (hierarchical clustering) as well as an adaptation of the classical traveling salesman problem to order spectral data.

Abstract 14:
Chemical effects of energetic electron precipitation during Southern Hemisphere winter
E. **Rozanov**[1,2]**,** P. Arsenovic[2*], A. Damiani[3], B. Funke[4], A. Stenke[2] and T. Peter[2]
[1]Physikalisch-Meteorologisches Observatorium Davos – World Radiation Center, Davos, Switzerland
[2]Institute for Atmospheric and Climate Science ETH, Zürich, Switzerland
[3]Center for Environmental Remote Sensing (CEReS), Chiba University, Chiba, Japan
[4]Instituto de Astrofisica de Andalucía, CSIC, Granada, Spain
*Now at Empa, Dübendorf, Switzerland
Abstract: Energetic particle precipitation (EPP) affects the chemistry of the polar middle atmosphere by producing reactive nitrogen and hydrogen oxides, which catalytically destroy ozone. Here we investigate the effects of low and middle ranges energy electrons stratospheric chemistry during Southern Hemisphere winters from 2002 to 2010 using the chemistry-climate model SOCOL3-MPIOM. Our results show that, in absence of solar proton events, low energy electrons are the main contributor to nitrogen oxides production in the polar mesosphere and stratosphere. Inside polar vortex, they affect ozone in the stratosphere down to 10 hPa. Comparing a year with intensive electron precipitation with a quiescent period, we found large (up to 80%) ozone depletion in the mesosphere and up to 15 % less ozone in the stratosphere during winter, which is confirmed by satellite observations. We show that our model reproduces the observed stratospheric ozone anomaly only when the both low and middle range energy electrons are considered.

Abstract 15:
Title: The Polarimetric and Helioseismic Imager on Solar Orbiter
First Author: Sami K. **Solanki**
Max Planck Institute for Solar System Research, Germany

Abstract: The Solar Orbiter is the next solar physics mission of the European Space Agency, ESA, in collaboration with NASA, with a launch planned in 2020. The spacecraft is designed to approach the Sun to within 0.28 AU at perihelion of a highly eccentric orbit. The proximity with the Sun will also allow the Sun to be observed at uniformly high resolution at EUV and visible wavelengths. Such observations are central for learning more about the magnetic coupling of the solar atmosphere. At a later phase in the mission the spacecraft will leave the ecliptic and study the enigmatic poles of the Sun from a heliographic latitude of up to 33.5 degrees.

A central instrument of Solar Orbiter is the Polarimetric and Helioseismic Imager, SO/PHI. It will do full Stokes imaging in the Lande g=2.5 Fe I 617.3 nm line. It is composed of two telescopes, a full-disk telescope and a high-resolution telescope, that will allow observations at a resolution as high as 200 km on the solar surface. SO/PHI will also be the first solar polarimeter to leave the Sun-Earth line, opening up new possibilities, such as stereoscopic polarimetry (besides stereoscopic imaging of the photosphere and stereoscopic helioseismology). Finally, SO/PHI will have a unique view of the solar poles, allowing not just more precise and exact measurements of the polar field than possible so far, but also enabling us to follow the dynamics of individual magnetic features at high latitudes and to determine solar surface and sub-surface flows right up to the poles.

In this presentation a brief introduction to the Solar Orbiter mission will be given, followed by the science goals and the capabilities of SO/PHI, as well as a brief overview of the instrument.

Abstract 16:
Title: Entire Atmosphere Global model (EAGLE): development and first results
First Author: Timofei **Sukhodolov** (1,2,3)
Co-authors: Fedor Bessarab (2), Nicolay Chirik (2), Berndt Funke (4), Maxim Klimenko (2), Vladimir Klimenko (2), Yuriy Korenkov (2), Dmitry Kulyamin (5), Katharina Meraner (6), Hauke Schmidt (6), Pavel Vasiliev (2), Irina Zaharenkova (2), Eugene Rozanov (1,2,3)
(1) PMOD/WRC and IAC ETH, Davos Dorf, Switzerland (timofei.sukhodolov@pmodwrc.ch), (2) West Department of Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propa-gation RAS, Kaliningrad, Russia, (3) Institute for Atmospheric and Climate Science, ETH Zurich, Zurich, Switzerland, (4) Instituto de Astrofısica de Andalucia, CSIC, Granada, Spain, (5) Research Computing Center, Lomonosov Moscow State University, Moscow, Russia, (6) Max Planck Institute for Meteorology, Hamburg, Germany

Abstract: Historically, numerical models of the upper atmosphere layers (>80 km) and the lower atmosphere layers (<80 km) progressed almost independently just prescribing

the lower/upper boundary conditions, which is usually a very rough approximation of all the physics happening below/above. With a rising knowledge about atmospheric sciences related to progress, both, in measurements and models, it became clear that interrelation between atmospheric layers is important and needs to be addressed explicitly. Here, we present a step in this direction with a focus on the ionosphere by showing our first results of the Entire Atmosphere Global Model (EAGLE) that combines Chemistry-Climate model (CCM) HAMMONIA and Global Self-Consistent Model of the Thermosphere, Ionosphere and Protonosphere (GSM TIP). The model allows calculating the atmospheric state from the ground to 15 radii of the Earth including ionosphere and plasmasphere interactively simulating the main physical, radiative, chemical, and dynamical processes in the lower, middle and upper atmosphere. The model treats thermodynamic interaction of charged and neutral components of photochemical ionospheric processes and excitation of the dynamo-electric field under the influence of the tidal winds. It also includes production of nitric oxides from energetic electron precipitation in the thermosphere, and is able to realistically describe the electric field distribution and other parameters of the ionosphere close to the geomagnetic equator. The vertical model domain starts from the ground, which allows studying the lower atmosphere influence on the thermosphere/ionosphere system.

Abstract 17:
Title: LGR ESA mission to the Lagrange point L5 - early warning system for Space Weather events
Author: Hajdas **Wojciech**, PSI
Abstract: The ESA LGR mission is in the middle of the B1 phase finalizing its payload. Its in-situ instrumentation contains plasma analyzer, magnetometer, mid-energy particle spectrometer, radiation monitor and x-ray spectrometer. We will present mission objectives and performance characteristics of above detection systems. Special attention will be given to the radiation monitor under development in Switzerland/PSI.