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SESSION 1

ASTRONOMY AND GEO-SPACE OBSERVATIONS FROM ANTARCTICA

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1275

Ionospheric TEC and scintillation climatology at SANAE station

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We report on an unprecedented climatological assessment of ionospheric scintillations and TEC gradients at Antarctic sub-auroral/auroral latitudes observed from the South African Antarctic station, SANAE IV (71°40’22”S, 2°50’26”W). The station is equipped with a Septentrio PolaRxS receiver providing access to ionospheric delay and related measurements from not only the GPS system of navigation satellites but also from the Russian GLObal NAvigation Satellite Systems (GLONASS) and European Galileo satellites. The field of the GNSS satellites in view from the station is mainly sub-auroral, but under perturbed geospatial conditions it can enter the auroral oval.
Our assessment of TEC and ionospheric scintillations is based on the data acquired along the period 2017-2019 and shows frequent occurrence of moderate to high σΦ level. The S4 climatological behavior testifies an infrequent occurrence of moderate amplitude scintillation. The σΦ index considered in our analysis is provided by the receiver firmware applying a cutoff frequency of 0.1 Hz for detrending. The detrending is necessary to remove the effect on the phase of the signal due to the relative velocity between the transmitter (onboard the satellite) and the receiver (at ground) and the slowly varying background ionosphere. A cutoff frequency of 0.1 Hz means to assume a relative velocity of about 40 m/s that is often inappropriate to describe the dynamics of the high latitude ionosphere. In such a framework we will critically discuss the “phase without amplitude” scintillations observed over SANAE.

1551

Keeping telescope optics free from ice on the Antarctic plateau

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The formation of ice on the optical elements of telescopes has been a long-term problem in Antarctica that has resisted a satisfactory solution. Various techniques have been tried, such as the use of desiccants for internal surfaces, indium tin oxide coatings on external windows, and hot air. Some of these techniques have negative effects on the astronomical observations, e.g, indium tin oxide will absorb some of the incoming light, and heating an element can introduce air turbulence.

This talk will review the physics of ice formation and sublimation under the unique conditions prevailing on the Antarctic plateau. There are been recent relevant experimental results, and atomic force microscopy of water molecules on metal surfaces. Proposals will be made for techniques to measure ice formation, and to efficiently eliminate it, while minimizing the effect on astronomical observations.

506

The Greenland Telescope

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The Greenland Telescope (GLT) has been participating in global very-long- baseline-interferometry (VLBI) observations from Thule Air Base since the spring of 2018. Located in northwestern Greenland, the telescope has provided an important northern location for global VLBI campaigns for studying supermassive black holes. The telescope has been completely rebuilt and commissioned, with many new components, from the ALMA North America Prototype antenna and equipped with a new set of sub-millimeter receivers operating at 86, 230, and 345 GHz, as well as a complete set of instruments and VLBI backends. This paper reports our progress of fine-tuning the telescope and the operational status from the past two years (2018 - 2020) for this unique submillimeter telescope in the Arctic Circle.

1188

Challenges and evolution of the ITM Antarctic telescope design

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The International Telescope Maffei (ITM) is a f/21.16 Cassegrain telescope located at Concordia Base in Dome C, Antarctica. The telescope has been developed as a project hosted by the Italian Programma Nazionale di Ricerche in Antartide (PNRA) and Consiglio Nazionale delle Ricerche (CNR) and has been operating in Concondia since 2005.
Over the years of activity several modifications have been made in order to increase the robustness of the system adopting new technologies and materials.
Moreover, during this period, the telescope facility received many observing proposals who challenged its observing capabilities and required to push the telescope initial limits even further.
Two years ago the ITM facility underwent a major upgrade starting from the refactorization of the whole control system.
The thermalized boxes containing the control devices and instruments have been re-designed to take into account the experience gained in the years.
The new telescope facility is focused on simplifying any human intervention in the system through a redundant, distributed and fully autonomous thermal control.
In this contribution we present the last step of the telescope upgrade, the new box design and new control system together with the lightweight web-app used to monitor and supervise remotely the facility even from Europe through the Concordia Base VPN and the main observing challenges that the telescope foresees in the next years.

1101

Impact of the South Pole Telescope (SPT) on Galaxy Cluster Science

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In this review-style presentation, I will discuss how the South Pole Telescope (SPT) has laid the groundwork and made significant contributions towards the science of studying galaxy clusters. Numerous space- and ground-based telescopes utilize surveys completed by SPT, and I would like to highlight these accomplishments from the past decade. Additionally, I'll cover the advantages of polar-located observatories, how SPT surveys of clusters compare to other surveys, and how future projects such as the James Webb Telescope can further the discoveries completed by SPT.

980

Ionospheric response to the June 2015 geomagnetic storm in the South American region

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The ionospheric dynamics in the South America (SA) sector during geomagnetic disturbed period from 21 to 24 June 2015 is investigated through ground ionosonde stations and Global Navigation Satellite System (GNSS) receivers. These disturbances were caused by 3 interplanetary shocks (IS) derived from 3 consecutives coronal mass ejections (CME) from the same solar active region; the first two CME were caused by filament eruptions, and the third was a much larger full halo CME, associated with a M2.6 solar flare. The first 2 shocks were compressive and did not cause an immediate response to the ionosphere in the analyzed region, while the third shock increased considerably the electron density from low to high-latitudes, triggering the second strongest geomagnetic storm of the 24th solar cycle. It was possible to observe the expansion of the crest of equatorial ionospheric anomaly (EIA) at midlatitudes and high-latitudes mainly due to prompt penetration electric field (PPEF) during the main phase and the recovery phase of the geomagnetic storm during the day.

1307

Two-colour photometry to search for transiting exoplanets with ASTEP at Dome C, Antarctica

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Dome C in Antarctica provides exceptional conditions for photometry thanks to the continuous night during the Antarctic winter, a high clear sky fraction, low wind speeds, and a cold and dry atmosphere. The ASTEP project (Antarctic Search for Transiting ExoPlanets) aims at detecting and characterising transiting exoplanets and qualifying this site for photometry in the visible. The main instrument, a 40 cm telescope, has been designed to perform high precision photometry under the extreme conditions of the Antarctic winter and has operated at the Concordia station since 2010. It will be upgraded with two new cameras and a new camera box in order to provide simultaneous two-colour photometry and substantially increase its throughput. The new setup will be operational for the winter campaign 2021 and will allow us to discover transiting exoplanets orbiting bright stars in particular low mass exoplanets, temperate exoplanets, exoplanets around young stars, and to refine the ephemerides of exoplanets discovered by the TESS mission. These observations will provide targets for first characterisation with the CHEOPS mission and atmospheric studies with the JWST and ARIEL missions. In this talk, I will describe the science goals and the upgrade of the ASTEP telescope.

1314

Searching for long period transiting exoplanets with ASTEP South at Dome C, Antarctica

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Much of our understanding of gas giant exoplanets come from those transiting in front of bright stars at short orbital separations (P ~ 3 days, a ~ 0.05 au). However, these "hot Jupiters" are coupled to their host stars: the strong irradiation and tidal interactions impact their orbital and physical properties. In contrast, "cold Jupiters" (P > 30 days, a > 0.2 au) are largely decoupled from their host stars and those transiting bright stars provide ideal benchmarks to study gas giant exoplanets. The 4-month continuous night during the Antarctic winter combined with excellent weather conditions is favorable to the detection of long period exoplanets, which are not accessible from temperate sites. We analysed four winters of photometric data collected with the ASTEP South instrument at Dome C and identified transit candidates with long orbital periods around bright stars. We conducted photometric follow-up of these objects using the 40-cm telescopes of the Las Cumbres Observatory Global network of Telescopes and we analysed their lightcurves extracted from the full frame images of the NASA TESS mission. In this talk, we will present these objects and the results of the photometric follow-up.

1340

The IceCube Upgrade Detector Project

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The IceCube Neutrino Observatory is a gigaton Cherenkov detector in full operation at the South Pole since early 2011. An enhancement to the observatory is currently under construction with expected deployment in the Austral Summer of 2022-2023. This in-fill detector will consist of about 700 closely-spaced optical modules plus calibration devices and R&D sensor modules. The project goals include neutrino oscillation physics, improved ice property measurements (and resulting systematic improvements to all IceCube data), and development of hardware for a next generation (Gen2) IceCube expansion for high-energy astrophysical neutrinos.

1173

NIAOT activity around Antarctic Astronomy

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From small optical telescope-CSTAR, NIAOT have made solid progress in Antarctic astronomical instruments, this talk will give brief introduction about current situation of updated moveable Cstar, third AST3 and KDUST.

1134

Space weather events and the possible impact on the temperature and ozone profiles at the Antarctic peninsula

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Disturbances in the terrestrial space environment can be caused by Space Weather events such as Geomagnetic storms, solar and interplanetary events that can last hours or days. Some episodes of transport and dissipation of energy in the ionosphere and magnetosphere named magnetospheric substorms are more frequent than geomagnetic storms but have shorter duration spanning from 10 minutes to a few hours. In this work we addressed the variability of temperature and ozone profiles at the lower and middle stratosphere at the Antarctic Peninsula during the mentioned space weather events.
We analyzed ozone-radio soundings at the Argentinean Marambio Station provided by the National Meteorological Service of Argentina and the Meteorological Institute of Finland from at solar cycles 23 (1998-2008) and 24 (2009-2018) taking into account strong and moderate geomagnetic storms and larger substorms.
We consider the Dst and AE indices that provide respectively a measure of the intensity of the energy contained in the Ring Current and a quantitative measure of the auroral magnetic activity, useful for the analysis of individual substorms.
We studied also the changes in the partial pressure of ozone (ppO3) during these events, for levels 9-13, 14-19 and 20-26 km, where the greatest variability of ozone occurs (Morozova et al. [2016]).
We present our preliminary results that will be useful to better understand the possible impact of Space Weather events on the Antarctic atmosphere.

185

A Cosmic Rays Observatory in the Argentine Marambio station at Antarctica: the first permanent Antarctic Node of the LAGO collaboration

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The Antarctic continent has the combined advantage for the installation of astroparticle detectors: (a) enough infrastructure in Antarctic stations, and (b) low geomagnetic field rigidity cut off, which allows the arrival of a huge flux of low energy particles, permitting a large amount of information related with physical processes in space.

LAGO (Latin American Giant Observatory) is a collaboration, forming a net of cosmic rays detectors based on water Cherenkov radiation. LAGO has nodes spanning from Mexico to Antarctica. Antarctic LAGO nodes allow to study particle fluxes that in middle latitudes won't be able to reach ground level since they are shielded by the geomagnetic field.

In this work, we will present results of the deployment and installation of a Space Weather laboratory, developed by the LAMP group (Laboratorio Argentino de Meteorología del esPacio, the Argentinean Space Weather Laboratory) during January-March 2019 at the Argentine Marambio station.
This Antarctic laboratory has a LAGO node (i.e. a Water Cherenkov
detector) in operations from March 2019. We also present the improved facilities of the laboratory and improvements of the operations of the detector developed during January-March 2020

The calibration and first results of the cosmic rays detector will also
be presented, as well the operative use of the real time data, which are transmitted to the servers of LAMP in Buenos Aires, and are publicly offered, and used to operative Space Weather activities by LAMP

1145

Operative Space Weather products offered by LAMP (Argentinean Space Weather Laboratory group)

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The Argentinean Space Weather Laboratory (LAMP) became a new regional warning center of ISES (International Space Environment Service) in January 2020. LAMP carries out several operative space weather (SW) activities since 2016. For instance, they produce daily monitoring of real-time information (space and ground-based instruments) on SW, a weekly bulletin which synthesizes the most relevant information, an alert system for extreme SW conditions, and participates in monthly briefings to discuss the situation of the previous days and generate ideas for new products. New operative SW products were developed by LAMP to better identify perturbed conditions in the Sun-Earth system. A study with energetic electron fluxes measured by GOES was carried out to develop a product that shows three different thresholds associated with low, medium and high perturbed conditions. Also, LAMP worked out a solar wind product with plasma and magnetic field data from ACE spacecraft. Moreover, real-time data from the water Cherenkov particle detector at Antarctic (Neurus) is included as a new product. This detector was installed by LAMP at the Argentine Marambio base during January-March 2019. In this work, we present details of some of the new operative Space Weather products developed in the LAMP group.

1614

Understanding the Expansion of Universe with South Pole Telescope

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The South Pole Telescope (SPT) is a 10-meter telescope located at the Amundsen-Scott South Pole station in Antarctica. The telescope is operating for over a decade and has completed 2,500 $\deg^2$ of SPT-SZ survey, 500 $\deg^2$ of SPT-pol survey and is currently in its 3rd generation (SPT-3G) to observe 1,500 $\deg^2$ of the sky with unprecedently low noise levels of 3 μK-arcmin. In this talk, I will present some of the major scientific results published in last couple of years. I will focus on the sub-millimeter wavelength properties of galaxy clusters and the anisotropies in cosmic microwave background (CMB) radiation. I will present the newly discovered galaxy clusters with this instrument along with a deep learning approach to estimate their mass. I will show recent cosmological results using galaxy clusters. I will present the CMB temperature power at high multipoles and recent advances in B-mode science with this instrument. And finally, I will show the statistical and the polarization properties of Active Galactic Nuclei (AGN) in clusters and in field.

650

Five-year meteorological data from KLAWS for astronomical site testing at Dome A, Antarctica

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We present and compare meteorological data of nearly five years from KLAWS (Hu et al. 2014) and KLAWS-2G (Hu et al. 2019). Both facilities are automated weather stations with multiple temperature sensors and anemometers at several elevations from 2 m to 14 m. By analyzing the data, we find that a strong temperature inversion (TI, temperature gradient could reach up to 7°C/m at 4 m) exists just above the ground surface for 50% or more of the time at all the elevations. The average wind speed at 4 m is around 4.0 m/s, the wind speed is seldom larger than 10.0 m/s. The strong TI and moderate wind lead to a stable atmosphere and a shallow boundary layer, above which we could obtain superb free-atmosphere (FA) seeing. Comparing monthly median values of temperature, TI and wind speed in different years, we find the climate at Dome A exhibits obvious annual variation. Finally, by correlating simultaneous data of 1.5 months from KLAWS-2G and KL-DIMM in 2019, we find that the FA seeing prefers to existence of strong TI. Therefore, the data from KLAWS are important for understanding atmospheric turbulence and can possibly be used to estimate the seeing at Dome A.

1517

Simultaneous observation of ionospheric plasma drift and thermospheric winds at Jang Bogo station, Antarctica

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In the high-latitude ionosphere, the plasma motion is mainly driven by the magnetospheric forcing and it is intimately coupled to the neutral motion via ion-neutral collisions. In other words, the neutral winds in the high-latitude region are controlled by the magnetospheric forcing, rather than solar EUV forcing. However, in spite of this well-known close coupling between ion and neutral motions in the polar region, specific details of the coupling processes are not well understood mainly due to the lack of observations of the ion drift and neutral winds. Since the establishment of Jang Bogo Station in Antarctica, Korea Polar Research Institute (KOPRI) has been operating Vertical Incidence Pulsed Ionospheric Radar (VIPIR) and Fabry-Perot interferometer (FPI) to simultaneously observe the ionosphere and thermosphere near the boundary between the auroral and polar cap regions. In this study, we used 3-year (2017-2019) measurements of the ion drifts and thermospheric winds from these instruments in order to investigate how closely they are coupled to each other under various geophysical conditions. The initial results of the study indicate that the background ionospheric density is one of the key parameters controlling the coupling processes. We will further use the TIEGCM simulation to verify the results of the analysis of the data.

1552

Polar thermospheric wind measurements at polar cap and aurora oval regions

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We present thermospheric winds from the ground-based Fabry-Perot Interferometer (FPI) at 630.0 nm airglow emission over two Arctic regions. Neutral dynamics at polar thermosphere are driven not only by a solar-induced pressure gradient force but also by ion drag effects from magnetosphere-ionosphere coupling. Korea Polar Research Institute has been operating two FPIs in Longyearbyen, Svalbard and Esrange, Sweden to uniquely study how polar thermospheric winds respond to different geomagnetic conditions with respect to different latitudes. In this study, we briefly introduce our preliminary results of neutral wind derived from FPI 630.0 nm emissions over two arctic regions.

1000

Measuring the turbulence profile at Dome A with AST3

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Dome A is characterized by a very thin boundary layer, the thickness of which is critical to determine the minimum height of future telescopes. We have developed a novel method, the Multistar Turbulence Monitor (MTM), to measure the low-altitude turbulence profile, Cn2, using the Antarctic Survey Telescope (AST3). As is well known, the stellar image motion seen in very short exposures reflects turbulence intensity. AST3 can capture dozens of bright stars, even with 10-ms exposures, due to its 4.3-deg2 field-of-view and 0.5-m diameter. The differential motions between star pairs, which are not affected by telescope vibration, are sensitive to certain height ranges of turbulence as a function of the separations between stars. By combining the differential motions between star pairs over a range of separations, we can estimate the low-altitude Cn2 profile, the high-altitude seeing and the outer scale. Here we will report the preliminary results from observations by AST3 in 2017. In optimized fields, there were typically ~50 stars having separations ranging from 0.05 to 2.3 deg, giving a sensitivity to turbulence within ~500 m above the telescope. We will introduce the data reduction technique, Cn2 profile reconstruction method and the main results.

1647

A Decade of Discovery: Results from the IceCube Neutrino Observatory

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The IceCube Neutrino Observatory at the South Pole, now in its tenth year of full operation, has a remarkably wide and expanding science reach. In addition to discovering the first high-energy astrophysical neutrinos and measuring their spectrum, IceCube has delivered on one of its primary goals, establishing the field of neutrino astronomy with real-time alerts. An overview of highlights from the last decade, including identifying the first point source of high-energy neutrinos (blazar TXS 0506+056), competitive neutrino oscillation measurements, and world-leading constraints on sterile neutrinos, dark matter, Lorentz invariance, magnetic monopoles, and physics beyond the Standard Model will be provided. The plans for next generation of the observatory, IceCube-Gen2, will be presented.

992

Development of an Optical Robotic Observatory at the Argentine Antartic Base Belgrano II

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We have designed and constructed an infrastructure made of poliestyrene fiber to house a telescope with a tube of up to 1.6m of length, as for example a 50cm f/3 Cassegrain. The infrastructure consists of a 2.5m diameter rotating dome, with an upper door shutter of kite-type opening, mounted on a cylindrical building 1.6m high. The building sits on a 1.5m high galvanized iron platform. Naturally the telescope pillar and infrastructure are decoupled mechanically.

All the designs are original, including for example the coupling between the dome and the building, its anti-tilt system, the motorization of the shutter, etc. Efforts due to wind gusts of up to 300 km/h at a temperature of around -20oC were simulated numerically, checking that the design is resistant to those conditions. We estimated an anchoring force of approximatelly 1.5Tn. All the materials used are stable at low temperatures of up to at least -40oC. This infrastructure is planned to be installed in the area of Belgrano II Base (Latitude 77:32:28 S, Longitude 34:37:37W) by the southern's hemisphere summer of 2020-2021. The galvanized iron platform has already been installed by the base in the past southern hemisphere's summer.

1673

Historical supernova signatures in an Antarctic ice core

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Gamma rays associated with nearby supernova explosions can cause changes in the chemical composition of the stratosphere from ~8 – 50 km altitude of the earth. The effect can then be recorded in the chemical composition of polar ice. Ice cores drilled at Dome Fuji station in Antarctica preserve mainly chemical components of the stratosphere, and hence worth studying traces of historical supernovae.

In this talk, I will focus on yearly-scale spikes that were observed in nitrate ion concentration profiles in a Dome Fuji ice core. We diagnose the yearly-scale spikes with respect to precision, reproducibility, and dating uncertainty, and discuss whether or not the spikes can be the traces of historical supernova explosions in our galaxy. Special attention will be given to SN1006 and SN1054. The energetics of the production of nitrogen oxides in the stratosphere induced by nuclear gamma rays from a galactic supernova will also be discussed. Since nitrate spikes are almost coincident with the dates of the known galactic supernovae within dating uncertainty, we propose that the yearly-scale nitrate spikes embedded in the Dome Fuji ice core be regarded as candidate signatures of supernovae that have occurred in our galaxy.

1678

Advances on the Development of a Peruvian Space Wheather Station

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As part of iour space weather program we are developing instrumentation aimed at studying the near-Earth space environment from the ground. Space weather studies in Antarcti are favoured because the direct coupling of the ionosphere the Earth's magnetosphere. We are testing the instruments during the last three Peruvian summer campaigns in Antarctica (ANTAR XXV, XXVI and XXVII). One of the instruments is a water Cherenkov detector of the Latin American Giant Observatory (LAGO, www.lagoproject.net) the other one is a vertical very low frequency (VLF) receiver.Here we present results of the validation of both instruments and the perspectives for their permanent operation in the Antarctic.

978

Features of GNSS signal outages from nearly conjugate polar locations

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GNSS signals are increasingly being used for characterizing detrimental impact of ionospheric irregularities on satellite-based communication and navigation systems and services, and the resulting signal outages. The polar regions of the Earth are some of the most challenged in terms of maintaining high levels of performance of GNSS from the operational point of view with mitigation strategies for cycle slips and loss-of-lock of the satellite signal by the receiver.
In the high latitudes, highly dynamic ionospheric irregularity structures encompassing scale sizes from hundreds of kilometers down to a few centimeters co-exist with varying convective motion determined by interplanetary magnetic field (IMF). The dynamics of these irregularity structures have a seasonal dependence being more convective in the winter hemisphere. In the present paper, data have been analyzed from the two stations, namely, Eureka Bay (87.65°N,91.57°W geomagnetic) and Concordia (83.90°S,138.72°W geomagnetic), located in the Arctic and Antarctic regions corresponding to four geomagnetic storms which occurred over the period 2012-13, within the framework of a GNSS project at the International Space Science Institute (ISSI).
It is found that the observed cycle slips are more or less correlated with intensity of Auroral Electrojet. The number of cycle slips observed at Concordia near the South pole are more than that observed from Eureka Bay located close to the North pole. The differences have increased in March 2012 and March 2013. This difference may possibly be attributed to more particle injection at South pole than the North pole.

1068

The SWIT-eSWua system: a cutting-edge infrastructure to access ionospheric data in polar areas.

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The polar regions are a privileged natural laboratory for the investigation of the ionosphere. Regular observations can provide timely information for the monitoring, forecasting and mitigation of the effects on modern technologies (such as telecommunication systems, power networks and in general systems relying on satellite navigation) during Space Weather events.

The Upper Atmosphere Physics and Radiopropagation group at the Istituto Nazionale di Geofisica e Vulcanologia (INGV, Italy) has a long tradition in managing ionospheric data and currently operates, among others, GNSS receivers for scintillation and TEC monitoring in Antarctica (Mario Zucchelli, Concordia and SANAE IV stations) and in Svalbard (Ny-Ålesund and Longyearbyen). The activities at polar latitudes are also included in the SCAR expert group GRAPE (GNSS Research and Application for Polar Environment, www.grape.scar.org).

Inspired by Open Science principles, the SWIT (Space Weather Information Technology) infrastructure coupled with the eSWua (electronic Space Weather upper atmosphere) web-platform provide Findable, Accessible, Interoperable, Re-usable (FAIR) ionospheric data from the INGV network in near real-time. In addition, the SWIT-eSWua system ensures the access to operational monitoring products related to the nowcasting and forecasting of different ionospheric parameters. This, with the aim to serve the scientific community as well as the Institutional stakeholders (like civil protection, civil aviation, etc.).

In this work the state of the art of the SWIT-eSWua system is described focusing on Arctic and Antarctica, together with examples of the products developed in the framework of national and international initiatives.

936

Ionospheric response to annular and partial solar eclipse of 29 April 2014 in Antarctica and Australian Regions

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Solar eclipse is one of the important solar terrestrial events which have a direct impact on Earth's ionosphere. A solar eclipse provides us with a rare opportunity to study the ionospheric effects associated with an accurately estimated variation of solar radiation during the eclipse period. An annular and partial solar eclipse was observed on 29 April 2014 over Australian and Antarctic regions. In this study we have analyzed the ionospheric response of this solar eclipse event. We have done a comprehensive study to find out the changes that occurred in various ionospheric parameters during the solar eclipse event over Australia and Antarctic region. We selected four Australian stations Brisbane (27.5∘S, 152.9∘E), Canberra (35.3∘S, 149.1∘E), Hobart (42.9∘S, 147.3∘E) and Perth (31.955∘S, 115.859∘E) as well as one Antarctic station Mawson (70.6455∘S, 131.2573∘E). We have studied the changes in the E and F ionospheric layers using the ground based observations at these stations. From our analysis we found that there occurred a decrease in the critical frequencies of sporadic E ($foEs$) and F ($foF2$) layers during the time eclipse was in progress at all the four Australian stations while as at Antarctic the value of $foF2$ recorded an enhancement. At the same time an increase in the corresponding heights of these layers ($h'Es$, $h'F2$) was also observed.
KEYWORDS: Annular solar eclipse; ionospheric parameters; sporadic E; critical frequency.

775

Astronomical Seeing at Dome A in 2019

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Following the installation of several unattended site testing instruments at Kunlun Station, Dome A in early 2019, we were able to operate KL-DIMM successfully to directly measure astronomical seeing through the winter for the first time. KL-DIMM is installed on a tower at a height of just 8 meters. Very good free-atmosphere seeing was detected above a thin boundary layer, comparable to that at a 20 m height at Dome C. We also find that the seeing and boundary layer thickness are correlated with local temperature inversion which is monitored by KLAWS, a multi-layer automatic weather station. These results further support Dome A to be a good site for optical/infrared astronomy.

403

A Path for Infrared Astronomy at Dome C

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The Antartic conditions are ideal for astronomical observations in the infrared. The Domes in particular offer combination of cloud cover, seeing and sky brightness that still remain under-exploited. We propose a path forward for the development of infrared observations at Dome C. A first phase consisting of equipping the existing telescopes with infrared cameras will allow for deep observations of the infrared sky and establishing the infrastructure and experience to make such observations routine on the ice. As a second phase, we propose to establish a state of the art IR survey telescope with aperture of 1m that will focus on the seach of gravitational wave event follow-up.

794

The unique polar perspective for Space Situational Awareness

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Artificial satellites encircle the Earth in elliptical trajectories that give rise to unique virtual ground tracks across the surface of the planet depending upon the characteristics of their orbit. Given the distribution of orbital inclination angles for objects in the public catalogues, the number of satellites that are visible each day strongly depend upon the observers location. The polar regions offer a factor of 2 improvement in observable satellite numbers over mid-latitude locations. This makes Antarctica a prime location for the observation of artificial satellites.

An important part of Space Situational Awareness is the determination or refinement of orbital parameters to improve our understanding of where objects are in space. In order to maintain a comprehensive and actionable catalogue, a very large number of objects must be routinely observed as they transit across the sky. Due to the improved object visibility at the poles, Antarctica offers a unique vantage point from which to maintain a global catalogue of man-made objects in space.

In this talk we detail the potential and parameters influencing the performance of SSA observatories in Antarctica. We describe the implications of finite data bandwidths and how these may be overcome by new communications opportunities such as satellite optical links. We also introduce SSA technologies in development with Curtin University and Lockheed Martin Australia which currently address communications and automated operation issues and are well suited to Antarctic deployment.

168

Immersive Rendering and Sonification of Large Scale Antarctic Astronomy Data in Virtual Reality: The Making of INSTRUMENT | One Antarctic Night

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INSTRUMENT | One Antarctic Night is (IOAN) is a multi-player virtual reality (VR) art + science installation created from data captured by the Antarctic Survey Telescope (AST3) on Dome A of 817,313 astronomical objects at the center of the Large Magellanic Cloud.

Watch 3 minute video: https://vimeo.com/352807613. Website: http://oneantarcticnight.com/

Immersed in a VR arena, three participants sonify data from the 817,313 individually manipulable astronomical objects as a musical instrument to create a never ending sound scape. Real-time database queries, selections, and filtering operations in VR enable immersed participants to collaboratively interact with the objects to remix and sonify the astronomical data. All of the graphics and sound are procedurally rendered in real time from the data. GAIA DR2 and SIMBAD data are cross referenced with AST3 data, in addition to analysis of AST3 time-series data with algorithms from Vartools, Astropy and some machine learning. For IOAN we created the VR Arena as a new kind of social multiplayer immersive experience. Spatially distributed 4K physical portals combine with multichannel spatialized ambisonic audio and multiple VR interactive systems each with individual user spatialized audio. Immersed participants perform astronomical data as a sonic composition for spectators to the VR Arena that see and hear the virtual world in correct spatial relation to their real world position in the exhibition space. Player point-of-view is shown on additional dedicated displays inside the arena. IOAN explores the beauty and the rhythms of the cosmos observed from Dome A during AST3's first Antarctic night of service.

123

Sporadic E layers during the Weddell Sea Anomaly under the different levels of solar activity as deduced from observations at the Akademik Vernadsky station

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Sporadic E layers (Es) are the plasma structures characterized by increased electron concentration or intensive plasma irregularities located at the heights of E region. The occurrence, disappearance and variability of Es are irregular. But Es heights demonstrate good repeatability from day to day and possibly show the location of wind shear in the lower thermosphere. Since Es depend on winds, it looks interesting to analyze their behavior in the region of Weddell Sea anomaly (WSA) that is appeared as a result of strong impact of thermospheric winds on the main ionospheric plasma characteristics. We are analyzing the Es data accumulated during 22 years at the Ukrainian Antarctic station Akademik Vernadsky located in the heart of WSA. It was found that the heights of Es at the nighttime are bigger under the high solar activity and lower at the low one. At the daytime the situation is opposite, Es heights are bigger under the quiet Sun conditions. The explanation of those dynamics could be the next. The horizontal gradients of the temperature, pressure and as a result the wind speed in lower thermosphere should increase with growth of solar UV flux and decrease in opposite case. That should lead to decreasing the height of wind shear at the daytime when polar-ward thermospheric winds are prevailed, and to upwelling the wind shear near midnight with equator-ward thermospheric winds. The morphology and causes of this phenomenon will be discussed in detail.

485

HF diagnostics of natural and artificially stimulated ionospheric irregularities at the Akademik Vernadsky station (Review)

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We report on the results of global diagnostics of ionospheric irregularities using coherent monitoring of HF signals. Radio signals were radiated by high-power HF heating facilities such as HAARP (Gakona, Alaska, USA), EISCAT (Tromsø, Norway), and Arecibo (Puerto Rico, USA) as well as by transmitters of time service in Europe (RWM, Russia) and Northern America (CHU, Canada) propagated on super long radio lines and detected at the Ukrainian Antarctic station Akademik Vernadsky (UAS). Simultaneous transmissions of time and frequency service are used as probe signals due to continuous highly stable operation. They have been recorded round-the-clock at the UAS since 2010. Analyses of the RWM signals allowed us to reveal four different pathways: the direct and reverse paths along the great circles and two trajectories formed by focusing along the solar terminator and scattering on the ionospheric irregularities of auroral ovals. The registration of the fourth spatial mode allows us to track the position of the oval and detect the drift velocity of plasma inhomogeneities. The second part of this paper is devoted to study of long-distance propagation of HF signals emitted by powerful heating facilities. Artificially excited irregularities scatter transmitted signals into the ionospheric waveguide formed between the E and F ionospheric layers. Trapping and channeling of waves provide super long-range propagation from the northern to the southern hemisphere. As a result, transmitted signals are consistently recorded at the UAS.

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