Overview

When: **June 30th, 9am - 2pm (EDT)**

Registration: Click here to register for the meeting and receive the zoom link via email.

Organizers:

Martin A. Reiss	Space Research Institute IWF, Austria martin.reiss@oeaw.ac.at
Karin Muglach	NASA Goddard Space Flight Center, USA karin.muglach@nasa.gov

Speakers:

Cooper Downs	Predictive Science Inc., USA
Robert Jarolim	University of Graz, Austria
Shibaji Chakraborty	Virginia Tech, USA
Jiwon Chung	InSpace Co., South Korea
C. Nick Arge	NASA Goddard, USA
Larisza Krista	University of Colorado, USA
Chris Lowder	Southwest Research Institute - Boulder, USA
Stephan Heinemann	Max Planck Institute, Germany
Jon Linker	Predictive Science Inc., USA
Emily Mason	NASA Goddard, USA
Michael Kirk	ASTRA, USA
Stefan Hofmeister	Columbia University, USA
Jeremy Grajeda	New Mexico State University, USA
Andrew Leisner	George Mason University, USA
Yang Zhou	University of Bath, UK

Format: Each presentation length is 10 min talk plus 2 min for questions.

Program

BLOCK 1, 9:00am - 10:30am (EDT)

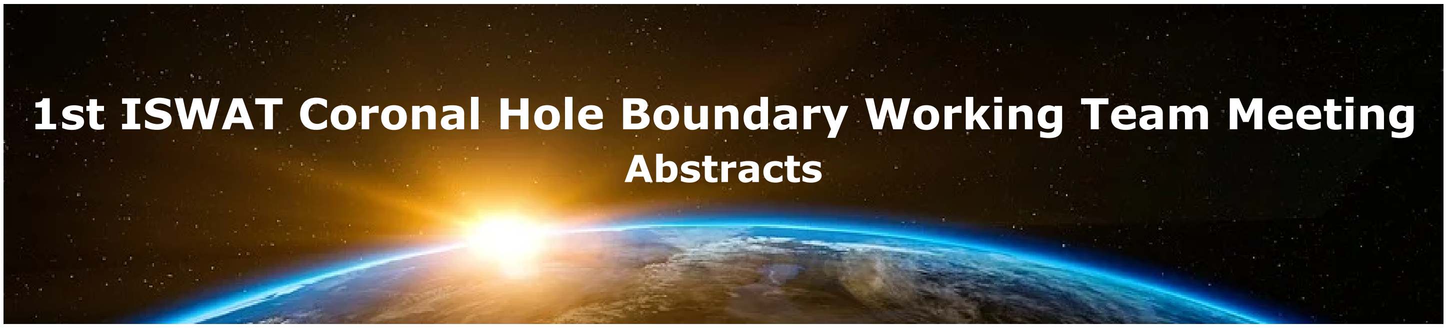
Speaker	Title	Time
Martin Reiss (chair)	Meeting Organizer Introduction	9:00
Karin Muglach (chair)	Progress Update of the ISWAT Coronal Hole Boundary Working Team	9:05
Cooper Downs	CHMAP: Coronal Hole Mapping and Analysis Pipeline	9:20
Robert Jarolim	CHRONNOS: Multi-channel Coronal Hole Detection with Convolutional Neural Networks	9:32
Shibaji Chakraborty	Detection of Coronal Hole Boundaries in SDO/AIA Images using Machine Vision	9:44
Jiwon Chung	DNN-based Coronal Hole Detection through Segmentation	9:56
C. Nick Arge	Solar Indices and Irradiance Working Group	10:08
	Community Q&A	time remaining

BLOCK 2, 10:45am - 12:00pm (EDT)

Speaker	Title	Time
Larisza Krista	The Evolution of Solar Coronal Holes Over Two Solar Cycles	10:45
Chris Lowder	Coronal Hole Observer and Regional Tracker for Long-term Examination	10:57
Stephan Heinemann	Magnetic Evolution of Coronal Holes	11:09
Jon Linker	Coronal Hole Detection and Open Magnetic Flux	11:21
Emily Mason	The Other Side of the Coin: Correlating Border Structures with Coronal Hole Boundary Characteristics	11:33
	Community Q&A	time remaining

BLOCK 3, 12:30pm - 2:00pm (EDT)

Speaker	Title	Time
Michael Kirk	Comparing Polar Coronal Holes Across Missions	12:30
Stefan Hofmeister	Revised SDO/AIA Point Spread Functions to Correct for Long-Distance Scattered Light	12:42
Jeremy Grajeda & Andrew Leisner	CHMAP: Identifying Coronal Holes in Solar Observations and Comparing Them to Coronal Model Predictions	12:54
Yang Zhou	Deep Learning models in confronting ADAPT and satellite observations	1:18
Martin Reiss	Work Approach and Future Perspectives of the ISWAT Coronal Hole Boundary Working Team	1:30
	Community Q&A, Discussion, and Wrap-Up	time remaining



ABSTRACT - C. Nick Arge

Title: Solar Indices and Irradiance Working Group

Nick Arge [1], Carl Henney [2], Karin Muglach [1,3]

[1] NASA/GSFC
[2] AFRL
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The Solar Indices and Irradiance Working Group is focused on how best to forecast the solar EUV variability of input parameters required of ionospheric and thermospheric (I/T) models (e.g., discrete spectral bands not observable from ground based observations). Solar ultraviolet (UV) radiation (0.1-200 nm) is absorbed in the Earth's upper atmosphere, driving ionization and heating of the neutral atmosphere. Areas of interest include, e.g.: how well do solar indices reproduce the observed variability of radiation bands within the VUV that drive the IT models on a cadence of 24 hours or less? Current I/T models are capable of using measured UV spectral information, along with solar indices (e.g., F10.7, the solar radio flux at 10.7 cm, along with Mg II core-to-wing ratio, total magnetic flux), to drive predictions. Knowing how well I/T models perform using actual EUV observations or EUV proxies will allow the space weather community to better understand current forecast uncertainties and future instrumentation requirements.

During the past year, COVID-19 delayed progress since the initial ISWAT meeting in early 2020. Currently we are optimistic that we will draft specifications for a F10.7 scoreboard and develop a prototype process by early 2022. Short-term goal is to create an F10.7 scoreboard that shows current and future f10.7 values with 24h time resolution and a 3 day prediction range.

The scoreboard will include f10.7 flux forecasts from publicly available sources and compares the predictions with the observed F10.7 values. Baseline models like persistence and recurrence will also be included to provide a baseline reference for skill score comparisons. We expect to develop an ensemble of model solutions, with realistic estimates of uncertainty, for the community to evaluate and utilize in near real-time.

ABSTRACT - Shibaji Chakraborty

Title: Detection of Coronal Hole Boundaries in SDO/AIA Images using Machine Vision

Shibaji Chakraborty [1], Martin A. Reiss [2], and Karin Muglach [3,4]

[1] Electrical and Computer Engineering, Virginia Tech, Blacksburg, Virginia, USA
[2] Space Research Institute, IWF, Graz, Austria
[3] Space Weather Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA
[4] Catholic University of America, Washington, DC 20064, USA

Coronal holes are the observational manifestation of open magnetic field lines that appear as dark regions in solar EUV imagery due to their lower density and temperature when compared to the surrounding coronal plasma. We present an automated tool for detecting coronal holes in multi-thermal images produced by the Atmospheric Imaging Assembly (AIA) instrument on board NASA's Solar Dynamics Observatory. Our detection scheme exploits the sudden change in intensity of the coronal holes relative to their neighborhood and uses lessons learned from solar physics research to identify coronal hole boundaries. The detection scheme relies on contour-based image processing and probabilistic thresholding methods. The first results show that the new scheme can accurately detect coronal holes in SDO/AIA images of the Sun.

ABSTRACT - Jiwon Chung

Title: DNN-based Coronal Hole Detection through Segmentation

Jiwon Chung [1], Sangmin Park [1], Jubhin Jeong [1], Dongyoung Kim [1], Haingja Seo [1], Myungjin Choi [1], Jae Hun Kim [2]

[1] InSpace Co., South Korea
[2] National Radio Research Agency, Korean Space Weather Center

Detecting coronal holes is important to predicting the effect of solar activity on the magnetic field of the Earth. Generally, the greater the size of coronal holes, the greater the impact on Earth. Common approaches to detecting such events include manual labeling, computer vision-based thresholding techniques, or machine learning. We have instead employed a segmentation technique through deep learning in automatic detection of the approximate location and the size of coronal holes. The classic U-Net architecture and its variants, such as the Attention U-Net and DeepUNet, were investigated in training separate models for coronal holes, and our main metric was the critical success rate (CSI). Several preprocessing steps were taken when converting the solar data into usable images by the network, and the final CSI of the trained model was calculated in units of independent objects, rather than pixels, while taking into account the size of the target

ABSTRACT - Cooper Downs

Title: CHMAP: Coronal Hole Mapping and Analysis Pipeline

Cooper Downs [1], James Turtle [1], Tamar Ervin [1], Opal Issan [1], Ronald M. Caplan [1], Jon A. Linker [1]

[1] Predictive Science Inc., United States

In this presentation we summarize an open source python framework for coronal hole mapping and analysis, CHMAP, which we are currently transitioning for community release. Following similar concepts to Caplan et al. (2016), our pipeline differs from typical detection schemes by emphasizing the full-sun, multi-spacecraft nature of the problem; aiming to capture coronal holes consistently in time as they evolve from days to weeks to several rotations. Key elements of the pipeline include: 1) A modern database approach for handling 14+ years of EUV imaging data and derived quantities. 2) Data-derived image corrections for center-to-limb and inter-instrument intensity variations based on long-term, 6+ month moving averages. 3) Flexible full-sun mapping methods and map types, including synchronic, synoptic, and time-averaged minimum intensity merged maps. 4) A new technique to identify and track the evolution of individual coronal holes and associated patches using time-dependent clustering methods and connectivity graphing. Examples illustrating key concepts and potential applications of our pipeline will be shown.

ABSTRACT - Jeremy Grajeda, Andrew Leisner

Title: CHMAP: Identifying Coronal Holes in Solar Observations and Comparing Them to Coronal Model Predictions

Jeremy Grajeda [1]**, Andrew Leisner** [2], Laura Boucheron [1], Michael Kirk [3], Jie Zhang [2], C. Nick Arge [4]

[1] New Mexico State University; [2] George Mason University; [3] ASTRA; [4] NASA/GSFC

Identifying coronal holes in solar disk images is very challenging, yet critical, as they serve as a key constraint for coronal models. In this shared talk, we discuss the Active Contours Without Edges (ACWE) method for identifying coronal holes in EUV disk images such as those from SDO/AIA and STEREO A&B. ACWE is an image segmentation technique that defines one or more contours which separate an image into foreground and background. When adapted to coronal hole segmentation, ACWE is first seeded with a group of initial contours consisting of dark pixels within the solar EUV image. These initial contours are evolved, in an iterative process, to maximize the homogeneity of segmented regions, producing a binary map of coronal holes in the original EUV image that is no longer defined by an intensity threshold. ACWE was used to derive coronal hole boundaries in a set of STEREO EUVI/A, EUVI/B, and SDO/AIA disk images from January 2011. The ACWE results were then combined into global synchronic maps using a synchronic map generating algorithm. Next, the ACWE synchronic maps were directly compared to WSA model coronal hole predictions, where ADAPT photospheric magnetic field maps were used as its input. This was done quantitatively by calculating both the Jaccard index and the overlap coefficient for each set of maps.

ABSTRACT - Stephan Heinemann

Title: Magnetic evolution of coronal holes

Stephan G. Heinemann [1], Manuela Temmer [2], Stefan J. Hofmeister [3]

[1] Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany
[2] Institute of Physics, University of Graz, Austria
[3] Columbia Astrophysics Laboratory, Columbia University, New York, USA

Understanding the evolution of coronal holes is the base on which any solar wind related research and forecast is built. Slow and high speed stream interaction regions may deliver large amount of energy into the Earth's magnetosphere-thermosphere-ionosphere system, cause geomagnetic storms, and shape interplanetary space. The open magnetic structure, its evolution and interplay with the local and global fields strongly defines the coronal and solar wind properties. Only by understanding these we can attempt to create a full picture of our heliosphere. By statistically investigating the long-term evolution of 16 well observed CHs, which are distributed in time over a full solar cycle, we aim to reveal processes that drive the observed changes in the CH parameters. We use remote sensing image data from SDO and focus on coronal, morphological and underlying photospheric magnetic field characteristics as well as investigate the evolution of the associated high-speed streams from in-situ measurements. We find that the CH area evolution mostly shows a rough trend of growing to a maximum followed by a decay. No correlation of the area evolution to the evolution of the signed magnetic flux and signed magnetic flux density enclosed in the projected coronal hole area was found. From this we conclude that the magnetic flux within the extracted coronal hole boundaries is not the main cause for its area evolution. Change rates of the signed mean magnetic flux density and the signed magnetic flux are derived to be dependent on the solar cycle rather than on the evolution of the individual CH. This clearly hints towards that the global magnetic field gives significant contribution to the evolution of open magnetic field structures on the Sun.

ABSTRACT - Stefan Hofmeister

Title: Revised SDO/AIA Point Spread Functions to Correct for Long-Distance Scattered Light

S.J. Hofmeister [1], M. Hahn [1], D.W. Savin [1]
[1] Columbia Astrophysics Laboratory, Columbia University, New York, NY, USA

The Atmospheric Imaging Assembly (AIA) on the Solar Dynamics Observatory (SDO) is one of the most-used data sources in solar physics. Its point spread functions (PSF) were well calibrated by the instrument team, and allows high-quality observations of the solar corona at a resolution of ~1.5 arcsec for quiet Sun and active regions. However, it is suspected that low-emission features such as coronal holes still contain a significant contribution of diffusive, long-distance scattered light due to the microroughness of the mirrors, which is not accounted for by the PSFs provided by the instrument team. We develop a novel analytical technique that uses eclipse images and enables us to update the existing PSFs for diffusively scattered light. No preexisting knowledge on the shape of the missing part of the PSF is required. Applying this technique to the point spread functions provided by the instrument team, combined with

analyzing 50 partial solar eclipses, shows that an additional 5% of the light is scattered farther away than 100 arcsec. These missing 5% have a noticeable effect for structures significantly brighter than the quiet Sun, and a significant effect on features that are substantially darker than the average quiet Sun. The intensity of bright structures, such as active regions, is increased by an additional 5% as compared to the AIA images deconvolved with the original PSFs. The intensity of dark structures, such as coronal holes, is decreased by about 40% as compared to images deconvolved with the original PSFs. Our results demonstrate that for dark structures such as coronal holes, coronal dimmings, and filament channels, taking into account and correcting for the long-distance scattered light is essential.

ABSTRACT - Robert Jarolim

Title:
CHRONNOS: Multi-channel coronal hole detection with convolutional neural networks.

Robert Jarolim [1], A. Veronig [1,2], S. Hofmeister [3], S. G. Heinemann [4], M. Temmer [1], T. Podladchikova [5], and K. Dissauer [1,6]

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[5] Skolkovo Institute for Science and Technology, Moscow, Russia
[6] NorthWest Research Associates, 3380 Mitchell Ln, Boulder, CO 80301, USA

Abstract:
We present a novel fully automatic method for coronal hole detection,that provides reliable full-disk segmentation maps and can perform in real-time. We use a convolutional neural network to identify the boundaries of coronal holes from the seven EUV channels of the Atmospheric Imaging Assembly (AIA) as well as from line-of-sight magnetograms from the Helioseismic and Magnetic Imager (HMI) onboard the Solar Dynamics Observatory (SDO). For our primary model (Coronal Hole RecOgnition Neural Network Over multi-Spectral-data; CHRONNOS), we use a progressively growing network approach that allows for efficient training, provides detailed segmentation maps and takes relations across the full solar-disk into account. We provide a thorough evaluation for performance, reliability and consistency by comparing the model results to an independent manually curated test set. The evaluation over almost the full solar cycle no. 24 shows that CHRONNOS provides reliable and consistent detections, independent of the solar activity. In addition, we train our model to identify coronal holes from each channel separately and show that segmentation maps can be also obtained solely from line-of-sight magnetograms. We conclude with an outlook on the future plans of the CHRONNOS project. (article status: accepted by A&A)

ABSTRACT - Michael S.F. Kirk
Title: Comparing Polar Coronal Holes Across Missions

Michael S.F. Kirk [1,2], W.Dean Pesnell [2], C. Nickolos Arge [2], Matthew J. West [3], Raphael Attíe [4,2]

[1] ASTRA; [2] NASA/GSFC; [3] SWRI; [4] GMU

Comparing coronal hole features between missions is difficult because of systematic uncertainties between how detectors image the sun. PROBA2's SWAP instrument images the full-disk EUV Sun using a CMOS-APS detector with a filter centered on 174 Å pass-band at a cadence of 1-2 minutes. In contrast, the AIA instrument on SDO has a band-pass filter centered on 171 Å and uses a CCD detector to make full-disk observations of the EUV corona. The images these two telescope designs produce are visually quite similar in active regions, coronal loops, and the quiet corona. Polar coronal holes are the longest-lived features on the sun and are a critical piece to understand the global state of the solar corona, but because of an oblique viewing angle, obstruction due to the coronal plasma scale height, and lack of ground truth magnetic field measurements make reliable segmentation of polar holes difficult. We use perimeter tracing to make consistent measurements of a polar hole's perimeter and area in both SWAP 174 Å and AIA 171 Å images. The generated time-series of coronal hole parameters rarely agree with each other. Direct comparison of polar hole measurements generated by these two imagers allows us to simultaneously analyze the physical properties of polar coronal holes and to identify systematic differences between the two different instruments.

ABSTRACT - Larisza Krista
Title: The Evolution of Solar Coronal Holes Over Two Solar Cycles

Larisza Krista [1,2]

[1] Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO 80309, USA
[2] National Centers for Environmental Information, National Oceanic and Atmospheric Administration, Boulder, CO 80305, USA

Combined data from the Solar Heliospheric Observatory (SOHO) and Solar Dynamics Observatory (SDO) provides us with a unique opportunity to study the evolution of solar phenomena over a period of 24 years and two solar cycles. Here, we present the results from the analysis of solar coronal holes observed almost every single day over two decades. An updated version of the Coronal Hole Automated Recognition and Monitoring (CHARM) tool was used to identify coronal holes using extreme ultraviolet observations and magnetograms. By identifying coronal holes and measuring their physical properties in a consistent manner, we were able to improve our understanding of their evolution over the solar activity cycle.

ABSTRACT - Jon Linker
Title: Coronal Hole Detection and Open Magnetic Flux

Jon Linker [1], and ISSI Open Flux Team

[1] Predictive Science, Inc., United States

We report on results from our International Space Science Institute (ISSI) study, Magnetic Open Flux And Solar Wind Structuring Of Interplanetary Space, led by Manuela Temmer, which first met in October, 2019. We studied a low-latitude coronal hole (CH) observed on 9/19/2010 and its associated Carrington Rotation (CR2101). We investigated the uncertainties in the calculation of open magnetic flux from remote observations by exploring the variability in the results that occur when different CH detection techniques, different wavelengths, instruments, and different photospheric magnetic maps, are used. As there is no "ground truth" measurement for the open flux on the Sun, we used a thermodynamic MHD model to simulate the corona for this time period and produced synthetic EUV emission images. The same analysis that was performed on the observations was repeated for the simulated data, where the "true" open flux is known. The observational and model results were related to in-situ estimates of the heliospheric magnetic flux. From that we assessed the overall ability of detection methods to account for solar open flux and identify potential sources of missing open flux. We find that there can be considerable variability between different methods in the detection of open field areas and open magnetic flux, and under-detection of open flux in CHs likely contributes to the recognized deficit in solar open flux (the "Open Flux Problem"). However, it is unlikely to be the main source of the discrepancy.

ABSTRACT - Chris Lowder
Title: Coronal Hole Observer and Regional Tracker for Long-term Examination

Chris Lowder [1]

[1] Southwest Research Institute - Boulder, Colorado, United States

Manifesting as regions of decreased emission in extreme ultraviolet (EUV) and x-ray wavelengths, coronal holes are the observational signatures of the roots of open solar magnetic field. Coronal plasma within these regions is free to flow outward along open magnetic field lines, resulting in reduced density and emission. Identifying and characterizing these coronal hole regions provides useful insights into their connection with open magnetic field, their evolution over the solar cycle, and impacts on space weather as a source of fast solar wind. The Coronal Hole Observer and Regional Tracker for Long-term Examination (CHORTLE) provides an automated and adaptive tool for coronal hole detection, using an intensity thresholding technique combined with a consideration of enclosed magnetic flux. Utilizing EUV data from a variety of sources including SOHO/EIT, SDO/AIA, and STEREO/EUVI A&B, coverage stretches back from solar cycle 23 to present, with multi-instrument merged observations providing enhanced polar and far-side coverage where available. Coronal hole

depth maps are generated at a variety of cadences, ranging from instantaneous snapshots to aggregate maps over solar rotation time scales. These maps are further assembled to provide coronal hole latitudinal distributions and enclosed open magnetic flux measurements over the span of solar cycles, yielding both a description of coronal hole evolutionary patterns and a long-term set of data for comparison with both models and observations.

ABSTRACT - Emily Mason

Title: The Other Side of the Coin: Correlating Border Structures with Coronal Hole Boundary Characteristics

Emily Mason [1,2]

[1] Solar Physics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA
[2] Universities Space Research Associations (USRA)

Coronal hole boundaries are observationally defined by the lack of EUV emission; the closed-field structures which border the open-field region provide the contrast for this definition, as well as important local magnetic context. This study is designed to address a critical open question: whether, and if so how, various closed structures affect the open/closed boundary in observations. First, the full date list for the ISWAT team was assessed to classify which structures bordered each coronal hole in the SDO/AIA field of view: helmet streamers, pseudostreamers, active regions, and prominences/filaments. This determination was achieved via analysis of data from SDO, STEREO, Proba2 SWAP, SOHO, MLSO K-Coronagraph, and potential field source surface extrapolations. Using standard SunPy contouring procedures, preliminary comparisons were made of the coronal hole boundaries in the date list using SDO AIA 193 and 211 Å channels. This contouring method was chosen as an accessible alternative to hand-drawing boundaries, and so that the results would not be biased towards or away from any of the automated methods studied in Reiss et al. 2021. First-cut statistical analysis of the relative boundary locations across the various channels, categorized by bordering closed-field structure, are presented here.

ABSTRACT - Yang Zhou

Title: Deep Learning models in confronting ADAPT and satellite observations

Y. Zhou [1], S. Gonzi [2], D. Jackson [2], C. Budd [1], T. F. Haines [1], A. Majumdar [3]

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[2] Met Office, United Kingdom
[3] University of Strathclyde, Department of Mathematics & Statistics, United Kingdom

In my PhD work, I use deep learning tools and numerical methods to improve the accuracy of space weather prediction models. An important intermediate model of the forecasting chain is the Wang-Sheeley-Arge (WSA) model. But the magnetogram synoptic maps that go into WSA have large errors. This is especially true for the representation of coronal holes (CHs). CHs are not directly observed in the synoptic maps but are the result of a numerical minimisation algorithm. We know there is large uncertainty in the description of the CHs that error is propagated through WSA. One way to overcome this uncertainty is the application of the ensemble method. The UK Met Office already uses ADAPT (Air Force Data Assimilative Photospheric Flux Transport) operationally which in one way or the other gives 12 different ensemble realisations in WSA. However, these 12 ensembles give different realisations of the CHs. In that case we lack the *ground truth* and it would be useful to understand which ADAPT ensemble members have the best representation. In my first year as a PhD student, I have developed a model to register satellite images and ADAPT-WSA ensemble outputs. The satellite images were first processed with an auto-segmentation software CHIMERA (Coronal Hole Identification via Multi-thermal Emission Recognition Algorithm). This gives me the hourly coronal boundaries segmentation from space-borne observations. These observations are projected onto the same coordinates, and this can allow us to compare ADAPT with satellite images like-to-like. I will show some primary results of my research where I apply a CNNs (Convolutional Neural Networks) based algorithm to analyse the ADAPT ensembles. Later this work will hopefully improve the solar wind forecast at Earth.