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פרופ' ארנון קרניאלי

המעבדה לחישה מרחוק
המכונים לחקר המדבר ע"ש יעקב בלאושטיין
אוניברסיטת בן-גוריון בנגב
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Science from Above

November 8, 2018

Dear colleagues,

Re: VENµS periodic news – 8 November 2018

1. VENµS End-users Conference and Workshops

Last call! The train is leaving on **November 10, 2018.** Registration link:

https://docs.google.com/spreadsheets/d/10YjKDqrdeEO9C556dYp2Ict1rHeOzKvLV7AaJ1s2nig/edit#gid=0

Thanks for all who have already registered online. In this form you can mark your participating for the conference, workshops, social events, tour, and/or transportation from/to Beer Sheva (central bus and train stations). Special request – despite of the early hour and the distance, please do your best to arrive at Sede Boker before the conference starts to honor our distinguished guests. We have a full and interested program. The program and abstracts are attached below. To stay within the tied time frame, each speaker has 15 minutes for the presentation plus 5 minutes for questions and discussion. **A total of 20 min per speaker!** The program and abstracts are attaching below. I would recommend to order accommodation at the Sede Boker Field School (http://sdeboker.co.il/) or at the variety of zimmer rooms (http://www.mapa.co.il/gnet/maps/map.aspx?rimx=129130&rimy=1029149&search_phrase=%EC%E9%F0%E4&subjectid=12&around_recordid=3888&external=true).

2. Technological Mission

Each year, between Oct.15 and Nov.14, the VENµS is devoted only for the technological mission. No images are acquired during this time. This month was selected since much less agriculture activities are performed in the northern hemisphere. The technological mission is aimed at qualifying an Israeli electric propulsion technology (IHET) by examining the maneuver capability of the satellite.

3. The Israeli VENμS Products Website

The Israeli VENμS Products Website is ready (in beta version) at the following URL: https://venus.bgu.ac.il/venus/ . Please follow the instruction detailed in section 4 of the attached document to register, order, and download the products (collection 1). Since this is a Beta version, please let us know whether you are facing any problems.

4. VENμS Metadata

The METADATA (HDR files) of VENμS products received before Oct. 27, 2018 contain erroneous values of wavelengths for the 12 bands. The correct values, after the in-orbit test period, are indicated in the following table:

Bands	Central Wavelength (nm)	Bandwidth (nm)	Main Driver
B1	423.9	40	Atmospheric correction
B2	446.9	40	Aerosol, clouds
B3	491.9	40	Atmospheric correction
B4	555.0	40	Land
B5	619.7	40	Land
B6	619.5	40	DEM, image quality
B7	666.2	30	Land
B8	702.0	24	Land
B9	741.1	16	Land
B10	782.2	16	Land
B11	861.1	40	Land
B12	908.7	20	Water vapor

From 27/10/2018 the METADATAs indicate rounded values of the wavelength (but they are correct).

5. Atmospheric correction parameters

The document below shows the formula used to compute the VENμS TOA reflectance from the VENμS TOA radiance.

Regards,

Manuel and Arnon

Version du 5 octobre 2018

Calculation of equivalent solar irradiance and equivalent wavelength for each Venµs spectral band:

$$E_k^{eq} = \frac{\int E_k(\lambda).S_k(\lambda)d\lambda}{\int S_k(\lambda)d\lambda}$$

Equivalent solar irradiance for the spectral band k

$$\lambda_k^{eq} = \frac{\int \lambda.S_k(\lambda)d\lambda}{\int S_k(\lambda)d\lambda}$$

Equivalent wavelength for the spectral band k

with: $S_k(\lambda)$ is the spectral sensitivity of band k

$E_k(\lambda)$ is the top of atmosphere solar spectrum for the band k

Spectral band	Equivalent solar irradiance (W/m²/µm)	Equivalent wavelength (nm)
B1	1661.634	423.9
B2	1954.005	446.9
B3	1990.678	491.9
B4	1830.509	555.0
B5	1669.217	619.7
B6	1670.402	619.5
B7	1510.949	666.2
B8	1428.368	702.0
B9	1290.557	741.1
B10	1163.151	782.2
B11	965.547	861.1
B12	879.865	908.7

For each spectral band k and for each pixel (i,j), the relationship between the top of atmosphere radiance $L_k(i,j)$ and the top of atmosphere reflectance $\rho_k(i,j)$ is:

$$\rho_k(i,j) = \frac{\pi.L_k(i,j)}{E_k^{eq}.u(t).\cos(\theta_s)}$$

with:

- $L_k(i,j)$: pixel (i,j) radiance for the spectral band k (W/m²/sr/µm)
- θ_s : solar zenithal angle
- $u(t)$: correction coefficient of the Earth – Sun distance calculated with a space mechanics library
- E_k^{eq} : equivalent solar irradiance for the spectral band k

Scientific Program and Abstracts

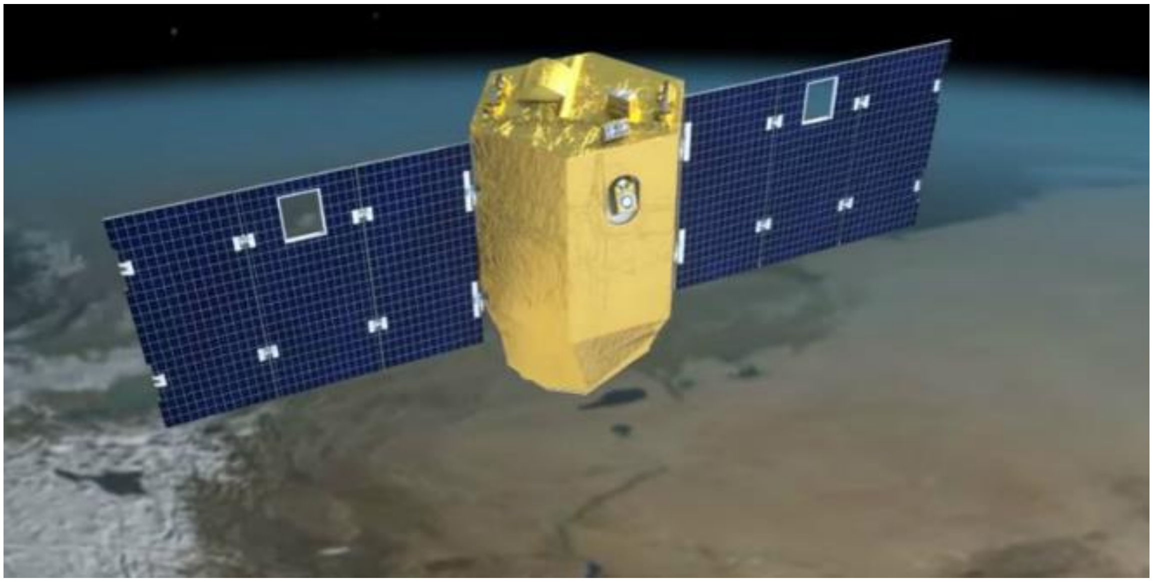
First International VENμS End-users Conference and Workshops

21-22 November 2018

The Jacob Blaustein Institutes for Desert Research

Sede Boker Campus

Ben-Gurion University of Negev



אירוע במסגרת עונת ישראל-צרפת 2018

Wednesday 21 November 2018

08:00 – 08:30 Registration at George Evens Family Auditorium

08:30 – 09:15 Greetings

Mr. Avi Blasberger, Director of Israel Space Agency, Israel

Mr. Jean-Yves Le Gall, President of CNES, France

Prof. Isaac Ben-Israel, Chairman of Israel Space Agency

Mr. Sebastien Linden, Scientific and Academic Attaché, French Embassy in Israel

Prof. Dan Blumberg, Vice President and Dean for Research and Development of Ben Gurion University

Prof. Noam Weisbrod, Director of the Jacob Blaustein Institutes for Desert Research, Ben Gurion University

09:15 – 11:00 Season 1: The VENμS System

Gerard Dedieu

Overview of the VENμS scientific mission

Pierric Ferrier

VENμS: A Successful Very First Cooperation in the Space Domain between France and Israel

Arthur Dick

VENμS Image Quality Commissioning Phase

Arnon Karnieli, **Manuel Salvoldi**

VENμS observations over Israel

Ofra Ainemer

The VENμS web site

11:00 – 11:30 – Coffee break

11:30 – 13:30 Session 2: Agricultural and Water Consumption

David Bonfil, Itamar Lensky

Assessing In-season Israeli Wheat Development, Grain Yields and Quality on Macro and Micro Scales by VENμS data.

Yafit Cohen, Graff Nitsan, Saranga Yehoshua, Gogumalla Pranuthi, Vellidis George, Liakos Vasileios, Arie Bosak, Snider John

VENμS Images for Estimating Water Status Measures and to Support Irrigation Decisions in Cotton.

Offer Rozenstein, Nitai Haymann, Gregoriy Kaplan, Josef Tanny

Estimating Crop Water Consumption using a Time Series of Satellite Imagery.

Andrew French, Charles Sanchez, Mazin Saber, Martin Porchas, Enrico Sanchez

Using High-Frequency VENμS Data to Estimate Crop Cover and Evapotranspiration at Ak-Chin, Arizona.

Maria Polinova, Keren Belinson, Anna Brook

Applicability of Multispectral UAV Imagery vs. Super-Spectral VENμS Satellite Imagery in Precision Agriculture.

Assaf Chen, Valerie Orlov-Levin, Oz Elhurar, Moshe Meron

Combining satellite imagery with high-resolution aerial scan of field crops for precision irrigation management and yield forecast.

13:30 – 15:00 Official Opening of VENµS Scientific Center hosted by **Prof. Arnon Karnieli** Architecture of the

Lunch at the Institutes' Administration Building

Isaac Meir

Desert architecture: An example of the Administration Building.

15:00 – 16:40 Session 3: Ecological Applications

Noam Levin, Itamar Lensky, Efrat Sheffer, Gilad Weil, Shelly Elbaz

Classifying Woody Mediterranean Species using Spectral and Phenological Observations.

Avi Bar-Massada, Eyal Weizman

Establishment of a Network of Ground-truth Sites for the Estimation of Live Fuel Moisture Content using VENµS Imagery.

Shay Adar, Marcelo Sternberg, Eli Zaady, Tarin Paz-Kagan, Zalmen Henkin, Ilan Stavi, Meni Ben Hur, Guy Dovrat, Efrat Sheffer Eli Argaman

Application of Remote Sensing Tools for Pasture Quantity and Quality in Mediterranean and Semi-Arid Grasslands using VENµS.

Paul Kamoun, T. Dana-Picard, T. Feingersh

Long-term Monitoring of Vegetation and Water Cycles for Modeling of Mediterranean Ecosystem Functioning.

Yaakov Garb

The Potential for Fusion of VENµS Coverage in a Long-term Study of Land Use Changes and their Relation to the Extent and Impacts of Waste Burning in the West Bank.

16:40 – 17:10 Coffee break

17:10 – 18:30 Session 4: Atmospheric Application/Education

Jean-Louis Roujean, Albert Olioso, Eric Ceschia, Olivier Hagolle, Marie Weiss

A Surface Albedo Product at High Spatial Resolution from a Combination of Sentinel-2 and (Forthcoming) VENµS Data: The Role of Surface Radiative Forcing from Agriculture Areas as a Major Contributor to an Abatement of Carbon Emission

Vladislav Dubinin, Tarin Paz-Kagan, Dan Yakir, Yagil Osem

Developing a New Approach of Atmospheric Correction for the VENµS Satellite.

Yevgeny Derimian

Optimized processing of fine spatial resolution satellite observations using simultaneous synergetic characterization of aerosol and surface.

Sivan Isaacson, Dan G. Blumberg, Simrit Maman

Education and Outreach Programs using VENµS Satellite Imagery.

18:30 Leaving from the Campus for a dinner at Desert Ship Khan (Sfinat HaMidbar)

Thursday 22 November 2018 – Atmospheric correction workshops

08:00 – 08:30 Welcome and coffee at George Evens Family Auditorium

08:30 – 10:00 Natalya Panov

Correction for the VENµS images using the 6S program.

10:00 – 10:30 Coffee break

10:30 – 12:00 Aimé Meygret, Gerard Dedieu

Correction for the VENµS images using the MAJA program.

12:00 – 13:00 Lunch at Miriam and Ed Vickar Information Center

13:00 – 14:30 Rudolf Richter, Daniel Schläpfer

Atmospheric & Topographic Correction, ATCOR, Processing of VENµS Imagery.

14:30 leaving from the Campus for a guided tour at Mitspe Ramon

Overview of the VENµS Scientific Mission

Gérard Dedieu[1], *Olivier Hagolle*[1], *Arnon Karnieli*[2], *Pierric Ferrier*[3], *Philippe Crébassol*[3], *Philippe Gamet*[3], *Camille Desjardins*[3], *Moti Yakov*[4], *Merav Cohen*[4] *and Ehud Hayun*[4]

[1]Centre d'Etudes Spatiales de la BIOsphère (CESBIO), Université de Toulouse, UMR 5126, 18, avenue Edouard Belin, 31401 Toulouse Cedex 9, France
[2]The Remote Sensing Laboratory, Jacob Blaustein Institutes for Desert Research
Ben Gurion University of the Negev, Sede Boker Campus 84990, Israel
[3]Centre National d'Etudes Spatiales (CNES), 18 avenue Edouard Belin, 31401 TOULOUSE Cedex 9, France
[4]MBT Space Division, Israel Aerospace Industries Ltd., P. O. Box 105, Yehud Israel, 56000

The VENµS mission is jointly developed, manufactured and operated by CNES, the French space agency, and the Israel Space Agency (ISA). It consists of two missions:

- A Scientific Mission which goal is to operate a super spectral camera for land environment monitoring.
- A Technological Mission that aims at qualifying an Israeli electric propulsion technology (IHET) and to demonstrate its mission enhancement capabilities.

The satellite was launched from Kourou on August 1st, 2017. The scientific mission (called VM1) is planned to last until mid-2020. During VM1, the satellite will fly in a near polar sun-synchronous orbit at 720 km height, leading to a 2-day orbital repeat cycle. At the end of the scientific mission the IHET will be used to decrease within 6 months (VM2) the altitude to 410 km and then (VM3) to maintain this altitude against atmospheric drag for one year. Image acquisitions will continue during this additional year with a repeat cycle of 2 days.

VENμS unique features are to acquire high resolution, multi-spectral images every second day with constant view angles over 110 sites of interest all around the world. Every two days, the satellite is at the same place, at the same hour. The equator is crossed by the satellite at 10:30 AM local time.

The general objectives of the VENμS mission are the provision of data for scientific studies dealing with the monitoring, analysis, and modeling of land surface functioning under the influences of environmental factors as well as human activities. The VENμS scientific mission is also aimed at demonstrating the relevance of superspectral, high spatial resolution observations, combined with frequent revisit capabilities.

We will present a summary of the mission characteristics, sites, and products.

VENµS: A Successful Very First Cooperation in the Space Domain between France and Israel

Pierric Ferrier[1]

[1]Centre National d'Etudes Spatiales (CNES), 18 avenue Edouard Belin, 31401 Toulouse Cedex 9, France

Combining an innovative Earth observation mission with a technological mission, on a new bus design, a new camera and a new plasma thruster and having this driven by two space agencies who never created such a project together has been quite challenging.

The French Israeli cross season celebration is a good opportunity to highlight some of the milestones which marked the course of these 12 years of development, from the MoU signature to the launch.

This short presentation will highlight some of the milestones and issues met within the course of this12-years long cooperation program (development phase).

In final the goal is to provide the audience with an overview of what it implies to start a very first challenging cooperation in the space domain, and what were the traps.

VENµS Image Quality Commissioning Phase

Arthur Dick[1]*, Philippe Gamet*[1]*, Sébastien Marcq*[1]*, Françoise De Lussy*[1]*, Florie Languille*[1]*, Renaud Binet*[1]*, Gérard Dedieu*[2]*, Olivier Hagolle*[2]*, Philippe Crébassol*[1]*, Jean-Louis Raynaud*[1]*, Bernard Specht*[1]*, Emmanuel Hillairet*[3]*, Silvia Juglea Enache*[3]*, Jean-Pascal Burochin*[3]*, Amandine Rolland*[4]

[1]Centre National d'Etudes Spatiales (CNES), 18 avenue Edouard Belin, 31401 Toulouse Cedex 9, France
[2]Centre d'Etudes Spatiales de la BIOsphère (CESBIO), Université de Toulouse, UMR 5126, 18 avenue Edouard Belin, 31401 Toulouse Cedex 9, France
[3]Magellium Toulouse, Parc technologique du Canal, 24, rue Hermès, 31521 Ramonville Saint-Agne, France
[4]Thales Services, 209, allée du Lac, 31670 Labège, France

For an earth observation mission, the commissioning phase consists of 3 major parts as far as image quality is concerned: geometric calibration, radiometric calibration and performance assessment. During the commissioning phase, radiometric calibration includes these following tasks:

- Viewing parameters optimization
- Defective pixel identification
- Dark signal estimation
- Equalization
- Stray light correction
- Polarization correction
- Absolute calibration

Similarly, the geometric image quality part consisted in:

- Pointing bias assessment and correction
- Geolocation performance assessment
- Line of sight calibration for each detector
- Multi-spectral and multi-temporal registration performance assessment
- Reference images assessment and setting
-

Each part has plenty of activities but the presentation will focus on the objectives and the organization of the commissioning phase and on the main results of radiometric and geometric calibration VENµS satellite.

VENµS observations over Israel

Arnon Karnieli[1], *Manuel Salvoldi*[1]

[1]The Remote Sensing Laboratory, Jacob Blaustein Institute for Desert Research, Ben Gurion University of the Negev

Taking advantage of the tilting capabilities of the VENµS, the State of Israel is covered by 27 tiles of 27x27 km each within three long strips, 27-km swath each. The western strip, observed in forward view angle, starts north of Rosh Anikra, passes Haifa Bay and the Mediterranean coastal plain, and ends in the Nizzana sand dunes by the border with Egypt. The eastern strip, starts north of the Hermon Mountain, passes Lake Kinneret, and ends south of Emek Beth Shean. The southern strip starts north of Perosdor Yerusalaim, passes the vicarious calibration site at Shizafon Playa, and ends in the Gulf of Eilat. The eastern and southern strips are observed in backward view angles. The location of the VENµS orbit and the view angles were determined in order to minimize sun glints from the Mediterranean and Lake Kinneret. The three strips were selected in order to optimize monitoring the agricultural areas of the country, the national reserved and parks, natural and planted forests, as well as the long-term ecological research (LTER) sites.

The VENµS scientific center was established at Sede Boker Campus of Ben Gurion University. This center coordinates the national activities that are derived from the VENµS scientific mission. Among these: receiving Level 0 and Level 1 images from CNES; convert Level 1 to Level 2 and Level 3; developing unique algorithms and applications for using the data; distribute images among certified end-users in Israel; and maintain the national archive for the VENµS images over Israel. In addition, the center will carry out the vicarious radiometric calibration activities in the Negev site. For the calibration and for accurate atmospheric correction, aerosol optical thickness and water vapor are monitored by sunphotometers in 5 designated locations across Israel: Eilat, Sede Boker, Rehovot, Haifa, and Kiriat Shemona.

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Israel Space Agency
Ministry of Science, Technology & Space

The Use of Commercial Off-The-Shelf (COTS) software for the Analysis, Visualization, and Interpretation of Venus Satellite Data

Rachel Meshulam[1], Mody Buchbinder[1], Netanel Ovadia[1], Ofra Ainemer[1]

[1]Systematics LTD, Telephone: +972-3-7660111

Within the scientific community there is a need for tools that manage the growing volume of earth observation data from satellite and photogrammetric sources. This lecture presents the capabilities of Esri's new off the shelf GIS software ArcPro to integrate and visualize satellite imagery using Venus satellite data. ArcPro provides capabilities for the integration, analysis, and visualization of imagery based on its specific band and wavelength combinations to create on-the-fly, static, or web based products for a variety of indices that are pertain to precision agriculture, water quality monitoring, and additional earth based observations.

This lecture also presents a web application that enables preliminary viewing and ordering of specific Venus imagery based on footprint and date, and an additional web application for more general viewing of earth observation imagery. It summarizes a comprehensive GIS-based solution that the scientific community can use to work with Venus data, and integrate with additional data sources for scientific monitoring and analysis.

Assessing In-season Israeli Wheat Development, Grain Yields and Quality on Macro and Micro Scales by VENµS Data

David Bonfil[1] *and Itamar Lensky*[2]

[1]Agriculture Research Organization, Gilat Center
[2] Bar Ilan University

Wheat is an important grain crop and component of dryland agricultural systems. Grain protein concentration is an important determinant of end-use quality standards. The objectives of this study are: (i) to characterize phenological stages of wheat growth through the use of time series data acquired from VENµS and MODIS; (ii) to develop, calibrate and validate algorithms for the retrieval of wheat biomass, phenological stage, grain yield, and grain quality from both multispectral and VI data; and (iii) to develop and calibrate a prototype of DSS "Assessing Wheat Yield and Quality" on a farm-regional-national scales based on multi/super spectral satellite sensors. In the first growing season, 2017-2018, ten experiments were conducted at the Gilat Research Center of the Agricultural Research Organization, located in the northern part of the Negev desert in Israel (31º21' N, 34º42' E). In 5 experiments several (3-15) cultivars varying in phenology have been sown at varied plot size (2 to 24 m wide by 12 to 24 m long). In addition, 16 experiments were conducted in commercial fields. Heading and yield from 132 fields and cultivars (in cultivar experiments); 245 biomass and 138 LAI samples were monitored. Proximal sensing using a RapidScan CS-45 sensor was conducted in 3 experimental fields once a week throughout the entire growing season from emergence to harvest, and in 12 field/experiments few times during the season. Time series algorithm was tested on MODIS images. All collected data is waiting for the relevant VENµS images.

אירוע במסגרת עונת ישראל-צרפת 2018

VENµS Images for Estimating Water Status Measures and to Support Irrigation Decisions in Cotton

Yafit Cohen[1], Nitsan Graff[1,2], Yehoshua Saranga[2], Gogumalla Pranuthi[1], George Vellidis[3], Vasileios Liakos[3], Arie Bosak[4], John L. Snider[3]

[1]Agricultural research organization, Israel;
[2]Faculty of agriculture, Hebrew university, Israel;
[3]University of Georgia, USA;
[4]Drom Yehuda Growers Association, Israel

Cotton is an economically important fiber crop for both the United States and Israel. Although cotton is widely regarded as drought tolerant, the negative impacts of drought on physiological processes and yield of cotton are well documented. Maximizing yields while at the same time improving WUE (more crop per drop) and reducing overall irrigation water use requires state-of-the art technologies and decision support tools (DST) for making better irrigation scheduling decisions. Precision irrigation or variable rate irrigation (VRI) is one approach for improving WUE.

In Israel cotton is irrigated based on evapotranspiration and crop coefficients. For optimal irrigation, coefficients are corrected using plant water status measures. In the vegetative growth period (usually from May to mid-July) crop coefficients are corrected based on growth rate using bi-weekly 2-3 plants heights measurements. These point measurements do not represent the in-field variability and it is under debate whether they represent the water status of the overall field. Satellite images with high spatial resolution can represent the in-field variability. Yet, for growth rate monitoring, high frequency is a prerequisite. VENµS images are adequate for this mission.

A 75 m north-to-south strip in a cotton field in Bney-Darom (Israel), which transforms from a sandy soil in its northers part to a clayish soil in its southern part, was selected for an irrigation experiment. The strip was divided into 3 strips which were each divided into 8 management cells (20-40 m length by 25 m width). One strip was irrigated based on the farmers' routine, and each cell in the two other strips was irrigated based on plant water status measures estimated from aerial and satellite remote-sensing images.

Bi-weekly height measurements were made in each of the 24 management cells from mid-May to mid-July. VENμS images and Sentinal-2 (S2) images were collected for this area for this period. A few spectral vegetation indices from the VIS-NIR range calculated from the S2 images, were highly correlated with height, but their 5-days revisit time limited their use to estimate growth rate. The VENμS images are currently under analysis and their ability to estimate growth rate will be presented.

Estimating Crop Water Consumption using a Time Series of Satellite Imagery

Offer Rozenstein [*1], *Nitai Haymann*[1], *Gregoriy Kaplan*[1], *and Josef Tanny*[1,2]

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Crop coefficient (K_c)-based estimation of crop water consumption is one of the most commonly used methods for irrigation management. Remote sensing modeling of K_c is possible due to the high correlations between K_c and the crop phenologic development and spectral reflectance. However, in practice, the use of satellite remote sensing to estimate crop water consumption has been limited due to lack of images at a spatial resolution enabling to capture the within-field variability of crop conditions at a sufficiently high frequency needed for irrigation management. In this study, evapotranspiration was measured in the field and K_c was estimated as the ratio between reference evapotranspiration and the measured crop evapotranspiration. We plan to use a dense time series of Venµs and Sentinel-2 imagery to produce vegetation indices (VIs) based on the sensors' unique spectral bands, and derive empirical K_c – VI models. In a previous study we showed that the most suitable bands for K_c prediction were based on the red and red-edge bands (MTCI, REP, and S2REP) and therefore we hypothesize that this result will be reproduced in this study. In addition, we propose to develop complementary processing methods to integrate the cloud penetrating synthetic aperture radar (SAR) from the newly launched Sentinel-1 in order to estimate crop water consumption on days with cloud coverage. Early results show that the SAR models are highly dependent on the incidence angle and we are attempting to tackle this challenge. This progress in estimating crop water consumption using satellite imagery that are available at no cost will be a leap forward towards the development of crop irrigation requirements models.

Using High-Frequency Venus Data to Estimate Crop Cover and Evapotranspiration at Ak-Chin, Arizona

Andrew French[1], Charles Sanchez[2], Mazin Saber[3], Martin Porchas[3], and Enrico Sanchez[3]

[1]USDA/ARS, Maricopa, AZ
[2]University of Arizona, Maricopa, AZ
[3]University of Arizona, Yuma, AZ

Irrigated agriculture in Arizona is a highly productive enterprise growing a range of crops nearly year-round. Crops grown include lettuce, broccoli, cauliflower, alfalfa, durum wheat, cotton, maize, melons, and sorghum. Long-standing drought in the US Southwest is threatening the viability of this industry because the Colorado River is approaching shortage declarations. Growers appear to be managing water efficiently—pressurized irrigation systems are increasingly being used, while level-basins are used elsewhere—but sustainability of current cropping practices will be difficult without accurate estimates and forecasts of cover and evapotranspiration (ET). Availability of high frequency, high spatial resolution multispectral data from Venus may greatly improve those estimates and forecasts. To test this potential, VENµS-derived vegetation indices are being tracked over multiple crops grown on Ak-Chin Indian Community Lands. We are estimating and modeling fractional cover and ET via crop coefficients, and then comparing results with ground observations. Those include irrigation deliveries, local cover measurements, and crop yield data. Preliminary results suggest good agreement, and in one instance may show the value of frequent images where yields appear to have been reduced by frost.

Applicability of Multispectral UAV Imagery vs. Super-Spectral VENμS Satellite Imagery in Precision Agriculture

Anna Brook[1]

[1]University of Haifa

The presented study estimates the imagery (spatial/spectral/temporal) data source effect on estimation of crop water requirements in irrigated crops. The data are compared by applying a "one-step" approach for calculation of Crop Potential Evapotranspiration (ETp) by using the crop parameters albedo (α) and Leaf Area Index (LAI) derived from processing of remote sensing imagery data, assuming fixed values for the stomatal resistance (sr≈100 sm-1) and hc (0.4 m) for herbaceous crop.

This approach exploits the consistent effort to estimate vegetation parameters (α, LAI) in the VIS and NIR regions, allowing to adapt the Penman–Monteith equation to be used directly with imagery LAI and α value. The ETp calculation requires standard meteorological data, LAI and surface α.

Maps of canopy development (LAI, α and fractional vegetation cover) have been derived from multispectral UAV imagery and super-spectral VENμS images, delivered in near real time and processed by using in-situ agro-meteorological variables (observed or modelled by Numerical Weather Prediction, i.e. BOLAM model). A portable LAI digital meter (Licor LAI-2000) is used to estimate the value of LAI in the field.

Combining Satellite Imagery with High-Resolution Aerial Scan of Field Crops for Precision Irrigation Management and Yield Forecast

Assaf Chen[1], Valerie Orlov-Levin[1], Oz Elhurar[1], Moshe Meron[1]*

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Precision irrigation can be defined as matching water application to crops' need in space, time and amount. Locating and determining irrigation uniformity issues is therefore of upmost importance for irrigation management. Several aerial scan campaigns were deployed in the Upper Galilee of Israel in the 2017 and 2018 growing seasons to follow up and evaluate the irrigation uniformity and efficiency of peanuts and cotton by RGB scans of DJI Phantom 4 and Phantom 4 Advanced multirotor unmanned aerial vehicles (UAV) and thermal scans of a DJI Inspire 1 UAV equipped with Zenmuse-XT radiometric thermal camera. Foliage intensity and coverage were enhanced by a green-red vegetation index (GRVI), which is a normalized difference vegetation index (NDVI)-like process where the green channel replaced the NIR. Thermal images were used to measure plant and soil temperature and plant water stress over time. The GRVI RGB based vegetation index product maps were compared to the thermal images maps following the crop phenological stages and irrigation uniformity patterns. Sentinel-2 and Venus satellite imaging of the cropped fields were analyzed in order to determine whether it is possible to determine irrigation uniformity issues using several-meter-scale spatial resolution satellite imaging. The results demonstrated that both the GRVI and the thermal product maps are suitable for the purpose of detecting and determining irrigation un-uniformity patterns. Field based crop biomass and yield measurements confirmed RGB and thermal varying plant vigor and plant stress mapping accurateness. Whereas the Venus images were able to detect the irrigation un-uniformity, Sentinel-2 images were not able to detect these differences, probably owing to VENμS's superior spatial resolution. This research demonstrates the efficient and complementing usage of both RGB and Thermal high-resolution images for the purpose of irrigation uniformity evaluation and management. These abilities could be combined with satellite imaging as a refined tool for large-scale general detection of irrigation uniformity issues.

Classifying Woody Mediterranean Species using Spectral and Phenological Observations

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Remote sensing of vegetation represents one of the major applications of Earth observing satellites. Remote sensing has proven capabilities for monitoring seasonal and inter-annual changes in vegetation, although usually without identifying specific tree and shrub species, due to their spectral similarity, and due to limits in spatial and temporal resolutions of traditional space borne sensors. The aims of our study are to examine the potential of the VENµS satellite, to distinguish between dominant woody plant species based on a combination of their spectral and phenological (blooming, flowering and leaf senescence) characteristics. We have acquired time series of ground photos at various sites in the Jerusalem mountains at weekly and bi-weekly intervals using a NIR-RGB 4 band camera, which enabled to examine which spectral indices best characterize phenological events for identifying woody species. Upscaling from the horizontal perspective, we have obtained time series of one of the sites (Mata) using a five band NIR-RGB sensor onboard a UAV, and have shown that at this fine spatial resolution (< 10 cm), woody species can be mapped. Using new high spatial resolution and frequent return time satellite imagery (VENµS and Planet Labs), we will examine whether woody species can be identified at spatial resolutions of 3-5 m, based on species' spectral-phenological signature, hopefully taking advantage of the availability of red edge bands in VENµS. The ability to map tree and shrub species in forests and woodlands, based on temporal changes in the spectral signature, will be of high importance for managing Mediterranean landscapes, and the identification of deviations from species-specific spectral-phenological pattern may eventually be used as an early warning signal of plant die off.

Establishment of a Network of Ground-truth Sites for the Estimation of Live Fuel Moisture Content using VENµS Imagery

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We generated a large empirical database of live fuel moisture content (LFMC) in multiple sites across Israel's climatic gradient. Six study sites were established in Mediterranean-type ecosystems, spanning a rainfall gradient from ~400mm to ~1000mm per year. Sites contain five study plots, each one corresponding with a single level-2 VENµS pixel. Vegetation sampling in these plots consists of recording woody species identity, and harvesting and weighting plant material. Samples are transferred to the lab, where they are oven-dried and re-weighted, facilitating the calculation of LFMC. From late June to October, we repeated this protocol at monthly intervals, totaling 2400 individual vegetation samples. We used these data to quantify the spatiotemporal dynamics of LFMC in Israel's Mediterranean region. LFMC decreased significantly along the season, was significantly lower at south facing slopes, and declined faster on south facing slopes. There was considerable variation in LFMC among species, whereas variation among sites was less pronounced. The grand average of LFMC across all sites and species was 95.65% in July, and it declined by 15% through early August, and by additional ~2% through early September. These results reveal the strong dynamic nature of LFMC in Israel's Mediterranean region, which in turn highlights the importance of incorporating site and climate variables in subsequent models that will attempt to predict LFMC using VENµS's vegetation indices.

Application of Remote Sensing Tools for Pasture Quantity and Quality in Mediterranean and Semi-Arid Grasslands using VENμS

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Rangelands are one of the most common land use types on Earth, with man-managed pasturelands covering more than 30% of the world's land surface and supporting the livelihood of around 2 billion people. Therefore, sustainable management of livestock in such areas has significant economic value for food production, as well as environmental implications.

Our study aims to develop a spatio-temporal approach using remote sensing platforms (i.e. satellite, aerial unmanned aerial vesical (UAV) and field based information), on two ecosystems types, to relate changes in forage quality and quantity under different grazing intensities while considering different plant functional groups.

The spatial and temporal products of VENµS are accompanied by aerial and field measurements. These will be performed during the grazing sessions. We will monitor the impact of water availability, due to rainfall pattern (rainstorm length, gaps and volume), forage quantity (above-ground plant biomass) and quality (fibers and proteins), digestibility and metabolic energy concentration, combining with laboratory ground spectral analyses in two long-term experimental rangelands in Israel, Migda and Karei-Deshe.

In the first year, biomass samples from destructive harvests have been collected, sorted into different plant functional types (i.e. grasses, legumes, thistles and forbs), and their forage quality was measured in both sites. These measurements allow an estimate of changes in plant functional diversity within the different grazing regimes. Then the estimated biomass will be related to UAV data on a regional scale. Additional measurements will be performed to monitor these changes throughout the growing season and relate them to VENµS Vegetation Indices.

Long-term Monitoring of Vegetation and Water Cycles for Modeling of Mediterranean Ecosystem Functioning

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The primary objective of our research with the VENµS data is the development and validation of natural and cultivated ecosystem functioning models that will be most suitable for Eastern Mediterranean landscapes. This requires spatial and temporal modeling of changes (and respective exchange rates) between dominant ecosystem players: soil, vegetation and the water supply chain. This is planned to be achieved through linking vegetation phenology and growth, through selected soil and vegetation status indicator (bio-geochemical/ bio-geophysical spectral indices), calculation of biomass cycle magnitudes, and seasonal water properties.

The second main objective is to relate vegetation status indicators to a carbon cycle model, using tools and models such as Net Primary Production (NPP) and their temporal dynamics, in a typical Mediterranean landscape. Through the analysis of the status of vegetation health and available radiation, models such as NPP will be calculated more precisely, and the carbon cycle in such Mediterranean regions and similar landscapes – better understood.

In this context there will also be an effort to establish new products such as those focused on monitoring of fire events, separating cloud spectra from smoke spectra based on expected differences in Rayleigh and Mie scattering mechanisms.

The third main objective will be to establish the role and spatio-temporal behavior of water cycle in these regional Mediterranean ecosystems, through the temporal analysis of the physical and chemical status of the variable sources water.

Four sites are required for this part of the project and for definition of regional, long-term water and vegetation dynamics. These sites cover the full diversity of this Mediterranean ecosystem and are expected to provide the inputs required to have a sound analysis for various vegetation types, micro-climates and sources of a full water-cycle.

The Potential for Fusion of VENμS Coverage in a Long-term Study of Land Use Changes and their Relation to the Extent and Impacts of Waste Burning in the West Bank

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The VENμS coverage will serve a long-standing research project I lead that works with local communities to examine waste burning sites and the diffusion and impacts of contaminants from these. As part of this project, remote sensing is used not only for the identification and detailed spatio-temporal tracking of burn sites (Davis and Garb, 2018b), but, increasingly, a variety of remote sensing sources (orthophoto, WV2, Sentinel, other) and field-based data are being used to analyze a range of broader related contextual and diagnostic issues. These uses include the analysis of land use and land-use change, development of appropriate object-based change detection techniques, crop phenology and classification, and detection of vegetation stress. My talk will discuss this overall project, and ways in which the incorporation of VENμS' high frequency multispectral coverage might support these efforts.

A Surface Albedo Product at High Spatial Resolution from a Combination of Sentinel-2 and VENµS Data: The Role of Surface Radiative Forcing from Agriculture Areas as a Major Contributor to an Abatement of Carbon Emission

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The surface albedo is an Essential Climate Variable (ECV) that needs to be generated on a regular basis in order to ensure continuous estimates as a contribution of the radiation budget to water and carbon balance. First of all, the removal of atmospheric effects must be properly handled. Thus, the consistency of the MAJA method for Sentinel-2 and VENµS is clearly an asset. The present developments are intended to generate a time evolving surface albedo product at the enhanced resolution of 10 m to foster an advanced research in agriculture area. Further, surface albedo product will be considered to estimate the radiation forcing due to the surface since for instance maintaining vegetation in wintertime would contribute to cool the atmosphere notable, thereby reducing carbon emission.

Hence, the method – applied to become operational since inherited from Copernicus Global Land Service - makes use of the well-established approach based on a semi-empirical BRDF kernel-driven model. Such model is applied to Level 1a data sets of Sentinel2 and VENµS. BRDF coefficients can serve to perform a normalization of the data and also to compute the spectral albedo in weighing the angular integrated kernels. Narrow to broadband albedo conversion rely on PROSAIL model ditto. Surface albedo products are generated with a Quality Flag and an uncertainty assessment.

A composite period of several weeks must be considered to gather sufficient observations in order to build a BRDF product from which the surface albedo is derived. The potential impact due to the frequency of revisit offered by Venµs compared to Sentinel2-A & -B only is assessed through time evolution analysis. For time being, the surface albedo product is refreshed during synthesis periods about 10 days or less based on an update of its intensity. Demonstrative results are shown for selected time periods of 2018. The validation is carried on for two anchor ICOS-like (Integrated Carbon Observation System) stations operated by CESBIO, which are covered by crops (maize, wheat, and sunflower, merely).

Developing a New Approach of Atmospheric Correction for the VENμS Satellite

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Accurate algorithm for atmospheric correction of the VENμS images is essential. The 6S physical-based atmospheric correction model uses data from sun photometer sites (AERONET) with limited spatial distribution. For example, in Israel, there are 5 stations. The ATCOR program combines the 6S algorithm with height factor by using Digital Elevation Model (DEM), but it also uses the limited data from AERONET stations. Our objectives were: (1) to develop an open-source 6S atmospheric correction integrating height factor, (2) to use meteorological data of MODIS with spatial resolution of 1 KM in complementarity to AERONET. The MODIS data contains aerosol optical depth, land surface temperature (LST) and water vapor (WV), (3) to compare our suggested algorithm to the commonly used models of 6S and ATCOR.

The suggested algorithm was based on the combination of 6S atmospheric correction and MODIS products. It includes the following steps: First, we used for the total optical depth calculation, MODIS products and geometric parameters of the terrain such as the viewing angles and solar angles, DEM etc. Then, we used the Beer–Lambert law to convert optical depth results to transmittance. Finally, we converted the transmittance to surface reflectance based on the 6S atmospheric correction algorithm. Our preliminary results showed that the suggested model improves the original 6S model, however, further analysis is still needed.

Optimized Processing of Satellite Observations for Synergetic Characterization of Aerosol and Surface

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Satellite observations with fine spatial resolution (several meters) become available in recent years for geophysical and environmental studies. These observations are mainly dedicated to the terrestrial surface monitoring; however, the used spectral bands can be also employed for deriving properties of atmospheric aerosol. Present-day aerosol observations by satellites exist only at relatively low spatial resolution (several kilometers) and it is assumed that aerosol characteristics do not change significantly in space. At the same time, high spatial resolution aerosol products were never available and discovered. Moreover, accurate retrievals of the surface reflectance properties require correction for atmospheric aerosol. Having experience in deriving the aerosol optical properties from reach in the information content remote sensing observations (multispectral, multidirectional and polarimetric), but at low spatial resolution, we see an interest to explore applications to sensors with high spatial resolution. A recently developed by our group versatile algorithm GRASP (Generalized Retrieval of Aerosol and Surface Properties) [Dubovik et al., 2011; Dubovik et al., 2014] enables flexibility in definition of aerosol model and a priori constrains. The algorithm demonstrates satisfactory performances also for limited in the information content observations. For example, only spectral measurements of space instruments such MERIS, VENµS or Sentinel-2 can be subject of simultaneous aerosol and surface reflectance retrievals. This talk will reveal capabilities of the GRASP algorithm to derive simultaneously the aerosol and the surface properties, and present a project on the algorithm optimization for sensors with high spatial resolution.

Education and Outreach Programs using VENµS Satellite Imagery

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The successful launch of VENµS, a state of the art Israeli-French remote sensing satellite was used as a unique opportunity to stimulate the natural curiosity of students to space studies and innovative technology. VENµS satellite images served as the main scientific basis in two of the Earth and Planetary Image Facility's education and outreach programs in the past year. The first, a remote sensing singular lesson plan for educators initiated by the Israeli Space Agency. The second, as the main motivation for a yearly remote sensing educational project for high-school girls ('She-Space').

Theoretical concepts such as spatial resolution, temporal resolution, radiometric resolution and spectral resolution were explained by using daily life examples alongside hands on activity using VENµS images combined with a Google-earth interface. The revisit time of VENµS s and its advantages in environmental and agricultural research were specifically addressed in greater detail.

These projects aim to promote STEM (Science, Technology, Engineering and Mathematics) studies by exposing the students and educators to remote sensing research concepts. This was achieved by exposing the students to the achievements of the Israeli space program and VENµS satellite particularly.

Workshop 1:

Second Simulation of the Satellite Signal in the Solar Spectrum, 6S

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Remote sensing from satellite or airborne platforms of land or sea surfaces in the visible and near infrared is strongly affected by the presence of the atmosphere along the path from Sun to target (surface) to sensor. This paper presents 6S (Second Simulation of the Satellite Signal in the Solar Spectrum), a computer code which can accurately simulate the above problems. The 6S code is an improved version of 5S (Simulation of the Satellite Signal in the Solar Spectrum), developed by the Laboratoire d'Optique Atmospherique ten years ago. The new version now permits calculations of near-nadir (down-looking) aircraft observations, accounting for target elevation, non lambertian surface conditions, and new absorbing species (CH/sub 4/, N/sub 2/O, CO). The computational accuracy for Rayleigh and aerosol scattering effects has been improved by the use of state-of-the-art approximations and implementation of the successive order of scattering (SOS) algorithm. The step size (resolution) used for spectral integration has been improved to 2.5 nm. The goal of this paper is not to provide a complete description of the methods used as that information is detailed in the 6S manual, but rather to illustrate the impact of the improvements between 5S and 6S by examining some typical remote sensing situations. Nevertheless, the 6S code has still limitations. It cannot handle spherical atmosphere and as a result, it cannot be used for limb observations. In addition, the decoupling the authors are using for absorption and scattering effects does not allow to use the code in presence of strong absorption bands.

Workshop 2:

Atmospheric & Topographic Correction, ATCOR, Processing of VENµS Imagery

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As part of the VENµS Scientific Meeting the ATCOR model of atmospheric correction will be presented with emphasis on the processing of VENµS imagery. The presentation starts with a brief description of the ATCOR-MAJA relationship, followed by an explanation of the ATCOR processing steps during GUI and batch processing. This will help interested participants to run the software after the presentation. The introduction will show some results of VENµS image processing provided to DLR as test data.

Most of the 2 h time slot is dedicated to demonstrate the ATCOR software (version 2019 Beta) on computers available at the workshop. The new features include an improved shadow and water detection, a geometric cloud shadow mask, and additional algorithms for topographic correction. All VENµS L2 output products are calculated at the 5-m spatial resolution (cloud, shadow, water masks, AOT550, water vapor, surface reflectance cube).

The participants are invited to bring their own VENµS data and run ATCOR on the desk-top computers available during the workshop.

Workshop 3:

MACCS ATCOR Joint Algorithm, MAJA

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The MAJA processor is a processor for cloud detection and atmospheric correction, specifically designed to process time series of optical images at high resolution, acquired under quasi constant viewing angles. It allows for instance to process time series of LANDSAT or Sentinel-2 images. Since 2016, it is progressively including methods taken from DLR's ATCOR processor. It is now the object of a collaboration between CNES, DLR and CESBIO, and benefits from ESA funding.

Its main feature is to use the multi-temporal information contained in time series to detect the clouds and their shadows, and to estimate the aerosol optical thickness and correct the atmospheric effects (taking into account the adjacency effect and the illumination variations due to topography).