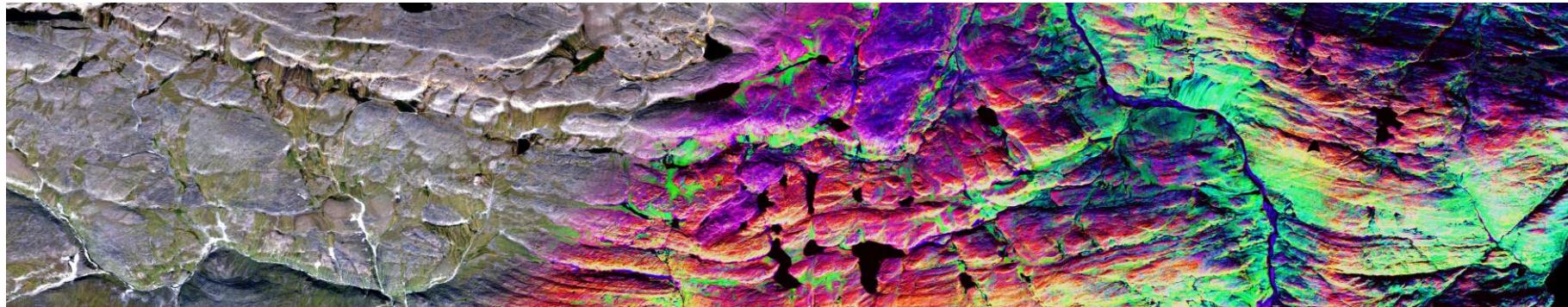


# GRSS Geoscience and Spaceborne Imaging Spectroscopy TC: Running and planned spaceborne imaging spectroscopy missions and related activities



Geoscience Spaceborne Imaging Spectroscopy TC Chairs  
Uta Heiden, DLR, Germany  
Cindy Ong, CSIRO, Australia  
Jens Nieke, ESA, The Netherlands  
*Supported by Nicole Pinnel, DLR, Germany*



## Outline

### Part I – GSIS TC Introduction

- Introduction to the general activities of the GSIS TC
- GRSS Survey
- How to join and get involved
- Recent activities on IGARSS (Sessions, TC meeting, ...)

### Part II – Short overview about spaceborne imaging spectroscopy missions

- Current and upcoming missions (overview and data access)
- Unique ISS mission constellation
- ESA's Copernicus Mission CHIME

This webinar will be recorded and published soon here:

<https://www.youtube.com/channel/UCNOdGBo--6UVCiwKSNTMqyg>

## GSIS TC Introduction - Mission

Founding members



Initiated by

- Alex Held (CSIRO, AU)
- Karl Staenz (Uni Lethbridge, CA)

IEEE GRSS Technical Committee  
since 2010

### What we do:

- Share information on running and future spaceborne imaging spectroscopy (“hyperspectral”) missions
- Provide opportunities for new partnerships
- Build a knowledge base on underpinning capabilities required for imaging spectroscopy missions
- Boost the uptake of spaceborne imaging spectroscopy by the geoscientific community.

### Which topics:

- Calibration and Validation
- Interoperability among missions
- Development of a forward work plan for improved coordination activities amongst national space agencies
- Information extraction and standardisation of data

## GSIS TC Introduction – Main activity fields





### GSIS TC Introduction – Global Activities



#### Global Activities (sessions, workshops, ...)

- Network meeting opportunities
  - Yearly IGARSS Invited session on “**International Spaceborne Imaging Spectroscopy Missions: Updates and News**”
  - Yearly GSIS TC meetings (during IGARSS)
  - Organise session on other workshops / conferences



### GSIS TC Introduction – Education



#### Education (summerschools, tutorials,...)

- Summerschools and Field courses before or after IGARSS with strong support of experts in the field of calibration / validation and error budgeting



## Geoscience and Remote Sensing Society

# July 2016 - Reflectance-Based Imaging Spectrometer Error Budget Training Course @ CSA, Beijing, China



Presented by:

Kurtis Thome (NASA Goddard)

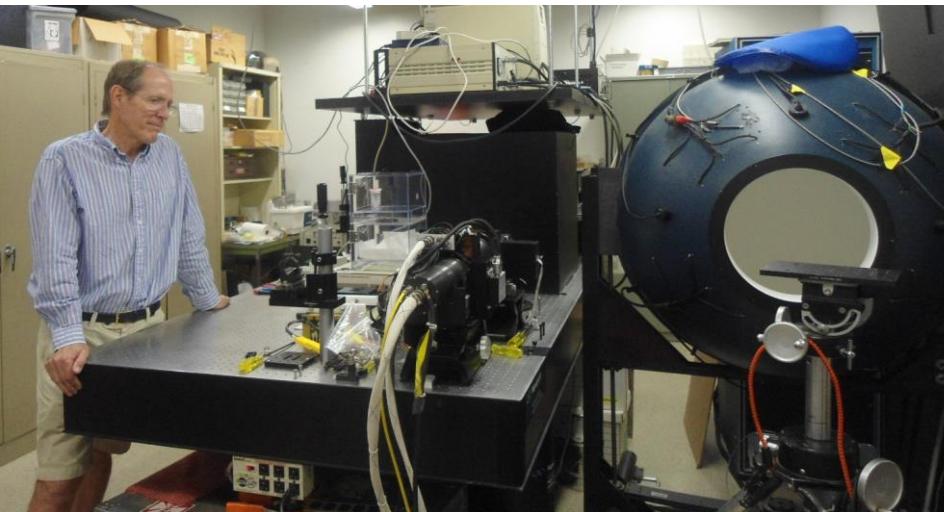
Chris MacLellan (University of Edinburgh)

Cindy Ong (CSIRO)

Martin Bachmann (DLR)

## August 2017 - Reflectance-based imaging spectrometer error budget field practicum in Rail Road Valley Test Site, USA

Demonstration of measurement protocols for surface and atmospheric parameters that minimize uncertainties and, weather permitting, collection of data as part of the reflectance-based calibration for an on-orbit sensor.



Thanks to: Kurtis Thome (NASA), Jeff Czapla-Myers and Stuart Biggar (University of Arizona), Ian Lau (CSIRO) and others



Video recordings (by Ian Lau)

<https://youtu.be/GEz7XfWHaIU>

<https://youtu.be/8ElkjgJ1NcY>

<https://youtu.be/4-JaPiqQvn0>

<https://youtu.be/3q2zJZEzHQ>

## July 2018 - Reflectance-Based Calibration of Imaging Spectrometer Training Course @ UVEG, Valencia, Spain

Thanks to: Kurt Thome (NASA), Ron Lockwood (Lincoln Lab), Cindy Ong (CSIRO), Luis Alonso (Uni of Valencia) and students of his lab



### Day 1

Background, terminology, introduction, reflectance-based method – overview, DN to radiance, reflectance, atmospheric measurements



### Day 2

Field practicum – soccer field adjacent to UVEG, concurrent to S2A overpass, reflectance method – surface measurements & radiative transfer



### Day 3

Processing of field practicum data, sensitivity analysis, error budget, conclusions



## GSIS TC Introduction – Outreach



### Outreach (membership, industry involvement,...)

**Panel discussion 2017 during IGARSS with members of Space Agencies, Industry and Geoscience Community**

Topics:

- Technical feasibility of compact spaceborne spectrometers
- Concept of virtual constellations
- Developments of UAV and micro-satellite technology and swarm or dove concepts
- Opportunities and challenges involved in coupling these currently disparate technological developments
- Need for alternative calibration and validation concepts
- Reducing on-board complexity
- Data processing and distribution approaches

**Panelists**

- David Bannon (Headwall)
- Matthew Ferraro (Planet)
- Jurry de la Mar (T-Systems)
- Steffen Kuntz (Infoterra)
- Sean Akam (Exogenesis)
- Rob Green (NASA)



## GSIS TC Introduction – Publication



### Publication (GRS Magazine)

#### Reflectance-based, imaging spectrometer error budget field practicum at the Railroad Valley Test Site, Nevada USA

Cindy Ong, Chair, IEEE GRSS GSIS TC, Member, IEEE, Kurt Thome, Member, IEEE, Uta Heiden, Co-Chair, IEEE GRSS GSIS TC, Member, IEEE, Jeff Czapla-Meyers, Member, IEEE and Andreas Mueller, Co-Chair, IEEE GRSS GSIS TC, Member, IEEE

##### Abstract

**Index Terms**—**vicarious, radiometric calibration, error budget, uncertainty, imaging spectrometer, RadCalNet**

##### I. INTRODUCTION

Calibration is the process of quantitatively defining a system's responses to known, controlled signal inputs and validation is the process of assessing, by independent means, the quality of the data products derived from those systems outputs [1]. Similar to other Earth Observation (EO) sensors, calibration and validation of spaceborne imaging spectroscopy sensors is a fundamental underpinning activity. Calibration and validation determines the quality and integrity of the data provided by spaceborne imaging spectroscopy sensors and has enormous downstream impacts on the accuracy and reliability of products generated from these sensors.

At least five imaging spectroscopy satellites are planned to be launched within the next five years, with the two most advanced scheduled to be launched in the next two years [2]. The launch of these sensors requires the establishment of suitable, standardised and harmonised calibration and validation strategies to ensure high data quality and comparability between sensor systems. Such activities are

based imaging spectroscopy error budgets. The training encompassed the complete chain of the process from the laboratory to field measurements.

Six attendees participated in the training which included a tour of the Remote Sensing Group's laboratory facilities at the University of Arizona and a field deployment at the Railroad Valley Playa test site in Nevada, USA. The field training activity included demonstrations of measurement protocols for surface and atmospheric parameters that minimize uncertainties and collection of data as part of the reflectance-based calibration for an on-orbit sensor. An emphasis was placed on techniques and protocols suitable for calibration of imaging spectrometers.

##### II. VICARIOUS CALIBRATION

Vicarious calibration is a crucial component for EO missions, especially for those instruments with limited on-board calibration capabilities. Vicarious calibration refers to techniques that make use of natural or artificial sites on the surface of Earth for post-launch calibration of sensors. The sites used for vicarious calibration are surveyed in near-coincident fashion by the sensor to be calibrated and by one or more well-calibrated and traceable sensor(s) which collects equivalent measurements. These reference sensors are usually ground instruments but can also include spaceborne and



[www.enmap.org/science/community/](http://www.enmap.org/science/community/)

### Spaceborne Imaging Spectroscopy Mission Compilation

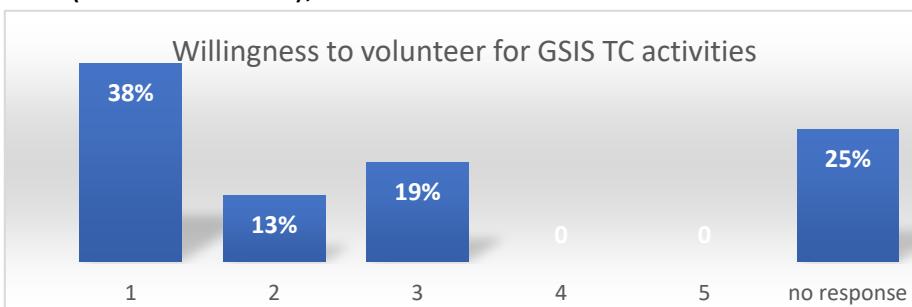
EnMAP Ground Segment Team  
GSIS GRSS Technical Committee

Status August, 2020

## GSIS TC Introduction – Survey amongst GSIS members (2020)

### Survey conclusions:

- 216 members, 16 responded to survey 7.4 %
- Increase visibility of our activities
- Workshops / Events that bring different application communities together
- Keep and foster strong links to other initiatives such as CEOS WGV IVOS, IEEE P4001 (Hypersp. Standards), IEEE P4005 (Soil Standards), etc.



### Applications Areas

- Vegetation (*Arid, Arctic*)
- Atmosphere
- soils (*composition*)
- mineralogic mapping
- Forestry (*geometric parameters (density, height, ...)*)
- environment
- exploration through cover
- mine face imaging
- forest
- space and security
- spectral modelling
- CBRNE
- TES
- thermal spectroscopy
- biodiversity
- Agro-environmental
- calibration and validation
- geology
- Urban
- pollution (*air, solid*)
- Smc
- urban area
- water and terrestrial
- astronomy

Survey results of all TCs published in „[Geoscience and Remote Sensing Magazin](#)“ of IEEE



### GSIS TC Introduction - Join and get involved

- Web:  
<http://www.grss-ieee.org/community/technical-committees/international-spaceborne-imaging-spectroscopy/>
- GSIS Email List: [gsis\\_chairs@grss-ieee.org](mailto:gsis_chairs@grss-ieee.org)
- Join the GSIS TC: [https://www.grss-ieee.org/tc\\_lists/tclist\\_signup.html?tc=GSIS](https://www.grss-ieee.org/tc_lists/tclist_signup.html?tc=GSIS)
- Contact us directly
- Come to our IGARSS sessions



## GSIS TC Introduction - Recent activities

A background image showing palm trees silhouetted against a pink and orange sunset over a body of water.

**IGARSS 2020**

**MO2.R4: International Spaceborne Imaging Spectroscopy Missions: Updates and News**  
will begin soon

Mon, 28 Sep, 14:30 - 16:30 (UTC)

Mon, 28 Sep, 22:30 - 00:30 China Standard Time (UTC +8)

Mon, 28 Sep, 16:30 - 18:30 Central Europe Summer Time (UTC +2)

Mon, 28 Sep, 07:30 - 09:30 Pacific Daylight Time (UTC -7)

**Guidelines during the session**

- The Session Chair will play a paper presentation video
- During the video, submit your questions using the Q&A feature of Zoom
- Following a presentation video, the paper presenter will answer questions

[https://igarss2020.org/view\\_session.php?SessionID=1018](https://igarss2020.org/view_session.php?SessionID=1018)

Co-Chairs: Uta Heiden (DLR)  
Cindy Ong (CSIRO)

### Missions:

- SBG / EMIT
- HISUI
- DESIS
- EnMAP
- PRISMA
- CLARREO



### GSIS TC Introduction - Recent activities

## IGARSS 2020

#### Tuesday, 29/09/2020 – [TU1.R14: Passive Optical, Hyperspectral Sensors and Calibration I](#)

- A HYPERSPECTRAL REFLECTANCE RECONSTRUCTION METHOD CONSIDERING SURFACE BRDF CHARACTERISTICS FOR AUTOMATIC MULTISPECTRAL RADIOMETERS
- IEEE P4001 HYPERSPECTRAL STANDARD IN 2019-2020: PROGRESS AND COOPERATION

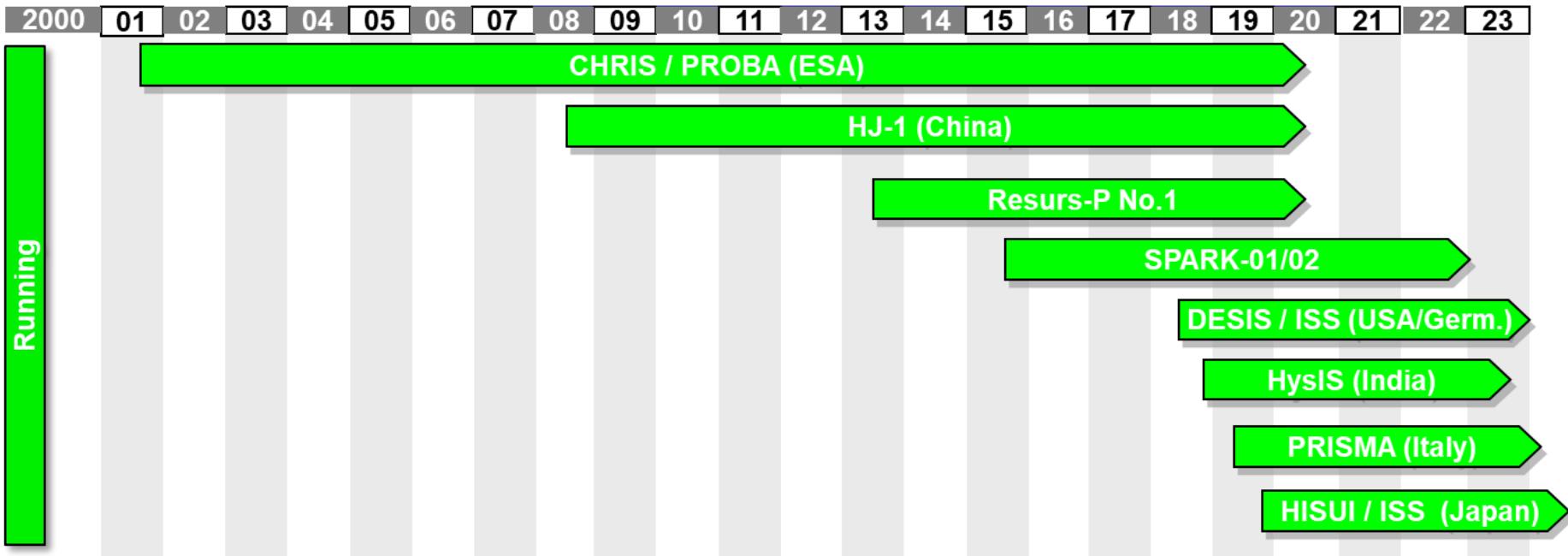
#### Wednesday, 30/09/2020 - [WE1.R15: Passive Optical, Hyperspectral Sensors and Calibration II](#)

- A CALIBRATION AND VALIDATION TOOL FOR DATA QUALITY ANALYSIS OF AIRBORNE IMAGING SPECTROSCOPY DATA
- BIDIRECTIONAL SPECTRAL REFLECTANCE FACTOR OF BAOTOU SANDY CALIBRATION SITE AND ITS APPLICATION IN VICARIOUS RADIOMETRIC CALIBRATION
- AN EARTH SCIENCE IMAGING SPECTROSCOPY MISSION: THE EARTH SURFACE MINERAL DUST SOURCE INVESTIGATION (EMIT)

#### Thursday, 01/10/2020 - [TH1.R15: Passive Optical, Hyperspectral Sensors and Calibration III](#)

- Development of a high-fidelity CLARREO pathfinder simulator
- RAILROAD VALLEY RADIOMETRIC CALIBRATION TEST SITE (RADCATS) AS PART OF A GLOBAL RADIOMETRIC CALIBRATION NETWORK (RADCALNET)
- AUSTRALIA, A HUB FOR SPACEBORNE IMAGING SPECTROSCOPY CALIBRATION AND VALIDATION

## Running spaceborne imaging spectroscopy missions *Launch and life time*



- HyperScout (Small-sat by VITO/Satellogic)
- Phase 0 study mission (NORSTAR Space Data Inc.)

## Running spaceborne imaging spectroscopy missions

### *Spatial characteristics*

**CHRIS / PROBA**

**HJ-1A**

**SPARK-01/02**

**Resurs-P 1/2/3**

**DESiS / ISS**

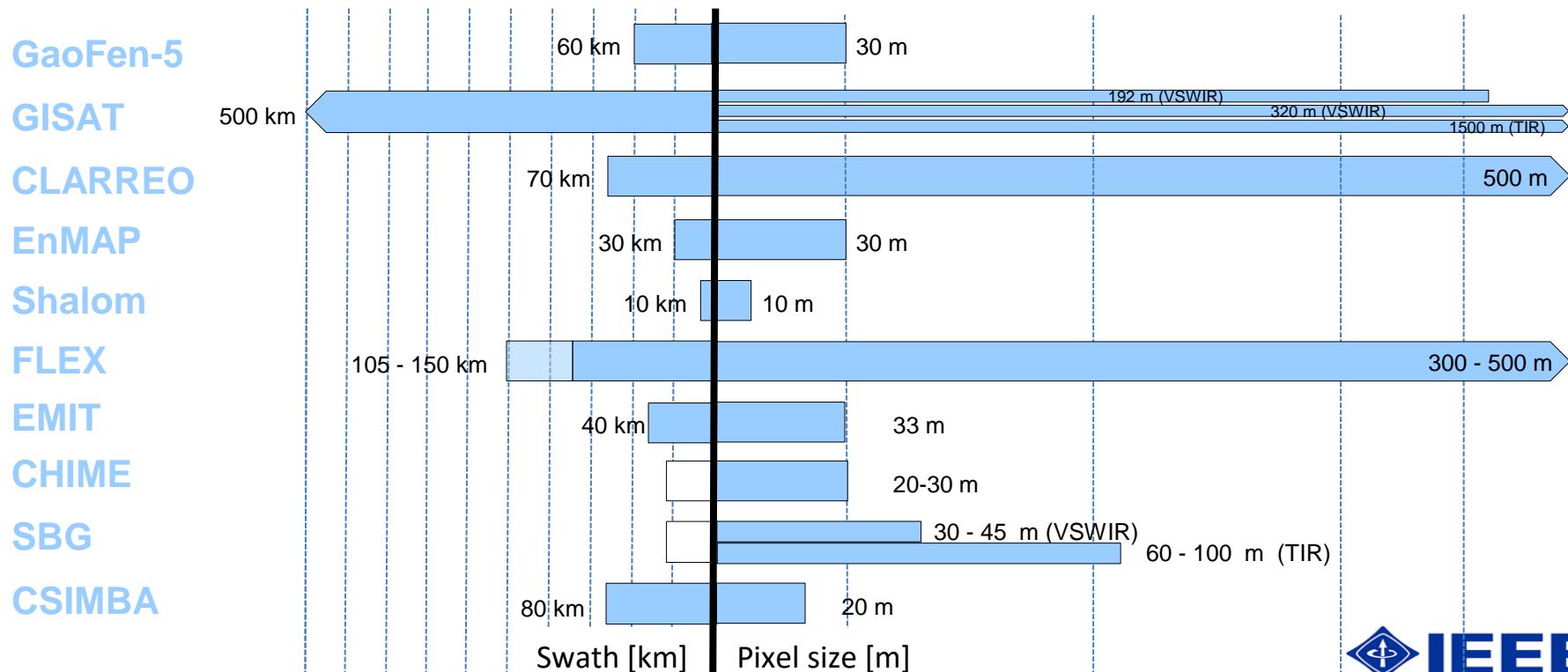
**PRISMA**

**HySIS**

**HISUI / ISS**



## Planned spaceborne imaging spectroscopy missions *Spatial characteristics*





## Running spaceborne imaging spectroscopy missions - *Data access*

### DESIS

- free and open for scientific purposes
- DESIS acquire data on user demand
- For new acquisitions, proposal submission is required ([desis-scientific@dlr.de](mailto:desis-scientific@dlr.de))
- For archived data – no proposal
- WEB:  
[https://www.dlr.de/eoc/DesktopDefault.aspx?tabid=13629/23675\\_read-54295/](https://www.dlr.de/eoc/desktopdefault.aspx/tabid-13629/23675_read-54295/)

### PRISMA

- free and open (until 12/20) mainly for scientific purposes
- National users have specific conditions (quota and priority)
- Tasking: 4 products maximum for the validity of the license (~ 1 month)
- Archive: currently 1 products per day only
- WEB: <http://prisma-i.it/index.php/en/>

### HISUI

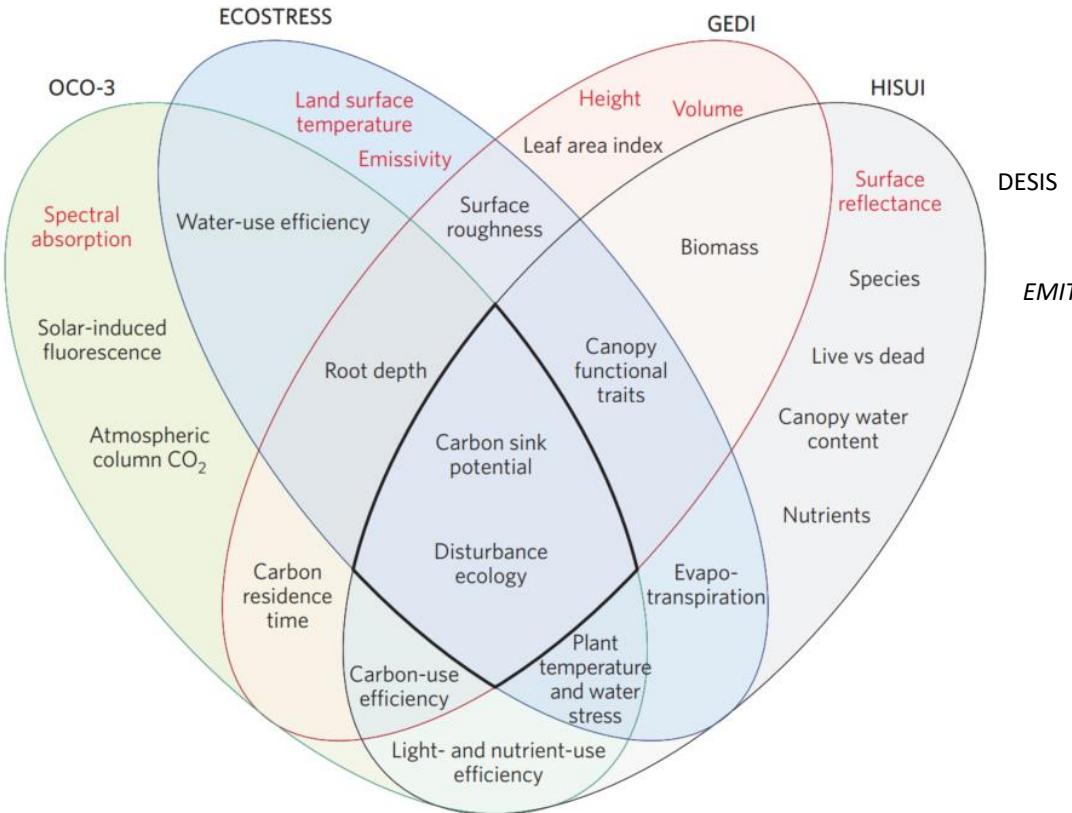
- Pre-nominal operation start in November 2020.
- HISUI data distribution to scientists worldwide under the framework of HISUI Research Announcement starts at the first half of 2021.  
Contact:  
[hisui\\_application@jspacesystems.or.jp](mailto:hisui_application@jspacesystems.or.jp)
- Data distribution to commercial users is now scheduled after April 2022.



## Instruments on ISS – Unique constellation

Mission	Objective	Sensor type	Launch date	Data policy
DESiS	Science, Precursor of EnMAP	Hyperspectral (0,4 – 1,0 µm)	July 2018	Free for science users
HISUI	Oil, gas, minerals	Hyperspectral (0,4 – 2,5 µm)	Jan 2020	Free for science users
EMIT	<i>Dust sources and emission</i>	<i>Hyperspectral (0,4 – 2,5 µm)</i>		<i>Free and open</i>
GEDI	Structural information: Carbon cycle, habitat degradation	High resolution laser	May 2019	Free and open
OCO-3	Understanding of surface CO <sub>2</sub> sources and sinks	3 high resolution grating spectrometer	Feb 2019	Free and open
ECOSTRESS	Evapotranspiration processes of vegetation	Thermal (8,3 – 12,0 µm)	July 2018	Free and open

## Instruments on ISS – Unique constellation



Modified from: E. Natasha Stavros et al., 2017. ***ISS observations offer insights*** into plant function. *Nature Ecology & Evolution*, DOI: 10.1038/s41559-017-0194

„... address ecosystem dynamics questions that cannot be answered from any one instrument and that have the ability to substantially enhance our understanding of ecosystem responses to global change. ...”



### Upcoming events – Supporting 2021 CHIME pre-launch campaign

#### CHIME: Copernicus Hyperspectral Imaging Mission for the Environment

- Provision of **routine** hyperspectral observations through the Copernicus Programme
- Supporting a range of EU- and related policies
- Enable the development of new and enhanced services for food security, agriculture and raw materials
- This includes biodiversity management, soil properties characterization, sustainable mining practices and environment preservation



#### CHIME pre-launch campaigns

- Foster strong collaboration with different communities to support mission development
- Build a sound transdisciplinary data base towards the alignment of national programmes and the input of multiple actors and stakeholders
- Ensured that the different applications are properly acknowledged by also allowing further analyses and exploitation during later mission implementation

#### Source: Mission requirement document

[http://esamultimedia.esa.int/docs/EarthObservation/Copernicus\\_CHIME\\_MRД\\_v2.1\\_Issued20190723.pdf](http://esamultimedia.esa.int/docs/EarthObservation/Copernicus_CHIME_MRД_v2.1_Issued20190723.pdf)



## Upcoming events – Supporting 2021 CHIME pre-launch campaign

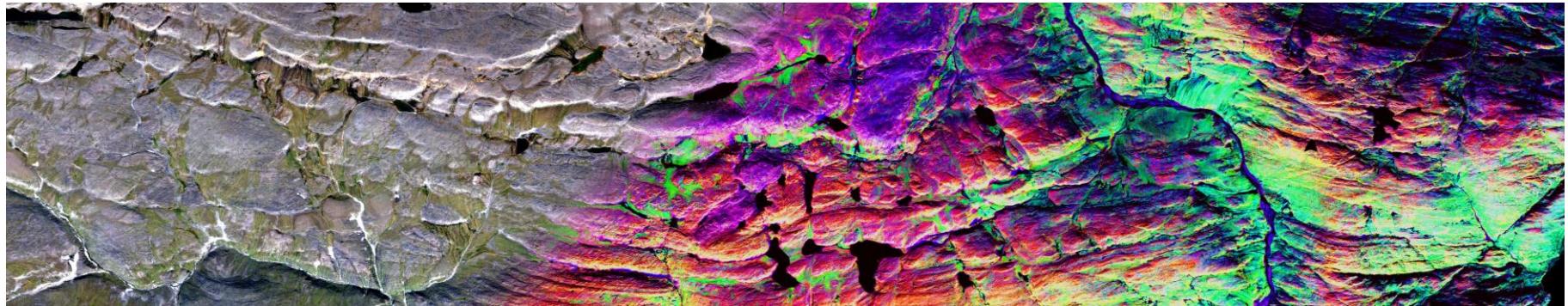
### CHIME: Prelaunch campaign 2021

- ESA plan a large scale field campaign in 2021 with NASA SBG partners
- GSIS TC has proposed to support the campaign by:
  - more participants in the campaign
  - Support the development of a unique data base comprising field, airborne (AVIRIS) and spaceborne hyperspectral data (e.g. PRISMA, DESIS)
  - Organise a workshop accompanying the campaign to discuss e.g. calibration and cross calibration of sensors, explore synergies between different application areas and to find commonalities that GSIS TC may take up as future activities



Financial support has still to be confirmed by GRSS

## GRSS Geoscience and Spaceborne Imaging Spectroscopy TC Many thanks for your attention!



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