11-16 December 2016
Qhy Nonh, Vietnam
Int. Conf.: Search for Life—From Early Earth to Exoplanets
http://rencontresduvietnam.org/conferences/2016/search-for-life/

15-19 May 2017
Lisbon, Portugal
3rd Int. Ocean Colour Science Meeting
http://iocs.ioccg.org/

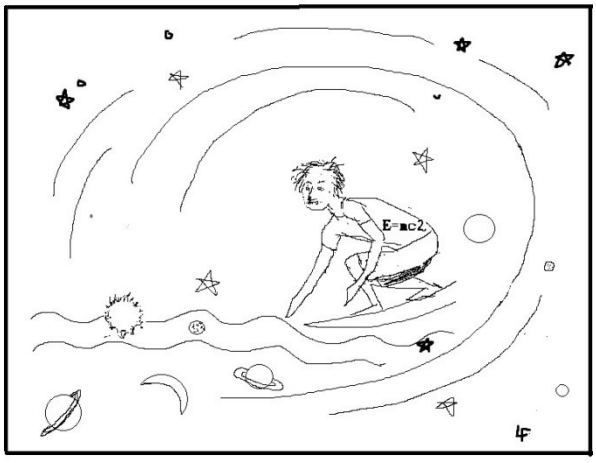
1-5 August 2017
Rio de Janeiro, Brazil
38th IUPS Congress
www.iups.org/congresses/2017-congress/

19-26 August 2017
Montreal, Canada
32nd URSI Gen. Assembly and Scientific Symposium
www.ursi.org

27 Aug.-1 Sept. 2017
Cape Town, South Africa
IAPSO - IAMAS - IAGA joint Assembly
www.iugg.org/IAGA/iaga_pages/assemblies/iaga_assemblies.htm

18-22 September 2017
Wuhan, China
ISPRS Geospatial Week 2017
www.isprs.org/

14-22 July 2018
Pasadena, CA, USA
42nd COSPAR Scientific Assembly
Contact: cospar@cosparhq.cnes.fr



Meeting Reports

COSPAR Panel on Planetary Protection Colloquium, Bern, Switzerland, September 2015

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The COSPAR Planetary Protection Policy describes requirements for different planetary protection categories depending on the type of mission, the target body and the type of scientific investigations [1].

Updating the COSPAR Planetary Protection Policy is an iterative process that involves the scientific community. This process is based on new scientific discoveries, new understanding of scientific observations, or, responds to needs identified to prepare future space missions.

In consultation with the COSPAR Scientific Commissions B (Space Studies of the Earth-Moon System, Planets, and Small Bodies of the Solar System) and F (Life Sciences as Related to Space), the COSPAR Panel on Planetary Protection organised a colloquium at the International Space Science Institute (ISSI)

in Bern, Switzerland, in September 2015, to discuss two pertinent topics:

- Icy moon sample return planetary protection requirements
- Mars Special Regions planetary protection requirements

These two topics were addressed in two separate sessions.

The recommendations described in this report are based on discussions in the course of the colloquium and reflect a consensus of the colloquium attendees that participated in one or both separate sessions. Any opinions, conclusions, or recommendations expressed in this report are those of the attendee(s) and do not necessarily reflect the views of the organisations that provided support for their participation.

1. ICY MOON SAMPLE RETURN PLANETARY PROTECTION REQUIREMENTS

Responding to the interest within the scientific community to return samples from the plumes of icy moons in general and from Enceladus in particular, the COSPAR Scientific Comm-ission B (Space Studies of the Earth-Moon System, Planets, and Small Bodies of the Solar System) identified a need to establish planetary protection requirements for such missions, which are currently not covered in the COSPAR Planetary Protection Policy.

1.1 Earth return planetary protection categorization for Enceladus

A previous COSPAR workshop on "Planetary Protection for Outer Planet Satellites and Small Bodies" [2] issued a recommendation to add Enceladus to Planetary Protection Categories III and IV. These categories cover fly-by, orbiter, and landed missions "*to a target body of chemical evolution and/or origin of life interest and for which scientific opinion provides a significant chance of contamination which could compromise future invest-igations"*. This recommendation was subsequently adopted by COSPAR and introduced in the COSPAR Planetary Protection Policy [1].

The COSPAR workshop in 2009, however, did not cover Earth return missions.

Based on the Planetary Protection Categories III and IV assignment for missions to Enceladus and the response of 'no' or 'uncertain' to all six questions described in the COSPAR Category Requirements for sample return missions from Small Solar System Bodies, it is **recommended** that Enceladus be added to the list of target bodies for a Planetary Protection Category V, restricted Earth return.

1.2 Planetary protection requirements for Europa and Enceladus

In line with the current Planetary Protection Categories III/IV for missions to Enceladus and with the recommended Earth return planetary protection categorization for Enceladus (see above), it is **recommended** that the current Planetary Protection Categories III/IV/V Requirements for Europa be extended to Enceladus.

To clarify the time period for which the probability of contamination applies, it is **recommended** that the following sentence be added:

The probability of inadvertent contamination of a Europan or Enceladan ocean of $1x10^{-4}$ applies to all mission phases including the duration that spacecraft introduced terrestrial organisms remain viable and could reach a sub-surface liquid water environment.

The current requirements for sample return from Europa have been copied from the relevant set of requirements for Mars. The requirement that is covered in the first bullet of the sample return missions from Europa requirements refers to a level of contamination not described for Europa:

"Unless specifically exempted, the outbound leg of the mission shall meet the contamination control requirements given above."

For Mars, this refers to the requirements for Planetary Protection Category IVb. The reason for having biological contamination control requirements within the framework of sample return requirements is explained in the second

part of the first bullet in the sample return missions from Europa requirements:

"This provision should avoid "false positive" indications in a life-detection and hazard-determination protocol, or in the search for life in the sample after it is returned. A "false positive" could prevent distribution of the sample from containment and could lead to unnecessarily increased rigour in the requirements for all later Europa missions."

In line with this explanation and the overall COSPAR Planetary Protection Policy statement "The conduct of scientific investigations of possible extraterrestrial life forms, precursors, and remnants must not be jeopardized", a biological contamination requirement for Europa and Enceladus in-situ life-detection and sample return missions is missing. It is **recommended** that this topic be discussed in the joint session (B.06) of Scientific Commissions B, F and the Panel on Planetary Protection during the next COSPAR Scientific Assembly in 2016 to address this issue and help develop a proposed wording to describe an adequate biological contamination requirement.

To avoid any ambiguity, it is **recommended** that plumes be considered as part of the Europa and Enceladus environments that warrant the same level of caution within the framework of sample return requirements as the surface and sub-surface.

To avoid misunderstandings and to properly reflect the Planetary Protection Category V policy statement "The Moon must be protected from back contamination to retain freedom from planetary protection requirements on Earth-Moon travel", it is **recommended** that the third bullet in the current sample return missions from Europa requirements be modified to read:

No uncontained hardware that contacts material from Europa, Enceladus or their plumes, shall be returned to the Earth's biosphere or the Moon.

In order to keep the trade-space open for different mission and trajectory options, it is **recommended** that the fourth bullet in the current sample return missions from Europa requirements be modified to read:

Reviews and approval of the continuation of the flight mission shall be required at three stages: 1) prior to launch from Earth; 2) subsequent to sample collection and prior to a manoeuvre to enter a biased Earth return trajectory and 3) prior to commitment to Earth re-entry.

1.3 Future research

It was generally recognised that evaluating the individual terms in the overall probability of contamination of a sub-surface ocean on Europa and Enceladus is challenging and would benefit from further work and guidance on the following aspects:

- Response of organisms to the conditions of impacts
- Physical exchange processes for transport from the surface to the sub-surface
- Survival of organisms during transport from the surface to the sub-surface

1.4 Conclusions on icy moon sample return planetary protection requirements

The participants of the colloquium proposed a categorisation for sample return missions from Enceladus. The associated requirements are identified in the Planetary Protection Category III/IV/V Requirements for Europa and are listed in Box 1.

The intention of these modifications is to close a gap in the current COSPAR Planetary Protection Policy and to provide a basis for technology developments and icy body sample return mission studies.

2. MARS SPECIAL REGIONS PLANETARY PROTECTION REQUIREMENTS

Mars Special Region is a term used to designate those places on Mars where the conditions might be conducive to microbial replication because Mars is cold, but not always, and very dry, but not everywhere.

The concept of Mars Special Regions was first discussed during the COSPAR Panel on

Planetary Protection Meeting in Warsaw, July 2000, and was recommended for inclusion in the COSPAR Planetary Protection Policy during the COSPAR/IAU Workshop on Planetary Protection in Williamsburg, April 2002.

To ensure that the COSPAR Planetary Protection Policy is based on current scientific knowledge the parameter definition of what constitutes a Mars Special Region as well as examples of environments on Mars that are treated as Special Regions should evolve over time as new scientific observations become available.

A first set of reviews of the Mars Special Regions concept and definition started with a NRC study in 2006 [3], followed by a NASA MEPAG study in the same year [4], and culminated in a COSPAR Panel on Planetary Protection Colloquium in 2007 [5]. Associated updates to the COSPAR Planetary Protection Requirements for Mars Special Regions were introduced and approved by COSPAR in 2008 [1].

A second set of reviews of the Mars Special Regions concept and definition was initiated with a NASA MEPAG study in 2013-14 [6], followed by a National Academies of Sciences, Engineering, and Medicine/European Science Foundation (Academies/ESF) Joint Committee study in 2014 [7]. Both reports served as input to the colloquium discussions.

2.1 Mars Special Regions parameter definitions

The current parameters defining Mars Special Regions are:

- Temperature: > -25°C
- Water activity: > 0.5
- Timescale of astronomical or geological events that could affect the environment: 500 years

Determining the lower temperature limit for the replication of terrestrial microorganisms is challenging mainly because the time required for replication increases nonlinearly with decreasing temperatures. A margin was added to the lowest published temperature in which experts had confidence that replication of terrestrial microorganisms had been observed. Based on the 2007 COSPAR Panel on Planetary Protection Colloquium [5], this margin is currently set at a conservative value of 10°C. Since the last update of the requirements for Mars Special Regions in 2007 more data have confirmed cell division at -15°C and literature not identified in the 2006-2007 review demonstrates cell division can occur down to -18°C (references in [6]).

It is **recommended** that a margin of 10°C on the threshold for the low-temperature limit that constitutes a Mars Special Region be maintained. As a consequence, it is **recommended** that the new low-temperature limit for parameters that defines Mars Special Regions be set to -28°C.

As more experiments are published and knowledge and confidence improves, the margin of 10°C may be relaxed in the future, if deemed appropriate by expert review.

In line with the MEPAG-SR-SAG2 report and the Academies/ESF Joint Committee report, it is **recommended** that the current lower limit for water activity of 0.5 be maintained.

In line with the MEPAG-SR-SAG2 report and the Academies/ESF Joint Committee report, it is **recommended** that the current long-term time limit for changes in the environmental conditions of 500 years be maintained.

2.2 Features that must be treated as Special Region

No Special Regions have been directly detected on Mars. However, current features that suggest the existence of environmental conditions that would qualify them as Special Regions, and that therefore must be treated as Mars Special Regions are:

- Gullies, and bright streaks associated with gullies
- Pasted-on terrain
- Subsurface below 5 m
- Others TBD (including dark streaks, possible geothermal sites, fresh craters with hydrothermal activity, modern

outflow channels, or sites of recent seismic activity)

Since the last 2006-2007 review, the understanding of gullies has evolved and discoveries of new features such as Recurrent Slope Lineae (RSL) [8] and near-surface atmospheric methane [9] have been made.

In line with the MEPAG-SR-SAG2 report and the Academies/ESF Joint Committee report, it is **recommended** that gullies of taxon 2 through 4 be treated as Special Regions until proven otherwise. The definition of the various taxons is based on the MEPAG-SR-SAG2 report [6].

In line with the MEPAG-SR-SAG2 report and the Academies/ESF Joint Committee report, it is **recommended** that confirmed and partially confirmed Recurrent Slope Lineae (RSL) be treated as Special Regions until demonstrated otherwise.

Due to an artificial observational bias it is **recommended** that candidate Recurrent Slope Lineae (RSL) be evaluated on a case-by-case basis.

It is **recommended** that the following definition of observational evidence for Recurrent Slope Lineae (RSL), adapted from [10], be used:

- Confirmed: observed simultaneous incremental growth of flows on a warm slope, fading, and recurrence of this sequence in multiple Mars years
- Partially confirmed: observed either incremental growth or recurrence
- Candidate: slope lineae that resemble RSL but observations needed for partial confirmation are lacking

In line with the MEPAG –SR-SAG2 report and the Academies/ESF Joint Committee report, it is **recommended** that caves and subsurface cavities be treated as Special Regions until demonstrated otherwise.

The colloquium participants agreed that it is appropriate that special consideration be given to the presence of methane, recently detected near the surface of Mars [9]. Methane is considered to be an organic compound of special interest. The lack of knowledge about the source(s) and sink(s) of methane requires that its sources, if identified, be evaluated to determine whether they should be designated as non-special, uncertain, or special regions.

In line with the Academies/ESF Joint Committee report, it is **recommended** that localized "sources of methane" be added to the list of sites that must be treated as Special Regions until demonstrated otherwise.

The MEPAG-SR-SAG2 report classified dark slope streaks as non-special (Table 11 in the MEPAG report, supported by finding 4-8 in the same report) [6]. The Academies/ESF Joint Committee report describes recent publications suggesting that not all dark slope streaks can be explained by dry granular flow, and therefore aqueous processes cannot be definitely excluded for all dark slope streaks [7]. As a consequence, the Academies/ESF Joint Committee advised, and the colloquium attendees have **recommended** that dark slope streaks be evaluated on a case-by-case basis.

2.3 Maps, landing and operational sites

The concern of the Academies/ESF Joint Committee with respect to the use of large-scale maps is supported by the participants of the colloquium. It is **recommended** that maps be dated and only used to illustrate the general concept of Special Regions but not be used to delineate their exact location because many relevant features and processes are likely to be sub-grid scale for such maps.

Until now it has been common understanding and practice that the temperature and water activity thresholds have to be exceeded at the same time for a location to qualify as Mars Special Region.

The MEPAG-SR-SAG2 has critically reviewed the timing of available liquid water and sufficiently high temperatures needed to allow replication and identified this as one of the knowledge gaps [6]. Taking into account the precautionary approach for planetary protection, the colloquium attendees expressed their concern about this aspect, mainly due to the lack of experimental data, the limited understanding of microenvironments and

disequilibrium conditions, and known abiotic and biotic processes to capture and retain liquid water.

In line with the Academies/ESF Joint Committee report and taking into account the critical review of the MEPAG-SR-SAG2 report regarding the timing of available water and sufficiently high temperatures, it is **recommended** that the following requirement to the current requirements for Mars Special Regions be added:

Planned 3-sigma pre-launch landing ellipses must be evaluated on a case-by-case basis as part of the (landing) site selection process, to determine whether the mission would land or come within contamination range of areas or volumes meeting the parameter definition for Mars Special Regions or would impinge on already described features that must be treated as Mars Special Regions. The evaluation must be based on the latest scientific evidence and in particular include an assessment of the extent to which the temperature and water activity values specified for Mars Special Regions are separated in time. The evaluation must be updated during the mission whenever new evidence indicates that the landing ellipse and/or the operational environment contain or are in contamination range to areas or volumes meeting the parameter definition for Mars Special Regions or already described features that must be treated as Mars Special Regions.

2.4 Planetary protection and human missions to Mars

The current COSPAR Planetary Protection Policy contains principles and guidelines for human missions to Mars.

In line with the concerns raised in the Academies/ESF Joint Committee to avoid misunderstandings and to ensure that the primary COSPAR Planetary Protection Policy statement is properly reflected in the current guidelines and future requirements, it is **recommended** that the clarification of the principles be extended to read:

The intent of this planetary protection policy is the same whether a mission to Mars is conducted robotically or with human explorers. Accordingly, the stated COSPAR Planetary Protection Policy must not be compromised to accommodate a human mission to Mars.

In addition, it is **recommended** that the following implementation guideline be deleted:

"Neither robotic systems nor human activities should contaminate "Special Regions" on Mars, as defined by this COSPAR policy."

And replaced with the following statement:

Requirements for human activities must be imposed to control the contamination of Mars in general and of Mars Special Regions, specifically, in line with the COSPAR Planetary Protection Policy.

2.5 Future research

The MEPAG-SR-SAG2 and Academies/ESF Joint Committee reports have identified a large number of research activities to reduce uncertainties and excessive conservatism in the requirements.

Based on this array of research activities it would be beneficial to investigate the following issues through laboratory experiments on Earth, modelling, and observations from Mars orbit and on the surface of Mars, with the highest priority:

- Replication of terrestrial microorganisms in the absence of liquid water (e.g., using atmospheric water vapour only)
- The capability of terrestrial microorganisms to replicate if liquid water and sufficiently high temperatures do not occur simultaneously
- Water activity in pore spaces, particularly in the presence of fluid-gas interfaces
- Methane production and localization
- Translocation of viable biological contamination on Mars

Conclusions for Mars Special Regions planetary protection requirements

The colloquium participants recommend a number of updates to the current COSPAR Planetary Protection Requirements for Mars

Special Regions (see Box 2). Most of these recommended updates are based on the MEPAG-SR-SAG2 report [6]and the Academies/ESF Joint Committee report [7] discussed during the colloquium.

A few clarifications are also recommended for the current COSPAR Planetary Protection Principles and Guidelines for Human Missions to Mars. One additional aspect identified by the MEPAG-SR-SAG2 study and endorsed by the colloquium participants is that the spread of terrestrial biological contamination on Mars is not only a concern for scientific investigations but could also impact life-support systems and the availability of Martian resources to human explorers as well. Therefore, planetary protection requirements are an integral element of sustainable human Mars exploration.

3. CLOSING STATEMENT OF THE COLLOQUIUM

This report will be presented and discussed at the COSPAR Panel on Planetary Protection during the 41st COSPAR Scientific Assembly in Turkey, Istanbul.

The publication of this colloquium report in the current issues of COSPAR's Information Bulletin is providing an opportunity for the interested members of the wider scientific community to become familiar with the proposed updates and to better contribute to the discussions during the Assembly.

Updates to the current COSPAR Planetary Protection Policy will be prepared by the COSPAR Panel on Planetary Protection, taking into account the colloquium report and the discussions during the Assembly, and submitted to the COSPAR Bureau with a request for adoption.

The organizers of the colloquium would like to thank the staff of ISSI for their excellent support in preparing and conducting this meeting.

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Box 1: Recommended update of the requirements for Europa

(Proposed changes in bold)

CATEGORY III/IV/V REQUIREMENTS FOR EUROPA **AND ENCELADUS**

Missions to Europa **and Enceladus**

Category III and IV. Requirements for Europa **and Enceladus** flybys, orbiters and landers, including bioburden reduction, shall be applied in order to reduce the probability of inadvertent contamination of a **E**uropan **or Enceladan** ocean to less than 1 x 10^{-4} per mission. **The probability of inadvertent contamination of a Europan or Enceladan ocean of 1x10^{-4} applies to all mission phases including the duration that spacecraft introduced terrestrial organisms remain viable and could reach a sub-surface liquid water environment.** These requirements will be refined in future years, but the calculation of this probability should include a conservative estimate of poorly known parameters, and address the following factors, at a minimum:

- Bioburden at launch
- Cruise survival for contaminating organisms
- Organism survival in the radiation environment adjacent to Europa **or Enceladus**
- Probability of landing on Europa **or Enceladus**
- The mechanisms and timescales of transport to **a E**uropan **or Enceladian** subsurface **liquid water environment**
- Organism survival and proliferation before, during, and after subsurface transfer

Preliminary calculations of the probability of contamination suggest that bioburden reduction

will likely be necessary even for Europa **and Enceladus** orbiters (Category III) as well as for landers, requiring the use of cleanroom technology and the cleanliness of all parts before assembly, and the monitoring of spacecraft assembly facilities to understand the bioburden and its microbial diversity, including specific problematic species. Specific methods should be developed to eradicate problematic species. Methods of bioburden reduction should reflect the type of environments found on Europa **or Enceladus**, focusing on Earth extremophiles most likely to survive on Europa **or Enceladus**, such as cold and radiation tolerant organisms (SSB 2000).

Sample Return Missions from Europa **and Enceladus**

Category V. The Earth return mission is classified, “Restricted Earth return.”

- Unless specifically exempted, the outbound leg of the mission shall meet the contamination control requirements given above. This provision should avoid “false positive” indications in a life-detection and hazard-determination protocol, or in the search for life in the sample after it is returned. A “false positive” could prevent distribution of the sample from containment and could lead to unnecessary increased rigor in the requirements for all later Europa **or Enceladus** missions.
- Unless the samples to be returned from Europa **or Enceladus** are subjected to an accepted and approved sterilization process, the canister(s) holding the samples returned from Europa **or Enceladus** shall be closed, with an

appropriate verification process, and the samples shall remain contained during all mission phases through transport to a receiving facility where it (they) can be opened under containment.

- The mission and the spacecraft design must provide a method to "break the chain of contact" with Europa or Enceladus. No uncontained hardware that contacts material from Europa, Enceladus or their plumes, shall be returned to the Earth's biosphere or the Moon. Isolation of such hardware from the Europan or Enceladan environment shall be provided during sample container loading into the containment system, launch from Europa or Enceladus, and any inflight transfer operations required by the mission.
- Reviews and approval of the continuation of the flight mission shall be required at three stages: prior to launch from Earth; 2) **subsequent to sample collection and** prior **to a manoeuvre to enter a biased Earth return trajectory**; and 3) prior to commitment to Earth re-entry.
- For unsterilized samples returned to Earth, a programme of life detection and biohazard testing, or a proven sterilization process, shall be undertaken as an absolute precondition for the controlled distribution of any portion of the sample (SSB 1998).

Box 2: Recommended update of the requirements and definition for Mars Special Regions

(Proposed changes in bold)

Category IVc. For missions which investigate Martian special regions (see definition below), even if they do not include life detection experiments, all of the requirements of Category IVa apply, along with the following requirement:

- Case 1. If the landing site is within the special region, the entire landed system is restricted to a surface bioburden level of ≤ 30* spores.
- Case 2. If the special region is accessed through horizontal or vertical mobility, either the entire landed system is restricted to a surface bioburden level of ≤ 30* spores, OR the subsystems which directly contact the special region shall be sterilized to these levels, and a method of preventing their recontamination prior to accessing the special region shall be provided.

If an off-nominal condition (such as a hard landing) would cause a high probability of inadvertent biological contamination of the special region by the spacecraft, the entire landed system must be sterilized to a surface bioburden level of ≤ 30* spores and a total (surface, mated, and encapsulated) bioburden level of $\leq 30 + (2 \times 10^5)$* spores.

Planned 3-sigma pre-launch landing ellipses must be evaluated on a case-by-case basis as part of the (landing) site selection process, to determine whether the mission would land or come within contamination range of areas or volumes meeting the parameter definition for Mars Special Regions or would impinge on already described features that must be treated as Mars Special Regions. The evaluation must be based on the latest scientific evidence and in particular include an assessment of the extent to which the temperature and water activity values specified for Mars Special Regions are separated in time. The evaluation must be updated during the mission whenever new evidence indicates that the landing ellipse and/or the operational environment contain or are in contamination range to areas or volumes meeting the parameter definition for Mars Special Regions or already described features that must be treated as Mars Special Regions.

Definition of 'Special Region'

A Special Region is defined as a region within which terrestrial organisms are likely to replicate. Any region which is interpreted to have a high potential for the existence of extant Martian life forms is also defined as a Special Region.

Given current understanding of terrestrial organisms, Special Regions are defined as areas or volumes within which sufficient water activity AND sufficiently warm temperatures to permit replication of Earth organisms may exist. The physical parameters delineating applicable water activity and temperature thresholds are given below:

- Lower limit for water activity: 0.5; Upper limit: 1.0
- Lower limit for temperature: -28C; No Upper limit defined
- Timescale within which limits can be identified: 500 years

Observed features that must be treated as Special Regions until demonstrated otherwise:

- Gullies **(taxon 2-4)**[†], and bright streaks associated with gullies
- Subsurface cavities
- Subsurface below 5 meters
- Confirmed and partially confirmed Recurrent Slope Lineae (RSL)[‡]

Features, if found, that must be treated as Special Region until **demonstrated** otherwise:

- Groundwater
- Source of methane
- Geothermal activity
- Modern outflow channel

Observed features that require a case-by-case evaluation:

- Dark streaks
- Pasted-on terrain
- Candidate RSL[‡]

Spacecraft-induced special regions are to be evaluated, consistent with these limits and features, on a case-by-case basis.

In the absence of specific information, no Special Regions are currently identified on the basis of possible Martian life forms. If and when information becomes available on this subject, Special Regions will be further defined on that basis (Kminek et al., 2008)

*This figure takes into account the occurrence of hardy organisms with respect to the sterilization modality. This specification assumes attainment of Category IVa surface cleanliness, followed by at least a four order-of-magnitude reduction in viable organisms. Verification of bioburden level is based on pre-sterilization bioburden assessment and knowledge of reduction factor of the sterilization modality.

[†]Description for Gully taxon ref. [6]

[‡]Observational evidence for Recurrent Slope Lineae (RSL), adapted from [11]:

- Confirmed: observed simultaneous incremental growth of flows on a warm slope, fading, and recurrence of this sequence in multiple Mars years
- Partially confirmed: observed either incremental growth or recurrence
- Candidate: slope lineae that resemble RSL but observations needed for partial confirmation are lacking.

[NOTE FROM THE EDITOR: As mentioned above the content of this report does not necessarily reflect the official opinion of COSPAR. Responsibility for the information and views expressed lies entirely with the author(s). Any recommendations or proposed changes in COSPAR policy mentioned therein must be duly processed by the relevant Scientific Commissions and the COSPAR Bureau.]

"Earth Observation of Trans-boundary Water Resources," COSPAR Capacity Building Workshop, 26 October-6 November 2015, Ho Chi Minh City, Vietnam

[Report by Bob Su (ITC, University of Twente), Vu Hien Phan (Ho Chi Minh City University of Technology)]

The COSPAR Capability Building Workshop on Earth Observation of Transboundary Water Resources took place at Ho Chi Minh City University of Technology (HCMUT), Ho Chi Minh City, Vietnam, from 26 October to 6 November 2015. The workshop was co-

organised by Ho Chi Minh City University of Technology (HCMUT) and the Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, the Netherlands. Funding was provided by COSPAR, ESA, and the University of Twente. HCMUT provided the lecture room, and computing facilities for participants.

The rationale of the workshop was that transboundary water resources pose huge challenges for monitoring, assessment, planning, and management because of the difficulty in collecting all needed data by traditional means and the different national and regional interests that need to be served. Often there is no agreement on how much water resource is available in a river basin and how it changes in space and time. Climate change and direct human intervention (e.g. via hydraulic-infrastructures and land-use changes) have exacerbated these challenges further. Recent advances in Earth Observation (EO) however have opened many new opportunities for quantifying and analysing the terrestrial water cycle, including precipitation, evapotranspiration, soil moisture, water level of reservoirs and lakes, snow and glaciers, as well as storage changes in time and space.

Because EO data are available from local to regional and global scale, use can be made to assist transboundary water resources management, in combination with in-situ observation data and modelling and data assimilation. As such the availabilities, changes and extremes in trans-boundary water resources can be transparently assessed for different regions and countries.

Satellite EO data from the European Space Agency (ESA) and the National Aeronautic and Space Administration (NASA) as well as from other national and regional space agencies provide indispensable resources for assessing the water resources variability. The challenges to users are how to translate the satellite data into water cycle and water resources information.

The aim of this workshop was to provide training for young researchers from South East Asia to develop skills in the access, processing, analysis and use of satellite EO and in-situ data as well as state-of-the-art model outputs for transboundary water resources applications. More specifically we aimed to provide hands-on guidance for the participants to be able to apply datasets and model outputs for their own specific regional applications. Focus was given to the applications of satellite data from ESA and NASA, including ESA's Climate Change Initiative (CCI) data. The workshop consisted of keynote lectures in the morning and practical hands-on sessions in the afternoon.

COSPAR Capacity Building Workshop in Ho Chi Minh city, Vietnam, group photo

Data and model outputs were provided by the organisers with a focus on open-access data so that the participants can continue to build on what they have learned during the workshop. The course built upon recent advanced trainings in the ESA Dragon programme and the research programme and MSc curricula of ITC, University of Twente. The following specific objectives were achieved:

- Provide theory and insights in the available EO and model data to study the terrestrial water cycle. Focus was on precipitation, evapo-transpiration, soil moisture, and changes in storages.
- Provide guide in downloading, processing and analysing the suite of EO-data available over transboundary river basins in SE Asia.
- Provide case studies in monitoring and evaluating water availability, extremes (floods and droughts) and water use relevant to water resources management and food security.

Data and Processing Software

Used satellite data included those from research and operational satellites and sensors, including MODIS, GRACE, GPM/TRMM, SMAP, ERS, ENVISAT, SMOS, Sentinels, as well as other publically accessible sources.

Data from global reanalysis including those from ERA-Interim and GLDAS as well as in-situ data from other publically available sources were also used.

The operating system was Windows. The software used was open source and has been used annually at the ESA Dragon training courses. The software included ILWIS (ITC), BEAM (ESA) as well as others identified by the lecturers.

The organisers have proposed to establish a network of participants for providing technical advice after they have returned home after the workshop through the ITC alumni networks and the ITC water and climate group (facebook) and have encouraged the participants to set up collaborative research projects with the organisers and with each other, which had proven a successful strategy in the ESA TIGER and the ESA Dragon programme, in which ITC of the University of Twente has been responsible for advanced training courses.

Participants

The participants were mainly junior researchers and staff members from universities and governmental organisations involved in areas of hydrometeorology, water resources and earth observation. 46 candidates from South-East Asian countries were selected among more than 100 applicants. But four selected candidates could not participate in the workshop due to logistical problems.

Organising Committee

The science organising committee consisted of Dr. Pierre-Philippe Mathieu (ESA, COSPAR PCB), Prof. Ernesto Lopez Baeza (COSPAR PCB), Prof. Z. Bob Su (University of Twente, ITC), and Dr. Vu Hien Phan (HCMUT, Faculty of Civil Engineering). The local organising committee consisted of Dr. Tam Minh Nguyen (HCMUT, Faculty of Civil Engineering), Assoc. Prof. Dr. Duc Trong Tran (HCMUT, Faculty of Civil Engineering), and Dr. Vu Hien Phan (HCMUT, Faculty of Civil Engineering).

Lecturers and Supporting Staff

The supporting staff included: ME. Viet Tuan Duong, ME. Ngan Truong Nguyen, Mrs. Nga Kim Nguyen of the Department of Geomatics Engineering, HCMUT and Mrs. Anke de Koning of the Department of Water Resources, ITC, University of Twente.

The lecturers were: Assoc. Prof. Dr. Wataru Takeuchi (University of Tokyo), Dr. Quan Nguyen- Hong (Institute for Environment and Resources, Ho Chi Minh City), Dr. Nguyen Lam-Dao (Vietnam Southern Satellite Technology Application Center), Dr. Vu Phan-Hien (Ho Chi Minh City University of Technology), Professor Bob Su (University of Twente), Professor Thuy Le-Toan (Centre d'Etudes Spatiales de la Biosphère), Dr. Jean-Louis Fellous (COSPAR), and MSc. Lichun Wang (University of Twente).

Workshop Outcome and Evaluation

A team of international and national experts provided teaching and practicals. The state of art science and techniques in Earth Observation of Transboundary Water Resources was offered.

1. **Anticipated outcomes (deliverables)** were that participants should have gained knowledge and skills in EO data access, processing and analysis for transboundary water resources monitoring. Participants received workshop materials (on USB sticks) and related software as open source codes for adaptation to their specific applications.
2. **The format of the workshop** was a two-week workshop with lectures given by international and local experts with hands-on practical sessions. The workshop focused on the assessment and monitoring of precipitation, evapotranspiration, soil moisture, and derived runoff and storage variables. Lectures were combined with hands-on practicals of regional case studies. A computer lab was available with freely available software for visualization and processing. Participants' own laptops were also used to facilitate, identify and utilize observational data and model/assimilation products as well as to adapt to particular applications after the workshop.
3. **Participants** were asked to form working groups choosing a topic of interest and worked together during the workshop. Seven groups were formed and excellent research-grade presentations were given before the closing of the workshop.

An online evaluation was conducted before the final group work presentation. Very positive responses were received from participants and suggestions made for organising future workshops. More information about the workshop can be found at this website: http://cospar2015.hcmut.edu.vn/destination.html.

Report on the COSPAR Capacity Building Workshop, "Planetary Missions Data Analysis", Guaratinguetá, São Paulo, Brazil, 26 October-6 November 2015

[Report by Silvia Maria Giuliatti Winter, UNESP, Brazil]

The workshop took place in the Universidade Estadual Paulista (UNESP) from 26 October to 6 November 2015. Primarily organized by COSPAR, it received support from UNESP and some international organizations such as the space agencies ESA and JAXA, and the International Astronomical Union (IAU).

Since 2001 COSPAR has been organizing Capacity Building Workshops to promote the use of data from space missions among scientists and students, mainly in developing countries. Nowadays there are several data bases available of free access with data from several space missions that have not been widely used, mainly because of lack of knowledge of the existence of the facilities and how to use them.

Due to the increasing number of scientists working on planetary sciences in Latin American countries this Workshop was devoted to the use of planetary missions databases. The purpose was to increase the use of data obtained from the planetary space missions and promote collaboration among scientists. There is a large amount of data obtained from space missions, some of them with free access.

This Workshop was intended to provide enough information to the participants in order to enable them to use the available tools to analyse the data. The Workshop was divided into Introductory and Planetary Missions data base lectures, and the development of a research project using the data. There were some introductory lectures about present knowledge of the solar system and its formation and the space missions. The participants worked with computers with Internet access in order to download and work with the data.

Participants

This Workshop was oriented to participants from Latin American countries (Brazil, Argentina, Uruguay, Colombia, Peru, Paraguay, Chile, Mexico, etc) interested in planetary sciences. The level of the participants was MSc and PhD students, post-docs and also young professionals. The following criteria were adopted in order to select the participants: i) background in the area; ii) experience in data reduction techniques, and iii) possibility to continue the research in their home institutes.

A total of 33 applicants were selected out of a 43 candidates. The selected participants were from Latin American countries (11 from Argentina, 17 from Brazil, 1 from Chile, 1 from Mexico and 3 from Uruguay). Some undergraduate students were also selected since they were working in planetary sciences.

Lecturers

The introductory lectures were given by Dr. Gonzalo Tancredi (Facultad Ciencias, Uruguay), Dr. Tabaré Gallardo (Facultad Ciencias, Uruguay) and Dr. Rodney Gomes (Observatório Nacional, Brazil). The planetary missions data base lectures were given by Dr. Makoto Yoshikawa (JAXA), Dr. Radwan Tajeddine *(*Cornell University*,* USA*),* Dr Bernhard Geiger (ESA/ESAC, Spain) and Dr. Alejandro Cardesín Moinelo (ESA/ESAC, Spain*)*. The following missions data were analysed: Cassini Mission, Hayabusa, Rosetta and Venus Express.

The second week of the Workshop was dedicated to the preparation and presentation of the projects.

Projects

The lecturers presented several projects and the participants could choose which one they would like to develop. There were 13 groups working in the following projects: a) Astrometry of Daphnis, based on Cassini's ISS images, b) Classification of gravity waves in VIRTIS data, c) Characterization of dust grains around comet 67P as seen in Rosetta navigation camera images, d) What about Enceladus' plumes? Analysis of images from Cassini ISS, e) Surface thermal emission in Venus, f) Propellers morphology, g) Correlation between gravitational potential and roughness of Itokawa, h) Venus, revealing hell, i) Near-IR oxygen nightglow and altitude-intensity profile for Venus, j) Analysis of the Venus' southern pole vortex, k) Reconstruct the light curve of Itokawas by using the Hayabusa AMICA, l) Comparison of Rosetta navigation camera and OSIRIS images taken at comet approach in August 2014 and m) Calculate the orbital evolution of ejecta and debris caused by the impactor. On the last day the participants presented their projects and some results.

Results

At the end of the workshop each group gave a short presentation of 15-20 minutes (plus 5 minutes for discussion) summarizing their results. For some students was the first time they gave a talk in English. Most of the results were good, and it seemed that all the participants understood the methodologies developed in the project. Most of them were able to continue the project in their home university/institute.

Venue

The Workshop took place in the Universidade Estadual Paulista-UNESP in Guaratinguetá, in the campus of the Faculty of Engineering. The host department was the mathematics department, which recently moved to a new building. In fact, the Workshop was the first event, inaugurating the facilities of this new building. The lectures were presented in the auditorium and the practical activities took place in the laboratory, both located on the same floor. The auditorium and the laboratory had enough space to comfortably accommodate the participants and lecturers. The lecturers also had their own room in the department.

The campus is connected to the RNP ("Rede Nacional de Pesquisa" – National Research Network) which provided a fast and reliable link. There was full Internet coverage via Wi-Fi within the building. Most of the participants brought their own computers, and the

organization also provided a number of desktops to be used in the laboratory during the developing of the projects. Dr. Rafael Sfair was the software advisor and was present, helping the participants, during the two weeks.

Participants, lecturers and some organisers of the Workshop during a coffee break

In the first week of the event we had a special dinner with all the lecturers in a different restaurant, and in the second week the lecturers, local and non-local participants went to a restaurant for a celebration, tasting local food and enjoying local music for an enjoyable night.

The Excursion

On Sunday the group went to the National Park of Itatiaia, a beautiful region with lakes, rivers and waterfalls. It was a great opportunity to see a wide variety of different species of birds. The group also stopped in Penedo for lunch and a walk around. Penedo is a town founded by Finnish settlers in Brazil with approximately 5,000 inhabitants.

General Evaluation

From the opinion of most of the participants the Workshop was a success. Despite the hotel not being close to the university, the bus took less than 20 minutes to bring participants and lecturers to the university. Guaratinguetá is a small town, which was good for the Workshop, surrounded by pleasant sites.

The lecturers were excellent professionals and helped the participants all the time. The Workshop had full support from the Faculty, which made the event possible. The Local Organizing Committee, the Scientific Organizing Committee, and UNESP, COSPAR, IAU, ESA and JAXA were responsible for the success of this event.

Report on the COSPAR Capacity Building Workshop "Improved Accuracy in the Equatorial Region and Progress toward a Real-Time IRI Model", 2-13 November 2015, Bangkok, Thailand

[Report by Assoc. Prof. Pornchai Supnithi (King Mongkut's Institute of Technology Ladkrabang, Thailand) and Prof. Dieter Bilitza, (George Mason University, USA)]

Training Week, 2-6 November 2015

Ten lecturers and 33 trainees participated in the five-day training session that took place in the computer lab #109 of the Engineering

Instructional Building, Faculty of Engineering, KMITL. The trainees were competitively selected from 114 applicants and represented 11 mostly Southeast-Asian countries including Thailand, Malaysia, Singapore, Philippines, Indonesia, Vietnam, India, South-Korea, Taiwan, China, and USA. On each training day, lectures were given in the morning, while the afternoons were devoted to the practical part and the time for Team Projects. On 2 November we welcomed Assoc. Prof. Komsan Maleesee, the Dean of Faculty of Engineering, who presided over the opening session and welcomed the participants. In addition, Prof. Mariano Mendez welcomed the participants and introduced the COSPAR activities and opportunities for fellowships. Prof. Dieter Bilitza gave a welcome message as well on behalf of the COSPAR/URSI International Reference Ionosphere (IRI) project.

The lecture topics during the training week were: Ionosphere—An introduction; IRI-Introduction and open problems; comparison of IRI with ionosonde data from the Asian sector, IRI web and related online services; ionosonde measurements; Real-Time IRI; ionosondes in the Asian Sector; ionosonde data online; GIRO and SPIDR; GNSS data and ionospheric studies; irregularities at equatorial latitudes; TEC comparisons with IRI in the Asian sector; access to GNSS data; coupling between ionosphere and thermosphere at low latitudes; ion densities and plasma temperatures; solar irradiance and upper atmospheric chemistry; incoherent scatter radar; and ionospheric storms.

On the first training day the trainees were divided into eight teams and the eight science problems were distributed to the teams via lottery. A lecturer was assigned to each problem to work as adviser with the specific team. Below are the topics/problems assigned to each team.

List of Problems

Problem 1: Compare the annual and semi-annual variation of foF2 in the two hemispheres. What are the differences? What could be possible causes? What does IRI predict?

Problem 2: Compare the annual and semi-annual variation of foF2 in the two hemispheres. What are the differences? What could be possible causes? What does IRI predict?

Problem 3: Investigate storm effects on foF2, hmF2, and TEC at a location in the Northern hemisphere. What are the differences? What is the storm effect on the slap thickness? Compare with IRI and IRI-Real-Time predictions. Use the Halloween storm (28 October – 1 November 2003) or select your own storm event.

Problem 4: Investigate storm effects on foF2, hmF2, and TEC at a location in the Southern hemisphere. What are the differences? What is the storm effect on the slap thickness? Compare with IRI and IRI-Real-Time predictions. Use the Halloween storm (28 October – 1 November 2003) or select your own storm event.

Problem 5: Different profile functions have been proposed for the representation of the topside electron density profile. Which ones are used in IRI and other models? Which give the best results? With each profile type a different scale height is defined how do they compare to the theoretically expected scale height?

Problem 6: How well is the Equatorial Ionization Anomaly (EIA) represented in IRI? Use the EIA parameter model developed by Xiong et al. (2013) based on CHAMP and GRACE data. Compare with EIA parameters determined from IRI. Suggest ways to improve IRI.

Problem 7: An East-West Coast difference has been reported over the continental US. Investigate analogous effects in the South-Asian sector. What are the causes for these differences? Are these differences reproduced by IRI?

Problem 8: E-region physics. Investigate improvements of the representation of foE and hmE for use in IRI. IRI currently depends on the 12-month running mean of sunspot number. Find out if a daily or monthly index can be used. Do you see a dependence on magnetic activity?

Lecturers: Profs. Bodo Reinisch and Ivan Galkin (University of Massachusetts, USA), Prof. Dieter Bilitza (George Mason University, USA), Assoc. Prof. Pornchai Supnithi (KMITL), Asst. Prof. Prasert Kenpankho (KMITL), Prof. Andrzej Krankowski (University of Warmia and Mazury, Poland), Prof. Shigeto Watanabe (University of Hokkaido, Japan), Dr. Vladimir Truhlik (Institute of Atmospheric Physics, Czech Republic), Dr. Takashi Maruyama (National Institute of Information and Communications Technology, Japan), Dr. Susumu Saito (Electronic Navigation Research Institute, Japan).

Besides the academic programme, some social activities and an excursion were included. On Sunday 1 November all trainees and lecturers were invited to attend an Ice Breaker dinner where everyone introduced him/herself and learned a little bit about Thai culture and about general issues to be aware of while being in Thailand.

On Wednesday 4 November we all visited the Ladkrabang Satellite Ground Station, a backup site of the Thai Geo-Informatics and Space Development Agency (GISTDA). We were given a tour of the facility and an overview of the activities of the stations. GISTDA operates the Thai THEOS satellite, which produces panchromatic (2-m resolution) and multi-spectral (15-m resolution) imagery of Thailand. This site can receive satellite signals from many remote-sensing satellites. After the overview, we were all invited to witness a Landsat satellite fly-by as well as the real-time image production.

During lunch on Wednesday and Thursday, there was a brief tour of the Rooftop Laboratory, where GNSS receivers and satellite beacon receiver are operated, and a brief overview of some ionospheric research activities at KMITL was given.

On Saturday 7 November there was a tour to the Emerald Buddha Temple, the Grand Palace as well as the Reclining Buddha Temple.

Presentation Week, 9-13 November 2015

During this week, a conference format with oral presentations and poster presentations was organized. We had received 116 abstract submissions from 25 countries. The accepted presentations were distributed in sessions entitled 'Improved Accuracy of IRI at Equatorial Latitudes I, II, III', 'Progress Towards Real-Time IRI', 'F-peak Modelling and Comparisons', 'Description of Plasma Temperatures and Ion Composition in IRI', 'TEC and Topside Modelling and Comparisons', 'Description of the Ionosphere Below the F-peak', Poster session, 'New Inputs and Applications'.

GISTDA ground satellite station visit

The opening session on 9 November was presided by Assoc. Prof. Supan Tungjitkusonman, Vice Provost in Academic and Research Affairs, and Assoc. Prof. Komsan Maleesee, the Dean of Faculty of Engineering. Representatives of the sponsor organizations received an appreciation certificate and a small gift.

A welcome reception was organized on Monday evening, where participants learned some basic Thai dances in circles. On Wednesday afternoon, two excursions were organized. One to the PTEC, the other to the Ladkrabang Satellite Ground Station.

On Wednesday evening, the workshop banquet took place during a Chaopraya River Cruise. The participants enjoyed the dinner buffet and views of the Chaopraya river, the main artery of Bangkok, the Old Historic section and the new modern section of Bangkok.

During a special session on Thursday, representatives of each team project from the first week made presentations about their findings and results. A lively question/answer period ensued after each presentation. Three judges (Profs. Shigeto Watanabe, Shunrong Zhang, and Yongliang Zhang) were assigned to choose the best three teams, to receive awards during the final session on Friday. At the end of this session, certificates from COSPAR were given out to each trainee. In the last session of Thursday poster presentations were made.

The Ice Breaker dinner

On Friday morning, participants were invited by the KMITL president to attend the welcome session of Her Royal Highness Princess Maha Sirindhorn who graciously presided over the opening of four new buildings on KMITL campus and the graduation ceremony.

On Friday the IRI Business Meeting was held in conjunction with final discussions and decisions regarding the next version of the IRI model. As a result of the presentations at the workshop new improved descriptions will be introduced into the IRI model for the topside electron density, the F-peak height hmF2, the ion composition at very low solar activities, and the occurrence probability of spread-F. High priority was assigned to the inclusion of GNSS measurements into the Real-Time IRI algorithm.

The venue for the next IRI 2017 Workshop was discussed and proposals were presented for Havana, Cuba and Irkutzk, Russia. Drs. Pornchai Supnithi and Prasert Kenpankho were elected as new members for the IRI Working Group. Finally, the awards for the best teams were given to:

Gold award: Team 5, Problem 3 (Chinmaya Kumar Nayak, Adrian Teck Keng TAN, Punyawi Jamjareegulgarn, Ednofri)

Silver award: Team 1, Problem 1 (Malini Aggarwal, Siti Aminah Bahari, Wang Zheng, Sanit Arunpold)

Bronze award: Team 4, Problem 4 (Dessi Marlia, Azad Ahmad Mansoori, Sarawoot Rungruenwajiake, V. Rajesh Chowdhary)

The 2nd COSPAR Symposium, "Water and Life in the Universe", 9-13 November 2016, Foz do Iguaçu, Brazil

[Report by Othon Cabo Winter, Symposium Chair]

The 2nd COSPAR Symposium was held from 9 to 13 November 2015 on the theme "Water and Life in the Universe*"* in Foz do Iguaçu, Brazil. About 187 participants from 23 countries attended the meeting. The venue was splendid with the nearby Cataratas do Iguaçu waterfalls, the huge ITAIPU hydroelectric power plant, and the magnificent bird sanctuary Parque das Aves*,* among other attractions.

Just after the Opening Ceremony there were two keynote speeches, the first given by Prof. Paulo Artaxo (USP, Brazil): "Amazonia: The close links between water, biological activity and climate change" and the second by Prof. Fabrizio Capaccioni (INAF/IAPS, Italy) on

"Water in the Solar System: Results from ROSETTA". After this there was a space agencies round table, chaired by Prof. Lennard Fisk (President of COSPAR), with the presence of representatives from the Brazilian Space Agency (AEB), the National Institute of Space Research (INPE), the Argentinian Space Agency (CONAE), the Italian Space Agency, (ASI), the French Space Agency (CNES), the Japanese Space Agency (JAXA), the European Space Agency (ESA) and the USA Space Agency (NASA).

Opening the activities of the first two afternoons there was a Plenary Talk. On Monday it was given by Dr. Eduardo Janot Pacheco (USP, Brazil) on the PLATO 2.0 mission. The following day Dr. Silvia Maria Giuliatti Winter (UNESP, Brazil) talked on "Pluto System Dynamics & the New Horizons Mission". There was then an Invited Lecture to open activities each morning. The first one on "The ASTER Mission: Exploring for the First Time a Triple System Asteroid" was delivered by Dr. Elbert Macau (INPE, Brazil).

On Wednesday Dr. Dara Entekhabi (JPL, USA) talked on "The NASA Soil Moisture Active Passive (SMAP) Mission Status and Early Results". The following day, Dr. Masaki Fujimoto (JAXA/ISAS, Japan) talked on "Formation of the Solar System, Terrestrial Water and Life: Sample Returns of Hydrated Dust and Organics from Small Bodies". Finally, on Friday there was a lecture on "Exploration and Sample Return from Other

Some of the organisers and participants of the 2nd COSPAR Symposium in Foz do Iguaçu

Shores: Planetary Protection for the Water Worlds" by John Rummel (McGill University, Canada). The Symposium was composed of oral and poster presentations distributed into nine sessions, described as follows:

Session 1 - Space astronomy missions to detect ingredients for life and exoplanets in the universe: status of current and future approved missions and new proposals.

This session presented results from space missions and ground observatories to study water, ices, organics in the galaxy, interstellar medium, around stars and on exoplanets. They reviewed the status of exoplanets research, in particular in the new context of habitability. They discussed the potential of upcoming space mission, and proposed observatories for the future.

Session 2 - Water and life in the universe and on Earth: impact on human consciousness and societies.

This was an interdisciplinary (and even trans-disciplinary) session connecting hard and social sciences, and even society, in the tradition of the education and outreach session at the COSPAR. The idea was to have lectures or contributions from scientists involved in astrophysics, geophysics, and environmental sciences, but also in geography, economy, sociology, history, health sciences, etc. and maybe an artist's view to get a picture of the impact of water both on Earth and in the cosmos on life, on society(ies), and on humanity.

Session 3 - Satellite and probe missions for water remote sensing on Earth, planets, and other celestial bodies.

The main goal of the session was: 1. to show achievements of especially dedicated satellite water missions such as ESA`s water mission SMOS (Soil Moisture and Ocean Salinity); NASA`s SMAP (Soil Moisture Active and Passive Mission); pioneering missions based on GNSS-R signals also transmitting information on soil moisture (ESA`s PARIS (Passive Reflectometry and Interferometry System) In orbit-demonstrator, and GRACE (Gravity Recovery and Climate Experiment). 2. to show how the GPM and TRMM missions (NASA-JAXA) are helping to advance our understanding of Earth`s water and energy cycle, improving forecasting of extreme events that cause natural hazard and disaster, and extend current capabilities in using accurate and timely information to directly benefit society.

Session 4 - Water and Life in the Solar System.

Solar system research has revealed evidence of present water both inside and outside the snow line, from Mercury, Moon, Mars to Europa, Ganymede, Enceladus and beyond. The "habitable zone" concept has been expanding from surface habitats on the terrestrial planets in close heliocentric orbits to deep habitats, like thermal vent eco-system on the Earth, underneath the satellites affected by strong tidal forces of giant planets. Organics and volatiles are also discovered by meteoritic analysis, space missions and astronomical observations of asteroids, comets, and icy bodies.

Cosmic dust plays a major role as a delivery vehicle of water and organics to the Earth. Extra-terrestrial water resources are also expected as a future exploitation target to support future deep space human exploration.

Session 5 - Water from chemical, biological, and physical perspectives.

Water use and reuse for life support, sources (combustion/propulsion reaction by-product; celestial bodies; organic decomposition; …). There have been very important theoretical & experimental developments in the mystery of water such as: (i) Constructions & prototypes of water batteries; (ii) Low frequency phenomena in water & their impact on the bio-system; (iii) Ferro-electric ordered domains in water leading to a super-phase of water; (iv) Low frequency magnetic phenomena in water; (v) Electromagnetic signals from DNA in water (vi); Coherence & non-transient effects in water.

Water in the Earth`s middle atmosphere is very small in amount but plays important roles. It was recently discovered that latent heat released by cumulus convection in the tropo-sphere plays an important role in generating atmospheric waves, such as gravity wave and tides, which go up to the mesosphere and even thermosphere and ionosphere up to a few hundred kilometres above ground, transporting momentum and energy and driving the atmosphere circulation and variations of iono-sphere. Water vapour is also one of the greenhouse gases and the trend in the middle atmosphere is of interest.

Session 6 - Role of water from the ground to the upper atmosphere.

At mesopause, water becomes ice in the summer polar region and forms noctilucent

Checking out the poster session

warming. Molecules related to water, such as OH, are also used for remote sensing of the mesosphere lower thermosphere region. This session treats various aspects of phenomena above ground up to the upper atmosphere related to water.

Session 7 - Astrobiology: habitability, synthesis of organics in ice, and prebiotic chemistry in liquid water.

The session covered three topics: i) Habitability: defining the notion of habitability related to the nature of the stars, then, expanding to habitability on Mars, icy satellites and possible exoplanets; ii) Synthesis of Organics in Ice: reports on laboratory work to synthesize organic molecules related to astrobiology in ices (water + CO + NH3 + …); iii) Prebiotic Chemistry in Liquid Water: could early prebiotic chemistry develop on surfaces of Mars or in icy satellites of giant planets?

Teacher training sessions were held in parallel with the Symposium

Session 8 - Water and life support for human exploration in low Earth orbit, the Moon and beyond.

The session discussed the use and recycling of water and organics for human missions and their reuse for life support on the ISS and beyond. The possibility of using water and organic resources on lunar sites (including poles), asteroids and Mars was discussed for life support, propulsion fuel, in-situ manufacturing and other by-products enabling human exploration. The session included talks and posters on terrestrial simulation analogue campaigns, and precursor robotic space experiments to survey these materials, to demonstrate their use for supporting biological and technical investigations, and provide lessons for future life support systems in human bases on the Moon and beyond.

Session 9 - SWOT altimetry mission for hydrology;

This was a session dedicated to SWOT, the altimeter mission for hydrology. On 12 November there was a special session to celebrate the one-year anniversary of the landing of *Philae* on the surface of comet 67P/Churyumov-Gerasimenko.

Simultaneously to the Symposium some other events were organized, including a public lecture, a teacher training session for local school teachers with lectures, hands-on activities and a planetarium session, and also a drawing contest for 8-11 year olds on the theme “Water and Life in the Universe”.

One of the winners of the children’s drawing contest

In the two weeks preceding the Symposium, a Capacity Building Workshop (CBW) on "Data

Analysis from Space Missions" was organized in the city of Guaratinguetá, Brazil, and some of the works developed by the participants of the CBW were presented in the Symposium.

International Conference on 'Solar Variability and its Heliospheric Effects', 2-6 November 2015, Athens, Greece

[Report by Olga E. Malandraki, Chair of SOC and LOC, IAASARS, National Observatory of Athens]

This international conference took place in Athens at the History Museum of the University of Athens, from 2 to 6 November 2015. The conference was organized under the auspices of IAASARS of the National Observatory of Athens (NOA). This is the sixth conference organized in the framework of the Balkan, Black Sea, and Caspian Sea Regional Network on Space Weather Studies (BBC SWS), which comprises 11 countries: Armenia, Azerbaijan, Bosnia/ Herzegovina, Bulgaria, Croatia, Georgia, Greece, Romania, Russia, Serbia, Turkey, and Ukraine (www.bbc-spaceweather.org/). The main goal of the conference was to bring together experts in different areas of solar-terrestrial research, in order to obtain a comprehensive picture of the chain of events originating from the Sun affecting the heliosphere and the Earth's environment and climate. 45 scientists attended the conference. In total 35 papers, with 31 oral (invited and contributed) papers and four posters were presented. Many young scientists and post-docs had the chance to participate as well as targeted invited scientists from the international community (e.g. USA, Germany, United Kingdom, Belgium, Spain). The scientific presentations given in the conference covered various aspects of solar-terrestrial research and space weather effects.

In Session 1, 'Sun and solar activity', Martens (Georgia State University, USA) focused on the 'Faint Young Sun Paradox': The geological and biological records support that the Earth's biosphere was considerably warmer than currently during the origin of life on Earth and for several billions of years thereafter. Yet, stellar evolution calculations support the Sun reaching the Zero Age Mean Sequence at ~75% of its present luminosity, and linearly increasing in time up to its current level. Climate models predict a "Snowball Earth" for such a low solar constant. As of now there is no theory, or even a credible scenario, to resolve this issue. Sokoloff (Moscow State University, Russia) presented available observations for the solar variability, including catastrophic events like Maunder minimum and other grand minima occurrences. It was argued that noisy contributions to the dynamo drivers can be sufficient to explain the observed variability of the solar cycle. Lefevre et al. (ROB, Belgium) presented the new sunspot number since its creation in 1849 and the simultaneous re-calibration of the Group Number (www.sidc.be/silso/). All applied corrections were described in detail. A main result was the uniform peak cycle amplitudes found over the last three centuries. Kilçik et al. (Akdeniz University (AU), Turkey) using the multi taper method and Morlet wavelet analysis methods showed that solar rotation periodicities are present in active latitudes of both hemispheres for cycles 21, 22, and 23.

Both northern and southern hemisphere active latitudes were found to shift toward the equator from the beginning of the cycle until the end following an oscillating path. Eren (AU, Turkey), applying a Pearson correlation method, concluded that the main source of X-ray solar flares are the complex/large sunspot groups. Georgieva et al. (BAS, Bulgaria) found that the characteristics of both the slow and fast solar wind change from minimum to minimum, which can explain the changes in the geomagnetic activity in consecutive sunspot minima, and can provide a proxy for long-term variations of solar wind parameters. Kirov et al. (BAS, Bulgaria) described the Langmuir probes included in the "Obstanovka" experiment aboard the International Space Station (ISS) which has been operating since April 2013. One of the main goals of this experiment is to study the surface charging of super-big objects like the ISS. Using measure-

ments by the SDO/AIA instrument Nindos et al. (University of Ioannina, Greece) found hot flux ropes in 32% of the flares but almost half (49%) of the eruptive events contained a hot flux rope configuration. It is argued that these percentages should be considered as lower limits of the actual rates of occurrence of hot flux ropes in large flares. Miteva et al. (NOA, Greece) presented a new SEP catalogue based on wind observations, which reports the date, onset and peak time, peak intensity and onset-to-peak fluence of the proton events and the properties of the SEP-associated flares and CMEs. Small-scale quiet-Sun swirling was the focus of the work by Tziotziou et al. (NOA, Greece). Upflow events were found that exhibited two distinctive apparent motions in the plane of sky for a few minutes: (1) a swirling motion with an average speed of 13 km/s, and (2) an expanding motion at a rate of 4–6 km/s. Georgoulis (RCAAM, Greece), highlighted major outstanding problems: stochasticity in solar-flare triggering, the flare-CME connection, understanding of solar pre-eruption configurations, the response and impact of the Parker spiral and the solar wind in the propagation of eruption products. Bothmer (Universität Göttingen, Germany) highlighted the key importance for any space weather forecast to predict the arrival times, field intensities and directions of CMEs and also provided a brief summary of the state-of-the-art modelling of CME magnetic field configurations enabling the quantitative forecast of geomagnetic storms.

Some of the scientists at the conference on Solar Variability and Its Heliospheric Effects

In session 2, 'Solar Wind and Heliosphere', Khabarova et al. (IZMIRAN, Russia) presented a new mechanism responsible for particle acceleration. The presence of magnetic islands inside magnetically confined cavities in the solar wind may lead to local particle energization, especially in the case when the particles have already been pre-accelerated to keV energies, for example, at shocks or due to magnetic reconnection at the heliospheric current sheet. Kislov et al. (IKI, Russia) presented a single-fluid 2-D analytical model of the axially-symmetric thin heliospheric current sheet (HCS) embedded into the heliospheric plasma sheet (HPS). A new approach was presented by Pavlos et al. (DUTH, Greece) who estimated the Tsallis q-triplet statistical parameters of Tsallis non-extensive statistics as well as other dynamical characteristics of the solar wind system during quiet and CMEs periods.

The results showed faithful agreement with the predictions of complexity theory and the non-extensive statistical theory of Tsallis.

Session 3 was dedicated to 'Solar Wind-Magnetosphere coupling'. As Troshichev (Arctic and Antarctic Research Inst., Russia) highlighted, in 2013 IAGA endorsed the polar cap magnetic activity (PC) index as a proxy of the solar wind energy that enters into the magnetosphere. Three researchers from the Romanian Academy, Romania presented important results. Demetrescu presented a case study on geophysically induced currents in Europe as an example of space weather hazard, based, on annual means of measured and reconstructed solar, heliospheric, and magneto-spheric parameters, as well as on measured and modelled main geomagnetic field data, and on recorded 1-min geomagnetic data from the network of European geomagnetic observatories. Dobrica et al. discussed the correlation between pairs of magnetospheric indices at various time scales, from hours to interdecadal, showing the effect of the long-term solar activity on the magnetosphere variability, as well as the two solar sources of the geomagnetic activity (sunspot- or non-sunspot-related) in relation to solar magnetic field. Beşliu-Ionescu et al. presented the current status of the problem and the methods proposed to evaluate the energy transfer from the solar wind into the magnetosphere during intense geomagnetic storms that occurred in solar cycle 23. Advances on the multi-spacecraft studies (e.g. 4 Cluster spacecraft) of Kelvin-Helmholtz instability in the Sun-Earth system were presented by Foullon (University of Exeter, UK). A range of benchmark values were derived from multi-spacecraft observations which form real constraints and references for input and for matching the observations with numerical simulations.

In Session 4, important results were presented on 'Solar effects on the ionosphere, atmo-sphere and climate'. Belehaki et al. (NOA, Greece) explored additional techniques for the identification and tracking of Large scale travelling ionospheric disturbances (LSTIDs) over Europe, benefiting from the dense network of DPS4D ionosondes and of GNSS ground-based receivers. This was a combined analysis based (a) on ionogram traces and the retrieved scaling parameters (foF2, hmF2, FF, HmF2), (b) on slant Total Electron Content (sTEC) residuals calculated from the signals transmitted from GNSS satellites seen by receivers co-located with the ionosondes and (c) on the reconstructed Electron Density Distribution using the Topside Sounders Model Profiler (TaD) over the specific DPS4D ionosondes. The results indicated that it is important to distinguish between LSTID signatures and the super-fountain effect. Another very important result was that the TaD model is sensitive in LSTID propagation and the corresponding electron density disturbances can be reproduced by the model predictions at heights around the maximum electron concentration. Chaldoupis et al. (University of Crete, Greece), taking advantage of an existing data base, reported on solar flare-related electron density measurements made with the Arecibo radar which monitors the ionosphere from 60-430 km altitude with a height resolution of ~600 m and a time resolution of ~1.8 min. Results were shown on the structure of the modified electron density profiles and the temporal altitudinal variations of electron densities relative to the radiation changes measured by GOES in the short (XS) and long (XL) X-ray bands of 0.5-4.0 Å and 1.0-8.0 Å, respectively. These results can be useful in the validation of existing D region photochemical models as well as VLF (very low frequency) and HF (high frequency) radio wave propagation models, and can also provide a judgment on the significance of ionospheric TEC changes anticipated during solar flare events of different magnitude. Results on modelling the ionospheric storm response to different solar wind drivers were presented by Tsagouri et al. (NOA, Greece). Observations obtained from ground-based ionosondes were analyzed in comparison with climatological estimates to quantify the ionospheric disturbances and follow their latitudinal and local time dependence through superposed epoch analysis. Solar wind parameters were obtained from ACE and magnetospheric/geomagnetic activity indices and energetic particle fluxes from NOAA/POES satellites were used as proxies of the solar wind energy input and dissipation in the Earth's magnetosphere, to

unmask the underlying processes that differentiate the ionospheric response to different space weather manifestations and help the prompt and accurate prediction of the ionospheric structure under all possible conditions. Didebulidze et al. (Abastumani Astrophysical Observatory (AAO), Georgia) considered the inter-annual variations of the atmosphere-ionosphere parameters since 1957 in the region of the AAO. The importance of annual and semi-annual variability in the long-term variations of the ionosphere F2 layer parameters (NmF2, hmF2), the hydroxyl OH bands, the oxygen green 557.7 nm and red 630.0 line intensities observed from Abastumani were noted.

Furthermore, in order to investigate the formation of sporadic E under the influence of atmospheric gravity waves, 2-D numerical simulations were performed in the case of northward directed background wind and formation of multi-layered sporadic E was demonstrated. Haralambous et al. (Frederick University, Cyprus) presented strong spatial and temporal variations of ionospheric characteristics over Europe driven by trough displacements during geomagnetic storms of the present solar cycle, currently undergoing its declining activity phase. In a study of the March 2012 CME and its related super storm, Anagnostopoulos (DUTH, Greece) showed solar and magneto-spheric particle events control extreme weather events all over the globe, as for instance, the historic March 2012 heat wave in East USA/ Canada, rainfall in south-east Mediterranean. Statistical results for 28 strong ICMEs observed between 1997 and May 2015, confirmed a strong correlation between Solar Energetic Particle (SEP) events and extreme atmospheric weather events. The procedure followed for the development of a solar radiation database using an integrated solar radiation model (MRM) developed at NOA was presented by Kambezidis et al. (NOA, Greece). The final database includes 15-year hourly values of the most important parameters for sizing solar energy systems i.e. air temperature, relative humidity, global and diffuse solar radiation on horizontal plane.

In Session 5: 'Space Weather monitoring instrumentation, Data and Services', Bothmer (Universitaet Goettingen, Germany) highlighted the advances that the Wide-field Imager for Solar Probe Plus (WISPR) will provide and what the capabilities will be for the new era of heliospheric imaging and space weather applications. Posner (NASA HQ, USA) highlighted that the forecasting of the sudden increase in intensity of protons from SEP events is relevant for radiation protection of humans on exploration missions and extra-vehicular activities. He discussed an analysis of the REleASE method of short-term forecasting of the intensity of prompt solar energetic protons of hazardous energies (~40 MeV) with relativistic electrons. He showed how REleASE forecasts from a near-Earth vantage point can be used to provide essential warnings also for human space exploration of Mars via the Hohmann-Parker effect. Núñez (University of Malaga, Spain) presented how the UMASEP scheme is being applied in the new 'HESPERIA' space weather project within HORIZON 2020 of the European Union for predicting >500 MeV SEP events. The new forecasting system will use a real-time correlation analysis between hard 1-minute X-ray flux and 1-minute neutron and proton flux. A prototype of this is expected to be released in May 2016. Malandraki (NOA, Greece) presented and discussed the 'HESPERIA' HORIZON 2020 project, coordinated by NOA, its main objectives, as well as the added value to the SEP research. The project will produce two novel Solar Energetic Particle (SEP) operational forecasting tools based upon proven concepts (UMASEP, REleASE) (http://hesperia-space.eu/). At the same time, it will advance our understanding of the physical mechanisms that result into high-energy SEP events through the systematic exploitation of the high-energy gamma-ray observations of the FERMI mission and other novel published datasets (PAMELA; AMS), together with in situ SEP measurements near 1 AU.

Presenting materials (PDF) of these papers have been linked to the final programme posted to the webpage of the conference (www.space.noa.gr/bbc-sws/programme/). We

hereby would like to express our deepest thanks to the various organizations whose financial support made this conference possible: Committee on Space Research (COSPAR), Variability of the Sun and its Terrestrial Impact (VarSITI)/Scientific Committee on Solar-Terrestrial Physics (SCOSTEP), Air Force Office of Scientific Research (AFOSR), National Observatory of Athens (NOA), and the Institute of Astronomy, Astrophysics, Space Applications and Remote Sensing (IAASARS).

Letter to the Editor

Scientific Disputes and the Public

[From Dileep V. Sathe]

In July 2015, the UK's Institute of Physics carried out a unique activity in Bristol, involving the public in scientific disputes (*Physics World*, 14 July 2015). It was initiated in response to the long-standing dispute concerning the Big Bang theory and the Steady State theory of the origin of universe. Of course, one can doubt the value of involving the public in disputes relating to advanced physics, such as the origin of universe, but, on the other hand, I think it would be useful to involve the public in ***latent*** educational disputes among students. For example, students give ***contrasting*** answers to very simple questions on circular motion – reported first by John Warren in *Physics Education* in 1971 and raised by others later. Contrast in answers can be attributed to contrasts in the mode of evaluation of answers. Actually, wrong answers from some students stems from pre-Newtonian ideas, used by even ***Kepler***.

Hence, I think that organizers of future debates, discussions and events can very well think of having sessions focusing on such contrasting answers, even involving the public, especially teachers, students and parents with appropriate academic background for throwing light on such educational latent disputes. I suggest that readers of SRT read the article entitled '*Settling scientific disputes in public', Physics World*, 14 July 2015.

Publications

Advances in Space Research: Top Reviewers of 2015

Advances in Space Research (*ASR*), as with any established scientific journal, insists on a rigorous peer-review process to maintain the integrity and quality of its published papers. An essential part of this process is the reviewer, spending his or her valuable time using unique expertise to evaluate the scientific quality of a manuscript and help the Editor make a fair and timely decision.

To further highlight the vital importance of reviewers to the quality of *ASR*, the Editors have selected their 10 top reviewers for the year 2015, taking into account criteria such as the number and the quality of the referee reports performed during this year. By publishing the names and short biographies of these selected reviewers in this issue of *Space Research Today*, we would like to acknowledge their valuable efforts. As an additional token of appreciation, these reviewers are offered an Amazon voucher by Elsevier, and their names will also be acknowledged on the journal homepage of *ASR*.

We also feel deeply obliged to all *ASR* reviewers who have contributed this past year who are not mentioned here, and we sincerely thank all of them for bringing the journal up to its current scientific standard.

Pascal Willis, *ASR* Editor-in-Chief
José Stoop, *ASR* Publisher (Elsevier)