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Preface

Preface to the special issue of PSS on "Surfaces and atmospheres of the outer planets, their satellites and ring systems: Part V"

This special issue of PSS represents selected articles based on research presented in 2008 at various planetary sessions organized under the auspices of the European Geosciences Union (EGU) (Vienna, Austria, from 13 to 18 April), the Asia Oceania Geosciences Society (AOGS) (Busan, South Korea, from 16 to 20 July), COSPAR (Montréal, Canada, from 13 to 20 July) and the European Planetary Science Congress (EPSC) (Münster, Germany from 21 to 26 September).

The Editors wish to recognize here the excellent work of the conveners of these sessions, whose tireless efforts in publicizing and promoting the outer planets sessions were evident in the large number of abstracts submitted and the big attendance at those sessions. We also wish to thank the reviewers who have done an excellent job in evaluating the papers presented here.

The sessions organized this past year focused on recent observations and models on the atmospheres and surfaces of the giant planets and their satellites. Particular attention was given to results from the Cassini–Huygens mission to the Saturnian system. After the successful descent and landing on Titan of the Huygens probe in 2005, the Cassini spacecraft has been returning a wealth of new data almost continuously, revealing an astonishingly complex and dynamic system. Complementary observations of the giant planets and their satellites were obtained from the ground. Besides the observations, several of papers in this issue discuss results from laboratory experiments and models.

Zuchowski et al. present a new parametrization scheme of Jovian moist convection based on a heat engine arguments. In comparison to other moist convection schemes, this framework allows the diagnosis of the total available convective energy and the corresponding mass flux as dynamic variables from the mean atmospheric state. Solutions involving the scheme are first evaluated in very simplified conditions that allow analytic solutions (always an excellent step) and the full scheme is then applied to 1D (column) simulations of the OPUS Jupiter primitive equation model. In agreement with previous numerical experiments and observations, the inclusion of moist convection leads to heat and water vapor transport from the water condensation level to higher altitudes. The time development of the modeled convective events is shown in this paper to be strongly influenced by successive lowering of the top of the cumulus tower, which leads to rapid reduction of convective energy. This is an important topic, because the community has long been building towards representing moist convection in 3D models of Jupiter, and this paper takes an admirable step in the right direction. The scheme attempts to incorporate the key physical ideas important for moist convection in a relatively simple context.

The paper by *Smith* et al. provides important clues about the interaction between the Saturn's magnetosphere and the Titan's dense nitrogen dominated atmosphere. The authors use Cassini MIMI INCA images of energetic neutral atoms (ENAs) for hydrogen atoms and images of energetic protons from the T18 flyby with Titan. These observations are compared with model simulations of energetic protons interacting with Titan's atmosphere for those trajectories and which, after exiting Titan's atmosphere, intersect with INCA's FOV. The simulations model electronic collisions, charge transfer and charge stripping collisions with Titan's N_2 atmosphere. From this analysis, taking into account ambient upstream proton intensity variations, the authors reconstruct energy deposition curves as a function of height z. These results are supportive of previous such attempts using both Voyager 1 and Cassini data. The results presented provide a foundation for future quantitative studies of energy deposition into Titan's atmosphere by magnetospheric energetic ions and the authors plan important future studies based on 3D Monte-Carlo atmospheric modeling, in order to perform more detailed analysis of the energy deposition by the magnetospheric plasma.

In their paper, *Sittler* et al., give a masterful synthesis of previously made observations, which result in a well thought-through and quantitative hypothesis that could have important consequences for the scenario of formation of pre-biotic molecules and life itself. The authors discuss the nature of the heavy ions detected by Cassini at heights superior than 950 km in altitude. The paper offers a review of the literature on ISM observations and combustion experiments and an extrapolation to Titan. Based on this, and using some modelling, the authors hypothesize that the particles detected in Titan's upper atmosphere could be polycyclic aromatic hydrocarbons (PAHs) and fullerenes (C60). They also discuss the fact that, as the upper atmosphere is bombarded by magnetospheric plasma, keV oxygen, hydroxyl and water ions can become trapped within the fullerenes. They argue that as the particles fall on Titan's surface, interaction with cosmic rays would release the trapped oxygen. They finally conclude that this process could drive pre-biotic chemistry on Titan's surface.

Vuitton et al.'s paper shows that negative ions are produced by dissociative electron attachment to the principal nitriles (mainly HCN), followed by charge transfer to less abundant nitriles and hydrocarbons, with eventual ion loss via associative detachment with H and CH_3. The model results explain how the low ion mass peaks detected by the CAPS instrument on Cassini can be formed in Titan's ionosphere.

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The determination of the abundance of propane (C_3H_8), an important trace constituent of the methane photochemistry on Titan, has been difficult in the past, due to reliance on a single (ν_{26}) band that is in close proximity to a stronger band of acetylene. *Nixon* et al. identify six bands of propane in the CIRS equatorial limb spectra of Titan, and determine the abundance of the molecule from two of them. They identify also the need for accurate laboratory measurements of line position and strengths of several of the propane bands.

Adamkovics et al. present, analyze, and interpret a series of ground-based observations obtained with the SINFONI integral-field spectrometer at the *Very Large Telescope* and with the Visual and Infrared Mapping Spectrometer instrument on the *Cassini* spacecraft. Combined radiative modeling and multiple observations allow ruling out surface reflectivity artifacts as the reason for an apparent increase in condensed-phase methane detected by Adamkovics et al. (*Science* 318, 962–965, 2007). This study provides constraint on the methane cycle at Titan as (a) it is a new observation of localized meteorology on Titan, and (b) results indicate that precipitations on Titan seem to occur in the morning *and* in the afternoon.

Hartogh et al. give a review of the aims of this project, focusing on three broad science arenas: water and climate on Mars, water and associated chemistry in the outer solar system (Jupiter, Saturn, Uranus, Neptune, and Titan), and water/neutral molecular outgassing from comets. The aims of Herschel, launched on 14 May 2009, cover the broad topic of water and its isotopologues in planetary and cometary atmospheres. The D/H ratio, the key parameter for constraining the origin and evolution of solar system species, should be measured for the first time in a Jupiter-family comet and compared with the D/H in Oort-cloud comets which would allow scientists to constrain the composition of pre-solar cometary grains and possibly the dynamics of the protosolar nebula. Additionally, new measurements of D/H in the giant planets and Mars will be obtained. Herschel measurements will enable the retrieval of vertical profiles of H_2O and HDO in Mars' atmosphere with temporal coverage and should allow the detection of several new species. A detailed study of the source of water in the upper atmosphere of the giant planets and Titan will be performed. The Herschel mission thus has a complement of instrumentation that will enable very interesting planetary science. Water and its isotopes will provide important clues to the origin and evolution of planetary atmospheres. The composition of cometary comae, especially the D/H ratio of numerous comets, is especially compelling.

Cooper et al. tackle the problem of the origin of cryovolcanic activity at Enceladus and propose an "Old Faithful Model for Radiolytic Gas-Driven Cryovolcanism at Enceladus". This model suggests the observed irradiation of water ice at the surface of Enceladus as the primary energy source leading to gas-driven volcanism at the satellite's South pole. Dioxygen and peroxide produced as a result of direct irradiation by energetic particles is buried by regolith. The interaction of these oxidants with very reducing compounds, such as the hydrocarbons species observed in Enceladus' plumes results in an exothermic reaction and significant gas production. In the context presented by this model, outgassing activity occurs over short periods between long periods of idle accumulation of oxidants at depth. In the context offered by this model, activity is independent of tidally-driven processes but relies on the presence of liquid water for increased intensity. The authors suggest that similar processes could possibly occur at other icy bodies, such as Europa and Ganymede, and that future missions to these objects should aim to detect their signature.

Pintassilgo and Loureiro studied the possibility of an afterglow plasma to be able to produce N-containing hydrocarbon species of the type of those existing in Titan's atmosphere by varying the discharge plasma parameters and afterglow times. Comparing to former laboratory studies carried out in that field since 30 years, starting from N_2–CH_4 mixtures, the authors gave substantial arguments to promote the afterglow of a pure N_2 flowing microwave discharge, with CH_4 addition in the post-discharge, as a simulation process having many more advantages. As an example this system is much more flexible compared to former discharge conducted in a N_2–CH_4 mixture, due to the possibility of obtaining the species existing in Titan's atmosphere within a large variety of concentrations by varying the operating parameters in a microwave N_2 discharge and the instant at which CH_4 is injected in the post-discharge, even if not all the conditions are adequate to reproduce the mixture composition of Titan's atmosphere. The possibilities offered by such system are certainly exciting.

The paper by *Hadamcik* et al. provides recent results from the PAMPRE experimental device. This experiment deals with the production of aerosols in microgravity with a reactive plasma. After a short description of the PAMPRE experiment, the authors try to correlate the aerosols physical properties (size of the grains, morphology) studied by Field Emission Gun Scanning Electron Microscopy (FEG-SEM) analysis, to the operating conditions. In a second step, they correlate their optical properties (linear polarization of scattered light measured on clouds of particles by the PROGRA2 experiment) to their physical properties. Finally, they compare their results to those obtained *in situ* for Titan's aerosols by the Pioneer 11, Voyager 2 and Huygens space probes.

McLain and Adams used an impressive experimental device to produce data relevant to molecular synthesis in the interstellar medium and the Titan ionosphere. This experiment was supported by a variable temperature flowing afterglow Langmuir probe technique (VT-FALP) to determine the equilibrium temperature dependencies of the dissociative electron–ion recombination of the protonated cyanide ions ($RCNH^+$, where R=H, CH_3 and C_2H_5) and their symmetrical proton bound dimers ($RCNH^+NCR$). Even if this article mainly focuses on the protonated cyanides, which were chosen because of their importance in the Titan ionosphere, it reveals great possibilities for further studies to better understand the complexity of Titan's ionospheric chemistry.

This issue then reports on current progress in the studies of the outer planets' systems from observational, experimental and modeling approaches, in the framework of a very active and exciting era in acquiring new data both from space and from the ground. The eleven original, specialized manuscripts published here give valuable glimpses of this progress.

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