

# Outer Solar System: Many Worlds to Explore

Welcome to OPAG

Meeting 26

Flagstaff Arizona

August 11-12, 2016

Alfred McEwen

University of Arizona



# OPAG Steering Committee

- Many thanks to outgoing members:
  - Candy Hansen (former chair), Jani Radebaugh, Kevin Baines, Jack Connerney, Bill McKinnon (another former chair), Heidi Hammell
- Welcome to new members:
  - Jeff Bowman, Scott Edgington, Amanda Hendrix, Terry Hurford, Carol Paty, Kunio Sayanagi
- Continuing members:
  - Jason Barnes, Pat Beauchamp, Mark Hofstadter, Alfred McEwen (chair), Jeff Moore, Julie Rathbun, Britney Schmidt, Linda Spilker, Zibi Turtle



## OPAG Agenda August 11-12, 2016

August 11:

8:00 coffee, registration, posters

8:20 Welcome, meeting objectives - Alfred McEwen (University of Arizona)

8:30 PSD and outer Solar System exploration updates – Curt Niebur (NASA HQ)

9:00 Q&A

9:15 Discussion of R&A reorganization impact on OPAG - Jared Leisner (NASA HQ)

9:45 Q&A

break

10:00 New Frontiers 4 draft AO - Curt Niebur (NASA HQ)

Q&A

*Updates on Current Missions*

10:45 JUICE – Nicolas Altobelli (ESA, ESAC) (remote call-in)

11:15 Cassini – Linda Spilker (JPL)

11:45 Update on Space Launch System (SLS) - Steve Creech (MSFC)

lunch

1:15 Juno – Steve Levin

1:45 Telescopic observation support to Juno – Glenn Orton (JPL)

2:00 Europa Clipper – Bob Pappalardo (JPL)

2:30 Europa Lander SDT Kevin Hand (JPL), Alison Murray (DRI), Jim Garvin (GSFC), SDT chairs

3:00 Potential European contributions to Europa Lander mission Michel Blanc

Q&A

Break and posters

3:45 Report on Participating Scientist white paper Louise Prockter

4:00 PDS plans for Europa and other future missions Lisa Gaddis (USGS)

4:15 MAPSIT update Jani Radebaugh (BYU)

4:30 Poster 2-minute presentations

5:00 Poster session

August 12:

8:00 coffee, posters

*Future Missions*

8:30 Roadmaps to Ocean Worlds (ROW)– Amanda Hendrix (PSI), Terry Hurford (GSFC)

Q&A

break, posters

10:00 Vision and Voyages discussion, future Decadal Survey recommendations - Larry Soderblom (USGS emeritus)

Q&A

11:00 Ice giant mission study report – Mark Hofstadter (JPL)

11:30 ESA M5 Saturn Probe concept -- Olivier Mousis (Aix-Marseille Université)

Q&A

lunch

1:00 NASA Science Education and Communications – Kristin Erickson (NASA HQ)

1:30 Show your (R&A) Nuggets

2:00 “RPS Looking Forward – Not Back” -- Dave Woerner (JPL)

break, posters

2:30 Small satellites for outer planet science – Mike Seabloom, Space Mission Directorate Chief Technologist (NASA HQ)

2:50 Titan Aeronomy and Climate workshop summary - Christophe Sotin (JPL)

3:00 Astrophysics Science and Technology Definition Team for the Far IR surveyor, and JWST call for early release science - Stefanie Milam (GSFC)

3:15 Key questions in planetary volcanology - Laz Kestay (USGS)

3:30 Summary of Enceladus conference – Paul Schenk (LPI) **(new)**

Q&A

4:00 Discussion of OPAG issues, findings

5:00 posters



# Major OPAG concern: Decade of Darkness starting in 2018

- Much happening now
  - Juno at Jupiter!
  - Cassini beginning intense orbital operations in high inclination orbits
  - New Horizons Pluto data still being returned
  - Europa Clipper Phase A progressing
    - Pre-phase A for candidate lander
  - JUICE
- Candidate Future Missions
  - Ocean Worlds
  - Ice Giants
  - New Frontiers and Discovery
  - ESA missions
- Challenge: How to keep outer planet science vibrant through the Decade of Darkness
  - No spacecraft data from Outer Planets between end of Cassini and Juno and arrival of Europa Clipper
  - ~10 year gap depending on when the Europa Clipper arrives



# **R&A is important to surviving the Decade of Darkness.**

## **What effect has R&A restructuring has on OPAG research?**

### **1. OPAG-relevant programs that didn't change much:**

- Cassini DAP
  - 18 grants/yr average before & after restructuring
- Origins of Solar Systems → Emerging Worlds
- Technology programs—renamed but comparable
  - New opportunities relevant to ocean worlds in future years

### **2. OPAG-relevant programs that changed more:**

- Several fundamental research programs important to OPAG have been merged into SSW
  - Outer Planets Research (OPR)
  - Planetary Geology and Geophysics (PGG)
  - Planetary Atmospheres (PATM)
- New R&A Programs: Habitable Worlds, PDART

**How has OPAG done overall, given these changes?**

# How Has Outer Planets Research Fared in New R&A Scheme?

- I looked at funded grants posted in NSPIRES, and made a judgment call as whether or not each was primarily OPAG-centric
  - Some late selections not posted in NSPIRES
- OPAG-centric selections in 2010-2013
  - OPR (not counting Pluto or comets): 107/4 years = 26.75/yr
  - PGG: 13/4 years = 3.25/yr
  - PATM: 34/4 years = 8.5/yr
  - Total: 38.5/yr
- OPAG-centric selections in 2014 (only year of new R&A grants available to me):
  - Habitable Worlds: 4
  - Solar Systems Workings: 22
  - PDART: 7 (but not fundamental research)
  - Total: 33/yr total; 26/yr (fundamental research)
- See backup slides for listings of all specific grants

## Conclusions:

1. There has been a 14% reduction in number of OPAG-centric R&A grants (but statistics are poor with just 2014 selections available).
2. There has been a 32.5% reduction in the number of fundamental research grants for Outer Planets and satellites.
3. OPAG-relevant technology funding will probably increase in future years.

**Overall, there has been a shift of emphasis, away from basic research and towards more directed R&A.**

# Backup slides

# 2010 OPR Selections

- Variations in UV Emission From The Io Plasma Torus Over The Galileo Epoch
- Amorphous and Crystalline Water Ice in the Outer Solar System: Laboratory Measurements of Optical Constants and Phase Transformations.
- Investigating the Saturnian Magnetosphere's Influence on the Ionosphere and Thermosphere of Titan
- Infrared Molecular Spectroscopy of Hydrocarbons for Planetary Atmospheres
- Orbital Evolution of Outer Solar System Satellites
- Photometry and Evolution of Jupiter's Rings
- Size Dependence of Coefficient of Restitution: Including the Effects of Rotation and Irregular Shape
- Atmospheric Composition and Hazes in Saturn's Ring-Shadowed North as Revealed by Cassini
- Spectral Behavior of Outer Solar System Ices
- Modeling of the Ice and Non-ice Components of Europa, Callisto, and Io using Recalibrated Galileo Near Infrared Mapping Spectrometer Data
- Seasonal Volatile Transport on Triton, Pluto, and Kuiper Belt Objects
- Photodesorption of Planetary Ices
- Molecular Escape and Evolution of Pluto's Atmosphere
- Electron-Impact Excitation of Metastable Species Relevant to Atmospheres of Outer Planetary Bodies-Measurement and Modeling
- The Formation of the Outer Solar System
- Consequences of the Late Heavy Bombardment for the Outer Planet Satellite Systems
- Analysis and Modeling of Jovian and Saturnian Wave-Particle Interaction and Electron Acceleration
- Atomistic Simulations for Inhomogeneous Modeling of Giant Planet Interiors.
- What Drives Variation in the Io Plasma Torus?
- Titan's Atmospheric Circulation and Methane Cycle.
- The Environment of Europa and Ganymede
- Enceladus' Plume: Coupling Eruptive Dynamics to Plasma Dynamics
- Polar Atmospheric Dynamics of Gas Giant Planets
- Probing the Enceladus Heat Engine: Analysis of Cassini CIRS Data
- Investigating Saturn's Cloud Structure and Composition with CASSINI/VIMS
- Tidal Dynamics and Heat of Oceans on the Icy Satellites
- Io Heat Flow: Small Thermal Sources
- Quantifying Ammonia Ice and Gas Distributions on Jupiter

28 total

# 2011 OPR Selections

- Stratospheric Hazes on Jupiter and Saturn: A Comprehensive View from Observation and Modeling
- Planetary Ice Attenuation Properties
- A Spectroscopic Study of Giant Planet Chromophores
- Ring-Moonlet Interactions: Propellers, Frogs, and Random Walks
- Chemical Interaction of Liquid Hydrocarbons and Icy Subsurface Materials: Laboratory Investigation and Implications for Titan
- Regolith Evolution of Small Outer Planet Satellites
- A Compositional Interpretation of TNO Taxonomy
- Jupiter's System III and System IV Hot Electron Modulation
- Understanding the Nucleus and the Outburst Behavior of Comet 29P/Schwassmann-Wachmann 1
- Influence of Water Vapor Saturation on the Cooling Histories of Uranus and Neptune
- First-Principles Equation of State of Complex Mixtures for Interior Structure and Evolution Models of the Outer Planets.
- A Laboratory Study of the Chemistry, Spectra, and Optical Constants of Pluto and Charon Ices
- Modeling Insights into the Vapor Plumes of Enceladus
- An Investigation of Atomic Hydrogen in the Saturn System
- Copious Volcanism on a Compression-Dominated Planet? Insights into Magma Ascent and Mountain Building on Io from Advanced Numerical Modeling and Data Analysis.
- An Investigation of the Feedbacks between Pluto's Atmosphere and Surface
- Understanding Titan's Three-Dimensional Dynamic Meteorology, and the Role of Atmospheric Waves in Titan's General Circulation Using Observations and Modeling
- Erosion on Titan as Revealed by its Crater Population
- Alkanes in Titan's Stratosphere From Cassini CIRS Spectroscopy
- Study of Coherent Backscattering Effect Using Near-Infrared Spectra of Outer Planet Satellites
- Winds, Climate and Organic Inventory from Dunes on Titan
- Long-term Thermal Evolution of Enceladus and the Transient Nature of the South Polar Thermal Anomaly
- Planetary Acoustic Mode Seismology Revisited Using CASSINI Imaging and Occultation Data Sets
- Analytic Models for Outcomes of Collisions between Icy Bodies for Outer Solar System Planet Formation and Evolution
- Hypervelocity Collisions: The Origins of Dusty Rings

25 total (red = KBO or comet focus, so not OPAG-centric)

# 2012 OPR Selections

- Haze Particles and Condensation of Ices in Titan's Atmosphere
- Infrared Absorption Cross Sections for the Outer Planets
- Solution Thermochemistry Relevant to Outer Planets and Satellites
- Modelling Thermal Emission from Lava Lakes and Skylights Using FLIR Data – Implications for Remote Sensing of Volcanism on Io (and Earth)
- Rheological Behavior of Icy Mixtures with Application to the Outer Planets
- Computer Simulations of Zonal Winds and Magnetic Fields in the Interiors of our Giant Planets
- Molecular Ion Recombination in Planetary, Moon, and Comet Atmospheres
- Laboratory Studies of Organic Materials in the Titan Hydrological Cycle
- Molecular Escape and Evolution of the Atmosphere of Pluto
- Plasma Energetics in Rotating Magnetospheres
- Investigations of Comets Observed by SOHO and STEREO
- Characteristics of Jupiter's Neutral Tori From Charged Particle Data
- Hydrodynamic Simulations of the Impact Origin of the Obliquity of Uranus
- Energy Transfer from Saturn's Magnetosphere to Titan
- Thermal Reactions in Ices Relevant to Satellites of the Outer Solar System
- Physical Processes in Titan's Seas
- Titan Photochemical Model-data Ion Density Discrepancies – What's Missing?
- Diphosphine Properties Relevant to Photochemistry and Haze Formation in Outer Planet Atmospheres
- Laboratory study of Shear Heating on Faults and Ridges of Icy Satellites Using Transient Friction Experiments
- Exogenic Landform and Surface Texture Evolution on Icy Satellites
- The Ins and Outs of the Io Plasma Torus: A Comparison of Two Decades of Io Plasma Torus and Io Volcanic Data
- Tropospheric Chemistry and Aerosol Formation on Jupiter and Saturn
- The Thermal Evolution of Icy Primordial Planetesimals
- Dynamical Origin of Small Body Populations during the Early Solar System's Instability
- Quantitative Measurements of Active Ionian Volcanoes: Global Distribution and Temporal Variability Using Galileo NIMS, PPR, Ground-based, and New Horizons Data
- The Yield of O(1S) from Water Photodissociation at 121.6 nm
- Strike-slip Faulting Processes on Ganymede: Morphological Inferences and Failure Mechanics
- Linking Dynamics on Local and Global Scales in Saturn's Rings
- CRYOCHEM: A Thermodynamic Equation of State of Fluid and Solid Solutions at Extremely Low Temperatures for Applications in the Outer Solar System
- Titan's Upper Atmosphere: Numerical Study of Major Neutral Species
- Understanding Io's Atmosphere

31 total

# 2013 OPR Selections

- Testing the Tectonic Resurfacing Hypothesis: 2D and 3D Numerical Modeling of Extending Ice Lithospheres
- Convective Ocean Dynamics of Europa: Effects Of Salinity
- Constraining the Composition and Physical Properties of Saturn's Rings Through Analysis of Cassini UVIS Data
- Aeolian Sediment Transport and Landscape Modification on Titan
- Influence of Ammonia on the Stability of Clathrate Hydrates: Implications for Outgassing on Titan
- Phases of Water Ice and the Origin of Volatiles in Outer Solar System Objects
- Ion Cyclotron Waves and Pickup Ions: Mapping Plasma Production in Saturn's Magnetosphere
- Orbital Evolution of Outer Solar System Satellites
- Coupling Geochemistry to Geophysics in Dwarf Planet Evolution Models
- Constraining Io's Mass Loss: Modeling the Magnetosphere-Satellite Interaction
- Volcanism and Interior Heating Processes on Io
- Observing Saturn's Rings In The Microwave With Cassini
- Dynamical Consequences of Charged Dust in the Enceladus Plume
- Determination of Key Radical Reaction Kinetics of Phosphine Photochemistry
- Constraining Moist Convection in Gas Giant Atmospheres using Observations and Modeling of the 2010 Great White Spot on Saturn
- Understanding Titan's Atmospheric Circulation and Methane Cycle Using a General Circulation Model
- Cometary vs. Asteroidal Impacts in Jupiter
- Callisto weathering
- Constraining Europas Interior Structure and Rotation History through Tidal- Tectonic Modeling
- Direct Numerical Modeling of Saturn's Dense Rings Informed by Cassini Data
- Formation and Preservation of the Equatorial Ridge on Iapetus
- Discovery of Europa's Transient Water Vapor Plumes
- Gas- and Condensed-Phase Infrared Spectroscopy Studies of Polycyclic Aromatic Hydrocarbons Relevant to Titan's Atmosphere
- Observations and Dynamics of Ring-Moon Systems
- An Investigation into the Unsteadiness of Tvashtar's Plume
- Regional Geologic Mapping of Titan
- Icy Satellite Surface Compositions from Thermal Infrared Spectroscopy
- Connecting Present and Past KBOs through Chemistry, Volatile Transport, and Atmospheric Escape

28 total

# PGG Selections from 2010-2013 relevant to OPAG

- Laboratory Controlled Experiments to investigate Coherent Backscatter from high albedo, atmosphereless solar system bodies
- Spectral Characterization of Planetary Surface Materials: Extended Temperature and Wavelength Coverage
- Volcanism on Io: Patera Structure, Formation, and Significance
- Laboratory Investigations into Radiolytically Induced Reactions in Salt and Sulfur-Containing Ices Relevant to Europa and Other Satellites
- Structure, Evolution, and Tectonics of Outer Planet Satellites
- Small Comets and Projectiles in the Solar System: The Issue of Secondaries on Large Icy Satellites
- Early Evolution of Saturn's Rings and Mid-sized Satellites
- Tidally-driven Dynamos: Applications to Ganymede and Mercury
- Radiation-Induced Alterations of Surfaces in the Solar System
- Geomorphic Effects of Volatile Loss in the Solar System
- Constraints On The Composition And Thermal State Of Io From Electromagnetic Induction
- A Global Geologic Map of Enceladus
- Partitioning of Soluble Impurities in Ice: A Foundation for Planetary Radar Exploration

$$13/4 = 3.25/\text{yr}$$

# PATM Selections from 2010-2013 relevant to OPAG

- Development of a Non-Hydrostatic Global Circulation Model for Jupiter's Ionosphere-Thermosphere system with Applications for JUNO
- Study of Electron-Hydrogen Collisions in the Jovian and Saturnian Atmospheres
- Jupiter Impact Modeling
- Chemical and Optical Properties of Titan Haze
- Analogs of Titan's Aerosol: Combined Laboratory, Modeling, and Observational Analyses in the Far-IR
- Kinetic Isotope Fractionation in Methane and Application to Titan
- Understanding the Near-Surface Atmospheres of Icy Bodies: Role of Photoionization of Organic Impurities in Icy Surfaces
- A Combined Laboratory and Observational Study of the Great Red Spot's Colors and Chemistry
- Collision Processes: Formation of and Escape from a Neutral Corona
- Electron Impact Induced Oxygen and Sulfur Emission Studies Important to the Jovian Satellites
- The Structures of the Atmospheres of Uranus and Neptune from Radiative Transfer Modeling of Voyager and HST Data
- Heterogeneous chemistry of organic haze in planetary atmospheres: Laboratory studies of the kinetics and products of radical + particle reactions
- Variability in Jupiter's Aurora from Multi-decadal Infrared Data
- Creating a Planetary Climate-modeling Hierarchy (PCH) to understand Titan's weather, climate, and winds
- UV Emission Processes in Planetary Atmospheres by Electron and Proton Impact
- Benzene and Ammonia Infrared Spectroscopy
- Constraining Interplanetary Dust Grain Fluxes to the Atmospheres of the Giant Planets and Titan
- Saturn's Winds: Their Extraction from Cassini ISS Images with the Advection Corrected Correlation Image Velocimetry (ACCIV) Method and 3D Simulation and Analyses
- Atmospheric gravity waves in Saturn's ionosphere
- Vibrational Distributions of Molecular Hydrogen in the Upper Atmospheres of Jupiter and Saturn
- Chemistry in the Outer Solar System: Ice-Giant Seasonal Variations
- The plasma interaction of the Galilean moon Europa with Jupiter's magnetosphere
- Low temperature laboratory and theoretical investigations of the formation processes of aerosols in Titan's atmosphere. Detection diagnostics for PAHs and hydrocarbons in Titan's haze.
- Laboratory Kinetic and Low Temperature Product Branching Ratio Measurements with Applications to Atmospheres of the Outer Planets and their Satellites
- Laboratory Kinetic and Low Temperature Product Branching Ratio Measurements with Applications to Atmospheres of the Outer Planets and their Satellites
- Energy Deposition in the Upper Atmospheres of Jupiter and Saturn by Energetic Particles: The Polar Aurora and Atmospheric Electrodynamics
- Moist Convection and Organic Haze Effects on General Circulation and Climate: Titan-Earth-Early Earth Comparisons with the GREP General Circulation Model
- Determination of Key Radical Reaction Kinetics of Phosphine Photochemistry
- Resolving Time-Dependent Atmospheric Dynamics on Jupiter and Saturn with Improved Planetary Cloud-Tracking Wind Measurement Methods
- Investigating Waves and Instabilities in Jupiter's Atmosphere
- Quantitative Analysis of Compositional Variation in Jupiter's Clouds
- Laboratory study of mid-IR propene for Titan and near-IR methane for planets
- Resonant tidal excitation and heating of giant-planet atmospheres
- Laboratory Studies of Cyanoacetylene Photochemistry in Titan's atmosphere: Expanding Current Photochemical Models of Nitriles

34/4 = 8.5/yr

# 2014 SSW Selections (1 of 3)

bold = primarily Outer Planets and Satellites

- Climatic Control Of Explosive Volcanism On Mars
- The Hydrology, Climate, and Sedimentary Deposits of Meridiani Planum and Gale Crater
- Space Processing of Asteroidal Surfaces and the Formation of New Chemical Species at Vesta and Ceres
- Characterizing Nanophase Materials on Mars: A Lab Spectroscopy and XRD Study of Allophane, Hydrated Silica, Iron Oxides/Hydroxides and Fe-Al-Si Oxide Species
- **Thrust Faulting of Rock and Ice Lithospheres in the Outer Solar System**
- Optical studies of icy regolith analogs: Constraining ice/rock ratio in high-radar- backscatter deposits (Mercury, Moon)
- Spatial-Spectral Studies of Water and the Physical Environment of Inner Cometary Atmospheres
- Understanding the Role of Waves and Tides in Regulating Venus' Highly Variable Upper Atmosphere Circulation (~70 - 170 km)
- Physical and Chemical Evolution of Airless Landscapes (mainly Lunar)
- **Investigating the Causes of Radar-Detected Layering in Ice**
- Experimental investigation of volatiles stability and interactions with the surface of Venus
- Noble-Gas Geochronology of the Inner Solar System
- Transient Foreshock Phenomena at Venus
- **Magnetic reconnection at Ganymede and its effects on global current systems and the aurora**
- **An Investigation of Electron Acceleration and Energy Transport by Alfvén Waves in the Jovian Magnetosphere**
- The Solar Wind Interaction with Pluto's Escaping Atmosphere
- **Dynamical and Collisional Evolution of the Uranian Satellites**
- Identifying and Quantifying Phyllosilicate-Bearing Materials on Solar System Bodies
- Dispersal of Pyroclastic Materials in the Mars Environment
- Hypervelocity Impact Experiments on Meteorites and Analogs: Constraints on Asteroid Cratering, Disruption, Recoil, and Dust Production
- **Thermal Evolution of the Ice Giants: The Effect of Water Condensation**
- Mars' Ancient Climate: Production and Evolution of a Reduced Greenhouse Atmosphere
- Rapid Thermal Demagnetization of Lunar Samples
- Proton and Laser Irradiation of Carbonaceous Chondrites: Towards an Understanding of How C-type Asteroids Space Weather.
- **Cryovolcanic Emplacement of Domes on Europa**
- **Ionospheric Outflow from Jupiter**

# 2014 SSW Selections (2 of 3)

- Spectroscopy of Salt-Bearing Mineral Assemblages (Mars and Earth)
- Laboratory Investigations of the Effects of Particulates on the Flow of Ice
- New Analysis of the Apollo 17 Surface Electrical Properties Experiment
- **Europa's Photochemical Sulfur Cycle**
- **Photochemical Processes in Titan's Lower Atmosphere**
- Lunar Impact Melt Flows: Geological Mapping, Experimental Simulation, and Numerical Modeling
- Dynamics and Consequences of Metallic Core Evolution
- Whitlockite and merrillite phosphate minerals: Potential recorders of formation and alteration processes from mantle to surface
- Modeling Dust Injection and Vertical Mixing for the Next Generation of Martian Exploration
- **Uranian Ring Dynamics and Constraints on Uranus' Internal Structure from Occultation Data**
- **Co-crystals on the surface of Titan**
- Icy Environments on Mars: Investigating Glacial Weathering in Volcanic Terrains
- **Antarctic Analog Study for Tidally Driven Diurnal Motions on Icy Satellites**
- Spectroscopy of Ilmenite-Rich Basalts: New Constraints for Remote Compositional Analyses of the Terrestrial Planets
- **A comparative Investigation of the Coupled Plasma-Magnetosphere-Interior Interactions at Mercury and Ganymede through Global MHD Modeling**
- Investigating the Plausibility of an Orbitally Forced Water Ice-Cloud Greenhouse on Mars
- Wind Erosion of Layered Sediments on Mars: The Role of Terrain
- How strong is the Venusian crust? The roles of trace amounts of water and ductile shear zones
- Application of Glacial Flow Models to Mars
- Investigation of the Solar Wind Influence on the Venus Upper Atmospheric Structure
- Testing the Fidelity of Using Laser Irradiation Experiments to Simulate Space Weathering on Airless Bodies
- Responses of Venus Ionosphere and Induced Magnetosphere to Solar Wind Variations
- Experimental Investigation into the Petrology and Mineralogy of low-FeO Planetary Surfaces
- Understanding the Interactions between Rocky Airless Bodies and their Local Environment with New Laboratory Experiments and Exospheric Models
- Size and Velocity of High-Speed Impact Ejecta
- Modeling Regolith Evolution During the Post-Basin Epoch of Lunar History
- **Current dynamics of Neptune's Distant mean Motion Resonances**

# 2014 SSW Selections (3 of 3)

- Studies of Physical and Dynamical Properties of Asteroid Families
- **Models of Neptune's Thermal and Compositional Structure from Spacecraft and Earth-Based Observations of Thermal Emission**
- Photochemistry and Dynamics in the Middle Atmosphere of Venus (~70-110 km): Modeling of SO<sub>2</sub> and Aerosol Distributions and Comparisons with Venus Express and Ground-based Observations
- Characterizing the Influence of ICMEs at Mercury using MESSENGER Observations and Multifluid Simulations
- Origin and distribution of water in Martian meteorites
- **Surface-Magnetosphere-Exosphere Coupling at Saturn's Inert Icy Moons**
- Interaction of Dusty Polar Cryo Jets with the Lower Atmosphere on Mars
- **Plate Tectonics on Europa**
- Are Mars Dust Disturbances Analogs to Terrestrial Deep Convection?
- Asteroids Under Stress: Constraining Strength and Evolution Through Simulations
- Developing a New Crater Production Function for Moon, Mars, and Mercury for Modeling Planetary Surface Ages
- Decoding the Origin of Continuum Coma Features in Comets
- Evaluating Crater Shape Variations on the Moon and Mars
- Surface Wind Stresses and the Dust Cycle on Mars
- **The interaction between Callisto and Jupiter's magnetosphere: A hybrid simulation study**
- Constraining the Oxidation States of Lunar Magmas and Impact Melts by Direct Measurement of Ti, V and Cr Valences in Individual Mafic Silicate Grains
- **Modeling the Internal Dynamics of Ice Giants**
- Shock-induced Melting and Vaporization Experiments on Planetary Materials
- Laboratory Investigations of the Microstructural Properties of Planetary Ice (Mars)
- **Using Rotational Librations to Peer Inside Enceladus**
- **Titan Aerosol Formation as a Sink for Stable Carbon and Nitrogen Isotopes**
- Optical Tomographic Map of the Zodiacal Cloud from STEREO Data
- Quantifying depositional environments on Mars using Askja Volcano, Iceland, as a Test-Bed for Characterizing Weathering of Ferrobaltic Volcanic Deposits.
- Upgrade of UCLA JXA-8200 Electron Microprobe
- Investigating the Ancient Lunar Dynamo
- Evaluation of Formation Mechanisms for Stepped Fans
- Laboratory Simulation of CO<sub>2</sub> and H<sub>2</sub>O Frosts on Mars
- Pluto Volatile Transport in the Era of New Horizons

**Total of 22 SSW selections focused on Outer Planets and Satellites in 2014**

# 2014 Habitable Worlds Selections

- Factors influencing the Habitability of Fe-Rich Systems on Mars
- **The Habitability of Cold Aqueous Salt Solutions on Icy Worlds**
- Microbial Communities of the Atacama Desert as Model Systems for Dry Worlds
- Evaluating the Limits of Orbital Habitable Zones With a Climate Model in Stochastic Resonance
- **Low Temperature Organic Synthesis on Icy Surfaces**
- Are O<sub>2</sub> and O<sub>3</sub> Reliable Biosignature Gases in Exoplanet Atmospheres?
- Determining the Inner Edge of the Habitable Zone Around M-Dwarf Stars Using 3-D Climate Models
- **Subsurface Oceans in Icy Satellites**
- Understanding Relict Martian Hydrothermal Systems Using Icelandic Analogs
- Evaluating Aqueous Martian Environments Through Coordinated Analysis of Carbonates in Martian Meteorite EETA 79001
- HAZMAT: Habitable Zones and M dwarf Activity Across Time
- Faint Young Sun Paradoxes and Habitable Worlds: Comparative Climatology of Early Earth and Mars
- Harnessing Energy From Stellar Radiation to Generate Metabolic Precursors
- **New Estimates of the Flux of Oxygen Into, and Its Distribution Within, Lake Vostok Using Radar Sounding Observations**

**Only 3 of these are clearly focused on outer planets and satellites, but we could probably add the last one listed (Lake Vostok) so the total is 4.**

## **2014 PDART Selections primarily applicable to Outer Planets**

- Archival of Cassini VIMS, ISS, and RADAR Global Datamap Products for Titan
- Resurrecting and Improving Galileo NIMS Data for Planning, Targeting, and Scientific Analysis
- Restoration, Calibration and Archiving of Voyager IRIS Observations
- Saturn's F ring in 360 degrees
- Restoration and Submission of Uranus Ring Occultation Observations to the Planetary Data System
- Higher Order Products for Galileo/EPD Energetic Particles
- Archiving Saturn and Titan ionospheric electron density profiles from Cassini