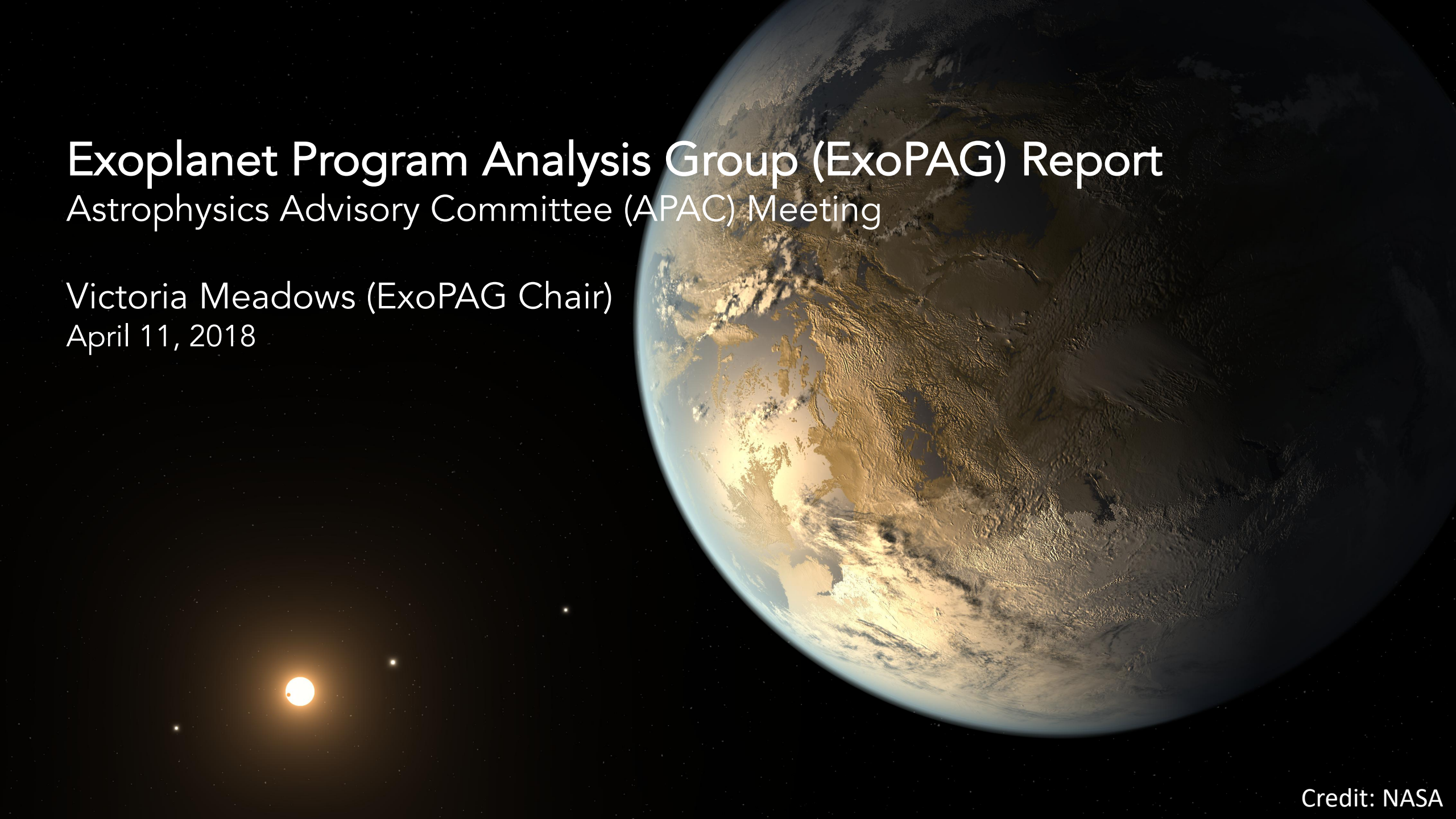
Exoplanet Program Analysis Group (ExoPAG) Report

Astrophysics Advisory Committee (APAC) Meeting

Victoria Meadows (ExoPAG Chair)

April 11, 2018

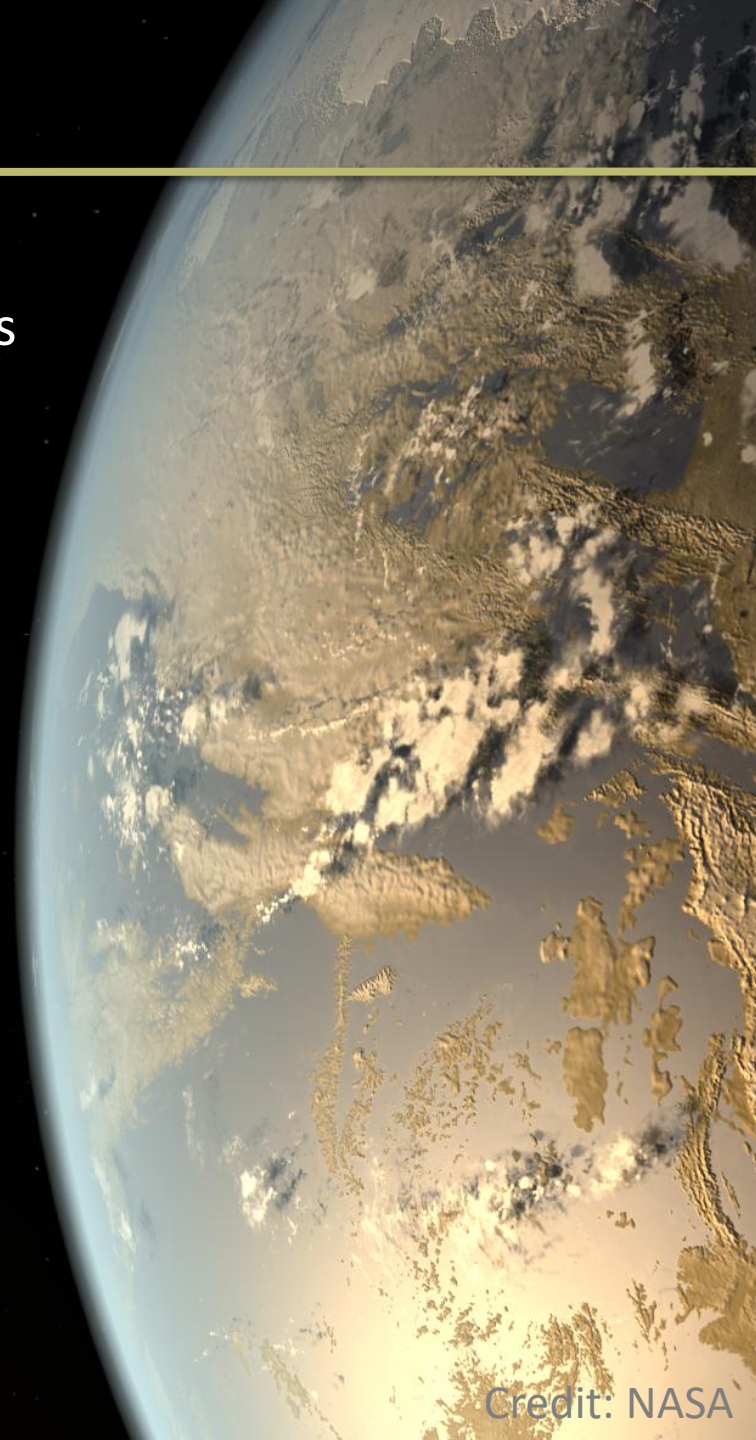


Credit: NASA

ExoPAG EC Membership

Victoria Meadows (Chair)	**University of Washington**
Tiffany Glassman	Northrup Grumman Aerospace Systems
Eliza Kempton*	University of Maryland
Dimitri Mawet	Caltech
Tyler Robinson	Northern Arizona University
Michael Meyer*	University of Michigan
Chris Stark*	Space Telescope Science Institute
Johanna Teske*	Carnegie Observatories **-> DTM**
Daniel Apai	University of Arizona
David Ciardi	NASA Exoplanet Science Institute
Shawn Domagal-Goldman	NASA Goddard Space Flight Center
Alan Boss (Past Chair)	Carnegie Institution
Martin Still (Ex officio)	NASA

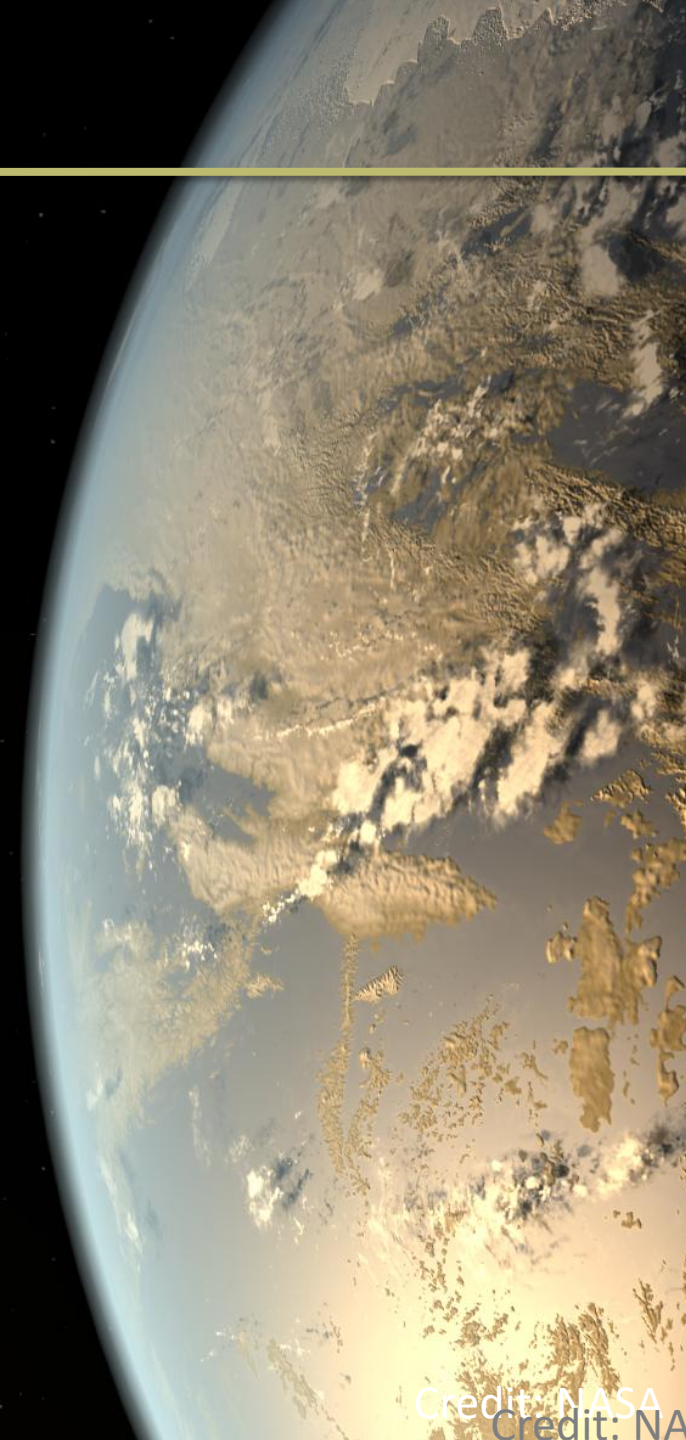
- New members in 2017
- **3 New EC Members currently being selected.**



Credit: NASA

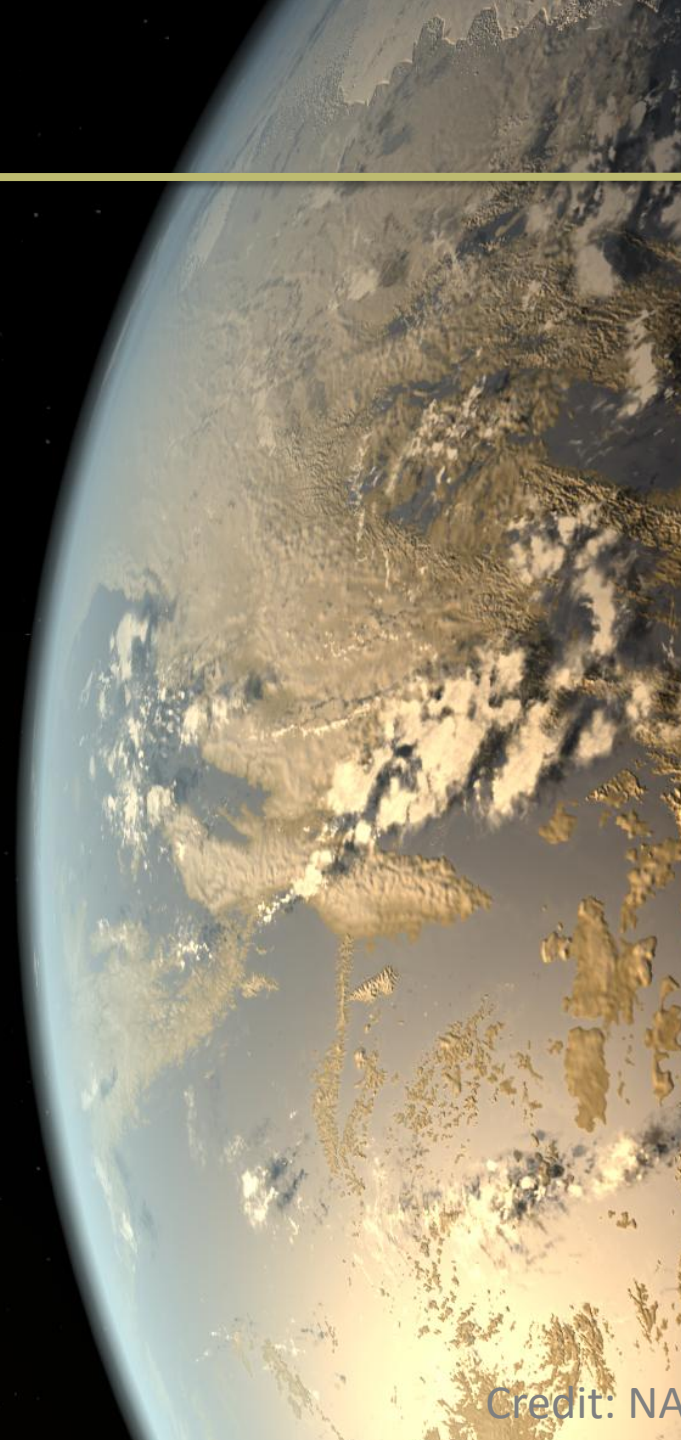
11 Completed Study Analysis Groups (SAGs)

Year	SAG	Title	Lead
2012	1	Debris Disks & Exozodiacal Dust	Roberge
2010	2	Potential for Exoplanet Science Measurements from Solar System Probes	Bennett, Coulter
2013	5	Exoplanet Flagship Requirements and Characteristics	Noecker, Greene
2015	8	Requirements and Limits of Future Precision Radial Velocity Measurements	Latham, Plavchan
2015	9	Exoplanet Probe to Medium Scale Direct-Imaging Mission Requirements and Characteristics	Soummer
2015	10	Characterizing the Atmospheres of Transiting Planets with JWST and Beyond	Cowan
2014	11	Preparing for the WFIRST Microlensing Survey	Yee
2017	12	Scientific potential and feasibility of high-precision astrometry for exoplanet detection and characterization.	Bendek
2017	13	Exoplanet Occurrence Rates and Distributions (closed out since last June)	Belikov
2017	15	Exploring Other Worlds: Observational Constraints and Science Questions for Direct Imaging Exoplanet Missions (closed out since June)	Apai
2017	18	Metrics for Direct-Imaging with Starshades (closed out since last June)	Glassman & Turnbull



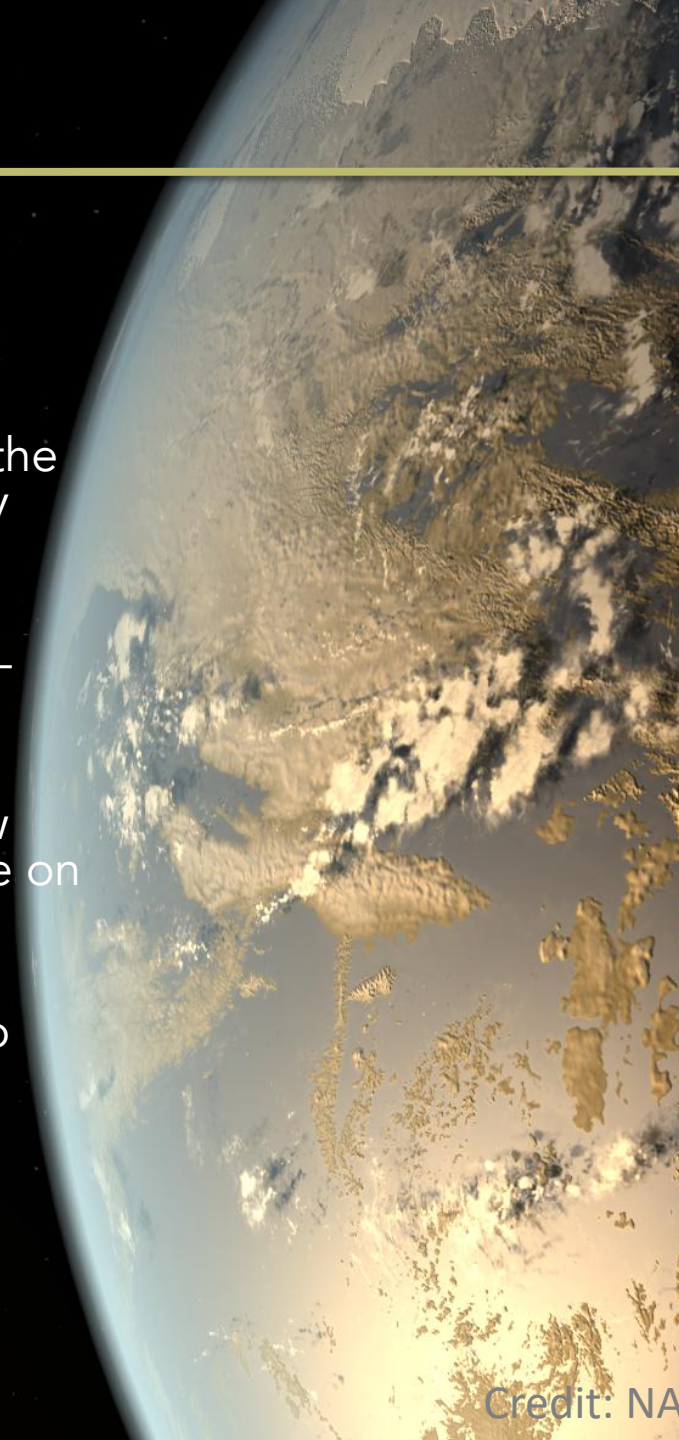
3 Active Study Analysis Groups (SAGs)

Year	SAG	Title	Lead
--	14	Characterization of Stars Targeted for NASA Exoplanet Missions (on hold)	Stassun
--	16	Exoplanet Biosignatures (active - closeout expected in 2018)	Domagal-Goldman
--	17	Community Resources Needed for K2 and TESS Planetary Candidate Confirmation (active - closeout expected in 2018)	Ciardi & Pepper
--	19	Exoplanet imaging signal detection theory and rigorous contrast metrics (active - closeout expected in 2018)	Mawet & Jensen-Clem



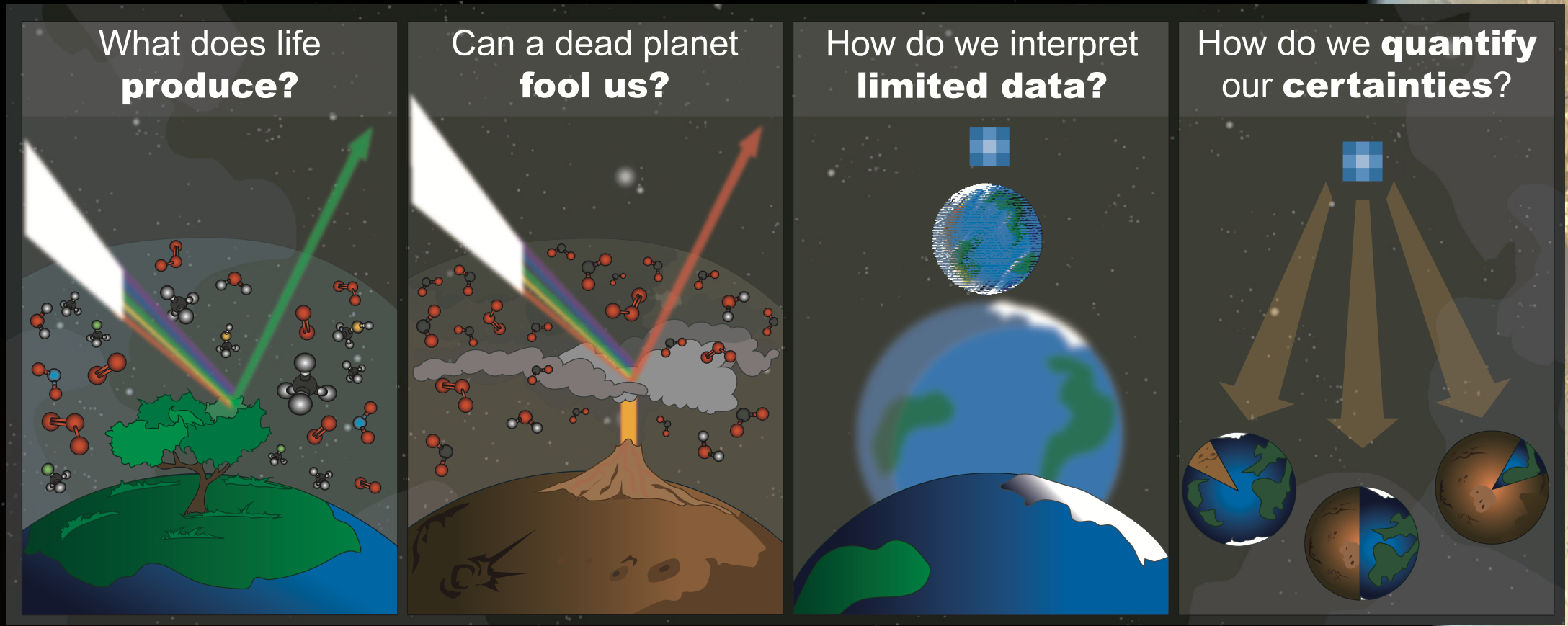
ExoPAG Recent Activities

- Held ExoPAG17 meeting at AAS in National Harbor, MD, on January 6-7, 2018
  - New format with mini-science symposium.
  - about 100 attendees.
- Hosted spreadsheet for exoplanet community to self-organize on white papers to the NAS Exoplanets Committee (38 papers listed and almost all requesting community participation).
- Previous SAG leads encouraged to summarize community input to final report at 5-page white papers (SAG Reports for SAGs 10, 11 and 15 summarized).
- ExoPAG recommendation for student support to ExoPAG meetings adopted. New program initiated and applications for student travel to ExoPAG meetings available on the ExoPAG website.
- Preliminary EC feedback provided on the ExEP draft Science Plan and Science Gap List.
- Nomination list send to Paul Hertz for selection of 3 new ExoPAG EC Members.



ExoPAG Recent Activities - Highlight

SAG16 (Exoplanet Biosignatures – Domagal-Goldman, Kiang, Parenteau) – Organized an in-person/virtual workshop in 2016 with extremely broad community participation to address fundamental scientific questions that will enhance the science return from NASA exoplanet characterization missions.



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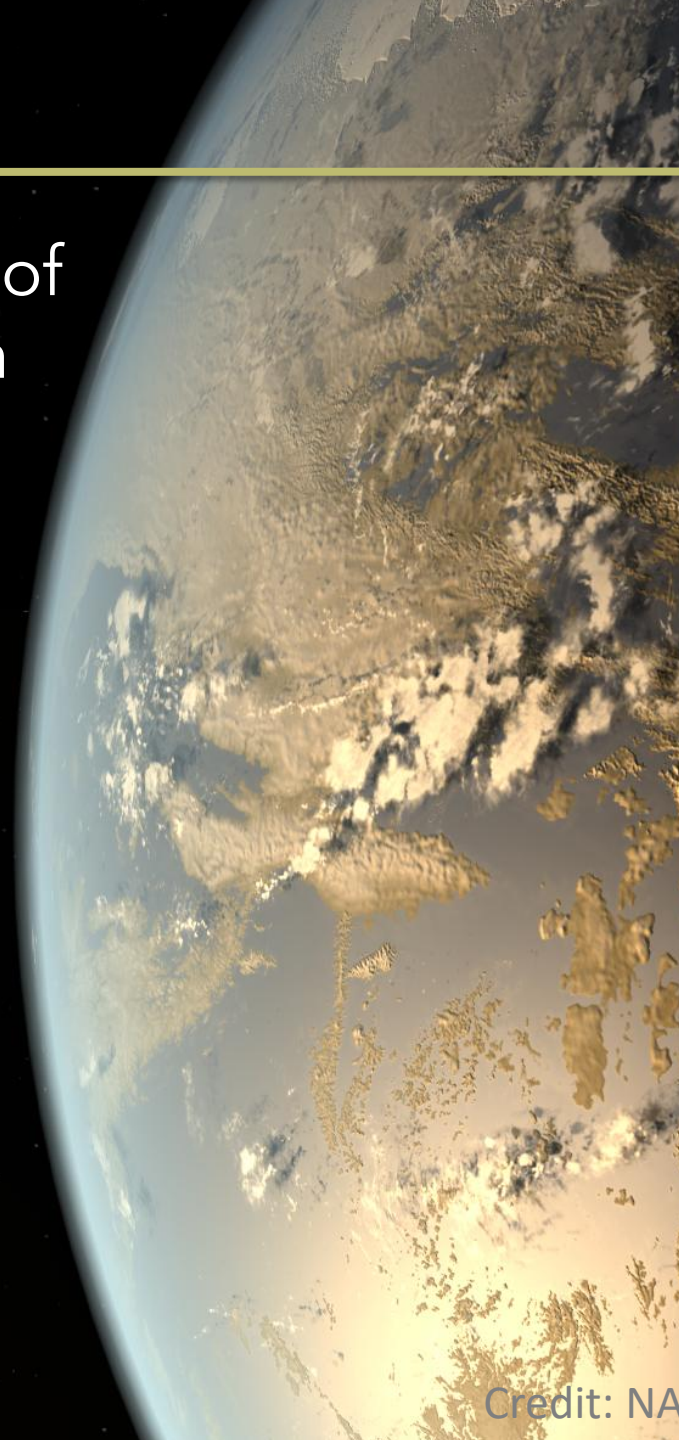
ExoPAG Recent Activities - Highlight

- SAG16 (Exoplanet Biosignatures) – As a direct outcome of the 2016 workshop, six community-led review papers on Exoplanet Biosignatures are now accepted to a special issue of *Astrobiology,* and will be published in the May 2018 edition.
  - Executive Summary (also the SAG16 Report: Kiang et al.)
  - A Review of Remotely Detectable Signs of Life (Schwieterman et al.)
  - Understanding Oxygen as a Biosignature in the Context of Its Environment (Meadows et al.)
  - A Framework for Their Assessment (Catling et al.)
  - Future Directions (Walker et al.)
  - Observational Prospects (Fujii et al.)



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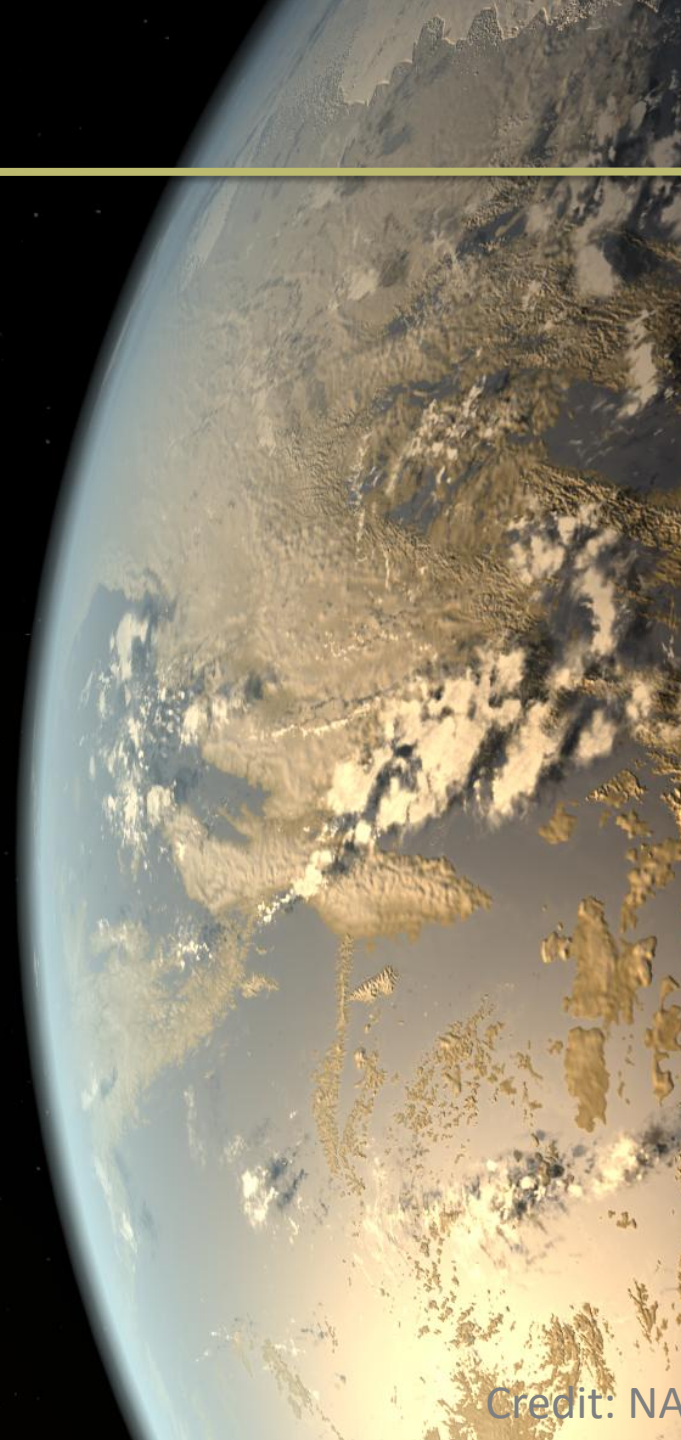
ExoPAG 2018 Future Activities

- Continue monthly ExoPAG EC telecons
- Continue ExoPAG e-mail updates
- Continue working towards a public ExEP Science Plan and Science Gap List.
- Finish work of three remaining SAGs – 16, 17, and 19 and request closeout
- Participate in Great Observatories SAG with CoPAG and PhysPAG.
- Initiate SIG on Demographics
- Continue to review ExEP Technology Gap List planning process



ExoPAG Future Activities (cont)

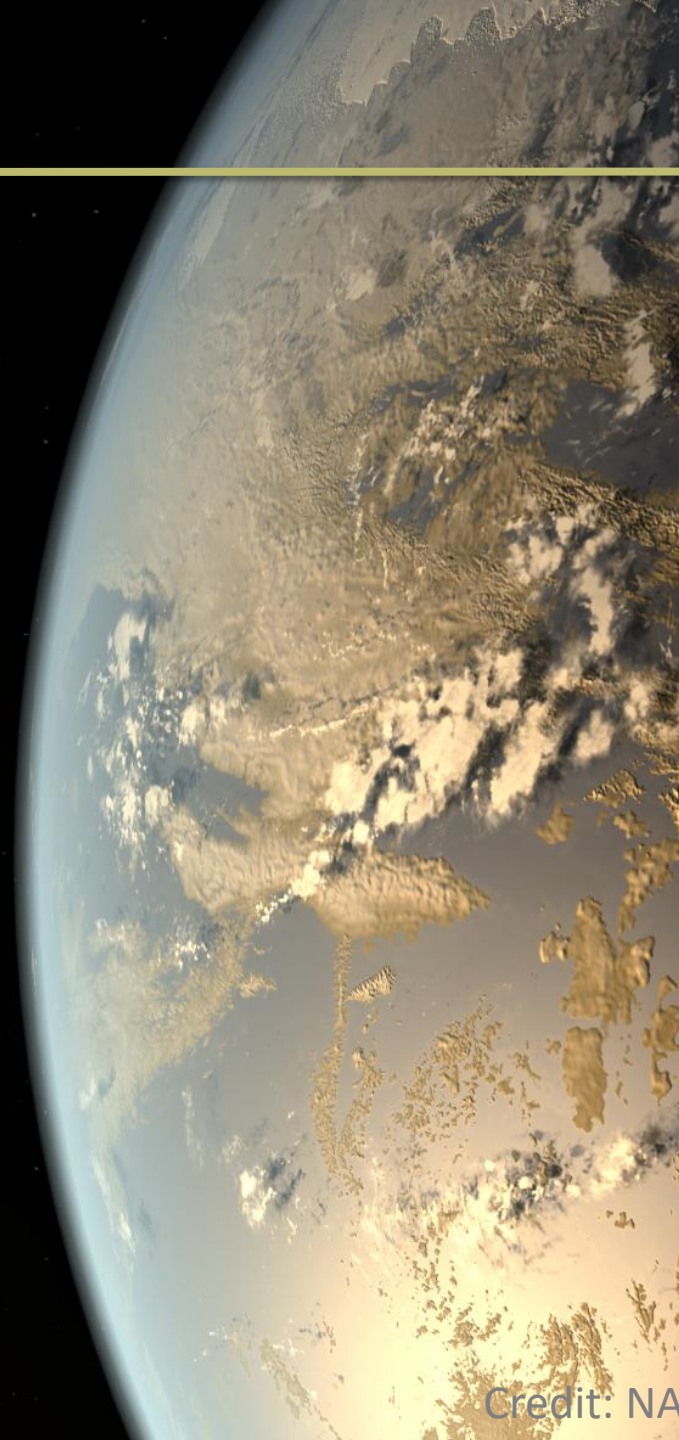
- Hold ExoPAG18 on July 29th, 2018, prior to Cool Stars 20 in Boston, MA.

- ExoPAG18 to feature a 2-3 hour mini-science symposium on the impact of M dwarfs on atmospheres, evolution, habitability and detectability of planets.

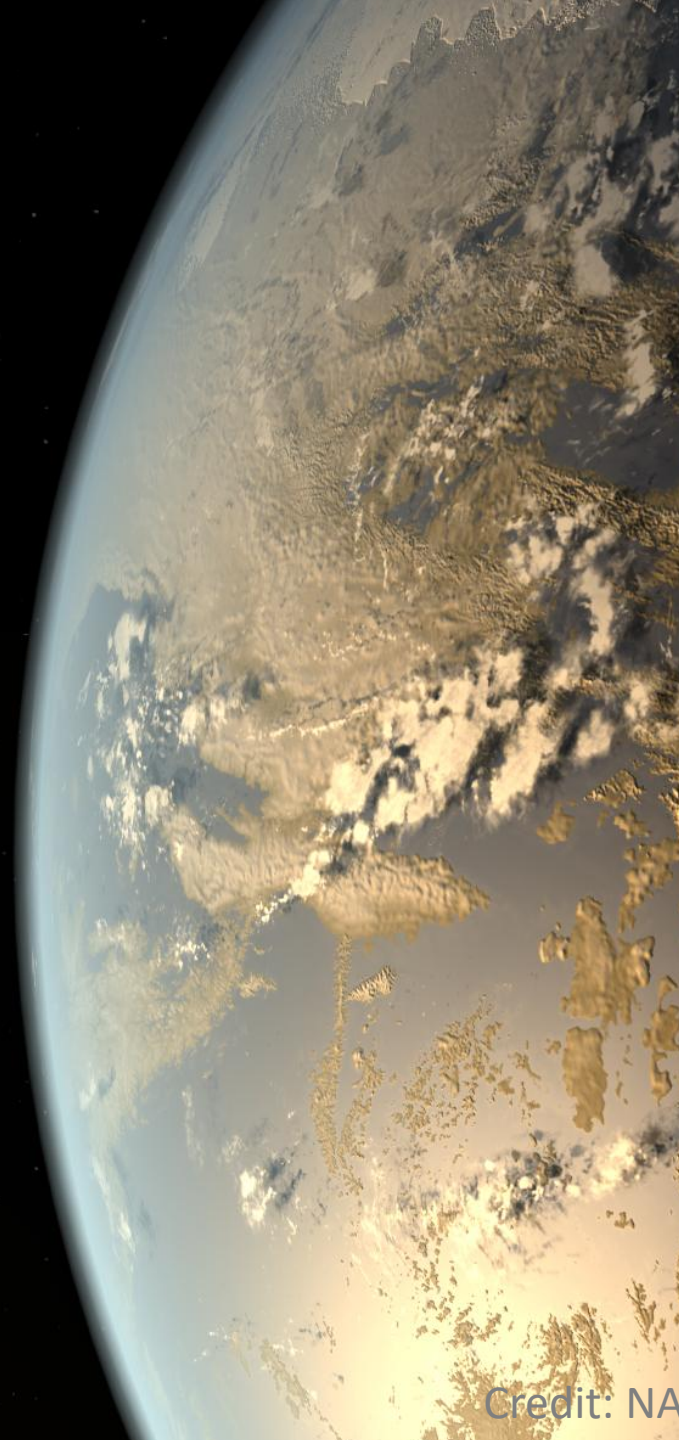
- ExoPAG18 will provide limited travel support for postdocs and students to attend and present at the ExoPAG meeting.
  - Program initiated and organized by Becky Jensen-Clem and David Ciardi
  - https://exoplanets.nasa.gov/exep/exopag/student-travel/

APAC Action Requested by ExoPAG EC

- None at this time.



Backup Slides



SAG 13: Exoplanet Occurrence Rates and Distributions (Rus Belikov, Chair)

Key objectives and questions:

1. Propose standard nominal conventions, definitions, and units for occurrence rates/ distributions to facilitate comparisons between different studies.
2. Do occurrence estimates from different teams/methods agree with each other to within statistical uncertainty? If not, why?
3. For occurrence rates where extrapolation is still necessary, what values should the community adopt as standard conventions for mission yield estimates?

Recent Progress:

- Computation/crowdsourcing of eta tables
- 11 participants submitted tables so far
- Latest estimates of occurrences of potentially habitable planets seem to be converging (at least to a factor of ~2-3), and explanations for discrepancies are starting to clarify
- Expected product in mid 2017: estimates of occurrence rates

SAG 14: Characterization of Stars Targeted for NASA Exoplanet Missions (Keivan Stassun, Chair, and TESS coI for Target Selection)

[TESS = Transiting Exoplanet Survey Satellite]

SAG 14 has prepared a preliminary analysis of potential benefits of a pre-launch spectroscopic survey of TESS targets:

- Primary TESS goal: discover ***50 Earth-sized transiting planets*** ($R < 4\ R_{Earth}$) ***whose masses can be measured*** by follow-up radial-velocity measurements.
  - Analysis of activity-driven RV jitter in TESS targets shows that, even in most stringent worst-case scenario, TESS is certain to deliver the above mission science requirement.
  - A pre-launch spectroscopic survey of TESS targets could help ensure an even larger yield on the above goal by identifying an even larger sample of low-activity, Doppler stable target stars.
- SAG 14 report is on hold.

SAG 15: Exploring Other Worlds: Observational Constraints and Science Questions for Direct Imaging Exoplanet Missions (Daniel Apai, Chair)

Charge:

1) What are the most important science questions in exoplanet characterization, apart from biosignature searches?
2) What type of data (spectra, polarization, photometry), with what quality (resolution, signal-to-noise, cadence), is required to answer these science questions?

Progress:

- SAG15 underway and on track
- Team, timeline, process, milestones identified
- Up-to-date status and documents: eos-nexus.org/SAG15/
- Currently finishing work on list of high-level science questions
- Target date for completion Spring 2017
- Report + refereed publication are foreseen
- Interactions with WFIRST and Large Mission STDTs important

SAG 16: Biosignatures (Shawn DomagalGoldman, Nancy Kiang, and Niki Parenteau, Co-Chairs)

Science Goals

We seek to answer 3 broad questions:

1) What are known remotelyobservable biosignatures, the processes that produce them, and their known nonbiological sources?

2) How can we identify additional biosignatures, and a more comprehensive framework for biosignature assessment?

3) What are the requirements for detecting these biosignatures to different levels of confidence?

A 3-day workshop was held on July 27-29, 2016, along with the NASA Astrobiology Institute (NAI) and the Nexus for Exoplanet System Science (NExSS). Plan is to draft a SAG report and a peer-reviewable paper by mid 2017, invite review and commentary from the community, and submit final SAG report by end of 2017.

SAG 17 – Community Resources Needed for K2 and TESS Planetary Candidate Confirmation (David Ciardi and Joshua Pepper, Co-Chairs)

- SAG 17 will study and enumerate the resources needed by the community to effectively and efficiently validate as many K2 and TESS candidates as possible, and propose methods to allow the community to coordinate and self-organize the process.
- Specific goals of SAG 17 include the following:
- Identify needed follow-up observations for K2 and TESS including but not limited to imaging, spectroscopy, and time-series follow-up
- Identify telescopes, instrument, and financial resources available to the US community
- Identify how archival resources can be utilized (e.g., Gaia)
- Identify how the community can be organized and communication facilitated particularly with regards TESS full frame images, candidate identification, single transiting events, and candidate prioritization.
- Identify needs to ensure efficient and effective characterization with JWST (and WFIRST)
- Identify connections to other SAG efforts (e.g., SAGs 15 and 16)

SAG 18 – Metrics for Direct-Imaging with Starshades (Tiffany Glassman and Maggie Turnbull, Co-Chairs)

- We propose to identify the areas of starshade performance where standardized metrics would be beneficial, and to create rigorous definitions of key terms, data processing techniques, and performance requirements.
- There have been informal definitions of contrast as the amount of residual starlight at the location of an exoplanet of interest and of suppression as the total amount of residual starlight entering the telescope.
- How can contrast or suppression be used as metrics of starshade performance (pros and cons)?
- How should contrast be defined?
- How should suppression be defined?
- What contrast limit is required to detect a planet of a given magnitude at the inner working angle (IWA)?

SAG 19 – Exoplanet Imaging Signal Detection Theory and Rigorous Contrast Metrics (Dimitri Mawet and Rebecca Jensen-Clem, Co-Chairs)

- Go back to the basics of Bayesian Signal Detection Theory (SDT), i.e., H0:signal absent / H1:signal present hypothesis testing.
- Rebuild a solid set of usual definitions used for or in lieu of “contrast” in different contexts, such as astrophysical contrast or ground truth, instrumental contrast used for coronagraph/instrument designs, and the measured onsky datadriven contrast.
- Identify what we can learn and apply from communities outside our field (e.g. medical imaging: receiver operating characteristic (ROC) curve).
- Define precise contrast computation and ROC curve computation recipes, a new “industry standard”.
- Identify how the new metrics and recipes can be used to define confidence levels for detection (H1) and subsequently error bars for photometric, spectroscopic, astrometric characterization.
- Perform a community data challenge before and after applying our proposed set of standardized SDT rules and recipes, and apply lessons learned.