EXPLORING THE JUPITER SYSTEM WITH EUROPA CLIPPER AND JUICE: THE POTENTIAL FOR UNIQUE JOINT SCIENCE OBSERVATIONS. Louise M. Prockter¹, Emma J. Bunce², Mathieu N. Choukroun, and the JUICE-Clipper Steering Committee. ¹Johns Hopkins Applied Physics Laboratory, U.S.A., louise.prockter@jhuapl.edu, ²University of Leicester, U.K., ³Jet Propulsion Laboratory, U.S.A.

Introduction: ESA’s JUpiter ICy moons Explorer (JUICE) launched on April 14, 2023, beginning an eight-year journey to the Jupiter system. Arriving in 2031, JUICE will undertake 35 total flybys of Ganymede, Europa, and Callisto before going into orbit about Ganymede for 1 year [1]. NASA’s Europa Clipper is scheduled to launch in October 2024, and arrives in the Jupiter system in 2030, a year ahead of JUICE. Clipper will spend a year in the system before focusing on over 50 flybys of Europa during a nominal four-year primary mission phase [2], while also making multiple serendipitous flybys of Ganymede and Callisto.

Having two highly instrumented flagship-class spacecraft in close proximity in time and space affords unprecedented opportunities for synergistic observations of Europa, Ganymede, Callisto, Io, Jupiter’s atmosphere, small satellites and rings, magnetosphere and environment, as well as opportunities for unique heliospheric and magnetosphere science during the missions’ cruise and Jupiter approach phases.

The JUICE-Clipper Steering Committee (JCSC) is comprised of a diverse group of scientists from both the JUICE and Europa Clipper teams. The JCSC has been tasked with identifying unique scientific experiments that could be accomplished through coordination of the two spacecraft. Appointed by the JUICE and Clipper Project Scientists, we reflect the broad scientific and instrument expertise of the two mission teams. There are currently no firm commitments from NASA or ESA to accomplish science beyond that of each mission’s primary science objectives, however, discussions are ongoing and we are optimistic that our recommendations for the unprecedented opportunities afforded by the two missions’ alignment will enable the necessary resources to be found.

Analysis of potential joint science opportunities has been underway for the past year, and will continue until Clipper’s launch in October 2024. Ideas have been collated from JCSC members as well as from three joint Clipper-JUICE workshops (2018, 2019, 2022), and the Science Traceability Matrix from a prior joint ESA-NASA study, the Europa Jupiter System Mission (EJSM) [3].

Cruise and Jupiter Approach: Our focus over the past year has been on science that can be accomplished during the two spacecrafts’ cruise and Jupiter approach phases. We have identified a number of potential opportunities for investigating the evolution of the solar wind plasma and interplanetary magnetic field and related structures such as monitoring Coronal Mass Ejections (CMEs) or Corotating Interaction Regions (CIRs) during times when the two spacecraft are radially aligned (i.e. within similar heliocentric longitude) or at similar heliocentric distances, as well as radio science observations of the solar wind and/or Solar Energetic Particle (SEP) events that could be observed during opposition or “superior conjunction” events. There is also potential for taking data and investigating the evolution of solar wind structures and disturbances when both spacecraft are “connected” through Parker Spiral field lines. The cruise science return from JUICE and Clipper could be further enhanced by data from other operational spacecraft (e.g., BepiColombo, Solar Orbiter, Parker Solar Probe, MAVEN), thus expanding the catalogue of opportunities for these identified configurations, as well as simultaneous observations by ground- and space-based observatories (e.g., JWST, Keck, etc.). The approach phase of the JUICE spacecraft while Europa Clipper orbits within the jovian magnetosphere provides a substantial opportunity to study the complexity of the solar wind-magnetosphere interaction and aurora, a topic where there remain many open questions.

Orbital Science: Once JUICE and Clipper are in orbit about Jupiter, multiple opportunities exist for joint science at several different targets within the Jovian system, including the large Galilean satellites Ganymede, Callisto, Io, the small satellites and rings, and the magnetosphere and local environment. Scientific objectives may fall into one or more categories: (1) time dependent, in which both spacecraft must acquire data at same time, or one spacecraft’s observations inform the other’s observations; (2) space dependent, in which each spacecraft acquires data from specific parts of the Jovian system, or both observe the same target with similar, or different viewing geometries; and (3) an increase in science data (e.g. temporal or spatial coverage) made possible due to the availability of additional instrument types or data collection opportunities.

JUICE will carry out two flybys of Europa during Europa Clipper’s prime mission phase, enabling two unique opportunities where the spacecraft are within 0.5Rj of each other and only a few hours apart (Figure 1). JUICE will also carry out 8 flybys of Ganymede and 21 of Callisto before insertion into Ganymede Orbit. Europa Clipper will carry out over 50 flybys of Europa,
and will also encounter Ganymede and Callisto 7 and 9 times respectively, at a range of illumination conditions and True Anomalies. All of these afford opportunities for coordinated science, and additional observations by ground and space-based telescopes may enhance the science return.

In this paper, we will discuss some of the potential combined science from JUICE and Clipper that can further enhance understanding of the Jupiter system and the origin and habitability of the Galilean moons. Examples include investigations of the Europa and Io tori time variability, monitoring of Io’s volcanos, constraining the orbital evolution of the satellites, investigating the regoliths and near-surface structures of the icy satellites; searching for active processes, e.g., plumes, on Europa, monitoring the Jovian magnetosphere, measuring in-situ plasma variations, improving the moments-of-inertia of the satellites, and investigating the dynamics of the ring particles.


Figure 1: Example of Europa Clipper and JUICE ground tracks below 750 km from one potential flyby scenario, overlaid onto a Mercator-projected map of Europa’s surface. Europa Clipper tracks are in blue; the two JUICE flybys are in red. One of the JUICE flybys occurs within a few hours of Clipper’s own flyby of Europa, and both enable ample opportunities for coordinated science and cross-calibration of instruments between the two spacecraft.