DIFFERENT BEHAVIOR OF THE MAGNETIC FIELDS OF JUPITER AND SATURN. H. Cao[1,2], C.T. Russell[1,2], S.P. Joy[1,2], U.R Christensen[3], M.K. Dougherty[4] [1]ESS, University of California, Los Angeles, CA 90095-1567; [2]IGPP, University of California, Los Angeles, CA 90095-1567; [3]Max Planck Institute for Solar System Research, 37191 Katlenburg-Lindau, Germany; [4]Imperial College, London, UK.

Introduction: Jupiter and Saturn have the most well observed outer planet magnetospheres. Orbital measurements of the magnetic field of these planets can be used to derive the intrinsic magnetic field, which in turn provides important constraints on the interior properties of these planets. Pioneer 10 and 11, Voyager 1 and 2, Ulysses, and Galileo have made in-situ measurements of the Jovian magnetic field. Several internal field models have been derived based on different ways of 'inverting' these measurements. For Saturn, the measurements of Pioneer 11, Voyager 1 and 2 provided preliminary models of the magnetic field of this planet, but only an axisymmetric field could be robustly determined. Since August 2004 the Cassini spacecraft has been orbiting the planet, making nearly continuous measurements of the magnetic field, allowing us to improve these models and to search for secular variation.

Previous Work and Limitations: For Jupiter, none of the widely used models, O6, VIP4, JPL/P11, are consistent with the Pioneer 11 measurements obtained close to the planet. We interpret this deviation as the effects of the higher degree moments of the intrinsic field that are relatively stronger at low altitudes. Yu and Russell [2009] analyzed all available data through 2002 and concluded that the internal magnetic field of Jupiter exhibits little if any secular variation other than a simple rotation of the dipole moment. This analysis was based on the O6 model and used measurements from 6 to 15 jovian radii where currents are produced by the mass loading of volcanically-derived plasma at Io. Thus these measurements may be affected by the dynamics in the Jovian magnetosphere.

For Saturn, Cao et al [2010] have shown that the internal field of the planet is extremely axisymmetric. The magnetic dipole tilt to the spin axis is confined to be within 0.06 degrees. They also find that the internal field of Saturn exhibits no detectable secular variation from the Pioneer epoch to the Cassini epoch.

This Work: For Jupiter, we restrict all our analysis inside 5.8 Rj (well inside Io's orbit). We first derive a 4^{th} degree model from Pioneer 11 observations. Our model has no systematic deviation from the near-planet measurements. This new model indicates that the dipole moment of Jupiter is about 2% weaker than estimated from the previous widely used models, O6 and VIP4. To investigate the evolution of the Jovian magnetic field from the Pioneer 11 epoch to the Galileo epoch, we make two different sets of assumptions: 1) no secular variation, only the IAU-defined rotation rate inaccuracy; 2) accurately defined rotation rate, only secular variation. They result in different explanations respectively: 1) a 9 ms correction to the IAU 1965 defined rotation period; 2) secular variation ~100 nT/year for degrees 1 and 2. Since the first assumption is the simplest (fewest parameters) solution, and because the correction to the period is within the uncertainty of the original definition, it is to be preferred (Occam's Razor).

For Saturn, we have analyzed new measurements provided by Cassini since the end of the previous analysis [Cao et al, 2010]. High latitude measurements have been re-examined to explore the existence of localized non-axisymmetric moments.

Summary: To date, we have no unambiguous evidence for secular variations at either Jupiter or Saturn. However, the field of Jupiter is quite strong, while the field of Saturn is quite weak. Further, the observed field of Jupiter is consistent with Cowling's theorem, whereas the observed field of Saturn is not outwardly consistent. Since the magnetic fields are so different, it is unlikely that, despite their similar compositions, the physical conditions in the interiors of Jupiter and Saturn are so similar.

References:

[1] Cao, H., Russell, C. T., Christensen, U. R., and Dougherty, M. K. (2010), American Geophysical Union, Fall Meeting 2010

[2] Yu, Z.J., and Russell, C.T. (2009), *Geophys. Res. Lett., 36*, L20202.