Original Text – Some information out of date: WFD – 27 Jan 2016

DIGITAL SOLAR SYNOPTIC CHARTS

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H-alpha synoptic charts were first developed by McIntosh [1972a, 1972b,1972c] as an outgrowth of efforts to infer solar magnetic fields from images obtained by solar flare patrols established to support solar-terrestrial prediction services. Charts have been regularly compiled and used for this purpose by the Space Environment Laboratory (SEL) of the National Oceanic and Atmospheric Administration (NOAA) in Boulder, Colorado. Preliminary versions began appearing monthly in Solar-Geophysical Data in 1973, and, shortly thereafter, in the NOAA weekly "Preliminary Report and Forecast of Solar-Geophysical Data." More complete charts were published as an atlas for the period of solar cycle 20 (1964- 1974) by McIntosh, [1979]. A complete description of the inference techniques, methods of compilation, and an evaluation of the H-alpha synoptic charts' reliability and utility can be found in that atlas.

H-alpha synoptic charts contain a wealth of information including the locations of filaments, filament channels, large sunspots, plage, coronal holes, and large-scale magnetic polarity. While the charts have proved valuable for research and forecasting [Roelof and Krimigis, 1973; McIntosh et al., 1976; McIntosh 1981; McIntosh and Wilson, 1985], the main limitation to their application has been the problems of handling large amounts of data in the printed form. An important development was made in 1989 when the collection was put into digital form by McIntosh and his co-workers at Space Environment Laboratory and by Suess at the NASA Marshall Space Flight Center. The digital versions of the charts do not include the full range of data available in the original charts but they contain the key elements: the large-scale magnetic field structure (positive or negative polarity) and the locations of coronal holes (also positive or negative polarity).

The digital synoptic maps were brought to IPS Radio and Space Services in Australia during an extended visit by McIntosh during 1989-90. At IPS, the maps were put into a standard format and computer programs were established to display the maps [Thompson, Willock and McIntosh, 1991] as well as to generate displays of sequences of map segments (stackplots) [Willock, Thompson and McIntosh, 1992]. This work resulted in the publication of an atlas of stackplots [McIntosh, Willock and Thompson,1991].

H-alpha synoptic charts display the entire solar globe in cylindrical, heliographic coordinates based on Carrington Rotations of 27.2753 days. They show patterns of neutral lines (lines of magnetic polarity inversion) mapped from filaments and from a variety of chromospheric structures whose forms and presence are governed by magnetic fields [McIntosh, 1972a, 1979]. Superposed on these patterns are the coronal holes observed with x-ray images (1973-74) and inferred from HeI lambda 10830 A spectroheliograms (1975-1987).

Most of the data on the charts come from solar images obtained in the H-alpha (lambda 6563 A line of neutral hydrogen, that reveal a wealth of fine structure formed by the influence of magnetic fields on the solar chromosphere and low corona. The H-alpha structures which form into interconnecting systems associated with lines of polarity reversal are: filaments, filament channels, fibril patterns surrounding active regions, plage corridors, and arch-filament systems. The positions of neutral lines are inferred from daily solar images, accumulating information on the complete patterns of neutral lines as structures form and disappear in, and above, the solar surface.

Photographic images are required to infer the neutral lines because: (1) full-disk images are necessary for derivation of absolute solar coordinates, and (2) photographic images still surpass electronic imagery in resolution when recording the full solar disk. Spatial resolution of at least 2 arcseconds, or 1 part in 1000 per solar diameter, is necessary for recognition of fibril patterns and for detection of narrow plage corridors. These features can indicate the location of important segments of neutral lines.

The inference of lines of polarity inversion from structures formed in magnetic fields can be a most valuable alternative to data derived by magnetographs, whose signal can be distorted by numerous physical and line-of-sight difficulties. Furthermore, the numerous patrol observatories operating in a global network provided H-alpha data with few interruptions, whereas magnetographs operated intermittently and at low resolution through the early part of the data interval, and even today do not form a complete synoptic patrol. The H-alpha inferred data, therefore, are complementary to the more objective, but less complete, magnetograph data.

An important aspect of the synoptic chart format is that it incorporates information about evolving features into a single chart for each rotation of the Sun. During the passage of a feature across the solar disk over a 13-15 day period, daily maps of a feature refine the determination of its coordinates, and confirm the existence of the more subtle portions of inferred neutral lines. The integration of data from all daily observations of a given solar location allows the interconnection of neutral lines not revealed by any single solar image. Some neutral lines extend uninterrupted around the entire solar globe. Others form into large cells that may reflect the scale of giant convective elements beneath the solar surface [Bumba and Howard, 1965; McIntosh, 1972b].

The outlines of coronal holes were scaled from daily spectroheliograms in HeI lambda 10830, provided by the Kitt Peak station of the National Solar Observatory in Tucson, Arizona. Only the data prior to August 1979 (CR1685) were mapped from coronal hole boundaries determined by Kitt Peak observers. All others were scaled independently by McIntosh, using a series of daily images to discern coronal holes from other complex aspects of the images by watching the bright coronal hole areas rotate across the solar disk. The variability of image quality and the intrinsic variability of the coronal holes required that the scaling use consistency among the daily images, and some continuity from earlier solar rotations.

The rotation-averaged nature of the charts has limitations for their use in studies of the short-term evolution of features. However, for studying the longer-term evolution of the Sun, this convenient format has advantages; evident when segments of many charts are combined to form stackplots.

Acknowledgements

The H-alpha synoptic charts were digitized and displayed as computer bitmaps with software developed at SEL by Michael Pearson, Randy Smith, and Vern Raben, extending software first written by Bill Retallack. The conversion of the bitmap archive to digital arrays was accomplished by Dr. Steve Suess of NASA Marshall Space Flight Center, freeing these data for transport to other computer systems and allowing computer analysis. At IPS Radio and Space Services, Craig Bevins, Colin Yuile, and Joe Van provided the computer system support so necessary for successful implementation of the programs used to process and display the digital synoptic maps. The assistance of all of these people is gratefully acknowledged.

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