SUDDEN IONOSPHERIC DISTURBANCE (SID)

Sudden Ionospheric Disturbance (after *Wikipedia, 2014*) – A sudden ionospheric disturbance (SID) is an abnormally high ionization/plasma density in the D region of the ionosphere caused by a solar flare. The SID results in a sudden increase in radio-wave absorption that is most severe in the upper medium frequency (MF) and lower high frequency (HF) ranges, and as a result often interrupts or interferes with telecommunications systems. The Dellinger effect, or Mögel–Dellinger effect, is another name for a sudden ionospheric disturbance. The effect was discovered by John Howard Dellinger around 1935 and also described by the German physicist Hans Mögel in 1930. The fadeouts are characterized by sudden onset and a recovery that takes minutes or hours.

When a solar flare occurs on the Sun a blast of intense ultraviolet and x-ray radiation hits the dayside of the Earth after a propagation time of about 8 minutes. This high energy radiation is absorbed by atmospheric particles, raising them to excited states and knocking electrons free in the process of photoionization. The low-altitude ionospheric layers (D region and E region) immediately increase in density over the entire dayside. The ionospheric disturbance enhances VLF radio propagation. Scientists on the ground can use this enhancement to detect solar flares; by monitoring the signal strength of a distant VLF transmitter, sudden ionospheric disturbances (SIDs) are recorded and indicate when solar flares have taken place.

Short wave radio waves (in the HF range) are absorbed by the increased particles in the low altitude ionosphere causing a complete blackout of radio communications. This is called a short-wave fading. These fadeouts last for a few minutes to a few hours and are most severe in the equatorial regions where the Sun is most directly overhead. The ionospheric disturbance enhances long wave (VLF) radio propagation. SIDs are observed and recorded by monitoring the signal strength of a distant VLF transmitter. SIDs are classified in a number of ways including; ShortWave Fadeouts (SWF), Sudden Cosmic Noise Absorption (SCNA), Sudden Enhancement of Atmospherics (SEA/SDA), Sudden Phase Anomalies (SFA), Sudden Enhancements of Signal (SES), Sudden Field Anomalies (SFA) and Sudden Frequency Deviations (SFD).

NGDC Dataset: SIDS

The Sudden Ionospheric Disturbances (SID) table lists one line per SID event. This table gives the date, beginning, maximum, and ending time in UT of each event; an importance rating; a widespread index; the number of station reports by type; and the H-alpha and/or X-ray flare time, X-ray classification, and NOAA/USAF region number, if known. The selected times of beginning, maximum, and ending are usually those of a sudden phase anomaly (SPA). The time chosen is selected considering the amplitude of the event and the time of the associated flare, if known. If SPA events are not available, shortwave fadeout (SWF) events are used to determine the times. In the table D = greater than, E = less than, U = approximate time. The importance rating is obtained by the subjective averaging of the importances reported by all stations for all the different types of SID. The importance rating is based on a scale of 1- the least to 3+ the most important.

The degree of confidence of identifying the event is reported by the stations as a subjective estimate (definiteness rating). This helps to decide whether the reported event is an SID or not. From the reports believed to be SIDs, a widespread index is prepared based on their geographic positions. The index ranges from 1 (possible -- single station) to 5 (definite -- event noted over whole sunlit hemisphere). An index of 3 indicates that the event reports came from roughly the same 30 degree rectangular area. Some phenomena are listed if noted at only one location if a flare or other type of flare-associated effect was reported for that time. In the flare column an * represents no flare patrol as yet available for the time of the event, and "No Flare" means that no flare was observed even though there was a flare patrol at that time. We consider also whether other reports are available from that longitude on that date.

The following table gives the two-letter station code, the types of SID reports submitted, and their monitoring frequencies. The SID data originated through the auspices of the International Ursigram and World Days Service (IUWDS), and private interested individual observers (AAVSO). Greater detail concerning the SID reports is in "The Listing of Sudden Ionospheric Disturbances," by J. Virginia Lincoln [Planet. Space Sci., 12, 419-434, 1964] and in earlier versions of this text.

SIDs and GIDs (gradual ionospheric disturbances) are detected in a number of ways: shortwave fadeouts (SWF), increases in cosmic noise absorption (SCNA), enhancement or decrease of low frequency atmospherics (SEA or SDA), sudden phase anomalies at VLF (SPA), sudden enhancements at VLF (SES), sudden phase anomalies at LF (SPA and SFA (Sudden Field Anomalies)), and sudden frequency deviations (SFD).

SWF -- Short Wave Fadeouts (SWF) events are recognized on field-strength recordings of distant high-frequency radio transmissions (1-30 MHz). The abnormal fades of field-strength not obviously ascribable to other causes are described as shortwave fadeouts with the following further classifications:

- S-SWF (S) - sudden dropout and gradual recovery
- Slow S-SWF (SL) - dropout taking 5 to 15 minutes and gradual recovery
- G-SWF (G) - gradual disturbance: fade irregular in either dropout or recovery or both.

The importance rating depends on; a) the degree to which the normal field strength is reduced (at midday a relatively smaller decrease may be as significant as a very deep fade earlier or later in the day); b) the duration of the fade, especially at the minimum phase (the longer the duration, the greater the importance); and c) the definiteness of the event. For importance rating 1- to 3+, roughly use:

1-	if duration is 14 minutes or less;
1	if 15-29 min;
1+	if 30-44 min;
2-	if 45-59 min;
2	if 60-74 min;
2+	if 75-89 min;
3-	if 90-104 min;
3	if 105-119 min;
3+	if greater than 120 min.

Raise the importance one step if the depth of the fade is equal to or greater than twice the normal variations from the median or diurnal trend line. Lower one step if the depth of fade is less than twice the normal variations.

For definiteness rating; 5 = definite, 4 = reasonably definite, 3 = reasonable, 2 = fair, 1 = possible, and 0 = questionable. Definiteness depends on the frequency recorded, the time of day, the presence of minor interference, the presence of a calibration signal, or the occurrence of an event during intermittent transmission from the station being monitored, etc. Depending on the depth and width of an event, use 4 or 5 if the event is obvious and well-defined before drawing the diurnal trend line; use 2 or 3 if the event then stands our clearly after drawing the diurnal trend line; and use 0 or 1 if the separation of the event from the background fading pattern is questionable after drawing the diurnal trend line. Use a higher rating if the depth of fade is greater than twice the normal variations from the diurnal trend line during middle daylight hours or three times the normal variations during early or late daylight hours, and the width is more than half an hour. Reduce the rating two units if it is likely that the fade was influenced by propagation mode changes, magnetic storms, wide fading pattern, equipment failure, etc. See J.V. Lincoln, *Planet. Space Sci., 12*, 419-434, 1964.

SCNA-SEA -- Sudden Cosmic Noise Absorption (SCNA) at 18-25 MHz are sudden decreases in the field strength of the recorded cosmic noise signal, followed by gradual recovery. Sudden Enhancement of Atmospherics (SEA) are sudden increases in the field strength of low-frequency recordings near 27 kHz. Similar rules as for SWF may be used to report SCNA and SEA. Importance guidelines are: 1 = small intensity change usually of relatively short duration, 2 = moderate intensity change and relatively long duration, 3 = great intensity change and relatively long duration. SCNA importance can be the % absorption ("(In-If)/In) x 100" where "In" is the noise diode current required to give a recorder reflection equal to that which would occur in the absence of a flare, and "If" is the noise diode current required to give a deflection equal to the level at the time of maximum absorption.

SPA and SES -- Sudden Phase Anomalies (SPA) are observed as a phase shift of the downcoming skywave on VLF recordings or on pulse measurements on LF recordings. An estimate of the intensity can be obtained in terms of the degree of phase shift [See Chilton, C.J., et al., J. Geophys. Res., 68, 5421-5435, 1963]. The length of path and amount of sunlight on the path must, of course, be considered. Sudden Enhancements of Signal Strength (SES) are observed on field strength recordings of extremely stable VLF transmissions (5 to 50 kHz). They are similar to SEA except that the receivers are narrow band and pick up manmade VLF transmissions. The definiteness system is identical to that for SWF. The importance scale is similar, but not identical. The importance scale is:

less than or equal to 18 minutes = 1-
19-25 minutes = 1
26-32 minutes = 1+
33-45 minutes = 2
46-85 minutes = 2+
86-125 minutes = 3
greater than or equal to 126 minutes = 3+

SPA recorded by LF pulse observations over a 1-hop propagation path yield information more indicative of the ionospheric changes occurring at the midpoint of the path, rather than over the entire path. LF phase observations, reported in degrees, represent an increase in sensitivity over VLF observations. The phase sensitivity is directly proportional to the ratio of the frequencies for identical paths. However since the height of energy deposition is related to the type of flare x-rays emitted, the LF measurements in conjunction with the VLF measurements will tend to indicate the x-ray intensity range. Since the LF signal can apparently be reflected from either of two layers within the D-region [Doherty, R.H., Radio Science, 2, 645-651, 1967], phase retardations as well as phase advances may occur during an SID at LF.

The amplitude of the low frequency pulse observations made at Loran stations normally changes during an SID. This change is usually, but not always in the direction of a signal enhancement (SES). The height of signal absorption is below the height of signal reflection.

LF amplitude observations along with the LF and VLF phase observations for any one event tend to indicate the x-ray intensities associated with that event. Amplitude changes are reported in dB to the nearest dB of voltage change. Since 6 dB represents doubling of the received signal and 20 dB represents a 10-fold change in amplitude, it is obvious that many SIDs produce large effects in LF propagation.

Guidelines for SPA importance; 1- = less than 45 degrees phase advance, 2 = more than 70 to 80 degrees phase advance, 2+ = more than 100 degrees phase advance, and 3 = more than 150 degrees phase advance. For LF SPA importance; 1- = less than 100 degrees phase advance, 2 = more than 200 degrees phase advance, and 3 = more than 300 degrees phase advance.

SFA -- On LF amplitude recordings on paths about 1000 km long, Sudden Field Anomalies (SFA) can be detected. These are events recognized by indirect phase measurements made evident by the 1-hop sky wave interfering with the ground wave.

SFD -- A Sudden Frequency Deviation (SFD) is an event where the received frequency of an HF radio wave reflected from the ionosphere increases suddenly, peaks, and then decays back to the transmitted frequency. Sometimes several peaks occur and usually the frequency deviation takes on negative values during the decaying portion of an SFD. The peak frequency deviation for most SFDs is less than 0.5 Hz. The start-to-maximum time is typically about 1 minute. SFDs are caused by sudden enhancements of ionization at E and F1 region heights produced by impulsive flare radiation at wavelengths from 10 - 1030A. A more complete discussion of SFDs can be found in Report UAG-36, An Atlas of Extreme Ultraviolet Flashes of Solar Flares Observed During the ATM-SKYLAB Missions, 1974, available from World Data Center A for Solar-Terrestrial Physics.

References

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