SOLAR SUB-SURFACE ACTIVITY - GEOGRAPHY

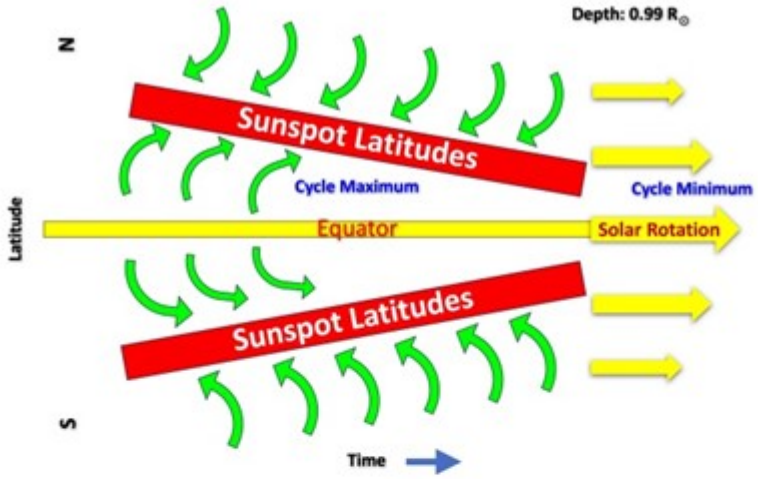
NEWS: An international team of solar physicists have traced giant tides of plasma **beneath the Sun's surface** at a region called **near-surface shear layer (NSSL).**

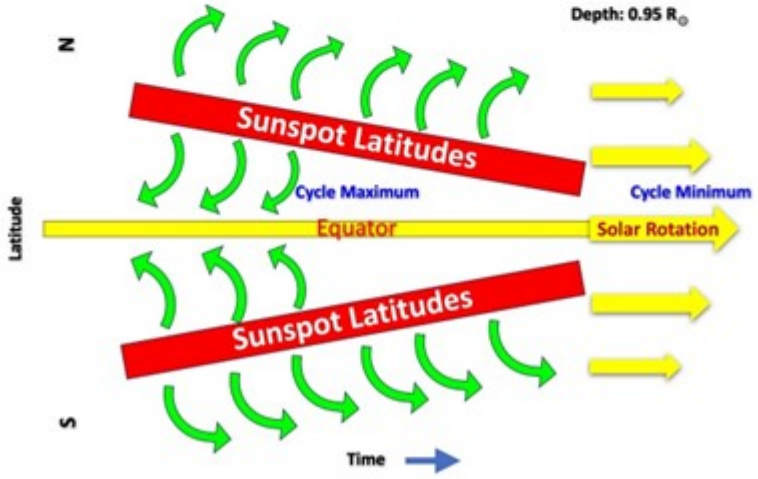
Using over a decade of data and a technique called **helioseismology**, the team has tracked how these plasma currents change over time in sync with the Sun's **11-year sunspot cycle**

WHAT'S IN THE NEWS?

Key Observations on Solar Sub-Surface Activity

1. **Plasma Flows Beneath the Sun's Surface:**
    - Plasma flows beneath the Sun's surface converge at sunspot zones but reverse direction midway through the Near-Surface Shear Layer (NSSL).
    - These plasma flows influence local motion, but they do not drive the Sun's large-scale torsional oscillations, suggesting the presence of deeper, as yet unknown drivers of solar dynamics.
2. **Active Regions:**
    - Active regions generate rotational shear and meridional flow patterns.
    - These flows are influenced by the Coriolis effect, similar to the storm systems seen on Earth.
3. **Helioseismology:**
    - Helioseismology involves the study of sound waves traveling through the Sun's interior.
    - It helps map the Sun's internal structure, dynamics, and activity by analyzing surface oscillations and vibrations, providing insights into solar behavior.
4. **Near-Surface Shear Layer (NSSL):**
    - The NSSL, located about 35,000 km beneath the Sun's surface, shows varying rotational behavior with depth and time.
    - This behavior is influenced by sunspot-related magnetic fields, affecting the Sun's surface dynamics and activity.





About the Solar Cycle

1. **11-Year Cycle:**
    - The solar cycle lasts approximately 11 years, during which the Sun’s magnetic field flips and returns to its original polarity.
    - Solar activity, including sunspots and solar flares, increases toward the solar maximum and decreases toward the solar minimum.
2. **Sunspot Count:**
    - Sunspot count serves as a key indicator of the solar cycle's progression.
    - Increased sunspot activity correlates with heightened solar activity and magnetic field changes.
3. **Magnetic Changes:**

- Magnetic changes during the solar cycle drive increased surface activity and energy releases, influencing space weather and solar phenomena.

Solar Surface Features and Their Characteristics

Feature	Description	Impact/Behavior
Sunspots	Dark, cooler regions with intense magnetic activity	Increase during solar maximum; affect magnetic dynamics and solar output
Solar Flares	Sudden, intense explosions of energy	Emit radiation across the electromagnetic spectrum; disrupt satellites and communications
Coronal Mass Ejections (CMEs)	Massive bursts of solar plasma and magnetic field	Can cause geomagnetic storms on Earth, disrupting technology and infrastructure
Plasma Tides	Flows of ionized gas beneath the Sun's surface, influenced by solar dynamics	Converge and diverge beneath the surface, shaped by the Coriolis effect
Torsional Oscillations	Global-scale interior flow patterns in the Sun	Not powered by shallow flows; suggest deeper, unknown forces driving solar dynamics
Meridional Flows	Pole-to-equator currents beneath the Sun's surface	Affected by sunspots and the Coriolis force, influencing solar surface activity

Impact of Solar Activities on Earth and Infrastructure

1. **Space Weather Hazards:**
    - Increased solar activity, such as solar flares and CMEs, can disrupt satellite operations, GPS signals, and radio communications.
    - High-energy radiation from solar events can also interfere with various communication systems and navigation technologies.
2. **Power Grid Vulnerability:**
    - Geomagnetic storms caused by CMEs can induce strong currents in power grids, damaging transformers and electrical infrastructure.
    - These disruptions can lead to widespread power outages and long-term infrastructure damage.
3. **Auroras:**

- Solar storms can trigger spectacular auroras near Earth's polar regions, resulting from solar particles interacting with Earth's atmosphere.
- These visual phenomena are an indirect effect of solar activity and highlight the energetic interactions between the Sun and Earth's magnetosphere.

4. **Radiation Exposure:**
    - Astronauts and individuals in high-altitude flights face higher radiation risks during intense solar flares.
    - Increased solar radiation poses a risk to human health and technological systems in space and the upper atmosphere.
5. **Navigation and Communication:**
    - Solar flares can cause high-frequency (HF) radio blackouts, affecting aviation and maritime communication and navigation.
    - The degradation of communication signals can disrupt critical operations in various sectors.
6. **Climate Influence (Minor/Indirect):**
    - Long-term variations in solar output, though minimal, can influence Earth's upper atmosphere temperature and circulation patterns.
    - This can have minor but measurable effects on climate variability, especially over extended periods.
7. **Technological Systems:**
    - Satellites may experience orbit perturbations and drag changes due to atmospheric heating from solar energy bursts.
    - This can affect the longevity and operational efficiency of space-based systems, such as communication satellites.

Source: https://dst.gov.in/scientists-chart-suns-subsurface-weather-tied-its-11-year-activity-cycle