CMEs and Space Weather

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Flares and Coronal Mass Ejections

Powerful flares are often accompanied by CMEs in the active regions.
Flares and CMEs – cont.

Short duration flares – no significant eruptions/CMEs

Long duration flare – usually followed by CMEs
Coronal Mass Ejection from a Filament Eruptions

The most energetic CMEs occur in close association with powerful flares in the active regions.

Nevertheless large-scale CMEs do occur in the absence of major flares even though these tend to be slower and less energetic.
CME Properties

- Mass: \( \sim 10^{15-16} \) g
- Speed: few hundred - 3000 km/s

..or

- Mass: \( \sim 1 \) million Nimitz-class aircraft carriers
- Speed: 1.5 - 10 million km/hour

- Arrives to Earth in 1-2 days
CME score

• A new category system for CMEs based on frequency of detection and speed
• Complements Flare Classes
• Applicable in space weather operations and research
Quick quiz

What do you think is causing CME?
CME Mechanism

Magnetic Reconnection – the release of free magnetic energy, transformed to heat and particle acceleration

Magnetic field at the base of the convective zone is stressed and pushed to surface due to convection motion

Newly emerged magnetic field interacts with the existing field, reconnection/reconfiguration takes place, leading to heating, flares and eruptions/CMEs
CME Interaction with the Earth’s Magnetic Field
CME Arrival at the Earth – Geomagnetic Storms

CME Arrival at ACE/Discover
Geomagnetic Storm Kp Index

Max KP Level: Moderate

Kp – index (German “Kennziffer” – characteristic digit)
CME Modeling – Space Weather Storms

2012–07–12T00:00

2012–07–12T00 +0.00 day

Ecliptic Plane

LAT = 4.05°

N90 LON = 0°

W180 R = 1.0 AU

ENUL=2.7 lowres=2125-a5b1f WSA_V2.2 60NG–2125

IMF polarity

Current sheath

3D IMF line
Quick Quiz

What physical parameters of CME do you think are important for the strength of the geomagnetic storm?
CME: Space Weather Impacts - Magnetopause Compression
CME: Space Weather Impacts – Geomagnetic Storm, GIC

Lasts few hours to 1-2 d after CME arriving at Earth

Geomagnetically Induced currents

An average CME can dump about 1,500 gigawatts of electricity into Earth’s atmosphere—about twice the power-generating capacity of the entire United States!

Electric blackout

Transformer damage saturation
Geomagnetic storms result in electron radiation enhancement in the near-Earth space: lasts 1-3 days

Affecting spacecraft electronics – surface charging/internal charging
CME Space Weather Impacts - SEP

Contributes to SEP (particle radiation): 20-30 minutes from the occurrence of the CME and after the CME arrival
United Airlines polar routes

Source: United Airlines
The END.