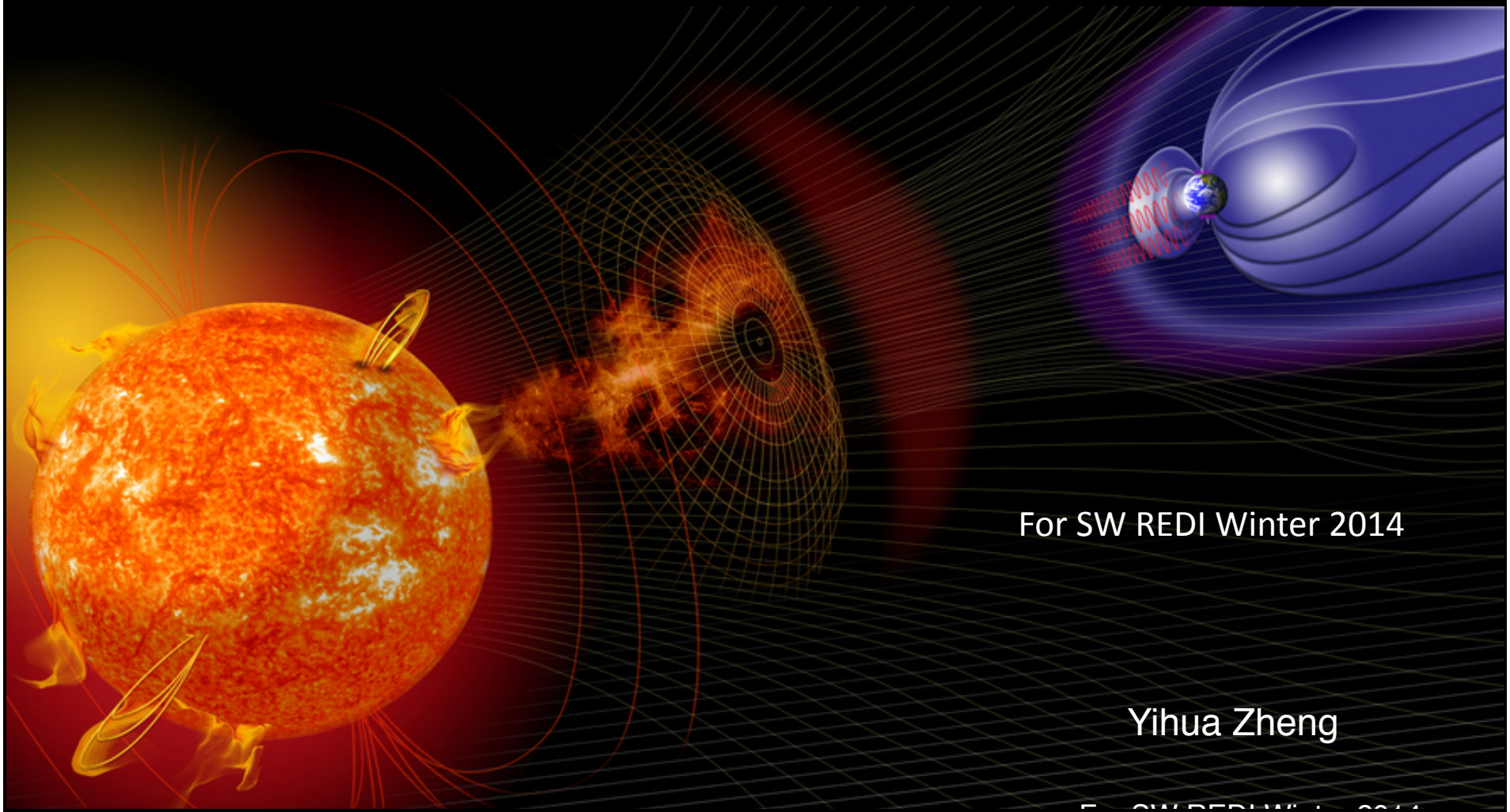
Overview of Space Weather Effects on Satellites



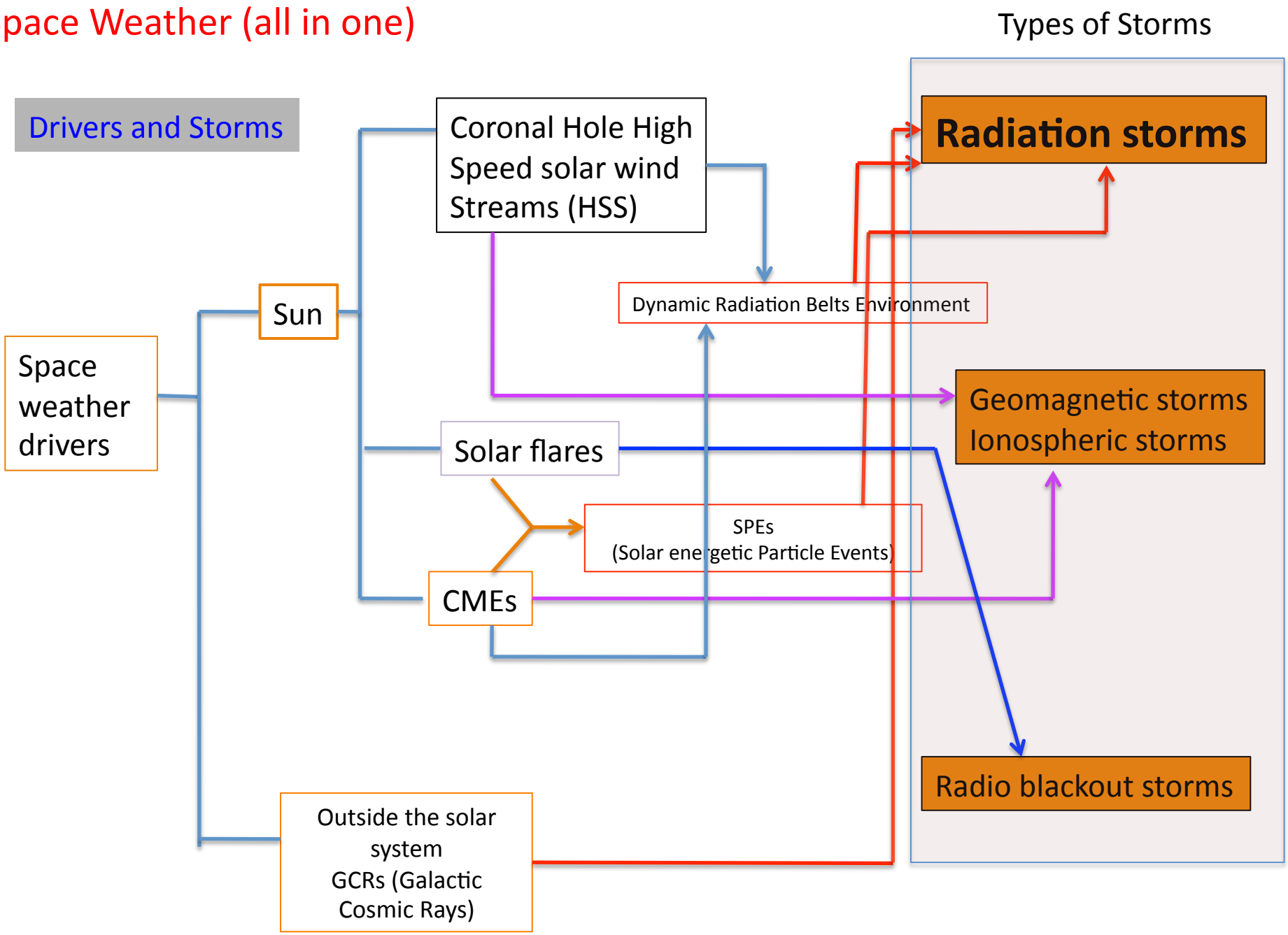
For SW REDI Winter 2014

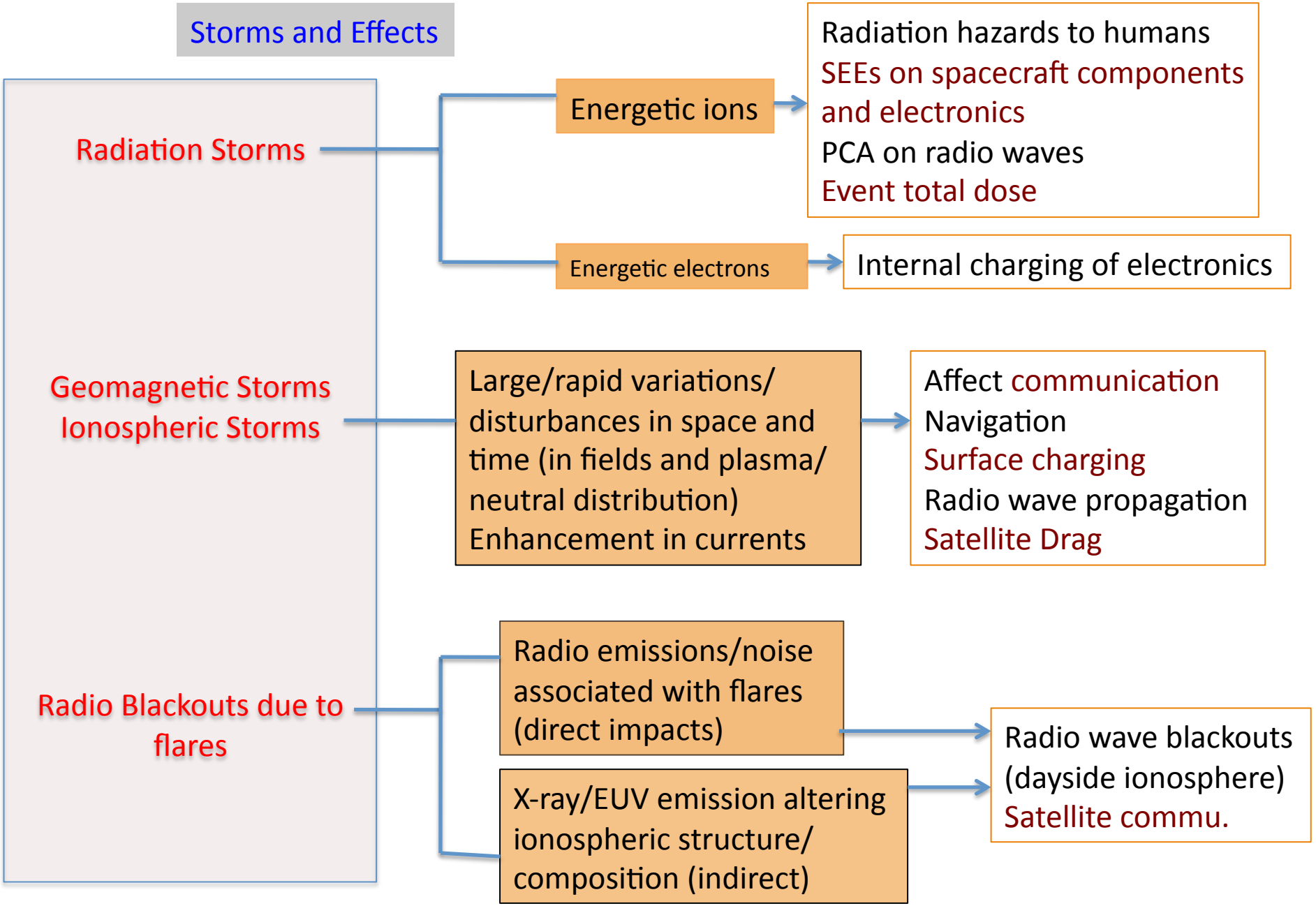
Yihua Zheng

Outline

- Space Weather all in one
- Space Weather Impacts on spacecraft
  - Direct impacts on SC components
  - Impacts on SC orbit
  - Impacts on SC communications

Space Weather (all in one)




Storms and Effects
Radiation Storms
Energetic ions
Radiation hazards to humans
SEEs on spacecraft components and electronics
PCA on radio waves
Event total dose
Energetic electrons
Internal charging of electronics
Geomagnetic Storms
Ionospheric Storms
Large/rapid variations/ disturbances in space and time (in fields and plasma/ neutral distribution)
Enhancement in currents
Affect communication
Navigation
Surface charging
Radio wave propagation
Satellite Drag
Radio Blackouts due to flares
Radio emissions/noise associated with flares (direct impacts)
X-ray/EUV emission altering ionospheric structure/ composition (indirect)
Radio wave blackouts (dayside ionosphere)
Satellite commu.

SWx Impacts on Satellites Electronics/ Components

hazards presented by the radiation and plasma environment in space

- Single Event Effects (affect all SC)
  - caused by protons and heavy ions with energies of 10s of MeV/amu
- Internal Charging (those in radiation belt)
  - caused by electrons with energies above about 100 keV that penetrate inside a vehicle
- Surface Charging (all in Earth's environment)
  - caused by electrons with energies of 10s of keV that interact with spacecraft surfaces
- Event Total Dose (all SC)
  - caused primarily by solar protons and possibly also by transient belts of trapped particles, typically protons with energies near 10 MeV

Effects on Satellite Orbit

- Satellite drag (LEO)
- Orientation effects (spacecraft that use Earth's magnetic field for orientation)

Effects on Satellite Communication

- During strong solar flares (strong radio noise)
  - Directly cause interference via solar radio noise
  - Through modification of the ionosphere
- Scintillation effects during geomagnetic storms

Environment Hazards for different orbits

Space hazard	Spacecraft charging		Single-event effects			Total radiation dose		Surface degradation		Plasma interference with communications	
Specific cause	Surface	Internal	Cosmic rays	Trapped radiation	Solar particle	Trapped radiation	Solar particle	Ion sputtering	O^+ erosion	Scintillation	Wave refraction
LEO <60°											
LEO >60°											
MEO											
GPS											
GTO											
GEO											
HEO											
Inter-planetary											

Important Relevant Not applicable

Anomaly resolution procedure

- Where is the satellite?
- Check if SEPs (solar energetic particles) play any role
- Any significant flare at the time?
- What is the geomagnetic activity?
- Scintillation effects?
- If the satellite in the radiation belt? What is the flux level? Could it be a factor?