Challenge topic

Precipitation into the ionosphere applied to spacecraft charging

Collaboration with CCMC/metrics & validation, LANL/SHIELDS

- Goals
  - Obtain improved understanding of the complex near -Earth space environment and identify main drivers of surface charging threats
  - mitigate spacecraft charging effects, assist spacecraft designers

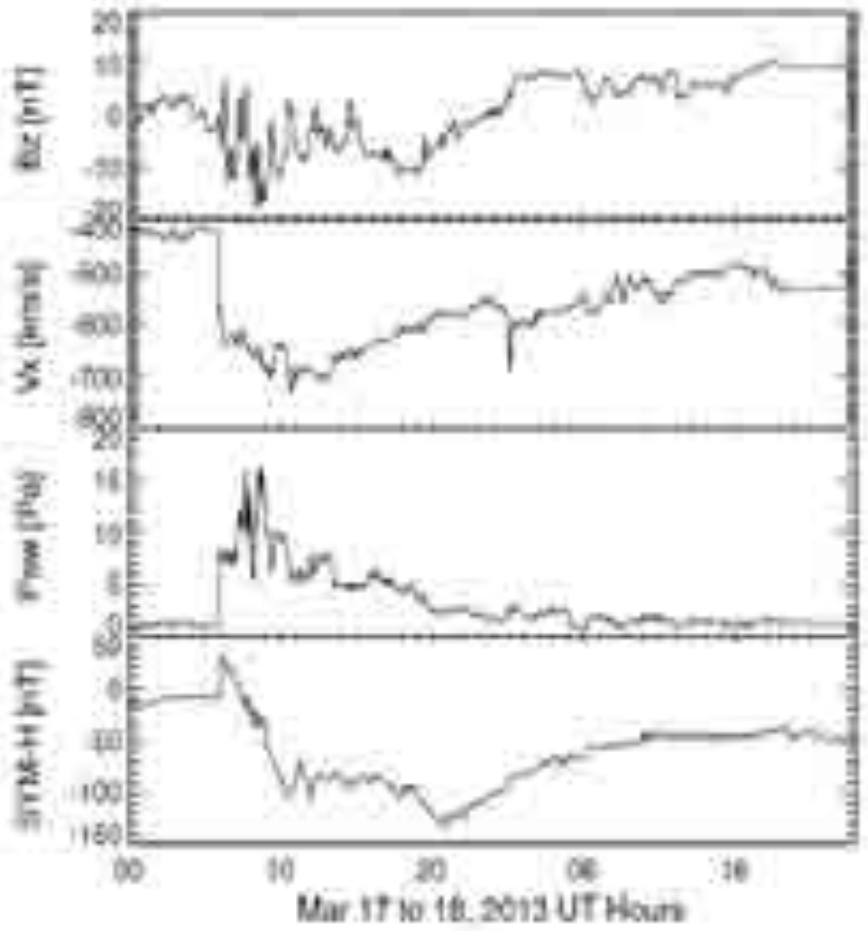
Satellite charging

- Low Earth Orbiting (LEO) satellites may be subject to surface charging events caused by:
  - precipitation (above certain particle energies)
  - (absence of) sunlight
  - electrical changes at photovoltaic arrays at day-night transitions

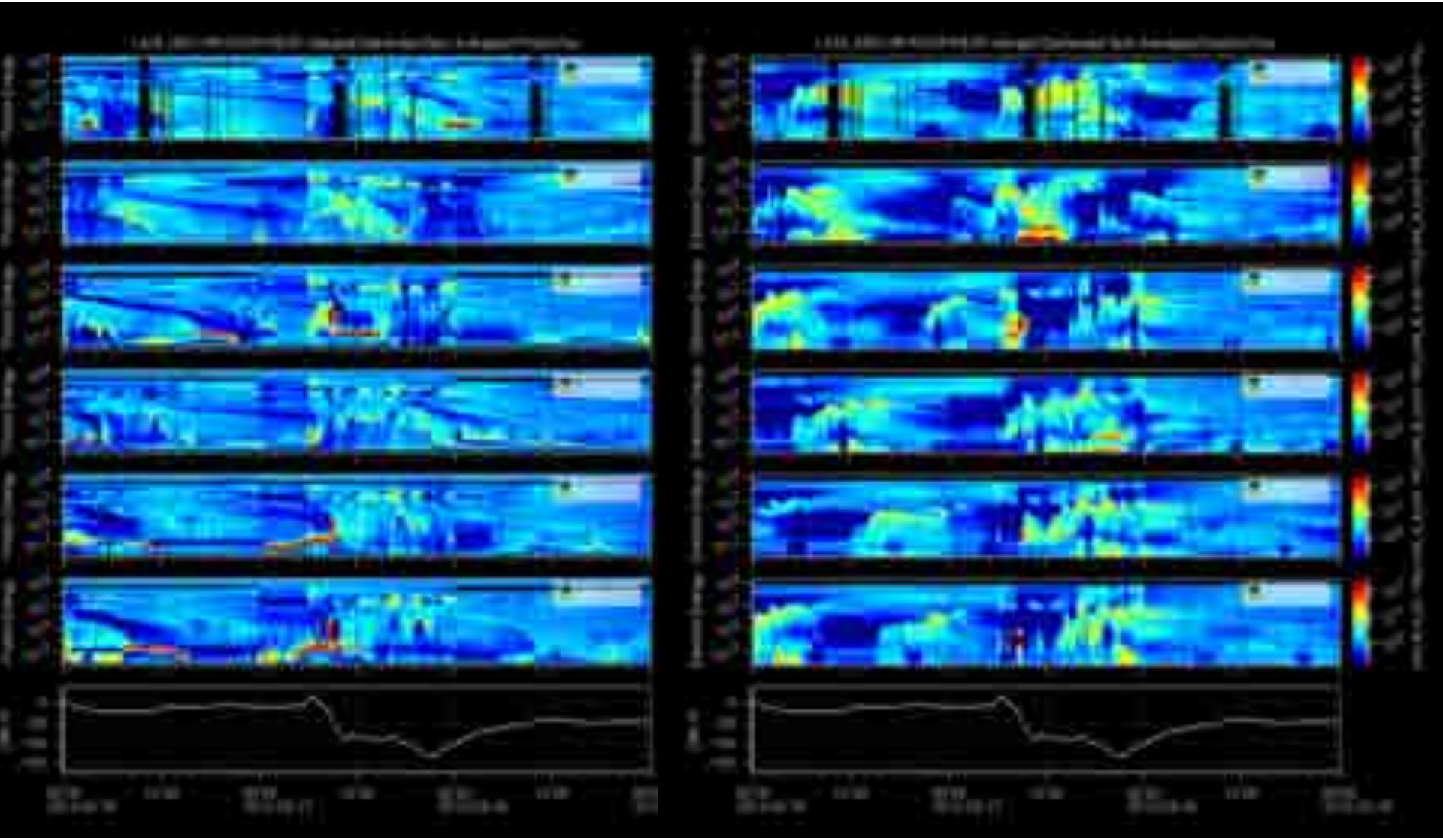
- Models to provide real time warning or post-event analysis:
  - Stand-alone inner magnetosphere (IM) kinetic models
  - Empirical ring current/radiation belt models
  - IM models driven by Global MHD models
  - Data assimilation models

Introduce Challenge Event

- Simulation of storm/substorm dynamics during 17-18 March 2013 using various approaches:
- Validation with in-situ satellite data from the Van Allen Probes & GEO satellites
- Analyze agreement with measured electron fluxes (~1 to 100 keV), electric and magnetic fields, S/C potential, sensitivity of the results …



LANL-GEO observations



Proton flux

Electron flux

Precipitation from model

- Example: Fok-RBE, differential electron fluxes provided by model on ionospheric grid.

At 10 keV:

To determine threat of charging,

…

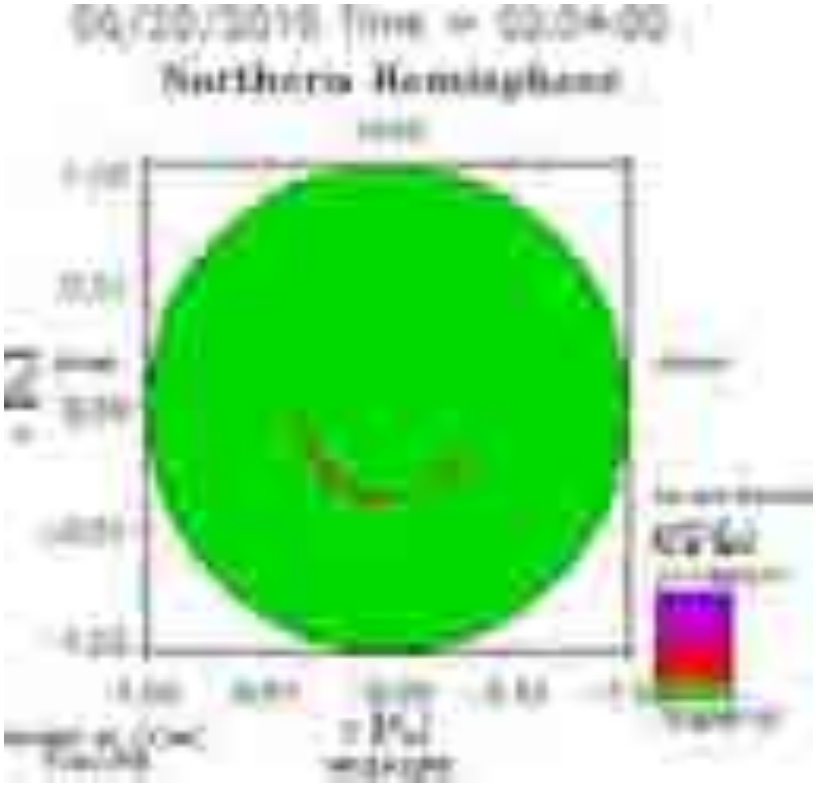
we need total flux above certain energy

…

in night side

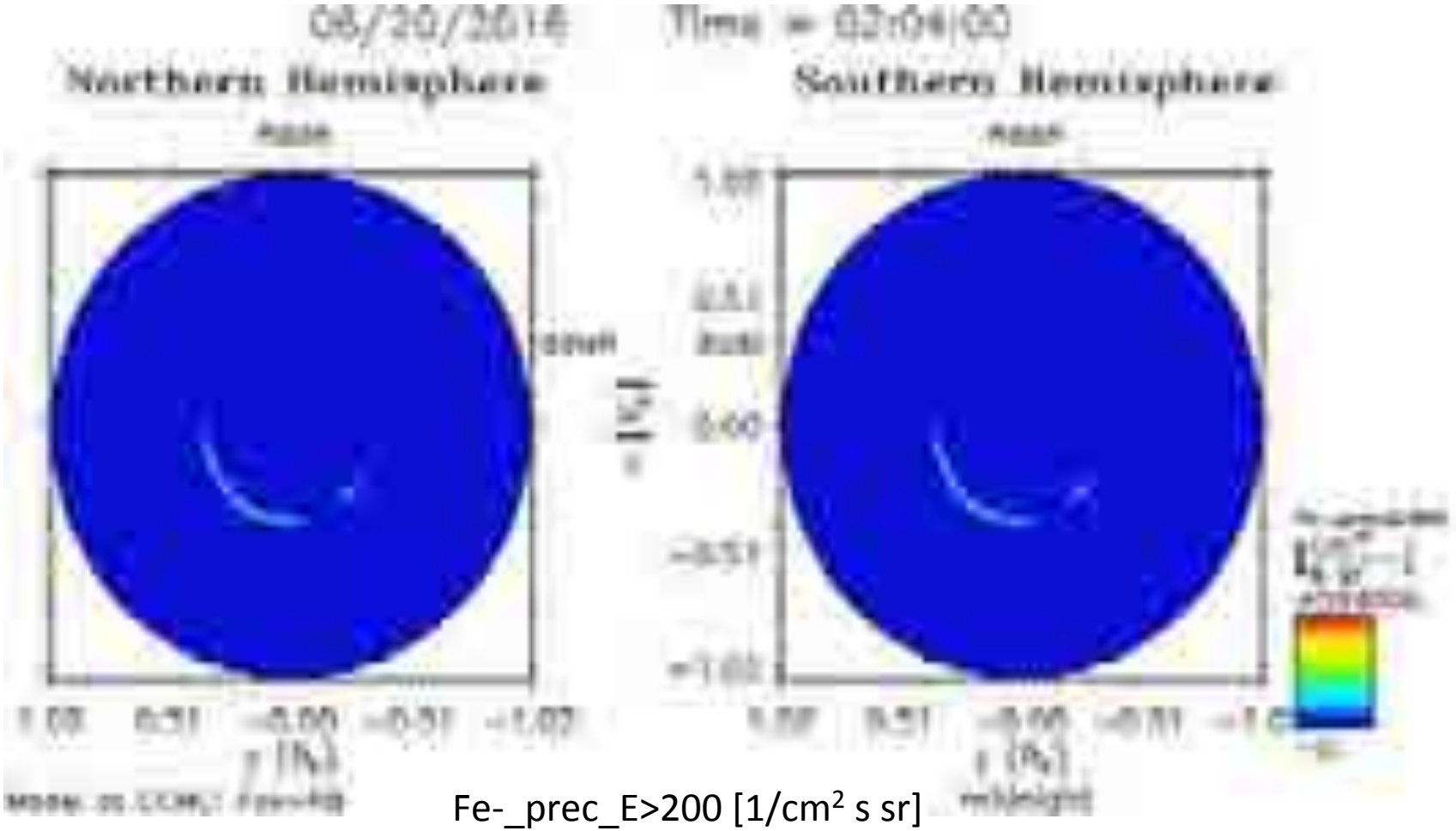
…

when plasma density is low…



Integrated flux

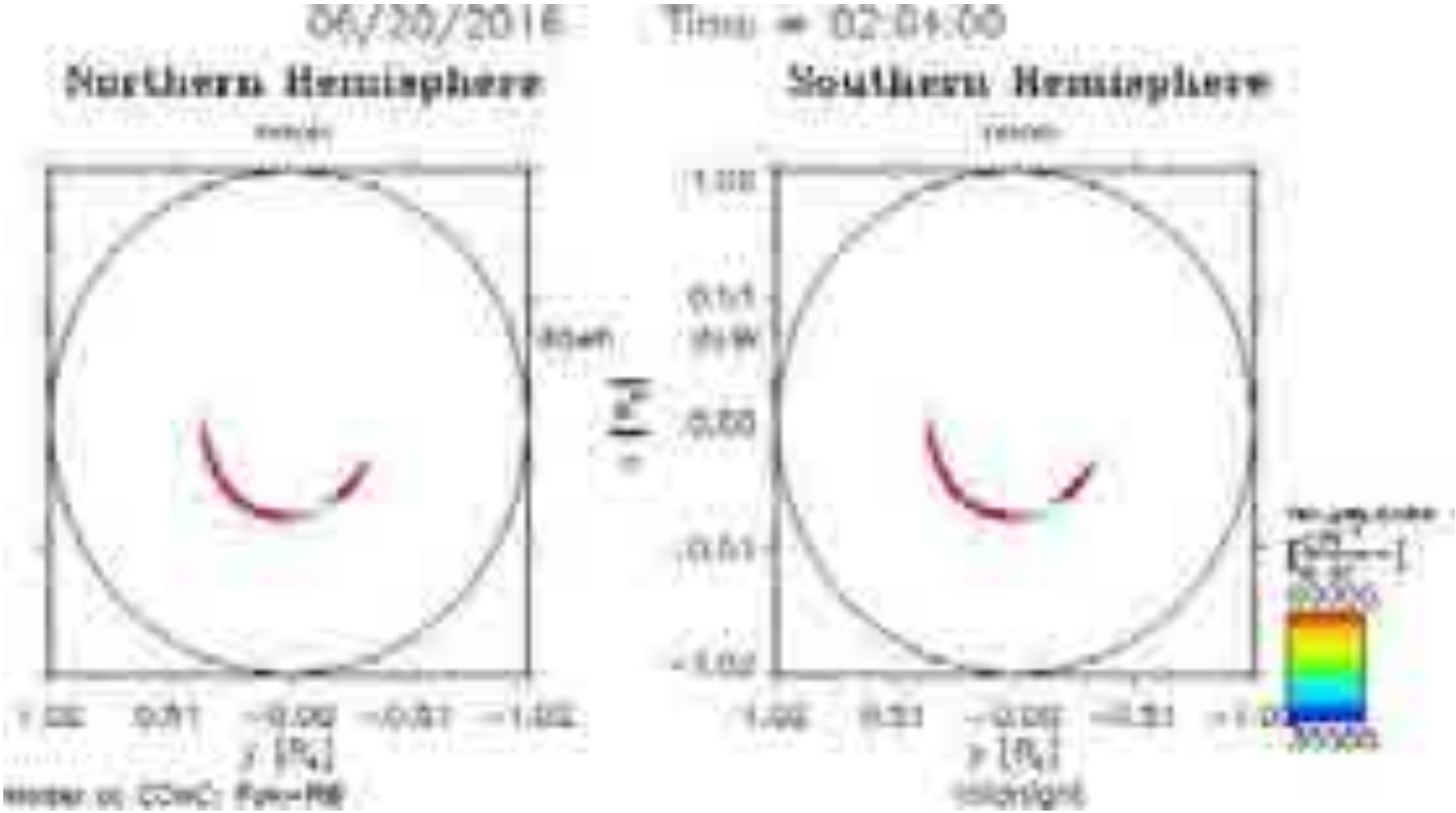
- specify threshold energy (200 keV) → integrated flux



Fe-_prec_E>200 [1/cm^2 s sr]

Apply flux threshold

- Fe-_prec_E>200 > 30000/(cm^2 s sr)

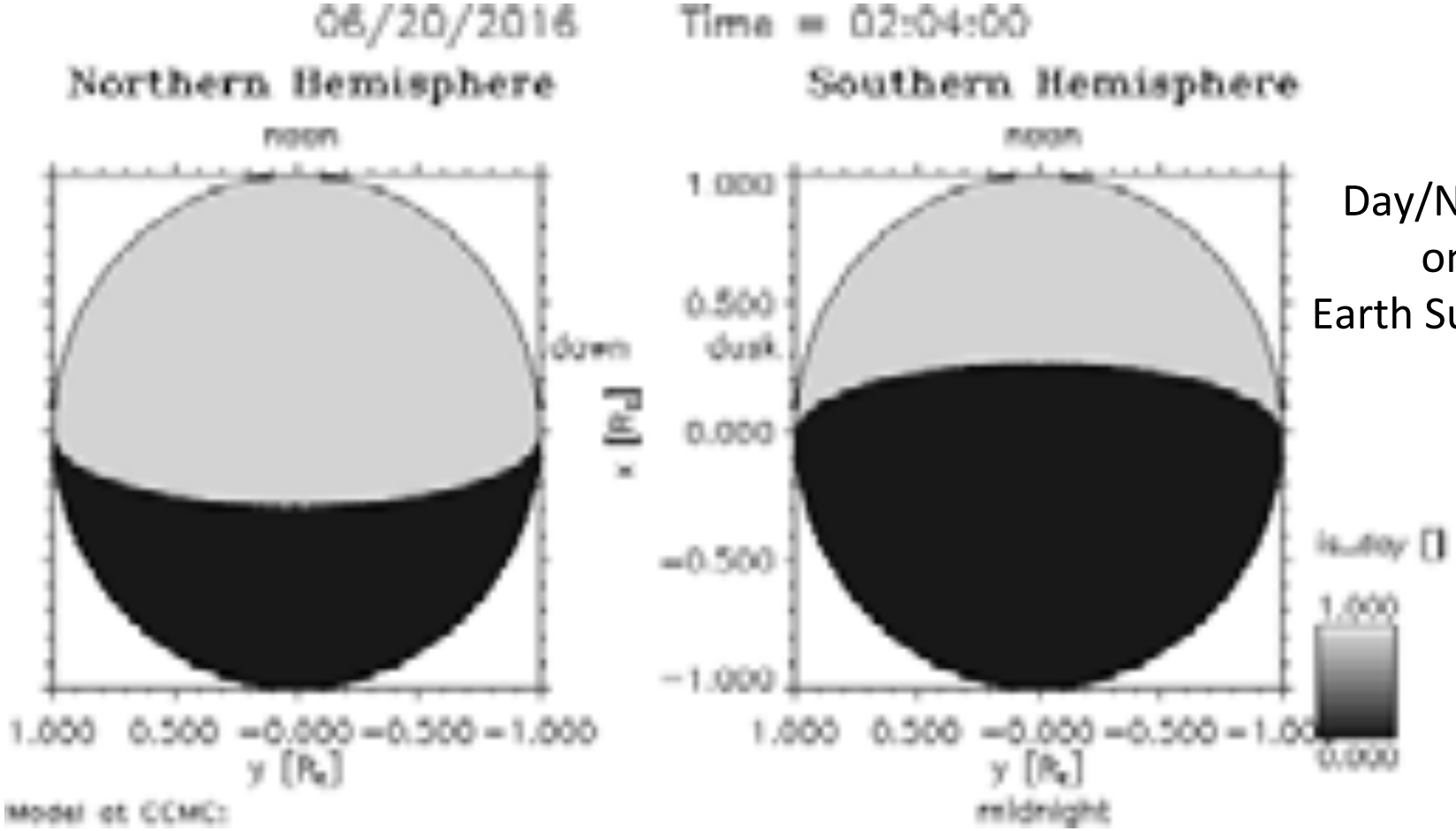


Day or Night

Sunlit Region:

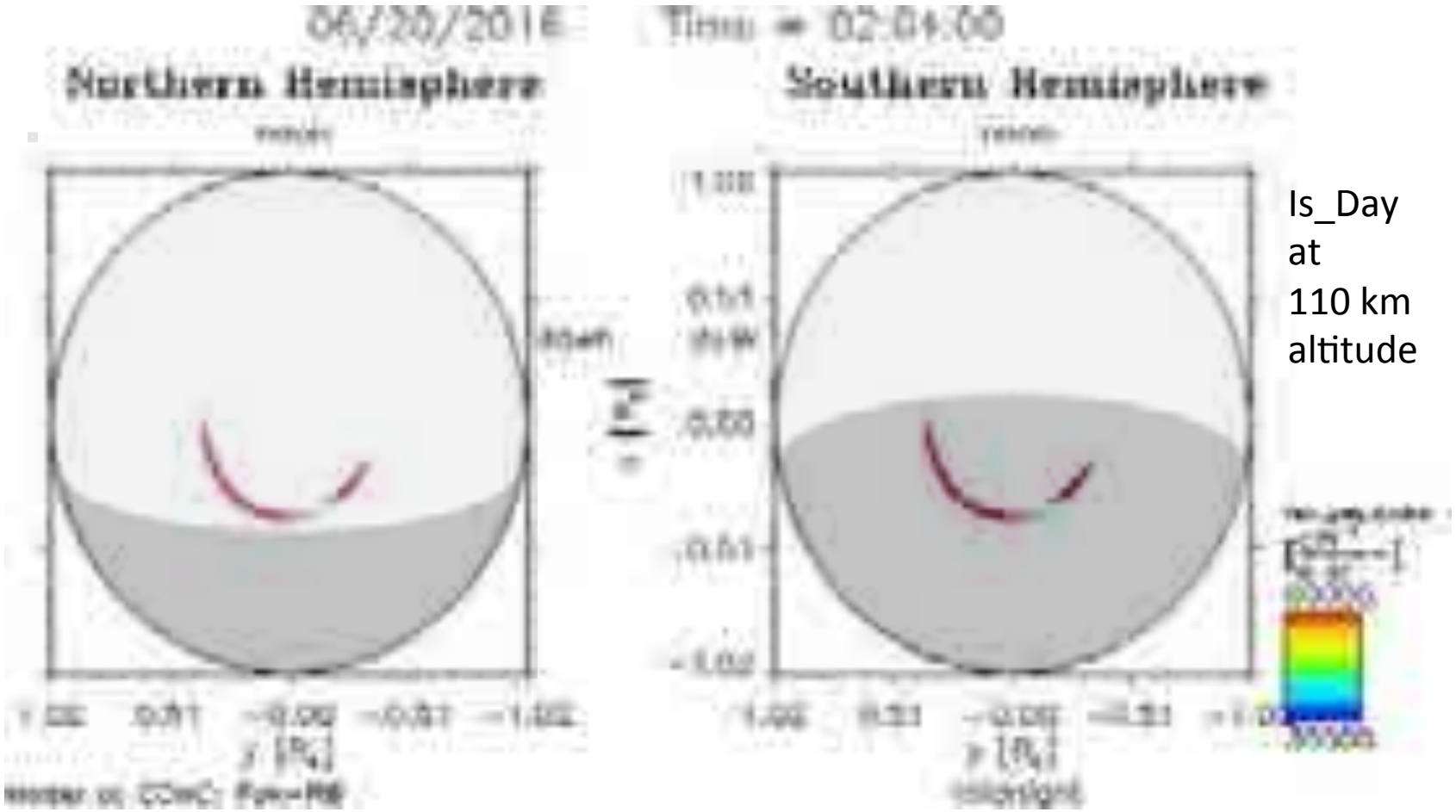
$Is\_Day = X_{GSE} > R_E \tan(p)$ OR $R_{GSE} > R_E [1 + X_{GSE} * \tan(p)]$

$R_{GSE} = \sqrt{Y_{GSE}^2 + Z_{GSE}^2}$ $\tan(p) = 0.5 R_S / AU$



Day/Night on Earth Surface

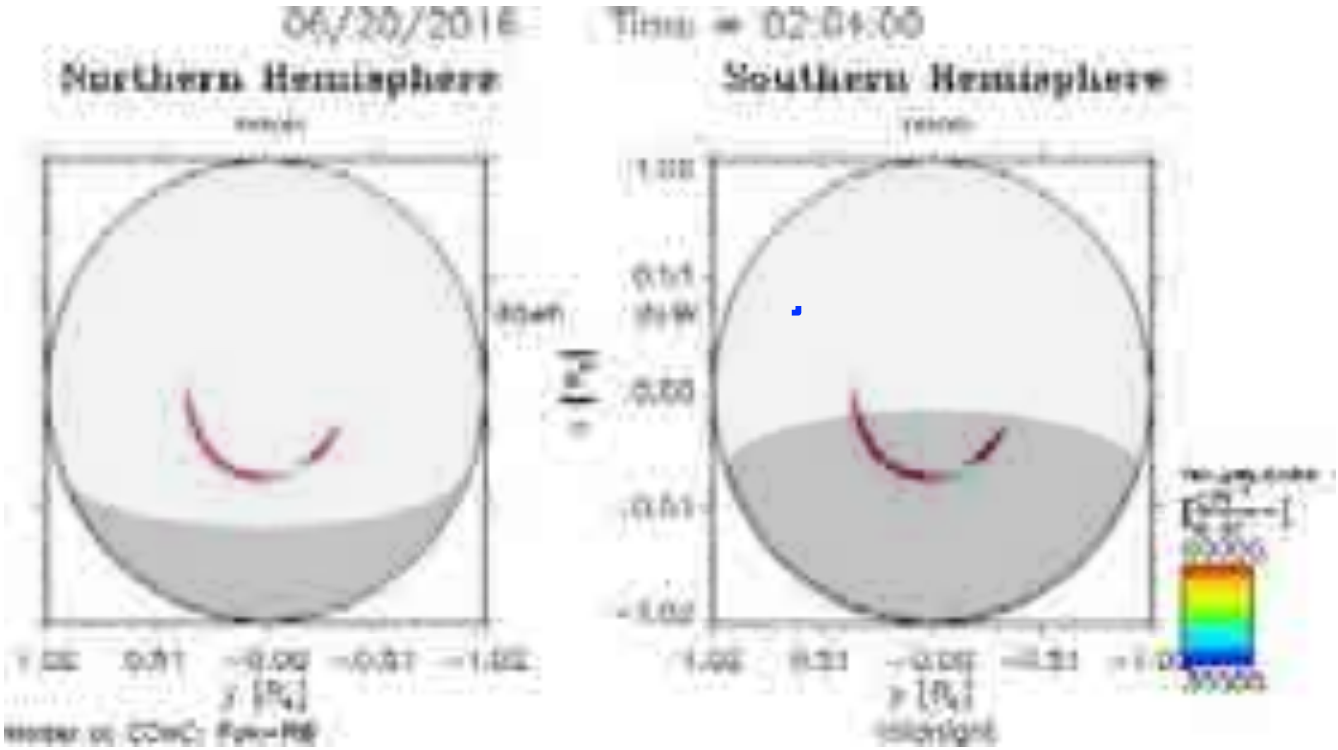
Combination: min(E), min(Flux), day/night



Day-night image overlaid with 25% opacity

Map between satellite altitude

- Example: s/c at ~400 km altitude
  - calculate day-night at 400 km
  - map satellite position and day-night to 110 km where the flux grid is located



Status and Plans (at CCMC)

- **Satellite tracking:**
  - Have mapping facilities for ionosphere
  - Have time series extraction at mapped positions
- **Add:**
  - Integrated fluxes w. energy threshold
  - Add day-or-night status flag (analytic, based on position transformed to X,Y,Z in GSE)
  - distance to region with thresholds (Energy: E0, Flux: F0) exceeded:
    Fe-_prec_E_gt_E0 > F0 and nightside
  - Apply to ensemble of models:
    - Fok-RB, CIMI, RAM-SCB, RCM-E, RCM, HEIDI (stand-alone)
    - SWMF-CRCM, SWMF-RCM, SWMF-RAMSCB, LFM-RCM, OpenGGCM-RCM (coupled)

Action Plan -- please participate!

1. Run your models for the March 17-18, 2013 event
2. Solar wind input data, LANL/GEO flux data will be online
3. Provide the simulation results to CCMC through anonymous ftp, including
   - Electron flux data as function of Energy (averaged over pitch-angle) in either the equatorial plane or the ionospheric altitude
   - Electron flux data along satellite (e.g.,Van Allen Probes)
4. CCMC will perform post-processing based on the simulation results
5. Challenge will be available online soon
   http://ccmc.gsfc.nasa.gov/challenges/index.php
6. Show results, discuss, and improve models
   - pre-AGU mini-GEM workshop (Dec 2016)
   - 2017 LANL/SHIELDS workshop
   - 2017 GEM summer workshop