THE NRL SPACE WEATHER PROGRAM: PAST, PRESENT, FUTURE

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Space Weather Workshop
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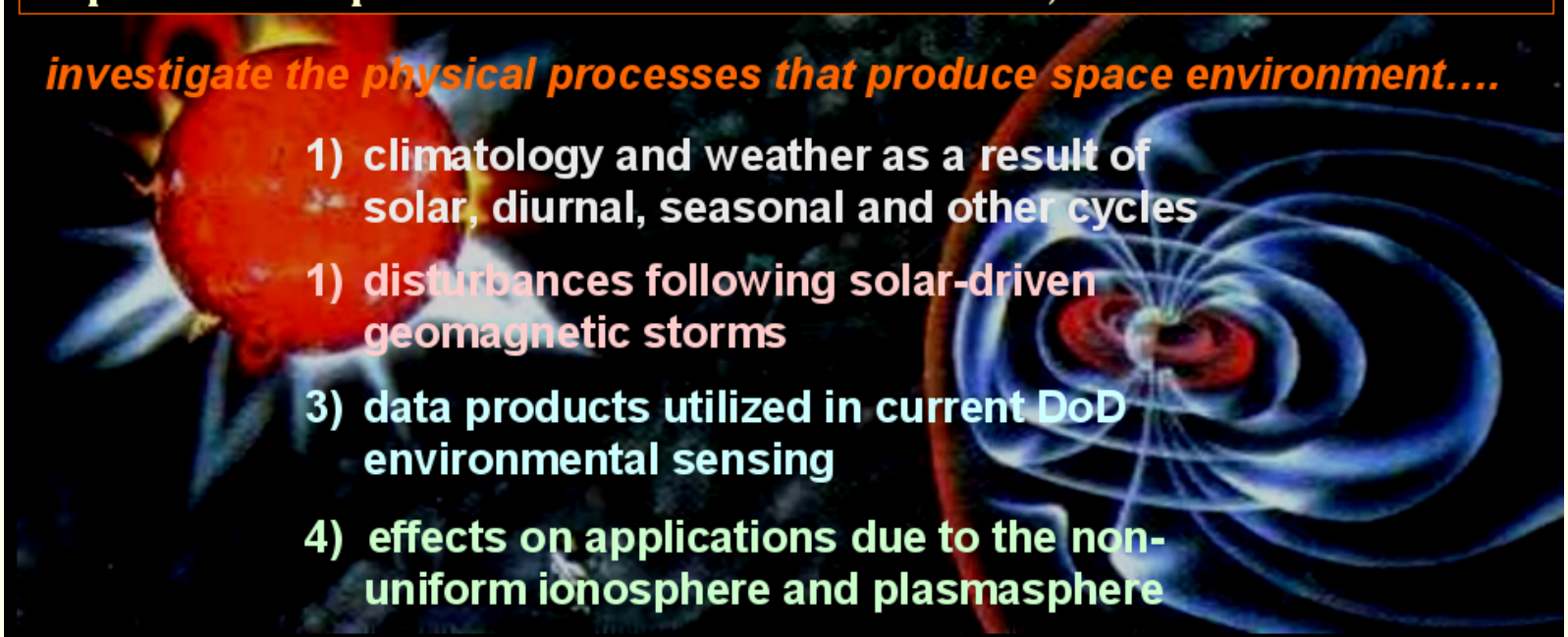
Supported by NASA and ONR

Scientific Objectives

Overall Objective:

Characterize and simulate the multiple chains of physical processes that link the Sun-Earth system, in order to advance space science and enable Naval operations to better account for, adapt to, and exploit operational impacts of the space environment due to electrons, ions and neutrals



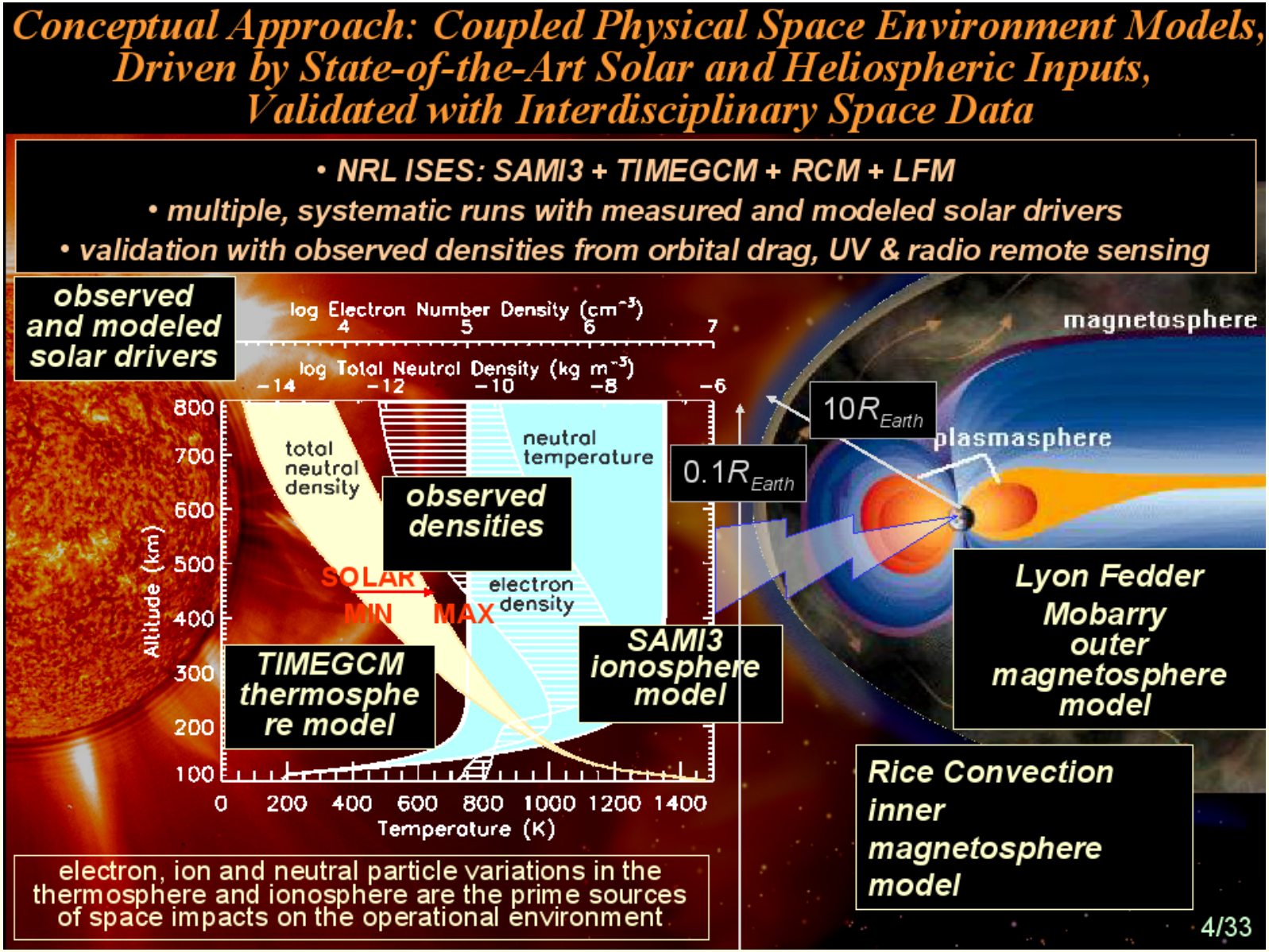
investigate the physical processes that produce space environment….

1) climatology and weather as a result of solar, diurnal, seasonal and other cycles
1) disturbances following solar-driven geomagnetic storms
3) data products utilized in current DoD environmental sensing
4) effects on applications due to the non-uniform ionosphere and plasmasphere

advance space science research, research-to-operations and operations-to-research

SPACE WEATHER AT NRL: FUTURE

NRL ISES-OE Program (PI: Judith Lean)



ONE DAY FORECASTS

One-Day Space Environment Forecasts: STEP # 1 – EUV photon impacts on TEC

- solar activity and EUV spectrum 1Day forecasts
- SAMI3 (with NRLMSIS & HWM) simulations
  - *forecast solar activity and irradiance & actual geomagnetic activity*
  - *forecast solar activity and irradiance & forecast geomagnetic activity*
  - *actual solar activity and irradiance & actual geomagnetic activity*
  - *repeat with GAIM initialization for each day*
- comparisons of forecast and observed TEC
  - *global and regional, non flaring conditions*
  - *skill score and RMS error*

Questions:

- time period? e.g., 30 days during solar minimum
- model output format, files and access?
- TEC global and regional availability?
- time frame for completion?

FIRST-PRINCIPLE MODELS

- SAMI3 (NRL ionosphere model)
- LFM (Outer magnetosphere model)
- RCM (Inner magnetosphere model)
- TIMEGCM (Thermosphere model)

$$\nabla \cdot \mathbf{J} = 0 \quad \mathbf{J} = \sigma \mathbf{E} \quad \rightarrow \quad \nabla \cdot \sigma \mathbf{E} = 0$$

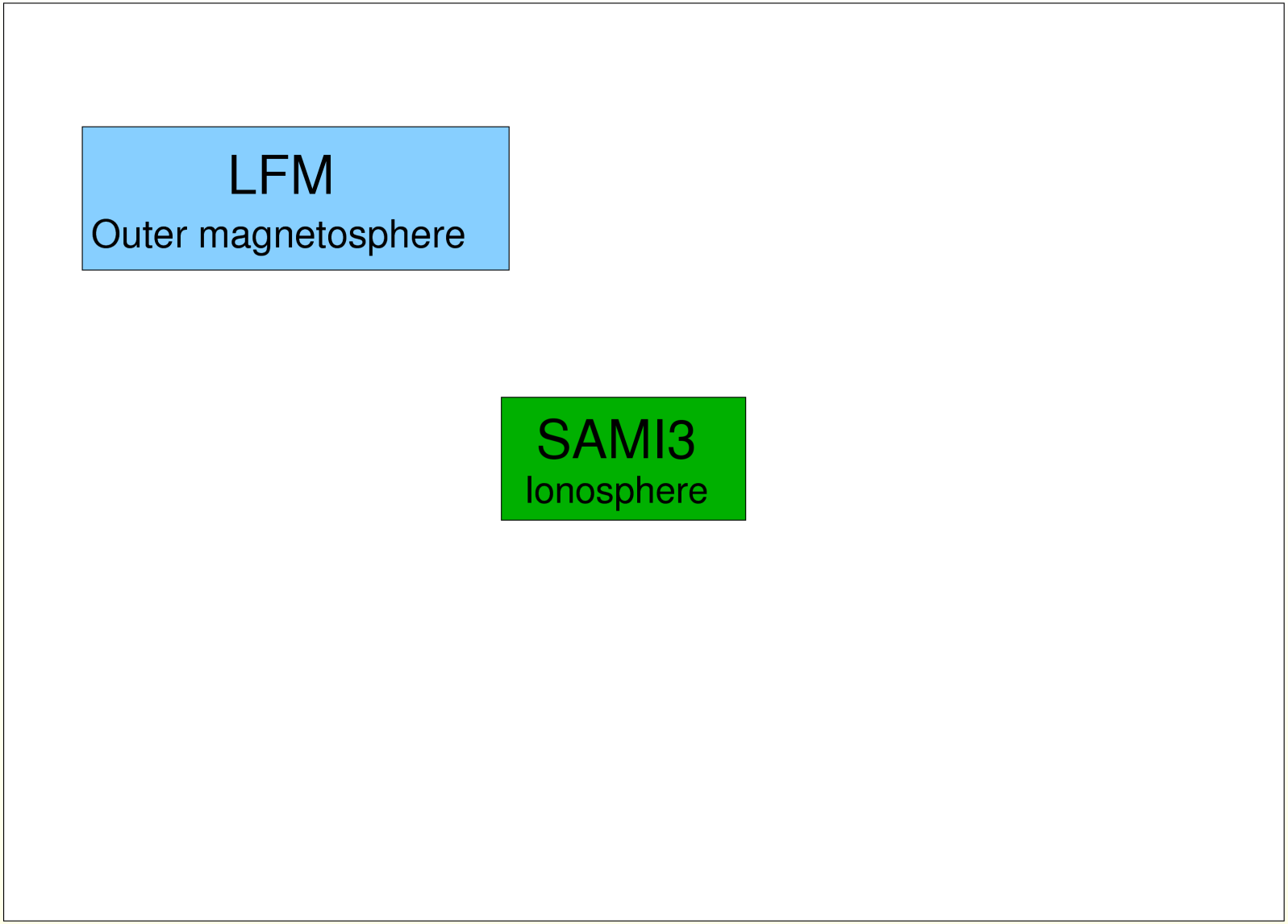
Field-line integration: $\int \nabla \cdot \sigma \mathbf{E}\, ds = 0$

$$\nabla \cdot \mathbf{\Sigma} \nabla \Phi = S(J_{\parallel}, V_n, ...)$$

$$\mathbf{E} = -\nabla \Phi$$

- Σ: Field-line integrated Hall and Pedersen conductivities
- $J_{\parallel}$: Magnetosphere driven (penetration)
- V_n: Solar and magnetosphere driven (dynamo)

SPACE WEATHER AT NRL: PAST

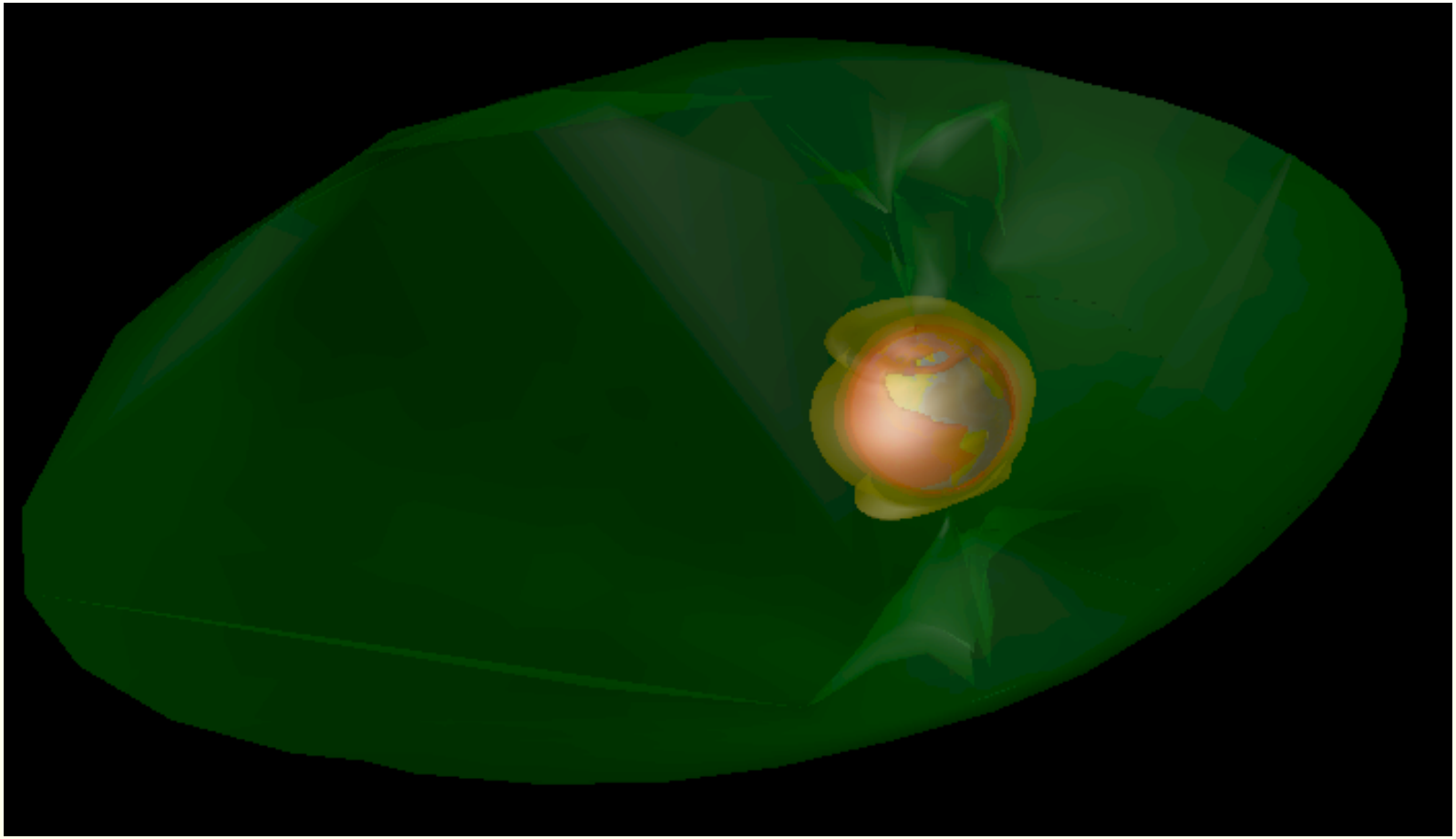


NRL SAMI3 IONOSPHERE MODEL

- Magnetic field: dipole model (aligned, tilted, offset and/or IGRF-like)
- Plasma motion
  - $\mathbf{E} \times \mathbf{B}$ drift perpendicular to $\mathbf{B}$ (vertical and zonal)
  - Dynamo electric field obtained from Fejer/Scherliess empirical model – not self-consistent (yet)
  - Parallel ion inertia
- Seven (equal) ion species (H^+, He^+, O^+, N^+, N_2^+, NO^+, O_2^+)
  - Solve continuity and momentum for all 7 species
  - Solve temperature for H^+, He^+, O^+, and e^-
- Neutral species: NRLMSISE00/HWM93 and TIMEGCM
- EUV models (EUVAC, NRLEUV, FISM)
- Nonorthogonal, nonuniform fixed grid (closed)
- Global coverage ($\pm 89^\circ$ magnetic latitude)

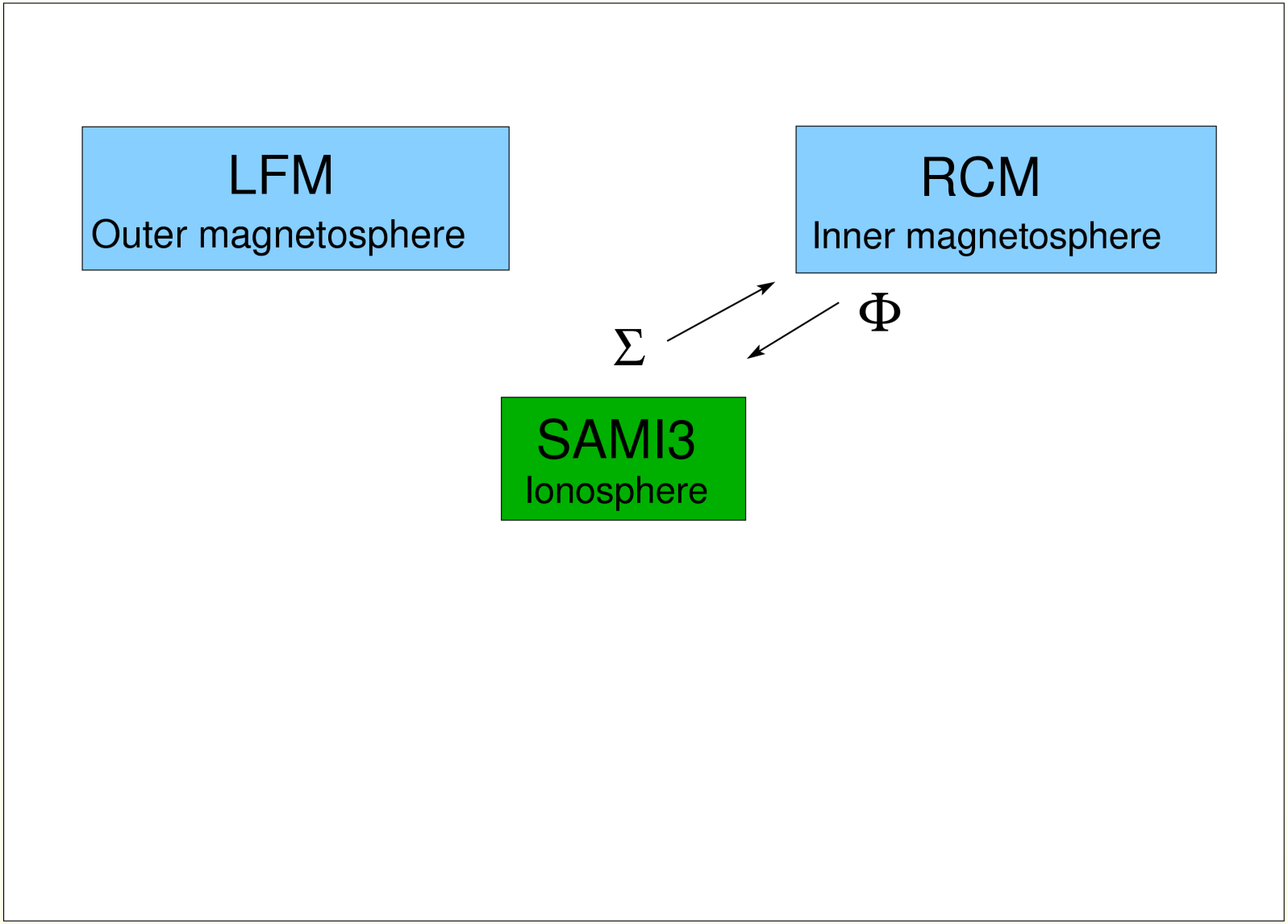
SCOPE OF SAMI3

Electron density isosurfaces



SPACE WEATHER AT NRL: PAST

Huba et al., *GRL*, 2005



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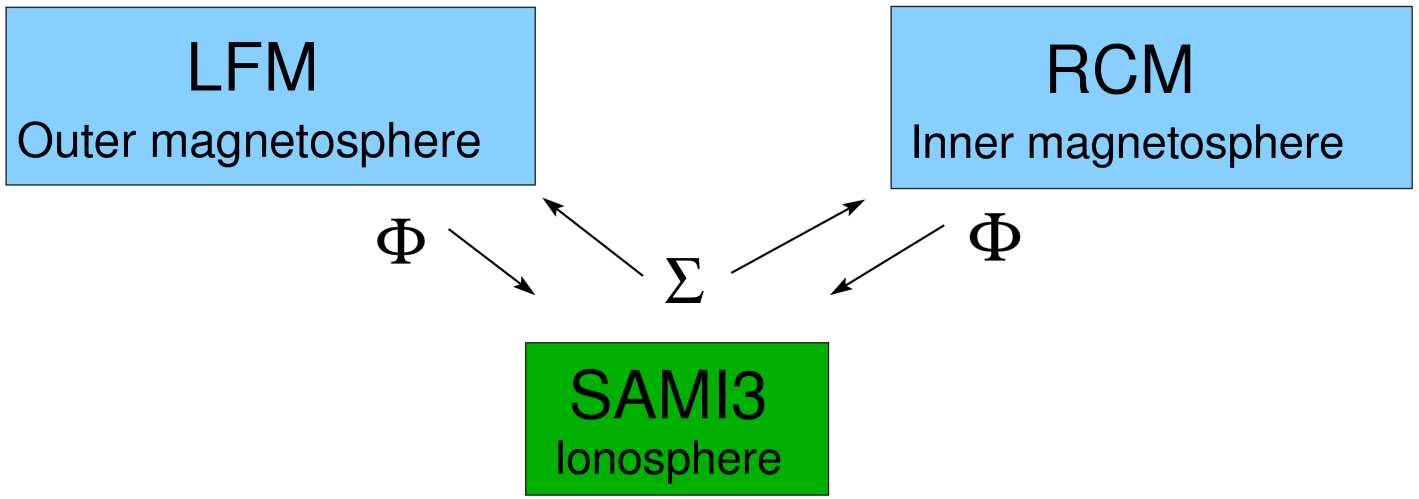
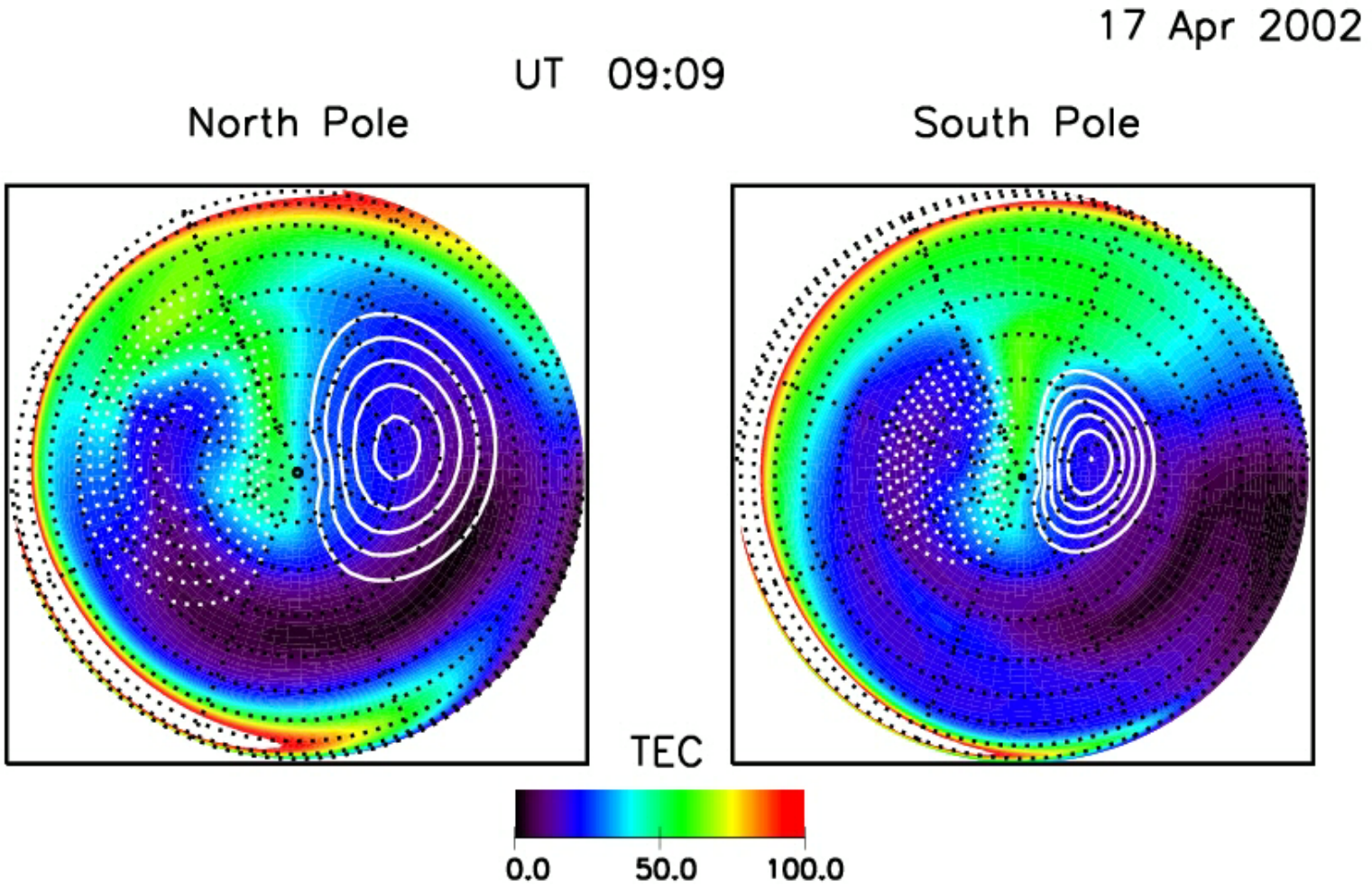
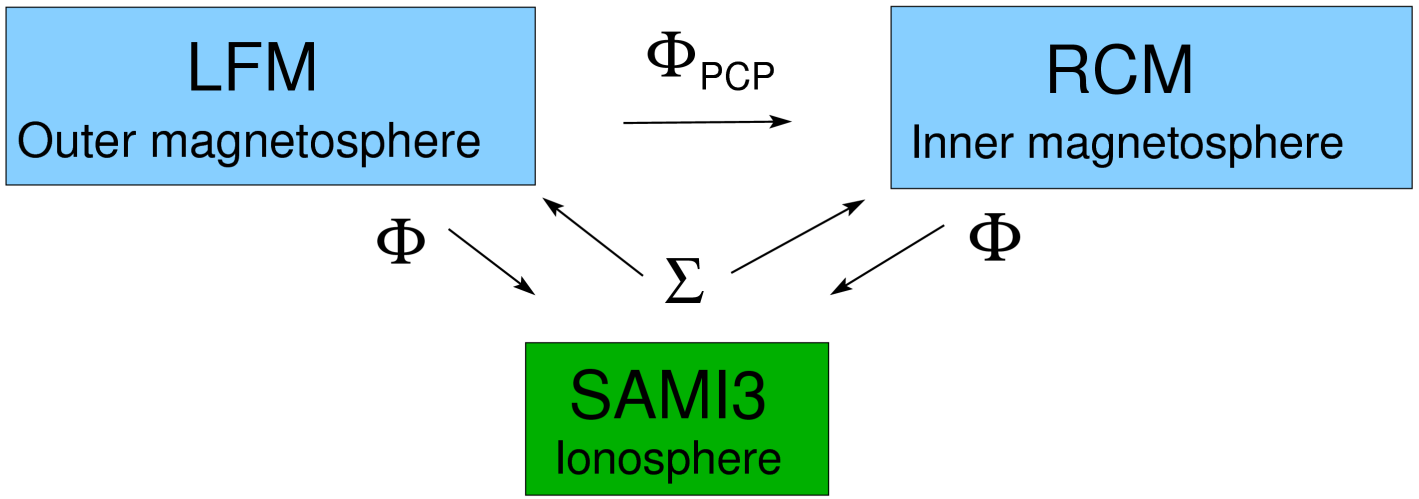


SAMI3/LFM RESULTS

17 April 2002 storm

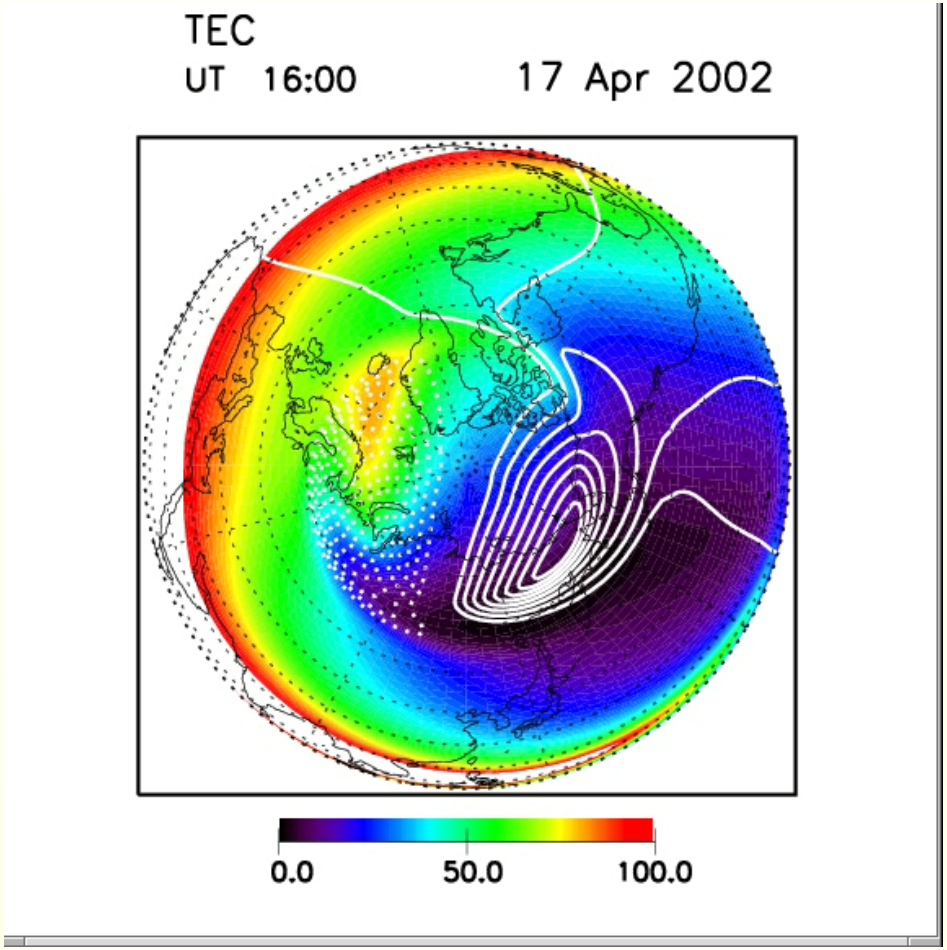


SPACE WEATHER AT NRL: PRESENT



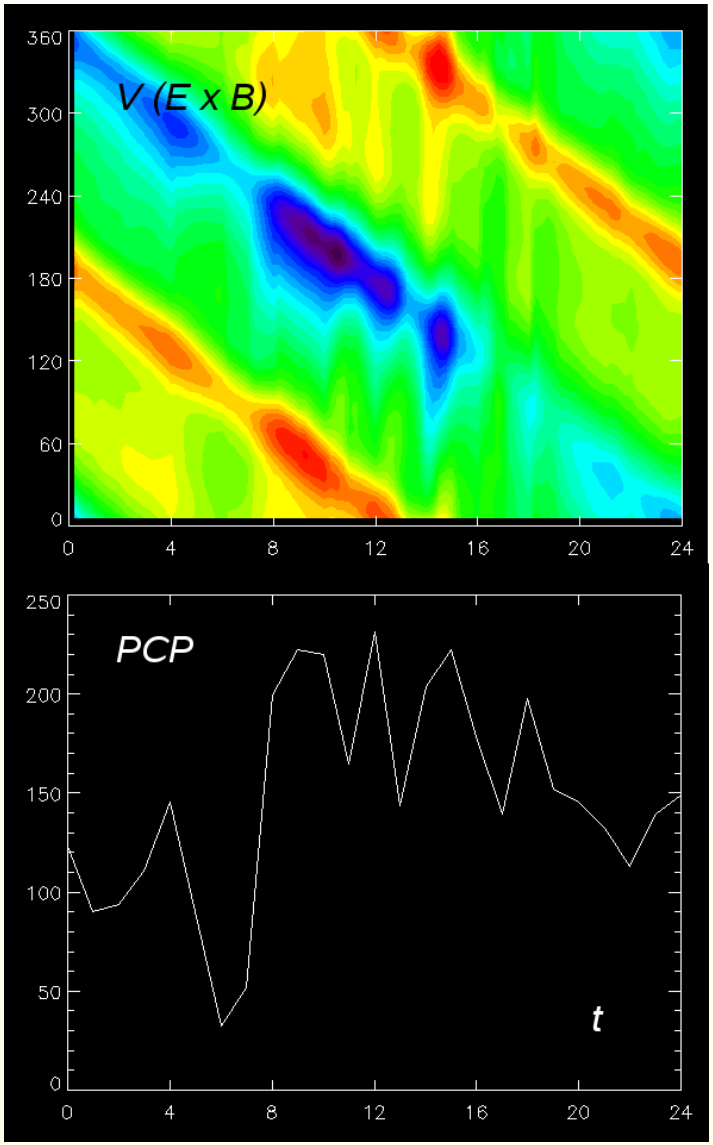
SAMI3/RCM RESULTS

17 April 2002 storm

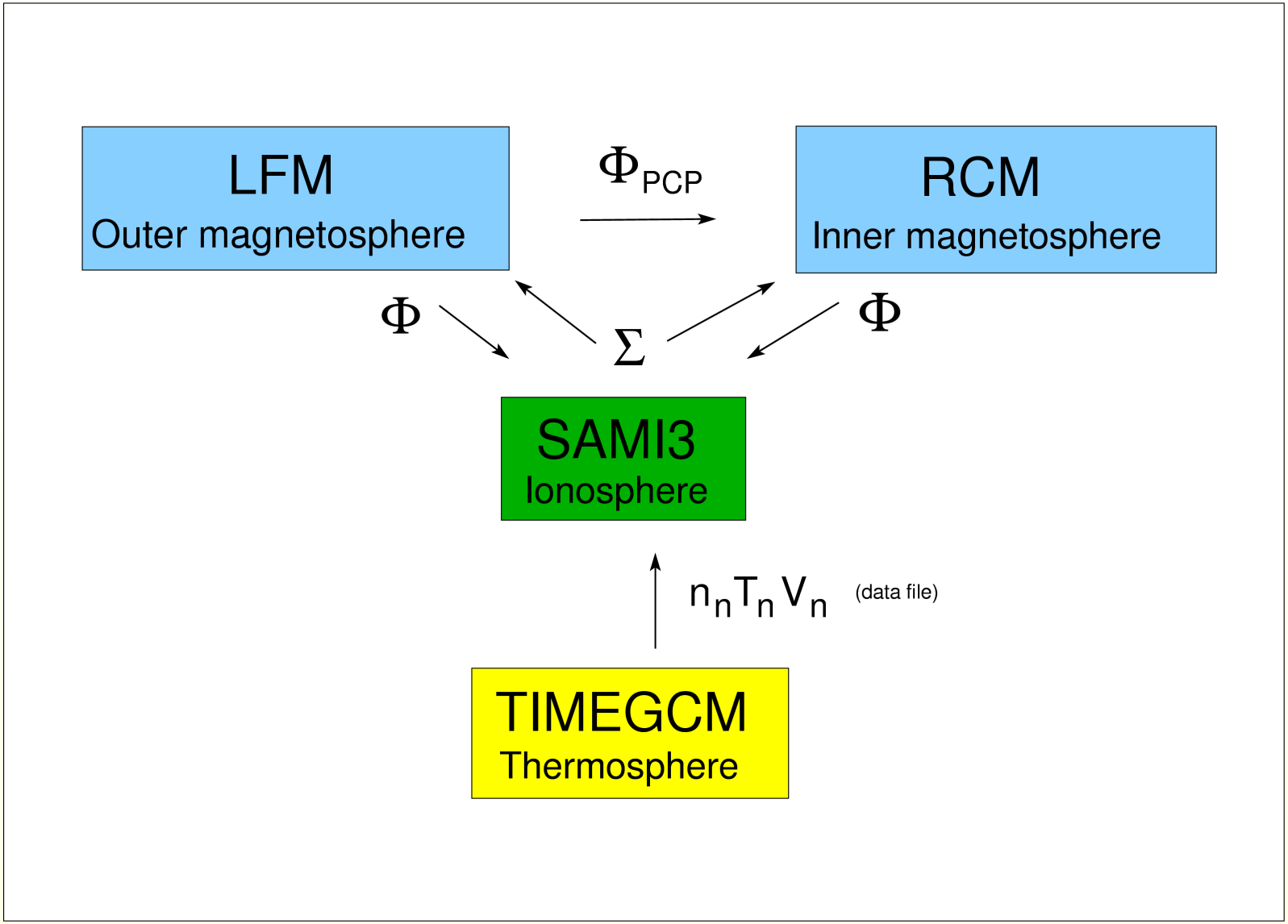


SAMI3/RCM RESULTS

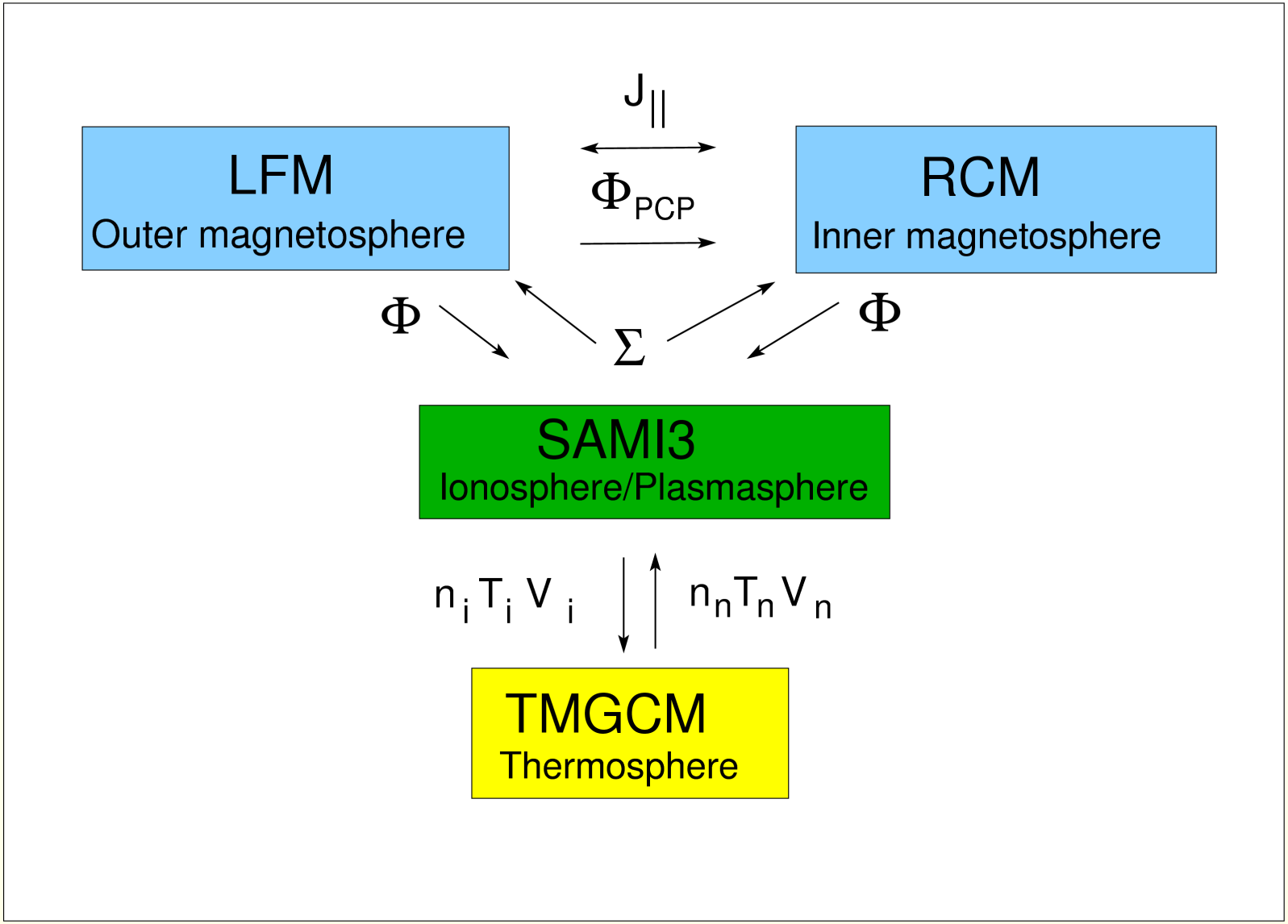
17 April 2002 storm



SPACE WEATHER AT NRL: PRESENT

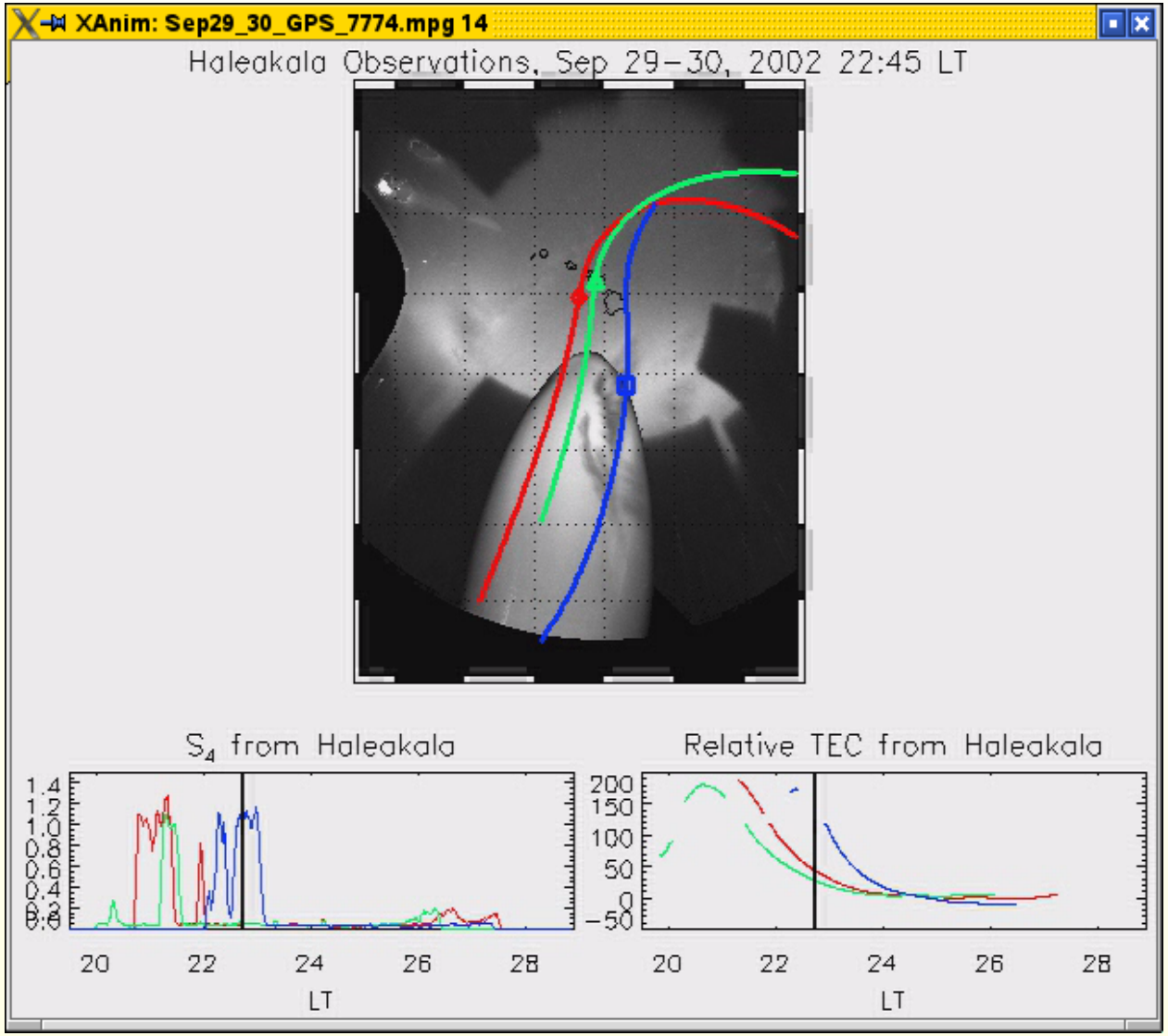


SPACE WEATHER AT NRL: FUTURE



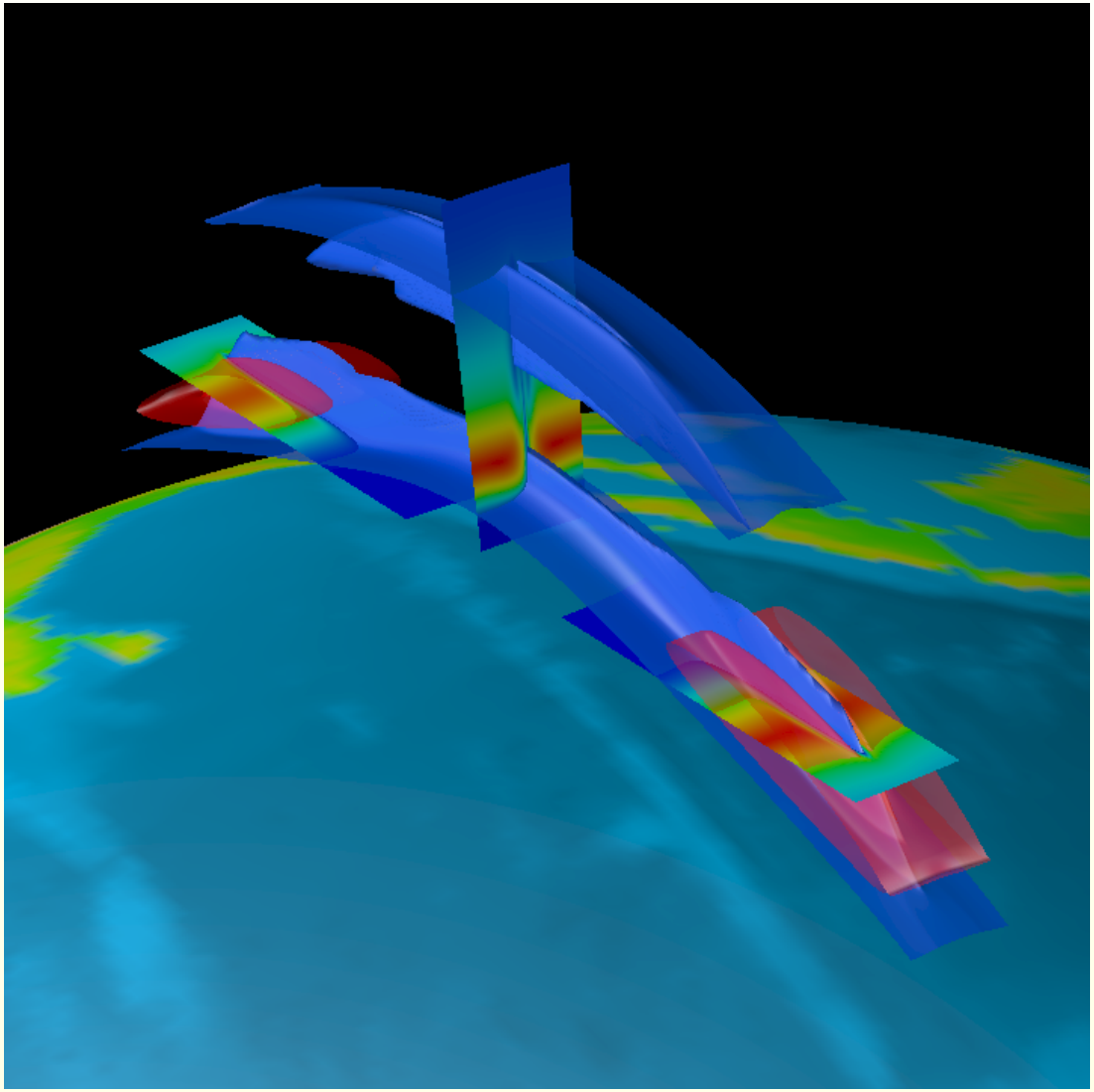
EQUATORIAL SPACE WEATHER: SPREAD F

'Everyday' occurrence (Jonathan Makela)



SAMI3/ESF WEDGE MODEL

3D results (Huba et al., *GRL*, 2008)



SUMMARY

- Comprehensive modeling program under development at NRL
- Address both storm-time events as well as quiet-time events (e.g., equatorial spread F)

NEW CUSTOMER FOR SPACE WEATHER?

Social Agencies

NewScientist Environment

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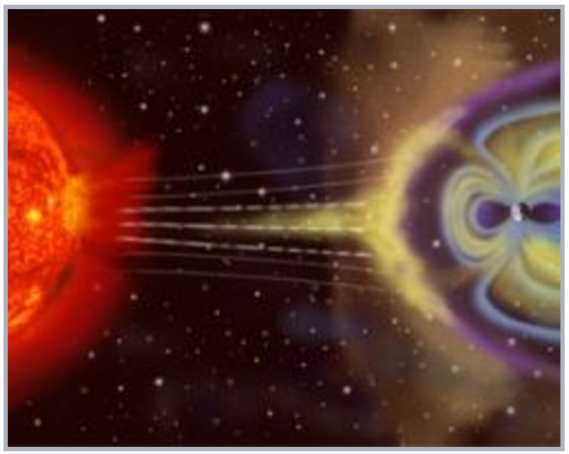
Does the Earth's magnetic field cause suicides?

13:39 24 April 2008
NewScientist.com news service
Catherine Brahic



Many animals can sense the Earth's magnetic field, so why not people, asks Oleg Shumilov of the Institute of North Industrial Ecology Problems in Russia.

Shumilov looked at activity in the Earth's geomagnetic field from 1948 to 1997 and found that it grouped into three seasonal peaks every year: one from March to May, another in July and the last in October.

Surprisingly, he also found that the geomagnetism peaks matched up with peaks in the number of suicides in the northern Russian city of Kirovsk over the same period.

Shumilov acknowledges that a correlation like this does not necessarily mean there is a causal link, but he points out that there have been several other studies suggesting a link between human health and geomagnetism.

For example, a 2006 review of research on cardiovascular health and disturbances in the geomagnetic field in the journal *Surveys in Geophysics* (DOI: 10.1007/s10712-006-9010-7) concluded that a link was possible and that the effects seemed to be more pronounced at high latitudes.