Space Weather and the Ionosphere

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Director

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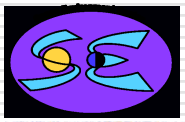
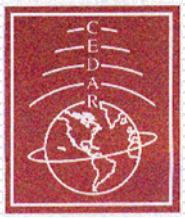




ORIGINS OF THE IONOSPHERE

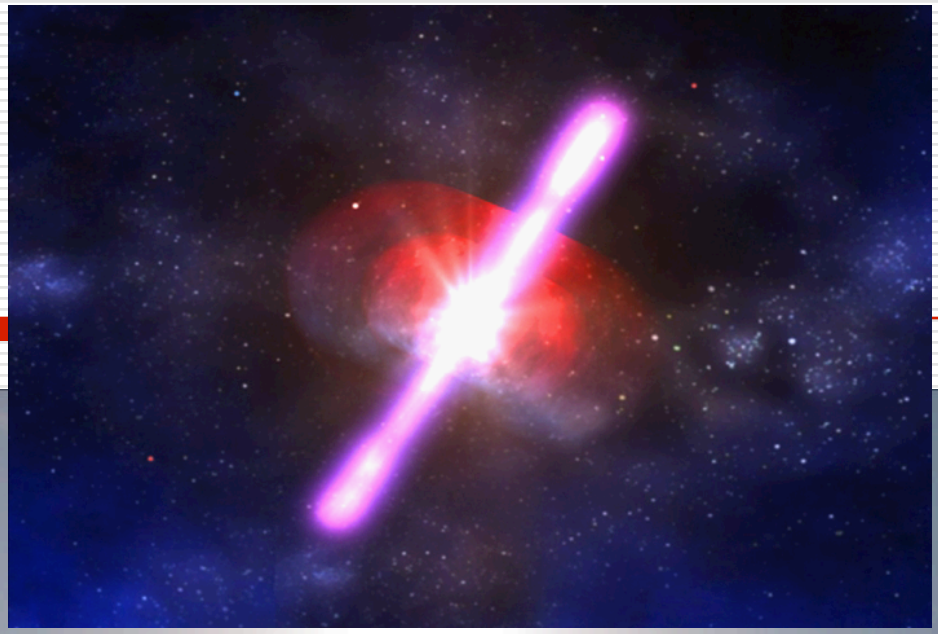
The ionosphere is that part of the upper atmosphere where free electrons occur in sufficient density [to have an appreciable influence on the propagation of radio frequency electromagnetic waves].

Less than 1% of constituents are ionized

Lower boundary at ~ 60 km
Upper boundary at ~ 1000 km

State variables: global electron density *n*
global neutral density *N*

ORIGINS OF SPACE WEATHER

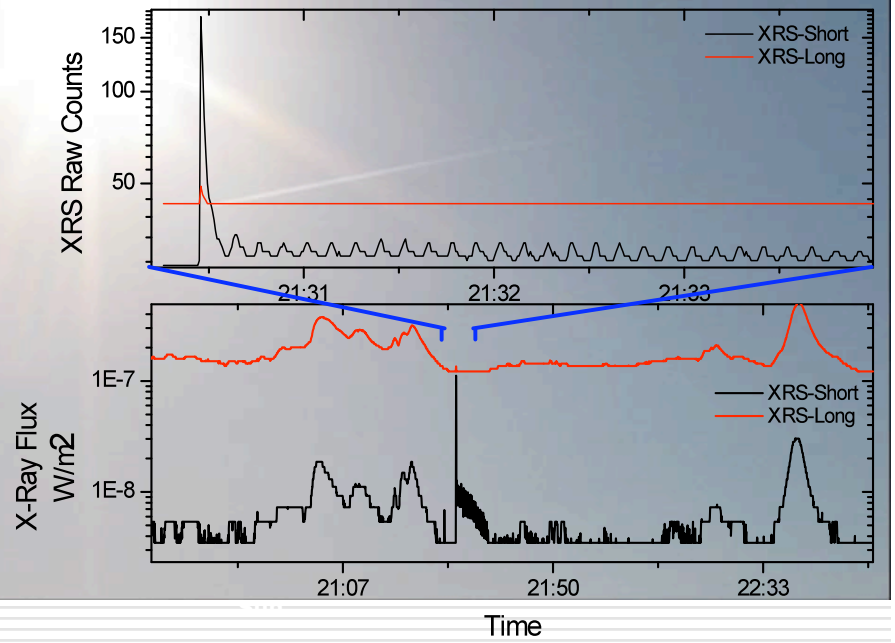


1 August 1983

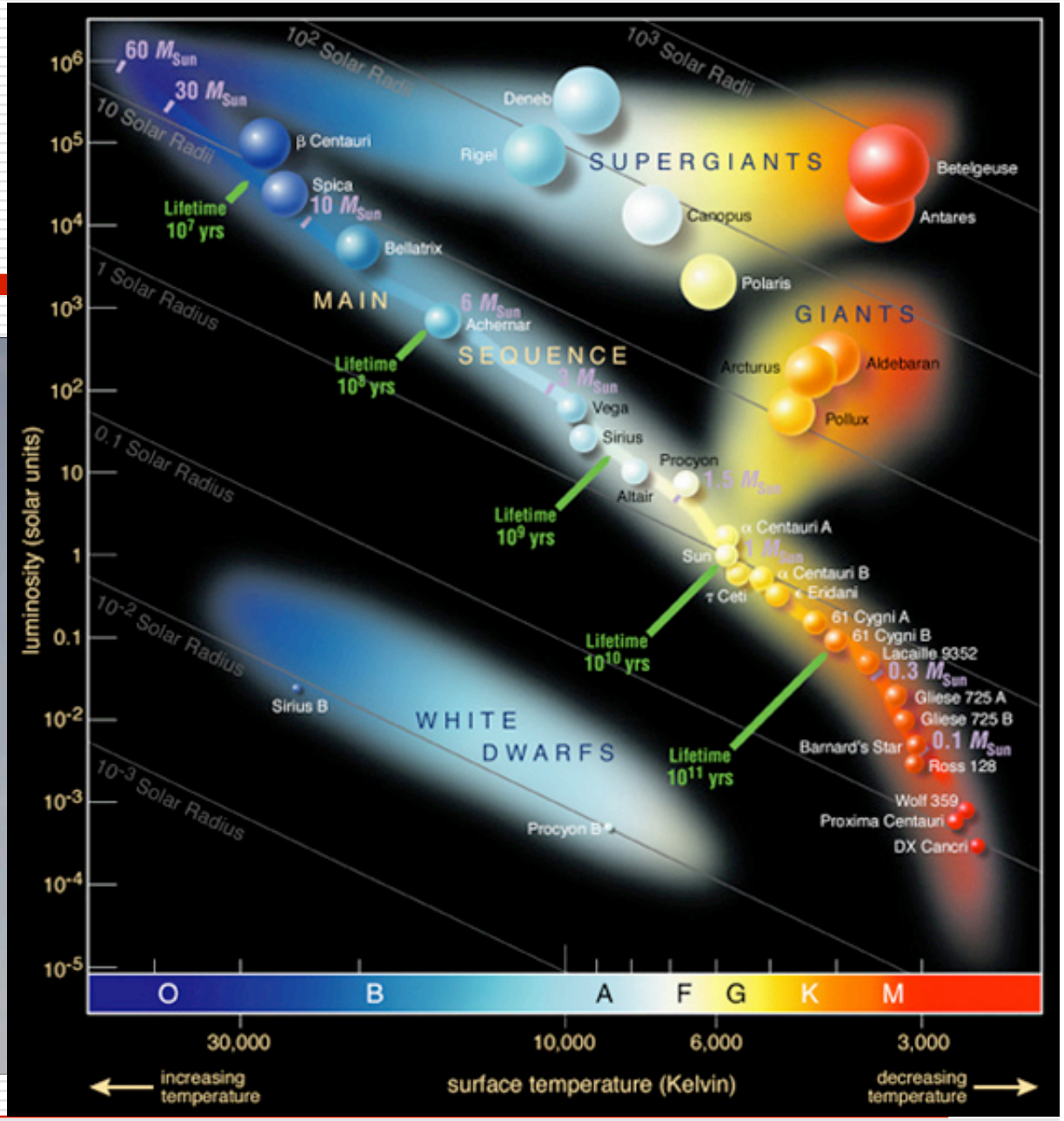
27 August 1998

29 March 2003

27 December 2004



NON-ORIGINS OF SPACE WEATHER

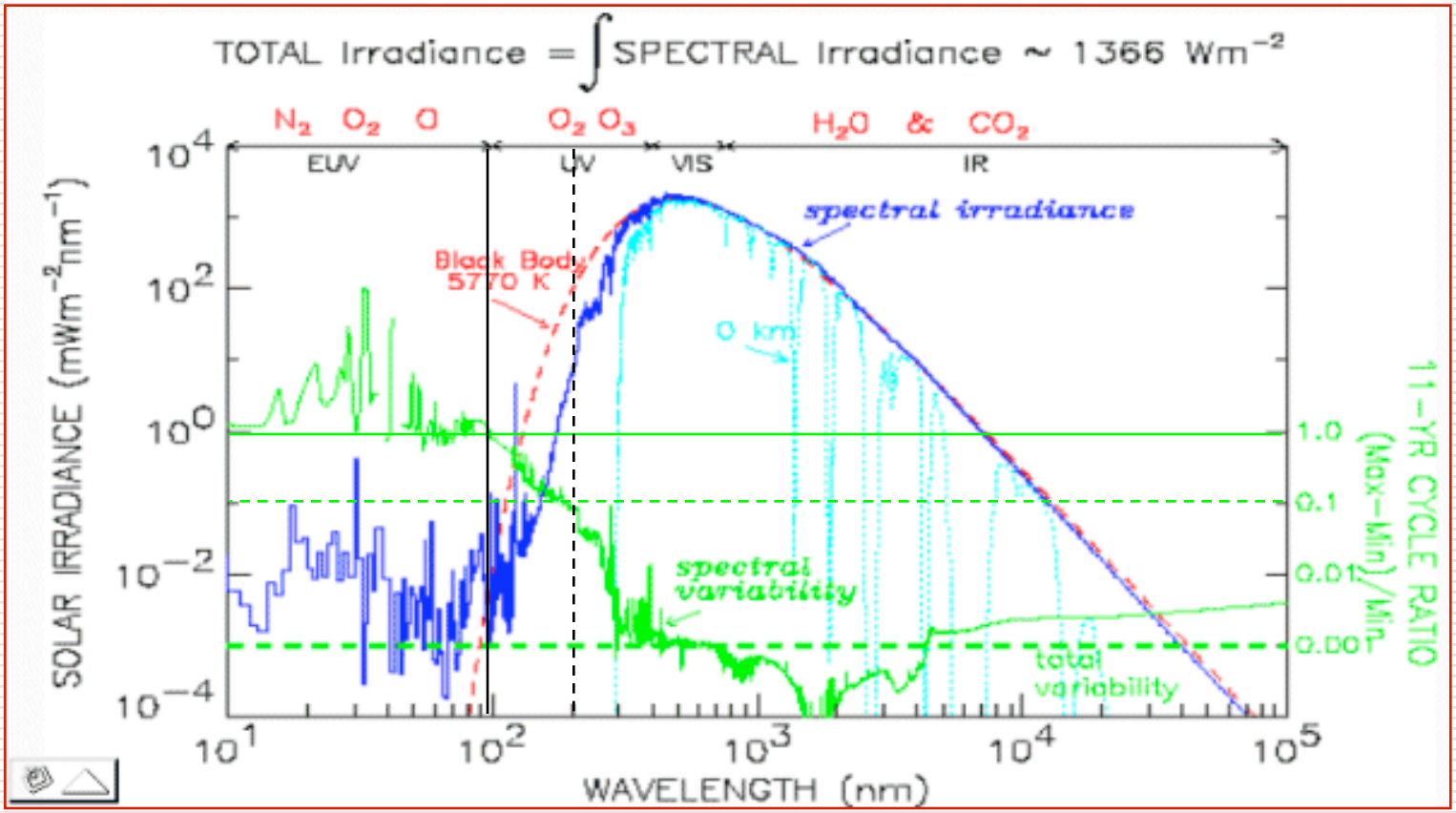


ORIGINS OF SPACE WEATHER

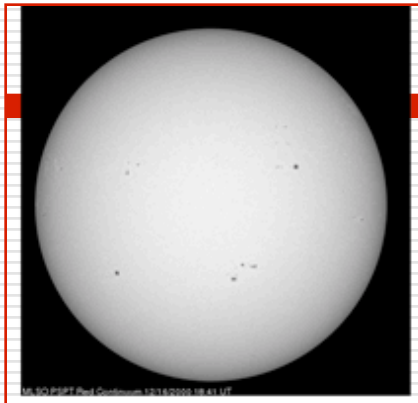
$O_2 + h\nu \rightarrow O_2^+ + e$ (102.8 nm)

$O + h\nu \rightarrow O^+ + e$ (91.0 nm)

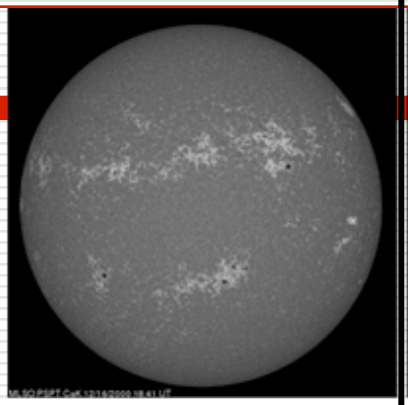
$N_2 + h\nu \rightarrow N_2^+ + e$ (79.5 nm)



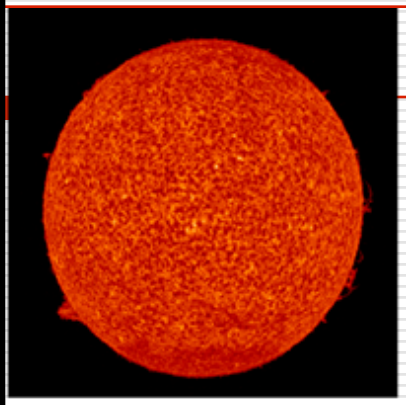
ORIGINS OF SPACE WEATHER



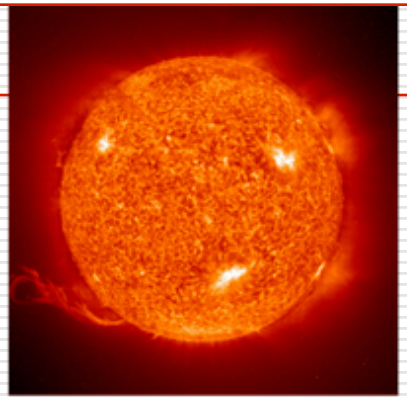
PSPT Red Continuum 607nm
Photosphere 6200K



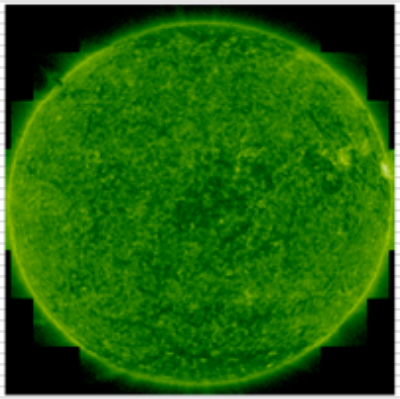
PSPT CaIIK Center 393nm
Photo/Chromosphere 7500K



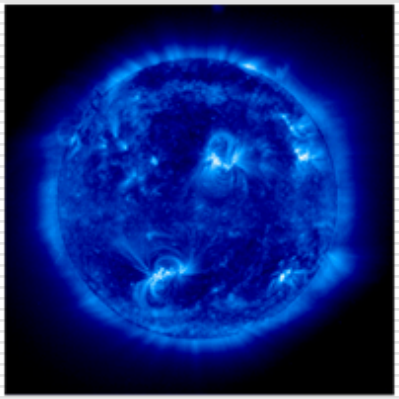
SUMER HeI emission 58.4nm
Chromosphere 20000K



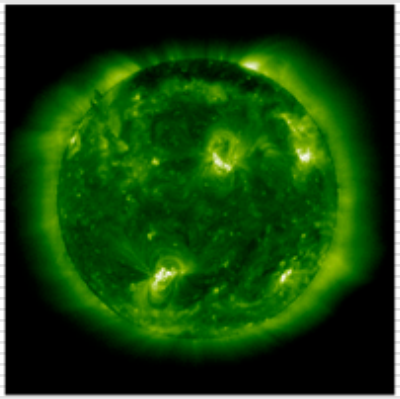
EIT HeII emission 30.4nm
Low Transition Region 60000K



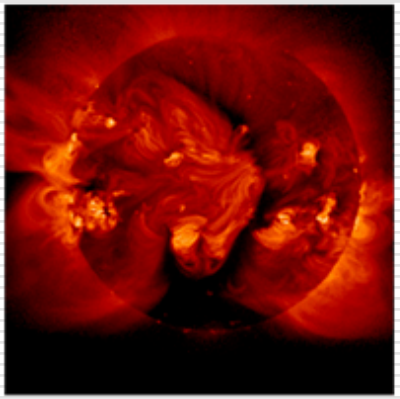
SUMER NeVIII emission
77.0nm Low Corona 600000K



EIT FeIX/X emission 17.1nm
Corona 10^6K

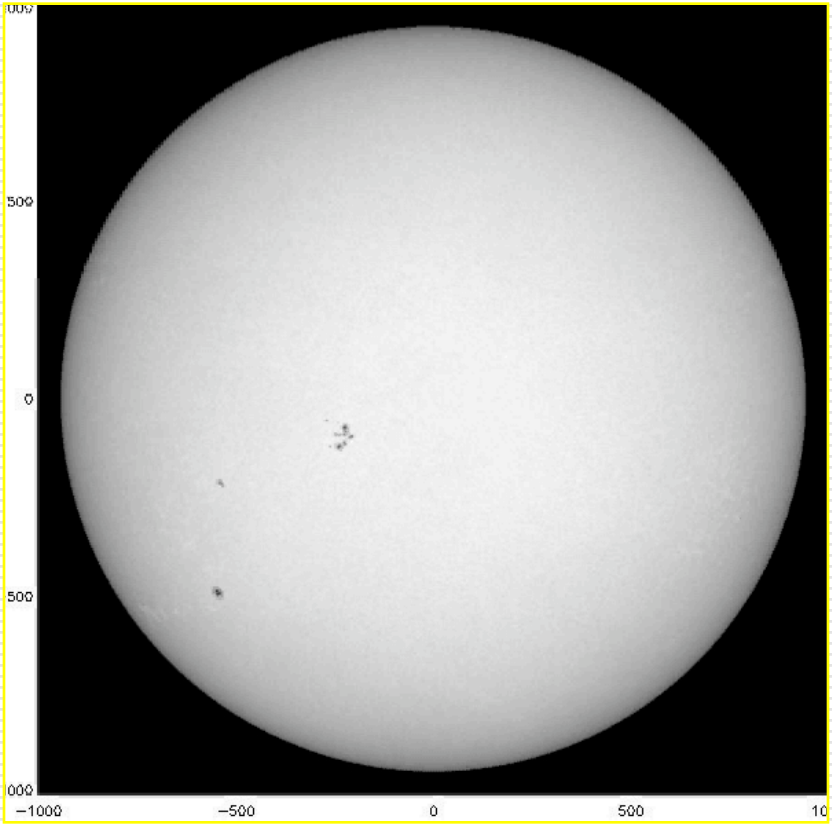


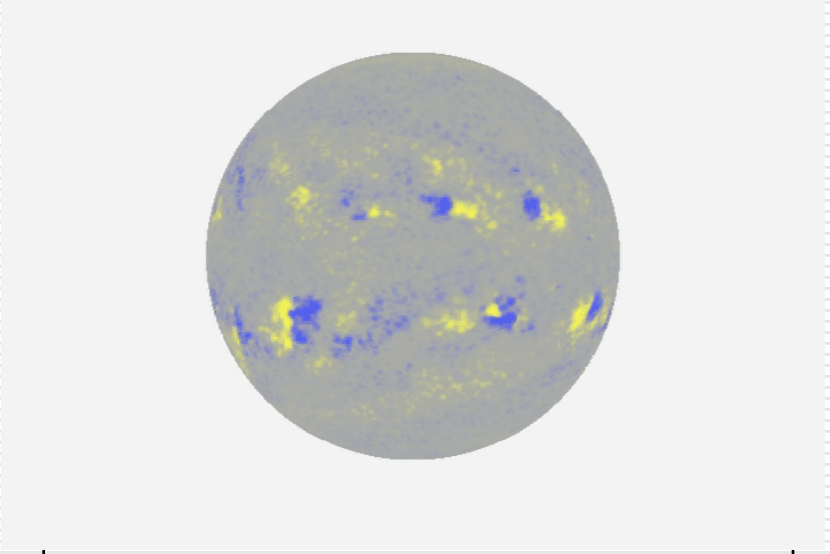
EIT FeXII emission 19.5nm
Corona 1.5×10^6K

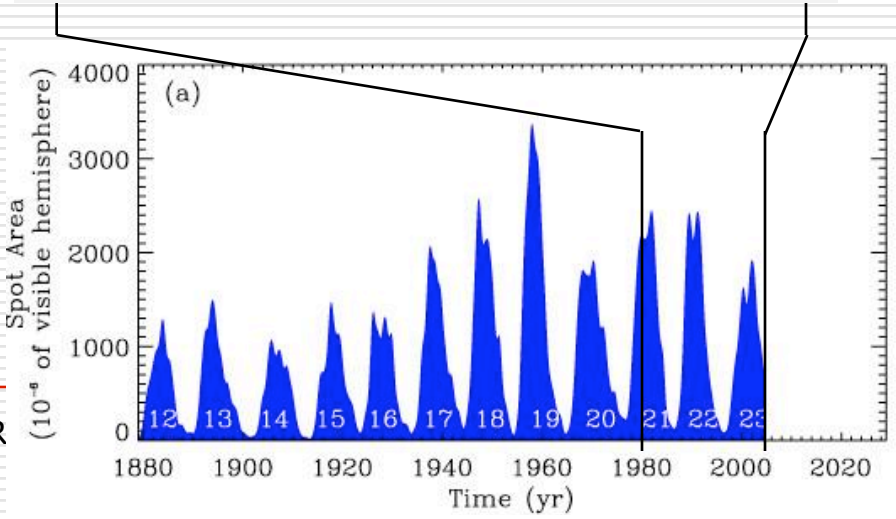


Yohkoh SXT X-ray 0.3 – 5nm
Corona K

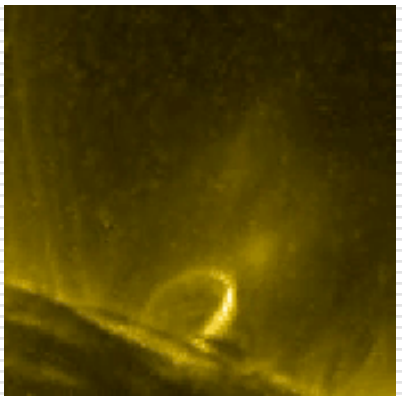
CONVECTION + MAGNETIC FIELDS + ROTATION

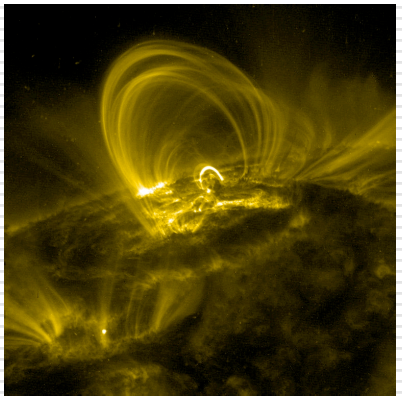




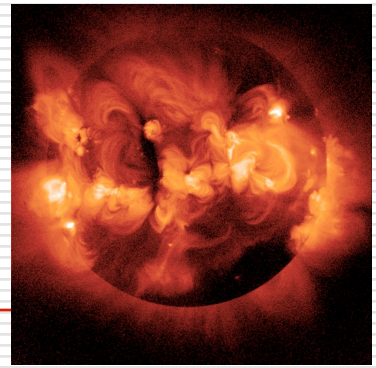


= SPACE WEATHER





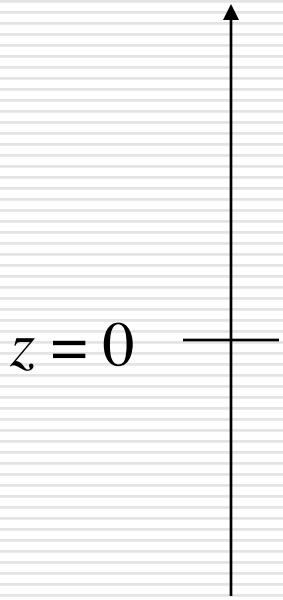
ORIGINS OF THE IONOSPHERE



$$dI/dz = +\sigma NI$$

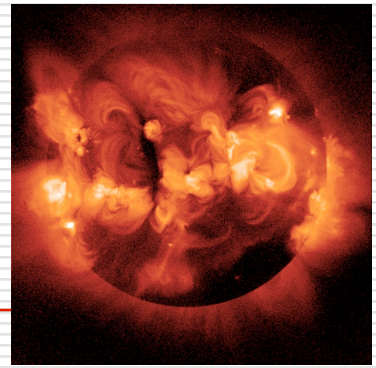
$$d(N+2n)/dz = -\varkappa(N+n)$$

$$\sigma NI/E = va^2n^2$$



		as $z \to +\infty$	as $z \to -\infty$
$I(z)$:	erg/cm^2/s	I_0	0
$N(z)$, $n(z)$:	#/cm^3	0, 0	∞, 0

ORIGINS OF THE IONOSPHERE



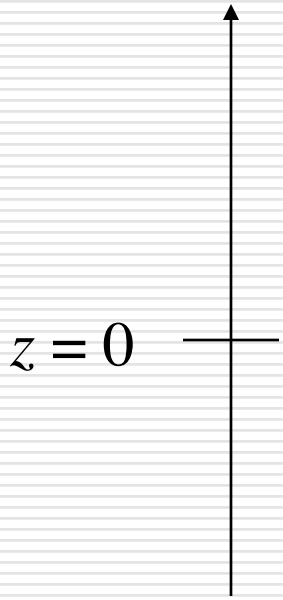
$$dI/dz = +\sigma NI$$

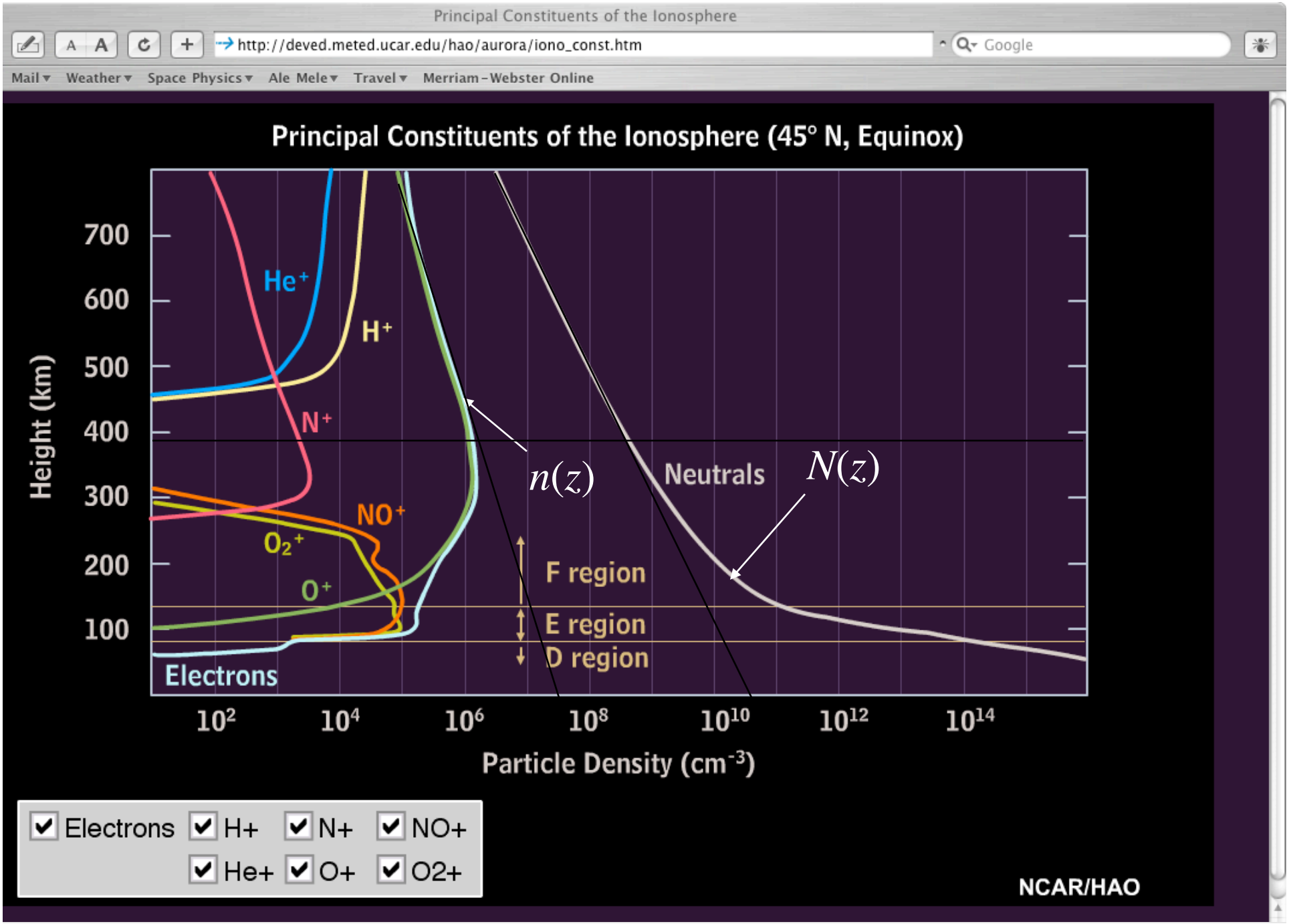
$$\sigma NI/\mathbf{E}va^2 = n^2$$

$$I_0/\mathbf{E}va^2 = \int n^2\, dz$$

$$\text{finite} = \int n\, dz \quad !!!!!$$

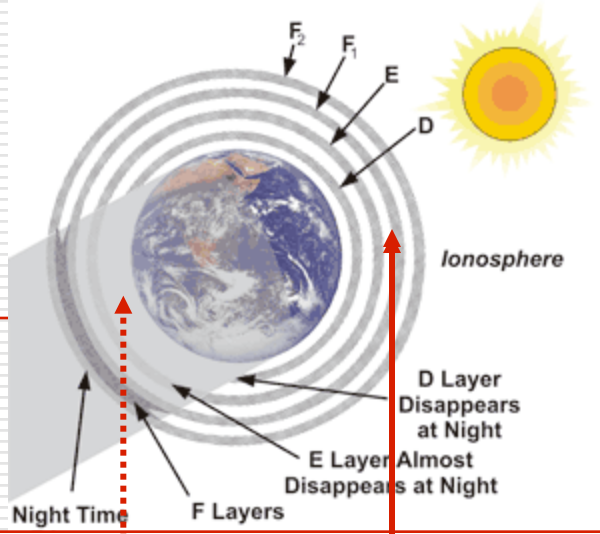
$$\text{infinite} = \int N\, dz$$

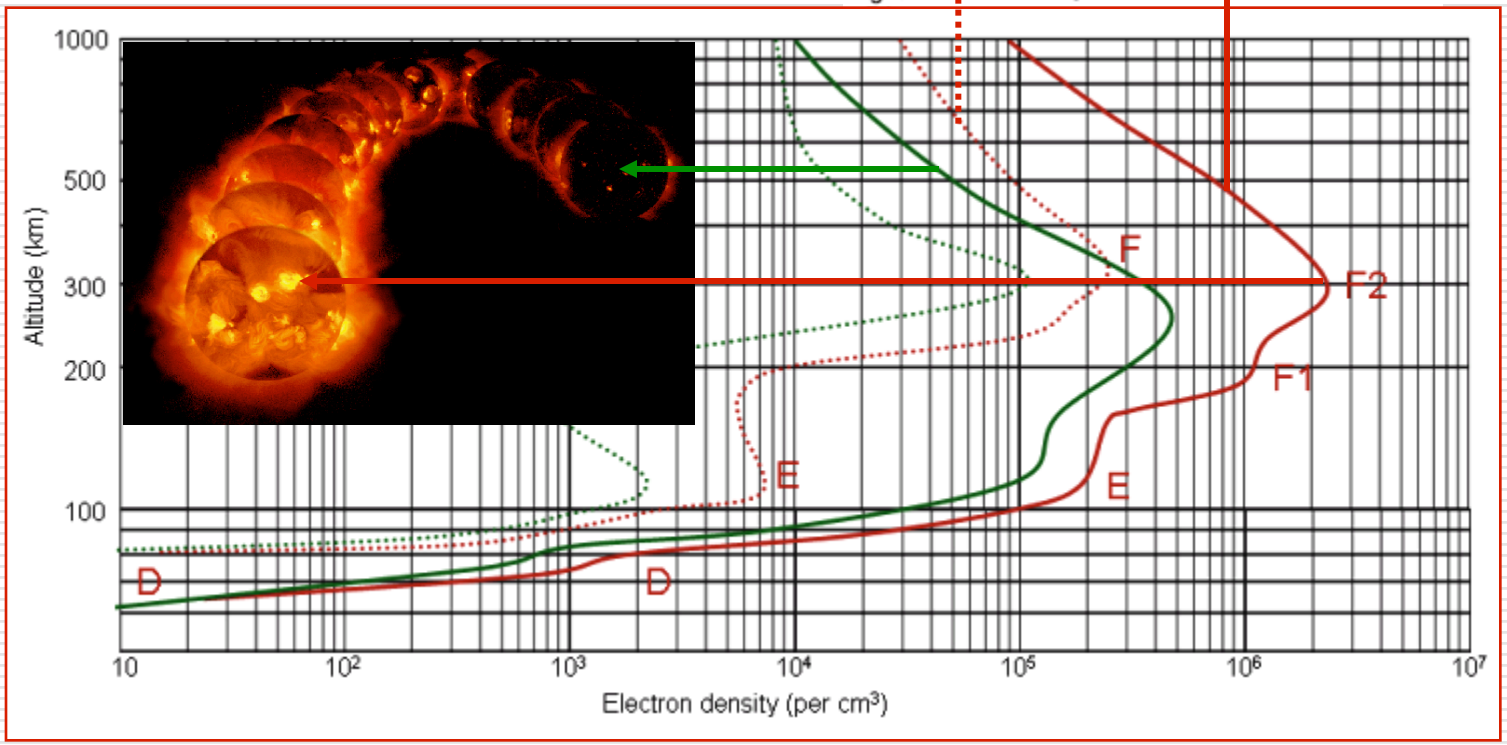



Principal Constituents of the Ionosphere
http://deved.meted.ucar.edu/hao/aurora/iono_const.htm
Google
Mail
Weather
Space Physics
Ale Mele
Travel
Merriam-Webster Online
Principal Constituents of the Ionosphere (45° N, Equinox)
Height (km)
700
600
500
400
300
200
100
He+
H+
N+
NO+
O2+
O+
Electrons
n(z)
N(z)
Neutrals
F region
E region
D region
10^2
10^4
10^6
10^8
10^10
10^12
10^14
Particle Density (cm^-3)
Electrons
H+
N+
NO+
He+
O+
O2+
NCAR/HAO

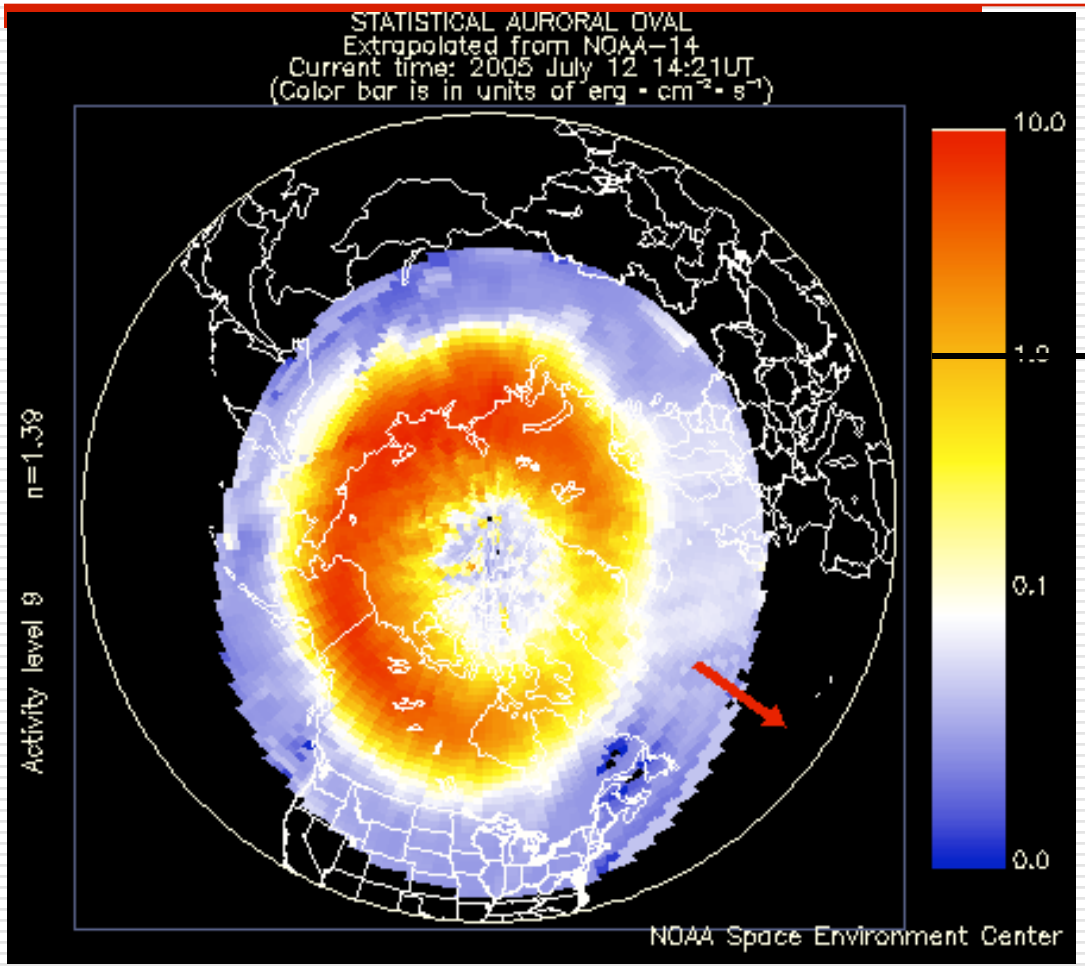
ORIGINS OF THE IONOSPHERE: SHORT WAVE RADIATION

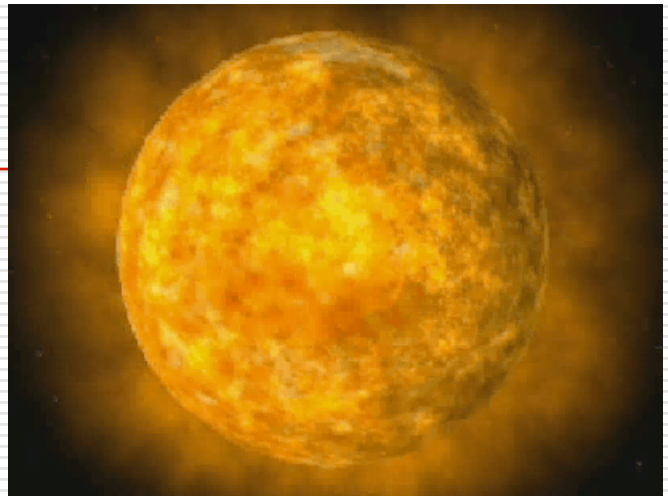
DIURNAL & CYCLIC VARIATIONS





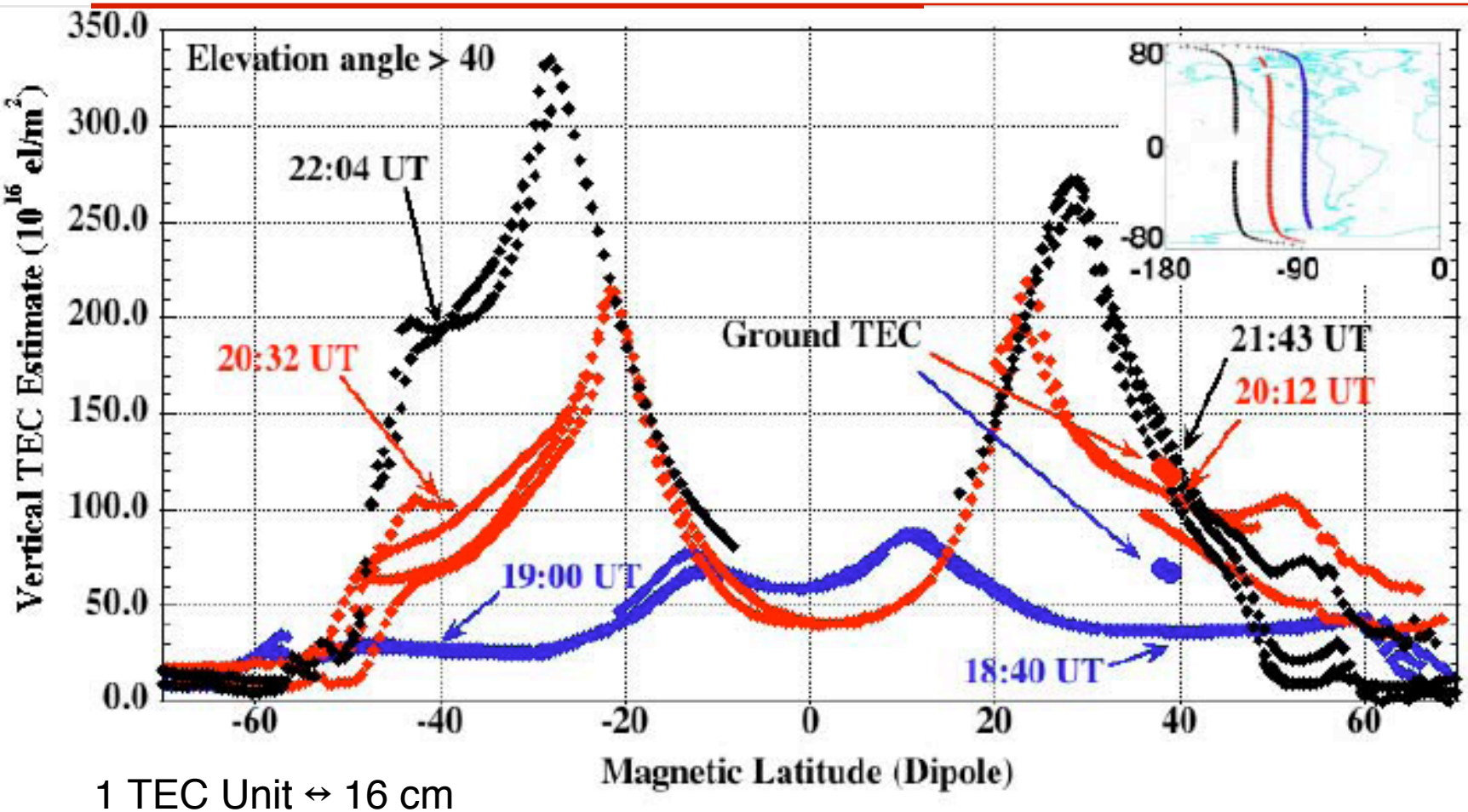
ORIGINS OF THE IONOSPHERE: ENERGETIC PARTICLE PRECIPITATION





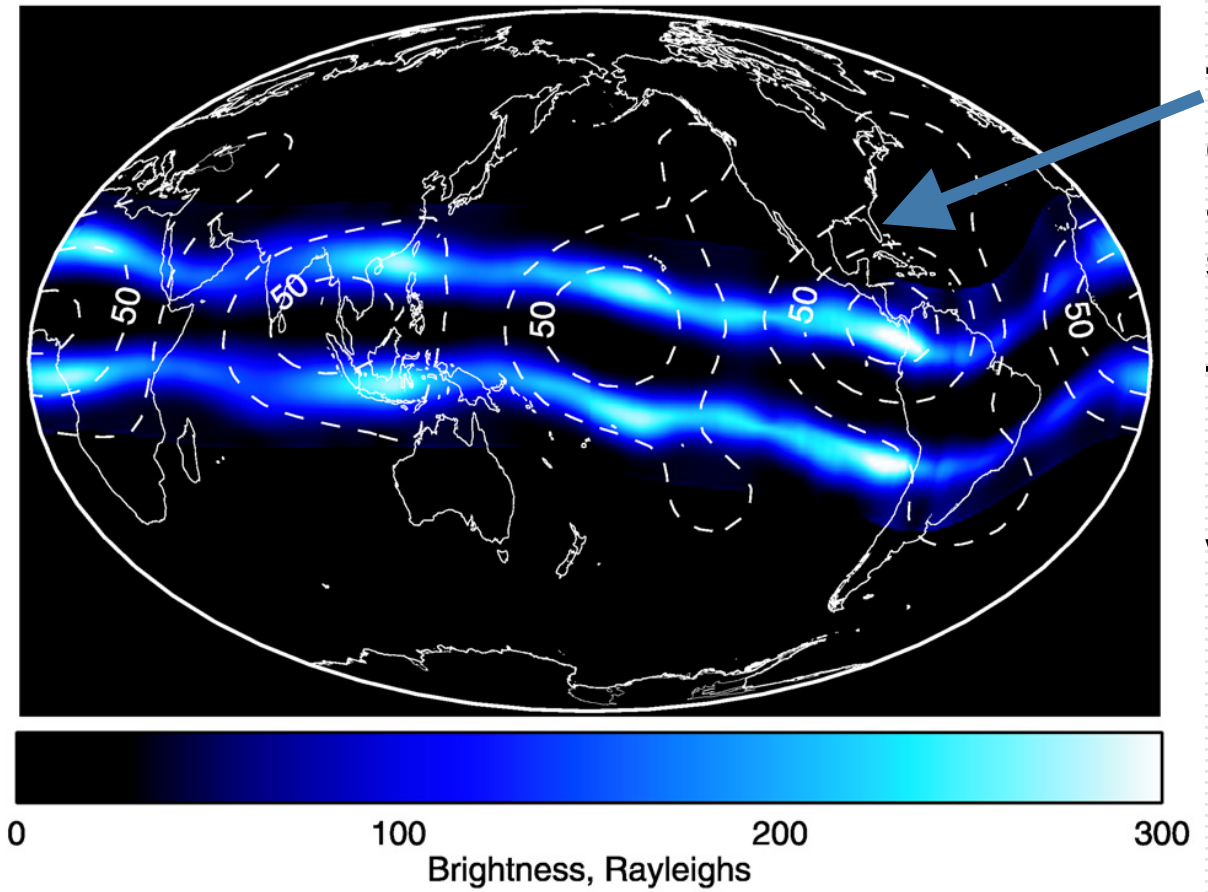
Nominal solar photon energy flux shortward of 100 nm!

ORIGINS OF THE IONOSPHERE: TRANSPORT & NEUTRAL INTERACTIONS



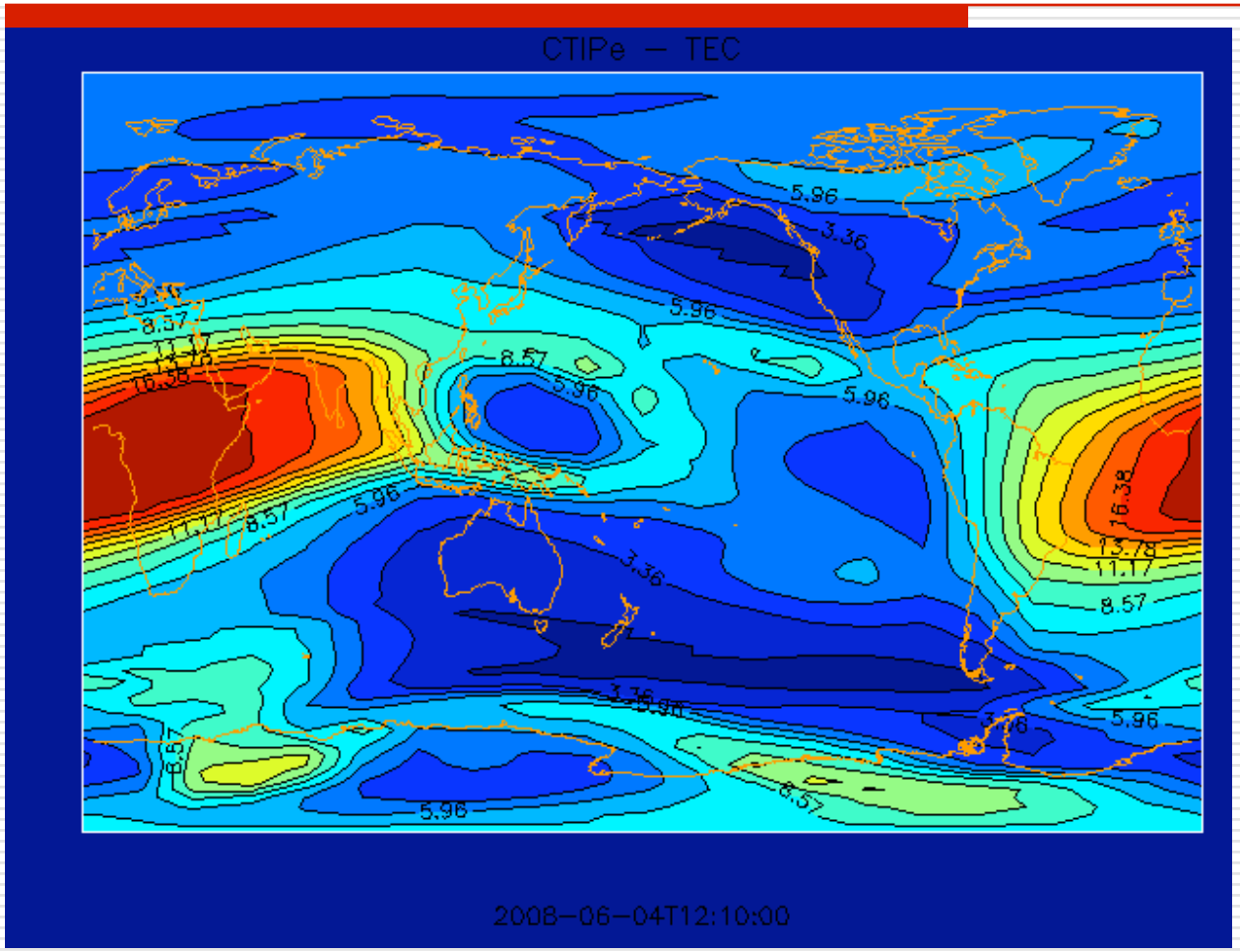
1 TEC Unit ↔ 16 cm

ORIGINS OF THE IONOSPHERE: TIDAL INTERACTIONS AND GRAVITY WAVES

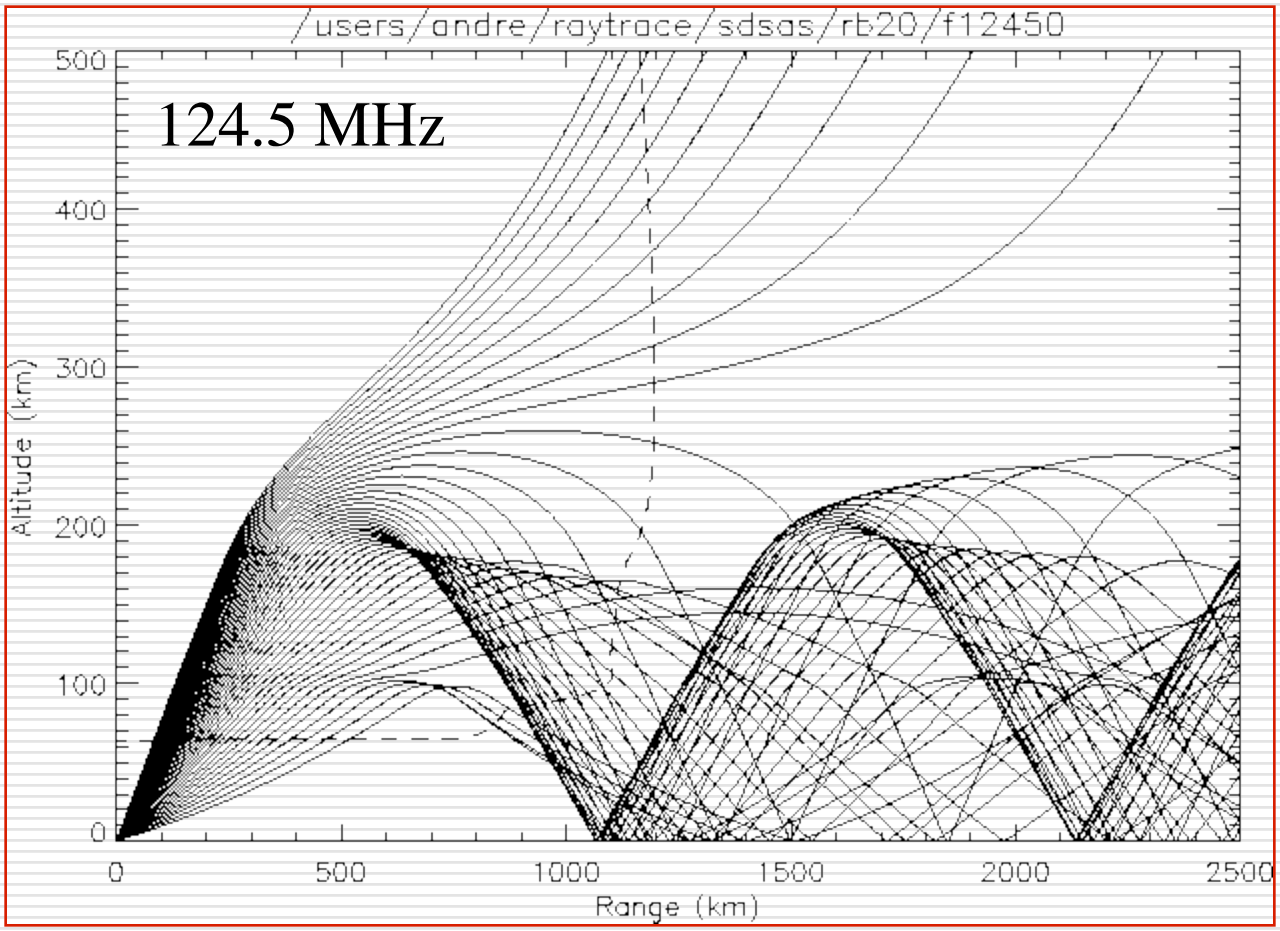


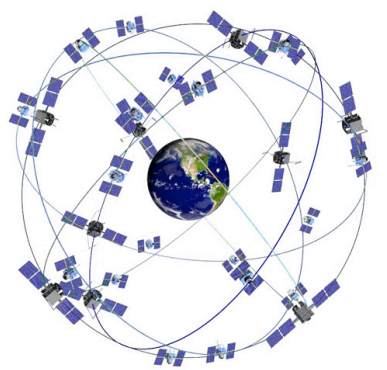
The four peaks in diurnal temperature amplitude result from superposition of the migrating (to the west) tide (DW1) and nonmigrating eastward mode with zonal wavenumber 3 (DE3).

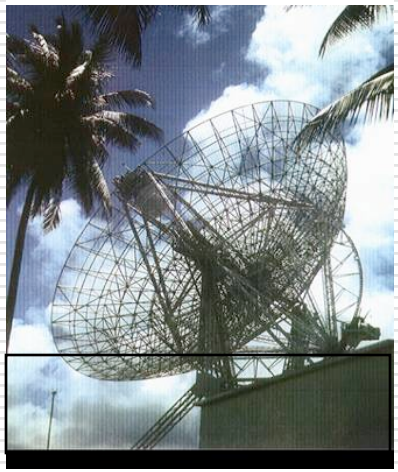
ORIGINS OF THE IONOSPHERE: NUMERICAL SIMULATIONS



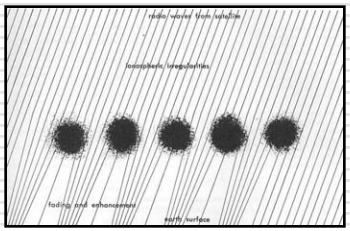
IMPACT OF THE IONOSPHERE: RADIO WAVE PROPAGATION



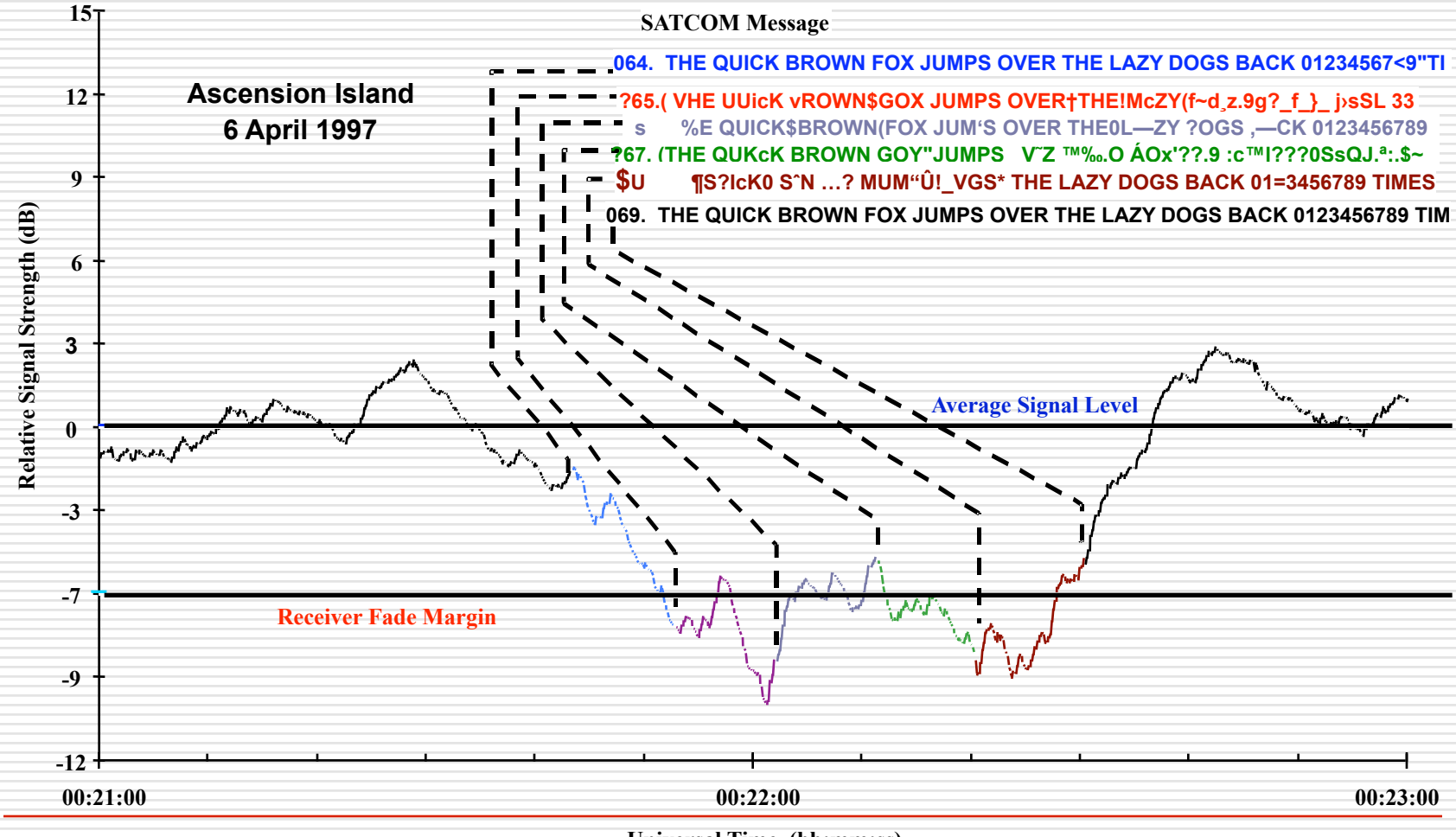




IMPACT OF THE IONOSPHERE: RADIO WAVE PROPAGATION

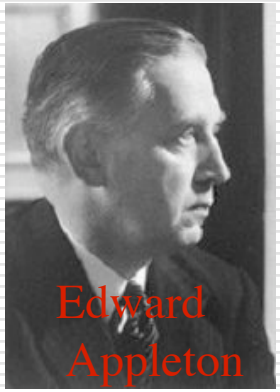


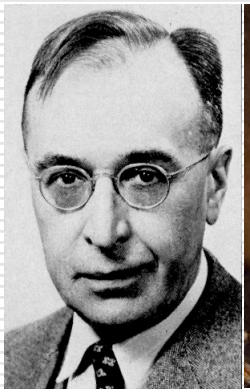
SATCOM MESSAGE ERRORS

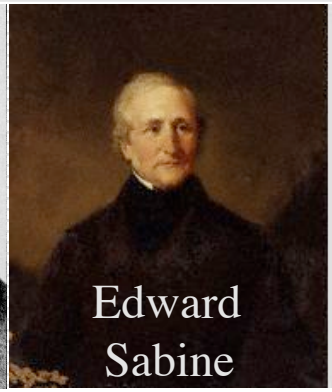


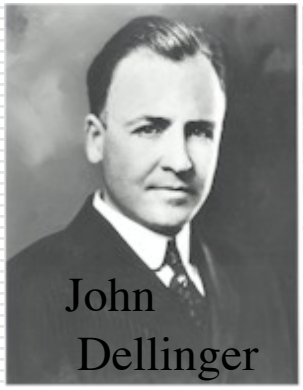
IMPACT OF THE IONOSPHERE: SOME PEOPLE WHO MADE A LIVING FROM IONOSPHERIC RESEARCH

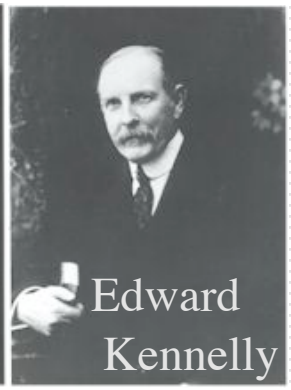
Gregory Breit

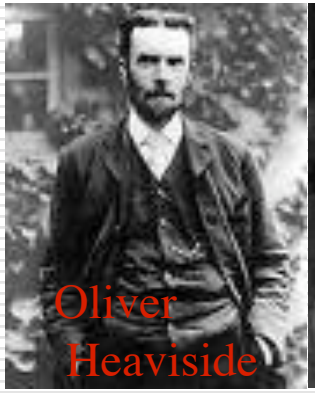


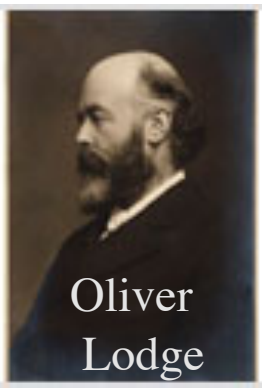








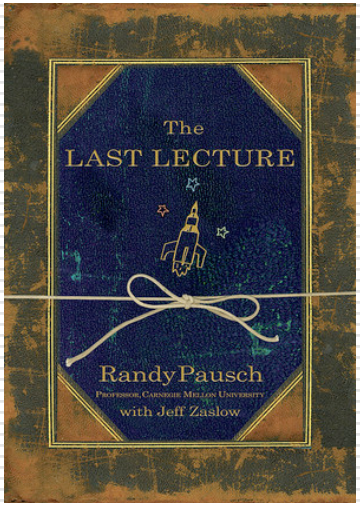




Your Picture Here

PARTING ADVICE: STAY ONE STEP AHEAD

http://www.spaceweather.gov

"I don't mind you thinking slowly, I mind you publishing faster than you think!"

-Wolfgang Pauli