# The MLT-X Grand Challenge Workshops, 2014-2017

## Coupling and Transport Processes from the Upper Mesosphere through the Middle Thermosphere (80-200 km)

**Organizers: Jeff Thayer, Gary Swenson, and Chet Gardner**

Grand Challenge Purpose:

- Provide focus / context / awareness of related research in this domain
- Spawn new initiatives
- Provide input to NSF program managers
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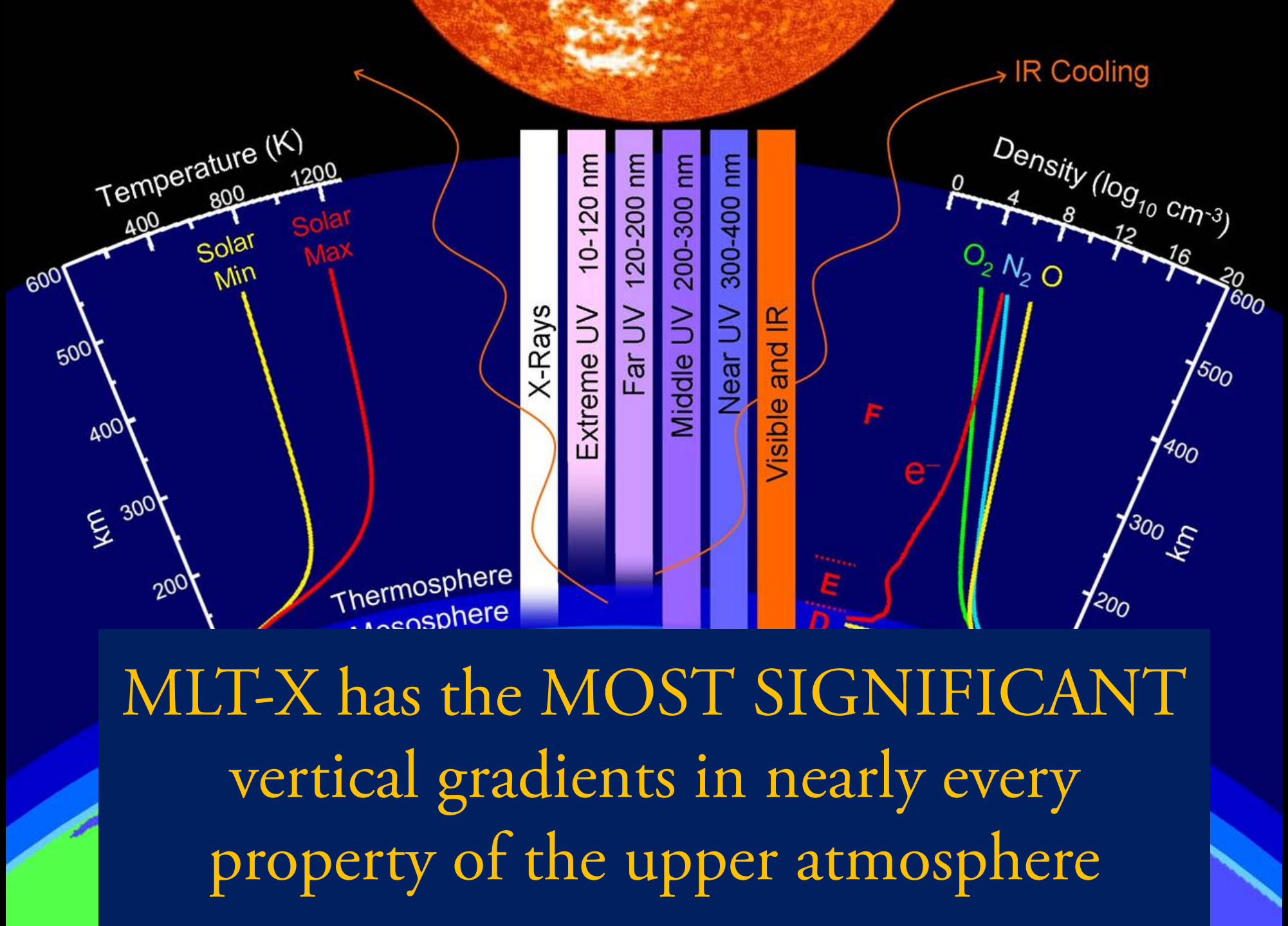
## CEDAR 2014-2017

- What is the role of the neutral gas in coupling with the plasma to establish the predominant state of the Earth's upper atmosphere and ionosphere between 80 and 200 km?

- How do wave-induced transport, dissipation and turbulence influence the structure, composition and circulation of Earth's upper atmosphere between 80 and 200 km?




MLT-X has the MOST SIGNIFICANT vertical gradients in nearly every property of the upper atmosphere

# Universal Processes in the MLT-X

*MLT-X Processing of External Inputs MAXIMIZE in the region*

- Processing of EUV Solar Radiative Flux
- Processing of Solar Wind / Magnetosphere Energy Flux
- Processing of Cosmic Dust Flux
- Processing of Lower Atmosphere Wave Flux
- Processing of Constituent flux

*MLT-X Internal Workings are HIGHLY DIVERSIFIED*

- Workings of Plasma-Neutral Interactions
- Workings of Wave Dissipation/Generation
- Workings of Instabilities and Turbulence
- Workings of Momentum, Energy and Constituent Transport
- Workings of Chemical Interactions

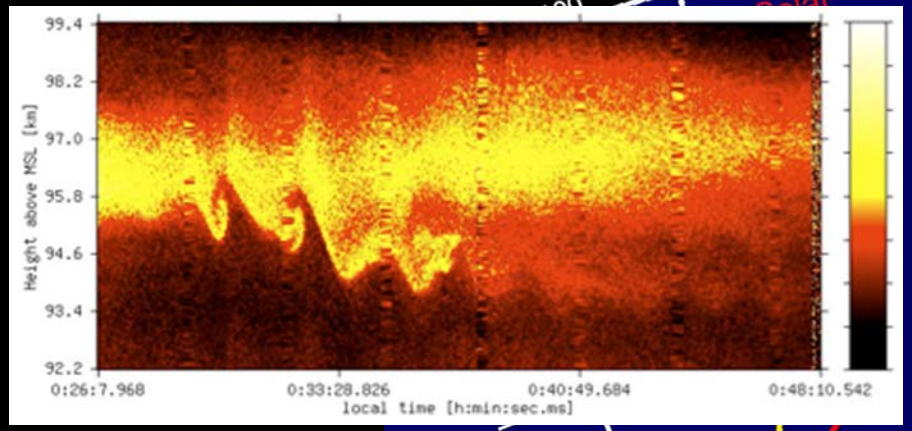
# MLT-X GC Workshop Four-Year Plan

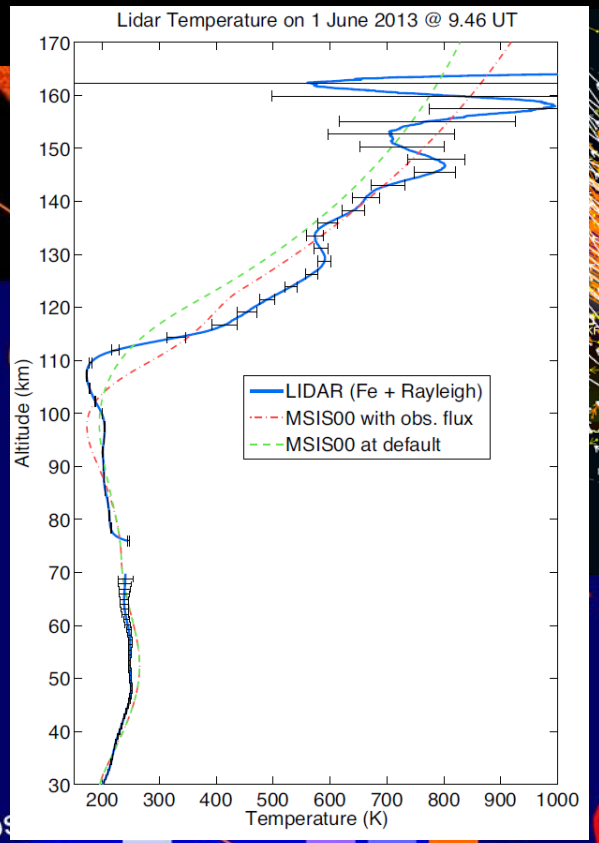
- *Year 1:* Hold a CEDAR workshop to establish middle thermosphere science goals related to the two questions posed by inviting theorists and experimentalists involved in middle thermosphere / ionosphere studies. Consider the diverse processes that occur at low, middle and high latitudes to identify the impact of the science.

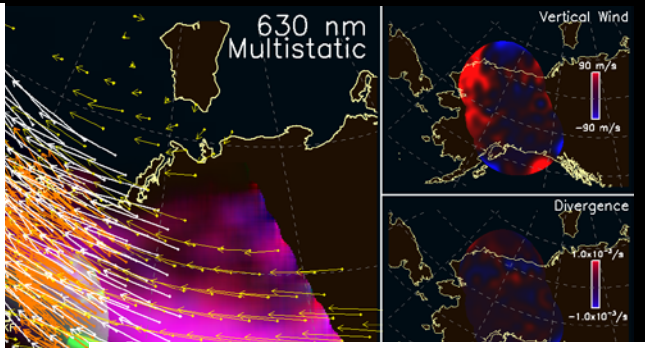
- *Year 2:* Hold a CEDAR workshop to consider the necessary measurement scenarios to achieve the goals established in the first year and align existing and planned instruments to meet the science requirements.

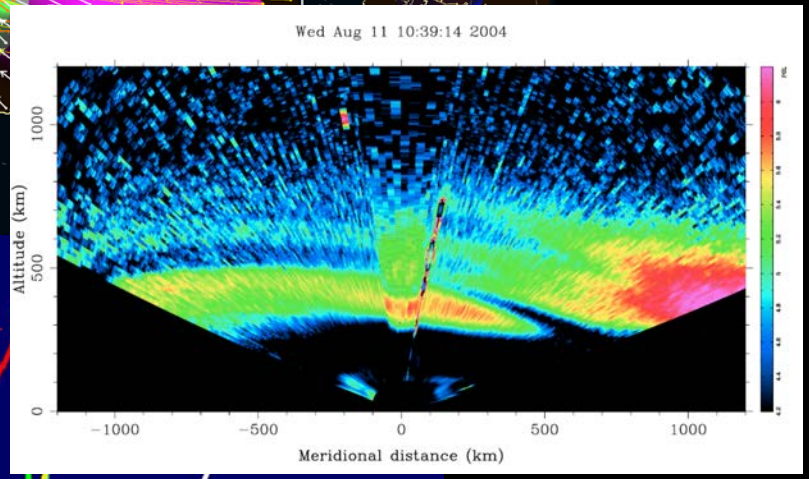
- *Year 3:* Hold a CEDAR workshop that establishes current numerical modeling capabilities of understanding the MLT-X and its broad influence on upper atmosphere processes in plasma-neutral coupling and wave / turbulence.

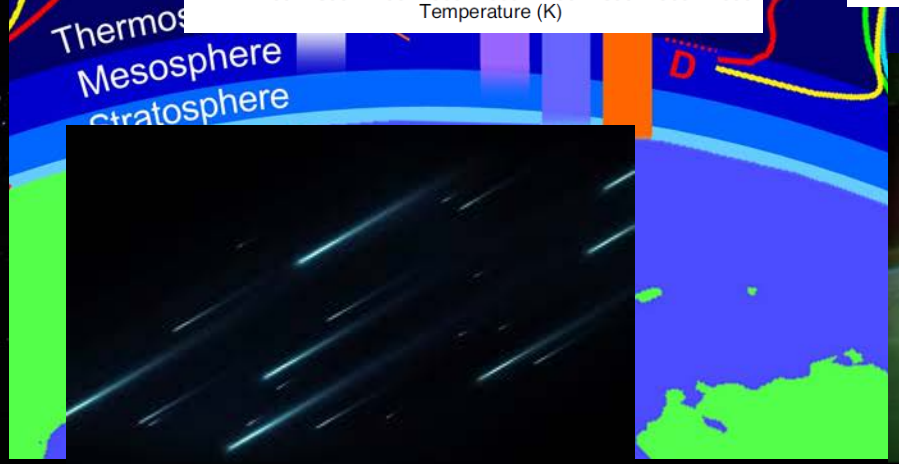
- *Year 4:* Hold a CEDAR workshop to plan campaigns and to motivate new measurements in this critical, poorly observed region of the thermosphere.


Height above MSL [km]
99.4
98.2
97.0
95.8
94.6
93.4
92.2
0:26:7.968
0:33:28.826
0:40:49.684
0:48:10.542
local time [h:min:sec.ms]


Lidar Temperature on 1 June 2013 @ 9.46 UT
Altitude (km)
Temperature (K)
LIDAR (Fe + Rayleigh)
MSIS00 with obs. flux
MSIS00 at default


630 nm
Multistatic
Vertical Wind
90 m/s
-90 m/s
Divergence

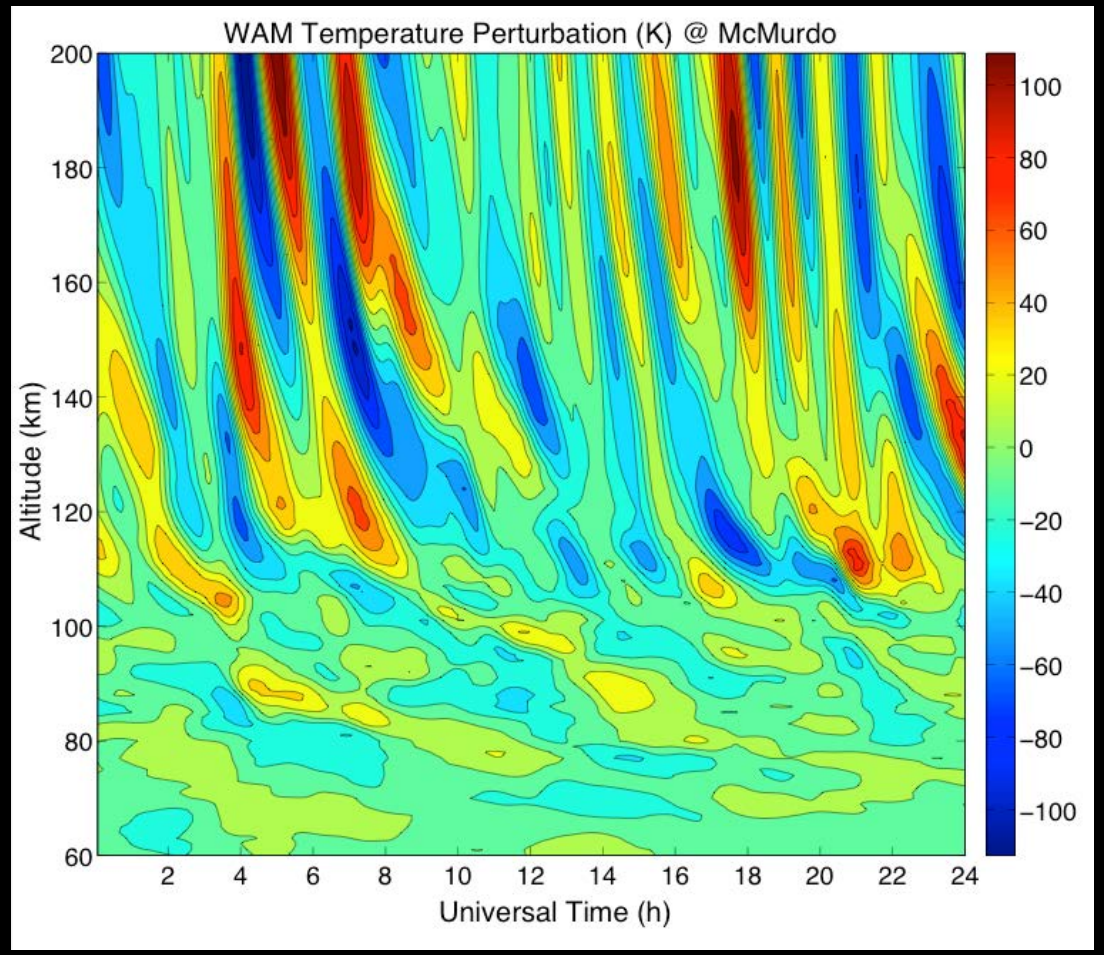

Wed Aug 11 10:39:14 2004
Altitude (km)
Meridional distance (km)

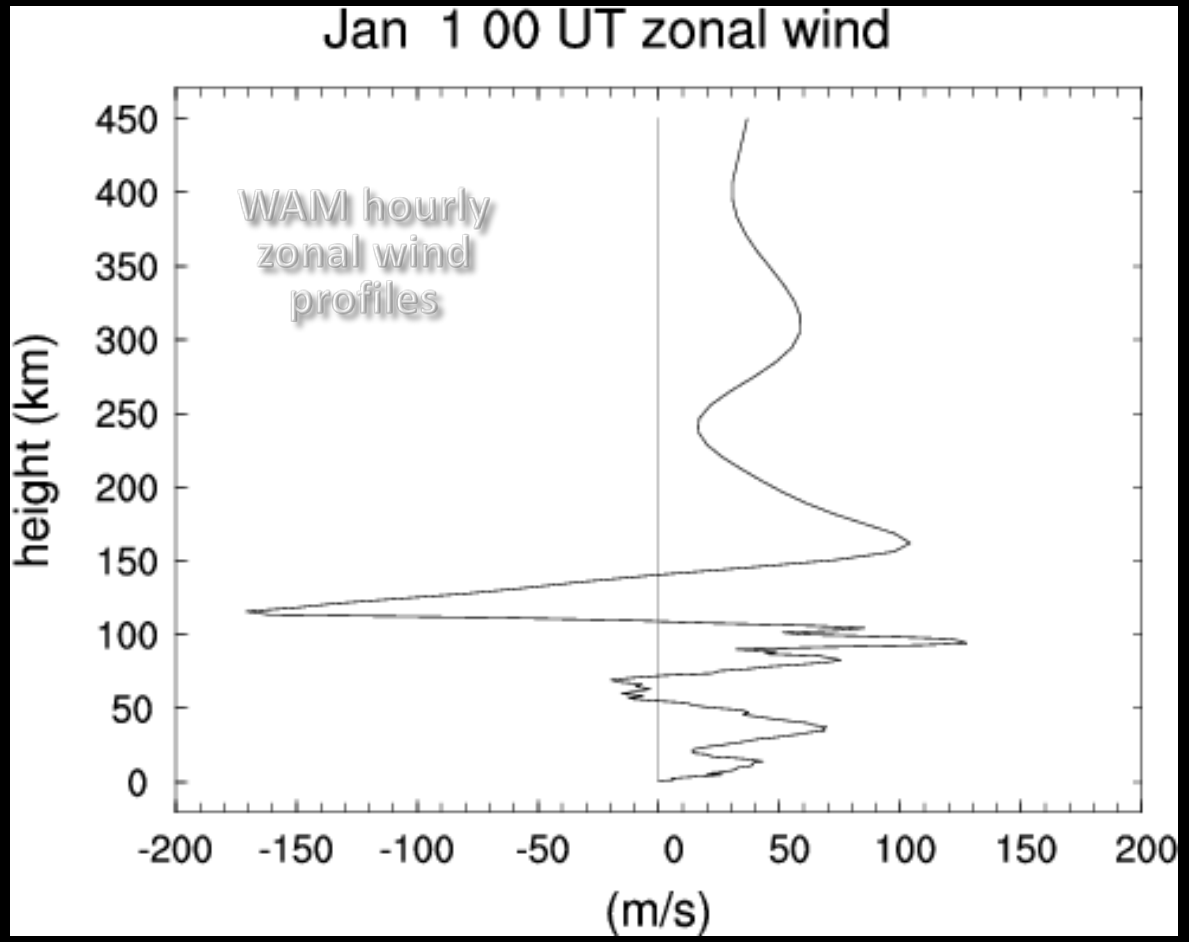

Thermos
Mesosphere
Stratosphere
e⁻
D



# Whole atmosphere simulations of a rich spectrum of waves propagating from the lower atmosphere impacting the thermosphere and ionosphere

A new paradigm in thermosphere-ionospheric modeling



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# An Observational Transformation is Required

- A new measurement scheme of neutral properties through the MLT-X region is required
  - The MLT-X is the least understood and observed, yet the most dynamic and structured region in the upper atmosphere (strong vertical gradients and rapid variability)
  - Progress in ionosphere physics is shackled by the lack of neutral measurements
- A new level of correlated measurement is required
  - Wave fluxes are needed to quantify the lower atmosphere influence on the MLT-X
  - Neutral density, plasma density, neutral winds, and ion motion
- A new means to test and advance Whole Atmosphere Models is required
  - No current measurements adequately verify whole atmosphere model predictions in the MLT-X

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# Observatory for Atmosphere Space Interaction Studies (OASIS)

From the desolate observational domain of the MLT-X domain there lies on the horizon an OASIS

*Where thirsty aeronomers can come and drink from its data pool and be enlightened.*

# OASIS - An Evolution in Observations of the MLT-X

- Fundamental MLT-X Properties
  - Neutral gas density, temperature, winds, and composition resolved in space and time (strong vertical gradients and temporal variations)
- Electrodynamic Measurements
  - Plasma and neutral properties (conductivity, dynamo winds, frictionally-heated neutral temperatures)
- Flux Measurements
  - Wave momentum, heat and constituent transport $\overline{w'u'}$ , $\overline{w'v'}$ , $\overline{w'T'}$ , $\overline{w'\rho'}$
  - Meteoric influx
  - Eddy coefficients of thermal, constituent, and momentum diffusivity

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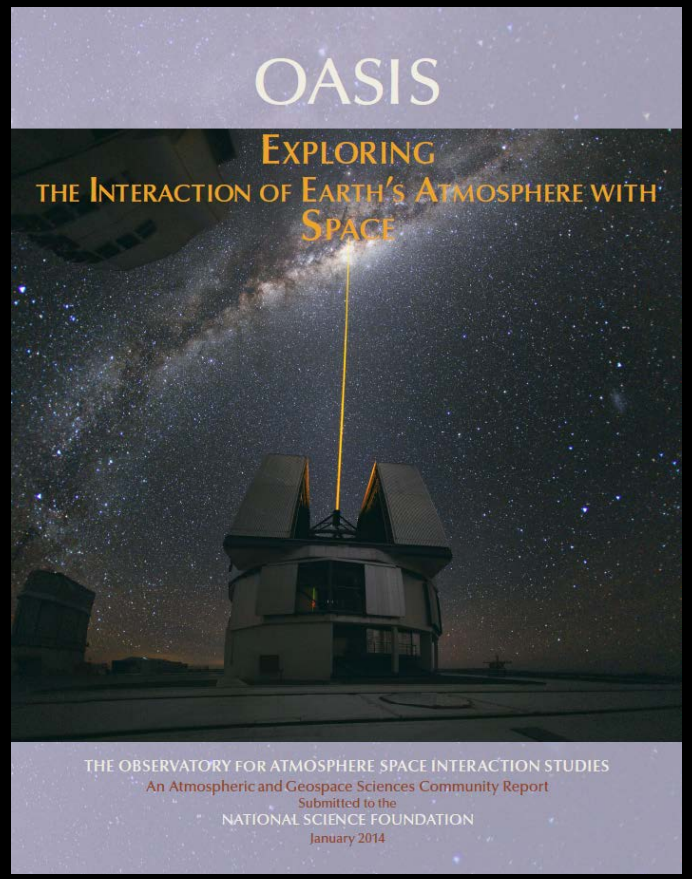
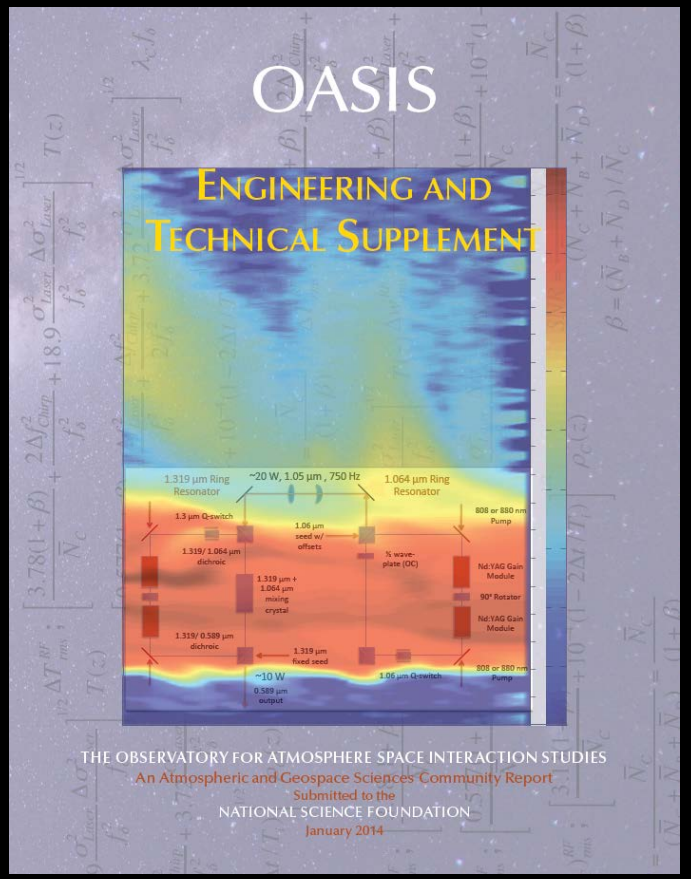
# OASIS
# Observatory for Atmosphere Space Interaction Studies




http://rsss.csl.illinois.edu/workshop

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# EXPLORING THE GEOSPACE FRONTIER: QUO VADIS?

| Science topic | Observational gap | Potential Facility Component(s) |
|---|---|---|
| Generation: Coronal and chromospheric Magnetism | Magnetic and energetic inputs at base of system. | CoSMO[1], FASR[2], SPRING[3] |
| Propagation: Interplanetary Space | The "93-million mile gap" | VHF Space Weather Radar[4] |
| Transference: Geospace plasma and energy sources | Undersampled in space and time | Ground and Space Distributed Sensor Networks[5] |
| Dissipation: Upper Atmosphere plasma-neutral interactions | Neutral and plasma observations above 100 km | OASIS[6] |

https://www2.hao.ucar.edu/events/GeospaceFrontier2016

# *OASIS*
# *Observatory for Atmosphere Space Interaction Studies*

- A Transformational Observatory
  - Able to observe neutral properties (T, u, v, w, ρ) from virtually the surface to 1000 km
  - Able to resolve wave fluxes into the thermosphere
  - Able to observe neutral and plasma interactions from 80 to 200 km
  - Able to detect meteor entry, ablation and fluxes
- A new kind of GeoSpace Facility
  - A centerpiece facility for lidar observing: the neutral gas equivalent to incoherent scatter radar plasma capability
  - Regional Coverage by: Incoherent scatter radar (AMISR), other radars, imagers, interferometers, spectrometers and, perhaps, in situ measurement capabilities using balloon and rocket payloads