TIMED

Thermosphere • Ionosphere • Mesosphere • Energetics and Dynamics

SCIENCE

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WHAT IS TIMED?

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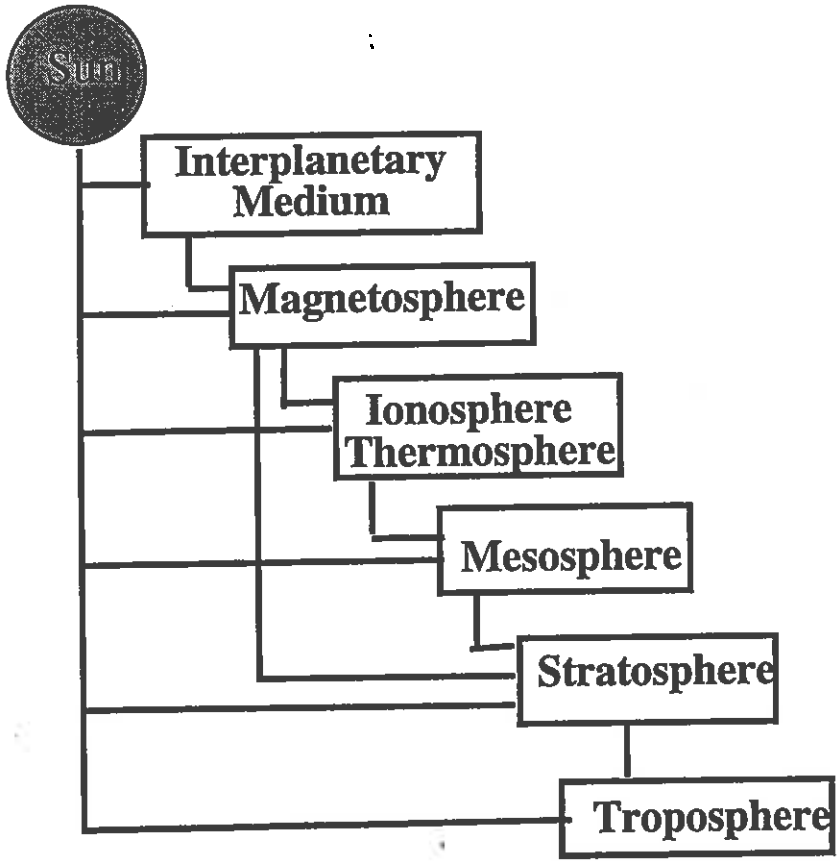

* Thermosphere, Ionosphere, Mesosphere, Energetics, Dynamics (TIMED)

* First mission in the NASA Solar Terrestrial Probes Program

* To understand the influence of the Sun on Earth's atmosphere

* To understand the influence of human activities on Earth's atmosphere

* To study the least-explored region of the atmosphere

* To improve the prediction of Space Weather

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- TIMED Core Region of Interest (60-180 km)
  - –the least-explored and least-understood region of the Earth's atmosphere
    - only limited data sets existed from rocket and groundbased experiments
      - –spatial limitation: limited in geographic location;
      - –temporal limitation: limited in time and duration of the observations.
    - SME and UARS provided the first glimpse of region
      - –lack of comprehensive and complete global data set to examine the basic structure and energy balance
  - –global data used to characterize the region can only be obtained from space using remote sensing techniques.

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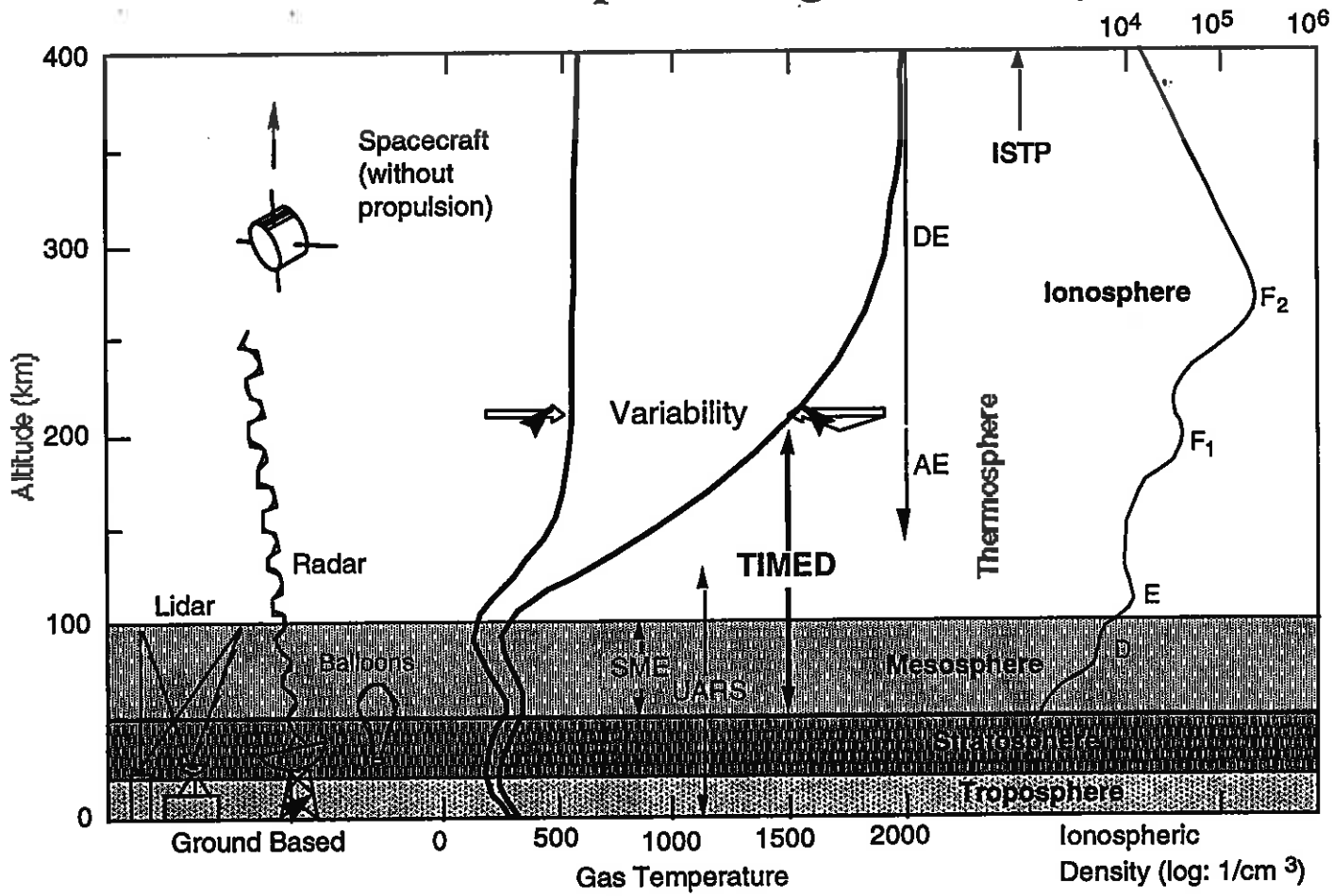
TIMED: Atmospheric Regions of Study



Scientific Rationale

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"The Earth's mesosphere and lower thermosphere are the least explored region on the Earth's atmosphere. They are influenced by varying solar extreme ultraviolet, ultraviolet, and X-ray radiation, auroral particles and fields, and upward propagating waves and tides from the lower atmosphere..... It is known that the global structure of this region of the atmosphere can be perturbed during stratospheric warmings and solar-terrestrial events (magnetospheric substorms, solar flares), but the overall structure and dynamics responses of these effects..... are not understood."

Space Science in the Twenty-First Century: Imperative for the Decades 1995-2015
The National Academy of Science, 1988

Mission Goals

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(1) To understand the influence of the Sun and lower atmospheric weather on Earth's upper atmosphere

-- Short-term variability caused by the sun from above and the weather from below

(2) To understand the influence of human activities on Earth's atmosphere

-- long-term variability caused by human activities from below

Mission Objectives

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* ***To Determine the MLTI Basic Structure:***

To determine the temperature, density, and wind structure in the Mesosphere, Lower thermosphere, and Ionosphere (MLTI) region (60-180 km), including the seasonal and latitudinal variations;

* ***To understand the MLTI Energy Balance:***

To determine the relative importance of the various radiative, chemical, electrodynamical, and dynamical sources and sinks of energy for the thermal structure of MLTI region.

Science Requirements: Measurements

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- **Atmospheric State Variables:**
  - Pressure, Density, Temperature, Winds.
- **Energy Input:**
  - Solar X-ray, EUV, FUV and MUV inputs;
  - Auroral particles and Joule Heating input;
- **Energy Output:**
  - Most important radiative emission rates.
- **Absorbing Species:**
  - O_2, N_2, O_3, CO_2;
- **Energy Redistribution:**
  - Chemical heating rates and Airglow Losses;
  - Dynamical heating or cooling rates;

TIMED Science Instrumentation

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- SEE (Solar EUV Experiment): ---------- Energy Input
  - A suite of photometers and spectrometer designed to measure the solar X-ray, UV and FUV irradiance.
- SABER (Sounding of the Atmosphere using Broadband Emission Radiometry): -------- State Variables, Minor Species, and Energy Output
  - A multichannel radiometer designed to measure the pressure, temperature, minor species and infra-red cooling rates.
- GUVI (Global Ultraviolet Imager): -------- State Variables and Energy Inputs
  - A spatial scanning UV spectrograph designed to measure the composition and temperature profiles, and auroral energy inputs.
- TIDI (TIMED Doppler Interferometer): ---------- State Variables
  - A Fabry-Perot Interferometer designed to measure the winds and temperature profiles.
- Groundbased Instrument Network: ----------State Variables and Energy Inputs
  - A network of groundbased instruments to provide measurement validation and supplementary atmospheric parameters.

Payload Instruments

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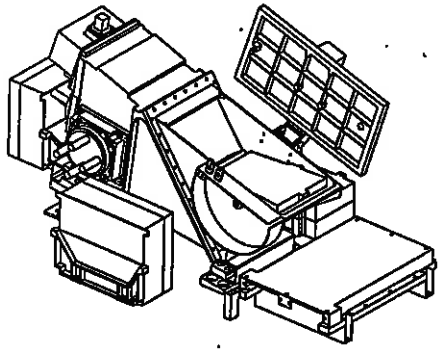
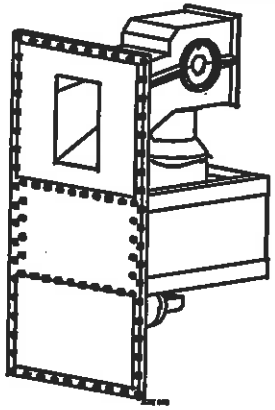


GUVI
(Aerospace Corp. APL/JHU)

* composition
* temperature
* auroral inputs
* electron density

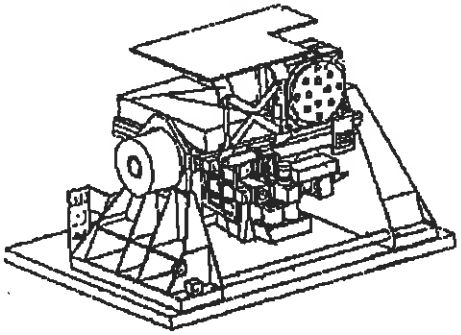
Global Ultra-Violet Imager



SABER
(Hampton Univ. NASA Langley, SDL/Utah State)

* pressure
* temperature
* infrared cooling rates
* composition

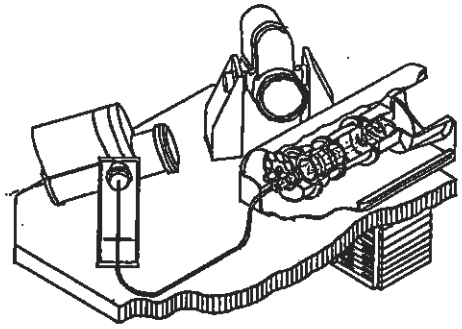
Sensing of Atmosphere using Broadband Emission Radiometry



SEE
(Univ. of Colorado)

* solar EUV irradiance
* composition

Solar EUV Experiment



TIDI
(Univ. of Michigan)

* vector winds
* temperature
* composition

TIMED Doppler Interferometer

Potential Ground Instrumentation

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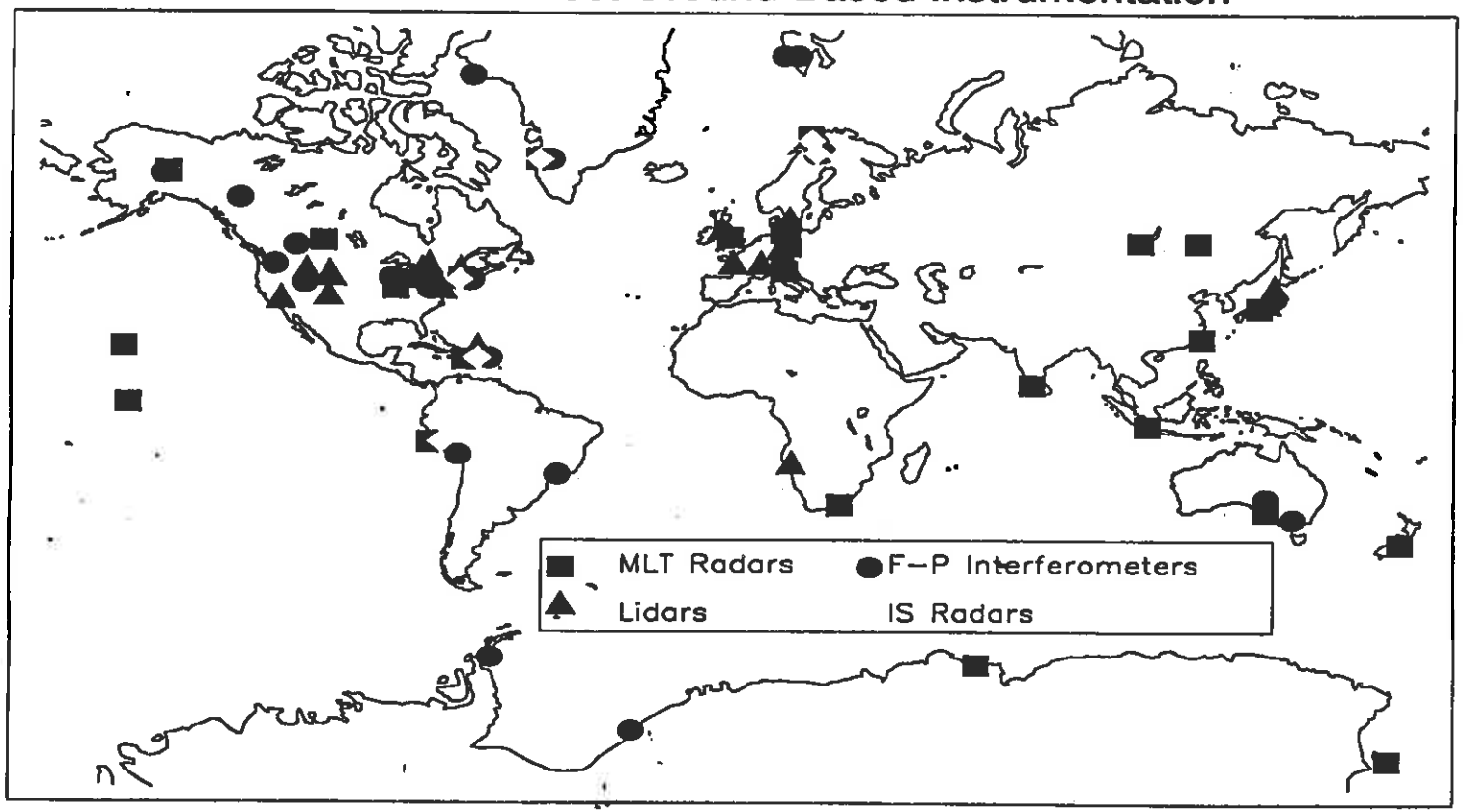
Locations of Select Ground-Based Instrumentation



Ground-Based Measurement Capabilities

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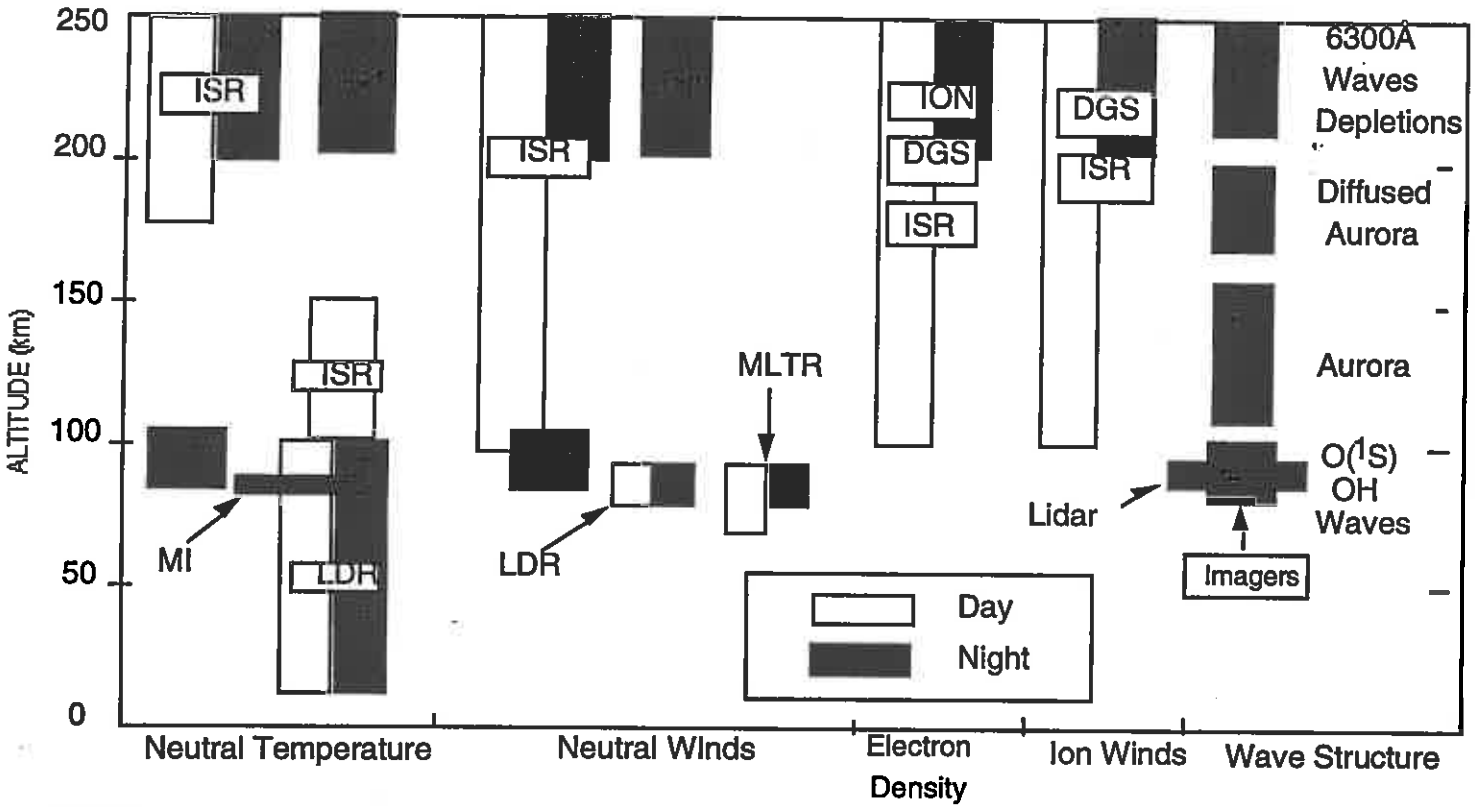

FPI : Fabry Perot Interferometer

ISR : Incoherent Scatter Radar

ION : Ionosonde

DGS : Digisonde

MI : Michelson Interferometer

MLTR : Mesosphere/Lower Thermosphere Radars (MF,Meteor, MST)

LDR : Lidars (Rayleigh, Sodium)

Measurement Complement

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	Instruments				
Measurements	**GUVI**	**SABER**	**SEE**	**TIDI**	**SM***
State Parameters					
Temperature	P	P		P	C
Density	P	P	C	C	C
Wind Velocity		C		P	C
Composition	P	P	C	C	C
Energy Inputs					
Solar	C		P		C
Auroral	P			C	P
Tides/Waves		P		P	P
Energy Outputs		P		C	

P: Primary Measurement; C: Contributing Measurement

*SM: Supporting Measurements (groundbased and other space missions)
Groundbased investigators are to be selected.

TIMED Measurement Capabilities

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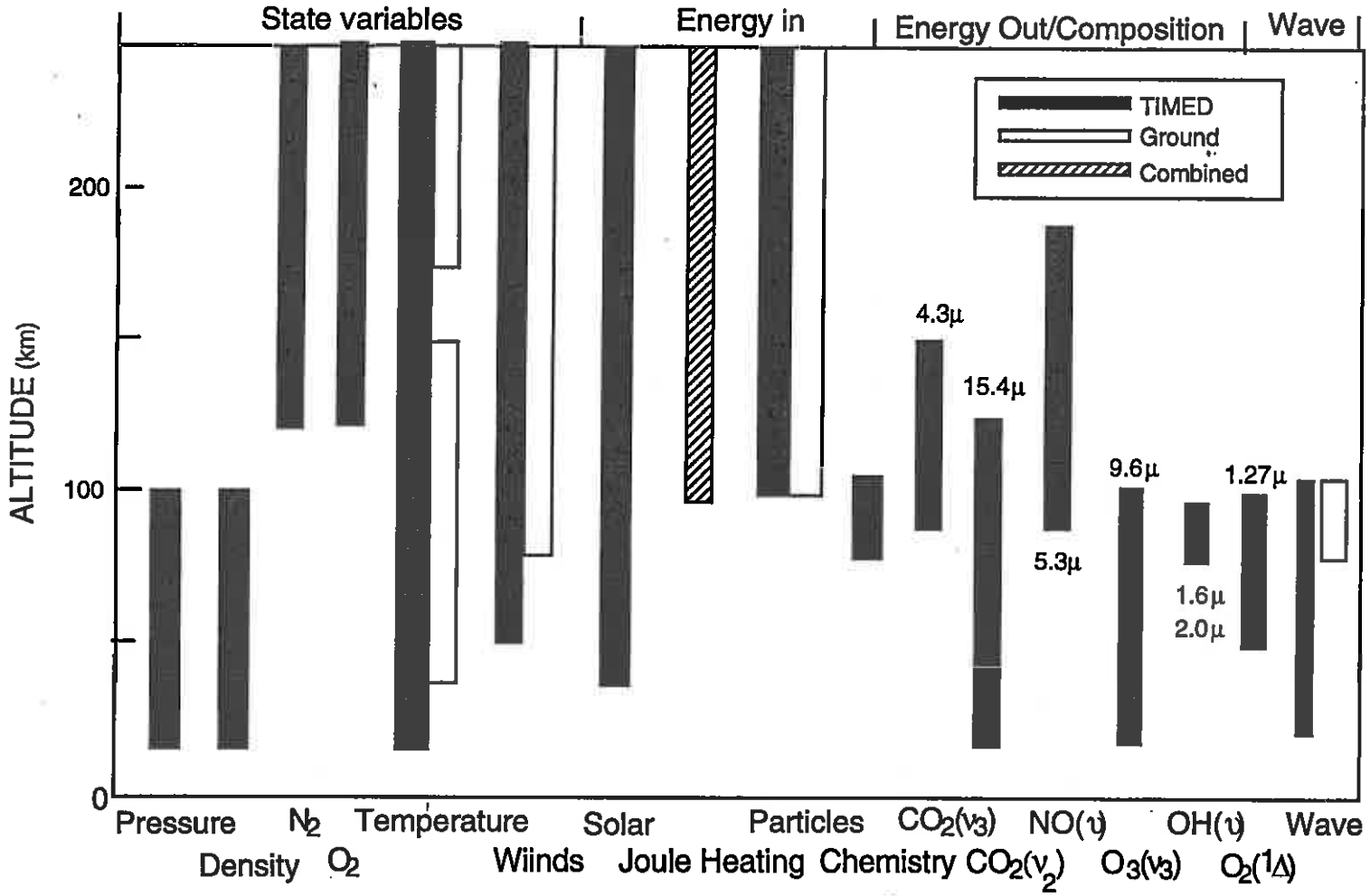

Mission Success Criteria

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"The TIMED program must provide global scale measurements of the distribution of

* *temperature;*
* *density (or pressure);*
* *wind velocity, and*
* *composition*

in the MLTI region (basic structure). These will be the first simultaneous measurements of the state parameters which are critical in characterizing the MLTI basic structure" (Mininum Success Criteria)

Mission Science Success (I)

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- 1 day of TIMED observations
  - a near-global data set on the structure and energetics of the MLTI region
    - » altitude and longitudinal variabilities examined.
- 10 days of TIMED observations
  - a near-global data set on the structure and energetics of the MLTI region
    - » near-global planetary wave scale variability (i.e. 2-day and 5-day waves) studies allowed.
- 60 days of TIMED observations
  - a near-global data set on the structure and energetics of the MLTI region
    - » near-global tidal and planetary-wave scale variability study examined (under either solstice or equinox conditions).

Mission Science Success (II)

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- 120 days of TIMED observations
  - a global data set on the structure and energetics of the MLTI region
    - » global seasonal variability examined (structure of either solstice or equinox established).
- 180 days of TIMED observations
  - a global data set on the structure and energetics of the MLTI region
    - » global seasonal variability examined (structures of both solstice or equinox established).
- 360 days of TIMED observations
  - a global data set on the structure and energetics of the MLTI region
    - » global inter-annual variability (i.e. semi-annual) examined.

Mission Science Success (III)

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- 2 years of TIMED observations
  - a global data set on the structure and energetics of the MLTI region
    - » quasi-bienial variability study allowed (i.e. QBO)
    - » solar-cycle variability study allowed.
- 4 years of TIMED observations
  - a global data set on the structure and energetics of the MLTI region
    - » quasi-bienial variability examined
    - » 11-year solar cycle variability examined.

TIMED Science Team

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- Project Scientist: Sam Yee
- Instrument PI:
  - Andy Christensen (GUVI), Timothy Killeen (TIDI), James Russell (SABER), Thomas Woods (SEE)
- Interdisciplinary Scientists (IDS):
  - Guy Brasseur: Middle Atmosphere Energetics and Dynamics
  - Jeffery Forbes: Large-scale Wave Dynamics (tides and waves)
  - Dave Fritts: Small-scale Wave Dynamics (gravity waves)
  - Janet Kozyra: Ionosphere/Magnetosphere Coupling
  - Hans Mayr: Wave Dynamics and Wave Energetics
  - Stan Solomon: Lower Thermosphere Energetics

- **Groundbased Instrument Representatives:**
  - **Joseph Salah (Radar), John Meriwether (Optical)**

Anticipated Accomplishments

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- Complete the first exploration of the MLTI regions and establish the distribution and variability of the state parameters (Basic Structures).
- Examine the major energy sources *(solar radiation, and auroral power inputs)*, transport processes *(air motions and heat conduction)* and energy sinks *(chemically active and radiatively significant molecules)* in this region, and apply this information to define the channels by which energy enters into, travels through, and is lost in the region (Energy Balance).
- Understand the influences of the sun and outer space on the Earth's middle/upper atmosphere and use this knowledge to increase our ability to predict space weather (e.g. satellite drag) (Space Weather).
- Provide a benchmark for the current state of the sensitive MLTI region for future studies of natural and human induced changes to the Earth's atmosphere, providing an avenue for early warning of global change (Anthropogenic Change).
- Supply knowledge of the upper atmospheric circulation pattern, important in the transport of chemically and radiatively active species (e.g. ozone).

Expected Return

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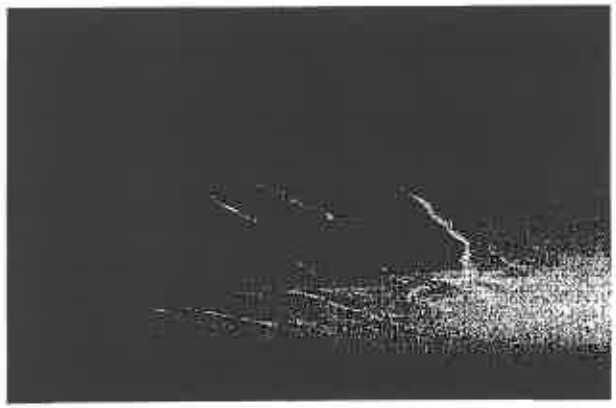
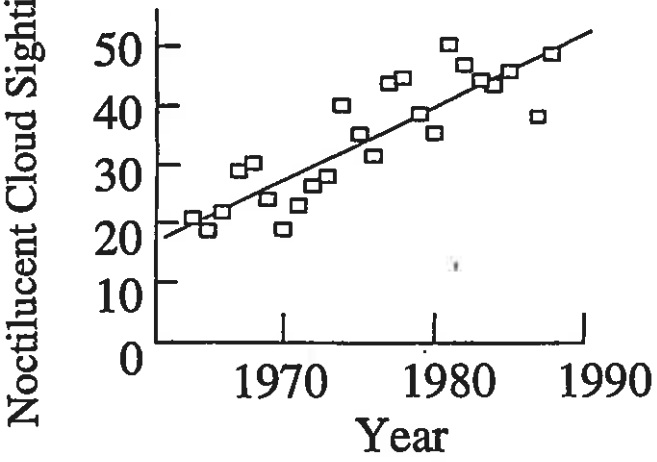
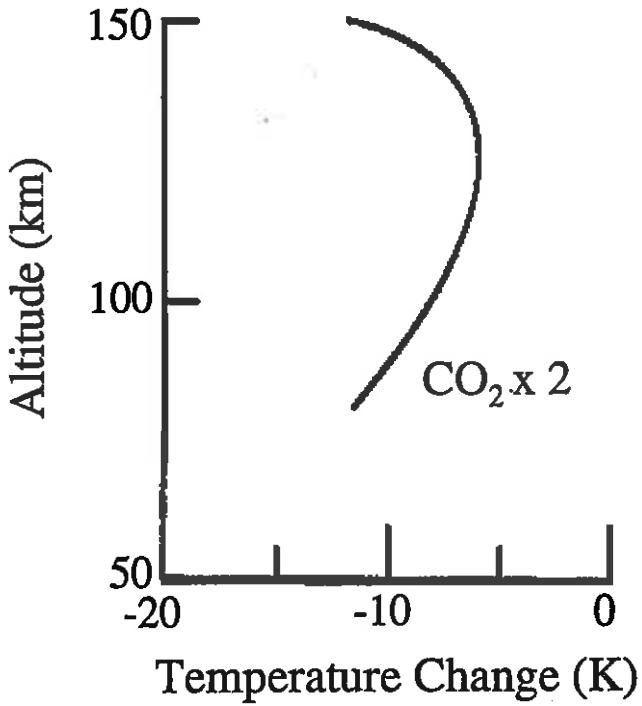
To Establish MLTI Benchmark and Predict its response to "Anthropogenic" Effects

Increasing Noctilucent Cloud Sightings





Predicted Temperature changes as CO_2 doubles in the atmosphere



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Expected Return

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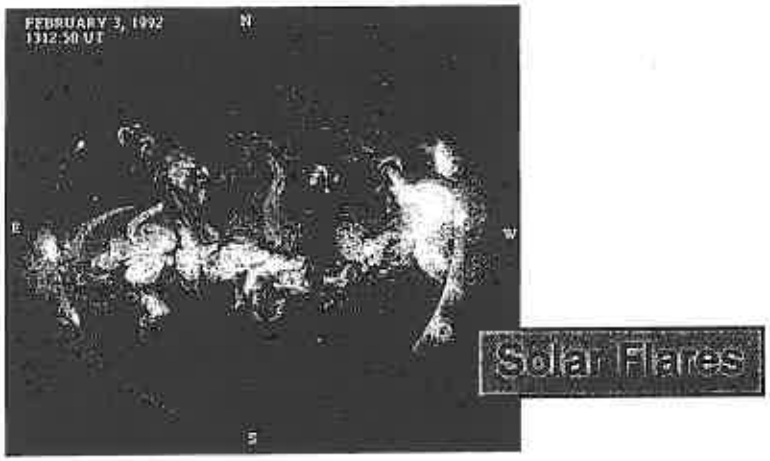
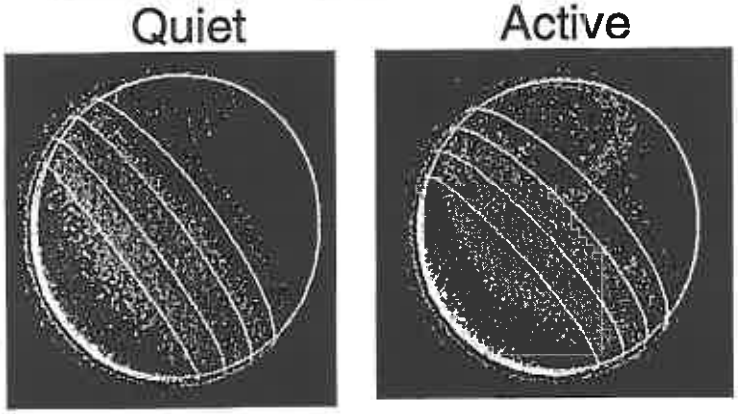
To Improve our Prediction of Space Weather





Earth UV Images indicating the change of composition as solar flare activity increases

* Better understanding of the effects of solar flares on:
  - satellite communication through modification of the ionosphere;
  - satellite tracking through compositional changes of the thermosphere;

* Better determination of atmospheric drag due to:
  - solar cycle effects (I.e. 11-year, 27-day effect);
  - solar flare (storm) effects;
  - tidal effects.

TIMED Data Distribution

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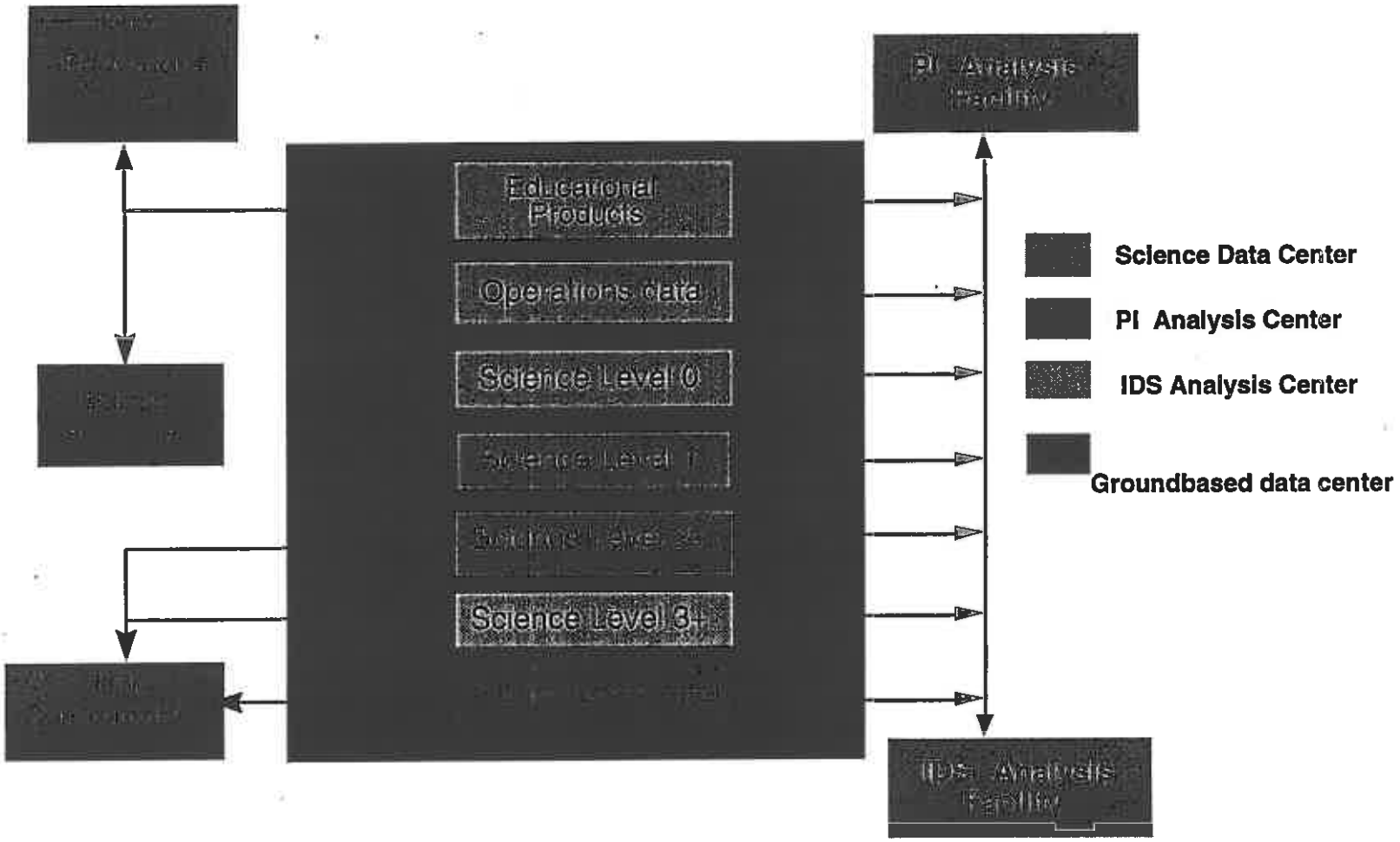

TIMED Education and Public Outreach

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- A TIMED educational and public outreach plan is being developed by an Education Outreach subcommittee of the TIMED Science Working Group and APL Communication and Public Affairs
- The TIMED Outreach Program Includes:
  - K-12 curriculum development through the efforts of K-12 educators, curriculum development specialists, classroom teachers, and TIMED scientists.
  - Outreach to museum, science centers, libraries and the news media.
  - Internet access to a TIMED WWW Home Page, including mission news and description, discoveries, selected images, data products, and classroom activities. A TIMED WWW Home Page is now online (http://sd-www.jhuapl/TIMED).
  - development and periodic distribution of Multimedia CDs to students and educators nationwide.
- TIMED project is developing education programs in coordination with ongoing local and nationwide education activities (e.g. NASA Langley's Outreach Program)

Outreach Plans

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Outreach activities will be similar to those conducted for the NEAR program

- Visiting educators will develop curricula and other materials during 8 week summer appointments
- A TIMED teachers conference will be held at APL shortly before launch
- Outreach materials will include fact sheets, videos, activity sheets, displays and inexpensive models
- Cooperative funding for outreach very likely
- The TIMED science team will work closely with educators throughout the program

Outreach Program Status

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- Outreach and Education Material Development:
  - **Ms. Ann Coren** (Chemistry teacher at Springbrook High School in Silver Spring, MD)
    - » worked APL during the summer of 1997
    - » developed a laboratory experiment of temperature sounding
    - » working with APL personnel, developed a concept for demonstrating remote temperature sensing using an inexpensive thermopile detector, reflecting mirror, and analog electronics