SOLAR ACTIVITY EFFECTS ON THE

MIDDLE ATMOSPHERE

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Aurora art: Tatyana Kornilova

Photo: Mikko Syrjäsuo

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MENU

- What is the middle atmosphere? - The so called ignorosphere?
- What is the solar input? - Variations in radiation and particles
- Why do we care? - Effects of particle precipitation
- How do we know? - Ways to measure

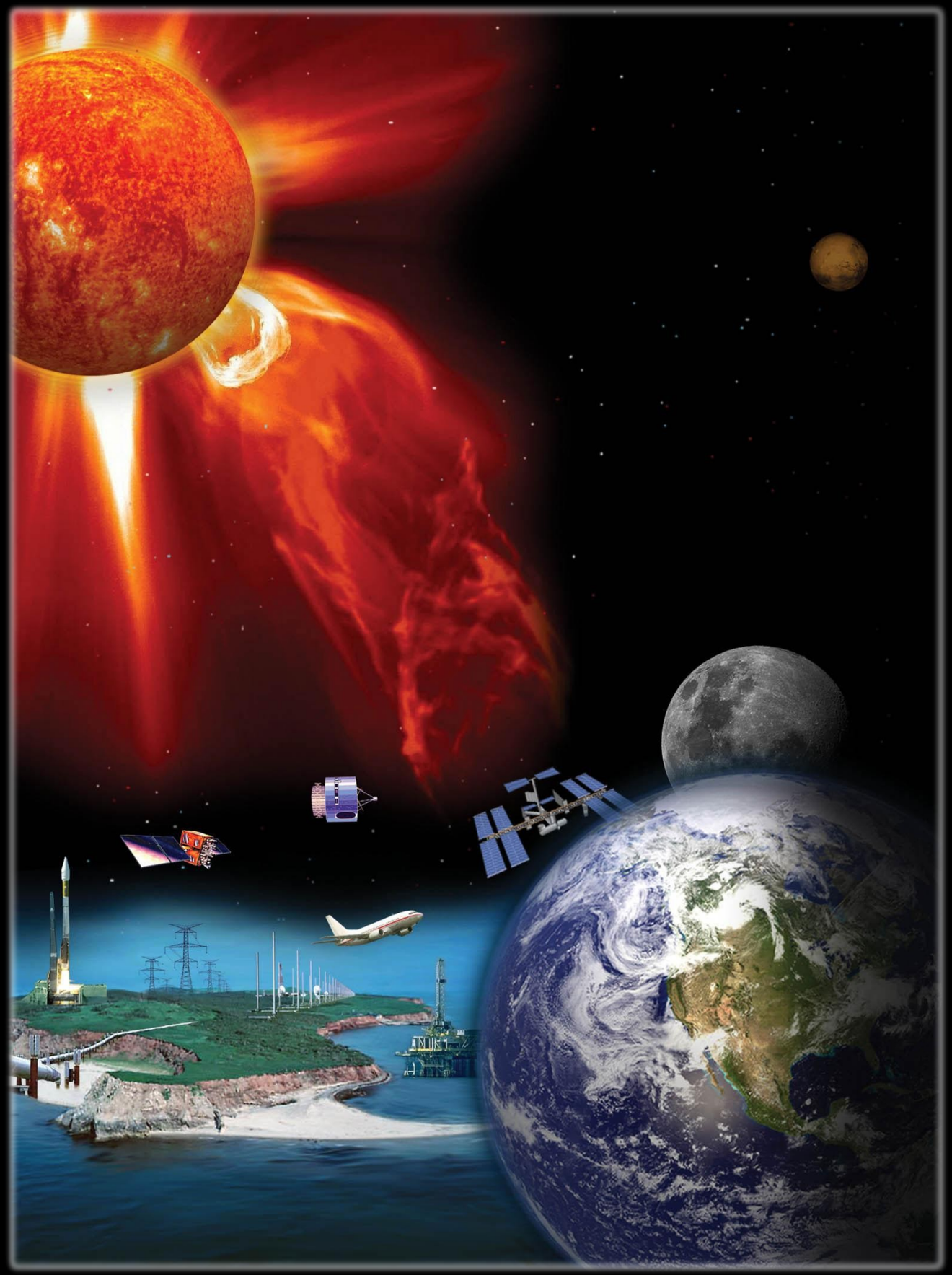
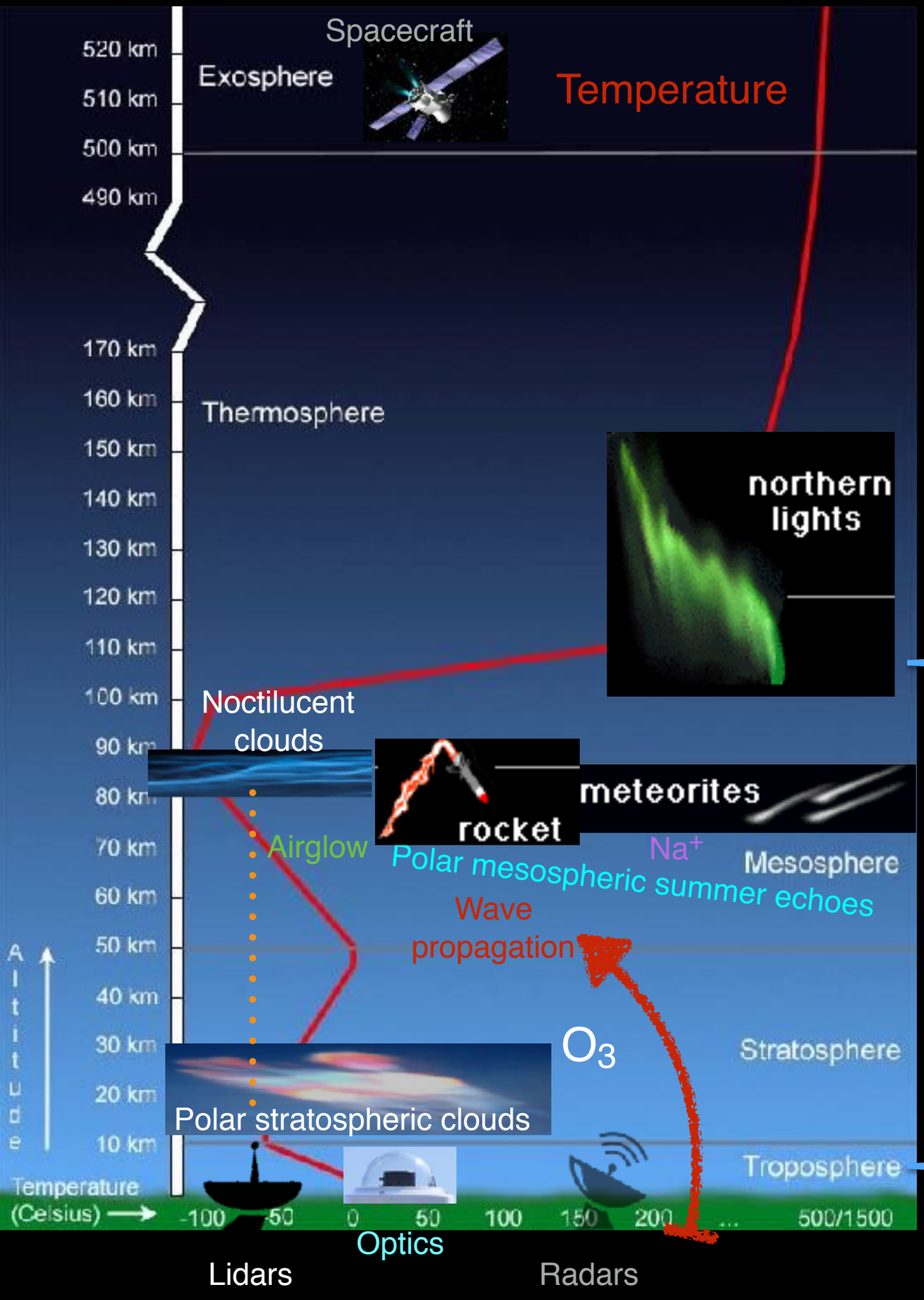


Illustration: NASA

THE MIDDLE ATMOSPHERE



Plasma

Weather

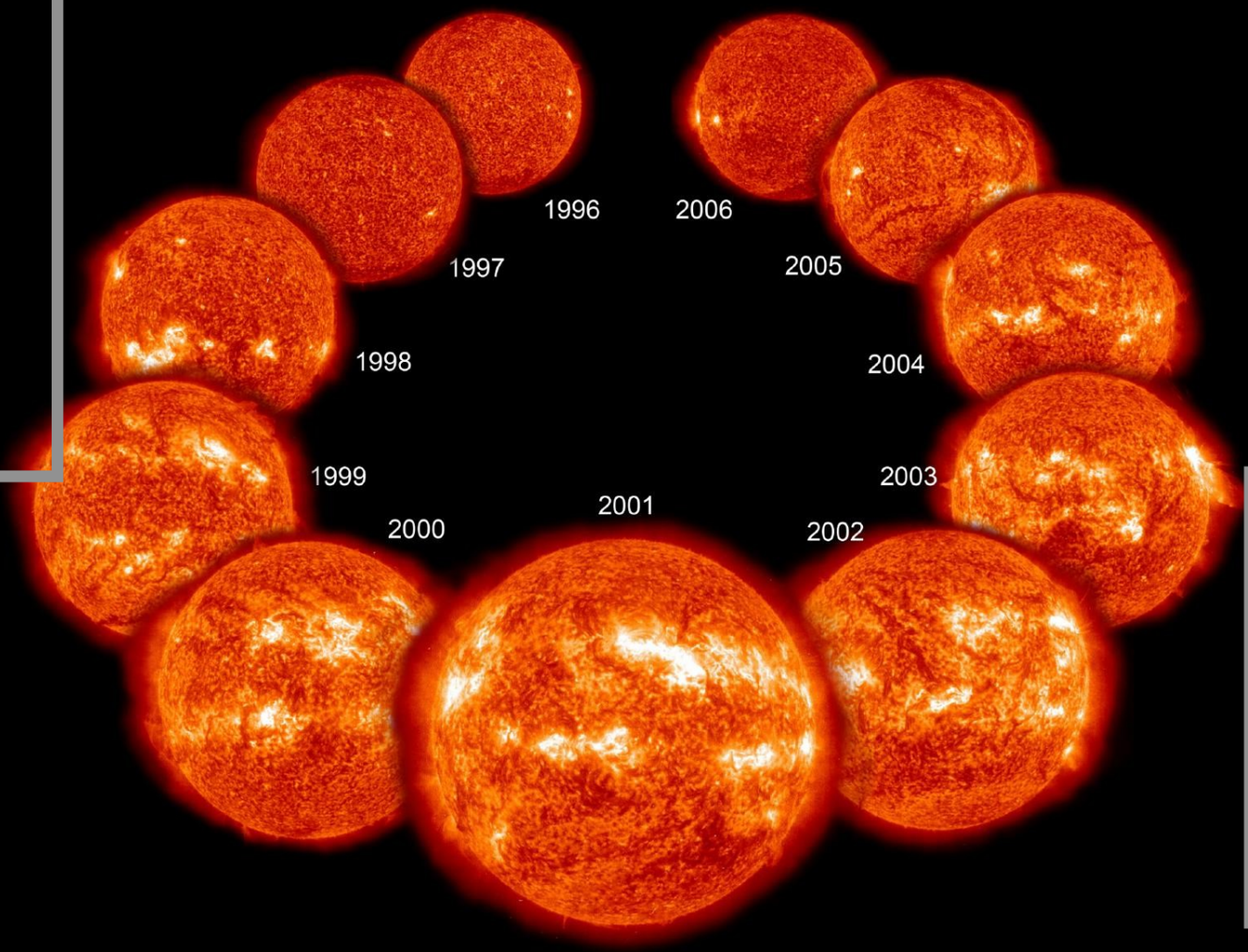
SOLAR CYCLE

Solar radiation

Total solar radiation power changes between the solar maximum and solar minimum are of the order of 0.1%

UV changes ~5-8%

Solar minima



Solar maximum

Solar particles

Particle output changes between the solar maximum and solar minimum are of the order of 100%

Illustration: NASA

INTERACTION BETWEEN THE SOLAR WIND AND THE MAGNETOSPHERE

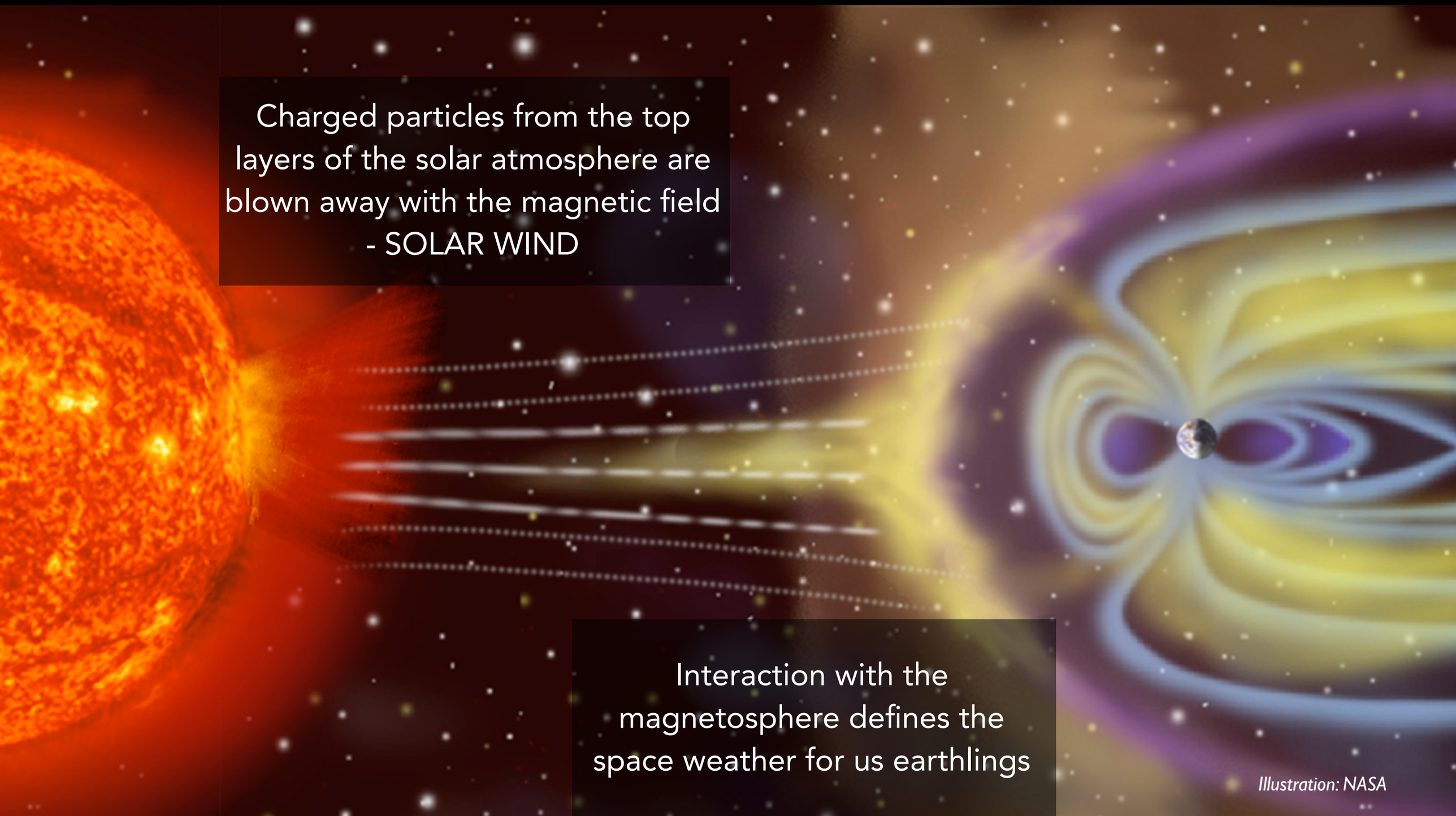
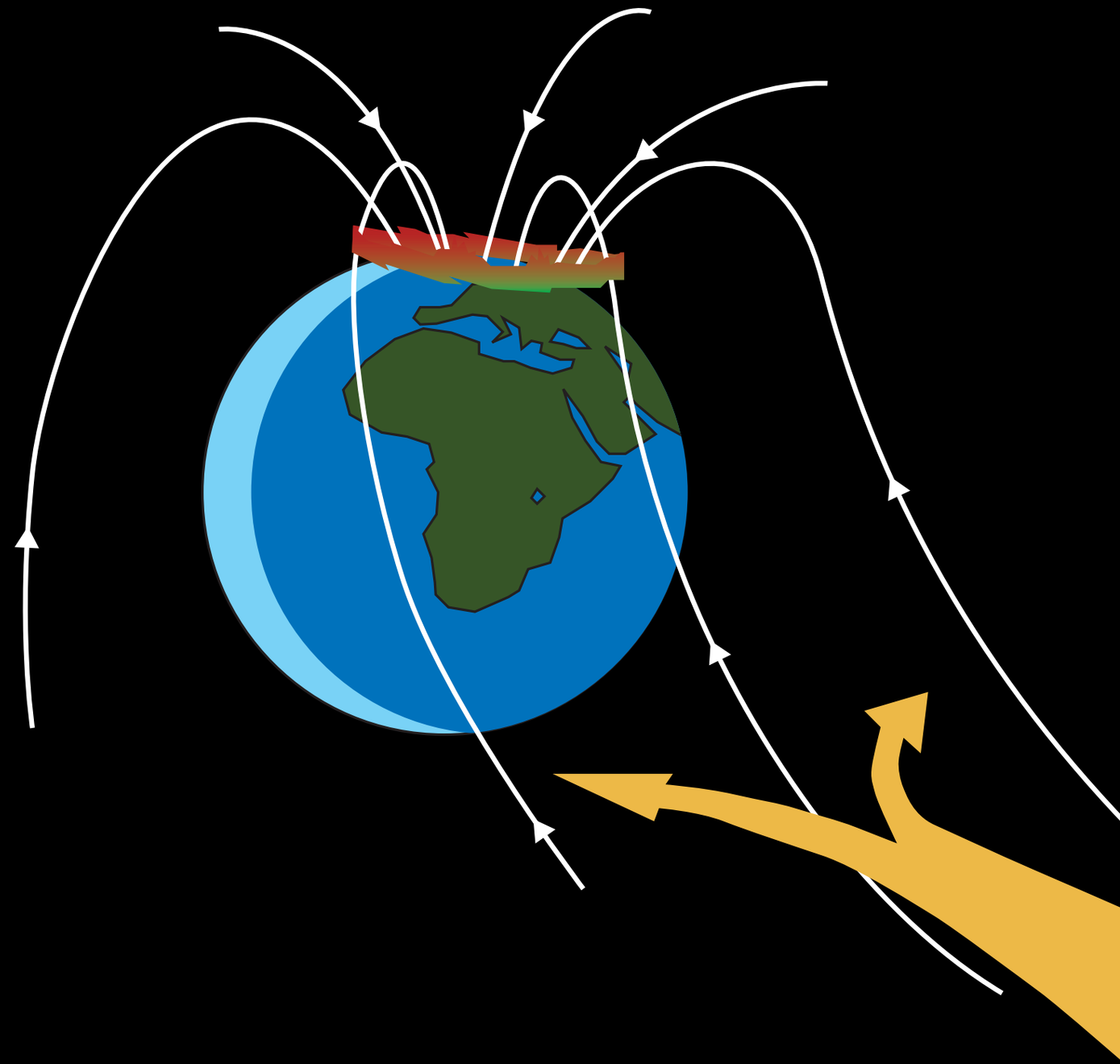


Illustration: NASA

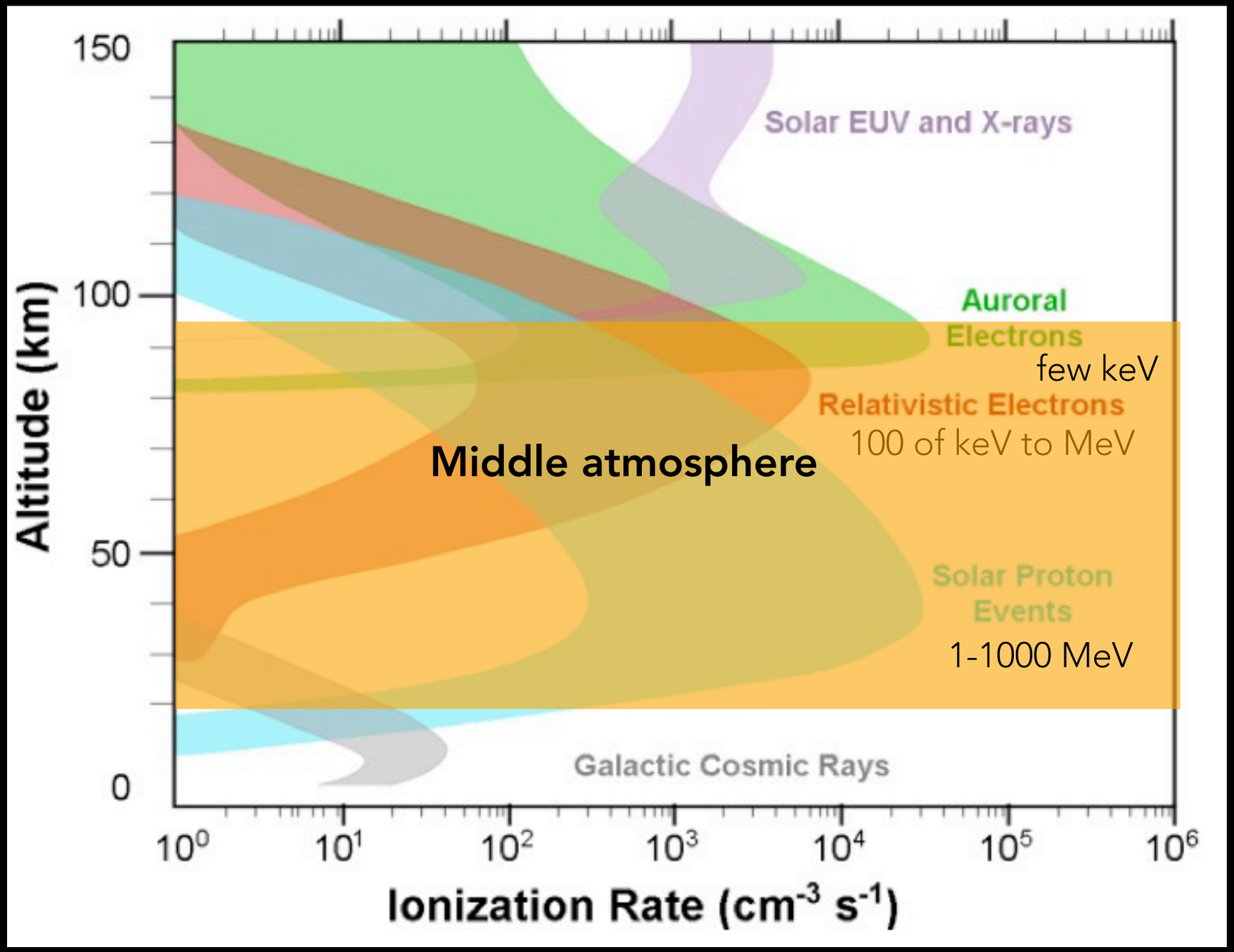
PATHWAY TO THE ATMOSPHERE

Guided by the Earth's magnetic field the energetic particles fall into the polar atmospheres.

The interaction between the incoming particles and the atmosphere causes aurora, currents and conductivities, and changes in the atmospheric composition.



PARTICLE ENERGIES AND IMPACT HEIGHTS



Particle energy determines the altitude of impact.

Ionisation rate = # of ion pairs/cm3/s

ENERGETIC PARTICLE EVENTS

Solar Proton Events:

- Source in the Sun
- Typical energies about 1 to 10[illegible] MeV
- Sporadic
- Intensity of [illegible] predictable
- Flux [illegible] available
- [illegible] on the [illegible] are well understood

Known, modelled, understood!

ENERGETIC PARTICLE EVENTS

Solar Proton Events:

- Source in the Sun
- Typical energies about 1 to 1000 MeV
- Sporadic
- Intensity of events unpredictable
- Flux information available
- Effect on the atmosphere well understood

Electron precipitation:

- Auroral and relativistic electrons
- Magnetospheric sources
- Typical energies from about keV to MeV
- Almost always present
- Fluxes not well known
- Atmospheric effects are less known

E ~ MeVs

E ~ keVs

CHAIN OF PROCESSES DUE TO PARTICLE PRECIPITATION

Energetic particle precipitation into the polar atmosphere (30-100 km) increases ionisation

Enhanced production of long-lived NOx and short-lived HOx

NOx and HOx gases can participate in catalytic ozone depletion

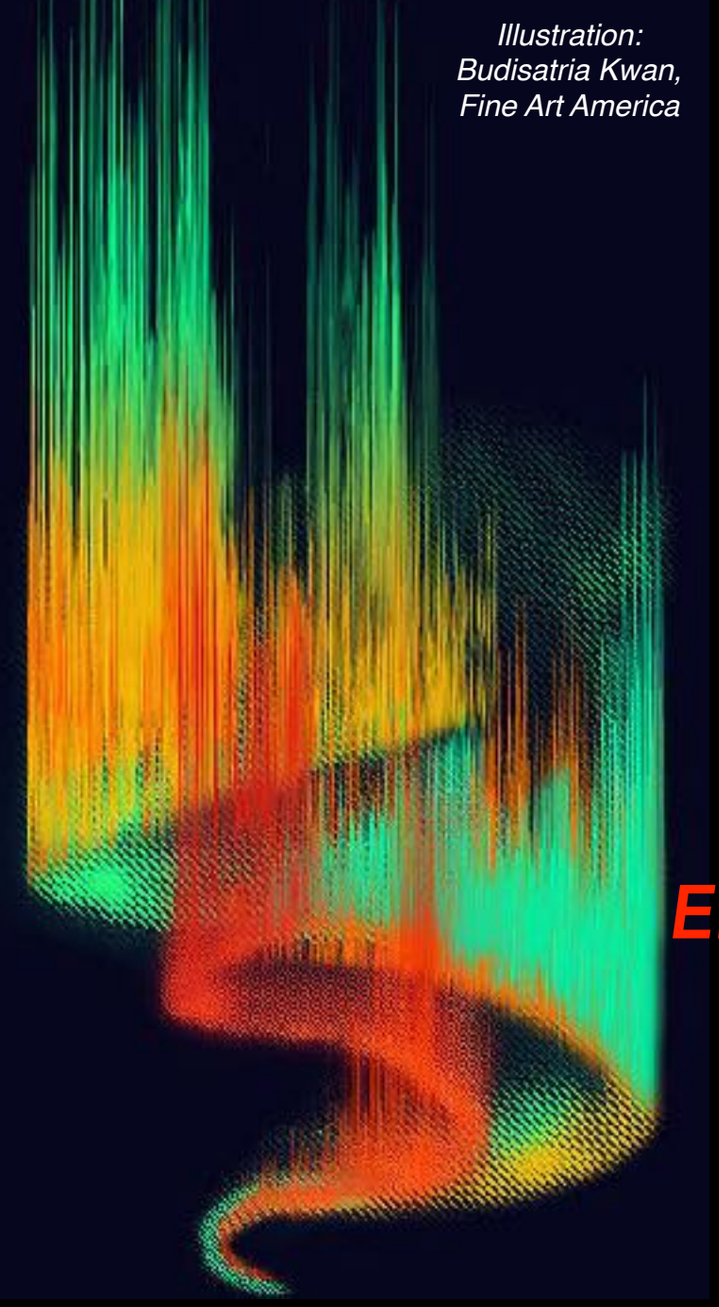


Illustration: Budisatria Kwan, Fine Art America

WE CARE ABOUT OZONE?

O_3 efficiently absorbs solar UV and radiates away warmth in the atmosphere

Temperature change in an atmospheric air column changes its pressure

Changing air pressure alters the wind pattern

Changes in the winds and general circulation modifies the energy transfer

Energetic particle precipitation may cause all this!

Video credit: Esa Turunen, SGO

MIDDLE ATMOSPHERE DYNAMICS

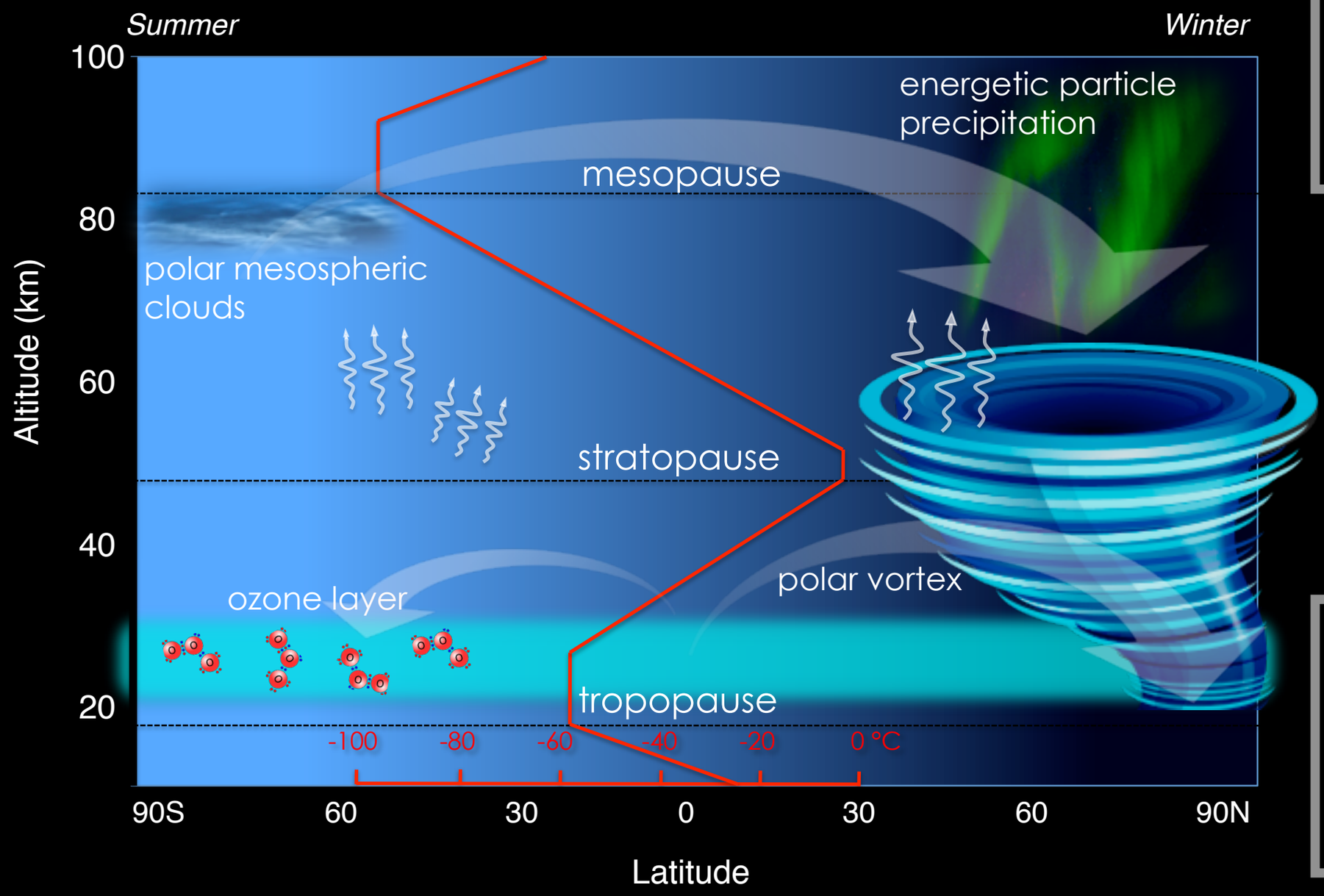


Illustration: LASP, UCB, USA

Energetic particles access the atmosphere in the polar regions ➜ Direct chemical changes

Strong winds around the winter pole form the polar vortex ➜ Downward transport in isolation

MIDDLE ATMOSPHERIC MONITORS IN THE SURROUNDINGS OF LONGYEARBYEN

Imaging riometer in Adventdalen

- Measures absorption of cosmic radio noise
- Energetic particles cause ionisation
  ➜ increased ionisation causes absorption

In photo: Arnau Vidal

MIDDLE ATMOSPHERIC MONITORS IN THE SURROUNDINGS OF LONGYEARBYEN

Meteor and mesosphere-stratosphere-troposphere (MST) radars in Adventdalen

- Measure radio wave backscatter from meteor trails and atmospheric irregularities, such as noctilucent clouds
- Data can be used to calculate winds and temperatures in the atmosphere

Photo credit: Chris Hall, UiT

MIDDLE ATMOSPHERIC MONITORS IN THE SURROUNDINGS OF LONGYEARBYEN

Incoherent scatter radar by Mine 7

- Measures radio wave backscatter from atmospheric electrons
  ➜ direct electron precipitation measurement!
- Ice particles in the cold mesopause can be charged and also scatter the radio waves

Photo credit: Shabnam Nikbakhsh, Aalto University

MIDDLE ATMOSPHERIC MONITORS IN THE SURROUNDINGS OF LONGYEARBYEN

Airglow spectrometer at KHO

- Spectrometer measures hydroxyl (OH) airglow
- Airglow emissions are powered by solar UV
- Airglow is present globally
- Emission intensities can be used to calculate mesopause temperatures

Photo credit: Mikko Syrjäsuo, UNIS

TAKE HOME ITEMS

- Middle atmosphere between weather and aurora includes the stratosphere and the mesosphere
- Solar radiation input sets the heat balance and wind patterns
- Solar particle input causes aurora and atmospheric composition changes, which can affect temperatures and dynamics
- Atmospheric layers are tightly coupled

Aurora art: Tatyana Kornilova