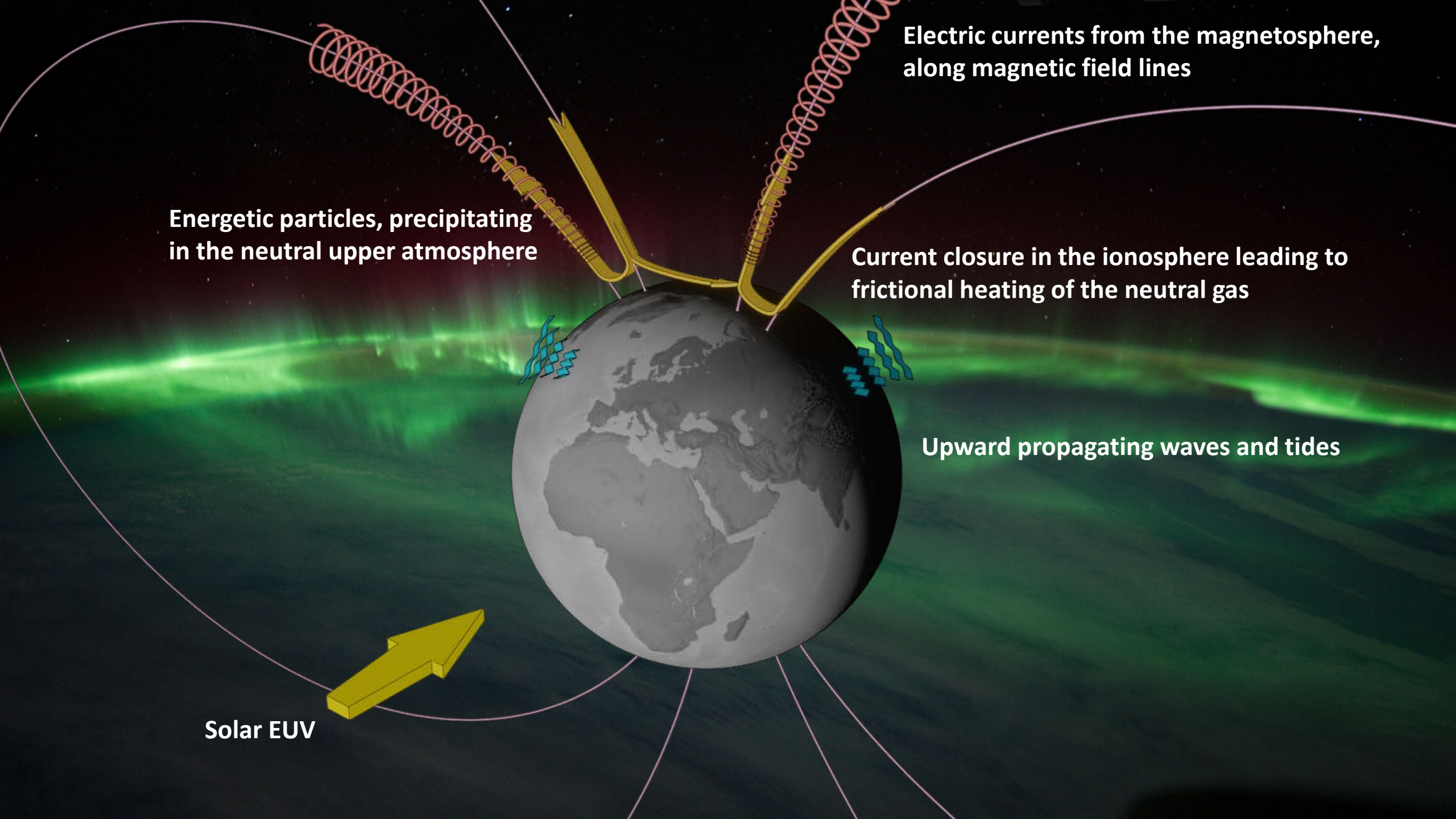


# daedalus

**TO EXPLORE HOW OUR  
ATMOSPHERE INTERACTS  
WITH SPACE**

# One of three candidate missions for Earth Explorer 10

- Three mission concepts have been in phase 0 studies from July 2019 to September 2020
- Assessment by ESA's Advisory Committee for Earth Observation this week
- Up to two missions will go into phase A in early 2021
- One mission to be selected to be implemented in September 2022
- Launch foreseen in the 2028-2030 timeframe
- The other two candidates are synthetic aperture radar missions: Harmony and Hydroterra



Electric currents from the magnetosphere,  
along magnetic field lines

Energetic particles, precipitating  
in the neutral upper atmosphere

Current closure in the ionosphere leading to  
frictional heating of the neutral gas

Upward propagating waves and tides

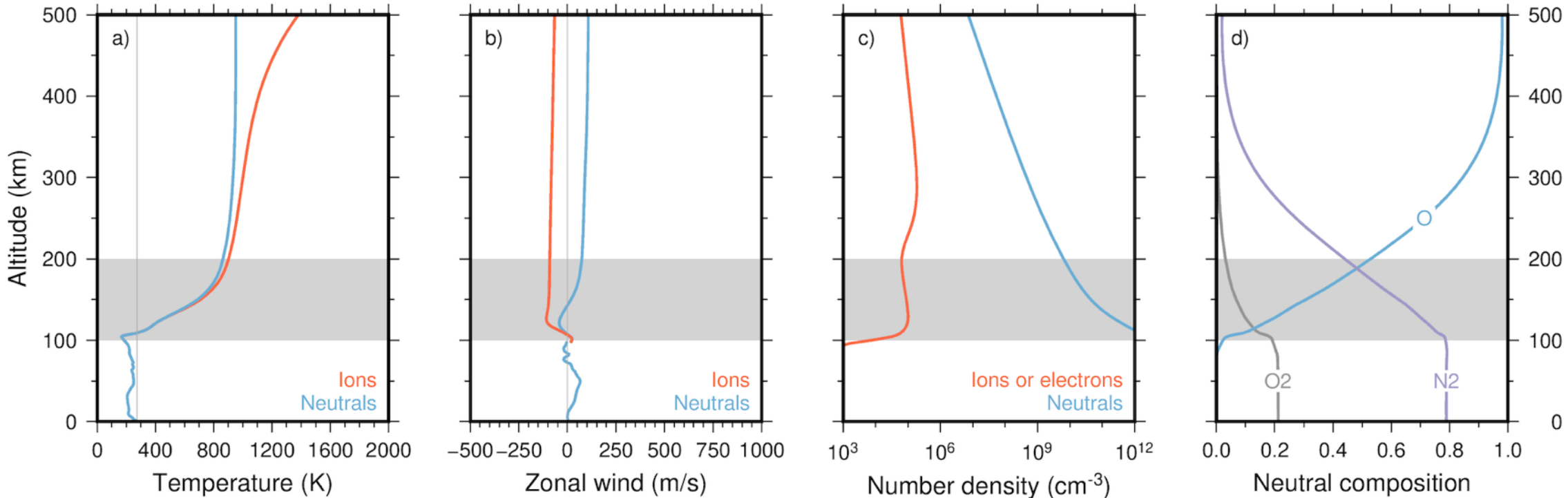
Solar EUV

# LTI variability as a response to geomagnetic activity

- Quiet conditions

WACCM-X / TIE-GCM profiles over Nordkapp, Norway (71°N, 26° E)

— 2015-03-16 20:39 UTC, quiet

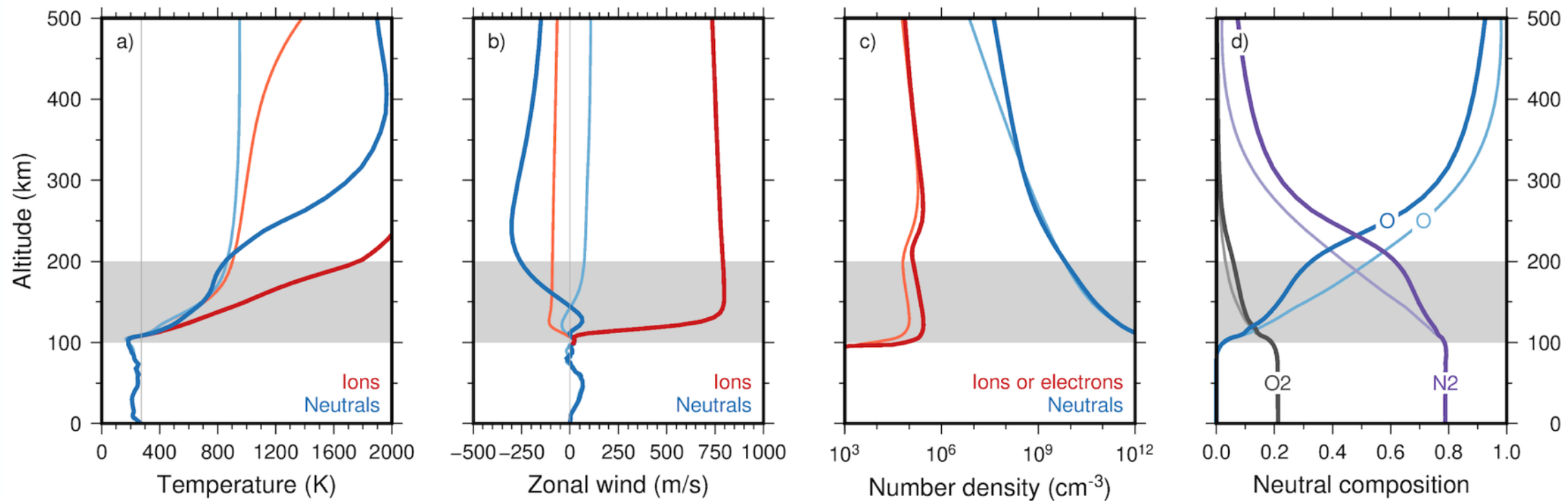


# LTI variability as a response to geomagnetic activity

- Active conditions

WACCM-X / TIE-GCM profiles over Nordkapp, Norway (71°N, 26° E)

— 2015-03-16 20:39 UTC, quiet  
— 2015-03-17 20:39 UTC, storm



# Observation Concept and Mission Requirements

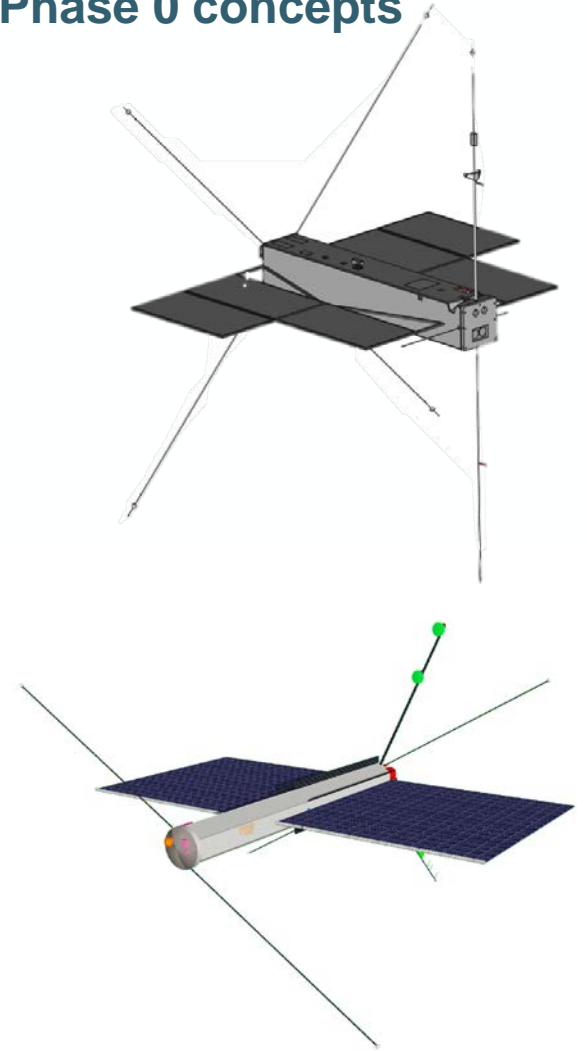
## Geophysical Observables

	Abbreviation	Geophysical Observable
Ionosphere	$\vec{v}_i$	Ion Drift velocity
	$T_i$	Ion Temperature
	$T_e$	Electron Temperature
	$N_i$	Ion Number Density
	$N_e$	Electron Number Density
	TEC	Total Electron Content
	$n_{ix}$	Ion Composition
thermosphere	$\vec{u}_n$	Neutral Wind Velocity
	$N_n$	Neutral Number Density
	$\rho$	Neutral Mass Density
	$a_{ng}$	Non-gravitational acceler.
	$T_n$	Neutral Temperature
	$n_{nx}$	Neutral Composition
fields	$\vec{B}$	Magnetic Field
	$\vec{E}$	Electric Field
EPP	$F_{le}, F_{he}, F_{li}, F_{le}$	Energetic Precipitating Particles (ions, electrons)

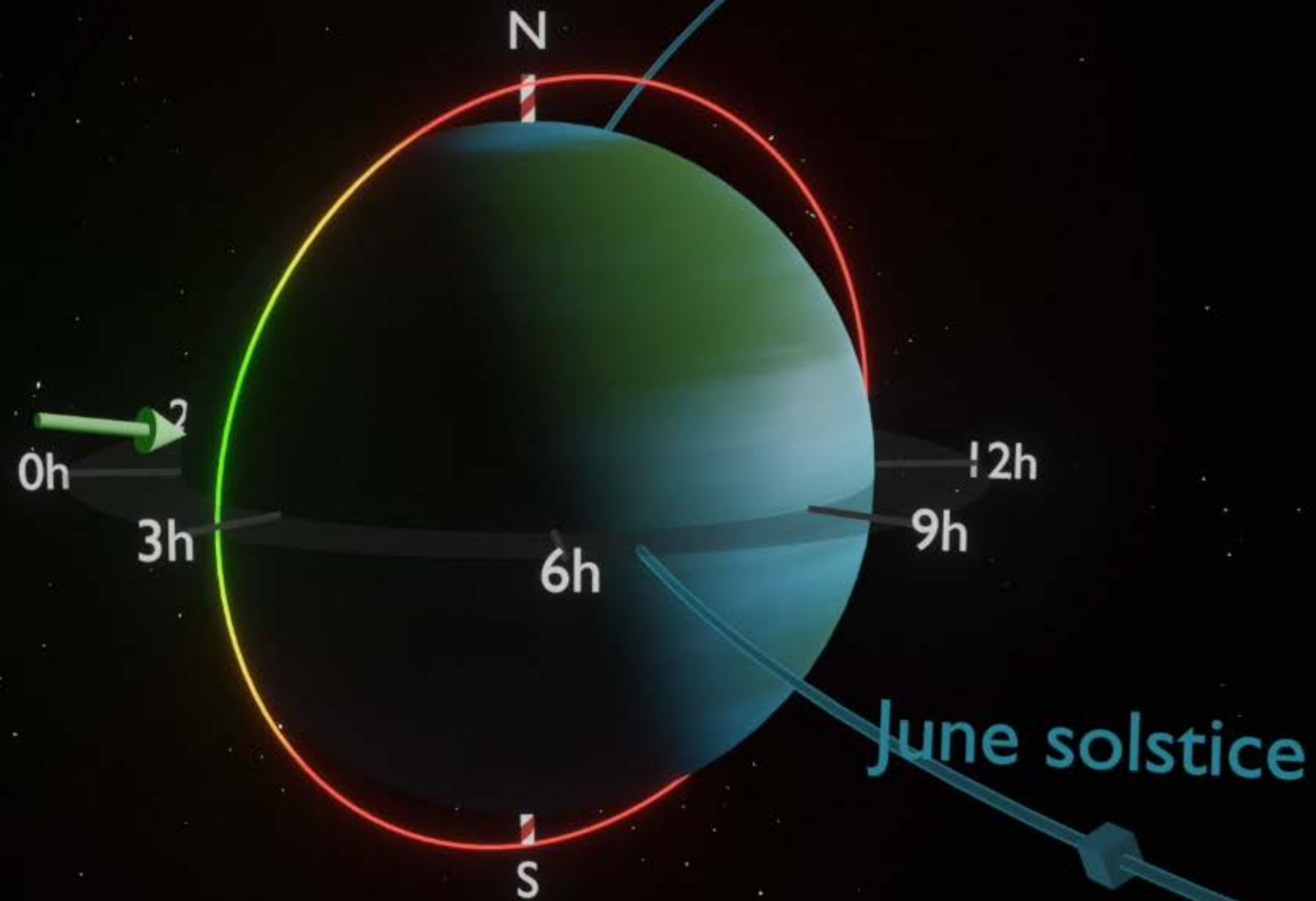
## Derived Products

	Derived Product	Derived Product Symbolism
Heating Sources	Joule Heating	$q_j = eN_e(\vec{v}_{i\perp} - \vec{u}_{n\perp}) \cdot (\vec{E} + \vec{u}_n \times \vec{B})$
	Ohmic Heating	$q_\Omega = \sigma_p  \vec{E} + \vec{u}_n \times \vec{B} ^2$
	Frictional Heating	$q_f = m_i v_{in} N_e  \vec{v}_{i\perp} - \vec{u}_{n\perp} ^2$
	Poynting Vector	$S = \vec{E} \times \Delta \vec{B} / \mu_0$
	Energetic Particle Precip. heating	$q_{EPP} = \pi \sum_i F_i(E) E_i dE_i$
	Currents	Perpendicular current (via $\vec{v}_i, \vec{v}_e$ )
Perpendicular current (via $\vec{J}_P, \vec{J}_H$ )		$\vec{J}_\perp = \vec{J}_P + \vec{J}_H = \sigma_p(\vec{E} + \vec{u}_n \times \vec{B}) + \sigma_H \hat{b} \times (\vec{E} + \vec{u}_n \times \vec{B})$
Magnetic Forcing		$\vec{f}_{mag} = \vec{J} \times \vec{B}$
Field Aligned Currents		$\vec{J}_{FAC} = (1/\mu_0)(\Delta \vec{B} / \Delta x)$
Conductivities, Cross-Sections		Conductivities
	Ion-Neutral Cross Sections	$\sigma_{in} = v_{in} N_n^{-1} (2k_B T_i / m_i)^{-1/2}$
	Ion-Neutral Collision Frequencies	$\nu_{in} = (e/m_i)  \vec{E}_\perp + \vec{v}_i \times \vec{B}  /  \vec{v}_{i\perp} - \vec{u}_{n\perp} $

## Phase 0 concepts

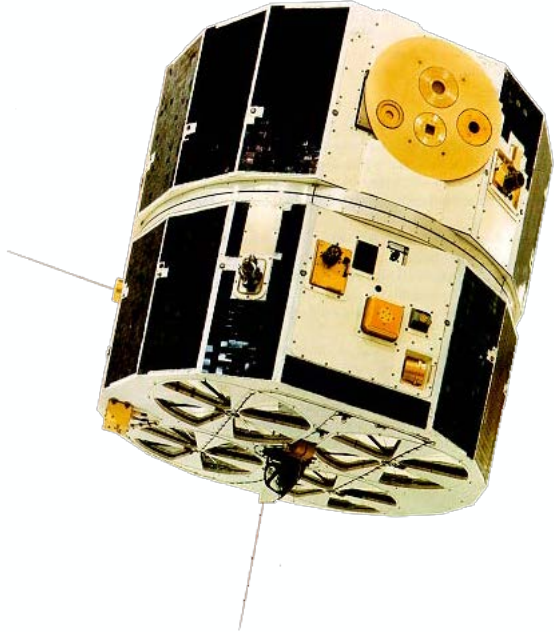
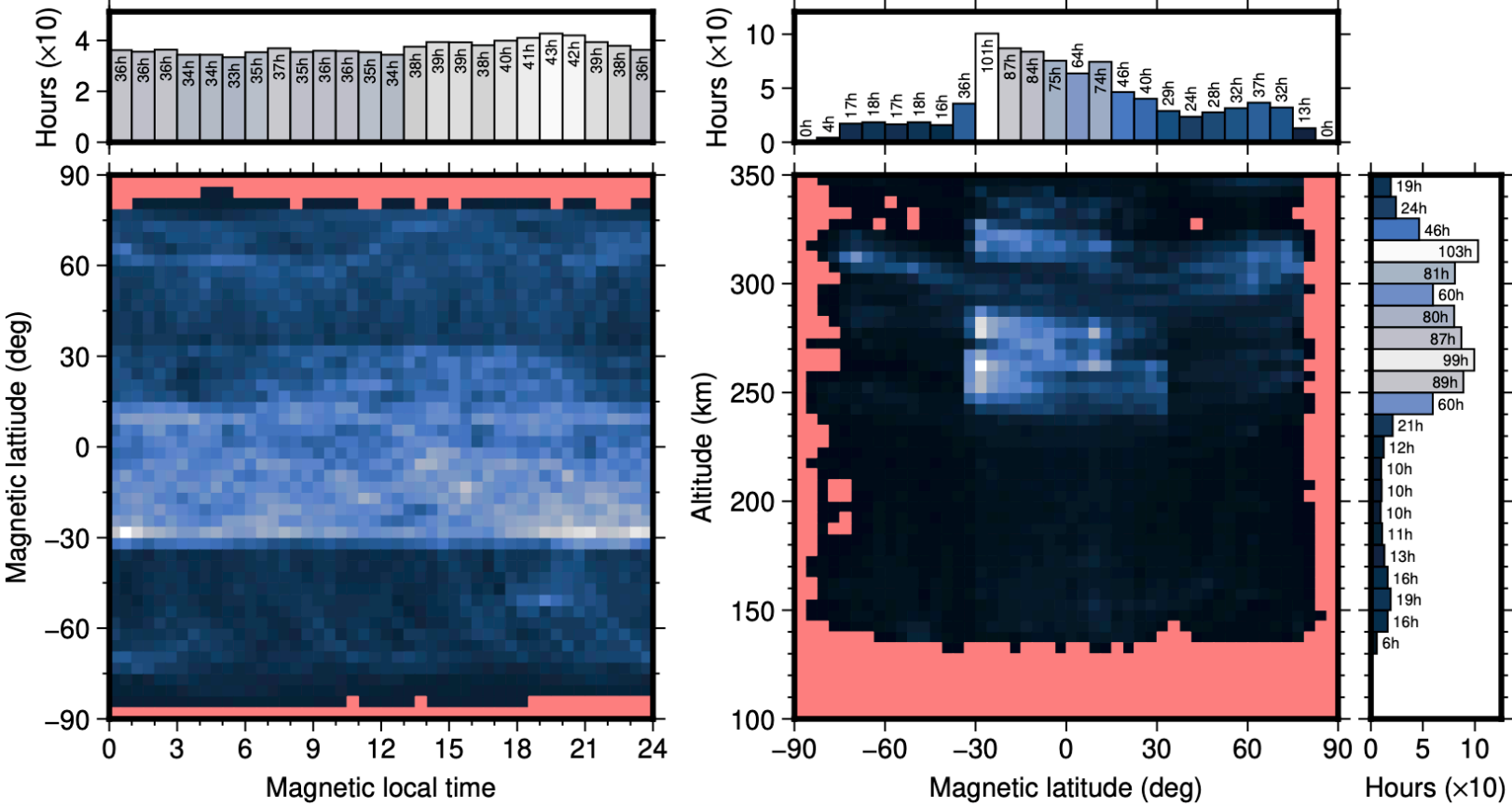


Figures by ADS and TAS, courtesy of ESA



# Observation Concept and Mission Requirements

- Atmosphere Explorers AE-C/D/E (1973-1981) – neutrals, plasma

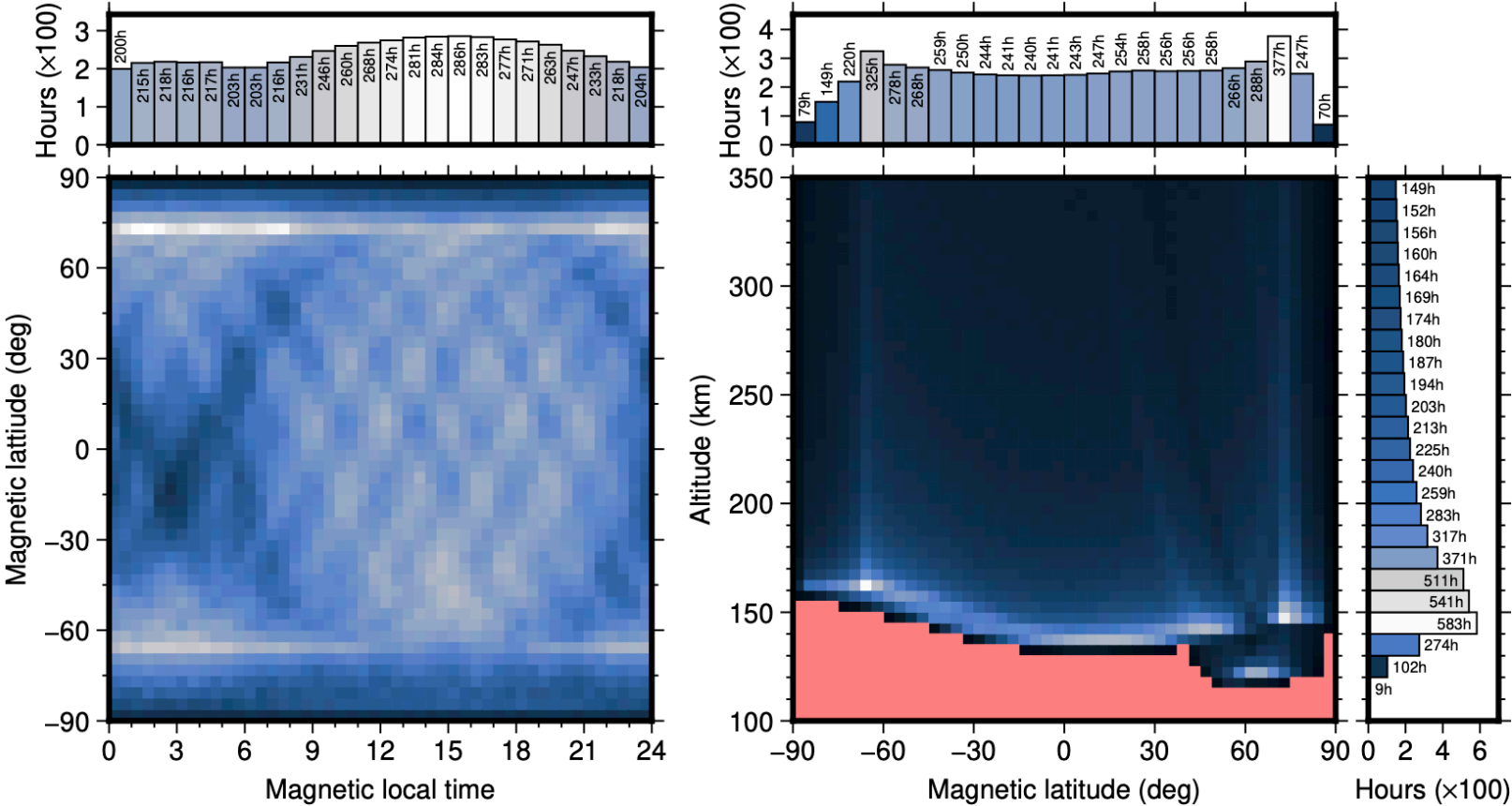


Total observation time < 200 km: 60.3 hours (Unified Abstract data)



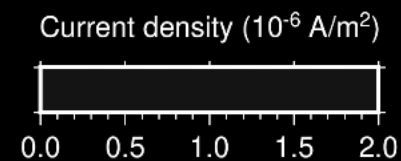
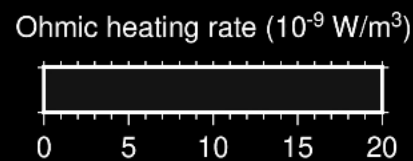
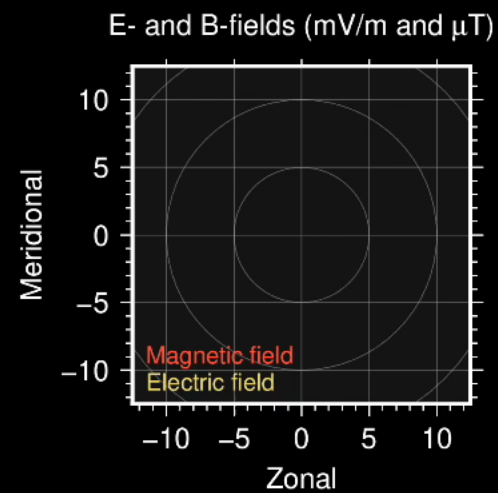
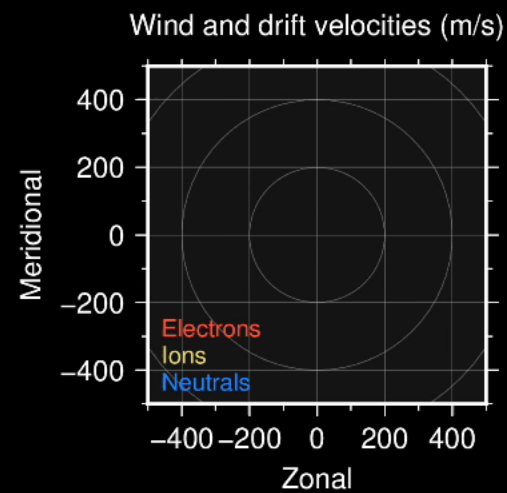
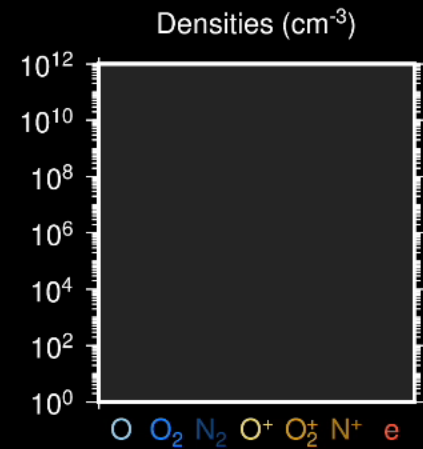
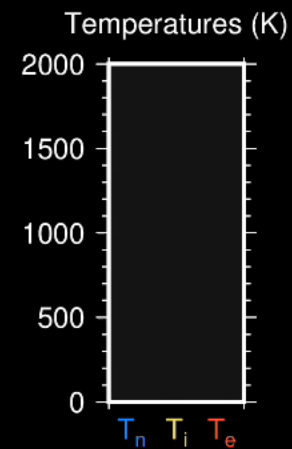
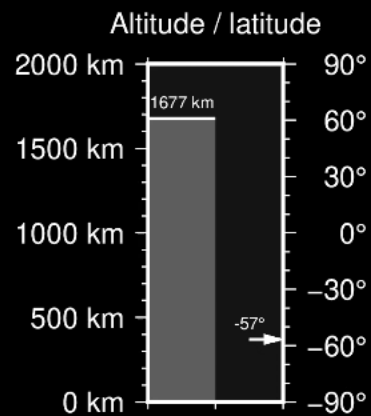
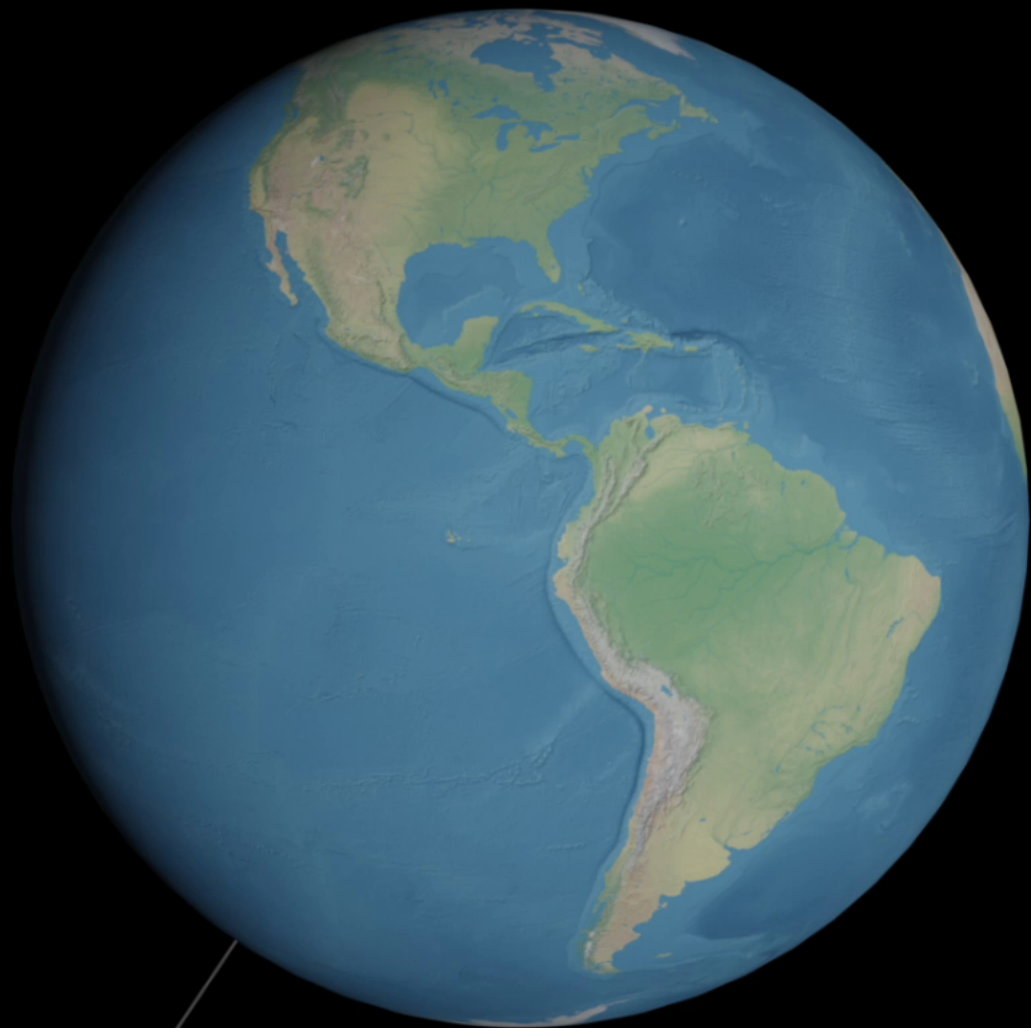
# Observation Concept and Mission Requirements

- Daedalus concept coverage based on 3-year Science Study orbit

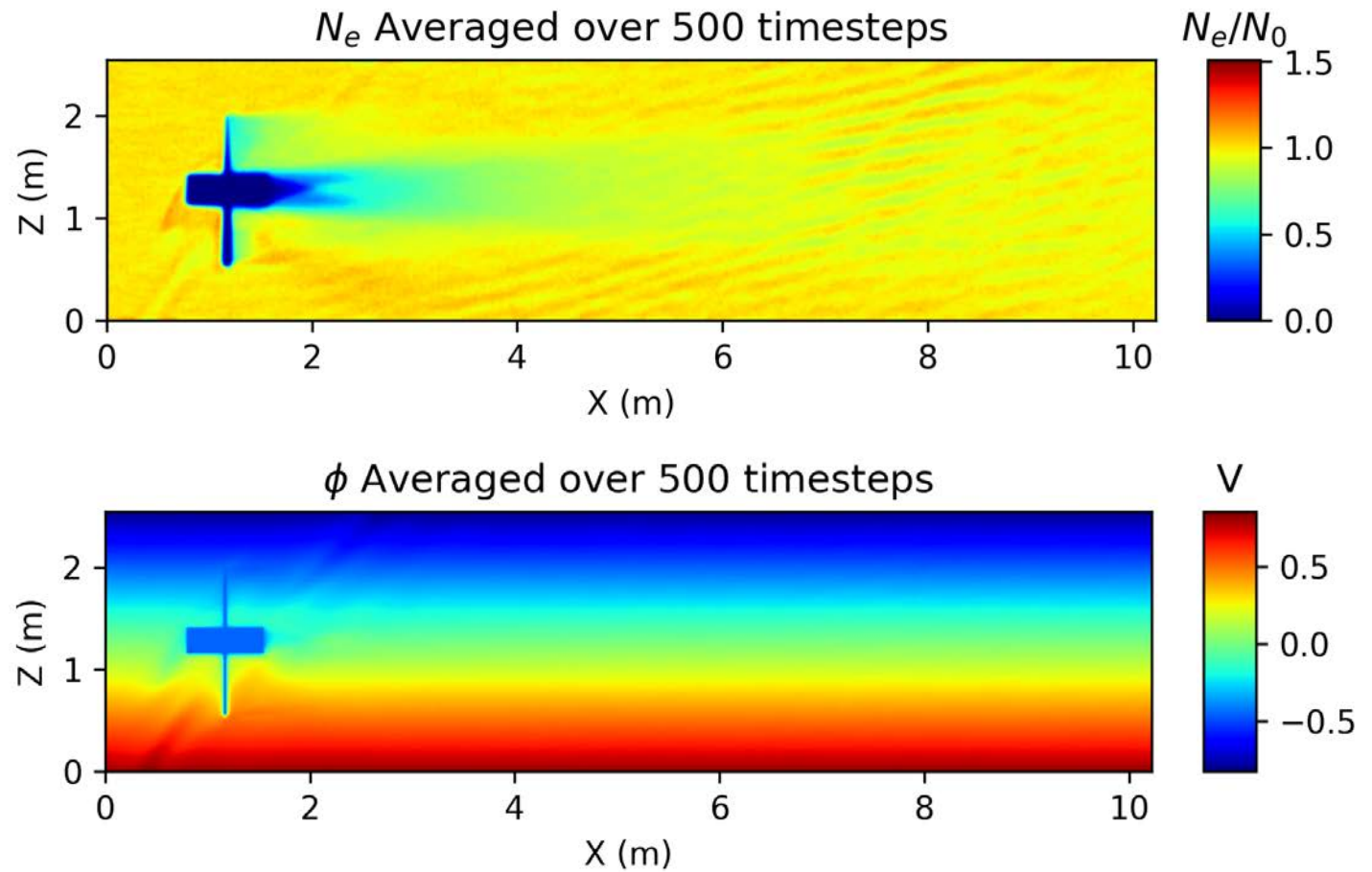
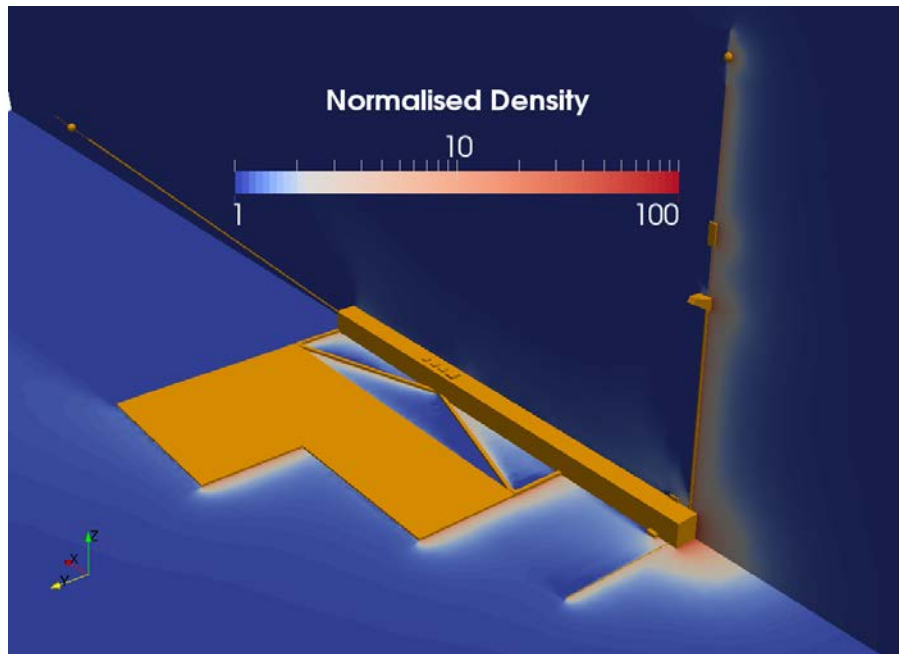


Total time < 200 km over 3 years: 1993.5 hours

- Daedalus total observation time: **order of magnitude increase** compared to existing measurements



# Particle-in-cell and Direct Simulation Monte Carlo simulations of effects at very low altitudes

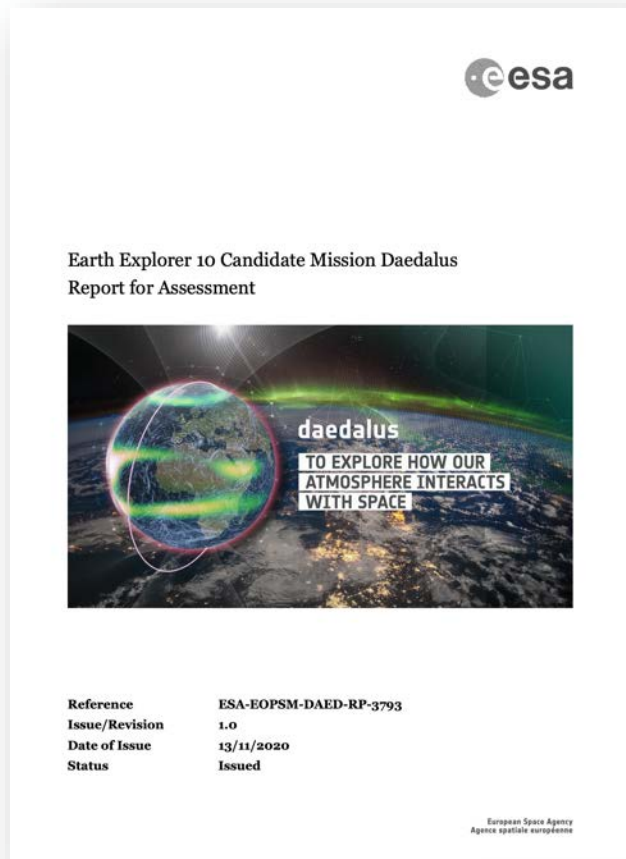


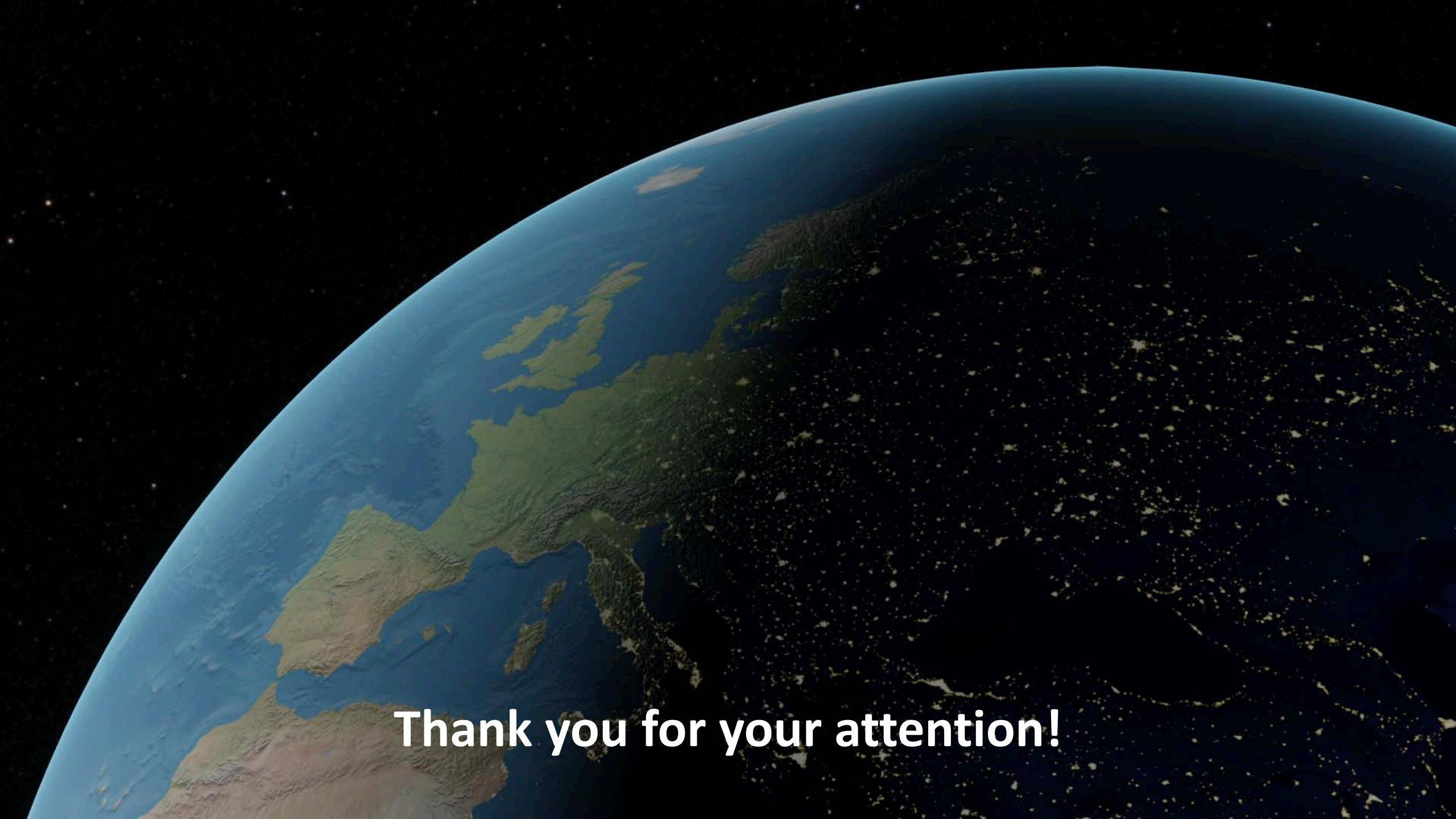
# We want to build a broad community, so please get in touch!

Daedalus website: <http://daedalus.earth/>

Report for Assessment (138 pages) and journal publications: <https://daedalus.earth/docs-refs/>

My email: [eelco.doornbos@knmi.nl](mailto:eelco.doornbos@knmi.nl), or Theodoros Sarris: [tsarris@ee.duth.gr](mailto:tsarris@ee.duth.gr)



A high-angle view of Earth from space, showing the Americas and the Pacific Ocean. The Earth's surface is illuminated from the left, showing the Americas in shades of green and brown, and the Pacific Ocean in deep blue. The right side of the image shows the dark side of the Earth, covered in a dense field of white and yellow lights representing city lights and urban areas. The text "Thank you for your attention!" is overlaid in white at the bottom center.

**Thank you for your attention!**