Investigations of Atmospheric Aerosol based on the Polarization Measurements of the Twilight Sky

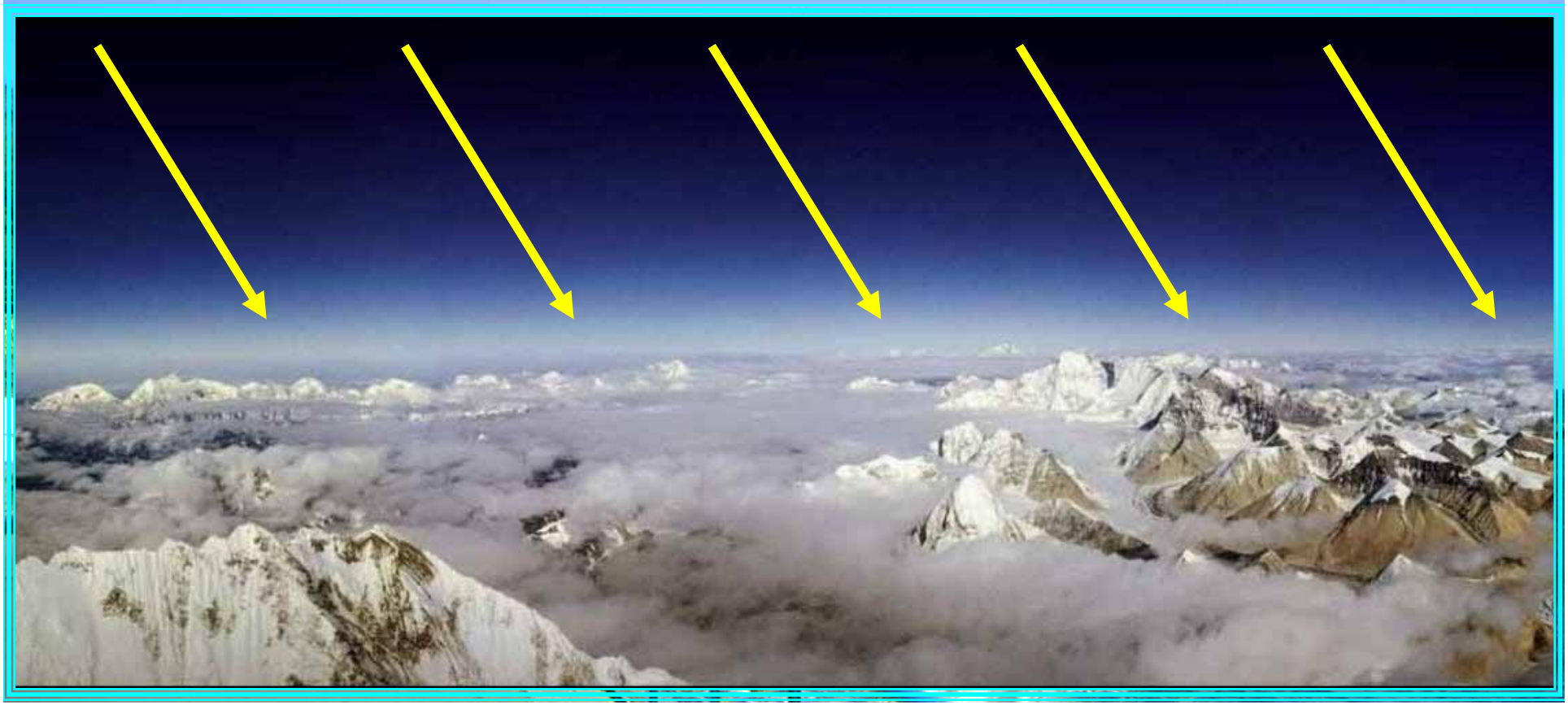
Oleg S. Ugolnikov

Space Research Institute,
Russian Academy of Sciences

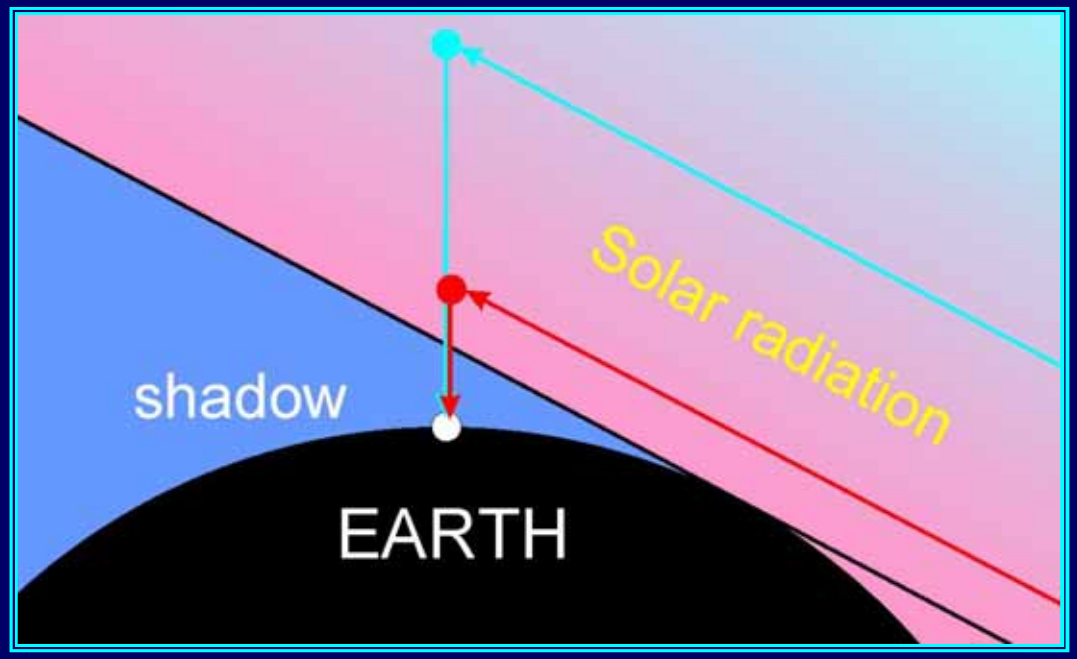
ougolnikov@gmail.com

Daytime sky background

It is defined by the scattering in the near-ground atmosphere (6-8 km)



Altitude scanning

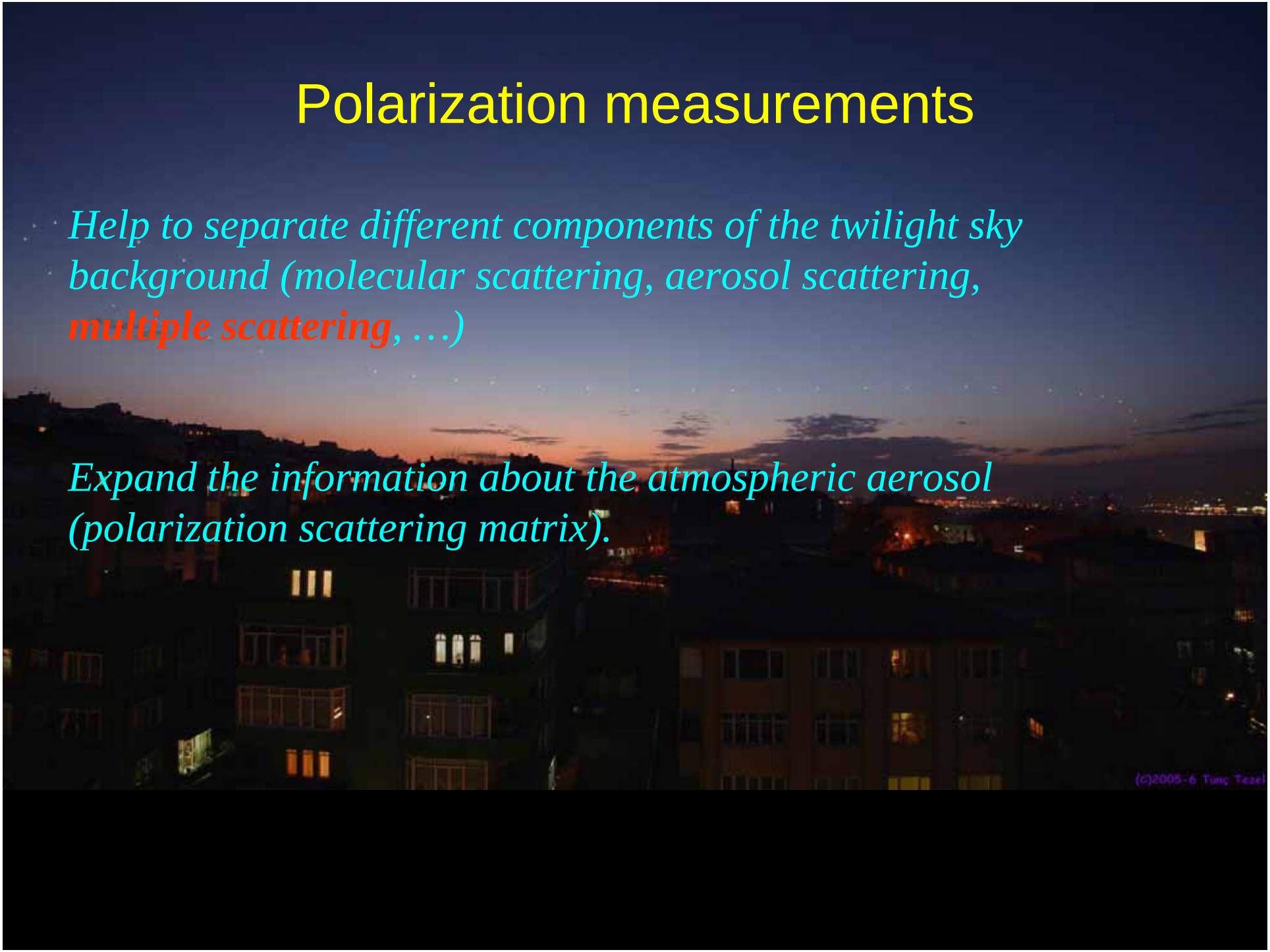


Use of different wavelengths: additional altitude separation, different mechanisms of scattering (molecular, aerosol, resonance, multiple).

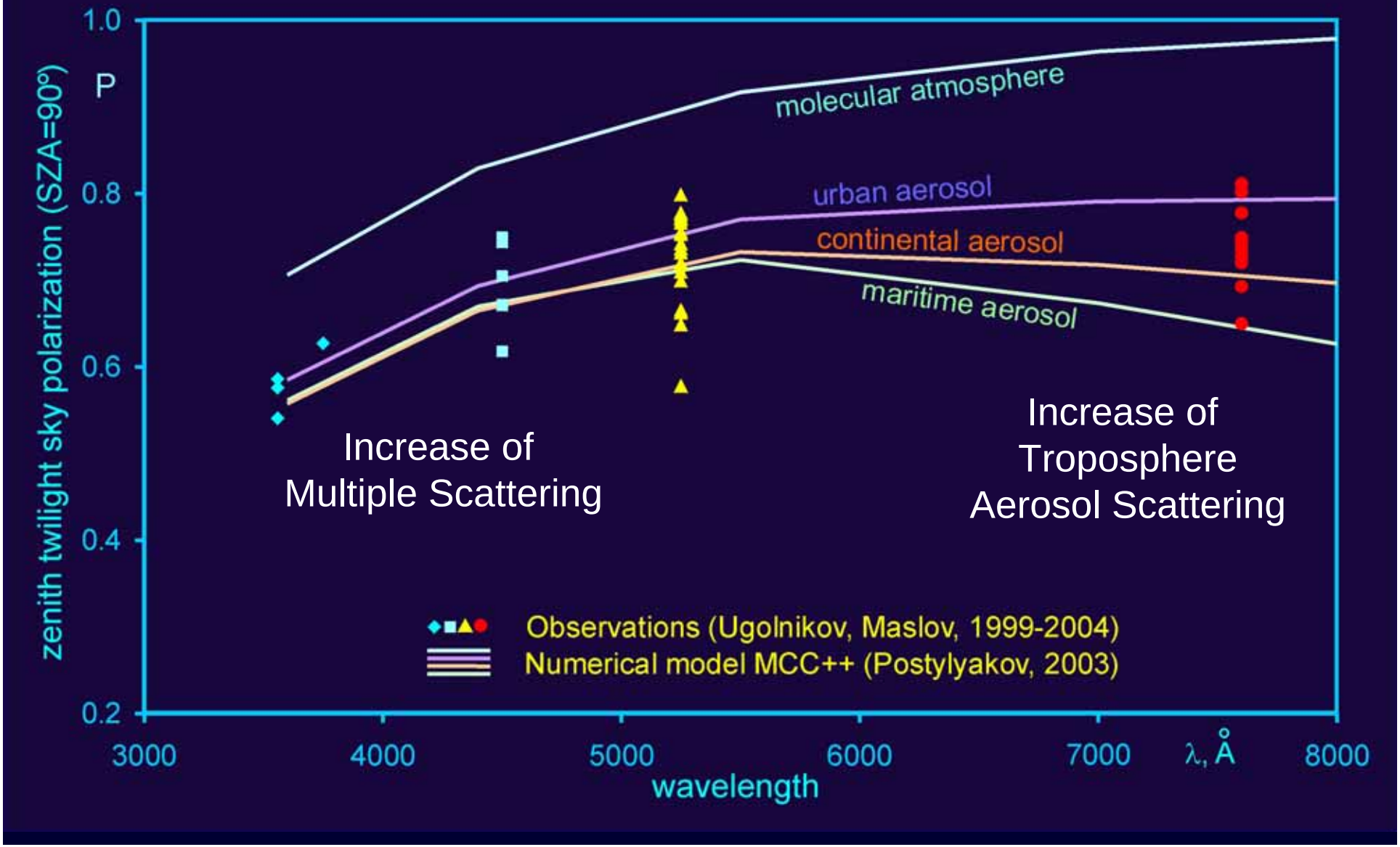
Polarization measurements

Help to separate different components of the twilight sky background (molecular scattering, aerosol scattering, ***multiple scattering****, …)*

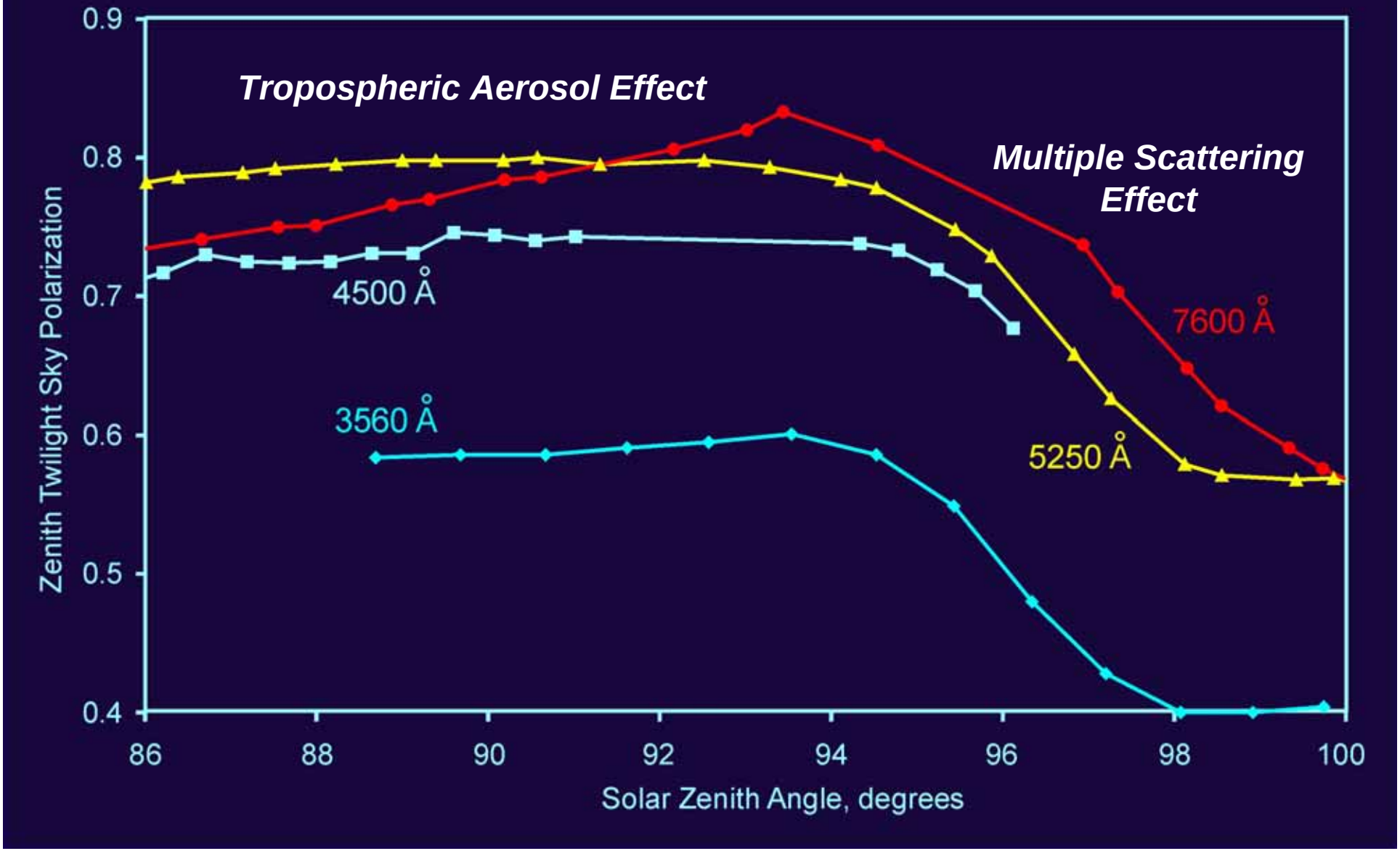
Expand the information about the atmospheric aerosol (polarization scattering matrix).



Twilight sky polarization (zenith, sunrise)



Twilight sky polarization



Detection of aerosol in the different layers

Observations: Wide-angle CCD-camera with polarization filter (Crimea, Ukraine).

Observable effects: changes of sky brightness and polarization distributions near the zenith for the definite stages of twilight.

Output data:

The value of aerosol scattering contribution in the sky background;

The ratio of aerosol and molecular scattering coefficients;

The polarization of aerosol scattering (scattering angle about 90°).

Stratospheric aerosol

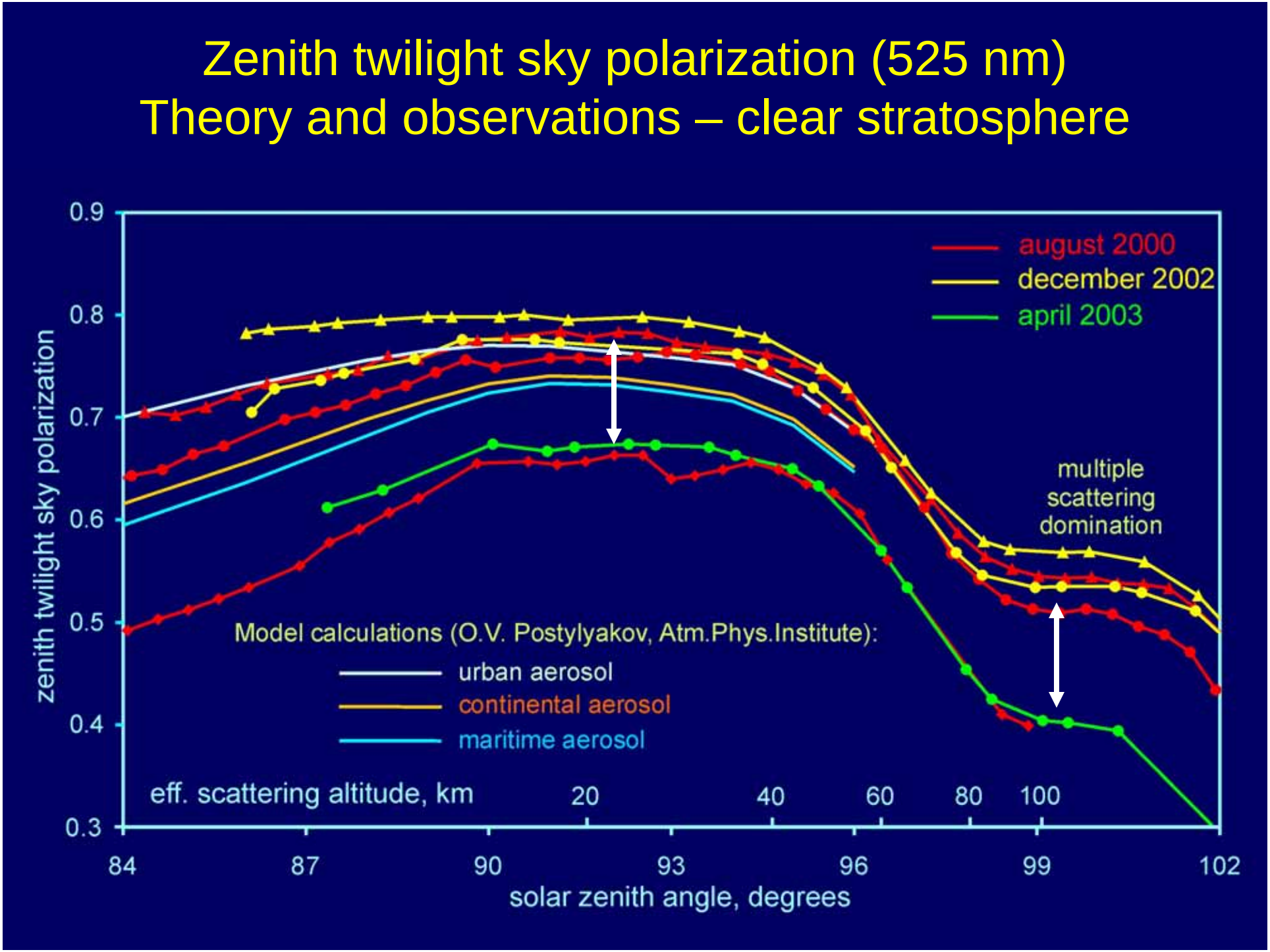
Altitude – above 20 km (the Junge layer).
Reveals itself at solar zenith angle 90º-94º (for 5250 A).

High latitudes: Polar Stratospheric Clouds.

Other locations: observed after the strong volcanic eruptions, the strongest one during the last decades was Pinatubo (1991, Volcano Eruption Index = 6).

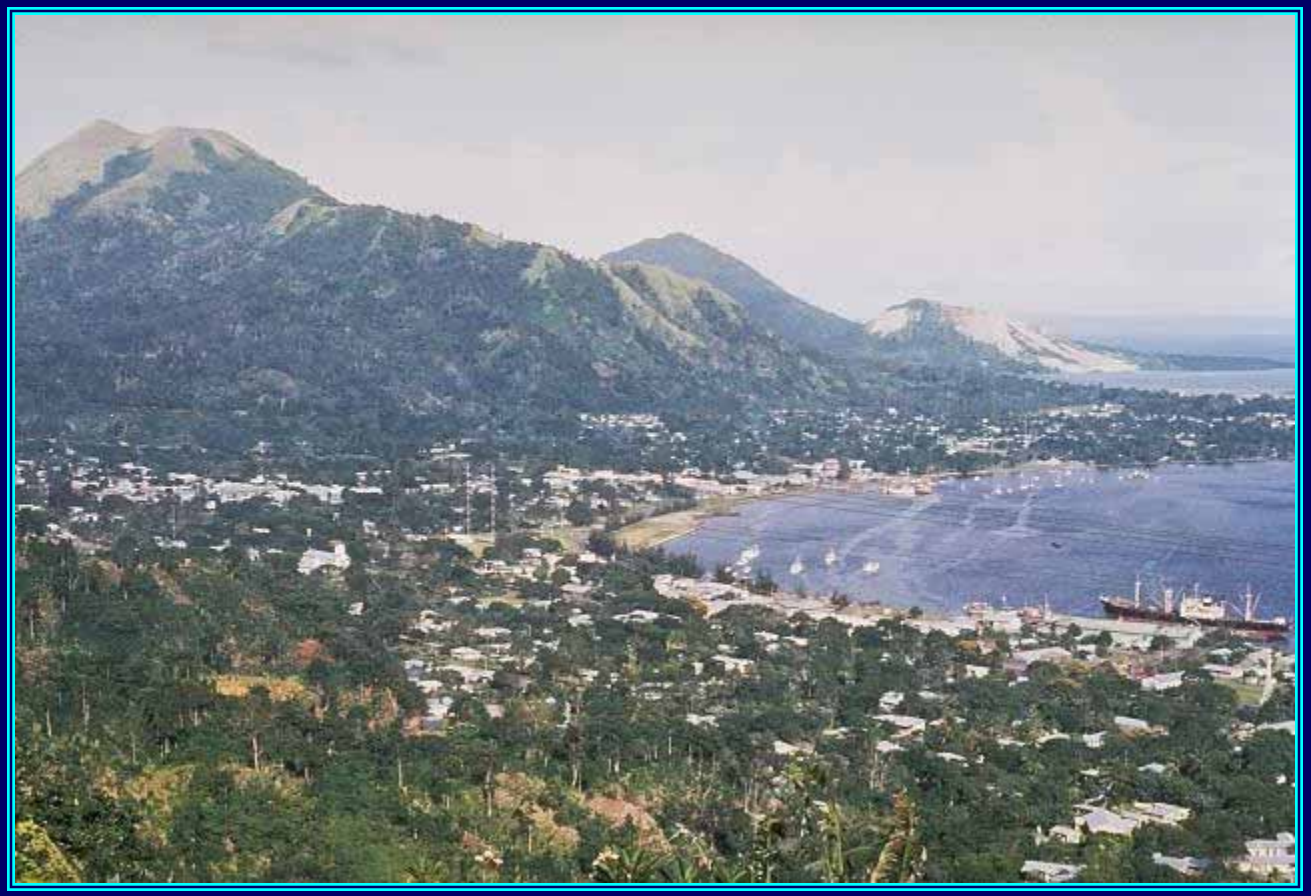
The stratospheric aerosol level was low since 1995 until the late 2006.

Zenith twilight sky polarization (525 nm)
Theory and observations – clear stratosphere



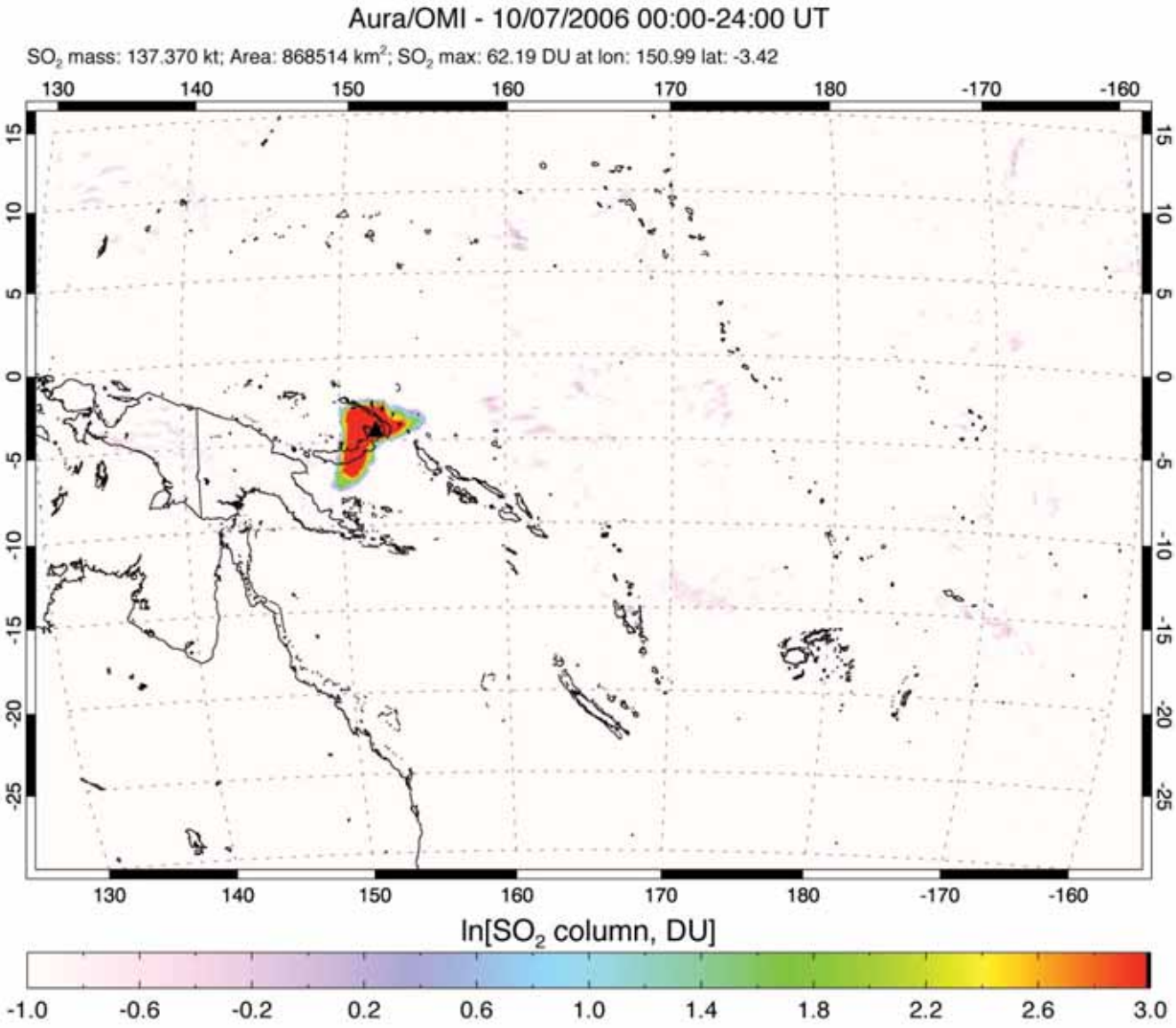
Rabaul Volcano (New Guinea)

Eruption with index 4 had started at October, 7, 2006.
The eruption products reached the altitude 18 km and threw up to the stratosphere.



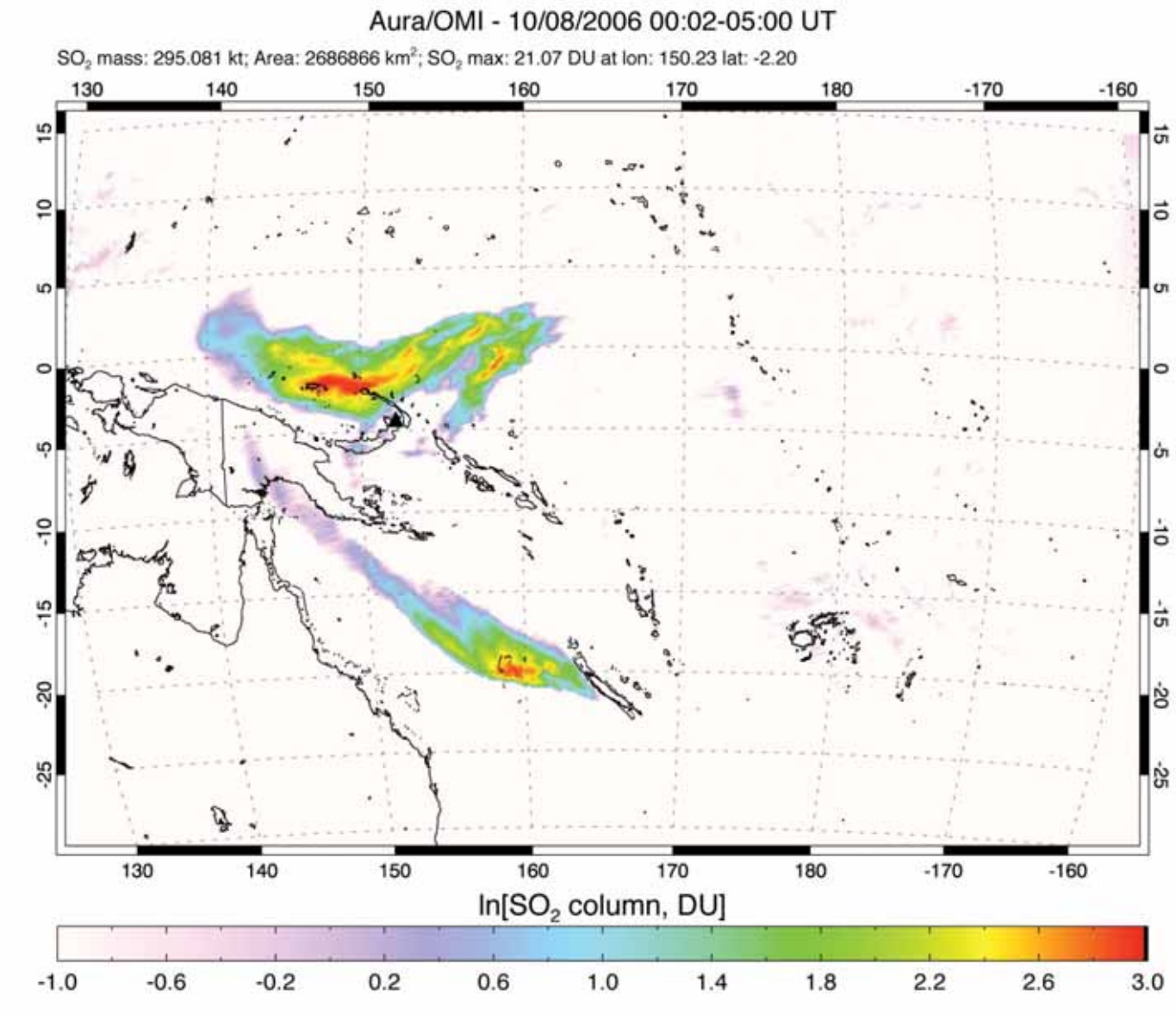
Sulfur dioxide emission

7.X.2006



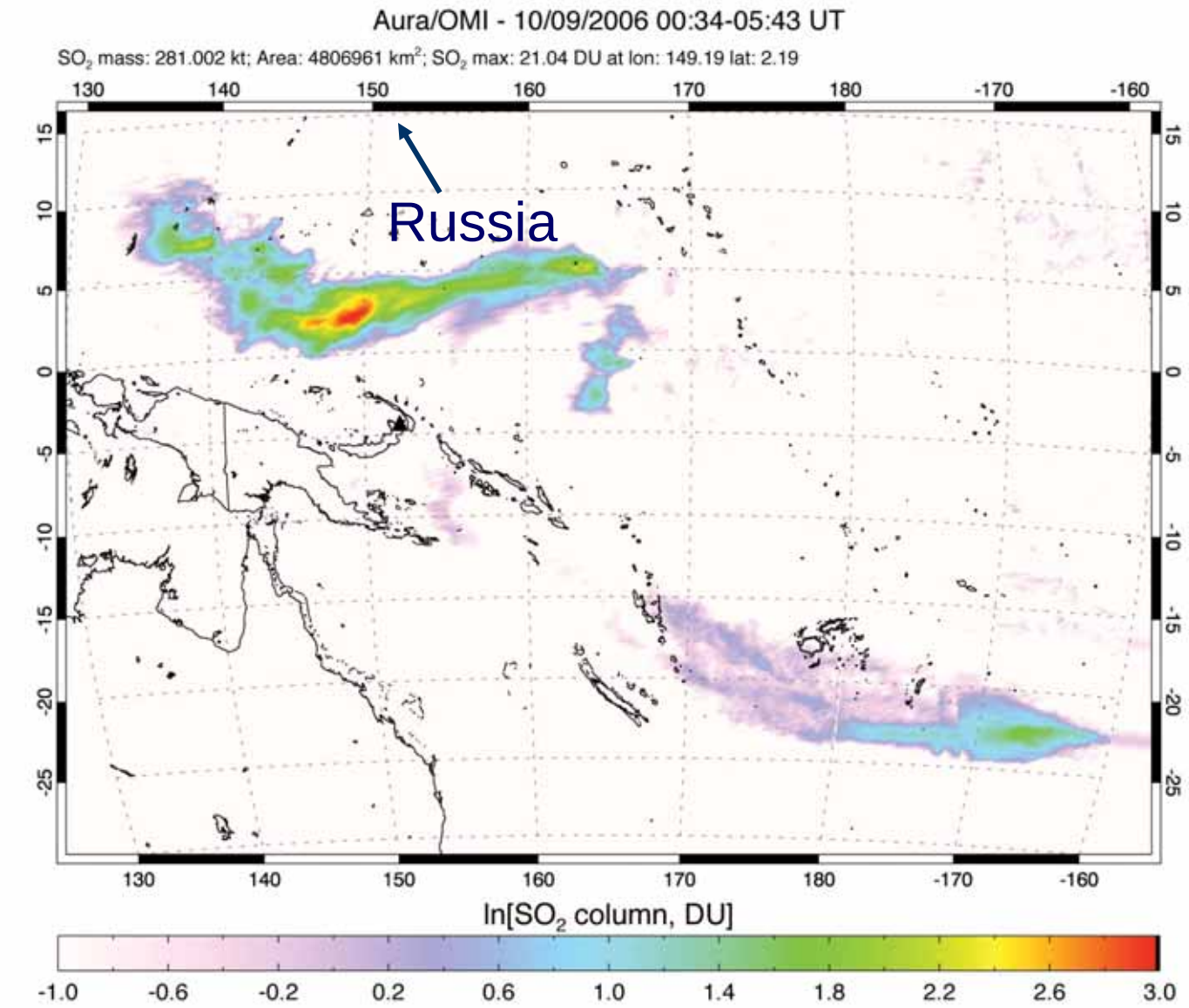
Sulfur dioxide emission

8.X.2006



Sulfur dioxide emission

9.X.2006



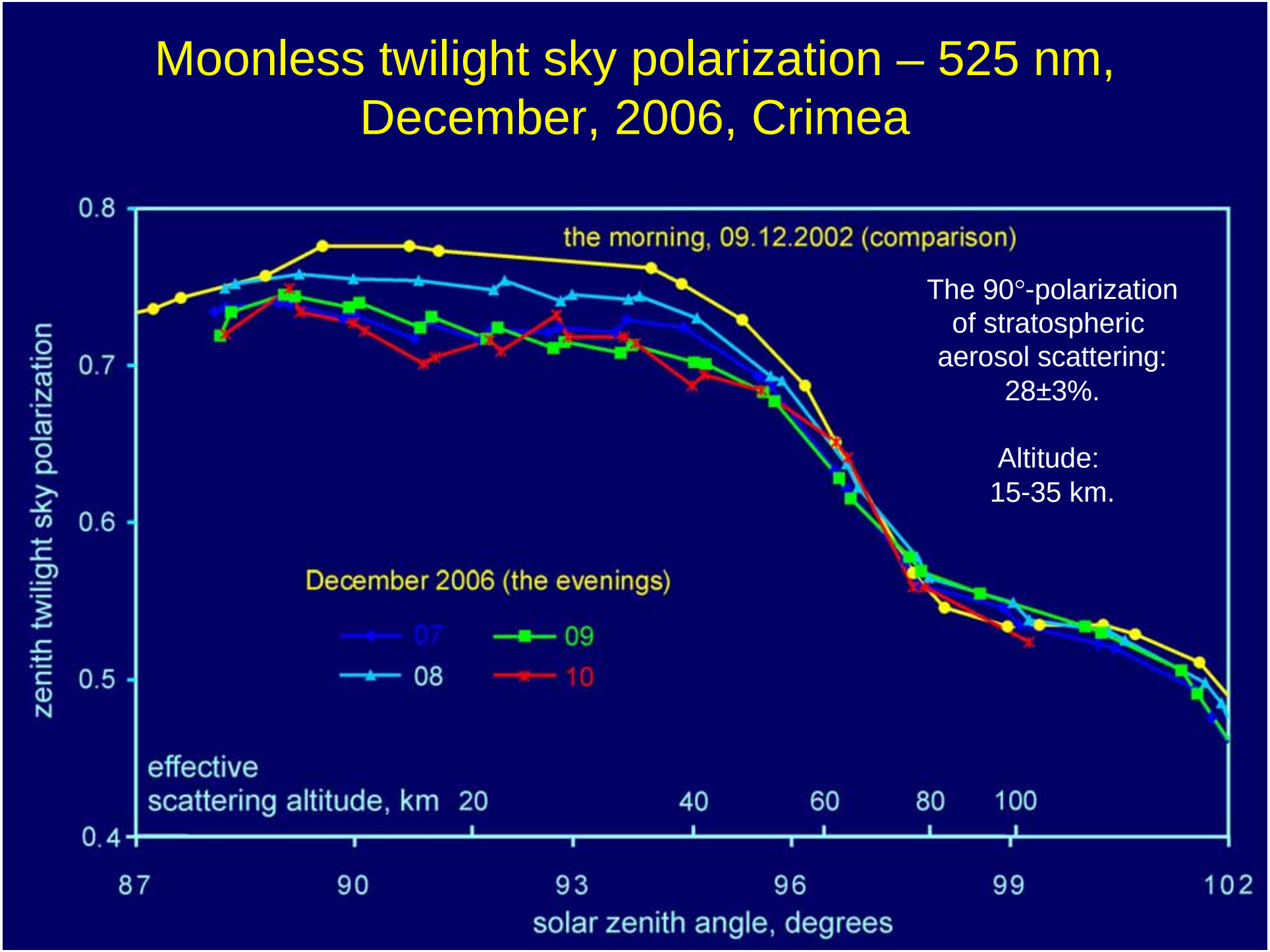
SO_2 in the stratosphere

Reaching the stratosphere, the sulfur dioxide (SO_2) is involved in the chemical reactions turning into the sulfur acid (H_2SO_4).

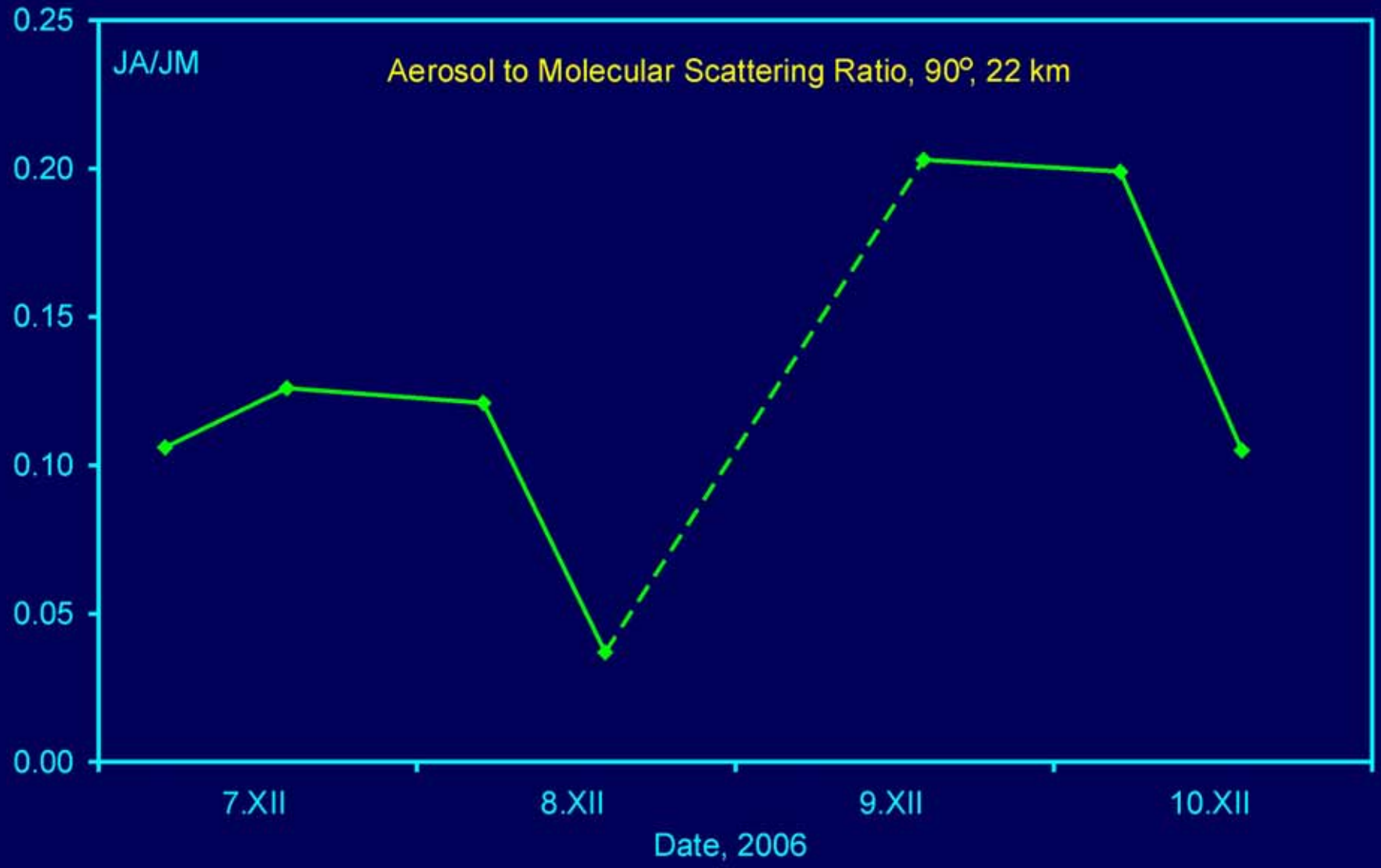
The vapor of sulfur acid condensates and expands over the large territories above the Earth.

The growth of stratospheric aerosol level was detected by the lidar station in Tomsk (Siberia, Russia) even at October, 17, 2006!

Moonless twilight sky polarization – 525 nm, December, 2006, Crimea



Scattering Coefficients Ratio



Mesospheric Aerosol

Noctilucent clouds – highest in the atmosphere (80-90 km). Observed at solar zenith angles more than 96°-97°.

Meteoric dust – appears basically after the maxima of major meteor showers. It can be the condensation nuclei for the noctilucent clouds.

Twilight photometry had registered the impacts from Quadrantids (Link, Robley, 1971), Orionids and h-Aquarids (Mateshvili et al., 1998-1990s).

Leonids

Parent comet is 56P/ Tempel-Tuttle.

Period: 33 years.

Radiant: Leo constellation

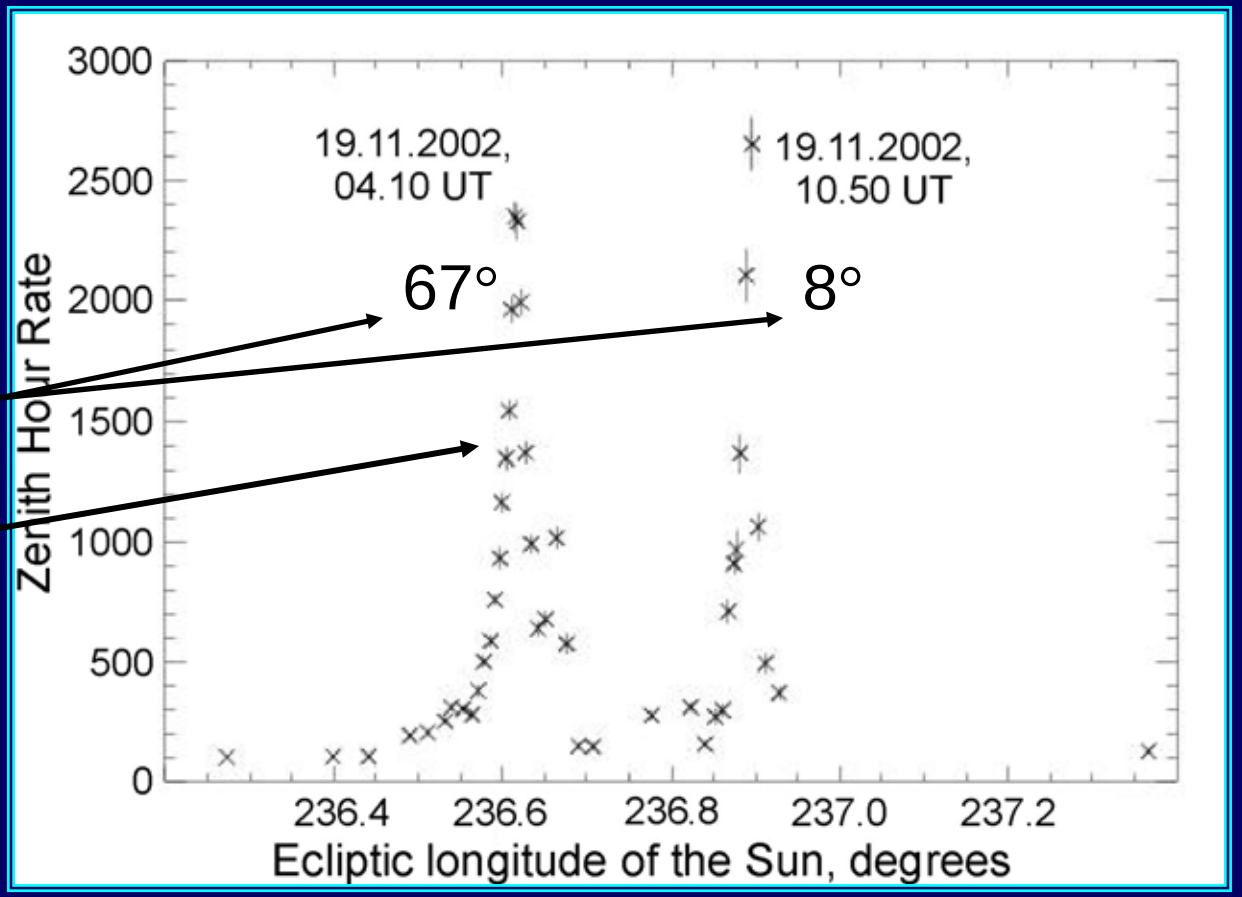
Last strong maxima: November 1998-2002

Leonids in 2002

Last strong maxima.

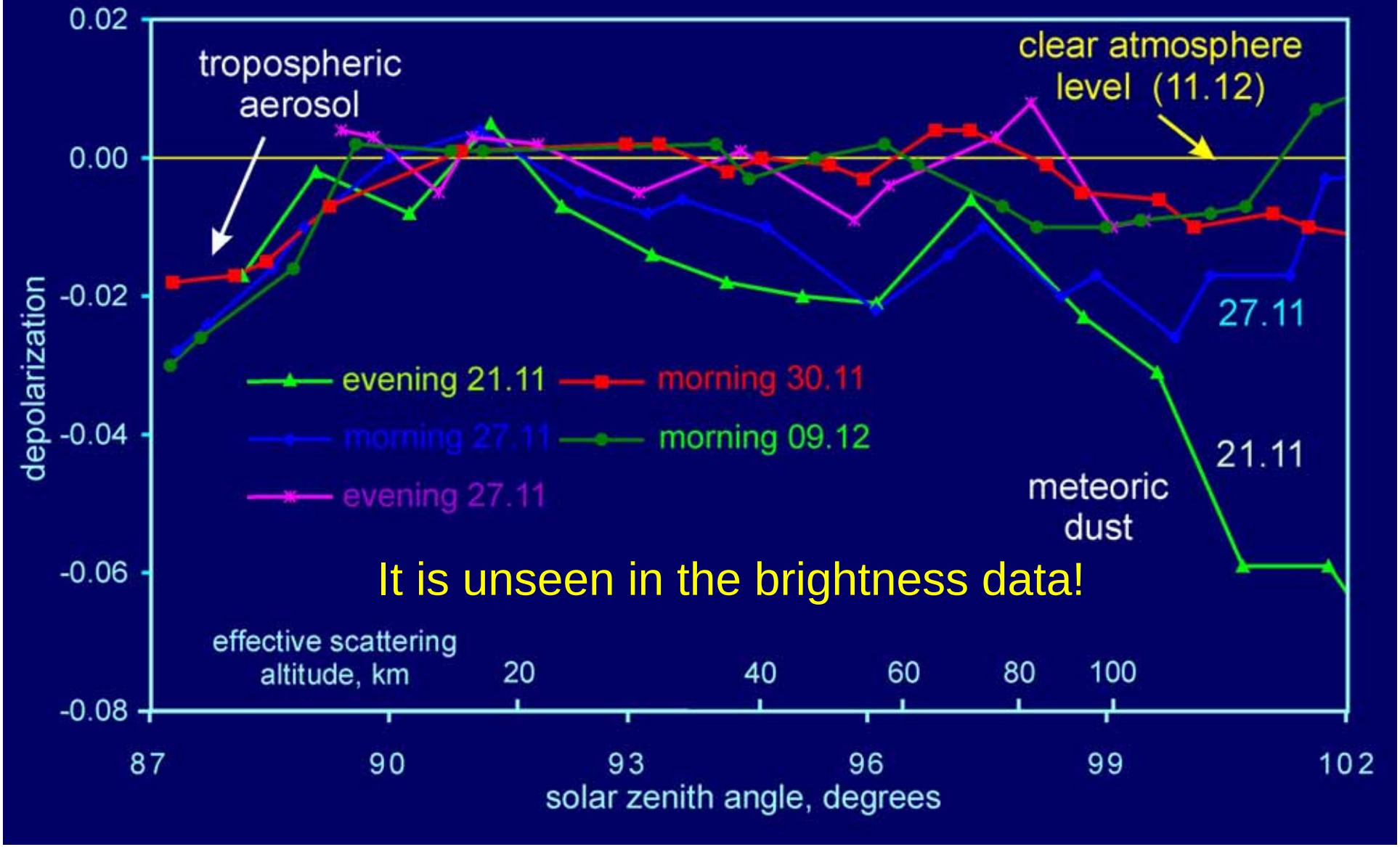
Radiant altitude in the observation point

Meteor Dust Inflow



Data of International Meteor Organization

Twilight sky polarization – November, 2002



Resume

Twilight sky background polarization analysis allows:

1. *To separate the multiple, molecular and aerosol scattering;*
2. *By the measurements during the whole twilight period – to find the altitude dependency of scattering matrix including the stratosphere and mesosphere;*
3. *By the wide-angle measurements – to find the angular dependency of the matrix (scattering function);*
4. *By the spectral measurements – to make the exact measurements of trace gases (such as NO_2) at different altitudes;*
5. *And making this all – to know A LOT about the atmosphere!*

Perspectives

Multi-point (network)
twilight background measurements:

Dynamical investigations of aerosol from troposphere to mesosphere above the large territories.

Thank you for the attention!