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Bulgarian Expedition for the Total Solar Eclipse on 2020 December 14

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Abstract

Total solar eclipses are not only an impressive phenomenon, but also a chance for scientists to find the answers of some still unanswered questions. Even today, in the era of space-based solar observations, total solar eclipses provide opportunities for studying the physical processes of the corona and the solar-terrestrial interactions. The possibility of studying the outermost layer of the solar atmosphere in details is important part of astronomy since the models of its formation and dynamics are the basis for understanding the structure of all other sun-like stars in our galaxy.

We are preparing an expedition to observe the total solar eclipse on 2020 December 14 from Argentina and here we present our preliminary research of choosing the location, preparing the equipment and planning the experiments.

Introduction

The total solar eclipses (TSEs) reveal some already established global parameters of the solar corona such as its shape, electron density, physical parameters of temperature and the magnetic field, as well as the presence of emission lines of highly ionized chemical elements. And yet the contemporary observation methods show us that the physics of dynamic processes related to energy transport in the corona, the connection between local active processes in the lower solar atmosphere and coronal mass ejection are not yet well studied. Every TSE is unique itself in its details and in actual fact an exact repetition could never be observed. To expect local active processes on the Sun and in the solar corona, the phase of solar activity (mainly connected to the 11-year cycle of solar activity) is of great importance. The presence of those activity processes (sunspots and prominences mostly) provides the basis for the solar-terrestrial interactions and determination of the space weather.

A total solar eclipse will occur on 2020 December 14 for observers situated in South America. The Moon's umbral shadow will successively pass through the South Pacific Ocean, central parts of Chile and Argentina and the South Atlantic Ocean [*Mobberley, M.*, 2007]. A partial eclipse will be visible from a much wider corridor, which includes a few islands located west of South America, parts of Uruguay, Paraguay, Brazil, Bolivia, Peru, Ecuador as well as the southwestern parts of Africa (Angola, Namibia, Botswana, South Africa, and others.).

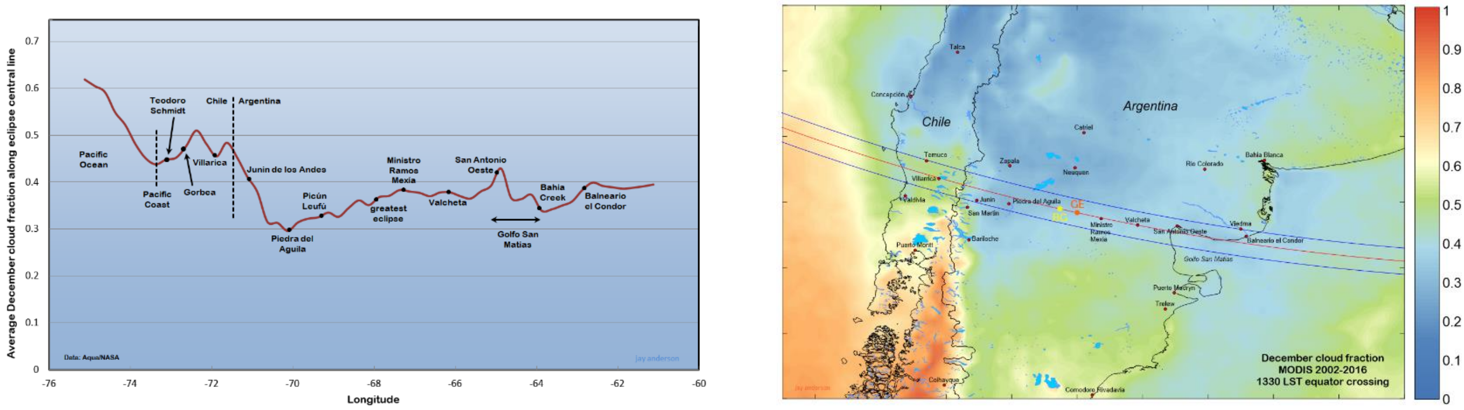
The greatest eclipse will be visible from central Argentina, near Sierra Colorada (about 1000 km southwest of Buenos Aires) – 40° 20.135' S and 67° 57.533' W, where the totality will continue 2 min 09.8 s (http://xjubier.free.fr/site_images/TSE_2020/TSE_2020_GeneralCircumstances.jpg).

We already did a preliminary research for choosing the best location on the path of totality for scientific observations. Taking into account the weather conditions we decided to position our team at Rio Negro province (Figure 1a). Data about the average cloud amount in December from MODIS instrument onboard Aqua satellite helped us choose a spot about 90 km northwest from Los Menucos (Figure 1b). Eclipse details for the preferred location (BG on Figure 1b) compared to these for the point of greatest eclipse (GE on Figure 1b) are listed in Table 1.

Table 1. *Eclipse details for the chosen observational area near Los Menucos (BG) compared to the spot of greatest eclipse (GE)* (https://www.timeanddate.com/eclipse/solar/2019-july-2).

Location	Magnitude	Duration (C1 to C4) [hh:mm:ss]	Duration of the totality [mm:ss]	Maximum [UT]	Sun's altitude at maximum
BG	1.01262	2:50:36	2:09.7	16:12:17	72.7°
GE	1.01268	2:51:38	2:09.8	16:13:30	72.7°

Another important aspect of the chosen location is its altitude – 980 m above the sea level, which contributes to greater transparency of the atmosphere. The observational are is secluded place, situated outside big cities in uninhabited part of Argentina to reduce effects of light pollution or unforeseen interruptions by random citizens.



a) b)

Fig. 1 a) Average cloudiness along the centerline of the eclipse in December. b) Average December fractional cloud amount along the eclipse track over South America. BG notes the location that we chose and GE – the point of greatest eclipse. Data are extracted from 17 years (2002-2015) of observations from the Aqua satellite. (https://eclipsophile.com/tse2020/).

Planned experiments and tasks

a) White-light observations of solar corona

It is well known that the shape of the corona is subject to significant variations during the solar cycle [*Gulyaev R. A.*, 1997]. The quantitatively description of the general coronal shape can be estimated by the method first suggested by Ludendorff more than 90 years ago by the definition of the flattening index [*Ludendorff H.*, 1928]. For the purpose we need to obtain long exposure photos of the white-light corona. On the other hand, processing various pictures of the corona with different lenses, exposure times and cameras can reveal the fine structure of the corona.

We prepared a couple of different instruments to photograph the corona with different lenses, exposure times and cameras to be able to capture the shape of the white-light corona at high altitudes, but also to be able to combine different images to achieve details of coronal fine structure [*Pasachoff J. M., et al.*, 2007]. Structures hard to be seen before a few decades, such as tiny loops, inhomogeneities in coronal streamers and cavities, polar plumes, etc. are now becoming observable. Such data, in combination with the ones from space-based solar observatories, are also useful for investigation of the connections between the different processes and formations in the solar atmosphere.

b) Polarimetric observations of corona and prominences

TSEs offer an opportunity to measure the polarization of the coronal emission at altitudes up to 5 solar radii. Since the intensity of the white-light corona is in linear correlation with the density of the free electrons, the polarimetric observations allow not only differentiation of the emission from different components of the corona (K- and F- corona), but also a direct measurements of coronal density.

Our task will include determination of the degree of polarization in the different parts of the corona. We also plan to investigate the electron distribution in the corona as a function of the distance from the centre of the Sun and the relationship between the degree of polarization and the wavelength. A comparison with white-light data will reveal the changes in the regions around the coronal structures.

In case that there are prominences visible on the solar limb during the eclipse we will pay special attention on their surroundings and supporting magnetic structures. The polarimetric observations will also be useful for determination of solar magnetic field parameters in these regions [*Lin H.*, 2005].

c) Shadows bands and atmospheric conditions during the eclipse

In the last moments right before and after the totality an atmospheric phenomenon called "shadow bands" that occurs as a result of interference of the light emitted from a thin solar crescent being refracted by the Earth's turbulent atmosphere could be observed [*Codona J. L.*, 1998]. Although they were first noticed almost three centuries ago [*Littmann M., et al.*, 2009], but even nowadays they are not fully studied yet, because of the difficulties connected to their registration.

During our expeditions for total solar eclipse on 2019 July 2 we performed a relatively new experiment looking for the possible influence on the shadow bands pattern by the wind [*Tsvetkov Ts., et al.*, 2019]. We successfully performed a videotaping of the bands and measured the wind speed and direction (4 times/second) using ultrasound anemometer. It is largely accepted that the "eclipse winds" depend on the topography of the terrain. Since our observational area was situated in the outskirts of the Atacama Desert and only 35 km east of the Pacific Ocean, we plan to reproduce the experiment again during the TSE 2020 as we plan to be located at the inner part of South America (Figure 1b). A possible successful implementation of the experiment will assure the possibility to compare the results and form hypothesis on the relationship between the wind properties and the shadow bands observed during TSEs.

Another aspect of the planned experimental tasks is connected to the eclipse meteorology. In addition to the wind properties, we will monitor the air temperature near the ground during the different phases of the eclipse as it usually drops between 5° and 15° during the totality [*Calmas D. M., et al.*, 2019; *Szalowski K.*, 2002].

Conclusions

For almost a year and a half South America will host the umbral path for a second time on 2020 December 14. Our team plans an expedition to observe the totals solar eclipse from the territory of Argentina. We already chose an observational location in Patagonia region, at Rio Negro province far from in inhabited places at almost 1000 m altitude.

The tasks we plan to perform are dedicated to 3 main topics: observations of the white-light solar corona, registration of polarized emission from the corona and typical coronal structures, detection of the pre- and post-totality shadow bands and monitoring the meteorological parameters of the wind and air temperature during the eclipse.

Some of the planned experiments are similar to the obtained during 2017 August 21 and 2019 July 2 total solar eclipses observed in the USA and Chile, respectively, and the results will be compared after the upcoming expedition.

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