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B - 1180 BRUXELLES

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Measurement of upper atmospheric winds at 160 and 275 kilometers

by M. ACKERMAN and E. VAN HEMELRIJCK

BELGISCH INSTITUUT VOOR RUIMTE-AERONOMIE

3 - Ringlaan
B - 1180 BRUSSEL

FOREWORD

"Measurement of upper atmospheric winds at 160 and 275 kilometers" by M. Ackermand and E. Van Hemelrijck are data which were obtained during the observation of AlO clouds released from two rockets launched in Sardinia. It will be published as a letter in the Journal of Geophysical Research.

AVANT-PROPOS

"Measurement of upper atmospheric winds at 160 and 275 kilometers" par M. Ackerman et E. Van Hemelrijck est le résultat de mesures effectuées au cours de l'expansion de nuages d'oxyde d'aluminium obtenus par le lancer de deux fusées en Sardaigne. Ce travail sera publié dans le Journal of Geophysical Research.

VOORWOORD

"Measurement of upper almospheric winds at 160 and 275 kilometers" door M. Ackerman en E. Van Hemelrijck is het resultaat van metingen verricht tijdens de waarneming van AlO wolken bekomen door twee raketlanceringen in Sardinië. Dit werk zal verschijnen in het Journal of Geophysical Research.

VORWORT

"Measurement of upper atmospheric winds at 160 and 275 kilometers" durch M. Ackerman und E. Van Hemelrijck sind Daten von Messungen durchgeführt während der Beobachtung von AlO Wolken bekommen durch zwei Raketeneksperimenten in Sardinie. Diese Arbeit wird in den Journal of Geophysical Research herausgegeben werden.

MEASUREMENT OF UPPER ATMOSPHERIC WINDS AT 160 and 275 KILOMETERS

by M. ACKERMAN and E. VAN HEMELRIJCK

Abstract

Artificial AlO clouds formed by ESRO payloads S 64 at altitudes of 160 and 275 km have been tracked by optical methods to determine their motions during evening twilight. Important vertical motions have been observed a the low altitude. Horizontal winds have been measured at both altitudes. The high altitude data are compared with satellite data and with a model.

Résumé

La poursuite optique de nuages artificiels d'AlO, réalisés au moyen des charges utiles ESRO S 64 à 160 et 275 kilomètres d'altitude a été réalisée au crépuscule du soir en vue de déterminer leur mouvement. D'importants mouvements verticaux ont été observés à basse altitude. Les vents horizontaux ont été mesurés aux deux altitudes. Les données de haute altitudes sont comparées avec les données fournies par satellites et avec un modèle.

Samenvatting

Het optisch volgen van kunstmatig geschapen AlO wolken, op 160 en 275 km hoogte door middel van de nuttige ladingen ESRO S 64, werd verwezenlijkt bij avondschemering met het oog op het bepalen van hun beweging. Belangrijke verticale bewegingen werden waargenomen op lage hoogte. De horizontale winden werden gemeten op de twee hoogten. De gegevens op grote hoogten zijn te vergelijken met deze geleverd door satellieten en door een model.

Zusammenfassung

Das optische Folgen von künstlichen AlO Wolken auf einer Höhe von 160 und 275 km mittelst der Nutzlasten ESRO S 64 wurde bei Abenddämmerung mit Rücksicht auf die Bestimming ihrer Bewegung durchgeführt. Wichtige Vertikalbewegungen wurden auf niedrige Höhe beobachtet. Die Horizontalwinden wurden auf die zwei Höhen gemessen. Die Daten auf grosse Höhen sind mit diesen geliefert durch Satelliten und durch ein Modell zu vergleichen.

The changes in the orbital inclinations of satellites have been analysed by King-Hele (1970) who has deduced from them an average angular velocity of the upper atmosphere. The results suggest that the atmosphere at heights between 200 and 400 km rotates faster than the earth with an excess speed ranging respectively from 10% to 50%. King-Hele (1970)) finds his results in agreement with the theoretical model of winds at 250 km computed by Challinor (1969). Wind measurements performed by making observations of artificial clouds released from rockets are suitable to provide more information on the subject. There are only a few measurements of this kind at altitudes higher than 200 km : two have been reported by Bedinger (1970) and two others by Rees (1970).

Another aspect of the dynamics of the upper thermosphere on which even fewer data have been obtained, concerns the vertical motions. Blamont and Baguette (1961) have however reported the observation of vertical winds above 120 km.

Information on these two subjects has been obtained by tracking photographically Al0 clouds released from two Skylark rockets launched from Sardinia (39.5° N, 10° E) by the European Space Research Organisation. The releases took place for the S 64-1 payload on July 6, 1969 and for the S 64-2 payload on July 13, 1969. The observations were made after sunset when the solar depression angles were 10° or larger ; the local mean launch times were respectively 8.30 and 8.21 pm.

The tracking of the low altitude clouds was performed by means of cameras equipped which objectives of 50 cm focal length and 10 cm diameter using plates of 8 x 10 inches. An angular coordinate system was defined on each plate by measurement of the positions of more than 50 star images by means of the Zeiss "Asco Record" measuring machine of the Observatoire Royal de Belgique. These measurements lead to an uncertainty smaller than 1 m sec^{-1} on the speed of the here discussed point released clouds for an observation time of 190 seconds. A larger uncertainty

results from the location of the cloud centers on the plates. This was performed by means of a Joyce and Loebl isodensitracer with an accuracy leading to a probable error of the order of $\pm$ 3 m sec^{-1} on the cloud velocity relative to the earth. The upper clouds were faint and it was necessary to use a lens with a larger aperture. However,since the focal length was smaller (8 cm), the probable error is $\pm$ 20 m sec^{-1}. The results are presented in Table I.

For the measurements at the low altitudes, the southward velocity components associated with a small zonal component confirm previous observations (Kochanski, 1964 ; Procunier and McDermott, 1969) made in Sardinia. The upward motions are difficult to relate with intrinsic atmospheric motions since buoyancy effects have also to be considered. Vertical winds of 30 m sec^{-1} or more do not however seem unrealistic and have been deduced from release experiments by Rees (1969). They may affect considerably the diffusion coefficient and have to be seriously taken into account when the altitude has to be assigned to the atmospheric densities deduced from diffusion rate measurements. In the case of the experiments reported here such effects will be discussed elsewhere in more detail by Ackerman and Simon (1971).

The eastward component of the wind observed at the highest altitudes is comparable in size to those observed by Bedinger (1970) at 260 km and by Rees (1970) at 240 km, both at evening twilight for approximately the same latitudes in the Northern and Southern hemispheres respectively. These two determinations were, however, made at different periods of the year : February 13th and May 31st respectively.

The components of the wind vector to be expected in Sardinia at the local mean times considered should be, according to the revised model computed by Challinor (1970), 170 m sec^{-1} eastward and 30 m sec^{-1} southward, approximately. The observed zonal component is smaller and the observed meridional component is directed in the opposite direction ;

these differences could be attributed to local fluctuations. It must however be pointed out that Rees (1970) has observed eastward components in the evening as well as in the morning, while Challinor (1970) predicts a westward component in this last case.

The eastward components observed at 275 and 278 km would correspond to an instantaneous and local ratio of the atmospheric angular velocity to the Earth's angular velocity equal to 1.3, while King-Hele (1970) deduces a global ratio of 1.4 from the analysis of satellites orbits.

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TABLE 1.-

Payload nr.	Altitude (km)	Components of motion	
		Direction	Speed ($m.sec^{-1}$)
S 64-1	161	Eastward	11
		Southward	111
		Upward	37
	275	Eastward	111
		Northward	48
S 64-2	157	Westward	9
		Southward	68
		Upward	22
	278	Eastward	110
		Northward	28

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