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A New Data Set of Satellite-Derived Surface Albedo Values for Operational Use at ECMWF

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With 2 Figures

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Summary

The method to determine satellite derived surface albedos as already described by Preuß and Geleyn [1] is applied with some minor modifications to the longer and denser data set of planetary albedos measured by NOAA-4 from June 1975 to May 1976. The resulting surface albedos are, as far as one can judge, of better quality than the previous ones and have therefore replaced them in operational use at ECMWF in December 1982.

Zusammenfassung

Über die Verwendung aus Satellitendaten abgeleiteter Bodenalbeden im Vorhersagemodell des EZMW

Die Methode zur Ableitung der Bodenalbedo aus Satellitenmessungen nach Preuß und Geleyn [1] wird mit kleinen Änderungen auf einen längeren Datensatz mit höherer räumlicher Auflösung (NOAA-4, Juni 1975 – Mai 1976) angewandt. Die resultierenden Bodenalbeden zeichnen sich durch eine bessere Qualität aus und werden seit Dezember 1982 im operationellen Vorhersagesystem des EZMW verwendet.

1. Introduction

In a previous paper on the same subject [1] the authors concluded that their results were still suffering from evident deficiencies but that the method they had developed would lead to better results when applied to longer and more reliable satellite data sets. The aim of this short paper is to substantiate this claim. Therefore, one year of NOAA-4 data have been processed, the method was slightly modified and due to the larger data set several improvements were made possible so that the results show the removal of most of the obvious deficiencies of the first albedo map. Let us now recall these points in more details.

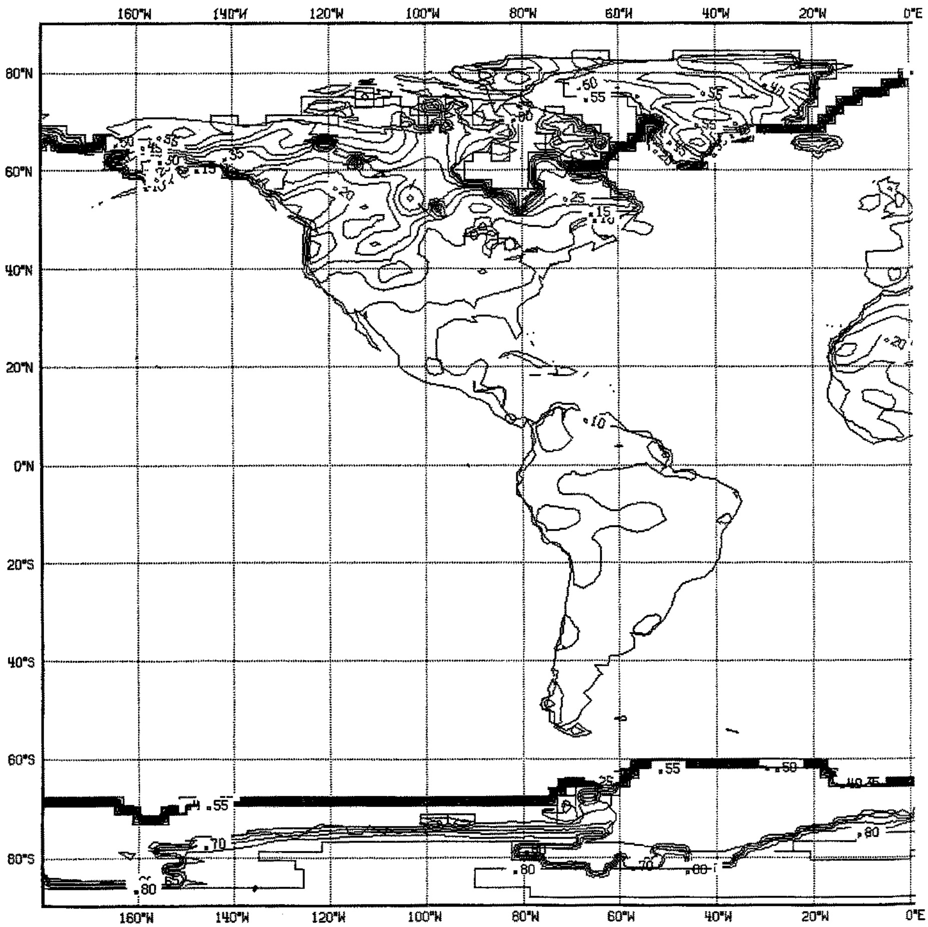
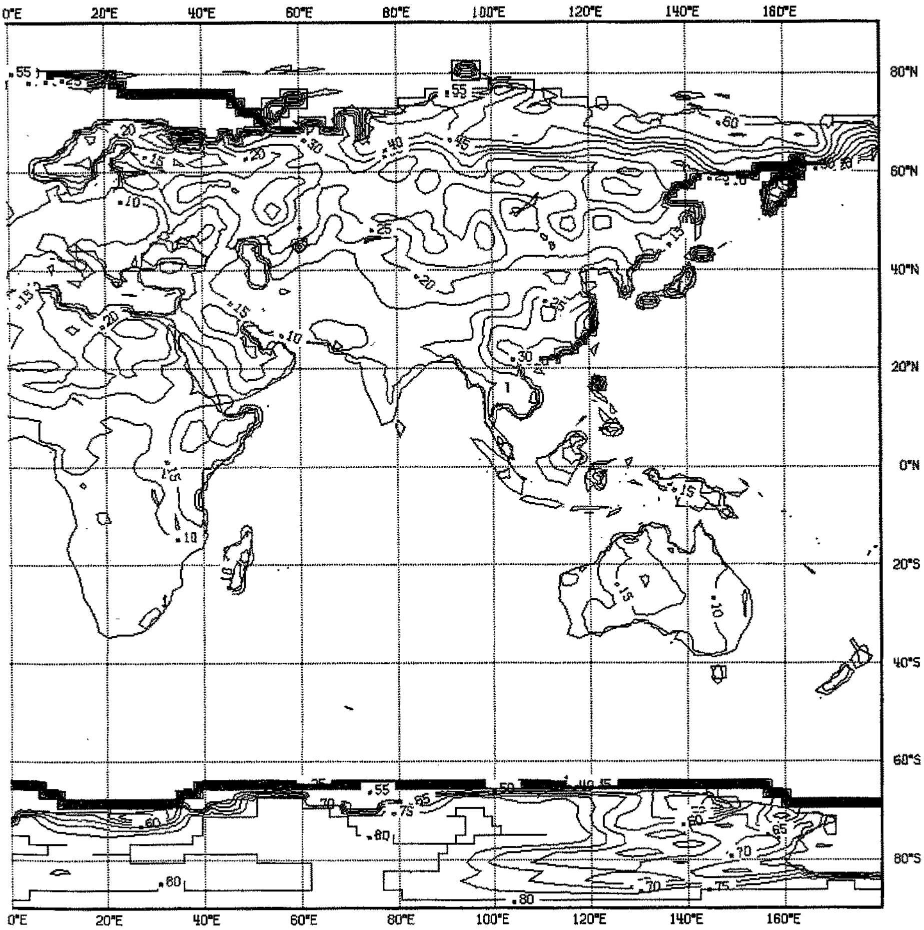


Fig. 1. Nimbus-3 derived land surface albedos (sea at 0.07, ice at 0.55)

2. Creation of the New Surface Albedo Values

The Nimbus-3 data for a few 15-day periods have been replaced by a complete set of one year of preprocessed NOAA-4 data [2] from June 1975 to May 1976. Using the visible reflected radiances, of original 4 km resolution at subsatellite track, NESS [2] obtained daily values of planetary albedo on three grids: one Mercator of $2.5° \times 2.5°$ resolution and two polar stereographic ones with a 200 km resolution at the pole. Given the high spatial density of these data that were our material for this study, we thought that it would be more convenient to interpolate the original planetary albedo



values to the N48 latitude/longitude grid of ECMWF rather than to interpolate the obtained surface albedo values as it was done in [1].

Contrary to the Nimbus-3 ones, the NOAA-4 data, however, are not representative for the whole solar spectrum but only for its visible part (500–700 nm against 200–4800 nm). So, to use them as planetary albedos leads likely to an overestimation for clouds and snow/ice and to underestimation elsewhere. Furthermore there was no correction for anisotropy and diurnal effects in the NOAA-4 processing. In summary, the change from Nimbus-3 to NOAA-4 has the advantage of a better spatial density and of a longer period (smaller risk of cloud contamination of the results), but the disadvantage of less reliable planetary albedo values.

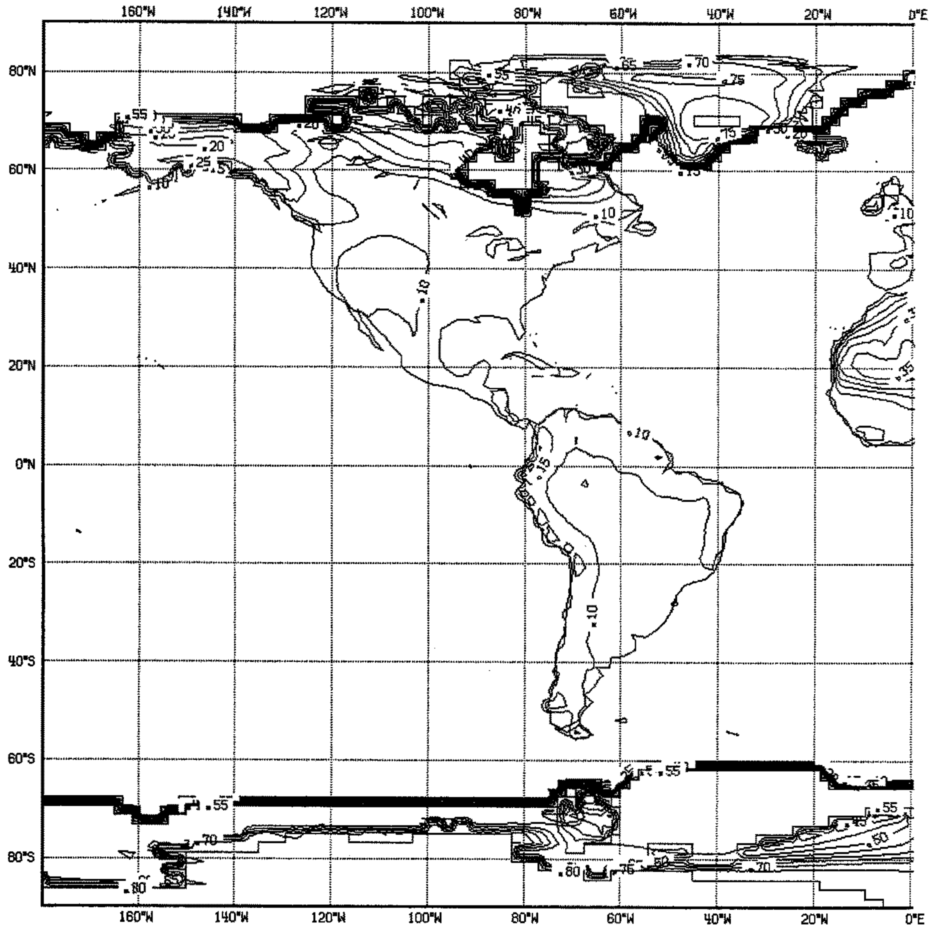
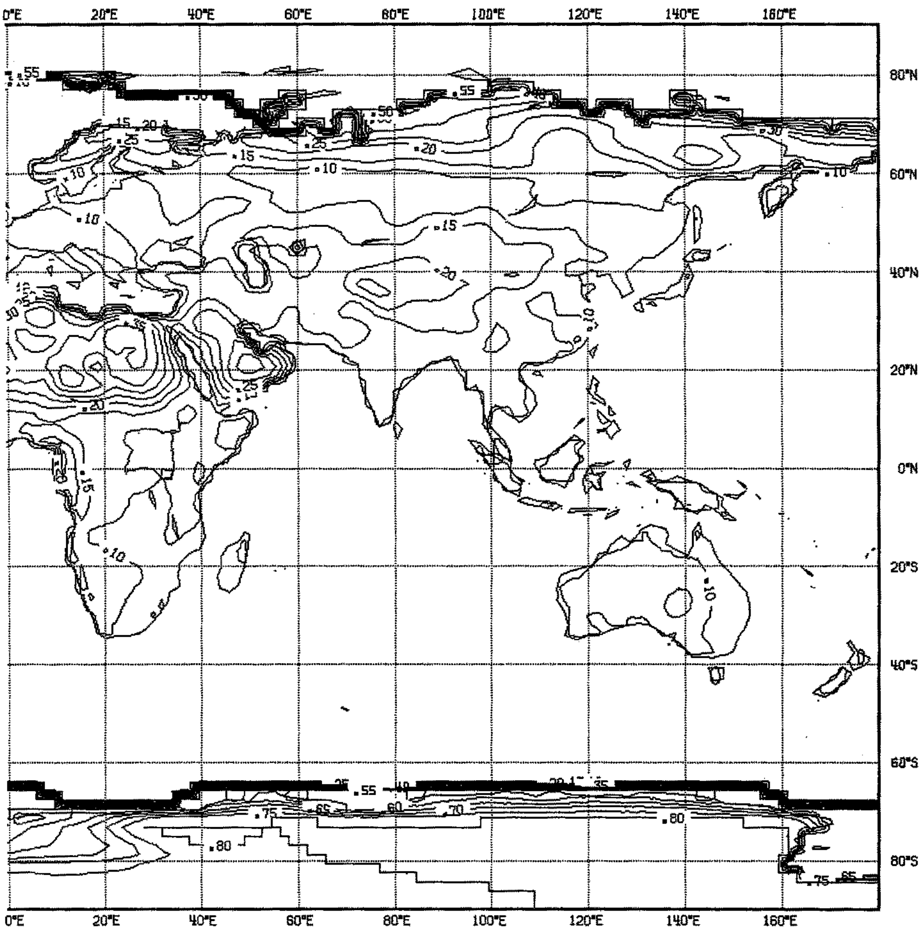


Fig. 2. NOAA-4 derived land surface albedos (sea at 0.07, ice at 0.55)

With one full year of data to our disposal we felt that a one month period for the search of minimum planetary albedos (in hope that they are associated with cloudfree conditions) would be better than the 15-day period of Nimbus-3. But prior to this search of minima, 38 days of data were eliminated, either because of missing data or because of suspiction about the quality of existing data. The time repartition of these 38 days among the 12 months (June 1975 to May 1976) is as follows: 3 – 9 – 5 – 8 – 11 – 0 – 0 – 0 – 0 – 1 – 0 – 1. Thus summer values bear a higher risk of cloud contamination than winter ones.

The most serious problem that we encountered during this work is the fact that the NOAA-4 minimum planetary albedo values are systematically lower



than the corresponding Nimbus-3 ones. This is due, as already mentioned, to the difference in spectral interval between the two sensors and it forced us to choose between:

– either recomputing the a and b coefficients of the relation between the minimum planetary albedo $\rho_{\min}$ and the surface albedo ρ_s

$$\rho_{\min} = a \cdot \rho_s + b \tag{1}$$

and doing this by "guessing" the radiative processes outside the measurement window, with all the associated risks,

– or making an empirical correction to try and reproduce on average the results of [1] where they appeared reasonable.

We elected the second course of action and found that all the b values of eq. (1) have to be divided by a factor, fixed at 2.66.
At this stage we had for each point of the N48 latitude/longitude grid 12 values of monthly surface albedo ρ_{si} ($i = 1, 12$). We could have kept the data set at this level, but we felt that its quality was still insufficient (i.e. summer months bias versus winter months, see above) and that a further compression of the information to a single value was necessary. Our aim was now to obtain one value $\bar{\rho}_s$ for snow free conditions (if they exist at all) and with as little effect as possible from doubtful values among each set of twelve. First we got from each set of monthly values an annual mean ρ_{so} and an amplitude ρ_s' for the yearly cycle with the help of a Fourier analysis

$$\rho_{so} = \frac{1}{12} \sum_{i=1}^{12} \rho_{si} \tag{2}$$

$$\rho_s' = \frac{1}{6} \sqrt{\left(\sum_{i=1}^{12} \rho_{si} \sin\left(\frac{2\pi i}{12}\right)\right)^2 + \left(\sum_{i=1}^{12} \rho_{si} \cdot \cos\left(\frac{2\pi i}{12}\right)\right)^2} \tag{3}$$

Since ρ_{so} is our best guess in regions without yearly variations and $\rho_{so} - \rho_s'$ our best estimate of the snow free conditions near the poles we took for our single value

$$\bar{\rho}_s = \rho_{so} - \rho_s' \cdot \sin^2 \varphi \tag{4}$$

with φ being the latitude. Finally the horizontal smoothing of the $\bar{\rho}_s$ data (to avoid grid point noise of various sources) was performed with a bi-Gaussian filter of radius 150 km.

3. Results

Fig. 1 and 2 show the old and new sets of land surface albedos derived from satellite measurements. It is readily seen that in Fig. 2 several deficiencies of the first map (Fig. 1) have been removed:
more realistic values for the Saharian and Arabic deserts, with better defined small scale structures;
cloud contaminated values over China have disappeared;
the values in the northern part of Canada and Siberia are more representative for snow free conditions and therefore more homogeneous.
However, there are some new problems:
too low values for Australia (our correction of the b coefficients might be too strong for southern hemispheric conditions);
cloud contamination in West Equatorial Africa (satellite passing time associated with evening convection?);

snow contamination in the high Equatorial Andes (may be realistic if there is permanent snow there).

4. Conclusion

On the whole and despite the shortcomings of the NOAA-4 data that forced one empirical correction, the use of one year of higher resolution data appears worthwhile. The new surface albedo values have been carefully tested in the ECMWF forecasting system and have lead to some improvements for the soil temperatures especially in the Saharian and Northern circumpolar regions. The new data set came into operational use in December 1982. It should not, however, be considered as a definitive solution, but as a good step forward.

Acknowledgements

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