© 2022 The Authors. Journal of Advances in Modeling Earth Systems published by Wiley Periodicals LLC on behalf of American Geophysical Union-This is an open access article under why parmits use. edution (Kannah et al., 2012). Furthermore, surface traduates observations the protocol of the surface irradiance and the by solar panels. It is therefore important to have a good model representation of the surface irradiance and the works should see well as emission are usually carameterized in weather and climate models. Existing parameterized in weather and climate models. a sometile neater the horizontal transport of radiation. Radiative transfer is considered partitioning between direct and diffuse radiation.

An Efficient Parameterization for Surface Shortwave 3D

Radiative Effects in Large-Eddy Simulations of Shallow

Meterology and Air Queley Group, Wagenapert Liverendy & Research, Wageningen, The Netherlands

whereas it increases the surface radiation in one sky Parches (cloud enhancement). In this study, we developed a simple method to account for the bottennial transfer of diffuse radiation. We spatially (liter the surface diffuse of the study of the stud

numper memory to account for the memory transfer of turnine manages, we spatially turner as interact entrume addition field with a Caussian filter, which is conceptually simple and comparisonally efficient. We applied

reasonon nera wina a unassan hare, emen is conceptuary simple ana companionally etuicant. Ne appear the foreign the results of Large Eddy simulations for new summer days in Cabasaw, the Necherlands, on

ter interne to the results of Large-Long summaries for two summer days in sansaw, the extensions, on which shallow camalus clouds formed during the day. We defined the optimal filter size by matching the

which studios canadis cousis termes during use day, we ensure use optimal times size by marcing the annulation results with detailed high-quality observations (1 Hz). Webbut the filtering, doubt enhancements are

sumanu reans was unaen nga-gany vaseraaras († 171), waard ta turene, coud enancemens ar no equiparte and the probability distribution of global nationals is summobil, whereas the observed distribution

net equires, and use presenting unarrangen of given quantum to uninterim mercer in experience ourrangent is bindled. After filtering, de probability durchenne of global relation is binnedd and cloud eshancements is bimodal. After filtering, the probability distribution of global radiation is bimotal and cloud economercient are simulated, in line with the observations. We found that small charges in the filter width do not strongly

ret simulates, in une word ne onservenons, we found that small enables in the uner word on one storegy influences the results. Furthermore, we showed that the wight of the filler can be parameterized as a interest of the storegy of the storegy of the storegy of the filler can be parameterized as a interest of the storegy of the filler can be parameterized as a interest of the storegy of the filler can be parameterized as a interest of the storegy of the filler can be parameterized as a interest of the storegy of the filler can be parameterized as a interest of the storegy of the filler can be parameterized as a interest of the storegy of the filler can be parameterized as a interest of the storegy of ncuence the result. Furthermore, we showed that the work of the titler can be parameterized as a timere function of for example, the cloud cover, Hence, this work presents a proof-of-concept for our method to come

Plain Language Summary The paper of radiation at the surface is characterized by the presence faith fangunge Shifilitary the patient of radius of a the surface is characterized by the press of cloud shadows and peaks in the nalision caused by scattering of tight by clouds. The amount of source

of cloud shadows and peaks in the tablation caused by scattering of URN by clouds. The amount on sour adjusted that teaches the Earth's suffice determines how much energy is produced by solar parallel and how the second communication of the state of the source of the second beam data to the source of the tanuon nar rester on tanta surrace deermins too much energy is prouved by solar goest and more much best and more its supplied to be doubt, this it influences how the claudi double. Exciting mode in the supplication of the s man new and measure is supplied to the course, this it influences now the coursi develop. Exating models angles to be catering of relations the horizontal direction, therefore the high peaks in the relations are en-

ndelect me scattering of relations in the horizontal ancient. Interesting the staff profile in the calibration are own modeled. In this Paper, we show for 2 days with shallow containing could how we can include the effect of the modeled in this Paper, we show for 2 days with shallow containing could how we can include the effect of the modeled in the paper.

nodelot, in ins paper, we saw for 2 only with mallow classifies clouds how we can include the effect of the hydroxida propagation of radiation. We redistribute the tradiation at the surface, and we compare our model

Netronita propagation of rulations. We robstribute the tadjation at the surface, and we compare our model in general, we get robatis with mesurements. After the fedaribution, the high peaks in indialism are modeled. In general, we get

a good maleh between the observed and enviced random aternmenter. we save unit the restarrenzion can be made a function of the clouds in the model. Hence, this work presents a proof of concept for our method to

routo wan measurement. Atter the construction, the high peaks in naturation are involved. In general, we pe

to more realistic surface irradiances by filtering diffuse reduation at the surface

or more a morene or nor server to use more preserve the more preserve come to more realistic surface radiation, without complex calculations.

Micjam Tijhuls¹ 🙃, Bart J. H. van Stratum¹ 🙆, Meano A. Veerman¹ 🔍 and

Cumulus Clouds

Chiel C. van Heerwaarden¹ 😳

The amount of solar energy that reaches the earth surface is arougly influenced by the complex interactions The ansault of solar energy that reaches the earth surface is strongly astroneed by the complex interactions between clouds and multislon. Therefore, solar energy party reaches the surface directly and party reaches the surface of the surface to the surface of the surface strongly and the surface directly and party reaches and the surface of the surface of the surface strongly astrongly astrongly astrongly astrongly as the surface directly as a surface directly as a surface of the surface directly as a surface of the surface directly astrongly astrongly astrongly as a surface directly between clouds and mulation. Therefore, only energy party reactes us write directly and party rescues to an another the statistical affect its scattered in the atmosphere by gates, are clouds and clouds. The total amount of the statistical affect its scattered in the atmosphere by scattered and clouds. The total amount of the statistical affect its scattered in the atmosphere by scattered and clouds. The total amount of the statistical affect its scattered at the statistits at the statistical affect its scattered at the writer is unitse manino arteri is scattero in the amosphere by gales, activity and closes. The total amount of solar energy reaching the surface, also referred to a surface tradiance of global relation. Proven any 1. Introduction of solar energy reaching the solates, also reterred to as some reasoner emanance or goout reasoner, governs many processes at the surface. It drives the sonable and latent hear fluxes, which supply measure and energy to use processes in the surface. It wrives the sension and also are not interesting on the surface (massive endowing of the surface (massive endowing of the surface (massive endowing endowin ary layer clouds and this determine their overopment. Agait from we surface tunes, the anterbee remainder data influence that photosynthesis, a diffuer elabation is taken up by the carety more efficiently than direct elaberts (Version et al. 1993). Examine the elabation is taken up by the carety more efficiently than direct ato influences plan possoyntesis, si ottuse radiano is tusen up oy the canoy mare effecting una meet adolos (Kanub et al., 2012). Futbernore, surface iradiane é dermines de protacion of renewale energy

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Supporting Information: Supporting Information may be found in the online version of this article.

cumulars cloud days with 1D radiative transfer for the 3D radiative effects in a post-processing step The probability distributions of diffuse and global radiation closely match the observations after fiftering the surface diffuse radiation The filter size can be parameterized as a linear function of one or multiple to a toron cloud variables, resulting in a minimal computational overhead

JAMES Journal of Advances in Modeling Earth Systems

RESEARCH ARTICLE 10.1029/2022MS003262 We correct simulations of shallow

Parameterization Radiative Effects Abstract Most amonghoric models consider radiative transfer only in the vertical direction (1D), as 3D Shallow Cumulus ADNITACI Must amonfeste model connect radius transfer only in the vertical anester (equily, as a) additive transfer alculations are too coals. Thereby, he from a reader of radiation is smitted, reading in the second s nadasive transfer calculations are too coarly. Thereby, horizonta transfer of natures is united, eposition shadow, normed surface natures on the calculation fields. The horizontal specialize of diffuse natures is during to the calculation of neeries sutine tanumin nenis. Lie mortonia spealing of ottine taatuen reality in datter (and statows) whereas the surface radiation in clear day pathese (clear enhancement). In this stady, we developed

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Clouds Yannick Burchart

An Efficient

for Surface Shortwave 3D

in Large-Eddy

Simulations of

- Corrected unrealistic surface solar irrdaiance from LES with 1D radiative transfer
- Approximated horizontal spreading of the diffuse radiation by Gaussian filtering the diffuse radiation at the surface
- Did LES for two ShCu days (04.07.16 & 15.08.16) in Cabauw, Netherlands

Gaussian Filter / Weierstrass Transform

An Efficient Parameterization for Surface Shortwave 3D Radiative Effects in Large-Eddy Simulations of Shallow Cumulus Clouds

Yannick Burchart

$$G(x,y) := \frac{1}{\sqrt{2\pi\sigma^2}} \exp(-\frac{x^2+y^2}{2\sigma^2})$$

$$[\mathbb{F}(r_{diff})](x,y) := [r_{diff} * G](x,y) :=$$
$$\frac{1}{\sqrt{2\pi\sigma^2}} \int_{\mathcal{D}} r_{diff}(\alpha,\beta) \exp(-\frac{(x-\alpha)^2 + (y-\beta)^2}{2\sigma^2}) d\alpha d\beta$$

 r_{diff} = diffuse radiation, D = domain, \mathbb{F} =filter



- Upper part 4 July 2016
- Bottom part 15 August 2016



- Temperature and humidity at 10m height
- Upper part 4 July 2016
- Bottom part 15 August 2016



- Upper part 4 July 2016
- Bottom part 15 August 2016



- Data for PDF just from 10 to 16 UTC
- Upper part 4 July 2016
- Bottom part 15 August 2016



- filtering enhanced radiation in cloud free areas
- PDF of global radiation looks better after filtering the diffuse radiation
- nice to read
- Just two days
- Overfitting? by choosing depth of filter by observations
- No new physical insights by applying a filter / smoothen things out