# RC LACE Research Stay Report

<u>Topic:</u> ***Shallow Convection Cloudiness***

Radmila Brozkova, Toulouse, 20th April -20th May 2015

## Introduction

The ALARO-1 version A configuration still deploys the shallow convection scheme based on the modified Richardson number (reference: Geleyn,J.-F. , 1987: „Use of a modified Richardson number for parameterizing the effect of shallow convection." J. Meteor. Soc. Japan, special NWP Symp. vol., 141-149.). This scheme has some known weaknesses, including possible oscillatory behavior, resulting also from small variations in the profile. Moist anti-fibrillation scheme has to be used in this case. Resulting shallow convection cloudiness is too scattered and may occur also above the PBL top, and as such is not suitable to enter the radiation scheme.

New approach to parameterize shallow convection is based on the recent work of Geleyn and Marquet, 2013 (reference: Marquet P. , Geleyn, J.-F. 2013. „On a general definition of the Brunt-Vaisala Frequency associated with the moist entropy potential temperature." Q. J. R. Meteorol. Soc., 139,85–100.) and of Lewellen & Lewellen, 2004 (reference Lewellen, D. C. and W. S. Lewellen 2004. „Buoyancy flux modeling for cloudy boundary layers" J. Atmos. Sci., 64,1147–1160.) . One of the ingredients of the scheme is a mass-flux type of computation, yielding a ratio between dry and saturated atmospheric conditions.

The purpose of the research stay was to develop the mass-flux type computation to obtain a shallow convection cloud profile.

## Development of the profile

As the basis we took the cloud profile computation from the moist deep convection scheme 3MT but of course with a lot of simplifications. For detailed documentation on the 3MT scheme updraft computations please refer to the note by Luc Gerard, March 2013. As it comes out from LL2004 paper, even a crude approximation of the mass-flux computation yields satisfactory results in comparison with LES experiments.

The profile starts at the lowest model level from wet bulb values of temperature and moisture of the environment. Cloud condensates are also equal to the grid scale ones; in contrast to 3MT there is no re-evaporation of the grid scale condensates when the cloud is present. Moist static energy is computed like in the 3MT scheme, but of course there is no modification due to slantwise or "shear-linked" convection.

Regarding the mixing, there is no dependency on the integrated buoyancy (and/or sophistication pending the relative humidity of environment), but on the turbulence activity via TKE. To simplify, there is no prognostic type of entrainment (LENTCH option), neither the promotion of less entraining warm clouds to reach higher levels. We keep two parameters to define minimum and maximum limits of the mixing, denoted as ETKE_ENTRN and ETKE_ENTRX. There is a third parameter, a value of TKE for which the mixing coefficient is a half-way between its minimum and maximum, denoted as ETKE_ENTCR, set provisionally to 0.1 [J/kg]. The modulation is based on the integrated values of turbulence activity within the cloud. The parameter ETKE_ENTCR is considered for a typical PBL depth, set now to 1750m, while the final modulation factor depends on the TKE integrated over geopotential layers, but only the active layers are counted. Like that, entrainment gets higher within the shallow cloud and reaches the maximum at the cloud top. The limit entrainment coefficients are chosen higher than for the moist deep convection, both limits are between two times or three times higher. Preliminary results show that the three times higher entrainment coefficient limits start to suffer from oscillations, when a cloud is aborted and starts again. Range of the entrainment coefficients (parameters of the scheme) can be found in the following table:

| Parameter | Low limit | High limit |
|---|---|---|
| ETKE_ENTRN | 1E-05 | 1.5E-05 |
| ETKE_ENTRX | 3.2E-04 | 5E-04 |

Updraught profile is constructed as moist entraining pseudo-adiabat, where mixing happens at a constant pressure. Moist static energy and total moisture are conserved when going up. The computation of updraught quantities, including cloud condensate, follows the 3MT algorithm. However in contrast to the moist deep convection scheme, no condensate is detrained, following the principle of shallow convection not yielding precipitation. Cloud is interrupted when one of the two conditions is not fulfilled. The first one is the same like in the 3MT scheme, so that temperature in the updraught should be warmer than the wet bulb temperature of the environment. The second condition is to have some turbulence activity, where TKE should be higher than a small background value, currently set to 1E-02 [J/kg]. In case of cloud interruption the updraught values are simply returned to the environment.

We created the procedure ACSCCTR to compute the shallow (non precipitating) convection profile. Preliminary tests were done at the diagnostic mode only, since the use of the updraught profile in ensuing computations of moist Brunt-Vaisalla frequency and shallow convection cloudiness need to be adapted. Below we present some profile examples from winter and summer situations.

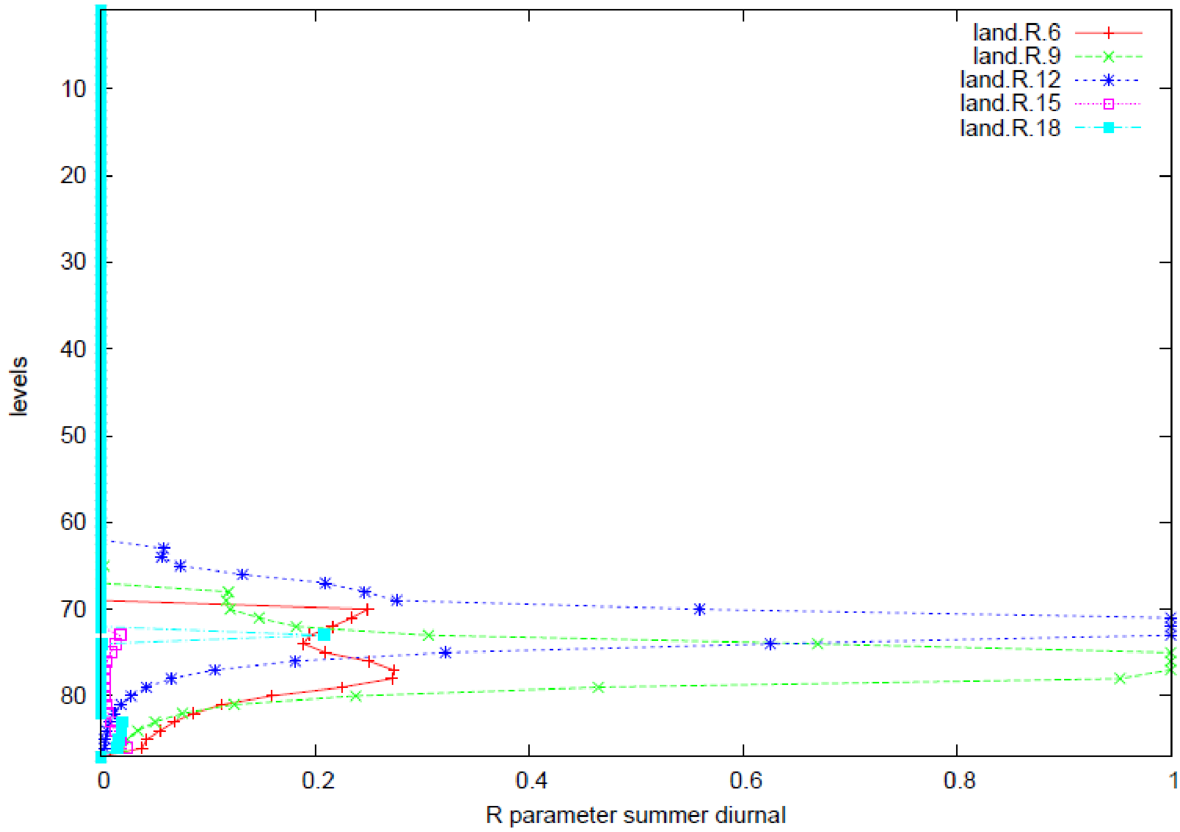


Fig.1: *Ratio between dry (0) and saturated (1) case of shallow convection at 6h, 9h, 12h, 15h and 18h UTC of a summer day (29 June 2009) over land. When the ration is equal to 1, there is a solid cloud.*

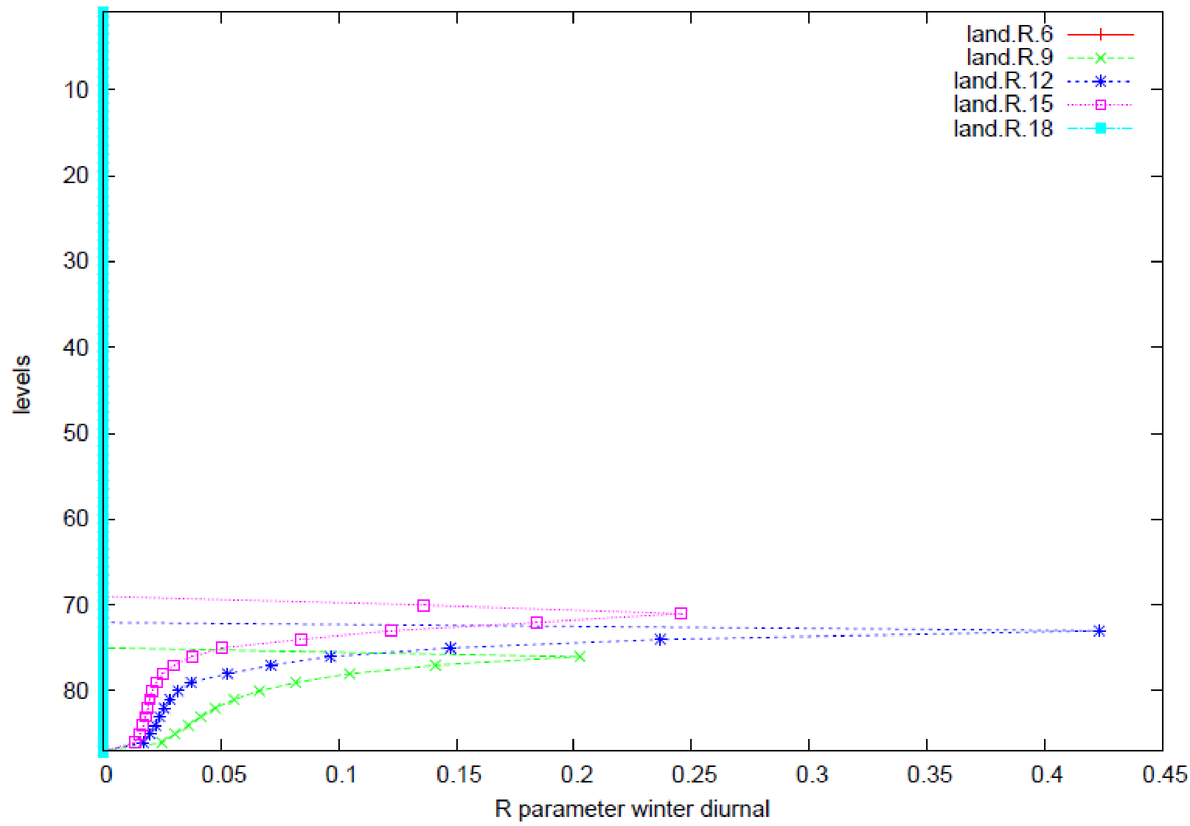


Fig.2: *Ratio between dry (0) and saturated (1) case of shallow convection at 6h, 9h, 12h, 15h and 18h UTC of a winter day (12 February 2015) over land.*

## Conclusion

During the research stay an algorithm to compute mass-flux type shallow convection profile was proposed, coded and tested. Preliminary tunings of entrainment coefficients were found. The procedure is now ready to be combined with the moist turbulence computations and to be further tested.