

Séminaire vendredi le 13 septembre 2019 11:00 / Seminar Friday September 13th 2019 11:00h

Sujet/Subject: Numerical simulations of turbulent processes within shallow and deep cumuli

Langue/language : Anglais/English

Conférenciers/Lecturers: Dan Kirshbaum (McGill University)

Résumé/Abstract:

This presentation summarizes three numerical studies of cumulus clouds and the turbulent processes influencing their macroscale development. The first study quantifies the sensitivity of shallow-cumulus entrainment to several relevant environmental parameters. Among these parameters, continentality and vertical wind shear are found to be the most influential, with background humidity and subcloud- and cloud-layer depth playing much lesser roles. All of these sensitivities are physically interpreted, most using a similarity theory based on the turbulent kinetic energy (TKE) budget. In the second study, simulations of precipitating cumuli forced conditionally unstable airflow over a smooth mountain ridge are conducted across the convection "grey zone", ranging from parameterized convection at 10 km horizontal grid spacing to resolved convection at 62.5 horizontal grid spacing. Relative to the higher-resolution cases, major errors in precipitation are found in the parameterized cases (with the Kain-Fritsch cumulus scheme), recovering a known bias in larger-scale models. Preliminary insight into these biases is provided by comparison of parameterized versus resolved updraft mass flux, entrainment, and detrainment in the simulations. To facilitate this comparison, a new diagnostic for cumulus entrainment/detrainment in large-eddy simulations of horizontally varying flows is developed. Continuing the grey-zone theme, the third study evaluates deep-convection initiation over a thermally forced convergence line, at a range of horizontal grid spacings (500 m, 250 m, and 125 m). As the grid spacing is decreased, the cloud-top heights and updraft mass flux systematically (though nonlinearly) decrease as well. This sensitivity is explained by differences in the numerical representation of turbulent processes not just within the cloud layer, but also within the subcloud layer. In summary, the findings support the use of flow-dependent entrainment rates within cumulus parameterization schemes, along with further refinements in the scale-awareness of 3D subgrid turbulence schemes.