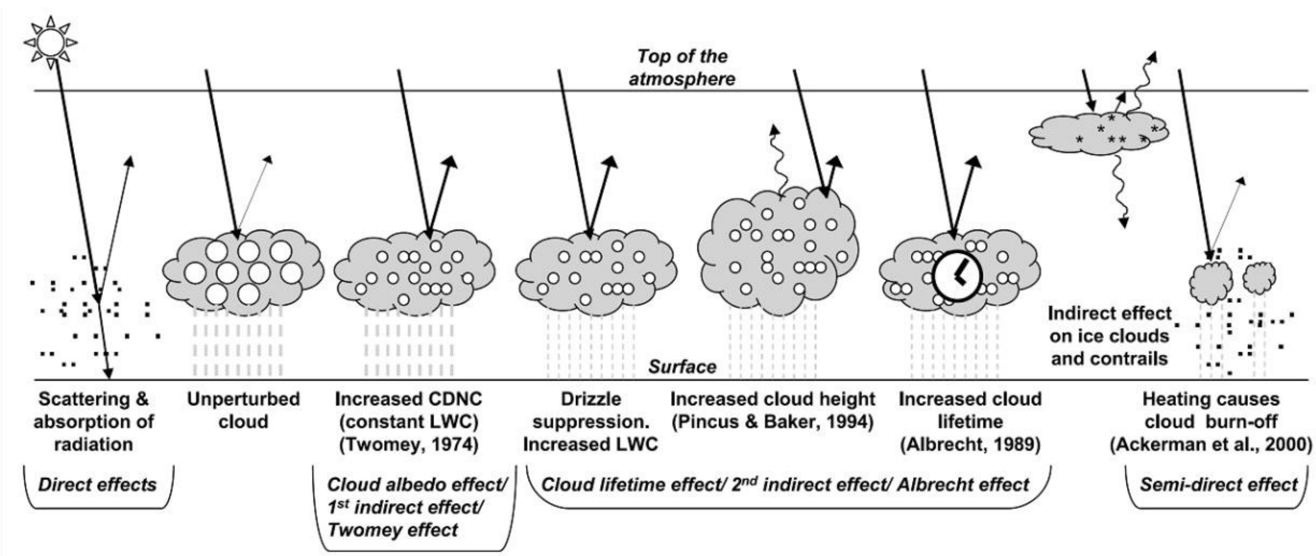
I. Implementation of a Satellite Simulator within ECHAM5

Space-bourne satellites provide a unique, un-obscured vantage point for observing atmospheric properties. The radar and lidar instruments on-board the CloudSat and CALIPSO satellites, working in the radio/microwave and visible/near-infrared frequencies respectively, capture the range, altitude and direction of clouds in addition to individual aerosol and cloud particles. These two satellites, together, provide three-dimensional views of cloud structures as well as information regarding the formation and evolution of aerosols and clouds.

The objective of current project is to implement the Cloud Feedback Model Intercomparison Project's *'CloudSat and CALIPSO Simulator'* within the ECHAM5 global atmospheric general circulation model. The simulator mimics CloudSat and CALIPSO signals within the model; taking cloud and atmosphere information from ECHAM5 and converting it into something comparable to satellite data. The CloudSat and CALIPSO Simulator is a valuable tool for evaluating the representation of clouds in ECHAM5. By studying the Cloud Frequency Altitude Diagrams (CFAD), cloud fraction, and Low, Mid, & High-level cloud cover provided by the simulator, one can reveal biases and identify model weaknesses; ultimately providing a better understanding of aerosol indirect effects on clouds and precipitation.

II. Impacts of Sub-grid Turbulence Exchange in the Vertical on Aerosol Indirect Effects



Intergovernmental Panel on Climate Change, AR4 WG1, 2007
http://www.ipcc.ch/graphics/graphics/ar4-wg1/jpg/fig-2-10.jpg

To date, the aerosol indirect effect remains one the greatest uncertainties in climate forcing. To improve our understanding and representation of aerosol-cloud interactions in boundary layer clouds one must look at the sub-grid scale of General Circulation Models (GCM). Currently, GCMs have a horizontal resolution in the order of 100s km, however, fundamental cloud processes act on the scale of individual cloud particles of the size of several micrometers. One of theses processes includes the cloud droplet activation process, which is the basis of the aerosol indirect effect.

Droplet activation, as described by Köhler theory, depends aerosol properties and supersaturation, the latter of which, is currently the most important shortcoming in aerosol indirect effect parameterization. To accurately represent the supersaturation an updraft velocity on the order of m/s (in cumulus) is needed. GCMs, however, compute grid-box mean vertical winds, which at best is in the order of cm/s and generally close to zero.

My objective is to refine the calculation of supersaturation to include the sub-grid vertical velocity variability in cloud droplet activation process and thereby aerosol indirect paramertization. In addition, simulated cloud fields will be evaluated with satellite observations.

In collaboration with C. Siegenthaler-Le Drian of the Eidgenössische Technische Hochschule Zürich (ETHZ) and G. Lenderink, R. Neggers and P. Siebesma of the Koninklijk Nederlands Meteorologisch Instituut (KNMI) several updates to the Planetary Boundary Layer (PBL) scheme have been prepared for application in ECHAM5. The new features include a re-formulation of Probability Density Function (PDF) scheme in terms of conserved variables (equivalent potential temperature and total water mixing ratio), a new length-scale, and a dual-mass flux scheme in addition to the turbulent kinetic energy scheme. These improvements, in particular dual mass-flux scheme for dry and moist shallow convection, will allow for the physical representation of updraft velocity at the scale of individual cumulus clouds. It is anticipated improvements will lead to a better representation of shallow marine clouds and thus cloud-climate feedbacks in ECHAM5.