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Cloud and aerosol properties in NWP models from a radiation point of view

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Historically, in NWP models the radiation and cloud microphysics have been treated separately, which may have led to inconsistencies in treatment of cloud-radiation interactions. What is the required level of complexity of the treatment of cloud-aerosol-radiation interactions? It is generally accepted that an NWP model should grow its own clouds and create precipitation using external aerosol data as a starting point. It is also widely accepted that an NWP model should not grow its own aerosol particles but take their concentrations and optical properties from somewhere else. In practice, the radiation parametrizations would benefit from using the physical properties of cloud particles and optical properties of the aerosol particles, generated outside of the radiation schemes themselves.

Aerosol concentration and properties such as size distribution and composition influence the formation of cloud droplets and ice crystals that determine the cloud optical properties. One of the key physical parameters is the effective radius of cloud particles used by the radiation schemes. It represents a combination, on an empirical basis, of the phase, size and shape of the particles for radiation. Inside the cloud microphysics parametrizations independent assumptions about the size distribution of cloud and precipitating particles are made, in order to treat the precipitation processes. Should there be more consistency between these two types of microphysics in the models? Can they benefit from each other?

The optical depth and scattering properties of the aerosol particles directly influence radiative transfer in the atmosphere. Aerosol impacts on radiation have been parametrized using classical climatological datasets that contain vertically integrated aerosol optical depths at a selected wavelength. Vertical distributions of the aerosols and the wavelength-dependent aerosol optical properties have been prescribed for the radiative transfer calculations using simplifying assumptions. However, contemporary three-dimensional aerosol data, available in real time, are produced by application of advanced atmospheric chemical transport models which are capable of forecasting the three-dimensional concentrations of aerosol species and constrained by the assimilation of satellite-derived observations. The spectral inherent optical properties (IOP) of different aerosol types are calculated theoretically and rely on laboratory measurements.

A combination of the observation-based aerosol concentrations with detailed prescribed IOPs, using the information of atmospheric humidity available during the time-integrations in the NWP models, allows improvements to be made to the parametrization of the radiative transfer at all wavelengths of solar and terrestrial radiation. On the other hand, use the near real-time aerosol concentration data may allow more realistic parametrization of cloud-precipitation processes. Would this also improve the simulation of cloud-radiation interactions and secondary aerosol effects? Is there potential for improved consistency between the parametrizations when these data are used in the NWP models used for operational weather forecasting? These and other important questions will be addressed in this overview presentation.