WGNE/GASS White Paper on scale-awareness, stochasticity, and convective organization

Second phase of the "Grey Zone" project based on the EUREC4A field campaign

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Although weather and climate models which include convection parameterizations are able to represent various features of the atmospheric dynamics and the general circulation reasonably well, many deficiencies remain. Four main "headline issues", where the representation of convection based on convection parameterizations may differ from explicitly resolved convection, can be identified:

(1) Convection parameterisations are in essence diagnostic, by definition they derive the characteristics of convection diagnostically from the present state of the larger scales; (2) Most present-day convection parameterizations are not designed to represent organized convection like mesoscale convective systems; (3) The coupling of convection parameterizations to the larger-scale circulation is difficult to adequately take into consideration when developing parameterizations and is therefore often problematic; (4) Many convection parameterizations include a microphysics scheme which is different from the large-scale microphysics in the model. These deficiencies of convection parameterizations can lead, among others, to incorrect diurnal behaviour, inadequate temperature dependent phase assumptions for detrained water, major issues with the land-sea distribution of rainfall and the sensitivity to warm sea surface temperatures, and thus even flawed signals in climate change simulations.

In recent years both weather and climate models have ventured into both the boundary layer as well as the convective "grey zone" of resolutions between 100 m to 10 km where boundary layer and convective processes are partially resolved and partially parameterized. This generates the urgent need for the development of parameterizations which are scale-aware, and at most weather and climate modeling centers this development process has started and is now maturing. But it is not only this practical need for appropriate parameterizations which makes the investigation of the "grey zone" so interesting and exigent, it is the scientific questions about the nature and essence of convective and boundary layer processes, and their relation to the larger scales, as outlined above in the four "headline issues", which puts the "grey zone" problem at the center stage of current boundary layer and convection research. In what way exactly do explicitly resolved convective and boundary layer processes differ from parameterized convection and turbulence, particularly in relation to the larger scales and with respect to convective organization?

Scale-awareness is an essential feature of a parameterization and in a sense is not separate from the question of how to conceptually represent convective and boundary layer processes in a parameterization. Nevertheless, it is not clear whether the way in which scale-awareness is built into a parameterization really matters. For instance, there are many ways of how to reduce the convective mass flux with increasing resolution in a mass-flux convection parameterization, but the effect may be ultimately similar. The fact that many modeling centers now are in the process of developing scale-aware convection and boundary layer parameterizations would make a model intercomparison a fruitful and enlightening enterprise. Moreover, one can now draw on the experience of the first phase of the "Grey Zone" project (Tomassini et al., 2017; Field et al., 2017) and better specify the required output diagnostics.

It is essential that such an intercomparison is built around a field campaign which provides suitable observations. The EUREC4A campaign would be a great opportunity for this purpose. We therefore propose a second phase of the "Grey Zone" project based on a case study built around EUREC4A.

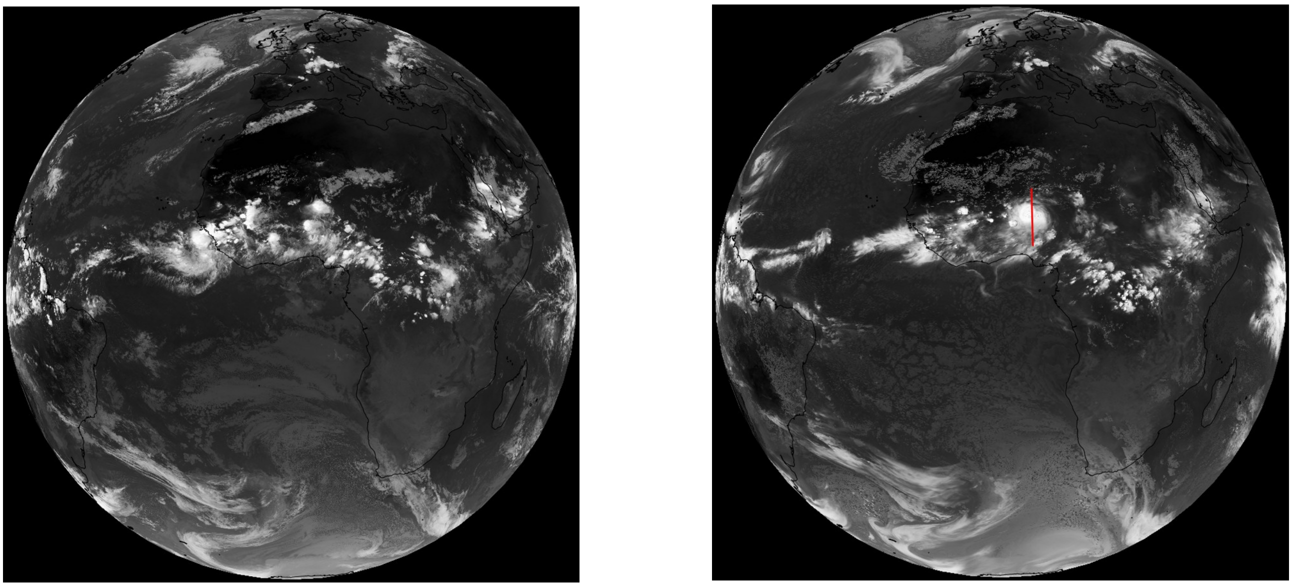

Figure 1: The left panel shows irradiances at 10.8 µm from the SEVIRI instrument on the Meteosat Second Generation satellite from July 10, 2010, at 18:00 UTC. The right panel depicts the same quantity based on a forecast with the Met Office Unified Model at 5 km global resolution. In the model simulation the convection parameterization was partially suppressed. The red line indicates the location of the trough of an African Easterly Wave. The mesoscale convective system ahead of the trough is qualitatively well simulated by the model, but shows a too organized and "blobby" appearance.

In a second phase of the "Grey Zone" project we would aim at ambitious high-resolution simulations including "real case" nested large-eddy simulations at *O*(100m) resolution and global convection-permitting model forecasts of *O*(5km) resolution (see the "ECMWF road map for 2025", and Figure 1). Convection and boundary layer statistics, which are used in parameterizations, such as the distribution of cloud sizes and vertical velocities, would be compared across the model simulations and linked to the larger-scale circulation.

Moreover, in recent investigations of the convective and boundary layer "grey zone", complementary radiative convective equilibrium simulations have proved to be a useful additional tool (for instance Becker et al., 2017). The fact that currently there is a RCE model intercomparison (Wing et al., 2017) under way in which many modeling centers participate might provide an opportunity to link the proposed second phase of the "Grey Zone" project to the simulations generated for the RCE intercomparison. For instance, this would allow for investigating the "blobbiness" of convective features in many convection-permitting models in greater depth.

The planned ParaCon convection conference at the Met Office in summer 2019 could be used to discuss various aspects of the case study in more detail, and to start preparations for the intercomparison.

References:

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P. Field et al. (2017), Exploring the convective grey zone with regional simulations of a cold air outbreak, Q. J. R. Meteorol. Soc., 143, 2537-2555.

L. Tomassini et al. (2017), The "Grey Zone" cold air outbreak global model intercomparison: a cross-evaluation using large-eddy simulations, J. Adv. Model. Earth Syst., 9, 39-64.

A. Wing et al. (2017), Radiative-convective equilibrium model intercomparison project, Geosci. Model Dev. Discuss.

Adrian Lock and Pier Siebesma will be at the Pan-GASS meeting 2018 in Lorne/Melbourne.