The Grey Zone Project
A WGNE-GASS initiative

Grey Zone committee:  Pier Siebesma, Martin Miller, Andy Brown, Jeanette Onvlee

Motivation

• Increased use of (operational) models in the “grey zone”  \( \Delta x = 1 \sim 10 \text{km} \)

• This has led to the “wrong” perception that these “grey-zone” models, when operating without (deep) convection parameterizations, can realistically represent turbulent transport of heat, moisture and momentum.

• Hence there is a urgent need of a systematic analysis of the behavior of models operating in the “grey-zone”:

“The Grey Zone Project”
Proposal (from WGNE 2010 meeting)

• Project driven by a few expensive experiments (controls) on a large domain at a ultra-high resolution ($\Delta x=100\sim500$ m) ($\sim2000\times2000\times200$ grid points).

• Coarse grain the output and diagnostics (fluxes etc) at resolutions of 0.5, 1, 2, 4, 8, 16, 32 km. (a posteriori coarse graining: COARSE)

• Repeat CONTROLS with 0.5km 1km, 2km, 4km, 8km, etc without convective parametrizations etc (a priori coarse graining: NOPARAMS)

• Run (coarse-grain) resolutions say 0.5, 1km, 2km, 4km and 8km with convection parametrizations (a priori coarse graining: PARAMS)
Aims

• Gain insight and understanding how models behave in the grey zone with & without conventional convection parameterizations

• Provide guidance and benchmark for the design of scale-aware convection parameterizations that could operate in the grey zone

Strong Support from both the international NWP and Climate community
The parametrization problem of the grey-zone

- Most parameterisation issues of clouds and convection evolve around finding the subgrid pdf of:

\[ P(T, q_t, w) \]

- Or, as a good approximation, the variances and covariances:

\[ q'^2, \theta'^2, w'^2, w'q', w'\theta', q'\theta', \]

- as a function of the resolution (especially in the grey zone)
The parametrization problem of the grey-zone

- Turbulent flux is overestimated at resolutions $l > 1000$ m -
- due to an overestimation of the subgrid (parameterized) fluxes.
- due to the fact that in LES subgrid flux parameterization is designed to work for large eddy-resolving scale $l < 1000$ m and not beyond!
Case Proposal: a cold air outbreak
Thanks to: Paul Field, Adrian Hill and Stephan de Roode

• The Mesoscale Community is interested to start with an extra-tropical case

• Cold-air outbreaks are of general interest for various communities

• Proposal: “Constrain” cold-air outbreak experiment
  31 January 2010

• Participation of global models, mesoscale models but also from LES models !!

• Domain of interest: 750X1500 km

• Quick Transition : ~ 14 hours
Case Proposal: a cold air outbreak

3 Different Flavours

1. Global Simulations (at the highest possible resolution up to 3~10 km) or lower res LAMs

2. Mesoscale Models (Eulerian) at various resolutions (up to 500m) LAM-set up

3. Mesoscale/LES Models (Lagrangian). Idealized with periodic BC. highest resolution (~200m)
Setup for LAM case used for driving LES models

**Met UM - based on Field et al, 2012**

**Time period**
- Cold air outbreak 12Z 31st January 2010 - 00Z 1st February 2010

**Standard domain and resolution of inner domain**
- centre of domain - 62N, 8.5W
- x,y domain = 752 km x 1504 km
- standard resolution - dx, dy = 1 km

**Parameterisation**
- Boundary layer scheme ON
- Convection OFF
- Microphysics – UM 8.0 single moment scheme with prognostic rain and ice
- Cloud fraction scheme – Smith scheme

**Lateral Boundary Conditions**
- From UM GLOBAL forecast
- ECMWF analysis for case also available
Work was needed on the LAM

• With UM, no ice showed a good match to LWP obs in lagrangian
  • Further work (modified ice nucleation & changes to the BL scheme) gave reasonable agreement with observations
• This is then used to drive the LES lagrangian experiments
Sensitive to microphysics in the LEM too

no ice

ice
Sensitive to microphysics in the LEM

- $N_c = 10 \text{ cm}^{-3}$
- $N_c = 50 \text{ cm}^{-3}$

- $t=13\text{ hr}$
- $t=10\text{ hr}$
- $t=7\text{ hr}$
- $t=3\text{ hr}$
Pro’s and Cons of the case

• Cold air outbreak has been on the wishlist of the NWP community for many years

• Excellent opportunity to entrain the mesoscale modeling community.

• It’s only now that high resolution models are able to faithfully reproduce the observed mesoscale structures associated with a cold air outbreak.

• There is a well observed case available (CONSTRAIN)

• Case is complicated because of the (ice) microphysics.

• Might not have been the first obvious choice for a grey zone perspective from the point of view of global models.

But........
Extensive tests have been done for all 3 flavours over the last year.

For the first time we have been able to resolve numerically a realistically looking cold air outbreak at a high resolution

Details of the mesoscale organisation depends on the details of the microphysics

E.g. the break up into open cell structure depends critically on the assumed cloud number concentration for turbulence resolving models

Case has been released

Volunteers for coordinating the subprojects have been identified:

Global Model runs : Verena Grutzun/ Axel Seifert (MPI Hamburg, DWD)

Mesoscale model runs (Eulerian) : Paul Field/Adrian Hill (Met Office)

LES/Mesoscale model runs (Lagrangian): Stephan de Roode/Pier Siebesma (TU Delft)
Large interest from all modeling communities

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# Time Line and concluding remarks

Submission deadline: April 2013

Meeting on discussion results: second half 2013

Grey Zone should also consider other cases.

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end

Only spares left
Example 1: A posteriori analysis for LES for shallow convection

Dorrestijn, Siebesma, Crommelin, Jonker, 2012