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” (Δx = 1 ~10km)

•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 (Δx=100~500m) (~2000x2000x200 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)**

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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

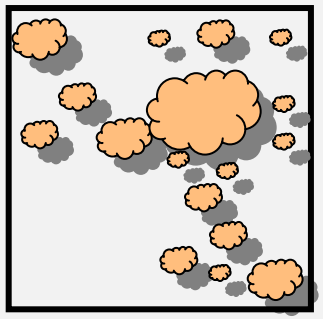
• Most parameterisation issues of clouds and convection evolve around finding the subgrid pdf of:

$$P(T, q_t, w)$$

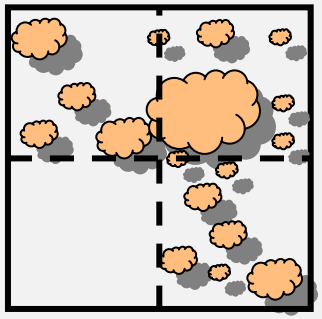
• Or, as a good approximation, the variances and covariances:

$$\overline{q'^2}, \overline{\theta'^2}, \overline{w'^2}, \overline{w'q'}, \overline{w'\theta'}, \overline{q'\theta'},$$

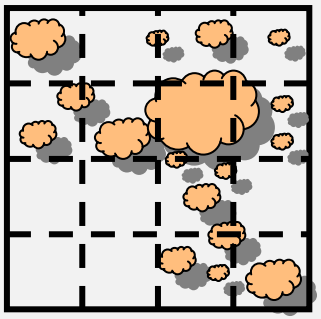
• as a function of the resolution (especially in the grey zone)



$\Delta x = \Delta y = 4$ km

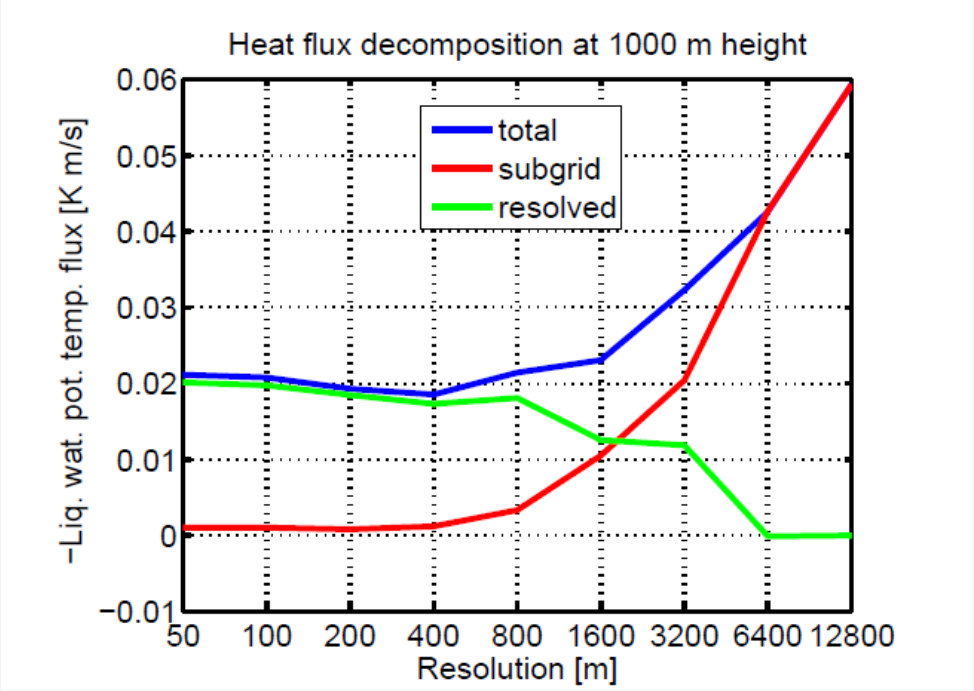


$\Delta x = \Delta y = 2$ km



$\Delta x = \Delta y = 1$ km

The parametrization problem of the grey-zone



• Turbulent flux is overestimated at resolutions l >1000m –

•due to an overestimation of the subgrid (parameterized) fluxes.

• due to the fact that in LES subgrid flux paramterization is designed to work for large eddy-resolving scale l< 1000m 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

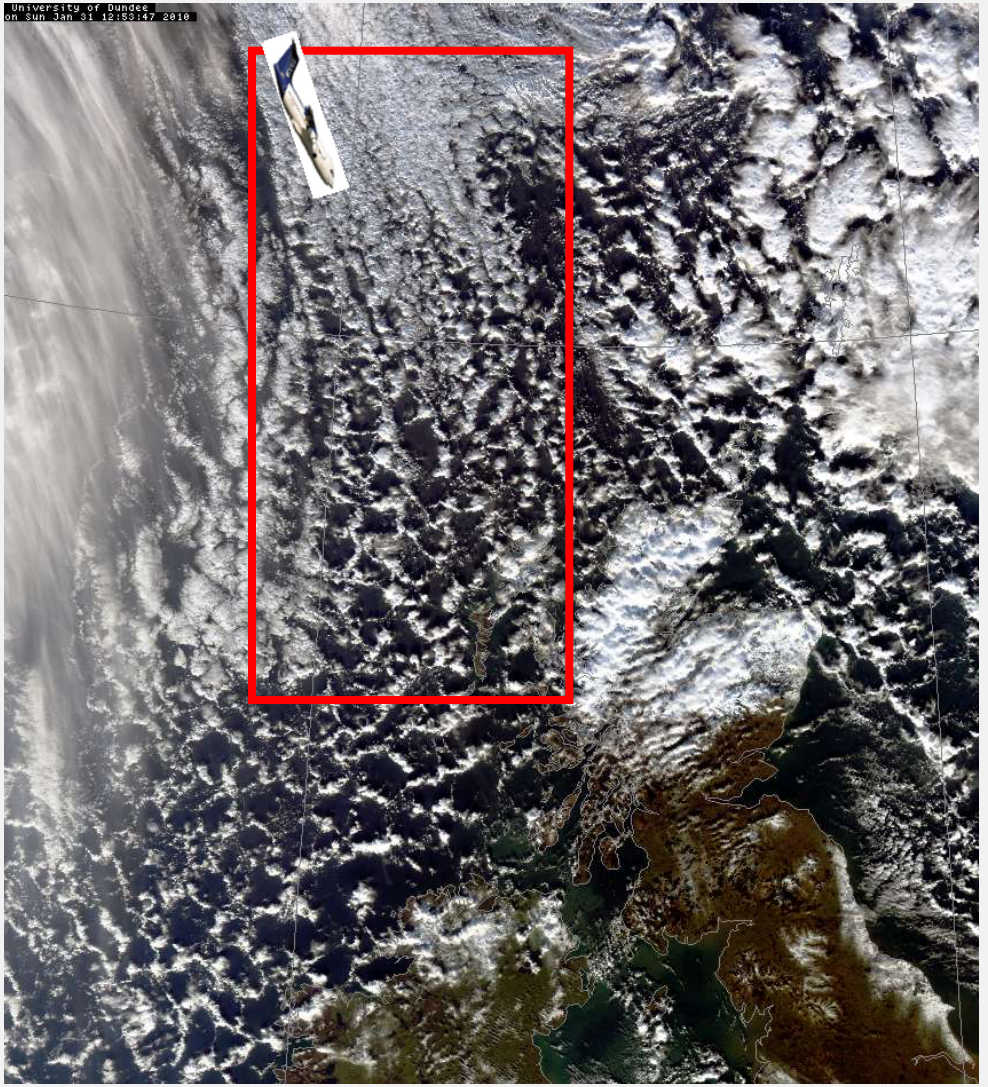
- Cold-air outbreaks are of general interest for various communities

- 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



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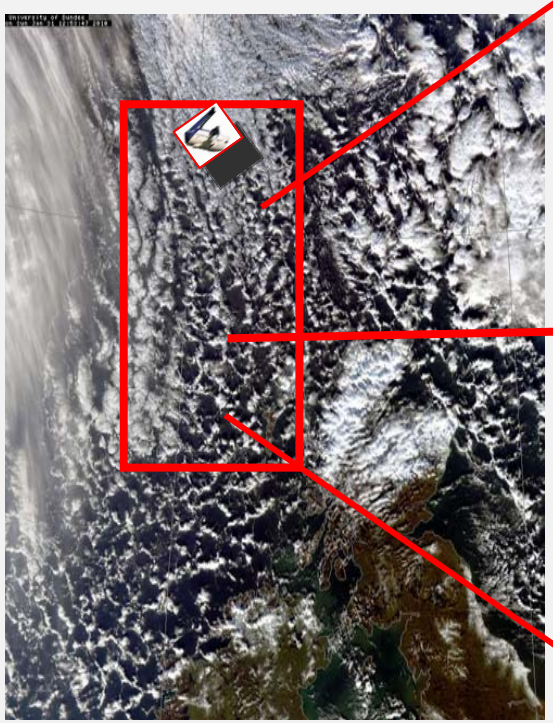
Case Proposal: a cold air outbreak

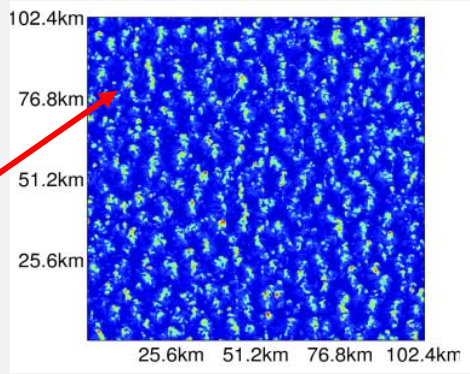
3 Different Flavours

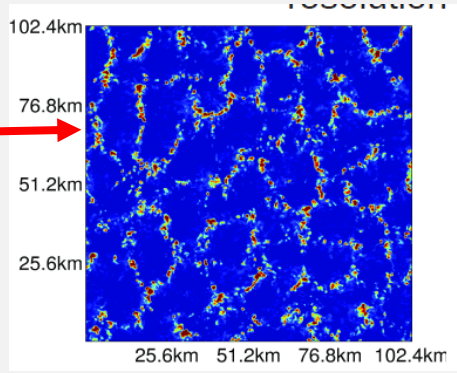
1. Global Simulations (at the highest possible resolution up to 3~10 km) or lower res LAMs

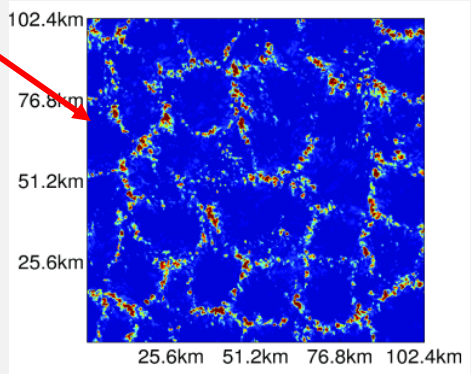
2. Mesoscale Models (Eulerian) at various resolutions (up to 500m) LAM-set up

3. Mesoscale/LES Models (Lagrangian).
   Idealized with periodic BC.
   highest resolution (~200m)









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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

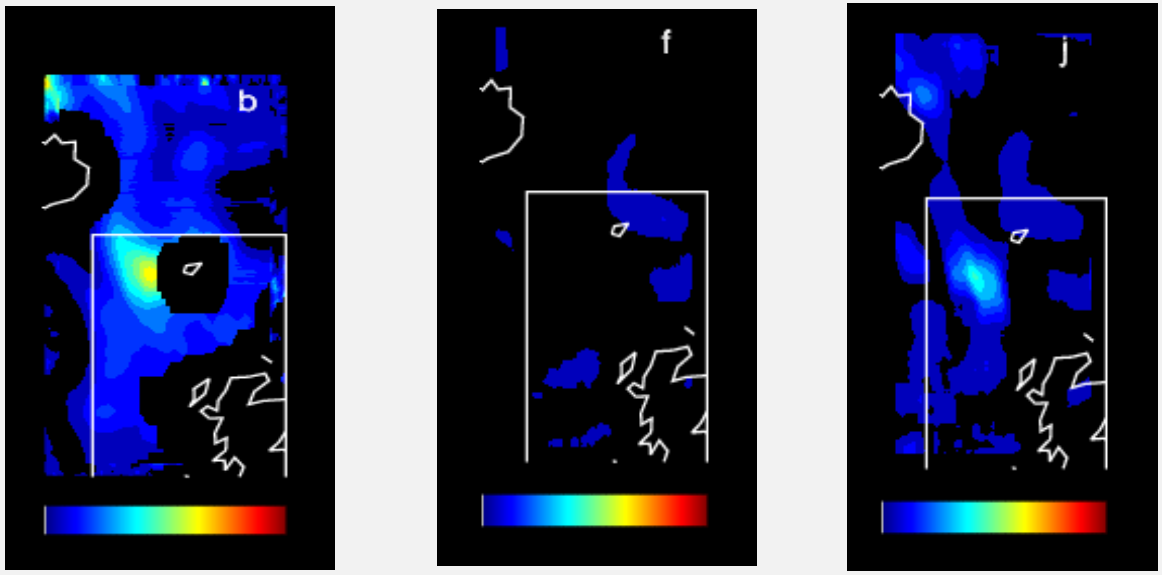
Lateral Boundary Conditions

- 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

AMSR LWP | **UM LWP** | **UM (modified) LWP**



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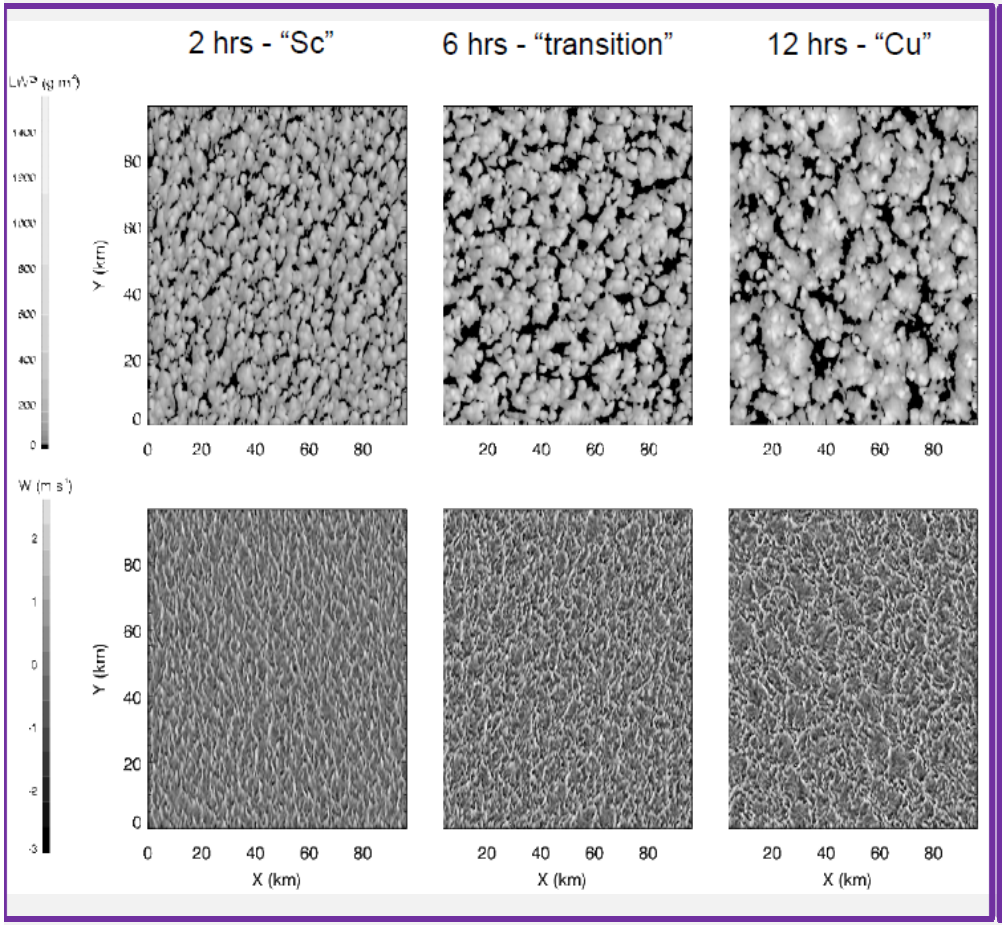
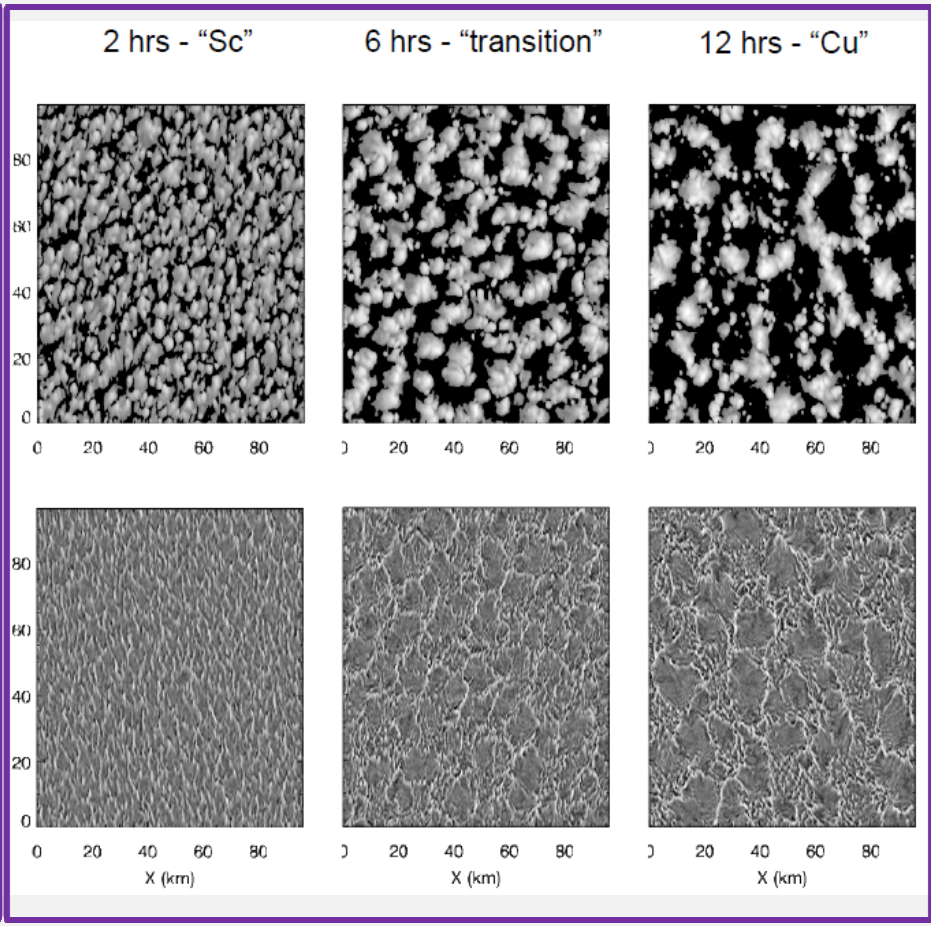
Sensitive to microphysics in the LEM too

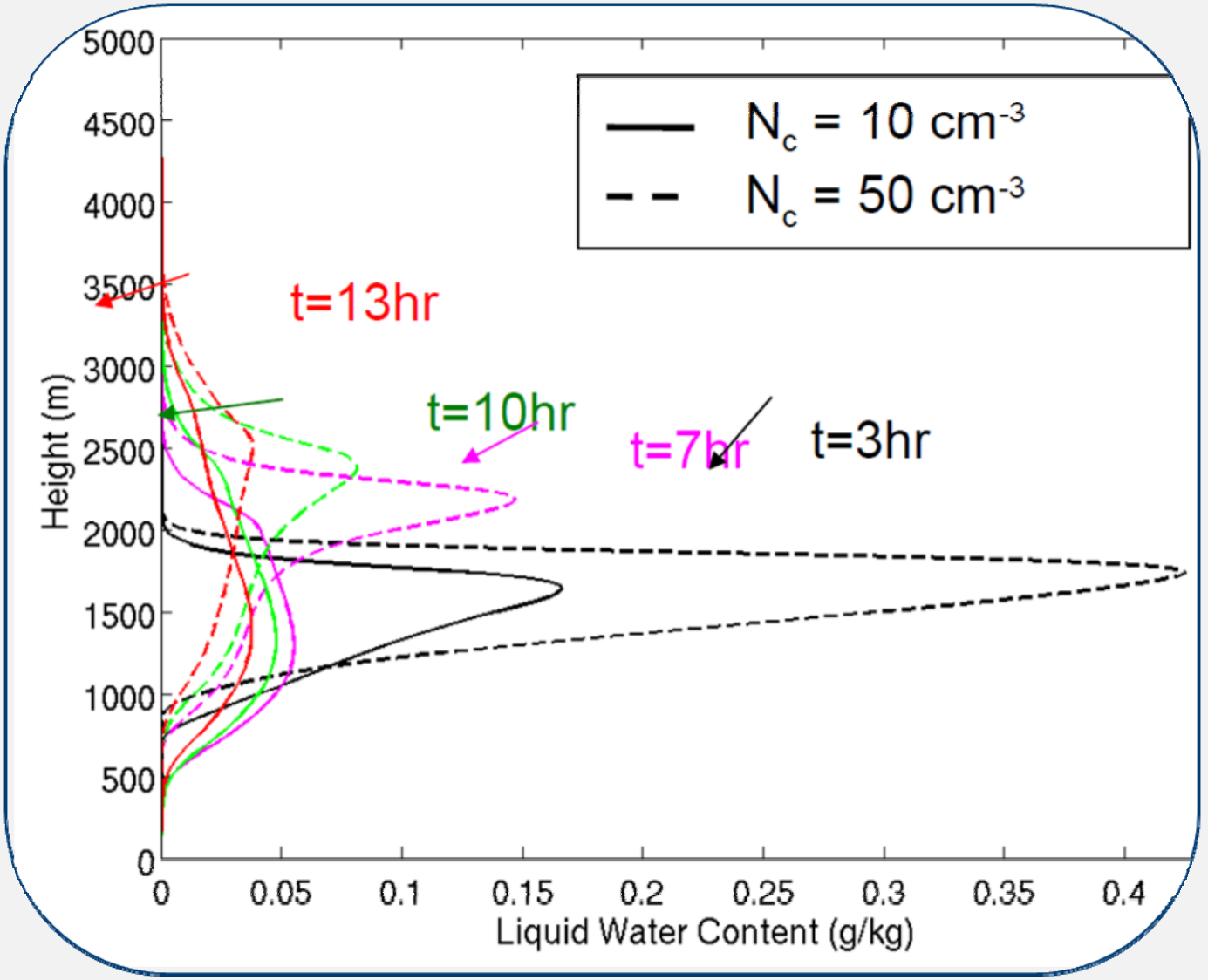
no ice



ice



Sensitive to microphysics in the LEM



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…….

Status

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 coodinating 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

	global	**LAM** **Eulerian**	**LES/LAM** **Lagrangian**	**CONTACT**
MetO	MetO global Model	MO meso	MOLEM MO-meso	Paul Field Adrian Lock
Meteo France	Arpege	AROME MesoNH	MesoNH	Bouysel Bazile/Couvreux
DWD (MPI-H)	ICON	COSMO-EU COSMO-DE	UCLA-LES COSMO-DE	Kohler/Seifert Grutzun
Met Service Canada		Canadian LAM	Canadian LES	Vaillancourt/ Milbrandt Zadra/ Belair
NCAR		WRF	WRF(p)	Jim Dudhia
ECMWF	IFS			Beljaars/Sandu
KNMI		HARMONIE		Wim de Rooy
TU Delft		Harmonie	DALES	de Roode/Siebesma
U of Tokyo	NICAM		LES	Saito
JMA	JMA			Kimoto
U of Hannover		 Alaro	LES	Raasch J-F Geleyn

Time Line and concluding remarks

Submission deadline: April 2013

Meeting on discussion results : second half 2013

Grey Zone should also consider other cases.

Further info: siebesma@knmi.nl

Website: www.knmi.nl/samenw/greyzone

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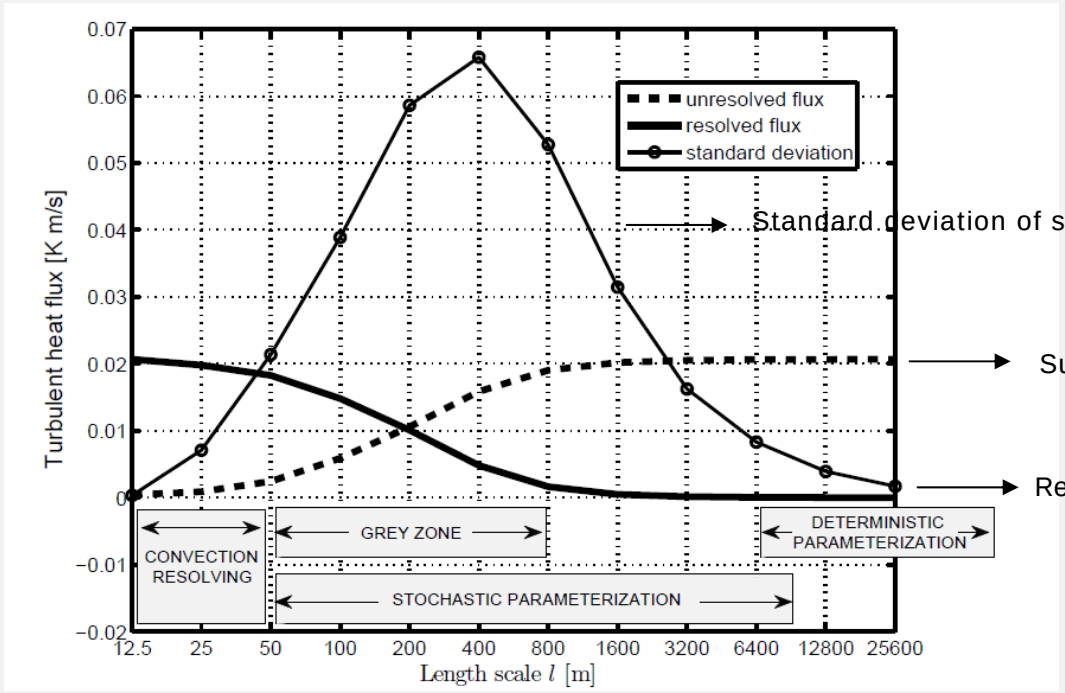
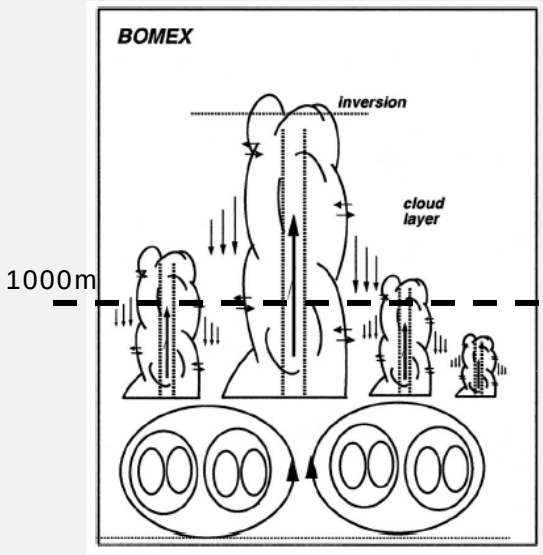
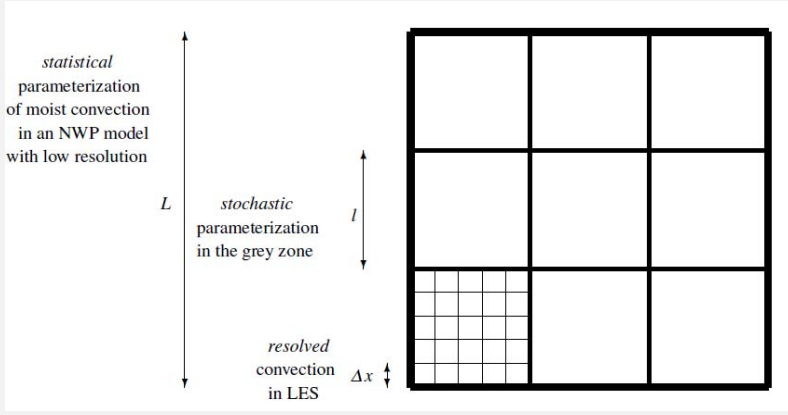
Only spares left

Example 1: A posteriori analysis for LES for shallow convection





Coarsed grained length scale l



Dorrestijn, Siebesma, Crommelin, Jonker, 2012