GASS: report to WGNE – including grey-zone project update

Jon Petch and Steve Klein – Co-chairs

SSC – Ann Fridlind, lazaros Oraiopoulos, Gunilla Svenson, Ben Shipway, Pier Siebesma, Adrian Lock, Robert Pincus, Hugh Morrison, Steve Woolnough and Chris Bretherton

March 2015

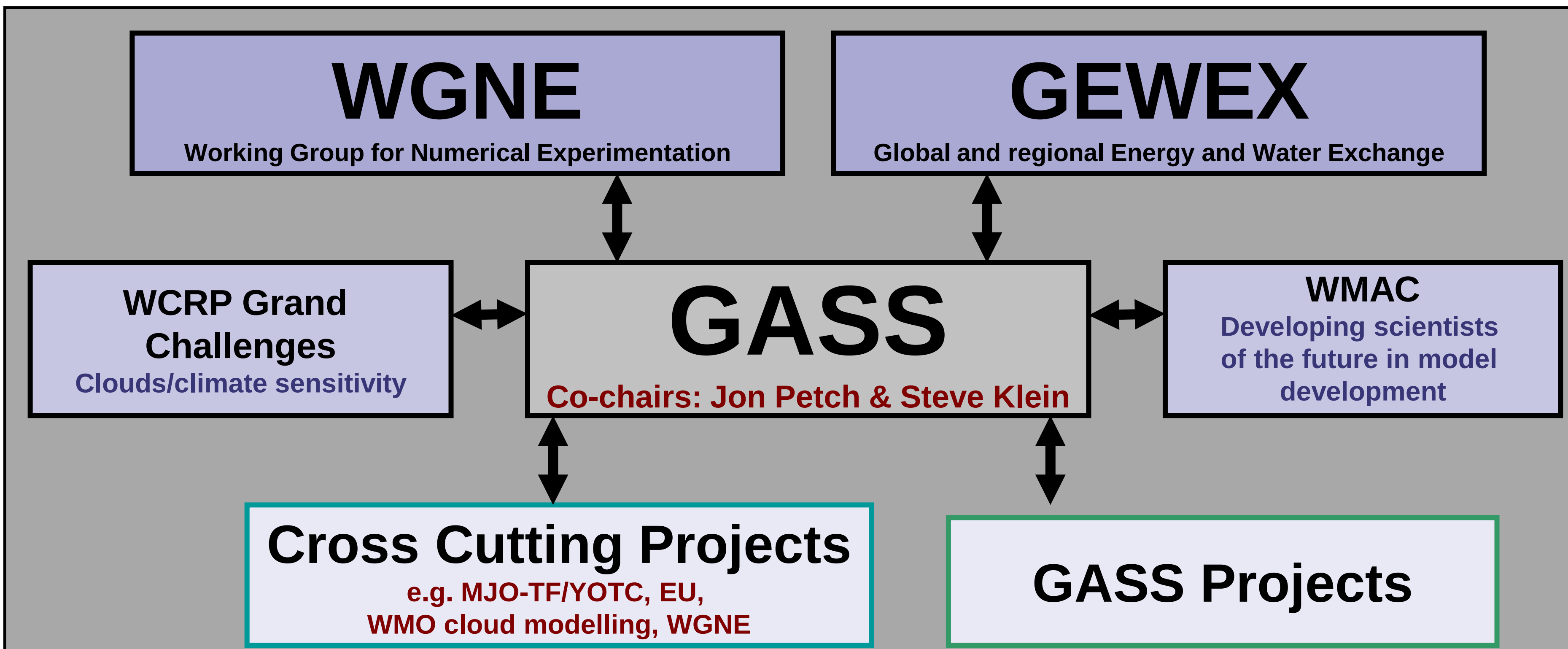
GASS GEWEX WCRP Global Atmospheric System Studies

Purpose

GASS provides leadership for the scientific community involved in improving the representation of atmosphere processes in weather and climate models.

through the coordination of scientific projects that bring together experts in process-modelling, observations, and the development of atmospheric parameterizations.

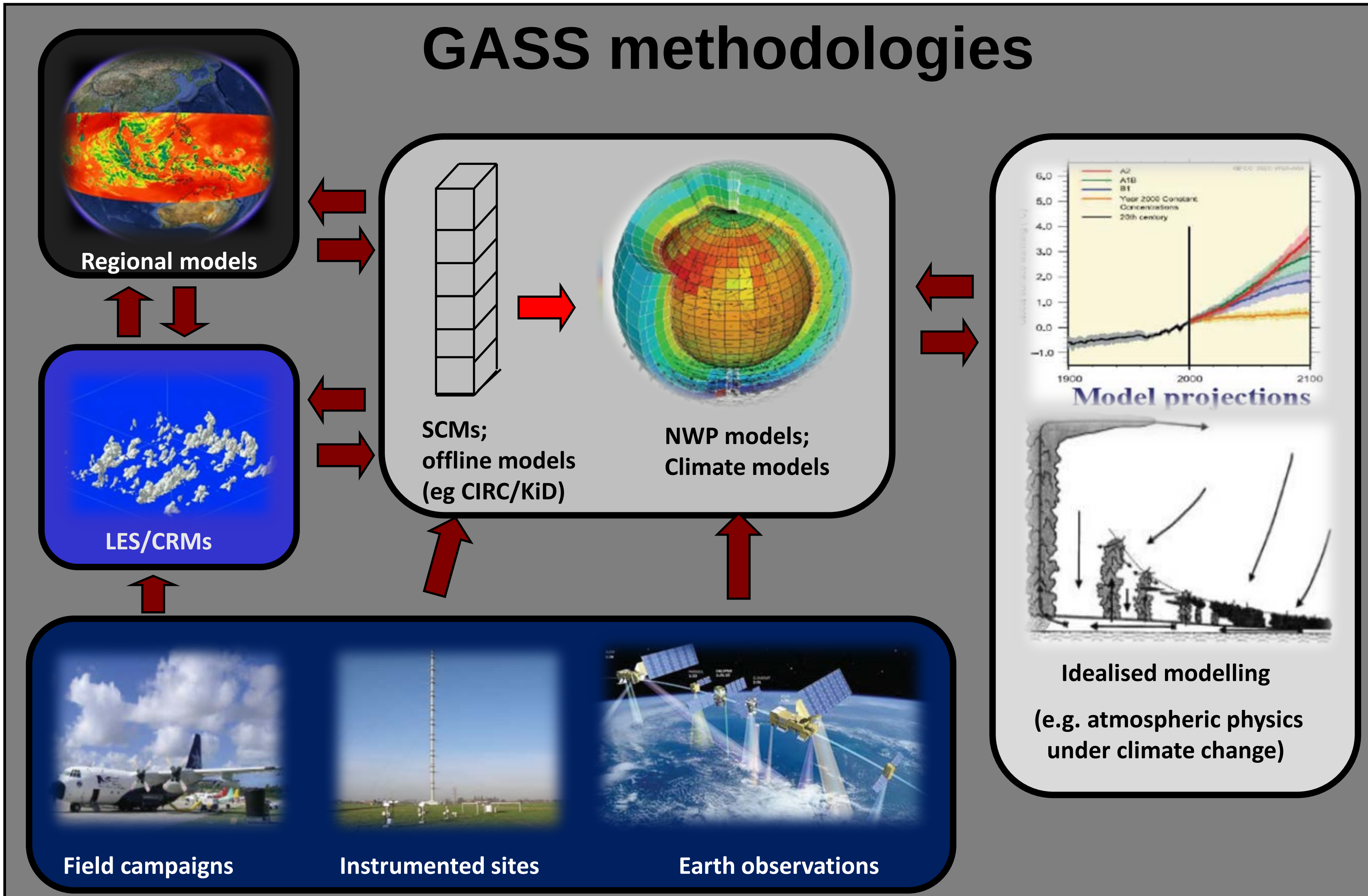
(All GASS projects to date involve model comparisons)



GASS GEWEX WCRP Global Atmospheric System Studies

Working with many model types

bringing together expertise in observations, modelling and understanding through intercomparison projects



Some highlights of GASS 2014/15

- GASS has 10 active model comparison projects
  - In the past year, a further 4 projects have finished.
- The Grey Zone resolution (1-10 km) is being studied using a cold-air outbreak case.
  - 40 scientists attended a Grey Zone project workshop that in December 2014 at the Max-Planck Institute for Meteorology.
- DICE is a joint GASS/GLASS DICE project looking at the boundary layer and land surface interactions
  - Over 15 different models are involved in the project and a workshop was held at the UK Met Office. in October 2013.
  - A joint GABLS4/DICE workshop will be held in May 2015 at MeteoFrance.
- Pan-GEWEX in the Hague 2014 provided the first opportunity for the GASS Scientific Steering Committee (SSC) meet in 2 years
  - Several sessions at meeting covered GASS projects
- The basic analysis stage of the MJO project is complete and 4 papers have been submitted
  - More detailed analysis of the results by individual centres is likely to follow. Several Tb of data available from all models

GASS legacy

- What is the real “legacy”/”impact” of GASS activities
  - **The model comparison papers – often several per project**
  - **The subsequent papers by individuals and groups who utilise the projects as a baseline to develop their models**
  - **The pull through of ideas and improvements from the projects into models for weather and climate predictions**
  - **The community that is built around the projects and the support that provides our scientists – including the development of Early Career Scientists**
- Should we measure this?
  - Depends how much this information would influence decisions and specific.
  - It can be done but it’s an activity that needs resourcing…
  - Plenty of good examples of impact studies and skills to carry these out if it is important enough…

GASS links

Active participant in the WCRP Climate Sensitivity Grand Challenge project

- GASS co-chairs have helped to write the white paper for the project
- GASS SSC members Christian Jakob, Robert Pincus and Pier Siebesma are co-leaders of initiatives
- GASS projects will be an active part of this Grand Challenge

Clouds, Circulation and Climate Sensitivity

Sandrine Bony[1,*], Bjorn Stevens[2], Dargan M. W. Frierson[3], Christian Jakob[4], Masa Kageyama[5], Robert Pincus[6], Theodore G. Shepherd[7], Steven C. Sherwood[8], A. Pier Siebesma[9], Adam H. Sobel[10], Masahiro Watanabe[11], Mark J. Webb[12]

[1] *LMD/IPSL, CNRS, Université Pierre et Marie Curie, UMR 8539, Paris, France*
[2] *Max Planck Institute for Meteorology, Hamburg, Germany*
[3] *Department of Atmospheric Sciences, University of Washington, Seattle, USA*
[4] *School of Mathematical Sciences, Monash University, Clayton, Australia*
[5] *LSCE/IPSL, CEA-CNRS-UVSQ UMR 8212, Gif-sur-Yvette, France*
[6] *University of Colorado and NOAA/Earth System Research Lab, Boulder, USA*
[7] *Department of Meteorology, University of Reading, Reading, UK*
[8] *CCRC and Centre of Excellence for Climate System Science, Univ. New South Wales, Sydney, Australia*
[9] *KNMI, De Bilt, The Netherlands*
[10] *Department of Applied Physics and Applied Mathematics, Columbia University, New York, USA*
[11] *Atmosphere and Ocean Research Institute, University of Tokyo, Chiba, Japan*
[12] *Hadley Centre, Met Office, Exeter, UK*

= GASS SSC, ex-GASS co-chair, or ex-GASS SSC

GASS GEWEX WCRP Global Atmospheric System Studies

GASS “live” projects

- Early stages – design still being tested or accepting new submissions
  - Clouds Above the United States and Errors at the Surface (CAUSES)
  - GABLS4: Stable Boundary Layer on the Antarctic Plateau
  - Kinematic Driver model - Aerosol intercomparison project (KiD-A)
  - Mid-latitude Cirrus
  - Polar Airmass Transition
  - Radiative Processes in Observations and Models
- Middle stages – analysis ongoing
  - Grey-Zone
  - Land-Atmosphere Interactions (DICE)
  - Low Cloud Feedbacks (CGILS)
  - Weak Temperature Gradient
- Late stages – analysis complete and being written up or recently written
  - GABLS3: Stable Boundary Layer at Cabauw
  - Polar Clouds
  - Stratocumulus-to-Cumulus Transition
  - Vertical Structure and Diabatic Processes of the MJO

GASS/MJOTF Project Data Archive

On the Earth System Grid at **https://earthsystemcog.org/projects/gass-yotc-mip/**

The archive contains

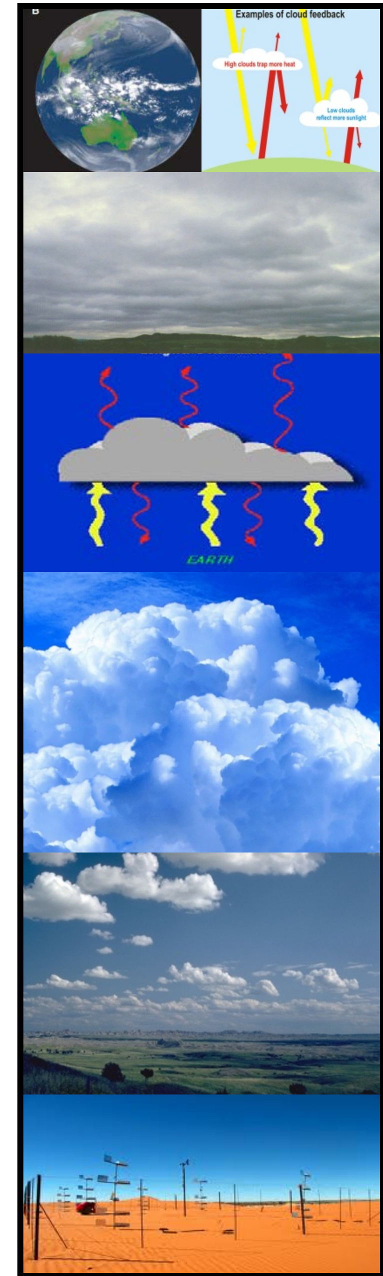
- Prognostic variables, cloud variables
- Surface and top of the atmosphere fluxes, near surface variables, integrated water paths
- tendencies from individual model parametrization schemes
- and for 2 day experiments some parametrization diagnostics

	Number of Models	Data domain	Data Resolution			Length of data
			Horizontal	Vertical	Temporal	
Climate	27	Global	2.5°x2.5°	22 press lev	6hrly	20 years
20 day	14	50°N-50°S	2.5°x2.5°	22 press lev	3hrly	94 x 20 day
2 day	11	10°N-10°S 60°E-180°E	Model Grid	Model Grid	Model timestep	44 x 2 day

This data could be analyzed for a wide variety of processes and phenomena

Projects to be discussed today

- CAUSES
- Grey-zone



The continental warm bias

Tackling the continental warm bias

CAUSES – Clouds Above the United States and Errors at the Surface

Cyril Morcrette, Kwinten Van Weverberg, Jon Petch, **Met Office, Exeter, United Kingdom.**

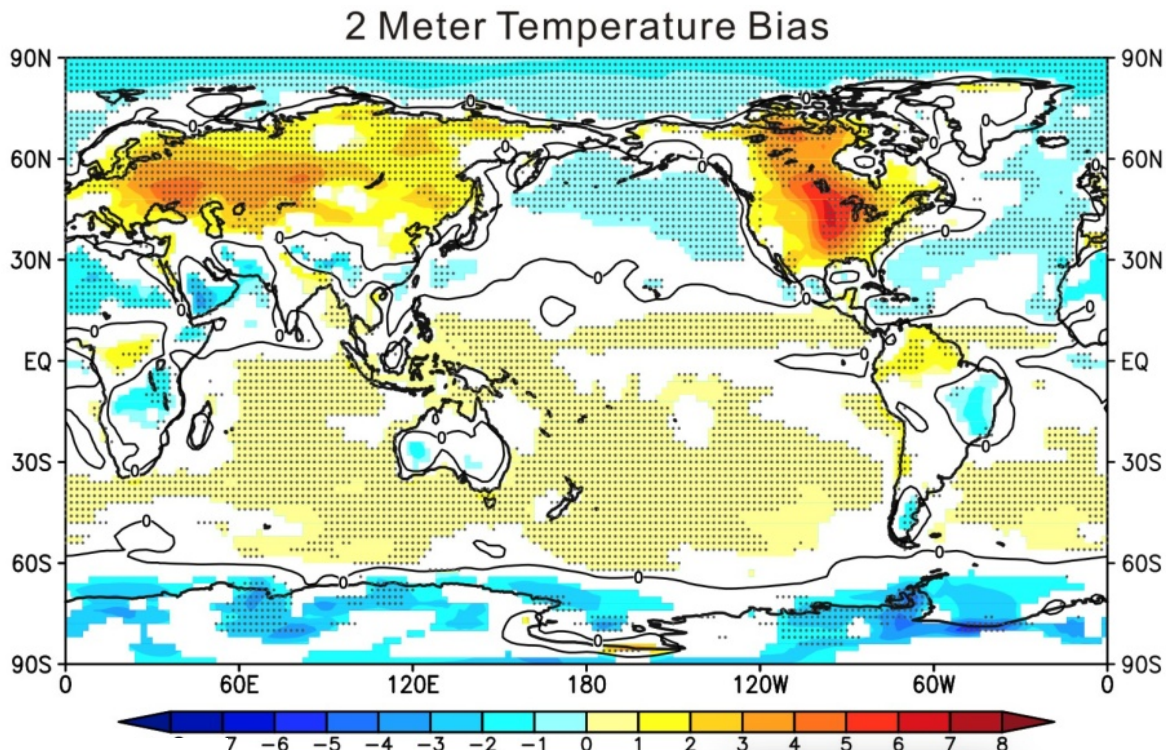
Hsi-Yen Ma, Stephen Klein, Shaocheng Xie, **PCMDI, Livermore, California, United States.**

A joint GASS/ASR comparison project aiming to **evaluate clouds and radiation** in several weather and climate models using ground-based observations.

The warm bias over the US in summer is common to many GCMs.

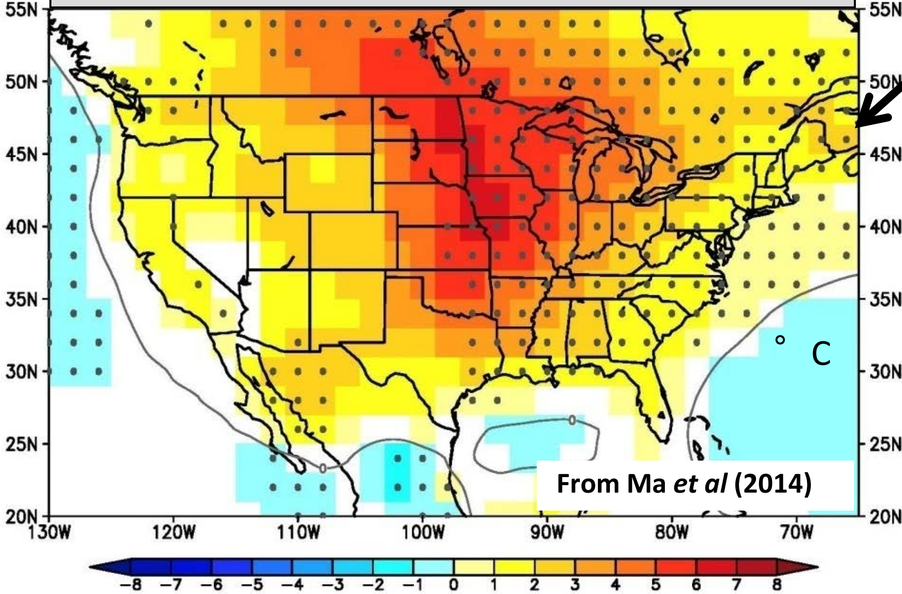
Its in several climate models

Its seen within a few days in NWP mode.



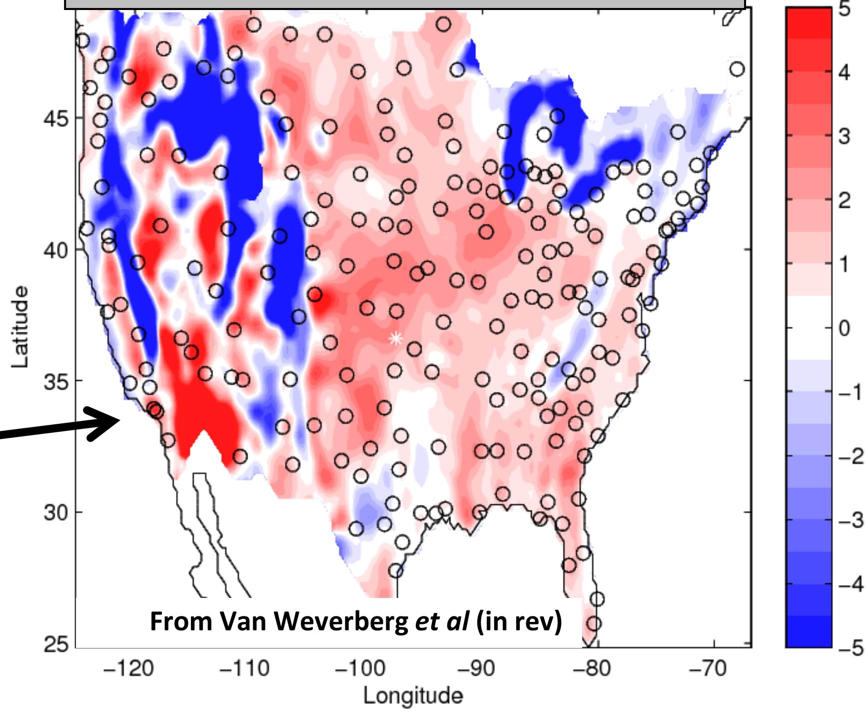
CAUSES experiment

CMIP5 multi-model mean of summer 2 m temperature bias (shaded)



Stippling indicates where 5-day NWP runs of the *same models* agree on the sign of the bias.

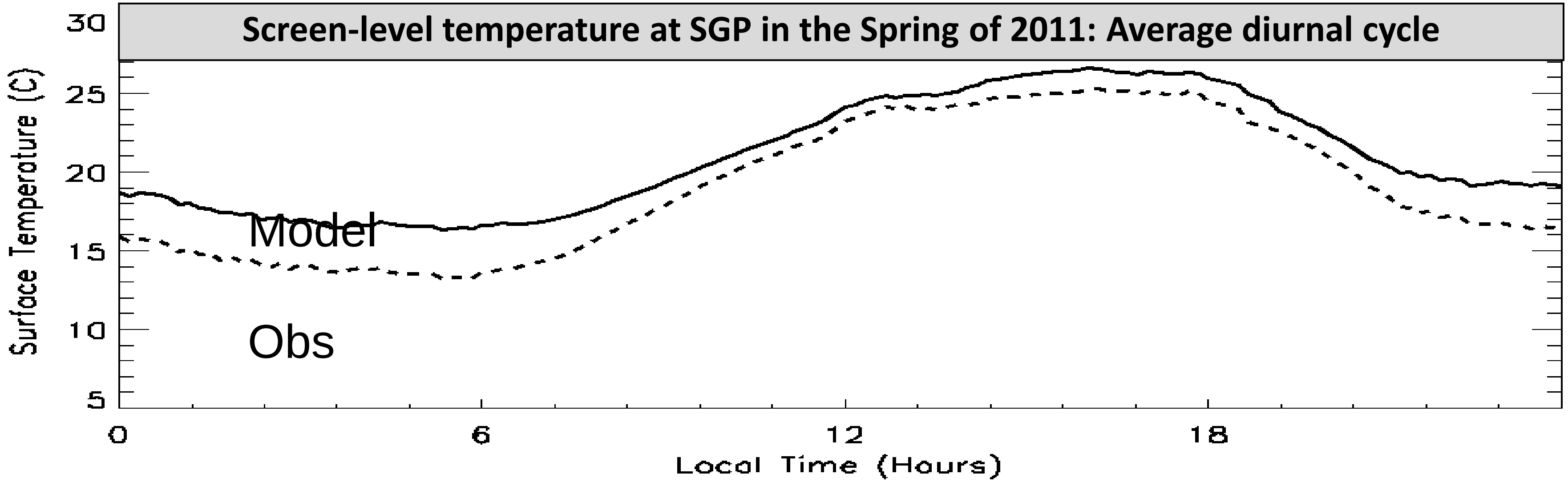
Average screen-level temperature error for MetUM on day 4

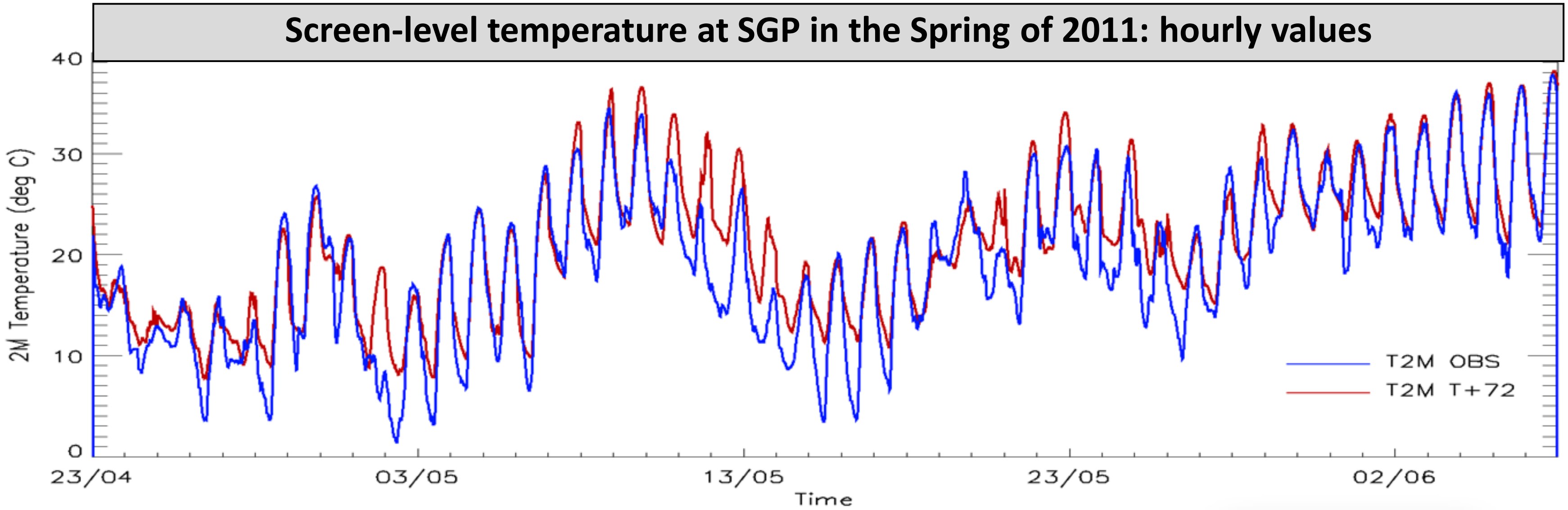


- **Met Office global model**
- **6 weeks during April – June 2011**
- **5 day forecasts started daily**

GASS GEWEX WCRP Global Atmospheric System Studies
ASR Atmospheric System Research
Met Office
PCMDI Program for Climate Model Diagnosis and Intercomparison
Met Office Unified Model™ Global Atmosphere
JULES Global Land

The Unified Model bias from CAUSES period





GASS GEWEX WCRP Global Atmospheric System Studies
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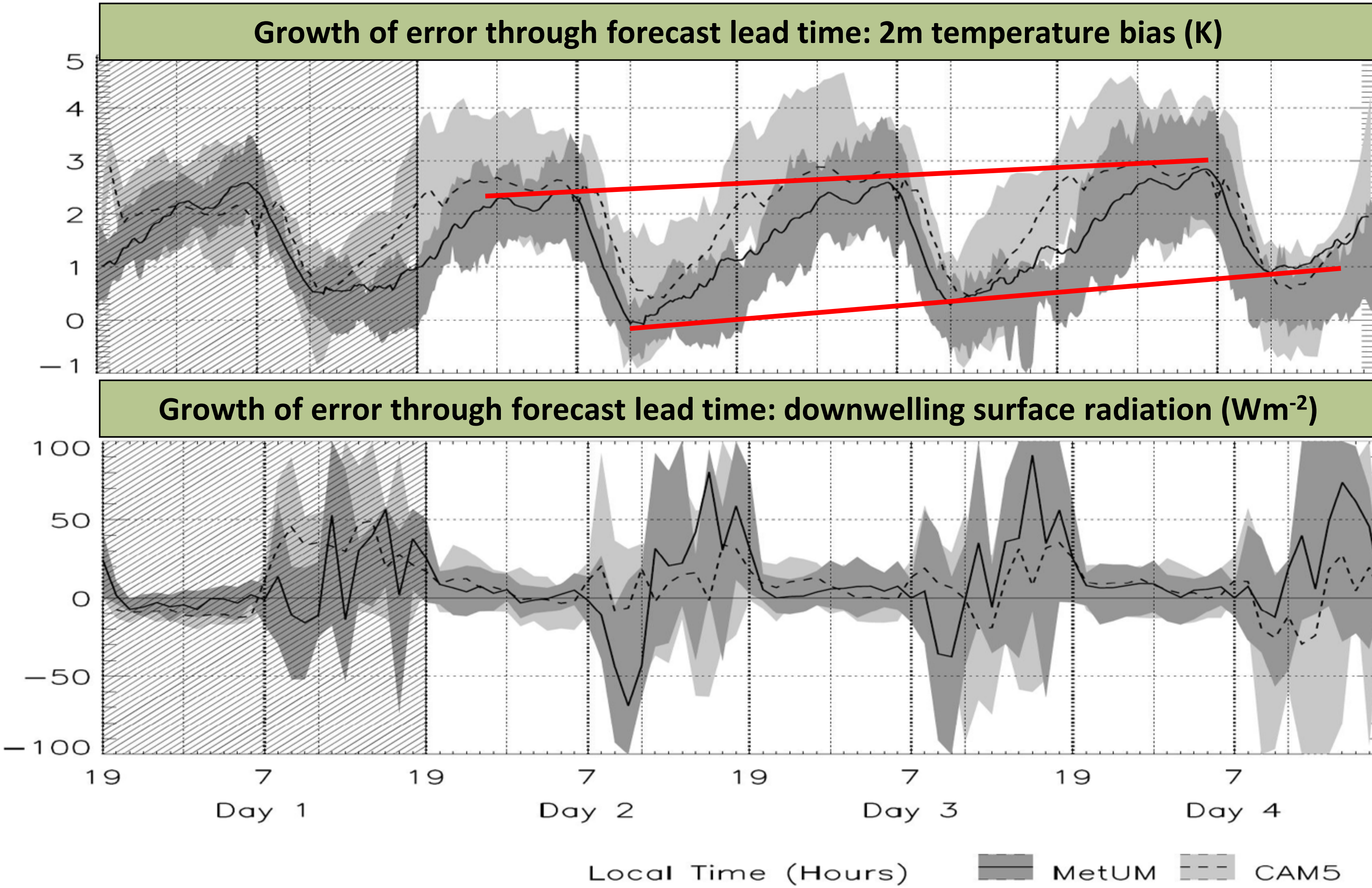
JULES Global Land

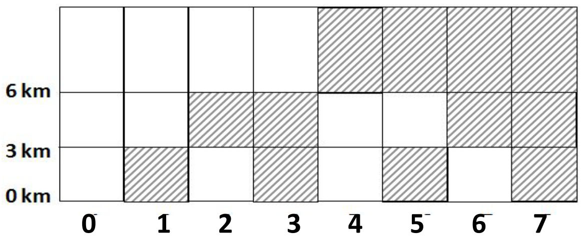
The Unified Model and CAM5 from CAUSES period

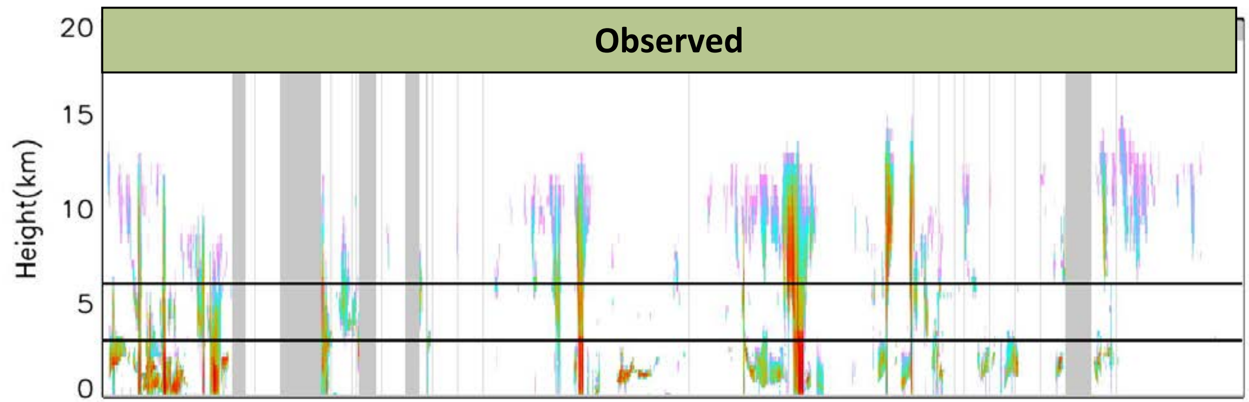


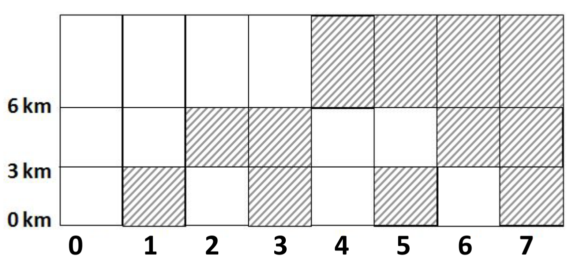
GASS GEWEX WCRP Global Atmospheric System Studies · ASR Atmospheric System Research · Met Office · PCMDI Program for Climate Model Diagnosis and Intercomparison · Met Office Unified Model™ Global Atmosphere · JULES Global Land

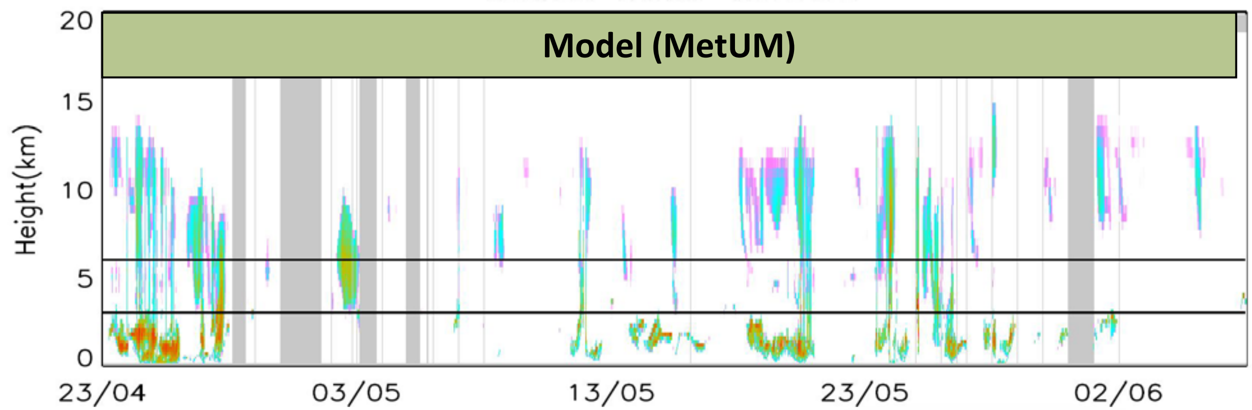
The Unified Model from CAUSES period vs. ARM SGP data

- Define 8 cloud regimes (cloud fraction >0)
- Also broken (<0.5) vs. strat. (>0.5) for 0, 3 & 7
- Gives 144 combinations of obs-model



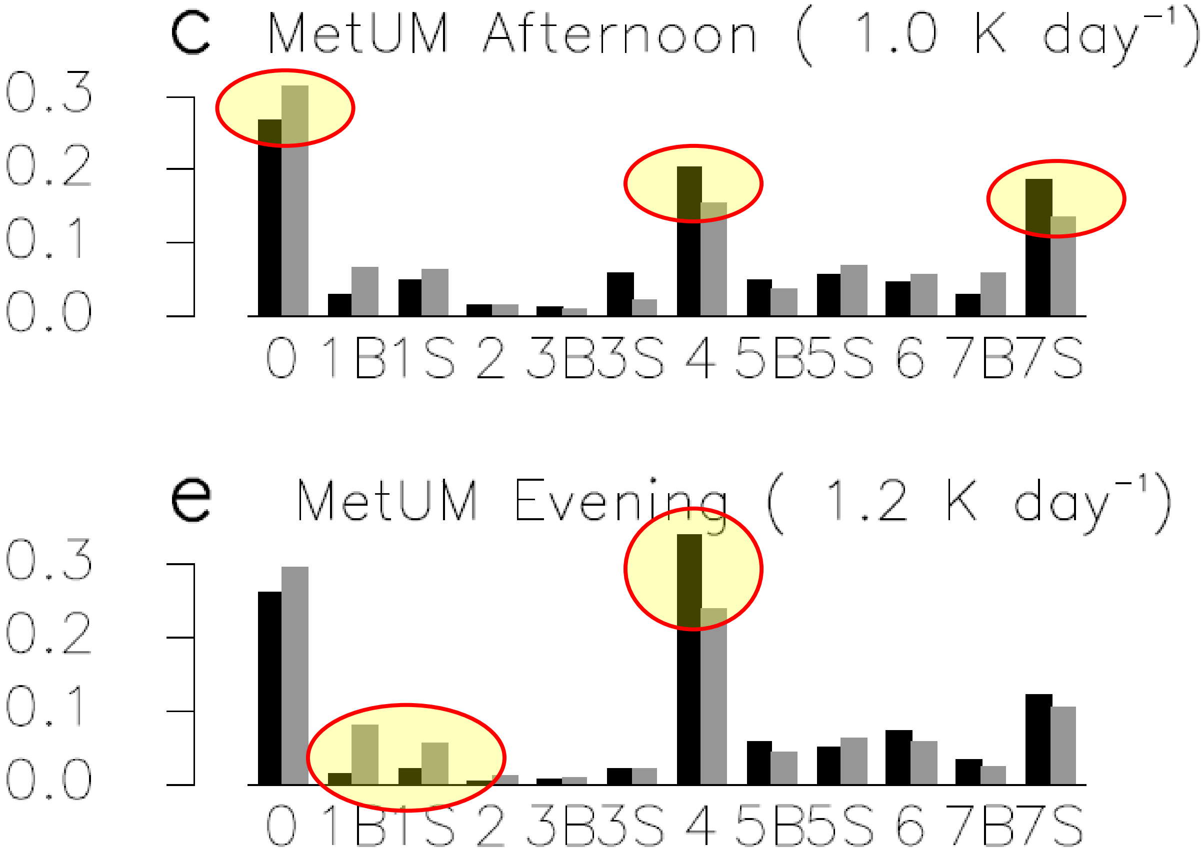






Focus on main periods of error growth

Frequency of occurrence of cloud types: observations (black) vs model (grey)



Afternoon = 11am to sunset

Evening = sunset to 1am

Focus on main periods of error growth

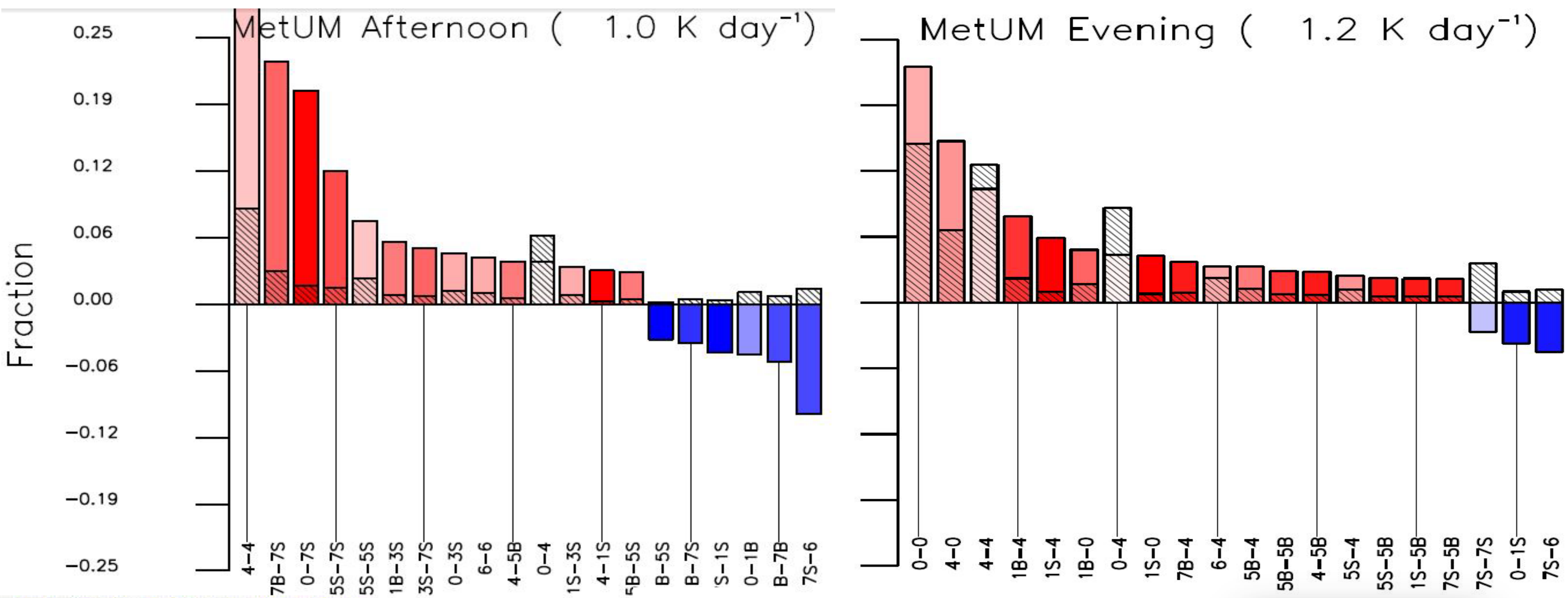
These bar charts contain 3 pieces of information:

a) **Height of coloured bar**: Relative contribution of that regime combination to overall T bias growth.

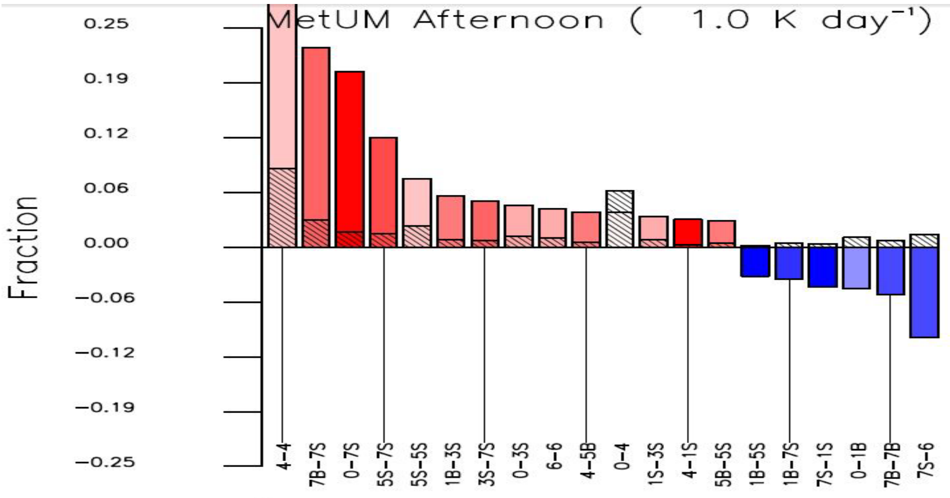
b) **Shading of coloured bar**: Average error in a variable (in this plot Temperature) for that regime combination.

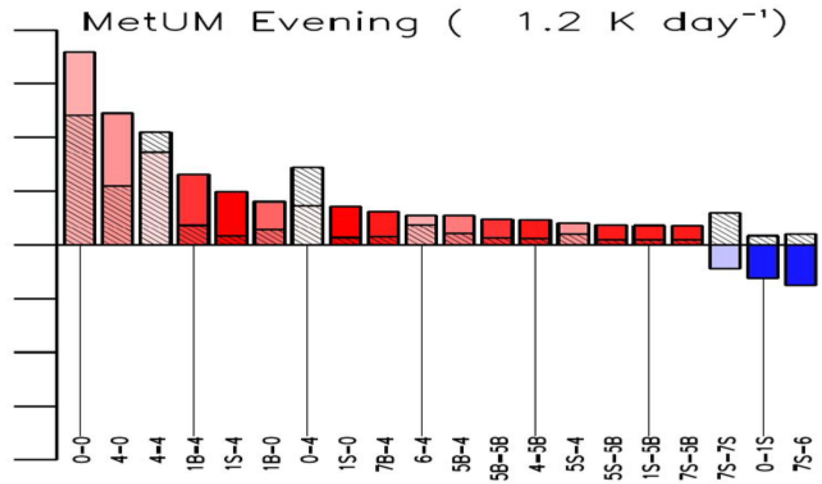
c) **Height of hatched bar**: Frequency of occurrence of that regime combination.

So a = b x c



Focus on main periods of error growth





Afternoon

- **4-4** happens a lot and weakly grows bias
  not enough water when there?
- **7B-7S** Not enough convective cloud fraction
- **0-7S** Missing convection
- **5S-7S** Low and high when it should be deep convection

Evening

- **0-0** happens a lot and weakly grows bias
  needs looking at more?
- **4-0** high cloud but should be clear
- **4-4** high cloud correctly
  not enough water when there?
- **1b/s-4** low cloud but should be high

Regime 4: not frequent enough, too overcast when present, not enough IWC, RH is O.K. So microphysics (deposition/sublimation/fall speed)

Met Office

CAUSES summary

- Short range forecasts can reproduce warm bias seen in climate models
- Strong technique to link bias growth and cloud prediction
    - Looks like missing and not enough convection during day is important
    - High cloud in evening stopping cooling also important?
- Not only story – also work to look at land-atmosphere interaction
    - Is there enough rain
    - Is the lack of cloud during land surface out?
- Several other models already submitted data to this GASS activity

Grey-zone – cold air outbreak case

Siebesma; Field

The first WGNE-GASS

Grey Zone Workshop

MPI for Meteorology, Hamburg, Germany

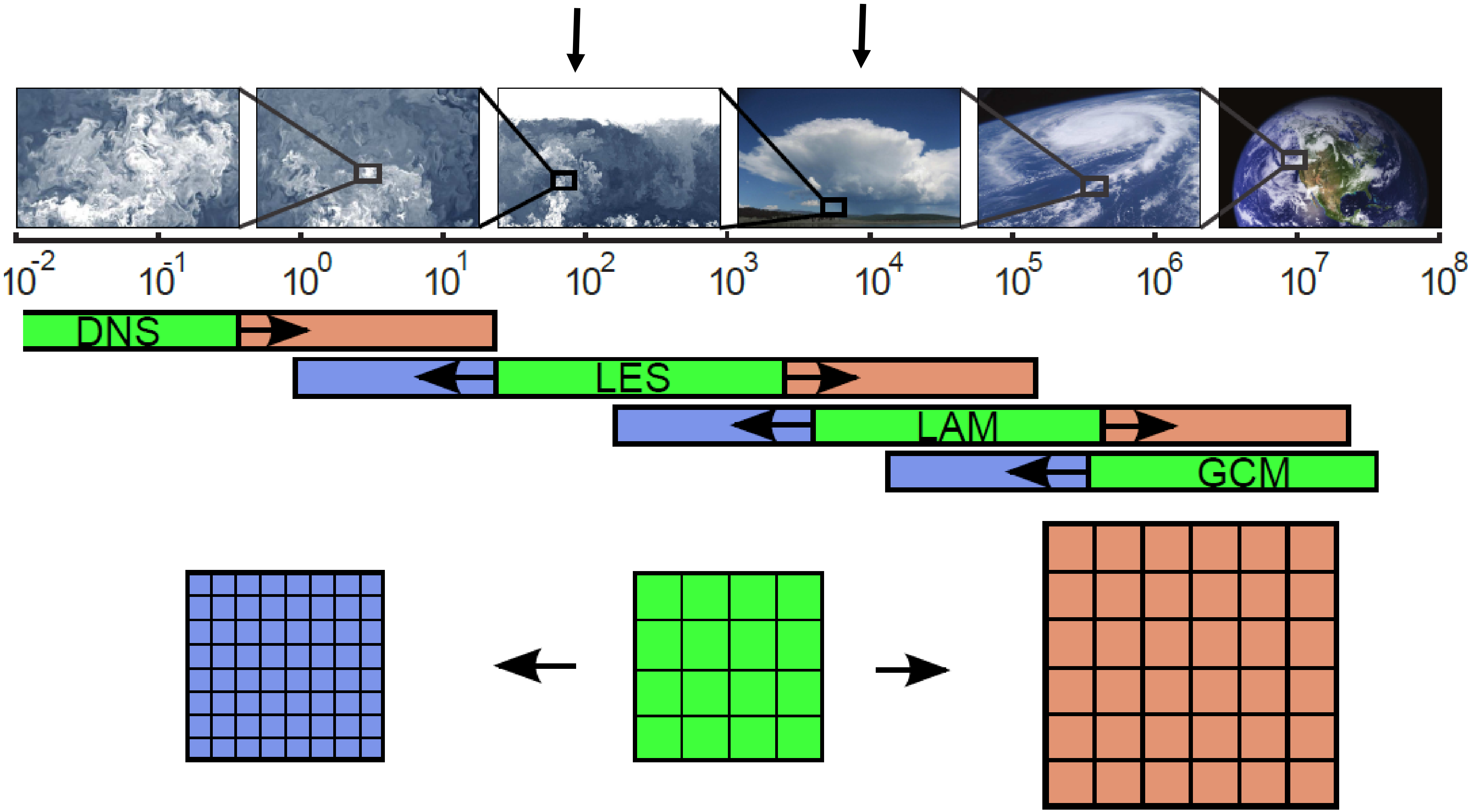
December 1-3, 2014

A. Pier Siebesma

siebesma@knmi.nl

Motivation

- *Most operational models are in or approaching "the Grey Zone"*
- *We do not know how to parameterize overturning related processes in the "Grey Zone"*
- *Yet it is these processes (clouds, turbulence, convection) that are key for weather and climate.*



Proposal (from WGNE 2010 meeting)

- 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)**

- Preference especially from the mesoscale community for a cold air outbreak

Aims of this Project

- Show how faithfully fluxes, variances, cloud structures, etc can be represented by comparing COARSE, NOPARAMS and PARAMS depending on all aspects of set-ups.

- Guide improvements in current schemes especially at these resolutions - essential for future progress

- Gain some insight and understanding of what can be achieved without parametrizations

- Clarify what cannot/should not be done without parametrization also!!

- Explore the importance/relevance of stochastic parameterizations

- …….but ultimately provide guidance for the design of scale aware parameterizations

Strong Support from both the international NWP and Climate community

Constrain

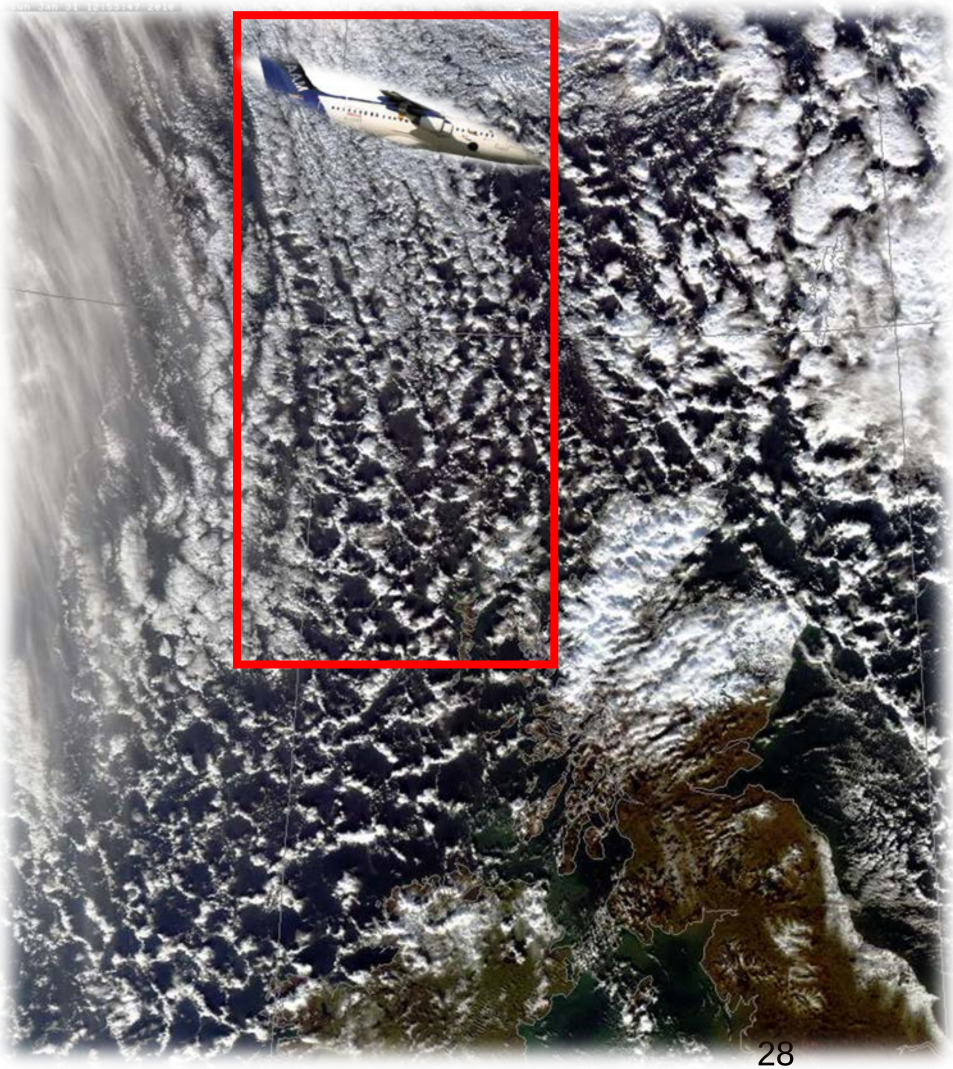
Full case description see: www.knmi.nl/samenw/greyzone

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, LAMs and LES models

•Domain of interest: 750X1500 km

•Fast Transition : ~ 36 hours

The Case (2)

Full case description see: www.knmi.nl/samenw/greyzone

3 Different Flavours

1. Global simulations

At the highest possible resolution (up to 5 km)

Coordinator: Lorenzo Tomassini

7 models contributing

2. Limited area models

At various resolutions (up to 1 km)

Coordinators: Paul Field & Adrian Hill

7 models contributing

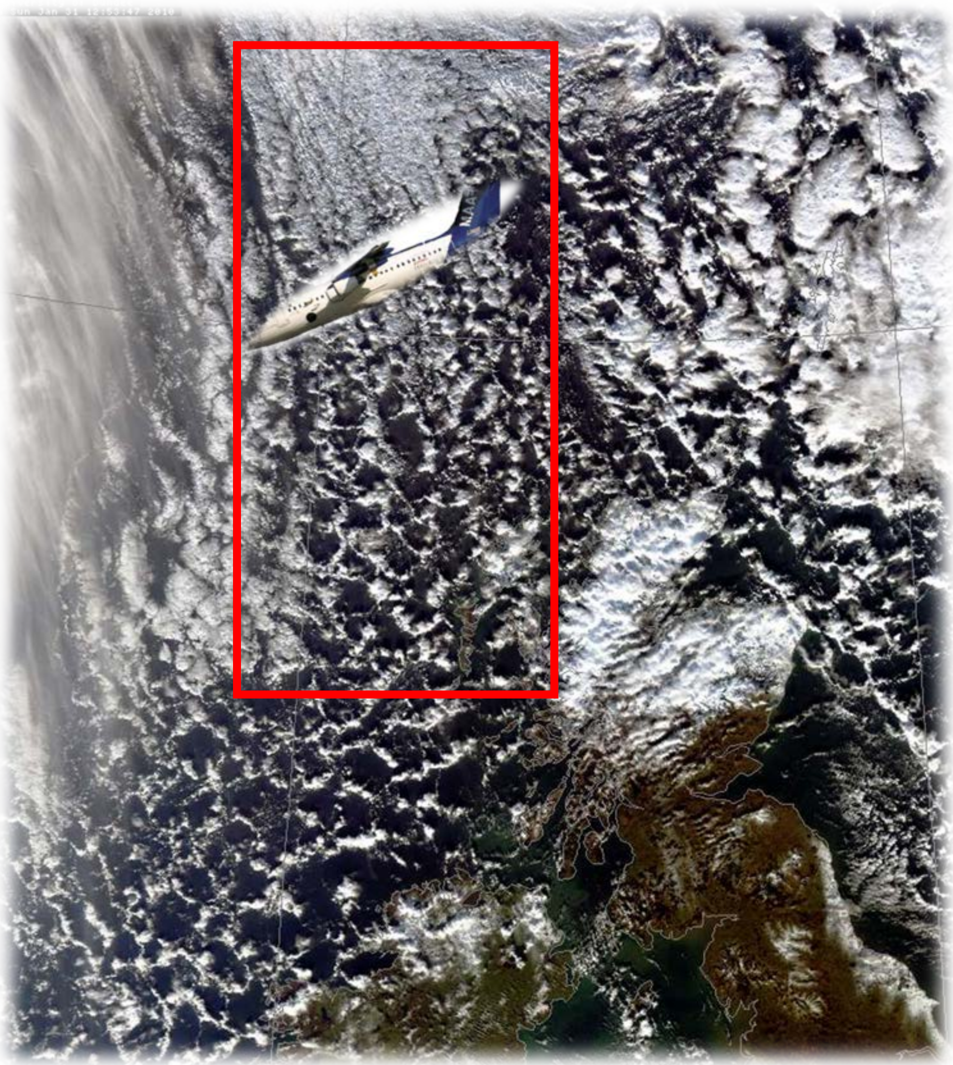
3. LES models (lagrangian)

Idealized with periodic BC

Highest resolution of ~100m

Coordinator: Stephan de Roode

7 models contributing



7 Global Models

Met Office (UK)	Paul field	Unified Model
ECMWF (EU)	Sylvie Malardel	IFS
Meteo France	Rachel Honnert	ARPEGE
DWD / MPI-M	Tobias Gocke	ICON
JMA	Masayuki Nakagawa	GMS
JAMSTEC	Akira T. Noda	NICAM
Env. Canada (Ca)	Ron McTaggart-Cowan	GMS

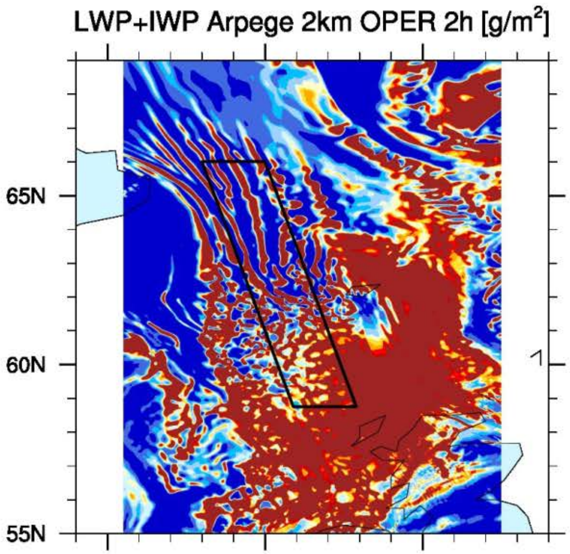
7 Mesoscale Models

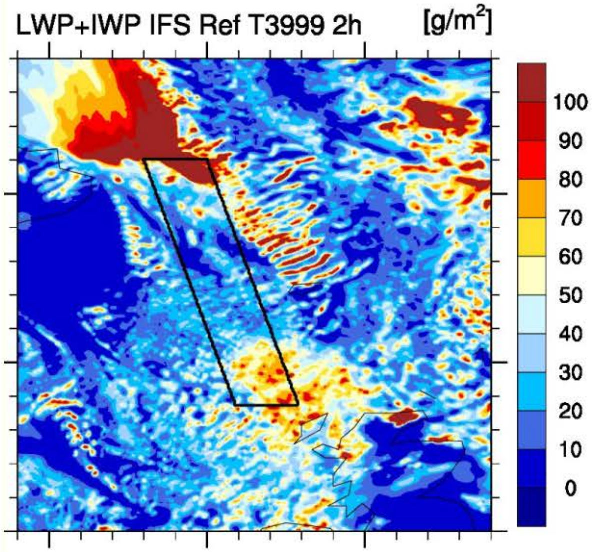
Met Office (UK)	Paul Field (paul.field@metoffice.gov.uk)	UM
CNRM (France)	Rachel Honnert (Rachel.Honnert@meteo.fr)	AROME
NCAR (USA)	Jimy Dudhia (dudhia@ucar.edu), Ming Chen (chenming@ucar.edu)	WRF_ncar
NOAA	Joseph Olson (joseph.b.olson@noaa.gov)	WRF_noaa
CHMI	Radmila Brožková [radmila.brozkova@chmi.cz]	ALADIN
JMA (Japan)	Tabito Hara (tabito.hara@met.kishou.go.jp)	NHM & ASUC
EC (Canada)	Ron McTaggart-Cowan (ron.mctaggartcowan@ec.gc.ca)	GEM

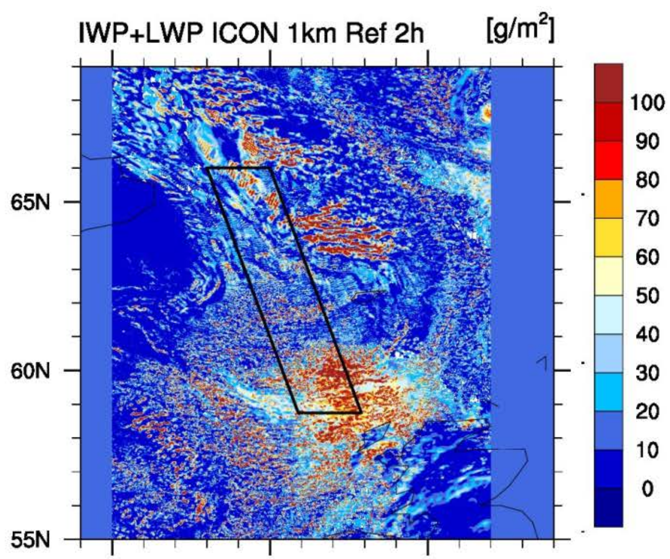
7 LES Codes

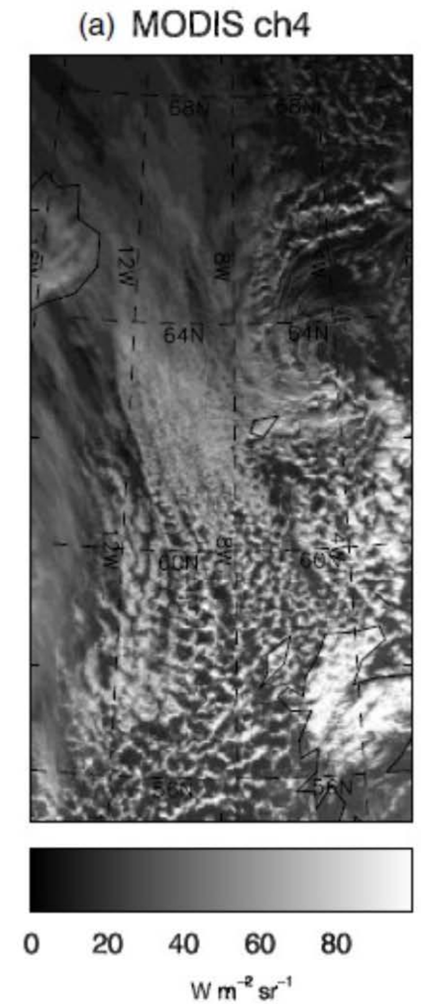
Met Office (UK)	Adrian Hill	MOLEM
TU Delft ((NL)	Stephan de Roode	DALES
Meteo France	Rachel Honnert	MF_LES
U of Hannover	Jens Fricke	PALM
JAMSTEC	Akira Noda	JAMSTEC LES
MPI	Lorenzo Tomassini	UCLA-LES
U of Utah	Steve Krueger	SAM

Global Models (LWP+IWP)



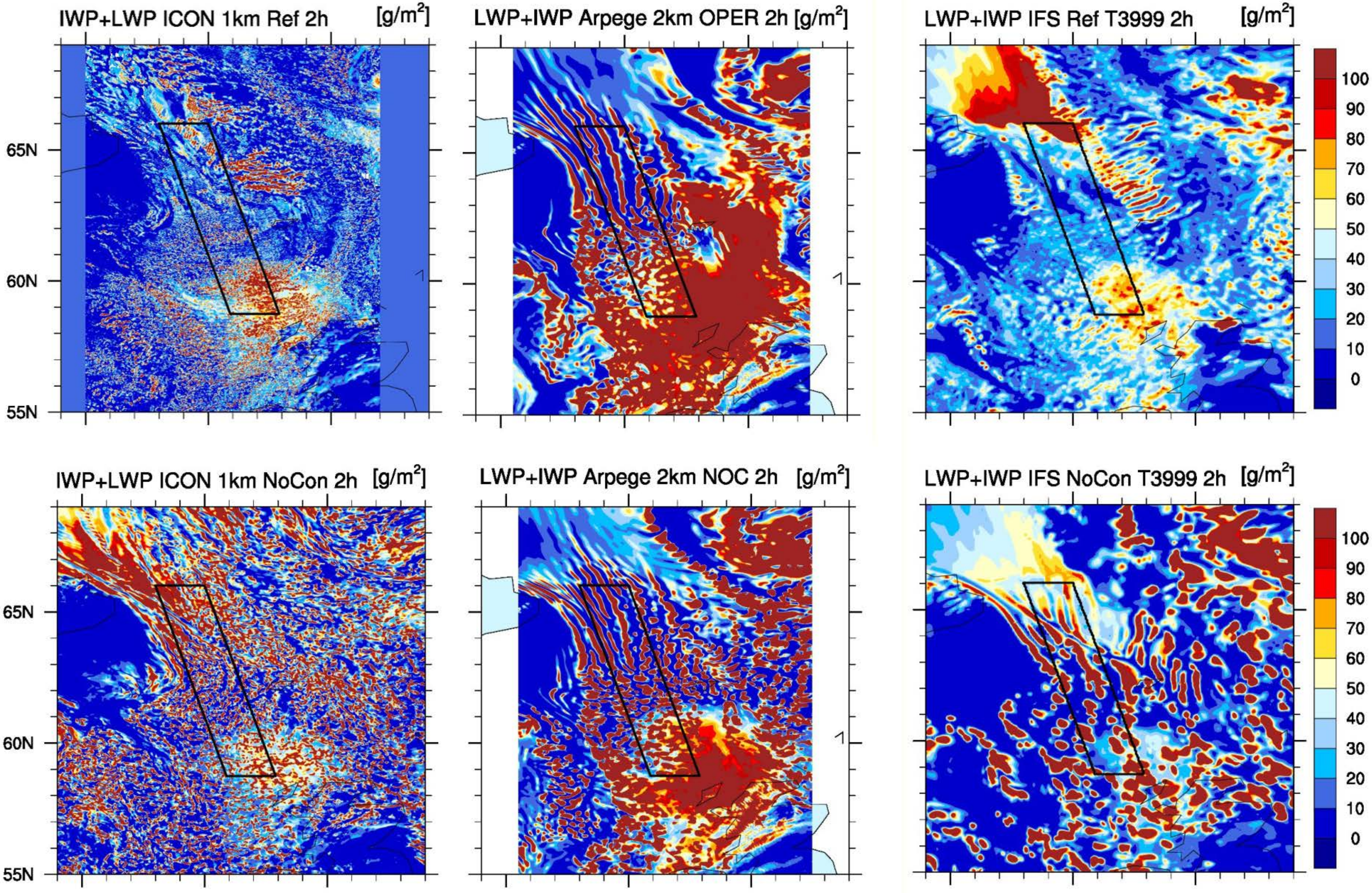






(UK MetOffice)

Global Models (convection param on and off)



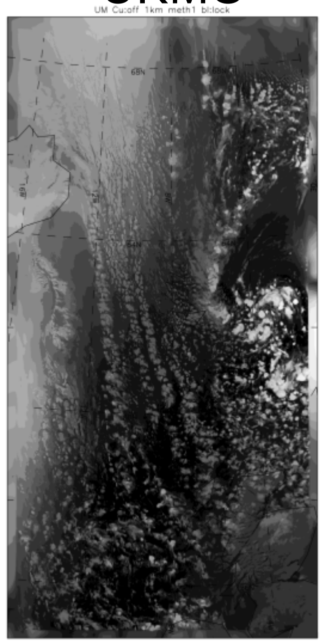
Limited Area Models – OLR

12Z 31 Jan 2010

~1 km grid length

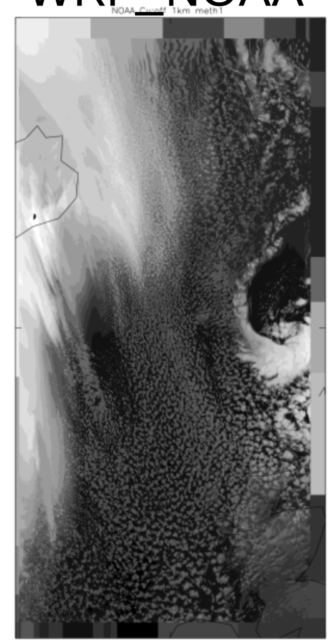
These are preliminary results – centres are updating their models/fixing minor bugs

UKMO

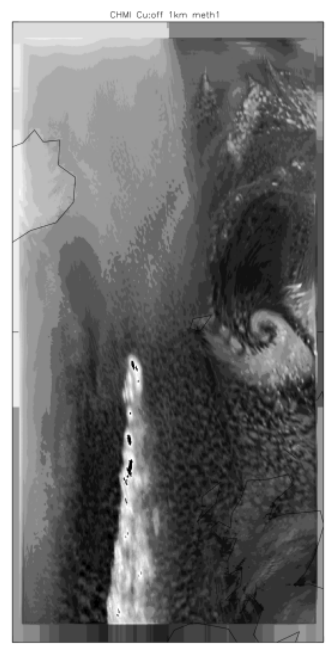


WRF_NCAR

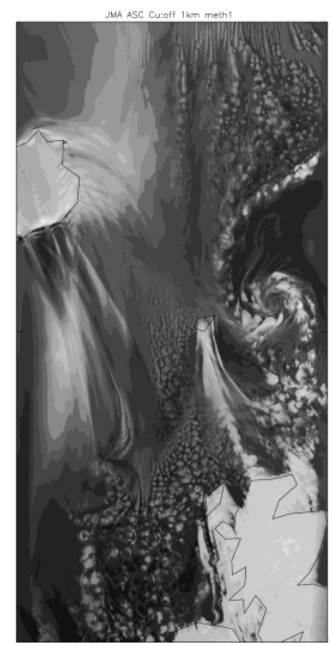
WRF_NOAA



MODIS



ALADIN



JMA

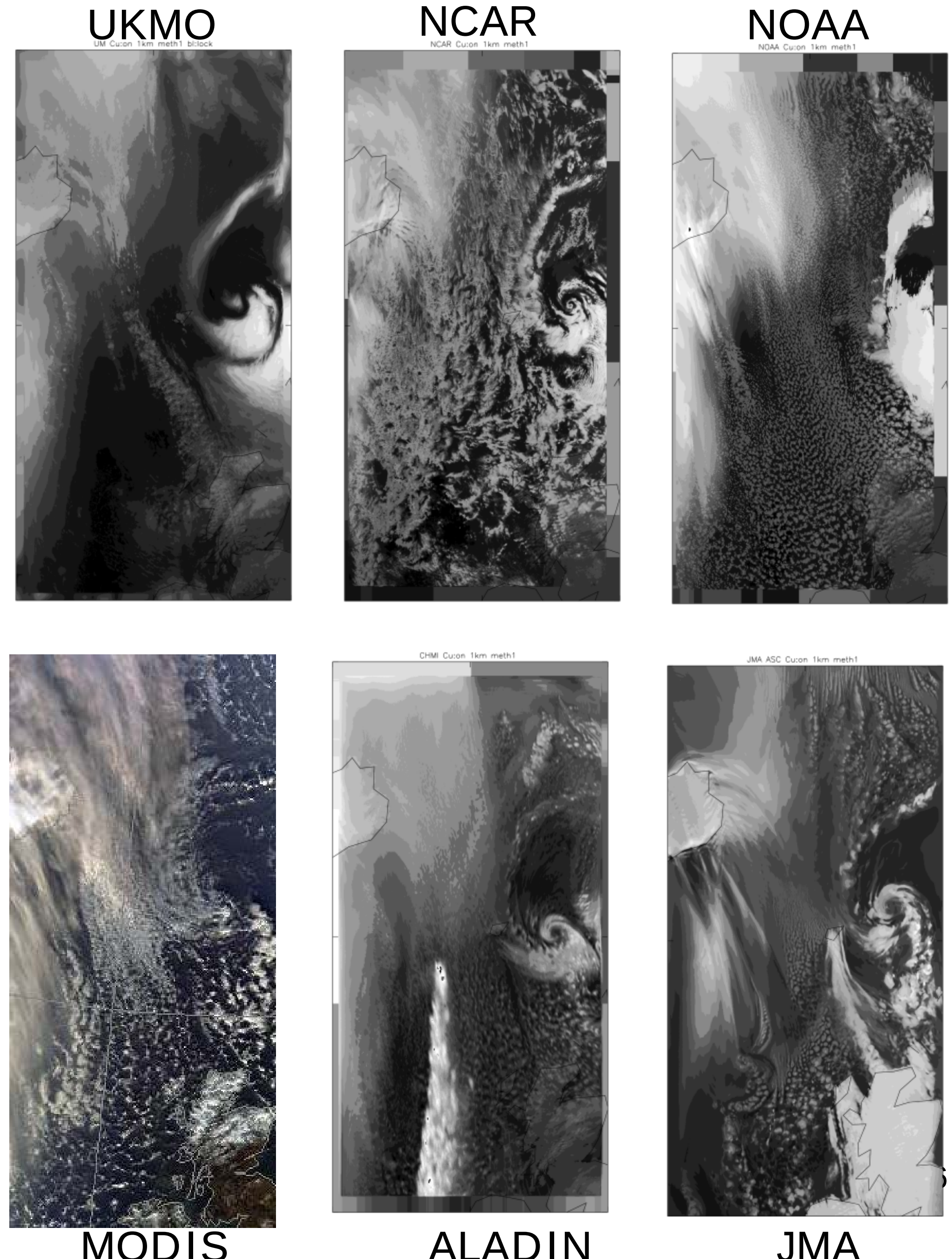
Limited Area Models – OLR

12Z 31 Jan 2010

~1 km grid length

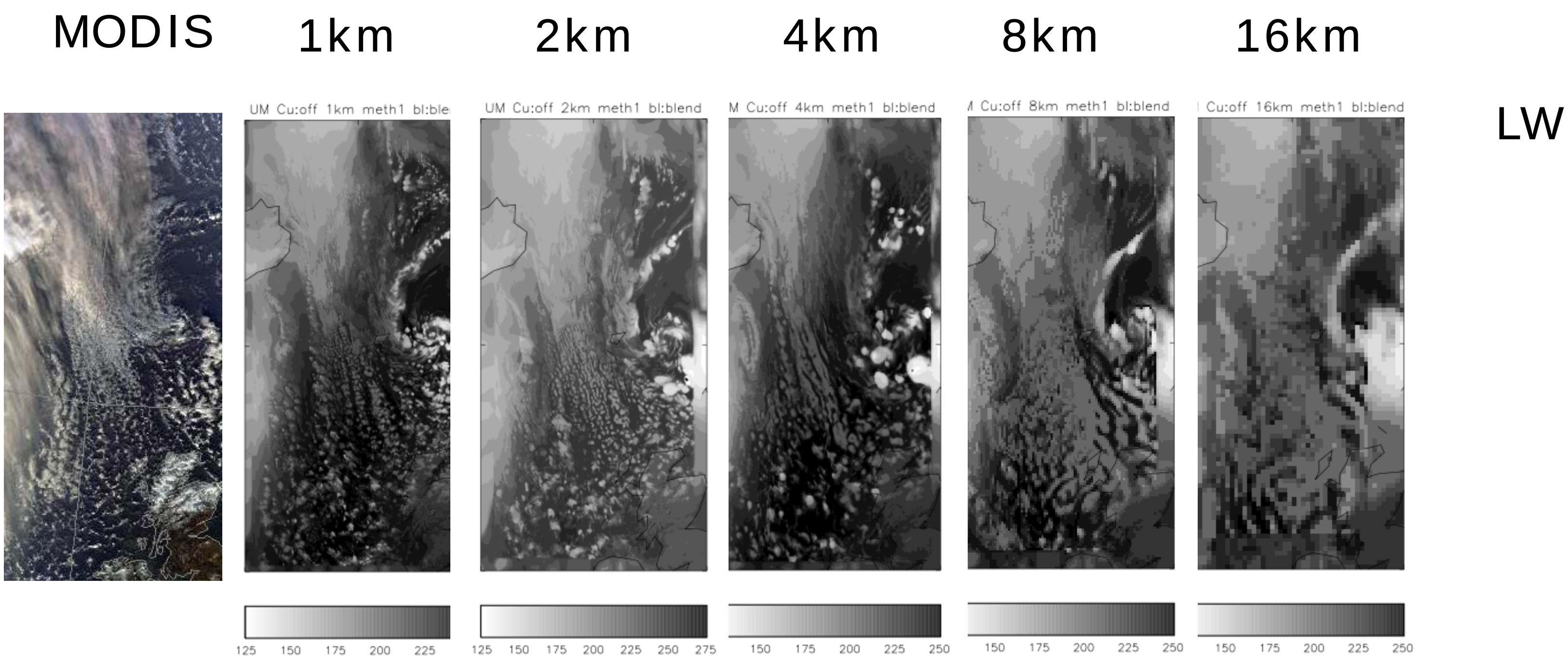
Convection on (as used in coarser models)

Note the big differences – some models more than others

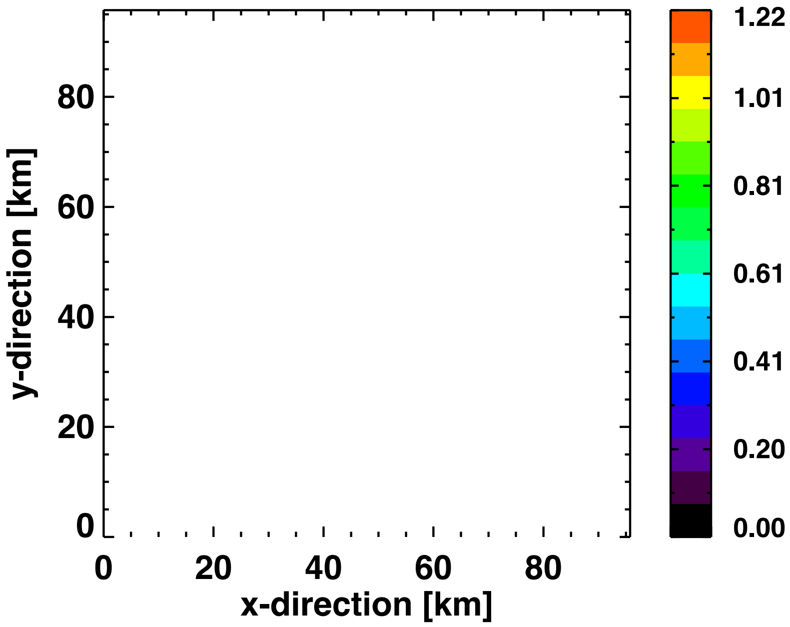


UM

No convection



Two LES results after 10 hours (after the break-up of Scu into Cumulus)



The simulations do show in general a break up into open cells with the typical observed mesoscale sizes…….

But the details depend strongly on the microphysics (e.g. droplet concentration)

Nc = 50 cm^{-3}

Nc = 10 cm^{-3}

1.22

1.01

0.81

0.61

* with lower droplet concentration less LWP and finer cloud structures

Some early conclusions

- LAM & LES reproduce qualitatively the breakup of the Scu into the Cu very well
- The Global Models (despite a similar resolution) show a poorer performance
- Microphysics does has a strong influence on the results
- Switching on/off the convection scheme at O(1km) resolution has different impact depending on model
- Area averaged metrics (LW, SW) do not vary greatly with changed resolution, despite the fact that the used parametrizations are not explicitly "scale-aware" formulated.
- Quite a bit to do – but could move to new case in parallel

5. Next Steps

- 2nd round adressing errors particiipants in set up and forcing (deadline April 2015)
- April – Sept 2015: Analysis and wrap up case
- Oct-Dec 2015: Reporting in peer reviewed journals (1 LES-paper / 2 combine GCM/LAM papers & one overview paper).
- **Discussion is open for a next case (Preferred one which is addressing deeper convection). This could be based on an already existing case.**

Input and Suggestions are Welcome!

More info : www.knmi.nl/samenw/greyzone

GASS GEWEX WCRP Global Atmospheric System Studies

Summary

- GASS still remains a very active group with projects at different stages of their life
  - Tackling all timescales – weather through to climate
  - Isolating processes in great detail
  - Working with observations
  - **Truly supporting model development – not just evaluation**
- Time for some new co-chairs to continue to evolve the direction
- Grey-zone making decent progress – with right volunteers it might be time to move to the tropics…
- 4 papers from MJO comparison – **and a raft of data we would like to advertise for broader use…**

GASS GEWEX WCRP Global Atmospheric System Studies

Questions

Which I may or may not know the answer to…