Predictability of precipitation determined by convection-permitting ensemble modeling

Christian Keil and George C .Craig

Meteorologisches Institut, Ludwig-Maximilians-Universität, München

Motivation

1. *Predictability*, or forecast uncertainty, of convective precipitation is influenced by all scales, but in different ways in different meteorological situations.

2. *Forced-frontal convective precipitation* associated with synoptic weather patterns may be predictable for several days and is primarily governed by lateral boundary conditions in limited area models.

3. Single convective cells developing during *air-mass convection* situations, which of themselves are predictable only for a matter of hours, are frequently triggered by local, small-scale processes enforced e.g. by mountain ridges and are anticipated to react sensitively to changes in the model physics.

Tools and Ingredients

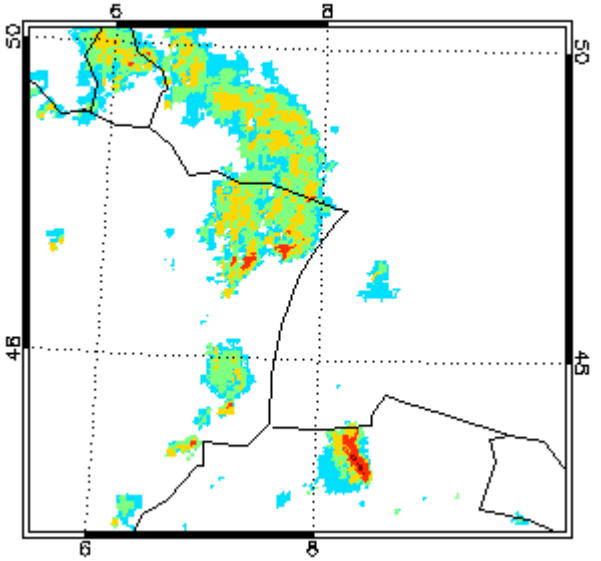
1. Forecasts of experimental COSMO-DE-EPS of DWD

2. Period in August 2007 during COPS characterized by different meteorological situations

3. COPS country

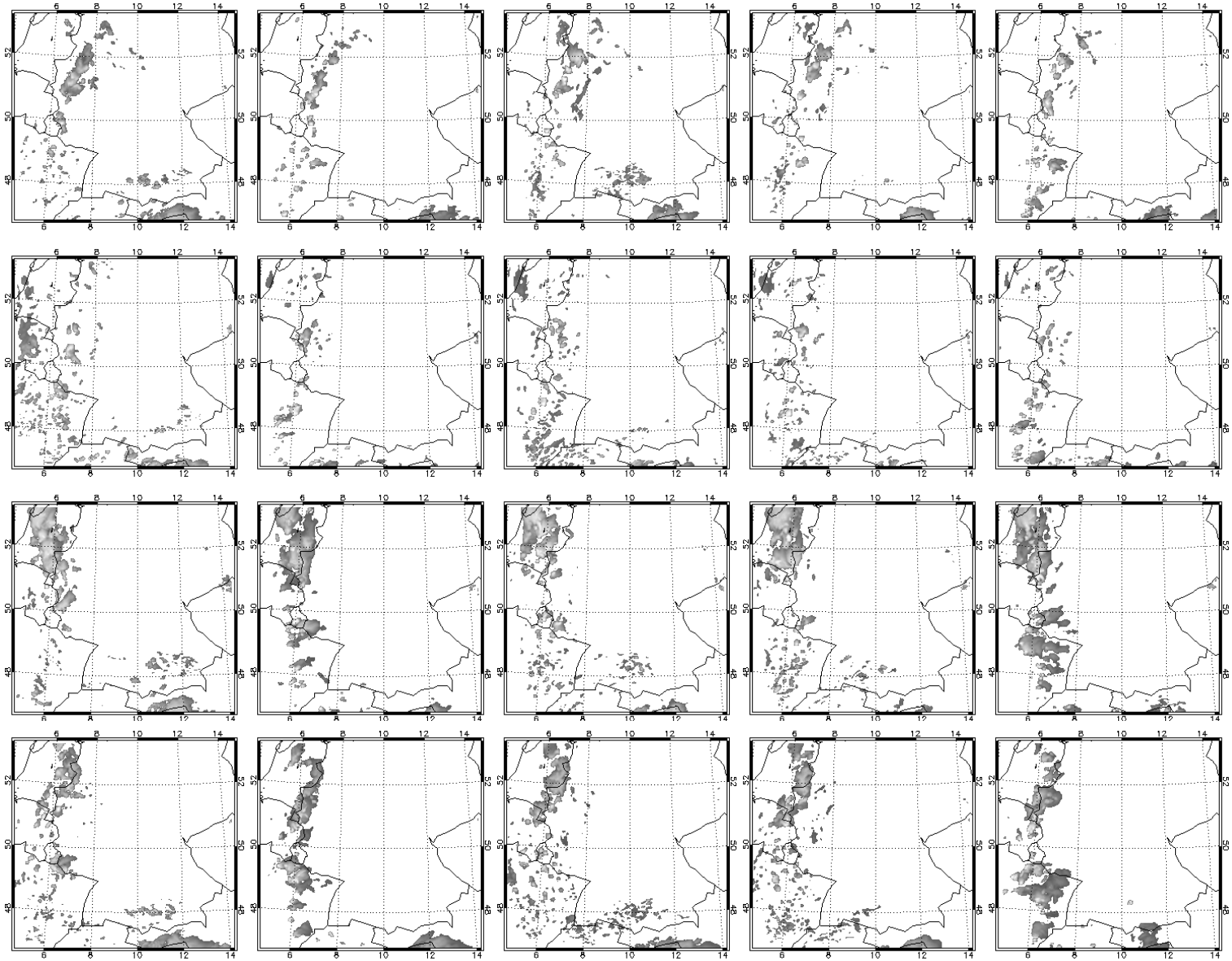
4. Observational data of the European Radar composite

5. Radar reflectivity dBZ_850 > 19 dbz @ xx:15 UTC

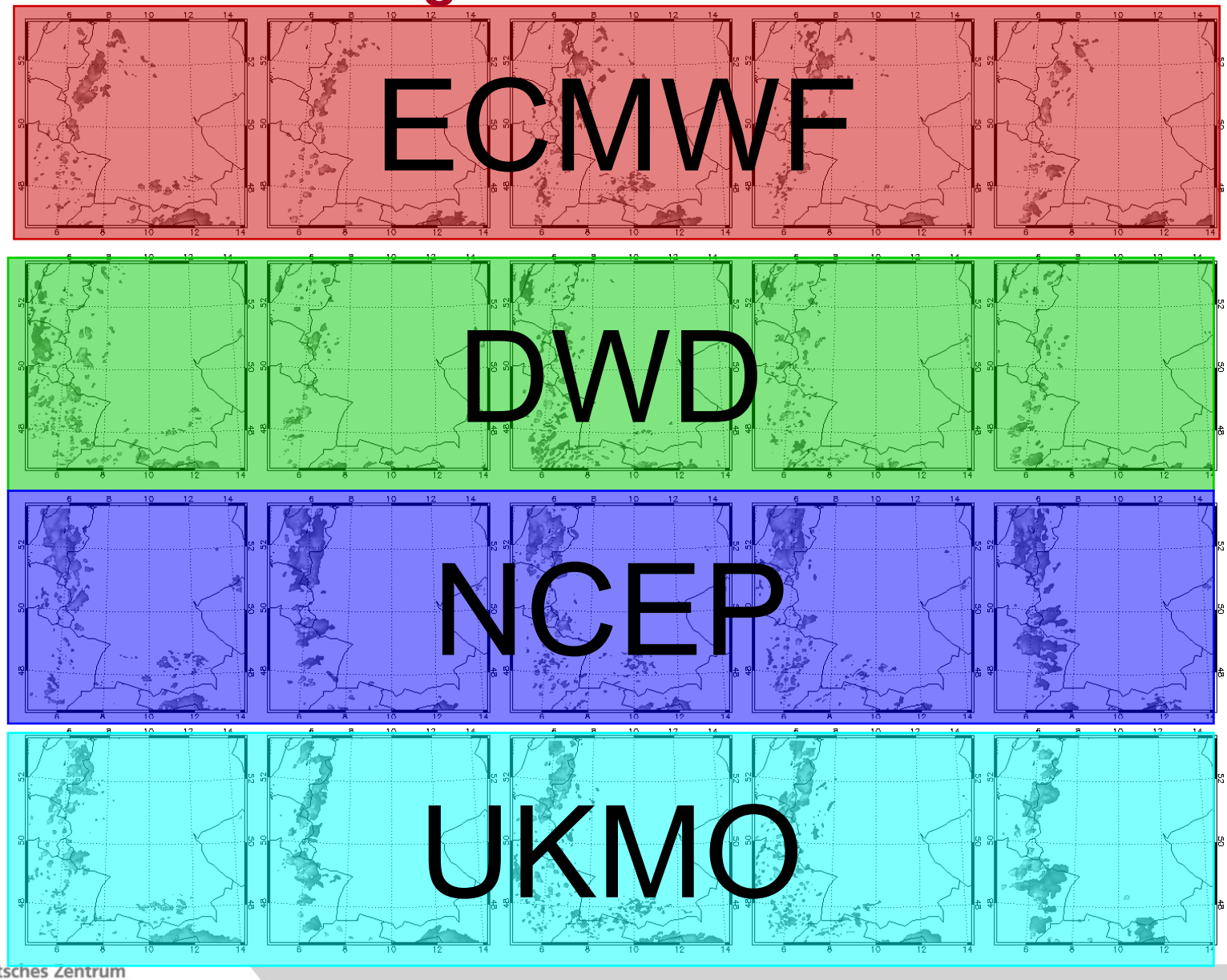


360 x 360 km^2

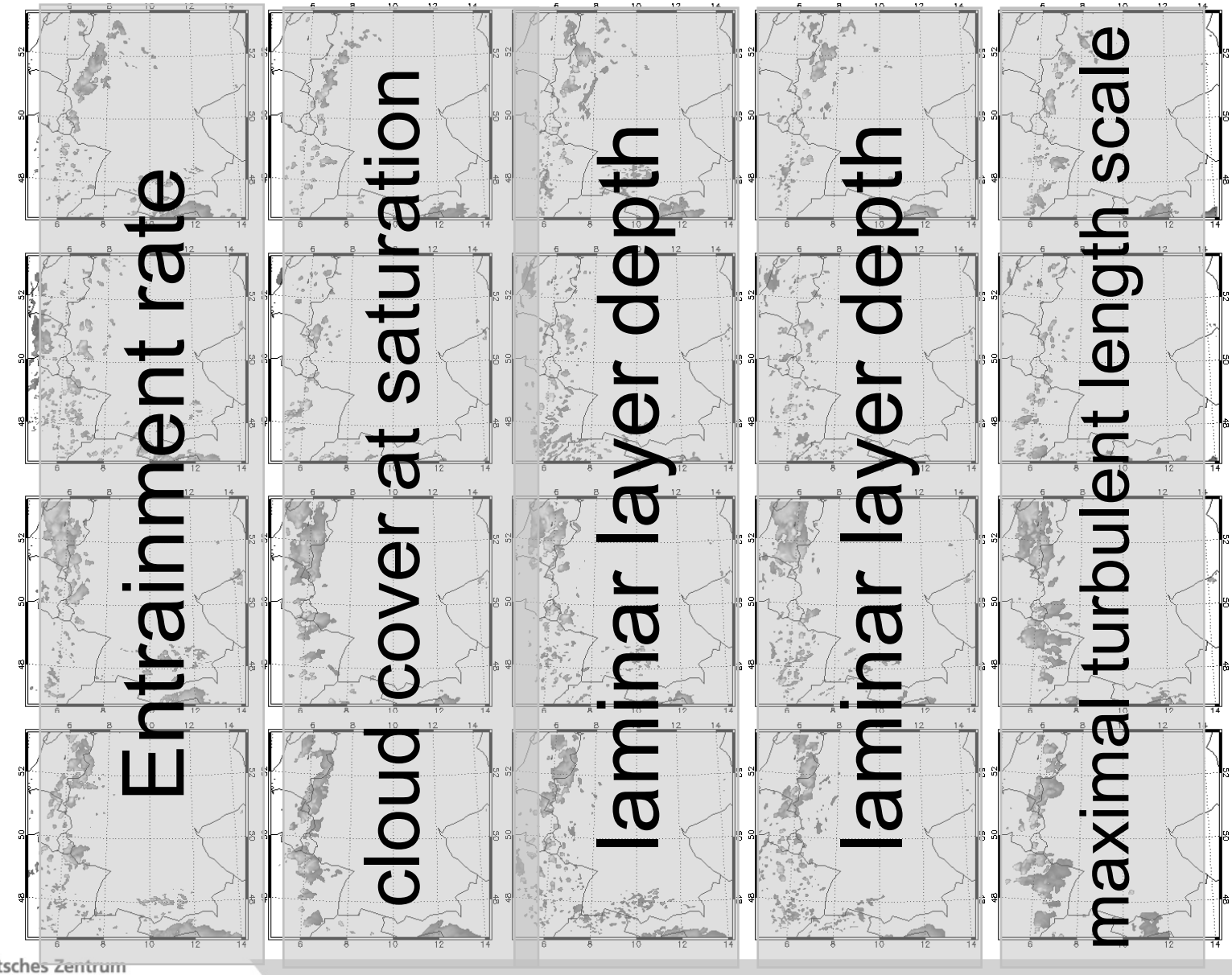
COSMO-DE-EPS: a cloud resolving EPS @ DWD



COSMO-DE-EPS: 4 global models



COSMO-DE-EPS: 5 physics perturbations



Measures and Methods

1. BIAS Score: $BIAS = \frac{hits + false\ alarms}{hits + misses}$

   to indicate whether the forecast system has a tendency to underforecast (BIAS<1) or overforecast (BIAS>1) events.

2. Concept of convective timescale

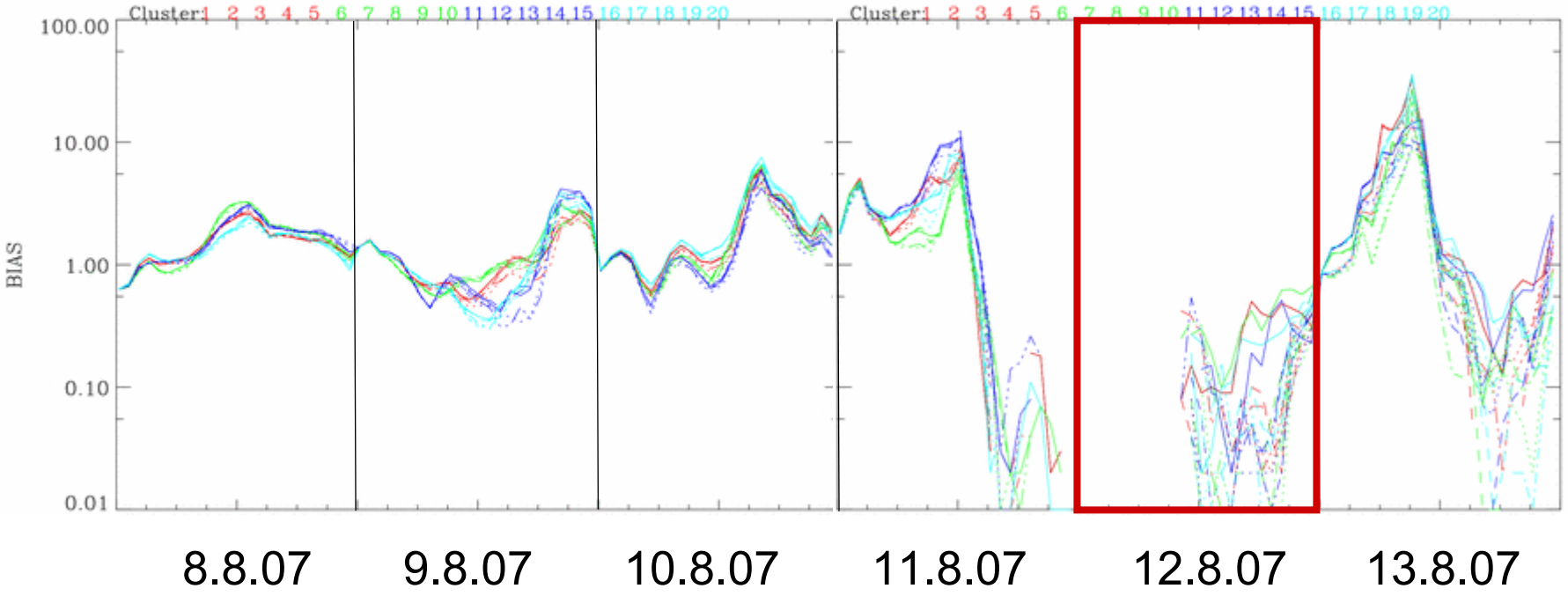
   to describe two mechanisms for control of convection

3. Displacement and Amplitude Score DAS

   a novel spatial verification measure employing an areal image matcher using classical optical flow technique

Keil, C. and G. C. Craig, 2009: A displacement and amplitude score employing an optical flow technique. *Wea. and Forecasting*, **24**, 1297-1308.

BIAS of COSMO-DE-EPS 8 - 13 Aug 2007

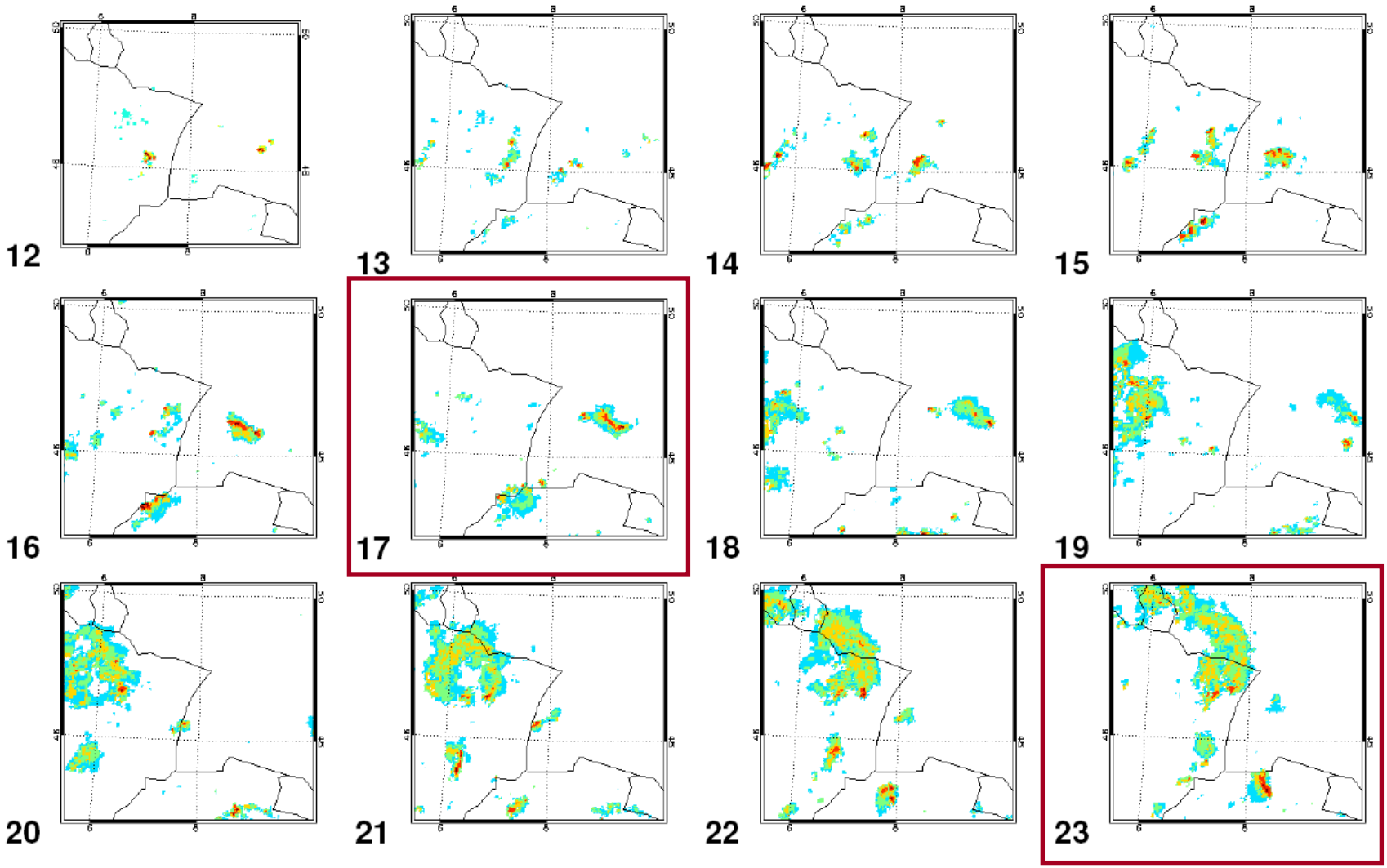


COPS IOP15

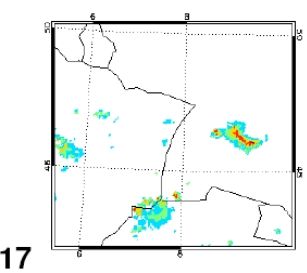
ECMWF DWD NCEP UKMO

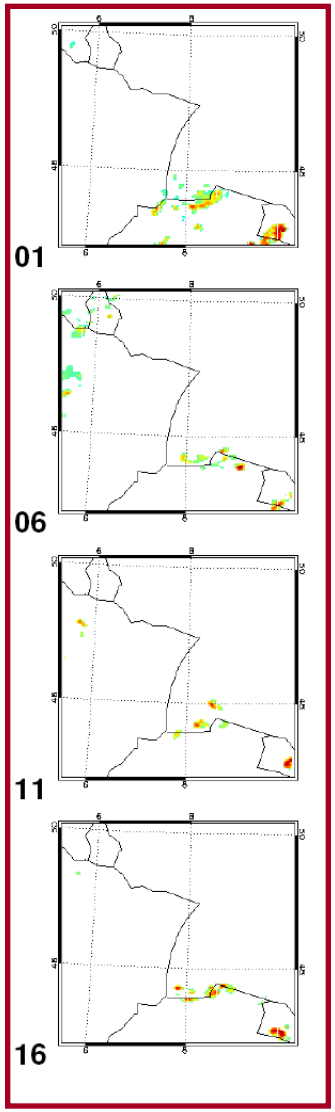
Z > 19 dbz

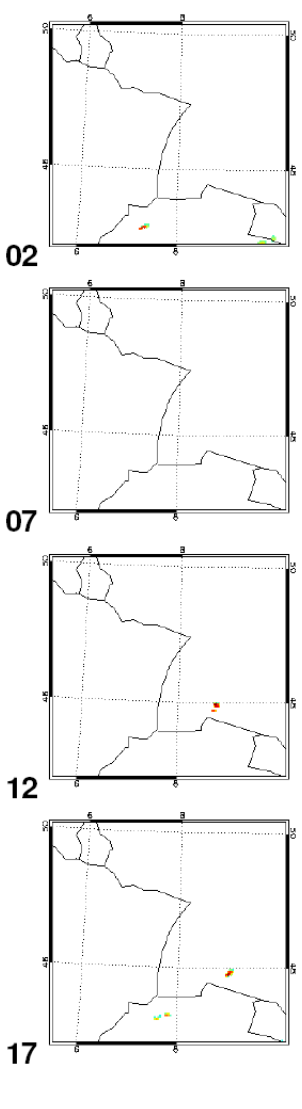
Convection on 12 Aug 2007 observed by Radar

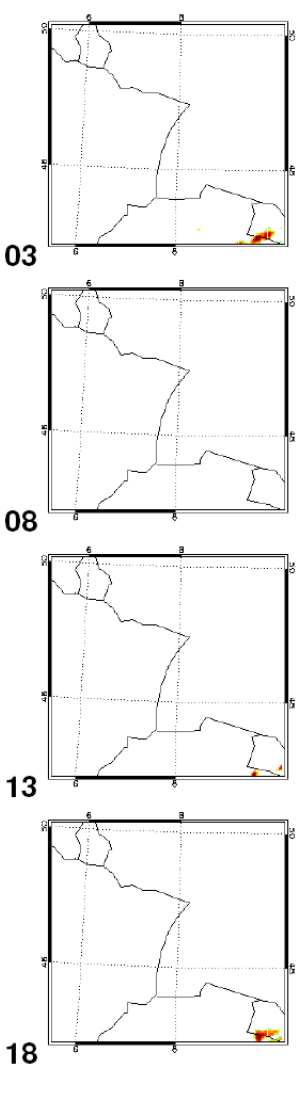


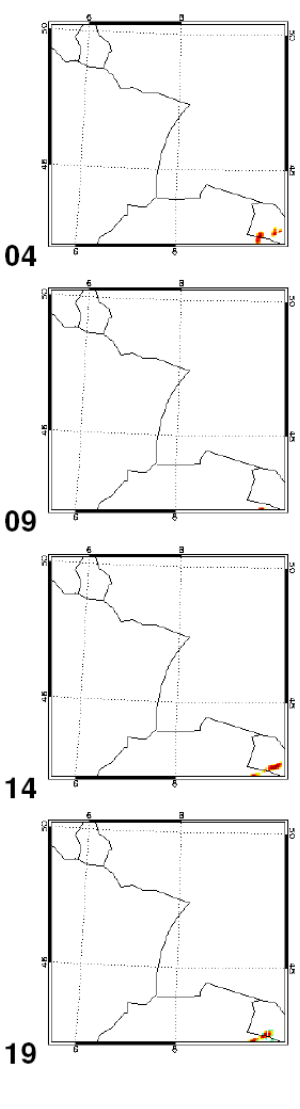
COSMO-DE-EPS on 12 Aug 2007 17:15 UTC

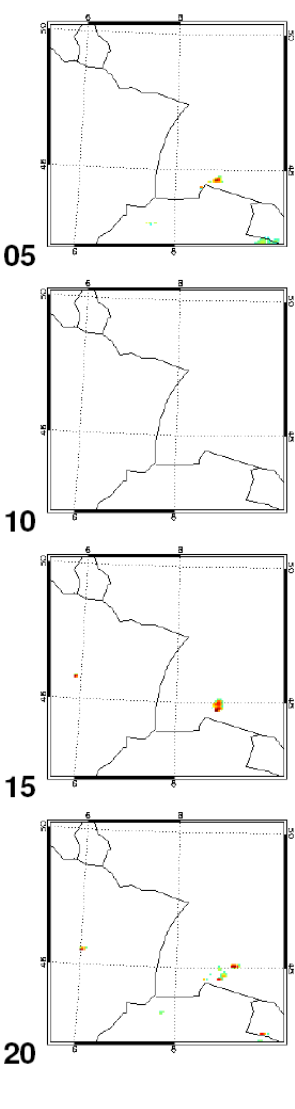




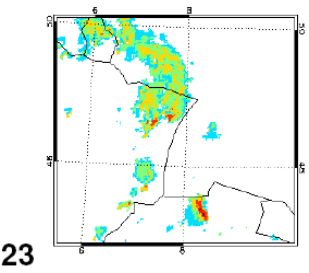




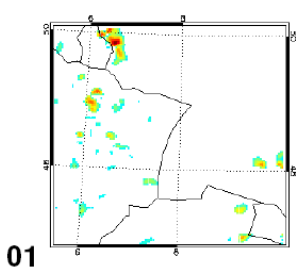


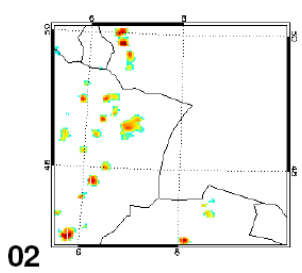


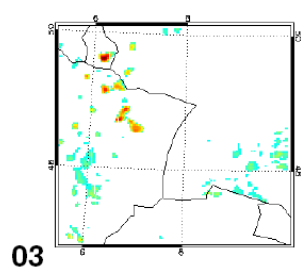
COSMO-DE-EPS on 12 Aug 2007 23:15 UTC

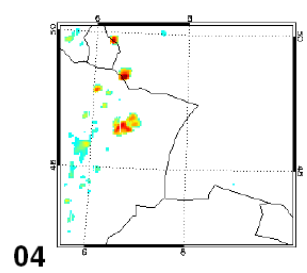


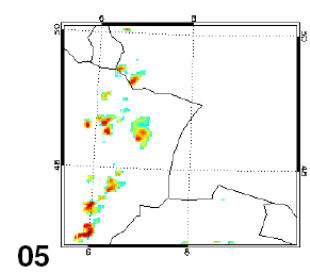
Radar

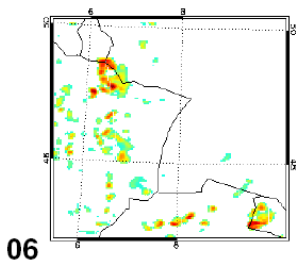


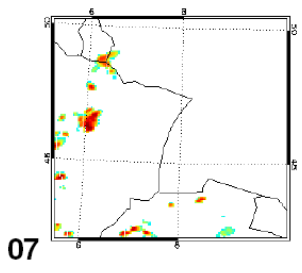


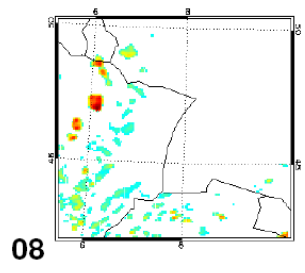


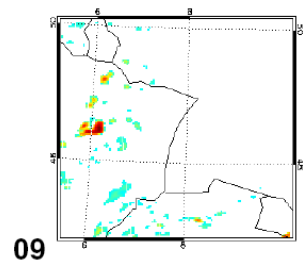


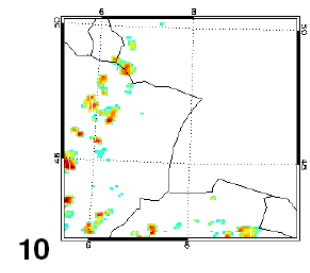


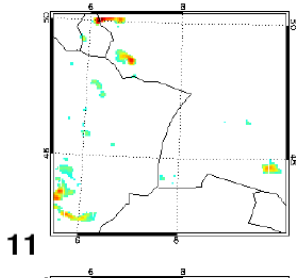


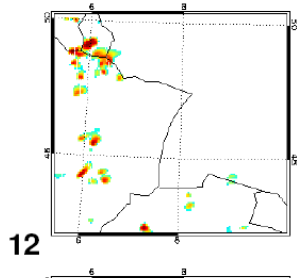


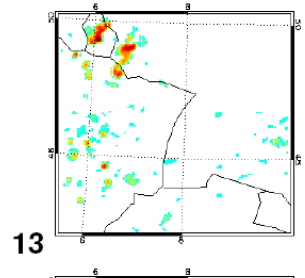


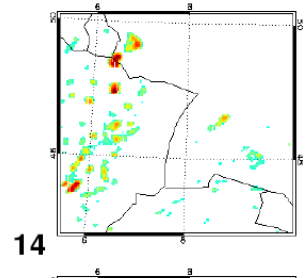


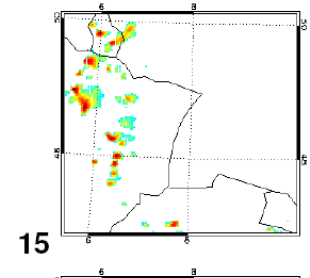


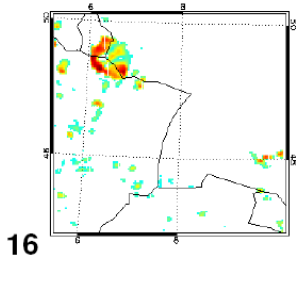


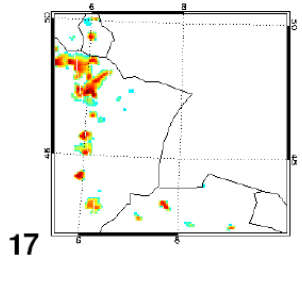


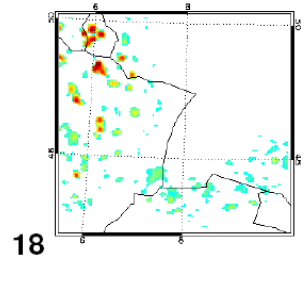


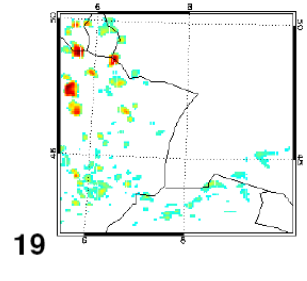


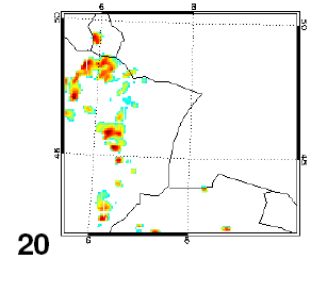






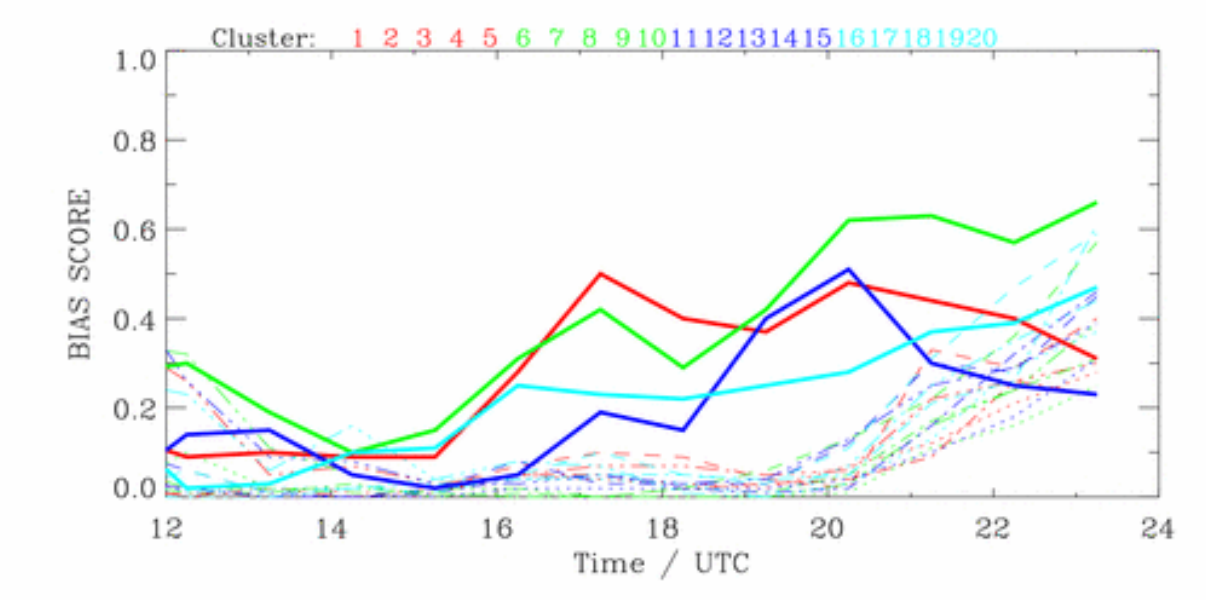






BIAS of COSMO-DE-EPS on 12 Aug 2007

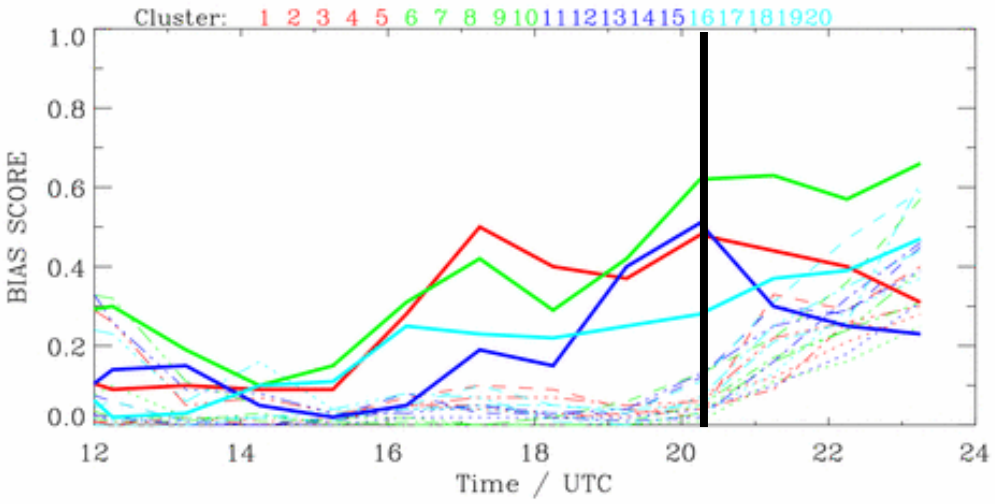
ECMWF DWD NCEP UKMO



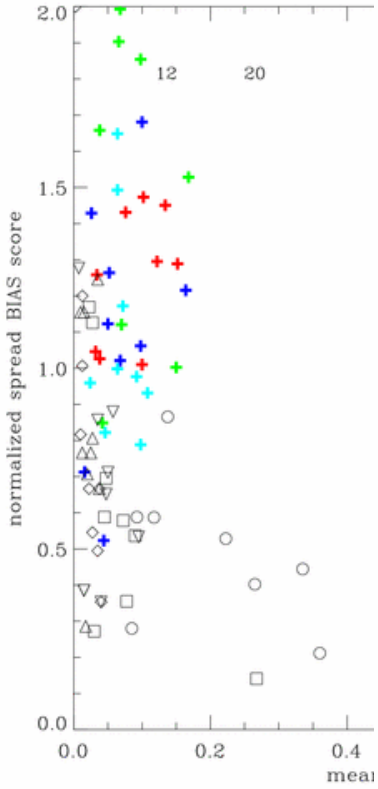
Z > 19 dbz

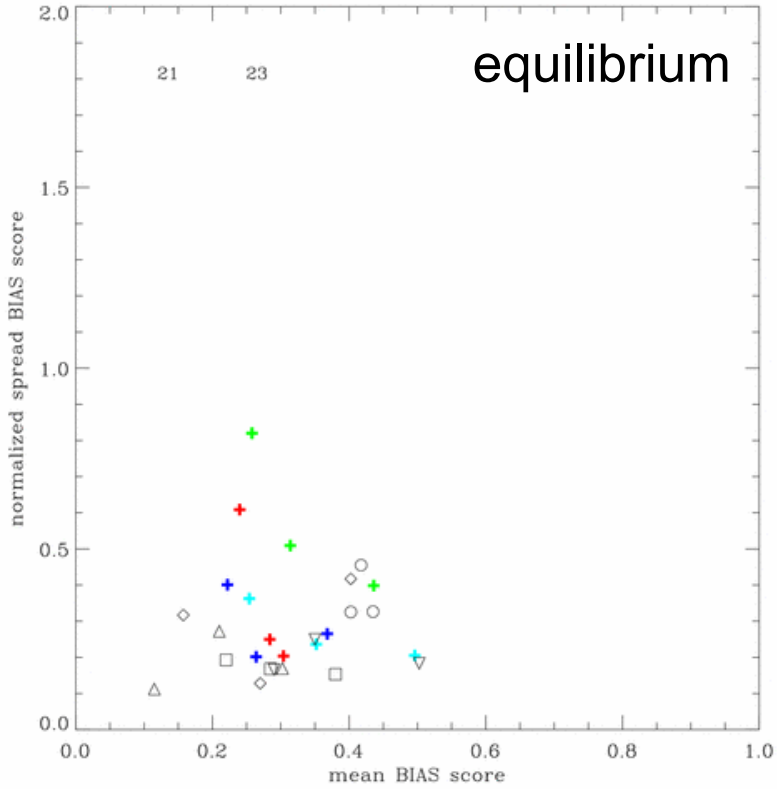
2 regimes on 12 Aug

ECMWF DWD NCEP UKMO



- BIAS score allows the separation between locally forced precipitation (triggered situations) and synoptically forced precipitation (equilibrium)





Measures and Methods

1. BIAS Score: $BIAS = \frac{hits + false\ alarms}{hits + misses}$

   to indicate whether the forecast system has a tendency to underforecast (BIAS<1) or overforecast (BIAS>1) events.

2. Concept of convective timescale

   to describe two mechanisms for control of convection

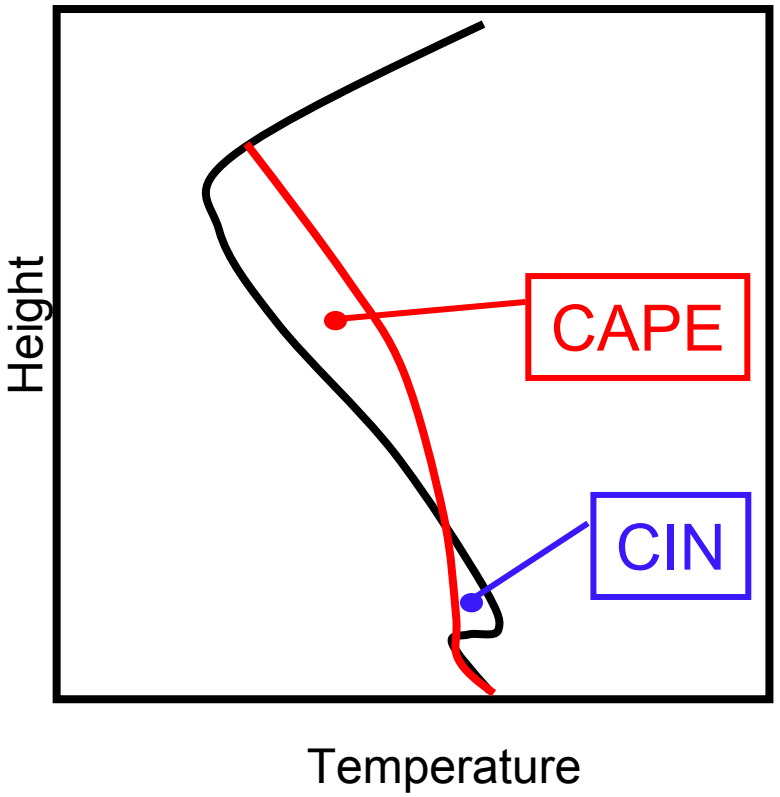
Two mechanisms for control of convection

1. Dynamical production of CAPE: *Equilibrium*

   - convection removes CAPE rapidly in comparison to the rate it is being generated

2. Local perturbations to overcome CIN: *Triggered*

   - large amounts of CAPE can build up if triggers not present

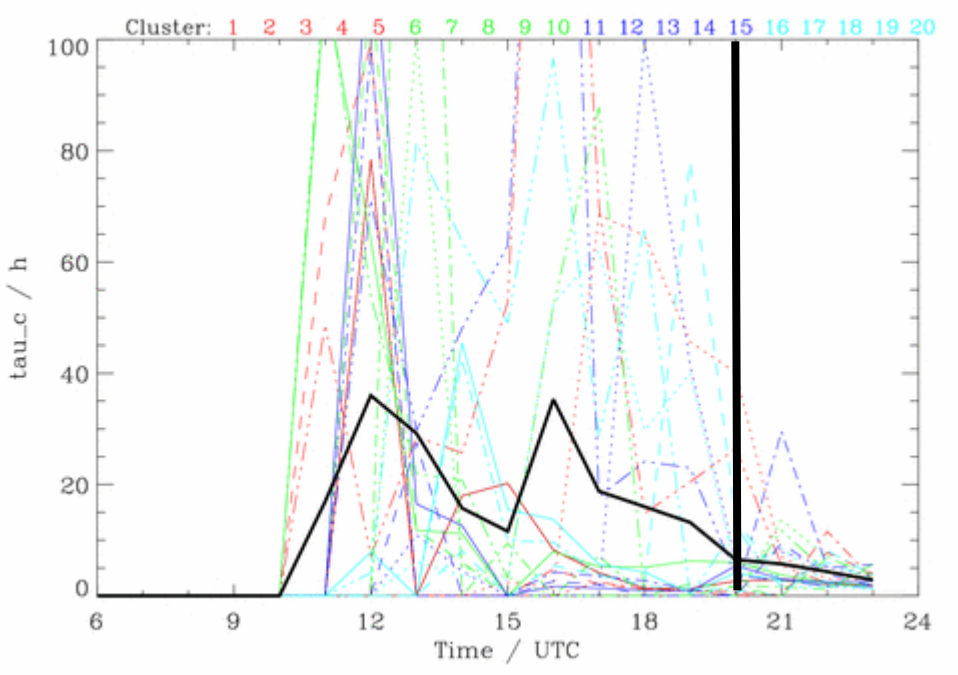


To identify regime, consider timescale over which convection removes CAPE

Convective timescale (Done et al. 2006)

$$\tau_c = \frac{CAPE}{dCAPE/dt} \sim \frac{CAPE}{Precip.\ rate}$$

Time series of convective timescale



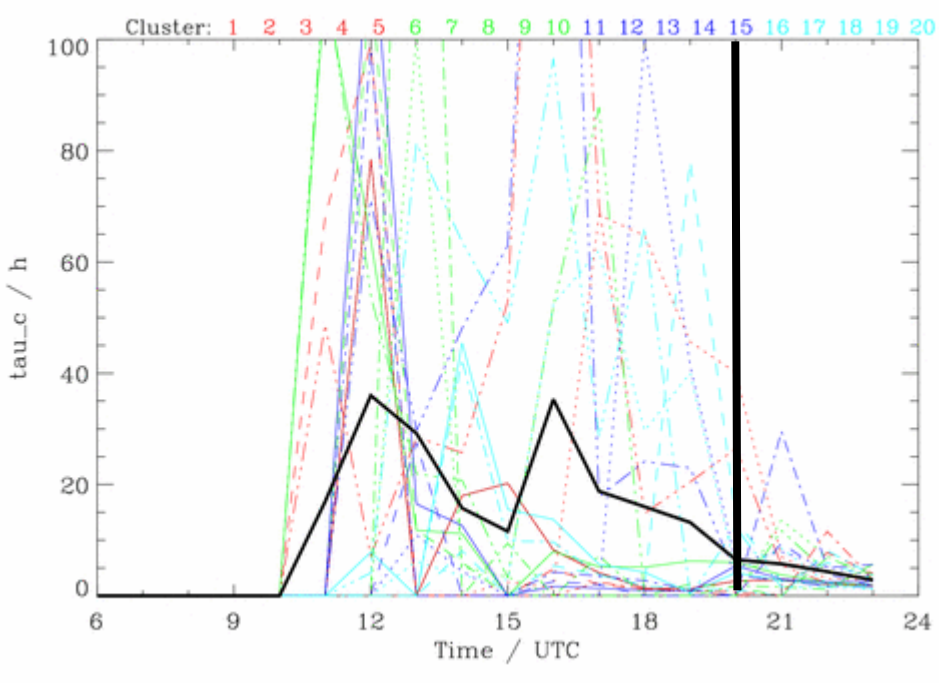
12-20UTC: ~25 hrs

Triggered convection

20-24UTC: ~ 5 hrs

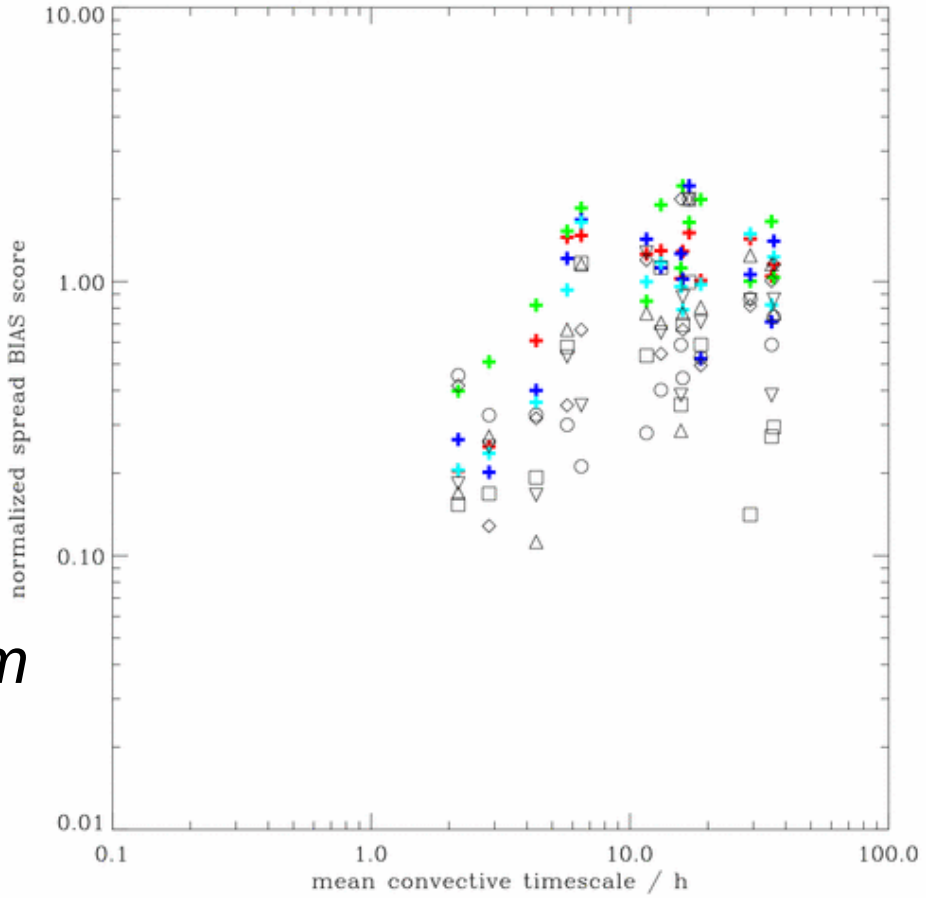
Equilibrium convection

Convective timescale vs ensemble spread

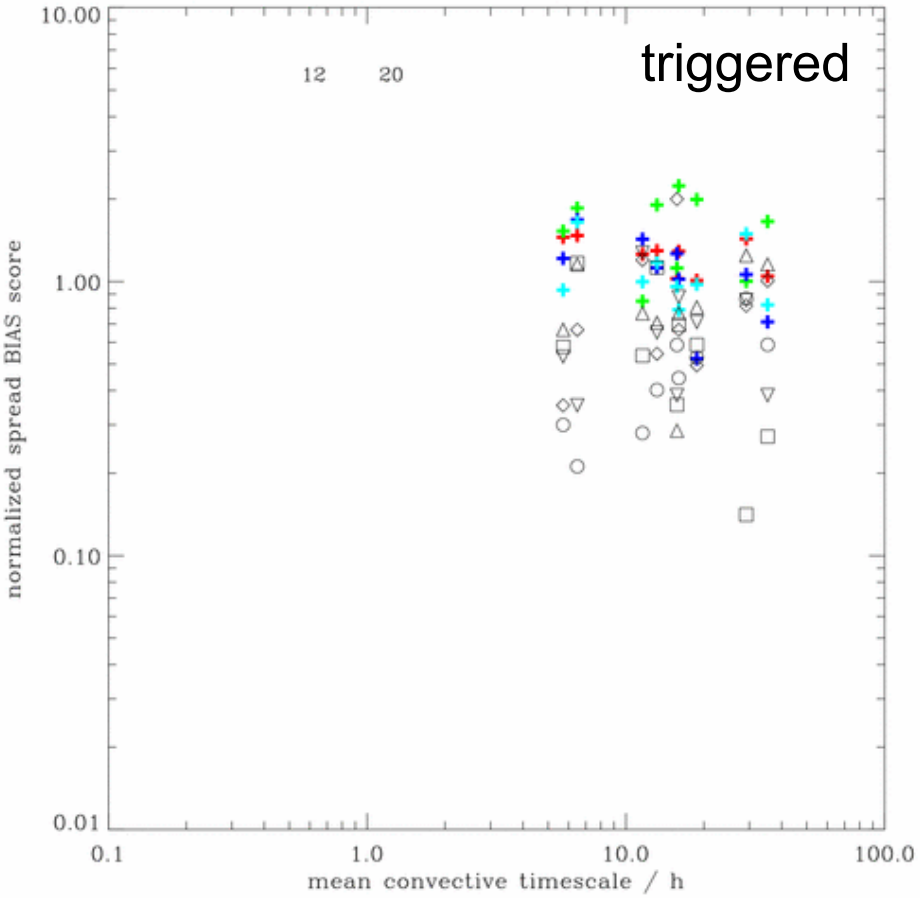


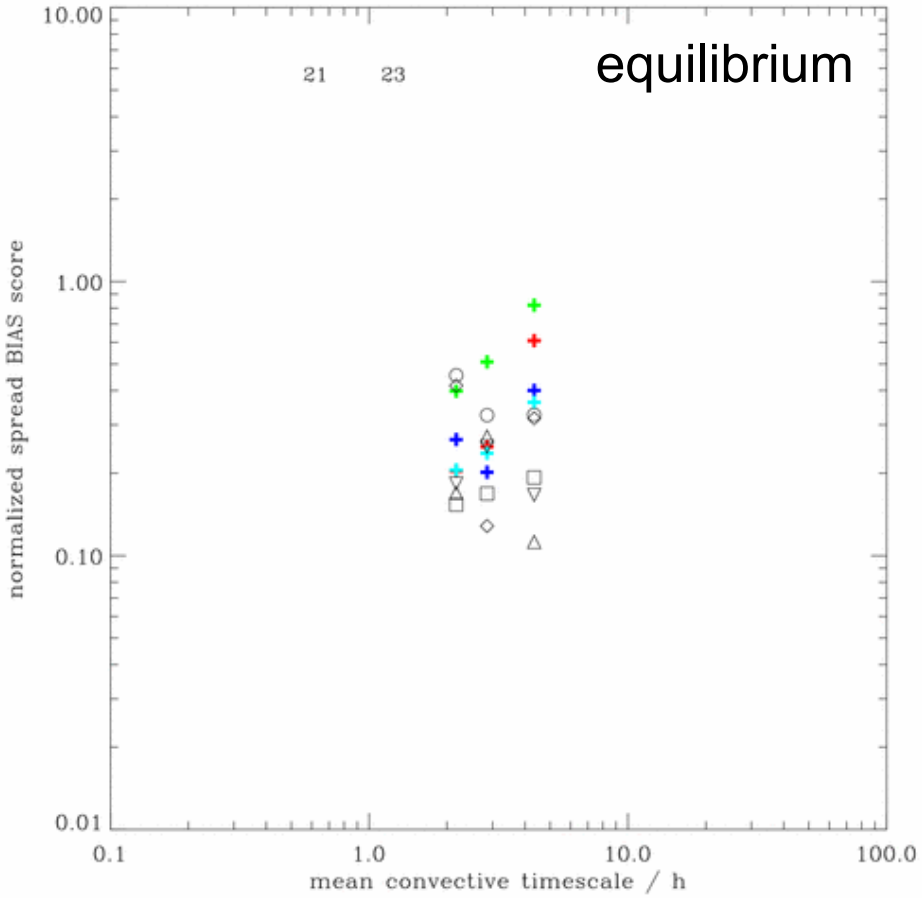
triggered convection

equilibrium

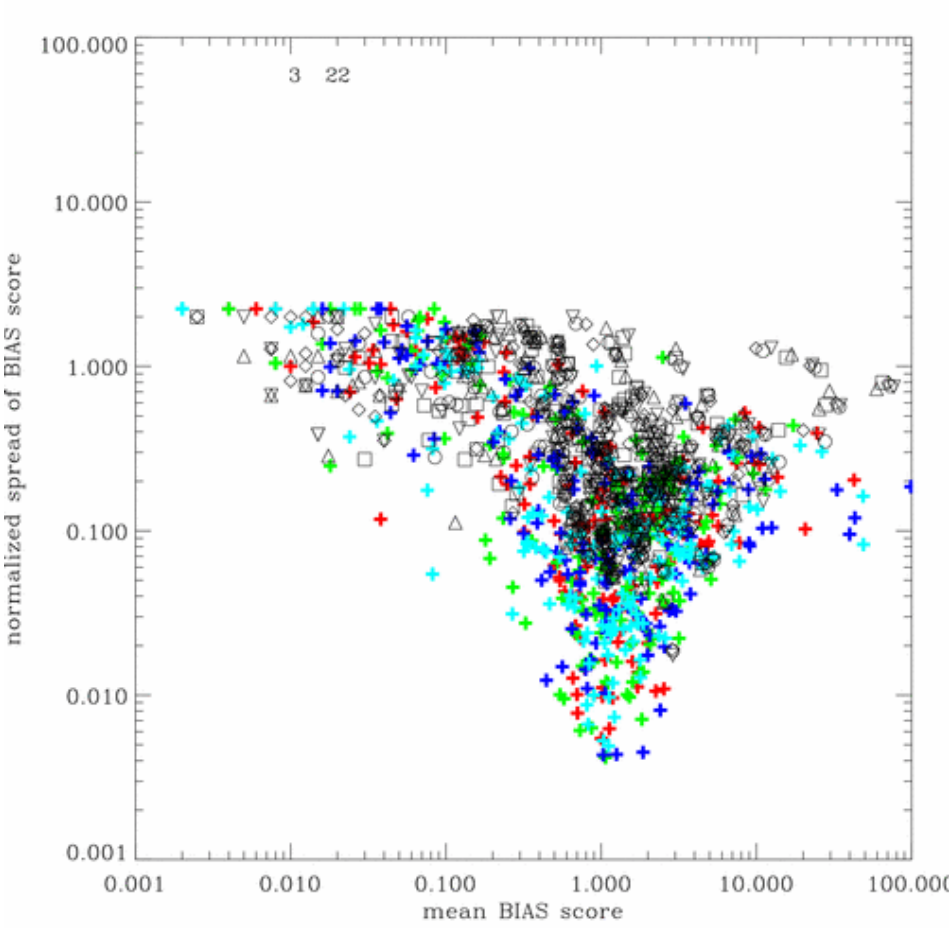


Convective timescale vs ensemble spread

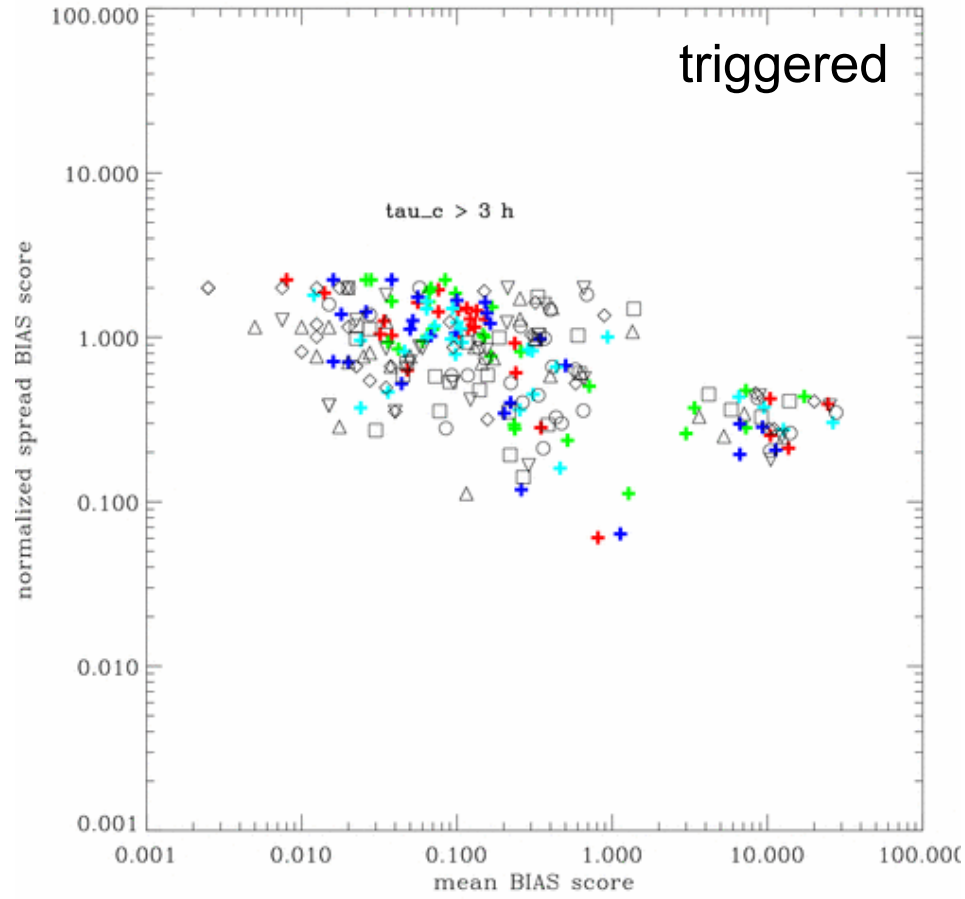


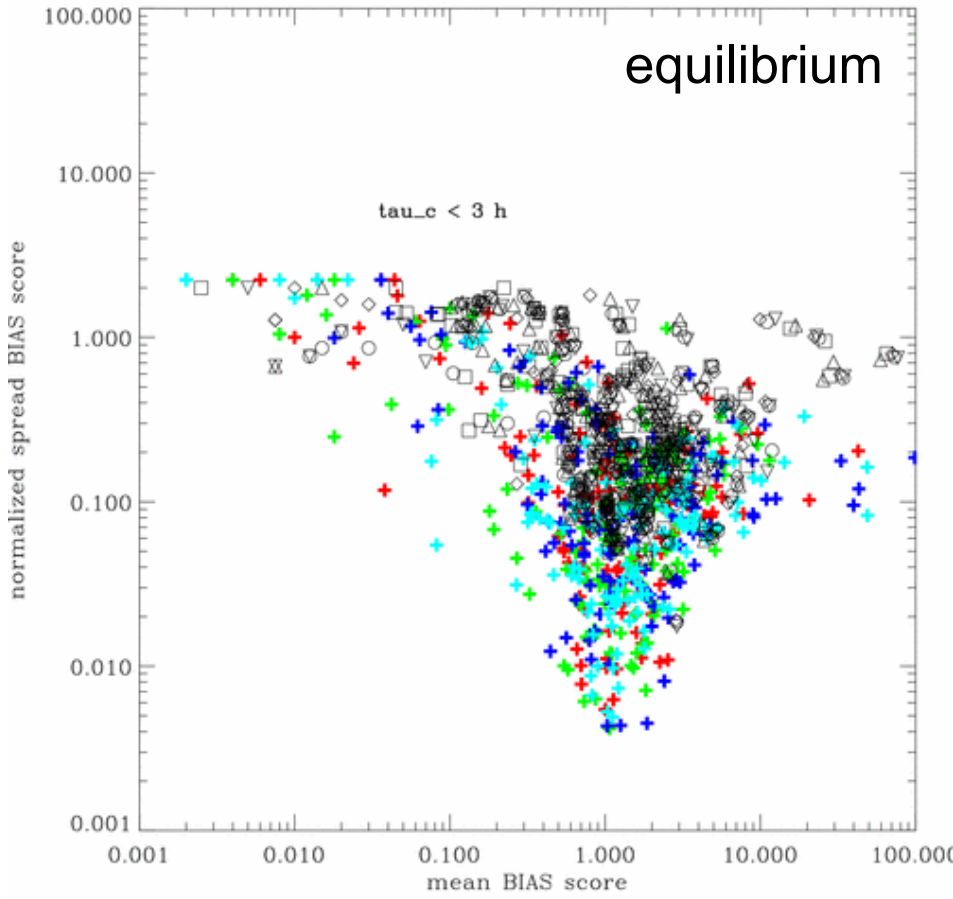


Mean bias score vs ensemble spread of all days



Mean bias score vs ensemble spread of all days





Summary

Two predictability regimes can be distinguished depending on the control of convection as measured by

- mean and spread of BIAS score
- the convective adjustment timescale τ_C

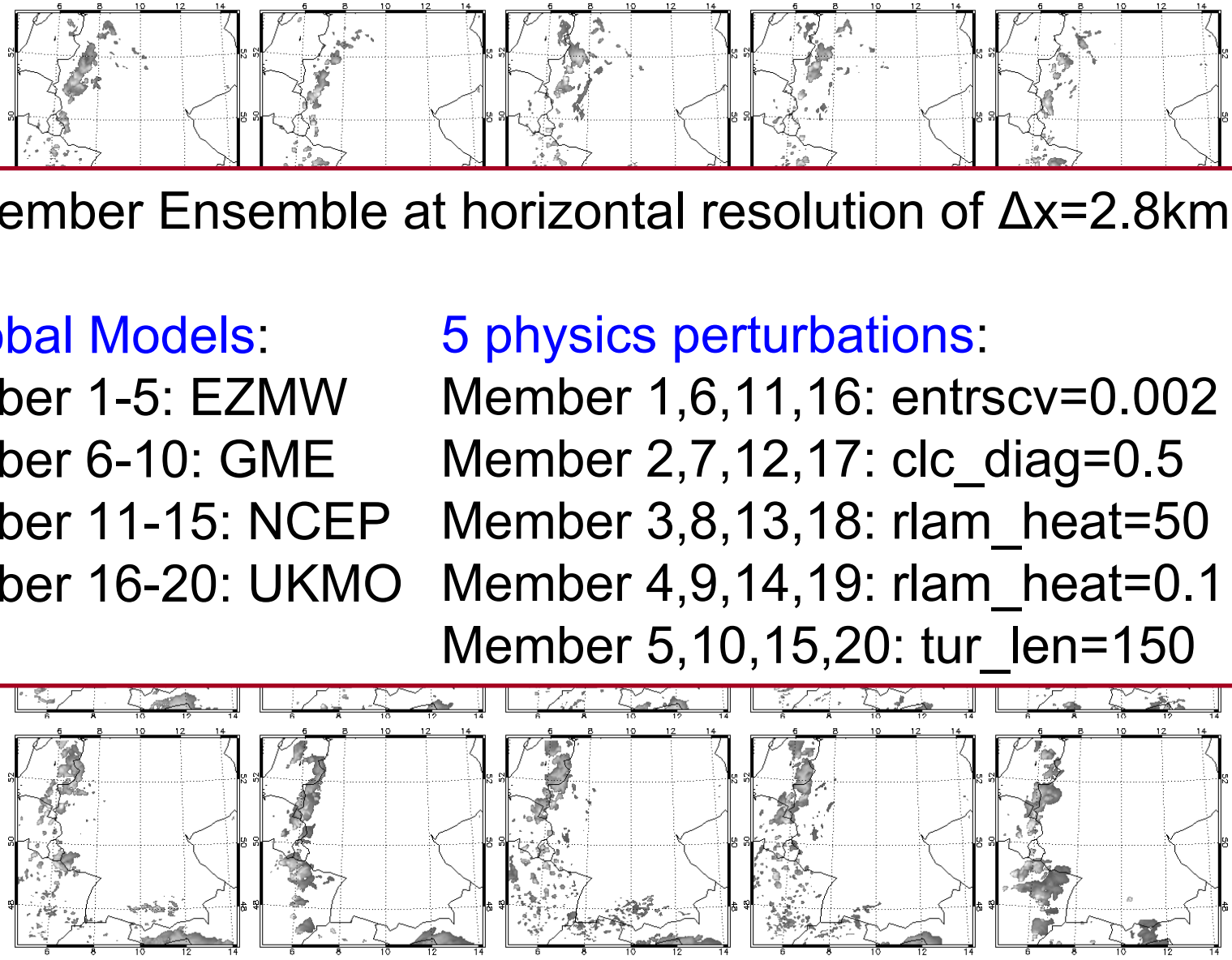
1. Triggered convection: forecast sensitive to changes in the model physics, τ_C of more than a few hours

2. Equilibrium convection: control of convection by synoptic forcing determining the creation of instability, short convective timescale τ_C

Scientific questions and Outlook

- application on larger data set (re-forecasts of summer 2009 using COSMO-DE-EPS output of DWD)
- application of DAS
- examine the potential of the convective adjustment timescale τ_C as a quantity to construct a convection permitting EPS (adaptive ensemble modelling)
- predictability studies within the HyMex field programme

COSMO-DE-EPS



20 Member Ensemble at horizontal resolution of Δx=2.8km

4 Global Models:	5 physics perturbations:
Member 1-5: EZMW	Member 1,6,11,16: entrscv=0.002
Member 6-10: GME	Member 2,7,12,17: clc_diag=0.5
Member 11-15: NCEP	Member 3,8,13,18: rlam_heat=50
Member 16-20: UKMO	Member 4,9,14,19: rlam_heat=0.1
	Member 5,10,15,20: tur_len=150