QPF Uncertainty of Radar Rainfall Data Assimilation

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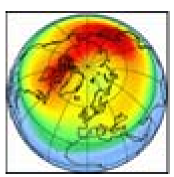
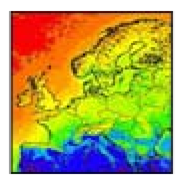
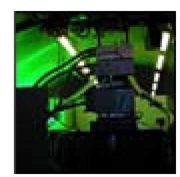






Motivation

1. Convection often missed in model at right location and time
2. Assimilate radar data to trigger convection at correct location and time
3. Latent Heat Nudging (LHN) is most common data assimilation method for models with kilometre-scale resolution
4. Convective environment crucial for the success of short-range QPF
5. Operational experience is suggesting that the impact decreases rapidly within the first 4 hours

Experimental design

Goal:

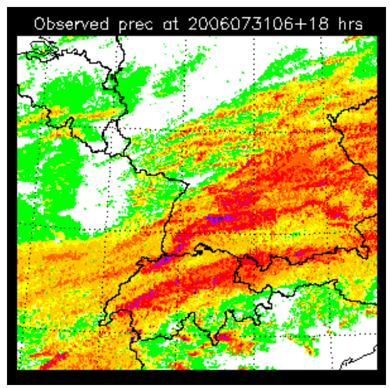
- Study the role of environment in the success of radar assimilation on QPF by performing a series of differently forced convection cases

Method and Tool:

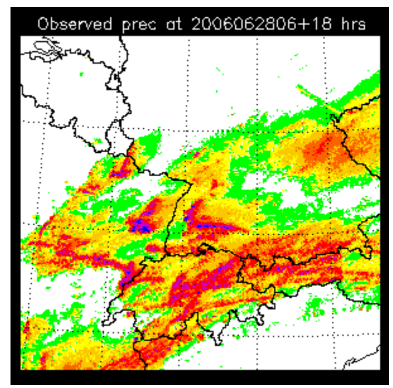
- Latent Heat Nudging experiments in COSMO-DE-Ensemble (Δx=2.8km)

Data:

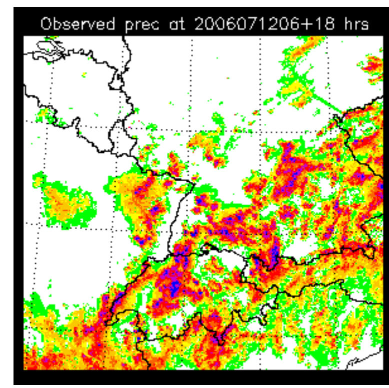
- 30 short range forecasts on 3 typical precipitation scenarios in COPS region:



forced frontal

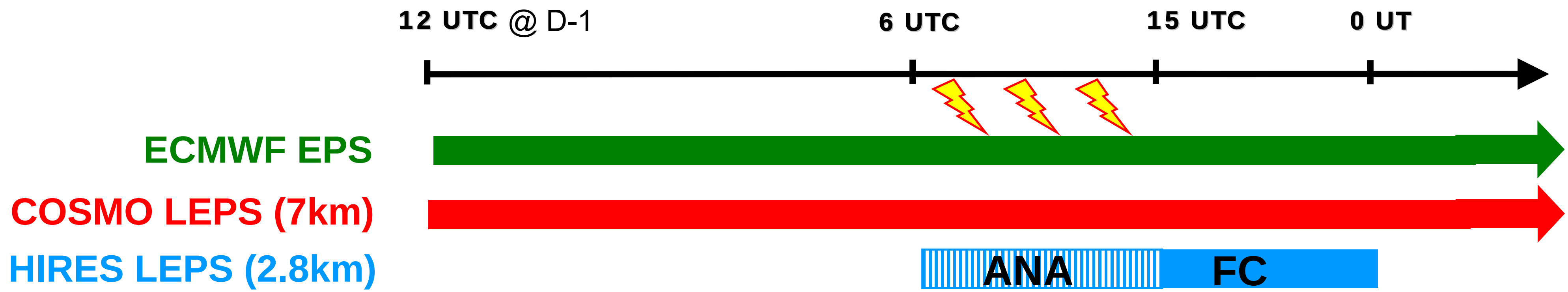


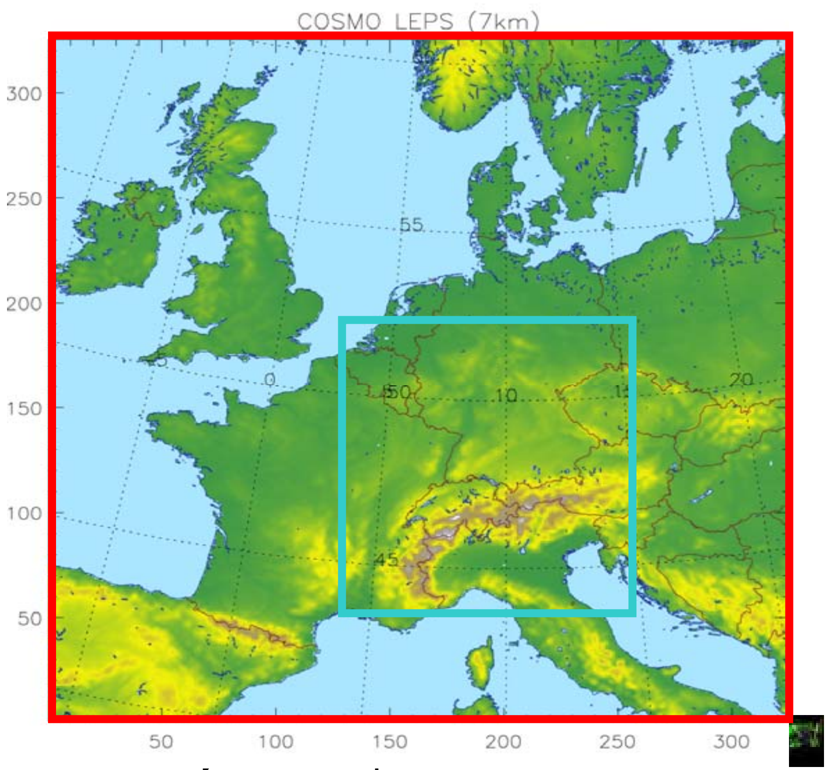
forced non-frontal

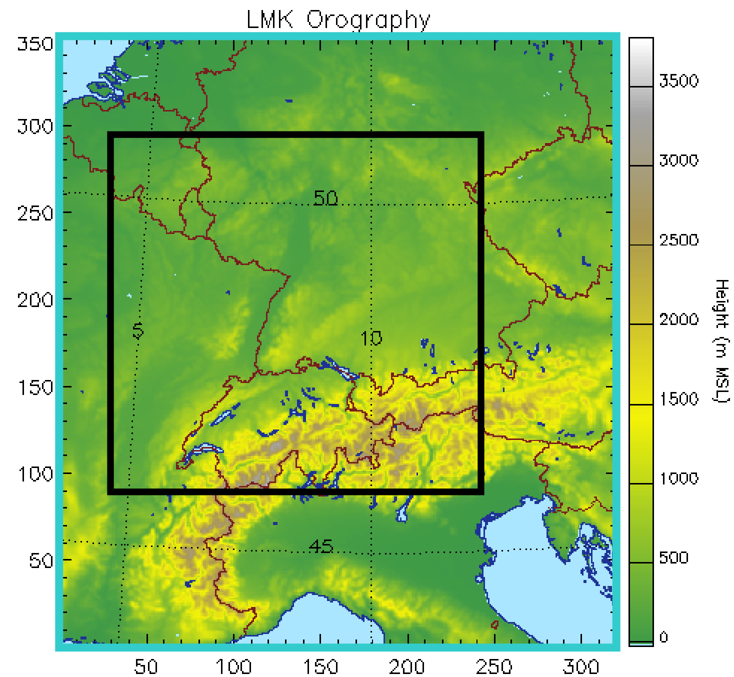


airmass conv.

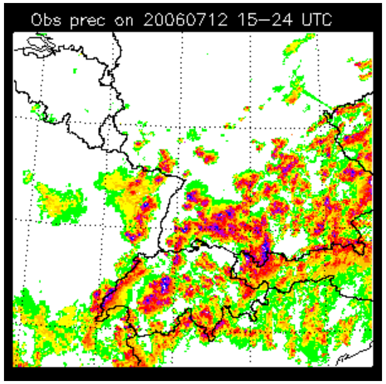
The high-resolution Ensemble Prediction System







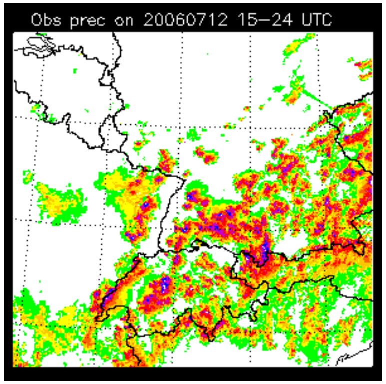
QPF on 12 July 2006



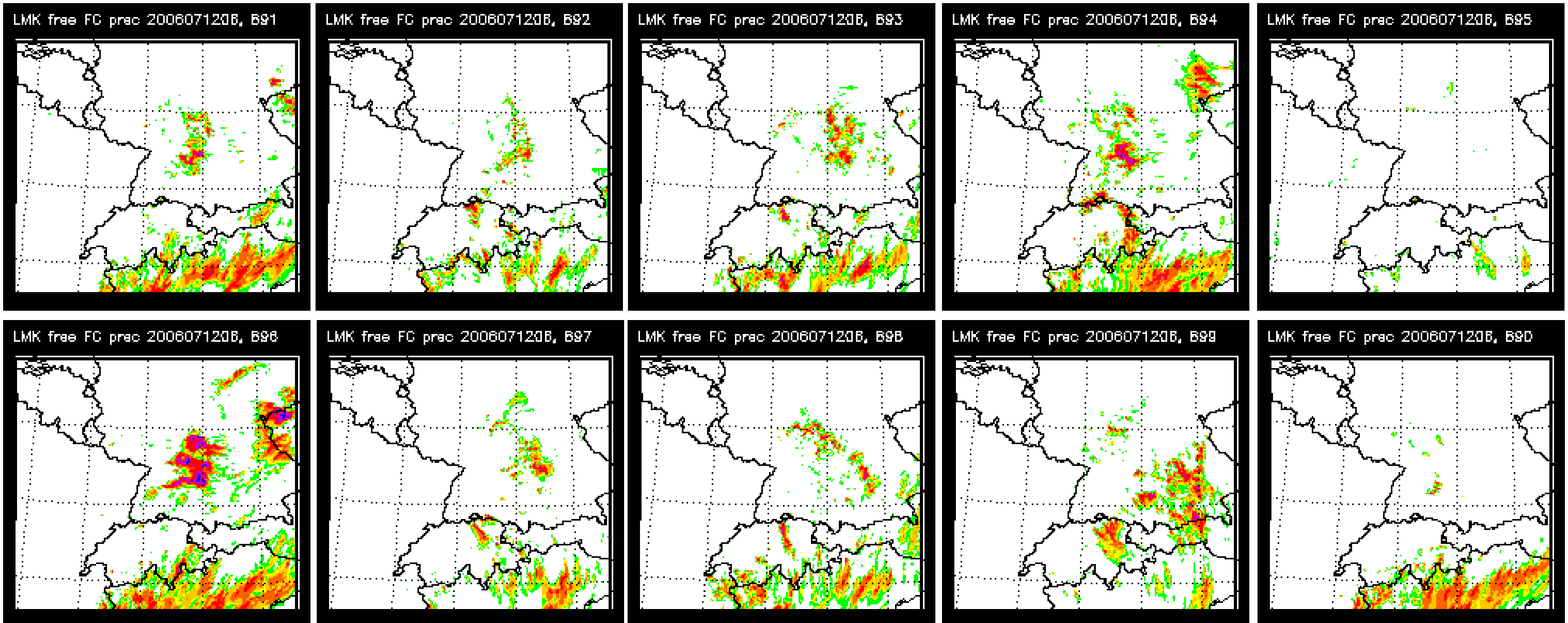
Radar observation

QPF on 12 July 2006

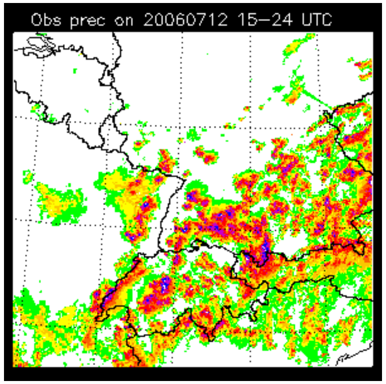
Radar observation



COSMO-DE

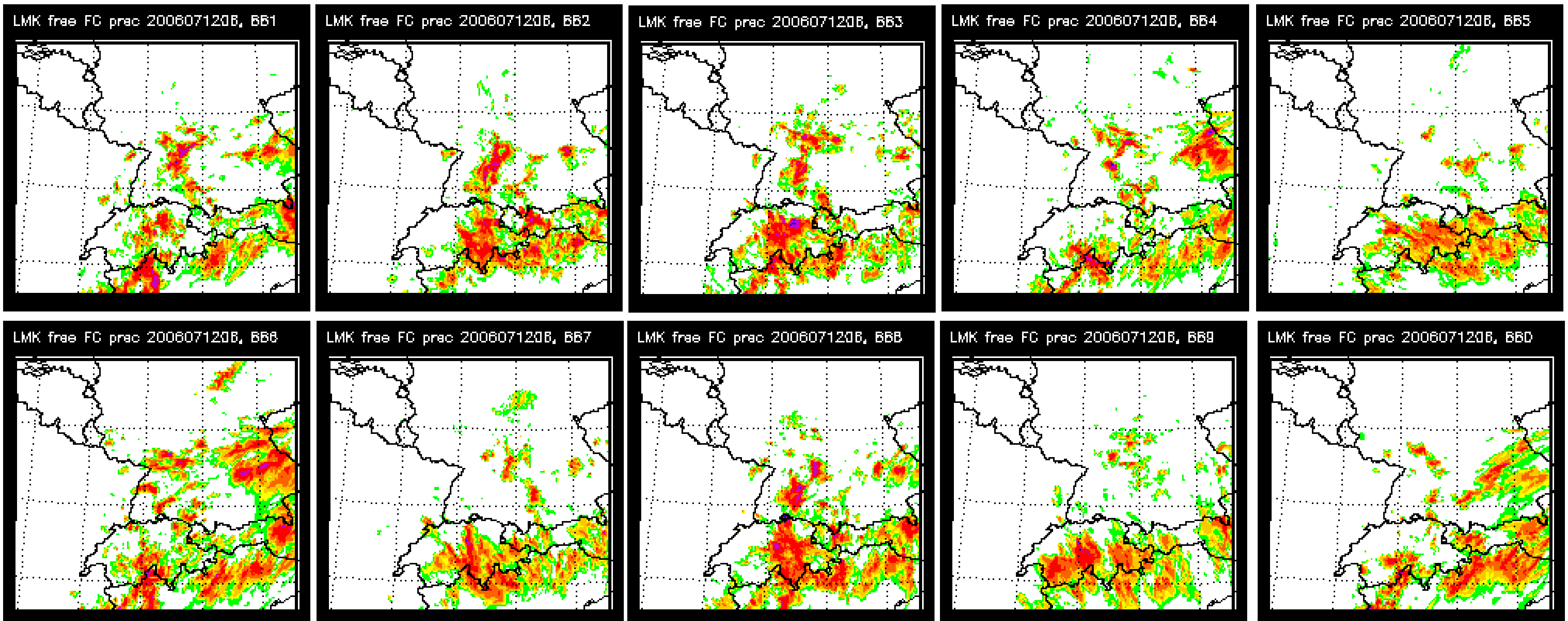


QPF on 12 July 2006

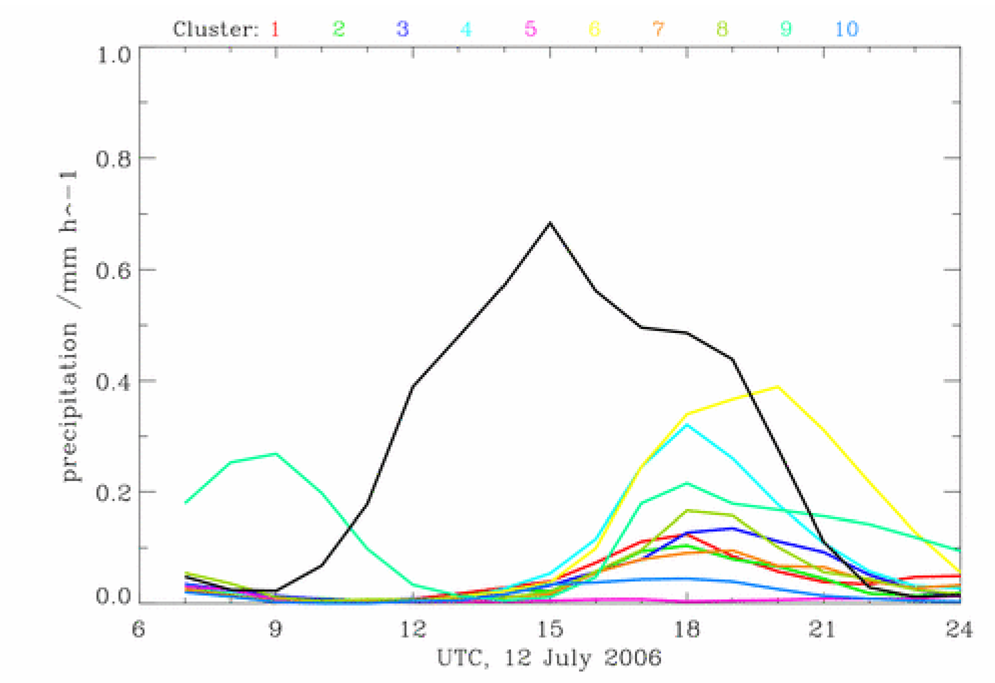


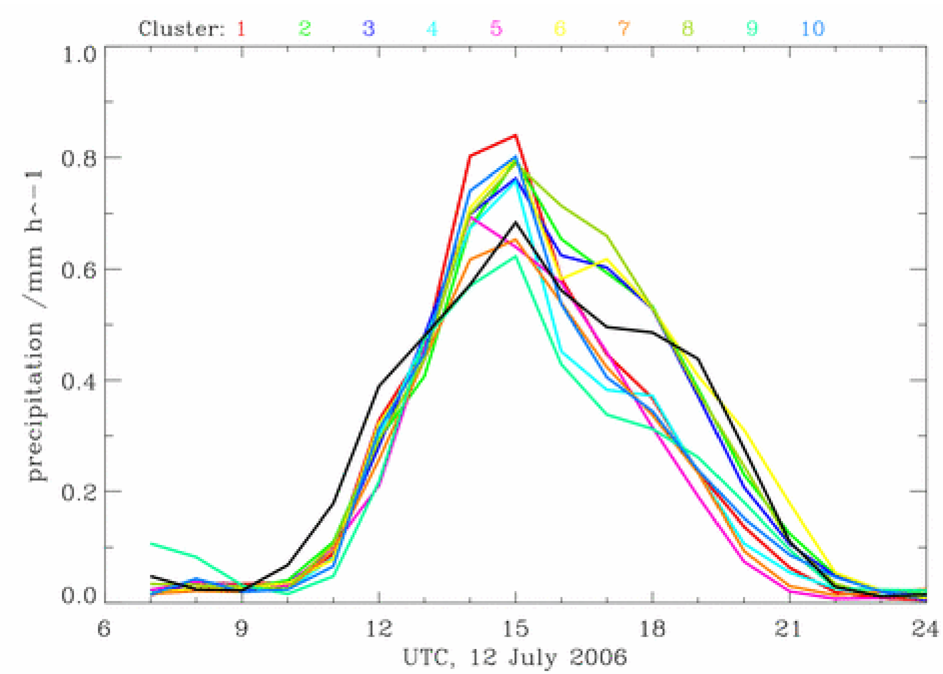
Radar observation

COSMO-DE with LHN



QPF on 12 July 2006





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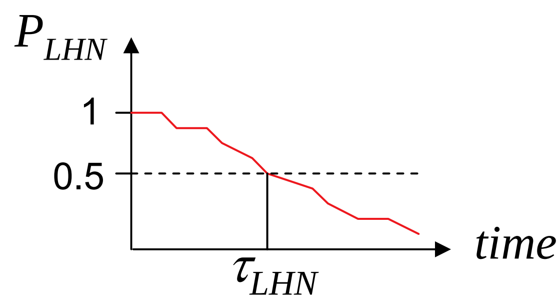
Experiments without LHN

Experiments with LHN

The impact timescale

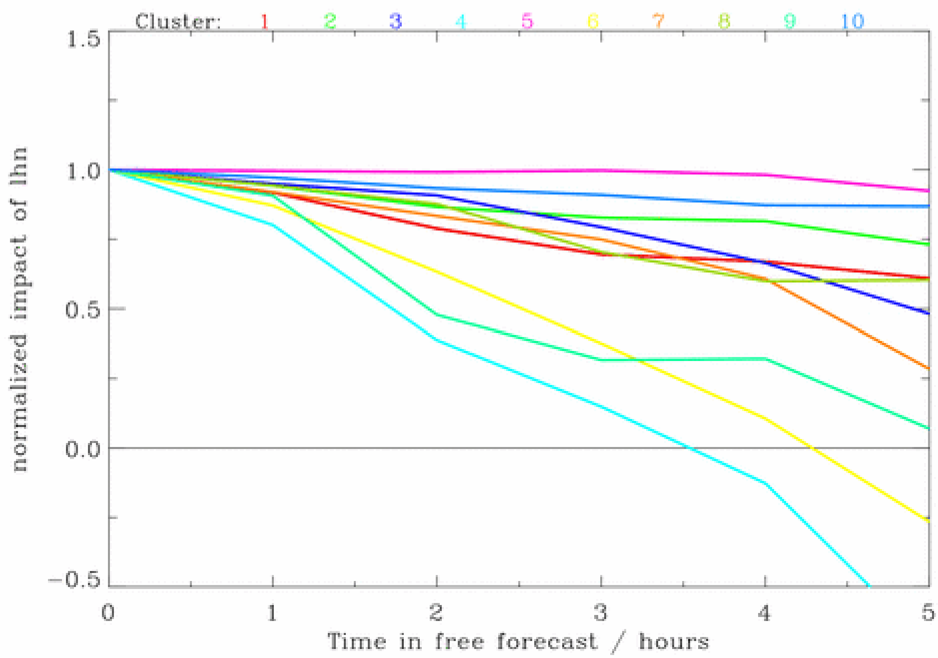
$$P^*(t) = \left| \frac{P_{LHN}(t) - P_{noLHN}(t)}{P_{LHN}(0) - P_{noLHN}(0)} \right|$$

$$\tau_{impact} = 0.5 \left(\frac{P^*(0) - P^*(\Delta t)}{\Delta t} \right)^{-1}$$



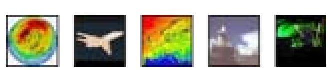
<u>impact timescale</u>: the impact timescale is estimated from the rate at which the impact of LHN decreases in the free forecast (to a value of 0.5); the impact of LHN is estimated from hourly precipitation rates.

Impact of LHN on 12 July 2006



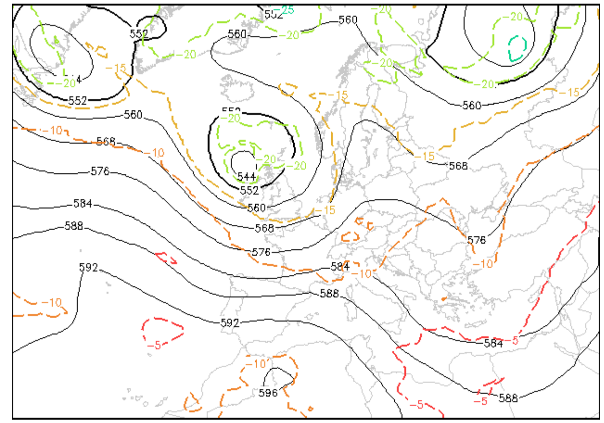
2 distinct regimes can be identified:

- all except 6,9,10: LHN triggers convection, little precip without LHN, impact stays more than 3hrs (Non-equilibrium)
- cl. 6,9,10: LHN has little effect, short-lived impact of LHN (Equilibrium)



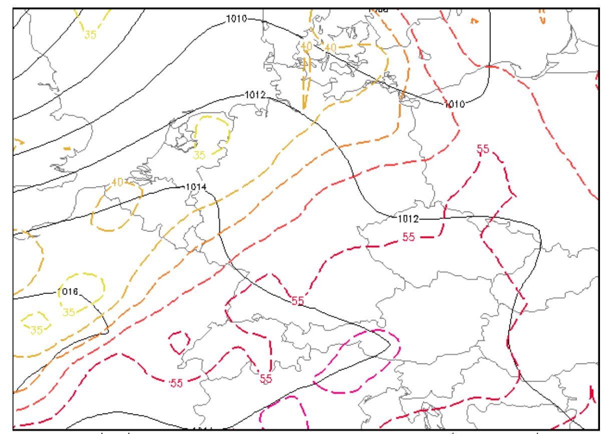
Ensemble Experiments in JJA 2006

- Type I: 31 July 2006
  - Forced frontal
- Type II: 28 June 2006
  - Forced non-frontal
- Type III: 12 July 2006
  - Air mass convection



Hoehe 500 hPa GFS (gpdm) Mo 31.07.06 12 GMT (Mo 00 + 12)
Temperatur 500 hPa GFS (°C) WetterOnline

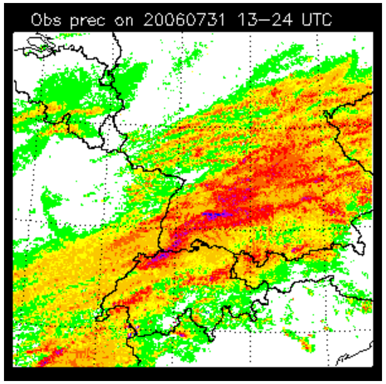
500 hPa



Bodendruck (hPa) Mo 31.07.06 12 GMT (Mo 00 + 12)
Equiv. Pot. Temp 850 hPa GFS (°C) WetterOnline

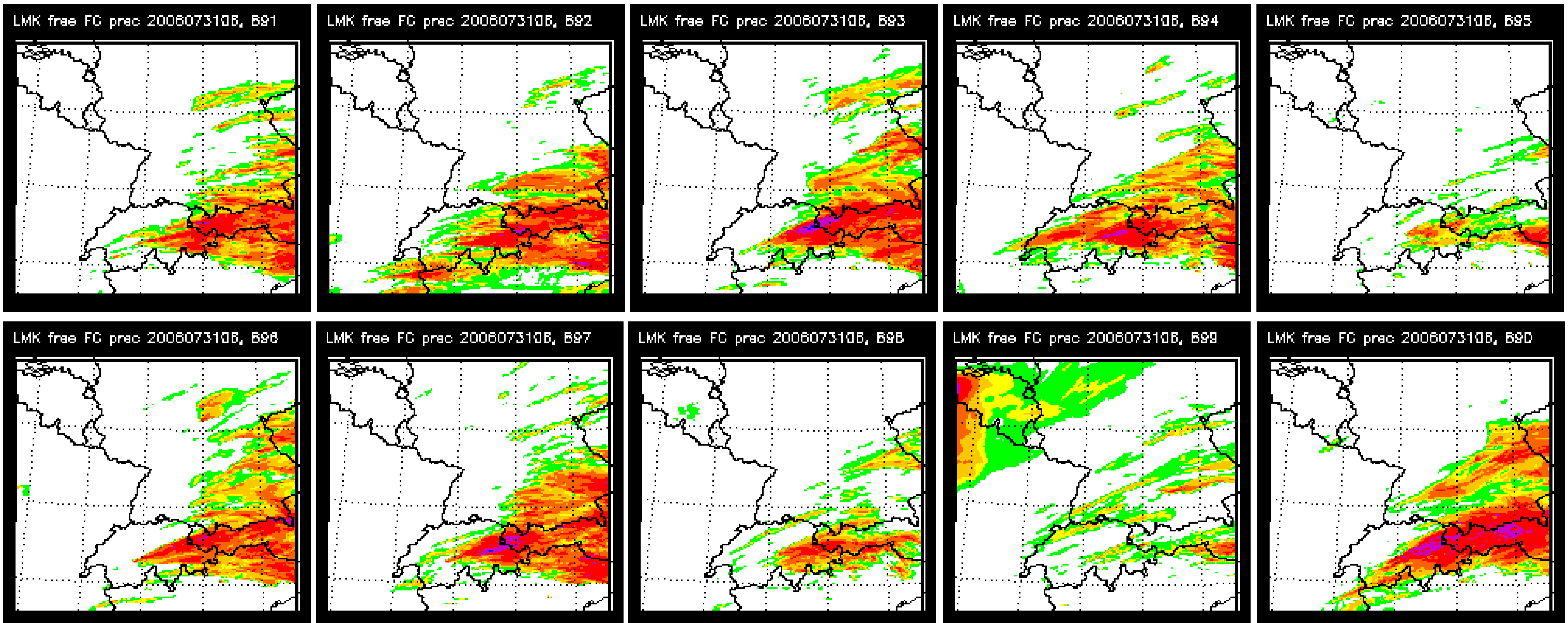
surface chart

QPF on 31 July 2006

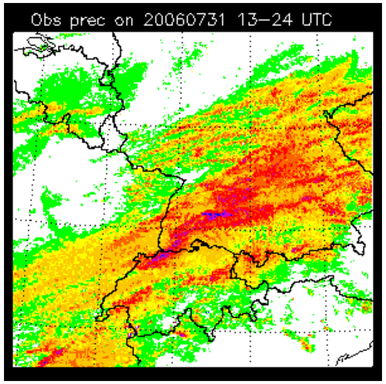


Radar observation

COSMO-DE

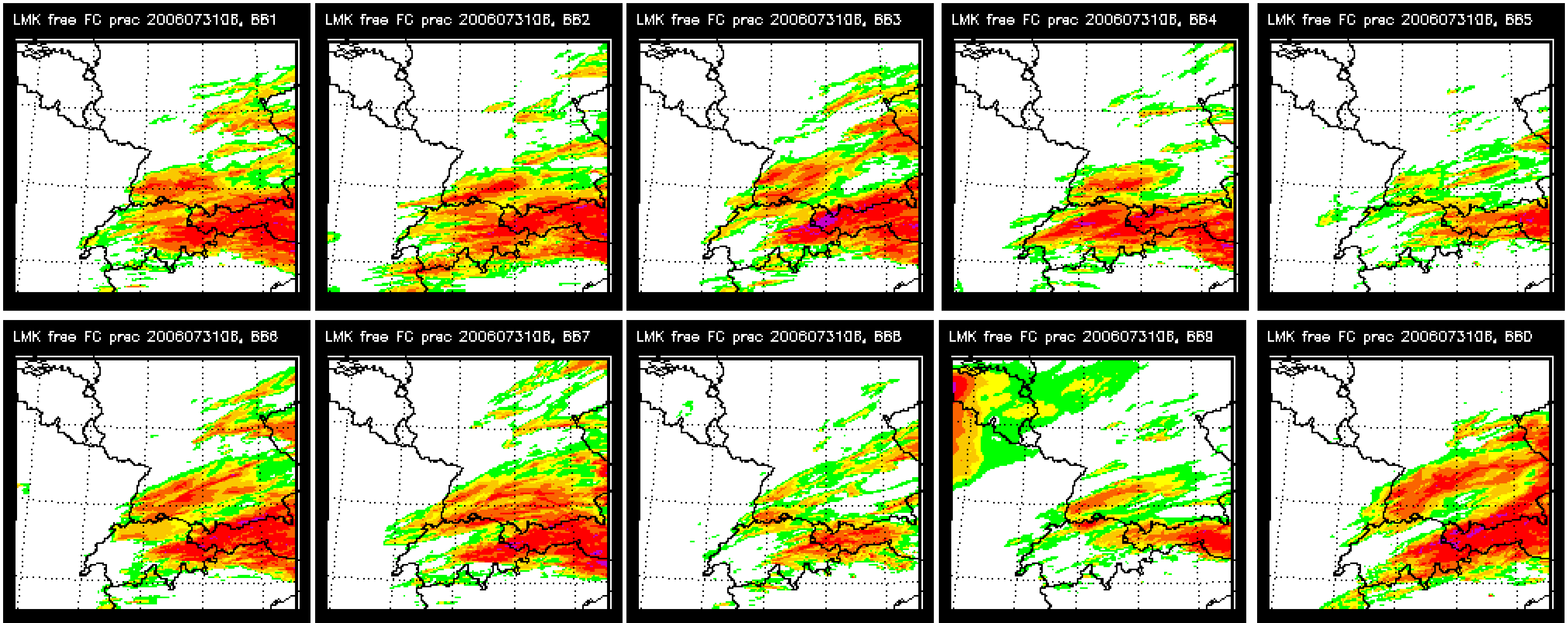


QPF on 31 July 2006

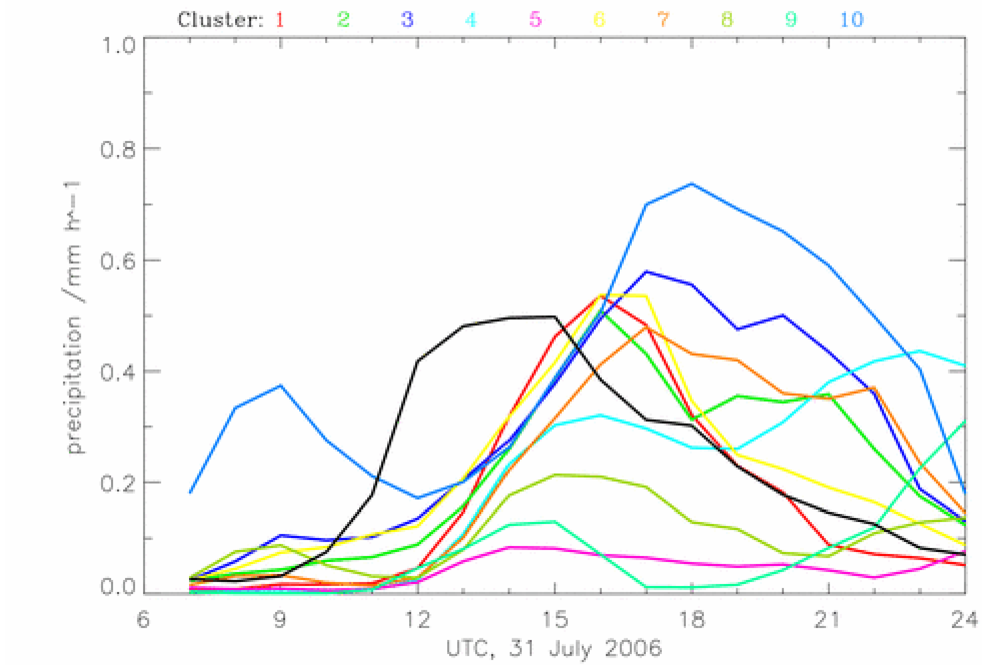


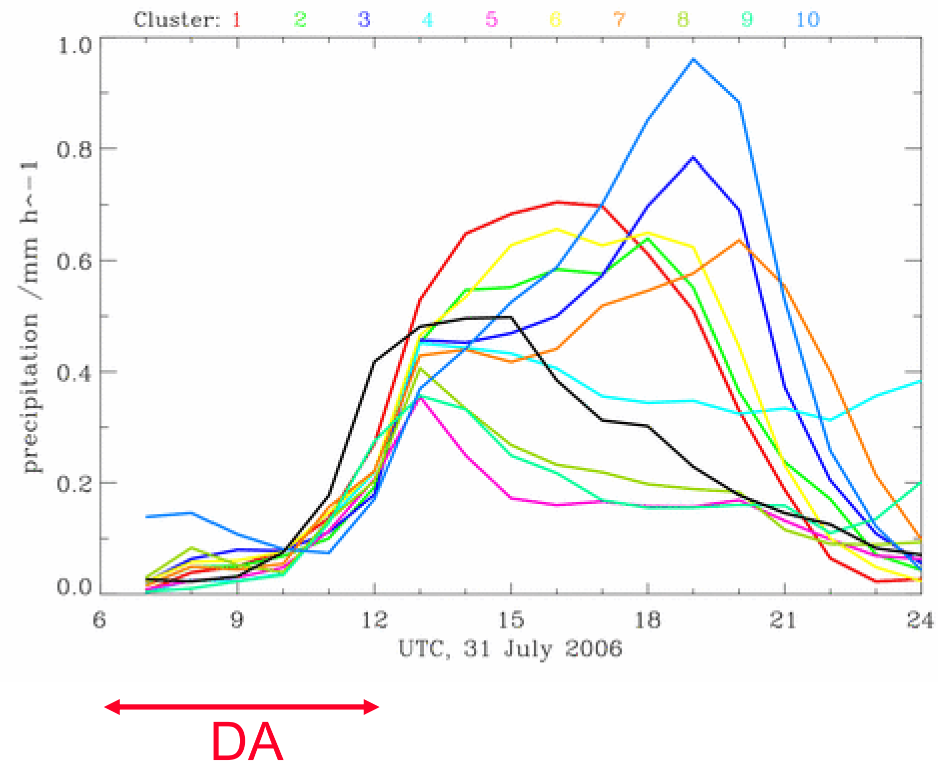
Radar observation

COSMO-DE with LHN



QPF on 31 July 2006

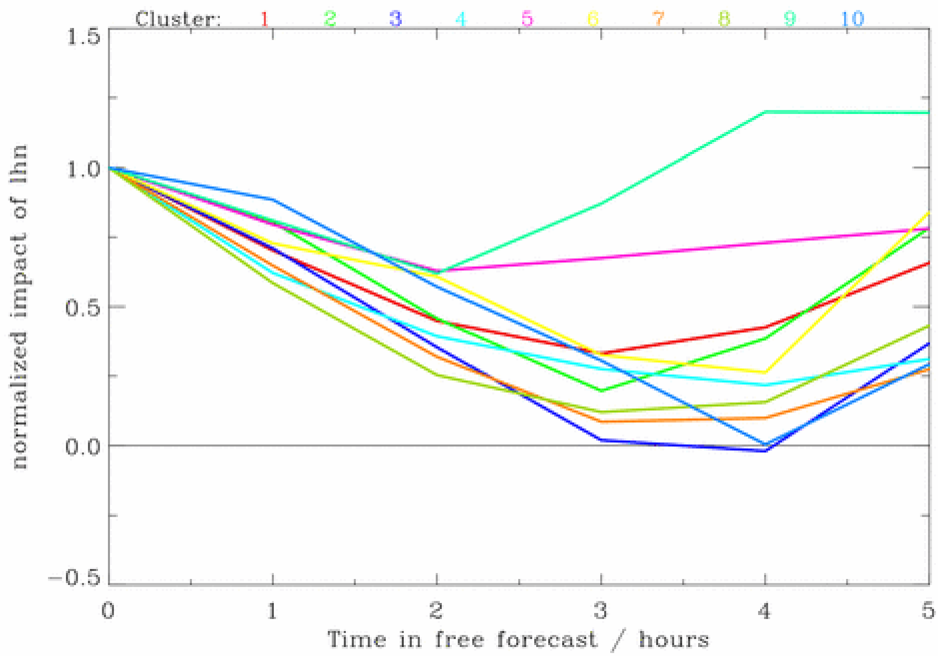




Experiments without LHN

Experiments with LHN

Impact of LHN on 31 July 2006



precipitation processes are governed by the synoptic-scale flow and the assimilation of radar data has only minor short-lived impact on QPF (equilibrium situation)

A second timescale: convective timescale

convective timescale: estimated from the rate at which instability (measured by CAPE) is being removed by convective heating (Done at al. QJ2006):

$$\boxed{\tau_c \sim \frac{CAPE}{d(CAPE)/dt}}$$

with d(CAPE)/dt can be determined from the precipitation rate P

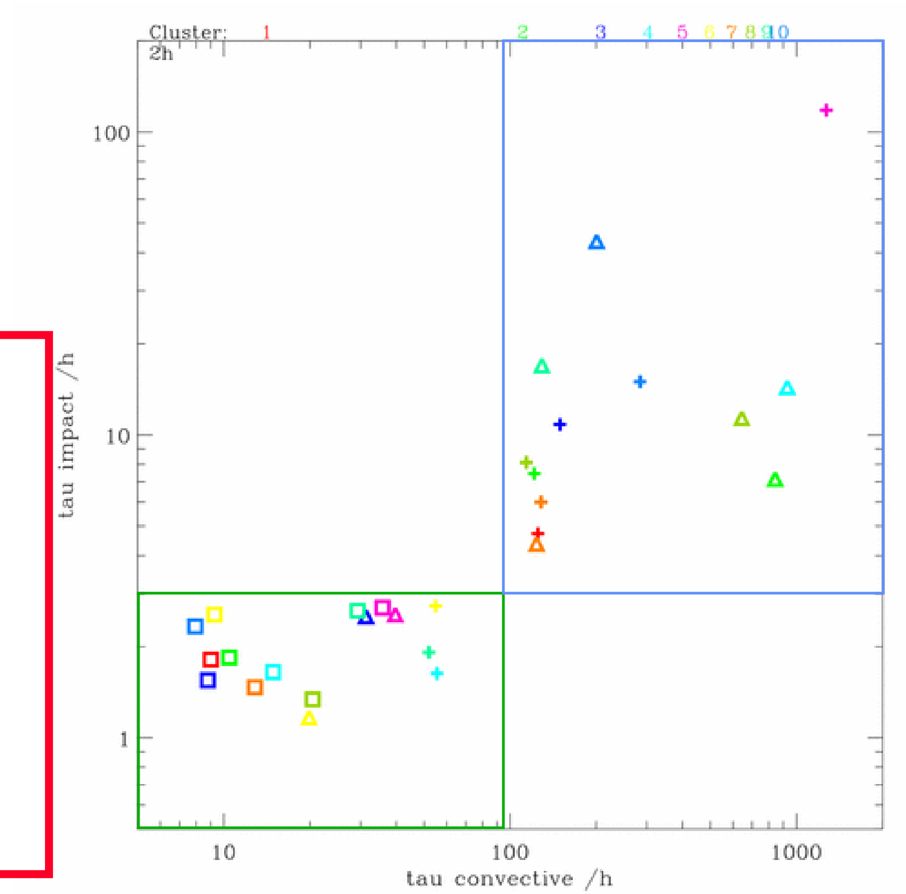
Stratification of Simulations

Scatter plot of different timescales of 30 forecasts of all cases:

Results suggest 2 different regimes:

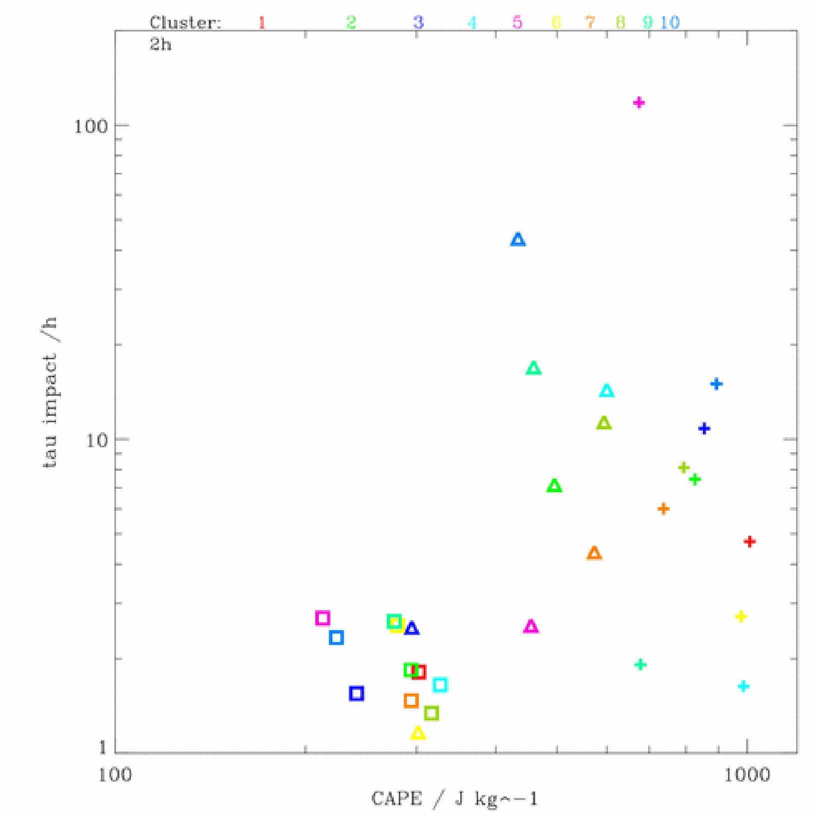
(a) equilibrium situation: convection only redistributed, short-lived impact of LHN

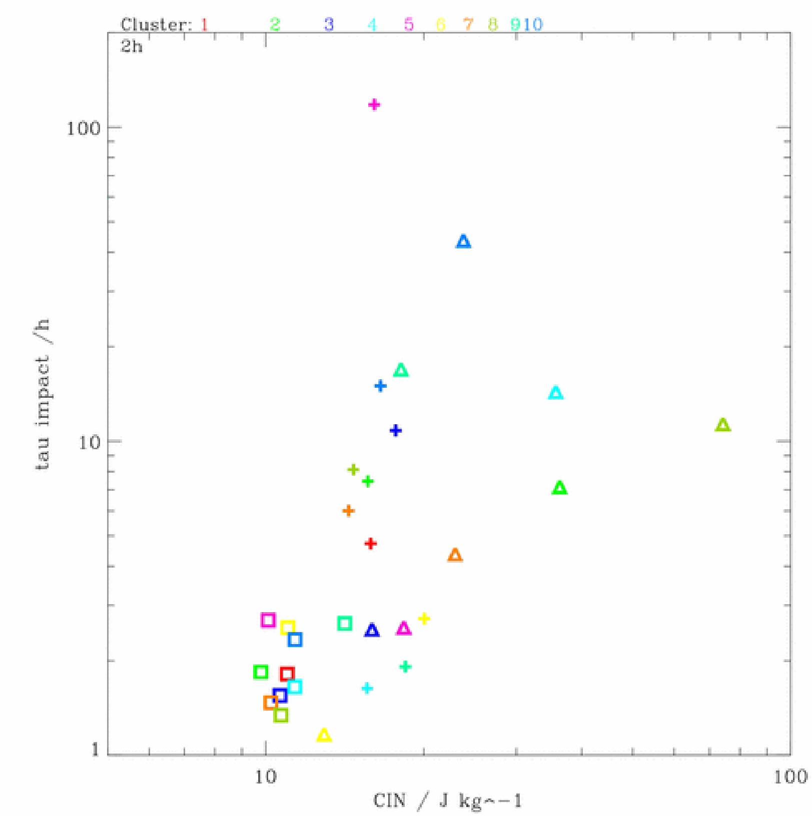
(b) non-equilibrium situation: LHN triggers convection, long lasting impact



□ forced frontal,
△ forced non-frontal
+ airmass

Stratification of Simulations

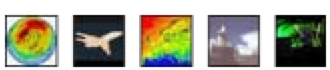




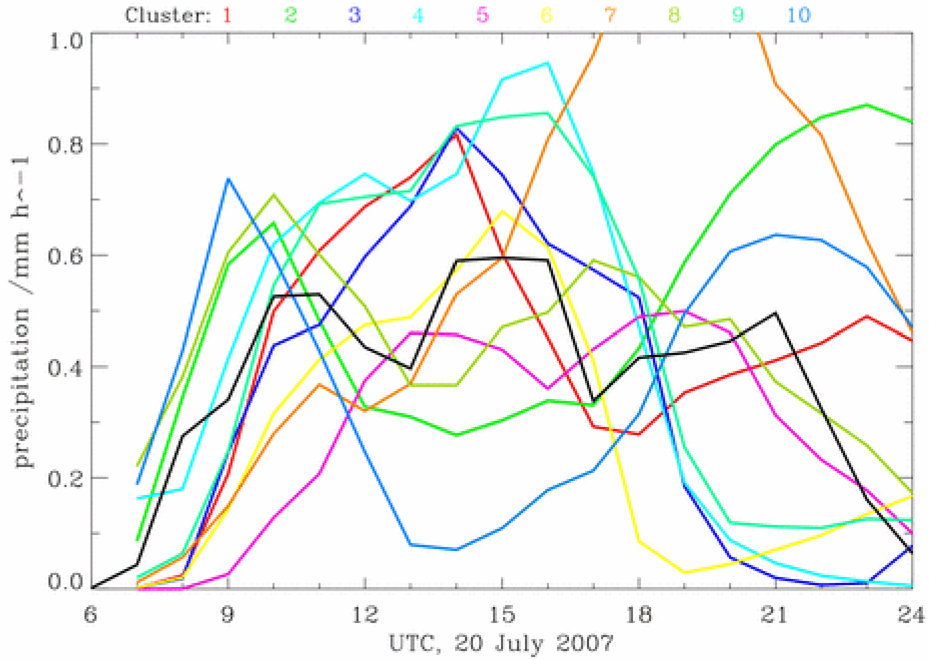
□ forced frontal,
Δ forced non-frontal
+ airmass

CAPE and CIN seem to be insufficient predictors

- of equilibrium or non-equilibrium conditions and
- the potential impact of LHN

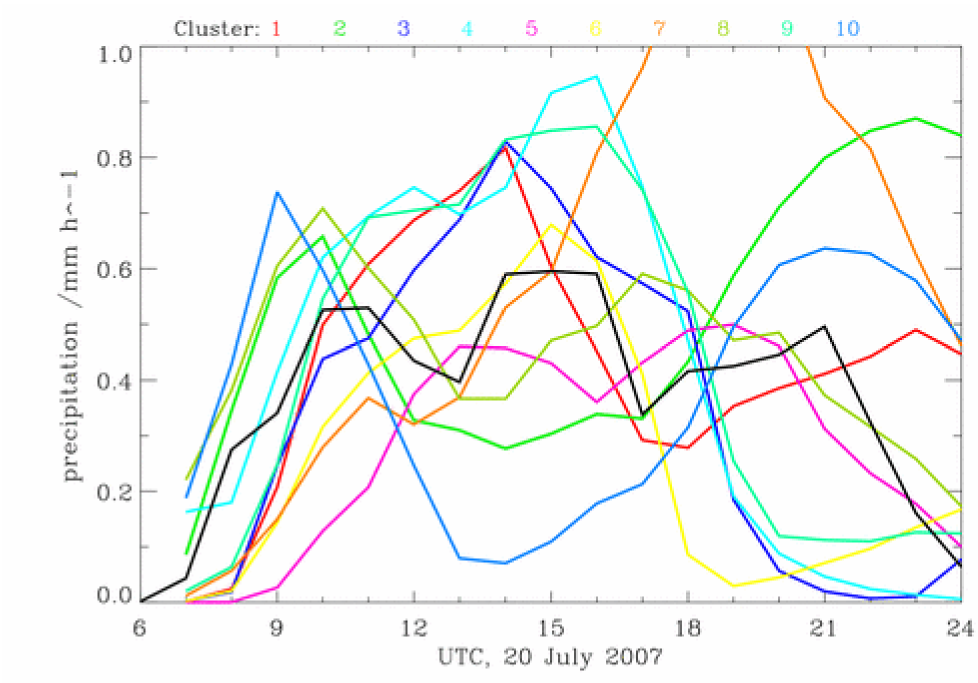


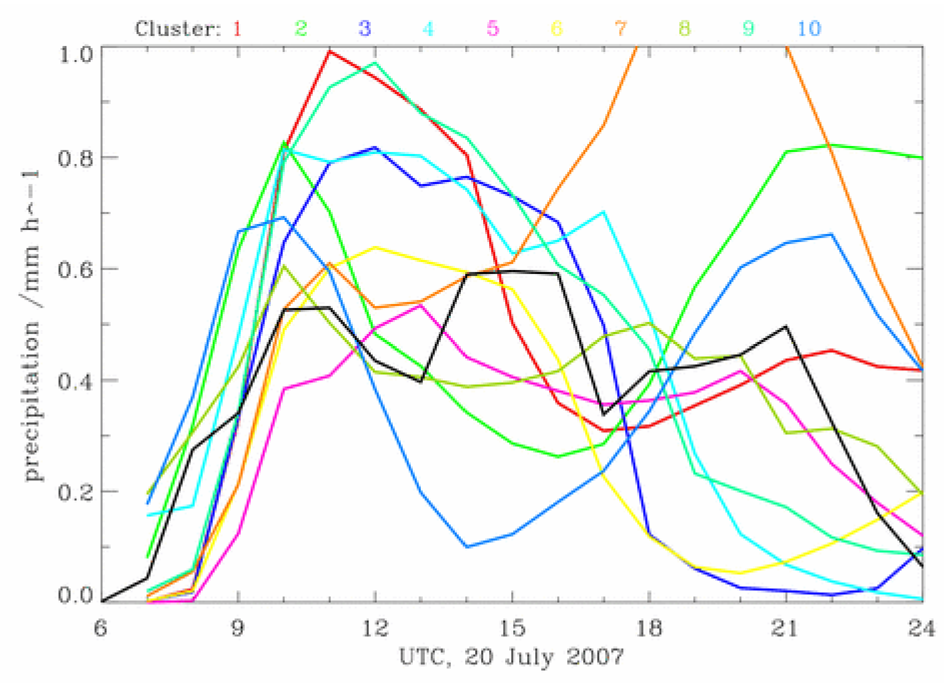
COPS IOP9c: QPF on 20 July 2007



Experiments without LHN

COPS IOP9c: QPF on 20 July 2007





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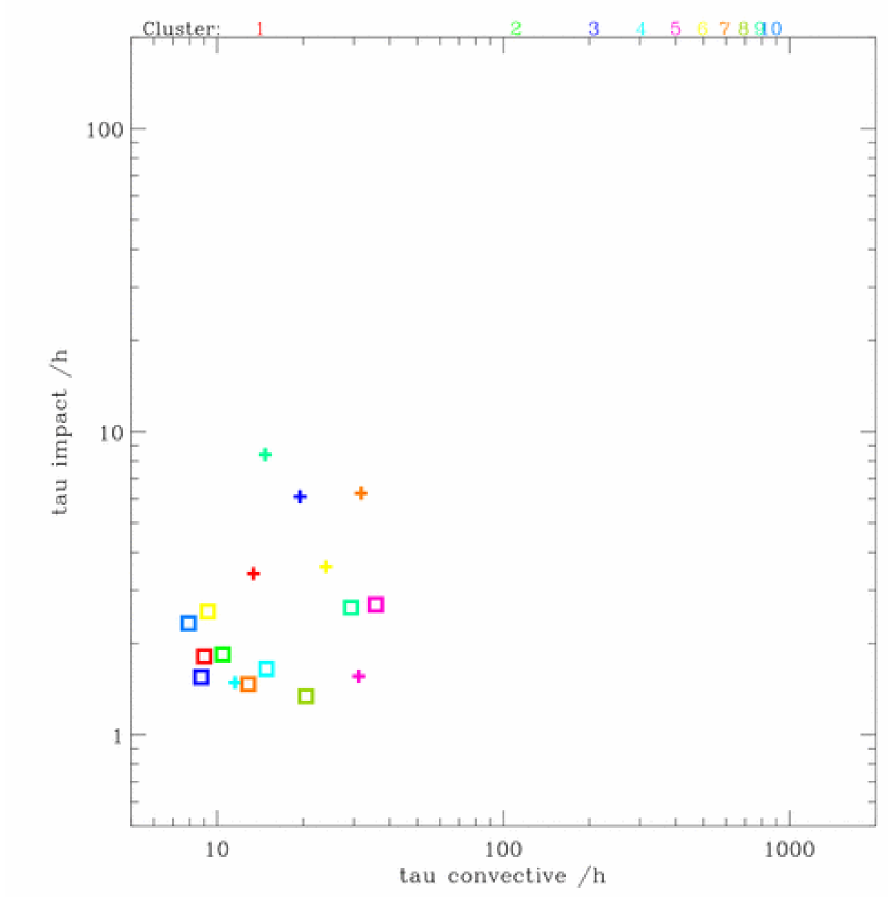
Experiments without LHN

Experiments with LHN

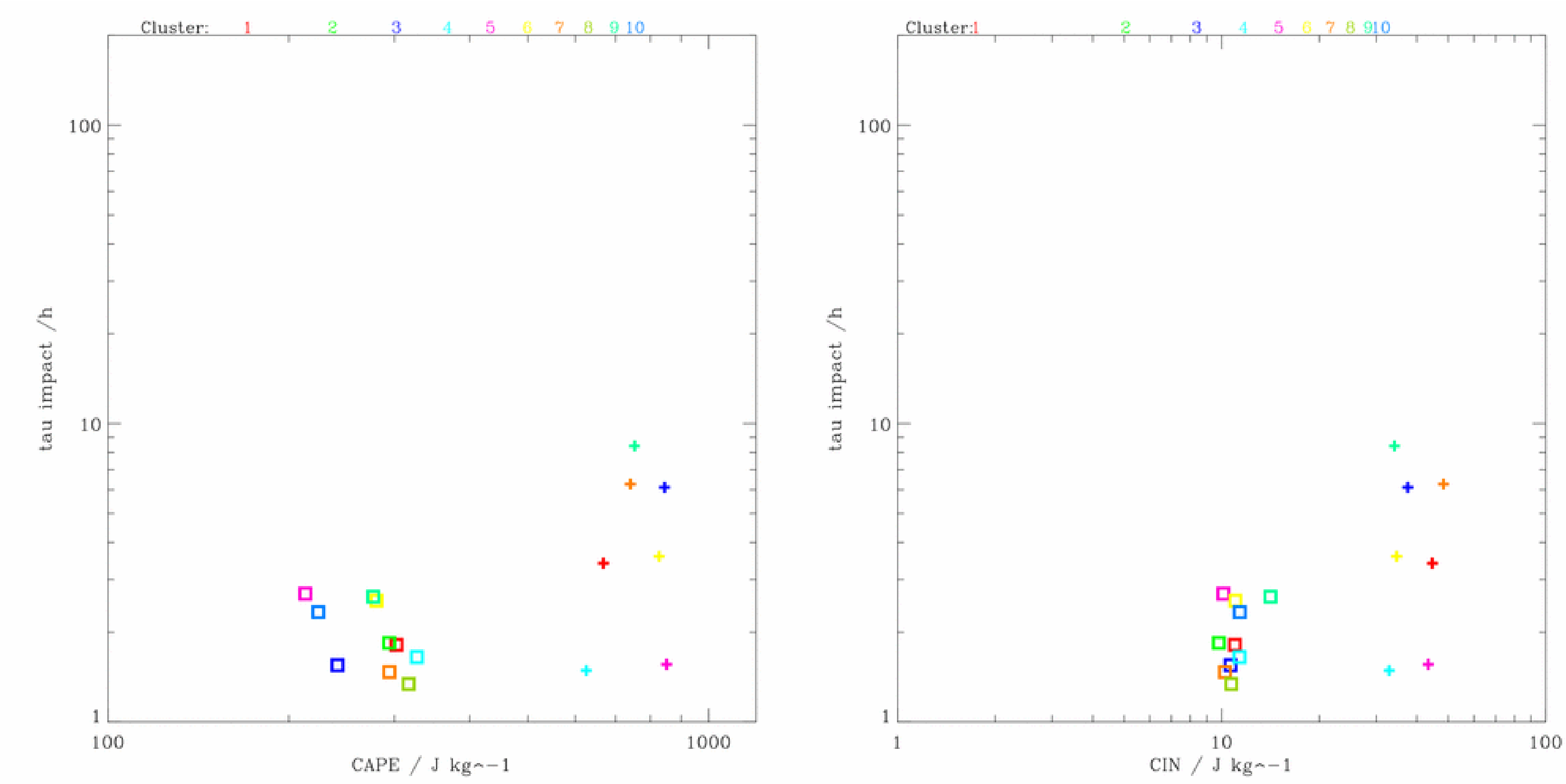
COPS IOP9c: 20 July 2007



□ 31 July 2006

+ 20 July 2007

COPS IOP9c: 20 July 2007



Summary

30 short range forecasts on 3 typical precipitation scenarios in COPS region support hypothesis on

<u>What determines the impact of LHN?</u>

Scenario 1: Forcing of convection is sufficiently homogeneous and slowly varying -> weak impact, conv. timescale 3-4 hours, 'equilibrium' situation

Scenario 2: weak synoptic scale forcing convection is governed by mesoscale details, no balance with large scale forcing -> large sensitivity of LHN, long-lived impact up to 6-8 hours, 'non-equilibrium' situation

Craig, Keil and Leuenberger: Constraints on the Impact of Radar Rainfall Data Assimilation on Forecasts of Cumulus Convection, *submitted to QJ 2008*