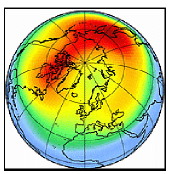
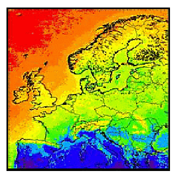
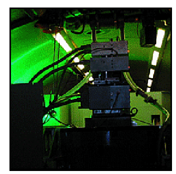
Predictability

George Craig

and the internet







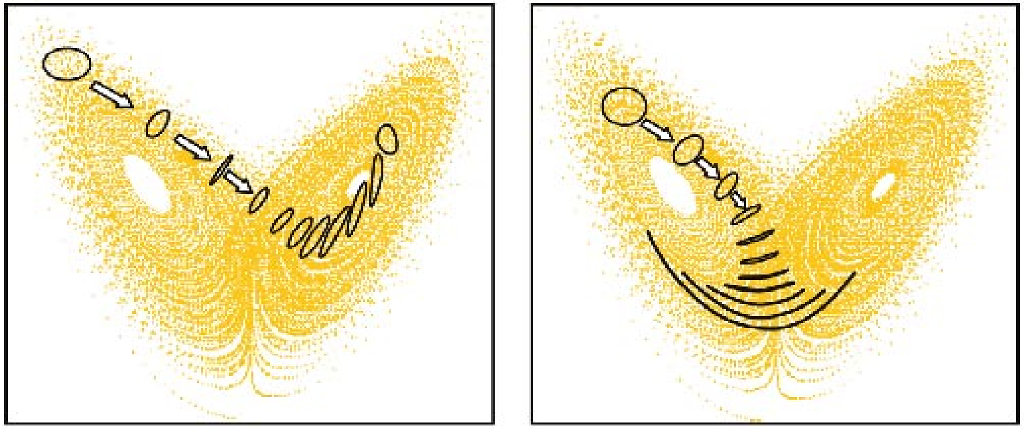
DLR

Institut für

Physik der Atmosphäre

Chaos and (Un)predictability

Sensitive dependence on initial conditions (sometimes)



$$\frac{dX}{dt} = F[X] \text{ is a nonlinear system}$$

$$\Rightarrow \frac{d\,\delta X}{dt} = \frac{dF}{dX}\delta X \equiv J\,\delta X$$

Since F is a nonlinear function of X

$$\Rightarrow J = J(X)$$

$\Rightarrow$ Finite time predictability depends on starting conditions

9 September 2002 ECMWF Seminar

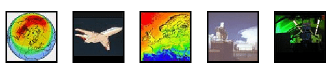
Palmer, 2002

Error Growth in Convection

Consider an idealised field of convective clouds (Lean, Gray and Clark, 2004)

- Nonhydrostatic NWP model, 4km resolution
- unstable sounding with capping inversion
- Initial pertubations to boundary layer theta
- same perturbation field with +/- amplitude

How fast do the simulations diverge?



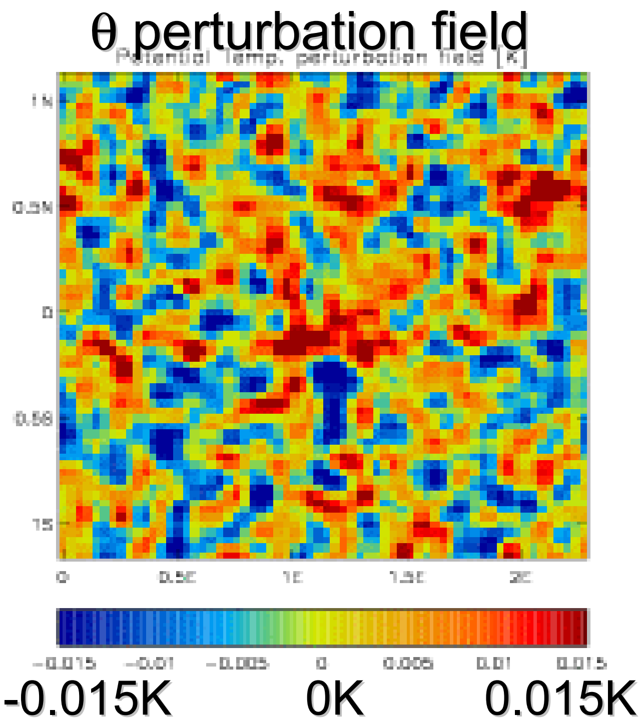
Perturbations

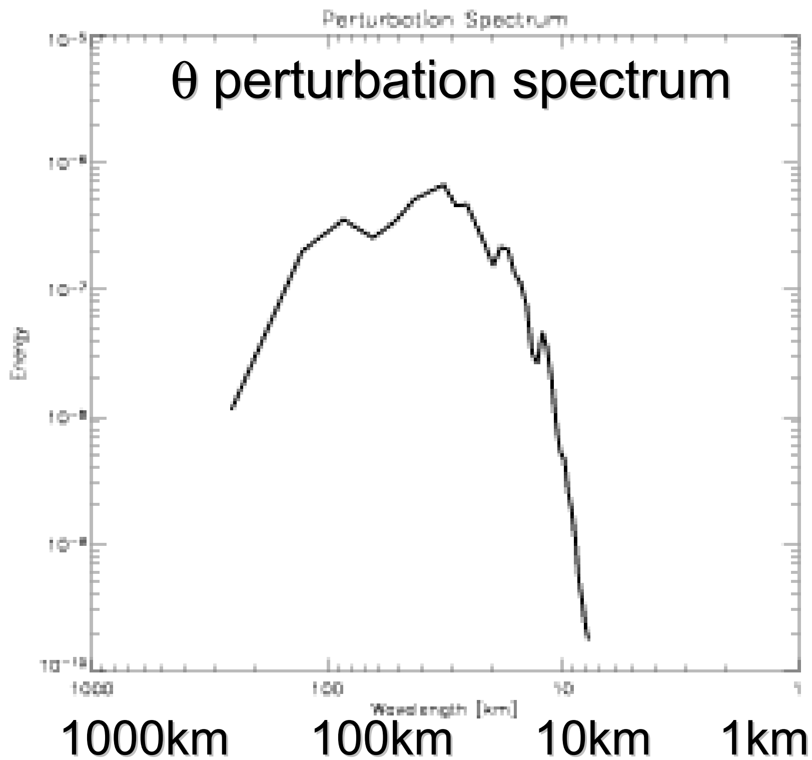
Random Gaussian Kernals

- Spatially coherent
- Allow user to specify spatial scale

Added to the θ field at the Lifting Condensation Level.

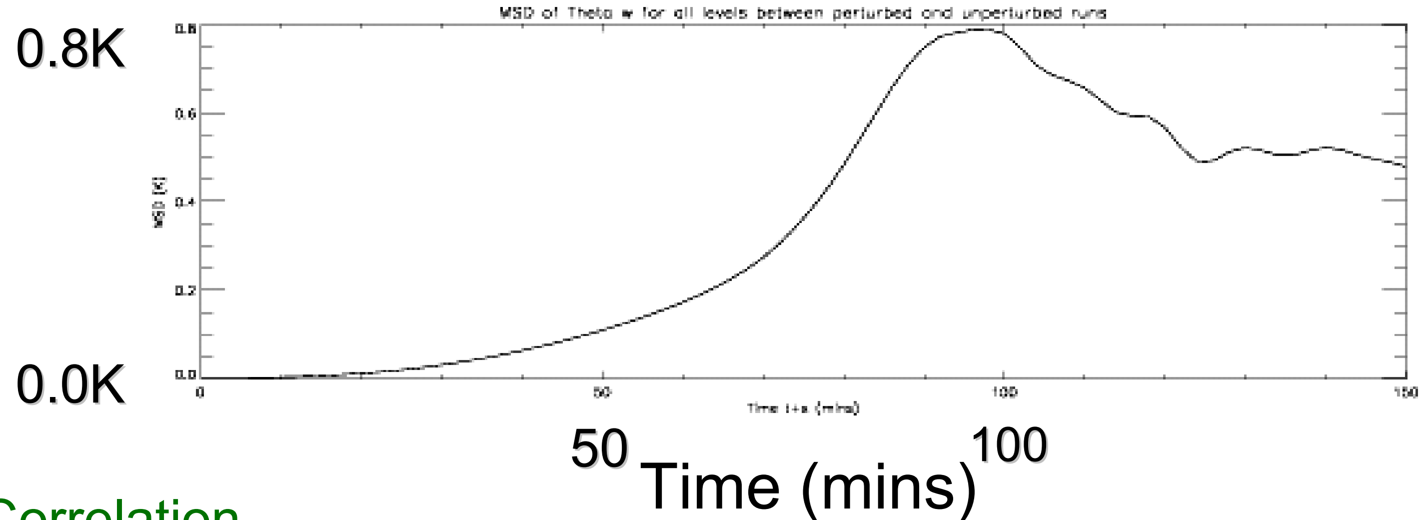
Lean, Gray and Clark, 2004



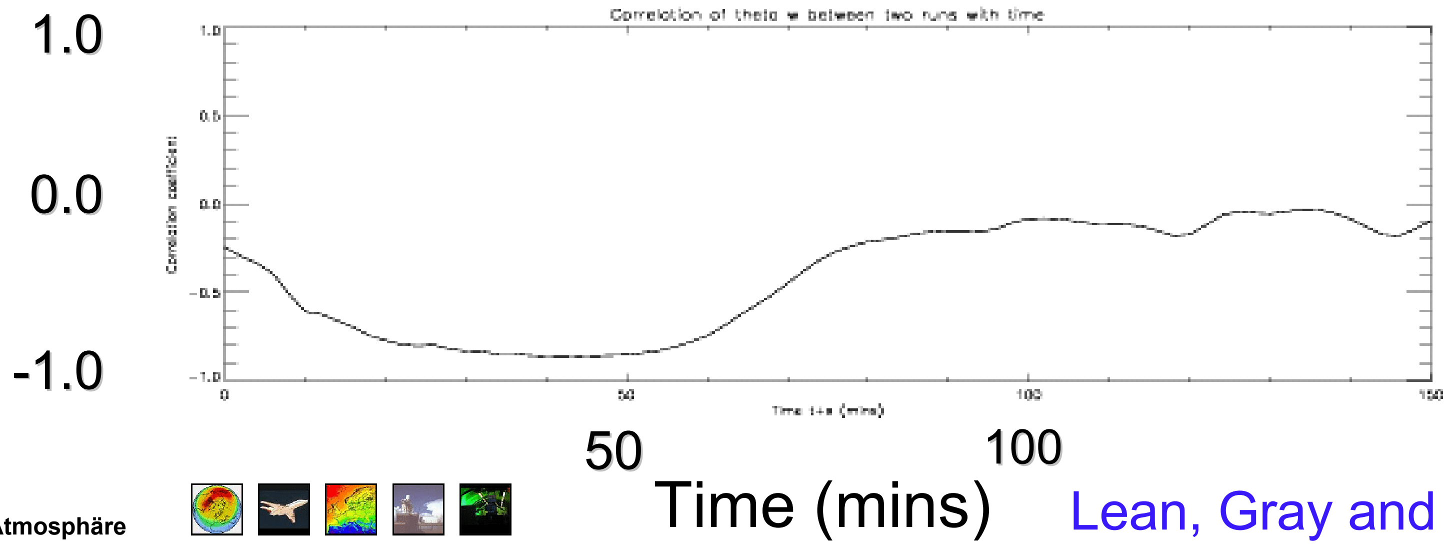


Growth of perturbations

- Mean Square Difference



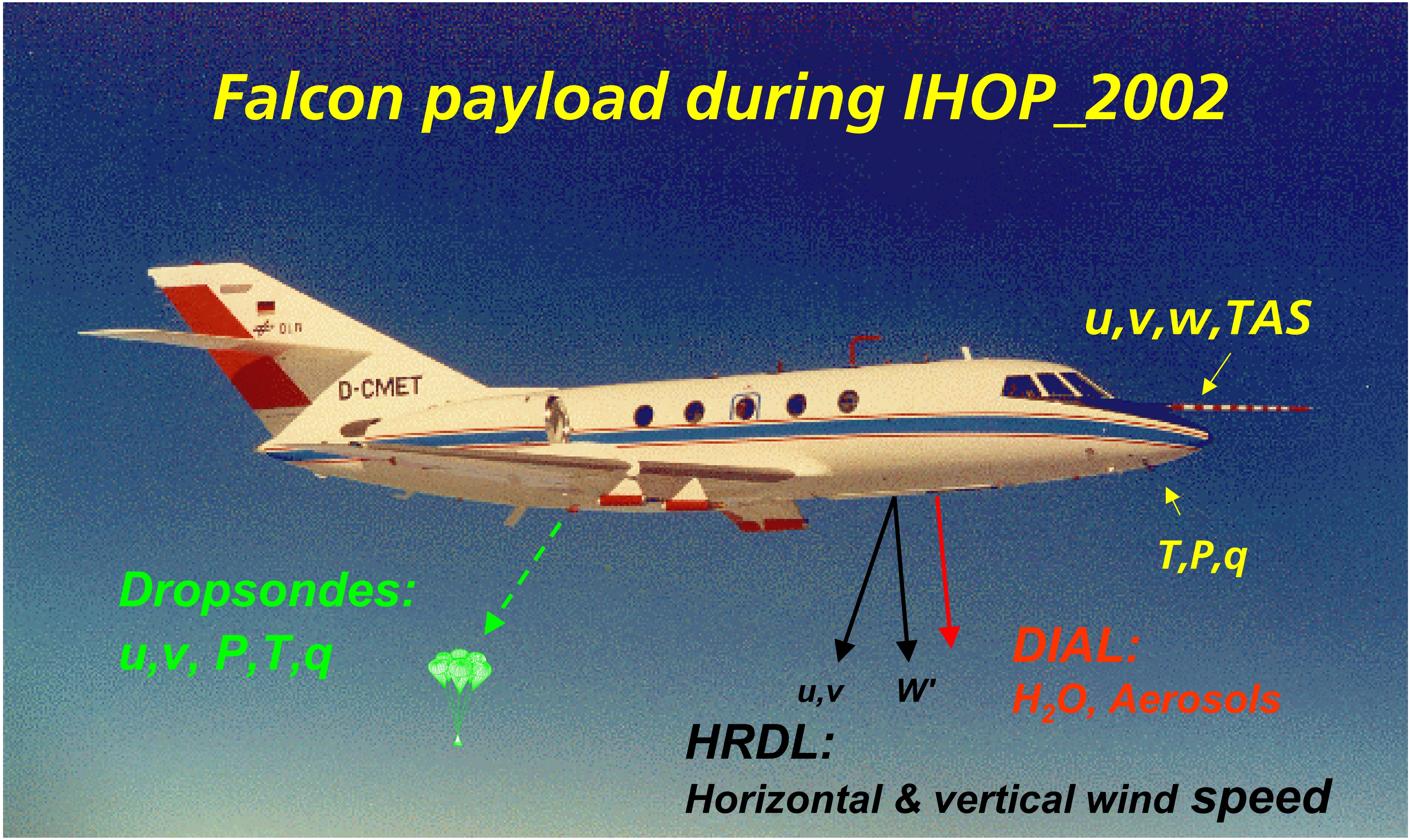
- Correlation



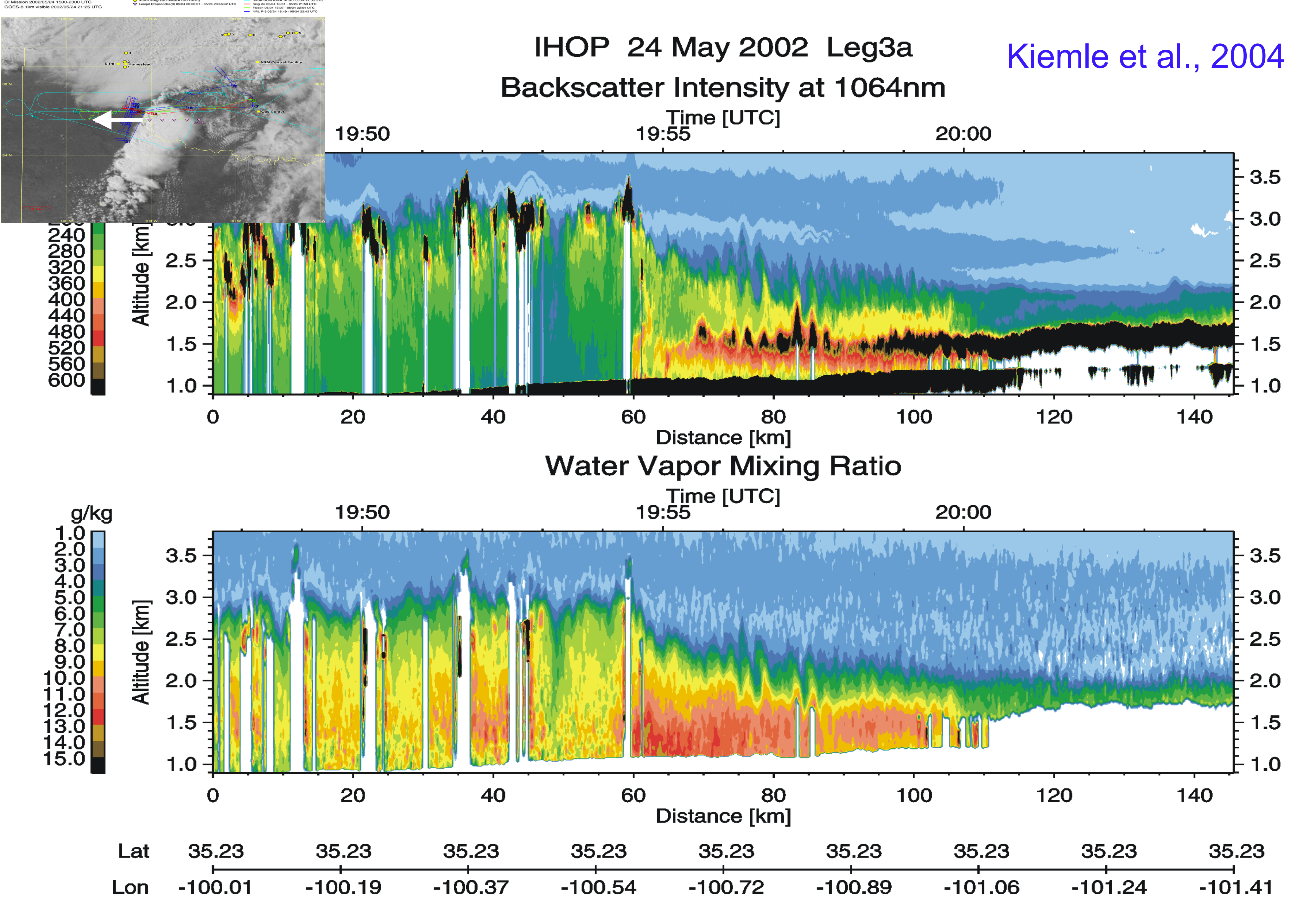
Lean, Gray and Clark, 2004

IHOP 2002

Importance of Mesoscale Structure



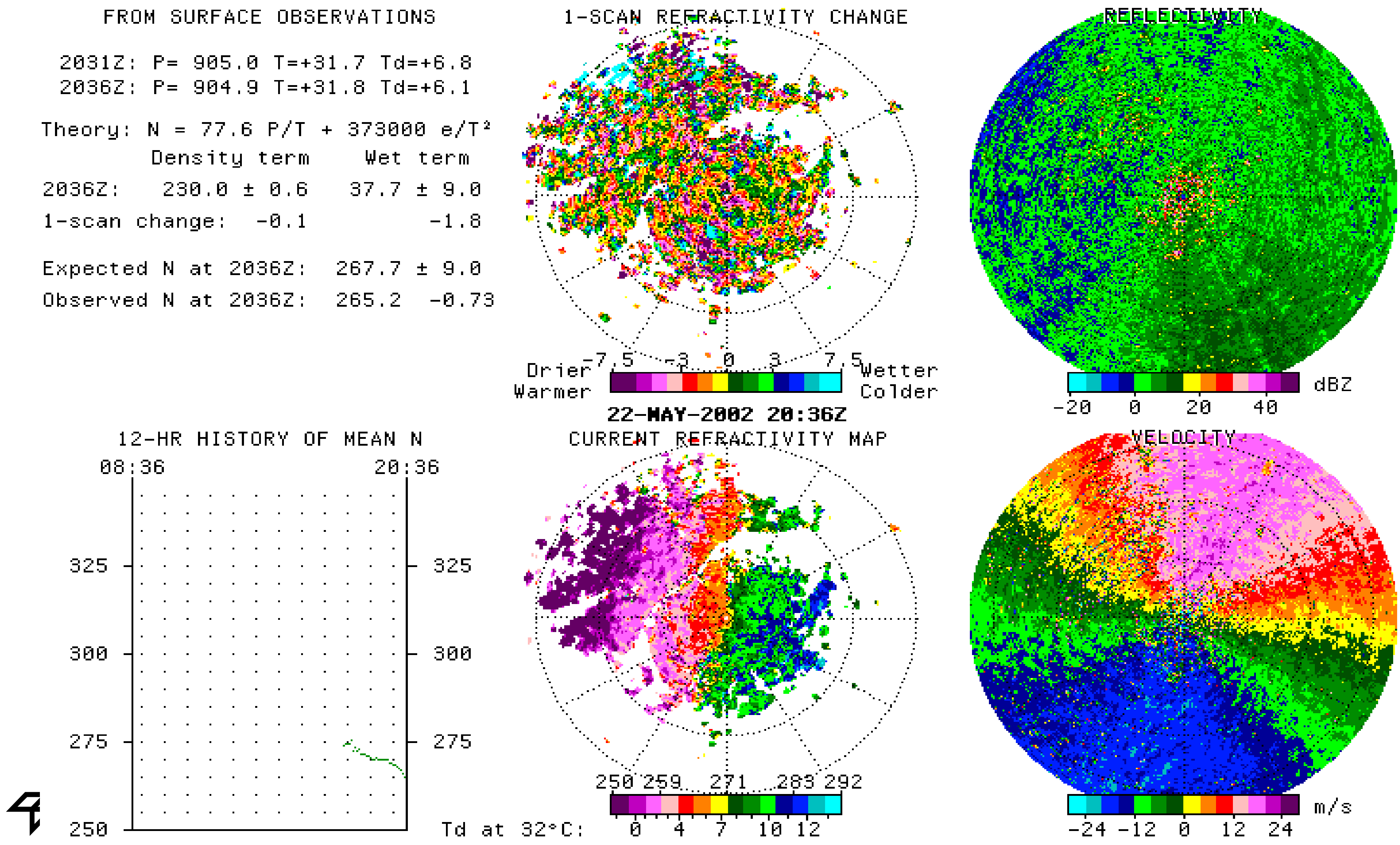
Kiemle, Ehret, Fix, Flentje, Poberaj, Wirth, Hardesty, Brewer and Sandberg, 2004



IHOP 24 May 2002 Leg3a
Kiemle et al., 2004
Backscatter Intensity at 1064nm
Time [UTC]
19:50
19:55
20:00
Altitude [km]
1.0
1.5
2.0
2.5
3.0
3.5
240
280
320
360
400
440
480
520
560
600
0
20
40
60
80
100
120
140
Distance [km]
Water Vapor Mixing Ratio
g/kg
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
Lat
35.23
Lon
-100.01
-100.19
-100.37
-100.54
-100.72
-100.89
-101.06
-101.24
-101.41
ARM Central Facility
S-Pol
Homestead
Ops Center

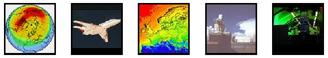
Example: Boundary Evolution

Fabry, 2004



MAP

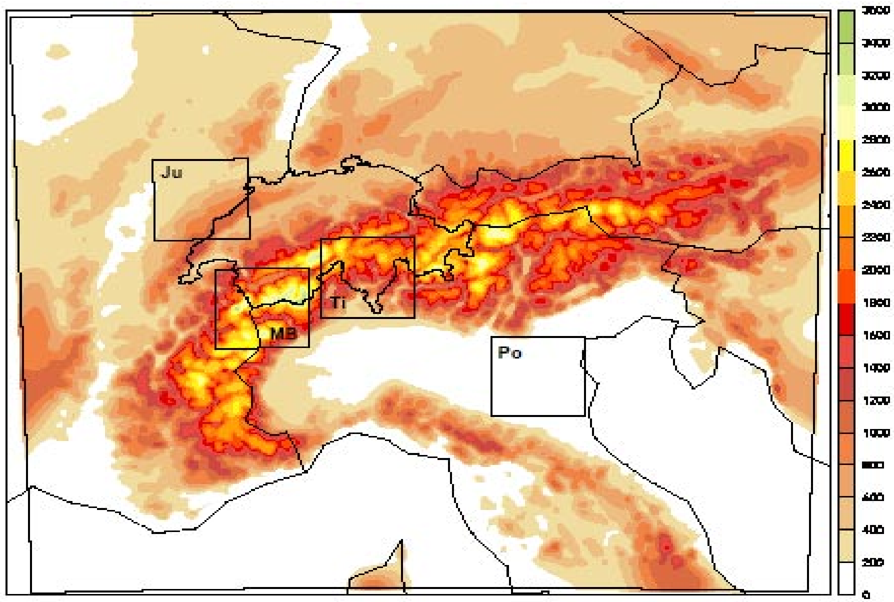
Importance of Orography



Ensemble Simulation (6 members)

The MC2 Model

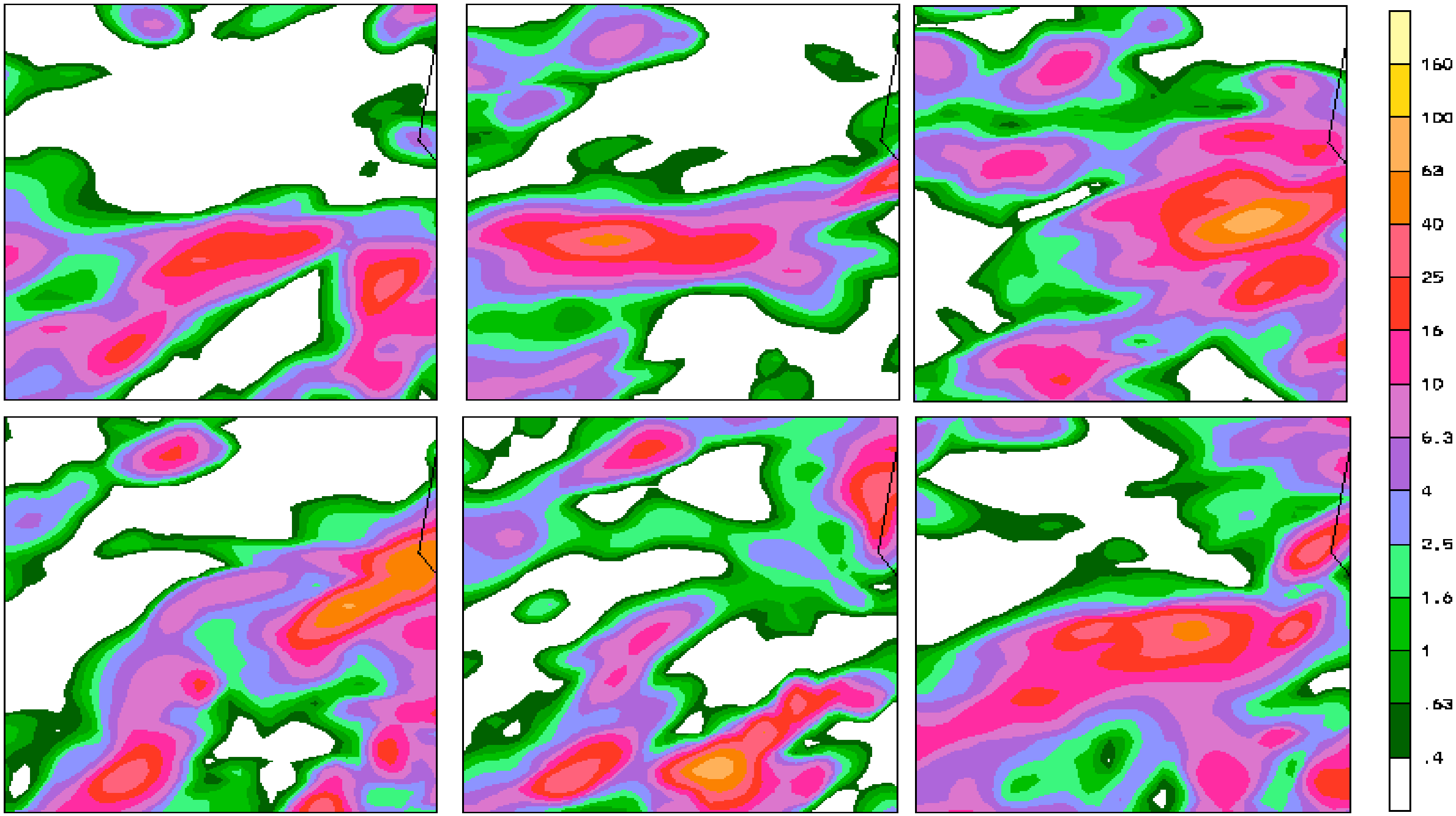
- 3 km horizontal grid-spacing
- 50 vertical levels
- 1030 x 880 km domain over the European Alps
- non-hydrostatic
- semi-lagrangian and semi-implicit
- convection treated explicitly (no parameterization)
- surface scheme: simplified force-restore method.



Walser, Lüthl and Schär, 2004

Flat terrain

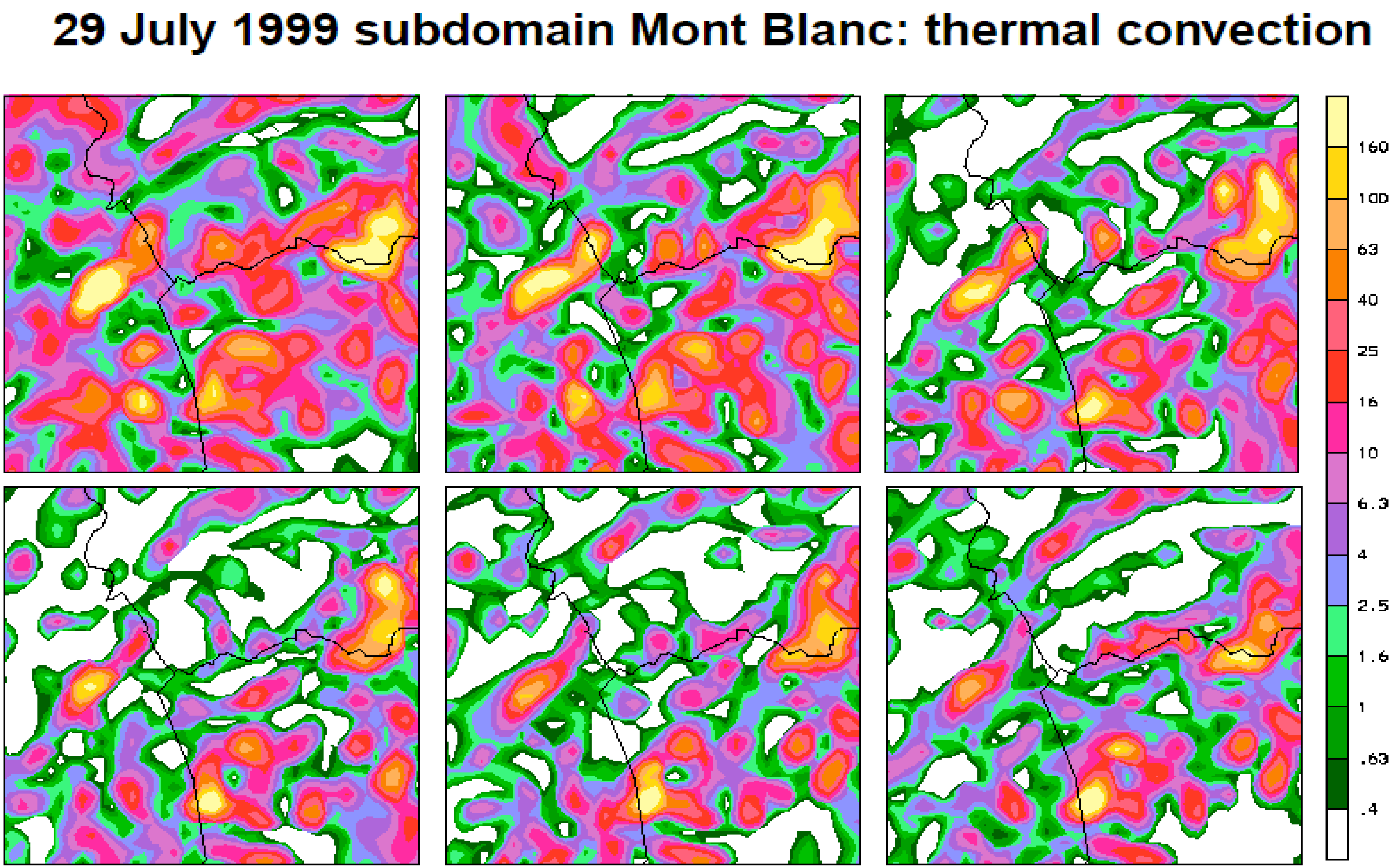
29 July 1999 subdomain Po: thermal convection



Daily precipitation sum [mm] for members 1-6

Walser, Lüthl and Schär, 2004

Alpine region

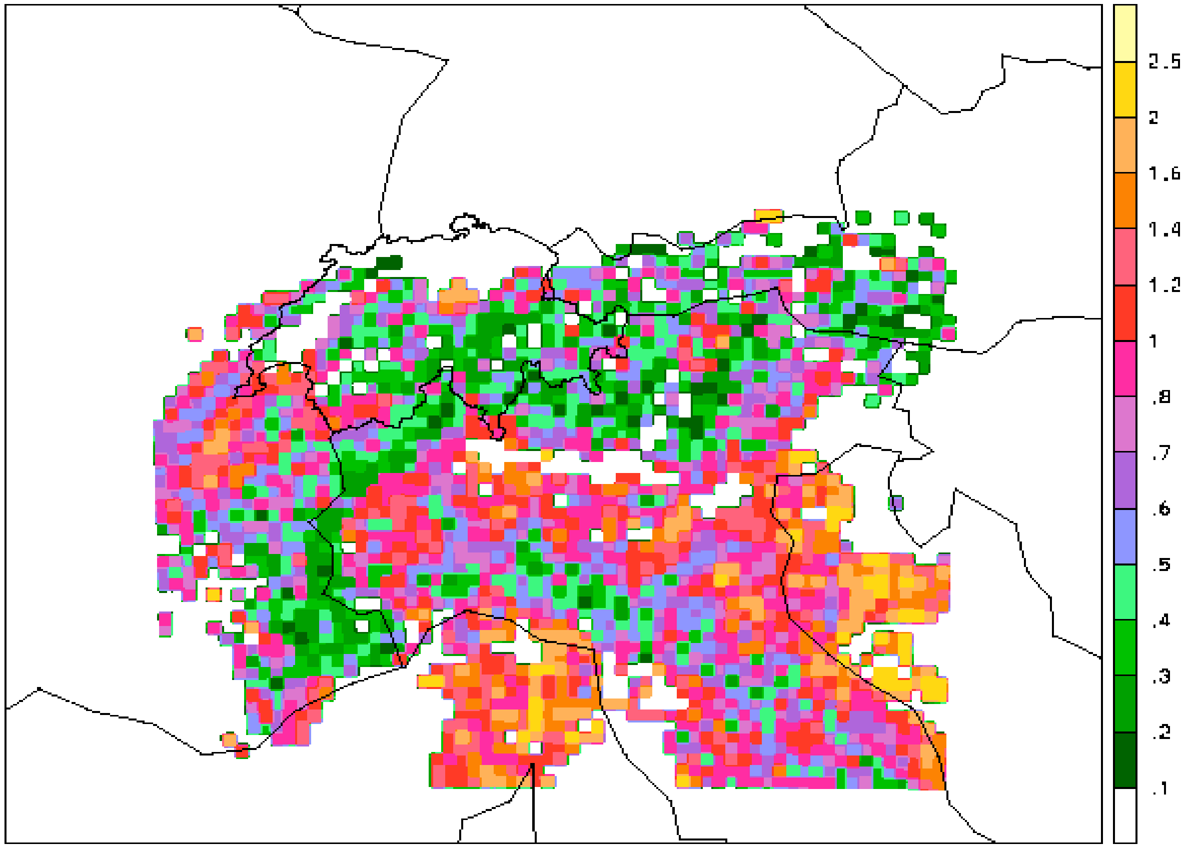


Daily precipitation sum [mm] for members 1-6.

Walser, Lüthl and Schär, 2004

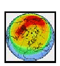
Variability of Precipitation in Ensemble

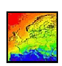
29 July 1999: Geographical variability of predictability



Ratio of standard deviation to the ensemble mean (threshold 1mm) of daily precipitation.

Walser, Lüthl and Schär, 2004



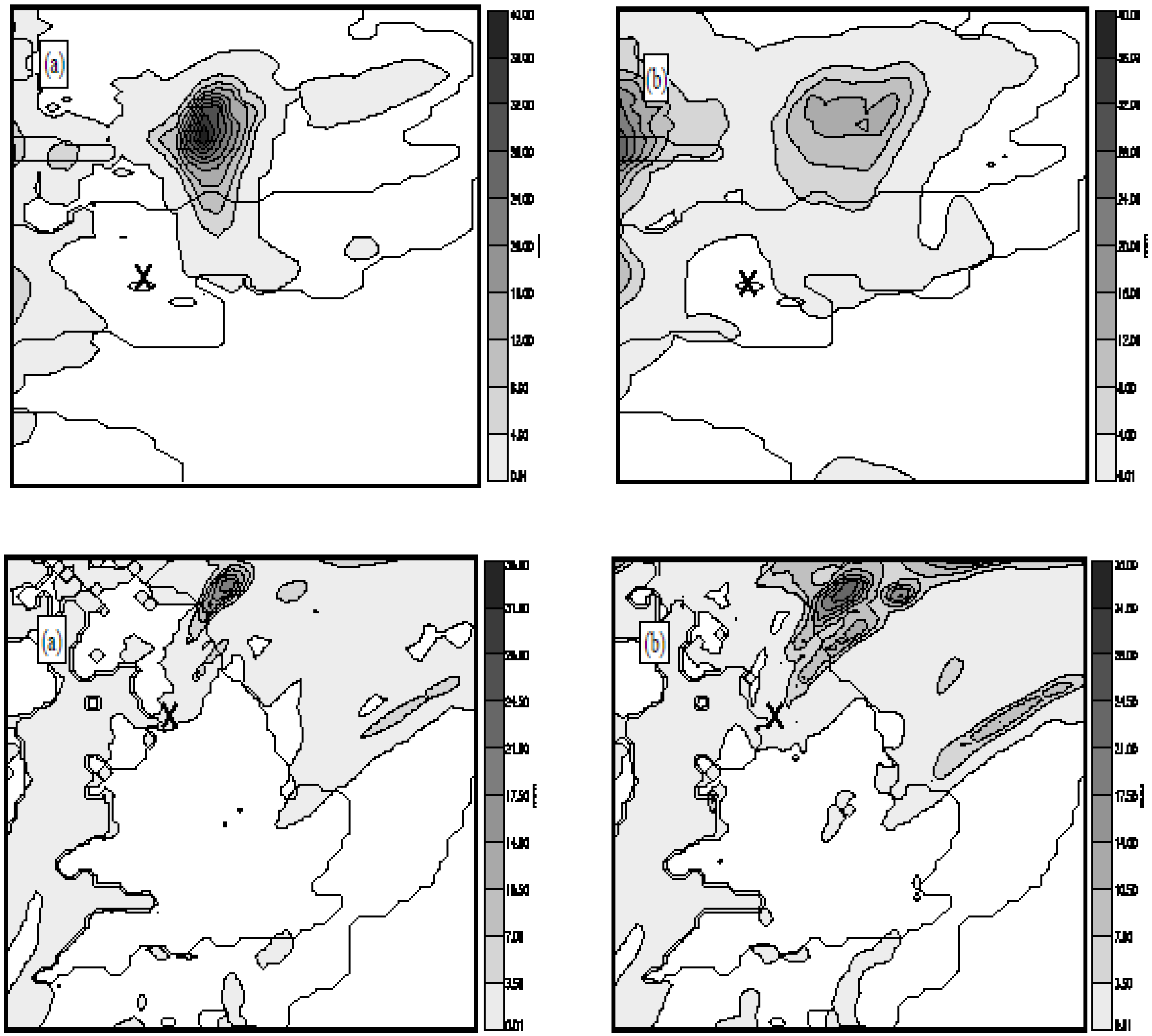


COPS

What determines extent of convective predictability in intermediate orography?

Different Kinds of Predictability

Deterministic Forecast | Ensemble Mean (6 mem)



6 hour accumulated precipitation

Elevated warm front

No CIN

Location unpredictable

Moderate orography

Moderate CIN

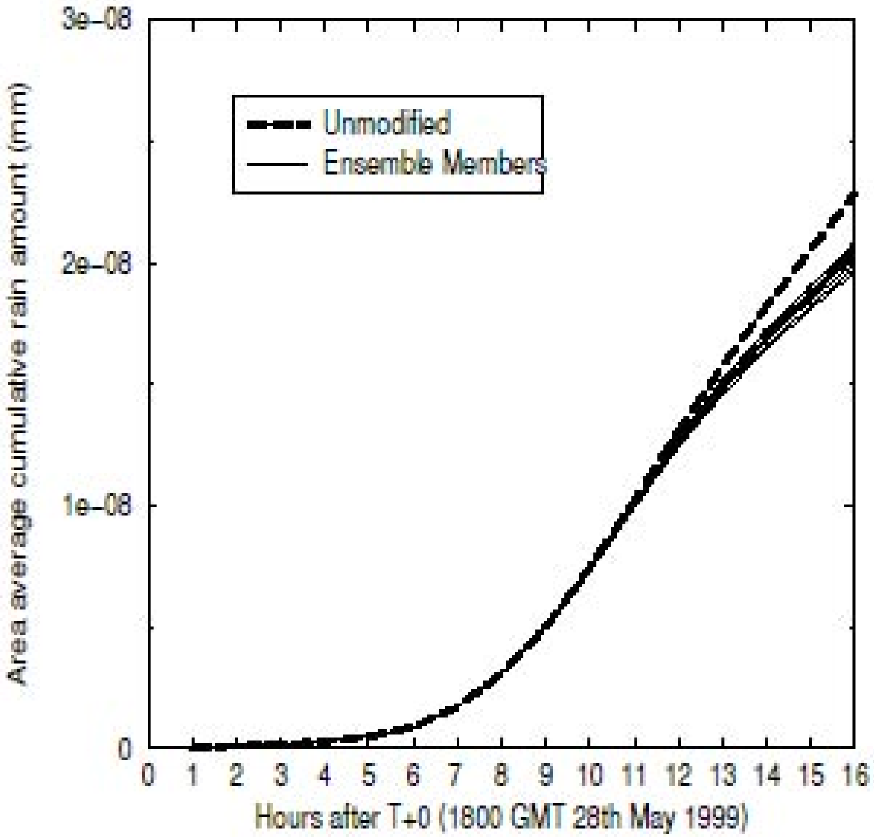
Location predictable

Done, Craig, Gray,

Clark and Gray, 2005

Elevated warm front

No CIN

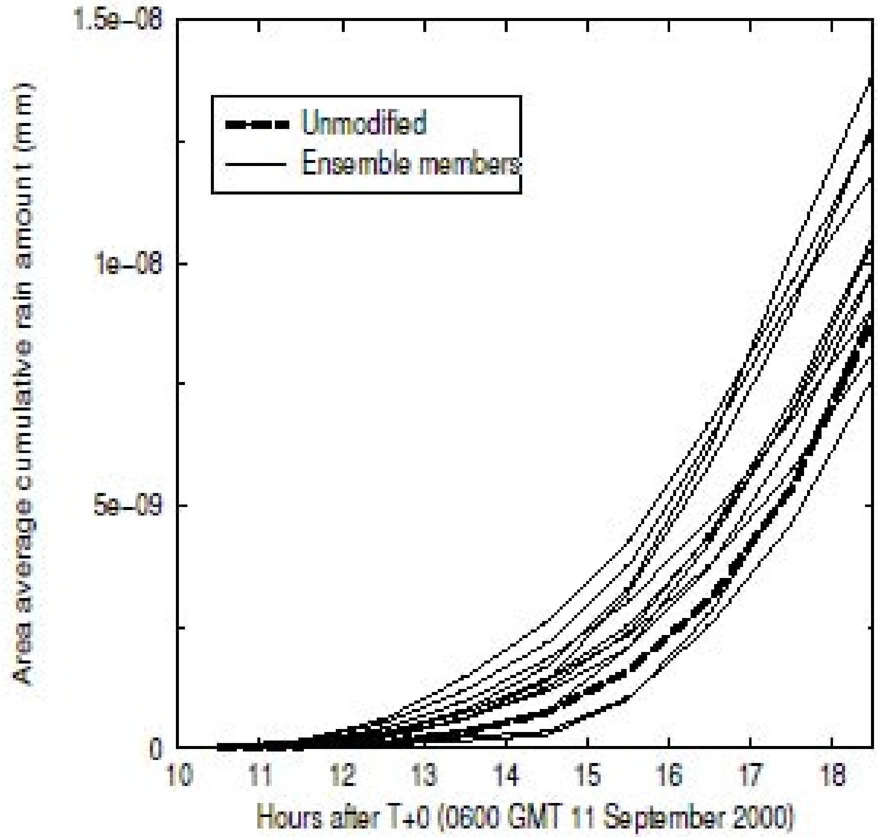


Location *un*predictable

Amount predictable

Moderate orography

Moderate CIN



Location predictable

Amount *un*predictable

Done, Craig, Gray, Clark and Gray, 2005

Conclusions

- User requirements can not always be satisfied.

  But we can do better, especially probabilistic info

- MAP - in strong orography, it may be enough to know the synoptic flow

- IHOP - small-scale triggers can often be observed

- For moderate orography, need to predict three things:

  1. orography
  2. synoptic environment
  3. mesoscale structure

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