Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Home Affairs FDHA
**Federal Office of Meteorology and Climatology MeteoSwiss**

# Precipitation forecasts in the Alps – an assessment by the forecast demonstration project MAP D-PHASE

## Felix Ament
## with thanks to all D-PHASE participants

## SRNWP Workshop, Bad Orb, 6.11.2007

# MAP D-PHASE

**D**emonstration of **P**robabilistic **H**ydrological and **A**tmospheric **S**imulation of flood **E**vents in the Alpine region

- 2nd WWRP FDP (forecast demonstration experiment) after Sydney 2000 and before Beijing 2008

- Focuses on heavy precipitation, hydrology, high-resolution numerical modeling and ensembles

- Huge number of participants: 28 atmospheric models, 17 hydrological models and more than 35 end users.

- Establishes an end-to-end forecasting system, which is operated from June until November 2007

**www.d-phase.info**
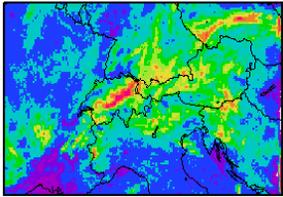
Real-time

- warnings of all models
- forecast chart
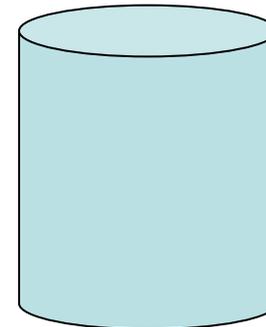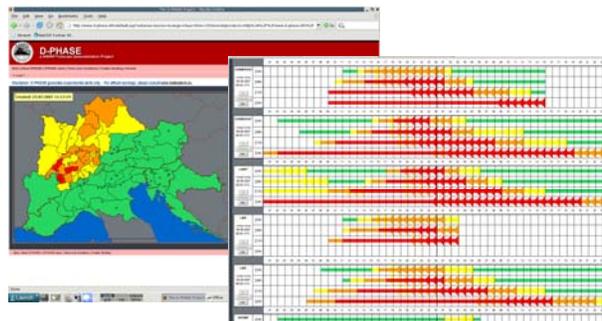
**Data archive**

- >10 GB model data
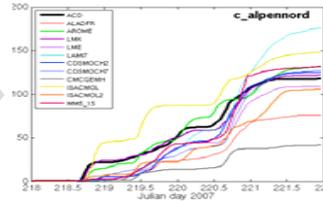- in a unified GRIB format
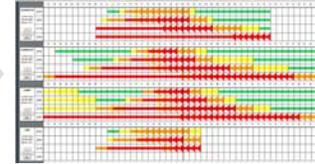
for scientific evaluation

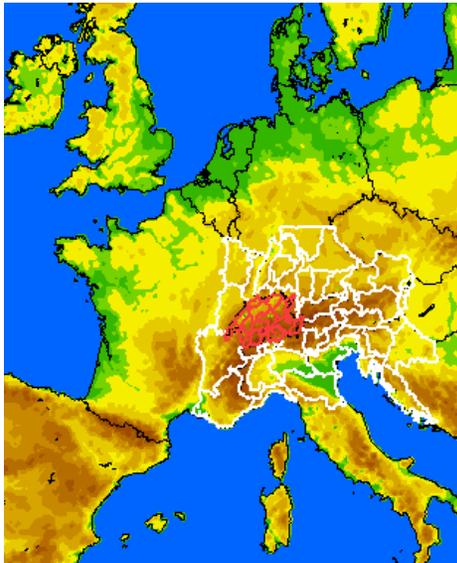# D-PHASE data processing



**Model output**

domain averages →

**RR time series**

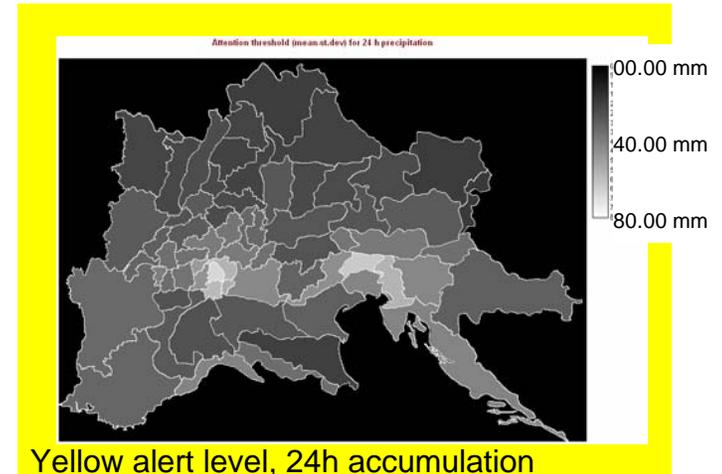apply warnlevels →

**Alert time series**

65 warning regions:



3 types of alerts:

| No alert | 10 times a year | Twice a year | Every 10 years |
|----------|-----------------|--------------|----------------|

(Accumulation times: 03h, 06h, 12h, 24h, 48h, 72h)



Yellow alert level, 24h accumulation

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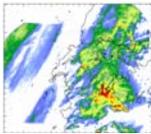**D-PHASE: Verification using Swiss Radar**
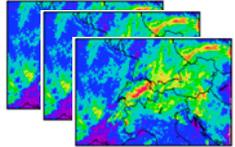Felix Ament@meteoswiss.ch

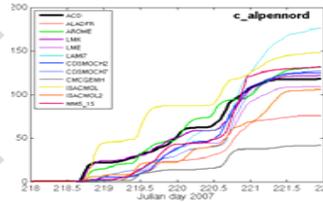# Verification strategy – JJA 2007

Models



OBS

**domain averages**
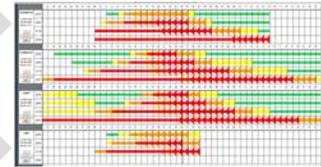
Most recent forecast, but
starting not before +03h
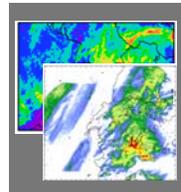
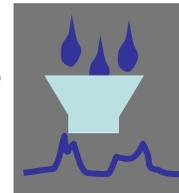hourly accumulations

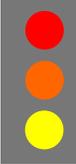**RR time series**

**apply warnlevels**

**Alert time series**

**Qualitative
Verification of alerts**

**Quantitative
Verification of mean RR**

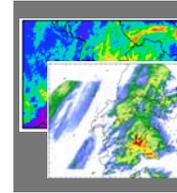**Structural
Verification of RR fields**

# Observational data
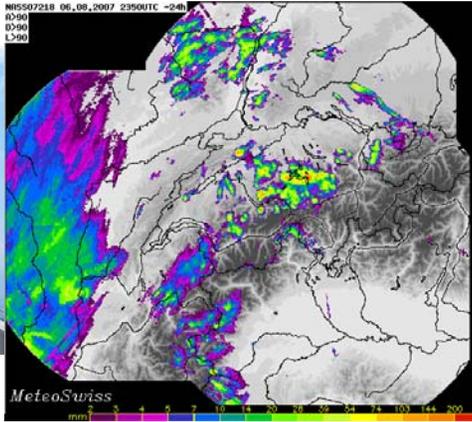
**Swiss Radar composite**

- 3 Radar stations
- 5 min scans accumulated to hourly estimates
- 1km resolution

**Gridded rain gauge data**

- Statistical interpolation + elevation correction
- Daily accumulations

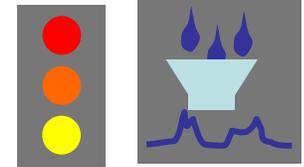**Calibrated radar time series**

- Warn regions averages
- Hourly accumulations
- Daily sums equivalent to gridded gauge data

# D-PHASE model zoo

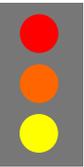| Name | Δx (km) | Runs per day | Forecast range (h) |
|---|---|---|---|
| **COSMO-2, Swiss** | 2 | 8 | 24-30 |
| COSMO-I2, Italy | 2 | 1 | 30 |
| **CSOMO-DE, Germany** | 2 | 8 | 21 |
| **ISACMOL, Italy** | 2 | 1 | 39 |
| **ISACMOL2, Italy** | 2 | 1 | 39 |
| ARPAMOL, Italy | 2 | 1 | 36 |
| MM5_2_CT, Germany | 2 | 1 | 24 |
| MM5_2_4D, Germany | 2 | 1 | 24 |
| MM5_325, Germany | 3 | 1 | 60 |
| **AROME, France** | 4 | 1 | 30 |
| **CMCGEMH, Canada** | 2 | 1 | 18 |

- High-resolution deterministic models (11)
- Driving deterministic models (10)
- Ensemble prediction systems (7)

| Name | Δx (km) | Runs per day | Forecast range (h) |
|---|---|---|---|
| **COSMO-7, Germany** | 7 | 2 | 72 |
| **COSMO-IT, Italy** | 7 | 2 | 72 |
| **COSMO-EU** | 7 | 4 | 78 |
| QBOLAM33, Italy | 33 | 1 | 60 |
| **QBOLAM11, Italy** | 11 | 1 | 48 |
| **ALADFR, France** | 12 | 1 | 54 |
| MM5_60, Germany | 60 | 2 | 72 |
| **MM5_15, Germany** | 15 | 2 | 72 |
| **ALADAT, Austria** | 9 | 2 | 48 |
| **CMCGEML, Canada** | 15 | 1 | 24 |

| Name | Members | Δx (km) | Runs per day | Forecast range (h) |
|---|---|---|---|---|
| CLEPS, Italy | 16 | 10 | 1 | 132 |
| MOGREPS, UK | 24 | 25 | 2 | 54 |
| INMSREPS, Spain | 20 | 27 | 2 | 72 |
| CSREPS, Italy | 16 | 10 | 1 | 72 |
| LAMEPSAT, Austria | 17 | 18 | 2 | 48 |
| PEPS, SRNWP | varying | 7 | 4 | 42 |
| MPEPS, S | varying | 2 | 8 | 18 |

# Alert Verification: Level yellow

Alert level yellow (10 events per year), aggregated on 6 hour intervals.
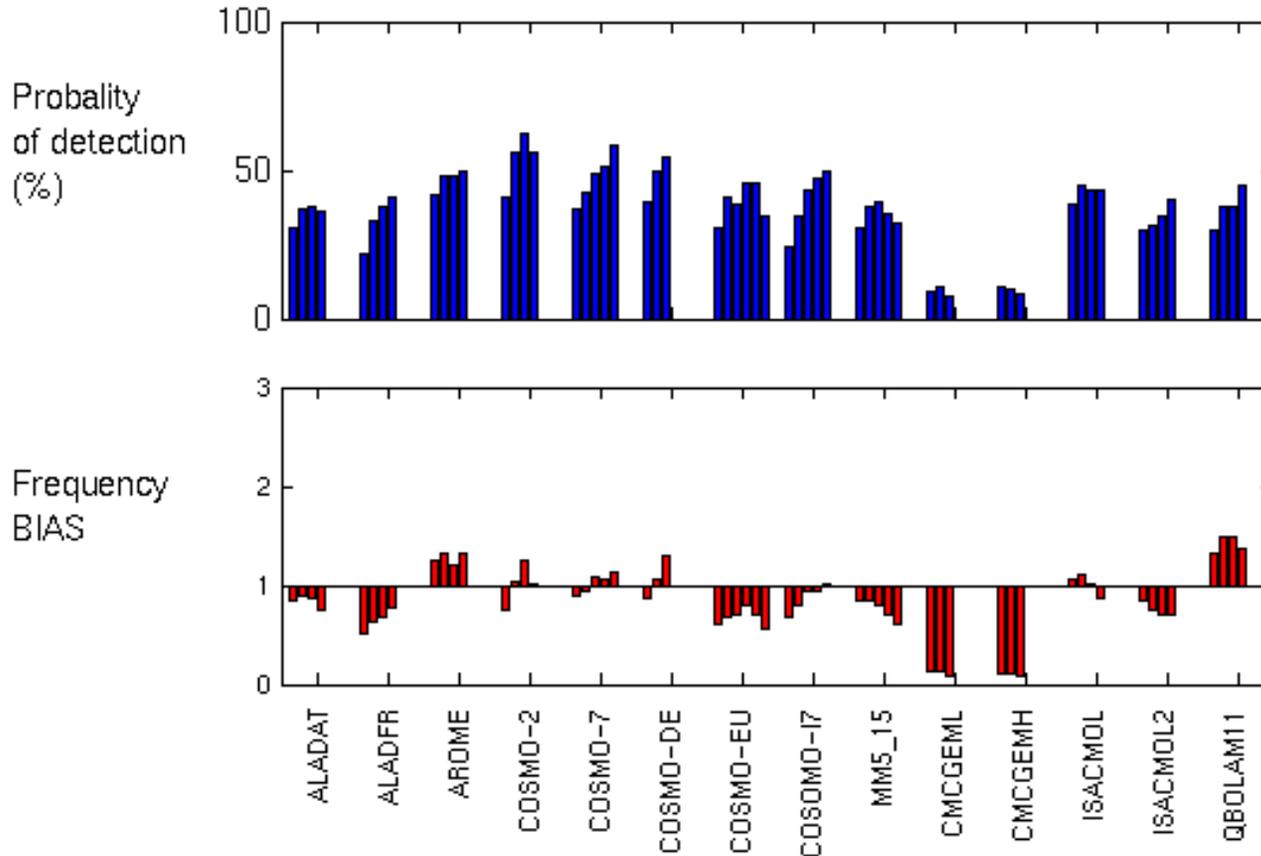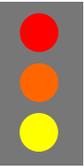


**probability to detect a real alert event**

**frequency model alert / frequency of real alert**
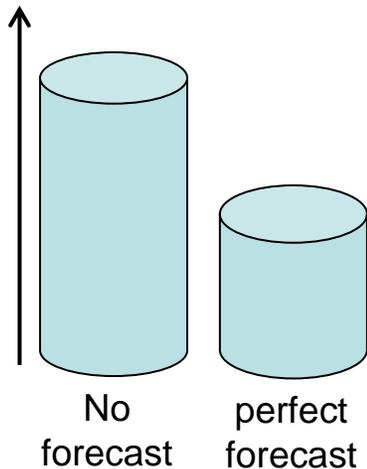
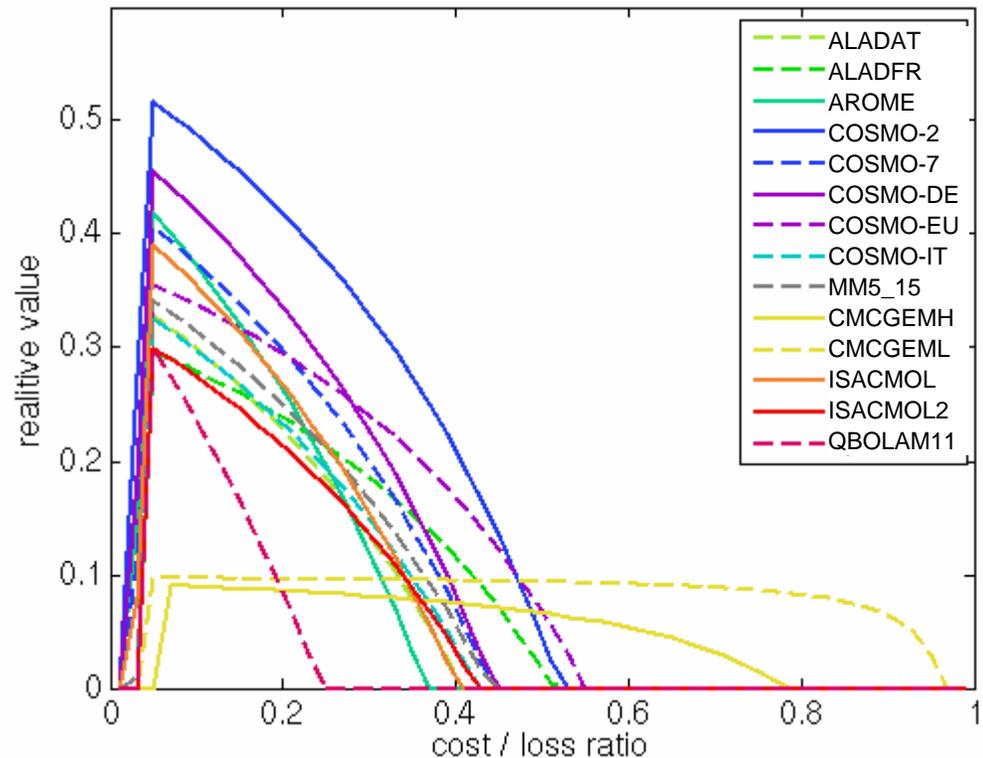Dependency on accumulation period:
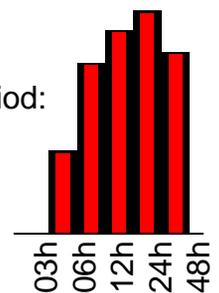
# Alert Verification: Relative value

Cost **C**
(buying trousers)
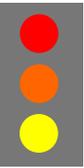
Loss **L**
(cleaning trousers)

Total Cost

No forecast | perfect forecast

**Relative value**

0

1

Alert level yellow (10 events per year),
aggregated on 6 hour intervals,
03h, 06h, 12h accumulations,
JJA 2007

**D-PHASE: Verification using Swiss Radar**
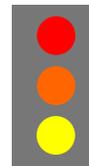Felix Ament@meteoswiss.ch

# Calibration I – User dependent alerts

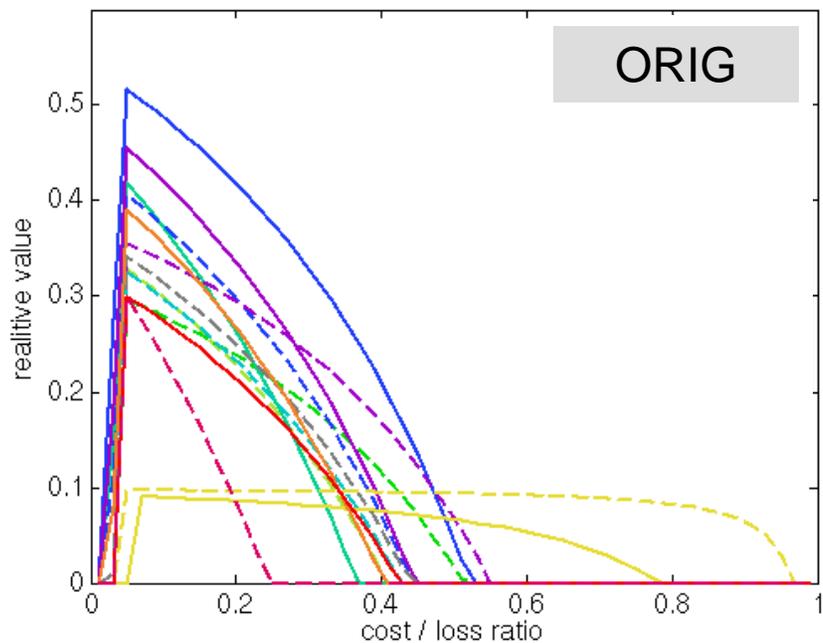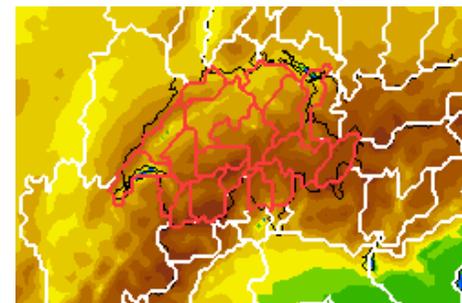Consider the forecast uncertainty – even of a deterministic forecast!
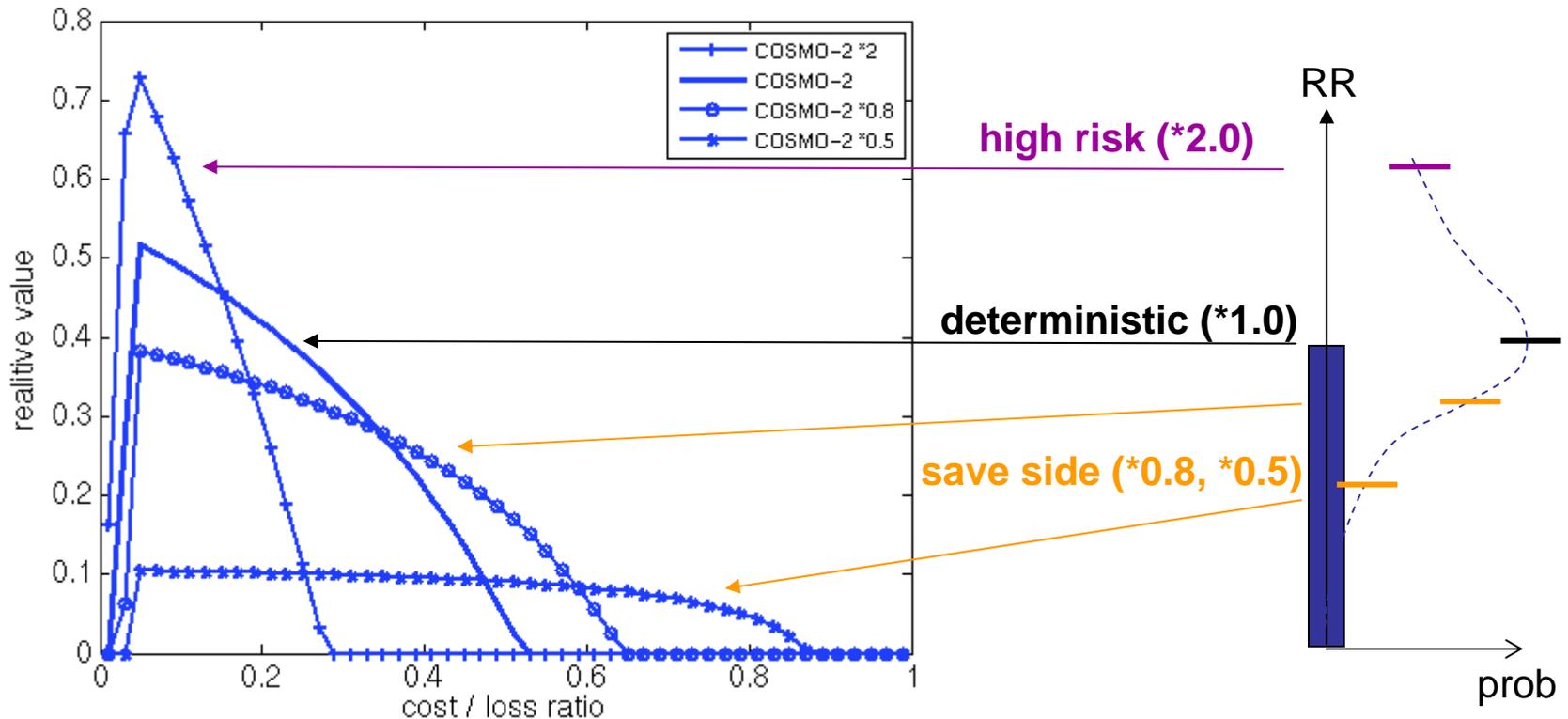
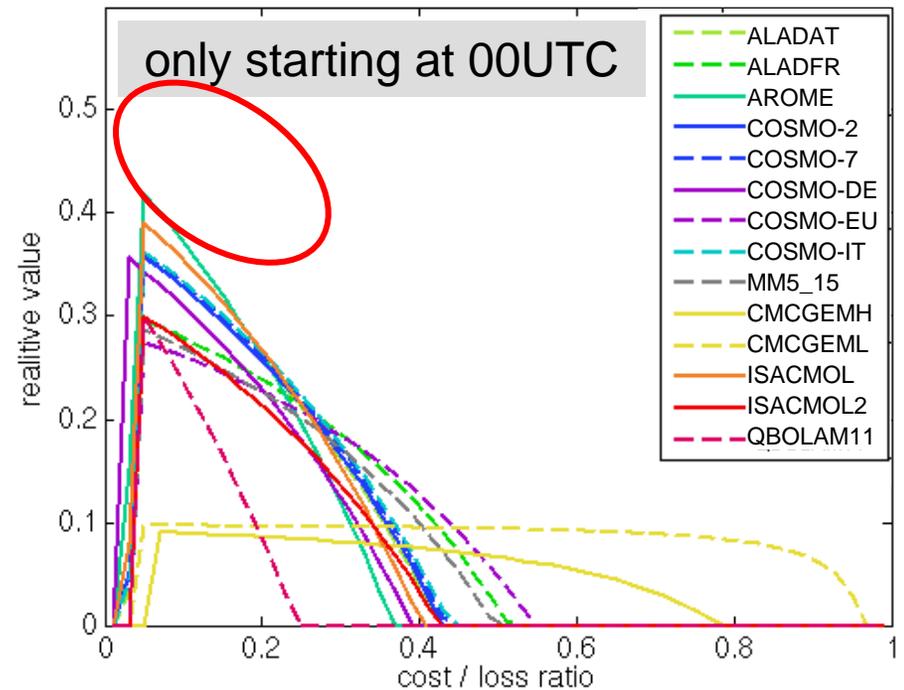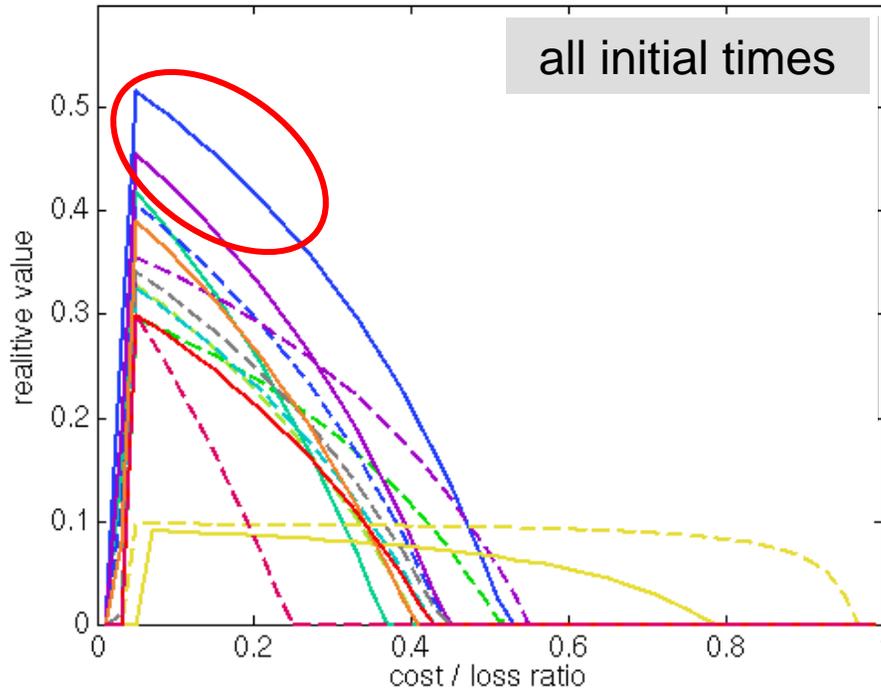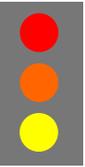# Calibration II – BIAS correction

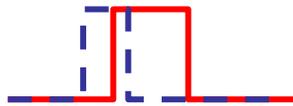Multiplicative correction of BIAS (averaged over 3 month) within each warn region for every model.
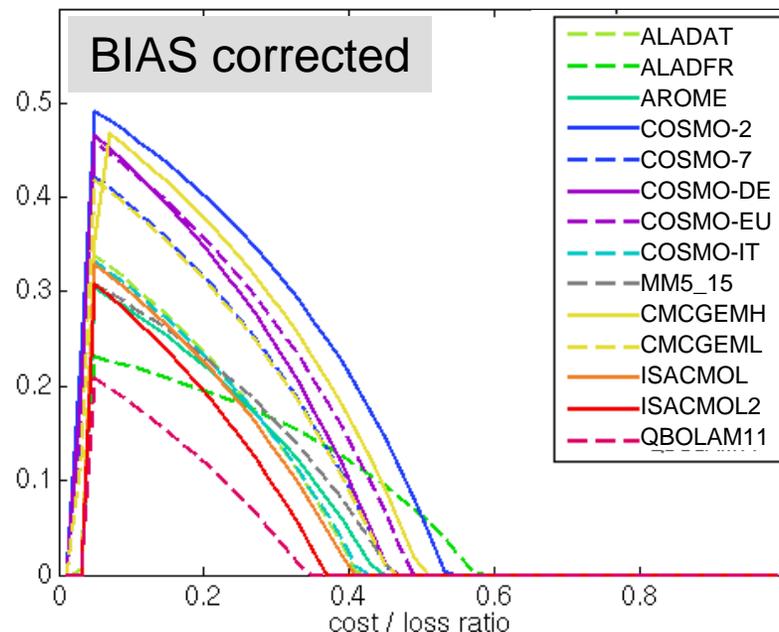
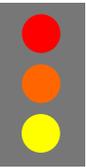# Rapid update cycle



- Rapid update of COSMO-2 and COSMO-DE (every 3h) has a clear positive impact.
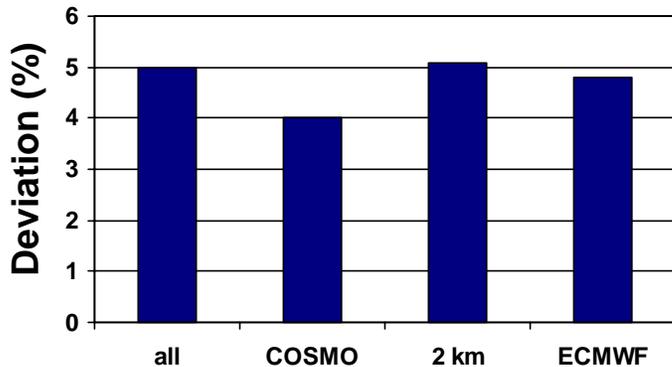
# How similar are the models?

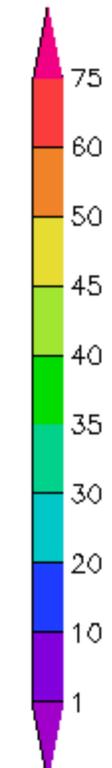|   | Y | N |
|---|---|---|
| Y | H | F1 |
| N | F2 | C |

**Deviation (0.1%), yellow alerts, accumulation 03, 06 & 12h**

different

Deviation = F1 + F2



similar

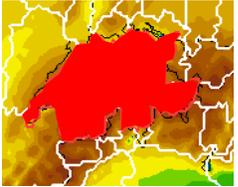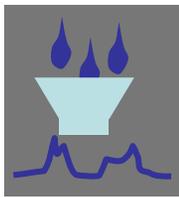|        | RAD | AAT | AFR | ARO | C2 | C7 | CDE | CEU | CIT | M15 | CMCL | CMCH | IMO | IMO2 | QB11 |
|--------|-----|-----|-----|-----|----|----|-----|-----|-----|-----|------|------|-----|------|------|
| RADAR    | 0  | 52 | 41 | 56 | 45 | 60 | 48 | 54 | 60 | 55 | 31 | 41 | 55 | 47 | 79 |
| ALADAT   | 52 | 0  | 40 | 57 | 49 | 53 | 49 | 46 | 50 | 52 | 37 | 35 | 55 | 47 | 79 |
| ALADFR   | 41 | 40 | 0  | 49 | 42 | 45 | 43 | 37 | 41 | 43 | 24 | 30 | 47 | 40 | 70 |
| AROME    | 56 | 57 | 49 | 0  | 58 | 54 | 57 | 53 | 54 | 56 | 54 | 61 | 58 | 56 | 80 |
| COSMO-2  | 45 | 49 | 42 | 58 | 0  | 41 | 36 | 38 | 43 | 47 | 39 | 47 | 50 | 47 | 74 |
| COSMO-7  | 60 | 53 | 45 | 54 | 41 | 0  | 43 | 44 | 47 | 57 | 37 | 41 | 53 | 52 | 82 |
| COSMO-DE | 48 | 49 | 43 | 57 | 36 | 43 | 0  | 34 | 42 | 48 | 40 | 46 | 53 | 48 | 77 |
| COSMO-EU | 54 | 46 | 37 | 53 | 38 | 44 | 34 | 0  | 40 | 46 | 24 | 28 | 53 | 43 | 77 |
| COSMO-IT | 60 | 50 | 41 | 54 | 43 | 47 | 42 | 40 | 0  | 52 | 31 | 34 | 54 | 49 | 76 |
| MM5_15   | 55 | 52 | 43 | 56 | 47 | 57 | 48 | 46 | 52 | 0  | 39 | 52 | 52 | 50 | 76 |
| CMCGEML  | 31 | 37 | 24 | 54 | 39 | 37 | 40 | 24 | 31 | 39 | 0  | 7  | 51 | 34 | 70 |
| CMCGEMH  | 41 | 35 | 30 | 61 | 47 | 41 | 46 | 28 | 34 | 52 | 7  | 0  | 63 | 43 | 85 |
| ISACMOL  | 55 | 55 | 47 | 58 | 50 | 53 | 53 | 53 | 54 | 52 | 51 | 63 | 0  | 48 | 69 |
| ISACMOL2 | 47 | 47 | 40 | 56 | 47 | 52 | 48 | 43 | 49 | 50 | 34 | 43 | 48 | 0  | 74 |
| QBOLAM11 | 79 | 79 | 70 | 80 | 74 | 82 | 77 | 77 | 76 | 76 | 70 | 85 | 69 | 74 | 0  |

# QPF-Verification Summary JJA



Verification versus Swiss Radar, 2007060100 – 2007083100

Relativ BIAS full domain (%)

Mean |rel. BIAS| of a region (%)

Mean temporal correlation in a region (%) (hourly)

Models: ALADAT, ALADFR, AROME, COSMO-2, COSMO-7, COSMO-DE, COSMO-EU, COSMO-I7, MM5_15, CMCGEML, CMCGEMH, ISACMOL, ISACMOL2, QBOLAM11
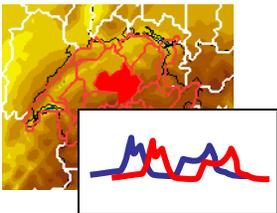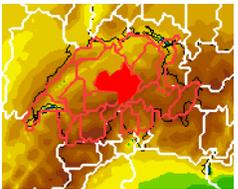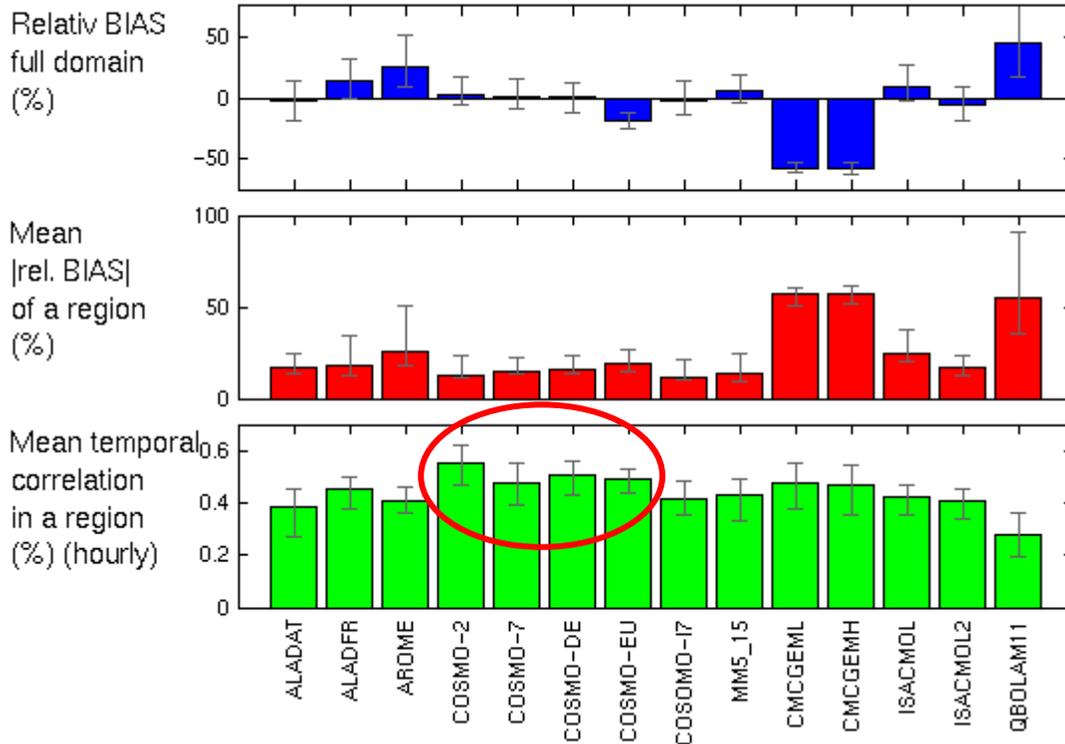
**Overall over- / underestimation?**

**Ability to resolve mean spatial patterns**

**Timing**

Felix.Ament@meteoswiss.ch
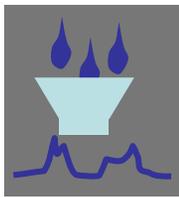
# Daily cycle



Deep convection resolving models — Mean daily cycle, 2007060100 – 2007083100
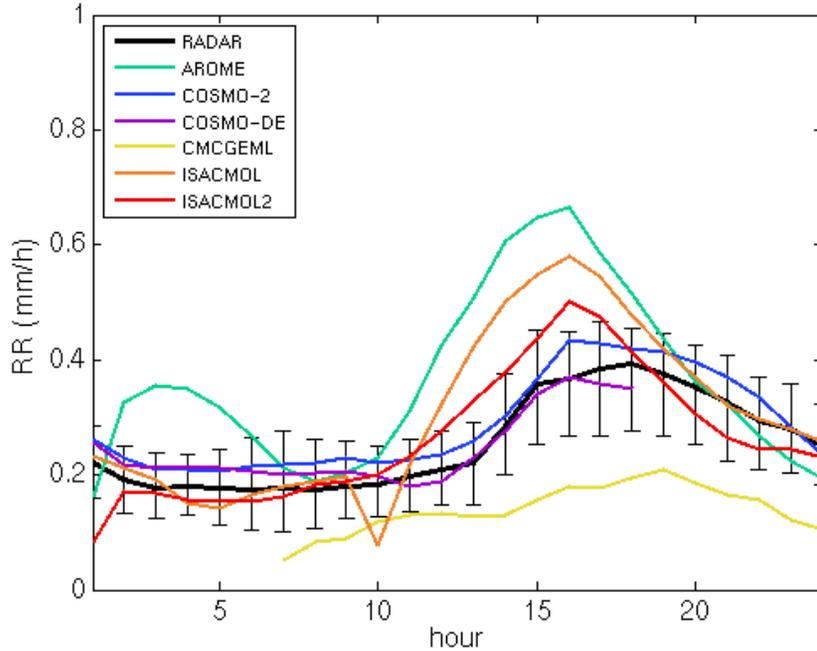
Parameterized convection — Mean daily cycle, 2007060100 – 2007083100
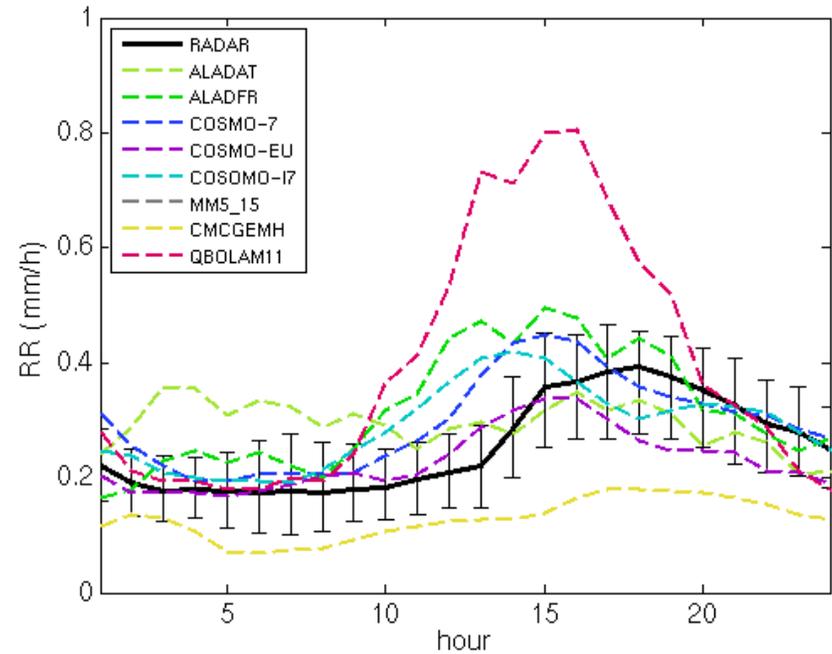
# Fine scale verification: Fuzzy Methods
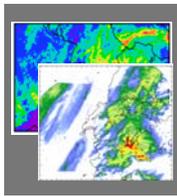
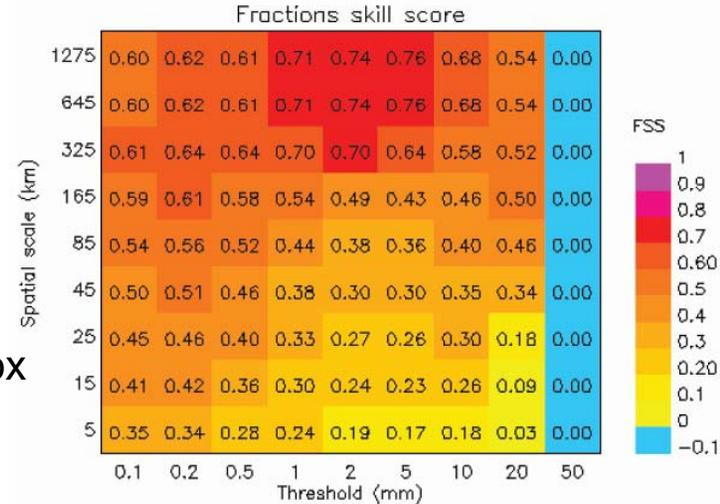"… do not evaluate a point by point match!"

**General Recipe**

- (Choose a threshold to define event and non-event)

- define scales of interest

- consider statistics at these scales for verification

Scale

observation        forecast
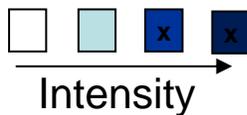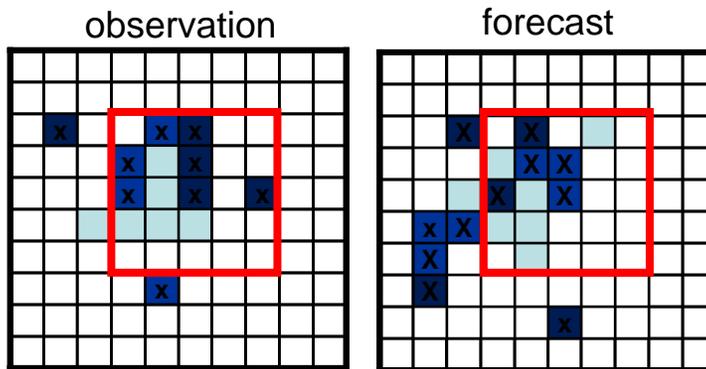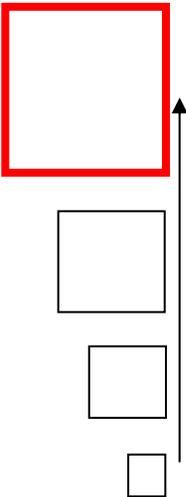
Evaluate box statistics

Fractions skill score

| | 0.1 | 0.2 | 0.5 | 1 | 2 | 5 | 10 | 20 | 50 |
|---|---|---|---|---|---|---|---|---|---|
| 1275 | 0.60 | 0.62 | 0.61 | 0.71 | 0.74 | 0.76 | 0.68 | 0.54 | 0.00 |
| 645 | 0.60 | 0.62 | 0.61 | 0.71 | 0.74 | 0.76 | 0.68 | 0.54 | 0.00 |
| 325 | 0.61 | 0.64 | 0.64 | 0.70 | 0.70 | 0.64 | 0.58 | 0.52 | 0.00 |
| 165 | 0.59 | 0.61 | 0.58 | 0.54 | 0.49 | 0.43 | 0.46 | 0.50 | 0.00 |
| 85 | 0.54 | 0.56 | 0.52 | 0.44 | 0.38 | 0.36 | 0.40 | 0.46 | 0.00 |
| 45 | 0.50 | 0.51 | 0.46 | 0.38 | 0.30 | 0.30 | 0.35 | 0.34 | 0.00 |
| 25 | 0.45 | 0.46 | 0.40 | 0.33 | 0.27 | 0.26 | 0.30 | 0.18 | 0.00 |
| 15 | 0.41 | 0.42 | 0.36 | 0.30 | 0.24 | 0.23 | 0.26 | 0.09 | 0.00 |
| 5 | 0.35 | 0.34 | 0.28 | 0.24 | 0.19 | 0.17 | 0.18 | 0.03 | 0.00 |

Spatial scale (km) — Threshold (mm)

FSS: 1, 0.9, 0.8, 0.7, 0.60, 0.5, 0.4, 0.3, 0.20, 0.1, 0, -0.1

Intensity

→ score depends on spatial scale and intensity

Ebert, E.E., 2007: Fuzzy verification of high resolution gridded forecasts: A review and proposed framework. Meteorol. Appls., in press.

# Characteristics of Fuzzy Scores
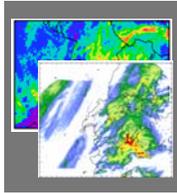
Idealized test:
Horizontal translation with variable displacement Δx
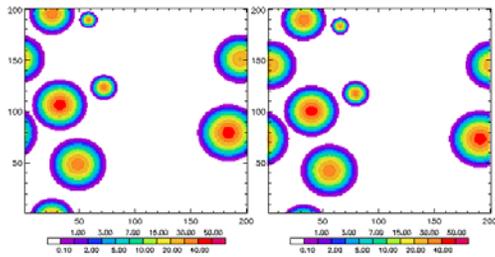
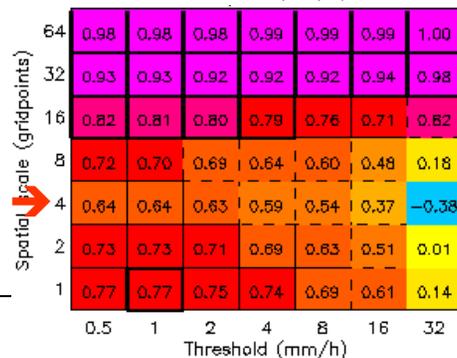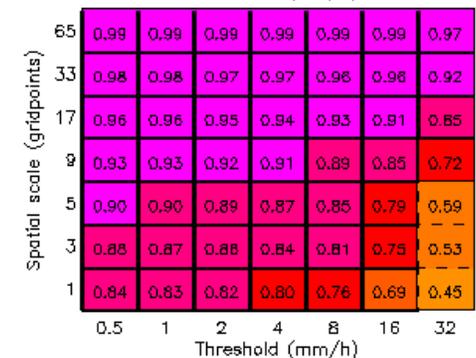• "Intensity scale" method (Casati et al., 2004) can detect spatial scale of perturbation

Δx=25km

Δx=10km

Δx=5km
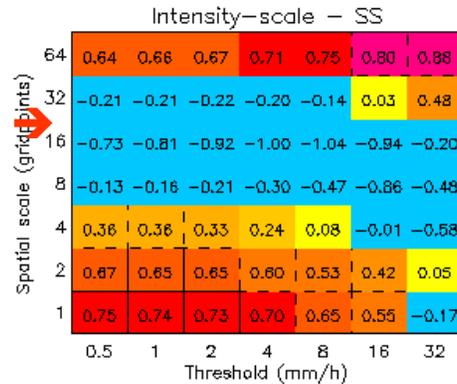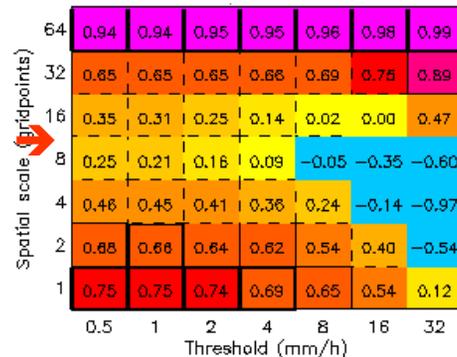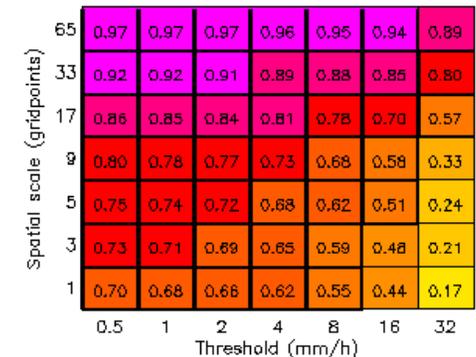
# D-PHASE: August 2007
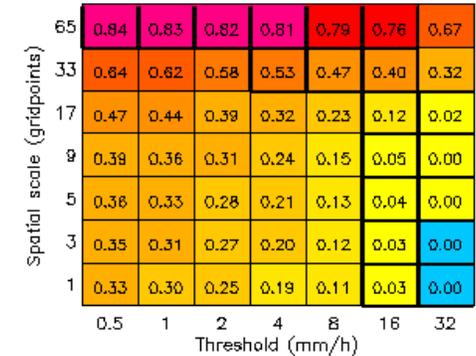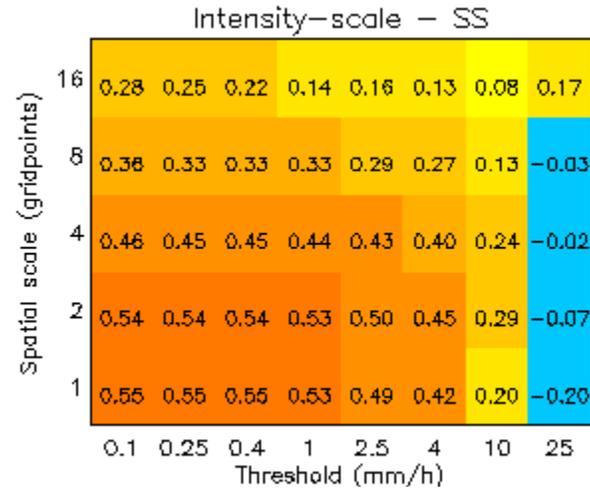**Intensity Scale score, 3h accumulation**
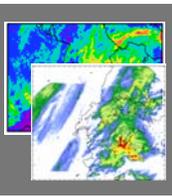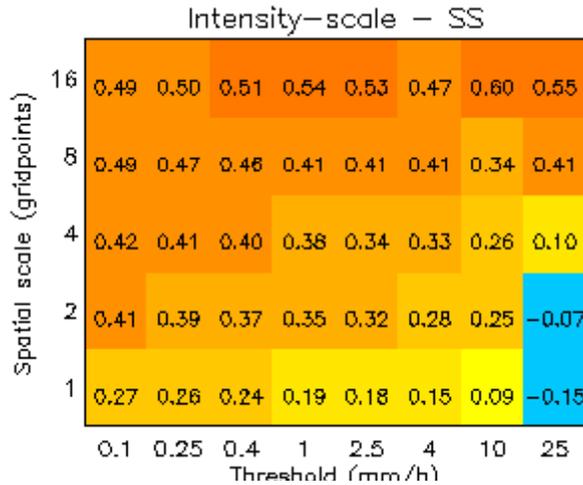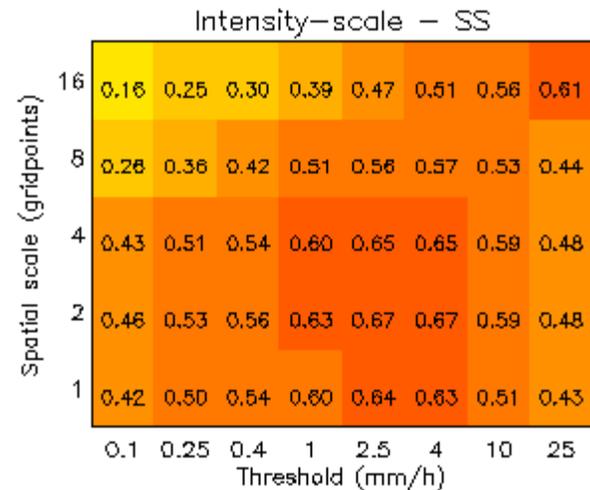
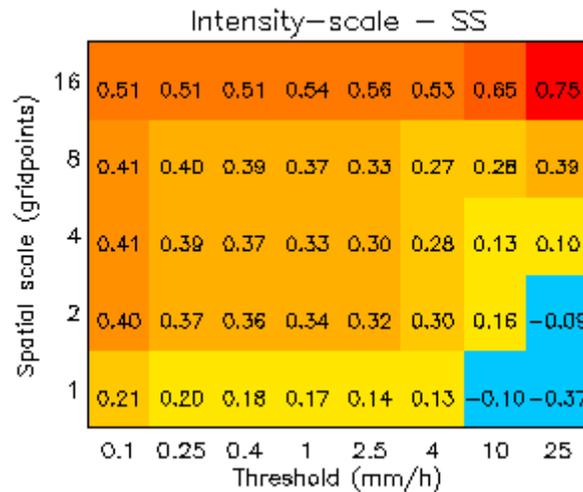# **Conclusions**

- MAP D-PHASE collects a lot of model data – a testbed for (new) models?

- Alert forecast:
  - Probability of detection (yellow alerts) ~50%; rather small frequency biases
  - user dependent calibration and rapid updates cycles are beneficial

- Precipitation forecast:
  - low relative biases for most models (<20%)
  - high resolution potentially improves daily cycle

- Structure: Intensity scale scores indicates realistic structures at small scales for deep convection resolving models

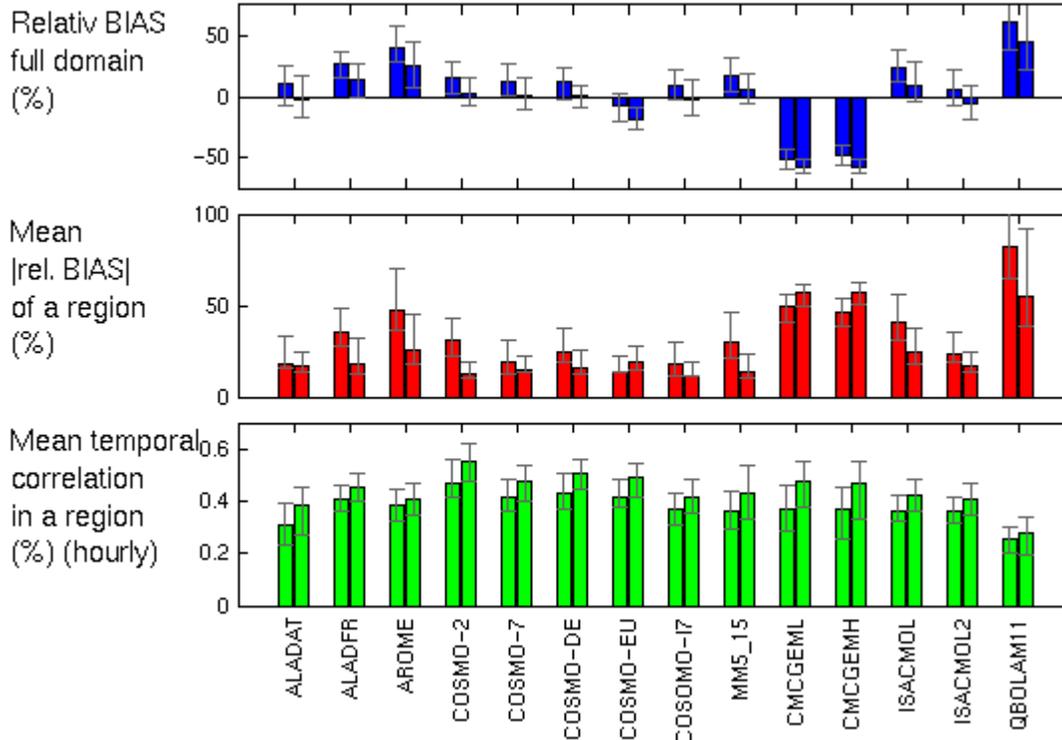- Future: Ensemble verification; looking on more than precipitation data (COPS and GOP observations)
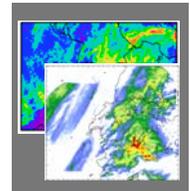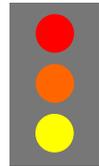
# QPF-Verification Summary JJA
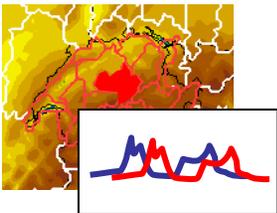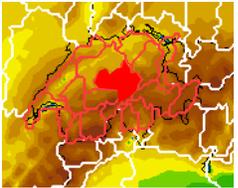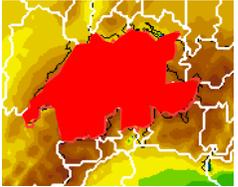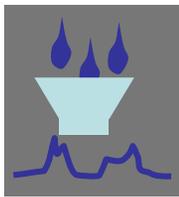


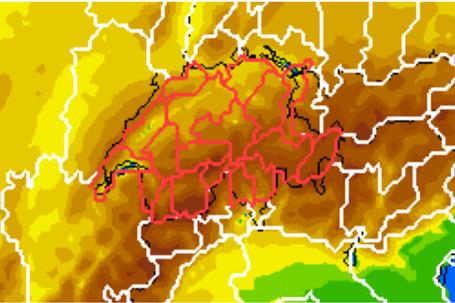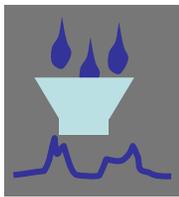Verification versus Swiss Radar, 2007060100 – 2007083100

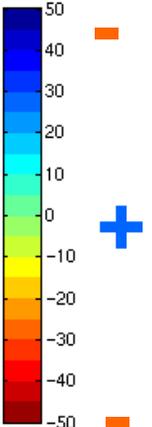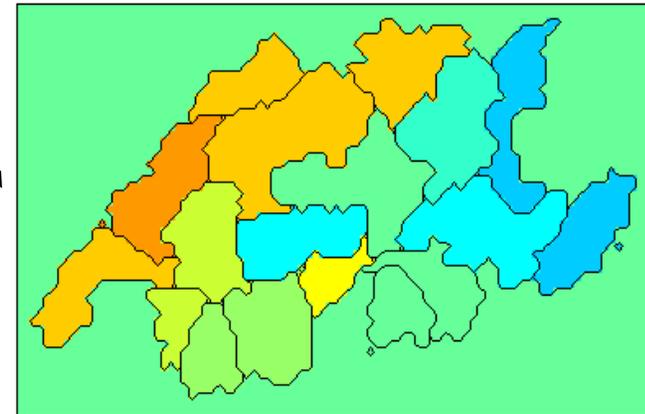# D-PHASE model ensemble

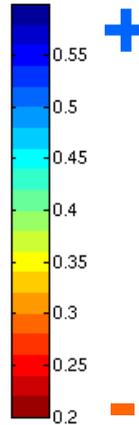BIAS of ensemble mean?
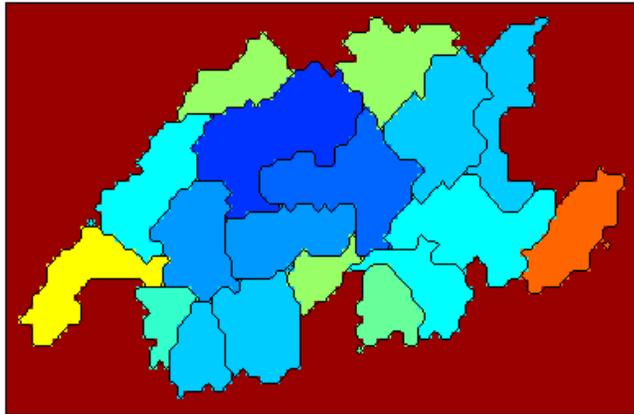
Mean ensemble spread?

Timing errors?

**Ensemble mean relative bias [%]**
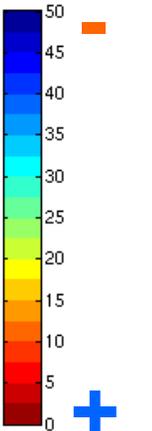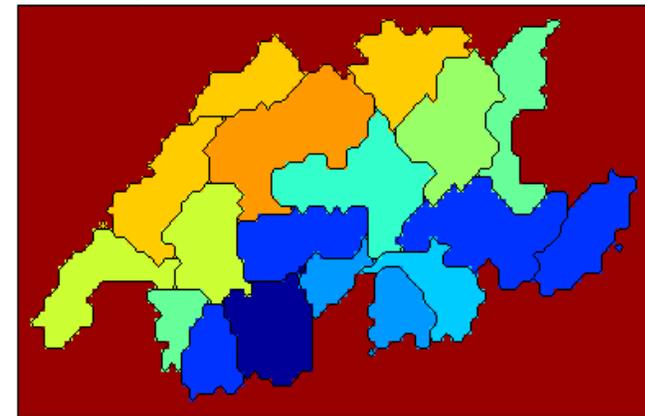all models, 2007060100 – 2007083100

**Mean temporal correlation**
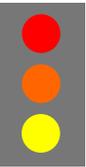all models, 2007060100 – 2007083100

**Ensemble STDEV of relative bias [%]**
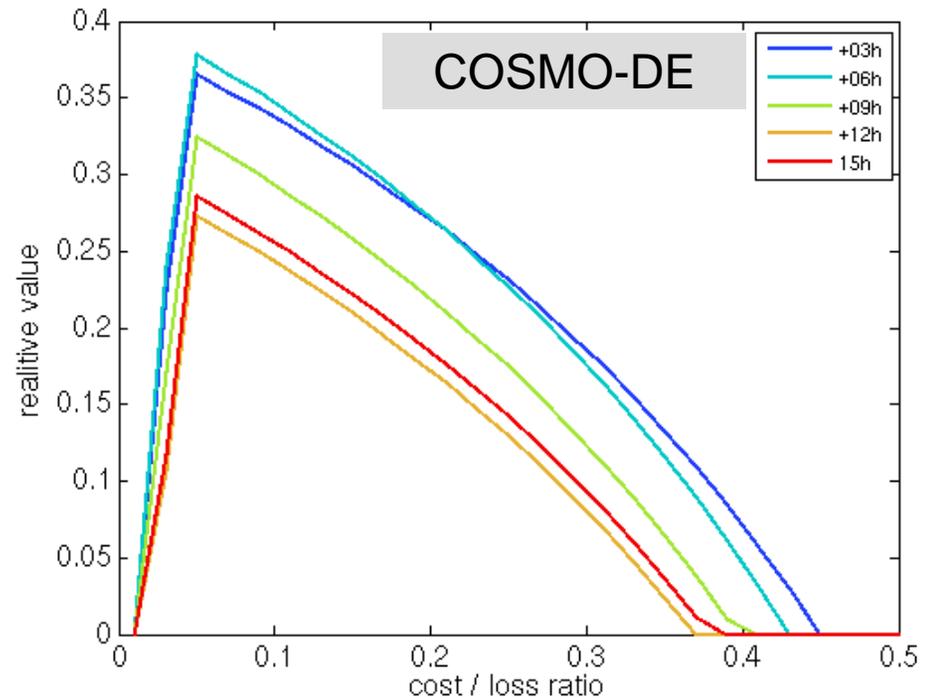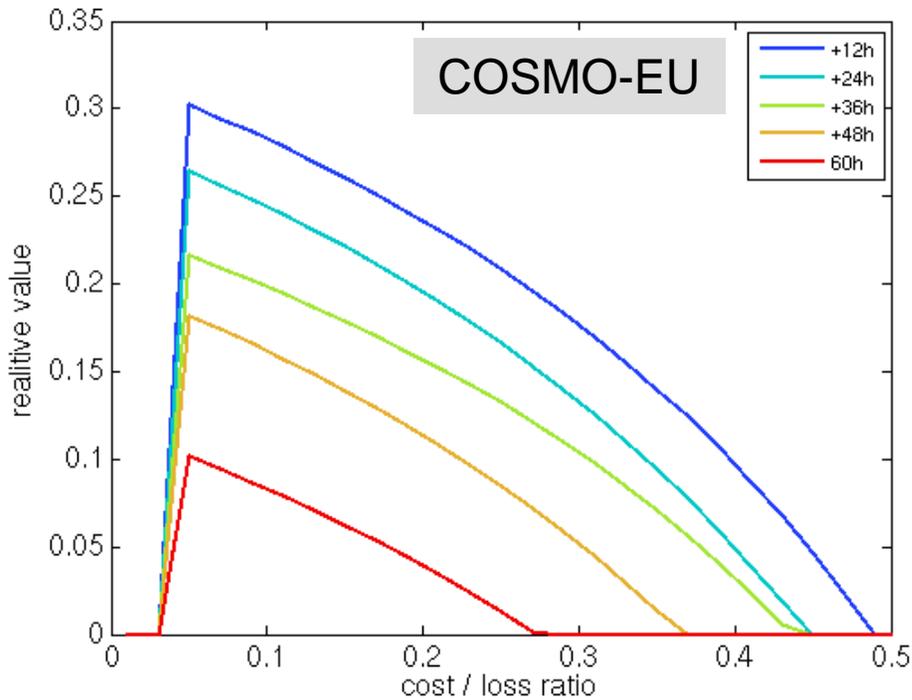all models, 2007060100 – 2007083100

# Lead times II

Alert level yellow (10 events per year),
aggregated on 6 hour intervals,
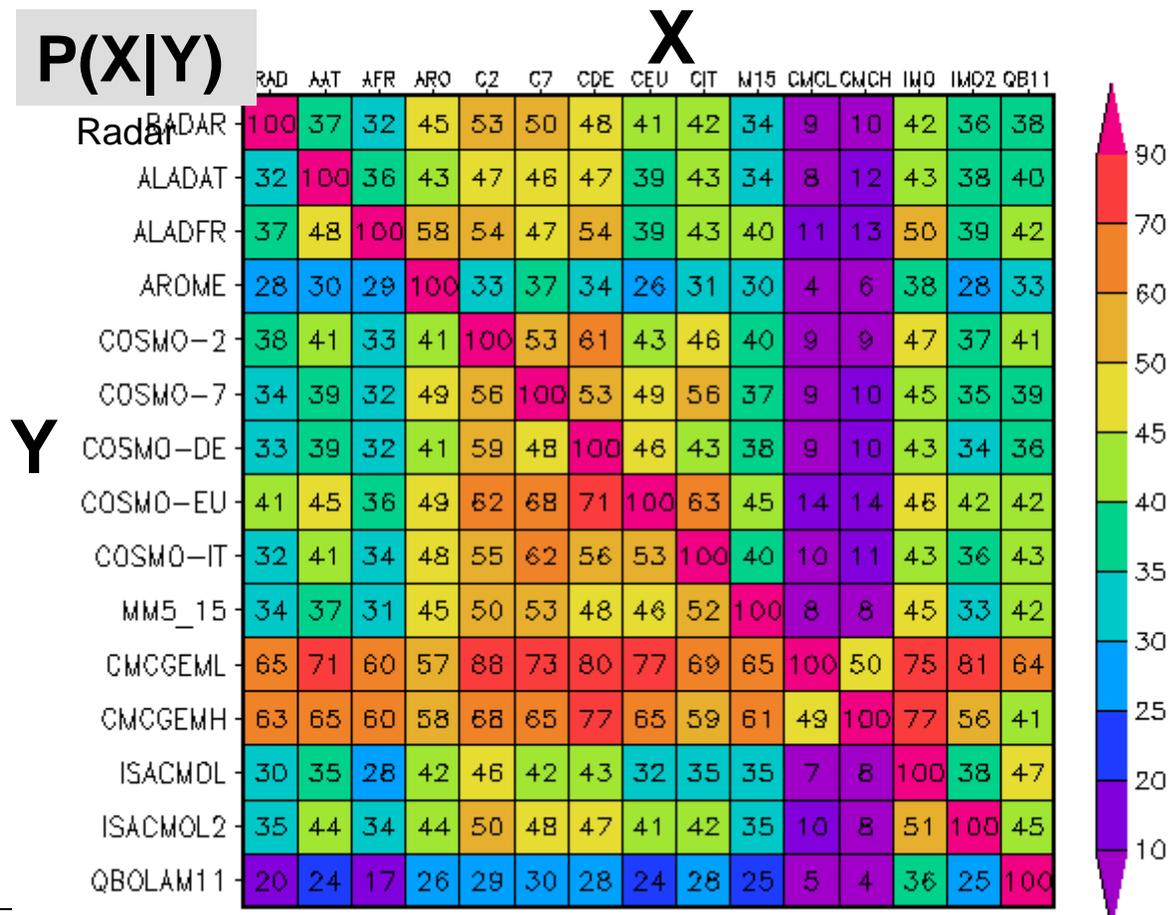03h, 06h, 12h accumulations,
JJA 2007

# Again, how similar are the models?

But in terms alerts:

Alert level yellow (10 events per year), aggregated on 6 hour intervals.

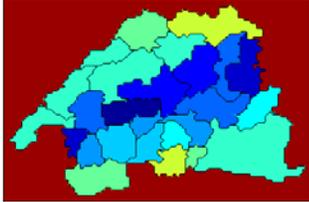Probability of an alert by model X given an alert by model Y

**P(X|Y)**

X

Y

Radar

| | RAD | AAT | AFR | ARO | C2 | C7 | CDE | CEU | CIT | M15 | CMCL | CMCH | IMO | IMO2 | QB11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RADAR | 100 | 37 | 32 | 45 | 53 | 50 | 48 | 41 | 42 | 34 | 9 | 10 | 42 | 36 | 38 |
| ALADAT | 32 | 100 | 36 | 43 | 47 | 46 | 47 | 39 | 43 | 34 | 8 | 12 | 43 | 38 | 40 |
| ALADFR | 37 | 48 | 100 | 58 | 54 | 47 | 54 | 39 | 43 | 40 | 11 | 13 | 50 | 39 | 42 |
| AROME | 28 | 30 | 29 | 100 | 33 | 37 | 34 | 26 | 31 | 30 | 4 | 6 | 38 | 28 | 33 |
| COSMO−2 | 38 | 41 | 33 | 41 | 100 | 53 | 61 | 43 | 46 | 40 | 9 | 9 | 47 | 37 | 41 |
| COSMO−7 | 34 | 39 | 32 | 49 | 56 | 100 | 53 | 49 | 56 | 37 | 9 | 10 | 45 | 35 | 39 |
| COSMO−DE | 33 | 39 | 32 | 41 | 59 | 48 | 100 | 46 | 43 | 38 | 9 | 10 | 43 | 34 | 36 |
| COSMO−EU | 41 | 45 | 36 | 49 | 62 | 68 | 71 | 100 | 63 | 45 | 14 | 14 | 46 | 42 | 42 |
| COSMO−IT | 32 | 41 | 34 | 48 | 55 | 62 | 56 | 53 | 100 | 40 | 10 | 11 | 43 | 36 | 43 |
| MM5_15 | 34 | 37 | 31 | 45 | 50 | 53 | 48 | 46 | 52 | 100 | 8 | 8 | 45 | 33 | 42 |
| CMCGEML | 65 | 71 | 60 | 57 | 88 | 73 | 80 | 77 | 69 | 65 | 100 | 50 | 75 | 81 | 64 |
| CMCGEMH | 63 | 65 | 60 | 58 | 68 | 65 | 77 | 65 | 59 | 61 | 49 | 100 | 77 | 56 | 41 |
| ISACMDL | 30 | 35 | 28 | 42 | 46 | 42 | 43 | 32 | 35 | 35 | 7 | 8 | 100 | 38 | 47 |
| ISACMOL2 | 35 | 44 | 34 | 44 | 50 | 48 | 47 | 41 | 42 | 35 | 10 | 8 | 51 | 100 | 45 |
| QBOLAM11 | 20 | 24 | 17 | 26 | 29 | 30 | 28 | 24 | 28 | 25 | 5 | 4 | 36 | 25 | 100 |

Color scale: 90, 70, 60, 50, 45, 40, 35, 30, 25, 20, 10

**D-PHASE: Verification using Swiss Radar**
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# A first overview

Total precipitation (mm) JJA 2007, averaged over D-PHASE target regions: