Evaluation of Humidity, Clouds and Precipitation in COSMO-CLM and MM5

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Outline and Strategy

Observations

Mesoscale meteorological models

GC

M5

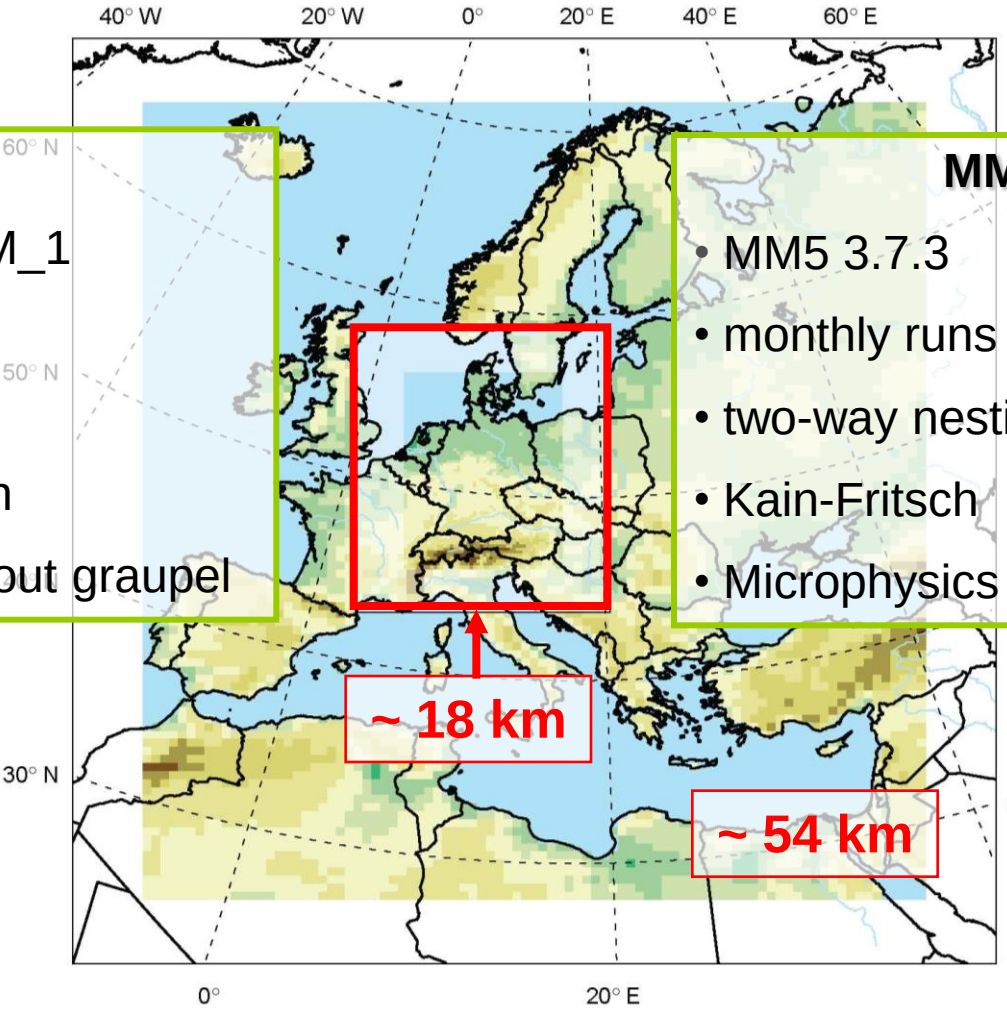
CCLM

- COSMO_4.8_CLM_1
- 2006-2008
- one-way nesting
- Tiedtke convection
- Microphysics without graupel

MM5

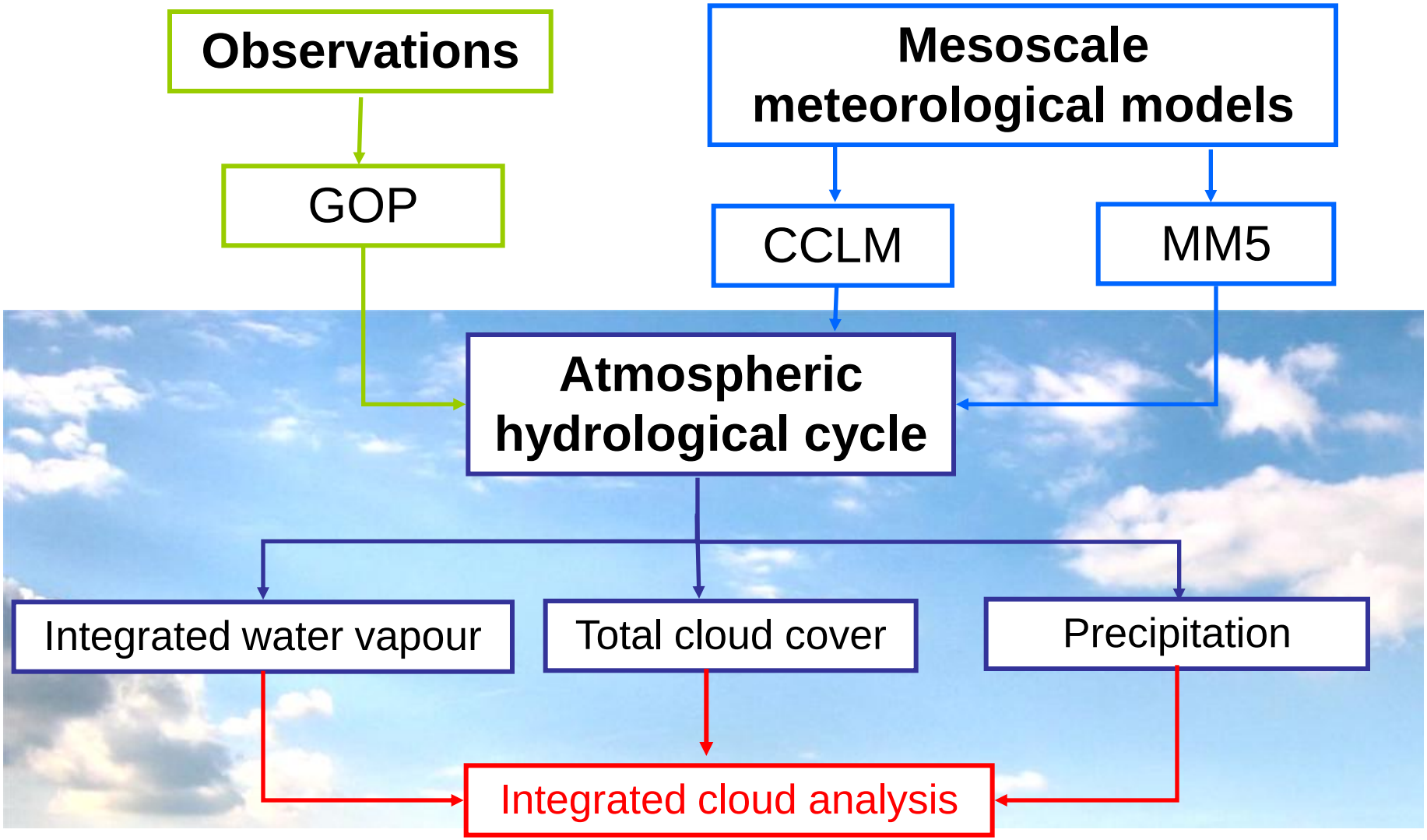
- MM5 3.7.3
- monthly runs
- two-way nesting
- Kain-Fritsch
- Microphysics with graupel

Integrated water v … ation



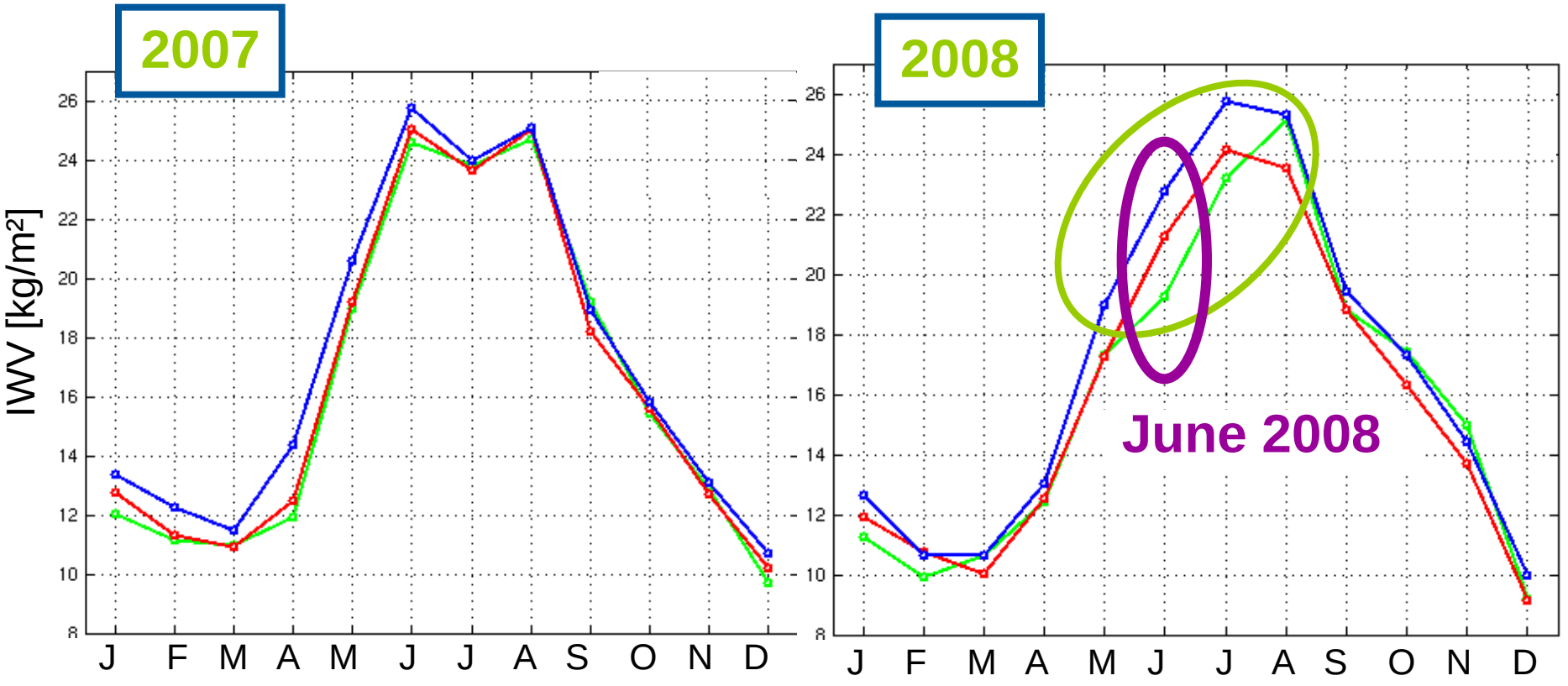
NCEP ~200 km

Outline and Strategy



Integrated Water Vapour: Annual Cycle

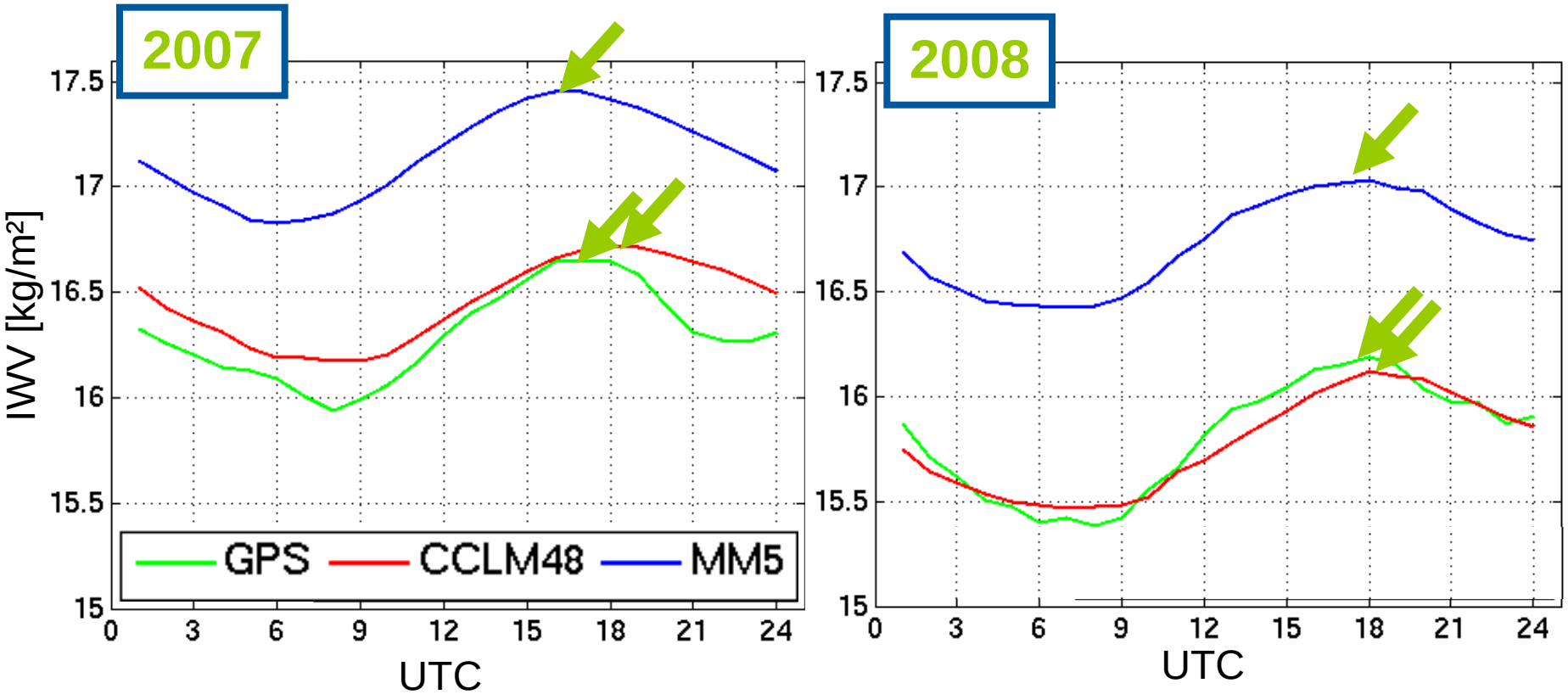
Monthly spatial mean



- Both models are able to represent the seasonal variability
- MM5 overestimates IWV
- Eye-catching: June, July, August 2008

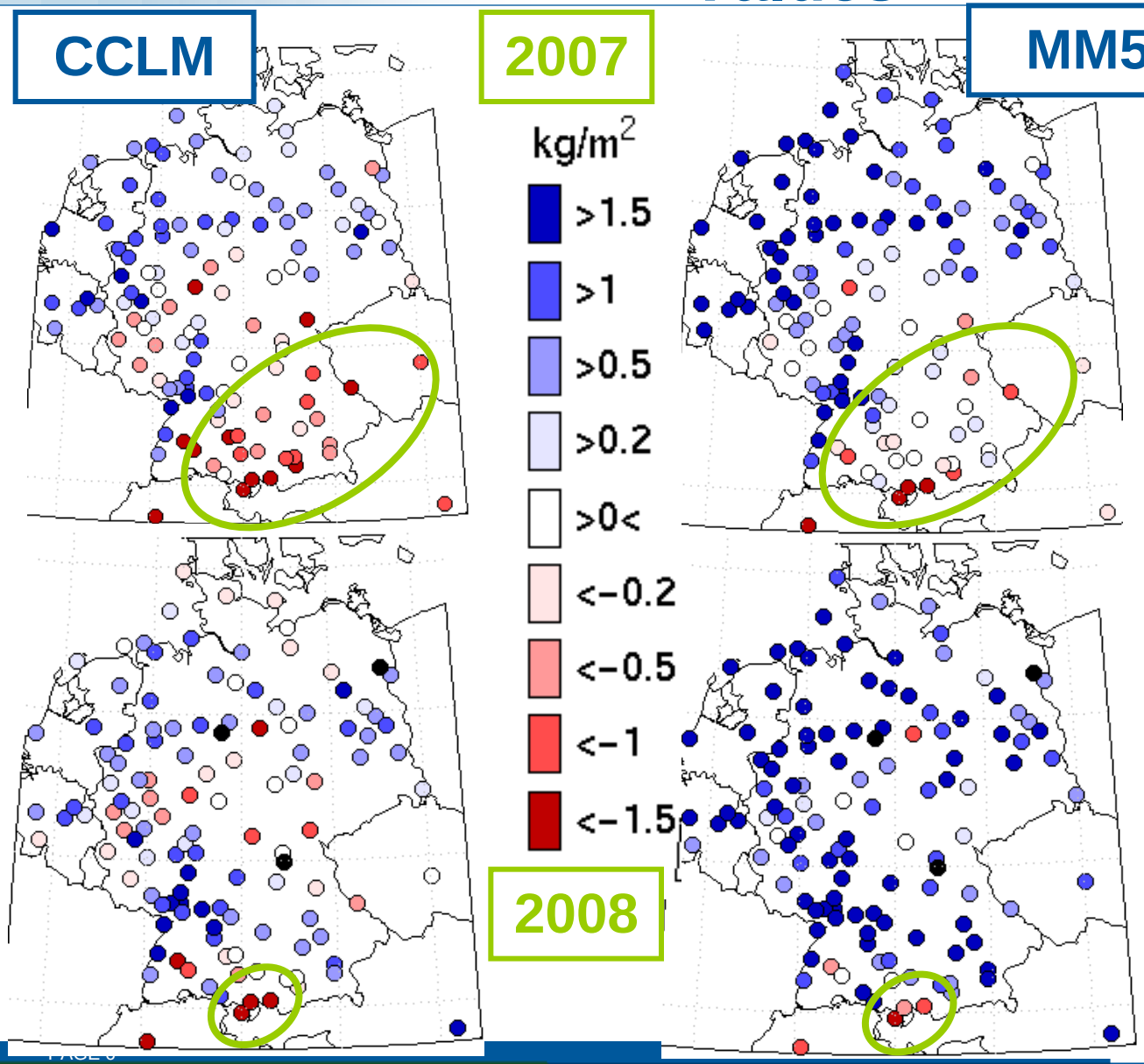
IWV: Diurnal Cycle

Spatial mean for each time of day



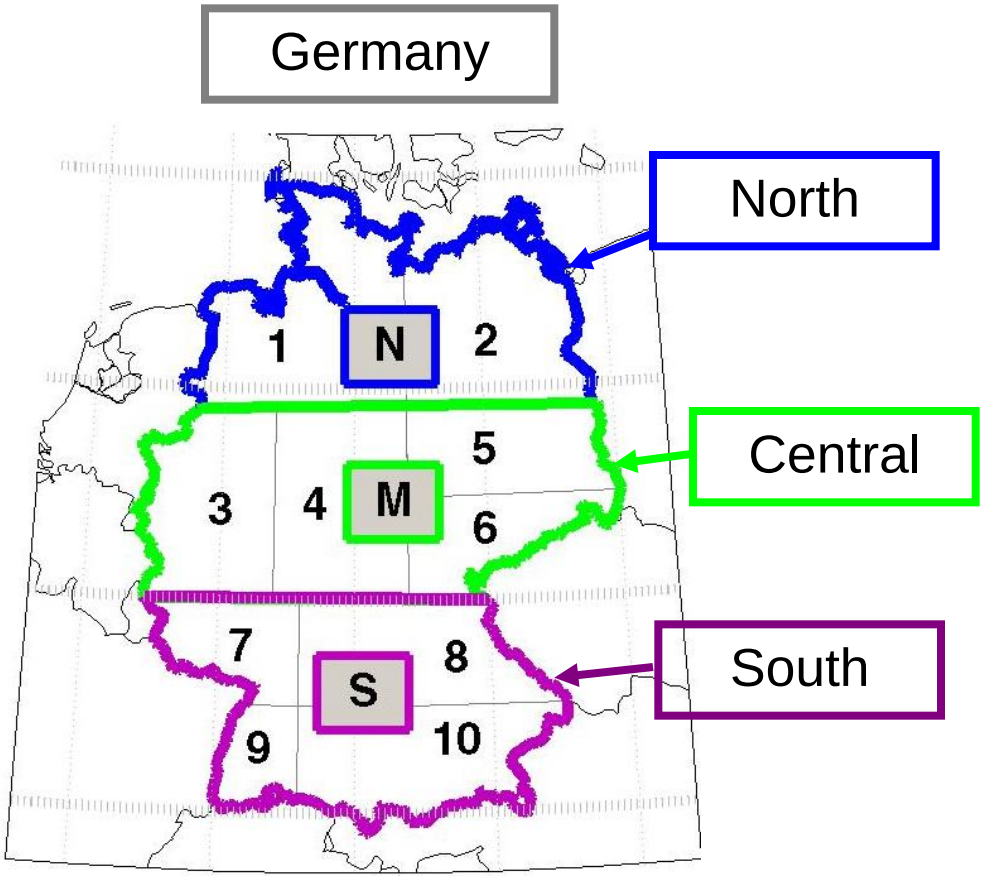
- Both models are able to represent the variability of the diurnal cycle
- MM5 shows an offset
- 2007: Slight shifts in maxima
- Very smooth curves

IWV: Mean Bias for Yearly Mean Values

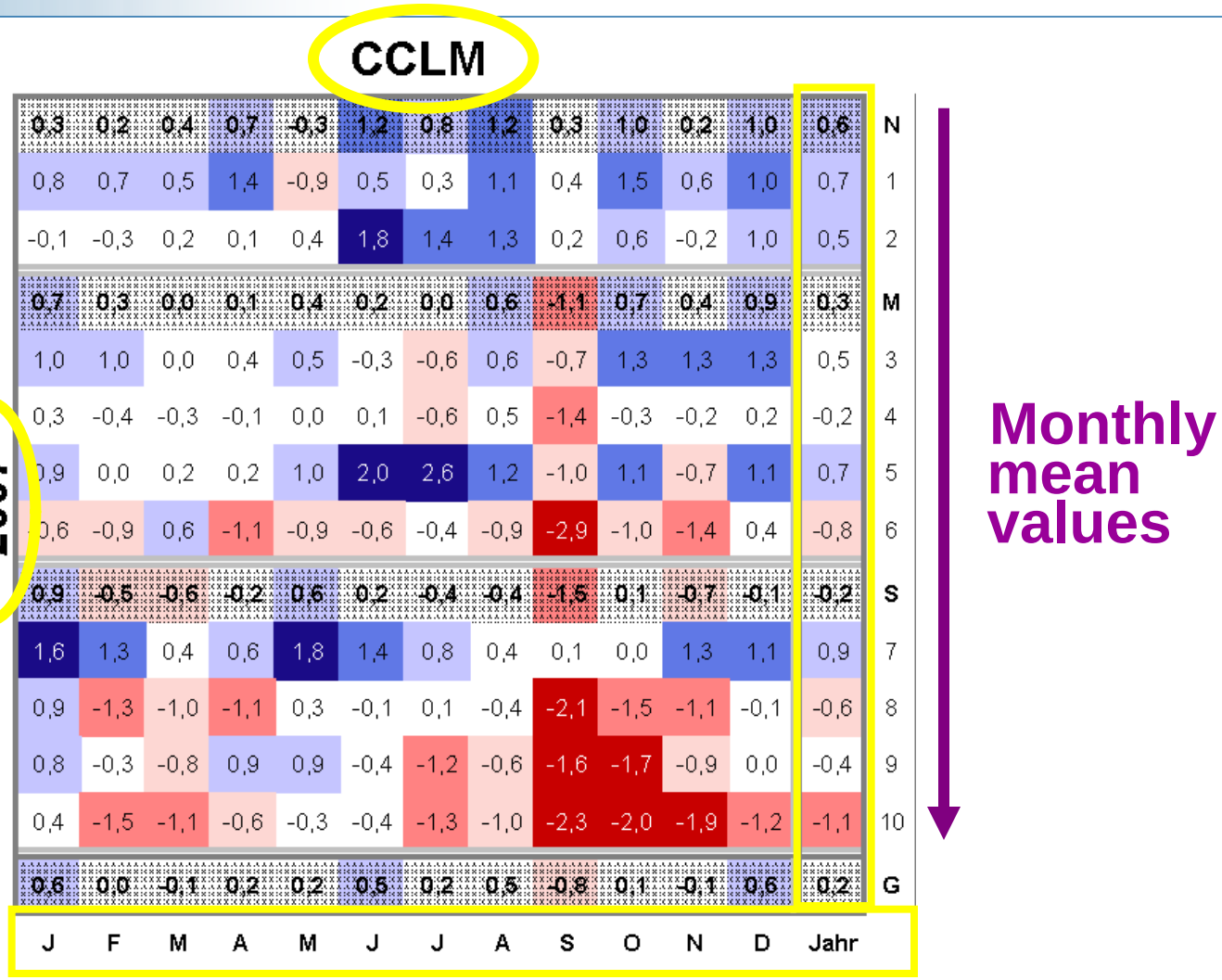


- Difference in bias pattern are mainly limited to the amplitude
- 2007: Dryness mainly in the South
- Too moist in the North

Subdomains: Short Introduction



Subdomains: Short Introduction

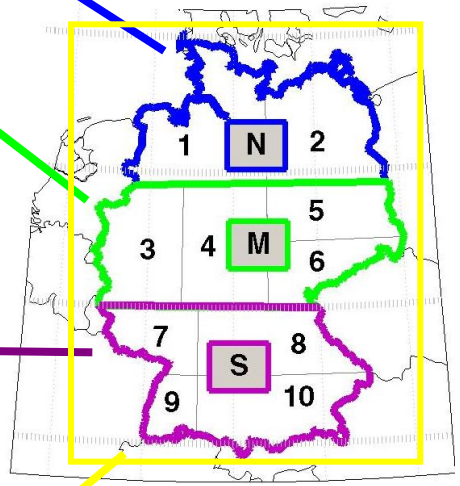


Subdomains: Short Introduction

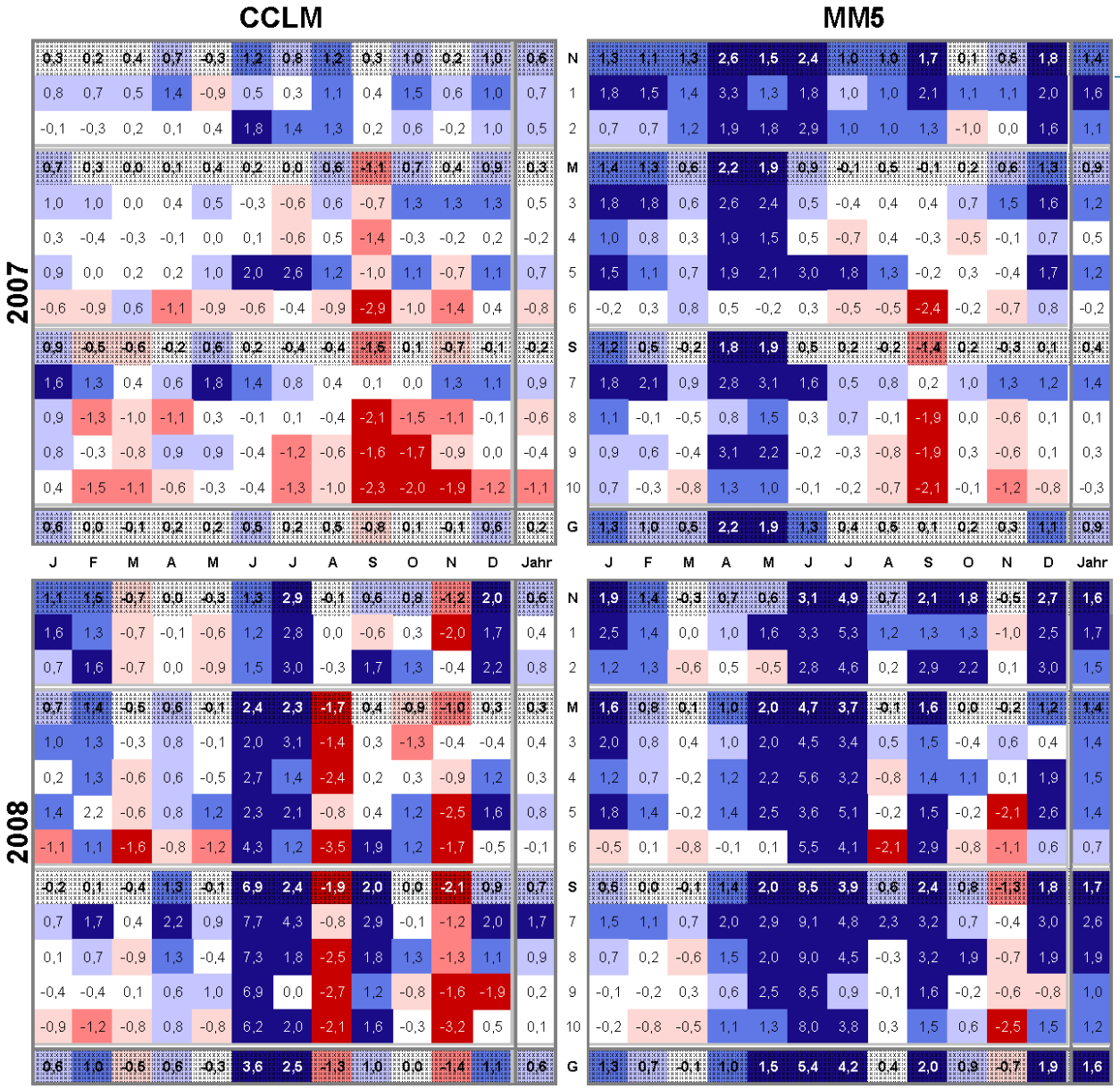
CCLM

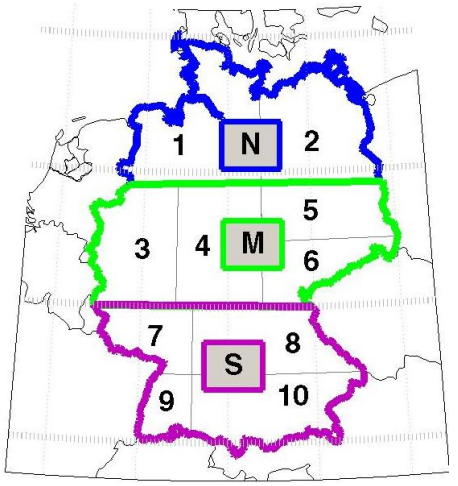
2007

J	F	M	A	M	J	J	A	S	O	N	D	Jahr	
0,3	0,2	0,4	0,7	-0,3	1,2	0,8	1,2	0,3	1,0	0,2	1,0	0,6	N
0,8	0,7	0,5	1,4	-0,9	0,5	0,3	1,1	0,4	1,5	0,6	1,0	0,7	1
-0,1	-0,3	0,2	0,1	0,4	1,8	1,4	1,3	0,2	0,6	-0,2	1,0	0,5	2
0,7	0,3	0,0	0,1	0,4	0,2	0,0	0,6	-1,1	0,7	0,4	0,9	0,3	M
1,0	1,0	0,0	0,4	0,5	-0,3	-0,6	0,6	-0,7	1,3	1,3	1,3	0,5	3
0,3	-0,4	-0,3	-0,1	0,0	0,1	-0,6	0,5	-1,4	-0,3	-0,2	0,2	-0,2	4
0,9	0,0	0,2	0,2	1,0	2,0	2,6	1,2	-1,0	1,1	-0,7	1,1	0,7	5
-0,6	-0,9	0,6	-1,1	-0,9	-0,6	-0,4	-0,9	-2,9	-1,0	-1,4	0,4	-0,8	6
0,9	-0,5	-0,6	-0,2	0,6	0,2	-0,4	-0,4	-1,5	0,1	-0,7	-0,1	-0,2	S
1,6	1,3	0,4	0,6	1,8	1,4	0,8	0,4	0,1	0,0	1,3	1,1	0,9	7
0,9	-1,3	-1,0	-1,1	0,3	-0,1	0,1	-0,4	-2,1	-1,5	-1,1	-0,1	-0,6	8
0,8	-0,3	-0,8	0,9	0,9	-0,4	-1,2	-0,6	-1,6	-1,7	-0,9	0,0	-0,4	9
0,4	-1,5	-1,1	-0,6	-0,3	-0,4	-1,3	-1,0	-2,3	-2,0	-1,9	-1,2	-1,1	10
0,6	0,0	-0,1	0,2	0,2	0,5	0,2	0,5	-0,8	0,1	-0,1	0,6	0,2	G



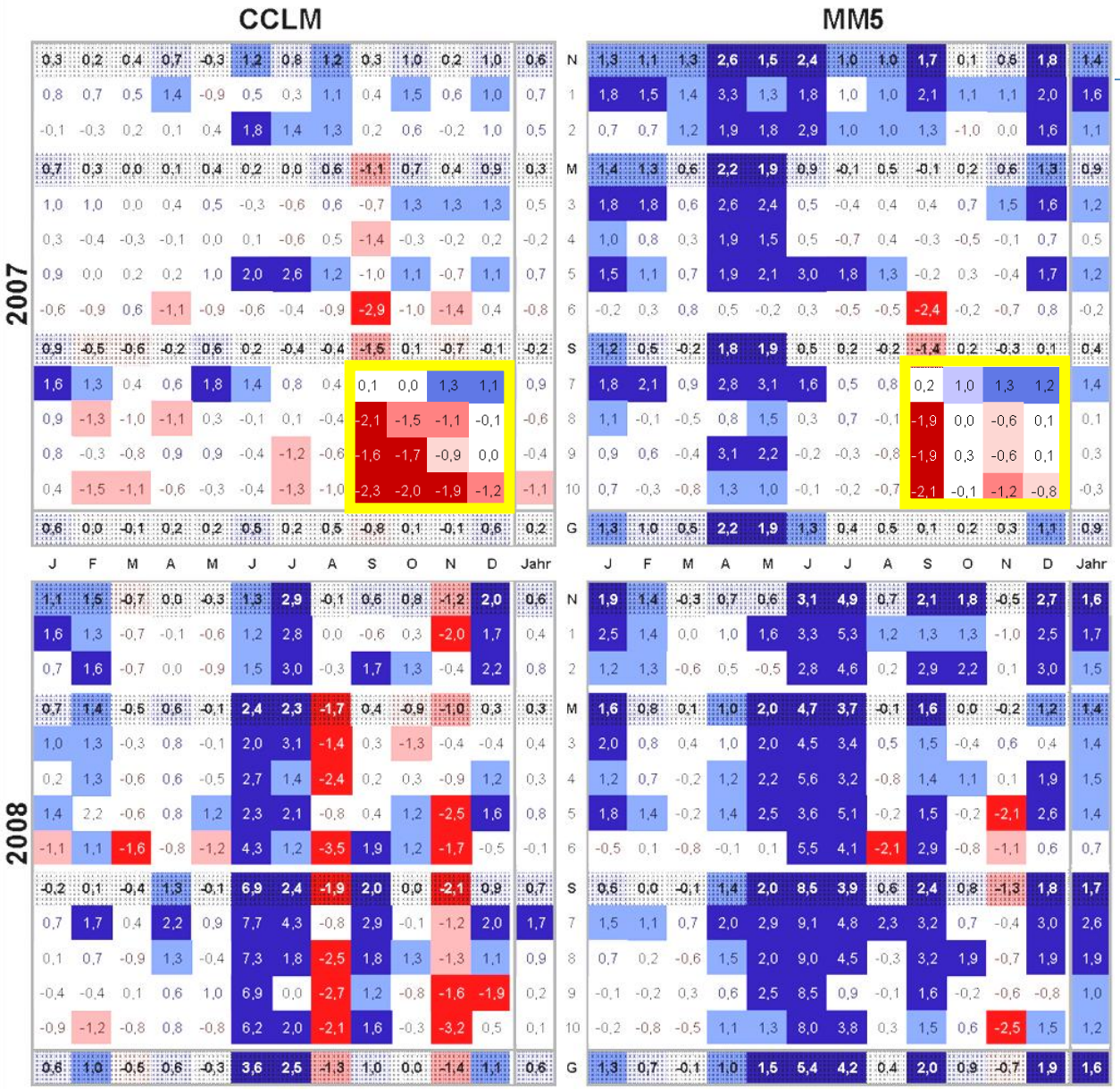
IWV: Bias





<2	<1	<0.5		>0.5	>1	>2

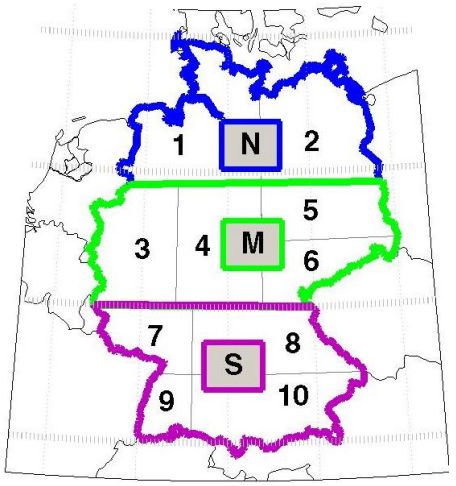
IWV: Bias



MM5 & CCLM:

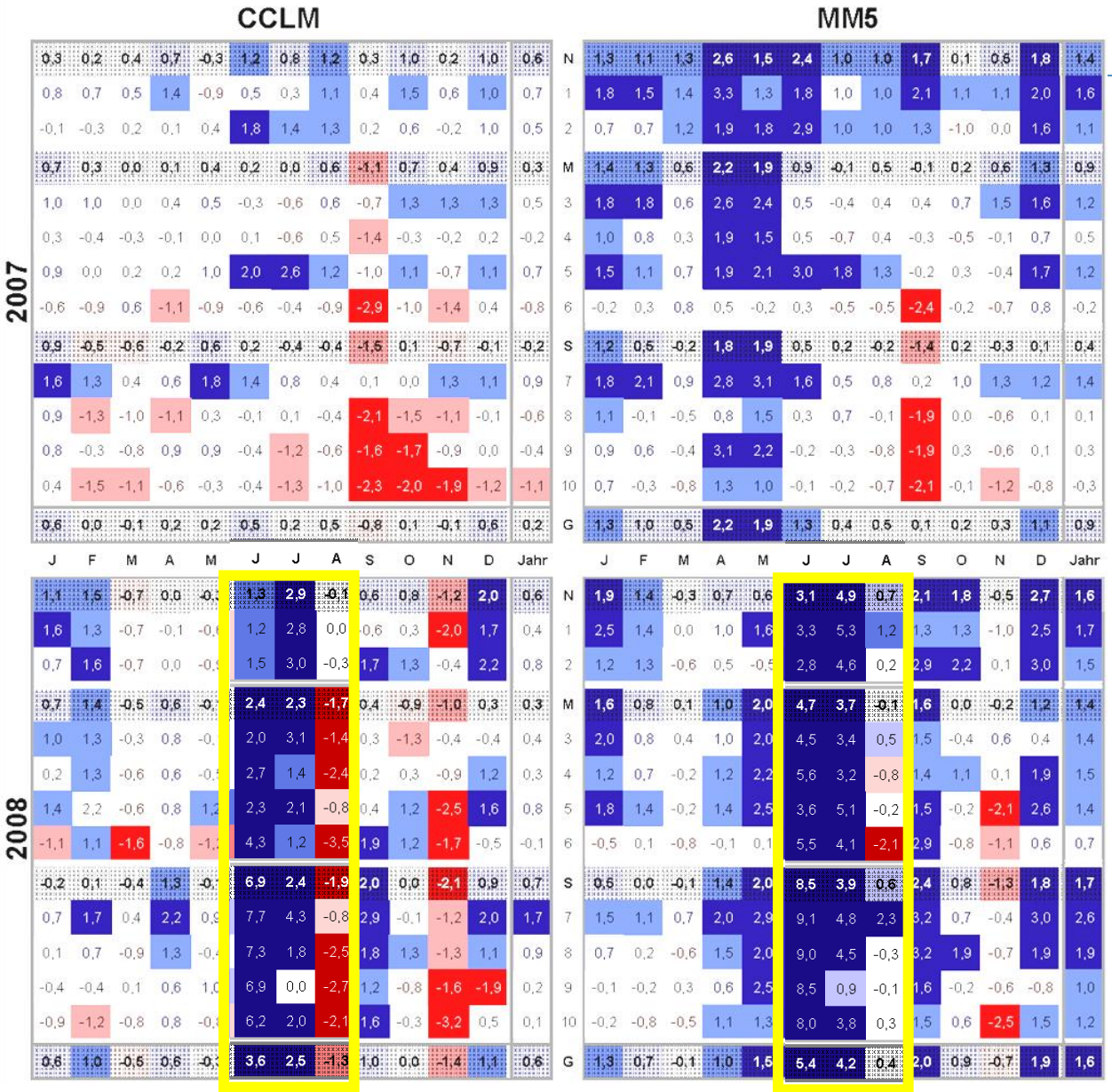
- related pattern with different amplitude

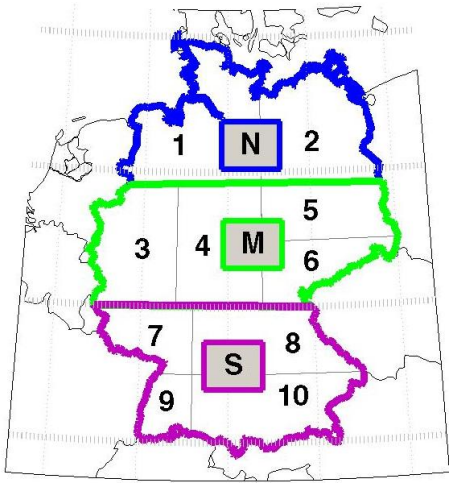
⇨ Maybe due to same forcing data



<2	<1	<0.5		>0.5	>1	>2

IWV: Bias





MM5 & CCLM:

- related pattern with different amplitude

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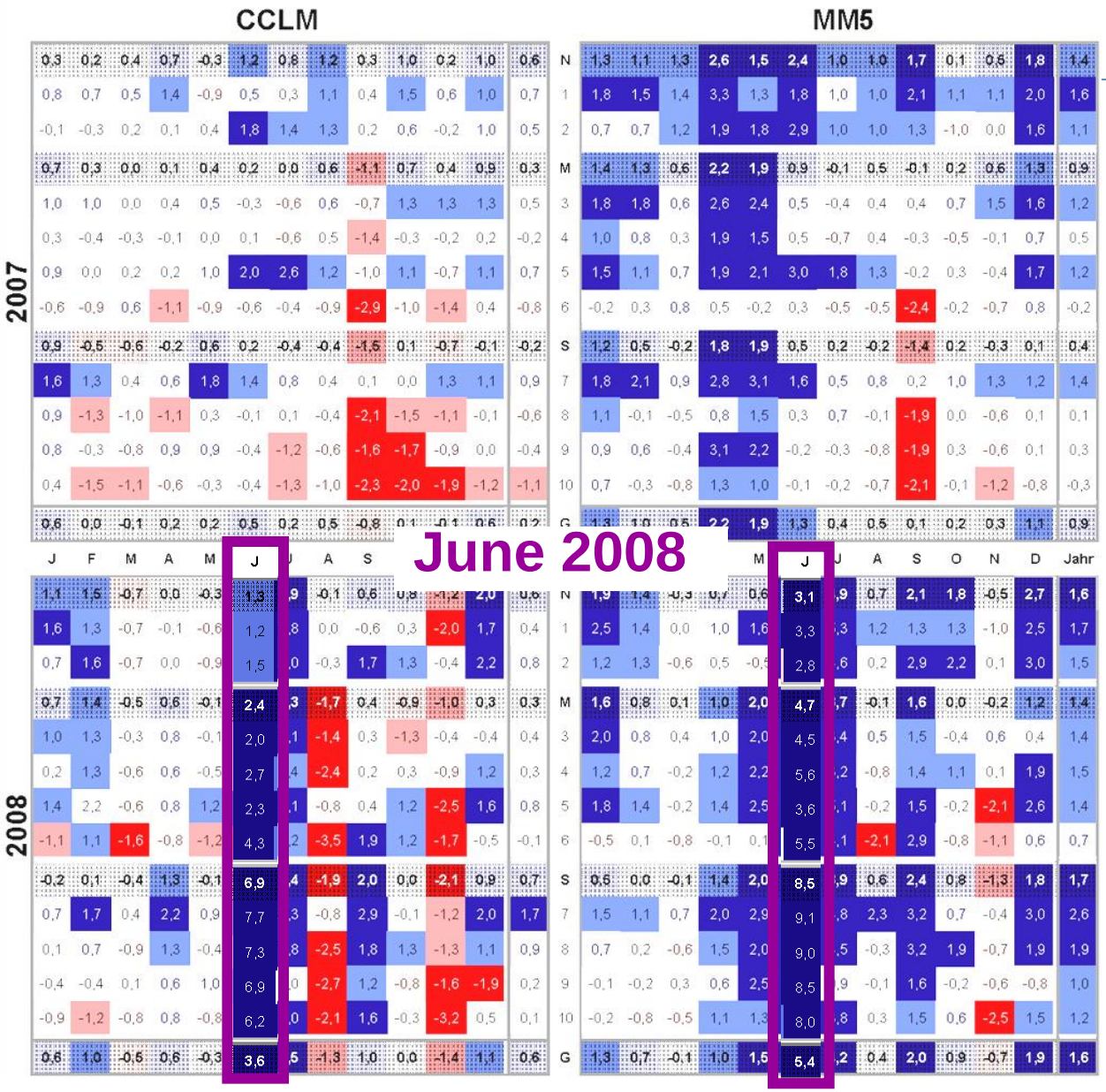
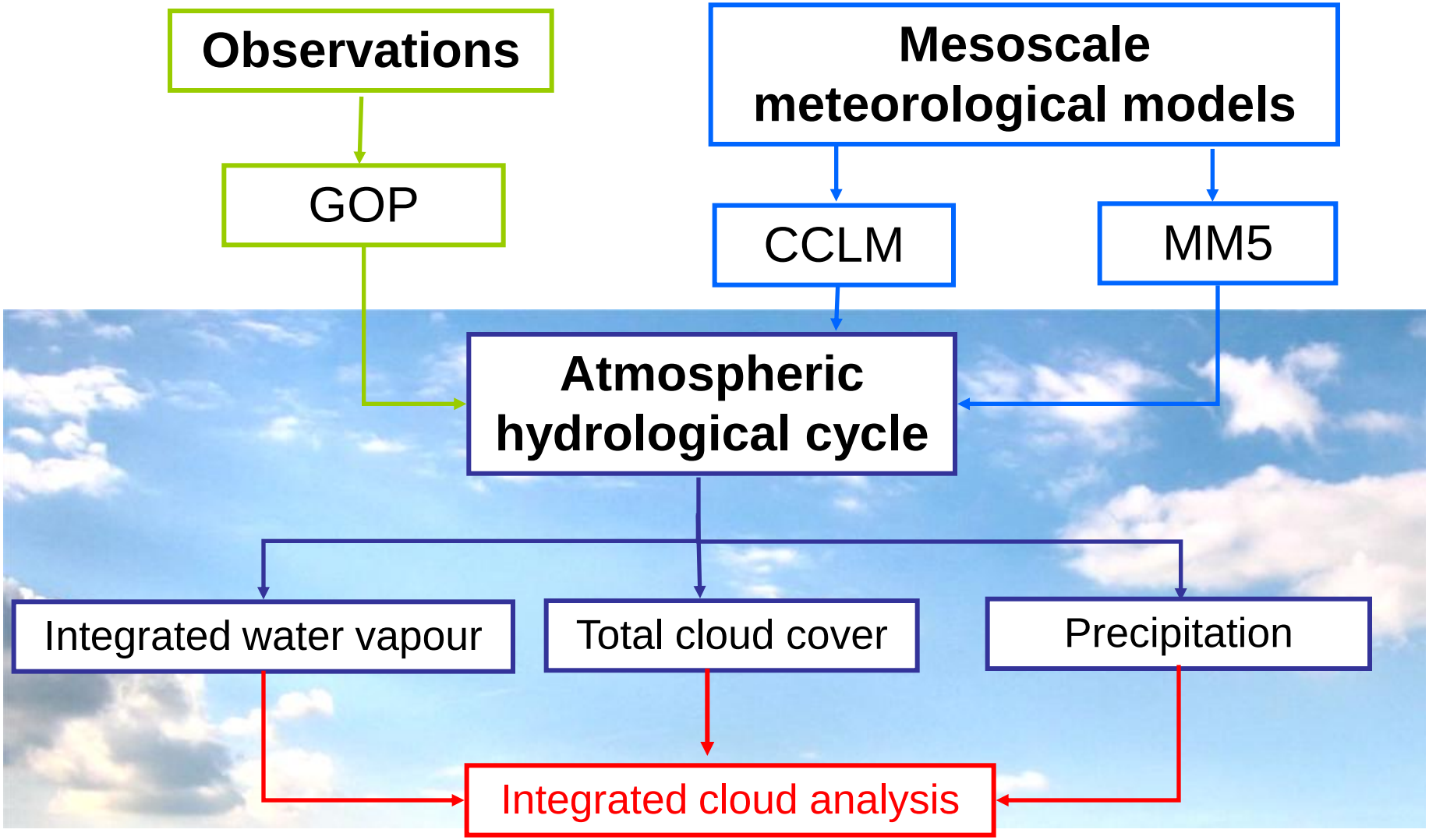
IWV: Bias

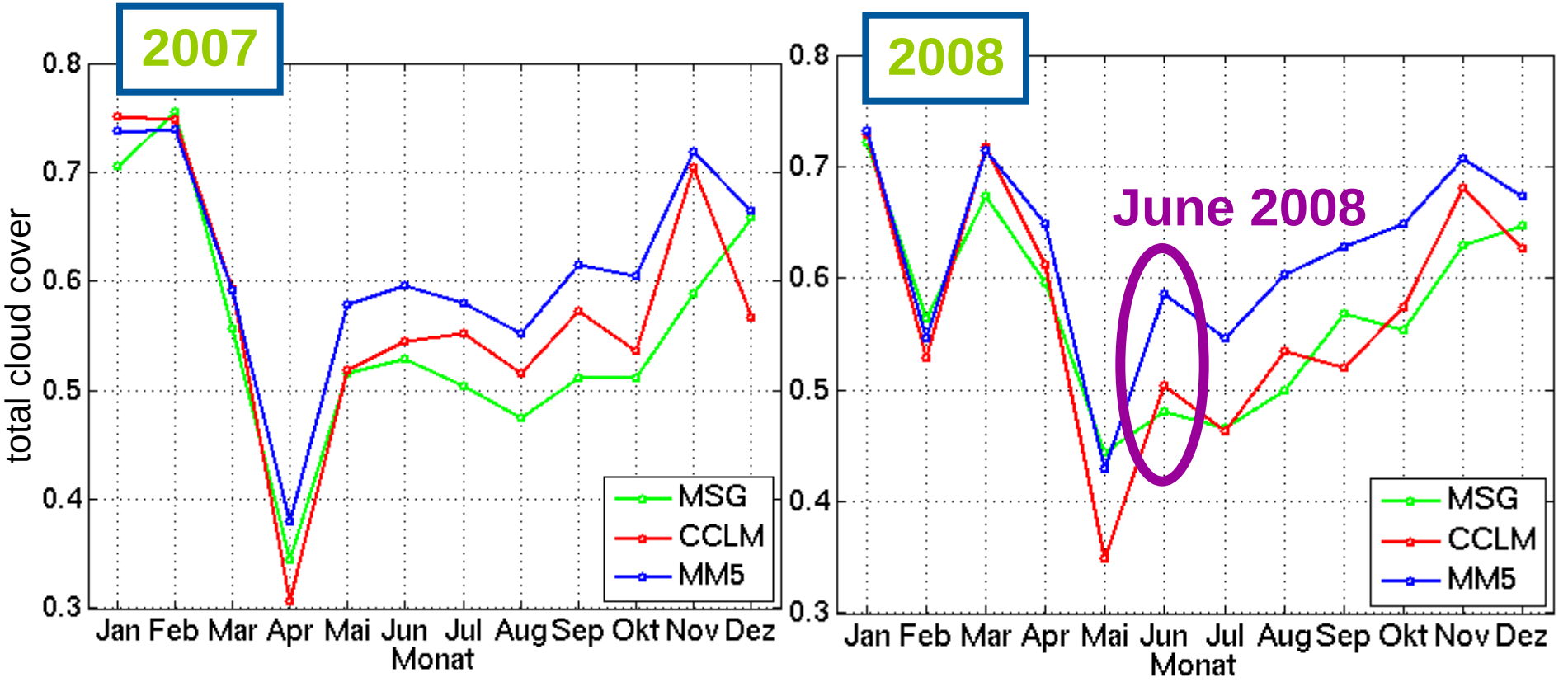

CCLM
MM5
2007
2008
June 2008
J F M A M J J A S O N D Jahr
N 1 2 M 3 4 5 6 S 7 8 9 10
<2
<1
<0.5
>0.5
>1
>2

Outline and Strategy



Total Cloud Cover: Annual Cycle

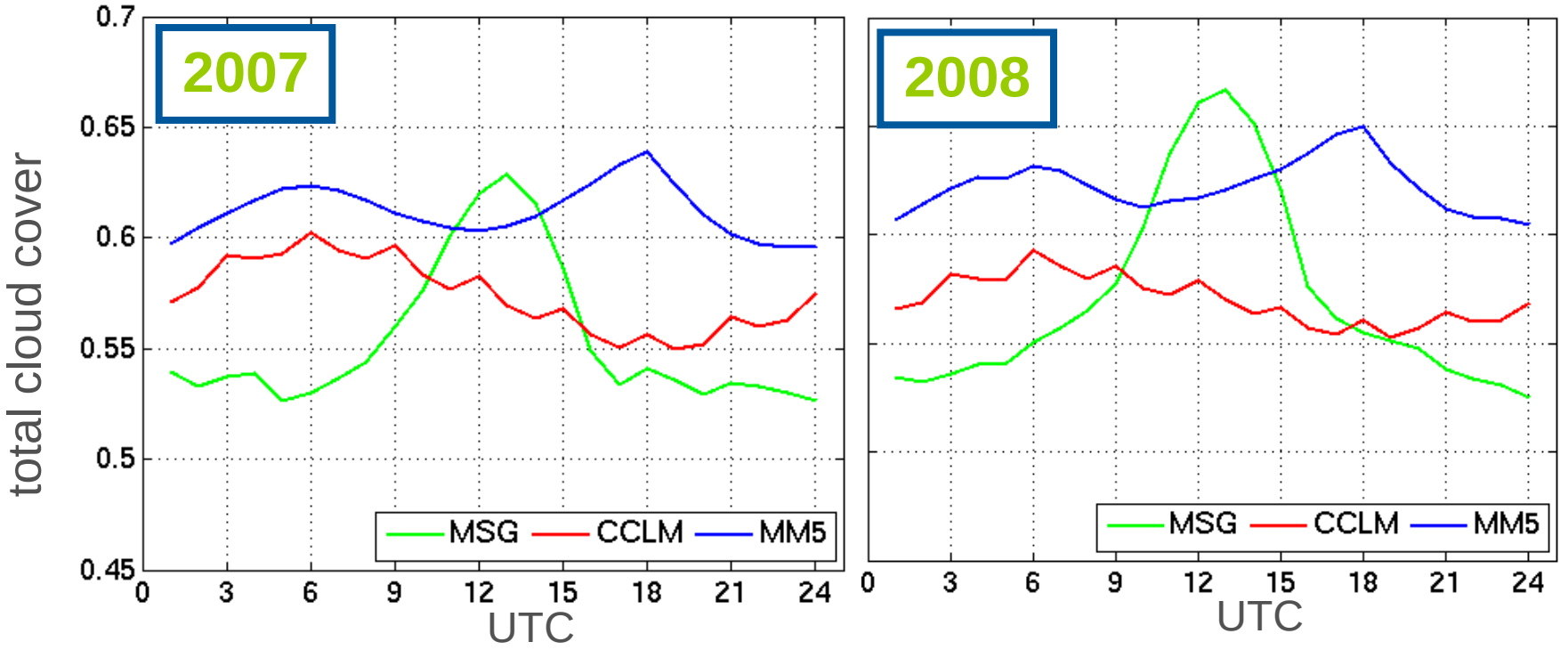
Montly spatial mean



- Just small deviations
- Both models are able to represent seasonal variability
- MM5 overestimates total cloud cover

Total cloud cover: Diurnal Cycle

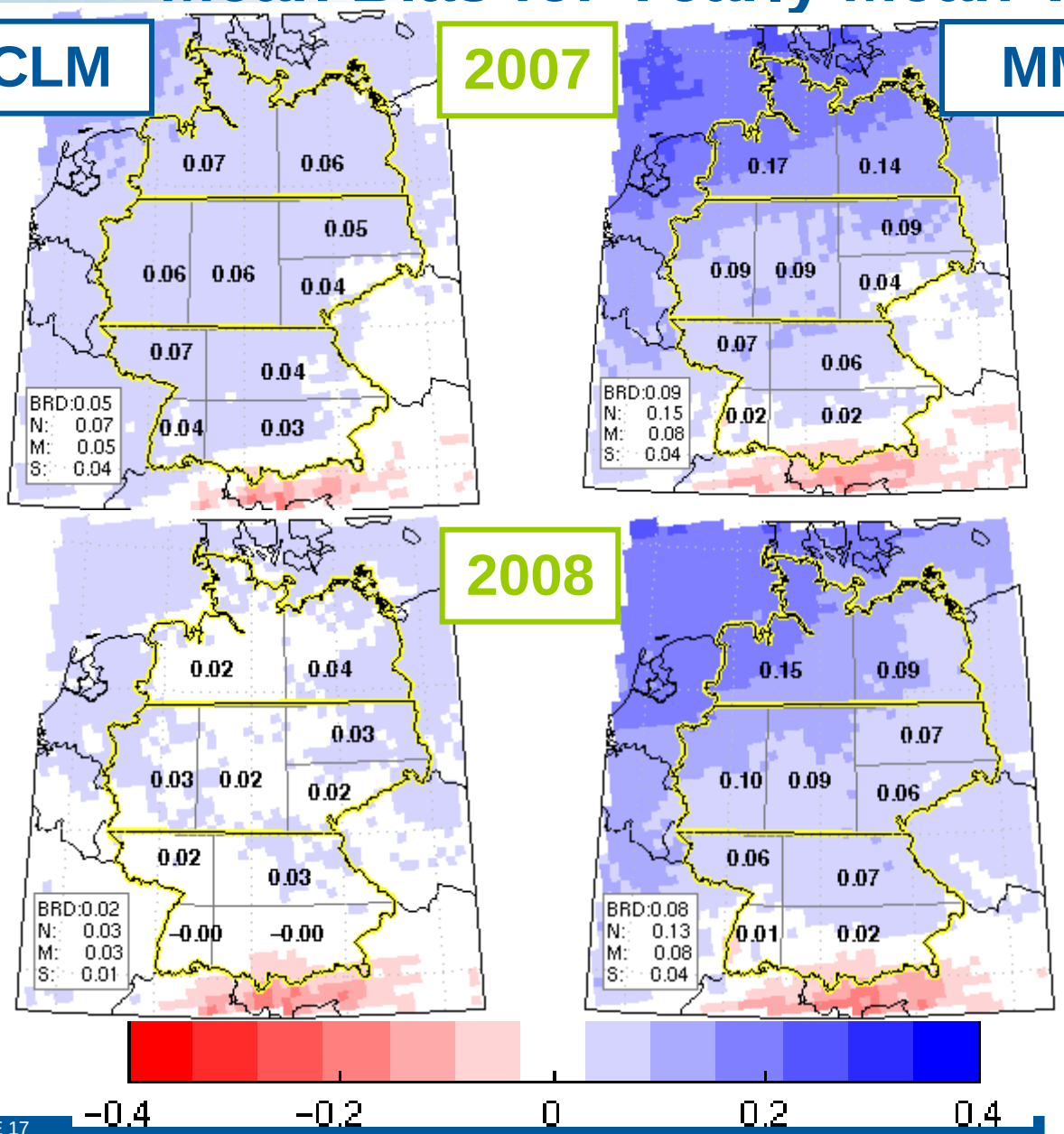
Spatial mean for each time of day



- Both models are not able to represent the diurnal cycle
- MM5 shows two slight maxima
- CCLM shows a maximum in the morning and a minimum in the afternoon

- a.m.: both models show a quite similar trend
- p.m.: they differ from each other
- CCLM seems to be strongly influencend by 3 hourly forcing data

Total Cloud Cover: Mean Bias for Yearly Mean Values



- The models show similar structures with different amplitudes
- North-South-Gradient
- Above the Alps, total cloud cover is underestimated
- Everywhere else: overestimations

Total Cloud Cover: Bias

CCLM

2007	J	F	M	A	M	J	J	A	S	O	N	D	Jahr
N	0.12	0.00	0.10	-0.03	0.02	0.06	0.07	0.08	0.10	0.09	0.18	0.00	0.07
1	0.10	0.01	0.09	-0.04	0.04	0.07	0.08	0.13	0.12	0.09	0.18	0.02	0.07
2	0.13	-0.02	0.10	-0.01	0.00	0.05	0.05	0.02	0.08	0.08	0.19	-0.01	0.06
M	0.11	-0.02	0.06	-0.07	0.08	0.08	0.06	0.09	-0.00	0.05	0.16	-0.02	-0.02
3	0.12	-0.03	0.03	-0.10	0.06	0.09	0.10	0.14	0.10	0.01	0.18	0.03	0.06
4	0.12	-0.03	0.04	-0.07	0.11	0.10	0.05	0.12	0.10	0.06	0.15	-0.02	0.06
5	0.11	-0.02	0.13	-0.04	0.04	0.06	0.03	0.03	0.06	0.09	0.17	-0.07	0.05
6	0.10	-0.02	0.04	-0.05	0.08	0.05	0.04	0.05	0.04	0.02	0.15	-0.07	0.04
S	0.12	0.00	0.05	-0.03	0.07	0.10	0.06	0.09	0.06	-0.01	0.09	0.11	0.04
7	0.14	0.01	0.08	-0.04	0.10	0.13	0.09	0.07	0.09	-0.01	0.15	-0.01	0.07
8	0.11	-0.01	0.04	-0.03	0.09	0.10	0.06	0.08	0.06	-0.01	0.09	-0.10	0.04
9	0.13	0.05	0.05	-0.03	0.04	0.11	0.00	0.08	0.07	-0.04	0.13	-0.13	0.04
10	0.12	-0.02	0.05	-0.02	0.04	0.09	0.05	0.10	0.05	0.01	0.06	-0.18	0.03
G	0.12	-0.01	0.07	-0.04	0.06	0.08	0.06	0.09	0.08	0.04	0.15	-0.04	0.06

MM5

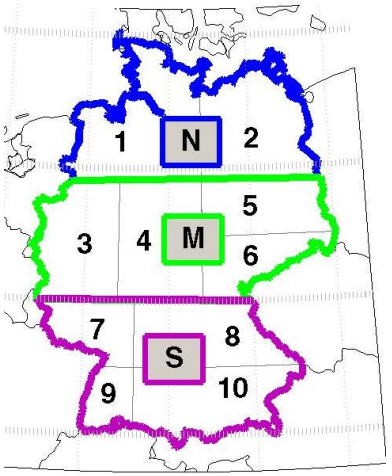
2007	J	F	M	A	M	J	J	A	S	O	N	D	Jahr
N	0.15	0.02	0.16	0.12	0.16	0.17	0.11	0.19	0.22	0.17	0.19	0.16	0.16
1	0.16	0.03	0.18	0.11	0.19	0.17	0.13	0.19	0.26	0.20	0.20	0.16	0.17
2	0.14	0.01	0.14	0.13	0.13	0.17	0.08	0.18	0.18	0.14	0.18	0.14	0.14
M	0.08	0.01	0.07	0.02	0.10	0.11	0.06	0.12	0.15	0.11	0.14	0.01	0.08
3	0.10	-0.01	0.09	-0.02	0.14	0.10	0.09	0.12	0.16	0.09	0.15	0.08	0.09
4	0.08	0.03	0.09	0.01	0.12	0.10	0.04	0.13	0.17	0.13	0.14	0.01	0.09
5	0.08	0.02	0.06	0.08	0.06	0.16	0.05	0.13	0.14	0.14	0.15	0.00	0.09
6	0.06	0.01	-0.01	0.01	0.04	0.09	0.07	0.08	0.10	0.07	0.10	-0.10	0.04
S	0.05	0.03	0.02	-0.01	0.06	0.04	0.07	0.08	0.08	0.10	0.10	0.14	0.04
7	0.07	0.03	0.08	-0.01	0.10	0.08	0.03	0.08	0.11	0.17	0.17	-0.01	0.08
8	0.08	0.05	0.02	0.01	0.06	0.05	0.09	0.10	0.09	0.13	0.11	-0.10	0.06
9	0.04	0.06	0.00	-0.05	0.06	0.04	0.04	0.05	0.08	-0.02	0.12	-0.20	0.02
10	0.03	0.01	-0.01	-0.01	0.04	0.02	0.09	0.06	0.07	0.08	0.06	-0.24	0.02
G	0.10	0.02	0.08	0.04	0.11	0.11	0.08	0.13	0.15	0.13	0.15	0.01	0.09

2008

2008	J	F	M	A	M	J	J	A	S	O	N	D	Jahr
N	0.02	0.02	0.09	-0.03	-0.04	0.03	0.00	0.12	-0.01	0.05	0.07	0.03	0.03
1	0.03	-0.02	0.07	-0.05	-0.08	0.05	0.02	0.13	-0.03	0.06	0.08	0.02	0.02
2	0.01	0.05	0.11	-0.01	-0.01	0.01	-0.03	0.11	0.01	0.04	0.06	0.05	0.03
M	0.01	0.04	0.07	0.03	-0.11	0.05	0.04	0.07	-0.02	0.04	0.04	0.08	0.03
3	0.00	0.00	0.05	0.07	-0.16	0.04	0.11	0.08	-0.01	0.04	0.06	0.09	0.03
4	0.01	0.03	0.05	0.00	-0.15	0.05	0.06	0.06	0.00	0.04	0.02	0.09	0.02
5	0.03	0.08	0.11	0.03	-0.02	0.04	-0.03	0.08	-0.06	0.06	0.05	0.05	0.04
6	0.01	0.08	0.07	0.01	-0.08	0.05	-0.01	0.04	-0.04	0.04	0.03	0.08	0.02
S	-0.02	-0.04	0.03	0.04	-0.08	0.07	0.05	0.01	-0.01	0.03	0.01	0.05	0.01
7	-0.03	-0.01	0.02	0.04	-0.11	0.08	0.08	-0.01	-0.01	0.00	0.07	0.09	0.02
8	0.01	0.02	0.03	0.04	-0.08	0.09	0.04	0.03	0.02	0.03	-0.01	0.09	0.03
9	-0.07	-0.08	0.00	0.01	-0.08	0.07	0.07	-0.03	-0.05	0.01	0.08	0.04	0.00
10	-0.02	-0.11	0.03	0.04	-0.08	0.05	0.04	0.03	-0.03	0.04	-0.03	-0.01	0.00
G	0.01	0.00	0.06	0.01	-0.08	0.05	0.03	0.07	-0.01	0.04	0.04	0.06	0.02

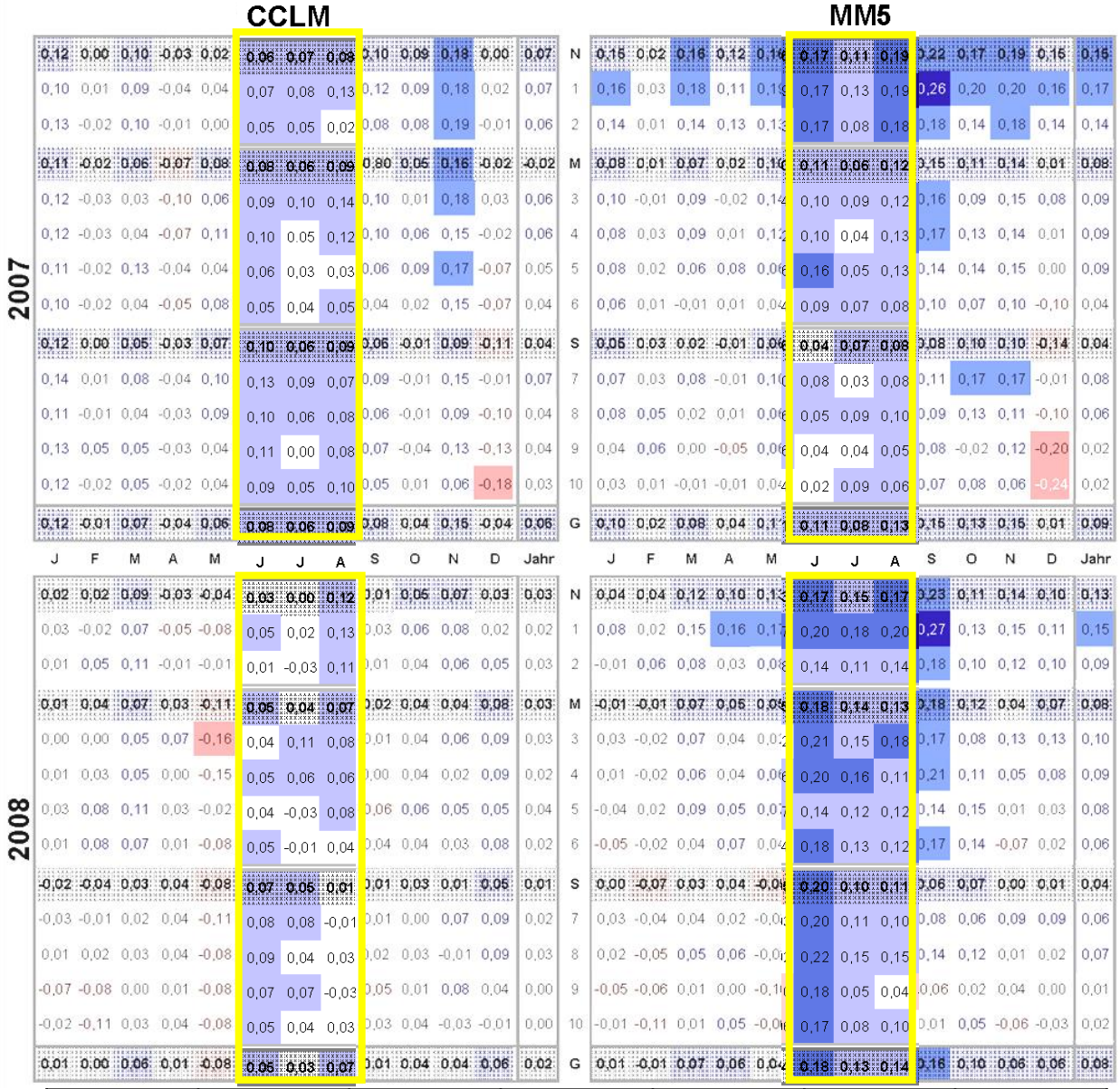
MM5

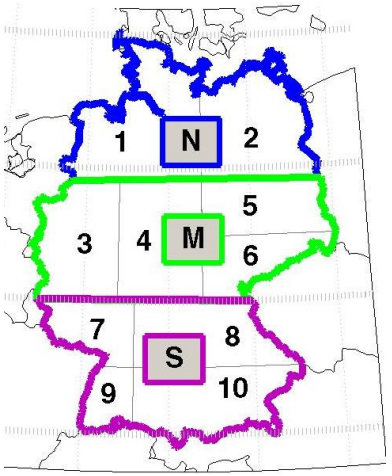
2008	J	F	M	A	M	J	J	A	S	O	N	D	Jahr
N	0.04	0.04	0.12	0.10	0.13	0.17	0.15	0.17	0.23	0.11	0.14	0.10	0.13
1	0.08	0.02	0.15	0.16	0.17	0.20	0.18	0.20	0.27	0.13	0.15	0.11	0.15
2	-0.01	0.06	0.08	0.03	0.08	0.14	0.11	0.14	0.18	0.10	0.12	0.10	0.09
M	-0.01	-0.01	0.07	0.06	0.05	0.18	0.14	0.13	0.18	0.12	0.04	0.07	0.08
3	0.03	-0.02	0.07	0.04	0.02	0.21	0.15	0.18	0.17	0.08	0.13	0.13	0.10
4	0.01	-0.02	0.06	0.04	0.06	0.20	0.16	0.11	0.21	0.11	0.05	0.08	0.09
5	-0.04	0.02	0.09	0.05	0.07	0.14	0.12	0.12	0.14	0.15	0.01	0.03	0.08
6	-0.05	-0.02	0.04	0.07	0.04	0.18	0.13	0.12	0.17	0.14	-0.07	0.02	0.06
S	0.00	-0.07	0.03	0.04	-0.05	0.20	0.10	0.11	0.06	0.07	0.00	0.01	0.04
7	0.03	-0.04	0.04	0.02	-0.03	0.20	0.11	0.10	0.08	0.06	0.09	0.09	0.06
8	0.02	-0.05	0.05	0.06	-0.02	0.22	0.15	0.15	0.14	0.12	0.01	0.02	0.07
9	-0.05	-0.06	0.01	0.00	-0.10	0.18	0.05	0.04	-0.06	0.02	0.04	0.00	0.01
10	-0.01	-0.11	0.01	0.05	-0.06	0.17	0.08	0.10	0.01	0.05	-0.06	-0.03	0.02
G	0.01	-0.01	0.07	0.06	0.04	0.18	0.13	0.14	0.16	0.10	0.06	0.06	0.08



<0.25	<0.15	<0.05		>0.05	>0.15	>0.25

Total Cloud Cover: Bias

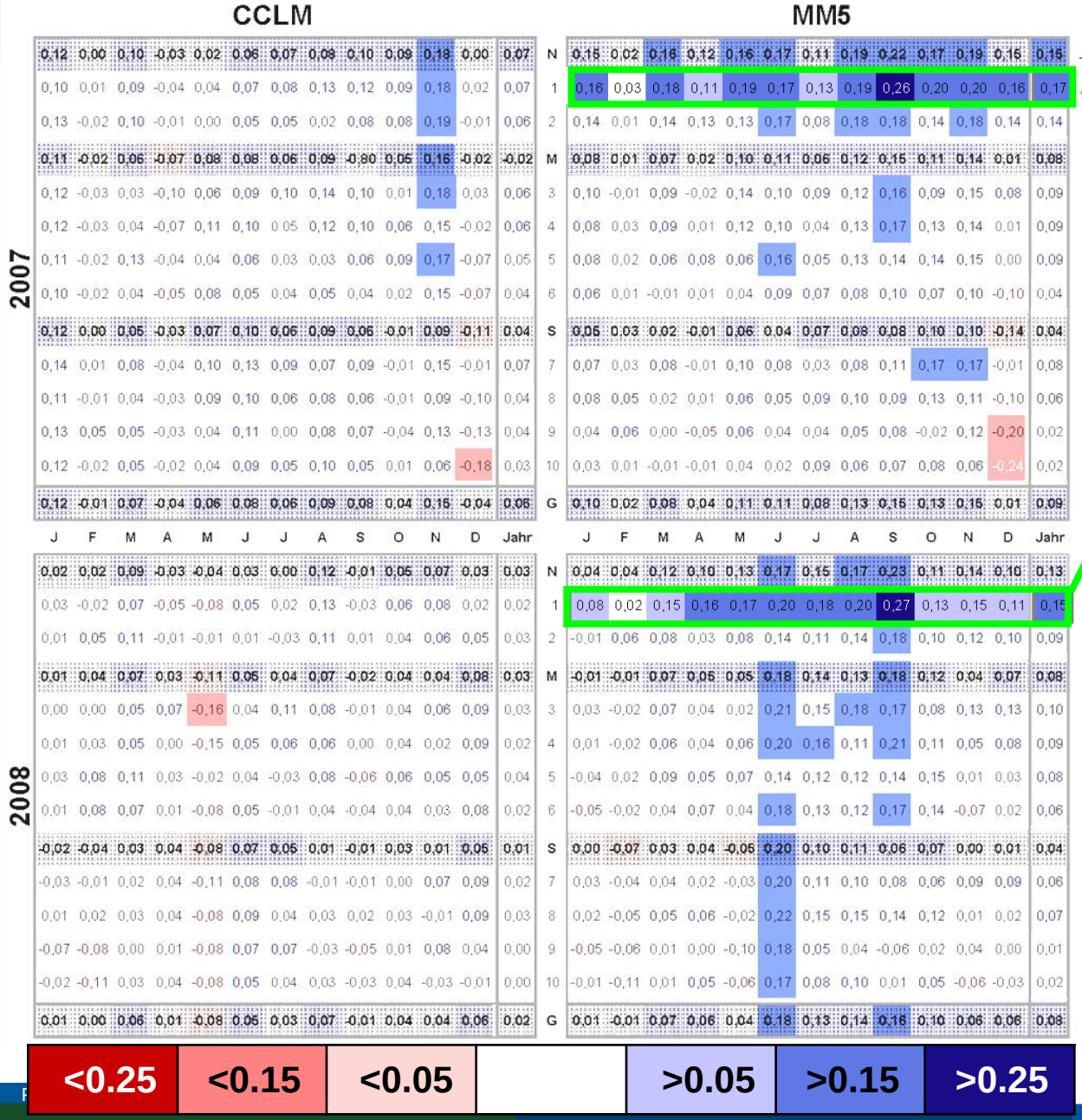


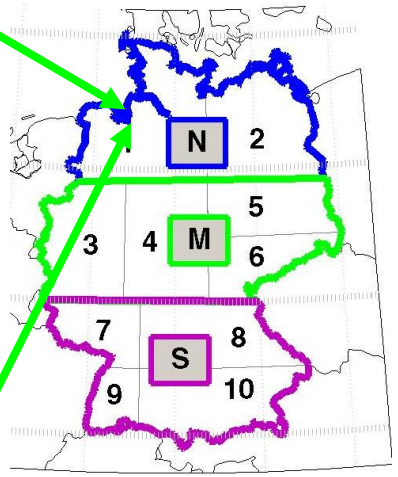


- CCLM & MM5: Increased overestimations in summer
- MM5: Overestimations predominately in the North

→ maritime influence

Total Cloud Cover: Bias

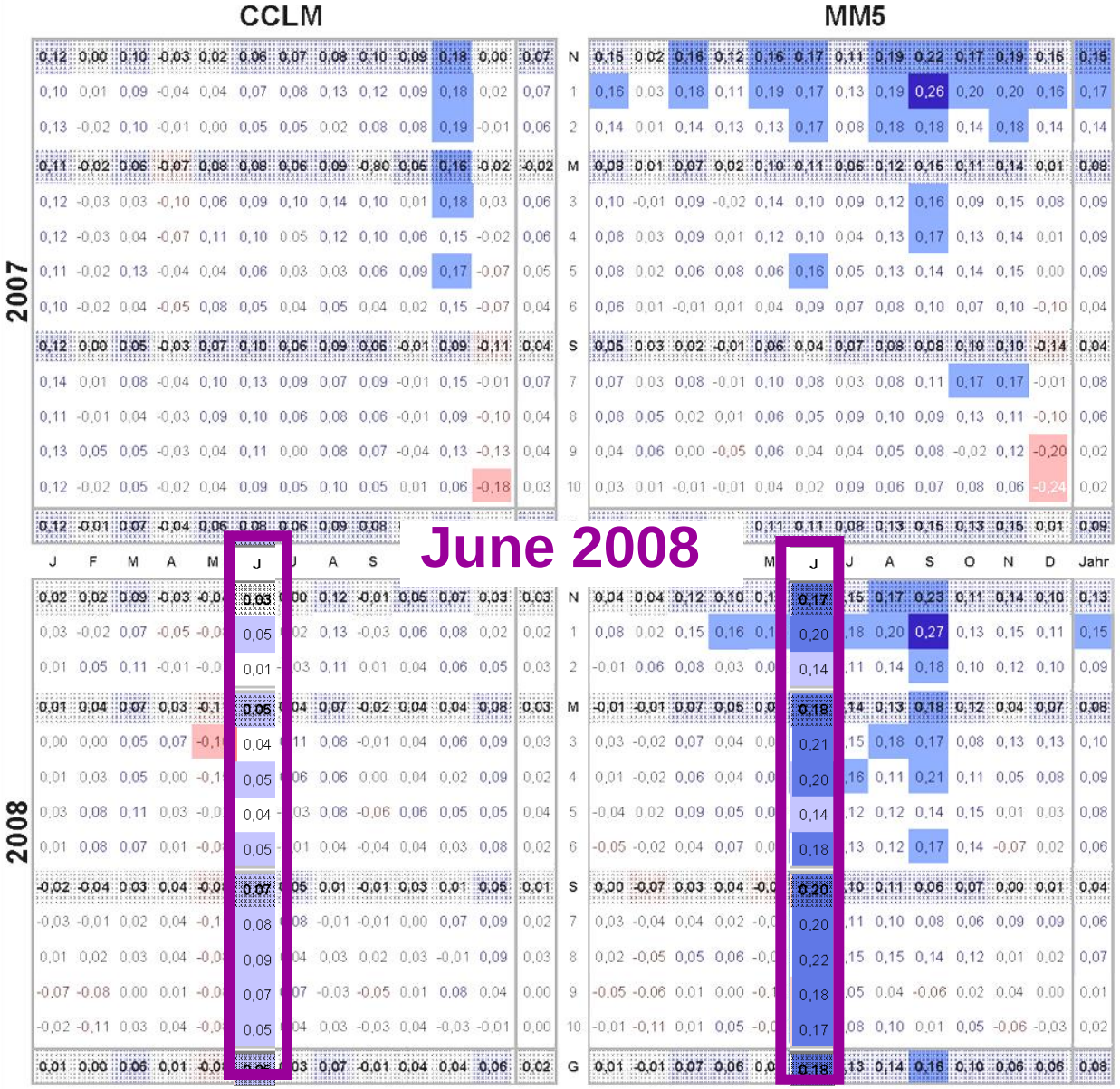


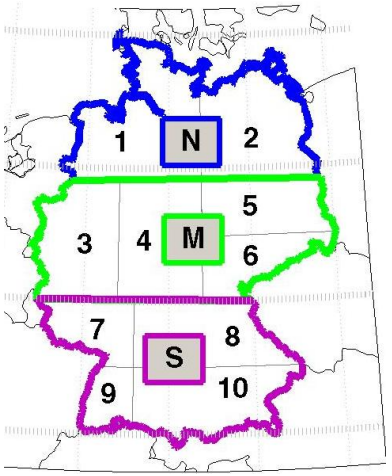


- CCLM & MM5: Increased overestimations in summer
- MM5: Overestimations predominately in the North

→ maritime influence

Total Cloud Cover: Bias





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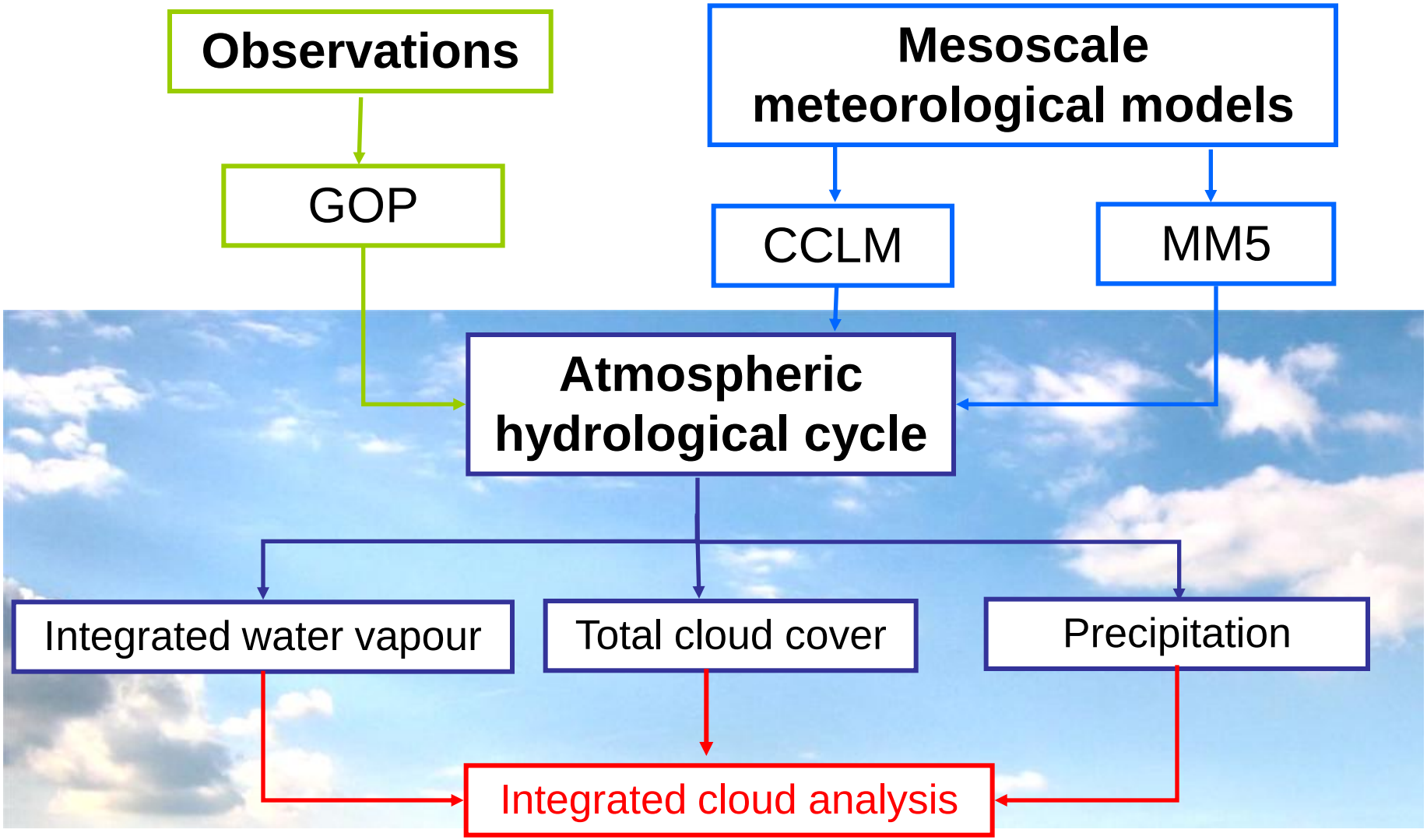
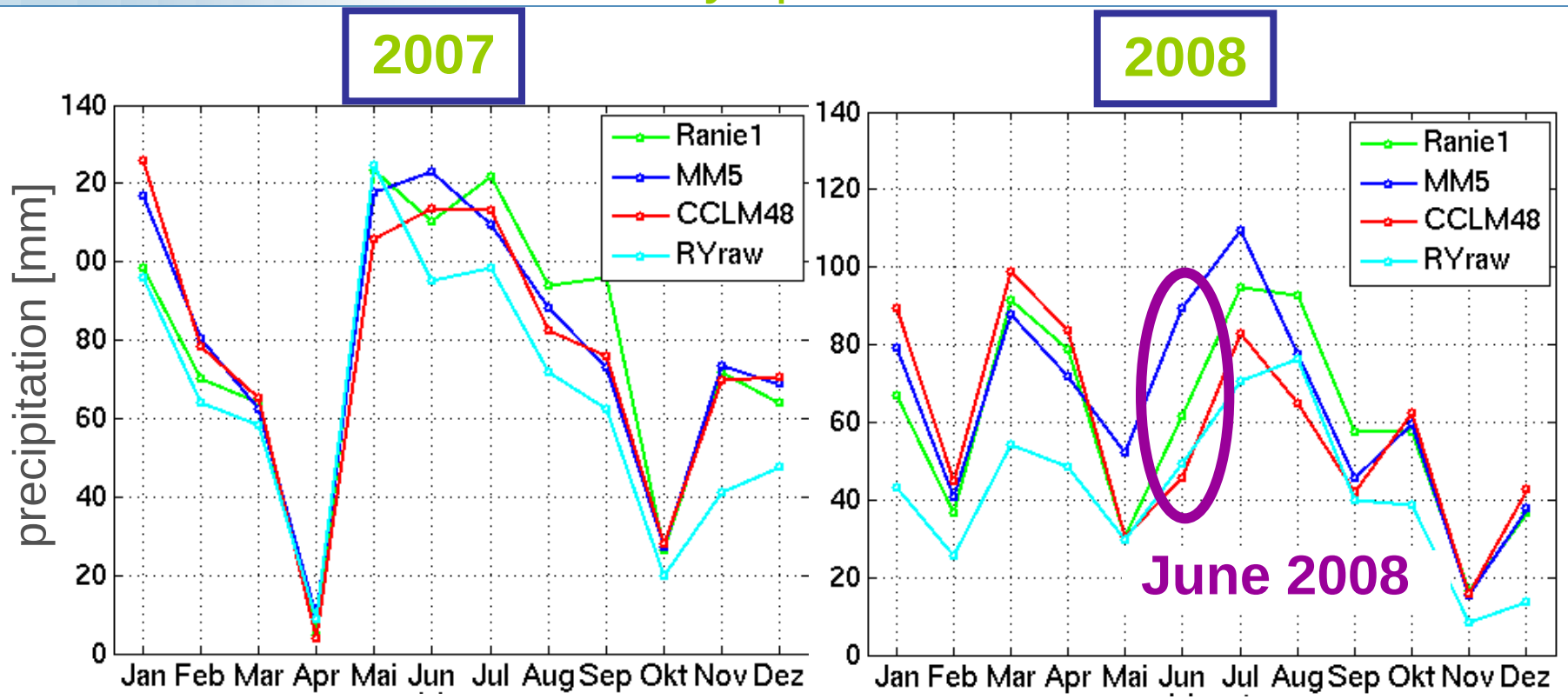
→ maritime influence

Outline and Strategy



Precipitation: Annual Cycle

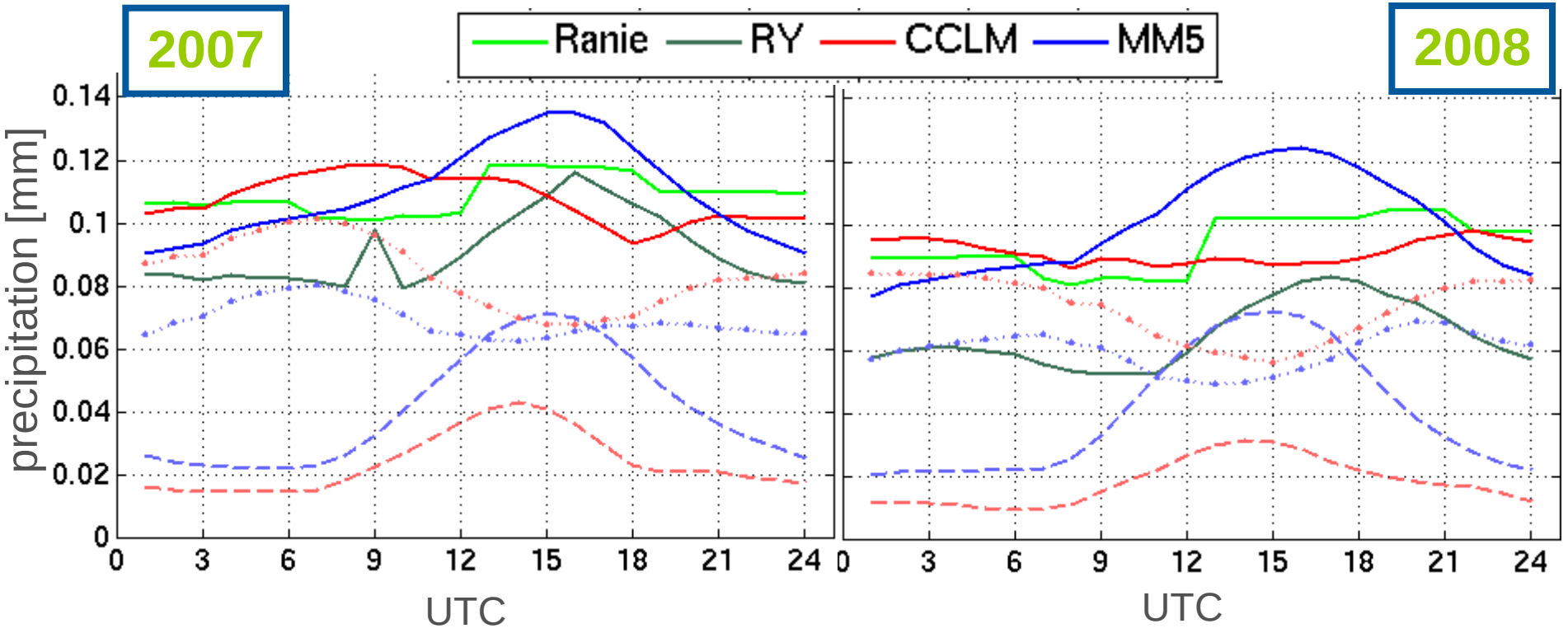
Monthly spatial mean



- Strongest differences between the models and largest deviations occur in summer
- The precipitation height is overestimated in winter and underestimated in summer by CCLM

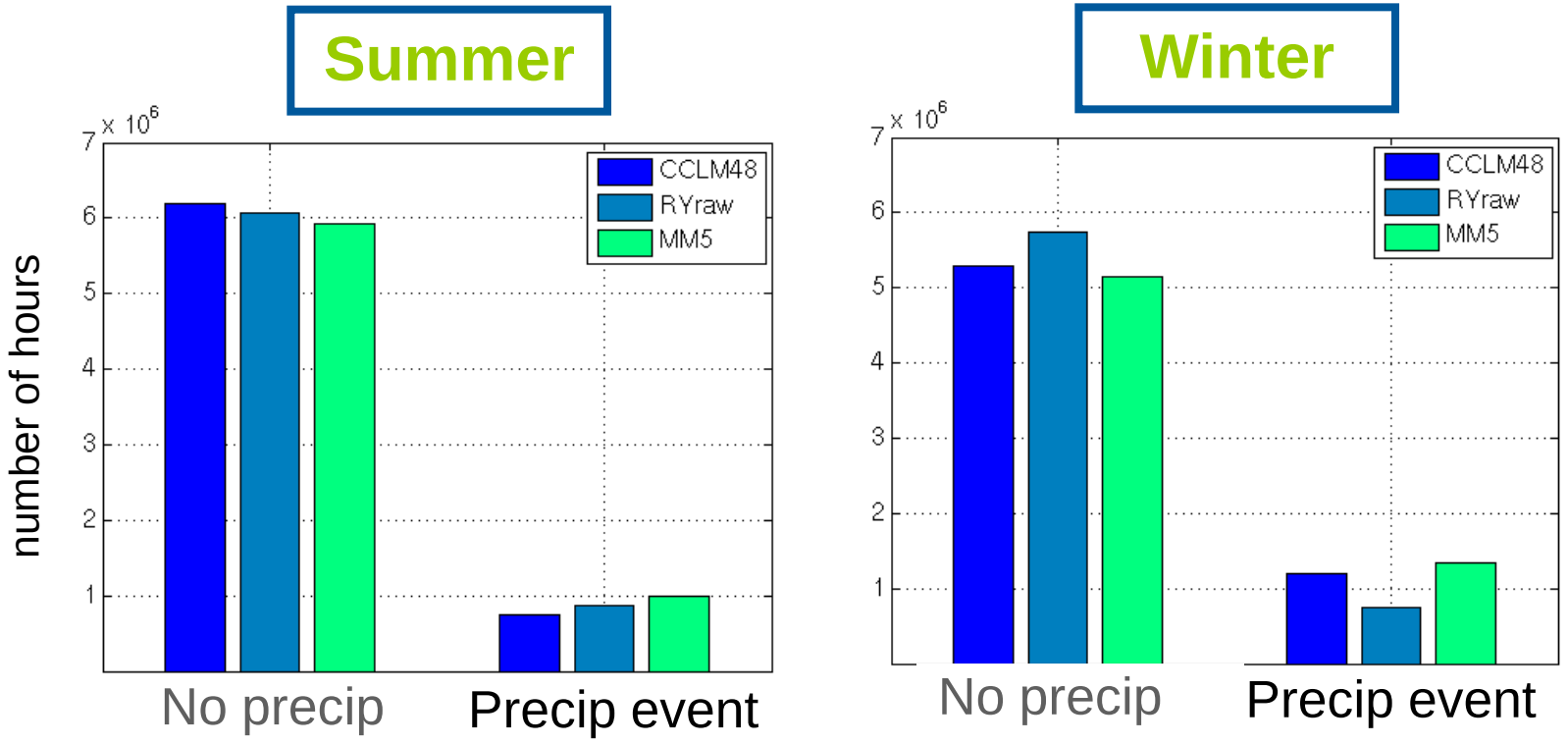
Precipitation: Diurnal Cycle

Spatial mean for each time of day



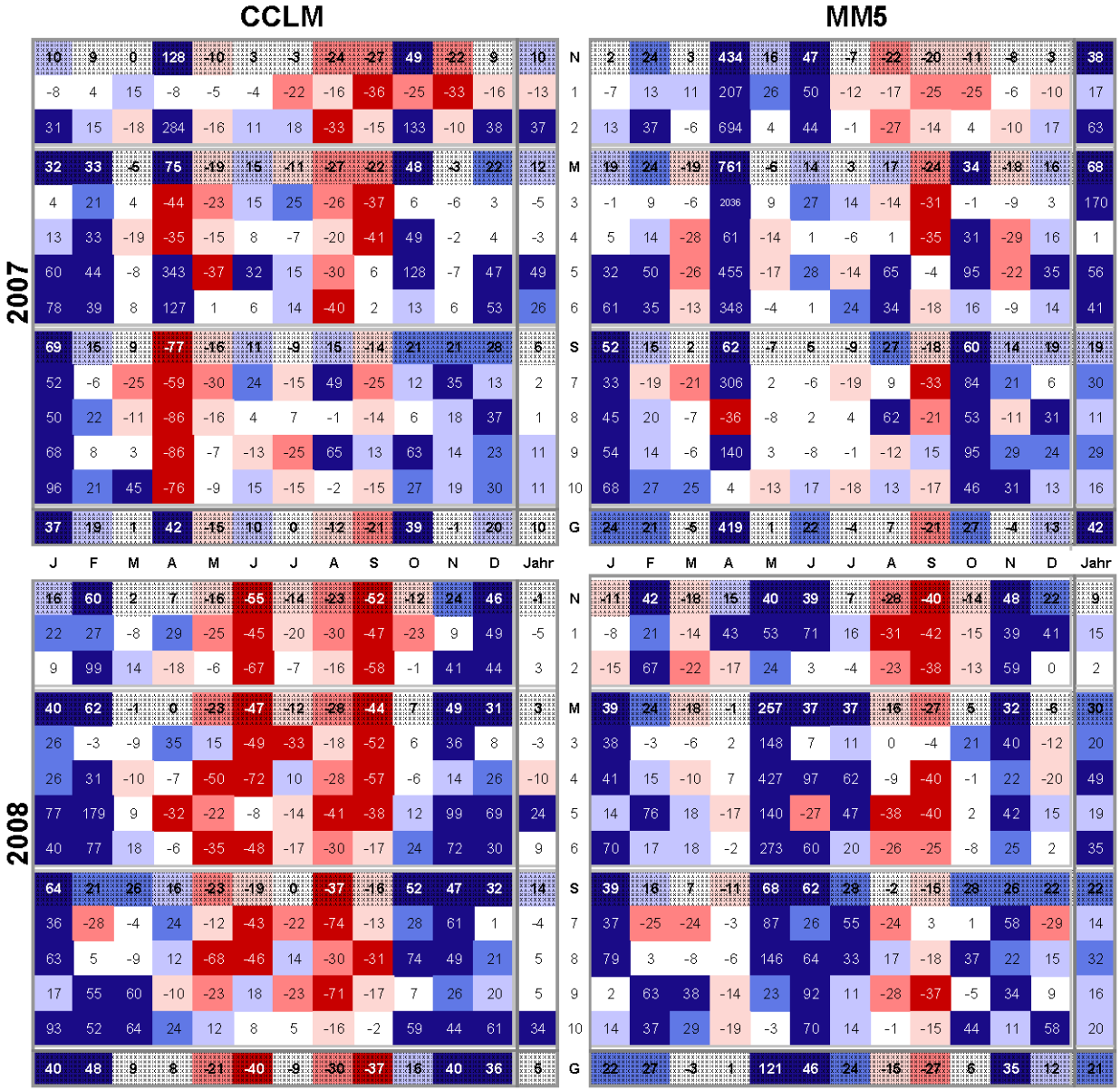
- MM5 overestimates the diurnal cycle
- CCLM shows no diurnal cycle
- Dashed lines: convective part: CCLM < MM5
- Dotted lines: gridscale part: CCLM > MM5

Frequency of Occurences of Precipitation Events

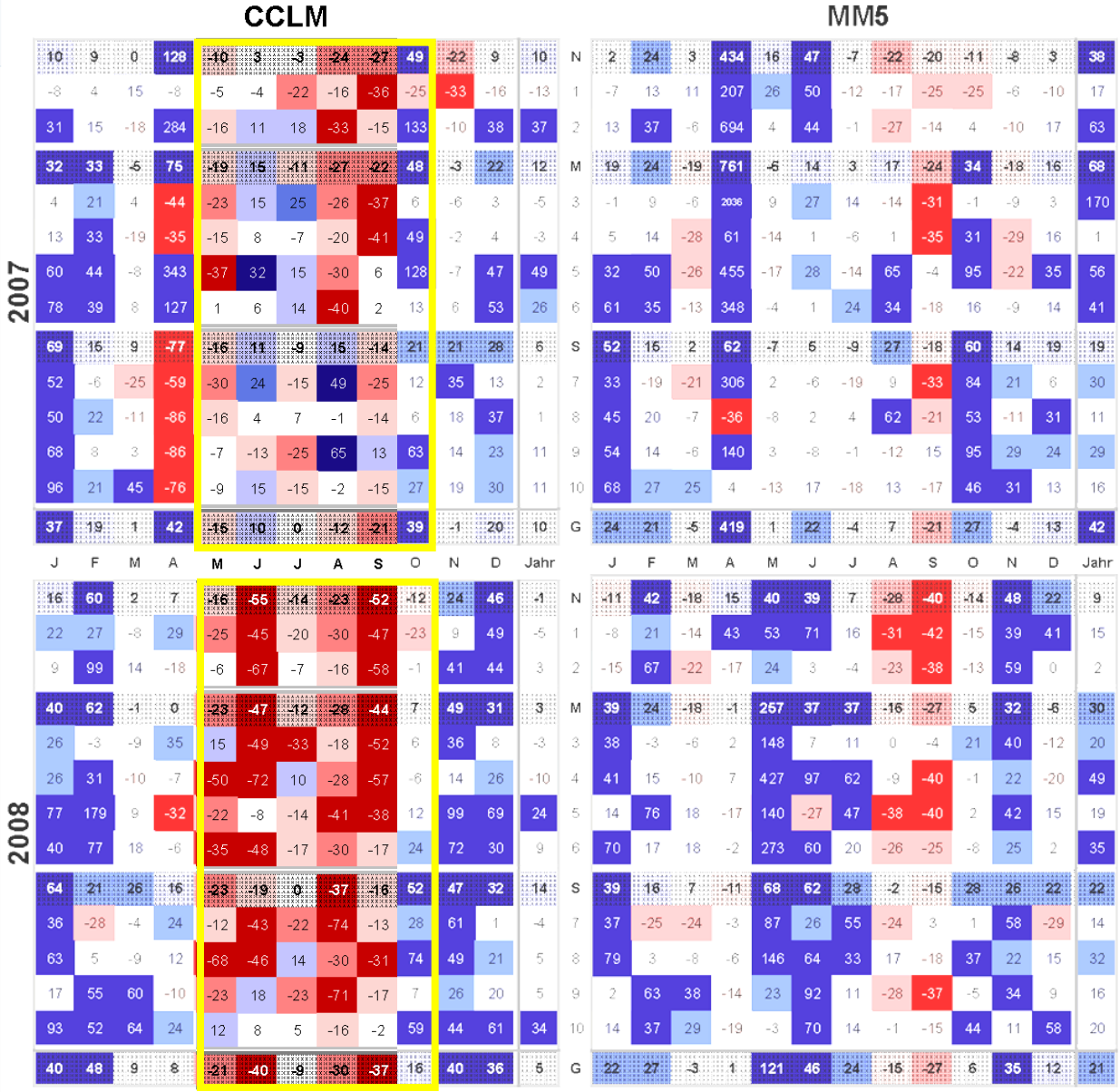


- CCLM overestimates in winter and underestimates in summer the frequency of precipitation events
- MM5 overestimates the occurence of precipitation
- Deviations are smaler in summer than in winter

Total Precipitation: Relative Bias

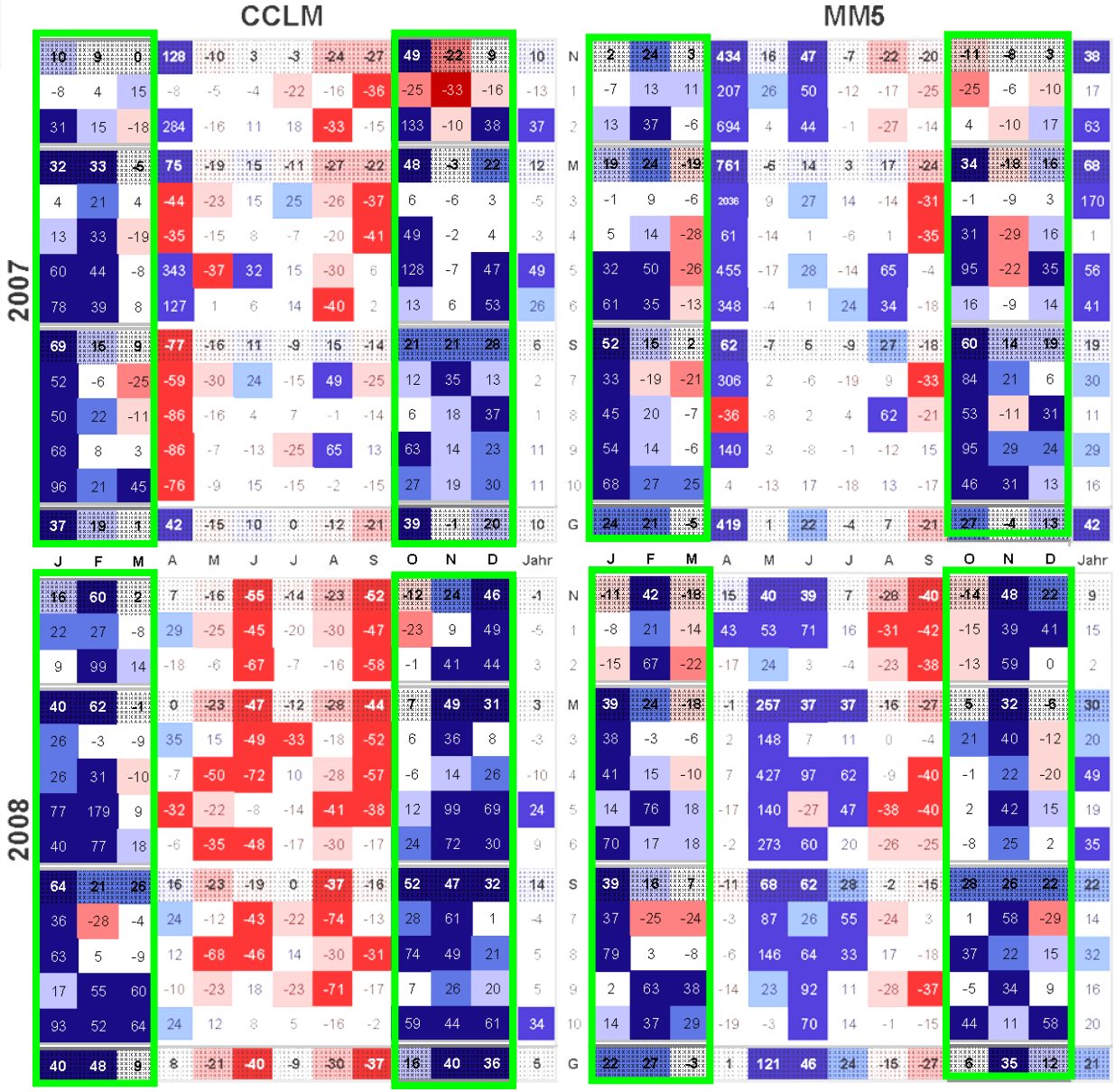


Total Precipitation: Relative Bias



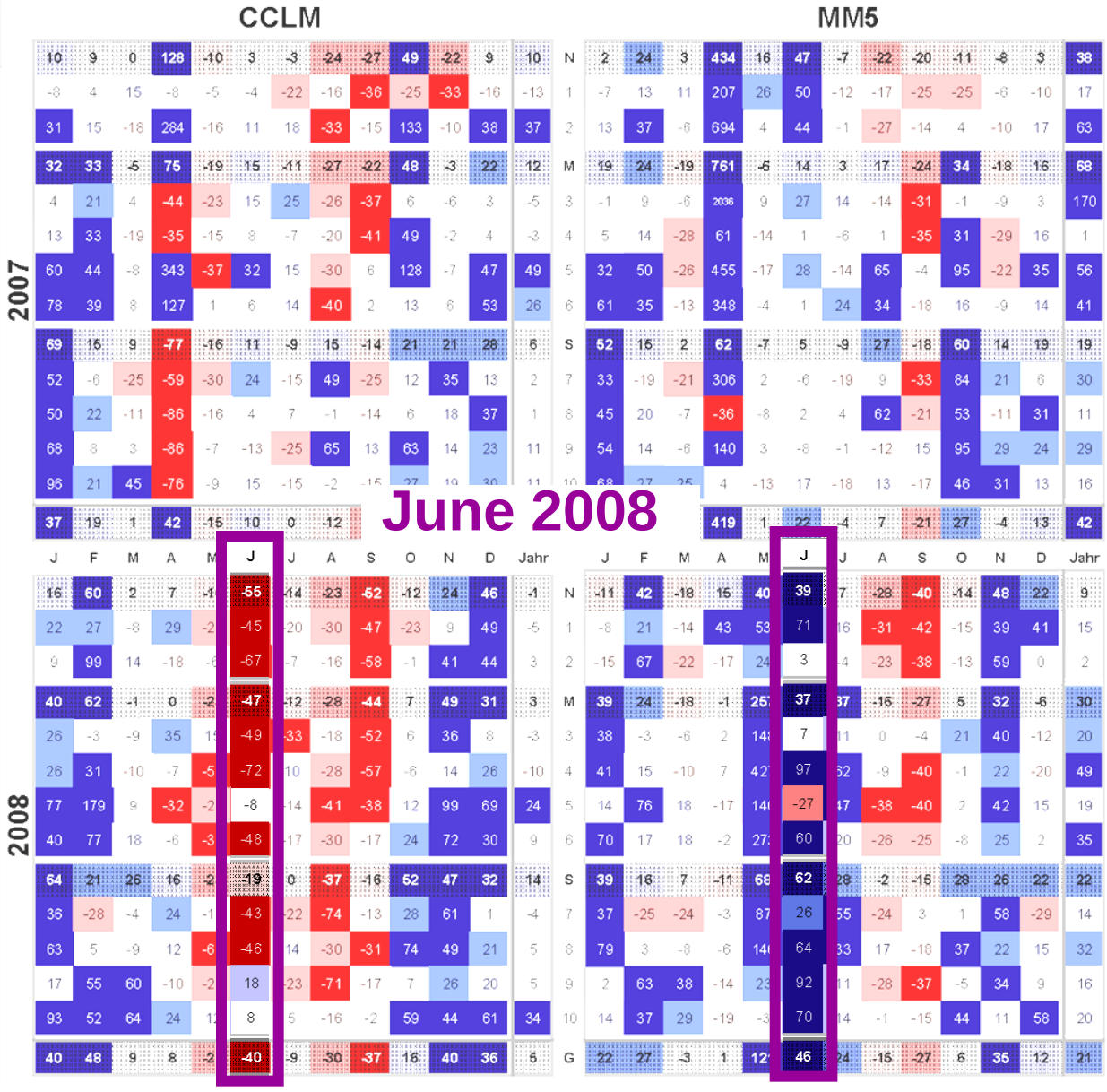
- CCLM: too dry in warm season

Total Precipitation: Relative Bias



- CCLM: too dry in warm season
- CCLM & MM5: too wet during the cold season

Total Precipitation: Relative Bias



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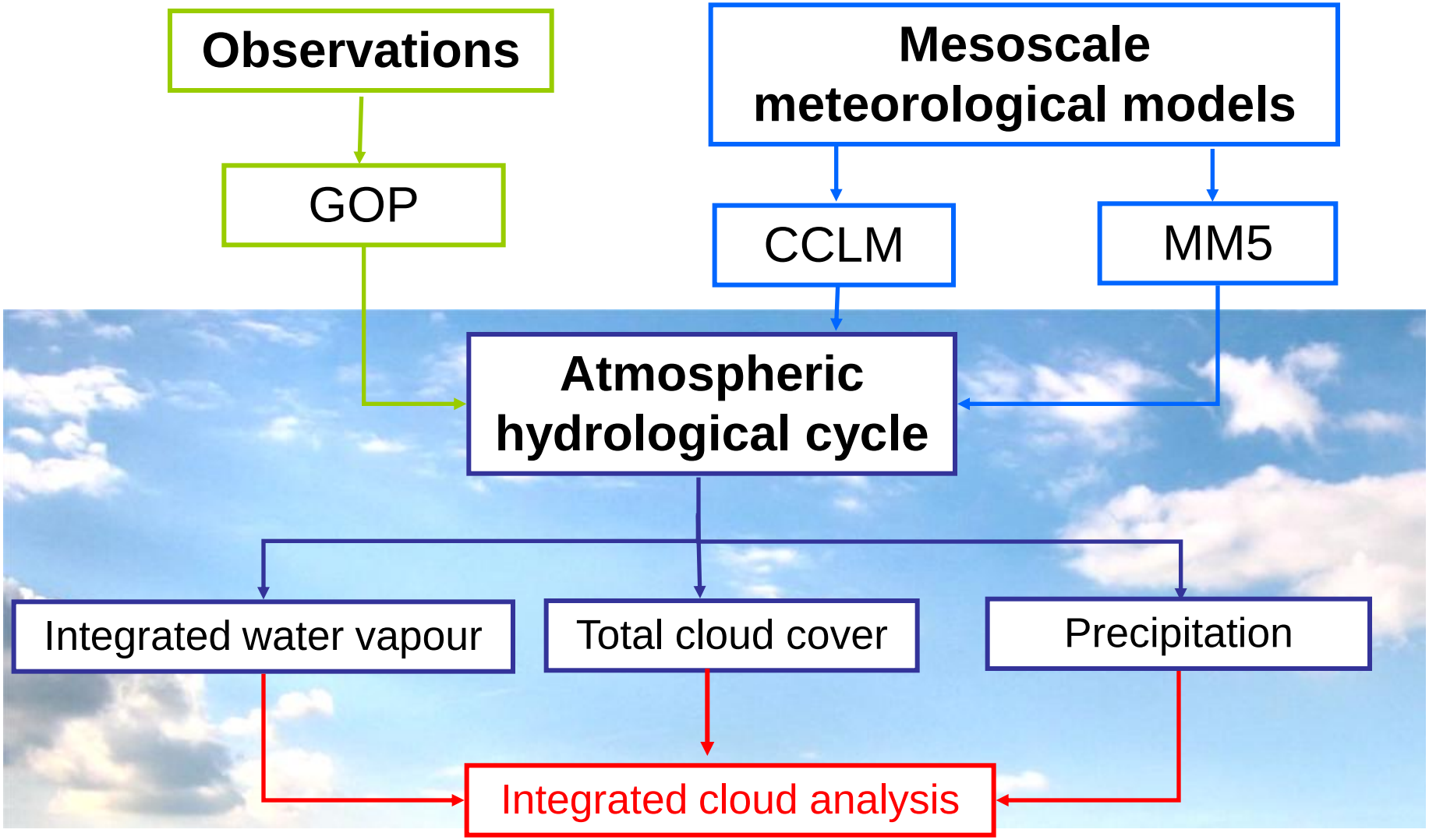
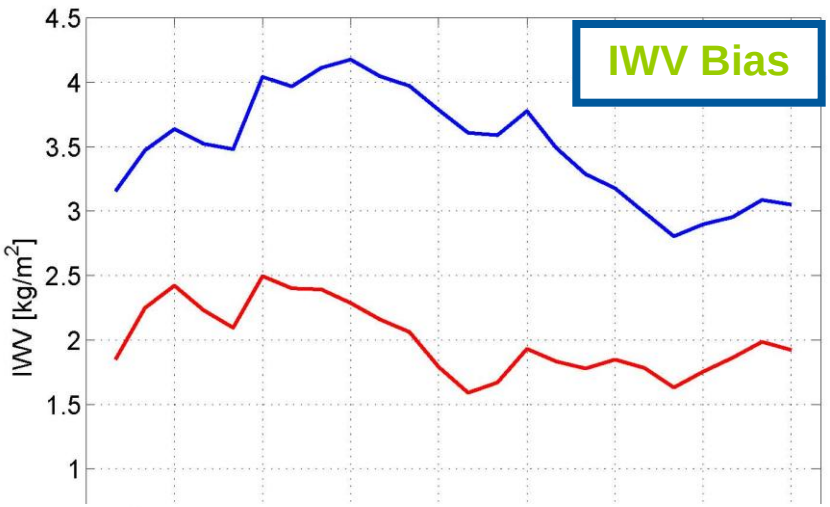
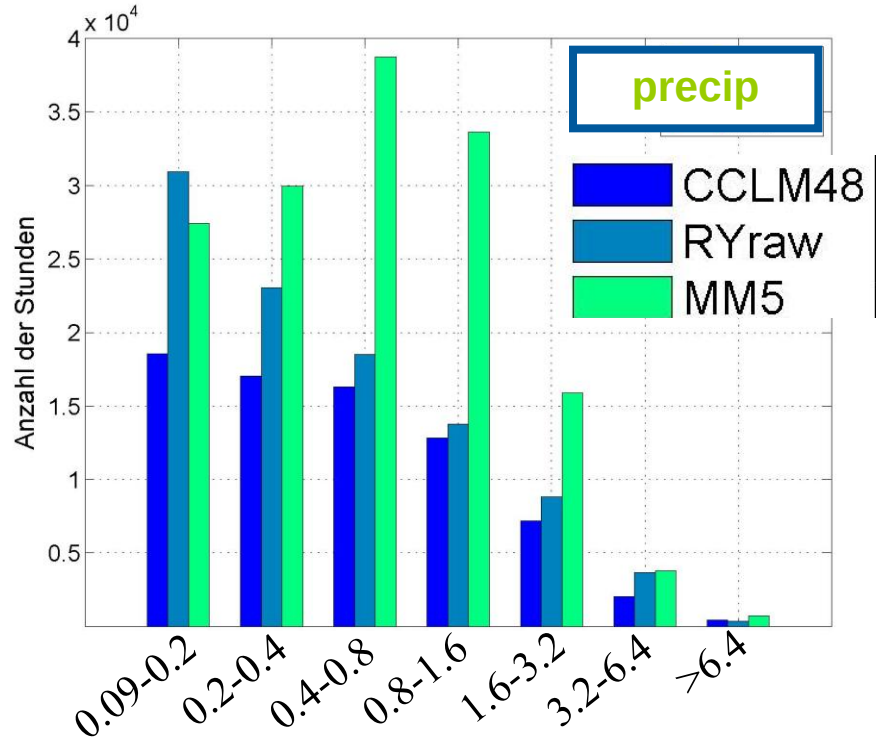
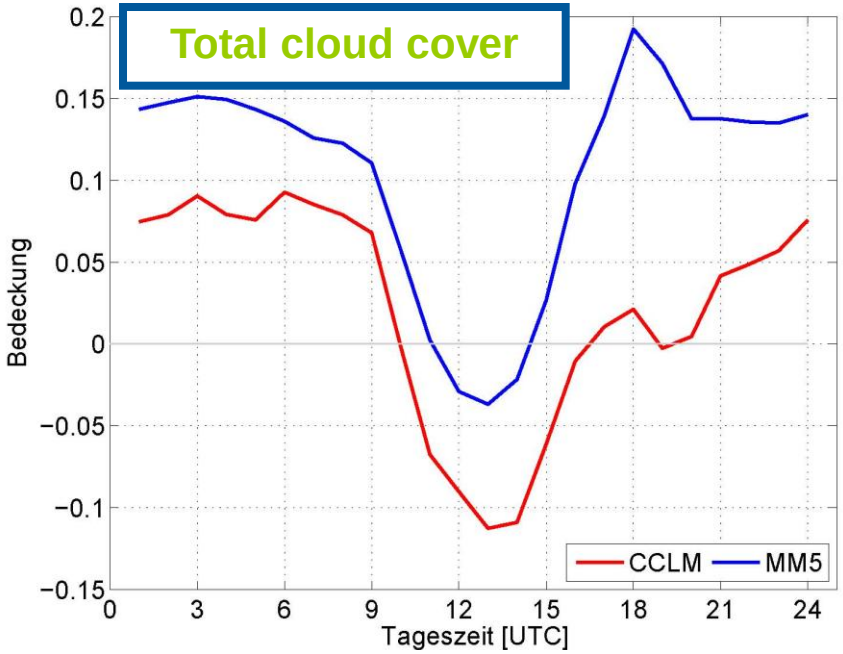
Outline and Strategy

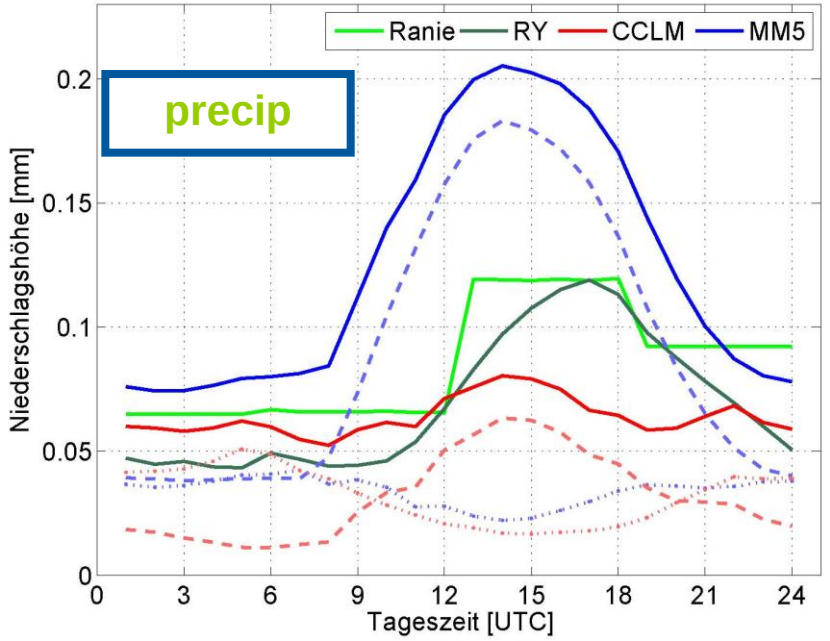


Integrated Cloud Analysis: June 2008



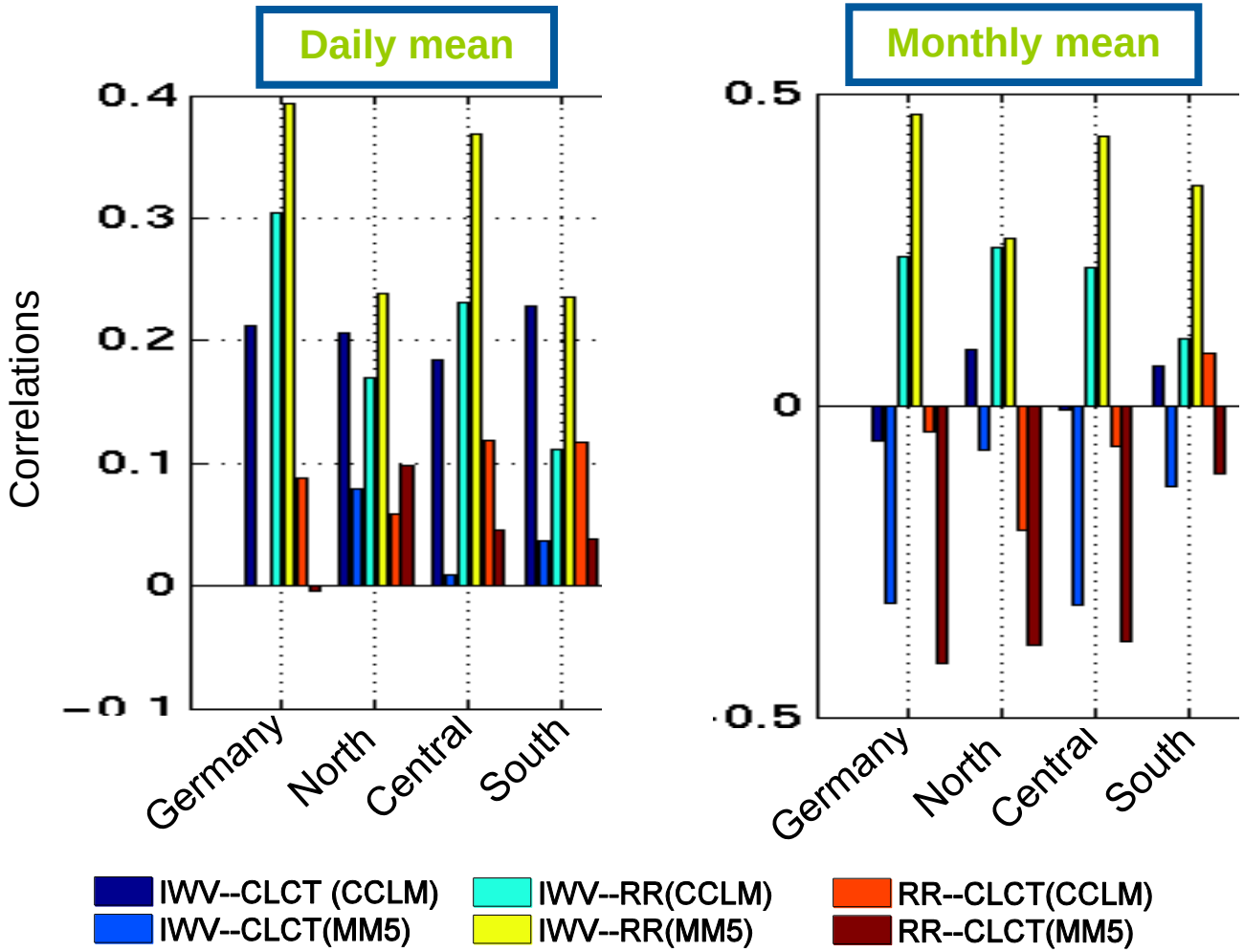




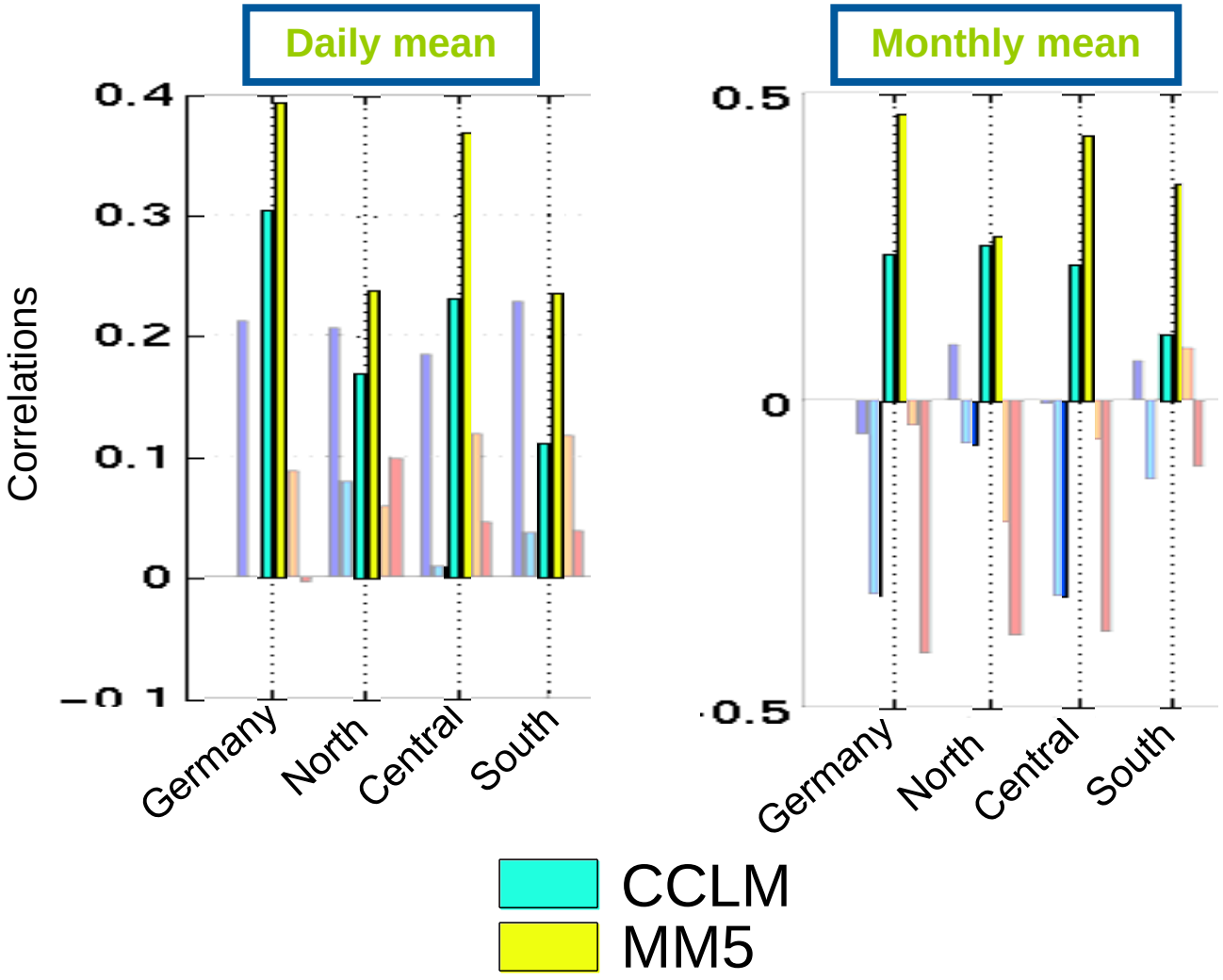


Correlations

Correlations analysis of **bias** from all presented components:

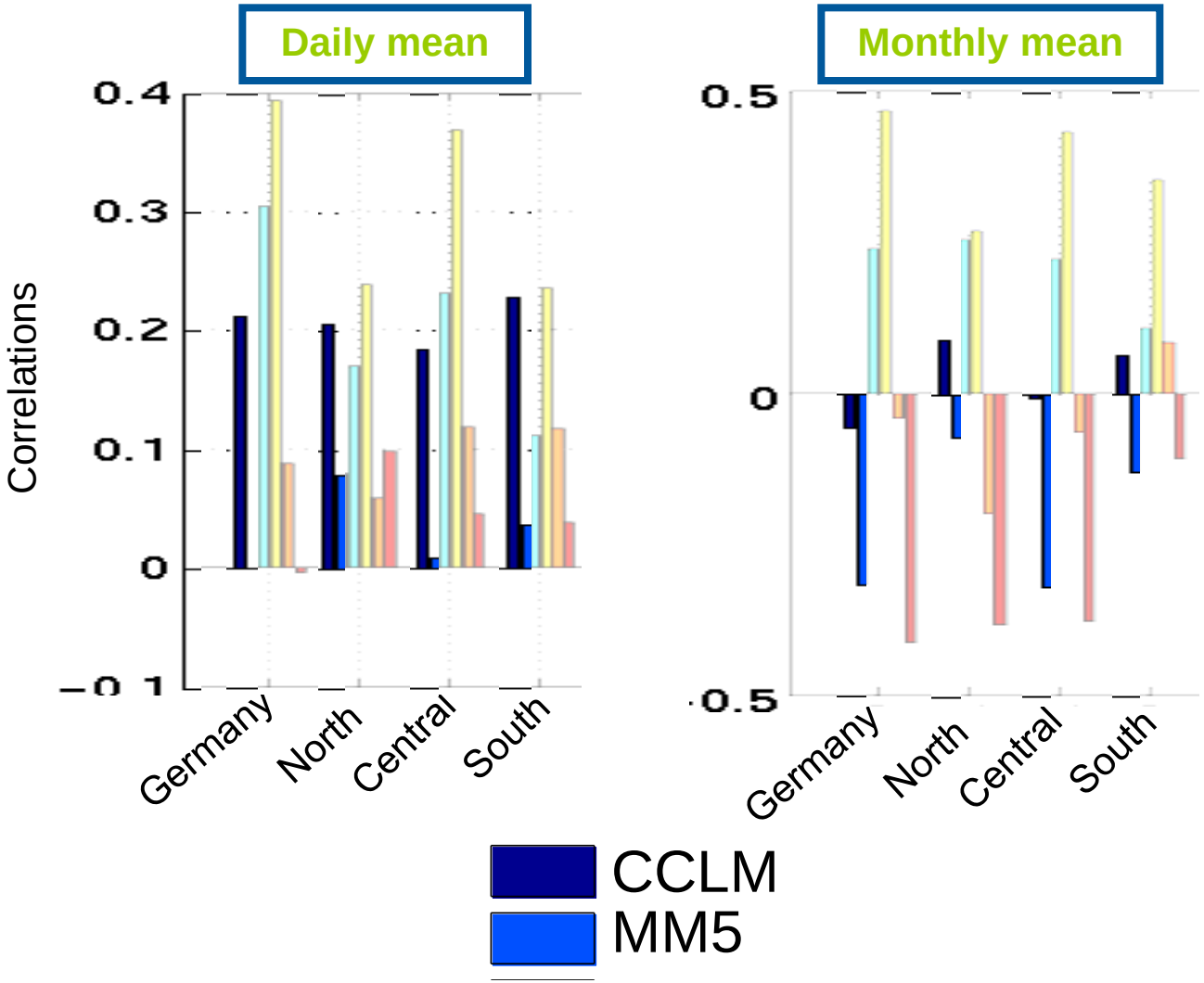


Correlations
IWV-Bias and RR-Bias



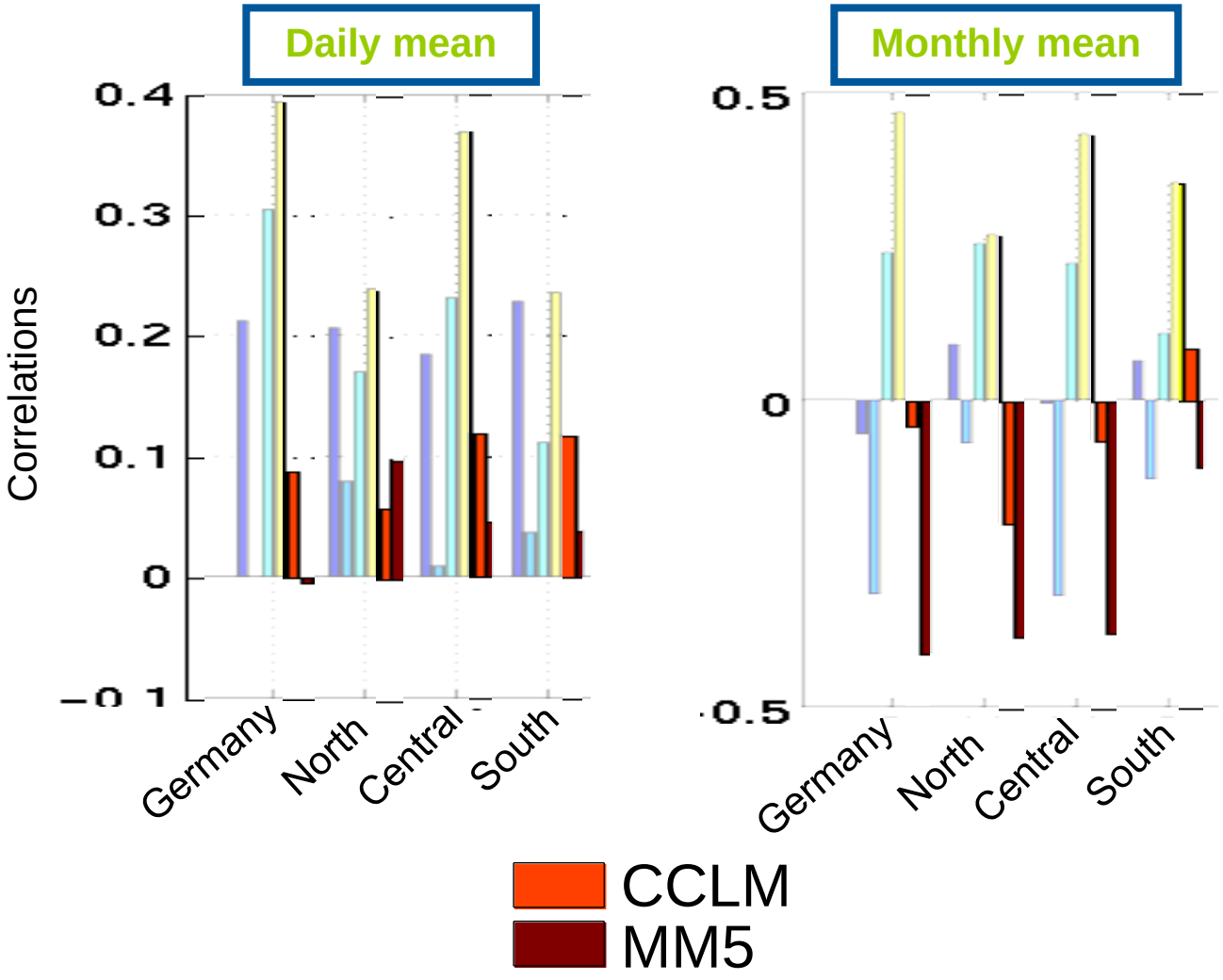
- Total and central Germany show the highest correlations
- Correlations for MM5 are higher than in CCLM
- Correlations for monthly mean values are higher than for daily mean values

Correlations
IWV-Bias and CLCT-Bias



- **MM5:**
  - no correlation for daily mean values
  - Weak **negative** correlations for monthly mean values
- **CCLM:**
  - Correlations changes over longer timescales from weak positve to no correlation

Correlations
RR-Bias and CLCT-Bias



- Both models show with larger timescales negative correlations
- Particularly MM5 shows clear negative correlations for monthly mean values

Conclusions

- Are regional climate models able to represent the atmospheric part of the hydrological cycle?

✓ Yes, they are, but with some weaknesses.

- Are there typical error structures?

✓ Yes, there are. Depending on

  - orography
  - season and
  - model physics

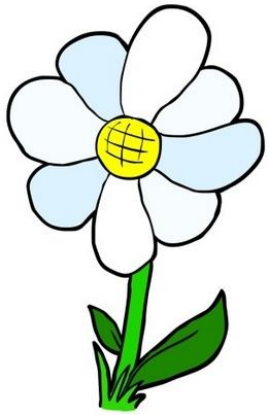
- May we even evaluate climate models over a very short period?

⇨ Yes, but we have to keep in mind the timescales!

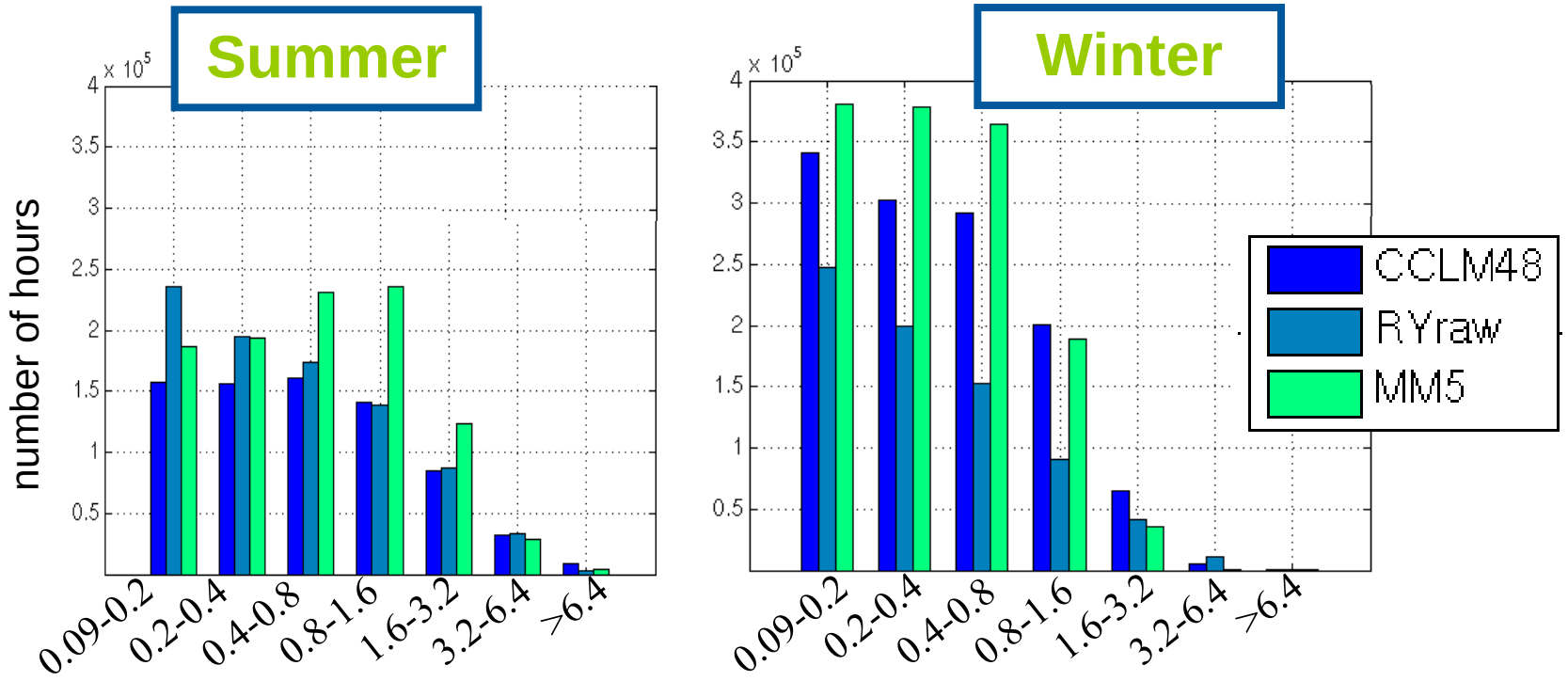
- What are the main differences between COSMO-CLM und MM5 in representing the atmospheric part of the hydrological cycle?

⇨ Differences become apparent mainly for precipitation, even though both models show similar trends for IWV and total cloud cover

Thank you for your attention and the great collaboration during my diploma thesis!



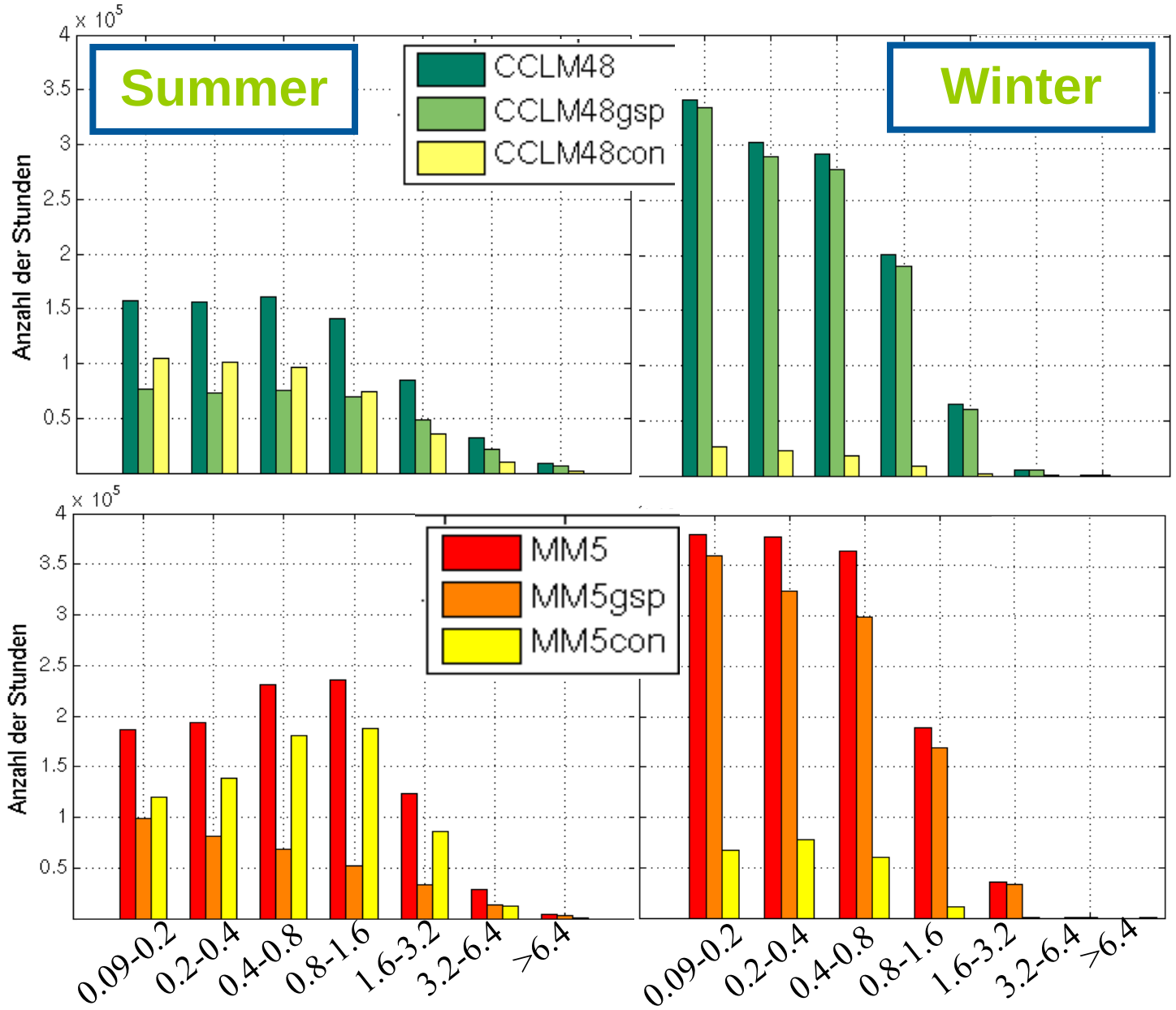
Frequency of occurences of precipitation events & -intensities



- **Summer:** both models underestimate small precipitation intensities
- MM5 overestimates precipitation amounts between 0.4 und 3.2 mm

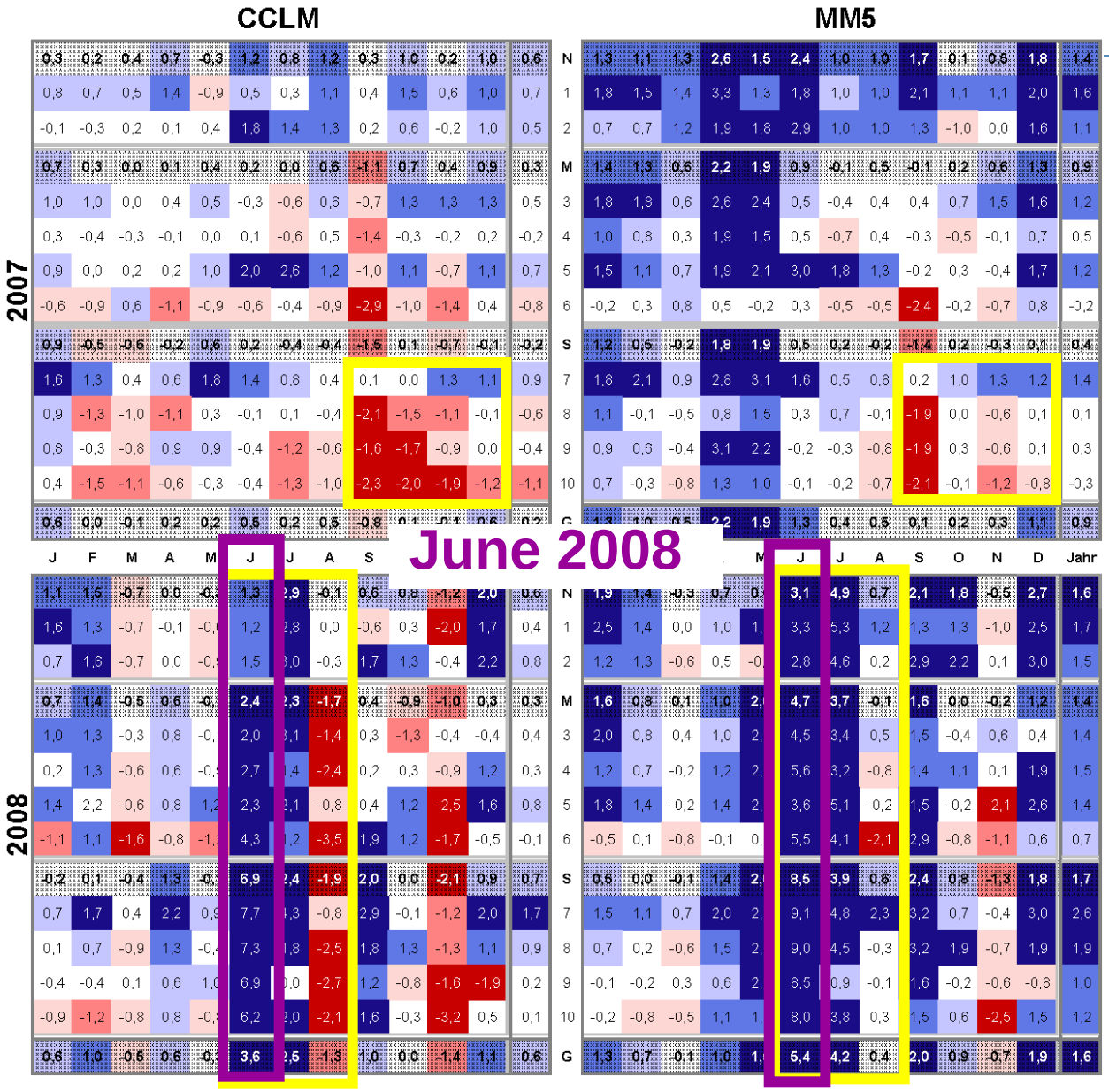
- **Winter:** both models overestimate the precipitation intensities clearly
- MM5 shows larger overestimations than CCLM

Frequency of precipitation intensities



- MM5 ist stronger influenced by its convective part
- CCLM: convective part more dominat the smaller the precip. intensity
- MM5: convective part shows highest values for precipitation sums between 0.4 und 1.6 mm

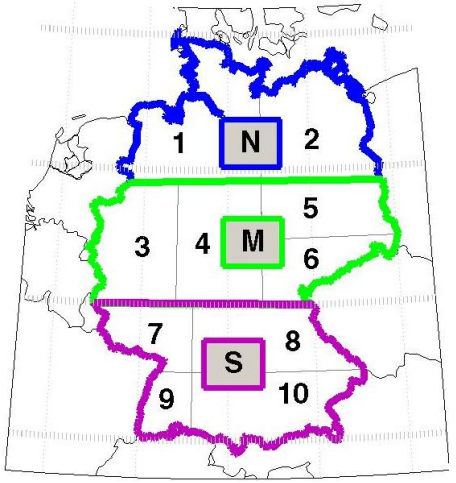
IWV: Bias



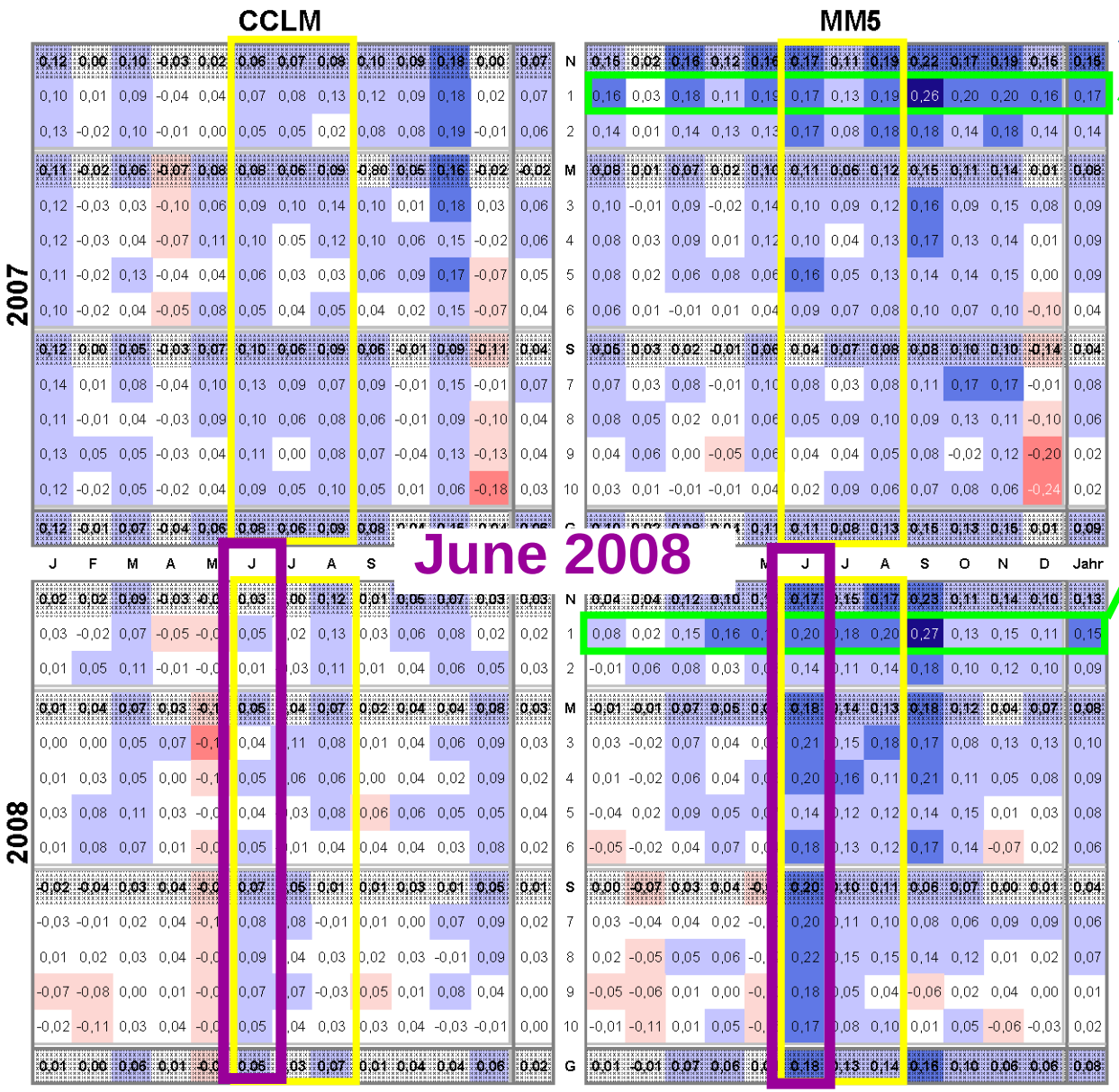
MM5 & CCLM:

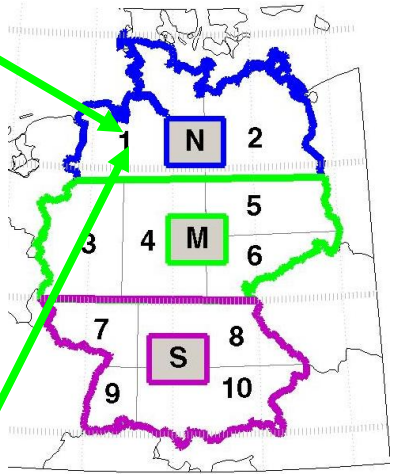
- related pattern with different amplitude

⇨ Maybe due to same forcing data



Total Cloud Cover: Bias





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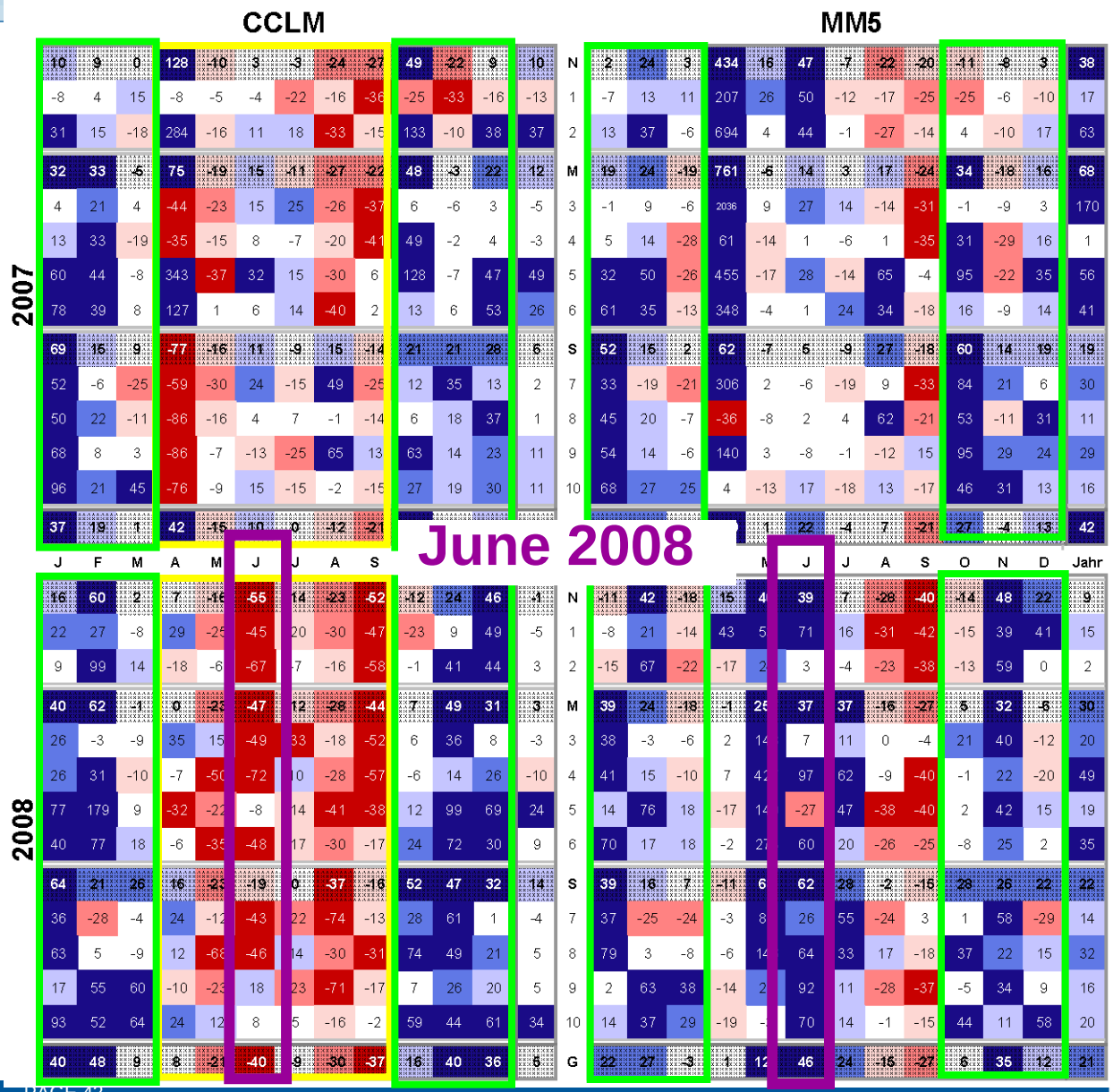
→ maritime influence

Total Precipitation: relative bias



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