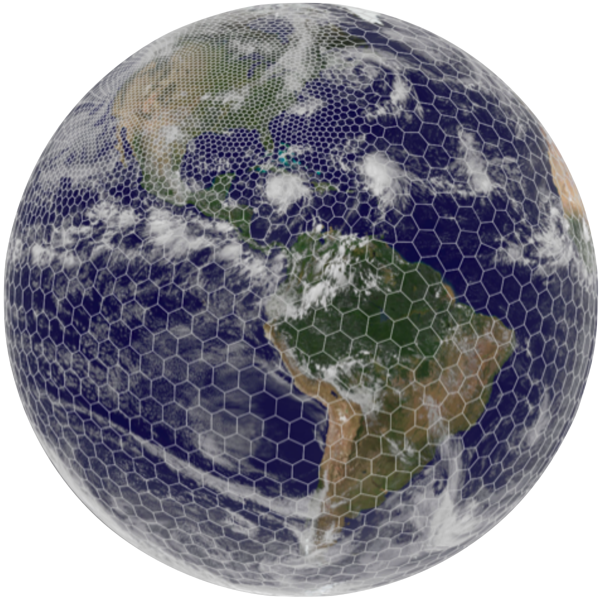


MPAS Extreme Scaling Experiment

Towards convection-resolving, global climate simulations

[1] KARLSRUHE INSTITUTE OF TECHNOLOGY, INSTITUTE OF METEOROLOGY AND CLIMATE RESEARCH
[2] NATIONAL CENTER FOR ATMOSPHERIC RESEARCH, MESOSCALE AND MICROSCALE METEOROLOGY LABORATORY
[2] AUGSBURG UNIVERSITY, DEPARTMENT OF GEOGRAPHY, CHAIR OF REGIONAL CLIMATE AND HYDROLOGY

16th Annual WRF Users' Workshop, 17/06/2015

Dominikus Heinzeller[1], Michael Duda[2] and Harald Kunstmann[1,3]

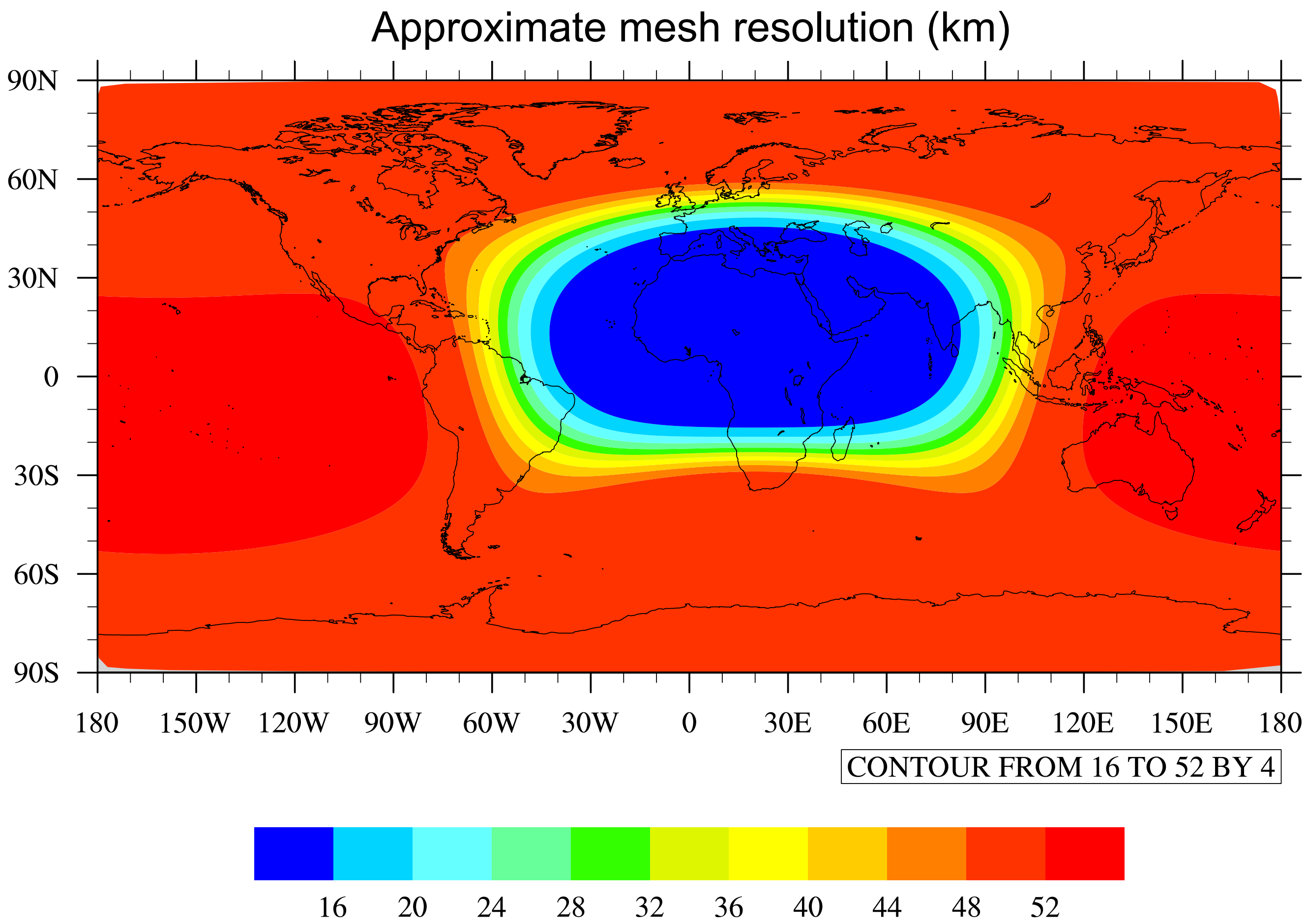
Karlsruhe Institute of Technology

KIT-Campus Alpin
IMK-IFU: Atmospheric Environmental Research

NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

MPAS variable-resolution mesh with 535554 cells

MPAS
Model for Prediction Across Scales



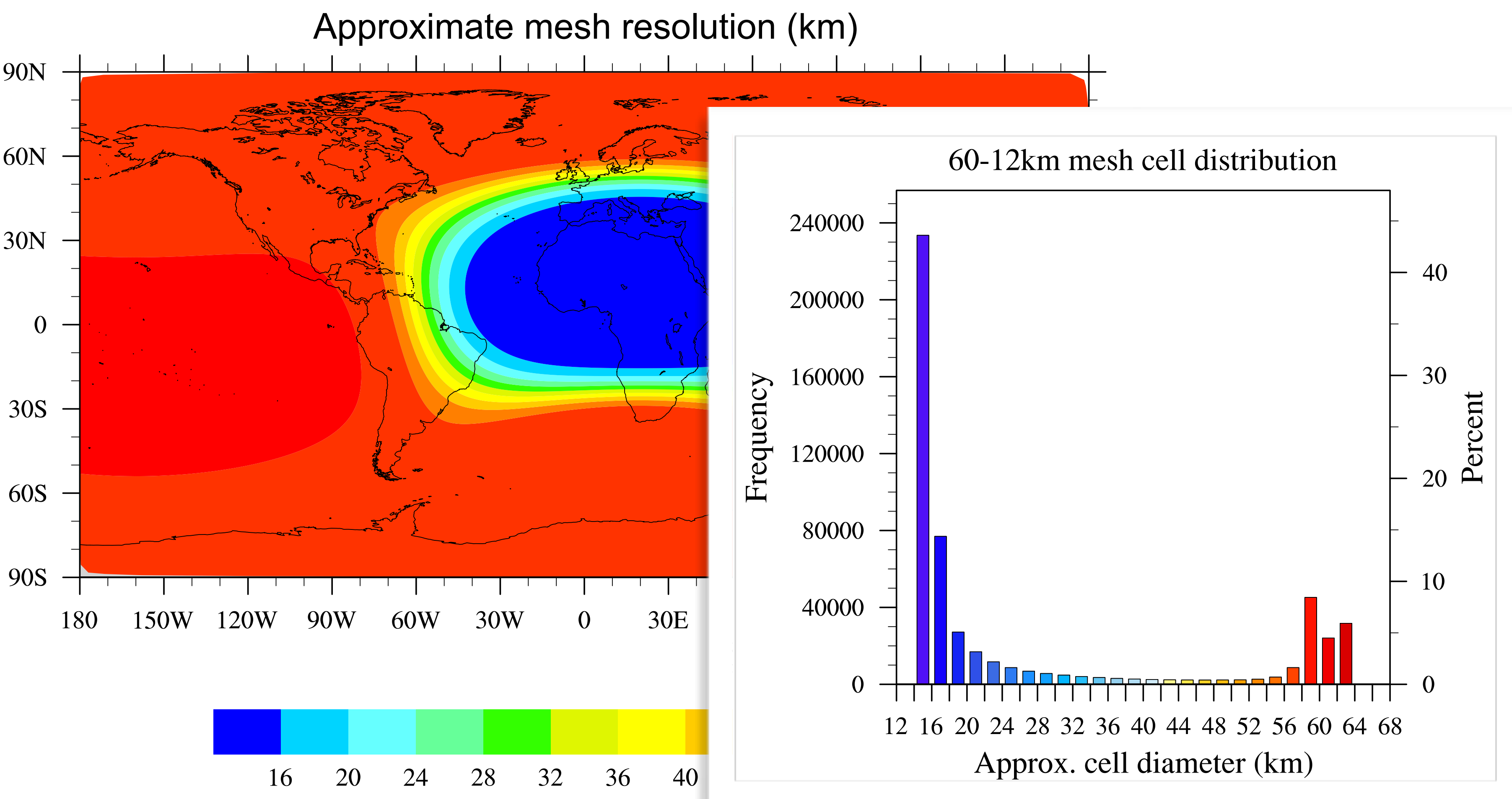
Model consistency:

land use / soil type classification

flow distortions of jets and waves

Research question: teleconnection between African monsoon systems and Atlantic/Indian ocean

MPAS variable-resolution mesh with 535554 cells



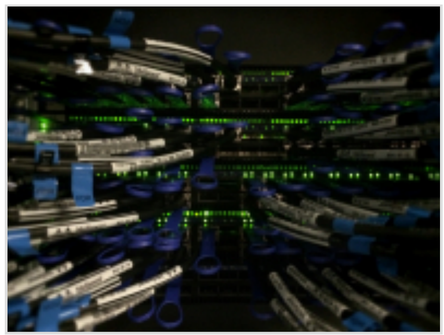
Research question: teleconnection between African monsoon systems and Atlantic/Indian ocean

Variable-resolution mesh with 535554 grid cells

Tested systems

TGCC Curie

FZJ Juropatest

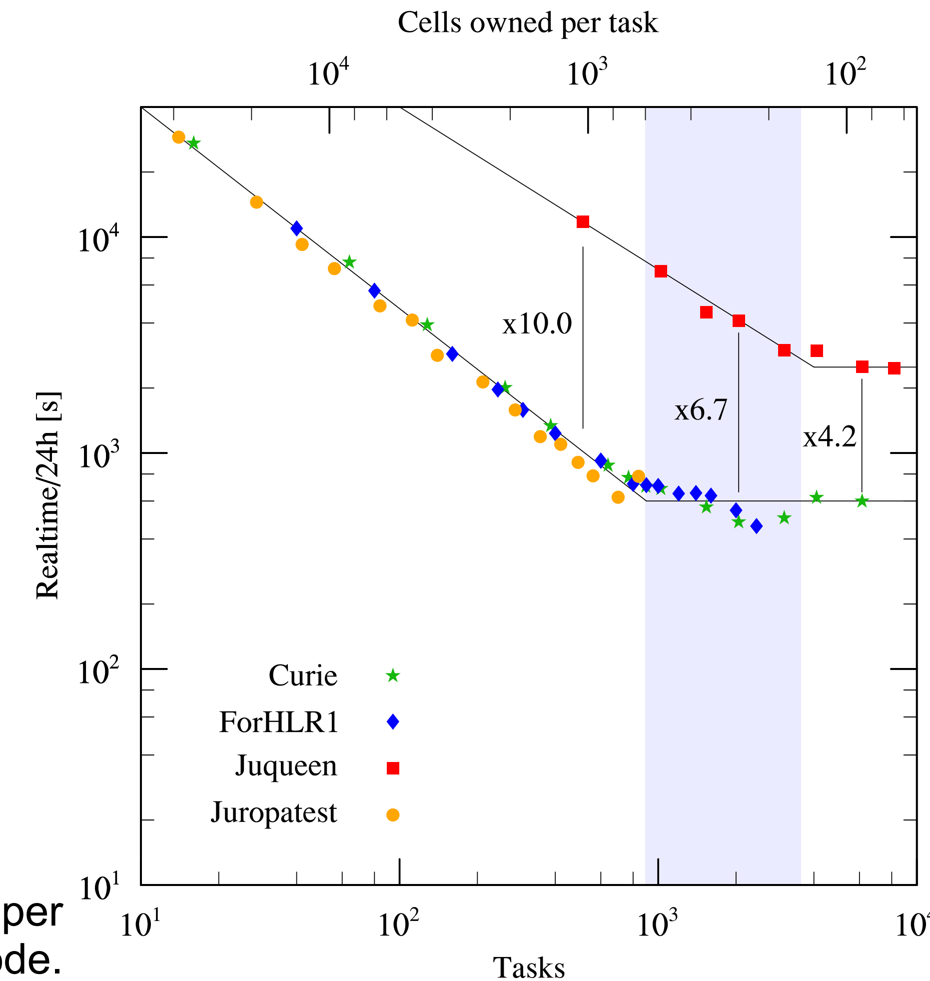


FZJ Juqueen

SCC ForHLR1

↑

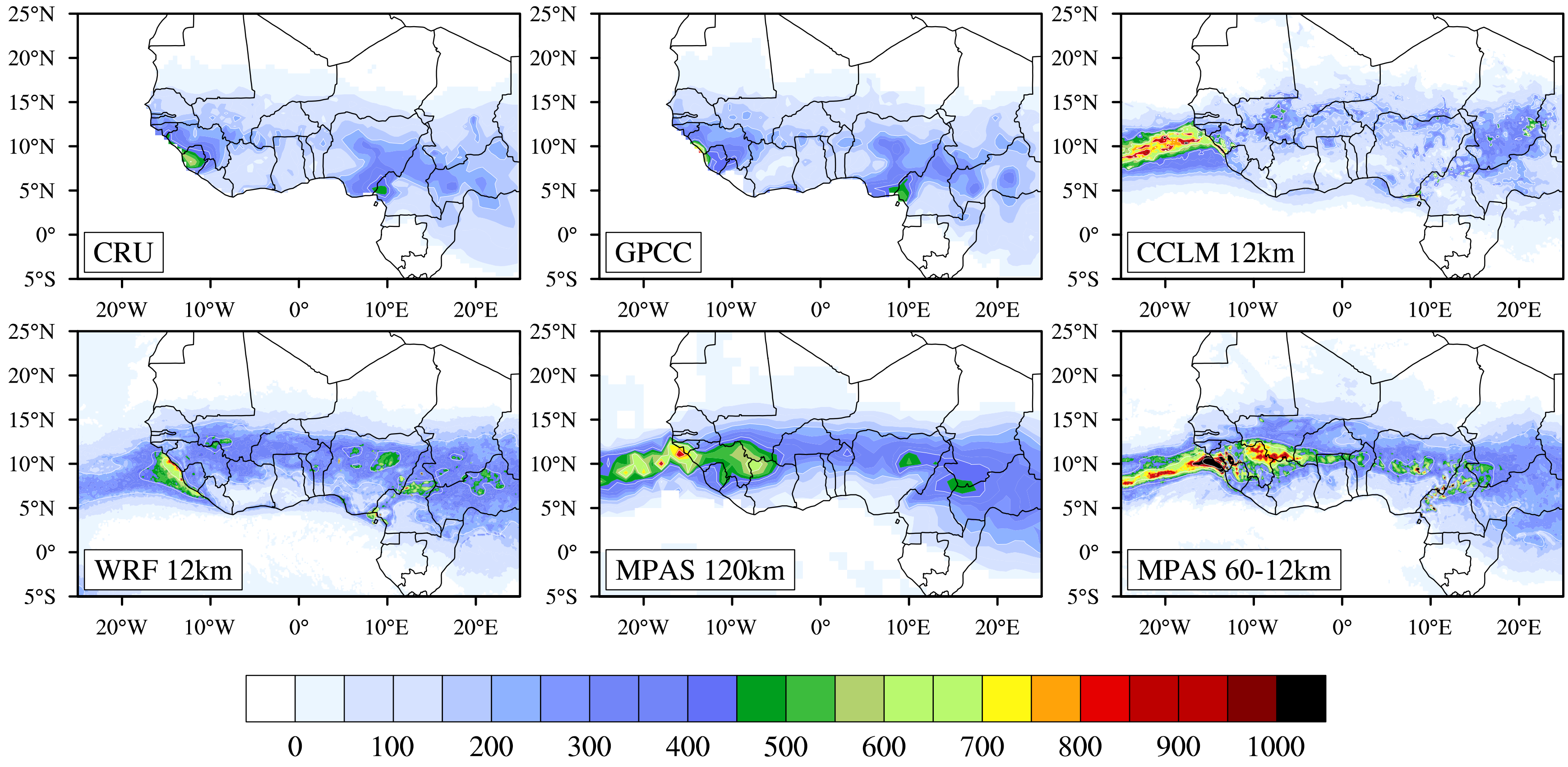
IBM Bluegene /Q: 28 racks, 1024 nodes per rack, 16 cores and 16GB memory per node.



West African Monsoon in MPAS, WRF, CCLM

Total monthly precipitation [mm] - July 1982

(initialisation: CCLM/WRF 1979-01-01, MPAS 1981-09-01)



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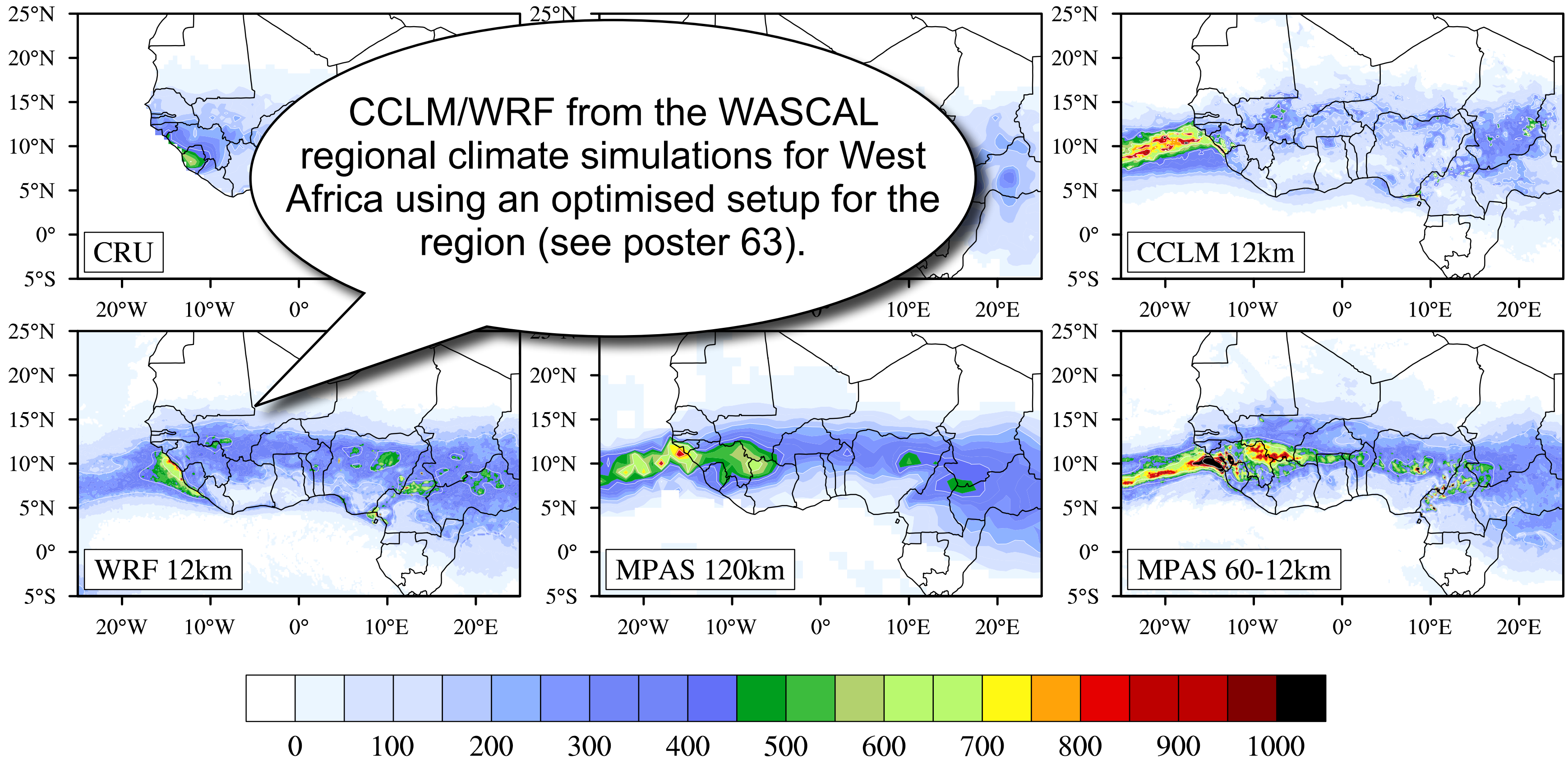
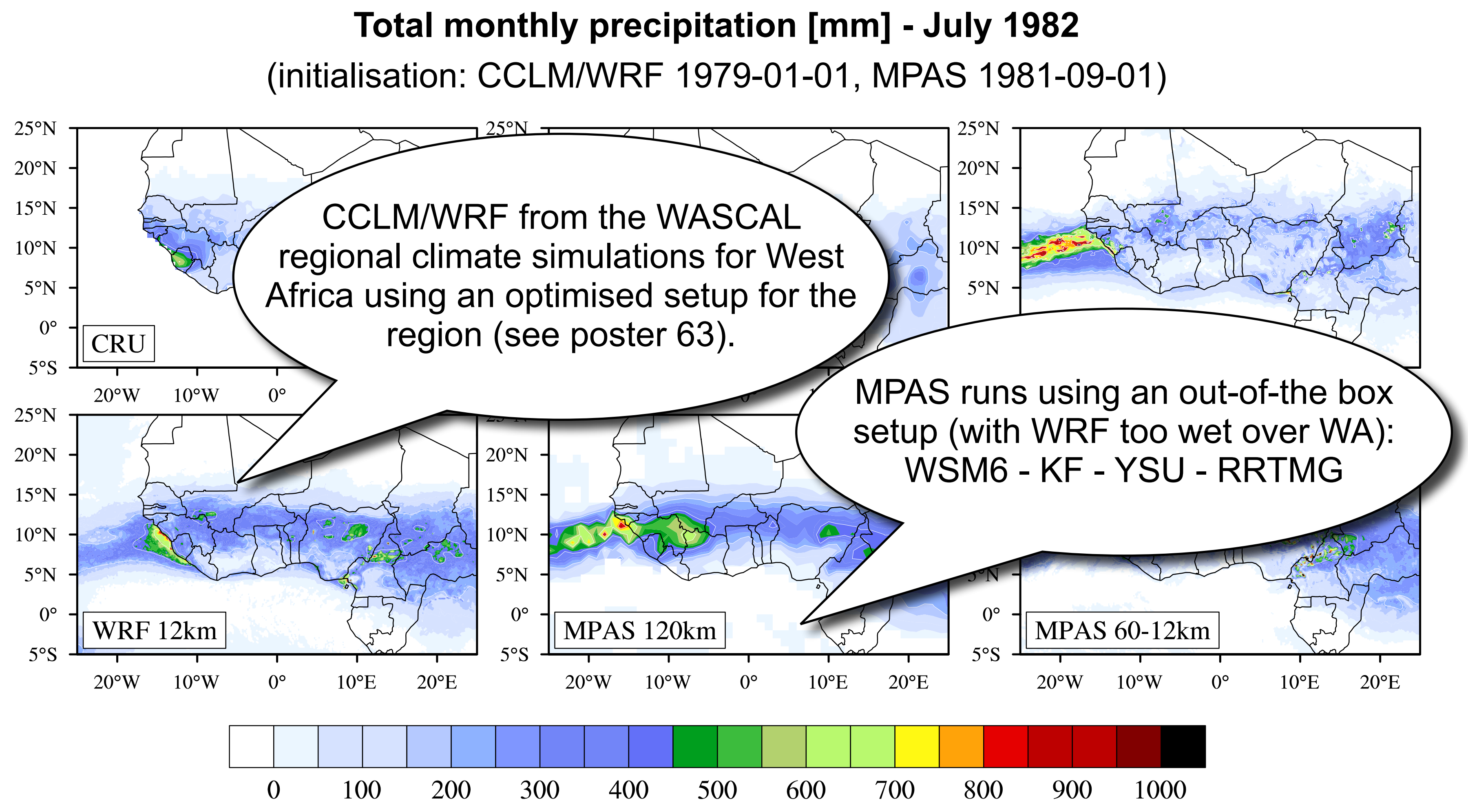


West African Monsoon in MPAS, WRF, CCLM



MPAS Extreme Scaling Experiment as part of the 3rd Juqueen Porting & Tuning Workshop

Extreme scaling on Juqueen: Pandora's box

regular 3km mesh x1.65536002 ncell = 65536002, nvert = 41	expect ≥70% parallel efficiency up to 400000 threads (150 cells per task)
double precision, physics+dynamics: memory requirement 0.175MB per cell	11.5TB of memory required for 3km mesh, minimum number of nodes is approx. 750
I/O sizes: initial condition 1.1TB, restart 2.1TB, diagnostics 15GB, history 250GB	

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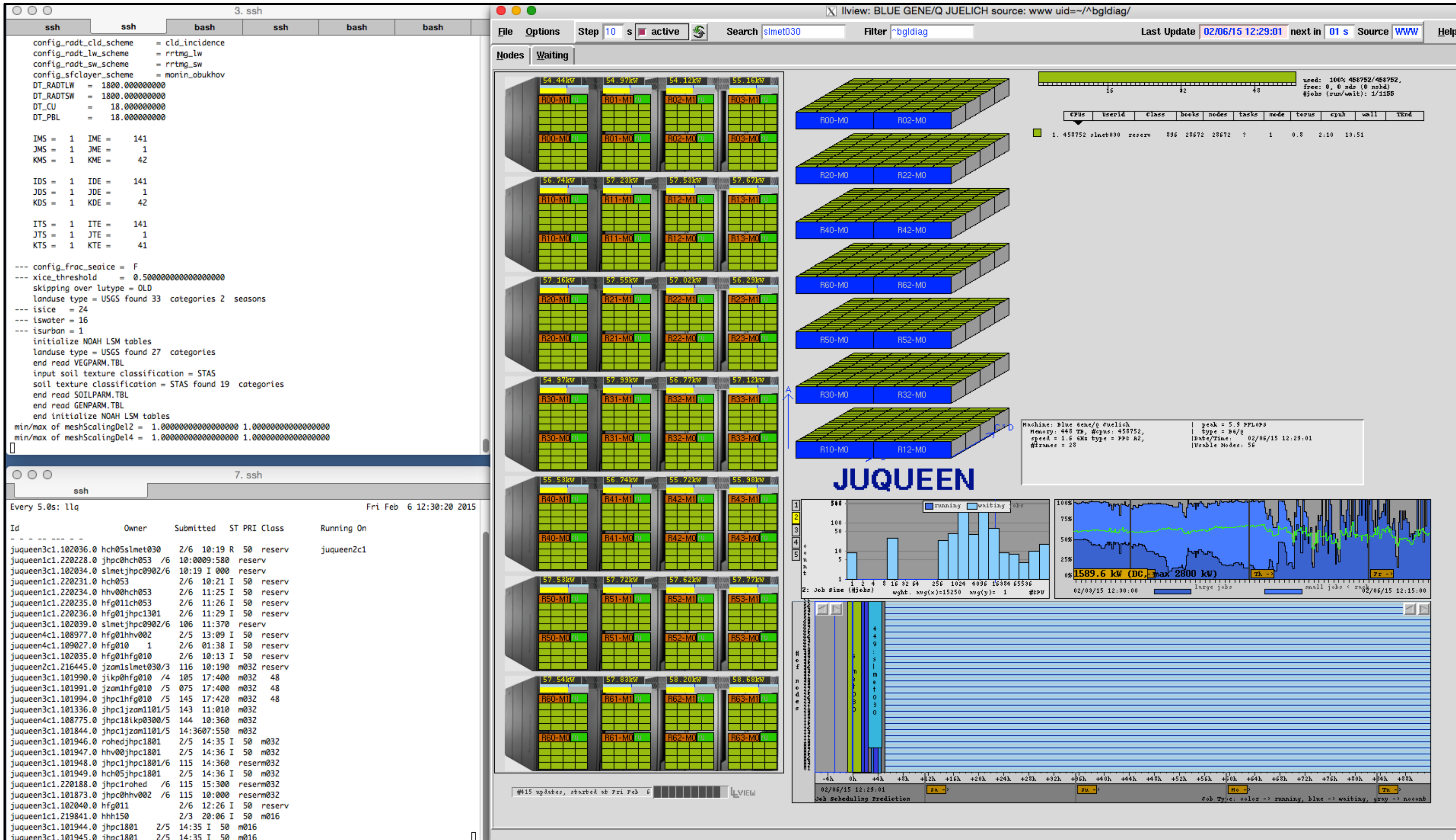
Pitfalls:

Test runs on 1 and 2 racks (1024, 2048 nodes) failed - memory errors. Defragmentation issue?

Model initialisation took way to long (1hr+), tuning of I/O and other parameters required

A moment of excitement (for geeks)

MPAS
Model for Prediction Across Scales

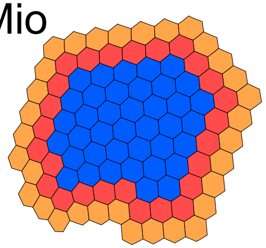


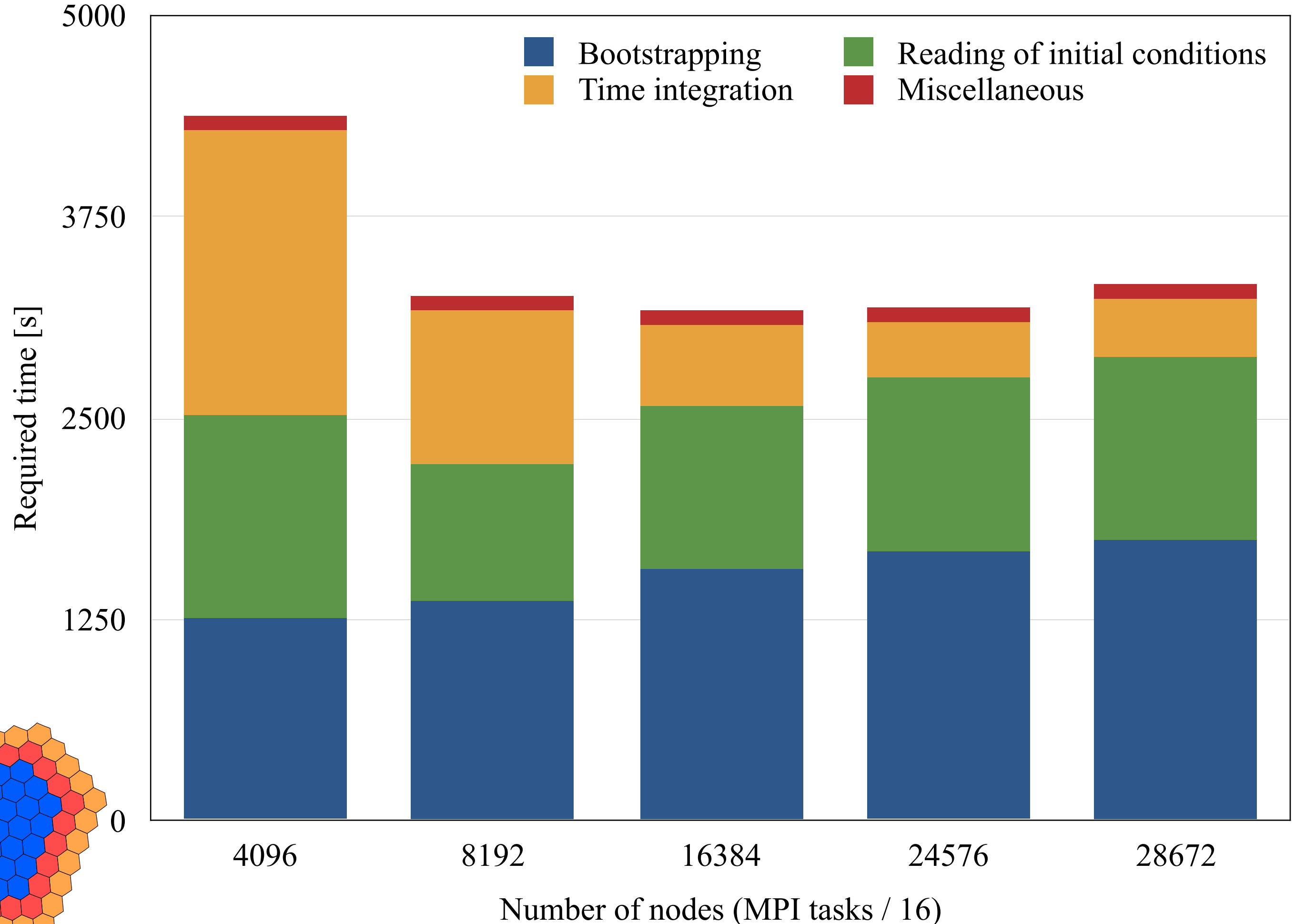
MPAS Model for Prediction Across Scales

Extreme scaling results

Key facts

- 1hr integration, cold start (init.nc)
- 12s integration time step (Δx*4) to avoid NaNs
- no output except one diagnostic file (15Gb)
- 1 I/O task per 128 tasks, i.e., 128 per rack
- hash table size increased from 27183 to 6 Mio





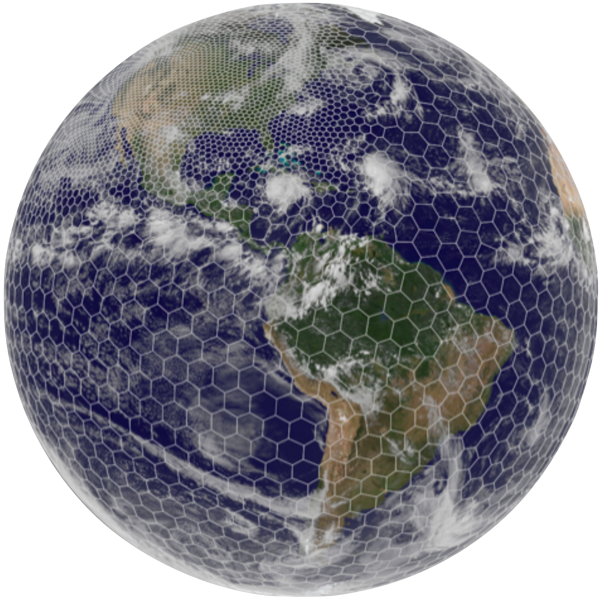
Extreme scaling results

MPAS
Model for Prediction Across Scales

BG size (# nodes)	Parallel efficiency integration only	Integration in 24h walltime (no output)	Estimated integration in 24h walltime (with output)
4096	100.0%	48h	29h
8192	91.2%	87h	53h
16384	90.1%	172h	104h
24576	87.7%	250h	152h
28672	69.5%	231h	141h

BG size (# nodes)	Number of tasks	CPUh per 24h model run time (with output)	Speedup wrt. real time (with output to disk)
4096	65536	1.30 Mio	1.21
8192	131072	1.42 Mio	2.21
16384	262144	1.45 Mio	4.33
24576	393216	1.49 Mio	6.33
28672	458752	1.87 Mio	5.88

Take home messages



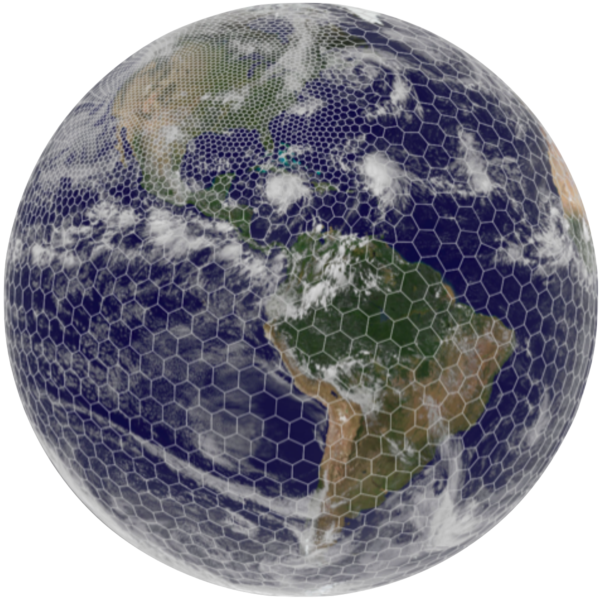
MPAS can reproduce the dynamics of the West African Summer Monsoon using an out-of-the box setup and is a promising tool for climate modelling.

Global, convection-resolving atmospheric simulations with MPAS are within reach of current/next generation HPC facilities. Open problems are model initialisation, disk I/O and post-processing of the data.

JÜLICH
FORSCHUNGSZENTRUM

PRACE

Take home messages



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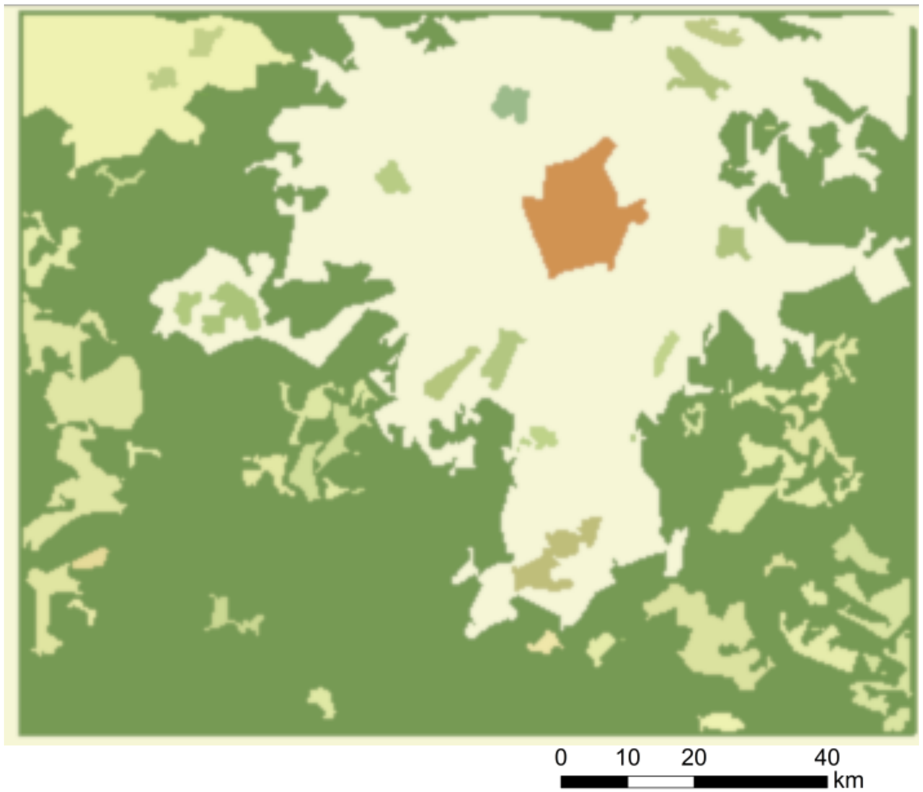
Bonus material

Limitations of limited area modelling

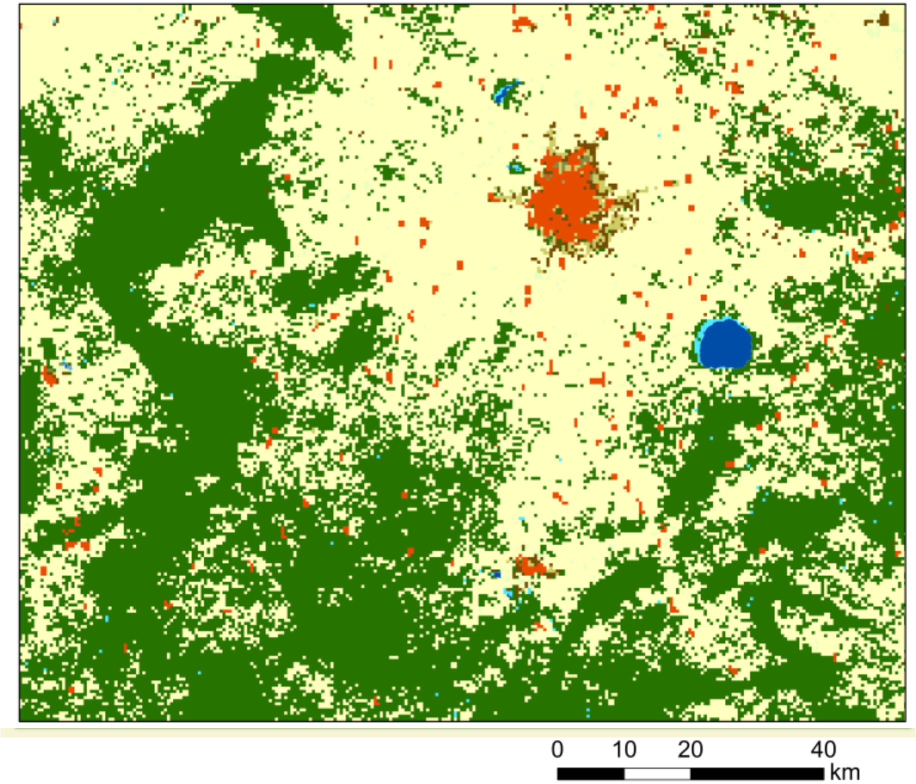
How to include new land surface and soil data or dynamic changes thereof in a consistent way?



GCM standard, Volta region (West Africa)

Limitations of limited area modelling

How to include new land surface and soil data or dynamic changes thereof in a consistent way?



GCM standard, Volta region (West Africa)

RCM standard land cover (MODIS)

Limitations of limited area modelling

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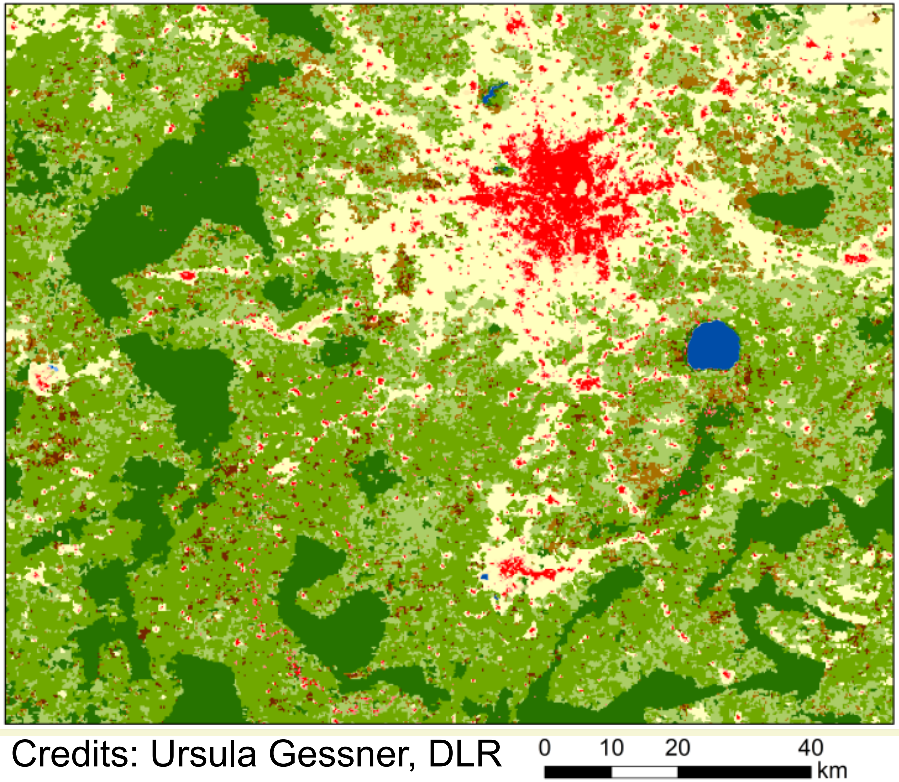

Credits: Ursula Gessner, DLR

GCM standard, Volta region (West Africa)

RCM standard land cover (MODIS)

RCM high-resolution land cover
(DLR: MODIS, ASAR, TanDEM-X)

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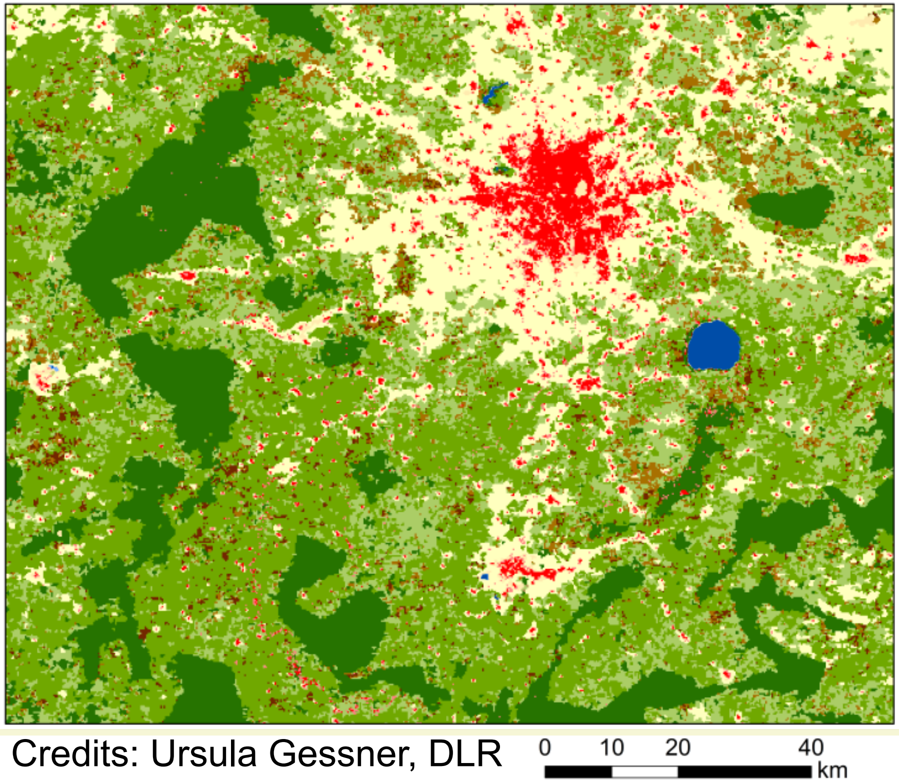

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RCM standard land cover (MODIS)

RCM high-resolution land cover
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Consistency? Feedback processes?

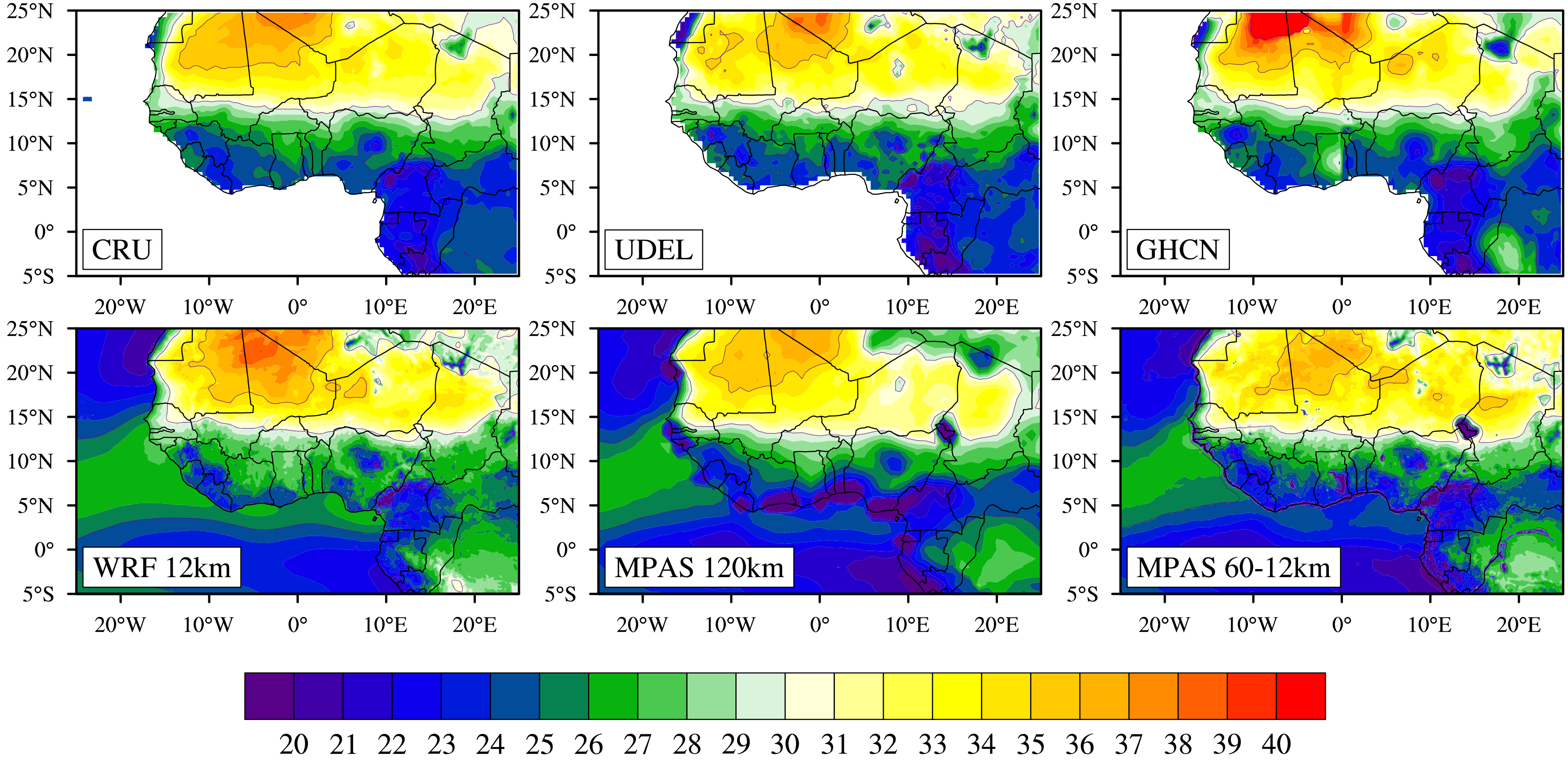
Dynamic changes of land use?

CMIP5 vs CORDEX issue:
land use classification
and land use change in
ESMs not reflected in RCMs

MPAS, WRF, CCLM vs. observations - any good?

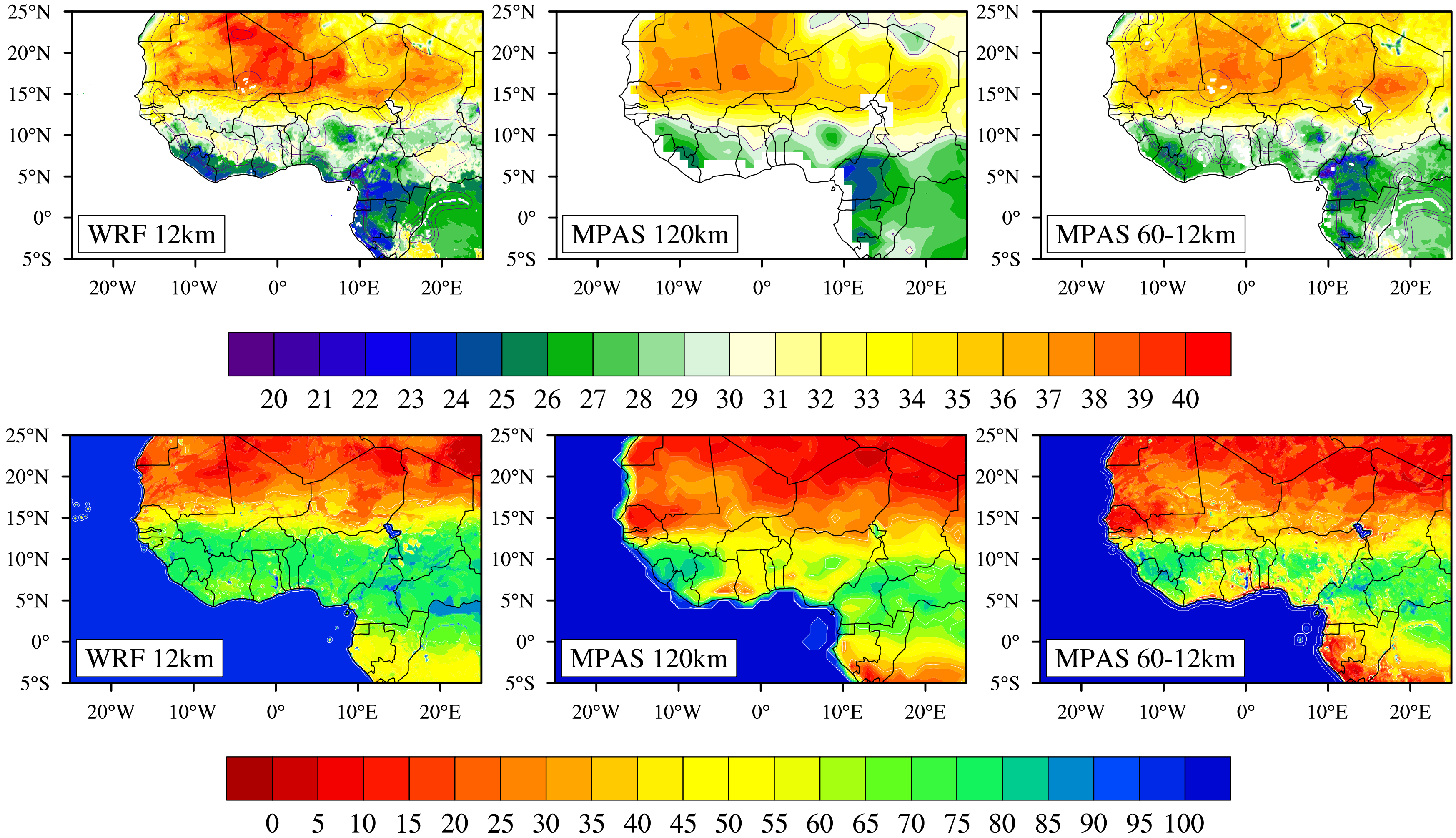
Near surface temperature [°C] - July 1982 monthly mean

(initialisation: WRF 1979-01-01, MPAS 1981-09-01)



At least one monsoon period needed for spinup

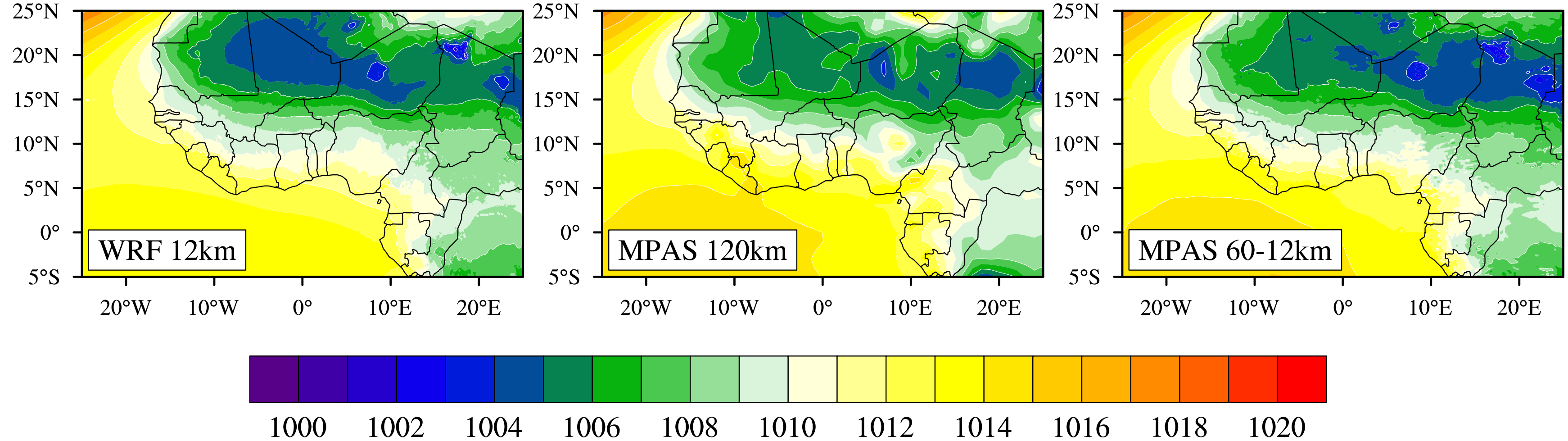
Soil temperature [°C] (top) and relative soil moisture [%] (bottom) - July 1982 mean

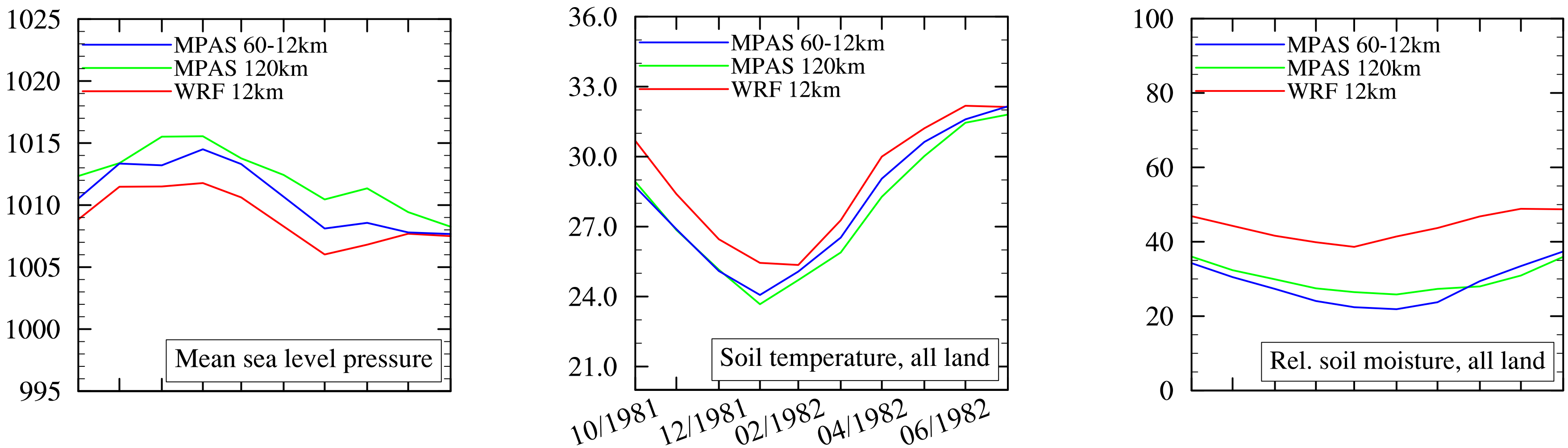


MPAS
Model for Prediction Across Scales

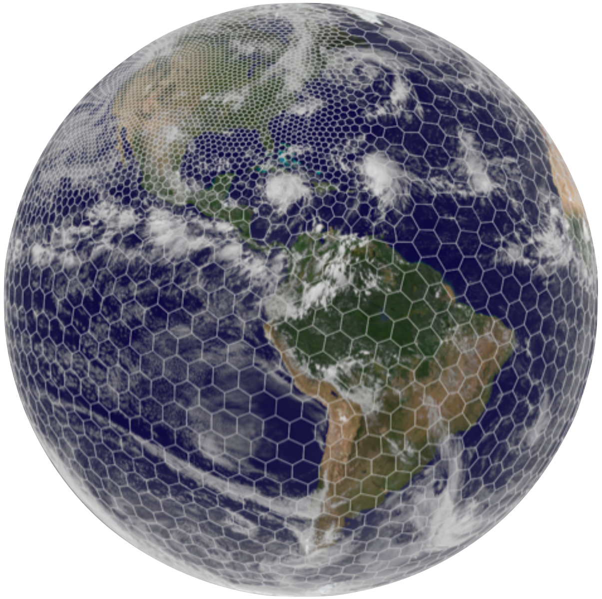
At least one monsoon period needed for spinup

Mean sea level pressure [hPa] - July 1982 monthly mean





Take home messages



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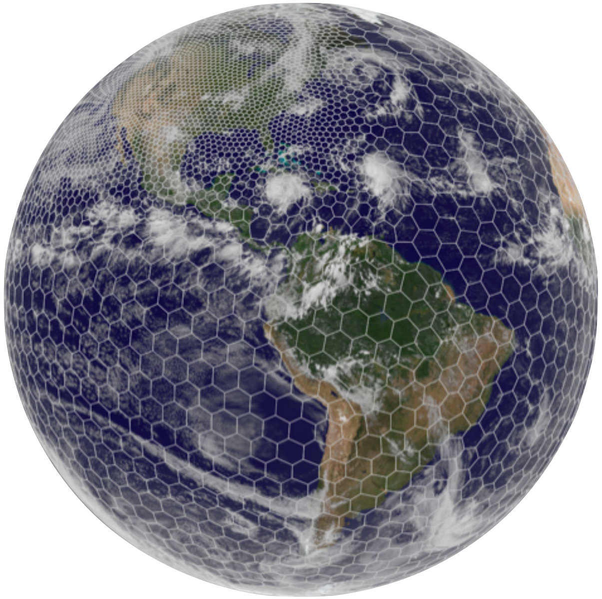

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