STEFAN SOBOLOWSKI, ERIKA COPPOLA AND THE FPS CONVECTION TEAM

The WCRP-CORDEX Flagship Pilot Study on Convection year two update: successes, challenges and the way forward

OUTLINE

- FPS and CORDEX
- Motivation for a coordinated effort
- Timeline
- Test Cases/ensemble performance
- Challenges
- Next Steps

Flooding in Gard department (Southern France), 09 August 2018. Credit: Pompiers du Gard, http://floodlist.com/europe/fr ardeche-gard-drome-augus

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WCRP CORDEX FLAGSHIP PILOT STUDIES

What are CORDEX & the Flagship Pilot Studies?

- WCRP-sponsored core project: Coordinated Regional Downscaling EXperiments (www.cordex.org)
- “The CORDEX vision is to advance and coordinate the science and application of regional climate downscaling through global partnerships”
- All land masses, all RCPs, most CMIP5 models, @ 12-50km resolution, multi-model ensemble
- Coordination with CMIP6 through CORDEX-MIP (Gutowski et al., 2016)

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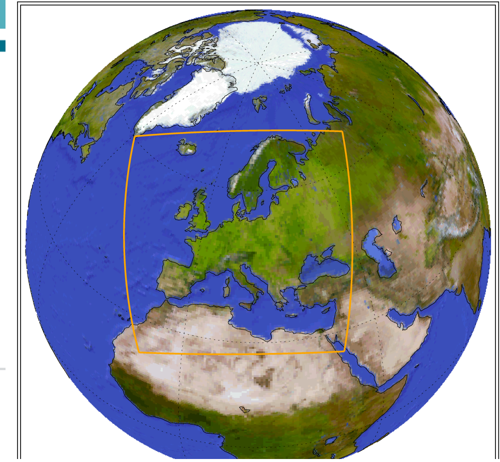

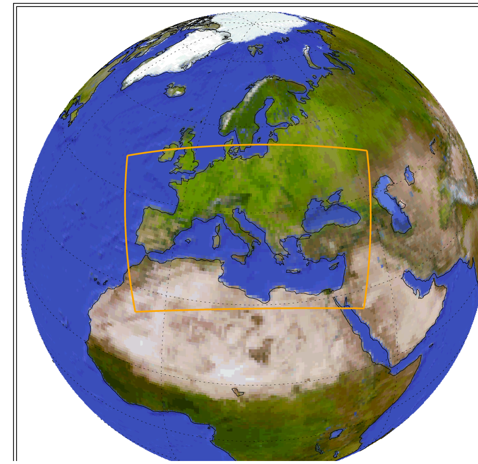

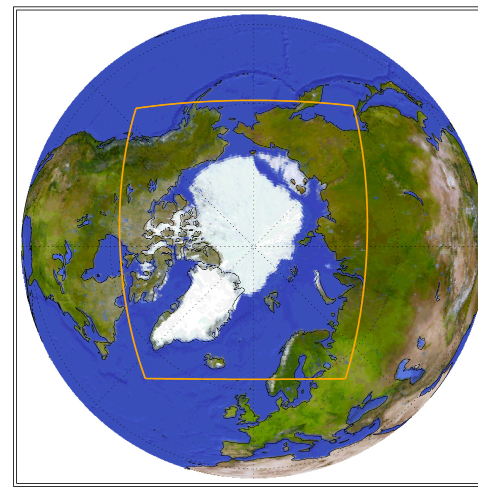

Pilot studies as a way to address challenges facing CORDEX and by extension climate services and impacts studies

- More rigorous and quantitative assessment of the added value of regional downscaling;
- Better understanding of processes and phenomena relevant for regional climate change;
- A broader and more process-based assessment of downscaling techniques and models;
- Moving towards very high resolution, convection permitting models;
- Better integration of CORDEX with other WCRP programs (e.g. GEWEX)

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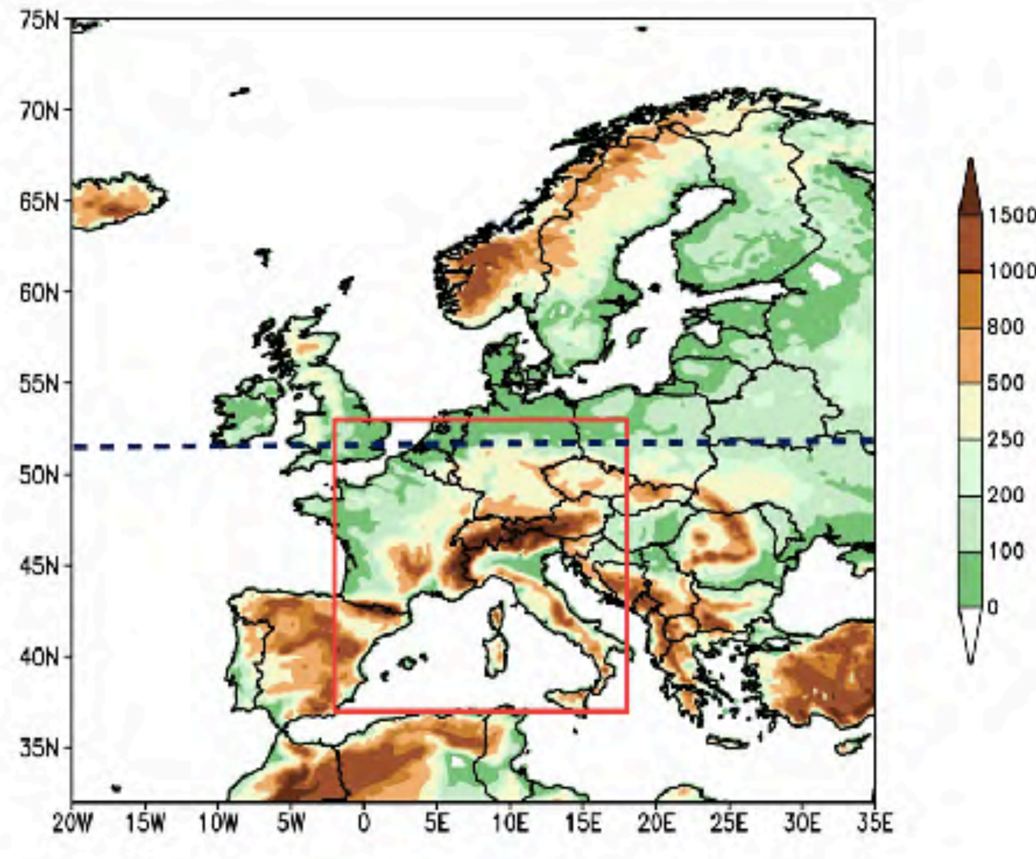
The FPS Convection launched Fall 2016 with these objectives

- **Investigate convective-scale events, related processes and their changes** in a few key regions of Europe and the Mediterranean using convection-permitting RCMs, statistical models and available observations
- **Provide a collective multi-model ensemble assessment and intercomparison** our modeling capacity at convection-permitting scale
- **Shape a coherent and robust assessment of the consequences of climate change on convective phenomena impacts at local to regional scales**



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FPS Convection timeline from Nov. 2016 to Present

Kickoff
Nov. 2016

- Outcome: Mandatory domain 1-17E, 40-50N @ 3km
- Outcome: Refined scientific aims
- Outcome: Tentative experiment design, protocol variable list

Euro-CORDEX
Jan. 2017

- Outcome: Request from CORDEX SAT for test cases

EGU
April 2017

- Outcome: Presentation by Erika
- Outcome: Side meeting to finalize test cases (successful) & variable list (now finalized)

FPS Convection timeline from Nov. 2016 to Present

Summer – Fall 2017

- Outcome: 22 member ensemble of 3 test cases (WL-CM) completed
- Outcome: Draft of *Clim. Dyn.* CPM special issue manuscript

2nd Annual Meeting Nov. 2017

- Outcomes
  - Finalized manuscript, additional test case evaluation, sensitivity testing
  - Finalized specifications, variable list, variable formatting, data handling, sharing, etc.
  - Finalized timeline for 2018 (ensemble era-interim climate runs 2000-2010+)

EGU April 2018

- Outcome: Presentation by Stefan
- Outcome: Splinter meeting to discuss storage solutions, cmorisation, simulation issues (e.g. snow over high elevations, glaciers)

Expanded Science Aims

› Science Aim 1
  - Include additional processes/phenomena such as high altitude snow and related hydro climatic impacts, mesoscale processes like low-level wind convergence, orographic phenomena
  - Life cycles of convective phenomena and related processes in the context of a changing climate
  - Land-atmosphere interactions and hydrological impacts

› Science Aim 2
  - Consider improvements in the aggregate statistics of other near-surface variables such as temperature and wind
  - Use convective permitting models to help the development of convective parameterization

› Science Aim 3
  - Include temporal discretization to elucidate sub-daily rainfall;
  - Expand to include temperature and wind.

Experiment timeline

2017: First set of simulations: RCM simulations will be run at convection-permitting resolutions for **selected test periods**

- Mandatory domain definition;
- sub-groups coordinate and test multi-physics options ;
- Perform test case study experiments with model systems run in weather like (WL) and climate
- mode (CM)

2018: Begin ERA-Interim evaluation

- 2000-2014 (minimum 10 years) ERA-Interim simulations. Present climate period chosen to overlap with recent high resolution observation campaigns.

- Develop a statistical convection model to:
  - identify mechanisms of long-term changes in convective precipitation
  - serve to evaluate the representation of underlying processes, assess added value
  - emulate convective precipitation.

2019-2021: Scenario simulations, event interpretation, detailed analyses and intercomparisons

- Scenario simulations - 10 year time slices CMIP5/CMIP6 GCM
- Periods: 1996-2005, 2041-50, 2090-99 (HIST and RCP8.5)
- Additional simulations focusing on extreme events under present and future conditions for the purpose of event interpretation;
- Open access to the CP-RCM output data through the ESGF
- Link to the impact community

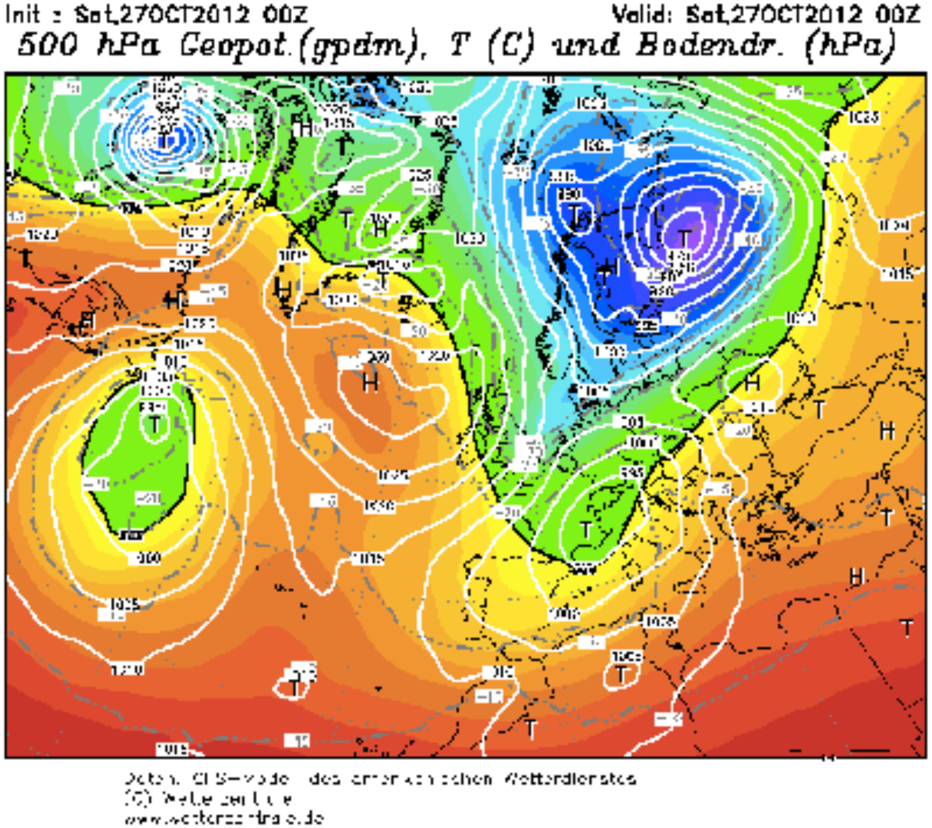
Test case selection

CASE	ACRONYM	Initialization Procedure	Analyzed Time Window
1	HymexIOP16	Starting DATE (WL): 2012-10-23 Ending DATE (WL): 2012-10-28 Starting DATE (CM): 2012-10-01 Ending DATE(CM): 2012-11-01	23 Oct 2012 00:00 - 28 Oct 2012 00:00
2	AUSTRIA	Starting DATE (WL): 2009-06-20 Ending DATE (WL): 2009-06-27 Starting DATE (CM): 2009-06-01 Ending DATE(CM): 2009-07-01	22 Jun 2009 00:00 - 25 Jun 2009 00:00
3	FOEHN	Starting DATE (WL): 2014-11-02 Ending DATE (WL): 2014-11-07 Starting DATE (CM): 2014-10-01 Ending DATE(CM): 2014-11-07	3 Nov 2014 00:00 - 7 Nov 2014 00:00

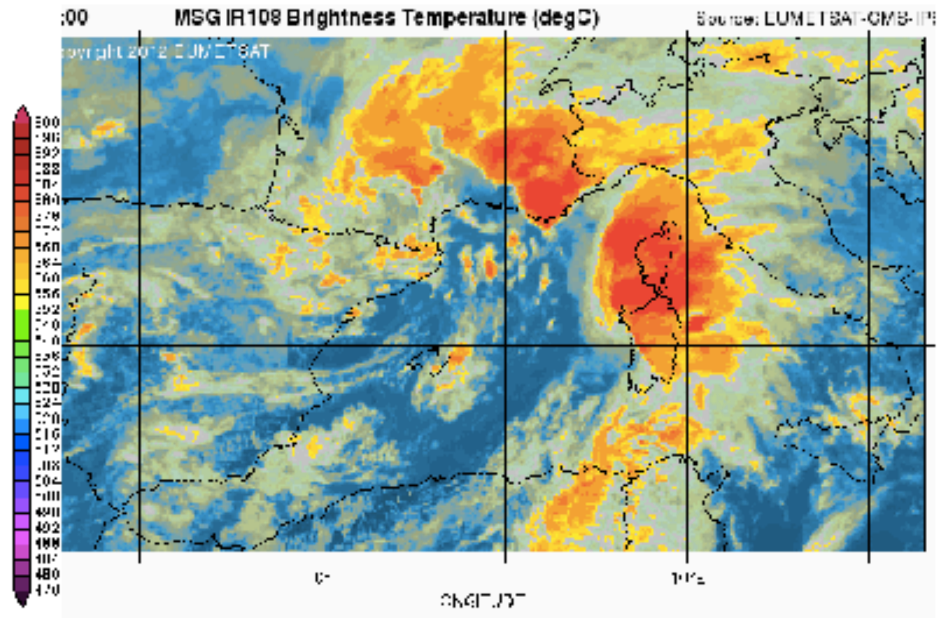
Test case purpose/protocol

- Reproduce different types of events and explicitly resolve convection at CP-scales (~3km), assess model performance given inherent limitations in running long-term climate simulations vs. nwp.
- Assess what can be expected from climate-type simulations with CP-RCMs with respect to heavy precipitation (HP) events.
- Set up a testing platform for new models/modeling teams entering the project.
- 21 member ensemble, 6 modeling systems (27 teams committed to longer simulations)

HyMeX-IOP16 25-29 Oct. 2012



26Z13

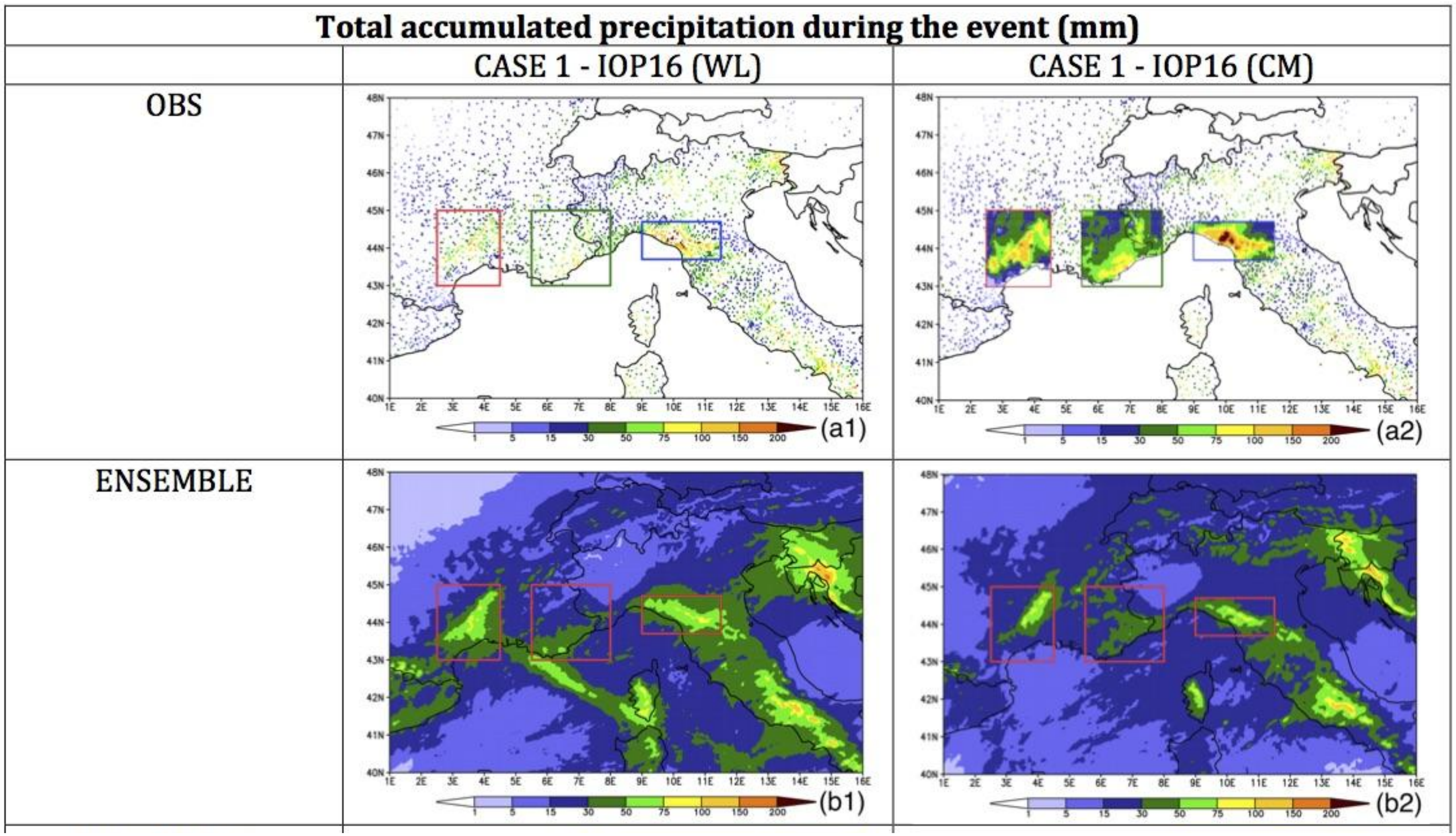


- Evolution of a **trough** interacting with an **upper-level low** pressure→ **Slow propagating MCS**
- FRANCE: **170 mm/36h (D26/27)** → Flood Event
- ITALY-LT: locally up to **245mm/24h (D26)** → Flood Event

Ducrocq et al., 2014 (BAMS) DOI: http://dx.doi.org/10.1175/BAMS-D-12-00244.1
And supplement 10.1175/BAMS-D-12-00244.2

The Abdus Salam International Centre for Theoretical Physics

Ensemble reproduces pattern of event in both WL (.67) and CM (.62)



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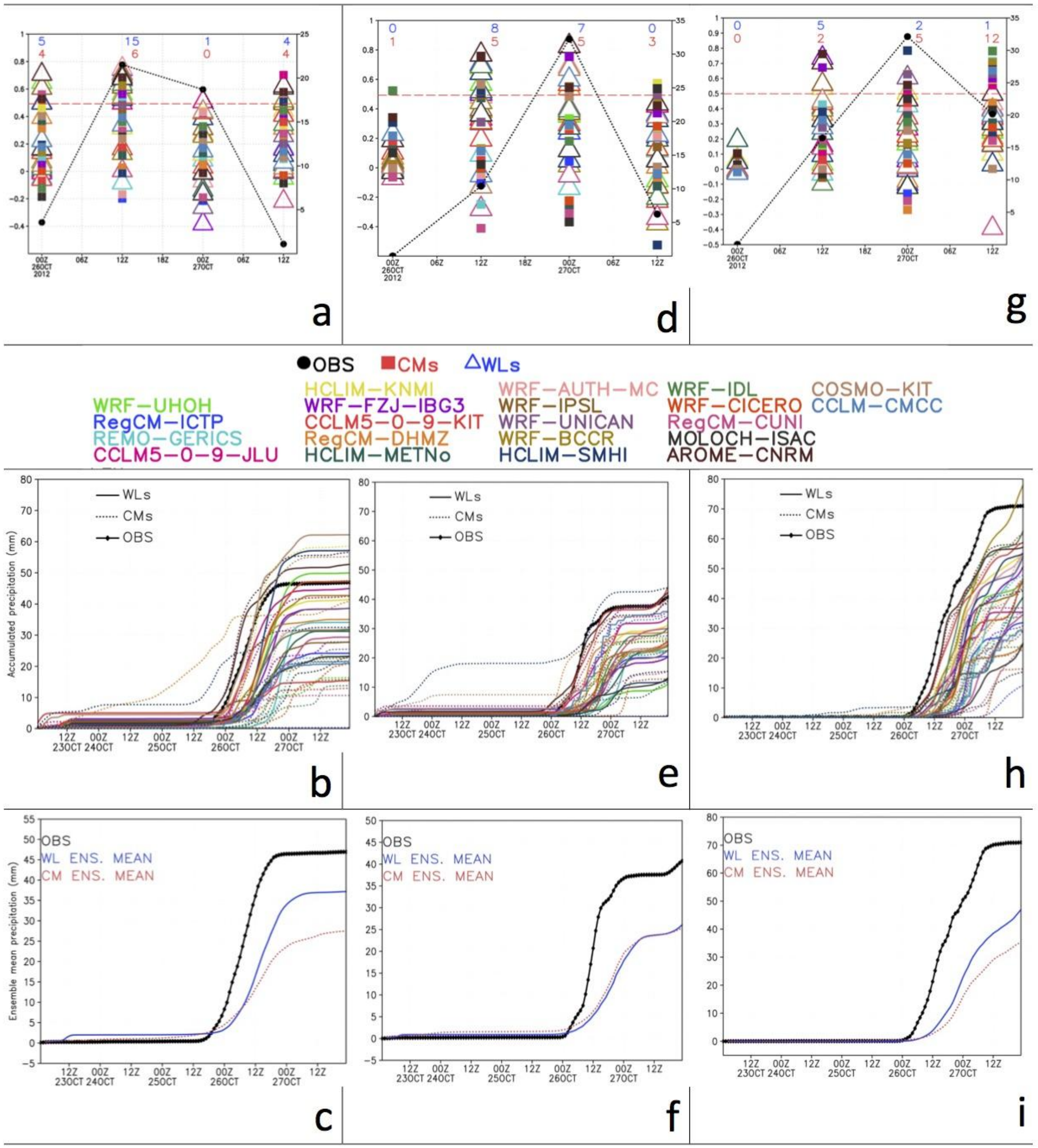
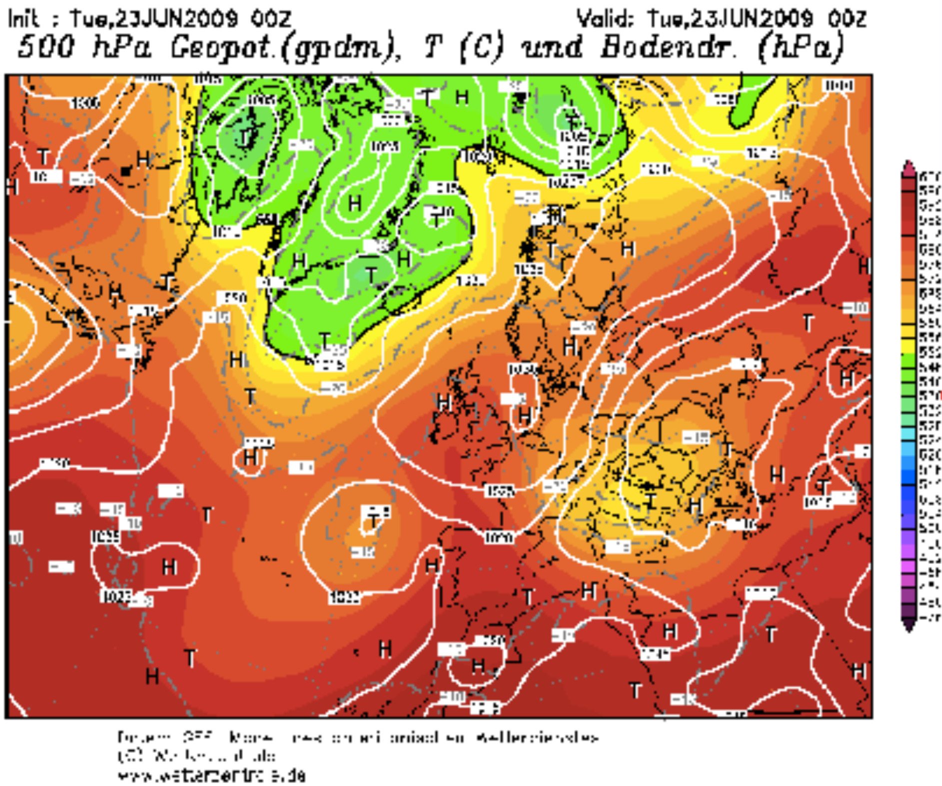
Accumulated precipitation during the event

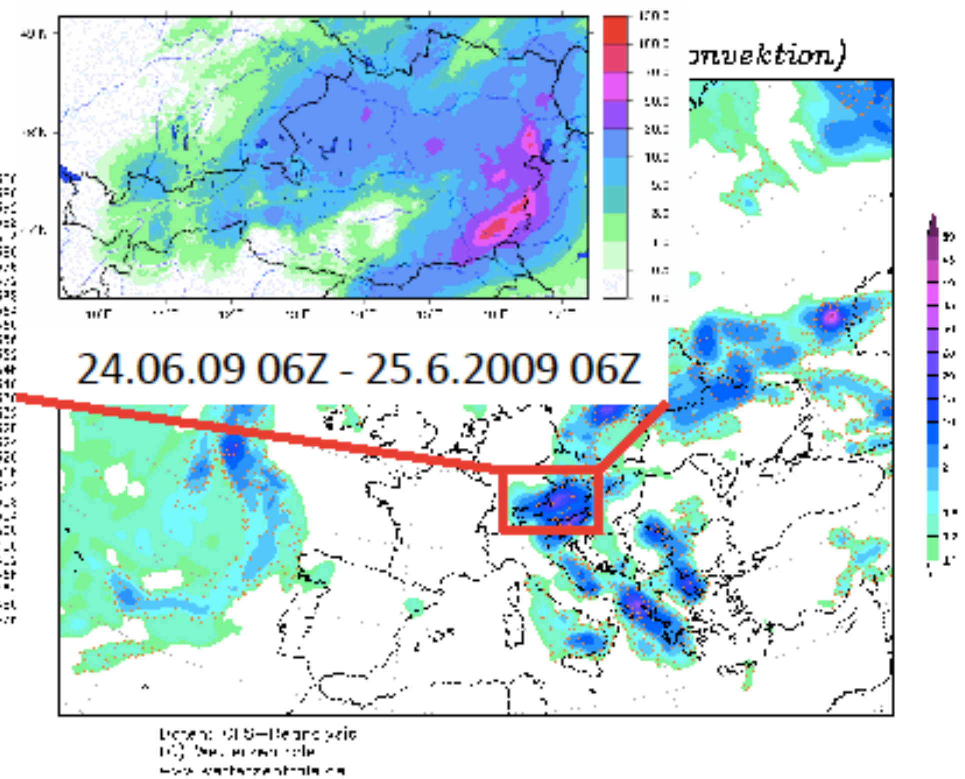
Spatial pattern correlation shows large spread

Large spread, general under-estimation, timing too late



AUSTRIA 22-27 Jun. 2009

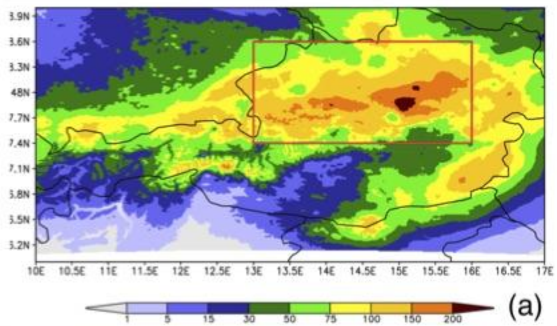
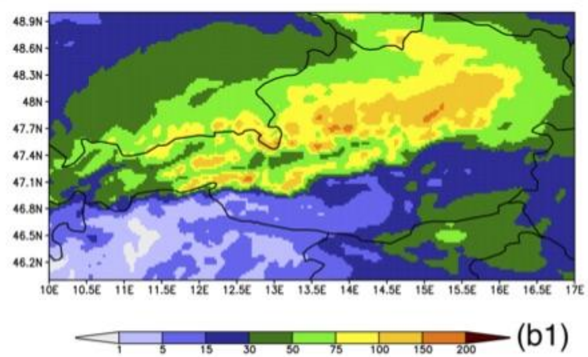
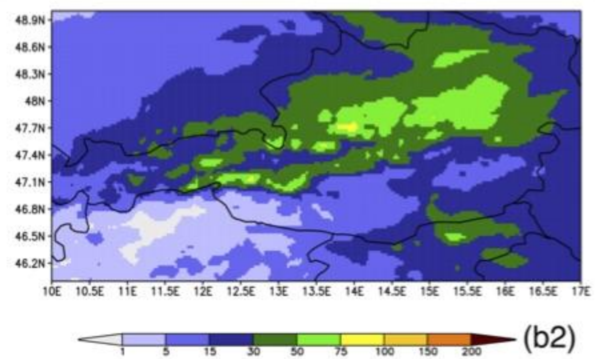




- **Cutoff low** isolated over Southern Europe
- persistent **unstable warm-moist air** impinging Alps with strong embedded **deep-convective cells**
- Total **354 mm** and a return period of more than **100 years** (max. 130mm/24h D24)

Godina, R. and Müller, G. (2009)
https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/wasserkreislauf/hydrograph_charakt_extrema/Hochwasser-Juni2009.html

Ensemble reproduces event in WL (**.82**) not as well in CM (**.81**)

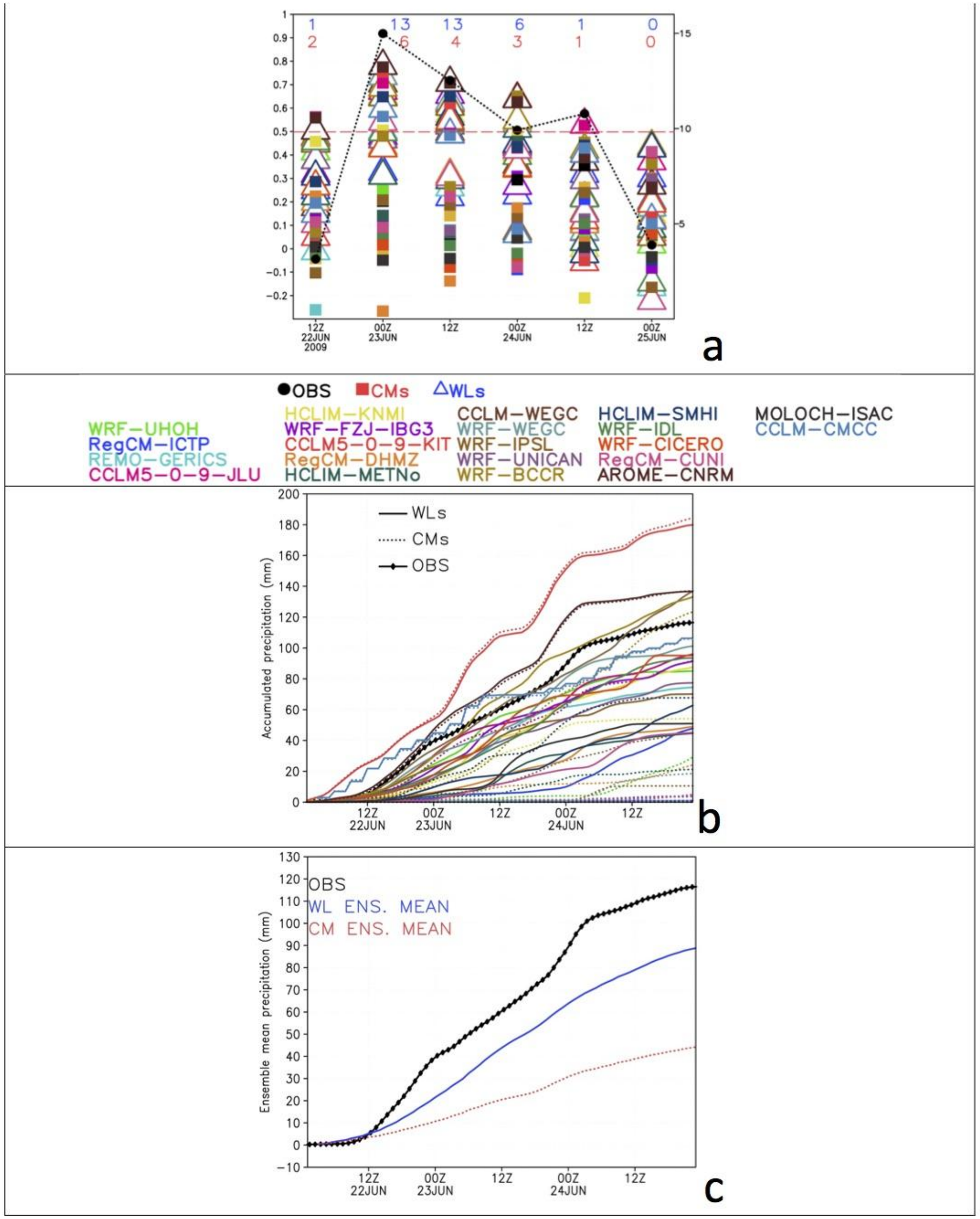
Total accumulated precipitation during the event (mm)		
	CASE 2 - AUSTRIA (WL)	CASE 2 - AUSTRIA (CM)
OBS		
ENSEMBLE		

Accumulated precipitation during the event

Spatial pattern correlation quite good in WL

Some simulations miss the event entirely

Ensemble mean WL is okay, CM rather poor



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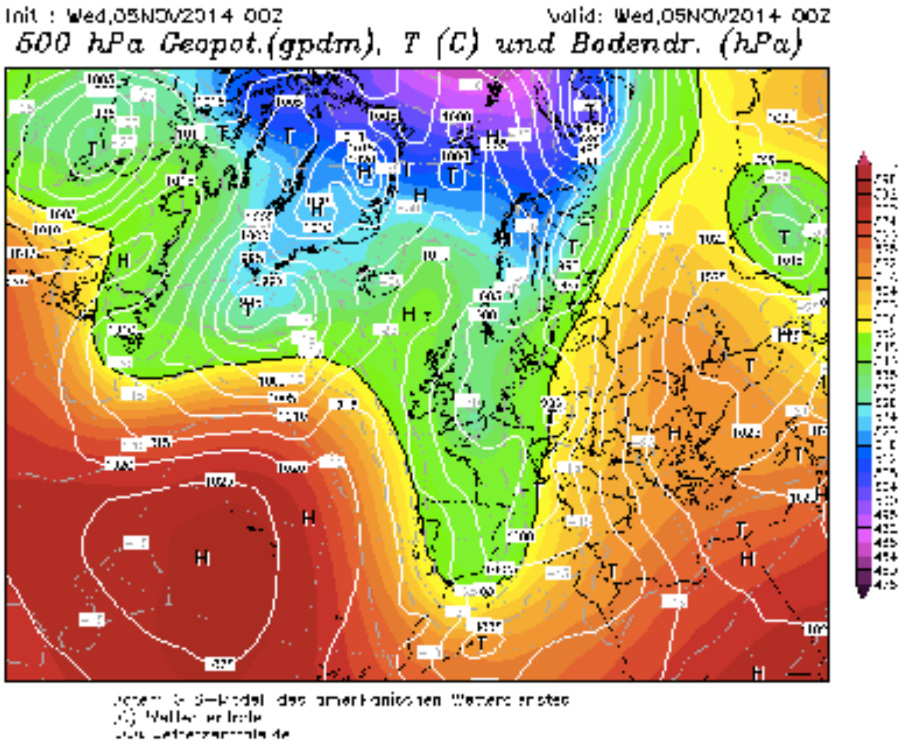
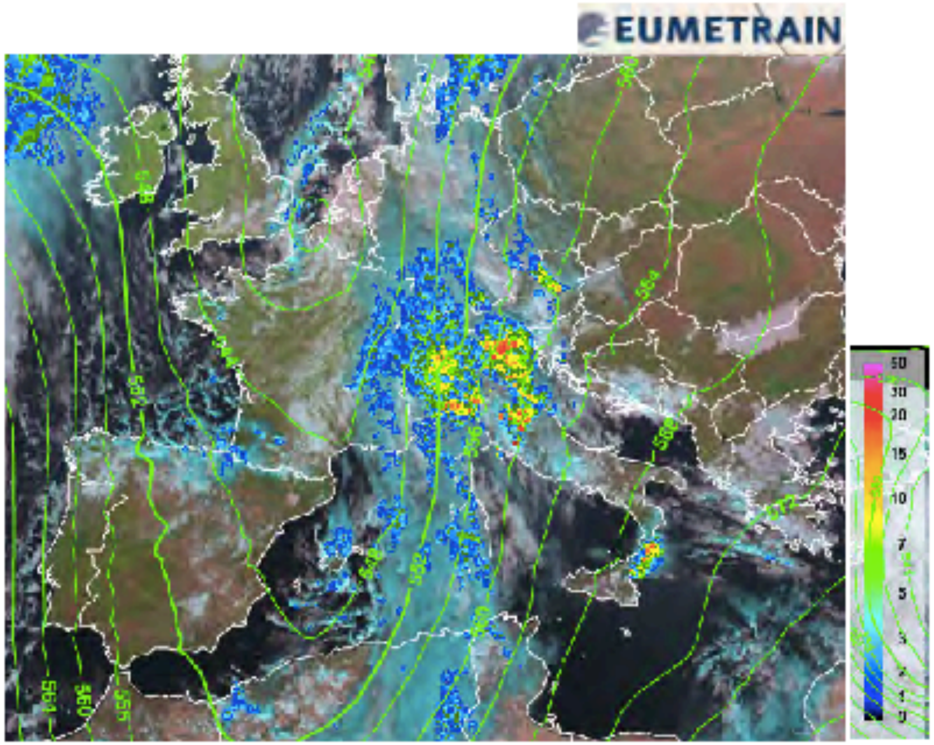
From Lavin-Gullon et al., 2018
https://pub.ame-web.org/index.php/JRD/article/view/1541

Side note on the Austria Case

- The singlemodel
- multi-initial-conditions ensemble shows similar or larger spread than the
- multi-physics CM ensemble. Moreover, similar synoptic circulation patterns were
- developed by the multi-physics and the internal variability ensemble. Therefore,
- caution should be taken when interpreting physical parameterization sensitivity
- studies, especially if spanning short testing periods as in this example. Whenever
- possible, RCM internal variability should be quantified to discern the effect of model
- modifications from the chaotic amplification of small perturbations.

FOEHN 4-5 Nov. 2014





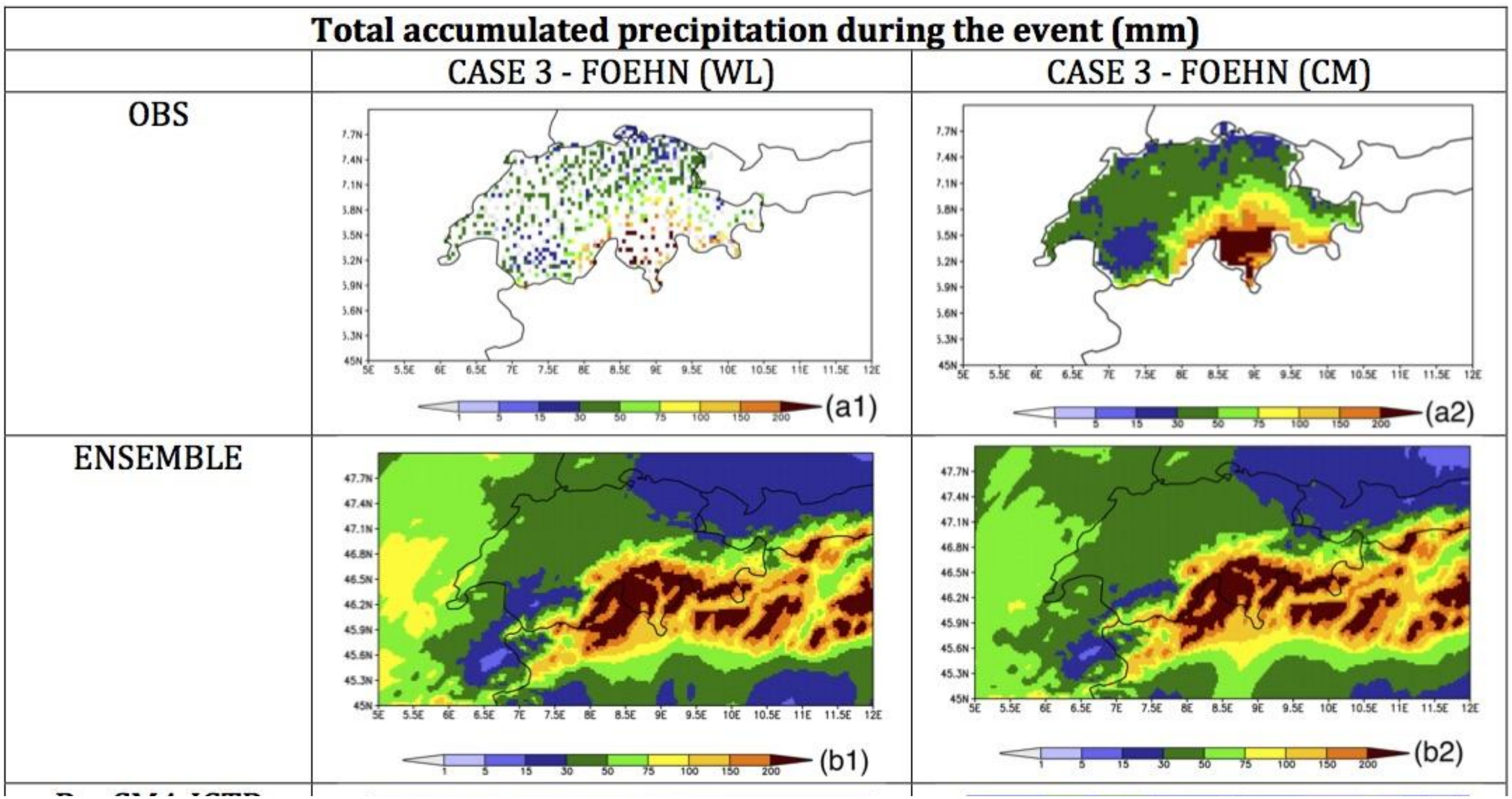
- Evolution of slow eastward **deep trough**
- Southerly persistent flow over the Swiss Alps
- **Steady OR. precipitation** on windward side [+ Foehn effect (larger T on the lee side of Alps)]

- Persistent rain → Total event **500mm** (D6Z00)

Kramer et al., 2017 (Climate Dynamics)

International Centre for Theoretical Physics

Ensemble reproduces event in both WL (.91) and CM (.90)

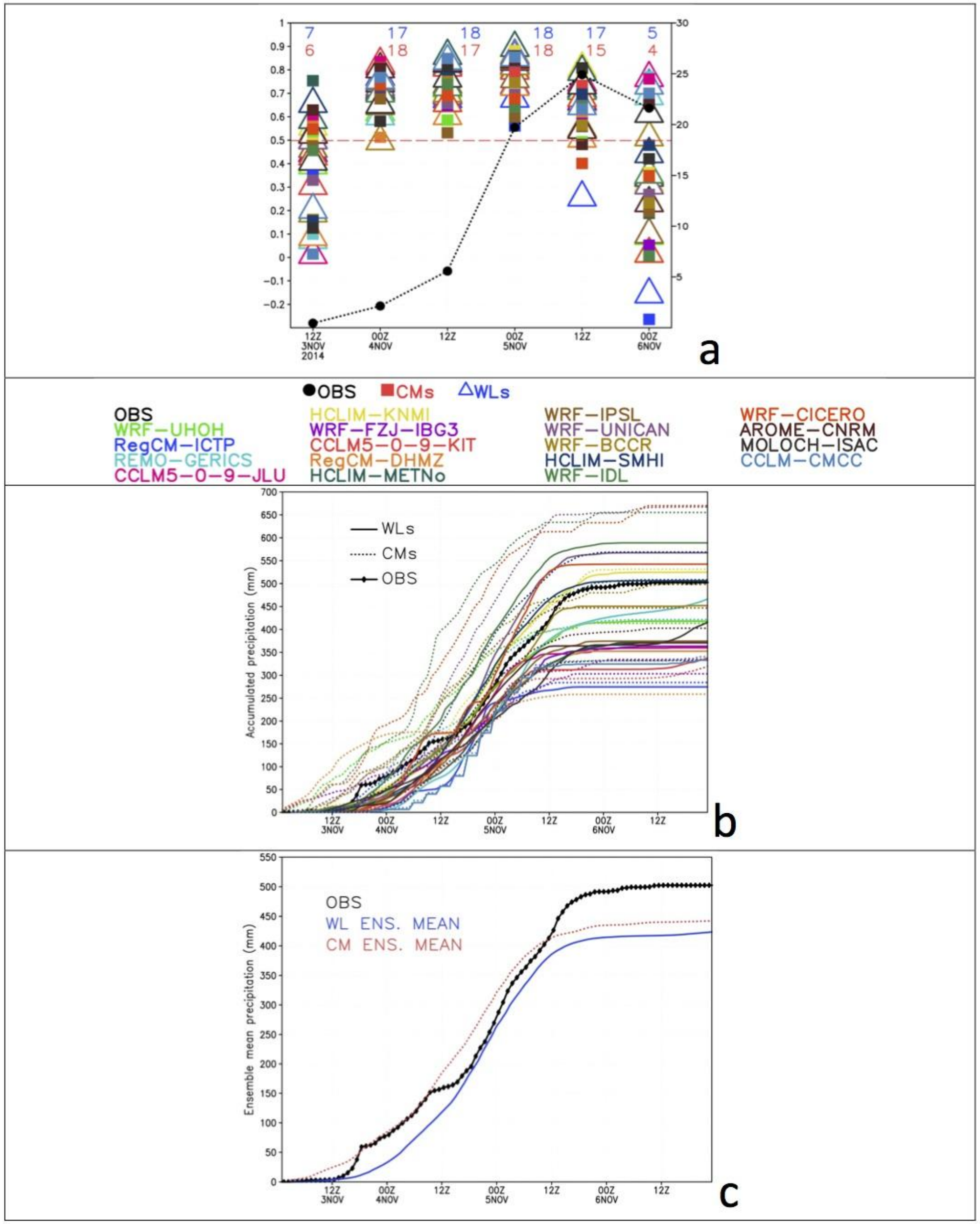


Accumulated precipitation during the event

Spatial pattern correlation high throughout; tight spread

Event well captured in both modes

Ensemble mean for both modes tracks obs well



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Summary

(Coppola et al., 2018. *Clim. Dyn.* (*in-revision*))

- The test cases designed to provide a zero-order assessment of the ensemble, its characteristics, limitations and capabilities.
- The three cases illustrate both the challenges and potential in CPM and provide a clear argument for the advantages of the ensemble based approach.
- Events driven by large-scale conditions, the closer the agreement between the ensemble members
- Complex local-scale interactions between flow and orography and land-ocean contrasts are readily apparent
- Weakly forced event over Austria is not as well reproduced
- Background synoptic state clearly matters

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Challenges: too many to list…

- Storage needed will likely be around 300TB; currently Juelich is hosting
- Homogenization of observation datasets for evaluation is a challenge (different resolutions, time periods, methodologies, coverage, etc., etc., etc.)
- How to distinguish between internal variability and physics parameterizations (Lavin-Gullon et al., 2018 https://pub.ame-web.org/index.php/JRD/article/view/1541)
- Not just of scientific interest to move beyond precipitation also practical (sub-surface – surface – atmosphere interactions matter!)
- Cant get away from dynamics especially in climate change contexts (e.g. how do circulation biases in GCMs impact cc signal in future CPM simulations?)
- Currently, hybrid dynamical-statistical efforts (i.e. convective emulators) are lagging behind

The way forward

contact:* *stefan.sobolowski@uni.no* *or* *coppolae@ictp.it

- Solve all challenges
- Save the world
- Or… ERA-Interim evaluation ensembles coming soon to storage facility near you!
- Lastly, CORDEX-FPS Convection aims to support the community forming around the use of the CPM on climate scales; all are welcome!