GEWEX CONVECTION-PERMITTING CLIMATE MODELING WORKSHOP II

The ICTP regional climate model (RegCM4) response in convection-permitting mode over different regions of the world

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ICTP-Earth System Physics Section

The Abdus Salam International Centre for Theoretical Physics

Convection and its related impacts

Convection is of high interest to atmospheric scientists, climate impacts researchers and the public due to the role it plays in:

- ✓ Driving damaging extreme events (heavy precipitation, floods windstorms)
- ✓ It is the dominant type of precipitation in many parts of the world (tropics)
- ✓ Influences the general circulation of the atmosphere (mixing, clouds circulation)

Unfortunally, parameterization of convection, which is required at the grid spacing of most Global and Regional Climate Models contributes to errors in climate simulations

Convection Permitting and Climate

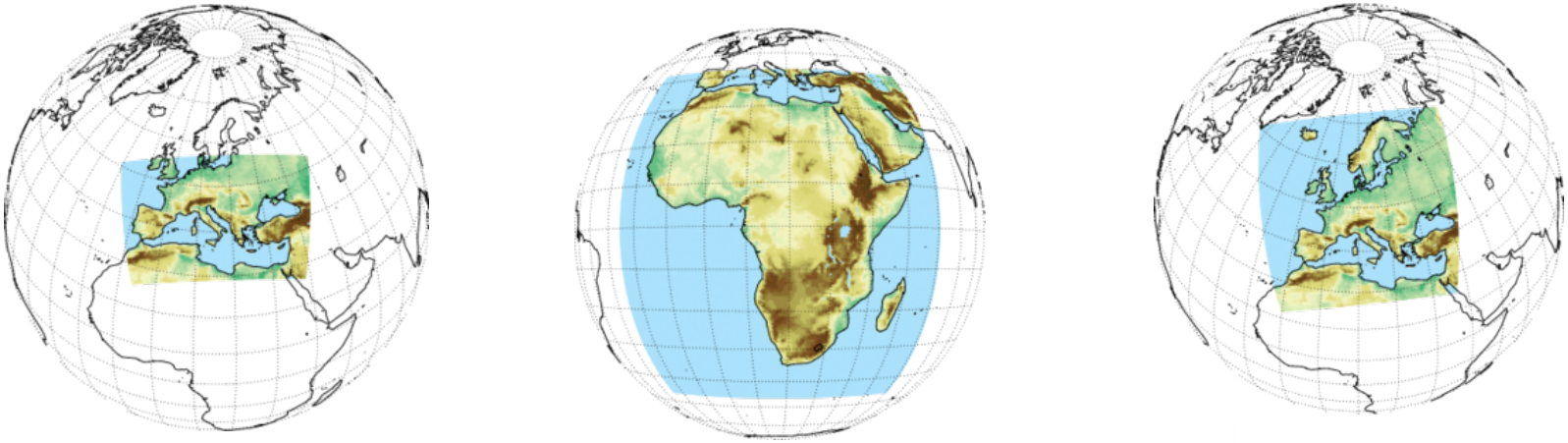
Climate activities at convection permitting scale

Motivation:

- The reduction of model errors associateds with parameterized convection;
- A more detailed representation of present convection phenomena;
- The need to investigate how the convection phonomena responsible of damnaging events will change in the future.

WCRP CORDEX
FLAGSHIP PILOT STUDIES

EUCP
European Climate Prediction system



FPS-CPS (**Euro-Mediterranean** and **ELVIC** – Climate Extremes in the Lake Victoria Basin)

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The ICTP regional climate model system

RegCM4 (Giorgi et al., 2012, CR SI 2012)

- **Dynamics**:
  Hydrostatic (Giorgi et al. 1993a,b)
  NoN-Hydrostatic (Grell et al. 1995)
- **Radiation**:
  CCM3 (Kiehl 1996)
  RRTM (Solmon)
- **Large-Scale Precipitation**:
  SUBEX (Pal et al 2000)
  Explicit microphysics (Nogherotto)
  WSM5 (Hong et., al 2004)
- **Cumulus convection**:
  Grell (1993)
  Anthes-Kuo (1977)
  MIT (Emanuel 1991)
  Mixed convection
  Tiedtke (1996)
  Kein-Fritsch, Kein (1990 2004)
- **Planetary Boundary Layer:**
  Modified Holstag (Holstag 1990)
  UW-PBL (O' Brien et al. 2011)
- **Land Surface:**
  BATS (Dickinson et 1993)
  SUB-BATS (Giorgi et al., 2003)
  CLM4.5 (Oleson et al, 2012)
- **Ocean Fluxes:**
  BATS (Dickinson et 1993)
  Zeng (Zeng et al., 1998)
  Diurnal SST

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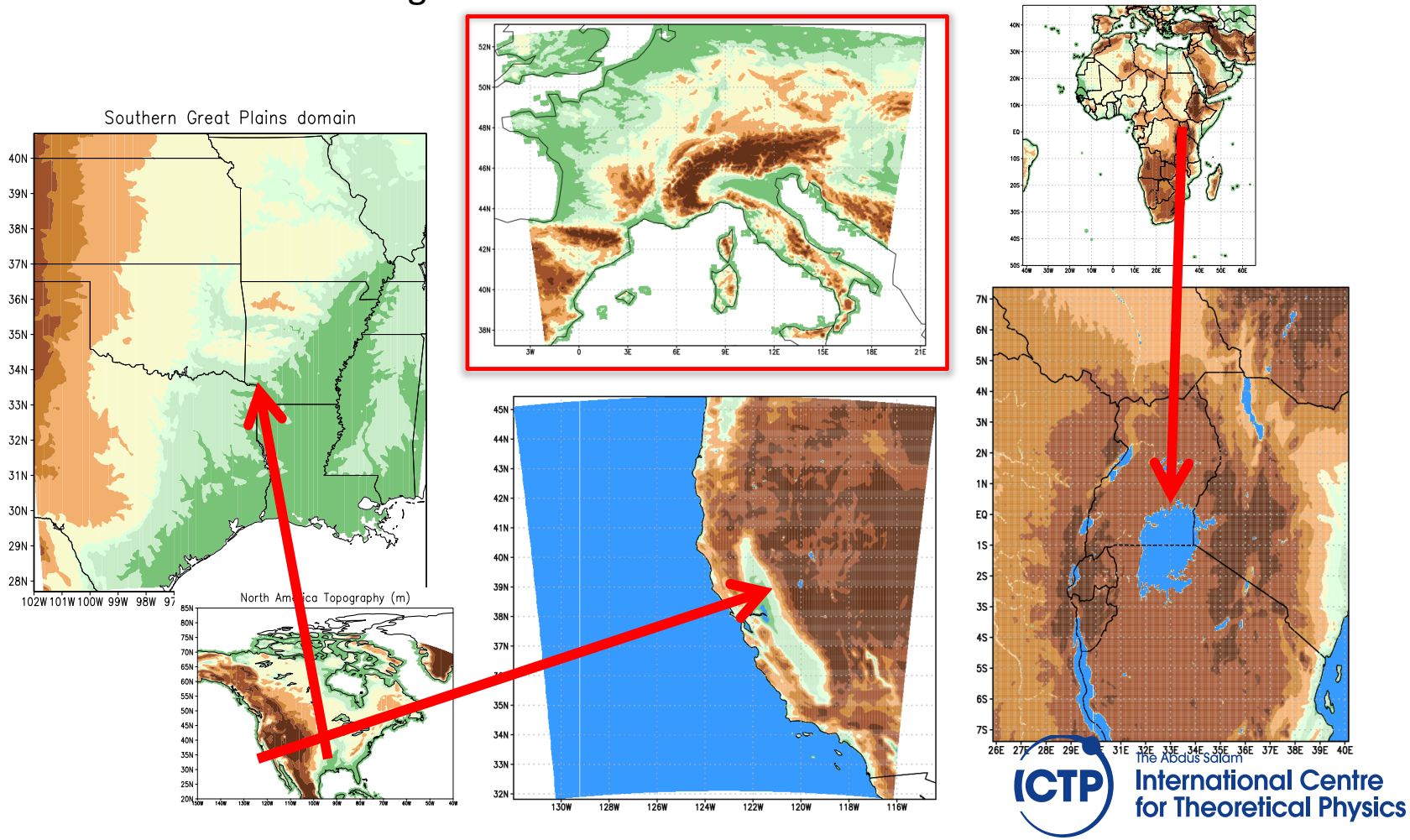
RegCM4.7 non-hydrostatic

Convection permitting: Domains tested so far…

The purpuse of the work was testing the new non hydrostatic core trying to reproduce convection explicity at convection permitting scales and perform a first assess of the model performance over different regions of the world



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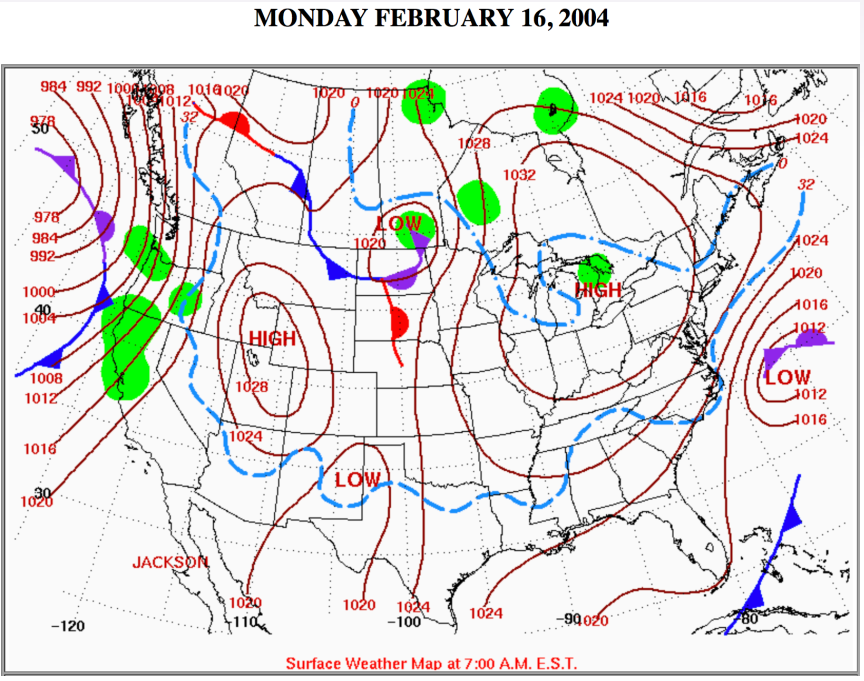
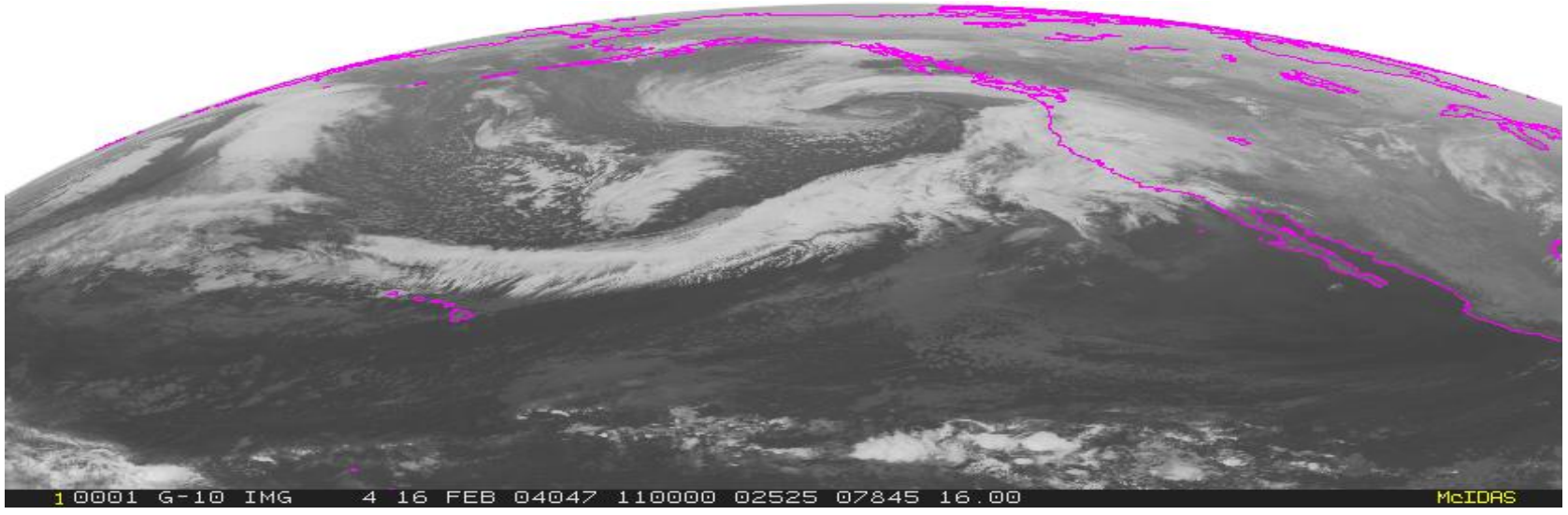
North California case : 16-18 February 2004 (*Ralph et al., 2006*)

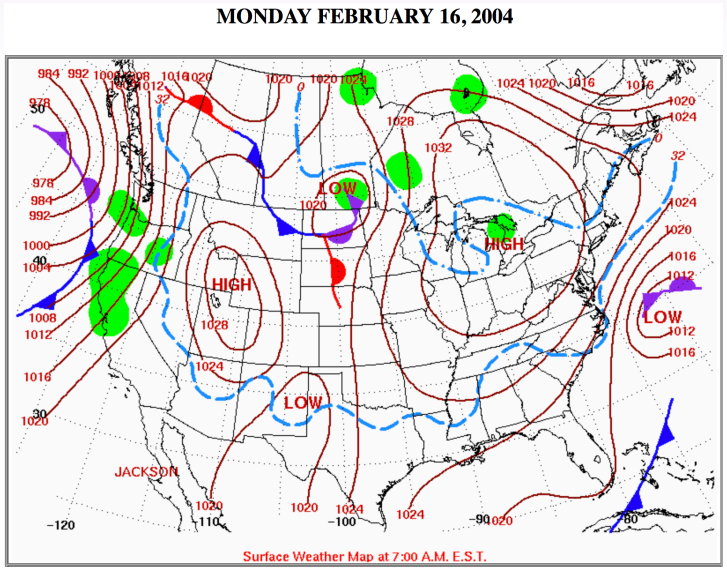


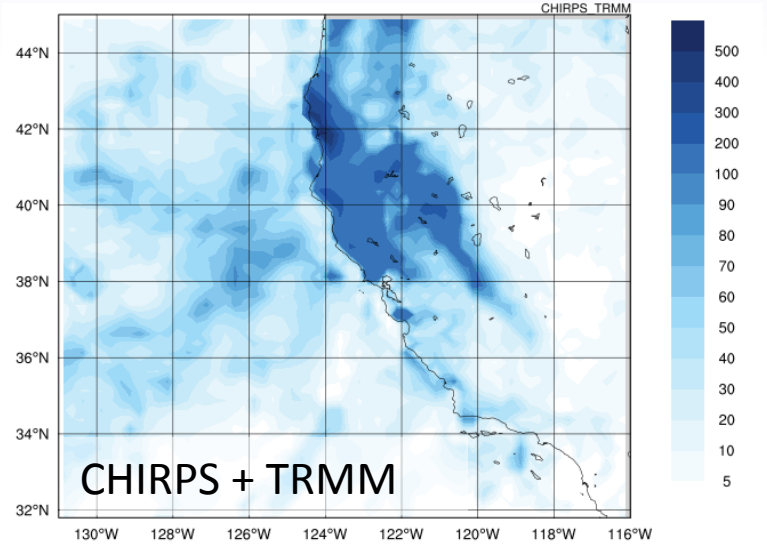
Prepared by the National Centers for Environmental Prediction, Hydrometeorological Prediction Center

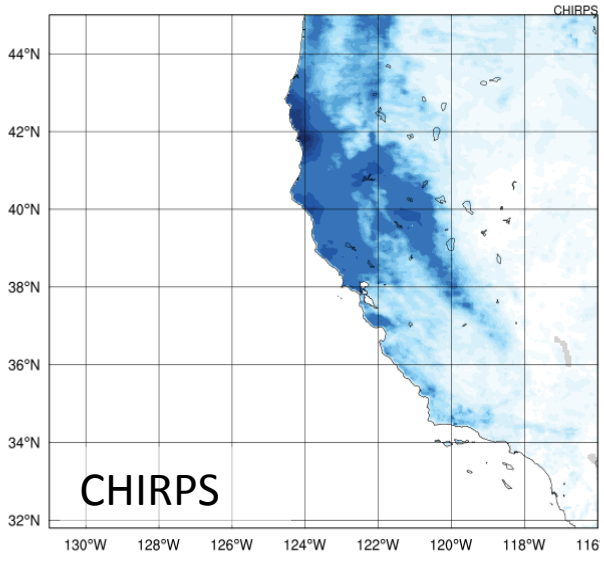


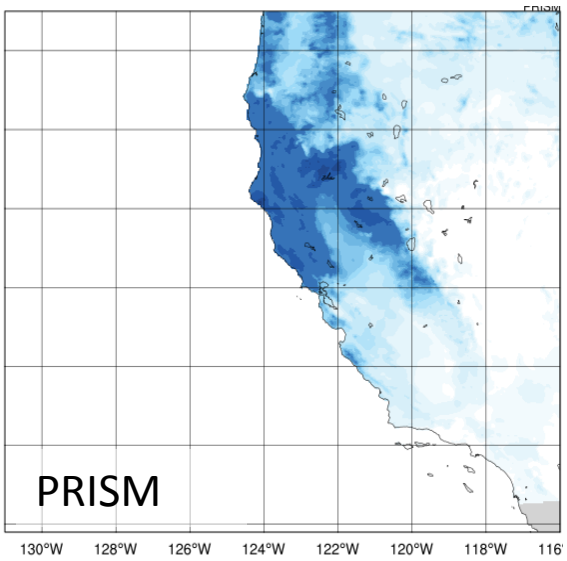
California case : Precipitation Accumulated in 96h (mm)

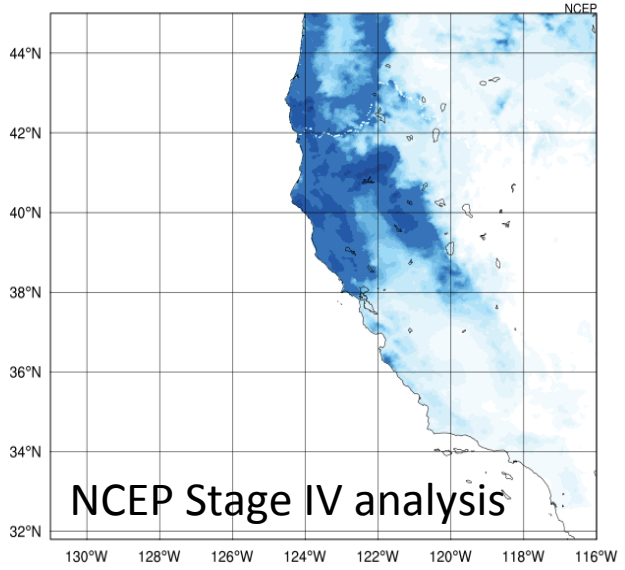
Observations



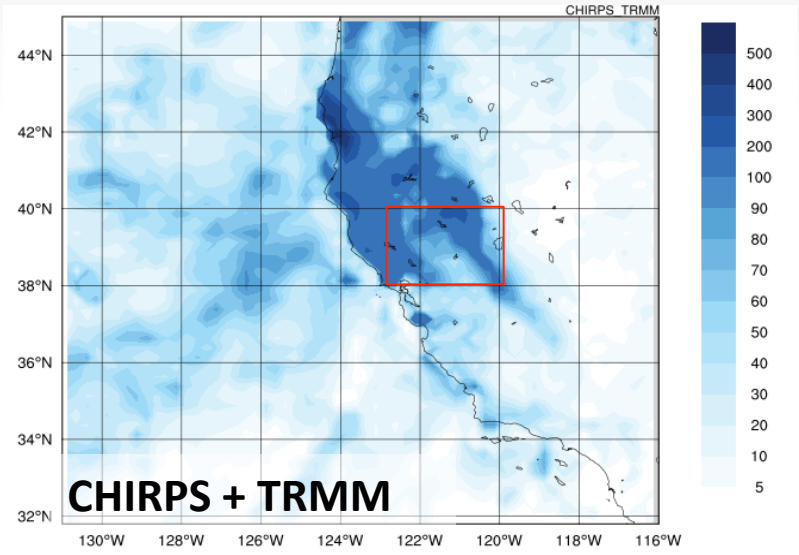


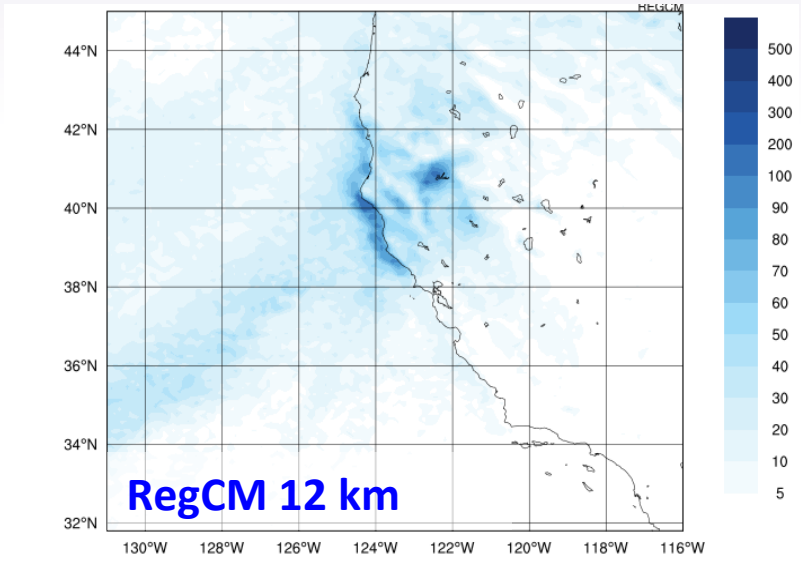


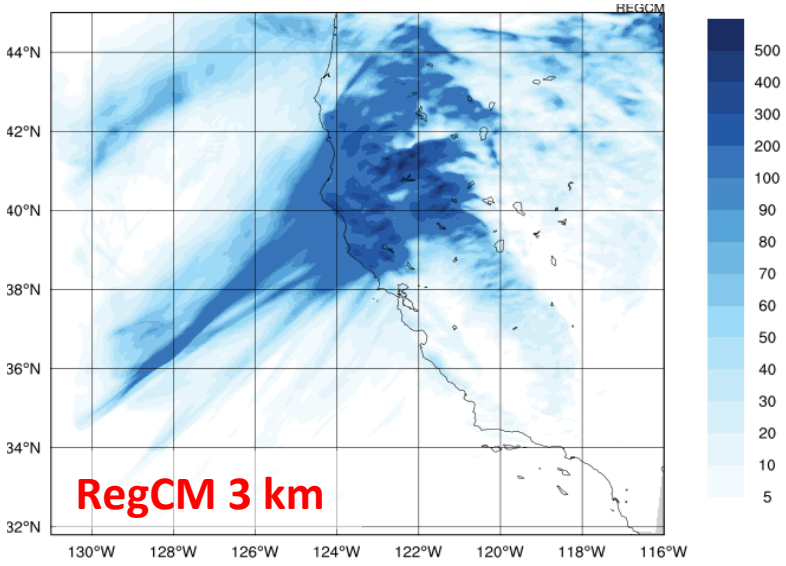


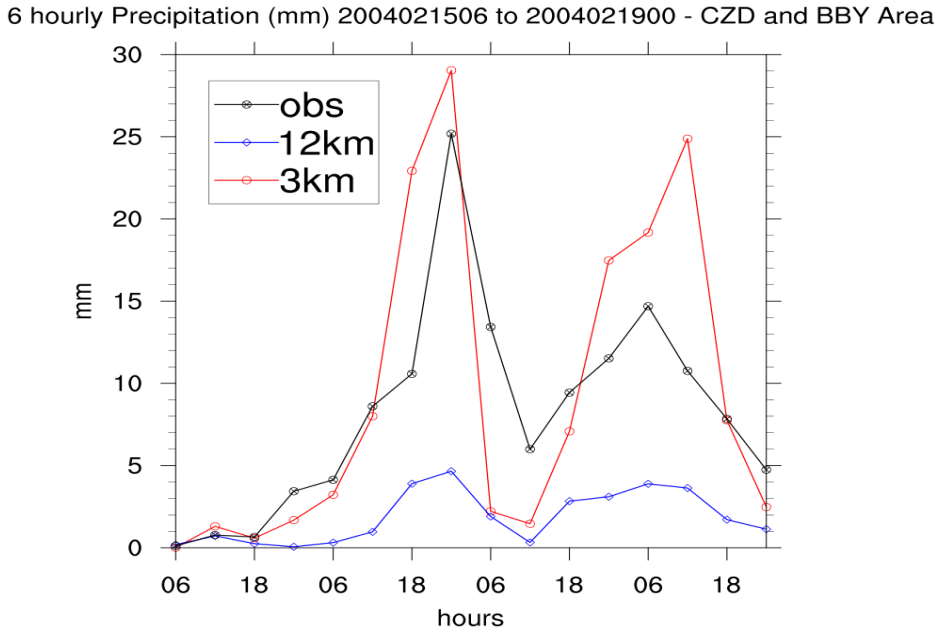


California case : OBS vs RegCM Precipitation Accumulated in 96h (mm)

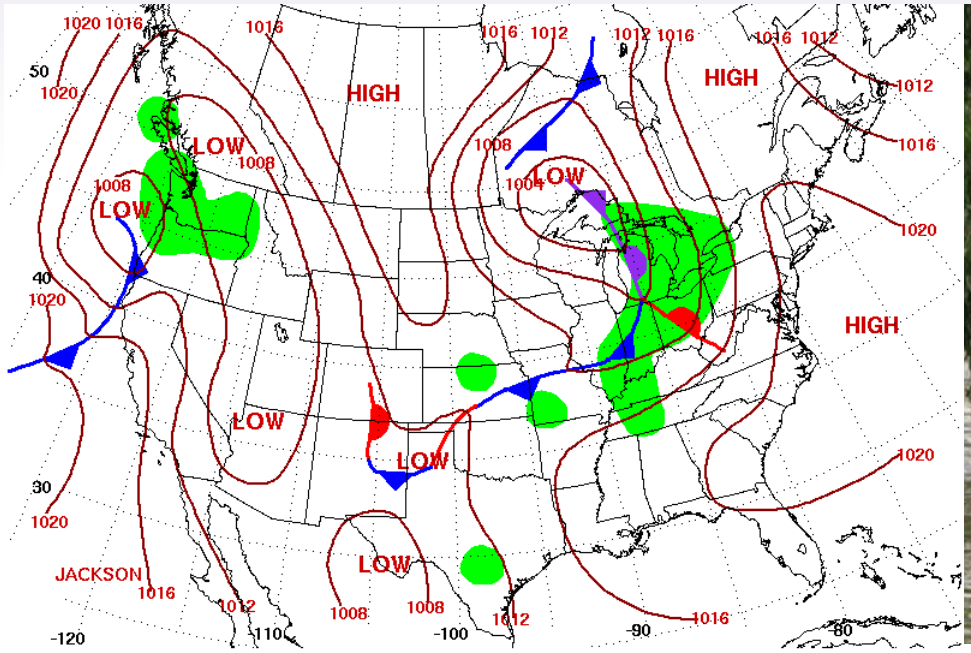






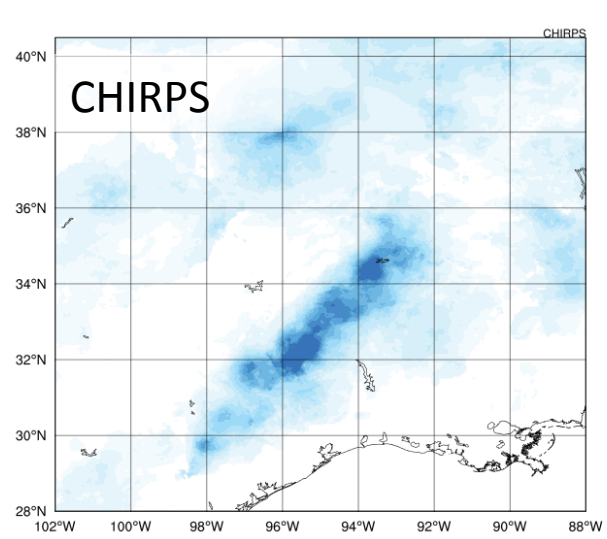


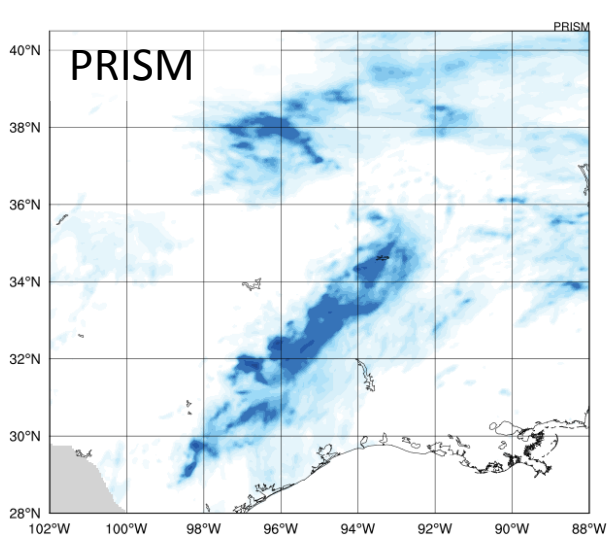
Northeastern Texas case : 9-11 June 2010 (R. W. Higgins *2011*)

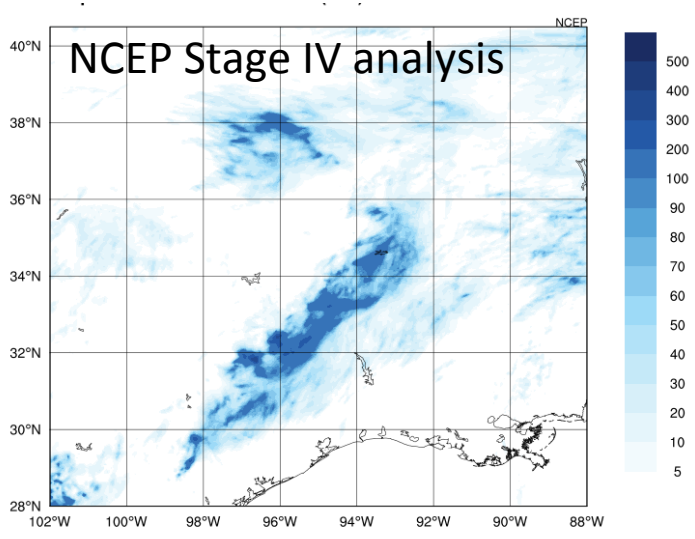


Surface Weather Map at 7:00 A.M. E.S.T.

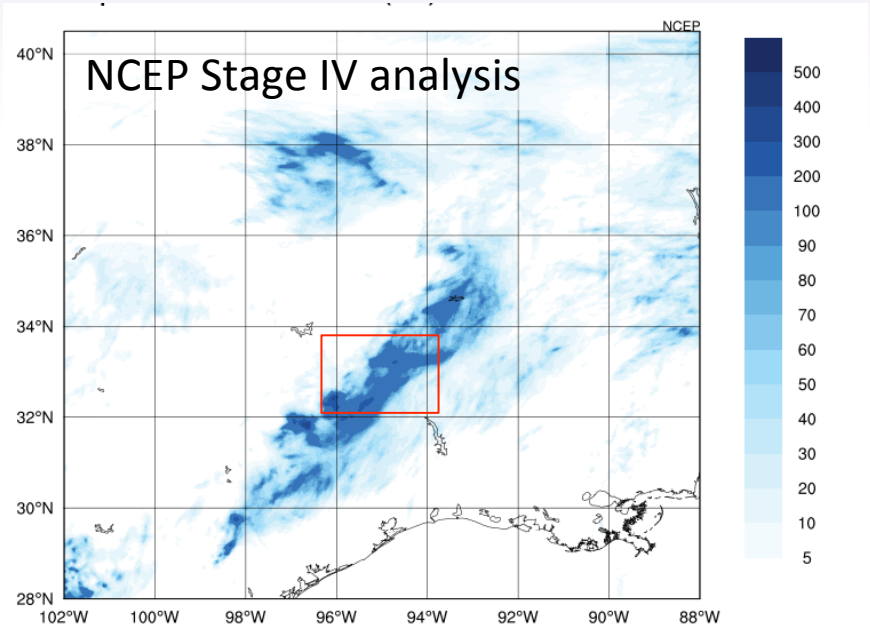
Prepared by the National Centers for Environmental Prediction,
Hydrometeorological Prediction Center

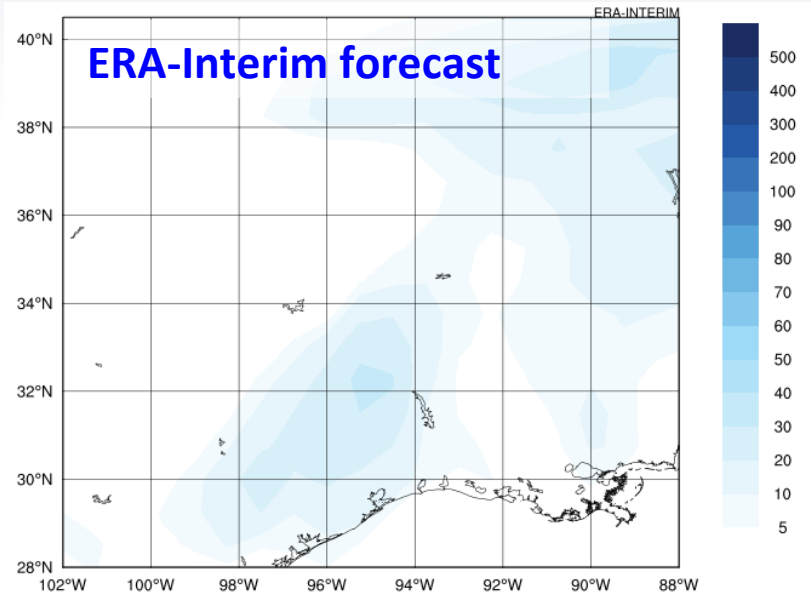


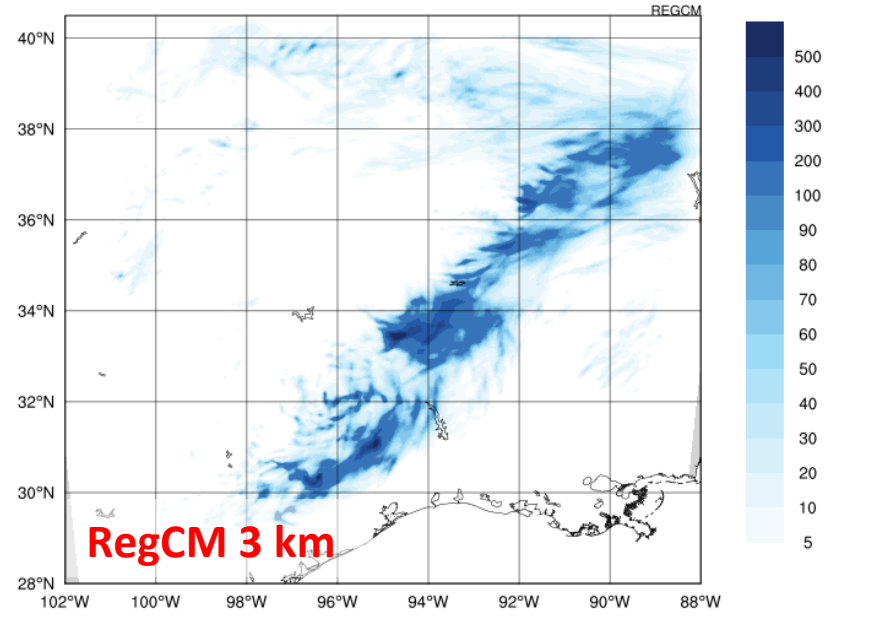


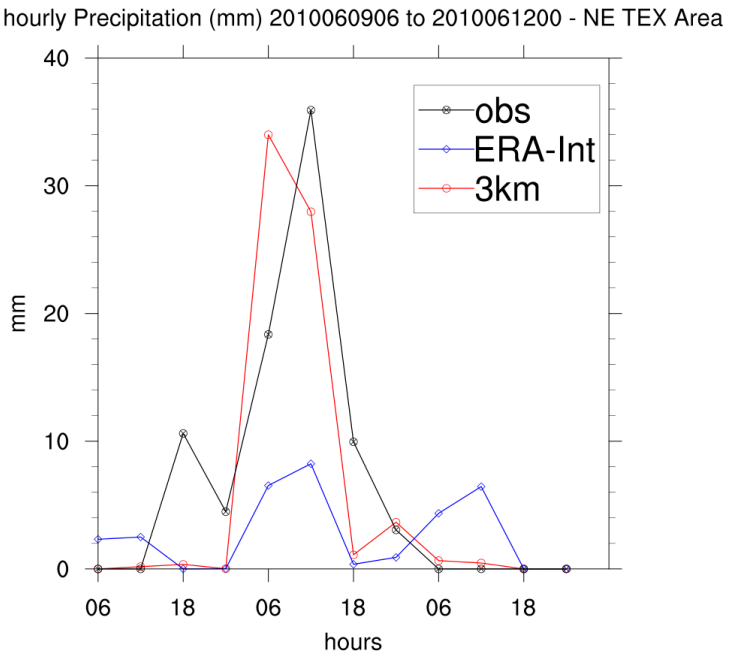


Northeastern Texas case : Comparison with RegCM Precipitation Accumulated in 72h (mm)





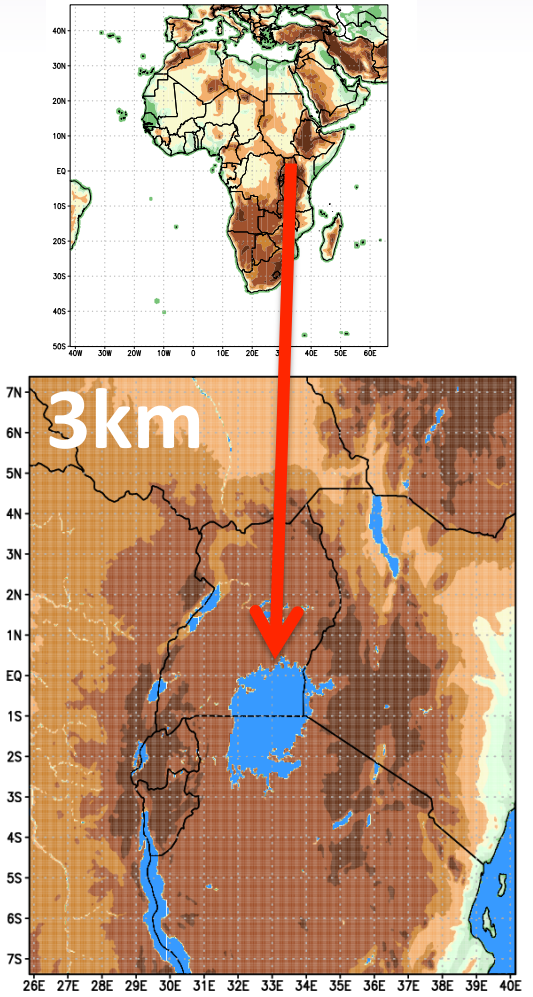




Lake Victoria case : 26 Nov-1 Dec 2009 (*SUN et. Al. 2009*)

CORDEX Flagship Pilot Study (FPS) “ELVIC – climate Extremes in the Lake VICtoria basin”

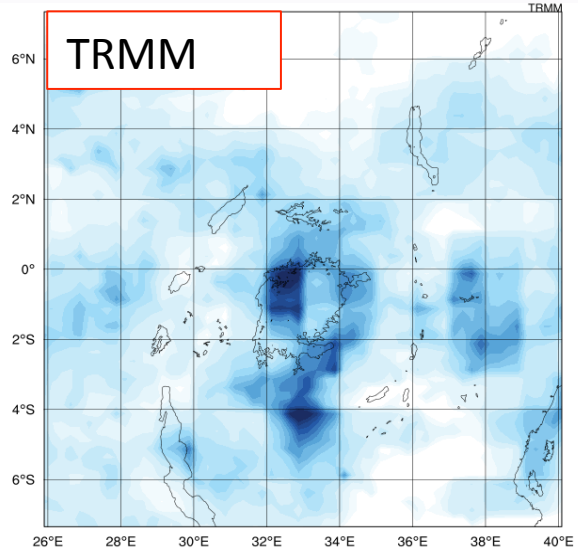
A severe storm above Lake Victoria. (Photo: Tomaz Kunst / Shutterstock)

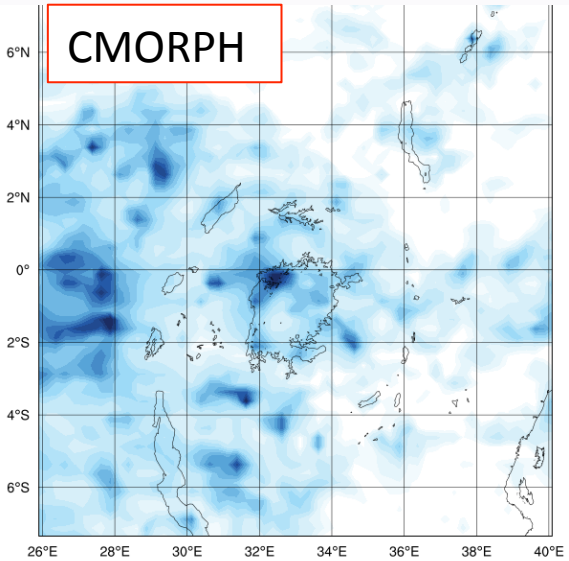


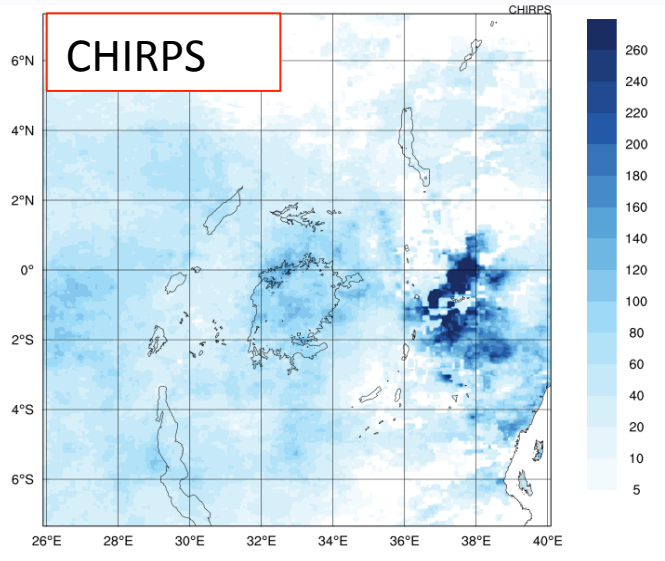
Lake Victoria can be so stormy at night because of the circulation (breezes) in the atmosphere above its enormous water surface; It is estimated that each year 3,000-5,000 fishermen perish on the lake due to nightly storms (Red Cross, 2014)

Lake Victoria case : Precipitation Accumulated in 144h (mm)

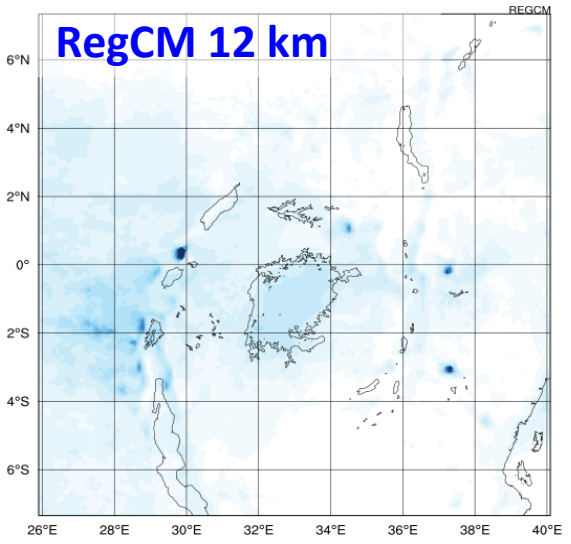
Comparison RegCM vs Measurements

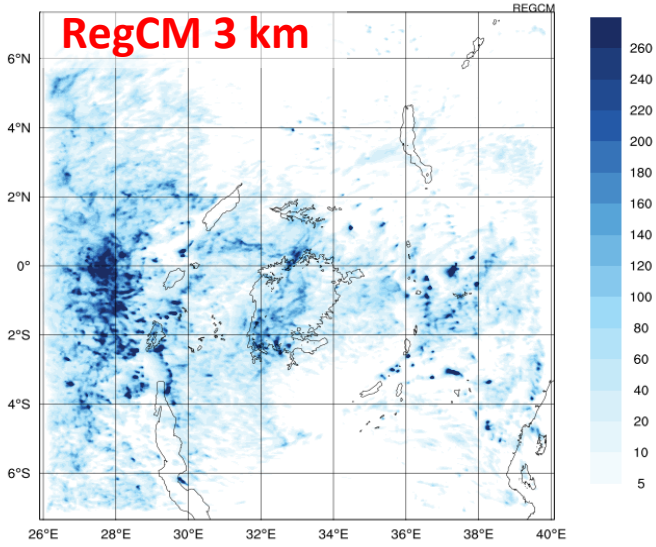




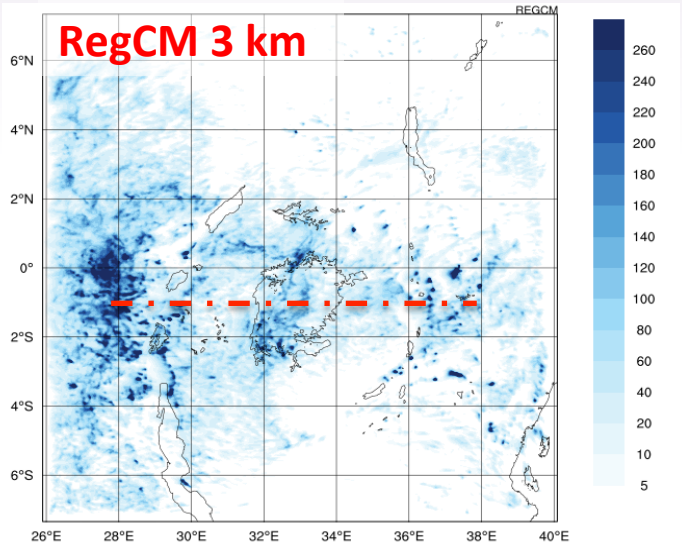


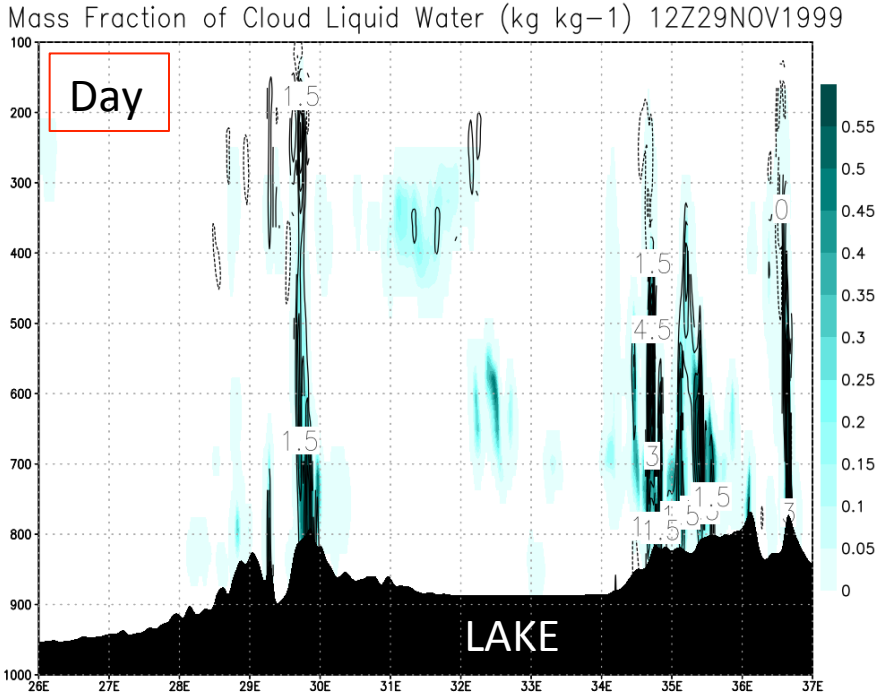
RegCM

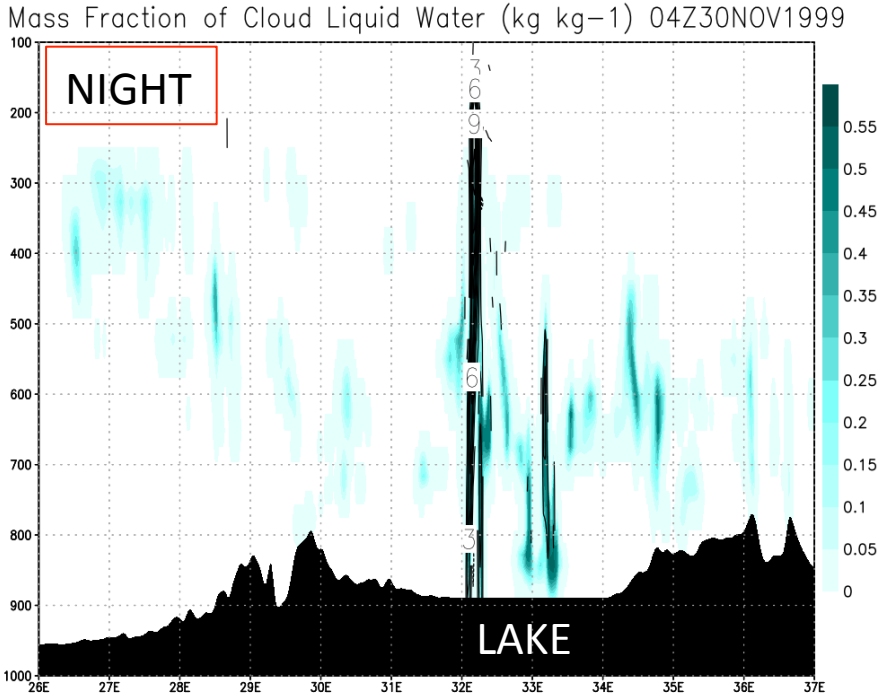




Converging breezes (Lake Breeze circulation)

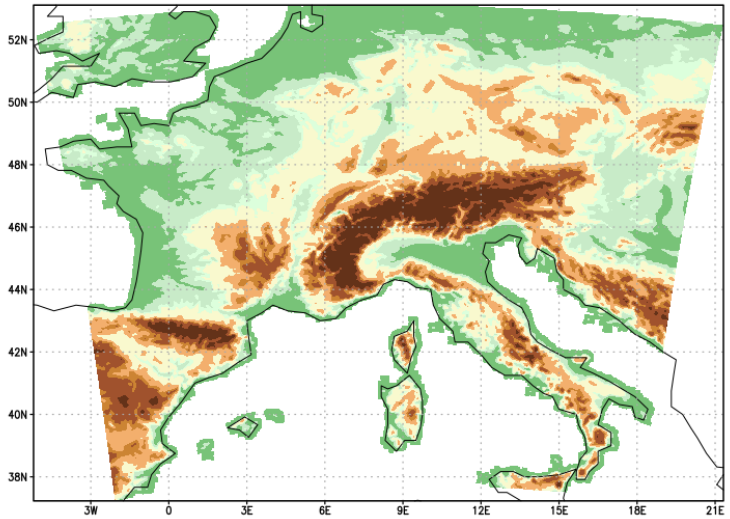




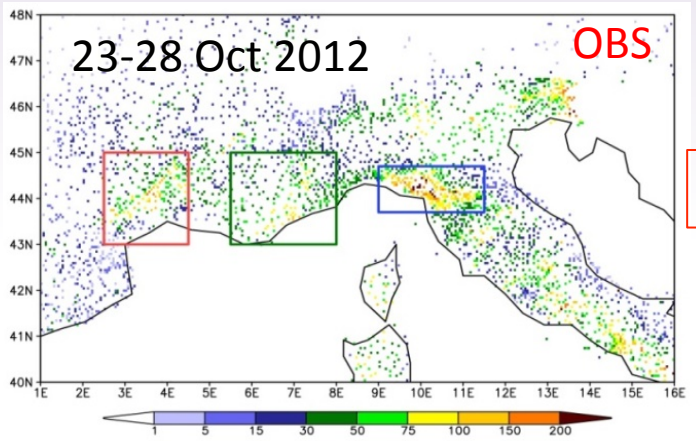


EUROPEAN CASES :

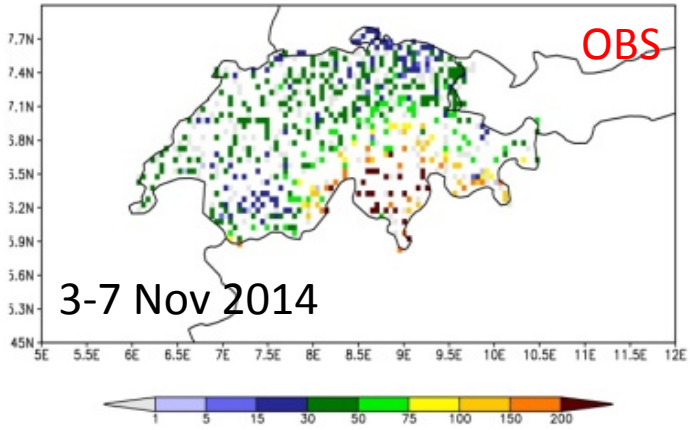
3km



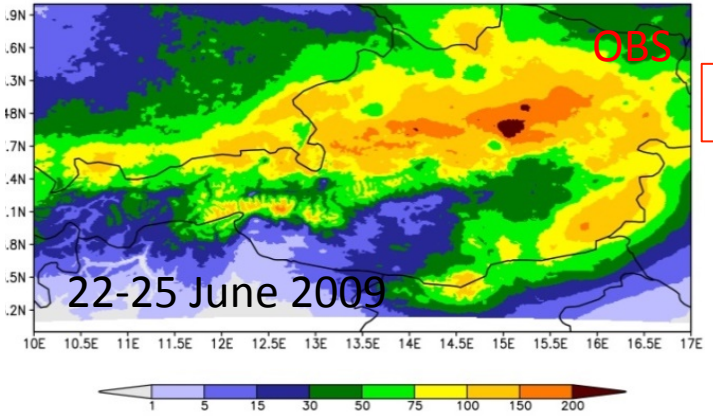
EURO-CORDEX FPS-CP
(Thursday, SEPT. 6TH, by Stefan Soboloski)



IOP16



FOEHN

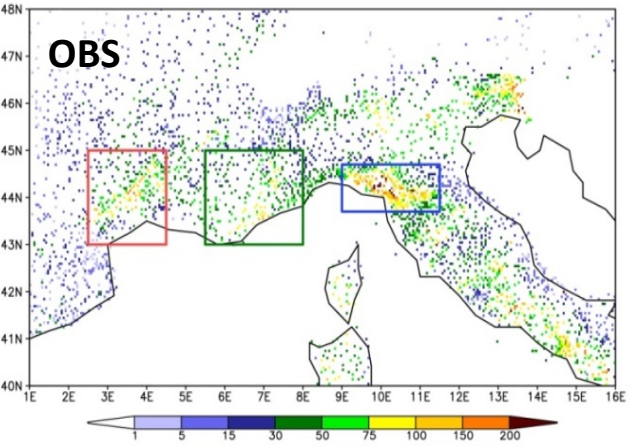


AUSTRIA

European cases : Precipitation Accumulated over the period (mm)

Comparison RegCM vs Measurements

IOP16



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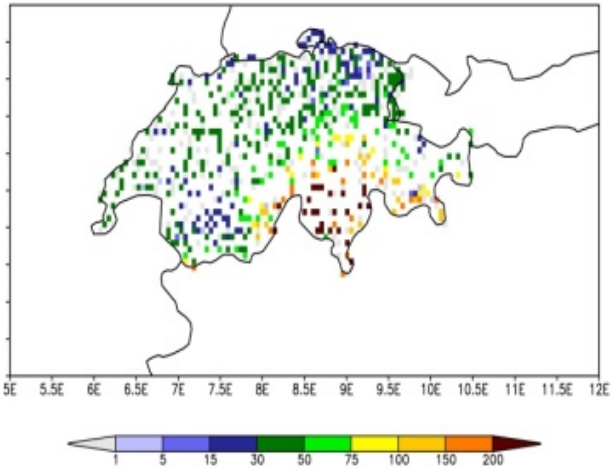
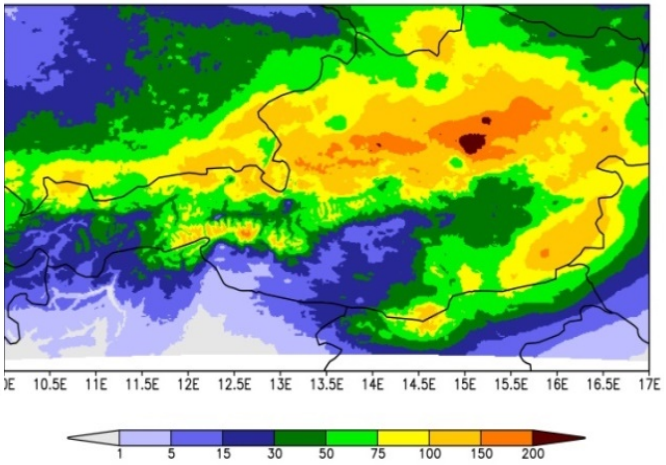
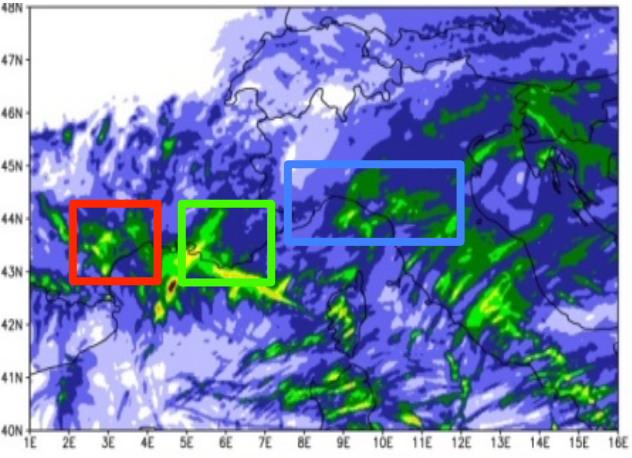
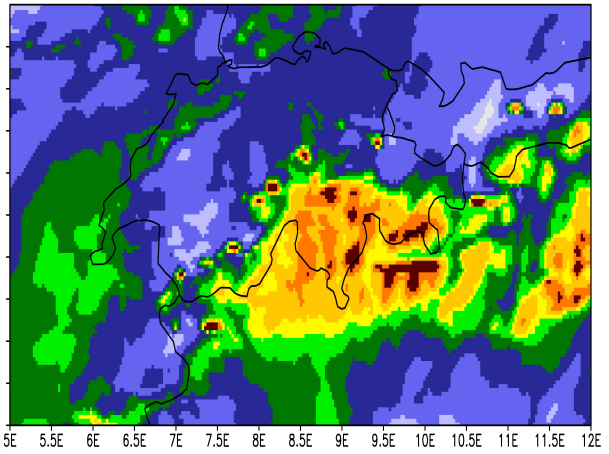


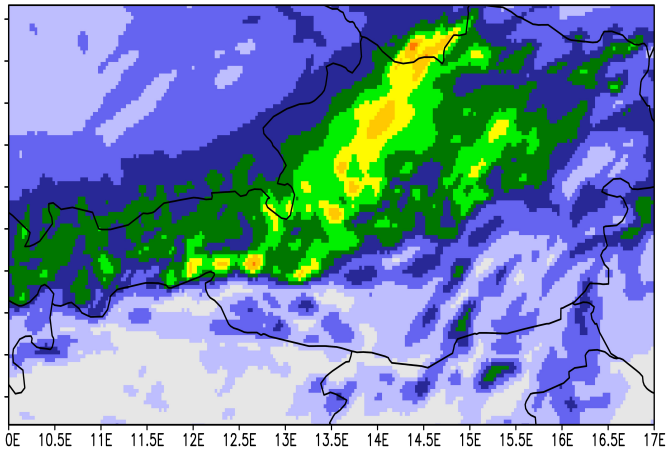
AUSTRIA



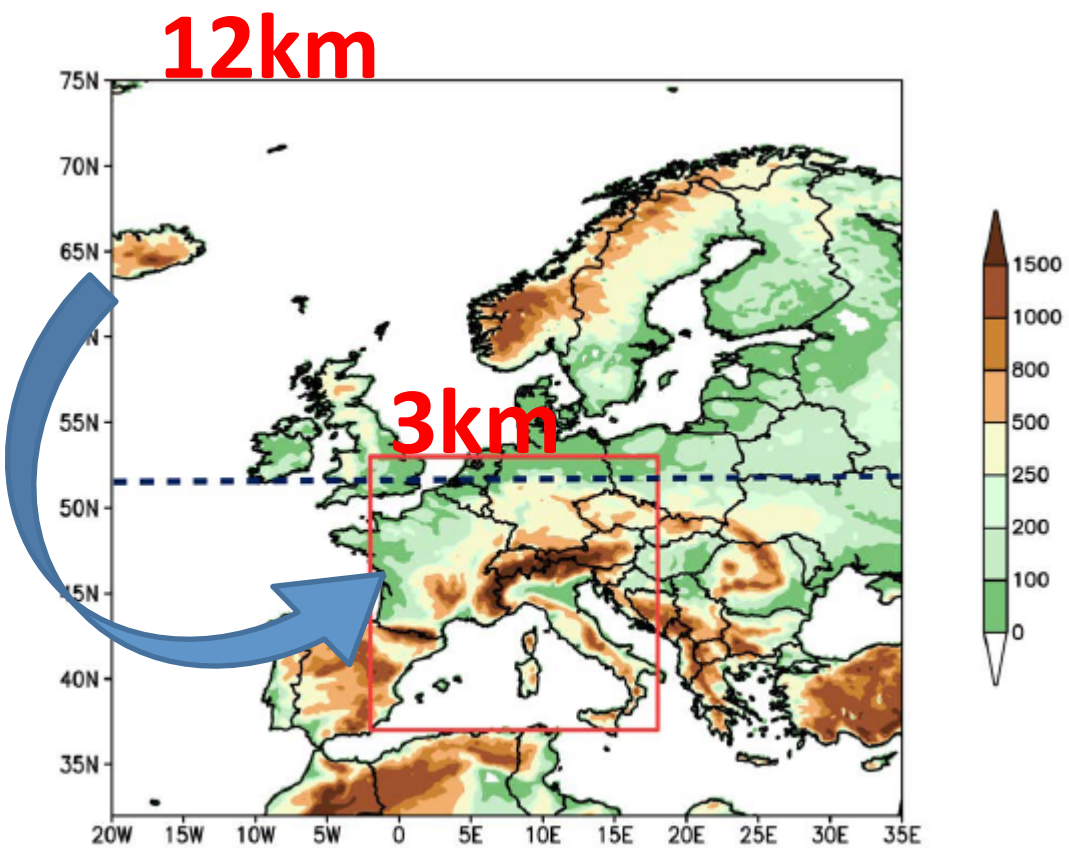
RegCM 3km







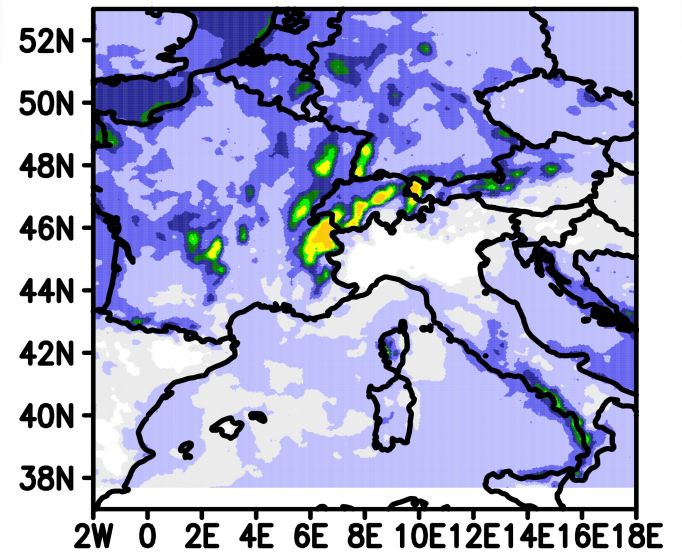
Long term CP simulation: 1999-2000



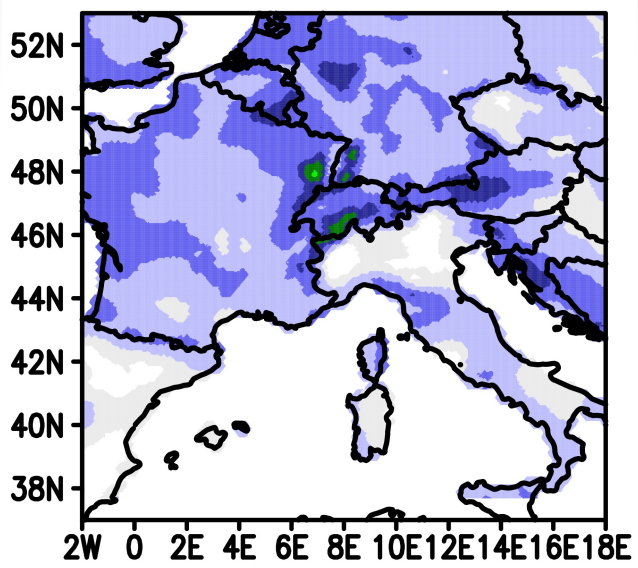
RegCM	
12 Km	3 Km
Hydrostatic core	Non-hydro.
23 v-levels	41 v-levels
ERA-Int IC-BC	12KM IC-BC
530x530	575x605

European Domain: Seasonal mean precipitation (DJF) (2000)

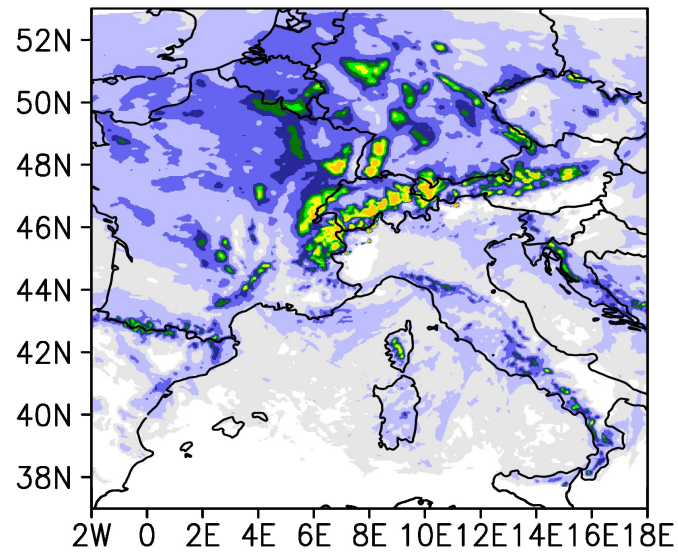
RegCM 12 km (mm/day)



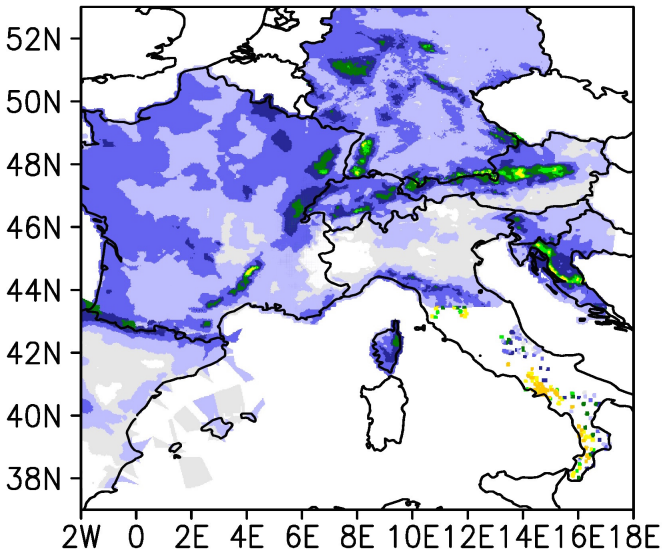
OBS : E OBS (mm/day)

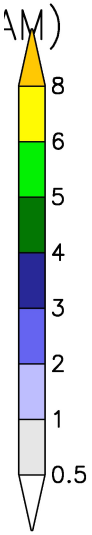


RegCM 3 km (mm/day)



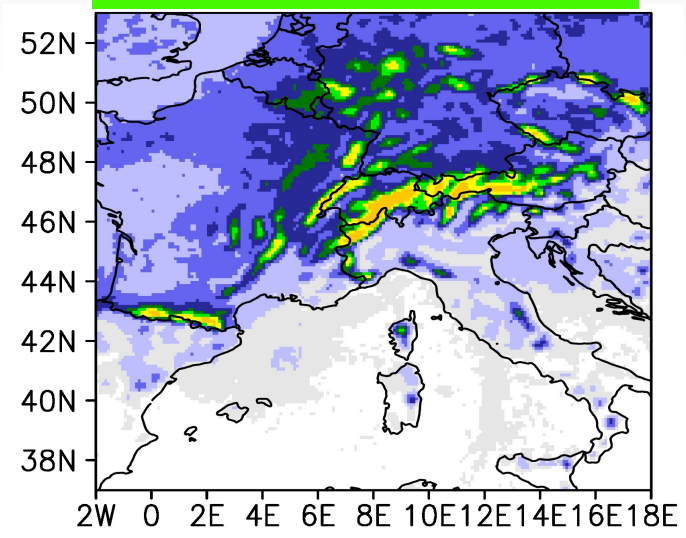
OBS : High res. (mm/day)



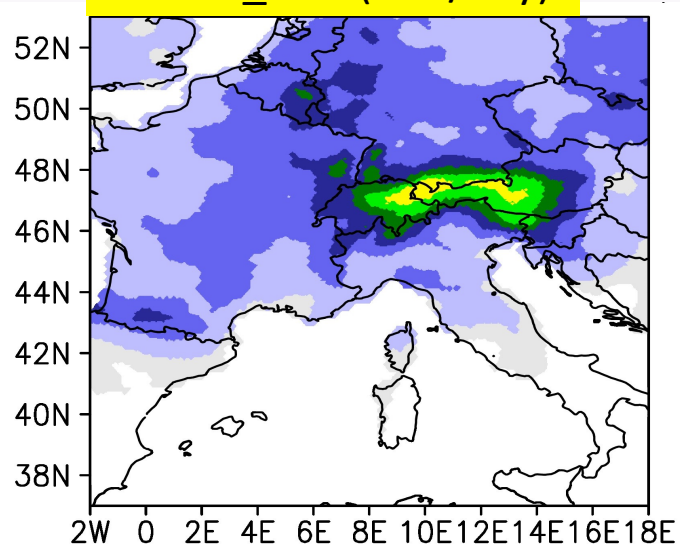


European Domain: Seasonal mean precipitation (JJA) (2000)

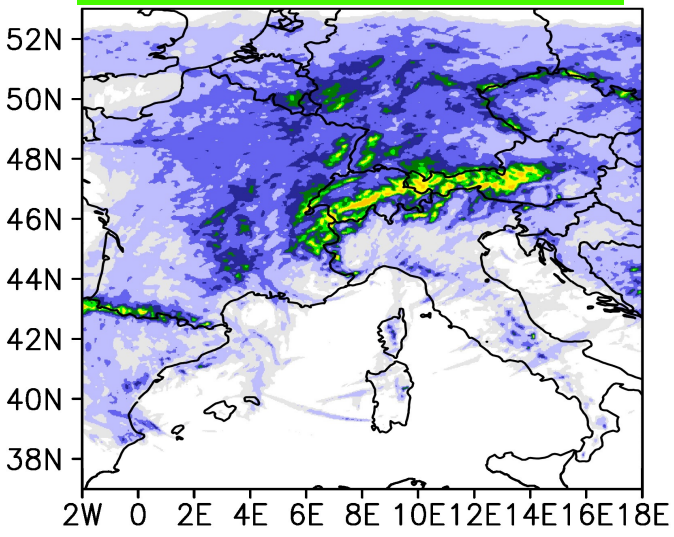
RegCM 12 km (mm/day)



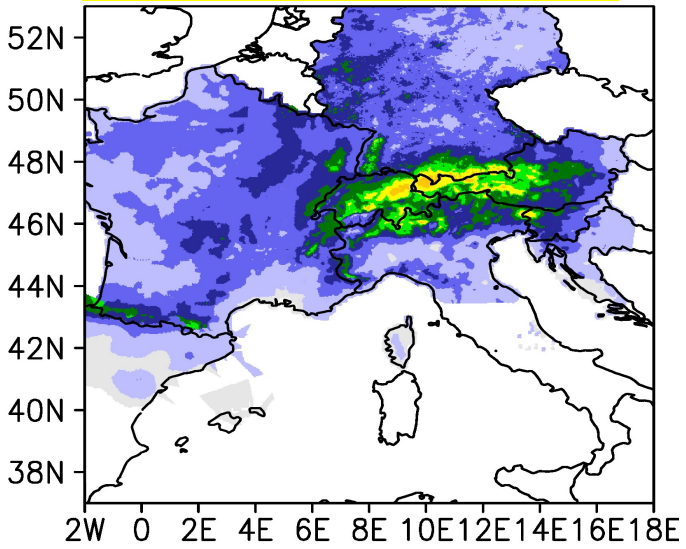
OBS : E_OBS (mm/day)

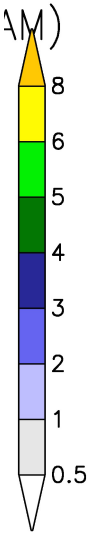


RegCM 3 km (mm/day)



OBS : High res. (mm/day)





Summary

Different type of heavy precipitation events simulated with the RegCM model at Convection-Permitting Scale (CPS) using a grid spacing of 3 km, were compared with in-situ and satellite-based observation.

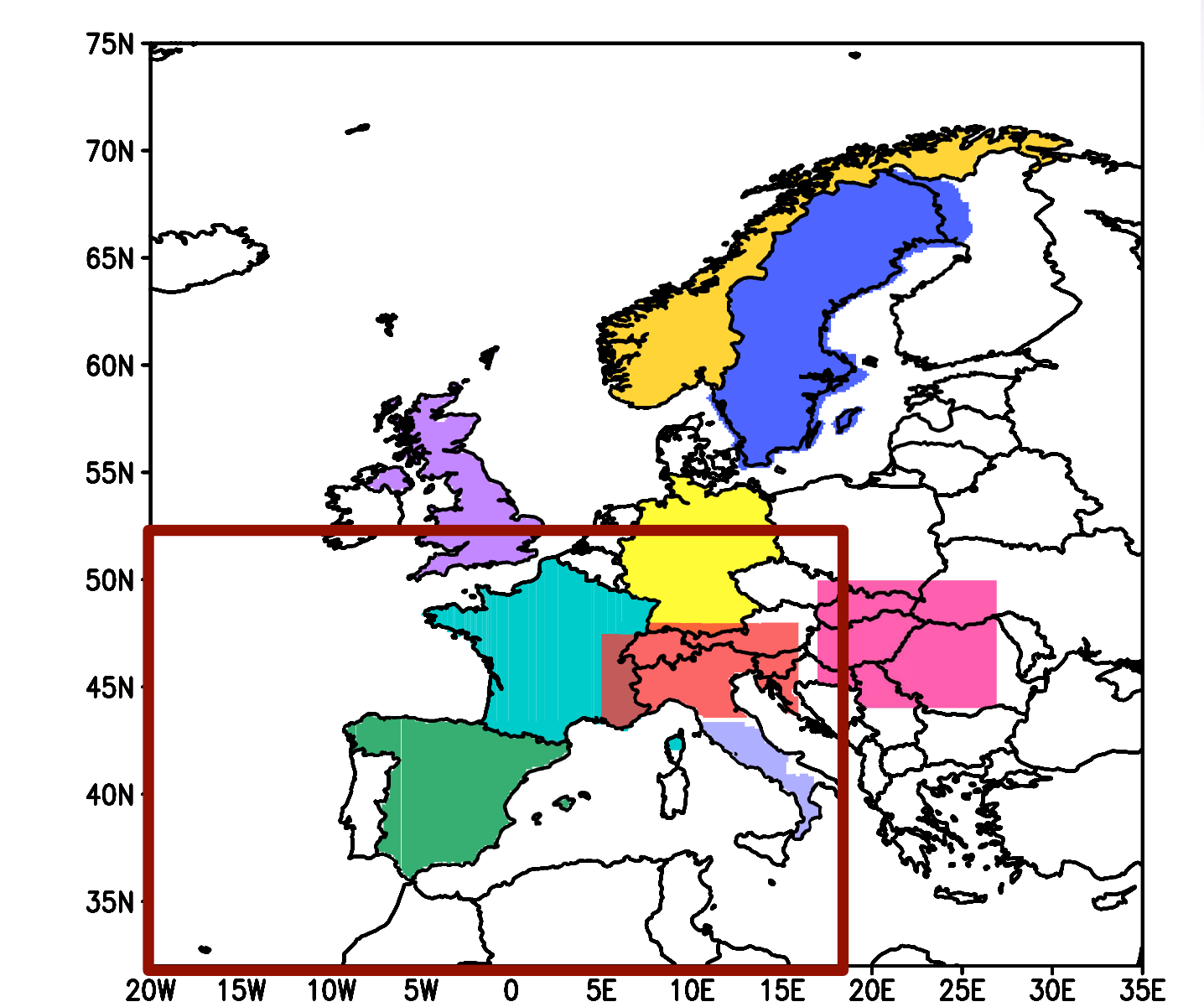
The goal of this work was to evaluate the performances of the “state of the art” regional convection-permitting climate model in different regions of the world (Europe, South America, North America and Africa)

Preliminary results of this analysis highlight that the model is able to represent the precipitation events in terms of intensity and spatial distribution at hourly resolution although the model performance can variate according to the nature of the event (*driven by complex mesoscale interactions or for example by large scale forcing*)

Observation uncertainty plays a big role at such high resolutions and highlights the need of adequate observational network essential for model validation.

THANK YOU FOR YOUR ATTENTION

Availiable regional observation datasets at high resolution



Availiable regional observation datasets at high resolution

Dataset	Institution	Region	Period	Resolution	Approximate maximum number of stations per 1000km^2	Reference
EURO4M-APGD	MeteoSwiss	Alps	1971-2008	5km	18	Isotta et al. (2013)
Spain02	Santander Meteorology Group	Spain	1971-2010	0.11 degrees	6	Herrera et al. (2010)
SAFRAN	Meteo-France	France	1958-2013	8km	7	Vidal et al. (2010)
UK gridded dataset	Met Office	United Kingdom	1990-2010	0.11 degrees	20	Perry et al. (2009)
KLIMAGRID	METNO	Norway	**1957-2013**	1km	5	Mohr (2009)
PTHBV	SMHI	Sweden and part of Finland	**1961-2010**	**4km**	4	Johansson (2002)
CARPATCLIM	Hungarian Meteorological Service	Carpathians	1961-2010	0.10 degrees	2	Szalai et al. (2013)
REGNIE	DWD	Germany	1961-2009	1km	11	Rauthe et al. (2013)
CETEMPS gridded dataset	CETEMPS, University of L'Aquila	Italy	**2000-2014**	**0.11 degrees**	8	

- All datasets are station-based except for France, which is a high resolution regional reanalysis. It should also be noted that the datasets are characterized by different station densities (and thus effective resolutions)

- the Italian dataset were gridded onto the 0.11° grid from about 1500 stations via the distance weighted approach using all stations lying within the surrounding grid boxes. Data were not available for the Marche and Puglia regions and thus gridding was not carried out there.

knowledge acquired up to now

Studies to date show that convection-permitting models do not necessarily better represent **daily mean precipitation** [*e.g., Chan et al. 2013, Berthou et al., 2018*] but have significantly better sub-daily rainfall characteristics with improved representation of the:

- **Diurnal cycle** of the amount, intensity and frequency of precipitation (*Ban et al. 2014, Kenond et al. 2012, Langhans et al. 2013, Prein et al., 2013, Fosser et al., 2014, Berthou et al., 2018*)

- **The spatial structure** of rainfall and its **duration-intensity** characteristics (*Kendon et al, 2012, Berthou et al., 2018*)

- **Intensity of hourly preciptiation extremes** (*Chan et al. 2014 Ban et.al 2014 Fosser et al. 2015*)

- **Orographic precipitation** (*Liu et al 2016*)