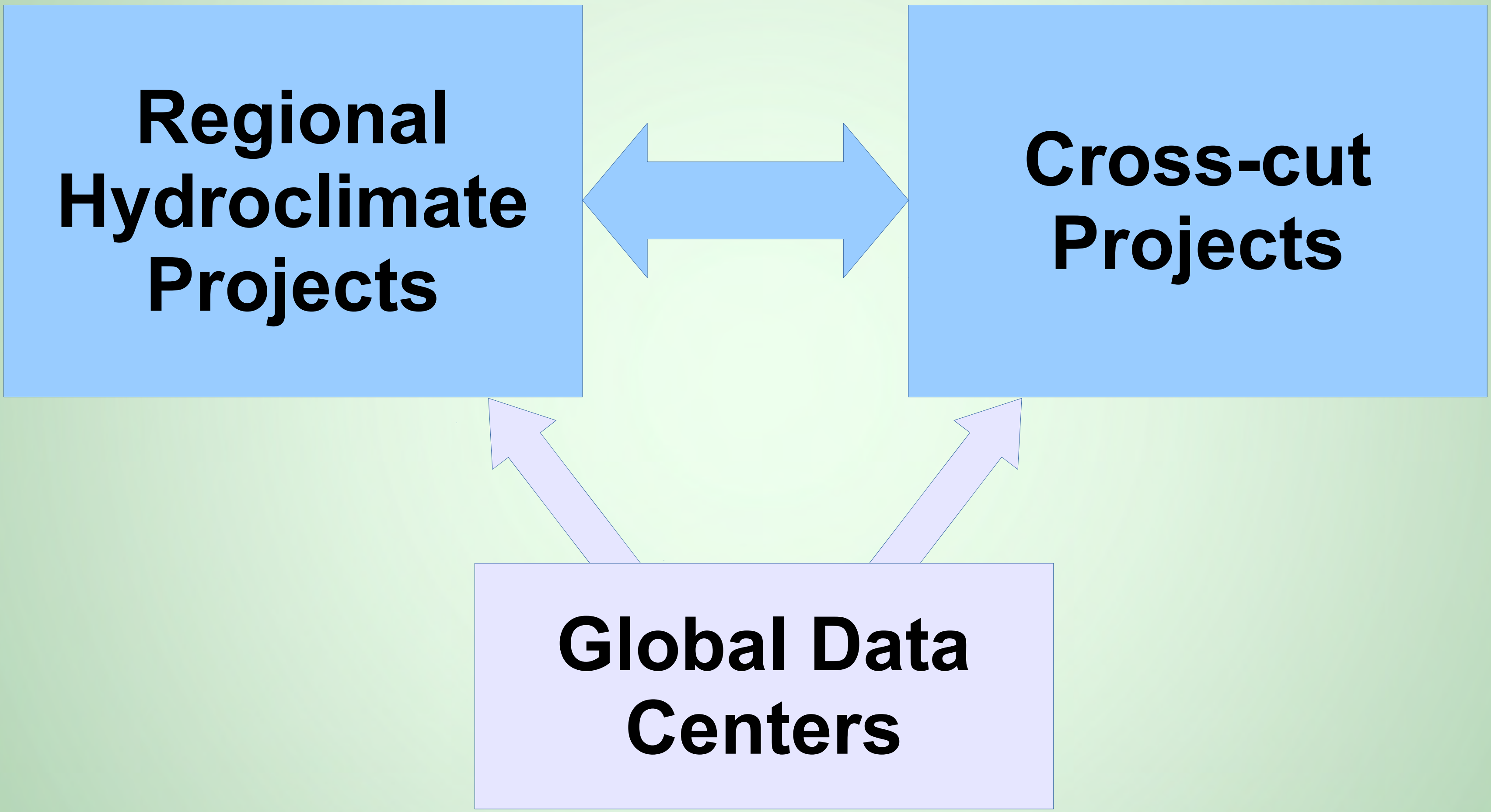
GEWEX Hydroclimate Panel – GHP
&
The GEWEX Science questions

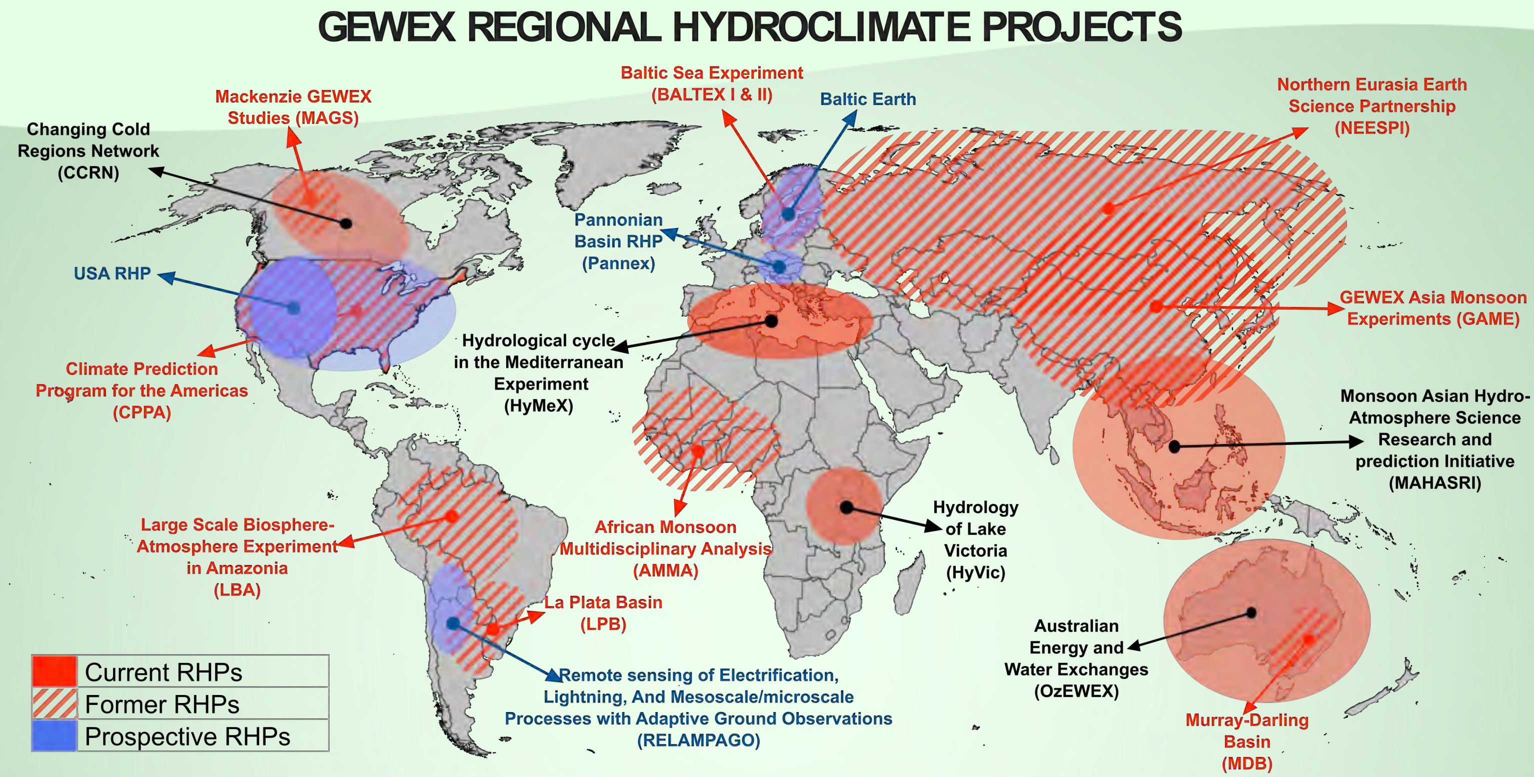
Co-Chairs: Jan Polcher
Jason Evans

- Status of the panel's activities
- The GEWEX Science questions
- Evolution of the panel
- Regional activities within WCRP

GHP Structure



Status of RHPs



Recently closed :

- NEESSPI (Pavel Groisman)

Currently active :

- CCRN (Howard Wheater)
- MAHASRI (Jun Matsumoto)
  - Closing with a workshop in early March 2016
- HyMex (Philippe Drobinski)

Initiating RHPs

OzEWEX (Albert VanDijk):

- The panel did not receive the annual report because of technical problems.
- The web-pages are not updated regularly.
- The management structure needs to be reinforced.

HyVic (Fred Semanzzi):

- With the HyCHRISTAL project funded by DfID the RHP is launched
- The link with LIV-HyNEWS needs to be clarified, an issue to be discussed with WWRP
- HyVic now requires a strong management structure

Two prospective RHPs : BalticEarth and RELAMPAGO – No news yet.

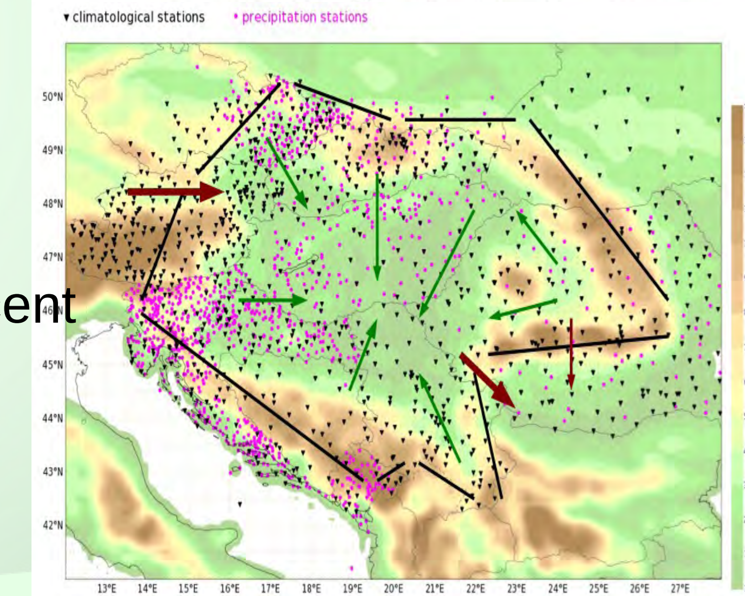
Pannex : a prospective RHP

1. Physical Motivation

- Practically a closed basin, with a large low central plain (100 m asl) surrounded by mountains with elevations nearing 2000 m asl, being a very good test area for many geophysical processes (natural or human-induced)
- The Pannonian basin is a transition area between mediterranean, atlantic and continental climates.

2. Opportunity

a) The area is fragmented in many different countries, sometimes with difficult communication amongst them.
b) Good research institutions and universities, some recent activities of networking, but no international visibility
c) Countries in good position to receive EU research funding.
d) Area between the HyMeX and Baltic Earth areas.
e) GEWEX may be a good mean to foster within-basin cooperation



GEWEX workshop on the climate of the Pannonian Basin

(Osijek, Croatia, 9-11 November 2015)

Conclusions:

- A preliminary agreement was reached and a Core Group formed.
- A first draft of a white book will be discussed in Budapest in June 2016. The countries of the area with no representation in the meeting will be invited to join the action (Ukraine, Austria, Bosnia, Montenegro and Slovenia).
- The aimed schedule is to present the action at the GHP meeting end 2016 and develop the full implementation plan during 2017 for consideration to GHP end 2017.
- Once the white book exists, special attention will be put on funding opportunities, even if they appear before the official status of RHP for PannEx.

The Flagship questions for Pannex

1) Adaptation of agronomic activities to weather and climate extremes
2) Understanding of air quality under different weather and climate conditions
3) Water management, droughts and floods
4) Toward a sustainable development
5) Education, knowledge transfer and outreach

International Planning Committee Nominated

Some participants agreed to become actively involved in the organization of the next steps towards an RHP for the Pannonian Basin:

Branka Ivancan-Picek
Head of the Research and Development, Meteorological and Hydrological Service of Croatia, Zagreb

Monika Lakatos
Climate Scientist at OMSZ Meteorological Service at Budapest, Hungary

Adina Croitoru
Associate Professor, Physical and Technical Geography Department, University of Cluj-Napoca, Romania

Danijel Jug
Professor of Agrometeorology at University of Osijek, Croatia

Vladimir Djurdjevic
Professor of Meteorology at University of Belgrade, Serbia

Tamás Weidinger
Professor of Meteorology at Eötvös Loránd University, Hungary

Ivan Guettler
Researcher at the Meteorological and Hydrological Service of Croatia, Zagreb

Status of Cross-cut projects

Currently active

● INTENSE (Sub-daily precipitation) (H. Fowler)

- The CC is supported by an ERC in Newcastle University
- Interactions with RHPs are under-way
- Collaboration with global data centre needs to be encouraged.

● Cold/Shoulder Season Precipitation Near 0°C, (R. Stewart/P. Groisman)

- The panel proposes that it be renamed

● INARCH (Mountain Hydrology) (J. Pomeroy)

- A workshop was held in 2015
- A special issue of earth system science data in preparation
- Contacts with HyMex and Pannex are planned for the Alps.
- Another workshop is planned in 2016

Proposed CCs

Proposed

- MOUNTerrain (Mountainous Terrain rainfall) (J. Renwick)
  - Session at the AGU fall meeting (2015)
  - Collaboration with INARCH
- Including water management in large scale models (R. Harding/J. Polcher)
  - Proposed to be jointly with GLASS
  - The rational is explained in a GEWEX News article
  - Workshop to held from 28 Sept. 2016 to 30 Sep, Gif-sur-Yvette
  - The workshop should produce tangible objectives

Potential

- Seasonal hydrological prediction (A. Wood/HEPEX)
- GDAP integrated product regional evaluation

Working on the GEWEX Science Questions

1) Observations and Predictions of Precipitation: How can we better understand and predict precipitation variability and changes?

2) Global Water Resource Systems: How do changes in land surface and hydrology influence past and future changes in water availability and security?

3) Changes in Extremes: How does a warming world affect climate extremes, esp. droughts, floods, and heat waves, and how do land area processes, in particular, contribute?

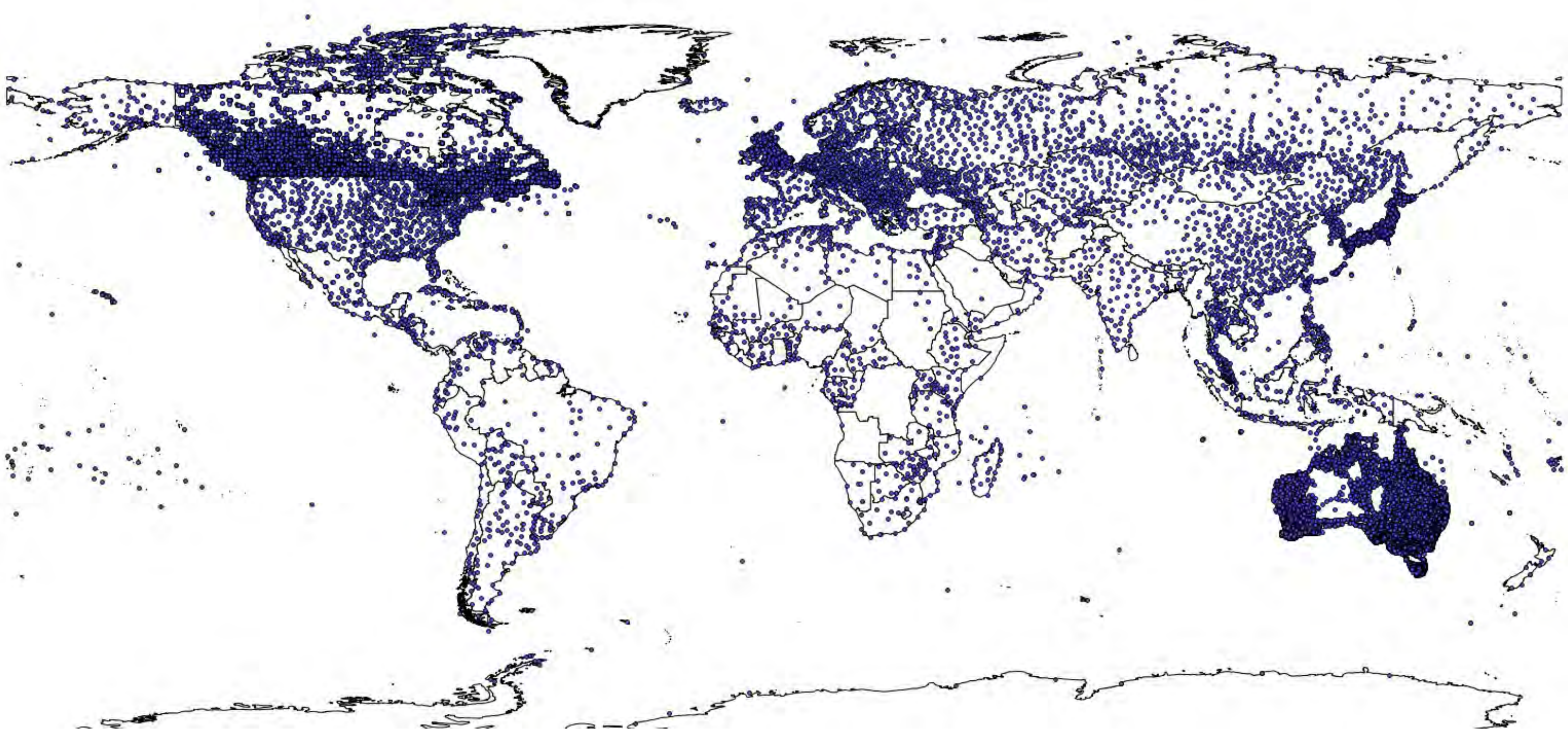
4) Water and Energy Cycles and Processes: How can understanding of the effects and uncertainties of water and energy exchanges in the current and changing climate be improved and conveyed?

Observations and Predictions of Precipitation

Examples from :

- INTENSE
- INARCH and MONTerrain
- CCRN
- MAHASRI
- HyMex

Main achievements: database



- Developed standard request letter and identified routes through to correct data provider for many locations with Lisa Alexander.
- Sub-daily precipitation data has been collected for: USA, Australia, Canada, Japan, Malaysia, UK, Netherlands, Singapore, HadISD (UK Met Office sub-daily dataset comprising precipitation and other variables).
- We are in the process of receiving data from Norway, Portugal, The Philippines and New Zealand. Contacts have been obtained for further countries and are being pursued.

Main achievements: quality control

Site specific tests

For example:

•rain gauge metadata,

•implausible large values (1h & 24h tested)

•“frequent tipping”

•long dry periods due to gauge malfunction

•accumulated totals (often at 9am)

•repeated values

•comparison with 24h gridded data

Nearby gauge comparisons

Statistical test of consistency with nearby gauges but problematical for extremes in summer/autumn therefore only partially applied

Multiple QC flags applied to each hour for each test

Automated rule base to define exclusions

For example:

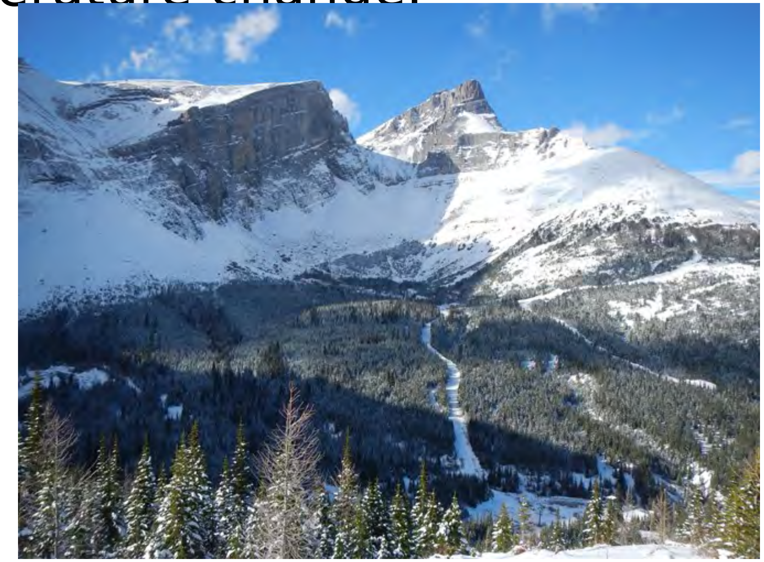
•all implausible hourly totals

•“large” hourly totals if in winter at 9am after ≥23 dry hours

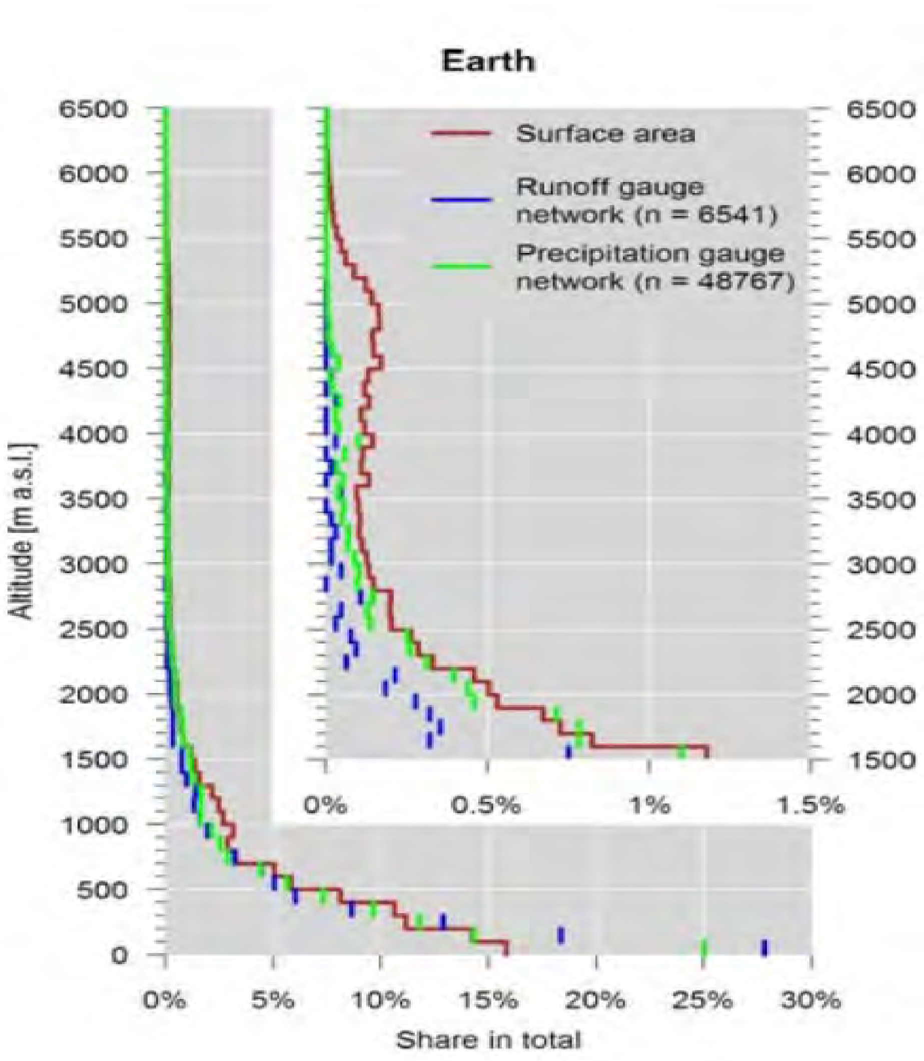
•“large” hourly totals if after gauge non-operation (long dry spell)

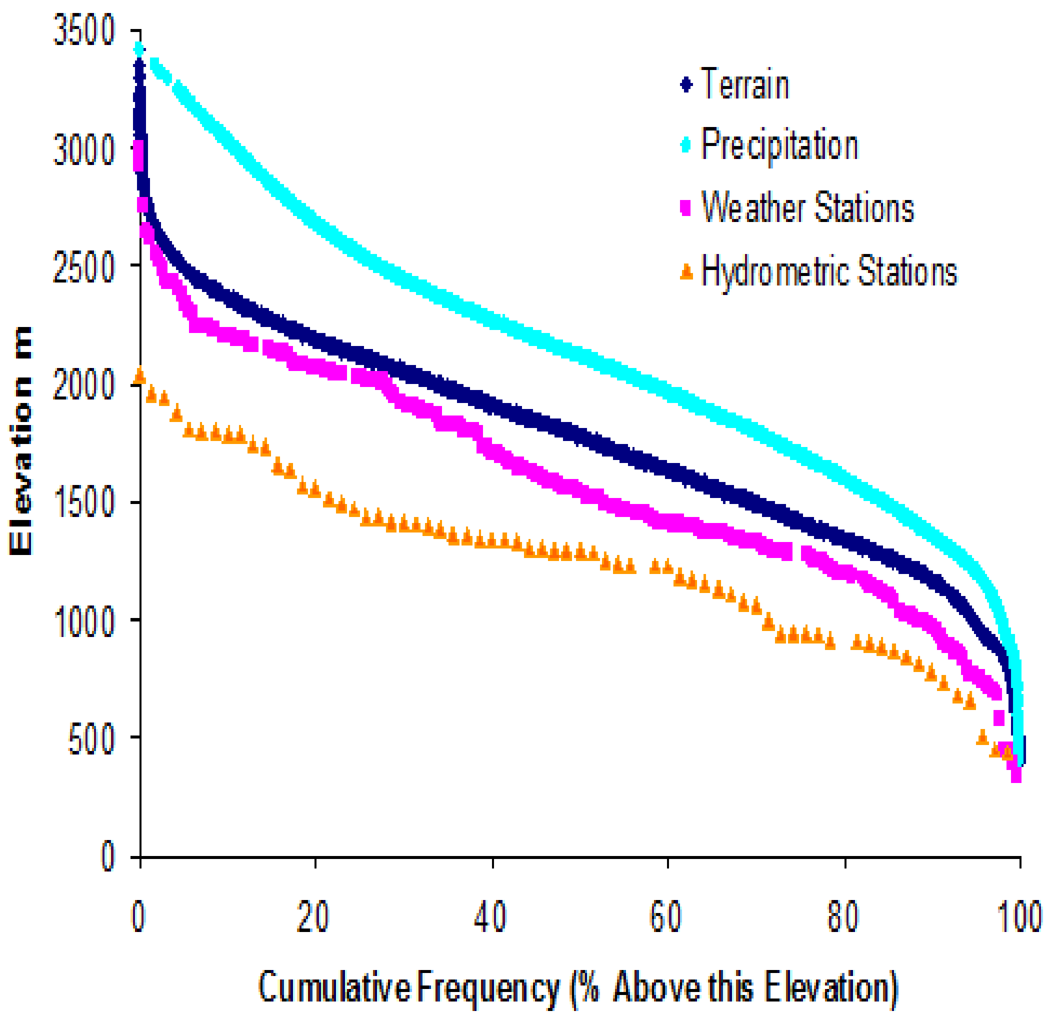
Urgency for monitoring mountainous areas

- to IPCC (2014) WG II report – "***In many regions, changing precipitation or melting snow and ice are altering hydrological systems, affecting water resources in terms of quantity and quality"***
- Alpine catchments receive and produce a disproportionately large fraction of global precipitation and runoff.
- Snowfall *does not equal accumulation on the ground!*
- Snow, ice, and phase change domination of alpine hydrology means that it is especially sensitive to temperature change.



Alpine Regions are Data Scarce

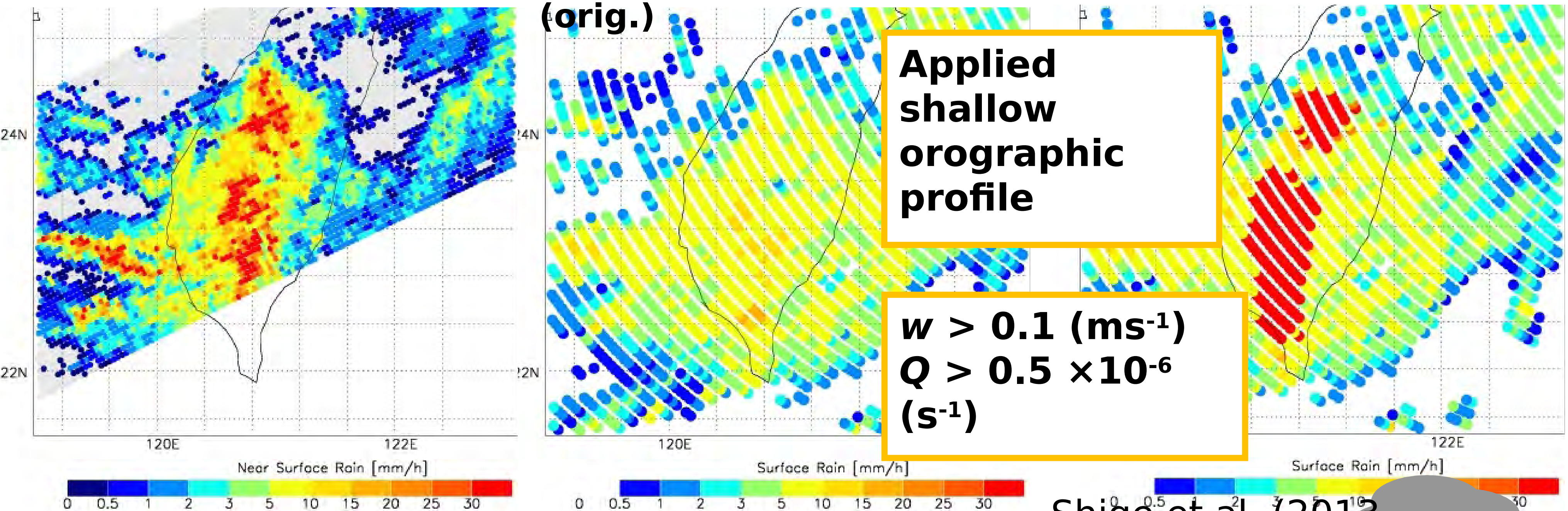




Left Side: (Viviroli et al. 2011).
Right Side: (Pomeroy, Sinclair – in preparation).

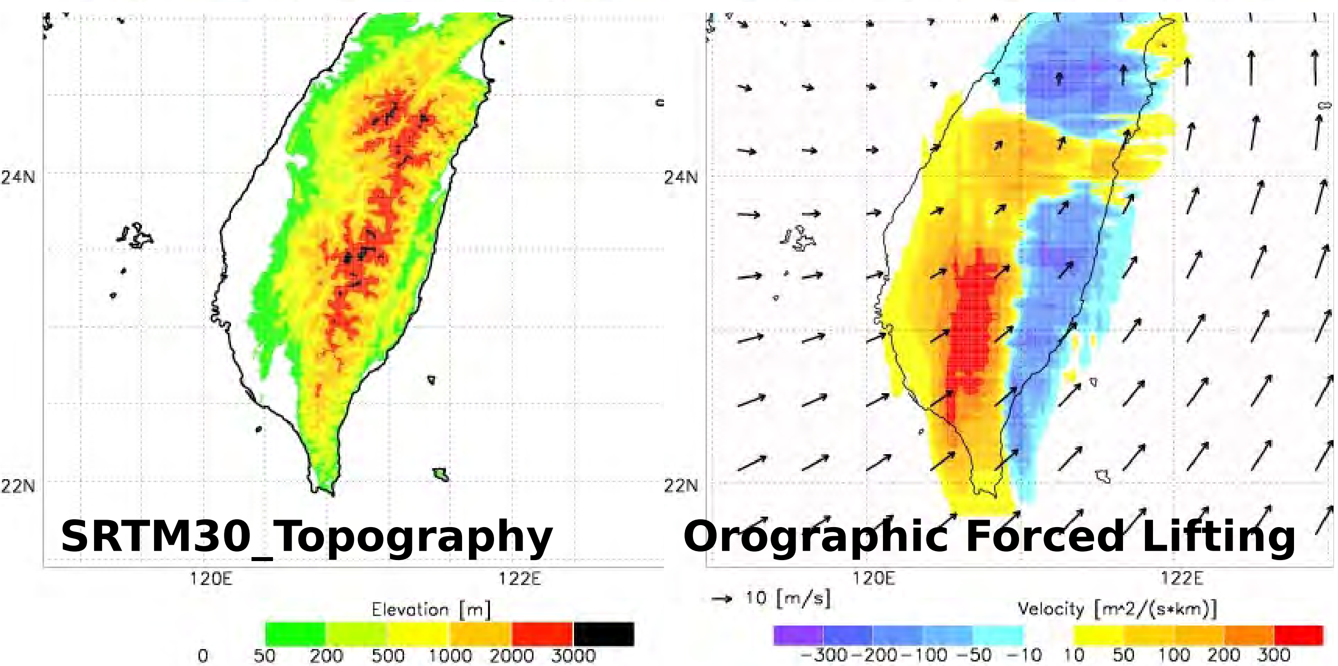
Typhoon Morakot (2009) over Taiwan
(Taniguchi et al. 2013, JHM)

PR _ Near Surface Rain | **GSMaP_TMI_Surface Rain (orig.)** | **GSMaP_TMI _Surface Rain**



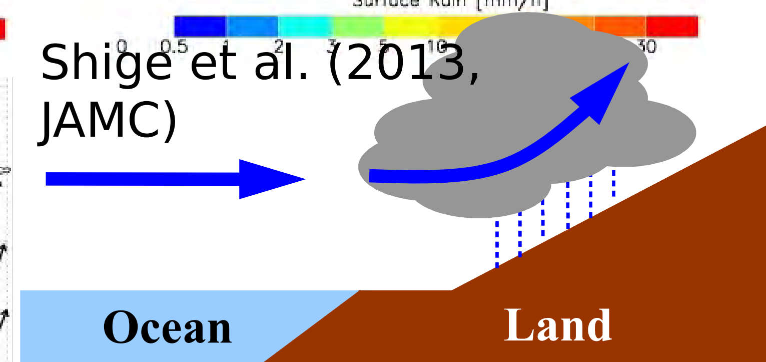
Applied shallow orographic profile

w **> 0.1 (ms^{-1})**
Q **> 0.5 ×10^{-6} (s^{-1})**



SRTM30_Topography | **Orographic Forced Lifting**

Shige et al. (2013, JAMC)



The revised scheme has been incorporated into the GSMaP V6 (Yamamoto and Shige 2015, AR).

Analysis of Calgary flood Weather Research and Forecasting (WRF) model analysis (Yanping Li)

Data Uncertainties

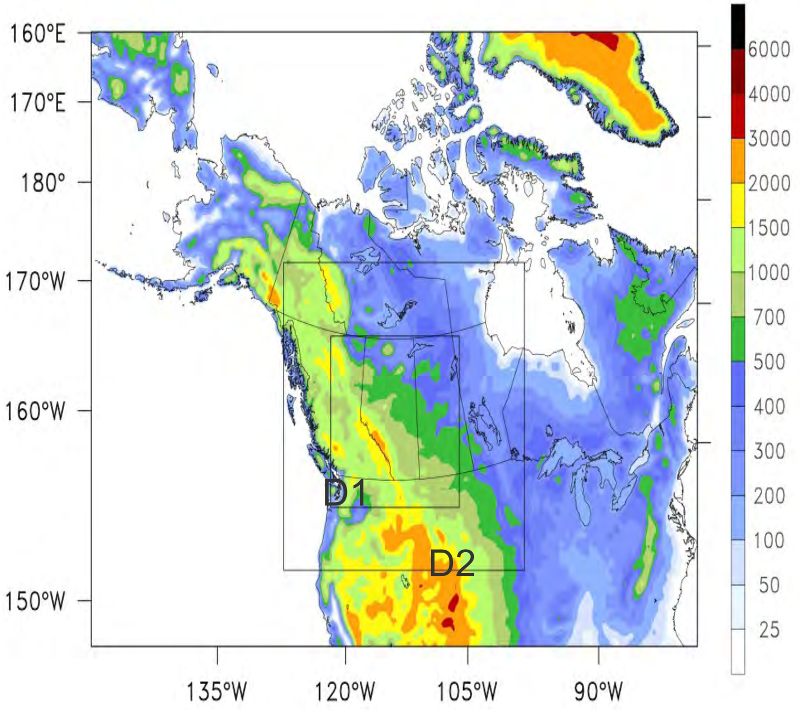
- Initial & Boundary Condition

  NCEP 6 hour reanalysis .

Model Uncertainties:

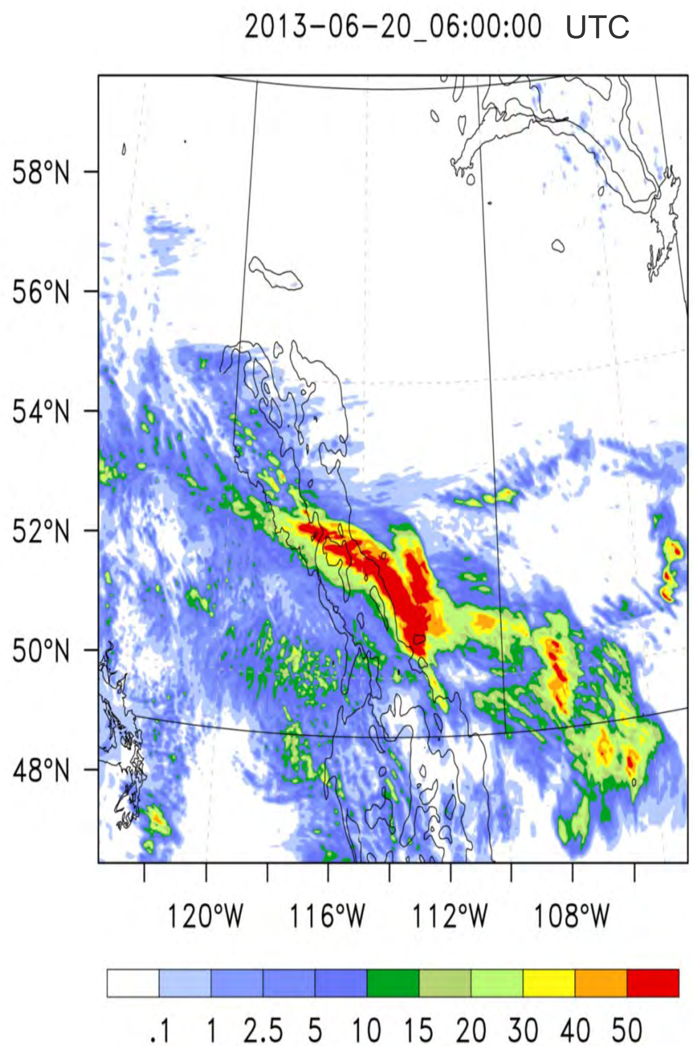
- Resolution

  D1: 3km, D2: 27km
- Dynamics
- Physical parameterization

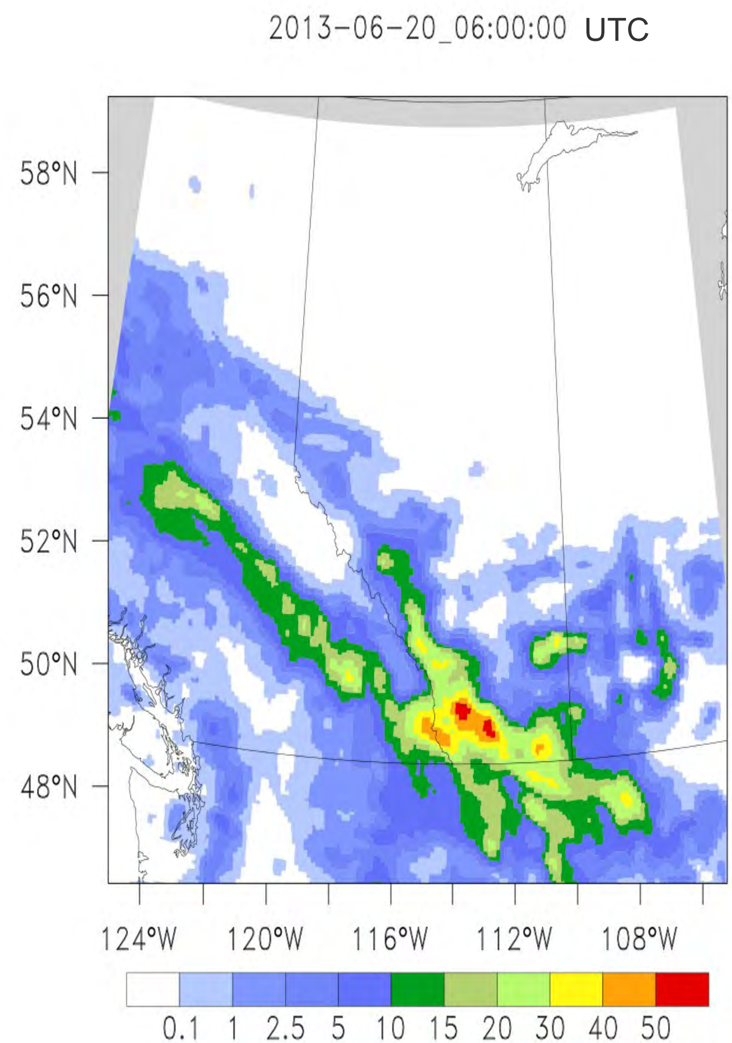


WRF simulation vs CaPA

WRF



CaPA



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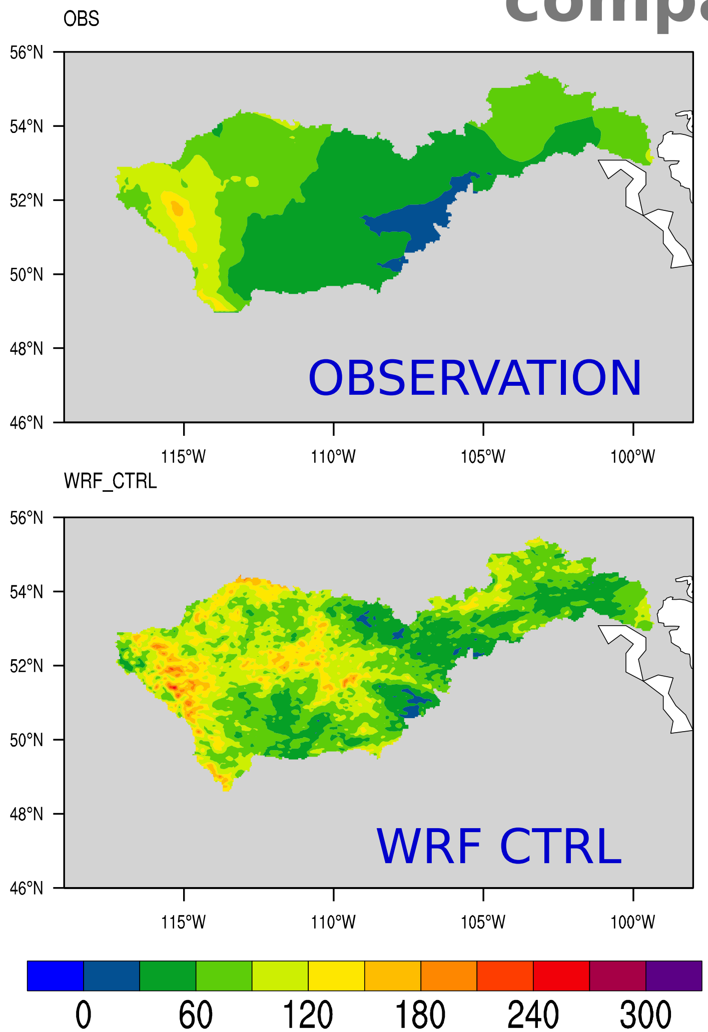
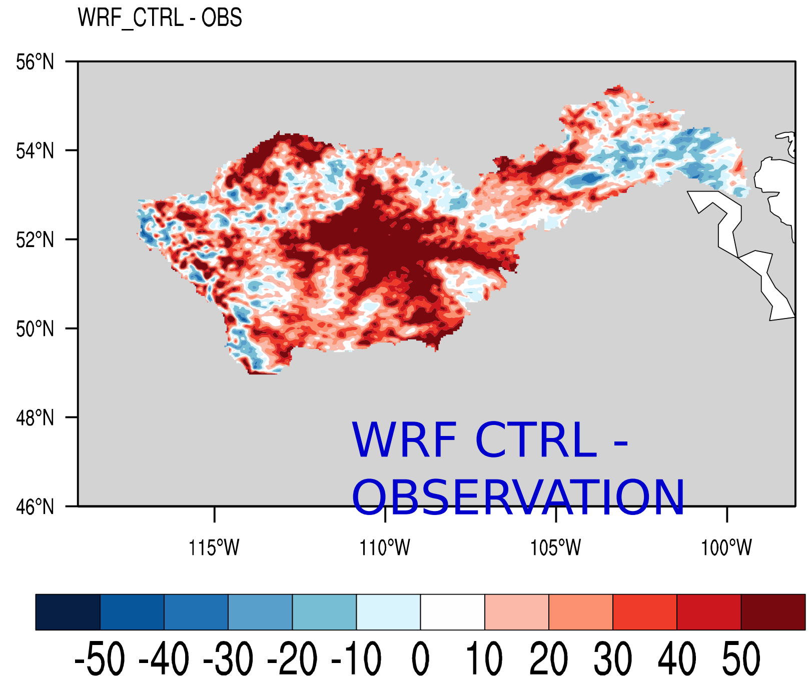
4km WRF-CTRL vs OBSERVATION comparison





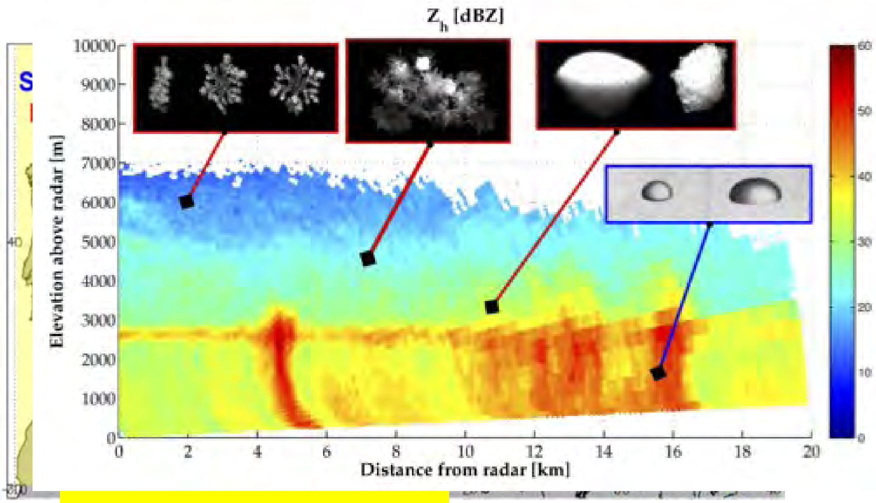
SRB (Precipitation June 2001)

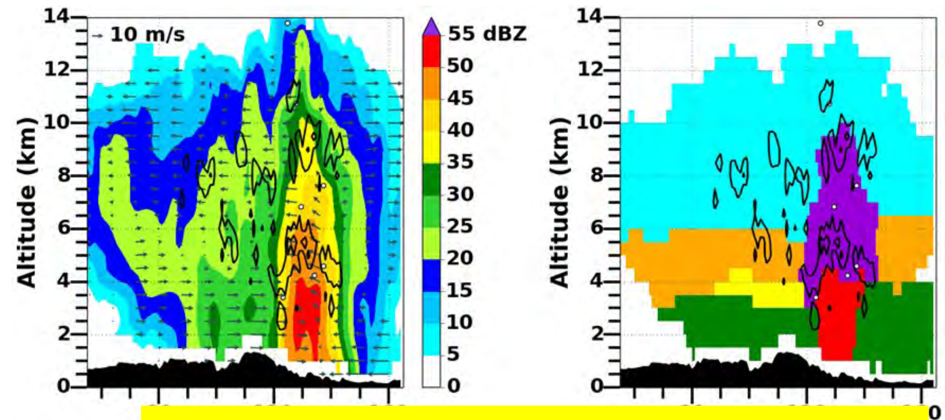
Results

Main advances in documenting HPE

An unprecedented cross-analysis of measurements from various platforms

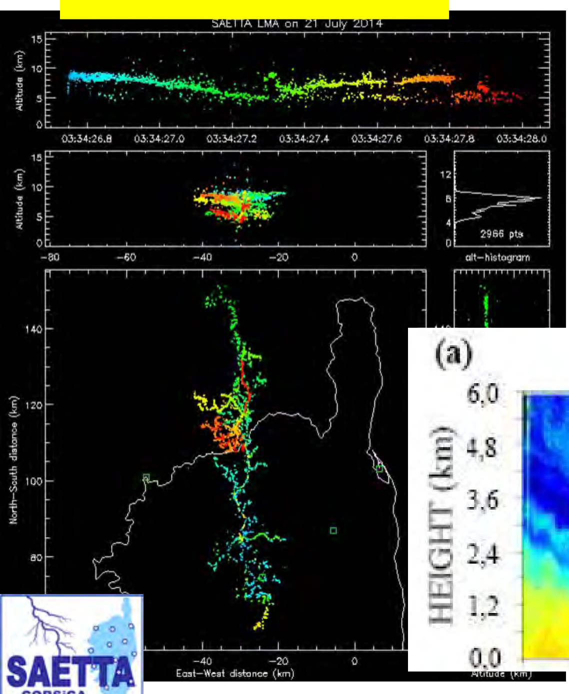
Defer et al., 2015, Bousquet et al. 2015 , Ribaud et al. 2015, Grazioli et al. 2015

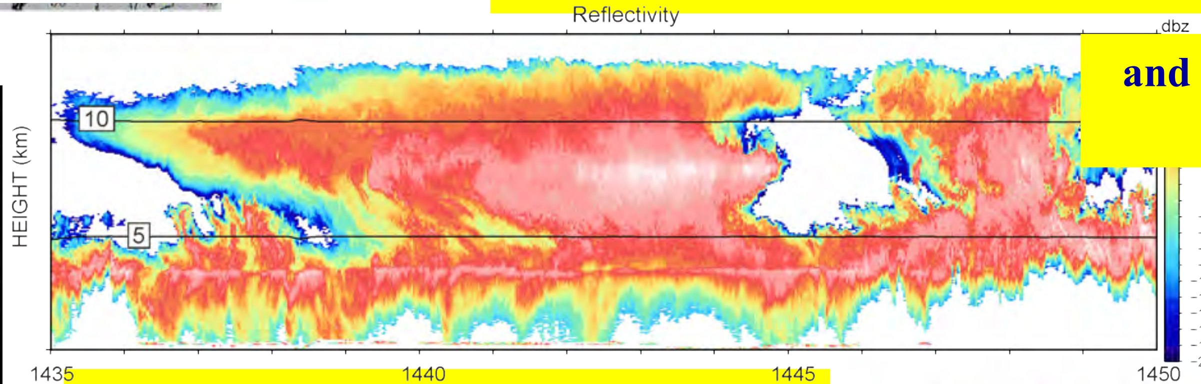




MICROPHYSISCS from RADAR …

LIGHTNING

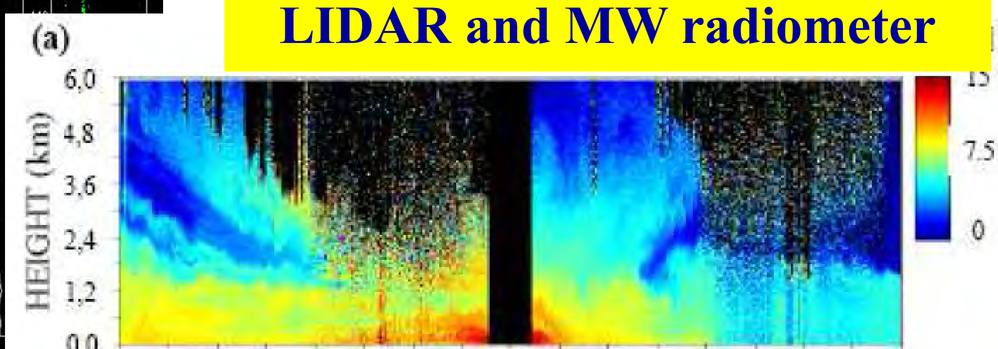




and from AIRCRAFT (Falcon20)

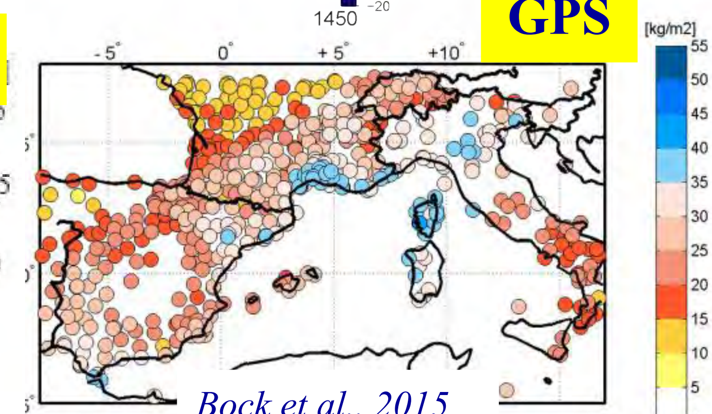
Lee KO et al., 2015

LIDAR and MW radiometer



Di Girolamo et al., 2015

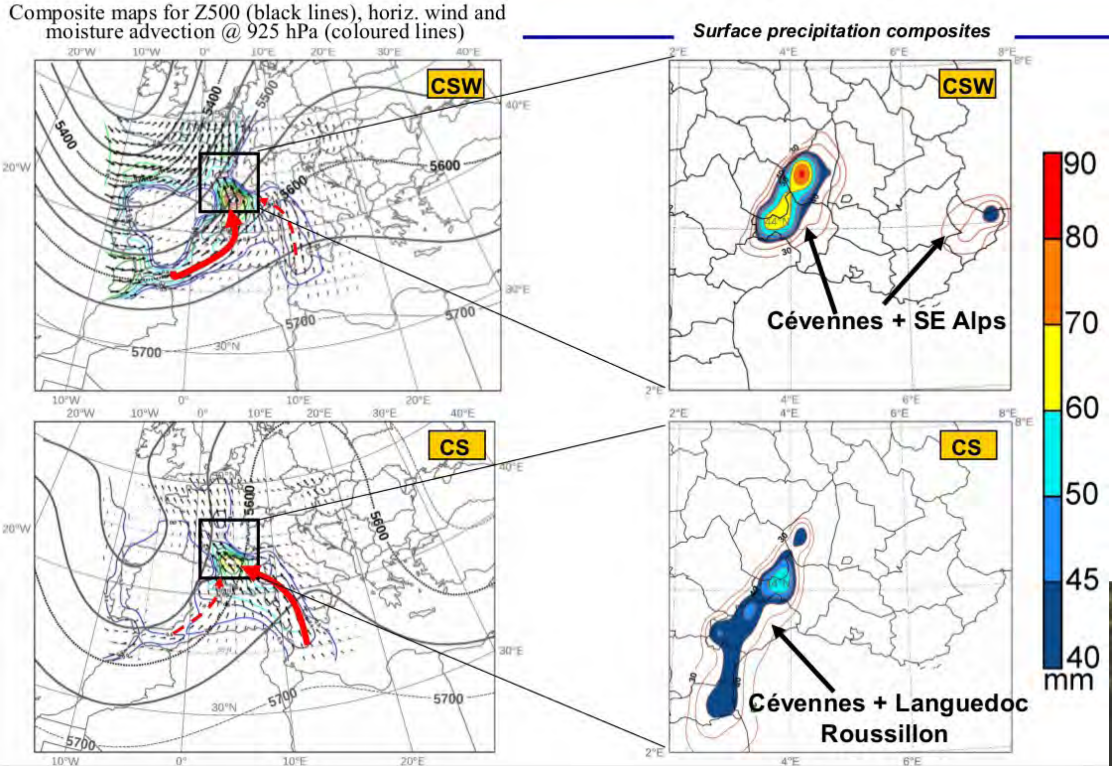
GPS



Bock et al., 2015

Results

Large-scale/mesoscale mechanisms leading to HPE

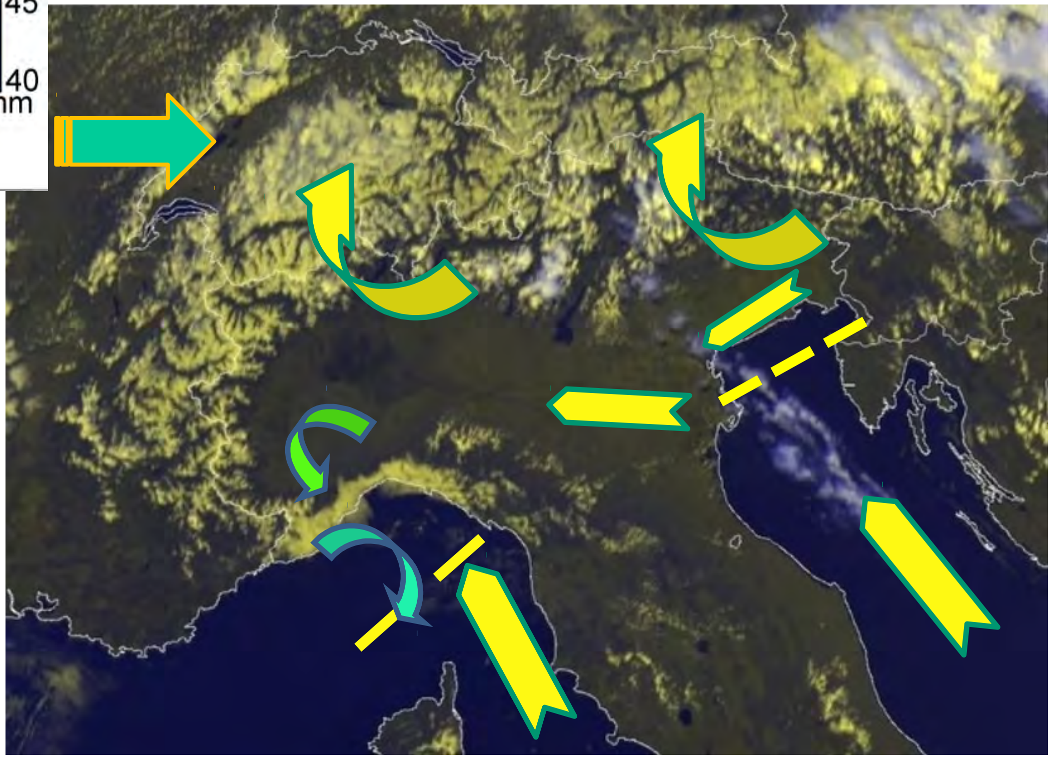


Nuissier et al. 2011

REQUIRED "INGREDIENTS"

- **Upper level trough NW of the area**
- **Low-level jet**
- **Low-level moisture convergence**

Davolio et al. 2015



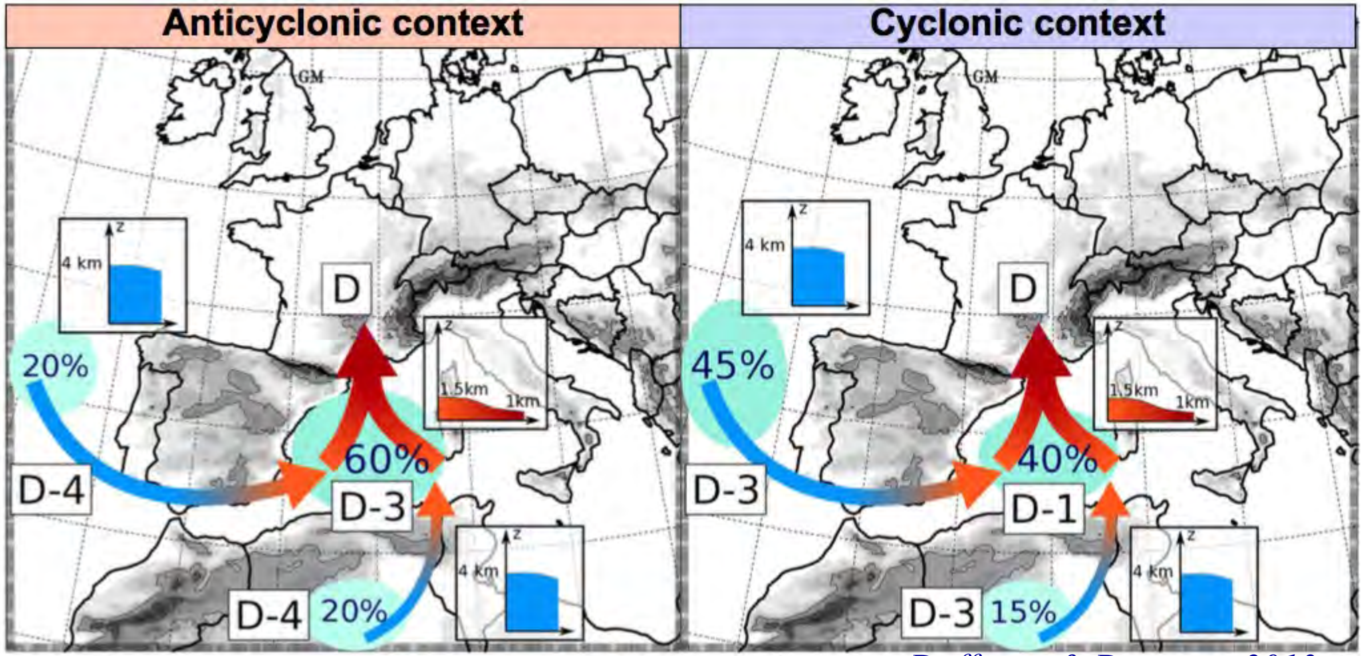
Role of the **interaction of Tropical Cyclones** with mid-latitude flow over the W-Atlantic: **it does not lead to a systematic intensification of precipitation over the Mediterranean.** Different with results obtained so far for the Pacific.

Pantillon et al. 2015

Results

Moisture sources and transport

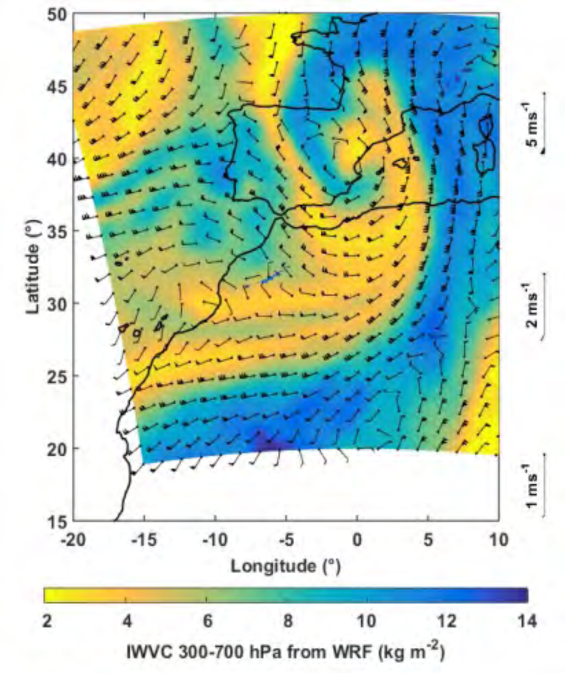
Where does moisture come from? Identification of WV origin



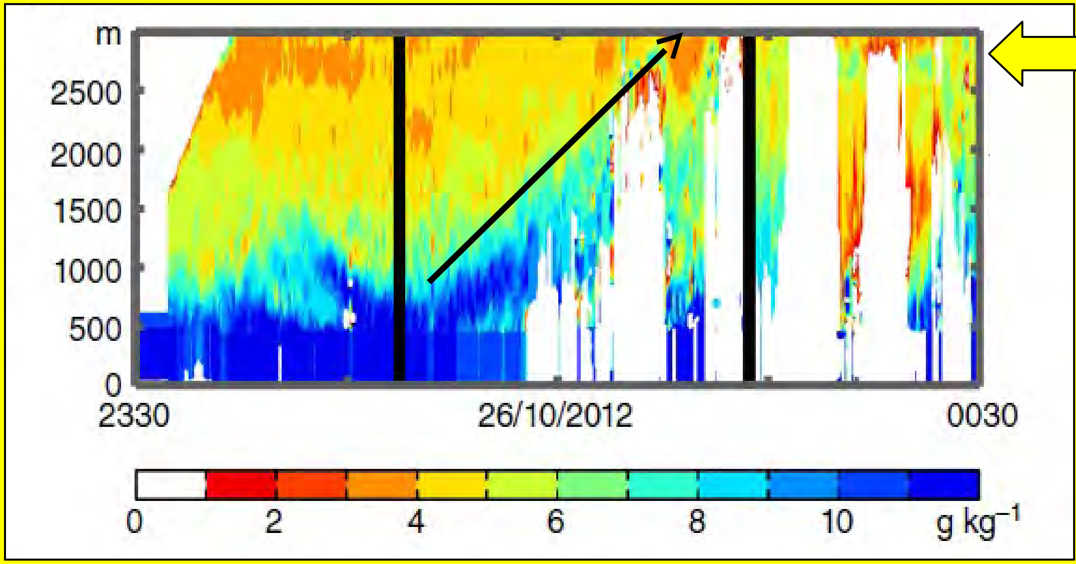
Duffourg & Ducrocq, 2013

modelling studies

Chazette et al. 2015



Tropical plume



Transport of water vapour along a Warm Conveyor Belt associated to a Mediterranean cyclone, **documented by <u>ATR42 flight (lidar LEANDRE 2)</u>**

Ascending velocity ~ 18 hPa/h

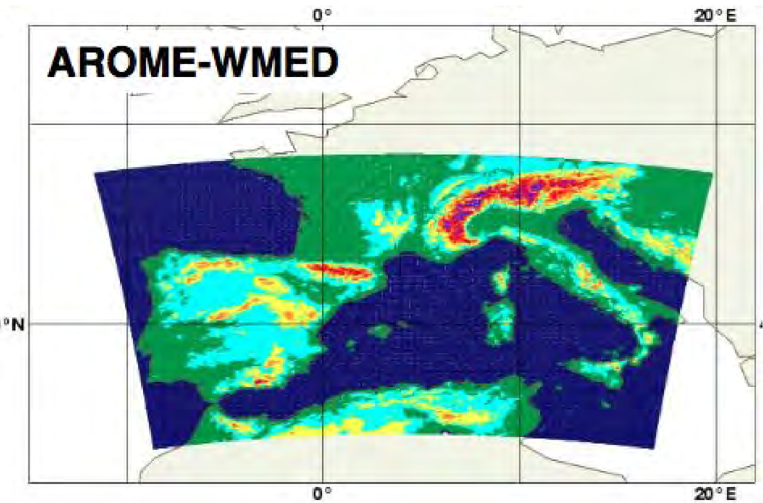
Flaounas et al. 2015

Results

Main advances in modelling/forecasting

NEW OBSERVATIONS Mesoscale Data Assimilation within cloudy and precipitating systems at convective scale:

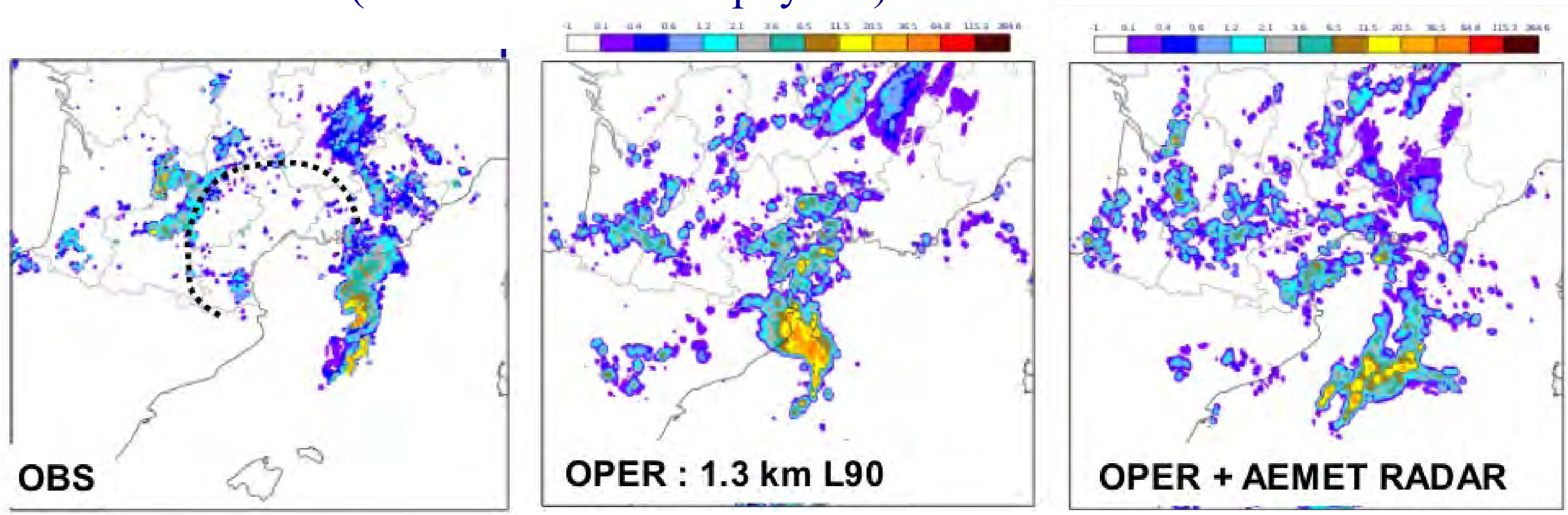
- Assimilation of field campaign **research observations**: lightning, MW radiometers, airborne and ground-based WV lidar) **AROME-WMED** SOP real-time and **REANALYSES**, impact studies (*Fourrié et al, 2015; Caumont et al, 2015*)
- Operational Radar data assimilation: assimilation of Spanish radars in AROME (never used before in real-time), radar refractivity, polarimetric weather radar observations (*Augros et al, 2015*)



- Satellite data assimilation: assimilation of cloudy radiance (*Martinet et al, 2013, 2014*)
- Improved **physical parameterizations** (turbulence & microphysics)

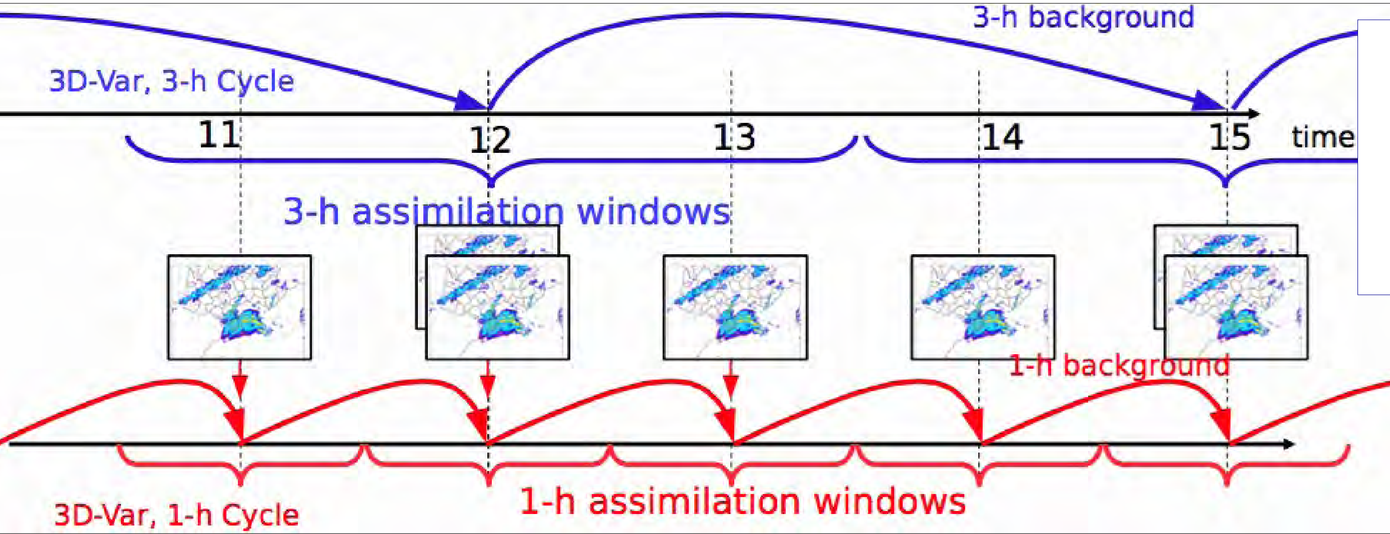
Assimilation of Spanish radar in AROME (oper) 18 h forecast

Montmerle (MF) & Geijo (AEMET)



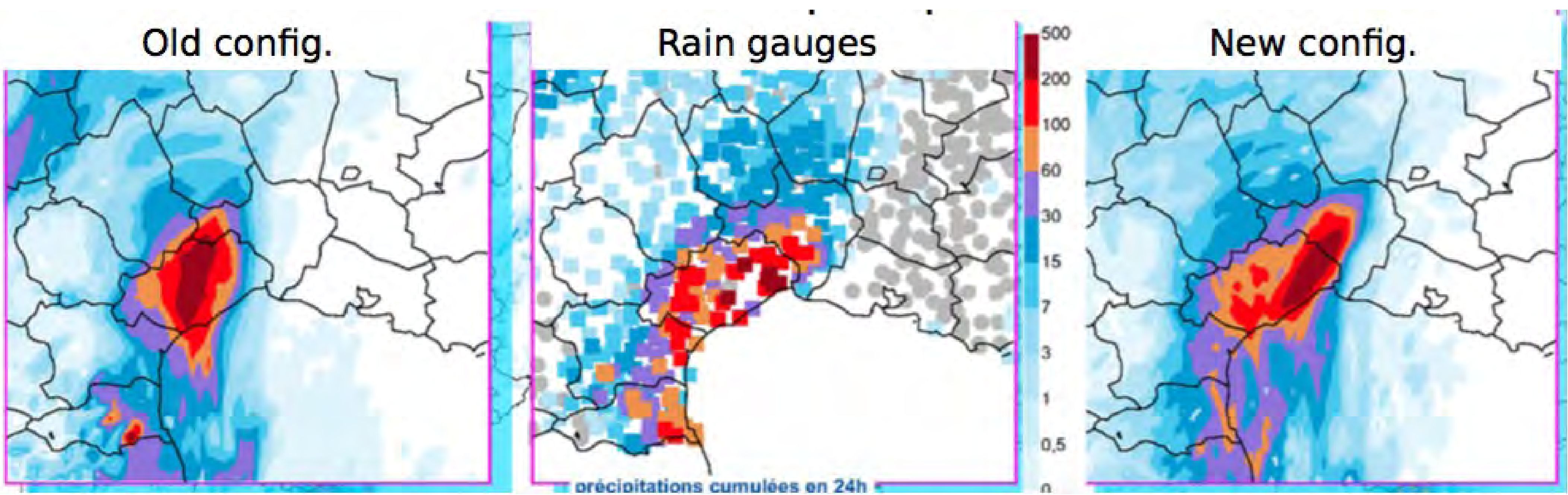
Results

Main advances in modelling/forecasting



New tools/methods for variational DATA ASSIMILATION

Brousseau et al. 2015



Global Water Resource Systems

Examples from :

- INARCH
- HyMex
- CCRN

Significance

- Ongoing change in climate has already resulted in shorter seasonal snowcover duration, earlier spring hydrographs, greater rainfall fraction of total precipitation, glacier volume decline, ground thaw and woody vegetation increase in many alpine catchments.
- Some alpine catchments are contributing to higher frequency of floods and/or droughts.

Water Security Impacts from Mountain Catchments

- **Mountains provide water supply for over half of humanity.**
  - **Diminishing supplies due to climate change and consumption, both in mountains and downstream**
- **Recent mountain flood deaths and damage from unprecedented precipitation - examples**
  - **Pakistan, Afghanistan, Nepal, India - since 2010**
    8225 deaths from heavy mountain rains.
  - **Bosnia, Serbia – May 2014,**
    62 deaths reported, 1.6 million affected
  - **Western Canada – June 2013,**
    4 deaths reported, $6 billion in damages
  - **Colorado, USA – Sept 2013,**
    10 deaths, 2000 homes damaged

Results on drought processes

➲Better understanding of underground water processes :

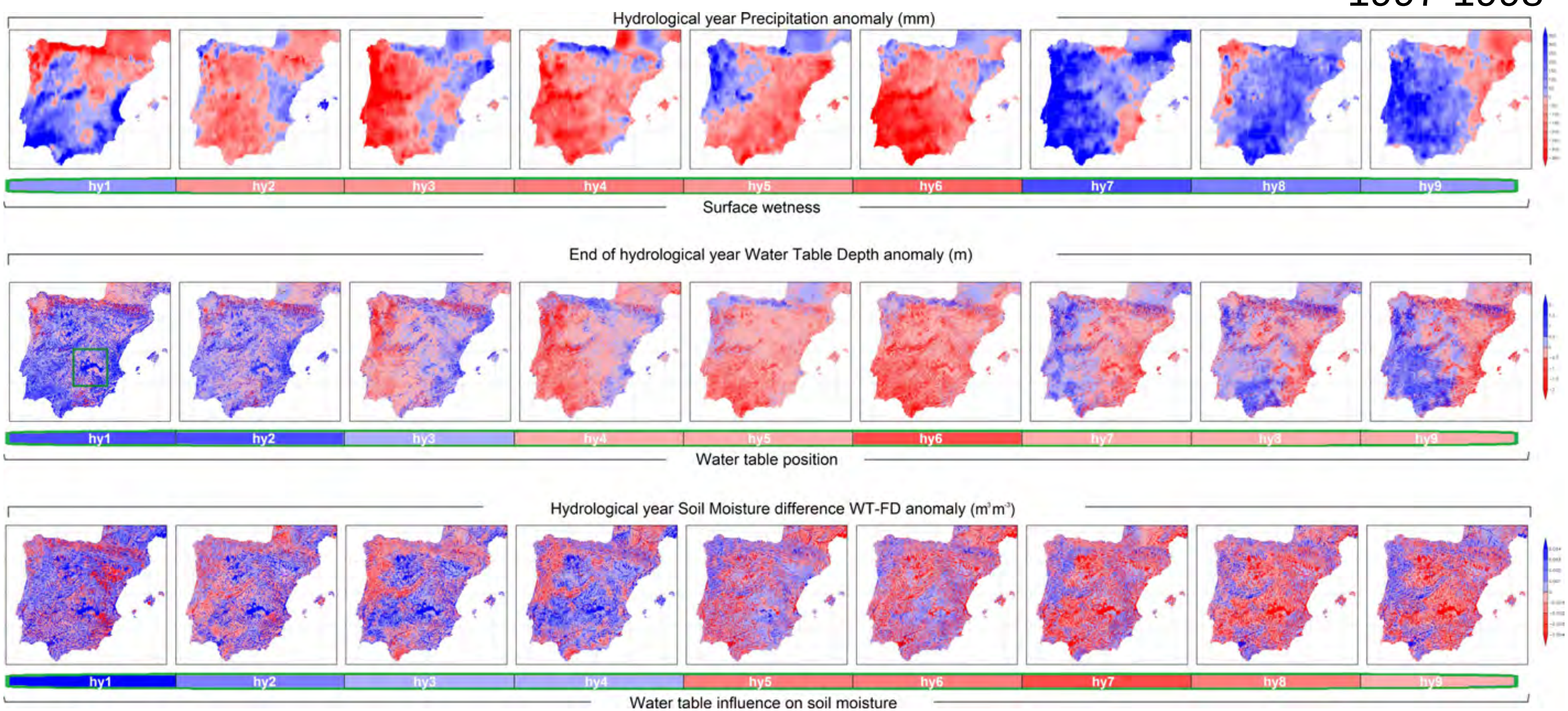
Comparing 2 simulation of LEAFHYDRO :

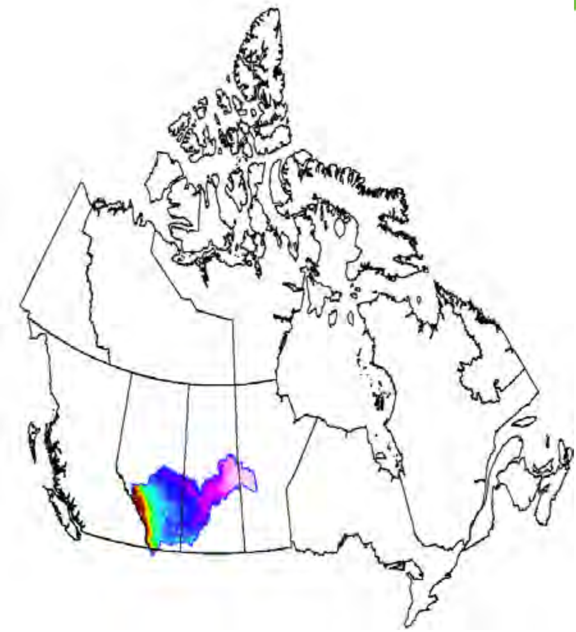
- WT : Run with water taible
- FD : Free drainage case.

Prolonged droughts reduce the influence of the water table on soil moisture and increase the impact. Míguez-Macho and Martinez de la Torre 2014.

1989-1990

1997-1998

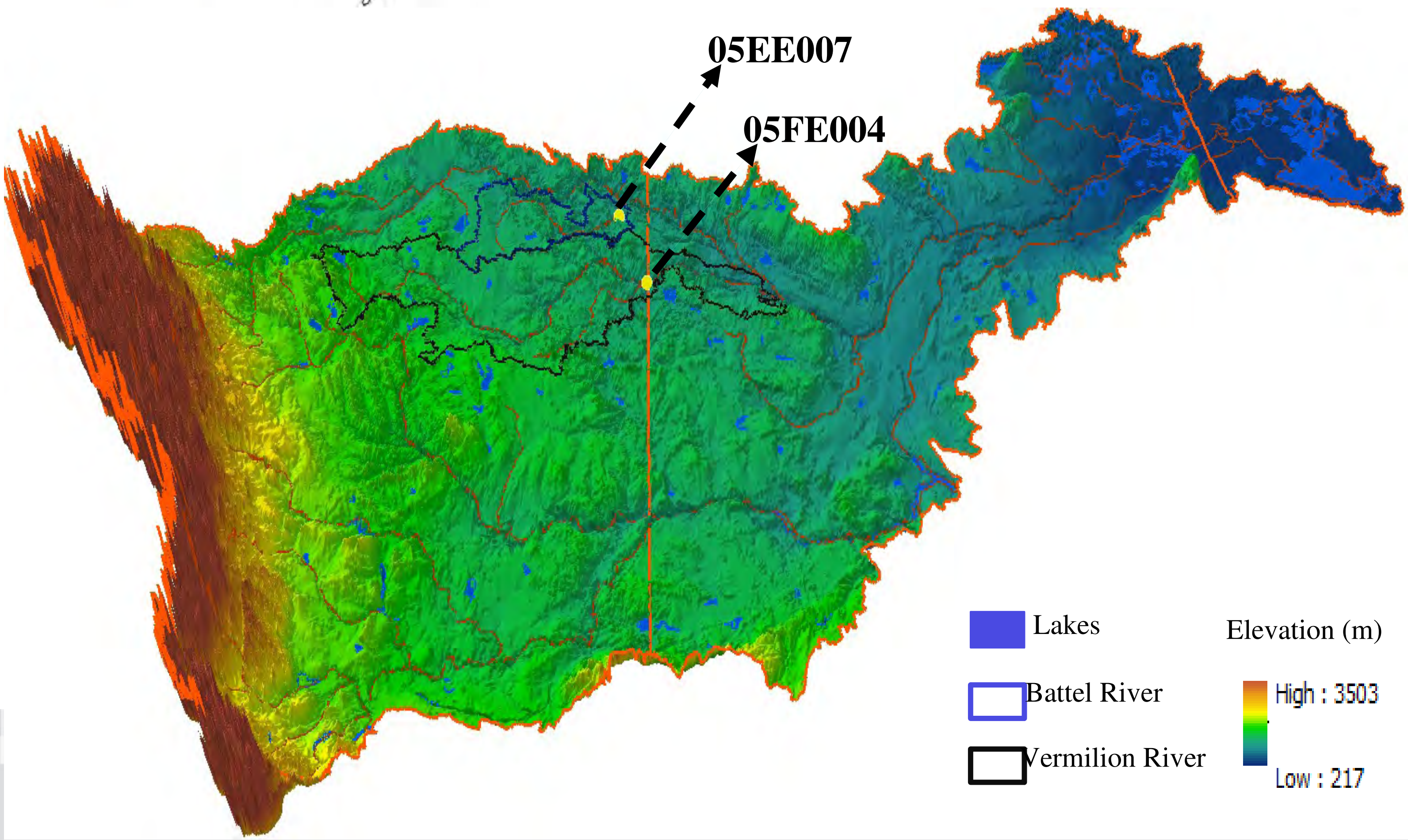




Data Assimilation - SaskRB

University of Saskatchewan
Global Institute for Water Security

- SaskRB Watershed area: 405,864 km^2
- Battle Watershed area: ≈30,000 km^2
- Vermilion Watershed area: ≈8,000 km^2
- Precipitation: up to 1500mm in the Rockies and 300-500mm in prairies
- DEM:1:250,000 (Geobase Canada and USGS)

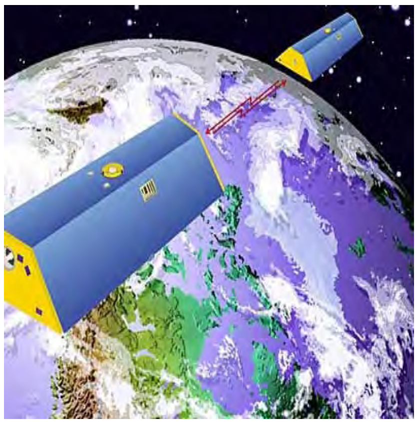


a/water

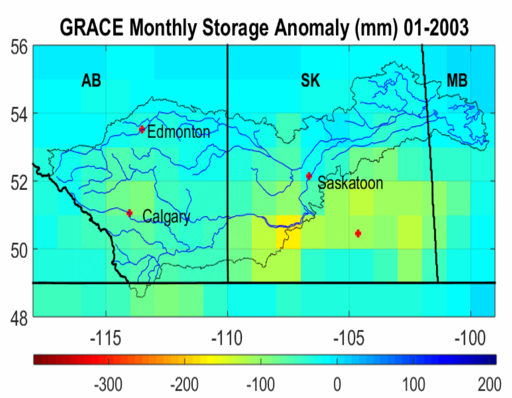
UNIVERSITY OF SASKATCHEWAN
Global Institute for Water Security

GRACE Total Water Storage (TWS) anomaly

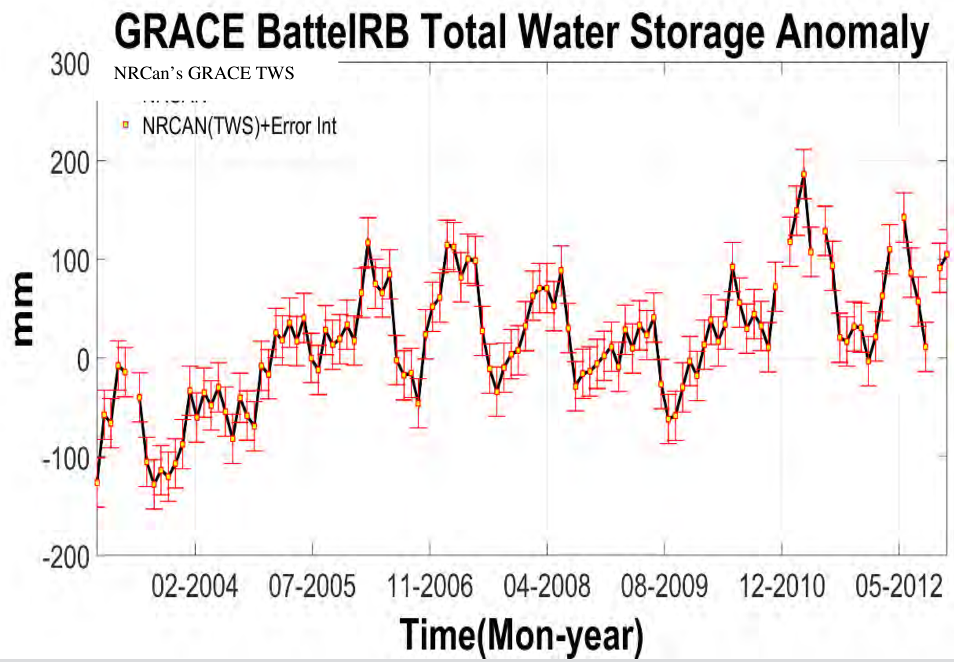
***GRACE** satellite (Photo credit: NASA)*



- Gravity Recovery and Climate Experiment (GRACE), delivers monthly averages of the spherical harmonic coefficients describing the Earth's gravity field, from which we infer time-variable changes in mass, averaged over arbitrary regions having length scales of few hundred kilometres to accuracies 1cm of equivalent water thickness.
- Monthly variation related to surface storage, soil moisture storage, groundwater changes, and Post Glacial Rebound
- We adopted GRACE TWS processed by Natural Resource Canada as in (Lambert et al., 2013) (Glacial Isostatic Adjustment (GIA) correction and filtering technique that that retain more signals)

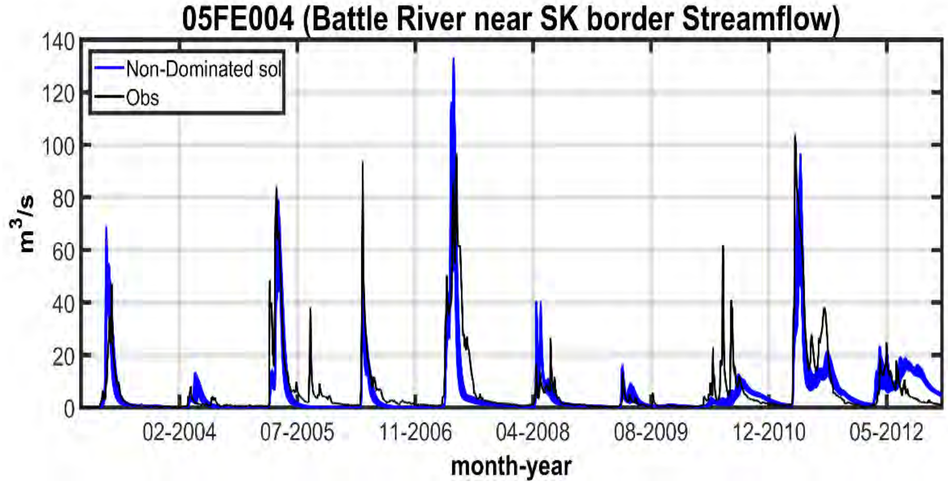


Swenson, 2012; Landerer and Swenson, 2012;
Swenson and Wahr, 2006;

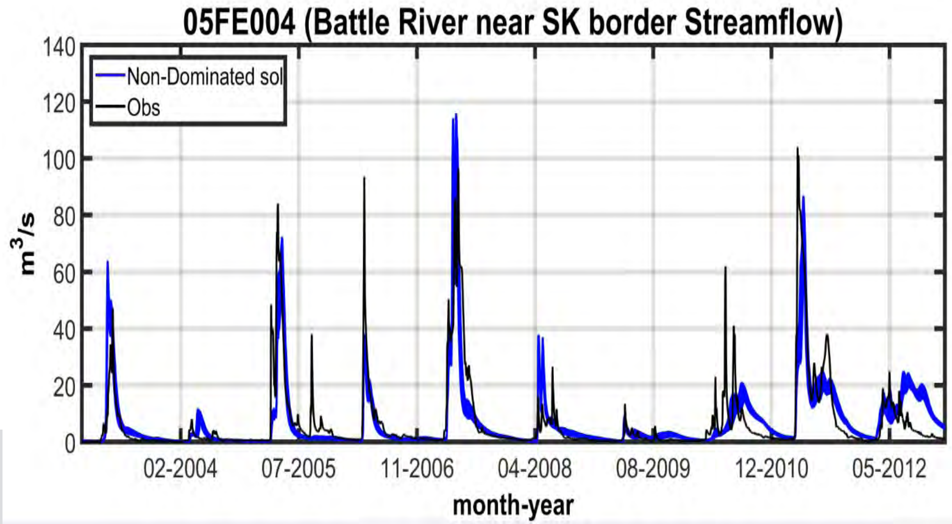


Streamflow comparisons

STREAMFLOW BASED

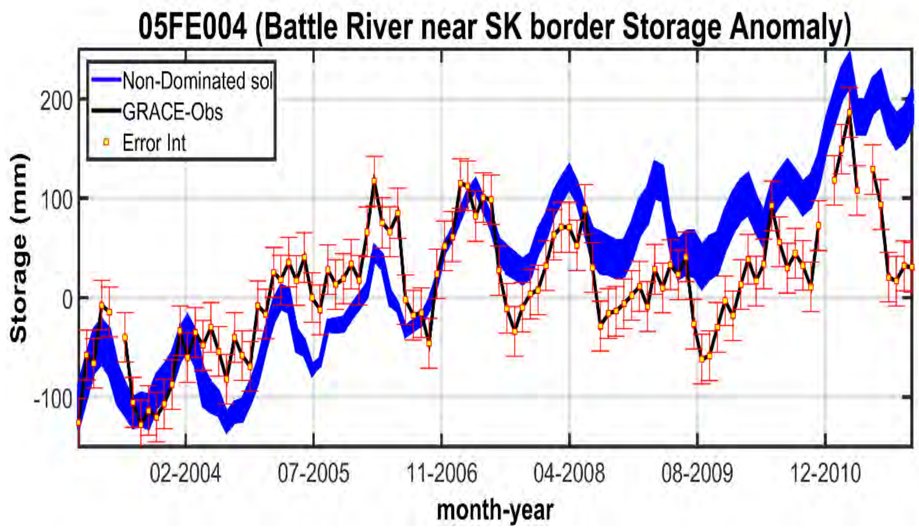


COMBINED STREAMFLOW & TWS ANOMALY

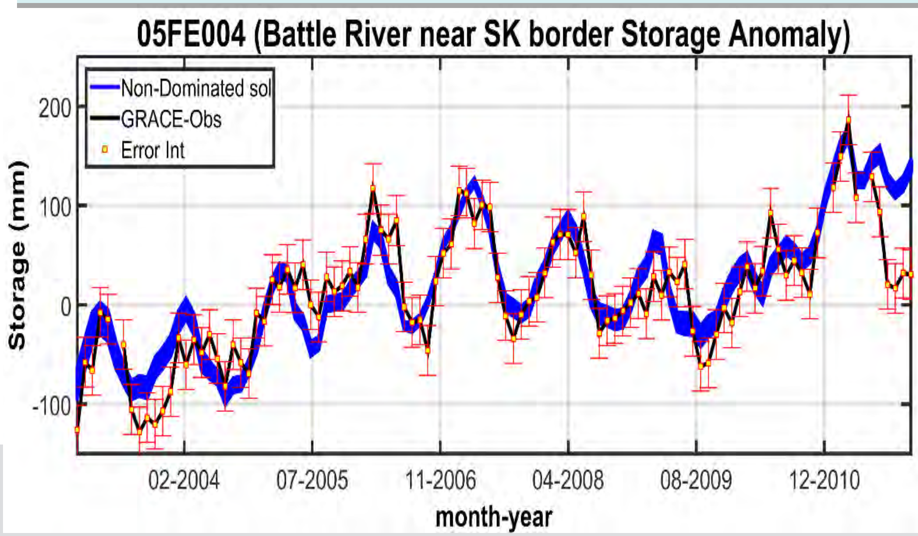


TWS anomaly comparisons

STREAMFLOW BASED



COMBINED STREAMFLOW & TWS ANOMALY

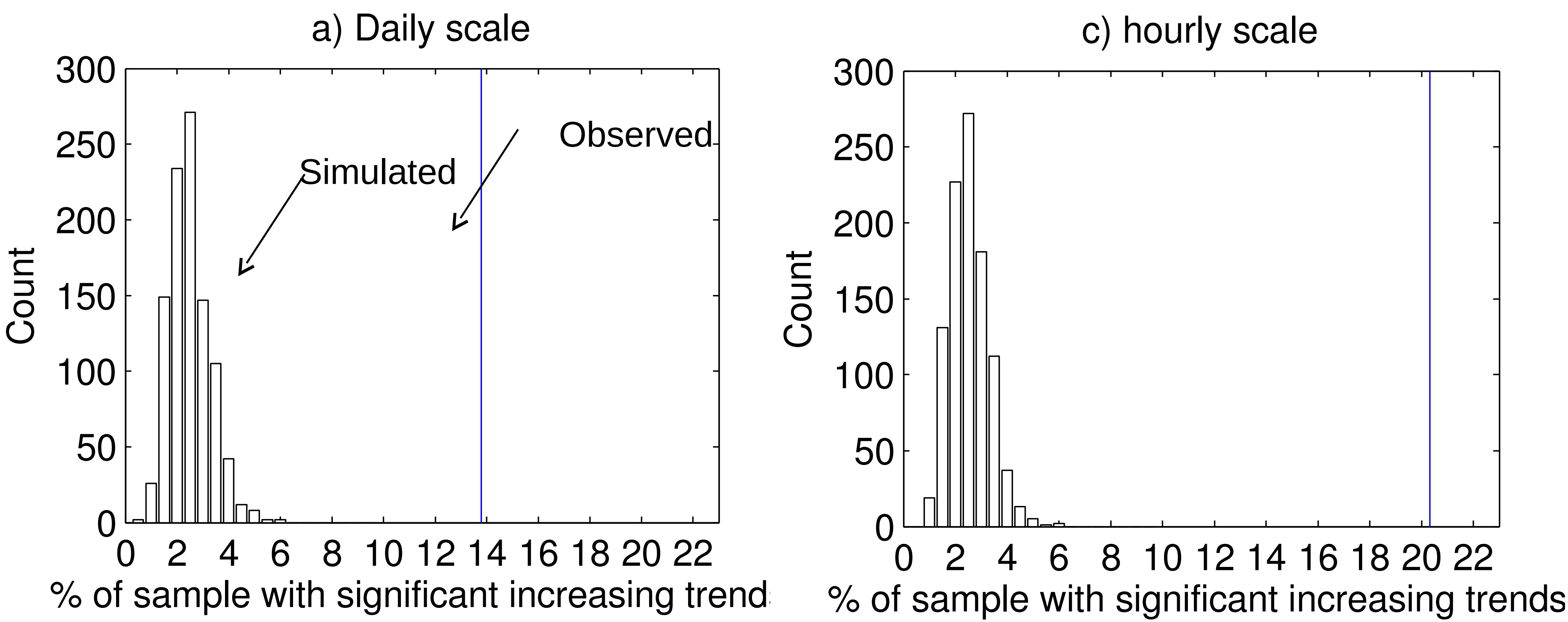


Changes in Extremes

Examples from :

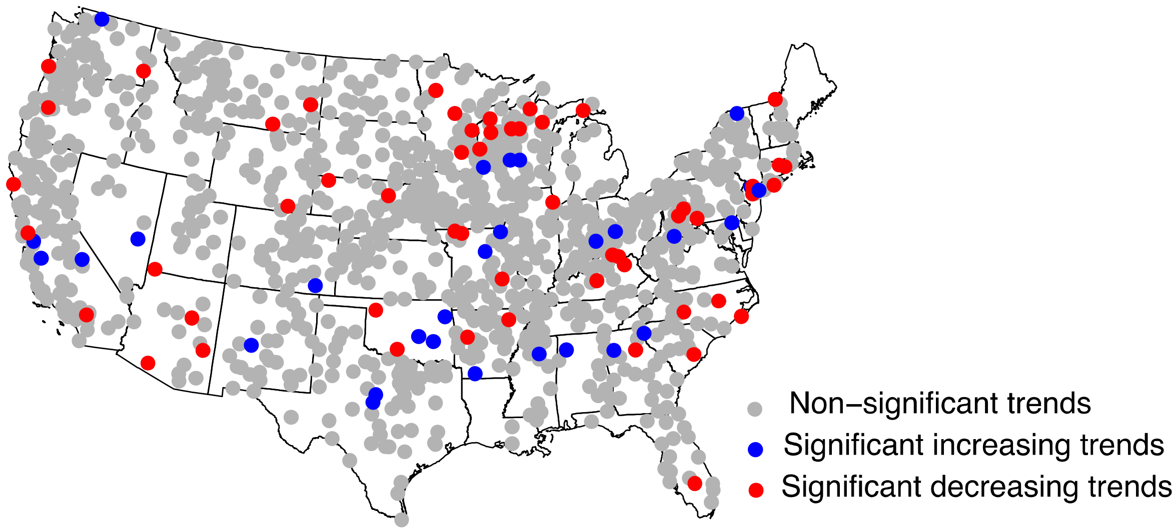
- INTENSE
- HyMex
- MAHASRI

Percent of US stations with significant increasing trends

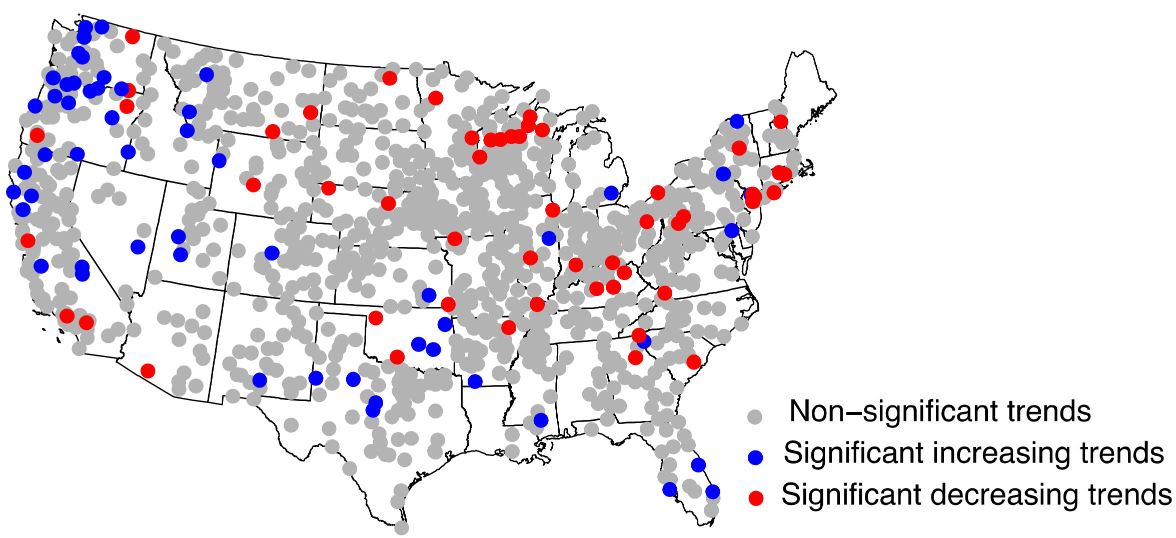


Trends in extreme P

a) Trends in JJA heavy rainfall events (daily scale)

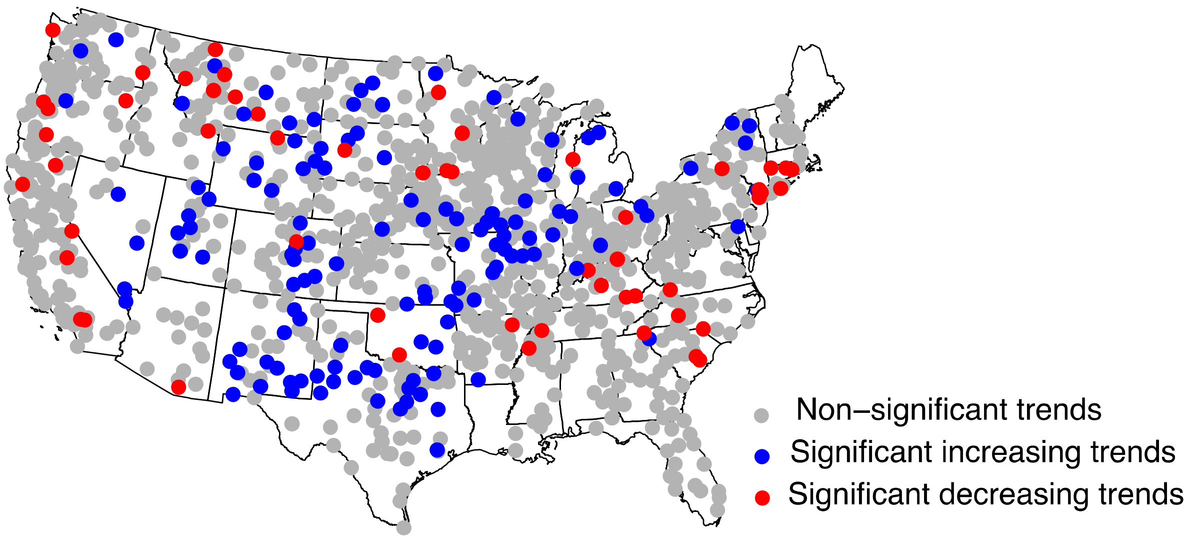


b) Trends in JJA heavy rainfall events (hourly scale)

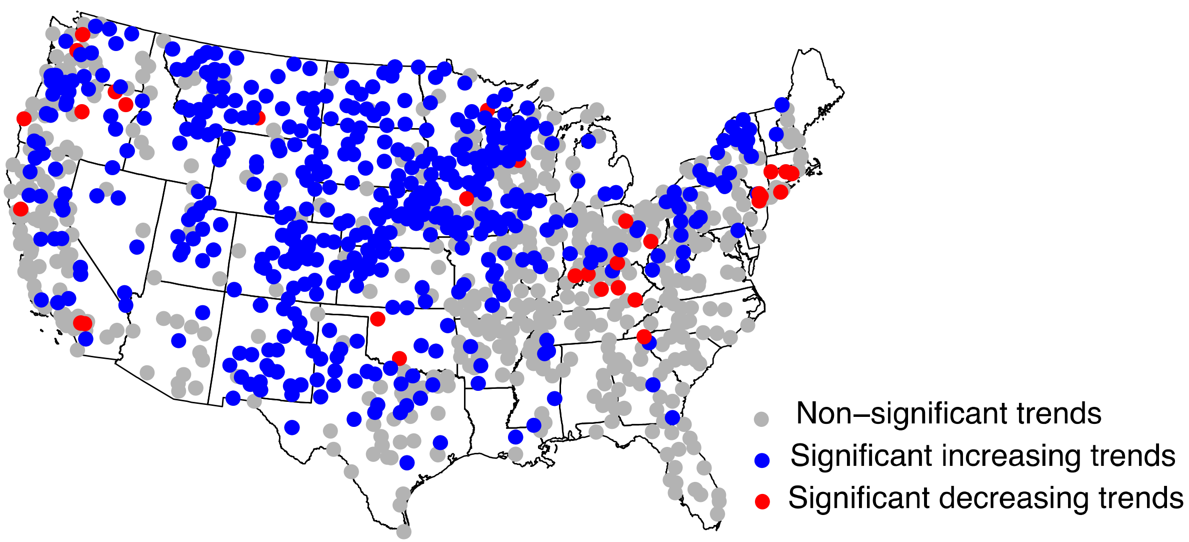


Trends in extreme P

a) Trends in DJF heavy rainfall events (daily scale)

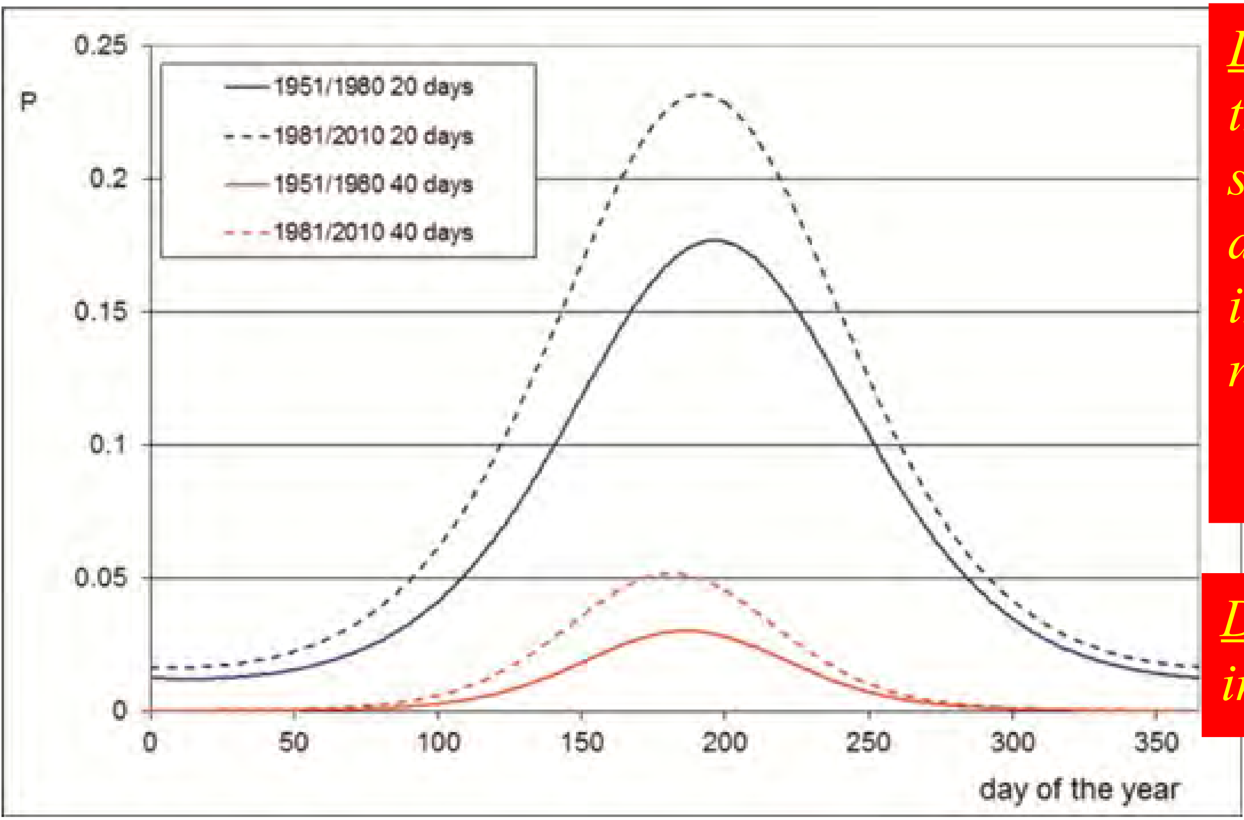


b) Trends in DJF heavy rainfall events (hourly scale)



Trends in Consecutive Dry Days

By means of a stochastic model, several thousands of series were generated, starting from the daily data of two sub-periods (1951-80 and 1981-2010) relative to some rain gauges of Calabria (Southern Italy). For each day of the year, the occurence probability to have dry spell with lenghts equal or greater than 20 days and 40 days was estimated *(in fig., the results relative to the Cosenza rain gauge).*

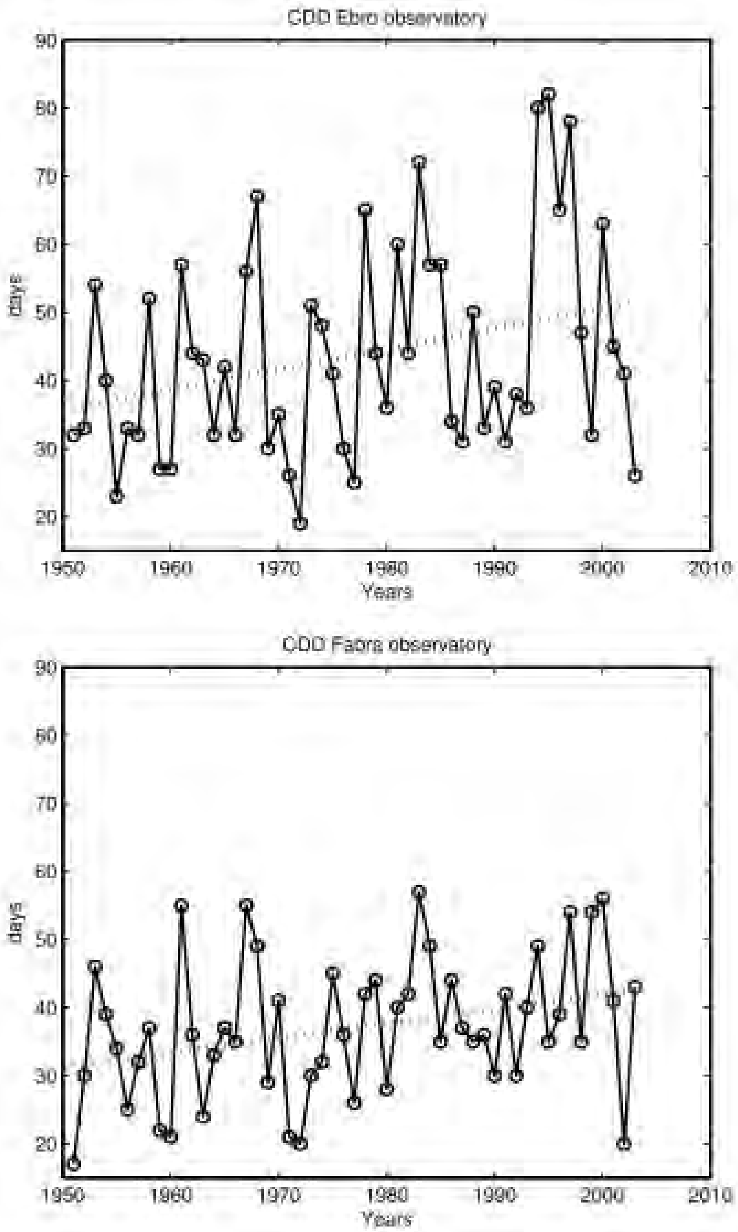


Dry spell lengths ≥ 20 days:
the probability values evaluated by the syntetic data generated from the real data of the sub-period 1981-2010 increase up to about 33% than those relative to the previous sub-period

Dry spell lenghts ≥ 40 gg:
increases up to about 70%

from: *Sirangelo B., Caloiero T., Coscarelli R., Ferrari E. (2015) - A stochastic model for the analysis of the temporal change of dry spells - Stoch. Environ. Res. Risk. Assess. Vol. 29*

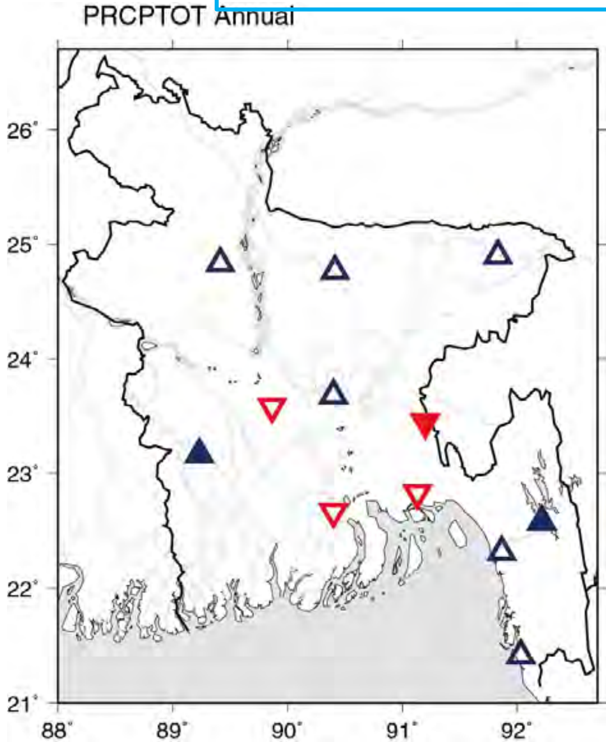
Trends in consecutive dry days

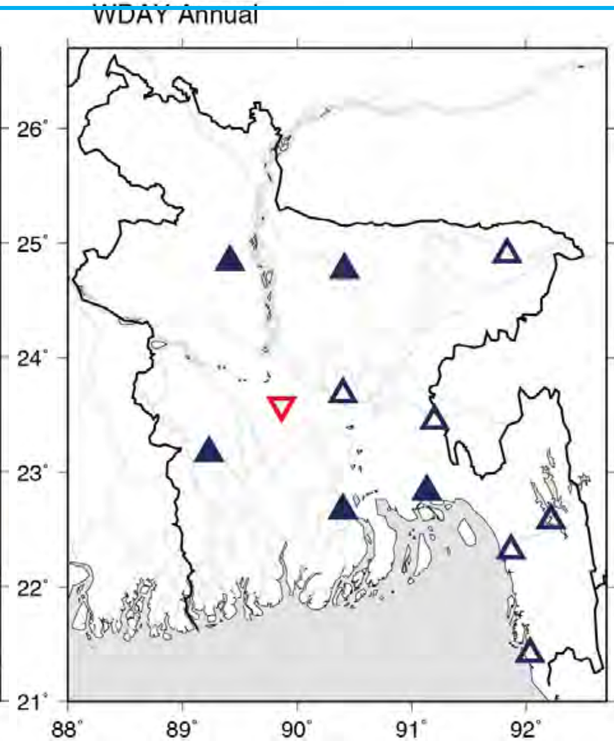


Turco and Llasat 2011

- Several studies have shown that there are positive trends of CDD across the Mediterranean.
- These trends, together with trends in many other variables show that drought duration, frequency and intensity is probably increasing in the Mediterranean.
- It is necessary to improve our understanding of these trends and their causes and consequences at the Mediterranean scale.

Trends in Precipitation Characteristics in Bangladesh from 1950 to 2008



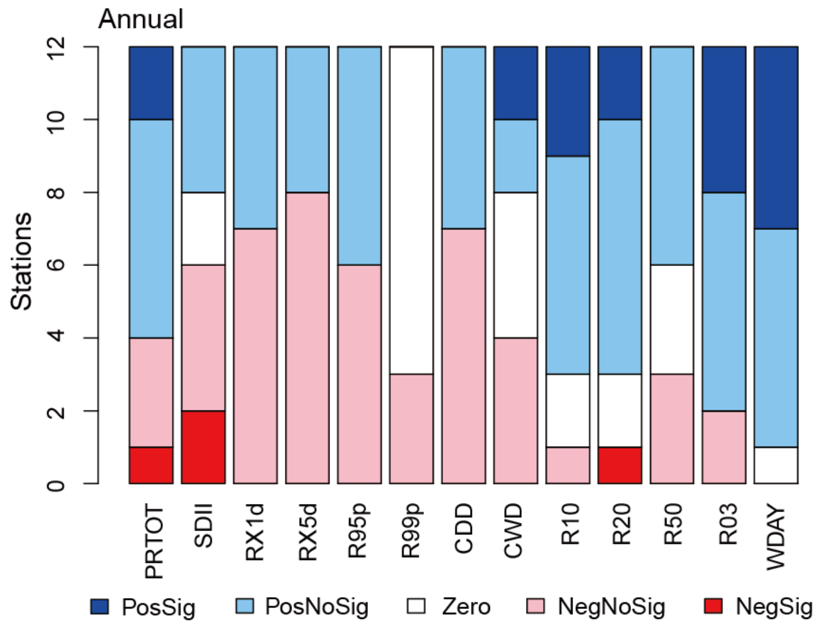


Increasing trend were prevailed in the number of wet days (R>=1mm) over Bangladesh.

Increasing (decreasing) trend in annual precipitation was Observed at two (one) station.

There is no significant trend in extreme rainfall indices.

It is note that frequency of Weak rainfall (R<3mm) tends to increase at 10 stations.



Endo et al. (SOLA, 2015)

Water and Energy Cycles and Processes

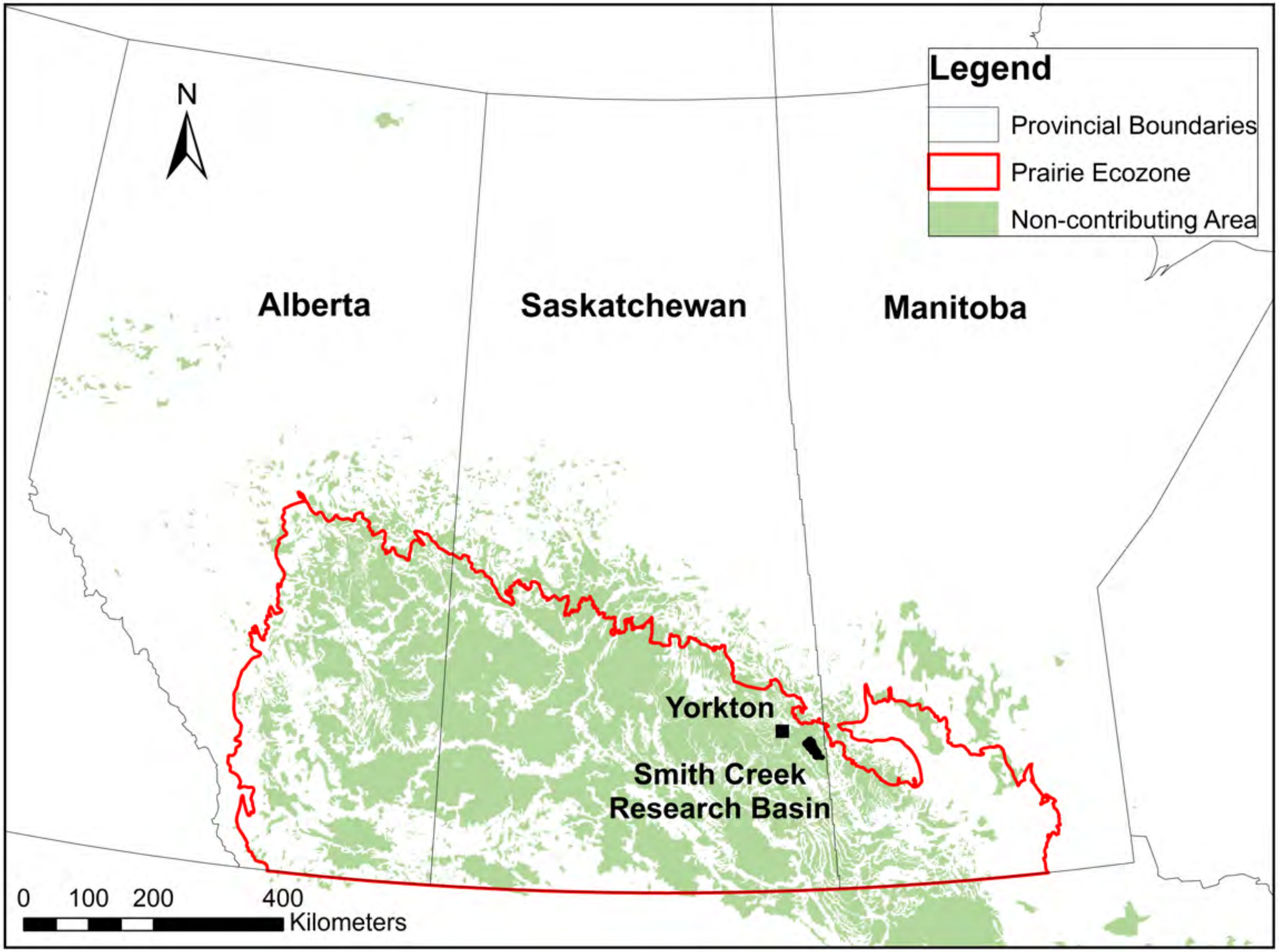
Examples from :

- CCRN
- HyMex

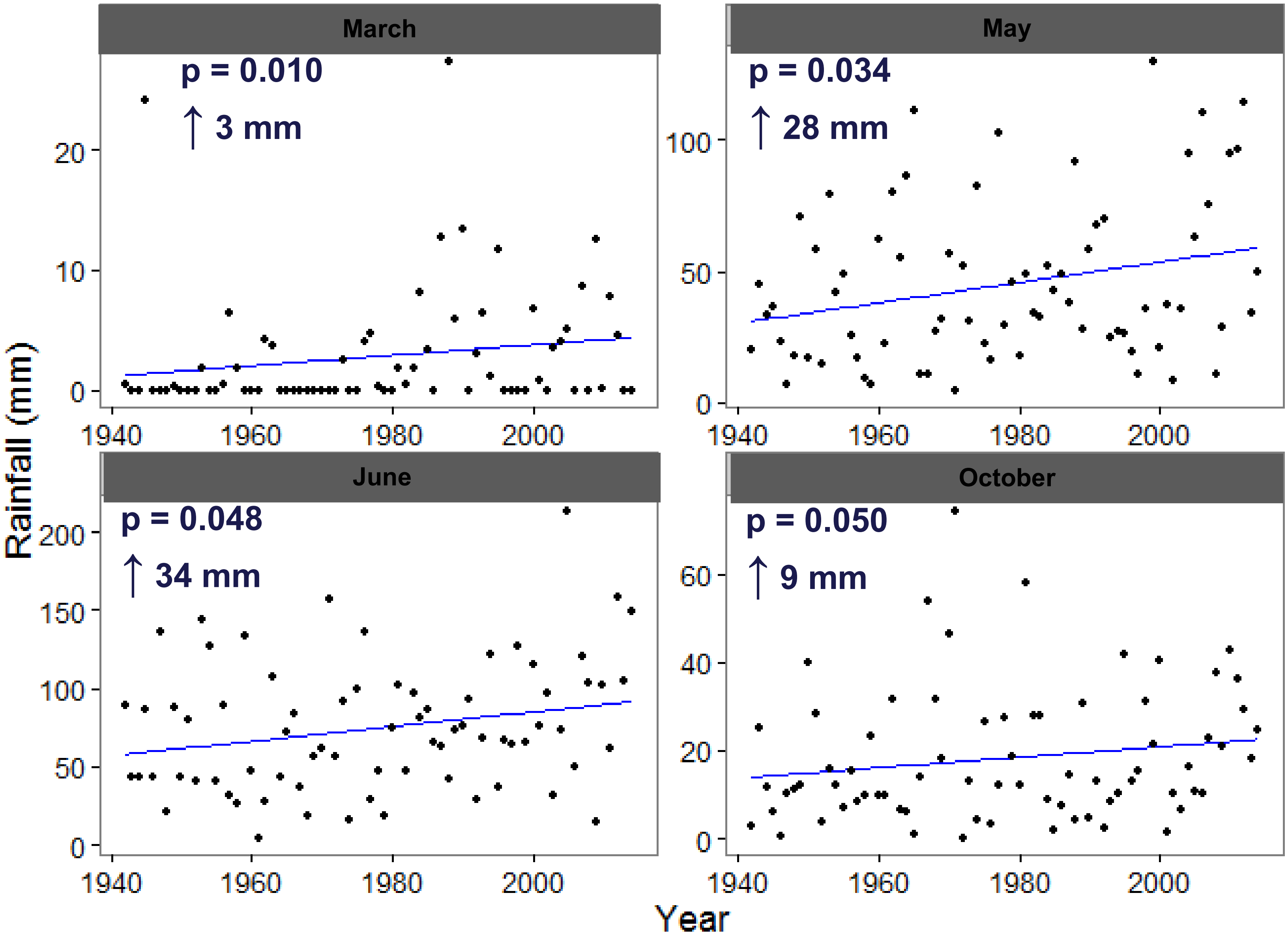
Example of observed change

Smith Creek Research Basin (SCRB), Saskatchewan

- Small, agriculturally dominated basin (393 km^2)



Monthly Rainfall
No change in annual precipitation



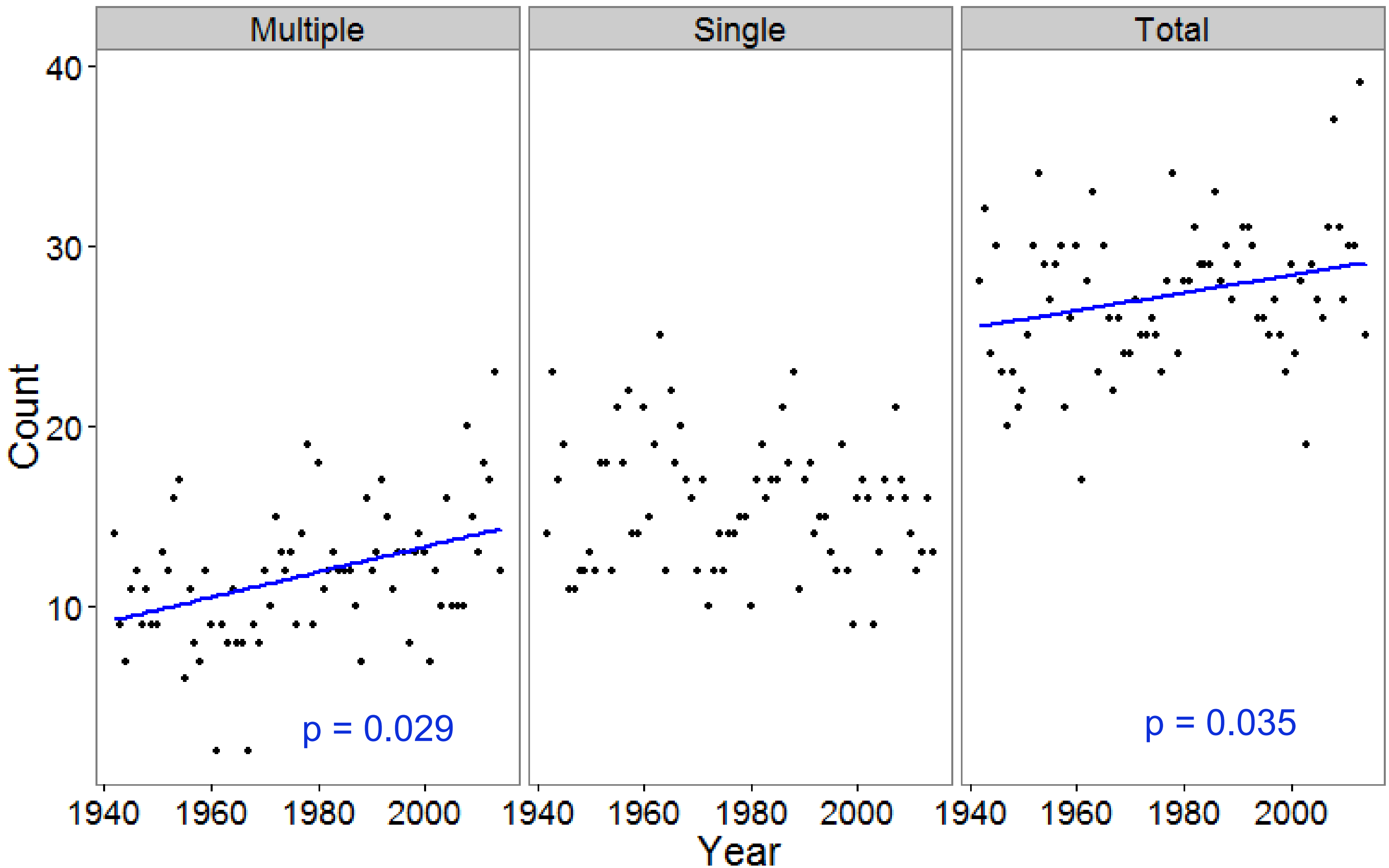
water

CCRN Changing Cold Regions Network

University of Saskatchewan Global Institute for Water Security

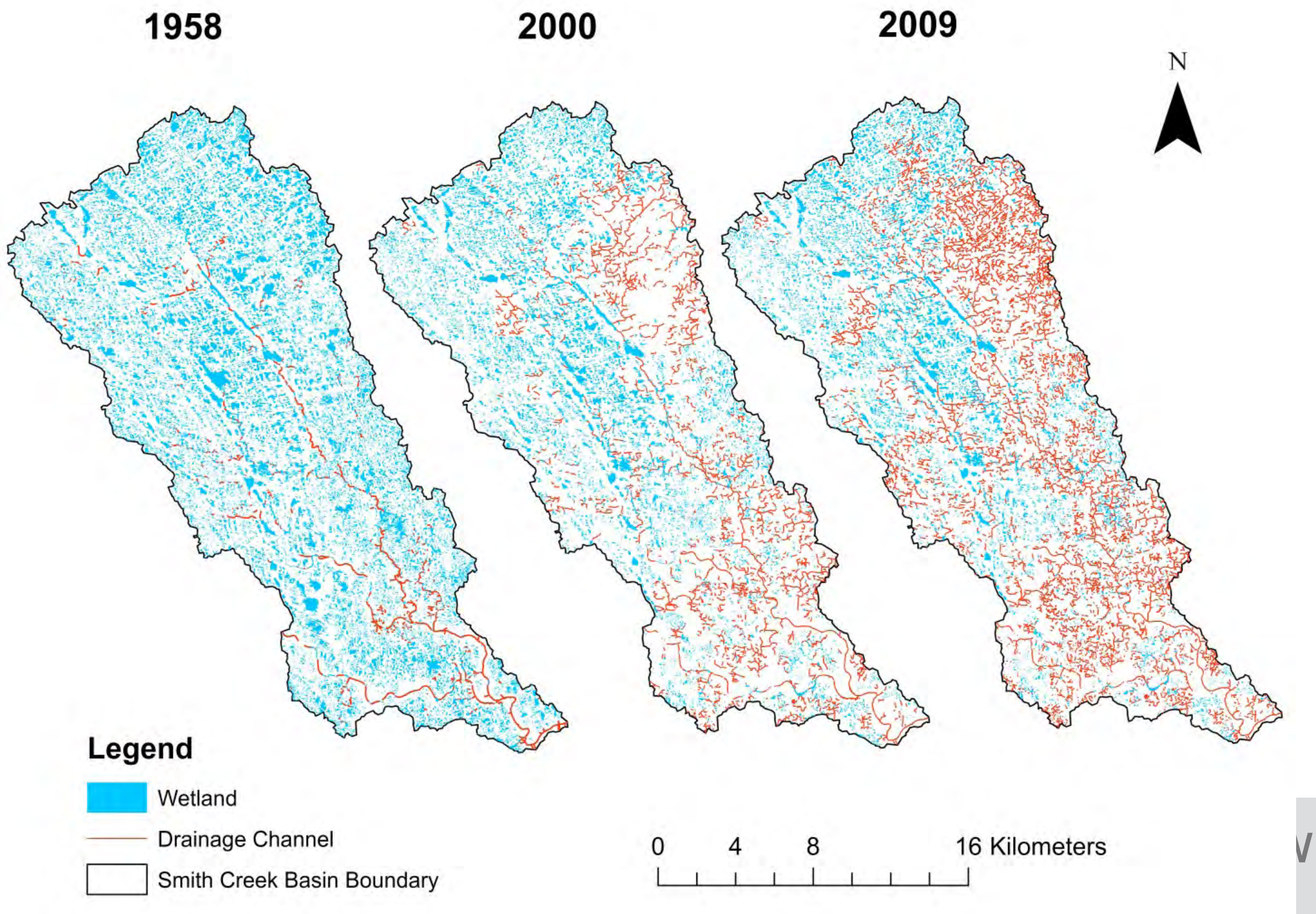
Rainfall Duration (May – Sept; 1942 - 2014)

- Multiple day vs. single day rainfall events (Frontal vs. Convective)
- 50% increase in number of multiple day events



Depressional Storage Drainage

- Depression extent reduced from 24% to 10% (58% reduction)
- Drainage channel length increased 8-fold



vater

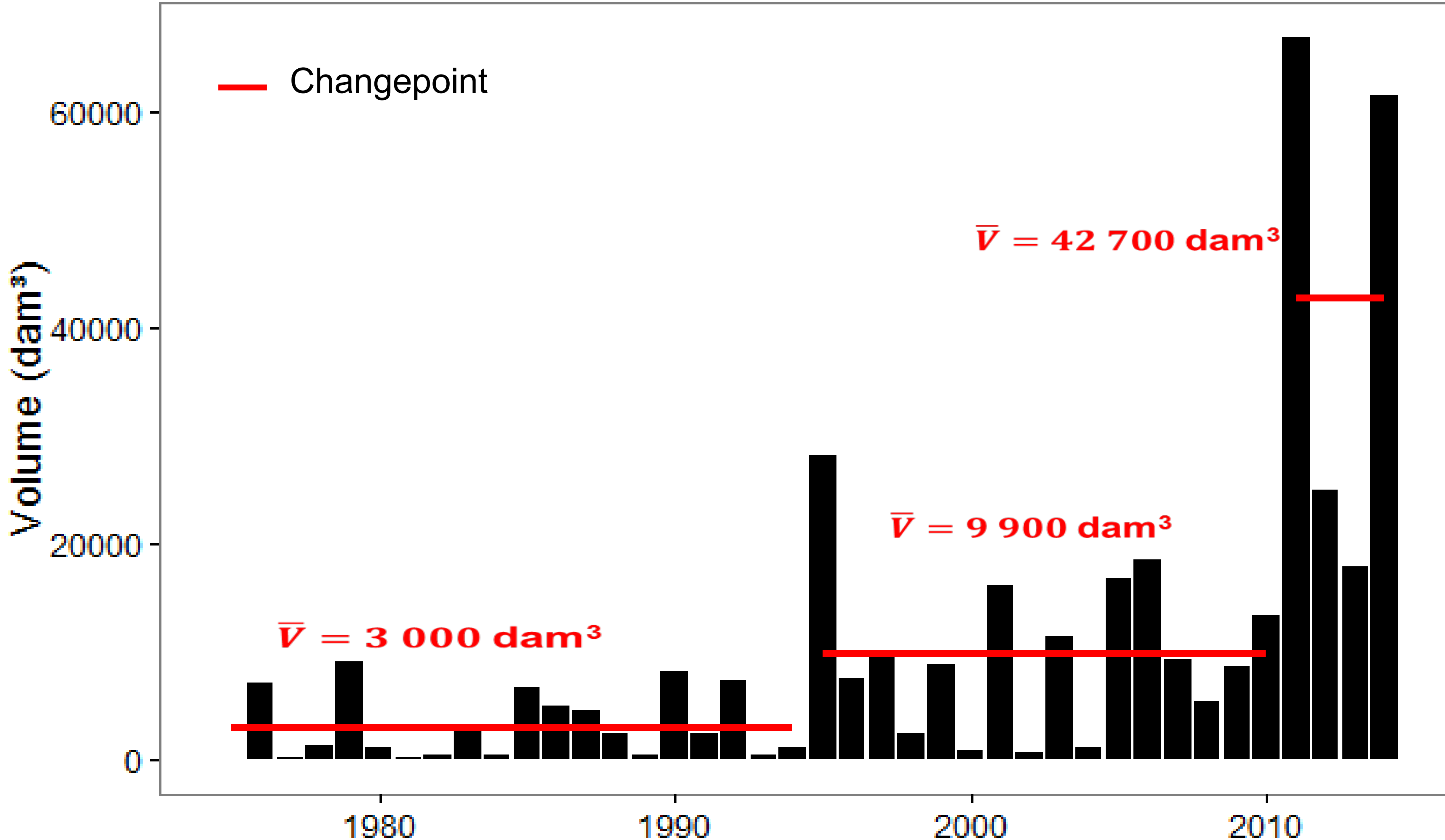
Loss of depressional storage capacity, increase in channelization

No Drainage

Artificial Drainage

Annual Streamflow Volume (1975 – 2014)

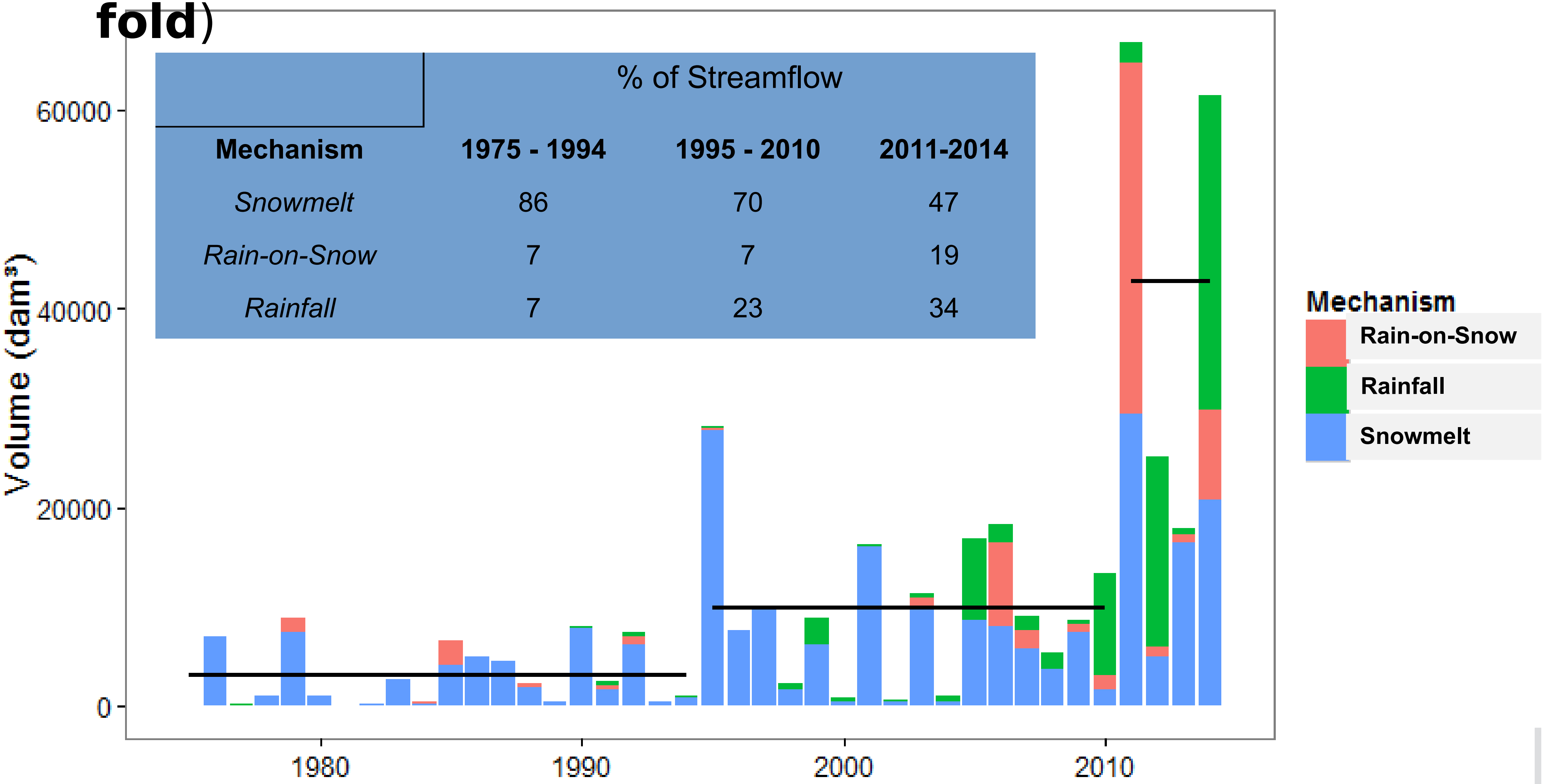
- 14-fold increase in streamflow volumes ($p<0.001$)



Runoff Processes (1975 – 2014)

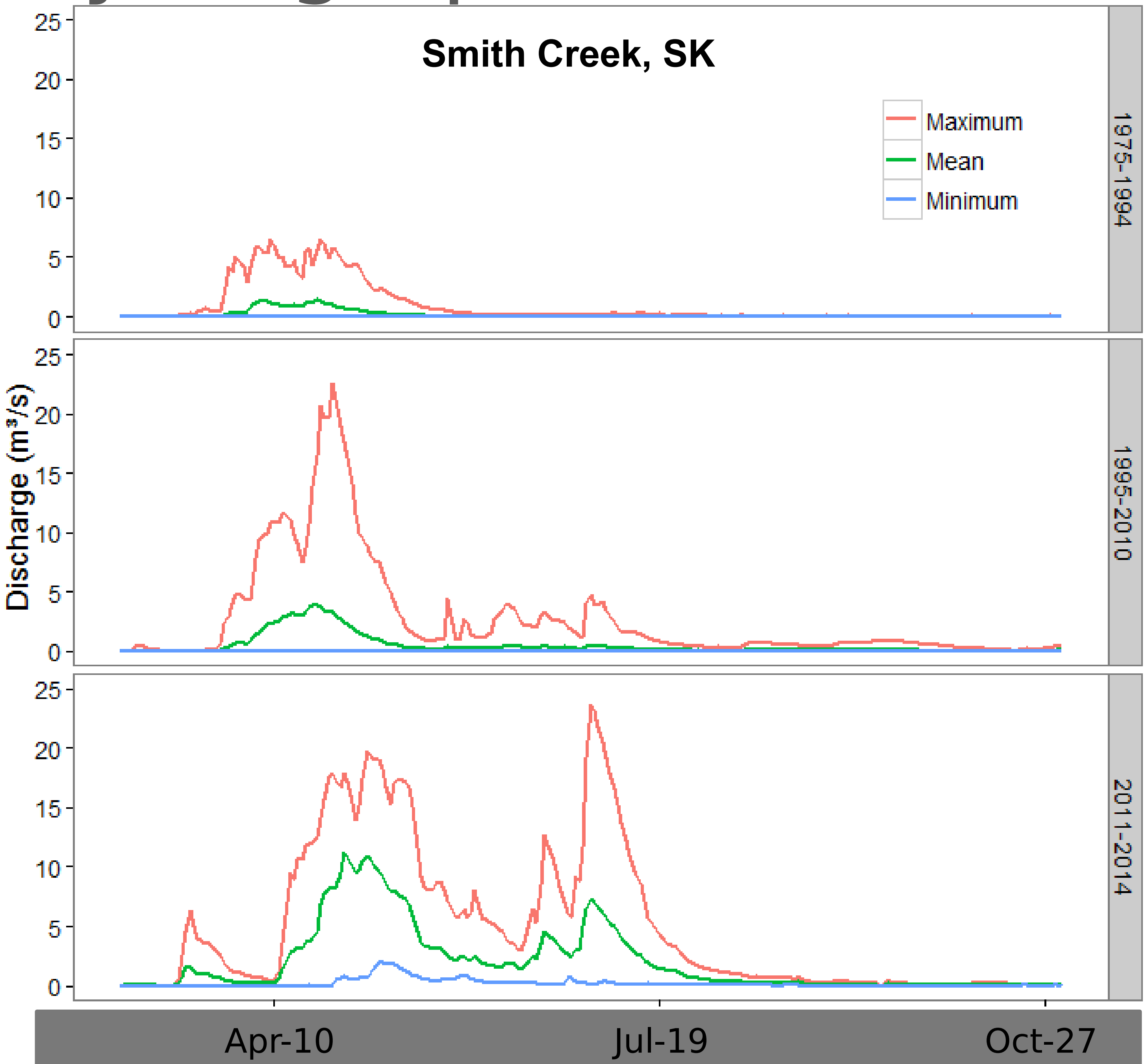
- Increased runoff contributions from:

  Snowmelt (**5-fold**), rain-on-snow (**34-fold**), rainfall (**150-fold**)



	% of Streamflow		
Mechanism	**1975 - 1994**	**1995 - 2010**	**2011-2014**
Snowmelt	86	70	47
Rain-on-Snow	7	7	19
Rainfall	7	23	34

Hydrographs



1975-1994

Snowmelt driven

1995-2010

Increased spring and summer runoff

2011-2014

Second peak flow in summer months caused solely by rainfall runoff

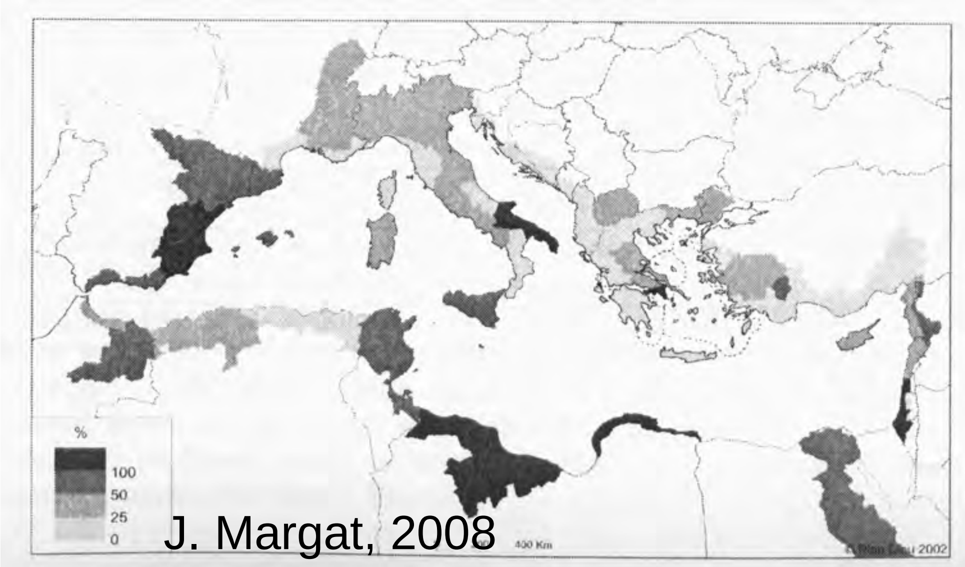
Estimating human usage of water

Combining hydrogeological, climatological, geographical and economical information some estimates can also be derived :

Period	Riverine inflow [km³/y]	Water consumption	Restitution	Net inflow [km³/y]
c.a 1940	550	Negl.	Negl.	550
1990	550	95	15	470
2000	550	152	20	418

Estimation without the Black Sea.
J. Margat, Pers. Comm.

- Plan-Bleu an UNEP initiative.
- This methodology also allows to estimate the water usage as a percentage of the renewable resource.



J. Margat, 2008

The complex picture of freshwater trends

The freshwater inflow into the Mediterranean (The Black Sea is neglected here).

Source	Period	Average annual inflow [km³/y]	Trend [km³/y/y]	Notes
J. Margat	Pre-ind. - Present	418	≈ -2.5	Only anthropogenic
CEFREM-V1	1960-2000	735	-2.4	Anthropogenic & climate
CEFREM-V2	1980-2009	801	Non sig.	Anthropogenic & climate
WFD-CRU	1958-2001	1462	-7.4	Climate only
WFDEI-CRU	1980-2012	871	-2.6 (p=0.15)	Climate only
WFDEI-GPCC	1980-2010	871	-2.6 (p=0.15)	Climate only

Comparable trends hide very different spatial structures :

- The model shows weak but homogeneous trends
- CEFREM displays the strongest trends in the Western Mediterranean

Evolution of the panel membership

Terms of the following members are ending :

- Kei Yoshimura
- Hamma Yacouba
- Yaohui LI

The following replacements are proposed :

- Sylvester Danuor, Kumasi University, Ghana
- Francina Dominguez, University of Illinois
- Xin Li, Chinese Academy of Sciences, Lanzhou

Time for change in the panel leadership

- In 2010 with Dennis Lettenmaier we reverted the name of the panel from CEOP to GHP.
- In 2011 Jason Evans replaced Dennis
- Cross-cuts were initiated
- New RHPs have been proposed and accepted
- The community is motivated to initiate new RHPs
- It is time to start the rotation process of co-chairs :
  - Joan Cuxart has accepted to replace Jan Polcher

GHP and WGRC

- What GEWEX gains from regional projects:
  - Brings regional scientific communities to the forefront in WCRP – They are often under-represented.
  - Allows to address water issues in a multi-disciplinary context.
  - Highlights regional processes and questions their relevance elsewhere or globally.
- Regional activities of GHP are weak in some areas:
  - Interaction with decision makers.
  - Address climate change issues.
  - Co-develop knowledge with stake holders.

The contribution of WGRC

- WGRC turns the “regional information” into “information for regions”
- Sees a challenge in distilling information for decision makers.
- Proposes to create Frontier of Climate Information (FOCI) projects. Their objectives will be :
  - connect climate information needs of decision makers with WCRP activities
  - Develop the knowledge needed at the local scale
  - Develop and sustain capacity in less favoured regions
  - Cross-cut disciplines to address the full complexity of environmental decision.

FOCI an extra dimension for RHPs

- Potential FOCI projects:
  - Maputo and its hinterland
  - Barcelona and the Ebro basin
  - Buenos-Aires/Monteviedo and the Plata basin
- The FOCI project management will be modelled on the one for RHPs
- GHP will gain a pull to tackle societal issues and make its science more relevant.
- It should be a grand challenge for WCRP to ensure that the knowledge it holds serves the people where they live.