Grand Challenge Water for the Food Baskets of the world

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Grand challenges

GEWEX

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Motivation for the food basket focus

- The first large scale interventions on the landscape go back to the Roman empire.
- The industrial revolution accelerate population growth and thus needs to produce food.
- In the second half of the XXth century human intervention in the landscape reached a global scale.
- Productivist agriculture is pushing the bounds on water resources.
- The human usage of the natural resources is directly affected by climate change.

The challenge for the community

- Our knowledge on the water cycle is essentially of a system perceived as natural.
- How well do we know the processes governing slower reservoirs (groundwater, snow, glaciers, …) ?
- Climate change will perturb the real system but how relevant is our knowledge of the natural cycle ?
- Practices for water resource management are based on past experience. Have they evolved and taken into account knowledge on climate change ?
- Is our science relevant for the practitioner … what do we need to make the transfer of knowledge effective ?

Possible Structure for GC questions

1)Quantification of human intervention on the landscape and management of water flows.

2)Feedbacks between human intervention and climate.

3)Interactions of climate change with a human controlled land surface.

4)Combined effect land & water use and climate change on air and water quality.

Proposed implementation plan

Observational based studies :

- Should be based on RHP in regions of intense agriculture.
- Better quantify human control on the water cycle.
- Process studies on surface atmosphere interaction.
- Promote inter-disciplinary analysis.

Enhancing predictive capabilities :

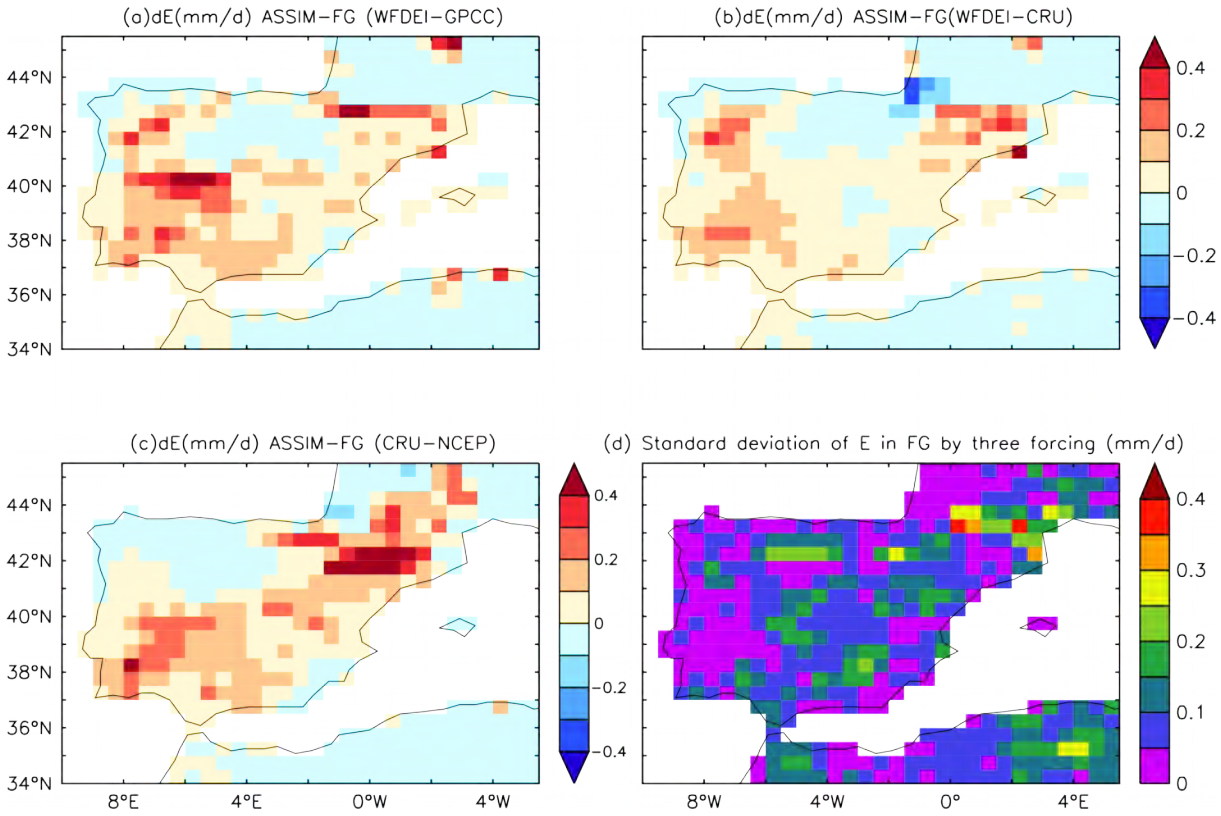
- Propose model inter-comparisons to promote model development.
- Re-visit the past evolution which combine climate change and increasing human intervention.
- Consolidate process knowledge in our models.

Observational based studies

Examples of on-going studies which could become part of the Grand challenge :

- HyMex
- PannEx
- Attempt at quantifying irrigation from remote sensed observations.

Assimilating river discharge



- Assimilating observed river discharge allows to correct the water divergence over the continents.
- ORCHIDEE forced by classical forcing data.
- 27 stations from the GRDC database can be used on the peninsula.

- The assimilation increases evaporation in areas known for intense agriculture.
- The correction in E is larger than the variance of E estimates of all 3 forcing.

Wang et al, 2018

The Ebro valley

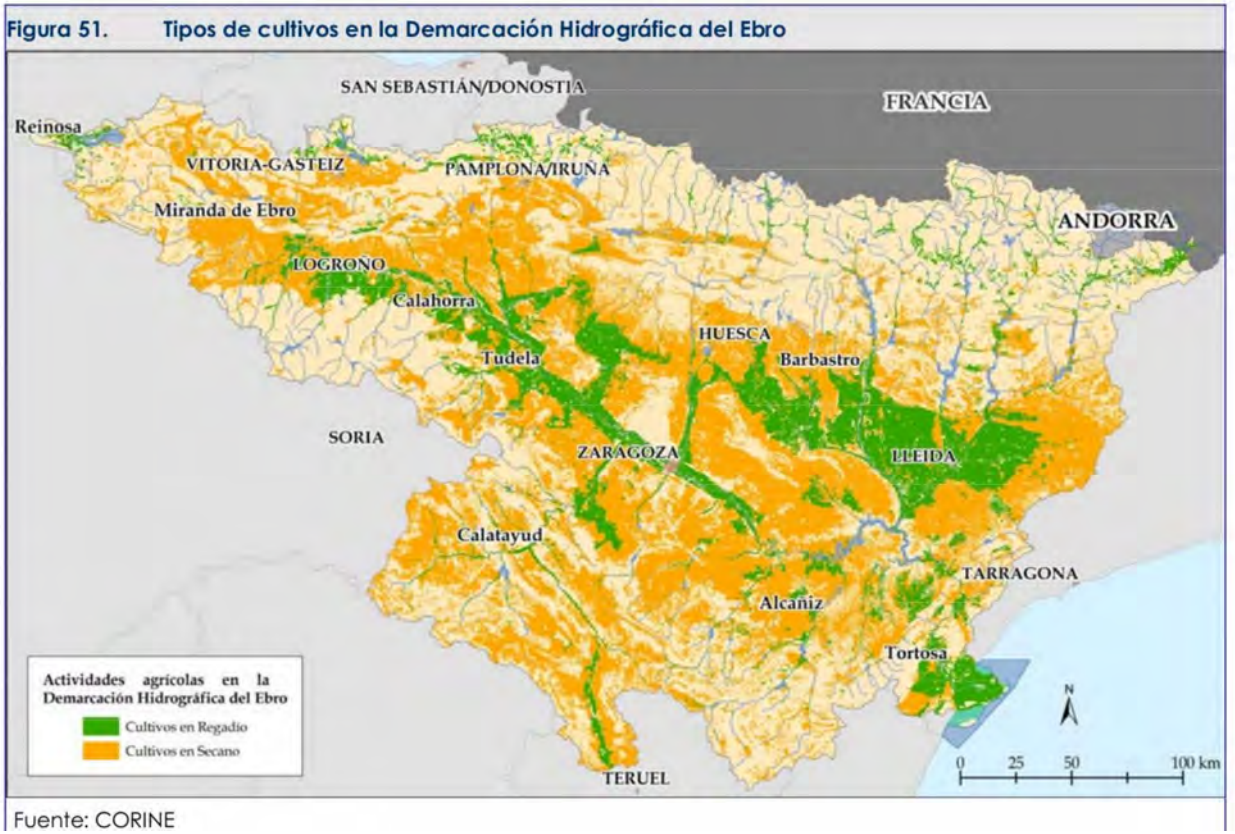
Agriculture

Agriculture is concentrated in the valleys.

Diversity of crops.

Water is needed mainly in spring and summer.

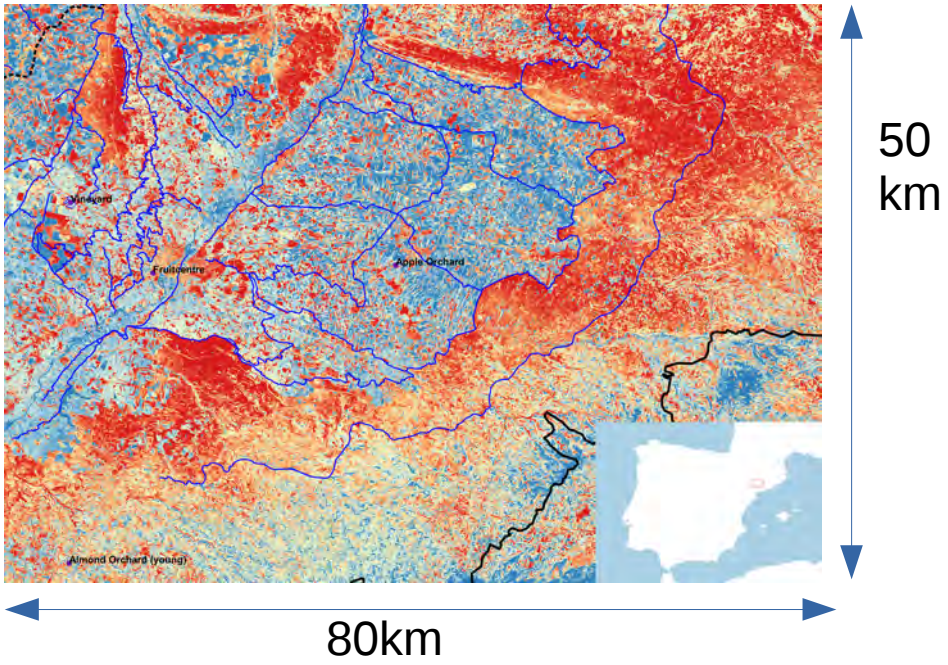
Water is stocked in dams and transported through the river and canal networks.



Only an understanding of the processes (Natural and socio-economic) should allow to represent this in our models.

The LIAISE field campaign

Sentinel2 IR image, ESA & sen2ET project.



- A field campaign is planned for 2020
- It will bring together resources from UK, France and Spain to observe the surface and atmosphere.
- Will involve ground and airborne observations.

Objectives :

- The dry-down of the surface and its impact of the surface heterogeneities.
- The impact of irrigation on the PBL and precipitating systems.
- Validate and improve coupled models over irrigated areas.

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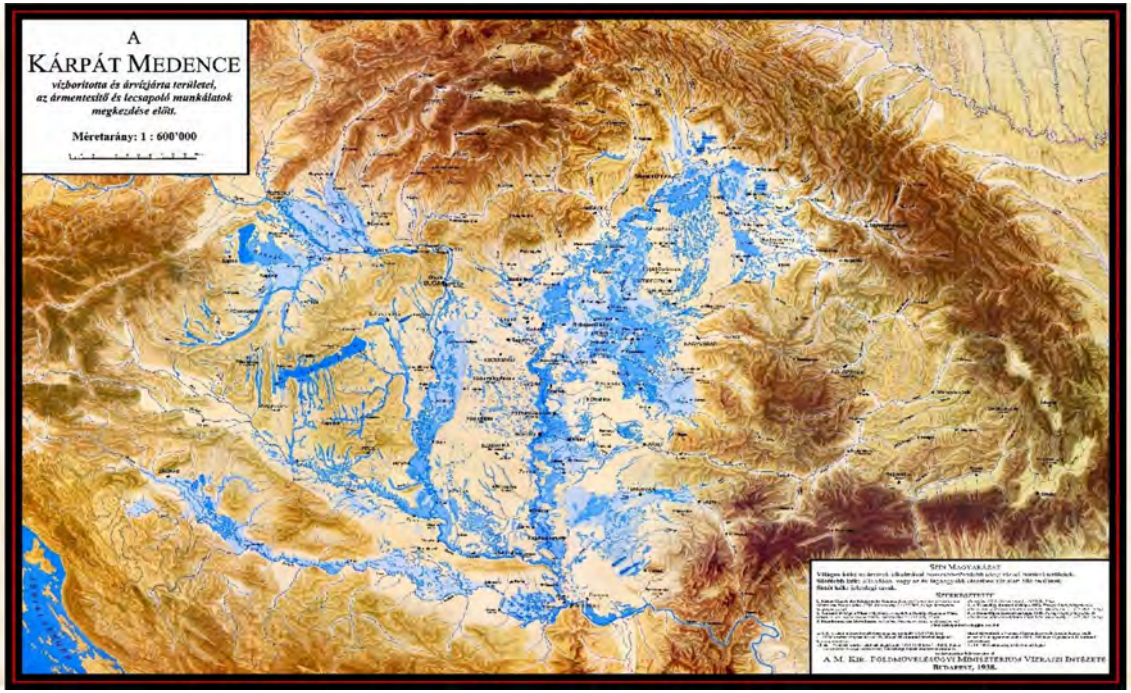
The Pannonian basin (Initiating RHP)

- Since the 19th century flood control measures were introduced along the Danube and its tributaries
- Fields were drained to make them arable.
- The Danube was developed as a waterway (Tiza river was shortened by 453km between 1846 and 1880).

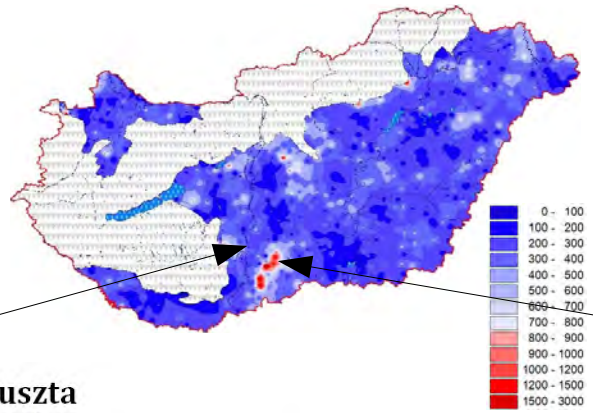


Blue regions used to be floodplains !

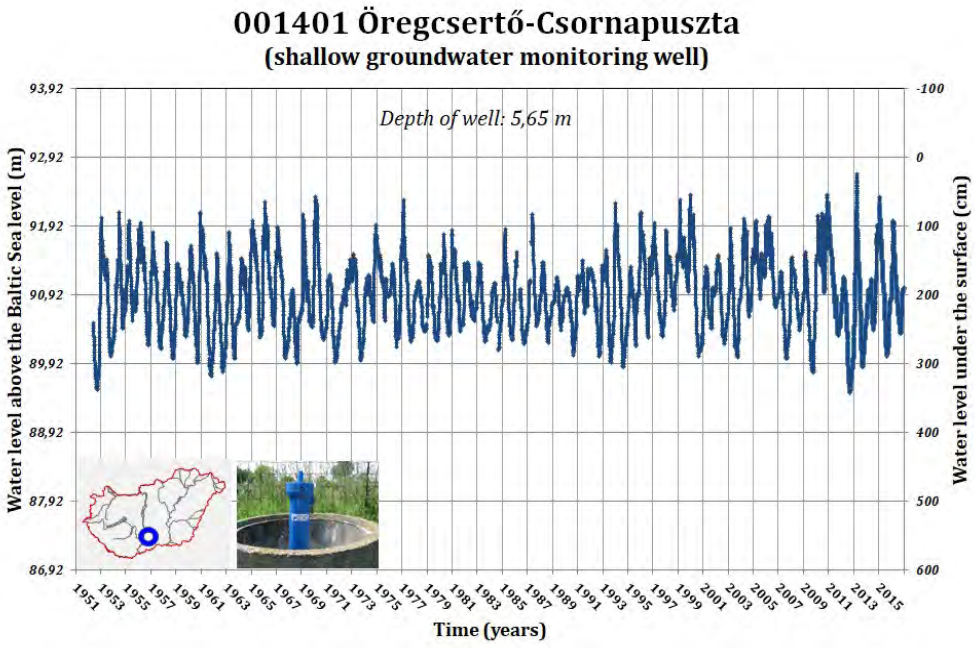
Ground water in the Pannonian Plain

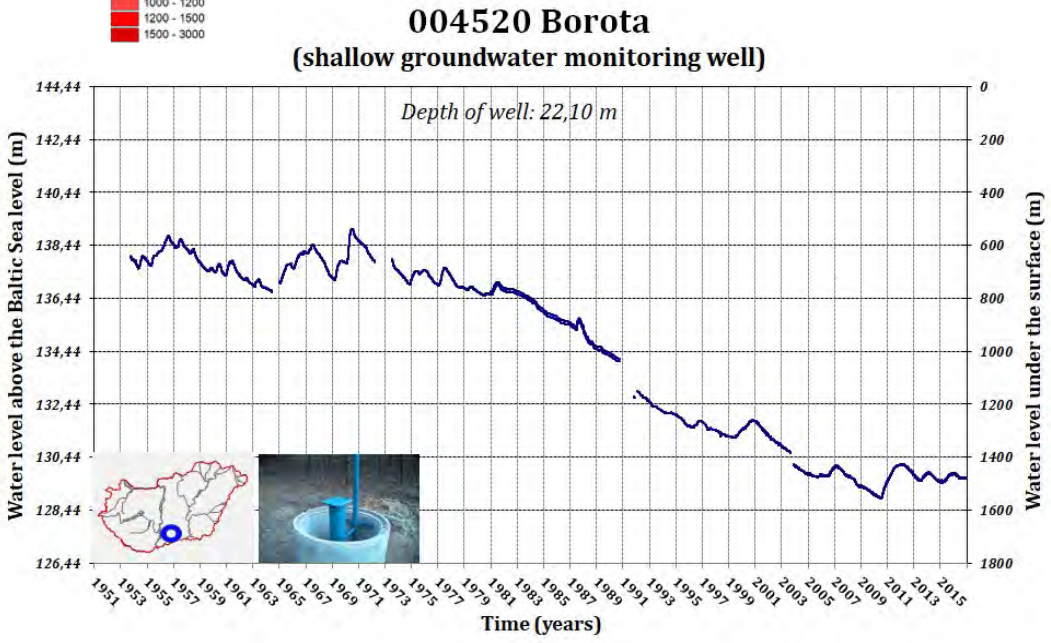
Average groundwater level (cm)
under the surface 1981-2010

A drained arm of the Danube has kept a shallow water table. Strong interactions with the atmosphere.



Under the moraine the water table is lower and shows long term trends : climate or land/water use ?





Source: Szalai,J.: Directorate General of Water Management, Hungary szalai.jozsef@ovf.hu

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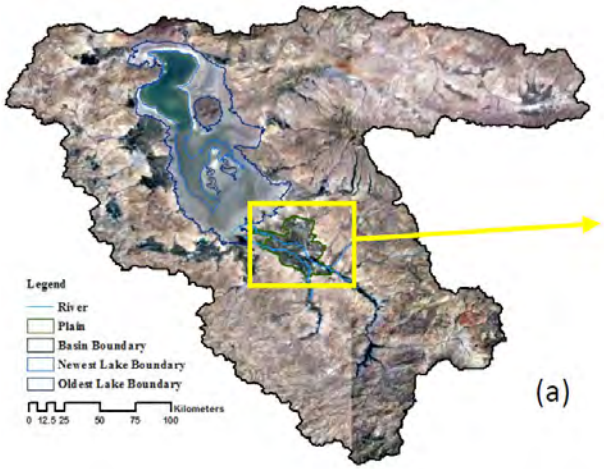
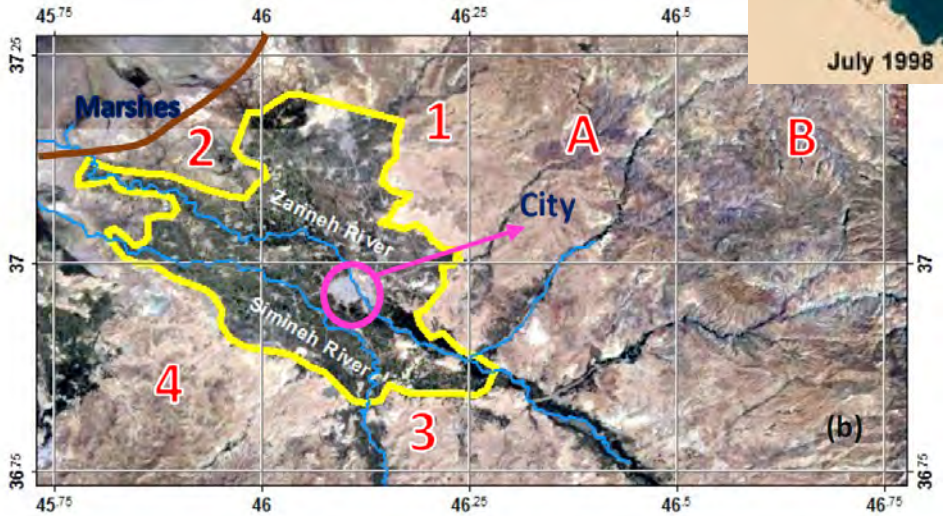
What can remote sensing bring ?

URMIA LAKE (Iran)

Vanishing Lake Urmia





DATASETS	AGENCY PRODUCER	SPATIAL EXTENSION	PERIOD	SPATIAL/TEMPORAL SAMPLING
GLEAM	ESA	Global	2011-2015	0.25-degree/1-day
AMSR2	JAXA	Global	2012-continuing	0.25-degree/~1-day
MSWEP	European Commission, Joint Research Centre (JRC)	Global	1979-2015	0.25/3 hours
In-situ Precipitation	Meteorological Organization	-	1980-continuing	1-day
In-situ irrigation	WRM organization	-	2012-2015	1-day

Initiated by Luca Brocca.

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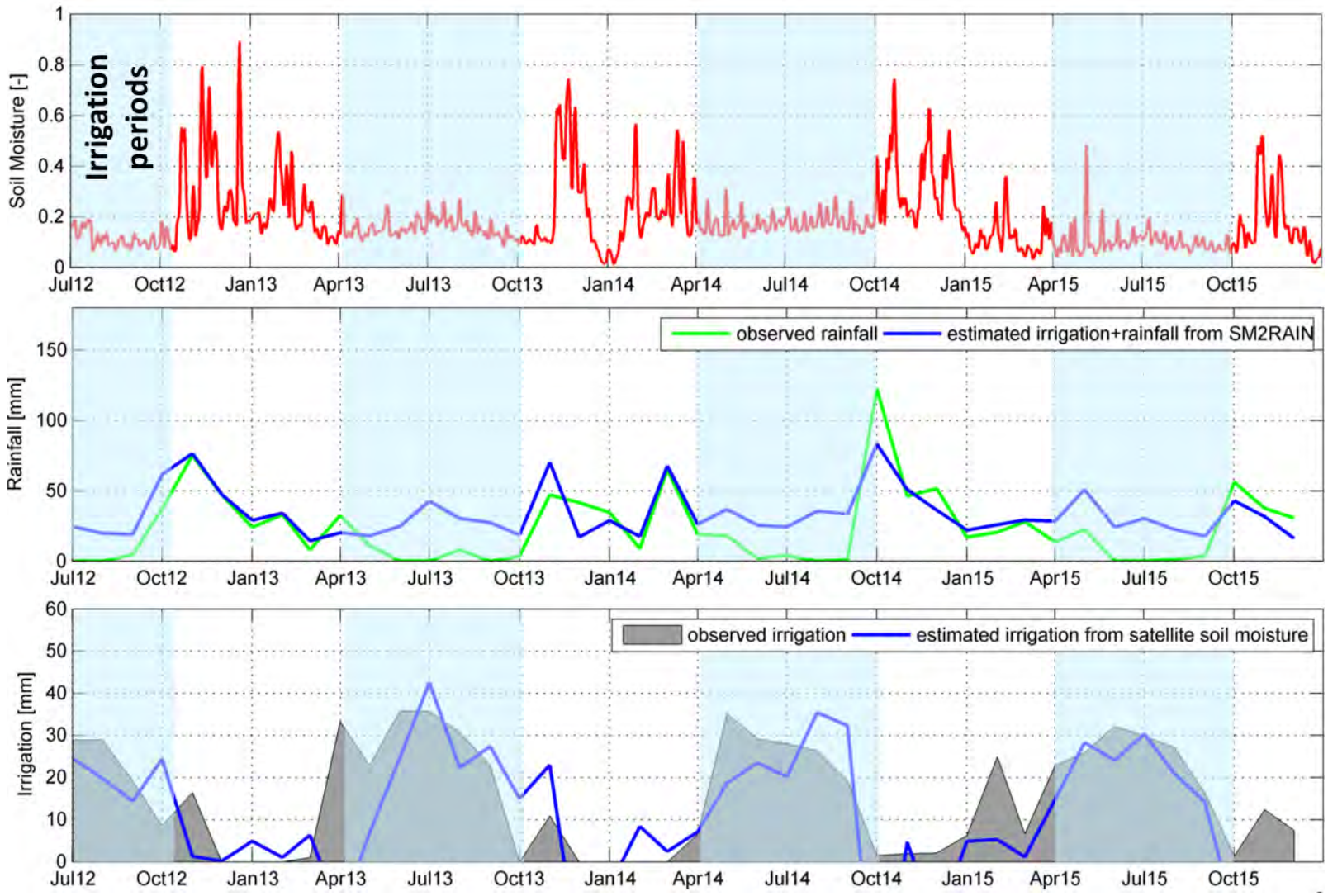
Remote sensing the timing of irrigation !



With current remote sensed variables, in some regions the irrigation can be identified.

Could this lead to global water cycle estimates that include human water usage ?

Jalilvand et al. 2018

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Enhancing predictive capabilities

Motivation :

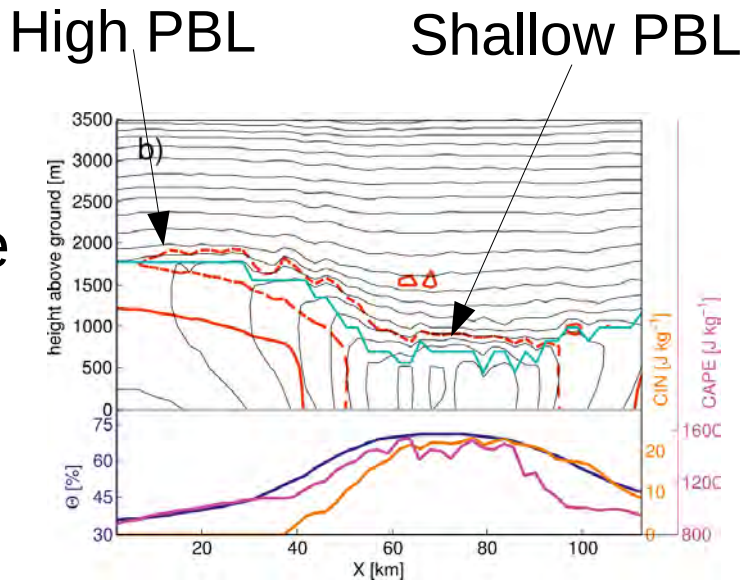
- Understand the interactions between water management and climate variability and change.
- Improve our modeling capabilities of human water management.
- Regional re-analysis which include the evolution of water usage and land use … thus reproduce the real water cycle.

Methodology :

- Downscaling with convection permitting models.
- Re-visit the last 50 years over a region with a large expansion of irrigated crops.

Why use CP-RCM ?

- The land surface and water usage changes have modified the planetary boundary layer :
  - In its diurnal development,
  - Its water and aerosol content,
  - Its chemistry !
- When humans cut trees, plant, irrigate build reservoirs, ... they create gradients at the surface. In the last years observations and modelling studies have shown that small scale gradients are key in the surface atmosphere interactions. Is it time to read again some old papers (Avissar et al.) ?

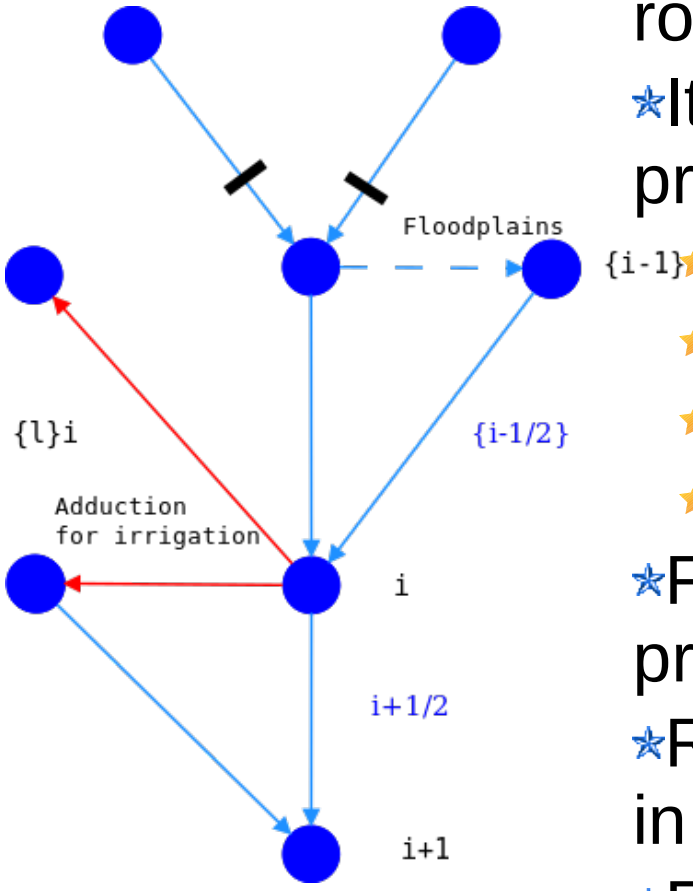


Froideveaux et al. (2014)

Where does land modeling stand ?

- Irrigation can be imposed without consideration for the water balance. Any LSM can participate.
- Parametrized management as in global hydrological models.
- Predicting human water management in the land surface models.
- With increasing degrees of liberty
  - Model errors become more problematic.
  - But, more feedbacks can be represented.
  - Less data is needed from a sensitive area for countries.

Adding water management to a LSM



A prototype for the water regulation in the routing scheme exists and is being tested :

- It predicts 4 value classes with the following priority:
  - *Ecological flow*
  - *Domestic water*
  - *Agricultural needs*
  - *Energy production*
- For analysis purposes the model continues to predict a natural flow.
- Runoff and drainage generate ecological flow in the graph.
- Regulation points (dams) can transfer water to other classes.
- Water bodies (regulated or not) revert all classes to ecological flow.

Thesis of Xudong Zhou

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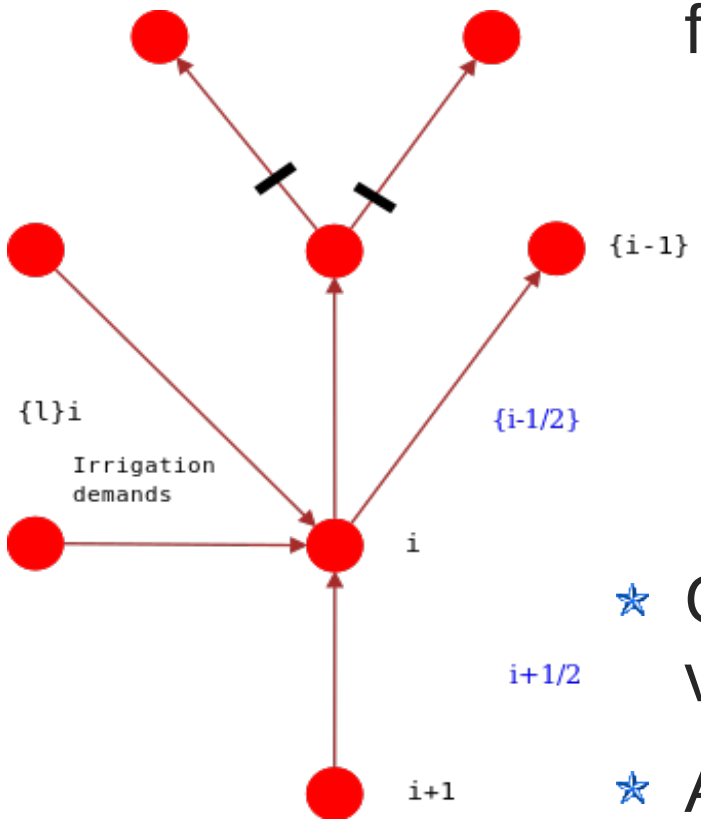
Modeling water demands



- For each value class a demand function is formulated at the grid box level :
  - Ecological flow : total water in river cannot fall below the 90% quantile.
  - Irrigation : based on the difference between potential and actual transpiration of crops.
  - Domestic & Hydro-power : to be implemented.
- Grid-box demands are transferred to the vertices following the adduction network.
- All unsatisfied demands are propagated up-stream (Daily time step).
- Dams respond with their management rules to unsatisfied demands integrated over downstream vertices.

Expected outcome of the modeling exercise

The re-visit of the last 50 years with and without water and land management will inform us on the following points :

- Can we reproduce the past evolution of the real water cycle ?
- What is the impact on near surface variables and the PBL ?
- Is there an interaction with extreme events ?
- Does potential evaporation change ?
- Relative contributions of climate and management to river flow changes ?
- Which are the the dominant processes in ground water evolution ?

Conclusion

- Since 2017 this Grand Challenge has progressed.
  - From a large scale scoping in early 2017 we have moved to more focused targets.
- We have focused more on GEWEX science questions.
  - Which panels want to contribute and how ?
  - There is a wide scope of processes to be studied around the water usage which exists in many regions.
- What is the future of grand challenges within WCRP ?
  - Perhaps we are too narrow with our proposal now !
  - But if WCRP does not want to carry this further, it could perhaps be useful for GEWEX !