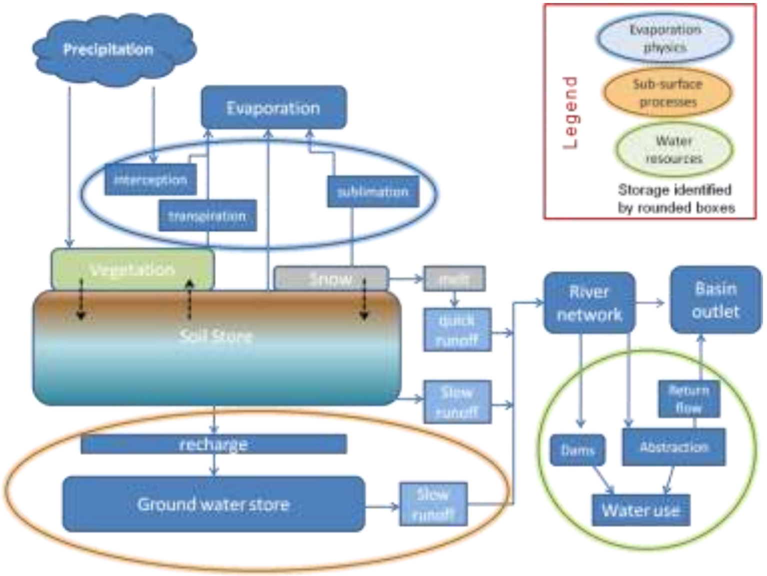
JULES and the Terrestrial Global Water Cycle

Richard Harding
Doug Clark
WATCH Partners



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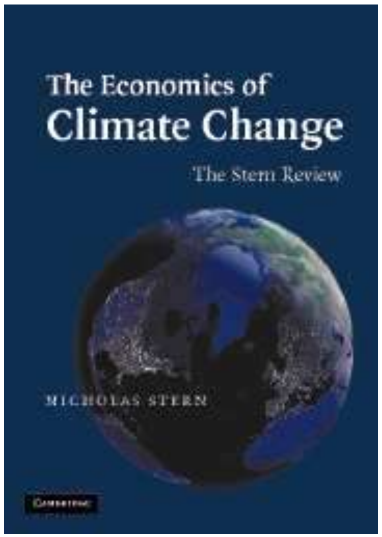
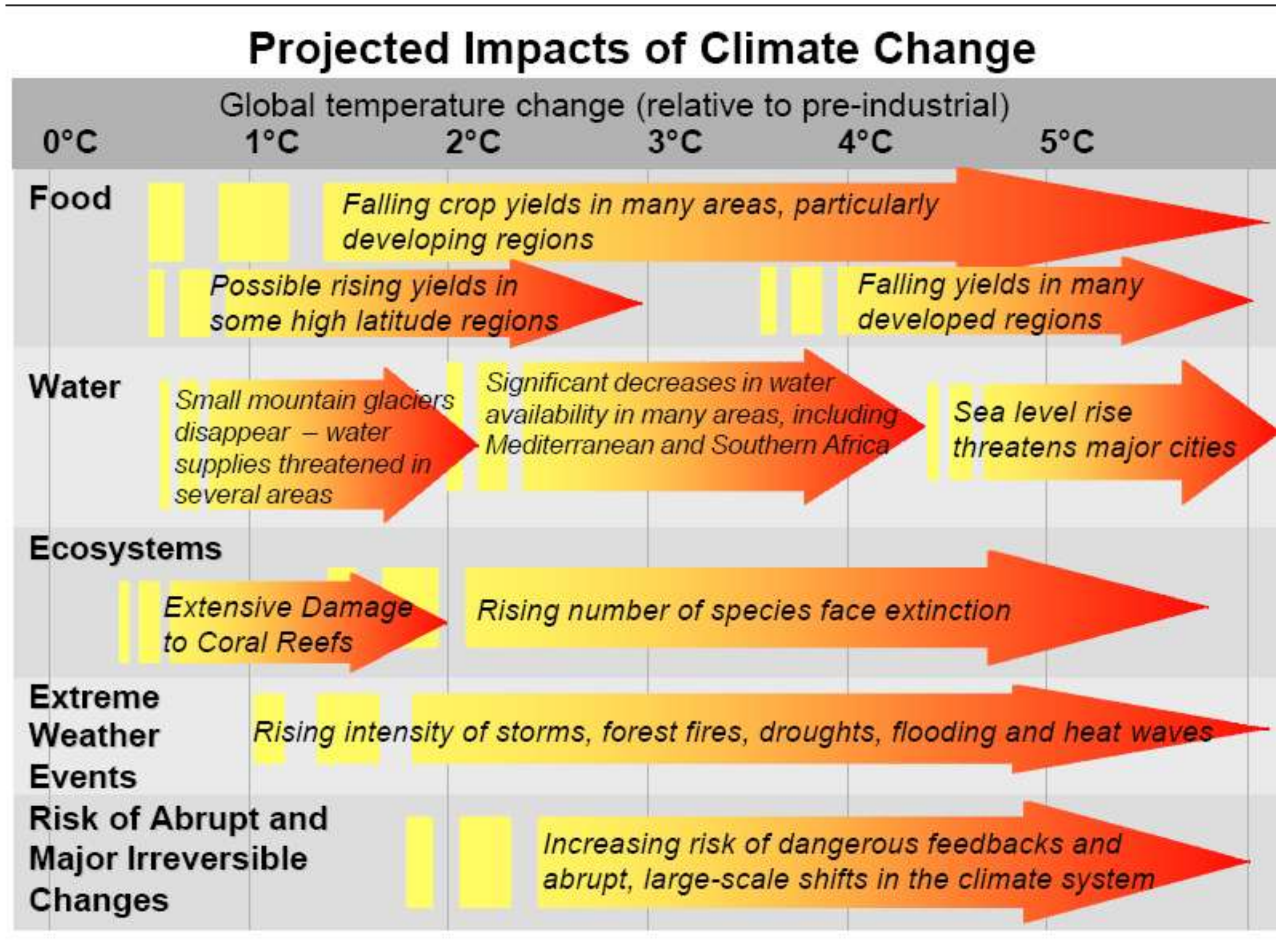
WATCH
Water and Global Change

Impacts of Climate Change





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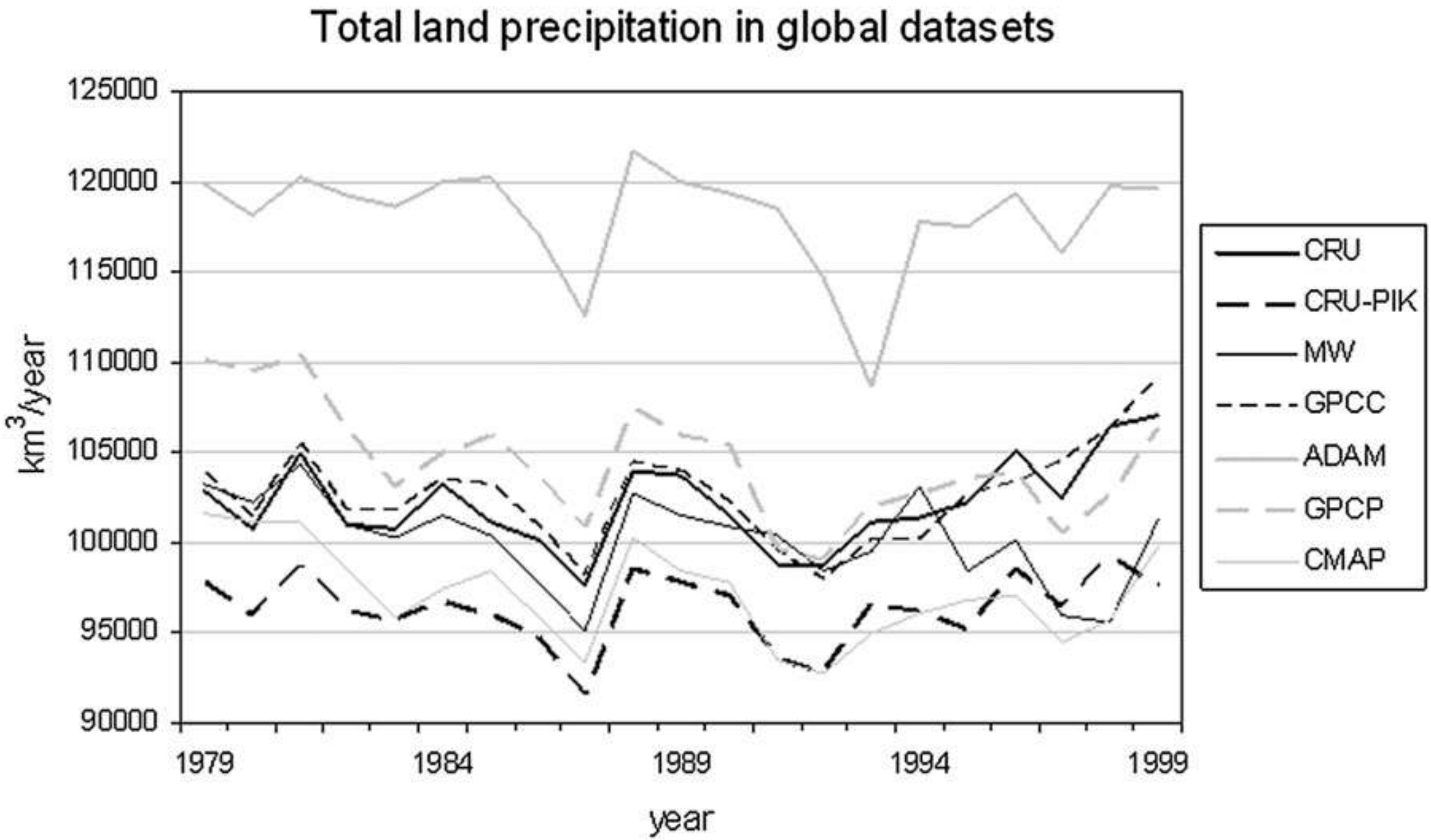
Uncertainty in land precipitation



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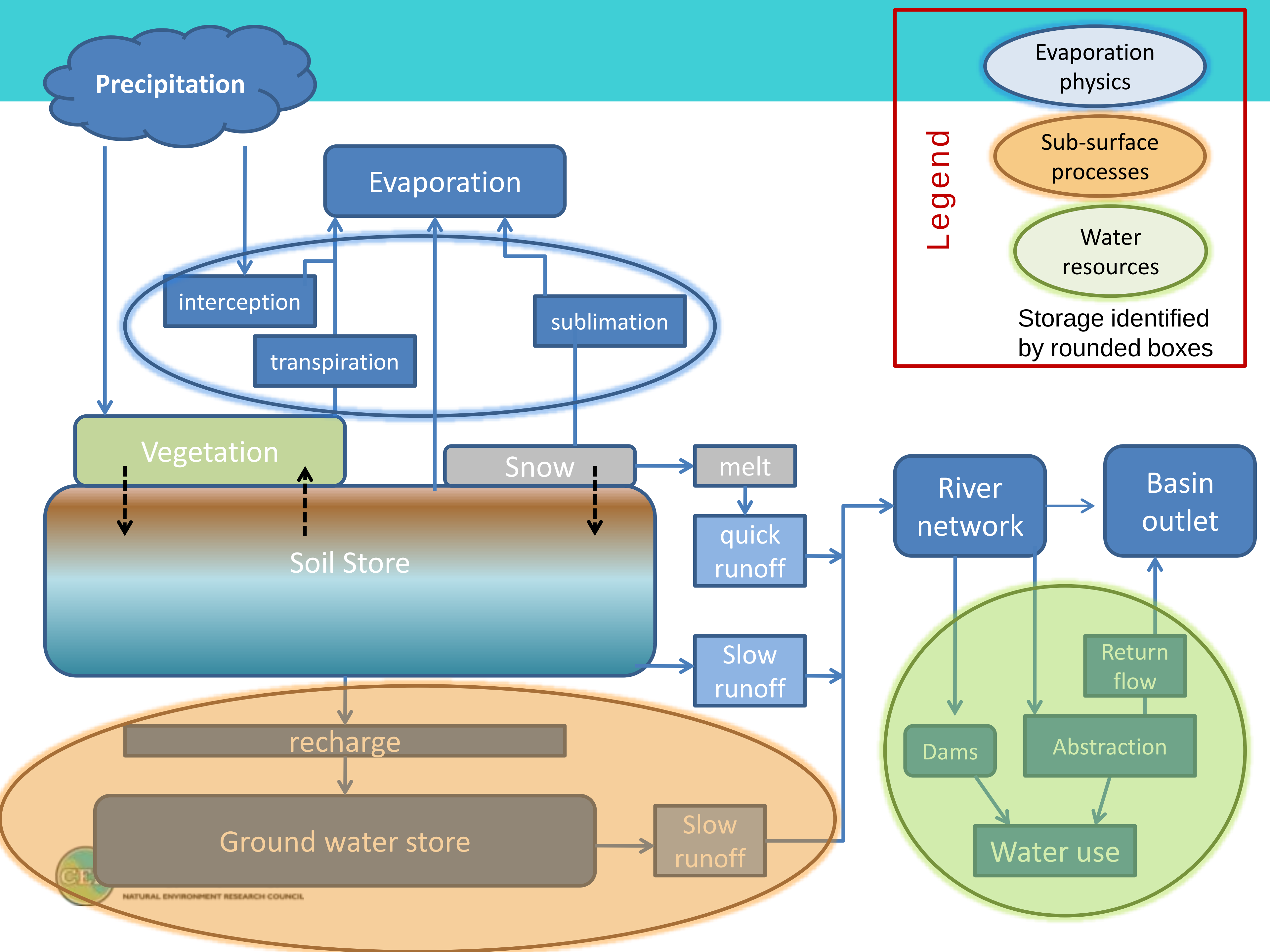
Biemans et al 2009


Precipitation
Evaporation
interception
transpiration
sublimation
Vegetation
Snow
Soil Store
melt
quick runoff
Slow runoff
River network
Basin outlet
recharge
Ground water store
Slow runoff
Return flow
Dams
Abstraction
Water use
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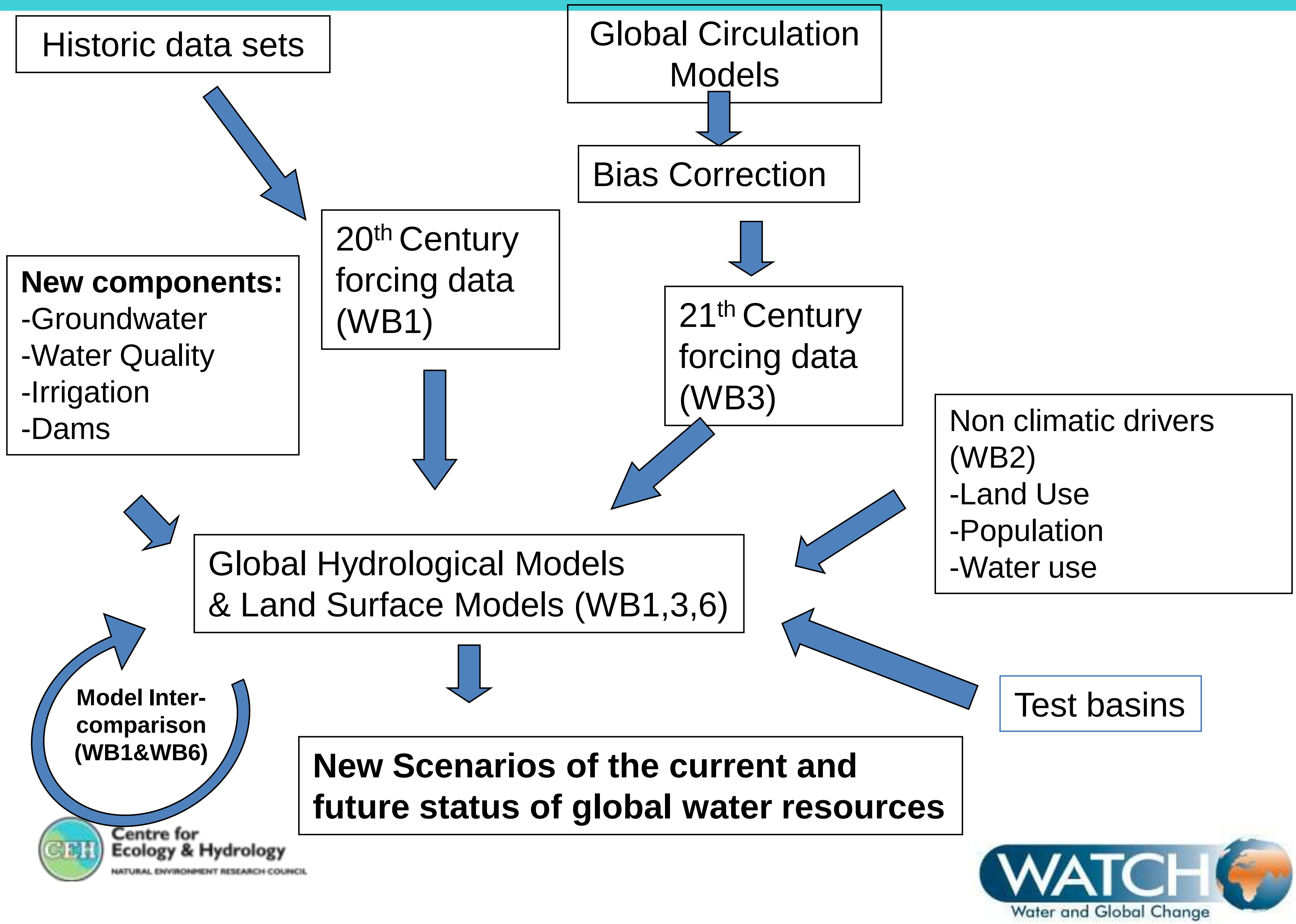
Legend
Evaporation physics
Sub-surface processes
Water resources
Storage identified by rounded boxes

The WATCH Modeling Frame work



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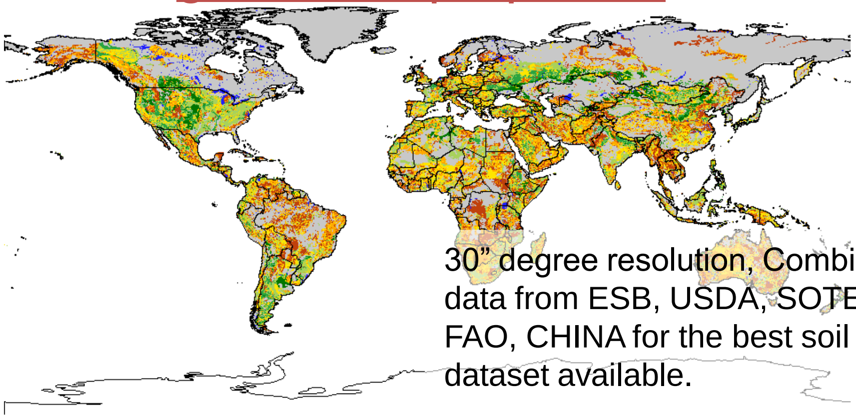
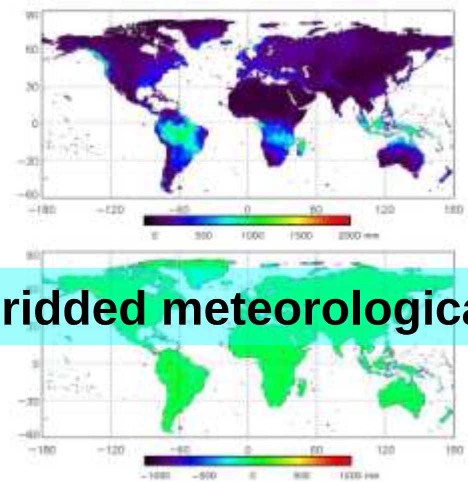
New global data products:

global soil properties

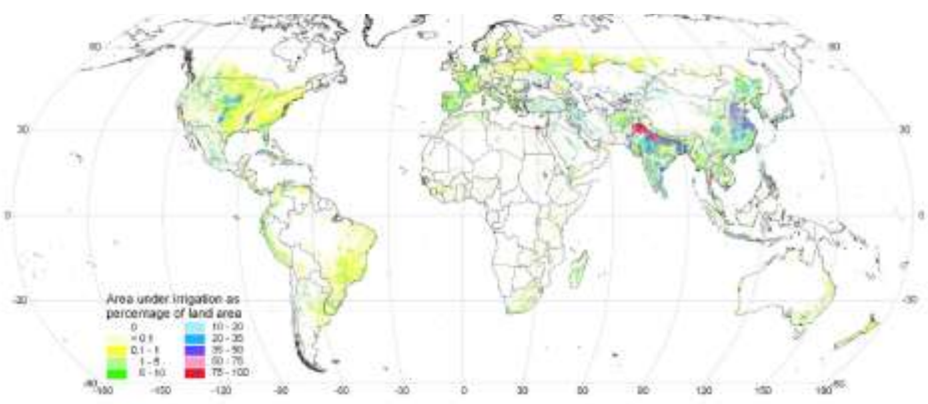


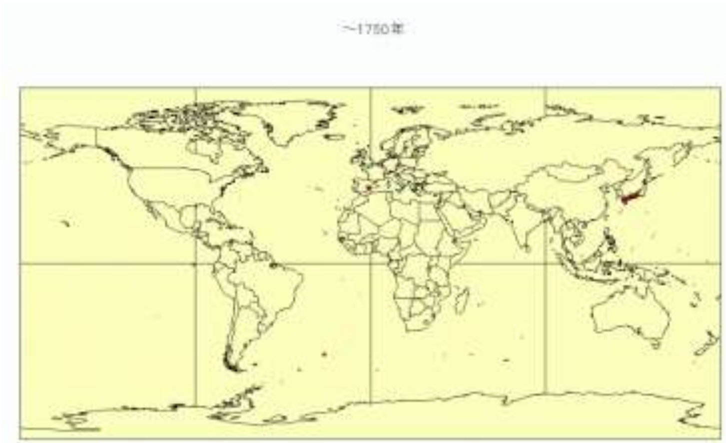
30" degree resolution, Combines data from ESB, USDA, SOTER, FAO, CHINA for the best soil dataset available.



Gridded meteorological data

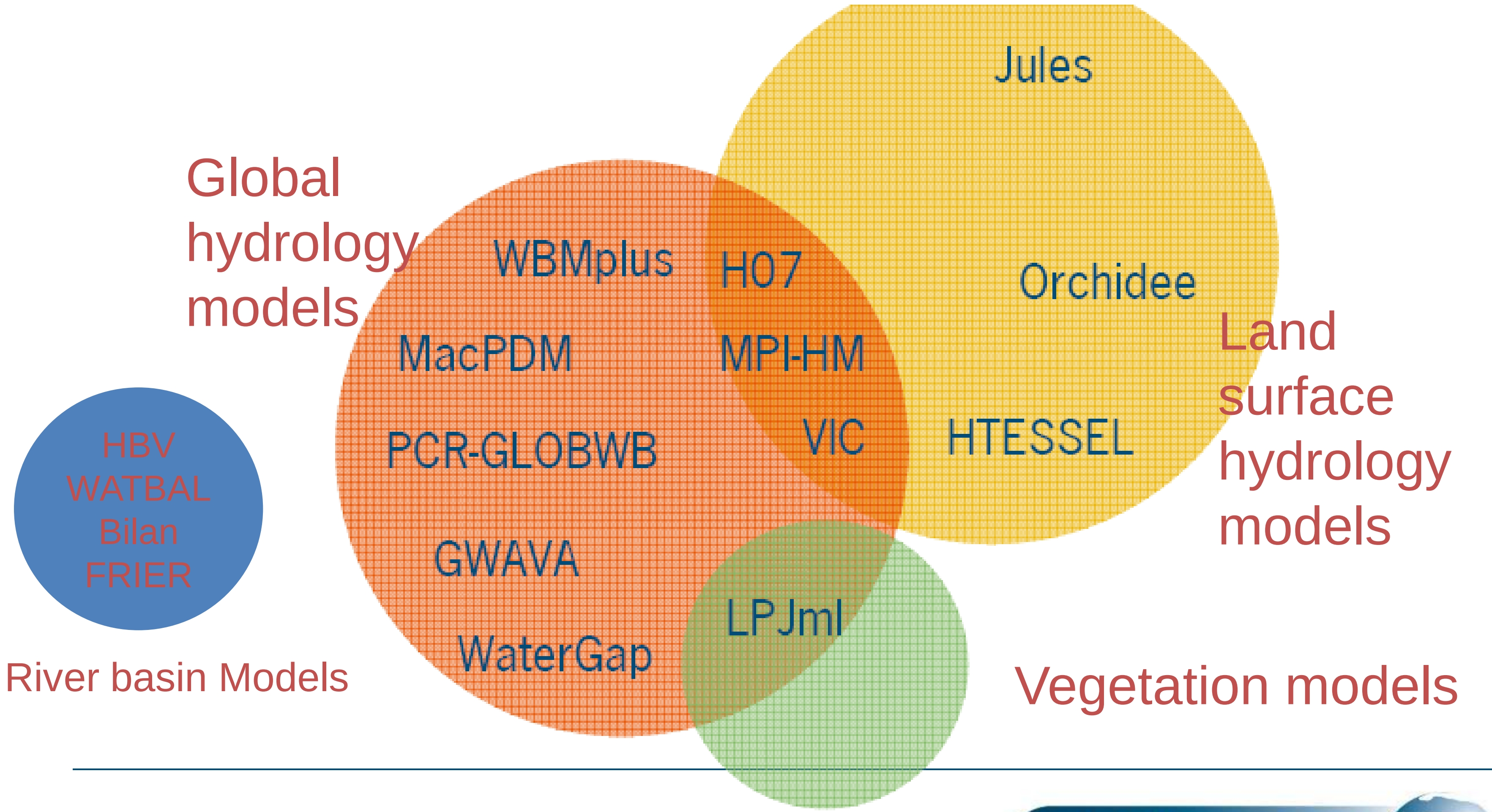
Irrigated areas of the World





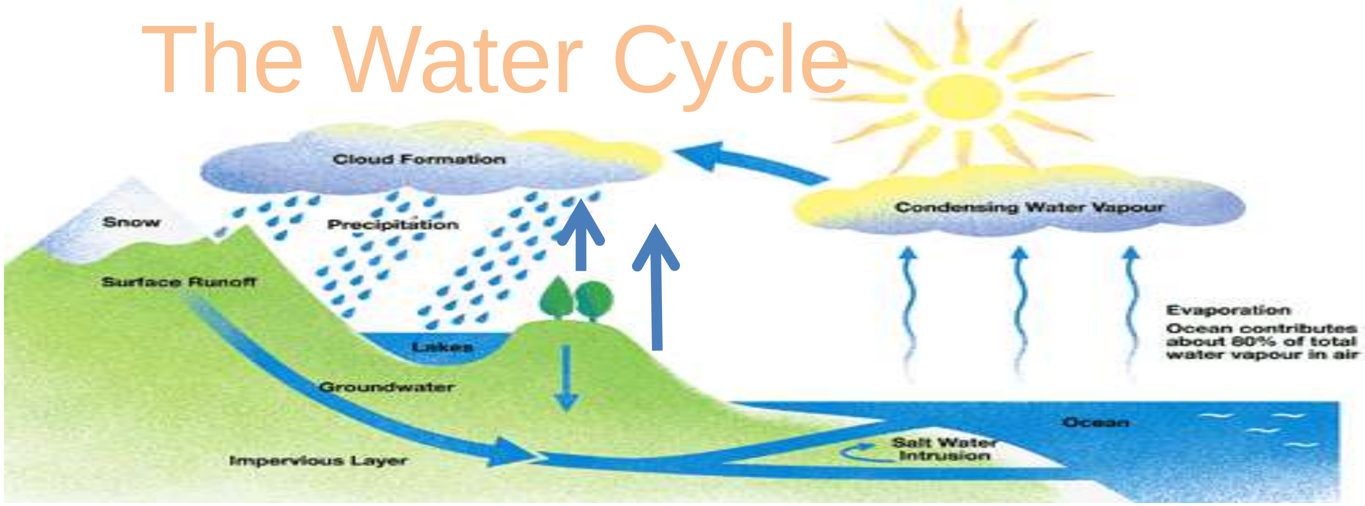
Global Reservoir Database

WaterMIP: Land Surface Hydrology Model/ Global Hydrology Model Intercomparison



The Global Water Cycle

The Water Cycle



Global land

Precipitation
Mean: 872 mm yr^{-1}

Evaporation
Mean: 499 mm yr^{-1}
Range: 415-586 mm yr^{-1}

Runoff
Mean: 375 mm yr^{-1}
Range: 290-457 mm yr^{-1}

ΔSoil = 16 mm, ΔSnow=33mm

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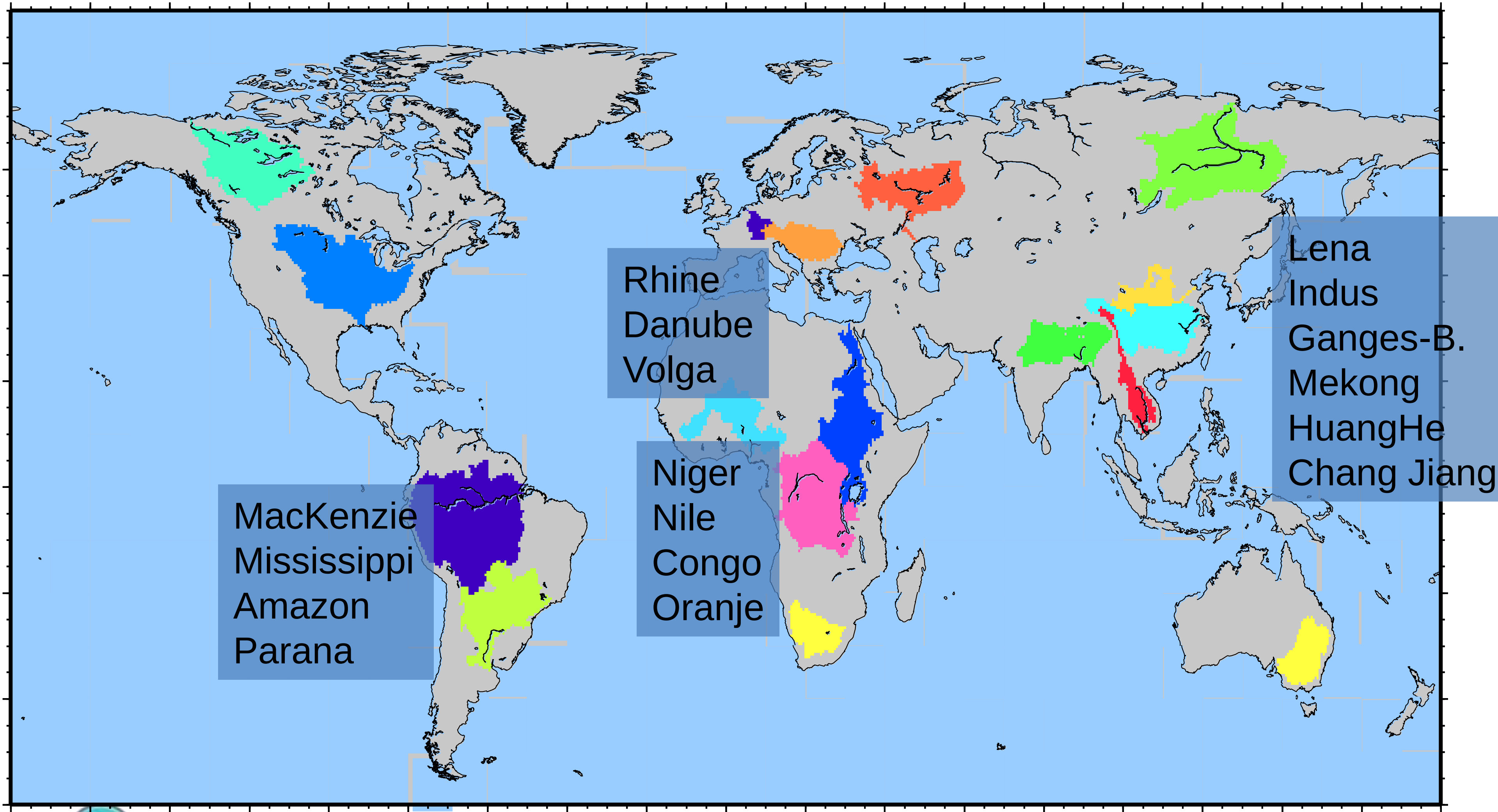
RIVER BASINS



Murray-Darling

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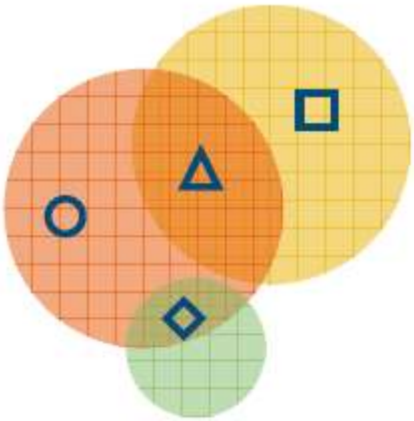
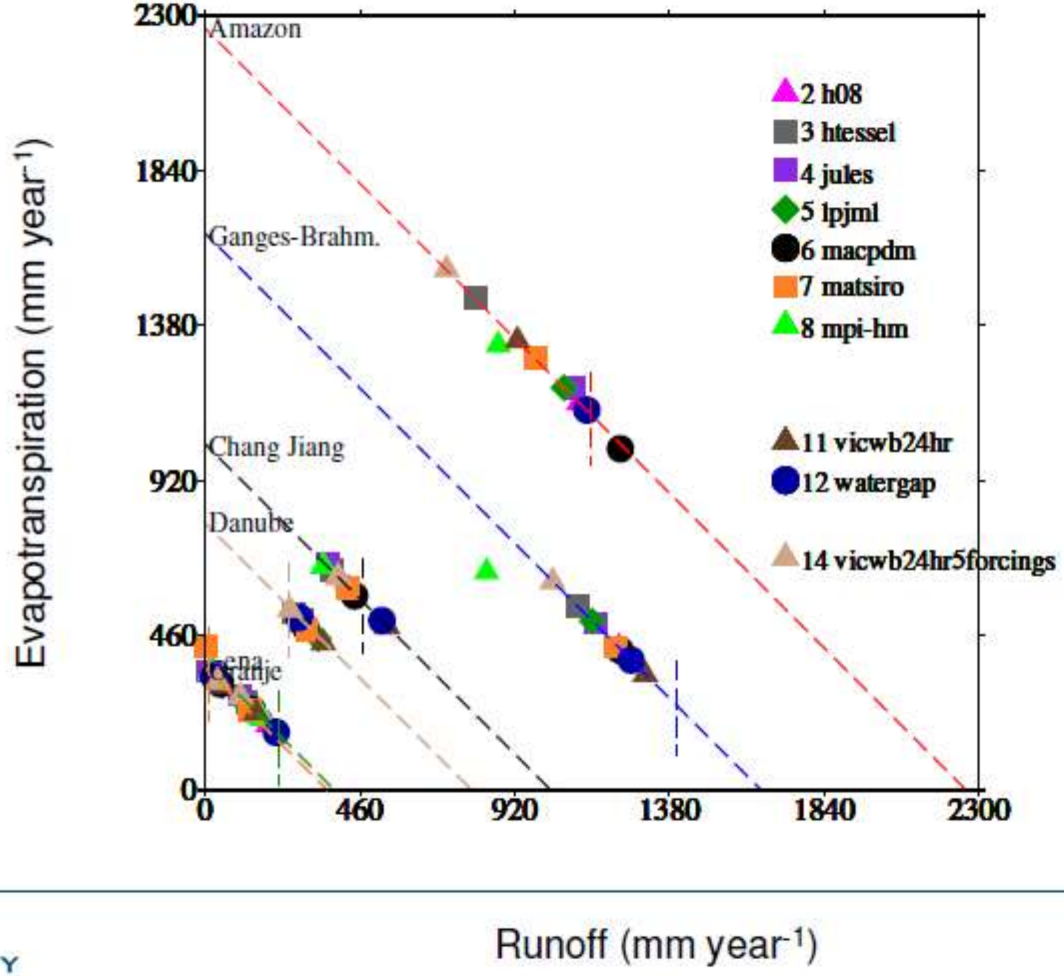
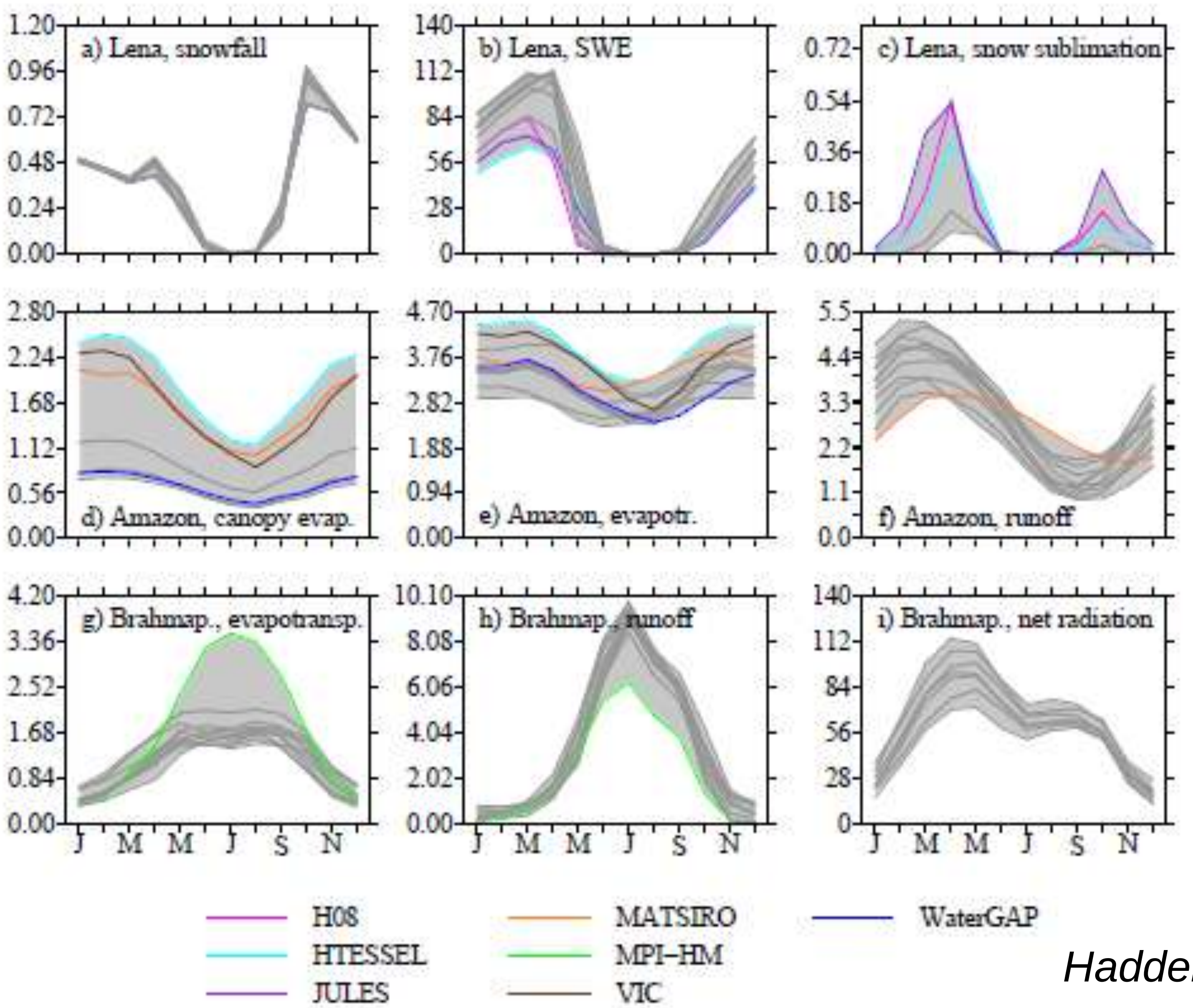
Mean annual water fluxes (mm year^{-1})





Seasonal spread of models



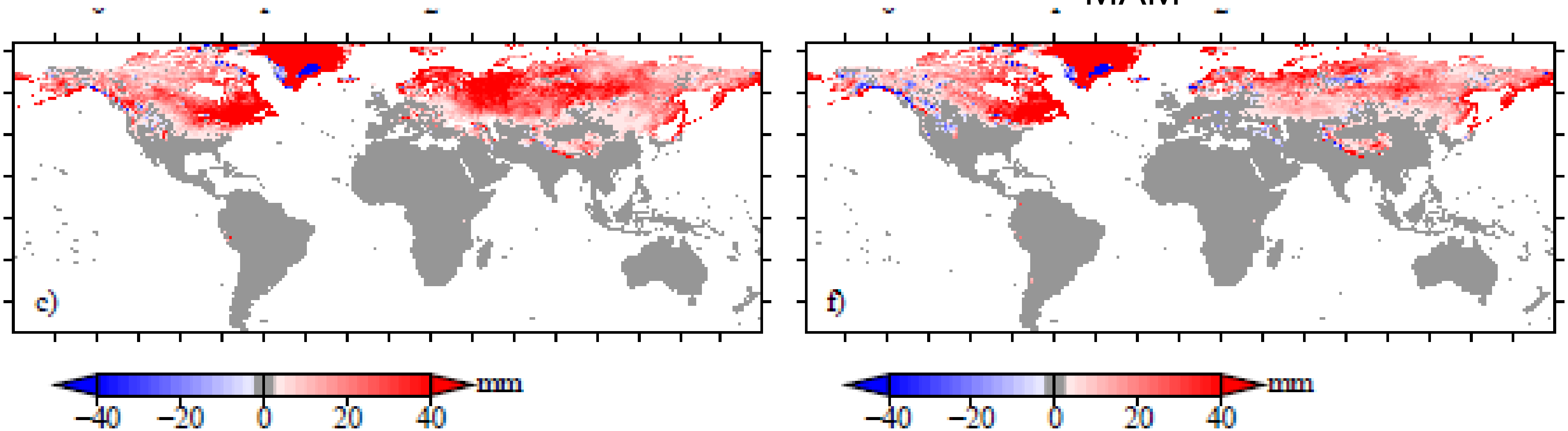
Haddeland et al 2011

Representation of snow

Mean snow water equivalent: degree day models minus energy balance models

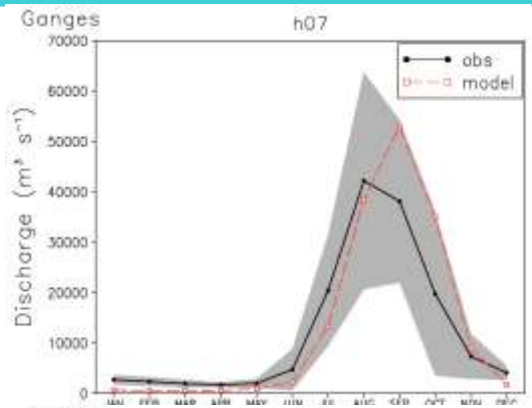
DJF

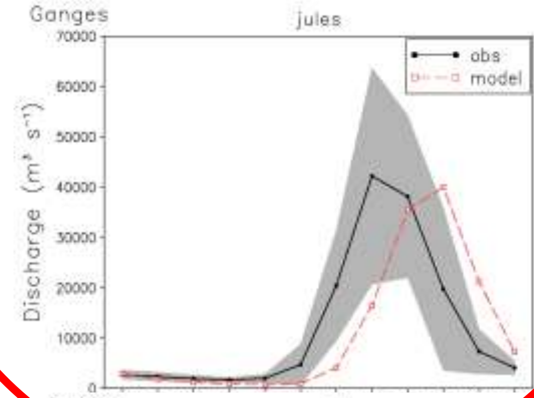
MAM

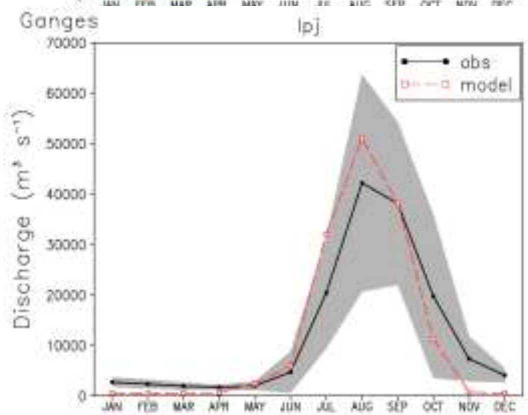


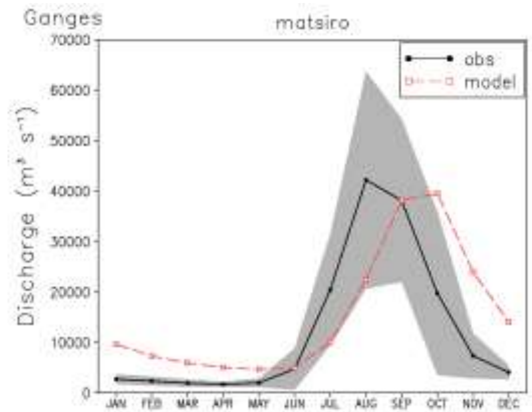
Haddeland et al 2011

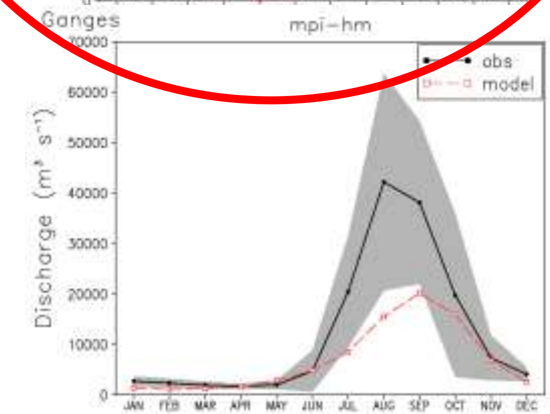
Simulations from 8 models for the Ganges basin (1985-1999)

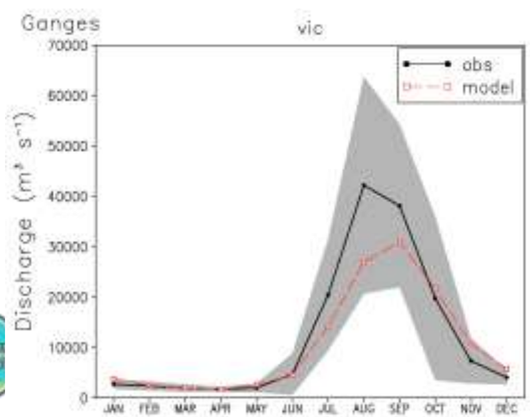


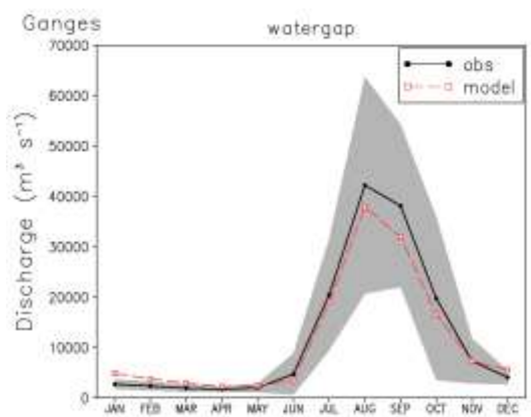


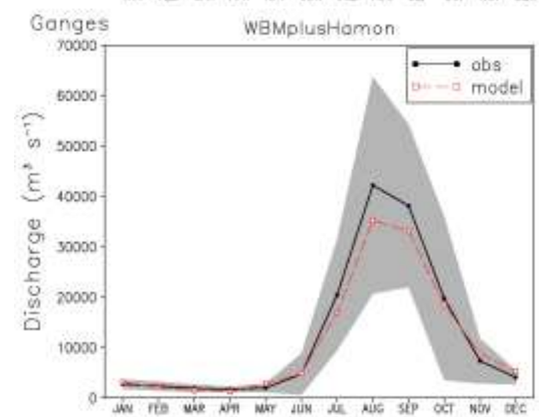






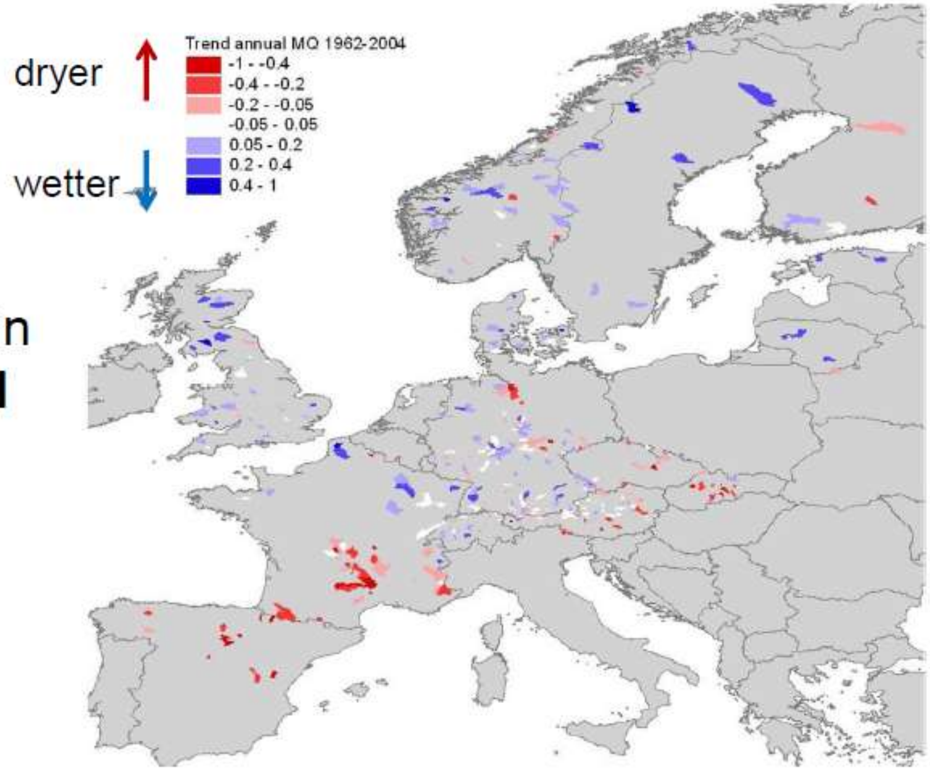






Drought 20th Century

Trend in **annual mean** flow

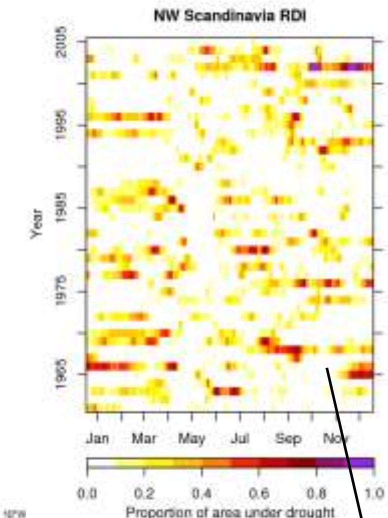


Observed pattern and changes

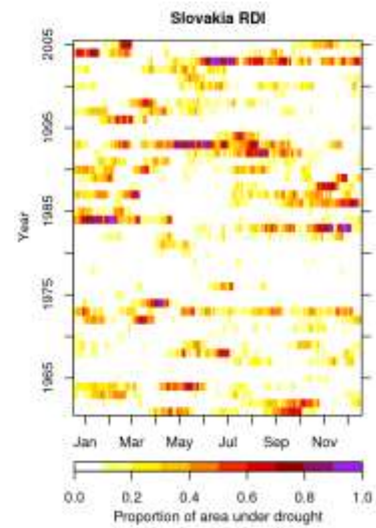
1962-2004

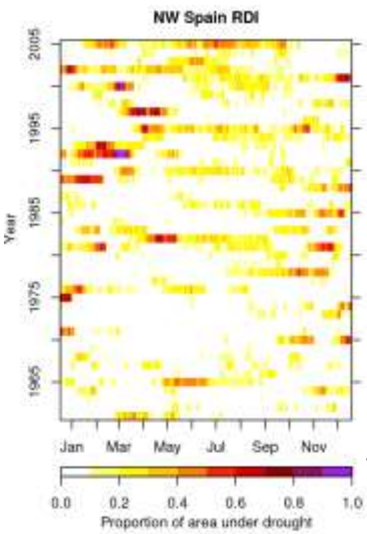
Stahl et al. (2010)

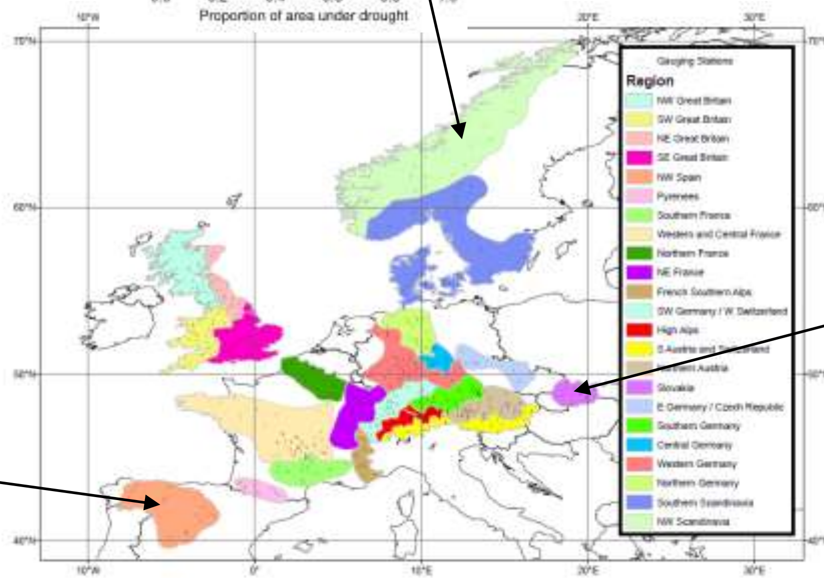
20TH CENTURY DROUGHT CATALOGUE



Norway, 2002







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Hannaford et al., (in press) Hydrol. Process

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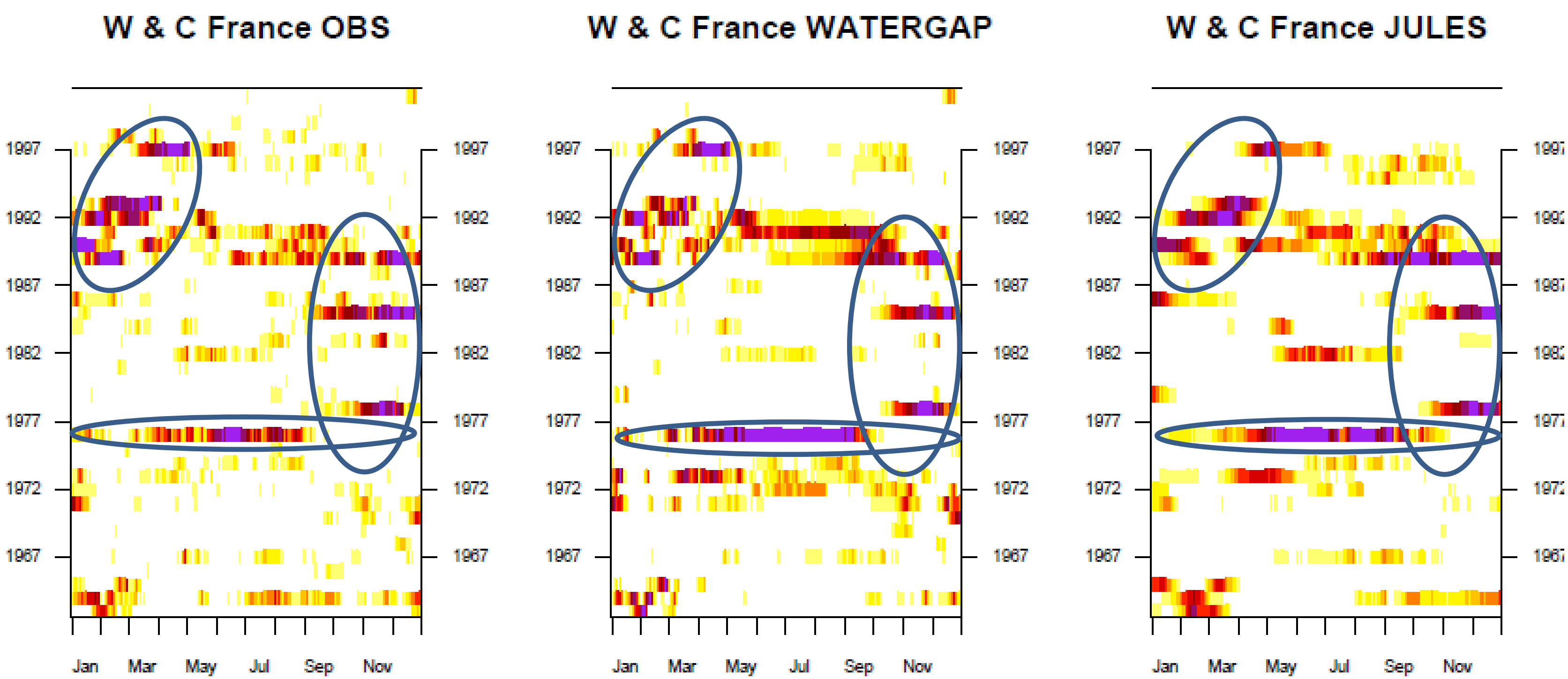
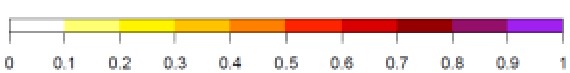
defra Department for Environment Food and Rural Affairs

Environment Agency

How well do we represent droughts?

Good reproduction of major drought events





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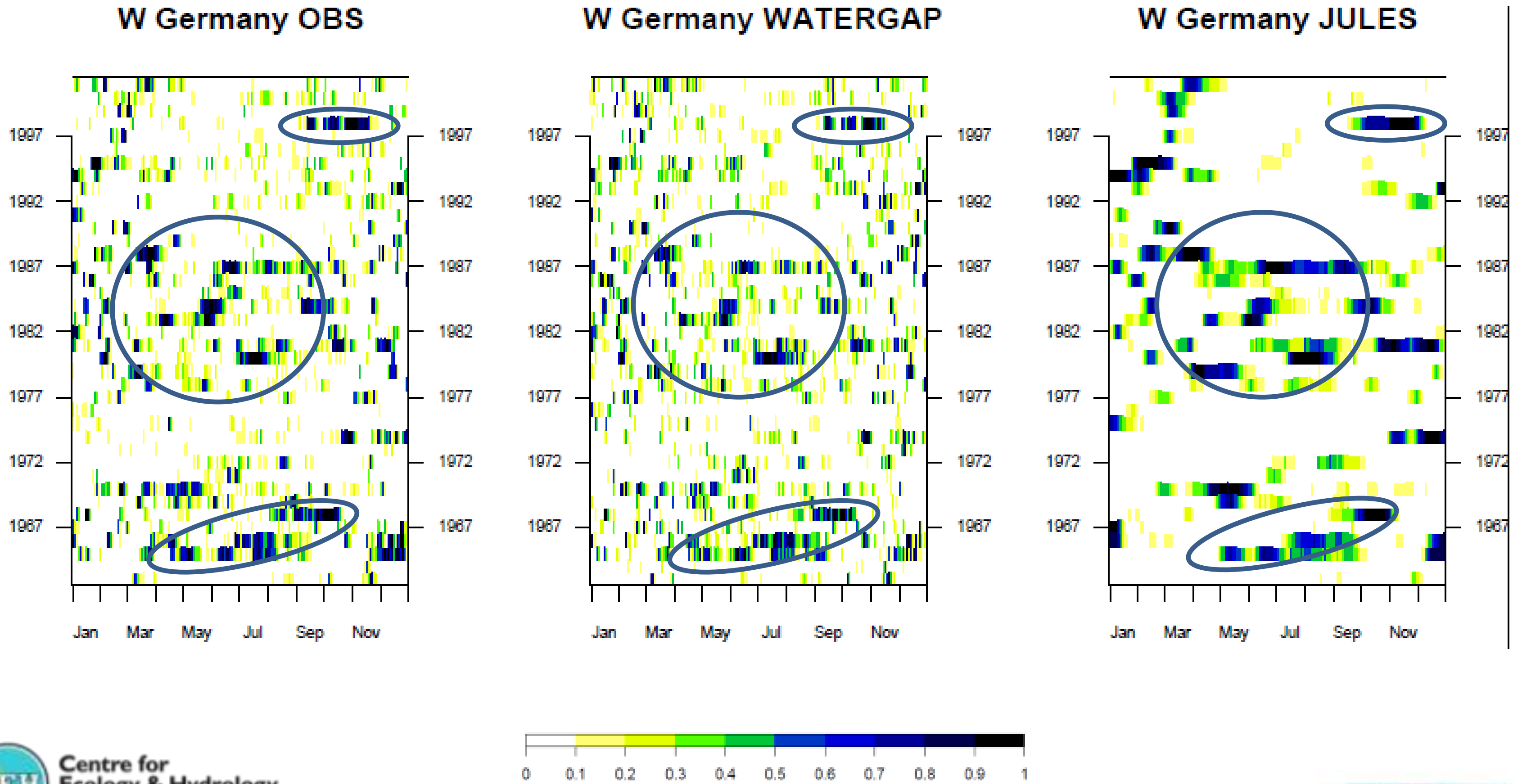
Analysis of floods

Good reproduction of major high flows/flood events



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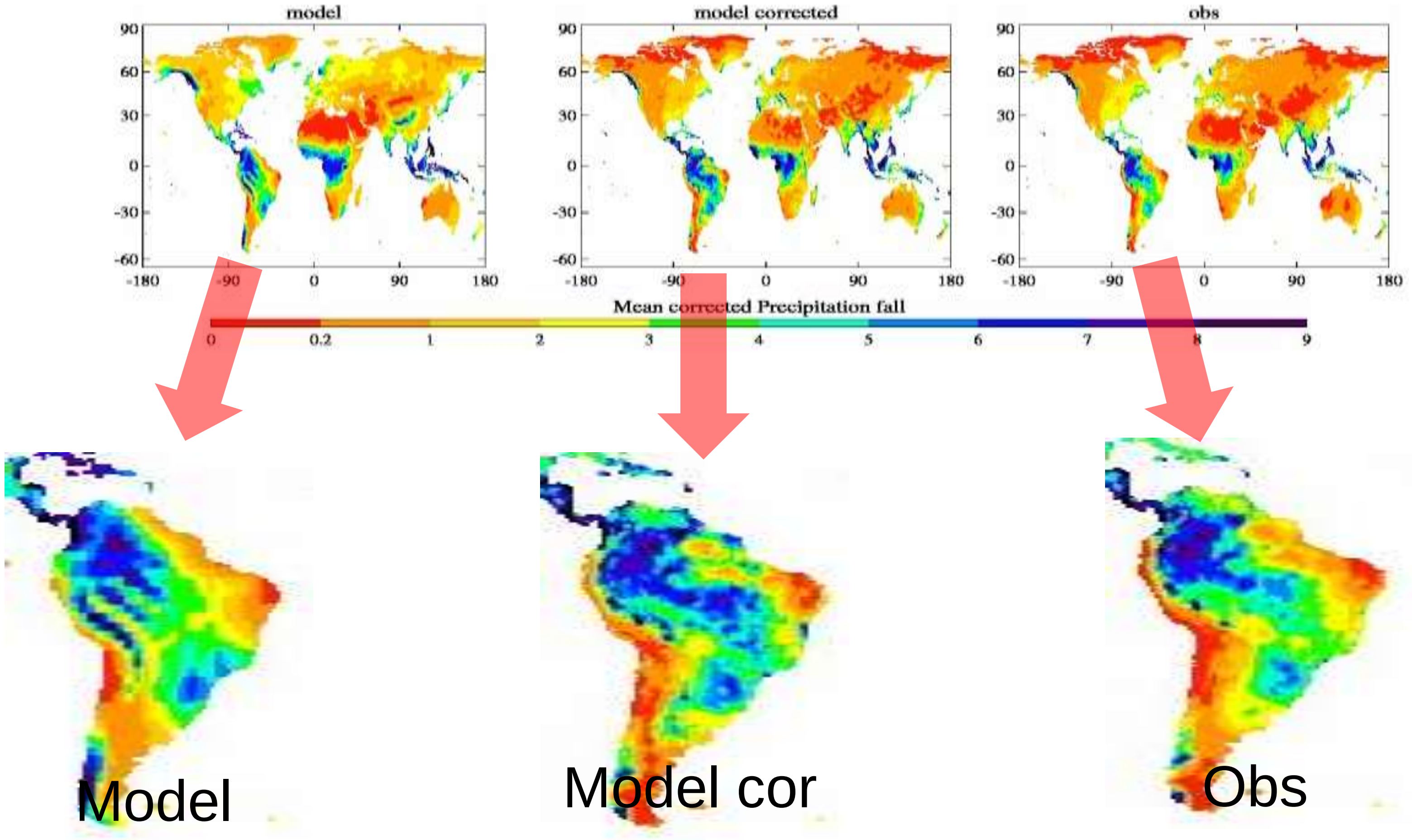
Does the method work?… well yes.



1990-2000 January precipitation over South America corrected using 1960-1970 transfer function.

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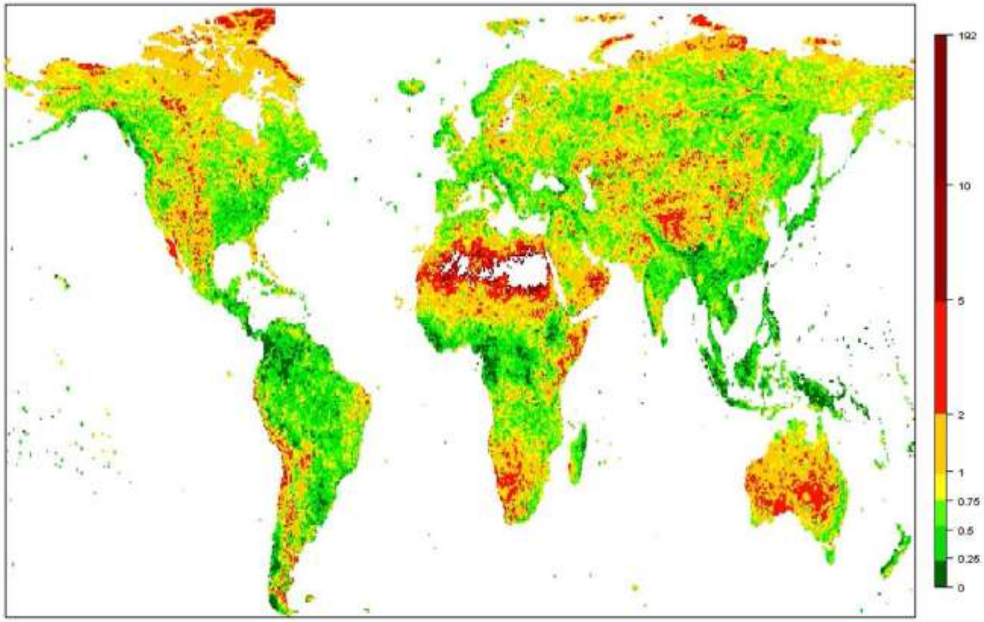
Drought 20th Century



low agreement

Average drought duration

Agreement large-scale models

high agreement

Van Huijgevoort et al., in prep.

The WATCH 20th Century Ensemble Product

Average values for seven models, daily, half-degree grid, global, 1901-2000.

Evapotranspiration
Soil moisture
Total runoff (Qs + Qsb)
Snow water equivalent

Product variables stored in NetCDF files:

mean	=	Mean value of nmodels
nmodels	=	Number of models averaged (usually = 7)
sem	=	Standard error of the mean
max	=	Maximum value of nmodels
min	=	Minimum value of nmodels
maxmodel	=	Code for model giving maximum value
minmodel	=	Code for mode giving minimum value
outmodel	=	Code for outlier model (Zero if no outlier)

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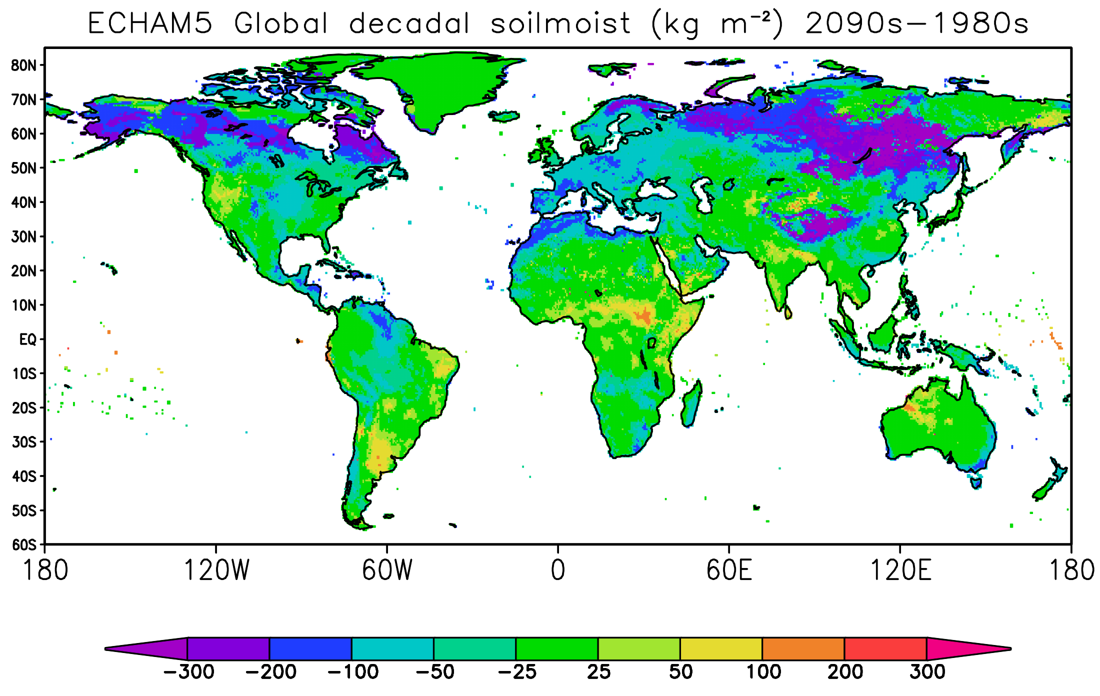
21st century runs of JULES in WATCH

- JULES was run for 1971-2100 (CEH and MetO)
- 0.5° x 0.5° global land grid
- Bias-corrected A2 scenario meteorology from 3 climate models: CNRM, ECHAM5 and IPSL
- Fixed land cover
- "no human impacts"



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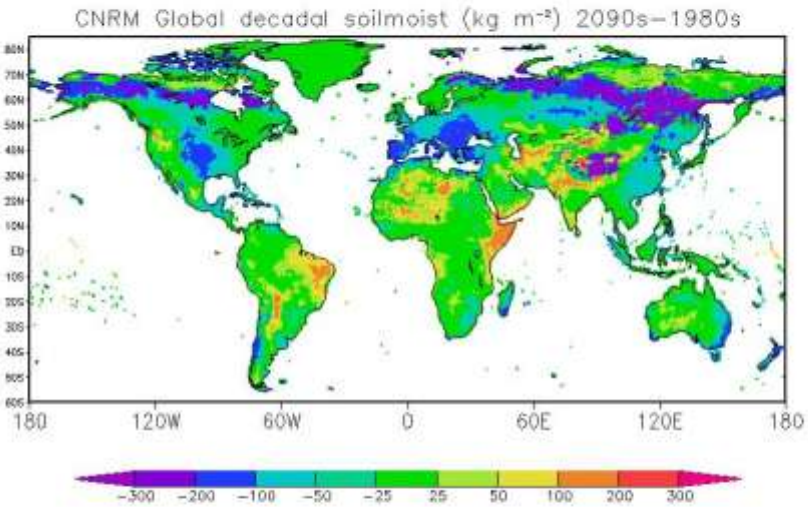
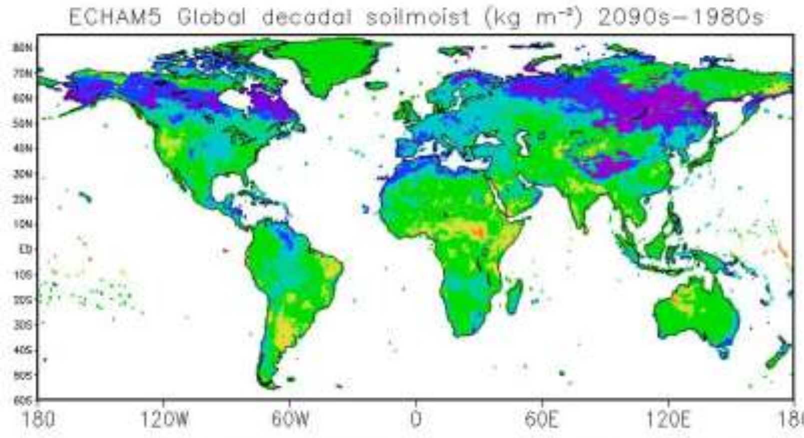
Soil moisture change 2090s-1980s





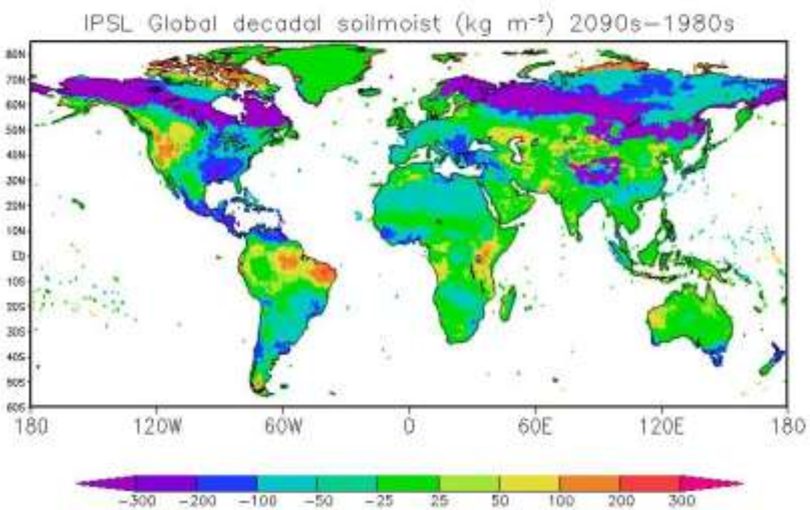
Some common features

e.g. Thawing at high latitudes (draining)

Mediterranean drier

but also differences

e.g. Amazonia



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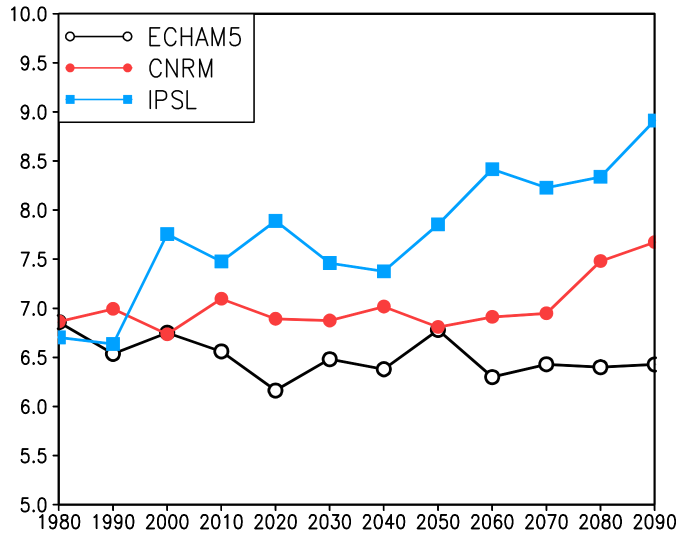
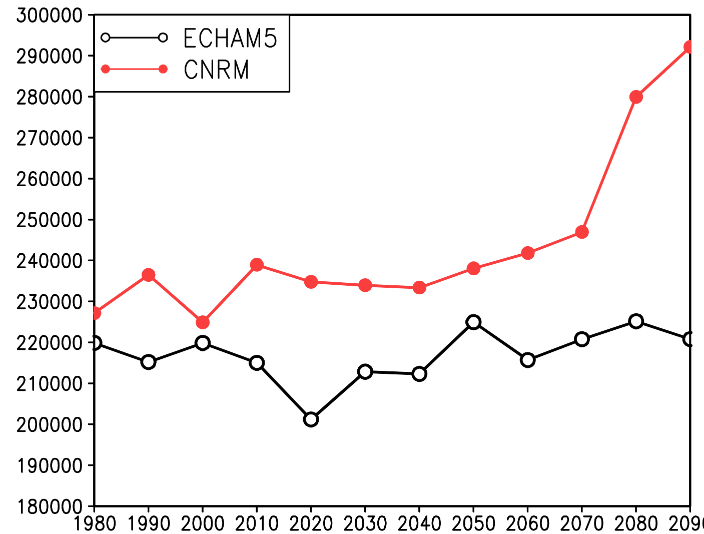
Decadal averages

Amazonia
:
Precipitation and riverflow

Precipitation (mm d⁻¹)

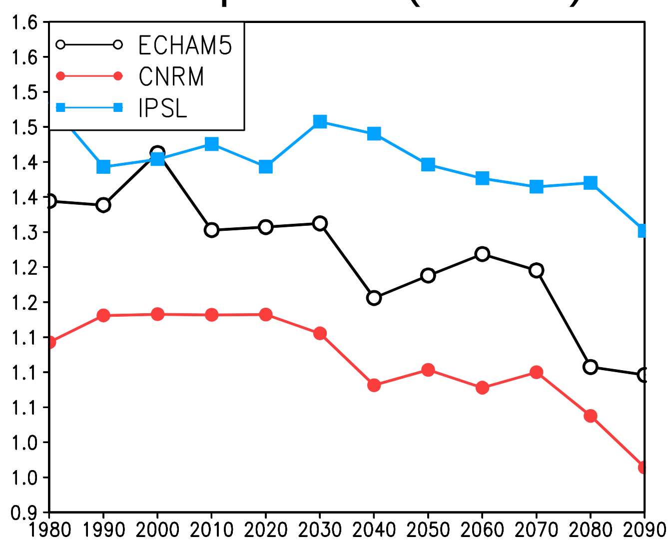


Discharge (m^3 s^{-1})

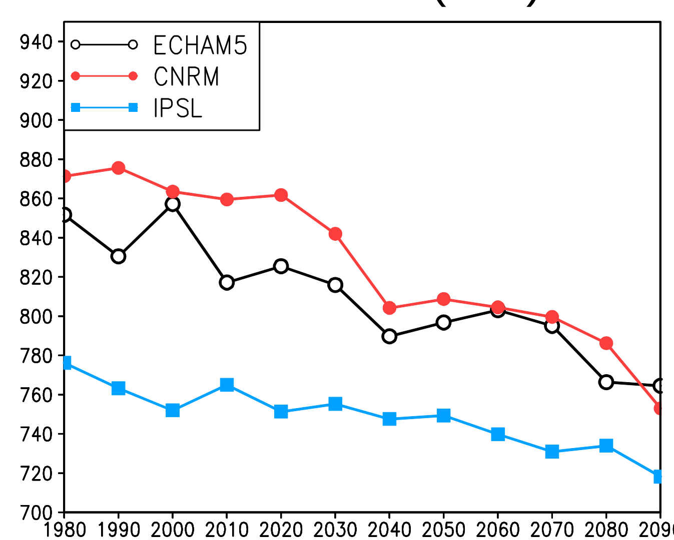


Mediterranean region:
Evaporation and soil moisture

Evaporation (mm d^{-1})



Soil moisture (mm)



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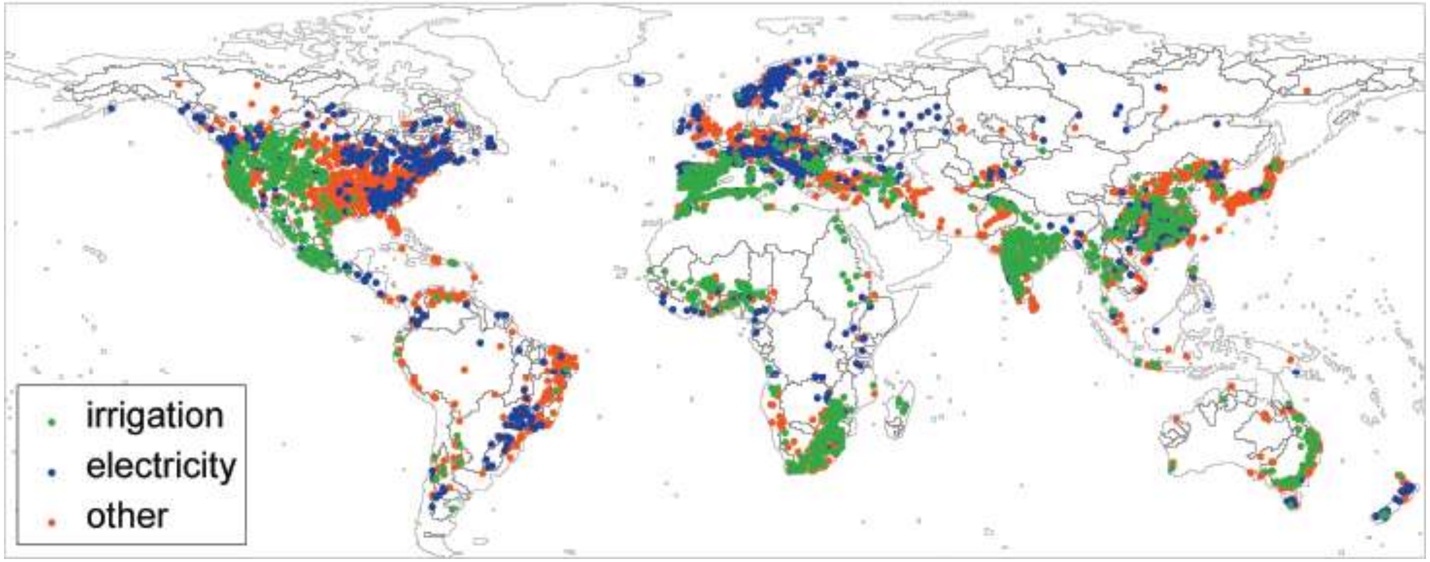
21st century runs of JULES in WATCH

- Daily and monthly diagnostics available:
  CEH Information Gateway: https://gateway.ceh.ac.uk

	Monthly	Daily
Precipitation	•	
Snowfall	•	
Evaporation	•	•
Surface runoff	•	•
Subsurface runoff	•	•
River discharge	•	•
Soil moisture	•	•
Snow mass	•	•

JULES: Irrigation and Dams

Dams, reservoirs and irrigation are important in many areas of the world.
They alter the amount and seasonality of water in rivers and fields.



Biemans et al., 2011, Water Res. Res., W03

In WATCH we added parameterisations of irrigation, dams and reservoirs to JULES.

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Dams

Added a simple parameterisation of dam operation, based on Biemans et al. (2011, WRR.), which works inside the river routing scheme (currently TRIP).

- Simple rules for water released from a dam as a function of the demand for water from downstream areas and the amount of water stored in the reservoir behind the dam.
- Each dam is considered to be either primarily for irrigation supply or for "other" purposes, and separate rules govern the operation of each type.
- Scheme currently considers water for irrigation and environmental flows, but has basic "stubs" for other demands.
- Location and characteristics of dams are taken from the Global Reservoir and Dam (GRanD) database (Lehner et al., 2011, in press).

WATCH products

Consistent global analyses (@50km) of rainfall, runoff, soil moisture, flood indices etc for 20th and 21st C

Regional analyses (@12km) for Europe and India

New hydrology/land surface models to include biogeophysical processes and human interventions (dams, irrigation, groundwater etc)

New data sets to drive and test models (evaporation, population, water use etc)

New tools - bias correction, downscaling, uncertainty

Conclusions

•Use a single hydrology model for climate impact studies with care

•The use of model ensembles is an option, but

•There is considerable scope and need for model improvement
• – dams, groundwater, calibration

•WATCH has provided methodologies, tools, models and data for future analyses

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Thank you

www.eu-watch.org - the project website providing information on partners, work blocks and publications.
www.eu-watch.tv - the online version of this report with video and audio supplements from those involved.
www.waterandclimatechange.eu - an introduction to the global water cycle and its links with climate change.

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