JULES Impacts Theme: proposed input to IPCC Fifth Assessment Report

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Background: global biophysical impacts in IPCC Fourth Assessment Report (AR4)

- Terrestrial ecosystems
- Fresh water
- Agricultural productivity

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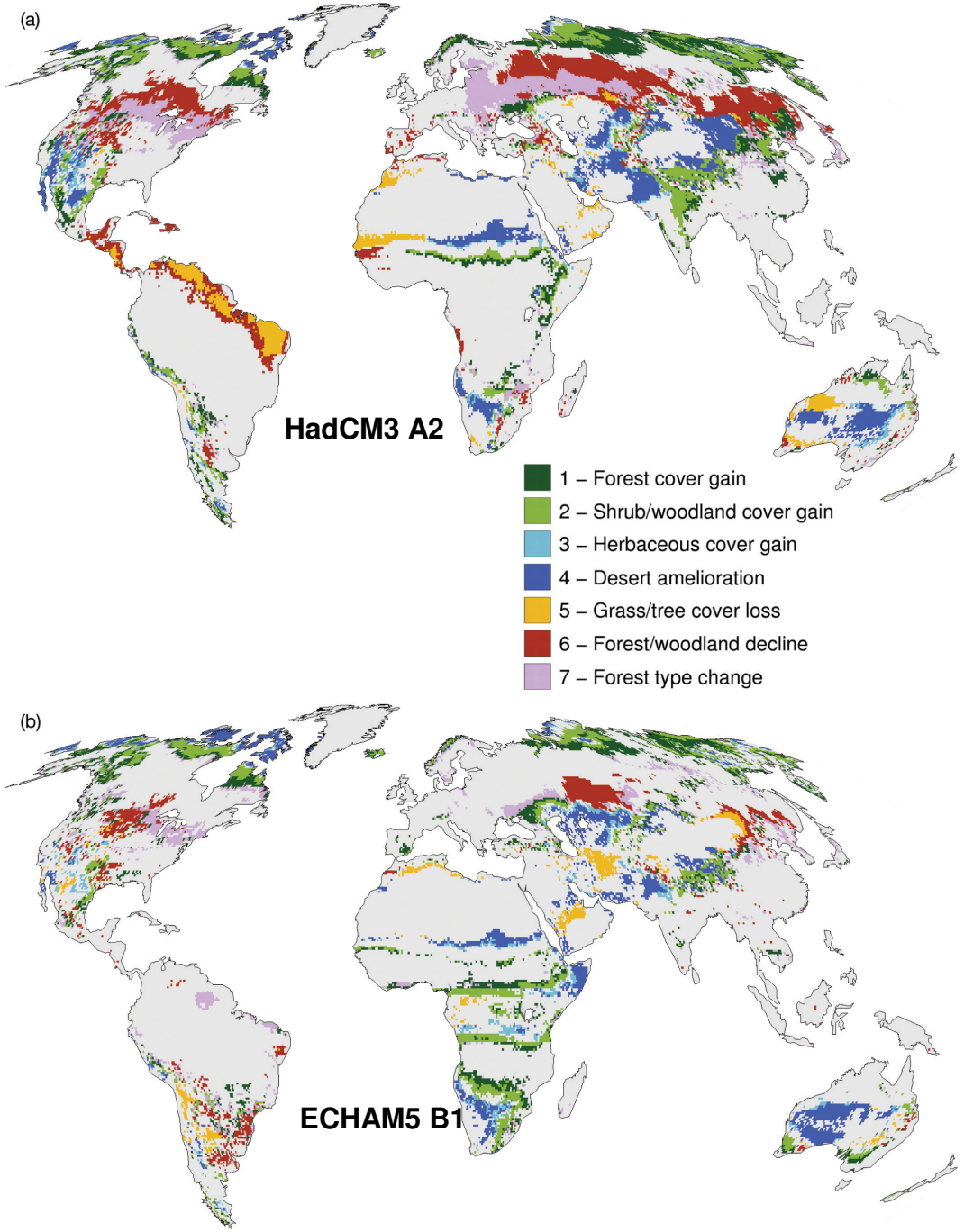
IPCC AR4:

Projected changes in terrestrial ecosystems

A2 and B1 scenarios

2100 compared to 2000

LPJ vegetation model

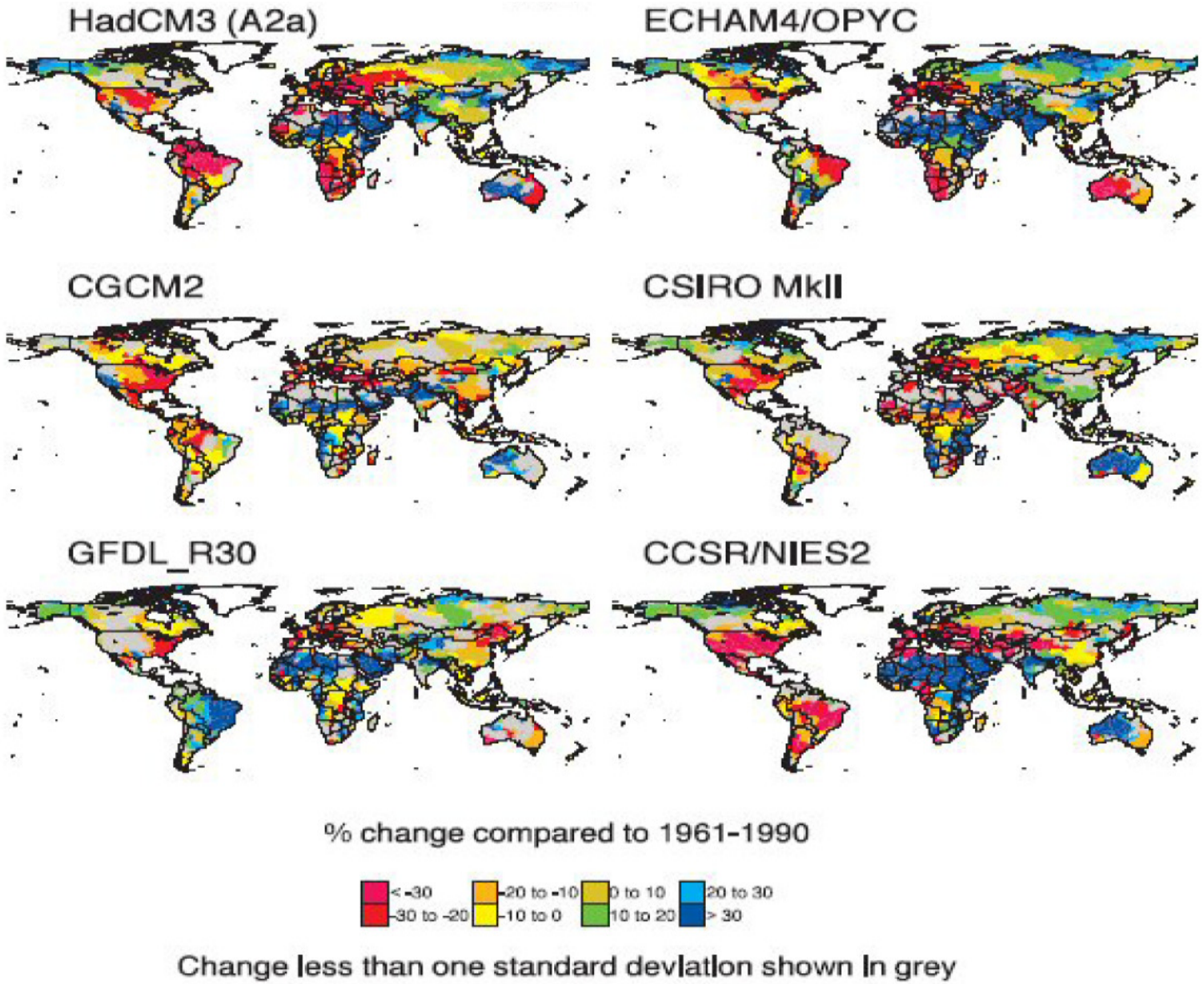


IPCC AR4: Projected changes in runoff

A2 scenario

2050s compared to 1961-1990

MacPDM(?) model

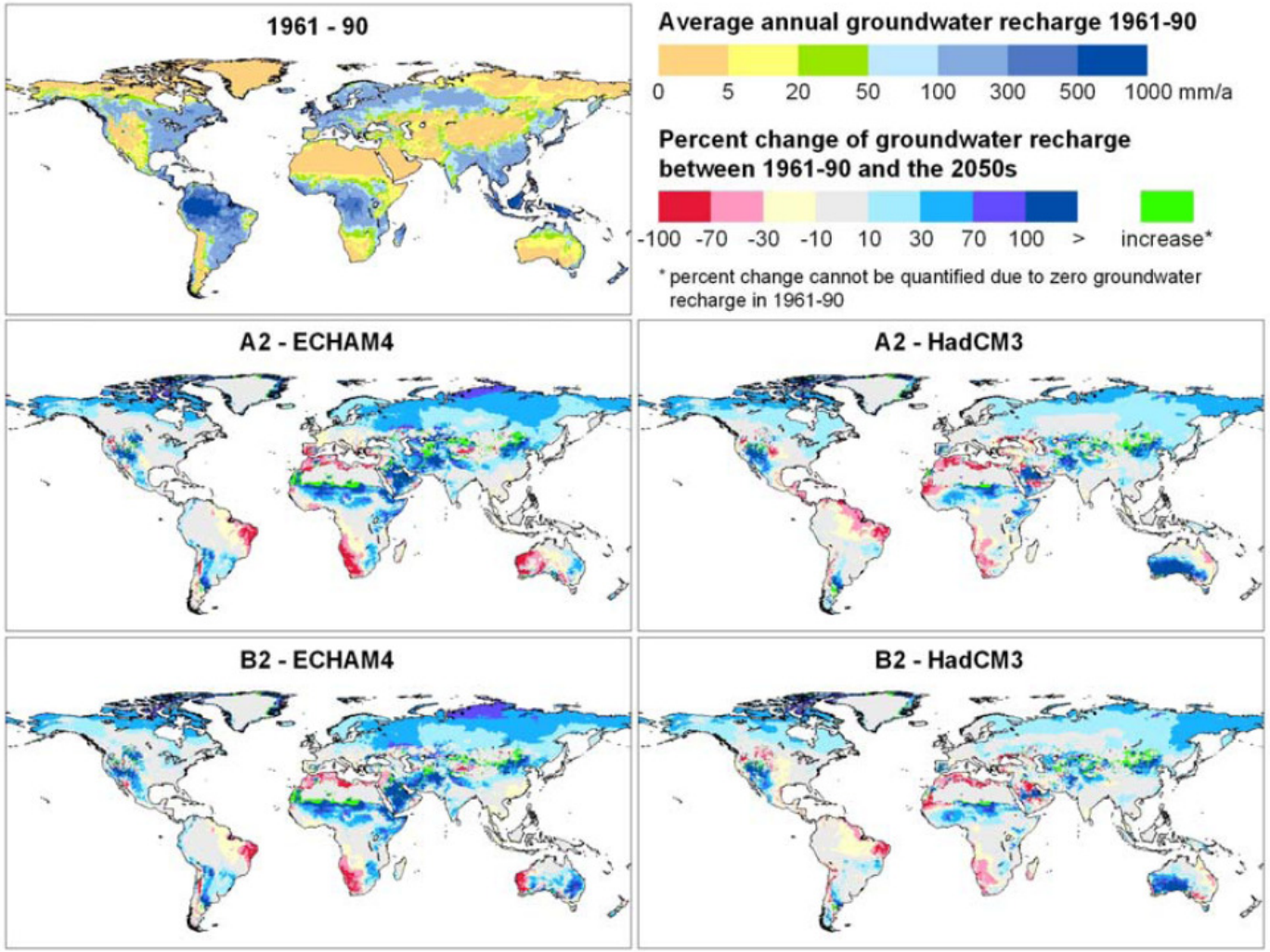


IPCC AR4: Projected changes in groundwater recharge

A2 and B2 scenarios

2050s compared to 1961-1990

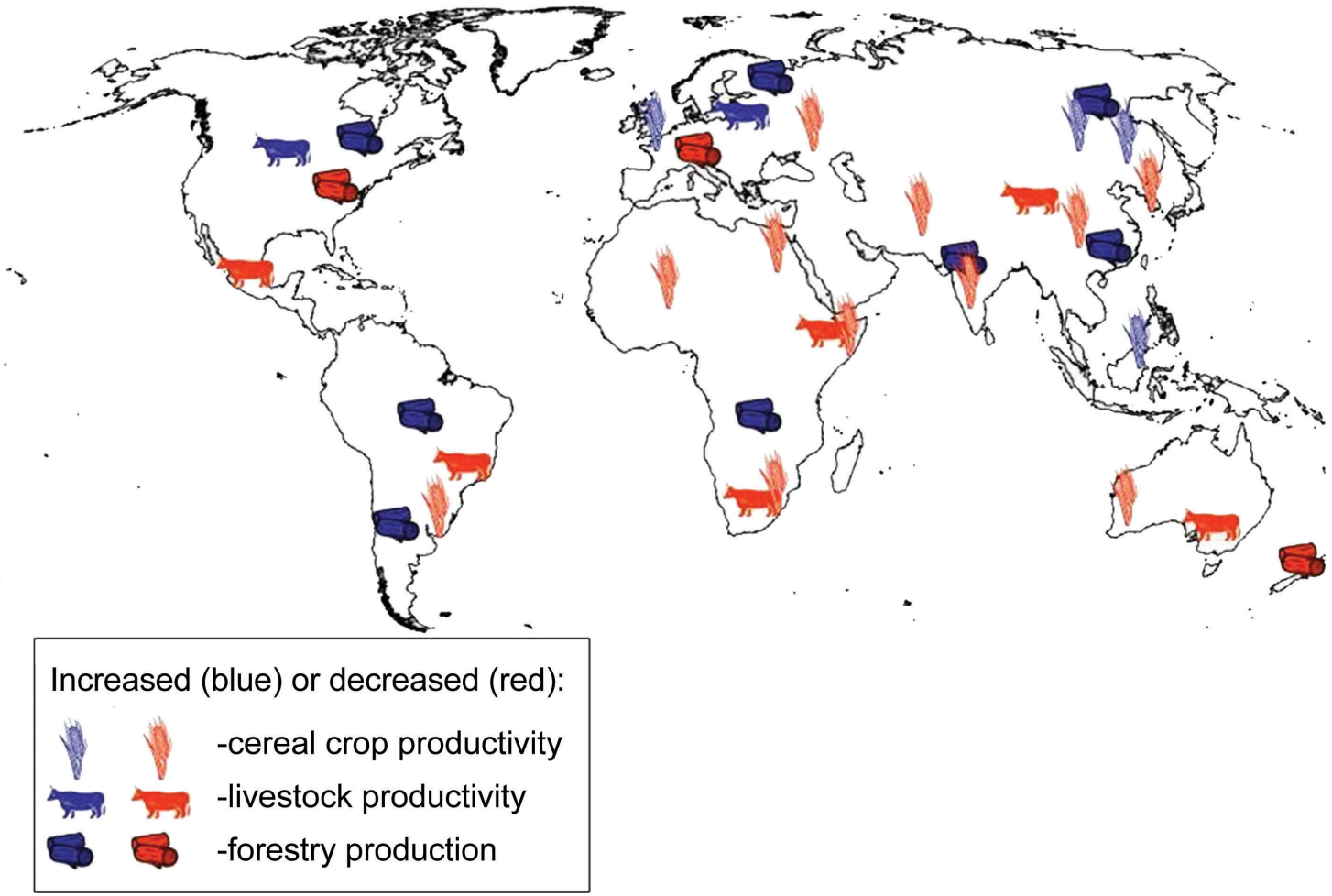
WGHM model



IPCC AR4: Changes in crop and livestock yields and forestry production

2050s compared to present day

"Literature and expert judgement"



Consistency of impacts projections

- Different models used for different impacts
- But often rely on same processes (eg: land surface hydrology)
- Are the impacts assessments physically consistent with each other?
  - Eg: do runoff / groundwater recharge projections take account of ecosystem / crop changes?

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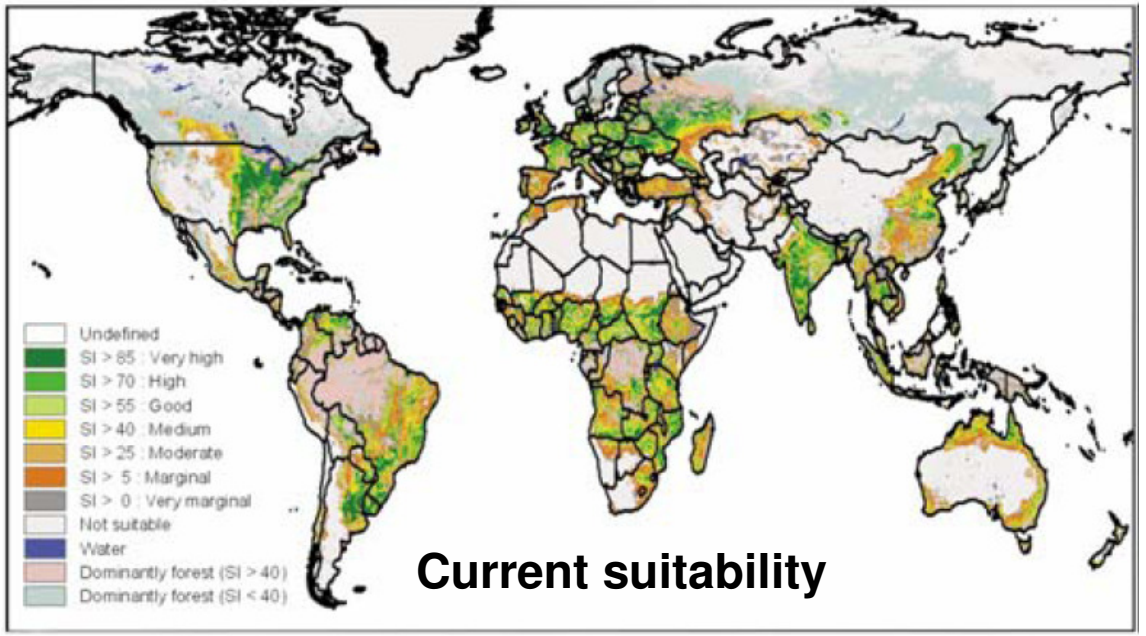
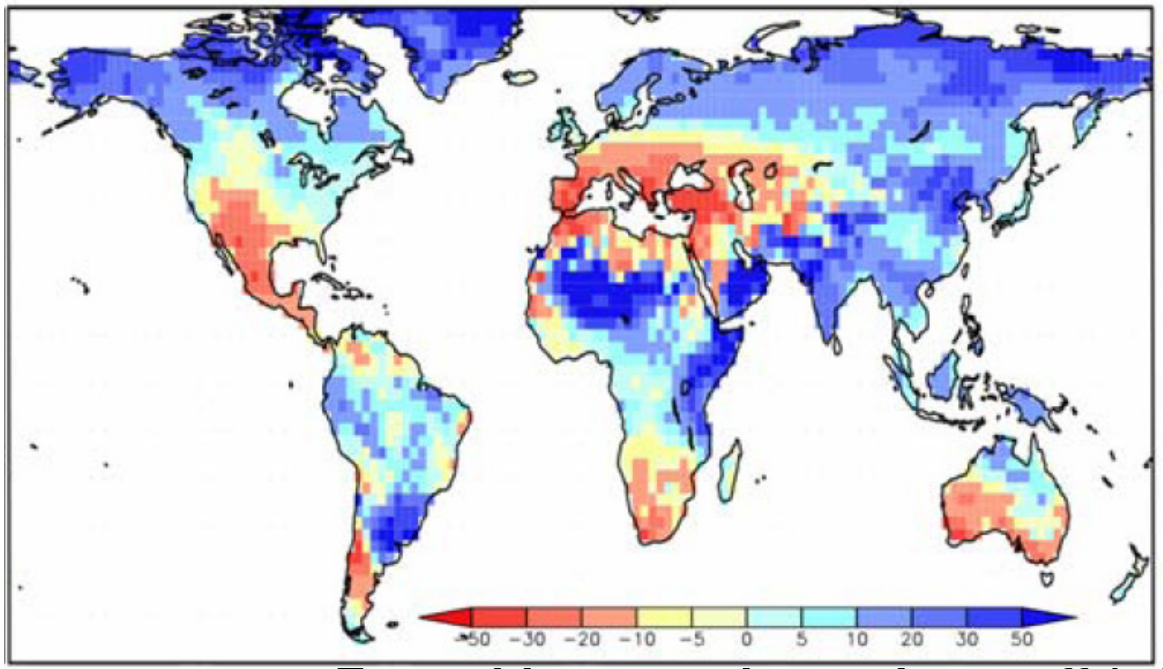
IPCC AR4: implications of climate change for rain-fed agriculture



Current suitability



Ensemble mean change in runoff (%)

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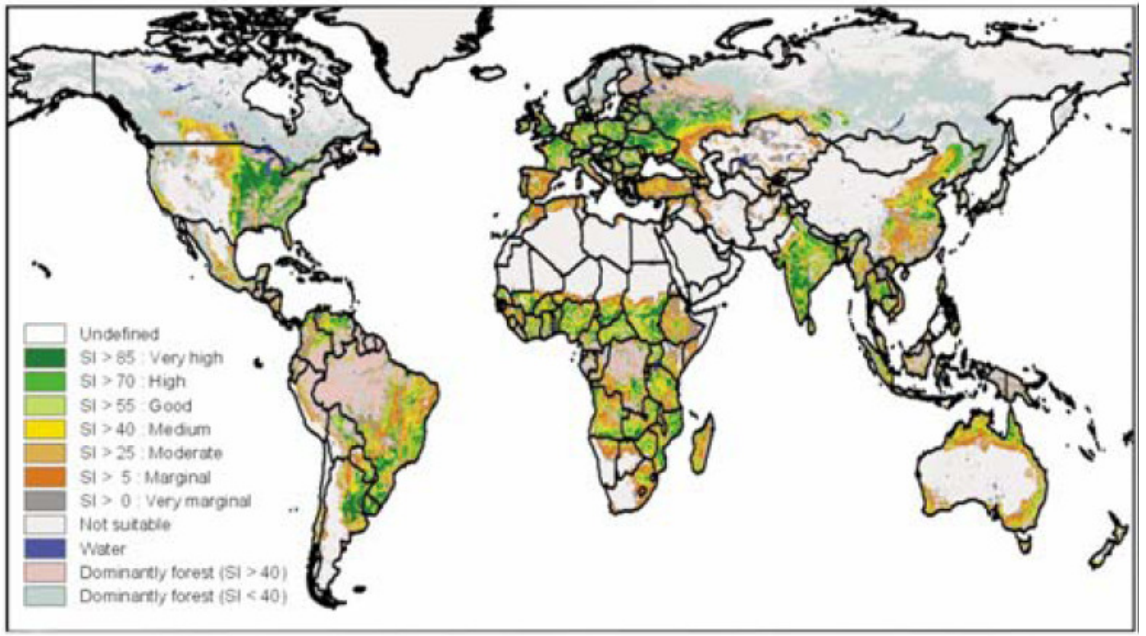
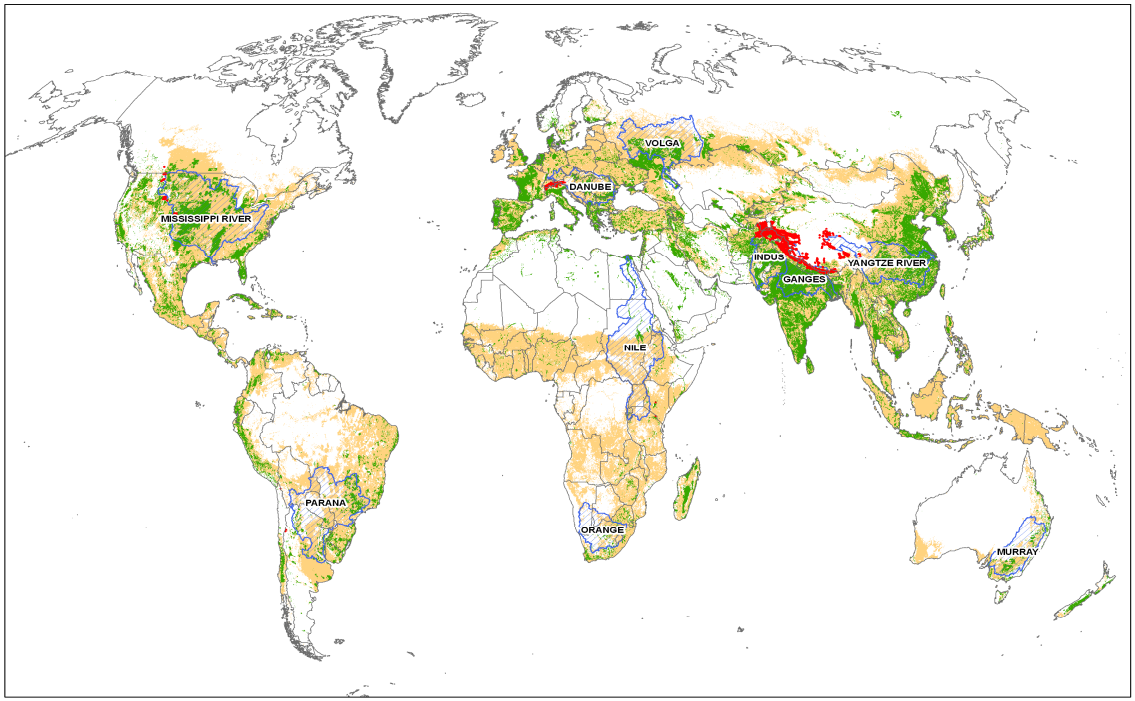


Croplands, irrigation and remote water sources



Accounting for changes in large-scale hydrology

- Can impacts which depend on terrestrial water resources be linked to projected changes in large-scale hydrology – eg: river flows, remote precipitation, glacier melt?

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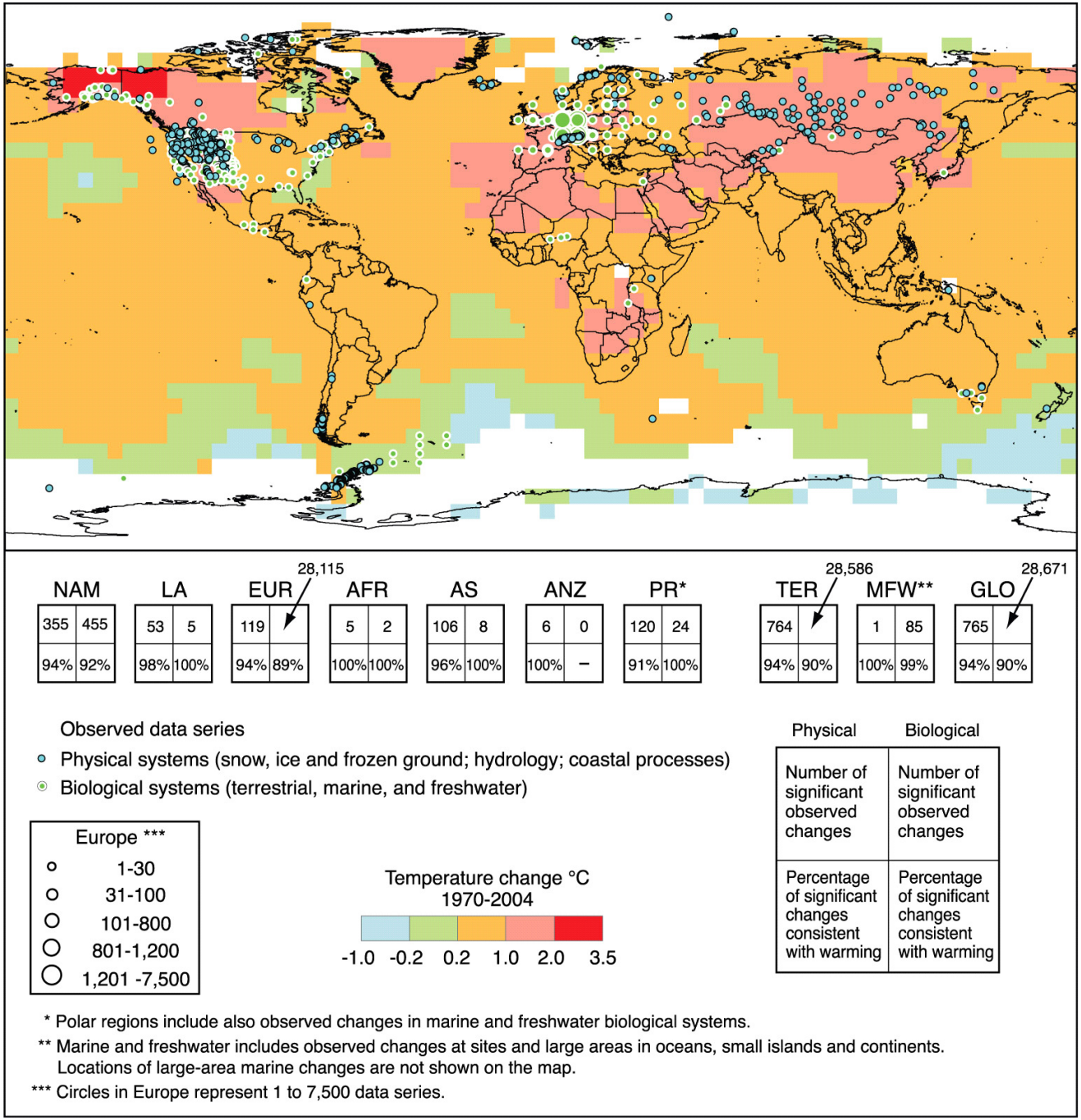
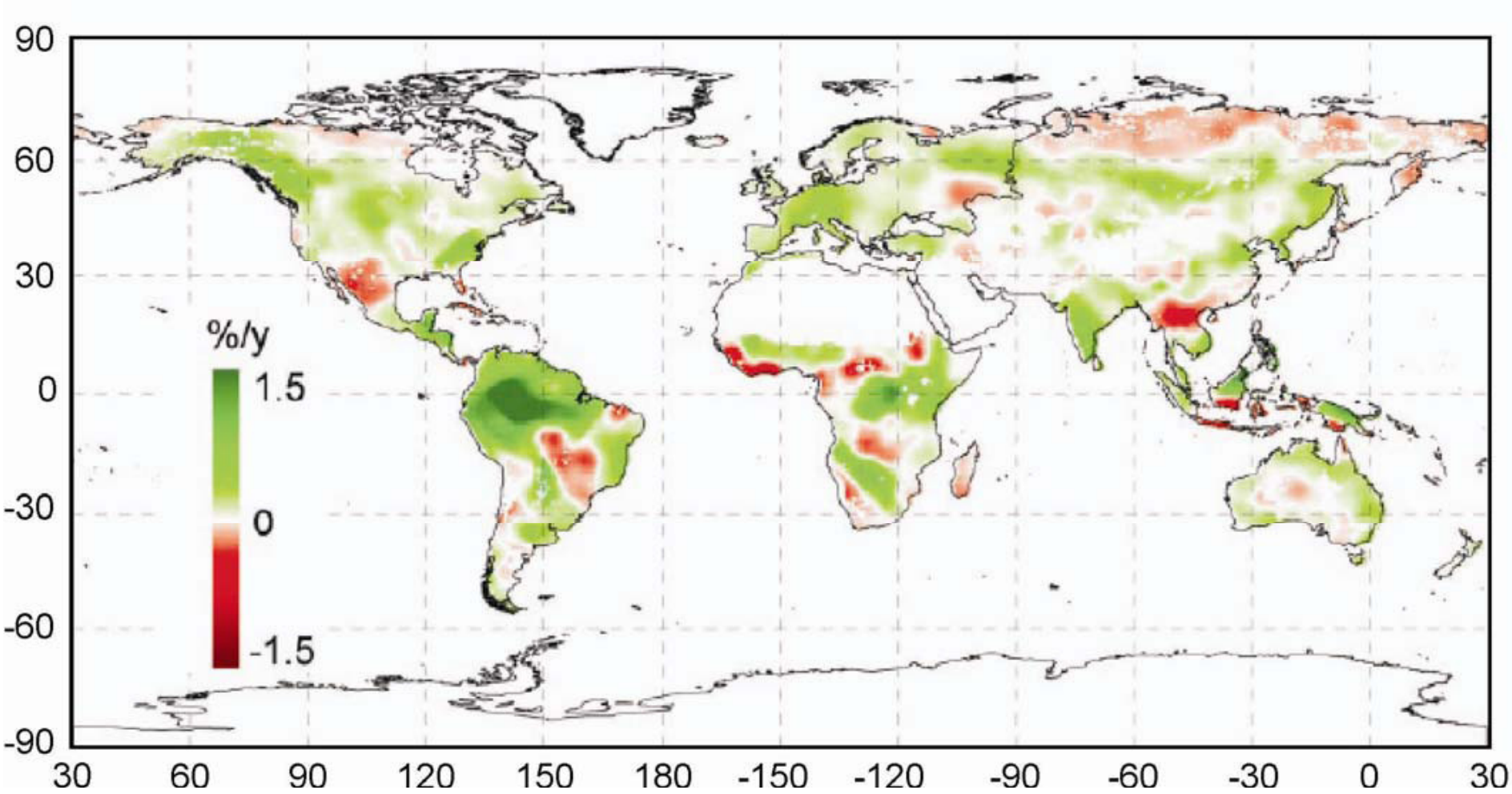
IPCC AR4: explaining observed changes in physical and biological systems



IPCC AR4: estimated changes in NPP 1982-1999

"An overall increase in NPP is observed, which is consistent with increased CO_2 and warming"



Attribution of impacts

- AR4 looked for changes consistent with local warming
- Many impacts driven by processes other than local warming
  - Local precipitation change
  - Remote precipation changes
  - Indirect effects via other impacts
  - Eg: hydrological changes due to vegetation responses, land use change, anthropogenic intervention…
- Can more complete and systematic attribution be done?

Proposed work for Fifth Assessment Report (AR5) with JULES: improved impacts projections

- Global-scale projections of biophysical impacts that are internally-consistent:
  - Runoff
  - Groundwater recharge
  - Terrestrial ecosystems
  - Crop productivity
- Include linkages via large-scale hydrology:
  - Irrigation
  - River flows
  - Glacier

Proposed work for AR5 with JULES: improved attribution

- Global-scale simulations of past biophysical impacts that are internally-consistent:
  - Runoff, river flows
  - Terrestrial ecosystems
- Include more complete treatment of direct and indirect climate processes:
  - Local precipitation + evaporation
  - Remote influences eg: via rivers – precip/evap, glaciers
  - Indirect effects eg: vegetation impacts on hydrology
  - Other anthropogenic drivers eg: land use, dams, irrigation

Timescales for inclusion in AR5 Working Group 2 report (Impacts, Adaptation and Vulnerability)

- Report publication 2014, final version late 2013
  - Papers will probably need to be published by summer 2013
- First draft out to review Spring 2012
  - Papers may well need to be submitted by then
- Second lead author meeting December 2011
  - Lead authors will need to be familiar with current work
- First lead author meeting January 2011, Zeroth draft for informal review Summer 2011
  - General shape of chapters will begin to form over this period

Proposal: maintain a well-defined configuration of JULES “frozen” across different JULES versions

- Analogous to the distinction between Unified Model versions and the different configurations (eg: HadCM3, HadGEM1, HadGEM2, HiGEM, FAMOUS, operational forecast model etc)
- The UM is the overall system containing *all* science, often with different options for different sections of the model
- The entire system is upgraded and a new *version* re-released periodically: UM vn7.0, 7.1, 7.2, etc
- The choice of particular options for each model section defines the *configuration* (eg: HadGEM2)
- The configuration is also defined by factors other than the physics code, eg: model domain, timescale / mode of operation, ancillary files etc

JULES:
One system, many choices…

vegetation dynamics:	TRIFFID	ED …
Soil carbon:	Single-pool	RothC ECOSSE …
River routing:	TRIP	Grid2Grid
Fire:	Nesterov+	SPITFIRE ...
Groundwater:	LSH …	
Irrigation:	Version 1	Version 2 …
Dams:	Version 1 …	
Crops:	JULES-crop	JULES-SUCROS …
Snow:	Single layer	Multi-layer …

Etc….

NB: This is just for illustration and is not a complete or even accurate list!

JULES:
One system, many choices…

MOSES2 (pre-JULES) in HadCM3LC (Cox et al 2000)

vegetation dynamics:	TRIFFID	ED …
Soil carbon:	Single-pool	RothC ECOSSE …
River routing:	TRIP	Grid2Grid
Fire:	Nesterov+	SPITFIRE ...
Groundwater:	LSH …	
Irrigation:	Version 1	Version 2 …
Dams:	Version 1 …	
Crops:	JULES-crop	JULES-SUCROS …
Snow:	Single layer	Multi-layer …

Etc….

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JULES:
One system, many choices…

MOSES2+ in HadGEM2-ES (AR5 Earth System Model)

vegetation dynamics:	TRIFFID	ED	…
Soil carbon:	Single-pool	RothC	ECOSSE …
River routing:	TRIP	Grid2Grid	
Fire:	Nesterov+	SPITFIRE ...	
Groundwater:	LSH …		
Irrigation:	Version 1	Version 2 …	
Dams:	Version 1 …		
Crops:	JULES-crop	JULES-SUCROS	…
Snow:	Single layer	Multi-layer …	

Etc….

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JULES:
One system, many choices…

JULES in QESM (future Earth System Model)

vegetation dynamics:	TRIFFID	ED …
Soil carbon:	Single-pool	RothC ECOSSE …
River routing:	TRIP	Grid2Grid
Fire:	Nesterov+	SPITFIRE …
Groundwater:	LSH …	
Irrigation:	Version 1	Version 2 …
Dams:	Version 1 …	
Crops:	JULES-crop	JULES-SUCROS …
Snow:	Single layer	Multi-layer …

Etc….

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JULES:
One system, many choices…

Available / under development for WATCH

vegetation dynamics:	TRIFFID	ED	…
Soil carbon:	Single-pool	RothC	ECOSSE …
River routing:	TRIP	Grid2Grid	
Fire:	Nesterov+	SPITFIRE ...	
Groundwater:	LSH …		
Irrigation:	Version 1	Version 2	..
Dams:	Version 1	…	
Crops:	JULES-crop	JULES-SUCROS	…
Snow:	Single layer	Multi-layer …	

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Etc….

JULES:
One system, many choices…

Available at latest JULES release (2.1)

vegetation dynamics:	TRIFFID	ED	…
Soil carbon:	Single-pool	RothC	ECOSSE …
River routing:	TRIP	Grid2Grid	
Fire:	Nesterov+	SPITFIRE ...	
Groundwater:	LSH …		
Irrigation:	Version 1	Version 2 …	
Dams:	Version 1 …		
Crops:	JULES-crop	JULES-SUCROS …	
Snow:	Single layer	Multi-layer …	

Etc….

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Priorities for delivering impacts to AR5

- Provide more integration between processes that have previously been assessed in AR4
- More complete representation of hydrological cycle
- Inclusion of crops
- Simulation of existing processes not compromised
- Fully operational on *global* grid:
  - Science works (and is credible!) everywhere in world
  - Driving data / ancillary files available on global grid
  - Validated on global grid
- Deliver in time to be assessed in the report!

Other priorities

- Remember JULES also intended as land surface scheme for Unified Model – both climate and weather forecast configurations
- JULES developments which reduce performance of atmosphere model will not be used in operational Met Office configurations of UM! (both climate and weather configurations)
- Limit divergence from UM version of JULES as far as possible – easier to test and maintain

Existing activities (1)

- EU project WATCH
  - CEH, MOHC
  - New hydrological cycle processes
  - 20th century simulations under observed climate
  - 21st century simulations under AR4 climate projections
  - Detection and attribution
- EU project HighNoon
  - MOHC
  - Himalayan glaciers linked to river model
- QUEST Earth System Model QESM
  - various JULES consortium members

Existing activities (2)

- Met Office Hadley Centre Integrated Climate Programme
  - JULES_crop development (Reading Uni + MOHC)
  - AR5 climate simulations with HadGEM2-ES
  - HadGEM3 development
- Met Office forecast model ongoing development
- Proposal to NERC: Global Scale Impacts
  - Reading, MOHC, CEH, Aberdeen + others
  - JULES_impact consolidation
  - Comparison with other impacts models
  - AR5 Earth System Model output + pattern scaling for other scenarios

Proposed build of JULES_impact (for discussion!)