A regional coupled approach to water cycle prediction during winter 2013/14 in the United Kingdom

Huw Lewis

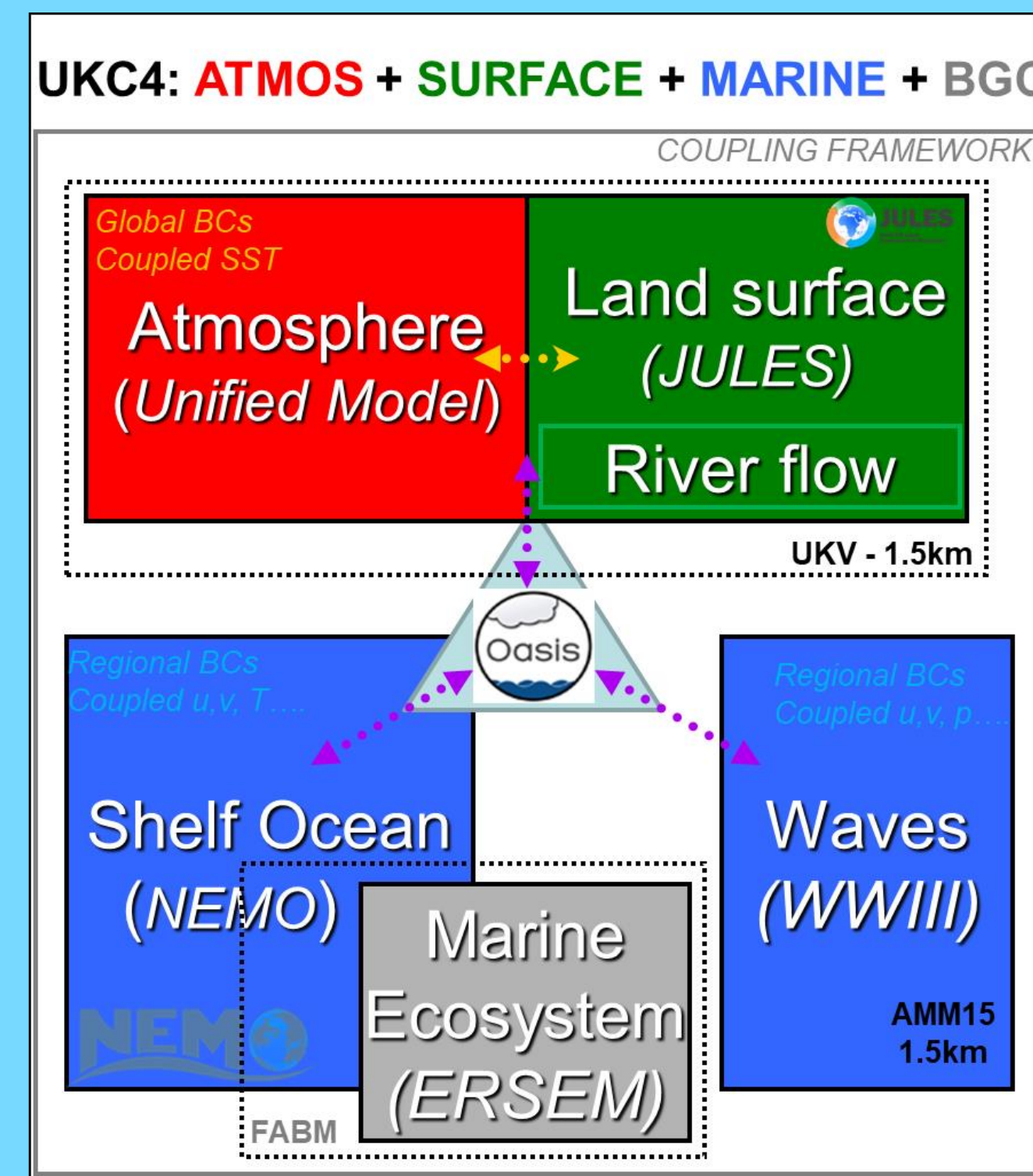## Regional Environmental Prediction

Multi-disciplinary R&D that aims to

- better understand **physical and biogeochemical interactions** between **atmosphere, land surface and marine** components of the environment,
- deliver modelling systems that better represent these processes.

Requires a **flexible modelling framework** able to provide *traceable* coupled and uncoupled simulations of varying complexity at **km-scale across timescales**.

- Does representing more interactions and feedbacks within the environment improve the accuracy of regional simulations?
- Do more integrated prediction systems provide new information and evidence on
  - combined risk and impacts of multiple natural hazards, now and in the future?
  - sensitivity to and impacts of environmental change through the system?
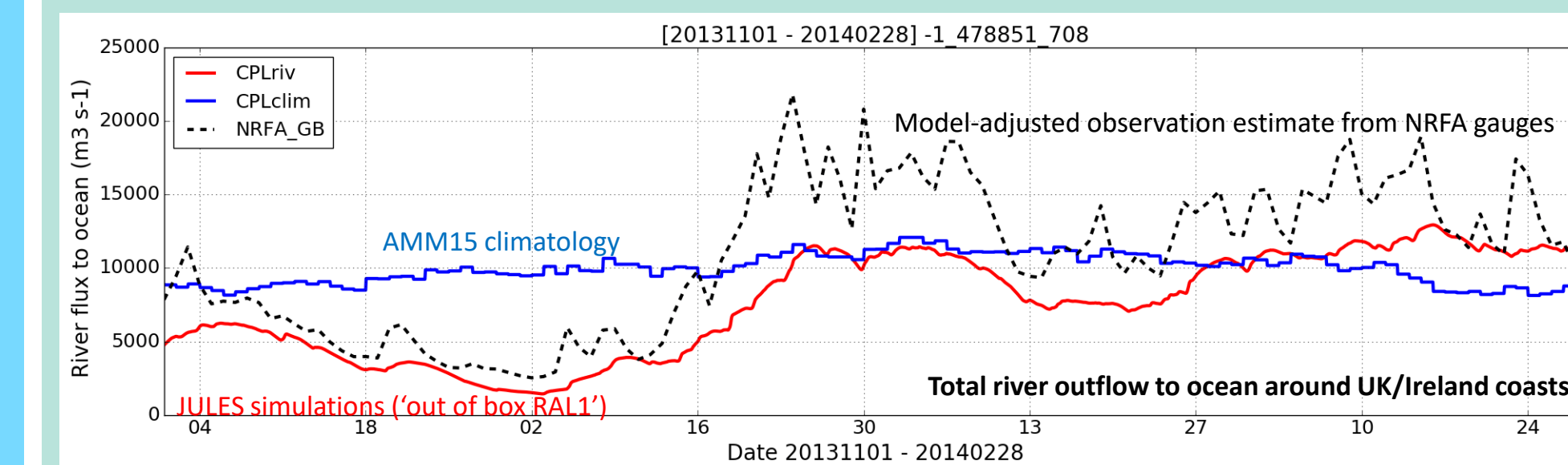
Regional Coupled system

UKC4: **ATMOS** + **SURFACE** + **MARINE** + BGC

COUPLING FRAMEWORK

Global BCs Coupled SST

Atmosphere (Unified Model)

Land surface (JULES)

River flow

UKV - 1.5km

Oasis

Regional BCs Coupled U, V, T

Shelf Ocean (NEMO)

Marine Ecosystem (ERSEM)

Regional BCs Coupled p, v, p

Waves (WWIII)

AMM15 1.5km

FABM

- 1.5 km res. variable grid atmosphere/land
- 1.5 km fixed res. eddy-resolving ocean
- RFM river routing in JULES

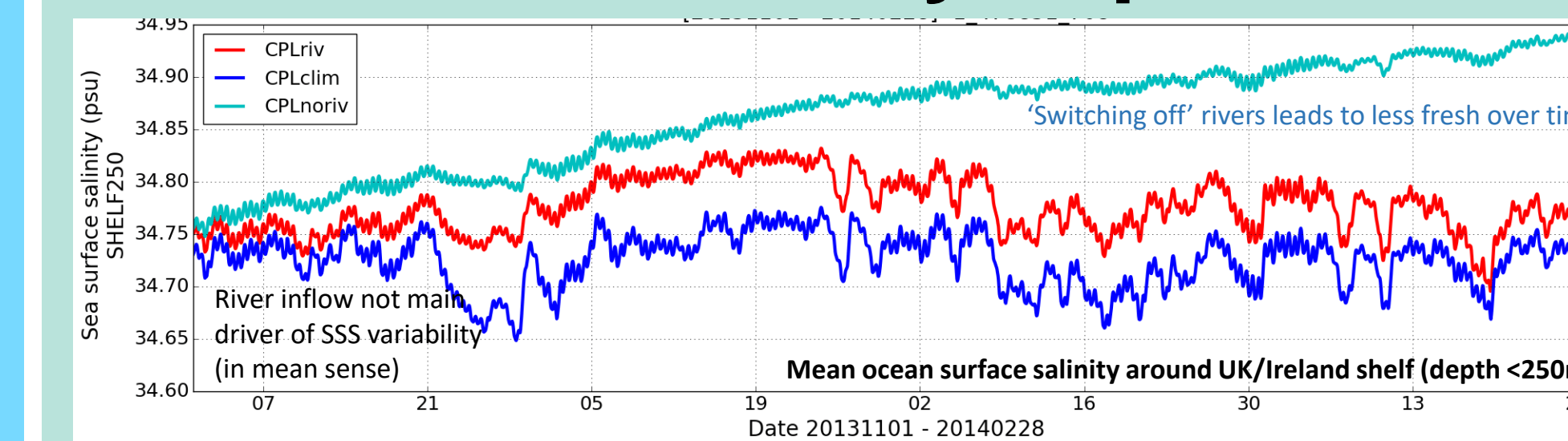| Run Name	UK + Ireland river discharge	Rest of domain river discharge
CPLriv	JULES simulation, OASIS coupled	AMM15 climatology
CPLclim	AMM15 climatology	AMM15 climatology
CPLnoriv	Zero flows	AMM15 climatology

- Typically, regional ocean model forced with daily climatological river outflow (e.g. 232 points over NW-Europe domain)
- In coupled system, 842 connection points between UK/Ireland land and neighbouring ocean, hourly coupling land freshwater to ocean
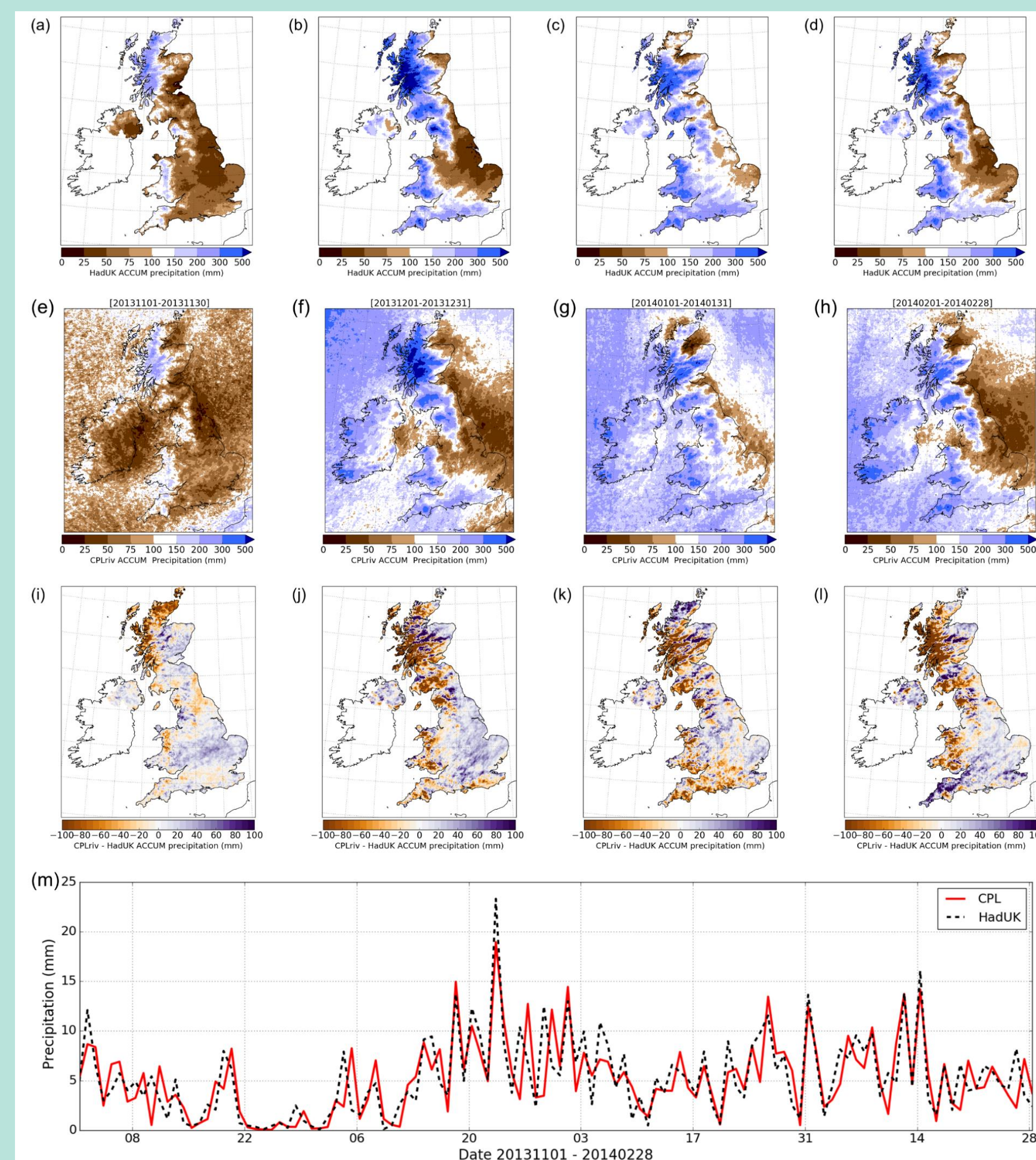
Discharge to ocean around UK

[20131101 - 20140228] -1_478851_708
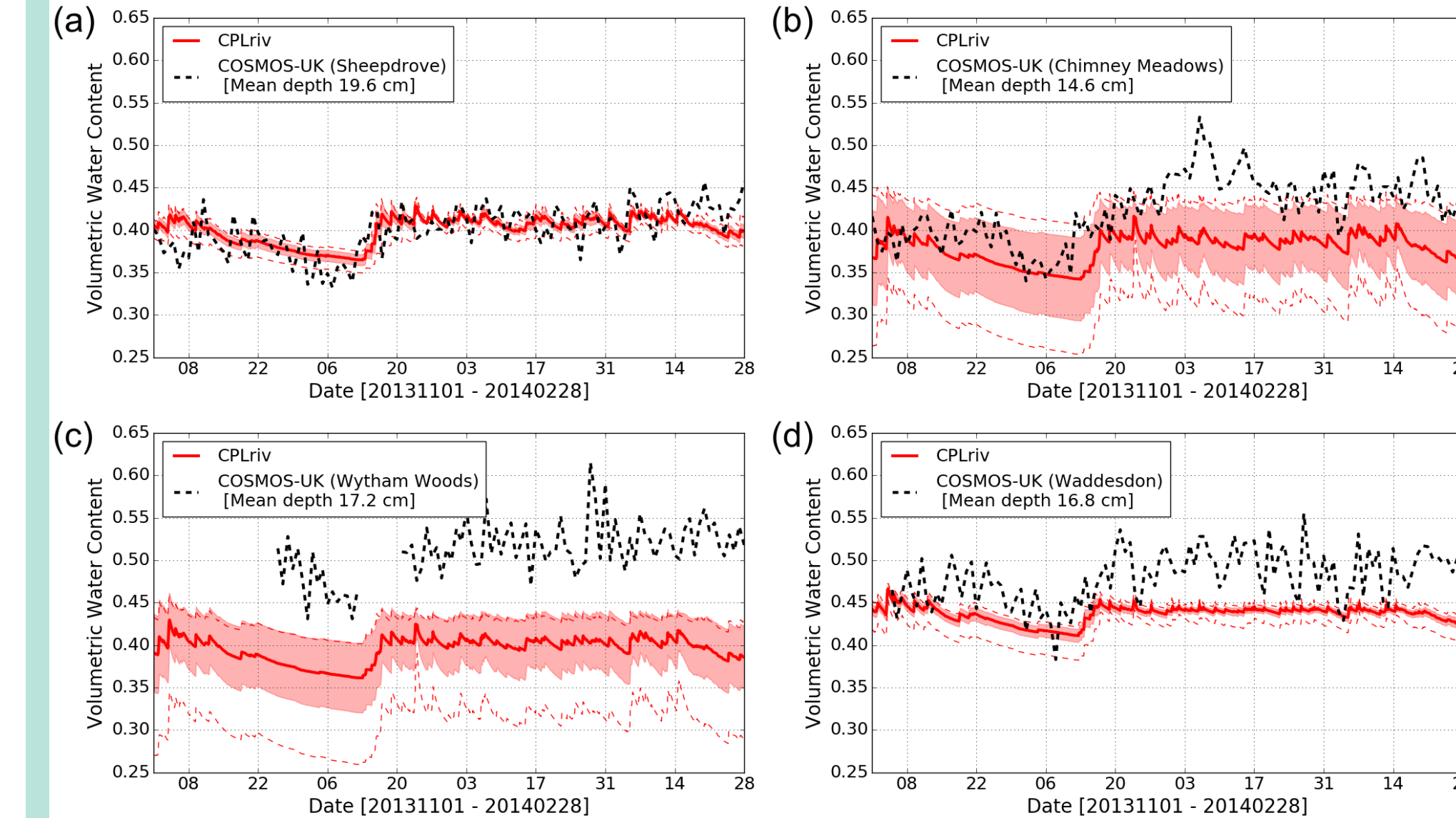
CPLriv
CPLclim
NRFA_GB

Model-adjusted observation estimate from NRFA gauges

AMM15 climatology

JULES simulations ('out of box RAL1')

Total river outflow to ocean around UK/Ireland coasts

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Near-coastal salinity impacts

CPLriv
CPLclim
CPLnoriv

'Switching off' rivers leads to less fresh over time

River inflow not main driver of SSS variability (in mean sense)

Mean ocean surface salinity around UK/Ireland shelf (depth <250m)

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Sensitivity to freshwater influence

SSS

Nov   Dec   Jan   Feb

Model riv vs Climatology riv

No rivers vs Climatology riv runs

Improved vertical salinity profiles

Precipitation

(a) (b) (c) (d)

(e) (f) (g) (h)

(i) (j) (k) (l)

(m)

CPL
HadUK

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Soil moisture

(a) CPLriv — COSMOS-UK (Sheepdrove) [Mean depth 19.6 cm]

(b) CPLriv — COSMOS-UK (Chimney Meadows) [Mean depth 14.6 cm]

(c) CPLriv — COSMOS-UK (Wytham Woods) [Mean depth 17.2 cm]

(d) CPLriv — COSMOS-UK (Waddesdon) [Mean depth 16.8 cm]

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River flows

(a) DECIPHeR [Bias=35.23, NS=0.62]
G2G_MORECS [Bias=39.52, NS=0.30]
CPLriv [Bias=-74.88, NS=0.39]
NRFA: Tay at Ballathie

(b) DECIPHeR [Bias=123.21, NS=0.06]
G2G_MORECS [Bias=11.35, NS=0.73]
CPLriv [Bias=30.03, NS=0.59]
NRFA: Thames at Kingston

(c) DECIPHeR [Bias=18.19, NS=0.86]
G2G_MORECS [Bias=6.39, NS=0.86]
CPLriv [Bias=-38.44, NS=0.62]
NRFA: Severn at Bewdley

(d) DECIPHeR [Bias=-2.49, NS=0.75]
G2G_MORECS [Bias=-5.77, NS=0.73]
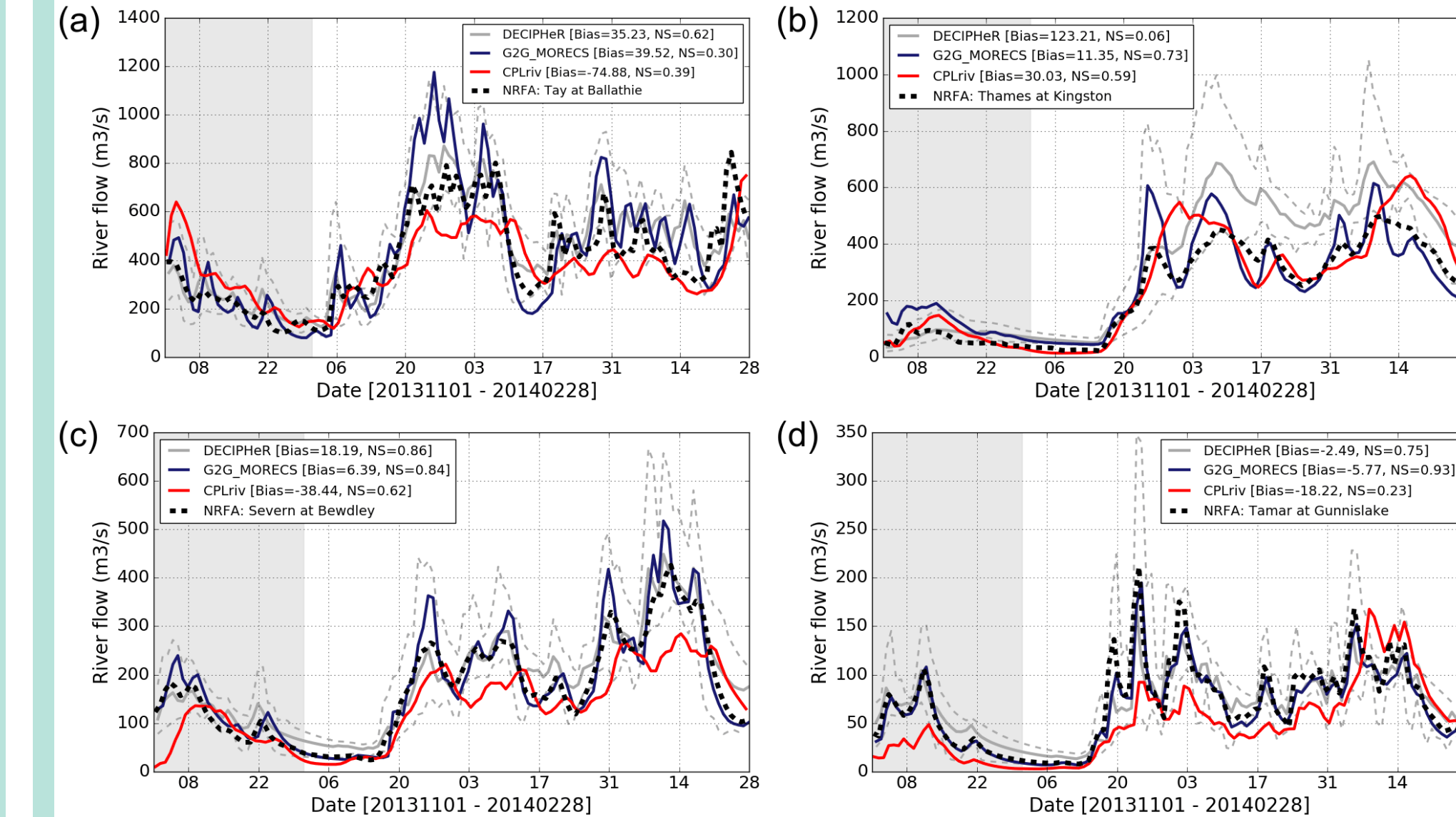CPLriv [Bias=-18.22, NS=0.23]
NRFA: Tamar at Gunnislake

Date [20131101 - 20140228]

- We can demonstrate a more integrated (coupled) approach to simulating UK water cycle across atmosphere, land and ocean model components for winter 2013/14
- Provides new framework and drivers for assessing component model performance:
  - E.g. Monthly mean convective-scale precipitation vs HadUK-grid highlights orographic precip biases to improve
  - E.g. Use of UKCEH COSMOS-UK soil moisture observations for assessing land sensitivity to model configurations
  - E.g. River routing within JULES (or post-processing) as observable component for NWP/climate assessment/monitoring
- Quantified sensitivity of near-coastal ocean to freshwater inputs around UK/Ireland
  - Some evidence of improving vertical salinity (and temperature) profiles with coupled river inputs relative to climatology
- Basis for further system improvements across components
  - Mutual benefits for improving weather & climate from improving hydrology and vice-versa!
  - Direct links to delivery of more consistent 'whole system' forecasts and assessments

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