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Testing the simulation skill of hydrological models under transient climate conditions for European case studies

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Hydrological change: Regional hydrological behaviour under transient climate and land use conditions

GEUS INRAE UNIVERSIDAD DE CÓRDOBA SMHI

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Project AQUACLEW is part of ERA4CS, an ERA-NET initiated by JPI Climate, and funded by FORMAS (SE), DLR (DE), BMWFW (AT), IFD (DK), MINECO (ES), ANR (FR) with co-funding by the European Union (Grant 690462).

Advancing QUAlity of CLimate services for European Water

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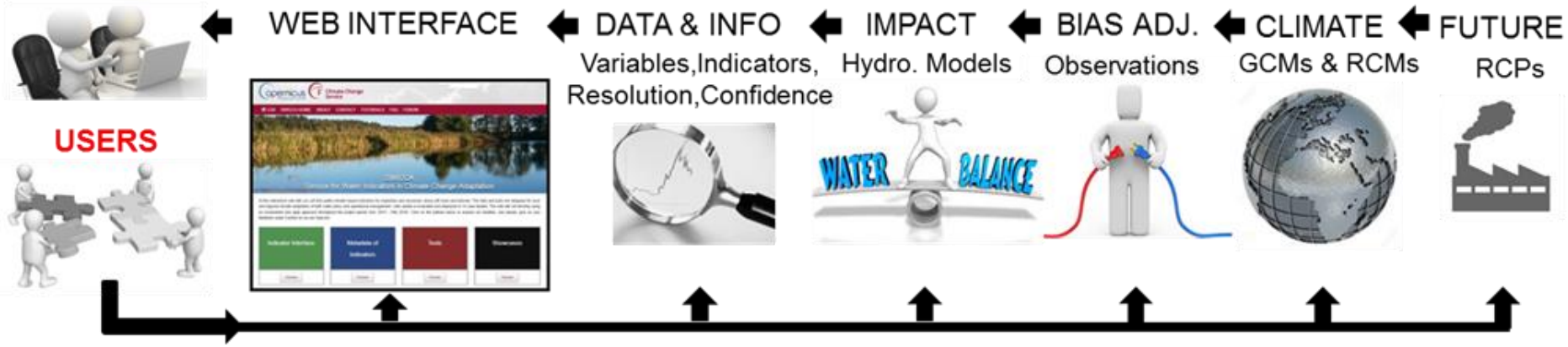
Aquaclew objectives



To advance the quality and usability of water-related climate services through co-development with the end users

Improvement of:

(a) indicators and resolution of the indicators (wider range of user needs)

(b) large-scale climate service data should be more reliable

(c) guidance and visualisation tools (wider range of user needs)

AquaClew develops different study cases across Europe

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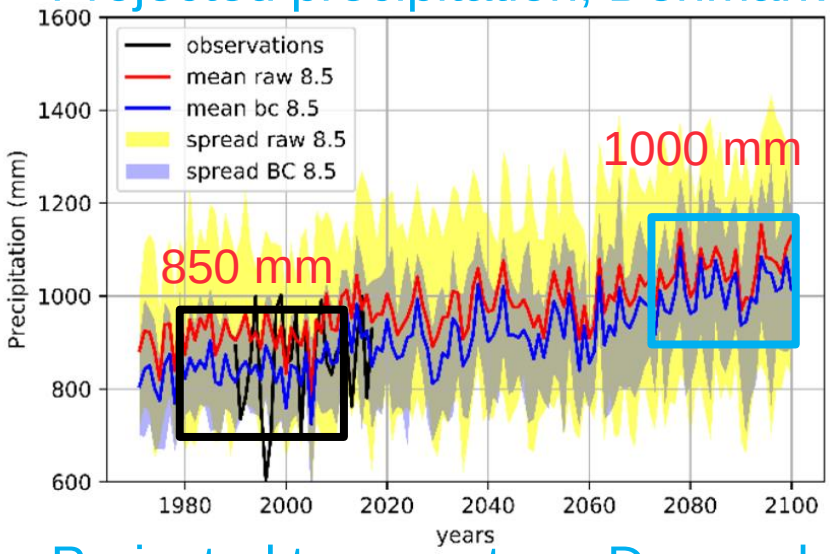
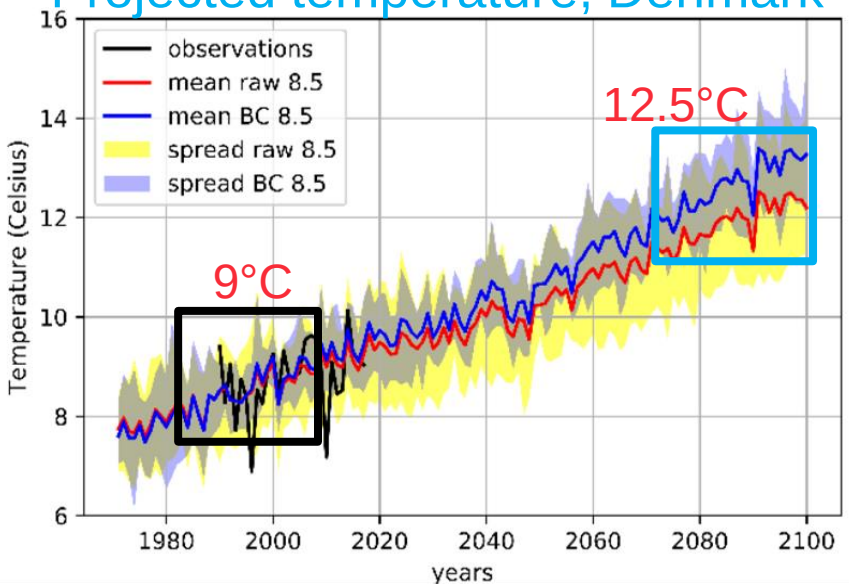
Introduction

- Climate change is expected to modify the current climate regimes
- Given that these changes directly impact on hydrology, we need to assess whether the impact models that we use in the present are fit for a changing climate
- An alternative to perform such assessment is the Differential Split Sample Test (DSST) (Klemeš, 1986)

Projected precipitation, Denmark



Projected temperature, Denmark



Research Questions

Considering that the climate regime is expected to change in the future, we focus on answering the following research questions:

- How skillful are the hydrological models that we currently use to simulate a changing-climate catchment? Are their results reliable under a climate change context?

- Are the purpose-specific metrics required by end-users simulated appropriately?

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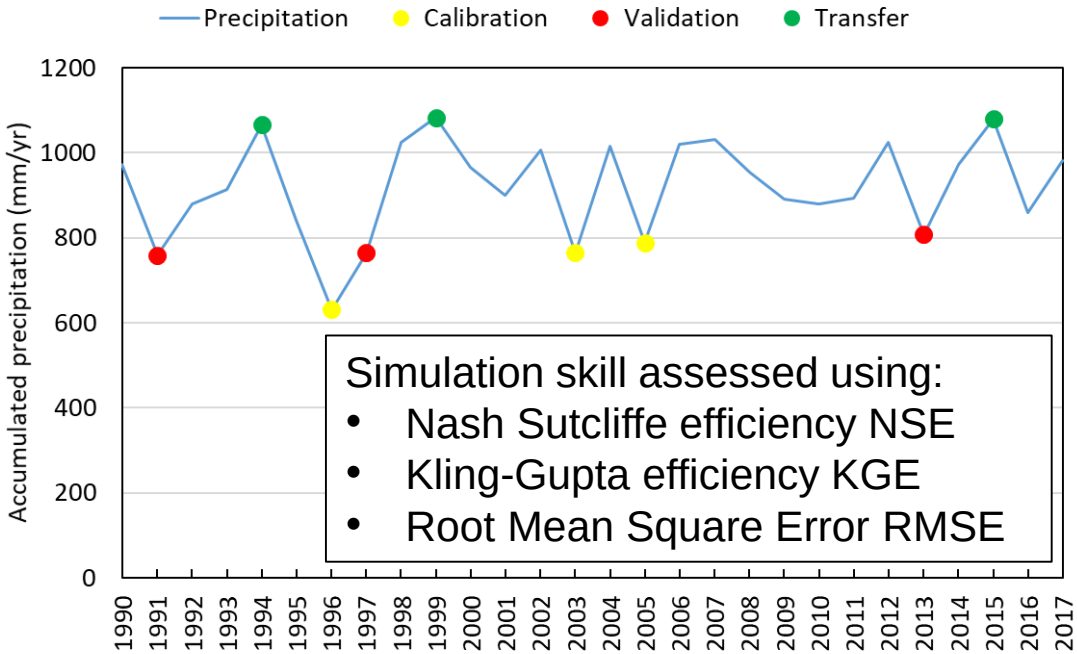
Differential Split Sampling Test (DSST) for Hydrological Models

- Uses historical periods of contrasting climate to calibrate and validate the hydrological model under non-stationary climate found in the present

- Gives an insight on the future simulation skill of models calibrated with observations in the present

Steps:

1) Calibration in 3 dry years (728 mm/yr)
2) Validation in dry years (778 mm/yr)
3) Evaluation in wet years average: 1076 mm/yr



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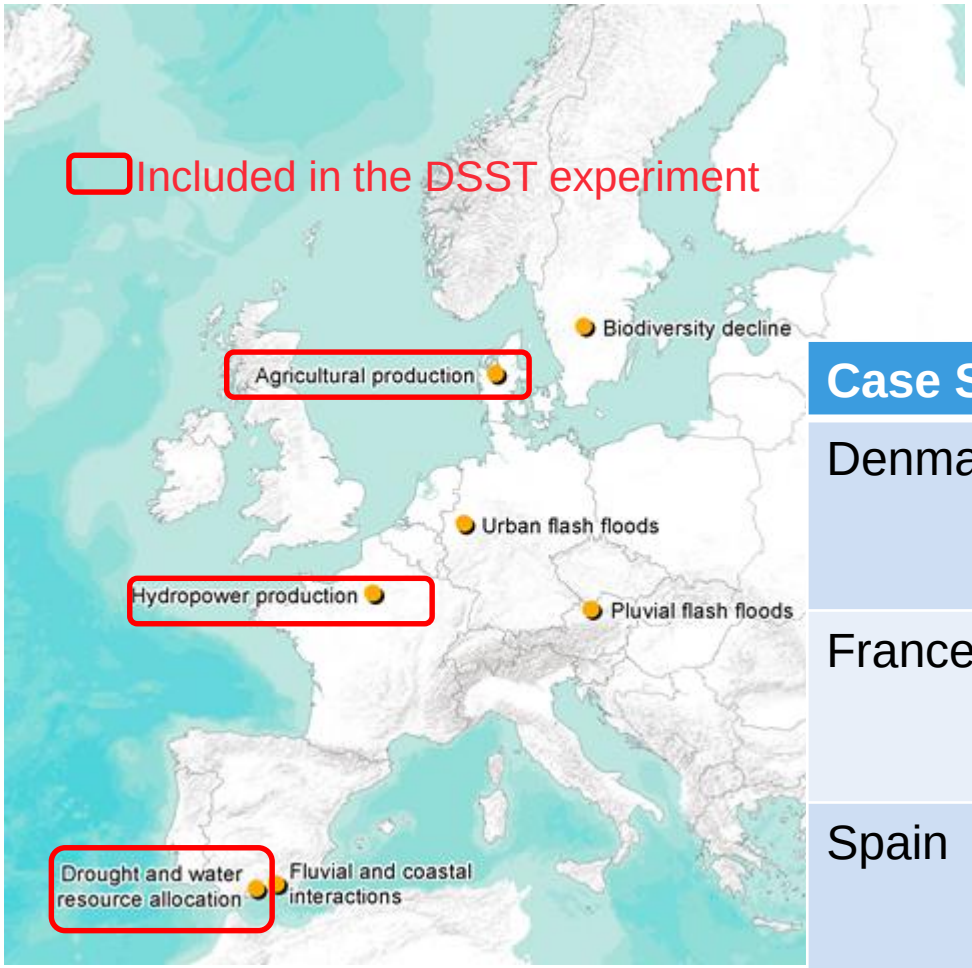
Case Studies



3 study sites across Europe
3 Hydrological models per site

Case Study	Hydrological models
Denmark	MIKE-SHE: 2-layer MIKE-SHE: Gravity flow MIKE-SHE: Richard's equation
France	GR4J TOPMO GR6J
Spain	WiMMed HYPE SWAT

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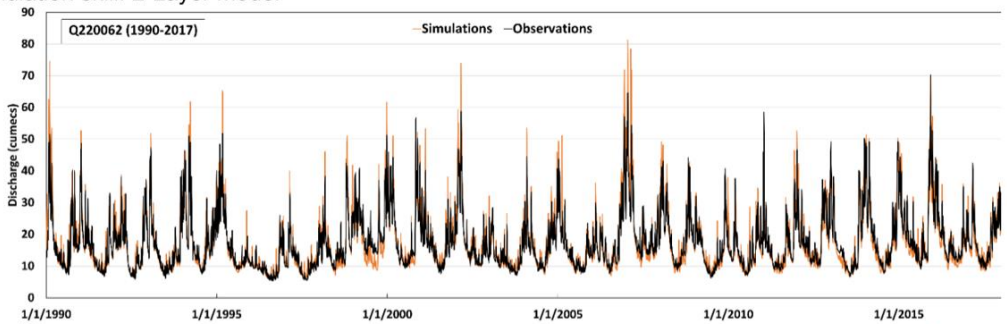
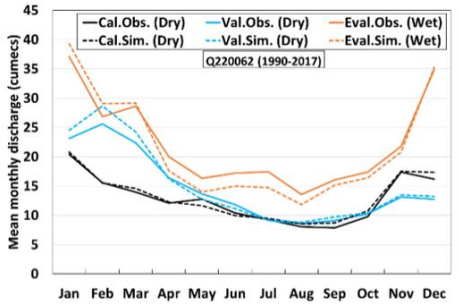
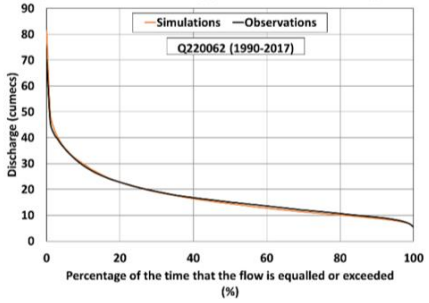
DSST – Analysis of the results

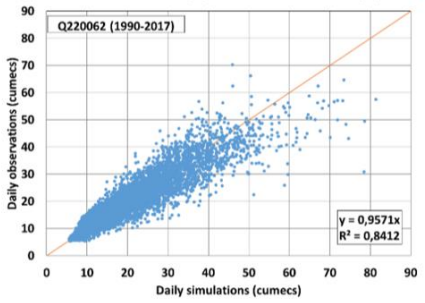
Denmark, 2-Layer

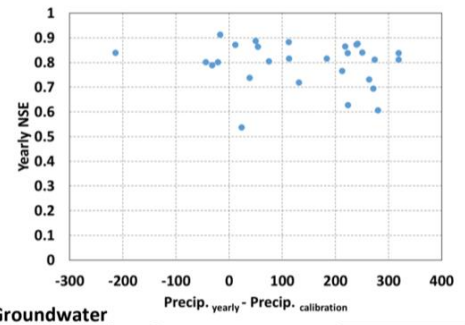
Simulation skill: 2-Layer model

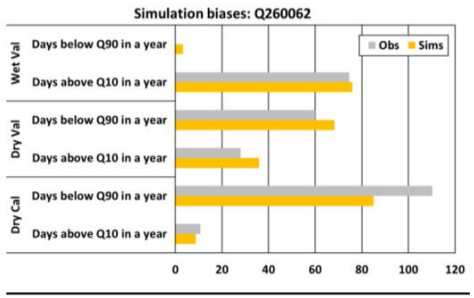


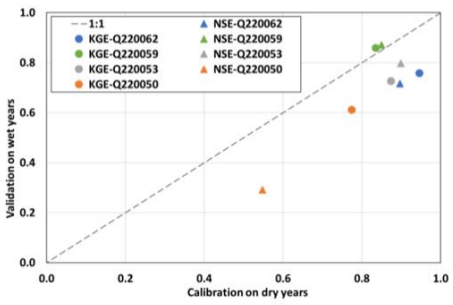


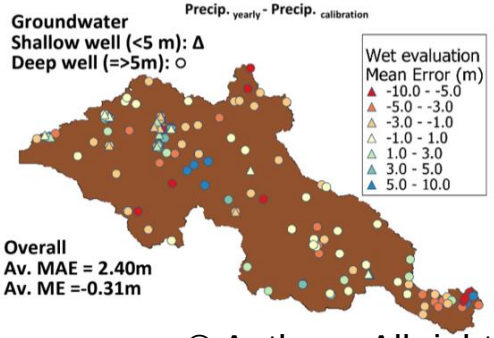












European Research Area for Climate Services

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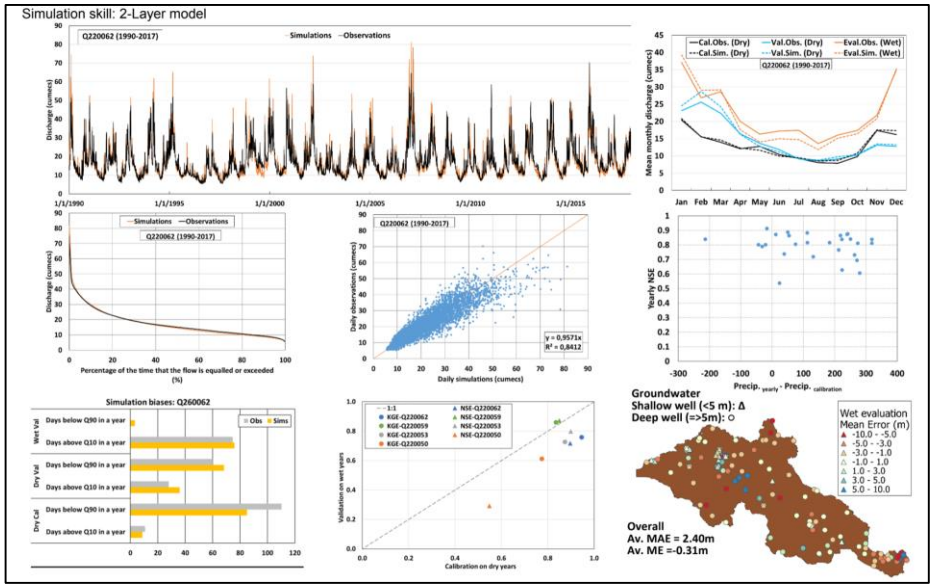
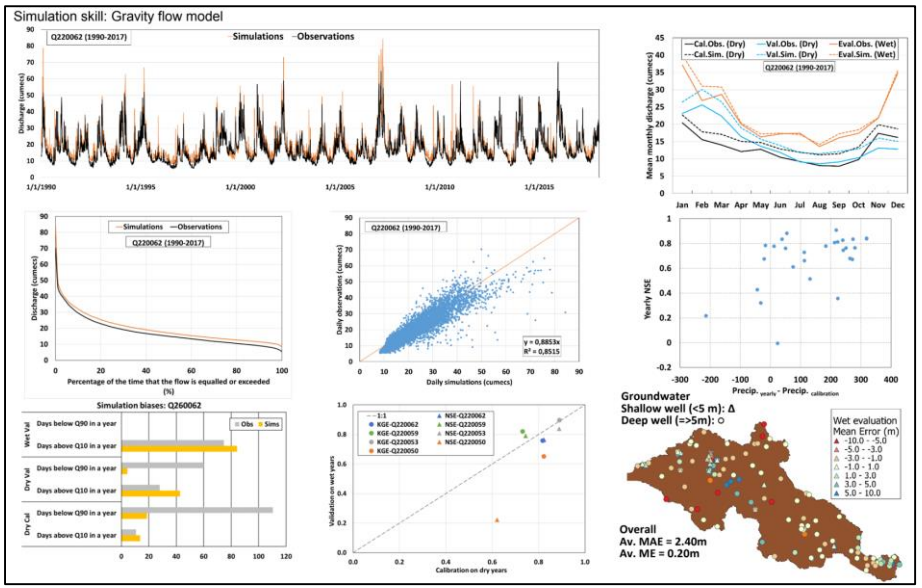
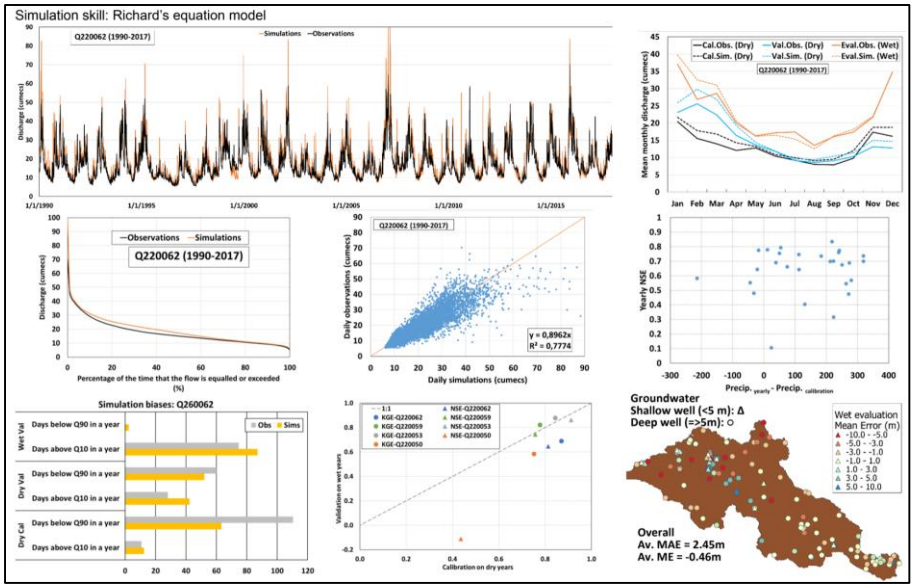




Danish study case:

Results for the three models

How to assess their simulation skill?



European Research Area for Climate Services

Metrics and weights

We use a set of metrics to evaluate the simulation skill of the models:

1: Mean absolute daily bias in the hydrograph
2: Mean absolute bias in the monthly regime
3: Mean absolute bias in the flow duration curve
4: Daily observed vs. simulated discharge
5: NSE at the catchment outlet for entire simulation period
6: NSE at the catchment outlet in contrasting climates
7: KGE at the catchment outlet in contrasting climates
8: Purpose-specific metrics – frequency of low flows and floods / groundwater depth

We define the performance of the models for each metric and aggregate them into four different weighting schemes for the hydrological models:

W1: using metrics 1 to 7
W2: using metrics 8
W3: using all metrics
W4: assigning same weight to all models

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Projection results

We drive the hydrological models with climate from five RCP 8.5 Euro-CORDEX RCMs and set the different weighting schemes assessing percentage changes in the far future (2070-2099) compared to the reference (1976-2005) for the annual frequency of low flows (Q95) and high flows (Q5)

Conclusions

- DSST has potential to be used as tool for evaluating the hydrological model simulation skill under climate change
- The simulation skill for the purpose-specific metrics varies among the models
- DSST can further be used to decrease the influence of unreliable models in the final ensemble projection
- For the Danish case, presented as example, the weight scheme influences the projected change in low flows only, not mean nor extreme discharge

Scheme	High flow frequency change	Low flow frequency change
W1	195%	53%
W2	195%	3%
W3	198%	77%
W4	195%	-23%

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