CaMa-Flood developer/user international meeting 2026

10th and 11th September, 2026 (Thursday - Friday)
at ECMWF headquarters in Reading, United Kingdom.

Presentation Abstracts

<Opening Session>

[Welcome Talk] Florian Pappenburger
European Centre for Medium-Range Weather Forecasts (ECMWF)

<Session 1: Development and Operations>

[D1-1-1] Gianpaolo BALSAMO
ECMWF

Enhanced hydrological coupling in the ECMWF Integrated Forecasting System: How modelling irrigation and inundation processes can influence weather forecasting.
Land surface models used in operational weather forecasting generally handle the water partitioning between land surface storages and fluxes but neglect the water made available to evaporation from inundated and irrigated areas. In this study, we show the importance of considering these processes, as simulated within the ECMWF Integrated Forecasting System. The Catchment-based Macro-scale Floodplain model CaMa-Flood is coupled with the ECMWF land surface model ecLand where the inundated areas are allowed to re-evaporate to the atmosphere. A novel irrigation scheme, based on monthly maps of global irrigation fraction, is used to specify an irrigation flux based on an optimal irrigation strategy. These two processes are evaluated in a set of medium-range forecasts over winter and summer months and show a large, localized impact on temperature, surface pressure, and wind prediction showing a marked positive impact on forecast skill in the area interested. The assumptions and simplifications necessary for considering these processes at the global scale will be illustrated and the steps planned to further increase the realism of dynamic water redistribution, and its land-atmosphere interaction will be discussed.

[D1-1-2] Dai YAMAZAKI
Institute of Industrial Science, The University of Tokyo

Recent development of CaMa-Flood model since 2024

Since the first CaMa-Flood developer/user meeting in 2024, the development landscape surrounding the model has evolved rapidly. This presentation reviews three major trends that have emerged over the past two years. First, the growing availability of SWOT and other satellite-based river products is moving model calibration and data assimilation from observing-system simulation experiments toward applications using actual observations. While satellite-based global river monitoring is becoming a powerful alternative to model-based reconstruction, two-dimensional observations of water-surface elevation also offer unprecedented opportunities to evaluate and improve CaMa-Flood. Second, the computational ecosystem of CaMa-Flood is expanding beyond its conventional implementation through continued development of the HPC branch, GPU- and matrix-based implementations, differentiable modelling, and AI-based surrogate models. Third, CaMa-Flood is gradually evolving from a model maintained primarily by its original developer into a community-based development platform. Annual online briefings, GitHub-based code management, and the reintegration of independently developed components—including sediment and heat transport schemes—are making model developments and user contributions more visible and connected.

Throughout these changes, CaMa-Flood continues to maintain its position as one of the world's leading global river hydrodynamic models. Its next stage of development should combine further advances in core hydrodynamics and new process representations with closer integration of observations, diversified computational approaches, and broader community participation. By bringing together model developers, data scientists, and users from a wide range of research and operational fields, the CaMa-Flood community can continue to develop innovative schemes and pursue ambitious applications at the frontiers of global river science.

Related Publication: Yamazaki, D. (2025). Advancing global river hydrodynamics simulations by catchment-based macro-scale floodplain modeling approach. Geoscience Letters, 12, 72. https://doi.org/10.1186/s40562-025-00452-z

[D1-1-3] Michel Wortmann

ECMWF

Hurdles and configuration of an operational CaMa-Flood in the ECMWF IFS

The implementation of CaMa-Flood in the ECMWF Integrated Forecasting System (IFS) has been nearly 10 years in the making. Although the model has been run in offline experiments for many years, coupling it fully within the operational IFS has proven difficult. The last hurdles have now been overcome, and implementation is planned for the next operational cycle. This talk will highlight how this research-to-operations journey has improved both CaMa-Flood and the IFS, and will describe the forecast configurations in which CaMa-Flood will be run.

<Session 2: Regional Applications>

[D1-2-1] Ikuto KAMBE
Weathernews Inc.

Realtime River Flood Forecasting for Southeast Asia using CaMa-Flood

Climate change is projected to increase both the frequency and severity of extreme weather events, with riverine flooding among the most destructive consequences. Asia is particularly vulnerable to flood hazards due to a combination of geographic, climatic, and socioeconomic factors, including dense populations on low-lying floodplains, intense monsoonal precipitation, and limited capacity for early warning and disaster response. In Southeast Asia, transboundary river systems and complex terrain further amplify flood risk, underscoring the urgent need for accurate, real-time forecasting systems capable of providing actionable early warnings.

In response, Weathernews Inc. has developed a real-time river flood forecasting system for Southeast Asia using CaMa-Flood.

The prediction pipeline consists of three sequential components. Atmospheric forcing is provided by "COMPASS", a weather forecasting system developed and operated by Weathernews Inc., at a horizontal resolution of 0.1 degree. These meteorological fields — including precipitation, temperature, and radiation — drive the Variable Infiltration Capacity (VIC) land surface model, which computes surface runoff through the simulation of evapotranspiration and soil moisture dynamics. The resulting runoff is subsequently fed into CaMa-Flood as lateral inflow for river routing, yielding spatially distributed forecasts of river discharge, water depth, and flood inundation extent across Southeast Asia.

Forecast accuracy is evaluated through hindcast experiments based on historical flood events in the region. Simulated discharge and inundation patterns are assessed against observational records and post-event reports. Additionally, predictions are benchmarked against Google Flood to provide an objective comparison of the two operational systems and to identify opportunities for further improvement.

Finally, we discuss the requirements and needs of local meteorological agencies in Southeast Asia as essential steps toward full operational deployment. Key considerations include data-sharing frameworks, integration of ground-based observations for model calibration, and effective communication of forecast uncertainty to end users and decision-makers. Bridging the gap between technical development and operational practice remains a central challenge in advancing flood early warning capabilities across the region.

[D1-2-2] Faizal I. W. ROHMAT
Institut Teknologi Bandung

A Preliminary Regional-Scale Feasibility Assessment of CaMa-Flood for Flood Screening and Monitoring Support in Data-Scarce Regions of Indonesia

Due to sparse monitoring networks, limited hydrological observations and the high data requirements of traditional hydrodynamic models, reliable flood assessment remains difficult in many parts of Indonesia. This study offers a preliminary regional-scale feasibility assessment of the CaMa-Flood global hydrodynamic model for flood assessment in data-sparse regions of Indonesia, using Kalimantan as a case study. The model is implemented at a spatial resolution of 1 arc-minute (~1.8 km) using runoff inputs derived from the ERA5 reanalysis dataset and topographic information from the MERIT-DEM and MERIT-Hydro datasets. The results of this modeling are then evaluated by comparing the observed flow at six observation points, the flow patterns and the river's properties. The results of the CaMa-flood model show that it can simulate the spatial structure of the river network in Kalimantan and capture seasonal flow patterns associated with the monsoon climate in Indonesia. The underlying river network data demonstrated strong agreement with manually digitized river widths, supporting the suitability of the hydrographic representation for regional applications. Temporally, the modeling results also accurately identify the timing of major flood events, although the model's performance varies widely, which can be attributed to uncertainty in the input data and the quality and reliability of observation data in Indonesia. Comparison with Sentinel-1-derived inundation maps revealed significant differences in flood extent estimates, highlighting model limitations and the uncertainties associated with satellite-based flood detection at large spatial scales. The results of this study show that the CaMa-flood can provide the first large-scale, rapid information on seasonal river flow patterns and potential flood locations, even when data in Indonesia are very limited. However, this model should not replace locally calibrated models with detailed scales for precise flood mapping and design purposes; it can still provide efficient answers for initial flood screening and prioritizing areas that require more in-depth investigation. In addition, this study also discusses several potential follow-up studies to further enhance regional hydrological understanding at scale.

[D1-2-3] Tobias CONRADT
Potsdam Institute for Climate Impact Research

Progress in the application of CaMa-Flood in the Danube River Basin

At the first international CaMa-Flood developer/user meeting in Tokyo in July 2024 I presented my first experiments with CaMa-Flood simulating the Danube River Basin extending over 800,000 km^2 in central and south-east Europe. Runoff input was generated for 13,641 sub-basins by the eco-hydrological model SWIM driven by E-OBS weather grids in 0.1-degree resolution.

While flood peaks were simulated nicely in the Upper Danube at Ingolstadt, Germany, water levels remained way too stable in many lowland rivers, e.g. the Sava River at Županja Stepenica, Croatia. Flood maps generated by CaMa-Flood's downscaling routine showed large river lakes which in reality do not exist any more. Human intervention including extensive levee structures was missing from the model.

Fast forward two years, thanks to the recently developed CaMa-Flood levee module (Zhao et al. 2025, https://doi.org/10.1029/2024WR039790), quite realistic flood hydrographs can now be simulated for many downstream sections of the Danube River system. I'll show how I solved the hurdle of providing levee distances and heights by estimating runoff–levee distance relationships and using Zhao et al's overtopping return period method for the heights. There are also some attempts to translate actual levee geometries from the Sava basin into levee distances to be presented as well as experiences with tuning the Manning parameters for flood wave celerity calibration.

To assess the shift of flood hazards under climate change, the SWIM–CaMa-Flood combination was driven by ten climate realizations each from SSP3-70 and SSP5-85 climate scenarios, bias-adjusted and uniformly downscaled to 0.5-degree resolution by the ISIMIP project (https://www.isimip.org). Although runoff return interval estimations from observed data differ more from scenario results for the recent past/near future than the latter differ from end-of-century simulations, it can be stated that tendencies of extreme floods becoming more frequent prevail, especially in the lowland parts of the basin.

A manuscript detailing much of the work presented here has been submitted to a Topical Collection on water security with the journal Climatic Change. This research was performed in the framework of the EU Horizon DIRECTED and Croatian SERIOUS projects funded by the European Union (grant no. 101073978) and the Croatian Science Foundation (IP-2024-05-1497).

Related Publication: Publication in preparation (manuscript submitted to Climatic Change): “Flood hazards in the Danube Basin under climate change: hydrological and hydrodynamic projections considering levee effects”

[D1-2-4] Nozomi Uemachi
Institute of Industrial Science, The University of Tokyo

Extending CaMa-SED for Robust Continental-Scale Hydro-Sediment-Morphodynamic Modeling

Sediment transport and topographic change are the next frontier for CaMa-Flood. The CMF approach converts unresolved channel and floodplain topography into effective large-scale hydrodynamics, enabling long-term regional to global simulations (Yamazaki, 2025). CaMa-SED extends this framework to suspended-load and bedload transport and resulting morphological change in river networks, moving beyond empirical sediment-export modeling (Hatono & Yoshimura, 2020). The remaining challenge is to make sediment transport and bed evolution scale-aware.

This study improves CaMa-SED by reformulating its local treatment of sediment transport and bed evolution. In the original model, transport capacity and bed elevation change are diagnosed from instantaneous hydraulic conditions at each timestep. Although physically interpretable at local scales, this formulation produces two failure modes on macro-scale grids: timestep-dependent oscillation in sediment transport and artificial channel clogging caused by excessive local deposition.

We interpret these problems as consequences of applying locally instantaneous sediment dynamics at CaMa-Flood scales. Oscillation occurs because suspended sediment concentration is evaluated from its initial timestep value, although erosion and deposition should continuously modify that concentration. Bed-flow exchange can therefore overshoot equilibrium concentration and generate artificial alternation between erosion-dominated and deposition-dominated states. Artificial clogging arises when deposition is distributed over an effective grid-scale channel width, reducing conveyance and transport capacity across the entire channel unit, especially in low-gradient downstream reaches.

We implemented two scale-aware modifications. First, the Equilibrium Concentration Scheme treats suspended sediment concentration as a prognostic variable that relaxes toward equilibrium within each timestep. This finite-time adjustment suppresses overshooting while retaining dependence on hydraulic conditions. Second, the Channel Concentration Scheme allows flow to remain concentrated in an effective active channel during aggradation. By dynamically adjusting effective channel width and velocity, it prevents deposition from reducing conveyance across the full grid-scale channel.

The improved CaMa-SED was evaluated through a 65-year Missouri River simulation from 1960 to 2024. The Equilibrium Concentration Scheme eliminated timestep-dependent oscillations, indicating that the previous instability mainly reflected a mismatch between sediment adjustment timescale and numerical timestep. The Channel Concentration Scheme substantially reduced artificial clogging in the lower mainstem by preventing grid-scale aggradation from suppressing conveyance and transport capacity. However, aggradation near tributaries and confluences remains incompletely interpretable, because deposition may reflect real flow deceleration and sediment mixing as well as unresolved sub-grid hydraulic geometry.

In conclusion, this study makes CaMa-SED more scale-aware by incorporating sub-timestep sediment relaxation and sub-grid channel concentration. The improved model preserves the computational and conceptual advantages of CMF while reducing timestep oscillation and artificial clogging. Future work should diagnose tributary and confluence reaches explicitly and validate morphodynamic changes against in situ observations and remote-sensing products.

<Session 3: Biogeochemistry>

[D1-3-1] Hong WANG
Institute of Industrial Science, The University of Tokyo

Hydrodynamic Controls on Riverine Carbon Emissions through Floodplain-Explicit Carbon Routing Modelling

Rivers are increasingly recognized not only as passive conduits transporting carbon from land to ocean, but also as active biogeochemical reactors that retain, transform, and release carbon to the atmosphere. However, large-scale estimates of riverine carbon cycling remain highly uncertain, partly because many models do not explicitly represent how floodplain inundation, transient storage, residence time, and channel–floodplain exchange regulate carbon transport and processing. These limitations are particularly important under hydroclimatic extremes, such as floods, droughts, and heatwaves, which can strongly alter whether river networks behave primarily as carbon “pipes” or biogeochemical “reactors”.

Here, I present the development of a floodplain-explicit carbon routing module within the Catchment-based

Macro-scale Floodplain model, CaMa-Flood. The model uses runoff and dissolved organic carbon leaching from JULES-DOCM as terrestrial inputs and routes carbon through separate river-channel and floodplain water stores. Within each catchment, the framework represents downstream DOC transport, hydrodynamically controlled residence time, DOC decomposition to dissolved CO_2, and CO_2 evasion to the atmosphere. By distinguishing river and floodplain storage, water depth, surface area, flow velocity, and exchange, the model allows carbon transformation and emissions to respond directly to floodplain inundation dynamics.

This work addresses two main questions: how can a floodplain-explicit carbon routing model diagnose carbon transport, transformation, storage, and emissions across large river networks; and under what hydroclimatic conditions do floodplains, rather than river channels, dominate riverine carbon cycling? The resulting framework aims to provide a more physically realistic representation of global river carbon emissions and to support future assessment of carbon cycle responses to changing floods, droughts, and thermal extremes.

[D1-3-2] Sonja Folwell
UK Centre for Ecology and Hydrology

Improving the Representation of Wetland Hydrodynamics and Methane Emissions in the JULES Land Surface Model

In recent years, tropical wetlands across East Africa have contributed to a rapid and globally significant increase in natural methane emissions. This increase is largely driven by enhanced seasonal rainfall, which promotes fluvial inundation and the expansion of wetland areas. These hydrological changes directly regulate the biogeochemical processes controlling methane production, with enhanced inundation promoting methane production. Furthermore these processes operate across multiple timescales. At seasonal timescales, the onset, duration, and extent of flooding control the timing and magnitude of methane pulses. At interannual timescales, variability in rainfall and upstream river discharge alters the spatial extent and persistence of inundation, leading to substantial year-to-year differences in methane emissions. The coupling between hydrology and biogeochemistry that underpins the methanogenic processes is not fully represented in current land surface models (LSMs).

While some LSM capabilities capture sub-grid heterogeneity and the formation of localised saturated areas, they do not adequately represent large fluvially flooded wetlands, such as those in East Africa and beyond, which receive water from upstream river networks. Furthermore, the lateral redistribution of water across very large (multi-gridbox) wetland deltas is not simulated, leading to an underestimation of the interannual variability in wetland extent.

Under the CurFEW (CURrent and Future Wetland Methane Emissions) project, a key objective is to improve the representation of critical processes within the JULES land surface model. These include wetland hydrodynamics, hydrology–vegetation interactions, and vegetation-mediated methane production, within the wider Earth system modelling framework.

The CaMa-Flood model has previously been integrated into JULES and is now being extended to include bifurcation functionality, which is essential for representing flow dynamics in large wetland systems. Building on this coupling between the land surface and river routing components, further development will enable a fully interactive floodplain scheme. This includes the introduction of an additional surface water store, allowing inundated water on floodplains to either re-infiltrate into the soil column or return to the atmosphere via evaporation.

To support this development, we are constructing a data assimilation framework to optimise bifurcation channel parameters at LSM-relevant scales. This framework will utilise a newly developed inundation dataset, based on TropWet and generated within the project.

Together, these developments will improve the ability of the JULES land surface model to represent wetland dynamics and associated methane emissions across timescales, reducing uncertainty in regional and global methane budgets.

Related Publication: CurFEW project webpages: https://sites.google.com/view/curfew-nerc/home

[D1-3-3] Leatile Tshabang Modie

Institute of Industrial Science, The University of Tokyo

Wavelet-Based Diagnostic Metrics for A Global Hydrodynamics Model Validation: Application to CaMa-Flood discharge

Accurate validation of large-scale hydrodyanamics models is challenging because conventional metrics like the Nash-Sutcliffe Efficiency and fixed-flow thresholds combine multiple error modes into a single score, obscuring model deficiencies. We present a wavelet-based validation framework applied to CaMa-Flood simulations at global scale (1980–2014) against daily discharge observations from GRDC gauging stations.

The framework derives four independent diagnostic metrics from the continuous wavelet transform of simulated and observed discharge records. The Flood Onset Phase Error (FOPE) quantifies timing misalignment at the dominant seasonal period as a mean absolute phase offset in days, independent of river magnitude. The Wavelet Entropy Divergence (WED) measures divergence between the spectral energy distributions of simulation and observation, capturing whether the model reproduces the correct balance of variability across timescales. The Hydrograph Shape Divergence (HSD) assesses morphological similarity and duration mismatch of the seasonal flood envelope. The Temporal Overlap Coefficient (TOC) measures the Jaccard overlap between extracted flood windows, quantifying temporal coverage accuracy.

Projecting stations onto a FOPE–WED diagnostic plane reveals four interpretable regimes: stations with correct CaMa-Flood reproduction of timing and spectral physics; stations with intact flood physics but routing delays; stations with correct timing but degraded spectral signatures; and stations with both failure modes. This classification guides model improvement by distinguishing routing parameter errors from water balance and storage errors, which a single efficiency score cannot..

Critically our framework requires no manually tuned thresholds, operates identically across all basin scales globally and is computationally efficient since all metrics are derived from a single wavelet decomposition per station.

<Session 4: Land Surface Coupling>

[D1-4-1] Leslie Enrique Salomon ALVÁN ENCINAS
universidad nacional agraria la molina

High-Resolution Hydrodynamic Modeling (CaMa-Flood v4.30) for the Identification of Backwater Zones and Sediment Traps in the Marañón, Pastaza and Nanay Basins (Loreto, Peru)

The identification of backwater zones in the Peruvian Amazon floodplain faces three fundamental challenges that this study explicitly addresses: (i) the absence of high-frequency hydrometric stations in the Marañón, Pastaza, and Nanay basins; (ii) the episodic nature of sediment pulses linked to ENSO events; and (iii) the need to incorporate sediment dynamics as part of the hydrodynamic solution, not as an independent post-process.

To address these challenges, we implement the global hydrodynamic model CaMa-Flood version 4.30 (Yamazaki et al., 2011; Bates et al., 2010) in its complete configuration, which includes: (a) the local inertial flow equation ($\partial q/\partial t + \partial(\beta q^2/h)/\partial x + gh\partial h/\partial x + g(n^2q|q|)/h^{(7/3)} = 0$); (b) the continuity balance with infiltration and runoff; and (c) critically, the sediment transport and deposition module natively incorporated in v4.30, which solves the suspended and bedload fractions through a coupled Exner formulation and Engelund-Hansen type transport capacity adapted for tropical systems. Input topography is MERIT-DEM v1.0.3 (Yamazaki et al., 2017) at ≈90 m resolution, corrected for vegetation bias and validated for the Amazon. Hydrological forcing comes from ERA5-Land (1934-2024) complemented with SENAMHI data for the 1970-2024 period, ensuring representation of extreme ENSO events (1982-83, 1997-98, 2015-16).

The operational novelty of this study lies in defining backwater zones from directly model-extractable variables, using physically justified thresholds for pristine systems with low hydraulic alteration: flow velocity $v \leq 0.25$ m/s (silt-clay <63 μm), hydraulic residence time $\tau \geq 20$ days (calculated via inverse Lagrangian tracking over the 2D velocity field), hydraulic gradient $\Delta h/\Delta x < 0.6\%$, and specific outflow $q_{out} < 0.01$ m^2/s. No ad-hoc criteria are used; each threshold derives from the Shields condition for incipient motion of cohesive particles and the sedimentary Péclet number.

Hydrodynamic validation —prior to any sedimentological calibration— is performed using Sentinel-2 NDWI and Sentinel-1 SAR flood time series (2015-2024), comparing simulated and observed inundation extent and persistence. Goodness-of-fit metrics for Manning's coefficient ($n_{channel} = 0.045 \pm 0.005$; $n_{floodplain} = 0.12 \pm 0.01$) are reported, obtained through global sensitivity analysis (Monte Carlo, 10,000 iterations, Sobol indices).

Key results for the region: (a) The lower Nanay, downstream of the Iquitos Arch, presents the most temporally persistent backwater zone ($\tau > 28$ days, linear extent >25 km), with hydrodynamic conditions optimal for preserving the fine stratigraphy required for ^{210}Pb dating. (b) The lower Marañón upstream of the Ucayali confluence develops an extensive backwater (up to 90 km) but with high seasonal variability (±40% in length), reflecting hydraulic backwater from the Amazon River. (c) In the Pastaza, backwater concentrates in the overflow lakes of the alluvial megafan, with $\tau \leq 18$ days but high episodic sedimentation rates associated with flood pulses.The sediment module of CaMa-Flood v4.30 is run in diagnostic mode (not yet calibrated with field data), yielding spatial predictions of sediment accumulation rates (SAR) consistent with backwater geometry: maximum predicted SAR (>1.5 cm/yr) in zones with $v \leq 0.25$ m/s and $\tau > 20$ days, and minima in high-velocity or short-residence areas. These predictions constitute a testable hypothesis that will be validated in the project's next phase with sediment cores and ^{210}Pb dating (Alpha Spectrometry, CRS model).

We conclude that CaMa-Flood v4.30 with MERIT-DEM constitutes a hydrodynamically sufficient and robust approach for identifying backwater zones in pristine Peruvian Amazonia, provided that inundation extent is validated with remote sensing and inherent limitations are acknowledged: (i) channel bathymetry is infered, not meseared: ii) the manning n formulation does not explicity capture flow resistence from emergent woody vegetation; and iii)sediment deposition in backwate zones requires local calibaration with radiometric dating. The final product delivers a high resolution prospective map that reduces the search area for future sedimentalogical sampling by 70%, with direct applicavbility to other Amazonian basins under similar condicionts.

[D1-4-2] Hashmi Fatima
National Centre for Medium Range Weather Forecasting (NCMRWF)

Preliminary experiments with Cama-flood using Mithuna couple model data over Indian region

Accurate prediction of inundation during the monsoon season is vital for disaster risk reduction and water resource management across the Indian subcontinent. This study employs the Cama-flood model using Mithuna couple model data at a 12 km spatial resolution to simulate surface hydrology and river discharge for predicting inundation patterns over India. The framework captures land-atmosphere interactions, soil moisture dynamics, and river routing processes essential for assessing flood extent and timing. In this study the experiments with Joint UK Land Environment Simulator coupled with the Total Runoff Integrating Pathways model (JULES-TRIP) at a 12 km spatial resolution has also been done over India for comparison with Cama-Flood output.

Validation against observed hydrological and satellite-derived flood data during recent monsoon seasons demonstrates the model's capability to identify high-risk zones and temporal evolution of flood events. The results highlight the comparison between JULES-TRIP and JULES-Camaflood for monsoon flood forecasting, offering valuable input for early warning systems, emergency planning, and climate adaptation strategies in flood-prone regions of India.

[D1-4-3] Toby Marthews
UK Centre for Ecology & Hydrology

A workflow for land-ocean interaction: river outflows and coastal inundation

In order to improve prediction of coastal hazards, a better representation is required of river outflows and the impacts of coastal sea surges. This has been a focus of much recent work in the CHAMFER project at the UK Centre for Ecology & Hydrology (UKCEH) and the UK National Oceanography Centre (NOC). We have taken a recent version of the global hydrodynamic model CaMa-Flood and combined it with the land surface model JULES and the ocean model NEMO in order to achieve this. Inserting a better representation of these fluxes requires updating water balance calculations across the land-sea interface. We outline here current work within the CHAMFER project to achieve this by producing an offline workflow operating on the UK500 grid, a 500m resolution grid covering the UK and surrounding territories.

Related Publication: https://www.tobymarthews.com/chamfer.html

<Session 5: Computational Advances>

[D2-1-1] Prakat MODI

SIT Research Laboratories, Shibaura Institute of Technology, Japan

Impact of Spatial Resolution on Large-scale Hydrodynamic Model Simulation and Physics

Large-scale global hydrodynamic models like CaMa-Flood are essential for global flood risk assessment, yet understanding how spatial-resolution choices systematically affect model physics and simulation accuracy remains a critical challenge. Historically, model assessments have relied heavily on macro-scale outputs validated at sparse, gauged stations, which overlook vast ungauged areas and mask localised physical discrepancies. To bridge this gap, this study systematically evaluates inter-resolution consistency across model simulations. By comparing multiple simulated hydrodynamic variables (discharge, water depth, flooded area, and flood extent) across resolutions, we overcame the constraints of limited field data, external parameter optimisation, and misjudgement of the model due to external factors like runoff forcing while examining the effects of spatial resolution on large-scale hydrodynamic simulations.

A multi-resolution comparison of CaMa-Flood simulations (1, 3, 6, and 15 arcminutes) across the Amazon River basin showed robust inter-resolution agreements, using the higher resolution as a benchmark in each pairwise comparison. Highly reliable consistency was achieved for both river discharge and water depth across the 1,198 virtual stations, with coefficients of determination exceeding 0.88 ($R2 > 0.88$) in more than 80% of locations. The normalized Nash–Sutcliffe efficiencies (NNSE) for discharge and water depth were greater than 0.83 and 0.68, respectively, in more than 75% of locations, suggesting that most locations had consistent hydrodynamics. While subgrid parameter derivation successfully maintained macro-scale relationships, spatial resolution significantly altered local physics in distinct zones.

Discrepancies in river discharge emerged at approximately 2.5% of locations, primarily concentrated near tributary junctions due to backwater effects and complex floodplain flow conveyance constraints in flat terrain. Water depth discrepancies occurred at roughly 3% of locations, predominantly across headwater regions where coarser grid cell averaging distorts narrow channel width parameters and cross-sections. Furthermore, comparing flood extents revealed that while flooding along major streams was well simulated, dissimilarities persisted in smaller streams due to the representation of smaller tributaries at low resolution and downscaling limitations.

Ultimately, our findings demonstrate that moderate-resolution configurations (e.g., 6 arcmin) are adequate for macro-scale modelling, successfully preserving hydrodynamic patterns. For future model improvement, development should prioritise localised subgrid parameterisation improvements, updated hydrography data for bifurcation channel representation, and enhanced downscaling methods for small streams.

Related Publication: Modi, P., Yamazaki, D., Hirabayashi, Y., Revel, M., & Zhou, X. (2025). How spatial resolutions impact the large-scale river hydrodynamic model simulations: Analysis focuses on model physics. Journal of Advances in Modeling Earth Systems, 17, e2025MS004961. https://doi.org/10.1029/2025MS004961

[D2-1-2] Shengyu Kang
Wuhan University

CaMa-Flood-GPU: A GPU-based hydrodynamic model implementation for scalable global simulations

Floods are among the costliest natural hazards, demanding scalable models to simulate river and floodplain dynamics at a global scale. The Catchment-based Macro-scale Floodplain (CaMa-Flood) model is a leading system for this purpose, but its CPU-based implementation is computationally demanding. This paper introduces CaMa-Flood-GPU, a fundamental refactoring of the model optimized for Graphics Processing Unit (GPU) architectures. We systematically reinterpreted its core algorithms—including river routing on irregular networks, runoff interpolation, and water depth diagnosis—into highly parallel, GPU-native operations. Key challenges were addressed by implementing scatter-add for flux updates, sparse matrix multiplication for runoff mapping, and branchless kernels for floodplain dynamics, all while preserving the original model's physical fidelity. Implemented in Python with Triton kernels and PyTorch, CaMa-Flood-GPU achieves multi-GPU scalability through optimized communication patterns that minimize synchronization overhead. The software adopts a modular structure with optional components (e.g., bifurcation routing, adaptive time stepping) and flexible data interfaces. Benchmarks demonstrate an order-of-magnitude speedup over a 192-core CPU baseline and near-linear scaling on multiple GPUs, with negligible numerical differences from the original model. This performance leap reduces simulation times for high-resolution global runs from days to hours, enabling larger ensembles and rapid scenario analysis. By providing a reproducible and efficient tool, CaMa-Flood-GPU lowers the barrier for adopting GPU acceleration in large-scale hydrology. The released implementation provides a reproducible reference for future method development.

Related Publication: Kang, S., Yin, J., & Yamazaki, D. (2026). CaMa-Flood-GPU: A GPU-based hydrodynamic model implementation for scalable global simulations. Geoscientific Model Development, 19, 5623-5640. https://doi.org/10.5194/gmd-19-5623-2026

[D2-1-3] Hancheng Ren
Beijing Normal University

GraphRiverCast: A Topology-Informed AI River Model for Global River Hydrodynamics

Artificial intelligence(AI) models have improved the prediction of a wide range of Earth system processes, such as atmospheric and ocean dynamics. However, their application to global river systems remains comparatively limited. A major challenge is that many existing autoregressive models rely heavily on accurate initialization of system states, whereas historical observations are unavailable for most river reaches worldwide. This dependence substantially hinders the development of a unified large-scale river learning model. Here, we introduce GraphRiverCast (GRC), a topology-informed AI model that represents the global river system as an interconnected network. By exploiting the inherent connectivity and energy-dissipative characteristics of river networks, GRC reconstructs daily multivariable hydrodynamic states for approximately 127,000 river reaches worldwide without requiring historical river observations for state initialization. Unlike conventional autoregressive models, whose errors may accumulate as the forecast horizon increases, GRC maintains relatively stable predictive performance over extended lead times. Attribution experiments indicate that this stability arises primarily from the explicit incorporation of river-network topology. By learning routing processes under topological constraints, the model reduces its dependence on purely temporal correlations and better represents the spatial propagation of hydrodynamic signals through river networks.GRC was pretrained using high-resolution hydrodynamic simulations generated by CaMa-Flood and fine-tuned with sparse in situ observations from hydrological stations. The fine-tuned model outperformed widely used physics-based and data-driven global river forecasting models. It also showed the ability to generalize to ungauged river reaches and to operate across different spatial scales.These results demonstrate that explicitly incorporating river-network topology into AI models can support a transition from fragmented basin-scale simulations toward integrated prediction of the global river system. Aligning with the evolution of hydrological models from lumped to distributed schemes, this work carries this progress into the AI era.

Related Publication: https://arxiv.org/abs/2602.22293

<Session 6: Satellite Integrations>

[D2-2-1] Xiaoyu Sun
Institute of Industrial Science, The University of Tokyo

Calibration of Effective Channel Depth in the CaMa-Flood Model Using SWOT Observations

Global hydrodynamic models are essential for simulating flood dynamics to support flood risk assessment and water resources management. However, model performance is strongly affected by channel depth, which controls channel storage and influences simulated water surface elevation (WSE) and remains a poorly constrained variable at global scale due to the scarcity of direct observations. Most global hydrodynamic models, including CaMa-Flood, estimate channel depth using empirical power-law formulations with globally fixed coefficients, which may not fully represent variability in channel morphology and lead to systematic biases in results. The Surface Water and Ocean Topography (SWOT) mission now provides spatially dense node level observations of river WSE, enabling systematic node-to-grid allocation and comparison between observations and simulations and calibration of model channel depth parameters at large scales. However, the feasibility and limitations of using SWOT WSE to calibrate effective channel depth in global hydrodynamic models remain insufficiently evaluated.

This study evaluates the feasibility of using SWOT WSE to calibrate model effective channel depth in CaMa-Flood at the sub-basin scale, using the Mississippi River basin as a case study. SWOT river nodes are spatially allocated to CaMa-Flood grid cells, and WSE biases are summarized at both grid and sub-basin scales. In this experiment, channel depth is represented by the default empirical power-law formulation, with a single sub-basin-level effective depth offset, H0, added to account for systematic WSE bias. For each sub-basin, Bayesian optimization is employed to identify the H0 value that minimizes the mean absolute bias between simulated WSE and SWOT WSE. SWOT observations from August 2023 to December 2024 are used for calibration, with the most stable 50% of observations selected to reduce noise, while all SWOT observations in 2025 are used for independent validation. Discharge is subsequently used as an independent diagnostic metric to evaluate the calibrated results relative to the default model configuration.

Results from the Mississippi River basin reveal large and spatially coherent WSE biases between the default CaMa-Flood simulation and SWOT observations. The sub-basin level H0 calibration substantially reduces these biases: during the calibration period, the mean absolute WSE bias averaged across sub-basins decreases from 2.35 m to 1.44 m, with 94 out of 97 sub-basins improved. Independent validation using all SWOT observations in 2025 shows a consistent reduction from 2.39 m to 1.66 m, and 88% of sub-basins remain improved. The calibrated H0 also reduces WSE bias across low, medium, and high flow conditions, suggesting that it captures a persistent and temporally transferable WSE bias signal. However, additional discharge diagnostics indicate that WSE based calibration does not fully isolate channel-depth effects from other sources of model error, such as runoff forcing or storage representation. These findings suggest that SWOT WSE can constrain model effective channel depth in CaMa-Flood, while the calibrated H0 should be interpreted as an effective depth correction rather than direct physical bathymetry.

Keywords: Parameter Calibration; CaMa-Flood; SWOT

[D2-2-2] Do Ngoc KHANH

Shibaura Institute of Technology

A global levee database derived from high resolution digital elevation models

The flooding of rivers can be both beneficial and disastrous to society. As global climate change progresses, hazard mapping utilizing river models has become crucial for mitigating disastrous consequences. Accurate inundation predictions from such models rely on precise data on the locations of levees. However, current levee databases have limited coverage. In this study, we propose a globally applicable method for detecting levees using morphological parameters derived from high-resolution LiDAR Digital Elevation Models (DEMs). Our method shows adequate detection performance. Notably, even unrecorded natural and artificial levees were identified. Further, we identified 49,000 km of levee across five countries, 27,000 km of which protect urban areas and cropland. A portion of the remainder consists of natural levees within natural landscapes. The detected levees may enhance the accuracy of flood modeling and risk assessment. Our method possesses significant application potential, which will increase further as the availability of DEMs expands globally.

Related Publication: Khanh, D. N., Tsumura, Y., Sasaki, O., Shiraishi, K., Akimoto, D., Yamazaki, D., Zhao, G., & Hirabayashi, Y. (2025). Mapping the world's river levees: A hyper-resolution levee database based on digital elevation models. Geophysical Research Letters, 52, e2024GL114121. https://doi.org/10.1029/2024GL114121

[D2-2-3] Yukinori KOJIMA
Institute of Industrial Science, The University of Tokyo

Bias-corrected Two-step Assimilation of Satellite Water Surface Elevation and Discharge for Large-scale River Reanalysis

Recent satellite missions enable observation or estimation of water surface elevation (WSE) and discharge (Q) which can be assimilated in large-scale river model. WSE is observed with high accuracy but depends on unknown riverbed elevation. Q is independent of riverbed elevation but more uncertain. There has been insufficient discussion and systematic verification regarding how to integrate WSE and Q. Here we investigate how these complementary observations can be combined to improve river reanalysis. WSE from multiple satellite missions and Q from SWOT was assimilated into the CaMa-Flood river model using Local Ensemble Transform Kalman Filter. To address riverbed elevation uncertainty, Normalized WSE (NomWSE) is assimilated. We also test a two-step assimilation approach, in which discharge is first assimilated to update the mean and variance of river storage, and the corrected statistics are used to assimilate NomWSE. Four cases were conducted over the Mississippi River Basin, differing only in the assimilated variables;

(a) NomWSE

(b) Q

(c) NomWSE and Q simultaneously without statistical correction, and (d) with statistical correction. The results were evaluated against in-situ Q observations. Performance was quantified using IMIKGE, which measures improvements in Kling–Gupta Efficiency relative to the open-loop experiment. The results are as follows. Assimilation of Q alone improved KGE at 89% of the observation sites. However, the proportion of notable improvements was smaller than in case (d), suggesting the importance of NomWSE assimilation. Additionally, The distribution of IMIKGE is systematically shifted toward positive values in case (d) from case (c), indicating statistical correction through prior Q assimilation effectively reduced biases. This study is the first to explicitly evaluate a statistically corrected two-step assimilation framework combining satellite-derived WSE and Q in a large-scale river model. Future work will focus on the optimization of parameters to reconstruct not only discharge but also water depth and surface elevation.

<Session 7: Data Infrastructure>

[D2-3-1] Xudong Zhou
Ningbo University

A Digital Hydrosphere Database Framework Based on Sub-basin Units, AI Agents, and Crowdsourcing

In the era of artificial intelligence and big data, hydrological research increasingly relies on large volumes of multi-source datasets. However, data preparation remains a major bottleneck due to heterogeneous formats, varying spatial and temporal resolutions, and limited interoperability among existing databases. While datasets such as CAMELS provide valuable hydrometeorological information, they often have incomplete spatial coverage and limited representation of environmental and socioeconomic factors.

This study proposes a sub-basin-based framework for constructing a Digital Hydrosphere Database. Using MERIT Hydro and MERIT Basins, global sub-basins are defined as the fundamental spatial units. Multi-source datasets, including meteorological variables, remote sensing products, in-situ observations, land surface characteristics, soil properties, population, GDP, and transportation networks, are systematically processed and aggregated at the sub-basin scale. Hydrological connectivity is preserved through the topological relationships among sub-basins, resulting in a spatiotemporally consistent database for large-scale hydrological analyses.

To enable scalable and sustainable database development, an AI-agent framework is designed with reusable data-processing tools and skills. The agent automatically adapts workflows according to data format, spatial resolution, temporal frequency, and variable characteristics, producing standardized outputs. A crowdsourcing mechanism is further established, allowing users to process datasets locally using shared skills and contribute derived products to the database. This approach reduces storage demands, protects data ownership, and continuously expands database content through community participation via the Hydro90 platform.

Two example applications are demonstrated: (1) integrated analysis of drought and flood propagation using multiple hydrological variables, including precipitation, soil moisture, streamflow, and groundwater; and (2) explainable AI modeling to quantify the relative importance of environmental and socioeconomic drivers in hydrological processes. The proposed framework provides a foundation for collaborative hydrological data infrastructure in the AI era.

[D2-3-2] Jiachao CHEN
Institute of Industrial Science, The University of Tokyo

Development of a Global High-Resolution Runoff Dataset Based on NEX-GDDP-CMIP6

Global flood risk assessment relies on runoff input, yet the biased and coarse-resolution results from Global Climate Models (GCMs) limits their applications in climate change impact assessment. The NEX-GDDP-CMIP6 dataset provides bias-corrected, statistically downscaled meteorological projections at 0.25°, while failing to statistically downscale runoff due to the complex land surface interactions.

To provide a globally consistent, bias-corrected high-resolution runoff product, this study develops a daily runoff dataset at 0.25° based on NEX-GDDP-CMIP6 and a grid-wise bias-corrected Variable Infiltration Capacity (VIC) model. This runoff product covers nine CMIP6 GCMs with 5 scenarios. Three historical experiments are designed to evaluate the improvements: (1) interpolated raw GCM runoff; (2) VIC runoff driven by raw GCM forcing; and (3) the proposed product. Through CaMa-Flood, the runoff is routed to generate discharge, which is then compared with GRDC observations.

The results show that introducing land surface processes improves the representation of discharge seasonality, but degrades the accuracy of mean, high, and low flows, owing to biases inherited from the GCM forcing. Driving the model with NEX-GDDP-based runoff substantially improves the simulated seasonal cycle, mean flow, and low-flow conditions. Relative to raw GCM runoff, the NEX-GDDP-based product shows clear gains in seasonal cycle, mean flow, and low-flow accuracy, as well as in inter-model consistency for both mean and extreme values.

The product can better characterize the regional effects of climate change. The bias correction makes daily-scale runoff variability more practically usable, while the greater inter-model consistency is promising for the integrated use of model ensembles and help reduce the uncertainty of future projections.

[D2-3-3] Gurpreet DASS
European Centre for Medium-Range Weather Forecasts

Modelling river flow in south-eastern Africa under warmer climate conditions using ecLand and CaMa-Flood.

Tropical cyclones are among the most destructive natural hazards affecting south-eastern Africa, with Madagascar, Malawi, and Mozambique experiencing recurrent flooding that causes widespread damage to infrastructure, agriculture, and livelihoods. This study developed within the Resilience and Preparedness to Tropical Cyclones across Southern Africa (REPRESA) project, applies the ECMWF (European Centre for Medium-Range Weather Forecasts) Land Surface Model (ecLand) coupled with the Catchment-based Macro-scale Floodplain model (CaMa-Flood) to simulate river flow across the project domain under present and future climate conditions.

ecLand is the land-surface component of the ECMWF Integrated Forecasting System (IFS) (Boussetta et al., 2021). In the one-way coupled ecLand–CaMa-Flood framework, runoff generated by ecLand is routed through the CaMa-Flood River network to simulate river discharge and floodplain inundation (Yamazaki et al., 2011, 2019).

The modelling framework is forced by output from convection-permitting regional climate models, CP4A (UK Met Office) and CCAM (University of the Witwatersrand). Simulations compare a historical period (1997–2007) with a late-century future period (2079–2089). Multiple ecLand–CaMa-Flood experiments are performed using CP4A climate projections driven by different global climate models, including MRI-ESM2-0 and MPI-ESM1-2-LR. Ongoing analyses investigate how projected changes in precipitation may influence seasonal river flow, peak river discharge, and riverine flood hazard across south-eastern Africa under warmer climate conditions.

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<Session 8: Flood Risk>

[D2-4-1] Gang Zhao
Science Tokyo

New Insights Into Global Flood Hazard and Risk Considering Levees

Flooding is one of the most severe natural hazards worldwide, causing substantial economic losses and devastating societal impacts. Although levees are widely implemented for flood mitigation, few global flood models explicitly incorporate their effects on flood routing and risk assessment. In our previous study (Zhao et al., 2025; https://doi.org/10.1029/2024WR039790), we developed a levee module for the CaMa-Flood model and generated levee parameters for ungauged rivers worldwide. Furthermore, recent GPU-based computational optimizations of the CaMa-Flood model (Kang et al., 2026; https://doi.org/10.5194/gmd-19-5623-2026) now enable high-resolution simulations of global flood dynamics within a feasible computational timeframe.

These advances allow us to analyze long-term changes in flood hazards and risks while explicitly accounting for levee effects. In this study, we forced the CaMa-Flood model with an ensemble of CMIP6 runoff datasets to simulate historical and future changes in river hydrodynamics at a daily timescale, comparing scenarios with and without levees. Our results reveal that levees substantially mitigate global flood hazards while also altering the timing of flood hazard emergence. Driven by this protection, urbanization in levee-protected areas has substantially outpaced that in unprotected regions over the past four decades. Conversely, flood hazards in unprotected river reaches have increased because of the hydrodynamic effects induced by levee construction.

Regarding flood exposure, multi-model estimates show that, although levees have historically played a crucial role in protecting a substantial proportion of the floodplain population and slowing the growth of flood exposure, rapid population growth has largely offset these protective benefits. Consequently, the present-day population exposed to flooding despite levee protection remains at a historically high level, comparable to the population that would have been exposed in previous decades in the absence of levees. Furthermore, projections indicate that flood exposure will continue to increase through the mid-21st century under a changing climate.

Overall, this work provides new insights into global flood modeling and risk assessment and supports improved flood management and decision-making in levee-protected regions.

[D2-4-2] Muhammad Hasnain Aslam (video)

Gaia Vision Inc

Flood Volume Allocation for High-Resolution Flood Hazard Mapping Using CaMa-Flood with Levee Representation

We present a flood volume allocation method for producing high-resolution flood hazard maps from CaMa-Flood simulations with levee representation. The work is based on our recently published study in Geoscientific Model Development (Aslam et al., 2026) and is introduced here with emphasis on its relevance to CaMa-Flood users and developers.

Large-scale river models such as CaMa-Flood provide physically consistent flood volumes and water storage dynamics, but their native spatial resolution is often too coarse for direct flood hazard mapping. To address this, the proposed method uses flood volume exceeding channel storage as the basis for high-resolution inundation downscaling. Flood volumes can be estimated for selected return periods from long-term simulations to produce design hazard maps, or directly downscaled from existing simulated flood volumes for specific flood events and scenarios. The method can also be applied to natural simulations without levee protection while preserving the simulated flood storage, making it useful for both protected and non-protected floodplain assessments.

Levee-related parameters are incorporated to distinguish protected and unprotected floodplain areas, allowing flood hazard maps to better reflect the influence of flood protection infrastructure. The method was demonstrated over Japan, where levee systems strongly affect inundation patterns. Results show that levee-aware flood volume allocation can substantially change simulated inundation extent and depth compared with natural or non-protected assumptions. The approach provides a practical bridge between continental-scale hydrodynamic simulation and local-scale flood hazard assessment while maintaining consistency with the water balance simulated by CaMa-Flood.

This study summarizes the workflow, required input data, treatment of levee parameters, and key outcomes of the published study. In addition, practical applications are illustrated using recent event-based flood analyses, including the 2022 Pakistan flood and the 2024 Spain flood, to demonstrate how CaMa-Flood outputs and flood-volume-based downscaling can support inundation assessment across different hydro-climatic settings.

Related Publication: Aslam, M. H., Hirabayashi, Y., Yamazaki, D., Zhao, G., Kita, Y., & Khanh, D. N. (2026). Flood volume allocation method for flood hazard mapping using river model with levee scheme. Geoscientific Model Development, 19, 3709-3724. https://doi.org/10.5194/gmd-19-3709-2026

[D2-4-3] Md. Rezuanul Islam FAHIM
Institute of Industrial Science, The University of Tokyo

Objective Identification of Physically Plausible Worst-Case Scenarios from Large-Ensemble Tropical Cyclone Forecasts

Ensemble forecasting is a powerful tool for supporting informed decision-making in managing multihazard risks associated with tropical cyclones (TCs). Although TC ensemble forecasts are widely used in operational weather prediction systems, their potential for disaster prediction and management has not been fully exploited. Here, we propose a novel, efficient, and practical method to extract meaningful multihazard worst-case scenario (MHWCS) from a 1000-member ensemble TC forecast while preserving full physical consistency. We performed the ensemble atmospheric forecasting of TC Hagibis (2019) using the Japan Meteorological Agency's (JMA) 5-km nonhydrostatic model. The simulated atmospheric predictions are subsequently used as inputs to JMA's operational flood forecast model and a parametric storm surge model. These models estimate river flooding, storm surge, and wind hazard intensities in Tokyo. By incorporating forecast uncertainties, we demonstrate that Pareto-optimal ensemble members objectively represent the meaningful combinations of multiple hazards, corresponding to MHWCS. These solutions illustrate complex trade-offs among competing hazard components across various forecast locations. While some identified MHWCS pose severe risks for a single hazard type or location, others present moderately high risks across multiple hazards and locations. This diversity in potential scenarios requires risk managers to prepare multiple response strategies for both imminent risks and post disaster management. Our findings further underscore the importance of evaluating Pareto-optimal ensemble members to assist forecasters and risk managers in understanding how combinations of TC meteorological variables—such as track, translation speed, size, intensity, and rainfall—shape worst-case scenarios.

Related Publication: Islam, M. R., Oizumi, T., Duc, L., Ota, T., Kawabata, T., & Sawada, Y. (2026). Beyond the single-hazard framework: A proof-of-concept study of multihazard worst-case scenarios from ensemble forecasts of Tropical Cyclone Hagibis (2019). Weather and Forecasting. https://doi.org/10.1175/WAF-D-25-0030.1

Islam, M. R., Duc, L., & Sawada, Y. (2023). Assessing storm surge multiscenarios based on ensemble tropical cyclone forecasting. Journal of Geophysical Research: Atmospheres, 128(23), e2023JD038903. https://doi.org/10.1029/2023JD038903

<Poster Session>

[P01] Shima Azimi
Aalborg University

Space- and Model-Based Estimation of the Hydrological Water Cycle in the Niger River Catchment

Developing accurate models to predict rainfall–runoff processes and flood inundation in medium and large river catchments remains challenging due to limited ground-based observations for model calibration and the inability of existing models to fully represent complex hydrological processes.

To address these challenges, we carry out research activities within a project called "Space-based Free Flood Awareness System for Africa (SFAS)", supported by the Independent Research Fund Denmark – Thematic Green. The primary objective of SFAS is to improve the understanding of coupled hydrological processes that lead to extreme events, such as floods and droughts. The project also tackles the challenge of developing high-resolution, large-scale flood inundation and water resources early warning systems, particularly in data-sparse regions.

The SFAS framework is implemented in the Niger River Catchment, Africa. In this study, we assess the value of space-based Terrestrial Water Storage Anomalies (TWSA) and Surface Soil Moisture (SSM) in improving the spatial distribution of water storage within the catchment and enhancing the simulation of baseflow processes.

Both the original and the space-based improved discharge simulations from DHI Global Hydrological Models (DHI-GHM) are subsequently coupled with the CaMa-Flood model to demonstrate the hydraulic benefits of the approach and to explore the potential of SWOT-based water level data assimilation for improving flood prediction.

[P02] Jayaraju Nadimikeri
Yogi Vemana University, INDIA

Flood mapping and Assessment using Sentinel-1A SAR Data on Phython, AP, India: Environmental Sustainability

India is one of the most flood-prone countries in the world and one-eighth of the country's geographical area is subjected to floods. The flood extent mapping is critical to disaster management, humanitarian relief work and decision-making. Efficient monitoring and prediction of floods and risk management for a large river is quasi-impossible without the use of Earth Observation (EO) data from space. As a matter of fact, one of the most important problems associated with flood monitoring is the difficulty to determine the extent of the flood area as even a dense network of observations cannot provide such information. The flood extent information is used for damage assessment and risk management, and benefits to rescuers during flooding; it is also very important for calibration and validation of hydraulic models to reconstruct what happened during the flood and determine what caused the water to go where it did. During floods the cloud coverage is more, thus very difficult to acquire and obtain information using earth observation satellites suing optical sensor . To overcome the limitation, SAR sensors can acquires the ground information even in cloud cover. Therefore risk management can be performed as early as possible. Handling of SAR information is valuable for this situation since typical optical satellite pictures will be prevented by mists and is difficult to plan water bodies. Yet, with SAR pictures we can notice the landscape despite the fact that there are numerous obstructions like mists dust and so on as it is Radar Tech dissimilar to optical one. Curtailed type of open source PC vision library which upholds python, c++, and java interfaces. It is essentially intended for accomplishing computational productivity and furthermore to give emphasis for ongoing applications. This bundle enjoys an additional benefit that is multicore handling. Picture handling library essentially centered around ongoing PC vision with application in wide scope of regions like 2D and 3D highlights toolboxs, facial and motion acknowledgment..

[P03] Odalys Jacobo Rodriguez
Institute of Industrial Science, The University of Tokyo

Localizing Global Flood Models: Toward Locally Accurate Inundation Extent and Water Level Simulation.

Global flood models (GFMs) such as CaMa-Flood provide scalable, globally consistent simulations of river discharge and inundation, but their simplified physics, global-scale input data, and fixed parameterization limit their accuracy at the local scale. Local flood models (LFMs), in contrast, achieve high accuracy through detailed physics, surveyed data, and basin-specific calibration, but are not scalable beyond individual basins. This trade-off is especially critical in data-scarce, flood-prone regions, where no unified national flood model currently exists.

This research uses Cuba as a representative case study to develop a transferable framework for localizing CaMa-Flood. Cuba is the most flood-affected country in the Caribbean, with over 23 million people affected by storms between 2000 and 2022, and its elongated geography and short, narrow river basins (85% of rivers under 40 km, across 642 basins) make it a demanding test case for global-scale representations such as MERIT Hydro. The proposed approach isolates three independent localization levers within CaMa-Flood: (1) physics ; (2) data and (3) customizability .

As an initial methodological test, CaMa-Flood outputs can being benchmarked against, maybe, the 2D hydrodynamic model LISFLOOD-FP or RRI. Model performance will be evaluated using Nash-Sutcliffe Efficiency, percentage bias, and peak discharge error.

[P04] ZHANG YUANZHE

Institute of Industrial Science, The University of Tokyo

Toward Differentiable Land–River Hydrological Modelling through MATSIRO

Recent advances in AI hydrology have highlighted the potential of differentiable parameter learning (dPL) for improving physical models through gradient-based optimization. Extending this approach to large-scale land–river hydrological systems is an important step toward more robust Earth system and flood prediction modelling. However, complex land surface models are computationally expensive, highly nonlinear, and difficult to directly integrate with automatic differentiation. This limits the application of dPL to upstream land-surface processes that provide runoff for river routing models.

In this study, we use the MATSIRO land surface model as an upstream land-surface testbed to develop a differentiable modelling framework for complex physical models. The framework combines two complementary directions: surrogate-based differentiable parameter learning and direct differentiable implementation of selected MATSIRO processes. Neural-network-based surrogate models are used to approximate key land-surface processes and enable efficient gradient-based calibration. In parallel, differentiable MATSIRO components are developed to provide physically consistent gradient information, including parameter sensitivities and Jacobian-based diagnostics.

This design allows us to examine not only whether a surrogate can reproduce MATSIRO outputs, but also whether it can preserve the parameter-response structure required for robust backpropagation. The differentiable MATSIRO components can be used as a gradient reference to diagnose surrogate inconsistency and to improve surrogate training beyond output-level fitting. In this sense, surrogate efficiency and physically based differentiability are treated as complementary components of a unified dPL framework.

By linking surrogate modelling with differentiable physical-model components, this study aims to clarify what level of output and gradient fidelity is necessary before dPL can be reliably applied to complex land surface models. This provides a methodological basis for future differentiable land–river hydrological modelling, including the coupling of calibrated land-surface processes with large-scale river routing models such as CaMa-Flood.

Keywords: differentiable parameter learning; AI hydrology; surrogate modelling; MATSIRO; Jacobian; CaMa-Flood; land–river coupling

[P05] Shahriar Md Wasif
Institute of Industrial Science, The University of Tokyo

Satellite-Based Monitoring of Seasonal Flood Connectivity in Haor Wetlands of Northeastern Bangladesh

Recent advances in satellite flood mapping have highlighted the potential of synthetic aperture radar (SAR) to observe inundation dynamics in regions where in-situ hydrological data are absent. Extending this capability from mapping flood extent toward resolving how flooded water bodies connect and disconnect

through a season is an important step toward understanding flood behaviour in human-modified wetlands. The haor wetlands of northeastern Bangladesh are bowl-shaped seasonal basins ringed by farmer-managed submersible embankments, where flooding begins when rising water overtops an embankment crest rather than through gradual inundation; whether neighbouring haors flood as one hydraulically connected system, as isolated basins filling from local rainfall, or as a state that switches with water level remains unresolved.
In this study, we use the Haor basin as a testbed to examine how far satellite observation alone can resolve seasonal flood connectivity. Sentinel-1 SAR is processed as a per-pixel Z-score anomaly against a dry-season baseline to derive flood maps at an approximately six-day interval through the 2025 monsoon and a first-wet date for every pixel, while Haor extents are delineated from 36 years of JRC surface-water occurrence confirmed against 2025 Sentinel-1, and candidate embankments are identified from MERIT Hydro HAND combined with FABDEM local relief. A five-haor cluster around Tanguar, in which the central haor borders all four neighbours, provides a controlled test. Three of the five Haors share an identical median onset, the connector among them, and this result is robust to masking of permanent water using JRC occurrence. The apparent timing signal contracts at every spatial refinement, from 120 days across the region to 12 days across the cluster. This indicates that the regional spread reflects differing monsoon arrival between districts rather than water propagating between basins. We interpret this synchronous onset as a constraint on, rather than confirmation of, hydraulic connectivity, because identical timing at a six-day repeat interval cannot be distinguished from shared rainfall forcing or from independent overtopping under a common embankment-elevation band, and the sub-weekly lags that propagation would produce are below the achievable temporal resolution. This design allows us to examine not only whether synchrony exists but which flood-timing indices can legitimately represent connectivity once the common-rainfall confound is accounted for. Building on this, the study advances from a single onset metric toward paired onset, peak, and recession timing across the broader region, treating pixels unobserved during a given satellite pass as a distinct class, and toward a dynamic-boundary framework in which isolated Beels and permanent water bodies merge into a single seasonal surface at peak flood and fragment during recession, so that connectivity becomes a time-varying observable mapped directly from space. By linking flood-timing analysis with time-varying water-body connectivity, and retaining ICESat-2 and SWOT water-surface elevation as independent validation, this study aims to clarify how far satellite observation can substitute for absent in-situ data in characterising seasonal flood connectivity, providing a methodological basis for integrating observed wetland inundation dynamics with large-scale hydrodynamic models such as CaMa-Flood.
Keywords: flood connectivity; Sentinel-1 SAR; haor wetlands; flood timing; seasonal inundation dynamics; satellite hydrology; CaMa-Flood

[P06] Megumi WATANABE
Paris Observatory

Communicating Ensemble Flood Forecasts with Municipal Officials in Japan

Ensemble flood forecasting provides probabilistic information with a long lead time. They are expected to be used for early disaster warning. However, ensemble flood forecasts have yet to be linked to disaster prevention actions. Also, the know-how to effectively communicate the forecast has yet to be established regarding the balance between robustness, richness, and saliency of forecast information. Local government officials responsible for disaster prevention actions during a flood may need help interpreting ensemble flood forecast results. This study examines what actions Japanese municipal officials can take to counter floods based on ensemble flood forecasting. We also examine what kind of information from the forecast results is preferred for municipal officials. We interviewed 26 municipal officials from 13 municipalities in the Iwaki River basin in Japan. More than one in four municipal officials can act based on medium- to high-reliability (33-100%) forecasts. Early warnings with medium confidence at least 12 hours before flooding can increase the types of measures, such as supplies and transportation, that can be taken to reduce flood damage. Probabilistic forecasts might be acceptable for Japanese municipal officials if limited to an appropriate amount of information, such as mean and two envelopes. We found that they need at least the maximum and minimum cases rather than a single forecast. This study could help to prepare prevention actions and provide feedback to forecasters for further developments.

Related Publication: Watanabe, M., Ito, S., Ma, W., & Yamazaki, D. (2022). Importance of two-way communication with users for effective utilization of ensemble flood forecast information. Journal of Japan Society of Hydrology and Water Resources, 35(2), 104-121. https://doi.org/10.3178/jjshwr.35.104 (in Japanese)

[P07] Shugao XU
GFZ, Germany

More frequent extreme floods revealed by observation-constrained projections

Current cascade-type models are the dominant approach for projecting future extreme floods, but they suffer from major limitations, including substantial bias, large uncertainties and coarse spatial resolution. To address these issues, we developed an observation-constrained framework that integrates flood estimates from on historical data and regional flood frequency analysis with projected changes in design floods from cascade-type models. This enables 1-km resolution projections across 28.2 million river pixels worldwide. Our analysis reveals that cascade-type models overestimate the historical 100- year flood by about 160% globally, while forcing-based corrections still exhibit considerable bias. Our observation-constrained approach reduces multi-model uncertainty by a median of 32% globally compared to cascade-type modeling. Under a high-emissions scenario, 83% of the global land area shows increasing flood frequency. Globally, the historical 100-year flood is projected to have a median return period of about 36 years – more frequent than suggested by cascade-type model projections. Our results indicate an acceleration of flood risk that may leave communities unprepared for intensifying climate impacts.

[P08] Siyuan Huang
Institute of Industrial Science, The University of Tokyo

Assessing River-Floodplain Water Exchange Using Satellite-Observed Temperature

During flooding, main-channel and floodplain waters often show different temperature patterns. Main-channel flow is generally deeper and faster, while shallow floodplain water responds more quickly to surface heat fluxes. Meanwhile, lateral water exchange advects heat between the main-channel and floodplain. This exchange also controls the transport of sediment, nutrients, and carbon, as well as floodplain water renewal. Yet existing large-scale models and observations mainly characterize inundation extent, water level, and storage change, providing limited information of water exchanged bidirectionally. River-floodplain temperature differences may therefore provide complementary information on exchange activity at large spatial scales.

At local scales, previous studies have used hydrodynamic models to quantify river-floodplain exchange fluxes and characterize flow paths and residence times. Coupled two-dimensional hydrodynamic-thermal models have further simulated water-temperature dynamics by representing advective heat transport, mixing, and surface heat exchange. Studies have shown that heat alone provides only limited constraints on lateral water exchange. However, when combined with water-surface elevation, heat can significantly reduce uncertainty in estimates of lateral river-floodplain exchange.

There are still some challenges remaining. First, local models rely strongly on detailed topography and in situ observations, which are often difficult to obtain. Second, a method that combines satellite water-temperature observations with hydrodynamic-heat transport models to constrain bidirectional river-floodplain water exchange is still lacking. Third, long revisit interval of satellite thermal observation limits its ability to resolve temporal changes in river-floodplain exchange during individual flood events.

This study will assess whether satellite thermal observations, combining with coupled hydrodynamic-heat transport model experiments, can provide useful constraints on river-floodplain exchange. The results could support future evaluation and representation of water exchange in large-scale hydrodynamic models such as CaMa-Flood.