ULYSSES: a global multi-model hydrological prediction system

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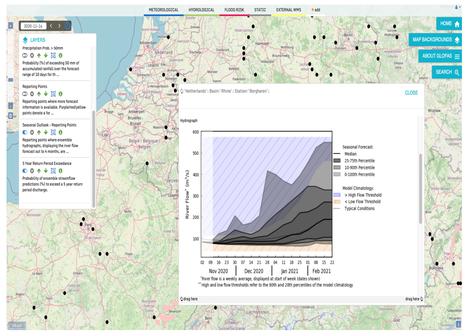
ULYSSES

Abstract

The Copernicus Climate Change Service aims at facilitating the emergence of a downstream market of climate services with the ultimate goal of supporting the development of a climate-smart society. Central to this vision is the free and unrestricted distribution of high-quality climate data through the Climate Data Store [1], with seasonal meteorological predictions among them. Within this unique and challenging framework, ULYSSES[2] will provide the first "seamless" multi-model hydrological seasonal prediction system, with a global coverage at a spatial resolution of 0.1°. The ULYSSES modeling chain is based on the successfully tested EDgE proof of concept [3] using four state-of-the-art hydrological models (Jules, HTESSEL, mHM, PCR-GLOBWB). A unique feature of this production chain consists of using the same land surface datasets (e.g. DEM, soil properties) with identical spatio-temporal resolutions and forecast inputs for all HMs, and the same river routing scheme (i.e., the multi-scale routing model mRM).

State-of-the-Art



GloFAS v2.1 https://www.globalfloods.eu

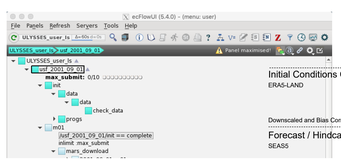
- Many regional systems
  e.g., EFAS, NWM
- Single HM system
  e.g., Lisflood, Noah-MP
- Few have global coverage
  → GloFAS
- Single target
  →Streamflow
- Forecasts at selected locations
- EDgE (C3S PoF): skillful up to 3 m lead time [4]

ULYSSES

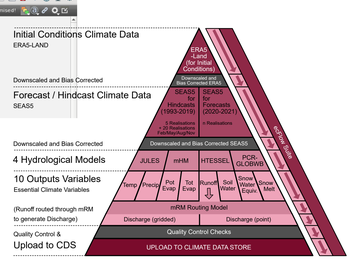
mULti-model hYdrological ULYSSES SeaSonal prEdictionS system

To provide a "seamless" system using state-of-the-art hydrological models at 0.1°globally
Funded by C3S, Adm. by ECMWF
Coorditated by UFZ

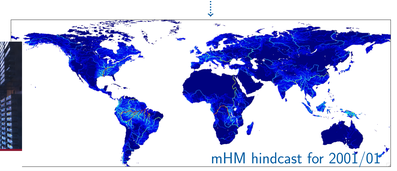
- Operated: scalable ecFlow suite
- Hindcasts: 1993–2020
- Realtime operation: 2020-2021
- Targets: Q, SM, PET, Tsurf, E, SWE



ecFlow Suite

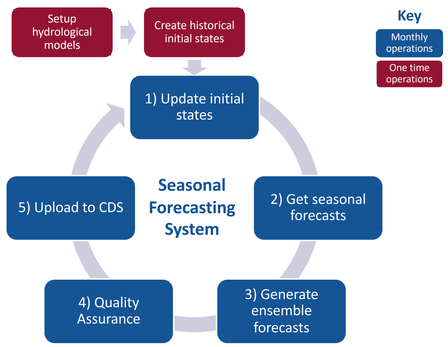


Climate Data Store



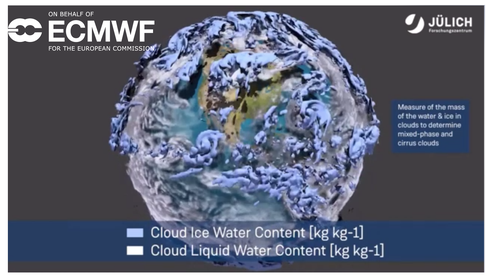
mHM hindcast for 2001/01

Forecasting workflow



Automatized with a ecFlow suite
Based on: Samaniego et al. BAMS 2019[3]

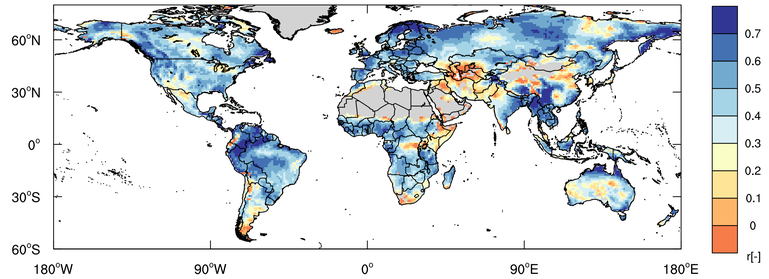
Generation of initial conditions



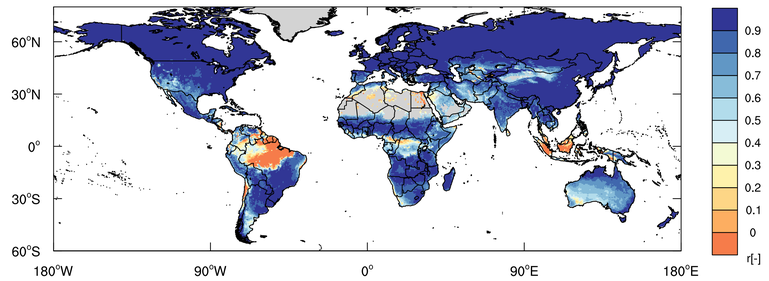
Vis: Jülich, https://bit.ly/38U6HPd
Data: ECMWF https://bit.ly/3kCF015

- GCM: IFS CY45R1
- ERA5-Land + ERA5: 0.1°grid spacing, $\Delta t = 1$ h
- Period 1950-present (ERA5-Land latency 30 days)
- 100 TB
- Forcing data:
  pr, tas, $tasmax$, $tasmin$, ps, $sfcWinf$, $huss$, $rsds$, $rlds$

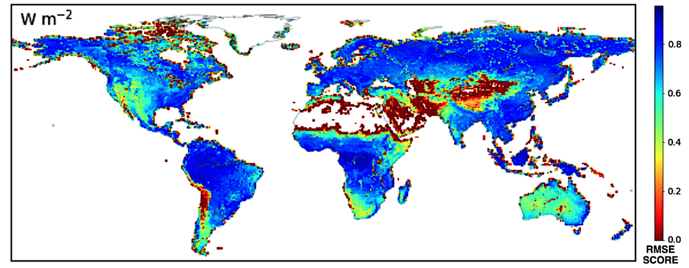
Evaluation againt GRACE TWS and ET-FLUXNET-MTE



Pearson correlation (TWS-GRACE,TWS-mHM)

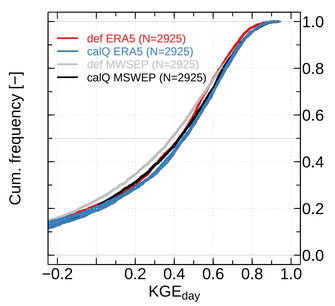


Pearson correlation (ET-FLUXNET,ET-mHM)

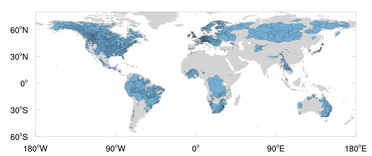


JULES evaluation in ILAMB (Collier et al. 2018) with LT-FLUXNET-MTE

Streamflow evaluation



Streamflow efficiency mHM, GRDC stations



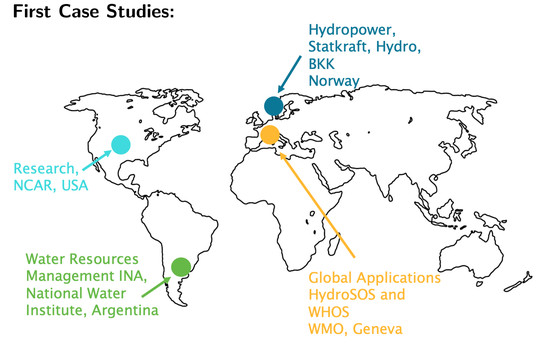
Location of the GRDC stations

Outputs, user support and skill assesment

Outputs:

- Distributed, daily outputs ingested in the CDS: Q, SM, PET, Tsurf, E, SWE
- User Guide
- CDS Helpdesk Manual
- Variable Fact Sheets
- Applications Case Studies
- Infographics
- Skill assesment of ReFo and OpFo [3] and [4]
- Case studies

First Case Studies:



References

[1] C3S Climate Data Store, https://cds.climate.copernicus.eu.

[2] C3S ULYSSES project, https://www.ufz.de/ulysses.

[3] L. Samaniego, S. Thober, N. Wanders, M. Pan, O. Rakovec, J. Sheffield, E. F. Wood, C. Prudhomme, G. Rees, H. Houghton-Carr, M. Fry, K. Smith, G. Watts, H. Hisdal, T. Estrela, C. Buontempo, A. Marx, and R. Kumar, "Hydrological Forecasts and Projections for Improved Decision-Making in the Water Sector in Europe," *Bulletin of the American Meteorological Society*, vol. 100, no. 12, pp. 2451 – 2472, 2019-12.

[4] N. Wanders, S. Thober, R. Kumar, M. Pan, J. Sheffield, L. Samaniego, and E. F. Wood, "Development and Evaluation of a Pan-European Multimodel Seasonal Hydrological Forecasting System," *Journal of Hydrometeorology*, vol. 20, no. 1, pp. 99 – 115, 2019-01.