



Land Monitoring

EU-Hydro upgrade

State of play and progress

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EU-Hydro v 1.3 – why an update?

- Inconsistencies in network topology due to the production approach
 - VHR photointerpretation, merged then with (partly) DEM-based river network extraction
 - Impossibility to use it for hydrological applications
- Outdated input data
 - HR imagery from 2006 (and updates with 2011-2013)
 - EU-DEM based on SRTM mission (2000)
 - Outdated reference data
- Addition of relevant ancillary data needed



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EU-Hydro 2.0 suite of products: summary

Pan-European reference dataset for hydrography, consisting of **river network**, **water bodies**, **catchments** and **man-made structures** created for mapping and hydrological applications.

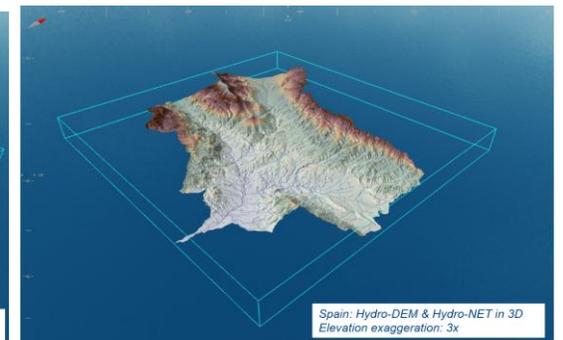
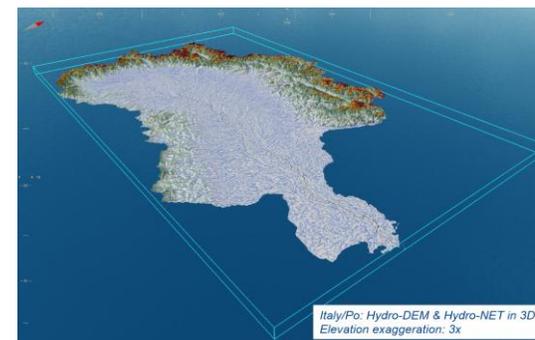
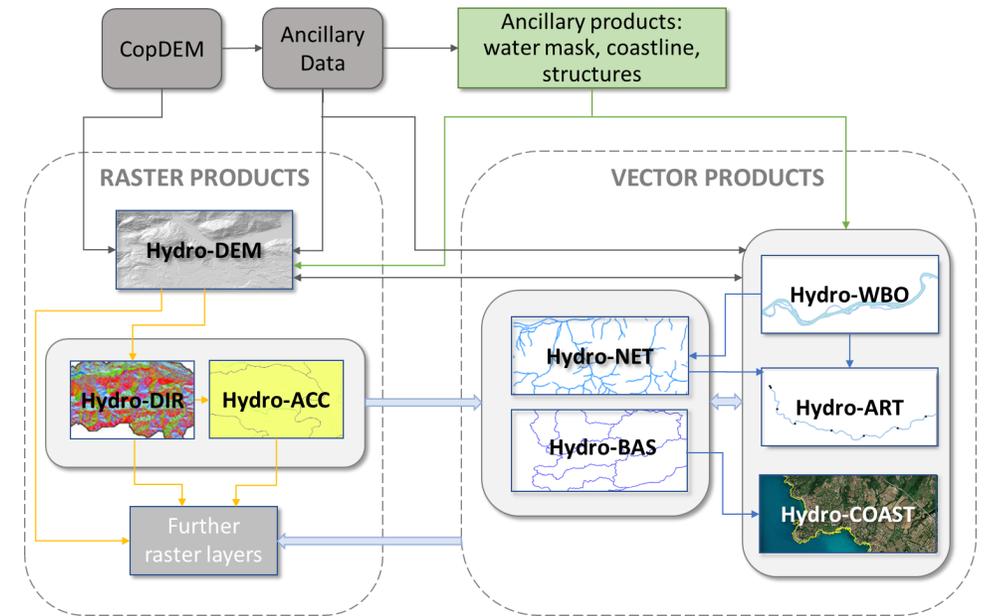
Upgrade 2.0 under preparation:

- Based on **Copernicus DEM 10 m** + ancillary data (VHR, national vector & raster datasets)
- **Raster layers** (Hydrologically conditioned DEM, flow direction, flow accumulation)
- **Vector layers** (River network, watersheds –basins and sub-basins, water bodies, coastline and artificial structures)

Roadmap:

- Ramp-up phase: Q3 2024 - Q2 2025
- Full production phase: Q4 2025 - Q4 2026
- Publication: Q1 2027

Produced by a **consortium** led by GAF AG, with e-GEOS, Telespazio Iberica, DLR and Confluvio



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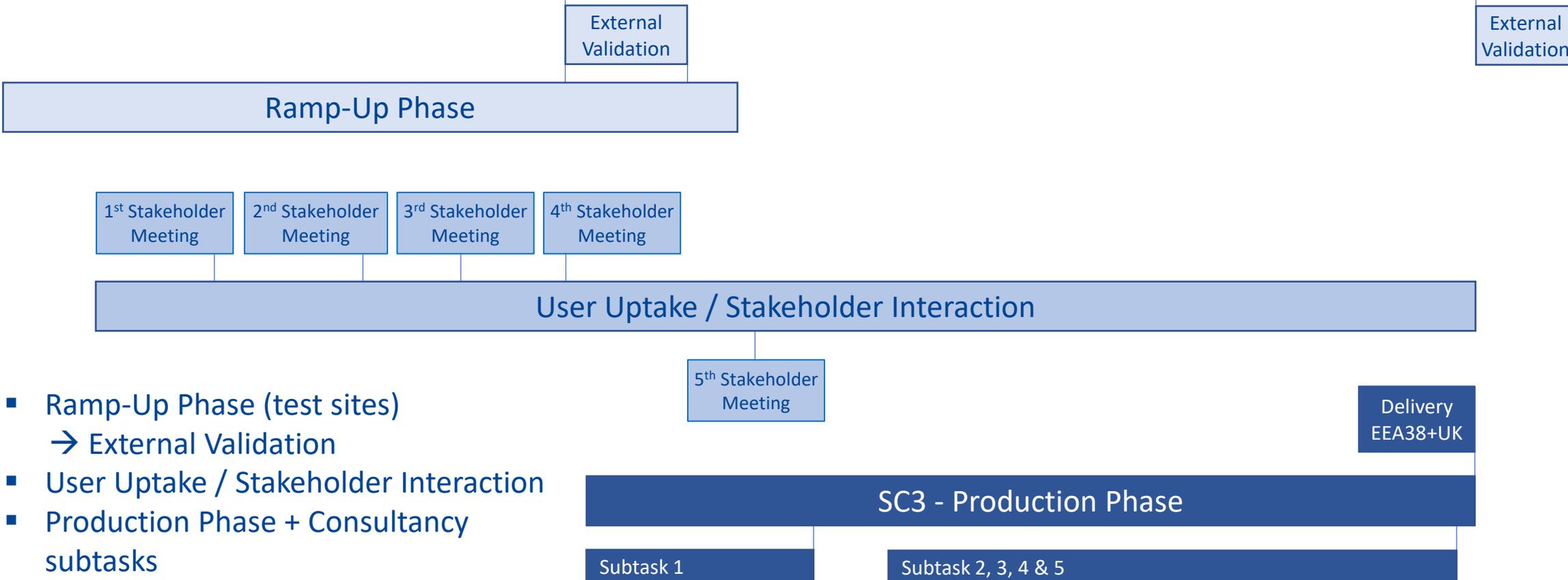
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Roadmap

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2024				2025								2026																	
Q3		Q4		Q1		Q2		Q3		Q4		Q1		Q2		Q3		Q4											
July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.



- Ramp-Up Phase (test sites)
 - External Validation
- User Uptake / Stakeholder Interaction
- Production Phase + Consultancy subtasks
 - External Validation



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Ramp-Up phase: Test sites

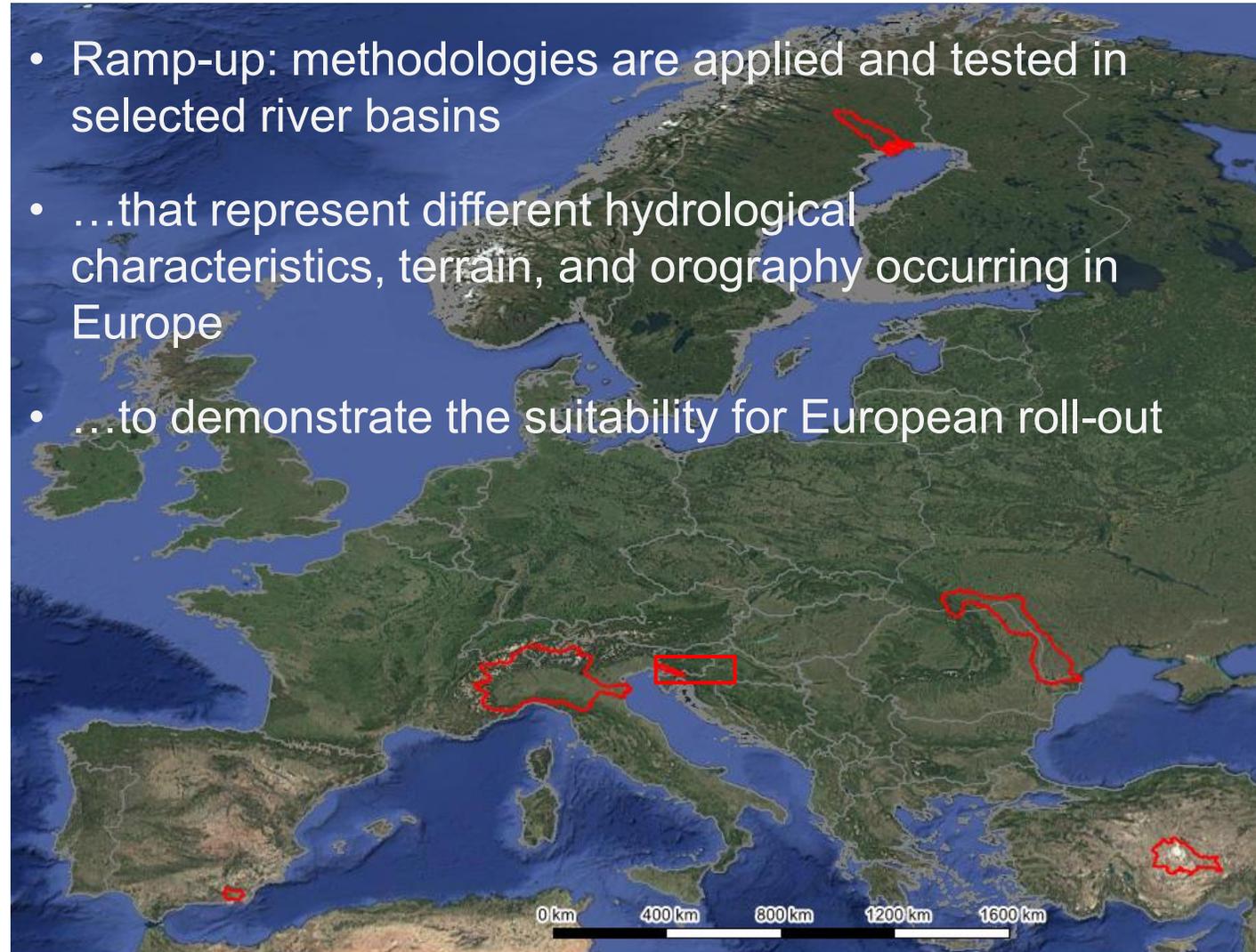
Fully tested areas:

- **AOI Italy (Po catchment)**
- **AOI Sweden (Råne river basin)**
- **AOI Spain (Andarax catchment)**

“Proof of concept” tested areas:

- AOI Moldova (outer boundary catchment)
- AOI Slovenia (karst area)
- AOI Turkey (Endorheic basis)

- Ramp-up: methodologies are applied and tested in selected river basins
- ...that represent different hydrological characteristics, terrain, and orography occurring in Europe
- ...to demonstrate the suitability for European roll-out



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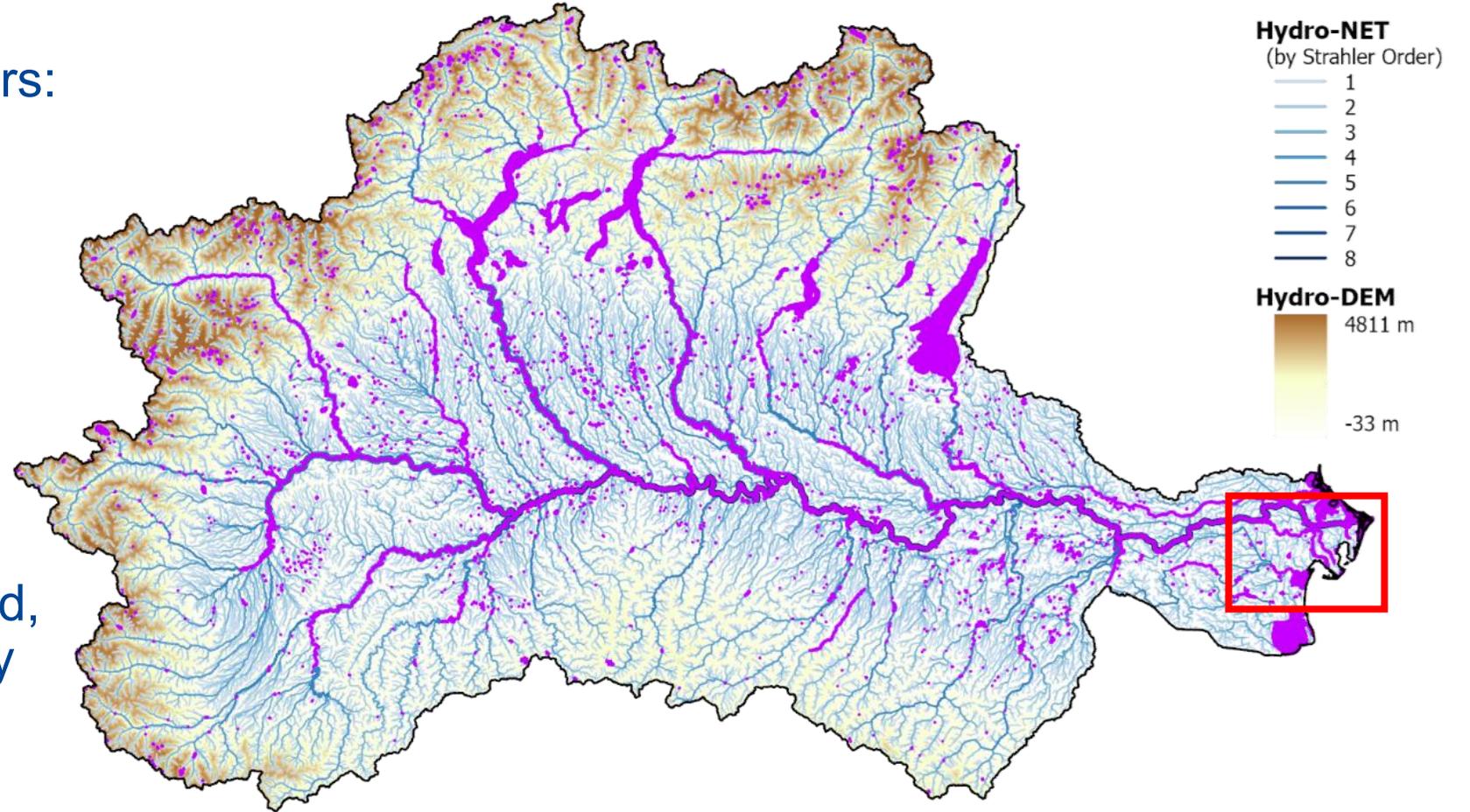
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Test area: Po river catchment (overview)

Po/Italy test site layers:

- Hydro-NET
- Hydro-WBO
- Hydro-DEM

All raster and vector layers are interrelated, scalable and logically consistent.



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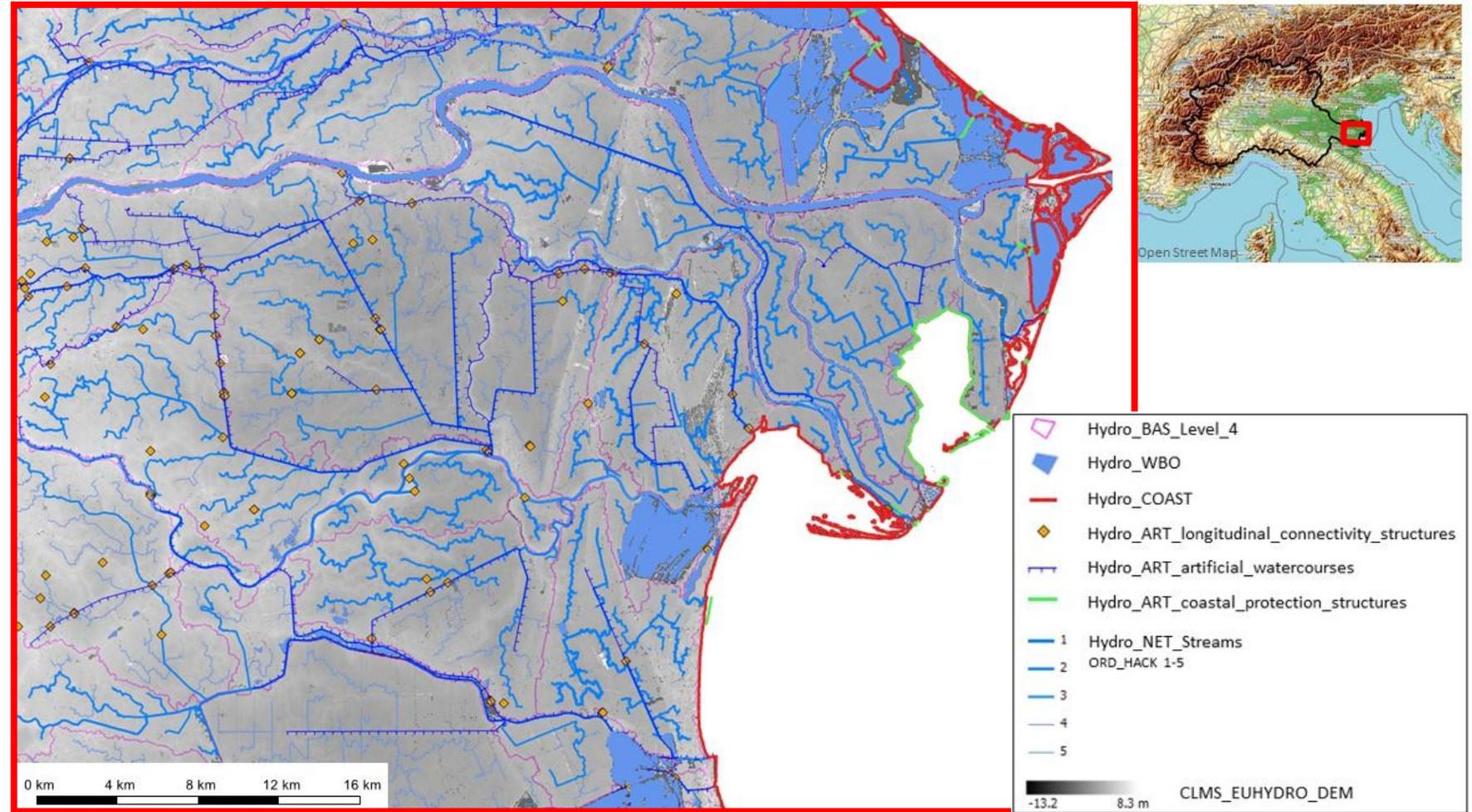


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Test area: Po river catchment (detail)

Layers:

- Hydro-NET
- Hydro-WBO
- Hydro-BAS
- Hydro-COAST
- Hydro-ART
- Hydro-DEM



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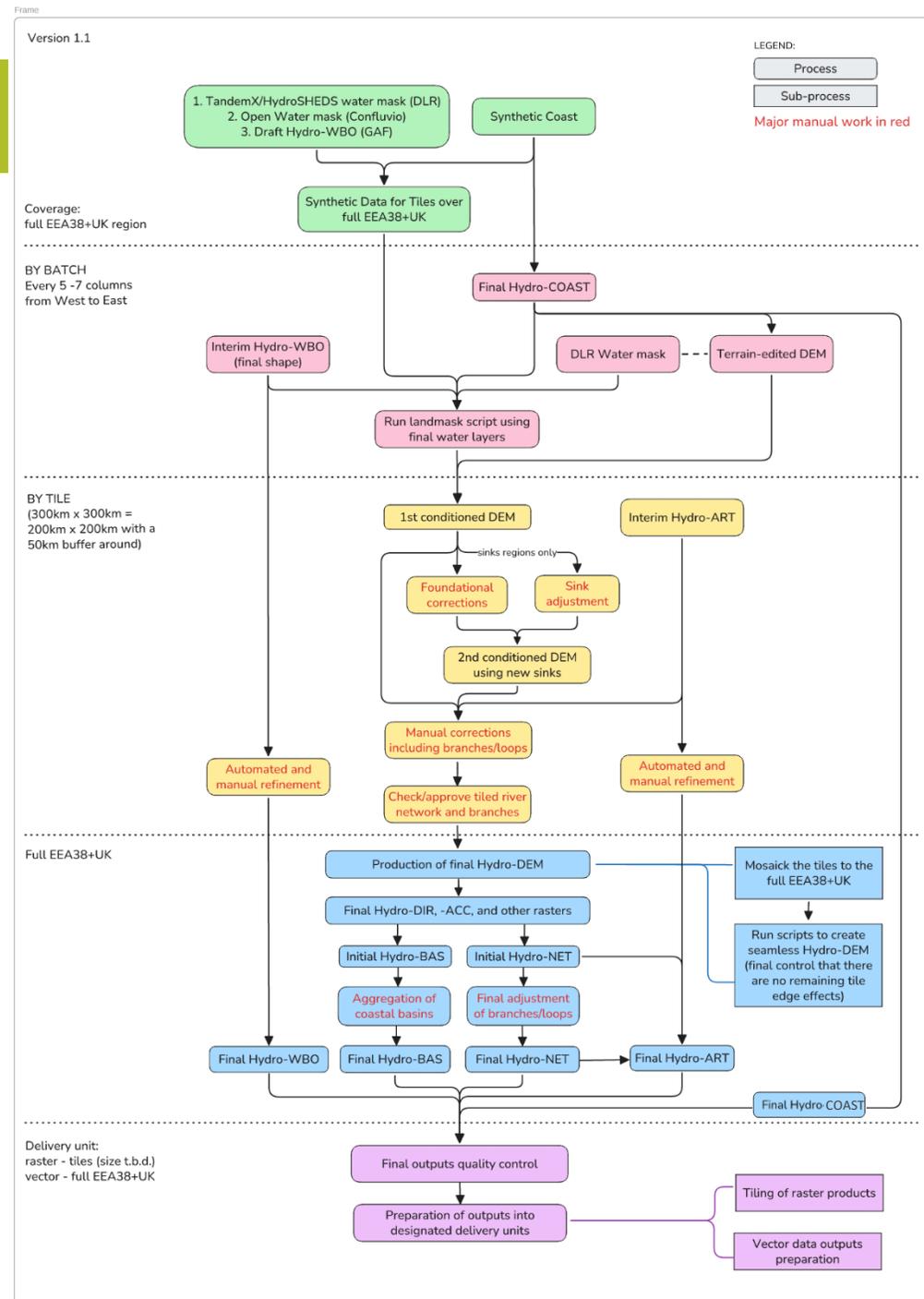


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Production workflow

From Ramp-Up Phase Experience to Production Workplan

- Complex workflow
- Partially tile-based, partially and on full EEA38+UK level
- Dependencies between the different layers



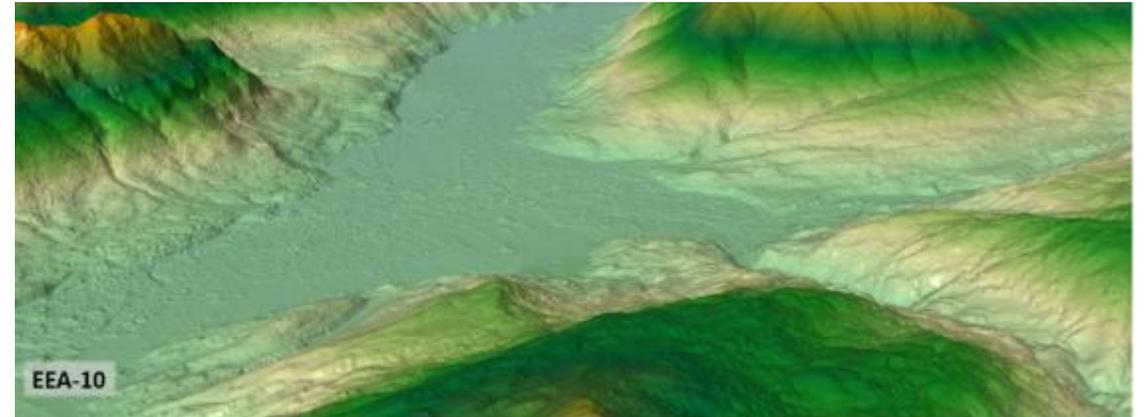
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Digital Elevation Model

- **Accurate elevation models are the main input** for deriving hydrologic features as stream networks and watersheds
- **Basis for EU-Hydro:**
 - Latest generation DEM = **EEA-10** instance of the **Copernicus DEM**
 - Coverage: EEA38+UK
→ for border catchments, GLO-30 to complement
 - Based on TanDEM-X data acquired between 12/2010 and 01/2015
 - Result = “**Hydro-DEM**”



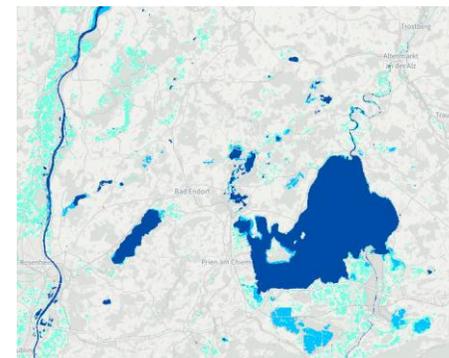
Copernicus DEM instances: EEA-10



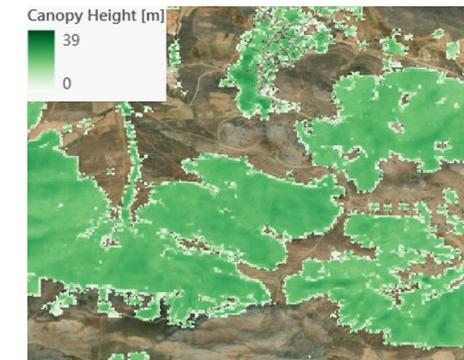
Ancillary data used in EU-Hydro

Very heavy use of ancillary/reference data:

- **River line data:** to force the water flow in the DEM in a certain direction (DEM hydro-conditioning)
- **Water bodies and river polygons:** helping the incorporation of water surfaces into the elevation model and enabling elevation adjustments; for DEM hydro-conditioning and generation of Hydro-WBO
- **Forest / Vegetation:** for DEM editing
- **Infrastructure and buildings:** for DEM editing
- **Coastline:** for DEM conditioning and for generation of Hydro-COAST
- **Human made objects** (dams & culverts, lateral structures, coastal protection structures etc.): largely based on ancillary data on European and national level – for generation of Hydro-ART;



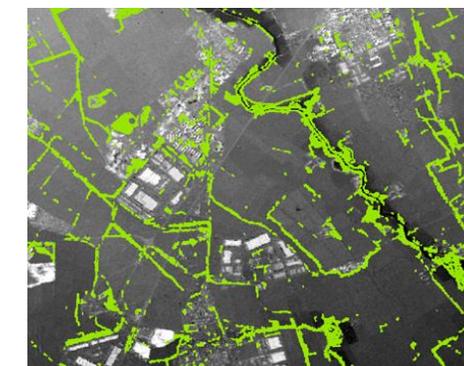
CLMS WaW



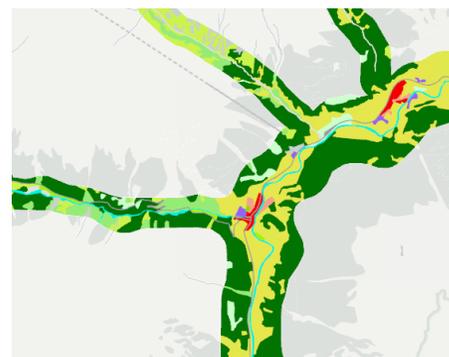
Global Canopy Height (ETHZ)*



Canals: OSM (blue), Hydro-ART (pink)



CLMS SWF



CLMS RZ



World Settlement Footprint (WSF)**

CLMS HRL Water and Wetness (WaW)

*Lang et al., 2023, Lang et al., 2020

Open Street Map (OSM) – waterways

CLMS Small Woody Features (SWF)

CLMS Riparian Zones (RZ)

**WSF: <https://geoservice.dlr.de/web/maps/eoc:wsf2019>

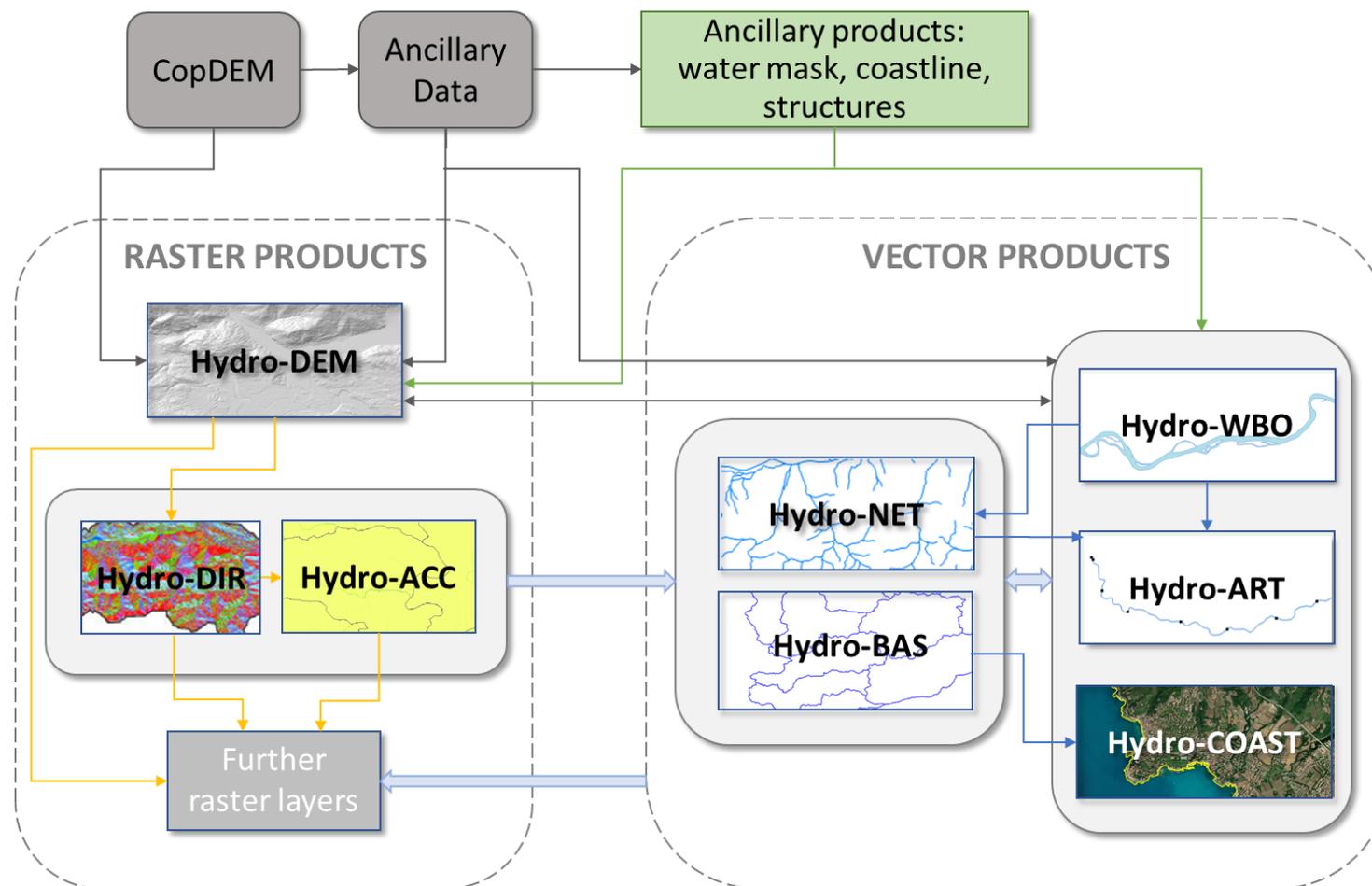




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EU-Hydro suite of products: raster and vector

- 3 Raster layers
- 5 Vector layers



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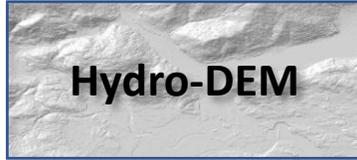


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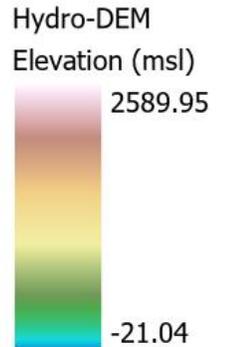
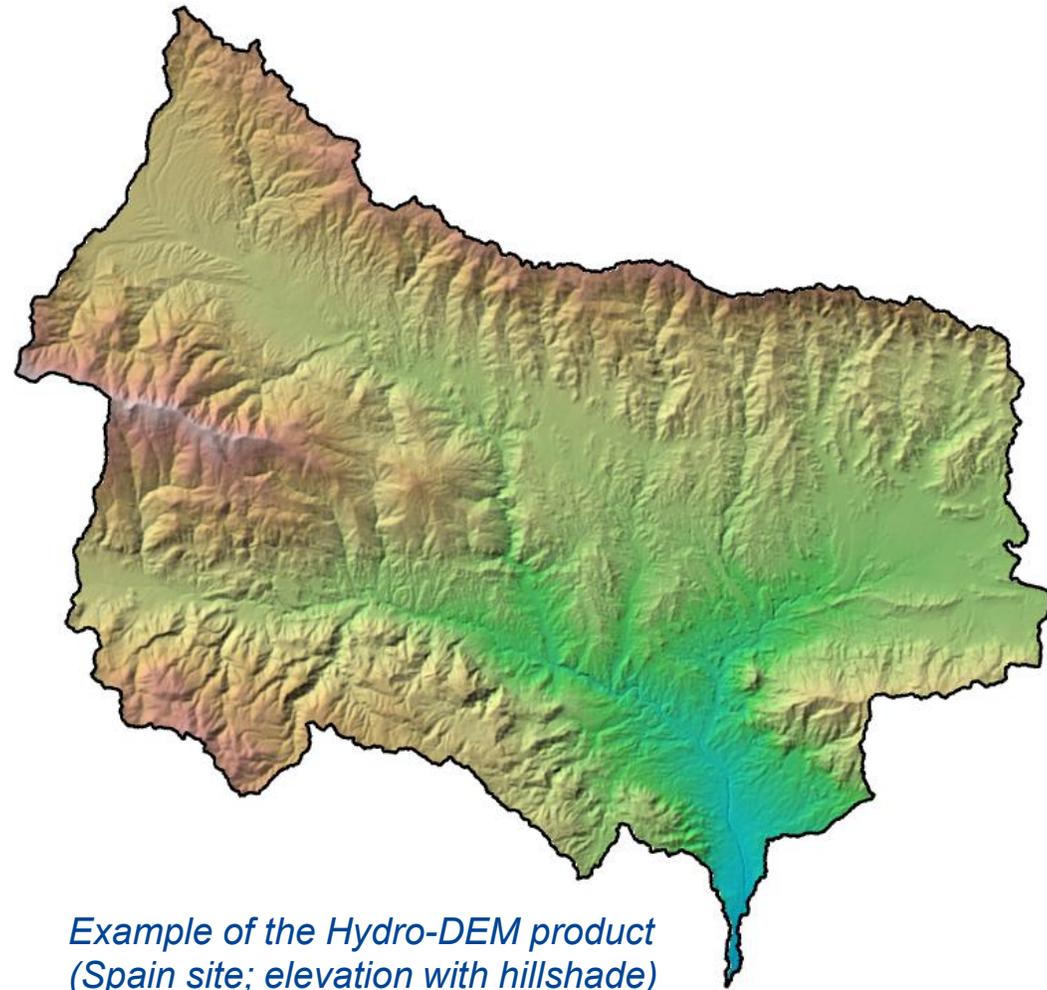


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Raster Products – Hydro-DEM



- **Hydro-DEM: fully hydrologically conditioned DEM**
 - The “core” of EU-Hydro
 - Result of **advanced DEM terrain-editing** and **hydrological conditioning** algorithms and **manual correction** procedures
 - Lambert Azimuthal Equal Area (LAEA) projection
 - 10 m resolution
 - raster format
 - Hydro-DEM will be used to derive further raster products (and consecutively, vector products):
 - Flow Direction (Hydro-DIR)
 - Flow Accumulation (Hydro-ACC)



*Example of the Hydro-DEM product
(Spain site; elevation with hillshade)*

0 100 Kilometers



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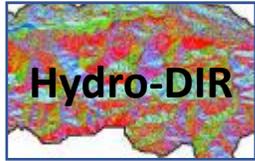
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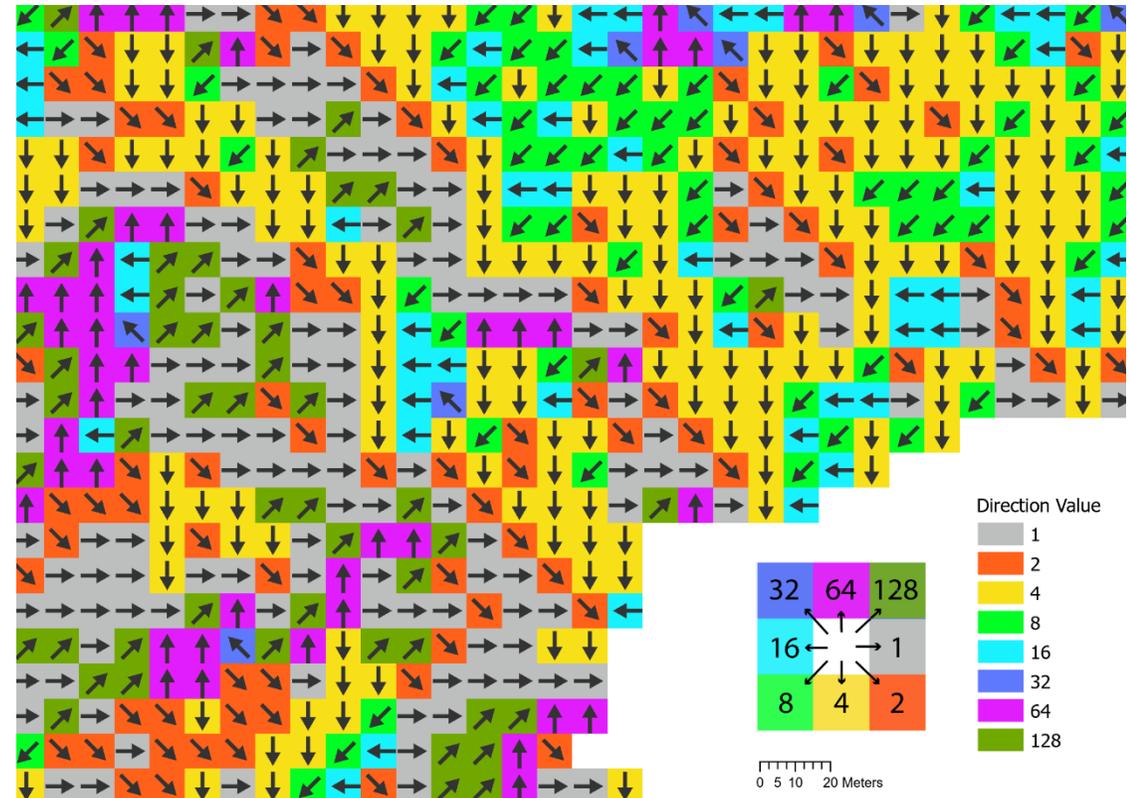


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Raster Products – Hydro-DIR



- **Hydro-DIR: flow direction**
 - containing eight values of possible directions in which streams can flow
 - first derivative from Hydro-DEM
 - serves as basis for hydrological modelling
 - prerequisite for the calculation of Hydro-BAS
- Methodological aspects:
 - D8 flow direction: single downstream direction based on steepest slope
 - Calculated using freely available TauDEM tools



Example of the Hydro-DIR product for a small area along the coast of Sweden



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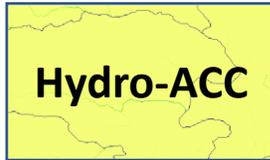
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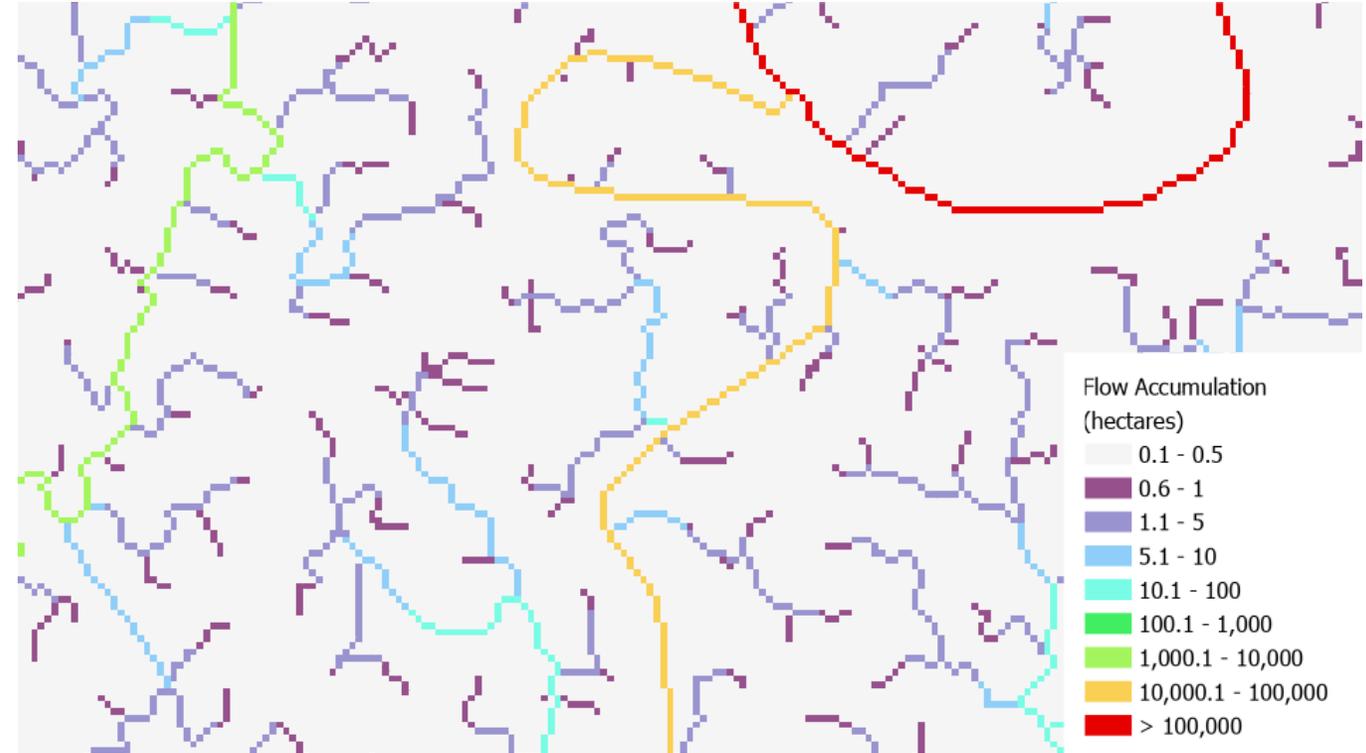


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Raster Products – Hydro-ACC



- **Hydro-ACC: flow accumulation**
 - directly derived from Hydro-DIR
 - provides the size of the area discharging into each cell
 - prerequisite for the calculation of Hydro-BAS and Hydro-NET
- Methodological aspects:
 - Flow accumulation grids are calculated from Hydro-DIR (flow direction) layer
 - Flow accumulation is used to calculate river network vector layer, but values exist for every pixel, even outside of the vector network



Example of the Hydro-ACC product (Italy site)



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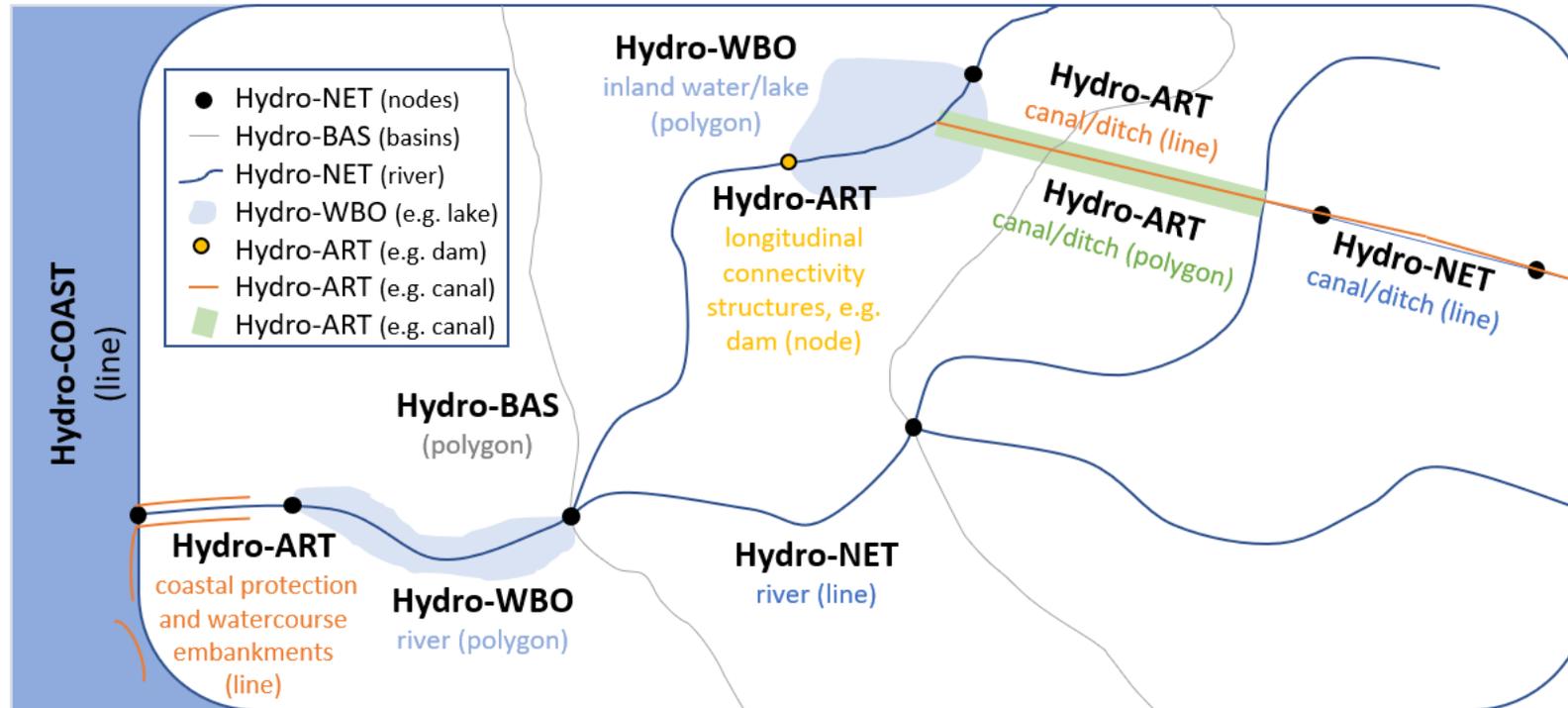
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EU-Hydro Vector Data Model



Line and polygon layers of Hydro-NET, -BAS, -WBO and -COAST are interrelated and Hydro-NET & Hydro-BAS are topologically connected (i.e., features contain information that allows for traversing (routing) along the flow network; Hydro-ART, as an exception, is a stand-alone layer and not topologically connected



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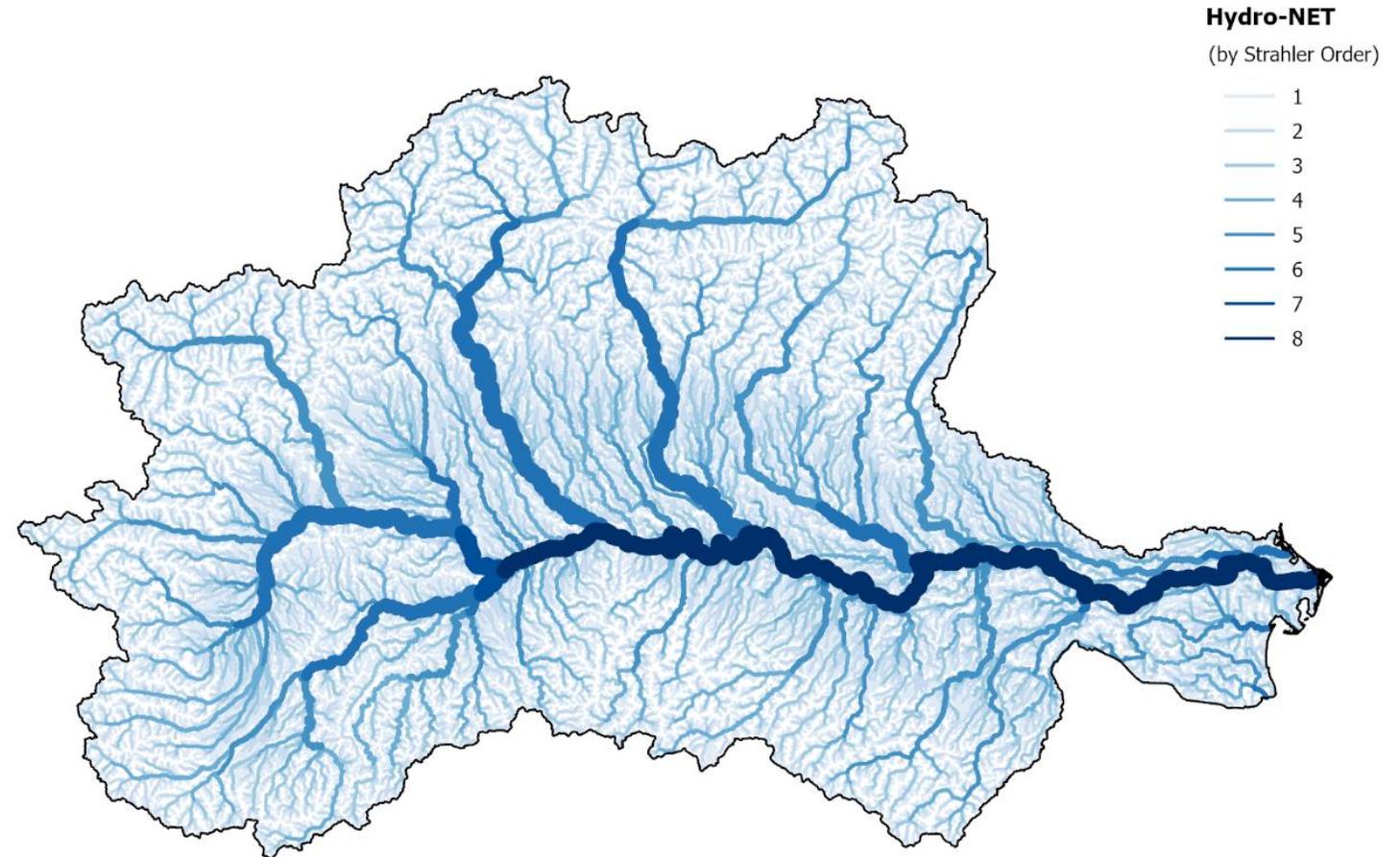


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Vector Products – Hydro-NET



- **Hydro-NET: river network**
 - extracted from Hydro-ACC
 - basis for core topology of the EU-Hydro suite;
 - key parameters as attributes (e.g. Strahler river order and others, reach length)
- River network is **continuous through water bodies (centrelines)**



Example of the Hydro-NET product (Po basin, Italy).



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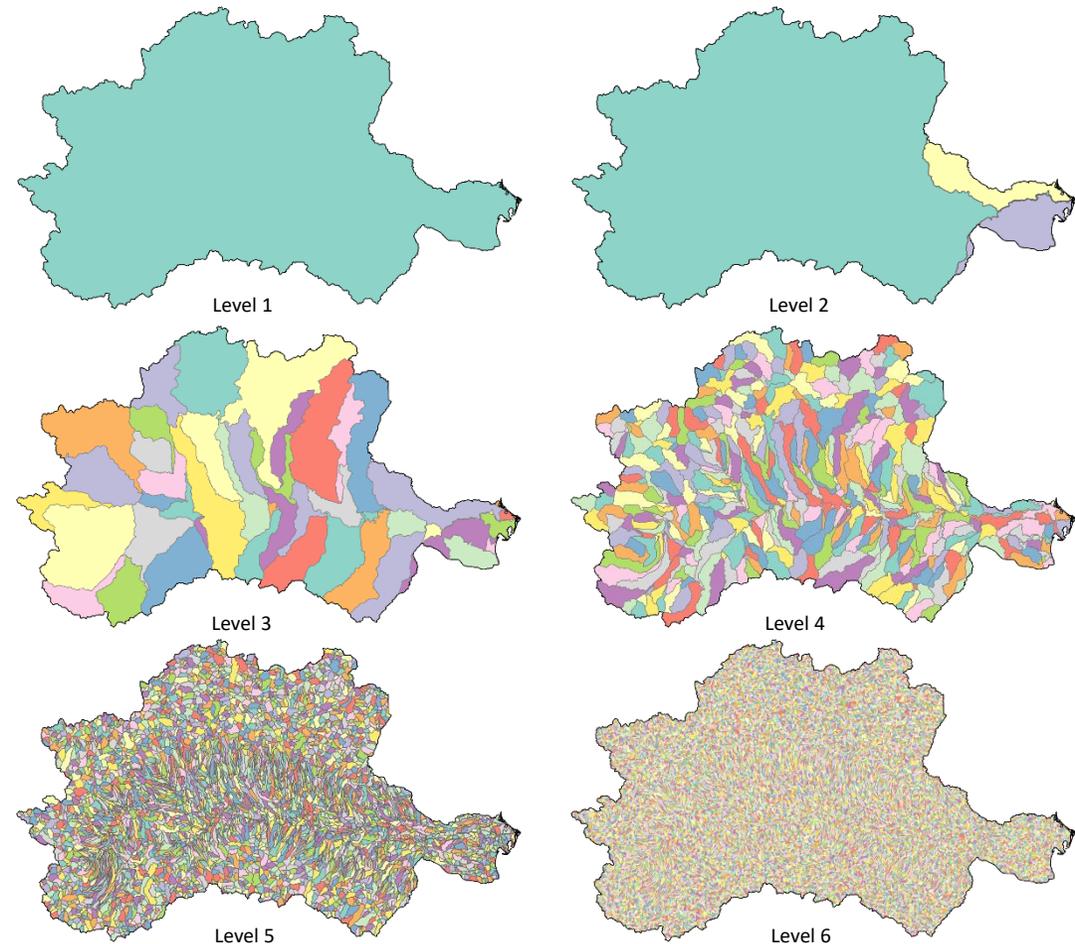
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Vector Products – Hydro-BAS



- **Hydro-BAS: watersheds**

- derived from Hydro-DIR/-ACC, using adaptation of the Pfafstetter coding system
- Hierarchically nested watershed units
- Sub-basins take on the ID of their parent basin with a 2-digit ID appended
- unique ID sequence for each basin and sub-basin, with the ability to identify parent basins based solely on the coding



Example of the Hydro-BAS product (Po basin, Italy).



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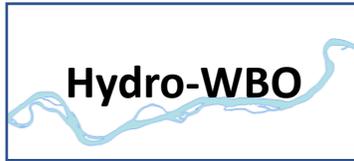
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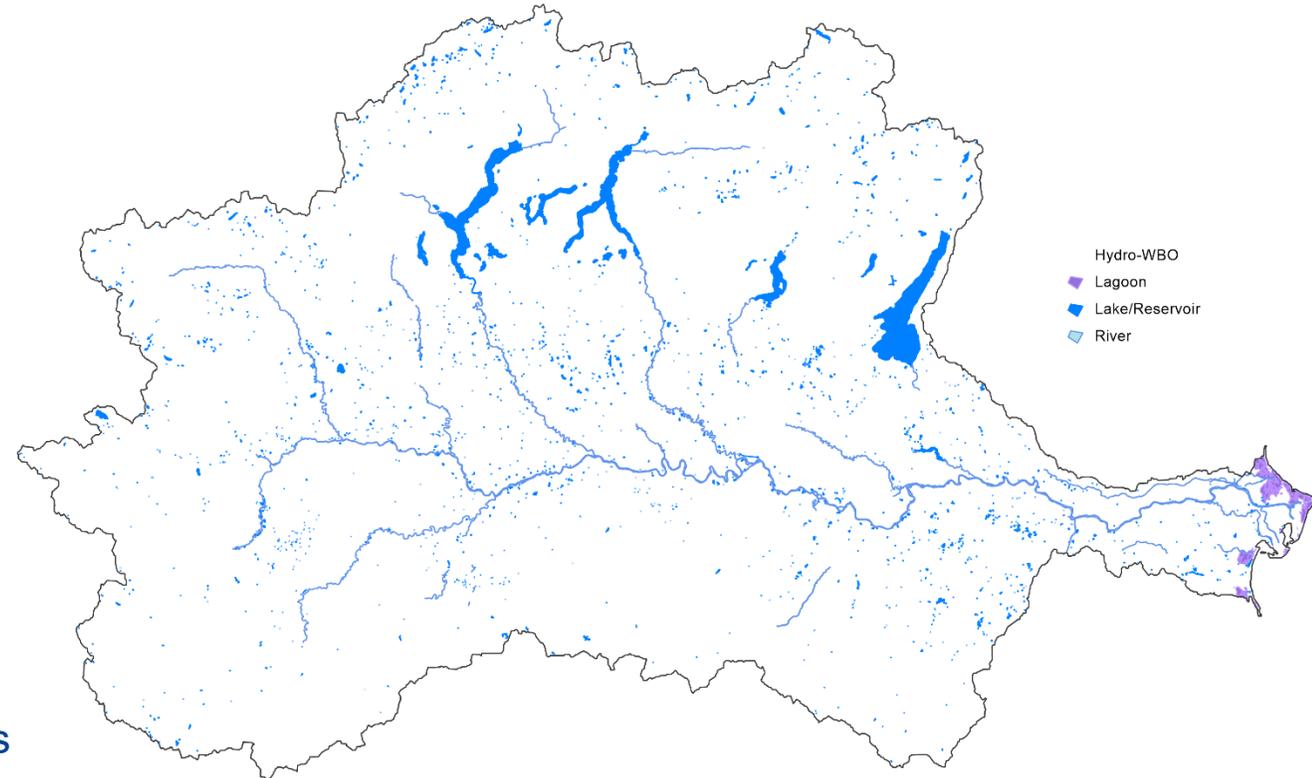
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Vector Products – Hydro-WBO



- **Hydro-WBO: water bodies**
 - Based on EU-Hydro v1.3 and CLMS RZ polygons
 - Updated with ancillary data water masks (CLMS WaW, CLCplus, HydroSHEDS openwater) incl. water body masks generated for DEM conditioning
 - ancillary vector data for refinement
- **Contains:**
 - **Lakes & wide rivers > 20m width** (separation by attributes)
 - Classes: Lakes/reservoirs, lagoons, rivers
 - **MMU 0.5 ha** (also for islands inside water bodies)
 - **Centrelines** go through waterbodies → improve in production with Hydro-WBO inclusion into DEM conditioning



Example of the Hydro-WBO product (Po test site). showing lagoons (purple), lakes (dark blue) and polygonal rivers (light blue).





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Vector Products – Hydro-COAST



Hydro-COAST: coastline

- Basis = **modified CLMS Coastal Zones (CZ) coastline**; adjusted with **TanDEM-X HydroSHEDS coastline**
- Meet requirements of mapping (e.g. CLMS CZ/RZ) and hydrologic modelling communities, include considerations from further stakeholders
- Updates: TanDEM-X coastline (concentrated on estuaries, river mouths, lagoons, islands)
- CZ 2018 classes (final product) + WFD classes → orientation for coastal water classes (e.g. transitional & estuarine waters)
- WBO inside Hydro-COAST (lagoons: in; estuaries, harbors: out); only ART features allowed outside of coastline
- Featuring islands with MMU of >0.5ha;
- Extent of the coastline: affects derived hydrographic information



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Hydro-COAST

- **Hydro-COAST: new features**
 - Higher **level of detail** by including small islands
 - Increased **accuracy** at artificial harbour areas
 - Different coastline definition at river outlets
- Coastline definition has significant effect on derived hydrologic layers



Example of the Hydro-COAST in terms of level of detail of EU-Hydro 1.3 (blue) compared with EU-Hydro 2.0 (red) in the Sweden test site.



Improved level of detail in artificial areas of Hydro-COAST (red) compared to EU-Hydro 1.3 (blue) in Porto.



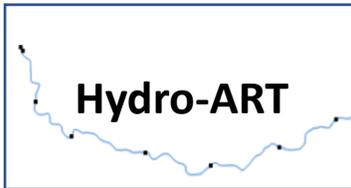
Example of the Hydro-COAST (red) definition in river mouths compared to EU-Hydro 1.3 (blue) in the Gironde outlet.





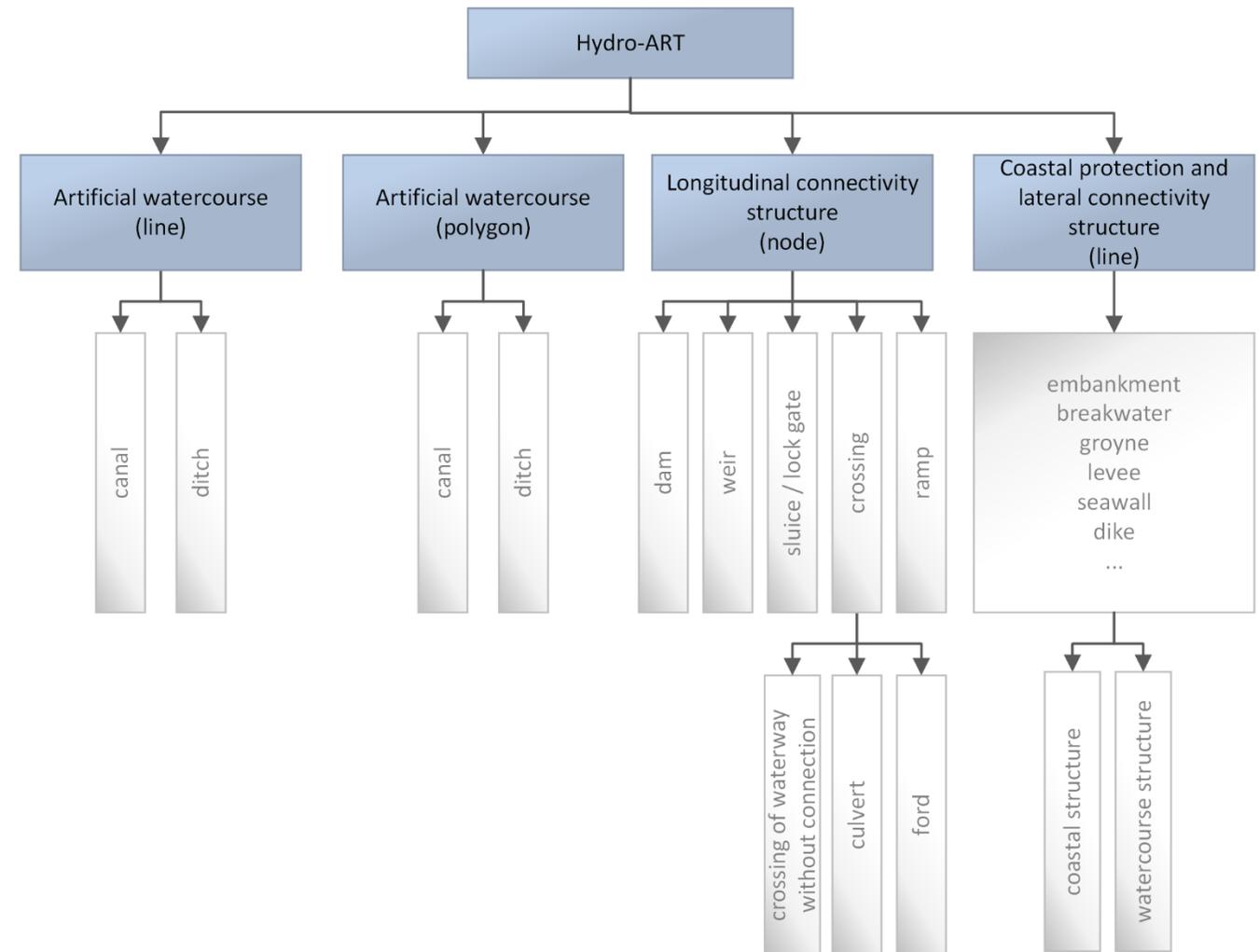
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Vector Products – Hydro-ART



Hydro-ART: artificial structures

- Human-made objects such as
 - Artificial watercourses (e.g. canals & ditches)
 - Longitudinal connectivity structures (e.g. dams & culverts),
 - Lateral connectivity structures (e.g. embankments)
 - Coastal protection structures (e.g. embankments,
- Terminology adjusted to Nature Restoration Regulation (NRR)
- Based only on ancillary data on European, national and regional level
- Cartographic product (not consistent with network of other layers)



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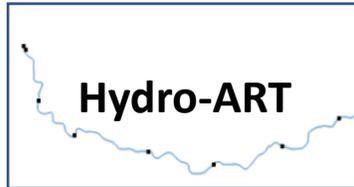
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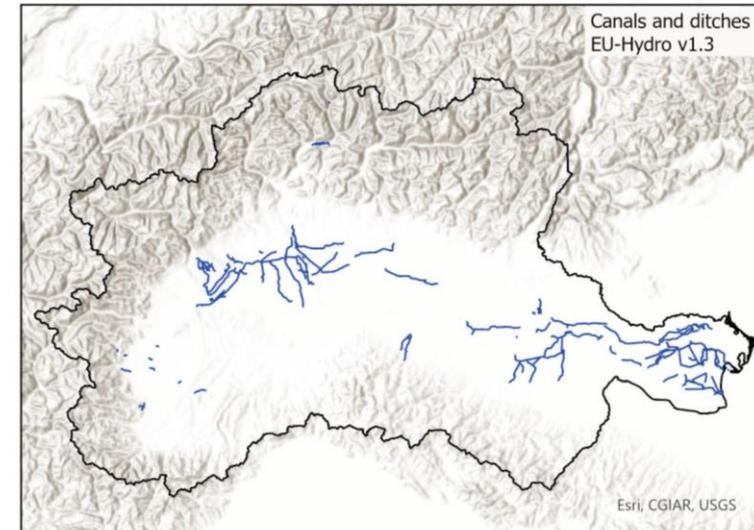
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Vector Products – ART

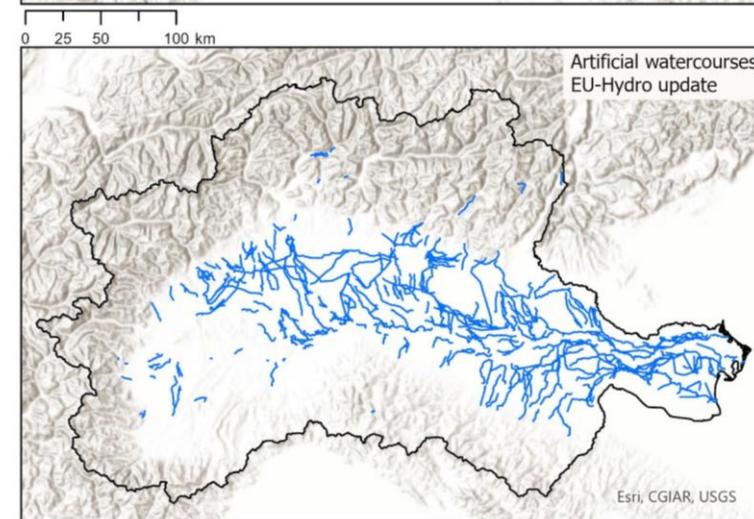


Artificial Watercourses:

- Features:
 - canals (purpose = navigation)
 - ditches (purpose = irrigation)
- Lines and polygons
- Cartographic product: Canals are not snapped to Hydro-NET (*possible future development*)
- Regional differences in ancillary data in terms of number/density and attribution
- Canals and ditches from different datasets have been merged
 - Example Po: canals quadrupled



Overview of the canals & ditches of EU-Hydro v1.3



Hydro-ART artificial watercourse lines in the Italy Ramp-Up AOI



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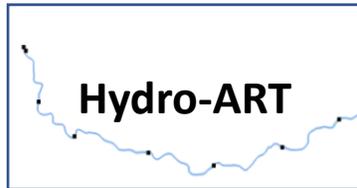
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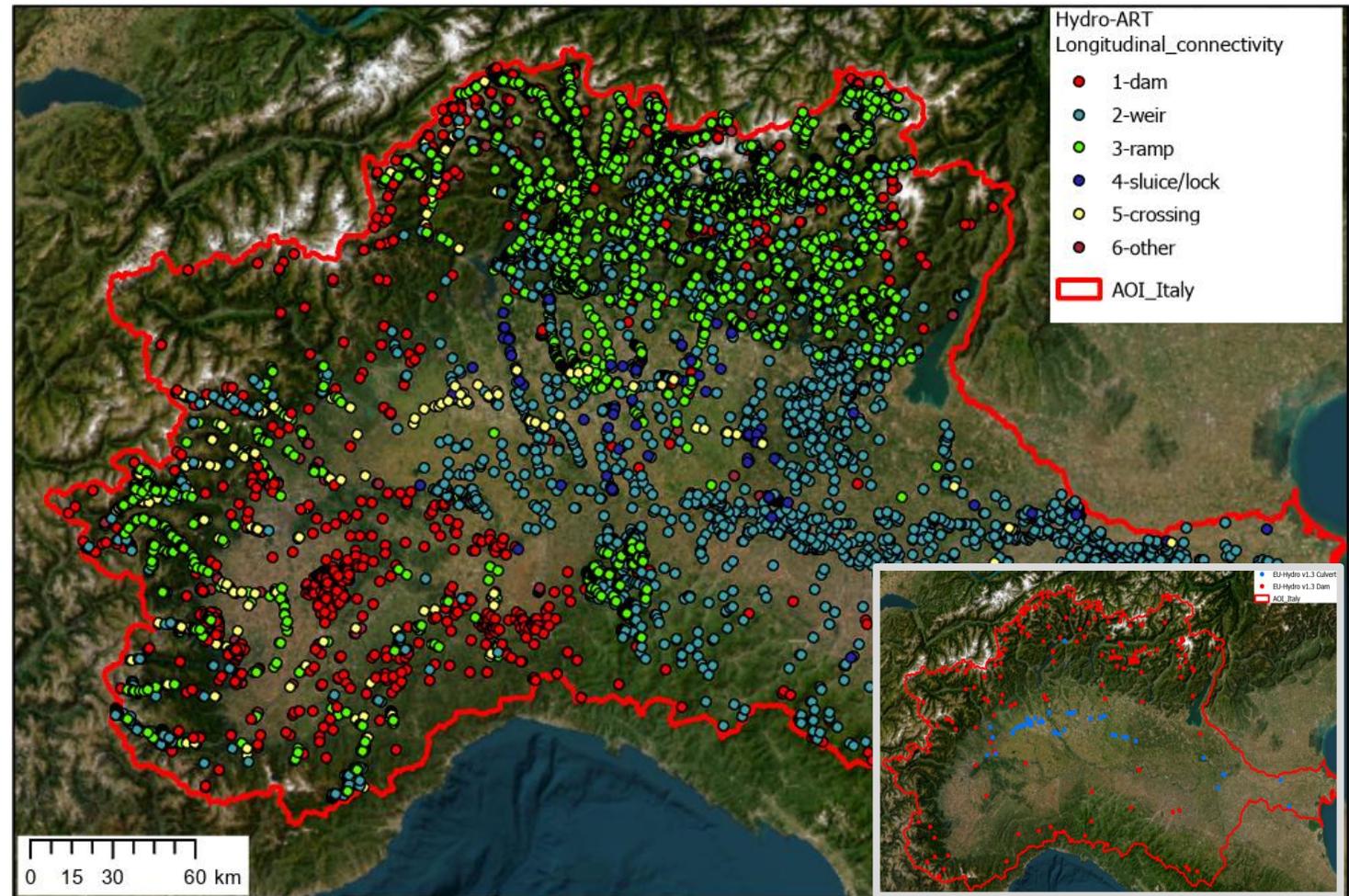
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Vector Products – Hydro-ART



Longitudinal Barrier Structures

- Strong difference in structure number/density, naming and attribution on regional level
- Data have been either
 - merged (where possible)
 - or the best dataset is chosen
- A lot of attributes as placeholder (different for certain regions)



Hydro-ART longitudinal barrier structures in the Ramp-Up Po site in Italy (dam, weir, ramp, sluice/lock, crossing, other); small figure: EU-Hydro v1.3 dams (red) and culverts (blue)

Background: Earthstar Geographics



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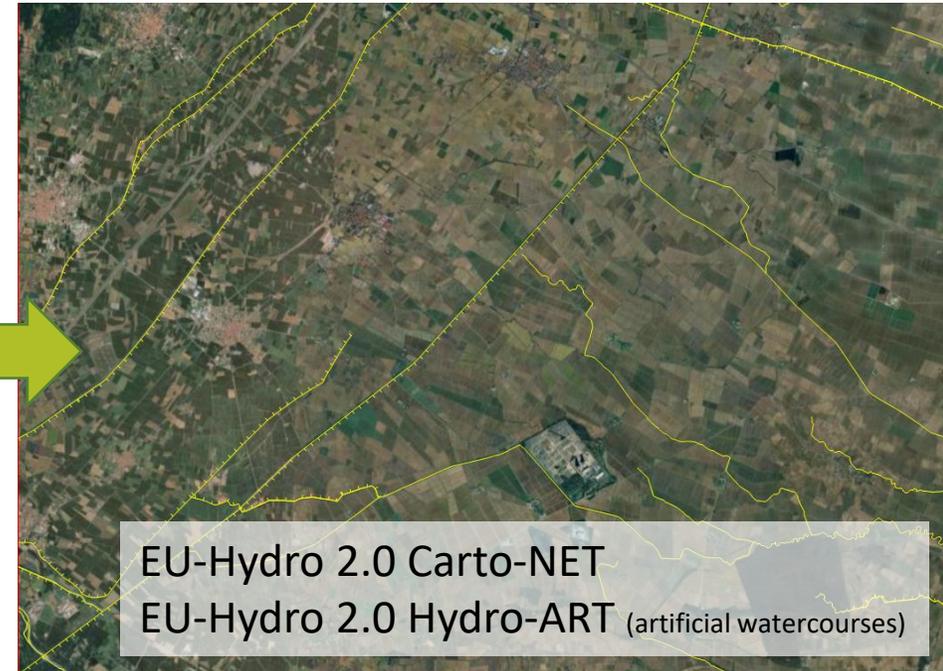
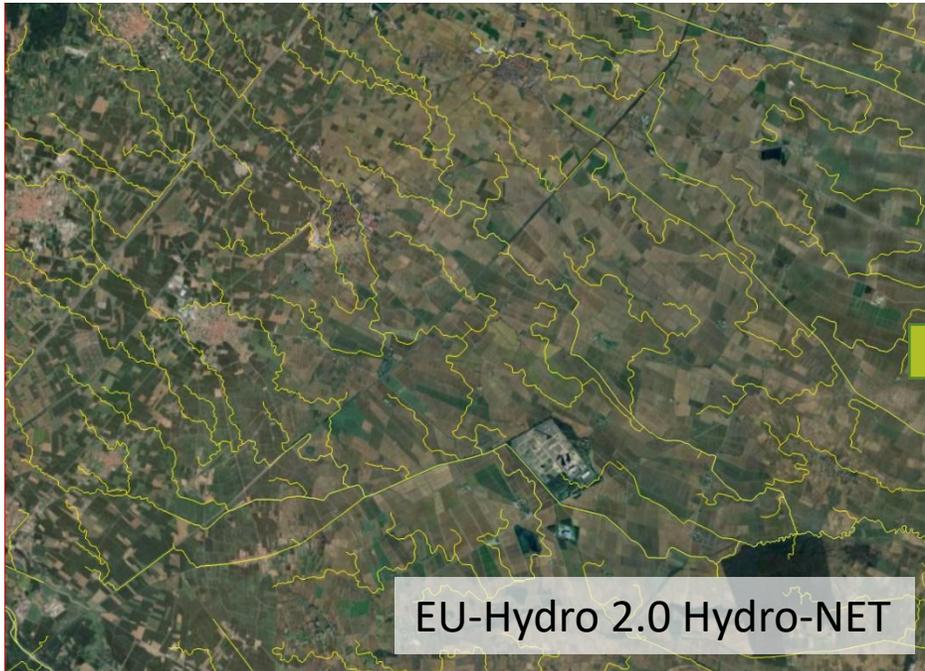




Vector Products – Carto-NET

A new proposed layer “Carto-NET” for cartographic improvements in **focus regions**:

- Clean / removal of ‘overland flow’ by attributes (no deletion from Hydro-NET → important for hydrology/network connectivity and routing)
- Rivers to be replaced with better canal geometries (in case of duplications)
- Alignment of Hydro-ART canals with reduced river network





QC and internal verification of the R-U phase

- **High Overall Quality:** the dataset is robust for hydrological modelling and operational use
- **Workflow review is essential**
 - Endpoint snapping matters
 - Introduce automatic checks and fixes to avoid small issues affecting network connectivity
 - Low order streams are more prone to errors
 - Positional errors and variability are highest in low-order segments -> major improvements would be possible (see trade-offs in quality and time)
 - Outliers impact accuracy:
 - Even a few major errors significantly affect overall reliability.





QCR - Results & Accuracy Assessment

• Quality Control (QC): positive

- Small issue – endpoint snapping in loops

• Internal Verification (geometric accuracy):

- Spain shows the highest positional accuracy (lowest mean distance - μ)
 - Italy → 22.6 m
 - Spain → 9.6 m
 - Sweden → 39.1 m
 - All → 25.9 m
- Italy and Sweden have larger deviations, particularly for lower-order streams.
- Outliers significantly affect Italy's mean distance; removing them improves accuracy
 - Impact of Removing Outliers
 - Italy: Mean Distance ↓~ 65% (22.6 m → 11.2 m)
 - Spain: Mean Distance ↓~ 46% (9.6 m → 4.8 m)
 - Sweden: Mean Distance ↓~ 10% (39.1 m → 34.6 m)
 - All: Mean Distance ↓~ 30% (25.9 m → 17.8 m)

Country	Group 1 (m)	Group 2 (m)	Group 3 (m)	All (m)
Italy	41.20	26.70	0.00	22.60
Spain	18.30	0.90	-	9.60
Sweden	60.20	18.00	-	39.10

Mean distance - μ



Figure 8: Example of a strong error on Italy area (approx. 630 m distance between the Reference point and Hydro-NET junction) (background: ESRI World Imagery)

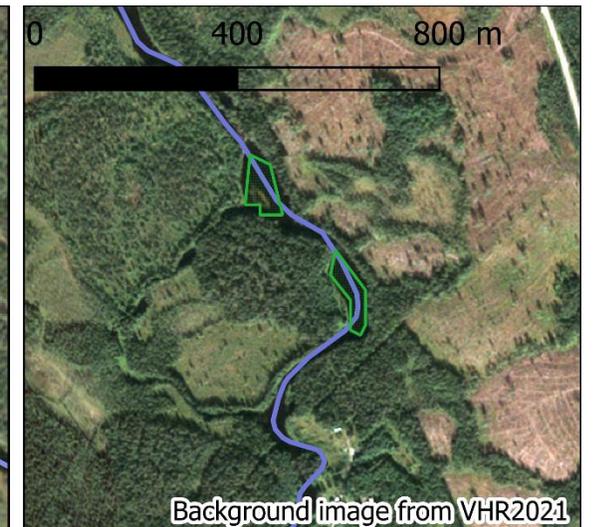
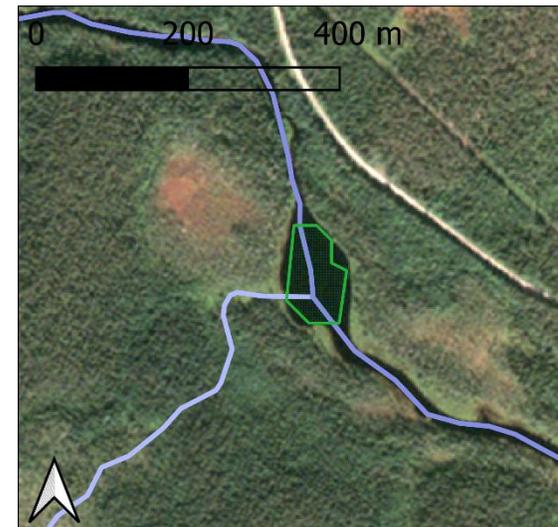
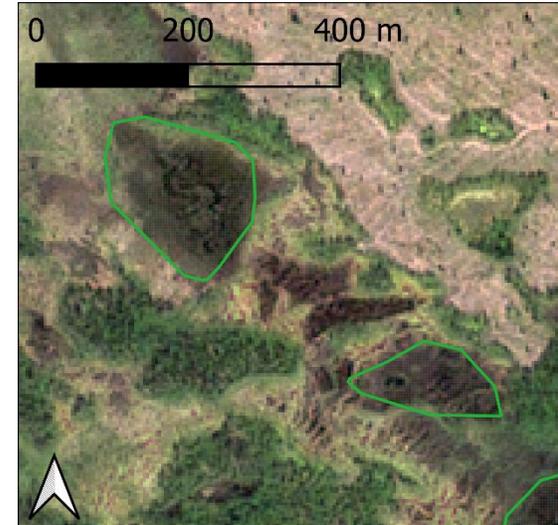




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Independent verification of the R-U phase

- Verification only on Po and Råne river basins and vector layers
- Focus on questions related to requirements and use cases
- Mainly qualitative results but giving quantitative results when possible
- Usability assessment of (draft) ATBD and PUM
- Main outcomes :
 - Each (test) layer of EU-Hydro is generally performing well
 - Production needs to ensure a fully harmonised and homogeneous product
 - Complex product to verify due to the multiple interrelated layers and different types of geometry!



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Current state of the production phase

- Production ongoing, started in Q4 2025, expected to conclude in Q4 2026
 - Production separated in seven batches (roughly west to east)
 - Phase 1 (pre-conditioning) over 50% complete for Europe (batches 1,2,3 completed; 4,5,6 ongoing)
 - Phase 2 (hydro-conditioning) further optimized and applied to Ireland, Iceland ongoing (batch 1)
 - Manual corrections already finalized for Ireland, Iceland ongoing
 - Hydro-WBO, Hydro-ART (interim for batch 1+2, ongoing for batch 3)
 - Early March: Ireland (all layers, v0.8) as a first area to be delivered
 - Will be re-delivered as part of NET and WBO v0.9 (Sep 2026) and at the end (v1.0) with all attributes
 - Between March and June: Hydro-COAST v1.0
 - The vector geometry is already finalized with only few pending issues
 - September 2026: partial delivery v0.9 to support CZ/RZ production
 - Hydro-NET, Hydro-WBO (other layers if needed)
 - December 2026: final delivery v1.0
 - All layers with final attribution
 - Improvements in focus regions





Final words: Improvements of EU-Hydro 2.0

- **Consistency/harmonization** – within and between layers
 - Including traceable and systematic layer generation
 - Including correct routing for both rivers and sub-basins
 - Including linkages between layers (incl. raster at pixel-level and vector)
- **Higher detail and quality** of hydrographic feature extraction
 - Extraction from latest generation CopDEM (10 m resolution, homogenous quality)
 - Including updates derived from latest (ancillary) data
- New products: **Hydro-ART** layer; **Hydro-DEM, -DIR, -ACC** raster layers; **Carto-NET** (improved cartographic representation in focus areas)
- Fit for various **applications/use cases**: from mapping to hydrologic modelling





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